IAEA
International Atomic Energy Agency

INDC(CCP)-0447
Distr. Web only

INDC International Nuclear Data Committee

Experimental and theoretical studies of the yields of residual product nuclei produced in thin Pb and Bi targets irradiated by 40 – 2600 MeV protons

Prepared by

Yu. E. Titarenko
Institute for Theoretical and Experimental Physics (ITEP)

Co-authors: V.F. Batyaev, E.I. Karpikhin, V.M. Zhivun, A.V. Ignatyuk,
V.P. Lunev, N.N. Titarenko, Yu.N. Shubin, V.S. Barashenkov
Institute for Theoretical and Experimental Physics (ITEP)

October 2009

IAEA Nuclear Data Section, Vienna International Centre, A-1400 Vienna, Austria

Selected INDC documents may be downloaded in electronic form from
http://www-nds.iaea.org/indc_sel.html or sent as an e-mail attachment.
Requests for hardcopy or e-mail transmittal should be directed to *services@iaeand.iaea.org*
or to:
Nuclear Data Section
International Atomic Energy Agency
Vienna International Centre
PO Box 100
A-1400 Vienna
Austria

Printed by the IAEA in Austria

October 2009

INDC(CCP)-0447
Distr. Web only

Experimental and theoretical studies of the yields of residual product nuclei produced in thin Pb and Bi targets irradiated by 40 – 2600 MeV protons

Prepared by

Yu. E. Titarenko
Institute for Theoretical and Experimental Physics (ITEP)

Co-authors: V.F. Batyaev, E.I. Karpikhin, V.M. Zhivun, A.V. Ignatyuk,
V.P. Lunev, N.N. Titarenko, Yu.N. Shubin, V.S. Barashenkov
Institute for Theoretical and Experimental Physics (ITEP)

Abstract

The Project is aimed at experimental determining and computer-aided theoretical simulating the independent and cumulative yields of residual radioactive product nuclei in high-energy proton-irradiated thin targets made of high-isotopic and natural lead (^{206}Pb, ^{207}Pb, ^{208}PB, ^{nat}Pb) and bismuth (^{209}Bi) that are the most probable choice to be the target materials in the accelerator-driven (hybrid) systems (ADS) coupled to a high-current proton accelerator. The yields of residual product nuclei are of great importance when estimating such basic radiation-technology characteristics of the hybrid facility targets as the total target activity, the target "poisoning", the buildup of long-lived nuclides, the α-activity, the content of low-pressure evaporated nuclides (Hg), the content of the chemically-active nuclides that drastically spoil the corrosion resistance of the facility structure materials, etc.

In view of the above, the radioactive product nuclide yields from targets materials were experimentally determined using the ITEP U-10 proton accelerator in 55 measurement runs using the monoisotopic and natural lead (^{206}Pb, ^{207}Pb, ^{208}PB, ^{nat}Pb) and bismuth (^{209}Bi) targets within the proton energy range fractionated minutely, namely at 0.04, 0.07, 0.10, 0.8, 1.2, 1.4, 1.6, and 2.6 GeV to cover the entire range of the internuclear hadron cascading.

As a result, 5972 cumulative and independent yields of residual radioactive product nuclei, whose lifetimes range from 8 minutes to 32 years, have been measured. Besides, the cross sections for the ^{27}Al(p,x)^{24}Na and ^{27}Al(p,x)^{7}Be monitor reactions have been measured at the same proton energies together with the ^{27}Al(n,p)^{27}Mg reaction rate that characterizes the neutron background contributions in each experiment. The experimental nuclide yields are determined by the direct γ-spectrometry method. The γ-spectrometer resolution is 1.8 keV in the 1332 keV ^{60}Co γ-line. The experimental γ-spectra are processed by the GENIE2000 code. The γ-lines are identified, and the cross sections calculated, by the ITEP-developed SIGMA code using the PCNUDAT database. The proton fluence is monitored by the ^{27}Al(p,x)22Na reaction.

Measurement data have been compared with the calculation results of the LAHET, CEM03, LAQGSM+GEM2, and INCL4+ABLA codes, as well as of the CASCADE, CASCADO, and LAHETO codes, whose associate INC models were being further specified under the Project. The predictive power of the tested codes has been found to be different, but still satisfactory throughout the mass and energy ranges of most of the reaction products obtained in the shallow spallation region by all the above-mentioned codes. On the other hand, the predictive power of the codes has proven to be very unsatisfactory for the reaction products within the deep spallation, fission, and fragmentation regions. Therefore, all the codes have to be improved, with their associate models for generation of the fission and fragmentation products being most desirable.

Keywords: nuclear reaction, spallation, deep spallation, fission, fragmentation, yields, residual nuclides, cross sections, simulation, Monte-Carlo codes, comparison.

October 2009

The work has been performed by the following Institutes and Collaborators:

1. Participating Institutes:

   1. Leading Institute: Institute for Theoretical and Experimental Physics (ITEP), B. Cheremushkinskaya 25, 117259, Moscow, Russia, Phone +7-095-123-6383, Fax +7-095-127-0543, E-mail Yury.Titarenko@itep.ru

2. Foreign Collaborators:

   1. **European Commission**, 200 rue de la Loi, Brussels, Belgium, MO 075 05/51 B-1049, Dr.**Vade Bhatnagar**, Tel: +322 2995896, E-mail: vade.bhatnagar@cec.eu.int;

   2. **Royal Institute of Technology**, Lindstedtvgen 30, Stockholm, Sweden, S-10044, Prof., academician **Waclaw Gudowski**, Tel: +46-8-7906394, Fax: +46-8-105519, E-mail: wacek@neutron.uth.se;

   3. **Forschungszemntrum Karlsruhe Institut fur Kern und Energiete**, Postfach 3640, Karlsruhe, Germany, 76021, Prof. **Colnelis H.M. Broeders**, Tel: +49-7247-822484, Fax: +49-7247-823824, E-mail: cornelis.broeders@inr.fzk.de;

   4. **Commissariat a l'Energy Atomique, Direction des Reacteurs Nucleaires, DAPNIA/SPhN, CEA Saclay**, Gif sur Yvette Cedex, Saclay, France, F-91191, Prof **S. Leray**, Tel: +33-1-6908 8361, Fax: +33-1-6908 7584, E-mail: sleray@cea.fr;

   5. **Commissariat a l'Energy Atomique, Direction des Reacteurs Nucleaires, CEN - Cadarache**, Saint Paul Lez Durance Cedex, Cadarache, France, F - 13108, Prof. **Massimo Salvatores**, Tel: +33-4-4225 3365, Fax: +33-4-4225 4142, E-mail: salvatores@drn.cea.fr, Prof. **Igor S. Slessarev**, E-mail: slessarev@cea.fr;

   6. **Zentrum fuer Strahlenschutz und Radiooekologie, University of Hannover**, Am Klenen Felde 30, Hannover, Germany, D - 30167, Prof. **R. Michel**, Tel: +49-511-762-3311, Fax: +49-511-762-3319, E-mail: michel@mbox.zsr.uni-hannover.de;

   7. **Los Alamos National Laboratory**, Los Alamos, USA, NM 87545, Dr. **S.G. Mashnik**, Tel: +1 505 667 9946, Fax: +1 505 667 1931, E-mail: mashnik@t2y.lanl.gov, Dr. **R.E. Prael**, Tel: +1 505 667 7283, Fax: +1 505 665 3046, E-mail: rep@lanl.gov, Dr. **G.J. Van Tuyle**, Tel: +1 505 665 4581, Fax: +1 505 667 4098, E-mail: vantuyle@lanl.gov;

   8. **Japan Atomic Energy Research Institute (JAERI)**, Shirakata-shirane 2-4, Tokai-mura, Naka-gun, Ibaraki-ken 319-1195, Japan, Dr. **Hiroshi Takada**, Tel: +81-29-282-5336, Fax: +81-29-282-6496, E-mail: takada@omega.tokai.jaeri.go.jp;

Contents

1 Introduction

The present work is the Final Technical Report on the ISTC Project #2002 "Experimental and theoretical studies of the yields of residual product nuclei produced in thin Pb and Bi targets irradiated by 40-2600 MeV protons"[1], which continues and expands the ISTC Project #839 "Experimental and theoretical study of the yields of residual product nuclei produced in thin targets irradiated by 100-2600 MeV protons"[2]. Despite the close similarity in the subjects of Projects #839 and #2002, they are somewhat different. Project #839 was aimed at measuring the residual product nuclide yields in many high-enrivhed and natural isotopic composition targets irradiated selectively by 100-2600 MeV protons (^{182,183,184,186}W by 0.2, 0.8, and 1.6 GeV protons; ^{nat}W, ^{56}Fe, ^{58}Ni, and ^{93}Nb by 2.6 GeV protons; ^{232}Th, ^{nat}U, and ^{99}Tc by 0.1, 0.2, 0.8, 1.2, and 1.6 GeV protons; ^{59}Co and ^{63,65}Cu by 0.2, 1.2, 1.6, and 2.6 GeV protons; ^{nat}Hg by 0.1, 0.2, 0.8, and 2.6 GeV protons; ^{208}Pb by 1.0 GeV protons) and at estimating the predictive power of different simulation codes, given the above set of proton-nucleus interactions.

Project #2002 is aimed at measuring the residual product nuclide yields in much less numerous high-enriched and natural-composition targets ($^{206,207,208,nat.}$Pb, ^{209}Bi), but with a more detailed division of the entire proton energy range throughout the intranuclear hadron cascading region (0.04, 0.07, 0.1, 0.15, 0.25, 0.4, 0.6, 0.8, 1.2, 1.6, and 2.6 GeV), i.e., at deriving the excitation functions of the residual product nuclei within the 40-2600 MeV energy range and at estimating the accuracy of predicting the excitation functions calculated via different codes (LAHET, CEM03, LAQGSM+GEM2, INCL4+ABLA, CASCADE, CASCADO, and LAHETO). Most of the codes are under development at different laboratories worldwide. Besides, when implementing the Project, the INC models of some codes (CASCADE, CASCADO, and LAHETO) were modified and verified using, among others, the experimental data obtained.

The spallation reactions have had an ever-increasing interest in recent years because, first of all, they can be used to design the intensive neutron sources to be used in the accelerator-driven subcritical reactor systems or in physical and technological researches [3]. Designing the accelerator-driven subcritical systems (ADS facilities) necessitates that the yields of various reaction-produced nuclei should be known to within a sufficient accuracy that would make it possible to predict the number of radioactive isotopes produced in a target. In fact, the short-lived isotopes can hamper operations of the ADS facilities, while the long-lived isotopes lead to a persistent increase in the ADS facility radioactivity. The Pb and Bi nuclear data are of particular importance because the two elements are regarded as the best-choice target materials in most of the latest conceptual designs of ADS facilities. Therefore, the excitation functions of the residual product nuclide yields in (^{206,207,208,nat}Pb and ^{209}Bi) are extremely desirable to measure in detail.

Table 1 is a detailed list of the energies and target materials used in the researches under the reported Project.

Table 1: Target materials and irradiation energies.

Target	Proton energy (GeV)										
	0.04	0.07	0.1	0.15	0.25	0.4	0.6	0.8	1.2	1.6	2.6
^{209}Bi	+	+	+	+	+	+	+	+	+	+	+
^{208}Pb	+	+	+	+	+	+	+	+	+	+	+
^{207}Pb	+	+	+	+	+	+	+	+	+	+	+
^{206}Pb	+	+	+	+	+	+	+	+	+	+	+
$^{nat.}$Pb	+	+	+	+	+	+	+	+	+	+	+

2 The techniques for experimental determining the cross sections for residual nuclide production

Like Project #839, the yields or cross sections of radioactive nuclei produced in proton (p) interactions with the $({}^{A_{Tag}}_{Z_{Tag}}Tag)$ target nuclei were determined under Project #2002 by the direct kinematics method $p \rightarrow {}^{A_{Tag}}_{Z_{Tag}} Tag$ using the semiconductor γ-spectrometry. The methodological support of the Project #2002 experiments was actually the same as in Project #839, the only difference being that the two-link structure of the decay chain relationships was replaced with its three-link counterpart to determine the cross sections for the identified radioactive residual product nuclei. The replacement makes it possible to apply the mathematical model of nuclear transformations to calculating any complicated nuclear decay chain.

2.1 Mathematical representation of three-link chain of reaction product yields

Under inelastic proton-target interactions, the residual product-nuclei are generated in different intranuclear processes, such as spallation, fission, fragmentation, emission of light nuclei and nucleons, and decays of their precursors in a transformation chain.

The general form of the proton-target interactions is

$$ {}^{A_{Tag}}_{Z_{Tag}}Tag(p,x){}^{A}_{Z}N \ , $$

where (p,x) denotes the type of nuclear reaction; Tag and N are the chemical symbols of elements (i.e., of target-nuclei and of products); A_{Tag} and Z_{Tag} are, respectively, the mass number and the charge of a target nucleus; A и Z are, respectively, the mass number and the charge of a nuclide produced in a respective nuclear reaction.

As a rule, the parentage chains of radioactive product decays include over 6-8 nuclides. In practice, however, the chains are always implied to permit a simplification. In particular the chains can be reduced to the three-link (and even two-link) patterns.

The following possible cases are meant (see Fig. 1):

- The characteristic decay time of an irradiated target sample before the measurements start is much longer than the halflife of the most long-lived precursor of nuclide N_1. In this case, conforming to Fig. 1, σ_1 is the cumulative yield of nuclide N_1 – σ_1^{cum} ;

- The halflife of the precursor of nuclide N_1 is much longer than both the nuclide halflife (the screening case) and the experiment time. In this case, nuclide N_1 may be treated to be the first in a transformation chain, i.e. σ_1 is the independent yield of nuclide N_1 – σ_1^{ind}; generic

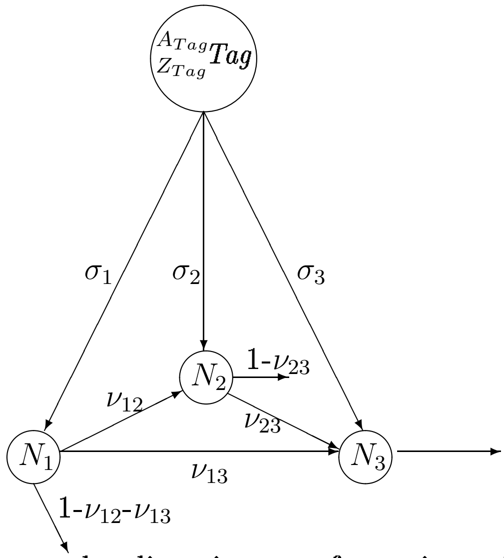


Fig. 1: A schematic of production and radioactive transformations of three nuclides in a chain.

The present work uses mainly the three-link transformation chain version that permits reduction to the two-link version. In the case of mono-energy proton beam, the production reaction rate of each residual product nucleus R_i $(i = 1, 2, 3, st)$ [c^{-1}] can be presented as

$$R_i^{cum/ind} = \sigma_i^{cum/ind} \cdot \Phi \qquad i = 1, 2, 3, st \tag{1}$$

where $\sigma_1^{cum/ind}$, σ_2^{ind}, and σ_3^{ind} are the cumulative or independent cross sections for production of nuclides N_1, N_2, and N_3, respectively; $\sigma_{st}^{cum/ind}$ are the cumulative or independent cross sections of the monitor reactions used in calculating the mean density of proton flux (see formulas 89 – 115); Φ is the mean proton flux density [proton$\cdot$(cm$^2 \cdot s)^{-1}$].

In terms of the above definition of reaction rates, the three-link transformation chain can be mathematically described by the following set of differential equations:

$$\begin{cases} \frac{dN_1(t)}{dt} &= N_{Tag}R_1^{cum/ind} - \lambda_1 N_1(t) \ , \\ \frac{dN_2(t)}{dt} &= N_{Tag}R_2^{ind} + \nu_{12}\lambda_1 N_1(t) - \lambda_2 N_2(t) \ , \\ \frac{dN_3(t)}{dt} &= N_{Tag}R_3^{ind} + \nu_{13}\lambda_1 N_1(t) + \nu_{23}\lambda_2 N_2(t) - \lambda_3 N_3(t) \ , \end{cases} \tag{2}$$

with initial conditions $N_1(0) = N_2(0) = N_3(0) = 0$. Here, $N_1(t)$, $N_2(t)$, $N_3(t)$ are numbers of product nuclei; $R_1^{cum/ind}$, R_2^{ind}, R_3^{ind} are, respectively, their cumulative or independent production rates; λ_1, λ_2, λ_3 are decay constants; ν_{ij} are probabilities for the i-th nuclide to decay into the j-th nuclide; N_{Tag} is the number of nuclei of element $^{A_{Tag}}_{Z_{Tag}}Tag$ in an experimental sample; t is current time measured from start moment of irradiation till its end.

The pulsed irradiation mode was used in the reported experiments, i.e. use was made of recurrent irradiation runs consisting each of K pulses of duration tau and repetition rate T (see Fig. 2).

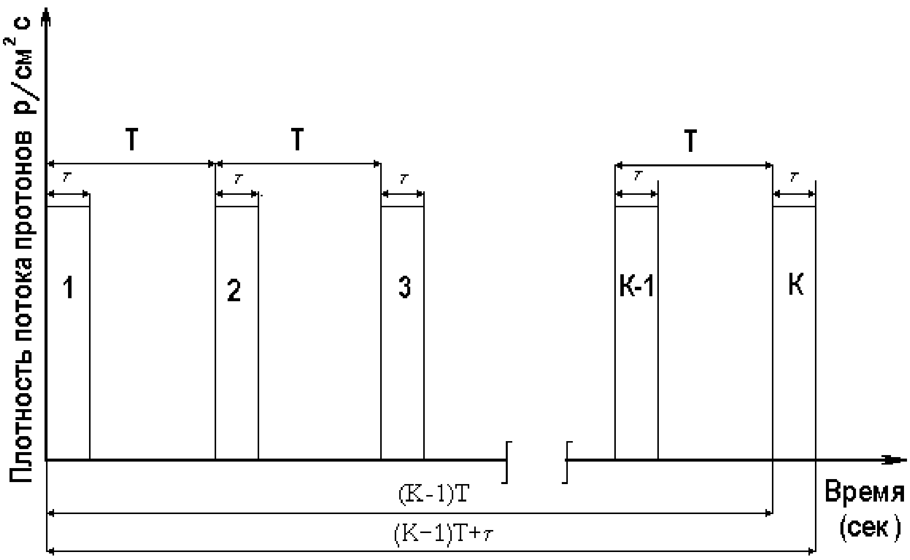


Fig. 2: Characteristics of pulsed irradiation mode

Given the pulsed irradiation mode, the solution for the set of differential equations (89) by the moment of irradiation end $t_{irr} = (K-1)T + \tau$ is described by the following formulas:

$$N_1(t_{irr}) = N_{Tag} R_1^{cum/ind} \frac{F_1}{\lambda_1}, \quad (3)$$

$$N_2(t_{irr}) = N_{Tag}\, \nu_{12} R_1^{cum/ind} \frac{\lambda_2}{\lambda_2 - \lambda_1} \cdot \frac{F_1}{\lambda_2} + N_{Tag} \left[R_2^{ind} - \nu_{12} R_1^{cum/ind} \frac{\lambda_1}{\lambda_2 - \lambda_1} \right] \cdot \frac{F_2}{\lambda_2}, \quad (4)$$

$$\begin{aligned} N_3(t_{irr}) &= N_{Tag}\, R_1^{cum/ind} \left[\nu_{13} + \nu_{12}\nu_{23} \frac{\lambda_2}{\lambda_2 - \lambda_1} \right] \frac{\lambda_3}{\lambda_3 - \lambda_1} \cdot \frac{F_1}{\lambda_3} + \\ &+ N_{Tag}\, \nu_{23} \left[R_2^{ind} - \nu_{12} R_1^{cum/ind} \frac{\lambda_1}{\lambda_2 - \lambda_1} \right] \frac{\lambda_3}{\lambda_3 - \lambda_2} \cdot \frac{F_2}{\lambda_3} + \\ &+ N_{Tag} \left[R_3^{ind} + \nu_{23} R_2^{ind} \frac{\lambda_2}{\lambda_2 - \lambda_3} + R_1^{cum/ind} \frac{\lambda_1}{\lambda_1 - \lambda_3} \left(\nu_{13} + \nu_{12}\nu_{23} \frac{\lambda_2}{\lambda_2 - \lambda_3} \right) \right] \frac{F_3}{\lambda_3} \end{aligned} \quad (5)$$

where F_i is a function determined as

$$F_i(t_{irr}) = \left(1 - e^{-\lambda_i \tau}\right) \frac{1 - e^{-\lambda_i t_{irr}}}{1 - e^{-\lambda_i T}}, \qquad i = 1, 2, 3. \quad (6)$$

The detailed transformations that lead to the above form of function F_i are presented below when calculating the mean proton flux density Φ (see formulas 89–96).

The irradiation having stopped, the decays of the product nucleons N_1, N_2, and N_3 are described by the following set of equations:

$$\begin{cases} \dfrac{dN_1(t)}{dt} &= -\lambda_1 N_1(t) \ , \\ \dfrac{dN_2(t)}{dt} &= \nu_{12}\lambda_1 N_1(t) - \lambda_2 N_2(t) \ , \\ \dfrac{dN_3(t)}{dt} &= \nu_{13}\lambda_1 N_1(t) + \nu_{23}\lambda_2 N_2(t) - \lambda_3 N_3(t), \end{cases} \tag{7}$$

with initial conditions $N_i(0)=N_{i_0}$, $i = 1,2,3$ where N_{i_0} is the number of nuclei in the first nuclide produced by the decay start moment (the irradiation stop moment); t is the current time measured from the irradiation stop moment. The solution for the set (7) at any moment t of "decay"is

$$N_1(t) = N_{1_0} e^{-\lambda_1 t} \ , \tag{8}$$

$$N_2(t) = \frac{\lambda_1}{\lambda_2 - \lambda_1} N_{1_0} \nu_{12} e^{-\lambda_1 t} + \left(N_{2_0} + \frac{\lambda_1}{\lambda_1 - \lambda_2} \nu_{12} N_{1_0} \right) e^{-\lambda_2 t} \ , \tag{9}$$

$$\begin{aligned} N_3(t) &= N_{1_0} \frac{\lambda_1}{\lambda_3 - \lambda_1} \left[\nu_{13} + \nu_{12}\nu_{23} \frac{\lambda_2}{\lambda_2 - \lambda_1} \right] e^{-\lambda_1 t} + \\ &+ \nu_{23} \frac{\lambda_2}{\lambda_3 - \lambda_2} \left(N_{2_0} - N_{1_0} \frac{\lambda_1}{\lambda_2 - \lambda_1} \right) e^{-\lambda_2 t} + \\ &+ \left[N_{3_0} + N_{2_0} \nu_{23} \frac{\lambda_2}{\lambda_2 - \lambda_3} + N_{1_0} \frac{\lambda_1}{\lambda_1 - \lambda_3} \left(\nu_{13} + \nu_{12}\nu_{23} \frac{\lambda_2}{\lambda_2 - \lambda_3} \right) \right] e^{-\lambda_3 t} \ . \end{aligned} \tag{10}$$

The number of product nuclei at the irradiation stop moment corresponds to that at the decaying tart moment. In this case, the following condition is satisfied:

$$N_{i_0} = N_i(t_{irr}), \qquad \text{i = 1, 2, 3.} \tag{11}$$

The γ- spectrometric experiment is actually to measure the areas of the total absorption peaks $\breve{S}_{1_l}, \breve{S}_{2_l}, \breve{S}_{3_l}$ (at γ-line energies E_1, E_2, E_3) in each l-th γ-spectrum. The areas can be expressed via count rates $\tilde{S}_{1_l} = \breve{S}_{1_l}/t_{live_l}$, $\tilde{S}_{2_l} = \breve{S}_{2_l}/t_{live_l}$, $\tilde{S}_{3_l} = \breve{S}_{3_l}/t_{live_l}$. This representation is used because the spectrometer performance has to be allowed for by introducing time corrections.

To gain the desired statistics, the spectrometer "live"time, t_{live_l}, is always set for measuring the l-th γ-spectrum, while the l-th γ-spectrum buildup time is defined by the "true"measurement time $t_{true_l} = (t_{e_l} - t_{b_l})$, where t_{b_l} and t_{e_l} are the start and stop times of the l-th γ-spectrum buildup. The spectrometer allows always for the "dead"time Δt_{dead_l} spent by the spectrometer for analyzing the input pulses. Therefore, the simple relation $t_{true_l} = t_{live_l} + \Delta t_{dead_l}$ holds between the "true"and "live"spectrometer operation times t_{true_l} and t_{live_l}.

During the stage of calculating the experimental count rates $\tilde{S}_{i_l}$, the measured γ-spectra are processed using the "live"measurement time t_{live_l}, thereby allowing for the spectrometer load. When simulating the experimental S_{i_l} values, however, the corrections for the nuclide decays that occur within the l-th γ-spectrum measurement time must be calculated by integration over "true"measurement time t_{true_l}.

At the same time, the S_{1_l}, S_{2_l}, and S_{3_l} values can be expressed via the $N_1(t)$, $N_2(t)$, and $N_3(t)$ values, which solve the set (7):

$$S_{i_l} = \frac{1}{t_{true_l}} \int\limits_{t_{c_l}}^{t_{c_l}+t_{true_l}} N_{i_0}\, \lambda_i\, \eta_i\, \varepsilon_i\, e^{-\lambda_i\, t}\, dt \ , \qquad (12)$$

where η_i are the quantum yields of γ-lines; ε_i are the detection effectiveness of the spectrometer at γ-line energies E_i; t_{c_l} is the time elapsed from the irradiation stop moment to the start moment of the l-the measurement start moment (i.e., the "decaying"or "cooling"time of a sample t_{cool}); t_{true_l} is the "true"time of the l-the measurement.

By the start moment of the l-th measurement and allowing for the condition (11), then, the calculated count rates S_{1_l}, S_{2_l}, and S_{3_l} can be presented as

$$\begin{aligned}
S_{1_l} &= A_1 \frac{1-e^{-\lambda_1 t_{true_l}}}{\lambda_1 t_{true_l}} e^{-\lambda_1 t_{c_l}} \ , && (13)\\
S_{2_l} &= B_1 \frac{1-e^{-\lambda_1 t_{true_l}}}{\lambda_1 t_{true_l}} e^{-\lambda_1 t_{c_l}} + B_2 \frac{1-e^{-\lambda_2 t_{true_l}}}{\lambda_2 t_{true_l}} e^{-\lambda_2 t_{c_l}} \ , && (14)\\
S_{3_l} &= C_1 \frac{1-e^{-\lambda_1 t_{true_l}}}{\lambda_1 t_{true_l}} e^{-\lambda_1 t_{c_l}} + C_2 \frac{1-e^{-\lambda_2 t_{true_l}}}{\lambda_2 t_{true_l}} e^{-\lambda_2 t_{c_l}} + C_3 \frac{1-e^{-\lambda_3 t_{true_l}}}{\lambda_3 t_{true_l}} e^{-\lambda_3 t_{c_l}} \ , && (15)
\end{aligned}$$

where

$$\begin{aligned}
A_1 &= N_{Tag} R_1^{cum/ind} \eta_1 \varepsilon_1 F_1 \ , && (16)\\
B_1 &= N_{Tag} R_1^{cum/ind} \eta_2 \varepsilon_2 \frac{\lambda_2}{\lambda_2-\lambda_1} \nu_{12} F_1 \ , && (17)\\
B_2 &= N_{Tag} \eta_2 \varepsilon_2 \left(R_2^{ind} - R_1^{cum/ind} \nu_{12} \frac{\lambda_1}{\lambda_2-\lambda_1} \right) F_2 \ , && (18)\\
C_1 &= N_{Tag} R_1^{cum/ind} \eta_3 \varepsilon_3 \frac{\lambda_3}{\lambda_3-\lambda_1} \left[\nu_{13} + \nu_{12}\nu_{23} \frac{\lambda_2}{\lambda_2-\lambda_1} \right] F_1 \ , && (19)\\
C_2 &= N_{Tag} \nu_{23} \eta_3 \varepsilon_3 \frac{\lambda_3}{\lambda_3-\lambda_2} \left(R_2^{ind} - R_1^{cum/ind} \nu_{12} \frac{\lambda_1}{\lambda_2-\lambda_1} \right) F_2 \ , && (20)\\
C_3 &= N_{Tag} \eta_3 \varepsilon_3 \left[R_3^{ind} + R_2^{ind} \nu_{23} \frac{\lambda_2}{\lambda_2-\lambda_3} + R_1^{cum/ind} \frac{\lambda_1}{\lambda_1-\lambda_3} \left(\nu_{13} + \nu_{12}\nu_{23} \frac{\lambda_2}{\lambda_2-\lambda_3} \right) \right] F_3 && (21)
\end{aligned}$$

The tree-link chain (Fig. 1) may be transformed into its two-link counterpart in case a chain is deprived of a nucleus, namely, N_3 (the first case), N_2 (the second case), and N_1 (the third case).

In the first case, when nucleus N_3 is absent ($\nu_{13} = 0$ и $\nu_{23} = 0$), each third equation is excluded from the sets (2) and (7). As a result, the factors A_1, B_1, and B_2 represented by formulas (16)-(18) for a given chain are only sought for. The detailed solution for this type of two-link chains is described in [4].

The second case occurs in the absence of nuclide N_2 when nuclide N_1 transmutes fully into N_3 ($\nu_{12} = 0$ and $\nu_{23} = 0$). The expressions (19)-(21), then, take the form

$$C_1 = N_{Tag} R_1^{cum/ind} \eta_3 \varepsilon_3 \frac{\lambda_3}{\lambda_3 - \lambda_2} \nu_{13} F_1 \ , \tag{22}$$

$$C_2 = 0 \ , \tag{23}$$

$$C_3 = N_{Tag} \eta_3 \varepsilon_3 \left[R_3^{ind} - R_1^{cum/ind} \nu_{13} \frac{\lambda_1}{\lambda_3 - \lambda_1} \right] F_3 \ . \tag{24}$$

The parameters C_1 and C_3 of the resulting two-link chain are completely in correspondence with the parameters B_1 and B_2 in the expressions (17) and (18) if subscript 2 in (17) and (18) is replaced with 3 subject that $\nu_{12} = 0$ and $\nu_{23} = 0$.

In the third case (nuclide N_1 is absent), the same occurs at $\nu_{12} = 0$ and $\nu_{13} = 0$, resulting in the chain that consists only of transmutation of N_2 into N_3. Given this version, the expressions (19)-(21) for parameters C_1, C_2, and C_3 take the form

$$C_1 = 0 \ , \tag{25}$$

$$C_2 = N_{Tag} \nu_{23} \eta_3 \varepsilon_3 \frac{\lambda_3}{\lambda_3 - \lambda_2} R_2^{ind} F_2 \ , \tag{26}$$

$$C_3 = N_{Tag} \eta_3 \varepsilon_3 \left[R_3^{ind} - R_2^{ind} \nu_{23} \frac{\lambda_2}{\lambda_3 - \lambda_2} \right] F_3 \ . \tag{27}$$

These formulas are the same as the expressions (17) and (18) for the parameters B_1 and B_2 of the two-link chain when subscript 2 in (27) and (27) is replaced with 1, and 3 with 2, subject that $\nu_{12} = 0$ and $\nu_{13} = 0$.

In case $\nu_{13} = \nu_{23} = 0$, the chain turns into the single-link chain, while the parameters C_1, C_2, and C_3 take the form

$$C_1 = 0 \ , \tag{28}$$

$$C_2 = 0 \ , \tag{29}$$

$$C_3 = N_{Tag} R_3^{ind} \eta_3 \varepsilon_3 F_3 \ . \tag{30}$$

The factors A_1, B_1, B_2, C_1, C_2, and C_3, which carry information on the reaction rates $R_1^{cum/ind}$, R_2^{ind}, and R_3^{ind}, are determined using the least squares method by fitting the experimental dots $\tilde{S}_{1_l}$, $\tilde{S}_{2_l}$, and $\tilde{S}_{3_l}$ that correspond to count rates for a definite peak in the next measurement run. The sets of the dots form so called decay curves. Fig. 3 show examples of the decay curves for some product nuclei of ^{208}Pb(p,x)-reactions.

The following functions are used in fitting:

$$g_1(t_{c_l}) = A_1 \frac{1 - e^{-\lambda_1 t_{true_l}}}{\lambda_1 t_{true_l}} e^{-\lambda_1 t_{c_l}} \ , \tag{31}$$

$$g_2(t_{c_l}) = B_1 \frac{1 - e^{-\lambda_1 t_{true_l}}}{\lambda_1 t_{true_l}} e^{-\lambda_1 t_{c_l}} + B_2 \frac{1 - e^{-\lambda_2 t_{true_l}}}{\lambda_2 t_{true_l}} e^{-\lambda_2 t_{c_l}} \ , \tag{32}$$

$$g_3(t_{c_l}) = C_1 \frac{1 - e^{-\lambda_1 t_{true_l}}}{\lambda_1 t_{true_l}} e^{-\lambda_1 t_{c_l}} + C_2 \frac{1 - e^{-\lambda_2 t_{true_l}}}{\lambda_2 t_{true_l}} e^{-\lambda_2 t_{c_l}} + C_3 \frac{1 - e^{-\lambda_3 t_{true_l}}}{\lambda_3 t_{true_l}} e^{-\lambda_3 t_{c_l}} \ . \tag{33}$$

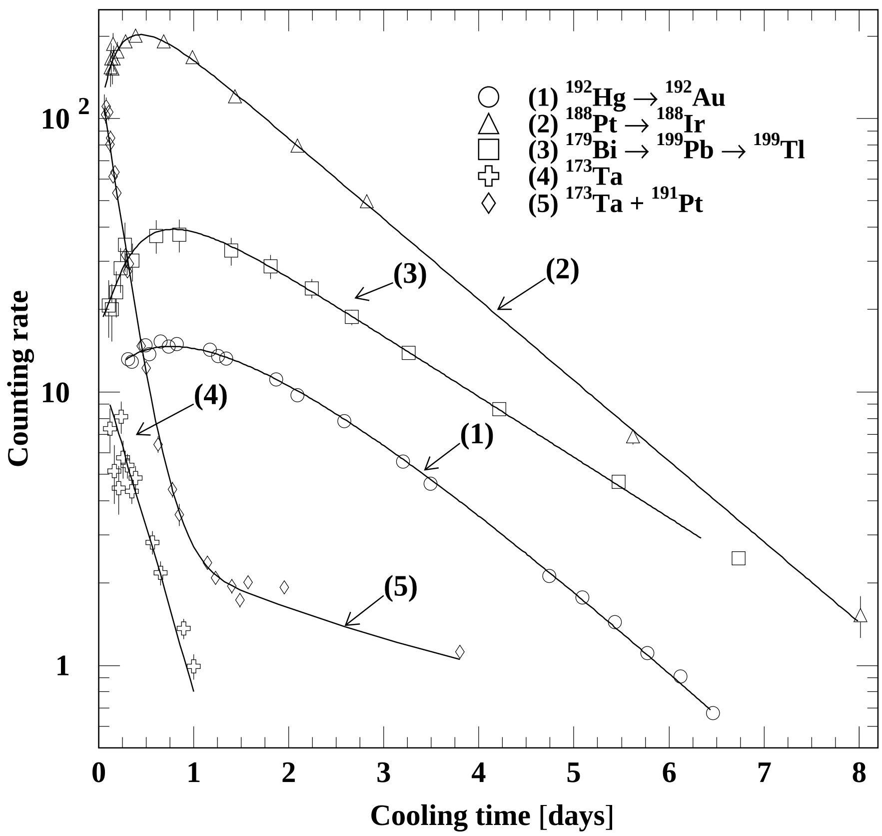


Fig. 3: Typical examples of the measured counting rates and fitted decay curves. Curve (1) is the generically related decay of two nuclides of sufficiently close halflives ^{192}Hg(4.85h) $\rightarrow$ ^{192}Au(4.94h), $E_\gamma(^{192}$Pt$)$ = 316.5 keV. Curve 2 is the same for substantially different halflives ^{188}Pt(10.2d) $\rightarrow$ ^{188}Ir(41.5h), $E_\gamma(^{188}$Os$)$ = 2214.6 keV. Curve (3) is the generically related decay of three nuclides ^{199}Bi(27m) $\rightarrow$ ^{199}Pb(90m) $\rightarrow$ ^{199}Tl(7.42h), $E_\gamma(^{199}$Tl$)$ = 208.2 кэВ. Curve (4) is the decay ^{173}Ta(3.14h), $E_\gamma(^{173}$Hf$)$ = 160.4 keV. Curve (5) describes the decay of two generically non-related nuclides [^{173}Ta(3.14h) + ^{191}Pt(2.802d)], with close E_γ = 172.2 keV of their daughters. To clarify the picture, the scaling factors have been introduced for some of the curves.

Conforming to least squares fitting, the quadratic functionals are introduced:

$$\Omega_i = \sum_{l=1}^{L_i} \left(\tilde{S}_{i_l} - g_i(t_{c_l}) \right)^2 \cdot W_{i_l} \ , \tag{34}$$

$$W_{i_l} = \frac{1}{\left(\Delta \tilde{S}_{i_l} \right)^2} \ , \qquad i = 1, 2, 3 \tag{35}$$

where $\Delta\tilde{S}_{i_l}$ are absolute errors in $\tilde{S}_{i_l}$; L_i is the number of experimental dots to support the i-th nuclide.

The condition of minimizing the functionals Ω_i may be used to obtain the expressions to determine the factors $\hat{A}_1$, $\hat{B}_1$, $\hat{B}_2$, $\hat{C}_1$, $\hat{C}_2$, $\hat{C}_3$ and their errors:

$$\hat{A}_1 = \frac{\sum_{l=1}^{L_1}\left(\tilde{S}_{1_l} e^{-\lambda_1 t_{c_l}} \cdot h_{1l} \cdot W_{1_l}\right)}{\sum_{l=1}^{L_1}\left(e^{-2\lambda_1 t_{c_l}} \cdot h_{1l}^2 \cdot W_{1_l}\right)}, \quad \Delta\hat{A}_1 = \sqrt{\frac{1}{\sum_{l=1}^{L_1}\left(e^{-2\lambda_1 t_{c_l}} \cdot h_{1l}^2 \cdot W_{1_l}\right)}} \cdot \sqrt{\frac{\hat{\Omega}_1}{L_1 - 1}}, \tag{36}$$

$$\vec{\hat{B}} = M_B^{-1} \cdot \vec{Z_B}, \qquad \Delta\hat{B}_i = \sqrt{\left(M_B^{-1}\right)_{ii}} \cdot \sqrt{\frac{\hat{\Omega}_2}{L_2 - 2}}, \qquad (i = 1, 2), \tag{37}$$

$$\vec{\hat{C}} = M_C^{-1} \cdot \vec{Z_C}, \qquad \Delta\hat{C}_i = \sqrt{\left(M_C^{-1}\right)_{ii}} \cdot \sqrt{\frac{\hat{\Omega}_3}{L_3 - 3}}, \qquad (i = 1, 2, 3), \tag{38}$$

$$\vec{\hat{B}} = \begin{Bmatrix} \hat{B}_1 \\ \hat{B}_2 \end{Bmatrix}, \qquad \vec{Z_B} = \begin{Bmatrix} Z_{B_1} \\ Z_{B_2} \end{Bmatrix},$$

$$\vec{\hat{C}} = \begin{Bmatrix} \hat{C}_1 \\ \hat{C}_2 \\ \hat{C}_3 \end{Bmatrix}, \qquad \vec{Z_C} = \begin{Bmatrix} Z_{C_1} \\ Z_{C_2} \\ Z_{C_3} \end{Bmatrix}.$$

where $\hat{\Omega}_1$, $\hat{\Omega}_2$, $\hat{\Omega}_3$ are the values of the functionals Ω_1, Ω_2, Ω_3 at $A_1 = \hat{A}_1$, $\vec{B} = \vec{\hat{B}}$, $\vec{C} = \vec{\hat{C}}$.

The matrices M_B, M_C and the vectors of the right-hand part $\vec{Z}_B$, $\vec{Z}_C$ of the input sets of linear equations are

$$\begin{cases} \left(M_B\right)_{ij} = \sum_{l=1}^{L_2}\left(e^{-(\lambda_i+\lambda_j)t_{c_l}} h_{il} h_{jl} \cdot W_{2_l}\right), \\ \left(Z_B\right)_i = \sum_{l=1}^{L_2}\left(\tilde{S}_{2l} e^{-\lambda_i t_{c_l}} h_{il} \cdot W_{2_l}\right), \qquad i, j = 1, 2, \end{cases} \tag{39}$$

$$\begin{cases} \left(M_C\right)_{ij} = \sum_{l=1}^{L_3}\left(e^{-(\lambda_i+\lambda_j)t_{c_l}} h_{il} h_{jl} \cdot W_{3_l}\right), \\ \left(Z_C\right)_i = \sum_{l=1}^{L_3}\left(\tilde{S}_{3l} e^{-\lambda_i t_{c_l}} h_{il} \cdot W_{3_l}\right), \qquad i, j = 1, 2, 3, \end{cases} \tag{40}$$

$$h_{il} = \frac{1 - e^{-\lambda_i t_{true\ l}}}{\lambda_i t_{true\ l}},$$

where h_{il}, h_{jl} is the set of the factors that allows for the decay of the i-th or j-th nuclide in the l-th measurement.

It should also be noted that a correction must be introduced to allow for absorption of γ-quanta in the materials of monitor and of experimental sample. The correction value and its error were calculated for γ-quanta of energy E_j in the experimental sample material as

$$k_{\mu_j} = \frac{k \cdot \sigma_{tot_j} \cdot H}{1 - e^{-k \cdot \sigma_{tot_j} \cdot H}} \ , \tag{41}$$

$$\frac{\Delta k_{\mu_j}}{k_{\mu_j}} = \left(1 - k_{\mu_j} e^{-k \cdot \sigma_{tot_j} \cdot H}\right) \frac{\Delta \sigma_{tot_j}}{\sigma_{tot_j}} \ , \tag{42}$$

where H is the experimental sample depth (g/cm^2); σ_{tot_j} is the cross section for interaction of γ-quanta of the j-th energy with matter (barn/atom; $k = \frac{N_{Av}}{M} \cdot 10^{-24}$ is the conversion factor from dimension [barn/atom] to dimension [cm^2/g], where N_{Av} is Avogadro number, M is molecular weight. The values of the cross sections for interaction of γ-quanta of the i-th energy with matter have been taken from [5]. Conforming to the recommendations of [5], the relative errors in the cross sections for interaction of the γ-quanta in the 100-2600 keV range were broken into two groups. The error was taken to be 10% in the first group (below 200 keV) and 5% in the second group (above 200 keV). In this case, the relative error of factor k_μ was 0.05% – 0.1% within a selected depth interval of experimental samples, the fact that failed actually to affect the error in the final results.

Formulas (16) and (36) can be used to obtain the expression for calculating the (cumulative or independent) reaction rate of the first nuclide:

$$R_1^{cum/ind} = \frac{1}{N_{Tag} \eta_1 \varepsilon_1} \cdot \frac{A_1^*}{F_1} \ . \tag{43}$$

In measuring the activity of the second nuclide in the chain, the formulas (17), (18), and (37) can be used to obtain expressions for simultaneous calculating the reaction rate of the first nuclide and for calculating the independent and cumulative reaction rates of the second nuclide:

$$R_1^{cum/ind} = \frac{1}{N_{Tag} \eta_2 \varepsilon_2} \cdot \frac{B_1^*}{F_1} \cdot \frac{1}{\nu_{12}} \left(1 - \frac{\lambda_1}{\lambda_2}\right) \ , \tag{44}$$

$$R_2^{ind} = \frac{1}{N_{Tag} \eta_2 \varepsilon_2} \left[\frac{B_2^*}{F_2} + \frac{B_1^*}{F_1} \frac{\lambda_1}{\lambda_2}\right] \ , \tag{45}$$

$$R_2^{cum} = R_2^{ind} + \nu_{12} R_1^{cum/ind} = \frac{1}{N_{Tag} \eta_2 \varepsilon_2} \left[\frac{B_1^*}{F_1} + \frac{B_2^*}{F_2}\right] \ . \tag{46}$$

In measuring the activity of the third nuclide in the chain, the formulas (19) – (21), and (38) can be used to obtain the expressions for simultaneous calculating the reaction rate of the first nuclide, for calculating the independent and cumulative reaction rates of the second nuclide, and for calculating the independent and cumulative reaction rates of the third nuclide:

$$R_1^{cum/ind} = \frac{1}{N_{Tag}\eta_3\varepsilon_3} \cdot \frac{C_1^*}{F_1} \cdot r \,, \tag{47}$$

$$R_2^{ind} = \frac{1}{N_{Tag}\eta_3\varepsilon_3}\left[\frac{C_1^*}{F_1}\nu_{12}\frac{\lambda_1}{\lambda_2-\lambda_1}\frac{1}{r} + \frac{C_2^*}{F_2}\frac{1}{\nu_{23}}\left(1-\frac{\lambda_2}{\lambda_3}\right)\right] \,, \tag{48}$$

$$R_2^{cum} = R_2^{ind} + \nu_{12}R_1^{cum/ind} = \frac{1}{N_{Tag}\eta_3\varepsilon_3}\left[\frac{C_1^*}{F_1}\nu_{12}\frac{\lambda_2}{\lambda_2-\lambda_1}\frac{1}{r} + \frac{C_2^*}{F_2}\frac{1}{\nu_{23}}\left(1-\frac{\lambda_2}{\lambda_3}\right)\right] \,, \tag{49}$$

$$R_3^{ind} = \frac{1}{N_{Tag}\eta_3\varepsilon_3}\left[\frac{C_1^*}{F_1}\frac{\lambda_1}{\lambda_3} + \frac{C_2^*}{F_2}\frac{\lambda_2}{\lambda_3} + \frac{C_3^*}{F_3}\right] \,, \tag{50}$$

$$R_3^{cum} = R_3^{ind} + \nu_{13}R_1^{cum/ind} + \nu_{23}R_2^{ind} + \nu_{12}\nu_{23}R_1^{cum/ind} = \frac{1}{N_{Tag}\eta_3\varepsilon_3}\left[\frac{C_1^*}{F_1} + \frac{C_2^*}{F_2} + \frac{C_3^*}{F_3}\right] \,, \tag{51}$$

$$\text{where} \quad r = \frac{1}{\nu_{13} + \nu_{12}\nu_{23}\frac{\lambda_2}{\lambda_2-\lambda_1}}\left(1-\frac{\lambda_1}{\lambda_3}\right) \,, \tag{52}$$

$A_1^* = \hat{A}_1 \cdot k_{\mu_1}$, $\overrightarrow{B}^* = \hat{\overrightarrow{B}} \cdot k_{\mu_2}$, $\overrightarrow{C}^* = \hat{\overrightarrow{C}} \cdot k_{\mu_3}$.

The yields of reaction products may be calculated later via their mean production rates obtained by averaging a few $(R_{ij}^{ind/cum} \pm \Delta R_{ij}^{ind/cum})$ values calculated for k different γ-lines. It is expedient, therefore, to use the definitions of the relative quantum yield and of the relative spectrometer detection effectiveness, between which the following relations hold:

$$\eta_{ij} = k_{\gamma_i} \cdot \eta_{ij}^{rel}; \qquad \varepsilon_{ij} = k_\varepsilon \cdot \varepsilon_{ij}^{rel} \tag{53}$$

In this case the values of $k_{\gamma_i} \pm \Delta k_{\gamma_i}$ were taken to conform to [34], while the value of factor $k_\varepsilon \pm \Delta k_\varepsilon$ was determined using the procedure described in 2.6.1. The relative reaction rate can, then, be determined via the above factors k_{γ_i} and k_ε, while the absolute reaction rates calculated by formulas (43), (44)-(46), and (47)-(52) can be presented as

$$^{rel}R_{ij}^{cum/ind} = R_{ij}^{cum/ind} \cdot k_{\gamma_i} \cdot k_\varepsilon \cdot N_{tag} \tag{54}$$

The errors in the relative count rates $\Delta R_1^{cum/ind}$, ΔR_2^{ind}, ΔR_2^{cum}, ΔR_3^{ind}, and ΔR_3^{cum} can be calculated using the error transfer formulas allowing for the errors in all values that enter expressions (43), (44) – (46), (47) – (52), and (54):

$$\Delta^{rel}R_1^{cum/ind} =^{rel} R_1^{cum/ind} \cdot \sqrt{\left(\frac{\Delta\hat{A}_1}{\hat{A}_1}\right)^2 + \left(\frac{\Delta k_{\mu_1}}{k_{\mu_1}}\right)^2 + \left(\frac{\Delta\eta_1^{rel}}{\eta_1^{rel}}\right)^2 + \left(\frac{\Delta\varepsilon_1^{rel}}{\varepsilon_1^{rel}}\right)^2} \tag{55}$$

$$\Delta^{rel}R_1^{cum/ind} =^{rel} R_1^{cum/ind} \cdot \sqrt{\left(\frac{\Delta\hat{B}_1}{\hat{B}_1}\right)^2 + \left(\frac{\Delta k_{\mu_2}}{k_{\mu_2}}\right)^2 + \left(\frac{\Delta\eta_2^{rel}}{\eta_2^{rel}}\right)^2 + \left(\frac{\Delta\varepsilon_2^{rel}}{\varepsilon_2^{rel}}\right)^2} \tag{56}$$

for single-link chain;

$$\Delta^{rel} R_2^{ind} =^{rel} R_2^{ind} \cdot \sqrt{\left(\frac{\Delta \hat{G}_{B_1}}{\hat{G}_{B_1}}\right)^2 + \left(\frac{\Delta k_{\mu_2}}{k_{\mu_2}}\right)^2 + \left(\frac{\Delta \eta_2^{rel}}{\eta_2^{rel}}\right)^2 + \left(\frac{\Delta \varepsilon_2^{rel}}{\varepsilon_2^{rel}}\right)^2} \tag{57}$$

$$\Delta^{rel} R_2^{cum} =^{rel} R_2^{cum} \cdot \sqrt{\left(\frac{\Delta \hat{G}_{B_2}}{\hat{G}_{B_2}}\right)^2 + \left(\frac{\Delta k_{\mu_2}}{k_{\mu_2}}\right)^2 + \left(\frac{\Delta \eta_2^{rel}}{\eta rel_2}\right)^2 + \left(\frac{\Delta \varepsilon_2^{rel}}{\varepsilon_2^{rel}}\right)^2} \tag{58}$$

for two-link chain;

$$\Delta^{rel} R_1^{cum/ind} =^{rel} R_1^{cum/ind} \cdot \sqrt{\left(\frac{\Delta \hat{C}_1}{\hat{C}_1}\right)^2 + \left(\frac{\Delta k_{\mu_3}}{k_{\mu_3}}\right)^2 + \left(\frac{\Delta \eta_3^{rel}}{\eta_3^{rel}}\right)^2 + \left(\frac{\Delta \varepsilon_3^{rel}}{\varepsilon_3^{rel}}\right)^2} \tag{59}$$

$$\Delta^{rel} R_2^{ind} =^{rel} R_2^{ind} \cdot \sqrt{\left(\frac{\Delta \hat{G}_{C_1}}{\hat{G}_{C_1}}\right)^2 + \left(\frac{\Delta k_{\mu_3}}{k_{\mu_3}}\right)^2 + \left(\frac{\Delta \eta_3^{rel}}{\eta_3^{rel}}\right)^2 + \left(\frac{\Delta \varepsilon_3^{rel}}{\varepsilon_3^{rel}}\right)^2} \tag{60}$$

$$\Delta^{rel} R_2^{cum} =^{rel} R_2^{cum} \cdot \sqrt{\left(\frac{\Delta \hat{G}_{C_2}}{\hat{G}_{C_2}}\right)^2 + \left(\frac{\Delta k_{\mu_3}}{k_{\mu_3}}\right)^2 + \left(\frac{\Delta \eta_3^{rel}}{\eta_3^{rel}}\right)^2 + \left(\frac{\Delta \varepsilon_3^{rel}}{\varepsilon_3^{rel}}\right)^2} \tag{61}$$

$$\Delta^{rel} R_3^{ind} =^{rel} R_3^{ind} \cdot \sqrt{\left(\frac{\Delta \hat{G}_{C_3}}{\hat{G}_{C_3}}\right)^2 + \left(\frac{\Delta k_{\mu_3}}{k_{\mu_3}}\right)^2 + \left(\frac{\Delta \eta_3^{rel}}{\eta_3^{rel}}\right)^2 + \left(\frac{\Delta \varepsilon_3^{rel}}{\varepsilon_3^{rel}}\right)^2} \tag{62}$$

$$\Delta^{rel} R_3^{cum} =^{rel} R_3^{cum} \cdot \sqrt{\left(\frac{\Delta \hat{G}_{C_4}}{\hat{G}_{C_4}}\right)^2 + \left(\frac{\Delta k_{\mu_3}}{k_{\mu_3}}\right)^2 + \left(\frac{\Delta \eta_3^{rel}}{\eta_3^{rel}}\right)^2 + \left(\frac{\Delta \varepsilon_3^{rel}}{\varepsilon_3^{rel}}\right)^2} \tag{63}$$

for three-link chain.

Considering formulas (36), (37), and (38), the errors in the functions

$$G_{B_1}(\overrightarrow{B}) = \frac{B_1}{F_1}\frac{\lambda_1}{\lambda_2} + \frac{B_2}{F_2} \ , \tag{64}$$

$$G_{B_2}(\overrightarrow{B}) = \frac{B_1}{F_1} + \frac{B_2}{F_2} \ , \tag{65}$$

$$G_{C_1}(\overrightarrow{C}) = \frac{C_1}{F_1}\nu_{12}\frac{\lambda_1}{\lambda_2 - \lambda_1}\frac{1}{r} + \frac{C_2}{F_2}\frac{1}{\nu_{23}}\left(1 - \frac{\lambda_2}{\lambda_3}\right) \ , \tag{66}$$

$$G_{C_2}(\overrightarrow{C}) = \frac{C_1}{F_1}\nu_{12}\frac{\lambda_2}{\lambda_2 - \lambda_1}\frac{1}{r} + \frac{C_2}{F_2}\frac{1}{\nu_{23}}\left(1 - \frac{\lambda_2}{\lambda_3}\right) \ , \tag{67}$$

$$G_{C_3}(\overrightarrow{C}) = \frac{C_1}{F_1}\frac{\lambda_1}{\lambda_3} + \frac{C_2}{F_2}\frac{\lambda_2}{\lambda_3} + \frac{C_3}{F_3} \ , \tag{68}$$

$$G_{C_4}(\overrightarrow{C}) = \frac{C_1}{F_1} + \frac{C_2}{F_2} + \frac{C_3}{F_3} \ , \tag{69}$$

of the parameters B_1, B_2, C_1, C_2, and C_3 that enter the expressions (64) – (69) were determined as

$$\Delta G_{B\,i}^2 = grad\ G_{B\,i} \cdot M_B^{-1} \cdot (grad\ G_{B\,i})^T \ , \qquad i = 1,2 \tag{70}$$

where

$$grad\ G_{B\,1} = \left\{ \frac{1}{F_1} \cdot \frac{\lambda_1}{\lambda_2} , \frac{1}{F_2} \right\} \ , \qquad grad\ G_{B\,2} = \left\{ \frac{1}{F_1} , \frac{1}{F_2} \right\} \ , \tag{71}$$

$$\Delta G_{C\,i}^2 = grad\ G_{C\,i} \cdot M_C^{-1} \cdot (grad\ G_{C\,i})^T \ , \qquad i = 1,2,3,4 \tag{72}$$

where

$$grad\ G_{C\,1} = \left\{ \frac{1}{F_1}\ \nu_{12}\ \frac{\lambda_1}{\lambda_2 - \lambda_1}\ \frac{1}{r} , \frac{1}{F_2}\frac{1}{\nu_{23}} \left(1 - \frac{\lambda_2}{\lambda_3}\right) , 0 \right\} \ , \tag{73}$$

$$grad\ G_{C\,2} = \left\{ \frac{1}{F_1}\ \nu_{12}\ \frac{\lambda_2}{\lambda_2 - \lambda_1}\ \frac{1}{r} , \frac{1}{F_2}\frac{1}{\nu_{23}} \left(1 - \frac{\lambda_2}{\lambda_3}\right) , 0 \right\} \ , \tag{74}$$

$$grad\ G_{C\,3} = \left\{ \frac{\lambda_1}{\lambda_3}\frac{1}{F_1} , \frac{\lambda_2}{\lambda_3}\frac{1}{F_2} , \frac{1}{F_3} \right\} \ . \tag{75}$$

$$grad\ G_{C\,4} = \left\{ \frac{1}{F_1} , \frac{1}{F_2} , \frac{1}{F_3} \right\} \ . \tag{76}$$

The mean relative independent or cumulative production rates of the i-th nuclide derived from j $\gamma-$lines were calculated to be

$${}^{rel}\overline{R}_i^{\ cum/ind} = \frac{\sum\limits_{j=1}^{k} {}^{rel}R_{ij}^{cum/ind} \cdot {}^{rel}W_{ij}}{\sum\limits_{j=1}^{k} {}^{rel}W_{ij}} \ , \qquad \text{где} \ \ {}^{rel}W_{ij} = \frac{1}{\left(\Delta^{rel}R_{ij}^{cum/ind}\right)^2} \ . \tag{77}$$

$$\Delta^{rel}\overline{R}_i^{\ cum/ind} = max \left\{ \left(\Delta^{rel}\overline{R}_i^{\ cum/ind}\right)' ; \left(\Delta^{rel}\overline{R}_i^{\ cum/ind}\right)'' \right\} \ , \qquad \text{где} \tag{78}$$

$$\left(\Delta^{rel}\overline{R}_i^{\ cum/ind}\right)' = \sqrt{\frac{\sum\limits_{j=1}^{k} {}^{rel}W_{ij} \left({}^{rel}\overline{R}_i^{\ cum/ind} - {}^{rel}R_{ij}\right)^2}{(k-1)\sum\limits_{j=1}^{k} {}^{rel}W_{ij}}} \ , \qquad \left(\Delta^{rel}\overline{R}_i^{\ cum/ind}\right)'' = \sqrt{\frac{1}{\sum\limits_{j=1}^{k} {}^{rel}W_{ij}}} \ , \tag{79}$$

The mean absolute independent or cumulative production rates of the i-th nuclides were calculated together with their errors from the relative production rates:

$$\overline{R}_i^{\ cum/ind} = \frac{{}^{rel}\overline{R}_i^{\ \ cum/ind}}{k_{\gamma_i} \cdot k_\varepsilon \cdot N_{tag}} \tag{80}$$

$$\Delta\overline{R}_i^{cum/ind} = \overline{R}_i^{cum/ind} \cdot \sqrt{\left(\frac{\Delta^{rel}\overline{R}_i^{cum/ind}}{{}^{rel}\overline{R}_i^{cum/ind}}\right)^2 + \left(\frac{\Delta k_{\gamma_i}}{k_{\gamma_i}}\right)^2 + \left(\frac{\Delta k_\varepsilon}{k_\varepsilon}\right)^2 + \left(\frac{\Delta N_{Tag}}{N_{Tag}}\right)^2} \tag{81}$$

In case but a single γ-line is involved in the reaction rate calculations (this is possible when but one of j γ-lines is selected, or when a nuclide shows a single γ-line, j=1), the absolute quantum yield of that sole γ-line ($\eta_i \pm \Delta\eta_i$) and the absolute detection effectiveness ($\varepsilon_i \pm \Delta\varepsilon_i$) are used in formulas (43), (44)-(46), and (47)-(52).

Since

$$\left(\frac{\Delta\eta_{ij}}{\eta_{ij}}\right)^2 = \left(\frac{\Delta k_{\gamma_i}}{k_{\gamma_i}}\right)^2 + \left(\frac{\Delta\eta_{ij}^{rel}}{\eta_{ij}^{rel}}\right)^2 \qquad \left(\frac{\Delta\varepsilon_{ij}}{\varepsilon_{ij}}\right)^2 = \left(\frac{\Delta k_\varepsilon}{k_\varepsilon}\right)^2 + \left(\frac{\Delta\varepsilon_{ij}^{rel}}{\varepsilon_{ij}^{rel}}\right)^2, \tag{82}$$

formula (81) is transformed, making allowance for formulas (56) - (63), to calculate the error in the reaction rate calculated for a single γ-line (formulas (88) and (120), for example).

In case a few nuclides of different halflives are of identical γ-quantum energy (within the spectrometer resolution), while the precursors of the nuclides are absent (or their halflives are much shorter (or much longer in the case of "screening") compared with any of the nuclides in question, the total count rate in total absorption peak S_{sum_l} at moment t_{c_l} equals the sum of count rates recorded when measuring γ-quanta from each of the nuclides and can be calculated as

$$S_{sum_l} = \sum_{k=1}^{n} \frac{1}{t_{true\ l}} \int_{t_{c_l}}^{t_{c_l}+t_{true_l}} A_{1_k}\, e^{-\lambda_k t} dt = \sum_{k=1}^{n} A_{1_k} \frac{1 - e^{-\lambda_k t_{true\ l}}}{\lambda_k t_{true\ l}} e^{-\lambda_k t_{c_l}} \quad , \tag{83}$$

$$A_{1_k} = N_T R_k^{ind/cum} \eta_k \varepsilon F_k \quad . \tag{84}$$

where n is the number of the nuclides; ε is the detection effectiveness corresponding to their common γ-line.

The factors A_{1_k} can be determined from the approximation curve using the least squares fitting via minimization of the functional

$$\begin{aligned} \Omega_4 &= \sum_{l=1}^{L_4} \left(\tilde{S}_{sum_l} - S_{sum_l}\right)^2 \cdot W_{sum_l} = \\ &= \sum_{l=1}^{L_4} \left(\tilde{S}_{sum_l} - \sum_{k=1}^{n} A_{1_k} h_{kl} e^{-\lambda_k t_{c_l}}\right)^2 \cdot W_{sum_l}\ , \end{aligned} \tag{85}$$

$$W_{sum_l} = \frac{1}{\left(\Delta\tilde{S}_{sum_l}\right)^2} \tag{86}$$

for the parameters A_{1_k}, where $\tilde{S}_{sum_l}$ and $\Delta\tilde{S}_{sum_l}$ are the experimental values of the recorded total count rate in the total absorption peak at moment t_{c_l} and of their error; L_4 is the number of experimental dots.

As a result, we get the following set of linear equations:

$$\overrightarrow{Z} = M \times \overrightarrow{A_1} \ ,$$

где

$$\overrightarrow{A_1} = \left\{ \begin{array}{c} A_{1_1} \\ A_{1_2} \\ \vdots \\ A_{1_n} \end{array} \right\} , \qquad \overrightarrow{Z} = \left\{ \begin{array}{c} Z_1 \\ Z_2 \\ \vdots \\ Z_n \end{array} \right\}$$

$$Z_i = \sum_{k=1}^{L} \tilde{S}_{sum_k} h_{ik} e^{-\lambda_i t_{c_k}} \cdot W_{sum_k} \ ,$$

$$M_{ij} = \sum_{k=1}^{L} e^{-(\lambda_i+\lambda_j)t_{c_k}} h_{ik} h_{jk} \cdot W_{sum_k} \ .$$

The solution for the set is

$$\hat{\overrightarrow{A_1}} = M^{-1} \times \overrightarrow{Z} \ ,$$

$$\Delta\hat{A}_{1_k} = \sqrt{(M^{-1})_{kk}} \cdot \sqrt{\frac{\hat{\Omega}_4}{L_4 - n}} \ , \qquad (k = 1, 2, ..n) \ ,$$

where $\hat{\Omega}_4$ is the value of functional Ω_4 at $A_{1_k} = \hat{A}_{1_k}$ $(k = 1, 2, ..n)$ calculated by formula (85).

The production rate for the k-th of n nuclides can, then, be written as

$$R_k^{ind/cum} = \frac{A^*_{1_k}}{\eta_k \varepsilon F_k N_{Tag}} \ , \qquad A^*_{1_k} = \hat{A}_{1_k} \cdot k_{\mu_1} \ . \tag{87}$$

The error in expression (87) is determined as

$$\Delta R_k^{ind/cum} = R_k^{ind/cum} \cdot \sqrt{\left(\frac{\Delta\hat{A}_{1_k}}{\hat{A}_{1_k}}\right)^2 + \left(\frac{\Delta k_{\mu_1}}{k_{\mu_1}}\right)^2 + \left(\frac{\Delta\eta_k}{\eta_k}\right)^2 + \left(\frac{\Delta\varepsilon}{\varepsilon}\right)^2 + \left(\frac{\Delta N_{Tag}}{N_{Tag}}\right)^2} \tag{88}$$

2.2 Mean proton flux determining

The production rates of the identified residual nuclei having been determined, the cross sections for their production will be determined if the mean proton flux density is known. The latter is determined here by the monitor techniques based on simultaneous irradiation of an experimental sample and an Al standard foil of identical dimensions. Aluminum has been selected to be the

$$\begin{array}{ccc} \underline{{}^{7}_{3}\mathrm{Li}} & \longleftarrow & {}^{7}_{4}\mathrm{Be} \\ & & 53.29\ \mathrm{d} \end{array}$$

Fig. 4: Isobaric chain $A = 7$.

$$\begin{array}{ccccccccc} \underline{{}^{22}_{10}\mathrm{Ne}} & \longleftarrow & {}^{22}_{11}\mathrm{Na} & \longleftarrow & {}^{22}_{12}\mathrm{Mg} & \longleftarrow & {}^{22}_{13}\mathrm{Al} & \longleftarrow & {}^{22}_{14}\mathrm{Si} \\ & & 2.6019\ \mathrm{y} & & 3.857\ \mathrm{s} & & 59\ \mathrm{ms} & & 29\ \mathrm{ms} \end{array}$$

Fig. 5: Isobaric chain $A = 22$.

$$\begin{array}{ccccccccc} {}^{24}_{8}\mathrm{O} & \xrightarrow{42\%} & {}^{24}_{9}\mathrm{F} & \xrightarrow{89\%} & {}^{24}_{10}\mathrm{Ne} & \longrightarrow & {}^{24}_{11}\mathrm{Na} & \longrightarrow & \underline{{}^{24}_{12}\mathrm{Mg}} \\ 61\ \mathrm{ms} & & 0.34\ \mathrm{s} & & 3.38\ \mathrm{m} & & 14.9512\ \mathrm{h} & & \end{array}$$

Fig. 6: Isobaric chain $A = 24$.

standard foil material because the reactions ^{27}Al(p,x)^{7}Be, ^{27}Al(p,x)^{22}Na, and ^{27}Al(p,x)^{24}Na are mostly used as monitor reaction to determine the proton flux density.

Figs. 4, 5, and 6 show the isobaric chains that include ^{7}Be, ^{22}Na, and ^{24}Na [126].

The ^{7}Be, ^{22}Na, and ^{24}Na production chains indicates that ^{7}Be alone is produced directly by nuclear reaction, while ^{22}Na and ^{24}Na are produced by both nuclear reaction and decay transmutations. Therefore, the independent cross section of the ^{27}Al(p,x)^{7}Be reaction and the cumulative cross sections of the ^{27}Al(p,x)^{22}Na and ^{27}Al(p,x)^{24}Na reactions are used as monitor cross sections. This is why the procedure of ^{22}Na and ^{24}Na measurements in the irradiated standard foils has to meet certain conditions because their precursors ^{22}Mg and ^{24}Ne need definite time to decay. In measuring ^{22}Na, the decay time must be above $\sim$30 s, i.e. $\sim$ 40 min for ^{24}Na. If these conditions are satisfied, the ^{22}Na and ^{24}Na production chains can be much simplified:

$$\begin{array}{ccc} \underline{{}^{22}_{10}\mathrm{Ne}} & \longleftarrow & {}^{22}_{11}\mathrm{Na} \\ & & 2.6019\ \mathrm{y} \end{array}$$

Fig. 7: Simplified isobaric chain $A = 22$.

Let the function $\ddot{R}_{st}^{ind/cum}(x, y, t)$, which is numerically equal to the ^{7}Be, ^{22}Na, and ^{24}Na production rates at a point with coordinates (x, y) at moment t, be introduced with a view to describing the production rates of ^{7}Be, ^{22}Na, and ^{24}Na at each point of the monitor foil

As noted above, the described experiments have been made in the pulsed irradiation mode, i.e. use was made of recurrent irradiation that included K pulses of duration τ each and

$$\begin{array}{ccc} {}^{24}_{11}\text{Na} & \longrightarrow & \underline{{}^{24}_{12}\text{Mg}} \\ 14.9512\text{ y} & & \end{array}$$

Fig. 8: Simplified isobaric chain $A = 24$.

repetition rate T (see Fig. 2).

The single-link radioactive transformation chains shown in Figs. 4, 7, and 8 can be described mathematically as

$$\frac{dN_{st}(x,y,t)}{dt} = N_{Al} \cdot \ddot{R}_{st}^{ind/cum}(x,y,t) - \lambda_{st} \cdot N_{st}(x,y,t) \ , \tag{89}$$

with initial conditions $N_{st}(x,y,0) = 0$, $st = {}^{7}\text{Be}, {}^{22}\text{Na}, {}^{24}\text{Na}$.

Here, $N_{st}(x,y,t)$ is the number of either ^{7}Be or ^{22}Na or ^{24}Na product nuclei in the vicinity of point (x,y); $\ddot{R}_{st}^{ind/cum}(x,y,t)$ are their independent (^{7}Be) or cumulative (^{22}Na and ^{24}Na) production rates in the vicinity of point (x,y) at time t measured from the start to stop moment of irradiation; λ_{st} are the ^{7}Be, ^{22}Na, and ^{24}Na decay constants; N_{Al} is the number of Al nuclei in the standard foil.

Conforming to the irradiation conditions, the function $\ddot{R}_{st}^{ind/cum}(x,y,t)$ for the j-th pulse can be presented as

$$\ddot{R}_{st}^{ind/cum}(x,y,t) = \begin{cases} R_{st}^{ind/cum}(x,y) \ , \text{for} (j-1)T \le t < (j-1)T + \tau \ , \\ 0 \ , \text{for} (j-1)T + \tau \le t \le jT \ , \end{cases} \tag{90}$$

Given the first pulse, the solution for the first equation (89) is

$$N_{st1}(x,y,t) = N_{Al} \cdot R_{st}^{ind/cum}(x,y) \cdot \frac{1 - e^{-\lambda_{st} \cdot t}}{\lambda_{st}} \tag{91}$$

where t runs through $0 < t < \tau$.

Considering the decays of the product nuclides(^{7}Be, ^{22}Na, and ^{24}Na) within time from τ to $(K-1) \cdot T + \tau$ (i.e. by the irradiation stop moment), the number of the nuclides produced in the first pulse is

$$N_{st1}(x,y,[(K-1) \cdot T + \tau]) = N_{Al} \cdot R_{st}^{ind/cum}(x,y) \cdot \frac{1 - e^{-\lambda_{st} \cdot \tau}}{\lambda_{st}} \cdot e^{-\lambda_{st} \cdot (K-1) \cdot T} \tag{92}$$

The number of nuclides produced from the j-th pulse at the irradiation stop moment is

$$N_{stj}(x,y,[(K-1) \cdot T + \tau]) = N_{Al} \cdot R_{st}^{ind/cum}(x,y) \cdot \frac{1 - e^{-\lambda_{st} \cdot \tau}}{\lambda_{st}} \cdot e^{-\lambda_{st} \cdot (K-j) \cdot T} \tag{93}$$

The total target nuclide number at the irradiation stop moment must be determined by summing up the partial contributions from all pulses:

$$
\begin{aligned}
N_{st}(x,y,[(K-1)\cdot T+\tau]) &= \sum_{j=1}^{K} N_{stj} = \\
&= \sum_{j=1}^{K} N_{Al}\cdot R_{st}^{ind/cum}(x,y)\cdot \frac{1-e^{-\lambda_{st}\cdot\tau}}{\lambda_{st}}\cdot e^{-\lambda_{st}\cdot(K-j)\cdot T} = \\
&= N_{Al}\cdot R_{st}^{ind/cum}(x,y)\cdot \frac{1-e^{-\lambda_{st}\cdot\tau}}{\lambda_{st}}\cdot\left[1+e^{-\lambda_{st}\cdot T}+e^{-\lambda_{st}\cdot 2T}+\ldots+e^{-\lambda_{st}\cdot(K-1)\cdot T}\right]
\end{aligned}
\tag{94}
$$

It should be noted that the square brackets in (94) contain a sum of geometric series members with geometric ratio $q = e^{-\lambda_{st}\cdot T}$. In this case, the eventual number of radioactive products from K pulses can be expressed as

$$
\begin{aligned}
N_{st}(x,y,[(K-1)\cdot T+\tau]) &= N_{Al}\cdot R_{st}^{ind/cum}(x,y)\cdot \frac{1-e^{-\lambda_{st}\cdot\tau}}{\lambda_{st}}\cdot\frac{1-q^K}{1-q} = \\
&= N_{Al}\cdot R_{st}^{ind/cum}(x,y)\cdot \frac{1-e^{-\lambda_{st}\cdot\tau}}{\lambda_{st}}\cdot\frac{1-e^{-\lambda_{st}\cdot KT}}{1-e^{-\lambda_{st}\cdot T}} = \frac{N_{Al}\cdot R_{st}^{ind/cum}(x,y)}{\lambda_{st}}\cdot F_{st}
\end{aligned}
\tag{95}
$$

The introduced definition of the function F_{st} reflects saturation of any nuclide irradiated at characteristic times τ, T, KT (see Fig.2):

$$
F_{st} = \left(1-e^{-\lambda_{st}\cdot\tau}\right)\frac{1-e^{-\lambda_{st}\cdot KT}}{1-e^{-\lambda_{st}\cdot T}} \cong \frac{\tau}{T}\cdot\left(1-e^{-\lambda_{st}\cdot[(K-1)\cdot T+\tau]}\right) , \tag{96}
$$

because τ, $T << \frac{1}{\lambda_{st}}$.

In this case, the expression

$$
\bar{R}_{st}^{ind/cum}(x,y) \cong \frac{\tau}{T}\cdot R_{st}^{ind/cum}(x,y) \tag{97}
$$

holds to within sufficient accuracy τ, where, $\bar{R}_{st}^{ind/cum}(x,y)$ is the T-averaged ^{7}Be, ^{22}Na, and ^{24}Na production rate in a single proton pulse at monitor point with coordinates (x,y).

The designation $t_{irr} = (K-1)T+\tau$ can, then, be used to present the expression (95) as

$$
N_{st}(x,y,T_{irr}) = \frac{N_{Al}\cdot\bar{R}_{st}^{ind/cum}(x,y)}{\lambda_{st}}\cdot\left(1-e^{-\lambda_{st}\cdot t_{irr}}\right) \tag{98}
$$

The number of ^{7}Be, ^{22}Na or ^{24}Na nuclei produced within time t_{irr} in the mass element dm located at point with coordinates (x,y) can be presented as

$$
dN_{st}(x,y,t_{irr}) = \frac{dm}{M}\cdot N_{Av}\cdot\frac{\bar{R}_{st}^{ind/cum}(x,y)}{\lambda_{st}}\cdot\left(1-e^{-\lambda_{st}\cdot t_{irr}}\right) \tag{99}
$$

The number of ^{7}Be, ^{22}Na or ^{24}Na nuclei produced within time t_{irr} in the mass element dm located at point with coordinates (x, y) can be presented as

$$dm = \rho \cdot dV = \rho \cdot H \cdot dS, \tag{100}$$

where ρ is the monitor density; H is the monitor depth: dS is the monitor spot area with coordinates (x,y).

If the thickness H is constant, then

$$\rho = \frac{m}{V} = \frac{m}{S \cdot H} \tag{101}$$

where m is monitor mass; S is monitor area.

Substituting (101) in (100), we get $dm = \frac{m}{S \cdot H} \cdot H \cdot dS = \frac{m}{S} \cdot dS$.

The expression (99) can, then, be presented as

$$dN_{st}(x, y, t_{irr}) = \frac{1}{S} \cdot \frac{m}{M} \cdot N_{Av} \cdot \frac{\bar{R}_{st}^{ind/cum}(x, y)}{\lambda_{st}} \cdot \left(1 - e^{-\lambda_{st} \cdot t_{irr}}\right) \cdot dS \tag{102}$$

where m is monitor mass; S is monitor area.

Substituting (101) in (100), we get $dm = \frac{m}{S \cdot H} \cdot H \cdot dS = \frac{m}{S} \cdot dS$.

The expression(99) can, then, be presented as

$$N_{st}(T_{irr}) = \frac{m}{M} \cdot N_{Av} \cdot \frac{1}{\lambda_{st}} \cdot \left(1 - e^{-\lambda_{st} \cdot T_{irr}}\right) \cdot \frac{1}{S} \iint\limits_{S} \bar{R}_{st}^{ind/cum}(x, y)\, dS \cdot \left(1 - e^{-\lambda_{st} \cdot T_{irr}}\right) \tag{103}$$

Here, $\widehat{R}_{st}^{\,ind/cum} = \frac{1}{S} \iint\limits_{S} \bar{R}_{st}^{\,ind/cum}(x, y)\, dS$ is the mean ^{7}Be, ^{22}Na, ^{24}Na production rate over the standard foil area.

We can write:

$$N_{st}(t_{irr}) = \frac{m}{M} \cdot N_{Av} \cdot \frac{\widehat{R}_{st}^{\,ind/cum}}{\lambda_{st}} \cdot \left(1 - e^{-\lambda_{st} \cdot t_{irr}}\right) = \frac{N_{Al} \cdot \widehat{R}_{st}^{\,ind/cum} \cdot F'_{st}}{\lambda_{st}} \tag{104}$$

where $F'_{st} = \left(1 - e^{-\lambda_{st} \cdot t_{irr}}\right)$.

The irradiation having stopped, the decays of the ^{7}Be, ^{22}Na or ^{24}Na product nuclides can be described as

$$\frac{dN_{st}(t)}{dt} = -\lambda_{st} \cdot N_{st}(t)\ , \tag{105}$$

where $F'_{st} = \left(1 - e^{-\lambda_{st} \cdot t_{irr}}\right)$.

The irradiation having stopped, the decays of the ^{7}Be, ^{22}Na or ^{24}Na product nuclides can be described as

$$N_{st}(t) \;=\; N_{st_0} \cdot e^{-\lambda_{st} \cdot t} \tag{106}$$

As noted above, the ^{7}Be, ^{22}Na or ^{24}Na total absorption peaks $\breve{S}_{i_l}$ are actually measured in the experiment at γ-line energies E_1= 477.6 keV, (10.5%), E_2=1274.5 keV (99.9%), and E_3=1369.0 keV (100%) that can be expressed via count rates $\tilde{S}_{i_l} = \breve{S}_{i_l}/t_{live_l}$.

Considering the above and using expressions (104) and (106), the calculated S_{st_l} values can be expressed via the $N_{st}(t_{irr})$ values as

$$\begin{aligned} S_{st_l} &= \frac{1}{t_{true_l}} \int_{t_{c_l}}^{t_{c_l}+t_{true_l}} N_{st_0} \cdot \lambda_{st} \cdot \eta_{st} \cdot \varepsilon_{st} \cdot e^{-\lambda_{st} \cdot t} \cdot dt = \\ &= N_{st_0} \cdot \lambda_{st} \cdot \eta_{st} \cdot \varepsilon_{st} \cdot e^{-\lambda_{st} \cdot t_{c_l}} \cdot \frac{1 - e^{-\lambda_{st} \cdot t_{true_l}}}{\lambda_{st} \cdot t_{true_l}} = D_{1_{st}} \cdot h_{st_l} \cdot e^{-\lambda_{st} \cdot t_{c_l}} \end{aligned} \tag{107}$$

$$D_{1_{st}} = N_{Al} \cdot \widehat{R}_{st} \cdot F'_{st} \cdot \eta_{st} \cdot \varepsilon_{st} \;, \qquad h_{st_l} = \frac{1 - e^{-\lambda_{st} \cdot t_{true_l}}}{\lambda_{st} \cdot t_{true_l}} \tag{108}$$

After introducing, by analogy of (106), the approximation function

$$g_{st}(t_{c_l}) = D_{1_{st}} \cdot \frac{1 - e^{-\lambda_{st} \cdot t_{true_l}}}{\lambda_{st} \cdot t_{true_l}} \cdot e^{-\lambda_{st} \cdot t_{c_l}} \tag{109}$$

to describe the calculated S_{st_l} values, the least squares fitting can be used to construct the quadratic functional

$$\Omega_{st} = \sum_{l=1}^{L_{st}} \Big(\tilde{S}_{st_l} - g_{st}(t_{c_l}) \Big)^2 \cdot W_{st_l}(t_{c_l}), \tag{110}$$

где $W_{st_l} = \left(\dfrac{1}{\Delta \tilde{S}_{st_l}} \right)^2$.

By minimizing this functional, we can calculate the $\hat{D}_{1_{st}}$ and $\Delta \hat{D}_{1_{st}}$ values as

$$\hat{D}_{1_{st}} = \frac{\sum\limits_{l=1}^{L_{st}} \left(\tilde{S}_{st_l} \cdot e^{-\lambda_{st} \cdot t_{true_l}} \cdot h_{st_l} \cdot W_{st_l} \right)}{\sum\limits_{l=1}^{L_{st}} \left(e^{-2\lambda_{st} \cdot t_{true_l}} \cdot h^2_{st_l} \cdot W_{st_l} \right)} \;, \qquad \Delta \hat{D}_{1_{st}} = \sqrt{\frac{1}{\sum\limits_{l=1}^{L_{st}} \left(e^{-2\lambda_{st} \cdot t_{true_l}} \cdot h^2_{st_l} \cdot W_{st_l} \right)}} \;, \tag{111}$$

The production rate of a respective nuclide $\widehat{R}^{ind/cum}_{st}$ and its error $\Delta \widehat{R}^{ind/cum}_{st}$ are

$$\widehat{R}^{ind/cum}_{st} \;=\; \frac{D^*_{1_{st}}}{N_{Al} \cdot F'_{st} \cdot \eta_{st} \cdot \varepsilon_{st}}, \tag{112}$$

where $D^*_{1_{st}} = \hat{D}_{1st} \cdot k_{\mu_{st}}$.

$$\frac{\Delta \widehat{R}^{ind/cum}_{st}}{\widehat{R}^{ind/cum}_{st}} = \sqrt{\left(\frac{\Delta \hat{D}_{1_{st}}}{\hat{D}_{1_{st}}}\right)^2 + \left(\frac{\Delta k_{\mu_{st}}}{k_{\mu_{st}}}\right)^2 + \left(\frac{\Delta \eta_{st}}{\eta_{st}}\right)^2 + \left(\frac{\Delta \varepsilon_{st}}{\varepsilon_{st}}\right)^2 + \left(\frac{\Delta N_{Al}}{N_{Al}}\right)^2} \tag{113}$$

If a reaction cross section is known, we can calculate the mean charged particle flux density $\widehat{\Phi}$, as averaged over time and sample area, together with its error $\Delta\widehat{\Phi}$:

$$\widehat{\Phi} \;=\; \frac{\widehat{R}^{ind/cum}_{st}}{\sigma^{ind/cum}_{st}} \tag{114}$$

$$\frac{\Delta\widehat{\Phi}}{\widehat{\Phi}} \;=\; \sqrt{\left(\frac{\Delta \widehat{R}^{ind/cum}_{st}}{\widehat{R}^{ind/cum}_{st}}\right)^2 + \left(\frac{\Delta \sigma^{ind/cum}_{st}}{\sigma^{ind/cum}_{st}}\right)^2} \tag{115}$$

2.3 Nuclide production cross section determining

Conforming to (1) and using (43), (44)-(46), (47)-(52), (80), (87) and (114) the independent and cumulative cross sections of the respective nuclides can be presented as

$$\sigma^{ind/cum}_i = \frac{R^{ind/cum}_i}{\Phi} \qquad \sigma^{ind/cum}_i = \frac{\overline{R}^{ind/cum}_i}{\Phi}, \qquad i = 1, 2, 3 \tag{116}$$

$$\Delta\sigma^{ind/cum}_i = \sigma^{ind/cum}_i \cdot \sqrt{\left(\frac{\Delta R^{ind/cum}_i}{R^{ind/cum}_i}\right)^2 + \left(\frac{\Delta\Phi}{\Phi}\right)^2}, \tag{117}$$

$$\Delta\sigma^{ind/cum}_i = \sigma^{ind/cum}_i \cdot \sqrt{\left(\frac{\Delta \overline{R}^{ind/cum}_i}{\overline{R}^{ind/cum}_i}\right)^2 + \left(\frac{\Delta\Phi}{\Phi}\right)^2} \tag{118}$$

It should be noted that formulas (47) – (49) were obtained on assumption that the γ-ray intensities of the two nuclides produced by irradiation are recorded up to the desired accuracy within the period from the irradiation start moment to the ultimate moment when the intensity can still be recorded. In practice, however, this requirement either can or cannot be met, thus creating either more or less favorite conditions of taking measurements and analyzing the results.

In some cases, where the fitting of experimental dots precludes determination of factor B^*_1, it is expedient to introduce the concept of supracumulative yield [6, 7]:

$$R^{cum^*}_2 \;=\; R^{ind}_2 + \frac{\lambda_1}{\lambda_1 - \lambda_2}\,\nu_1\, R^{cum}_1 = \frac{B^*_2}{N_{Tag}\eta_2\varepsilon_2 F_2} \tag{119}$$

$$\Delta R_2^{cum*} = R_2^{cum*} \cdot \sqrt{\left(\frac{\Delta \hat{B}_2}{\hat{B}_2}\right)^2 + \left(\frac{\Delta k_{\mu_2}}{k_{\mu_2}}\right)^2 + \left(\frac{\Delta \eta_2}{\eta_2}\right)^2 + \left(\frac{\Delta \varepsilon_2}{\varepsilon_2}\right)^2 + \left(\frac{\Delta N_{Tag}}{N_{Tag}}\right)^2} \quad (120)$$

$$\sigma_2^{cum^*} = \frac{R_2^{cum^*}}{\Phi} \quad (121)$$

$$\Delta\sigma_2^{cum^*} = \sigma_2^{cum*} \cdot \sqrt{\left(\frac{\Delta R_2^{cum*}}{R_2^{cum*}}\right)^2 + \left(\frac{\Delta \Phi}{\Phi}\right)^2} \quad (122)$$

From formula (119) it follows that the $\sigma_2^{cum^*}$ value can be taken to be the upper boundary when comparing between experiment and calculations.

2.4 Preparing, certifying, and irradiating the experimental samples

The experimental samples and the monitors were prepared by cutting them off (^{27}Al) metal foil, by pressing (^{209}Bi) metal powder, and by pressing separate tiny (^{nat}Pb, ^{208}Pb, ^{207}Pb, and ^{206}Pb) pellets. All the prepared experimental samples and monitors were of the same 10.5-mm diameter.

Table 2 presents the isotopic composition of the samples used.

Table 2: Isotopic composition of targets.

Isotope	Certificate No.	Isotopic composition, %
^{209}Bi	ALDRICH – – Nr 26,400-8	^{209}Bi - 99.99 %
^{208}Pb	334-12	^{204}Pb - -; ^{206}Pb - 0.87 %; ^{207}Pb - 1.93 %; ^{208}Pb - 97.20 %.
^{207}Pb	65-1.б	^{204}Pb - 0.03 %; ^{206}Pb - 2.61 %; ^{207}Pb - 88.3 $\pm$ 0.2 %; ^{208}Pb - 9.06 %.
^{206}Pb	332-8	^{204}Pb - - %; ^{206}Pb - 94.00 %; ^{207}Pb - 4.04 %; ^{208}Pb - 1.96 %.
^{nat}Pb	[15]*	^{204}Pb - 1.4 %; ^{206}Pb - 24.1 %; ^{207}Pb - 22.1 %; ^{208}Pb - 52.4 %.

* isotopic composition was not determined, the data are from [15].

From Table 2 it follows that the researches are characterized by using mostly the experimental samples that are high-enriched with appropriate isotopes. Undoubtedly, the research results could have been much affected by any chemical impurity in the samples. Therefore, the contents of the impurities were analyzed thoroughly. In case the respective certificates failed to indicate appropriate data, the samples were analyzed ($^{nat.}$Pb, ^{209}Bi) at the mass-spectrometry and chromatography laboratories (MS & GS Lab) of the State Metrology Center (GIREDMET). The analysis was made by spark mass-spectrometry using the Japanese (JEOL Co)-made JMS-01-BM2 double-focusing mass spectrometer. Table 3 presents the total content of chemical impurities in the samples acoording to [9] – [13].

Having been prepared, the samples and the monitors were weighed by the BP-61 analytical balance (SARTORIUS Co-made [8], a $\leq 1 \cdot 10^{-4}$ g weighing accuracy), whereupon each sample and a monitor were placed, preserving their geometry, in a polyethylene envelope that was welded tight to be irradiated later.

Table 3: The content of chemical impurities in high-enriched samples.

Chemical impurities, % at	Target				
	^{209}Bi	^{208}Pb	^{207Pb}W	^{206}Pb	^{nat}Pb
Na	<0.01%	0.0005	0.0002	0.001	<0.000006
Mg	for	0.0004	0.0003	0.0007	0.000005
Al	all	<0.001	<0.001	0.001	0.00002
Si	impurities	0.002	0.003	0.003	0.00001
Ca		<0.0009	0.0009	0.001	0.0001
Cr		<0.0003		<0.0003	0.00002
Mn					<0.000003
Fe		0.002	<0.001	0.0003	0.0002
Ni		<0.0003		<0.0003	0.000009
Cu		<0.0003	<0.0003	0.0003	<0.00002
Zn		<0.001		<0.001	<0.000006
Ag		<0.0002		<0.0002	<0.00001
Sn		<0.0003	<0.0003	<0.0003	<0.00002
Sb		<0.001	<0.001	<0.001	<0.00002
Bi		<0.0003	<0.0003	<0.0003	<0.0001
					the rest impurities have an even lower content
	Certificate No.				
	ALDRICH – Nr 26,400-8	334-12	65-1.б	332-8	7336.99

2.5 Irradiation of experimental samples

2.5.1 The general irradiation pattern

The samples were actually irradiated by the monoenergetic proton beam extracted from the ITEP U-10 proton synchrotron, which is a ring-shaped facility capable of accelerating protons up to 9.3 GeV at 25 MeV injection into the ring.

Fig.9 is a schematic of the sample-irradiating facility. The proton beam fast extraction units are also shown.

The proton beam goes from an accelerating ring to the transport channel, wherefrom protons of any energy within the 40-2600 MeV range can be extracted by the fast extraction system that includes a kicker-magnet of 15 mrad bending angle, a correcting magnet of 20-30 mrad bending angle, and two magnetic lenses that focus the beam into an ellipsis of 10-15 mm axes. The focusing has actually made all protons hit a sample, except for energies below 150 MeV and 2600 MeV (see Fig. 10).

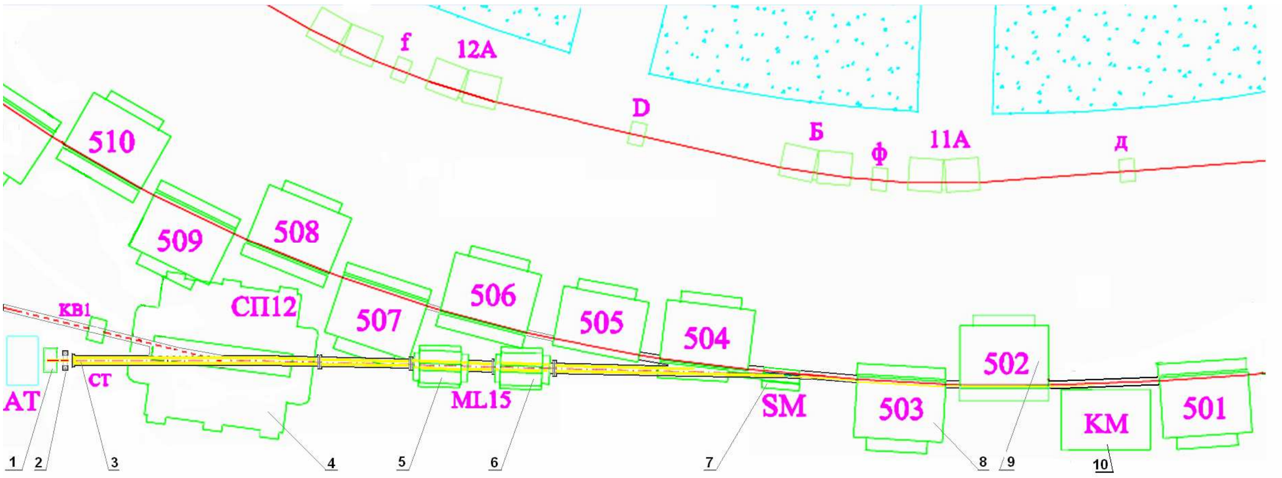


Fig. 9: The facility schematic and the fast extraction units: 1. Table to place the samples to be irradiated. 2. Current transformer. 3. Outlet flange of vacuumized proton guide. 4. Bending magnet. 5, 6. Doublet of quadrupole lenses. 7. Septum magnet. 8, 9. Magnetic units of accelerating ring. 10. Kicker-magnet.

Pending the irradiation runs, a sample-Al interlayer-Al monitor sandwich was scotch-fastened to a 50x50-mm, 0.1-mm thick Al plate placed normally to proton beam. The experimental samples and the monitors were manufactured to within the accuracy that provided for their identical geometric dimensions.

The geometry selected has prevented ^{24}Na, ^{22}Na, and ^{7}Be from making an additional contribution to the experimental samples by being ejected from Al monitors. The Al plate was used to monitor the total proton beam intensity (see Subsection 2.5.2.2).

The basic irradiation parameters are given in Table 4. The proton beam parameters are presented in detail is Subsection 2.5.2. Within 10-15 min after an irradiation run end, the "sandwich"was take off from the irradiated polyethylene envelope, whereupon the experimental sample and the monitor were placed inside non-irradiated polyethylene envelopes welded tight to prevent any possible loss during later measurements. After that, the envelopes were γ-spectrometered. To estimate the possible loss of radioactive recoil nuclei that can have escaped from an experimental sample, the unsealed irradiated envelopes were monitored using a γ-spectrometer. The loss has been found to be below the detection threshold of the spectrometer.

2.5.2 The proton beam parameters

2.5.2.1 Proton beam energies

The energy of the extracted proton beam has to be known because the reported project was eventually aimed at deriving the energy dependence (i.e. the excitation function) of the yields (cross sections) of residual product nuclei.

In accelerating protons, their energy is measured making allowance for one of the main synchrotron characteristics, namely, the invariable length of the closed proton orbit inside a ring. This means that the proton energy can be calculated by measuring the proton orbiting frequency f_r:

$$E_0 = \frac{m_p c}{\sqrt{c^2 - L^2 f_r^2}} - m_p, \tag{123}$$

where E_0 is the kinetic energy of a ring-orbiting proton; m_p=938.26 Mev is proton mass; L=251.21 m is the closed-orbit length; $c = 2.99776 \times 10^8$ m/s is speed of light.

Значение The f_r value is multiple to the accelerating radio frequency:

$$f_a = h f_r \tag{124}$$

where h=4 is number of harmonics; f_a is the accelerating radio frequency that varies from 1.07 to 4.85 MHz. The f_a signal gets shaped safely, thus precluding any problem in measuring the f_a values up to 10^{-4} and even better. The energy measurement error is energy-dependent and can be calculated as

$$\frac{\Delta E_f}{E_0} = \beta^2 \frac{\gamma^3}{\gamma - 1} \sqrt{\left(\frac{\Delta f_a}{f_a}\right)^2 + \left(\frac{\Delta L}{L}\right)^2}, \tag{125}$$

where β is the proton velocity that equals $L f_a / hc$; γ is a relativistic factor that equals $1/\sqrt{1-\beta^2}$.The L value is known up to relativistic error of 10^{-4}.

On the way of transporting the beam to the samples, a minor beam energy fraction is lost for proton interactions with the transport channel structure materials, with air that fills the transport channel-target spacing, and in the targets proper. The loss is allowed for via the expression

$$E_{sample} = E_0 - E_{loss} \tag{126}$$

where E_{sample} is the proton beam energy at half-depth of experimental sample (target); E_{loss} is the energy loss along proton path from transport channel to mid-target determined as $E_{loss} = \delta E_{mem} - \delta E_{air} - 0.5 \cdot \delta E_{sample}$, where δE_{mem}, δE_{air}, and δE_{sample} are, respectively, energy losses in the metal membrane at the transport channel outlet, in the channel-target air spacing, and in the target proper. The losses were calculated by the formula $\delta E = (dE/dx)X$, which is valid because the material depth (X) traversed by the beam is insignificant, so the specific loss for ionization dE/dx can well be regarded as constant. At proton energies of 70 MeV and 40 MeV, however, the energy loss for ionization is sufficiently high, so its variations over the proton paths via samples and monitors have to be allowed for. The dE/dx values were taken from [39].

The energies and their loss in the membrane (0.1-mm steel), in the outlet flange-sample spacing, in the samples proper, and in the monitors are presented in Table 4 for each of the irradiation runs. The Table 4 presents also the ^{27}Al(p,x)^{22}Na monitor reaction cross sections used in the Project at the proton energies calculated for the sample and monitor half-depths.

Besides, the Table 4lists the energy uncertainties calculated as

$$\Delta E_{sample} = \sqrt{\Delta E_0^2 + \Delta E_{spread}^2/4 + \sum (\delta E_{loss})^2} \tag{127}$$

where ΔE_0 is the energy uncertainty of the transport channel protons determined as

$$\Delta E_0 = \sqrt{\Delta E_f^2 + \Delta E_p^2}\ , \tag{128}$$

where ΔE_f is the energy measurement error determined by formula (125); ΔE_p is the proton energy dissipation in an accelerator ring determined as

$$\Delta E_p = \frac{0.005 \cdot p}{m_p + E_0} \cdot \sqrt{220MeV/c \cdot p}; \tag{129}$$

ΔE_{spread} is the energy difference between the target inlet and outlet; $\sum \delta E_{loss}$ is root of the sum of dispersions of the Landau fluctuation of energy loss [38]; p is a pulse corresponding to energy E_0.

Additionally, Table 4 presents the energies and their uncertainties calculated at the monitor half-depths using formulas similar to (126) and (127).

From Table 4 it follows that the proton and monitor proton energy uncertainties are ranging from 0.3% (at 2.6 GeV) to 4% (at 0.04 GeV).

Table 4: The energies of the proton beams that irradiate the sample-monitor sandwich including the loss for ionization in the transport channel structure material; the ^{27}Al(p,x)^{22}Na monitor reaction cross sections at the calculated energies.

Sample	Date	Freq. MHz	E$_0$, MeV	weight samp. (g)	weight monit. (g)	Length air (mm)	E_{loss} in membrane (MeV)	E_{loss} in sample (MeV)	E_{loss} in monitor (MeV)	E_{loss} in air (MeV)	$\sum E_{loss}$ in sample	$\sum E_{loss}$ in monitor	E$_{sample}$ in sample	E$_{monitor}$ in monitor	σ_{mon} (mb)
^{nat}Pb	23-окт-2001	4.6033	2608.9±7.9	0.2045	0.1100	2500	0.11±0.02	0.26±0.05	0.20±0.03	0.59±0.47	0.84±0.47	1.07±0.47	2608±8	2608±8	11.4±0.9
^{nat}Pb-2	23-окт-2003	4.602	2595.6±7.8	0.2034	0.1200	185	0.11±0.02	0.26±0.05	0.22±0.03	0.04±0.04	0.29±0.05	0.53±0.07	2595±8	2595±8	11.4±0.9
^{209}Bi	29-окт-2001	4.6034	2609.9±7.9	0.2913	0.1104	2500	0.11±0.02	0.38±0.07	0.21±0.03	0.59±0.47	0.89±0.47	1.19±0.48	2609±8	2609±8	11.4±0.9
^{208}Pb	5-ноя-2001	4.6031	2606.8±7.9	0.1261	0.1203	2500	0.11±0.02	0.16±0.03	0.22±0.03	0.59±0.47	0.79±0.47	0.98±0.47	2606±8	2606±8	11.4±0.9
^{207}Pb	30-окт-2001	4.6035	2610.9±7.9	0.1368	0.1095	2500	0.11±0.02	0.18±0.03	0.20±0.03	0.59±0.47	0.79±0.47	0.98±0.47	2610±8	2610±8	11.4±0.9
^{206}Pb	6-ноя-2001	4.6034	2609.9±7.9	0.1230	0.1112	2500	0.11±0.02	0.16±0.03	0.21±0.03	0.59±0.47	0.79±0.47	0.97±0.47	2609±8	2609±8	11.4±0.9
^{nat}Pb	8-апр-2002	4.435	1599.2±4.0	0.2054	0.1111	1770	0.12±0.02	0.27±0.05	0.21±0.03	0.43±0.35	0.68±0.35	0.92±0.35	1598±4	1598±4	13.2±1.0
^{209}Bi	8-апр-2002	4.435	1599.2±4.0	0.3429	0.1111	1770	0.12±0.02	0.45±0.08	0.21±0.03	0.43±0.35	0.77±0.35	1.09±0.36	1598±4	1598±4	13.2±1.0
^{208}Pb	11-апр-2002	4.4357	1601.7±4.0	0.1438	0.1104	1770	0.12±0.02	0.19±0.03	0.21±0.03	0.43±0.35	0.64±0.35	0.83±0.35	1601±4	1601±4	13.2±1.0
^{207}Pb	11-апр-2002	4.435	1599.2±4.0	0.1434	0.1106	1770	0.12±0.02	0.19±0.03	0.21±0.03	0.43±0.35	0.64±0.35	0.83±0.35	1599±4	1598±4	13.2±1.0
^{206}Pb	15-апр-2002	4.435	1599.2±4.0	0.1358	0.1101	1770	0.12±0.02	0.18±0.03	0.21±0.03	0.43±0.35	0.63±0.35	0.82±0.35	1599±4	1598±4	13.2±1.0
^{nat}Pb	22-фев-2002	4.287	1195.3±3.2	0.1378	0.1106	1770	0.12±0.02	0.19±0.04	0.22±0.04	0.44±0.37	0.66±0.37	0.86±0.37	1195±3	1194±3	14.4±1.0
^{209}Bi	26-фев-2002	4.285	1191.2±3.2	0.2905	0.1115	1770	0.12±0.02	0.40±0.08	0.22±0.04	0.44±0.37	0.76±0.37	1.07±0.38	1190±3	1190±3	14.4±1.0
^{208}Pb	4-мар-2002	4.29	1201.6±3.2	0.1368	0.1096	1770	0.12±0.02	0.19±0.04	0.22±0.04	0.44±0.37	0.66±0.37	0.86±0.37	1201±3	1201±3	14.4±1.0
^{207}Pb	11-мар-2002	4.289	1199.5±3.2	0.1450	0.1102	1770	0.12±0.02	0.20±0.04	0.22±0.04	0.44±0.37	0.66±0.37	0.87±0.37	1199±3	1199±3	14.4±1.0
^{206}Pb	15-мар-2002	4.284	1189.1±3.2	0.1380	0.1105	1770	0.12±0.02	0.19±0.04	0.22±0.04	0.44±0.37	0.66±0.37	0.86±0.37	1188±3	1188±3	14.4±1.0
^{nat}Pb	18-апр-2002	4.018	799.8±2.5	0.1913	0.1227	1770	0.13±0.02	0.27±0.06	0.26±0.05	0.48±0.41	0.74±0.41	1.01±0.41	799±2	799±2	15.5±1.1
^{209}Bi	18-апр-2002	4.018	799.8±2.5	0.2865	0.1228	1770	0.13±0.02	0.41±0.09	0.26±0.05	0.48±0.41	0.81±0.41	1.15±0.42	799±2	799±2	15.5±1.1
^{208}Pb	6-июн-2002	4.018	799.8±2.5	0.1389	0.1224	1770	0.13±0.02	0.20±0.04	0.26±0.05	0.48±0.41	0.71±0.41	0.94±0.41	799±2	799±2	15.5±1.1
^{207}Pb	6-июн-2002	4.018	799.8±2.5	0.1393	0.1226	1770	0.13±0.02	0.20±0.04	0.26±0.05	0.48±0.41	0.71±0.41	0.94±0.41	799±2	799±2	15.5±1.1
^{206}Pb	10-июн-2002	4.018	799.8±2.5	0.1420	0.1220	1770	0.13±0.02	0.20±0.04	0.26±0.04	0.48±0.41	0.71±0.41	0.94±0.41	799±2	799±2	15.5±1.1
^{nat}Pb	13-июн-2002	3.783	600.3±2.1	0.1537	0.1187	1770	0.14±0.03	0.24±0.05	0.28±0.05	0.52±0.45	0.78±0.45	1.04±0.46	600±2	599±2	16.0±1.0
^{209}Bi	17-июн-2002	3.783	600.3±2.1	0.3016	0.2243	1770	0.14±0.03	0.47±0.10	0.52±0.09	0.52±0.45	0.90±0.46	1.40±0.47	599±2	599±2	16.0±1.0
^{208}Pb	17-июн-2002	3.783	600.3±2.1	0.1401	0.1227	1770	0.14±0.03	0.22±0.05	0.29±0.05	0.52±0.45	0.77±0.45	1.03±0.46	600±2	599±2	16.0±1.0
^{207}Pb	24-июн-2002	3.783	600.3±2.1	0.1478	0.1227	1770	0.14±0.03	0.23±0.05	0.29±0.05	0.52±0.45	0.78±0.45	1.04±0.46	600±2	599±2	16.0±1.0
^{206}Pb	24-июн-2002	3.783	600.3±2.1	0.1403	0.1224	1770	0.14±0.03	0.22±0.05	0.29±0.05	0.52±0.45	0.77±0.45	1.03±0.46	600±2	599±2	16.0±1.0
^{nat}Pb	14-окт-2002	3.404	400.1±1.6	0.2435	0.1209	185	0.17±0.03	0.44±0.10	0.33±0.06	0.06±0.06	0.46±0.08	0.84±0.12	400±2	399±2	15.8±1.0
^{209}Bi	14-окт-2002	3.404	400.1±1.6	0.2936	0.1233	185	0.17±0.03	0.53±0.12	0.34±0.06	0.06±0.06	0.50±0.09	0.94±0.14	400±2	399±2	15.8±1.0
^{208}Pb	21-окт-2002	3.404	400.1±1.6	0.1424	0.1230	185	0.17±0.03	0.26±0.06	0.34±0.06	0.06±0.06	0.36±0.07	0.66±0.09	400±2	399±2	15.8±1.0
^{207}Pb	17-окт-2002	3.402	399.3±1.6	0.1452	0.1230	185	0.17±0.03	0.26±0.06	0.34±0.06	0.06±0.06	0.37±0.07	0.67±0.10	399±2	399±2	15.8±1.0
^{206}Pb	21-окт-2002	3.404	400.1±1.6	0.1383	0.1208	185	0.17±0.03	0.25±0.06	0.33±0.06	0.06±0.06	0.36±0.07	0.65±0.09	400±2	399±2	15.8±1.0
^{nat}Pb	28-окт-2002	2.929	250.0±1.2	0.1123	0.1231	185	0.22±0.04	0.26±0.06	0.44±0.08	0.08±0.08	0.43±0.09	0.78±0.12	250±1	249±1	15.0±0.9
^{209}Bi	24-окт-2002	2.929	250.0±1.2	0.2860	0.1225	185	0.22±0.04	0.66±0.16	0.44±0.08	0.08±0.08	0.63±0.12	1.18±0.18	249±1	249±1	15.0±0.9
^{208}Pb	31-окт-2002	2.929	250.0±1.2	0.1386	0.1234	185	0.22±0.04	0.32±0.08	0.44±0.08	0.08±0.08	0.46±0.10	0.84±0.12	250±1	249±1	15.0±0.9
^{207}Pb	28-окт-2002	2.929	250.0±1.2	0.1298	0.1235	185	0.22±0.04	0.30±0.07	0.44±0.08	0.08±0.08	0.45±0.10	0.82±0.12	250±1	249±1	15.0±0.9
^{206}Pb	31-окт-2002	2.929	250.0±1.2	0.1374	0.1231	185	0.22±0.04	0.32±0.07	0.44±0.08	0.08±0.08	0.46±0.10	0.84±0.12	250±1	249±1	15.0±0.9
^{nat}Pb	2-дек-2002	2.418	150.0±0.9	0.1049	0.1466	185	0.30±0.07	0.33±0.08	0.72±0.15	0.12±0.11	0.58±0.13	1.10±0.17	149±1	149±1	17.1±1.1
^{209}Bi	5-дек-2002	2.418	150.0±0.9	0.2944	0.1471	185	0.30±0.07	0.92±0.23	0.72±0.15	0.12±0.11	0.88±0.17	1.70±0.28	149±1	148±1	17.1±1.1
^{208}Pb	9-дек-2002	2.418	150.0±0.9	0.1390	0.1442	185	0.30±0.07	0.44±0.11	0.71±0.14	0.12±0.11	0.63±0.14	1.21±0.18	149±1	149±1	17.1±1.1
^{207}Pb	5-дек-2002	2.418	150.0±0.9	0.1393	0.1220	185	0.30±0.07	0.44±0.11	0.60±0.12	0.12±0.11	0.63±0.14	1.15±0.18	149±1	149±1	17.1±1.1

Prolongation of Table 4.

Sample	Date	Freq. MHz	E_0, MeV	weight samp. (g)	weight monit. (g)	Length air (mm)	E_{loss} in membrane (MeV)	E_{loss} in sample (MeV)	E_{loss} in monitor (MeV)	E_{loss} in air (MeV)	$\sum E_{loss}$ in sample	$\sum E_{loss}$ in monitor	E_{sample} in sample	$E_{monitor}$ in monitor	σ_{mon} (mb)
^{206}Pb	9-дек-2002	2.418	150.0±0.9	0.1413	0.1432	185	0.30±0.07	0.44±0.11	0.70±0.14	0.12±0.11	0.64±0.14	1.21±0.18	149±1	149±1	17.1±1.1
^{nat}Pb	24-фев-2003	2.046	100.2±0.7	0.2010	0.1231	185	0.40±0.09	0.82±0.22	0.81±0.17	0.15±0.15	0.96±0.21	1.78±0.29	99.3±0.8	98.5±0.8	19.8±1.2
^{209}Bi	27-фев-2003	2.048	100.5±0.7	0.2986	0.1216	185	0.40±0.09	1.22±0.33	0.80±0.17	0.15±0.15	1.16±0.24	2.18±0.38	99.3±0.9	98.3±0.9	19.8±1.2
^{208}Pb	3-мар-2003	2.047	100.4±0.7	0.1387	0.1212	185	0.40±0.09	0.57±0.15	0.79±0.17	0.15±0.15	0.84±0.19	1.52±0.25	99.5±0.8	98.8±0.8	19.8±1.2
^{207}Pb	27-фев-2003	2.048	100.5±0.7	0.1481	0.1203	185	0.40±0.09	0.61±0.16	0.79±0.17	0.15±0.15	0.86±0.19	1.55±0.25	99.6±0.8	98.9±0.8	19.8±1.2
^{206}Pb	3-мар-2003	2.047	100.4±0.7	0.1420	0.1208	185	0.40±0.09	0.58±0.16	0.79±0.17	0.15±0.15	0.84±0.19	1.53±0.25	99.5±0.8	98.8±0.8	19.8±1.2
^{nat}Pb	14-апр-2003	1.749	70.13±0.52	0.1941	0.1213	185	0.52±0.12	1.03±0.29	1.06±0.24	0.20±0.20	1.23±0.27	2.28±0.39	68.9±0.8	67.8±0.8	22.4±1.4
^{209}Bi	17-апр-2003	1.747	69.95±0.52	0.3036	0.1216	185	0.52±0.12	1.61±0.46	1.07±0.24	0.20±0.20	1.52±0.33	2.86±0.53	68.4±1.0	67.1±0.9	22.7±1.4
^{208}Pb	21-апр-2003	1.749	70.13±0.52	0.1358	0.1211	185	0.52±0.12	0.72±0.20	1.06±0.23	0.20±0.20	1.08±0.25	1.97±0.33	69.1±0.7	68.2±0.8	22.3±1.4
^{207}Pb	17-апр-2003	1.747	69.95±0.52	0.1552	0.1202	185	0.52±0.12	0.82±0.23	1.05±0.23	0.20±0.20	1.13±0.26	2.07±0.35	68.8±0.7	67.9±0.8	22.4±1.4
^{206}Pb	21-апр-2003	1.749	70.13±0.52	0.1405	0.1204	185	0.52±0.12	0.75±0.21	1.06±0.23	0.20±0.20	1.09±0.25	1.99±0.33	69.0±0.7	68.1±0.8	22.3±1.4
^{nat}Pb	19-июн-2003	1.351	40.00±0.35	0.2076	0.1211	185	0.79±0.21	1.70±0.53	1.73±0.41	0.32±0.32	1.96±0.46	3.68±0.68	38.0±1.0	36.3±1.2	25.9±2.0
^{209}Bi	23-июн-2003	1.351	40.00±0.35	0.3083	0.1215	185	0.79±0.21	2.55±0.79	1.76±0.42	0.32±0.32	2.38±0.55	4.54±0.90	37.6±1.4	35.5±1.3	22.1±2.0
^{208}Pb	30-июн-2003	1.351	40.00±0.35	0.1378	0.1213	185	0.79±0.21	1.12±0.35	1.71±0.41	0.32±0.32	1.68±0.42	3.09±0.55	38.3±0.8	36.9±1.1	28.4±2.0
^{208}Pb-2	3-июл-2003	1.353	40.13±0.35	0.1396	0.1201	185	0.79±0.20	1.13±0.35	1.69±0.40	0.32±0.32	1.68±0.42	3.09±0.55	38.4±0.8	37.0±1.1	28.9±2.0
^{207}Pb	23-июн-2003	1.351	40.00±0.35	0.1276	0.1210	185	0.79±0.21	1.04±0.32	1.70±0.40	0.32±0.32	1.63±0.41	3.00±0.54	38.4±0.7	37.0±1.1	28.7±2.0
^{206}Pb	30-июн-2003	1.351	40.00±0.35	0.1419	0.1208	185	0.79±0.21	1.16±0.36	1.70±0.41	0.32±0.32	1.69±0.42	3.12±0.56	38.3±0.8	36.9±1.1	28.2±2.0

2.5.2.2 Geometric parameters of proton beams

As mentioned in 2.5.1, two Al foils were used in each measurement run to monitor the proton beam, namely, (1) a ∅10.5 mm foil to determine the number of protons that passed through an irradiated sample and (2) a 50x50 mm foil to determine the total number of the extracted beam protons. Having been multiplied by the foil-to-foil area ratio, the ^{24}Na production rate ratio of the two foils makes it possible to determine the proton beam fraction that traversed an experimental sample.

Fig. 10 shows the resulting dependence on proton energy and demonstrates that the system provides stable parameters of proton beam extraction in the 150–2600 MeV range. Given the energy range below 150 MeV and 2600MeV energy, the proton beam gets broadened somewhat, thus decreasing the percentage of protons across a sample, so the desired proton fluence was attained by increasing the irradiation time.

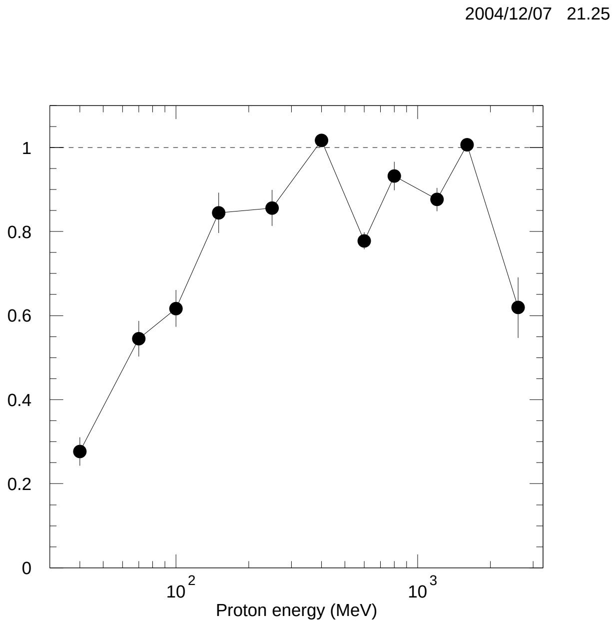


Fig. 10: The proton beam fraction across an experimental sample versus proton energy.

The results of detailed calculating the ^{24}Na production rates in the ∅10.5 standard foil and in the 50x50 mm large squre foil at $E_p = \sim 40$ MeV, ~ 70 MeV, 100 MeV, 150 MeV, 250 MeV, 400 MeV, 600 MeV, 800 MeV, 1200 MeV, 1600 MeV, and 2600 MeV are listed in Tables 7, 13, 19, 25, 31, 37, 43, 49, 55, 61, and 67 in Section 2 of Appendix to the present Report. The weights of the foils are presented in Tables 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32, and 34 of this Report.

2.5.2.3 The fine structure oscillograms of proton beam The oscillograms were recorded using the current transformer developed and manufactured by ITEP (Fig. 9, unit 2). The LeCroy LT-344 oscilloscope of 2-ns resolution was used as a meter. The digitized oscilloscope readings were written to a file at a 2μs full sweep ($\sim$ 1000 values). Fig.11 shows the fine structure oscillograms of proton beams (E_p = 40 MeV and E_p = 800 MeV) recorded with the LeCroy

LT-344 oscilloscope.

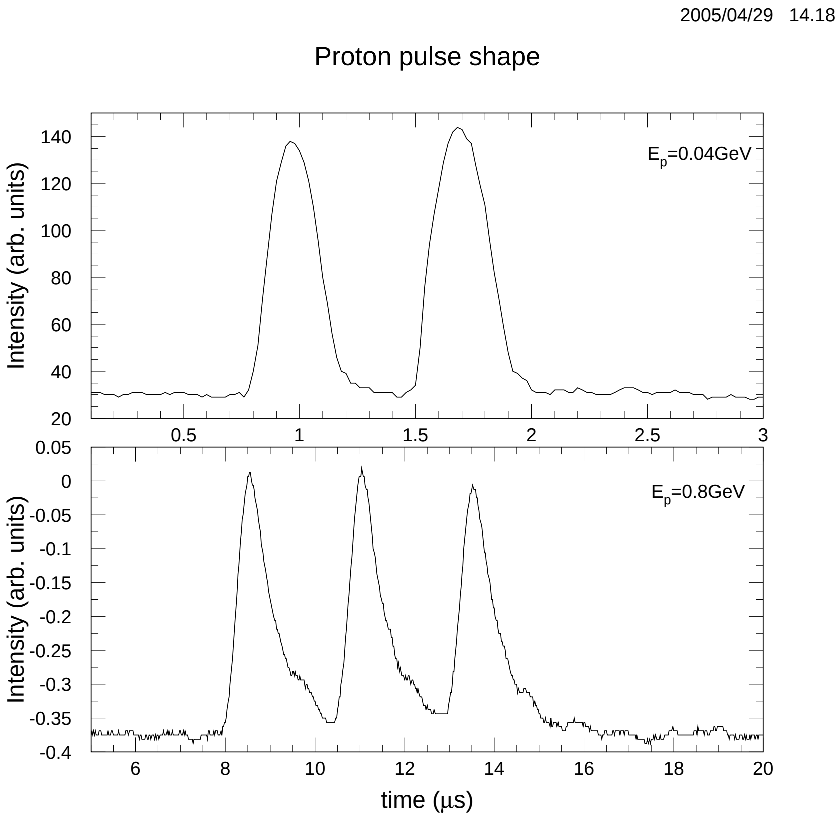


Fig. 11: The fine structure oscillograms of proton beams ($E_p = 40$ MeV and $E_p = 800$ MeV).

2.5.3 Time stability of proton beam

In some experiments (^{nat}Pb, $E_p = 40$ MeV and $E_p = 800$ MeV), the proton beam stability was estimated not only in space, but also in time. With that purpose, the current transformer was used throughout the measurement cyle to measure the intensity of each extracted proton bunch. Fig.12 shows the time distribution of proton beam intensity throughout the irradiation period. From the figure it follows that the proton beam instability is sufficiently weak and can be disregarded when determining the cross sections of the measured products.

2.5.4 Neutron background

When irradiated, the experimental samples are induced not only by primary beam protons, but also by secondaries that are mainly neutrons produced in the primary proton interactions with transport channel structure materials, shielding, as well as with a sample proper, with Al monitor, with interlayer, and with polyethylene envelope. To estimate the contribution of the background particles, whose interactions account for production of identical reaction products in experimental samples, the Al monitors were measured to determine the number of ^{27}Mg nuclei and the numbers of ^{7}Be, ^{22}Na, and ^{24}Na nuclei produced in the ^{27}Al(n,p)^{27}Mg, ^{27}Al(p,x) ^{7}Be,

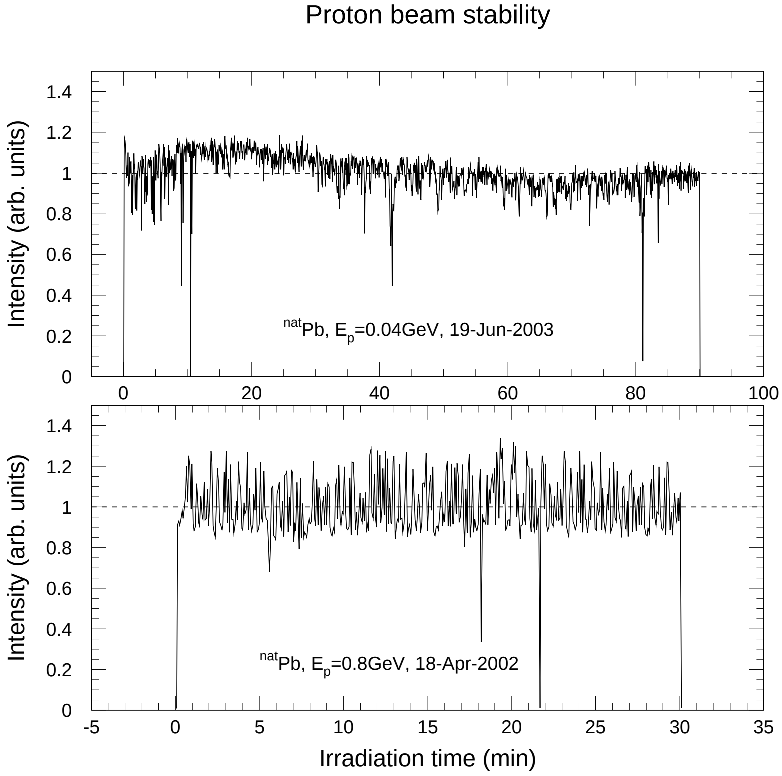


Fig. 12: Time distribution of the 40 MeV and 800 MeV proton beam intensities.

^{27}Al(p,x)^{22}Na, and ^{27}Al(p,x)^{24}Na reactions, respectively. The relevant ratio of mean secondary neutron flux to mean primary proton flux $\overline{\Phi}_n/\overline{\Phi}_p$ can be found from the expression [2]

$$\frac{\overline{\Phi}_n}{\overline{\Phi}_p} = \frac{\sigma_{p,x}^{^7Be,^{22}Na,^{24}Na}/\overline{\sigma}_{n,p}^{^{27}Mg}}{N^{^7Be,^{22}Na,^{24}Na}/N^{^{27}Mg} - \overline{\sigma}_{n,x}^{^7Be,^{22}Na,^{24}Na}/\overline{\sigma}_{n,p}^{^{27}Mg}} \tag{130}$$

where $\overline{\sigma}_{n,p}^{^{27}Mg}, \overline{\sigma}_{n,x}^{^7Be}, \overline{\sigma}_{n,x}^{^{22}Na}$, and $\overline{\sigma}_{n,\alpha}^{^{24}Na}$ are the respective reaction cross sections mean-weighted over neutron spectrum an calculated by formula (131); $\sigma_{p,x}^{^{22}Na}, \sigma_{p,x}^{^{24}Na}$ и $\sigma_{p,x}^{^7Be}$ are the ^{27}Al(p,x)^{24}Na, ^{27}Al(p,x)^{22}Na, and ^{27}Al(p,x)^{7}Be reaction cross sections; $N^{^{24}Na}$, $N^{^{22}Na}$, $N^{^{27}Mg}$, and $N^{^7Be}$ are numbers of ^{24}Na, ^{22}Na, ^{27}Mg, and ^{7}Be nuclei produced in Al monitors, with their decay under irradiaton being allowed for.

The expression for calculating the reaction cross sections mean-weighted over neutron spectrum is

$$\overline{\sigma}_x = \frac{\int \sigma_x(E)\Phi(E)dE}{\int \Phi(E)dE} \tag{131}$$

where x designates ^{27}Al(n,p)^{27}Mg, ^{27}Al(n,α)^{24}Na, ^{27}Al(n,x)^{22}Na, and ^{27}Al(n,x)^{7}Be.

The neutron spectrum $\Phi(E)$ used to calculate the weighted mean cross sections of ^{27}Al(n,p)^{27}Mg, ^{27}Al(n,α)^{24}Na, ^{27}Al(n,x)^{22}Na, and ^{27}Al(n,x)^{7}Be reactions vas estimated by LAHET code. The excitation functions of the above reactions were taken from the MENDL2 database [14]. The mean weighted cross section $\overline{\sigma}_{n,p}^{^{27}Mg}$ was taken to be 25 mbarn.

Note that the values of the ^{27}Al(p,x)^{24}Na and ^{27}Al(p,x)^{7}Be reaction cross sections used here have been determined in this work (see 2.7).

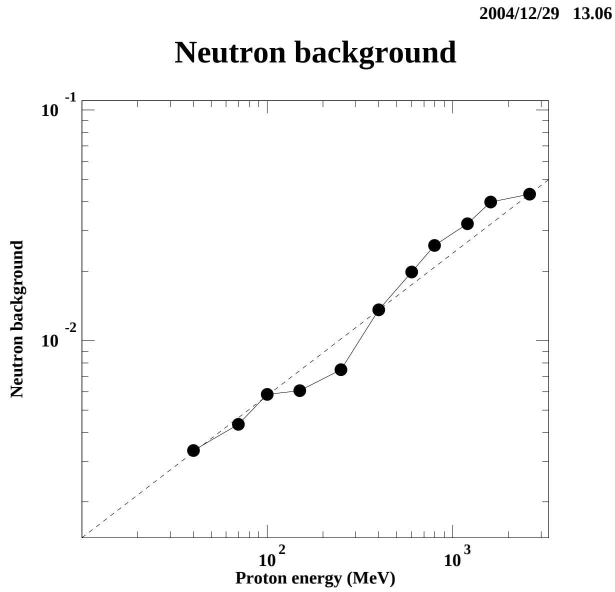


Fig. 13: The mean neutron flux-to-mean proton flux density ratio in the proton flux versus proton beam energy.

Fig. 13 shows the measurement results. Presented on double logarithmic scale, the nearly-linear rise of the $\overline{\Phi}_n/\overline{\Phi}_p$ ratio with increasing proton energy indicates a correlation between the increases in neutron yield and in neutron background. The appropriate estimates have shown that, given the highest $\overline{\Phi}_n/\overline{\Phi}_p$ value, the contribution of the neutron component at 2.6 GeV proton energy (the (n,Xn) reaction) is insignificant (to the (p,p(X-1)n)reaction, respectively).

2.6 γ-spectrum measurements

The facility used to measure the irradiated samples and monitors is the spectrometer manufactured by CANBERRA PACKARD Trading Corp. (a 1.8 keV resolution in the 1332 keV ^{60}Co (γ-line) based on GC-2518 coaxial Ge crystal, a 1510 integrated signal processor (a 6000 V power supply, a 100 MHz 8192-channel ADC, and a spectrometric amplifier), a SYSTEM-100 master card (near the end of the Project implementation, avis major forced us to replace that card with a AccuSpec-B master card) that emulates a multichannel analyzer (a complete card of the PC standard for 8K memory channels with DMA-interface and NIM unit) as an integral part of IBM PC.

2.6.1 Characteristics of the spectrometer

The very numerous radioactive reaction products involved in the measurements, the γ-spectra are extremely complicated, especially during the initial decay period. Besides, the γ-spectrum intensity varies by a few orders throughout the γ-spectrum measurement time. Therefore, the possible instability of the spectrometer performance may not only hamper in acquiring and processing experimental data, but also distort the results obtained. That is why the performance characteristics were constantly monitored during the experiments.

2.6.1.1 Determination of admissible measurement modes The spectrometer parameters that define the admissible measurement modes include

- temperature and time stability,
- cascade summation effects,
- ultimate spectrometer load,
- absolute height-energy effectiveness of the spectrometer.

2.6.1.1.1 Temperature stability The temperature stability was supported by a conditioner for producing the appropriate microclimate in the Laboratory measurement room.

2.6.1.1.2 Time stability The time stability is estimated by recurrent measuring γ-emission from ^{152}Eu. The long-term observations (see Fig. 14) made at the Laboratory have shown that the fluctuations of the channel positions of the 121.78 keV, 778.90 keV, and 1408.01 keV γ-line photopeak detection maxima from their means in the channels are mostly within 0.10 %. The observed temperature drift of instrumental line in the measured γ-spectra is allowed for by permanent calibrating the spectrometer, thus providing a 0.1-0.3 keV error in measuring the energy of γ-emission from the irradiated samples. In such a way, we can substantially reduce the number of the nuclide γ-lines that are to be considered as additional contributions to the determined cross section od a respective reaction.

Fig.15 shows the total statistics of the spectrometer time stability.

2.6.1.1.3 Quantitative estimation of count loss The count loss at high spectrometer loads was estimated by the method of two sources. One of the sources (^{137}Cs) was fixed at H that defines the Ge detector - γ-source spacing, while the height of the second source (^{152}Eu) was decreased during measurements. The position of the first source provided a moderate load of the spectrometer, while the position of the second source imitated the increased load inherent to the measurements. Fig.16 shows the variations of the ^{137}Cs γ-line resolution and peak area versus spectrometer load.

The results obtained were used to determine the ultimate spectrometer load that failed to exceed 5% in all measurement runs. To maintain there conditions, the experimental samples began being monitored at height ~1240 mm and higher, which decreased then down to the ultimate height of 40 mm to reduce the influence of the cascade summation effects. The experimental estimation of the cascade summation effects that distort the measured γ-spectra, which was made using nuc24Na and ^{60}Co placed at a 40-mm height, together with the computational estimation of the same effects by the method described in [36], showed that $\Delta k_{\gamma,\gamma} \leqslant 3.0$ %.

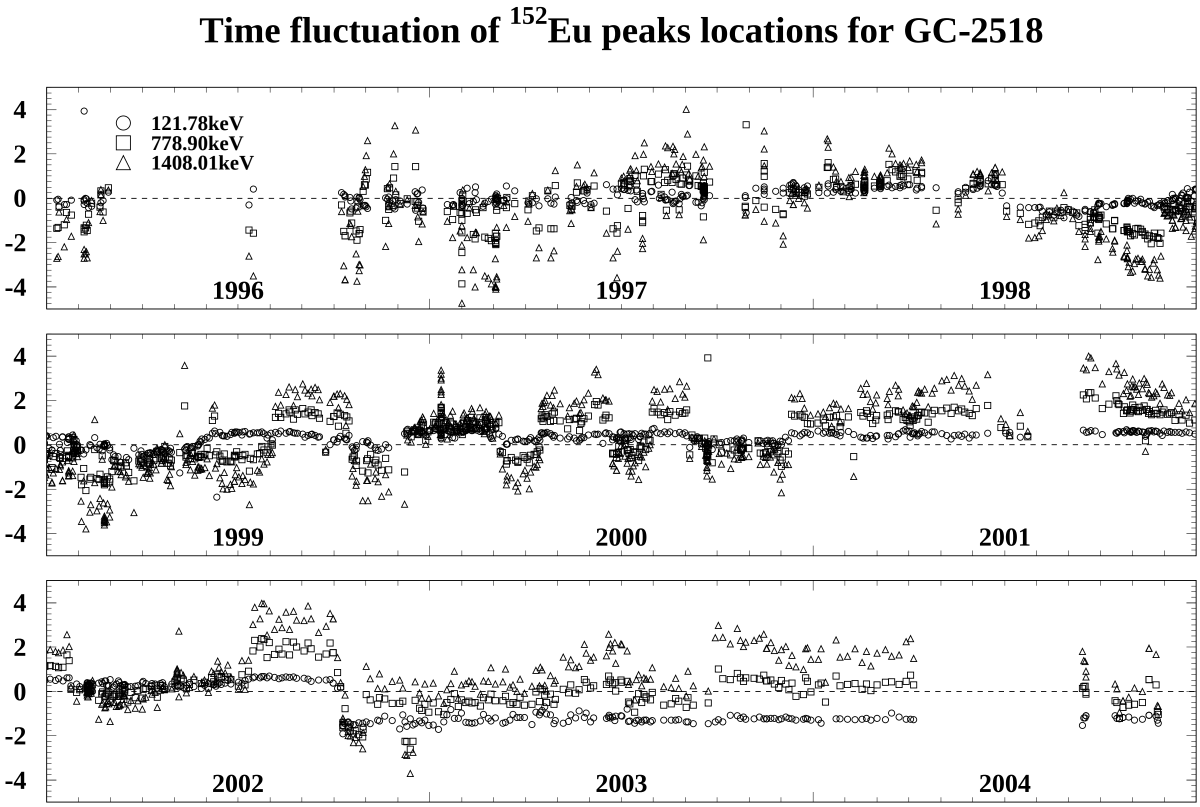


Fig. 14: Positions of the 121.78 keV, 778.90 keV, and 1408.01 keV γ-line photopeak detection maxima.

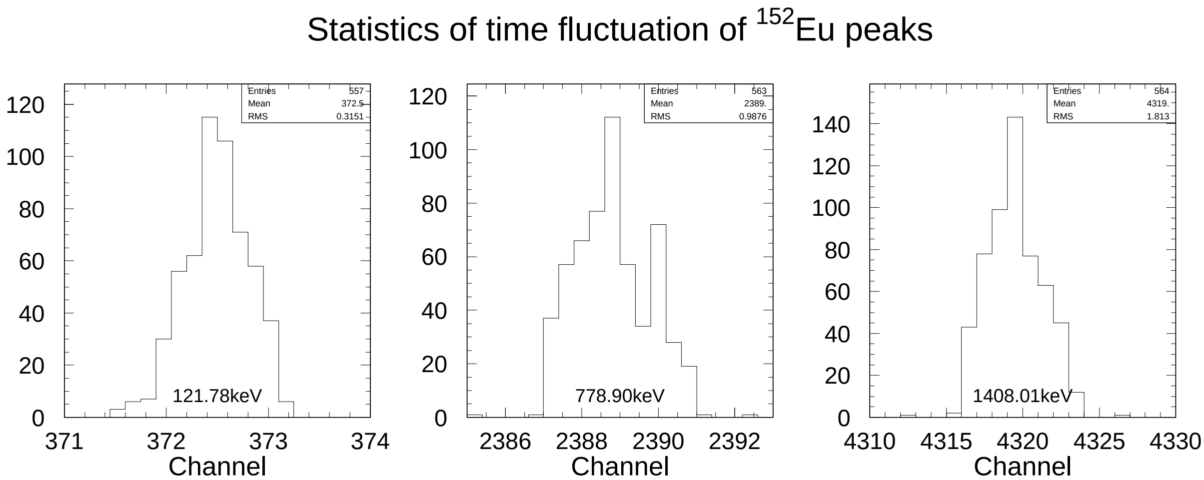


Fig. 15: General statistics of the spectrometer time stability.

2.6.1.1.4 The detection effectiveness of the spectrometer The absolute height-energy effectiveness of the spectrometer detection effectiveness is an important characteristic of the spectrometer because its value is used directly to calculate the independent and cumulative yields in formulas (43-49 and 87). Therefore, the measurements were made under preselected standard conditions that included the effects that distort the form of the instrumental spectrum. Like the routine measurements, the standard measures were taken to reduce the contribution

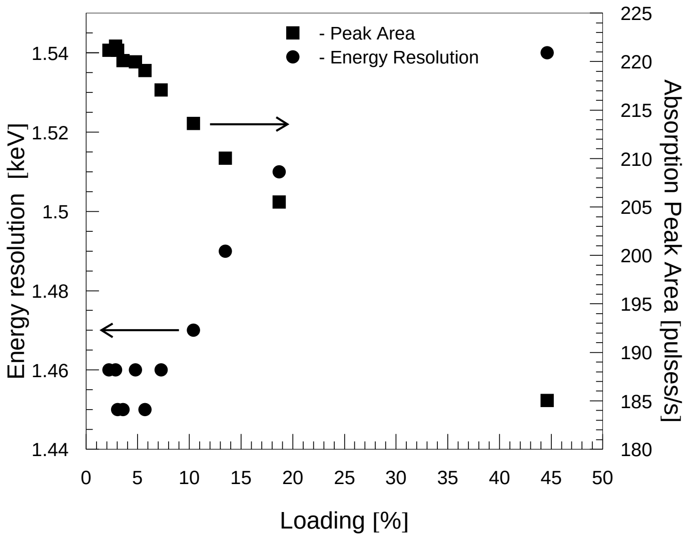


Fig. 16: Load characteristics of the spectrometer

from the errors associated with the geometric reproducibility (provided by a job-oriented support), with the system deadtime (determined by t_{live} and t_{true} of the spectrometer), with the measurement time (determined by the accuracy of the PC quartz generator), and with the source halflives (determined by selecting a set of γ-sources, whose certification date is close the date of measurements).

The absolute height-energy effectiveness $\varepsilon(E_0)$ for energy E_0, that corresponds to the γ-line energy of a monitored source, as well as its error, can be presented as

$$\varepsilon(E_0) = \frac{S}{A \cdot e^{-\lambda \cdot t_d} \cdot \eta} \tag{132}$$

where S is count rate in total absorption peak (pulse/s) at energy E_0; η is the absolute γ-line quantum yield; A is the certified γ-source activity reduced to the measurement moment.; t_d is time span between the γ-source certification date and measurement time; $\lambda = 0.693/T_{1/2}$ is the γ-source decay constant.

$$\Delta\varepsilon(E_0) = \varepsilon(E_0) \cdot \sqrt{\left(\frac{\Delta S}{S}\right)^2 + \left(\frac{\Delta A}{A}\right)^2 + \left(\frac{0.693 \cdot t_d \cdot \Delta T_{1/2}}{T_{1/2}^2}\right)^2 + \left(\frac{\Delta \eta}{\eta}\right)^2} \tag{133}$$

Use was made of the certified independent γ-sources from the OSGI-3#9402 set of sources tested an approved by D.I. Mendeleev VNIIIM. The set includes ^{54}Mn, ^{57}Co, ^{60}Co, ^{88}Y, ^{109}Cd, ^{113}Sn, ^{133}Ba, ^{137}Cs, ^{139}Ce, ^{152}Eu, ^{228}Th, ^{241}Am.

Additionally, use was made of the ^{22}Na source from the OSGI#237 set tested and approved by the VNIIFTRI.

The source certification date, the activity, and the nuclear data used to calculate the absolute effectiveness were taken to conform to the Certificate ratings [37].

The techniques for determining the absolute height-energy effectiveness of the spectrometer detection are described in detail in the Final Report on ISTC Project#839 [2]. In the present Project, the detection effectiveness was also determined for 900 mm and 1240 mm heights.

Fig. 17 shows the results of experimental determining and computational simulating the absolute spectrometer detection effectiveness at different heights.

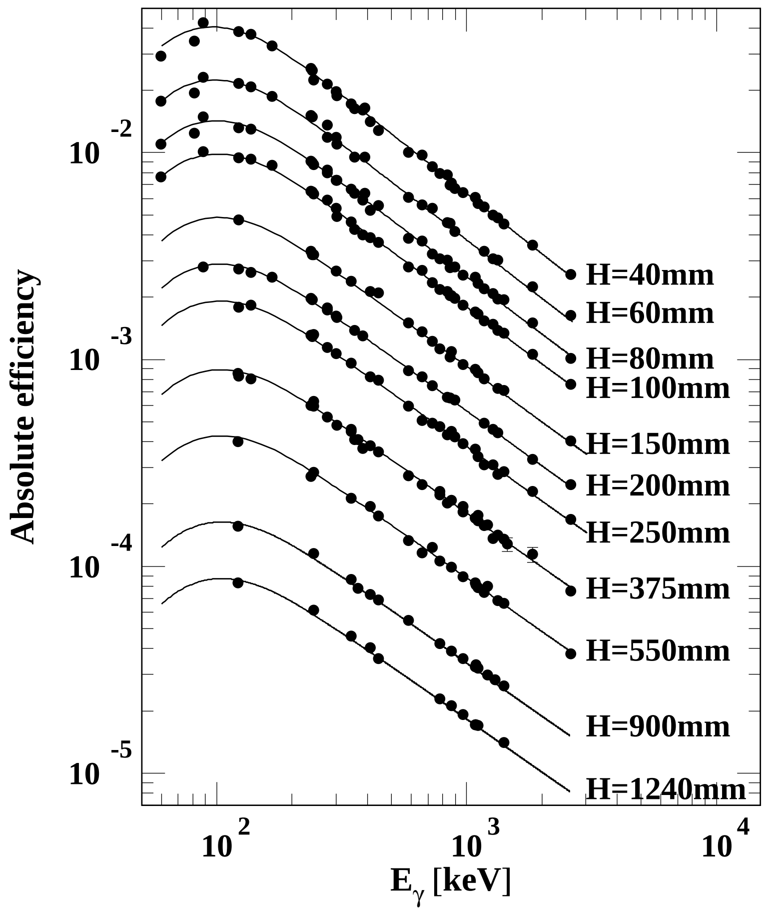


Fig. 17: The computational height-energy simulation of the absolute spectrometer detection effectiveness

From Fig. 17 it follows that the techniques developed makes it possible to adequately describe the experimental values of the absolute spectrometer detection effectiveness at any height and to correctly reproduce the variations of the slope of the energy dependence curve of the spectrometer detection effectiveness on double-logarithmic scale with varying height H.

The proposed techniques make it possible to calculate the absolute spectrometer detection effectiveness at 100 keV $\div$ 2600 keV energies and 40 mm $\div$ 1240 mm heights. The calculated values of the absolute height-energy detection effectiveness of the spectrometer were used to calculate the height factors when plotting the decay time dependences of the nuclide γ-line count rates.

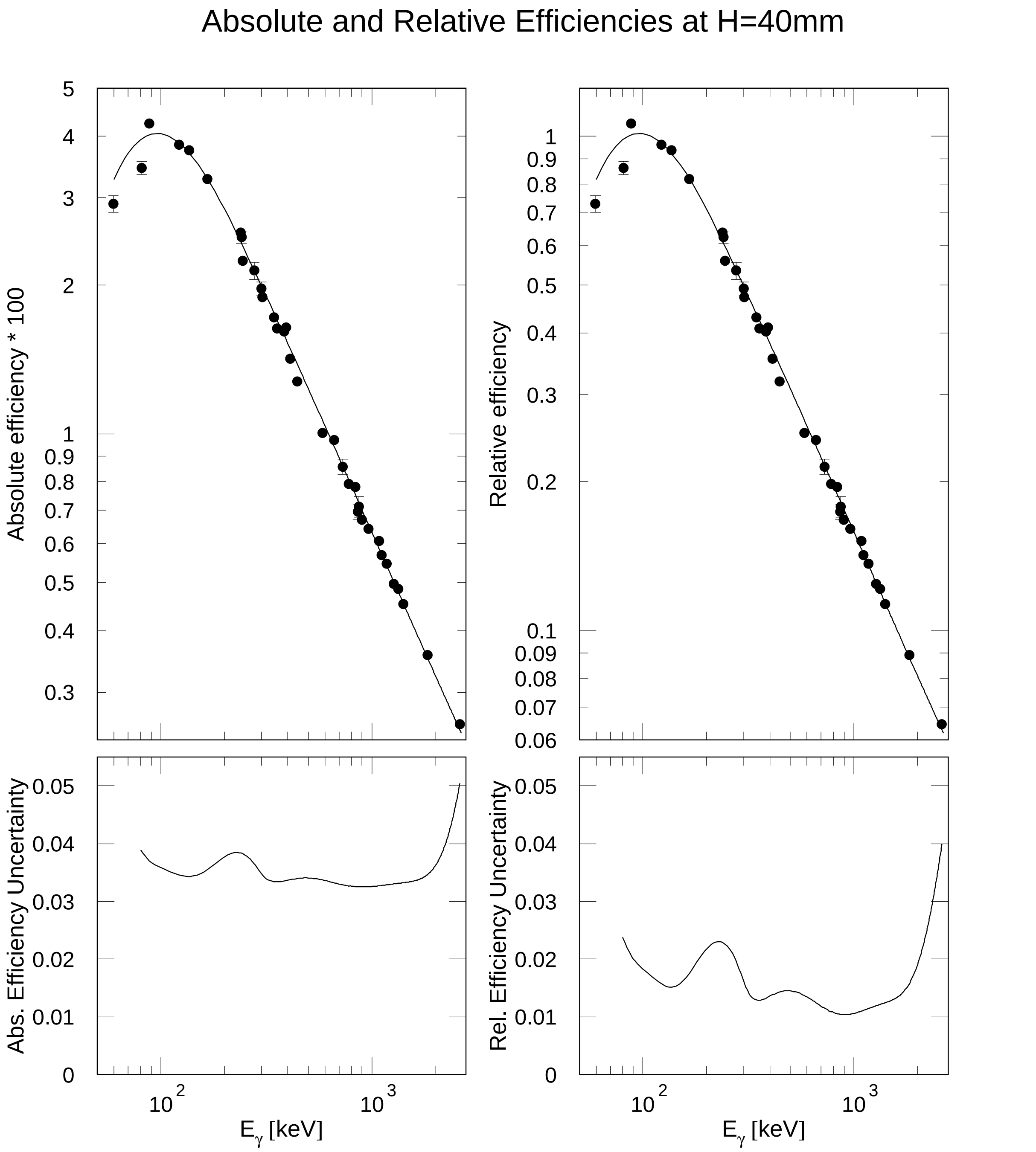


Fig. 18: The absolute and relative detection effectivenesses at 40 mm height and their respective relative errors.

Since all the measured count rates of the nuclide γ-lines were reduced to the 40 mm height, the relative spectrometer detection effectiveness was also calculated for that height by renormalizing the reference points of the measured absolute effectiveness. As noted in 2.1, the absolute detection effectiveness of the spectrometer can also be presented via relative effectiveness to be a product of two co-factors:

$$\varepsilon(E) = k_\varepsilon \cdot \varepsilon^{rel}(E), \tag{134}$$

where k_ε is a fixed factor with a 0.7% error defined by the certified γ-source activity accuracy; $\varepsilon^{rel}(E)$ is the relative effectiveness with an error defined by the error in relative quantum yields and by the measurement statistics.

Given the above representation, the error in the absolute detection effectiveness is calculated as

$$\frac{\Delta\varepsilon(E)}{\varepsilon(E)} = \sqrt{\left(\frac{\Delta\varepsilon^{rel}(E)}{\varepsilon^{rel}(E)}\right)^2 + \left(\frac{\Delta k_\varepsilon}{k_\varepsilon}\right)^2 + \left(\frac{\Delta k_{\gamma\gamma}}{k_{\gamma\gamma}}\right)^2} \tag{135}$$

The formula for calculating the relative detection effectiveness is of the same form as used to calculate the absolute detection effectiveness:

$$\varepsilon^{rel}(E) = exp\left[\sum_{i=k}^{k+3} P_i \cdot (\ln E)^{i-k}\right] \tag{136}$$

where

$$k = \begin{cases} 1, \text{ для } \ln E < \ln E_0 \\ 5, \text{ для } \ln E \geqslant \ln E_0 \end{cases}$$

The error in the relative detection effectiveness of the spectrometer is determined as

$$\Delta\varepsilon^{rel} = \varepsilon^{rel} \cdot \sqrt{\frac{\chi^2}{F}} \cdot \sqrt{\sum_{i=k}^{k+3}\sum_{j=k}^{k+3} M_{ij}^{-1} \cdot (\ln E)^{i-k} \cdot (\ln E)^{j-k}} \tag{137}$$

where

$$\chi^2 = \sum_{i=1}^{N_1+N_2} \left[\varepsilon^{exp}(E_i) - \varepsilon^{calc}(E_i)\right]^2 \cdot \frac{1}{\Delta_i^2}, \tag{138}$$

The $\varepsilon^{calc}(E_i)$ is calculated by formula (136); Δ_i is absolute error in the relative detection effectiveness of the spectrometer at energy E_i.

$$F = N_1 + N_2 - m_1 - m_2 + k - 3, \tag{139}$$

Table 5 lists the coefficients for calculating the relative detection effectiveness.

Fig.18 shows the absolute and relative detection effectivenesses of spectrometer at H = 40 mm together with their errors. The fixed factor for H=40 mm corresponds to k_ε=25.24 ± 0.17. The error in the relative detection effectiveness of spectrometer is within (1–4)% (see Fig.18).

In the ranges of relatively low and high energies (E_γ <100 кэВ, E_γ >1840 кэВ), the mean error is ≈ 2.5 %; in the 400 keV< E_γ <600 keV energy range that is supported by scanty reference points, the mean error is ≈ 2.0 %; in the remaining ranges, the error is within ≈ 1.5 %. The error in the absolute detection effectiveness of spectrometer is within (4.2–5.5)% (see Fig.18).

Table 5: The values of the parameters of the relative detection effectiveness curve for H = 40 mm.

	P_1	P_2	P_3	P_4
E≤300кэВ	-68.656518692	40.107437134	-7.6702423096	0.47793984413
	P_5	P_6	P_7	P_8
E>300кэВ	-18.926873917	9.6137084961	-1.5634212494	0.076607346535

2.6.1.2 The laboratory room background The occurrences of the background γ-lines produced in a sample by the natural radioactive background and by possible radioactive impurities are allowed for by analyzing the γ-spectra of the non-irradiated samples, whose measurement conditions are the same as those of irradiated samples. Fig. 19 shows the laboratory room radioactive background (buildup time $\sim$ 4 days) that is characteristic of γ-spectrometry. The background implies occurrences of the natural radionuclides that enter the ^{238}U, ^{235}U, and ^{232}Th decay chains, except for γ-line energies 661 keV (^{137}Cs) and 344.9, 722.9 keV (^{108}Ag). The presence of ^{137}Cs and ^{108}Ag is a probable result of the long-term heavy-water reactor operation in the ITEP area.

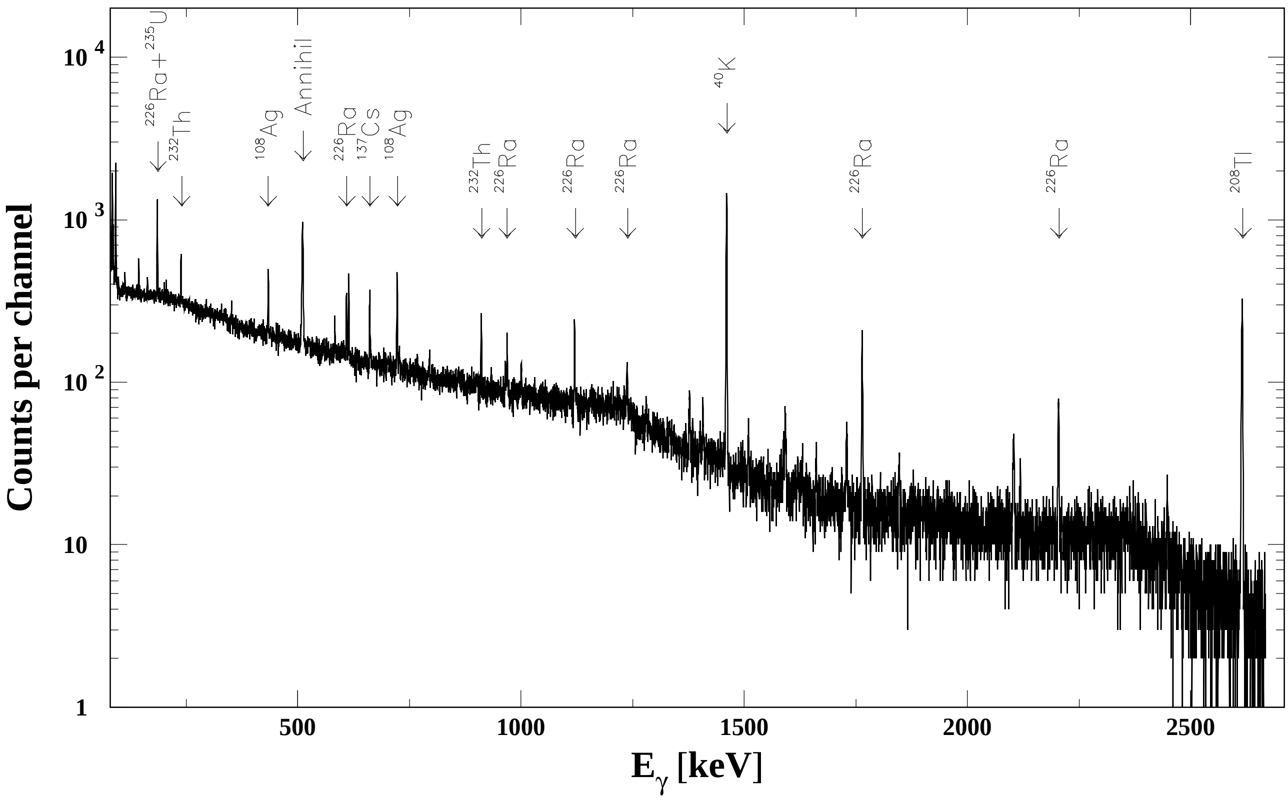


Fig. 19: Radioactive background spectrum of laboratory room.

2.6.2 Processing of γ-spectra

It was as early as the Project #839 implementation period that the potentialities of the codes with automatic γ-spectra processing mode were found to be restricted by the extremely complicated nature of the measured γ-spectra, resulting from the very numerous γ-lines and from the fact that they are essentially variable.

Despite the fact that we have reached the ultimate resolution inherent to our Ge detector, the transient multiplets were rather numerous in the spectra.

Considering the above, the GENIE-2000 code [16] was used to process the γ-spectra. The code is advantageous in that it permits the automatic packet-mode processing of the measured γ-spectra by interactive fitting the peaks in each of the spectra to be followed by additional monitoring of the tentative processing result outside the packet. Namely, an effort is made to find out whether the domains of the peaks are multiplets, real peaks that fail to satisfy the search criterion, spurious peaks, or else. The fitting quality is displayed to be dots of normalized differences between the input data and the fitting results.

The said techniques for spectrum processing have made it possible to substantially raise the quality of processing the measured γ-spectra. The GENIE-2000 code uses the generalized second derivative method to seek for the peaks. The areas of the peaks are determined using the summation algorithm or by least squares fitting in terms of the modified Gauss function. The highest number of iterations is 30. Convergence is improved by damping.

The algorithm includes calculations of the peak domain boundaries and of the areas of peaks together with their errors for both singlets and multiplets. The underpeak background is approximated by either linear or stepwise form. Up to sixteen peaks may occur in a multiplet. A single ROI may contain up to 512 channels. Any range, wherein more than 16 peaks or 512 channels are expected, must be broken in the deepest depression region to provide formation of two domains with less that 16 peaks or 512 channels. The errors are calculated by the techniques that are typical of the γ-spectrometry method on assumption that the channels are devoid of any correlation of counts. The comprehensive description of the algorithms used in the GENIE-2000 can be found in the Manual on Designer's Software [16] and in [17]-[32].

Figs. 20 and 21 exemplify the extra-packet usage of the GENIE-2000 code. The figures present the operation window of the code, showing an analyzed spectrum fraction of the 600 GeV proton-irradiated ^{nat}Pb spectrum in $\sim = 12$ hours after irradiation. The processing reports are also shown. The energies within the γ-spectrum fragment are ranging from 562.7 keV to 590.4 keV.

The upper panels show the results of primary processing the spectrum by the automatic packet mode of GENIE2000 code. Separation of multiplets does not prove to be satisfactory, as confirmed by the report. The lower panels show the result of the additional manual processing by the interactive fitting mode. Table 6 presents the nuclear physics characteristics of the identified nuclides from [33] together with the positions of maxima calculated using the energy calibration of the spectrometer for all GENIE2000-determined 10 peaks.

Obviously, the multiplet separation quality got improved, thus permitting the code to separate the peaks by energy differences of ~ 1 keV. In turn, this has made it possible to additionally identify ~ 10 nuclides. In such a way, the number of the identified nuclides increased substantially, with the quality of determining their yields being improved

Table 6: Nuclear-physics parameters of the nuclides identified.

	Nuclide	$T_{1/2}$	Energy, keV (PCNUDAT)	Energy, keV (GENIE)	γ-yield, %
1	^{165}Tm	30.06 h	564.18	564.52	2.31
	^{191}Au	3.18 h	565.13		0.49
2	^{189}Pt	10.87 h	568.85	568.94	7.1
	^{96}Nb	23.54 h	568.87		58.0
3	^{170}Hf	16.01 h	572.90	573.21	15
	^{193}Hg	11.8 h	573.25		26
4	^{187}Ir	10.5 h	576.60	576.62	0.85
5	^{202}Bi	1.72 h	578.56	579.15	7.3
	^{200}Tl	26.1 h	579.28		13.8
6	^{198}Au	4.94 h	582.63	582.57	2.7
7	^{186}Ir	16.64 h	584.42	584.70	5.4
	^{200}Tl	26.1 h	584.55		3.56
	^{195}Hg	9.9 h	585.13		1.99
8	^{191}Au	3.18 h	586.44	586.54	17.00
9	^{198}Tl	1.87 h	587.20	587.95	52.5
	^{181}Re	19.9 h	587.40		0.69
	^{192}Au	4.94 h	588.58		0.30
10	^{187}Ir	10.5 h	589.47	589.47	0.277

The processed γ-spectra were united to form a single input file for SIGMA code, which plots the temporal intensity variations of a selected γ-line and, then, uses the γ-line energy and the nuclide lifetimes estimated by the code proper, together with the PCNUDAT database [33, 34, 35], to identify the product nuclei and to calculate their yields by formulas 43-49), and (87).

The contribution of pair production in the Ge detector was analyzed for all peaks with E_γ >1022 keV by calculating the energies of the peaks of single snd double ejections. For that purpose, the peaks with E_i - 511 keV and E_i - 1022 keV were set to correspondence with the peaks at E_i - 511 keV and E_i - 1022 keV. Any peak, whose energy was found to coincides with the said difference to within the energy measurement error ($\sim$ 0.15 keV), was excluded from further analysis.

It should be noted that all the data (the irradiation parameters, the experimental sample characteristics, the spectrometer calibration data, the measured γ-spectra, and the experimental results obtained), which must be used to determine the yields, can be found in the "ExpData"experimental database of the Laboratory. The database is being replenished with fresh data and is stored on the Laboratory server to provide prompt access.

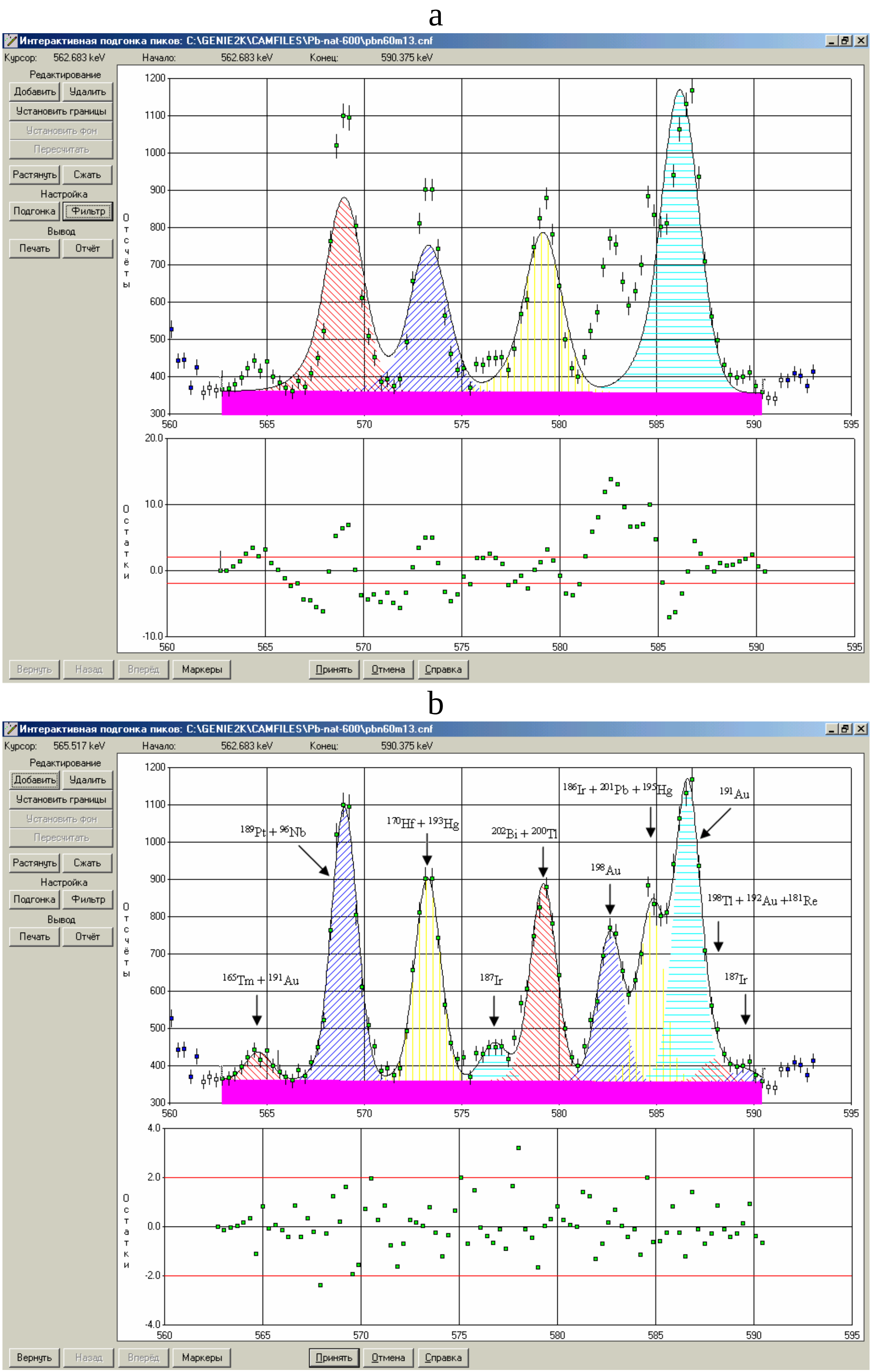
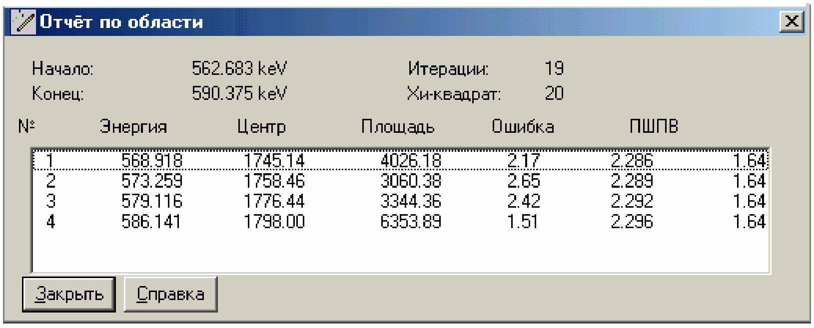


Fig. 20: The results of primary processing a γ-spectrum by the automatic (a) and manual interactive fitting(b) modes of the GENIE-2000 code.

a



Отчёт по области

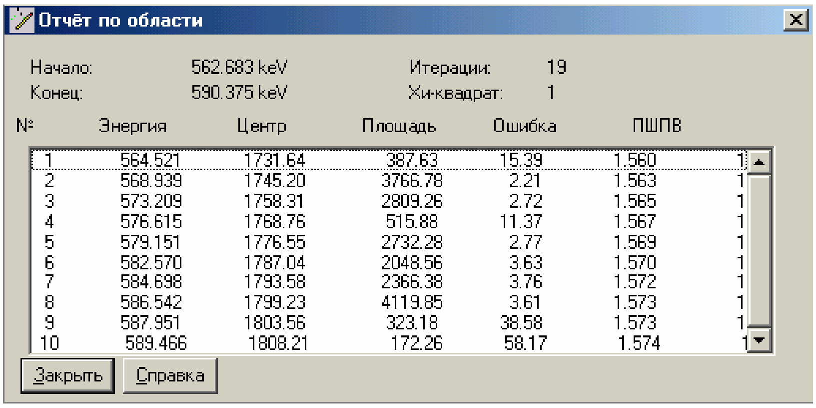
Начало: 562.683 keV Итерации: 19

Конец: 590.375 keV Хи-квадрат: 20

№	Энергия	Центр	Площадь	Ошибка	ПШПВ	
1	568.918	1745.14	4026.18	2.17	2.286	1.64
2	573.259	1758.46	3060.38	2.65	2.289	1.64
3	579.116	1776.44	3344.36	2.42	2.292	1.64
4	586.141	1798.00	6353.89	1.51	2.296	1.64

Закрыть Справка

b



Отчёт по области

Начало: 562.683 keV Итерации: 19

Конец: 590.375 keV Хи-квадрат: 1

№	Энергия	Центр	Площадь	Ошибка	ПШПВ	
1	564.521	1731.64	387.63	15.39	1.560	1
2	568.939	1745.20	3766.78	2.21	1.563	1
3	573.209	1758.31	2809.26	2.72	1.565	1
4	576.615	1768.76	515.88	11.37	1.567	1
5	579.151	1776.55	2732.28	2.77	1.569	1
6	582.570	1787.04	2048.56	3.63	1.570	1
7	584.698	1793.58	2366.38	3.76	1.572	1
8	586.542	1799.23	4119.85	3.61	1.573	1
9	587.951	1803.56	323.18	38.58	1.573	1
10	589.466	1808.21	172.26	58.17	1.574	1

Закрыть Справка

Fig. 21: The GENIE-2000 report on the parameters of the found peaks. The legend (a) and (b) is the same as in Fig. 20.

2.7 The monitoring reactions

The $^{27}Al(p,x)^{22}Na$ reaction was used to monitor the proton beam. Fig. 22 shows all the data from the EXFOR database (29 publications in total) [40], together with the data by J. Tobailem from [42] and [43]. Simlarly to [44], the data by G.F. Steyn et al. [41] were used at energies below 200 MeV, while the data by J. Tobailem [43] were used above 200 MeV.

The "Eye quide" method was used to plot a smooth curve that evaluates the $^{27}Al(p,x)^{22}Na$ reaction excitation function within a 30-3000 MeV range. The desired monitoring reaction cross sections were derived from the curve at the real proton beam energies at the monitor half-depths (see Table 4).

The sufficiently low contribution from the neutron component (as seen in Fig. 13 $\Phi_n/\Phi_p <\sim 4-5\%$) has made it possible to attain the desired accuracy of calculating not only the production rate $R_{^{22}Na}$, but also the production rates $R_{^{24}Na}$ and $R_{^{7}Be}$ by formula (112). Tables 7, 13, 19, 25, 31, 37, 43, 49, 55, 61, and 67 in Section 2 of Appendix to this Report present the detailed results of the ^{7}Be, ^{24}Na, and ^{22}Na production rate measurments in the standard foils. The production cross sections $\sigma_{^{24}Na}$ and $\sigma_{^{7}Be}$ can, then, be presented as

$$\frac{\sigma_{^{24}Na,^{7}Be}}{\sigma_{^{22}Na}} = \frac{D^*_{1_{^{24}Na,^{7}Be}}}{D^*_{1_{^{22}Na}}} \cdot \frac{(\eta \cdot \varepsilon)_{^{22}Na}}{(\eta \cdot \varepsilon)_{^{24}Na,^{7}Be}} \cdot \frac{F_{^{22}Na}}{F_{^{24}Na,^{7}Be}} \ . \qquad (140)$$

Figs. 23 and 24 show the excitation functions of the $^{27}Al(p,x)^{24}Na$ and $^{27}Al(p,x)^{7}Be$ reactions together with the data obtained elsewhere. Table 7 presents numerically the nuclide production cross sections $\sigma^{^{24}Na}$ and $\sigma^{^{7}Be}$ at the respective energies. The absolute errors $\Delta\sigma^{^{24}Na}$ and $\Delta\sigma^{^{7}Be}$ are presented in Table 7 disregarding/including the error in the monitoring cross section, i.e. $\Delta\sigma^{^{22}Na}$.

Table 7: The monitoring cross sections (mbarn) for ^{27}Al(p,x)^{22}Na production and the cross sections (mbarn) obtained for ^{27}Al(p,x)^{24}Na and ^{27}Al(p,x)^{7}Be production.

Proton energy (MeV)	^{27}Al(p,x)^{22}Na	^{27}Al(p,x)^{7}Be	^{27}Al(p,x)^{24}Na
2606 ± 8	11.4 ± 0.9	9.18 ± (0.29/0.78)	10.87 ± (0.34/0.92)
1599 ± 4	13.2 ± 1.0	9.06 ± (0.29/0.75)	12.59 ± (0.40/1.03)
1194 ± 3	14.4 ± 1.0	8.23 ± (0.26/0.63)	13.26 ± (0.42/1.01)
799 ± 2	15.5 ± 1.1	6.33 ± (0.21/0.49)	13.40 ± (0.42/1.04)
599 ± 2	16.0 ± 1.0	4.89 ± (0.16/0.34)	13.09 ± (0.41/0.92)
399 ± 2	15.8 ± 1.0	3.11 ± (0.10/0.22)	12.01 ± (0.38/0.85)
249 ± 1	15.0 ± 0.9	1.79 ± (0.06/0.12)	10.65 ± (0.33/0.72)
149 ± 1	17.1 ± 1.1	1.26 ± (0.04/0.09)	11.02 ± (0.35/0.79)
98.7 ± 0.8	19.8 ± 1.2	0.957 ± (0.033/0.067)	11.73 ± (0.37/0.80)
68.2 ± 0.8	22.3 ± 1.4	0.672 ± (0.028/0.051)	11.74 ± (0.43/0.85)
68.1 ± 0.8	22.3 ± 1.4	0.854 ± (0.039/0.067)	11.74 ± (0.43/0.85)
67.9 ± 0.8	22.4 ± 1.4	0.646 ± (0.026/0.048)	11.70 ± (0.43/0.85)
67.8 ± 0.8	22.4 ± 1.4	0.590 ± (0.027/0.046)	11.09 ± (0.40/0.80)
67.1 ± 0.9	22.7 ± 1.4	0.658 ± (0.030/0.051)	11.69 ± (0.43/0.84)
37.0 ± 1.1	28.7 ± 2.0	0.209 ± (0.033/0.036)	0.824 ± (0.031/0.065)
36.9 ± 1.1	28.4 ± 2.0	0.198 ± (0.069/0.071)	0.804 ± (0.030/0.064)
36.9 ± 1.1	28.2 ± 2.0	0.172 ± (0.033/0.036)	0.796 ± (0.029/0.064)
35.5 ± 1.3	22.1 ± 2.0	0.328 ± (0.028/0.041)	0.564 ± (0.021/0.055)
36.3 ± 1.2	25.9 ± 2.0	0.166 ± (0.024/0.027)	0.703 ± (0.026/0.060)

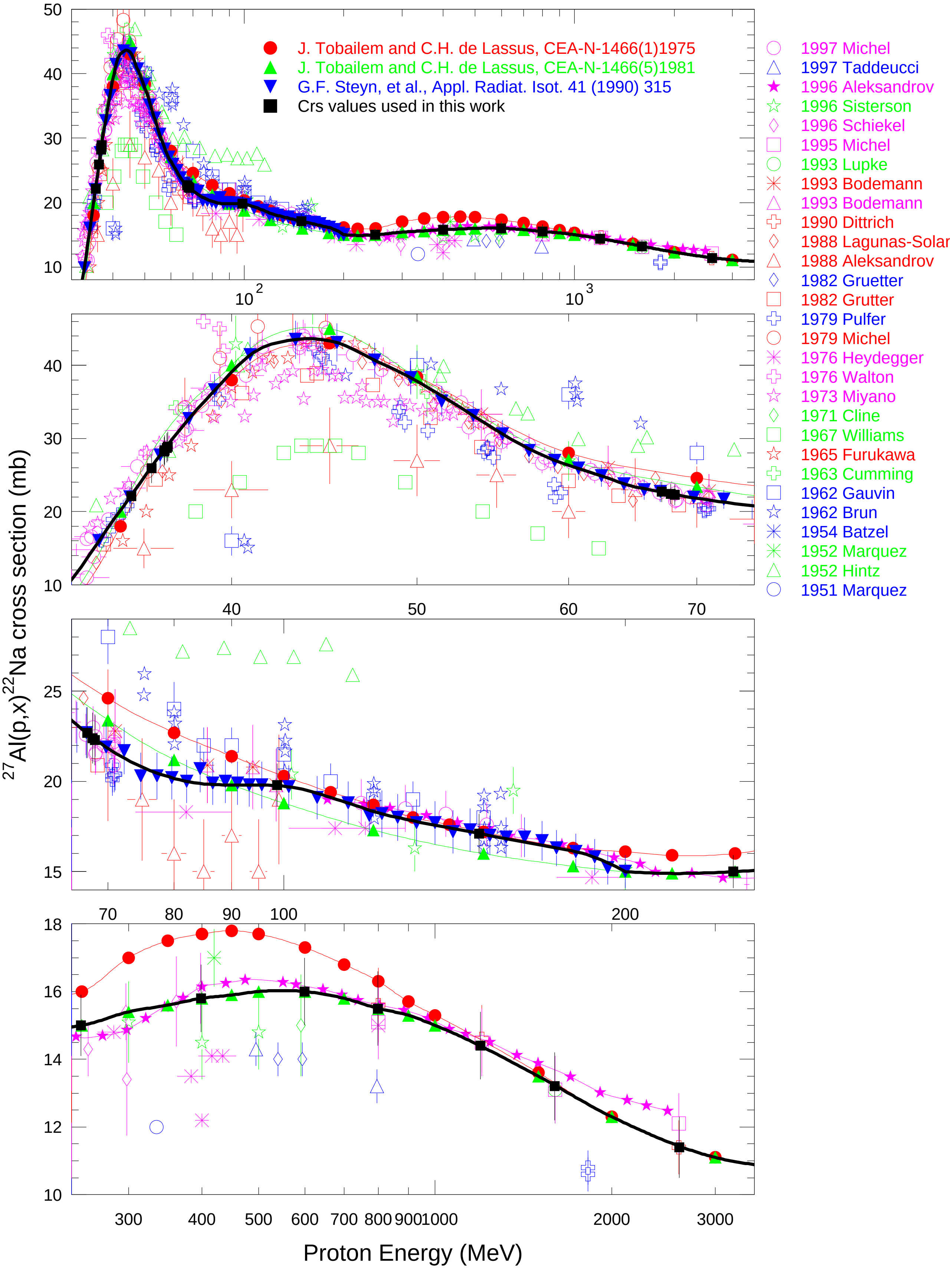


Fig. 22: The ^{27}Al(p,x)^{22}Na reaction cross sections. The black line is the applied evaluation. The values used in the experiments are labeled with black squares.

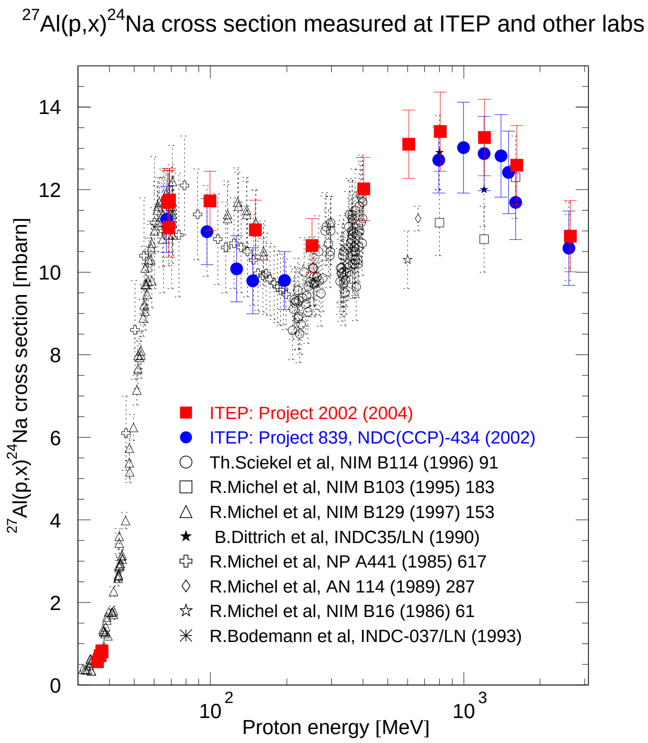


Fig. 23: The results obtained here for ^{27}Al(p,x)^{24}Na reaction (red squares) together with the data obtained elsewhere.

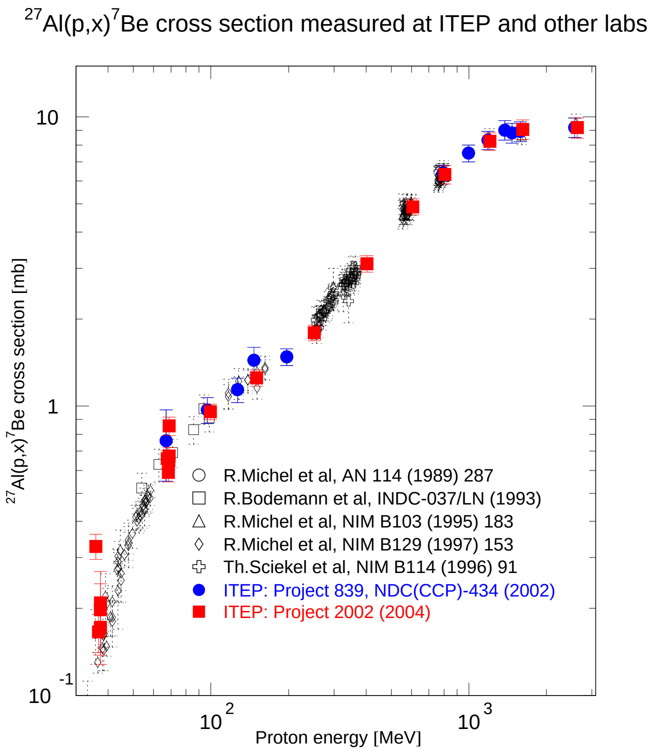


Fig. 24: The results obtained here for ^{27}Al(p,x)^{7}Be reaction (red squares) together with the data obtained elsewhere.

2.8 Conclusion

Conforming to the tasks outlined in the ISTC # 2002 Workplan (see Section 4 "Scope of activities"):

- **Task 1: Manufacture of samples,**
- **Task 2: Calibration of spectrometer; stability tests,**
- **Task 3: Adjustment of the 600 MeV proton beam extraction,**
- **Task 4: Irradiation of experimental samples,**
- **Task 5: γ-spectrometering of experimental samples,**
- **Task 6: Processing of γ-spectra,**
- **Task 7: Identification of γ-lines and determination of residual radioactive nuclide yields,**

the preparatory and current works that support implementation of the researches under the Project are described at length in Chapter 2, namely,

1. manufacture and certification of 55 experimental samples (targets) of high-enriched and natural lead (^{206}Pb, ^{207}Pb, ^{208}Pb, ^{nat}Pb) and bismuth (^{209}Bi) of 9.85 g total weight, as well as 55 aluminum monitors (^{27}Al) of 6.75 g total weight (Subsection 2.4);
2. description of spectrometer and of its admissible operation modes (the temperature and time stability, the cascade summation effects, the ultimate load, the absolute height-energy detecton effectiveness (Subsection 2.6.1);
3. description of the external proton beam designed to suit the Project tasks and to provide extraction of 40-2600 MeV protons; detailed description of the techniques for determining the proton energies, the neutrino background, and the geometric parameters of the beam (Subsections 2.5.2.1, 2.5.4, 2.5.2.2);
4. techniques for irradiating 55 experimental samples (Subsection 2.4);
5. techniques for γ-spectrometering 55 irradiated experimental samples/targets and monitors (Subsection 2.6 and for processing 1548 measured γ-spectra of samples/targets and 604 γ-spectra of monitors (Subsection 2.6);
6. modification of SIGMA code that is used to identify γ-lines and to determine yields/cross sections of radioactive residual product nuclei. The modification was to go over from the mathematical two-link model of nuclear chains to the three-link model
7. evaluation of the excitation function of the ^{27}Al(p,x)^{22}Na monitoring reaction in the 0.04 - 2.6 GeV energy range (Subsection 2.7);

3 Experimental results and their errors

In total (see Table 9), 5972 yields (cross section for production) of radioactive residual products have been determined, of which 702 independent yields (labeled (i)), 712 independent yields of metastable state (i(Σm_j)), 546 sums od independent yields of metastable and ground states (i(Σm_j+g)), and 4012 cumulative and supracumulative yields (c + c*). To visualize the presentation, the list of measurements of each reaction product has been compiled and presented in Table 8 for all 55 experiments carried out. The values of the yields or cross sections for production of residual nuclei were calculated by formulas (116), and their errors by formulas (117) and (118). Formulas (116) show that each of the production rates of a residual product can be obtained via both a single γ-line and a few different γ-lines. The detailed information on calculating each of the production rates of a residual product in experimental samples and in monitors, as well as their errors, can be found in Section 2 of Appendix to the present Report. All the experimental values of the yields (cross sections for production) of residual nuclides are presented in Tables 13, 15, 17, 19, 21, 23, 25, 27, 29, 31, and 33 for ^{206}Pb, ^{207}Pb, ^{208}Pb, and ^{nat}Pb, and in Table 35 for ^{209}Bi. The proton energies and their errors, as well as the proton flux densities and their errors that must be used to calculate the yields (cross sections for production) of radioactive residual nuclei by formulas (114) and (115), are presented together with some other irradiation parameters in Tables 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32, and 34.

In some cases, the presented values of the yields have been obtained from experimental data via simple calculations. For convenience, Table 8 and the Tables of results 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32, and 34 make use of a particular marker (* in front of the reaction product name). Such cases are discussed in detail below.

1. Only supracumulative production rate of a measured nuclide $R_n^{cum^*}$ and the cumulative production rate of its precursor R_{n-1}^{cum} are often determined experimentally. In this case, the modified formula (119) can be used to calculate the cumulative production rate R_n^{cum} of a measured nuclide and its error ΔR_n^{cum} as

$$R_n^{cum^*} = R_n^{ind} + \frac{\lambda_{n-1}}{\lambda_{n-1} - \lambda_n} \cdot \nu_{n-1,n} \cdot R_{n-1}^{cum} = R_n^{cum} + \frac{\lambda_n}{\lambda_{n-1} - \lambda_n} \cdot \nu_{n-1,n} \cdot R_{n-1}^{cum} \quad (141)$$

$$\Delta R_n^{cum^*} = \sqrt{\Delta(R_n^{cum})^2 + \left(\frac{\lambda_n}{\lambda_{n-1} - \lambda_n} \cdot \nu_{n-1,n}\right)^2 \cdot \Delta(R_{n-1}^{cum})^2} \quad (142)$$

$$R_n^{cum} = R_n^{cum^*} - \frac{\lambda_n}{\lambda_{n-1} - \lambda_n} \cdot \nu_{n-1,n} \cdot R_{n-1}^{cum} \quad (143)$$

$$\Delta R_n^{cum} = \sqrt{\Delta(R_n^{cum^*})^2 + \left(\frac{\lambda_n}{\lambda_{n-1} - \lambda_n} \cdot \nu_{n-1,n}\right)^2 \cdot \Delta(R_{n-1}^{cum})^2} \quad (144)$$

Formulas (143) and (144) were used together with formulas (149) and (150) to calculate the cumulative yields and their errors for the following 13 products: $*^{204}$Bi, $*^{203}$Pb, $*^{201}$Pb, $*^{201}$Tl, $*^{197}$Tl, $*^{181}$Re, $*^{177}$Ta, $*^{173}$Hf, $*^{170}$Lu, $*^{169}$Yb, $*^{152}$Tb, $*^{149}$Eu, and $*^{147}$Eu.

2. The situation occurs sometimes where cumulative reaction rate is determined for a reaction product at certain energies, while supracumulative rate is determined at some other energies for the same reaction product. To facilitate plotting, the respective values of supracumulative yields and their errors have been additionally either calculated ($*^{204}$Bi, $*^{202}$Bi, and $*^{201}$Pb using the modified formula (141) and (142) and formulas (149) and (151)) or determined via decay curves (^{199}Tl, ^{201}Tl, ^{171}Lu, formula (121)).

3. In the case of $*^{202}$Tl, the reaction product experimental data were corrected to calculate the independent yield of the nuclide and its error using formulas (145), (149), (152), and (146):

$$R^{ind}_{202Tl} = R^{cum}_{202Tl} - 0.095 \cdot R^{ind}_{202m\,Pb} \tag{145}$$

$$\Delta R^{ind}_{202Tl} = \sqrt{\Delta(R^{cum}_{202Tl})^2 + 0.095^2 \cdot \Delta(R^{ind}_{202m\,Pb})^2} \tag{146}$$

4. The total cumulative rate and its error have been calculated for $*^{195}$Hg making allowance for the contribution of independent reaction rate of long-lived metastable state of ^{195m}Hg. Considering formulas(147), (149), (148), and (153), the total cumulative yield of ^{195}Hg is presented in the Tables of results.

$$R^{cum_t}_{195\,Hg} = R^{cum}_{195\,Hg} + R^{ind}_{195m\,Hg} \tag{147}$$

$$\Delta R^{cum_t}_{195\,Hg} = \sqrt{\Delta(R^{cum}_{195\,Hg})^2 + \Delta(R^{ind}_{195m\,Hg})^2} \tag{148}$$

The resulting reaction rates were used to calculate the values of σ^{cum}_n, $\sigma^{cum^*}_n$, $\sigma^{ind}_{202\mathrm{Tl}}$ и $\sigma^{cum_t}_{195\mathrm{Hg}}$ and their errors:

$$\sigma^{cum}_n = \frac{R^{cum}_n}{\Phi}, \qquad \sigma^{cum^*}_n = \frac{R^{cum^*}_n}{\Phi}, \qquad \sigma^{ind}_{202Tl} = \frac{R^{ind}_{202Tl}}{\Phi}, \qquad \sigma^{cum_t}_{195\,Hg} = \frac{R^{cum_t}_{195\,Hg}}{\Phi} \tag{149}$$

$$\Delta\sigma^{cum}_n = \sigma^{cum}_n \cdot \sqrt{\left(\frac{\Delta R^{cum}_n}{R^{cum}_n}\right)^2 + \left(\frac{\Delta\Phi}{\Phi}\right)^2}, \tag{150}$$

$$\Delta\sigma^{cum^*}_n = \sigma^{cum^*}_n \cdot \sqrt{\left(\frac{\Delta R^{cum^*}_n}{R^{cum^*}_n}\right)^2 + \left(\frac{\Delta\Phi}{\Phi}\right)^2}, \tag{151}$$

$$\Delta\sigma^{ind}_{^{202}Tl} = \sigma^{ind}_{^{202}Tl} \cdot \sqrt{\left(\frac{\Delta R^{ind}_{^{202}Tl}}{R^{ind}_{^{202}Tl}}\right)^2 + \left(\frac{\Delta\Phi}{\Phi}\right)^2} \tag{152}$$

$$\Delta\sigma^{cum_t}_{^{195}Hg} = \sigma^{cum_t}_{^{195}Hg} \cdot \sqrt{\left(\frac{\Delta R^{cum_t}_{^{195}Hg}}{R^{cum_t}_{^{195}Hg}}\right)^2 + \left(\frac{\Delta\Phi}{\Phi}\right)^2} \tag{153}$$

The aggregate Table 9 has special columns (Yield type (calc)) showing the total number of the yields calculated. Table 8 presens the energies, at which the yields were calculated. The total number of the yields calculated is 311 that include 51 independent yields and 260 cumulative and supracumulative yields. All the calculated values are presented in the Tables of results. The results obtained have made it possible to plot 1024 excitation functions for 215 residual nuclides in the 0.04 - 2.6 GeV proton energy range, which are shown in Figs. 53 - 83.

Table 8: List of product measurements in each experiment.

Нуклид	Тип	$T_{1/2}$	Total	Энергия (ГэВ)										
				0.04	0.07	0.1	0.15	0.25	0.4	0.6	0.8	1.2	1.6	2.6
^{207}Po	i(m+g)	5.80H	11	−−−−+	−−−−+	−−−−+	−−−−+	−−−−+	−−−−+	−−−−+	−−−−+	−−−−+	−−−−+	−−−−+
^{206}Po	i	8.8D	11	−−−−+	−−−−+	−−−−+	−−−−+	−−−−+	−−−−+	−−−−+	−−−−+	−−−−+	−−−−+	−−−−+
^{205}Po	i	1.66H	7	−−−−+	−−−−+	−−−−+	−−−−+	−−−−+	−−−−+	−−−−+	−−−−−	−−−−−	−−−−−	−−−−−
^{204}Po	i	3.53H	6	−−−−−	−−−−+	−−−−+	−−−−+	−−−−+	−−−−+	−−−−+	−−−−−	−−−−−	−−−−−	−−−−−
^{203}Po	i(m+g)	36.7M	4	−−−−−	−−−−+	−−−−+	−−−−+	−−−−+	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−
^{202}Po	i	44.7M	4	−−−−−	−−−−+	−−−−+	−−−−+	−−−−+	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−
^{201}Po	i(m+g)	15.3M	2	−−−−−	−−−−−	−−−−+	−−−−+	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−
^{207}Bi	i	31.55Y	28	−+++−	−+++−	++++−	−+++−	−+++−	−+++−	−−++−	−−++−	−−−+−	−−++−	−−++−
^{207}Bi	c	31.55Y	11	−−−−+	−−−−+	−−−−+	−−−−+	−−−−+	−−−−+	−−−−+	−−−−+	−−−−+	−−−−+	−−−−+
^{206}Bi	i	6.243D	55	+++++	+++++	+++++	+++++	+++++	+++++	+++++	+++++	+++++	+++++	+++++
^{206}Bi	c	6.243D	11	−−−−+	−−−−+	−−−−+	−−−−+	−−−−+	−−−−+	−−−−+	−−−−+	−−−−+	−−−−+	−−−−+
^{205}Bi	i	15.31D	44	++++−	++++−	++++−	++++−	++++−	++++−	++++−	++++−	++++−	++++−	++++−
^{205}Bi	c	15.31D	11	−−−−+	−−−−+	−−−−+	−−−−+	−−−−+	−−−−+	−−−−+	−−−−+	−−−−+	−−−−+	−−−−+
^{204}Bi	i	11.22H	48	++++−	+++++	+++++	+++++	+++++	++++−	++++−	++++−	++++−	++++−	++++−
^{204}Bi	c	11.22H	4	−−−−−	−−−−+	−−−−+	−−−−+	−−−−+	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−
* ^{204}Bi	c	11.22H	2	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−	−−−−+	−−−−+	−−−−−	−−−−−	−−−−−	−−−−−
^{204}Bi	c*	11.22H	6	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−	−−−−+	−−−−+	−−−−+	−−−−+	−−−−+	−−−−+
* ^{204}Bi	c*	11.22H	4	−−−−−	−−−−+	−−−−+	−−−−+	−−−−+	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−
^{203}Bi	i(m+g)	11.76H	44	++++−	++++−	++++−	++++−	++++−	++++−	++++−	++++−	++++−	++++−	++++−
^{203}Bi	c	11.76H	10	−−−−−	−−−−+	−−−−+	−−−−+	−−−−+	−−−−+	−−−−+	−−−−+	−−−−+	−−−−+	−−−−+
^{202}Bi	i	1.72H	46	+−−+−	+++++	+++++	+++++	+++++	++++−	++++−	++++−	++++−	++++−	++++−
^{202}Bi	c	1.72H	4	−−−−−	−−−−+	−−−−+	−−−−+	−−−−+	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−
^{202}Bi	c*	1.72H	6	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−	−−−−+	−−−−+	−−−−+	−−−−+	−−−−+	−−−−+
* ^{202}Bi	c*	1.72H	4	−−−−−	−−−−+	−−−−+	−−−−+	−−−−+	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−
^{201}Bi	i	108M	17	−−−+−	++++−	++++−	++++−	++++−	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−
^{201}Bi	c*	108M	3	−−−−−	−−−−−	−−−−+	−−−−+	−−−−+	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−
^{199}Bi	i	27M	8	−−−−−	−−−−−	++++−	++++−	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−
^{199}Bi	c*	27M	2	−−−−−	−−−−−	−−−−−	−−−−+	−−−−+	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−
^{204m}Pb	i(m)	67.2M	51	+−−++	++++−	++++−	+++++	+++++	+++++	+++++	+++++	+++++	+++++	+++++
^{204m}Pb	c	67.2M	48	+−−+−	++++−	++++−	++++−	++++−	+++++	+++++	+++++	+++++	+++++	+++++
^{203}Pb	i(m1+m2+g)	51.873H	21	++++−	++++−	+++++	−−−−+	−−−−+	−−−−+	−−−−+	−−−−+	−−−−+	−−−−+	−−−−+
^{203}Pb	c	51.873H	21	++++−	++++−	+++++	−−−−+	−−−−+	−−−−+	−−−−+	−−−−+	−−−−+	−−−−+	−−−−+
* ^{203}Pb	c	51.873H	33	−−−−−	−−−−+	−−−−−	++++−	++++−	++++−	++++−	++++−	++++−	++++−	++++−
^{203}Pb	c*	51.873H	34	−−−−+	−−−−+	−−−−−	++++−	++++−	++++−	++++−	++++−	++++−	++++−	++++−
^{202m}Pb	i(m)	3.53H	51	+−−−−	+++++	+++++	+++++	+++++	+++++	+++++	+++++	+++++	+++++	+++++
^{201}Pb	i(m+g)	9.33H	9	−−−+−	++++−	++++−	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−
^{201}Pb	c	9.33H	9	−−−+−	++++−	++++−	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−
* ^{201}Pb	c	9.33H	8	−−−−−	−−−−−	−−−−−	++++−	++++−	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−
^{201}Pb	c*	9.33H	42	−−−−−	−−−−+	−−−−+	+++++	+++++	+++++	+++++	+++++	+++++	+++++	+++++
* ^{201}Pb	c*	9.33H	9	−−−+−	++++−	++++−	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−
^{200}Pb	c	21.5H	50	−−−−−	+++++	+++++	+++++	+++++	+++++	+++++	+++++	+++++	+++++	+++++
^{199}Pb	c*	90M	45	−−−−−	−−−−−	+++++	+++++	+++++	+++++	+++++	+++++	+++++	+++++	+++++
^{198}Pb	c	2.4H	44	−−−−−	−−−−−	++−++	+++++	+++++	+++++	+++++	+++++	+++++	+++++	+++++
^{197m}Pb	c*	43M	44	−−−−−	−−−−−	++−++	+++++	+++++	+++++	+++++	+++++	+++++	+++++	+++++
^{196}Pb	c*	37M	20	−−−−−	−−−−−	−−−−−	+++++	+++++	+++++	+++++	−−−−−	−−−−−	−−−−−	−−−−−
^{195m}Pb	i(m)	15.0M	35	−−−−−	−−−−−	−−−−−	++++−	+++++	+++++	+++++	+++++	+++++	+++++	−−−−+
* ^{202}Tl	i	12.23D	51	+−−−−	+++++	+++++	+++++	+++++	+++++	+++++	+++++	+++++	+++++	+++++
^{202}Tl	c	12.23D	54	++++−	+++++	+++++	+++++	+++++	+++++	+++++	+++++	+++++	+++++	+++++
^{201}Tl	c	72.912H	4	−−−−−	−−−−−	−−−−−	++++−	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−
* ^{201}Tl	c	72.912H	13	−−−+−	++++−	++++−	−−−−−	++++−	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−
^{201}Tl	c*	72.912H	52	+−−+−	+++++	+++++	+++++	+++++	+++++	+++++	+++++	+++++	+++++	+++++
^{200}Tl	i	26.1H	49	−−−−−	++++−	+++++	+++++	+++++	+++++	+++++	+++++	+++++	+++++	+++++
^{200}Tl	c	26.1H	50	−−−−−	+++++	+++++	+++++	+++++	+++++	+++++	+++++	+++++	+++++	+++++
^{199}Tl	c	7.42H	19	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−	++++−	++++−	++++−	++++−	+++−−
^{199}Tl	c*	7.42H	49	−−−−−	++++−	+++++	+++++	+++++	+++++	+++++	+++++	+++++	+++++	+++++
^{198m}Tl	i(m)	1.87H	45	−−−−−	+−−−−	++++−	+++++	+++++	+++++	+++++	+++++	+++++	+++++	+++++
* ^{197}Tl	c	2.84H	27	−−−−−	−−−−−	++−+−	+++++	+++++	+++++	+++++	−−−−+	−−−−+	−−−−+	−−−−+
^{197}Tl	c*	2.84H	28	−−−−−	−−−−−	++++−	+++++	+++++	+++++	+++++	−−−−+	−−−−+	−−−−+	−−−−+
^{196m}Tl	i(m)	1.41H	43	−−−−−	−−−−−	++−+−	+++++	+++++	+++++	+++++	+++++	+++++	+++++	+++++
^{195}Tl	c*	1.16H	19	−−−−−	−−−−−	−−−−−	++++−	+++++	+++++	+++++	−−−−−	−−−−−	−−−−−	−−−−−
^{203}Hg	c	46.612D	45	−+−+−	++++−	++++−	+++++	+++++	+++++	++++−	++++−	++++−	++++−	++++−
^{197m}Hg	i(m)	23.8H	40	−−−−−	−−−−−	−−−−−	+++++	+++++	+++++	+++++	+++++	+++++	+++++	+++++
^{197}Hg	c*	64.14H	18	−−−−−	−−−−−	+−−+−	+++++	+++++	+++++	−−−−+	−−−−−	−−−−−	−−−−−	−−−−−
^{195m}Hg	i(m)	41.6H	37	−−−−−	−−−−−	−−−−−	++++−	+++++	+++++	+++++	+++++	+++++	++++−	++++−
* ^{195}Hg	ct	9.9H	19	−−−−−	−−−−−	−−−−−	++++−	+++++	+++++	+++++	−−−−−	−−−−−	−−−−−	−−−−−
^{195}Hg	c	9.9H	19	−−−−−	−−−−−	−−−−−	++++−	+++++	+++++	+++++	−−−−−	−−−−−	−−−−−	−−−−−
^{193m}Hg	i(m)	11.8H	39	−−−−−	−−−−−	−−−−−	++++−	+++++	+++++	+++++	+++++	+++++	+++++	+++++
^{192}Hg	c	4.85H	39	−−−−−	−−−−−	−−−−−	++++−	+++++	+++++	+++++	+++++	+++++	+++++	+++++
^{190}Hg	c*	20.0M	35	−−−−−	−−−−−	−−−−−	−−−−−	+++++	+++++	+++++	+++++	+++++	+++++	+++++
^{198m}Au	i(m)	2.27D	30	−−−−−	−−−−−	−−−−−	++++−	++++−	++++−	+++++	+++++	++++−	++++−	−−−−−
^{198}Au	i(m+g)	2.69517D	34	−−−−−	−−−−−	−−−−−	++++−	++++−	++++−	+++++	+++++	++++−	++++−	++++−
^{198}Au	i	2.69517D	31	−−−−−	−−−−−	−−−−−	++++−	++++−	+++++	+++++	+++++	++++−	++++−	−−−−−
^{196}Au	i(m1+m2+g)	6.183D	43	−−−−−	−−−−−	++++−	++++−	+++++	+++++	+++++	+++++	+++++	+++++	+++++
^{195}Au	c	186.098D	43	−−−−−	−−−−−	++−+−	+++++	+++++	+++++	+++++	+++++	+++++	+++++	+++++
^{194}Au	i(m1+m2+g)	38.02H	39	−−−−−	−−−−−	−−−−−	++++−	+++++	+++++	+++++	+++++	+++++	+++++	+++++
^{192}Au	i(m+g)	4.94H	38	−−−−−	−−−−−	−−−−−	+−++−	+++++	+++++	+++++	+++++	+++++	+++++	+++++
^{192}Au	c	4.94H	39	−−−−−	−−−−−	−−−−−	++++−	+++++	+++++	+++++	+++++	+++++	+++++	+++++
^{191}Au	c*	3.18H	31	−−−−−	−−−−−	−−−−−	−−−−−	+++++	+++++	+++++	+++++	+++++	+++++	−−−−+
^{190}Au	c	42.8M	34	−−−−−	−−−−−	−−−−−	−−−−−	+++++	++++−	+++++	+++++	+++++	+++++	+++++
^{191}Pt	c	2.802D	35	−−−−−	−−−−−	−−−−−	−−−−−	+++++	+++++	+++++	+++++	+++++	+++++	+++++
^{189}Pt	c	10.87H	35	−−−−−	−−−−−	−−−−−	−−−−−	+++++	+++++	+++++	+++++	+++++	+++++	+++++
^{188}Pt	c	10.2D	35	−−−−−	−−−−−	−−−−−	−−−−−	+++++	+++++	+++++	+++++	+++++	+++++	+++++

Continuation of Table 8.

Нуклид	Тип	$T_{1/2}$	Total	Энергия (ГэВ) 0.04	0.07	0.1	0.15	0.25	0.4	0.6	0.8	1.2	1.6	2.6
^{187}Pt	c	2.35H	14	-----	-----	-----	-----	-----	++++-	+++++	+++++	-----	-----	-----
^{186}Pt	c	2.08H	34	-----	-----	-----	-----	++++-	+++++	+++++	+++++	+++++	+++++	+++++
^{184}Pt	c	17.3M	24	-----	-----	-----	-----	-----	++++-	+++++	+++++	+++++	+++++	-----
^{192}Ir	i(m1+g)	73.827D	19	-----	-----	-----	-----	-----	--++-	++++-	++++-	++++-	++++-	---+-
^{190}Ir	i(m1+g)	11.78D	21	-----	-----	-----	-----	-----	++++-	++++-	++++-	++++-	++++-	---+-
^{189}Ir	c	13.2D	35	-----	-----	-----	-----	+++++	+++++	+++++	+++++	+++++	+++++	+++++
^{188}Ir	i	41.5H	22	-----	-----	-----	-----	++++-	++++-	++++-	++++-	++++-	--++-	-----
^{188}Ir	c	41.5H	34	-----	-----	-----	-----	+++++	+++++	+++++	+++++	+++++	+++++	++++-
^{187}Ir	c*	10.5H	30	-----	-----	-----	-----	-----	+++++	+++++	+++++	+++++	+++++	+++++
^{186}Ir	c	16.64H	34	-----	-----	-----	-----	++++-	+++++	+++++	+++++	+++++	+++++	+++++
^{185}Ir	c	14.4H	30	-----	-----	-----	-----	-----	+++++	+++++	+++++	+++++	+++++	+++++
^{184}Ir	c*	3.09H	30	-----	-----	-----	-----	-----	+++++	+++++	+++++	+++++	+++++	+++++
^{183}Ir	c	57M	14	-----	-----	-----	-----	-----	++++-	++++-	+++++	----+	-----	-----
^{185}Os	c	93.6D	35	-----	-----	-----	-----	+++++	+++++	+++++	+++++	+++++	+++++	+++++
^{183m}Os	c*	9.9H	30	-----	-----	-----	-----	-----	+++++	+++++	+++++	+++++	+++++	+++++
^{182}Os	c	22.10H	30	-----	-----	-----	-----	-----	+++++	+++++	+++++	+++++	+++++	+++++
^{181}Os	c	105M	14	-----	-----	-----	-----	-----	----+	+++++	+++++	----+	----+	----+
^{180}Os	c	21.5M	29	-----	-----	-----	-----	-----	++++-	+++++	+++++	+++++	+++++	+++++
^{183}Re	c	70.0D	35	-----	-----	-----	-----	+++++	+++++	+++++	+++++	+++++	+++++	+++++
^{182m}Re	c	12.7H	30	-----	-----	-----	-----	-----	+++++	+++++	+++++	+++++	+++++	+++++
* ^{181}Re	c	19.9H	14	-----	-----	-----	-----	-----	----+	+++++	+++++	----+	----+	----+
^{181}Re	c*	19.9H	30	-----	-----	-----	-----	-----	+++++	+++++	+++++	+++++	+++++	+++++
^{179}Re	c*	19.5M	25	-----	-----	-----	-----	-----	-----	+++++	+++++	+++++	+++++	+++++
^{178}Re	c*	13.2M	25	-----	-----	-----	-----	-----	-----	+++++	+++++	+++++	+++++	+++++
^{178}W	c	21.6D	22	-----	-----	-----	-----	-----	-----	+++++	+++++	+++++	+++++	---++
^{177}W	c	135M	25	-----	-----	-----	-----	-----	-----	+++++	+++++	+++++	+++++	+++++
^{176}W	c	2.5H	12	-----	-----	-----	-----	-----	-----	++++-	++++-	++++-	-----	-----
* ^{177}Ta	c	56.56H	25	-----	-----	-----	-----	-----	-----	+++++	+++++	+++++	+++++	+++++
^{177}Ta	c*	56.56H	25	-----	-----	-----	-----	-----	-----	+++++	+++++	+++++	+++++	+++++
^{176}Ta	c	8.09H	20	-----	-----	-----	-----	-----	-----	++++-	++++-	++++-	++++-	++++-
^{176}Ta	c*	8.09H	5	-----	-----	-----	-----	-----	-----	----+	----+	----+	----+	----+
^{175}Ta	c	10.5H	25	-----	-----	-----	-----	-----	-----	+++++	+++++	+++++	+++++	+++++
^{174}Ta	c	1.14H	20	-----	-----	-----	-----	-----	-----	-----	+++++	+++++	+++++	+++++
^{173}Ta	c	3.14H	25	-----	-----	-----	-----	-----	-----	+++++	+++++	+++++	+++++	+++++
^{172}Ta	c*	36.8M	20	-----	-----	-----	-----	-----	-----	-----	+++++	+++++	+++++	+++++
^{175}Hf	c	70D	31	-----	-----	-----	-----	+----	+++++	+++++	+++++	+++++	+++++	+++++
* ^{173}Hf	c	23.6H	25	-----	-----	-----	-----	-----	-----	+++++	+++++	+++++	+++++	+++++
^{173}Hf	c*	23.6H	26	-----	-----	-----	-----	-----	----+	+++++	+++++	+++++	+++++	+++++
^{172}Hf	c	1.87Y	27	-----	-----	-----	-----	-----	---++	+++++	+++++	+++++	+++++	+++++
^{171}Hf	c	12.1H	12	-----	-----	-----	-----	-----	-----	-----	-----	++++-	++++-	++++-
^{170}Hf	c	16.01H	25	-----	-----	-----	-----	-----	-----	+++++	+++++	+++++	+++++	+++++
^{168}Hf	c	25.95M	2	-----	-----	-----	-----	-----	-----	-----	-----	-----	----+	----+
^{173}Lu	c	1.37Y	30	-----	-----	-----	-----	-----	+++++	+++++	+++++	+++++	+++++	+++++
^{172}Lu	i(m+g)	6.70D	14	-----	-----	-----	-----	-----	-----	-----	-----	++++-	+++++	+++++
^{172}Lu	c	6.70D	27	-----	-----	-----	-----	-----	---++	+++++	+++++	+++++	+++++	+++++
^{171}Lu	c*	8.24D	29	-----	-----	-----	-----	-----	++++-	+++++	+++++	+++++	+++++	+++++
^{171}Lu	c	8.24D	12	-----	-----	-----	-----	-----	-----	-----	-----	++++-	++++-	++++-
^{170}Lu	c	2.012D	13	-----	-----	-----	-----	-----	-----	-----	-----	++++-	++++-	+++++
* ^{170}Lu	c	2.012D	12	-----	-----	-----	-----	-----	-----	+++++	+++++	----+	----+	-----
^{170}Lu	c*	2.012D	13	-----	-----	-----	-----	-----	-----	+++++	+++++	----+	----+	----+
^{169}Lu	c	34.06H	25	-----	-----	-----	-----	-----	-----	+++++	+++++	+++++	+++++	+++++
^{167}Lu	c	51.5M	20	-----	-----	-----	-----	-----	-----	-----	+++++	+++++	+++++	+++++
* ^{169}Yb	c	32.026D	25	-----	-----	-----	-----	-----	-----	+++++	+++++	+++++	+++++	+++++
^{169}Yb	c*	32.026D	25	-----	-----	-----	-----	-----	-----	+++++	+++++	+++++	+++++	+++++
^{166}Yb	c	56.7H	24	-----	-----	-----	-----	-----	-----	++++-	+++++	+++++	+++++	+++++
^{162}Yb	c	18.87M	3	-----	-----	-----	-----	-----	-----	-----	-----	----+	----+	----+
^{167}Tm	c	9.25D	24	-----	-----	-----	-----	-----	-----	++++-	+++++	+++++	+++++	+++++
^{165}Tm	c	30.06H	25	-----	-----	-----	-----	-----	-----	+++++	+++++	+++++	+++++	+++++
^{163}Tm	c	1.810H	3	-----	-----	-----	-----	-----	-----	-----	-----	----+	----+	----+
^{161}Er	c*	3.21H	19	-----	-----	-----	-----	-----	-----	-----	++++-	+++++	+++++	+++++
^{160}Er	c	28.58H	20	-----	-----	-----	-----	-----	-----	-----	+++++	+++++	+++++	+++++
^{159}Er	c*	36M	15	-----	-----	-----	-----	-----	-----	-----	-----	+++++	+++++	+++++
^{160m}Ho	c	5.02H	19	-----	-----	-----	-----	-----	-----	-----	++++-	+++++	+++++	+++++
^{156}Ho	c*	56M	15	-----	-----	-----	-----	-----	-----	-----	-----	+++++	+++++	+++++
^{157}Dy	c	8.14H	20	-----	-----	-----	-----	-----	-----	-----	+++++	+++++	+++++	+++++
^{155}Dy	c*	9.9H	19	-----	-----	-----	-----	-----	-----	-----	++++-	+++++	+++++	+++++
^{152}Dy	c	2.38H	14	-----	-----	-----	-----	-----	-----	-----	-----	++++-	+++++	+++++
^{155}Tb	c*	5.32D	20	-----	-----	-----	-----	-----	-----	-----	+++++	+++++	+++++	+++++
^{153}Tb	c*	2.34D	19	-----	-----	-----	-----	-----	-----	-----	++++-	+++++	+++++	+++++
^{152}Tb	c	17.5H	4	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	++++-
* ^{152}Tb	c	17.5H	10	-----	-----	-----	-----	-----	-----	-----	-----	++++-	+++++	----+
^{152}Tb	c*	17.5H	10	-----	-----	-----	-----	-----	-----	-----	-----	++++-	+++++	----+
^{151}Tb	c	17.609H	14	-----	-----	-----	-----	-----	-----	-----	-----	++++-	+++++	+++++
^{150}Tb	c	3.48H	3	-----	-----	-----	-----	-----	-----	-----	-----	----+	----+	----+
^{149}Tb	c	4.118H	10	-----	-----	-----	-----	-----	-----	-----	-----	-----	+++++	+++++
^{148}Tb	c	60M	10	-----	-----	-----	-----	-----	-----	-----	-----	-----	+++++	+++++
^{153}Gd	c	240.4D	19	-----	-----	-----	-----	-----	-----	-----	++++-	+++++	+++++	+++++
^{151}Gd	c	124D	15	-----	-----	-----	-----	-----	-----	-----	-----	+++++	+++++	+++++
^{149}Gd	c	9.28D	24	-----	-----	-----	-----	-----	-----	++++-	+++++	+++++	+++++	+++++
^{147}Gd	c	38.06H	15	-----	-----	-----	-----	-----	-----	-----	-----	+++++	+++++	+++++
^{146}Gd	c	48.27D	20	-----	-----	-----	-----	-----	-----	-----	+++++	+++++	+++++	+++++
* ^{149}Eu	c	93.1D	15	-----	-----	-----	-----	-----	-----	-----	-----	+++++	+++++	+++++
^{149}Eu	c*	93.1D	15	-----	-----	-----	-----	-----	-----	-----	-----	+++++	+++++	+++++

Continuation of Table 8.

Нуклид	Тип	$T_{1/2}$	Total	Энергия (ГэВ)										
				0.04	0.07	0.1	0.15	0.25	0.4	0.6	0.8	1.2	1.6	2.6
* ^{147}Eu	c	24.1D	15	-----	-----	-----	-----	-----	-----	-----	-----	+++++	+++++	+++++
^{147}Eu	c*	24.1D	15	-----	-----	-----	-----	-----	-----	-----	-----	+++++	+++++	+++++
^{146}Eu	i	4.61D	20	-----	-----	-----	-----	-----	-----	-----	+++++	+++++	+++++	+++++
^{146}Eu	c	4.61D	20	-----	-----	-----	-----	-----	-----	-----	+++++	+++++	+++++	+++++
^{145}Eu	c	5.93D	15	-----	-----	-----	-----	-----	-----	-----	-----	+++++	+++++	+++++
^{143}Pm	c	265D	15	-----	-----	-----	-----	-----	-----	-----	-----	+++++	+++++	+++++
^{136}Nd	c	50.65M	5	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	+++++
^{134}Pr	c*	17M	1	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	----+
^{139}Ce	c	137.640D	36	-----	-----	-----	----+	+++++	+++++	+++++	+++++	+++++	+++++	+++++
^{135}Ce	c	17.7H	10	-----	-----	-----	-----	-----	-----	-----	-----	-----	+++++	+++++
^{134}Ce	c	3.16D	5	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	+++++
^{132}Ce	c	3.51H	10	-----	-----	-----	-----	-----	-----	-----	-----	-----	+++++	+++++
^{130}Ce	c	25M	1	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	----+
^{132}La	c	4.8H	11	-----	-----	-----	-----	-----	-----	-----	-----	----+	+++++	+++++
^{133}Ba	c	3848.9D	11	-----	-----	-----	-----	-----	-----	-----	-----	----+	+++++	+++++
^{131}Ba	c	11.50D	21	-----	-----	-----	-----	-----	----+	-----	+++++	+++++	+++++	+++++
^{128}Ba	c	2.43D	15	-----	-----	-----	-----	-----	-----	-----	-----	+++++	+++++	+++++
^{129}Cs	c	32.06H	14	-----	-----	-----	-----	-----	----+	----+	----+	----+	+++++	+++++
^{127}Xe	c	36.4D	40	-----	-----	-----	+++++	+++++	+++++	+++++	+++++	+++++	+++++	+++++
^{125}Xe	c	16.9H	2	-----	-----	-----	-----	-----	-----	-----	-----	-----	----+	----+
^{123}Xe	c	2.08H	11	-----	-----	-----	-----	-----	-----	-----	-----	----+	+++++	+++++
^{126}I	i	13.11D	7	-----	-----	-----	----+	----+	----+	----+	----+	----+	----+	-----
^{124}I	i	4.1760D	3	-----	-----	-----	-----	-----	----+	----+	----+	-----	-----	-----
^{121}I	c*	2.12H	3	-----	-----	-----	-----	-----	-----	-----	----+	-----	----+	----+
^{123m}Te	i(m)	119.7D	42	-----	-----	+---+	+++++	+++++	+++++	+++++	+++++	+++++	+++++	+++++
^{121m}Te	i(m)	154D	36	-----	-----	-----	----+	+++++	+++++	+++++	+++++	+++++	+++++	+++++
^{121}Te	c	19.16D	35	-----	-----	-----	-----	+++++	+++++	+++++	+++++	+++++	+++++	+++++
^{119m}Te	i(m)	4.70D	26	-----	-----	-----	-----	-----	----+	+++++	+++++	+++++	+++++	+++++
^{119}Te	c	16.05H	1	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	----+
^{116}Te	c	2.49H	3	-----	-----	-----	-----	-----	-----	-----	-----	----+	----+	----+
^{124}Sb	i(m1+m2+g)	60.20D	29	-----	++--+	+++++	+++++	+++++	+-+++	-++++	+-++-	-----	-----	-----
^{122}Sb	i(m+g)	2.7238D	3	-----	-----	----+	----+	----+	-----	-----	-----	-----	-----	-----
^{120m}Sb	i(m)	5.76D	43	-----	-----	+--++	+++++	+++++	+++++	+++++	+++++	+++++	+++++	+++++
^{118m}Sb	i(m)	5.00H	4	-----	-----	-----	-----	-----	----+	-----	----+	----+	-----	----+
^{115}Sb	c*	32.1M	2	-----	-----	-----	-----	-----	-----	-----	-----	-----	----+	----+
^{117m}Sn	i(m)	13.60D	8	-----	-----	-----	----+	----+	----+	----+	----+	----+	----+	----+
^{113}Sn	c	115.09D	29	-----	-----	-----	-----	-----	++-++	+++++	+++++	+++++	+++++	+++++
^{114m}In	i(m)	49.51D	36	-----	-----	-----	----+	+++++	+++++	+++++	+++++	+++++	+++++	+++++
^{111}In	c	2.8047D	23	-----	-----	-----	-----	----+	----+	----+	+++++	+++++	+++++	+++++
^{110}In	i	4.9H	4	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	++++-
^{109}In	c	4.2H	5	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	+++++
^{115}Cd	c	53.46H	5	-----	-----	----+	----+	----+	----+	----+	-----	-----	-----	-----
^{110m}Ag	i(m)	249.76D	43	-----	-----	++--+	+++++	+++++	+++++	+++++	+++++	+++++	+++++	+++++
^{106m}Ag	i(m)	8.28D	31	-----	-----	-----	-----	----+	+++++	+++++	+++++	+++++	+++++	+++++
^{105}Ag	c	41.29D	18	-----	-----	-----	-----	-----	----+	----+	----+	+++++	+++++	+++++
^{100}Pd	c	3.63D	17	-----	-----	-----	-----	-----	-----	-----	+---+	+++++	+++++	+++++
^{107}Rh	c	21.7M	3	-----	----+	----+	----+	-----	-----	-----	-----	-----	-----	-----
^{105}Rh	c	35.36H	29	-----	----+	----+	----+	+++++	+++++	+++++	+++++	+++++	----+	-----
^{102m}Rh	i(m)	2.9Y	5	-----	-----	-----	-----	----+	----+	----+	----+	----+	-----	-----
^{102}Rh	i	207D	27	-----	-----	-----	-----	-----	++++-	++++-	+++++	++++-	+++++	+++++
^{101m}Rh	c	4.34D	35	-----	-----	-----	-----	+++++	+++++	+++++	+++++	+++++	+++++	+++++
^{101}Rh	c	3.3Y	1	-----	-----	-----	-----	-----	----+	-----	-----	-----	-----	-----
^{100}Rh	i(m+g)	20.8H	17	-----	-----	-----	-----	-----	-----	-----	+---+	+++++	+++++	+++++
^{100}Rh	c	20.8H	17	-----	-----	-----	-----	-----	-----	-----	+---+	+++++	+++++	+++++
^{99m}Rh	c	4.7H	1	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	----+
^{106}Ru	c	373.59D	4	-----	----+	----+	----+	----+	-----	-----	-----	-----	-----	-----
^{103}Ru	c	39.26D	51	----+	+++++	+++++	+++++	+++++	+++++	+++++	+++++	+++++	+++++	+++++
^{96}Tc	i(m+g)	4.28D	31	-----	-----	-----	-----	----+	+++++	+++++	+++++	+++++	+++++	+++++
^{99}Mo	c	65.94H	42	-----	----+	+++++	+++++	+++++	+++++	----+	+++++	+++++	+++++	+++++
^{93m}Mo	i(m)	6.85H	12	-----	-----	-----	-----	-----	-----	-----	----+	----+	+++++	+++++
^{96}Nb	i	23.35H	42	-----	-----	+---+	+++++	+++++	+++++	+++++	+++++	+++++	+++++	+++++
^{95}Nb	i(m+g)	34.975D	43	----+	----+	+++++	+++++	+++++	+++++	+++++	+++++	+++++	+++++	----+
^{95}Nb	c	34.975D	51	----+	+++++	+++++	+++++	+++++	+++++	+++++	+++++	+++++	+++++	+++++
^{92m}Nb	i(m)	10.15D	16	-----	-----	-----	-----	-----	+++++	+++++	+++++	----+	-----	-----
^{90}Nb	c*	14.60H	17	-----	-----	-----	-----	-----	----+	-----	----+	+++++	+++++	+++++
^{97}Zr	c	16.744H	34	-----	-+++-	+++++	+++++	+++++	+++++	+++++	+++++	----+	-----	-----
^{95}Zr	c	64.02D	51	----+	+++++	+++++	+++++	+++++	+++++	+++++	+++++	+++++	+++++	+++++
^{89}Zr	c	78.41H	35	-----	-----	-----	-----	+++++	+++++	+++++	+++++	+++++	+++++	+++++
^{88}Zr	c	83.4D	36	-----	-----	-----	++---	+-+++	+++++	+++++	+++++	+++++	+++++	+++++
^{90m}Y	i(m)	3.19H	19	-----	-----	-----	-----	----+	+++++	+++++	+++++	----+	----+	----+
^{88}Y	i	106.65D	37	-----	-----	-----	++---	+++++	+++++	+++++	+++++	+++++	+++++	+++++
^{88}Y	c	106.65D	38	-----	-----	-----	++--+	+++++	+++++	+++++	+++++	+++++	+++++	+++++
^{87}Y	c*	79.8H	35	-----	-----	-----	-----	+++++	+++++	+++++	+++++	+++++	+++++	+++++
^{86}Y	c	14.74H	12	-----	-----	-----	-----	-----	-----	-----	-----	++++-	++++-	++++-
^{85}Sr	c	64.84D	35	-----	-----	-----	-----	+++++	+++++	+++++	+++++	+++++	+++++	+++++
^{86}Rb	i(m+g)	18.631D	22	-----	-----	-----	----+	+++++	+++++	+++++	+++++	----+	-----	-----
^{84}Rb	i(m+g)	32.77D	25	-----	-----	-----	+++++	+++++	++++-	-----	-----	----+	+++++	+++++
^{83}Rb	c	86.2D	36	-----	-----	-----	----+	+++++	+++++	+++++	+++++	+++++	+++++	+++++
^{82m}Rb	i(m)	6.472H	20	-----	-----	-----	-----	-----	-----	-----	+++++	+++++	+++++	+++++
^{82}Br	i(m+g)	35.30H	41	-----	-----	----+	+++++	+++++	+++++	+++++	+++++	+++++	+++++	+++++
^{75}Se	c	119.779D	34	-----	-----	-----	-----	++-++	+++++	+++++	+++++	+++++	+++++	+++++
^{76}As	i	1.0778D	6	-----	-----	-----	-----	-----	----+	----+	----+	----+	----+	----+
^{74}As	i	17.77D	35	-----	-----	-----	-----	+++++	+++++	+++++	+++++	+++++	+++++	+++++

Continuation of Table 8.

Нуклид	Тип	$T_{1/2}$	Total	Энергия (ГэВ) 0.04	0.07	0.1	0.15	0.25	0.4	0.6	0.8	1.2	1.6	2.6
^{71}As	c	65.28H	15	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−	+++++	+++++	+++++
^{72}Ga	i	14.10H	31	−−−−−	−−−−−	−−−−−	−−−−−	++++−	+++++	+++++	+++++	+++++	+++++	−−−++
^{72}Ga	c	14.10H	31	−−−−−	−−−−−	−−−−−	−−−−−	++++−	+++++	+++++	+++++	+++++	+++++	−−−++
^{72}Zn	c	46.5H	31	−−−−−	−−−−−	−−−−−	−−−−−	++++−	+++++	+++++	+++++	+++++	+++++	−−−++
^{65}Zn	c	244.26D	3	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−	−−−−+	−−−−+	−−−−+
^{58}Co	i(m+g)	70.86D	10	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−	+++++	+++++
^{56}Co	c	77.233D	2	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−	−−−++
^{59}Fe	c	44.472D	34	−−−−−	−−−−−	−−−−−	−−−−−	−++++	+++++	+++++	+++++	+++++	+++++	+++++
^{54}Mn	i	312.11D	20	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−	+++++	+++++	+++++	+++++
^{52}Mn	c	5.591D	1	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−	−−−−+
^{48}V	c	15.9735D	15	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−	+++++	+++++	+++++
^{48}Sc	i	43.67H	16	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−	−−−−+	+++++	+++++	+++++
^{46}Sc	i(m+g)	83.79D	26	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−	−−−−+	+++++	+++++	+++++	+++++	+++++
^{28}Mg	c	20.915H	9	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−	+++−+	+++++
^{24}Na	c	14.9590H	11	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−	−−−−−	−−−−+	+++++	+++++
^{7}Be	i	53.29D	27	−−−−−	−−−−−	−−−−−	−−−−−	−−−−+	−−−−+	+++++	+++++	+++++	+++++	+++++

Table 9: Number of measured reaction product yields of different types in each experiment.

Experiment	**Yield type (measured)**							**Yield type (calc)**				**Total**
	c*	c	i	i(m+g)	i(m)	i(m1+m2+g)	i(m1+g)	c*	c	i	c_t	
^{206}Pb, E_p=0.04GeV	1	3	4	1	2	1	–	–	–	1	–	13
^{207}Pb, E_p=0.04GeV	–	3	4	1	–	1	–	–	–	–	–	9
^{208}Pb, E_p=0.04GeV	–	2	4	1	–	1	–	–	–	–	–	8
^{nat}Pb, E_p=0.04GeV	1	5	6	2	1	1	–	1	1	–	–	18
^{209}Bi, E_p=0.04GeV	1	6	3	2	1	–	–	–	–	–	–	13
^{206}Pb, E_p=0.07GeV	2	10	6	2	3	2	–	1	1	1	–	28
^{207}Pb, E_p=0.07GeV	2	11	7	2	2	2	–	1	1	1	–	29
^{208}Pb, E_p=0.07GeV	2	11	7	2	2	1	–	1	1	1	–	28
^{nat}Pb, E_p=0.07GeV	2	11	7	2	2	1	–	1	1	1	–	28
^{209}Bi, E_p=0.07GeV	3	16	7	3	1	1	–	2	1	1	–	35
^{206}Pb, E_p=0.1GeV	6	14	9	3	7	3	–	1	2	1	–	46
^{207}Pb, E_p=0.1GeV	5	14	8	3	5	3	–	1	2	1	–	42
^{208}Pb, E_p=0.1GeV	4	12	8	3	3	3	–	1	1	1	–	36
^{nat}Pb, E_p=0.1GeV	6	14	8	3	5	3	–	1	2	1	–	43
^{209}Bi, E_p=0.1GeV	6	20	9	6	4	2	–	2	–	1	–	50
^{206}Pb, E_p=0.15GeV	10	19	10	6	12	3	–	–	3	1	1	65
^{207}Pb, E_p=0.15GeV	10	19	11	5	12	3	–	–	3	1	1	65
^{208}Pb, E_p=0.15GeV	10	17	10	6	12	3	–	–	3	1	1	63
^{nat}Pb, E_p=0.15GeV	10	17	10	6	12	3	–	–	3	1	1	63
^{209}Bi, E_p=0.15GeV	10	26	10	8	11	2	–	2	1	1	–	71
^{206}Pb, E_p=0.25GeV	13	39	12	7	14	3	–	–	4	1	1	94
^{207}Pb, E_p=0.25GeV	13	38	13	7	14	3	–	–	4	1	1	94
^{208}Pb, E_p=0.25GeV	13	38	13	7	14	3	–	–	4	1	1	94
^{nat}Pb, E_p=0.25GeV	13	39	13	7	14	3	–	–	4	1	1	95
^{209}Bi, E_p=0.25GeV	14	44	13	9	17	4	–	2	1	1	1	106
^{206}Pb, E_p=0.4GeV	18	49	12	8	17	3	1	–	2	1	1	112
^{207}Pb, E_p=0.4GeV	18	49	13	8	17	2	1	–	2	1	1	112
^{208}Pb, E_p=0.4GeV	18	48	13	8	17	3	2	–	2	1	1	113
^{nat}Pb, E_p=0.4GeV	18	51	13	8	17	3	2	–	2	1	1	116
^{209}Bi, E_p=0.4GeV	20	58	14	7	20	4	–	–	3	1	1	128
^{206}Pb, E_p=0.6GeV	23	64	13	8	18	2	2	–	7	1	1	139
^{207}Pb, E_p=0.6GeV	23	64	13	8	18	3	2	–	7	1	1	140
^{208}Pb, E_p=0.6GeV	23	64	14	8	18	3	2	–	7	1	1	141
^{nat}Pb, E_p=0.6GeV	23	64	14	8	18	3	2	–	7	1	1	141
^{209}Bi, E_p=0.6GeV	26	66	14	8	20	4	–	–	7	1	1	147

Continuation of Table 9.

Experiment	**Yield type (measured)**							**Yield type (calc)**				**Total**
	c*	c	i	i(m+g)	i(m)	i(m1+m2+g)	i(m1+g)	c*	c	i	c_t	
^{206}Pb, E_p=0.8GeV	25	76	15	9	19	3	2	–	6	1	–	156
^{207}Pb, E_p=0.8GeV	25	74	15	8	19	2	2	–	6	1	–	152
^{208}Pb, E_p=0.8GeV	25	74	16	8	19	3	2	–	6	1	–	154
^{nat}Pb, E_p=0.8GeV	25	74	16	8	19	3	2	–	6	1	–	154
^{209}Bi, E_p=0.8GeV	27	77	16	9	23	3	–	–	6	1	–	162
^{206}Pb, E_p=1.2GeV	30	86	16	9	17	2	2	–	7	1	–	170
^{207}Pb, E_p=1.2GeV	30	86	16	9	17	2	2	–	7	1	–	170
^{208}Pb, E_p=1.2GeV	30	86	16	9	17	2	2	–	7	1	–	170
^{nat}Pb, E_p=1.2GeV	30	86	17	9	17	2	2	–	7	1	–	171
^{209}Bi, E_p=1.2GeV	33	94	13	9	22	3	–	–	8	1	–	183
^{206}Pb, E_p=1.6GeV	30	94	15	11	18	2	2	–	7	1	–	180
^{207}Pb, E_p=1.6GeV	30	94	15	11	18	2	2	–	7	1	–	180
^{208}Pb, E_p=1.6GeV	30	94	17	11	18	2	2	–	7	1	–	182
^{nat}Pb, E_p=1.6GeV	30	93	17	11	18	2	2	–	7	1	–	181
^{209}Bi, E_p=1.6GeV	36	101	14	10	18	3	–	–	9	1	–	192
^{206}Pb, E_p=2.6GeV	28	94	14	10	16	2	–	–	6	1	–	171
^{207}Pb, E_p=2.6GeV	28	94	14	10	16	2	–	–	6	1	–	171
^{208}Pb, E_p=2.6GeV	28	94	15	10	16	2	–	–	6	1	–	172
^{nat}Pb, E_p=2.6GeV	28	97	16	10	16	2	2	–	6	1	–	178
^{209}Bi, E_p=2.6GeV	37	107	13	10	19	3	–	–	8	1	–	198
Total	952	2800	651	374	712	132	40	17	224	51	19	5972

3.1 Errors in experimental results

Determination of errors in the residual nuclide cross sections and in the energies at which they are produced forms an important part of any experimental work. This issue is particularly topical in this work because not only the the cross sections for production of residual products from ^{208,207,206,nat}Pb and ^{209}Bi are experimentally determined in the 40 - 2600 MeV range, but also the predictive power of certain theoretical codes to describe the respective excitation functions is estimated. Therefore, the uncertainties in both energies and cross sections have been analyzed carefully.

The proton energy uncertainty is produced by the U-10 synchrotron operation and by the geometric parameters of transport channel that provides the 40 MeV<E<3000 MeV proton beam extraction. The proton energy uncertainties are listed in Table 4.

The uncertainty in the cross sections for production of residual nuclei is due to the following two factors. The first arises from the technical performances of the materials and equipment used, namely, γ-spectrometer operation [16], the certification accuracy of the γ-sources used for calibrating , the accuracy of the analytical BP-61 balance, and by the certification accuracy of the compositions of materials used in irradiations. The second factor arises from the nuclear data uncertainty in different databases and reference sources used:

- ENSDF [35],
- PCNUDAT [33],
- Tables of Isotopes (8th Edithion) [34],
- Photon cross section from 1 keV to 100 MeV for elements Z=1 to Z=100, [5],
- Original works (cross sectons of the ^{27}Al(p,x)^{22}Na monitor reaction [43]).

The errors in the presented cross sections for production of residuals consist of the errors in their production rates and the errors in determining the proton flux densities.

Systematization of the uncertainties in the cofactors that enter the rates of residual nuclide production in experimental samples and in monitor, as well as their relative contribution to the total error, are presented in Tables 10 and 11. The comparative analysis of separate sources of the uncertainties (see Tables 10 and 11) demonstrates that the significance of the sources varies largely.

In the case of experimental samples, the major uncertainties of reaction rates are represented by statistical error, by absolute spectimeter effectiveness, and by uncertainty in absolute abundance, but the absolute spectrometer effectiveness alone counts in uncertainties of the monitoring reaction rates.

The uncertainty in proton flux density is determined solely by the monitoring reaction cross section uncertainty.

The uncertainties were disregarded if they arose from sample composition uncertainties, from uncertainy in the correction that allows for production of measured nuclides by secondaries (see 2.5.4, 2.5.2.2), from uncertainty in the decay constant, from uncertainties in irradiation time, decay time, and measurement time (t_{irr}, t_d, t), and from uncertainty in proton flux constancy throughout irradiation time.

As a result, the uncertainty of experimental determining the presented yields (cross sections for production) of radioactive residuals is ranging from 7.5 to 72.3% with average value 11.5%. The distributions of uncertainties of reaction rates and of cross sections are shown in Fig. 25.

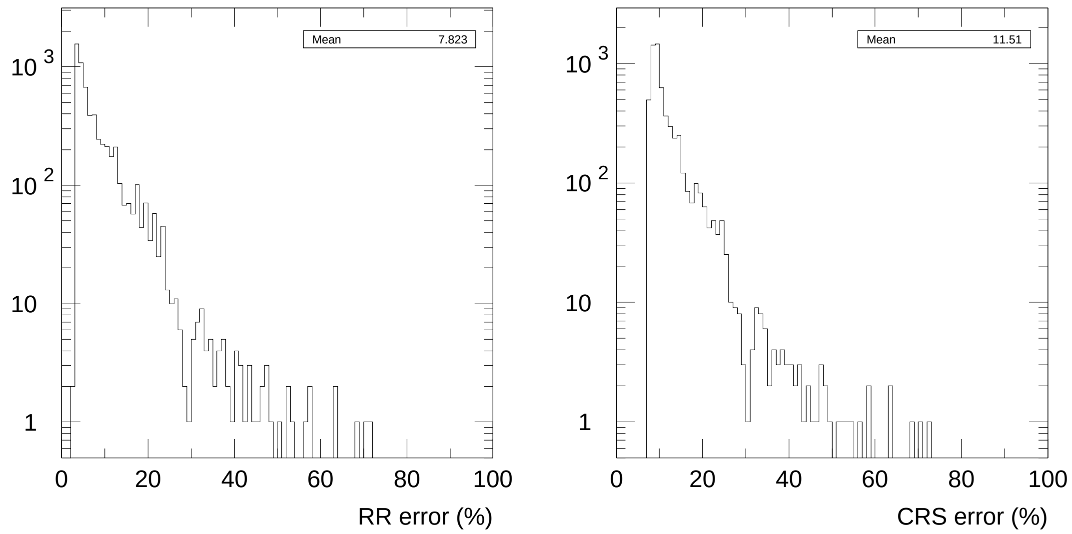


Fig. 25: Distributions of uncertainties of reaction rates (left panel) and of cross sections (right panel).

Table 10: The uncertainties in the values used to calculate the reaction rates in the samples together with their relative contribution to the total uncertainty.

Uncertainty source	Absolute uncertainty (%)	Percentage in the total uncertainty
PROTON ENERGY UNCERTAINTIES		
Uncertainty of proton energy determination allowing for geometric dimensions of transport channel and of samples (see 2.5.2.1, табл. 4), (E)		
E_p>70 MeV	0.25 – 0.91	100
$E_p \leq$70 MeV	0.87 – 3.72	100
UNCERTAINTIES IN MEASURED REACTION RATES IN SAMPLES		
Statistical error of count rate in total absorption peak with due allowance for correction of unresolved γ-lines (see 2.1), background under the peak, and γ-spectrum transients (see 2.6), and allowing for the dead time and count loss of the spectrometer (see 2.6.1), (A, B, C)	0.05 – 71.82	0.02 – 99.75
Uncertainty of correction for γ-quantum absorption in a sample (see 2.1), k_μ	0.00 – 5.07	0.00 – 52.42
Uncertainty of absolute detection effectiveness of spectrometer (see 2.6.1), (ε^E)	3.25 – 4.32	0.23 – 100.00
Uncertainty of relative detection effectiveness of spectrometer (ε^E_{rel}) and of relative-to-absolute effectiveness scaling factor	1.04 – 3.03	0.03 – 42.10
$(k_{\varepsilon^E_{rel}})$ (see 2.6.1)	0.71	0.01 – 4.69
Uncertainty of absolute quantum yield of γ-lines, (η)	0.00 – 16.67	0.00 – 94.48
Uncertainty of absolute-to-relative γ-line quantum yield scaling factor, (k_γ)		
Uncertainty of the number of experimental sample nuclei	0.03 – 0.10	0.00 – 0.08
Total uncertainty	3.28 – 71.95	100

Table 11: The uncertainties in the values used to calculate the reaction rates in the monitors together with their relative contribution to the total uncertainty. Uncertainty of proton flux.

Uncertainty source	Absolute uncertainty (%)	Percentage in the total uncertainty
PROTON ENERGY UNCERTAINTIES		
Uncertainty of proton energy determination allowing for geometric dimensions of transport channel and of samples and monitors (see 2.5.2.1, табл. 4), (E)		
E_p>70 MeV	0.25 – 0.92	100
$E_p \leq$70 MeV	1.18 – 3.66	100
UNCERTAINTIES IN MEASURED REACTION RATES IN MONITORS		
Statistical error of count rate in total absorption peak with due allowance for correction of unresolved γ-lines (see 2.1), background under the peak, and γ-spectrum transients (see 2.6), and allowing for the dead time and count loss of the spectrometer (see 2.6.1), (A, B, C)	0.57 – 1.39	2.90 – 14.99
Uncertainty of correction for γ-quantum absorption in a sample (see 2.1), k_μ	0.01 – 0.04	0.00 – 0.01
Uncertainty of absolute detection effectiveness of spectrometer (see 2.6.1), (ε^E)	3.31	85.01 – 97.63
Uncertainty of absolute quantum yield of γ-lines, (η)	0.01	0.00
Uncertainty of the number of experimental sample nuclei	0.03 – 0.10	0.01 – 0.08
Total uncertainty	3.35 – 3.59	100
UNCERTAINTIES IN PROTON FLUX		
Uncertainty of monitoring reaction cross section $\sigma_{^{22}Na}$	6.00 – 9.05	74.83 – 87.76
Total uncertainty	6.87 – 9.66	100

3.2 Experimental results for 0.04 GeV proton-irradiated ^{nat,208,207,206}Pb targets.

Table 12 presents parameters of ^{nat,208,207,206}Pb irradiation by 0.04GeV protons. Table 13 presents values of the measured residual nuclide yields.

Table 12: Parameters of irradiation of ^{nat,208,207,206}Pb.

Target	Proton energy (MeV)	Weight of sample (mg)	Weight of monitor (mg)	Weight of monitor-plate (mg) (mg)	Time of irradiation (min)	Average proton flux p/(cm$^2 \cdot s$) $\times 10^{-10}$	Number of γ-specra sample/ monitor/ plate	ExpData index
^{nat}Pb	38.0±1.0	207.6	121.1	714.5	90	1.39±0.12	24/11/1	pbn040
^{208}Pb	38.3±0.8	137.8	121.3	708.8	75	1.95±0.15	20/12/1	pb8040
^{207}Pb	38.4±0.7	127.6	121.0	706.0	90	2.11±0.16	23/08/1	pb7040
^{206}Pb	38.3±0.8	141.9	120.8	702.4	75	2.08±0.16	23/09/1	pb6040

Table 13: Experimental values of measured yields of ^{206,207,208,nat}Pb(p,x) reaction products for $E_p = 0.04$ GeV.

Product	Type	T$_{1/2}$	Yields [mbarn] for			
			^{206}Pb	^{207}Pb	^{208}Pb	^{nat}Pb
^{207}Bi	i	31.55Y	–	30.2±3.9	89.4±7.3	51.2±4.5
^{206}Bi	i	6.243D	26.9±2.3	82.6±7.0	197±17	130±12
^{205}Bi	i	15.31D	119±10	328±28	1059±91	659±60
^{204}Bi	i	11.22H	285±24	961±84	46.6±4.2	286±26
^{203}Bi	i(m+g)	11.76H	933±79	44.2±3.7	9.34±0.78	253±23
^{202}Bi	i	1.72H	0.854±0.124	–	–	6.76±0.63
^{201}Bi	i	108M	–	–	–	10.7±1.0
^{204m}Pb	i(m)	67.2M	34.3±3.0	–	–	11.3±1.2
^{204m}Pb	c	67.2M	76.8±6.6	–	–	54.0±4.9
^{203}Pb	i(m1+m2+g)	51.873H	34.1±4.0	4.52±1.10	0.333±0.075	11.4±1.5
^{203}Pb	c	51.873H	965±78	47.9±3.9	9.72±0.79	267±23
^{202m}Pb	i(m)	3.53H	0.755±0.292	–	–	–
^{201}Pb	i(m+g)	9.33H	–	–	–	1.16±0.55
^{201}Pb	c	9.33H	–	–	–	11.9±1.3
*^{201}Pb	c*	9.33H	–	–	–	14.4±1.5
*^{202}Tl	i	12.23D	5.04±0.44	–	–	–
^{202}Tl	c	12.23D	5.11±0.42	4.65±0.37	0.474±0.056	2.56±0.22
*^{201}Tl	c	72.912H	–	–	–	12.7±1.2
^{201}Tl	c*	72.912H	6.46±0.59	–	–	14.4±1.3
^{203}Hg	c	46.612D	–	0.091±0.063	–	0.047±0.025

3.3 Experimental results for 0.07 GeV proton-irradiated ^{nat,208,207,206}Pb targets.

Table 14 presents parameters of ^{nat,208,207,206}Pb irradiation by 0.07GeV protons. Table 15 presents values of the measured residual nuclide yields.

Table 14: Parameters of irradiation of ^{nat,208,207,206}Pb.

Target	Proton energy (MeV)	Weight of sample (mg)	Weight of monitor (mg)	Weight of monitor-plate (mg) (mg)	Time of irradiation (min)	Average proton flux p/(cm$^2\cdot s$) $\times 10^{-10}$	Number of γ-specra sample/ monitor/ plate	ExpData index
^{nat}Pb	68.9 ± 0.8	194.1	121.3	707.5	75	0.840 ± 0.060	22/13/1	pbn070
^{208}Pb	69.1 ± 0.7	135.8	121.1	708.5	60	2.31 ± 0.16	20/11/1	pb8070
^{207}Pb	68.8 ± 0.7	155.2	120.2	718.2	75	2.41 ± 0.17	21/11/1	pb7070
^{206}Pb	69.0 ± 0.7	140.5	120.4	711.2	60	2.07 ± 0.15	22/10/1	pb6070

Table 15: Experimental values of measured yields of ^{206,207,208,nat}Pb(p,x) reaction products for $E_p = 0.07$ GeV.

Product	Type	$T_{1/2}$	Yields [mbarn] for			
			^{206}Pb	^{207}Pb	^{208}Pb	^{nat}Pb
^{207}Bi	i	31.55Y	–	14.6±1.3	36.5±3.0	30.5±5.0
^{206}Bi	i	6.243D	13.4±1.1	37.1±2.9	57.8±4.6	46.3±3.6
^{205}Bi	i	15.31D	45.1±3.6	83.9±6.7	103±8	93.9±7.4
^{204}Bi	i	11.22H	71.8±5.6	106±8	122±9	121±9
^{203}Bi	i(m+g)	11.76H	124±10	179±14	255±20	269±21
^{202}Bi	i	1.72H	175±14	327±26	370±29	305±24
^{201}Bi	i	108M	410±32	370±29	27.8±2.2	187±14
^{204m}Pb	i(m)	67.2M	41.3±3.3	57.0±4.5	54.0±4.4	54.8±4.3
^{204m}Pb	c	67.2M	51.9±4.1	72.8±5.7	72.2±5.8	72.9±5.7
^{203}Pb	i(m1+m2+g)	51.873H	138±10	136±10	98.6±7.8	110±13
^{203}Pb	c	51.873H	264±20	317±23	355±26	388±29
^{202m}Pb	i(m)	3.53H	47.5±3.9	43.3±3.6	19.9±2.4	28.7±2.5
^{201}Pb	i(m+g)	9.33H	80.8±8.8	31.4±4.1	5.08±1.41	32.3±4.3
^{201}Pb	c	9.33H	497±48	406±39	33.2±3.2	222±21
*^{201}Pb	c*	9.33H	595±56	494±46	39.8±3.7	267±25
^{200}Pb	c	21.5H	253±20	15.0±1.2	2.41±0.19	49.6±3.8
*^{202}Tl	i	12.23D	4.74±0.51	4.35±0.47	4.50±0.44	4.97±0.47
^{202}Tl	c	12.23D	9.26±0.69	8.46±0.63	6.40±0.48	7.70±0.57
*^{201}Tl	c	72.912H	529±44	434±36	43.6±3.7	238±20
^{201}Tl	c*	72.912H	602±45	493±37	48.4±3.7	271±20
^{200}Tl	i	26.1H	10.1±1.8	11.3±1.0	10.1±0.8	12.4±1.4
^{200}Tl	c	26.1H	255±20	26.1±2.1	12.4±1.0	60.7±4.8
^{199}Tl	c*	7.42H	12.9±1.4	11.6±1.1	4.92±0.86	16.4±1.5
^{198m}Tl	i(m)	1.87H	8.56±0.73	–	–	–
^{203}Hg	c	46.612D	0.050±0.013	0.297±0.024	0.518±0.041	0.354±0.056
^{124}Sb	i(m1+m2+g)	60.20D	0.106±0.018	0.077±0.017	–	–
^{103}Ru	c	39.26D	1.68±0.13	1.33±0.10	0.848±0.067	1.18±0.09
^{95}Nb	c	34.975D	1.62±0.12	1.29±0.09	0.847±0.080	1.06±0.10
^{97}Zr	c	16.744H	–	1.35±0.11	1.02±0.09	1.10±0.10

Continuation of Table 15.

Product	Type	$T_{1/2}$	Yields [mbarn] for			
			^{206}Pb	^{207}Pb	^{208}Pb	^{nat}Pb
^{95}Zr	c	64.02D	1.59±0.12	1.22±0.09	0.749±0.058	1.01±0.08

3.4 Experimental results for 0.1 GeV proton-irradiated ^{nat,208,207,206}Pb targets.

Table 16 presents parameters of ^{nat,208,207,206}Pb irradiation by 0.1GeV protons. Table 17 presents values of the measured residual nuclide yields.

Table 16: Parameters of irradiation of ^{nat,208,207,206}Pb.

Target	Proton energy (MeV)	Weight of sample (mg)	Weight of monitor (mg)	Weight of monitor-plate (mg) (mg)	Time of irradiation (min)	Average proton flux p/(cm$^2 \cdot s$) $\times 10^{-10}$	Number of γ-specra sample/ monitor/ plate	ExpData index
^{nat}Pb	99.3 ± 0.8	201.0	123.1	702.8	40	1.43 ± 0.10	32/11/1	pbn100
^{208}Pb	99.5 ± 0.8	138.7	121.2	701.3	45	2.38 ± 0.17	26/11/1	pb8100
^{207}Pb	99.6 ± 0.8	148.1	120.3	709.0	35	2.03 ± 0.14	25/11/1	pb7100
^{206}Pb	99.5 ± 0.8	142.0	120.8	712.3	45	2.74 ± 0.19	27/11/1	pb6100

Table 17: Experimental values of measured yields of ^{206,207,208,nat}Pb(p,x) reaction products for $E_p = 0.1$ GeV.

Product	Type	T$_{1/2}$	Yields [mbarn] for			
			^{206}Pb	^{207}Pb	^{208}Pb	^{nat}Pb
^{207}Bi	i	31.55Y	2.27±1.12	11.0±1.5	26.7±3.2	14.8±1.9
^{206}Bi	i	6.243D	8.93±0.69	24.8±1.9	42.6±3.3	29.4±2.3
^{205}Bi	i	15.31D	29.8±2.3	52.8±4.1	67.1±5.2	53.0±4.1
^{204}Bi	i	11.22H	43.2±3.3	56.6±4.3	67.2±5.1	58.0±4.4
^{203}Bi	i(m+g)	11.76H	62.2±4.7	81.6±6.2	90.6±6.9	82.0±6.2
^{202}Bi	i	1.72H	73.8±5.8	90.5±7.1	105±8	95.0±7.4
^{201}Bi	i	108M	97.5±7.4	125±9	139±11	129±10
^{199}Bi	i	27M	106±9	130±11	68.4±7.6	113±11
^{204m}Pb	i(m)	67.2M	33.3±2.6	44.5±3.5	53.1±4.1	47.6±3.7
^{204m}Pb	c	67.2M	39.7±3.1	52.9±4.1	63.1±4.9	56.2±4.4
^{203}Pb	i(m1+m2+g)	51.873H	121±9	121±10	129±10	124±10
^{203}Pb	c	51.873H	181±13	204±15	219±16	205±15
^{202m}Pb	i(m)	3.53H	38.6±3.7	46.0±4.4	51.6±4.5	46.5±4.2
^{201}Pb	i(m+g)	9.33H	120±12	109±11	106±10	109±11
^{201}Pb	c	9.33H	218±21	237±23	247±23	239±23
*^{201}Pb	c*	9.33H	242±23	267±25	280±26	270±25
^{200}Pb	c	21.5H	243±19	266±21	275±21	268±21
^{199}Pb	c*	90M	489±47	455±39	212±18	334±29
^{198}Pb	c	2.4H	292±23	99.8±8.2	–	106±8
^{197m}Pb	c*	43M	31.8±4.7	2.68±0.63	–	12.6±1.2
*^{202}Tl	i	12.23D	13.0±1.1	13.5±1.2	12.0±1.1	12.4±1.1
^{202}Tl	c	12.23D	16.7±1.2	17.8±1.3	16.9±1.2	16.8±1.2
*^{201}Tl	c	72.912H	247±24	271±26	281±25	270±24
^{201}Tl	c*	72.912H	279±25	305±27	317±27	305±26
^{200}Tl	i	26.1H	31.5±3.5	25.7±3.5	21.4±3.2	21.5±2.3
^{200}Tl	c	26.1H	224±17	245±19	249±19	237±18
^{199}Tl	c*	7.42H	320±25	308±24	146±12	225±18
^{198m}Tl	i(m)	1.87H	8.02±0.71	8.74±1.19	11.8±1.6	10.7±0.9
*^{197}Tl	c	2.84H	63.9±24.3	23.5±8.0	–	36.4±13.2

Continuation of Table 17.

Product	Type	$T_{1/2}$	Yields [mbarn] for			
			^{206}Pb	^{207}Pb	^{208}Pb	^{nat}Pb
^{197}Tl	c*	2.84H	74.6±24.3	24.4±8.0	18.1±6.0	40.6±13.2
^{196m}Tl	i(m)	1.41H	27.0±5.0	22.5±4.2	–	14.6±2.7
^{203}Hg	c	46.612D	0.141±0.020	0.514±0.051	0.921±0.070	0.703±0.063
^{197}Hg	c*	64.14H	55.8±4.9	–	–	30.2±5.5
^{196}Au	i(m1+m2+g)	6.183D	0.079±0.010	0.095±0.024	0.118±0.022	0.095±0.032
^{195}Au	c	186.098D	12.3±1.4	3.19±0.47	–	5.76±0.76
^{123m}Te	i(m)	119.7D	0.146±0.014	–	–	–
^{124}Sb	i(m1+m2+g)	60.20D	0.178±0.018	0.191±0.024	0.206±0.026	0.223±0.033
^{120m}Sb	i(m)	5.76D	0.111±0.010	–	–	0.704±0.130
^{110m}Ag	i(m)	249.76D	0.287±0.030	0.236±0.041	–	–
^{103}Ru	c	39.26D	3.51±0.26	2.97±0.22	2.28±0.18	2.73±0.21
^{99}Mo	c	65.94H	4.12±0.32	3.55±0.28	2.98±0.23	3.19±0.25
^{96}Nb	i	23.35H	1.09±0.12	–	–	–
^{95}Nb	i(m+g)	34.975D	0.493±0.037	0.327±0.031	0.068±0.043	0.206±0.043
^{95}Nb	c	34.975D	3.52±0.25	2.93±0.21	2.32±0.18	2.75±0.20
^{97}Zr	c	16.744H	1.59±0.12	1.55±0.13	1.59±0.14	1.63±0.12
^{95}Zr	c	64.02D	3.04±0.23	2.53±0.19	2.15±0.16	2.42±0.18

3.5 Experimental results for 0.15 GeV proton-irradiated ^{nat,208,207,206}Pb targets.

Table 18 presents parameters of ^{nat,208,207,206}Pb irradiation by 0.15GeV protons. Table 19 presents values of the measured residual nuclide yields.

Table 18: Parameters of irradiation of ^{nat,208,207,206}Pb.

Target	Proton energy (MeV)	Weight of sample (mg)	Weight of monitor (mg)	Weight of monitor-plate (mg) (mg)	Time of irradiation (min)	Average proton flux p/(cm$^2 \cdot s$) $\times 10^{-10}$	Number of γ-specra sample/ monitor/ plate	ExpData index
^{nat}Pb	149 ± 1	104.9	146.6	704.8	60	1.58 ± 0.12	36/13/1	pbn150
^{208}Pb	149 ± 1	139.0	144.2	702.3	45	4.23 ± 0.31	26/08/1	pb8150
^{207}Pb	149 ± 1	139.3	122.0	701.5	40	3.54 ± 0.26	26/10 /1	pb7150
^{206}Pb	149 ± 1	141.3	143.2	721.8	45	4.25 ± 0.31	24/08/1	pb6150

Table 19: Experimental values of measured yields of ^{206,207,208,nat}Pb(p,x) reaction products for $E_p = 0.15$ GeV.

Product	Type	T$_{1/2}$	Yields [mbarn] for			
			^{206}Pb	^{207}Pb	^{208}Pb	^{nat}Pb
^{207}Bi	i	31.55Y	–	7.78±1.23	18.6±1.7	10.9±1.3
^{206}Bi	i	6.243D	6.02±0.49	15.3±1.2	25.9±2.1	17.6±1.4
^{205}Bi	i	15.31D	19.8±1.6	31.0±2.5	37.6±3.0	30.6±2.5
^{204}Bi	i	11.22H	26.7±2.1	31.6±2.5	35.2±2.8	30.4±2.4
^{203}Bi	i(m+g)	11.76H	38.1±3.1	40.7±3.3	42.8±3.4	39.7±3.2
^{202}Bi	i	1.72H	38.4±3.2	40.4±3.3	42.7±3.5	39.8±3.2
^{201}Bi	i	108M	41.7±4.3	38.8±4.3	49.3±5.2	41.1±4.2
^{199}Bi	i	27M	31.8±3.0	29.1±3.4	37.6±4.7	33.3±3.6
^{204m}Pb	i(m)	67.2M	23.9±2.1	29.9±2.5	36.5±3.0	30.4±2.5
^{204m}Pb	c	67.2M	27.9±2.3	34.6±2.8	41.8±3.4	35.0±2.8
*^{203}Pb	c	51.873H	125±10	126±10	131±11	126±10
^{203}Pb	c*	51.873H	136±11	138±11	143±12	137±11
^{202m}Pb	i(m)	3.53H	30.5±2.6	34.1±3.0	39.1±3.3	35.2±2.9
*^{201}Pb	c	9.33H	127±10	136±11	134±11	129±10
^{201}Pb	c*	9.33H	137±11	145±11	146±12	139±11
^{200}Pb	c	21.5H	122±10	119±9	120±10	116±9
^{199}Pb	c*	90M	216±22	217±20	224±19	210±19
^{198}Pb	c	2.4H	182±17	172±16	158±13	164±14
^{197m}Pb	c*	43M	108±12	92.2±10.5	78.0±8.0	85.7±10.4
^{196}Pb	c*	37M	97.0±10.5	69.6±8.4	42.5±6.4	62.1±6.7
^{195m}Pb	i(m)	15.0M	40.1±3.4	22.2±2.0	6.74±1.01	19.1±2.7
*^{202}Tl	i	12.23D	18.7±1.6	20.0±1.7	20.3±1.7	19.3±1.6
^{202}Tl	c	12.23D	21.6±1.8	23.2±1.9	24.0±2.0	22.7±1.9
^{201}Tl	c	72.912H	168±16	168±15	172±17	167±15
^{201}Tl	c*	72.912H	194±19	192±16	196±19	191±18
^{200}Tl	i	26.1H	37.0±4.0	38.7±3.9	35.4±3.8	33.9±3.5
^{200}Tl	c	26.1H	158±13	157±13	152±12	150±12
^{199}Tl	c*	7.42H	194±17	185±16	175±15	178±16
^{198m}Tl	i(m)	1.87H	20.6±1.7	17.4±1.4	16.3±1.4	18.3±1.5

Continuation of Table 19.

Product	Type	$T_{1/2}$	Yields [mbarn] for			
			^{206}Pb	^{207}Pb	^{208}Pb	^{nat}Pb
$*^{197}$Tl	c	2.84H	155±29	138±25	113±19	123±25
^{197}Tl	c*	2.84H	191±30	169±26	139±20	152±25
^{196m}Tl	i(m)	1.41H	34.5±6.6	28.7±5.5	22.5±4.4	26.7±5.1
^{195}Tl	c*	1.16H	63.5±8.9	36.4±5.3	19.3±2.9	36.3±5.1
^{203}Hg	c	46.612D	0.376±0.035	0.866±0.081	1.44±0.12	1.05±0.12
^{197m}Hg	i(m)	23.8H	4.83±0.42	4.72±0.42	5.46±0.48	4.52±0.39
^{197}Hg	c*	64.14H	157±14	132±12	109±10	120±11
^{195m}Hg	i(m)	41.6H	6.04±0.48	5.28±0.42	4.76±0.38	5.63±0.45
$*^{195}$Hg	ct	9.9H	89.2±11.2	54.7±6.9	30.3±3.6	51.3±6.2
^{195}Hg	c	9.9H	83.1±10.9	49.4±6.7	25.6±3.4	45.7±6.0
^{193m}Hg	i(m)	11.8H	3.64±0.88	2.63±0.50	1.23±0.41	2.49±0.37
^{192}Hg	c	4.85H	13.6±1.1	6.62±0.53	1.39±0.11	6.13±0.49
^{198m}Au	i(m)	2.27D	0.100±0.022	0.102±0.035	0.115±0.023	0.071±0.013
^{198}Au	i(m+g)	2.69517D	0.208±0.031	0.307±0.042	0.414±0.040	0.355±0.030
^{198}Au	i	2.69517D	0.108±0.046	0.206±0.069	0.299±0.047	0.283±0.029
^{196}Au	i(m1+m2+g)	6.183D	0.514±0.043	0.527±0.052	0.547±0.045	0.501±0.042
^{195}Au	c	186.098D	88.1±8.3	53.4±4.9	28.9±3.2	48.6±5.3
^{194}Au	i(m1+m2+g)	38.02H	0.761±0.092	0.701±0.093	0.544±0.068	0.721±0.087
^{192}Au	i(m+g)	4.94H	0.646±0.309	–	1.42±0.41	0.783±0.177
^{192}Au	c	4.94H	18.0±2.6	8.28±1.22	3.39±0.53	8.38±1.22
^{127}Xe	c	36.4D	0.178±0.016	0.113±0.014	0.071±0.016	0.090±0.015
^{123m}Te	i(m)	119.7D	0.330±0.030	0.303±0.035	0.222±0.030	0.337±0.033
^{124}Sb	i(m1+m2+g)	60.20D	0.149±0.016	0.189±0.020	0.197±0.019	0.166±0.024
^{120m}Sb	i(m)	5.76D	0.328±0.029	0.250±0.022	0.146±0.013	0.207±0.024
^{110m}Ag	i(m)	249.76D	0.961±0.089	0.580±0.100	0.354±0.036	0.552±0.077
^{103}Ru	c	39.26D	4.81±0.40	4.11±0.34	3.42±0.29	3.82±0.32
^{99}Mo	c	65.94H	4.69±0.39	4.23±0.35	3.80±0.32	4.09±0.34
^{96}Nb	i	23.35H	2.30±0.19	1.61±0.13	1.13±0.10	1.56±0.13
^{95}Nb	i(m+g)	34.975D	1.86±0.16	1.17±0.09	0.749±0.062	1.07±0.09
^{95}Nb	c	34.975D	5.15±0.42	4.26±0.34	3.47±0.28	4.07±0.33
^{97}Zr	c	16.744H	1.12±0.10	1.33±0.11	1.29±0.14	1.23±0.11
^{95}Zr	c	64.02D	3.27±0.26	3.05±0.24	2.74±0.22	2.92±0.23
^{88}Zr	c	83.4D	0.071±0.029	0.041±0.024	–	–
^{88}Y	i	106.65D	0.289±0.026	0.146±0.021	–	–
^{88}Y	c	106.65D	0.360±0.036	0.187±0.019	–	–
^{84}Rb	i(m+g)	32.77D	0.421±0.046	0.160±0.050	0.136±0.042	0.161±0.072
^{82}Br	i(m+g)	35.30H	1.39±0.11	0.990±0.094	0.776±0.065	1.00±0.08

3.6 Experimental results for 0.25 GeV proton-irradiated ^{nat,208,207,206}Pb targets.

Table 20 presents parameters of ^{nat,208,207,206}Pb irradiation by 0.25GeV protons. Table 21 presents values of the measured residual nuclide yields.

Table 20: Parameters of irradiation of ^{nat,208,207,206}Pb.

Target	Proton energy (MeV)	Weight of sample (mg)	Weight of monitor (mg)	Weight of monitor-plate (mg) (mg)	Time of irradiation (min)	Average proton flux p/(cm$^2\cdot s$) $\times 10^{-10}$	Number of γ-specra sample/ monitor/ plate	ExpData index
^{nat}Pb	250 ± 1	112.3	123.1	714.9	30	6.92 ± 0.48	27/10/1	pbn250
^{208}Pb	250 ± 1	138.6	123.4	706.4	20	5.12 ± 0.35	25/09/1	pb8250
^{207}Pb	250 ± 1	129.8	123.5	711.2	30	6.99 ± 0.48	26/11/1	pb7250
^{206}Pb	250 ± 1	137.4	123.1	715.6	25	5.23 ± 0.36	25/10/1	pb6250

Table 21: Experimental values of measured yields of ^{206,207,208,nat}Pb(p,x) reaction products for $E_p = 0.25$ GeV.

Product	Type	T$_{1/2}$	Yields [mbarn] for ^{206}Pb	^{207}Pb	^{208}Pb	^{nat}Pb
^{207}Bi	i	31.55Y	–	3.50±0.43	10.3±1.2	5.48±0.61
^{206}Bi	i	6.243D	3.30±0.26	8.39±0.65	13.8±1.1	10.3±0.8
^{205}Bi	i	15.31D	10.9±0.8	17.1±1.3	20.0±1.6	17.7±1.4
^{204}Bi	i	11.22H	15.1±1.1	17.2±1.3	17.8±1.3	17.6±1.3
^{203}Bi	i(m+g)	11.76H	20.9±1.6	21.8±1.7	20.6±1.6	21.6±1.7
^{202}Bi	i	1.72H	19.5±1.6	19.6±1.5	18.2±1.6	19.7±1.6
^{201}Bi	i	108M	24.9±6.8	18.7±4.9	19.8±5.2	20.3±5.3
^{204m}Pb	i(m)	67.2M	16.7±1.4	19.6±1.6	21.2±1.7	20.1±1.6
^{204m}Pb	c	67.2M	18.9±1.5	22.1±1.7	23.9±1.9	22.8±1.8
*^{203}Pb	c	51.873H	77.0±6.1	75.3±6.0	74.1±5.8	78.8±6.2
^{203}Pb	c*	51.873H	83.2±6.5	81.7±6.3	80.1±6.2	85.1±6.6
^{202m}Pb	i(m)	3.53H	20.4±2.0	22.4±2.0	23.6±2.1	23.5±2.3
*^{201}Pb	c	9.33H	75.6±6.3	73.1±6.0	70.9±5.8	71.9±6.3
^{201}Pb	c*	9.33H	81.6±6.5	77.6±6.2	75.6±6.0	76.7±6.5
^{200}Pb	c	21.5H	67.7±5.1	63.6±4.8	62.8±4.8	66.6±5.0
^{199}Pb	c*	90M	127±13	121±10	122±11	122±11
^{198}Pb	c	2.4H	105±9	97.9±8.7	90.6±7.8	95.8±7.9
^{197m}Pb	c*	43M	67.2±6.3	61.7±5.8	56.6±5.8	63.9±5.9
^{196}Pb	c*	37M	69.3±9.8	59.5±8.3	50.3±7.4	61.2±8.7
^{195m}Pb	i(m)	15.0M	39.9±3.5	33.4±2.8	28.3±2.5	35.0±2.8
*^{202}Tl	i	12.23D	20.5±1.6	21.7±1.7	22.6±1.8	22.8±1.8
^{202}Tl	c	12.23D	22.4±1.7	23.8±1.9	24.9±1.9	25.1±2.0
*^{201}Tl	c	72.912H	111±9	109±9	107±9	113±9
^{201}Tl	c*	72.912H	122±10	120±9	117±9	123±10
^{200}Tl	i	26.1H	35.7±3.4	38.7±3.4	36.8±3.5	38.0±3.2
^{200}Tl	c	26.1H	103±8	102±8	96.1±7.4	104±8
^{199}Tl	c*	7.42H	125±10	125±10	117±10	127±11
^{198m}Tl	i(m)	1.87H	28.3±2.9	26.9±2.3	27.2±2.5	24.1±3.0
*^{197}Tl	c	2.84H	122±22	106±21	109±18	106±18

Continuation of Table 21.

Product	Type	$T_{1/2}$	Yields [mbarn] for			
			^{206}Pb	^{207}Pb	^{208}Pb	^{nat}Pb
^{197}Tl	c*	2.84H	145±23	127±21	128±18	128±19
^{196m}Tl	i(m)	1.41H	61.1±11.5	57.9±10.9	55.7±10.5	56.1±10.6
^{195}Tl	c*	1.16H	76.6±10.4	59.1±8.2	55.7±7.8	60.6±8.3
^{203}Hg	c	46.612D	0.805±0.083	1.58±0.13	2.44±0.20	1.92±0.15
^{197m}Hg	i(m)	23.8H	7.75±0.63	9.41±0.79	9.55±0.80	9.14±0.76
^{197}Hg	c*	64.14H	120±11	112±10	103±9	117±10
^{195m}Hg	i(m)	41.6H	10.7±0.8	10.8±0.8	11.4±0.9	11.2±0.9
*^{195}Hg	ct	9.9H	104±12	101±12	87.0±10.2	94.5±11.2
^{195}Hg	c	9.9H	93.5±12.0	89.8±11.6	75.6±9.7	83.3±10.8
^{193m}Hg	i(m)	11.8H	10.1±1.8	9.65±1.59	8.09±1.52	9.17±1.90
^{192}Hg	c	4.85H	51.0±3.8	41.4±3.1	32.1±2.4	41.5±3.1
^{190}Hg	c*	20.0M	25.1±1.9	18.3±1.4	13.5±1.0	19.4±1.5
^{198m}Au	i(m)	2.27D	0.198±0.016	0.237±0.021	0.398±0.030	0.264±0.044
^{198}Au	i(m+g)	2.69517D	0.561±0.043	0.780±0.061	1.02±0.08	0.882±0.077
^{198}Au	i	2.69517D	0.363±0.030	0.543±0.046	0.686±0.076	0.619±0.086
^{196}Au	i(m1+m2+g)	6.183D	1.28±0.10	1.52±0.12	1.78±0.14	1.69±0.13
^{195}Au	c	186.098D	115±10	107±9	86.0±8.3	104±9
^{194}Au	i(m1+m2+g)	38.02H	2.32±0.27	3.01±0.28	2.93±0.26	2.97±0.27
^{192}Au	i(m+g)	4.94H	3.99±1.09	2.74±0.39	4.20±0.63	2.90±0.41
^{192}Au	c	4.94H	66.1±5.3	54.3±4.3	44.3±3.5	54.5±4.3
^{191}Au	c*	3.18H	37.2±5.5	29.5±3.4	22.4±3.8	34.5±5.1
^{190}Au	c	42.8M	29.2±2.6	22.3±2.0	16.3±1.8	21.1±2.3
^{191}Pt	c	2.802D	37.2±3.0	29.9±2.4	23.4±1.9	30.0±2.4
^{189}Pt	c	10.87H	26.1±2.2	20.4±1.7	16.3±1.5	20.2±1.7
^{188}Pt	c	10.2D	17.9±1.4	13.0±1.0	9.22±0.70	13.2±1.0
^{186}Pt	c	2.08H	7.73±1.77	4.77±1.10	3.09±0.73	4.66±1.07
^{189}Ir	c	13.2D	23.3±3.0	16.2±2.1	12.4±1.6	16.4±2.1
^{188}Ir	i	41.5H	1.19±0.34	0.913±0.184	1.34±0.33	0.839±0.180
^{188}Ir	c	41.5H	19.3±1.9	14.4±1.4	10.7±1.0	13.6±1.3
^{186}Ir	c	16.64H	3.65±0.34	2.69±0.25	1.71±0.16	2.78±0.24
^{185}Os	c	93.6D	5.33±0.41	3.46±0.27	2.22±0.19	3.52±0.29
^{183}Re	c	70.0D	2.34±0.25	1.34±0.12	0.674±0.079	1.36±0.13
^{175}Hf	c	70D	0.240±0.029	–	–	–
^{139}Ce	c	137.640D	0.143±0.015	0.128±0.014	0.099±0.021	0.135±0.013
^{127}Xe	c	36.4D	0.392±0.033	0.270±0.027	0.201±0.025	0.272±0.025
^{123m}Te	i(m)	119.7D	0.382±0.044	0.332±0.029	0.265±0.029	0.341±0.028
^{121m}Te	i(m)	154D	0.343±0.026	0.256±0.019	0.171±0.013	0.250±0.019
^{121}Te	c	19.16D	0.432±0.046	0.340±0.036	0.221±0.047	0.270±0.027
^{124}Sb	i(m1+m2+g)	60.20D	0.159±0.022	0.119±0.016	0.131±0.025	0.133±0.017
^{120m}Sb	i(m)	5.76D	0.465±0.037	0.378±0.032	0.313±0.026	0.375±0.031
^{114m}In	i(m)	49.51D	1.13±0.11	0.827±0.118	0.632±0.078	0.838±0.091
^{110m}Ag	i(m)	249.76D	1.30±0.11	1.04±0.08	0.895±0.080	1.08±0.09
^{105}Rh	c	35.36H	5.34±0.45	4.84±0.41	4.25±0.36	4.71±0.40
^{101m}Rh	c	4.34D	0.298±0.034	0.224±0.029	0.185±0.029	0.171±0.019
^{103}Ru	c	39.26D	4.94±0.39	4.46±0.35	3.87±0.31	4.57±0.36
^{99}Mo	c	65.94H	4.40±0.42	4.20±0.56	4.05±0.38	4.40±0.40
^{96}Nb	i	23.35H	2.77±0.23	2.35±0.19	1.81±0.14	2.35±0.18
^{95}Nb	i(m+g)	34.975D	2.80±0.22	2.25±0.17	1.75±0.14	2.27±0.18
^{95}Nb	c	34.975D	5.94±0.46	5.26±0.40	4.56±0.35	5.35±0.41
^{97}Zr	c	16.744H	0.933±0.080	1.04±0.09	1.19±0.10	1.01±0.08

Continuation of Table 21.

Product	Type	$T_{1/2}$	Yields [mbarn] for			
			^{206}Pb	^{207}Pb	^{208}Pb	^{nat}Pb
^{95}Zr	c	64.02D	3.19±0.24	3.06±0.23	2.76±0.21	3.12±0.24
^{89}Zr	c	78.41H	0.411±0.046	0.235±0.021	0.204±0.024	0.236±0.021
^{88}Zr	c	83.4D	0.141±0.053	–	0.064±0.016	0.049±0.026
^{88}Y	i	106.65D	1.05±0.09	0.792±0.065	0.547±0.044	0.820±0.067
^{88}Y	c	106.65D	1.19±0.10	0.833±0.065	0.612±0.048	0.869±0.068
^{87}Y	c*	79.8H	0.507±0.040	0.321±0.027	0.211±0.019	0.321±0.027
^{85}Sr	c	64.84D	0.684±0.064	0.404±0.037	0.295±0.039	0.429±0.041
^{86}Rb	i(m+g)	18.631D	4.23±0.40	2.84±0.25	2.56±0.27	2.82±0.24
^{84}Rb	i(m+g)	32.77D	1.64±0.14	1.15±0.10	0.699±0.119	1.13±0.10
^{83}Rb	c	86.2D	0.675±0.069	0.504±0.053	0.429±0.079	0.532±0.054
^{82}Br	i(m+g)	35.30H	1.82±0.15	1.57±0.13	1.32±0.11	1.56±0.13
^{75}Se	c	119.779D	0.138±0.033	0.097±0.014	–	0.082±0.017
^{74}As	i	17.77D	0.393±0.045	0.261±0.029	0.172±0.025	0.282±0.031
^{72}Ga	i	14.10H	0.439±0.230	0.553±0.097	0.523±0.103	0.616±0.131
^{72}Ga	c	14.10H	0.832±0.213	0.856±0.104	0.752±0.102	0.876±0.132
^{72}Zn	c	46.5H	0.393±0.048	0.303±0.034	0.230±0.027	0.260±0.039
^{59}Fe	c	44.472D	–	0.209±0.028	0.185±0.108	0.214±0.044

3.7 Experimental results for 0.4 GeV proton-irradiated ^{nat,208,207,206}Pb targets.

Table 22 presents parameters of ^{nat,208,207,206}Pb irradiation by 0.4GeV protons. Table 23 presents values of the measured residual nuclide yields.

Table 22: Parameters of irradiation of ^{nat,208,207,206}Pb.

Target	Proton energy (MeV)	Weight of sample (mg)	Weight of monitor (mg)	Weight of monitor-plate (mg) (mg)	Time of irradiation (min)	Average proton flux p/(cm$^2 \cdot s$) $\times 10^{-10}$	Number of γ-specra sample/ monitor/ plate	ExpData index
^{nat}Pb	400 ± 2	243.5	120.9	710.2	25	6.78 ± 0.50	32/13 /1	pbn400
^{208}Pb	400 ± 2	142.4	123.0	702.7	25	6.24 ± 0.45	29/10/1	pb8400
^{207}Pb	399 ± 2	145.2	123.0	716.6	20	4.45 ± 0.32	34/10/1	pb7400
^{206}Pb	400 ± 2	138.3	120.8	716.7	25	6.70 ± 0.48	28/10/1	pb6400

Table 23: Experimental values of measured yields of ^{206,207,208,nat}Pb(p,x) reaction products for $E_p = 0.4$ GeV.

Product	Type	T$_{1/2}$	Yields [mbarn] for			
			^{206}Pb	^{207}Pb	^{208}Pb	^{nat}Pb
^{207}Bi	i	31.55Y	–	5.66±1.06	6.06±0.72	4.18±0.46
^{206}Bi	i	6.243D	2.10±0.17	5.32±0.44	8.31±0.68	6.42±0.53
^{205}Bi	i	15.31D	6.77±0.55	10.9±0.9	12.0±1.0	10.5±0.9
^{204}Bi	i	11.22H	9.34±0.73	10.7±0.8	10.8±0.8	10.5±0.8
^{203}Bi	i(m+g)	11.76H	12.8±1.0	13.2±1.1	12.6±1.0	12.8±1.0
^{202}Bi	i	1.72H	10.8±1.0	11.0±1.0	9.40±0.84	9.77±0.91
^{204m}Pb	i(m)	67.2M	14.2±1.2	17.1±1.4	17.1±1.4	16.7±1.4
^{204m}Pb	c	67.2M	15.6±1.3	18.7±1.5	18.7±1.5	18.3±1.5
*^{203}Pb	c	51.873H	58.1±4.7	57.5±5.0	51.8±4.3	57.0±4.7
^{203}Pb	c*	51.873H	61.9±5.0	61.4±5.2	55.6±4.6	60.8±5.0
^{202m}Pb	i(m)	3.53H	15.5±1.6	18.1±1.7	19.0±1.7	17.7±1.6
^{201}Pb	c*	9.33H	54.9±4.8	53.2±4.4	49.9±4.1	55.0±4.7
^{200}Pb	c	21.5H	43.9±3.5	44.7±3.5	39.5±3.1	43.4±3.5
^{199}Pb	c*	90M	79.6±7.7	81.4±7.9	69.3±6.4	75.5±7.0
^{198}Pb	c	2.4H	66.1±6.6	64.4±6.0	58.5±5.9	65.2±6.0
^{197m}Pb	c*	43M	47.0±4.1	46.8±4.1	39.8±3.4	43.9±3.9
^{196}Pb	c*	37M	48.8±6.9	47.5±6.6	42.1±5.9	44.0±6.3
^{195m}Pb	i(m)	15.0M	25.9±2.2	25.0±2.1	21.7±1.8	23.3±2.3
*^{202}Tl	i	12.23D	20.9±1.7	22.2±1.8	22.2±1.8	21.9±1.8
^{202}Tl	c	12.23D	22.4±1.7	23.9±1.8	24.0±1.8	23.5±1.8
^{201}Tl	c*	72.912H	91.6±6.9	94.1±7.1	86.3±6.5	92.6±7.2
^{200}Tl	i	26.1H	36.8±3.7	36.8±3.5	36.3±3.4	36.4±3.3
^{200}Tl	c	26.1H	79.8±6.5	80.3±6.4	75.2±6.1	79.2±6.5
^{199}Tl	c*	7.42H	98.6±11.2	98.3±11.1	90.3±9.6	97.8±10.2
^{198m}Tl	i(m)	1.87H	31.0±2.8	29.8±3.1	30.4±2.9	25.6±5.0
*^{197}Tl	c	2.84H	95.0±17.3	87.5±16.1	87.2±15.3	92.9±15.5
^{197}Tl	c*	2.84H	111±18	103±17	101±16	108±16
^{196m}Tl	i(m)	1.41H	58.8±11.0	62.4±11.6	58.4±10.9	60.3±11.3
^{195}Tl	c*	1.16H	63.8±9.0	57.7±7.9	57.1±8.2	56.3±7.9

Continuation of Table 23.

Product	Type	$T_{1/2}$	Yields [mbarn] for			
			^{206}Pb	^{207}Pb	^{208}Pb	^{nat}Pb
^{203}Hg	c	46.612D	1.24±0.10	2.39±0.18	3.44±0.26	2.64±0.20
^{197m}Hg	i(m)	23.8H	11.2±0.9	13.3±1.1	14.0±1.1	13.4±1.2
^{197}Hg	c*	64.14H	101±9	109±9	105±9	107±9
^{195m}Hg	i(m)	41.6H	15.0±1.2	16.8±1.3	16.3±1.3	17.0±1.4
*^{195}Hg	ct	9.9H	99.9±11.8	102±12	91.8±10.7	95.4±11.2
^{195}Hg	c	9.9H	84.9±10.9	85.5±10.9	75.5±9.7	78.4±10.2
^{193m}Hg	i(m)	11.8H	14.5±2.5	15.1±2.7	14.5±2.5	16.9±3.9
^{192}Hg	c	4.85H	65.4±5.1	62.5±4.9	53.7±4.2	59.0±4.8
^{190}Hg	c*	20.0M	44.6±3.5	40.6±3.2	35.2±2.8	40.2±3.2
^{198m}Au	i(m)	2.27D	0.293±0.023	0.431±0.034	0.651±0.051	0.485±0.039
^{198}Au	i(m+g)	2.69517D	1.07±0.08	1.53±0.12	1.80±0.14	1.61±0.12
^{198}Au	i	2.69517D	0.793±0.083	1.11±0.10	1.14±0.10	1.14±0.09
^{196}Au	i(m1+m2+g)	6.183D	2.24±0.18	2.94±0.24	3.38±0.27	3.06±0.25
^{195}Au	c	186.098D	92.0±10.1	92.9±10.5	96.1±10.0	113±10
^{194}Au	i(m1+m2+g)	38.02H	4.56±0.42	5.25±0.55	5.93±0.55	5.83±0.54
^{192}Au	i(m+g)	4.94H	6.59±0.99	9.55±0.91	9.63±1.39	9.05±1.13
^{192}Au	c	4.94H	86.3±7.1	83.7±6.8	76.2±6.5	81.0±7.0
^{191}Au	c*	3.18H	61.6±6.5	65.0±6.4	53.8±7.1	63.9±6.4
^{190}Au	c	42.8M	53.1±4.7	49.2±4.3	43.6±3.8	46.6±4.3
^{191}Pt	c	2.802D	58.8±4.9	58.3±5.3	50.1±4.3	57.1±4.9
^{189}Pt	c	10.87H	56.6±4.7	53.4±4.5	47.0±4.1	53.6±4.5
^{188}Pt	c	10.2D	46.8±3.7	42.7±3.4	37.3±2.9	42.0±3.4
^{187}Pt	c	2.35H	33.5±3.8	29.6±2.9	26.1±2.7	28.2±3.3
^{186}Pt	c	2.08H	31.2±7.1	28.6±6.5	23.8±5.4	26.7±6.1
^{184}Pt	c	17.3M	24.6±5.2	19.8±4.3	16.6±3.3	19.0±3.9
^{192}Ir	i(m1+g)	73.827D	–	–	0.069±0.019	0.076±0.009
^{190}Ir	i(m1+g)	11.78D	0.166±0.075	0.210±0.056	0.348±0.049	0.243±0.026
^{189}Ir	c	13.2D	47.0±3.9	44.8±3.7	38.7±3.2	46.5±4.1
^{188}Ir	i	41.5H	1.38±0.26	2.41±0.30	1.48±0.41	3.57±0.70
^{188}Ir	c	41.5H	48.3±3.9	44.8±3.6	38.4±3.1	45.7±3.7
^{187}Ir	c*	10.5H	47.3±4.3	43.1±3.9	38.8±3.4	46.2±4.3
^{186}Ir	c	16.64H	16.9±1.5	15.3±1.3	13.2±1.2	15.1±1.5
^{185}Ir	c	14.4H	24.0±2.5	21.2±1.9	17.2±1.5	20.2±2.2
^{184}Ir	c*	3.09H	27.2±2.3	23.2±2.0	18.5±1.6	23.2±2.0
^{183}Ir	c	57M	20.1±5.4	18.0±4.6	18.7±4.9	17.7±4.6
^{185}Os	c	93.6D	30.8±2.5	27.3±2.2	22.3±1.8	25.9±2.1
^{183m}Os	c*	9.9H	12.5±1.0	10.9±0.9	8.82±0.71	10.4±0.9
^{182}Os	c	22.10H	20.3±1.6	16.7±1.3	13.3±1.0	16.8±1.4
^{180}Os	c	21.5M	10.6±1.0	7.96±0.83	6.62±0.59	8.15±0.78
^{183}Re	c	70.0D	22.2±1.8	19.2±1.6	15.1±1.3	18.1±1.6
^{182m}Re	c	12.7H	21.3±1.9	18.0±1.8	14.4±1.3	16.0±1.5
^{181}Re	c*	19.9H	14.5±1.9	11.4±1.5	8.94±1.17	10.8±1.4
^{175}Hf	c	70D	2.68±0.22	2.11±0.18	1.37±0.12	1.90±0.16
^{172}Hf	c	1.87Y	–	–	–	0.726±0.077
^{173}Lu	c	1.37Y	1.38±0.15	1.37±0.16	0.767±0.132	0.910±0.097
^{172}Lu	c	6.70D	–	–	–	0.808±0.084
^{171}Lu	c*	8.24D	0.587±0.053	0.482±0.059	0.347±0.052	0.433±0.042
^{139}Ce	c	137.640D	0.169±0.019	0.158±0.017	0.160±0.016	0.187±0.019
^{127}Xe	c	36.4D	0.595±0.052	0.512±0.057	0.424±0.036	0.471±0.042
^{123m}Te	i(m)	119.7D	0.431±0.035	0.379±0.031	0.356±0.029	0.392±0.032

Continuation of Table 23.

Product	Type	$T_{1/2}$	Yields [mbarn] for			
			^{206}Pb	^{207}Pb	^{208}Pb	^{nat}Pb
^{121m}Te	i(m)	154D	0.507±0.040	0.421±0.036	0.309±0.024	0.421±0.034
^{121}Te	c	19.16D	0.807±0.069	0.597±0.053	0.482±0.052	0.513±0.044
^{124}Sb	i(m1+m2+g)	60.20D	0.122±0.014	–	0.125±0.015	0.112±0.018
^{120m}Sb	i(m)	5.76D	0.543±0.049	0.505±0.063	0.436±0.054	0.546±0.055
^{113}Sn	c	115.09D	0.324±0.038	0.323±0.043	–	0.222±0.023
^{114m}In	i(m)	49.51D	1.64±0.14	1.33±0.13	1.05±0.09	1.26±0.12
^{110m}Ag	i(m)	249.76D	1.57±0.13	1.50±0.12	1.20±0.10	1.39±0.11
^{106m}Ag	i(m)	8.28D	0.536±0.073	0.386±0.059	0.279±0.042	0.361±0.048
^{105}Rh	c	35.36H	5.51±0.45	5.53±0.48	4.82±0.40	5.15±0.44
^{102}Rh	i	207D	0.712±0.112	0.554±0.124	0.410±0.065	0.406±0.078
^{101m}Rh	c	4.34D	0.823±0.082	0.663±0.078	0.465±0.048	0.556±0.056
^{103}Ru	c	39.26D	5.47±0.41	5.30±0.40	4.81±0.37	5.14±0.40
^{96}Tc	i(m+g)	4.28D	0.630±0.055	0.502±0.046	0.290±0.059	0.495±0.044
^{99}Mo	c	65.94H	5.31±0.41	5.45±0.42	4.72±0.37	4.94±0.41
^{96}Nb	i	23.35H	3.36±0.27	3.00±0.25	2.59±0.22	3.19±0.27
^{95}Nb	i(m+g)	34.975D	3.84±0.28	3.46±0.26	2.88±0.22	3.29±0.25
^{95}Nb	c	34.975D	7.07±0.52	6.83±0.50	5.84±0.43	6.39±0.48
^{92m}Nb	i(m)	10.15D	0.315±0.029	0.302±0.026	0.315±0.031	0.270±0.022
^{97}Zr	c	16.744H	0.842±0.074	0.816±0.087	0.980±0.079	0.986±0.091
^{95}Zr	c	64.02D	3.23±0.25	3.37±0.26	2.99±0.24	3.13±0.25
^{89}Zr	c	78.41H	1.11±0.09	0.916±0.069	0.630±0.054	0.850±0.067
^{88}Zr	c	83.4D	0.374±0.029	0.275±0.022	0.182±0.014	0.288±0.023
^{90m}Y	i(m)	3.19H	3.99±0.35	3.43±0.27	3.10±0.26	3.86±0.35
^{88}Y	i	106.65D	2.36±0.21	2.04±0.18	1.62±0.15	1.85±0.15
^{88}Y	c	106.65D	2.72±0.23	2.27±0.19	1.66±0.14	2.06±0.17
^{87}Y	c*	79.8H	1.44±0.11	1.16±0.09	0.768±0.059	1.06±0.08
^{85}Sr	c	64.84D	1.64±0.14	1.31±0.12	1.00±0.09	1.15±0.10
^{86}Rb	i(m+g)	18.631D	4.95±0.42	4.56±0.39	3.88±0.32	3.83±0.32
^{84}Rb	i(m+g)	32.77D	2.59±0.28	3.45±0.32	2.51±0.25	2.14±0.18
^{83}Rb	c	86.2D	1.93±0.17	1.49±0.14	1.18±0.11	1.35±0.12
^{82}Br	i(m+g)	35.30H	2.40±0.20	2.22±0.18	1.86±0.15	2.26±0.18
^{75}Se	c	119.779D	0.436±0.037	0.345±0.031	0.262±0.028	0.349±0.040
^{74}As	i	17.77D	0.988±0.103	0.787±0.083	0.622±0.075	0.784±0.081
^{72}Ga	i	14.10H	0.990±0.170	0.841±0.173	1.03±0.21	0.989±0.120
^{72}Ga	c	14.10H	1.36±0.17	1.34±0.17	1.37±0.20	1.37±0.14
^{72}Zn	c	46.5H	0.368±0.050	0.496±0.068	0.344±0.064	0.382±0.037
^{59}Fe	c	44.472D	0.380±0.039	0.357±0.076	0.287±0.043	0.352±0.064

3.8 Experimental results for 0.6 GeV proton-irradiated ^{nat,208,207,206}Pb targets.

Table 24 presents parameters of ^{nat,208,207,206}Pb irradiation by 0.6GeV protons. Table 25 presents values of the measured residual nuclide yields.

Table 24: Parameters of irradiation of ^{nat,208,207,206}Pb.

Target	Proton energy (MeV)	Weight of sample (mg)	Weight of monitor (mg)	Weight of monitor-plate (mg) (mg)	Time of irradiation (min)	Average proton flux p/(cm$^2\cdot s$) $\times 10^{-10}$	Number of γ-specra sample/ monitor/ plate	ExpData index
^{nat}Pb	600 ± 2	153.7	118.7	729.2	25	5.15 ± 0.37	32/10/1	pbn600
^{208}Pb	600 ± 2	140.1	122.7	720.1	29	4.27 ± 0.30	27/10/1	pb8600
^{207}Pb	600 ± 2	147.8	122.7	707.0	30	4.70 ± 0.34	31/10/1	pb7600
^{206}Pb	600 ± 2	140.3	122.4	713.2	30	5.14 ± 0.37	29/09/1	pb6600

Table 25: Experimental values of measured yields of ^{206,207,208,nat}Pb(p,x) reaction products for $E_p = 0.6$ GeV.

Product	Type	T$_{1/2}$	Yields [mbarn] for			
			^{206}Pb	^{207}Pb	^{208}Pb	^{nat}Pb
^{207}Bi	i	31.55Y	–	–	4.83±0.90	3.68±0.74
^{206}Bi	i	6.243D	1.51±0.12	3.66±0.29	5.40±0.43	4.04±0.32
^{205}Bi	i	15.31D	4.85±0.38	7.19±0.56	7.99±0.63	6.95±0.55
^{204}Bi	i	11.22H	6.14±0.48	7.03±0.55	6.97±0.54	6.83±0.53
^{203}Bi	i(m+g)	11.76H	7.80±0.64	7.65±0.74	7.35±0.72	7.68±0.70
^{202}Bi	i	1.72H	6.93±2.01	6.28±1.41	6.09±0.76	7.33±1.20
^{204m}Pb	i(m)	67.2M	13.5±1.1	14.4±1.1	14.4±1.1	14.7±1.2
^{204m}Pb	c	67.2M	14.4±1.2	15.5±1.2	15.4±1.2	15.7±1.3
*^{203}Pb	c	51.873H	48.0±3.9	45.1±3.7	40.7±3.3	44.8±3.6
^{203}Pb	c*	51.873H	50.3±3.7	47.4±3.5	42.9±3.2	47.1±3.5
^{202m}Pb	i(m)	3.53H	12.6±1.1	14.0±1.2	14.3±1.3	13.3±1.1
^{201}Pb	c*	9.33H	43.6±3.8	40.5±3.5	35.2±3.6	40.2±3.5
^{200}Pb	c	21.5H	31.9±2.5	30.4±2.4	27.7±2.2	30.1±2.3
^{199}Pb	c*	90M	64.0±11.4	60.4±10.9	54.8±9.9	55.2±9.8
^{198}Pb	c	2.4H	44.6±8.2	42.0±7.7	38.0±7.0	40.2±7.4
^{197m}Pb	c*	43M	31.1±2.7	29.3±2.5	27.0±2.3	29.7±2.6
^{196}Pb	c*	37M	30.3±4.2	28.4±4.0	25.5±3.6	32.6±4.6
^{195m}Pb	i(m)	15.0M	17.4±3.6	14.9±3.0	14.7±3.0	16.9±3.7
*^{202}Tl	i	12.23D	20.1±1.6	20.5±1.7	20.3±1.7	20.6±1.7
^{202}Tl	c	12.23D	21.2±1.6	21.9±1.6	21.7±1.6	21.9±1.6
^{201}Tl	c*	72.912H	72.6±5.4	70.4±5.2	66.2±4.9	69.8±5.2
^{200}Tl	i	26.1H	28.4±2.3	28.5±2.5	29.1±2.5	28.2±2.3
^{200}Tl	c	26.1H	59.9±4.7	59.0±4.6	56.6±4.5	58.0±4.6
^{199}Tl	c	7.42H	58.0±6.9	55.4±6.4	55.9±5.5	58.0±5.6
^{199}Tl	c*	7.42H	69.2±6.3	66.7±6.0	65.4±5.9	67.4±6.1
^{198m}Tl	i(m)	1.87H	25.2±3.7	26.9±3.7	25.3±3.5	24.5±3.4
*^{197}Tl	c	2.84H	44.4±19.0	48.0±20.1	46.2±19.1	61.6±24.7
^{197}Tl	c*	2.84H	54.9±19.0	57.9±20.1	55.3±19.1	71.7±24.7
^{196m}Tl	i(m)	1.41H	49.2±9.2	49.4±9.2	48.8±9.1	50.6±9.4

Continuation of Table 25.

Product	Type	$T_{1/2}$	Yields [mbarn] for			
			^{206}Pb	^{207}Pb	^{208}Pb	^{nat}Pb
^{195}Tl	c*	1.16H	50.5±7.3	41.3±5.7	36.6±5.1	43.7±6.3
^{203}Hg	c	46.612D	1.64±0.12	2.95±0.23	4.14±0.31	3.17±0.24
^{197m}Hg	i(m)	23.8H	9.83±0.78	11.8±0.9	13.1±1.0	12.0±1.0
^{195m}Hg	i(m)	41.6H	14.6±1.4	16.6±1.5	17.0±1.5	16.3±1.5
*^{195}Hg	ct	9.9H	78.5±9.0	78.3±8.8	73.4±8.1	76.8±8.6
^{195}Hg	c	9.9H	63.9±8.1	61.7±7.8	56.4±7.2	60.4±7.7
^{193m}Hg	i(m)	11.8H	22.1±3.7	22.8±3.7	22.2±3.7	22.5±3.5
^{192}Hg	c	4.85H	56.1±4.4	54.3±4.2	51.1±4.0	53.5±4.2
^{190}Hg	c*	20.0M	43.5±7.2	40.8±6.8	38.8±6.4	41.8±7.0
^{198m}Au	i(m)	2.27D	0.407±0.032	0.561±0.044	0.769±0.060	0.629±0.049
^{198}Au	i(m+g)	2.69517D	1.38±0.11	1.94±0.14	2.40±0.18	2.04±0.15
^{198}Au	i	2.69517D	1.00±0.11	1.40±0.12	1.62±0.13	1.45±0.13
^{196}Au	i(m1+m2+g)	6.183D	2.84±0.23	3.66±0.30	4.35±0.36	3.80±0.30
^{195}Au	c	186.098D	58.2±6.8	72.6±8.5	68.9±8.1	75.0±8.9
^{194}Au	i(m1+m2+g)	38.02H	5.63±0.51	7.00±0.63	7.76±0.70	7.03±0.64
^{192}Au	i(m+g)	4.94H	8.24±1.34	11.2±1.7	10.5±1.6	11.5±1.7
^{192}Au	c	4.94H	77.3±10.9	78.9±11.2	74.6±10.5	77.6±11.0
^{191}Au	c*	3.18H	74.2±7.0	73.2±6.1	68.5±5.8	73.0±5.9
^{190}Au	c	42.8M	55.8±6.2	57.3±5.9	53.2±5.3	52.8±4.7
^{191}Pt	c	2.802D	56.0±4.7	56.6±4.8	54.7±4.6	55.5±4.7
^{189}Pt	c	10.87H	61.4±5.0	60.4±4.9	57.8±4.7	59.2±4.9
^{188}Pt	c	10.2D	55.3±4.3	54.9±4.3	51.4±4.0	53.1±4.1
^{187}Pt	c	2.35H	49.7±11.1	45.9±10.4	40.3±9.0	42.5±9.5
^{186}Pt	c	2.08H	44.4±10.1	42.5±9.6	39.2±8.9	37.0±2.9
^{184}Pt	c	17.3M	37.6±7.2	34.1±6.5	30.6±6.0	34.8±6.8
^{192}Ir	i(m1+g)	73.827D	0.100±0.018	0.114±0.020	0.163±0.018	0.124±0.016
^{190}Ir	i(m1+g)	11.78D	0.357±0.045	0.457±0.041	0.478±0.075	0.450±0.052
^{189}Ir	c	13.2D	53.5±4.3	53.1±4.3	51.9±4.2	52.5±4.3
^{188}Ir	i	41.5H	1.99±0.26	2.63±0.32	2.95±0.31	2.48±0.32
^{188}Ir	c	41.5H	57.3±4.5	57.4±4.5	54.0±4.3	55.4±4.4
^{187}Ir	c*	10.5H	59.6±5.1	56.3±5.0	49.9±4.3	53.6±4.5
^{186}Ir	c	16.64H	23.8±2.0	23.9±2.0	22.3±1.9	23.8±1.9
^{185}Ir	c	14.4H	37.0±3.3	35.8±3.2	32.7±2.9	35.1±3.1
^{184}Ir	c*	3.09H	44.3±3.6	42.5±3.5	39.1±3.3	40.5±3.5
^{183}Ir	c	57M	39.7±9.8	38.9±9.6	33.3±8.2	35.2±8.9
^{185}Os	c	93.6D	48.8±3.8	48.3±3.9	44.4±3.5	46.5±3.7
^{183m}Os	c*	9.9H	25.6±2.2	24.0±2.2	20.3±2.2	23.1±1.8
^{182}Os	c	22.10H	43.3±3.4	41.6±3.2	38.7±3.0	40.0±3.1
^{181}Os	c	105M	14.3±2.0	12.3±1.7	11.2±1.6	12.8±1.8
^{180}Os	c	21.5M	32.4±2.7	27.9±2.3	24.5±2.1	25.9±2.2
^{183}Re	c	70.0D	44.1±3.9	42.8±3.5	38.5±3.3	41.2±3.4
^{182m}Re	c	12.7H	45.1±3.8	42.6±3.7	37.2±3.3	40.3±3.5
*^{181}Re	c	19.9H	30.9±4.1	28.9±3.9	27.0±3.6	29.9±4.1
^{181}Re	c*	19.9H	32.2±4.2	30.1±3.9	28.0±3.7	31.2±4.1
^{179}Re	c*	19.5M	39.7±3.7	35.1±4.9	29.8±2.7	35.7±3.5
^{178}Re	c*	13.2M	35.3±4.9	29.8±4.2	27.4±3.9	30.9±4.5
^{178}W	c	21.6D	20.8±2.9	18.9±2.8	19.2±3.1	17.4±1.8
^{177}W	c	135M	20.3±2.6	18.1±2.3	15.5±2.0	18.6±2.4
^{176}W	c	2.5H	7.40±2.92	8.89±3.26	8.80±2.17	15.0±2.8
*^{177}Ta	c	56.56H	20.9±5.2	20.9±5.2	18.0±4.6	21.2±5.2

Continuation of Table 25.

Product	Type	$T_{1/2}$	Yields [mbarn] for			
			^{206}Pb	^{207}Pb	^{208}Pb	^{nat}Pb
^{177}Ta	c*	56.56H	21.7±5.1	21.7±5.1	18.7±4.6	21.9±5.2
^{176}Ta	c	8.09H	23.0±2.6	19.5±2.4	16.0±1.8	17.4±2.0
^{175}Ta	c	10.5H	18.0±1.5	15.9±1.3	13.3±1.2	15.5±1.3
^{173}Ta	c	3.14H	13.5±1.8	12.1±1.6	11.1±1.6	11.0±1.5
^{175}Hf	c	70D	17.1±1.4	15.1±1.2	12.7±1.0	14.7±1.2
*^{173}Hf	c	23.6H	12.5±1.3	10.5±1.1	8.06±0.87	10.7±1.1
^{173}Hf	c*	23.6H	14.6±1.3	12.3±1.1	9.76±0.88	12.4±1.1
^{172}Hf	c	1.87Y	9.46±0.73	8.07±0.63	6.42±0.50	7.83±0.61
^{170}Hf	c	16.01H	7.38±1.18	6.11±1.19	5.26±0.78	5.96±1.22
^{173}Lu	c	1.37Y	12.1±1.0	10.5±0.9	8.68±0.74	10.1±0.9
^{172}Lu	c	6.70D	9.55±0.77	8.23±0.67	6.62±0.57	7.54±0.70
^{171}Lu	c*	8.24D	9.45±0.73	7.93±0.61	6.34±0.49	7.63±0.59
*^{170}Lu	c	2.012D	5.66±0.81	5.01±0.94	3.45±0.71	5.42±0.94
^{170}Lu	c*	2.012D	9.32±0.81	8.04±0.89	6.06±0.72	8.38±0.88
^{169}Lu	c	34.06H	5.22±0.42	4.26±0.37	3.74±0.32	4.30±0.41
*^{169}Yb	c	32.026D	5.51±0.47	4.72±0.41	3.72±0.34	4.50±0.38
^{169}Yb	c*	32.026D	5.75±0.48	4.92±0.42	3.90±0.35	4.70±0.39
^{166}Yb	c	56.7H	2.87±0.28	2.33±0.24	1.77±0.18	2.43±0.25
^{167}Tm	c	9.25D	3.99±0.82	3.32±0.68	2.55±0.52	3.23±0.67
^{165}Tm	c	30.06H	2.12±0.21	1.71±0.16	1.15±0.12	1.61±0.16
^{149}Gd	c	9.28D	0.246±0.030	0.245±0.029	0.141±0.023	0.167±0.023
^{139}Ce	c	137.640D	0.255±0.025	0.225±0.021	0.254±0.029	0.265±0.030
^{127}Xe	c	36.4D	0.806±0.066	0.742±0.061	0.626±0.055	0.694±0.057
^{123m}Te	i(m)	119.7D	0.416±0.034	0.420±0.037	0.429±0.045	0.374±0.038
^{121m}Te	i(m)	154D	0.586±0.045	0.553±0.043	0.465±0.036	0.500±0.039
^{121}Te	c	19.16D	1.12±0.09	0.946±0.079	0.820±0.069	0.953±0.079
^{119m}Te	i(m)	4.70D	0.454±0.036	0.364±0.040	0.260±0.025	0.396±0.034
^{124}Sb	i(m1+m2+g)	60.20D	–	0.107±0.015	0.125±0.018	0.150±0.021
^{120m}Sb	i(m)	5.76D	0.531±0.040	0.527±0.039	0.471±0.038	0.500±0.042
^{113}Sn	c	115.09D	0.578±0.058	0.540±0.066	0.377±0.044	0.404±0.045
^{114m}In	i(m)	49.51D	1.76±0.14	1.91±0.16	1.52±0.15	1.66±0.19
^{110m}Ag	i(m)	249.76D	1.66±0.14	1.57±0.14	1.44±0.13	1.52±0.13
^{106m}Ag	i(m)	8.28D	0.883±0.073	0.738±0.066	0.507±0.048	0.667±0.058
^{105}Rh	c	35.36H	5.89±0.48	5.62±0.47	5.33±0.43	5.58±0.47
^{102}Rh	i	207D	0.898±0.130	0.758±0.121	0.682±0.108	0.679±0.111
^{101m}Rh	c	4.34D	1.24±0.12	1.01±0.10	0.801±0.084	1.00±0.10
^{103}Ru	c	39.26D	5.32±0.40	5.10±0.38	4.93±0.37	5.07±0.38
^{96}Tc	i(m+g)	4.28D	1.19±0.10	0.953±0.081	0.760±0.065	0.935±0.080
^{96}Nb	i	23.35H	3.31±0.27	3.07±0.27	3.08±0.32	2.99±0.26
^{95}Nb	i(m+g)	34.975D	4.17±0.30	3.92±0.29	3.42±0.25	3.82±0.28
^{95}Nb	c	34.975D	7.14±0.52	6.94±0.51	6.38±0.47	6.79±0.49
^{92m}Nb	i(m)	10.15D	0.385±0.036	0.355±0.030	0.335±0.029	0.334±0.028
^{97}Zr	c	16.744H	0.723±0.065	0.835±0.077	0.880±0.070	0.880±0.070
^{95}Zr	c	64.02D	2.97±0.23	2.99±0.23	2.95±0.23	2.93±0.23
^{89}Zr	c	78.41H	1.93±0.14	1.60±0.12	1.18±0.09	1.57±0.12
^{88}Zr	c	83.4D	0.749±0.058	0.610±0.047	0.478±0.037	0.550±0.043
^{90m}Y	i(m)	3.19H	3.76±0.29	3.42±0.28	3.36±0.26	3.51±0.27
^{88}Y	i	106.65D	3.63±0.29	3.07±0.25	2.53±0.20	3.11±0.24
^{88}Y	c	106.65D	4.32±0.36	3.70±0.31	2.94±0.24	3.51±0.28
^{87}Y	c*	79.8H	2.81±0.25	2.32±0.23	1.87±0.22	2.17±0.17

Continuation of Table 25.

Product	Type	$T_{1/2}$	Yields [mbarn] for			
			^{206}Pb	^{207}Pb	^{208}Pb	^{nat}Pb
^{85}Sr	c	64.84D	2.82±0.24	2.40±0.20	1.86±0.16	2.29±0.20
^{86}Rb	i(m+g)	18.631D	5.13±0.39	4.51±0.39	4.20±0.38	3.88±0.36
^{83}Rb	c	86.2D	3.23±0.27	2.58±0.23	2.18±0.19	2.66±0.23
^{82}Br	i(m+g)	35.30H	2.66±0.22	2.52±0.21	2.30±0.19	2.51±0.21
^{75}Se	c	119.779D	0.986±0.082	0.884±0.074	0.610±0.052	0.818±0.067
^{74}As	i	17.77D	1.73±0.17	1.49±0.15	1.15±0.12	1.40±0.14
^{72}Ga	i	14.10H	1.44±0.15	1.19±0.23	1.10±0.21	1.17±0.12
^{72}Ga	c	14.10H	1.86±0.17	1.64±0.23	1.47±0.21	1.51±0.14
^{72}Zn	c	46.5H	0.419±0.048	0.448±0.063	0.378±0.047	0.348±0.035
^{59}Fe	c	44.472D	0.751±0.064	0.681±0.071	0.528±0.050	0.638±0.056
^{46}Sc	i(m+g)	83.79D	0.116±0.016	0.108±0.015	0.112±0.016	0.142±0.022
^{7}Be	i	53.29D	1.15±0.20	0.918±0.204	1.14±0.22	1.15±0.22

3.9 Experimental results for 0.8 GeV proton-irradiated ^{nat,208,207,206}Pb targets.

Table 26 presents parameters of ^{nat,208,207,206}Pb irradiation by 0.8GeV protons. Table 27 presents values of the measured residual nuclide yields.

Table 26: Parameters of irradiation of ^{nat,208,207,206}Pb.

Target	Proton energy (MeV)	Weight of sample (mg)	Weight of monitor (mg)	Weight of monitor-plate (mg) (mg)	Time of irradiation (min)	Average proton flux p/(cm$^2\cdot s$) $\times10^{-10}$	Number of γ-specra sample/ monitor/ plate	ExpData index
^{nat}Pb	799 ± 2	191.3	122.7	703.9	30	4.58 ± 0.36	27/11/1	pbn800
^{208}Pb	799 ± 2	138.9	122.4	720.3	30	4.73 ± 0.37	31/10/1	pb8800
^{207}Pb	799 ± 2	139.3	122.6	713.9	30	4.68 ± 0.37	29/10/1	pb7800
^{206}Pb	799 ± 2	142.0	122.0	708.6	30	5.15 ± 0.41	33/10/1	pb6800

Table 27: Experimental values of measured yields of ^{206,207,208,nat}Pb(p,x) reaction products for $E_p = 0.8$ GeV.

Product	Type	T$_{1/2}$	Yields [mbarn] for			
			^{206}Pb	^{207}Pb	^{208}Pb	^{nat}Pb
^{207}Bi	i	31.55Y	–	–	5.78±0.90	3.39±0.64
^{206}Bi	i	6.243D	1.27±0.11	3.06±0.27	4.52±0.40	3.41±0.29
^{205}Bi	i	15.31D	3.83±0.33	5.83±0.50	6.46±0.56	5.67±0.49
^{204}Bi	i	11.22H	4.75±0.40	5.68±0.48	5.59±0.47	5.64±0.48
^{203}Bi	i(m+g)	11.76H	5.31±0.54	6.11±0.61	5.38±0.56	5.75±0.57
^{202}Bi	i	1.72H	6.56±0.73	5.60±0.71	5.29±0.71	6.06±0.66
^{204m}Pb	i(m)	67.2M	12.2±1.1	13.8±1.2	13.9±1.2	12.6±1.1
^{204m}Pb	c	67.2M	12.9±1.1	14.6±1.3	14.8±1.3	13.5±1.2
*^{203}Pb	c	51.873H	41.9±3.7	39.0±3.4	35.2±3.1	39.2±3.4
^{203}Pb	c*	51.873H	43.5±3.5	40.8±3.3	36.8±3.0	40.9±3.3
^{202m}Pb	i(m)	3.53H	10.5±1.1	12.2±1.3	12.1±1.2	11.5±1.2
^{201}Pb	c*	9.33H	35.4±3.6	34.9±3.6	31.8±3.3	33.8±3.5
^{200}Pb	c	21.5H	25.1±2.1	24.0±2.0	21.6±1.8	24.0±2.0
^{199}Pb	c*	90M	45.1±8.1	46.0±8.3	45.7±8.3	44.5±8.0
^{198}Pb	c	2.4H	32.9±6.1	30.7±5.8	28.6±5.3	29.9±5.6
^{197m}Pb	c*	43M	24.4±2.3	23.9±2.3	21.5±2.0	23.6±5.2
^{195m}Pb	i(m)	15.0M	13.0±2.7	11.6±2.4	9.99±2.08	11.8±2.4
*^{202}Tl	i	12.23D	18.6±1.6	19.0±1.7	18.9±1.7	18.9±1.7
^{202}Tl	c	12.23D	19.6±1.6	20.2±1.6	20.1±1.6	20.0±1.6
^{201}Tl	c*	72.912H	59.7±4.9	59.2±4.8	55.9±4.6	58.5±4.8
^{200}Tl	i	26.1H	23.6±2.1	25.8±2.3	26.0±2.3	24.9±2.3
^{200}Tl	c	26.1H	48.7±4.2	49.7±4.3	47.6±4.1	48.6±4.2
^{199}Tl	c	7.42H	43.6±6.2	44.8±6.3	43.6±6.1	42.4±5.9
^{199}Tl	c*	7.42H	55.5±7.7	52.6±7.3	52.4±7.3	53.1±7.5
^{198m}Tl	i(m)	1.87H	22.8±3.2	24.5±3.6	24.0±3.3	23.8±3.5
^{196m}Tl	i(m)	1.41H	38.2±7.2	38.2±7.3	39.7±7.5	40.1±7.6
^{203}Hg	c	46.612D	1.75±0.15	3.21±0.26	4.46±0.37	3.39±0.28
^{197m}Hg	i(m)	23.8H	8.93±0.78	10.8±0.9	11.9±1.0	11.1±1.0
^{195m}Hg	i(m)	41.6H	12.5±1.2	14.4±1.4	16.2±1.6	14.7±1.4

Continuation of Table 27.

Product	Type	$T_{1/2}$	Yields [mbarn] for			
			^{206}Pb	^{207}Pb	^{208}Pb	^{nat}Pb
^{193m}Hg	i(m)	11.8H	18.1±4.0	19.9±3.9	20.0±4.1	19.2±4.1
^{192}Hg	c	4.85H	42.8±3.6	43.6±3.7	41.3±3.5	42.4±3.6
^{190}Hg	c*	20.0M	33.0±5.6	32.0±5.5	29.7±5.1	33.9±5.8
^{198m}Au	i(m)	2.27D	0.339±0.029	0.636±0.054	0.878±0.074	0.593±0.050
^{198}Au	i(m+g)	2.69517D	1.45±0.12	1.96±0.16	2.47±0.20	2.10±0.17
^{198}Au	i	2.69517D	1.12±0.10	1.31±0.11	1.57±0.14	1.51±0.15
^{196}Au	i(m1+m2+g)	6.183D	2.78±0.25	3.68±0.32	4.43±0.38	3.80±0.33
^{195}Au	c	186.098D	49.6±6.2	68.7±8.5	64.6±7.9	61.0±7.7
^{194}Au	i(m1+m2+g)	38.02H	5.23±0.51	6.75±0.65	7.86±0.76	7.02±0.69
^{192}Au	i(m+g)	4.94H	8.54±1.26	10.3±1.6	12.8±1.9	10.1±1.5
^{192}Au	c	4.94H	61.0±8.8	64.4±9.3	64.0±9.3	63.1±9.2
^{191}Au	c*	3.18H	60.3±5.4	59.1±5.4	61.8±5.6	61.4±5.5
^{190}Au	c	42.8M	45.1±4.4	46.9±4.4	45.4±4.4	45.1±4.1
^{191}Pt	c	2.802D	45.6±4.2	47.8±4.5	47.7±4.5	47.2±4.4
^{189}Pt	c	10.87H	50.3±4.4	53.9±4.7	52.6±4.6	51.4±4.5
^{188}Pt	c	10.2D	46.9±4.0	49.6±4.2	49.0±4.2	48.2±4.1
^{187}Pt	c	2.35H	37.2±8.6	33.9±7.9	38.2±8.8	37.0±8.4
^{186}Pt	c	2.08H	39.4±9.0	40.2±9.2	39.5±9.0	40.6±9.3
^{184}Pt	c	17.3M	36.9±7.6	33.9±6.7	33.3±6.6	34.4±6.7
^{192}Ir	i(m1+g)	73.827D	0.118±0.014	0.193±0.028	0.165±0.022	0.152±0.017
^{190}Ir	i(m1+g)	11.78D	0.311±0.044	0.483±0.049	0.559±0.055	0.448±0.044
^{189}Ir	c	13.2D	44.2±3.9	47.0±4.1	47.6±4.2	46.1±4.1
^{188}Ir	i	41.5H	2.64±0.49	3.21±0.31	3.80±0.49	3.26±0.38
^{188}Ir	c	41.5H	49.4±4.2	52.3±4.5	52.6±4.5	51.2±4.4
^{187}Ir	c*	10.5H	52.9±5.1	54.0±5.4	49.7±4.7	52.5±5.3
^{186}Ir	c	16.64H	21.6±2.0	22.3±2.0	23.6±2.1	23.1±2.1
^{185}Ir	c	14.4H	34.6±3.3	35.8±3.4	36.2±3.4	34.3±3.3
^{184}Ir	c*	3.09H	43.6±4.0	45.2±4.0	43.1±3.9	45.2±4.1
^{183}Ir	c	57M	42.9±10.8	48.3±11.9	42.4±10.5	44.4±10.9
^{185}Os	c	93.6D	46.3±4.0	49.3±4.2	48.5±4.2	47.6±4.1
^{183m}Os	c*	9.9H	26.3±2.3	26.8±2.4	25.7±2.2	26.2±2.2
^{182}Os	c	22.10H	42.0±4.0	44.5±4.0	43.5±4.0	43.8±4.0
^{181}Os	c	105M	16.1±2.3	16.7±2.6	16.3±2.4	15.3±2.3
^{180}Os	c	21.5M	37.1±3.4	36.2±3.2	35.0±3.1	35.0±3.1
^{183}Re	c	70.0D	45.9±4.1	48.3±4.3	45.5±4.8	45.7±4.3
^{182m}Re	c	12.7H	49.2±4.5	49.6±4.4	47.1±4.2	45.9±4.1
*^{181}Re	c	19.9H	41.0±5.6	42.2±5.8	40.5±5.5	40.8±5.6
^{181}Re	c*	19.9H	42.5±5.7	43.8±5.8	42.1±5.6	42.3±5.7
^{179}Re	c*	19.5M	49.0±5.2	48.6±5.0	46.3±5.9	45.5±5.7
^{178}Re	c*	13.2M	54.1±8.0	50.1±7.1	45.7±6.6	53.9±7.6
^{178}W	c	21.6D	27.1±3.6	29.1±4.3	29.1±3.8	27.8±3.4
^{177}W	c	135M	30.5±4.0	30.9±4.1	28.4±3.7	29.3±3.9
^{176}W	c	2.5H	24.4±3.2	20.1±4.6	18.2±3.2	24.2±2.8
*^{177}Ta	c	56.56H	32.2±8.1	32.2±8.1	30.6±7.6	33.4±8.6
^{177}Ta	c*	56.56H	33.4±8.0	33.4±8.0	31.8±7.6	34.7±8.5
^{176}Ta	c	8.09H	31.4±2.8	31.7±3.1	30.7±2.9	30.1±2.7
^{175}Ta	c	10.5H	30.3±2.8	29.3±2.7	27.2±2.6	28.4±2.8
^{174}Ta	c	1.14H	24.4±2.9	24.2±2.9	22.1±2.6	22.1±2.6
^{173}Ta	c	3.14H	27.1±3.6	26.1±3.5	23.7±3.2	26.3±3.5
^{172}Ta	c*	36.8M	13.3±1.7	12.0±1.5	10.3±1.4	11.2±1.4

Continuation of Table 27.

Product	Type	$T_{1/2}$	Yields [mbarn] for			
			^{206}Pb	^{207}Pb	^{208}Pb	^{nat}Pb
^{175}Hf	c	70D	28.7±2.5	28.9±2.5	26.7±2.3	27.5±2.4
*^{173}Hf	c	23.6H	27.1±2.5	26.0±2.5	24.0±2.4	25.5±2.5
^{173}Hf	c*	23.6H	31.2±2.8	30.0±2.7	27.6±2.6	29.5±2.7
^{172}Hf	c	1.87Y	19.9±1.7	19.5±1.6	17.7±1.5	18.9±1.6
^{170}Hf	c	16.01H	22.5±2.4	21.8±2.3	18.8±2.0	21.2±2.3
^{173}Lu	c	1.37Y	23.8±2.2	23.5±2.1	21.7±2.0	23.2±2.1
^{172}Lu	c	6.70D	20.3±1.8	19.6±1.7	17.9±1.6	19.0±1.6
^{171}Lu	c*	8.24D	22.6±2.0	21.8±1.9	19.9±1.8	21.4±1.8
*^{170}Lu	c	2.012D	13.3±2.0	13.1±2.0	11.6±1.7	12.2±1.9
^{170}Lu	c*	2.012D	24.5±2.3	23.9±2.4	20.9±2.0	22.7±2.2
^{169}Lu	c	34.06H	13.5±1.2	12.9±1.1	11.2±1.0	12.4±1.1
^{167}Lu	c	51.5M	8.93±0.98	8.62±0.86	10.3±1.4	10.2±1.1
*^{169}Yb	c	32.026D	15.6±1.4	14.6±1.3	13.1±1.2	14.4±1.3
^{169}Yb	c*	32.026D	16.2±1.4	15.2±1.3	13.6±1.2	15.0±1.3
^{166}Yb	c	56.7H	10.3±0.9	9.59±0.81	8.24±0.70	9.11±0.77
^{167}Tm	c	9.25D	13.0±2.7	12.1±2.5	10.7±2.2	11.7±2.4
^{165}Tm	c	30.06H	9.24±0.86	8.36±0.75	7.20±0.71	8.45±0.76
^{161}Er	c*	3.21H	9.09±0.97	8.24±0.89	7.21±0.84	7.84±0.85
^{160}Er	c	28.58H	4.91±0.42	4.50±0.38	3.68±0.31	4.23±0.36
^{160m}Ho	c	5.02H	5.59±1.17	4.36±1.42	3.89±1.11	5.56±1.19
^{157}Dy	c	8.14H	2.62±0.25	2.20±0.22	1.85±0.17	2.36±0.22
^{155}Dy	c*	9.9H	1.68±0.16	1.51±0.15	1.28±0.14	1.59±0.16
^{155}Tb	c*	5.32D	1.84±0.19	1.58±0.17	1.26±0.13	1.44±0.16
^{153}Tb	c*	2.34D	1.21±0.13	1.12±0.13	0.929±0.113	0.828±0.103
^{153}Gd	c	240.4D	1.12±0.12	0.995±0.124	0.765±0.095	0.953±0.099
^{149}Gd	c	9.28D	0.788±0.080	0.669±0.074	0.557±0.067	0.703±0.082
^{146}Gd	c	48.27D	0.482±0.044	0.411±0.037	0.309±0.032	0.384±0.034
^{146}Eu	i	4.61D	0.090±0.028	0.051±0.016	0.105±0.024	0.118±0.015
^{146}Eu	c	4.61D	0.572±0.055	0.462±0.042	0.414±0.042	0.501±0.045
^{139}Ce	c	137.640D	0.472±0.043	0.423±0.042	0.396±0.035	0.465±0.041
^{131}Ba	c	11.50D	0.571±0.093	0.586±0.079	0.521±0.059	0.543±0.060
^{127}Xe	c	36.4D	0.892±0.080	0.875±0.098	0.793±0.071	0.850±0.076
^{123m}Te	i(m)	119.7D	0.388±0.034	0.392±0.041	0.322±0.035	0.380±0.043
^{121m}Te	i(m)	154D	0.533±0.045	0.508±0.043	0.475±0.040	0.524±0.044
^{121}Te	c	19.16D	1.16±0.10	1.06±0.09	0.948±0.084	1.10±0.12
^{119m}Te	i(m)	4.70D	0.502±0.045	0.392±0.048	0.400±0.038	0.427±0.051
^{124}Sb	i(m1+m2+g)	60.20D	0.096±0.015	–	0.077±0.014	0.118±0.015
^{120m}Sb	i(m)	5.76D	0.434±0.037	0.471±0.040	0.476±0.042	0.471±0.040
^{113}Sn	c	115.09D	0.736±0.067	0.583±0.068	0.559±0.053	0.642±0.061
^{114m}In	i(m)	49.51D	1.59±0.14	1.78±0.17	1.60±0.16	1.80±0.16
^{111}In	c	2.8047D	1.10±0.10	0.972±0.086	0.814±0.095	0.943±0.085
^{110m}Ag	i(m)	249.76D	1.35±0.12	1.42±0.13	1.35±0.12	1.36±0.12
^{106m}Ag	i(m)	8.28D	1.03±0.09	0.926±0.084	0.755±0.068	0.836±0.076
^{100}Pd	c	3.63D	0.080±0.009	–	–	–
^{105}Rh	c	35.36H	5.46±0.49	5.37±0.48	5.28±0.48	5.31±0.48
^{102}Rh	i	207D	1.31±0.19	1.07±0.16	1.09±0.16	1.37±0.19
^{101m}Rh	c	4.34D	1.47±0.15	1.26±0.13	1.10±0.11	1.29±0.14
^{100}Rh	i(m+g)	20.8H	0.711±0.062	–	–	–
^{100}Rh	c	20.8H	0.791±0.069	–	–	–
^{103}Ru	c	39.26D	4.37±0.36	4.63±0.38	4.47±0.37	4.47±0.37

Continuation of Table 27.

Product	Type	$T_{1/2}$	Yields [mbarn] for			
			^{206}Pb	^{207}Pb	^{208}Pb	^{nat}Pb
^{96}Tc	i(m+g)	4.28D	1.43±0.13	1.30±0.12	1.04±0.09	1.20±0.11
^{99}Mo	c	65.94H	3.69±0.31	3.78±0.32	3.85±0.33	3.85±0.33
^{96}Nb	i	23.35H	2.88±0.25	2.78±0.26	2.74±0.26	2.76±0.30
^{95}Nb	i(m+g)	34.975D	3.79±0.30	3.75±0.30	3.46±0.28	3.60±0.29
^{95}Nb	c	34.975D	6.31±0.51	6.50±0.52	6.13±0.49	6.22±0.50
^{92m}Nb	i(m)	10.15D	0.393±0.033	0.395±0.033	0.318±0.027	0.358±0.034
^{97}Zr	c	16.744H	0.683±0.070	0.731±0.073	0.651±0.059	0.686±0.065
^{95}Zr	c	64.02D	2.50±0.21	2.63±0.22	2.65±0.22	2.59±0.22
^{89}Zr	c	78.41H	2.44±0.20	2.19±0.18	1.80±0.14	2.06±0.17
^{88}Zr	c	83.4D	1.07±0.09	0.925±0.078	0.763±0.065	0.866±0.073
^{90m}Y	i(m)	3.19H	3.56±0.30	3.55±0.31	3.23±0.30	3.26±0.29
^{88}Y	i	106.65D	4.03±0.38	3.64±0.31	3.29±0.28	3.49±0.33
^{88}Y	c	106.65D	5.01±0.44	4.58±0.39	3.86±0.36	4.30±0.38
^{87}Y	c*	79.8H	3.49±0.34	3.12±0.31	2.62±0.26	2.98±0.27
^{85}Sr	c	64.84D	3.44±0.31	3.14±0.29	2.58±0.24	2.98±0.27
^{86}Rb	i(m+g)	18.631D	4.84±0.41	4.78±0.41	4.56±0.40	5.23±0.45
^{83}Rb	c	86.2D	4.03±0.37	3.50±0.32	3.06±0.28	3.45±0.31
^{82m}Rb	i(m)	6.472H	1.43±0.15	1.38±0.15	1.06±0.13	1.21±0.14
^{82}Br	i(m+g)	35.30H	2.39±0.21	2.46±0.21	2.38±0.20	2.49±0.22
^{75}Se	c	119.779D	1.49±0.13	1.38±0.12	1.06±0.09	1.23±0.11
^{74}As	i	17.77D	2.13±0.22	1.97±0.21	1.72±0.18	1.86±0.20
^{72}Ga	i	14.10H	1.25±0.18	1.44±0.18	1.53±0.18	1.62±0.19
^{72}Ga	c	14.10H	1.65±0.19	1.90±0.20	1.88±0.20	1.92±0.20
^{72}Zn	c	46.5H	0.399±0.049	0.463±0.053	0.349±0.045	0.301±0.041
^{59}Fe	c	44.472D	0.772±0.072	0.851±0.095	0.844±0.085	0.903±0.084
^{54}Mn	i	312.11D	0.357±0.043	0.395±0.055	0.332±0.037	0.358±0.037
^{46}Sc	i(m+g)	83.79D	0.180±0.022	0.237±0.066	0.206±0.042	0.238±0.023
^{7}Be	i	53.29D	1.40±0.25	1.42±0.52	1.53±0.23	1.34±0.20

3.10 Experimental results for 1.2 GeV proton-irradiated ^{nat,208,207,206}Pb targets.

Table 28 presents parameters of ^{nat,208,207,206}Pb irradiation by 1.2GeV protons. Table 29 presents values of the measured residual nuclide yields.

Table 28: Parameters of irradiation of ^{nat,208,207,206}Pb.

Target	Proton energy (MeV)	Weight of sample (mg)	Weight of monitor (mg)	Weight of monitor-plate (mg) (mg)	Time of irradiation (min)	Average proton flux p/(cm$^2 \cdot s$) $\times 10^{-10}$	Number of γ-specra sample/ monitor/ plate	ExpData index
^{nat}Pb	1195 ± 3	139.0	110.6	704.8	30	7.76 ± 0.60	33/13/1	pbn12g
^{208}Pb	1201 ± 3	136.8	109.6	712.7	20	5.01 ± 0.39	31/12/1	pb812g
^{207}Pb	1199 ± 3	145.0	110.2	700.3	20	5.90 ± 0.46	28/12/1	pb712g
^{206}Pb	1188 ± 3	138.0	110.5	692.1	20	6.84 ± 0.53	31/12/1	pb612g

Table 29: Experimental values of measured yields of ^{206,207,208,nat}Pb(p,x) reaction products for $E_p = 1.2$ GeV.

Product	Type	$T_{1/2}$	Yields [mbarn] for			
			^{206}Pb	^{207}Pb	^{208}Pb	^{nat}Pb
^{207}Bi	i	31.55Y	–	–	–	3.46±0.63
^{206}Bi	i	6.243D	1.27±0.11	2.65±0.23	3.75±0.33	2.92±0.25
^{205}Bi	i	15.31D	3.42±0.36	4.43±0.40	4.93±0.44	4.71±0.41
^{204}Bi	i	11.22H	3.99±0.33	4.33±0.36	4.48±0.37	4.46±0.37
^{203}Bi	i(m+g)	11.76H	4.78±0.48	3.98±0.53	3.93±0.42	4.13±0.41
^{202}Bi	i	1.72H	6.21±0.66	4.34±0.66	4.47±0.71	3.86±0.53
^{204m}Pb	i(m)	67.2M	11.8±1.1	11.0±1.0	10.3±1.1	11.6±1.1
^{204m}Pb	c	67.2M	12.4±1.2	11.6±1.0	10.9±1.1	12.3±1.1
*^{203}Pb	c	51.873H	38.8±3.3	32.5±2.8	29.3±2.5	32.5±2.8
^{203}Pb	c*	51.873H	40.2±3.2	33.7±2.7	30.4±2.4	33.7±2.7
^{202m}Pb	i(m)	3.53H	8.60±0.90	9.79±1.07	9.67±1.06	9.50±0.97
^{201}Pb	c*	9.33H	30.6±3.1	26.3±2.7	24.0±2.4	26.0±2.6
^{200}Pb	c	21.5H	21.0±1.7	18.3±1.5	17.0±1.4	17.6±1.5
^{199}Pb	c*	90M	42.3±7.6	35.5±6.4	33.6±6.0	32.4±5.9
^{198}Pb	c	2.4H	30.2±5.6	25.0±4.7	23.6±4.4	23.7±4.4
^{197m}Pb	c*	43M	18.8±4.1	15.9±3.5	15.0±3.3	15.6±3.4
^{195m}Pb	i(m)	15.0M	8.90±1.83	7.57±1.56	6.88±1.45	7.87±1.66
*^{202}Tl	i	12.23D	18.0±1.5	16.6±1.4	16.6±1.4	16.5±1.4
^{202}Tl	c	12.23D	18.8±1.5	17.5±1.4	17.5±1.4	17.4±1.4
^{201}Tl	c*	72.912H	52.5±4.2	48.0±3.8	44.4±3.6	46.0±3.7
^{200}Tl	i	26.1H	22.3±2.0	21.3±2.1	21.0±2.2	22.0±2.0
^{200}Tl	c	26.1H	42.8±3.6	38.8±3.3	37.1±3.2	38.6±3.3
^{199}Tl	c	7.42H	38.5±5.4	39.0±5.5	33.6±4.8	33.3±4.8
^{199}Tl	c*	7.42H	44.6±6.2	40.8±5.7	38.0±5.3	40.2±5.6
^{198m}Tl	i(m)	1.87H	18.9±2.6	23.0±3.2	19.0±2.7	19.5±3.1
^{196m}Tl	i(m)	1.41H	32.0±6.0	31.2±5.9	30.8±5.8	29.5±5.6
^{203}Hg	c	46.612D	1.90±0.16	3.07±0.25	4.24±0.34	3.23±0.26
^{197m}Hg	i(m)	23.8H	8.49±0.73	8.76±0.77	10.1±0.9	8.87±0.76
^{195m}Hg	i(m)	41.6H	13.2±2.0	13.4±2.1	12.7±2.0	12.8±2.0

Continuation of Table 29.

Product	Type	$T_{1/2}$	Yields [mbarn] for			
			^{206}Pb	^{207}Pb	^{208}Pb	^{nat}Pb
^{193m}Hg	i(m)	11.8H	14.0±3.4	13.7±2.7	14.8±3.4	13.2±2.7
^{192}Hg	c	4.85H	33.2±2.8	31.5±2.6	30.5±2.5	29.9±2.5
^{190}Hg	c*	20.0M	24.1±4.1	22.5±3.8	22.6±3.8	21.7±3.7
^{198m}Au	i(m)	2.27D	0.361±0.030	0.461±0.038	0.722±0.060	0.583±0.048
^{198}Au	i(m+g)	2.69517D	1.51±0.12	1.97±0.15	2.50±0.21	1.88±0.16
^{198}Au	i	2.69517D	1.19±0.11	1.51±0.12	1.84±0.20	1.27±0.15
^{196}Au	i(m1+m2+g)	6.183D	2.69±0.23	3.19±0.27	3.91±0.33	3.26±0.28
^{195}Au	c	186.098D	34.2±4.2	44.0±5.4	47.3±5.7	41.9±5.1
^{194}Au	i(m1+m2+g)	38.02H	5.02±0.57	5.67±0.64	6.60±0.75	5.75±0.65
^{192}Au	i(m+g)	4.94H	8.95±1.41	8.39±1.41	9.82±1.48	8.71±1.33
^{192}Au	c	4.94H	47.4±6.8	44.5±6.4	45.2±6.5	43.9±6.3
^{191}Au	c*	3.18H	47.3±5.7	44.5±5.3	45.4±5.2	41.7±4.7
^{190}Au	c	42.8M	33.3±3.7	34.8±3.5	36.5±3.3	31.4±3.9
^{191}Pt	c	2.802D	34.5±3.8	33.2±3.9	34.7±3.5	32.3±3.4
^{189}Pt	c	10.87H	40.5±3.6	38.9±3.4	40.0±3.5	37.9±3.3
^{188}Pt	c	10.2D	37.8±3.1	36.7±3.0	36.9±3.1	35.2±2.9
^{186}Pt	c	2.08H	30.2±6.9	29.3±6.7	28.6±6.5	29.1±6.7
^{184}Pt	c	17.3M	29.7±5.8	23.8±5.0	25.4±5.0	30.1±6.2
^{192}Ir	i(m1+g)	73.827D	0.109±0.017	0.144±0.018	0.210±0.022	0.164±0.015
^{190}Ir	i(m1+g)	11.78D	0.395±0.040	0.414±0.059	0.569±0.056	0.383±0.041
^{189}Ir	c	13.2D	32.4±4.2	33.8±4.4	35.0±4.6	32.7±4.3
^{188}Ir	i	41.5H	3.06±0.68	2.79±0.34	4.47±0.57	3.77±0.54
^{188}Ir	c	41.5H	42.3±3.6	40.9±3.4	42.6±3.6	40.4±3.4
^{187}Ir	c*	10.5H	36.2±4.1	37.8±4.0	36.2±3.8	35.3±3.2
^{186}Ir	c	16.64H	17.8±1.7	17.4±1.6	18.0±1.6	18.1±1.6
^{185}Ir	c	14.4H	28.3±2.7	26.5±2.5	28.3±2.7	26.2±2.5
^{184}Ir	c*	3.09H	34.4±3.0	34.3±3.0	36.2±3.2	34.8±3.0
^{185}Os	c	93.6D	37.6±3.2	36.6±3.1	37.8±3.2	35.8±3.0
^{183m}Os	c*	9.9H	21.9±1.9	21.5±1.9	21.0±1.8	21.0±1.9
^{182}Os	c	22.10H	36.9±3.4	35.3±3.2	34.5±3.2	34.1±3.1
^{180}Os	c	21.5M	31.9±2.8	30.9±2.9	32.2±3.0	28.1±2.7
^{183}Re	c	70.0D	38.9±3.5	38.0±3.3	39.7±3.5	36.9±3.3
^{182m}Re	c	12.7H	40.4±3.8	38.4±3.6	39.3±3.8	37.6±3.5
^{181}Re	c*	19.9H	33.2±4.4	32.9±4.4	33.9±4.5	31.4±4.2
^{179}Re	c*	19.5M	47.4±5.1	46.6±4.3	45.0±4.1	42.7±5.1
^{178}Re	c*	13.2M	50.1±7.0	46.8±6.5	47.3±7.0	49.0±7.0
^{178}W	c	21.6D	29.3±3.9	29.3±2.9	24.1±5.5	25.5±3.2
^{177}W	c	135M	32.7±4.3	32.6±4.3	33.7±4.4	33.1±4.3
^{176}W	c	2.5H	27.9±5.3	30.7±3.9	30.4±5.7	23.8±3.4
*^{177}Ta	c	56.56H	33.9±8.4	34.5±8.6	33.6±8.4	32.2±8.0
^{177}Ta	c*	56.56H	35.2±8.4	35.9±8.6	35.0±8.4	33.6±8.0
^{176}Ta	c	8.09H	35.5±3.5	34.3±3.3	33.9±3.4	34.7±3.1
^{175}Ta	c	10.5H	34.4±3.2	33.2±3.0	33.3±3.2	32.8±3.2
^{174}Ta	c	1.14H	34.1±4.0	32.2±3.7	32.7±3.8	31.5±3.7
^{173}Ta	c	3.14H	35.1±4.6	35.1±4.6	34.5±4.5	34.1±4.5
^{172}Ta	c*	36.8M	17.4±2.2	17.1±2.1	17.1±2.2	17.9±2.3
^{175}Hf	c	70D	34.0±2.9	32.8±2.8	33.6±2.9	31.9±2.8
*^{173}Hf	c	23.6H	35.2±3.2	33.2±3.0	33.4±3.1	32.1±2.9
^{173}Hf	c*	23.6H	40.6±3.5	38.6±3.3	38.7±3.4	37.3±3.2
^{172}Hf	c	1.87Y	28.6±2.4	28.0±2.3	27.6±2.3	27.3±2.3

Continuation of Table 29.

Product	Type	$T_{1/2}$	Yields [mbarn] for			
			^{206}Pb	^{207}Pb	^{208}Pb	^{nat}Pb
^{171}Hf	c	12.1H	31.3±3.2	27.9±3.1	27.9±3.6	27.8±3.5
^{170}Hf	c	16.01H	37.9±4.0	36.6±3.8	35.2±3.7	35.0±3.7
^{173}Lu	c	1.37Y	33.0±2.9	30.8±2.7	31.9±2.8	30.3±2.7
^{172}Lu	i(m+g)	6.70D	0.147±0.049	0.161±0.054	0.212±0.031	0.181±0.021
^{172}Lu	c	6.70D	29.2±2.5	28.5±2.5	28.1±2.4	27.2±2.3
^{171}Lu	c*	8.24D	35.2±3.0	33.9±2.9	33.3±3.2	32.6±2.9
^{171}Lu	c	8.24D	32.2±2.7	30.7±2.5	30.8±2.5	29.6±2.4
^{170}Lu	c	2.012D	26.8±2.5	26.5±2.3	25.5±2.3	24.6±2.1
^{169}Lu	c	34.06H	24.7±2.2	23.6±2.0	22.7±2.0	22.4±1.9
^{167}Lu	c	51.5M	23.5±2.8	22.5±3.3	20.6±3.2	20.8±3.8
*^{169}Yb	c	32.026D	27.6±2.4	25.7±2.2	26.3±2.2	25.2±2.1
^{169}Yb	c*	32.026D	28.7±2.4	26.8±2.3	27.3±2.3	26.2±2.2
^{166}Yb	c	56.7H	24.2±2.0	22.3±1.9	21.7±1.8	21.1±1.8
^{167}Tm	c	9.25D	27.8±5.8	26.0±5.4	25.7±5.3	25.1±5.2
^{165}Tm	c	30.06H	23.6±2.1	22.0±1.9	21.3±1.9	21.1±1.9
^{161}Er	c*	3.21H	23.6±2.4	23.6±2.4	22.7±2.3	23.0±2.3
^{160}Er	c	28.58H	17.9±1.5	16.5±1.4	15.2±1.3	15.7±1.3
^{159}Er	c*	36M	21.4±1.8	18.8±1.6	17.1±1.4	20.2±1.7
^{160m}Ho	c	5.02H	18.9±2.4	17.8±2.2	17.4±3.1	17.4±2.2
^{156}Ho	c*	56M	14.2±1.2	13.0±1.2	11.5±1.1	11.9±1.1
^{157}Dy	c	8.14H	13.5±1.2	12.5±1.1	11.2±1.0	11.9±1.1
^{155}Dy	c*	9.9H	10.7±0.9	9.55±0.81	8.94±0.77	9.38±0.80
^{152}Dy	c	2.38H	4.97±0.45	4.67±0.40	4.19±0.38	4.57±0.41
^{155}Tb	c*	5.32D	10.4±1.2	9.41±1.22	9.22±0.92	8.60±1.35
^{153}Tb	c*	2.34D	7.84±0.80	7.41±0.75	6.89±0.70	6.87±0.70
*^{152}Tb	c	17.5H	6.72±0.75	5.58±0.65	5.58±0.68	5.89±0.66
^{152}Tb	c*	17.5H	7.50±0.76	6.32±0.67	6.24±0.68	6.61±0.67
^{151}Tb	c	17.609H	5.18±0.53	4.04±0.56	4.26±0.47	4.99±0.50
^{153}Gd	c	240.4D	7.39±0.67	6.68±0.67	6.35±0.58	6.57±0.59
^{151}Gd	c	124D	5.60±0.66	5.01±0.63	5.48±0.67	5.42±0.62
^{149}Gd	c	9.28D	6.63±0.64	5.80±0.55	5.18±0.52	5.69±0.56
^{147}Gd	c	38.06H	5.04±0.46	4.39±0.41	3.64±0.34	4.04±0.55
^{146}Gd	c	48.27D	4.81±0.41	4.06±0.34	3.54±0.30	3.90±0.33
*^{149}Eu	c	93.1D	8.16±0.81	6.52±0.91	7.26±1.14	5.78±0.63
^{149}Eu	c*	93.1D	8.89±0.81	7.16±0.91	7.84±1.14	6.41±0.64
*^{147}Eu	c	24.1D	5.54±0.50	4.90±0.49	4.21±0.39	4.49±0.42
^{147}Eu	c*	24.1D	5.90±0.52	5.21±0.51	4.47±0.41	4.78±0.44
^{146}Eu	i	4.61D	0.632±0.057	0.666±0.061	0.679±0.059	0.650±0.058
^{146}Eu	c	4.61D	5.44±0.46	4.72±0.40	4.22±0.36	4.55±0.38
^{145}Eu	c	5.93D	3.40±0.34	2.93±0.28	2.41±0.23	2.76±0.26
^{143}Pm	c	265D	3.07±0.32	2.47±0.26	2.21±0.25	2.42±0.25
^{139}Ce	c	137.640D	2.21±0.18	1.99±0.16	1.86±0.15	1.91±0.15
^{131}Ba	c	11.50D	1.21±0.12	1.13±0.11	1.15±0.13	1.19±0.12
^{128}Ba	c	2.43D	0.705±0.104	0.797±0.098	0.675±0.111	0.650±0.078
^{127}Xe	c	36.4D	1.33±0.11	1.13±0.13	1.11±0.10	1.07±0.10
^{123m}Te	i(m)	119.7D	0.261±0.032	0.318±0.049	0.356±0.044	0.280±0.035
^{121m}Te	i(m)	154D	0.494±0.041	0.446±0.037	0.392±0.033	0.443±0.037
^{121}Te	c	19.16D	1.52±0.13	1.41±0.12	1.24±0.11	1.29±0.11
^{119m}Te	i(m)	4.70D	0.586±0.051	0.638±0.060	0.501±0.053	0.490±0.043
^{120m}Sb	i(m)	5.76D	0.377±0.041	0.388±0.046	0.395±0.041	0.367±0.032

Continuation of Table 29.

Product	Type	$T_{1/2}$	Yields [mbarn] for			
			^{206}Pb	^{207}Pb	^{208}Pb	^{nat}Pb
^{113}Sn	c	115.09D	1.11±0.10	0.874±0.091	0.817±0.076	0.854±0.075
^{114m}In	i(m)	49.51D	1.64±0.16	1.44±0.17	1.34±0.12	1.27±0.11
^{111}In	c	2.8047D	1.45±0.12	1.22±0.10	1.08±0.09	1.18±0.10
^{110m}Ag	i(m)	249.76D	1.10±0.09	1.06±0.11	1.02±0.09	1.03±0.09
^{106m}Ag	i(m)	8.28D	1.20±0.11	1.02±0.10	0.972±0.089	0.953±0.093
^{105}Ag	c	41.29D	1.34±0.14	1.11±0.12	0.914±0.167	1.20±0.24
^{100}Pd	c	3.63D	0.190±0.026	0.106±0.038	0.136±0.025	0.099±0.028
^{105}Rh	c	35.36H	4.88±0.44	3.96±0.37	4.36±0.41	4.03±0.39
^{102}Rh	i	207D	1.04±0.15	0.887±0.138	0.867±0.147	0.992±0.140
^{101m}Rh	c	4.34D	1.86±0.19	1.57±0.16	1.38±0.15	1.49±0.15
^{100}Rh	i(m+g)	20.8H	1.05±0.10	0.819±0.101	0.797±0.079	1.01±0.12
^{100}Rh	c	20.8H	1.24±0.11	0.925±0.097	0.932±0.084	1.11±0.12
^{103}Ru	c	39.26D	3.48±0.28	3.35±0.27	3.46±0.28	3.33±0.27
^{96}Tc	i(m+g)	4.28D	1.71±0.15	1.42±0.13	1.30±0.12	1.39±0.12
^{99}Mo	c	65.94H	3.07±0.26	2.86±0.24	3.12±0.26	2.87±0.24
^{96}Nb	i	23.35H	2.25±0.25	2.15±0.19	1.93±0.17	2.09±0.19
^{95}Nb	i(m+g)	34.975D	3.40±0.27	3.14±0.26	2.98±0.24	2.94±0.23
^{95}Nb	c	34.975D	5.20±0.41	4.96±0.39	4.99±0.39	4.81±0.38
^{90}Nb	c*	14.60H	1.07±0.11	0.973±0.130	0.847±0.108	0.964±0.111
^{95}Zr	c	64.02D	1.78±0.15	1.84±0.15	1.96±0.16	1.89±0.16
^{89}Zr	c	78.41H	3.07±0.24	2.61±0.20	2.37±0.19	2.59±0.21
^{88}Zr	c	83.4D	1.47±0.12	1.19±0.10	1.11±0.09	1.22±0.10
^{88}Y	i	106.65D	4.02±0.34	3.73±0.32	3.35±0.28	3.52±0.30
^{88}Y	c	106.65D	5.47±0.48	4.78±0.40	4.47±0.38	4.73±0.41
^{87}Y	c*	79.8H	4.21±0.33	3.56±0.28	3.18±0.25	3.42±0.27
^{86}Y	c	14.74H	1.76±0.16	1.39±0.15	1.30±0.21	1.41±0.13
^{85}Sr	c	64.84D	4.17±0.39	3.57±0.32	3.22±0.29	3.41±0.31
^{83}Rb	c	86.2D	4.74±0.43	4.13±0.37	3.87±0.35	4.00±0.39
^{82m}Rb	i(m)	6.472H	2.12±0.26	1.66±0.17	1.54±0.20	1.70±0.16
^{82}Br	i(m+g)	35.30H	1.90±0.16	1.85±0.16	1.90±0.16	1.94±0.16
^{75}Se	c	119.779D	2.03±0.18	1.73±0.16	1.58±0.16	1.68±0.16
^{74}As	i	17.77D	2.57±0.27	2.17±0.23	2.09±0.22	2.18±0.23
^{71}As	c	65.28H	0.351±0.033	0.184±0.038	0.143±0.025	0.199±0.019
^{72}Ga	i	14.10H	1.04±0.16	1.52±0.17	1.36±0.16	1.30±0.18
^{72}Ga	c	14.10H	1.47±0.18	1.82±0.18	1.70±0.17	1.68±0.19
^{72}Zn	c	46.5H	0.428±0.047	0.297±0.051	0.339±0.051	0.381±0.047
^{59}Fe	c	44.472D	1.15±0.11	1.07±0.10	1.01±0.09	1.09±0.10
^{54}Mn	i	312.11D	0.741±0.092	0.638±0.086	0.581±0.059	0.590±0.066
^{48}V	c	15.9735D	0.092±0.012	0.074±0.013	0.094±0.015	0.079±0.013
^{48}Sc	i	43.67H	0.430±0.043	0.423±0.049	0.434±0.040	0.395±0.036
^{46}Sc	i(m+g)	83.79D	0.584±0.053	0.513±0.071	0.452±0.060	0.539±0.051
^{7}Be	i	53.29D	2.56±0.32	1.94±0.18	2.88±0.42	2.19±0.26

3.11 Experimental results for 1.6 GeV proton-irradiated ^{nat,208,207,206}Pb targets.

Table 30 presents parameters of ^{nat,208,207,206}Pb irradiation by 1.6GeV protons. Table 31 presents values of the measured residual nuclide yields.

Table 30: Parameters of irradiation of ^{nat,208,207,206}Pb.

Target	Proton energy (MeV)	Weight of sample (mg)	Weight of monitor (mg)	Weight of monitor-plate (mg) (mg)	Time of irradiation (min)	Average proton flux p/(cm$^2 \cdot s$) $\times 10^{-10}$	Number of γ-specra sample/ monitor/ plate	ExpData index
^{nat}Pb	1598 ± 4	205.4	111.1	696.6	20	5.42 ± 0.45	28/10/1	pbn16g
^{208}Pb	1601 ± 4	143.8	110.4	700.8	30	3.40 ± 0.28	26/10/1	pb816g
^{207}Pb	1599 ± 4	143.4	110.6	691.3	30	2.27 ± 0.19	26/10/1	pb716g
^{206}Pb	1599 ± 4	135.8	110.1	721.9	30	4.07 ± 0.34	29/11/1	pb616g

Table 31: Experimental values of measured yields of ^{206,207,208,nat}Pb(p,x) reaction products for $E_p = 1.6$ GeV.

Product	Type	T$_{1/2}$	Yields [mbarn] for			
			^{206}Pb	^{207}Pb	^{208}Pb	^{nat}Pb
^{207}Bi	i	31.55Y	–	–	4.96±0.98	3.66±0.84
^{206}Bi	i	6.243D	1.35±0.13	3.23±0.29	3.92±0.35	3.14±0.29
^{205}Bi	i	15.31D	3.37±0.39	4.63±0.48	5.20±0.50	4.54±0.46
^{204}Bi	i	11.22H	3.91±0.35	4.92±0.44	4.41±0.39	4.66±0.41
^{203}Bi	i(m+g)	11.76H	4.29±0.47	5.22±0.55	4.08±0.44	5.08±0.54
^{202}Bi	i	1.72H	3.18±0.45	3.84±0.54	2.95±0.46	2.69±0.45
^{204m}Pb	i(m)	67.2M	10.8±1.0	12.1±1.2	13.1±1.2	11.2±1.1
^{204m}Pb	c	67.2M	11.4±1.0	12.9±1.3	13.7±1.3	11.9±1.2
*^{203}Pb	c	51.873H	36.3±3.3	33.8±3.1	27.8±2.6	31.5±2.9
^{203}Pb	c*	51.873H	37.6±3.2	35.4±3.1	29.0±2.5	33.0±2.8
^{202m}Pb	i(m)	3.53H	8.97±1.11	10.3±1.0	9.09±0.88	9.19±1.11
^{201}Pb	c*	9.33H	27.1±2.9	26.4±2.8	22.4±2.4	24.1±2.6
^{200}Pb	c	21.5H	18.8±1.7	18.0±1.6	16.9±1.5	16.5±1.5
^{199}Pb	c*	90M	33.0±6.0	34.8±6.4	27.5±5.0	34.6±6.3
^{198}Pb	c	2.4H	24.5±4.6	25.9±4.9	21.5±4.1	21.6±4.2
^{197m}Pb	c*	43M	15.8±3.5	15.6±3.5	13.4±3.0	14.1±3.1
^{195m}Pb	i(m)	15.0M	6.86±1.45	6.81±1.48	5.78±1.23	5.74±1.21
*^{202}Tl	i	12.23D	16.7±1.5	17.8±1.6	15.9±1.5	16.0±1.5
^{202}Tl	c	12.23D	17.6±1.5	18.7±1.6	16.7±1.4	16.9±1.5
^{201}Tl	c*	72.912H	47.0±4.0	48.9±4.2	40.8±3.6	43.2±3.7
^{200}Tl	i	26.1H	19.5±1.8	21.0±2.0	18.5±2.0	18.2±1.7
^{200}Tl	c	26.1H	38.0±3.4	38.9±3.5	34.7±3.1	34.6±3.1
^{199}Tl	c	7.42H	33.0±4.7	29.5±4.6	23.5±3.7	29.6±4.5
^{199}Tl	c*	7.42H	38.6±5.5	38.4±5.6	34.1±4.9	35.9±5.2
^{198m}Tl	i(m)	1.87H	16.2±2.3	19.6±2.8	15.6±2.4	15.1±2.2
^{196m}Tl	i(m)	1.41H	28.4±5.4	30.9±5.9	27.1±5.2	27.2±5.2
^{203}Hg	c	46.612D	1.81±0.16	3.29±0.29	4.21±0.37	3.24±0.28
^{197m}Hg	i(m)	23.8H	7.32±0.68	9.58±0.88	9.17±0.84	8.71±0.82
^{195m}Hg	i(m)	41.6H	11.5±2.0	13.4±2.2	13.0±2.1	12.3±1.9

Continuation of Table 31.

Product	Type	$T_{1/2}$	Yields [mbarn] for			
			^{206}Pb	^{207}Pb	^{208}Pb	^{nat}Pb
^{193m}Hg	i(m)	11.8H	14.6±2.5	18.1±3.1	15.3±2.6	16.4±2.8
^{192}Hg	c	4.85H	27.4±2.4	28.7±2.6	25.1±2.2	25.4±2.3
^{190}Hg	c*	20.0M	18.4±3.2	20.4±3.6	15.9±2.8	16.1±2.8
^{198m}Au	i(m)	2.27D	0.381±0.043	0.542±0.092	0.790±0.079	0.655±0.089
^{198}Au	i(m+g)	2.69517D	1.25±0.11	1.91±0.18	2.17±0.19	1.76±0.16
^{198}Au	i	2.69517D	0.874±0.093	1.36±0.19	1.38±0.15	1.11±0.16
^{196}Au	i(m1+m2+g)	6.183D	2.43±0.23	3.32±0.31	3.62±0.33	3.14±0.30
^{195}Au	c	186.098D	44.2±5.5	37.8±4.8	40.0±5.0	38.7±5.0
^{194}Au	i(m1+m2+g)	38.02H	4.52±0.54	5.65±0.67	5.85±0.69	5.19±0.61
^{192}Au	i(m+g)	4.94H	6.24±1.07	8.12±1.41	8.55±1.46	8.02±1.29
^{192}Au	c	4.94H	37.5±5.6	40.7±6.0	37.3±5.5	36.7±5.4
^{191}Au	c*	3.18H	40.4±4.7	43.9±5.5	37.4±4.7	34.3±4.2
^{190}Au	c	42.8M	28.8±3.3	30.2±3.4	27.2±2.8	30.1±3.1
^{191}Pt	c	2.802D	28.8±3.2	31.3±3.8	29.1±3.4	28.7±3.4
^{189}Pt	c	10.87H	34.4±3.2	36.8±3.5	33.3±3.1	34.9±3.4
^{188}Pt	c	10.2D	28.8±2.6	31.1±2.8	28.7±2.6	28.0±2.5
^{186}Pt	c	2.08H	24.4±5.6	26.3±6.1	23.5±5.4	22.9±5.3
^{184}Pt	c	17.3M	22.7±4.6	24.8±5.8	21.7±4.4	19.6±4.4
^{192}Ir	i(m1+g)	73.827D	0.120±0.022	0.203±0.047	0.204±0.030	0.123±0.017
^{190}Ir	i(m1+g)	11.78D	0.371±0.073	0.478±0.092	0.513±0.070	0.332±0.092
^{189}Ir	c	13.2D	25.4±3.4	31.4±4.3	26.1±3.7	30.4±4.0
^{188}Ir	i	41.5H	–	–	2.78±0.53	1.51±0.56
^{188}Ir	c	41.5H	28.4±3.8	33.0±4.4	32.1±4.3	30.1±4.0
^{187}Ir	c*	10.5H	30.1±3.0	32.4±3.4	30.2±3.3	26.2±3.9
^{186}Ir	c	16.64H	13.3±1.3	15.6±1.5	14.9±1.4	14.1±1.3
^{185}Ir	c	14.4H	21.6±2.4	23.7±2.5	21.2±3.5	21.3±2.3
^{184}Ir	c*	3.09H	27.3±2.5	30.6±2.8	27.5±2.5	27.8±2.6
^{185}Os	c	93.6D	29.6±2.8	32.7±2.9	30.6±2.8	29.7±2.7
^{183m}Os	c*	9.9H	17.2±1.9	18.8±1.7	17.4±1.6	16.4±1.7
^{182}Os	c	22.10H	30.3±2.9	33.9±3.3	28.7±3.0	28.8±2.8
^{180}Os	c	21.5M	24.0±2.3	27.0±2.5	26.2±2.5	26.2±2.4
^{183}Re	c	70.0D	30.7±2.8	33.5±3.2	31.6±3.4	30.6±2.9
^{182m}Re	c	12.7H	30.8±3.0	32.2±4.7	31.9±3.2	28.6±3.0
^{181}Re	c*	19.9H	27.9±3.8	30.5±4.2	28.3±3.9	26.6±3.6
^{179}Re	c*	19.5M	38.8±5.9	41.1±4.7	37.8±4.0	38.3±3.7
^{178}Re	c*	13.2M	41.6±6.0	45.2±6.6	43.7±6.3	40.6±6.0
^{178}W	c	21.6D	21.8±2.5	26.1±4.7	22.2±4.1	22.5±2.9
^{177}W	c	135M	25.0±3.4	30.9±4.2	26.4±3.6	26.9±3.8
*^{177}Ta	c	56.56H	27.0±6.8	33.0±8.3	29.3±7.4	31.0±7.8
^{177}Ta	c*	56.56H	28.0±6.7	34.2±8.3	30.3±7.3	32.1±7.8
^{176}Ta	c	8.09H	27.5±3.9	31.4±2.9	29.5±2.8	28.1±4.0
^{175}Ta	c	10.5H	28.5±2.8	32.3±3.2	29.4±3.2	27.9±2.7
^{174}Ta	c	1.14H	29.1±3.5	32.7±4.0	29.5±3.6	29.6±3.6
^{173}Ta	c	3.14H	30.8±4.2	36.4±5.0	30.5±4.2	34.2±4.7
^{172}Ta	c*	36.8M	17.9±2.3	22.0±2.9	18.8±2.4	17.3±2.4
^{175}Hf	c	70D	28.2±2.6	31.6±2.9	29.2±2.7	28.9±2.7
*^{173}Hf	c	23.6H	29.0±2.8	32.9±3.2	30.8±3.0	29.4±2.9
^{173}Hf	c*	23.6H	33.8±3.1	38.4±3.6	35.5±3.3	34.7±3.2
^{172}Hf	c	1.87Y	24.9±2.2	27.2±2.4	25.6±2.3	25.3±2.2
^{171}Hf	c	12.1H	24.6±3.6	28.2±3.5	24.4±2.8	22.6±3.9

Continuation of Table 31.

Product	Type	$T_{1/2}$	Yields [mbarn] for			
			^{206}Pb	^{207}Pb	^{208}Pb	^{nat}Pb
^{170}Hf	c	16.01H	34.4±3.8	38.1±4.3	34.5±3.8	34.4±3.8
^{173}Lu	c	1.37Y	28.3±2.7	31.1±3.0	28.8±2.7	28.5±2.7
^{172}Lu	i(m+g)	6.70D	0.095±0.024	0.245±0.044	0.281±0.031	0.218±0.030
^{172}Lu	c	6.70D	24.7±2.4	27.2±2.7	25.9±2.5	24.8±2.4
^{171}Lu	c*	8.24D	31.4±3.1	34.8±3.2	32.7±3.1	31.0±3.0
^{171}Lu	c	8.24D	28.7±2.5	31.9±2.8	29.4±2.6	28.5±2.5
^{170}Lu	c	2.012D	23.8±2.3	27.5±2.6	25.5±2.4	23.8±2.8
^{169}Lu	c	34.06H	23.4±2.4	25.5±2.5	23.5±2.2	22.8±2.2
^{167}Lu	c	51.5M	22.6±3.0	26.8±2.9	21.5±3.2	23.7±2.9
*^{169}Yb	c	32.026D	26.1±2.4	28.0±2.6	26.1±2.4	26.0±2.4
^{169}Yb	c*	32.026D	27.2±2.5	29.2±2.6	27.2±2.5	27.1±2.4
^{166}Yb	c	56.7H	24.7±2.2	27.8±2.5	25.9±2.3	24.3±2.2
^{167}Tm	c	9.25D	27.6±5.8	30.1±6.3	27.9±5.8	26.6±5.6
^{165}Tm	c	30.06H	25.6±2.4	28.3±2.7	25.3±2.4	24.9±2.3
^{161}Er	c*	3.21H	27.3±2.9	30.2±3.2	26.0±2.8	26.8±2.9
^{160}Er	c	28.58H	24.3±2.2	26.3±2.3	23.0±2.0	22.6±2.0
^{159}Er	c*	36M	30.2±2.7	30.1±2.7	27.0±2.4	26.8±2.4
^{160m}Ho	c	5.02H	23.6±3.0	24.4±3.2	22.8±2.9	22.3±2.9
^{156}Ho	c*	56M	25.2±2.3	26.5±2.5	24.2±2.2	24.7±2.2
^{157}Dy	c	8.14H	20.8±2.0	22.7±2.2	20.2±1.9	19.7±1.9
^{155}Dy	c*	9.9H	18.1±1.6	18.8±1.7	17.3±1.6	16.3±1.5
^{152}Dy	c	2.38H	10.3±0.9	11.0±1.0	9.12±0.86	9.82±0.90
^{155}Tb	c*	5.32D	17.3±2.0	18.7±1.9	17.1±1.6	17.0±1.6
^{153}Tb	c*	2.34D	14.2±1.5	15.8±1.7	14.0±1.5	12.8±1.4
*^{152}Tb	c	17.5H	11.1±1.3	12.6±1.5	10.8±1.3	10.5±1.2
^{152}Tb	c*	17.5H	12.7±1.3	14.4±1.5	12.3±1.3	12.1±1.3
^{151}Tb	c	17.609H	10.6±1.1	11.3±1.1	9.64±0.97	9.96±1.18
^{149}Tb	c	4.118H	4.42±0.57	4.44±0.88	2.90±0.82	4.32±0.75
^{148}Tb	c	60M	6.81±0.62	6.17±0.59	5.28±0.57	5.77±0.69
^{153}Gd	c	240.4D	13.1±1.2	13.8±1.3	12.7±1.2	12.4±1.2
^{151}Gd	c	124D	11.6±1.3	11.8±1.5	10.7±1.3	10.2±1.2
^{149}Gd	c	9.28D	14.0±1.3	14.7±1.4	12.6±1.2	12.9±1.2
^{147}Gd	c	38.06H	11.2±1.0	11.5±1.1	9.89±0.95	9.58±0.89
^{146}Gd	c	48.27D	11.7±1.0	11.8±1.0	9.95±0.89	10.5±0.9
*^{149}Eu	c	93.1D	15.0±1.5	15.2±1.7	14.5±1.5	15.0±1.6
^{149}Eu	c*	93.1D	16.5±1.6	16.8±1.7	15.9±1.5	16.4±1.6
*^{147}Eu	c	24.1D	13.1±1.2	13.5±1.3	11.8±1.1	11.8±1.1
^{147}Eu	c*	24.1D	13.9±1.3	14.3±1.4	12.5±1.2	12.5±1.2
^{146}Eu	i	4.61D	1.54±0.14	1.73±0.16	1.65±0.15	1.47±0.13
^{146}Eu	c	4.61D	13.0±1.2	13.5±1.2	11.4±1.0	11.8±1.1
^{145}Eu	c	5.93D	8.85±0.83	8.98±0.85	7.81±0.74	8.17±0.77
^{143}Pm	c	265D	7.75±0.82	8.56±0.91	7.11±0.76	7.00±0.76
^{139}Ce	c	137.640D	6.81±0.58	6.91±0.60	5.99±0.52	6.24±0.54
^{135}Ce	c	17.7H	4.20±0.42	4.60±0.44	3.69±0.37	3.93±0.38
^{132}Ce	c	3.51H	2.95±0.29	3.67±0.35	2.59±0.26	3.48±0.35
^{132}La	c	4.8H	3.06±0.36	3.27±0.42	2.90±0.35	2.93±0.45
^{133}Ba	c	3848.9D	4.24±0.55	4.81±0.69	3.63±0.51	3.47±0.43
^{131}Ba	c	11.50D	3.67±0.35	3.78±0.35	3.25±0.30	3.39±0.31
^{128}Ba	c	2.43D	2.43±0.24	2.59±0.30	2.09±0.34	2.16±0.20
^{129}Cs	c	32.06H	4.19±0.44	4.31±0.46	3.54±0.38	3.85±0.40

Continuation of Table 31.

Product	Type	$T_{1/2}$	Yields [mbarn] for			
			^{206}Pb	^{207}Pb	^{208}Pb	^{nat}Pb
^{127}Xe	c	36.4D	3.06±0.30	3.05±0.28	2.61±0.24	2.72±0.26
^{123}Xe	c	2.08H	3.29±0.40	3.19±0.38	2.94±0.34	3.38±0.52
^{123m}Te	i(m)	119.7D	0.270±0.028	0.247±0.047	0.288±0.030	0.249±0.030
^{121m}Te	i(m)	154D	0.459±0.041	0.506±0.045	0.466±0.042	0.468±0.042
^{121}Te	c	19.16D	2.41±0.22	2.52±0.23	2.20±0.20	2.24±0.20
^{119m}Te	i(m)	4.70D	0.695±0.071	0.883±0.082	0.701±0.069	0.695±0.064
^{120m}Sb	i(m)	5.76D	0.349±0.037	0.382±0.049	0.358±0.034	0.354±0.048
^{113}Sn	c	115.09D	1.40±0.13	1.11±0.13	1.24±0.11	1.27±0.11
^{114m}In	i(m)	49.51D	1.17±0.25	1.06±0.18	1.30±0.16	1.50±0.66
^{111}In	c	2.8047D	1.81±0.21	1.82±0.17	1.55±0.14	1.61±0.16
^{110m}Ag	i(m)	249.76D	0.875±0.083	0.967±0.111	0.901±0.084	0.891±0.086
^{106m}Ag	i(m)	8.28D	1.15±0.11	1.21±0.12	1.12±0.11	1.10±0.12
^{105}Ag	c	41.29D	1.66±0.22	1.47±0.17	1.26±0.16	1.36±0.15
^{100}Pd	c	3.63D	0.288±0.049	0.283±0.038	0.130±0.094	0.264±0.063
^{102}Rh	i	207D	0.888±0.134	0.924±0.153	0.913±0.136	0.899±0.131
^{101m}Rh	c	4.34D	2.00±0.24	2.02±0.23	1.69±0.18	1.72±0.18
^{100}Rh	i(m+g)	20.8H	1.30±0.16	1.34±0.16	1.08±0.15	1.10±0.22
^{100}Rh	c	20.8H	1.58±0.17	1.63±0.17	1.21±0.13	1.36±0.20
^{103}Ru	c	39.26D	2.74±0.24	2.88±0.26	2.69±0.24	2.63±0.23
^{96}Tc	i(m+g)	4.28D	1.69±0.16	1.76±0.17	1.47±0.14	1.48±0.14
^{99}Mo	c	65.94H	2.35±0.21	2.57±0.24	2.40±0.22	2.33±0.22
^{93m}Mo	i(m)	6.85H	1.09±0.11	1.15±0.12	0.906±0.093	1.23±0.15
^{96}Nb	i	23.35H	1.79±0.18	1.95±0.20	1.77±0.24	1.64±0.16
^{95}Nb	i(m+g)	34.975D	2.58±0.22	2.85±0.25	2.59±0.23	2.59±0.22
^{95}Nb	c	34.975D	4.14±0.35	4.58±0.39	4.16±0.36	4.10±0.35
^{90}Nb	c*	14.60H	1.43±0.14	1.39±0.17	1.15±0.13	1.12±0.11
^{95}Zr	c	64.02D	1.45±0.13	1.71±0.15	1.59±0.14	1.50±0.13
^{89}Zr	c	78.41H	3.20±0.27	3.21±0.28	2.60±0.22	2.70±0.23
^{88}Zr	c	83.4D	1.77±0.16	1.61±0.14	1.36±0.12	1.40±0.12
^{88}Y	i	106.65D	3.69±0.33	3.65±0.34	3.20±0.29	3.47±0.37
^{88}Y	c	106.65D	5.48±0.49	5.46±0.51	4.56±0.41	4.75±0.45
^{87}Y	c*	79.8H	4.33±0.37	4.27±0.37	3.46±0.30	3.60±0.31
^{86}Y	c	14.74H	1.91±0.17	1.74±0.23	1.42±0.14	1.84±0.18
^{85}Sr	c	64.84D	4.21±0.40	4.28±0.41	3.50±0.33	3.70±0.35
^{84}Rb	i(m+g)	32.77D	3.80±0.35	4.39±0.41	3.48±0.33	3.42±0.31
^{83}Rb	c	86.2D	4.94±0.47	5.36±0.58	4.32±0.47	4.32±0.41
^{82m}Rb	i(m)	6.472H	1.94±0.24	1.98±0.26	1.73±0.25	2.16±0.24
^{82}Br	i(m+g)	35.30H	1.65±0.15	1.83±0.17	1.67±0.15	1.53±0.14
^{75}Se	c	119.779D	2.26±0.22	2.22±0.21	1.87±0.18	1.98±0.19
^{74}As	i	17.77D	2.60±0.28	2.59±0.28	2.21±0.24	2.34±0.26
^{71}As	c	65.28H	0.487±0.054	0.497±0.053	0.394±0.042	0.521±0.048
^{72}Ga	i	14.10H	1.13±0.25	1.38±0.18	1.45±0.20	0.883±0.079
^{72}Ga	c	14.10H	1.49±0.24	1.76±0.19	1.85±0.21	1.10±0.10
^{72}Zn	c	46.5H	0.364±0.099	0.382±0.063	0.394±0.062	0.216±0.019
^{58}Co	i(m+g)	70.86D	0.859±0.099	0.801±0.092	0.828±0.103	0.750±0.080
^{59}Fe	c	44.472D	1.16±0.11	1.29±0.16	1.23±0.12	1.22±0.11
^{54}Mn	i	312.11D	1.06±0.10	1.21±0.12	0.944±0.101	0.970±0.091
^{48}V	c	15.9735D	0.177±0.019	0.179±0.021	0.154±0.017	0.167±0.018
^{48}Sc	i	43.67H	0.543±0.054	0.629±0.063	0.609±0.058	0.489±0.070
^{46}Sc	i(m+g)	83.79D	1.02±0.11	0.993±0.094	0.878±0.084	0.814±0.094

Continuation of Table 31.

Product	Type	$T_{1/2}$	Yields [mbarn] for			
			^{206}Pb	^{207}Pb	^{208}Pb	^{nat}Pb
^{28}Mg	c	20.915H	0.460±0.061	0.366±0.041	0.408±0.043	–
^{24}Na	c	14.9590H	1.53±0.14	2.01±0.21	1.88±0.18	1.88±0.17
^{7}Be	i	53.29D	4.27±0.45	3.62±0.44	5.76±0.69	3.53±0.34

3.12 Experimental results for 2.6 GeV proton-irradiated ^{nat,208,207,206}Pb targets.

Table 32 presents parameters of ^{nat,208,207,206}Pb irradiation by 2.6GeV protons. Table 33 presents values of the measured residual nuclide yields.

Table 32: Parameters of irradiation of ^{nat,208,207,206}Pb.

Target	Proton energy (MeV)	Weight of sample (mg)	Weight of monitor (mg)	Weight of monitor-plate (mg) (mg)	Time of irradiation (min)	Average proton flux p/(cm$^2\cdot s$) $\times 10^{-10}$	Number of γ-specra sample/ monitor/ plate	ExpData index
^{nat}Pb	2595 ± 8	203.4	120.0	722.9	33	6.98 ± 0.60	29/12/1	pbn26g
^{208}Pb	2606 ± 8	126.1	120.3	415.0	60	1.00 ± 0.09	36/13/1	pb826g
^{207}Pb	2610 ± 8	136.8	109.5	431.9	81	0.396 ± 0.034	31/13/1	pb726g
^{206}Pb	2609 ± 8	123.0	111.2	396.0	45	1.20 ± 0.10	33/12/1	pb626g

Table 33: Experimental values of measured yields of ^{206,207,208,nat}Pb(p,x) reaction products for E_p = 2.6 GeV.

Product	Type	T$_{1/2}$	Yields [mbarn] for			
			^{206}Pb	^{207}Pb	^{208}Pb	^{nat}Pb
^{207}Bi	i	31.55Y	–	–	6.08±1.37	7.94±0.98
^{206}Bi	i	6.243D	1.54±0.15	2.59±0.25	3.10±0.29	3.29±0.31
^{205}Bi	i	15.31D	4.00±0.81	4.16±0.48	4.48±0.64	4.87±0.47
^{204}Bi	i	11.22H	3.62±0.33	3.17±0.29	3.36±0.31	4.11±0.38
^{203}Bi	i(m+g)	11.76H	3.66±0.41	3.02±0.32	3.14±0.33	4.23±0.44
^{202}Bi	i	1.72H	2.73±0.48	2.72±0.76	2.02±0.41	3.48±0.50
^{204m}Pb	i(m)	67.2M	12.0±1.1	10.5±1.0	10.3±1.0	11.9±1.1
^{204m}Pb	c	67.2M	12.6±1.2	11.1±1.1	10.8±1.0	12.5±1.2
*^{203}Pb	c	51.873H	33.8±3.2	25.1±2.4	22.2±2.1	30.0±2.8
^{203}Pb	c*	51.873H	34.9±3.1	26.0±2.3	23.1±2.0	31.3±2.8
^{202m}Pb	i(m)	3.53H	8.61±0.91	7.93±1.38	7.68±0.79	8.17±0.82
^{201}Pb	c*	9.33H	24.1±2.6	18.7±2.0	16.7±1.8	20.9±2.3
^{200}Pb	c	21.5H	15.6±1.4	12.8±1.2	11.5±1.1	14.1±1.3
^{199}Pb	c*	90M	31.4±5.7	25.7±4.7	21.0±3.9	25.2±2.3
^{198}Pb	c	2.4H	23.5±4.5	19.2±3.7	14.9±2.8	18.8±3.6
^{197m}Pb	c*	43M	13.1±2.9	11.0±2.5	9.93±2.21	10.1±2.3
*^{202}Tl	i	12.23D	15.3±1.4	12.7±1.2	12.9±1.2	14.7±1.4
^{202}Tl	c	12.23D	16.1±1.4	13.4±1.2	13.7±1.2	15.5±1.4
^{201}Tl	c*	72.912H	41.6±3.8	32.7±3.0	31.2±2.8	38.4±3.4
^{200}Tl	i	26.1H	17.7±1.7	13.5±1.3	13.9±1.3	16.9±1.6
^{200}Tl	c	26.1H	33.0±3.1	26.2±2.4	25.2±2.3	31.3±2.9
^{199}Tl	c	7.42H	27.3±4.1	21.7±3.4	22.5±3.8	–
^{199}Tl	c*	7.42H	35.7±5.2	26.7±3.9	25.4±3.7	27.3±2.5
^{198m}Tl	i(m)	1.87H	15.3±2.3	11.0±1.7	12.0±1.7	11.5±1.6
^{196m}Tl	i(m)	1.41H	24.9±4.8	22.8±4.4	20.6±4.0	23.7±4.6
^{203}Hg	c	46.612D	1.55±0.17	2.12±0.20	3.39±0.30	3.01±0.27
^{197m}Hg	i(m)	23.8H	6.31±0.59	6.51±0.61	6.68±0.64	7.03±0.67
^{195m}Hg	i(m)	41.6H	11.0±1.7	9.57±1.52	10.6±1.7	11.7±1.9
^{193m}Hg	i(m)	11.8H	13.0±2.2	11.3±1.9	11.2±1.9	13.5±2.3

Continuation of Table 33.

Product	Type	$T_{1/2}$	Yields [mbarn] for			
			^{206}Pb	^{207}Pb	^{208}Pb	^{nat}Pb
^{192}Hg	c	4.85H	21.1±1.9	18.3±1.7	17.3±1.6	19.3±1.8
^{190}Hg	c*	20.0M	13.2±2.4	16.1±3.1	14.9±2.8	12.1±2.2
^{198}Au	i(m+g)	2.69517D	1.17±0.16	1.87±0.41	1.36±0.25	1.44±0.16
^{196}Au	i(m1+m2+g)	6.183D	2.18±0.19	2.33±0.22	2.87±0.27	2.70±0.25
^{195}Au	c	186.098D	27.4±3.5	26.4±3.5	28.8±3.6	33.5±4.4
^{194}Au	i(m1+m2+g)	38.02H	3.74±0.45	3.91±0.47	4.46±0.54	4.62±0.56
^{192}Au	i(m+g)	4.94H	6.61±1.05	5.74±0.94	7.60±1.17	7.00±1.10
^{192}Au	c	4.94H	30.2±4.5	25.3±3.8	26.6±4.0	28.6±4.3
^{190}Au	c	42.8M	27.9±3.7	25.8±3.2	24.6±3.0	27.0±3.2
^{191}Pt	c	2.802D	20.4±2.9	18.1±2.6	18.6±2.7	21.2±2.2
^{189}Pt	c	10.87H	25.7±2.7	22.6±2.5	22.8±2.4	24.2±3.0
^{188}Pt	c	10.2D	20.4±2.1	19.1±1.9	19.9±1.9	20.6±1.9
^{186}Pt	c	2.08H	18.8±4.4	16.7±3.9	16.2±3.8	17.4±4.0
^{192}Ir	i(m1+g)	73.827D	–	–	–	0.159±0.015
^{190}Ir	i(m1+g)	11.78D	–	–	–	0.389±0.046
^{189}Ir	c	13.2D	22.2±3.1	16.2±2.3	20.3±2.8	21.7±2.9
^{188}Ir	c	41.5H	22.6±3.1	20.5±2.8	20.8±2.8	22.8±2.1
^{187}Ir	c*	10.5H	23.4±2.7	23.2±2.4	20.4±2.3	18.1±2.1
^{186}Ir	c	16.64H	9.77±0.93	9.11±0.88	9.36±0.96	10.9±1.0
^{185}Ir	c	14.4H	15.9±2.1	13.4±1.9	14.3±1.9	14.4±2.8
^{184}Ir	c*	3.09H	20.8±2.0	19.8±1.9	18.8±1.8	19.5±1.9
^{185}Os	c	93.6D	21.5±2.0	19.4±1.8	20.2±1.9	22.0±2.0
^{183m}Os	c*	9.9H	11.6±1.1	10.7±1.0	11.0±1.0	12.1±1.1
^{182}Os	c	22.10H	20.4±2.1	19.1±2.0	19.2±2.0	24.6±2.3
^{180}Os	c	21.5M	19.2±2.0	20.1±2.0	17.9±1.8	16.0±1.5
^{183}Re	c	70.0D	21.8±2.0	21.0±2.0	21.6±2.0	22.1±2.2
^{182m}Re	c	12.7H	24.1±2.4	21.3±2.2	21.6±2.2	22.9±2.5
^{181}Re	c*	19.9H	20.1±2.8	18.2±2.5	18.7±2.6	21.0±2.9
^{179}Re	c*	19.5M	32.3±3.4	36.1±4.2	28.3±4.3	22.2±4.5
^{178}Re	c*	13.2M	31.7±4.9	36.4±5.6	30.7±4.6	24.8±3.8
^{178}W	c	21.6D	–	–	–	15.7±2.1
^{177}W	c	135M	18.9±2.6	18.0±2.5	17.6±2.4	19.1±2.7
*^{177}Ta	c	56.56H	21.2±5.4	19.6±5.0	19.0±4.8	20.9±5.3
^{177}Ta	c*	56.56H	22.0±5.4	20.4±5.0	19.7±4.8	21.7±5.3
^{176}Ta	c	8.09H	20.4±2.0	18.1±2.0	20.5±2.7	21.7±2.5
^{175}Ta	c	10.5H	20.5±2.1	17.8±1.9	18.1±1.9	18.9±2.2
^{174}Ta	c	1.14H	21.2±2.6	18.9±2.4	19.6±2.4	20.8±2.7
^{173}Ta	c	3.14H	23.5±3.4	22.1±3.1	22.4±3.1	22.9±3.2
^{172}Ta	c*	36.8M	14.3±1.9	16.0±2.4	14.4±1.9	13.4±1.8
^{175}Hf	c	70D	19.6±1.9	17.8±1.7	18.5±1.7	19.8±1.9
*^{173}Hf	c	23.6H	19.9±2.0	17.1±1.9	18.6±1.9	20.9±2.2
^{173}Hf	c*	23.6H	23.5±2.3	20.5±2.1	22.0±2.1	24.4±2.4
^{172}Hf	c	1.87Y	17.3±1.6	16.1±1.5	16.8±1.5	17.7±1.6
^{171}Hf	c	12.1H	14.5±2.5	11.3±1.4	16.0±2.2	18.0±2.4
^{170}Hf	c	16.01H	23.5±2.6	21.3±2.4	21.6±2.4	24.2±2.7
^{173}Lu	c	1.37Y	18.7±1.8	17.2±1.7	18.0±1.8	18.5±1.8
^{172}Lu	i(m+g)	6.70D	0.172±0.031	0.163±0.054	0.196±0.056	0.217±0.023
^{172}Lu	c	6.70D	17.3±1.8	15.9±1.7	16.9±1.8	17.9±1.7
^{171}Lu	c*	8.24D	21.4±1.9	19.0±1.7	20.1±1.8	21.5±1.9
^{171}Lu	c	8.24D	20.5±1.9	18.3±1.7	19.2±1.7	20.3±1.8

Continuation of Table 33.

Product	Type	$T_{1/2}$	Yields [mbarn] for			
			^{206}Pb	^{207}Pb	^{208}Pb	^{nat}Pb
^{170}Lu	c	2.012D	18.1±1.8	16.0±1.9	16.6±1.7	17.4±1.8
^{169}Lu	c	34.06H	16.3±1.5	14.8±1.4	15.4±1.4	16.7±1.9
^{167}Lu	c	51.5M	17.9±1.8	18.2±1.9	16.7±1.7	15.2±1.9
*^{169}Yb	c	32.026D	18.5±1.7	16.9±1.6	17.6±1.6	18.8±1.8
^{169}Yb	c*	32.026D	19.3±1.8	17.6±1.6	18.3±1.7	19.6±1.8
^{166}Yb	c	56.7H	18.1±1.7	16.0±1.5	16.4±1.5	18.4±1.7
^{167}Tm	c	9.25D	20.2±4.3	17.9±3.8	19.1±4.0	19.7±4.1
^{165}Tm	c	30.06H	19.8±1.9	17.9±1.9	18.7±2.0	18.8±1.8
^{161}Er	c*	3.21H	24.8±2.7	21.4±2.4	22.3±2.4	23.8±2.6
^{160}Er	c	28.58H	20.3±1.9	18.4±1.7	18.9±1.7	19.9±1.8
^{159}Er	c*	36M	23.5±2.2	26.4±2.4	20.2±1.8	25.7±2.4
^{160m}Ho	c	5.02H	21.6±2.8	18.5±2.4	18.8±2.5	19.5±2.3
^{156}Ho	c*	56M	23.2±2.2	23.2±2.3	20.7±1.9	22.3±2.1
^{157}Dy	c	8.14H	18.7±1.8	17.2±1.7	17.5±1.7	18.6±1.8
^{155}Dy	c*	9.9H	17.1±1.6	15.3±1.4	16.1±1.5	16.4±1.5
^{152}Dy	c	2.38H	11.6±1.1	10.6±1.0	10.3±0.9	11.2±1.0
^{155}Tb	c*	5.32D	16.9±1.6	15.9±1.7	16.8±1.6	17.0±1.7
^{153}Tb	c*	2.34D	14.8±1.6	13.0±1.4	13.7±1.5	14.4±1.6
^{152}Tb	c	17.5H	11.9±1.3	10.8±1.2	11.5±1.4	12.3±1.3
^{151}Tb	c	17.609H	13.1±1.3	11.5±1.1	11.1±1.1	12.2±1.5
^{149}Tb	c	4.118H	7.25±0.84	6.25±0.64	5.39±0.64	5.19±0.64
^{148}Tb	c	60M	8.63±0.80	7.36±0.76	7.15±0.69	7.49±0.70
^{153}Gd	c	240.4D	12.6±1.2	12.4±1.2	12.9±1.3	13.3±1.5
^{151}Gd	c	124D	12.4±1.5	11.7±1.9	11.7±1.4	12.6±1.5
^{149}Gd	c	9.28D	16.4±1.6	14.0±1.4	14.4±1.4	15.8±1.5
^{147}Gd	c	38.06H	13.5±1.3	12.2±1.2	12.1±1.2	13.4±1.3
^{146}Gd	c	48.27D	14.8±1.4	12.6±1.2	12.6±1.1	14.8±1.4
*^{149}Eu	c	93.1D	18.7±2.0	16.0±2.7	16.4±2.2	19.2±1.9
^{149}Eu	c*	93.1D	20.5±2.0	17.5±2.8	17.9±2.2	21.0±1.9
*^{147}Eu	c	24.1D	17.9±1.7	14.5±1.4	14.9±1.4	16.6±1.6
^{147}Eu	c*	24.1D	18.8±1.8	15.3±1.5	15.8±1.5	17.6±1.7
^{146}Eu	i	4.61D	2.07±0.20	1.95±0.19	2.27±0.21	2.28±0.21
^{146}Eu	c	4.61D	17.2±1.6	14.9±1.4	15.2±1.4	16.6±1.5
^{145}Eu	c	5.93D	12.9±1.2	10.9±1.1	11.1±1.1	12.0±1.2
^{143}Pm	c	265D	12.5±1.4	11.2±1.3	11.1±1.2	12.4±1.3
^{136}Nd	c	50.65M	8.88±1.05	7.81±1.02	5.54±0.67	6.80±0.82
^{139}Ce	c	137.640D	13.0±1.2	11.7±1.0	11.7±1.0	12.7±1.1
^{135}Ce	c	17.7H	11.4±1.2	9.45±0.91	9.77±1.02	11.3±1.1
^{134}Ce	c	3.16D	9.81±1.08	9.26±1.17	10.2±1.1	10.8±1.2
^{132}Ce	c	3.51H	8.54±0.78	8.36±0.77	8.01±0.73	9.10±0.83
^{132}La	c	4.8H	8.94±1.07	7.48±0.89	7.40±0.88	8.31±0.99
^{133}Ba	c	3848.9D	9.09±1.13	7.92±1.93	10.9±1.2	10.4±0.9
^{131}Ba	c	11.50D	9.74±0.91	8.48±0.83	8.74±0.89	9.20±0.90
^{128}Ba	c	2.43D	7.77±1.01	6.93±0.68	6.73±0.84	7.16±0.70
^{129}Cs	c	32.06H	10.8±1.1	9.36±0.99	9.51±1.00	10.3±1.1
^{127}Xe	c	36.4D	8.61±0.81	7.32±0.69	7.60±0.71	8.23±0.78
^{123}Xe	c	2.08H	8.28±0.78	7.62±0.75	7.29±0.68	7.64±0.74
^{123m}Te	i(m)	119.7D	0.214±0.070	0.210±0.041	0.219±0.037	0.218±0.023
^{121m}Te	i(m)	154D	0.548±0.050	0.549±0.051	0.709±0.065	0.641±0.059
^{121}Te	c	19.16D	6.71±0.63	5.60±0.53	5.79±0.55	6.45±0.60

Continuation of Table 33.

Product	Type	$T_{1/2}$	Yields [mbarn] for			
			^{206}Pb	^{207}Pb	^{208}Pb	^{nat}Pb
^{119m}Te	i(m)	4.70D	1.41±0.13	1.41±0.14	1.33±0.12	1.42±0.12
^{120m}Sb	i(m)	5.76D	0.344±0.049	0.302±0.049	0.333±0.033	0.334±0.033
^{113}Sn	c	115.09D	4.08±0.37	3.27±0.31	3.30±0.31	3.75±0.33
^{114m}In	i(m)	49.51D	1.32±0.14	0.907±0.211	1.15±0.19	1.29±0.14
^{111}In	c	2.8047D	4.23±0.39	3.64±0.34	3.51±0.33	4.05±0.38
^{110}In	i	4.9H	2.75±0.28	1.97±0.38	2.15±0.27	2.44±0.35
^{109}In	c	4.2H	3.91±0.42	2.91±0.28	2.99±0.28	3.40±0.32
^{110m}Ag	i(m)	249.76D	0.660±0.073	0.668±0.107	0.651±0.098	0.723±0.068
^{106m}Ag	i(m)	8.28D	1.64±0.16	1.49±0.19	1.35±0.13	1.59±0.15
^{105}Ag	c	41.29D	3.20±0.31	2.46±0.26	2.35±0.24	2.94±0.28
^{100}Pd	c	3.63D	0.723±0.079	0.530±0.101	0.571±0.059	0.756±0.072
^{102}Rh	i	207D	0.905±0.153	0.922±0.180	0.645±0.116	0.757±0.115
^{101m}Rh	c	4.34D	3.33±0.37	3.06±0.34	2.71±0.30	3.22±0.35
^{100}Rh	i(m+g)	20.8H	1.81±0.20	1.29±0.17	1.56±0.16	1.94±0.21
^{100}Rh	c	20.8H	2.53±0.25	1.82±0.19	2.13±0.21	2.70±0.27
^{103}Ru	c	39.26D	2.20±0.21	2.02±0.20	1.93±0.18	2.01±0.18
^{96}Tc	i(m+g)	4.28D	2.04±0.20	1.66±0.16	1.62±0.16	1.87±0.18
^{99}Mo	c	65.94H	2.07±0.19	1.60±0.16	1.76±0.16	1.86±0.18
^{93m}Mo	i(m)	6.85H	1.45±0.14	1.36±0.14	1.31±0.13	1.42±0.15
^{96}Nb	i	23.35H	1.31±0.13	1.23±0.16	1.34±0.18	1.14±0.21
^{95}Nb	c	34.975D	3.16±0.28	2.70±0.24	2.81±0.25	3.04±0.27
^{90}Nb	c*	14.60H	2.53±0.24	1.89±0.18	1.63±0.15	1.95±0.19
^{95}Zr	c	64.02D	1.15±0.11	1.14±0.12	1.19±0.12	1.14±0.10
^{89}Zr	c	78.41H	3.96±0.35	3.18±0.28	2.99±0.26	3.60±0.32
^{88}Zr	c	83.4D	2.56±0.23	2.21±0.20	1.90±0.17	2.22±0.20
^{88}Y	i	106.65D	3.03±0.30	2.86±0.29	2.95±0.28	3.05±0.29
^{88}Y	c	106.65D	6.03±0.59	4.81±0.47	4.42±0.41	5.41±0.51
^{87}Y	c*	79.8H	5.05±0.45	4.03±0.36	4.07±0.36	4.44±0.42
^{86}Y	c	14.74H	2.64±0.24	2.05±0.19	1.96±0.18	2.63±0.25
^{85}Sr	c	64.84D	4.79±0.47	4.05±0.40	3.81±0.37	4.28±0.42
^{84}Rb	i(m+g)	32.77D	3.23±0.31	3.09±0.39	2.63±0.26	3.09±0.28
^{83}Rb	c	86.2D	5.30±0.55	4.46±0.47	4.23±0.50	5.15±0.62
^{82m}Rb	i(m)	6.472H	2.28±0.23	1.95±0.20	2.06±0.21	2.42±0.25
^{82}Br	i(m+g)	35.30H	1.28±0.12	1.02±0.10	1.02±0.10	1.24±0.12
^{75}Se	c	119.779D	2.77±0.25	2.29±0.21	2.19±0.20	2.52±0.23
^{74}As	i	17.77D	2.49±0.28	2.13±0.25	2.05±0.23	2.40±0.27
^{71}As	c	65.28H	0.800±0.084	0.684±0.079	0.582±0.058	0.867±0.081
^{72}Ga	i	14.10H	–	–	–	1.19±0.22
^{72}Ga	c	14.10H	–	–	–	1.42±0.23
^{72}Zn	c	46.5H	–	–	–	0.227±0.041
^{58}Co	i(m+g)	70.86D	1.45±0.18	1.51±0.28	1.15±0.23	1.26±0.12
^{56}Co	c	77.233D	–	–	–	0.106±0.011
^{59}Fe	c	44.472D	1.43±0.15	1.26±0.14	1.31±0.15	1.46±0.14
^{54}Mn	i	312.11D	1.85±0.18	1.60±0.24	1.66±0.16	1.68±0.15
^{48}V	c	15.9735D	0.434±0.043	0.332±0.036	0.303±0.031	0.382±0.037
^{48}Sc	i	43.67H	0.884±0.101	0.746±0.072	0.760±0.072	0.910±0.087
^{46}Sc	i(m+g)	83.79D	1.89±0.17	1.68±0.16	1.58±0.14	1.86±0.17
^{28}Mg	c	20.915H	1.05±0.10	0.923±0.091	0.983±0.091	1.04±0.10
^{24}Na	c	14.9590H	4.56±0.40	3.88±0.35	3.93±0.35	4.51±0.40
^{7}Be	i	53.29D	7.01±0.86	8.35±0.87	5.45±0.55	7.06±0.63

3.13 Experimental results for ^{209}Bi targets irradiated with 0.04, 0.07, 0.1, 0.15, 0.25, 0.4, 0.6, 0.8, 1.2, 1.6, 2.6 GeV protons.

Table 34 presents parameters of ^{209}Bi irradiation by 0.04, 0.07, 0.1, 0.15, 0.25, 0.4, 0.6, 0.8, 1.2, 1.6, 2.6GeV protons. Table 35 presents values of the measured residual nuclide yields.

Table 34: Parameters of ^{209}Bi irradiation.

Proton energy (MeV)	Weight of sample (mg)	Weight of monitor (mg)	Weight of monitor-plate (mg) (mg)	Time of irradiation (min)	Average proton flux p/(cm$^2 \cdot s$) $\times 10^{-10}$	Number of γ-specra sample/ monitor/ plate	ExpData index
37.6±1.4	308.3	121.5	707.6	60	1.78±0.17	25/11/1	bi9040
68.4±1.0	303.6	121.6	713.0	45	2.32±0.16	25/13/1	bi9070
99.3±0.9	298.6	121.6	711.6	20	2.63±0.18	24/13/1	bi9100
149±1	294.4	147.1	713.0	30	3.67±0.27	29/13/1	bi9150
249±1	286.0	122.5	707.6	20	8.26±0.57	36/13/1	bi9250
400±2	293.6	123.3	700.6	30	6.64±0.48	34/12/1	bi9400
599±2	301.6	224.3	719.0	15	3.84±0.27	28/10/1	bi9600
799±2	286.5	122.8	688.4	20	4.34±0.34	26/11/1	bi9800
1190±3	290.5	111.5	692.6	20	5.06±0.39	39/13/1	bi912g
1598±4	342.9	111.1	701.9	20	3.38±0.28	28/11/1	bi916g
2609±8	291.4	110.4	427.6	70	0.978±0.084	31/13/1	bi926g

Table 35: Experimental values of measured yields of ^{209}Bi(p,x) reaction products for E_p = 0.04, 0.07, 0.1, 0.15, 0.25, 0.4, 0.6, 0.8, 1.2, 1.6, 2.6 GeV.

Product	Type	$T_{1/2}$	Yields [mbarn] for 0.04	0.07	0.1	0.15	0.25	0.4	0.6	0.8	1.2	1.6	2.6
^{207}Po	i(m+g)	5.80H	303±31	75.9±6.0	47.4±4.3	29.4±2.4	15.3±1.3	9.67±0.73	6.54±0.50	5.77±0.49	4.86±0.42	4.54±0.41	4.32±0.39
^{206}Po	i	8.8D	1178±120	108±8	61.2±4.6	34.6±2.7	18.9±1.4	10.8±0.8	7.36±0.57	6.17±0.52	4.83±0.40	4.66±0.41	4.15±0.38
^{205}Po	i	1.66H	10.3±1.1	162±13	77.0±6.0	39.8±3.2	22.2±2.0	14.0±1.4	8.29±1.13	–	–	–	–
^{204}Po	i	3.53H	–	351±27	91.9±7.0	42.4±3.3	21.2±1.6	12.9±1.5	9.23±0.86	–	–	–	–
^{203}Po	i(m+g)	36.7M	–	301±24	89.1±7.3	34.6±3.4	16.9±1.7	–	–	–	–	–	–
^{202}Po	i	44.7M	–	3.63±0.28	112±8	27.4±2.2	18.5±2.6	–	–	–	–	–	–
^{201}Po	i(m+g)	15.3M	–	–	29.0±2.5	7.14±1.19	–	–	–	–	–	–	–
^{207}Bi	c	31.55Y	446±45	219±17	169±13	116±10	81.9±6.4	66.4±5.4	61.0±6.1	59.6±5.1	58.7±5.0	60.0±5.4	57.3±5.4
^{206}Bi	i	6.243D	30.4±3.2	124±10	101±8	70.9±5.7	48.9±3.8	40.6±3.3	35.9±2.9	34.2±3.0	32.9±2.8	32.1±2.9	28.7±2.7
^{206}Bi	c	6.243D	1146±117	224±18	159±12	104±8	67.0±5.2	51.1±4.1	42.9±3.4	40.5±3.5	37.1±3.2	36.6±3.3	32.7±3.1
^{205}Bi	c	15.31D	12.8±1.4	295±23	203±16	128±10	78.9±6.0	55.8±4.4	44.7±3.5	40.2±3.5	36.1±3.0	33.9±3.1	29.4±2.7
^{204}Bi	i	11.22H	–	98.0±8.9	119±11	86.0±7.5	51.7±5.2	–	–	–	–	–	–
^{204}Bi	c	11.22H	–	450±37	209±19	125±11	73.6±6.0	–	–	–	–	–	–
*^{204}Bi	c	11.22H	–	–	–	–	–	44.0±3.6	33.0±2.6	–	–	–	–
^{204}Bi	c*	11.22H	–	–	–	–	–	49.9±3.9	37.2±2.9	32.7±2.8	27.6±2.3	25.7±2.3	21.7±2.0
*^{204}Bi	c*	11.22H	–	611±47	251±21	144±12	83.4±6.6	–	–	–	–	–	–
^{203}Bi	c	11.76H	–	413±32	227±17	133±10	77.0±5.8	54.7±4.3	34.6±2.7	30.0±2.5	24.7±2.1	23.3±2.1	18.1±1.7
^{202}Bi	i	1.72H	–	2.56±0.95	110±9	99.8±8.3	67.6±5.8	–	–	–	–	–	–
^{202}Bi	c	1.72H	–	6.87±0.55	220±17	125±10	71.7±5.5	–	–	–	–	–	–
^{202}Bi	c*	1.72H	–	–	–	–	–	47.0±3.9	30.8±2.9	26.7±2.3	21.1±1.9	20.1±1.9	15.0±1.4
*^{202}Bi	c*	1.72H	–	9.64±0.76	305±23	146±11	85.9±6.6	–	–	–	–	–	–
^{201}Bi	c*	108M	–	–	168±14	105±9	68.7±5.2	–	–	–	–	–	–
^{199}Bi	c*	27M	–	–	–	49.8±4.9	29.2±2.9	–	–	–	–	–	–
^{204m}Pb	i(m)	67.2M	3.37±0.35	–	–	9.55±1.75	11.3±1.3	9.69±1.12	10.6±1.0	11.3±1.1	10.4±1.0	10.4±1.1	9.08±0.93
^{204m}Pb	c	67.2M	–	–	–	–	–	16.9±1.5	16.1±1.3	16.2±1.4	14.5±1.3	14.2±1.4	12.3±1.2
^{203}Pb	i(m1+m2+g)	51.873H	–	–	13.9±2.8	27.7±3.6	28.4±2.6	25.2±1.9	30.1±2.9	27.7±2.6	24.3±2.2	19.9±3.1	19.5±2.2
^{203}Pb	c	51.873H	–	–	244±18	161±13	106±8	80.6±6.0	63.3±4.7	57.0±4.6	48.4±3.9	43.5±3.8	36.7±3.3
*^{203}Pb	c	51.873H	–	409±34	–	–	–	–	–	–	–	–	–
^{203}Pb	c*	51.873H	1.39±0.14	530±41	–	–	–	–	–	–	–	–	–
^{202m}Pb	i(m)	3.53H	–	5.34±0.70	8.78±1.28	14.0±1.3	16.7±1.5	14.8±1.3	14.1±1.2	14.4±1.6	11.7±1.3	10.6±1.1	9.60±0.95
^{201}Pb	c*	9.33H	–	12.6±1.2	260±21	171±14	116±9	85.5±7.1	64.9±5.4	58.3±6.1	48.3±4.8	39.7±4.2	32.4±3.4
^{200}Pb	c	21.5H	–	5.28±0.41	67.3±5.3	140±11	86.6±6.5	68.9±5.4	48.6±3.8	39.8±3.4	32.0±2.7	27.7±2.5	21.7±2.0
^{199}Pb	c*	90M	–	–	23.1±2.6	195±20	171±14	143±14	90.9±12.2	56.2±4.8	56.1±5.7	42.2±5.6	38.9±6.2
^{198}Pb	c	2.4H	–	–	27.0±2.5	93.7±7.9	112±9	72.8±5.7	51.8±4.0	55.5±10.3	44.0±8.2	37.9±7.2	30.2±5.8
^{197m}Pb	c*	43M	–	–	6.96±0.64	34.8±3.1	69.0±5.7	62.2±5.7	46.5±4.0	38.0±3.7	28.2±2.6	23.8±2.3	17.6±1.8
^{196}Pb	c*	37M	–	–	–	20.2±2.9	58.1±7.9	60.5±8.4	50.6±7.0	–	–	–	–
^{195m}Pb	i(m)	15.0M	–	–	–	–	30.0±6.0	35.1±7.2	26.1±5.3	20.5±4.2	13.7±2.8	12.2±2.6	9.02±1.92
*^{202}Tl	i	12.23D	–	0.737±0.094	1.82±0.20	2.81±0.27	4.46±0.39	5.97±0.51	6.32±0.54	6.34±0.58	5.95±0.53	5.66±0.53	4.80±0.46
^{202}Tl	c	12.23D	–	1.24±0.09	2.66±0.19	4.14±0.31	6.05±0.43	7.37±0.55	7.66±0.57	7.71±0.63	7.06±0.56	6.67±0.57	5.71±0.50
^{201}Tl	c*	72.912H	–	14.7±1.2	273±20	185±14	129±9	101±8	78.2±5.9	68.1±5.6	55.2±4.5	46.9±4.1	38.5±3.4
^{200}Tl	i	26.1H	–	–	7.51±1.02	16.4±5.1	17.5±2.0	12.6±1.2	14.6±1.4	15.5±1.5	12.5±1.1	11.3±1.4	9.28±0.97
^{200}Tl	c	26.1H	–	5.50±0.45	62.4±4.9	133±11	99.9±7.7	82.2±6.5	62.3±4.9	54.6±4.7	43.8±3.7	38.1±3.4	30.6±2.8
^{199}Tl	c*	7.42H	–	–	23.6±3.1	133±11	121±10	96.1±8.4	79.2±7.5	65.4±6.3	55.5±5.4	45.4±4.6	36.2±3.7
^{198m}Tl	i(m)	1.87H	–	–	–	5.27±0.53	8.91±0.92	15.6±2.2	15.5±3.2	18.9±2.8	12.3±1.8	9.73±1.65	9.51±1.42
*^{197}Tl	c	2.84H	–	–	–	60.7±23.5	88.8±25.1	84.6±27.8	78.3±19.4	57.2±18.1	40.3±16.4	44.6±17.2	18.0±8.4
^{197}Tl	c*	2.84H	–	–	–	72.4±23.5	112±25	106±28	94.0±19.7	70.0±18.4	49.8±16.6	52.7±17.3	24.0±8.5
^{196m}Tl	i(m)	1.41H	–	–	–	12.8±2.5	27.7±5.2	36.4±6.8	34.2±6.5	37.8±7.2	29.2±5.5	24.1±4.6	18.8±3.6
^{195}Tl	c*	1.16H	–	–	–	–	48.9±6.7	60.9±8.7	46.7±6.6	–	–	–	–
^{203}Hg	c	46.612D	–	–	–	0.075±0.022	0.109±0.016	0.229±0.024	–	–	–	–	–

Continuation of Table 35.

Product	Type	$T_{1/2}$	Yields [mbarn] for										
			0.04	0.07	0.1	0.15	0.25	0.4	0.6	0.8	1.2	1.6	2.6
^{197m}Hg	i(m)	23.8H	–	–	–	2.21±0.24	3.55±0.51	5.32±0.57	5.73±0.55	5.65±0.56	4.68±0.44	4.21±0.46	3.57±0.40
^{197}Hg	c*	64.14H	–	–	–	45.5±4.3	80.7±8.1	86.8±7.6	56.0±7.9	–	–	–	–
^{195m}Hg	i(m)	41.6H	–	–	–	–	5.46±1.28	8.05±0.63	9.51±1.42	10.2±1.6	7.24±1.11	–	–
*^{195}Hg	ct	9.9H	–	–	–	–	63.0±7.7	76.4±9.3	69.1±8.3	–	–	–	–
^{195}Hg	c	9.9H	–	–	–	–	57.5±7.2	68.3±8.7	59.6±7.6	–	–	–	–
^{193m}Hg	i(m)	11.8H	–	–	–	–	5.08±1.03	9.54±2.35	11.8±1.7	14.2±2.8	11.1±2.5	7.62±1.58	5.48±1.14
^{192}Hg	c	4.85H	–	–	–	–	23.1±1.7	46.1±3.6	51.7±4.0	46.5±3.9	34.7±2.9	27.2±2.4	19.7±1.8
^{190}Hg	c*	20.0M	–	–	–	–	13.6±2.7	32.0±2.5	43.1±3.3	37.4±3.2	25.0±2.1	19.3±1.7	15.4±2.8
^{198m}Au	i(m)	2.27D	–	–	–	–	–	–	0.057±0.041	0.034±0.016	–	–	–
^{198}Au	i(m+g)	2.69517D	–	–	–	–	–	–	0.514±0.048	0.665±0.055	–	–	–
^{198}Au	i	2.69517D	–	–	–	–	–	0.378±0.031	0.457±0.074	0.631±0.058	–	–	–
^{196}Au	i(m1+m2+g)	6.183D	–	–	–	–	0.327±0.031	0.720±0.055	0.985±0.074	1.11±0.09	1.16±0.10	1.09±0.11	0.860±0.085
^{195}Au	c	186.098D	–	–	–	24.5±2.7	61.7±7.1	70.0±9.1	63.9±8.3	53.0±7.1	39.7±5.3	31.0±4.4	24.4±3.4
^{194}Au	i(m1+m2+g)	38.02H	–	–	–	–	0.641±0.075	1.67±0.19	2.55±0.28	2.74±0.32	2.60±0.30	2.27±0.28	1.92±0.23
^{192}Au	i(m+g)	4.94H	–	–	–	–	0.920±0.471	4.25±0.84	5.83±1.33	6.25±1.03	4.79±0.79	4.60±0.77	4.06±0.67
^{192}Au	c	4.94H	–	–	–	–	29.8±2.4	62.5±5.1	67.0±9.5	61.2±8.9	44.6±6.4	35.5±5.2	26.0±3.9
^{191}Au	c*	3.18H	–	–	–	–	16.3±1.7	45.0±4.2	55.3±4.9	58.9±5.8	32.1±3.7	24.9±3.6	20.5±2.6
^{190}Au	c	42.8M	–	–	–	–	12.0±1.9	–	46.3±4.3	42.7±3.9	36.2±3.3	26.2±3.4	25.2±3.1
^{191}Pt	c	2.802D	–	–	–	–	16.1±1.3	38.8±3.2	45.8±3.7	42.9±3.8	32.3±2.9	25.7±2.5	18.5±2.1
^{189}Pt	c	10.87H	–	–	–	–	9.60±1.87	38.2±3.2	51.1±4.9	49.6±4.4	37.6±3.3	31.6±3.1	25.5±2.7
^{188}Pt	c	10.2D	–	–	–	–	5.10±0.38	27.7±2.2	43.1±3.4	44.9±3.8	33.9±2.8	26.4±2.3	18.4±1.8
^{187}Pt	c	2.35H	–	–	–	–	–	–	29.3±7.2	33.9±8.0	–	–	–
^{186}Pt	c	2.08H	–	–	–	–	–	19.5±4.4	26.9±2.1	28.9±2.4	30.6±7.0	24.4±5.6	16.8±3.9
^{184}Pt	c	17.3M	–	–	–	–	–	–	31.6±6.2	33.2±6.7	28.1±5.6	24.8±5.3	–
^{189}Ir	c	13.2D	–	–	–	–	7.96±1.00	30.4±2.5	40.5±3.5	46.8±7.4	31.5±2.7	26.4±3.5	18.6±2.5
^{188}Ir	c	41.5H	–	–	–	–	4.02±0.39	31.4±2.5	42.0±3.3	46.6±4.0	36.0±3.1	27.5±2.7	–
^{187}Ir	c*	10.5H	–	–	–	–	–	24.4±2.4	38.0±3.4	46.4±4.8	35.2±3.5	24.6±2.9	17.0±1.9
^{186}Ir	c	16.64H	–	–	–	–	–	9.55±0.87	18.4±1.7	20.4±1.9	15.5±1.4	12.5±1.2	8.43±0.83
^{185}Ir	c	14.4H	–	–	–	–	–	13.2±1.3	26.6±2.4	31.0±2.9	24.8±2.3	18.6±1.9	12.3±1.5
^{184}Ir	c*	3.09H	–	–	–	–	–	13.2±1.3	33.6±2.9	39.5±3.7	34.9±3.1	26.4±2.5	18.0±1.7
^{183}Ir	c	57M	–	–	–	–	–	–	–	38.0±9.5	33.7±8.3	–	–
^{185}Os	c	93.6D	–	–	–	–	1.27±0.10	16.2±1.3	35.8±2.9	42.7±3.7	35.2±3.0	27.6±2.5	18.8±1.8
^{183m}Os	c*	9.9H	–	–	–	–	–	6.15±0.50	17.3±1.4	23.9±2.1	21.1±1.8	16.7±1.5	10.7±1.0
^{182}Os	c	22.10H	–	–	–	–	–	9.15±0.72	30.3±2.4	42.3±3.6	40.4±3.4	30.6±2.7	20.6±1.9
^{181}Os	c	105M	–	–	–	–	–	3.71±0.57	10.5±1.6	13.1±1.9	12.6±1.9	8.01±1.30	7.36±1.17
^{180}Os	c	21.5M	–	–	–	–	–	–	21.5±1.9	33.3±3.4	32.1±2.9	27.4±2.6	18.8±2.2
^{183}Re	c	70.0D	–	–	–	–	0.442±0.042	10.6±0.9	30.8±2.5	40.7±3.5	35.0±3.2	27.9±2.6	19.5±1.9
^{182m}Re	c	12.7H	–	–	–	–	–	10.7±1.0	32.9±2.7	44.4±4.1	38.9±3.4	30.5±2.9	21.1±2.1
*^{181}Re	c	19.9H	–	–	–	–	–	6.13±1.05	24.4±3.2	35.9±4.7	34.2±4.4	27.5±3.9	16.5±2.4
^{181}Re	c*	19.9H	–	–	–	–	–	6.48±1.04	25.4±3.3	37.2±4.8	35.4±4.5	28.3±3.9	17.2±2.4
^{179}Re	c*	19.5M	–	–	–	–	–	–	23.4±2.6	42.0±5.3	45.9±4.3	39.9±3.8	25.1±3.4
^{178}Re	c*	13.2M	–	–	–	–	–	–	23.7±3.3	43.8±6.2	49.0±6.9	38.9±5.7	28.6±4.4
^{178}W	c	21.6D	–	–	–	–	–	–	23.9±4.3	33.5±4.3	28.2±2.9	25.4±2.6	18.5±3.3
^{177}W	c	135M	–	–	–	–	–	–	15.0±2.1	26.5±3.7	32.7±4.6	28.1±4.2	18.4±2.7
*^{177}Ta	c	56.56H	–	–	–	–	–	–	15.7±4.0	27.9±7.2	34.6±8.8	27.8±7.2	18.8±4.8
^{177}Ta	c*	56.56H	–	–	–	–	–	–	16.3±4.0	29.0±7.2	36.0±8.8	29.0±7.2	19.5±4.8
^{176}Ta	c*	8.09H	–	–	–	–	–	–	16.2±1.8	31.6±3.3	42.2±3.7	35.2±3.5	22.7±2.3
^{175}Ta	c	10.5H	–	–	–	–	–	–	11.2±1.0	25.0±2.6	31.7±3.0	26.2±4.8	17.0±2.9
^{174}Ta	c	1.14H	–	–	–	–	–	–	–	19.6±2.3	30.5±3.6	28.6±3.5	18.6±2.3
^{173}Ta	c	3.14H	–	–	–	–	–	–	10.0±1.4	22.6±3.0	35.3±4.7	32.8±4.5	24.1±3.3
^{172}Ta	c*	36.8M	–	–	–	–	–	–	–	10.7±1.4	18.7±2.3	17.9±2.3	14.3±1.9
^{175}Hf	c	70D	–	–	–	–	–	0.967±0.083	10.2±0.8	23.1±2.0	31.9±2.8	27.6±2.5	17.8±1.7

Continuation of Table 35.

Product	Type	$T_{1/2}$	Yields [mbarn] for										
			0.04	0.07	0.1	0.15	0.25	0.4	0.6	0.8	1.2	1.6	2.6
$*^{173}$Hf	c	23.6H	–	–	–	–	–	–	4.81±1.04	19.6±1.9	33.6±3.8	31.4±4.0	23.7±2.9
^{173}Hf	c*	23.6H	–	–	–	–	–	0.628±0.086	6.34±1.07	23.0±2.1	39.0±4.1	36.5±4.2	27.3±3.1
^{172}Hf	c	1.87Y	–	–	–	–	–	0.265±0.060	5.32±0.41	16.1±1.4	26.2±2.2	25.4±2.3	15.9±1.5
^{170}Hf	c	16.01H	–	–	–	–	–	–	4.70±0.55	12.2±1.0	32.6±3.0	32.1±3.5	22.0±2.5
^{168}Hf	c	25.95M	–	–	–	–	–	–	–	–	–	25.2±6.9	18.8±5.1
^{173}Lu	c	1.37Y	–	–	–	–	–	0.414±0.068	6.90±0.60	19.2±1.8	29.7±2.6	27.1±2.6	16.9±1.7
^{172}Lu	i(m+g)	6.70D	–	–	–	–	–	–	–	–	–	0.149±0.026	0.158±0.023
^{172}Lu	c	6.70D	–	–	–	–	–	0.351±0.083	5.33±0.43	16.3±1.4	26.3±2.3	25.1±2.3	16.5±1.6
^{171}Lu	c*	8.24D	–	–	–	–	–	–	5.28±0.41	17.5±1.5	32.0±2.7	30.0±2.7	20.3±1.9
^{170}Lu	c	2.012D	–	–	–	–	–	–	–	–	–	–	15.2±1.6
$*^{170}$Lu	c	2.012D	–	–	–	–	–	–	3.10±0.48	11.9±1.3	19.6±2.2	19.8±2.6	–
^{170}Lu	c*	2.012D	–	–	–	–	–	–	5.44±0.53	17.9±1.6	35.7±3.1	35.7±3.4	24.5±2.3
^{169}Lu	c	34.06H	–	–	–	–	–	–	2.89±0.31	9.37±0.85	21.6±1.9	21.5±2.0	15.4±1.4
^{167}Lu	c	51.5M	–	–	–	–	–	–	–	8.48±1.84	22.9±1.9	24.1±3.4	17.8±2.0
$*^{169}$Yb	c	32.026D	–	–	–	–	–	–	2.94±0.24	12.3±1.1	26.0±2.2	26.2±2.4	18.0±1.7
^{169}Yb	c*	32.026D	–	–	–	–	–	–	3.07±0.25	12.7±1.1	27.0±2.3	27.2±2.5	18.7±1.8
^{166}Yb	c	56.7H	–	–	–	–	–	–	–	7.36±0.62	21.2±1.8	23.1±2.2	16.4±1.6
^{162}Yb	c	18.87M	–	–	–	–	–	–	–	–	16.3±2.5	22.8±3.5	18.8±3.1
^{167}Tm	c	9.25D	–	–	–	–	–	–	–	9.21±1.91	23.9±2.2	25.7±2.7	18.1±1.9
^{165}Tm	c	30.06H	–	–	–	–	–	–	0.830±0.108	6.61±0.65	21.2±1.9	24.9±2.4	18.2±2.0
^{163}Tm	c	1.810H	–	–	–	–	–	–	–	–	15.6±1.9	20.2±2.7	16.3±2.0
^{161}Er	c*	3.21H	–	–	–	–	–	–	–	–	16.6±1.7	23.4±2.6	20.0±2.2
^{160}Er	c	28.58H	–	–	–	–	–	–	–	3.50±0.60	15.3±1.3	22.1±2.0	18.4±1.7
^{159}Er	c*	36M	–	–	–	–	–	–	–	–	15.5±1.3	23.7±2.1	22.4±2.0
^{160m}Ho	c	5.02H	–	–	–	–	–	–	–	–	18.4±2.8	22.3±2.9	17.6±2.3
^{156}Ho	c*	56M	–	–	–	–	–	–	–	–	11.5±1.0	21.2±1.9	22.6±2.1
^{157}Dy	c	8.14H	–	–	–	–	–	–	–	1.68±0.17	11.1±1.0	18.2±1.8	17.2±1.7
^{155}Dy	c*	9.9H	–	–	–	–	–	–	–	–	8.53±0.75	15.0±1.4	15.8±1.5
^{152}Dy	c	2.38H	–	–	–	–	–	–	–	–	–	8.96±0.81	10.8±1.0
^{155}Tb	c*	5.32D	–	–	–	–	–	–	–	1.19±0.15	8.59±0.85	15.6±1.5	14.9±1.4
^{153}Tb	c*	2.34D	–	–	–	–	–	–	–	–	5.75±1.04	11.6±1.7	13.0±1.5
$*^{152}$Tb	c	17.5H	–	–	–	–	–	–	–	–	–	10.2±1.2	11.0±1.4
^{152}Tb	c*	17.5H	–	–	–	–	–	–	–	–	–	11.6±1.3	12.7±1.4
^{151}Tb	c	17.609H	–	–	–	–	–	–	–	–	–	9.90±0.95	11.2±1.1
^{150}Tb	c	3.48H	–	–	–	–	–	–	–	–	2.54±0.47	5.32±0.91	6.05±1.01
^{149}Tb	c	4.118H	–	–	–	–	–	–	–	–	–	5.07±0.54	5.92±0.62
^{148}Tb	c	60M	–	–	–	–	–	–	–	–	–	7.07±0.71	6.97±0.73
^{153}Gd	c	240.4D	–	–	–	–	–	–	–	–	5.73±0.57	10.9±1.2	11.7±1.2
^{151}Gd	c	124D	–	–	–	–	–	–	–	–	4.78±0.45	10.1±1.0	11.4±1.1
^{149}Gd	c	9.28D	–	–	–	–	–	–	–	0.646±0.132	5.06±0.47	12.5±1.2	15.1±1.5
^{147}Gd	c	38.06H	–	–	–	–	–	–	–	–	3.82±0.36	9.47±0.90	12.7±1.2
^{146}Gd	c	48.27D	–	–	–	–	–	–	–	0.360±0.036	3.76±0.31	9.86±0.88	14.0±1.3
$*^{149}$Eu	c	93.1D	–	–	–	–	–	–	–	–	6.41±0.62	13.9±1.4	17.1±1.6
^{149}Eu	c*	93.1D	–	–	–	–	–	–	–	–	6.97±0.66	15.2±1.5	18.7±1.8
$*^{147}$Eu	c	24.1D	–	–	–	–	–	–	–	–	4.41±0.40	11.4±1.1	15.5±1.5
^{147}Eu	c*	24.1D	–	–	–	–	–	–	–	–	4.68±0.41	12.1±1.1	16.4±1.6
^{146}Eu	i	4.61D	–	–	–	–	–	–	–	0.227±0.090	0.585±0.051	1.35±0.12	1.86±0.19
^{146}Eu	c	4.61D	–	–	–	–	–	–	–	0.587±0.096	4.25±0.36	11.1±1.0	15.8±1.6
^{145}Eu	c	5.93D	–	–	–	–	–	–	–	–	2.50±0.23	7.71±0.73	10.9±1.0
^{143}Pm	c	265D	–	–	–	–	–	–	–	–	2.27±0.30	6.76±0.72	11.5±1.2
^{136}Nd	c	50.65M	–	–	–	–	–	–	–	–	–	–	7.80±0.97
^{134}Pr	c*	17M	–	–	–	–	–	–	–	–	–	–	6.92±0.79

Continuation of Table 35.

Product	Type	$T_{1/2}$	Yields [mbarn] for										
			0.04	0.07	0.1	0.15	0.25	0.4	0.6	0.8	1.2	1.6	2.6
^{139}Ce	c	137.640D	–	–	–	0.100±0.012	0.171±0.015	0.267±0.021	0.326±0.029	0.541±0.047	1.94±0.16	5.86±0.51	11.7±1.0
^{135}Ce	c	17.7H	–	–	–	–	–	–	–	–	–	3.72±0.37	10.3±1.1
^{134}Ce	c	3.16D	–	–	–	–	–	–	–	–	–	–	9.63±0.98
^{132}Ce	c	3.51H	–	–	–	–	–	–	–	–	–	3.05±0.27	8.70±0.79
^{130}Ce	c	25M	–	–	–	–	–	–	–	–	–	–	5.07±0.62
^{132}La	c	4.8H	–	–	–	–	–	–	–	–	0.692±0.163	2.66±0.32	7.19±0.86
^{133}Ba	c	3848.9D	–	–	–	–	–	–	–	–	1.50±0.72	3.63±0.40	9.19±1.06
^{131}Ba	c	11.50D	–	–	–	–	–	0.435±0.061	–	0.820±0.108	1.43±0.13	3.33±0.31	8.81±0.83
^{128}Ba	c	2.43D	–	–	–	–	–	–	–	–	0.829±0.104	2.14±0.22	6.97±0.78
^{129}Cs	c	32.06H	–	–	–	–	–	1.11±0.11	1.25±0.16	1.70±0.18	2.25±0.23	4.27±0.47	9.78±1.02
^{127}Xe	c	36.4D	–	–	–	0.271±0.025	0.532±0.043	0.830±0.068	1.12±0.09	1.36±0.12	1.75±0.15	3.10±0.28	7.71±0.72
^{125}Xe	c	16.9H	–	–	–	–	–	–	–	–	–	3.80±0.38	8.01±0.74
^{123}Xe	c	2.08H	–	–	–	–	–	–	–	–	2.37±0.31	3.79±0.45	7.34±0.72
^{126}I	i	13.11D	–	–	–	0.650±0.144	0.617±0.076	0.501±0.077	0.390±0.063	0.389±0.061	0.256±0.050	0.245±0.045	–
^{124}I	i	4.1760D	–	–	–	–	–	0.696±0.058	0.962±0.083	0.975±0.086	–	–	–
^{121}I	c*	2.12H	–	–	–	–	–	–	–	2.32±0.24	–	2.92±0.32	7.05±0.68
^{123m}Te	i(m)	119.7D	–	–	0.254±0.023	0.584±0.047	0.659±0.052	0.723±0.056	0.687±0.064	0.641±0.062	0.560±0.054	0.411±0.038	0.316±0.039
^{121m}Te	i(m)	154D	–	–	–	0.272±0.027	0.527±0.040	0.755±0.059	0.876±0.068	0.899±0.076	0.726±0.060	0.691±0.062	0.680±0.062
^{121}Te	c	19.16D	–	–	–	–	0.382±0.037	0.981±0.079	1.42±0.13	1.65±0.14	1.91±0.16	2.58±0.24	6.11±0.61
^{119m}Te	i(m)	4.70D	–	–	–	–	–	0.345±0.031	0.508±0.042	0.772±0.069	0.806±0.067	0.866±0.088	1.36±0.12
^{119}Te	c	16.05H	–	–	–	–	–	–	–	–	–	–	3.61±0.34
^{116}Te	c	2.49H	–	–	–	–	–	–	–	–	1.38±0.24	1.30±0.25	3.71±0.49
^{124}Sb	i(m1+m2+g)	60.20D	–	0.283±0.025	0.415±0.037	0.347±0.030	0.254±0.031	0.212±0.020	0.159±0.019	–	–	–	–
^{122}Sb	i(m+g)	2.7238D	–	–	0.630±0.055	0.773±0.065	0.717±0.057	–	–	–	–	–	–
^{120m}Sb	i(m)	5.76D	–	–	0.201±0.028	0.683±0.056	0.815±0.065	1.04±0.08	1.10±0.13	0.884±0.102	0.625±0.053	0.555±0.052	0.410±0.039
^{118m}Sb	i(m)	5.00H	–	–	–	–	–	1.11±0.12	–	1.16±0.16	0.896±0.116	–	1.04±0.12
^{115}Sb	c*	32.1M	–	–	–	–	–	–	–	–	–	2.30±0.28	5.58±0.56
^{117m}Sn	i(m)	13.60D	–	–	–	0.924±0.075	1.24±0.10	1.58±0.12	1.71±0.14	1.60±0.13	1.22±0.10	1.11±0.10	0.833±0.080
^{113}Sn	c	115.09D	–	–	–	–	–	0.408±0.037	0.622±0.058	1.05±0.09	1.32±0.11	1.61±0.14	3.55±0.31
^{114m}In	i(m)	49.51D	–	–	–	0.757±0.117	1.45±0.12	2.00±0.17	2.24±0.20	2.55±0.22	2.27±0.20	1.62±0.21	1.54±0.15
^{111}In	c	2.8047D	–	–	–	–	0.217±0.029	0.646±0.065	1.20±0.11	1.61±0.14	1.92±0.17	2.13±0.20	4.10±0.38
^{109}In	c	4.2H	–	–	–	–	–	–	–	–	–	–	3.39±0.35
^{115}Cd	c	53.46H	–	–	1.59±0.20	1.19±0.10	0.868±0.076	0.695±0.064	0.598±0.053	–	–	–	–
^{110m}Ag	i(m)	249.76D	–	–	0.466±0.048	1.43±0.12	1.99±0.15	2.43±0.19	2.62±0.21	2.39±0.20	1.83±0.15	1.45±0.13	1.03±0.10
^{106m}Ag	i(m)	8.28D	–	–	–	–	0.222±0.037	0.505±0.070	1.03±0.20	1.33±0.12	1.43±0.13	1.44±0.13	1.69±0.16
^{105}Ag	c	41.29D	–	–	–	–	–	0.348±0.152	0.905±0.111	1.10±0.13	1.72±0.17	1.90±0.20	2.79±0.30
^{100}Pd	c	3.63D	–	–	–	–	–	–	–	0.066±0.037	0.168±0.034	0.261±0.036	0.656±0.067
^{107}Rh	c	21.7M	–	3.55±0.46	8.12±1.01	9.86±1.32	–	–	–	–	–	–	–
^{105}Rh	c	35.36H	–	4.17±0.51	6.47±0.54	8.77±0.83	8.27±0.78	9.23±0.75	8.28±0.68	9.05±0.79	6.58±0.58	5.00±0.51	–
^{102m}Rh	i(m)	2.9Y	–	–	–	–	0.720±0.077	1.04±0.11	1.90±0.80	1.93±0.23	1.90±0.26	–	–
^{102}Rh	i	207D	–	–	–	–	–	–	–	0.440±0.213	–	1.36±0.19	1.04±0.15
^{101m}Rh	c	4.34D	–	–	–	–	0.268±0.030	0.840±0.089	1.61±0.16	1.96±0.21	2.33±0.24	2.46±0.26	3.45±0.37
^{101}Rh	c	3.3Y	–	–	–	–	–	0.343±0.059	–	–	–	–	–
^{100}Rh	i(m+g)	20.8H	–	–	–	–	–	–	–	1.08±0.12	1.27±0.14	1.50±0.18	1.67±0.19
^{100}Rh	c	20.8H	–	–	–	–	–	–	–	1.15±0.11	1.44±0.14	1.76±0.19	2.33±0.24
^{99m}Rh	c	4.7H	–	–	–	–	–	–	–	–	–	–	1.61±0.20
^{106}Ru	c	373.59D	–	2.49±0.27	4.08±0.44	2.62±0.54	2.97±0.27	–	–	–	–	–	–
^{103}Ru	c	39.26D	0.464±0.064	3.53±0.27	6.50±0.48	8.10±0.62	8.21±0.60	8.66±0.70	8.33±0.67	7.69±0.63	5.69±0.46	4.49±0.39	3.34±0.30
^{96}Tc	i(m+g)	4.28D	–	–	–	–	0.227±0.028	0.714±0.081	1.38±0.12	1.93±0.18	2.13±0.19	2.11±0.20	2.15±0.21
^{99}Mo	c	65.94H	–	3.47±0.34	6.91±0.59	7.56±0.68	7.99±0.68	7.98±0.68	7.76±0.66	6.50±0.60	5.15±0.46	3.89±0.38	2.98±0.29
^{93m}Mo	i(m)	6.85H	–	–	–	–	–	–	–	1.10±0.14	0.986±0.115	1.07±0.17	1.41±0.14
^{96}Nb	i	23.35H	–	–	1.62±0.17	3.20±0.26	4.10±0.31	5.15±0.41	5.13±0.43	4.77±0.42	3.72±0.32	3.00±0.29	1.71±0.18

Continuation of Table 35.

Product	Type	$T_{1/2}$	Yields [mbarn] for										
			0.04	0.07	0.1	0.15	0.25	0.4	0.6	0.8	1.2	1.6	2.6
^{95}Nb	i(m+g)	34.975D	0.069±0.007	0.118±0.048	0.882±0.073	2.43±0.18	4.07±0.29	5.44±0.40	5.91±0.43	5.98±0.48	4.86±0.38	3.96±0.35	2.79±0.25
^{95}Nb	c	34.975D	0.388±0.038	3.15±0.23	6.22±0.44	8.04±0.59	9.22±0.65	10.6±0.8	10.9±0.8	10.2±0.8	7.90±0.62	6.54±0.56	4.50±0.39
^{92m}Nb	i(m)	10.15D	–	–	–	–	–	0.311±0.030	0.441±0.035	0.419±0.040	0.422±0.048	–	–
^{90}Nb	c*	14.60H	–	–	–	–	–	0.260±0.054	–	0.898±0.105	1.26±0.11	1.47±0.15	2.09±0.21
^{97}Zr	c	16.744H	–	–	2.83±0.23	2.26±0.20	2.25±0.17	1.43±0.12	1.12±0.10	1.17±0.11	1.01±0.09	–	–
^{95}Zr	c	64.02D	0.322±0.033	3.02±0.23	5.28±0.40	5.63±0.44	5.21±0.39	5.17±0.40	5.05±0.39	4.16±0.35	3.10±0.26	2.57±0.23	1.72±0.16
^{89}Zr	c	78.41H	–	–	–	–	0.400±0.041	1.21±0.09	2.35±0.18	3.10±0.25	3.82±0.30	3.75±0.32	4.10±0.36
^{88}Zr	c	83.4D	–	–	–	–	0.071±0.045	0.293±0.023	0.809±0.063	1.24±0.11	1.81±0.15	2.00±0.18	2.49±0.23
^{90m}Y	i(m)	3.19H	–	–	–	–	3.89±0.29	5.68±0.50	6.37±0.82	5.49±0.46	4.27±0.36	3.35±0.33	2.23±0.22
^{88}Y	i	106.65D	–	–	–	–	1.33±0.10	3.02±0.28	4.42±0.33	5.40±0.47	5.17±0.41	4.75±0.43	3.60±0.33
^{88}Y	c	106.65D	–	–	–	0.333±0.030	1.40±0.10	3.24±0.28	5.16±0.38	6.55±0.58	7.07±0.56	6.82±0.62	6.18±0.59
^{87}Y	c*	79.8H	–	–	–	–	0.578±0.047	1.62±0.15	3.14±0.25	4.47±0.36	5.29±0.42	5.26±0.45	5.57±0.49
^{85}Sr	c	64.84D	–	–	–	–	0.622±0.060	1.70±0.15	3.33±0.28	4.36±0.40	5.08±0.45	5.12±0.49	4.91±0.48
^{86}Rb	i(m+g)	18.631D	–	–	–	2.41±0.21	4.17±0.31	6.46±0.49	6.74±0.53	6.96±0.58	5.33±0.46	–	–
^{84}Rb	i(m+g)	32.77D	–	–	–	0.510±0.109	1.59±0.14	–	–	–	5.30±0.47	4.75±0.43	3.62±0.38
^{83}Rb	c	86.2D	–	–	–	0.218±0.082	0.756±0.073	2.01±0.17	3.77±0.32	5.04±0.46	5.88±0.52	5.79±0.55	5.57±0.54
^{82m}Rb	i(m)	6.472H	–	–	–	–	–	–	–	1.77±0.30	2.28±0.31	2.76±0.36	2.99±0.34
^{82}Br	i(m+g)	35.30H	–	–	1.00±0.09	1.81±0.19	2.49±0.19	3.26±0.26	3.65±0.31	3.56±0.31	3.17±0.33	2.20±0.20	1.66±0.16
^{75}Se	c	119.779D	–	–	–	–	0.125±0.019	0.513±0.056	1.12±0.12	1.82±0.18	2.37±0.23	2.84±0.27	3.15±0.38
^{76}As	i	1.0778D	–	–	–	–	–	2.45±0.24	2.68±0.26	3.21±0.33	4.48±0.43	4.88±0.64	3.06±0.39
^{74}As	i	17.77D	–	–	–	–	0.452±0.063	1.09±0.11	2.02±0.21	2.75±0.29	3.18±0.33	3.08±0.34	2.75±0.31
^{71}As	c	65.28H	–	–	–	–	–	–	–	–	0.368±0.034	0.490±0.049	0.845±0.080
^{72}Ga	i	14.10H	–	–	–	–	–	1.40±0.21	1.99±0.22	2.12±0.20	2.03±0.21	1.23±0.16	1.41±0.14
^{72}Ga	c	14.10H	–	–	–	–	–	1.91±0.24	2.42±0.24	2.58±0.23	2.41±0.23	1.81±0.19	1.60±0.16
^{72}Zn	c	46.5H	–	–	–	–	–	0.511±0.046	0.440±0.049	0.457±0.047	0.379±0.050	0.583±0.063	0.186±0.030
^{65}Zn	c	244.26D	–	–	–	–	–	–	–	–	1.08±0.11	1.31±0.13	2.01±0.18
^{58}Co	i(m+g)	70.86D	–	–	–	–	–	–	–	–	–	0.967±0.102	1.33±0.19
^{56}Co	c	77.233D	–	–	–	–	–	–	–	–	–	–	0.075±0.017
^{59}Fe	c	44.472D	–	–	–	–	0.253±0.033	0.501±0.071	0.915±0.109	1.13±0.11	1.43±0.12	1.51±0.14	1.59±0.15
^{54}Mn	i	312.11D	–	–	–	–	–	–	–	0.410±0.056	0.789±0.066	1.17±0.13	1.79±0.16
^{52}Mn	c	5.591D	–	–	–	–	–	–	–	–	–	–	0.198±0.025
^{48}V	c	15.9735D	–	–	–	–	–	–	–	–	0.129±0.014	0.154±0.018	0.385±0.054
^{48}Sc	i	43.67H	–	–	–	–	–	–	–	0.317±0.039	0.566±0.048	0.576±0.055	0.797±0.087
^{46}Sc	i(m+g)	83.79D	–	–	–	–	–	0.046±0.008	0.094±0.020	0.321±0.036	0.578±0.053	0.998±0.091	1.88±0.16
^{28}Mg	c	20.915H	–	–	–	–	–	–	–	–	–	0.367±0.044	1.04±0.10
^{24}Na	c	14.9590H	–	–	–	–	–	–	–	–	0.865±0.080	1.81±0.18	4.38±0.39
^{7}Be	i	53.29D	–	–	–	–	1.07±0.13	1.23±0.13	1.72±0.26	2.01±0.24	3.77±0.36	5.33±0.48	8.18±0.73

3.14 Inconsistence of PCNUDAT database

The nuclear decay data from PCNUDAT database [33] were used to obtain the nuclear reaction cross sections. Analysis of obtained experimental data together with the observed behavior of the decay curves of the reaction products have exposed some drawbacks of the database, namely,

1. PCNUDAT is devoid of some nuclide γ-lines that occur in the γ-spectra of measured samples:
   - γ-lines of two ^{158m}Ho metastable states ($T_{1/2}$ = 28 min. and 21.3 min) and ground state ($T_{1/2}$ = 11.3 min.) with energy above 67.2 keV are absent, while the 846.7 и 847.4 keV γ-lines of ^{158m}Ho ($T_{1/2}$ = 28 min) make it difficult to determine the ^{56}Mn ($T_{1/2}$ = 2.5789 h) by the 845.75 keV γ-line;
   - data on ^{171}Hf ($T_{1/2}$ = 12.1 h) γ-lines are absent, except for 20.0 keV γ-line. Therefore, the ^{171}Hf cross section was inferred from the ^{171}Hf $\rightarrow$ ^{171}Lu decay curve;
   - information on the ^{188}Au ($T_{1/2}$ = 8.84 min.) γ-lines is absent outright, whereas the peaks of the nuclide are observed in the measured γ-spectra and are present in the REUS database [127].
2. PCNUDAT presents discrepant quantum yields for some nuclides. Therefore, the cross sections inferred from quantum yields of a given nuclide prove to be very different. From Table 36 it follows that the ^{188}Pt cross sections inferred from the ^{188}Ir γ-line energies of up to 1210 keV are 1.44 times the cross sections inferred from the γ-line energies above 1210 keV.

Table 36: The ^{188}Pt cross sections inferred from the ^{188}Ir γ-line energies of up to 1210 keV.

E_γ	Q. yield	Error	Cr. sect.	Error
2214.59	18.7	1.6	38.4	3.4
2059.65	7.1	0.6	36.4	3.2
2049.78	5.0	0.4	35.9	3.0
1715.67	6.2	0.5	35.1	2.9
1574.48	2.63	0.24	34.6	3.3
	mean		36.0	1.4
1209.77	6.9	0.7	53.8	5.5
633.02	18	3	58.1	9.7
477.99	14.7	0.6	51.0	2.3
322.91	1.62	0.15	50.4	4.8
155.05	30	3	54.6	5.6
	mean		51.8	1.8

Table 37 lists the ^{188}Pt cross sections inferred from the ^{188}Pt lines.

The mean cross section from Table 37 is seen to be the same, within the errors, as the mean cross section in Table 36 at energies of up to 1210 keV. In all the experimental runs,

Table 37: The ^{188}Pt cross sections inferred from ^{188}Pt eigenlines.

E_γ	Q. yield	Error	Cr. sect.	Error
187.59	19.4	1.2	52.8	3.5
195.05	18.6	1.2	51.6	3.5
423.34	4.4	0.3	51.9	3.7
381.43	7.5	0.5	50.5	3.5
	mean		51.7	1.8

therefore, the ^{188}Ir and ^{188}Pt cross sections were inferred from γ-line energies of up to 1210 keV.

A twofold difference is observed in the ^{198}Pb ($T_{1/2}$ = 2.4 h) cross sections inferred from the, 173.4 and 290.3 keV γ-lines. In the experiments with 100 - 600 MeV protons, the nuclide cross section can be inferred from other γ-lines. Within the errors, the cross sections coincide with those inferred from the 173.4 keV γ-line. Therefore, the 173.4 keV γ-line was selected in all experiments to determine the cross sections.

The ^{177}W cross section inferred from the 115.65 keV γ-line is about two times as small as the cross sections inferred from other γ-lines of the nuclide. In all the experiments, the cross sections were inferred from the 115.65 keV γ-line because it has the highest quantum yield.

3. The determined cross sections were sometimes found to be unbalanced within the same isobaric chain. In a few chains, the cumulative cross sections of nuclides exceeded the cross sections of their isobaric chain daughters, which may be accounted for by occurrences of unknown transitions in the radionuclide decay chains.

   - The ^{199}Pb ($T_{1/2}$=90min) cross sections are significantly in excess of the ^{199}Tl ($T_{1/2}$ = 7.42h) cross sections for Pb at E_p = 100 and 150 MeV and for Bi at E_p = 150, 250, and 400 MeV. The differences for the rest targets and proton energies are within experimental errors;
   - the cross section of ^{189}Pt ($T_{1/2}$ = 10.87 h) exceeds that of ^{189}Ir ($T_{1/2}$ = 13.2 h). Normally, the difference fails to extend to beyond the error in experimental determining the cross sections, but is always observed experimentally;
   - the cross sections of ^{173}Lu ($T_{1/2}$ = 1.37 years) are significantly below those of its precursors ^{173}Hf ($T_{1/2}$ = 23.6 h) and ^{173}Ta ($T_{1/2}$ = 3.14 h);
   - the cross sections of ^{170}Lu ($T_{1/2}$ = 2.012 days) are significantly below those of its precursor ^{170}Hf ($T_{1/2}$ = 16.01 hours).

3.15 Comparison with the data obtained elsewhere

To compare the reported Project results with the data obtained elsewhere, we have analyzed 326 works from the EXFOR international database that determined the cross sections and yields of secondary nuclear reaction products. Of 326 works, 82 publications ([45] – [123]) used the Pb and Bi as target nuclei, just as in this Project. The data from 68 publications were compared with the reported results. The rest 14 works were excluded from the comparison because:

- work [78] studied the reaction cross sections of the ^{204}Pb isotope, which we did not use;
- works [47], [48], [49], [50], [111], and [112] experimented with thick targets;
- works [72], [84], [96], [99], [104], [107], and [110] measured the ratios of secondary nuclide reaction rates rather than the absolute values of the reaction rates;

Figs. 53 - 83 present the reported data together with the results obtained elsewhere. Most (>90%) of the displayed data of other laboratories are from [56, 82, 83, 90, 93, 94, 102, 105, 106, 108, 117, 123]. It should be noted that nearly all works make use of the same method as in the reported Project, namely the direct kinematics together with γ-spectrometry, thus permitting a straightforward comparison among the results. The works [102] and [123] use the inverse kinematics method, so their data were recalculated using formulas (160) and (161) with the branching factors from the ENSDF database (see Section 5 for more details).

The comparison of most (above ~80%) of the data reported here with the results obtained elsewhere has demonstrated a satisfactory agreement. To exemplify the agreement, Fig. 26 shows the ^{203}Bi(i(m+g)), ^{203}Pb(c), and ^{200}Pb(c) excitation functions.

In some cases, however, the agreement with the inverse kinematics results are explicitly unsatisfactory. Presented as an example in Fig. 27 are the data for ^{186}Ir(c), ^{105}Rh(c), and ^{59}Fe(c)), which, on the other hand, demonstrate a satisfactory agreement with most of the direct kinematics results.

A satisfactory agreement with the inverse kinematics results is also observed sometimes (the examples are presented in Fig. 28 for ^{173}Lu(c)), while the agreement with the direct kinematics results is not satisfactory. Finally, there exist the cases of unsatisfactory agreement with both direct and inverse kinematics results (^{121}Te(c) in Fig. 28 is a relevant example).

The observed disagreement with the direct kinematics results is accounted for by the differences in the methods used to process γ-spectra, by the errors in identifying γ-speectra, and by discrepancies in the decay databases and in the monitor reaction cross sections. Importance of using different decay data bases and of different $\gamma-$spectra processing methods is well demonstrated via the data comparison with the data obtained in our previous works, for example in [4], which was made using GDISP database [124] and ASPRO [125] $\gamma-$processing code with just automatic mode.

The observed disagreement with the inverse kinematics results can also be accounted for by uncertainties in the decay chain branching factors (see Subsection 5.1 for details). The detailed comparison between the direct and inverse kinematics data can be found in [2].

It should be noted that the discrepancy in the experimental data makes it very difficult to modify the theoretical models (see Subsection 4). Therefore, the causes of the disagreement between the ITEP and GSI data must be examined in more detail using simpler target nuclei.

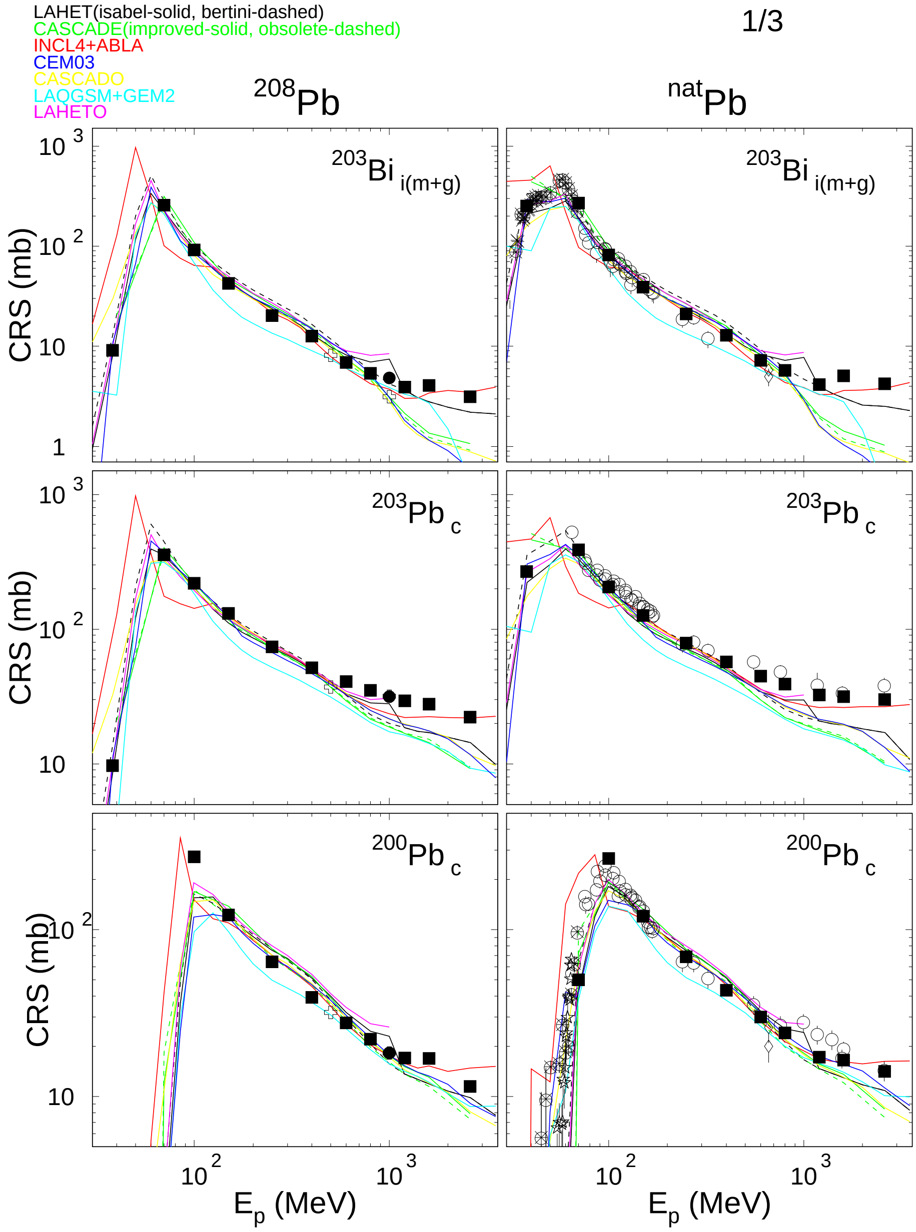


Fig. 26: Comparison with the results obtained elsewhere: ^{203}Bi, ^{203}Pb, and ^{200}Pb. ■ - This Report, ○ - [117, 105, 82, 108], ♢ - [83, 93], open star - [56, 90], + - [123, 102], star - [106], • - [6], □ - [94]

.

Say, ^{56}Fe may be irradiated with 300-1500 MeV protons at ITEP because the respective data have been obtained at GSI.

Note also that, despite some differences between the ITEP and ZSR [117] data, the two datasets can well be used to obtain the commonly estimated excitation functions. The data that suffer great differences must be reprocessed and, if necessary, repeated measurements must be made.

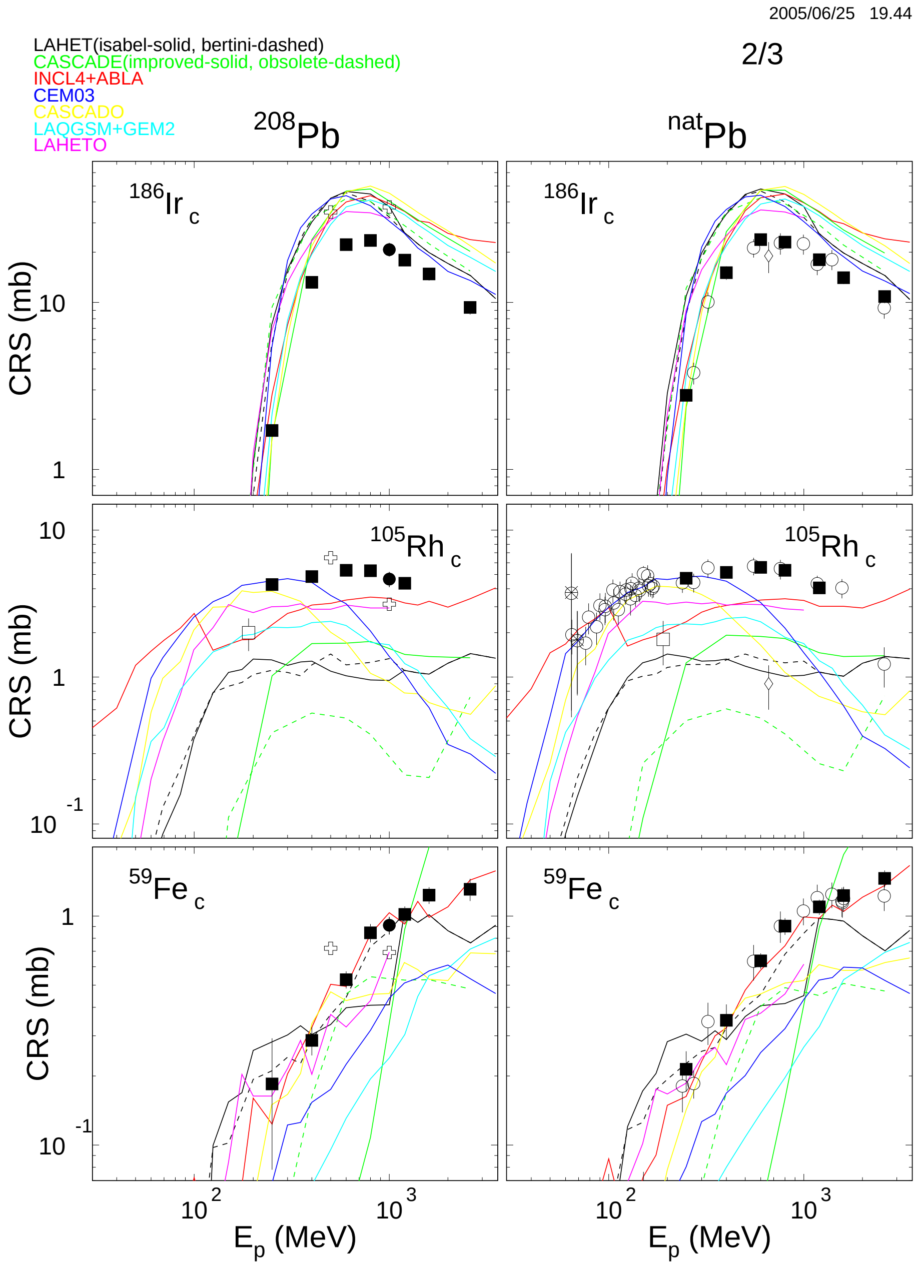


Fig. 27: Comparison with the results obtained elsewhere: ^{186}Ir, ^{105}Rh, and ^{59}Fe. ■ - This Report, ○ - [117, 105, 82, 108], ♢ - [83, 93], open star - [56, 90], + - [123, 102], star - [106], ● - [6], □ - [94]

.

Analysis of different groups of measured excitation functions has shown that the data obtained by the same method are more consistent than the data obtained by different methods. The causes of the discrepancies found are to be studied later.

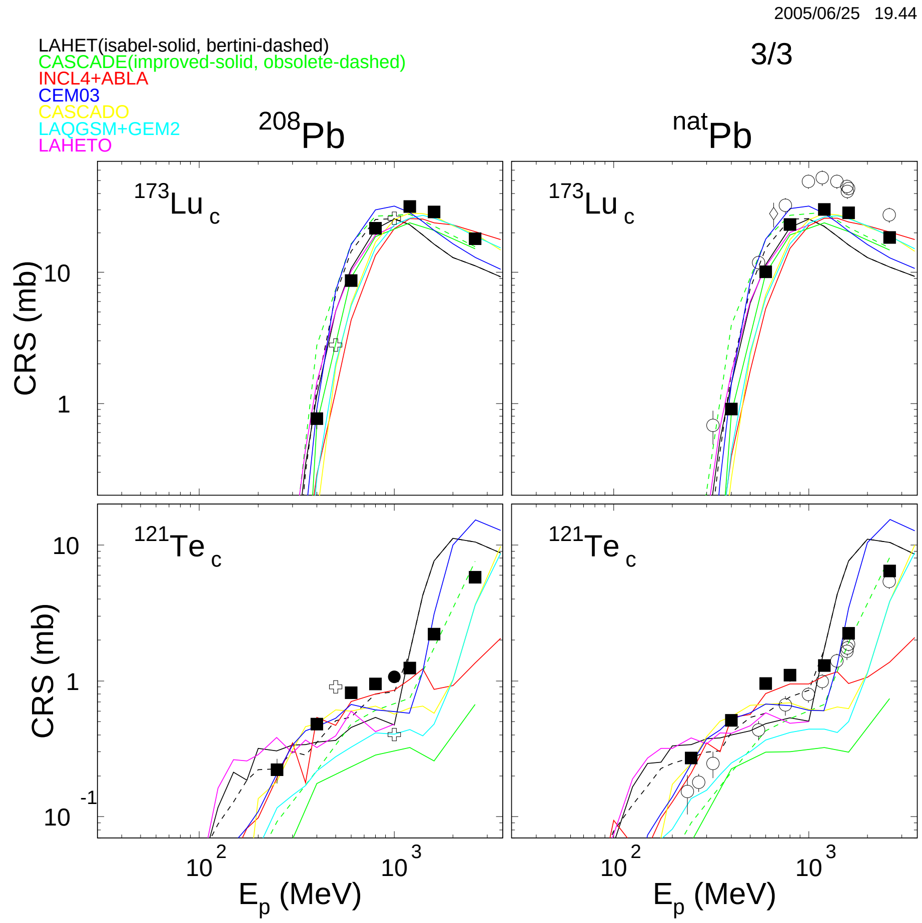


Fig. 28: Comparison with the results obtained elsewhere: ^{173}Lu and ^{121}Te. ■ - This Report, ○ - [117, 105, 82, 108], ◊ - [83, 93], open star - [56, 90], + - [123, 102], star - [106], • - [6], □ - [94]

.

3.16 Conclusions

In pursuance of the ISTC Project#2002 Workplan item (see Section 4 **Scope of activities**):

- Task 7: Identification of γ-lines and determination of residual radioactive nuclide yields,

Chapter 3 presents the following results obtained for five target types (^{nat}Pb, ^{206}Pb, ^{207}Pb, ^{208}Pb, and ^{209}Bi) and eleven proton energies (E_p = 0.04, 0.07, 0.1, 0.15, 0.25, 0.4, 0.6, 0.8, 1.2, 1.6, and 2.6 GeV):

1. 5972 numerical values of measured yields of radioactive residual product nuclei, of which 702 independent yields, 712 independent yields of metastable state, 546 sums of independent yields of metastable and ground states, 4012 cumulative and supracumulative yields.

2. The results obtained have made it possible to obtain 1024 excitation functions for 215 different reaction products.

3. The main sources of errors in the experimental data obtained have been analyzed.

4. The obtained data have been compared with the available experimental data obtained elsewhere. The comparison results have been analyzed.

4 Analysis of Spallation and Fission Residual Yields with the Intranuclear Cascade Model

The analysis of the recent experimental data on spallation reaction yields [123, 144, 145] demonstrated that calculations with many widely used simulation codes do not guarantee accuracies required for technical applications related to accelerator-driven power systems. In this connection, a task of improvement of simulation codes based on the Intranuclear Cascade Model (INCM) was taken up as essential part of the present Project beside the main task of new measurements of reaction product yields induced by incident protons on separated isotopes of lead and bismuth, which are considered as advanced materials of ADS targets.

Along with the data obtained under the Project we include into consideration also data of other experiments. Above all it relates to the recent GSI data measured with the inverse kinematics method [123, 143, 144]. In this experiment, practically all nuclides produced in spallation, fission and fragmentation processes were identified, and a high accuracy of obtained data permits considering them as a crucial benchmark for models included in different simulation codes. The GSI data can be directly compared with residual yields calculated by the INCM codes in contrast to the data of activation measurements, which require a transformation of independent yields into the cumulative ones and include the corresponding uncertainties of branching for analyzed decay chains.

Below we consider all sets of recent experimental data that can be used to test and improve the modern versions of the INCM codes.

4.1 Main ingredients of INCM

Spallation reactions are generally modeled as a two-stage process. In the first stage, the nucleon-nucleon collisions inside the nucleus induce the loss of a few high-energy nucleons and lead to the formation of excited prefragments [128, 129, 130]. This process can be continued by a preequilibrium emission of nucleons in some versions of the INCM [131, 133]. In the second stage, the prefragments get deexcited by evaporation of neutrons and light charged particles or by fission.

As an example the mass and excitation energy distributions of prefragments, which arise in the reaction ^{208}Pb+$p(1GeV)$ after a cascade of nucleon-nucleon collisions inside the nucleus, are shown in Fig. 29. Calculations are performed with three versions of the INCM, which we want to discuss in this Report:

- the LAHET [131]with default parameters including the pre-equilibrium emission of particles;

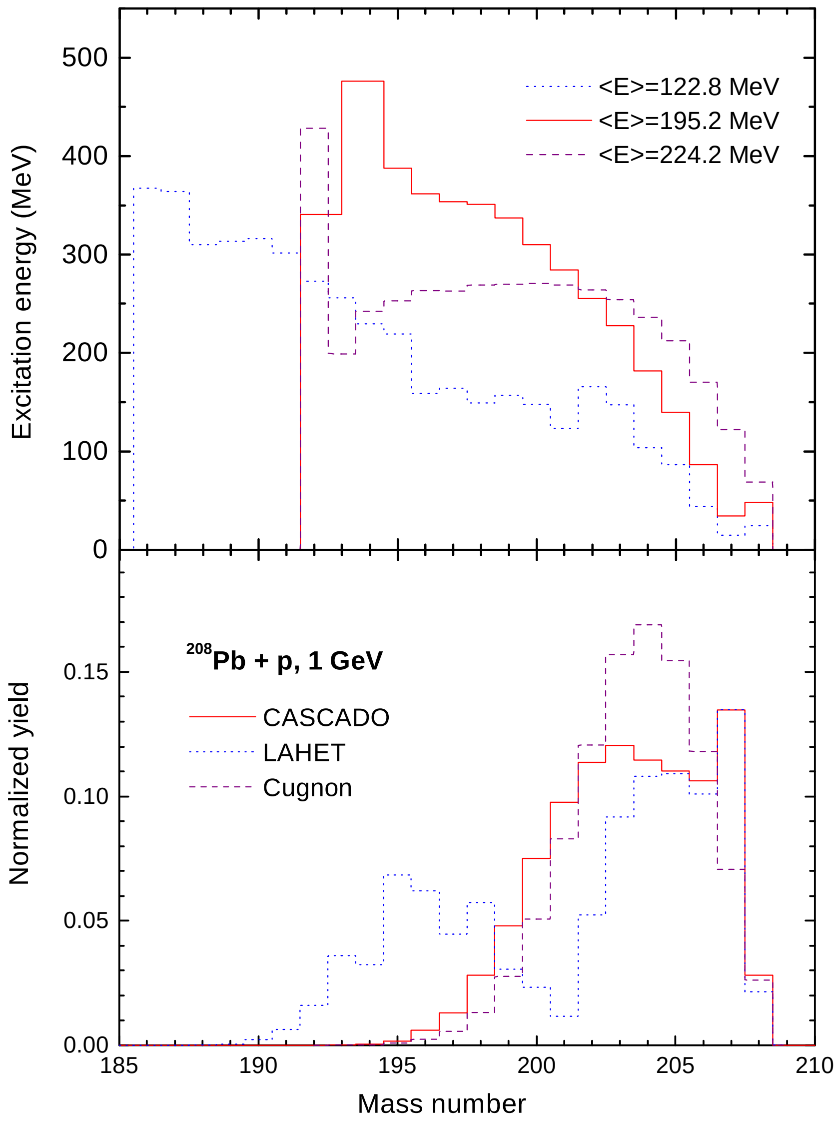


Fig. 29: Distribution of the prefragment masses and excitation energies after the first stage of the INC.

- the INCL-3 code based on the Cugnon model [146], [147] combined with the ABLA evaporation model developed at GSI [16] [148];
- the CASCADO code related historically to the CASCADE code [130], but with an essentially modified evaporation approach that takes into account the IPPE experience on the level-density and nuclear-fission analysis [149].

All codes give rather low excitation energies 25-50 MeV for the prefragments close to lead and the increase of excitation energies up to the averaged values of $<U> = 150\text{-}200$ MeV for the most probable prefragments with A$\sim$200-206. Prefragments with higher excitation energies arise in the mass region A$<$200 with a relatively low probability. The distributions shown in Fig. 29 can be considered as the input data for the second (evaporation) stage of the INC.

All evaporation models are based on the well-known Weisskopf-Ewing formula [150] for the emission widths

$$\Gamma_i(U) = \frac{(2s+1)\, m_i \int\limits_0^{U-B_i} \varepsilon\sigma_i(\varepsilon)\rho_i(U-B_i-\varepsilon)\, d\varepsilon}{\pi^2\hbar^3\rho_c(U)} , \tag{154}$$

where s_i and m_i are the spin and mass of the emitted particle, B_i is its binding energy in the compound nucleus with the excitation energy U, σ_i is the absorption cross section for the inverse reaction, ρ_i and ρ_c are the level densities for the residual and compound nucleus, respectively.

The absorption cross section is usually approximated by the relation

$$\sigma(\varepsilon) = \begin{cases} 0, & \text{for } \varepsilon < C_{Cool} \\ \pi R_i^2, & \text{for } \varepsilon \geq C_{Cool} \end{cases} \tag{155}$$

where C_{Coul} is the Coulomb barrier height and $R_i = r_i A^{1/3}$ is the radius of a nucleus with mass A and kinetic energy e. In accordance with such an approach the relation (154) can be approximated by a rather simple formula

$$\Gamma_i(U) = \frac{(2s+1)\, m_i r_i^2 A_i^{2/3} T_i^2 \rho_i(U-B_i-C_i)}{\pi^2\hbar^3\rho_c(U)} , \tag{156}$$

where T_i is the nuclear temperature for the appropriate residual nucleus.

More complex formula for the emission width were considered by Dresner [151], who used the Fermi-gas-model relations for the level density to calculate the integral of Eq. (154) in an explicit form taking into account some small corrections related to pre-exponential factors in the level density expressions. For excitation energies above the neutron binding energy, which are important for most of the practical applications, the difference between the Dresner's approximation and calculations based on Eq. (156) can be neglected as a rule.

An important question concerning the simple approximation (155) relates to the estimation of the radius parameters r_i and the Coulomb barrier. For the original Weisskopf-Ewing formula (154), all calculations can be made on the basis of optical models without any reference to the geometrical cross-section and the effective Coulomb barrier that are required for Eq. (156). The best choice of the parameters r_i, which could differ for different emitted particles, corresponds to the agreement of the results obtained from Eq.(156) with more accurate statistical calculations based on Eq. (154). It is obvious that an exact equality of the two results can be achieved at a certain energy only. Nevertheless, we could require an agreement between calculations based on Eqs. (154) and (156) for the crucial energies, which correspond to the average energies of the Maxwell spectra of evaporated particles. In the practical versions of the INCM the parameters of the effective Coulomb barriers and the geometrical cross-sections are usually estimated by fitting some experimental data and we should note that the values of r_i differ essentially in the widely used codes.

Another important component of evaporation models relates to the description of the fission widths. Usually, the following simplified form of the well-known Bohr-Wheeler formula [152] is applied for this purpose and can : as

$$\Gamma_f^{BW}(U) = \frac{T_f \rho_f(U-B_f)}{2\pi\rho_c(U)} \tag{157}$$

where B_f is the fission barrier height and ρ_f is the density of nuclear levels in fission channel.

In the last decades it was recognized that the description of the fission probability for high excitation energies requires some essential modifications of the Bohr-Wheeler approach relevant to the collective motion dynamics. To create a collective mode similar to the fission process, some transient time is required [153]. The dependence of such a time on nuclear properties can be derived by solving the time-dependent Fokker-Planck equation for the collective degree of freedom. For an oscillator form of collective potential, the transient time for overdamped regime can be approximated by a rather simple relation [153]

$$\tau_f = \frac{\beta}{2\omega^2} \ln \frac{10 B_f}{T_f} \qquad (158)$$

where β is the reduced damping coefficient and ω is the frequency of the corresponding collective oscillations. Taking into consideration the transient time, the relation for the fission width can be written as

$$\Gamma_f(U) = \Gamma_f^{BW}(U)\, f_K(\beta) \cdot e^{\{-\tau_f \sum_\nu \Gamma_\nu(U)/\hbar\}} \qquad (159)$$

where $f_K = [1 + (\beta/2\omega)^2 - \beta/2\omega]^{1/2}$ is the Kramer's coefficient [154], that estimates a reduction of the fission probability induced by dissipation of collective motion, and the sum in Eq. (159) includes all decay channels that compete with fission.

The main effect of factors that are additional to the Bohr-Wheeler formula is a hindrance of fission for times smaller than the transient time, and this hindrance reduces the fission widths strongly at excitation energies 100-150 MeV over the fission barrier. As shown by the analysis of heavy Цion-induced reactions, the hindrance of fission plays a crucial role in the consistent description of the total amount of neutrons and light charged particles emitted by the fissile nuclei [155], as well as of the residual product yields observed in the fragmentation of relativistic heavy ions [156].

The fission barriers used by different INCM codes are compared in Fig. 30 with the experimental fission-barrier values available for pre-actinide nuclei [149]. All codes try to include shell corrections to fission barriers that are very important for near-magic pre-actinides at excitation energies below 50 MeV, but a transition to the liquid-drop values is realized in a different way. A simple liquid-drop model is used in the LAHET and the earlier CASCADE [130], the Sierk's barriers [157] in the GSI model, and the droplet model fitted to experimental barriers [149] in CASCADO. It is obvious that the barrier variation affects essentially the calculated fission-fragment yields. The barriers used in LAHET seem too high for near-magic nuclei, which [underestimates?, see file 2002-RU6] strongly the fissility of such nuclei and always requires some adjustment of barriers to obtain correct values of fission cross sections.

In addition to the above mentioned differences in the particle emission conditions and in the various systematics for fission barriers, there are some discrepancies in the hadrons interaction cross-sections used by the codes. The experimental data on the cross sections of $p-p$ and $n-p$ interactions compiled in [160], are compared in Fig. codes. The similar data for the $\pi^{\pm}p$ interactions are shown in Fig. 32 .

The differences in the parameterizations of the total cross-sections in various codes are negligible, whereas the elastic and inelastic cross-sections disagree more essentially. In particular, the CASCADE parameterization for the elastic cross-section was based on relatively old experimental

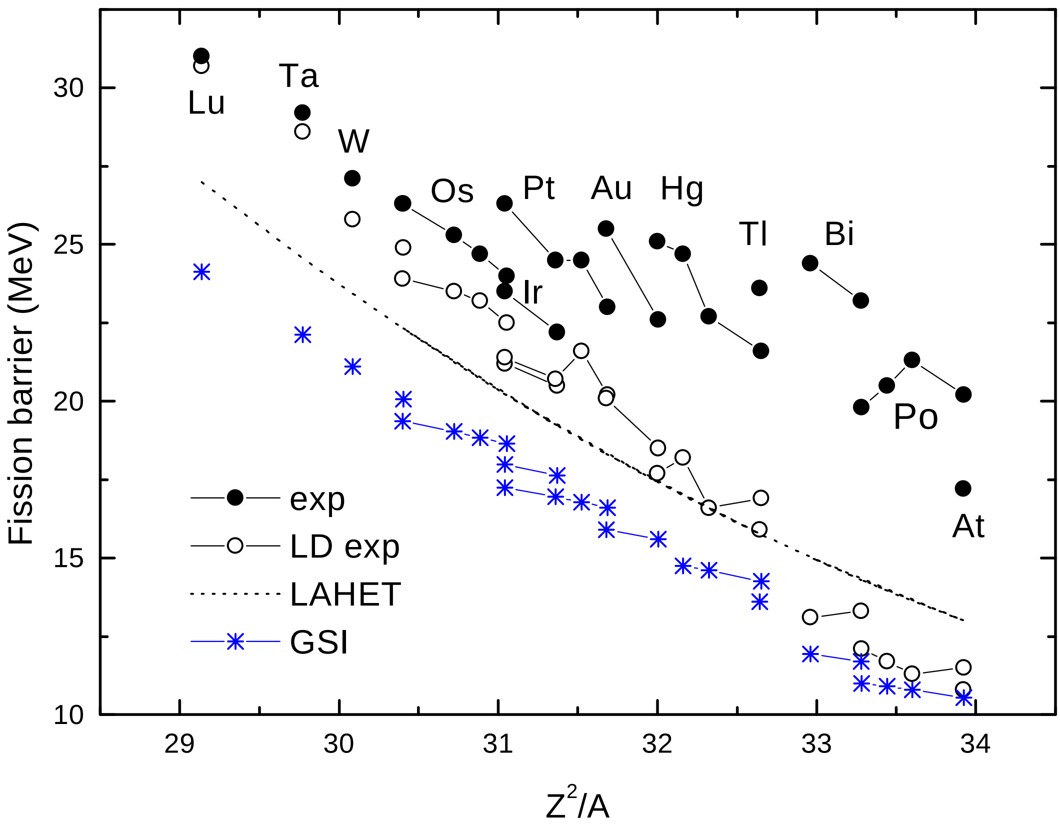


Fig. 30: Fission barriers (solid circles) and their liquid-drop components (open circles) estimated from the experimental data analysis as compared with the liquid-drop barriers used in the LAHET (dotted curve) and GSI (asterisks) codes.

data, which differ essentially in the energy range 400 - 4000 MeV from new experimental data, as well as from the parameterization used by the INCL-3 code [141]. Deviations in the elastic cross section affect the inelastic cross-sections directly due to restrictions connected with the total cross sections. In the CASCADO, The hadron interaction cross-sections corrected in accordance with the recent experimental data [160] . Similar corrections seem to be used also in the last version of the INCL-4 code [141], as well as in the updated versions of the CEM code [134]. Note that, in the case of LAHET code, the updated hadrons-interaction cross-sections are used only in the LAHET (Isabel) version that operates at the incident particle energies below 1 GeV. At higher particle energies, the LAHET (Bertini) version alone, which includes old parameterizations of hadron interactions, is available. The direct consequence of that is a rather bad description of the reaction product yields in the LAHET calculations at the proton energies above 1 GeV, examples of which will be demonstrated below.

4.2 Experimental data analysis with the previous versions of codes

Calculations performed with different INC plus evaporation-fission models are compared in Fig. 33 with the experimental data on the isotopic distributions of residual yields measured at GSI for the ^{208}Pb+p (1 GeV) reaction [123]. To avoid too complex plots, only a part of available

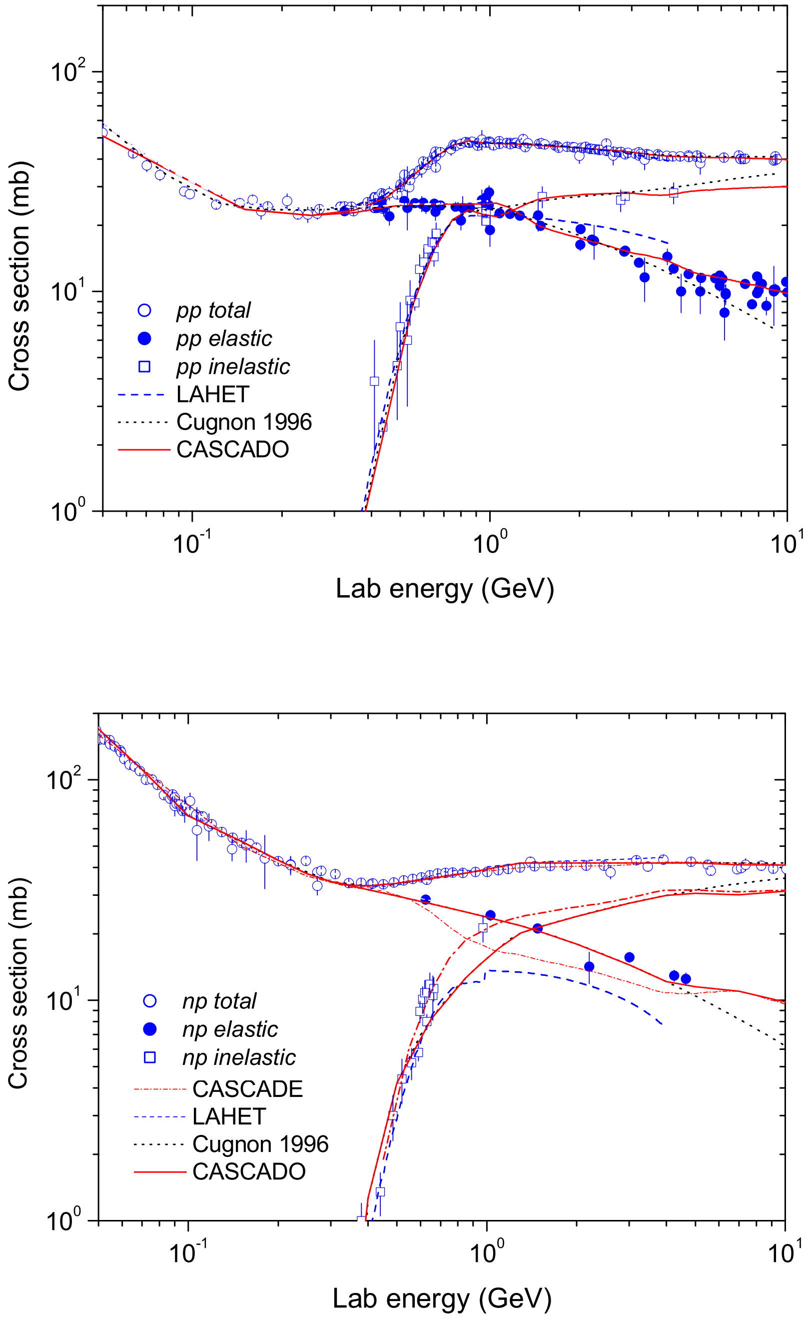


Fig. 31: Total, elastic, and inelastic cross sections for $p-p$ and $n-p$ collisions used by various INCM codes in comparison with experimental data.

data is shown. Most of the observed isotopic distributions have a shape close to the Gaussian, the position of whose maximum is determined by a competing evaporation of neutrons and charged-particles. Essential deviations from the Gaussian are observed for fragments with masses close to the target mass (the projectile for inverse kinematics reactions). For such fragments the emission of a small number of neutrons is possible only without a competition with proton

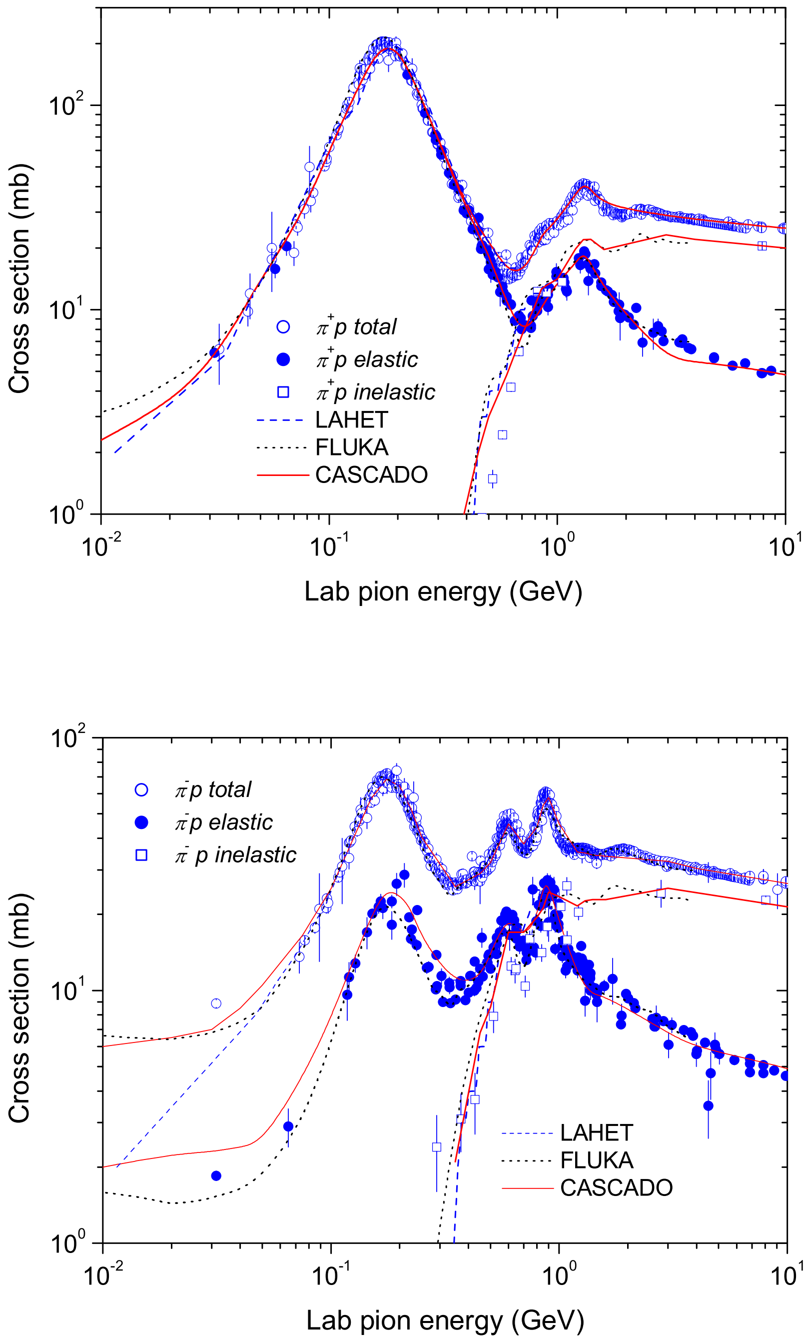


Fig. 32: Total, elastic, and inelastic cross sections for $\pi^+ - p$ and $\pi^- - p$ collisions used by various INCM codes in comparison with experimental data .

evaporation.

The calculations made with the commonly used LAHET code system (Isabel version) [131] give the isotopic distributions shifted with respect to the experimental ones towards the neutron-rich side (Fig. 33). This can be related to the fact that the prediction of the neutron-proton evaporation competition is not satisfactory enough. On the other hand, in a mass region very close to the target mass, LAHET calculations are in good agreement with the experimental data and this result is the direct consequence of a reasonable estimation of the excitation-energy distribution at the end of the INC stage.

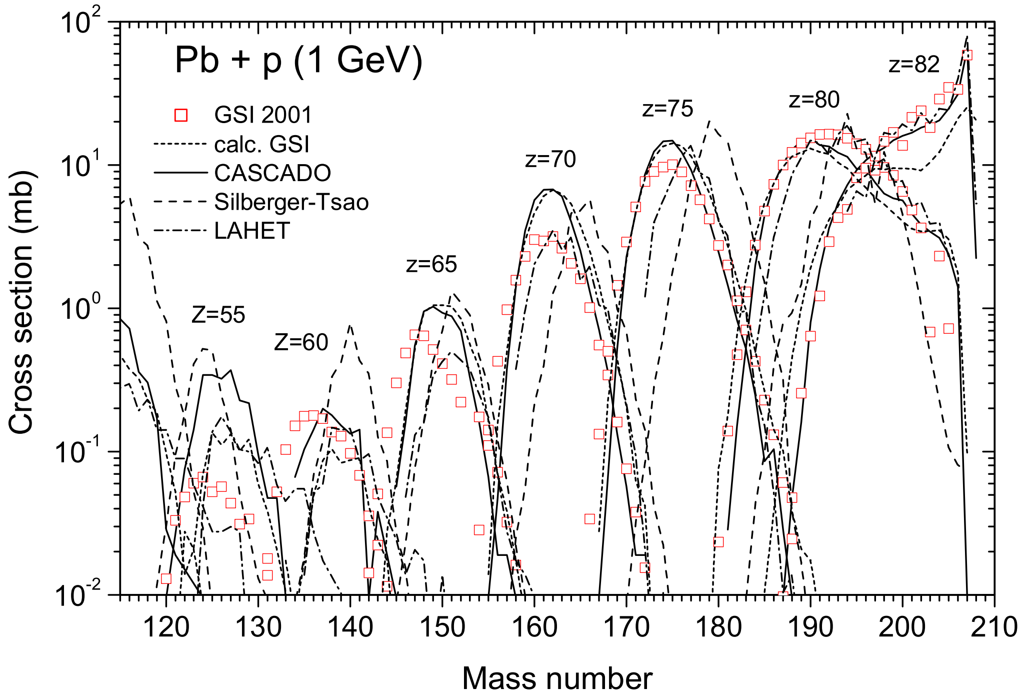


Fig. 33: Experimental data on isotopic distribution of spallation residues in the reaction 1A ГэВ ^{208}Pb on hydrogen in comparison with the results calculated by different versions of INCM and with the empirical systematics [159].

The calculations with the INCL-3 code [147], combined with the GSI evaporation-fission model, reproduce experimental data much better than the LAHET code. This comes mainly from a better description of the neutron-proton competition as compared with LAHET [131]. The main defect of the INCL-3 calculations is the underestimation of production of residuals that are very close to the target nuclei, which represents an important part of the total cross section. This is ascribed to the sharp-surface approximation in the INCL-3 model [147], which leads to a bad description of the most peripheral reactions. These defects are eliminated in the new INCL-4 code [141], on the basis of which a much better description of product yields is achieved for the mass region A>180, but an essential underestimation of product yields still remains for masses 150<A<180.

Calculations by CASCADO, which uses practically the same approximations for the evaporation-fission model as in the GSI model, differ from the GSI calculations in a mass region close to the projectile. The CASCADO results are close to the LAHET ones for Z=82, which can be explained by the similarity of the excitation-energy distributions of the two codes at the end of the INC stage. Differences between the GSI and CASCADO results in the low mass region for Z=55 are attributed to the fission-fragment contribution, which is probably overestimated in the CASCADO calculations. This problem requires an additional analysis of the fission-product distribution simulation.

Fig. 33 shows also the results of the empirical parameterization by Silberger et al. [159] for the production cross sections of individual isotopes in high-energy proton interaction, which is widely used in astrophysical applications. It can be seen that the parameterization fails clearly to predict the center-position of isotopic distributions. As shown in Ref. [123], the differences between the empirical predictions and the experimental data increase even more for the fission-fragment region.

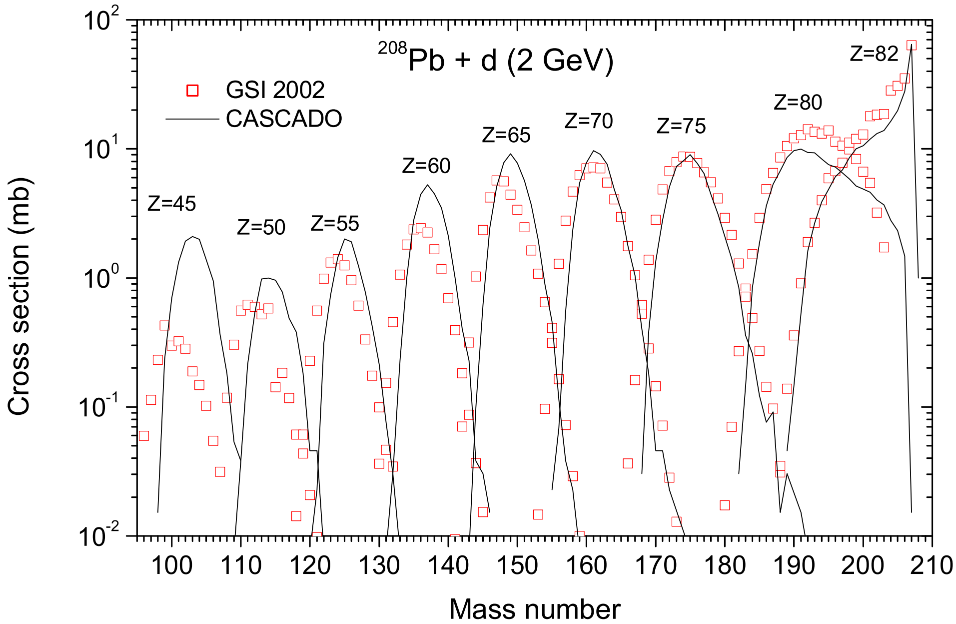


Fig. 34: Experimental data on isotopic distribution of spallation residues in the reaction of 1A GeV ^{208}Pb on deuterium incomparison with CASCADO calculations.

The calculations withCASCADO for other initial conditions, namely for the reaction ^{208}Pb + d (2 ГэВ), are shown in Fig. 34 together with experimental data from [144]. The entry energy in this case is two times higher than for the hydrogen target, and the corresponding difference arises in the distribution of excitation energies at the end of the INC stage. So, the production cross-sections remain approximately the same for Z>70, but increase by several times for lighter spallation and fission products. The general quality of the theoretical simulation of the experimental data is the same as in the case of proton interactions (see Fig. 33). Some overestimation of calculated yields for Z<46 can again be related to the defects of the fission-product yield description.

4.3 The model modifications and the calculations with updated codes

The above disagreements between calculations and experimental data require a more accurate estimation of the respective model parameters and some modifications of available codes. For example, to improve the description of fission-fragment yields with LAHET, it is necessary to use a better parameterization of the fission-fragment mass distribution, on the one hand, and to achieve a consistent description of observed fission cross sections, on the other hand. Needs for improvements of the fission-product distribution are seen distinctly from Fig. 35 that presents the comparison of LAHET calculations with experimental data for two incident proton energies: 1 GeV and 160 MeV. In the case of the lead target for default parameters, the calculated fission cross sections are underestimated at all energies and the widths of mass distributions are always overestimated.

The available experimental data on fission cross sections for pre-actinides are compiled in Ref. [161], where they were used to develop a phenomenological systematics of the proton-induced fission cross section for energies up to 10 GeV. So, in the following calculations we always adjusted the fission barriers to get an agreement with experimental data, where they were available, and with the systematics predictions [161] in other cases.

In addition to residual-product yields, the spectra of emitted particles are used to verify the INCM codes. As an example, the experimental data on double-differential neutron spectra are compared in Fig. 36 with calculations for the incident proton energies 800 and 113 MeV. High-energy parts of spectra are reproduced reasonably by all the codes, but some essential discrepancies are seen in the case of low energy parts of the spectra . In particular, the CASCADO results simulate better the low energy part of neutron spectra for the proton energy 113 MeV, but they underestimate the high energy part at backward directions. The latter is a direct consequence of a low contribution of preequilibrium processes in the early CASCADO versions.

The causes of the above discrepancies are:

1. different break-off conditions for the cascade stage of nucleons collisions, which are introduced by imposing some restrictions on energies of colliding nucleons [130], or some stopping-time to the cascade evolution consideration [146], or more complex additional conditions to the optical potential formation [133] ;

2. different Coulomb barrier parameterizations, which determine charge particle evaporation widths as competed with the dominant neutron evaporation channel;

3. different preequilibrium process contributions, which are neglected in INCL-3 and ealier CASCADE and are, probably, overestimated in CEM-95.

To get a consistent description of neutron and light charged-particle yields, a contribution of preequilibrium processes should be taken into account rather accurately. The available experimental data on neutron and charged-particle spectra were carefully analyzed to estimate an optimal parameterization of matrix elements that determine a preequilibrium process contribution at different excitation energies. As an example, a description of the inclusive neutron and proton spectra at the incident proton energy of 62 MeV is shown in Fig. 37 for both default

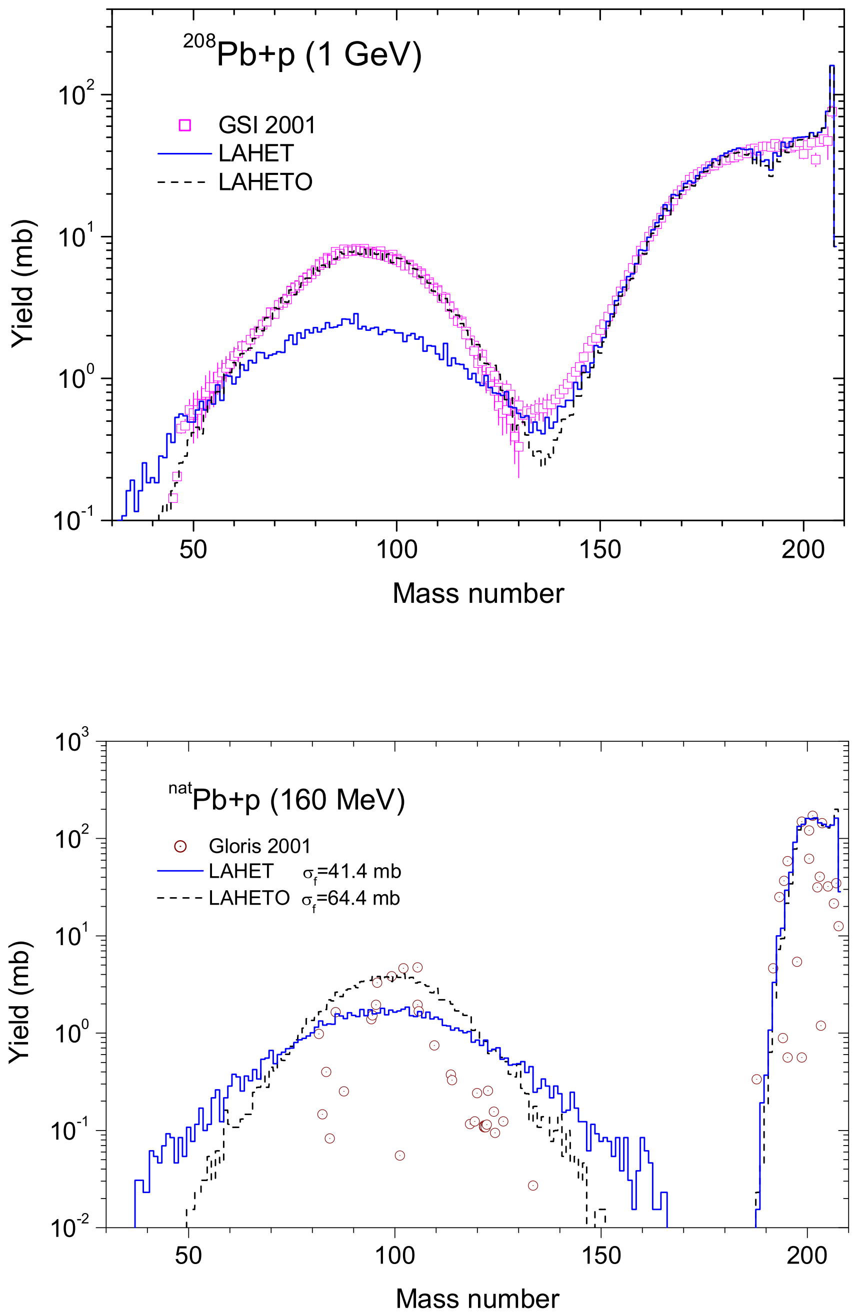


Fig. 35: Experimental data on the residual-product mass distributions for the reaction 208Pb+p at the incident proton energies of 1 GeV (upper plot) and 160 MeV (lower plot) compared with the default LAHET calculations and the modified LAHETO calculations.

and modified LAHET calculations. The Coulomb radius parameters required for calculations of charged particle widths or similar widths of preequilibrium emission were taken in accordance with recommendations of the GSI group. These modifications of the preequilibrium evaporation model are rather similar to modifications used in the latest versions of the INC model, which

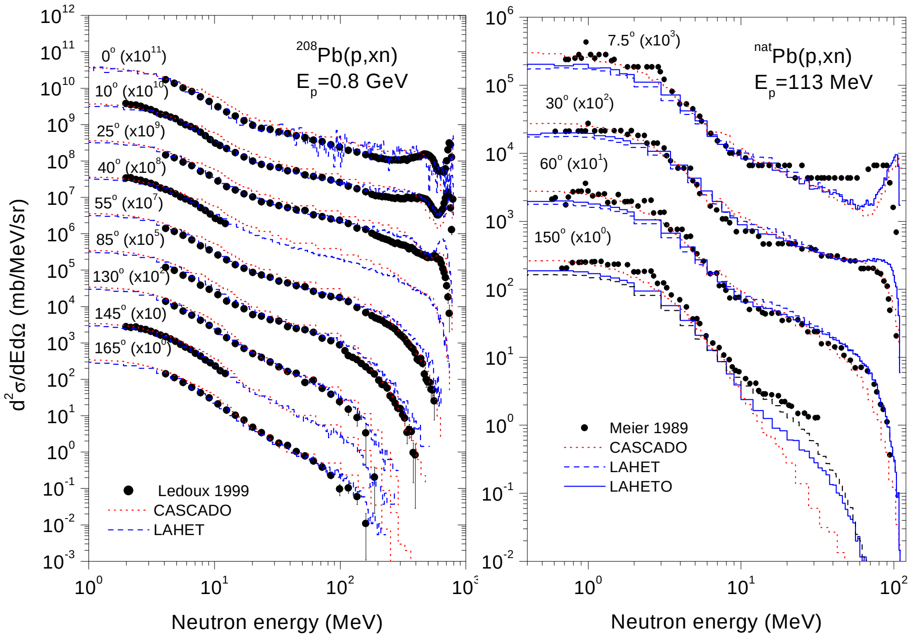


Fig. 36: Experimental data on spectra of the 208Pb(p,xn) reaction for the incident proton energies of 800 and 113 MeV compared with the default LAHET calculations including I

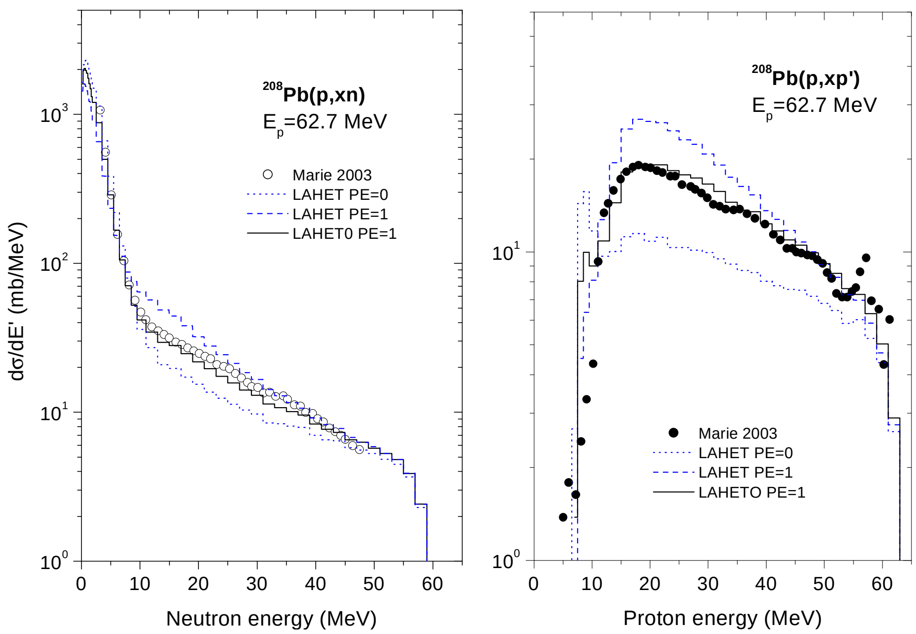


Fig. 37: Experimental data on spectra of the ^{208}Pb(p,xn) and ^{208}Pb(p,xp') reactions for the incident proton energy of 62,7 MeV [28] compared with thedefault LAHET calculations including (PE=1) and without (PE=0) preequilibrium processes and with the modified LAHETO calculations.

is under development at LANL [134, 137].

The main part of the fission barriers systematics from CEM-95 was inserted by us into the CASCADO code. At the same time, we added the blocks to CEM-95 for calculating fission product yields and neutron evaporation from the excited fission fragments. In all codes, we adjusted the liquid drop model parameters and the corresponding shell corrections for level densities and fission barriers to achieve an optimal agreement of calculated fission cross-sections with the available experimental data. By means of a phenomenological parameterization of the fission-fragment mass and charge distributions, we adjusted the description of the experimental data for the fission product yields. The details of the improvements for the LAHET code are presented in the Appendix.

As a result of the above modifications, the CASCADO code was modified essentially, the CEM-95 code was transformed into the CAMO code, and the LAHET code was transformed into the LAHETO code.

The spallation and fission-fragment mass distributions calculated with the modified codes for the incident proton energy of 1 GeV are compared in Fig. 38 with the GSI data [123] and with the recent activation measurements of cumulative product yields [117, 6]. Since the GSI data are obtained by means of integration over the complete isobaric-product distribution, while the cumulative yields correspond to but a part of the product distribution, the activation measurement results should coincide within errors, or be lower than the integrated isobaric yields. Such disposition of data is really observed in most cases, but some results of activation measurements run above the GSI data. This contradiction in the data indicates some latent systematic errors, which should be understood with a view to eventual exhaustive test of all INCM codes.

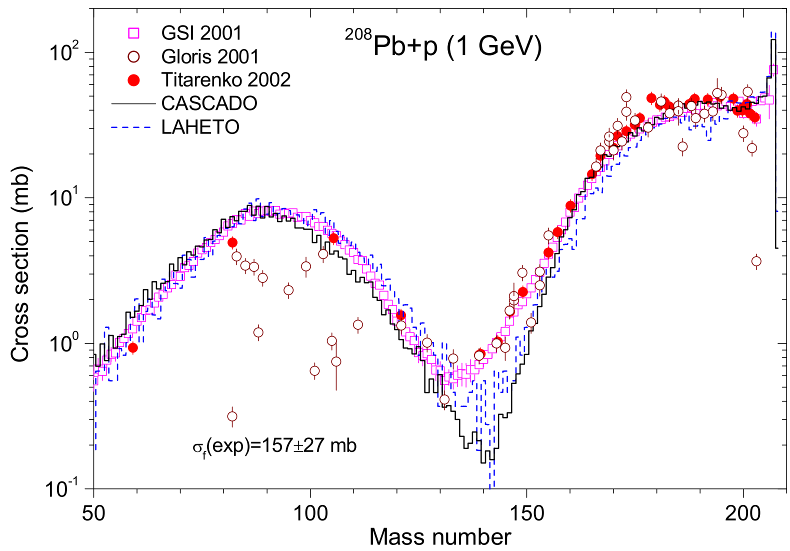


Fig. 38: Experimental data on the residual-mass distribution (open squares) and residual cumulative yields (solid circles) for the ^{208}Pb+p(1 ГэВ) reaction in comparison with cascade-model calculations.

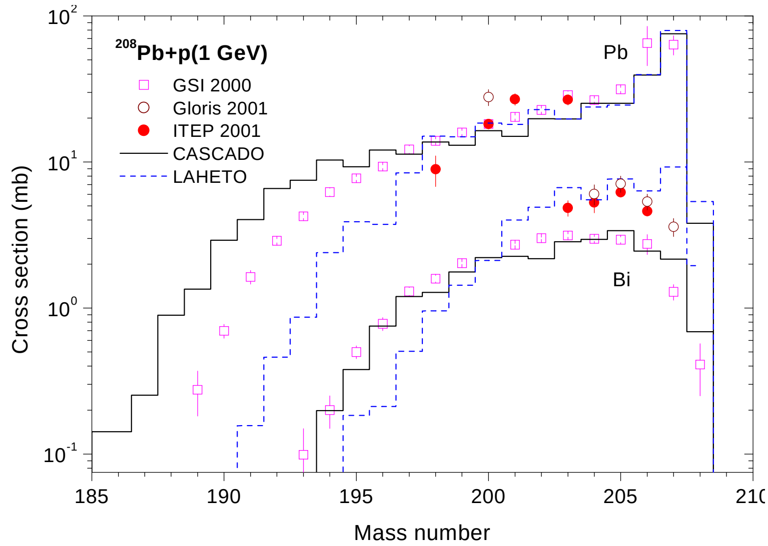


Fig. 39: Experimental data on ^{Pb}and ^{Bi}isotopic yields for the ^{208}Pb+p(1 ГэВ) reaction in comparison with cascade-model calculations.

The calculations of the isotopic lead and bismuth yields for the above mentioned reaction are compared with experimental data in Fig. 39. In the case of lead isotopes, we observe a good agreement between the experimental data, butthe experimental data are rather discrepant in the case of bismuth isotopes, so a choice of preferable model parameters is difficult on the basis of them.

Cumulative yields of spallation and fission products were measured under the Project for the targets of ^{206}Pb, ^{207}Pb, and ^{208}Pb irradiated by 2.6 GeV protons. The data obtained for ^{208}Pb are compared with the CASCADO and LAHETO calculations in Figs. 40 and 41. The CASCADO results reproduce the experimental data approximately to the same degree as the above calculations at 1 GeV. At the same time, the LAHETO (Bertini) results look too low for the spallation-product yields and too high for fission products. This is a consequence of the improper parameterization of the hadron interactions in the LAHET (Bertini) code at energies above 1 GeV, and essential improvements of the code must be carried out to to reach a consistent simulation of spallation and fission product yields at high energies.

To understand better the main regularities of the spallation and fission product distributions at various Energies, we performed calculations of residual-product yields for several intermediate energies between 70 MeV and 1 GeV. The calculations with the LAHETO, CASCADO, and CAMO at the incident proton energy 750 MeV are compared in Fig. 42 with the experimental data obtained by Gloris et al. [117] and Blanchard et al. [163] for proton energies of 754 and 759 MeV, respectively, and with the data obtained under the present Project at 799 MeV. Similar calculations at the incident proton energy 550 MeV are compared in the lower panel of Fig. 42 with the experimental data by Blanchard et al. [163] and Gloris et al. [117] available for energies 548 and 553 MeV and with the data of this Project for 600 MeV.

The new experimental data obtained recently at GSI by the inverse kinematics method for ^{208}Pb + p reaction at the energy 500 MeV per nucleon [162] are shown in Fig. 43 together with data by Gloris et al. [117] for the proton energy 550 MeV. The GSI data are reproduced

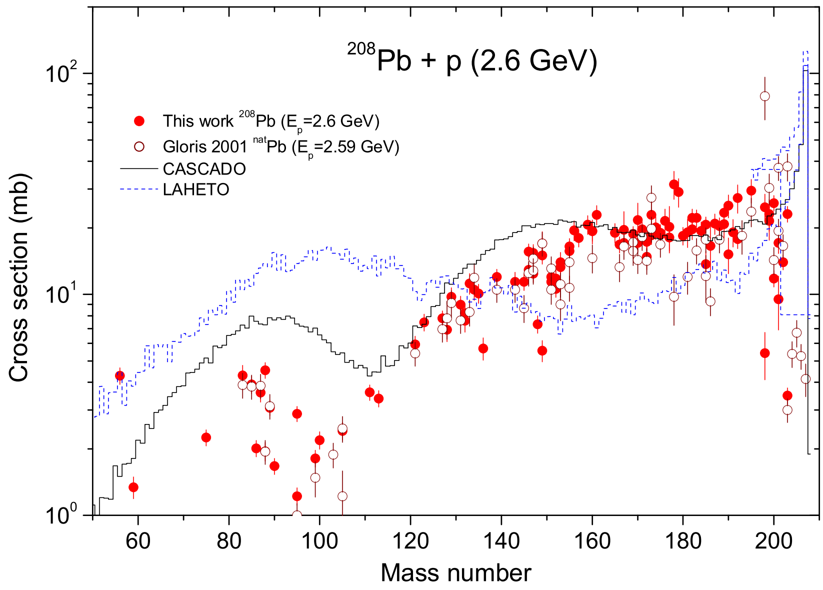


Fig. 40: Experimental data on residual cumulative yields for the ^{208}Pb + p (2.6 GeV) reaction compared with cascade-model calculations.

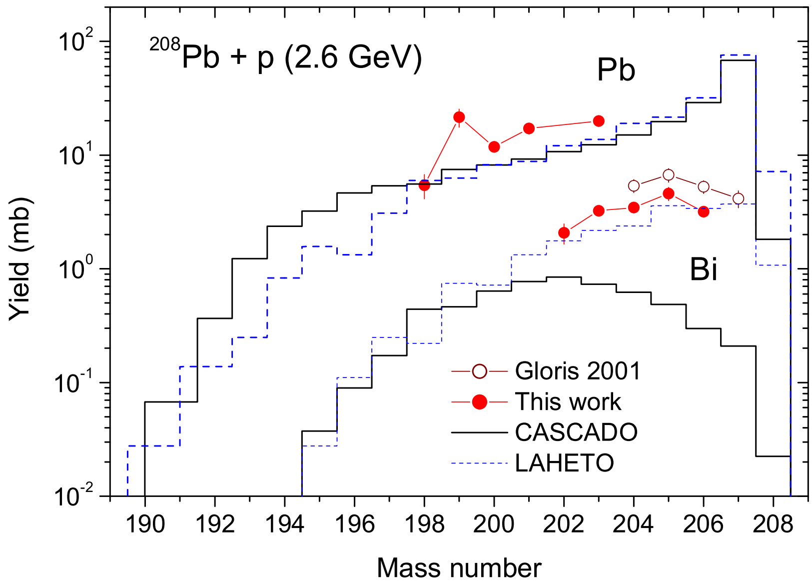


Fig. 41: Experimental data on ^{Pb}and ^{Bi}isotopic yields for the ^{208}Pb + p (2.6 GeV) reaction compared with cascade-model calculations.

well by the CASCADO calculations and a little worse by the CAMO and LAHETO ones.

Unfortunately, the GSI data for the fission product yields are available as but tentative and they should be reanalyzed because they contradict the estimations of the integral fission cross section. Calculations of the isotopic lead and bismuth yields are compared with the experimental data in Fig. 44. The calculations agree reasonably with the GSI data at mass region of maximal yields, but show some discrepancies on the left-hand slope of isotopic yields and overestimate essentially the yields of for bismuth isotopes close to the target nucleus (A>205).

The calculations at the incident proton energy 300 MeV are compared in Fig. 45 with the data by Gloris et al. [117] and by Blanchard et al. [163] for the proton energies 312 and 322 MeV, respectively. The experimental data for the proton energies 230 and 239 MeV, as well as the data of the present Project at the energy 250 MeV are compared in Fig. 46 with calculations at the proton energy of 230 MeV. All codes describe reasonably the available data, but the deep spallation product yields look better if reproduced by the LAHETO code. It should be noted that we a good agreement of the fission cross sections calculated by all the codes with evaluations based on the experimental data systematics [161], and such an agreement seems important enough to get a consistent description of all the available experimental data.

The calculations with all three codes at the proton energy 150 MeV are compared with the data by Gloris et al. [117] and with the data of the present Project in Fig. 47. The upper panel shows the data for the ^{208}Pb+p reaction, while the lower panel includes similar results for the ^{206}Pb target . The yields of bismuth isotopes in both reactions are compared with calculations in Fig. 48. All calculations reproduce reasonably the experimental data except for the heaviest bismuth isotopes, for which the calculated yields are 20-30% above the experimental ones. The data for ^{207}Pb target obtained under the Project are intermediate between the data for ^{206}Pb and ^{208}Pb targets, as their agreement with calculations looks similar to the results shown in Figs. 47 and 48.

The experimental data obtained under the Project for the bismuth target are compared with the calculations in Fig. 49 for the residual mass yields (upper panel) and the yields of ^{Po}isotopes (lower panel). Data for bismuth are of particular interest for the current ADS designs that consider a lead-bismuth eutectic as an advanced promising heavy-metal coolant. The general conclusion concerning the agreement between experiment and calculations for bismuth is the same as for lead isotopes.

We have performed calculations and analysis of the mass and isotopic yields of the spallation and fission products at proton energies below 100 MeV. The calculations for ^{208}Pb target at the incident proton energy 70 MeV are compared with the available experimental data in Fig. 50. The agreement between the experimental data and calculations remains approximately the same as in the case of higher proton energies.

The analysis of all the above calculations allows us to conclude that the INCM codes with parameters tuned to the reliable experimental data simulate consistently the mass and charge distributions of spallation and fissions products for a broad range of incident proton energies, from 40-50 MeV up to 2-4 GeV. For lower energies, the nuclear structure effects, which are disregarded under semi-classical consideration of intranuclear collisions in the INCM, increase essentially, and many approximations of the INCM become justified poorly.

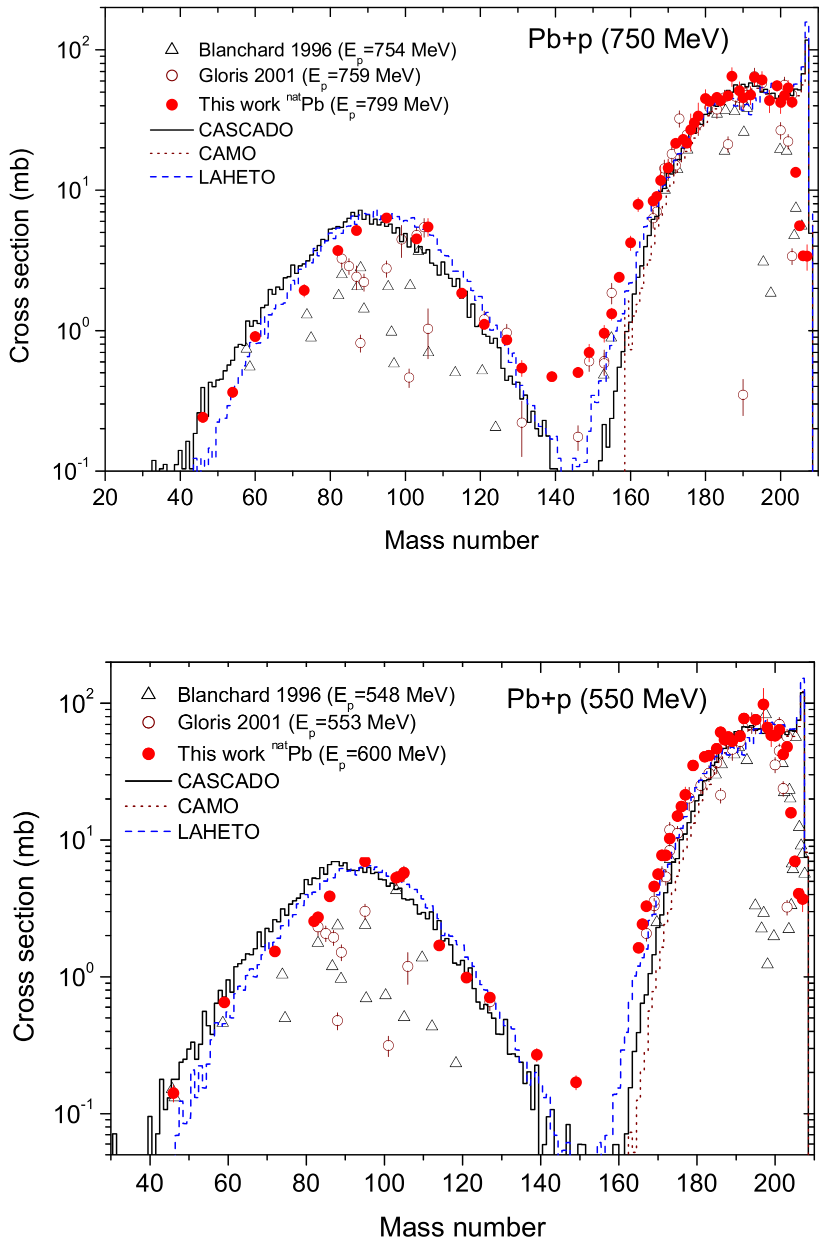


Fig. 42: Experimental data on residual cumulative yields for the ^{208}Pb+p reaction at the incident proton energies around 750 MeV (upper part) and about 550 MeV (lower part) compared with cascade-model calculations.

4.4 Conclusions

In pursuance of the ISTC Project#2002 Workplan item (see Section 4 **Scope of activities**):

- Task 9: Updating the models and codes on the basis of comparison of the simulation results with new experimental data obtained under the Project,

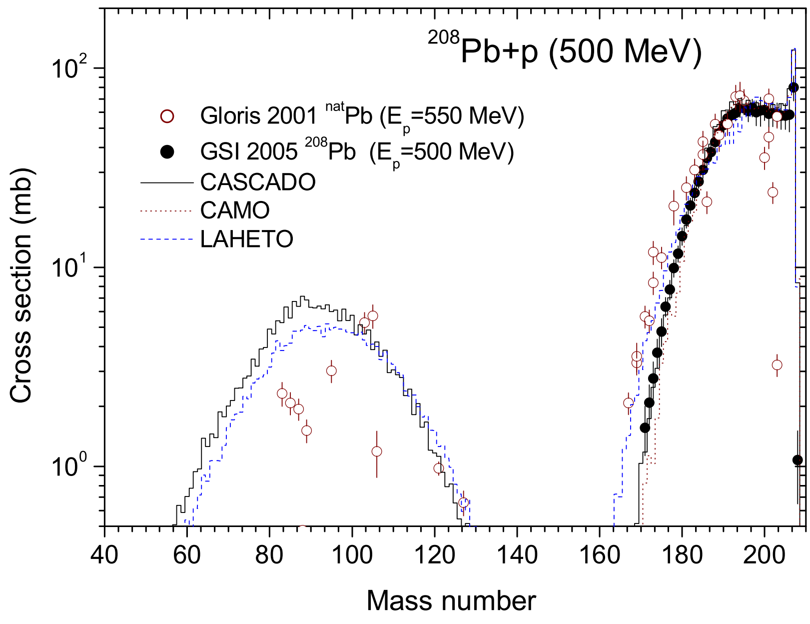


Fig. 43: The new experimental data on residues mass yields for the ^{208}Pb+p reaction at the incident proton energies 500 MeV compared with cascade-model calculations .

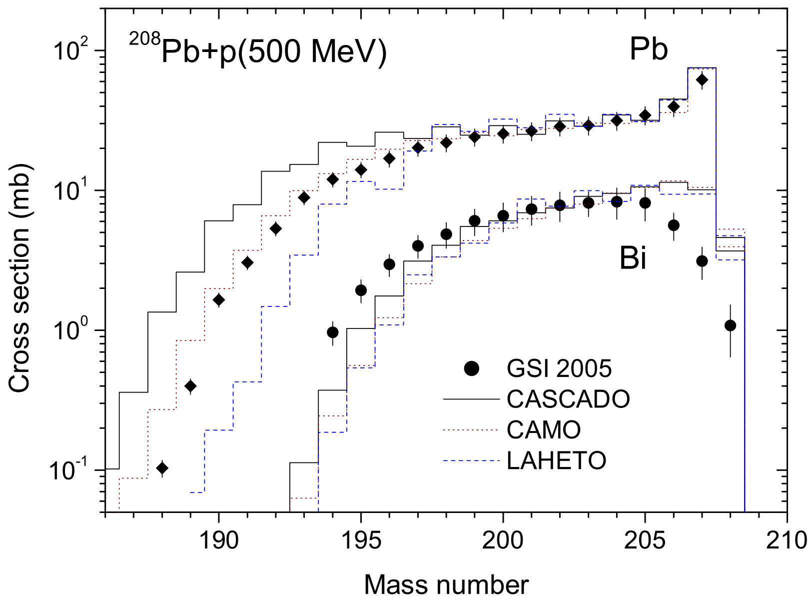


Fig. 44: Experimental data on the bismuth and lead isotopic yields for ^{208}Pb irradiated by 500 MeV protons compared with cascade-model calculations.

the following results have been obtained:

1. The yields of spallation and fission products for the proton-induced reactions on lead and bismuth targets have been calculated with some widely used codes that correspond to various versions of the INC model.

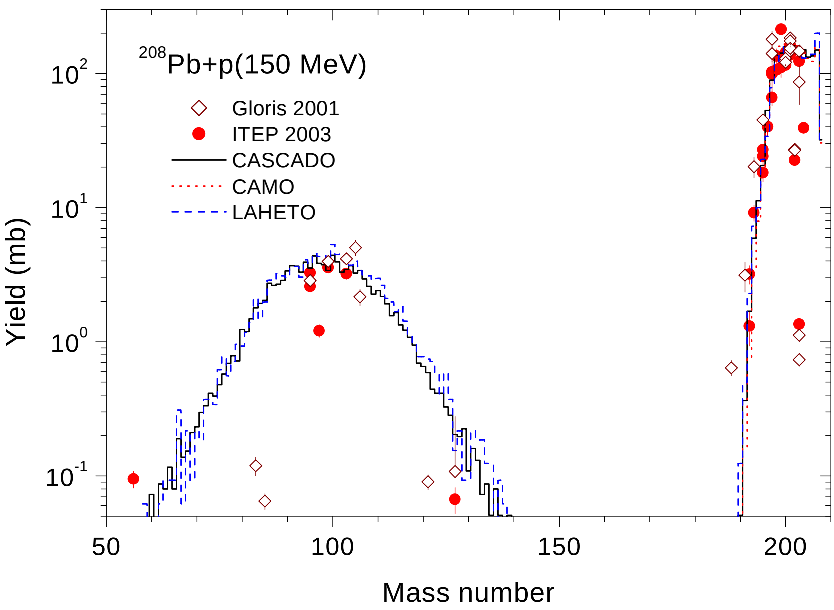
2. Differences between calculation results were analyzed, and the effect of both main approximations and model parameters on the obtained results studied, for the recent versions of the most popular codes.

3. In addition to the reaction product yields, the spectra of emitted neutrons and charged particles were analyzed, and contributions of the fast cascade, preequilibrium and equilibrium evaporation reaction mechanisms to the observed spectra investigated in details.

4. Some modifications of codes connected with a more correct simulation of nuclear processes and with a more accurate selection of model parameters have allowed us to improve the description of the available experimental data essentially. The recent GSI data together with the experimental data of the present Project have made it possible to achieve an optimal estimation of the model parameters for the proton-induced reactions on separated isotopes of lead and bismuth targets at energies close to 1 GeV.

5. Updated versions of the CASCADO, LAHETO, and CAMO codes describe consistently the total experimental dataset of spallation and fission product yields at the proton interaction with ^{206,207,208}Pb and ^{209}Bi targets in the wide energy range from 40 MeV up to 2.6 GeV.

   With a view to future improving the theoretical models and increasing their prediction power, it seems quite important to reduce the above discussed disagreement between the experimental data obtained in the activation measurements and by the inverse kinematics method.



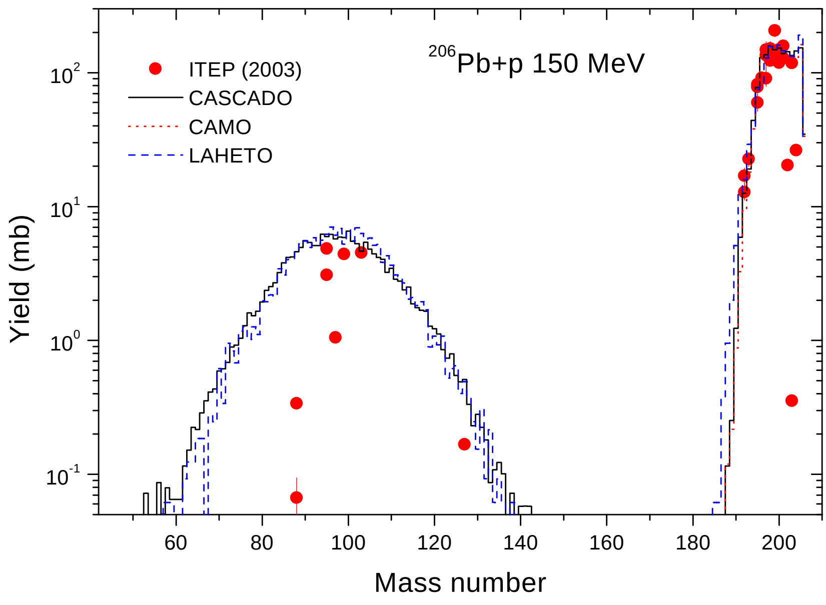


Fig. 45: The same as in Fig. 14 for the incident proton energies about 300 MeV .

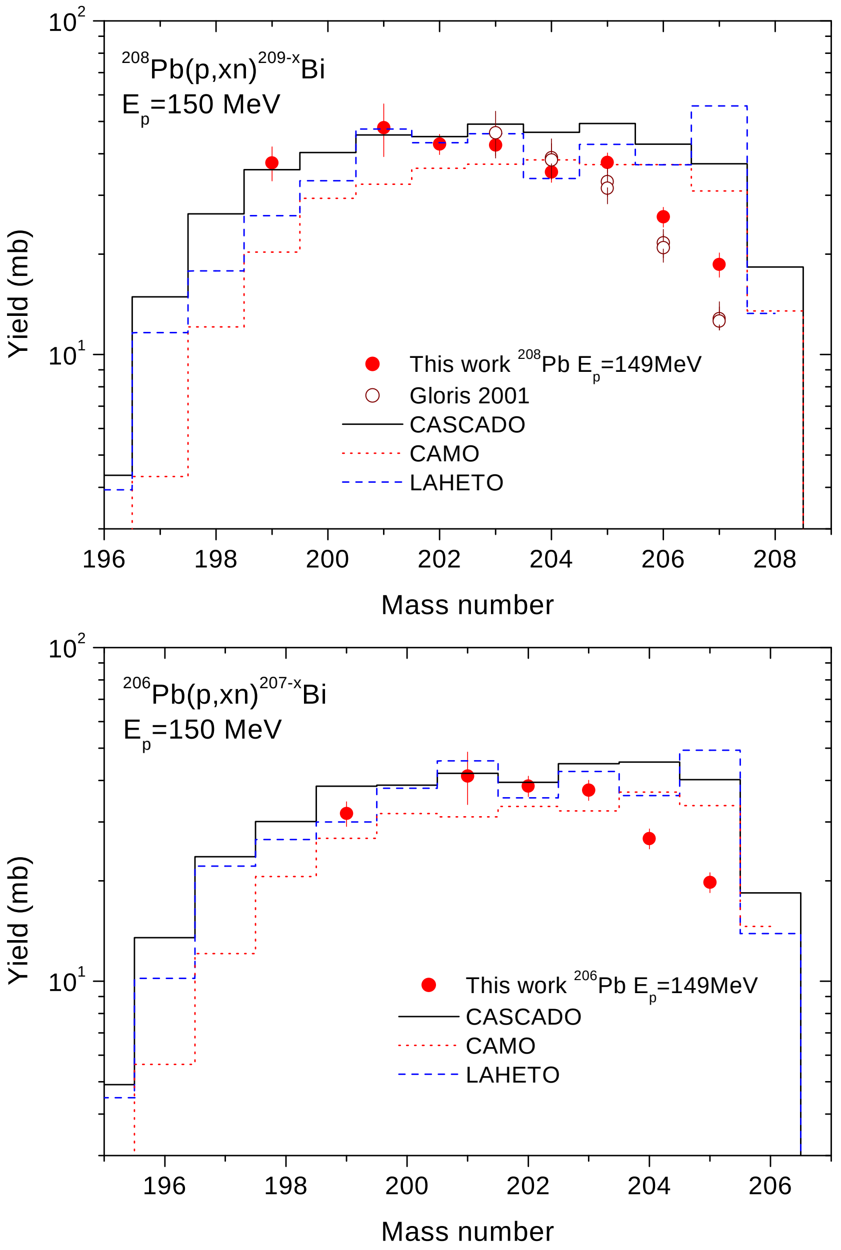


Fig. 46: The same as in Fig. 14 for the incident proton energies about 230 MeV

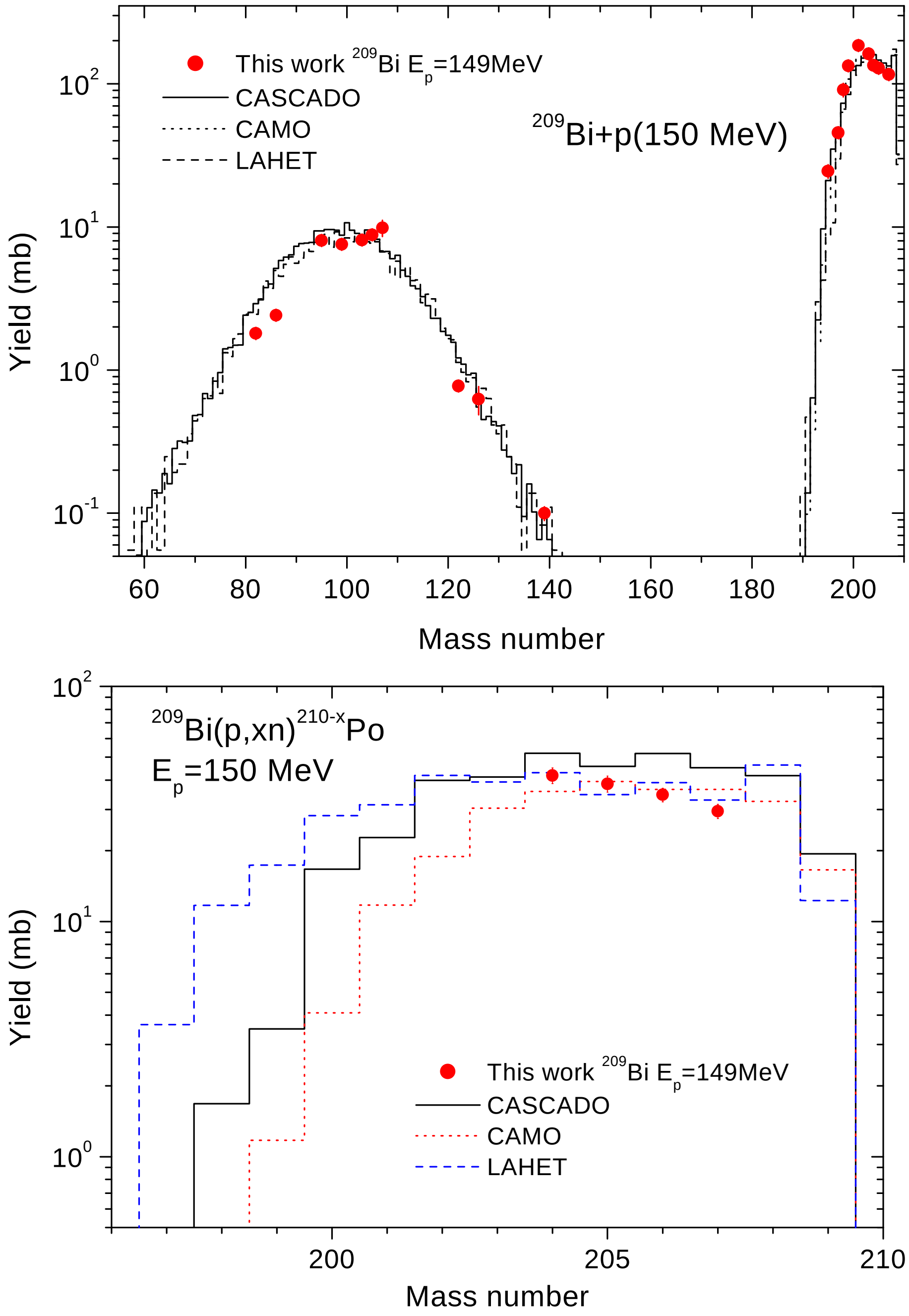
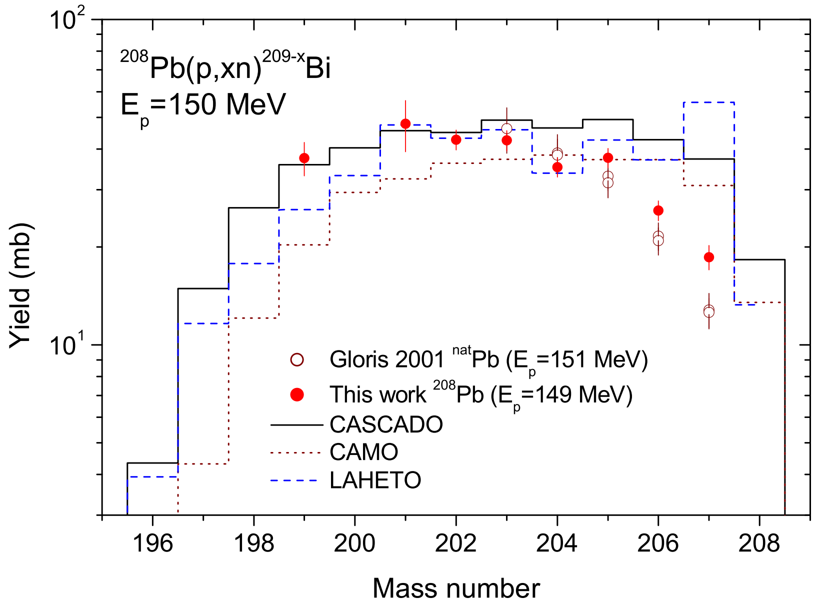


Fig. 47: Experimental data on cumulative yields of spallation and fission products for ^{208}Pb and ^{206}Pb targets irradiated by 150 MeV protons compared with cascade-model calculations.



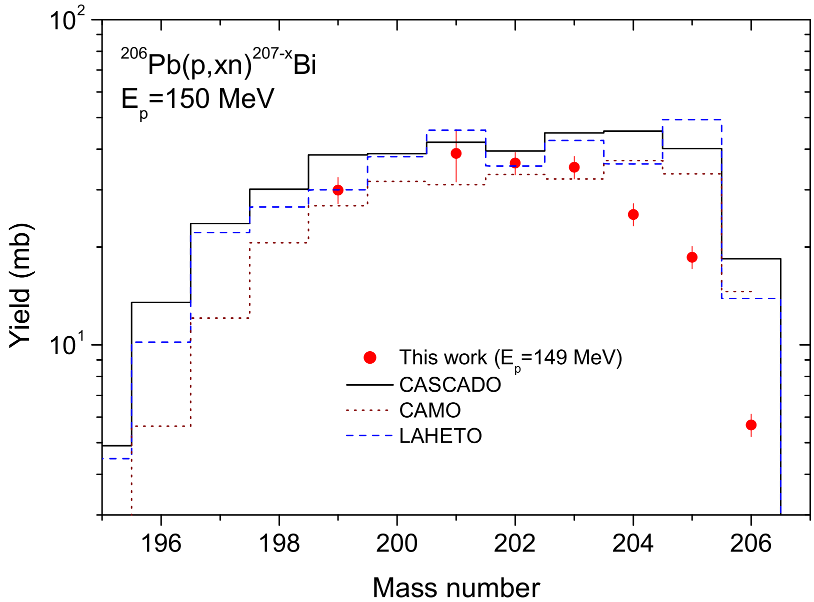


Fig. 48: Experimental data on the bismuth isotopic yields for ^{208}Pb and ^{206}Pb targets irradiated by 150 MeV protons compared with cascade-model calculations.

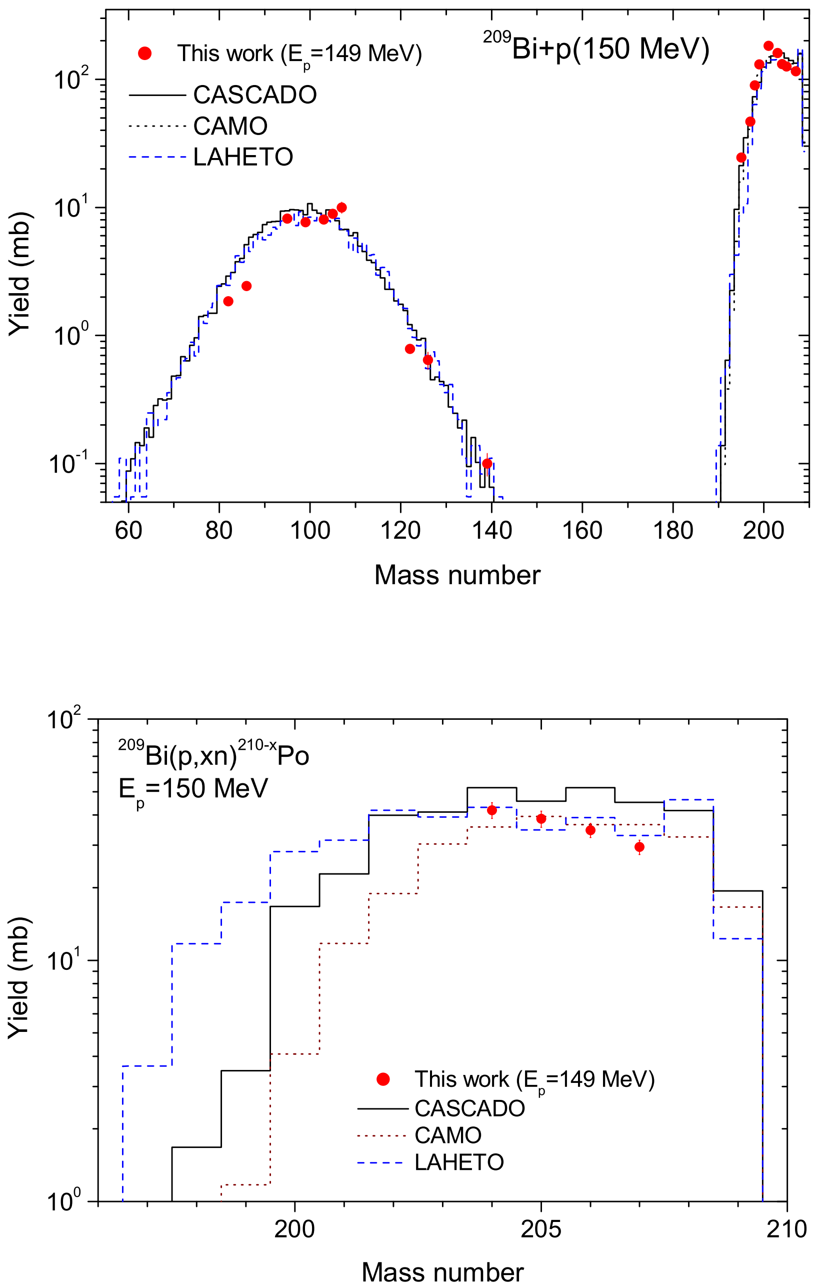
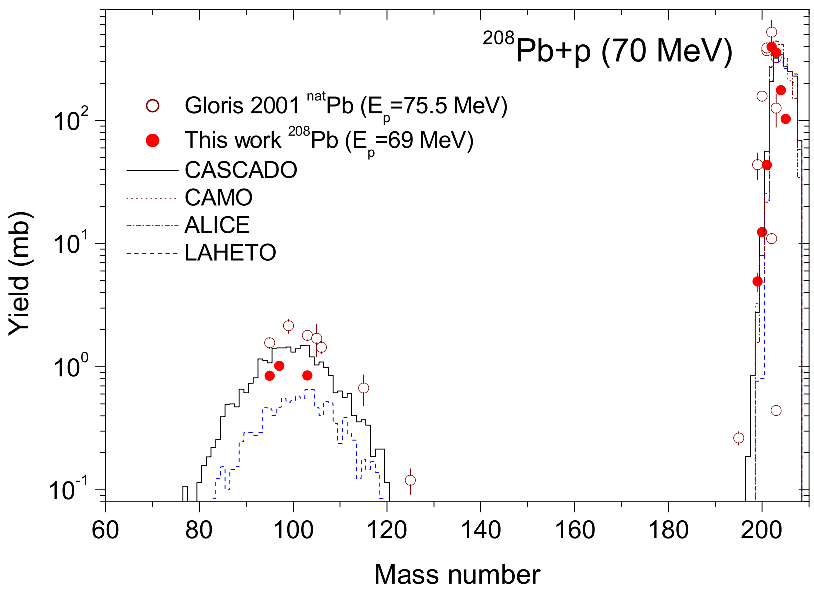


Fig. 49: Experimental data on cumulative yields of spallation and fission products and on the polonium isotopic yields for ^{209}Bi target irradiated by 150 MeV protons compared with cascade-model calculations.



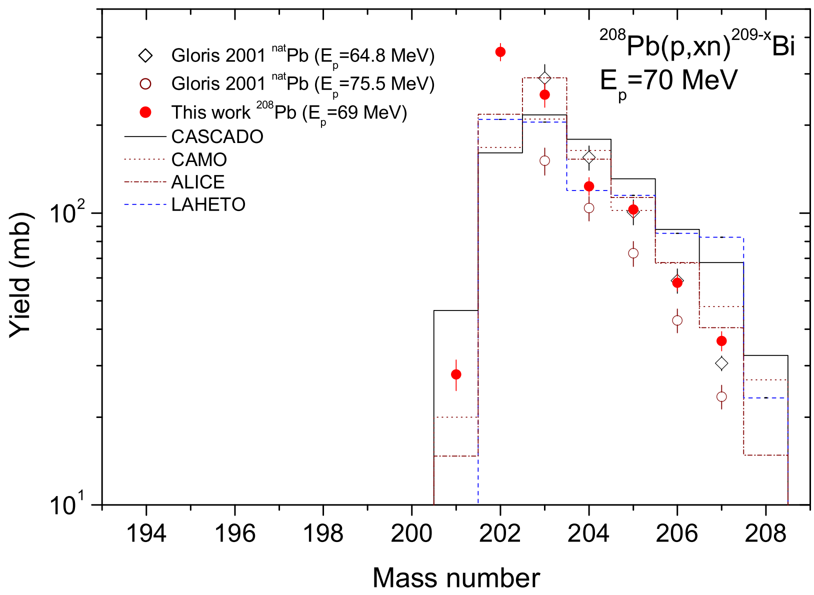


Fig. 50: Experimental data on cumulative yields of spallation and fission products and on the bismuth isotopic yields for ^{208}Pb target irradiated by 70 MeV protons compared with cascade-model calculations.

5 Theoretical simulaton of experimental data by different codes

As noted above, any computational simulation implies calculations of independent product yields only, whereas most of the experimental results (except for the GSI inverse kinematics data) are the cumulative and supracumulative yields. In case the experimental and simulated independent yields are involved directly in the comparison or representation of excitation functions, any correct comparison or representation of the excitation functions of the values of cumulative and supracumulative yields necessitates the procedure of their calculations from independent simulated or experimental values of their precursor yields.

5.1 Radioactive decay chains used in simulations

In general, the radioactive nuclide production chain can be presented as

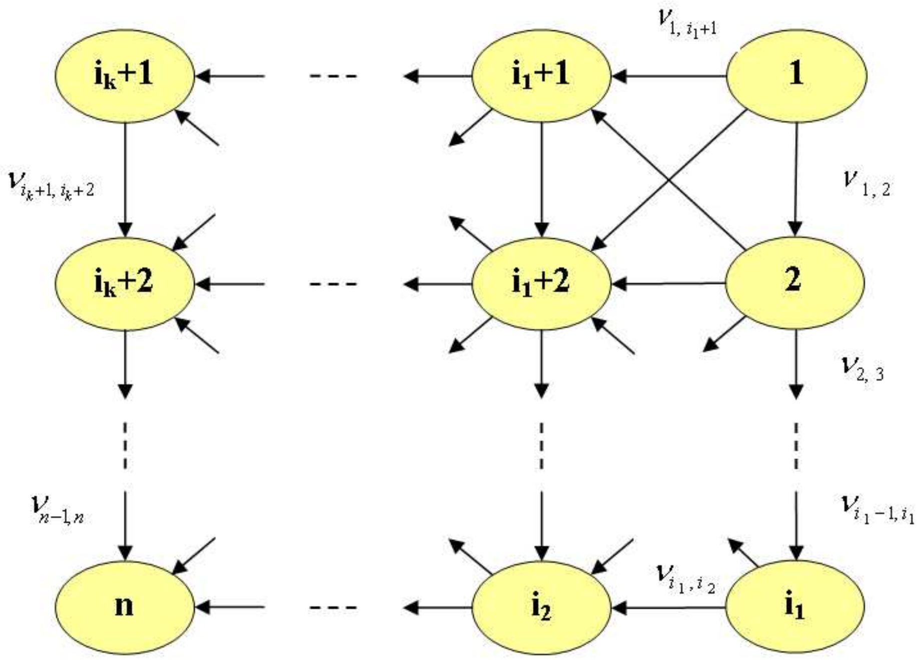


Fig. 51: Radioactive transformation pattern.

Examine a chain of n nuclides connected to each other by β^-, ε, n, p, and α transitions. Let all the chain nuclides be so numbered that a lower-number nuclide gets always transformed into a higher-number nuclide. Having known, then, the independent cross sections for production of all the chain nuclides, we can calculate the respective cumulative cross sections as

$$\sigma_k^{cum} = \sum_{j=1}^{k} m_{kj} \cdot \sigma_j^{ind}\ , k = 1, 2, ..., n \tag{160}$$

where m_{kj} is a matrix, whose elements are calculated as

$$m_{kj} = \begin{cases} \sum_{i=j}^{k-1} \nu_{ik} \cdot m_{ij}, \text{ for} k > j \ , \\ 1 \ , \ \text{for } k = j \ , \\ 0 \ , \ \text{for } k < j \ , \end{cases} \tag{161}$$

where ν_{ik} are the branching factors, i.e. denote the probability for the i-th nuclide to be transformed into the k-th nuclide. The vector form of the expression for calculating the cumulative yields is

$$\overrightarrow{\sigma}^{cum} = M \cdot \overrightarrow{\sigma}^{ind}, \tag{162}$$

where M is a matrix with elements m_{kj}; $\overrightarrow{\sigma}^{cum}$ and $\overrightarrow{\sigma}^{ind}$ are the vectors, whose elements are, respectively, the cumulative and independent cross sections of the chain elements.

$$\overrightarrow{\sigma}^{cum} = \begin{Bmatrix} \sigma_1^{cum} \\ \sigma_2^{cum} \\ \vdots \\ \sigma_n^{cum} \end{Bmatrix} , \qquad \overrightarrow{\sigma}^{ind} = \begin{Bmatrix} \sigma_1^{ind} \\ \sigma_2^{ind} \\ \vdots \\ \sigma_n^{ind} \end{Bmatrix} \tag{163}$$

The cumulative cross section errors can be calculated as

$$\Delta\sigma_k^{cum} = \sqrt{\sum_{i=1}^{n} m_{kj}^2 \cdot \left(\Delta\sigma_j^{ind}\right)^2} \tag{164}$$

where $\Delta\sigma_j^{ind}$ is absolute error of cross section σ_j^{ind}.

The values of branching factors ν_{ik} were retrieved from the ENSDF database taken from http://ie.lbl.gov/databases/ENSDFdata.exe (Database: Self-extracting ENSDF archive (23 MB). Last updated March, 2005) [35]. Note that the ENSDF database turns out to use 18 modes [2] of radioactive nuclide decays: β^-, $\beta^- n$, IT, ε, $\varepsilon{+}\beta^+$, p, α, $\beta^+ p$, $\beta^+\alpha$, $\beta^+ 2p$, εp, $\varepsilon\alpha$, 2ε, n, β^+, $2\beta^-$, $2\beta^+$, $2|e$.

All modes that lead to identical changes in nuclear charge and mass were combined to form twelve groups of decays, as tabulated below.

Table 38: Modes of decays and variations in nuclear charges and masses

Nos.	Mode	Modes from ENSDF	Δ A	Δ Z
1	β^-	β^-	0	+1
2	β^+	β^+, ε, $\varepsilon{+}\beta^+$	0	-1
3	$\beta^- n$	$\beta^- n$	-1	+1
4	$\beta^+ p$	$\beta^+ p$, εp	-1	-2
5	$\beta^+\alpha$	$\beta^+\alpha$, $\varepsilon\alpha$	-4	-3
6	$\beta^+ 2p$	$\beta^+ 2p$	-2	-3

[2]There exists also the SF-mode, which is irrelevant to our researches.

7	p	p	-1	-1
8	α	α	-4	-2
9	$2\beta^+$	$2\beta^+$, 2ε, $2\|e$	0	-2
10	n	n	-1	0
11	$2\beta^-$	$2\beta^-$	0	+2
12	IT	IT	0	0

Use was made of branching factors for ground states or, in case the latter are absent, for the first metastable state. If an accurate branching factor value is unknown and presented as (<) or (>) that a certain limit, the branching factor is taken to equal the value of the limit, i.e. (<) or (>) was replaced with (=).

If a branching factor value is indicated to be unknown (marked ?), it was taken to be 0 in case numerical values of other branching factors are presented (considering the above remark), or else 1 in case other decay modes are not indicated. If other decay modes are presented, but the sum of their values is below 100%, the unknown branching factor was taken to equal 100% less the sum of the rest presented decay modes. If a few decay modes with unknown branchig factors are presented, their values are taken to equal the ratio of 100% to the number of the presented modes. If but a single decay mode with its branching factor below 100% is presented (for example, α=4.5% is only presented for ^{161}Ta), the missing difference was ascribed to the β^+ mode (in the case of neutron-deficient nuclides) or to the β^- mode (in the case of neutron-excessive nuclides).

If a delayed-decay mode ($\beta^+\alpha$, for instance) is indicated, the value of the delayed mode (α) was subtracted from the value of the principal mode (β^+). The branching factors for ^{181}Ta and ^{151}La were taken from Nuclear Wallet Cards (January 2000) because their values were not found in the ENSDFdata.exe file [126]. In total, 2470 nuclides with their branching factors have been selected from the ENSDFdata.exe file. Of them, 610 precursors were used to build the respective decay chains.

It should be noted that branching factor values derived in the above manner from the ENSDFdata.exe file are sometimes very different from the data of other sources. In the case of ^{177}Au, for example, ENSDF gives $\alpha \leq 100$ %, ε+β^+-?, whereas the Nuclear Wallet Cards indicates $\varepsilon \geq 60$.

On account of all the above reasons and considering the great importance of the given information in verifying the relevant codes, all chains are presented together with their branching factors in Chapter 4 of Appendix to this Report. Plotted as an example in Fig. 52 is the ^{143}Pm chain that includes 43 precursors.

For convenience, the analyzed decay chains were broken into groups of ^{208,207,206,nat}Pb and ^{209}Bi decay chains. The ^{208,207,206,nat}Pb decay chain members were restricted to the Bi isotopes, and the ^{209}Bi decay chain members to the Po isotopes. The chains, wherein Po was not found, are identical. Note that some codes simulate the yields of the Po isotopes from ^{208,207,206,nat}Pb, and of the At isotopes from из ^{209}Bi. The yields of the products are, however, so small (<< 1 mb) that they can well be disregarded to avoid any excessive complication of the chains. The presented radioactive chains permit them to be grouped into independent yields (**i**, **i**(Σ**m**$_j$+**g**)), cumulative yields **c**, and supracumulative yields **c***.

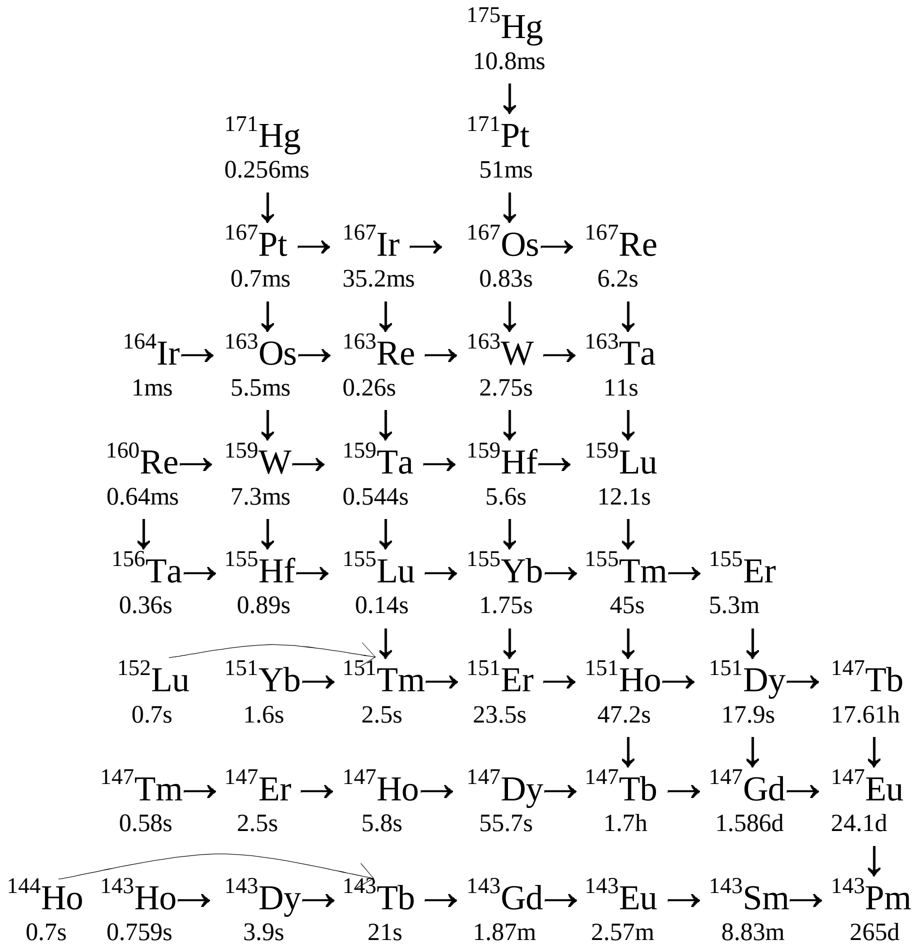


Fig. 52: The ^{143}Pm chain.

In addition, Table (39) lists the nuclides with supracumulative yields, their branching factors ν, and their supracumulativity coefficients k_{cum^*} that are calculated by formula (141).

Table 39: List of nuclides together with their supracumulative yields, halflives, branching factors, and supracumulativity coefficients.

Nos.	Nuclide (2)	$T_{2_{1/2}}$	Nuclide (1)	$T_{1_{1/2}}$	Type Pb	Type Bi	ν_{12}	$\frac{\lambda_1}{\lambda_1-\lambda_2}$	k_{cum^*}
1	2	3	4	5	6	7	8	9	10
14	$^{204}_{83}$Bi	11.22h	$^{204}_{84}$Po	3.53h		c*	0.9934	1.4590	1.4494
18	$^{202}_{83}$Bi	1.72h	$^{202}_{84}$Po	44.7m		c*	0.9808	1.7641	1.7302
19	$^{201}_{83}$Bi	108m	$^{201}_{84}$Po	15.3m		c*	0.984	1.1650	1.1464
20	$^{199}_{83}$Bi	27m	$^{199}_{84}$Po	4.58m		c*	0.925	1.2043	1.1140
28	$^{201}_{82}$Pb	9.33h	$^{201}_{83}$Bi	108m	c*	c*	1	1.2390	1.2390
30	$^{199}_{82}$Pb	90m	$^{199}_{83}$Bi	27m	c*	c*	1	1.4286	1.4286
32	$^{197m}_{82}$Pb	43m	$^{197m}_{83}$Bi	5.04m	c*	c*	0.45	1.1328	0.5097
33	$^{196}_{82}$Pb	37m	$^{196}_{83}$Bi	308s	c*	c*	1	1.1611	1.1611

1	2	3	4	5	6	7	8	9	10
40	${}^{199}_{81}$Tl	7.42h	${}^{199}_{82}$Pb	90m	c*		1	1.2534	1.2534
44	${}^{195}_{81}$Tl	1.16h	${}^{195}_{82}$Pb	≈15m	c*	c*	1	1.2747	1.2747
46	${}^{197}_{80}$Hg	64.14h	${}^{197}_{81}$Tl	2.84h	c*	c*	1	1.0463	1.0463
53	${}^{190}_{80}$Hg	20.0m	${}^{190}_{81}$Tl	3.7m	c*	c*	1	1.2270	1.2270
62	${}^{191}_{79}$Au	3.18h	${}^{191}_{80}$Hg	49m	c*	c*	1	1.3456	1.3456
75	${}^{187}_{77}$Ir	10.5h	${}^{187}_{78}$Pt	2.35h	c*	c*	1	1.2883	1.2883
78	${}^{184}_{77}$Ir	3.09h	${}^{184}_{78}$Pt	17.3m	c*	c*	1	1.1029	1.1029
81	${}^{183m}_{76}$Os	9.9h	${}^{183}_{77}$Ir	57m	c*	c*	1	1.1061	1.1061
88	${}^{179}_{75}$Re	19.5m	${}^{179}_{76}$Os	6.5m	c*	c*	1	1.5000	1.5000
89	${}^{178}_{75}$Re	13.2m	${}^{178}_{76}$Os	5.0m	c*	c*	1	1.6098	1.6098
94	${}^{176}_{73}$Ta	8.09h	${}^{176}_{74}$W	2.5h		c*	1	1.4472	1.4472
98	${}^{172}_{73}$Ta	36.8m	${}^{172}_{74}$W	6.6m	c*	c*	1	1.2185	1.2185
118	${}^{161}_{68}$Er	3.21h	${}^{161}_{69}$Tm	33m	c*	c*	1	1.2068	1.2068
120	${}^{159}_{68}$Er	36m	${}^{159}_{69}$Tm	9.13m	c*	c*	1	1.3398	1.3398
122	${}^{156}_{67}$Ho	56m	${}^{156}_{68}$Er	19.5m	c*	c*	1	1.5342	1.5342
124	${}^{155}_{66}$Dy	9.9h	${}^{155}_{67}$Ho	48m	c*	c*	1	1.0879	1.0879
127	${}^{155}_{65}$Tb	5.32d	${}^{155}_{66}$Dy	9.9h		c*	1	1.0841	1.0841
128	${}^{153}_{65}$Tb	2.34d	${}^{153}_{66}$Dy	6.4h	c*	c*	0.9999	1.0478	1.0477
146	${}^{134}_{59}$Pr	17m	${}^{134}_{60}$Nd	8.5m		c*	1	2.0000	2.0000
162	${}^{121}_{53}$I	2.12h	${}^{121}_{54}$Xe	40.1m		c*	1	1.4604	1.4604
173	${}^{115}_{51}$Sb	32.1m	${}^{115}_{52}$Te	5.8m		c*	1	1.2205	1.2205
203	${}^{90}_{41}$Nb	14.60h	${}^{90}_{42}$Mo	5.56h	c*	c*	1	1.6150	1.6150
211	${}^{87}_{39}$Y	79.8h	${}^{87m}_{39}$Y	13.37h	c*	c*	0.9843	1.2013	1.1824

Analyzing the radioactive transformation chains presented in Chapter 4 of Appendix to this Report permits the following general comments:

- 29 of the measured metastable states are excluded from the comparison: ${}^{204m}_{82}$Pb, ${}^{202m}_{82}$Pb, ${}^{197m}_{82}$Pb, ${}^{195m}_{82}$Pb, ${}^{198m}_{81}$Tl, ${}^{196m}_{81}$Tl, ${}^{197m}_{80}$Hg, ${}^{195m}_{80}$Hg, ${}^{193m}_{80}$Hg, ${}^{198m}_{79}$Au, ${}^{183m}_{76}$Os, ${}^{182m}_{75}$Re, ${}^{160m}_{67}$Ho, ${}^{123m}_{52}$Te, ${}^{121m}_{52}$Te, ${}^{119m}_{52}$Te, ${}^{120m}_{51}$Sb, ${}^{118m}_{51}$Sb, ${}^{117m}_{50}$Sn, ${}^{114m}_{49}$In, ${}^{110m}_{47}$Ag, ${}^{106m}_{47}$Ag, ${}^{102m}_{45}$Rh, ${}^{101m}_{45}$Rh, ${}^{99m}_{45}$Rh, ${}^{93m}_{42}$Mo, ${}^{92m}_{41}$Nb, ${}^{90m}_{39}$Y, ${}^{82m}_{37}$Rb.

- The nuclides, whose branching factors of metastable states (except for IT-mode) differ from those of ground states, may also be radioactive chain members. In such a case, the total branching factor of a given nuclide differs from the ground state branching factor presented here, thereby introducing a systematic error.

  This is of particular importance in case the decay modes of the nuclides extend to other chains. Of 44 nuclides belonging to the chain presented in Fig. 52, ^{167}Re is such a nuclide. According to the ENDSFdat.exe file, ^{167}Re has $\beta^+ \sim 99\%$, $\alpha \sim 1\%$, while ^{167m}Re has $\alpha \sim 100\%$. Table 40 presents other examples of different branching factors of metastable and ground states. This problem is also urgent in the cases where a measured nuclide (it makes no difference if the nuclide yield is independent or cumulative) has its metastable states with their internal conversion factor IT below 100% (the nuclides are exemplified in Table 41).

Table 40: Examples of the ^{208,207,206,nat}Pb and ^{209}Bi decay chain nuclides with different α-decay fractions of their ground and metastable states.

Nuc-lide	$T_{2_{1/2}}$	Decay mode ε %	Decay mode α %	Iso-mer	$T_{1_{1/2}}$	Decay mode IT %	Decay mode ε %	Decay mode α %
$^{203}_{84}$Po	36.7m	99.89	0.11	$^{203m}_{84}$Po	45s	≈100		0.04
$^{201}_{84}$Po	15.3m	98.4	1.6	$^{201m}_{84}$Po	8.9m	56	41	2.9
$^{199}_{84}$Po	4.58m	92.5	7.5	$^{199m}_{84}$Po	4.13m	2.5	73.5	24
$^{197}_{84}$Po	1.4m	56	44	$^{197m}_{84}$Po	31s	0.01	16	84
$^{201}_{83}$Bi	108m	100	$<1.0 \cdot 10^{-4}$	$^{201m}_{83}$Bi	59.1m	≤6.8	>93	≈ 0.3
$^{197}_{83}$Bi	9.33m	100	$1.0 \cdot 10^{-4}$	$^{197m}_{83}$Bi	5.04m	<0.3	45	55

Table 41: Examples of measured nuclides and their metastable state decay fractions.

Nuc-lide (2)	$T_{2_{1/2}}$	Isomer (1)	$T_{1_{1/2}}$	Decay type IT %	Decay type ε %	Decay type α %	Decay type β^- %
$^{203}_{84}$Po	36.7m	$^{201m}_{84}$Po	45s	≈ 100	-	0.04	-
$^{201}_{84}$Po	15.3m	$^{201m}_{84}$Po	8.9m	56	41	2.9	-
$^{201}_{83}$Bi	108m	$^{201m}_{83}$Bi	59.1m	≤ 6.8	> 93	≈ 0.3	-
$^{199}_{83}$Bi	27m	$^{199m}_{83}$Bi	24.70m	≤ 2	98	≈ 0.01	-
$^{199}_{82}$Pb	90m	$^{199m}_{82}$Pb	12.2 m	93	7	-	-

The above features of the chains have an undoubted effect on the values of the squared deviation factor $< F >$ that determine the predictive power of the tested codes.

5.2 The codes used to simulate the experimental results

Apart of CASCADO and LAHETO, other five codes were used to calculate our measured cross sections:

- LAHET [131] is a well known and one of the most widely used in different nuclear applications code. It involves Monte-Carlo modeling of transport of nucleons, pions, muons, light ions, and antinucleons in extended objects or thin targets (interactions with nuclei). LAHET was developed at Los Alamos National Laboratory and includes several options of models to choose from to simulate the intranuclear cascade (INC), preequilibrium, evaporation, and fission of nuclei. The Bertini and ISABEL INC, Multistage Preequilibrium Model (MPM), Dresner's evaporation, and Atchison's (RAL) fission models (see details and references in [131]) are used in the work.
- CEM03 is the last, 2003, version of the improved Cascade-Exciton Model (CEM) [132] proposed initially at JINR, Dubna [133]. It has a longer cascade stage, less preequilibrium emission, and a longer evaporation stage with a higher initial excitation energy compared

to its precursors CEM97 and CEM95. It is based on an improved [134] Dubna INC, extended Fermi break up and coalescence models from [135], and includes an improved version of the Generalized Evaporation-fission Model (GEM2) by Furihata [136]. CEM03 and/or its precursors are incorporated into the MARS, MCNPX, and LAHET transport codes and are used in many applications. The above modifications of CEM03 and the simulations were carried out at LANL by S.G.Mashnik.

- LAQGSM+GEM2 is a further development [137] of the Los Alamos version of the Quark-Gluon String Model [138] based of the Quark-Gluon String Model (QGSM) realized initially at JINR, Dubna [139]. It includes an improved version [134] of a time-dependent Dubna intranuclear cascade model, often referred in the literature simply as the Dubna intranuclear Cascade Model (DCM) [135] that makes use of experimental elementary cross sections (or those calculated with the Quark-Gluon String Model[139] for energies above 4.5 GeV/A), the improved pre-equilibrium model from CEM03 described above, refined versions of the Fermi break-up and coalescence models from [135], and an improved version of the Furihata's Generalized Evaporation-fission Model (GEM2) [136] as realized in CEM03. Here, we use the last, 2003, version of the code LAQGSM+GEM2, named LAQGSM03 [140], that was incorporated recently into the MARS and LAHET transport codes and is currently being incorporated into MCNPX. The above modifications of LAQGSM+GEM2 and the simulations were carried out at LANL by S.G.Mashnik, K. Gudima, and A. Sierk.

- INCL4+ABLA [141], [142] code is based on a recent version of the Liege INC by Cugnon et al. [141] merged with the GSI evaporation/fission model ABLA by Schmidt et al. [142]. This code system was developed in the framework of the HINDAS project, it was incorporated into LAHET3 and MCNPX transport codes, and is widely used at present in Europe. The above modifications of INCL4+ABLA were carried out at CEA-Sacley by A. Boudard.

- CASCADE is a transport code system developed at JINR, Dubna [130]. It allows to calculate nuclear reactions both on thin and thick targets and includes a time-dependent INC (different from [135]), the preequilibrium and evaporation models of CEM [133], and the Fong statistical fission model. It is under further development at JINR; its different modifications are used at present in many nuclear applications, mainly in the Former USSR.

To get a correct comparison for the results obtained by different codes, the calculated yields values were renormalized to the same cross sections for inelastic proton-nucleus interactions. We calculated the cross sections via the semi-empirical formula [168]:

$$\begin{aligned} \sigma_{inel} &= 45A^{0.7}f(A)g(E), (\text{ in mb}) \qquad (165) \\ f(A) &= 1 + 0.016\sin(5.3 - 2.63\log A), \\ g(E) &= 1 - 0.62\exp(-E/200)\sin(10.9E^{-0.28}), \end{aligned}$$

where A is the mass number of the target, E is the energy (in MeV) of the projectile proton.

The calculated proton-nucleus inelastic cross sections of the targets are presented in Table 42.

Table 42: Inelastic proton-nucleus interaction cross sections [mbarn] calculated by formulae [168].

Target	Proton energy (GeV)										
	0.04	0.07	0.1	0.15	0.25	0.4	0.6	0.8	1.2	1.6	2.6
^{206}Pb	2487	1995	1757	1612	1613	1714	1798	1833	1851	1853	1853
^{207}Pb	2495	2002	1762	1617	1618	1720	1804	1839	1857	1859	1860
^{208}Pb	2503	2008	1768	1622	1624	1726	1810	1845	1863	1865	1866
^{209}Bi	2512	2015	1774	1628	1629	1732	1816	1851	1869	1872	1872

5.3 Simualtion-to-Experimental Comparison

The modeling was carried out at 25 energies from 0.03 to 3.5 GeV to produce smooth excitation functions (EF). The **default options** were used in all the simulation codes without modifying the latter to get the optimal agreement with experimental data. All the calculations were made prio to obtaining any experimental results. With such an approach, our comparisons demonstrate the real predictive, rather than the descriptive power of the codes. To make the comparison to experimental data (ED) correct, the required cumulative yields were calculated on the base of simulated independent yields with the use of formulas 160 and 162. The metastable products were not simulated. We compared simulated and experimental EF both qualitatively (by plots) and quantitatively (by the mean simulated-to-experiment squared deviation factor <F>, $< F > = 10^{\sqrt{< \log{(\sigma_{cal,i}/\sigma_{exp,i})}^2 >}}$). Three set of figures were drawn for the qualitative comparison:

1. 884 figures with EF simulated by the codes and ED measured (Figs. 53 – 83).
2. 55 figures with mass production cross sections measured and simulated (Figs 84 – 138, plotted both in logarithmic and linear scale). The measured data shown at these figures are the measured cumulative and supra cumulative yields of the nuclides that are in immediate proximity to the stable isotope of a given mass (or the sum of such yields from either side in the cases where both left- and right-hand branches of the chain are present).Obviously, the simulation results do not contradict the experimental data if the simulated values run above the experimental data and follow the general trend of the latter. This is because the direct γ-spectrometry identifies only the radioactive products, which generally form a significant fraction of the total mass yield, but are never equal to the total mass yield when a stable isobar is produced.
3. 10 figures with simulation-to-experimental ration statistics (Figs 139 – 148) to be used for the quantitative comparison.

To understand how different codes agree with the data in different nuclide production regions, we divided conventionally all products into four groups: shallow spallation products (A>170), deep spallation products (140<A<170), fission products (30<A<140), and fragmentation products (A<30).

Besides, the energy ranges are conditionally broken into groups of low (E_p <0.1GeV), medium (0.1GeV< E_p <1.0GeV), and high (E_p >1.0GeV) energies. The mean deviation factors <F> are presented in Table 43 for each combination of product and energy groups, and in Table 44 for each group separately together with the <F> values for all the comparison events. To facilitate the analysis, three least <F> values are shown to be red, and three highest <F> values to be blue, in each of the comparison event groups.

Table 43: Mean squared deviation factors <F> for different ranges of products in three energy groups: <0.1 / 0.1-1.0 / >1.0 GeV.

Code	Product mass (A), Proton energy group (Ep, GeV)											
	A > 170			140 < A < 170			30 < A < 140			A < 30		
	<0.1	0.1-1.0	>1.0	<0.1	0.1-1.0	>1.0	<0.1	0.1-1.0	>1.0	<0.1	0.1-1.0	>1.0
ISABEL	4.29	1.62	–	–	1.77	–	7.98	3.13	–	–	334.	–
BERTINI	3.97	1.54	1.69	–	2.30	1.82	5.73	2.95	2.41	–	418.	25.2
INCL4+ABLA	5.19	1.84	1.40	–	7.76	2.80	2.12	1.92	2.53	–	–	49.9
CASCADE	2.99	1.58	1.85	–	2.53	1.86	80.7	10.8	3.61	–	–	162.
CASCADE-2004	3.84	1.87	1.71	–	1.66	1.41	105	6.72	3.96	–	–	61.0
LAQGSM+GEM2	3.19	1.88	1.94	–	4.88	1.59	2.23	2.83	2.61	–	42.1	15.1
CEM03	2.21	1.61	2.46	–	2.75	1.87	1.32	1.89	2.64	–	14.4	7.69
CASCADO	2.93	2.01	1.79	–	4.98	1.38	1.39	2.47	3.26	–	177.	58.5
LAHETO	5.30	1.65	–	–	1.96	–	2.93	1.94	–	–	–	–

Table 44: Mean squared deviation factors <F> separately for different energy groups and ranges of products (A>30) and for all comparisons as well.

Code	Product mass (A)			Proton energy (E_p, GeV)			**Total**
	A>170	140<A<170	30<A<140	E_p <0.1	0.1<E_p <1.0	E_p >1.0	
ISABEL	1.81	1.81	2.87	4.88	2.13	–	**2.16**
BERTINI	1.75	1.93	2.75	4.26	2.06	1.97	**2.10**
INCL4+ABLA	1.90	3.74	2.22	4.63	2.18	2.13	**2.25**
CASCADE	1.77	2.01	6.93	4.93	3.93	2.44	**3.25**
CASCADE-2004	1.93	1.47	5.54	6.54	3.23	2.42	**2.94**
LAQGSM+GEM2	1.98	2.32	2.71	3.03	2.35	2.09	**2.26**
CEM03	1.98	2.07	2.25	2.08	1.77	2.39	**2.07**
CASCADO	1.99	2.22	2.83	2.69	2.33	2.22	**2.29**
LAHETO	1.99	1.96	1.98	4.85	1.76	–	**1.98**

5.4 Conclusions

In pursuance of the ISTC Project#2002 Workplan item (see Section 4 **Scope of activities**):

- Task 8: Theoretical simulations and calculations by different codes,

Chapter 5 presents the tables and figures that permit the following conclusions:

1. A>170 (shallow spallation products): most of the products from this region are predicted satisfactorily, with a mean deviation factor below 2. Deviations above factor 2 are observed, as a rule, for independent yields (e.g., for ^{192}Ir), for (p,xn) reactions, and for near-threshold energies, the fact that markedly affects <F> below 0.1 GeV. Also, the deviations between ED and simulated EF's as well as between results by different codes increase at energies above 1 GeV. The near-target products (A above 200) are predicted variously at different proton energies: For instance, CEM03 predicts such products with <F> ~1.5 at energies below 1 GeV, but underestimates them significantly (<F> ~6) at energies above 1 GeV. On the contrary, LAHET and LAQGSM+GEM2 predict these products with <F> ~ 1.5 – 2 at energies above 1 GeV, but fail to do so well at lower energies (<F> ~ 4 – 5). The similar is true for INCL4+ABLA: <F> ~ 1.3 – 1.5 at E_p > 0.1 GeV, <F> ~ 6 at E_p < 0.1 GeV. Note also that all codes gave similar <F> values averaged over all energies, which makes it difficult to choose the best among them.

2. 140<A<170 (deep spallation products). With decreasing mass of the products (excitation energy after the intranuclear cascade stage of a reaction increasing), the predictive power of almost all the codes also decreases. The degradation of the predictive power of different codes varies. For example, for BERTINI, <F> increases up to only 1.9; for LAQGSM+GEM2, <F> increases up to 2.3; and in the case of INCL4+ABLA , <F> increases up to 3.7. The INCL4+ABLA underestimates significantly the deep spallation products, thus overestimating their threshold energies. Note also that the thresholds of some reactions predicted by different codes may vary by up to hundreds of MeV. For example, the threshold for the production of ^{146}Eu predicted by different codes varies from 600 to 1200 MeV. Judging from the <F> values, CASCADE-2004 is much ahead of the rest codes (<F> =1.47 against <F> =1.81 for BERTINI).

3. Fission products (FP) are about a third of all measured and analyzed nuclides, and are described by the codes worse than the spallation products. The deviation between ED and simulated EF's as well as between different calculations themselves are much bigger than for the spallation products. INCL4+ABLA and CEM03, as well as LAHETO, show the best predictive power for fission products, whose <F> is ranging from 2.0 to 2.3. It should be noted, however, that LAHETO was not used to make calculations in the highest-energy group (E_p >1.0GeV), for which the INCL4+ABLA and CEM03 predictive powers get decreased, so the best resulting <F> value (1.98) cannot be a credible argument for considering LAHETO the best fission code. A peculiar agreement is demonstrated by the code INCL4+ABLA: <F> is too high (up to 6) in the 120<A<140 region where FP's overlap with deep spallation products, however, its agreement becomes the best (<F> from 1.5 to 2.0) in comparison with other codes for fission products with A<120. LAQGSM+GEM2 shows somewhat bigger deviation from ED (<F> up to 4), however, the agreement is better in the 80<A<110 region, with <F> around 2. CASCADE shows a much worse agreement on FP's (<F> up to ~ 20) compared with all the rest codes. Note

that most of the simulated EF's are below ED in the fission region, i.e. the fission mode seems to be underestimated by the codes. The agreement of calculations with the fission data varies with the proton energy. For example, INCL4+ABLA underestimates FP's at energies from $\sim$0.1 to $\sim$1 GeV, shows a good agreement at $\sim$1 GeV, and overestimates them at higher energies. CEM03 predicts most of FP at relatively low energies ($< \sim 0.5$ GeV) much better than at higher energies.

4. Despite the fact that but few fragmentation products have been measured and, then, compared with simulations under the reported Project, it can be concluded definitely that the fragmentation products are much underestimated by all the codes tested. The simulations underestimate the measured fragmentation yields by an order and more. As a whole, the CEM03 and LAQGSM+GEM2 results for these fragments are closest to ED.

The comparison among the mean deviation factors obtained for different energy groups has demonstrated an explicit decrease in the predictive power in the low-energy range ($E_p < 0.1$GeV), for which CEM03 alone gives <F> = 2.1, thus permitting it to be regarded as the stablest "universal"(as regards predictive power) code. As for the mean deviation factor, CEMO3 also gives high results (2.1), like ISABEL and LAHETO, which, however, were not used to make calculations in the upper range of energies.

Finally, we would like to mention that, as the gamma-spectrometry method used to obtain all experimental data analyzed here allows measuring only part of the products from any nuclear reaction, our comparison does not pretend to be comprehensive and to choose the best from the tested codes. Rather, it points to some distinct problems each code still has, helping the authors of the codes to further improve them.

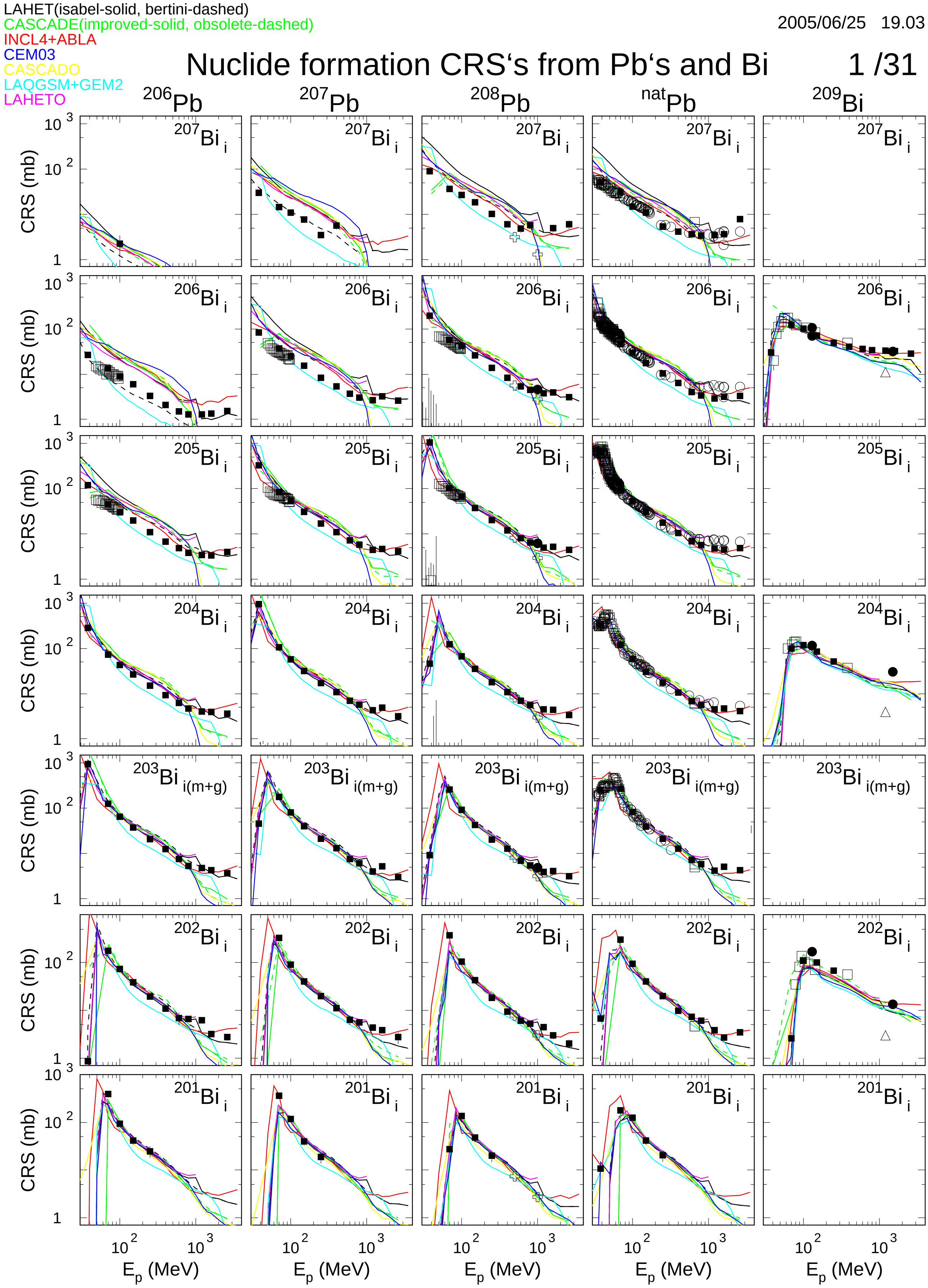


Fig. 53: The simulated and experimental cross sections of the measured reactions (■ - this work, + - [123], ○ - [117], ● - [6, 4], △ - [101], □ - other works; LAHET -black (ISABEL - solid, BERTINI - dashed), CEM03 - blue, INCL4+ABLA - red, CASCADE - green, LAQGSM03 - cyan, LEHETO- magenta, CASCADO - yellow.

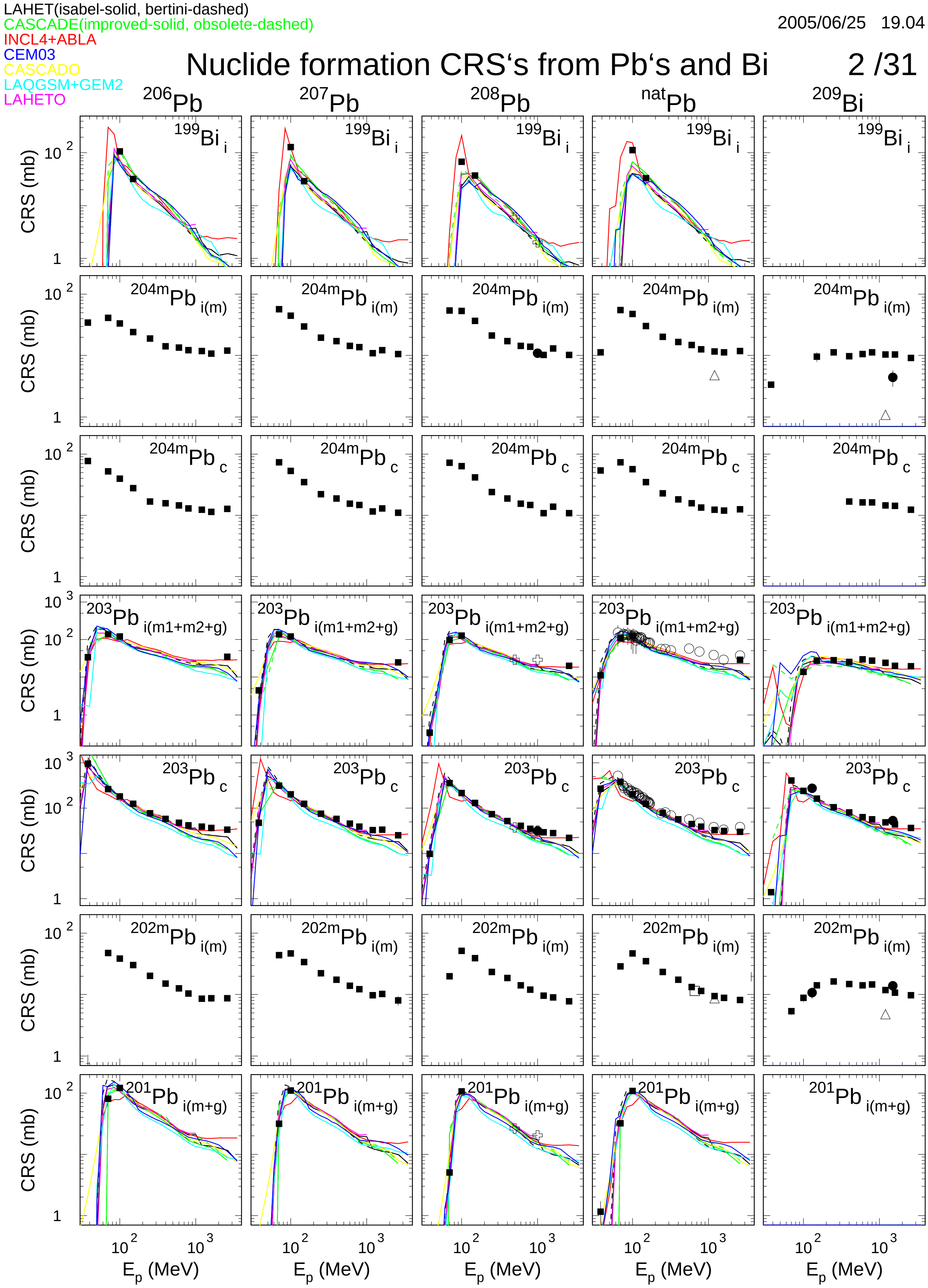


Fig. 54: The simulated and experimental cross sections of the measured reactions (Continuation of Fig. 53).

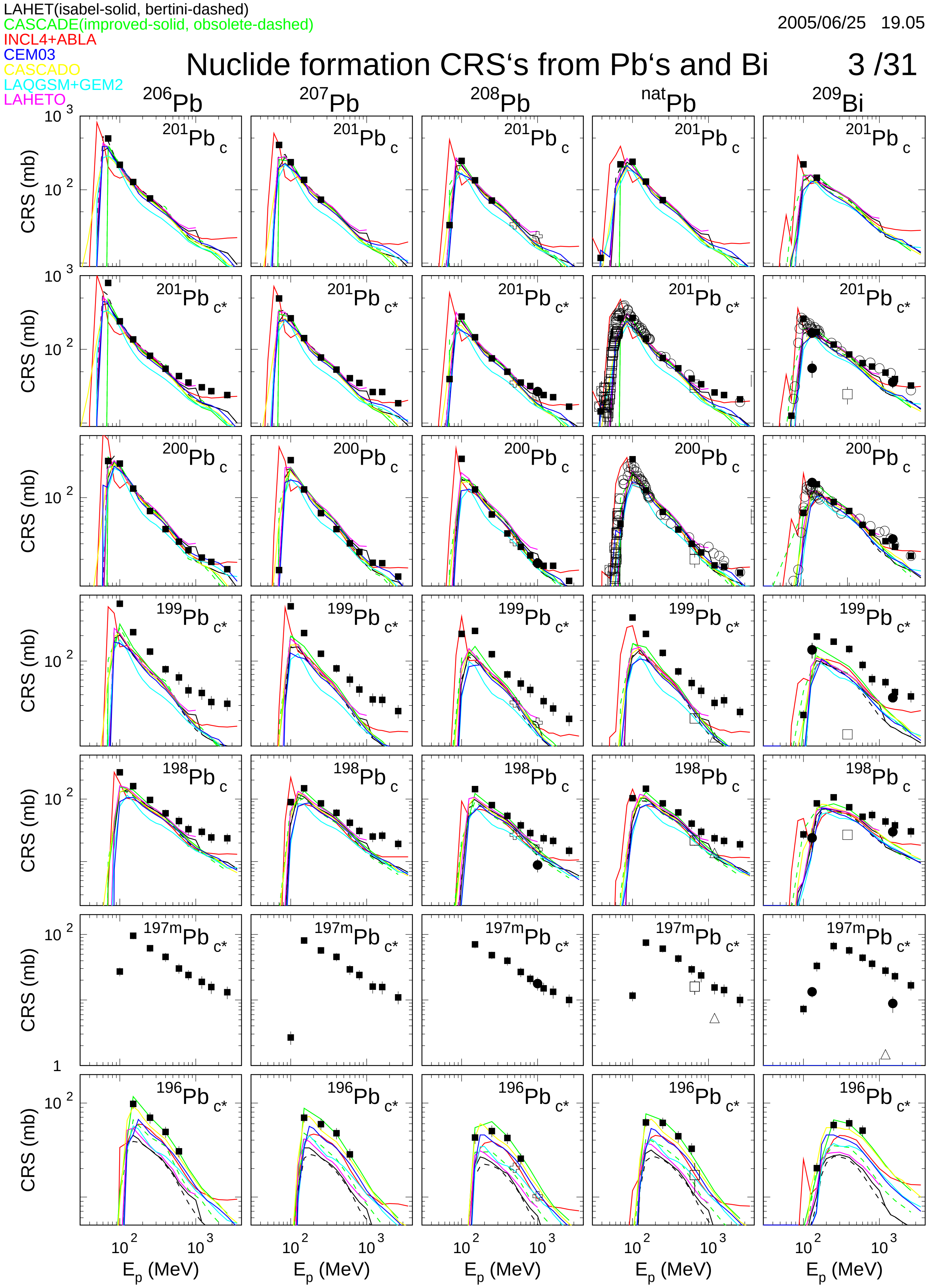


Fig. 55: The simulated and experimental cross sections of the measured reactions (Continuation of Fig. 53).

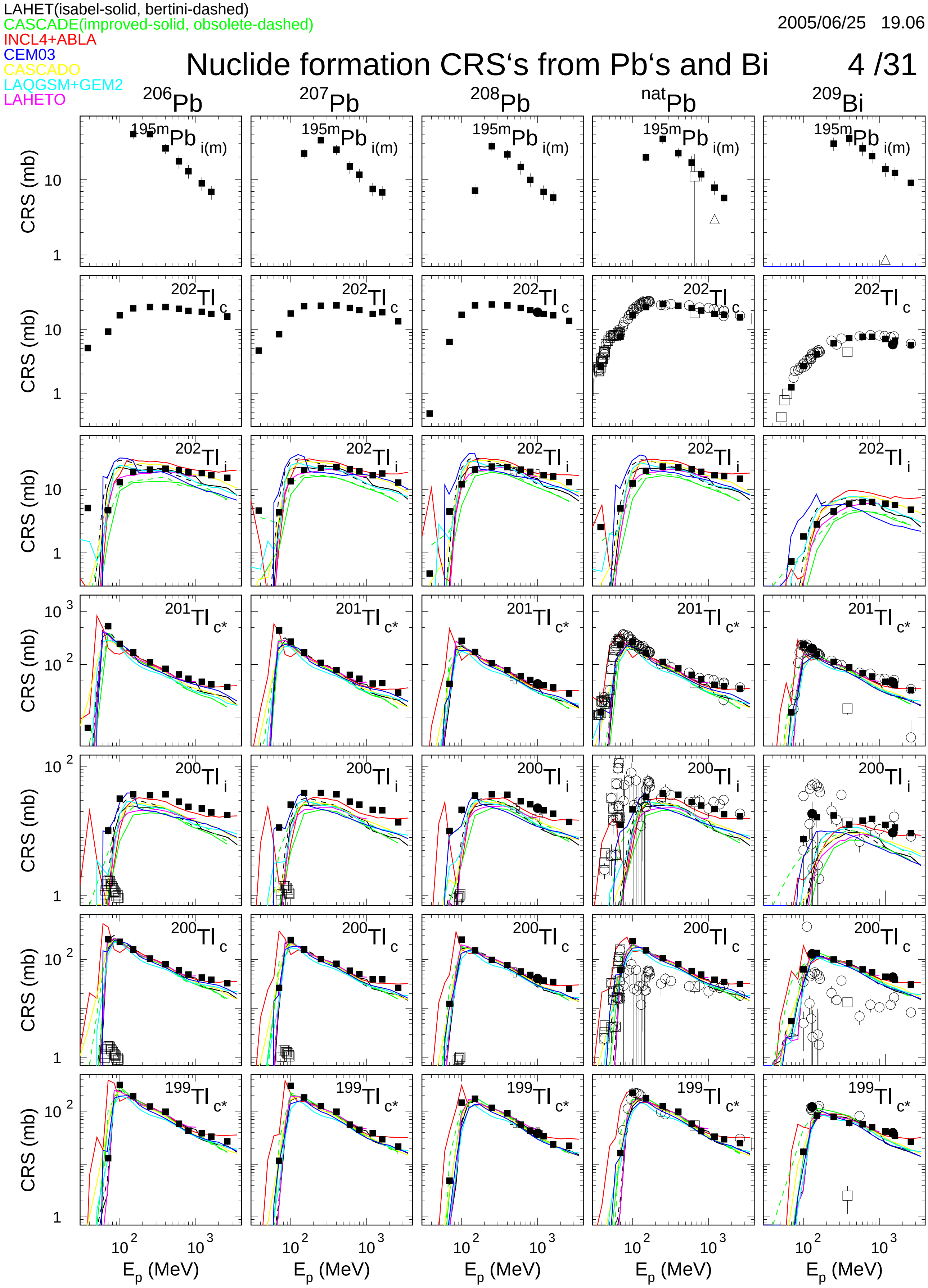


Fig. 56: The simulated and experimental cross sections of the measured reactions (Continuation of Fig. 53).

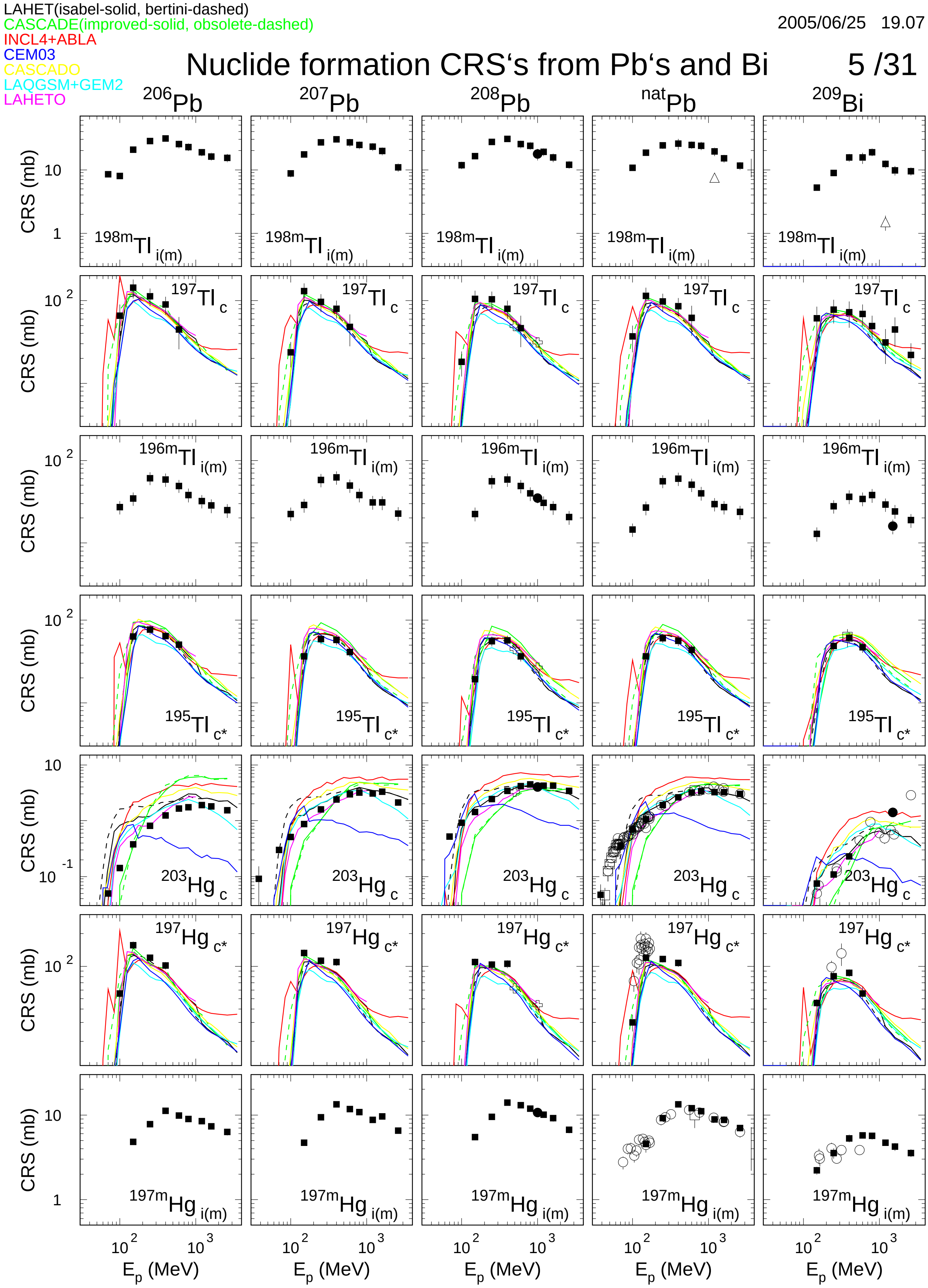


Fig. 57: The simulated and experimental cross sections of the measured reactions (Continuation of Fig. 53).

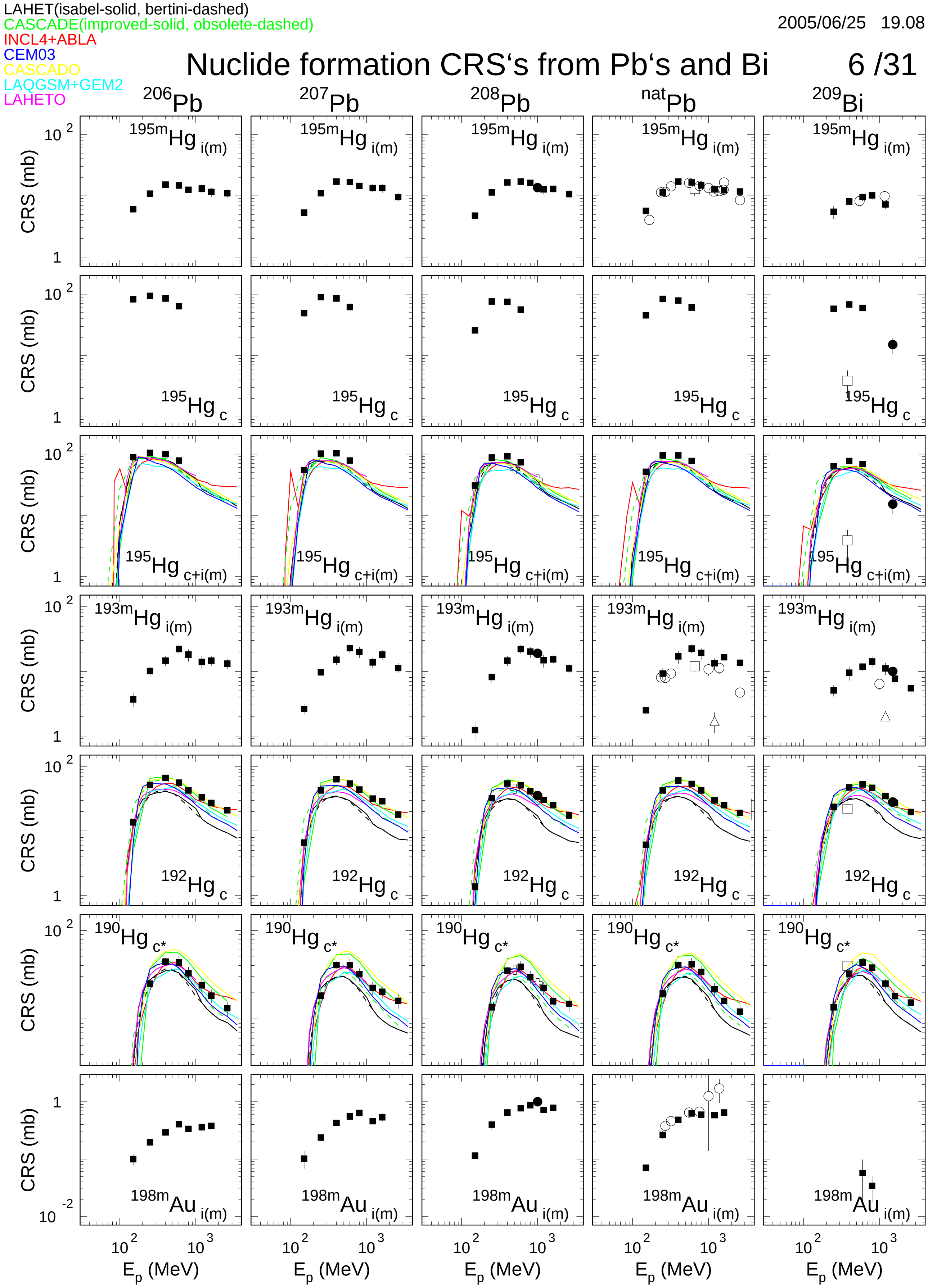


Fig. 58: The simulated and experimental cross sections of the measured reactions (Continuation of Fig. 53).

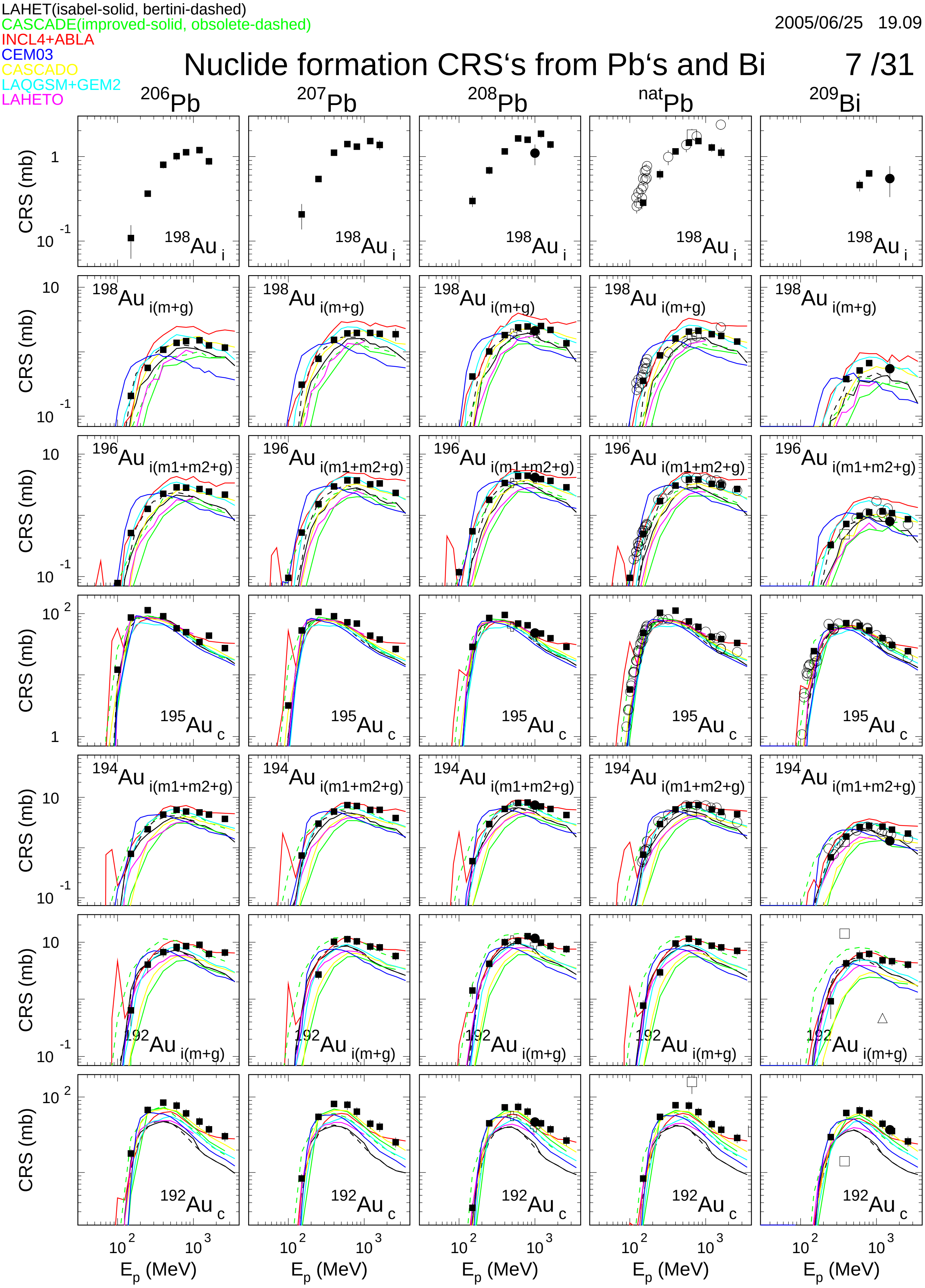


Fig. 59: The simulated and experimental cross sections of the measured reactions (Continuation of Fig. 53).

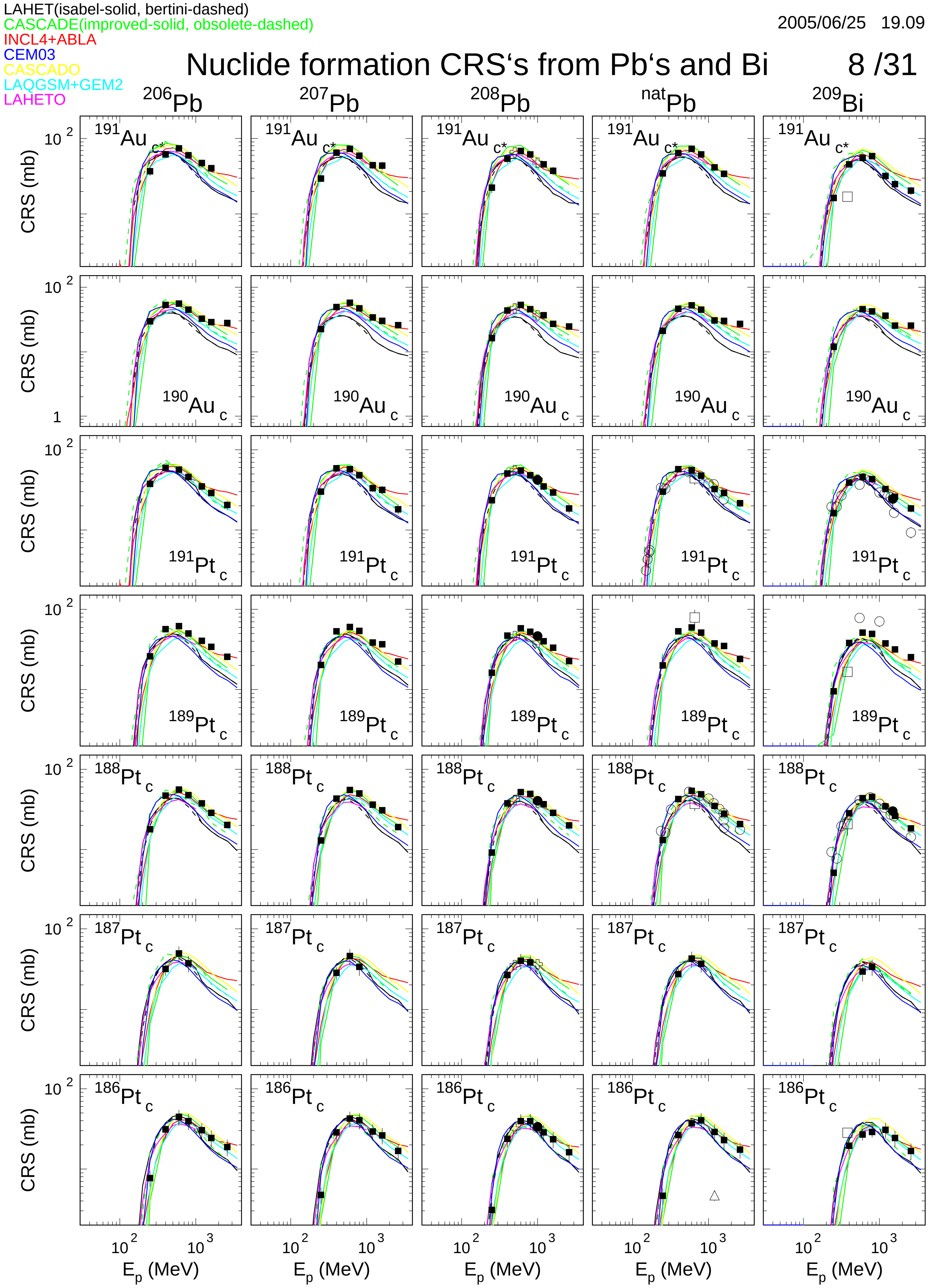


Fig. 60: The simulated and experimental cross sections of the measured reactions (Continuation of Fig. 53).

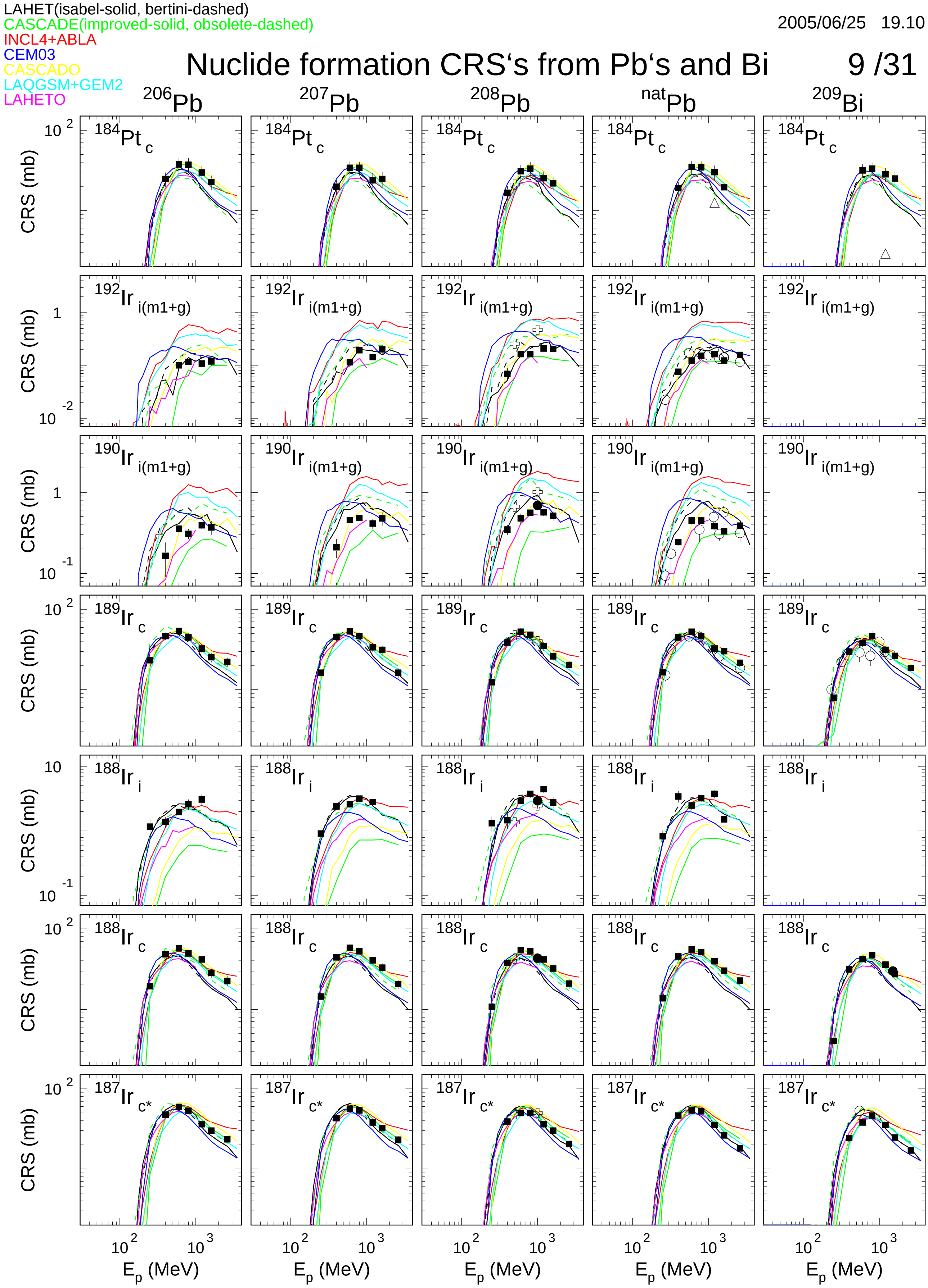


Fig. 61: The simulated and experimental cross sections of the measured reactions (Continuation of Fig. 53).

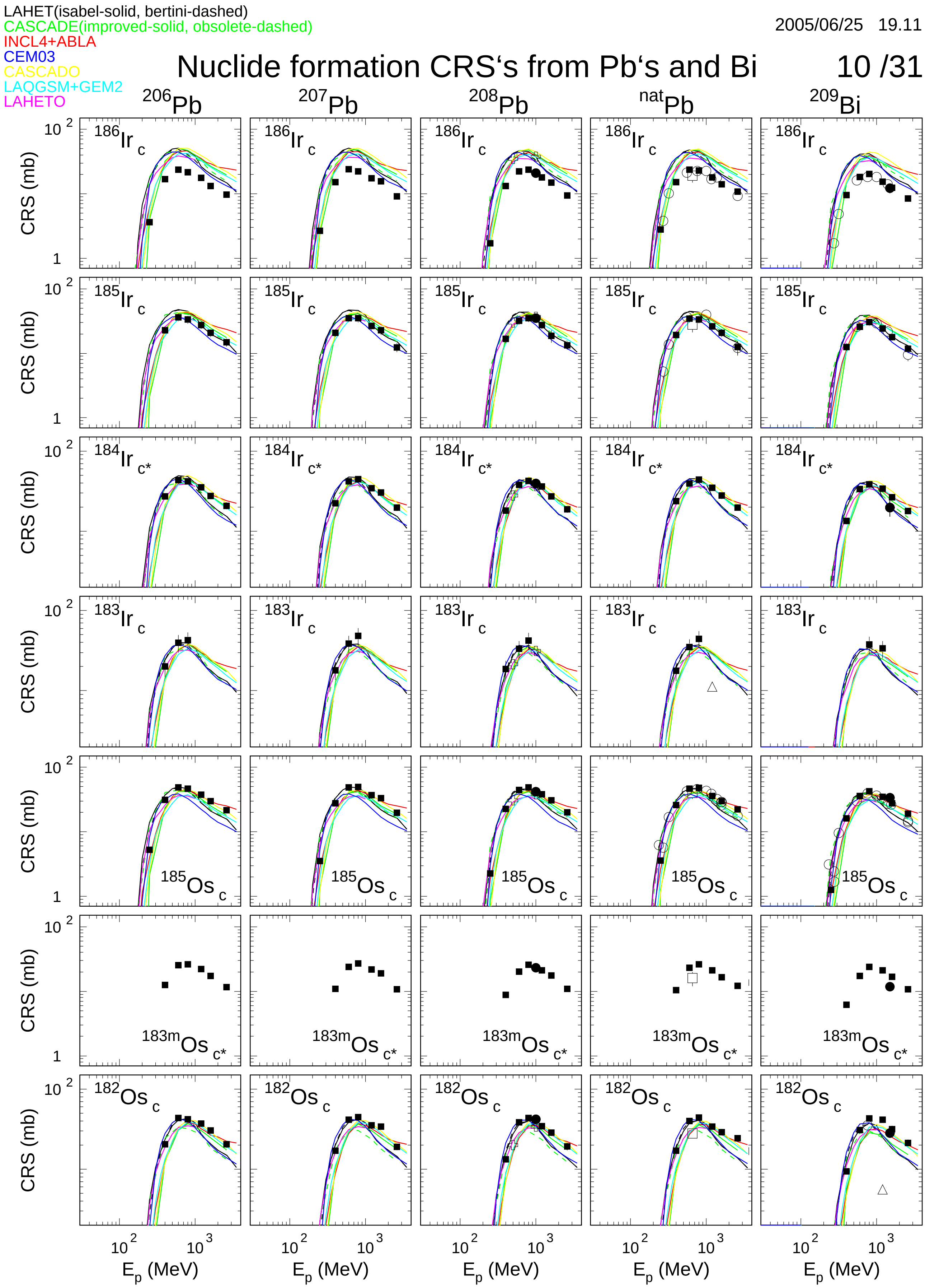


Fig. 62: The simulated and experimental cross sections of the measured reactions (Continuation of Fig. 53).

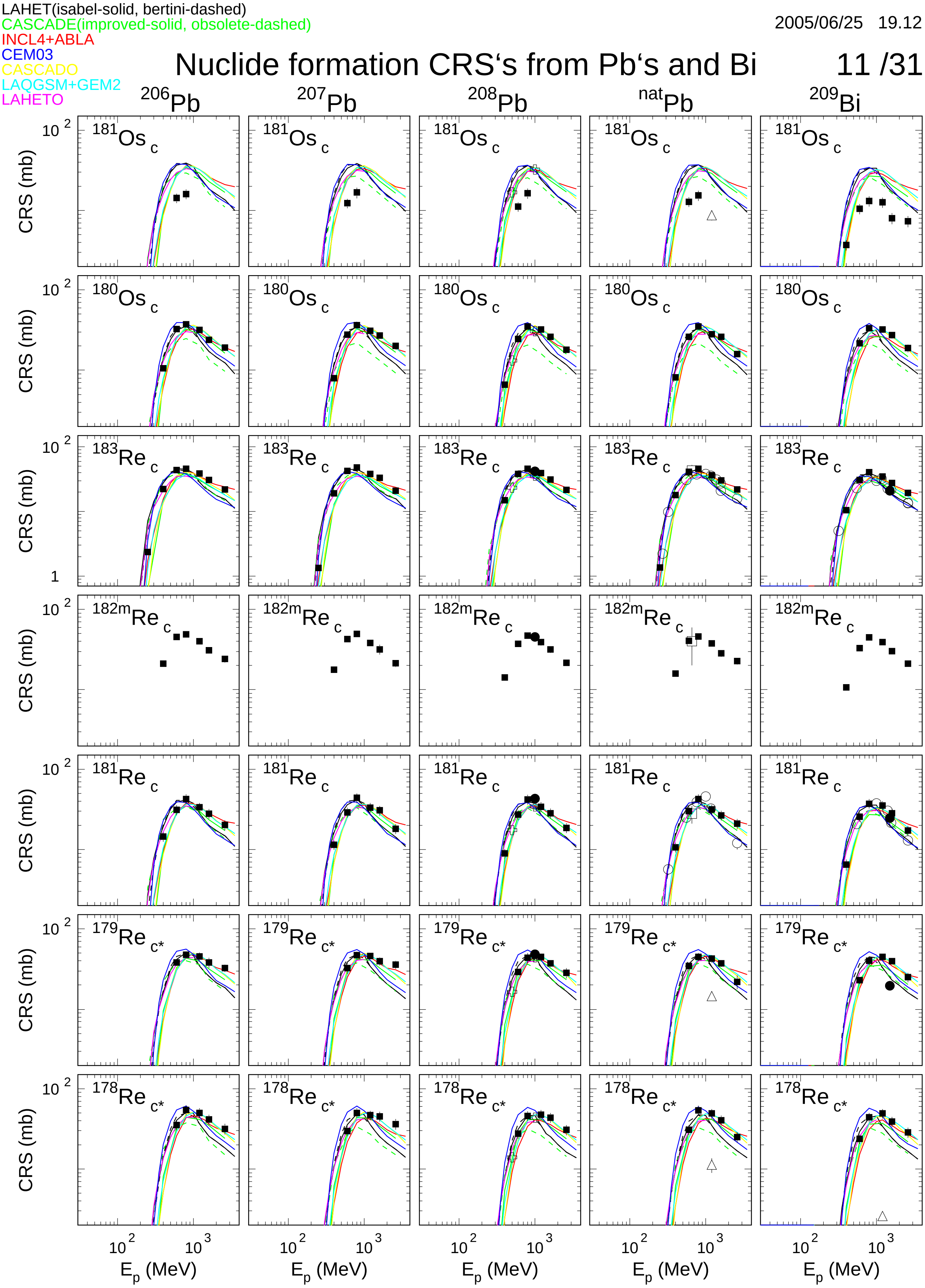


Fig. 63: The simulated and experimental cross sections of the measured reactions (Continuation of Fig. 53).

Nuclide formation CRS's from Pb's and Bi

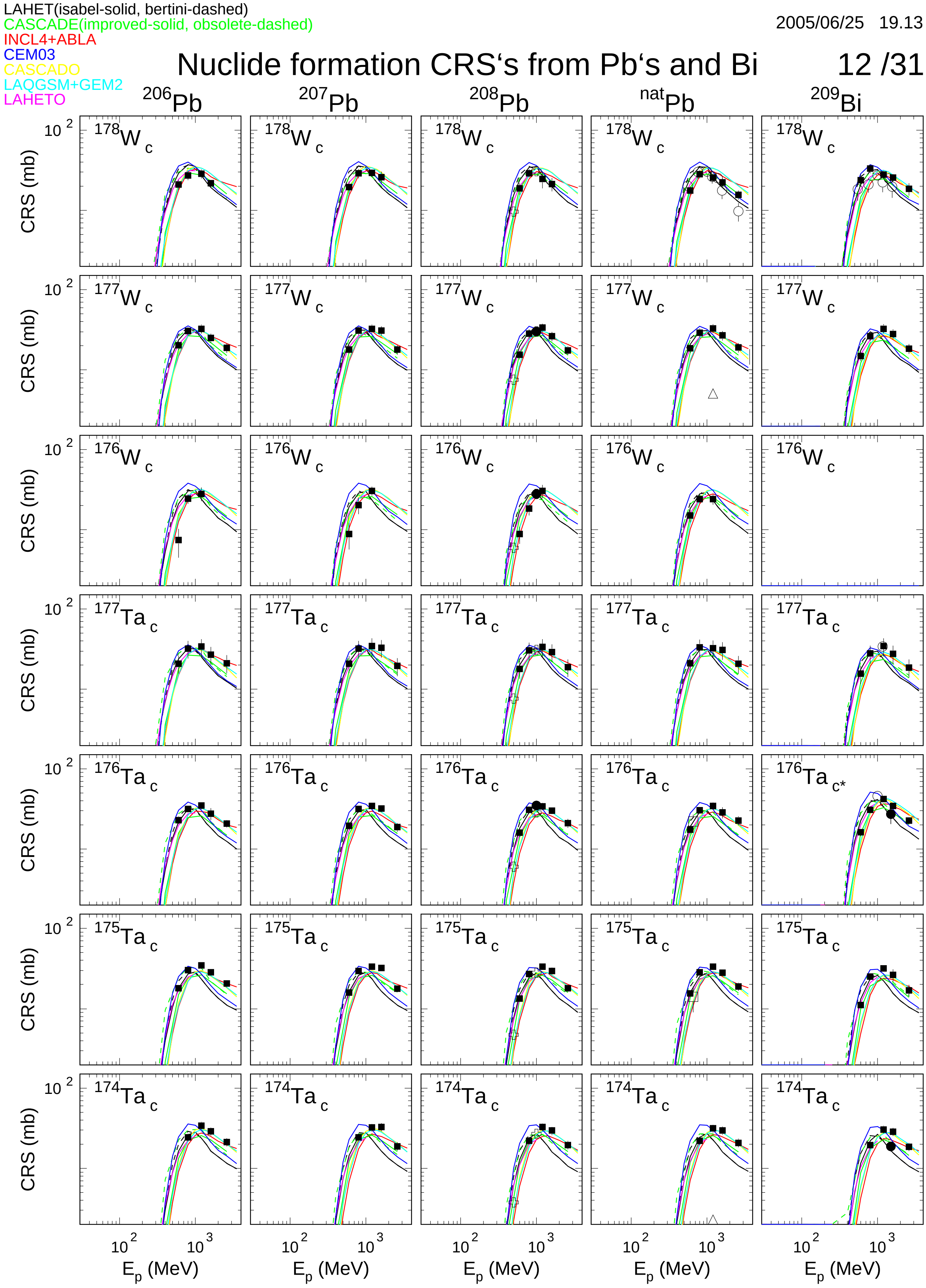


Fig. 64: The simulated and experimental cross sections of the measured reactions (Continuation of Fig. 53).

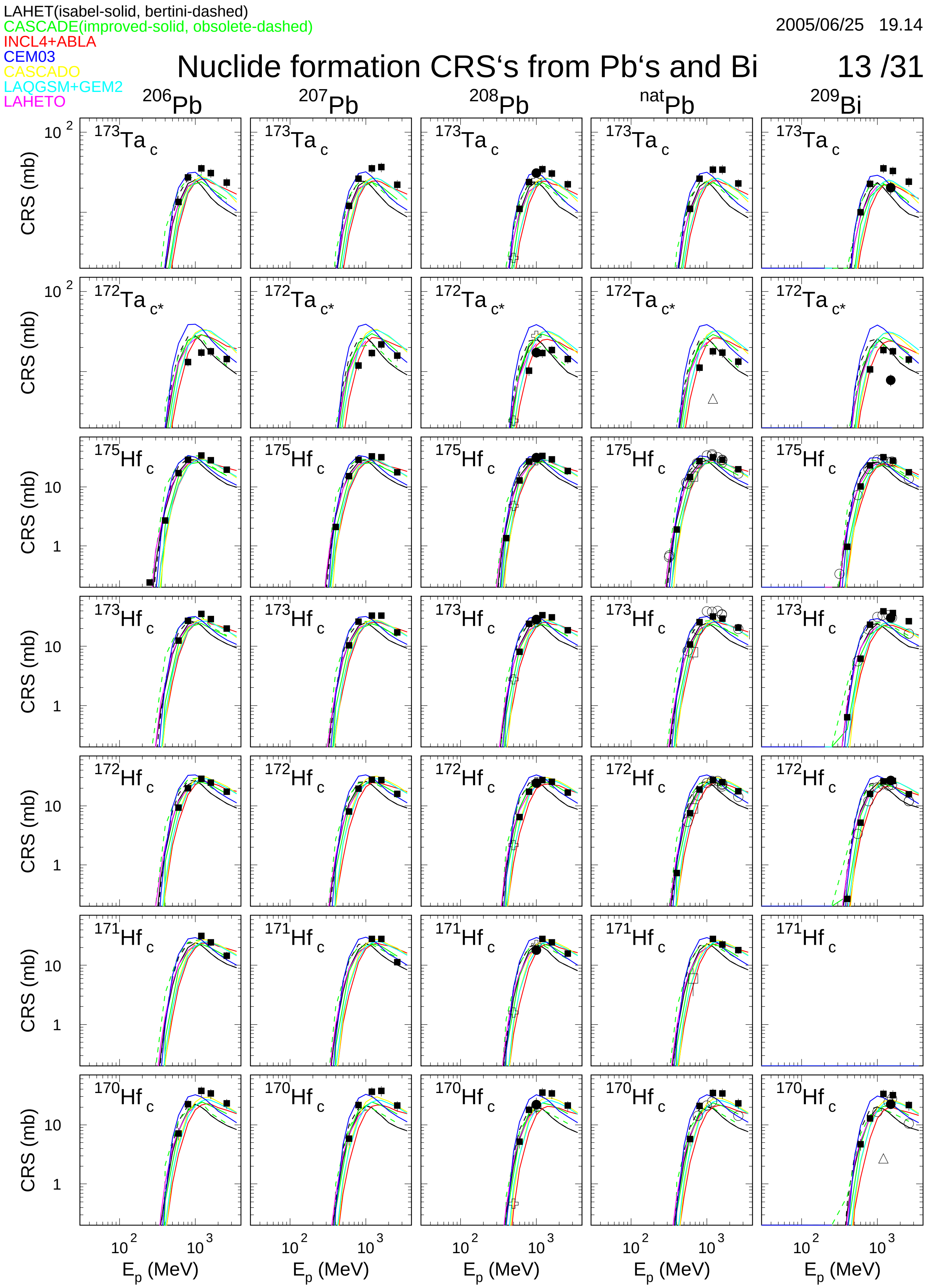


Fig. 65: The simulated and experimental cross sections of the measured reactions (Continuation of Fig. 53).

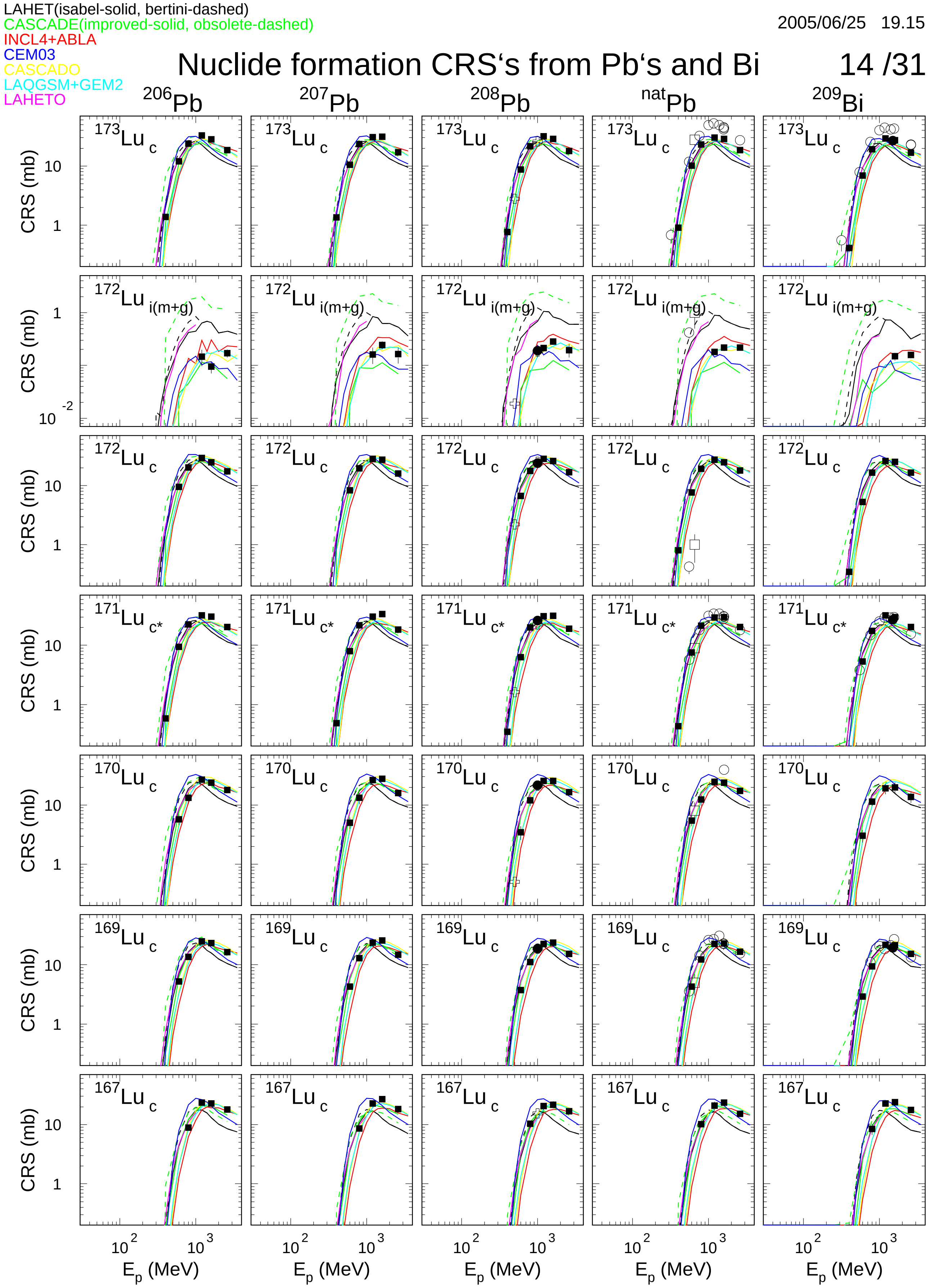


Fig. 66: The simulated and experimental cross sections of the measured reactions (Continuation of Fig. 53).

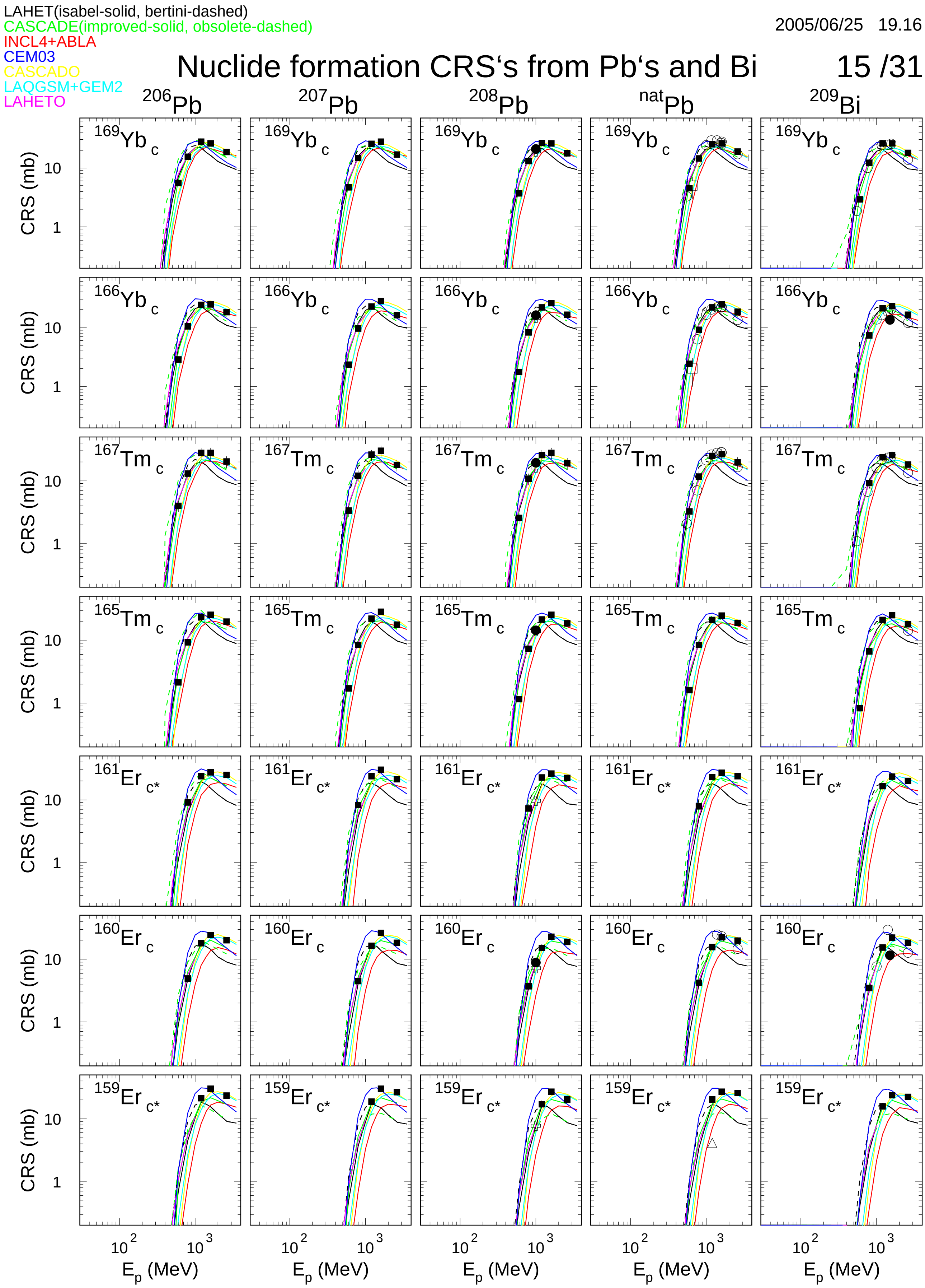


Fig. 67: The simulated and experimental cross sections of the measured reactions (Continuation of Fig. 53).

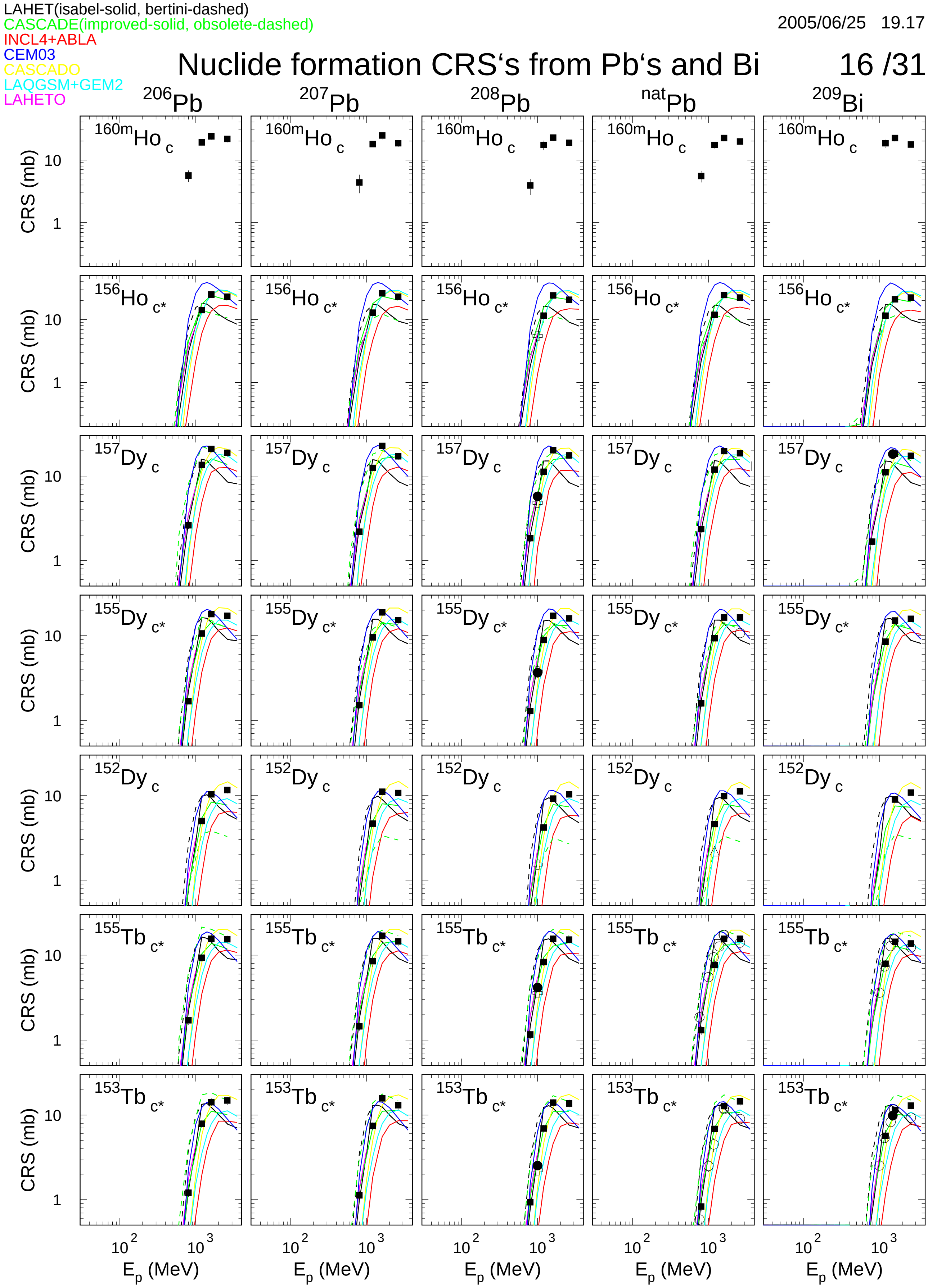


Fig. 68: The simulated and experimental cross sections of the measured reactions (Continuation of Fig. 53).

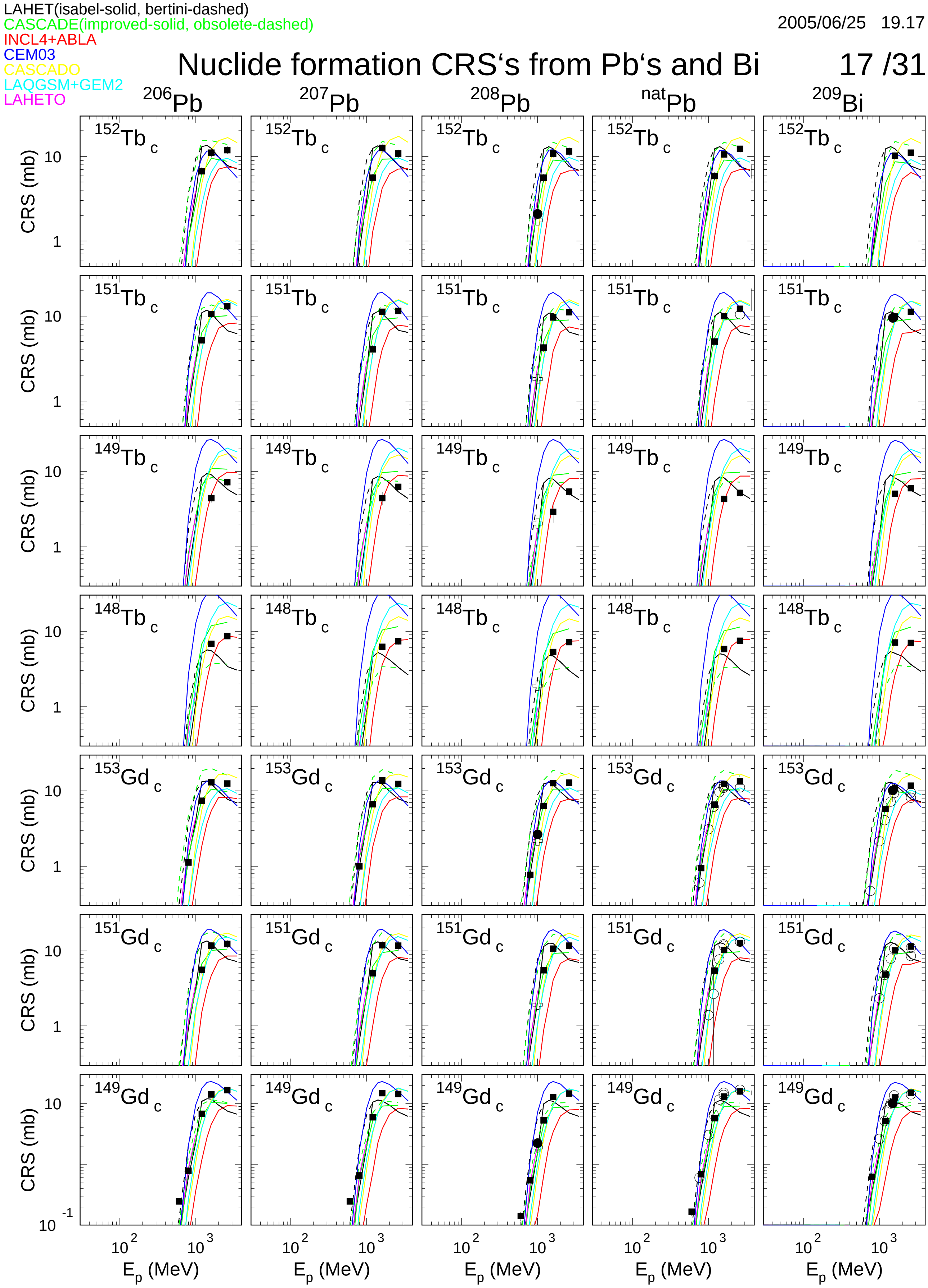


Fig. 69: The simulated and experimental cross sections of the measured reactions (Continuation of Fig. 53).

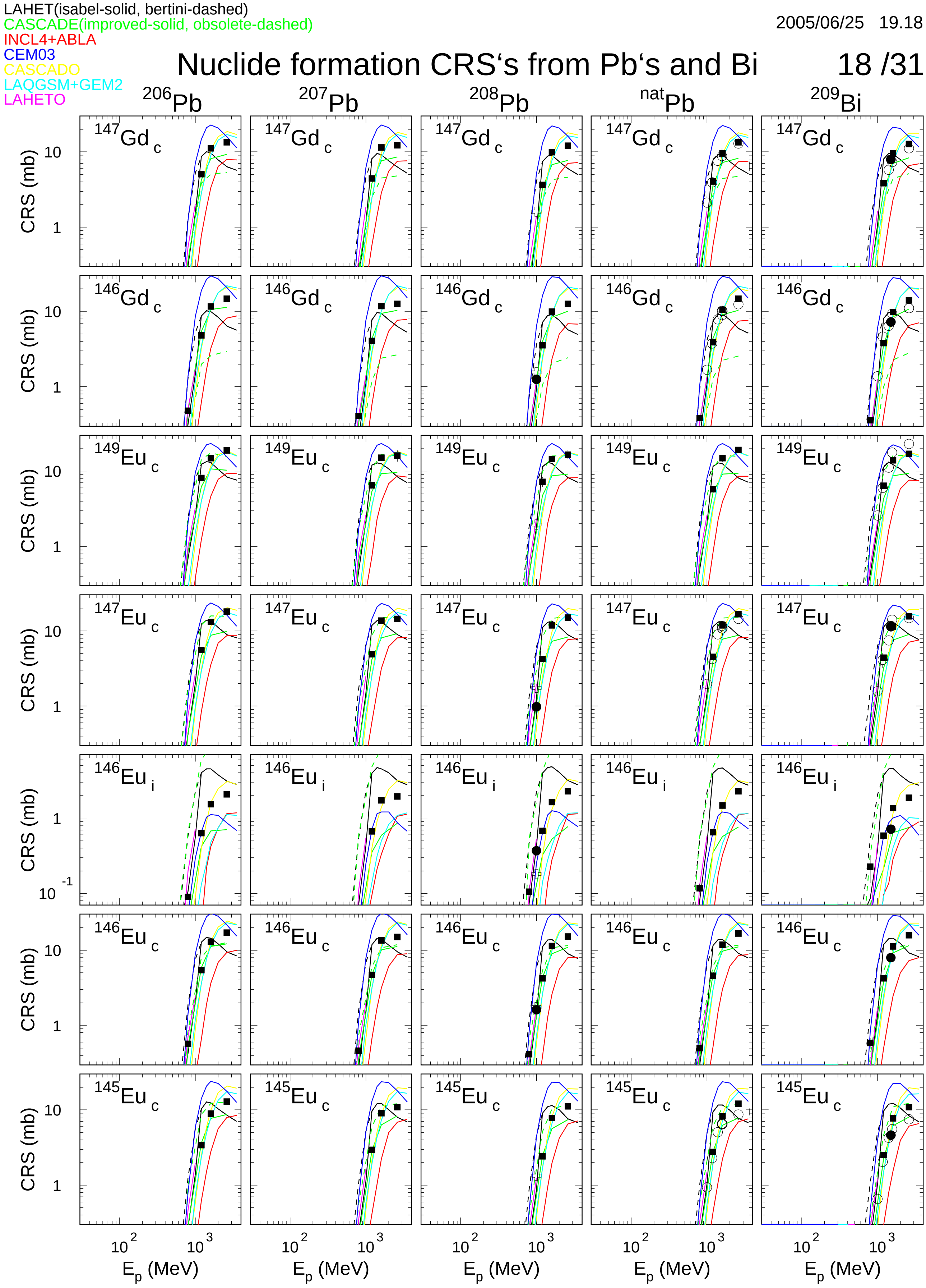


Fig. 70: The simulated and experimental cross sections of the measured reactions (Continuation of Fig. 53).

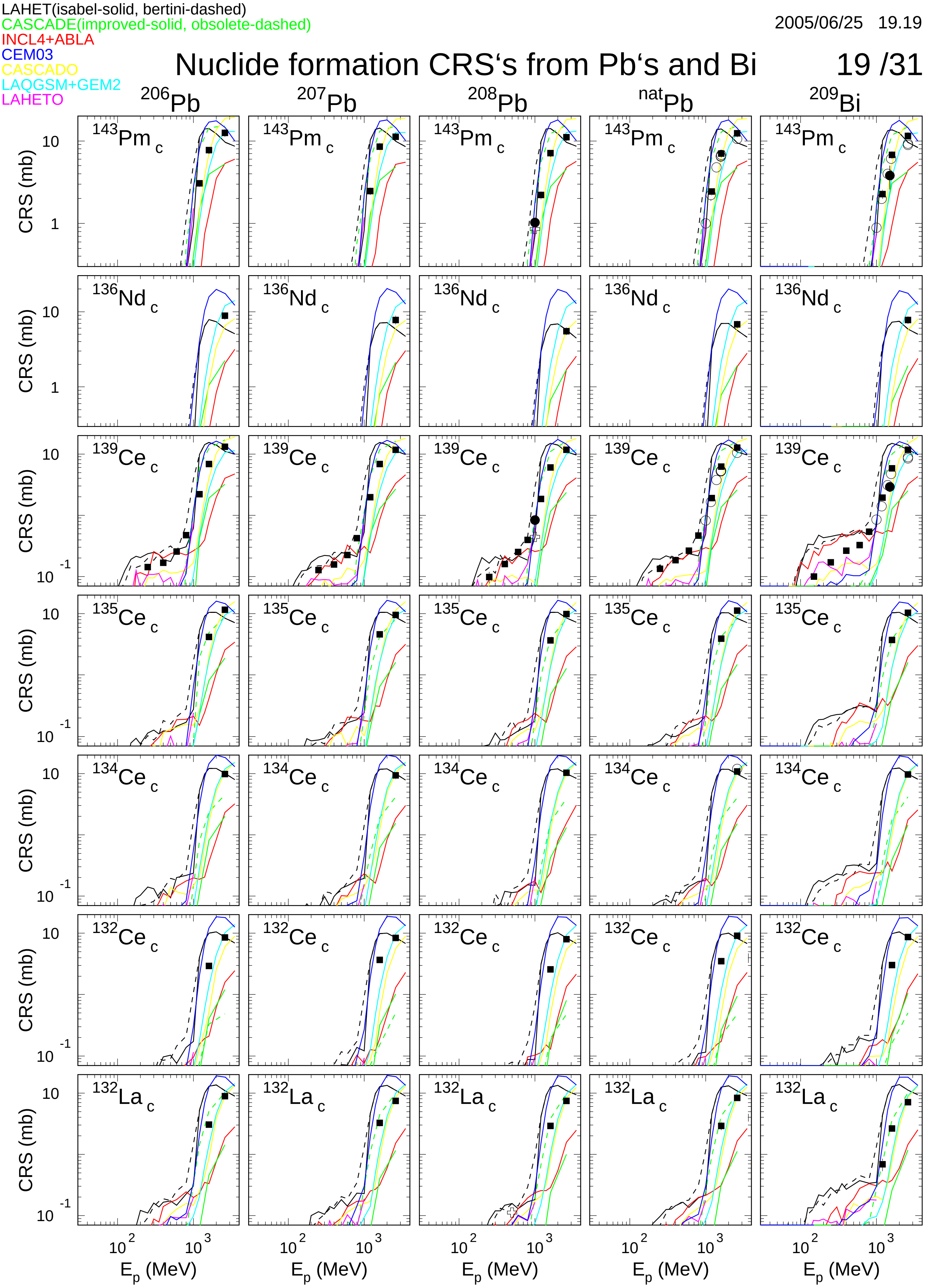


Fig. 71: The simulated and experimental cross sections of the measured reactions (Continuation of Fig. 53).

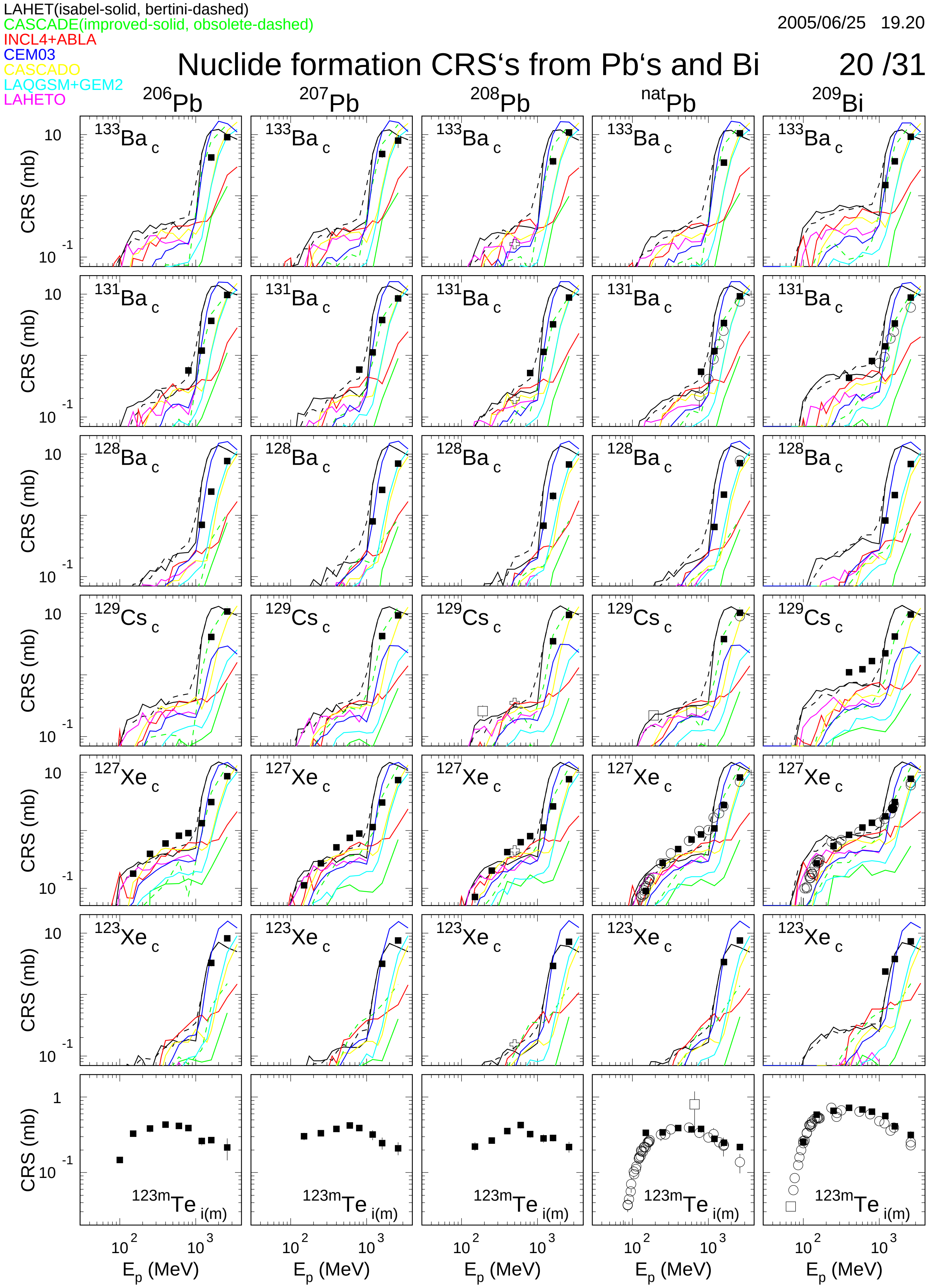


Fig. 72: The simulated and experimental cross sections of the measured reactions (Continuation of Fig. 53).

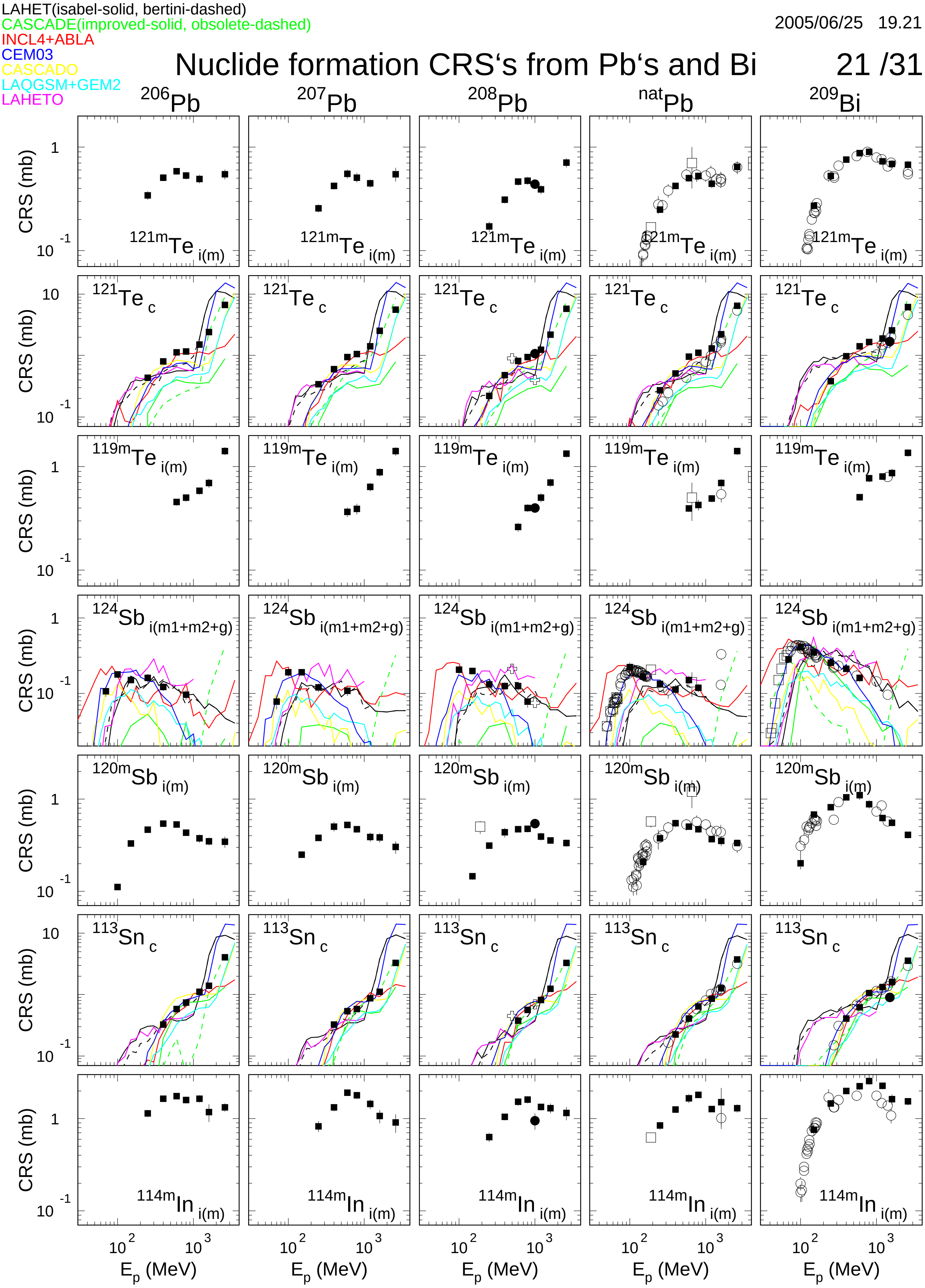


Fig. 73: The simulated and experimental cross sections of the measured reactions (Continuation of Fig. 53).

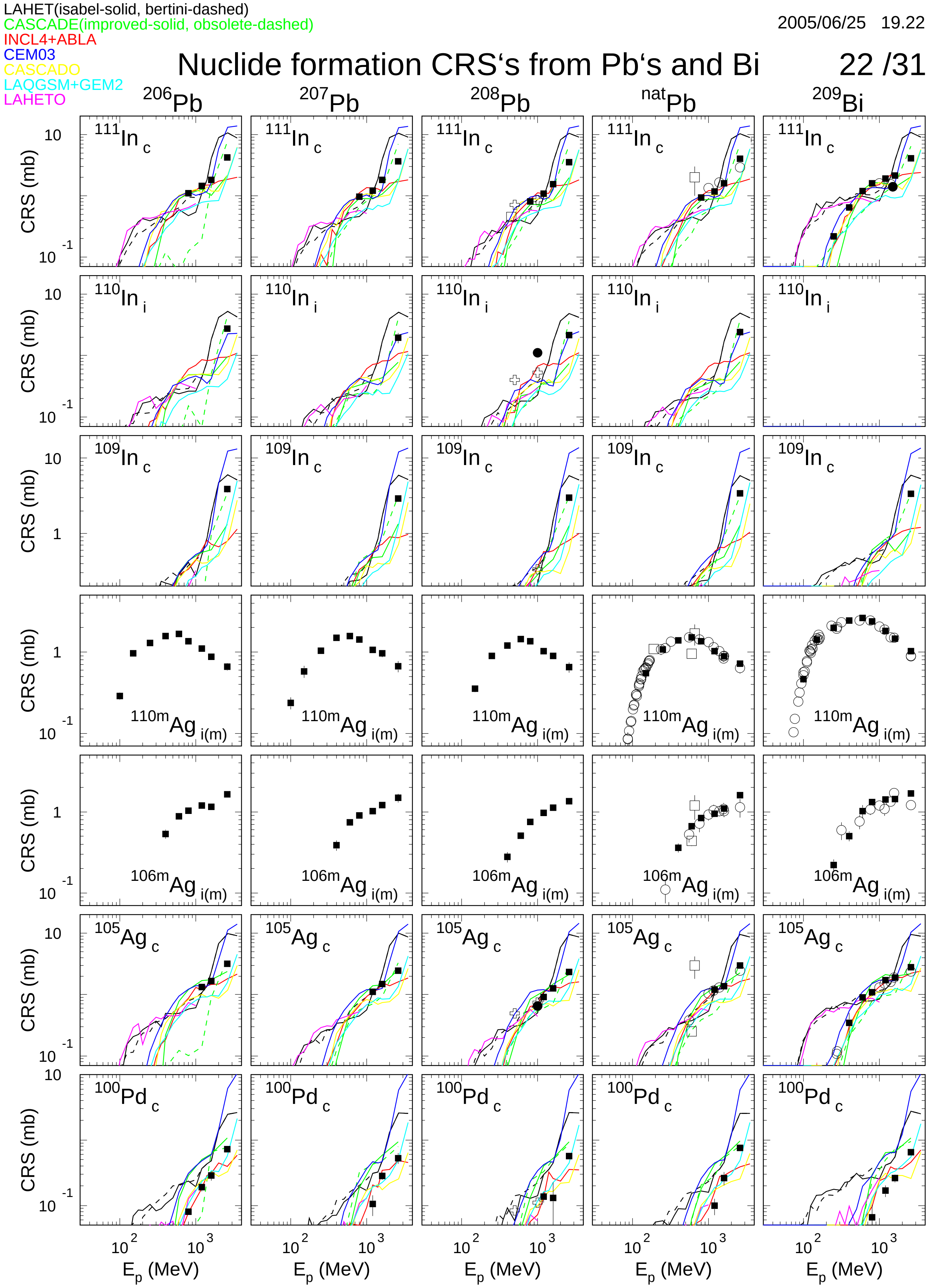


Fig. 74: The simulated and experimental cross sections of the measured reactions (Continuation of Fig. 53).

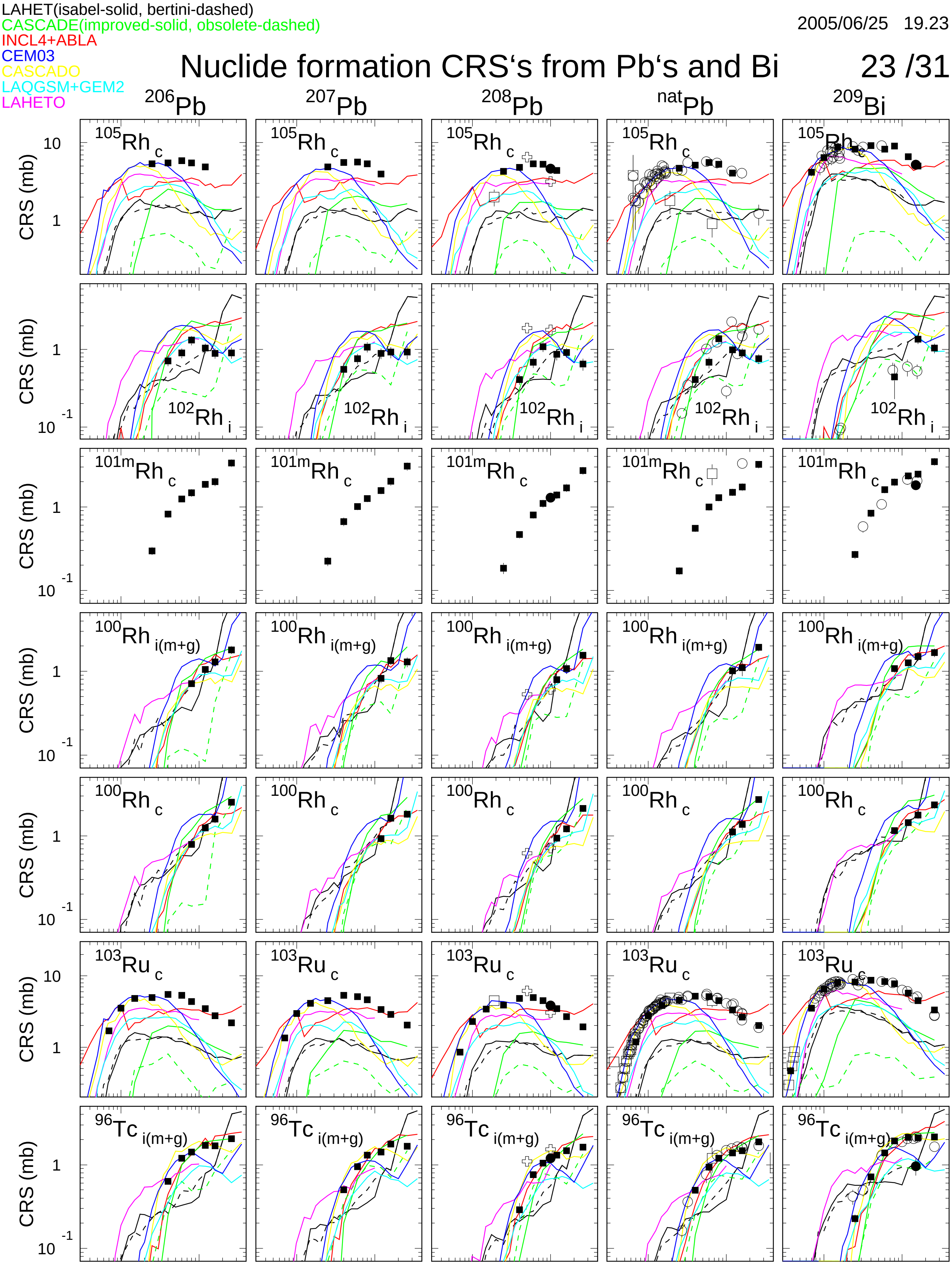


Fig. 75: The simulated and experimental cross sections of the measured reactions (Continuation of Fig. 53).

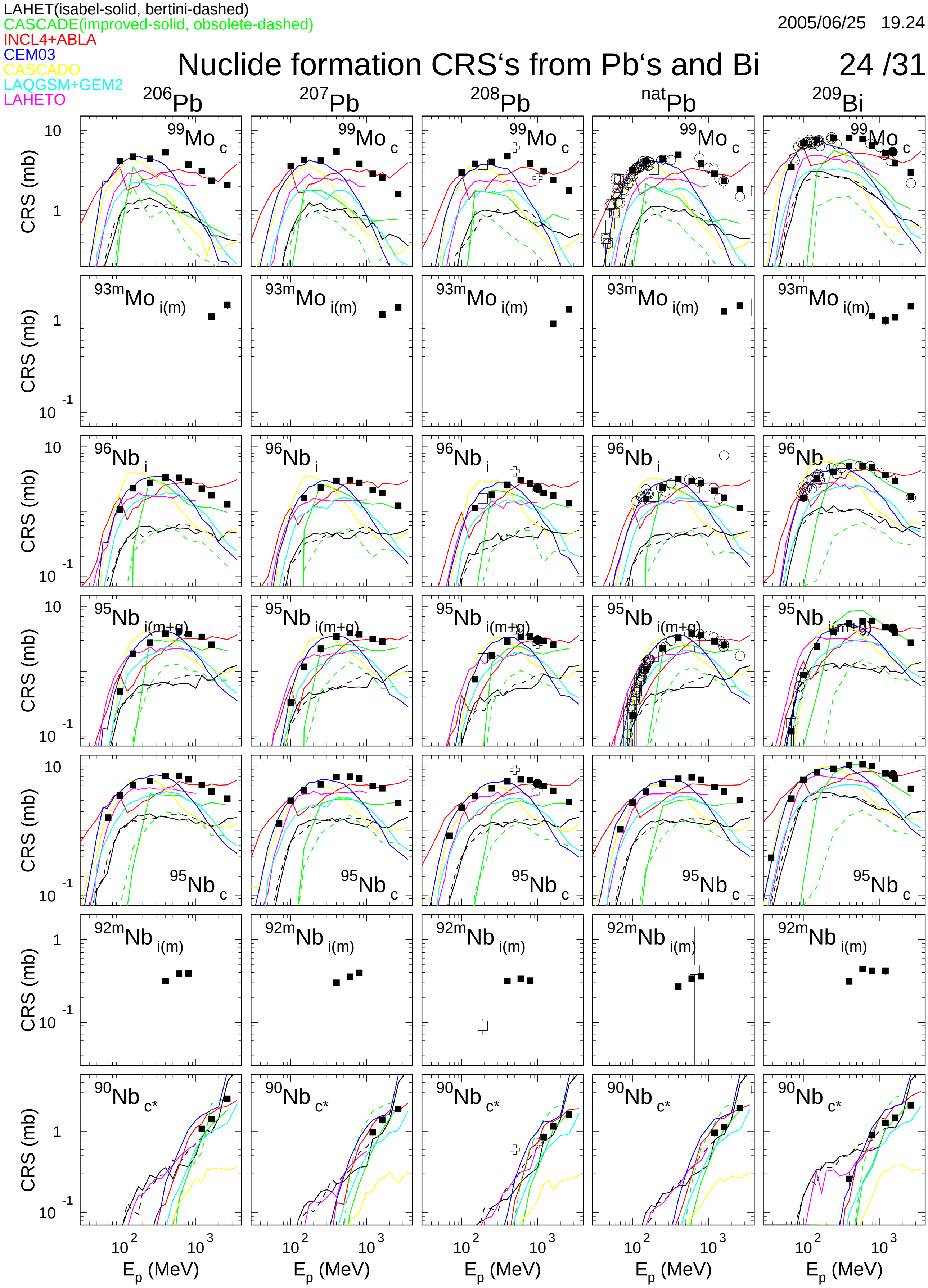


Fig. 76: The simulated and experimental cross sections of the measured reactions (Continuation of Fig. 53).

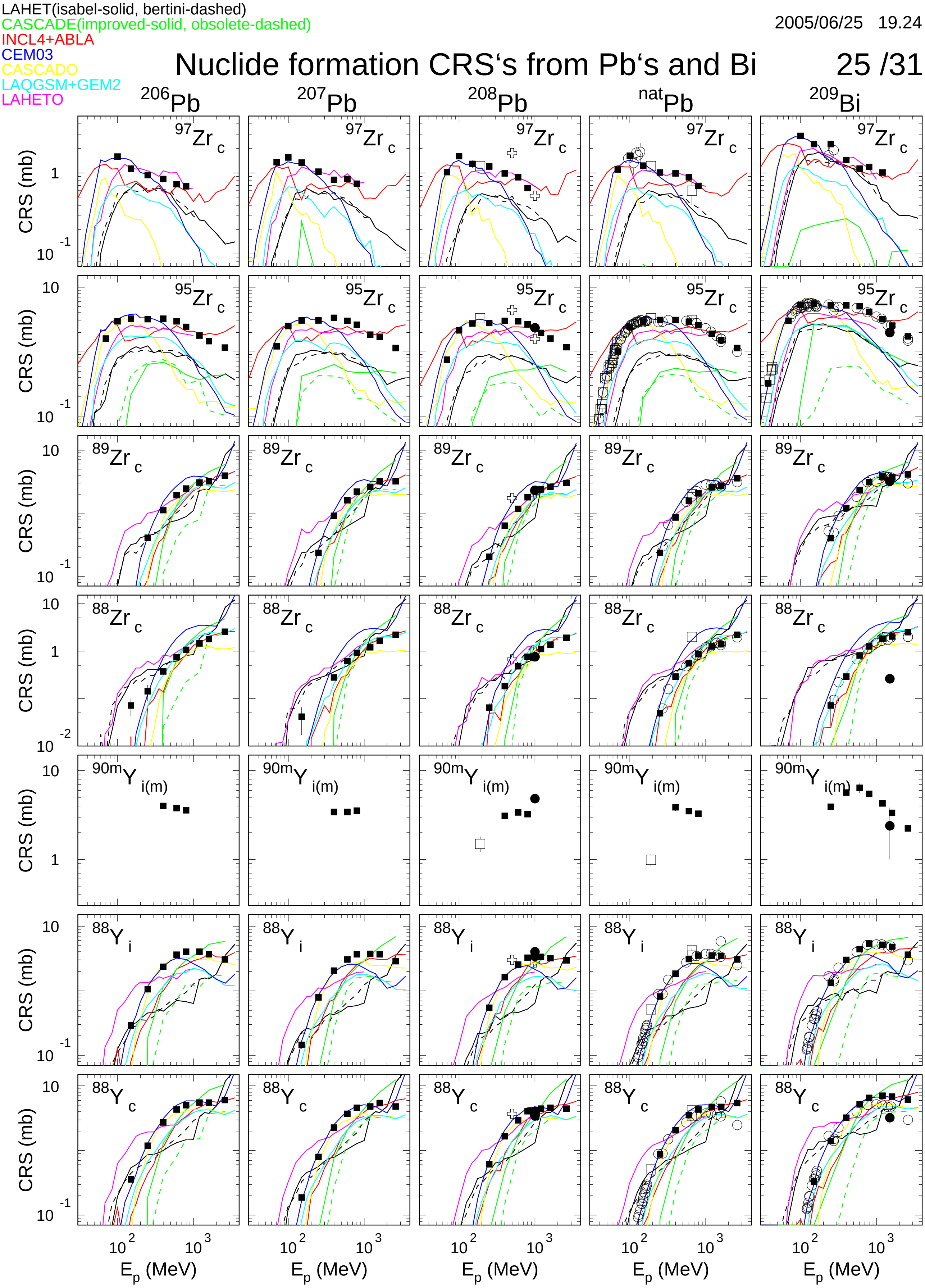


Fig. 77: The simulated and experimental cross sections of the measured reactions (Continuation of Fig. 53).

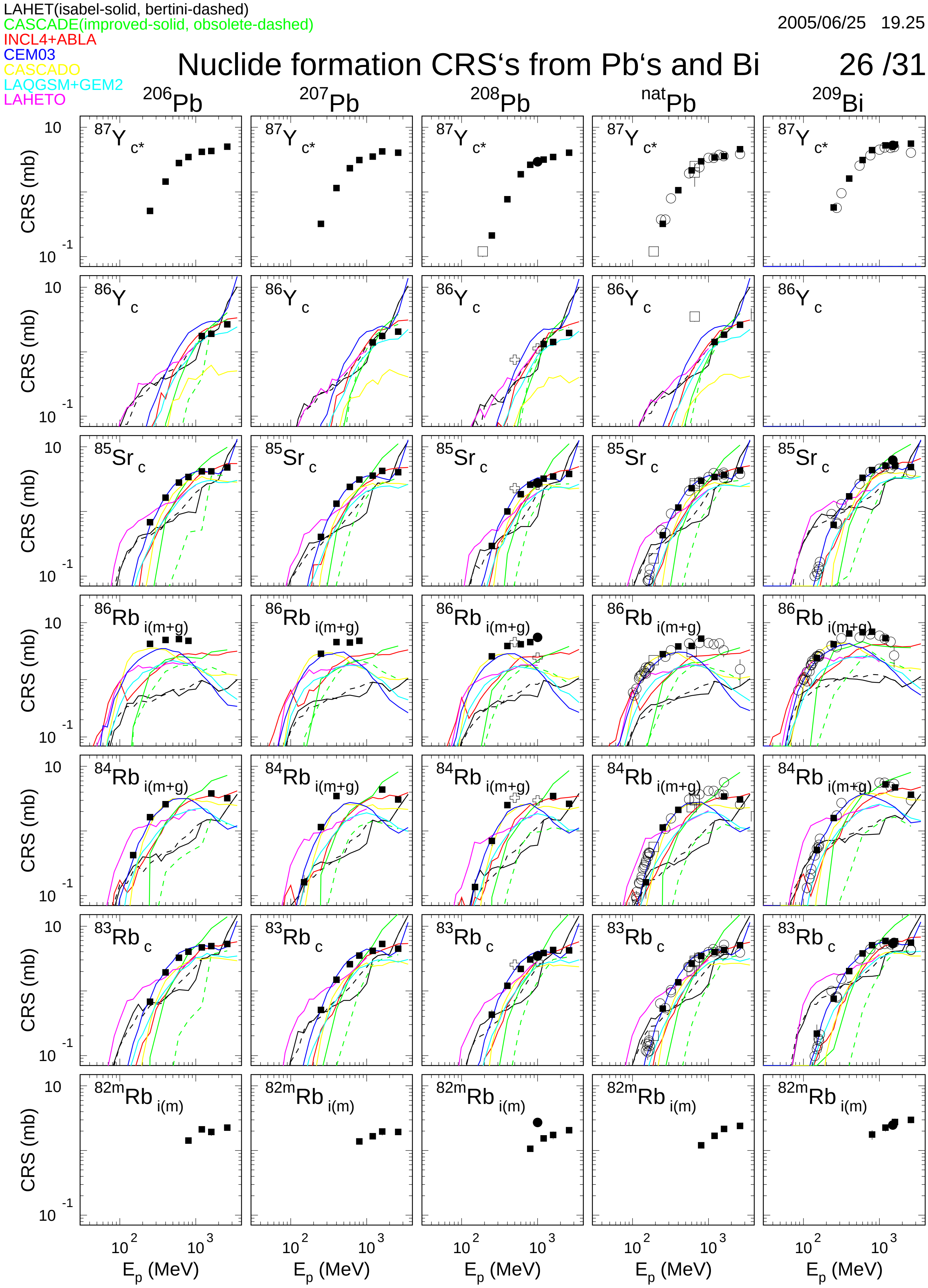


Fig. 78: The simulated and experimental cross sections of the measured reactions (Continuation of Fig. 53).

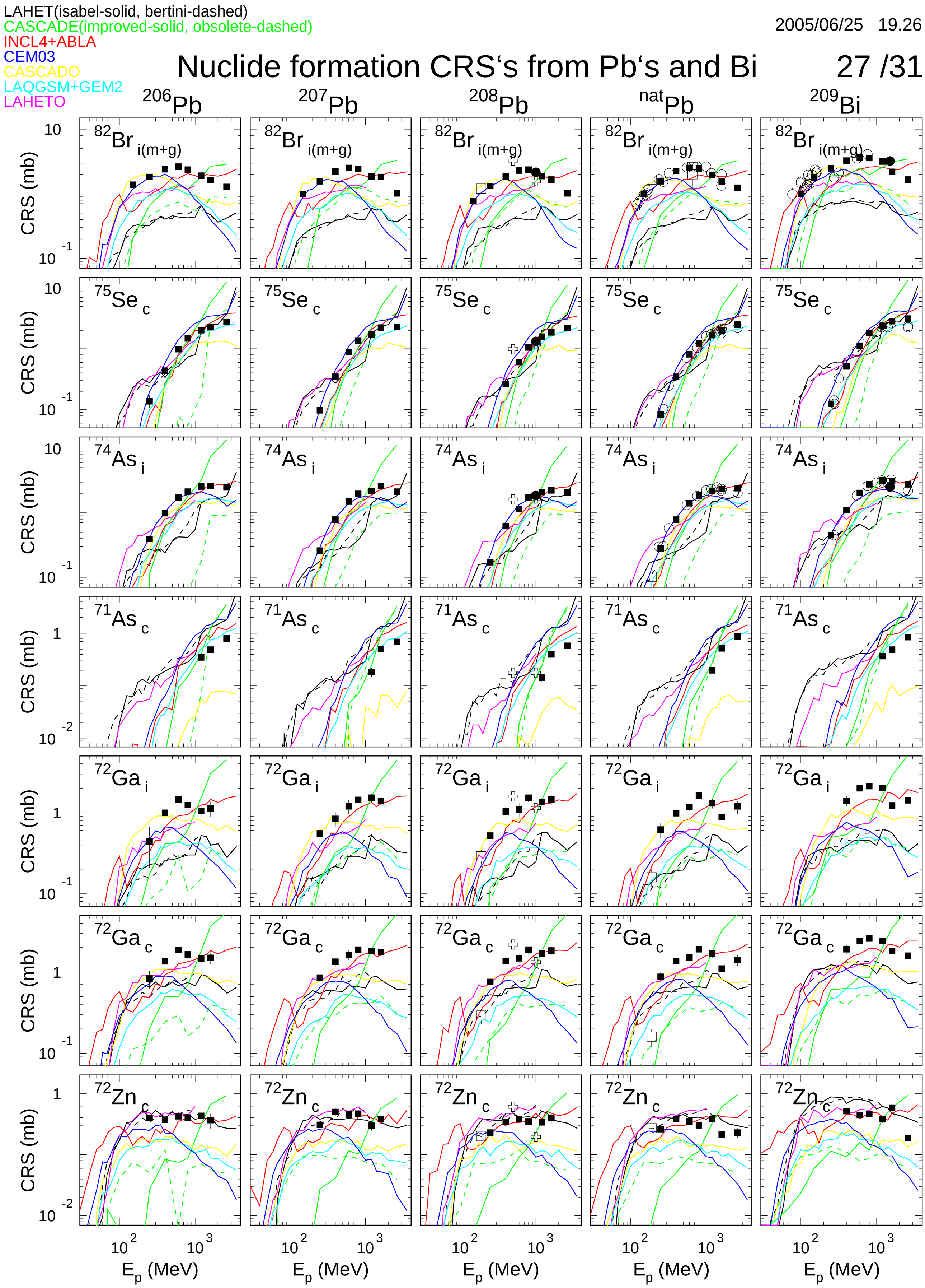


Fig. 79: The simulated and experimental cross sections of the measured reactions (Continuation of Fig. 53).

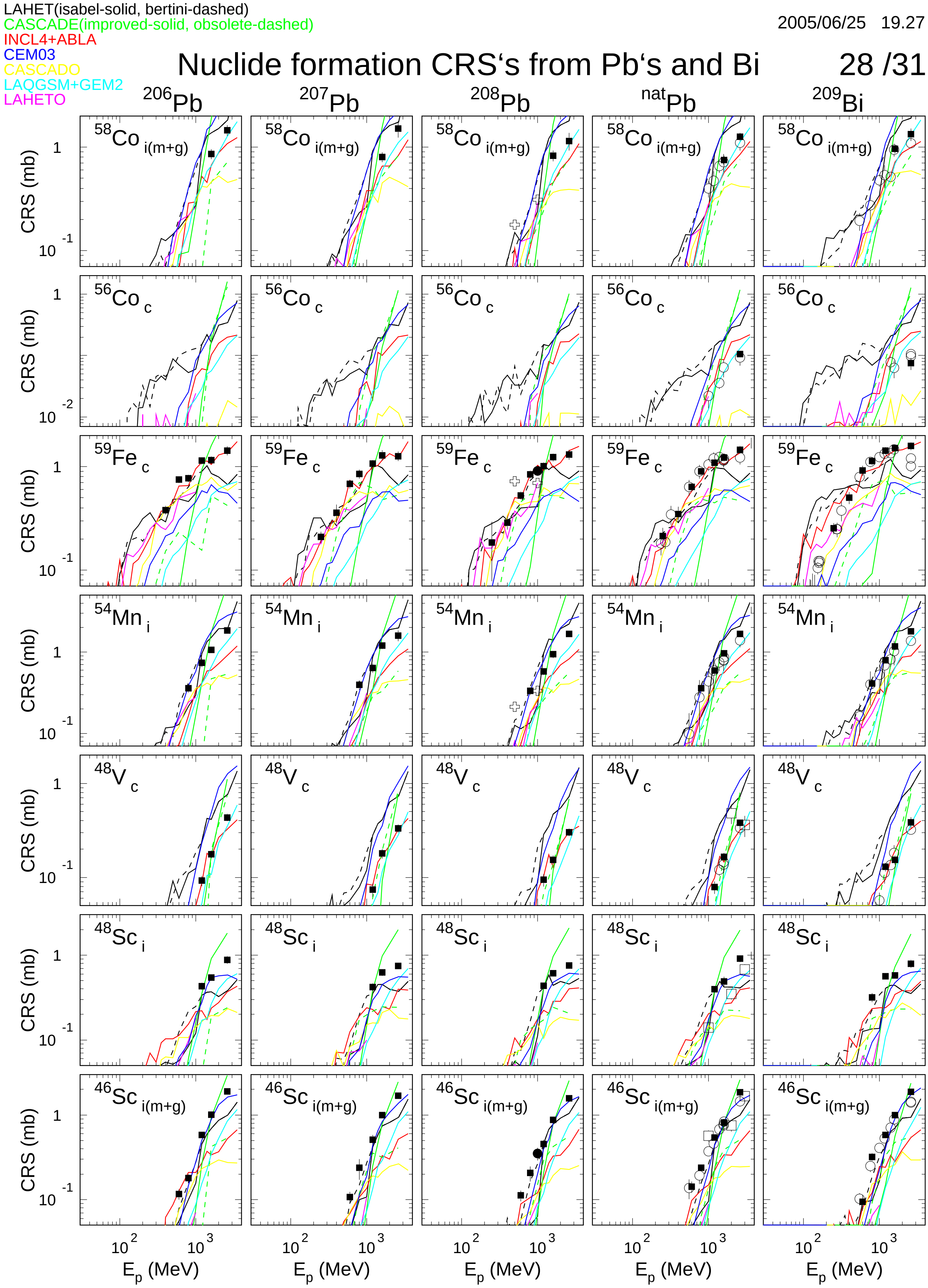


Fig. 80: The simulated and experimental cross sections of the measured reactions (Continuation of Fig. 53).

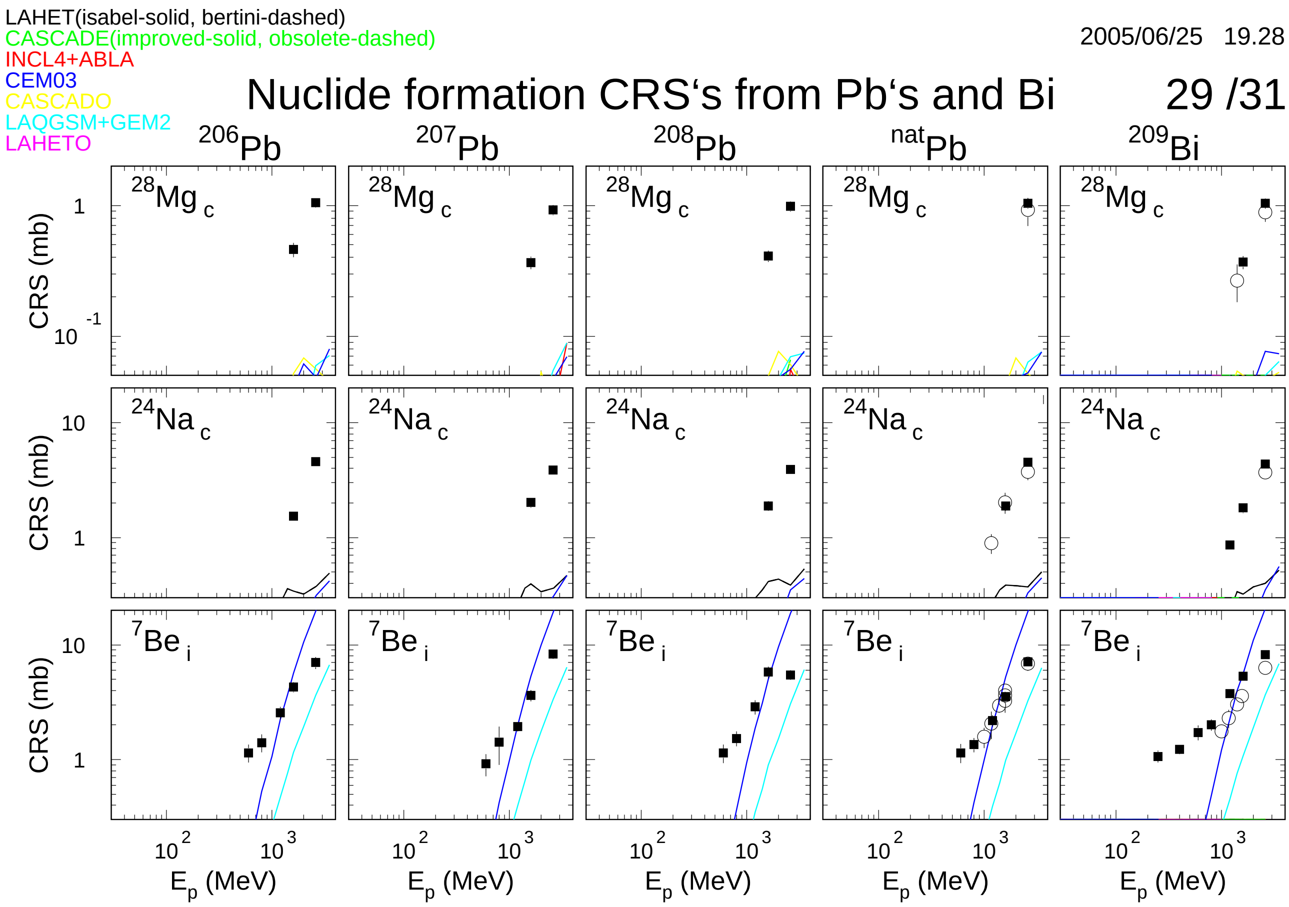


Fig. 81: The simulated and experimental cross sections of the measured reactions (Continuation of Fig. 53).

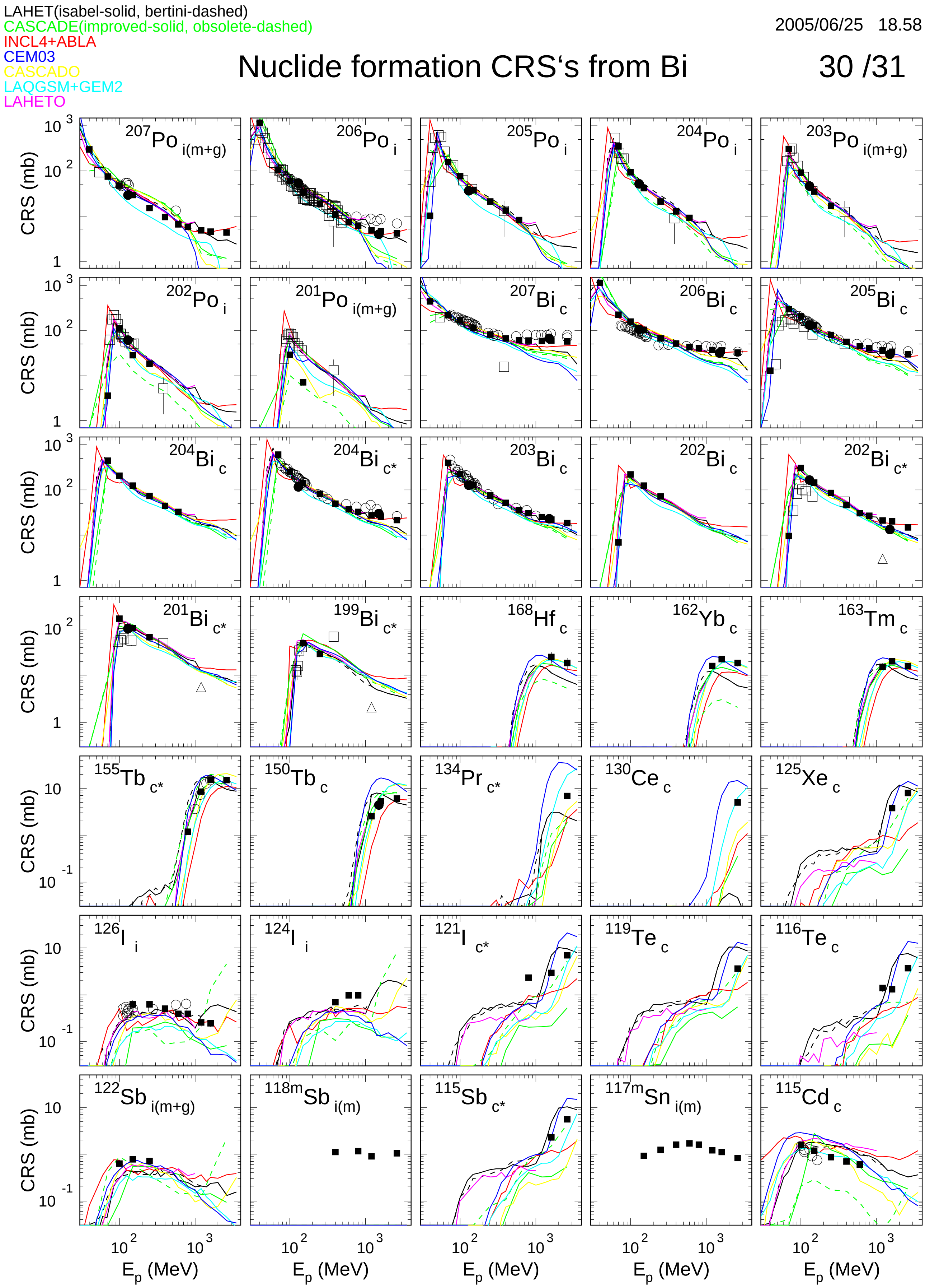


Fig. 82: The simulated and experimental cross sections of the measured reactions (Continuation of Fig. 53).

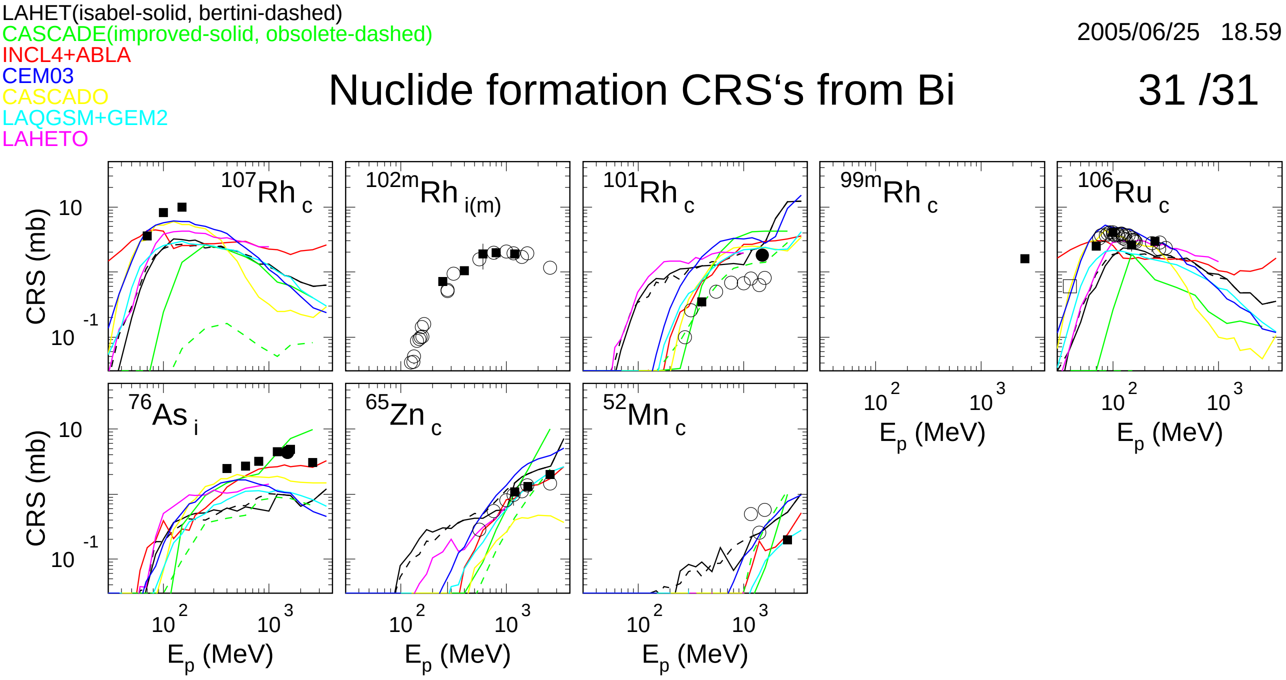


Fig. 83: The simulated and experimental cross sections of the measured reactions (Continuation of Fig. 53).

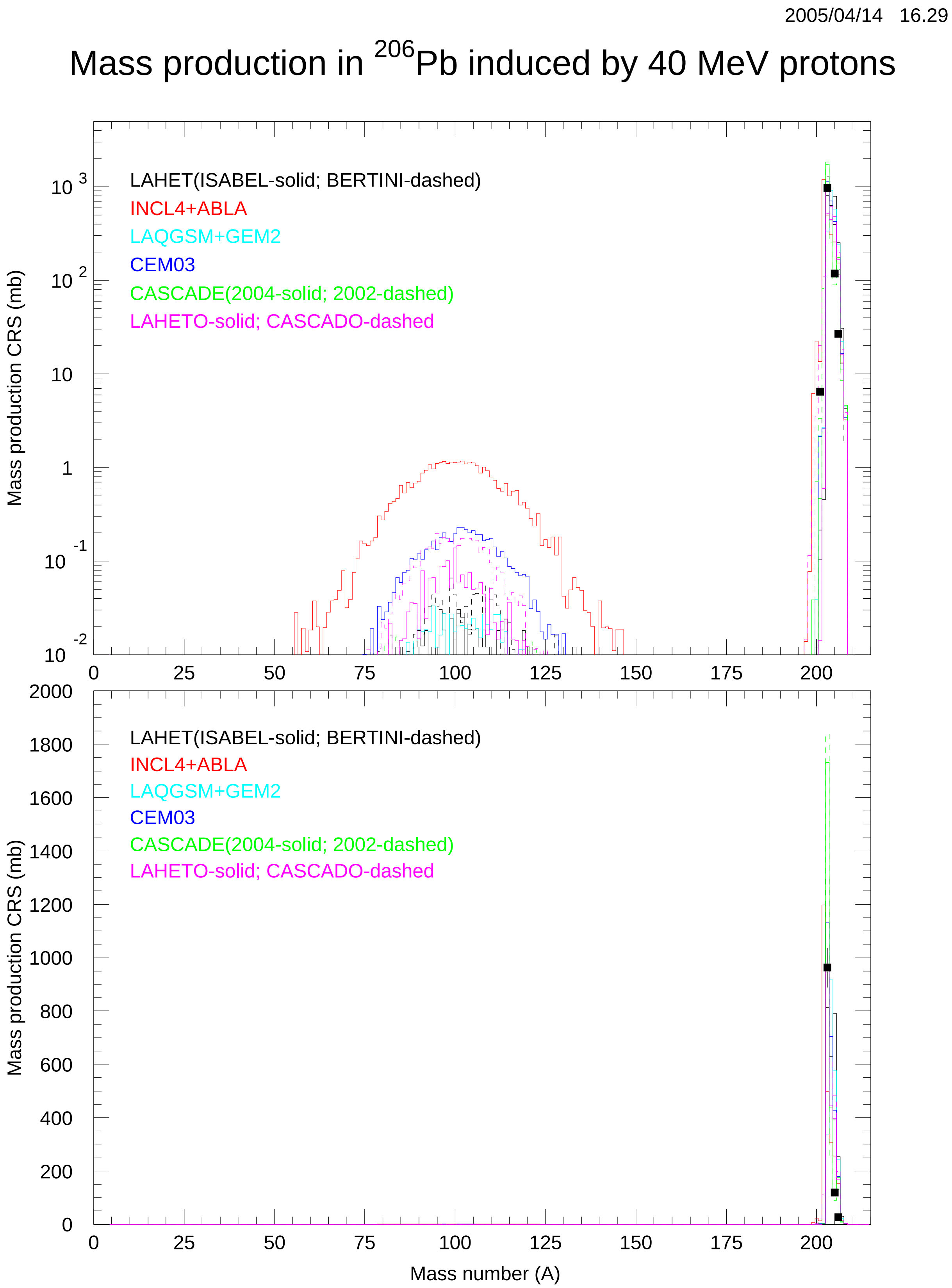


Fig. 84: The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{206}Pb irradiated with 0.04 GeV protons.

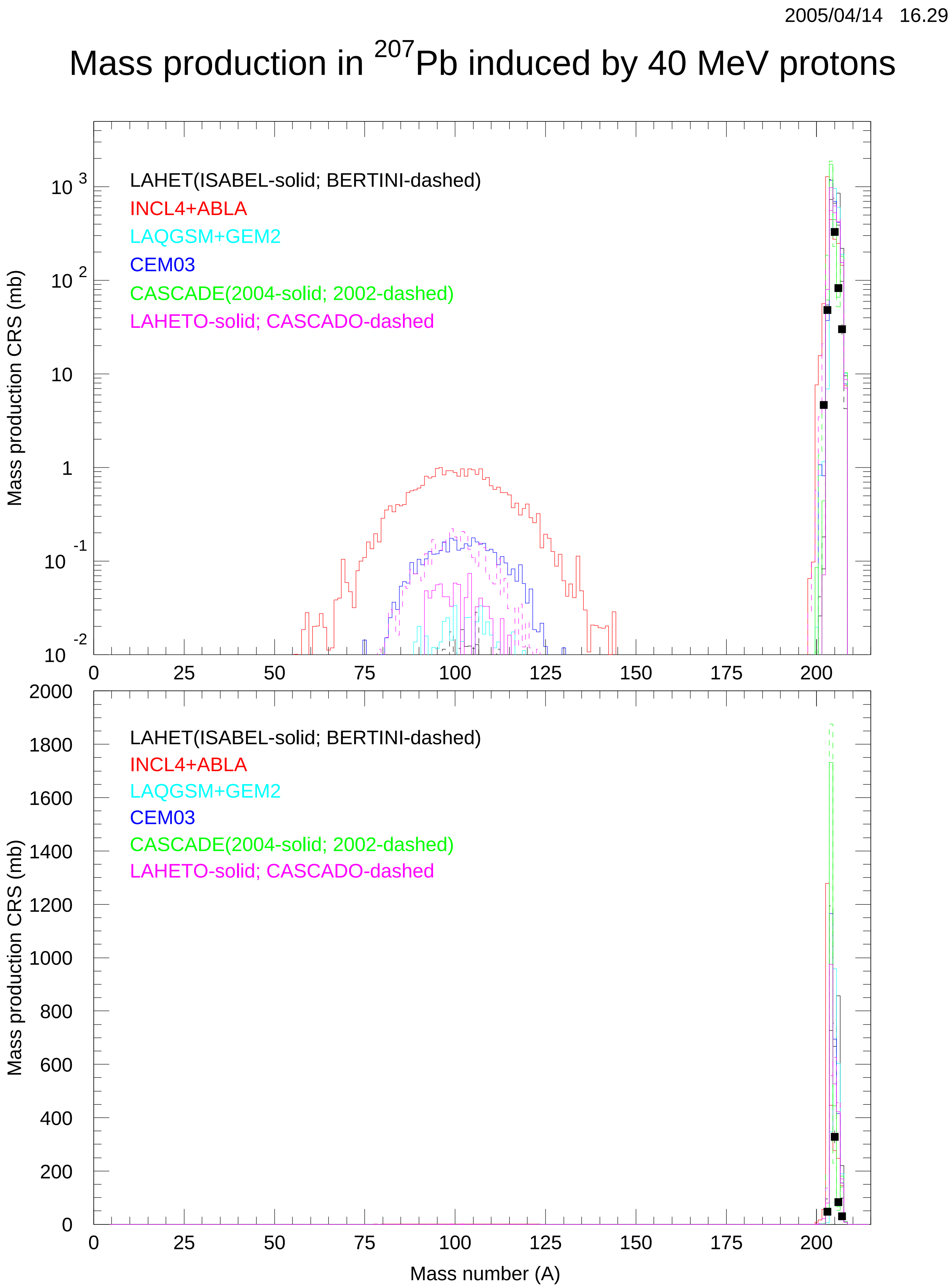


Fig. 85: The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{207}Pb irradiated with 0.04 GeV protons.

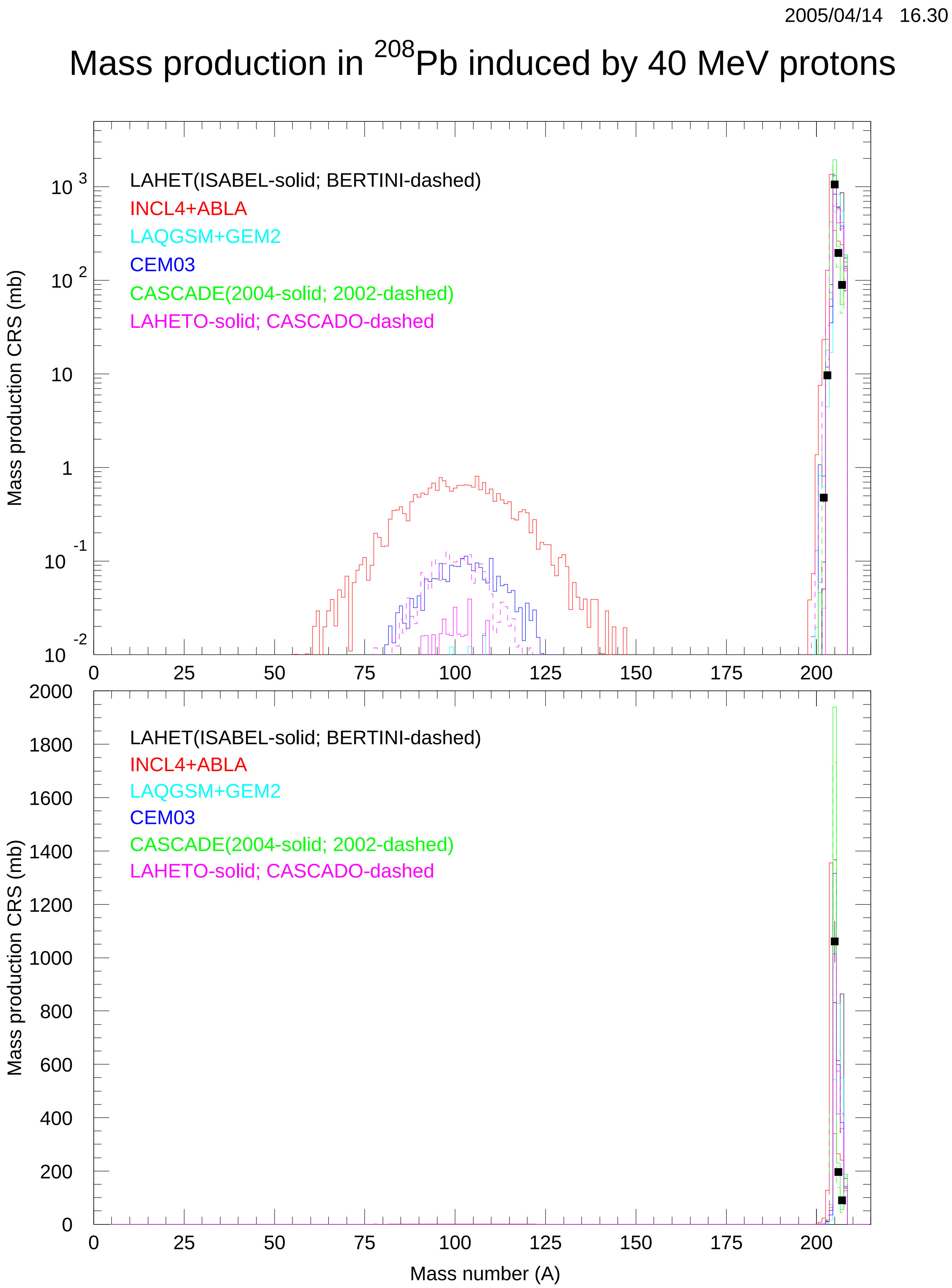


Fig. 86: The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{208}Pb irradiated with 0.04 GeV protons.

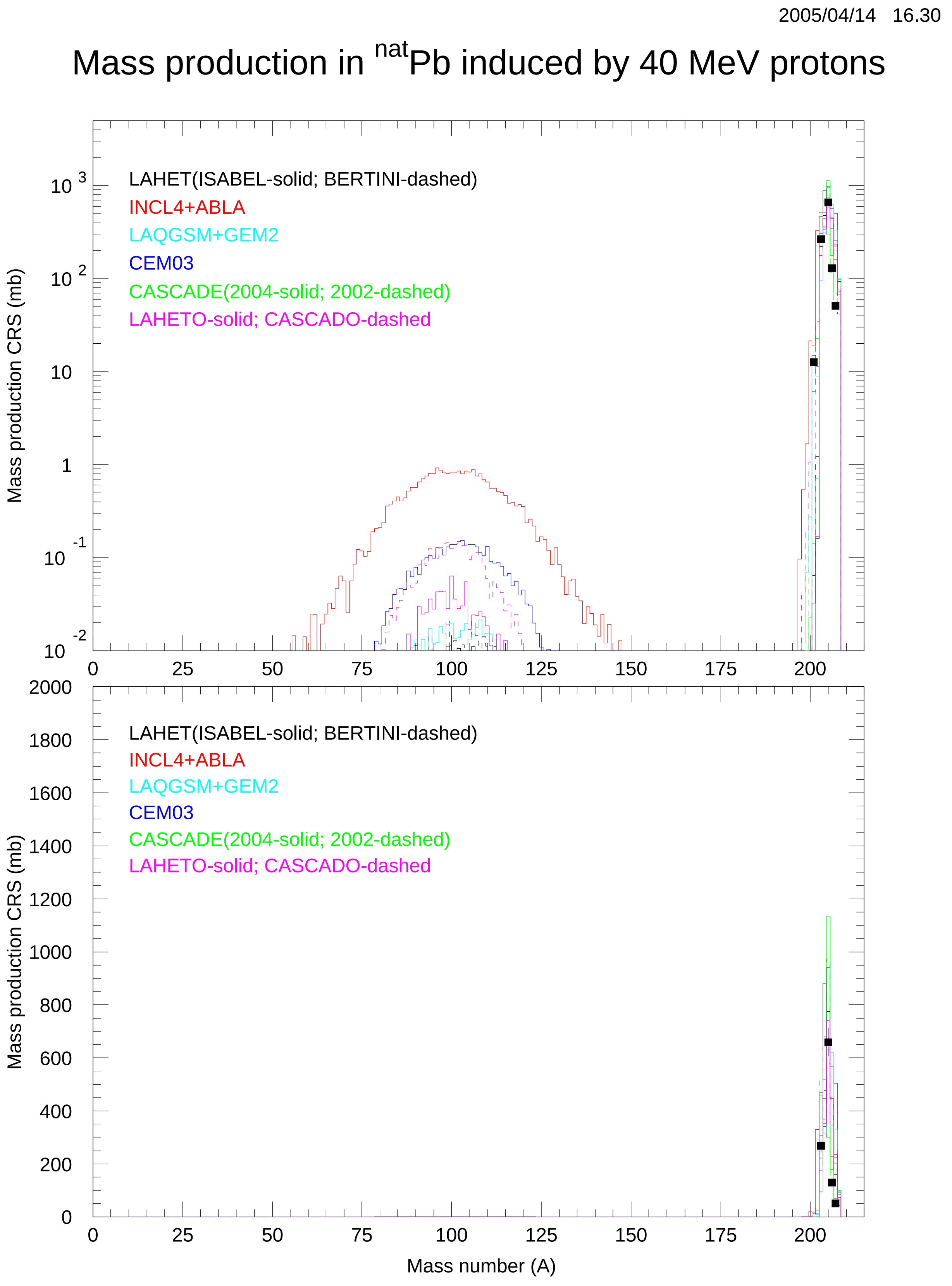


Fig. 87: The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{nat}Pb irradiated with 0.04 GeV protons.

2005/04/14 16.30

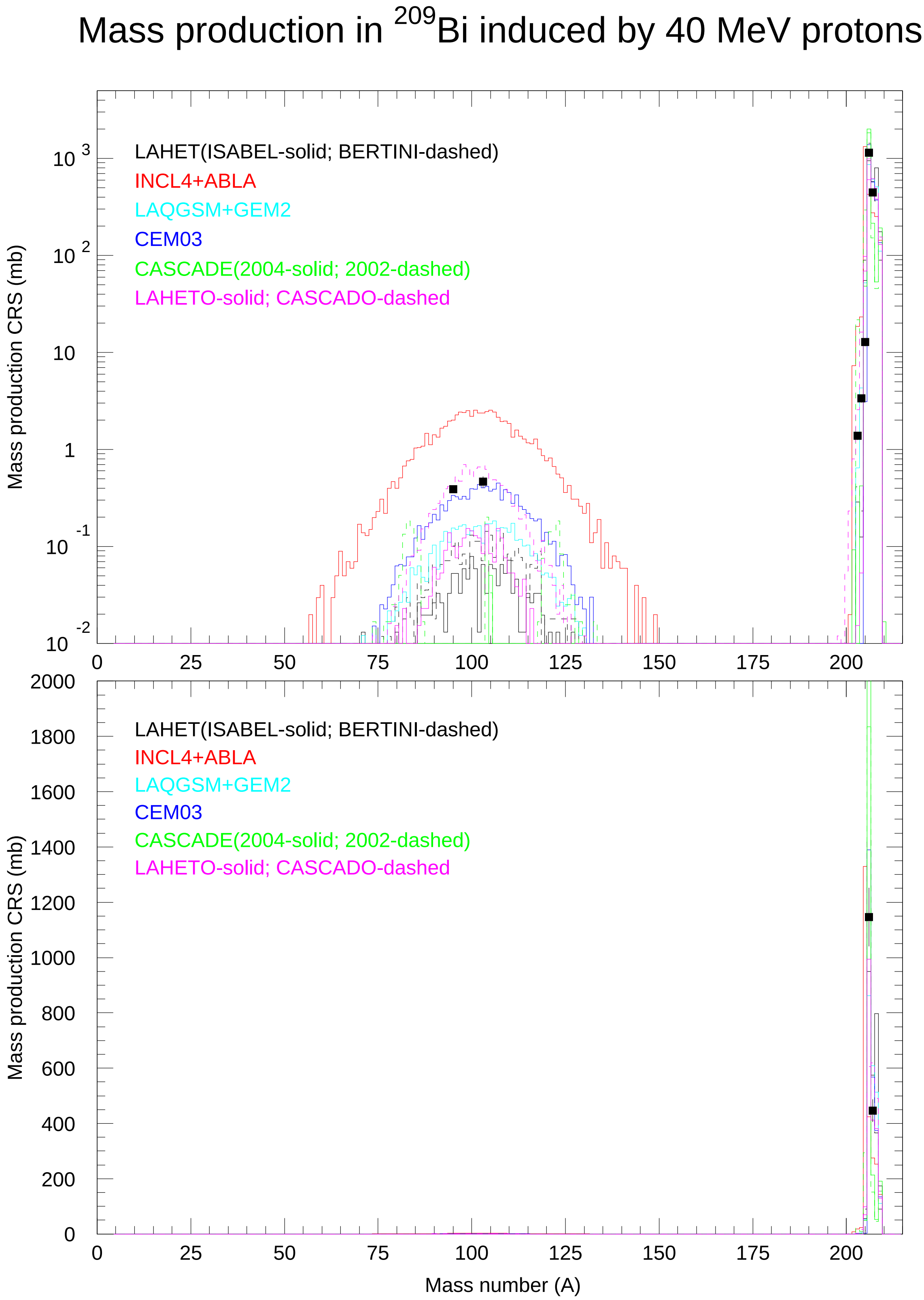


Fig. 88: The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{209}Bi irradiated with 0.04 GeV protons.

2005/04/14 16.30

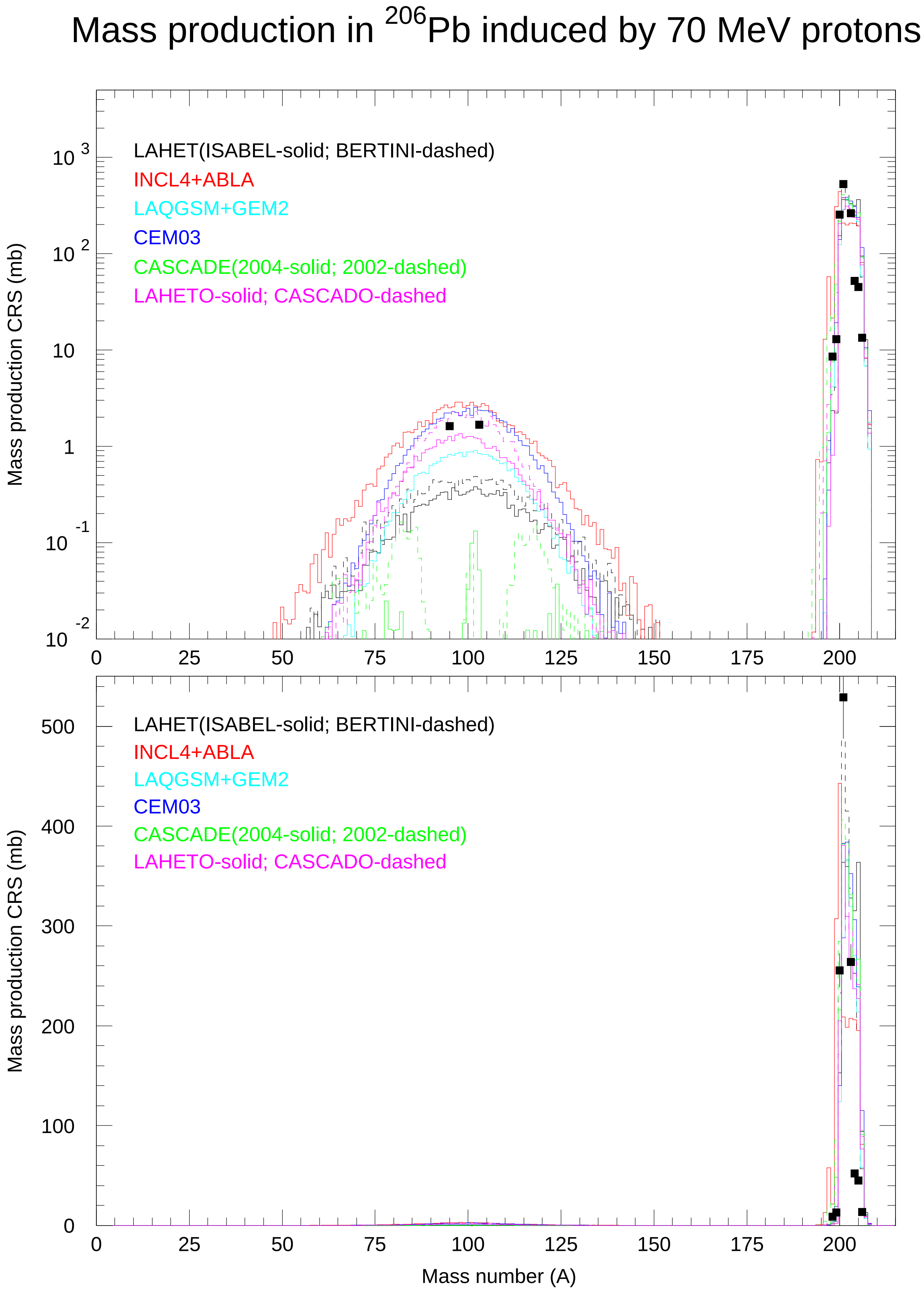


Fig. 89: The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{206}Pb irradiated with 0.07 GeV protons.

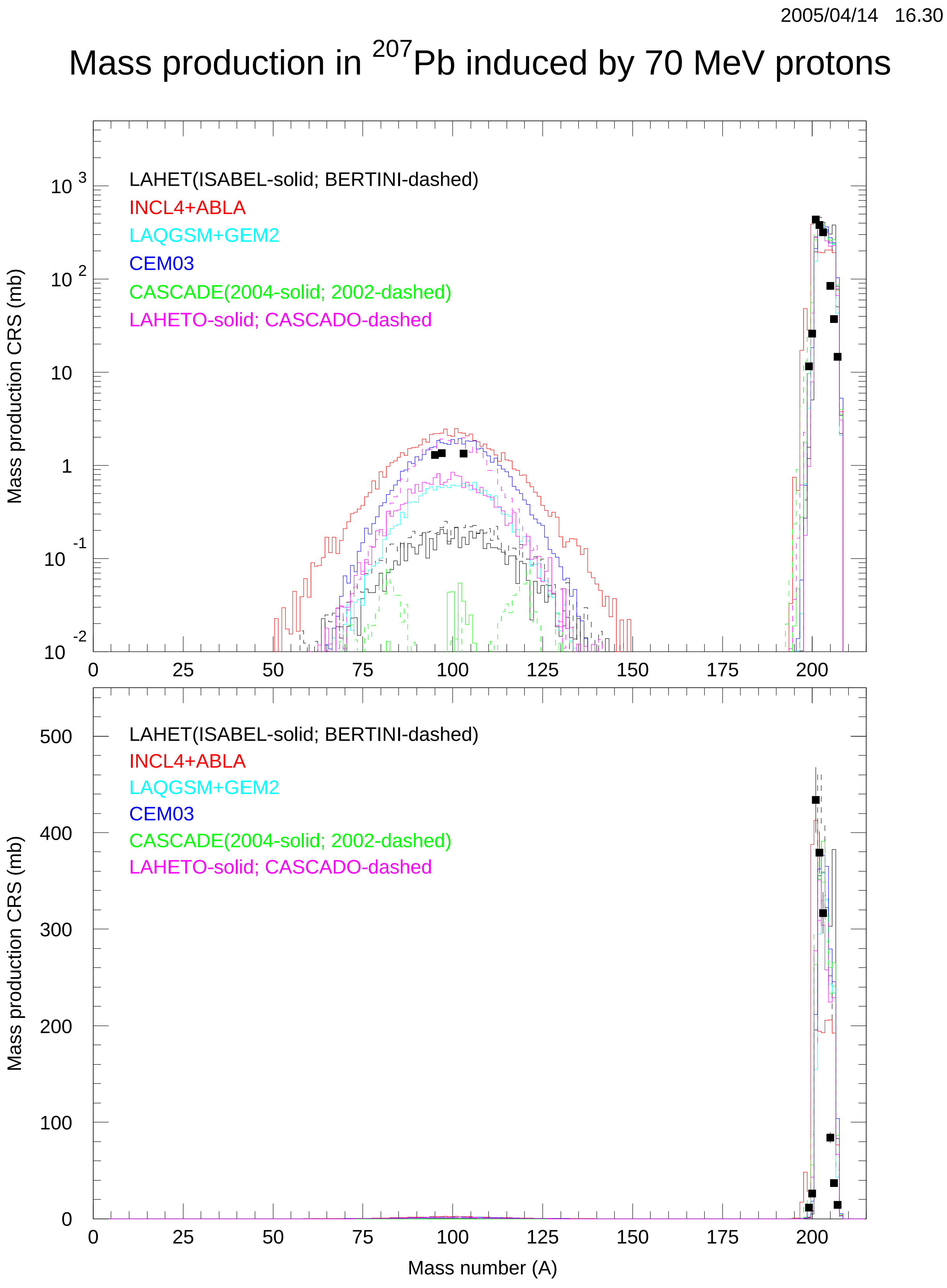


Fig. 90: The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{207}Pb irradiated with 0.07 GeV protons.

2005/04/14 16.30

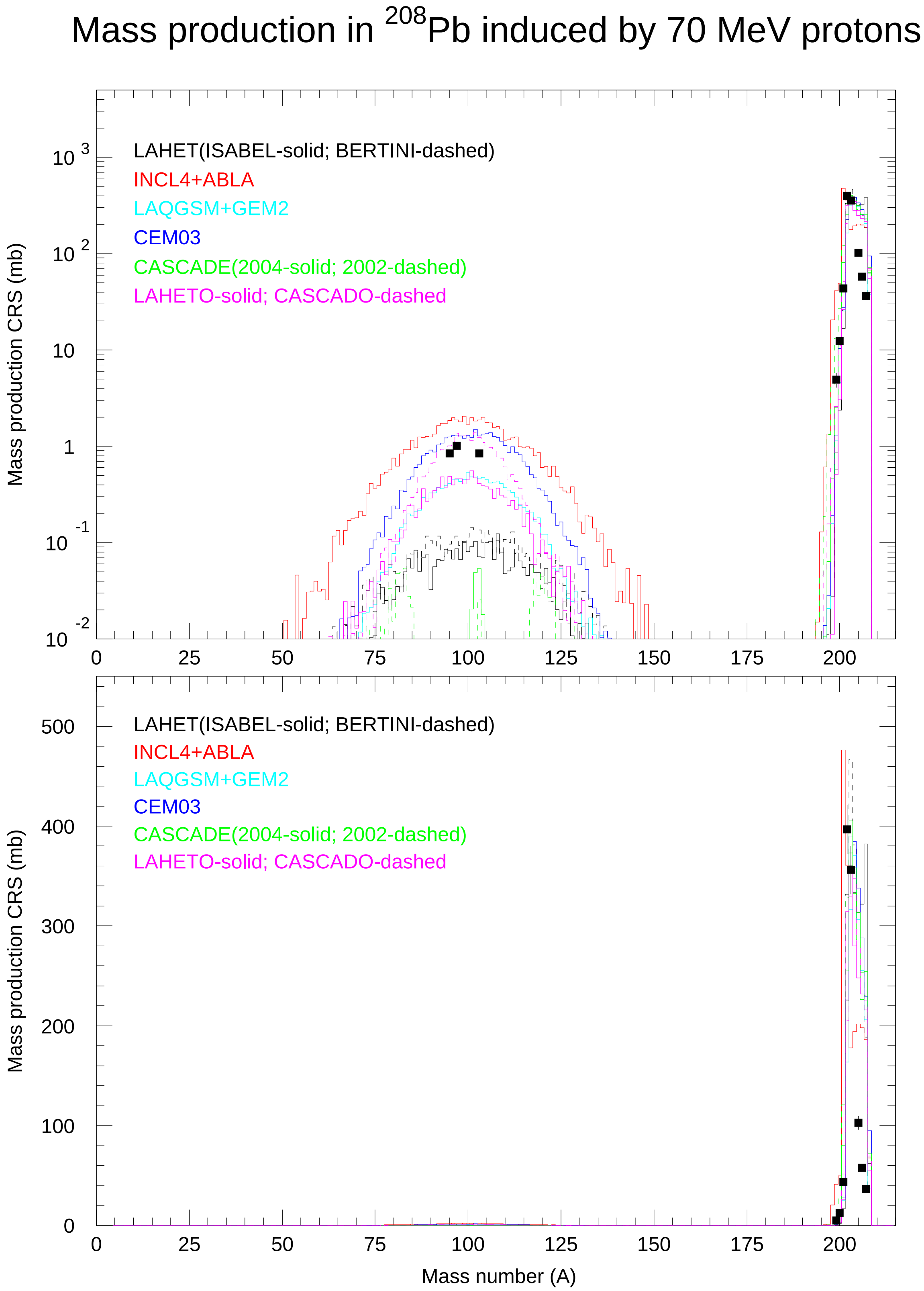


Fig. 91: The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{208}Pb irradiated with 0.07 GeV protons.

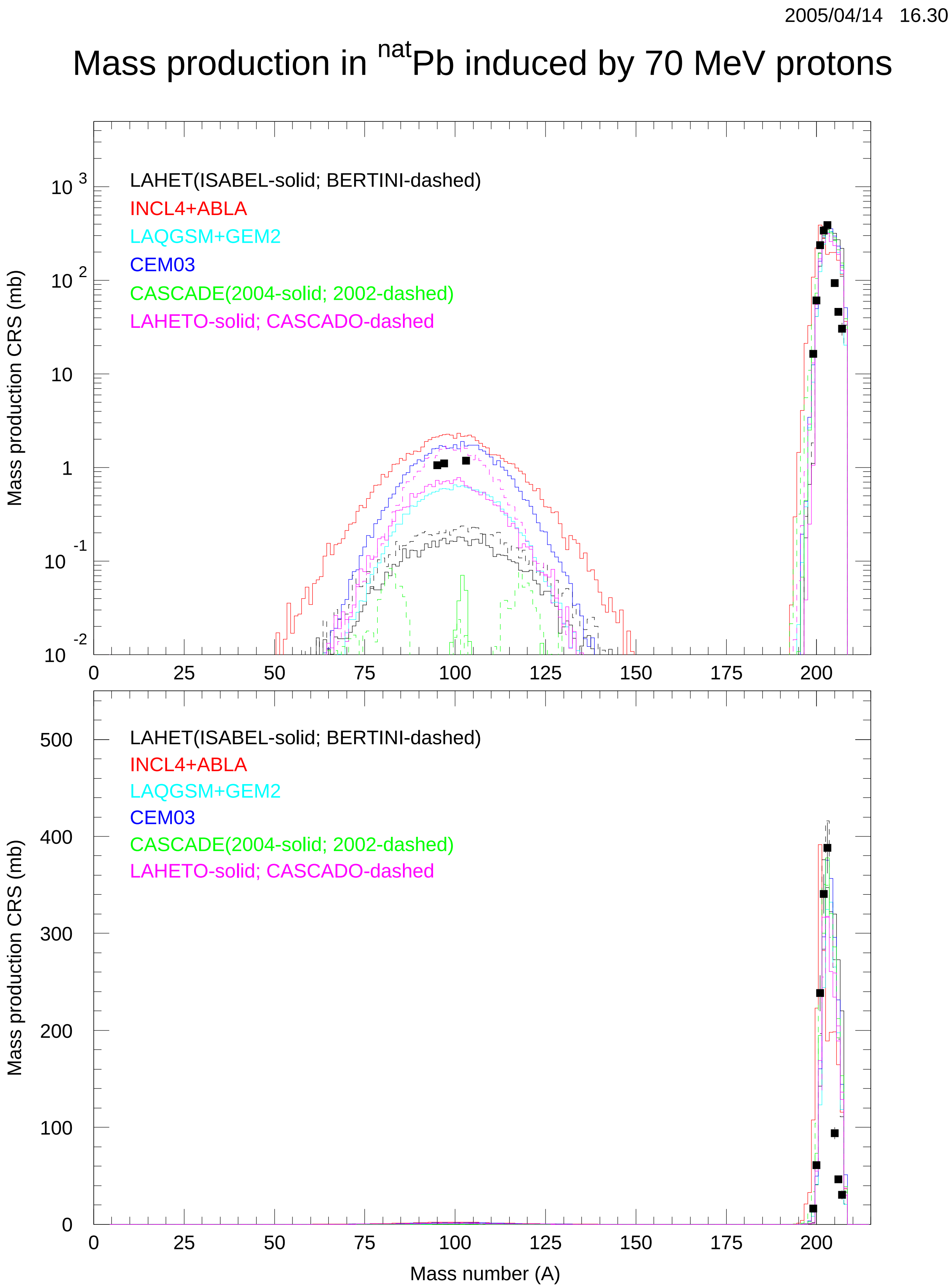


Fig. 92: The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{nat}Pb irradiated with 0.07 GeV protons.

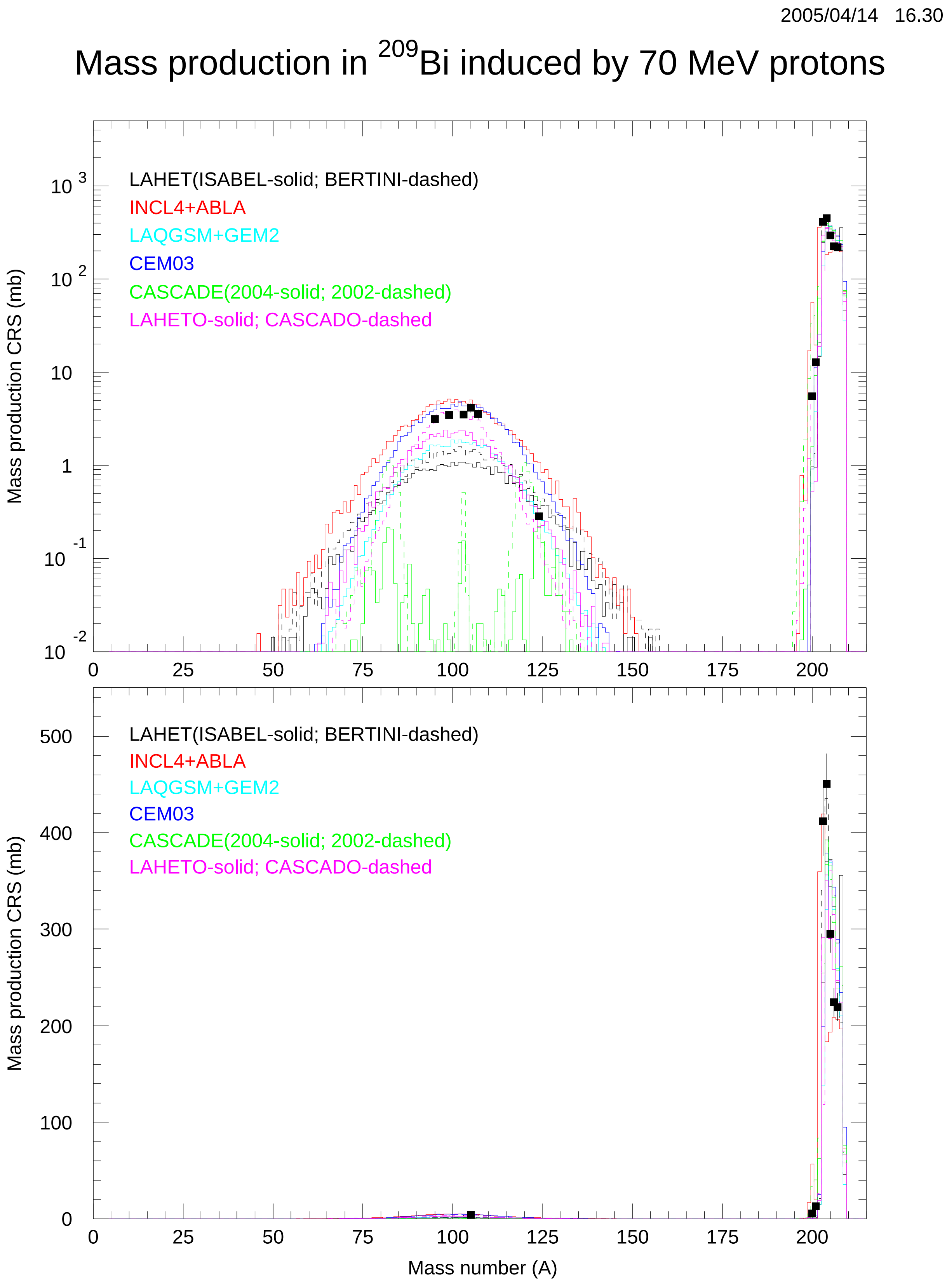


Fig. 93: The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{209}Bi irradiated with 0.07 GeV protons.

2005/04/14 16.30

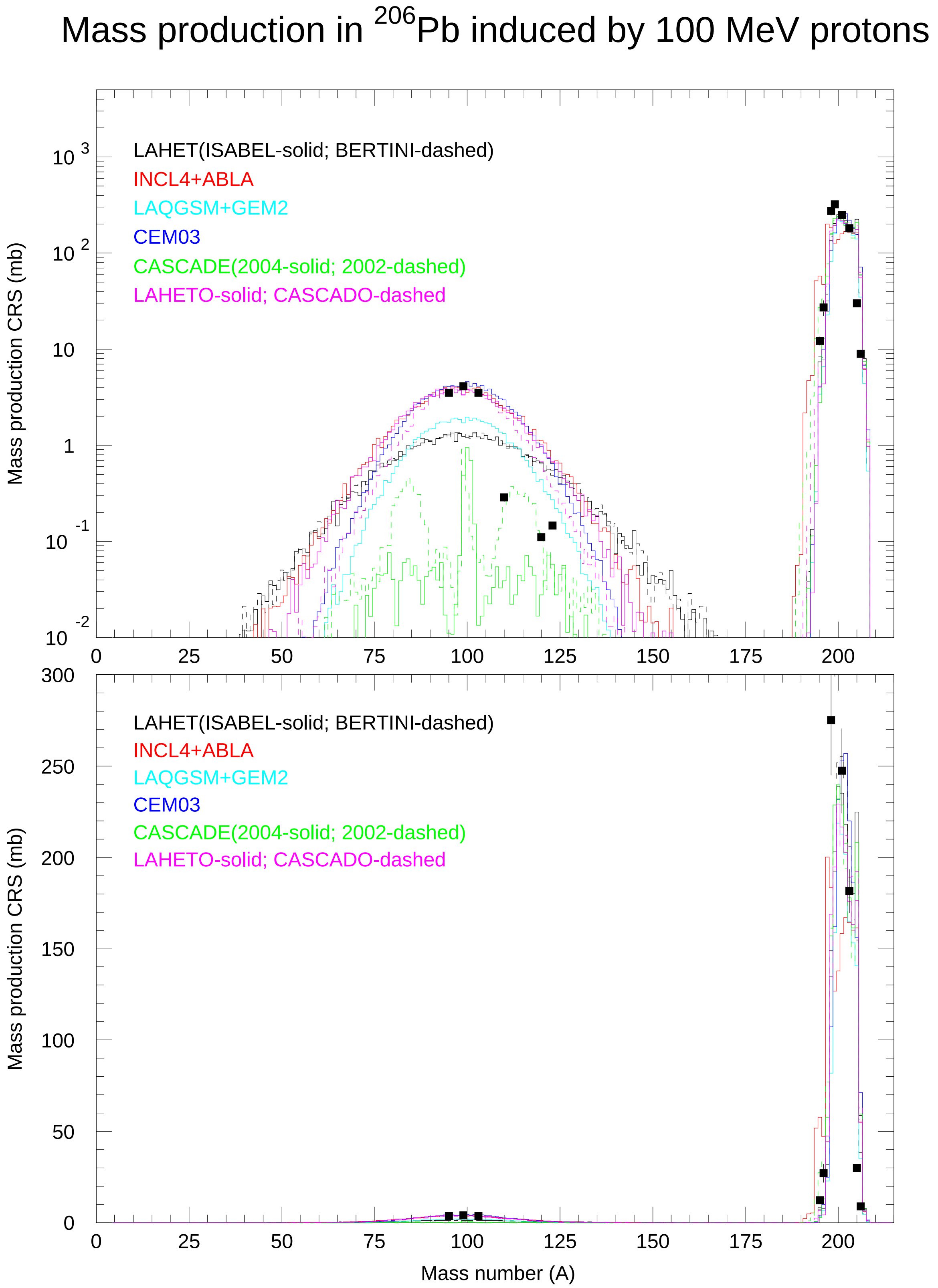


Fig. 94: The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{206}Pb irradiated with 0.1 GeV protons.

2005/04/14 16.30

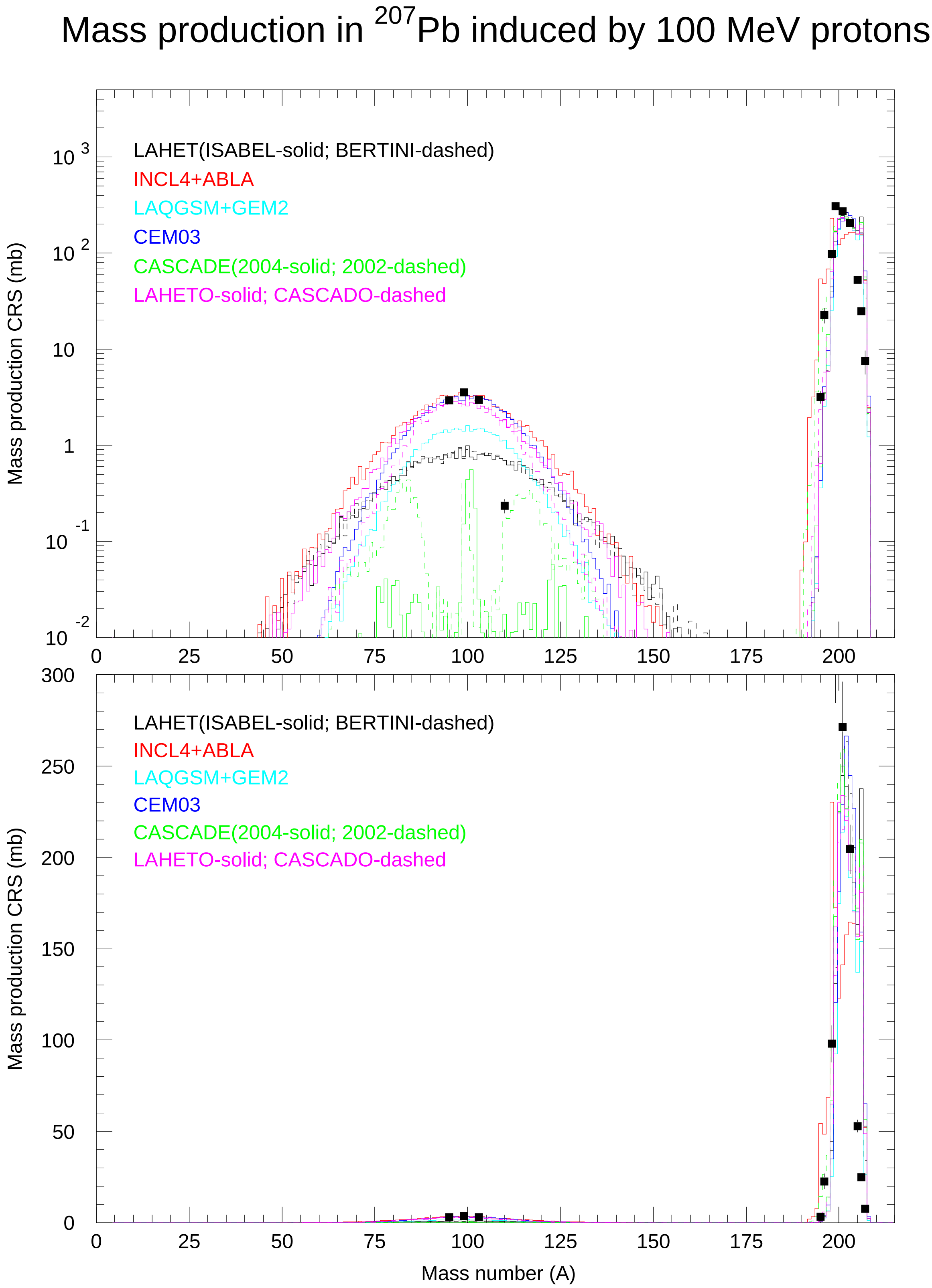


Fig. 95: The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{207}Pb irradiated with 0.1 GeV protons.

2005/04/14 16.30

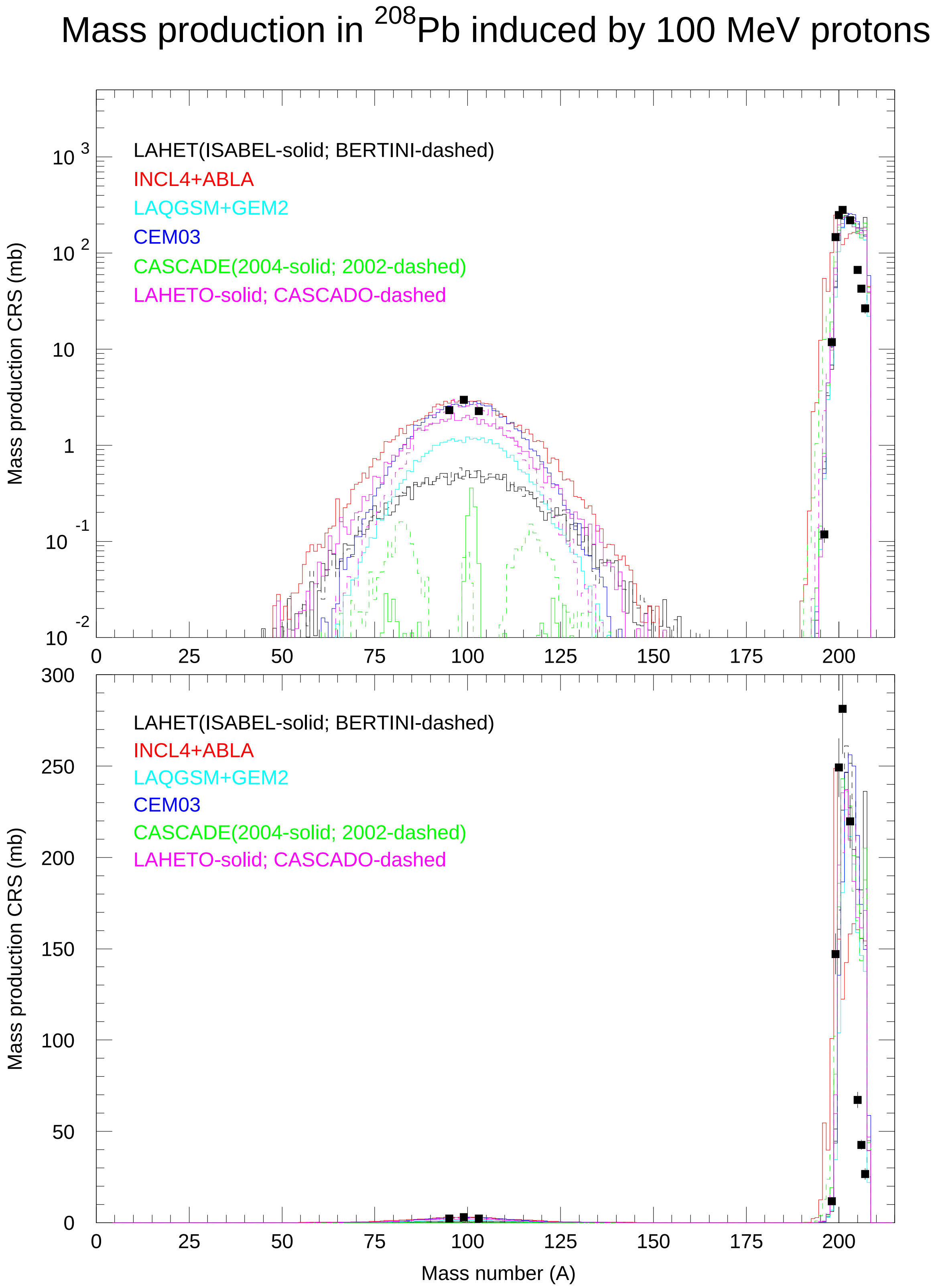


Fig. 96: The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{208}Pb irradiated with 0.1 GeV protons.

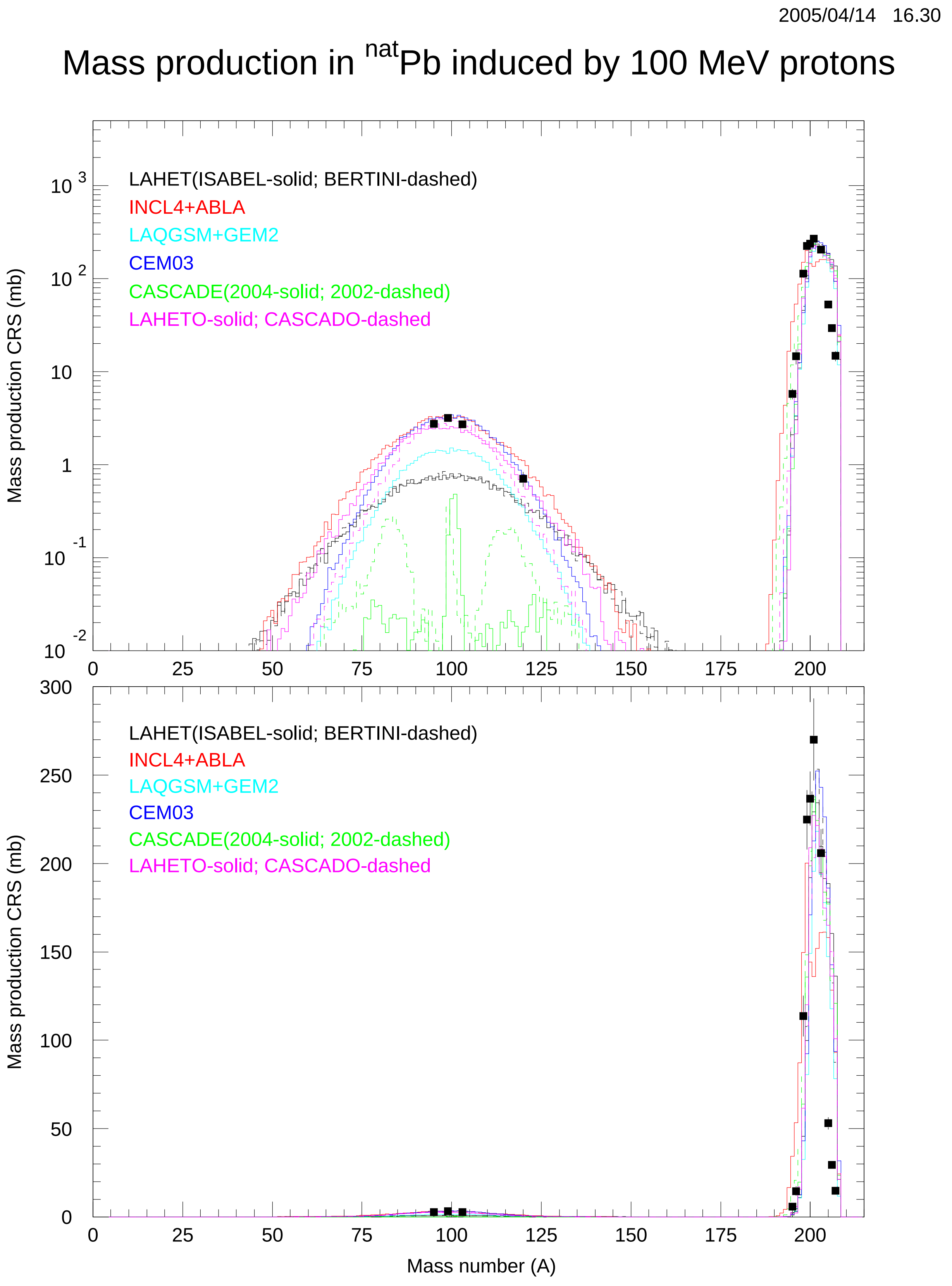


Fig. 97: The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{nat}Pb irradiated with 0.1 GeV protons.

2005/04/14 16.30

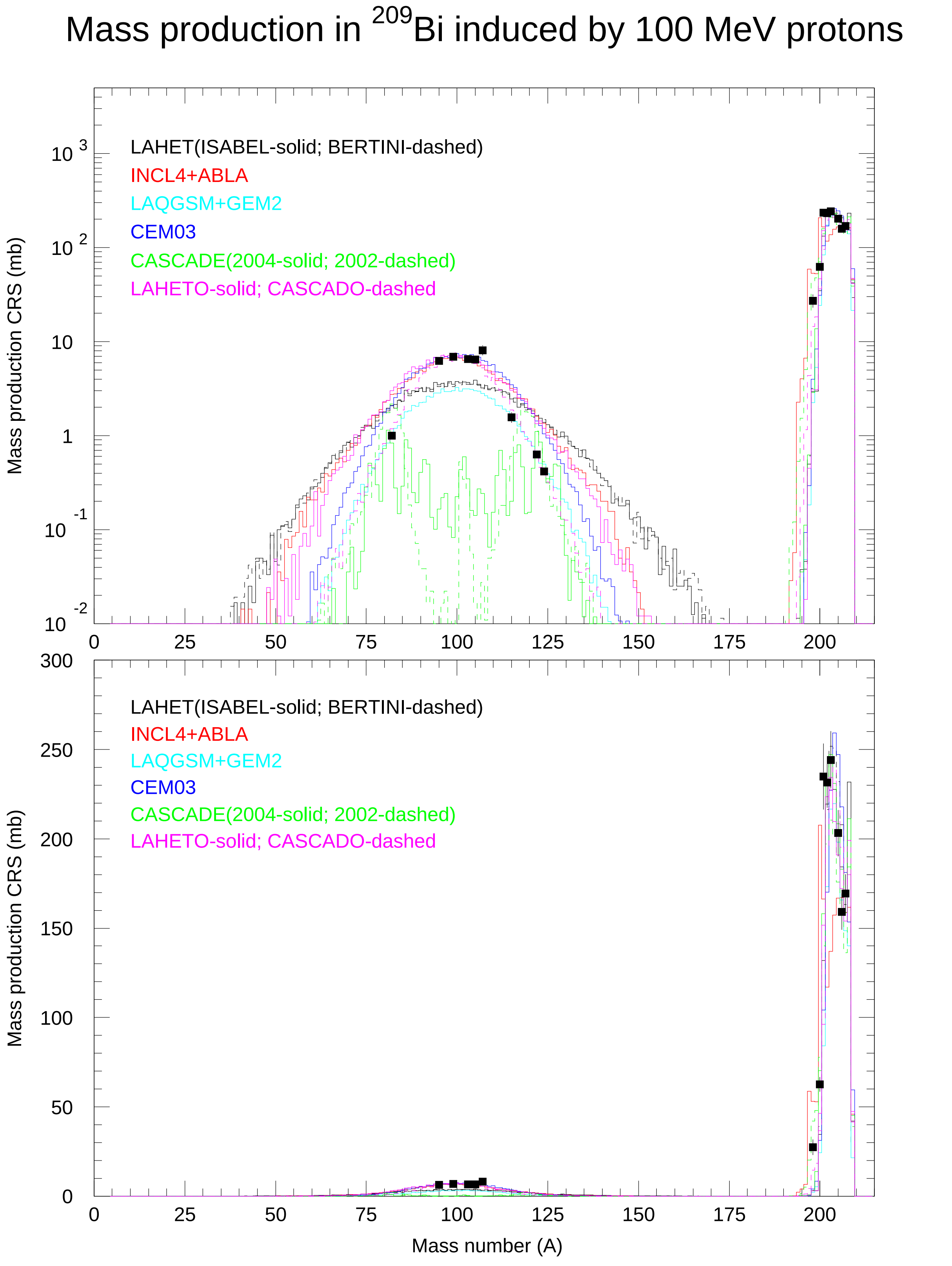


Fig. 98: The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{209}Bi irradiated with 0.1 GeV protons.

2005/04/14 16.30

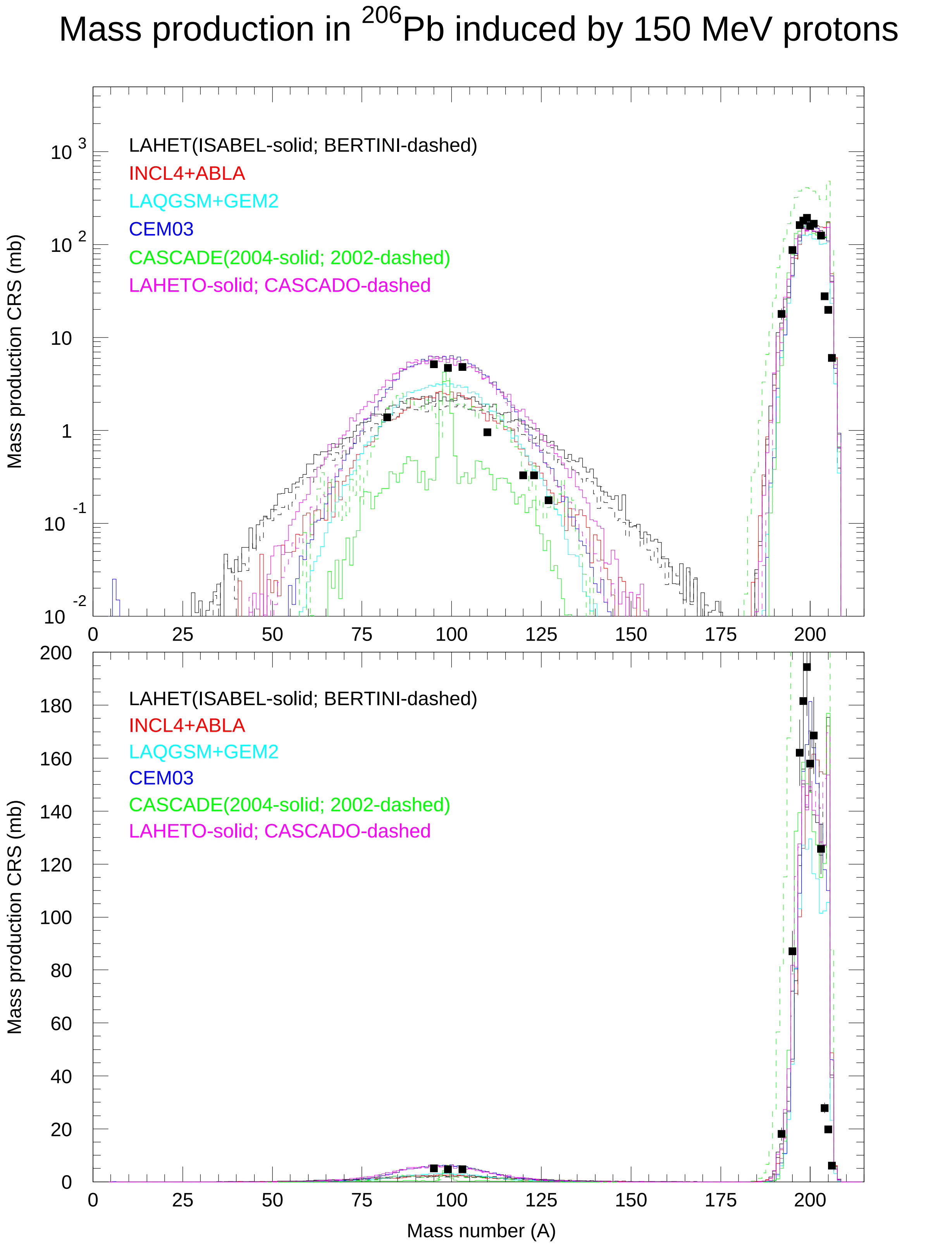


Fig. 99: The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{206}Pb irradiated with 0.15 GeV protons.

2005/04/14 16.30

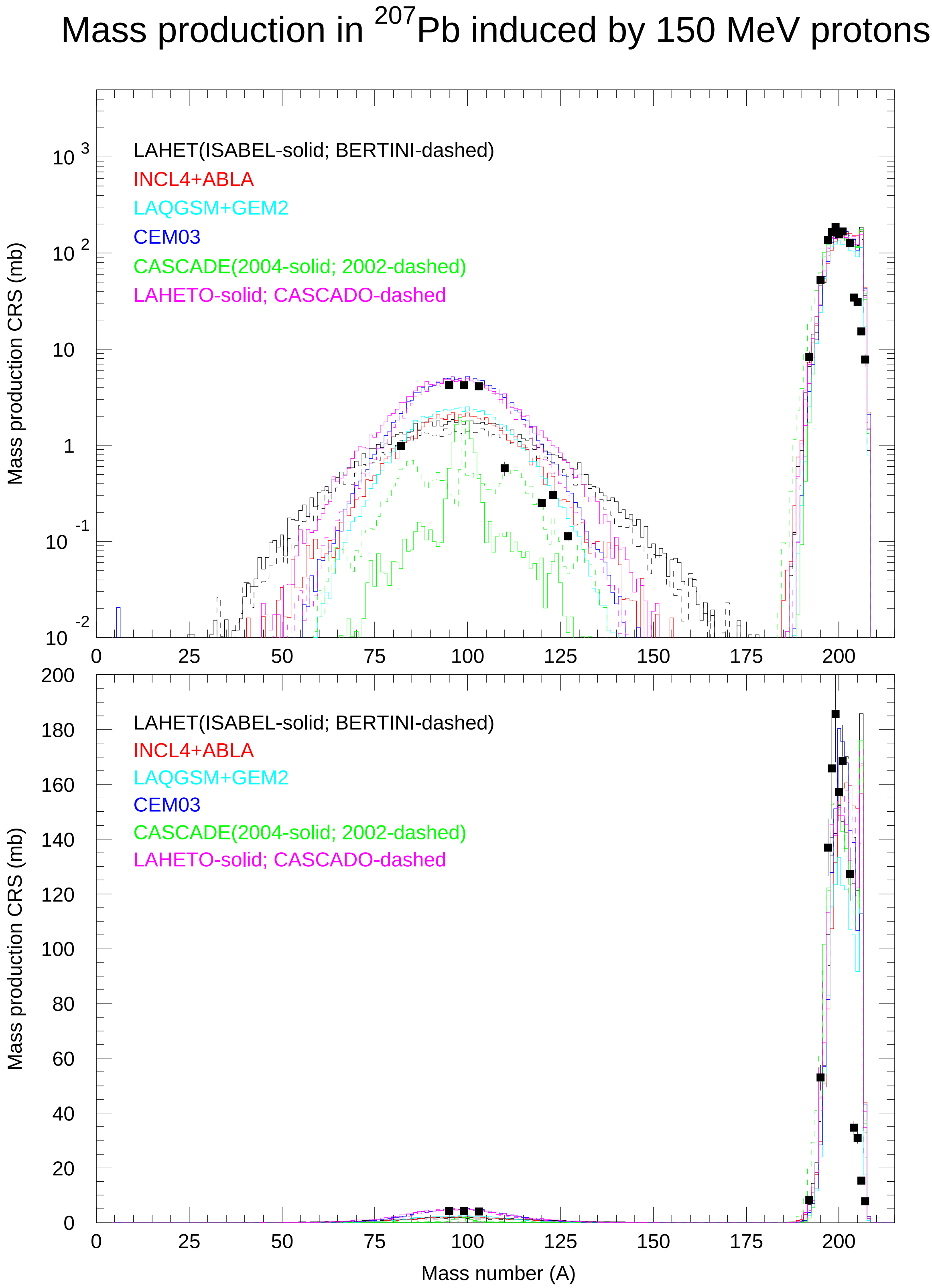


Fig. 100: The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{207}Pb irradiated with 0.15 GeV protons.

2005/04/14 16.30

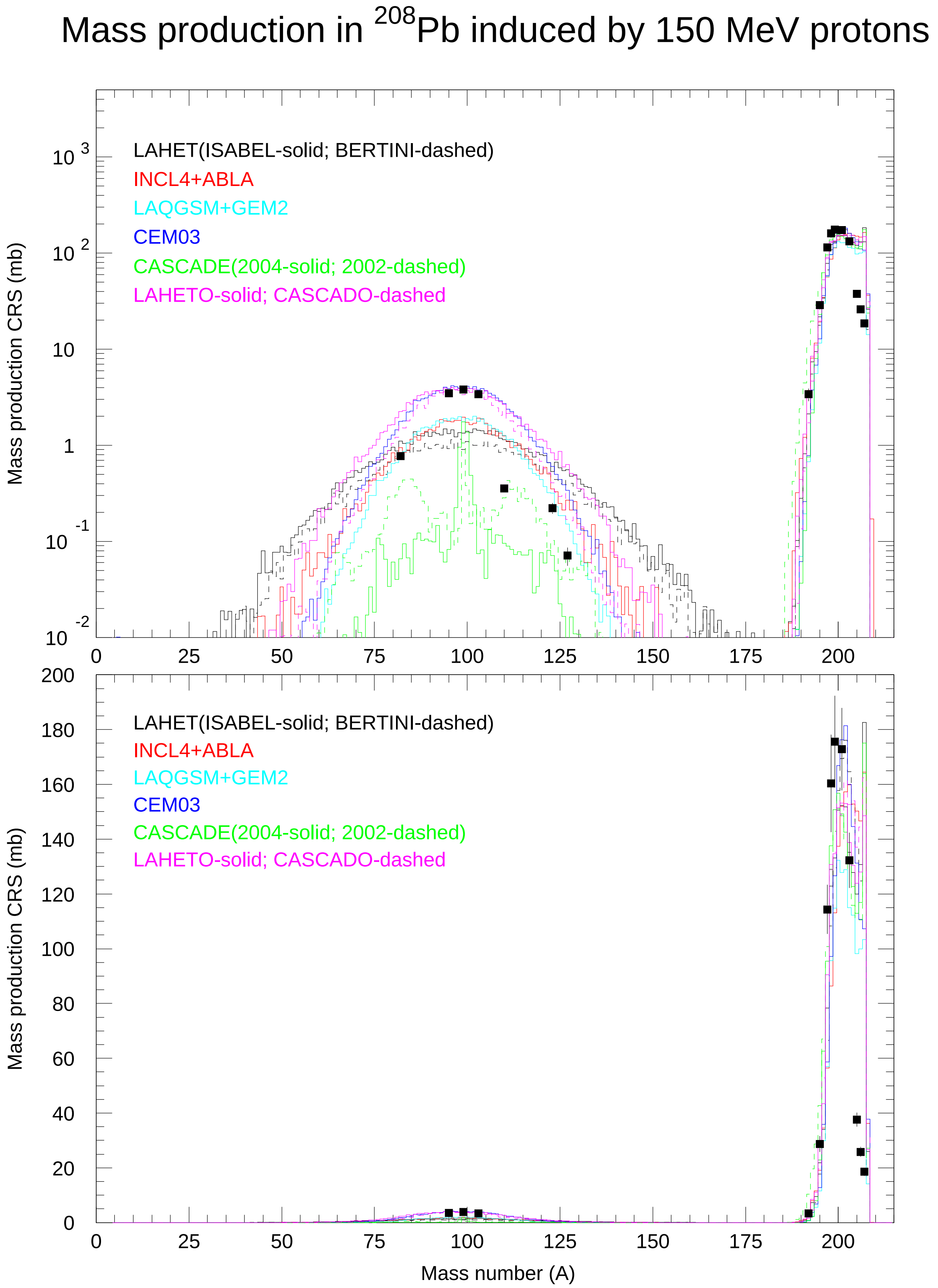


Fig. 101: The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{208}Pb irradiated with 0.15 GeV protons.

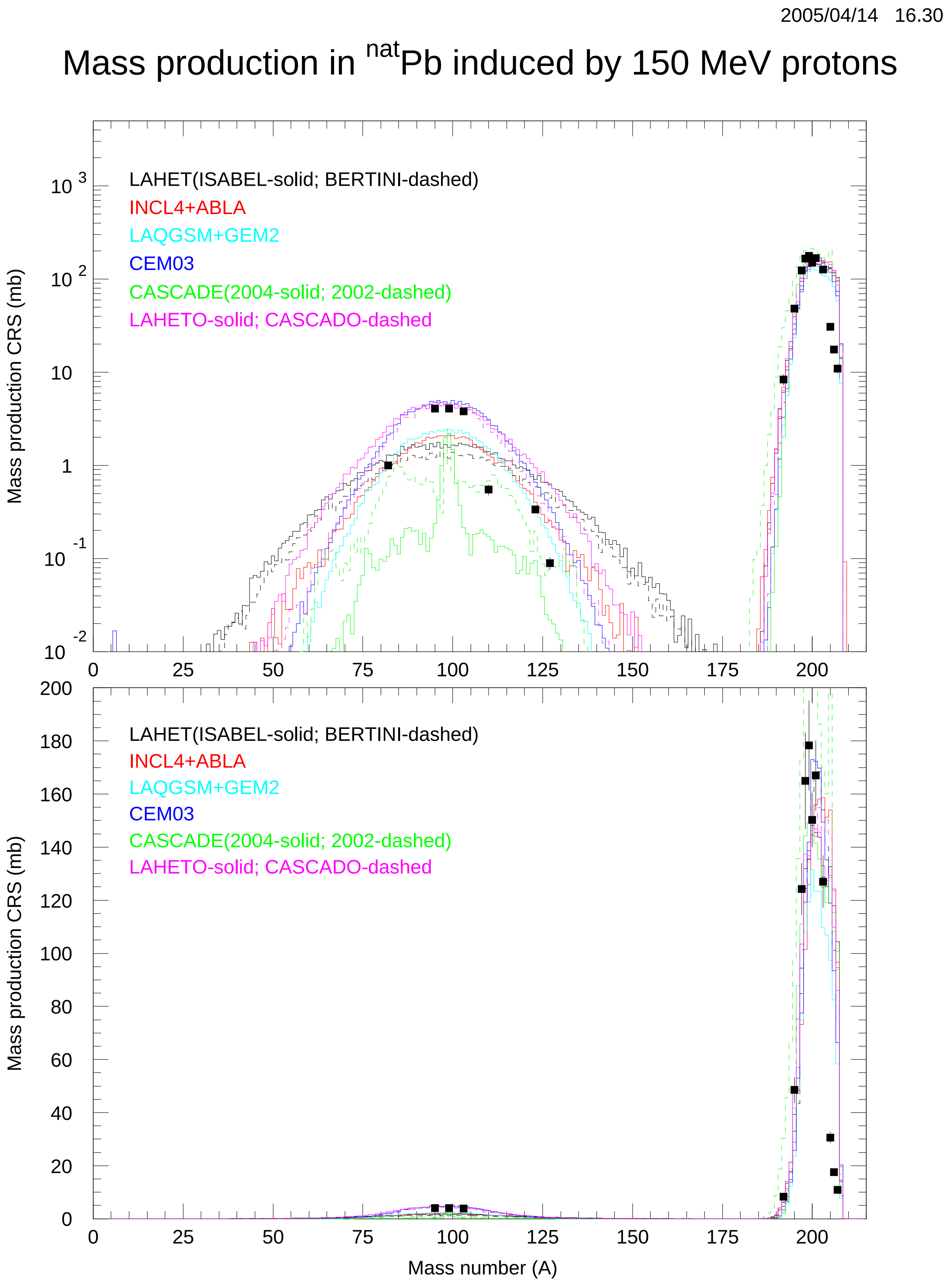


Fig. 102: The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{nat}Pb irradiated with 0.15 GeV protons.

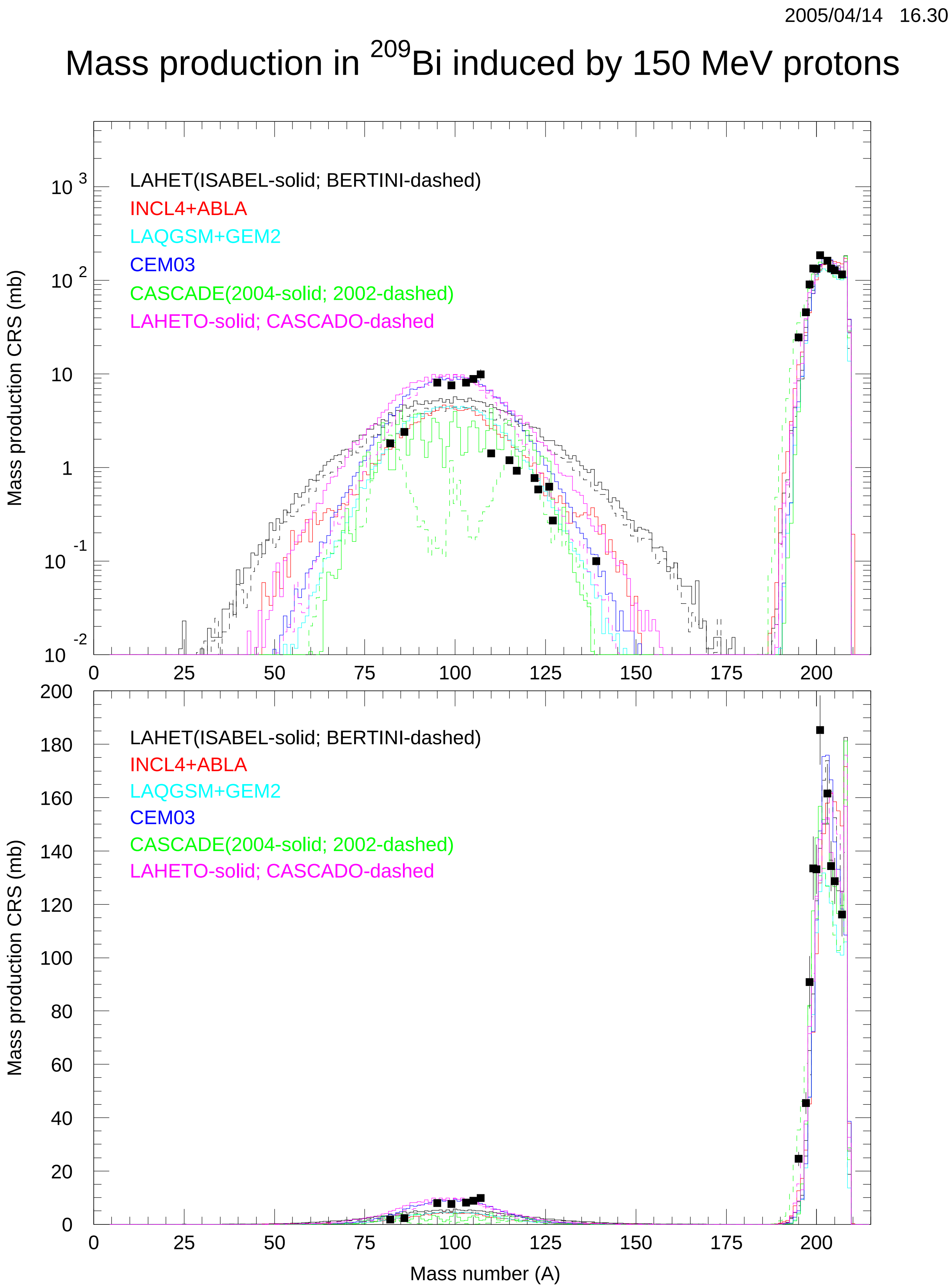


Fig. 103: The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{209}Bi irradiated with 0.15 GeV protons.

2005/04/14 16.30

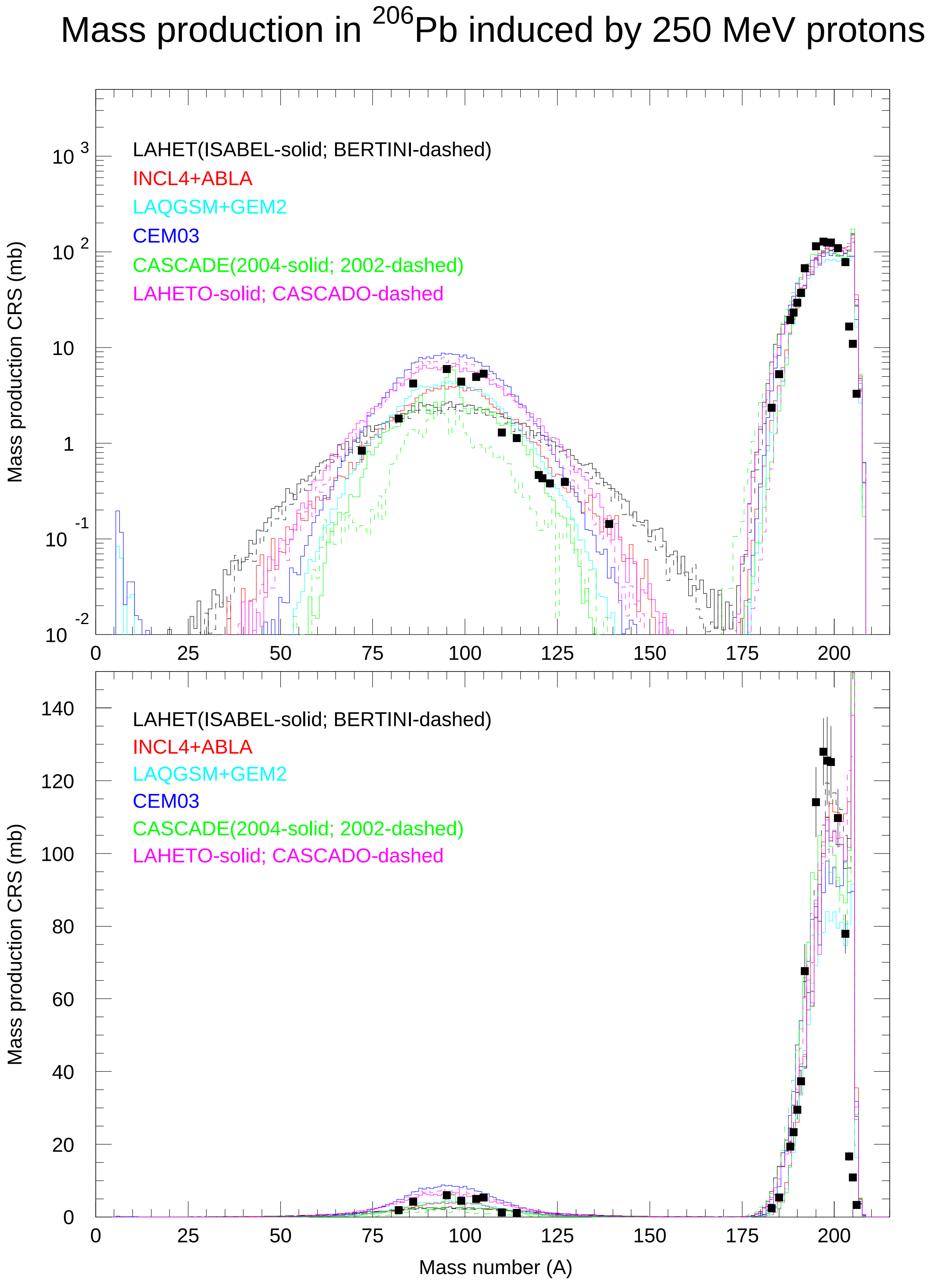


Fig. 104: The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{206}Pb irradiated with 0.25 GeV protons.

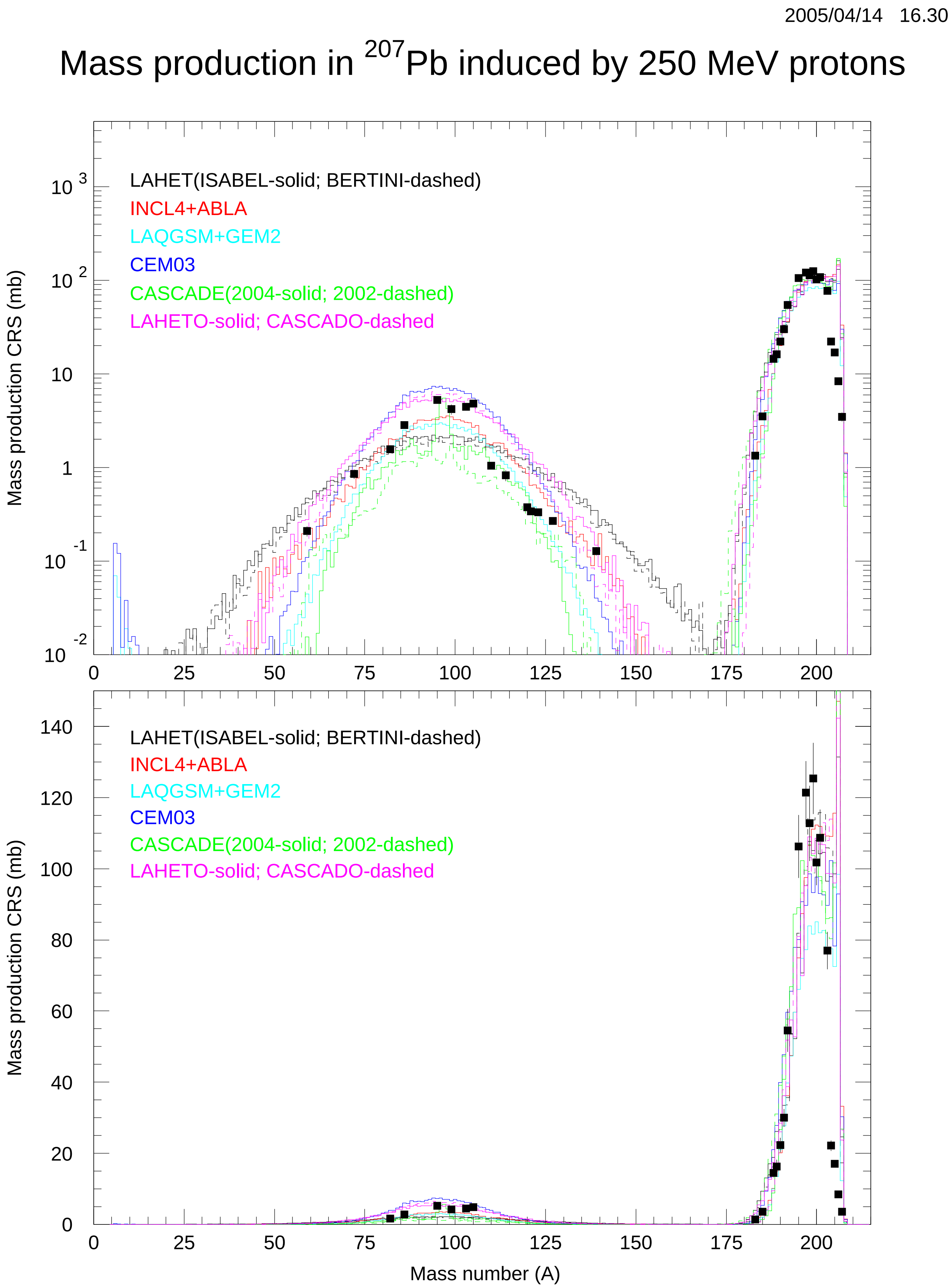


Fig. 105: The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{207}Pb irradiated with 0.25 GeV protons.

2005/04/14 16.30

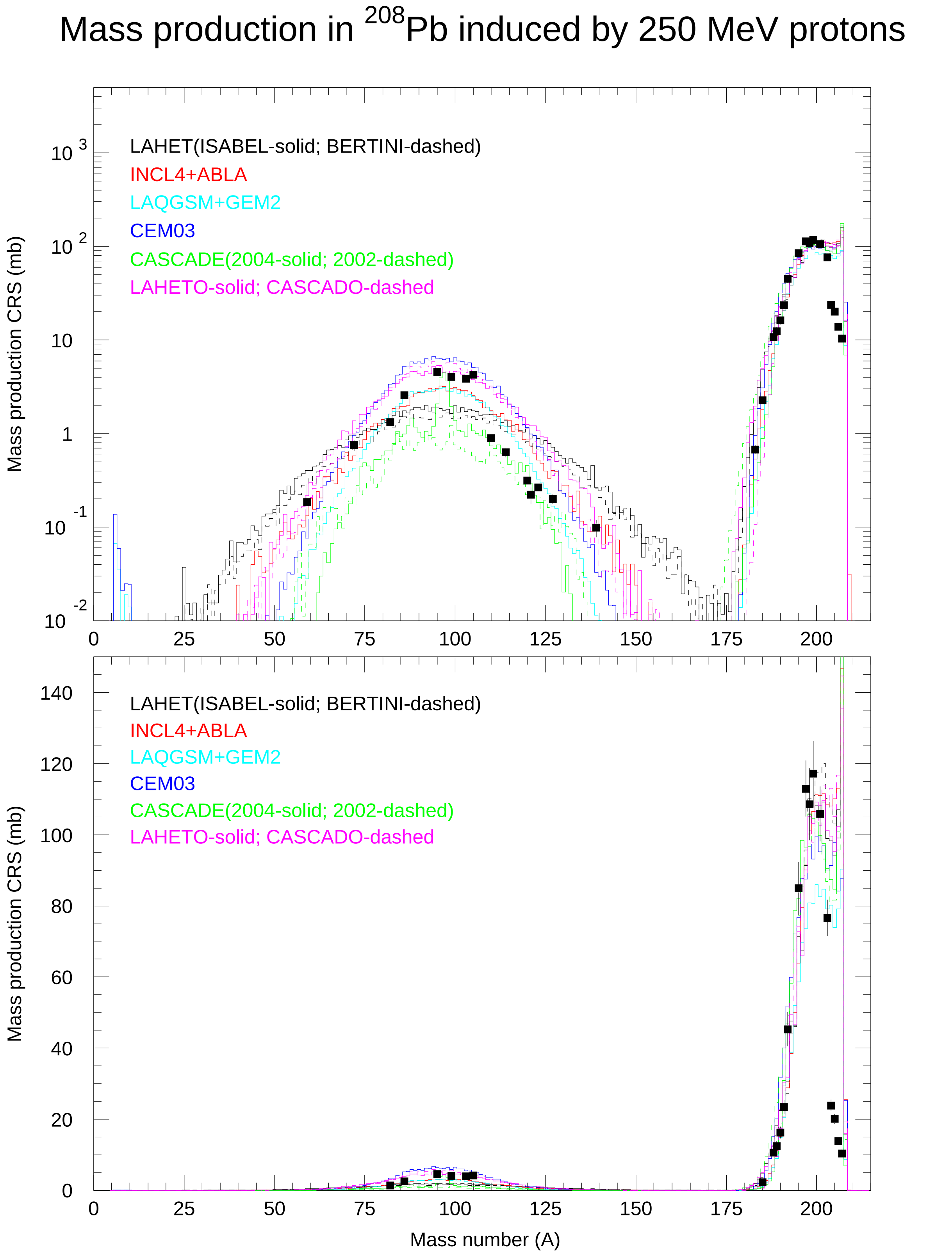


Fig. 106: The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{208}Pb irradiated with 0.25 GeV protons.

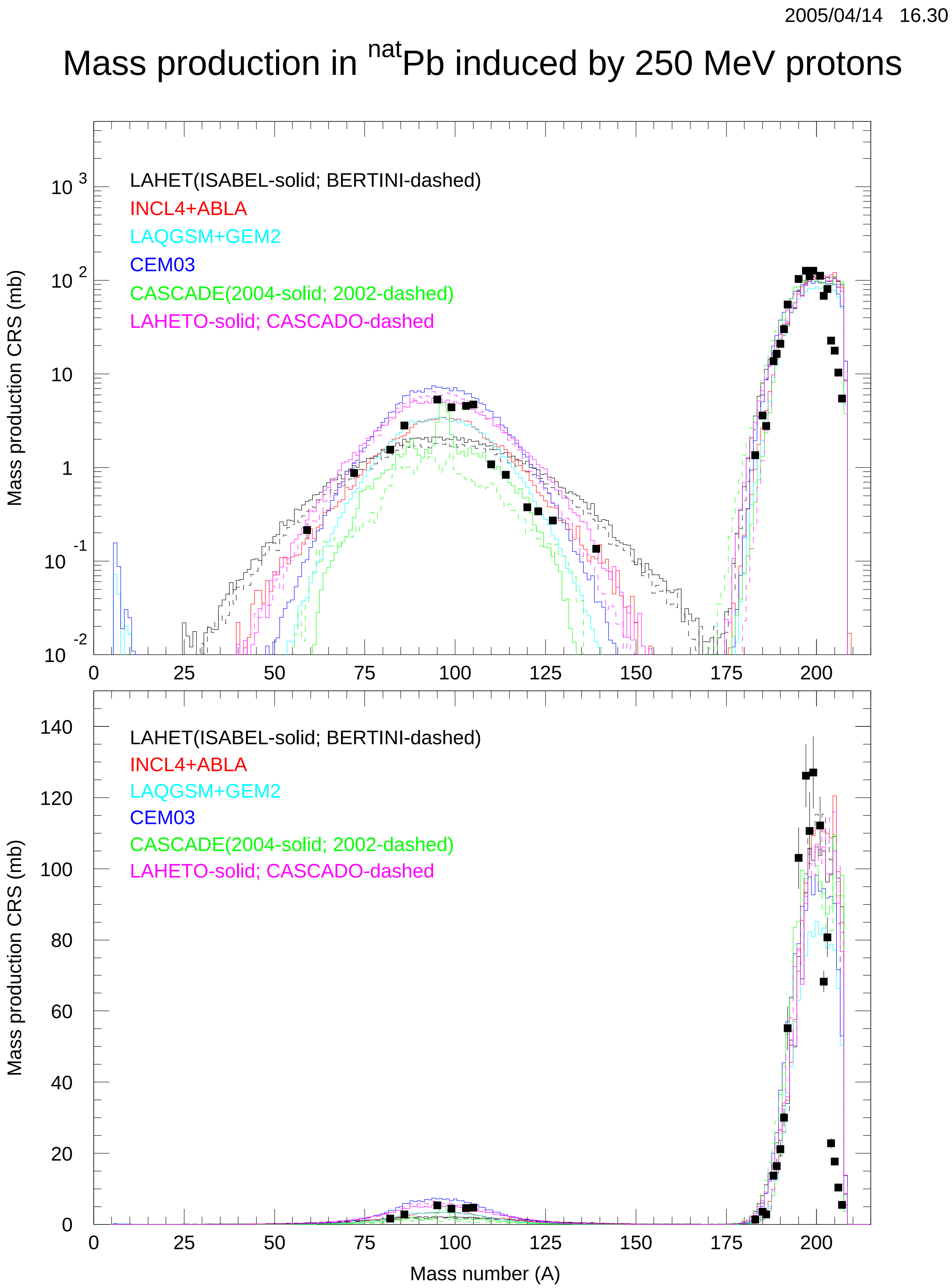


Fig. 107: The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{nat}Pb irradiated with 0.25 GeV protons.

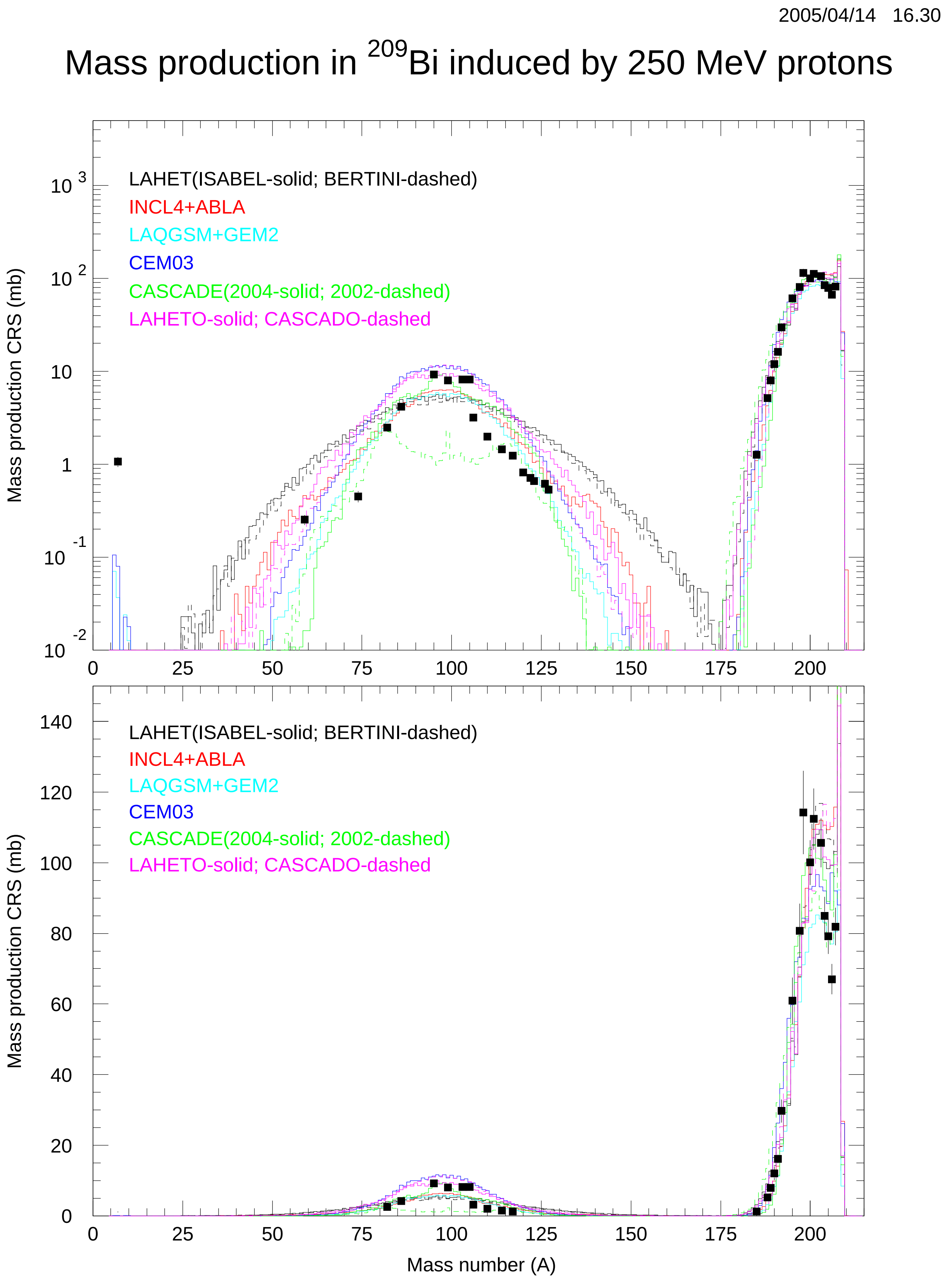


Fig. 108: The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{209}Bi irradiated with 0.25 GeV protons.

2005/04/14 16.30

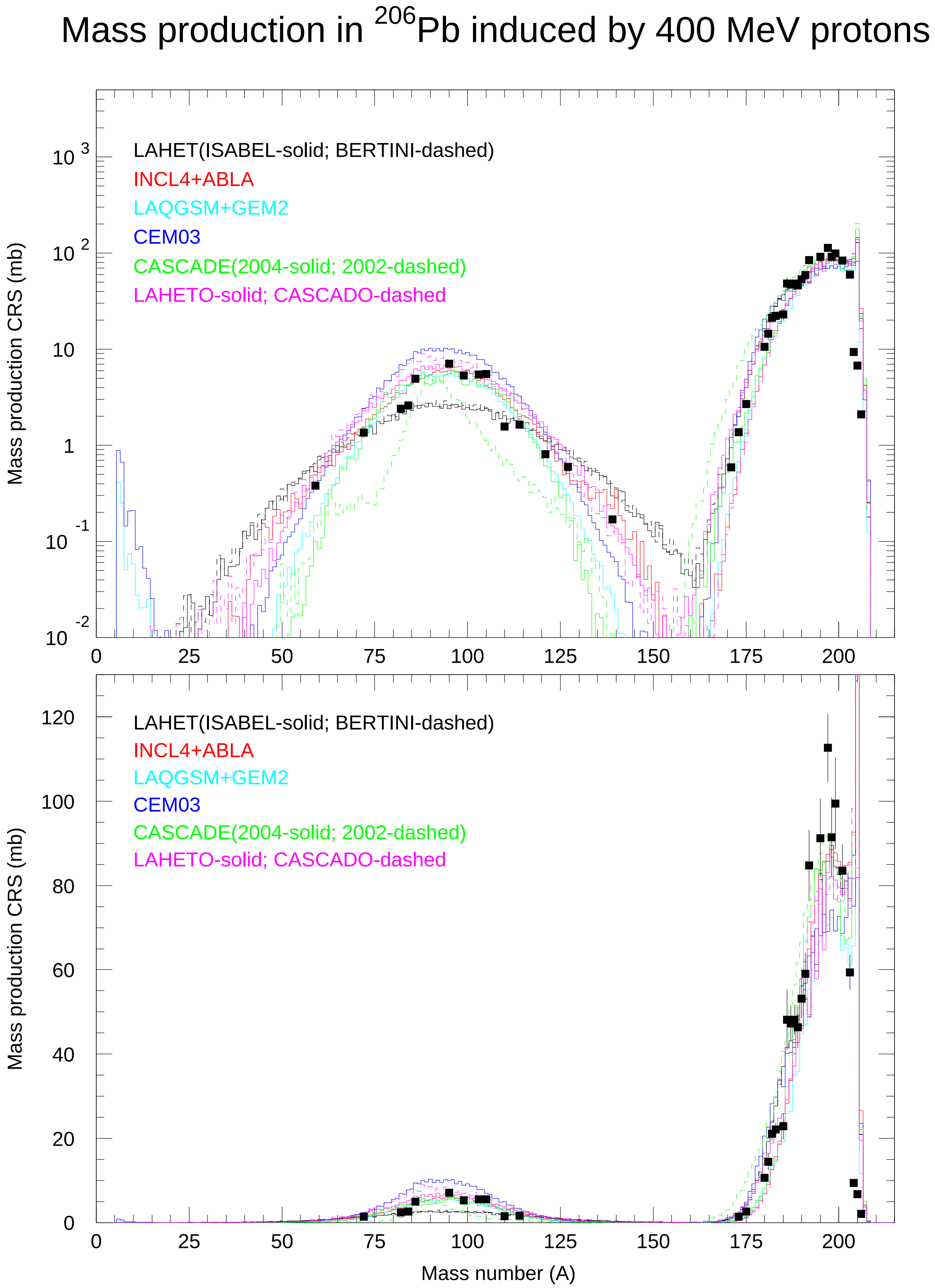


Fig. 109: The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{206}Pb irradiated with 0.4 GeV protons.

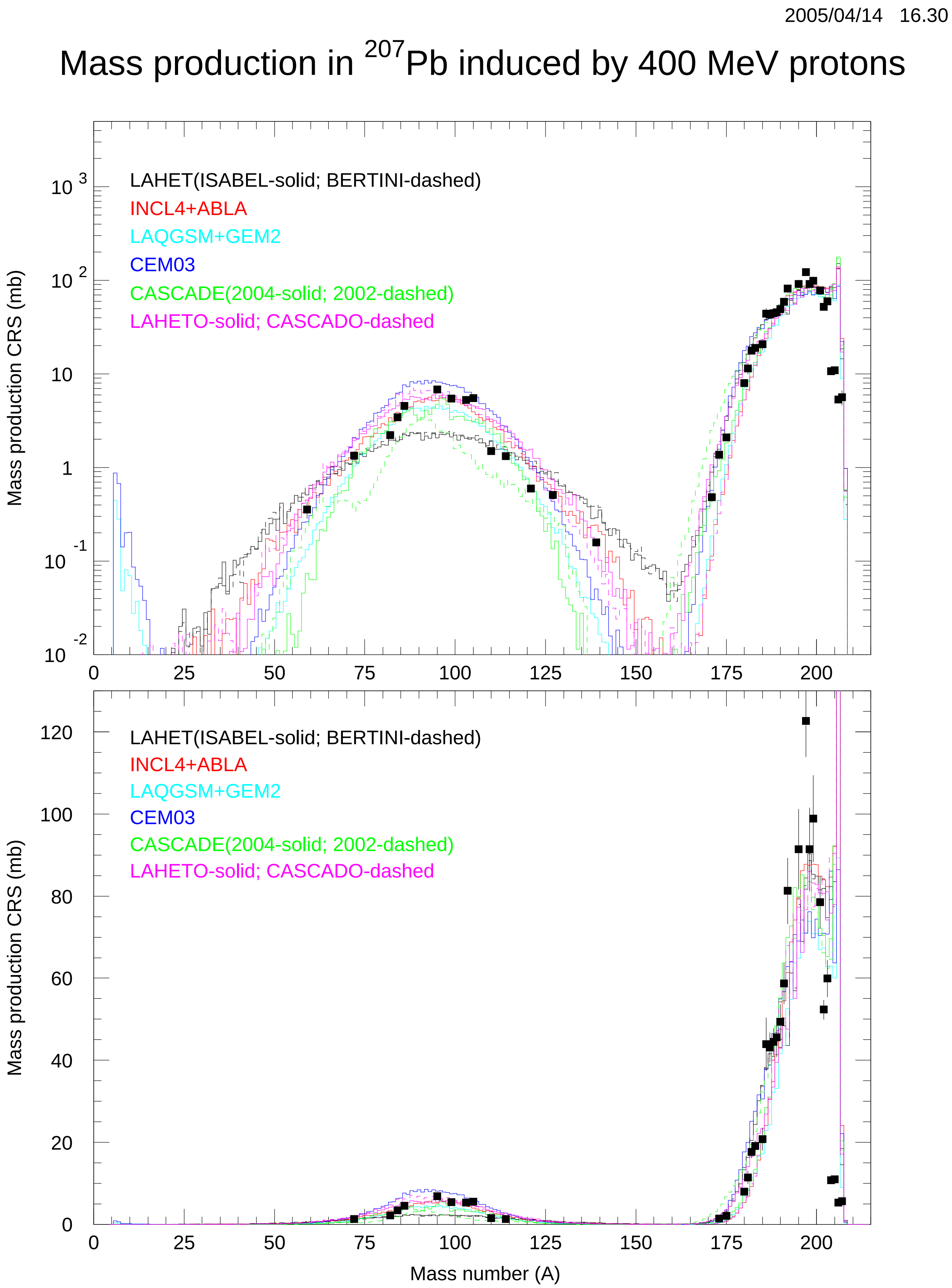


Fig. 110: The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{207}Pb irradiated with 0.4 GeV protons.

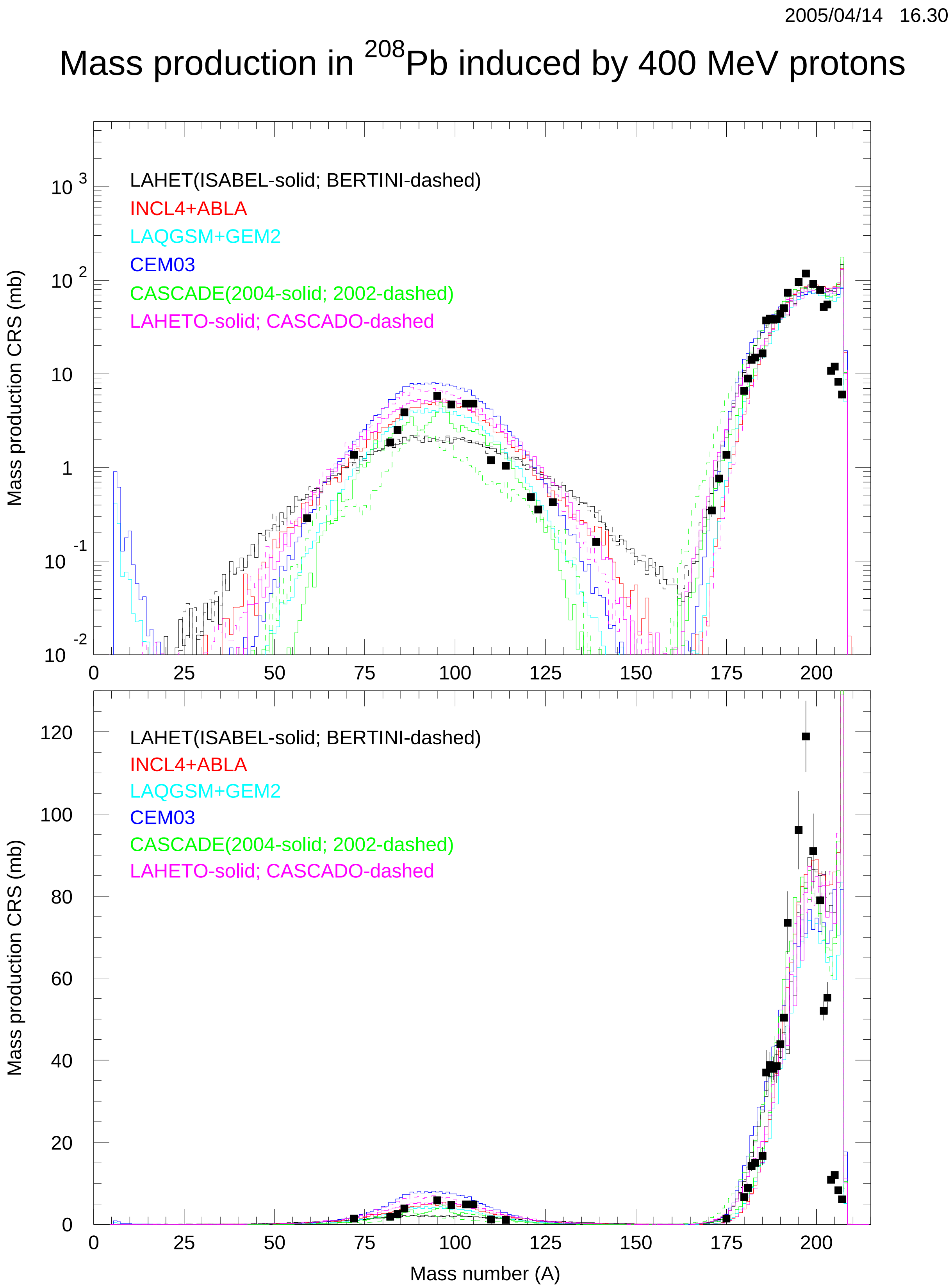


Fig. 111: The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{208}Pb irradiated with 0.4 GeV protons.

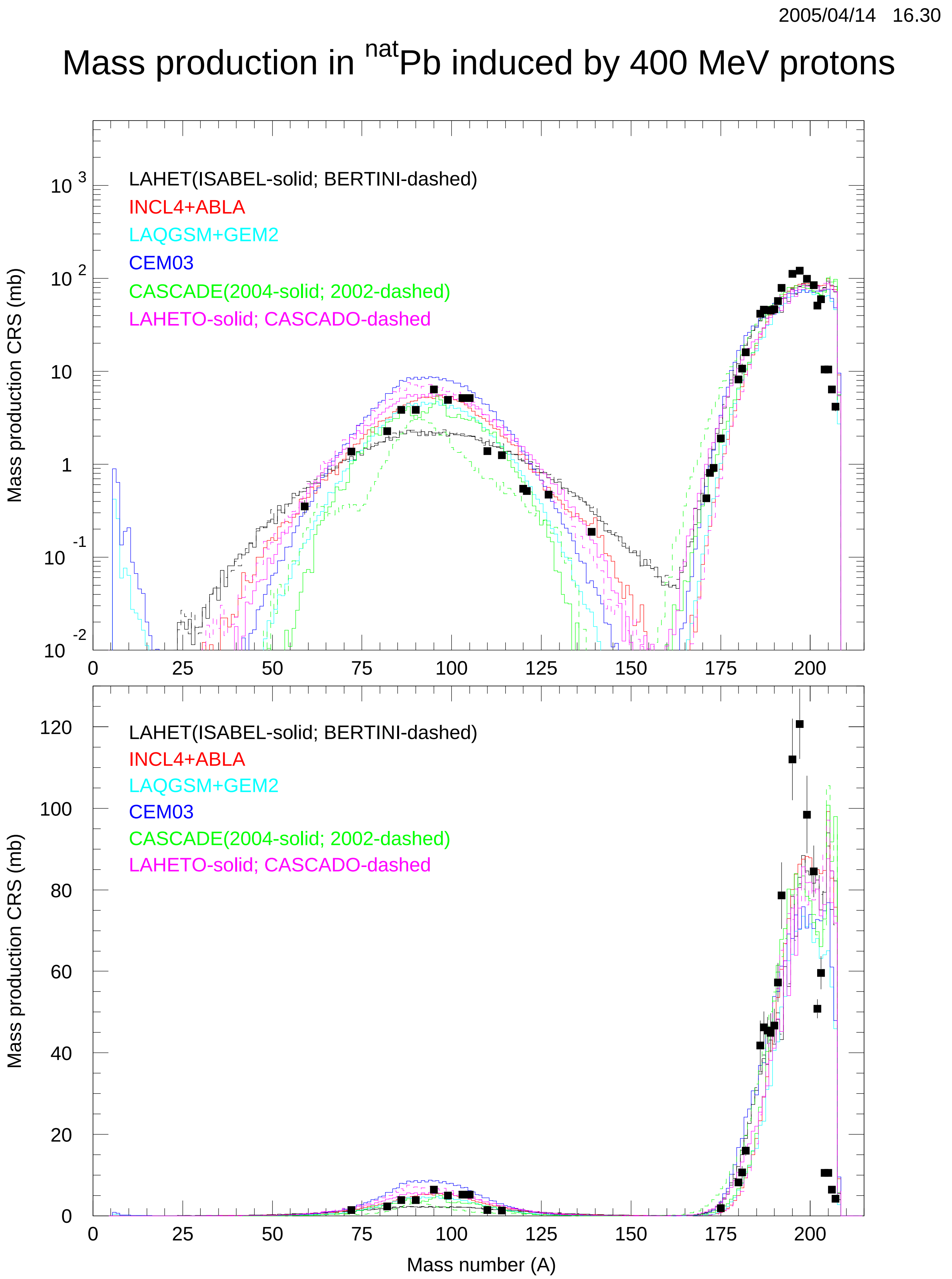


Fig. 112: The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{nat}Pb irradiated with 0.4 GeV protons.

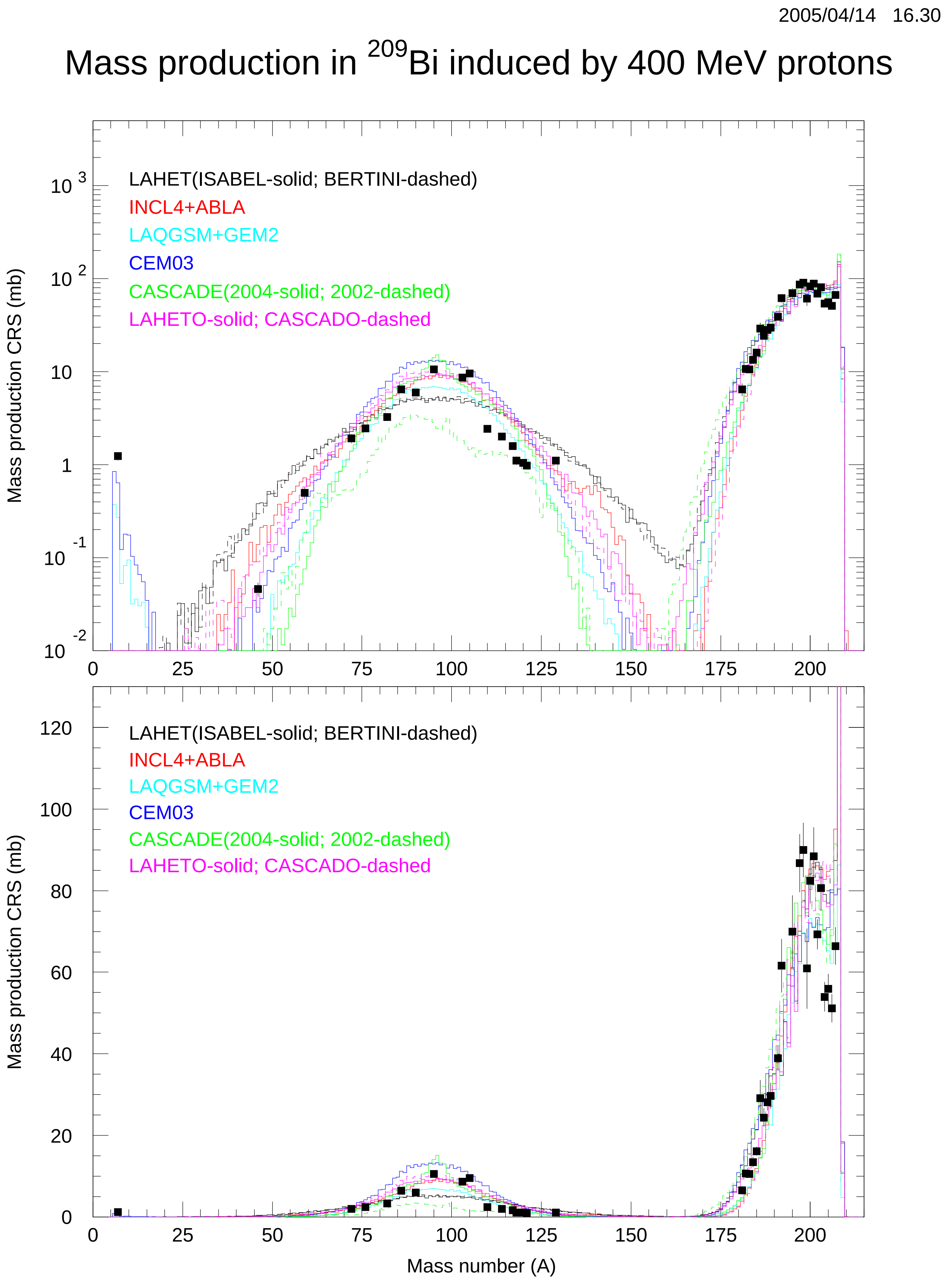


Fig. 113: The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{209}Bi irradiated with 0.4 GeV protons.

2005/04/14 16.30

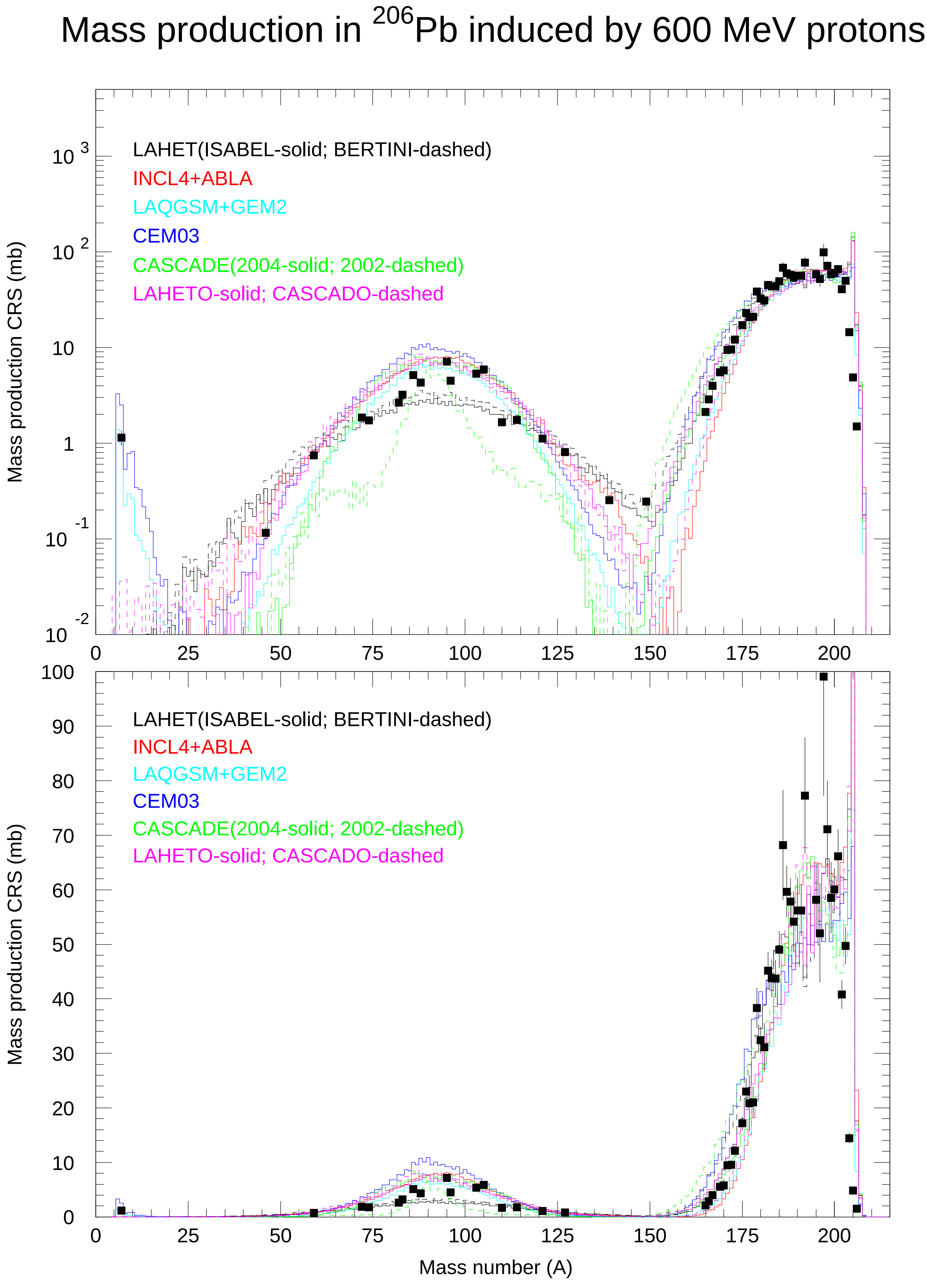


Fig. 114: The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{206}Pb irradiated with 0.6 GeV protons.

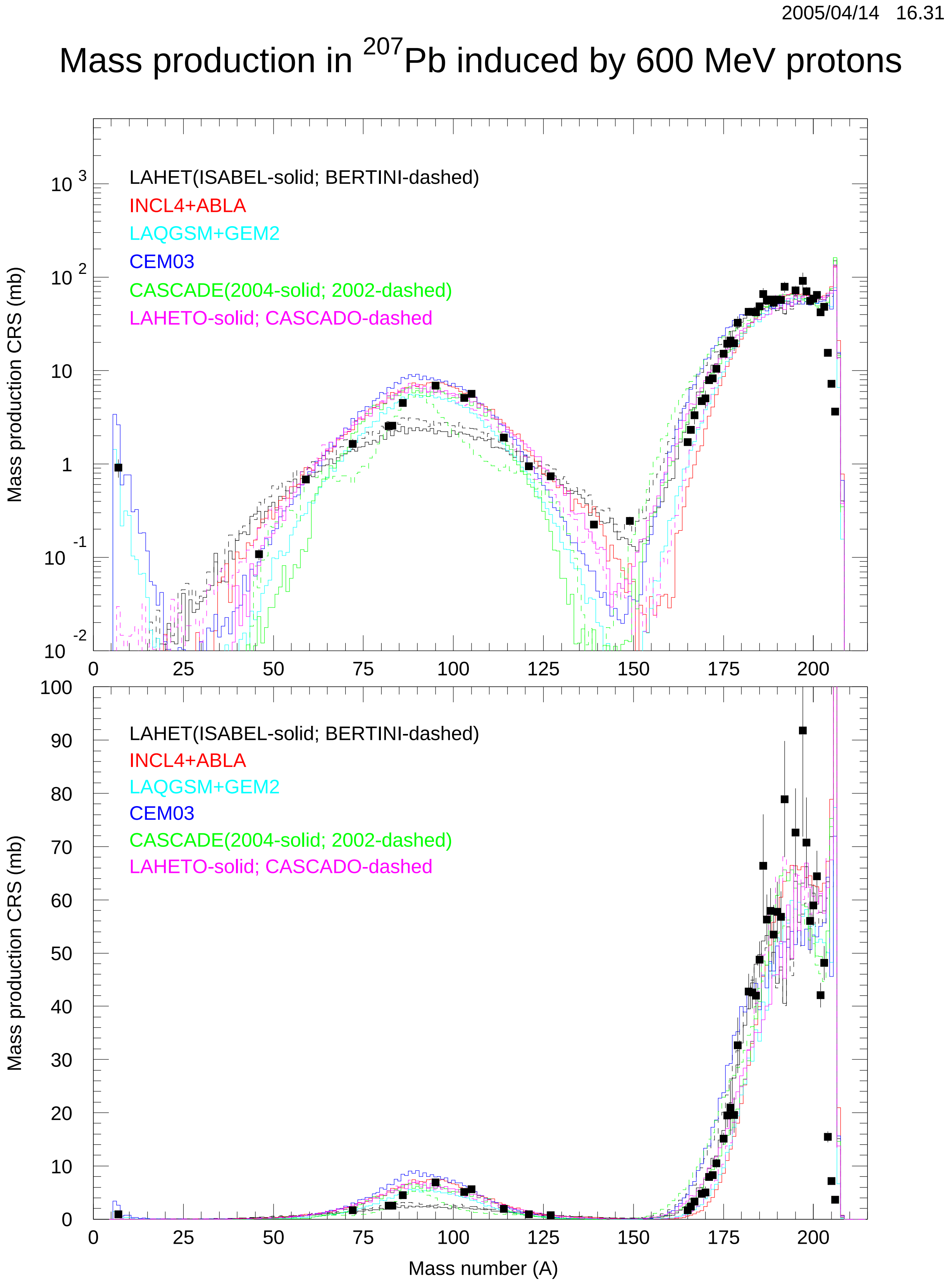


Fig. 115: The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{207}Pb irradiated with 0.06 GeV protons.

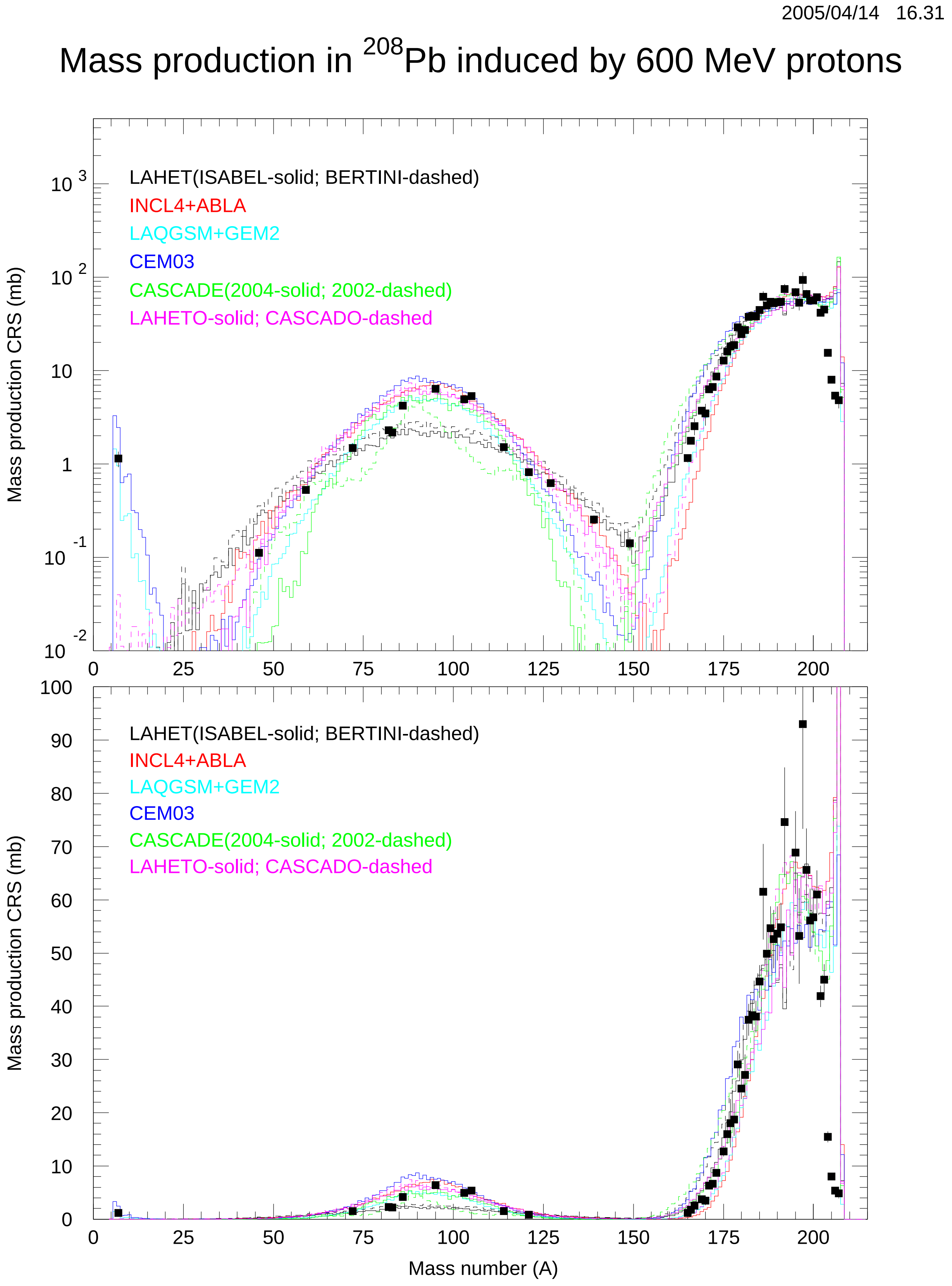


Fig. 116: The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{208}Pb irradiated with 0.6 GeV protons.

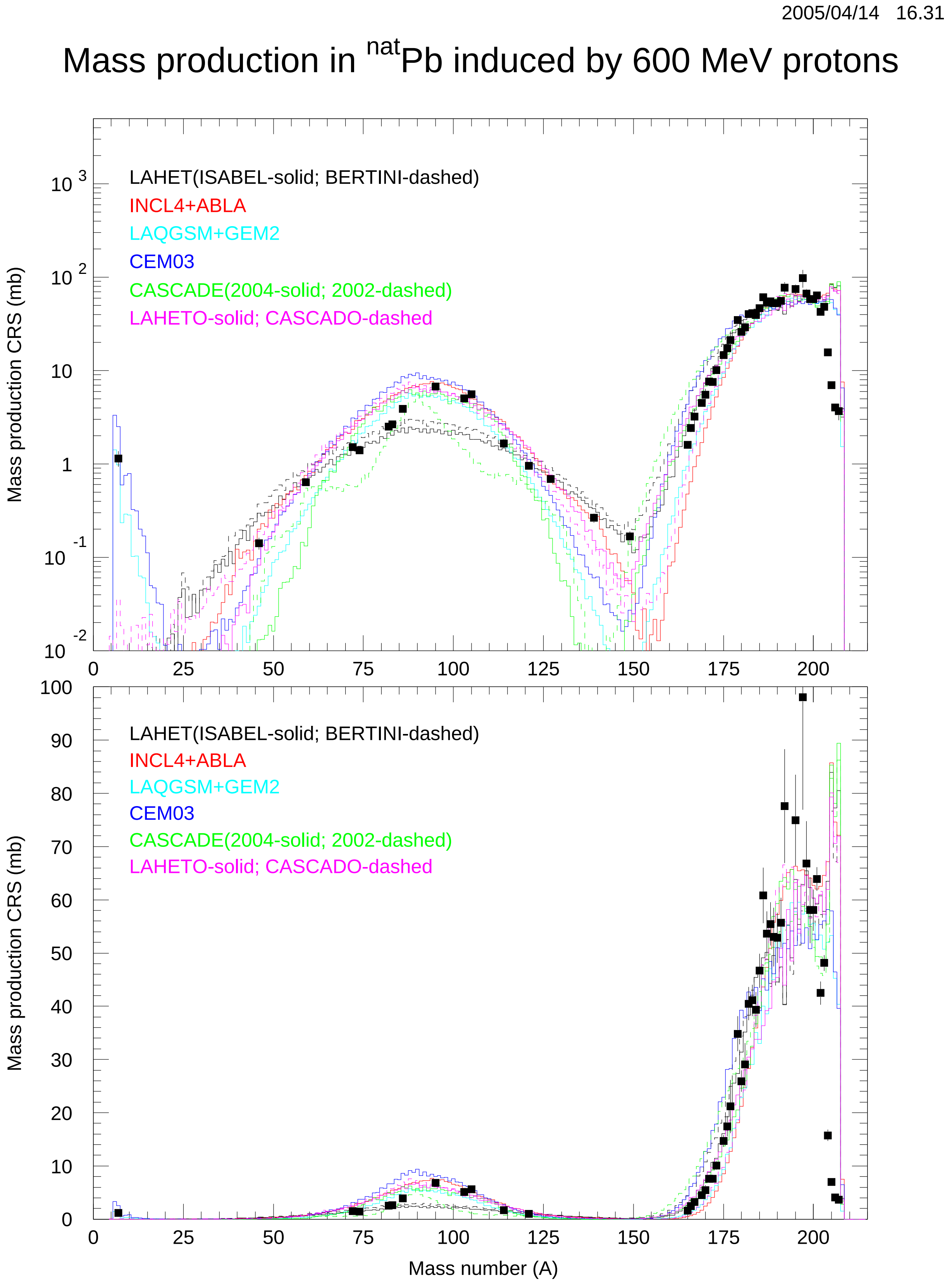


Fig. 117: The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{nat}Pb irradiated with 0.6 GeV protons.

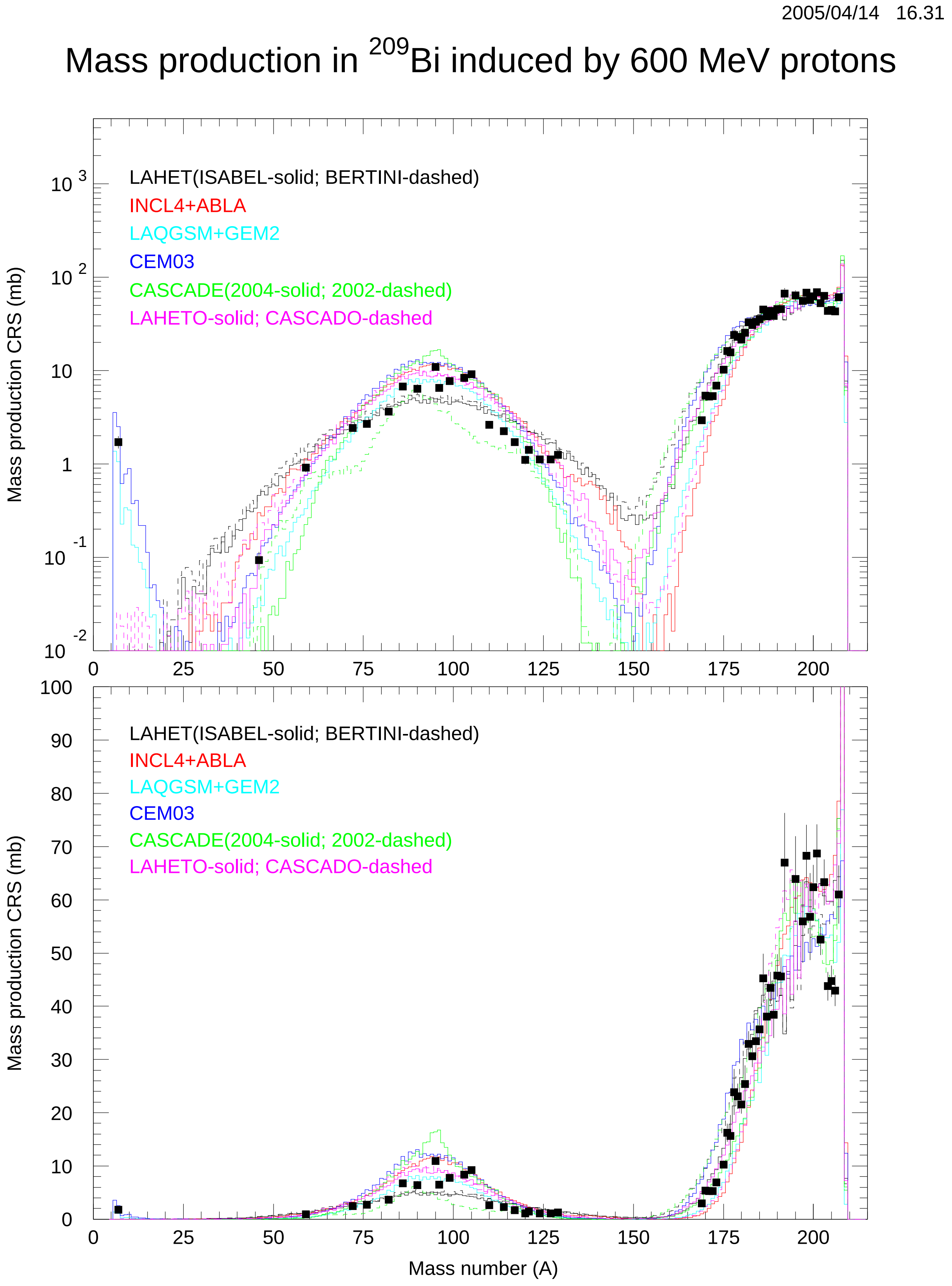


Fig. 118: The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{209}Bi irradiated with 0.6 GeV protons.

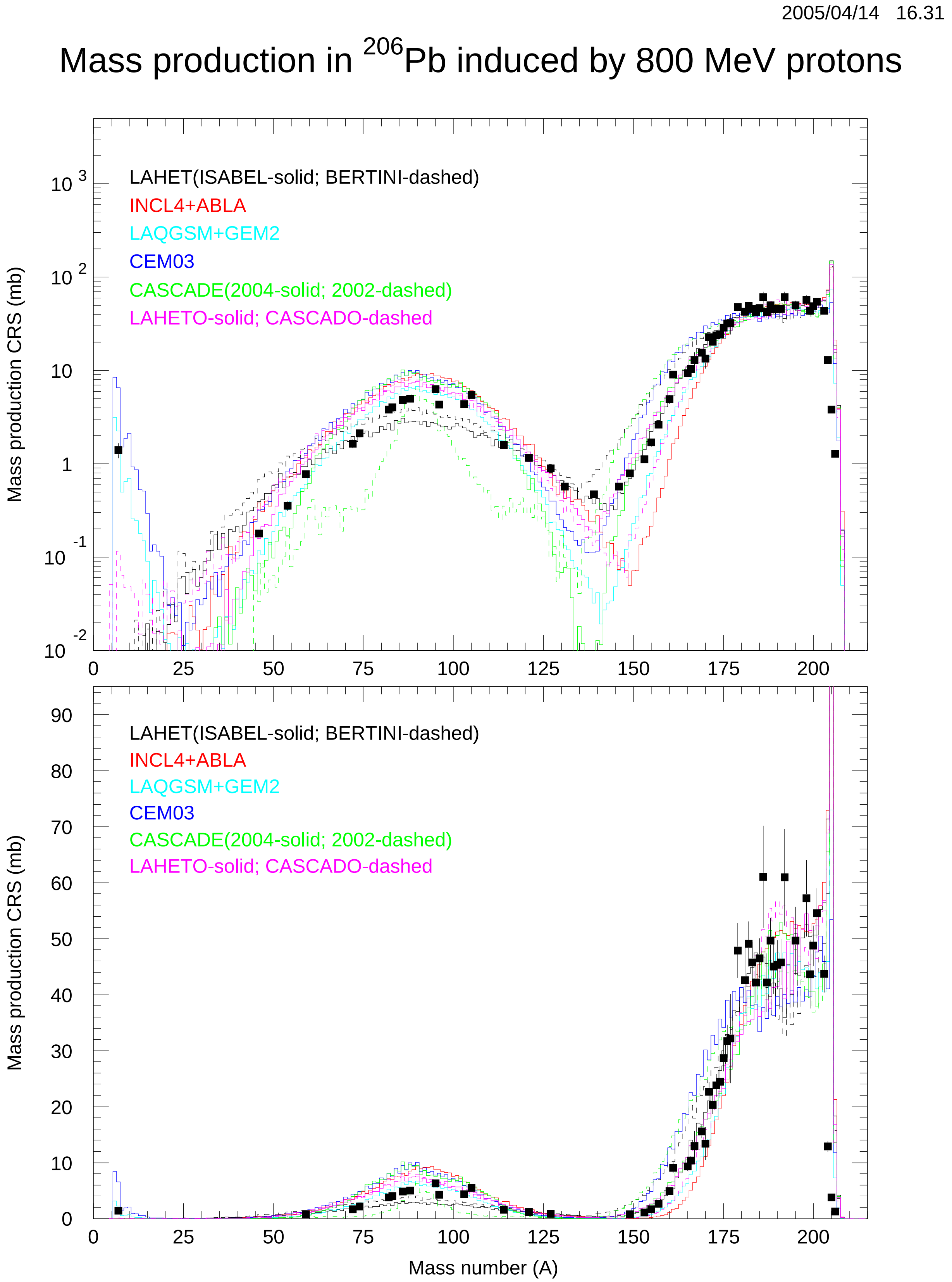


Fig. 119: The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{206}Pb irradiated with 0.8 GeV protons.

2005/04/14 16.31

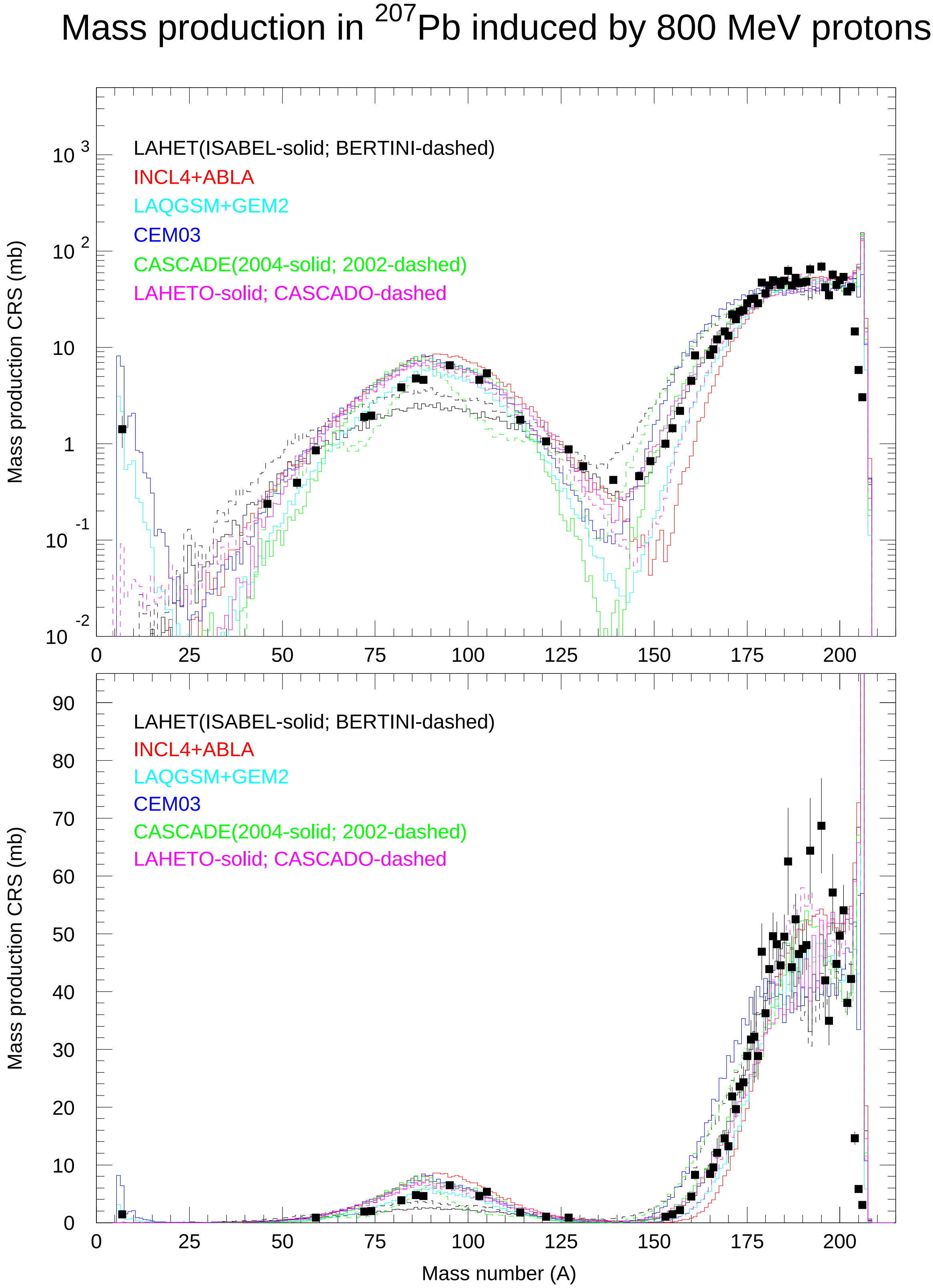


Fig. 120: The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{207}Pb irradiated with 0.8 GeV protons.

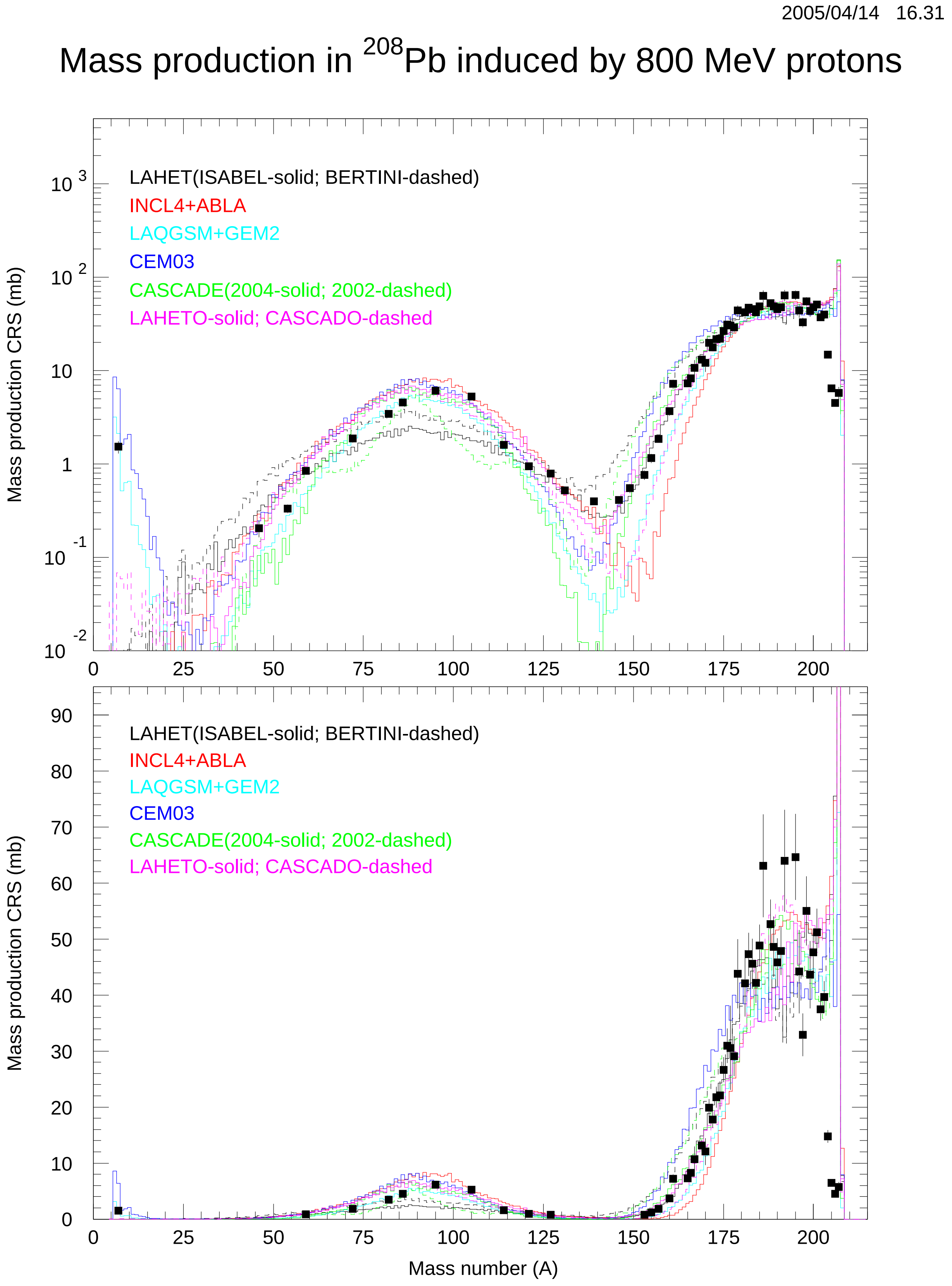


Fig. 121: The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{208}Pb irradiated with 0.8 GeV protons.

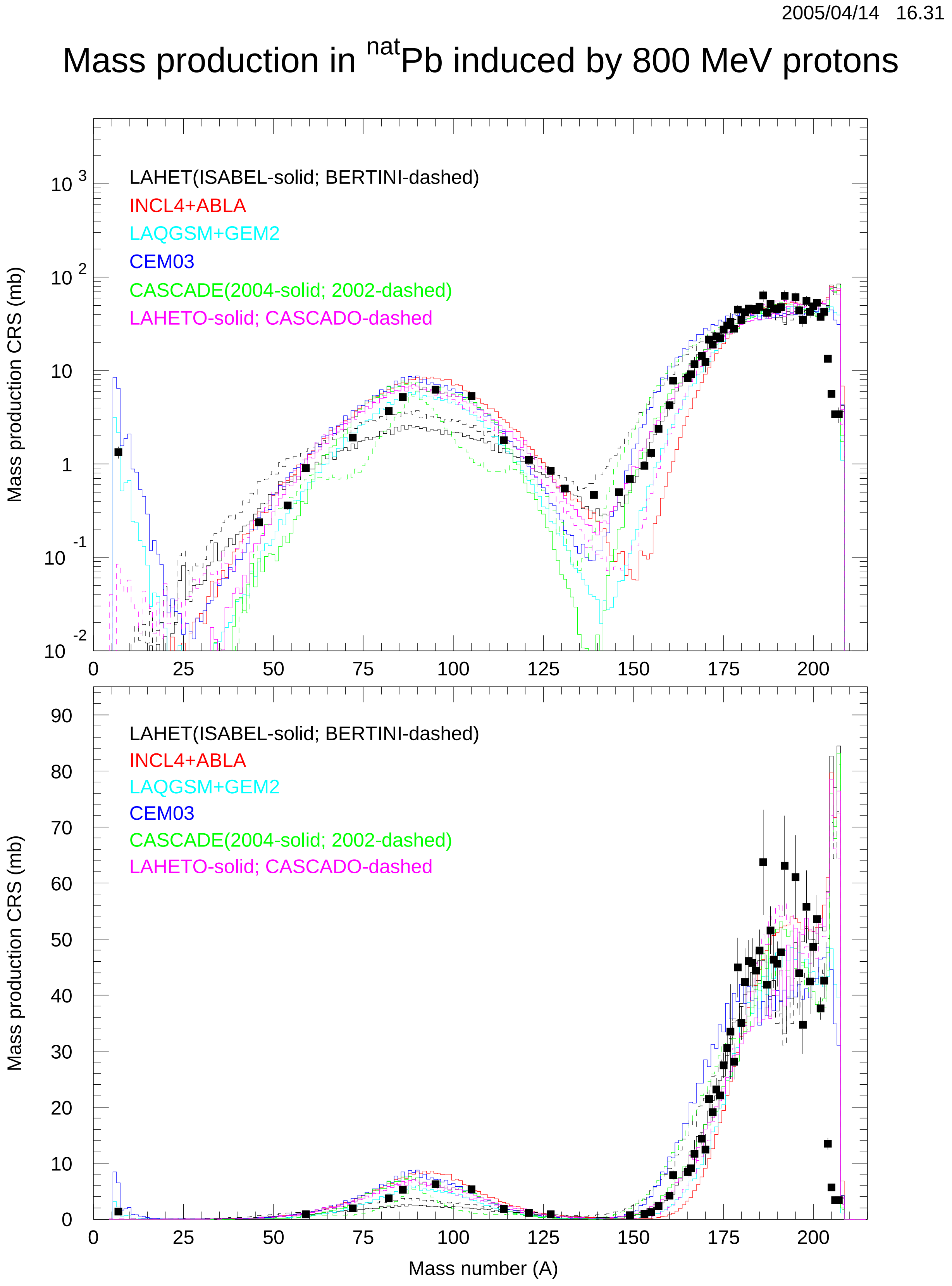


Fig. 122: The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{nat}Pb irradiated with 0.8 GeV protons.

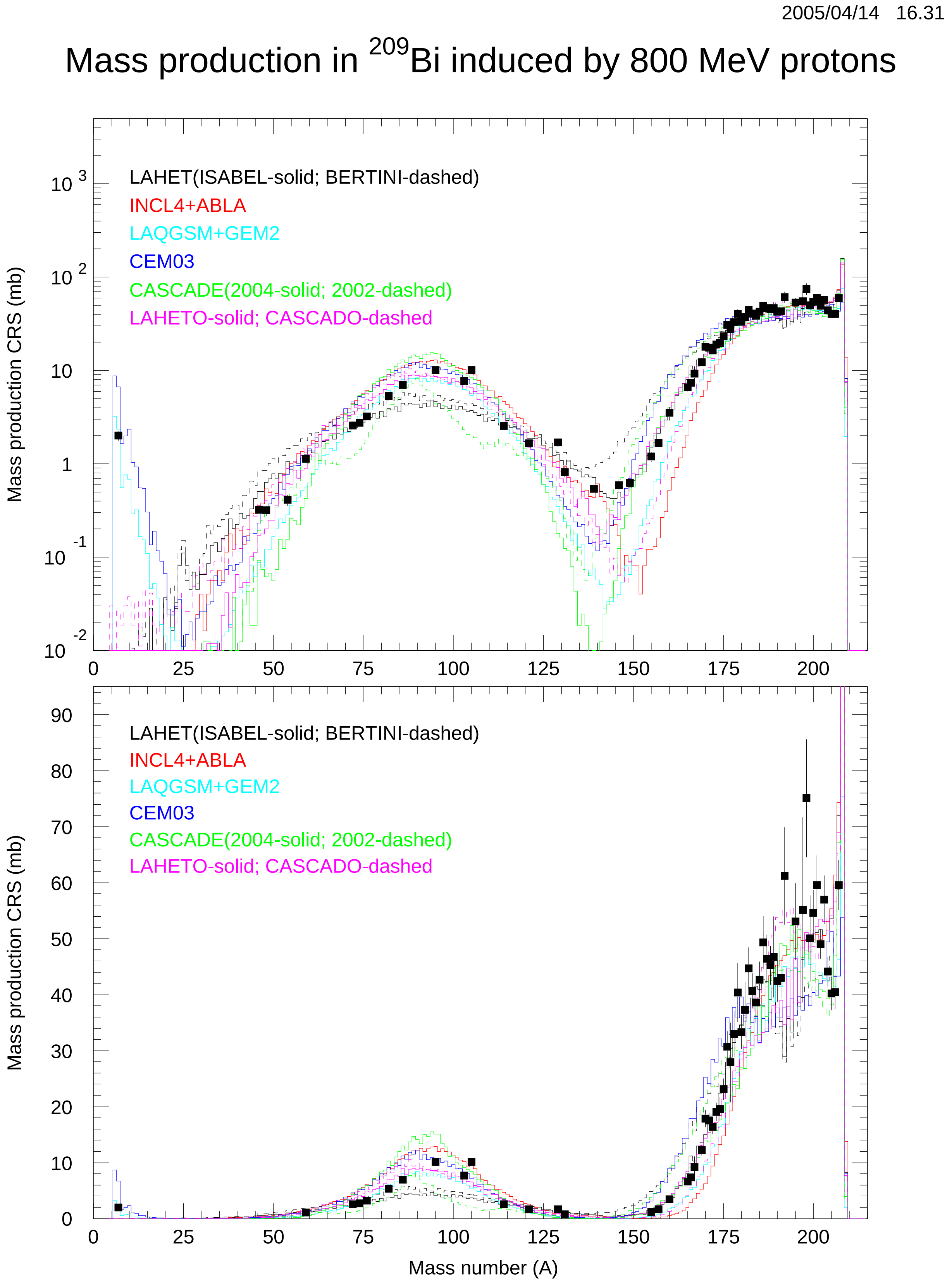


Fig. 123: The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{209}Bi irradiated with 0.8 GeV protons.

2005/04/14 16.31

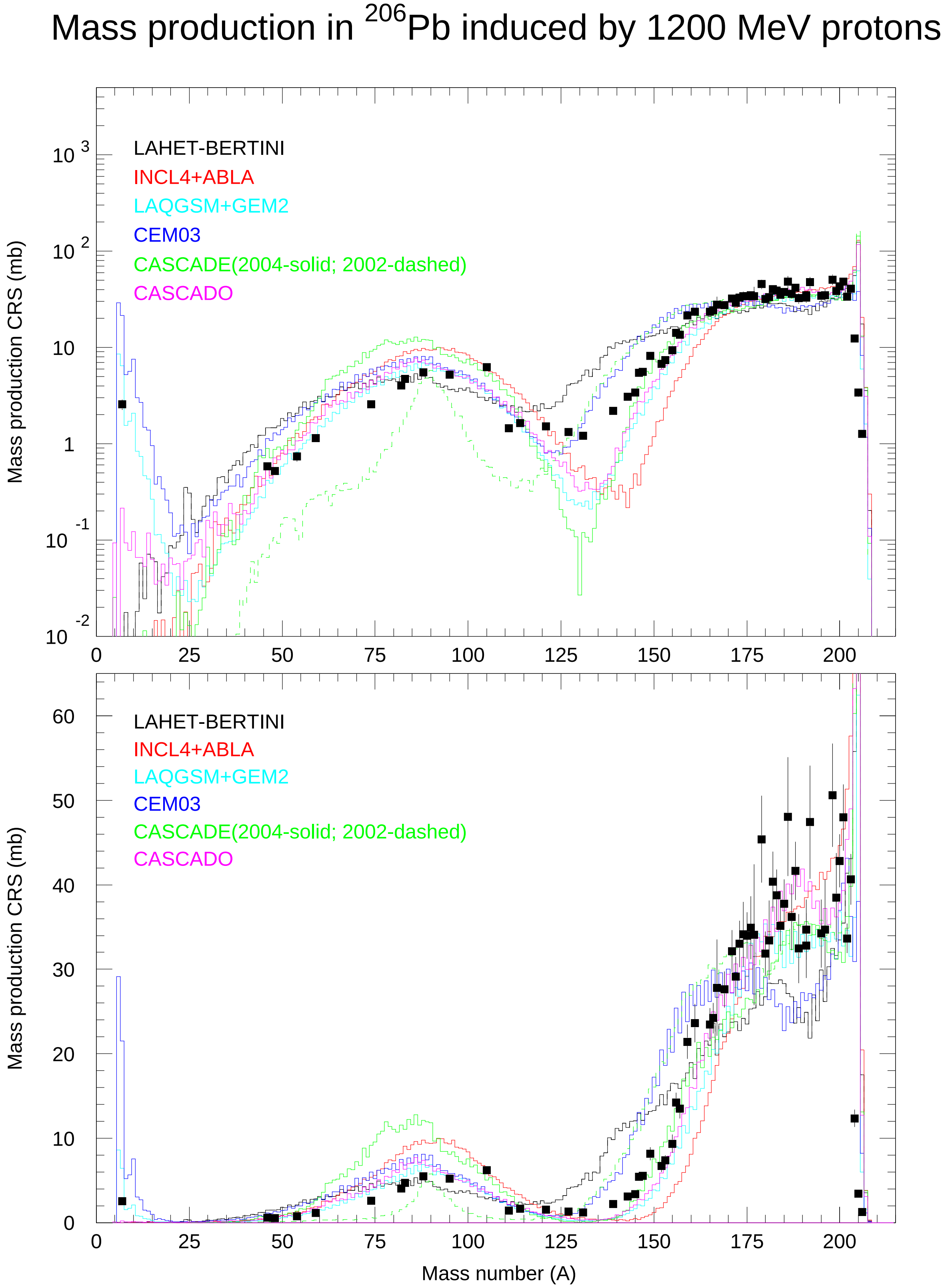


Fig. 124: The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{206}Pb irradiated with 1.2 GeV protons.

2005/04/14 16.31

Mass production in ^{207}Pb induced by 1200 MeV protons

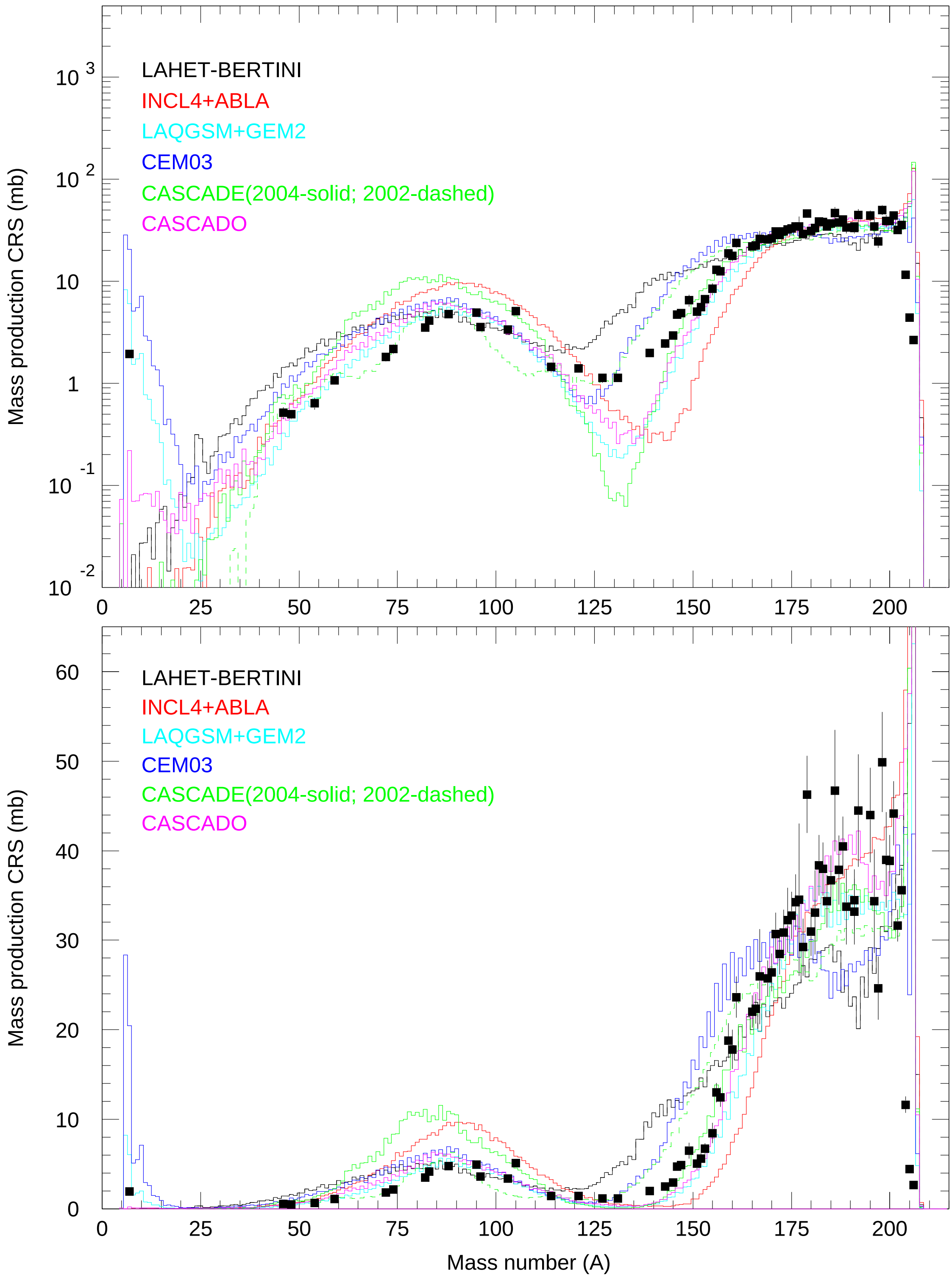


Fig. 125: The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{207}Pb irradiated with 1.2 GeV protons.

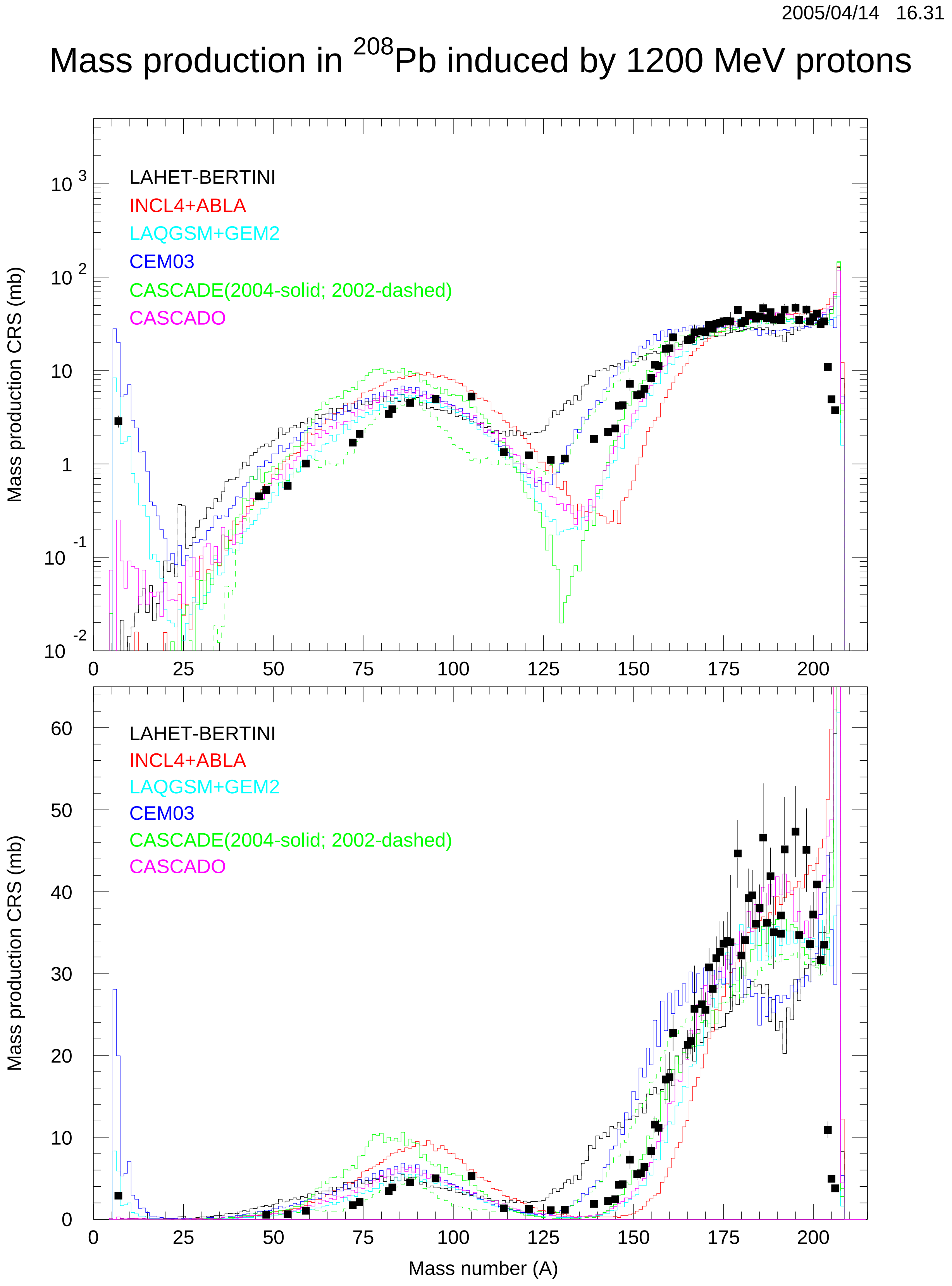


Fig. 126: The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{208}Pb irradiated with 1.2 GeV protons.

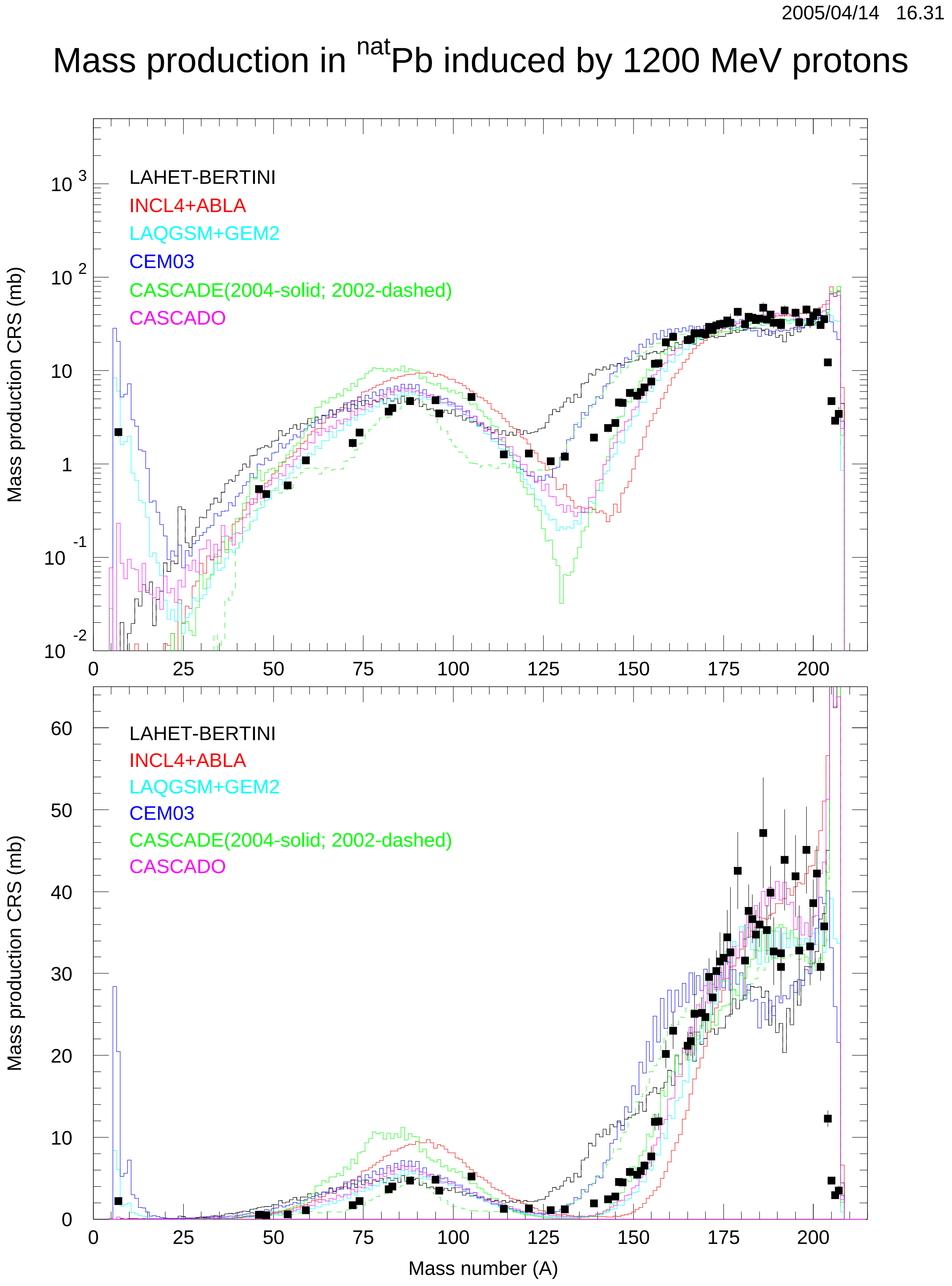


Fig. 127: The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{nat}Pb irradiated with 1.2 GeV protons.

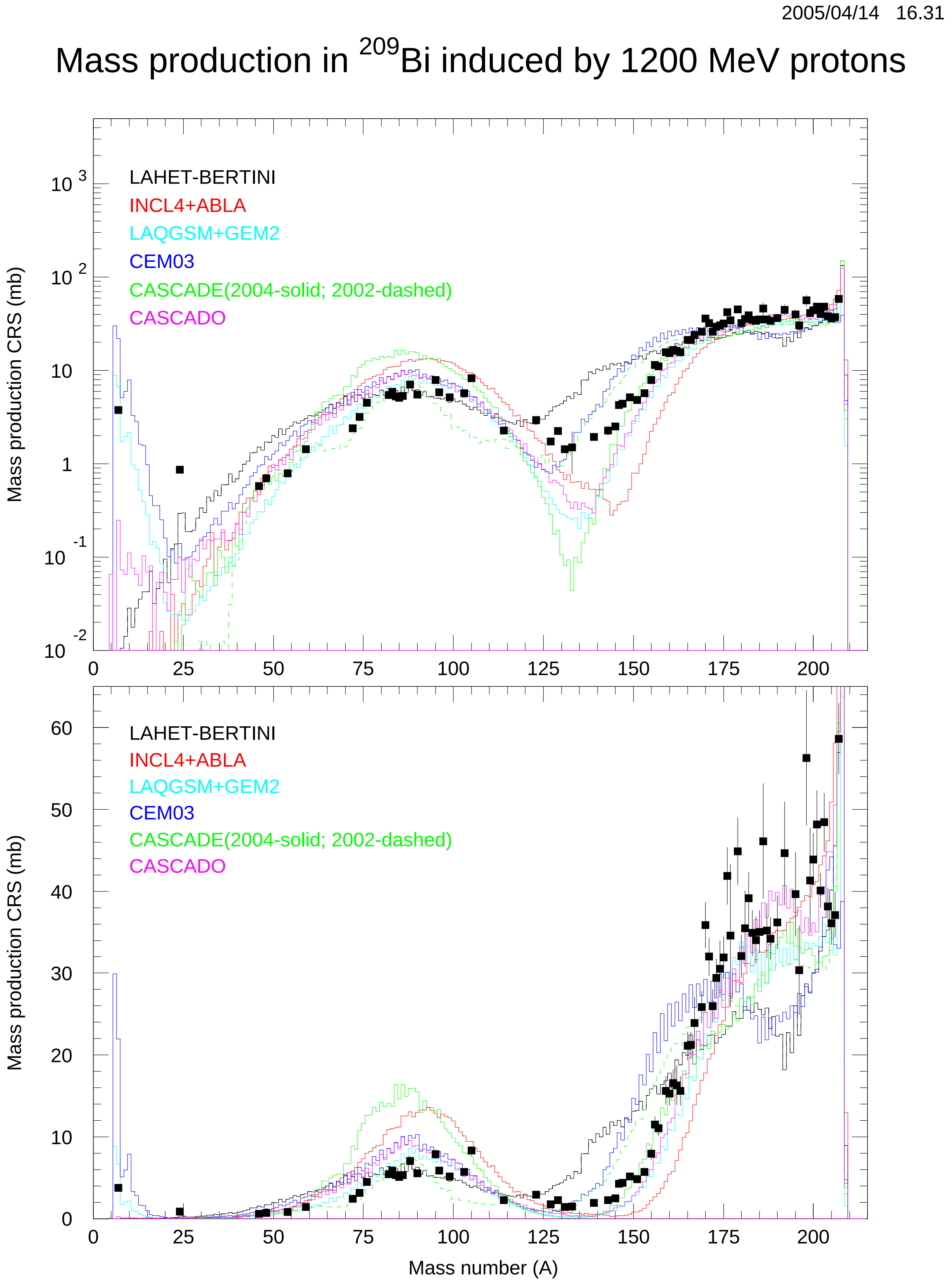


Fig. 128: The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{209}Bi irradiated with 1.2 GeV protons.

2005/04/14 16.31

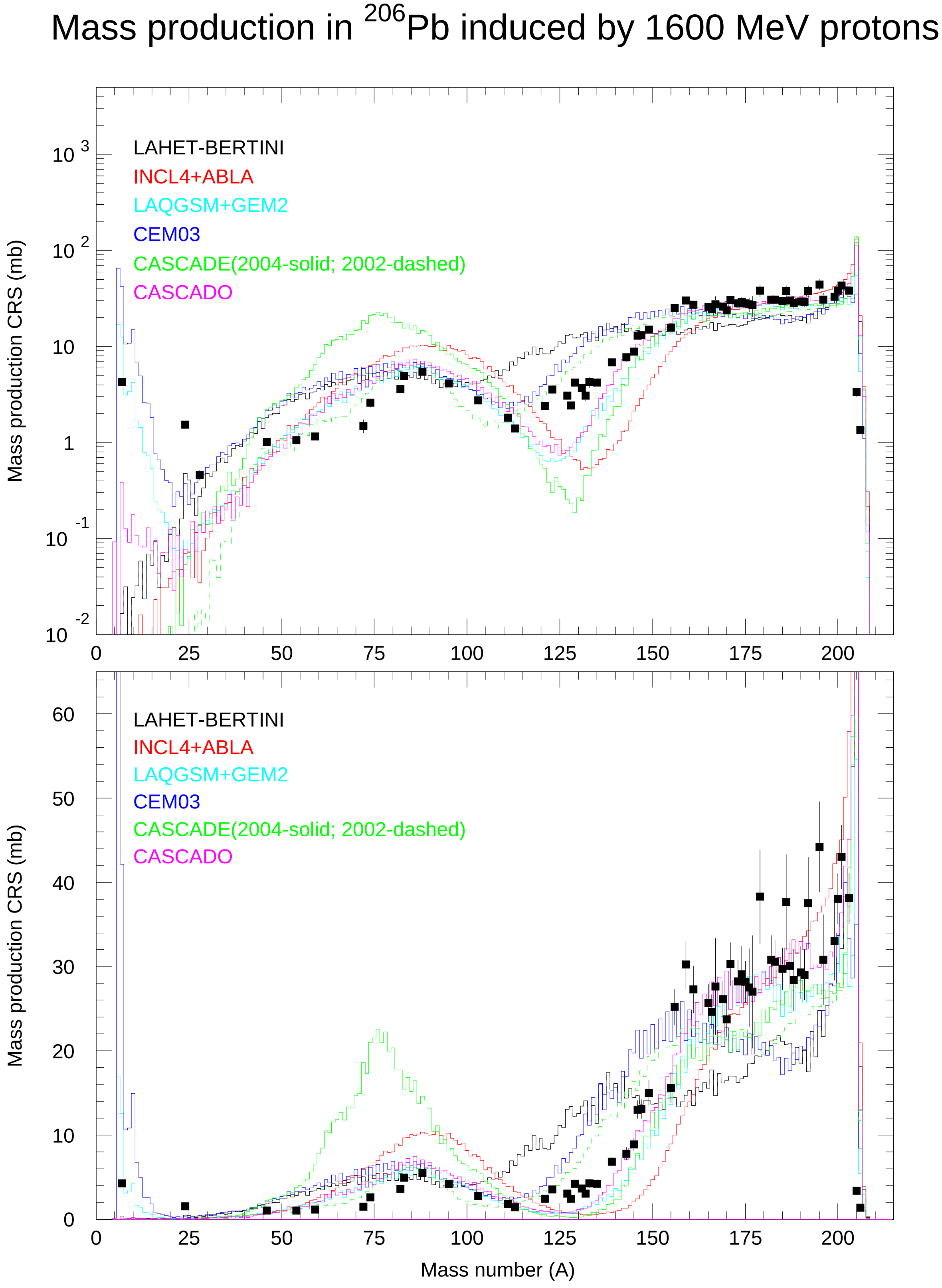


Fig. 129: The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{206}Pb irradiated with 1.6 GeV protons.

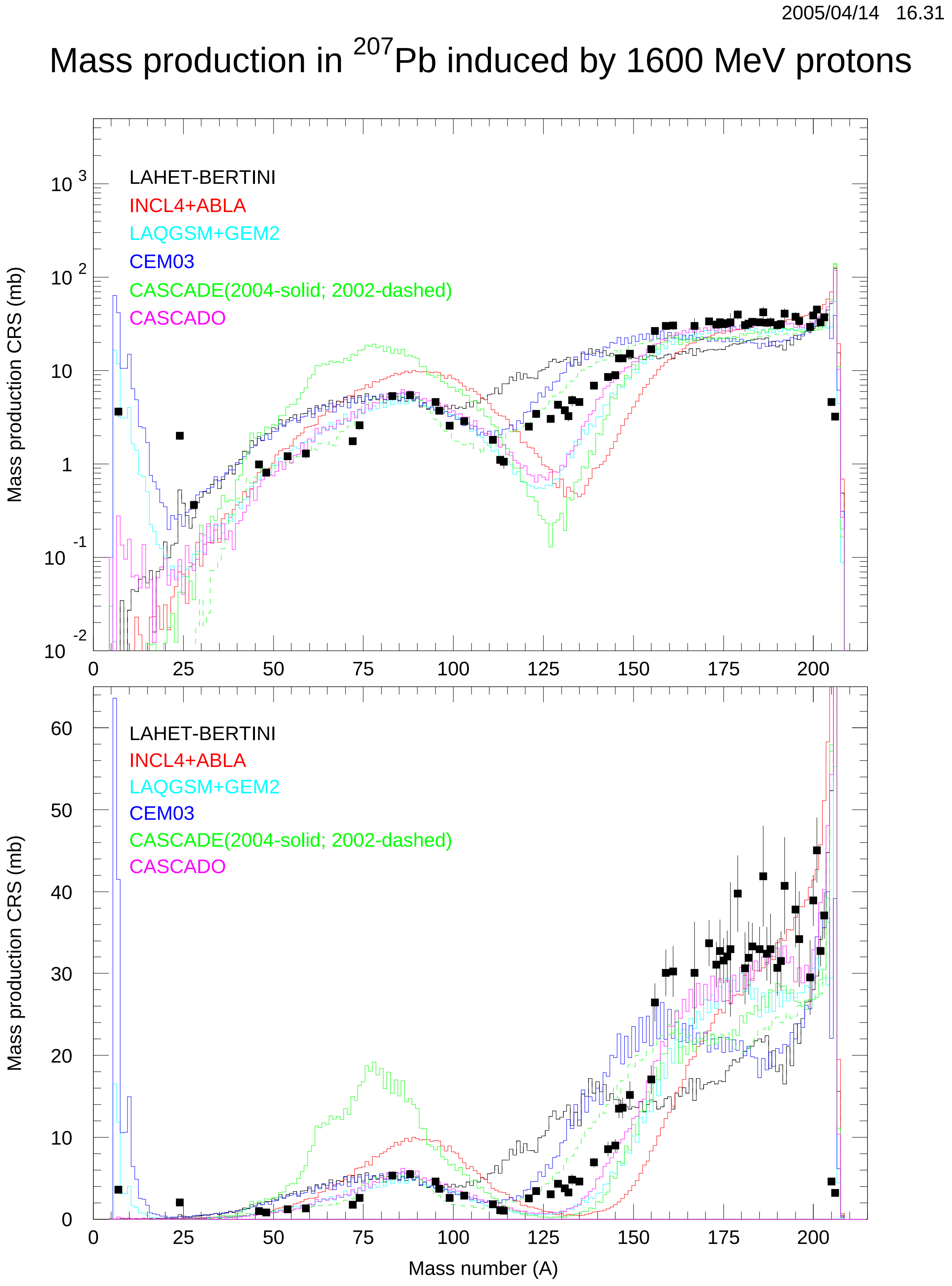


Fig. 130: The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{207}Pb irradiated with 1.6 GeV protons.

2005/04/14 16.31

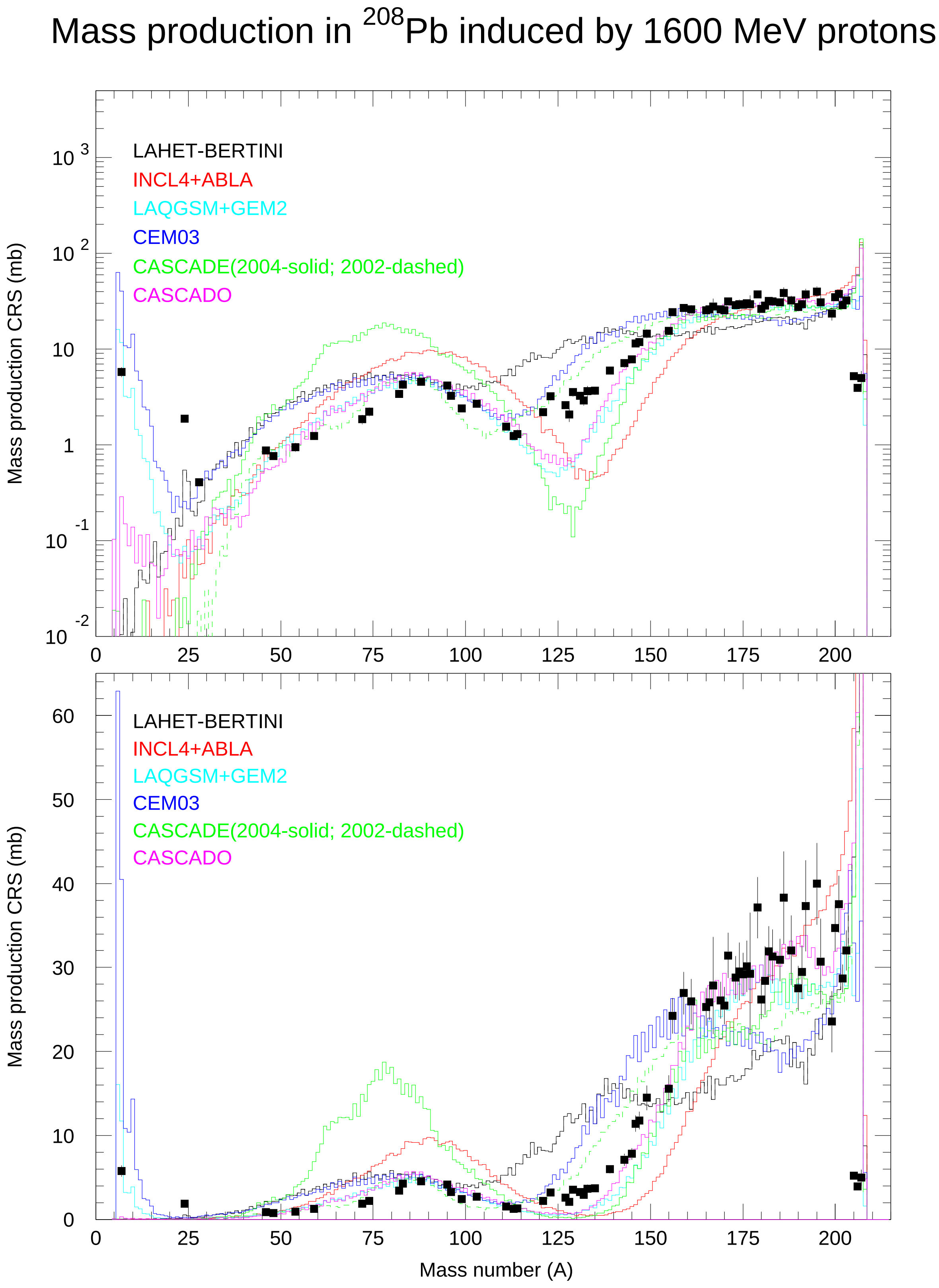


Fig. 131: The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{208}Pb irradiated with 1.6 GeV protons.

2005/04/14 16.31

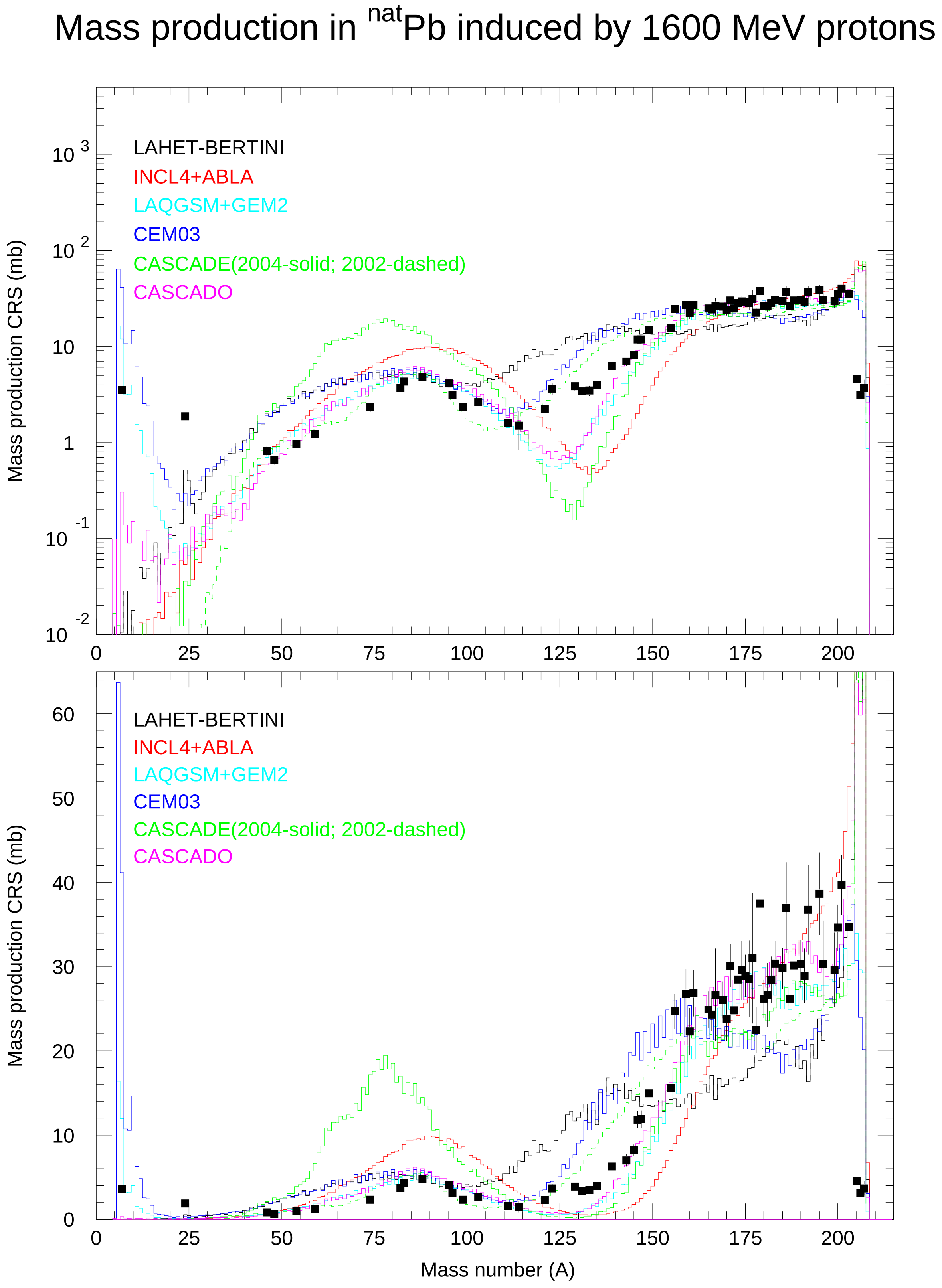


Fig. 132: The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{nat}Pb irradiated with 1.6 GeV protons.

2005/04/14 16.31

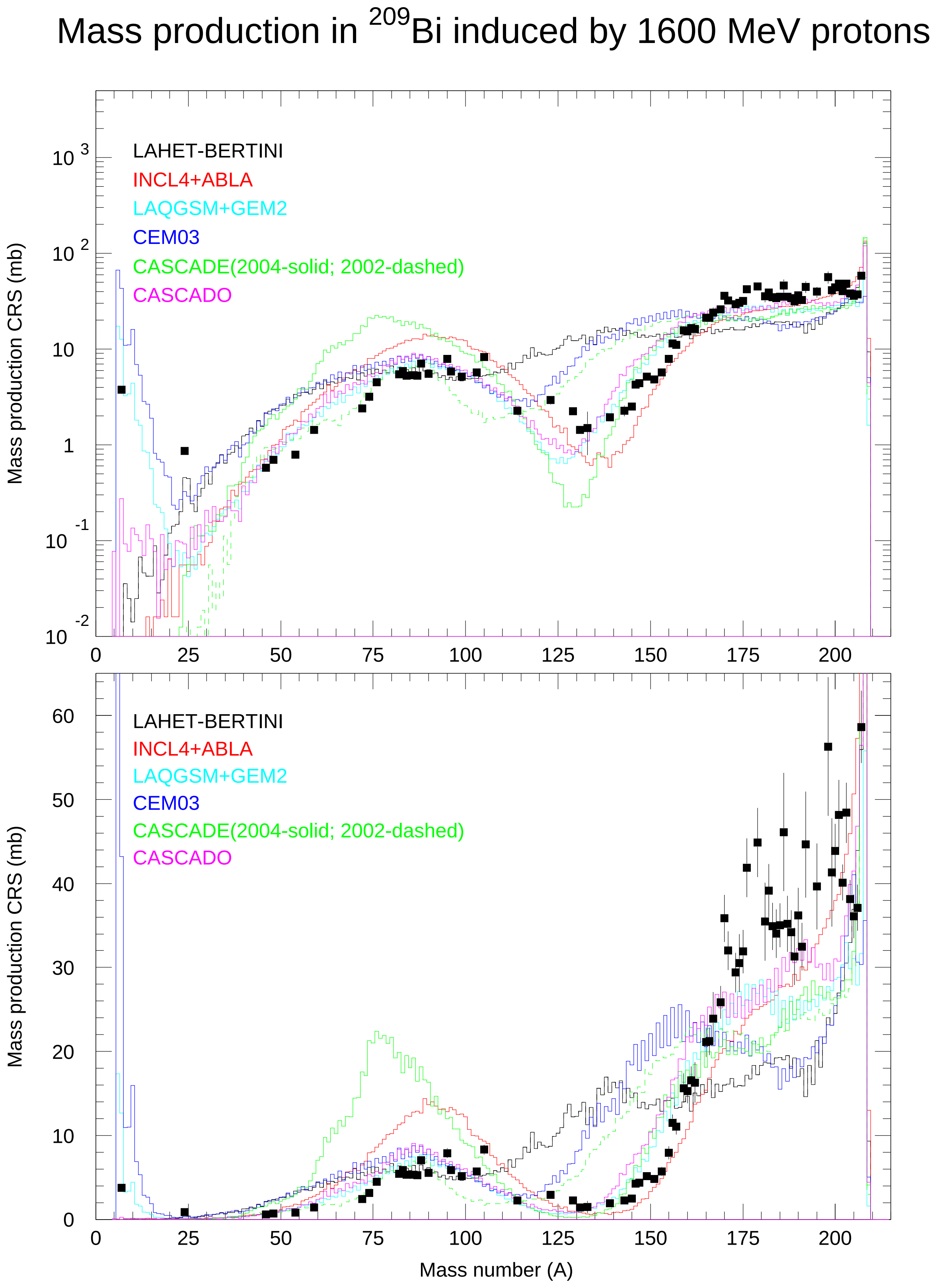


Fig. 133: The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{209}Bi irradiated with 1.6 GeV protons.

2005/04/14 16.31

Mass production in ^{206}Pb induced by 2600 MeV protons

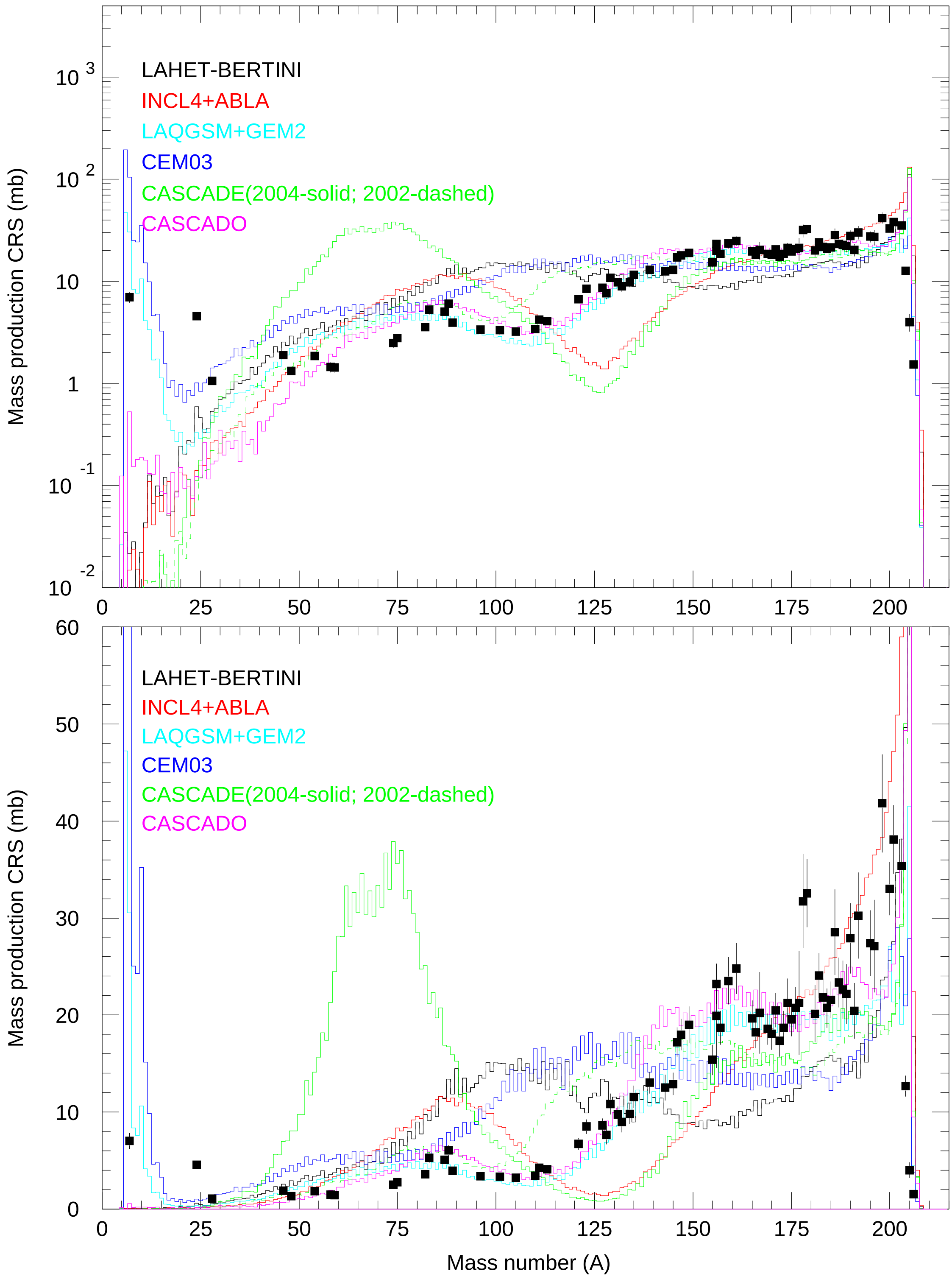


Fig. 134: The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{206}Pb irradiated with 2.6 GeV protons.

2005/04/14 16.31

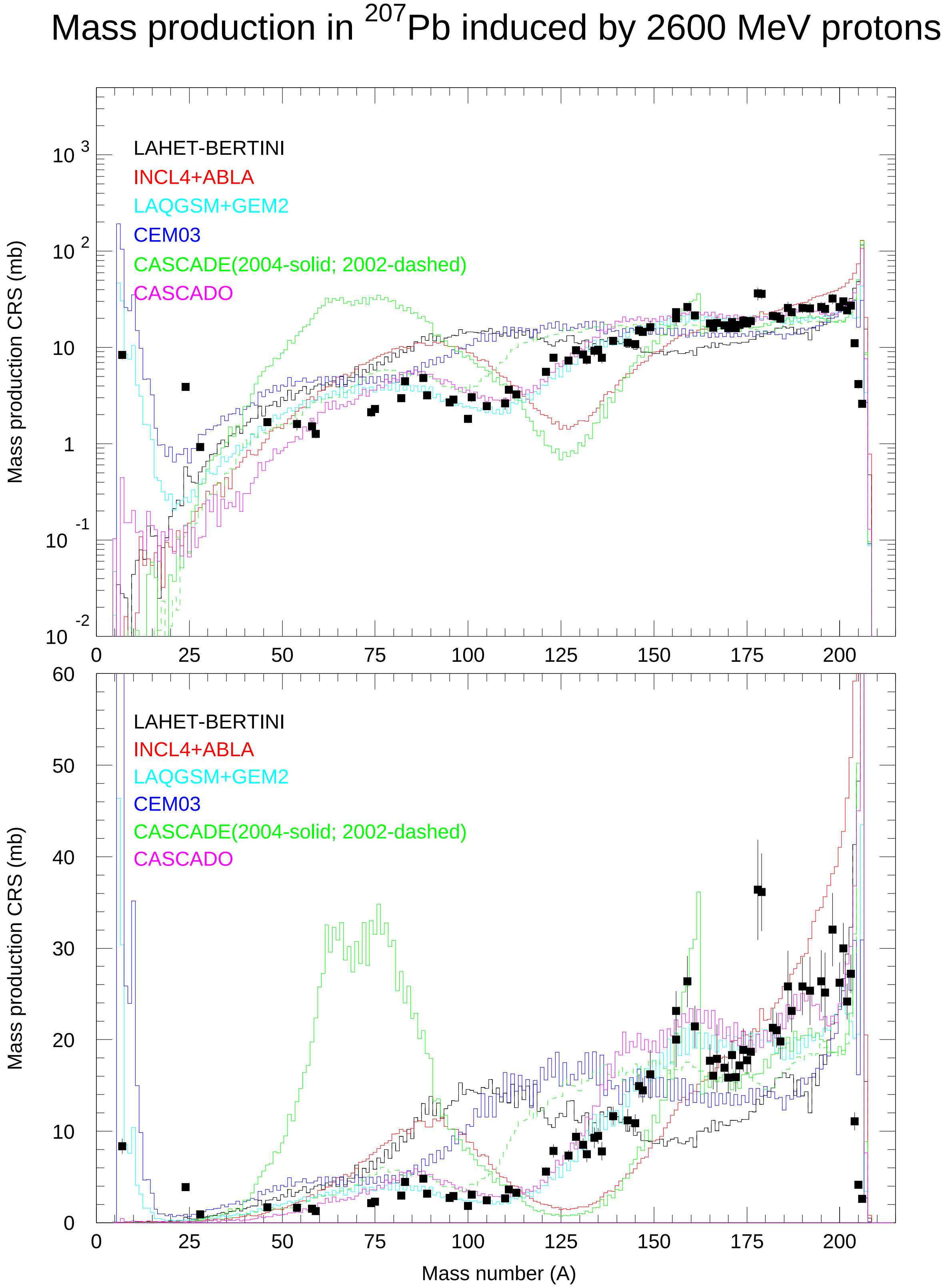


Fig. 135: The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{207}Pb irradiated with 2.6 GeV protons.

2005/04/14 16.31

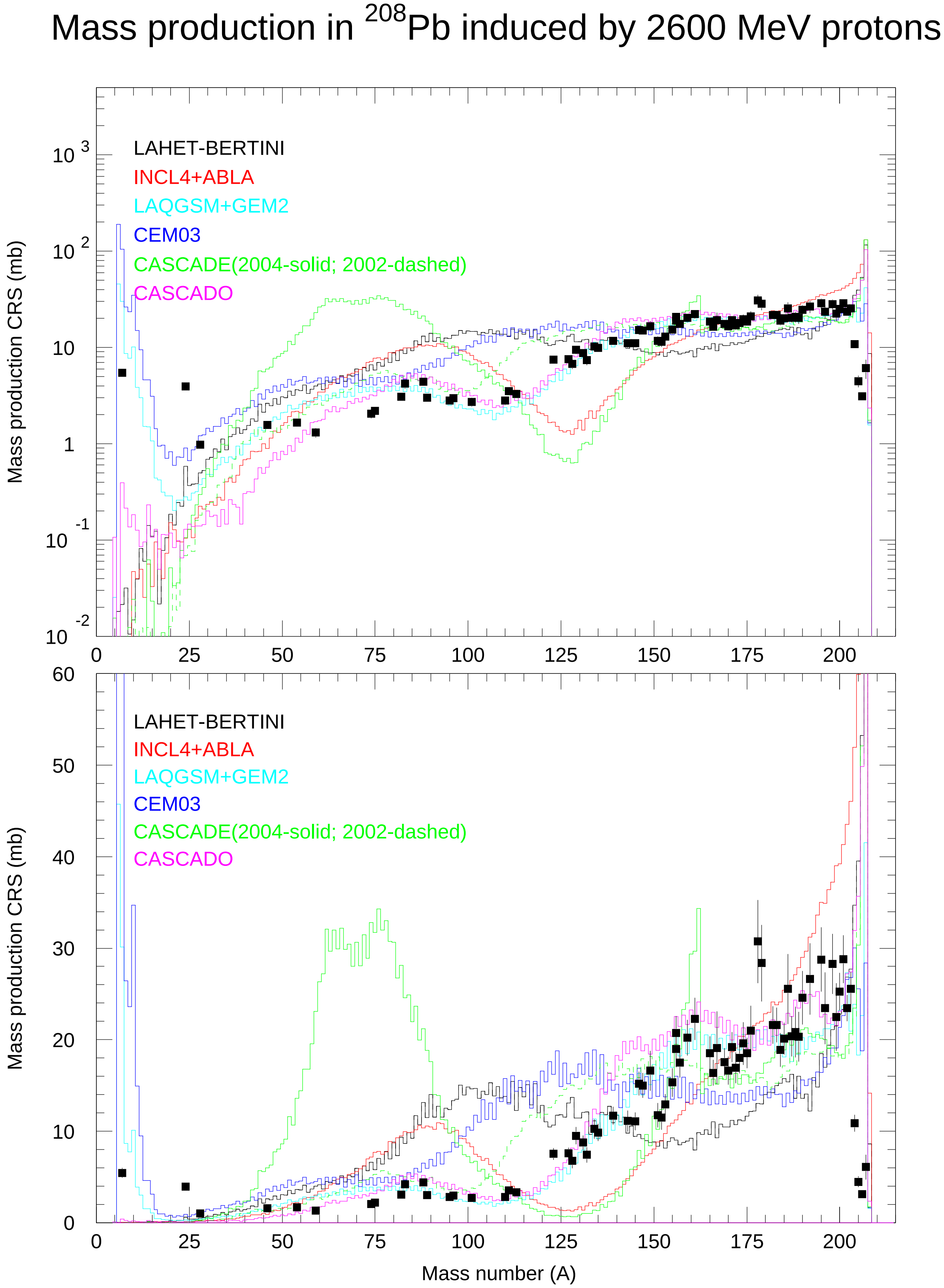


Fig. 136: The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{208}Pb irradiated with 2.6 GeV protons.

2005/04/14 16.31

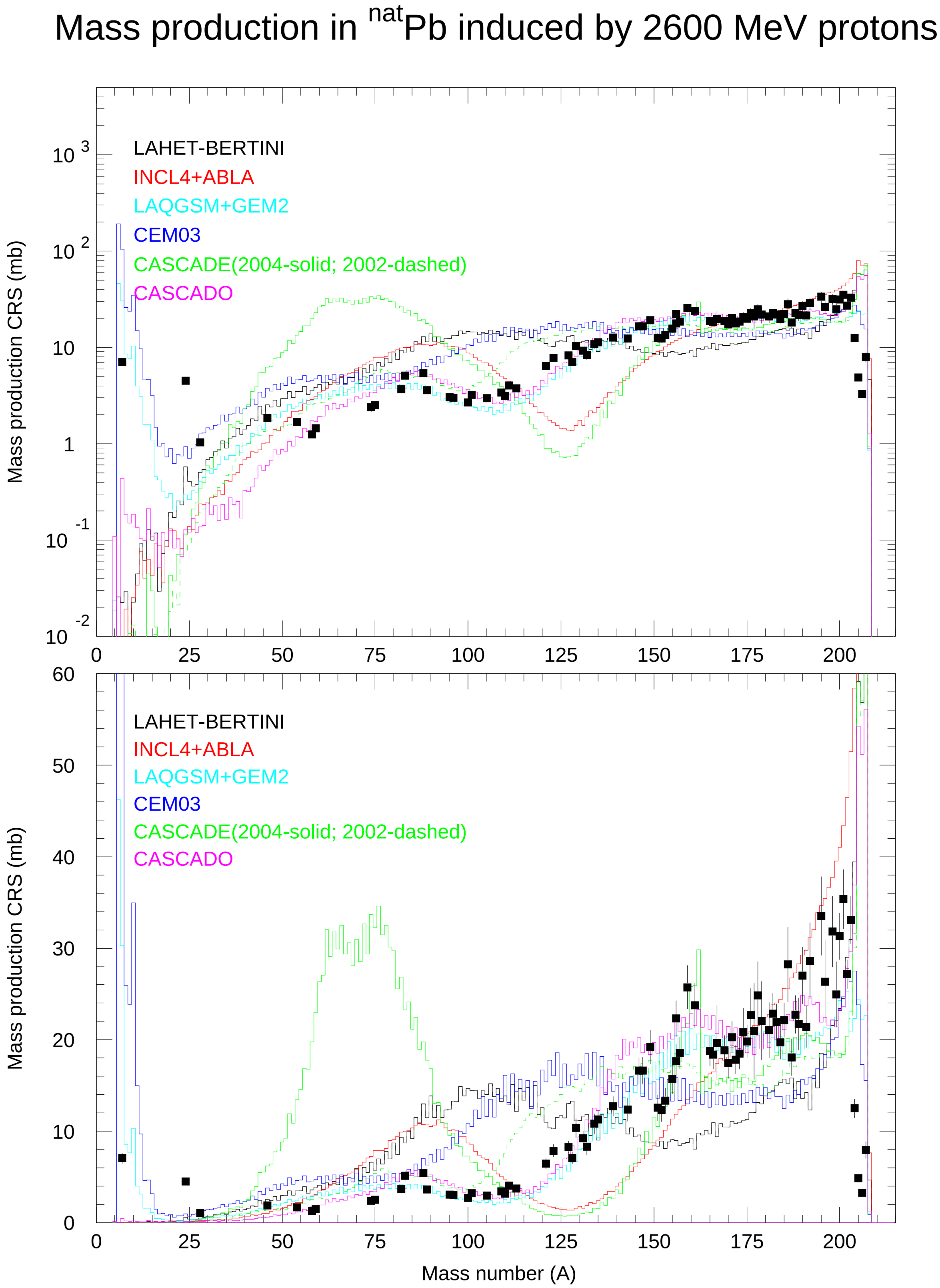


Fig. 137: The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{nat}Pb irradiated with 2.6 GeV protons.

2005/04/14 16.31

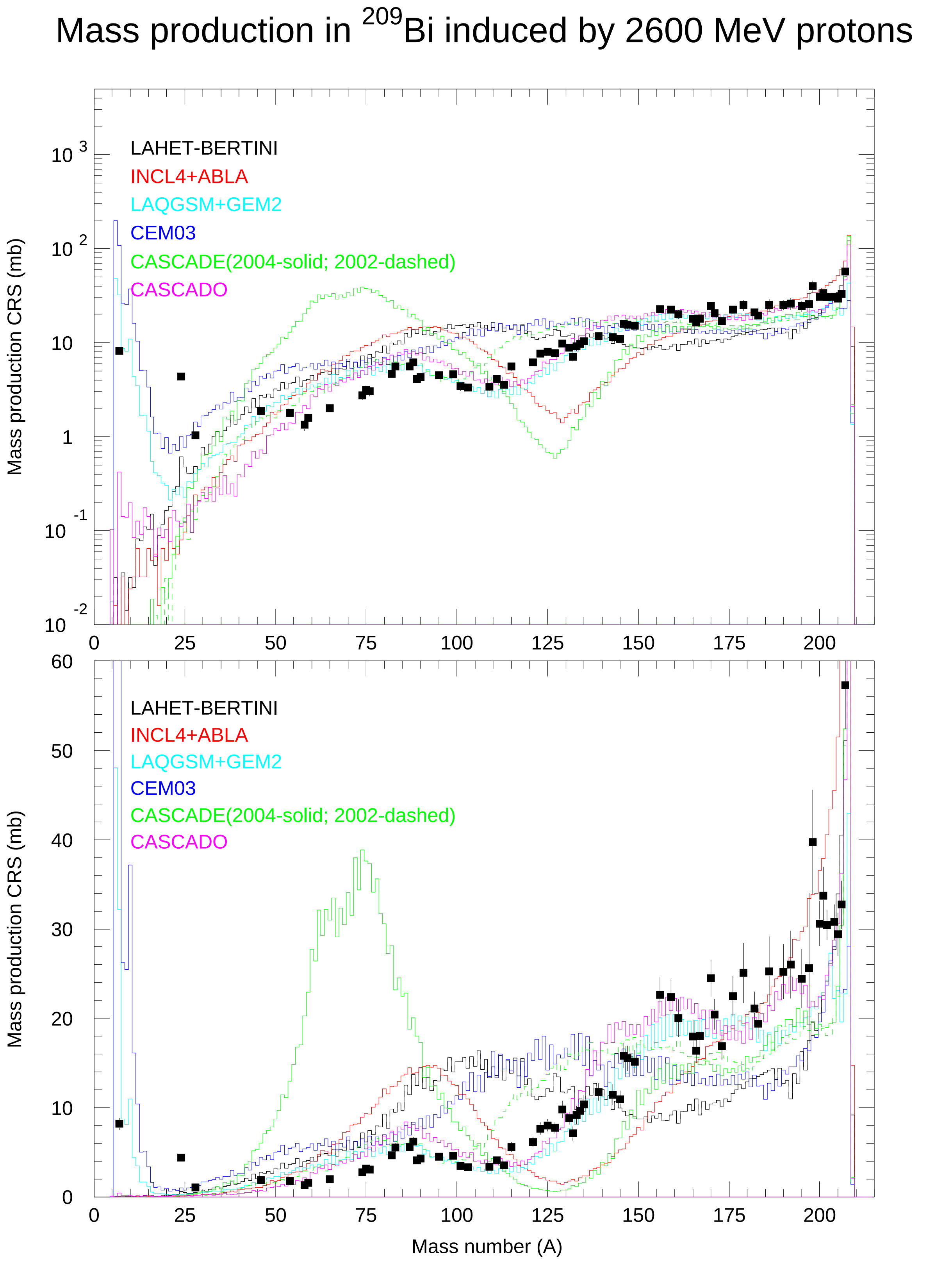


Fig. 138: The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{209}Bi irradiated with 2.6 GeV protons.

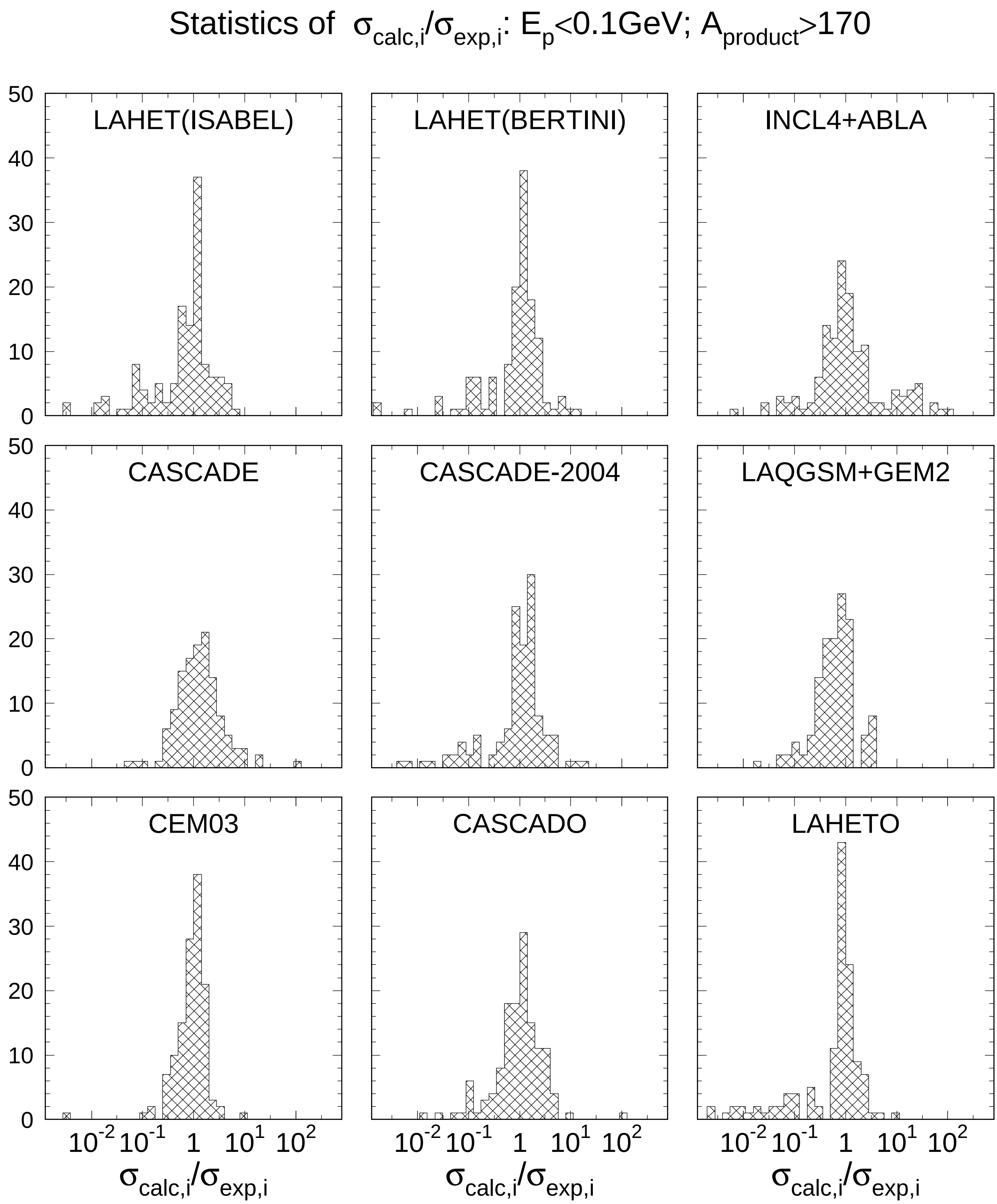


Fig. 139: Statistics of the simulation-to-experiment ratios for shallow spallation products (A>170) at $E_p < 0.1$ GeV.

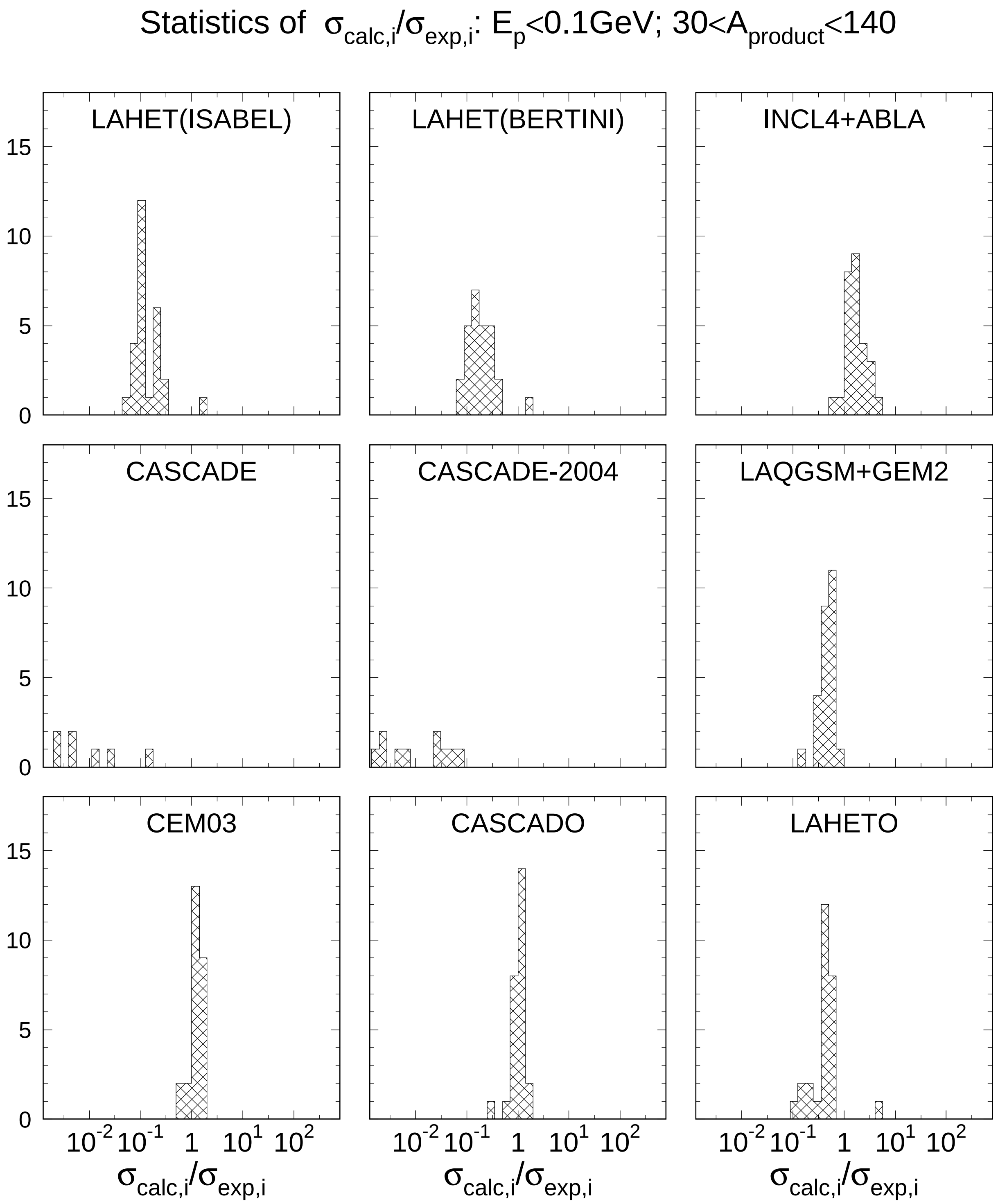


Fig. 140: Statistics of the simulation-to-experiment ratios for fission products (30<A<140) at $E_p < 0.1$ GeV.

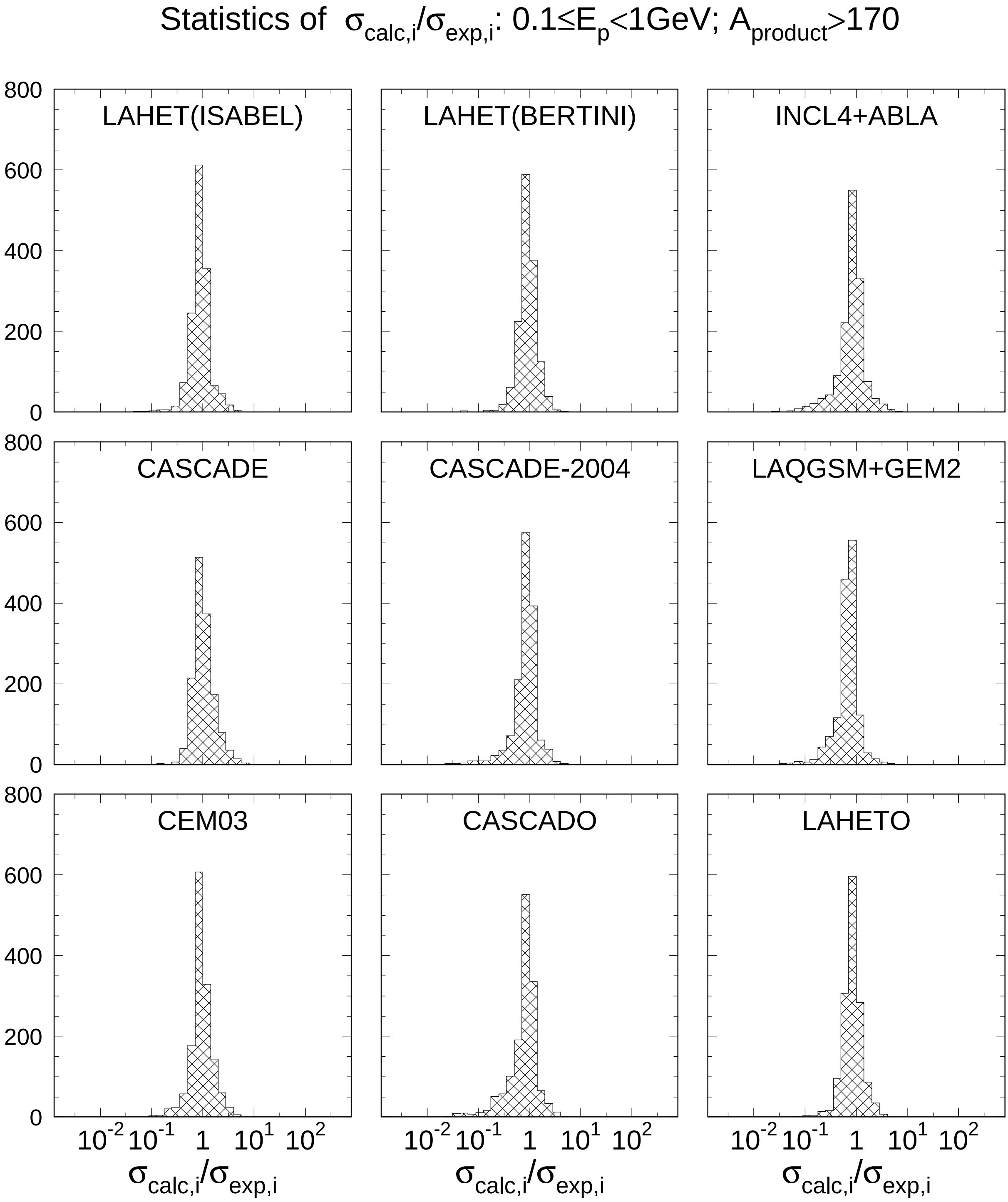


Fig. 141: Statistics of the simulation-to-experiment ratios for shallow spallation products (A>170) at 0.1 GeV $\leq$ E_p < 1.0 GeV.

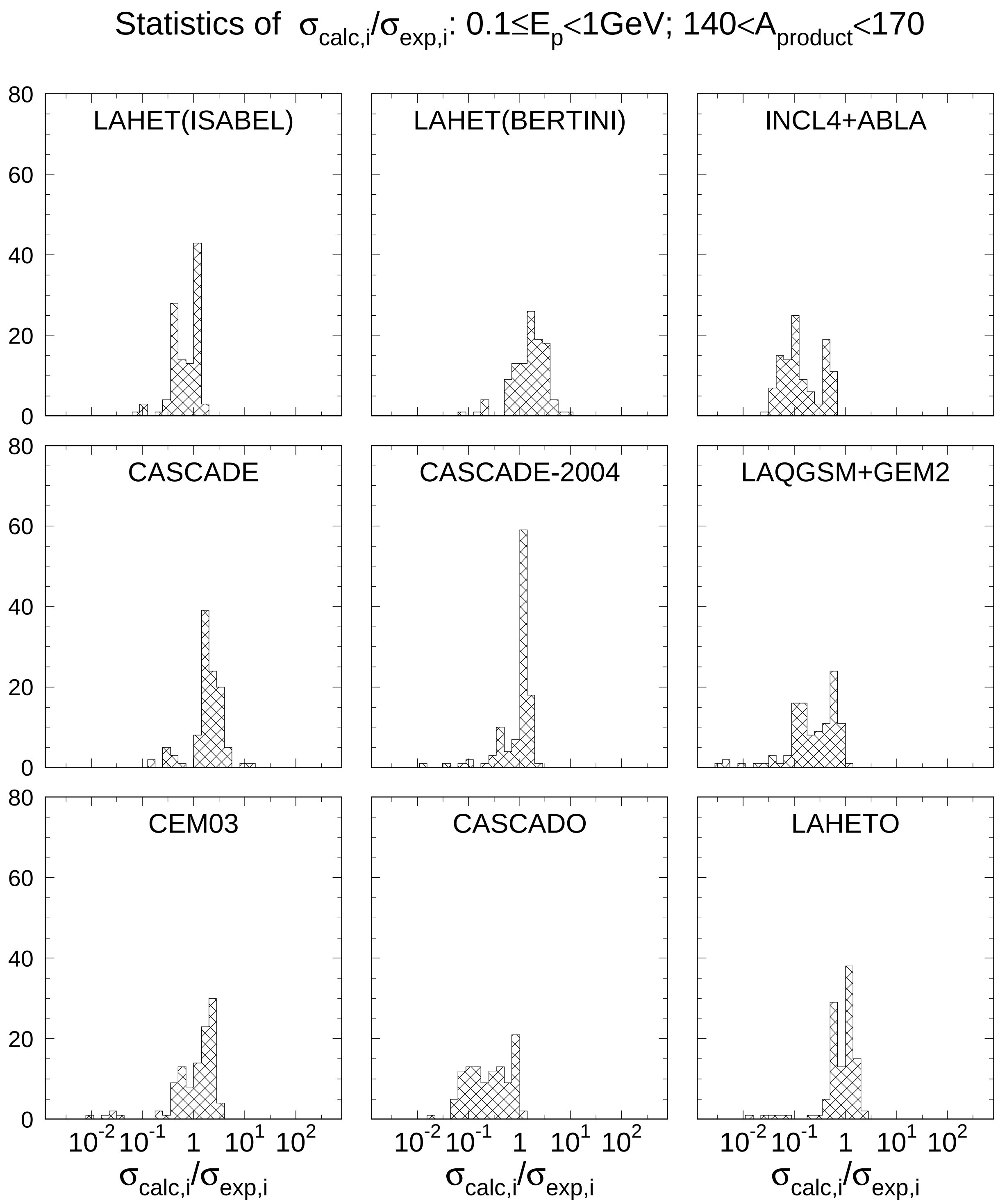


Fig. 142: Statistics of the simulation-to-experiment ratios for deep spallation products (140<A<170) at 0.1 GeV $\leq$ E_p < 1.0 GeV.

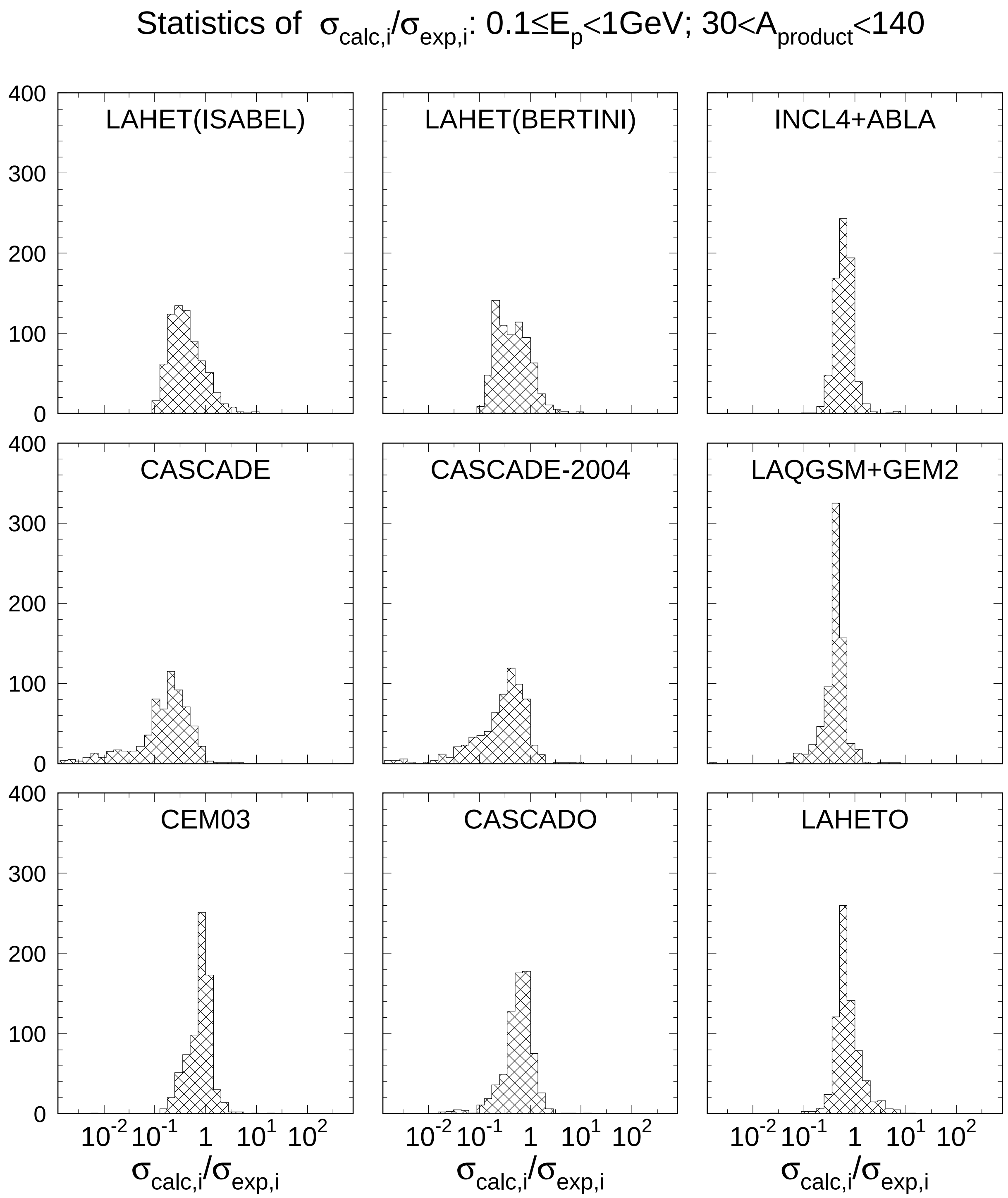


Fig. 143: Statistics of the simulation-to-experiment ratios for fission products (30<A<140) at 0.1 GeV $\leq$ E$_p$ < 1.0 GeV.

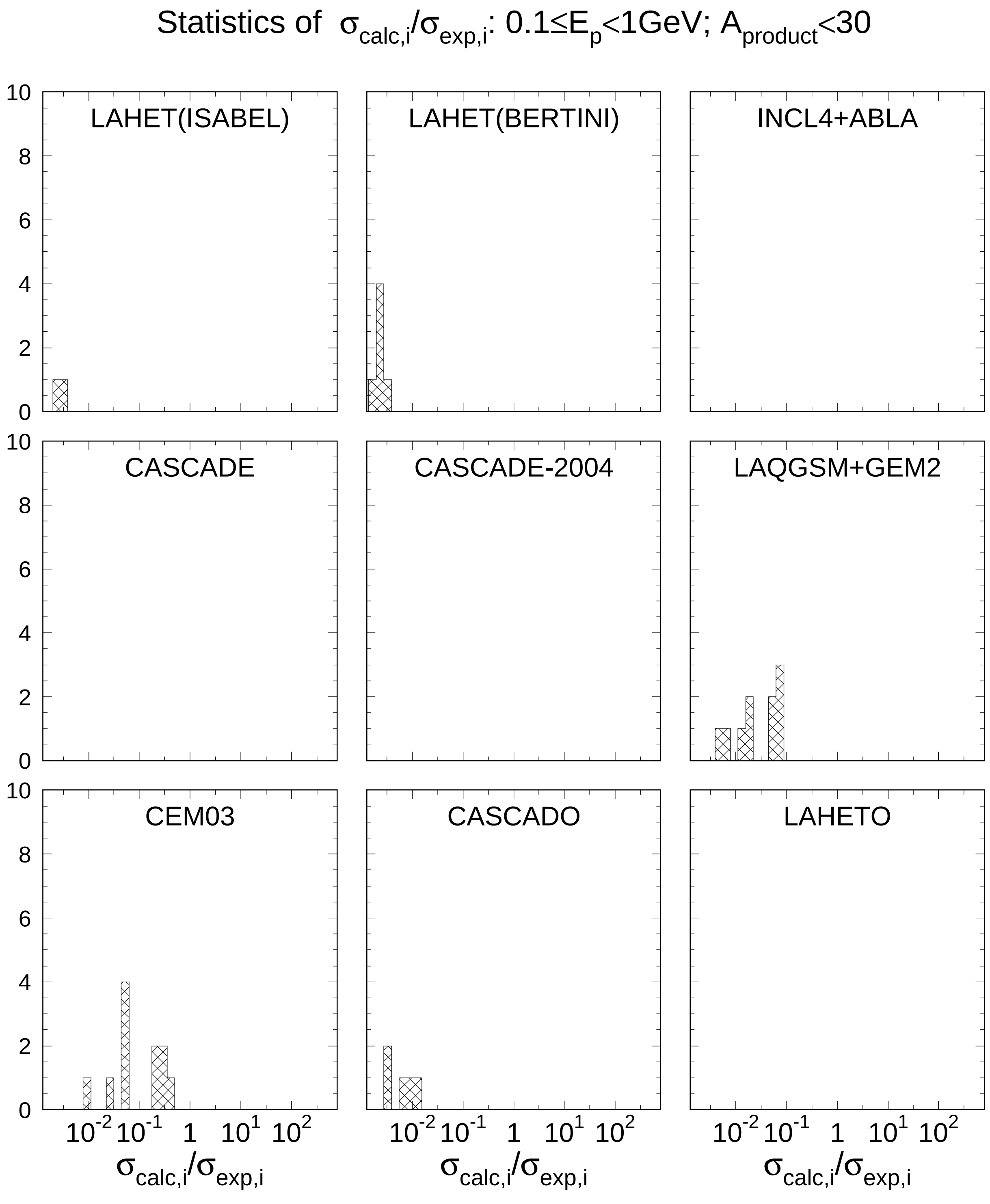


Fig. 144: Statistics of the simulation-to-experiment ratios for fragmentation products (A<30) at 0.1 GeV $\leq$ E_p < 1.0 GeV.

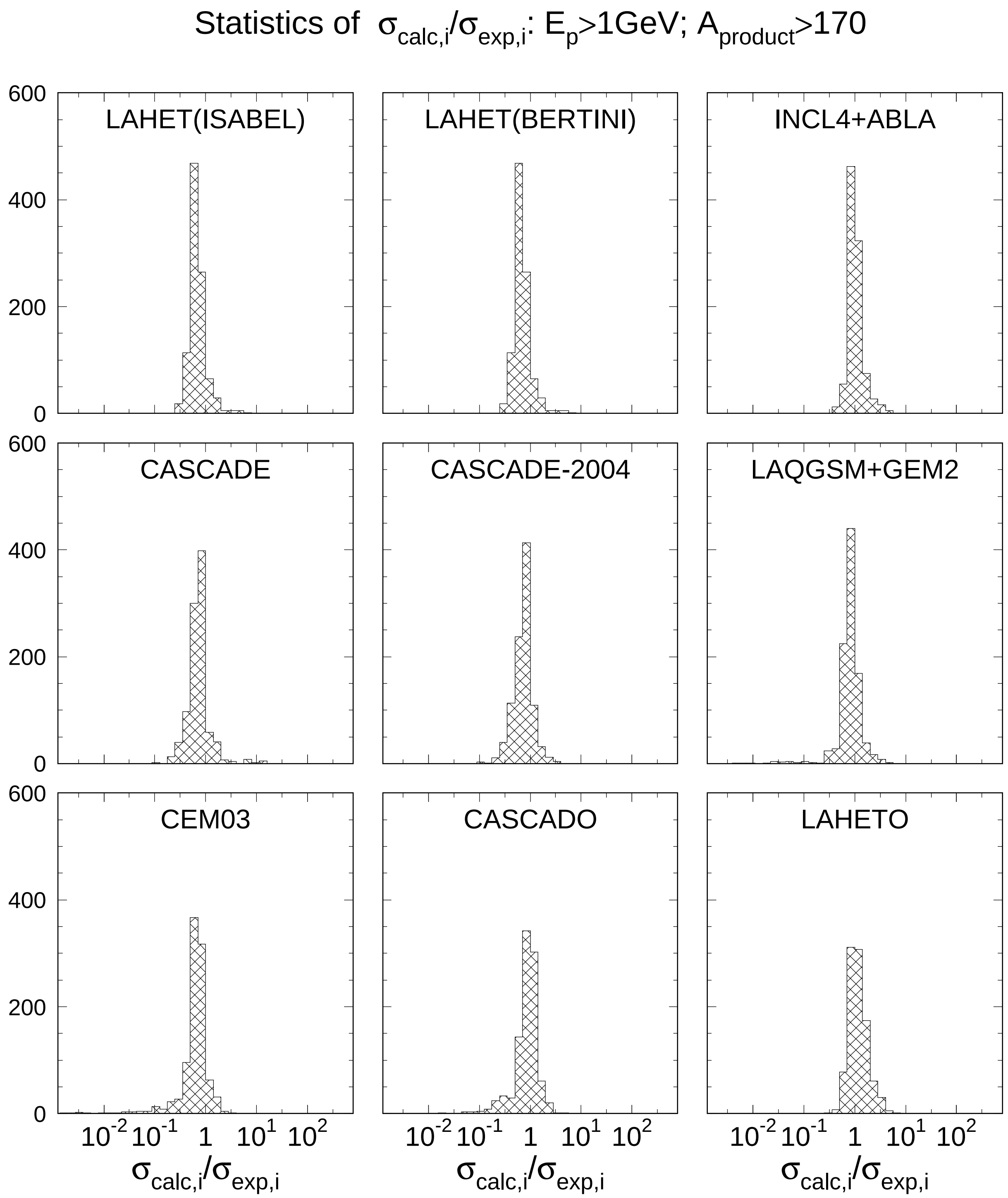


Fig. 145: Statistics of the simulation-to-experiment ratios for shallow spallation products (A>170) at E_p > 1.0 GeV.

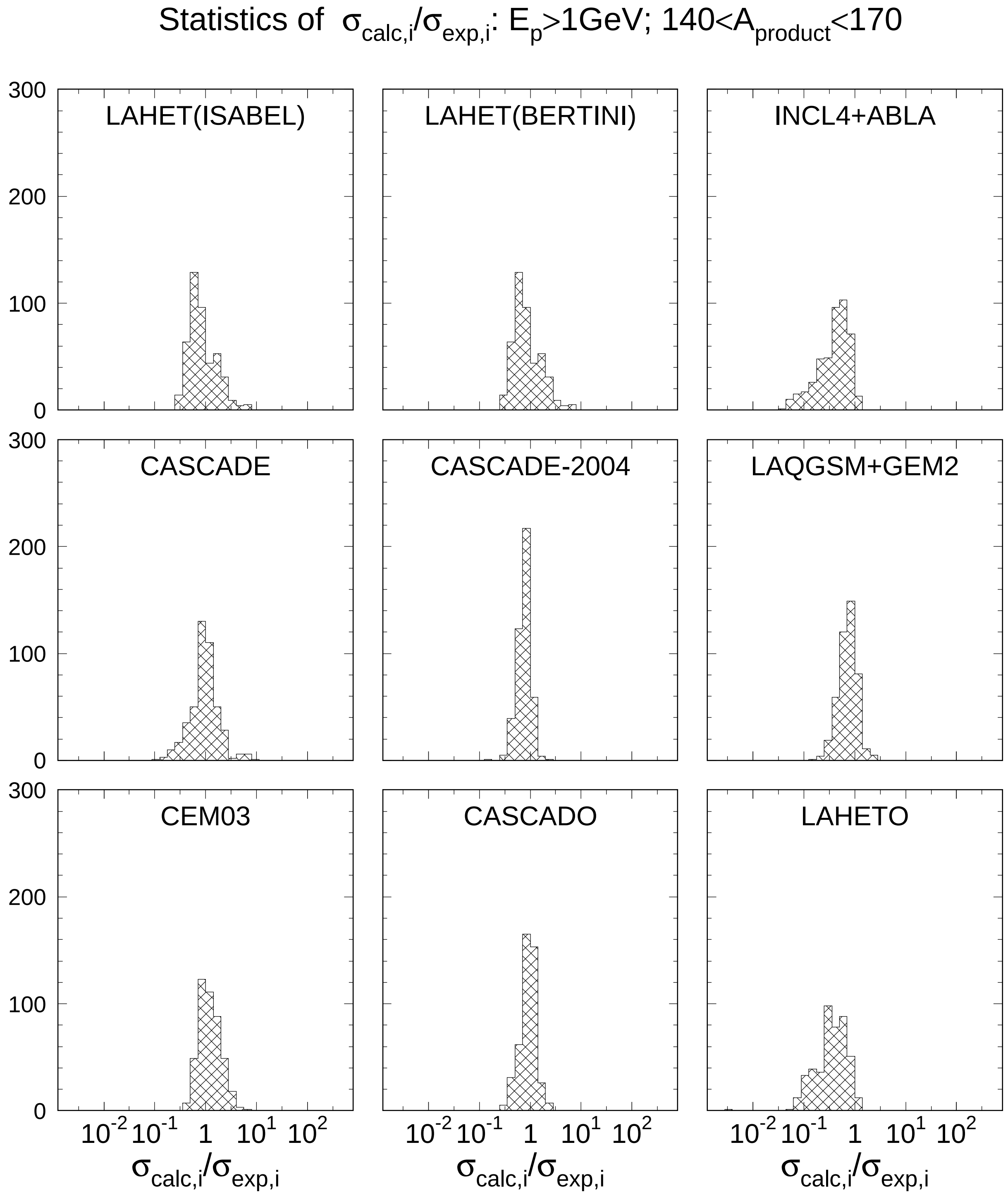


Fig. 146: Statistics of the simulation-to-experiment ratios for deep spallation products (140<A<170) at $E_p > 1.0$ GeV.

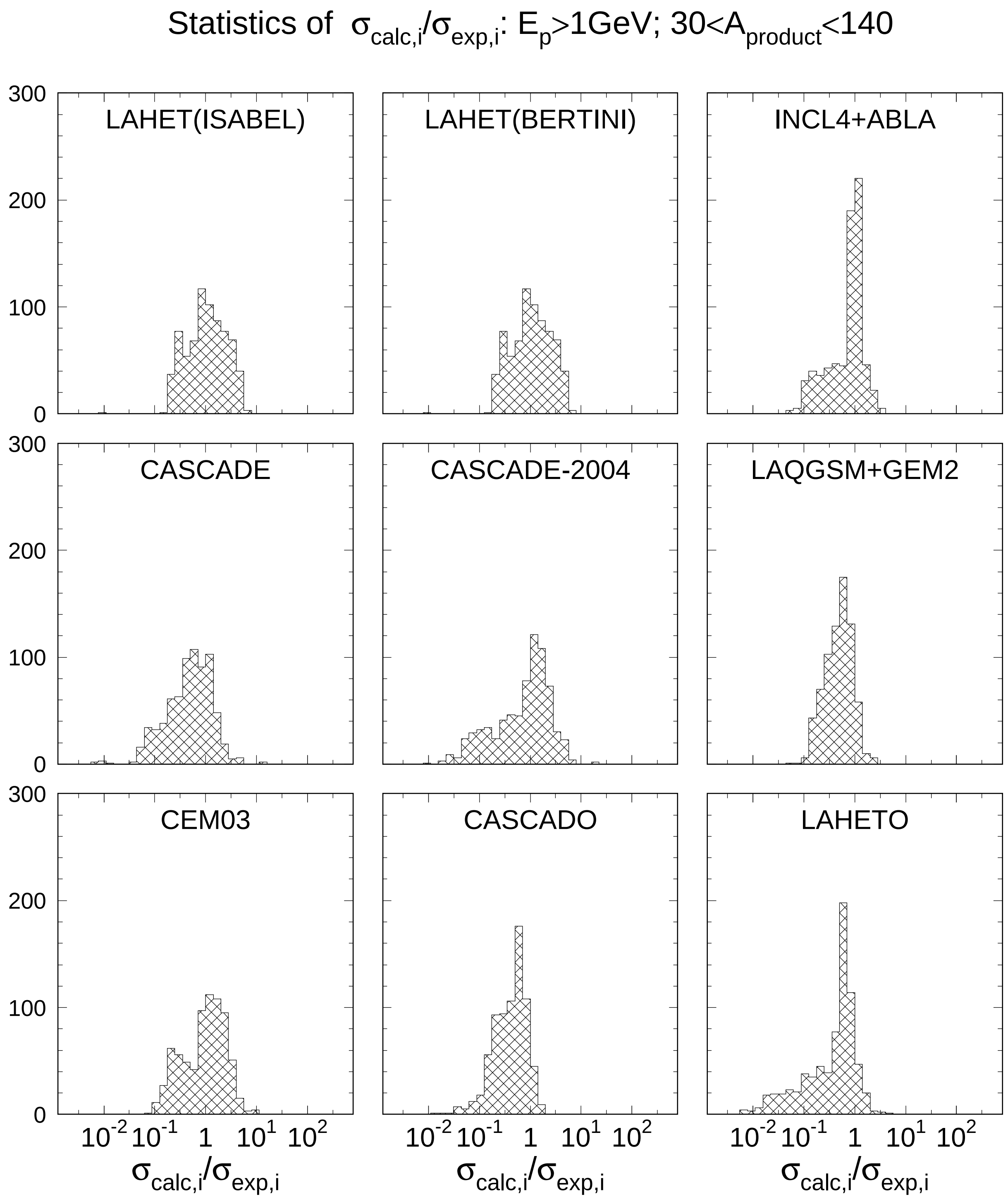


Fig. 147: Statistics of the simulation-to-experiment ratios for fission products (30<A<140) at $E_p > 1.0$ GeV.

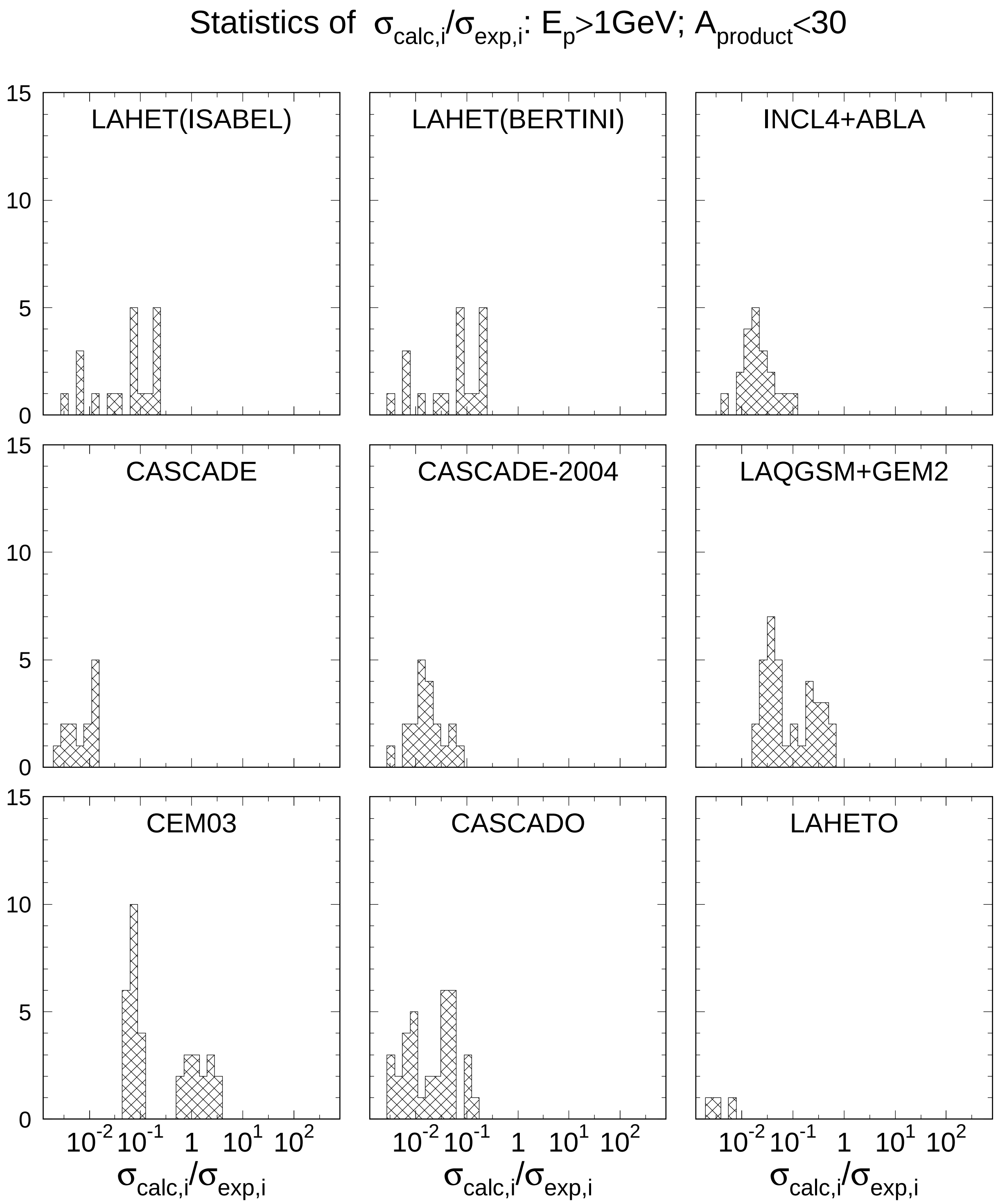


Fig. 148: Statistics of the simulation-to-experiment ratios for fragmentation products (A<30) at $E_p > 1.0$ GeV.

6 CONCLUSION

The *experimental* researches realized using the job-oriented ITEP U-10 proton accelerator external beam, which has been purportedly created under the reported Project, have resulted in 5972 independent and cumulative yields of radioactive product nuclides halflives ranging from 8 min to 32 years for the most promising ADS target materials.

In total, 55 experiments have been carried out to irradiate monoisotopic and high-enriched (^{206}Pb, ^{207}Pb, ^{208}Pb, ^{nat}Pb), and (^{209}Bi) targets within a broad range of projectile proton energies (0.04, 0.07, 0.10, 0.15, 0.25, 0.6, 0.8, 1.2, 1.4, 1.6, and 2.6 GeV), which covers the entire region of intranuclear hadron cascading. Besides, the ^{27}Al(p,x)^{24}Na and ^{27}Al(p,x)^{7}Be monitor reaction cross sections have been measured at the same proton beam energies.

In pursuance of the Project Workplan, 2152 γ-spectra of the irradiated targets have been measured and processed.

The following conclusions are drawn from the results of *theoretical* studies under the reported Project:

- The cross sections of spallation product yields have been calculated using different codes based on the INC models and the preequilibrium and evaporation models. The discrepancies have been studied in the results of predicting the cross sections for proton interactions with Pb and Bi isotopes by different computational codes. The approximations and parameters used in different INC codes were studied. Not only the data on the product yield cross sections, but also the spectra of emitted neutrons and charged particles have been analyzed. The contributions of the various reaction mechanisms and their impact on different reaction characteristics were examined.

- It has been shown that, to improve the description of the total experimental dataset, the parameters of the models that underlie the codes have to be specified further, and the codes proper modified to a certain degree. With the view to optimal describing the experimental 1 GeV data, the GSI experimental data were used to consistently determine the parameters of the models that underlie different codes.

- The mass and isotope distributions of the products of spallation reactions on Pb and Bi isotopes have been calculated using the updated CASCADO, LAHETO, CAMO, and ALICE-IPPE codes; the calculation results have been compared with the experimental 70 MeV - 2.6 GeV data.

- The above analyses and the comparison results demonstrate a reasonable agreement of the calculations by our updated codes with the available experimental data on the mass and isotope distributions of the products of spallation reactions on the Pb and Bi isotopes in a broad energy range. The agreement has proved to be much better than that observed prior to implementing the Project.

- The predictive power of the codes tested here varies, but was found to be satisfactory for most of the nuclides in the spallation region, though none of the benchmarked codes agrees well with the data in the entire mass region of product nuclides, which necessitates further updating of the codes. On the whole, the predictive power of all codes in the fission region is worse than in the spallation region; the agreement is even worse in the fragmentation region and at the boundary between spallation and fission. Therefore, development of better evaporation/fission/fragmentation models is now of high priority.

7 Acknowledgments

The authors are indebted to:

- Dr. Vade Bhatnagar (European Commission) for his support and constant attention to the reported researches when discussing the results of the Project.
- Academician of Royal Academy of Sciences of Sweden, Professor Waclaw Gudowski (Royal Institute of Technology, Stockholm) for informative disccussions of practical uses of the results obtained under ADS Projects (SAD and others) and possible futute extension of the like researches;
- Professor Colnelis H.M. Broeders (Forschungszemntrum Karlsruhe Institut fur Kern und Energiete) for informative discussion of the uses of the Project results at proton energy 600 MeV;
- Drs. S.G.Mashnik (LANL) and K.K.Gudima (LANL, Institute of Applied Physics, Academy of Science of Moldova, Kishinev, Moldova), who are authors of the CEM03 and LAQGSM+GEM2 codes, for their calculations and for their providing the calculation results of the codes; special thanks are to Dr. S.G.Mashnik for his great assistance in discussing the experiment-to-calculation comparison result. Unfortunately, the standing ISTC rules prevents indicating foreigners as a rightful participant in the Project in the front page. This will be remedied in the pending publications;
- Professors Massimo Salvatores, Igor S. Slessarev (CEN - Cadarache) for the discussions concerning the analysis of the need for nuclear data in the ADS target assembly;
- Professor Sylvie Leray (DAPNIA/SPhN, CEA Sacle) for discussions of the Project results as applied to verifying the high-energy transport codes;
- Dr. Alain Boudard (CEA-Sacley) for his providing the INCL4+ABLA code and for his helpful remarks on the calculation results of the code;
- Dr. K.H. Schmidt (GSI) for fruitful discussions the results of cpmparing the GSI inverse kinematics results with the data obtained under the reported Project by the direcs kinematics method;
- Prof. R.Michel (ZSR) for his helpful remarks for his recommendations to coose definite cross sections of monitor reactins;
- Dr. F.E.Chukreev for his recommendations concerning corrections in the data on nuclear transformation chais;

- Dr. A.J. Sierk (LANL) for discussions of the problems relevant to heavy nuclide fission in high-energy range;
- Dr. R.E. Prael (LANL) for his consultations concernins the LAHET code functioning and for his constant attention to the reported researches;
- Dr. G.J. Van Tuyle, (LANL) for discussions of feasible practical uses of the Project results;
- Dr. H. Takada, (JAERI) for his attention to the reported researches;
- Dr. L.Tocheny (ISTC) for permanent attention and technical support during the whole period of the project preparation and activity.

8 References

[1] http://tech-db.istc.ru/ISTC/sc.nsf/html/projects.htm?open&id=2002.

[2] Titarenko, Yu. E., et al. (15 authors). Experimental and Theoretical Study of the Yields of Residual Product Nuclei in Thin Targets Irradiated by 100 - 2600 MeV Protons. IAEA, Nuclear Data Section, INDC(CCP)-434, September, 2002, http://www-nds.iaea.org/reports/indc-ccp-434.pdf.

[3] Proc. Intern. Conf. on Accelerator-Driven Transmutation Technologies and Applications, (Las Vegas, 1994). Ed. E. D. Arthur, A. Rodrigues, and S. O. Schriber. AIP Press, Woodbury, NY, 1995.

[4] Yu.E. Titarenko, et al., Experimental and computer simulation study of the radionuclides produced in thin ^{209}Bi targets by 130 MeV and 1.5 GeV proton-induced reactions. // Nucl. Instr. Meth., 1998, A 414, p. 73.

[5] E.Storm, H.I. Israel. Photon cross section from 1 keV to 100 MeV for elements Z=1 to Z=100. // Nuclear Data Tables A7, 1970, p. 565.

[6] Yu.E. Titarenko, O.V. Shvedov, V.F. Batyaev, E.I. Karpikhin, V.M. Zhivun, A.B. Koldobsky, R.D. Mulambetov, S.V. Kvasova, A.N. Sosnin, S.G. Mashnik, R.E. Prael, A.J. Sierk, T.A. Gabriel, M. Saito, H. Yasuda. Cross sections for nuclide production in 1 GeV proton-irradiated ^{208}Pb. // E-print nucl-th/0011083; LANL Report, LA-UR-00-4779; Phys.Rev. C, 2002, 65, 064610, p. 1.

[7] Yu.E.Titarenko, O.V.Shvedov, V.F.Batyaev, V.M.Zhivun, E.I.Karpikhin, R.D. Mulambetov, D.V.Fischenko, S.V.Kvasova, SG.Mashnik, R.E.Prael, A.J.Sierk. Study of Residual Product Nuclide Yields in 1.0 GeV Proton Irradiated ^{208}Pb and 2.6 GeV Proton Irradiated ^{nat}W Thin Targets. // Proc. of Int. Workshop "Shielding Aspects of Accelerators, Irradiation and Target Facilities (SATIF-5)", OECD Headquarters, Paris, France, July 20-21, 2000; LANL Report, LA-UR-00-3597; E-print nucl-ex/0008011.

[8] $SartoriusBasic.^{plus}$ Electronic Semi-micro-, Analitical and Precision Balances. Approved for Use as Legal Measuring Instruments. 98648-004-59. Sartorius

[9] Quality Certificate #332-8. Lead 206. Characteristic of Isotope-Enriched Product. State Scientific Center of the Russian Federathion - Inctitute of Physics and Power Engineering. Science-Technical Center "Stable Isotopes".

[10] Passport #65-16. Parameters of isotopicaly enriched product - 207-lead. Scientific-technology Center "Stable Isotopes"(in Russian).

[11] Quality Certificate #334-12. Lead 208. Characteristic of Isotope-Enriched Product. State Scientific Center of the Russian Federathion - Institute of Physics and Power Engineering. Science-Technical Center "Stable Isotopes".

[12] 26,400-8 00914HQ [7440-69-9] Bismuth, powder, 100 mesh, 99.99 + %, ALDRICH Chem. Co., WI 53201, 414-273-3850.

[13] Minutes for the impurity content testings #7336.99. MS&Gc Lab, 8 february 1999 (in Russian).

[14] Yu.N.Shubin, V.P.Lunev, A.Yu.Korovin, A.I.Dityuk, "Cross Section Data Library MENDL-2 to Study Activation and Transmutation of Materials Irradiated by Neutrons of Intermediate Energies", Report IAEA, IC(CCP)-385, Vienna, 1995.

[15] N.E. Holden, R.L. Martin and I.L.Barnes, "Isotopic compositions of the elements 1983", Pure & Appl. Chem., Vol. 56, No. 6, pp. 675-694, 1984.

[16] Spectrometry system Genie-2000, model S502. Canberra Industries. Operations, Rept. 9230846E, V1.2A Russian, 6/99.

[17] "Calibration and Usage og Germanium Detectors for measurement of Gamma-Ray Emission of Radionuclides" , ANSI Standart #42.14-1978, American National Standarts Institute, 1978.

[18] G.W. Phillips, Nucl. Instr. & Meth. 153 (1978) 449.

[19] D.W.Marqward, J. Soc. Indust. Appl. Math. 11(1963),431.

[20] L.V.East, R.L. Phillips, A.R. Strong, Nucl. Instr. & Meth. 193 (1982) 147.

[21] M.A. Mariscotti, Nucl. Instr. & Meth. 50 (1967) 309.

[22] J.T.Routti and S.G.Prussin, Nucl. Instr. & Meth. 72 (1969) 125.

[23] M.J.Koskelo, P.A.Aarnio, and J.T.Routti, Nucl. Instr. & Meth. 190 (1981) 89.

[24] W.H.Press, B.P. Flannery, S.A. Teukolsky and W.T. Vetterline. "Numerical Recipes in C", 2nd Ed.,Cambridge University Press,1992.

[25] Y.Bar-Shalom and X-R. Li, "Estimation and Tracking: Principles, Techniques, and Software", Artech House, Inc., 1993.

[26] R.L. Burden and J.D. Faires, "Numerical Analysis", 4th Ed., PWS-KENT Publishing Company, 1989.

[27] M.J. Kaskelo and M.T. Mercier, Nucl. Instr. & Meth. A299 (1990) 318.

[28] M.T. Mercier and M.J. Kaskelo J. Radioanal & Nucl. Chem. 160 (1992) 233.

[29] M.J. Kaskelo, P.A. Aarnio, and J.T. Routti, Nucl. Instr. & Meth. 190 (1981) 89.

[30] R. Gunnink and J.B. Niday, University of California Lawrence Livermore Laboratory, Report UCRL-51061 (1972)

[31] L.A. Currie, Anal. Chem. 40(1968) 586.

[32] "Measuring, Evaluating and Reporting Radioactivity in Releases of Radioactive Materials in Liquid and Airborne Effuents from Nuclear Fuel Processing and Fabrication Plants", US Nuclear Regulatory Commission Regulatory Gwide 4.16 (December 1985).

[33] Kinsey R.R., et al. The NUDAT/PCNUDAT Program for Nuclear Data. // Proc. 9th Int. Symp. of Capture-Gamma-Ray Spectroscopy and Related Topics. 8-12 October 1996, Budapest, Hungary.

[34] R.B. Firestone. Tables of Isotopes. 8th Edition, New York - London, 1998, p. 695.

[35] ENSDF database. http://ie.lbl.gov/databases/ENSDFdata.exe. Self-extracting ENSDF archive (23 MB). Last updated March, 2005.

[36] Ts. Vylov, Zh. Zhelev, A.I. Ivanov, Emitting spectra of radioactive nuclides, Tashkent, 1980 (in Russian).

[37] Certificate of compliance #31/96/19826, D.I.Mendeleyev Institute for Metrology, State Center for Measuring Instrument Testing and Certification, Nov. 1995.

[38] A.N. Kalinovsky, N.V. Mokhov, Yu.P. Nikitin, Penetration of high energy particles through matter, M. Energoatomizdat, 1985 (in Russian).

[39] Dermott E. Cullen. Program Epicshow. A Computer Code to Allow Interactive Viewing of the EPIC Data Libraries (version 98-1). IAEA-NDS-194. February 1999.

[40] EndVer integrated with EXFOR-CINDA for Applications, Database and Retrieval Systems, Version 1.63, November 2004, Nuclear Data Services, International Atomic Energy Agency.

[41] G.F. Steyn et al., Appl. Radiat. Isot. 41(1990)315.

[42] J. Tobailem and C.H. de Lassus CEA-N-1466(1)1975.

[43] J. Tobailem and C.H. de Lassus CEA-N-1466(5)1981.

[44] I. Leya, R.Wieler, J.-C. David, S.Leray, L.Donadille, J.Cugnon, R.Michel, Production of noble gas isotopes by proton-induced reactions on lead, Nucl. Instr. and Meth. B (2004).

[45] C.Damdinsuren, V.J.Llyushchenko, P.Kozma, D.Chultem. Yields of Radionuclides Formed in The Interaction Of3.65 A*GeV 12c-Ions And Protons with Nat-Pb // R, Jinr-E1-89-481, 1989.

[46] M.Adilbish, N.G.Zajceva, O.Knotek, M.I.Fominykh, V.A.Khalkin. Cumulative Cross Sections of 200, 201, 202Tl Production in 660 MeV Proton-induced SpallationoOf Lead and Bismuth. // R, Jinr-6-80-517, 800816 (Russian); J, RRL, 45, 3, 227, 80.

[47] P.P.Dmitriev, G.A.Molin. Radioactive Nuclide Yields for Thick Target at 22 MeV Proton Energy. // J, Yk, 44, 5, 43, 81 Main Reference. R, INDCCCP-188/L, 83 (English Translation); J, AE, 48, 402, 80 (Experimental Details); J, AE, 48, 122, 80 (Experimental Details); J, AE, 46, 185, 79 (Experimental Details).

[48] P.P.Dmitriev. Systematics of Nuclear Reaction Yields for Thick Target at 22 MeV Proton Energy. // J, YK, 2, 57, 83.

[49] S.Mukhammedov, A.Vasidov, E.Pardaev. Application of Proton and Neutron Activation Method of Analisis for the Determination of Elements with Z Greater 42. // J, AE, 56, 50, 84.

[50] M.Isshiki, Y.Fukuda, K.Igaki. Proton Activation Analysis of Trace Impurities in Purified Cobalt. // J, JRN, 82, 135, 84.

[51] O.N.Vysotskij, S.N.Kondrat'ev, V.S.Prokopenko, V.D.Sklyarenko, Yu.S.Stryuk, V.V.Tokarevskij. The Investigation of 209-Bi(D, N)210-Po And 209-Bi(P, G) 210-Po. // J, Izv, 55, 153, 9101 C, 90lening,, 340, 90 Short Communication.

[52] K.Miyano, M.Sekikawa, T.Kaneko, M.Nomoto. Reactions on Bi-209 Induced by Intermediate Energy Protons and the Effect Of Direct Reactions // J, Np/A, 230, 98, 1974.

[53] C.Birattari, E.Gadioli, A.M.Grassi Strini, G.Strini, G.Tagliaferri, L.Zetta. (P, Xn)Reactions induced in Tm-169, Ta-181 and Bi-209 with 20 To 45 MeV Protons // J, NP/A, 166, 605, 1971.

[54] K.Miyano, T.Ando, H.Kudo, M.Yanokura, H.Nakahara. The (P, N) Reaction on Bi-209 and Pre-Compound Process. // J, JPJ, 45, 1071, 1978 J, JPJ, 35, 953, 1973 Previous Data.

[55] J.Gonzalez-Vidal, W.H.Wade. Survey of Tritium-Producing Nuclear Reactions // J, PR, 120, 1354, 196011 J, PR, 107, 1311, 195709 Data For 197au, 232Th and 238U Experimental Procedures Given.

[56] M.C.Lagunas-Solar, F.E.Little, J.A.Jungerman. Proton induced Reactions on Natural Pb Targets. A Potential New Cyclotron Method For 201tl Production // J, ARI, 32, 817, 1981 J, RCA, 60, 57, 1993 Data Compared To Alice Calculations.

[57] I.Dostrovsky, R.Davis, Jr., A.M.Poskanzer, P.L.Reeder. Cross Sections For the Production of Li-9, C-16, and N-17 in Irradiations with GeV-Energy Protons // J, PR/B, 139, 1513, 65.

[58] M.C.Lagunas-Solar, O.F.Carvacho, L.Nagahara, A.Mishra, N.J.Parks. Cyclotron Production of no-Carrier-added 206Bi (6.24D) and 205Bi (15.31D) as Tracers for Biological Studies and for the Development of Alpha-Emitting Radiotherapeutic Agents // J, ARI, 38, 129, 1987 J, RCA, 60, 57, 1993 Data Compared To Alice Calculations.

[59] F.S.Rowland, R.L.Wolfgang. Production of He-6 by High-Energy Protons // J, PR, 110, 175, 58.

[60] P.Kruger, N.Sugarman. High-Energy Fission of Heavy Elements. Nuclear Charge Dependence // J, PR, 99, 1459, 55.

[61] J.A.Panontin, N.T.Porile. Charge Distribution and Recoil Properties in the Fission of 208Pb by 11.5 GeV Protons // J, JIN, 33, 3211, 71.

[62] K.Baechmann. Rare Earth Yields in the interaction of 28-GeV Protons with Uranium, Bismuth and Gold // J, JIN, 32, 1, 70.

[63] R.Wolfgang, E.W.Baker, A.A.Caretto, J.B.Cumming, G.Friedlander, J.Hudis. Radiochemical Studies of the interaction of Lead with Protons in the Energy Range 0.6 to 3.0 Bev // J, PR, 103, 394, 56.

[64] G.Friedlander, L.Yaffe. Cross Sections For the Production of Cl, K, Ca, and Sc Isotopes in the Bombardment of Pb and U with 3.0-Bev Protons // J, PR, 117, 578, 60.

[65] N.T.Porile. Yields of Products with A=100-117 in the Interaction of 3- and 28-GeV Protons with Uranium and Lead // J, PR, 148, 1235, 66.

[66] L.G.Jodra, N.Sugarman. High-Energy Fission of Bismuth. Proton Energy Dependence // J, PR, 99, 1470, 55.

[67] E.T.Hunter, J.M.Miller. Spallation of Bismuth by 380-MeV Protons // J, PR, 115, 1053, 59.

[68] Y.L.Beyec, M.Lefort. Reactions Between Protons with 30 to 155 MeV and Complicated Heavy Nucleus // J, NP/A, 99, 131, 67.

[69] W.R.Pierson, N.Sugarman. Yields of Polonium and Bismuth Nuclides from Bi-209 and Recoil Studies of Bi-209(P, P+2n)Bi-207 Reaction at 450 MeV // J, PR/B, 133, 384, 64.

[70] H.Gauvin, M.Lefort, X.Tarrago. Emission of Alpha Particles from the Spallation Reactions // J, NP, 39, 447, 1962.

[71] N.Sugarman, R.B.Duffield, G.Friedlander, J.M.Miller. Disintegration of Bismuth by 2.2 Bev Protons // J, PR, 95, 1704, 54.

[72] J.M.D'auria, M.Dombsky, G.Sheffer, T.E.Ward, H.J.Karwowski, A.I.Yavin, J.L.Clark. Inclusive Measurement of Quasifree (P, Xn) Charge Exchange Reactions on Bismuth from 62 to 800 MeV // J, PR/C, 30, 236, 198407.

[73] L.Winsberg. Recoil Studies of Nuclear Reactions induced by High- Energy Particles. I. Production of Tb149 // J, PR/B, 135, 1105, 196409.

[74] L.A.Currie, W.F.Libby, R.L.Woldgang. Tritium Production by High-Energy Protons // J, PR, 101, 1557, 1956.

[75] S.D.Schery, D.A.Lind, H.W.Fielding, C.D.Zafiratos. The (P, N) Reaction to the Isobaric Analogue State of High-Z Elements at 25.8 MeV. // J, NP/A, 234, 109, 74.

[76] V.I.Bogatin, V.F.Litvin, O.V.Lozhkin, N.A.Perfilov, Yu.P.Yakovlev. Isotopic Effects in High-Energy Nuclear Reactions and Isospin Correlations of Fragmentation Cross Sections. // J, NP/A, 260, 446, 76.

[77] R.R.Doering, D.M.Patterson, A.Galonsky. Microscopic Description of Isobaric-Analog-State Transitions induced by 25, 35 and 45 MeV Protons. // J, PR/C, 12, 378, 75.

[78] N.G.Zaitseva, E.Rurarz, M.Vobecky, V.A.Khalkin, Kim Hyn Hwan, V.N.Gluschenko, L.M.Popinenkova, S.V.Sokolov, V.B.Pugachevich. Excitation Functions For the Formation of Pb-200, 201 and Pb-202 by Proton induced Nuclear Reactions on Enriched Pb-204. // J, RCA, 65, 151, 94.

[79] L.A.Currie, W.F.Libby, R.L.Wolfgang. Tritium Production by High-Energy Protons. // J, PR, 101, 1557, 56.

[80] C.Deptula, V.A.Kalkin, Kim Sen Han, O.Knotek, V.A.Konov, P.Mikecz, L.M.Popinenkova, E.Rurarz, N.G.Zaitseva. Excitation Functions and Yields For Medically Generator Sr-82-Rb-82, Xe-123-I-123 and Bi-201-Pb-201- Tl-201 Obtained with 100 MeV Protons. // J, NKA, 35, 3, 90.

[81] F.I.Pavlotskaya, A.K.Lavrukhina. Isotopic Composition Rare Earth Elements Obtained at Fission Nuclei of U, Th and Bi by 680 MeV Protons. // J, AE, 1, 115, 56.

[82] M.Gloris, R.Michel, U.Herpers, F.Sudbrock, D.Filges. Production of Residual Nuclei from Irradiation of Thin Pb-Targets with Protons up to 1.6 GeV. // J, NIM/B, 113, 429, 96.

[83] Yu.V.Aleksandrov, S.K.Vasil'ev, R.B.Ivanov, M.A.Mikhaylova, V.P.Prikhodtseva, A.V.Saul'skij, V.G.Eismont. Production Cross Section For Radioactive Nuclides in Lead Target Bombarded by 660. MeV Protons. // C, 96, Moscow, 221, 96.

[84] A.A.Kotov, G.G.Semenchuk, L.N.Andronenko, M.N.Andronenko, B.L.Gorshkov, G.G.Kovshevny, V.R.Reznik, G.E.Solyakin. Energy and Mass Distributions of Fragments from Fissionof Bi-209, Au-197, W-Nat and Yb-Nat by 1 GeV Protons. // J, YF, 20, 467, 74 in Russian J, SNP, 20, 251, 74 in English.

[85] Yu.V.Aleksandrov, S.K.Vasil'ev, R.B.Ivanov, M.A.Mikhaylova, V.P.Prikhodtseva, A.V.Saul'skij, V.G.Eismont. Production Cross Section of Some Short-Lived Radionuclides in Thin Lead Target Irradiated by 660. MeV Protons. (in Russian) // C, 97, Obninsk, 153, 97.

[86] Yu.E.Titarenko, E.I.Karpikhin, A.F.Smolyakov, M.M.Igumnov, O.V.Shvedov, N.V.Stepanov, V.D.Kazarizki, V.F.Batyaev, S.G.Mashnik, T.A.Gabriehl. Experimental and Calculative Research of Radioactive Nuclei Formation-Products of Target and Constructional Materials of Electronuclear Facilities Irradiated by Protons With Energies 1.5 GeV and 130 MeV. // C, 96, Sarov, 184, 96.

[87] T.E.Ward, P.P.Singh, D.L.Friesel, A.Yavin, A.Doron, J.M.D'auria, G.Sheffer, M.Dillig. Radiochemical Study of the Combined (P, Pi0) and (P, Gamma) Reactions on Bismuth with Protons from 62 to 480 MeV. // J, PR/C, 24, 588, 81.

[88] A.Juliano, N.T.Porile. Formation of Na-24 in the interaction of 12 GeV Protonswith Isotopes of Uranium and Lead. // J, JIN, 29, 2859, 1967.

[89] C.G.Andre, J.R.Huizenga, J.F.Mechi, W.J.Ramler, E.G.Rauh, S.R.Rocklin. Proton Cross Sections of Bi-209. // J, PR, 101, 645, 1956.

[90] M.C.Lagunas-Solar, R.P.Haff. Theoretical and Experimental Excitation Functions For Proton induced Nuclear Reactions on Z=10 to Z=82 Target Nuclides. // J, RCA, 60, 57, 93 W, Zeng, 980423 Data For Mo-90 Are incorrect.

[91] Y.Le.Beyec, M.Lefort, J.Peter. Competition Fission Evaporation Neutrons at Bombardment Bi by 100-150 MeV Protons. // J, NP, 88, 215, 1966.

[92] M.Lagarde-Simonoff, G.N.Simonoff. Cross Sections and Recoil Properties of Rb-83, -84, -86 Formed by 0.6-21 GeV H-1 Reactions with Target of Y to U. // J, PR/C, 20, 1498, 1979.

[93] Yu.A.Alexandrov, V.P.Eismont, R.B.Ivanov, M.A.Mikhailova, V.P.Prikhodtseva, A.V.Saulsky, S.K.Vasiljev. New Data For the Production of Radionuclides in Thin Lead Target by 660 MeV Protons. // C, 97Triest, 59, 1525, 1997.

[94] M.C.Duijvestijn, A.J.Koning, J.P.M.Beijers, A.Ferrari, M.Gastal, J.Van Klinken, R.W.Ostendorf. Proton-Induced Fission at 190 MeV of W-Nat, Au-197, Pb-Nat, Pb-208 and Th-232. // J, PR/C, 59, 776, 1999 W, Duijvestijn, 19990706 Some Corrections and Explanations.

[95] R.E.Marrs, R.E.Pollock. inclusive (P, Pi+) Cross Sections Near Threshold. // J, PR/C, 20, 2446, 1979.

[96] E.Hagebo. Relative Yields of the Pairs Nb-95-G-Nb-95-M and Nb-96-Nb-95 in Fission of Pb, Bi, Th and U induced by 15-157 MeV Protons. // J, JIN, 25, 1201, 1963.

[97] M.Enke, C.-M.Herbach, D.Hilscher, U.Jahnke, O.Schapiro, A.Letourneau, J.Galin, F.Goldenbaum, B.Lott, A.Peghaire, D.Filges, R.-D.Neef, K.Nuenighoff, N.Paul, H.Schaal, G.Sterzenbach, A.Tietze, L.Pienkowski. Evolution of A Spallation Reaction: Experiment and Monte-Carlo Simulation. // J, NP/A, 657, 317, 1999 W, Herbach, 20000124 Corrections of Some Misprintings.

[98] R.E.Bell, H.M.Skarsgard. Cross Sections of (P, Xn) Reactions in the Isotopes of Lead and Bismuth. // J, CJP, 34, 745, 1956.

[99] T.Bjornstad, L.C.Carraz, H.A.Gustafsson, J.Heinemeier, B.Jonson, O.C.Jonsson, V.Lindfors, S.Mattsson, H.L.Ravn. New Targets For on-Line Mass Separation of Nuclei Formed in 600 MeV Proton and 910 MeV He-3 Reactions. // J, NIM, 186, 391, 1981.

[100] G.K.Wolf. The Decay Properties of Hg-206 and the Pb(P, 3p)Hg-206 Reaction. // J, NP/A, 116, 387, 1968.

[101] E.Porras, F.Sanchez, V.Reglero, B.Cordier, A.J.Dean, F.Lei, J.M.Perez, B.M.Swinyard. Production Rate of Proton-Induced Isotopes in Differentmaterials. // J, NIM/B, 160, 73, 2000.

[102] W.Wlazlo, T.Enqvist, P.Armbruster, J.Benlliure, M.Bernas, A.Boudard, S.Czajkowski, R.Legrain, S.Leray, B.Mustapha, M.Pravikoff, F.Rejmund, K.H.Schmidt, C.Stephan, J.Taieb, L.Tassan-Got, C.Volant. Cross Sections of Spallation Residues Produced in 1*A GeV Pb-208 on Proton Reactions. // J, PRL, 84, 5736, 2000.

[103] H.Kawakami, M.Koike, K.Komura, M.Sakai, N.Yoshikawa, R.Donangelo, J.O.Rasmussen. Cross Sections and Reaction Mechanisms of (P, Pxn) Reactions on Pb-208 in the 24-52 MeV Range. // J, NP/A, 262, 52, 1976.

[104] J.Raisanen, T.Witting, J.Keinonen. Absolute Thick-Target Gamma Ray Yields For Elemental Analysis by 7 and 9 MeV Protons // J, NIM/B, 28, 199, 1987.

[105] J.Kuhnhenn, U.Herpers, W.Glasser, R.Michel, P.W.Kubik, M.Suter. Thin Target Cross Sections For Proton-Induced Production of Radionuclides from Lead For E(P)<71 MeV. // J, RCA, 89, 697, 2001.

[106] J.Kuhnhenn. Thin Target Cross Sections For Proton-Induced Production of Radionuclides from Lead and Bismuth Over the Proton Energy Range from 9 to 71 MeV. // T, Kuhnhenn, 2001.

[107] U.Georg, A.R.Junghans, H.Simon, U.C.Bergmann, R.Catherall, T.Giles, O.C.Jonsson, U.Koester, E.Kugler, J.Lettry, T.Nilsson, H.Ravn, K.-H.Schmidt, C.Tamburella. Isotope Production Comparison at Isolde with 1 and 1.4-GeV. // J, NP/A, 701, 137, 2002.

[108] R.Michel, M.Gloris, J.Protoschill, U.Herpers, J.Kuhnhenn, F.Sudbrock, P.Malmborg, P.Kubik. Cross Sections For the Production of Radionuclides by Proton-Induced Reactions on W, Ta, Pb and Bi from Thresholds up to 2.6 GeV // J, NSTS, 2, 242, 2002.

[109] P.J.Daly, P.F.D.Shaw. Radiative Proton Capture Cross-Sections in Heavy Nuclei // J, NP, 56, 322, 1964.

[110] J.M.D'auria, M.Dombsky, G.Sheffer, T.E.Ward, H.J.Karwowski, A.I.Yavin, J.I.Clark. inclusive Measurement of Quasifree (P, Xn) Exchange Re- Actions on Bismuth from 62 to 800 MeV // J, PR/C, 30, 236, 8407.

[111] M.Isshiki, Y.Fukuda, K.Igaki. Proton Activation Analysis of Trace Impurities in Puri-Fied Cobalt // J, JRN, 82, 1, 135, 8401.

[112] Katunori Abe, Atsushi Iizuka, Arika Hasegawa, Shotar Morozumi. induced Radioactivity of Component Materials by 16-MeV Protons and 30-MeV Alpha Particles // J, JNM, 122/123, 972, 8403.

[113] J.Wing, J.R.Huizenga. (P, N) Cross Sections of V51, Cr52, Cu63, Cu65, Ag107, Ag109, Cd111, Cd114, and La139 from 5 to 10.5 MeV // J, PR, 128, 280, 1962 R, Tid-12696, 1961 Values Superseded.

[114] T.E.Ward, P.P.Singh, D.L.Friesel, A.Yavin, A.Doron, J.M.D'auria, G.Sheffer, M.Dillig. Radiochemical Study of the Combined (p, pi0) and (P, Gamma) Reactions on Bismuth with Protons from 62 to 480 MeV. // J, PR/C, 24, 588, 198108.

[115] G.J.Igo, C.A.Whitten, J.-L.Perrenoud, J.W.Verba, T.J.Woods, J.C.Young, L.Welch. Proton Decay of the Isobaric Analog of the Ground State of 208Pb Populated by the (P, N) Reaction // J, PRL, 22, 724, 196904.

[116] T.J.Woods, C.A.Whitten Jr., G.J.Igo. Optical Model Analysis of the 208Pb(p,n)208Bi (Ias) Reaction // J, NP/A, 198, 542, 1972 J, PL/B, 34, 594, 1971 30.5 MeV Data.

[117] M. Gloris, R. Michel, F.Sudbrok, et al., Proton-Induced Production of Residual Radionuclides in Lead at intermediate Energies, Nucl. Instr. and Meth., A463(2001)593; EXFOR file O0500.

[118] Y. Y. Chu, G. Friedlander, L. Husain Production of Nuclides with Atomic Mass 43<=A<=51 in the interaction of 1-28.5 GeV Protons with V, Ag, in, Pb and U Targets. Phys. Rev. C15(1977) 352; EXFOR file O0399.

[119] E.Hagebo, T.Lund, Fission of Lead induced by 600 MeV Protons. Inorganic Nuclear Chemistry, 37(1975)1569; EXFOR file O0327 .

[120] J.Hudis, S.Tanaka Production of Be-7, Na-22, and Na-24 Fragments from Heavy Elements at 3, 10, and 30 GeV. Phys. Rev. 171(1968)1297; EXFOR file C0341 .

[121] R.G.Korteling, A.A.Caretto, Systematics of Na-24 and Na-22 Production with 400 MeV Protons. Inorganic Nuclear Chemistry 29(1967)2863; EXFOR file O0412.

[122] J. A. Panontin, N. T. Porile, Recoil Properties and Charge Distribution in the Fission of Pb-208 by 450 MeV Protons. inorganic Nuclear Chemistry 30(1968)2891; EXFOR file O0332.

[123] T. Enqvist, W. Wlazlo, P. Armbruster et al., Isotopic Yields and Kinetic Energies of Primary Residues in 1 A GeV ^{208}Pb + p Reactions, Nucl. Phys. A686, 481 (2001); see also: Cross sections of spallation residues produced in 1A GeV Pb on proton reactions, Phys. Rev. Lett. 84 (2000) 5736.

[124] L. Spanier and P. Ekstrom, Nuclear Physics Report LUNFD6 (NFFR-3059)/1-11, Lund, Sweden (1989).

[125] V.V. Atrashkevich, Ya.K. Vaivade, V.P. Kolotov and V.V. Filippov, Analiticheskaya Khimiya 45 (1990) 5 (in Russian).

[126] Jagdish K. Tuli, Nuclear Wallet Cards, Brookhaven National Laboratory, P.O. Box 5000, Upton, New York 11973-5000, USA. 6th edition, January 2000.

[127] U. Reus and W.Westmeier, Catalog of gamma rays from radioactive decay. Atomic Data and Nuclear Data Tables, vol. 29, No. 2, 1983.

[128] H. W. Bertini, intranuclear-cascade calculation of the secondary nucleou spectra from nucleon-nucleus interactions in the energy range 340 to 2900 MeV and comparisons with experiment, Phys. Rev., 188 (1969) 1711.

[129] Y. Yariv and Z. Frankel, Intranuclear cascade calculation of high-energy heavy-ion interactions, Phys. Rev., C 20 (1979) 227.

[130] V. S. Barashenkov and V. D. Toneev, Interaction of high energy particles and nuclei with atomic nuclei, Moscow, Atomizdat, 1972 (in Russian); V. S. Barashenkov, Monte Carlo Simulation of Ionization and Nuclear Processes Initiated by Hadrons and Ion Beams in Media. Comp. Phys. Comm. 126, 28-31 (2000).

[131] Prael, R. E., Lichtenstein, H. User Guide to LCS: The LAHET Code System. LA-UR-89-3014, Los Alamos (1989).

[132] Mashnik, S. G., Sierk, A. J. Recent Developments of the Cascade-Exciton Model of Nuclear Reactions. J. Nucl. Sci. Techn. Suppl. 2, 720-725 (2002); E-print: nucl-th/0208074.

[133] Gudima, K. K., Mashnik, S. G., Toneev, V. D. Cascade-Exciton Model of Nuclear Reactions. Nucl. Phys. A401, 329-361 (1983).

[134] Mashnik, S.G., Gudima, K.K., Sierk, A.J, Prael, R.E. Improved intranuclear cascade models for the codes CEM2k and LAQGSM, Los Alamos LA-UR-04-0039 (2004).

[135] Toneev, V. D., Gudima, K. K. Particle emission in light and heavy-ion reactions. Nucl. Phys. A400, 173c-190c (1983).

[136] Furihata, S. Statistical analysis of light fragment production from medium energy proton-induced reactions. Nucl. Instrum. Methods. B171(3), 251-258 (2000); The GEM code version 2. User's manual, Mitsubishi Research Institute, Inc., Tokyo, Japan (2001).

[137] Mashnik, S. G., Gudima, K. K., Sierk, A. J. Merging the CEM2k and LAQGSM Codes with GEM2 to Describe Fission and Light-Fragment Production. Proc. SATIF-6, OECD, Paris, pp. 337-366 (2004); Eprint: nucl-th/0304012. April 10-12, 2002, Stanford Linear Accelerator Center, CA 94025, USA.

[138] Gudima, K. K., Mashnik, S. G., Sierk, A. J. User manual for the code LAQGSM. LA-UR-01-6804, Los Alamos National Laboratory (2001).

[139] Amelin, N. S., Gudima, K. K., Toneev, V. D. Further Development of the Model of Quark-Gluon Strings for the Description of High-Energy Collisions with a Target Nucleus. Sov. J. Nucl. Phys. 52, 172-178 (1990).

[140] Mashnik, S. G., Gudima, K. K., Prael, R. E., Sierk, A.J. Recent developments in LAQGSM, LA-UR-03-7377.

[141] Boudard, A., Cugnon, J., Leray, S., Volant, C. Intranuclear cascade model for a comprehensive description of spallation reaction data. Phys. Rev. C66, 044615 (2002).

[142] Gaimard, J.-J., Schmidt, K.-H. A reexamination of the abrasion-ablation model for the description of the nuclear fragmentation reaction. Nucl. Phys. A531, 709-5 (1991); Jungans, A. R. et al (6 authors). Projectile-fragment yields as a probe for the collective enhancement in the nuclear level density. Nucl. Phys. A629, 635-655 (1998).

[143] F. Rejmund, B. Mustapha, P. Armbruster, J. Benlliure, M. Bernas, A. Boudard, J. P. Dufour, T. Enqvist, R. Legrain, S. Leray, K.-H. Schmidt, C. Stephan, J. Taieb, L. Tassan-Got, and C. Volant, Nucl. Phys. A 683 (2001) 540.

[144] T.Enqvist, P.Ambruster, J.Benlliure, M.Bernas, A.Boudard, S.Czaikowski, R.Legrain, S.Leray, B.Mustapha, M.Pravikoff, F.Rejmund, K.-H.Schmidt, C.Stefan, J.Taieb, L.Tassan-Got, F.Vives, C.Volant, W.Wlazlo. Primary-Residue Production Cross Sections and Kinetic Energy in 1 A GeV ^{208}Pb on Deuteron Reactions, Nucl. Phys., A703 (2002) 435; B. Fernandez, Ph.D. Thesis, University de Caen, France, March 2003.

[145] R. Michel and P. Nagel, International Codes and Model Intercomparison for Intermediate Energy Activation Yields (OECD-NEA, Paris, 1997).

[146] J. Cugnon, Proton-nucleus interaction at high energy, Nucl. Phys., A462 (1987) 751.

[147] J. Cugnon, C. Volant, and S. Vuillier, Nucl. Phys., A620 (1997) 457.

[148] J.-J. Gaimard and K.-H. Schmidt, A reexamination of the abrasion-ablation model for the description of the nuclear fragmentation reaction, Nucl. Phys., A 531 (1991) 709; A. R. Junghans, M. de Jong, H.-G. Clerc, A. V. Ignatyuk, G. A Kudyaev and K.-H. Schmidt, Nucl. Phys., A 629 (1998) 635.

[149] A. V. Ignatyuk, G. N. Smirenkin, M. G. Itkis et al., Studies of the pre-actinides fissility induced by light charged particles, Sov. J. Part. Nucl., 16 (1985) 307.

[150] V. F. Weisskopf and D. H. Ewing, On the yield of nuclear reactions with heavy elements, Phys. Rev., 57 (1940) 935.

[151] L. Dresner, Oak Ridge National Laboratory Report ORNL-TM-196, 1962.

[152] N. Bohr, J. A. Wheeler, The mechanism of nuclear fission, Phys. Rev., 56 (1939) 426.

[153] P. Grange, L. Jun-Qing, H. A. Weidenmuller, Induced nuclear fission viewed as a diffusion process: Transients, Phys. Rev., C 27 (1983) 2063; K. H. Bhatt, P. Grange, B. Hiller. Nuclear friction and lifetime of induced fission, Phys. Rev., C 33 (1986) 954.

[154] H. A. Kramers, Brownian motion in a field of force and the diffusion model of chemical reactions, Physica, 7 (1940) 284.

[155] D. Hilscher and H. Rossner, Dynamic of nuclear fission, Ann. Phys. (Fr.), 17 (1992) 471.

[156] A. V. Ignatyuk, G. A. Kudyaev, A. Junghans, M. de Jong, H.-G. Clerc, K.-H. Schmidt, Analysis of dissipative effects in nuclear fission observed in the fragmentation of ^{238}U projectiles, Nucl. Phys., A 593 (1995) 519.

[157] A. J. Sierk, Macroscopic model of rotating nuclei, Phys. Rev., C 33 (1986) 2039.

[158] F. Atchison, In: Proc. Meeting on Targets for Neutron Beam Spallation Sources (Julich, 1979), Jul-Conf-34 (Kernforschungsanlage, Julich GmbH, 1980).

[159] R. Silberberg, C. H. Tsao, and A. F. Barghouty, Updated partial cross sections of proton-nucleus reactions, Astrophys. J., 501 (1998) 911.

[160] D.E.Groom et al. Summary tables of particle properties, European Phys. Journal, C15 (2000) 1.

[161] A.V.Prokofiev. Compilation and systematics of proton-induced fission cross-section data, Nucl. Instr. Meth., A463 (2001) 557.

[162] L.Audouin. PhD Theses, University Pierre et Marie Curi, Paris, September 2003.

[163] X.Blanchard, J.L.Flament, J.Frehaut, J.Laurec, P.Morel, B.Cordier, N.Diallo and F.Albernhe. In: Proc. Int Conf ADTTA Kalmar, Sweden (1996) edit. H. Conde. p.543

[164] M.M.Meier, D.A.Clark, C.A.Goulding, J.B.McClelland, G.L.Morgan, C.E.Moss, W.B.Amin. Differential neutron production cross sections and neutron yields from stopping-length targets for 113 MeV, Nucl. Sci. Eng., 102 (1989) 310.

[165] X.Ledoux, F.Borne, A.Boudard, et al. Spallation neutron production by 0.8, 1.2 and 1.6 GeV protons on Pb targets, Phys. Rev. Lett., 82 (1999) 4412.

[166] N.Marie et al., In: TRAMU Meeting, Darmstadt, 2003, http:/www.gsi.de/tramu/

[167] Yu.E.Titarenko, V.F.Batyaev, O.V.Shvedov et al., In: Proc. TRAMU Meeting (Darmstadt 2003), http: www.gsi.de/tramu/;

[168] J.R. Letaw et al. Ap. J. Suppl., 51 (1983) 271.

9 List of publications

1. M. Saito, A. Stankovskii, V. Artisyuk, Yu. Korovin, A. Schmelev, and Yu. Titarenko. Radiological Hazard of Spallation Products in Accelerator-Driven Systems. // Jour. Nuc Sci. Eng. 142 (2002) pp. 22-36.

2. O. V. Shvedov, Yu.E.Titarenko, V.F. Batyaev, E. I. Karpikhin, V. M. Zhivun, A. B. Koldobsky, R. D. Mulambetov, D. V. Fischenko, S. V. Kvasova, A. N. Sosnin, S. G. Mashnik, R. E. Prael, A. J. Sierk, T. A. Gabriel, M. Saito, H. Yasuda. Cross Sections for Nuclide Production in 1 GeV Proton-Irradiated ^{208}Pb. // Phys. Rev. C65 (2002) 064610, pp.1-19.

3. Yu.E. Titarenko, V.F. Batyaev, E.I.Karpikhin, V.M.Zhivun, A.B.Koldobsky, R.D. Mulambetov, S.V. Mulambetova, S.G.Mashnik, R.E.Prael. Nuclide Production in ^{197}Au, ^{208}Pb and ^{nat}U Irradiated with 0.8-1 GeV Protons: Comparison with other Experiments and with Theoretical Predictions. // Workshop on Nuclear Data for the Transmutation of Nuclear Waste, September 1-5, 2003 at GSI-Darmstadt, Germany.

4. A.V.Ignatyuk, N.T.Kulagin, V.P.Lunev, Yu.N.Shubin, N.N.Titarenko, V.F.Batyaev, Yu.E.Titarenko, V.M.Zhivun. Analysis of Spallation Residues for Separated Lead Isotopes Irradiated by Protons at Energies 0.15, 1.0 and 2.6 GeV. // Workshop on Nuclear Data for the Transmutation of Nuclear Waste, September 1-5, 2003 at GSI-Darmstadt, Germany.

5. Yu. E. Titarenko, V. F. Batyaev, V. M. Zhivun, E. I. Karpikhin, A. B. Koldobsky, R. D. Mulambetov, S. V. Mulambetova, Yu. V. Trebukhovsky, S. L. Zaitsev, K. A. Lipatov, S. G. Mashnik, and R. E. Prael. Theoretical simulation of residual nuclide products in ^{208,207,206}Pb, ^{nat}Pb and ^{209}Bi(p,x) reactions at inter-medium and high energies. Tenth International Conference on Radiation Shielding (ICRS-10) and Thirteenth Topical Meeting on Radiation Protection and Shielding (RPS-2004) 9-14 May 2004 Funchal (Portugal). Book of abstracts p. 465; LA-UR-04-3274.

6. Yu. E. Titarenko, V. F. Batyaev, V. M. Zhivun,E. I. Karpikhin, A. V. Koldobsky, R. D. Mulambetov, S. V. Mulambetova, Yu. V. Trebukhovsky, S. L. Zaitsev, K. A. Lipatov, and S.G. Mashnik. Experimental study of independent and cumulative product yields in ^{208,207,206,nat}Pb and ^{209}Bi targets irradiated with 0.04-2.6 GeV protons. Proc. of Seventh Meeting Workshop Shielding Aspects at accelerators, Targets and Irradiation Facilities, 17-18 May 2004, Sacavem (Portugal), pp. 103–114, OECD 2005; LA-UR-04-3046, LA-UR-04-3708.

7. Yury E. Titarenko, Vyacheslav F. Batyaev, Valery M. Zhivun, Evgeny I. Karpikhin, Alexander B. Koldobsky, Ruslan D. Mulambetov, Svetlana V. Mulambetova, Yury V. Trebukhovsky, Sergey L. Zaitsev, Konstantin A. Lipatov, Stepan G. Mashnik, Richard E. Prael. Excitation Functions of Products from ^{208,207,206,nat}Pb and ^{209}Bi(p,x) Reactions Measured in the 40–2600 Energy Range and Predicted Theoretically. // International Conference on Nuclear Data for Science and Technology (ND2004), September 26-October 1, 2004, Santa Fe, NM, USA, pp. 1070–1073; Book of abstracts (LA-UR-04-5900) p. 147; LA-UR-04-8090; LA-UR-04-0403

8. A.V. Ignatyuk, N.T. Kulagin, V.P. Lunev, N.N. Titarenko, Yu.N. Shubin, V.F. Batyaev, Yu.E. Titarenko, V.M. Zhivun. Analysis of Spallation and Fission Fragment Residues for Lead Isotopes Irradiated by Protons at Energies 0.15, 1.0 and 2.6 GeV. // International Conference on Nuclear Data for Science and Technology (ND2004), September 26-October 1, 2004, Santa Fe, NM, USA, pp. 1307–1312; Book of abstracts LA-UR-04-5900 p. 258.

9. Yu.E. Titarenko, V.F. Batyaev, V.M. Zhivun, A.B. Koldobsky, Yu.V. Trebukhovsky, E.I. Karpikhin, R.D. Mulambetov, S.V. Mulambetova, Yu.V. Nekrasov, A.Yu Titarenko, K.A. Lipatov, S.G. Mashnik, R.E. Prael, K. Gudima, M. Baznat. Cross Sections for Nuclide Production in 1 GeV Proton-Irradiated ^{208}Pb and 0.8 GeV Proton-Irradiated ^{197}Au. // Imbedded topical AccAppЎ03 (Nuclear Applications of Accelerator Technology) 2003 Annual Meeting of the American Nuclear Society (ANS) in San Diego, 1-5 June 2003, California, USA, pp.839–846; LANL Report LA-UR-03-3401; nucl-ex/0305024.

10 List of contributions at conferences and workshops

10.1 List of conferences

1. Workshop on Nuclear Data for the Transmutation of Nuclear Waste, September 1-5, 2003 at GSI-Darmstadt, Germany.

2. Tenth International Conference on Radiation Shielding (ICRS-10) and Thirteenth Topical Meeting on Radiation Protection and Shielding (RPS-2004) 9-14 May 2004 Funchal (Portugal).

3. Shielding Aspects at accelerators, Targets and Irradiation Facilities Seventh Meetings, 17-18 May 2004, Sacavem (Portugal);

4. International Conference on Nuclear Data for Science and Technology (ND2004), September 26-October 1, 2004, Santa Fe, NM, USA

10.2 List of presentations

1. Yu.E. Titarenko, V.F. Batyaev, E.I.Karpikhin, V.M.Zhivun, A.B.Koldobsky, R.D. Mulambetov, S.V. Mulambetova, S.G.Mashnik, R.E.Prael. Nuclide Production in ^{197}Au, ^{208}Pb and natU Irradiated with 0.8-1 GeV Protons: Comparison with other Experiments and with Theoretical Predictions. // Workshop on Nuclear Data for the Transmutation of Nuclear Waste, September 1-5, 2003 at GSI-Darmstadt, Germany.

2. A.V.Ignatyuk, N.T.Kulagin, V.P.Lunev, Yu.N.Shubin, N.N.Titarenko, V.F.Batyaev, Yu.E.Titarenko, V.M.Zhivun. Analysis of Spallation Residues for Separated Lead Isotopes Irradiated by Protons at Energies 0.15, 1.0 and 2.6 GeV. // Workshop on Nuclear Data for the Transmutation of Nuclear Waste, September 1-5, 2003 at GSI-Darmstadt, Germany.

3. Yu. E. Titarenko, V. F. Batyaev, V. M. Zhivun, E. I. Karpikhin, A. B. Koldobsky, R. D. Mulambetov, S. V. Mulambetova, Yu. V. Trebukhovsky, S. L. Zaitsev, K. A. Lipatov, S. G. Mashnik, and R. E. Prael. Theoretical simulation of residual nuclide products in ^{208,207,206}Pb, ^{nat}Pb and ^{209}Bi(p,x) reactions at inter-medium and high energies. Tenth International Conference on Radiation Shielding (ICRS-10) and Thirteenth Topical Meeting on Radiation Protection and Shielding (RPS-2004) 9-14 May 2004 Funchal (Portugal). Book of abstracts p. 465; LA-UR-04-3274.

4. Yu. E. Titarenko, V. F. Batyaev, V. M. Zhivun,E. I. Karpikhin, A. V. Koldobsky, R. D. Mulambetov, S. V. Mulambetova, Yu. V. Trebukhovsky, S. L. Zaitsev, K. A. Lipatov, and S.G. Mashnik. Experimental study of independent and cumulative product yields in ^{208,207,206,nat}Pb and ^{209}Bi targets irradiated with 0.04-2.6 GeV protons. Proc. of Seventh Meeting Workshop Shielding Aspects at accelerators, Targets and Irradiation Facilities, 17-18 May 2004, Sacavem (Portugal), pp. 103–114, OECD 2005; LA-UR-04-3046, LA-UR-04-3708.

5. Yury E. Titarenko, Vyacheslav F. Batyaev, Valery M. Zhivun, Evgeny I. Karpikhin, Alexander B. Koldobsky, Ruslan D. Mulambetov, Svetlana V. Mulambetova, Yury V. Trebukhovsky, Sergey L. Zaitsev, Konstantin A. Lipatov, Stepan G. Mashnik, Richard E. Prael. Excitation Functions of Products from ^{208,207,206,nat}Pb and ^{209}Bi(p,x) Reactions Measured in the 40–2600 Energy Range and Predicted Theoretically. // International Conference on Nuclear Data for Science and Technology (ND2004), September 26-October 1, 2004, Santa Fe, NM, USA, pp. 1070–1073; Book of abstracts (LA-UR-04-5900) p. 147; LA-UR-04-8090; LA-UR-04-0403

6. A.V. Ignatyuk, N.T. Kulagin, V.P. Lunev, N.N. Titarenko, Yu.N. Shubin, V.F. Batyaev, Yu.E. Titarenko, V.M. Zhivun. Analysis of Spallation and Fission Fragment Residues for Lead Isotopes Irradiated by Protons at Energies 0.15, 1.0 and 2.6 GeV. // International Conference on Nuclear Data for Science and Technology (ND2004), September 26-October 1, 2004, Santa Fe, NM, USA, pp. 1307–1312; Book of abstracts LA-UR-04-5900 p. 258.

7. Yu.E. Titarenko, V.F. Batyaev, V.M. Zhivun, A.B. Koldobsky, Yu.V. Trebukhovsky, E.I. Karpikhin, R.D. Mulambetov, S.V. Mulambetova, Yu.V. Nekrasov, A.Yu Titarenko, K.A. Lipatov, S.G. Mashnik, R.E. Prael, K. Gudima, M. Baznat. Cross Sections for Nuclide Production in 1 GeV Proton-Irradiated ^{208}Pb and 0.8 GeV Proton-Irradiated ^{197}Au. // Imbedded topical AccAppЎ03 (Nuclear Applications of Accelerator Technology) 2003 Annual Meeting of the American Nuclear Society (ANS) in San Diego, 1-5 June 2003, California, USA, pp.839–846; LANL Report LA-UR-03-3401; nucl-ex/0305024.

10.3 List of workshops

	Workshop	Presentation title
1	BASTRA Cluster Meeting of EC funded FP5 projects, CERN, Geneva, Switzerland, December 5, 2001	ISTC Project #2002: Experimental and theoretical studies of the yields of residual product nuclei produced in thin Pb and Bi targets irradiated by 40-2600 MeV protons
2	Second BASTRA Cluster Meeting at Uppsala University, Uppsala,12 September 2002	The ISTC Projects #2002 and 2405 differential and integral nuclear data experiments relevant for waste transmutation
3	ADS R&D Workshop, Minsk, Belarus, 27 May 2003	The ADS-related experimental activity at ITEP
4	IAEA Training workshop YTechnology and Applications of ADS¥, Trieste, Italy, 13-17 October 2003	The ADS-related experimental activity at ITEP
5	ENEA Centre in Casaccia, Rome, Italy, Oct 21, 2003	Prolongation of the ISTC project #2002. Support for data measurements for the TRADE Project by Russian ISTC groups
6	ADS-related ISTC Projects Meeting at Moscow, 24 January 2004	ISTC Project #2002: current status and results
7	ADS-related ISTC Projects Meeting at Moscow, 24 January 2004	Prolongation of #2002 Џ collaborative effort with TRADE
8	IAEA Technical Meeting on ADS XS libraries, Vienna, Austria, 15-17 December 2004.	ITEP potential for ADS XS library creation

11 Co-operation with Foreign Collaborators

1. S. Mashnik carryied out the nuclide production yield simulation via the CEM03 and LAQGSM+GEM2 codes.

2. A. Boudard delivered the INCL4+ABLA to be used in the Project simulations (October 2003) and gave useful remarks on the code results (April 2004).

3. The preliminary results of the project were sent to:

- C.H.M. Broeders ^{nat}Pb 600MeV (February 2003) who used them under the MEGAPIE and PDS-XADS projects;

- E. Gonzales (March 2004);

- K.H. Schmidt (technical report draft was sent in December 2004);

- W. Gudowski (technical report draft was given in December 2004);

4. S.Leray, R.Michel, C.H.M. Broeders, S. Mashnik, H. Ait-Abderhamid, T.Fukahory, E.Pitcher, W. Gudowski, P. Ferguson, N. Hertel: the working plan of the project proposal ISTC#3266 was coordinated (January - March 2005)

12 Appendix 1. Detailed calculation of nuclide production rates.

12.1 Detailed calculation of nuclide production rates for ^{206}Pb, ^{207}Pb, ^{208}Pb, ^{nat}Pb and ^{209}Bi for $E_p = 0.04$ GeV

12.1.1 Nuclide production rates for ^{206}Pb

Table 45: Detailed calculation of nuclide production rates for ^{206}Pb for $E_p = 0.04$ GeV, used to determine the cross sections for their production.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{206}Bi	i	6.243D	1878.7	2.01 ± 0.05	56.55 ± 2.83
			1718.7	31.8 ± 0.6	58.60 ± 2.33
			1595.3	5.01 ± 0.08	67.13 ± 3.48
			1098.3	13.50 ± 0.21	54.10 ± 2.07
			1018.6	7.60 ± 0.11	59.37 ± 2.21
			881.0	66.2 ± 1.0	60.83 ± 2.23
			803.1	98.9 ± 1.4	56.77 ± 2.06
			657.2	1.91 ± 0.04	57.63 ± 2.93
			632.2	4.47 ± 0.07	53.17 ± 2.39
			537.5	30.5 ± 0.5	50.31 ± 2.23
			516.2	40.7 ± 0.6	54.17 ± 2.18
			497.1	15.31 ± 0.22	52.74 ± 2.36
			398.0	10.74 ± 0.15	51.66 ± 1.96
			343.5	23.4 ± 0.4	54.15 ± 2.11
			262.7	3.02 ± 0.06	52.77 ± 4.86
			184.0	15.8 ± 0.4	61.85 ± 2.87
				RR_{mean} =	**55.91 ± 1.96**
^{205}Bi	i	15.31D	1903.4	2.47 ± 0.04	260.7 ± 11.5
			1861.7	6.17 ± 0.10	260.9 ± 10.4
			1775.8	3.99 ± 0.08	267.1 ± 11.1
			1764.3	32.5 ± 0.7	267.2 ± 11.0
			1614.3	2.28 ± 0.04	276.2 ± 11.2
			1190.0	2.26 ± 0.07	265.3 ± 12.5
			1043.8	7.51 ± 0.10	242.0 ± 8.6
			987.7	16.13 ± 0.17	260.8 ± 9.1
			703.5	31.1 ± 0.1	243.9 ± 8.4
			579.8	5.44 ± 0.07	237.4 ± 8.9
			570.6	4.34 ± 0.07	228.2 ± 8.6
			549.8	2.95 ± 0.04	219.8 ± 8.2
			284.1	1.69 ± 0.02	245.5 ± 10.6
			260.5	1.09 ± 0.04	237.1 ± 15.0
				RR_{mean} =	**246.5 ± 8.8**
^{204}Bi	i	11.22H	1755.3	1.22 ± 0.12	643.5 ± 70.0
			1211.7	3.0 ± 0.4	563.6 ± 78.4
			984.0	59 ± 4	617.1 ± 46.5
			918.3	10.8 ± 0.9	694.0 ± 62.2
			899.2	98 ± 9	590.0 ± 19.4
			791.2	3.3 ± 0.3	776.7 ± 75.5

Continuation of Table 45.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			670.7	11.4 ± 0.9	646.4 ± 55.5
			374.8	82 ± 5	695.9 ± 145.1
			176.1	1.12 ± 0.09	799.9 ± 71.7
				RR_{mean} =	**593.2 ± 18.3**
^{203}Bi	i(m+g)	11.76H	2011.0	1.76 ± 0.09	1901 ± 121
			1983.0	0.88 ± 0.05	1997 ± 137
			1893.0	8.2 ± 0.6	1963 ± 160
			1888.0	1.94 ± 0.10	1977 ± 125
			1847.3	11.4 ± 0.8	1882 ± 148
			1719.6	3.40 ± 0.23	1836 ± 142
			1679.6	8.8 ± 0.7	1889 ± 164
			1536.5	7.5 ± 0.6	1920 ± 167
			1506.7	3.7 ± 0.3	1854 ± 163
			1034.0	8.8 ± 0.5	1922 ± 126
			896.8	13.1 ± 0.7	1935 ± 121
			820.2	29.6 ± 1.5	1974 ± 119
			816.3	4.03 ± 0.21	1991 ± 123
			722.4	4.8 ± 0.4	1985 ± 178
			569.3	1.22 ± 0.07	2100 ± 142
			279.2	*	1936 ± 71
			264.2	5.2 ± 0.4	1944 ± 167
			186.6	3.11 ± 0.22	2200 ± 177
				RR_{mean} =	**1939 ± 60.**
^{202}Bi	i	1.72H	960.7	99.28 ± 0.02	1.486 ± 0.439
			657.5	60.6 ± 1.8	1.491 ± 0.366
			422.1	83.7 ± 2.5	2.084 ± 0.297
				RR_{mean} =	**1.775 ± 0.217**
$^{204m}Pb_i$	i(m)	67.2M	899.2	99.17 ± 0.02	71.17 ± 2.75
			374.7	89 ± 15	76.16 ± 13.18
				RR_{mean} =	**71.25 ± 2.75**
$^{204m}Pb_c$	c	67.2M	899.2	99.17 ± 0.02	159.6 ± 5.4
			374.7	89 ± 15	163.5 ± 28.1
				RR_{mean} =	**159.7 ± 5.4**
$^{203}Pb_i$	i(m1+m2+g)	51.873H	279.2	80.8 ± 0.2	**70.88 ± 6.48**
$^{203}Pb_c$	c	51.873H	279.2	80.8 ± 0.2	**2007 ± 73.**
^{202m}Pb	i(m)	3.53H	960.7	92 ± 8	**1.569 ± 0.596**
^{202}Tl	c	12.23D	439.6	91.4 ± 1.0	**10.63 ± 0.39**
^{201}Tl	c*	72.912H	167.4	10.00 ± 0.06	**13.44 ± 0.74**

12.1.2 Nuclide production rates for ^{207}Pb

Table 46: Detailed calculation of nuclide production rates for ^{207}Pb for $E_p = 0.04$ GeV, used to determine the cross sections for their production.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{207}Bi	i	31.55Y	1063.7	74.5 ± 0.2	**63.71 ± 6.87**
^{206}Bi	i	6.243D	1878.7	2.01 ± 0.05	189.7 ± 8.6
			1718.7	31.8 ± 0.6	185.9 ± 7.3
			1595.3	5.01 ± 0.08	199.1 ± 7.7

Continuation of Table 46.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			1098.3	13.50 ± 0.21	172.6 ± 6.5
			1018.6	7.60 ± 0.11	187.8 ± 6.9
			881.0	66.2 ± 1.0	183.4 ± 6.6
			803.1	98.9 ± 1.4	176.2 ± 6.3
			657.2	1.91 ± 0.04	177.3 ± 7.5
			632.2	4.47 ± 0.07	168.0 ± 6.3
			620.5	5.76 ± 0.09	164.8 ± 6.7
			537.5	30.5 ± 0.5	159.9 ± 6.2
			516.2	40.7 ± 0.6	170.9 ± 6.4
			497.1	15.31 ± 0.22	162.3 ± 6.1
			398.0	10.74 ± 0.15	164.4 ± 6.1
			343.5	23.4 ± 0.4	167.0 ± 6.3
			262.7	3.02 ± 0.06	173.6 ± 8.1
			184.0	15.8 ± 0.4	193.4 ± 8.7
				RR_{mean} =	**174.2 ± 6.0**
^{205}Bi	i	15.31D	1903.4	2.47 ± 0.04	717.6 ± 28.2
			1861.7	6.17 ± 0.10	725.5 ± 28.4
			1775.8	3.99 ± 0.08	735.0 ± 29.4
			1764.3	32.5 ± 0.7	741.6 ± 30.0
			1614.3	2.28 ± 0.04	776.0 ± 31.0
			1190.0	2.26 ± 0.07	718.2 ± 32.8
			1043.8	7.51 ± 0.10	667.6 ± 23.7
			987.7	16.13 ± 0.17	722.1 ± 24.8
			703.5	31.1 ± 0.1	675.0 ± 22.6
			579.8	5.44 ± 0.07	649.7 ± 23.7
			570.6	4.34 ± 0.07	629.0 ± 23.8
				RR_{mean} =	**691.4 ± 24.6**
^{204}Bi	i	11.22H	1755.3	1.22 ± 0.12	2047 ± 214
			1652.1	0.56 ± 0.08	2081 ± 308
			1211.7	3.0 ± 0.4	1769 ± 243
			1043.6	1.27 ± 0.17	1814 ± 256
			984.0	59 ± 4	1847 ± 139
			918.3	10.8 ± 0.9	2101 ± 188
			899.2	98 ± 9	2051 ± 200
			791.2	3.3 ± 0.3	2176 ± 211
			670.7	11.4 ± 0.9	1946 ± 167
			374.8	82 ± 5	2070 ± 144
			176.1	1.12 ± 0.09	2541 ± 226
				RR_{mean} =	**2025 ± 84.**
^{203}Bi	i(m+g)	11.76H	2011.0	1.76 ± 0.09	131.3 ± 11.7
			1983.0	0.88 ± 0.05	124.8 ± 13.2
			1893.0	8.2 ± 0.6	105.4 ± 8.9
			1888.0	1.94 ± 0.10	113.0 ± 8.2
			1847.3	11.4 ± 0.8	88.91 ± 7.12
			1679.6	8.8 ± 0.7	86.13 ± 7.66
			1536.5	7.5 ± 0.6	207.2 ± 18.4
			1506.7	3.7 ± 0.3	81.35 ± 8.78
			1034.0	8.8 ± 0.5	91.24 ± 6.32
			896.8	13.1 ± 0.7	79.42 ± 6.15
			820.2	29.6 ± 1.5	124.5 ± 7.6
			816.3	4.03 ± 0.21	103.4 ± 10.3

Continuation of Table 46.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			722.4	4.8 ± 0.4	97.58 ± 10.11
			279.2	*	91.47 ± 3.77
			264.2	5.2 ± 0.4	101.7 ± 9.4
			186.6	3.11 ± 0.22	109.8 ± 10.4
				RR_{mean} =	**93.14 ± 2.87**
$^{203}Pb_i$	i(m1+m2+g)	51.873H	279.2	80.8 ± 0.2	**9.536 ± 2.213**
$^{203}Pb_c$	c	51.873H	279.2	80.8 ± 0.2	**101.0 ± 3.7**
^{202}Tl	c	12.23D	439.6	91.4 ± 1.0	**9.797 ± 0.355**
^{203}Hg	c	46.612D	279.2	81.46 ± 0.13	**0.1918 ± 0.1310**

12.1.3 Nuclide production rates for ^{208}Pb

Table 47: Detailed calculation of nuclide production rates for ^{208}Pb for $E_p = 0.04$ GeV, used to determine the cross sections for their production.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{207}Bi	i	31.55Y	1063.7	74.5 ± 0.2	**174.2 ± 6.5**
^{206}Bi	i	6.243D	1878.7	2.01 ± 0.05	414.2 ± 18.3
			1718.7	31.8 ± 0.6	408.0 ± 16.0
			1595.3	5.01 ± 0.08	414.4 ± 16.0
			1098.3	13.50 ± 0.21	377.9 ± 14.8
			1018.6	7.60 ± 0.11	414.9 ± 15.0
			881.0	66.2 ± 1.0	398.6 ± 14.4
			803.1	98.9 ± 1.4	382.5 ± 13.7
			657.2	1.91 ± 0.04	373.1 ± 15.7
			632.2	4.47 ± 0.07	384.6 ± 16.3
			620.5	5.76 ± 0.09	364.7 ± 15.4
			537.5	30.5 ± 0.5	353.6 ± 13.7
			516.2	40.7 ± 0.6	375.4 ± 14.1
			497.1	15.31 ± 0.22	355.1 ± 13.7
			398.0	10.74 ± 0.15	359.8 ± 13.9
			343.5	23.4 ± 0.4	367.4 ± 14.2
			262.7	3.02 ± 0.06	408.4 ± 19.9
			184.0	15.8 ± 0.4	424.5 ± 19.2
				RR_{mean} =	**383.4 ± 13.0**
^{205}Bi	i	15.31D	1903.4	2.47 ± 0.04	2170 ± 85
			1861.7	6.17 ± 0.10	2201 ± 85
			1775.8	3.99 ± 0.08	2218 ± 91
			1764.3	32.5 ± 0.7	2256 ± 91
			1614.3	2.28 ± 0.04	2312 ± 88
			1190.0	2.26 ± 0.07	2141 ± 99
			1043.8	7.51 ± 0.10	2013 ± 72
			987.7	16.13 ± 0.17	2136 ± 74
			703.5	31.1 ± 0.1	2040 ± 68
			579.8	5.44 ± 0.07	1970 ± 72
			570.6	4.34 ± 0.07	1941 ± 74
			549.8	2.95 ± 0.04	1850 ± 70
			284.1	1.69 ± 0.02	2033 ± 80
			260.5	1.09 ± 0.04	1974 ± 106

Continuation of Table 47.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
				$RR_{mean} =$	**2063 ± 72.**
^{204}Bi	i	11.22H	1755.3	1.22 ± 0.12	74.67 ± 8.21
			1652.1	0.56 ± 0.08	83.46 ± 13.53
			1211.7	3.0 ± 0.4	75.52 ± 10.60
			1043.6	1.27 ± 0.17	122.7 ± 26.1
			984.0	59 ± 4	85.98 ± 6.49
			918.3	10.8 ± 0.9	96.62 ± 8.70
			899.2	98 ± 9	96.83 ± 9.46
			791.2	3.3 ± 0.3	87.15 ± 8.75
			670.7	11.4 ± 0.9	90.92 ± 7.84
			374.8	82 ± 5	97.30 ± 6.80
			176.1	1.12 ± 0.09	111.8 ± 10.2
				$RR_{mean} =$	**90.82 ± 4.19**
^{203}Bi	i(m+g)	11.76H	2011.0	1.76 ± 0.09	17.16 ± 1.52
			1893.0	8.2 ± 0.6	17.62 ± 1.48
			1888.0	1.94 ± 0.10	16.55 ± 1.44
			1847.3	11.4 ± 0.8	16.85 ± 1.37
			1679.6	8.8 ± 0.7	15.25 ± 1.40
			1536.5	7.5 ± 0.6	25.10 ± 2.29
			1506.7	3.7 ± 0.3	16.74 ± 1.81
			1034.0	8.8 ± 0.5	16.12 ± 1.11
			896.8	13.1 ± 0.7	17.99 ± 1.25
			820.2	29.6 ± 1.5	18.43 ± 1.14
			816.3	4.03 ± 0.21	16.03 ± 1.18
			722.4	4.8 ± 0.4	19.84 ± 2.01
			279.2	*	18.28 ± 0.69
			264.2	5.2 ± 0.4	17.73 ± 1.61
			186.6	3.11 ± 0.22	19.75 ± 1.73
				$RR_{mean} =$	**18.19 ± 0.56**
$^{203}Pb_i$	i(m1+m2+g)	51.873H	279.2	80.8 ± 0.2	**0.6482 ± 0.1393**
$^{203}Pb_c$	c	51.873H	279.2	80.8 ± 0.2	**18.93 ± 0.70**
^{202}Tl	c	12.23D	439.6	91.4 ± 1.0	**0.9223 ± 0.0869**

12.1.4 Nuclide production rates for ^{nat}Pb

Table 48: Detailed calculation of nuclide production rates for ^{nat}Pb for $E_p = 0.04$ GeV, used to determine the cross sections for their production.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{207}Bi	i	31.55Y	1063.7	74.5 ± 0.2	**71.24 ± 2.93**
^{206}Bi	i	6.243D	1878.7	2.01 ± 0.05	194.6 ± 8.7
			1718.7	31.8 ± 0.6	194.7 ± 7.6
			1595.3	5.01 ± 0.08	204.5 ± 7.9
			1018.6	7.60 ± 0.11	193.9 ± 7.0
			881.0	66.2 ± 1.0	189.6 ± 6.8
			803.1	98.9 ± 1.4	182.4 ± 6.5
			657.2	1.91 ± 0.04	189.4 ± 7.9
			632.2	4.47 ± 0.07	177.1 ± 7.0
			620.5	5.76 ± 0.09	168.2 ± 6.3

Continuation of Table 48.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			537.5	30.5 ± 0.5	166.9 ± 6.3
			516.2	40.7 ± 0.6	177.5 ± 6.6
			497.1	15.31 ± 0.22	168.2 ± 6.3
			398.0	10.74 ± 0.15	169.8 ± 6.2
			343.5	23.4 ± 0.4	173.7 ± 6.5
			262.7	3.02 ± 0.06	182.2 ± 8.3
			184.0	15.8 ± 0.4	201.6 ± 9.2
				RR_{mean} =	**180.5 ± 6.3**
^{205}Bi	i	15.31D	1861.7	6.17 ± 0.10	980.0 ± 37.9
			1775.8	3.99 ± 0.08	998.2 ± 39.8
			1764.3	32.5 ± 0.7	993.8 ± 40.2
			1614.3	2.28 ± 0.04	1038 ± 40
			1190.0	2.26 ± 0.07	967.2 ± 44.2
			1043.8	7.51 ± 0.10	899.0 ± 31.8
			987.7	16.13 ± 0.17	971.3 ± 33.3
			703.5	31.1 ± 0.1	908.6 ± 30.2
			579.8	5.44 ± 0.07	879.0 ± 32.0
			570.6	4.34 ± 0.07	849.6 ± 32.0
			549.8	2.95 ± 0.04	823.2 ± 30.3
			284.1	1.69 ± 0.02	905.8 ± 35.3
			260.5	1.09 ± 0.04	882.7 ± 46.8
				RR_{mean} =	**917.5 ± 32.7**
^{204}Bi	i	11.22H	1755.3	1.22 ± 0.12	398.1 ± 42.4
			1652.1	0.56 ± 0.08	502.9 ± 76.2
			1211.7	3.0 ± 0.4	396.2 ± 54.7
			1043.6	1.27 ± 0.17	478.0 ± 68.4
			984.0	59 ± 4	407.6 ± 30.7
			918.3	10.8 ± 0.9	459.3 ± 41.2
			899.2	98 ± 9	396.0 ± 13.0
			791.2	3.3 ± 0.3	475.9 ± 46.5
			670.7	11.4 ± 0.9	431.0 ± 37.0
			374.8	82 ± 5	476.1 ± 99.3
			176.1	1.12 ± 0.09	538.9 ± 48.2
				RR_{mean} =	**398.5 ± 12.3**
^{203}Bi	i(m+g)	11.76H	2011.0	1.76 ± 0.09	354.3 ± 22.8
			1983.0	0.88 ± 0.05	354.8 ± 24.8
			1893.0	8.2 ± 0.6	355.0 ± 29.0
			1888.0	1.94 ± 0.10	351.6 ± 22.4
			1847.3	11.4 ± 0.8	338.2 ± 26.6
			1679.6	8.8 ± 0.7	335.9 ± 29.2
			1536.5	7.5 ± 0.6	368.2 ± 32.1
			1506.7	3.7 ± 0.3	336.6 ± 29.7
			1034.0	8.8 ± 0.5	341.1 ± 22.5
			896.8	13.1 ± 0.7	339.8 ± 21.4
			820.2	29.6 ± 1.5	361.4 ± 21.9
			816.3	4.03 ± 0.21	355.4 ± 22.1
			722.4	4.8 ± 0.4	355.6 ± 32.1
			401.3	*	327.7 ± 18.2
			279.2	*	356.0 ± 13.1
			264.2	5.2 ± 0.4	358.4 ± 30.9
			186.6	3.11 ± 0.22	391.4 ± 31.6

Continuation of Table 48.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
				RR_{mean} =	**351.7 ± 10.8**
^{202}Bi	i	1.72H	960.7	99.28 ± 0.02	9.510 ± 0.354
			657.5	60.6 ± 1.8	8.925 ± 0.514
				RR_{mean} =	**9.408 ± 0.365**
^{201}Bi	i	108M	1650.9	5.8 ± 1.3	15.89 ± 4.33
			629.1	24 ± 6	14.60 ± 3.71
			331.2	*	14.88 ± 1.28
				RR_{mean} =	**14.90 ± 0.46**
$^{204m}Pb_i$	i(m)	67.2M	899.2	99.17 ± 0.02	15.82 ± 1.15
			374.7	89 ± 15	15.30 ± 2.75
				RR_{mean} =	**15.75 ± 1.09**
$^{204m}Pb_c$	c	67.2M	899.2	99.17 ± 0.02	75.19 ± 2.62
			374.7	89 ± 15	75.03 ± 12.92
				RR_{mean} =	**75.19 ± 2.62**
$^{203}Pb_i$	i(m1+m2+g)	51.873H	279.2	80.8 ± 0.2	**15.81 ± 1.63**
$^{203}Pb_c$	c	51.873H	279.2	80.8 ± 0.2	**371.8 ± 13.6**
$^{201}Pb_i$	i(m+g)	9.33H	331.2	79 ± 5	**1.614 ± 0.749**
$^{201}Pb_c$	c	9.33H	331.2	79 ± 5	**16.50 ± 1.20**
^{202}Tl	c	12.23D	439.6	91.4 ± 1.0	**3.560 ± 0.132**
^{201}Tl	c*	72.912H	167.4	10.00 ± 0.06	**20.03 ± 0.84**
^{203}Hg	c	46.612D	279.2	81.46 ± 0.13	**0.06505 ± 0.03477**

12.1.5 Nuclide production rates for ^{209}Bi

Table 49: Detailed calculation of nuclide production rates for ^{209}Bi for $E_p = 0.04$ GeV, used to determine the cross sections for their production.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{207}Po	i(m+g)	5.80H	2060.2	1.32 ± 0.09	488.6 ± 38.5
			1662.7	0.32 ± 0.04	549.5 ± 72.4
			1372.4	1.22 ± 0.03	592.1 ± 25.4
			1360.4	0.57 ± 0.07	515.9 ± 66.3
			1148.3	5.72 ± 0.12	544.8 ± 21.9
			992.3	59.3 ± 0.9	517.4 ± 18.8
			947.9	1.17 ± 0.06	583.3 ± 36.2
			911.8	17.0 ± 0.3	535.4 ± 20.1
			892.3	0.37 ± 0.02	536.5 ± 37.3
			742.6	28.2 ± 0.5	545.6 ± 20.6
			687.6	1.82 ± 0.06	526.3 ± 25.2
			629.8	1.34 ± 0.04	515.4 ± 23.9
			405.8	9.7 ± 0.6	552.2 ± 39.1
			369.5	1.73 ± 0.06	550.4 ± 27.0
			345.3	2.01 ± 0.06	559.2 ± 25.5
			307.6	0.56 ± 0.04	596.3 ± 48.5
			297.4	0.95 ± 0.02	537.2 ± 23.7
			249.6	1.60 ± 0.09	544.7 ± 37.8
				RR_{mean} =	**538.6 ± 17.4**
^{206}Po	i	8.8D	1878.7	*	2246 ± 101
			1718.7	*	2238 ± 89

Continuation of Table 49.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			1595.3	*	2231 ± 87
			1405.0	*	2210 ± 93
			1190.9	0.47 ± 0.07	2264 ± 347
			1114.5	0.29 ± 0.05	2228 ± 393
			1098.3	*	2100 ± 79
			1032.3	33 ± 5	2142 ± 332
			1007.2	3.1 ± 0.4	2010 ± 268
			980.2	7.1 ± 0.9	2096 ± 275
			902.5	0.25 ± 0.04	2280 ± 376
			895.1	*	2208 ± 81
			881.0	*	2154 ± 79
			860.9	3.5 ± 0.5	2054 ± 301
			818.2	1.04 ± 0.14	2203 ± 306
			807.4	23 ± 3	2066 ± 278
			803.1	*	2090 ± 76
			784.6	*	2119 ± 99
			677.7	1.47 ± 0.20	2060 ± 289
			668.8	0.86 ± 0.12	2095 ± 301
			632.2	*	2109 ± 81
			620.5	*	2006 ± 81
			579.8	1.06 ± 0.14	1942 ± 265
			554.6	1.56 ± 0.21	1988 ± 276
			537.5	*	1923 ± 76
			522.5	15.7 ± 2.0	2021 ± 267
			516.2	*	1990 ± 76
			497.1	*	1988 ± 76
			469.0	0.26 ± 0.04	1974 ± 315
			463.4	1.79 ± 0.24	2042 ± 283
			457.8	0.15 ± 0.02	1733 ± 265
			398.0	*	1971 ± 76
			381.2	0.18 ± 0.03	2232 ± 328
			369.1	0.17 ± 0.03	2211 ± 334
			354.9	0.39 ± 0.06	1922 ± 304
			343.5	*	2019 ± 80
			338.4	19.2 ± 2.5	2181 ± 293
			311.6	4.2 ± 0.6	2245 ± 330
			286.4	24 ± 3	2217 ± 289
			281.9	0.84 ± 0.11	1948 ± 265
			262.7	*	2192 ± 99
			184.0	*	2328 ± 111
				RR_{mean} =	**2094 ± 65.**
^{205}Po	i	1.66H	1239.1	4.6 ± 0.4	17.63 ± 1.75
			1001.2	28.8 ± 2.2	17.95 ± 1.51
			872.4	37 ± 2	18.43 ± 1.19
			849.8	25.5 ± 2.1	18.86 ± 1.71
			836.8	19.2 ± 1.6	19.02 ± 1.74
			261.0	4.0 ± 0.4	15.40 ± 1.83
				RR_{mean} =	**18.33 ± 0.62**
^{207}Bi	c	31.55Y	1770.2	6.87 ± 0.04	800.4 ± 34.8
			1063.7	74.5 ± 0.2	789.6 ± 26.5
			569.7	97.74 ± 0.03	793.0 ± 27.2

Continuation of Table 49.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
				RR_{mean} =	**792.0 ± 25.5**
$^{206}Bi_i$	i	6.243D	1718.7	31.8 ± 0.6	50.98 ± 2.31
			1595.3	5.01 ± 0.08	59.20 ± 4.86
			1405.0	1.43 ± 0.03	59.86 ± 8.10
			1098.3	13.50 ± 0.21	57.87 ± 3.81
			895.1	15.66 ± 0.23	47.51 ± 2.36
			881.0	66.2 ± 1.0	53.01 ± 2.23
			803.1	98.9 ± 1.4	54.19 ± 2.73
			784.6	0.54 ± 0.01	69.30 ± 31.57
			632.2	4.47 ± 0.07	45.35 ± 4.60
			620.5	5.76 ± 0.09	49.12 ± 7.38
			537.5	30.5 ± 0.5	61.85 ± 5.14
			516.2	40.7 ± 0.6	66.51 ± 5.73
			497.1	15.31 ± 0.22	61.56 ± 4.10
			398.0	10.74 ± 0.15	61.60 ± 5.58
			343.5	23.4 ± 0.4	68.27 ± 5.79
			262.7	3.02 ± 0.06	67.40 ± 7.07
			184.0	15.8 ± 0.4	61.62 ± 3.84
				RR_{mean} =	**53.96 ± 2.15**
$^{206}Bi_c$	c	6.243D	1878.7	2.01 ± 0.05	2166 ± 94
			1718.7	31.8 ± 0.6	2166 ± 84
			1595.3	5.01 ± 0.08	2167 ± 82
			1405.0	1.43 ± 0.03	2149 ± 87
			1098.3	13.50 ± 0.21	2042 ± 75
			895.1	15.66 ± 0.23	2134 ± 76
			881.0	66.2 ± 1.0	2089 ± 75
			803.1	98.9 ± 1.4	2029 ± 73
			784.6	0.54 ± 0.01	2072 ± 90
			632.2	4.47 ± 0.07	2038 ± 76
			620.5	5.76 ± 0.09	1945 ± 75
			537.5	30.5 ± 0.5	1879 ± 72
			516.2	40.7 ± 0.6	1947 ± 73
			497.1	15.31 ± 0.22	1941 ± 73
			398.0	10.74 ± 0.15	1924 ± 72
			343.5	23.4 ± 0.4	1976 ± 76
			262.7	3.02 ± 0.06	2138 ± 93
			184.0	15.8 ± 0.4	2261 ± 104
				RR_{mean} =	**2037 ± 67.**
^{205}Bi	c	15.31D	1861.7	6.17 ± 0.10	22.88 ± 1.06
			1764.3	32.5 ± 0.7	25.58 ± 1.15
			987.7	16.13 ± 0.17	23.77 ± 1.08
			703.5	31.1 ± 0.1	20.73 ± 0.89
				RR_{mean} =	**22.82 ± 1.26**
^{204m}Pb	i(m)	67.2M	899.2	99.17 ± 0.02	5.980 ± 0.212
			374.7	89 ± 15	6.933 ± 1.194
				RR_{mean} =	**5.987 ± 0.212**
^{203}Pb	c*	51.873H	279.2	80.8 ± 0.2	**2.474 ± 0.107**
^{103}Ru	c	39.26D	497.1	91.0 ± 1.3	**0.8249 ± 0.0853**
$^{95}Nb_i$	i(m+g)	34.975D	765.8	99.81 ± 0.03	**0.1227 ± 0.0040**
$^{95}Nb_c$	c	34.975D	765.8	99.81 ± 0.03	**0.6901 ± 0.0226**
^{95}Zr	c	64.02D	765.8	*	0.5726 ± 0.0188

Continuation of Table 49.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			756.7	54.46 ± 0.10	0.5808 ± 0.0514
				RR_{mean} =	**0.5727 ± 0.0177**

12.1.6 Nuclide production rates for ^{27}Al

Table 50: Detailed calculation of nuclide production rates for in ^{27}Al-monitors and ^{27}Al-plates for E_p = 0.04 GeV, used for calculating proton flux (including total over the plate area), cross sections for production of ^{7}Be, ^{24}Naand neutron background.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			^{27}Al-monitor for ^{206}Pb		
^{7}Be	i	53.29D	477.6	10.52 ± 0.06	**0.3581 ± 0.0685**
^{27}Mg	c	9.458M	843.8	71.8 ± 0.4	0.1669 ± 0.0084
			1014.4	28.0 ± 0.4	0.1677 ± 0.0145
				RR_{mean} =	**0.1670 ± 0.0079**
^{22}Na	c	2.6019Y	1274.5	99.94 ± 0.01	**58.62 ± 1.98**
^{24}Na	c	14.9590H	1369.0	100 ± 0	**1.654 ± 0.056**
			^{27}Al-plate for ^{206}Pb		
^{24}Na	c	14.9590H	1369.0	100 ± 0	**0.1691 ± 0.0059**
			^{27}Al-monitor for ^{207}Pb		
^{7}Be	i	53.29D	477.6	10.52 ± 0.06	**0.4402 ± 0.0674**
^{27}Mg	c	9.458M	843.8	71.8 ± 0.4	0.1733 ± 0.0069
			1014.4	28.0 ± 0.4	0.1774 ± 0.0101
				RR_{mean} =	**0.1741 ± 0.0066**
^{22}Na	c	2.6019Y	1274.5	99.94 ± 0.01	**60.49 ± 2.04**
^{24}Na	c	14.9590H	1369.0	100 ± 0	**1.737 ± 0.058**
			^{27}Al-plate for ^{207}Pb		
^{24}Na	c	14.9590H	1369.0	100 ± 0	**0.1693 ± 0.0058**
			^{27}Al-monitor for ^{207}Pb		
^{7}Be	i	53.29D	477.6	10.52 ± 0.06	**0.3851 ± 0.1341**
^{27}Mg	c	9.458M	843.8	71.8 ± 0.4	0.1613 ± 0.0074
			1014.4	28.0 ± 0.4	0.1663 ± 0.0090
				RR_{mean} =	**0.1631 ± 0.0067**
^{22}Na	c	2.6019Y	1274.5	99.94 ± 0.01	**55.31 ± 1.87**
^{24}Na	c	14.9590H	1369.0	100 ± 0	**1.565 ± 0.053**
			^{27}Al-plate for ^{207}Pb		
^{24}Na	c	14.9590H	1369.0	100 ± 0	**0.1782 ± 0.0062**
			^{27}Al-monitor for ^{nat}Pb		
^{7}Be	i	53.29D	477.6	10.52 ± 0.06	**0.2313 ± 0.0320**
^{27}Mg	c	9.458M	843.8	71.8 ± 0.4	0.1129 ± 0.0044
			1014.4	28.0 ± 0.4	0.1196 ± 0.0069
				RR_{mean} =	**0.1141 ± 0.0043**
^{22}Na	c	2.6019Y	1274.5	99.94 ± 0.01	**36.03 ± 1.21**
^{24}Na	c	14.9590H	1369.0	100 ± 0	**0.9787 ± 0.0329**
			^{27}Al-plate for ^{nat}Pb		
^{24}Na	c	14.9590H	1369.0	100 ± 0	**0.1056 ± 0.0036**
			^{27}Al-monitor for ^{209}Bi		
^{7}Be	i	53.29D	477.6	10.52 ± 0.06	**0.5836 ± 0.0485**

Continuation of Table 50.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{27}Mg	c	9.458M	843.8	71.8 ± 0.4	0.1576 ± 0.0062
			1014.4	28.0 ± 0.4	0.1635 ± 0.0088
				RR_{mean} =	**0.1589 ± 0.0060**
^{22}Na	c	2.6019Y	1274.5	99.94 ± 0.01	**39.28 ± 1.33**
^{24}Na	c	14.9590H	1369.0	100 ± 0	**1.003 ± 0.034**
^{27}Al-plate for ^{209}Bi					
^{24}Na	c	14.9590H	1369.0	100 ± 0	**0.1842 ± 0.0066**

12.2 Detailed calculation of nuclide production rates for ^{206}Pb, ^{207}Pb, ^{208}Pb, ^{nat}Pb and ^{209}Bi for $E_p = 0.07$ GeV

12.2.1 Nuclide production rates for ^{206}Pb

Table 51: Detailed calculation of nuclide production rates for ^{206}Pb for $E_p = 0.07$ GeV, used to determine the cross sections for their production.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{206}Bi	i	6.243D	1878.7	2.01 ± 0.05	30.50 ± 1.82
			1718.7	31.8 ± 0.6	30.33 ± 1.23
			1595.3	5.01 ± 0.08	29.72 ± 1.63
			1098.3	13.50 ± 0.21	27.71 ± 1.26
			1018.6	7.60 ± 0.11	29.40 ± 1.19
			895.1	15.66 ± 0.23	30.07 ± 1.21
			881.0	66.2 ± 1.0	28.99 ± 1.06
			803.1	98.9 ± 1.4	27.98 ± 1.01
			657.2	1.91 ± 0.04	26.67 ± 1.97
			632.2	4.47 ± 0.07	27.10 ± 1.55
			620.5	5.76 ± 0.09	26.57 ± 1.29
			537.5	30.5 ± 0.5	23.84 ± 0.96
			516.2	40.7 ± 0.6	27.02 ± 1.05
			497.1	15.31 ± 0.22	25.28 ± 1.11
			398.0	10.74 ± 0.15	26.14 ± 1.02
			343.5	23.4 ± 0.4	27.23 ± 1.06
			262.7	3.02 ± 0.06	27.38 ± 2.06
			184.0	15.8 ± 0.4	30.57 ± 1.42
				$RR_{mean} =$	**27.64 ± 0.97**
^{205}Bi	i	15.31D	1903.4	2.47 ± 0.04	95.37 ± 5.20
			1861.7	6.17 ± 0.10	98.14 ± 4.09
			1775.8	3.99 ± 0.08	102.9 ± 4.3
			1764.3	32.5 ± 0.7	101.9 ± 4.2
			1614.3	2.28 ± 0.04	105.5 ± 4.5
			1190.0	2.26 ± 0.07	104.0 ± 6.7
			1043.8	7.51 ± 0.10	92.87 ± 3.44
			987.7	16.13 ± 0.17	93.03 ± 3.36
			894.6	0.62 ± 0.01	77.19 ± 10.37
			703.5	31.1 ± 0.1	92.59 ± 3.15
			579.8	5.44 ± 0.07	89.18 ± 3.52
			570.6	4.34 ± 0.07	89.37 ± 3.53
			549.8	2.95 ± 0.04	84.99 ± 3.30
			284.1	1.69 ± 0.02	93.97 ± 3.89
			260.5	1.09 ± 0.04	87.41 ± 5.78
				$RR_{mean} =$	**93.29 ± 3.20**
^{204}Bi	i	11.22H	1755.3	1.22 ± 0.12	174.8 ± 19.5
			1211.7	3.0 ± 0.4	139.5 ± 19.5
			1043.6	1.27 ± 0.17	214.9 ± 31.9
			984.0	59 ± 4	153.5 ± 11.6
			918.3	10.8 ± 0.9	172.6 ± 15.6
			899.2	98 ± 9	147.6 ± 4.9
			791.2	3.3 ± 0.3	178.9 ± 17.8
			670.7	11.4 ± 0.9	157.5 ± 13.6

Continuation of Table 51.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			374.8	82 ± 5	173.3 ± 36.2
			176.1	1.12 ± 0.09	199.7 ± 20.1
				RR_{mean} =	**148.5 ± 4.6**
^{203}Bi	i(m+g)	11.76H	2011.0	1.76 ± 0.09	241.8 ± 16.2
			1983.0	0.88 ± 0.05	232.0 ± 17.4
			1893.0	8.2 ± 0.6	259.5 ± 21.3
			1888.0	1.94 ± 0.10	256.7 ± 18.2
			1847.3	11.4 ± 0.8	253.3 ± 20.0
			1719.6	3.40 ± 0.23	252.5 ± 20.1
			1679.6	8.8 ± 0.7	256.2 ± 22.4
			1536.5	7.5 ± 0.6	252.5 ± 22.5
			1506.7	3.7 ± 0.3	245.3 ± 22.3
			1034.0	8.8 ± 0.5	257.8 ± 17.2
			896.8	13.1 ± 0.7	256.7 ± 16.3
			847.2	8.5 ± 0.5	260.1 ± 17.8
			820.2	29.6 ± 1.5	262.1 ± 15.9
			816.3	4.03 ± 0.21	260.6 ± 16.5
			722.4	4.8 ± 0.4	258.4 ± 23.5
			569.3	1.22 ± 0.07	291.2 ± 22.8
			401.3	*	195.8 ± 20.0
			279.2	*	260.2 ± 10.0
			264.2	5.2 ± 0.4	254.4 ± 22.1
			186.6	3.11 ± 0.22	323.3 ± 26.4
				RR_{mean} =	**257.0 ± 7.9**
^{202}Bi	i	1.72H	960.7	99.28 ± 0.02	366.4 ± 12.5
			954.5	7.8 ± 0.5	338.0 ± 25.3
			927.3	7.1 ± 0.4	314.4 ± 22.9
			657.5	60.6 ± 1.8	361.9 ± 16.9
			578.6	7.3 ± 0.4	358.7 ± 25.8
			569.3	4.8 ± 0.3	344.1 ± 26.9
			422.1	83.7 ± 2.5	368.5 ± 17.6
			346.5	4.6 ± 0.3	349.8 ± 27.6
			168.1	4.8 ± 0.3	385.2 ± 29.1
				RR_{mean} =	**362.2 ± 12.0**
^{201}Bi	i	108M	1650.9	5.8 ± 1.3	728.1 ± 166.0
			1570.8	2.4 ± 0.6	801.7 ± 204.3
			1325.2	6.1 ± 1.3	737.8 ± 161.0
			1108.1	3.9 ± 0.9	760.2 ± 180.1
			936.2	11.3 ± 2.5	763.5 ± 171.4
			847.7	1.8 ± 0.4	715.0 ± 162.9
			629.1	24 ± 6	714.6 ± 180.5
			331.2	*	861.7 ± 62.6
				RR_{mean} =	**847.7 ± 26.1**
$^{204m}Pb_i$	i(m)	67.2M	899.2	99.17 ± 0.02	85.32 ± 2.89
			374.7	89 ± 15	89.05 ± 15.34
				RR_{mean} =	**85.34 ± 2.89**
$^{204m}Pb_c$	c	67.2M	899.2	99.17 ± 0.02	107.5 ± 3.6
			374.7	89 ± 15	110.8 ± 19.1
				RR_{mean} =	**107.5 ± 3.6**
$^{203}Pb_i$	i(m1+m2+g)	51.873H	279.2	80.8 ± 0.2	**285.9 ± 11.1**

Continuation of Table 51.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
$^{203}Pb_c$	c	51.873H	279.2	80.8 ± 0.2	**546.1 ± 19.9**
^{202m}Pb	i(m)	3.53H	960.7	92 ± 8	93.62 ± 8.87
			490.5	9.1 ± 0.7	105.8 ± 9.4
			459.7	8.6 ± 0.7	105.2 ± 9.9
			422.1	86 ± 5	96.31 ± 6.98
			389.9	6.2 ± 0.6	93.19 ± 12.74
				RR_{mean} =	**98.36 ± 4.07**
$^{201}Pb_i$	i(m+g)	9.33H	331.2	79 ± 5	**167.2 ± 14.7**
$^{201}Pb_c$	c	9.33H	331.2	79 ± 5	**1029 ± 74.**
^{200}Pb	c	21.5H	1604.5	*	486.9 ± 50.2
			1514.9	*	506.0 ± 42.2
			1362.9	*	536.5 ± 67.4
			1205.7	*	522.9 ± 36.8
			605.4	0.56 ± 0.05	632.7 ± 62.8
			579.3	*	537.9 ± 35.2
			525.5	0.42 ± 0.04	503.9 ± 57.4
			367.9	*	506.3 ± 19.4
			268.4	3.96 ± 0.20	587.0 ± 38.9
			257.2	4.46 ± 0.17	598.6 ± 34.8
			235.6	4.30 ± 0.17	606.2 ± 35.0
			147.6	37.7 ± 1.4	543.5 ± 29.5
				RR_{mean} =	**523.1 ± 16.1**
^{202}Tl	c	12.23D	439.6	91.4 ± 1.0	**19.15 ± 0.70**
^{201}Tl	c*	72.912H	167.4	10.00 ± 0.06	**1245 ± 46.**
$^{200}Tl_i$	i	26.1H	1604.5	1.17 ± 0.10	48.64 ± 28.69
			1362.9	3.4 ± 0.4	28.34 ± 16.75
			1205.7	29.9 ± 1.8	23.62 ± 5.75
			886.2	2.02 ± 0.13	36.24 ± 20.67
			367.9	87.2 ± 0.4	17.62 ± 4.35
				RR_{mean} =	**20.94 ± 3.36**
$^{200}Tl_c$	c	26.1H	1604.5	1.17 ± 0.10	535.6 ± 51.4
			1362.9	3.4 ± 0.4	564.8 ± 69.7
			1205.7	29.9 ± 1.8	546.5 ± 37.9
			886.2	2.02 ± 0.13	546.3 ± 40.9
			367.9	87.2 ± 0.4	523.9 ± 19.2
				RR_{mean} =	**528.0 ± 18.6**
^{199}Tl	c*	7.42H	455.5	12.4 ± 1.4	24.55 ± 3.06
			247.3	9.3 ± 1.1	26.05 ± 3.52
			208.2	12.3 ± 1.4	31.01 ± 3.92
				RR_{mean} =	**26.68 ± 2.07**
^{198m}Tl	i(m)	1.87H	636.7	57 ± 6	17.78 ± 2.07
			587.2	52.5 ± 2.0	17.71 ± 1.10
			282.8	28 ± 3	17.51 ± 2.32
				RR_{mean} =	**17.70 ± 0.83**
^{203}Hg	c	46.612D	279.2	81.46 ± 0.13	**0.1044 ± 0.0265**
^{124}Sb	i(m1+m2+g)	60.20D	602.7	98.3 ± 0.4	**0.2190 ± 0.0334**
^{103}Ru	c	39.26D	497.1	91.0 ± 1.3	**3.484 ± 0.146**
$^{95}Nb_c$	c	34.975D	765.8	99.81 ± 0.03	**3.348 ± 0.115**
^{95}Zr	c	64.02D	765.8	*	3.314 ± 0.117
			756.7	54.46 ± 0.10	3.188 ± 0.184

Continuation of Table 51.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
				RR_{mean} =	**3.299 ± 0.102**

12.2.2 Nuclide production rates for ^{207}Pb

Table 52: Detailed calculation of nuclide production rates for ^{207}Pb for $E_p = 0.07$ GeV, used to determine the cross sections for their production.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{207}Bi	i	31.55Y	1063.7	74.5 ± 0.2	36.53 ± 2.37
			569.7	97.74 ± 0.03	34.33 ± 2.07
				RR_{mean} =	**35.26 ± 1.74**
^{206}Bi	i	6.243D	1878.7	2.01 ± 0.05	100.0 ± 4.6
			1718.7	31.8 ± 0.6	95.12 ± 3.75
			1595.3	5.01 ± 0.08	101.0 ± 3.9
			1098.3	13.50 ± 0.21	88.80 ± 3.34
			1018.6	7.60 ± 0.11	95.75 ± 3.52
			895.1	15.66 ± 0.23	95.67 ± 3.49
			881.0	66.2 ± 1.0	92.70 ± 3.34
			803.1	98.9 ± 1.4	90.34 ± 3.22
			657.2	1.91 ± 0.04	87.35 ± 3.93
			632.2	4.47 ± 0.07	87.01 ± 3.41
			620.5	5.76 ± 0.09	83.06 ± 3.18
			537.5	30.5 ± 0.5	82.37 ± 3.12
			516.2	40.7 ± 0.6	86.98 ± 3.25
			497.1	15.31 ± 0.22	83.00 ± 3.10
			398.0	10.74 ± 0.15	83.99 ± 3.13
			343.5	23.4 ± 0.4	86.43 ± 3.29
			262.7	3.02 ± 0.06	92.74 ± 4.29
			184.0	15.8 ± 0.4	98.47 ± 4.44
				RR_{mean} =	**89.38 ± 3.06**
^{205}Bi	i	15.31D	1903.4	2.47 ± 0.04	216.7 ± 8.8
			1861.7	6.17 ± 0.10	211.3 ± 8.3
			1775.8	3.99 ± 0.08	215.5 ± 8.8
			1764.3	32.5 ± 0.7	214.5 ± 8.7
			1614.3	2.28 ± 0.04	228.9 ± 9.2
			1190.0	2.26 ± 0.07	211.2 ± 9.7
			1043.8	7.51 ± 0.10	195.3 ± 7.0
			987.7	16.13 ± 0.17	210.3 ± 7.4
			894.6	0.62 ± 0.01	176.4 ± 13.6
			703.5	31.1 ± 0.1	197.5 ± 6.6
			579.8	5.44 ± 0.07	191.5 ± 7.0
			570.6	4.34 ± 0.07	184.8 ± 7.1
				RR_{mean} =	**202.2 ± 7.1**
^{204}Bi	i	11.22H	1755.3	1.22 ± 0.12	278.3 ± 31.7
			1211.7	3.0 ± 0.4	250.6 ± 35.2
			1043.6	1.27 ± 0.17	335.9 ± 48.8
			984.0	59 ± 4	264.6 ± 20.0
			918.3	10.8 ± 0.9	291.7 ± 26.2
			899.2	98 ± 9	254.1 ± 8.3

Continuation of Table 52.

Nuclide	Type	$T_{1/2}$	E_{γ}, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			791.2	3.3 ± 0.3	308.1 ± 30.4
			670.7	11.4 ± 0.9	280.0 ± 24.1
			374.8	82 ± 5	299.5 ± 62.5
			176.1	1.12 ± 0.09	337.3 ± 33.9
				RR_{mean} =	**255.9 ± 7.9**
^{203}Bi	i(m+g)	11.76H	2011.0	1.76 ± 0.09	412.9 ± 27.2
			1983.0	0.88 ± 0.05	453.2 ± 32.6
			1893.0	8.2 ± 0.6	435.4 ± 35.8
			1888.0	1.94 ± 0.10	441.2 ± 29.1
			1847.3	11.4 ± 0.8	422.6 ± 33.4
			1719.6	3.40 ± 0.23	416.3 ± 34.3
			1679.6	8.8 ± 0.7	424.1 ± 36.9
			1536.5	7.5 ± 0.6	449.2 ± 39.6
			1506.7	3.7 ± 0.3	429.4 ± 38.8
			1034.0	8.8 ± 0.5	421.6 ± 27.9
			936.0	0.74 ± 0.04	424.6 ± 42.7
			896.8	13.1 ± 0.7	418.1 ± 26.4
			847.2	8.5 ± 0.5	436.6 ± 29.7
			820.2	29.6 ± 1.5	443.4 ± 26.9
			816.3	4.03 ± 0.21	442.1 ± 27.6
			722.4	4.8 ± 0.4	444.3 ± 40.1
			569.3	1.22 ± 0.07	470.8 ± 37.5
			401.3	*	353.0 ± 26.5
			279.2	*	435.0 ± 16.4
			264.2	5.2 ± 0.4	440.9 ± 38.4
			186.6	3.11 ± 0.22	520.2 ± 42.2
				RR_{mean} =	**431.5 ± 13.3**
^{202}Bi	i	1.72H	960.7	99.28 ± 0.02	791.4 ± 28.2
			954.5	7.8 ± 0.5	763.2 ± 57.5
			927.3	7.1 ± 0.4	783.0 ± 53.1
			657.5	60.6 ± 1.8	790.4 ± 36.5
			578.6	7.3 ± 0.4	774.6 ± 51.8
			569.3	4.8 ± 0.3	808.7 ± 60.3
			422.1	83.7 ± 2.5	783.1 ± 36.5
			346.5	4.6 ± 0.3	752.5 ± 56.7
			168.1	4.8 ± 0.3	836.3 ± 61.8
				RR_{mean} =	**788.5 ± 26.3**
^{201}Bi	i	108M	1650.9	5.8 ± 1.3	780.2 ± 177.5
			1570.8	2.4 ± 0.6	876.9 ± 222.3
			1325.2	6.1 ± 1.3	795.8 ± 173.3
			1108.1	3.9 ± 0.9	848.0 ± 199.0
			936.2	11.3 ± 2.5	758.4 ± 170.5
			847.7	1.8 ± 0.4	820.3 ± 187.1
			629.1	24 ± 6	773.8 ± 196.0
			331.2	*	902.3 ± 65.1
				RR_{mean} =	**890.7 ± 27.5**
$^{204m}Pb_i$	i(m)	67.2M	899.2	99.17 ± 0.02	137.3 ± 4.6
			374.7	89 ± 15	141.2 ± 24.3
				RR_{mean} =	**137.3 ± 4.6**
$^{204m}Pb_c$	c	67.2M	899.2	99.17 ± 0.02	175.4 ± 5.8
			374.7	89 ± 15	178.8 ± 30.7

Continuation of Table 52.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
				RR_{mean} =	**175.4 ± 5.8**
$^{203}Pb_i$	i(m1+m2+g)	51.873H	279.2	80.8 ± 0.2	**327.3 ± 13.0**
$^{203}Pb_c$	c	51.873H	279.2	80.8 ± 0.2	**762.3 ± 27.8**
^{202m}Pb	i(m)	3.53H	960.7	92 ± 8	102.7 ± 10.2
			490.5	9.1 ± 0.7	108.5 ± 9.7
			459.7	8.6 ± 0.7	120.6 ± 11.7
			422.1	86 ± 5	100.3 ± 7.4
			389.9	6.2 ± 0.6	102.0 ± 12.1
				RR_{mean} =	**104.3 ± 4.5**
$^{201}Pb_i$	i(m+g)	9.33H	331.2	79 ± 5	**75.56 ± 8.66**
$^{201}Pb_c$	c	9.33H	331.2	79 ± 5	**977.8 ± 70.1**
^{200}Pb	c	21.5H	1514.9	*	33.17 ± 3.51
			1205.7	*	37.71 ± 2.83
			367.9	*	35.73 ± 1.34
			235.6	4.30 ± 0.17	46.65 ± 4.59
			147.6	37.7 ± 1.4	39.66 ± 2.22
				RR_{mean} =	**36.12 ± 1.11**
^{202}Tl	c	12.23D	439.6	91.4 ± 1.0	**20.39 ± 0.75**
^{201}Tl	c*	72.912H	167.4	10.00 ± 0.06	**1188 ± 44.**
$^{200}Tl_i$	i	26.1H	1514.9	4.0 ± 0.3	34.58 ± 4.44
			1205.7	29.9 ± 1.8	28.89 ± 2.55
			367.9	87.2 ± 0.4	26.77 ± 1.13
				RR_{mean} =	**27.19 ± 1.29**
$^{200}Tl_c$	c	26.1H	1514.9	4.0 ± 0.3	67.74 ± 5.80
			1205.7	29.9 ± 1.8	66.60 ± 4.64
			367.9	87.2 ± 0.4	62.50 ± 2.16
				RR_{mean} =	**62.84 ± 2.14**
^{199}Tl	c*	7.42H	455.5	12.4 ± 1.4	26.51 ± 3.39
			247.3	9.3 ± 1.1	26.60 ± 4.05
			208.2	12.3 ± 1.4	31.09 ± 4.09
				RR_{mean} =	**27.90 ± 1.71**
^{203}Hg	c	46.612D	279.2	81.46 ± 0.13	**0.7156 ± 0.0337**
^{124}Sb	i(m1+m2+g)	60.20D	602.7	98.3 ± 0.4	**0.1848 ± 0.0380**
^{103}Ru	c	39.26D	497.1	91.0 ± 1.3	**3.215 ± 0.126**
$^{95}Nb_c$	c	34.975D	765.8	99.81 ± 0.03	**3.112 ± 0.103**
^{97}Zr	c	16.744H	743.4	93.06 ± 0.16	**3.253 ± 0.164**
^{95}Zr	c	64.02D	765.8	*	2.953 ± 0.099
			756.7	54.46 ± 0.10	2.847 ± 0.117
				RR_{mean} =	**2.932 ± 0.090**

12.2.3 Nuclide production rates for ^{208}Pb

Table 53: Detailed calculation of nuclide production rates for ^{208}Pb for $E_p = 0.07$ GeV, used to determine the cross sections for their production.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{207}Bi	i	31.55Y	1063.7	74.5 ± 0.2	**84.38 ± 4.19**
^{206}Bi	i	6.243D	1878.7	2.01 ± 0.05	143.8 ± 6.6
			1718.7	31.8 ± 0.6	142.9 ± 5.7

Continuation of Table 53.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			1595.3	5.01 ± 0.08	151.1 ± 5.9
			1098.3	13.50 ± 0.21	133.8 ± 5.0
			1018.6	7.60 ± 0.11	145.6 ± 5.3
			895.1	15.66 ± 0.23	141.8 ± 5.2
			881.0	66.2 ± 1.0	139.5 ± 5.0
			803.1	98.9 ± 1.4	135.3 ± 4.8
			657.2	1.91 ± 0.04	129.6 ± 6.2
			632.2	4.47 ± 0.07	129.7 ± 5.0
			620.5	5.76 ± 0.09	124.3 ± 4.7
			537.5	30.5 ± 0.5	123.1 ± 4.7
			516.2	40.7 ± 0.6	130.8 ± 4.9
			497.1	15.31 ± 0.22	124.8 ± 4.6
			398.0	10.74 ± 0.15	124.1 ± 4.6
			343.5	23.4 ± 0.4	130.2 ± 4.9
			262.7	3.02 ± 0.06	132.8 ± 6.0
			184.0	15.8 ± 0.4	148.8 ± 6.7
				RR_{mean} =	**133.6 ± 4.6**
^{205}Bi	i	15.31D	1903.4	2.47 ± 0.04	248.2 ± 10.7
			1861.7	6.17 ± 0.10	245.8 ± 9.7
			1775.8	3.99 ± 0.08	251.0 ± 10.3
			1764.3	32.5 ± 0.7	253.7 ± 10.4
			1614.3	2.28 ± 0.04	253.5 ± 10.5
			1190.0	2.26 ± 0.07	248.5 ± 11.6
			1043.8	7.51 ± 0.10	229.6 ± 8.3
			987.7	16.13 ± 0.17	245.3 ± 8.5
			894.6	0.62 ± 0.01	246.2 ± 26.9
			703.5	31.1 ± 0.1	232.0 ± 7.9
			579.8	5.44 ± 0.07	223.8 ± 8.2
			570.6	4.34 ± 0.07	221.8 ± 9.1
				RR_{mean} =	**237.6 ± 8.0**
^{204}Bi	i	11.22H	1755.3	1.22 ± 0.12	297.1 ± 33.0
			1211.7	3.0 ± 0.4	276.1 ± 38.5
			1043.6	1.27 ± 0.17	386.6 ± 55.6
			984.0	59 ± 4	293.8 ± 22.3
			918.3	10.8 ± 0.9	326.5 ± 29.3
			899.2	98 ± 9	280.2 ± 9.4
			791.2	3.3 ± 0.3	337.0 ± 33.4
			670.7	11.4 ± 0.9	309.3 ± 26.7
			374.8	82 ± 5	333.0 ± 69.5
			176.1	1.12 ± 0.09	387.1 ± 35.2
				RR_{mean} =	**282.6 ± 8.7**
^{203}Bi	i(m+g)	11.76H	2011.0	1.76 ± 0.09	579.8 ± 37.6
			1983.0	0.88 ± 0.05	628.3 ± 44.0
			1893.0	8.2 ± 0.6	596.5 ± 48.8
			1888.0	1.94 ± 0.10	592.6 ± 38.6
			1847.3	11.4 ± 0.8	578.6 ± 45.7
			1719.6	3.40 ± 0.23	552.4 ± 47.0
			1679.6	8.8 ± 0.7	575.4 ± 50.0
			1536.5	7.5 ± 0.6	596.0 ± 52.0
			1506.7	3.7 ± 0.3	552.5 ± 49.0
			1034.0	8.8 ± 0.5	589.0 ± 38.9

Continuation of Table 53.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			936.0	0.74 ± 0.04	646.2 ± 43.7
			896.8	13.1 ± 0.7	573.9 ± 36.3
			847.2	8.5 ± 0.5	601.4 ± 40.7
			820.2	29.6 ± 1.5	603.4 ± 36.5
			816.3	4.03 ± 0.21	600.2 ± 37.3
			722.4	4.8 ± 0.4	606.3 ± 54.8
			569.3	1.22 ± 0.07	663.9 ± 55.7
			401.3	*	551.3 ± 35.3
			279.2	*	594.3 ± 22.2
			264.2	5.2 ± 0.4	606.7 ± 52.4
			186.6	3.11 ± 0.22	680.6 ± 55.0
				RR_{mean} =	**590.2 ± 18.2**
^{202}Bi	i	1.72H	960.7	99.28 ± 0.02	859.2 ± 30.3
			954.5	7.8 ± 0.5	867.5 ± 64.1
			927.3	7.1 ± 0.4	859.3 ± 58.3
			657.5	60.6 ± 1.8	846.4 ± 39.6
			578.6	7.3 ± 0.4	872.9 ± 57.5
			569.3	4.8 ± 0.3	857.0 ± 67.9
			422.1	83.7 ± 2.5	854.4 ± 40.2
			346.5	4.6 ± 0.3	809.2 ± 60.9
			168.1	4.8 ± 0.3	889.8 ± 65.5
				RR_{mean} =	**856.9 ± 28.5**
^{201}Bi	i	108M	1650.9	5.8 ± 1.3	45.71 ± 15.15
			1325.2	6.1 ± 1.3	72.11 ± 16.60
			1108.1	3.9 ± 0.9	84.18 ± 21.71
			936.2	11.3 ± 2.5	53.91 ± 12.63
			629.1	24 ± 6	54.83 ± 14.01
			331.2	*	64.94 ± 5.39
				RR_{mean} =	**64.41 ± 1.99**
^{204m}Pb$_i$	i(m)	67.2M	899.2	99.17 ± 0.02	124.8 ± 4.8
			374.7	89 ± 15	131.4 ± 22.7
				RR_{mean} =	**125.0 ± 4.8**
^{204m}Pb$_c$	c	67.2M	899.2	99.17 ± 0.02	166.9 ± 6.0
			374.7	89 ± 15	173.1 ± 29.9
				RR_{mean} =	**166.9 ± 6.0**
^{203}Pb$_i$	i(m1+m2+g)	51.873H	279.2	80.8 ± 0.2	**228.0 ± 10.3**
^{203}Pb$_c$	c	51.873H	279.2	80.8 ± 0.2	**822.3 ± 30.0**
^{202m}Pb	i(m)	3.53H	960.7	92 ± 8	43.95 ± 4.95
			490.5	9.1 ± 0.7	47.99 ± 4.69
			459.7	8.6 ± 0.7	66.75 ± 7.00
			422.1	86 ± 5	36.99 ± 4.17
			389.9	6.2 ± 0.6	48.61 ± 5.89
				RR_{mean} =	**46.13 ± 4.50**
^{201}Pb$_i$	i(m+g)	9.33H	331.2	79 ± 5	**11.75 ± 3.17**
^{201}Pb$_c$	c	9.33H	331.2	79 ± 5	**76.69 ± 5.53**
^{200}Pb	c	21.5H	1205.7	*	6.852 ± 0.971
			579.3	*	6.076 ± 1.518
			367.9	*	5.269 ± 0.245
			147.6	37.7 ± 1.4	8.170 ± 0.745
				RR_{mean} =	**5.580 ± 0.172**

Continuation of Table 53.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{202}Tl	c	12.23D	439.6	91.4 ± 1.0	**14.80 ± 0.55**
^{201}Tl	c*	72.912H	167.4	10.00 ± 0.06	**112.0 ± 4.4**
^{200}Tl$_i$	i	26.1H	1205.7	29.9 ± 1.8	24.09 ± 2.30
			579.3	13.8 ± 0.7	22.76 ± 2.54
			367.9	87.2 ± 0.4	23.24 ± 0.87
				RR_{mean} =	**23.26 ± 0.85**
^{200}Tl$_c$	c	26.1H	1205.7	29.9 ± 1.8	30.94 ± 2.31
			579.3	13.8 ± 0.7	28.84 ± 2.07
			367.9	87.2 ± 0.4	28.51 ± 1.00
				RR_{mean} =	**28.63 ± 0.98**
^{199}Tl	c*	7.42H	455.5	12.4 ± 1.4	**11.39 ± 1.85**
^{203}Hg	c	46.612D	279.2	81.46 ± 0.13	**1.198 ± 0.054**
^{103}Ru	c	39.26D	497.1	91.0 ± 1.3	**1.961 ± 0.091**
^{95}Nb$_c$	c	34.975D	765.8	99.81 ± 0.03	**1.959 ± 0.135**
^{97}Zr	c	16.744H	743.4	93.06 ± 0.16	**2.351 ± 0.141**
^{95}Zr	c	64.02D	765.8	*	1.795 ± 0.146
			756.7	54.46 ± 0.10	1.694 ± 0.117
				RR_{mean} =	**1.732 ± 0.053**

12.2.4 Nuclide production rates for ^{nat}Pb

Table 54: Detailed calculation of nuclide production rates for ^{nat}Pb for $E_p = 0.07$ GeV, used to determine the cross sections for their production.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{207}Bi	i	31.55Y	1063.7	74.5 ± 0.2	28.37 ± 2.71
			569.7	97.74 ± 0.03	20.58 ± 3.52
				RR_{mean} =	**25.61 ± 3.81**
^{206}Bi	i	6.243D	1878.7	2.01 ± 0.05	42.15 ± 2.18
			1718.7	31.8 ± 0.6	41.50 ± 1.63
			1595.3	5.01 ± 0.08	42.49 ± 1.68
			1098.3	13.50 ± 0.21	38.84 ± 1.46
			1018.6	7.60 ± 0.11	41.28 ± 1.54
			895.1	15.66 ± 0.23	41.62 ± 1.58
			881.0	66.2 ± 1.0	40.54 ± 1.46
			803.1	98.9 ± 1.4	39.28 ± 1.40
			657.2	1.91 ± 0.04	36.72 ± 1.95
			632.2	4.47 ± 0.07	37.80 ± 1.52
			620.5	5.76 ± 0.09	37.67 ± 1.52
			537.5	30.5 ± 0.5	36.15 ± 1.37
			516.2	40.7 ± 0.6	38.07 ± 1.43
			497.1	15.31 ± 0.22	35.79 ± 1.34
			398.0	10.74 ± 0.15	36.62 ± 1.35
			343.5	23.4 ± 0.4	38.07 ± 1.46
			262.7	3.02 ± 0.06	40.01 ± 1.86
			184.0	15.8 ± 0.4	43.22 ± 1.99
				RR_{mean} =	**38.88 ± 1.31**
^{205}Bi	i	15.31D	1903.4	2.47 ± 0.04	81.68 ± 3.41
			1861.7	6.17 ± 0.10	81.64 ± 3.19

Continuation of Table 54.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			1775.8	3.99 ± 0.08	84.74 ± 3.50
			1764.3	32.5 ± 0.7	83.04 ± 3.38
			1614.3	2.28 ± 0.04	87.51 ± 3.63
			1190.0	2.26 ± 0.07	81.35 ± 3.79
			1043.8	7.51 ± 0.10	75.68 ± 2.71
			987.7	16.13 ± 0.17	81.63 ± 2.83
			894.6	0.62 ± 0.01	68.81 ± 10.71
			703.5	31.1 ± 0.1	76.88 ± 2.62
			579.8	5.44 ± 0.07	74.07 ± 2.90
			570.6	4.34 ± 0.07	72.54 ± 3.01
				RR_{mean} =	**78.91 ± 2.71**
^{204}Bi	i	11.22H	1755.3	1.22 ± 0.12	106.1 ± 12.2
			1211.7	3.0 ± 0.4	86.12 ± 12.09
			1043.6	1.27 ± 0.17	145.6 ± 20.5
			984.0	59 ± 4	104.0 ± 7.9
			918.3	10.8 ± 0.9	118.0 ± 10.6
			899.2	98 ± 9	101.5 ± 3.3
			791.2	3.3 ± 0.3	125.2 ± 12.2
			670.7	11.4 ± 0.9	109.4 ± 9.4
			374.8	82 ± 5	119.0 ± 24.8
			176.1	1.12 ± 0.09	137.9 ± 12.9
				RR_{mean} =	**101.9 ± 3.1**
^{203}Bi	i(m+g)	11.76H	2011.0	1.76 ± 0.09	222.9 ± 14.4
			1983.0	0.88 ± 0.05	239.4 ± 16.8
			1893.0	8.2 ± 0.6	228.5 ± 18.7
			1888.0	1.94 ± 0.10	206.8 ± 13.4
			1847.3	11.4 ± 0.8	223.7 ± 17.6
			1719.6	3.40 ± 0.23	230.6 ± 18.1
			1679.6	8.8 ± 0.7	216.4 ± 18.8
			1536.5	7.5 ± 0.6	230.1 ± 20.1
			1506.7	3.7 ± 0.3	212.7 ± 18.8
			1034.0	8.8 ± 0.5	227.4 ± 15.0
			936.0	0.74 ± 0.04	239.1 ± 16.5
			896.8	13.1 ± 0.7	224.4 ± 14.1
			847.2	8.5 ± 0.5	231.2 ± 15.7
			820.2	29.6 ± 1.5	232.4 ± 14.1
			816.3	4.03 ± 0.21	224.4 ± 13.9
			722.4	4.8 ± 0.4	234.6 ± 21.1
			569.3	1.22 ± 0.07	248.4 ± 18.0
			401.3	*	176.6 ± 14.3
			279.2	*	233.5 ± 10.6
			264.2	5.2 ± 0.4	228.0 ± 19.7
			186.6	3.11 ± 0.22	268.5 ± 21.7
				RR_{mean} =	**226.2 ± 7.0**
^{202}Bi	i	1.72H	960.7	99.28 ± 0.02	259.3 ± 9.4
			954.5	7.8 ± 0.5	254.5 ± 18.8
			927.3	7.1 ± 0.4	241.4 ± 17.1
			657.5	60.6 ± 1.8	259.5 ± 12.4
			578.6	7.3 ± 0.4	239.4 ± 17.4
			569.3	4.8 ± 0.3	254.3 ± 19.6
			422.1	83.7 ± 2.5	253.6 ± 12.2

Continuation of Table 54.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			346.5	4.6 ± 0.3	240.0 ± 18.4
			168.1	4.8 ± 0.3	266.1 ± 20.1
				RR_{mean} =	**255.8 ± 8.6**
^{201}Bi	i	108M	1650.9	5.8 ± 1.3	130.2 ± 30.0
			1570.8	2.4 ± 0.6	161.0 ± 41.5
			1325.2	6.1 ± 1.3	145.8 ± 31.6
			1108.1	3.9 ± 0.9	140.9 ± 33.1
			936.2	11.3 ± 2.5	130.6 ± 29.4
			847.7	1.8 ± 0.4	131.6 ± 33.5
			629.1	24 ± 6	139.9 ± 35.5
			331.2	*	159.3 ± 11.7
				RR_{mean} =	**157.0 ± 4.8**
^{204m}Pb$_i$	i(m)	67.2M	899.2	99.17 ± 0.02	46.03 ± 1.58
			374.7	89 ± 15	46.76 ± 8.08
				RR_{mean} =	**46.04 ± 1.58**
^{204m}Pb$_c$	c	67.2M	899.2	99.17 ± 0.02	61.26 ± 2.05
			374.7	89 ± 15	61.69 ± 10.63
				RR_{mean} =	**61.26 ± 2.05**
^{203}Pb$_i$	i(m1+m2+g)	51.873H	279.2	80.8 ± 0.2	**92.26 ± 8.75**
^{203}Pb$_c$	c	51.873H	279.2	80.8 ± 0.2	**325.8 ± 12.0**
^{202m}Pb	i(m)	3.53H	960.7	92 ± 8	22.88 ± 2.32
			490.5	9.1 ± 0.7	26.13 ± 2.78
			459.7	8.6 ± 0.7	26.24 ± 2.83
			422.1	86 ± 5	23.42 ± 2.02
			389.9	6.2 ± 0.6	23.70 ± 2.84
				RR_{mean} =	**24.12 ± 1.15**
^{201}Pb$_i$	i(m+g)	9.33H	331.2	79 ± 5	**27.11 ± 3.16**
^{201}Pb$_c$	c	9.33H	331.2	79 ± 5	**186.4 ± 13.4**
^{200}Pb	c	21.5H	1604.5	*	42.03 ± 6.85
			1514.9	*	44.97 ± 4.31
			1362.9	*	43.13 ± 5.53
			1205.7	*	42.62 ± 2.99
			579.3	*	40.68 ± 2.91
			367.9	*	40.51 ± 1.42
			268.4	3.96 ± 0.20	45.93 ± 3.00
			257.2	4.46 ± 0.17	48.21 ± 2.78
			147.6	37.7 ± 1.4	48.63 ± 2.72
				RR_{mean} =	**41.64 ± 1.28**
^{202}Tl	c	12.23D	439.6	91.4 ± 1.0	**6.468 ± 0.240**
^{201}Tl	c*	72.912H	167.4	10.00 ± 0.06	**227.6 ± 8.5**
^{200}Tl$_i$	i	26.1H	1604.5	1.17 ± 0.10	15.51 ± 8.78
			1514.9	4.0 ± 0.3	7.405 ± 2.925
			1362.9	3.4 ± 0.4	10.29 ± 2.70
			1205.7	29.9 ± 1.8	11.05 ± 1.21
			886.2	2.02 ± 0.13	22.98 ± 3.91
			579.3	13.8 ± 0.7	10.59 ± 2.11
			367.9	87.2 ± 0.4	9.684 ± 0.915
				RR_{mean} =	**10.45 ± 0.96**
^{200}Tl$_c$	c	26.1H	1604.5	1.17 ± 0.10	57.54 ± 6.93
			1514.9	4.0 ± 0.3	52.38 ± 4.49

Continuation of Table 54.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			1362.9	3.4 ± 0.4	53.42 ± 6.65
			1205.7	29.9 ± 1.8	53.67 ± 3.73
			886.2	2.02 ± 0.13	59.44 ± 4.71
			579.3	13.8 ± 0.7	51.27 ± 3.35
			367.9	87.2 ± 0.4	50.19 ± 1.80
				RR_{mean} =	**50.99 ± 1.77**
^{199}Tl	c*	7.42H	455.5	12.4 ± 1.4	13.32 ± 1.63
			247.3	9.3 ± 1.1	13.04 ± 1.72
			208.2	12.3 ± 1.4	15.22 ± 1.90
				RR_{mean} =	**13.78 ± 0.78**
^{203}Hg	c	46.612D	279.2	81.46 ± 0.13	**0.2978 ± 0.0428**
^{103}Ru	c	39.26D	497.1	91.0 ± 1.3	**0.9909 ± 0.0446**
^{95}Nb$_c$	c	34.975D	765.8	99.81 ± 0.03	**0.8904 ± 0.0566**
^{97}Zr	c	16.744H	743.4	93.06 ± 0.16	**0.9259 ± 0.0597**
^{95}Zr	c	64.02D	765.8	*	0.9093 ± 0.0698
			756.7	54.46 ± 0.10	0.7648 ± 0.0788
				RR_{mean} =	**0.8486 ± 0.0262**

12.2.5 Nuclide production rates for ^{209}Bi

Table 55: Detailed calculation of nuclide production rates for ^{209}Bi for $E_p = 0.07$ GeV, used to determine the cross sections for their production.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{207}Po	i(m+g)	5.80H	1148.3	5.72 ± 0.12	190.4 ± 9.1
			992.3	59.3 ± 0.9	173.0 ± 6.4
			742.6	28.2 ± 0.5	176.2 ± 7.8
			405.8	9.7 ± 0.6	174.9 ± 14.2
				RR_{mean} =	**176.2 ± 6.4**
^{206}Po	i	8.8D	1878.7	*	263.9 ± 11.8
			1844.5	*	253.7 ± 18.7
			1595.3	*	272.9 ± 10.8
			1405.0	*	266.2 ± 11.3
			1098.3	*	243.1 ± 9.6
			1032.3	33 ± 5	262.9 ± 40.8
			1032.3	33 ± 5	262.7 ± 40.7
			1018.6	*	269.3 ± 9.8
			1007.2	3.1 ± 0.4	246.3 ± 32.9
			980.2	7.1 ± 0.9	258.1 ± 33.8
			895.1	*	264.1 ± 9.7
			881.0	*	260.2 ± 9.6
			818.2	1.04 ± 0.14	300.4 ± 42.3
			807.4	23 ± 3	247.8 ± 33.4
			803.1	*	249.0 ± 9.1
			677.7	1.47 ± 0.20	267.9 ± 38.9
			657.2	*	264.1 ± 20.7
			632.2	*	238.7 ± 10.0
			620.5	*	241.8 ± 11.2
			554.6	1.56 ± 0.21	219.1 ± 31.3

Continuation of Table 55.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			537.5	*	230.7 ± 9.1
			522.5	15.7 ± 2.0	244.2 ± 32.2
			516.2	*	244.5 ± 9.4
			497.1	*	230.9 ± 9.4
			463.4	1.79 ± 0.24	240.7 ± 33.5
			398.0	*	235.4 ± 9.6
			386.2	*	216.2 ± 10.9
			343.5	*	242.8 ± 9.6
			338.4	19.2 ± 2.5	260.5 ± 35.1
			311.6	4.2 ± 0.6	268.3 ± 39.5
			286.4	24 ± 3	262.3 ± 34.1
			184.0	*	279.2 ± 13.5
				RR_{mean} =	**249.9 ± 7.7**
^{205}Po	i	1.66H	1513.7	2.11 ± 0.22	394.7 ± 45.0
			1239.1	4.6 ± 0.4	362.6 ± 34.7
			1001.2	28.8 ± 2.2	355.9 ± 29.8
			872.4	37 ± 2	376.9 ± 24.5
			849.8	25.5 ± 2.1	381.0 ± 33.9
			836.8	19.2 ± 1.6	375.5 ± 34.2
			261.0	4.0 ± 0.4	377.9 ± 42.3
				RR_{mean} =	**375.0 ± 13.0**
^{204}Po	i	3.53H	1964.8	*	691.9 ± 237.7
			1703.3	*	820.1 ± 111.6
			1524.1	*	671.7 ± 107.2
			1414.7	*	653.2 ± 153.1
			1274.8	*	717.2 ± 131.7
			1211.7	*	612.6 ± 94.9
			1040.0	9.6 ± 0.5	863.6 ± 53.6
			1016.3	24.1 ± 1.0	824.8 ± 44.1
			984.0	*	727.0 ± 55.4
			918.3	*	862.7 ± 83.2
			899.2	*	831.4 ± 84.9
			884.0	29.9 ± 1.2	836.5 ± 43.5
			762.5	11.5 ± 0.5	809.1 ± 44.8
			680.4	7.6 ± 0.4	786.7 ± 51.3
			670.7	*	772.8 ± 67.5
			539.5	1.35 ± 0.10	880.0 ± 74.8
			534.9	13.2 ± 0.8	774.4 ± 54.4
			451.9	1.91 ± 0.10	887.4 ± 58.7
			440.5	*	928.0 ± 159.4
			426.8	1.88 ± 0.14	804.1 ± 68.6
			374.8	*	829.4 ± 58.4
			317.0	4.3 ± 0.5	840.4 ± 102.4
			305.0	3.26 ± 0.17	785.0 ± 50.0
			289.3	*	883.0 ± 86.3
			270.1	27.8 ± 1.3	814.0 ± 49.3
			219.4	*	961.7 ± 88.0
			203.6	2.81 ± 0.13	937.7 ± 59.4
			176.1	*	921.4 ± 120.4
			137.0	9.7 ± 0.4	907.2 ± 63.4
				RR_{mean} =	**815.4 ± 25.1**

Continuation of Table 55.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{203}Po	i(m+g)	36.7M	1264.0	0.93 ± 0.13	719.5 ± 108.6
			1242.4	4.6 ± 0.4	675.3 ± 64.6
			1123.9	1.59 ± 0.19	753.0 ± 95.5
			1090.9	19.2 ± 1.6	666.5 ± 64.6
			908.6	55 ± 3	676.7 ± 47.8
			893.5	18.7 ± 1.5	666.7 ± 60.9
			822.9	2.36 ± 0.21	762.6 ± 74.8
			647.7	2.03 ± 0.20	798.5 ± 86.3
			419.3	2.4 ± 0.3	974.6 ± 133.1
			389.9	1.10 ± 0.13	858.5 ± 108.5
			214.8	14.3 ± 1.4	788.0 ± 85.1
			189.5	3.8 ± 0.4	608.0 ± 70.8
			175.2	3.0 ± 0.4	705.8 ± 99.6
				RR_{mean} =	**697.9 ± 27.7**
^{202}Po	i	44.7M	960.7	*	10.20 ± 2.12
			688.6	51 ± 6	7.768 ± 1.292
				RR_{mean} =	**8.420 ± 0.260**
^{207}Bi	c	31.55Y	1770.2	6.87 ± 0.04	541.0 ± 55.1
			1063.7	74.5 ± 0.2	507.6 ± 17.1
			569.7	97.74 ± 0.03	511.7 ± 21.2
				RR_{mean} =	**508.8 ± 16.9**
^{206}Bi$_i$	i	6.243D	1878.7	2.01 ± 0.05	316.5 ± 13.9
			1844.5	0.57 ± 0.03	331.4 ± 24.3
			1595.3	5.01 ± 0.08	321.6 ± 13.1
			1405.0	1.43 ± 0.03	285.4 ± 12.2
			1098.3	13.50 ± 0.21	288.2 ± 13.2
			1018.6	7.60 ± 0.11	300.0 ± 10.8
			895.1	15.66 ± 0.23	305.4 ± 11.2
			881.0	66.2 ± 1.0	294.6 ± 11.1
			803.1	98.9 ± 1.4	303.8 ± 11.6
			657.2	1.91 ± 0.04	258.8 ± 38.2
			632.2	4.47 ± 0.07	290.8 ± 14.5
			620.5	5.76 ± 0.09	254.7 ± 17.7
			537.5	30.5 ± 0.5	252.4 ± 10.4
			516.2	40.7 ± 0.6	254.8 ± 10.1
			497.1	15.31 ± 0.22	258.1 ± 12.3
			398.0	10.74 ± 0.15	262.3 ± 13.0
			386.2	0.52 ± 0.01	317.1 ± 15.0
			343.5	23.4 ± 0.4	265.7 ± 11.5
			184.0	15.8 ± 0.4	322.6 ± 16.0
				RR_{mean} =	**287.9 ± 10.4**
^{206}Bi$_c$	c	6.243D	1878.7	2.01 ± 0.05	565.9 ± 24.4
			1844.5	0.57 ± 0.03	571.2 ± 36.9
			1595.3	5.01 ± 0.08	579.6 ± 21.8
			1405.0	1.43 ± 0.03	536.9 ± 21.4
			1098.3	13.50 ± 0.21	517.9 ± 19.6
			1018.6	7.60 ± 0.11	554.5 ± 19.8
			895.1	15.66 ± 0.23	554.9 ± 19.9
			881.0	66.2 ± 1.0	540.5 ± 19.5
			803.1	98.9 ± 1.4	539.0 ± 19.5
			657.2	1.91 ± 0.04	508.3 ± 31.3

Continuation of Table 55.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			632.2	4.47 ± 0.07	516.4 ± 20.2
			620.5	5.76 ± 0.09	483.2 ± 20.5
			537.5	30.5 ± 0.5	470.4 ± 18.0
			516.2	40.7 ± 0.6	485.8 ± 18.2
			497.1	15.31 ± 0.22	476.4 ± 18.3
			398.0	10.74 ± 0.15	484.8 ± 18.6
			386.2	0.52 ± 0.01	521.4 ± 21.8
			343.5	23.4 ± 0.4	495.1 ± 19.1
			184.0	15.8 ± 0.4	586.4 ± 27.3
				RR_{mean} =	**520.5 ± 18.0**
^{205}Bi	c	15.31D	1903.4	2.47 ± 0.04	735.2 ± 28.9
			1861.7	6.17 ± 0.10	712.4 ± 27.8
			1775.8	3.99 ± 0.08	747.7 ± 30.5
			1764.3	32.5 ± 0.7	725.6 ± 29.7
			1619.1	0.37 ± 0.02	768.4 ± 45.0
			1614.3	2.28 ± 0.04	769.4 ± 29.5
			1551.0	0.97 ± 0.03	687.0 ± 32.6
			1351.5	1.06 ± 0.04	744.1 ± 38.1
			1190.0	2.26 ± 0.07	714.6 ± 33.0
			1072.4	0.30 ± 0.01	669.5 ± 30.6
			1043.8	7.51 ± 0.10	665.5 ± 24.3
			992.7	0.09 ± 0.04	786.3 ± 353.1
			987.7	16.13 ± 0.17	710.0 ± 24.7
			910.9	1.64 ± 0.04	661.6 ± 27.3
			872.0	0.42 ± 0.01	691.2 ± 30.3
			828.2	0.29 ± 0.01	722.9 ± 44.9
			813.8	0.47 ± 0.01	668.7 ± 31.4
			761.3	0.68 ± 0.04	662.9 ± 45.9
			761.3	0.68 ± 0.04	660.2 ± 45.6
			759.1	1.04 ± 0.05	756.0 ± 44.9
			744.7	0.70 ± 0.02	673.9 ± 28.6
			703.5	31.1 ± 0.1	678.5 ± 22.6
			579.8	5.44 ± 0.07	640.1 ± 23.5
			573.8	0.62 ± 0.01	609.6 ± 27.4
			570.6	4.34 ± 0.07	660.4 ± 33.2
			549.8	2.95 ± 0.04	610.0 ± 24.0
			493.6	0.37 ± 0.01	653.2 ± 29.8
			349.5	0.56 ± 0.01	676.0 ± 33.7
				RR_{mean} =	**684.1 ± 22.5**
^{204}Bi$_i$	i	11.22H	1964.8	0.37 ± 0.04	278.6 ± 290.2
			1703.3	1.99 ± 0.17	249.3 ± 107.1
			1524.1	0.96 ± 0.09	298.9 ± 107.1
			1414.7	0.97 ± 0.12	390.7 ± 169.5
			1274.8	2.14 ± 0.25	189.3 ± 126.3
			1211.7	3.0 ± 0.4	302.6 ± 67.5
			984.0	59 ± 4	210.5 ± 16.6
			918.3	10.8 ± 0.9	184.5 ± 40.5
			899.2	98 ± 9	204.7 ± 33.8
			670.7	11.4 ± 0.9	220.3 ± 22.3
			440.5	2.5 ± 0.4	236.1 ± 68.7
			374.8	82 ± 5	221.7 ± 16.0

Continuation of Table 55.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			289.3	2.86 ± 0.25	284.7 ± 34.6
			219.4	2.30 ± 0.17	430.3 ± 50.3
			176.1	1.12 ± 0.09	295.1 ± 112.7
				RR_{mean} =	**227.4 ± 13.0**
$^{204}Bi_c$	c	11.22H	1964.8	0.37 ± 0.04	965.9 ± 133.5
			1703.3	1.99 ± 0.17	1064 ± 101
			1524.1	0.96 ± 0.09	966.1 ± 100.3
			1414.7	0.97 ± 0.12	1040 ± 140
			1274.8	2.14 ± 0.25	901.8 ± 113.9
			1211.7	3.0 ± 0.4	911.2 ± 126.0
			984.0	59 ± 4	932.7 ± 70.3
			918.3	10.8 ± 0.9	1042 ± 94
			899.2	98 ± 9	1031 ± 101
			791.2	3.3 ± 0.3	1227 ± 130
			670.7	11.4 ± 0.9	988.0 ± 84.7
			440.5	2.5 ± 0.4	1158 ± 190
			374.8	82 ± 5	1046 ± 73
			289.3	2.86 ± 0.25	1162 ± 110
			219.4	2.30 ± 0.17	1386 ± 117
			176.1	1.12 ± 0.09	1210 ± 111
				RR_{mean} =	**1044 ± 44.**
^{203}Bi	c	11.76H	2011.0	1.76 ± 0.09	906.2 ± 58.7
			2001.0	0.83 ± 0.05	915.7 ± 67.3
			1983.0	0.88 ± 0.05	959.8 ± 67.2
			1893.0	8.2 ± 0.6	939.1 ± 76.7
			1888.0	1.94 ± 0.10	938.7 ± 60.0
			1847.3	11.4 ± 0.8	900.9 ± 71.0
			1719.6	3.40 ± 0.23	789.4 ± 74.1
			1679.6	8.8 ± 0.7	889.6 ± 77.3
			1536.5	7.5 ± 0.6	953.2 ± 83.2
			1506.7	3.7 ± 0.3	882.2 ± 78.1
			1224.0	0.73 ± 0.04	860.3 ± 60.5
			1199.0	2.02 ± 0.11	1032 ± 68
			1034.0	8.8 ± 0.5	910.4 ± 60.6
			1000.3	0.98 ± 0.05	972.9 ± 67.3
			936.0	0.74 ± 0.04	1008 ± 70
			896.8	13.1 ± 0.7	868.6 ± 54.7
			866.5	1.49 ± 0.08	825.7 ± 57.8
			847.2	8.5 ± 0.5	950.6 ± 64.3
			825.2	14.6 ± 1.1	937.3 ± 77.3
			820.2	29.6 ± 1.5	934.6 ± 56.6
			816.3	4.03 ± 0.21	934.9 ± 58.5
			722.4	4.8 ± 0.4	957.0 ± 86.4
			401.3	*	936.4 ± 43.5
			381.7	1.28 ± 0.07	971.4 ± 65.0
			279.2	*	973.6 ± 36.1
			264.2	5.2 ± 0.4	948.2 ± 82.2
			186.6	3.11 ± 0.22	1054 ± 86
				RR_{mean} =	**959.3 ± 29.6**
$^{202}Bi_i$	i	1.72H	960.7	99.28 ± 0.02	**5.946 ± 2.175**

Continuation of Table 55.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
$^{202}Bi_c$	c	1.72H	960.7	99.28 ± 0.02	**15.94 ± 0.79**
^{203}Pb	c*	51.873H	680.5	0.75 ± 0.02	1231 ± 58
			401.3	3.35 ± 0.07	1225 ± 51
			279.2	80.8 ± 0.2	1232 ± 46
				RR_{mean} =	**1230 ± 42.**
^{202m}Pb	i(m)	3.53H	960.7	92 ± 8	**12.40 ± 1.42**
^{201}Pb	c*	9.33H	331.2	79 ± 5	**29.24 ± 2.20**
^{200}Pb	c	21.5H	367.9	*	12.50 ± 0.61
			147.6	37.7 ± 1.4	10.84 ± 1.14
				RR_{mean} =	**12.25 ± 0.38**
^{202}Tl	c	12.23D	439.6	91.4 ± 1.0	**2.887 ± 0.120**
^{201}Tl	c*	72.912H	167.4	10.00 ± 0.06	**34.08 ± 1.67**
$^{200}Tl_c$	c	26.1H	367.9	87.2 ± 0.4	**12.75 ± 0.66**
^{124}Sb	i(m1+m2+g)	60.20D	602.7	98.3 ± 0.4	**0.6574 ± 0.0403**
^{107}Rh	c	21.7M	302.8	66 ± 6	**8.236 ± 0.941**
^{105}Rh	c	35.36H	318.9	19.1 ± 0.6	**9.676 ± 1.000**
^{106}Ru	c	373.59D	621.9(D)	9.93 ± 0.23	**5.785 ± 0.516**
^{103}Ru	c	39.26D	497.1	91.0 ± 1.3	**8.185 ± 0.336**
^{99}Mo	c	65.94H	140.5	90.27 ± 0.33	**8.055 ± 0.608**
$^{95}Nb_i$	i(m+g)	34.975D	765.8	99.81 ± 0.03	**0.2728 ± 0.1094**
$^{95}Nb_c$	c	34.975D	765.8	99.81 ± 0.03	**7.317 ± 0.254**
^{95}Zr	c	64.02D	765.8	*	7.109 ± 0.253
			756.7	54.46 ± 0.10	6.945 ± 0.249
			724.2	44.17 ± 0.16	6.597 ± 0.344
				RR_{mean} =	**7.003 ± 0.216**

12.2.6 Nuclide production rates for ^{27}Al

Table 56: Detailed calculation of nuclide production rates for in ^{27}Al-monitors and ^{27}Al-plates for $E_p = 0.07$ GeV, used for calculating proton flux (including total over the plate area), cross sections for production of ^{7}Be, ^{24}Naand neutron background.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			^{27}Al-monitor for ^{206}Pb		
^{24}Na	c	14.9590H	1369.0	100 ± 0	**24.20 ± 0.81**
^{7}Be	i	53.29D	477.6	10.52 ± 0.06	**1.761 ± 0.077**
^{27}Mg	c	9.458M	843.8	71.8 ± 0.4	**0.1827 ± 0.0179**
^{22}Na	c	2.6019Y	1274.5	99.94 ± 0.01	**45.98 ± 1.55**
^{24}Na	c	14.9590H	1369.0	100 ± 0	**24.20 ± 0.81**
			^{27}Al-plate for ^{206}Pb		
^{24}Na	c	14.9590H	1369.0	100 ± 0	**1.681 ± 0.056**
			^{27}Al-monitor for ^{207}Pb		
^{7}Be	i	53.29D	477.6	10.52 ± 0.06	**1.555 ± 0.059**
^{27}Mg	c	9.458M	843.8	71.8 ± 0.4	0.3004 ± 0.0236
			1014.4	28.0 ± 0.4	0.2354 ± 0.0836
				RR_{mean} =	**0.2963 ± 0.0229**
^{22}Na	c	2.6019Y	1274.5	99.94 ± 0.01	**53.94 ± 1.81**
^{24}Na	c	14.9590H	1369.0	100 ± 0	**28.17 ± 0.94**

Continuation of Table 56.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			^{27}Al-plate for ^{207}Pb		
^{24}Na	c	14.9590H	1369.0	100 ± 0	**1.426 ± 0.048**
			^{27}Al-monitor for ^{207}Pb		
^{7}Be	i	53.29D	477.6	10.52 ± 0.06	**1.555 ± 0.062**
^{27}Mg	c	9.458M	843.8	71.8 ± 0.4	0.2241 ± 0.0217
			1014.4	28.0 ± 0.4	0.2088 ± 0.0558
				RR_{mean} =	**0.2222 ± 0.0205**
^{22}Na	c	2.6019Y	1274.5	99.94 ± 0.01	**51.58 ± 1.73**
^{24}Na	c	14.9590H	1369.0	100 ± 0	**27.16 ± 0.91**
			^{27}Al-plate for ^{207}Pb		
^{24}Na	c	14.9590H	1369.0	100 ± 0	**1.672 ± 0.056**
			^{27}Al-monitor for ^{nat}Pb		
^{7}Be	i	53.29D	477.6	10.52 ± 0.06	**0.4960 ± 0.0216**
^{27}Mg	c	9.458M	843.8	71.8 ± 0.4	**0.09431 ± 0.01289**
^{22}Na	c	2.6019Y	1274.5	99.94 ± 0.01	**18.82 ± 0.63**
^{24}Na	c	14.9590H	1369.0	100 ± 0	**9.316 ± 0.310**
			^{27}Al-plate for ^{nat}Pb		
^{24}Na	c	14.9590H	1369.0	100 ± 0	**0.6985 ± 0.0234**
			^{27}Al-monitor for ^{209}Bi		
^{7}Be	i	53.29D	477.6	10.52 ± 0.06	**1.527 ± 0.066**
^{27}Mg	c	9.458M	843.8	71.8 ± 0.4	0.3509 ± 0.0277
			1014.4	28.0 ± 0.4	0.2876 ± 0.1070
				RR_{mean} =	**0.3475 ± 0.0270**
^{22}Na	c	2.6019Y	1274.5	99.94 ± 0.01	**52.67 ± 1.79**
^{24}Na	c	14.9590H	1369.0	100 ± 0	**27.11 ± 0.90**
			^{27}Al-plate for ^{209}Bi		
^{24}Na	c	14.9590H	1369.0	100 ± 0	**1.418 ± 0.048**

12.3 Detailed calculation of nuclide production rates for ^{206}Pb, ^{207}Pb, ^{208}Pb, ^{nat}Pb and ^{209}Bi for $E_p = 0.1$ GeV

12.3.1 Nuclide production rates for ^{206}Pb

Table 57: Detailed calculation of nuclide production rates for ^{206}Pb for $E_p = 0.1$ GeV, used to determine the cross sections for their production.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{207}Bi	i	31.55Y	569.7	97.74 ± 0.03	**6.229 ± 3.049**
^{206}Bi	i	6.243D	1878.7	2.01 ± 0.05	27.28 ± 1.48
			1718.7	31.8 ± 0.6	26.48 ± 1.05
			1595.3	5.01 ± 0.08	28.59 ± 1.24
			1098.3	13.50 ± 0.21	23.93 ± 0.94
			1018.6	7.60 ± 0.11	25.04 ± 1.03
			895.1	15.66 ± 0.23	25.65 ± 0.95
			881.0	66.2 ± 1.0	25.43 ± 0.93
			803.1	98.9 ± 1.4	24.48 ± 0.88
			657.2	1.91 ± 0.04	25.75 ± 1.71
			632.2	4.47 ± 0.07	24.03 ± 1.56
			620.5	5.76 ± 0.09	22.01 ± 1.01
			537.5	30.5 ± 0.5	22.46 ± 0.86
			516.2	40.7 ± 0.6	23.49 ± 0.88
			497.1	15.31 ± 0.22	23.50 ± 1.01
			398.0	10.74 ± 0.15	22.91 ± 0.86
			343.5	23.4 ± 0.4	24.35 ± 0.96
			262.7	3.02 ± 0.06	27.65 ± 3.15
			184.0	15.8 ± 0.4	27.82 ± 1.28
				RR_{mean} =	**24.45 ± 0.84**
^{205}Bi	i	15.31D	1861.7	6.17 ± 0.10	86.90 ± 3.45
			1775.8	3.99 ± 0.08	87.69 ± 3.88
			1764.3	32.5 ± 0.7	87.92 ± 3.57
			1614.3	2.28 ± 0.04	94.90 ± 4.06
			1190.0	2.26 ± 0.07	86.19 ± 4.11
			1043.8	7.51 ± 0.10	78.32 ± 2.89
			987.7	16.13 ± 0.17	84.77 ± 2.96
			703.5	31.1 ± 0.1	80.43 ± 2.70
			579.8	5.44 ± 0.07	76.23 ± 3.08
			570.6	4.34 ± 0.07	74.56 ± 2.94
			284.1	1.69 ± 0.02	78.74 ± 3.41
			260.5	1.09 ± 0.04	78.08 ± 4.38
				RR_{mean} =	**81.70 ± 2.90**
^{204}Bi	i	11.22H	1755.3	1.22 ± 0.12	129.6 ± 17.1
			1211.7	3.0 ± 0.4	133.9 ± 19.2
			984.0	59 ± 4	121.6 ± 9.2
			918.3	10.8 ± 0.9	138.8 ± 12.6
			899.2	98 ± 9	117.8 ± 3.9
			791.2	3.3 ± 0.3	170.2 ± 17.6
			670.7	11.4 ± 0.9	124.3 ± 10.8
			374.8	82 ± 5	138.9 ± 29.0
				RR_{mean} =	**118.4 ± 3.7**
^{203}Bi	i(m+g)	11.76H	2011.0	1.76 ± 0.09	169.1 ± 11.7

Continuation of Table 57.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			1893.0	8.2 ± 0.6	178.8 ± 14.8
			1888.0	1.94 ± 0.10	170.9 ± 12.6
			1847.3	11.4 ± 0.8	169.4 ± 13.4
			1679.6	8.8 ± 0.7	181.8 ± 15.9
			1536.5	7.5 ± 0.6	177.3 ± 15.8
			1506.7	3.7 ± 0.3	165.2 ± 15.0
			1034.0	8.8 ± 0.5	174.8 ± 11.7
			896.8	13.1 ± 0.7	167.4 ± 10.7
			847.2	8.5 ± 0.5	179.4 ± 12.5
			820.2	29.6 ± 1.5	184.1 ± 11.2
			816.3	4.03 ± 0.21	199.7 ± 12.8
			722.4	4.8 ± 0.4	185.9 ± 17.0
			279.2	*	165.9 ± 8.4
			264.2	5.2 ± 0.4	172.3 ± 15.1
			186.6	3.11 ± 0.22	213.6 ± 20.0
				RR_{mean} =	**170.4 ± 5.3**
^{202}Bi	i	1.72H	960.7	99.28 ± 0.02	199.5 ± 7.0
			954.5	7.8 ± 0.5	191.0 ± 15.8
			927.3	7.1 ± 0.4	204.9 ± 15.6
			657.5	60.6 ± 1.8	223.0 ± 10.6
			569.3	4.8 ± 0.3	190.6 ± 19.4
			422.1	83.7 ± 2.5	208.5 ± 10.2
			346.5	4.6 ± 0.3	171.0 ± 17.8
				RR_{mean} =	**202.2 ± 7.4**
^{201}Bi	i	108M	1650.9	5.8 ± 1.3	204.9 ± 47.4
			1570.8	2.4 ± 0.6	240.6 ± 62.3
			1325.2	6.1 ± 1.3	270.2 ± 58.8
			1108.1	3.9 ± 0.9	265.3 ± 63.0
			936.2	11.3 ± 2.5	247.9 ± 55.8
			629.1	24 ± 6	230.2 ± 58.3
			331.2	*	269.6 ± 20.2
				RR_{mean} =	**267.1 ± 8.2**
^{199}Bi	i	27M	1034.0	5.8 ± 0.4	294.5 ± 26.1
			946.0	10.8 ± 0.6	252.1 ± 18.8
			841.7	11 ± 0	300.5 ± 14.6
			837.4	9.5 ± 0.6	311.0 ± 27.8
				RR_{mean} =	**289.5 ± 15.1**
$^{204m}Pb_i$	i(m)	67.2M	899.2	99.17 ± 0.02	91.07 ± 3.21
			374.7	89 ± 15	99.46 ± 17.13
				RR_{mean} =	**91.15 ± 3.21**
$^{204m}Pb_c$	c	67.2M	899.2	99.17 ± 0.02	108.7 ± 3.7
			374.7	89 ± 15	116.9 ± 20.1
				RR_{mean} =	**108.8 ± 3.7**
$^{203}Pb_i$	i(m1+m2+g)	51.873H	279.2	80.8 ± 0.2	**331.0 ± 14.2**
$^{203}Pb_c$	c	51.873H	279.2	80.8 ± 0.2	**496.9 ± 18.2**
^{202m}Pb	i(m)	3.53H	960.7	92 ± 8	112.6 ± 10.6
			657.5	32.4 ± 1.7	86.68 ± 6.95
			490.5	9.1 ± 0.7	125.1 ± 11.4
			459.7	8.6 ± 0.7	124.2 ± 11.8
			422.1	86 ± 5	110.1 ± 7.7
			389.9	6.2 ± 0.6	112.4 ± 14.9

Continuation of Table 57.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
				RR_{mean} =	**105.7 ± 6.9**
$^{201}Pb_i$	i(m+g)	9.33H	331.2	79 ± 5	**328.6 ± 24.2**
$^{201}Pb_c$	c	9.33H	331.2	79 ± 5	**598.1 ± 42.9**
^{200}Pb	c	21.5H	605.4	0.56 ± 0.05	687.8 ± 69.7
			525.5	0.42 ± 0.04	616.2 ± 66.2
			450.5	3.33 ± 0.08	675.8 ± 29.2
			268.4	3.96 ± 0.20	663.2 ± 43.1
			257.2	4.46 ± 0.17	690.4 ± 38.3
			235.6	4.30 ± 0.17	657.4 ± 37.5
			147.6	37.7 ± 1.4	624.4 ± 33.7
			142.3	3.16 ± 0.19	662.1 ± 48.8
				RR_{mean} =	**665.6 ± 22.3**
^{199}Pb	c*	90M	1749.7	2.3 ± 0.4	1037 ± 194
			1382.7	2.9 ± 0.5	1448 ± 295
			1135.0	7.8 ± 1.2	1561 ± 250
			937.9	2.1 ± 0.4	1332 ± 276
			781.5	1.9 ± 0.3	1106 ± 180
			762.0	2.2 ± 0.4	1125 ± 210
			720.2	6.5 ± 1.0	1483 ± 238
			366.9	44 ± 7	1572 ± 260
			353.4	9.5 ± 1.5	1596 ± 269
				RR_{mean} =	**1338 ± 88.**
^{198}Pb	c	2.4H	865.3	5.9 ± 1.2	654.1 ± 135.1
			575.0	3.1 ± 0.7	685.9 ± 157.2
			365.4	19 ± 5	816.9 ± 217.0
			259.5	5.8 ± 1.2	732.2 ± 154.3
			173.4	18 ± 3	812.6 ± 138.8
				RR_{mean} =	**800.6 ± 31.3**
^{197m}Pb	c*	43M	774.3	14 ± 3	61.65 ± 13.98
			387.7	25 ± 6	76.50 ± 18.66
			385.9	74 ± 15	97.51 ± 20.08
				RR_{mean} =	**87.17 ± 11.21**
^{202}Tl	c	12.23D	439.6	91.4 ± 1.0	**45.66 ± 1.64**
^{201}Tl	c*	72.912H	167.4	10.00 ± 0.06	739.9 ± 27.4
			135.3	2.56 ± 0.02	826.2 ± 35.2
				RR_{mean} =	**763.2 ± 44.9**
$^{200}Tl_c$	c	26.1H	1604.5	1.17 ± 0.10	654.0 ± 61.9
			1514.9	4.0 ± 0.3	651.0 ± 53.8
			1366.3	0.9 ± 0.3	609.8 ± 204.6
			1362.9	3.4 ± 0.4	682.4 ± 83.7
			1291.1	0.60 ± 0.06	700.8 ± 77.7
			1205.7	29.9 ± 1.8	632.3 ± 43.5
			886.2	2.02 ± 0.13	615.2 ± 45.8
			828.3	10.8 ± 0.7	645.3 ± 47.5
			783.6	0.57 ± 0.18	548.5 ± 176.4
			628.6	1.00 ± 0.08	561.8 ± 54.1
			579.3	13.8 ± 0.7	632.8 ± 39.9
			367.9	87.2 ± 0.4	605.8 ± 21.6
				RR_{mean} =	**614.0 ± 20.8**
$^{200}Tl_i$	i	26.1H	828.3	10.8 ± 0.7	**86.37 ± 7.78**
^{199}Tl	c*	7.42H	750.4	1.04 ± 0.12	932.7 ± 114.7

Continuation of Table 57.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			492.3	1.53 ± 0.17	884.7 ± 107.0
			455.5	12.4 ± 1.4	831.0 ± 98.2
			403.5	1.72 ± 0.19	850.0 ± 100.1
			333.9	1.76 ± 0.20	982.0 ± 118.1
			284.1	2.21 ± 0.24	918.4 ± 106.3
			247.3	9.3 ± 1.1	868.6 ± 108.5
			208.2	12.3 ± 1.4	844.8 ± 101.9
			158.4	5.0 ± 0.6	804.0 ± 101.0
				RR_{mean} =	**875.4 ± 32.9**
^{198m}Tl	i(m)	1.87H	587.2	52.5 ± 2.0	21.84 ± 1.50
			282.8	28 ± 3	22.66 ± 2.89
				RR_{mean} =	**21.96 ± 1.21**
^{197}Tl	c*	2.84H	152.2	7.3 ± 2.3	**204.4 ± 65.3**
^{196m}Tl	i(m)	1.41H	695.4	41 ± 7	**73.93 ± 13.02**
^{203}Hg	c	46.612D	279.2	81.46 ± 0.13	**0.3863 ± 0.0484**
^{197}Hg	c*	64.14H	191.4	0.63 ± 0.02	**152.7 ± 9.6**
^{196}Au	i(m1+m2+g)	6.183D	355.7	87.0 ± 0.8	**0.2158 ± 0.0244**
^{195}Au	c	186.098D	98.9	10.9 ± 0.9	**33.68 ± 3.32**
^{124}Sb	i(m1+m2+g)	60.20D	602.7	98.3 ± 0.4	**0.4885 ± 0.0395**
^{123m}Te	i(m)	119.7D	159.0	84.0 ± 0.4	**0.4009 ± 0.0298**
^{120m}Sb	i(m)	5.76D	1171.7	100 ± 0	0.2820 ± 0.0221
			1023.3	99.4 ± 0.3	0.2903 ± 0.0302
			197.3	87.0 ± 1.1	0.3291 ± 0.0224
				RR_{mean} =	**0.3029 ± 0.0181**
^{110m}Ag	i(m)	249.76D	657.8	94.3 ± 0.3	**0.7862 ± 0.0650**
^{103}Ru	c	39.26D	497.1	91.0 ± 1.3	**9.610 ± 0.379**
^{99}Mo	c	65.94H	140.5	90.27 ± 0.33	**11.29 ± 0.53**
^{96}Nb	i	23.35H	1091.3	48.5 ± 1.6	**2.979 ± 0.280**
^{95}Nb$_i$	i(m+g)	34.975D	765.8	99.81 ± 0.03	**1.349 ± 0.056**
^{95}Nb$_c$	c	34.975D	765.8	99.81 ± 0.03	**9.636 ± 0.321**
^{97}Zr	c	16.744H	743.4	93.06 ± 0.16	**4.347 ± 0.198**
^{95}Zr	c	64.02D	765.8	*	8.362 ± 0.284
			756.7	54.46 ± 0.10	7.551 ± 0.281
			724.2	44.17 ± 0.16	8.730 ± 0.397
				RR_{mean} =	**8.332 ± 0.257**

12.3.2 Nuclide production rates for ^{207}Pb

Table 58: Detailed calculation of nuclide production rates for ^{207}Pb for $E_p = 0.1$ GeV, used to determine the cross sections for their production.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{207}Bi	i	31.55Y	569.7	97.74 ± 0.03	**22.43 ± 2.67**
^{206}Bi	i	6.243D	1878.7	2.01 ± 0.05	51.94 ± 2.53
			1718.7	31.8 ± 0.6	53.74 ± 2.17
			1595.3	5.01 ± 0.08	59.89 ± 2.58
			1098.3	13.50 ± 0.21	49.10 ± 1.82
			1018.6	7.60 ± 0.11	54.50 ± 2.12
			895.1	15.66 ± 0.23	53.53 ± 1.97

Continuation of Table 58.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			881.0	66.2 ± 1.0	53.24 ± 1.92
			803.1	98.9 ± 1.4	50.65 ± 1.84
			657.2	1.91 ± 0.04	55.19 ± 2.71
			632.2	4.47 ± 0.07	50.86 ± 2.39
			620.5	5.76 ± 0.09	46.84 ± 2.10
			537.5	30.5 ± 0.5	46.00 ± 1.76
			516.2	40.7 ± 0.6	49.17 ± 1.83
			497.1	15.31 ± 0.22	46.53 ± 1.80
			398.0	10.74 ± 0.15	47.06 ± 1.84
			343.5	23.4 ± 0.4	48.49 ± 1.83
			262.7	3.02 ± 0.06	45.66 ± 3.14
			184.0	15.8 ± 0.4	56.52 ± 2.55
				RR_{mean} =	**50.42 ± 1.76**
^{205}Bi	i	15.31D	1861.7	6.17 ± 0.10	112.9 ± 4.4
			1775.8	3.99 ± 0.08	121.1 ± 5.2
			1764.3	32.5 ± 0.7	114.9 ± 4.7
			1614.3	2.28 ± 0.04	121.6 ± 5.4
			1190.0	2.26 ± 0.07	110.6 ± 5.3
			1043.8	7.51 ± 0.10	103.6 ± 3.8
			987.7	16.13 ± 0.17	111.6 ± 3.9
			703.5	31.1 ± 0.1	104.1 ± 3.5
			579.8	5.44 ± 0.07	100.8 ± 4.0
			570.6	4.34 ± 0.07	98.59 ± 4.23
			284.1	1.69 ± 0.02	106.1 ± 4.5
			260.5	1.09 ± 0.04	100.7 ± 5.7
				RR_{mean} =	**107.4 ± 3.8**
^{204}Bi	i	11.22H	1755.3	1.22 ± 0.12	123.4 ± 14.2
			1211.7	3.0 ± 0.4	111.7 ± 15.8
			984.0	59 ± 4	118.1 ± 9.0
			918.3	10.8 ± 0.9	132.0 ± 11.9
			899.2	98 ± 9	114.4 ± 3.8
			791.2	3.3 ± 0.3	129.1 ± 14.4
			670.7	11.4 ± 0.9	124.1 ± 10.7
			374.8	82 ± 5	136.5 ± 28.5
			176.1	1.12 ± 0.09	164.9 ± 17.5
				RR_{mean} =	**115.1 ± 3.6**
^{203}Bi	i(m+g)	11.76H	2011.0	1.76 ± 0.09	156.9 ± 10.8
			1893.0	8.2 ± 0.6	159.8 ± 13.3
			1888.0	1.94 ± 0.10	162.4 ± 11.5
			1847.3	11.4 ± 0.8	159.4 ± 12.6
			1679.6	8.8 ± 0.7	158.3 ± 13.8
			1536.5	7.5 ± 0.6	162.9 ± 14.3
			1506.7	3.7 ± 0.3	143.9 ± 13.1
			1034.0	8.8 ± 0.5	153.6 ± 10.3
			896.8	13.1 ± 0.7	162.1 ± 10.3
			847.2	8.5 ± 0.5	165.3 ± 11.4
			820.2	29.6 ± 1.5	166.0 ± 10.1
			816.3	4.03 ± 0.21	172.1 ± 11.2
			722.4	4.8 ± 0.4	170.1 ± 15.5
			279.2	*	167.9 ± 9.5
			264.2	5.2 ± 0.4	152.8 ± 13.4

Continuation of Table 58.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			186.6	3.11 ± 0.22	204.8 ± 17.0
				RR_{mean} =	**165.9 ± 5.1**
^{202}Bi	i	1.72H	960.7	99.28 ± 0.02	183.5 ± 6.5
			954.5	7.8 ± 0.5	177.2 ± 18.2
			927.3	7.1 ± 0.4	153.8 ± 12.2
			657.5	60.6 ± 1.8	194.4 ± 9.3
			569.3	4.8 ± 0.3	182.7 ± 15.9
			422.1	83.7 ± 2.5	190.4 ± 9.1
			346.5	4.6 ± 0.3	178.5 ± 15.0
				RR_{mean} =	**184.0 ± 6.6**
^{201}Bi	i	108M	1650.9	5.8 ± 1.3	206.2 ± 47.5
			1570.8	2.4 ± 0.6	245.5 ± 63.5
			1325.2	6.1 ± 1.3	218.6 ± 48.3
			1108.1	3.9 ± 0.9	198.2 ± 46.8
			936.2	11.3 ± 2.5	217.4 ± 49.3
			629.1	24 ± 6	200.6 ± 50.9
			331.2	*	260.3 ± 19.4
				RR_{mean} =	**254.0 ± 7.8**
^{199}Bi	i	27M	1034.0	5.8 ± 0.4	294.3 ± 27.5
			946.0	10.8 ± 0.6	243.2 ± 19.0
			841.7	11 ± 0	267.3 ± 16.3
			837.4	9.5 ± 0.6	265.2 ± 22.9
				RR_{mean} =	**263.7 ± 12.2**
^{204m}Pb$_i$	i(m)	67.2M	899.2	99.17 ± 0.02	90.40 ± 3.27
			374.7	89 ± 15	97.86 ± 16.85
				RR_{mean} =	**90.48 ± 3.26**
^{204m}Pb$_c$	c	67.2M	899.2	99.17 ± 0.02	107.5 ± 3.8
			374.7	89 ± 15	115.0 ± 19.8
				RR_{mean} =	**107.6 ± 3.8**
^{203}Pb$_i$	i(m1+m2+g)	51.873H	279.2	80.8 ± 0.2	**246.9 ± 12.9**
^{203}Pb$_c$	c	51.873H	279.2	80.8 ± 0.2	**414.9 ± 15.3**
^{202m}Pb	i(m)	3.53H	960.7	92 ± 8	99.41 ± 9.38
			657.5	32.4 ± 1.7	77.50 ± 5.95
			490.5	9.1 ± 0.7	105.8 ± 9.3
			459.7	8.6 ± 0.7	113.9 ± 10.9
			422.1	86 ± 5	97.93 ± 6.83
			389.9	6.2 ± 0.6	106.7 ± 11.7
				RR_{mean} =	**93.50 ± 6.08**
^{201}Pb$_i$	i(m+g)	9.33H	331.2	79 ± 5	**221.6 ± 16.6**
^{201}Pb$_c$	c	9.33H	331.2	79 ± 5	**481.9 ± 34.6**
^{200}Pb	c	21.5H	605.4	0.56 ± 0.05	575.6 ± 56.6
			525.5	0.42 ± 0.04	518.2 ± 54.6
			450.5	3.33 ± 0.08	548.7 ± 23.2
			268.4	3.96 ± 0.20	531.6 ± 34.6
			257.2	4.46 ± 0.17	572.3 ± 32.1
			235.6	4.30 ± 0.17	513.6 ± 29.3
			147.6	37.7 ± 1.4	505.4 ± 27.5
			142.3	3.16 ± 0.19	554.7 ± 42.0
				RR_{mean} =	**541.1 ± 18.3**
^{199}Pb	c*	90M	1749.7	2.3 ± 0.4	760.8 ± 137.5
			1382.7	2.9 ± 0.5	1030 ± 192

Continuation of Table 58.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			1135.0	7.8 ± 1.2	952.5 ± 152.1
			937.9	2.1 ± 0.4	842.7 ± 171.7
			781.5	1.9 ± 0.3	872.0 ± 144.3
			762.0	2.2 ± 0.4	796.7 ± 154.0
			720.2	6.5 ± 1.0	934.9 ± 166.4
			366.9	44 ± 7	1020 ± 172
			353.4	9.5 ± 1.5	1124 ± 185
				RR_{mean} =	**925.4 ± 47.4**
^{198}Pb	c	2.4H	865.3	5.9 ± 1.2	172.1 ± 36.3
			575.0	3.1 ± 0.7	146.5 ± 34.5
			365.4	19 ± 5	201.5 ± 53.6
			259.5	5.8 ± 1.2	194.5 ± 41.3
			173.4	18 ± 3	207.1 ± 35.4
				RR_{mean} =	**203.0 ± 9.1**
^{197m}Pb	c*	43M	385.9	74 ± 15	**5.455 ± 1.235**
^{202}Tl	c	12.23D	439.6	91.4 ± 1.0	**36.28 ± 1.30**
^{201}Tl	c*	72.912H	167.4	10.00 ± 0.06	603.5 ± 22.2
			135.3	2.56 ± 0.02	670.9 ± 28.9
				RR_{mean} =	**620.8 ± 35.1**
^{200}Tl$_c$	c	26.1H	1604.5	1.17 ± 0.10	500.3 ± 48.5
			1514.9	4.0 ± 0.3	522.3 ± 43.5
			1366.3	0.9 ± 0.3	529.3 ± 177.7
			1362.9	3.4 ± 0.4	539.5 ± 66.3
			1291.1	0.60 ± 0.06	494.5 ± 53.9
			1205.7	29.9 ± 1.8	507.6 ± 35.0
			886.2	2.02 ± 0.13	522.2 ± 38.8
			828.3	10.8 ± 0.7	514.8 ± 37.7
			783.6	0.57 ± 0.18	393.0 ± 126.8
			628.6	1.00 ± 0.08	462.0 ± 44.6
			579.3	13.8 ± 0.7	503.8 ± 31.4
			367.9	87.2 ± 0.4	495.7 ± 17.6
				RR_{mean} =	**498.9 ± 16.9**
^{200}Tl$_i$	i	26.1H	828.3	10.8 ± 0.7	**52.34 ± 6.31**
^{199}Tl	c*	7.42H	750.4	1.04 ± 0.12	643.8 ± 80.9
			492.3	1.53 ± 0.17	602.0 ± 71.1
			455.5	12.4 ± 1.4	600.8 ± 71.1
			403.5	1.72 ± 0.19	626.8 ± 73.4
			333.9	1.76 ± 0.20	701.8 ± 85.0
			284.1	2.21 ± 0.24	695.5 ± 81.8
			247.3	9.3 ± 1.1	615.9 ± 77.1
			208.2	12.3 ± 1.4	590.9 ± 71.4
			158.4	5.0 ± 0.6	589.1 ± 74.2
				RR_{mean} =	**626.0 ± 23.7**
^{198m}Tl	i(m)	1.87H	587.2	52.5 ± 2.0	16.90 ± 1.35
			282.8	28 ± 3	22.46 ± 2.73
				RR_{mean} =	**17.77 ± 2.09**
^{197}Tl	c*	2.84H	152.2	7.3 ± 2.3	**49.68 ± 15.96**
^{196m}Tl	i(m)	1.41H	695.4	41 ± 7	**45.79 ± 8.05**
^{203}Hg	c	46.612D	279.2	81.46 ± 0.13	**1.045 ± 0.081**
^{124}Sb	i(m1+m2+g)	60.20D	602.7	98.3 ± 0.4	**0.3885 ± 0.0429**

Continuation of Table 58.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{196}Au	i(m1+m2+g)	6.183D	355.7	87.0 ± 0.8	**0.1931 ± 0.0463**
^{195}Au	c	186.098D	98.9	10.9 ± 0.9	**6.479 ± 0.872**
^{110m}Ag	i(m)	249.76D	657.8	94.3 ± 0.3	**0.4806 ± 0.0767**
^{103}Ru	c	39.26D	497.1	91.0 ± 1.3	**6.039 ± 0.247**
^{99}Mo	c	65.94H	140.5	90.27 ± 0.33	**7.224 ± 0.341**
^{95}Nb$_i$	i(m+g)	34.975D	765.8	99.81 ± 0.03	**0.6641 ± 0.0468**
^{95}Nb$_c$	c	34.975D	765.8	99.81 ± 0.03	**5.955 ± 0.205**
^{97}Zr	c	16.744H	743.4	93.06 ± 0.16	**3.159 ± 0.169**
^{95}Zr	c	64.02D	765.8	*	5.339 ± 0.191
			756.7	54.46 ± 0.10	4.782 ± 0.193
			724.2	44.17 ± 0.16	5.047 ± 0.244
				RR_{mean} =	**5.154 ± 0.159**

12.3.3 Nuclide production rates for ^{208}Pb

Table 59: Detailed calculation of nuclide production rates for ^{208}Pb for E_p = 0.1 GeV, used to determine the cross sections for their production.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{207}Bi	i	31.55Y	569.7	97.74 ± 0.03	**63.40 ± 6.41**
^{206}Bi	i	6.243D	1878.7	2.01 ± 0.05	111.1 ± 5.5
			1718.7	31.8 ± 0.6	109.1 ± 4.3
			1595.3	5.01 ± 0.08	115.1 ± 4.8
			1098.3	13.50 ± 0.21	101.0 ± 3.7
			1018.6	7.60 ± 0.11	109.4 ± 4.0
			895.1	15.66 ± 0.23	106.8 ± 3.8
			881.0	66.2 ± 1.0	106.2 ± 3.8
			803.1	98.9 ± 1.4	101.9 ± 3.6
			657.2	1.91 ± 0.04	95.33 ± 4.38
			632.2	4.47 ± 0.07	99.45 ± 3.92
			620.5	5.76 ± 0.09	96.33 ± 3.63
			537.5	30.5 ± 0.5	93.67 ± 3.54
			516.2	40.7 ± 0.6	98.90 ± 3.67
			497.1	15.31 ± 0.22	94.42 ± 3.57
			398.0	10.74 ± 0.15	94.43 ± 3.46
			343.5	23.4 ± 0.4	98.34 ± 3.70
			262.7	3.02 ± 0.06	100.7 ± 4.7
			184.0	15.8 ± 0.4	113.3 ± 5.1
				RR_{mean} =	**101.3 ± 3.4**
^{205}Bi	i	15.31D	1861.7	6.17 ± 0.10	165.7 ± 6.5
			1775.8	3.99 ± 0.08	168.7 ± 7.0
			1764.3	32.5 ± 0.7	169.8 ± 6.9
			1614.3	2.28 ± 0.04	179.9 ± 7.4
			1190.0	2.26 ± 0.07	157.9 ± 7.8
			1043.8	7.51 ± 0.10	153.4 ± 5.7
			987.7	16.13 ± 0.17	166.8 ± 5.8
			703.5	31.1 ± 0.1	156.2 ± 5.3
			579.8	5.44 ± 0.07	151.1 ± 5.7
			570.6	4.34 ± 0.07	146.7 ± 6.3

Continuation of Table 59.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			284.1	1.69 ± 0.02	152.0 ± 6.7
			260.5	1.09 ± 0.04	149.2 ± 8.1
				RR_{mean} =	**159.4 ± 5.5**
^{204}Bi	i	11.22H	1755.3	1.22 ± 0.12	158.4 ± 20.1
			1211.7	3.0 ± 0.4	147.5 ± 20.8
			984.0	59 ± 4	166.7 ± 12.6
			918.3	10.8 ± 0.9	187.0 ± 16.9
			899.2	98 ± 9	158.7 ± 5.3
			791.2	3.3 ± 0.3	179.2 ± 18.8
			670.7	11.4 ± 0.9	175.7 ± 15.2
			374.8	82 ± 5	188.4 ± 39.3
				RR_{mean} =	**159.6 ± 4.9**
^{203}Bi	i(m+g)	11.76H	2011.0	1.76 ± 0.09	229.3 ± 15.9
			1893.0	8.2 ± 0.6	212.1 ± 17.6
			1888.0	1.94 ± 0.10	193.9 ± 13.9
			1847.3	11.4 ± 0.8	211.8 ± 16.8
			1679.6	8.8 ± 0.7	209.7 ± 18.4
			1536.5	7.5 ± 0.6	232.1 ± 20.8
			1506.7	3.7 ± 0.3	203.6 ± 18.8
			1034.0	8.8 ± 0.5	213.6 ± 14.5
			896.8	13.1 ± 0.7	207.2 ± 13.2
			847.2	8.5 ± 0.5	230.4 ± 16.1
			820.2	29.6 ± 1.5	225.8 ± 13.7
			816.3	4.03 ± 0.21	228.6 ± 14.7
			722.4	4.8 ± 0.4	239.6 ± 22.0
			279.2	*	213.9 ± 9.1
			264.2	5.2 ± 0.4	218.6 ± 19.1
			186.6	3.11 ± 0.22	265.8 ± 21.8
				RR_{mean} =	**215.3 ± 6.6**
^{202}Bi	i	1.72H	960.7	99.28 ± 0.02	249.2 ± 8.8
			954.5	7.8 ± 0.5	247.4 ± 20.1
			927.3	7.1 ± 0.4	227.3 ± 16.7
			657.5	60.6 ± 1.8	259.7 ± 12.6
			569.3	4.8 ± 0.3	249.2 ± 22.3
			422.1	83.7 ± 2.5	257.7 ± 12.3
			346.5	4.6 ± 0.3	215.9 ± 18.0
				RR_{mean} =	**249.0 ± 8.6**
^{201}Bi	i	108M	1650.9	5.8 ± 1.3	278.0 ± 64.7
			1570.8	2.4 ± 0.6	348.9 ± 90.8
			1325.2	6.1 ± 1.3	320.7 ± 71.7
			936.2	11.3 ± 2.5	304.7 ± 68.5
			629.1	24 ± 6	283.2 ± 71.9
			331.2	*	333.9 ± 24.2
				RR_{mean} =	**330.8 ± 10.2**
^{199}Bi	i	27M	1034.0	5.8 ± 0.4	194.5 ± 28.8
			841.7	11 ± 0	148.8 ± 17.6
			837.4	9.5 ± 0.6	169.1 ± 30.4
				RR_{mean} =	**162.5 ± 14.0**
$^{204m}Pb_i$	i(m)	67.2M	899.2	99.17 ± 0.02	126.0 ± 4.5
			374.7	89 ± 15	132.8 ± 22.9

Continuation of Table 59.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
				RR_{mean} =	**126.1 ± 4.5**
$^{204m}Pb_c$	c	67.2M	899.2	99.17 ± 0.02	149.8 ± 5.2
			374.7	89 ± 15	156.4 ± 27.0
				RR_{mean} =	**149.9 ± 5.2**
$^{203}Pb_i$	i(m1+m2+g)	51.873H	279.2	80.8 ± 0.2	**305.8 ± 12.7**
$^{203}Pb_c$	c	51.873H	279.2	80.8 ± 0.2	**519.6 ± 19.0**
^{202m}Pb	i(m)	3.53H	960.7	92 ± 8	125.2 ± 11.8
			657.5	32.4 ± 1.7	106.1 ± 8.3
			490.5	9.1 ± 0.7	143.2 ± 12.5
			459.7	8.6 ± 0.7	132.0 ± 12.2
			422.1	86 ± 5	125.3 ± 8.8
			389.9	6.2 ± 0.6	132.8 ± 14.3
				RR_{mean} =	**122.6 ± 6.4**
$^{201}Pb_i$	i(m+g)	9.33H	331.2	79 ± 5	**252.0 ± 18.5**
$^{201}Pb_c$	c	9.33H	331.2	79 ± 5	**585.9 ± 42.0**
^{200}Pb	c	21.5H	605.4	0.56 ± 0.05	824.9 ± 86.2
			525.5	0.42 ± 0.04	593.1 ± 66.6
			450.5	3.33 ± 0.08	656.6 ± 27.9
			268.4	3.96 ± 0.20	646.3 ± 41.7
			257.2	4.46 ± 0.17	680.7 ± 38.1
			235.6	4.30 ± 0.17	664.6 ± 38.5
			147.6	37.7 ± 1.4	611.6 ± 32.9
			142.3	3.16 ± 0.19	630.9 ± 46.9
				RR_{mean} =	**652.4 ± 22.5**
^{199}Pb	c*	90M	1749.7	2.3 ± 0.4	411.2 ± 84.8
			1382.7	2.9 ± 0.5	576.0 ± 127.2
			1135.0	7.8 ± 1.2	491.2 ± 81.8
			781.5	1.9 ± 0.3	565.5 ± 97.3
			762.0	2.2 ± 0.4	483.4 ± 92.8
			720.2	6.5 ± 1.0	455.6 ± 78.7
			366.9	44 ± 7	534.2 ± 88.0
			353.4	9.5 ± 1.5	534.2 ± 89.5
				RR_{mean} =	**503.4 ± 23.2**
^{202}Tl	c	12.23D	439.6	91.4 ± 1.0	**40.12 ± 1.45**
^{201}Tl	c*	72.912H	167.4	10.00 ± 0.06	734.1 ± 26.9
			135.3	2.56 ± 0.02	802.2 ± 33.9
				RR_{mean} =	**752.6 ± 38.1**
$^{200}Tl_c$	c	26.1H	1604.5	1.17 ± 0.10	626.5 ± 59.0
			1514.9	4.0 ± 0.3	607.3 ± 50.1
			1366.3	0.9 ± 0.3	600.8 ± 202.3
			1362.9	3.4 ± 0.4	635.7 ± 78.2
			1291.1	0.60 ± 0.06	632.1 ± 68.3
			1205.7	29.9 ± 1.8	602.4 ± 41.6
			886.2	2.02 ± 0.13	617.0 ± 46.7
			828.3	10.8 ± 0.7	609.6 ± 44.8
			783.6	0.57 ± 0.18	499.5 ± 164.0
			628.6	1.00 ± 0.08	563.4 ± 56.1
			579.3	13.8 ± 0.7	610.4 ± 38.2
			367.9	87.2 ± 0.4	583.5 ± 20.8
				RR_{mean} =	**591.0 ± 20.0**

Continuation of Table 59.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
$^{200}Tl_i$	i	26.1H	367.9	87.2 ± 0.4	**50.85 ± 6.90**
^{199}Tl	c*	7.42H	750.4	1.04 ± 0.12	404.3 ± 56.9
			492.3	1.53 ± 0.17	378.6 ± 47.5
			455.5	12.4 ± 1.4	318.9 ± 37.8
			403.5	1.72 ± 0.19	363.9 ± 43.0
			284.1	2.21 ± 0.24	398.6 ± 50.0
			247.3	9.3 ± 1.1	338.1 ± 42.3
			208.2	12.3 ± 1.4	321.3 ± 38.9
			158.4	5.0 ± 0.6	332.0 ± 41.8
				RR_{mean} =	**347.2 ± 15.3**
^{198m}Tl	i(m)	1.87H	282.8	28 ± 3	**28.00 ± 3.46**
^{197}Tl	c*	2.84H	152.2	7.3 ± 2.3	**42.92 ± 14.11**
^{203}Hg	c	46.612D	279.2	81.46 ± 0.13	**2.188 ± 0.096**
^{124}Sb	i(m1+m2+g)	60.20D	602.7	98.3 ± 0.4	**0.4905 ± 0.0534**
^{196}Au	i(m1+m2+g)	6.183D	355.7	87.0 ± 0.8	**0.2807 ± 0.0480**
^{103}Ru	c	39.26D	497.1	91.0 ± 1.3	**5.413 ± 0.257**
^{99}Mo	c	65.94H	140.5	90.27 ± 0.33	**7.072 ± 0.313**
$^{95}Nb_i$	i(m+g)	34.975D	765.8	99.81 ± 0.03	**0.1606 ± 0.1018**
$^{95}Nb_c$	c	34.975D	765.8	99.81 ± 0.03	**5.502 ± 0.240**
^{97}Zr	c	16.744H	743.4	93.06 ± 0.16	**3.784 ± 0.237**
^{95}Zr	c	64.02D	765.8	*	5.390 ± 0.264
			756.7	54.46 ± 0.10	4.780 ± 0.257
			724.2	44.17 ± 0.16	5.347 ± 0.540
				RR_{mean} =	**5.118 ± 0.158**

12.3.4 Nuclide production rates for ^{nat}Pb

Table 60: Detailed calculation of nuclide production rates for ^{nat}Pb for E_p = 0.1 GeV, used to determine the cross sections for their production.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{207}Bi	i	31.55Y	569.7	97.74 ± 0.03	**21.15 ± 2.36**
^{206}Bi	i	6.243D	1878.7	2.01 ± 0.05	45.14 ± 2.27
			1718.7	31.8 ± 0.6	45.54 ± 1.80
			1595.3	5.01 ± 0.08	48.72 ± 2.07
			1098.3	13.50 ± 0.21	41.78 ± 1.58
			1018.6	7.60 ± 0.11	45.13 ± 1.66
			895.1	15.66 ± 0.23	43.70 ± 1.58
			881.0	66.2 ± 1.0	43.88 ± 1.58
			803.1	98.9 ± 1.4	42.20 ± 1.51
			657.2	1.91 ± 0.04	40.70 ± 2.29
			632.2	4.47 ± 0.07	40.21 ± 1.67
			620.5	5.76 ± 0.09	39.99 ± 1.75
			537.5	30.5 ± 0.5	38.79 ± 1.47
			516.2	40.7 ± 0.6	40.90 ± 1.54
			497.1	15.31 ± 0.22	39.52 ± 1.52
			398.0	10.74 ± 0.15	39.84 ± 1.48
			343.5	23.4 ± 0.4	41.26 ± 1.57
			262.7	3.02 ± 0.06	40.31 ± 2.83

Continuation of Table 60.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			184.0	15.8 ± 0.4	46.56 ± 2.11
				RR_{mean} =	**42.11 ± 1.42**
^{205}Bi	i	15.31D	1861.7	6.17 ± 0.10	79.29 ± 3.15
			1775.8	3.99 ± 0.08	82.89 ± 3.46
			1764.3	32.5 ± 0.7	81.82 ± 3.32
			1190.0	2.26 ± 0.07	78.30 ± 3.94
			1043.8	7.51 ± 0.10	73.50 ± 2.70
			987.7	16.13 ± 0.17	79.05 ± 2.74
			703.5	31.1 ± 0.1	74.56 ± 2.50
			579.8	5.44 ± 0.07	73.35 ± 2.82
			570.6	4.34 ± 0.07	71.89 ± 2.88
			549.8	2.95 ± 0.04	72.82 ± 2.91
			284.1	1.69 ± 0.02	74.59 ± 3.42
			260.5	1.09 ± 0.04	72.51 ± 4.42
				RR_{mean} =	**75.83 ± 2.53**
^{204}Bi	i	11.22H	1755.3	1.22 ± 0.12	89.38 ± 10.39
			1703.3	1.99 ± 0.17	99.64 ± 9.46
			1211.7	3.0 ± 0.4	74.60 ± 10.43
			984.0	59 ± 4	85.51 ± 6.45
			918.3	10.8 ± 0.9	98.33 ± 8.83
			899.2	98 ± 9	82.46 ± 2.73
			791.2	3.3 ± 0.3	98.25 ± 9.80
			670.7	11.4 ± 0.9	90.24 ± 7.80
			374.8	82 ± 5	97.75 ± 20.39
			176.1	1.12 ± 0.09	105.7 ± 10.1
				RR_{mean} =	**83.06 ± 2.56**
^{203}Bi	i(m+g)	11.76H	2011.0	1.76 ± 0.09	120.6 ± 8.0
			1893.0	8.2 ± 0.6	117.1 ± 9.6
			1888.0	1.94 ± 0.10	112.7 ± 7.7
			1847.3	11.4 ± 0.8	112.9 ± 8.9
			1679.6	8.8 ± 0.7	115.7 ± 10.1
			1536.5	7.5 ± 0.6	120.9 ± 10.6
			1506.7	3.7 ± 0.3	105.2 ± 9.4
			1034.0	8.8 ± 0.5	114.0 ± 7.6
			896.8	13.1 ± 0.7	118.5 ± 7.5
			847.2	8.5 ± 0.5	119.7 ± 8.2
			820.2	29.6 ± 1.5	120.6 ± 7.3
			816.3	4.03 ± 0.21	117.4 ± 7.3
			722.4	4.8 ± 0.4	121.8 ± 11.0
			279.2	*	116.8 ± 5.8
			264.2	5.2 ± 0.4	116.5 ± 10.1
			186.6	3.11 ± 0.22	141.8 ± 11.5
				RR_{mean} =	**117.4 ± 3.6**
^{202}Bi	i	1.72H	960.7	99.28 ± 0.02	135.7 ± 4.7
			954.5	7.8 ± 0.5	138.4 ± 10.6
			927.3	7.1 ± 0.4	116.7 ± 8.9
			657.5	60.6 ± 1.8	143.9 ± 6.8
			569.3	4.8 ± 0.3	138.9 ± 10.7
			422.1	83.7 ± 2.5	140.2 ± 6.7
			346.5	4.6 ± 0.3	123.5 ± 10.5

Continuation of Table 60.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
				RR_{mean} =	**136.1 ± 4.7**
^{201}Bi	i	108M	1650.9	5.8 ± 1.3	150.8 ± 34.7
			1570.8	2.4 ± 0.6	205.2 ± 52.4
			1325.2	6.1 ± 1.3	165.4 ± 36.1
			1108.1	3.9 ± 0.9	180.0 ± 42.9
			936.2	11.3 ± 2.5	164.7 ± 37.2
			629.1	24 ± 6	162.1 ± 41.1
			331.2	*	186.6 ± 13.7
				RR_{mean} =	**184.2 ± 5.7**
^{199}Bi	i	27M	1034.0	5.8 ± 0.4	166.8 ± 17.0
			837.4	9.5 ± 0.6	157.8 ± 15.3
				RR_{mean} =	**161.8 ± 11.9**
^{204m}Pb$_i$	i(m)	67.2M	899.2	99.17 ± 0.02	68.08 ± 2.37
			374.7	89 ± 15	72.22 ± 12.44
				RR_{mean} =	**68.11 ± 2.37**
^{204m}Pb$_c$	c	67.2M	899.2	99.17 ± 0.02	80.44 ± 2.75
			374.7	89 ± 15	84.48 ± 14.54
				RR_{mean} =	**80.47 ± 2.75**
^{203}Pb$_i$	i(m1+m2+g)	51.873H	279.2	80.8 ± 0.2	**176.8 ± 8.2**
^{203}Pb$_c$	c	51.873H	279.2	80.8 ± 0.2	**293.6 ± 10.8**
^{202m}Pb	i(m)	3.53H	960.7	92 ± 8	70.18 ± 6.56
			657.5	32.4 ± 1.7	57.23 ± 4.19
			490.5	9.1 ± 0.7	75.08 ± 6.49
			459.7	8.6 ± 0.7	74.03 ± 6.73
			422.1	86 ± 5	70.76 ± 4.88
			389.9	6.2 ± 0.6	68.56 ± 7.72
				RR_{mean} =	**66.51 ± 3.74**
^{201}Pb$_i$	i(m+g)	9.33H	331.2	79 ± 5	**155.6 ± 11.6**
^{201}Pb$_c$	c	9.33H	331.2	79 ± 5	**342.2 ± 24.5**
^{200}Pb	c	21.5H	605.4	0.56 ± 0.05	433.1 ± 43.0
			525.5	0.42 ± 0.04	396.7 ± 42.3
			450.5	3.33 ± 0.08	385.4 ± 16.4
			268.4	3.96 ± 0.20	386.8 ± 24.7
			257.2	4.46 ± 0.17	395.5 ± 21.7
			235.6	4.30 ± 0.17	384.0 ± 21.7
			147.6	37.7 ± 1.4	365.9 ± 20.5
			142.3	3.16 ± 0.19	369.0 ± 27.6
				RR_{mean} =	**384.4 ± 12.8**
^{199}Pb	c*	90M	1749.7	2.3 ± 0.4	386.3 ± 70.1
			1382.7	2.9 ± 0.5	477.2 ± 88.4
			1135.0	7.8 ± 1.2	507.0 ± 81.8
			937.9	2.1 ± 0.4	440.5 ± 87.7
			781.5	1.9 ± 0.3	460.0 ± 75.6
			762.0	2.2 ± 0.4	411.8 ± 79.9
			720.2	6.5 ± 1.0	464.8 ± 78.1
			366.9	44 ± 7	546.0 ± 90.9
			353.4	9.5 ± 1.5	584.2 ± 95.8
				RR_{mean} =	**478.9 ± 25.1**
^{198}Pb	c	2.4H	865.3	5.9 ± 1.2	143.7 ± 30.1
			575.0	3.1 ± 0.7	141.9 ± 32.9
			365.4	19 ± 5	157.1 ± 41.7

Continuation of Table 60.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			259.5	5.8 ± 1.2	144.8 ± 30.6
			173.4	18 ± 3	151.9 ± 26.0
				RR_{mean} =	**151.2 ± 5.8**
^{197m}Pb	c*	43M	387.7	25 ± 6	14.74 ± 3.72
			385.9	74 ± 15	18.39 ± 3.80
				RR_{mean} =	**17.99 ± 1.26**
^{202}Tl	c	12.23D	439.6	91.4 ± 1.0	**24.03 ± 0.87**
^{201}Tl	c*	72.912H	167.4	10.00 ± 0.06	427.1 ± 16.2
			135.3	2.56 ± 0.02	467.1 ± 22.2
				RR_{mean} =	**436.2 ± 21.5**
^{200}Tl$_c$	c	26.1H	1604.5	1.17 ± 0.10	331.9 ± 30.9
			1514.9	4.0 ± 0.3	359.1 ± 29.6
			1366.3	0.9 ± 0.3	333.0 ± 111.6
			1362.9	3.4 ± 0.4	365.1 ± 44.7
			1291.1	0.60 ± 0.06	354.1 ± 38.1
			1205.7	29.9 ± 1.8	347.4 ± 23.9
			886.2	2.02 ± 0.13	345.7 ± 25.1
			828.3	10.8 ± 0.7	349.7 ± 25.5
			783.6	0.57 ± 0.18	318.1 ± 101.4
			628.6	1.00 ± 0.08	296.2 ± 28.9
			579.3	13.8 ± 0.7	348.8 ± 21.4
			367.9	87.2 ± 0.4	336.9 ± 11.7
				RR_{mean} =	**338.7 ± 11.3**
^{200}Tl$_i$	i	26.1H	367.9	87.2 ± 0.4	**30.74 ± 2.61**
^{199}Tl	c*	7.42H	750.4	1.04 ± 0.12	361.0 ± 44.5
			492.3	1.53 ± 0.17	320.7 ± 37.7
			455.5	12.4 ± 1.4	304.8 ± 36.0
			403.5	1.72 ± 0.19	352.0 ± 41.7
			284.1	2.21 ± 0.24	328.9 ± 38.4
			247.3	9.3 ± 1.1	318.1 ± 39.7
			208.2	12.3 ± 1.4	307.5 ± 37.1
			158.4	5.0 ± 0.6	299.9 ± 37.7
				RR_{mean} =	**322.2 ± 12.3**
^{198m}Tl	i(m)	1.87H	587.2	52.5 ± 2.0	15.33 ± 0.89
			282.8	28 ± 3	15.13 ± 1.80
				RR_{mean} =	**15.32 ± 0.68**
^{197}Tl	c*	2.84H	152.2	7.3 ± 2.3	**58.17 ± 18.51**
^{196m}Tl	i(m)	1.41H	695.4	41 ± 7	**20.85 ± 3.67**
^{203}Hg	c	46.612D	279.2	81.46 ± 0.13	**1.007 ± 0.065**
^{197}Hg	c*	64.14H	191.4	0.63 ± 0.02	**43.18 ± 7.38**
^{196}Au	i(m1+m2+g)	6.183D	355.7	87.0 ± 0.8	**0.1365 ± 0.0453**
^{195}Au	c	186.098D	98.9	10.9 ± 0.9	**8.250 ± 0.958**
^{124}Sb	i(m1+m2+g)	60.20D	602.7	98.3 ± 0.4	**0.3193 ± 0.0434**
^{120m}Sb	i(m)	5.76D	1023.3	99.4 ± 0.3	**1.008 ± 0.175**
^{103}Ru	c	39.26D	497.1	91.0 ± 1.3	**3.911 ± 0.171**
^{99}Mo	c	65.94H	140.5	90.27 ± 0.33	**4.571 ± 0.225**
^{95}Nb$_i$	i(m+g)	34.975D	765.8	99.81 ± 0.03	**0.2956 ± 0.0582**
^{95}Nb$_c$	c	34.975D	765.8	99.81 ± 0.03	**3.935 ± 0.158**
^{97}Zr	c	16.744H	743.4	93.06 ± 0.16	**2.328 ± 0.090**
^{95}Zr	c	64.02D	765.8	*	3.672 ± 0.165

Continuation of Table 60.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			756.7	54.46 ± 0.10	3.218 ± 0.172
			724.2	44.17 ± 0.16	3.368 ± 0.230
				RR_{mean} =	**3.464 ± 0.107**

12.3.5 Nuclide production rates for ^{209}Bi

Table 61: Detailed calculation of nuclide production rates for ^{209}Bi for $E_p = 0.1$ GeV, used to determine the cross sections for their production.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{207}Po	i(m+g)	5.80H	992.3	59.3 ± 0.9	121.0 ± 4.5
			742.6	28.2 ± 0.5	135.4 ± 6.0
				RR_{mean} =	**124.5 ± 7.2**
^{206}Po	i	8.8D	1878.7	*	167.2 ± 9.0
			1718.7	*	173.4 ± 7.1
			1595.3	*	178.4 ± 8.2
			1405.0	*	146.2 ± 8.5
			1098.3	*	162.6 ± 6.0
			1032.3	33 ± 5	165.2 ± 25.6
			1018.6	*	173.1 ± 6.7
			1007.2	3.1 ± 0.4	149.1 ± 20.1
			895.1	*	171.9 ± 6.5
			881.0	*	172.1 ± 6.4
			818.2	1.04 ± 0.14	193.4 ± 29.7
			807.4	23 ± 3	156.9 ± 21.1
			803.1	*	161.9 ± 5.9
			677.7	1.47 ± 0.20	161.7 ± 23.2
			657.2	*	154.3 ± 9.9
			632.2	*	156.1 ± 6.3
			620.5	*	151.5 ± 6.4
			537.5	*	147.5 ± 5.7
			522.5	15.7 ± 2.0	151.0 ± 19.9
			516.2	*	155.1 ± 6.0
			497.1	*	151.9 ± 5.7
			463.4	1.79 ± 0.24	143.2 ± 21.3
			398.0	*	155.3 ± 6.4
			343.5	*	155.1 ± 6.0
			338.4	19.2 ± 2.5	162.3 ± 21.8
			311.6	4.2 ± 0.6	168.2 ± 24.8
			286.4	24 ± 3	165.5 ± 21.5
			184.0	*	178.2 ± 8.5
				RR_{mean} =	**160.8 ± 5.0**
^{205}Po	i	1.66H	1001.2	28.8 ± 2.2	193.3 ± 16.9
			872.4	37 ± 2	202.8 ± 13.3
			849.8	25.5 ± 2.1	208.4 ± 18.8
			836.8	19.2 ± 1.6	203.3 ± 18.7
				RR_{mean} =	**202.3 ± 7.2**
^{204}Po	i	3.53H	1211.7	*	288.9 ± 66.4
			1040.0	9.6 ± 0.5	266.4 ± 17.6

Continuation of Table 61.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			1016.3	24.1 ± 1.0	242.7 ± 13.2
			984.0	*	220.3 ± 19.9
			918.3	*	269.7 ± 36.0
			899.2	*	213.2 ± 22.8
			884.0	29.9 ± 1.2	257.2 ± 13.6
			762.5	11.5 ± 0.5	253.6 ± 15.1
			680.4	7.6 ± 0.4	245.8 ± 18.6
			670.7	*	214.7 ± 25.8
			534.9	13.2 ± 0.8	241.4 ± 21.6
			374.8	*	229.3 ± 19.6
			317.0	4.3 ± 0.5	277.3 ± 35.7
			305.0	3.26 ± 0.17	241.8 ± 23.2
			270.1	27.8 ± 1.3	246.9 ± 15.1
			219.4	*	320.8 ± 86.7
			137.0	9.7 ± 0.4	254.6 ± 18.6
				RR_{mean} =	**241.2 ± 7.4**
^{203}Po	i(m+g)	36.7M	1090.9	19.2 ± 1.6	248.2 ± 24.3
			908.6	55 ± 3	231.9 ± 15.3
			893.5	18.7 ± 1.5	218.5 ± 20.3
			214.8	14.3 ± 1.4	332.6 ± 40.3
			175.2	3.0 ± 0.4	271.9 ± 42.1
				RR_{mean} =	**233.9 ± 10.3**
^{202}Po	i	44.7M	960.7	*	281.0 ± 16.1
			688.6	51 ± 6	313.8 ± 38.5
			657.5	*	231.7 ± 25.1
			422.1	*	307.7 ± 14.9
			316.0	14.3 ± 1.8	300.0 ± 39.8
				RR_{mean} =	**293.1 ± 9.0**
^{201}Po	i(m+g)	15.3M	890.1	91 ± 4	**76.05 ± 4.61**
^{207}Bi	c	31.55Y	1770.2	6.87 ± 0.04	478.6 ± 45.2
			1063.7	74.5 ± 0.2	437.2 ± 16.7
			569.7	97.74 ± 0.03	449.1 ± 16.3
				RR_{mean} =	**444.8 ± 15.2**
^{206}Bi$_i$	i	6.243D	1878.7	2.01 ± 0.05	291.9 ± 13.8
			1718.7	31.8 ± 0.6	282.7 ± 11.2
			1595.3	5.01 ± 0.08	300.1 ± 12.5
			1405.0	1.43 ± 0.03	299.6 ± 13.5
			1098.3	13.50 ± 0.21	258.0 ± 9.4
			1018.6	7.60 ± 0.11	279.8 ± 10.3
			895.1	15.66 ± 0.23	286.5 ± 10.5
			881.0	66.2 ± 1.0	274.1 ± 9.9
			803.1	98.9 ± 1.4	267.0 ± 9.6
			657.2	1.91 ± 0.04	273.6 ± 14.6
			632.2	4.47 ± 0.07	261.0 ± 10.0
			620.5	5.76 ± 0.09	253.5 ± 10.1
			537.5	30.5 ± 0.5	245.5 ± 9.3
			516.2	40.7 ± 0.6	253.5 ± 9.5
			497.1	15.31 ± 0.22	243.6 ± 9.0
			398.0	10.74 ± 0.15	245.0 ± 9.4
			343.5	23.4 ± 0.4	257.3 ± 9.7
			184.0	15.8 ± 0.4	300.5 ± 13.8

Continuation of Table 61.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
				RR_{mean} =	**264.9 ± 9.1**
$^{206}Bi_c$	c	6.243D	1878.7	2.01 ± 0.05	449.8 ± 19.7
			1718.7	31.8 ± 0.6	446.5 ± 17.4
			1595.3	5.01 ± 0.08	468.8 ± 17.7
			1405.0	1.43 ± 0.03	437.7 ± 17.7
			1098.3	13.50 ± 0.21	411.6 ± 14.9
			1018.6	7.60 ± 0.11	443.3 ± 15.9
			895.1	15.66 ± 0.23	448.9 ± 16.1
			881.0	66.2 ± 1.0	436.7 ± 15.7
			803.1	98.9 ± 1.4	420.1 ± 15.0
			657.2	1.91 ± 0.04	419.4 ± 17.5
			632.2	4.47 ± 0.07	408.5 ± 15.2
			620.5	5.76 ± 0.09	396.7 ± 14.8
			537.5	30.5 ± 0.5	384.9 ± 14.5
			516.2	40.7 ± 0.6	400.1 ± 14.9
			497.1	15.31 ± 0.22	387.1 ± 14.3
			398.0	10.74 ± 0.15	391.7 ± 14.4
			343.5	23.4 ± 0.4	403.8 ± 15.2
			184.0	15.8 ± 0.4	468.9 ± 21.5
				RR_{mean} =	**418.2 ± 14.2**
^{205}Bi	c	15.31D	1903.4	2.47 ± 0.04	570.5 ± 22.6
			1861.7	6.17 ± 0.10	556.6 ± 21.6
			1775.8	3.99 ± 0.08	564.8 ± 22.9
			1764.3	32.5 ± 0.7	568.8 ± 23.0
			1614.3	2.28 ± 0.04	587.3 ± 22.7
			1551.0	0.97 ± 0.03	558.7 ± 30.3
			1351.5	1.06 ± 0.04	579.0 ± 30.0
			1190.0	2.26 ± 0.07	569.9 ± 26.2
			1043.8	7.51 ± 0.10	511.0 ± 18.1
			987.7	16.13 ± 0.17	549.0 ± 18.9
			910.9	1.64 ± 0.04	503.1 ± 21.4
			759.1	1.04 ± 0.05	561.1 ± 34.2
			744.7	0.70 ± 0.02	519.0 ± 22.9
			703.5	31.1 ± 0.1	517.7 ± 17.3
			579.8	5.44 ± 0.07	483.5 ± 18.3
			570.6	4.34 ± 0.07	511.3 ± 19.9
				RR_{mean} =	**532.7 ± 18.1**
$^{204}Bi_i$	i	11.22H	1211.7	3.0 ± 0.4	159.5 ± 73.9
			984.0	59 ± 4	283.1 ± 24.6
			918.3	10.8 ± 0.9	283.8 ± 42.6
			899.2	98 ± 9	357.4 ± 36.2
			670.7	11.4 ± 0.9	320.5 ± 35.8
			374.8	82 ± 5	344.4 ± 27.3
			219.4	2.30 ± 0.17	420.1 ± 113.1
				RR_{mean} =	**313.5 ± 19.5**
$^{204}Bi_c$	c	11.22H	1211.7	3.0 ± 0.4	446.5 ± 64.5
			984.0	59 ± 4	502.0 ± 38.0
			918.3	10.8 ± 0.9	551.8 ± 50.3
			899.2	98 ± 9	569.1 ± 55.6
			670.7	11.4 ± 0.9	533.8 ± 46.2
			374.8	82 ± 5	572.2 ± 40.0

Continuation of Table 61.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			219.4	2.30 ± 0.17	738.8 ± 68.7
				RR_{mean} =	**548.8 ± 30.5**
^{203}Bi	c	11.76H	2011.0	1.76 ± 0.09	568.6 ± 37.4
			2001.0	0.83 ± 0.05	555.8 ± 41.2
			1983.0	0.88 ± 0.05	557.7 ± 40.0
			1893.0	8.2 ± 0.6	604.6 ± 49.4
			1888.0	1.94 ± 0.10	573.6 ± 37.8
			1719.6	3.40 ± 0.23	645.7 ± 55.6
			1679.6	8.8 ± 0.7	574.1 ± 49.9
			1536.5	7.5 ± 0.6	610.8 ± 53.5
			1506.7	3.7 ± 0.3	545.2 ± 48.4
			1199.0	2.02 ± 0.11	629.1 ± 41.7
			1034.0	8.8 ± 0.5	558.2 ± 40.2
			936.0	0.74 ± 0.04	608.3 ± 46.4
			896.8	13.1 ± 0.7	575.9 ± 36.3
			866.5	1.49 ± 0.08	566.8 ± 37.5
			847.2	8.5 ± 0.5	599.9 ± 40.8
			825.2	14.6 ± 1.1	643.0 ± 53.8
			820.2	29.6 ± 1.5	599.6 ± 36.6
			816.3	4.03 ± 0.21	571.5 ± 35.7
			722.4	4.8 ± 0.4	623.1 ± 56.5
			401.3	*	438.4 ± 74.2
			381.7	1.28 ± 0.07	706.5 ± 47.6
			279.2	*	604.8 ± 22.8
			264.2	5.2 ± 0.4	585.6 ± 50.8
			186.6	3.11 ± 0.22	707.2 ± 57.8
				RR_{mean} =	**595.2 ± 18.4**
$^{202}Bi_i$	i	1.72H	960.7	99.28 ± 0.02	300.9 ± 17.2
			422.1	83.7 ± 2.5	282.9 ± 13.4
				RR_{mean} =	**288.9 ± 12.3**
$^{202}Bi_c$	c	1.72H	960.7	99.28 ± 0.02	576.3 ± 19.6
			657.5	60.6 ± 1.8	580.8 ± 27.8
			422.1	83.7 ± 2.5	584.4 ± 26.5
				RR_{mean} =	**577.9 ± 19.2**
^{201}Bi	c*	108M	1650.9	5.8 ± 1.3	431.0 ± 99.1
			1325.2	6.1 ± 1.3	463.1 ± 100.5
			1014.1	10.7 ± 2.3	457.6 ± 99.8
			936.2	11.3 ± 2.5	445.8 ± 100.2
			902.0	8.4 ± 1.8	414.8 ± 90.3
			629.1	24 ± 6	443.5 ± 112.1
				RR_{mean} =	**442.5 ± 18.2**
$^{203}Pb_i$	i(m1+m2+g)	51.873H	279.2	80.8 ± 0.2	**36.54 ± 7.03**
$^{203}Pb_c$	c	51.873H	279.2	80.8 ± 0.2	**641.3 ± 23.6**
^{202m}Pb	i(m)	3.53H	960.7	92 ± 8	**23.06 ± 3.04**
^{201}Pb	c*	9.33H	1277.1	1.63 ± 0.12	618.3 ± 52.0
			1238.8	1.18 ± 0.08	672.0 ± 57.5
			692.4	4.27 ± 0.16	676.2 ± 37.9
			584.5	3.56 ± 0.16	662.8 ± 38.4
			361.3	9.9 ± 0.5	725.1 ± 44.6
			331.2	79 ± 5	749.6 ± 54.5

Continuation of Table 61.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
				$RR_{mean}=$	**682.5 ± 26.8**
^{200}Pb	c	21.5H	450.5	3.33 ± 0.08	186.6 ± 9.7
			268.4	3.96 ± 0.20	169.8 ± 11.2
			257.2	4.46 ± 0.17	178.9 ± 10.4
			235.6	4.30 ± 0.17	173.8 ± 11.1
			147.6	37.7 ± 1.4	170.4 ± 10.5
			142.3	3.16 ± 0.19	166.3 ± 13.8
				$RR_{mean}=$	**176.6 ± 6.4**
^{199}Pb	c*	90M	366.9	44 ± 7	65.36 ± 12.36
			353.4	9.5 ± 1.5	57.16 ± 10.67
				$RR_{mean}=$	**60.58 ± 5.40**
^{198}Pb	c	2.4H	365.4	19 ± 5	74.82 ± 20.02
			173.4	18 ± 3	70.58 ± 12.53
				$RR_{mean}=$	**70.81 ± 4.23**
^{197m}Pb	c*	43M	387.7	25 ± 6	21.02 ± 5.44
			385.9	74 ± 15	18.05 ± 3.78
				$RR_{mean}=$	**18.28 ± 1.09**
^{202}Tl	c	12.23D	439.6	91.4 ± 1.0	**6.984 ± 0.262**
^{201}Tl	c*	72.912H	167.4	10.00 ± 0.06	**717.1 ± 27.6**
$^{200}Tl_i$	i	26.1H	1514.9	4.0 ± 0.3	23.48 ± 9.06
			1205.7	29.9 ± 1.8	18.70 ± 3.72
			579.3	13.8 ± 0.7	18.07 ± 4.47
			367.9	87.2 ± 0.4	21.51 ± 4.00
				$RR_{mean}=$	**19.73 ± 2.31**
$^{200}Tl_c$	c	26.1H	1604.5	1.17 ± 0.10	172.1 ± 22.0
			1514.9	4.0 ± 0.3	168.3 ± 14.5
			1362.9	3.4 ± 0.4	172.3 ± 21.1
			1225.5	3.36 ± 0.21	166.4 ± 19.1
			1205.7	29.9 ± 1.8	170.8 ± 11.9
			579.3	13.8 ± 0.7	166.5 ± 10.3
			367.9	87.2 ± 0.4	162.1 ± 6.1
				$RR_{mean}=$	**163.9 ± 5.8**
^{199}Tl	c*	7.42H	455.5	12.4 ± 1.4	71.93 ± 9.03
			247.3	9.3 ± 1.1	49.74 ± 6.91
			208.2	12.3 ± 1.4	66.32 ± 8.26
				$RR_{mean}=$	**61.93 ± 6.94**
^{123m}Te	i(m)	119.7D	159.0	84.0 ± 0.4	**0.6677 ± 0.0444**
^{124}Sb	i(m1+m2+g)	60.20D	602.7	98.3 ± 0.4	**1.090 ± 0.068**
^{122}Sb	i(m+g)	2.7238D	564.2	70.67 ± 0.18	**1.655 ± 0.102**
^{120m}Sb	i(m)	5.76D	197.3	87.0 ± 1.1	**0.5273 ± 0.0643**
^{115}Cd	c	53.46H	527.9	27.4 ± 0.6	2.878 ± 0.525
			336.2	45.9 ± 1.0	4.300 ± 0.226
				$RR_{mean}=$	**4.172 ± 0.428**
^{110m}Ag	i(m)	249.76D	884.7	72.7 ± 0.4	1.372 ± 0.211
			657.8	94.3 ± 0.3	1.194 ± 0.100
				$RR_{mean}=$	**1.224 ± 0.092**
^{107}Rh	c	21.7M	302.8	66 ± 6	**21.32 ± 2.30**
^{105}Rh	c	35.36H	318.9	19.1 ± 0.6	17.15 ± 0.88
			306.1	5.1 ± 0.4	15.40 ± 2.06
				$RR_{mean}=$	**17.00 ± 0.78**

Continuation of Table 61.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{106}Ru	c	373.59D	621.9(D)	9.93 ± 0.23	**10.71 ± 0.95**
^{103}Ru	c	39.26D	497.1	91.0 ± 1.3	**17.07 ± 0.66**
^{99}Mo	c	65.94H	181.1	5.99 ± 0.12	17.11 ± 1.41
			140.5	90.27 ± 0.33	18.54 ± 1.00
				RR_{mean} =	**18.14 ± 0.89**
^{96}Nb	i	23.35H	1091.3	48.5 ± 1.6	3.986 ± 0.520
			778.2	96.45 ± 0.22	4.390 ± 0.401
				RR_{mean} =	**4.245 ± 0.329**
^{95}Nb$_i$	i(m+g)	34.975D	765.8	99.81 ± 0.03	**2.316 ± 0.124**
^{95}Nb$_c$	c	34.975D	765.8	99.81 ± 0.03	**16.33 ± 0.55**
^{97}Zr	c	16.744H	743.4	93.06 ± 0.16	**7.443 ± 0.394**
^{95}Zr	c	64.02D	765.8	*	14.14 ± 0.48
			756.7	54.46 ± 0.10	13.52 ± 0.49
			724.2	44.17 ± 0.16	13.35 ± 0.75
				RR_{mean} =	**13.87 ± 0.43**
^{82}Br	i(m+g)	35.30H	554.3	70.8 ± 1.0	**2.636 ± 0.166**

12.3.6 Nuclide production rates for ^{27}Al

Table 62: Detailed calculation of nuclide production rates for in ^{27}Al-monitors and ^{27}Al-plates for E_p = 0.1 GeV, used for calculating proton flux (including total over the plate area), cross sections for production of ^{7}Be, ^{24}Naand neutron background.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
		^{27}Al-monitor for ^{206}Pb			
^{7}Be	i	53.29D	477.6	10.52 ± 0.06	**2.572 ± 0.101**
^{27}Mg	c	9.458M	843.8	71.8 ± 0.4	0.3452 ± 0.0278
			1014.4	28.0 ± 0.4	0.3581 ± 0.0834
				RR_{mean} =	**0.3463 ± 0.0268**
^{22}Na	c	2.6019Y	1274.5	99.94 ± 0.01	**54.22 ± 1.84**
^{24}Na	c	14.9590H	1369.0	100 ± 0	**31.97 ± 1.06**
		^{27}Al-plate for ^{206}Pb			
^{24}Na	c	14.9590H	1369.0	100 ± 0	**1.463 ± 0.050**
		^{27}Al-monitor for ^{207}Pb			
^{7}Be	i	53.29D	477.6	10.52 ± 0.06	**1.910 ± 0.124**
^{27}Mg	c	9.458M	843.8	71.8 ± 0.4	**0.2359 ± 0.0174**
^{22}Na	c	2.6019Y	1274.5	99.94 ± 0.01	**40.26 ± 1.37**
^{24}Na	c	14.9590H	1369.0	100 ± 0	**23.82 ± 0.79**
		^{27}Al-plate for ^{207}Pb			
^{24}Na	c	14.9590H	1369.0	100 ± 0	**1.318 ± 0.044**
		^{27}Al-monitor for ^{207}Pb			
^{7}Be	i	53.29D	477.6	10.52 ± 0.06	**2.270 ± 0.114**
^{27}Mg	c	9.458M	843.8	71.8 ± 0.4	**0.3282 ± 0.0661**
^{22}Na	c	2.6019Y	1274.5	99.94 ± 0.01	**47.05 ± 1.59**
^{24}Na	c	14.9590H	1369.0	100 ± 0	**27.59 ± 0.92**
		^{27}Al-plate for ^{207}Pb			
^{24}Na	c	14.9590H	1369.0	100 ± 0	**1.617 ± 0.054**
		^{27}Al-monitor for ^{nat}Pb			

Continuation of Table 62.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{7}Be	i	53.29D	477.6	10.52 ± 0.06	**1.397 ± 0.060**
^{27}Mg	c	9.458M	843.8	71.8 ± 0.4	0.3203 ± 0.0254
			1014.4	28.0 ± 0.4	0.3521 ± 0.1013
				RR_{mean} =	**0.3219 ± 0.0249**
^{22}Na	c	2.6019Y	1274.5	99.94 ± 0.01	**28.35 ± 0.97**
^{24}Na	c	14.9590H	1369.0	100 ± 0	**16.89 ± 0.56**
		^{27}Al-plate for ^{nat}Pb			
^{24}Na	c	14.9590H	1369.0	100 ± 0	**1.120 ± 0.037**
		^{27}Al-monitor for ^{209}Bi			
^{7}Be	i	53.29D	477.6	10.52 ± 0.06	**2.553 ± 0.109**
^{27}Mg	c	9.458M	843.8	71.8 ± 0.4	0.4970 ± 0.0256
			1014.4	28.0 ± 0.4	0.4669 ± 0.0445
				RR_{mean} =	**0.4912 ± 0.0239**
^{22}Na	c	2.6019Y	1274.5	99.94 ± 0.01	**52.00 ± 1.75**
^{24}Na	c	14.9590H	1369.0	100 ± 0	**31.09 ± 1.04**
		^{27}Al-plate for ^{209}Bi			
^{24}Na	c	14.9590H	1369.0	100 ± 0	**1.452 ± 0.049**

12.4 Detailed calculation of nuclide production rates for ^{206}Pb, ^{207}Pb, ^{208}Pb, ^{nat}Pb and ^{209}Bi for $E_p = 0.15$ GeV

12.4.1 Nuclide production rates for ^{206}Pb

Table 63: Detailed calculation of nuclide production rates for ^{206}Pb for $E_p = 0.15$ GeV, used to determine the cross sections for their production.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{206}Bi	i	6.243D	1878.7	2.01 ± 0.05	24.29 ± 1.46
			1718.7	31.8 ± 0.6	27.32 ± 1.21
			1595.3	5.01 ± 0.08	29.19 ± 1.27
			1098.3	13.50 ± 0.21	25.22 ± 0.96
			1018.6	7.60 ± 0.11	26.13 ± 1.02
			895.1	15.66 ± 0.23	26.58 ± 1.00
			881.0	66.2 ± 1.0	26.14 ± 0.95
			803.1	98.9 ± 1.4	25.01 ± 0.90
			632.2	4.47 ± 0.07	31.63 ± 1.33
			620.5	5.76 ± 0.09	26.51 ± 1.09
			537.5	30.5 ± 0.5	23.42 ± 0.92
			516.2	40.7 ± 0.6	24.57 ± 0.94
			497.1	15.31 ± 0.22	24.37 ± 1.04
			398.0	10.74 ± 0.15	23.99 ± 0.91
			343.5	23.4 ± 0.4	24.56 ± 0.96
			262.7	3.02 ± 0.06	27.42 ± 2.68
			184.0	15.8 ± 0.4	29.26 ± 1.35
				RR_{mean} =	**25.60 ± 0.90**
^{205}Bi	i	15.31D	1861.7	6.17 ± 0.10	88.20 ± 3.58
			1775.8	3.99 ± 0.08	89.60 ± 3.74
			1764.3	32.5 ± 0.7	89.47 ± 3.68
			1614.3	2.28 ± 0.04	95.64 ± 3.96
			1190.0	2.26 ± 0.07	84.07 ± 4.05
			1043.8	7.51 ± 0.10	81.56 ± 3.04
			987.7	16.13 ± 0.17	88.24 ± 3.05
			759.1	1.04 ± 0.05	87.82 ± 5.63
			703.5	31.1 ± 0.1	82.87 ± 2.79
			579.8	5.44 ± 0.07	79.04 ± 3.24
			573.8	0.62 ± 0.01	90.42 ± 7.10
			570.6	4.34 ± 0.07	79.37 ± 3.21
			549.8	2.95 ± 0.04	76.91 ± 3.13
			284.1	1.69 ± 0.02	76.43 ± 3.65
				RR_{mean} =	**84.08 ± 2.91**
^{204}Bi	i	11.22H	1211.7	3.0 ± 0.4	105.7 ± 15.4
			984.0	59 ± 4	117.0 ± 9.0
			918.3	10.8 ± 0.9	133.8 ± 12.2
			899.2	98 ± 9	112.8 ± 3.9
			670.7	11.4 ± 0.9	119.2 ± 10.4
			374.8	82 ± 5	134.5 ± 28.1
				RR_{mean} =	**113.5 ± 3.5**
^{203}Bi	i(m+g)	11.76H	1893.0	8.2 ± 0.6	156.8 ± 13.0
			1847.3	11.4 ± 0.8	152.5 ± 12.2
			1679.6	8.8 ± 0.7	156.4 ± 13.8

Continuation of Table 63.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			1536.5	7.5 ± 0.6	164.3 ± 14.6
			1506.7	3.7 ± 0.3	140.1 ± 13.0
			1034.0	8.8 ± 0.5	150.3 ± 10.1
			896.8	13.1 ± 0.7	171.3 ± 11.2
			847.2	8.5 ± 0.5	161.4 ± 11.3
			820.2	29.6 ± 1.5	164.6 ± 10.1
			816.3	4.03 ± 0.21	162.1 ± 10.9
			722.4	4.8 ± 0.4	174.2 ± 16.1
			264.2	5.2 ± 0.4	160.1 ± 14.2
			186.6	3.11 ± 0.22	33.88 ± 52.83
				RR_{mean} =	**161.8 ± 5.5**
^{202}Bi	i	1.72H	960.7	99.28 ± 0.02	162.3 ± 6.1
			422.1	83.7 ± 2.5	170.5 ± 10.3
				RR_{mean} =	**163.4 ± 6.0**
^{201}Bi	i	108M	1325.2	6.1 ± 1.3	179.0 ± 39.9
			629.1	24 ± 6	170.6 ± 43.2
				RR_{mean} =	**177.1 ± 12.6**
^{199}Bi	i	27M	946.0	10.8 ± 0.6	115.4 ± 24.3
			841.7	11 ± 0	134.1 ± 9.0
			837.4	9.5 ± 0.6	152.6 ± 19.1
				RR_{mean} =	**135.2 ± 8.2**
$^{204m}Pb_i$	i(m)	67.2M	899.2	99.17 ± 0.02	101.4 ± 4.0
			374.7	89 ± 15	131.5 ± 23.1
				RR_{mean} =	**101.8 ± 4.5**
$^{204m}Pb_c$	c	67.2M	899.2	99.17 ± 0.02	118.3 ± 4.4
			374.7	89 ± 15	148.3 ± 25.9
				RR_{mean} =	**118.6 ± 4.7**
^{203}Pb	c*	51.873H	680.5	0.75 ± 0.02	603.1 ± 28.9
			401.3	3.35 ± 0.07	565.2 ± 22.7
			279.2	80.8 ± 0.2	582.0 ± 21.2
				RR_{mean} =	**579.5 ± 19.8**
^{202m}Pb	i(m)	3.53H	960.7	92 ± 8	123.5 ± 11.6
			490.5	9.1 ± 0.7	138.7 ± 12.4
			459.7	8.6 ± 0.7	124.2 ± 11.9
			422.1	86 ± 5	130.8 ± 9.9
				RR_{mean} =	**129.6 ± 5.6**
^{201}Pb	c*	9.33H	1277.1	1.63 ± 0.12	558.3 ± 49.3
			1238.8	1.18 ± 0.08	516.4 ± 44.0
			1098.5	1.83 ± 0.12	515.3 ± 39.7
			1069.9	1.14 ± 0.11	658.0 ± 82.0
			946.0	7.4 ± 0.6	536.5 ± 47.8
			907.6	5.7 ± 0.4	571.5 ± 45.1
			767.3	3.16 ± 0.16	602.7 ± 38.6
			692.4	4.27 ± 0.16	580.1 ± 30.3
			361.3	9.9 ± 0.5	624.7 ± 38.4
			331.2	79 ± 5	639.7 ± 46.1
			167.4	*	676.5 ± 59.2
			135.3	*	383.6 ± 293.4
				RR_{mean} =	**583.4 ± 18.0**
^{200}Pb	c	21.5H	1514.9	*	534.2 ± 44.7
			1407.6	*	571.7 ± 55.8

Continuation of Table 63.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			1362.9	*	544.2 ± 67.2
			1225.5	*	516.6 ± 37.4
			1205.7	*	541.9 ± 37.4
			886.2	*	470.0 ± 38.7
			828.3	*	522.2 ± 38.7
			701.6	*	509.3 ± 44.4
			579.3	*	481.3 ± 30.5
			525.5	0.42 ± 0.04	565.4 ± 63.9
			450.5	3.33 ± 0.08	626.3 ± 27.6
			367.9	*	504.5 ± 17.5
			268.4	3.96 ± 0.20	629.4 ± 41.0
			257.2	4.46 ± 0.17	635.6 ± 36.4
			235.6	4.30 ± 0.17	606.5 ± 37.0
			147.6	37.7 ± 1.4	573.4 ± 31.5
			142.3	3.16 ± 0.19	554.4 ± 41.1
				RR_{mean} =	**519.9 ± 16.0**
^{199}Pb	c*	90M	1502.0	2.1 ± 0.4	912.9 ± 183.6
			1382.7	2.9 ± 0.5	965.8 ± 186.0
			1135.0	7.8 ± 1.2	933.7 ± 152.2
			1029.2	1.62 ± 0.25	711.7 ± 116.6
			781.5	1.9 ± 0.3	856.9 ± 141.8
			762.0	2.2 ± 0.4	1139 ± 222
			720.2	6.5 ± 1.0	1006 ± 160
			366.9	44 ± 7	1099 ± 183
			353.4	9.5 ± 1.5	1297 ± 224
				RR_{mean} =	**918.1 ± 62.0**
^{198}Pb	c	2.4H	865.3	5.9 ± 1.2	586.4 ± 121.5
			575.0	3.1 ± 0.7	629.8 ± 144.9
			365.4	19 ± 5	840.6 ± 223.2
			173.4	18 ± 3	792.3 ± 135.8
				RR_{mean} =	**771.9 ± 42.3**
^{197m}Pb	c*	43M	774.3	14 ± 3	381.3 ± 83.8
			695.6	9.5 ± 2.0	369.8 ± 82.4
			387.7	25 ± 6	471.6 ± 114.7
			385.9	74 ± 15	521.5 ± 107.2
			222.8	25 ± 6	367.9 ± 90.0
				RR_{mean} =	**457.5 ± 38.4**
^{196}Pb	c*	37M	502.1	26 ± 3	420.8 ± 51.0
			253.1	27 ± 3	404.4 ± 49.0
				RR_{mean} =	**412.3 ± 32.7**
^{195m}Pb	i(m)	15.0M	394.2	44 ± 8	167.6 ± 31.6
			383.6	107 ± 20	174.7 ± 33.4
				RR_{mean} =	**170.2 ± 7.4**
^{202}Tl	c	12.23D	439.6	91.4 ± 1.0	**91.80 ± 3.32**
^{201}Tl$_c$	c	72.912H	167.4	10.00 ± 0.06	703.3 ± 27.0
			135.3	2.57 ± 0.02	831.5 ± 55.4
				RR_{mean} =	**715.0 ± 43.0**
^{201}Tl	c*	72.912H	135.3	2.56 ± 0.02	908.0 ± 39.1
			167.4	10.00 ± 0.06	800.5 ± 29.4
				RR_{mean} =	**826.5 ± 52.7**
^{200}Tl$_i$	i	26.1H	1514.9	4.0 ± 0.3	150.6 ± 18.5

Continuation of Table 63.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			1407.6	1.45 ± 0.13	207.1 ± 27.3
			1362.9	3.4 ± 0.4	188.6 ± 27.9
			1225.5	3.36 ± 0.21	166.7 ± 18.4
			1205.7	29.9 ± 1.8	118.5 ± 10.9
			886.2	2.02 ± 0.13	232.7 ± 40.0
			828.3	10.8 ± 0.7	173.6 ± 19.3
			701.6	1.29 ± 0.10	230.0 ± 28.5
			579.3	13.8 ± 0.7	216.6 ± 25.3
			367.9	87.2 ± 0.4	150.3 ± 13.2
				RR_{mean} =	**157.3 ± 12.4**
$^{200}Tl_c$	c	26.1H	1514.9	4.0 ± 0.3	684.8 ± 56.8
			1407.6	1.45 ± 0.13	778.8 ± 75.2
			1362.9	3.4 ± 0.4	732.8 ± 90.1
			1225.5	3.36 ± 0.21	683.3 ± 49.0
			1205.7	29.9 ± 1.8	660.4 ± 45.6
			886.2	2.02 ± 0.13	702.8 ± 54.7
			828.3	10.8 ± 0.7	695.8 ± 51.5
			701.6	1.29 ± 0.10	739.3 ± 63.3
			579.3	13.8 ± 0.7	697.9 ± 45.0
			367.9	87.2 ± 0.4	654.8 ± 23.8
				RR_{mean} =	**669.6 ± 22.9**
^{199}Tl	c*	7.42H	455.5	12.4 ± 1.4	840.5 ± 99.7
			247.3	9.3 ± 1.1	831.2 ± 104.0
			208.2	12.3 ± 1.4	808.2 ± 97.8
				RR_{mean} =	**826.6 ± 40.6**
^{198m}Tl	i(m)	1.87H	587.2	52.5 ± 2.0	87.52 ± 4.65
			282.8	28 ± 3	87.62 ± 10.14
				RR_{mean} =	**87.53 ± 3.38**
^{197}Tl	c*	2.84H	1411.3	4.5 ± 1.5	619.8 ± 208.4
			152.2	7.3 ± 2.3	956.5 ± 304.2
			134.0	2.0 ± 0.7	803.5 ± 284.5
				RR_{mean} =	**811.3 ± 112.7**
^{196m}Tl	i(m)	1.41H	695.4	41 ± 7	**146.6 ± 25.8**
^{195}Tl	c*	1.16H	884.5	10.0 ± 1.1	**270.0 ± 32.2**
^{203}Hg	c	46.612D	279.2	81.46 ± 0.13	**1.600 ± 0.089**
^{197}Hg	c*	64.14H	191.4	0.63 ± 0.02	**668.2 ± 35.2**
^{197m}Hg	i(m)	23.8H	134.0	33.5 ± 0.4	**20.55 ± 0.99**
^{195m}Hg	i(m)	41.6H	560.3	7.0 ± 0.6	25.79 ± 2.47
			261.8	31 ± 4	26.29 ± 3.59
			779.8	54.2 ± 0.1	24.58 ± 5.05
				RR_{mean} =	**25.67 ± 0.79**
$^{195}Hg_c$	c	9.9H	779.8	6.8 ± 0.7	**353.3 ± 38.3**
^{193m}Hg	i(m)	11.8H	573.2	26 ± 4	13.59 ± 2.30
			407.6	32 ± 6	22.05 ± 4.26
				RR_{mean} =	**15.49 ± 3.57**
^{192}Hg	c	4.85H	316.5	*	73.73 ± 9.31
			274.8	50.2 ± 2.5	55.56 ± 3.83
				RR_{mean} =	**57.85 ± 1.78**
^{198m}Au	i(m)	2.27D	411.8	*	**0.4250 ± 0.0874**
$^{198}Au_i$	i	2.69517D	411.8	95.58 ± 0.12	**0.4596 ± 0.1926**

Continuation of Table 63.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
$^{198}Au_c$	i(m+g)	2.69517D	411.8	95.58 ± 0.12	**0.8846 ± 0.1136**
^{196}Au	i(m1+m2+g)	6.183D	355.7	87.0 ± 0.8	2.209 ± 0.088
			333.0	22.9 ± 0.6	2.079 ± 0.127
				RR_{mean} =	**2.184 ± 0.085**
^{195}Au	c	186.098D	129.8	0.82 ± 0.05	387.3 ± 30.3
			98.9	10.9 ± 0.9	347.6 ± 33.9
				RR_{mean} =	**374.5 ± 21.9**
^{194}Au	i(m1+m2+g)	38.02H	328.5	61 ± 5	**3.235 ± 0.309**
$^{192}Au_i$	i(m+g)	4.94H	316.5	58 ± 7	**2.748 ± 1.297**
$^{192}Au_c$	c	4.94H	316.5	58 ± 7	**76.48 ± 9.62**
^{127}Xe	c	36.4D	202.9	68.3 ± 0.5	**0.7553 ± 0.0416**
^{124}Sb	i(m1+m2+g)	60.20D	602.7	98.3 ± 0.4	**0.6329 ± 0.0522**
^{123m}Te	i(m)	119.7D	159.0	84.0 ± 0.4	**1.403 ± 0.074**
^{120m}Sb	i(m)	5.76D	1171.7	100 ± 0	1.400 ± 0.057
			1023.3	99.4 ± 0.3	1.322 ± 0.054
			197.3	87.0 ± 1.1	1.512 ± 0.065
				RR_{mean} =	**1.396 ± 0.067**
^{110m}Ag	i(m)	249.76D	657.8	94.3 ± 0.3	**4.084 ± 0.232**
^{103}Ru	c	39.26D	497.1	91.0 ± 1.3	**20.45 ± 0.77**
^{99}Mo	c	65.94H	140.5	90.27 ± 0.33	**19.93 ± 0.81**
^{96}Nb	i	23.35H	1091.3	48.5 ± 1.6	9.712 ± 0.555
			849.9	20.45 ± 0.20	10.19 ± 0.63
			778.2	96.45 ± 0.22	9.813 ± 0.361
			460.0	26.62 ± 0.20	9.573 ± 0.444
				RR_{mean} =	**9.782 ± 0.338**
$^{95}Nb_i$	i(m+g)	34.975D	765.8	99.81 ± 0.03	**7.890 ± 0.312**
$^{95}Nb_c$	c	34.975D	765.8	99.81 ± 0.03	**21.88 ± 0.76**
^{97}Zr	c	16.744H	743.4	93.06 ± 0.16	**4.756 ± 0.211**
^{95}Zr	c	64.02D	765.8	*	14.11 ± 0.56
			756.7	54.46 ± 0.10	13.79 ± 0.49
				RR_{mean} =	**13.89 ± 0.43**
^{88}Zr	c	83.4D	898.0	*	**0.3009 ± 0.1213**
$^{88}Y_i$	i	106.65D	898.0	93.7 ± 0.3	**1.228 ± 0.063**
$^{88}Y_c$	c	106.65D	898.0	93.7 ± 0.3	**1.529 ± 0.101**
^{84}Rb	i(m+g)	32.77D	881.6	69.0 ± 1.6	**1.790 ± 0.145**
^{82}Br	i(m+g)	35.30H	1317.5	26.5 ± 0.4	6.201 ± 0.390
			776.5	83.5 ± 1.2	6.002 ± 0.244
			554.3	70.8 ± 1.0	5.745 ± 0.230
				RR_{mean} =	**5.889 ± 0.212**

12.4.2 Nuclide production rates for ^{207}Pb

Table 64: Detailed calculation of nuclide production rates for ^{207}Pb for $E_p = 0.15$ GeV, used to determine the cross sections for their production.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{207}Bi	i	31.55Y	569.7	97.74 ± 0.03	**27.55 ± 3.86**
^{206}Bi	i	6.243D	1878.7	2.01 ± 0.05	57.09 ± 3.18

Continuation of Table 64.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			1718.7	31.8 ± 0.6	58.17 ± 2.30
			1595.3	5.01 ± 0.08	63.22 ± 2.80
			1098.3	13.50 ± 0.21	54.05 ± 2.03
			1018.6	7.60 ± 0.11	56.57 ± 2.08
			895.1	15.66 ± 0.23	56.66 ± 2.08
			881.0	66.2 ± 1.0	56.80 ± 2.06
			803.1	98.9 ± 1.4	54.23 ± 1.93
			632.2	4.47 ± 0.07	51.72 ± 2.40
			620.5	5.76 ± 0.09	52.97 ± 2.22
			537.5	30.5 ± 0.5	50.72 ± 1.95
			516.2	40.7 ± 0.6	52.78 ± 1.96
			497.1	15.31 ± 0.22	50.29 ± 1.94
			398.0	10.74 ± 0.15	51.41 ± 1.92
			343.5	23.4 ± 0.4	52.40 ± 2.08
			262.7	3.02 ± 0.06	54.22 ± 3.49
			184.0	15.8 ± 0.4	60.26 ± 2.71
				RR_{mean} =	**54.26 ± 1.83**
^{205}Bi	i	15.31D	1861.7	6.17 ± 0.10	116.7 ± 4.6
			1775.8	3.99 ± 0.08	119.9 ± 4.9
			1764.3	32.5 ± 0.7	119.1 ± 4.9
			1614.3	2.28 ± 0.04	124.4 ± 5.0
			1190.0	2.26 ± 0.07	115.1 ± 5.6
			1043.8	7.51 ± 0.10	108.2 ± 4.0
			987.7	16.13 ± 0.17	115.5 ± 4.0
			759.1	1.04 ± 0.05	112.5 ± 8.2
			703.5	31.1 ± 0.1	107.9 ± 3.6
			579.8	5.44 ± 0.07	104.4 ± 4.1
			573.8	0.62 ± 0.01	98.43 ± 5.62
			570.6	4.34 ± 0.07	107.6 ± 4.2
			549.8	2.95 ± 0.04	96.15 ± 3.79
			284.1	1.69 ± 0.02	103.4 ± 4.5
				RR_{mean} =	**109.7 ± 3.9**
^{204}Bi	i	11.22H	1211.7	3.0 ± 0.4	102.6 ± 15.9
			984.0	59 ± 4	118.2 ± 9.0
			918.3	10.8 ± 0.9	130.5 ± 11.9
			899.2	98 ± 9	111.1 ± 3.8
			670.7	11.4 ± 0.9	116.6 ± 10.2
			374.8	82 ± 5	130.4 ± 27.2
				RR_{mean} =	**111.8 ± 3.4**
^{203}Bi	i(m+g)	11.76H	1893.0	8.2 ± 0.6	142.5 ± 11.8
			1847.3	11.4 ± 0.8	137.8 ± 11.0
			1679.6	8.8 ± 0.7	132.9 ± 11.7
			1536.5	7.5 ± 0.6	141.8 ± 12.6
			1506.7	3.7 ± 0.3	113.8 ± 11.1
			1034.0	8.8 ± 0.5	134.6 ± 9.2
			896.8	13.1 ± 0.7	145.7 ± 9.3
			847.2	8.5 ± 0.5	141.3 ± 9.8
			820.2	29.6 ± 1.5	148.2 ± 9.0
			816.3	4.03 ± 0.21	155.7 ± 11.7
			722.4	4.8 ± 0.4	156.9 ± 14.7
			264.2	5.2 ± 0.4	144.7 ± 14.2

Continuation of Table 64.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			186.6	3.11 ± 0.22	105.1 ± 23.5
				RR_{mean} =	**144.2 ± 5.0**
^{202}Bi	i	1.72H	960.7	99.28 ± 0.02	142.1 ± 5.4
			422.1	83.7 ± 2.5	147.5 ± 7.9
				RR_{mean} =	**143.1 ± 5.2**
^{201}Bi	i	108M	1325.2	6.1 ± 1.3	134.1 ± 30.7
			629.1	24 ± 6	147.4 ± 37.4
				RR_{mean} =	**137.4 ± 11.3**
^{199}Bi	i	27M	946.0	10.8 ± 0.6	90.14 ± 20.32
			841.7	11 ± 0	97.44 ± 8.10
			837.4	9.5 ± 0.6	124.8 ± 13.3
				RR_{mean} =	**103.2 ± 9.2**
$^{204m}Pb_i$	i(m)	67.2M	899.2	99.17 ± 0.02	105.6 ± 4.1
			374.7	89 ± 15	131.7 ± 22.7
				RR_{mean} =	**106.0 ± 4.4**
$^{204m}Pb_c$	c	67.2M	899.2	99.17 ± 0.02	122.3 ± 4.6
			374.7	89 ± 15	148.0 ± 25.5
				RR_{mean} =	**122.6 ± 4.6**
^{203}Pb	c*	51.873H	680.5	0.75 ± 0.02	494.3 ± 26.3
			401.3	3.35 ± 0.07	478.9 ± 19.2
			279.2	80.8 ± 0.2	494.3 ± 18.0
				RR_{mean} =	**489.0 ± 16.7**
^{202m}Pb	i(m)	3.53H	960.7	92 ± 8	119.4 ± 11.3
			490.5	9.1 ± 0.7	131.2 ± 13.0
			459.7	8.6 ± 0.7	105.6 ± 10.0
			422.1	86 ± 5	124.8 ± 8.9
				RR_{mean} =	**120.8 ± 6.0**
^{201}Pb	c*	9.33H	1277.1	1.63 ± 0.12	472.2 ± 43.8
			1238.8	1.18 ± 0.08	435.3 ± 39.4
			1098.5	1.83 ± 0.12	442.9 ± 35.1
			1069.9	1.14 ± 0.11	580.6 ± 63.3
			946.0	7.4 ± 0.6	462.4 ± 41.5
			907.6	5.7 ± 0.4	478.7 ± 37.6
			767.3	3.16 ± 0.16	511.8 ± 33.0
			692.4	4.27 ± 0.16	487.2 ± 27.9
			584.5	3.56 ± 0.16	599.2 ± 35.2
			361.3	9.9 ± 0.5	523.7 ± 32.4
			331.2	79 ± 5	535.4 ± 38.6
			167.4	*	571.4 ± 38.8
			135.3	*	516.0 ± 104.9
				RR_{mean} =	**513.5 ± 15.8**
^{200}Pb	c	21.5H	886.2	*	390.5 ± 29.6
			701.6	*	386.4 ± 35.8
			579.3	*	384.8 ± 24.2
			1514.9	*	446.7 ± 36.9
			1407.6	*	484.6 ± 49.2
			1362.9	*	446.2 ± 55.3
			1225.5	*	425.4 ± 30.9
			1205.7	*	431.9 ± 29.8
			525.5	0.42 ± 0.04	483.4 ± 52.2
			450.5	3.33 ± 0.08	507.6 ± 21.7

Continuation of Table 64.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			367.9	*	407.9 ± 14.3
			268.4	3.96 ± 0.20	490.2 ± 32.2
			257.2	4.46 ± 0.17	505.3 ± 30.1
			235.6	4.30 ± 0.17	504.6 ± 29.6
			147.6	37.7 ± 1.4	478.0 ± 26.2
			142.3	3.16 ± 0.19	470.8 ± 38.3
				RR_{mean} =	**423.2 ± 13.1**
^{199}Pb	c*	90M	1502.0	2.1 ± 0.4	685.7 ± 138.4
			1382.7	2.9 ± 0.5	749.2 ± 138.1
			1135.0	7.8 ± 1.2	800.2 ± 131.6
			1029.2	1.62 ± 0.25	637.8 ± 105.4
			781.5	1.9 ± 0.3	656.0 ± 117.2
			762.0	2.2 ± 0.4	820.6 ± 174.1
			720.2	6.5 ± 1.0	892.3 ± 143.3
			366.9	44 ± 7	854.4 ± 141.4
			353.4	9.5 ± 1.5	907.4 ± 151.9
				RR_{mean} =	**769.0 ± 43.7**
^{198}Pb	c	2.4H	865.3	5.9 ± 1.2	442.5 ± 91.9
			575.0	3.1 ± 0.7	486.6 ± 112.1
			365.4	19 ± 5	629.9 ± 167.3
			173.4	18 ± 3	623.2 ± 106.6
				RR_{mean} =	**608.0 ± 33.7**
^{197m}Pb	c*	43M	774.3	14 ± 3	265.2 ± 58.6
			695.6	9.5 ± 2.0	254.9 ± 59.0
			387.7	25 ± 6	346.9 ± 84.2
			385.9	74 ± 15	371.6 ± 76.5
			222.8	25 ± 6	265.1 ± 64.8
				RR_{mean} =	**326.7 ± 28.4**
^{196}Pb	c*	37M	502.1	26 ± 3	274.8 ± 33.9
			253.1	27 ± 3	229.0 ± 27.2
				RR_{mean} =	**246.7 ± 23.5**
^{195m}Pb	i(m)	15.0M	394.2	44 ± 8	79.92 ± 16.79
			383.6	107 ± 20	78.21 ± 14.98
				RR_{mean} =	**78.56 ± 4.36**
^{202}Tl	c	12.23D	439.6	91.4 ± 1.0	**82.28 ± 3.00**
^{201}Tl$_c$	c	72.912H	167.4	10.00 ± 0.06	584.2 ± 21.9
			135.3	2.57 ± 0.02	641.4 ± 30.9
				RR_{mean} =	**596.1 ± 29.6**
^{201}Tl	c*	72.912H	135.3	2.56 ± 0.02	717.6 ± 30.7
			167.4	10.00 ± 0.06	667.9 ± 24.5
				RR_{mean} =	**681.3 ± 30.5**
^{200}Tl$_i$	i	26.1H	1514.9	4.0 ± 0.3	116.3 ± 12.1
			1407.6	1.45 ± 0.13	148.0 ± 33.4
			1362.9	3.4 ± 0.4	148.2 ± 24.6
			1225.5	3.36 ± 0.21	129.2 ± 14.9
			1205.7	29.9 ± 1.8	116.4 ± 10.2
			886.2	2.02 ± 0.13	171.1 ± 22.0
			828.3	10.8 ± 0.7	155.7 ± 16.9
			701.6	1.29 ± 0.10	230.3 ± 33.7
			579.3	13.8 ± 0.7	185.8 ± 19.5
			367.9	87.2 ± 0.4	139.7 ± 12.7

Continuation of Table 64.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
				$RR_{mean} =$	**137.1 ± 9.4**
$^{200}Tl_c$	c	26.1H	1514.9	4.0 ± 0.3	563.1 ± 46.5
			1407.6	1.45 ± 0.13	632.7 ± 62.8
			1362.9	3.4 ± 0.4	594.5 ± 73.4
			1225.5	3.36 ± 0.21	554.6 ± 39.8
			1205.7	29.9 ± 1.8	548.4 ± 37.9
			886.2	2.02 ± 0.13	561.6 ± 41.8
			828.3	10.8 ± 0.7	565.4 ± 41.9
			701.6	1.29 ± 0.10	616.6 ± 54.2
			579.3	13.8 ± 0.7	570.6 ± 36.3
			367.9	87.2 ± 0.4	547.6 ± 20.2
				$RR_{mean} =$	**556.2 ± 19.1**
^{199}Tl	c*	7.42H	455.5	12.4 ± 1.4	638.8 ± 75.6
			247.3	9.3 ± 1.1	671.1 ± 84.8
			208.2	12.3 ± 1.4	668.4 ± 80.9
				$RR_{mean} =$	**656.6 ± 32.3**
^{198m}Tl	i(m)	1.87H	587.2	52.5 ± 2.0	61.33 ± 3.30
			282.8	28 ± 3	68.63 ± 7.93
				$RR_{mean} =$	**61.65 ± 2.43**
^{197}Tl	c*	2.84H	1411.3	4.5 ± 1.5	452.9 ± 152.6
			152.2	7.3 ± 2.3	689.0 ± 218.8
			134.0	2.0 ± 0.7	646.9 ± 230.5
				$RR_{mean} =$	**599.4 ± 80.6**
^{196m}Tl	i(m)	1.41H	695.4	41 ± 7	**101.5 ± 18.1**
^{195}Tl	c*	1.16H	884.5	10.0 ± 1.1	**129.0 ± 16.2**
^{203}Hg	c	46.612D	279.2	81.46 ± 0.13	**3.066 ± 0.178**
^{197}Hg	c*	64.14H	191.4	0.63 ± 0.02	**468.4 ± 25.0**
^{197m}Hg	i(m)	23.8H	134.0	33.5 ± 0.4	**16.73 ± 0.84**
^{195m}Hg	i(m)	41.6H	560.3	7.0 ± 0.6	18.02 ± 1.86
			261.8	31 ± 4	20.30 ± 2.79
			779.8	54.2 ± 0.1	20.57 ± 5.79
				$RR_{mean} =$	**18.69 ± 0.58**
$^{195}Hg_c$	c	9.9H	779.8	6.8 ± 0.7	**175.1 ± 20.1**
^{193m}Hg	i(m)	11.8H	573.2	26 ± 4	8.322 ± 1.425
			407.6	32 ± 6	11.92 ± 2.31
				$RR_{mean} =$	**9.308 ± 1.630**
^{192}Hg	c	4.85H	316.5	*	31.87 ± 4.10
			274.8	50.2 ± 2.5	22.39 ± 1.58
				$RR_{mean} =$	**23.46 ± 0.72**
^{198m}Au	i(m)	2.27D	411.8	*	**0.3598 ± 0.1203**
$^{198}Au_i$	i	2.69517D	411.8	95.58 ± 0.12	**0.7282 ± 0.2374**
$^{198}Au_c$	i(m+g)	2.69517D	411.8	95.58 ± 0.12	**1.088 ± 0.127**
^{196}Au	i(m1+m2+g)	6.183D	355.7	87.0 ± 0.8	1.935 ± 0.092
			333.0	22.9 ± 0.6	1.688 ± 0.121
				$RR_{mean} =$	**1.866 ± 0.125**
^{195}Au	c	186.098D	129.8	0.82 ± 0.05	195.7 ± 15.7
			98.9	10.9 ± 0.9	177.4 ± 17.3
				$RR_{mean} =$	**189.3 ± 10.5**
^{194}Au	i(m1+m2+g)	38.02H	328.5	61 ± 5	**2.485 ± 0.275**
$^{192}Au_c$	c	4.94H	316.5	58 ± 7	**29.33 ± 3.77**

Continuation of Table 64.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{127}Xe	c	36.4D	202.9	68.3 ± 0.5	**0.3995 ± 0.0384**
^{124}Sb	i(m1+m2+g)	60.20D	602.7	98.3 ± 0.4	**0.6709 ± 0.0523**
^{123m}Te	i(m)	119.7D	159.0	84.0 ± 0.4	**1.073 ± 0.094**
^{120m}Sb	i(m)	5.76D	1023.3	99.4 ± 0.3	0.8687 ± 0.0601
			197.3	87.0 ± 1.1	0.8952 ± 0.0449
				RR_{mean} =	**0.8872 ± 0.0403**
^{110m}Ag	i(m)	249.76D	657.8	94.3 ± 0.3	**2.055 ± 0.322**
^{103}Ru	c	39.26D	497.1	91.0 ± 1.3	**14.57 ± 0.55**
^{99}Mo	c	65.94H	140.5	90.27 ± 0.33	**14.99 ± 0.61**
^{96}Nb	i	23.35H	1091.3	48.5 ± 1.6	6.096 ± 0.389
			849.9	20.45 ± 0.20	6.019 ± 0.669
			778.2	96.45 ± 0.22	5.613 ± 0.270
			460.0	26.62 ± 0.20	5.613 ± 0.315
				RR_{mean} =	**5.719 ± 0.227**
^{95}Nb$_i$	i(m+g)	34.975D	765.8	99.81 ± 0.03	**4.146 ± 0.137**
^{95}Nb$_c$	c	34.975D	765.8	99.81 ± 0.03	**15.08 ± 0.49**
^{97}Zr	c	16.744H	743.4	93.06 ± 0.16	**4.722 ± 0.212**
^{95}Zr	c	64.02D	765.8	*	11.03 ± 0.36
			756.7	54.46 ± 0.10	9.990 ± 0.397
				RR_{mean} =	**10.82 ± 0.33**
^{88}Zr	c	83.4D	898.0	*	**0.1440 ± 0.0832**
^{88} Y$_i$	i	106.65D	898.0	93.7 ± 0.3	**0.5187 ± 0.0622**
^{88} Y$_c$	c	106.65D	898.0	93.7 ± 0.3	**0.6627 ± 0.0491**
^{84}Rb	i(m+g)	32.77D	881.6	69.0 ± 1.6	**0.5683 ± 0.1720**
^{82}Br	i(m+g)	35.30H	1317.5	26.5 ± 0.4	4.633 ± 0.818
			776.5	83.5 ± 1.2	3.756 ± 0.195
			554.3	70.8 ± 1.0	3.300 ± 0.168
				RR_{mean} =	**3.508 ± 0.215**

12.4.3 Nuclide production rates for ^{208}Pb

Table 65: Detailed calculation of nuclide production rates for ^{208}Pb for $E_p = 0.15$ GeV, used to determine the cross sections for their production.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{207}Bi	i	31.55Y	569.7	97.74 ± 0.03	**78.79 ± 4.63**
^{206}Bi	i	6.243D	1878.7	2.01 ± 0.05	114.6 ± 6.1
			1718.7	31.8 ± 0.6	117.2 ± 4.6
			1595.3	5.01 ± 0.08	127.9 ± 5.5
			1098.3	13.50 ± 0.21	108.4 ± 4.0
			1018.6	7.60 ± 0.11	117.5 ± 4.3
			895.1	15.66 ± 0.23	113.1 ± 4.2
			881.0	66.2 ± 1.0	114.3 ± 4.1
			803.1	98.9 ± 1.4	110.1 ± 3.9
			632.2	4.47 ± 0.07	105.5 ± 4.1
			620.5	5.76 ± 0.09	107.3 ± 4.1
			537.5	30.5 ± 0.5	101.1 ± 3.8
			516.2	40.7 ± 0.6	106.7 ± 4.0
			497.1	15.31 ± 0.22	101.8 ± 3.9

Continuation of Table 65.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			398.0	10.74 ± 0.15	102.7 ± 3.8
			343.5	23.4 ± 0.4	107.0 ± 4.1
			262.7	3.02 ± 0.06	111.2 ± 5.7
			184.0	15.8 ± 0.4	122.7 ± 5.5
				RR_{mean} =	**109.5 ± 3.7**
^{205}Bi	i	15.31D	1861.7	6.17 ± 0.10	167.4 ± 6.6
			1775.8	3.99 ± 0.08	173.6 ± 7.2
			1764.3	32.5 ± 0.7	170.7 ± 7.0
			1614.3	2.28 ± 0.04	177.1 ± 7.0
			1190.0	2.26 ± 0.07	162.6 ± 7.6
			1043.8	7.51 ± 0.10	154.5 ± 5.8
			987.7	16.13 ± 0.17	167.2 ± 5.9
			759.1	1.04 ± 0.05	165.4 ± 11.4
			703.5	31.1 ± 0.1	157.1 ± 5.3
			579.8	5.44 ± 0.07	151.0 ± 5.7
			573.8	0.62 ± 0.01	138.2 ± 9.8
			570.6	4.34 ± 0.07	155.1 ± 6.2
			549.8	2.95 ± 0.04	144.8 ± 5.7
			284.1	1.69 ± 0.02	153.5 ± 6.4
				RR_{mean} =	**159.3 ± 5.5**
^{204}Bi	i	11.22H	1211.7	3.0 ± 0.4	136.5 ± 19.4
			984.0	59 ± 4	155.7 ± 11.8
			918.3	10.8 ± 0.9	172.5 ± 15.7
			899.2	98 ± 9	148.1 ± 5.0
			670.7	11.4 ± 0.9	158.0 ± 13.8
			374.8	82 ± 5	171.9 ± 35.9
				RR_{mean} =	**148.8 ± 4.6**
^{203}Bi	i(m+g)	11.76H	1893.0	8.2 ± 0.6	189.0 ± 15.6
			1847.3	11.4 ± 0.8	176.3 ± 14.0
			1679.6	8.8 ± 0.7	179.2 ± 15.9
			1536.5	7.5 ± 0.6	189.3 ± 16.7
			1506.7	3.7 ± 0.3	165.1 ± 15.3
			1034.0	8.8 ± 0.5	173.6 ± 11.9
			896.8	13.1 ± 0.7	183.4 ± 11.7
			847.2	8.5 ± 0.5	175.8 ± 12.7
			820.2	29.6 ± 1.5	182.6 ± 11.2
			816.3	4.03 ± 0.21	195.3 ± 13.9
			722.4	4.8 ± 0.4	175.5 ± 16.5
			264.2	5.2 ± 0.4	184.0 ± 16.5
			186.6	3.11 ± 0.22	135.2 ± 26.6
				RR_{mean} =	**181.4 ± 5.9**
^{202}Bi	i	1.72H	960.7	99.28 ± 0.02	180.3 ± 6.6
			422.1	83.7 ± 2.5	183.9 ± 9.7
				RR_{mean} =	**180.9 ± 6.5**
^{201}Bi	i	108M	1325.2	6.1 ± 1.3	217.9 ± 49.0
			629.1	24 ± 6	187.9 ± 47.6
				RR_{mean} =	**209.0 ± 15.9**
^{199}Bi	i	27M	946.0	10.8 ± 0.6	121.9 ± 13.9
			841.7	11 ± 0	165.2 ± 9.2
			837.4	9.5 ± 0.6	193.1 ± 19.3

Continuation of Table 65.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
				RR_{mean} =	**159.0 ± 16.0**
$^{204m}Pb_i$	i(m)	67.2M	899.2	99.17 ± 0.02	154.4 ± 5.5
			374.7	89 ± 15	182.6 ± 31.5
				RR_{mean} =	**154.6 ± 5.5**
$^{204m}Pb_c$	c	67.2M	899.2	99.17 ± 0.02	176.6 ± 6.2
			374.7	89 ± 15	204.2 ± 35.2
				RR_{mean} =	**176.8 ± 6.2**
^{203}Pb	c*	51.873H	680.5	0.75 ± 0.02	622.2 ± 46.6
			401.3	3.35 ± 0.07	597.3 ± 24.0
			279.2	80.8 ± 0.2	611.4 ± 22.3
				RR_{mean} =	**606.9 ± 20.8**
^{202m}Pb	i(m)	3.53H	960.7	92 ± 8	159.9 ± 15.0
			490.5	9.1 ± 0.7	171.3 ± 15.9
			459.7	8.6 ± 0.7	160.0 ± 14.6
			422.1	86 ± 5	167.6 ± 11.8
				RR_{mean} =	**165.7 ± 6.8**
^{201}Pb	c*	9.33H	1277.1	1.63 ± 0.12	571.2 ± 49.0
			1238.8	1.18 ± 0.08	565.4 ± 49.4
			1098.5	1.83 ± 0.12	547.9 ± 46.8
			1069.9	1.14 ± 0.11	717.2 ± 84.0
			946.0	7.4 ± 0.6	543.2 ± 48.3
			907.6	5.7 ± 0.4	572.3 ± 45.0
			767.3	3.16 ± 0.16	633.1 ± 40.2
			692.4	4.27 ± 0.16	619.9 ± 31.9
			584.5	3.56 ± 0.16	659.0 ± 39.4
			361.3	9.9 ± 0.5	623.8 ± 38.2
			331.2	79 ± 5	640.6 ± 46.2
			167.4	*	641.2 ± 30.8
			135.3	*	620.1 ± 121.7
				RR_{mean} =	**617.2 ± 19.0**
^{200}Pb	c	21.5H	1514.9	*	514.9 ± 42.5
			1407.6	*	564.8 ± 54.8
			1362.9	*	537.5 ± 66.3
			1225.5	*	510.1 ± 37.7
			1205.7	*	521.0 ± 35.9
			886.2	*	471.6 ± 38.1
			828.3	*	490.9 ± 36.4
			701.6	*	442.7 ± 45.9
			579.3	*	461.5 ± 29.1
			525.5	0.42 ± 0.04	533.5 ± 58.2
			450.5	3.33 ± 0.08	578.0 ± 26.0
			367.9	*	492.3 ± 17.4
			268.4	3.96 ± 0.20	584.5 ± 37.4
			257.2	4.46 ± 0.17	609.4 ± 34.6
			235.6	4.30 ± 0.17	610.1 ± 36.2
			147.6	37.7 ± 1.4	565.9 ± 31.0
			142.3	3.16 ± 0.19	539.0 ± 39.3
				RR_{mean} =	**506.4 ± 15.6**
^{199}Pb	c*	90M	1502.0	2.1 ± 0.4	1077 ± 221
			1382.7	2.9 ± 0.5	1063 ± 192
			1135.0	7.8 ± 1.2	858.3 ± 139.4

Continuation of Table 65.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			1029.2	1.62 ± 0.25	901.5 ± 145.9
			781.5	1.9 ± 0.3	921.7 ± 152.4
			762.0	2.2 ± 0.4	955.3 ± 182.8
			720.2	6.5 ± 1.0	953.7 ± 156.4
			366.9	44 ± 7	1015 ± 169
			353.4	9.5 ± 1.5	1078 ± 179
				RR_{mean} =	**949.9 ± 39.7**
^{198}Pb	c	2.4H	865.3	5.9 ± 1.2	545.0 ± 112.8
			575.0	3.1 ± 0.7	561.8 ± 129.3
			365.4	19 ± 5	691.9 ± 183.7
			173.4	18 ± 3	676.8 ± 115.6
				RR_{mean} =	**668.2 ± 27.7**
^{197m}Pb	c*	43M	774.3	14 ± 3	277.9 ± 60.5
			695.6	9.5 ± 2.0	291.8 ± 68.4
			387.7	25 ± 6	327.9 ± 79.6
			385.9	74 ± 15	366.0 ± 75.3
			222.8	25 ± 6	255.9 ± 62.6
				RR_{mean} =	**330.1 ± 24.0**
^{196}Pb	c*	37M	502.1	26 ± 3	211.0 ± 26.0
			253.1	27 ± 3	163.2 ± 19.4
				RR_{mean} =	**180.1 ± 23.5**
^{195m}Pb	i(m)	15.0M	394.2	44 ± 8	40.80 ± 10.33
			383.6	107 ± 20	27.48 ± 5.49
				RR_{mean} =	**28.56 ± 3.74**
^{202}Tl	c	12.23D	439.6	91.4 ± 1.0	**101.7 ± 3.7**
$^{201}Tl_c$	c	72.912H	167.4	10.00 ± 0.06	710.6 ± 26.2
			135.3	2.57 ± 0.02	812.2 ± 38.3
				RR_{mean} =	**729.6 ± 45.6**
^{201}Tl	c*	72.912H	135.3	2.56 ± 0.02	905.5 ± 38.4
			167.4	10.00 ± 0.06	804.7 ± 29.5
				RR_{mean} =	**830.7 ± 51.0**
$^{200}Tl_i$	i	26.1H	1514.9	4.0 ± 0.3	167.9 ± 15.5
			1407.6	1.45 ± 0.13	199.0 ± 24.8
			1362.9	3.4 ± 0.4	148.9 ± 23.9
			1225.5	3.36 ± 0.21	140.9 ± 19.0
			1205.7	29.9 ± 1.8	119.8 ± 9.8
			886.2	2.02 ± 0.13	163.1 ± 29.9
			828.3	10.8 ± 0.7	178.2 ± 17.7
			701.6	1.29 ± 0.10	282.2 ± 53.2
			579.3	13.8 ± 0.7	210.0 ± 21.8
			367.9	87.2 ± 0.4	130.6 ± 15.9
				RR_{mean} =	**149.7 ± 11.7**
$^{200}Tl_c$	c	26.1H	1514.9	4.0 ± 0.3	682.8 ± 56.2
			1407.6	1.45 ± 0.13	763.8 ± 73.6
			1362.9	3.4 ± 0.4	686.4 ± 84.4
			1225.5	3.36 ± 0.21	650.9 ± 47.0
			1205.7	29.9 ± 1.8	640.9 ± 44.1
			886.2	2.02 ± 0.13	634.8 ± 48.1
			828.3	10.8 ± 0.7	669.2 ± 49.2
			701.6	1.29 ± 0.10	724.9 ± 66.5
			579.3	13.8 ± 0.7	671.6 ± 42.5

Continuation of Table 65.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			367.9	87.2 ± 0.4	622.9 ± 23.6
				RR_{mean} =	**641.6 ± 22.3**
^{199}Tl	c*	7.42H	455.5	12.4 ± 1.4	726.1 ± 85.9
			247.3	9.3 ± 1.1	747.1 ± 93.4
			208.2	12.3 ± 1.4	760.2 ± 92.0
				RR_{mean} =	**742.6 ± 36.4**
^{198m}Tl	i(m)	1.87H	587.2	52.5 ± 2.0	68.87 ± 3.75
			282.8	28 ± 3	73.66 ± 8.47
				RR_{mean} =	**69.12 ± 2.77**
^{197}Tl	c*	2.84H	1411.3	4.5 ± 1.5	459.9 ± 154.4
			152.2	7.3 ± 2.3	674.0 ± 214.0
			134.0	2.0 ± 0.7	580.2 ± 207.7
				RR_{mean} =	**589.0 ± 71.9**
^{196m}Tl	i(m)	1.41H	695.4	41 ± 7	**95.39 ± 17.26**
^{195}Tl	c*	1.16H	884.5	10.0 ± 1.1	**81.84 ± 10.71**
^{203}Hg	c	46.612D	279.2	81.46 ± 0.13	**6.085 ± 0.230**
^{197}Hg	c*	64.14H	191.4	0.63 ± 0.02	**461.2 ± 26.1**
^{197m}Hg	i(m)	23.8H	134.0	33.5 ± 0.4	**23.12 ± 1.15**
^{195m}Hg	i(m)	41.6H	560.3	7.0 ± 0.6	18.21 ± 2.14
			261.8	31 ± 4	22.60 ± 3.07
			779.8	54.2 ± 0.1	22.71 ± 4.84
				RR_{mean} =	**20.14 ± 0.62**
^{195}Hg$_c$	c	9.9H	779.8	6.8 ± 0.7	**108.3 ± 12.1**
^{193m}Hg	i(m)	11.8H	573.2	26 ± 4	4.235 ± 0.936
			407.6	32 ± 6	8.184 ± 1.636
				RR_{mean} =	**5.213 ± 1.713**
^{192}Hg	c	4.85H	316.5	*	8.320 ± 1.350
			274.8	50.2 ± 2.5	4.762 ± 0.910
				RR_{mean} =	**5.881 ± 0.181**
^{198m}Au	i(m)	2.27D	411.8	*	**0.4887 ± 0.0887**
^{198}Au$_i$	i	2.69517D	411.8	95.58 ± 0.12	**1.266 ± 0.174**
^{198}Au$_c$	i(m+g)	2.69517D	411.8	95.58 ± 0.12	**1.755 ± 0.108**
^{196}Au	i(m1+m2+g)	6.183D	355.7	87.0 ± 0.8	2.320 ± 0.091
			333.0	22.9 ± 0.6	2.190 ± 0.281
				RR_{mean} =	**2.315 ± 0.088**
^{195}Au	c	186.098D	129.8	0.82 ± 0.05	130.8 ± 11.1
			98.9	10.9 ± 0.9	111.8 ± 10.9
				RR_{mean} =	**122.5 ± 10.2**
^{194}Au	i(m1+m2+g)	38.02H	328.5	61 ± 5	**2.303 ± 0.231**
^{192}Au$_i$	i(m+g)	4.94H	316.5	58 ± 7	**6.026 ± 1.694**
^{192}Au$_c$	c	4.94H	316.5	58 ± 7	**14.35 ± 1.98**
^{127}Xe	c	36.4D	202.9	68.3 ± 0.5	**0.3013 ± 0.0624**
^{124}Sb	i(m1+m2+g)	60.20D	602.7	98.3 ± 0.4	**0.8355 ± 0.0528**
^{123m}Te	i(m)	119.7D	159.0	84.0 ± 0.4	**0.9407 ± 0.1084**
^{120m}Sb	i(m)	5.76D	1023.3	99.4 ± 0.3	0.6005 ± 0.0344
			197.3	87.0 ± 1.1	0.6629 ± 0.0497
				RR_{mean} =	**0.6186 ± 0.0342**
^{110m}Ag	i(m)	249.76D	657.8	94.3 ± 0.3	**1.498 ± 0.105**
^{103}Ru	c	39.26D	497.1	91.0 ± 1.3	**14.49 ± 0.59**
^{99}Mo	c	65.94H	140.5	90.27 ± 0.33	**16.10 ± 0.66**

Continuation of Table 65.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{96}Nb	i	23.35H	1091.3	48.5 ± 1.6	4.901 ± 0.359
			849.9	20.45 ± 0.20	4.682 ± 0.604
			778.2	96.45 ± 0.22	4.860 ± 0.249
			460.0	26.62 ± 0.20	4.513 ± 0.362
				RR_{mean} =	**4.790 ± 0.208**
^{95}Nb$_i$	i(m+g)	34.975D	765.8	99.81 ± 0.03	**3.173 ± 0.123**
^{95}Nb$_c$	c	34.975D	765.8	99.81 ± 0.03	**14.71 ± 0.49**
^{97}Zr	c	16.744H	743.4	93.06 ± 0.16	**5.443 ± 0.448**
^{95}Zr	c	64.02D	765.8	*	11.64 ± 0.40
			756.7	54.46 ± 0.10	11.55 ± 0.44
				RR_{mean} =	**11.61 ± 0.36**
^{84}Rb	i(m+g)	32.77D	881.6	69.0 ± 1.6	**0.5742 ± 0.1726**
^{82}Br	i(m+g)	35.30H	1317.5	26.5 ± 0.4	3.850 ± 0.476
			776.5	83.5 ± 1.2	3.342 ± 0.169
			554.3	70.8 ± 1.0	3.208 ± 0.152
				RR_{mean} =	**3.284 ± 0.133**

12.4.4 Nuclide production rates for ^{nat}Pb

Table 66: Detailed calculation of nuclide production rates for ^{nat}Pb for $E_p = 0.15$ GeV, used to determine the cross sections for their production.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{207}Bi	i	31.55Y	1063.7	74.5 ± 0.2	19.60 ± 5.05
			569.7	97.74 ± 0.03	16.97 ± 1.75
				RR_{mean} =	**17.23 ± 1.67**
^{206}Bi	i	6.243D	1878.7	2.01 ± 0.05	30.02 ± 1.69
			1718.7	31.8 ± 0.6	29.74 ± 1.21
			1595.3	5.01 ± 0.08	30.99 ± 1.50
			1098.3	13.50 ± 0.21	27.24 ± 1.04
			1018.6	7.60 ± 0.11	29.37 ± 1.10
			895.1	15.66 ± 0.23	29.14 ± 1.09
			881.0	66.2 ± 1.0	29.09 ± 1.05
			803.1	98.9 ± 1.4	28.15 ± 1.01
			632.2	4.47 ± 0.07	27.34 ± 1.18
			620.5	5.76 ± 0.09	26.57 ± 1.11
			537.5	30.5 ± 0.5	26.21 ± 1.00
			516.2	40.7 ± 0.6	27.26 ± 1.03
			497.1	15.31 ± 0.22	26.26 ± 1.09
			398.0	10.74 ± 0.15	26.76 ± 1.00
			343.5	23.4 ± 0.4	26.90 ± 1.02
			262.7	3.02 ± 0.06	28.62 ± 1.92
			184.0	15.8 ± 0.4	31.14 ± 1.40
				RR_{mean} =	**27.91 ± 0.92**
^{205}Bi	i	15.31D	1861.7	6.17 ± 0.10	51.13 ± 2.04
			1775.8	3.99 ± 0.08	52.03 ± 2.26
			1764.3	32.5 ± 0.7	51.56 ± 2.12
			1614.3	2.28 ± 0.04	51.93 ± 2.19
			1190.0	2.26 ± 0.07	50.77 ± 2.54

Continuation of Table 66.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			1043.8	7.51 ± 0.10	46.12 ± 1.74
			987.7	16.13 ± 0.17	50.53 ± 1.80
			759.1	1.04 ± 0.05	50.82 ± 3.63
			703.5	31.1 ± 0.1	47.44 ± 1.60
			579.8	5.44 ± 0.07	45.47 ± 1.83
			573.8	0.62 ± 0.01	50.75 ± 3.81
			570.6	4.34 ± 0.07	46.01 ± 1.79
			284.1	1.69 ± 0.02	47.65 ± 2.01
				RR_{mean} =	**48.47 ± 1.63**
^{204}Bi	i	11.22H	1211.7	3.0 ± 0.4	43.34 ± 6.17
			984.0	59 ± 4	49.46 ± 3.75
			918.3	10.8 ± 0.9	56.95 ± 5.24
			899.2	98 ± 9	47.97 ± 1.61
			670.7	11.4 ± 0.9	52.03 ± 4.50
			374.8	82 ± 5	56.23 ± 11.74
				RR_{mean} =	**48.16 ± 1.49**
^{203}Bi	i(m+g)	11.76H	1893.0	8.2 ± 0.6	60.53 ± 5.00
			1847.3	11.4 ± 0.8	59.83 ± 4.76
			1679.6	8.8 ± 0.7	60.86 ± 5.34
			1536.5	7.5 ± 0.6	64.44 ± 5.69
			1506.7	3.7 ± 0.3	52.82 ± 4.98
			1034.0	8.8 ± 0.5	60.04 ± 4.02
			896.8	13.1 ± 0.7	63.30 ± 4.01
			847.2	8.5 ± 0.5	63.91 ± 4.44
			820.2	29.6 ± 1.5	64.08 ± 3.90
			816.3	4.03 ± 0.21	63.10 ± 4.09
			722.4	4.8 ± 0.4	65.00 ± 6.02
			264.2	5.2 ± 0.4	64.76 ± 5.62
			186.6	3.11 ± 0.22	58.50 ± 8.84
				RR_{mean} =	**62.92 ± 2.03**
^{202}Bi	i	1.72H	960.7	99.28 ± 0.02	63.22 ± 2.32
			422.1	83.7 ± 2.5	62.50 ± 3.13
				RR_{mean} =	**63.07 ± 2.25**
^{201}Bi	i	108M	629.1	24 ± 6	66.39 ± 16.83
			1325.2	6.1 ± 1.3	64.81 ± 14.42
				RR_{mean} =	**65.13 ± 4.63**
^{199}Bi	i	27M	946.0	10.8 ± 0.6	44.09 ± 9.73
			841.7	11 ± 0	50.60 ± 3.85
			837.4	9.5 ± 0.6	61.53 ± 6.09
				RR_{mean} =	**52.71 ± 4.12**
$^{204m}Pb_i$	i(m)	67.2M	899.2	99.17 ± 0.02	48.05 ± 1.75
			374.7	89 ± 15	59.57 ± 10.29
				RR_{mean} =	**48.15 ± 1.82**
$^{204m}Pb_c$	c	67.2M	899.2	99.17 ± 0.02	55.24 ± 1.96
			374.7	89 ± 15	66.63 ± 11.50
				RR_{mean} =	**55.32 ± 1.96**
^{203}Pb	c*	51.873H	680.5	0.75 ± 0.02	230.8 ± 10.5
			279.2	80.8 ± 0.2	216.6 ± 7.9
			401.3	3.35 ± 0.07	212.4 ± 8.6
				RR_{mean} =	**217.5 ± 8.0**
^{202m}Pb	i(m)	3.53H	960.7	92 ± 8	52.66 ± 4.95

Continuation of Table 66.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			490.5	9.1 ± 0.7	57.78 ± 5.08
			459.7	8.6 ± 0.7	51.88 ± 4.85
			422.1	86 ± 5	56.91 ± 3.94
				RR_{mean} =	**55.68 ± 2.23**
^{201}Pb	c*	9.33H	1277.1	1.63 ± 0.12	230.8 ± 19.9
			1238.8	1.18 ± 0.08	195.4 ± 15.7
			1098.5	1.83 ± 0.12	191.3 ± 15.2
			1069.9	1.14 ± 0.11	239.3 ± 25.5
			946.0	7.4 ± 0.6	201.1 ± 17.7
			907.6	5.7 ± 0.4	206.7 ± 16.1
			767.3	3.16 ± 0.16	214.9 ± 13.5
			692.4	4.27 ± 0.16	213.0 ± 10.9
			584.5	3.56 ± 0.16	261.7 ± 15.0
			361.3	9.9 ± 0.5	227.7 ± 13.9
			331.2	79 ± 5	231.2 ± 16.6
			167.4	*	231.3 ± 21.1
			135.3	*	283.9 ± 41.9
				RR_{mean} =	**220.3 ± 6.8**
^{200}Pb	c	21.5H	886.2	*	173.0 ± 12.9
			701.6	*	169.9 ± 16.7
			268.4	3.96 ± 0.20	215.9 ± 13.8
			1514.9	*	193.9 ± 16.1
			1407.6	*	199.7 ± 20.3
			1362.9	*	195.5 ± 24.0
			1225.5	*	186.5 ± 13.6
			1205.7	*	192.6 ± 13.3
			828.3	*	178.6 ± 13.1
			579.3	*	171.2 ± 10.6
			525.5	0.42 ± 0.04	211.0 ± 28.0
			450.5	3.33 ± 0.08	233.1 ± 10.0
			367.9	*	179.3 ± 6.3
			235.6	4.30 ± 0.17	202.9 ± 11.6
			147.6	37.7 ± 1.4	211.4 ± 11.1
			142.3	3.16 ± 0.19	210.9 ± 15.3
				RR_{mean} =	**184.4 ± 5.7**
^{199}Pb	c*	90M	1502.0	2.1 ± 0.4	293.3 ± 59.2
			1382.7	2.9 ± 0.5	344.5 ± 62.7
			1135.0	7.8 ± 1.2	326.9 ± 52.3
			1029.2	1.62 ± 0.25	312.9 ± 51.3
			781.5	1.9 ± 0.3	278.9 ± 47.9
			762.0	2.2 ± 0.4	388.8 ± 73.7
			720.2	6.5 ± 1.0	318.9 ± 52.0
			366.9	44 ± 7	374.2 ± 61.2
			353.4	9.5 ± 1.5	424.4 ± 70.1
				RR_{mean} =	**331.9 ± 17.4**
^{198}Pb	c	2.4H	173.4	18 ± 3	263.7 ± 45.0
			865.3	5.9 ± 1.2	203.9 ± 42.3
			575.0	3.1 ± 0.7	211.7 ± 48.5
			365.4	19 ± 5	267.9 ± 71.1
				RR_{mean} =	**259.7 ± 11.7**
^{197m}Pb	c*	43M	385.9	74 ± 15	158.0 ± 32.5

Continuation of Table 66.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			774.3	14 ± 3	104.3 ± 23.3
			695.6	9.5 ± 2.0	110.7 ± 25.1
			387.7	25 ± 6	138.8 ± 33.7
			222.8	25 ± 6	105.9 ± 25.8
				RR_{mean} =	**135.7 ± 13.1**
^{196}Pb	c*	37M	502.1	26 ± 3	106.1 ± 12.9
			253.1	27 ± 3	92.68 ± 11.00
				RR_{mean} =	**98.27 ± 7.72**
^{195m}Pb	i(m)	15.0M	383.6	107 ± 20	28.37 ± 5.52
			394.2	44 ± 8	36.65 ± 7.48
				RR_{mean} =	**30.30 ± 3.62**
^{202}Tl	c	12.23D	439.6	91.4 ± 1.0	**35.87 ± 1.32**
^{201}Tl$_c$	c	72.912H	167.4	10.00 ± 0.06	256.8 ± 9.8
			135.3	2.57 ± 0.02	282.1 ± 12.6
				RR_{mean} =	**263.8 ± 13.9**
^{201}Tl	c*	72.912H	135.3	2.56 ± 0.02	326.6 ± 13.2
			167.4	10.00 ± 0.06	291.9 ± 10.7
				RR_{mean} =	**302.2 ± 18.4**
^{200}Tl$_i$	i	26.1H	701.6	1.29 ± 0.10	78.57 ± 15.10
			1407.6	1.45 ± 0.13	78.81 ± 13.25
			1205.7	29.9 ± 1.8	39.83 ± 3.91
			1514.9	4.0 ± 0.3	45.23 ± 5.32
			1362.9	3.4 ± 0.4	56.57 ± 7.70
			1225.5	3.36 ± 0.21	49.80 ± 6.02
			886.2	2.02 ± 0.13	57.05 ± 6.47
			828.3	10.8 ± 0.7	64.71 ± 5.66
			579.3	13.8 ± 0.7	68.36 ± 5.78
			367.9	87.2 ± 0.4	56.81 ± 5.29
				RR_{mean} =	**53.63 ± 4.00**
^{200}Tl$_c$	c	26.1H	1205.7	29.9 ± 1.8	232.5 ± 16.1
			1514.9	4.0 ± 0.3	239.2 ± 19.8
			1407.6	1.45 ± 0.13	278.5 ± 27.3
			1362.9	3.4 ± 0.4	252.1 ± 30.9
			1225.5	3.36 ± 0.21	236.3 ± 16.9
			886.2	2.02 ± 0.13	230.1 ± 16.8
			828.3	10.8 ± 0.7	243.3 ± 17.8
			701.6	1.29 ± 0.10	248.5 ± 22.1
			579.3	13.8 ± 0.7	239.6 ± 14.8
			367.9	87.2 ± 0.4	236.1 ± 8.6
				RR_{mean} =	**237.6 ± 8.1**
^{199}Tl	c*	7.42H	455.5	12.4 ± 1.4	279.6 ± 33.1
			247.3	9.3 ± 1.1	286.0 ± 35.7
			208.2	12.3 ± 1.4	282.0 ± 34.0
				RR_{mean} =	**282.1 ± 13.8**
^{198m}Tl	i(m)	1.87H	587.2	52.5 ± 2.0	28.87 ± 1.57
			282.8	28 ± 3	29.30 ± 3.36
				RR_{mean} =	**28.90 ± 1.16**
^{197}Tl	c*	2.84H	1411.3	4.5 ± 1.5	177.0 ± 59.6
			134.0	2.0 ± 0.7	259.9 ± 92.1
			152.2	7.3 ± 2.3	283.3 ± 89.9

Continuation of Table 66.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
				RR_{mean} =	**241.0 ± 36.2**
^{196m}Tl	i(m)	1.41H	695.4	41 ± 7	**42.20 ± 7.42**
^{195}Tl	c*	1.16H	884.5	10.0 ± 1.1	**57.43 ± 6.91**
^{203}Hg	c	46.612D	279.2	81.46 ± 0.13	**1.662 ± 0.151**
^{197}Hg	c*	64.14H	191.4	0.63 ± 0.02	**189.5 ± 10.7**
^{197m}Hg	i(m)	23.8H	134.0	33.5 ± 0.4	**7.153 ± 0.325**
^{195m}Hg	i(m)	41.6H	261.8	31 ± 4	9.156 ± 1.245
			560.3	7.0 ± 0.6	8.827 ± 0.856
			779.8	54.2 ± 0.1	9.032 ± 2.040
				RR_{mean} =	**8.911 ± 0.275**
^{195}Hg$_c$	c	9.9H	779.8	6.8 ± 0.7	**72.33 ± 7.88**
^{193m}Hg	i(m)	11.8H	573.2	26 ± 4	3.616 ± 0.589
			407.6	32 ± 6	4.715 ± 0.915
				RR_{mean} =	**3.935 ± 0.513**
^{192}Hg	c	4.85H	316.5	*	12.02 ± 1.51
			274.8	50.2 ± 2.5	9.359 ± 0.640
				RR_{mean} =	**9.709 ± 0.300**
^{198m}Au	i(m)	2.27D	411.8	*	**0.1131 ± 0.0180**
^{198}Au$_i$	i	2.69517D	411.8	95.58 ± 0.12	**0.4485 ± 0.0331**
^{198}Au$_c$	i(m+g)	2.69517D	411.8	95.58 ± 0.12	**0.5616 ± 0.0235**
^{196}Au	i(m1+m2+g)	6.183D	355.7	87.0 ± 0.8	0.7995 ± 0.0320
			333.0	22.9 ± 0.6	0.7227 ± 0.0632
				RR_{mean} =	**0.7923 ± 0.0332**
^{195}Au	c	186.098D	98.9	10.9 ± 0.9	71.63 ± 6.81
			129.8	0.82 ± 0.05	83.14 ± 7.65
				RR_{mean} =	**76.87 ± 6.20**
^{194}Au	i(m1+m2+g)	38.02H	328.5	61 ± 5	**1.142 ± 0.109**
^{192}Au$_i$	i(m+g)	4.94H	316.5	58 ± 7	**1.239 ± 0.266**
^{192}Au$_c$	c	4.94H	316.5	58 ± 7	**13.26 ± 1.67**
^{127}Xe	c	36.4D	202.9	68.3 ± 0.5	**0.1421 ± 0.0207**
^{124}Sb	i(m1+m2+g)	60.20D	602.7	98.3 ± 0.4	**0.2634 ± 0.0326**
^{123m}Te	i(m)	119.7D	159.0	84.0 ± 0.4	**0.5332 ± 0.0354**
^{120m}Sb	i(m)	5.76D	1023.3	99.4 ± 0.3	0.2800 ± 0.0259
			1171.7	100 ± 0	0.3409 ± 0.0490
			197.3	87.0 ± 1.1	0.3641 ± 0.0249
				RR_{mean} =	**0.3275 ± 0.0299**
^{110m}Ag	i(m)	249.76D	657.8	94.3 ± 0.3	**0.8732 ± 0.1035**
^{103}Ru	c	39.26D	497.1	91.0 ± 1.3	**6.050 ± 0.258**
^{99}Mo	c	65.94H	140.5	90.27 ± 0.33	**6.473 ± 0.256**
^{96}Nb	i	23.35H	1091.3	48.5 ± 1.6	2.656 ± 0.155
			849.9	20.45 ± 0.20	2.631 ± 0.196
			778.2	96.45 ± 0.22	2.417 ± 0.096
			460.0	26.62 ± 0.20	2.483 ± 0.151
				RR_{mean} =	**2.476 ± 0.093**
^{95}Nb$_i$	i(m+g)	34.975D	765.8	99.81 ± 0.03	**1.698 ± 0.083**
^{95}Nb$_c$	c	34.975D	765.8	99.81 ± 0.03	**6.441 ± 0.232**
^{97}Zr	c	16.744H	743.4	93.06 ± 0.16	**1.943 ± 0.089**
^{95}Zr	c	64.02D	765.8	*	4.786 ± 0.202
			756.7	54.46 ± 0.10	4.460 ± 0.195
				RR_{mean} =	**4.624 ± 0.143**

Continuation of Table 66.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{84}Rb	i(m+g)	32.77D	881.6	69.0 ± 1.6	**0.2552 ± 0.1119**
^{82}Br	i(m+g)	35.30H	1317.5	26.5 ± 0.4	1.764 ± 0.120
			776.5	83.5 ± 1.2	1.581 ± 0.071
			554.3	70.8 ± 1.0	1.535 ± 0.076
				RR_{mean} =	**1.584 ± 0.068**

12.4.5 Nuclide production rates for ^{209}Bi

Table 67: Detailed calculation of nuclide production rates for ^{209}Bi for $E_p = 0.15$ GeV, used to determine the cross sections for their production.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{207}Po	i(m+g)	5.80H	992.3	59.3 ± 0.9	107.3 ± 4.1
			742.6	28.2 ± 0.5	111.4 ± 5.7
				RR_{mean} =	**108.1 ± 3.9**
^{206}Po	i	8.8D	1878.7	*	140.3 ± 10.1
			1718.7	*	136.9 ± 5.6
			1595.3	*	147.0 ± 7.3
			1098.3	*	126.2 ± 5.4
			1032.3	33 ± 5	128.5 ± 19.9
			1018.6	*	133.9 ± 5.7
			1007.2	3.1 ± 0.4	119.7 ± 16.2
			980.2	7.1 ± 0.9	130.8 ± 17.1
			895.1	*	133.9 ± 5.4
			881.0	*	130.7 ± 4.9
			807.4	23 ± 3	111.8 ± 15.1
			803.1	*	129.0 ± 4.7
			677.7	1.47 ± 0.20	149.0 ± 21.1
			632.2	*	123.5 ± 7.0
			620.5	*	116.5 ± 5.0
			554.6	1.56 ± 0.21	115.6 ± 16.6
			537.5	*	118.3 ± 5.1
			522.5	15.7 ± 2.0	120.6 ± 15.9
			516.2	*	123.6 ± 5.5
			497.1	*	117.8 ± 4.7
			463.4	1.79 ± 0.24	125.4 ± 17.8
			398.0	*	121.9 ± 6.1
			343.5	*	122.8 ± 5.2
			338.4	19.2 ± 2.5	128.1 ± 17.2
			311.6	4.2 ± 0.6	120.7 ± 18.1
			286.4	24 ± 3	130.2 ± 16.9
			184.0	*	143.1 ± 7.1
				RR_{mean} =	**127.1 ± 3.9**
^{205}Po	i	1.66H	1001.2	28.8 ± 2.2	135.9 ± 11.9
			872.4	37 ± 2	147.8 ± 9.5
			849.8	25.5 ± 2.1	135.5 ± 12.6
				RR_{mean} =	**146.3 ± 5.3**
^{204}Po	i	3.53H	1211.7	*	89.82 ± 86.42
			1040.0	9.6 ± 0.5	154.6 ± 11.8

Continuation of Table 67.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			1016.3	24.1 ± 1.0	156.9 ± 8.6
			984.0	*	112.6 ± 9.3
			918.3	*	173.3 ± 23.2
			899.2	*	146.1 ± 17.1
			884.0	29.9 ± 1.2	166.9 ± 8.9
			670.7	*	123.3 ± 20.8
			534.9	13.2 ± 0.8	148.7 ± 11.9
			374.8	*	174.0 ± 15.9
			270.1	27.8 ± 1.3	163.8 ± 10.1
			137.0	9.7 ± 0.4	169.1 ± 12.5
				RR_{mean} =	**155.6 ± 4.8**
^{203}Po	i(m+g)	36.7M	908.6	55 ± 3	**127.2 ± 9.2**
^{202}Po	i	44.7M	960.7	*	97.69 ± 10.34
			688.6	51 ± 6	145.1 ± 17.9
			422.1	*	95.05 ± 7.99
			316.0	14.3 ± 1.8	127.3 ± 17.3
				RR_{mean} =	**100.8 ± 3.1**
^{201}Po	i(m+g)	15.3M	890.1	91 ± 4	**26.22 ± 4.01**
^{207}Bi	c	31.55Y	1770.2	6.87 ± 0.04	469.1 ± 29.4
			1063.7	74.5 ± 0.2	437.4 ± 17.5
			569.7	97.74 ± 0.03	415.0 ± 15.4
				RR_{mean} =	**426.3 ± 17.1**
^{206}Bi$_i$	i	6.243D	1878.7	2.01 ± 0.05	280.2 ± 14.5
			1718.7	31.8 ± 0.6	276.7 ± 10.9
			1595.3	5.01 ± 0.08	291.7 ± 11.9
			1098.3	13.50 ± 0.21	256.7 ± 9.9
			1018.6	7.60 ± 0.11	280.1 ± 10.7
			895.1	15.66 ± 0.23	275.8 ± 10.2
			881.0	66.2 ± 1.0	273.8 ± 9.9
			803.1	98.9 ± 1.4	256.7 ± 9.2
			632.2	4.47 ± 0.07	258.9 ± 10.8
			620.5	5.76 ± 0.09	255.4 ± 9.8
			537.5	30.5 ± 0.5	238.5 ± 9.4
			516.2	40.7 ± 0.6	249.1 ± 9.9
			497.1	15.31 ± 0.22	242.8 ± 9.1
			398.0	10.74 ± 0.15	241.2 ± 9.9
			343.5	23.4 ± 0.4	249.1 ± 9.7
			184.0	15.8 ± 0.4	295.2 ± 13.9
				RR_{mean} =	**260.4 ± 9.0**
^{206}Bi$_c$	c	6.243D	1878.7	2.01 ± 0.05	412.8 ± 18.4
			1718.7	31.8 ± 0.6	406.1 ± 15.8
			1595.3	5.01 ± 0.08	430.6 ± 16.2
			1098.3	13.50 ± 0.21	375.9 ± 13.8
			1018.6	7.60 ± 0.11	406.6 ± 14.7
			895.1	15.66 ± 0.23	402.4 ± 14.4
			881.0	66.2 ± 1.0	397.4 ± 14.3
			803.1	98.9 ± 1.4	378.6 ± 13.5
			632.2	4.47 ± 0.07	375.6 ± 14.1
			620.5	5.76 ± 0.09	365.5 ± 13.6
			537.5	30.5 ± 0.5	350.4 ± 13.3
			516.2	40.7 ± 0.6	365.9 ± 13.7

Continuation of Table 67.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			497.1	15.31 ± 0.22	354.1 ± 13.1
			398.0	10.74 ± 0.15	356.4 ± 13.2
			343.5	23.4 ± 0.4	365.1 ± 13.8
			184.0	15.8 ± 0.4	430.4 ± 19.8
				RR_{mean} =	**380.6 ± 13.2**
^{205}Bi	c	15.31D	1861.7	6.17 ± 0.10	481.1 ± 18.6
			1775.8	3.99 ± 0.08	491.0 ± 19.7
			1764.3	32.5 ± 0.7	492.6 ± 19.9
			1619.1	0.37 ± 0.02	506.1 ± 33.1
			1614.3	2.28 ± 0.04	516.0 ± 19.8
			1551.0	0.97 ± 0.03	492.5 ± 25.2
			1351.5	1.06 ± 0.04	489.7 ± 25.7
			1190.0	2.26 ± 0.07	505.3 ± 23.3
			1043.8	7.51 ± 0.10	447.6 ± 16.1
			987.7	16.13 ± 0.17	480.1 ± 16.5
			890.2	0.68 ± 0.01	510.8 ± 21.2
			759.1	1.04 ± 0.05	494.4 ± 29.1
			744.7	0.70 ± 0.02	443.2 ± 18.8
			703.5	31.1 ± 0.1	448.6 ± 15.0
			260.5	1.09 ± 0.04	450.3 ± 24.3
				RR_{mean} =	**471.2 ± 15.9**
^{204}Bi$_i$	i	11.22H	1211.7	3.0 ± 0.4	326.4 ± 124.2
			984.0	59 ± 4	322.9 ± 24.7
			918.3	10.8 ± 0.9	309.6 ± 35.7
			899.2	98 ± 9	328.9 ± 34.1
			670.7	11.4 ± 0.9	337.2 ± 36.8
			374.8	82 ± 5	296.6 ± 24.2
				RR_{mean} =	**315.7 ± 15.2**
^{204}Bi$_c$	c	11.22H	1211.7	3.0 ± 0.4	415.7 ± 65.7
			984.0	59 ± 4	434.7 ± 32.7
			918.3	10.8 ± 0.9	481.8 ± 43.5
			899.2	98 ± 9	474.0 ± 46.3
			670.7	11.4 ± 0.9	459.7 ± 39.9
			374.8	82 ± 5	469.5 ± 32.9
				RR_{mean} =	**458.2 ± 20.1**
^{203}Bi	c	11.76H	2011.0	1.76 ± 0.09	486.3 ± 32.4
			1983.0	0.88 ± 0.05	486.0 ± 39.4
			1893.0	8.2 ± 0.6	478.6 ± 39.2
			1888.0	1.94 ± 0.10	465.7 ± 31.3
			1847.3	11.4 ± 0.8	466.5 ± 36.8
			1679.6	8.8 ± 0.7	458.2 ± 39.9
			1536.5	7.5 ± 0.6	500.6 ± 43.8
			1506.7	3.7 ± 0.3	456.1 ± 40.6
			1034.0	8.8 ± 0.5	450.7 ± 30.8
			896.8	13.1 ± 0.7	461.6 ± 29.4
			847.2	8.5 ± 0.5	504.3 ± 34.2
			825.2	14.6 ± 1.1	520.0 ± 43.2
			820.2	29.6 ± 1.5	501.8 ± 30.4
			816.3	4.03 ± 0.21	492.0 ± 31.1
			722.4	4.8 ± 0.4	518.3 ± 47.1
			401.3	*	428.9 ± 80.9

Continuation of Table 67.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			279.2	*	490.5 ± 19.8
			264.2	5.2 ± 0.4	508.2 ± 44.1
				RR_{mean} =	**488.6 ± 15.1**
$^{202}Bi_i$	i	1.72H	960.7	99.28 ± 0.02	363.0 ± 16.9
			422.1	83.7 ± 2.5	370.6 ± 18.2
				RR_{mean} =	**366.4 ± 14.7**
$^{202}Bi_c$	c	1.72H	960.7	99.28 ± 0.02	458.7 ± 15.4
			657.5	60.6 ± 1.8	472.1 ± 22.7
			422.1	83.7 ± 2.5	463.8 ± 21.1
				RR_{mean} =	**460.6 ± 15.2**
^{201}Bi	c*	108M	1650.9	5.8 ± 1.3	345.6 ± 79.0
			1325.2	6.1 ± 1.3	396.0 ± 86.7
			1014.1	10.7 ± 2.3	396.2 ± 86.4
			936.2	11.3 ± 2.5	424.9 ± 95.9
			902.0	8.4 ± 1.8	373.4 ± 82.3
			629.1	24 ± 6	395.0 ± 99.7
				RR_{mean} =	**387.3 ± 16.5**
^{199}Bi	c*	27M	841.7	11 ± 0	**182.7 ± 13.5**
^{204m}Pb	i(m)	67.2M	899.2	99.17 ± 0.02	33.25 ± 3.17
			374.7	89 ± 15	53.48 ± 9.69
				RR_{mean} =	**35.06 ± 5.88**
$^{203}Pb_i$	i(m1+m2+g)	51.873H	401.3	3.35 ± 0.07	170.4 ± 99.6
			279.2	80.8 ± 0.2	101.0 ± 11.2
				RR_{mean} =	**101.8 ± 11.1**
$^{203}Pb_c$	c	51.873H	401.3	3.35 ± 0.07	599.3 ± 31.7
			279.2	80.8 ± 0.2	591.5 ± 21.8
				RR_{mean} =	**592.9 ± 21.2**
^{202m}Pb	i(m)	3.53H	960.7	92 ± 8	52.31 ± 5.43
			422.1	86 ± 5	51.07 ± 4.80
				RR_{mean} =	**51.58 ± 3.24**
^{201}Pb	c*	9.33H	1277.1	1.63 ± 0.12	608.0 ± 55.2
			1238.8	1.18 ± 0.08	640.7 ± 53.9
			767.3	3.16 ± 0.16	657.5 ± 42.4
			692.4	4.27 ± 0.16	586.5 ± 30.9
			361.3	9.9 ± 0.5	652.8 ± 40.0
			331.2	79 ± 5	677.6 ± 49.1
				RR_{mean} =	**627.5 ± 24.8**
^{200}Pb	c	21.5H	450.5	3.33 ± 0.08	510.8 ± 22.6
			268.4	3.96 ± 0.20	527.8 ± 34.5
			257.2	4.46 ± 0.17	526.3 ± 30.4
			235.6	4.30 ± 0.17	551.6 ± 31.4
			147.6	37.7 ± 1.4	486.0 ± 30.0
			142.3	3.16 ± 0.19	494.3 ± 39.8
				RR_{mean} =	**515.1 ± 17.7**
^{199}Pb	c*	90M	1382.7	2.9 ± 0.5	804.4 ± 155.6
			1135.0	7.8 ± 1.2	722.6 ± 118.0
			720.2	6.5 ± 1.0	582.4 ± 99.8
			366.9	44 ± 7	775.3 ± 133.0
			353.4	9.5 ± 1.5	829.4 ± 138.7
				RR_{mean} =	**715.1 ± 51.6**
^{198}Pb	c	2.4H	865.3	5.9 ± 1.2	275.7 ± 58.2

Continuation of Table 67.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			575.0	3.1 ± 0.7	288.8 ± 67.4
			365.4	19 ± 5	358.3 ± 95.3
			259.5	5.8 ± 1.2	321.4 ± 68.2
			173.4	18 ± 3	351.8 ± 60.3
				RR_{mean} =	**344.0 ± 15.0**
^{197m}Pb	c*	43M	387.7	25 ± 6	111.8 ± 27.2
			385.9	74 ± 15	129.3 ± 26.6
				RR_{mean} =	**127.6 ± 6.4**
^{196}Pb	c*	37M	253.1	27 ± 3	**74.12 ± 9.27**
^{202}Tl	c	12.23D	439.6	91.4 ± 1.0	**15.20 ± 0.56**
^{201}Tl	c*	72.912H	167.4	10.00 ± 0.06	**680.5 ± 26.2**
^{200}Tl$_i$	i	26.1H	579.3	13.8 ± 0.7	99.82 ± 24.46
			367.9	87.2 ± 0.4	91.44 ± 18.79
			1205.7	29.9 ± 1.8	41.12 ± 11.00
				RR_{mean} =	**60.04 ± 18.24**
^{200}Tl$_c$	c	26.1H	1604.5	1.17 ± 0.10	447.8 ± 41.9
			1514.9	4.0 ± 0.3	483.5 ± 40.0
			1366.3	0.9 ± 0.3	468.5 ± 158.0
			1362.9	3.4 ± 0.4	499.3 ± 61.8
			1225.5	3.36 ± 0.21	559.4 ± 43.3
			1205.7	29.9 ± 1.8	479.1 ± 33.7
			886.2	2.02 ± 0.13	481.8 ± 40.2
			579.3	13.8 ± 0.7	504.8 ± 33.5
			367.9	87.2 ± 0.4	484.4 ± 21.2
				RR_{mean} =	**488.8 ± 18.1**
^{199}Tl	c*	7.42H	455.5	12.4 ± 1.4	475.6 ± 56.6
			247.3	9.3 ± 1.1	491.1 ± 61.6
			208.2	12.3 ± 1.4	491.7 ± 59.5
			158.4	5.0 ± 0.6	506.7 ± 64.6
				RR_{mean} =	**489.1 ± 22.6**
^{198m}Tl	i(m)	1.87H	587.2	52.5 ± 2.0	**19.34 ± 1.49**
^{197}Tl	c*	2.84H	152.2	7.3 ± 2.3	**266.0 ± 84.6**
^{196m}Tl	i(m)	1.41H	695.4	41 ± 7	**47.18 ± 8.75**
^{203}Hg	c	46.612D	279.2	81.46 ± 0.13	**0.2762 ± 0.0802**
^{197}Hg	c*	64.14H	191.4	0.63 ± 0.02	**167.1 ± 11.4**
^{197m}Hg	i(m)	23.8H	134.0	33.5 ± 0.4	**8.110 ± 0.696**
^{195}Au	c	186.098D	129.8	0.82 ± 0.05	91.79 ± 13.33
			98.9	10.9 ± 0.9	89.27 ± 9.99
				RR_{mean} =	**90.08 ± 7.35**
^{139}Ce	c	137.640D	165.9	79.89 ± 0.01	**0.3654 ± 0.0358**
^{127}Xe	c	36.4D	202.9	68.3 ± 0.5	**0.9949 ± 0.0639**
^{126} I	i	13.11D	666.3	33.1 ± 2.5	2.852 ± 0.314
			388.6	34 ± 3	1.865 ± 0.274
				RR_{mean} =	**2.386 ± 0.498**
^{123m}Te	i(m)	119.7D	159.0	84.0 ± 0.4	**2.143 ± 0.098**
^{121m}Te	i(m)	154D	212.2	81.4 ± 1.1	**0.9990 ± 0.0718**
^{124}Sb	i(m1+m2+g)	60.20D	602.7	98.3 ± 0.4	**1.274 ± 0.069**
^{122}Sb	i(m+g)	2.7238D	564.2	70.67 ± 0.18	**2.838 ± 0.149**
^{120m}Sb	i(m)	5.76D	1171.7	100 ± 0	2.545 ± 0.110
			197.3	87.0 ± 1.1	2.441 ± 0.126

Continuation of Table 67.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
				RR_{mean} =	**2.507 ± 0.099**
^{117m}Sn	i(m)	13.60D	158.6	86.4 ± 0.4	**3.394 ± 0.163**
^{114m}In	i(m)	49.51D	190.3	15.56 ± 0.16	**2.780 ± 0.389**
^{115}Cd	c	53.46H	527.9	27.4 ± 0.6	4.324 ± 0.287
			336.2	45.9 ± 1.0	4.425 ± 0.296
				RR_{mean} =	**4.373 ± 0.218**
^{110m}Ag	i(m)	249.76D	1384.3	24.9 ± 0.8	6.144 ± 0.823
			937.5	34.2 ± 0.6	4.695 ± 0.388
			884.7	72.7 ± 0.4	5.110 ± 0.201
			657.8	94.3 ± 0.3	5.374 ± 0.202
				RR_{mean} =	**5.233 ± 0.198**
^{107}Rh	c	21.7M	302.8	66 ± 6	**36.22 ± 4.22**
^{105}Rh	c	35.36H	318.9	19.1 ± 0.6	31.55 ± 1.68
			306.1	5.1 ± 0.4	36.58 ± 3.42
				RR_{mean} =	**32.19 ± 1.95**
^{106}Ru	c	373.59D	621.9(D)	9.93 ± 0.23	**9.604 ± 1.885**
^{103}Ru	c	39.26D	497.1	91.0 ± 1.3	**29.74 ± 1.12**
^{99}Mo	c	65.94H	739.5	12.13 ± 0.22	26.25 ± 1.14
			181.1	5.99 ± 0.12	29.05 ± 1.49
			140.5	90.27 ± 0.33	30.18 ± 1.59
				RR_{mean} =	**27.77 ± 1.47**
^{96}Nb	i	23.35H	1091.3	48.5 ± 1.6	11.01 ± 0.65
			778.2	96.45 ± 0.22	11.92 ± 0.49
			460.0	26.62 ± 0.20	11.96 ± 0.63
				RR_{mean} =	**11.75 ± 0.45**
^{95}Nb$_i$	i(m+g)	34.975D	765.8	99.81 ± 0.03	**8.908 ± 0.325**
^{95}Nb$_c$	c	34.975D	765.8	99.81 ± 0.03	**29.54 ± 0.98**
^{97}Zr	c	16.744H	743.4	93.06 ± 0.16	**8.295 ± 0.515**
^{95}Zr	c	64.02D	765.8	*	20.82 ± 0.71
			756.7	54.46 ± 0.10	19.60 ± 0.71
			724.2	44.17 ± 0.16	20.80 ± 0.75
				RR_{mean} =	**20.69 ± 0.64**
^{88}Y$_c$	c	106.65D	898.0	93.7 ± 0.3	**1.222 ± 0.073**
^{86}Rb	i(m+g)	18.631D	1077.0	8.64 ± 0.04	**8.862 ± 0.503**
^{84}Rb	i(m+g)	32.77D	881.6	69.0 ± 1.6	**1.873 ± 0.382**
^{83}Rb	c	86.2D	520.4	45 ± 4	**0.7999 ± 0.2966**
^{82}Br	i(m+g)	35.30H	776.5	83.5 ± 1.2	6.965 ± 0.317
			554.3	70.8 ± 1.0	5.980 ± 0.383
				RR_{mean} =	**6.657 ± 0.501**

12.4.6 Nuclide production rates for ^{27}Al

Table 68: Detailed calculation of nuclide production rates for in ^{27}Al-monitors and ^{27}Al-plates for E_p = 0.15 GeV, used for calculating proton flux (including total over the plate area), cross sections for production of ^{7}Be, ^{24}Naand neutron background.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{27}Al-monitor for ^{206}Pb					

Continuation of Table 68.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{7}Be	i	53.29D	477.6	10.52 ± 0.06	**5.520 ± 0.239**
^{27}Mg	c	9.458M	843.8	71.8 ± 0.4	0.5949 ± 0.0381
			1014.4	28.0 ± 0.4	0.7315 ± 0.1020
				RR_{mean} =	**0.6087 ± 0.0453**
^{22}Na	c	2.6019Y	1274.5	99.94 ± 0.01	**72.67 ± 2.59**
^{24}Na	c	14.9590H	1369.0	100 ± 0	**47.19 ± 1.57**
			^{27}Al-plate for ^{206}Pb		
^{24}Na	c	14.9590H	1369.0	100 ± 0	**1.708 ± 0.058**
			^{27}Al-monitor for ^{207}Pb		
^{7}Be	i	53.29D	477.6	10.52 ± 0.06	**4.444 ± 0.173**
^{27}Mg	c	9.458M	843.8	71.8 ± 0.4	0.5137 ± 0.0423
			1014.4	28.0 ± 0.4	0.6629 ± 0.1040
				RR_{mean} =	**0.5329 ± 0.0526**
^{22}Na	c	2.6019Y	1274.5	99.94 ± 0.01	**60.58 ± 2.10**
^{24}Na	c	14.9590H	1369.0	100 ± 0	**38.95 ± 1.30**
			^{27}Al-plate for ^{207}Pb		
^{24}Na	c	14.9590H	1369.0	100 ± 0	**1.779 ± 0.061**
			^{27}Al-monitor for ^{207}Pb		
^{7}Be	i	53.29D	477.6	10.52 ± 0.06	**5.238 ± 0.202**
^{27}Mg	c	9.458M	843.8	71.8 ± 0.4	0.6326 ± 0.0382
			1014.4	28.0 ± 0.4	0.6038 ± 0.0808
				RR_{mean} =	**0.6283 ± 0.0360**
^{22}Na	c	2.6019Y	1274.5	99.94 ± 0.01	**72.41 ± 2.54**
^{24}Na	c	14.9590H	1369.0	100 ± 0	**46.73 ± 1.55**
			^{27}Al-plate for ^{207}Pb		
^{24}Na	c	14.9590H	1369.0	100 ± 0	**1.607 ± 0.055**
			^{27}Al-monitor for ^{nat}Pb		
^{7}Be	i	53.29D	477.6	10.52 ± 0.06	**1.991 ± 0.077**
^{27}Mg	c	9.458M	843.8	71.8 ± 0.4	0.2113 ± 0.0196
			1014.4	28.0 ± 0.4	0.2058 ± 0.0816
				RR_{mean} =	**0.2110 ± 0.0192**
^{22}Na	c	2.6019Y	1274.5	99.94 ± 0.01	**27.07 ± 0.94**
^{24}Na	c	14.9590H	1369.0	100 ± 0	**17.47 ± 0.58**
			^{27}Al-plate for ^{nat}Pb		
^{24}Na	c	14.9590H	1369.0	100 ± 0	**0.8073 ± 0.0270**
			^{27}Al-monitor for ^{209}Bi		
^{7}Be	i	53.29D	477.6	10.52 ± 0.06	**4.573 ± 0.173**
^{27}Mg	c	9.458M	843.8	71.8 ± 0.4	0.7536 ± 0.0450
			1014.4	28.0 ± 0.4	0.7470 ± 0.1172
				RR_{mean} =	**0.7529 ± 0.0433**
^{22}Na	c	2.6019Y	1274.5	99.94 ± 0.01	**62.79 ± 2.11**
^{24}Na	c	14.9590H	1369.0	100 ± 0	**40.25 ± 1.35**
			^{27}Al-plate for ^{209}Bi		
^{24}Na	c	14.9590H	1369.0	100 ± 0	**1.507 ± 0.052**

12.5 Detailed calculation of nuclide production rates for ^{206}Pb, ^{207}Pb, ^{208}Pb, ^{nat}Pb and ^{209}Bi for E_p = 0.25 GeV

12.5.1 Nuclide production rates for ^{206}Pb

Table 69: Detailed calculation of nuclide production rates for ^{206}Pb for $E_p = 0.25$ GeV, used to determine the cross sections for their production.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{206}Bi	i	6.243D	1718.7	31.8 ± 0.6	19.27 ± 0.81
			1098.3	13.50 ± 0.21	16.81 ± 1.86
			895.1	15.66 ± 0.23	20.47 ± 0.87
			881.0	66.2 ± 1.0	17.43 ± 0.67
			803.1	98.9 ± 1.4	16.99 ± 0.62
			620.5	5.76 ± 0.09	18.03 ± 1.07
			537.5	30.5 ± 0.5	15.74 ± 0.66
			516.2	40.7 ± 0.6	16.46 ± 0.62
			497.1	15.31 ± 0.22	18.87 ± 0.90
			398.0	10.74 ± 0.15	15.89 ± 0.68
			343.5	23.4 ± 0.4	16.26 ± 0.67
			184.0	15.8 ± 0.4	21.71 ± 1.04
				RR_{mean} =	**17.27 ± 0.70**
^{205}Bi	i	15.31D	579.8	5.44 ± 0.07	54.78 ± 3.41
			1861.7	6.17 ± 0.10	64.67 ± 3.38
			1775.8	3.99 ± 0.08	63.40 ± 4.09
			1764.3	32.5 ± 0.7	59.87 ± 2.48
			1614.3	2.28 ± 0.04	58.66 ± 3.19
			1190.0	2.26 ± 0.07	64.76 ± 4.35
			1043.8	7.51 ± 0.10	56.62 ± 2.29
			987.7	16.13 ± 0.17	64.52 ± 2.93
			759.1	1.04 ± 0.05	60.17 ± 4.84
			703.5	31.1 ± 0.1	55.88 ± 1.90
			570.6	4.34 ± 0.07	50.80 ± 2.85
			549.8	2.95 ± 0.04	51.28 ± 2.48
			284.1	1.69 ± 0.02	58.82 ± 6.02
				RR_{mean} =	**57.06 ± 2.05**
^{204}Bi	i	11.22H	984.0	59 ± 4	83.15 ± 6.31
			918.3	10.8 ± 0.9	90.26 ± 8.56
			899.2	98 ± 9	78.54 ± 2.72
			670.7	11.4 ± 0.9	81.64 ± 7.44
			374.8	82 ± 5	86.51 ± 18.17
				RR_{mean} =	**79.03 ± 2.44**
^{203}Bi	i(m+g)	11.76H	1893.0	8.2 ± 0.6	103.8 ± 9.1
			1847.3	11.4 ± 0.8	105.4 ± 8.8
			1679.6	8.8 ± 0.7	101.6 ± 9.1
			1034.0	8.8 ± 0.5	102.9 ± 7.8
			896.8	13.1 ± 0.7	107.3 ± 7.1
			847.2	8.5 ± 0.5	115.2 ± 8.3
			820.2	29.6 ± 1.5	111.7 ± 6.9
				RR_{mean} =	**109.6 ± 3.7**
^{202}Bi	i	1.72H	960.7	99.28 ± 0.02	103.0 ± 4.8
			422.1	83.7 ± 2.5	98.66 ± 7.97

Continuation of Table 69.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
				RR_{mean} =	**102.1 ± 4.5**
^{201}Bi	i	108M	629.1	24 ± 6	**130.2 ± 34.3**
$^{204m}Pb_c$	c	67.2M	899.2	99.17 ± 0.02	98.60 ± 3.92
			374.7	89 ± 15	124.0 ± 21.6
				RR_{mean} =	**98.94 ± 4.22**
$^{204m}Pb_i$	i(m)	67.2M	899.2	99.17 ± 0.02	86.82 ± 3.62
			374.7	89 ± 15	113.2 ± 19.8
				RR_{mean} =	**87.23 ± 4.22**
^{203}Pb	c*	51.873H	401.3	3.35 ± 0.07	424.9 ± 17.3
			279.2	80.8 ± 0.2	441.0 ± 16.1
				RR_{mean} =	**435.1 ± 15.5**
^{202m}Pb	i(m)	3.53H	960.7	92 ± 8	98.29 ± 9.49
			490.5	9.1 ± 0.7	140.4 ± 15.5
			459.7	8.6 ± 0.7	92.46 ± 10.39
			422.1	86 ± 5	109.4 ± 8.1
				RR_{mean} =	**106.5 ± 7.4**
^{201}Pb	c*	9.33H	1277.1	1.63 ± 0.12	460.2 ± 39.7
			1238.8	1.18 ± 0.08	378.2 ± 38.1
			1098.5	1.83 ± 0.12	371.5 ± 35.7
			1069.9	1.14 ± 0.11	474.6 ± 56.0
			946.0	7.4 ± 0.6	391.8 ± 34.7
			907.6	5.7 ± 0.4	433.6 ± 34.1
			692.4	4.27 ± 0.16	425.9 ± 23.1
			361.3	9.9 ± 0.5	456.1 ± 28.0
			331.2	79 ± 5	447.4 ± 32.2
				RR_{mean} =	**426.9 ± 16.9**
^{200}Pb	c	21.5H	1514.9	*	367.8 ± 31.5
			1407.6	*	432.7 ± 42.3
			1362.9	*	359.7 ± 44.5
			1225.5	*	346.0 ± 26.7
			1205.7	*	377.5 ± 26.0
			886.2	*	330.3 ± 29.9
			828.3	*	333.3 ± 26.1
			701.6	*	296.8 ± 29.0
			579.3	*	334.4 ± 22.2
			450.5	3.33 ± 0.08	463.9 ± 20.6
			367.9	*	350.9 ± 12.3
			268.4	3.96 ± 0.20	490.2 ± 44.1
			235.6	4.30 ± 0.17	409.2 ± 23.4
			147.6	37.7 ± 1.4	370.2 ± 20.0
			142.3	3.16 ± 0.19	388.4 ± 29.8
				RR_{mean} =	**354.0 ± 10.9**
^{199}Pb	c*	90M	1135.0	7.8 ± 1.2	685.0 ± 109.5
			762.0	2.2 ± 0.4	941.9 ± 189.3
			720.2	6.5 ± 1.0	564.2 ± 92.0
			366.9	44 ± 7	697.7 ± 114.7
			353.4	9.5 ± 1.5	742.2 ± 122.8
				RR_{mean} =	**665.4 ± 46.9**
^{198}Pb	c	2.4H	865.3	5.9 ± 1.2	452.5 ± 93.9
			575.0	3.1 ± 0.7	462.8 ± 111.1
			365.4	19 ± 5	605.2 ± 161.0

Continuation of Table 69.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			173.4	18 ± 3	555.6 ± 95.3
				RR_{mean} =	**546.9 ± 24.1**
^{197m}Pb	c*	43M	774.3	14 ± 3	307.5 ± 67.5
			695.6	9.5 ± 2.0	263.6 ± 67.1
			387.7	25 ± 6	377.7 ± 91.7
			385.9	74 ± 15	378.1 ± 77.9
			222.8	25 ± 6	321.8 ± 78.9
				RR_{mean} =	**351.6 ± 22.3**
^{196}Pb	c*	37M	502.1	26 ± 3	**362.6 ± 44.8**
^{195m}Pb	i(m)	15.0M	394.2	44 ± 8	214.6 ± 42.1
			383.6	107 ± 20	205.1 ± 39.6
				RR_{mean} =	**208.8 ± 11.2**
^{202}Tl	c	12.23D	439.6	91.4 ± 1.0	**117.3 ± 4.3**
^{201}Tl	c*	72.912H	167.4	10.00 ± 0.06	**636.6 ± 23.4**
^{200}Tl$_i$	i	26.1H	1514.9	4.0 ± 0.3	190.6 ± 23.8
			1407.6	1.45 ± 0.13	158.5 ± 22.4
			1362.9	3.4 ± 0.4	239.9 ± 32.2
			1225.5	3.36 ± 0.21	191.2 ± 25.0
			1205.7	29.9 ± 1.8	162.1 ± 11.8
			886.2	2.02 ± 0.13	232.5 ± 39.8
			828.3	10.8 ± 0.7	269.2 ± 26.6
			701.6	1.29 ± 0.10	317.3 ± 39.5
			579.3	13.8 ± 0.7	198.1 ± 22.8
			367.9	87.2 ± 0.4	181.8 ± 10.8
				RR_{mean} =	**186.9 ± 12.3**
^{200}Tl$_c$	c	26.1H	1514.9	4.0 ± 0.3	558.4 ± 47.0
			1407.6	1.45 ± 0.13	591.2 ± 57.2
			1362.9	3.4 ± 0.4	599.6 ± 73.7
			1225.5	3.36 ± 0.21	537.2 ± 39.7
			1205.7	29.9 ± 1.8	539.6 ± 37.1
			886.2	2.02 ± 0.13	562.8 ± 45.2
			828.3	10.8 ± 0.7	602.5 ± 44.7
			701.6	1.29 ± 0.10	614.2 ± 54.2
			579.3	13.8 ± 0.7	532.4 ± 34.2
			367.9	87.2 ± 0.4	532.7 ± 18.8
				RR_{mean} =	**540.7 ± 18.2**
^{199}Tl	c*	7.42H	750.4	1.04 ± 0.12	689.2 ± 90.7
			455.5	12.4 ± 1.4	642.9 ± 76.7
			333.9	1.76 ± 0.20	649.2 ± 80.5
			247.3	9.3 ± 1.1	633.7 ± 80.5
			208.2	12.3 ± 1.4	648.9 ± 78.6
			158.4	5.0 ± 0.6	676.9 ± 87.1
				RR_{mean} =	**653.3 ± 27.8**
^{198m}Tl	i(m)	1.87H	587.2	52.5 ± 2.0	144.1 ± 14.2
			282.8	28 ± 3	155.3 ± 18.2
				RR_{mean} =	**148.1 ± 10.9**
^{197}Tl	c*	2.84H	1411.3	4.5 ± 1.5	560.6 ± 189.6
			152.2	7.3 ± 2.3	871.3 ± 276.5
			134.0	2.0 ± 0.7	845.3 ± 299.7
				RR_{mean} =	**757.7 ± 106.7**

Continuation of Table 69.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{196m}Tl	i(m)	1.41H	695.4	41 ± 7	**319.6 ± 56.0**
^{195}Tl	c*	1.16H	884.5	10.0 ± 1.1	**400.6 ± 46.9**
^{203}Hg	c	46.612D	279.2	81.46 ± 0.13	**4.212 ± 0.326**
^{197}Hg	c*	64.14H	191.4	0.63 ± 0.02	**628.8 ± 34.3**
^{197m}Hg	i(m)	23.8H	134.0	33.5 ± 0.4	**40.53 ± 1.79**
^{195m}Hg	i(m)	41.6H	779.8	54.2 ± 0.1	52.47 ± 10.73
			560.3	7.0 ± 0.6	55.69 ± 5.44
			261.8	31 ± 4	59.76 ± 8.04
				RR_{mean} =	**55.78 ± 1.72**
^{195}Hg$_c$	c	9.9H	779.8	6.8 ± 0.7	**489.0 ± 53.3**
^{193m}Hg	i(m)	11.8H	573.2	26 ± 4	47.58 ± 7.59
			407.6	32 ± 6	67.01 ± 12.80
				RR_{mean} =	**52.59 ± 8.65**
^{192}Hg	c	4.85H	2335.7	*	313.7 ± 68.1
			316.5	*	323.5 ± 40.8
			296.0	*	324.0 ± 46.5
			274.8	50.2 ± 2.5	258.8 ± 16.6
				RR_{mean} =	**266.6 ± 8.2**
^{190}Hg	c*	20.0M	295.8	*	126.4 ± 13.6
			142.6	68 ± 10	145.5 ± 22.9
				RR_{mean} =	**131.2 ± 4.0**
^{198m}Au	i(m)	2.27D	411.8	*	**1.035 ± 0.047**
^{198}Au$_i$	i	2.69517D	411.8	95.58 ± 0.12	**1.901 ± 0.085**
^{198}Au$_c$	i(m+g)	2.69517D	411.8	95.58 ± 0.12	**2.936 ± 0.103**
^{196}Au	i(m1+m2+g)	6.183D	426.1	6.6 ± 0.8	7.865 ± 1.312
			355.7	87.0 ± 0.8	6.576 ± 0.252
			333.0	22.9 ± 0.6	6.953 ± 0.335
				RR_{mean} =	**6.673 ± 0.247**
^{195}Au	c	186.098D	129.8	0.82 ± 0.05	620.9 ± 48.6
			98.9	10.9 ± 0.9	565.0 ± 55.1
				RR_{mean} =	**603.0 ± 32.0**
^{194}Au	i(m1+m2+g)	38.02H	328.5	61 ± 5	13.32 ± 1.18
			293.6	10.4 ± 0.8	11.11 ± 1.04
				RR_{mean} =	**12.11 ± 1.17**
^{192}Au$_i$	i(m+g)	4.94H	316.5	58 ± 7	19.65 ± 4.36
			296.0	22 ± 3	45.58 ± 17.32
				RR_{mean} =	**20.87 ± 5.52**
^{192}Au$_c$	c	4.94H	316.5	58 ± 7	343.1 ± 43.1
			296.0	22 ± 3	369.6 ± 52.9
				RR_{mean} =	**345.8 ± 13.7**
^{191}Au	c*	3.18H	586.4	17 ± 0	**194.5 ± 25.7**
^{190}Au$_c$	c	42.8M	301.8	23.4 ± 1.5	162.5 ± 16.8
			295.8	71 ± 5	149.7 ± 12.4
				RR_{mean} =	**153.0 ± 8.2**
^{191}Pt	c	2.802D	538.9	13.7 ± 1.6	205.1 ± 25.0
			456.5	3.4 ± 0.4	197.8 ± 24.5
			409.4	8.0 ± 0.9	186.9 ± 22.0
			172.2	3.5 ± 0.4	193.5 ± 23.3
				RR_{mean} =	**194.5 ± 8.4**
^{189}Pt	c	10.87H	607.6	8.10 ± 0.16	133.2 ± 7.0

Continuation of Table 69.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			568.8	7.1 ± 0.6	144.1 ± 14.5
			544.9	5.8 ± 0.5	153.4 ± 15.4
			243.5	7.0 ± 1.2	130.7 ± 23.2
				RR_{mean} =	**136.6 ± 6.4**
^{188}Pt	c	10.2D	1209.8	*	99.03 ± 10.73
			634.9	*	98.56 ± 16.12
			423.3	4.4 ± 0.3	95.89 ± 7.50
			381.4	7.5 ± 0.5	89.72 ± 6.81
			195.1	18.6 ± 1.2	90.22 ± 6.76
			187.6	19.4 ± 1.2	92.96 ± 6.84
			155.1	*	95.01 ± 10.10
			140.4	2.33 ± 0.15	103.3 ± 12.5
				RR_{mean} =	**93.77 ± 2.89**
^{186}Pt	c	2.08H	689.4	70 ± 15	**40.43 ± 8.82**
^{189}Ir	c	13.2D	245.1	6.0 ± 0.6	**121.8 ± 13.3**
^{188}Ir$_i$	i	41.5H	634.9	5.0 ± 0.8	4.149 ± 1.317
			155.1	30 ± 3	7.655 ± 1.157
				RR_{mean} =	**6.209 ± 1.737**
^{188}Ir$_c$	c	41.5H	1209.8	6.9 ± 0.7	98.75 ± 10.68
			634.9	5.0 ± 0.8	102.7 ± 16.8
			155.1	30 ± 3	102.7 ± 10.9
				RR_{mean} =	**101.0 ± 6.9**
^{186}Ir	c	16.64H	434.8	33.9 ± 1.1	**19.09 ± 1.22**
^{185}Os	c	93.6D	874.8	6.29 ± 0.25	28.68 ± 2.38
			717.4	3.94 ± 0.16	23.29 ± 3.39
			646.1	78 ± 3	27.94 ± 1.46
				RR_{mean} =	**27.88 ± 0.99**
^{183}Re	c	70.0D	208.8	2.95 ± 0.09	15.01 ± 1.51
			162.3	23.3 ± 0.7	11.95 ± 0.64
				RR_{mean} =	**12.24 ± 0.97**
^{175}Hf	c	70D	343.4	84 ± 3	**1.258 ± 0.122**
^{139}Ce	c	137.640D	165.9	79.89 ± 0.01	**0.7498 ± 0.0607**
^{127}Xe	c	36.4D	202.9	68.3 ± 0.5	2.051 ± 0.108
			172.1	25.5 ± 0.8	2.050 ± 0.266
				RR_{mean} =	**2.051 ± 0.103**
^{124}Sb	i(m1+m2+g)	60.20D	602.7	98.3 ± 0.4	**0.8296 ± 0.0988**
^{123m}Te	i(m)	119.7D	159.0	84.0 ± 0.4	**1.999 ± 0.182**
^{121m}Te	i(m)	154D	573.1	88.6 ± 0.1	2.102 ± 0.229
			212.2	81.4 ± 1.1	1.740 ± 0.106
				RR_{mean} =	**1.794 ± 0.055**
^{121}Te$_c$	c	19.16D	573.1	80.3 ± 2.5	**2.259 ± 0.183**
^{120m}Sb	i(m)	5.76D	1023.3	99.4 ± 0.3	2.427 ± 0.105
			197.3	87.0 ± 1.1	2.435 ± 0.113
				RR_{mean} =	**2.431 ± 0.093**
^{114m}In	i(m)	49.51D	190.3	15.56 ± 0.16	**5.933 ± 0.434**
^{110m}Ag	i(m)	249.76D	937.5	34.2 ± 0.6	7.618 ± 0.576
			884.7	72.7 ± 0.4	6.797 ± 0.362
			657.8	94.3 ± 0.3	6.451 ± 0.377
				RR_{mean} =	**6.780 ± 0.341**
^{105}Rh	c	35.36H	318.9	19.1 ± 0.6	**27.92 ± 1.33**

Continuation of Table 69.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{101m}Rh	c	4.34D	306.9	81 ± 5	**1.560 ± 0.143**
^{103}Ru	c	39.26D	497.1	91.0 ± 1.3	**25.85 ± 0.98**
^{99}Mo	c	65.94H	739.5	12.13 ± 0.22	21.90 ± 0.92
			140.5	90.27 ± 0.33	24.58 ± 1.06
				RR_{mean} =	**23.04 ± 1.50**
^{96}Nb	i	23.35H	1091.3	48.5 ± 1.6	15.19 ± 0.88
			849.9	20.45 ± 0.20	16.85 ± 0.79
			778.2	96.45 ± 0.22	13.76 ± 0.57
			568.9	58.0 ± 0.3	13.68 ± 0.55
			460.0	26.62 ± 0.20	15.07 ± 0.64
				RR_{mean} =	**14.47 ± 0.69**
^{95}Nb$_i$	i(m+g)	34.975D	765.8	99.81 ± 0.03	**14.63 ± 0.50**
^{95}Nb$_c$	c	34.975D	765.8	99.81 ± 0.03	**31.07 ± 1.04**
^{97}Zr	c	16.744H	743.4	93.06 ± 0.16	**4.882 ± 0.249**
^{95}Zr	c	64.02D	765.8	*	16.59 ± 0.61
			756.7	54.46 ± 0.10	16.61 ± 0.60
			724.2	44.17 ± 0.16	17.46 ± 0.95
				RR_{mean} =	**16.67 ± 0.51**
^{89}Zr	c	78.41H	909.2	99.04 ± 0.03	**2.150 ± 0.187**
^{88}Zr	c	83.4D	898.0	*	**0.7393 ± 0.2715**
^{88} Y$_i$	i	106.65D	898.0	93.7 ± 0.3	**5.513 ± 0.300**
^{88} Y$_c$	c	106.65D	898.0	93.7 ± 0.3	**6.252 ± 0.254**
^{87} Y	c*	79.8H	484.8	89.7 ± 0.7	**2.651 ± 0.105**
^{85}Sr	c	64.84D	514.0	96 ± 4	**3.579 ± 0.223**
^{86}Rb	i(m+g)	18.631D	1077.0	8.64 ± 0.04	**22.13 ± 1.43**
^{84}Rb	i(m+g)	32.77D	881.6	69.0 ± 1.6	**8.580 ± 0.471**
^{83}Rb	c	86.2D	529.6	29.3 ± 2.1	3.353 ± 0.391
			520.4	45 ± 4	3.742 ± 0.432
				RR_{mean} =	**3.529 ± 0.268**
^{82}Br	i(m+g)	35.30H	1317.5	26.5 ± 0.4	10.59 ± 0.56
			776.5	83.5 ± 1.2	9.721 ± 0.398
			698.4	28.5 ± 0.4	9.177 ± 0.415
			554.3	70.8 ± 1.0	9.260 ± 0.387
				RR_{mean} =	**9.526 ± 0.381**
^{75}Se	c	119.779D	136.0	58.3 ± 0.8	**0.7204 ± 0.1678**
^{74}As	i	17.77D	595.8	59 ± 4	**2.057 ± 0.188**
^{72}Ga$_i$	i	14.10H	2201.7	25.9 ± 0.5	**2.295 ± 1.195**
^{72}Ga$_c$	c	14.10H	2201.7	25.9 ± 0.5	**4.352 ± 1.073**
^{72}Zn	c	46.5H	2201.7	*	**2.057 ± 0.205**

12.5.2 Nuclide production rates for ^{207}Pb

Table 70: Detailed calculation of nuclide production rates for ^{207}Pb for $E_p = 0.25$ GeV, used to determine the cross sections for their production.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{207}Bi	i	31.55Y	569.7	97.74 ± 0.03	**24.45 ± 2.47**
^{206}Bi	i	6.243D	1878.7	2.01 ± 0.05	63.04 ± 4.12

Continuation of Table 70.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			1718.7	31.8 ± 0.6	62.77 ± 2.53
			1595.3	5.01 ± 0.08	68.60 ± 3.01
			1098.3	13.50 ± 0.21	63.95 ± 3.22
			1018.6	7.60 ± 0.11	72.68 ± 3.65
			895.1	15.66 ± 0.23	63.16 ± 2.35
			881.0	66.2 ± 1.0	59.92 ± 2.16
			803.1	98.9 ± 1.4	58.02 ± 2.08
			620.5	5.76 ± 0.09	57.62 ± 2.35
			537.5	30.5 ± 0.5	53.65 ± 2.05
			516.2	40.7 ± 0.6	56.85 ± 2.12
			497.1	15.31 ± 0.22	55.14 ± 2.18
			398.0	10.74 ± 0.15	54.63 ± 2.04
			343.5	23.4 ± 0.4	56.73 ± 2.17
			184.0	15.8 ± 0.4	68.39 ± 3.22
				RR_{mean} =	**58.65 ± 2.14**
^{205}Bi	i	15.31D	1861.7	6.17 ± 0.10	125.2 ± 5.0
			1775.8	3.99 ± 0.08	126.1 ± 5.4
			1764.3	32.5 ± 0.7	127.4 ± 5.2
			1614.3	2.28 ± 0.04	132.6 ± 6.1
			1190.0	2.26 ± 0.07	128.8 ± 6.4
			1043.8	7.51 ± 0.10	116.8 ± 4.3
			987.7	16.13 ± 0.17	132.0 ± 4.7
			759.1	1.04 ± 0.05	128.1 ± 8.5
			703.5	31.1 ± 0.1	116.1 ± 3.9
			579.8	5.44 ± 0.07	113.3 ± 4.6
			570.6	4.34 ± 0.07	112.8 ± 4.5
			549.8	2.95 ± 0.04	108.8 ± 4.2
			284.1	1.69 ± 0.02	122.7 ± 5.2
				RR_{mean} =	**119.7 ± 4.3**
^{204}Bi	i	11.22H	984.0	59 ± 4	125.4 ± 9.6
			918.3	10.8 ± 0.9	133.5 ± 12.7
			899.2	98 ± 9	119.4 ± 4.2
			670.7	11.4 ± 0.9	121.9 ± 10.8
			374.8	82 ± 5	139.4 ± 29.1
				RR_{mean} =	**120.0 ± 3.7**
^{203}Bi	i(m+g)	11.76H	1893.0	8.2 ± 0.6	137.9 ± 11.9
			1847.3	11.4 ± 0.8	140.4 ± 11.3
			1679.6	8.8 ± 0.7	141.1 ± 12.8
			1034.0	8.8 ± 0.5	149.6 ± 10.4
			896.8	13.1 ± 0.7	150.2 ± 10.1
			847.2	8.5 ± 0.5	153.4 ± 11.0
			820.2	29.6 ± 1.5	155.8 ± 9.5
				RR_{mean} =	**152.4 ± 5.2**
^{202}Bi	i	1.72H	960.7	99.28 ± 0.02	136.6 ± 5.5
			422.1	83.7 ± 2.5	139.5 ± 7.7
				RR_{mean} =	**137.3 ± 5.2**
^{201}Bi	i	108M	629.1	24 ± 6	**131.0 ± 33.3**
^{204m}Pb$_i$	i(m)	67.2M	899.2	99.17 ± 0.02	136.6 ± 5.3
			374.7	89 ± 15	170.7 ± 29.5
				RR_{mean} =	**137.0 ± 5.7**
^{204m}Pb$_c$	c	67.2M	899.2	99.17 ± 0.02	154.5 ± 5.8

Continuation of Table 70.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			374.7	89 ± 15	188.2 ± 32.5
				RR_{mean} =	**154.9 ± 5.9**
^{203}Pb	c*	51.873H	401.3	3.35 ± 0.07	557.8 ± 22.7
			279.2	80.8 ± 0.2	579.3 ± 21.2
				RR_{mean} =	**571.3 ± 20.5**
^{202m}Pb	i(m)	3.53H	960.7	92 ± 8	146.5 ± 13.8
			490.5	9.1 ± 0.7	195.0 ± 18.1
			459.7	8.6 ± 0.7	144.6 ± 14.0
			422.1	86 ± 5	156.1 ± 10.9
				RR_{mean} =	**156.5 ± 9.0**
^{201}Pb	c*	9.33H	1277.1	1.63 ± 0.12	562.1 ± 48.9
			1238.8	1.18 ± 0.08	473.9 ± 42.5
			1098.5	1.83 ± 0.12	464.8 ± 63.8
			1069.9	1.14 ± 0.11	515.5 ± 59.3
			946.0	7.4 ± 0.6	485.8 ± 42.9
			907.6	5.7 ± 0.4	528.0 ± 42.0
			692.4	4.27 ± 0.16	562.7 ± 29.4
			361.3	9.9 ± 0.5	581.1 ± 35.8
			331.2	79 ± 5	585.1 ± 42.1
				RR_{mean} =	**542.5 ± 22.0**
^{200}Pb	c	21.5H	1514.9	*	462.6 ± 38.9
			1407.6	*	509.7 ± 51.1
			1362.9	*	499.9 ± 61.7
			1225.5	*	442.3 ± 35.0
			1205.7	*	471.2 ± 32.6
			886.2	*	442.3 ± 33.9
			828.3	*	458.3 ± 33.8
			701.6	*	388.3 ± 35.3
			579.3	*	419.9 ± 26.9
			450.5	3.33 ± 0.08	570.6 ± 26.1
			367.9	*	438.5 ± 15.3
			268.4	3.96 ± 0.20	582.0 ± 50.7
			235.6	4.30 ± 0.17	566.8 ± 32.9
			147.6	37.7 ± 1.4	460.9 ± 25.8
			142.3	3.16 ± 0.19	602.7 ± 43.9
				RR_{mean} =	**445.0 ± 13.7**
^{199}Pb	c*	90M	1135.0	7.8 ± 1.2	851.9 ± 140.1
			762.0	2.2 ± 0.4	1114 ± 216
			720.2	6.5 ± 1.0	805.4 ± 129.7
			366.9	44 ± 7	823.9 ± 134.9
			353.4	9.5 ± 1.5	864.6 ± 144.1
				RR_{mean} =	**844.9 ± 40.6**
^{198}Pb	c	2.4H	865.3	5.9 ± 1.2	498.9 ± 103.7
			575.0	3.1 ± 0.7	553.5 ± 128.4
			365.4	19 ± 5	741.2 ± 198.2
			173.4	18 ± 3	702.4 ± 120.2
				RR_{mean} =	**684.9 ± 38.5**
^{197m}Pb	c*	43M	774.3	14 ± 3	358.4 ± 78.5
			695.6	9.5 ± 2.0	384.5 ± 93.7
			387.7	25 ± 6	456.9 ± 111.1
			385.9	74 ± 15	467.2 ± 96.2

Continuation of Table 70.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			222.8	25 ± 6	375.5 ± 91.7
				RR_{mean} =	**431.6 ± 27.4**
^{196}Pb	c*	37M	502.1	26 ± 3	**416.2 ± 50.6**
^{195m}Pb	i(m)	15.0M	394.2	44 ± 8	232.7 ± 44.9
			383.6	107 ± 20	233.8 ± 44.6
				RR_{mean} =	**233.3 ± 11.3**
^{202}Tl	c	12.23D	439.6	91.4 ± 1.0	**166.4 ± 6.0**
^{201}Tl	c*	72.912H	167.4	10.00 ± 0.06	**839.7 ± 30.9**
^{200}Tl$_i$	i	26.1H	1514.9	4.0 ± 0.3	256.2 ± 25.7
			1407.6	1.45 ± 0.13	279.4 ± 39.3
			1362.9	3.4 ± 0.4	254.3 ± 34.7
			1225.5	3.36 ± 0.21	267.9 ± 33.7
			1205.7	29.9 ± 1.8	231.6 ± 18.1
			886.2	2.02 ± 0.13	274.6 ± 28.3
			828.3	10.8 ± 0.7	331.2 ± 25.6
			701.6	1.29 ± 0.10	414.3 ± 42.1
			579.3	13.8 ± 0.7	296.2 ± 27.7
			367.9	87.2 ± 0.4	260.6 ± 14.5
				RR_{mean} =	**270.4 ± 14.9**
^{200}Tl$_c$	c	26.1H	1514.9	4.0 ± 0.3	718.8 ± 59.7
			1407.6	1.45 ± 0.13	789.2 ± 77.3
			1362.9	3.4 ± 0.4	754.2 ± 92.7
			1225.5	3.36 ± 0.21	710.1 ± 52.9
			1205.7	29.9 ± 1.8	702.8 ± 48.6
			886.2	2.02 ± 0.13	716.9 ± 53.0
			828.3	10.8 ± 0.7	789.5 ± 57.5
			701.6	1.29 ± 0.10	802.6 ± 68.9
			579.3	13.8 ± 0.7	716.1 ± 45.8
			367.9	87.2 ± 0.4	699.2 ± 24.9
				RR_{mean} =	**710.4 ± 24.1**
^{199}Tl	c*	7.42H	750.4	1.04 ± 0.12	965.3 ± 130.3
			455.5	12.4 ± 1.4	831.4 ± 99.0
			333.9	1.76 ± 0.20	946.5 ± 118.7
			247.3	9.3 ± 1.1	849.4 ± 106.1
			208.2	12.3 ± 1.4	841.9 ± 102.0
			158.4	5.0 ± 0.6	882.4 ± 113.3
				RR_{mean} =	**871.5 ± 37.2**
^{198m}Tl	i(m)	1.87H	587.2	52.5 ± 2.0	185.5 ± 11.9
			282.8	28 ± 3	206.9 ± 23.9
				RR_{mean} =	**188.0 ± 9.4**
^{197}Tl	c*	2.84H	1411.3	4.5 ± 1.5	649.1 ± 219.4
			152.2	7.3 ± 2.3	1056 ± 335
			134.0	2.0 ± 0.7	919.1 ± 327.5
				RR_{mean} =	**889.5 ± 137.0**
^{196m}Tl	i(m)	1.41H	695.4	41 ± 7	**404.9 ± 70.8**
^{195}Tl	c*	1.16H	884.5	10.0 ± 1.1	**413.2 ± 49.9**
^{203}Hg	c	46.612D	279.2	81.46 ± 0.13	**11.06 ± 0.50**
^{197}Hg	c*	64.14H	191.4	0.63 ± 0.02	**783.0 ± 44.6**
^{197m}Hg	i(m)	23.8H	134.0	33.5 ± 0.4	**65.82 ± 3.14**
^{195m}Hg	i(m)	41.6H	779.8	54.2 ± 0.1	65.59 ± 13.75

Continuation of Table 70.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			560.3	7.0 ± 0.6	77.40 ± 7.29
			261.8	31 ± 4	82.77 ± 11.23
				RR_{mean} =	**75.79 ± 2.34**
$^{195}Hg_c$	c	9.9H	779.8	6.8 ± 0.7	**627.8 ± 68.6**
^{193m}Hg	i(m)	11.8H	573.2	26 ± 4	61.38 ± 9.89
			407.6	32 ± 6	83.55 ± 15.99
				RR_{mean} =	**67.46 ± 10.10**
^{192}Hg	c	4.85H	2335.7	*	328.7 ± 66.6
			316.5	*	359.7 ± 45.2
			296.0	*	371.0 ± 53.2
			274.8	50.2 ± 2.5	280.6 ± 17.7
				RR_{mean} =	**289.4 ± 8.9**
^{190}Hg	c*	20.0M	295.8	*	123.3 ± 15.4
			142.6	68 ± 10	137.3 ± 21.1
				RR_{mean} =	**128.1 ± 4.0**
^{198m}Au	i(m)	2.27D	411.8	*	**1.659 ± 0.092**
$^{198}Au_i$	i	2.69517D	411.8	95.58 ± 0.12	**3.796 ± 0.190**
$^{198}Au_c$	i(m+g)	2.69517D	411.8	95.58 ± 0.12	**5.456 ± 0.198**
^{196}Au	i(m1+m2+g)	6.183D	426.1	6.6 ± 0.8	10.52 ± 1.72
			355.7	87.0 ± 0.8	10.49 ± 0.38
			333.0	22.9 ± 0.6	11.40 ± 0.52
				RR_{mean} =	**10.65 ± 0.41**
^{195}Au	c	186.098D	129.8	0.82 ± 0.05	768.7 ± 58.2
			98.9	10.9 ± 0.9	705.8 ± 68.2
				RR_{mean} =	**751.1 ± 36.5**
^{194}Au	i(m1+m2+g)	38.02H	328.5	61 ± 5	20.31 ± 1.81
			293.6	10.4 ± 0.8	22.53 ± 2.36
				RR_{mean} =	**21.04 ± 1.30**
$^{192}Au_i$	i(m+g)	4.94H	316.5	58 ± 7	19.25 ± 3.35
			296.0	22 ± 3	14.01 ± 19.14
				RR_{mean} =	**19.17 ± 2.42**
$^{192}Au_c$	c	4.94H	316.5	58 ± 7	378.9 ± 47.5
			296.0	22 ± 3	385.0 ± 55.4
				RR_{mean} =	**379.5 ± 14.8**
^{191}Au	c*	3.18H	586.4	17 ± 0	**206.1 ± 18.9**
$^{190}Au_c$	c	42.8M	301.8	23.4 ± 1.5	155.1 ± 18.8
			295.8	71 ± 5	156.6 ± 13.5
				RR_{mean} =	**156.3 ± 9.2**
^{191}Pt	c	2.802D	538.9	13.7 ± 1.6	223.9 ± 27.3
			456.5	3.4 ± 0.4	201.9 ± 24.9
			409.4	8.0 ± 0.9	201.2 ± 23.7
			172.2	3.5 ± 0.4	213.9 ± 25.8
				RR_{mean} =	**209.0 ± 9.0**
^{189}Pt	c	10.87H	607.6	8.10 ± 0.16	143.5 ± 7.8
			568.8	7.1 ± 0.6	137.4 ± 16.3
			544.9	5.8 ± 0.5	147.4 ± 15.5
			243.5	7.0 ± 1.2	135.5 ± 24.2
				RR_{mean} =	**142.9 ± 6.9**
^{188}Pt	c	10.2D	1209.8	*	100.8 ± 10.8
			634.9	*	98.64 ± 16.21

Continuation of Table 70.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			423.3	4.4 ± 0.3	90.21 ± 7.06
			381.4	7.5 ± 0.5	85.73 ± 6.49
			195.1	18.6 ± 1.2	88.25 ± 6.63
			187.6	19.4 ± 1.2	90.80 ± 6.59
			155.1	*	93.82 ± 9.96
			140.4	2.33 ± 0.15	94.61 ± 9.05
				RR_{mean} =	**91.22 ± 2.81**
^{186}Pt	c	2.08H	689.4	70 ± 15	**33.38 ± 7.31**
^{189}Ir	c	13.2D	245.1	6.0 ± 0.6	**113.5 ± 12.2**
$^{188}Ir_i$	i	41.5H	634.9	5.0 ± 0.8	2.990 ± 4.546
			155.1	30 ± 3	6.641 ± 1.284
				RR_{mean} =	**6.388 ± 1.210**
$^{188}Ir_c$	c	41.5H	1209.8	6.9 ± 0.7	101.5 ± 11.0
			634.9	5.0 ± 0.8	101.6 ± 17.1
			155.1	30 ± 3	100.4 ± 10.7
				RR_{mean} =	**101.0 ± 7.0**
^{186}Ir	c	16.64H	434.8	33.9 ± 1.1	**18.83 ± 1.15**
^{185}Os	c	93.6D	874.8	6.29 ± 0.25	24.59 ± 1.86
			717.4	3.94 ± 0.16	27.81 ± 2.76
			646.1	78 ± 3	24.02 ± 1.27
				RR_{mean} =	**24.20 ± 0.89**
^{183}Re	c	70.0D	162.3	23.3 ± 0.7	**9.363 ± 0.538**
^{139}Ce	c	137.640D	165.9	79.89 ± 0.01	**0.8971 ± 0.0742**
^{127}Xe	c	36.4D	202.9	68.3 ± 0.5	1.889 ± 0.185
			172.1	25.5 ± 0.8	1.890 ± 0.190
				RR_{mean} =	**1.890 ± 0.138**
^{124}Sb	i(m1+m2+g)	60.20D	602.7	98.3 ± 0.4	**0.8324 ± 0.0986**
^{123m}Te	i(m)	119.7D	159.0	84.0 ± 0.4	**2.323 ± 0.120**
^{121m}Te	i(m)	154D	573.1	88.6 ± 0.1	2.080 ± 0.241
			212.2	81.4 ± 1.1	1.756 ± 0.099
				RR_{mean} =	**1.792 ± 0.055**
$^{121}Te_c$	c	19.16D	573.1	80.3 ± 2.5	**2.376 ± 0.196**
^{120m}Sb	i(m)	5.76D	1023.3	99.4 ± 0.3	2.561 ± 0.126
			197.3	87.0 ± 1.1	2.784 ± 0.152
				RR_{mean} =	**2.646 ± 0.136**
^{114m}In	i(m)	49.51D	190.3	15.56 ± 0.16	**5.786 ± 0.721**
^{110m}Ag	i(m)	249.76D	937.5	34.2 ± 0.6	6.916 ± 0.423
			884.7	72.7 ± 0.4	7.627 ± 0.336
			657.8	94.3 ± 0.3	7.136 ± 0.317
				RR_{mean} =	**7.292 ± 0.300**
^{105}Rh	c	35.36H	318.9	19.1 ± 0.6	**33.88 ± 1.65**
^{101m}Rh	c	4.34D	306.9	81 ± 5	**1.564 ± 0.170**
^{103}Ru	c	39.26D	497.1	91.0 ± 1.3	**31.21 ± 1.17**
^{99}Mo	c	65.94H	739.5	12.13 ± 0.22	26.64 ± 1.13
			140.5	90.27 ± 0.33	33.17 ± 1.36
				RR_{mean} =	**29.40 ± 3.35**
^{96}Nb	i	23.35H	1091.3	48.5 ± 1.6	16.48 ± 0.99
			849.9	20.45 ± 0.20	18.47 ± 0.97
			778.2	96.45 ± 0.22	16.02 ± 0.76
			568.9	58.0 ± 0.3	16.15 ± 0.96

Continuation of Table 70.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			460.0	26.62 ± 0.20	15.87 ± 0.72
				RR_{mean} =	**16.40 ± 0.67**
$^{95}Nb_i$	i(m+g)	34.975D	765.8	99.81 ± 0.03	**15.75 ± 0.55**
$^{95}Nb_c$	c	34.975D	765.8	99.81 ± 0.03	**36.78 ± 1.23**
^{97}Zr	c	16.744H	743.4	93.06 ± 0.16	**7.263 ± 0.325**
^{95}Zr	c	64.02D	765.8	*	21.22 ± 0.77
			756.7	54.46 ± 0.10	21.29 ± 0.74
			724.2	44.17 ± 0.16	22.19 ± 0.91
				RR_{mean} =	**21.37 ± 0.66**
^{89}Zr	c	78.41H	909.2	99.04 ± 0.03	**1.644 ± 0.091**
$^{88}Y_i$	i	106.65D	898.0	93.7 ± 0.3	**5.541 ± 0.247**
$^{88}Y_c$	c	106.65D	898.0	93.7 ± 0.3	**5.825 ± 0.220**
^{87}Y	c*	79.8H	484.8	89.7 ± 0.7	**2.242 ± 0.114**
^{85}Sr	c	64.84D	514.0	96 ± 4	**2.824 ± 0.174**
^{86}Rb	i(m+g)	18.631D	1077.0	8.64 ± 0.04	**19.85 ± 1.09**
^{84}Rb	i(m+g)	32.77D	881.6	69.0 ± 1.6	**8.074 ± 0.388**
^{83}Rb	c	86.2D	552.6	16.0 ± 1.1	4.647 ± 0.837
			529.6	29.3 ± 2.1	3.517 ± 0.459
			520.4	45 ± 4	3.340 ± 0.384
				RR_{mean} =	**3.525 ± 0.283**
^{82}Br	i(m+g)	35.30H	1317.5	26.5 ± 0.4	12.12 ± 0.64
			776.5	83.5 ± 1.2	11.44 ± 0.49
			698.4	28.5 ± 0.4	10.16 ± 0.55
			554.3	70.8 ± 1.0	10.65 ± 0.45
				RR_{mean} =	**11.00 ± 0.49**
^{75}Se	c	119.779D	136.0	58.3 ± 0.8	**0.6814 ± 0.0879**
^{74}As	i	17.77D	595.8	59 ± 4	**1.823 ± 0.155**
$^{72}Ga_i$	i	14.10H	2201.7	25.9 ± 0.5	**3.868 ± 0.620**
$^{72}Ga_c$	c	14.10H	2201.7	25.9 ± 0.5	**5.990 ± 0.597**
^{72}Zn	c	46.5H	2201.7	*	**2.122 ± 0.190**
^{59}Fe	c	44.472D	1291.6	43.2 ± 1.4	1.447 ± 0.174
			1099.2	56.5 ± 1.9	1.648 ± 0.562
				RR_{mean} =	**1.463 ± 0.165**

12.5.3 Nuclide production rates for ^{208}Pb

Table 71: Detailed calculation of nuclide production rates for ^{208}Pb for $E_p = 0.25$ GeV, used to determine the cross sections for their production.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{207}Bi	i	31.55Y	569.7	97.74 ± 0.03	**52.91 ± 4.94**
^{206}Bi	i	6.243D	1878.7	2.01 ± 0.05	75.81 ± 5.39
			1718.7	31.8 ± 0.6	75.17 ± 3.01
			1595.3	5.01 ± 0.08	88.83 ± 4.89
			1098.3	13.50 ± 0.21	72.08 ± 2.97
			1018.6	7.60 ± 0.11	79.50 ± 3.35
			895.1	15.66 ± 0.23	74.60 ± 2.86
			881.0	66.2 ± 1.0	71.70 ± 2.63
			803.1	98.9 ± 1.4	69.78 ± 2.49

Continuation of Table 71.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			620.5	5.76 ± 0.09	72.58 ± 3.03
			537.5	30.5 ± 0.5	64.92 ± 2.49
			516.2	40.7 ± 0.6	67.35 ± 2.56
			497.1	15.31 ± 0.22	67.29 ± 2.68
			398.0	10.74 ± 0.15	66.57 ± 2.50
			343.5	23.4 ± 0.4	68.04 ± 2.58
			184.0	15.8 ± 0.4	81.85 ± 3.73
				RR_{mean} =	**70.55 ± 2.49**
^{205}Bi	i	15.31D	1861.7	6.17 ± 0.10	111.7 ± 4.7
			1775.8	3.99 ± 0.08	111.9 ± 5.1
			1764.3	32.5 ± 0.7	107.1 ± 4.4
			1614.3	2.28 ± 0.04	108.6 ± 4.9
			1190.0	2.26 ± 0.07	115.7 ± 6.1
			1043.8	7.51 ± 0.10	102.1 ± 4.4
			987.7	16.13 ± 0.17	109.9 ± 4.1
			759.1	1.04 ± 0.05	109.6 ± 7.9
			703.5	31.1 ± 0.1	98.21 ± 3.31
			579.8	5.44 ± 0.07	98.69 ± 4.08
			570.6	4.34 ± 0.07	101.3 ± 4.4
			549.8	2.95 ± 0.04	89.01 ± 4.93
			284.1	1.69 ± 0.02	90.68 ± 4.40
				RR_{mean} =	**102.3 ± 3.7**
^{204}Bi	i	11.22H	984.0	59 ± 4	92.07 ± 7.10
			918.3	10.8 ± 0.9	106.7 ± 9.9
			899.2	98 ± 9	90.55 ± 3.07
			670.7	11.4 ± 0.9	98.95 ± 9.62
			374.8	82 ± 5	103.8 ± 21.7
				RR_{mean} =	**91.00 ± 2.81**
^{203}Bi	i(m+g)	11.76H	1893.0	8.2 ± 0.6	93.96 ± 8.12
			1847.3	11.4 ± 0.8	108.8 ± 9.0
			1679.6	8.8 ± 0.7	104.8 ± 9.7
			1034.0	8.8 ± 0.5	97.72 ± 7.10
			896.8	13.1 ± 0.7	102.2 ± 6.8
			847.2	8.5 ± 0.5	106.4 ± 7.7
			820.2	29.6 ± 1.5	110.6 ± 6.9
				RR_{mean} =	**105.5 ± 3.9**
^{202}Bi	i	1.72H	960.7	99.28 ± 0.02	94.87 ± 4.16
			422.1	83.7 ± 2.5	85.07 ± 7.14
				RR_{mean} =	**93.25 ± 4.64**
^{201}Bi	i	108M	629.1	24 ± 6	**101.4 ± 25.8**
^{204m}Pb$_i$	i(m)	67.2M	899.2	99.17 ± 0.02	108.3 ± 4.0
			374.7	89 ± 15	137.8 ± 23.8
				RR_{mean} =	**108.6 ± 4.3**
^{204m}Pb$_c$	c	67.2M	899.2	99.17 ± 0.02	121.9 ± 4.4
			374.7	89 ± 15	150.8 ± 26.0
				RR_{mean} =	**122.1 ± 4.5**
^{203}Pb	c*	51.873H	401.3	3.35 ± 0.07	404.1 ± 16.1
			279.2	80.8 ± 0.2	413.2 ± 15.1
				RR_{mean} =	**409.8 ± 14.1**
^{202m}Pb	i(m)	3.53H	960.7	92 ± 8	115.0 ± 10.8
			490.5	9.1 ± 0.7	138.3 ± 15.9

Continuation of Table 71.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			459.7	8.6 ± 0.7	103.0 ± 10.1
			422.1	86 ± 5	126.4 ± 8.9
				RR_{mean} =	**120.8 ± 7.0**
^{201}Pb	c*	9.33H	1277.1	1.63 ± 0.12	386.8 ± 34.5
			1238.8	1.18 ± 0.08	369.8 ± 33.7
			1098.5	1.83 ± 0.12	335.6 ± 31.7
			1069.9	1.14 ± 0.11	386.3 ± 63.0
			946.0	7.4 ± 0.6	346.9 ± 31.1
			907.6	5.7 ± 0.4	386.5 ± 30.5
			692.4	4.27 ± 0.16	403.7 ± 23.4
			361.3	9.9 ± 0.5	412.9 ± 25.4
			331.2	79 ± 5	403.4 ± 29.0
				RR_{mean} =	**386.9 ± 15.0**
^{200}Pb	c	21.5H	1514.9	*	307.3 ± 26.8
			1407.6	*	396.7 ± 41.2
			1362.9	*	334.2 ± 41.7
			1225.5	*	304.5 ± 23.9
			1205.7	*	329.1 ± 23.0
			886.2	*	278.0 ± 23.4
			828.3	*	291.8 ± 21.6
			701.6	*	250.5 ± 26.7
			579.3	*	286.5 ± 18.3
			450.5	3.33 ± 0.08	398.2 ± 17.0
			367.9	*	317.0 ± 11.1
			268.4	3.96 ± 0.20	410.4 ± 31.8
			235.6	4.30 ± 0.17	374.1 ± 21.2
			147.6	37.7 ± 1.4	334.6 ± 18.1
			142.3	3.16 ± 0.19	425.3 ± 31.2
				RR_{mean} =	**321.2 ± 9.9**
^{199}Pb	c*	90M	1135.0	7.8 ± 1.2	694.0 ± 112.4
			762.0	2.2 ± 0.4	677.4 ± 155.4
			720.2	6.5 ± 1.0	541.5 ± 93.6
			366.9	44 ± 7	574.8 ± 95.2
			353.4	9.5 ± 1.5	703.3 ± 118.3
				RR_{mean} =	**623.4 ± 39.5**
^{198}Pb	c	2.4H	865.3	5.9 ± 1.2	353.9 ± 74.5
			575.0	3.1 ± 0.7	380.4 ± 88.7
			365.4	19 ± 5	477.6 ± 126.9
			173.4	18 ± 3	474.7 ± 81.3
				RR_{mean} =	**463.7 ± 24.1**
^{197m}Pb	c*	43M	774.3	14 ± 3	269.3 ± 60.3
			695.6	9.5 ± 2.0	167.0 ± 49.4
			387.7	25 ± 6	316.3 ± 76.8
			385.9	74 ± 15	310.9 ± 64.0
			222.8	25 ± 6	245.8 ± 60.0
				RR_{mean} =	**289.7 ± 22.0**
^{196}Pb	c*	37M	502.1	26 ± 3	**257.5 ± 33.2**
^{195m}Pb	i(m)	15.0M	394.2	44 ± 8	138.4 ± 28.1
			383.6	107 ± 20	147.6 ± 28.3
				RR_{mean} =	**144.8 ± 7.9**

Continuation of Table 71.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{202}Tl	c	12.23D	439.6	91.4 ± 1.0	**127.1 ± 4.6**
^{201}Tl	c*	72.912H	167.4	10.00 ± 0.06	**598.1 ± 22.0**
^{200}Tl$_i$	i	26.1H	1514.9	4.0 ± 0.3	230.8 ± 25.2
			1407.6	1.45 ± 0.13	196.6 ± 33.9
			1362.9	3.4 ± 0.4	200.4 ± 29.8
			1225.5	3.36 ± 0.21	200.4 ± 23.1
			1205.7	29.9 ± 1.8	173.4 ± 14.9
			886.2	2.02 ± 0.13	221.0 ± 28.1
			828.3	10.8 ± 0.7	253.7 ± 20.2
			701.6	1.29 ± 0.10	302.1 ± 40.7
			579.3	13.8 ± 0.7	221.6 ± 18.1
			367.9	87.2 ± 0.4	164.0 ± 8.9
				RR_{mean} =	**188.3 ± 12.4**
^{200}Tl$_c$	c	26.1H	1514.9	4.0 ± 0.3	538.0 ± 45.1
			1407.6	1.45 ± 0.13	593.3 ± 58.6
			1362.9	3.4 ± 0.4	534.6 ± 66.0
			1225.5	3.36 ± 0.21	504.9 ± 36.9
			1205.7	29.9 ± 1.8	502.6 ± 34.9
			886.2	2.02 ± 0.13	499.0 ± 38.2
			828.3	10.8 ± 0.7	545.4 ± 39.8
			701.6	1.29 ± 0.10	552.6 ± 49.6
			579.3	13.8 ± 0.7	508.0 ± 31.7
			367.9	87.2 ± 0.4	481.0 ± 16.7
				RR_{mean} =	**491.5 ± 16.8**
^{199}Tl	c*	7.42H	750.4	1.04 ± 0.12	746.4 ± 93.2
			455.5	12.4 ± 1.4	595.3 ± 70.8
			333.9	1.76 ± 0.20	553.5 ± 67.4
			247.3	9.3 ± 1.1	571.5 ± 71.5
			208.2	12.3 ± 1.4	574.8 ± 69.5
			158.4	5.0 ± 0.6	628.9 ± 79.8
				RR_{mean} =	**597.4 ± 30.3**
^{198m}Tl	i(m)	1.87H	587.2	52.5 ± 2.0	136.9 ± 10.6
			282.8	28 ± 3	147.8 ± 17.2
				RR_{mean} =	**139.3 ± 8.6**
^{197}Tl	c*	2.84H	1411.3	4.5 ± 1.5	504.6 ± 169.9
			152.2	7.3 ± 2.3	742.2 ± 235.6
			134.0	2.0 ± 0.7	716.3 ± 257.9
				RR_{mean} =	**656.8 ± 81.6**
^{196m}Tl	i(m)	1.41H	695.4	41 ± 7	**285.1 ± 50.0**
^{195}Tl	c*	1.16H	884.5	10.0 ± 1.1	**284.8 ± 34.7**
^{203}Hg	c	46.612D	279.2	81.46 ± 0.13	**12.46 ± 0.55**
^{197}Hg	c*	64.14H	191.4	0.63 ± 0.02	**529.1 ± 28.2**
^{197m}Hg	i(m)	23.8H	134.0	33.5 ± 0.4	**48.84 ± 2.30**
^{195m}Hg	i(m)	41.6H	779.8	54.2 ± 0.1	53.13 ± 10.41
			560.3	7.0 ± 0.6	59.47 ± 5.82
			261.8	31 ± 4	59.03 ± 7.99
				RR_{mean} =	**58.08 ± 1.79**
^{195}Hg$_c$	c	9.9H	779.8	6.8 ± 0.7	**386.8 ± 41.9**
^{193m}Hg	i(m)	11.8H	573.2	26 ± 4	37.20 ± 6.05
			407.6	32 ± 6	53.49 ± 10.28

Continuation of Table 71.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
				RR_{mean} =	**41.36 ± 7.22**
^{192}Hg	c	4.85H	2335.7	*	127.7 ± 32.7
			316.5	*	203.7 ± 25.6
			296.0	*	215.5 ± 31.5
			274.8	50.2 ± 2.5	159.8 ± 10.1
				RR_{mean} =	**164.2 ± 5.1**
^{190}Hg	c*	20.0M	295.8	*	66.21 ± 8.42
			142.6	68 ± 10	74.46 ± 11.65
				RR_{mean} =	**69.00 ± 2.13**
^{198m}Au	i(m)	2.27D	204.1	40.8 ± 2.4	2.407 ± 0.201
			411.8	*	1.690 ± 0.188
				RR_{mean} =	**2.038 ± 0.063**
^{198}Au$_i$	i	2.69517D	411.8	95.58 ± 0.12	**3.507 ± 0.303**
^{198}Au$_c$	i(m+g)	2.69517D	411.8	95.58 ± 0.12	**5.197 ± 0.215**
^{196}Au	i(m1+m2+g)	6.183D	426.1	6.6 ± 0.8	8.266 ± 1.278
			355.7	87.0 ± 0.8	9.046 ± 0.327
			333.0	22.9 ± 0.6	9.435 ± 0.444
				RR_{mean} =	**9.105 ± 0.312**
^{195}Au	c	186.098D	129.8	0.82 ± 0.05	458.7 ± 36.0
			98.9	10.9 ± 0.9	403.5 ± 39.3
				RR_{mean} =	**440.0 ± 29.4**
^{194}Au	i(m1+m2+g)	38.02H	328.5	61 ± 5	15.39 ± 1.37
			293.6	10.4 ± 0.8	14.63 ± 1.32
				RR_{mean} =	**15.00 ± 0.86**
^{192}Au$_i$	i(m+g)	4.94H	316.5	58 ± 7	21.36 ± 3.86
			296.0	22 ± 3	25.87 ± 17.62
				RR_{mean} =	**21.48 ± 2.87**
^{192}Au$_c$	c	4.94H	2335.7	1.7 ± 0.3	234.2 ± 52.5
			316.5	58 ± 7	225.1 ± 28.3
			296.0	22 ± 3	241.4 ± 35.4
				RR_{mean} =	**226.6 ± 9.0**
^{191}Au	c*	3.18H	586.4	17 ± 0	**114.8 ± 17.9**
^{190}Au$_c$	c	42.8M	295.8	71 ± 5	**83.29 ± 7.12**
^{191}Pt	c	2.802D	538.9	13.7 ± 1.6	127.2 ± 15.5
			456.5	3.4 ± 0.4	121.7 ± 15.0
			409.4	8.0 ± 0.9	116.4 ± 13.7
			172.2	3.5 ± 0.4	115.7 ± 14.0
				RR_{mean} =	**119.5 ± 5.1**
^{189}Pt	c	10.87H	607.6	8.10 ± 0.16	82.40 ± 5.29
			568.8	7.1 ± 0.6	98.58 ± 10.03
			544.9	5.8 ± 0.5	86.06 ± 10.01
			243.5	7.0 ± 1.2	65.23 ± 11.91
				RR_{mean} =	**83.61 ± 5.36**
^{188}Pt	c	10.2D	1209.8	*	53.96 ± 5.95
			634.9	*	50.42 ± 8.36
			423.3	4.4 ± 0.3	46.50 ± 4.36
			381.4	7.5 ± 0.5	47.63 ± 3.64
			195.1	18.6 ± 1.2	44.13 ± 3.35
			187.6	19.4 ± 1.2	46.22 ± 3.38
			155.1	*	47.10 ± 5.02

Continuation of Table 71.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			140.4	2.33 ± 0.15	48.51 ± 4.81
				RR_{mean} =	**47.18 ± 1.46**
^{186}Pt	c	2.08H	689.4	70 ± 15	**15.82 ± 3.54**
^{189}Ir	c	13.2D	245.1	6.0 ± 0.6	**63.22 ± 6.89**
^{188}Ir$_i$	i	41.5H	634.9	5.0 ± 0.8	2.814 ± 2.289
			155.1	30 ± 3	7.503 ± 0.992
				RR_{mean} =	**6.854 ± 1.632**
^{188}Ir$_c$	c	41.5H	1209.8	6.9 ± 0.7	55.08 ± 6.08
			634.9	5.0 ± 0.8	53.23 ± 8.90
			155.1	30 ± 3	54.61 ± 5.82
				RR_{mean} =	**54.58 ± 3.79**
^{186}Ir	c	16.64H	434.8	33.9 ± 1.1	**8.755 ± 0.536**
^{185}Os	c	93.6D	874.8	6.29 ± 0.25	14.65 ± 1.85
			717.4	3.94 ± 0.16	17.59 ± 4.02
			646.1	78 ± 3	11.26 ± 0.61
				RR_{mean} =	**11.37 ± 0.58**
^{183}Re	c	70.0D	162.3	23.3 ± 0.7	**3.449 ± 0.325**
^{139}Ce	c	137.640D	165.9	79.89 ± 0.01	**0.5053 ± 0.1030**
^{127}Xe	c	36.4D	202.9	68.3 ± 0.5	0.9805 ± 0.0765
			172.1	25.5 ± 0.8	1.248 ± 0.159
				RR_{mean} =	**1.026 ± 0.106**
^{124}Sb	i(m1+m2+g)	60.20D	602.7	98.3 ± 0.4	**0.6708 ± 0.1184**
^{123m}Te	i(m)	119.7D	159.0	84.0 ± 0.4	**1.356 ± 0.113**
^{121m}Te	i(m)	154D	573.1	88.6 ± 0.1	1.059 ± 0.294
			212.2	81.4 ± 1.1	0.8601 ± 0.0930
				RR_{mean} =	**0.8771 ± 0.0271**
^{121}Te$_c$	c	19.16D	573.1	80.3 ± 2.5	**1.129 ± 0.225**
^{120m}Sb	i(m)	5.76D	1023.3	99.4 ± 0.3	1.586 ± 0.101
			197.3	87.0 ± 1.1	1.615 ± 0.093
				RR_{mean} =	**1.602 ± 0.076**
^{114m}In	i(m)	49.51D	190.3	15.56 ± 0.16	**3.234 ± 0.329**
^{110m}Ag	i(m)	249.76D	937.5	34.2 ± 0.6	4.960 ± 0.480
			884.7	72.7 ± 0.4	4.914 ± 0.270
			657.8	94.3 ± 0.3	4.317 ± 0.221
				RR_{mean} =	**4.581 ± 0.255**
^{105}Rh	c	35.36H	318.9	19.1 ± 0.6	**21.74 ± 1.08**
^{101m}Rh	c	4.34D	306.9	81 ± 5	**0.9487 ± 0.1353**
^{103}Ru	c	39.26D	497.1	91.0 ± 1.3	**19.81 ± 0.79**
^{99}Mo	c	65.94H	739.5	12.13 ± 0.22	18.90 ± 1.05
			140.5	90.27 ± 0.33	21.43 ± 0.86
				RR_{mean} =	**20.69 ± 1.31**
^{96}Nb	i	23.35H	1091.3	48.5 ± 1.6	10.03 ± 0.53
			849.9	20.45 ± 0.20	8.399 ± 0.916
			778.2	96.45 ± 0.22	9.224 ± 0.356
			568.9	58.0 ± 0.3	8.934 ± 0.396
			460.0	26.62 ± 0.20	9.433 ± 0.425
				RR_{mean} =	**9.263 ± 0.332**
^{95}Nb$_i$	i(m+g)	34.975D	765.8	99.81 ± 0.03	**8.937 ± 0.364**
^{95}Nb$_c$	c	34.975D	765.8	99.81 ± 0.03	**23.31 ± 0.81**
^{97}Zr	c	16.744H	743.4	93.06 ± 0.16	**6.084 ± 0.299**

Continuation of Table 71.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{95}Zr	c	64.02D	765.8	*	14.51 ± 0.58
			756.7	54.46 ± 0.10	14.12 ± 0.59
			724.2	44.17 ± 0.16	13.47 ± 0.67
				RR_{mean} =	**14.14 ± 0.44**
^{89}Zr	c	78.41H	909.2	99.04 ± 0.03	**1.042 ± 0.102**
^{88}Zr	c	83.4D	1836.1	*	0.4513 ± 0.6167
			898.0	*	0.3241 ± 0.0779
				RR_{mean} =	**0.3261 ± 0.0773**
^{88} Y_i	i	106.65D	1836.1	99.2 ± 0.3	2.839 ± 0.608
			898.0	93.7 ± 0.3	2.800 ± 0.112
				RR_{mean} =	**2.800 ± 0.112**
^{88} Y_c	c	106.65D	1836.1	99.2 ± 0.3	3.290 ± 0.375
			898.0	93.7 ± 0.3	3.124 ± 0.114
				RR_{mean} =	**3.128 ± 0.114**
^{87} Y	c*	79.8H	484.8	89.7 ± 0.7	**1.081 ± 0.063**
^{85}Sr	c	64.84D	514.0	96 ± 4	**1.509 ± 0.169**
^{86}Rb	i(m+g)	18.631D	1077.0	8.64 ± 0.04	**13.09 ± 1.03**
^{84}Rb	i(m+g)	32.77D	881.6	69.0 ± 1.6	**3.578 ± 0.555**
^{83}Rb	c	86.2D	529.6	29.3 ± 2.1	2.530 ± 0.431
			520.4	45 ± 4	1.795 ± 0.452
				RR_{mean} =	**2.195 ± 0.372**
^{82}Br	i(m+g)	35.30H	1317.5	26.5 ± 0.4	7.739 ± 0.408
			776.5	83.5 ± 1.2	6.585 ± 0.293
			698.4	28.5 ± 0.4	6.566 ± 0.400
			554.3	70.8 ± 1.0	6.525 ± 0.304
				RR_{mean} =	**6.737 ± 0.321**
^{74}As	i	17.77D	595.8	59 ± 4	**0.8811 ± 0.1122**
^{72}Ga$_i$	i	14.10H	2201.7	25.9 ± 0.5	**2.674 ± 0.492**
^{72}Ga$_c$	c	14.10H	2201.7	25.9 ± 0.5	**3.848 ± 0.450**
^{72}Zn	c	46.5H	2201.7	*	**1.175 ± 0.109**
^{59}Fe	c	44.472D	1099.2	56.5 ± 1.9	**0.9448 ± 0.5468**

12.5.4 Nuclide production rates for ^{nat}Pb

Table 72: Detailed calculation of nuclide production rates for ^{nat}Pb for $E_p = 0.25$ GeV, used to determine the cross sections for their production.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{207}Bi	i	31.55Y	569.7	97.74 ± 0.03	**37.91 ± 3.34**
^{206}Bi	i	6.243D	1595.3	5.01 ± 0.08	82.92 ± 3.85
			1018.6	7.60 ± 0.11	86.43 ± 3.93
			184.0	15.8 ± 0.4	80.71 ± 3.76
			1878.7	2.01 ± 0.05	73.78 ± 3.93
			1718.7	31.8 ± 0.6	77.03 ± 3.13
			1098.3	13.50 ± 0.21	76.85 ± 3.05
			895.1	15.66 ± 0.23	76.62 ± 2.86
			881.0	66.2 ± 1.0	73.60 ± 2.67
			803.1	98.9 ± 1.4	71.17 ± 2.54
			620.5	5.76 ± 0.09	69.24 ± 2.81

Continuation of Table 72.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			537.5	30.5 ± 0.5	64.62 ± 2.56
			516.2	40.7 ± 0.6	69.07 ± 2.57
			497.1	15.31 ± 0.22	67.63 ± 2.62
			398.0	10.74 ± 0.15	65.80 ± 2.48
			343.5	23.4 ± 0.4	68.37 ± 2.61
				RR_{mean} =	**71.50 ± 2.60**
^{205}Bi	i	15.31D	1861.7	6.17 ± 0.10	133.6 ± 5.4
			1775.8	3.99 ± 0.08	133.8 ± 6.4
			1764.3	32.5 ± 0.7	130.2 ± 5.4
			1614.3	2.28 ± 0.04	135.8 ± 5.9
			1190.0	2.26 ± 0.07	130.0 ± 8.5
			1043.8	7.51 ± 0.10	117.8 ± 4.7
			987.7	16.13 ± 0.17	131.3 ± 4.7
			759.1	1.04 ± 0.05	120.4 ± 8.4
			703.5	31.1 ± 0.1	119.2 ± 4.0
			579.8	5.44 ± 0.07	114.1 ± 4.7
			570.6	4.34 ± 0.07	111.1 ± 4.4
			284.1	1.69 ± 0.02	123.4 ± 5.5
				RR_{mean} =	**122.4 ± 4.4**
^{204}Bi	i	11.22H	984.0	59 ± 4	122.4 ± 9.3
			918.3	10.8 ± 0.9	134.6 ± 12.4
			899.2	98 ± 9	121.8 ± 4.1
			670.7	11.4 ± 0.9	129.7 ± 11.7
			374.8	82 ± 5	140.6 ± 29.4
				RR_{mean} =	**122.2 ± 3.8**
^{203}Bi	i(m+g)	11.76H	1893.0	8.2 ± 0.6	142.1 ± 12.1
			1847.3	11.4 ± 0.8	142.7 ± 11.8
			1679.6	8.8 ± 0.7	147.2 ± 13.3
			1034.0	8.8 ± 0.5	140.7 ± 10.1
			896.8	13.1 ± 0.7	147.1 ± 9.6
			847.2	8.5 ± 0.5	145.7 ± 10.4
			820.2	29.6 ± 1.5	152.8 ± 9.3
				RR_{mean} =	**149.3 ± 4.9**
^{202}Bi	i	1.72H	960.7	99.28 ± 0.02	134.8 ± 5.4
			422.1	83.7 ± 2.5	146.3 ± 9.0
				RR_{mean} =	**136.7 ± 6.0**
^{201}Bi	i	108M	629.1	24 ± 6	**140.6 ± 35.7**
^{204m}Pb$_i$	i(m)	67.2M	899.2	99.17 ± 0.02	139.2 ± 4.8
			374.7	89 ± 15	176.6 ± 30.5
				RR_{mean} =	**139.4 ± 5.1**
^{204m}Pb$_c$	c	67.2M	899.2	99.17 ± 0.02	157.5 ± 5.4
			374.7	89 ± 15	194.3 ± 33.5
				RR_{mean} =	**157.7 ± 5.5**
^{203}Pb	c*	51.873H	401.3	3.35 ± 0.07	575.0 ± 23.5
			279.2	80.8 ± 0.2	596.9 ± 21.8
				RR_{mean} =	**589.0 ± 21.0**
^{202m}Pb	i(m)	3.53H	960.7	92 ± 8	153.8 ± 14.5
			490.5	9.1 ± 0.7	208.6 ± 19.0
			459.7	8.6 ± 0.7	147.6 ± 14.6
			422.1	86 ± 5	160.4 ± 11.5

Continuation of Table 72.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
				RR_{mean} =	**162.4 ± 10.9**
^{201}Pb	c*	9.33H	1277.1	1.63 ± 0.12	538.1 ± 53.9
			1238.8	1.18 ± 0.08	463.1 ± 42.6
			1098.5	1.83 ± 0.12	453.7 ± 42.7
			1069.9	1.14 ± 0.11	443.1 ± 50.8
			946.0	7.4 ± 0.6	485.9 ± 43.7
			907.6	5.7 ± 0.4	529.0 ± 42.9
			692.4	4.27 ± 0.16	559.5 ± 31.0
			361.3	9.9 ± 0.5	598.9 ± 37.3
			331.2	79 ± 5	597.3 ± 43.0
				RR_{mean} =	**531.1 ± 25.5**
^{200}Pb	c	21.5H	1514.9	*	484.4 ± 40.4
			1407.6	*	539.2 ± 57.4
			1362.9	*	508.3 ± 62.8
			1225.5	*	451.7 ± 33.7
			1205.7	*	492.7 ± 34.3
			886.2	*	456.4 ± 36.0
			828.3	*	472.3 ± 35.6
			701.6	*	423.0 ± 44.9
			579.3	*	427.8 ± 27.0
			450.5	3.33 ± 0.08	569.9 ± 25.4
			367.9	*	454.8 ± 15.7
			268.4	3.96 ± 0.20	607.3 ± 48.1
			235.6	4.30 ± 0.17	595.5 ± 34.5
			147.6	37.7 ± 1.4	473.6 ± 25.3
			142.3	3.16 ± 0.19	538.3 ± 39.5
				RR_{mean} =	**461.1 ± 14.2**
^{199}Pb	c*	90M	1135.0	7.8 ± 1.2	834.5 ± 136.8
			762.0	2.2 ± 0.4	1106 ± 220
			720.2	6.5 ± 1.0	771.6 ± 122.6
			366.9	44 ± 7	919.2 ± 153.4
			353.4	9.5 ± 1.5	899.2 ± 147.0
				RR_{mean} =	**847.9 ± 47.2**
^{198}Pb	c	2.4H	865.3	5.9 ± 1.2	536.9 ± 111.1
			575.0	3.1 ± 0.7	515.4 ± 119.1
			365.4	19 ± 5	734.9 ± 195.4
			173.4	18 ± 3	673.8 ± 115.1
				RR_{mean} =	**663.5 ± 30.3**
^{197m}Pb	c*	43M	774.3	14 ± 3	366.5 ± 80.0
			695.6	9.5 ± 2.0	461.2 ± 109.1
			387.7	25 ± 6	482.6 ± 117.1
			385.9	74 ± 15	470.7 ± 96.8
			222.8	25 ± 6	373.4 ± 91.0
				RR_{mean} =	**442.2 ± 26.8**
^{196}Pb	c*	37M	502.1	26 ± 3	**424.0 ± 52.7**
^{195m}Pb	i(m)	15.0M	394.2	44 ± 8	244.2 ± 45.6
			383.6	107 ± 20	237.1 ± 45.2
				RR_{mean} =	**242.2 ± 9.6**
^{202}Tl	c	12.23D	439.6	91.4 ± 1.0	**173.4 ± 6.3**
^{201}Tl	c*	72.912H	167.4	10.00 ± 0.06	**854.1 ± 31.3**
^{200}Tl$_i$	i	26.1H	1514.9	4.0 ± 0.3	245.2 ± 23.1

Continuation of Table 72.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			1407.6	1.45 ± 0.13	265.2 ± 54.3
			1362.9	3.4 ± 0.4	262.2 ± 36.3
			1225.5	3.36 ± 0.21	283.8 ± 28.5
			1205.7	29.9 ± 1.8	223.8 ± 19.1
			886.2	2.02 ± 0.13	285.2 ± 33.3
			828.3	10.8 ± 0.7	306.7 ± 26.1
			701.6	1.29 ± 0.10	390.2 ± 59.8
			579.3	13.8 ± 0.7	324.6 ± 25.7
			367.9	87.2 ± 0.4	253.0 ± 12.3
				RR_{mean} =	**262.9 ± 13.1**
$^{200}Tl_c$	c	26.1H	1514.9	4.0 ± 0.3	729.6 ± 60.3
			1407.6	1.45 ± 0.13	804.4 ± 81.9
			1362.9	3.4 ± 0.4	770.5 ± 94.7
			1225.5	3.36 ± 0.21	735.5 ± 53.3
			1205.7	29.9 ± 1.8	716.6 ± 49.8
			886.2	2.02 ± 0.13	741.6 ± 55.6
			828.3	10.8 ± 0.7	779.0 ± 57.1
			701.6	1.29 ± 0.10	813.2 ± 74.0
			579.3	13.8 ± 0.7	752.4 ± 47.1
			367.9	87.2 ± 0.4	707.7 ± 24.7
				RR_{mean} =	**719.8 ± 24.1**
^{199}Tl	c*	7.42H	750.4	1.04 ± 0.12	955.1 ± 132.1
			455.5	12.4 ± 1.4	915.5 ± 109.5
			333.9	1.76 ± 0.20	1031 ± 126
			247.3	9.3 ± 1.1	822.4 ± 102.8
			208.2	12.3 ± 1.4	816.1 ± 98.6
			158.4	5.0 ± 0.6	823.6 ± 105.3
				RR_{mean} =	**879.3 ± 43.8**
^{198m}Tl	i(m)	1.87H	587.2	52.5 ± 2.0	158.3 ± 13.0
			282.8	28 ± 3	197.9 ± 22.6
				RR_{mean} =	**166.6 ± 17.0**
^{197}Tl	c*	2.84H	1411.3	4.5 ± 1.5	687.3 ± 230.8
			152.2	7.3 ± 2.3	1023 ± 325
			134.0	2.0 ± 0.7	859.5 ± 306.3
				RR_{mean} =	**885.9 ± 112.5**
^{196m}Tl	i(m)	1.41H	695.4	41 ± 7	**388.7 ± 68.1**
^{195}Tl	c*	1.16H	884.5	10.0 ± 1.1	**419.7 ± 49.4**
^{203}Hg	c	46.612D	279.2	81.46 ± 0.13	**13.27 ± 0.51**
^{197}Hg	c*	64.14H	191.4	0.63 ± 0.02	**810.2 ± 42.7**
^{197m}Hg	i(m)	23.8H	134.0	33.5 ± 0.4	**63.28 ± 2.88**
^{195m}Hg	i(m)	41.6H	779.8	54.2 ± 0.1	74.33 ± 15.70
			560.3	7.0 ± 0.6	77.30 ± 7.27
			261.8	31 ± 4	84.42 ± 11.40
				RR_{mean} =	**77.79 ± 2.40**
$^{195}Hg_c$	c	9.9H	779.8	6.8 ± 0.7	**576.6 ± 63.3**
^{193m}Hg	i(m)	11.8H	573.2	26 ± 4	56.86 ± 9.02
			407.6	32 ± 6	86.02 ± 16.47
				RR_{mean} =	**63.52 ± 12.39**
^{192}Hg	c	4.85H	2335.7	*	302.8 ± 66.3
			316.5	*	356.0 ± 44.7

Continuation of Table 72.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			296.0	*	345.4 ± 49.9
			274.8	50.2 ± 2.5	278.7 ± 17.5
				RR_{mean} =	**287.1 ± 8.9**
^{190}Hg	c*	20.0M	295.8	*	137.4 ± 13.8
			142.6	68 ± 10	128.0 ± 19.7
				RR_{mean} =	**134.4 ± 4.1**
^{198m}Au	i(m)	2.27D	411.8	*	**1.825 ± 0.274**
^{198}Au$_i$	i	2.69517D	411.8	95.58 ± 0.12	**4.283 ± 0.518**
^{198}Au$_c$	i(m+g)	2.69517D	411.8	95.58 ± 0.12	**6.108 ± 0.328**
^{196}Au	i(m1+m2+g)	6.183D	426.1	6.6 ± 0.8	12.05 ± 1.62
			355.7	87.0 ± 0.8	11.53 ± 0.42
			333.0	22.9 ± 0.6	12.47 ± 0.59
				RR_{mean} =	**11.69 ± 0.44**
^{195}Au	c	186.098D	129.8	0.82 ± 0.05	745.4 ± 57.9
			98.9	10.9 ± 0.9	671.5 ± 64.0
				RR_{mean} =	**720.9 ± 41.3**
^{194}Au	i(m1+m2+g)	38.02H	328.5	61 ± 5	20.89 ± 1.88
			293.6	10.4 ± 0.8	20.21 ± 2.01
				RR_{mean} =	**20.59 ± 1.25**
^{192}Au$_i$	i(m+g)	4.94H	316.5	58 ± 7	19.85 ± 3.16
			296.0	22 ± 3	45.39 ± 21.77
				RR_{mean} =	**20.08 ± 2.49**
^{192}Au$_c$	c	4.94H	316.5	58 ± 7	375.8 ± 47.1
			296.0	22 ± 3	390.8 ± 56.2
				RR_{mean} =	**377.2 ± 14.7**
^{191}Au	c*	3.18H	586.4	17 ± 0	**238.8 ± 31.0**
^{190}Au$_c$	c	42.8M	295.8	71 ± 5	**146.1 ± 12.1**
^{191}Pt	c	2.802D	538.9	13.7 ± 1.6	222.7 ± 27.1
			456.5	3.4 ± 0.4	201.1 ± 24.8
			409.4	8.0 ± 0.9	198.5 ± 23.4
			172.2	3.5 ± 0.4	212.9 ± 25.7
				RR_{mean} =	**207.4 ± 8.9**
^{189}Pt	c	10.87H	607.6	8.10 ± 0.16	139.5 ± 6.9
			568.8	7.1 ± 0.6	143.5 ± 15.1
			544.9	5.8 ± 0.5	140.9 ± 14.1
			243.5	7.0 ± 1.2	126.2 ± 22.6
				RR_{mean} =	**139.5 ± 6.3**
^{188}Pt	c	10.2D	1209.8	*	101.2 ± 10.8
			634.9	*	95.26 ± 15.58
			423.3	4.4 ± 0.3	93.05 ± 7.52
			381.4	7.5 ± 0.5	86.87 ± 6.55
			195.1	18.6 ± 1.2	86.76 ± 6.49
			187.6	19.4 ± 1.2	88.88 ± 6.42
			155.1	*	91.99 ± 9.78
			140.4	2.33 ± 0.15	96.85 ± 8.73
				RR_{mean} =	**91.09 ± 2.81**
^{186}Pt	c	2.08H	689.4	70 ± 15	**32.27 ± 7.07**
^{189}Ir	c	13.2D	245.1	6.0 ± 0.6	**113.8 ± 12.5**
^{188}Ir$_i$	i	41.5H	634.9	5.0 ± 0.8	6.672 ± 1.724
			155.1	30 ± 3	5.021 ± 1.631

Continuation of Table 72.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
				RR_{mean} =	**5.807 ± 1.179**
$^{188}Ir_c$	c	41.5H	1209.8	6.9 ± 0.7	89.61 ± 9.81
			634.9	5.0 ± 0.8	101.9 ± 16.7
			155.1	30 ± 3	97.01 ± 10.37
				RR_{mean} =	**94.32 ± 6.52**
^{186}Ir	c	16.64H	434.8	33.9 ± 1.1	**19.26 ± 1.04**
^{185}Os	c	93.6D	874.8	6.29 ± 0.25	27.91 ± 1.93
			717.4	3.94 ± 0.16	22.99 ± 2.41
			646.1	78 ± 3	24.05 ± 1.27
				RR_{mean} =	**24.39 ± 1.13**
^{183}Re	c	70.0D	208.8	2.95 ± 0.09	12.19 ± 2.18
			162.3	23.3 ± 0.7	9.316 ± 0.517
				RR_{mean} =	**9.405 ± 0.575**
^{139}Ce	c	137.640D	165.9	79.89 ± 0.01	**0.9361 ± 0.0603**
^{127}Xe	c	36.4D	202.9	68.3 ± 0.5	1.845 ± 0.094
			172.1	25.5 ± 0.8	2.130 ± 0.190
				RR_{mean} =	**1.886 ± 0.116**
^{124}Sb	i(m1+m2+g)	60.20D	602.7	98.3 ± 0.4	**0.9226 ± 0.0959**
^{123m}Te	i(m)	119.7D	159.0	84.0 ± 0.4	**2.363 ± 0.110**
^{121m}Te	i(m)	154D	573.1	88.6 ± 0.1	1.577 ± 0.153
			212.2	81.4 ± 1.1	1.774 ± 0.095
				RR_{mean} =	**1.730 ± 0.053**
$^{121}Te_c$	c	19.16D	573.1	80.3 ± 2.5	**1.866 ± 0.133**
^{120m}Sb	i(m)	5.76D	1023.3	99.4 ± 0.3	2.624 ± 0.155
			197.3	87.0 ± 1.1	2.576 ± 0.128
				RR_{mean} =	**2.594 ± 0.113**
^{114m}In	i(m)	49.51D	190.3	15.56 ± 0.16	**5.798 ± 0.484**
^{110m}Ag	i(m)	249.76D	937.5	34.2 ± 0.6	8.051 ± 0.511
			884.7	72.7 ± 0.4	7.570 ± 0.317
			657.8	94.3 ± 0.3	7.195 ± 0.313
				RR_{mean} =	**7.459 ± 0.299**
^{105}Rh	c	35.36H	318.9	19.1 ± 0.6	**32.59 ± 1.62**
^{101m}Rh	c	4.34D	306.9	81 ± 5	**1.185 ± 0.106**
^{103}Ru	c	39.26D	497.1	91.0 ± 1.3	**31.65 ± 1.19**
^{99}Mo	c	65.94H	739.5	12.13 ± 0.22	28.78 ± 1.70
			140.5	90.27 ± 0.33	31.76 ± 1.62
				RR_{mean} =	**30.45 ± 1.75**
^{96}Nb	i	23.35H	1091.3	48.5 ± 1.6	16.40 ± 1.03
			849.9	20.45 ± 0.20	15.56 ± 1.26
			778.2	96.45 ± 0.22	16.59 ± 0.64
			568.9	58.0 ± 0.3	15.44 ± 0.80
			460.0	26.62 ± 0.20	16.18 ± 0.83
				RR_{mean} =	**16.24 ± 0.57**
$^{95}Nb_i$	i(m+g)	34.975D	765.8	99.81 ± 0.03	**15.70 ± 0.55**
$^{95}Nb_c$	c	34.975D	765.8	99.81 ± 0.03	**37.06 ± 1.24**
^{97}Zr	c	16.744H	743.4	93.06 ± 0.16	**6.980 ± 0.320**
^{95}Zr	c	64.02D	765.8	*	21.56 ± 0.76
			756.7	54.46 ± 0.10	20.92 ± 0.79
			724.2	44.17 ± 0.16	23.10 ± 0.95
				RR_{mean} =	**21.57 ± 0.67**

Continuation of Table 72.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{89}Zr	c	78.41H	909.2	99.04 ± 0.03	**1.636 ± 0.094**
^{88}Zr	c	83.4D	898.0	*	**0.3411 ± 0.1806**
^{88} Y_i	i	106.65D	898.0	93.7 ± 0.3	**5.678 ± 0.247**
^{88} Y_c	c	106.65D	898.0	93.7 ± 0.3	**6.019 ± 0.224**
^{87} Y	c*	79.8H	484.8	89.7 ± 0.7	**2.222 ± 0.104**
^{85}Sr	c	64.84D	514.0	96 ± 4	**2.967 ± 0.192**
^{86}Rb	i(m+g)	18.631D	1077.0	8.64 ± 0.04	**19.54 ± 0.93**
^{84}Rb	i(m+g)	32.77D	881.6	69.0 ± 1.6	**7.837 ± 0.455**
^{83}Rb	c	86.2D	529.6	29.3 ± 2.1	3.876 ± 0.375
			520.4	45 ± 4	3.368 ± 0.423
				RR_{mean} =	**3.683 ± 0.271**
^{82}Br	i(m+g)	35.30H	1317.5	26.5 ± 0.4	12.33 ± 0.67
			776.5	83.5 ± 1.2	10.87 ± 0.45
			698.4	28.5 ± 0.4	9.784 ± 0.641
			554.3	70.8 ± 1.0	10.33 ± 0.52
				RR_{mean} =	**10.79 ± 0.52**
^{75}Se	c	119.779D	136.0	58.3 ± 0.8	**0.5644 ± 0.1081**
^{74}As	i	17.77D	595.8	59 ± 4	**1.952 ± 0.168**
^{72}Ga_i	i	14.10H	2201.7	25.9 ± 0.5	**4.265 ± 0.861**
^{72}Ga_c	c	14.10H	2201.7	25.9 ± 0.5	**6.067 ± 0.809**
^{72}Zn	c	46.5H	2201.7	*	**1.802 ± 0.239**
^{59}Fe	c	44.472D	1099.2	56.5 ± 1.9	**1.479 ± 0.285**

12.5.5 Nuclide production rates for ^{209}Bi

Table 73: Detailed calculation of nuclide production rates for ^{209}Bi for $E_p = 0.25$ GeV, used to determine the cross sections for their production.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{207}Po	i(m+g)	5.80H	992.3	59.3 ± 0.9	128.9 ± 4.8
			742.6	28.2 ± 0.5	113.3 ± 6.6
				RR_{mean} =	**126.4 ± 6.9**
^{206}Po	i	8.8D	1878.7	*	170.0 ± 11.8
			1718.7	*	166.6 ± 7.8
			1098.3	*	156.7 ± 6.6
			1032.3	33 ± 5	160.1 ± 24.8
			1018.6	*	172.1 ± 7.1
			1007.2	3.1 ± 0.4	160.3 ± 21.6
			980.2	7.1 ± 0.9	158.2 ± 20.8
			895.1	*	162.2 ± 6.0
			881.0	*	162.9 ± 6.1
			807.4	23 ± 3	150.0 ± 20.2
			803.1	*	155.1 ± 5.8
			620.5	*	169.7 ± 6.4
			537.5	*	140.6 ± 5.6
			522.5	15.7 ± 2.0	148.1 ± 19.6
			516.2	*	148.2 ± 5.7
			497.1	*	148.8 ± 7.3
			463.4	1.79 ± 0.24	159.5 ± 22.6

Continuation of Table 73.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			398.0	*	149.0 ± 5.9
			343.5	*	146.6 ± 6.0
			338.4	19.2 ± 2.5	155.3 ± 20.9
			311.6	4.2 ± 0.6	164.5 ± 24.3
			286.4	24 ± 3	158.6 ± 20.6
			184.0	*	163.6 ± 7.9
				RR_{mean} =	**156.1 ± 4.8**
^{205}Po	i	1.66H	1001.2	28.8 ± 2.2	154.2 ± 13.6
			872.4	37 ± 2	189.7 ± 12.6
			849.8	25.5 ± 2.1	175.3 ± 16.1
				RR_{mean} =	**183.1 ± 10.6**
^{204}Po	i	3.53H	1040.0	9.6 ± 0.5	177.7 ± 12.1
			1016.3	24.1 ± 1.0	168.8 ± 9.3
			899.2	*	166.3 ± 18.7
			884.0	29.9 ± 1.2	179.1 ± 9.8
			670.7	*	156.6 ± 27.4
			534.9	13.2 ± 0.8	160.7 ± 12.5
			374.8	*	188.6 ± 19.2
			270.1	27.8 ± 1.3	192.8 ± 11.9
				RR_{mean} =	**175.2 ± 5.4**
^{203}Po	i(m+g)	36.7M	908.6	55 ± 3	**139.3 ± 10.6**
^{202}Po	i	44.7M	688.6	51 ± 6	**152.8 ± 19.2**
^{207}Bi	c	31.55Y	1770.2	6.87 ± 0.04	670.2 ± 44.9
			1063.7	74.5 ± 0.2	699.1 ± 24.9
			569.7	97.74 ± 0.03	659.1 ± 23.0
				RR_{mean} =	**676.1 ± 25.0**
$^{206}Bi_i$	i	6.243D	1878.7	2.01 ± 0.05	433.2 ± 21.7
			1718.7	31.8 ± 0.6	430.9 ± 18.0
			1595.3	5.01 ± 0.08	431.0 ± 17.5
			1098.3	13.50 ± 0.21	403.0 ± 15.2
			1018.6	7.60 ± 0.11	433.3 ± 16.2
			895.1	15.66 ± 0.23	433.4 ± 15.6
			881.0	66.2 ± 1.0	417.3 ± 15.1
			803.1	98.9 ± 1.4	405.6 ± 14.6
			537.5	30.5 ± 0.5	370.2 ± 14.1
			516.2	40.7 ± 0.6	386.0 ± 14.4
			497.1	15.31 ± 0.22	372.0 ± 14.6
			398.0	10.74 ± 0.15	376.1 ± 14.0
			343.5	23.4 ± 0.4	390.0 ± 14.9
			184.0	15.8 ± 0.4	471.7 ± 21.7
				RR_{mean} =	**404.0 ± 14.3**
$^{206}Bi_c$	c	6.243D	1878.7	2.01 ± 0.05	593.9 ± 26.5
			1718.7	31.8 ± 0.6	588.4 ± 23.2
			1595.3	5.01 ± 0.08	613.8 ± 23.2
			1098.3	13.50 ± 0.21	551.1 ± 20.1
			1018.6	7.60 ± 0.11	595.9 ± 21.5
			895.1	15.66 ± 0.23	586.7 ± 21.0
			881.0	66.2 ± 1.0	571.2 ± 20.5
			803.1	98.9 ± 1.4	552.2 ± 19.7
			537.5	30.5 ± 0.5	503.1 ± 19.0
			516.2	40.7 ± 0.6	526.0 ± 19.5

Continuation of Table 73.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			497.1	15.31 ± 0.22	512.7 ± 19.2
			398.0	10.74 ± 0.15	516.9 ± 18.9
			343.5	23.4 ± 0.4	528.6 ± 19.9
			184.0	15.8 ± 0.4	626.3 ± 28.7
				RR_{mean} =	**553.5 ± 19.7**
^{205}Bi	c	15.31D	1861.7	6.17 ± 0.10	663.8 ± 25.9
			1775.8	3.99 ± 0.08	673.5 ± 27.6
			1764.3	32.5 ± 0.7	685.1 ± 27.7
			1614.3	2.28 ± 0.04	721.1 ± 28.0
			1551.0	0.97 ± 0.03	684.1 ± 33.6
			1351.5	1.06 ± 0.04	714.4 ± 38.1
			1190.0	2.26 ± 0.07	645.4 ± 29.8
			1043.8	7.51 ± 0.10	607.9 ± 21.6
			987.7	16.13 ± 0.17	662.1 ± 23.0
			890.2	0.68 ± 0.01	673.0 ± 41.9
			872.0	0.42 ± 0.01	665.6 ± 32.8
			759.1	1.04 ± 0.05	689.8 ± 41.3
			703.5	31.1 ± 0.1	629.1 ± 21.1
				RR_{mean} =	**651.4 ± 22.1**
$^{204}Bi_i$	i	11.22H	984.0	59 ± 4	457.3 ± 36.2
			918.3	10.8 ± 0.9	300.1 ± 42.0
			899.2	98 ± 9	466.3 ± 46.7
			670.7	11.4 ± 0.9	447.4 ± 47.9
			374.8	82 ± 5	439.4 ± 34.9
				RR_{mean} =	**426.5 ± 31.2**
$^{204}Bi_c$	c	11.22H	984.0	59 ± 4	580.7 ± 43.8
			918.3	10.8 ± 0.9	609.5 ± 55.2
			899.2	98 ± 9	631.5 ± 61.6
			670.7	11.4 ± 0.9	602.9 ± 52.1
			374.8	82 ± 5	626.8 ± 43.8
				RR_{mean} =	**608.1 ± 26.9**
^{203}Bi	c	11.76H	2011.0	1.76 ± 0.09	634.3 ± 44.6
			1893.0	8.2 ± 0.6	606.7 ± 49.8
			1888.0	1.94 ± 0.10	564.6 ± 38.2
			1847.3	11.4 ± 0.8	602.1 ± 47.5
			1679.6	8.8 ± 0.7	596.6 ± 52.1
			1536.5	7.5 ± 0.6	639.5 ± 56.6
			1506.7	3.7 ± 0.3	571.5 ± 51.5
			1034.0	8.8 ± 0.5	626.7 ± 41.8
			896.8	13.1 ± 0.7	603.5 ± 38.5
			847.2	8.5 ± 0.5	623.2 ± 42.3
			825.2	14.6 ± 1.1	700.4 ± 57.8
			820.2	29.6 ± 1.5	647.0 ± 39.2
			816.3	4.03 ± 0.21	626.2 ± 40.9
			722.4	4.8 ± 0.4	829.1 ± 75.3
			279.2	*	637.4 ± 25.8
			264.2	5.2 ± 0.4	702.0 ± 61.0
				RR_{mean} =	**635.7 ± 19.6**
$^{202}Bi_i$	i	1.72H	960.7	99.28 ± 0.02	517.1 ± 29.5
			657.5	60.6 ± 1.8	610.2 ± 46.0
			422.1	83.7 ± 2.5	575.4 ± 27.8

Continuation of Table 73.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
				RR_{mean} =	**558.2 ± 29.3**
$^{202}Bi_c$	c	1.72H	960.7	99.28 ± 0.02	589.8 ± 20.7
			657.5	60.6 ± 1.8	599.1 ± 29.7
			422.1	83.7 ± 2.5	596.9 ± 27.2
				RR_{mean} =	**592.2 ± 20.0**
^{201}Bi	c*	108M	1325.2	6.1 ± 1.3	491.8 ± 107.6
			936.2	11.3 ± 2.5	497.1 ± 112.1
			902.0	8.4 ± 1.8	566.4 ± 124.4
			629.1	24 ± 6	503.1 ± 127.2
			361.3	*	583.3 ± 53.5
			331.2	*	565.0 ± 42.7
				RR_{mean} =	**567.6 ± 17.5**
^{199}Bi	c*	27M	841.7	11 ± 0	**240.9 ± 19.2**
^{204m}Pb	i(m)	67.2M	899.2	99.17 ± 0.02	91.83 ± 5.33
			374.7	89 ± 15	136.8 ± 24.0
				RR_{mean} =	**93.42 ± 8.77**
$^{203}Pb_i$	i(m1+m2+g)	51.873H	279.2	80.8 ± 0.2	**234.8 ± 16.3**
$^{203}Pb_c$	c	51.873H	279.2	80.8 ± 0.2	**872.1 ± 32.1**
^{202m}Pb	i(m)	3.53H	960.7	92 ± 8	126.9 ± 12.2
			422.1	86 ± 5	141.3 ± 10.1
				RR_{mean} =	**137.7 ± 7.5**
^{201}Pb	c*	9.33H	1277.1	1.63 ± 0.12	894.4 ± 79.0
			946.0	7.4 ± 0.6	858.5 ± 75.6
			767.3	3.16 ± 0.16	978.8 ± 64.5
			692.4	4.27 ± 0.16	994.4 ± 54.4
			361.3	9.9 ± 0.5	968.2 ± 60.1
				RR_{mean} =	**956.1 ± 38.8**
^{200}Pb	c	21.5H	1604.5	*	665.2 ± 67.0
			1514.9	*	769.7 ± 65.7
			1366.3	*	743.7 ± 250.8
			1362.9	*	850.2 ± 105.0
			1225.5	*	742.7 ± 54.9
			1205.7	*	753.1 ± 52.2
			886.2	*	765.0 ± 62.0
			579.3	*	717.7 ± 48.0
			450.5	3.33 ± 0.08	844.5 ± 36.9
			257.2	4.46 ± 0.17	943.0 ± 62.1
			235.6	4.30 ± 0.17	898.7 ± 52.3
			147.6	37.7 ± 1.4	811.2 ± 49.3
			367.9	*	676.2 ± 23.8
				RR_{mean} =	**715.3 ± 22.1**
^{199}Pb	c*	90M	1502.0	2.1 ± 0.4	1226 ± 244
			1382.7	2.9 ± 0.5	1466 ± 262
			1135.0	7.8 ± 1.2	1351 ± 217
			720.2	6.5 ± 1.0	1363 ± 220
			366.9	44 ± 7	1419 ± 234
			353.4	9.5 ± 1.5	1667 ± 274
				RR_{mean} =	**1410 ± 67.**
^{198}Pb	c	2.4H	865.3	5.9 ± 1.2	783.9 ± 163.1
			575.0	3.1 ± 0.7	788.9 ± 182.4
			365.4	19 ± 5	940.4 ± 249.7

Continuation of Table 73.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			259.5	5.8 ± 1.2	939.6 ± 198.5
			173.4	18 ± 3	940.2 ± 160.9
				RR_{mean} =	**928.5 ± 35.4**
^{197m}Pb	c*	43M	387.7	25 ± 6	514.2 ± 124.8
			385.9	74 ± 15	575.0 ± 118.3
				RR_{mean} =	**569.8 ± 26.8**
^{196}Pb	c*	37M	502.1	26 ± 3	**479.9 ± 58.4**
^{195m}Pb	i(m)	15.0M	383.6	107 ± 20	**247.7 ± 47.5**
^{202}Tl	c	12.23D	439.6	91.4 ± 1.0	**49.94 ± 1.83**
^{201}Tl	c*	72.912H	167.4	10.00 ± 0.06	**1068 ± 41.**
^{200}Tl$_i$	i	26.1H	579.3	13.8 ± 0.7	158.0 ± 27.4
			367.9	87.2 ± 0.4	140.6 ± 14.9
				RR_{mean} =	**144.4 ± 13.4**
^{200}Tl$_c$	c	26.1H	1604.5	1.17 ± 0.10	780.1 ± 73.7
			1514.9	4.0 ± 0.3	868.8 ± 72.4
			1366.3	0.9 ± 0.3	748.1 ± 251.5
			1362.9	3.4 ± 0.4	845.1 ± 104.0
			1225.5	3.36 ± 0.21	845.4 ± 61.1
			1205.7	29.9 ± 1.8	836.0 ± 57.7
			886.2	2.02 ± 0.13	834.1 ± 63.3
			579.3	13.8 ± 0.7	875.7 ± 54.9
			367.9	87.2 ± 0.4	816.8 ± 29.5
				RR_{mean} =	**825.1 ± 28.3**
^{199}Tl	c*	7.42H	247.3	9.3 ± 1.1	986.5 ± 123.2
			208.2	12.3 ± 1.4	1014 ± 124
			158.4	5.0 ± 0.6	1098 ± 139
			455.5	12.4 ± 1.4	957.9 ± 113.4
				RR_{mean} =	**1003 ± 46.**
^{198m}Tl	i(m)	1.87H	587.2	52.5 ± 2.0	**73.56 ± 6.05**
^{197}Tl	c*	2.84H	1411.3	4.5 ± 1.5	699.3 ± 235.0
			152.2	7.3 ± 2.3	1100 ± 349
				RR_{mean} =	**925.9 ± 200.4**
^{196m}Tl	i(m)	1.41H	695.4	41 ± 7	**229.0 ± 40.5**
^{195}Tl	c*	1.16H	884.5	10.0 ± 1.1	**403.4 ± 49.5**
^{203}Hg	c	46.612D	279.2	81.46 ± 0.13	**0.8965 ± 0.1222**
^{197}Hg	c*	64.14H	191.4	0.63 ± 0.02	**666.2 ± 52.5**
^{197m}Hg	i(m)	23.8H	134.0	33.5 ± 0.4	**29.30 ± 3.82**
^{195m}Hg	i(m)	41.6H	779.8	54.2 ± 0.1	**45.08 ± 10.21**
^{195}Hg$_c$	c	9.9H	779.8	6.8 ± 0.7	**474.7 ± 51.5**
^{193m}Hg	i(m)	11.8H	407.6	32 ± 6	**41.93 ± 8.14**
^{192}Hg	c	4.85H	316.5	*	238.2 ± 30.0
			296.0	*	248.4 ± 36.2
			274.8	50.2 ± 2.5	184.6 ± 11.6
				RR_{mean} =	**190.5 ± 5.9**
^{190}Hg	c*	20.0M	301.8	*	120.0 ± 101.4
			295.8	*	111.6 ± 22.5
				RR_{mean} =	**111.9 ± 21.2**
^{196}Au	i(m1+m2+g)	6.183D	355.7	87.0 ± 0.8	**2.704 ± 0.196**
^{195}Au	c	186.098D	129.8	0.82 ± 0.05	544.1 ± 47.3
			98.9	10.9 ± 0.9	453.8 ± 50.4

Continuation of Table 73.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
				RR_{mean} =	**509.7 ± 46.6**
^{194}Au	i(m1+m2+g)	38.02H	328.5	61 ± 5	**5.294 ± 0.529**
^{192}Au$_i$	i(m+g)	4.94H	316.5	58 ± 7	**7.601 ± 3.863**
^{192}Au$_c$	c	4.94H	316.5	58 ± 7	245.8 ± 30.9
			296.0	22 ± 3	244.5 ± 35.1
				RR_{mean} =	**245.7 ± 9.7**
^{191}Au	c*	3.18H	586.4	17 ± 0	**134.6 ± 11.2**
^{190}Au$_c$	c	42.8M	301.8	23.4 ± 1.5	172.2 ± 64.8
			295.8	71 ± 5	96.26 ± 13.30
				RR_{mean} =	**98.75 ± 13.88**
^{191}Pt	c	2.802D	538.9	13.7 ± 1.6	136.6 ± 16.9
			456.5	3.4 ± 0.4	134.1 ± 17.1
			409.4	8.0 ± 0.9	126.1 ± 15.0
			359.9	6.0 ± 0.7	125.4 ± 16.1
			351.2	3.4 ± 0.4	151.2 ± 19.5
			172.2	3.5 ± 0.4	135.1 ± 18.0
				RR_{mean} =	**132.9 ± 5.6**
^{189}Pt	c	10.87H	243.5	7.0 ± 1.2	**79.29 ± 14.68**
^{188}Pt	c	10.2D	478.0	*	40.77 ± 2.38
			381.4	7.5 ± 0.5	47.32 ± 3.84
			195.1	18.6 ± 1.2	43.09 ± 3.27
			187.6	19.4 ± 1.2	41.55 ± 3.05
			155.1	*	45.37 ± 4.87
				RR_{mean} =	**42.15 ± 1.30**
^{189}Ir	c	13.2D	245.1	6.0 ± 0.6	**65.77 ± 7.23**
^{188}Ir$_c$	c	41.5H	2214.6	18.7 ± 1.6	31.17 ± 3.02
			2059.6	7.1 ± 0.6	35.39 ± 4.50
			478.0	14.7 ± 0.6	39.34 ± 6.07
				RR_{mean} =	**33.23 ± 2.30**
^{185}Os	c	93.6D	646.1	78 ± 3	**10.45 ± 0.56**
^{183}Re	c	70.0D	162.3	23.3 ± 0.7	**3.653 ± 0.261**
^{139}Ce	c	137.640D	165.9	79.89 ± 0.01	**1.416 ± 0.084**
^{127}Xe	c	36.4D	202.9	68.3 ± 0.5	4.378 ± 0.191
			172.1	25.5 ± 0.8	4.473 ± 0.358
				RR_{mean} =	**4.391 ± 0.182**
^{126} I	i	13.11D	388.6	34 ± 3	**5.091 ± 0.545**
^{123m}Te	i(m)	119.7D	159.0	84.0 ± 0.4	**5.438 ± 0.264**
^{121m}Te	i(m)	154D	573.1	88.6 ± 0.1	4.289 ± 0.214
			212.2	81.4 ± 1.1	4.435 ± 0.232
				RR_{mean} =	**4.354 ± 0.134**
^{121}Te$_c$	c	19.16D	573.1	80.3 ± 2.5	**3.154 ± 0.230**
^{124}Sb	i(m1+m2+g)	60.20D	602.7	98.3 ± 0.4	**2.095 ± 0.219**
^{122}Sb	i(m+g)	2.7238D	564.2	70.67 ± 0.18	**5.918 ± 0.302**
^{120m}Sb	i(m)	5.76D	1171.7	100 ± 0	6.976 ± 0.513
			197.3	87.0 ± 1.1	6.686 ± 0.282
				RR_{mean} =	**6.728 ± 0.273**
^{117m}Sn	i(m)	13.60D	158.6	86.4 ± 0.4	**10.20 ± 0.55**
^{114m}In	i(m)	49.51D	190.3	15.56 ± 0.16	**12.01 ± 0.69**
^{111}In	c	2.8047D	245.4	94 ± 1	**1.790 ± 0.208**
^{115}Cd	c	53.46H	336.2	45.9 ± 1.0	**7.164 ± 0.440**

Continuation of Table 73.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{110m}Ag	i(m)	249.76D	1505.0	13.60 ± 0.19	16.66 ± 1.04
			1384.3	24.9 ± 0.8	18.31 ± 1.01
			937.5	34.2 ± 0.6	16.98 ± 0.92
			884.7	72.7 ± 0.4	16.35 ± 0.58
			763.9	22.62 ± 0.21	16.22 ± 0.99
			657.8	94.3 ± 0.3	16.19 ± 0.56
				RR_{mean} =	**16.40 ± 0.54**
^{106m}Ag	i(m)	8.28D	451.0	28.2 ± 0.8	**1.829 ± 0.281**
^{105}Rh	c	35.36H	318.9	19.1 ± 0.6	69.77 ± 3.41
			306.1	5.1 ± 0.4	57.82 ± 6.33
				RR_{mean} =	**68.32 ± 4.44**
^{102m}Rh	i(m)	2.9Y	631.3	56 ± 2	6.361 ± 1.563
			475.1	95 ± 4	5.905 ± 0.506
				RR_{mean} =	**5.944 ± 0.488**
^{101m}Rh	c	4.34D	306.9	81 ± 5	**2.209 ± 0.205**
^{106}Ru	c	373.59D	621.9(D)	9.93 ± 0.23	**24.57 ± 1.58**
^{103}Ru	c	39.26D	497.1	91.0 ± 1.3	**67.77 ± 2.57**
^{96}Tc	i(m+g)	4.28D	849.9	98 ± 4	**1.874 ± 0.197**
^{99}Mo	c	65.94H	181.1	5.99 ± 0.12	63.63 ± 3.39
			140.5	90.27 ± 0.33	68.71 ± 3.63
				RR_{mean} =	**66.00 ± 3.25**
^{96}Nb	i	23.35H	1091.3	48.5 ± 1.6	36.14 ± 1.96
			849.9	20.45 ± 0.20	32.32 ± 1.89
			778.2	96.45 ± 0.22	34.31 ± 1.25
			568.9	58.0 ± 0.3	32.95 ± 1.41
			460.0	26.62 ± 0.20	33.23 ± 1.51
				RR_{mean} =	**33.82 ± 1.15**
$^{95}Nb_i$	i(m+g)	34.975D	765.8	99.81 ± 0.03	**33.61 ± 1.12**
$^{95}Nb_c$	c	34.975D	765.8	99.81 ± 0.03	**76.16 ± 2.50**
^{97}Zr	c	16.744H	743.4	93.06 ± 0.16	**18.62 ± 0.85**
^{95}Zr	c	64.02D	765.8	*	42.94 ± 1.43
			756.7	54.46 ± 0.10	41.85 ± 1.50
			724.2	44.17 ± 0.16	44.66 ± 1.55
				RR_{mean} =	**42.99 ± 1.33**
^{89}Zr	c	78.41H	909.2	99.04 ± 0.03	**3.302 ± 0.266**
^{88}Zr	c	83.4D	898.0	*	**0.5869 ± 0.3732**
^{90m} Y	i(m)	3.19H	202.5	97.3 ± 0.4	**32.09 ± 1.39**
^{88} Y_i	i	106.65D	898.0	93.7 ± 0.3	**10.96 ± 0.48**
^{88} Y_c	c	106.65D	898.0	93.7 ± 0.3	**11.55 ± 0.44**
^{87} Y	c*	79.8H	484.8	89.7 ± 0.7	4.767 ± 0.263
			388.5	82.1 ± 0.5	4.776 ± 0.267
				RR_{mean} =	**4.771 ± 0.213**
^{85}Sr	c	64.84D	514.0	96 ± 4	**5.134 ± 0.376**
^{86}Rb	i(m+g)	18.631D	1077.0	8.64 ± 0.04	**34.41 ± 1.41**
^{84}Rb	i(m+g)	32.77D	881.6	69.0 ± 1.6	**13.15 ± 0.86**
^{83}Rb	c	86.2D	552.6	16.0 ± 1.1	5.447 ± 0.707
			529.6	29.3 ± 2.1	6.675 ± 0.683
			520.4	45 ± 4	6.460 ± 0.726
				RR_{mean} =	**6.242 ± 0.418**
^{82}Br	i(m+g)	35.30H	776.5	83.5 ± 1.2	20.78 ± 0.83

Continuation of Table 73.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			698.4	28.5 ± 0.4	19.80 ± 1.14
			554.3	70.8 ± 1.0	20.45 ± 0.91
				RR_{mean} =	**20.54 ± 0.73**
^{75}Se	c	119.779D	264.7	58.9 ± 0.4	1.484 ± 0.308
			136.0	58.3 ± 0.8	0.9914 ± 0.0952
				RR_{mean} =	**1.031 ± 0.138**
^{74}As	i	17.77D	595.8	59 ± 4	**3.735 ± 0.470**
^{59}Fe	c	44.472D	1291.6	43.2 ± 1.4	**2.093 ± 0.240**
^{7}Be	i	53.29D	477.6	10.52 ± 0.06	**8.818 ± 0.959**

12.5.6 Nuclide production rates for ^{27}Al

Table 74: Detailed calculation of nuclide production rates for in ^{27}Al-monitors and ^{27}Al-plates for E_p = 0.25 GeV, used for calculating proton flux (including total over the plate area), cross sections for production of ^{7}Be, ^{24}Naand neutron background.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			^{27}Al-monitor for ^{206}Pb		
^{7}Be	i	53.29D	477.6	10.52 ± 0.06	**9.362 ± 0.356**
^{27}Mg	c	9.458M	843.8	71.8 ± 0.4	0.9740 ± 0.0550
			1014.4	28.0 ± 0.4	1.007 ± 0.095
				RR_{mean} =	**0.9810 ± 0.0509**
^{22}Na	c	2.6019Y	1274.5	99.94 ± 0.01	**78.48 ± 2.66**
^{24}Na	c	14.9590H	1369.0	100 ± 0	**56.10 ± 1.88**
			^{27}Al-plate for ^{206}Pb		
^{24}Na	c	14.9590H	1369.0	100 ± 0	**2.491 ± 0.083**
			^{27}Al-monitor for ^{207}Pb		
^{7}Be	i	53.29D	477.6	10.52 ± 0.06	**12.58 ± 0.48**
^{27}Mg	c	9.458M	843.8	71.8 ± 0.4	1.186 ± 0.069
			1014.4	28.0 ± 0.4	1.046 ± 0.120
				RR_{mean} =	**1.158 ± 0.067**
^{22}Na	c	2.6019Y	1274.5	99.94 ± 0.01	**104.9 ± 3.6**
^{24}Na	c	14.9590H	1369.0	100 ± 0	**74.42 ± 2.47**
			^{27}Al-plate for ^{207}Pb		
^{24}Na	c	14.9590H	1369.0	100 ± 0	**2.829 ± 0.095**
			^{27}Al-monitor for ^{207}Pb		
^{7}Be	i	53.29D	477.6	10.52 ± 0.06	**9.009 ± 0.365**
^{27}Mg	c	9.458M	843.8	71.8 ± 0.4	0.9677 ± 0.0546
			1014.4	28.0 ± 0.4	0.8547 ± 0.0883
				RR_{mean} =	**0.9420 ± 0.0556**
^{22}Na	c	2.6019Y	1274.5	99.94 ± 0.01	**76.73 ± 2.63**
^{24}Na	c	14.9590H	1369.0	100 ± 0	**54.04 ± 1.80**
			^{27}Al-plate for ^{207}Pb		
^{24}Na	c	14.9590H	1369.0	100 ± 0	**2.356 ± 0.080**
			^{27}Al-monitor for ^{nat}Pb		
^{7}Be	i	53.29D	477.6	10.52 ± 0.06	**12.47 ± 0.46**
^{27}Mg	c	9.458M	843.8	71.8 ± 0.4	1.179 ± 0.100
			1014.4	28.0 ± 0.4	1.082 ± 0.261

Continuation of Table 74.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
				$RR_{mean} =$	**1.168 ± 0.095**
^{22}Na	c	2.6019Y	1274.5	99.94 ± 0.01	**103.8 ± 3.6**
^{24}Na	c	14.9590H	1369.0	100 ± 0	**73.36 ± 2.44**
		^{27}Al-plate for ^{nat}Pb			
^{24}Na	c	14.9590H	1369.0	100 ± 0	**2.755 ± 0.092**
		^{27}Al-monitor for ^{209}Bi			
^{7}Be	i	53.29D	477.6	10.52 ± 0.06	**14.94 ± 0.58**
^{27}Mg	c	9.458M	843.8	71.8 ± 0.4	2.255 ± 0.117
			1014.4	28.0 ± 0.4	2.216 ± 0.223
				$RR_{mean} =$	**2.249 ± 0.111**
^{22}Na	c	2.6019Y	1274.5	99.94 ± 0.01	**123.9 ± 4.2**
^{24}Na	c	14.9590H	1369.0	100 ± 0	**88.37 ± 2.94**
		^{27}Al-plate for ^{209}Bi			
^{24}Na	c	14.9590H	1369.0	100 ± 0	**3.117 ± 0.105**

12.6 Detailed calculation of nuclide production rates for ^{206}Pb, ^{207}Pb, ^{208}Pb, ^{nat}Pb and ^{209}Bi for $E_p = 0.4$ GeV

12.6.1 Nuclide production rates for ^{206}Pb

Table 75: Detailed calculation of nuclide production rates for ^{206}Pb for $E_p = 0.4$ GeV, used to determine the cross sections for their production.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{206}Bi	i	6.243D	1718.7	31.8 ± 0.6	13.95 ± 0.76
			1098.3	13.50 ± 0.21	10.92 ± 0.93
			895.1	15.66 ± 0.23	16.30 ± 1.33
			881.0	66.2 ± 1.0	16.44 ± 0.96
			803.1	98.9 ± 1.4	14.09 ± 0.52
			620.5	5.76 ± 0.09	17.01 ± 1.67
			537.5	30.5 ± 0.5	13.06 ± 1.07
			516.2	40.7 ± 0.6	13.63 ± 0.65
			497.1	15.31 ± 0.22	14.77 ± 1.03
			398.0	10.74 ± 0.15	14.19 ± 0.84
			343.5	23.4 ± 0.4	14.00 ± 0.76
				RR_{mean} =	**14.07 ± 0.54**
^{205}Bi	i	15.31D	1861.7	6.17 ± 0.10	46.49 ± 3.46
			1861.7	6.17 ± 0.10	46.01 ± 3.91
			1775.8	3.99 ± 0.08	56.58 ± 4.04
			1764.3	32.5 ± 0.7	47.17 ± 2.35
			1614.3	2.28 ± 0.04	55.91 ± 6.19
			1190.0	2.26 ± 0.07	51.66 ± 4.12
			1043.8	7.51 ± 0.10	41.22 ± 1.85
			703.5	31.1 ± 0.1	45.25 ± 1.56
			570.6	4.34 ± 0.07	44.92 ± 2.14
			284.1	1.69 ± 0.02	51.64 ± 4.47
				RR_{mean} =	**45.35 ± 1.67**
^{204}Bi	i	11.22H	984.0	59 ± 4	66.68 ± 5.17
			918.3	10.8 ± 0.9	77.95 ± 7.73
			899.2	98 ± 9	62.13 ± 2.14
			670.7	11.4 ± 0.9	65.73 ± 6.43
			374.8	82 ± 5	68.73 ± 14.38
				RR_{mean} =	**62.55 ± 1.93**
^{203}Bi	i(m+g)	11.76H	1893.0	8.2 ± 0.6	92.16 ± 8.12
			1847.3	11.4 ± 0.8	82.36 ± 7.35
			1679.6	8.8 ± 0.7	74.88 ± 7.43
			896.8	13.1 ± 0.7	81.76 ± 5.93
			820.2	29.6 ± 1.5	87.65 ± 5.55
				RR_{mean} =	**85.59 ± 3.32**
^{202}Bi	i	1.72H	960.7	99.28 ± 0.02	70.88 ± 3.70
			422.1	83.7 ± 2.5	79.22 ± 6.91
				RR_{mean} =	**72.35 ± 3.88**
^{204m}Pb$_i$	i(m)	67.2M	899.2	99.17 ± 0.02	95.03 ± 3.55
			374.7	89 ± 15	111.2 ± 19.3
				RR_{mean} =	**95.20 ± 3.55**
^{204m}Pb$_c$	c	67.2M	899.2	99.17 ± 0.02	104.3 ± 3.8
			374.7	89 ± 15	119.8 ± 20.7

Continuation of Table 75.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
				RR_{mean} =	**104.5 ± 3.8**
^{203}Pb	c*	51.873H	401.3	3.35 ± 0.07	408.2 ± 16.5
			279.2	80.8 ± 0.2	418.2 ± 15.3
				RR_{mean} =	**414.6 ± 14.3**
^{202m}Pb	i(m)	3.53H	960.7	92 ± 8	98.77 ± 9.49
			459.7	8.6 ± 0.7	82.69 ± 12.05
			422.1	86 ± 5	110.8 ± 8.3
				RR_{mean} =	**104.1 ± 7.5**
^{201}Pb	c*	9.33H	1277.1	1.63 ± 0.12	396.4 ± 37.8
			1238.8	1.18 ± 0.08	351.6 ± 44.3
			1098.5	1.83 ± 0.12	300.5 ± 27.6
			946.0	7.4 ± 0.6	380.9 ± 34.0
			907.6	5.7 ± 0.4	414.3 ± 34.7
			692.4	4.27 ± 0.16	359.4 ± 20.8
			331.2	79 ± 5	406.2 ± 29.2
				RR_{mean} =	**367.7 ± 18.5**
^{200}Pb	c	21.5H	1514.9	*	278.2 ± 23.9
			1407.6	*	311.7 ± 36.7
			1362.9	*	276.3 ± 35.0
			1225.5	*	269.0 ± 21.4
			1205.7	*	317.6 ± 21.9
			828.3	*	289.0 ± 22.8
			701.6	*	279.4 ± 32.4
			579.3	*	269.7 ± 18.2
			367.9	*	293.7 ± 10.3
			147.6	37.7 ± 1.4	325.3 ± 17.4
				RR_{mean} =	**294.0 ± 9.1**
^{199}Pb	c*	90M	1135.0	7.8 ± 1.2	486.6 ± 79.9
			366.9	44 ± 7	564.7 ± 92.5
			353.4	9.5 ± 1.5	579.2 ± 99.7
				RR_{mean} =	**533.1 ± 33.9**
^{198}Pb	c	2.4H	365.4	19 ± 5	525.1 ± 140.6
			865.3	5.9 ± 1.2	322.8 ± 68.5
			173.4	18 ± 3	453.6 ± 78.0
				RR_{mean} =	**442.9 ± 30.4**
^{197m}Pb	c*	43M	387.7	25 ± 6	323.6 ± 78.6
			385.9	74 ± 15	318.9 ± 65.7
			222.8	25 ± 6	273.3 ± 66.8
				RR_{mean} =	**315.1 ± 14.8**
^{196}Pb	c*	37M	502.1	26 ± 3	**327.1 ± 40.7**
^{195m}Pb	i(m)	15.0M	394.2	44 ± 8	175.6 ± 33.2
			383.6	107 ± 20	170.8 ± 32.6
				RR_{mean} =	**173.5 ± 7.7**
^{202}Tl	c	12.23D	439.6	91.4 ± 1.0	**149.8 ± 5.4**
^{201}Tl	c*	72.912H	167.4	10.00 ± 0.06	**613.5 ± 22.6**
^{200}Tl$_i$	i	26.1H	1514.9	4.0 ± 0.3	295.2 ± 26.9
			1407.6	1.45 ± 0.13	418.9 ± 51.3
			1362.9	3.4 ± 0.4	354.5 ± 46.5
			1225.5	3.36 ± 0.21	318.9 ± 29.2
			1205.7	29.9 ± 1.8	208.5 ± 15.1
			828.3	10.8 ± 0.7	345.0 ± 27.5

Continuation of Table 75.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			701.6	1.29 ± 0.10	306.8 ± 50.3
			579.3	13.8 ± 0.7	270.4 ± 25.0
			367.9	87.2 ± 0.4	228.4 ± 10.4
				RR_{mean} =	**246.5 ± 17.5**
$^{200}Tl_c$	c	26.1H	1514.9	4.0 ± 0.3	573.4 ± 47.5
			1407.6	1.45 ± 0.13	730.6 ± 71.6
			1362.9	3.4 ± 0.4	630.9 ± 77.7
			1225.5	3.36 ± 0.21	587.9 ± 42.9
			1205.7	29.9 ± 1.8	526.1 ± 36.2
			828.3	10.8 ± 0.7	634.0 ± 46.4
			701.6	1.29 ± 0.10	586.2 ± 54.9
			579.3	13.8 ± 0.7	540.0 ± 34.9
			367.9	87.2 ± 0.4	522.1 ± 18.2
				RR_{mean} =	**534.5 ± 20.2**
^{199}Tl	c*	7.42H	247.3	9.3 ± 1.1	624.1 ± 78.4
			208.2	12.3 ± 1.4	626.3 ± 76.5
			158.4	5.0 ± 0.6	830.4 ± 108.8
				RR_{mean} =	**660.4 ± 58.3**
^{198m}Tl	i(m)	1.87H	587.2	52.5 ± 2.0	204.8 ± 14.3
			282.8	28 ± 3	222.0 ± 25.8
				RR_{mean} =	**207.6 ± 11.5**
^{197}Tl	c*	2.84H	1411.3	4.5 ± 1.5	569.6 ± 191.7
			152.2	7.3 ± 2.3	877.4 ± 280.3
			134.0	2.0 ± 0.7	812.8 ± 291.4
				RR_{mean} =	**742.6 ± 106.4**
^{196m}Tl	i(m)	1.41H	695.4	41 ± 7	**393.9 ± 69.0**
^{195}Tl	c*	1.16H	884.5	10.0 ± 1.1	**427.4 ± 53.1**
^{203}Hg	c	46.612D	279.2	81.46 ± 0.13	**8.281 ± 0.359**
^{197}Hg	c*	64.14H	191.4	0.63 ± 0.02	**679.7 ± 36.4**
^{197m}Hg	i(m)	23.8H	134.0	33.5 ± 0.4	**74.78 ± 3.37**
^{195m}Hg	i(m)	41.6H	779.8	54.2 ± 0.1	89.22 ± 18.39
			560.3	7.0 ± 0.6	103.2 ± 9.7
			261.8	31 ± 4	104.9 ± 14.1
				RR_{mean} =	**100.8 ± 3.1**
$^{195}Hg_c$	c	9.9H	779.8	6.8 ± 0.7	**568.5 ± 62.7**
^{193m}Hg	i(m)	11.8H	573.2	26 ± 4	88.49 ± 14.07
			407.6	32 ± 6	122.6 ± 23.4
				RR_{mean} =	**97.44 ± 15.30**
^{192}Hg	c	4.85H	2335.7	*	424.0 ± 83.8
			2236.9	*	477.2 ± 80.8
			316.5	*	536.0 ± 67.4
			296.0	*	525.7 ± 74.6
			274.8	50.2 ± 2.5	425.9 ± 26.8
				RR_{mean} =	**437.8 ± 13.5**
^{190}Hg	c*	20.0M	301.8	*	288.7 ± 47.1
			295.8	*	297.2 ± 26.9
			142.6	68 ± 10	309.1 ± 47.7
				RR_{mean} =	**298.6 ± 9.2**
^{198m}Au	i(m)	2.27D	204.1	40.8 ± 2.4	2.085 ± 0.239
			411.8	*	1.826 ± 0.247

Continuation of Table 75.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
				RR_{mean} =	**1.962 ± 0.061**
$^{198}Au_i$	i	2.69517D	411.8	95.58 ± 0.12	**5.314 ± 0.435**
$^{198}Au_c$	i(m+g)	2.69517D	411.8	95.58 ± 0.12	**7.139 ± 0.304**
^{196}Au	i(m1+m2+g)	6.183D	426.1	6.6 ± 0.8	14.67 ± 2.17
			355.7	87.0 ± 0.8	14.95 ± 0.55
			333.0	22.9 ± 0.6	15.44 ± 0.75
				RR_{mean} =	**15.04 ± 0.52**
^{195}Au	c	186.098D	129.8	0.82 ± 0.05	658.6 ± 56.3
			98.9	10.9 ± 0.9	563.4 ± 55.4
				RR_{mean} =	**616.4 ± 51.0**
^{194}Au	i(m1+m2+g)	38.02H	328.5	61 ± 5	31.57 ± 2.81
			293.6	10.4 ± 0.8	29.70 ± 2.62
				RR_{mean} =	**30.56 ± 1.73**
$^{192}Au_i$	i(m+g)	4.94H	2335.7	1.7 ± 0.3	175.2 ± 94.9
			2236.9	5.6 ± 0.9	20.10 ± 26.42
			316.5	58 ± 7	43.13 ± 6.64
			296.0	22 ± 3	85.26 ± 24.57
				RR_{mean} =	**44.15 ± 5.80**
$^{192}Au_c$	c	4.94H	2335.7	1.7 ± 0.3	599.2 ± 125.3
			2236.9	5.6 ± 0.9	497.3 ± 84.0
			316.5	58 ± 7	579.1 ± 72.7
			296.0	22 ± 3	611.0 ± 87.1
				RR_{mean} =	**578.0 ± 22.4**
^{191}Au	c*	3.18H	586.4	17 ± 0	419.7 ± 22.9
			293.5	2.84 ± 0.19	354.8 ± 32.0
			166.5	3.32 ± 0.24	494.0 ± 46.0
				RR_{mean} =	**412.5 ± 31.5**
$^{190}Au_c$	c	42.8M	301.8	23.4 ± 1.5	348.8 ± 33.0
			295.8	71 ± 5	359.8 ± 28.9
				RR_{mean} =	**356.0 ± 17.9**
^{191}Pt	c	2.802D	538.9	13.7 ± 1.6	418.3 ± 51.0
			456.5	3.4 ± 0.4	379.2 ± 46.6
			409.4	8.0 ± 0.9	373.6 ± 44.0
			351.2	3.4 ± 0.4	399.9 ± 50.7
			172.2	3.5 ± 0.4	418.6 ± 51.9
				RR_{mean} =	**394.1 ± 16.5**
^{189}Pt	c	10.87H	721.4	9.3 ± 0.8	460.1 ± 43.7
			607.6	8.10 ± 0.16	372.1 ± 15.6
			568.8	7.1 ± 0.6	379.0 ± 35.7
			544.9	5.8 ± 0.5	403.9 ± 38.6
			243.5	7.0 ± 1.2	385.9 ± 68.1
				RR_{mean} =	**379.1 ± 15.3**
^{188}Pt	c	10.2D	1209.8	*	327.1 ± 35.1
			634.9	*	341.1 ± 56.0
			633.0	*	345.8 ± 58.8
			478.0	*	311.4 ± 17.0
			423.3	4.4 ± 0.3	321.3 ± 24.8
			381.4	7.5 ± 0.5	305.3 ± 22.8
			322.9	*	297.8 ± 29.8
			195.1	18.6 ± 1.2	309.9 ± 23.2
			187.6	19.4 ± 1.2	317.4 ± 22.9

Continuation of Table 75.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			155.1	*	326.9 ± 34.7
			140.4	2.33 ± 0.15	322.0 ± 25.1
				RR_{mean} =	**313.5 ± 9.7**
^{187}Pt	c	2.35H	304.8	4.3 ± 1.0	191.2 ± 47.3
			106.4	8.8 ± 1.8	234.7 ± 50.4
				RR_{mean} =	**224.4 ± 19.7**
^{186}Pt	c	2.08H	689.4	70 ± 15	**209.0 ± 45.4**
^{184}Pt	c	17.3M	548.3	23 ± 4	**164.6 ± 33.2**
^{190}Ir	i(m1+g)	11.78D	605.1	39.9 ± 1.9	**1.110 ± 0.498**
^{189}Ir	c	13.2D	275.9	0.54 ± 0.07	301.7 ± 41.9
			245.1	6.0 ± 0.6	315.8 ± 34.0
				RR_{mean} =	**314.7 ± 12.4**
^{188}Ir$_i$	i	41.5H	633.0	18 ± 3	8.474 ± 2.810
			478.0	14.7 ± 0.6	13.00 ± 5.68
			155.1	30 ± 3	9.178 ± 2.033
				RR_{mean} =	**9.247 ± 1.575**
^{188}Ir$_c$	c	41.5H	1209.8	6.9 ± 0.7	322.0 ± 34.7
			634.9	5.0 ± 0.8	344.1 ± 56.5
			633.0	18 ± 3	354.3 ± 60.3
			478.0	14.7 ± 0.6	324.4 ± 18.0
			322.9	1.62 ± 0.15	294.2 ± 29.6
			155.1	30 ± 3	336.1 ± 35.7
				RR_{mean} =	**323.5 ± 11.8**
^{187}Ir	c*	10.5H	977.5	3.14 ± 0.11	**316.8 ± 20.3**
^{186}Ir	c	16.64H	773.3	8.9 ± 0.5	101.7 ± 7.9
			434.8	33.9 ± 1.1	109.3 ± 5.7
			137.2	41.4 ± 0.7	120.7 ± 5.6
				RR_{mean} =	**113.5 ± 6.2**
^{185}Ir	c	14.4H	1829.0	10.1 ± 1.5	166.3 ± 25.7
			254.2	13.3 ± 2.4	139.7 ± 26.2
				RR_{mean} =	**161.0 ± 11.8**
^{184}Ir	c*	3.09H	841.3	8.0 ± 0.8	192.9 ± 22.7
			264.0	68 ± 4	182.5 ± 13.1
			119.8	31 ± 3	175.4 ± 19.0
				RR_{mean} =	**182.5 ± 7.5**
^{183}Ir	c	57M	392.5	10.4 ± 2.4	**134.7 ± 35.0**
^{185}Os	c	93.6D	880.5	5.17 ± 0.21	215.7 ± 15.4
			874.8	6.29 ± 0.25	212.4 ± 11.4
			717.4	3.94 ± 0.16	211.5 ± 11.9
			646.1	78 ± 3	202.2 ± 10.3
				RR_{mean} =	**206.1 ± 7.0**
^{183m}Os	c*	9.9H	1107.9	22.4 ± 0.6	84.86 ± 4.34
			1101.9	49.0 ± 1.3	83.34 ± 3.87
				RR_{mean} =	**83.88 ± 3.07**
^{182}Os	c	22.10H	1221.5	*	141.5 ± 10.4
			1189.2	*	139.7 ± 10.6
			1121.4	*	137.4 ± 8.5
			180.2	33.5 ± 1.7	132.5 ± 9.0
				RR_{mean} =	**136.2 ± 4.2**
^{180}Os	c	21.5M	902.8(D)	101.5 ± 3.4	**71.00 ± 4.50**

Continuation of Table 75.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{183}Re	c	70.0D	291.7	3.05 ± 0.18	144.5 ± 10.7
			208.8	2.95 ± 0.09	148.4 ± 7.7
			162.3	23.3 ± 0.7	149.2 ± 7.1
				RR_{mean} =	**148.4 ± 5.6**
^{182m}Re$_c$	c	12.7H	1221.5	24.8 ± 1.6	128.5 ± 9.7
			1189.2	15 ± 1	149.0 ± 11.6
			1121.4	31.8 ± 1.6	148.8 ± 9.5
				RR_{mean} =	**142.6 ± 8.0**
^{181}Re	c*	19.9H	639.0	6.4 ± 1.4	91.97 ± 20.78
			365.5	56 ± 8	98.81 ± 14.60
				RR_{mean} =	**96.93 ± 10.50**
^{175}Hf	c	70D	343.4	84 ± 3	**17.97 ± 0.90**
^{173}Lu	c	1.37Y	272.1	21.2 ± 0.8	**9.216 ± 0.770**
^{171}Lu	c*	8.24D	739.8	47.8 ± 1.2	**3.934 ± 0.239**
^{139}Ce	c	137.640D	165.9	79.89 ± 0.01	**1.132 ± 0.100**
^{127}Xe	c	36.4D	202.9	68.3 ± 0.5	4.033 ± 0.198
			172.1	25.5 ± 0.8	3.496 ± 0.487
				RR_{mean} =	**3.983 ± 0.199**
^{124}Sb	i(m1+m2+g)	60.20D	602.7	98.3 ± 0.4	**0.8145 ± 0.0793**
^{123m}Te	i(m)	119.7D	159.0	84.0 ± 0.4	**2.888 ± 0.140**
^{121m}Te	i(m)	154D	212.2	81.4 ± 1.1	3.463 ± 0.162
			573.1	88.6 ± 0.1	3.144 ± 0.251
				RR_{mean} =	**3.394 ± 0.105**
^{121}Te$_c$	c	19.16D	573.1	80.3 ± 2.5	**5.404 ± 0.293**
^{120m}Sb	i(m)	5.76D	1023.3	99.4 ± 0.3	3.566 ± 0.145
			197.3	87.0 ± 1.1	4.033 ± 0.259
				RR_{mean} =	**3.635 ± 0.200**
^{113}Sn	c	115.09D	391.7	64.97 ± 0.17	**2.169 ± 0.212**
^{114m}In	i(m)	49.51D	190.3	15.56 ± 0.16	**11.00 ± 0.55**
^{110m}Ag	i(m)	249.76D	937.5	34.2 ± 0.6	11.30 ± 0.61
			884.7	72.7 ± 0.4	10.52 ± 0.41
			657.8	94.3 ± 0.3	10.03 ± 0.47
				RR_{mean} =	**10.49 ± 0.43**
^{106m}Ag	i(m)	8.28D	1045.8	29.6 ± 1.0	3.803 ± 0.422
			717.3	28.9 ± 0.8	2.453 ± 0.453
			451.0	28.2 ± 0.8	3.891 ± 0.289
				RR_{mean} =	**3.590 ± 0.412**
^{105}Rh	c	35.36H	318.9	19.1 ± 0.6	**36.89 ± 1.82**
^{102}Rh	i	207D	475.1	46 ± 5	**4.767 ± 0.685**
^{101m}Rh	c	4.34D	306.9	81 ± 5	**5.514 ± 0.413**
^{103}Ru	c	39.26D	497.1	91.0 ± 1.3	**36.62 ± 1.37**
^{96}Tc	i(m+g)	4.28D	849.9	98 ± 4	4.137 ± 0.275
			812.5	82 ± 4	4.290 ± 0.266
				RR_{mean} =	**4.218 ± 0.212**
^{99}Mo	c	65.94H	140.5	90.27 ± 0.33	**35.60 ± 1.46**
^{96}Nb	i	23.35H	1091.3	48.5 ± 1.6	23.23 ± 1.18
			778.2	96.45 ± 0.22	22.76 ± 0.93
			568.9	58.0 ± 0.3	21.64 ± 0.88
			460.0	26.62 ± 0.20	23.11 ± 1.05
				RR_{mean} =	**22.49 ± 0.79**

Continuation of Table 75.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
$^{95}Nb_i$	i(m+g)	34.975D	765.8	99.81 ± 0.03	**25.70 ± 0.87**
$^{95}Nb_c$	c	34.975D	765.8	99.81 ± 0.03	**47.38 ± 1.57**
^{92m}Nb	i(m)	10.15D	934.4	99.07 ± 0.04	**2.113 ± 0.134**
^{97}Zr	c	16.744H	743.4	93.06 ± 0.16	**5.637 ± 0.333**
^{95}Zr	c	64.02D	765.8	*	21.88 ± 0.76
			756.7	54.46 ± 0.10	21.17 ± 0.76
			724.2	44.17 ± 0.16	21.97 ± 1.03
				RR_{mean} =	**21.61 ± 0.67**
^{89}Zr	c	78.41H	909.2	99.04 ± 0.03	**7.465 ± 0.298**
^{88}Zr	c	83.4D	392.9	97.24 ± 0.00	2.467 ± 0.213
			1836.1	*	2.504 ± 0.089
			898.0	*	2.779 ± 0.354
				RR_{mean} =	**2.507 ± 0.077**
^{90m}Y	i(m)	3.19H	479.5	90.74 ± 0.05	**26.73 ± 1.57**
$^{88}Y_i$	i	106.65D	1836.1	99.2 ± 0.3	16.26 ± 0.57
			898.0	93.7 ± 0.3	14.98 ± 0.58
				RR_{mean} =	**15.80 ± 0.78**
$^{88}Y_c$	c	106.65D	1836.1	99.2 ± 0.3	18.77 ± 0.65
			898.0	93.7 ± 0.3	17.76 ± 0.61
				RR_{mean} =	**18.22 ± 0.75**
^{87}Y	c*	79.8H	484.8	89.7 ± 0.7	**9.655 ± 0.348**
^{85}Sr	c	64.84D	514.0	96 ± 4	**10.96 ± 0.60**
^{86}Rb	i(m+g)	18.631D	1077.0	8.64 ± 0.04	**33.17 ± 1.78**
^{84}Rb	i(m+g)	32.77D	881.6	69.0 ± 1.6	**17.33 ± 1.45**
^{83}Rb	c	86.2D	552.6	16.0 ± 1.1	13.19 ± 1.42
			529.6	29.3 ± 2.1	13.66 ± 1.21
			520.4	45 ± 4	11.92 ± 1.18
				RR_{mean} =	**12.93 ± 0.68**
^{82}Br	i(m+g)	35.30H	1317.5	26.5 ± 0.4	18.24 ± 1.20
			776.5	83.5 ± 1.2	16.02 ± 0.66
			698.4	28.5 ± 0.4	16.34 ± 0.83
			554.3	70.8 ± 1.0	15.52 ± 0.68
				RR_{mean} =	**16.05 ± 0.62**
^{75}Se	c	119.779D	264.7	58.9 ± 0.4	2.913 ± 0.157
			136.0	58.3 ± 0.8	2.927 ± 0.159
				RR_{mean} =	**2.920 ± 0.129**
^{74}As	i	17.77D	595.8	59 ± 4	**6.622 ± 0.533**
$^{72}Ga_i$	i	14.10H	2201.7	25.9 ± 0.5	**6.633 ± 1.050**
$^{72}Ga_c$	c	14.10H	2201.7	25.9 ± 0.5	**9.097 ± 0.976**
^{72}Zn	c	46.5H	2201.7	*	**2.465 ± 0.292**
^{59}Fe	c	44.472D	1291.6	43.2 ± 1.4	2.863 ± 0.399
			1099.2	56.5 ± 1.9	2.471 ± 0.209
				RR_{mean} =	**2.547 ± 0.187**

12.6.2 Nuclide production rates for ^{207}Pb

Table 76: Detailed calculation of nuclide production rates for ^{207}Pb for $E_p = 0.4$ GeV, used to determine the cross sections for their production.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{207}Bi	i	31.55Y	569.7	97.74 ± 0.03	**25.18 ± 4.41**
^{206}Bi	i	6.243D	1718.7	31.8 ± 0.6	26.10 ± 1.14
			1098.3	13.50 ± 0.21	24.03 ± 1.72
			895.1	15.66 ± 0.23	27.85 ± 1.18
			881.0	66.2 ± 1.0	23.57 ± 1.08
			803.1	98.9 ± 1.4	23.96 ± 0.87
			620.5	5.76 ± 0.09	22.57 ± 1.16
			537.5	30.5 ± 0.5	22.21 ± 0.95
			516.2	40.7 ± 0.6	23.46 ± 1.01
			497.1	15.31 ± 0.22	23.63 ± 1.27
			398.0	10.74 ± 0.15	20.89 ± 0.91
			343.5	23.4 ± 0.4	23.03 ± 0.96
			184.0	15.8 ± 0.4	28.23 ± 1.61
				RR_{mean} =	**23.69 ± 0.92**
^{205}Bi	i	15.31D	1861.7	6.17 ± 0.10	54.32 ± 2.77
			1775.8	3.99 ± 0.08	52.61 ± 3.04
			1764.3	32.5 ± 0.7	50.29 ± 2.15
			1614.3	2.28 ± 0.04	54.45 ± 4.28
			1190.0	2.26 ± 0.07	47.95 ± 4.28
			1043.8	7.51 ± 0.10	46.84 ± 2.32
			703.5	31.1 ± 0.1	47.69 ± 1.61
			570.6	4.34 ± 0.07	47.34 ± 2.37
			284.1	1.69 ± 0.02	48.46 ± 3.75
				RR_{mean} =	**48.53 ± 1.65**
^{204}Bi	i	11.22H	984.0	59 ± 4	50.12 ± 3.83
			918.3	10.8 ± 0.9	54.46 ± 5.43
			899.2	98 ± 9	47.36 ± 1.62
			670.7	11.4 ± 0.9	48.78 ± 4.37
			374.8	82 ± 5	53.98 ± 11.27
				RR_{mean} =	**47.61 ± 1.47**
^{203}Bi	i(m+g)	11.76H	1893.0	8.2 ± 0.6	52.77 ± 4.79
			1847.3	11.4 ± 0.8	58.45 ± 4.89
			1679.6	8.8 ± 0.7	56.64 ± 5.31
			896.8	13.1 ± 0.7	58.35 ± 4.06
			820.2	29.6 ± 1.5	59.54 ± 3.77
				RR_{mean} =	**58.53 ± 2.06**
^{202}Bi	i	1.72H	960.7	99.28 ± 0.02	50.49 ± 2.53
			422.1	83.7 ± 2.5	46.41 ± 2.93
				RR_{mean} =	**48.95 ± 2.49**
^{204m}Pb$_i$	i(m)	67.2M	899.2	99.17 ± 0.02	76.03 ± 2.78
			374.7	89 ± 15	86.18 ± 14.87
				RR_{mean} =	**76.13 ± 2.78**
^{204m}Pb$_c$	c	67.2M	899.2	99.17 ± 0.02	83.13 ± 2.98
			374.7	89 ± 15	92.95 ± 16.02
				RR_{mean} =	**83.22 ± 2.98**
^{203}Pb	c*	51.873H	401.3	3.35 ± 0.07	259.2 ± 11.8
			279.2	80.8 ± 0.2	278.8 ± 10.2
				RR_{mean} =	**273.2 ± 12.2**

Continuation of Table 76.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{202m}Pb	i(m)	3.53H	960.7	92 ± 8	72.25 ± 6.89
			459.7	8.6 ± 0.7	71.76 ± 7.01
			422.1	86 ± 5	84.87 ± 5.86
				RR_{mean} =	**80.34 ± 5.00**
^{201}Pb	c*	9.33H	1277.1	1.63 ± 0.12	243.2 ± 22.2
			1238.8	1.18 ± 0.08	224.0 ± 25.5
			1098.5	1.83 ± 0.12	210.4 ± 25.7
			946.0	7.4 ± 0.6	238.6 ± 21.2
			907.6	5.7 ± 0.4	253.2 ± 20.1
			692.4	4.27 ± 0.16	226.0 ± 13.3
			331.2	79 ± 5	260.4 ± 18.7
				RR_{mean} =	**236.8 ± 9.9**
^{200}Pb	c	21.5H	1514.9	*	209.7 ± 18.0
			1407.6	*	279.5 ± 34.0
			1362.9	*	214.3 ± 26.9
			1225.5	*	176.7 ± 13.1
			1205.7	*	207.9 ± 14.4
			828.3	*	192.6 ± 16.2
			701.6	*	138.3 ± 15.2
			579.3	*	184.9 ± 12.0
			367.9	*	195.7 ± 6.9
			147.6	37.7 ± 1.4	217.2 ± 11.7
				RR_{mean} =	**198.8 ± 6.1**
^{199}Pb	c*	90M	1135.0	7.8 ± 1.2	334.4 ± 53.9
			366.9	44 ± 7	371.1 ± 61.2
			353.4	9.5 ± 1.5	409.3 ± 68.4
				RR_{mean} =	**362.2 ± 23.8**
^{198}Pb	c	2.4H	365.4	19 ± 5	412.9 ± 110.5
			865.3	5.9 ± 1.2	219.3 ± 46.3
			173.4	18 ± 3	290.7 ± 49.8
				RR_{mean} =	**286.7 ± 17.2**
^{197m}Pb	c*	43M	387.7	25 ± 6	217.1 ± 52.9
			385.9	74 ± 15	210.1 ± 43.4
			222.8	25 ± 6	184.9 ± 45.3
				RR_{mean} =	**208.2 ± 10.2**
^{196}Pb	c*	37M	502.1	26 ± 3	**211.6 ± 26.1**
^{195m}Pb	i(m)	15.0M	394.2	44 ± 8	112.2 ± 21.2
			383.6	107 ± 20	110.4 ± 21.1
				RR_{mean} =	**111.4 ± 5.0**
^{202}Tl	c	12.23D	439.6	91.4 ± 1.0	**106.4 ± 3.8**
^{201}Tl	c*	72.912H	167.4	10.00 ± 0.06	**418.8 ± 15.4**
^{200}Tl$_i$	i	26.1H	1514.9	4.0 ± 0.3	151.3 ± 14.8
			1407.6	1.45 ± 0.13	130.5 ± 38.3
			1362.9	3.4 ± 0.4	178.7 ± 24.2
			1225.5	3.36 ± 0.21	207.8 ± 16.0
			1205.7	29.9 ± 1.8	144.4 ± 10.3
			828.3	10.8 ± 0.7	224.5 ± 18.8
			701.6	1.29 ± 0.10	268.4 ± 28.4
			579.3	13.8 ± 0.7	167.9 ± 13.3
			367.9	87.2 ± 0.4	155.6 ± 7.2

Continuation of Table 76.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
				$RR_{mean}=$	**163.7 ± 10.2**
$^{200}Tl_c$	c	26.1H	1514.9	4.0 ± 0.3	361.0 ± 29.9
			1407.6	1.45 ± 0.13	410.0 ± 43.0
			1362.9	3.4 ± 0.4	393.0 ± 48.3
			1225.5	3.36 ± 0.21	384.6 ± 27.4
			1205.7	29.9 ± 1.8	352.3 ± 24.2
			828.3	10.8 ± 0.7	417.0 ± 30.6
			701.6	1.29 ± 0.10	406.6 ± 35.3
			579.3	13.8 ± 0.7	352.7 ± 22.0
			367.9	87.2 ± 0.4	351.3 ± 12.2
				$RR_{mean}=$	**357.2 ± 12.4**
^{199}Tl	c*	7.42H	247.3	9.3 ± 1.1	407.5 ± 51.1
			208.2	12.3 ± 1.4	417.8 ± 50.4
			158.4	5.0 ± 0.6	540.0 ± 68.7
				$RR_{mean}=$	**437.6 ± 38.0**
^{198m}Tl	i(m)	1.87H	587.2	52.5 ± 2.0	128.7 ± 9.4
			282.8	28 ± 3	153.2 ± 17.5
				$RR_{mean}=$	**132.8 ± 10.0**
^{197}Tl	c*	2.84H	1411.3	4.5 ± 1.5	342.3 ± 115.2
			152.2	7.3 ± 2.3	534.1 ± 169.5
			134.0	2.0 ± 0.7	501.1 ± 179.2
				$RR_{mean}=$	**459.6 ± 65.8**
^{196m}Tl	i(m)	1.41H	695.4	41 ± 7	**277.5 ± 48.4**
^{195}Tl	c*	1.16H	884.5	10.0 ± 1.1	**257.0 ± 30.8**
^{203}Hg	c	46.612D	279.2	81.46 ± 0.13	**10.64 ± 0.42**
^{197}Hg	c*	64.14H	191.4	0.63 ± 0.02	**486.6 ± 26.6**
^{197m}Hg	i(m)	23.8H	134.0	33.5 ± 0.4	**59.30 ± 2.70**
^{195m}Hg	i(m)	41.6H	779.8	54.2 ± 0.1	65.82 ± 13.88
			560.3	7.0 ± 0.6	75.36 ± 7.47
			261.8	31 ± 4	82.02 ± 11.04
				$RR_{mean}=$	**74.57 ± 2.30**
$^{195}Hg_c$	c	9.9H	779.8	6.8 ± 0.7	**380.3 ± 41.5**
^{193m}Hg	i(m)	11.8H	573.2	26 ± 4	60.73 ± 9.68
			407.6	32 ± 6	84.87 ± 16.20
				$RR_{mean}=$	**67.02 ± 10.80**
^{192}Hg	c	4.85H	2335.7	*	283.8 ± 61.0
			2236.9	*	270.0 ± 45.7
			316.5	*	332.3 ± 41.7
			296.0	*	332.0 ± 47.3
			274.8	50.2 ± 2.5	271.3 ± 17.0
				$RR_{mean}=$	**278.0 ± 8.6**
^{190}Hg	c*	20.0M	301.8	*	183.9 ± 23.4
			295.8	*	175.3 ± 17.7
			142.6	68 ± 10	190.2 ± 29.3
				$RR_{mean}=$	**180.7 ± 5.6**
^{198m}Au	i(m)	2.27D	204.1	40.8 ± 2.4	2.045 ± 0.255
			411.8	*	1.871 ± 0.158
				$RR_{mean}=$	**1.916 ± 0.059**
$^{198}Au_i$	i	2.69517D	411.8	95.58 ± 0.12	**4.932 ± 0.290**
$^{198}Au_c$	i(m+g)	2.69517D	411.8	95.58 ± 0.12	**6.803 ± 0.256**

Continuation of Table 76.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{196}Au	i(m1+m2+g)	6.183D	426.1	6.6 ± 0.8	14.46 ± 2.01
			355.7	87.0 ± 0.8	12.95 ± 0.46
			333.0	22.9 ± 0.6	13.89 ± 0.64
				RR_{mean} =	**13.10 ± 0.48**
^{195}Au	c	186.098D	129.8	0.82 ± 0.05	439.6 ± 35.2
			98.9	10.9 ± 0.9	370.2 ± 36.3
				RR_{mean} =	**413.5 ± 36.0**
^{194}Au	i(m1+m2+g)	38.02H	328.5	61 ± 5	25.22 ± 2.24
			293.6	10.4 ± 0.8	21.99 ± 1.95
				RR_{mean} =	**23.38 ± 1.75**
^{192}Au$_i$	i(m+g)	4.94H	2335.7	1.7 ± 0.3	61.61 ± 58.01
			2236.9	5.6 ± 0.9	56.49 ± 17.57
			316.5	58 ± 7	41.71 ± 5.65
			296.0	22 ± 3	58.33 ± 15.74
				RR_{mean} =	**42.49 ± 2.66**
^{192}Au$_c$	c	4.94H	2335.7	1.7 ± 0.3	345.5 ± 69.9
			2236.9	5.6 ± 0.9	326.5 ± 54.8
			316.5	58 ± 7	374.0 ± 46.9
			296.0	22 ± 3	390.3 ± 55.5
				RR_{mean} =	**372.3 ± 14.4**
^{191}Au	c*	3.18H	586.4	17 ± 0	291.3 ± 16.0
			293.5	2.84 ± 0.19	257.3 ± 21.5
			166.5	3.32 ± 0.24	336.8 ± 28.5
				RR_{mean} =	**289.1 ± 19.5**
^{190}Au$_c$	c	42.8M	301.8	23.4 ± 1.5	217.0 ± 18.7
			295.8	71 ± 5	220.2 ± 18.2
				RR_{mean} =	**218.7 ± 10.8**
^{191}Pt	c	2.802D	538.9	13.7 ± 1.6	273.0 ± 33.2
			456.5	3.4 ± 0.4	244.0 ± 30.1
			409.4	8.0 ± 0.9	237.4 ± 27.9
			351.2	3.4 ± 0.4	307.0 ± 37.9
			172.2	3.5 ± 0.4	268.8 ± 32.5
				RR_{mean} =	**259.7 ± 14.0**
^{189}Pt	c	10.87H	721.4	9.3 ± 0.8	289.3 ± 26.8
			607.6	8.10 ± 0.16	232.5 ± 10.1
			568.8	7.1 ± 0.6	234.9 ± 23.0
			544.9	5.8 ± 0.5	256.4 ± 24.0
			243.5	7.0 ± 1.2	230.4 ± 40.6
				RR_{mean} =	**237.6 ± 10.2**
^{188}Pt	c	10.2D	1209.8	*	205.8 ± 22.1
			634.9	*	207.6 ± 34.1
			633.0	*	213.9 ± 36.4
			478.0	*	190.4 ± 10.2
			423.3	4.4 ± 0.3	194.2 ± 14.9
			381.4	7.5 ± 0.5	185.9 ± 13.9
			322.9	*	189.6 ± 19.0
			195.1	18.6 ± 1.2	188.7 ± 14.1
			187.6	19.4 ± 1.2	191.1 ± 13.9
			155.1	*	197.4 ± 21.0
			140.4	2.33 ± 0.15	182.8 ± 15.4

Continuation of Table 76.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
				RR_{mean} =	**190.0 ± 5.9**
^{187}Pt	c	2.35H	304.8	4.3 ± 1.0	116.8 ± 28.3
			106.4	8.8 ± 1.8	135.7 ± 28.9
				RR_{mean} =	**132.0 ± 8.6**
^{186}Pt	c	2.08H	689.4	70 ± 15	**127.4 ± 27.7**
^{184}Pt	c	17.3M	548.3	23 ± 4	**88.03 ± 18.07**
^{190}Ir	i(m1+g)	11.78D	605.1	39.9 ± 1.9	**0.9325 ± 0.2395**
^{189}Ir	c	13.2D	275.9	0.54 ± 0.07	211.1 ± 29.3
			245.1	6.0 ± 0.6	198.5 ± 21.5
				RR_{mean} =	**199.5 ± 8.2**
^{188}Ir$_i$	i	41.5H	633.0	18 ± 3	12.33 ± 2.41
			478.0	14.7 ± 0.6	9.431 ± 1.783
			155.1	30 ± 3	11.10 ± 1.64
				RR_{mean} =	**10.74 ± 1.08**
^{188}Ir$_c$	c	41.5H	634.9	5.0 ± 0.8	206.9 ± 34.0
			633.0	18 ± 3	226.2 ± 38.5
			478.0	14.7 ± 0.6	199.9 ± 10.7
			322.9	1.62 ± 0.15	176.4 ± 18.1
			155.1	30 ± 3	208.5 ± 22.2
				RR_{mean} =	**199.4 ± 6.9**
^{187}Ir	c*	10.5H	977.5	3.14 ± 0.11	**192.0 ± 12.0**
^{186}Ir	c	16.64H	773.3	8.9 ± 0.5	64.91 ± 4.48
			434.8	33.9 ± 1.1	66.97 ± 3.26
			137.2	41.4 ± 0.7	69.99 ± 3.28
				RR_{mean} =	**67.94 ± 2.63**
^{185}Ir	c	14.4H	1829.0	10.1 ± 1.5	95.33 ± 14.63
			254.2	13.3 ± 2.4	88.69 ± 16.61
				RR_{mean} =	**94.29 ± 5.03**
^{184}Ir	c*	3.09H	841.3	8.0 ± 0.8	84.52 ± 11.58
			264.0	68 ± 4	104.9 ± 7.4
			119.8	31 ± 3	100.6 ± 10.9
				RR_{mean} =	**103.1 ± 4.8**
^{183}Ir	c	57M	392.5	10.4 ± 2.4	**80.29 ± 19.80**
^{185}Os	c	93.6D	880.5	5.17 ± 0.21	132.0 ± 10.3
			874.8	6.29 ± 0.25	120.0 ± 6.4
			717.4	3.94 ± 0.16	128.4 ± 7.4
			646.1	78 ± 3	120.3 ± 6.1
				RR_{mean} =	**121.4 ± 4.1**
^{183m}Os	c*	9.9H	1107.9	22.4 ± 0.6	47.62 ± 2.43
			1101.9	49.0 ± 1.3	48.83 ± 2.18
				RR_{mean} =	**48.46 ± 1.73**
^{182}Os	c	22.10H	1221.5	*	78.65 ± 5.81
			1189.2	*	83.25 ± 6.39
			1121.4	*	74.53 ± 4.58
			180.2	33.5 ± 1.7	71.85 ± 4.70
				RR_{mean} =	**74.53 ± 2.30**
^{180}Os	c	21.5M	902.8(D)	101.5 ± 3.4	**35.42 ± 2.87**
^{183}Re	c	70.0D	291.7	3.05 ± 0.18	80.35 ± 6.29
			208.8	2.95 ± 0.09	81.69 ± 4.94
			162.3	23.3 ± 0.7	87.81 ± 4.14

Continuation of Table 76.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
				$RR_{mean} =$	**85.29 ± 3.48**
$^{182m}Re_c$	c	12.7H	1221.5	24.8 ± 1.6	71.99 ± 5.44
			1189.2	15 ± 1	75.46 ± 6.03
			1121.4	31.8 ± 1.6	87.06 ± 5.42
				$RR_{mean} =$	**80.15 ± 5.47**
^{181}Re	c*	19.9H	639.0	6.4 ± 1.4	52.00 ± 11.67
			365.5	56 ± 8	50.56 ± 7.49
				$RR_{mean} =$	**50.91 ± 5.52**
^{175}Hf	c	70D	343.4	84 ± 3	**9.369 ± 0.479**
^{173}Lu	c	1.37Y	272.1	21.2 ± 0.8	**6.076 ± 0.607**
^{171}Lu	c*	8.24D	739.8	47.8 ± 1.2	**2.145 ± 0.219**
^{139}Ce	c	137.640D	165.9	79.89 ± 0.01	**0.7053 ± 0.0580**
^{127}Xe	c	36.4D	202.9	68.3 ± 0.5	2.349 ± 0.142
			172.1	25.5 ± 0.8	1.814 ± 0.314
				$RR_{mean} =$	**2.277 ± 0.195**
^{123m}Te	i(m)	119.7D	159.0	84.0 ± 0.4	**1.685 ± 0.085**
^{121m}Te	i(m)	154D	212.2	81.4 ± 1.1	**1.874 ± 0.103**
$^{121}Te_c$	c	19.16D	573.1	80.3 ± 2.5	**2.656 ± 0.159**
^{120m}Sb	i(m)	5.76D	1023.3	99.4 ± 0.3	2.076 ± 0.095
			197.3	87.0 ± 1.1	2.525 ± 0.118
				$RR_{mean} =$	**2.249 ± 0.230**
^{113}Sn	c	115.09D	391.7	64.97 ± 0.17	**1.440 ± 0.165**
^{114m}In	i(m)	49.51D	190.3	15.56 ± 0.16	**5.900 ± 0.426**
^{110m}Ag	i(m)	249.76D	937.5	34.2 ± 0.6	6.838 ± 0.437
			884.7	72.7 ± 0.4	6.741 ± 0.292
			657.8	94.3 ± 0.3	6.517 ± 0.320
				$RR_{mean} =$	**6.678 ± 0.252**
^{106m}Ag	i(m)	8.28D	1045.8	29.6 ± 1.0	1.662 ± 0.218
			717.3	28.9 ± 0.8	1.049 ± 0.294
			451.0	28.2 ± 0.8	1.946 ± 0.170
				$RR_{mean} =$	**1.717 ± 0.230**
^{105}Rh	c	35.36H	318.9	19.1 ± 0.6	**24.59 ± 1.40**
^{102}Rh	i	207D	475.1	46 ± 5	**2.464 ± 0.529**
^{101m}Rh	c	4.34D	306.9	81 ± 5	**2.952 ± 0.287**
^{103}Ru	c	39.26D	497.1	91.0 ± 1.3	**23.60 ± 0.90**
^{96}Tc	i(m+g)	4.28D	849.9	98 ± 4	2.121 ± 0.158
			812.5	82 ± 4	2.339 ± 0.155
				$RR_{mean} =$	**2.235 ± 0.129**
^{99}Mo	c	65.94H	140.5	90.27 ± 0.33	**24.27 ± 1.02**
^{96}Nb	i	23.35H	1091.3	48.5 ± 1.6	14.07 ± 0.69
			778.2	96.45 ± 0.22	13.66 ± 0.50
			568.9	58.0 ± 0.3	12.29 ± 0.67
			460.0	26.62 ± 0.20	12.97 ± 0.54
				$RR_{mean} =$	**13.36 ± 0.52**
$^{95}Nb_i$	i(m+g)	34.975D	765.8	99.81 ± 0.03	**15.38 ± 0.53**
$^{95}Nb_c$	c	34.975D	765.8	99.81 ± 0.03	**30.38 ± 1.01**
^{92m}Nb	i(m)	10.15D	934.4	99.07 ± 0.04	**1.344 ± 0.074**
^{97}Zr	c	16.744H	743.4	93.06 ± 0.16	**3.634 ± 0.303**
^{95}Zr	c	64.02D	765.8	*	15.13 ± 0.53
			756.7	54.46 ± 0.10	14.51 ± 0.62

Continuation of Table 76.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			724.2	44.17 ± 0.16	15.22 ± 0.72
				RR_{mean} =	**15.01 ± 0.46**
^{89}Zr	c	78.41H	909.2	99.04 ± 0.03	**4.075 ± 0.155**
^{88}Zr	c	83.4D	898.0	*	0.9535 ± 0.6036
			1836.1	*	0.8760 ± 0.4233
			392.9	97.24 ± 0.00	1.289 ± 0.161
				RR_{mean} =	**1.223 ± 0.038**
^{90m} Y	i(m)	3.19H	479.5	90.74 ± 0.05	**15.25 ± 0.67**
^{88} Y_i	i	106.65D	1836.1	99.2 ± 0.3	9.381 ± 0.573
			898.0	93.7 ± 0.3	8.758 ± 0.606
				RR_{mean} =	**9.098 ± 0.461**
^{88} Y_c	c	106.65D	1836.1	99.2 ± 0.3	10.26 ± 0.39
			898.0	93.7 ± 0.3	9.711 ± 0.462
				RR_{mean} =	**10.09 ± 0.40**
^{87} Y	c*	79.8H	484.8	89.7 ± 0.7	**5.159 ± 0.207**
^{85}Sr	c	64.84D	514.0	96 ± 4	**5.839 ± 0.352**
^{86}Rb	i(m+g)	18.631D	1077.0	8.64 ± 0.04	**20.28 ± 1.14**
^{84}Rb	i(m+g)	32.77D	881.6	69.0 ± 1.6	**15.37 ± 0.97**
^{83}Rb	c	86.2D	552.6	16.0 ± 1.1	6.520 ± 0.982
			529.6	29.3 ± 2.1	6.507 ± 0.622
			520.4	45 ± 4	6.871 ± 0.726
				RR_{mean} =	**6.631 ± 0.398**
^{82}Br	i(m+g)	35.30H	1317.5	26.5 ± 0.4	9.591 ± 0.888
			776.5	83.5 ± 1.2	10.12 ± 0.40
			698.4	28.5 ± 0.4	9.931 ± 0.458
			554.3	70.8 ± 1.0	9.394 ± 0.432
				RR_{mean} =	**9.861 ± 0.351**
^{75}Se	c	119.779D	264.7	58.9 ± 0.4	1.592 ± 0.112
			136.0	58.3 ± 0.8	1.492 ± 0.101
				RR_{mean} =	**1.536 ± 0.082**
^{74}As	i	17.77D	595.8	59 ± 4	**3.505 ± 0.287**
^{72}Ga$_i$	i	14.10H	2201.7	25.9 ± 0.5	**3.745 ± 0.732**
^{72}Ga$_c$	c	14.10H	2201.7	25.9 ± 0.5	**5.951 ± 0.658**
^{72}Zn	c	46.5H	2201.7	*	**2.207 ± 0.266**
^{59}Fe	c	44.472D	1291.6	43.2 ± 1.4	2.157 ± 0.605
			1099.2	56.5 ± 1.9	1.416 ± 0.335
				RR_{mean} =	**1.589 ± 0.317**

12.6.3 Nuclide production rates for ^{208}Pb

Table 77: Detailed calculation of nuclide production rates for ^{208}Pb for E_p = 0.4 GeV, used to determine the cross sections for their production.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{207}Bi	i	31.55Y	569.7	97.74 ± 0.03	**37.82 ± 3.73**
^{206}Bi	i	6.243D	1718.7	31.8 ± 0.6	57.67 ± 2.29
			1098.3	13.50 ± 0.21	50.17 ± 2.75
			895.1	15.66 ± 0.23	58.91 ± 2.40
			881.0	66.2 ± 1.0	53.85 ± 2.20

Continuation of Table 77.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			803.1	98.9 ± 1.4	52.30 ± 1.90
			620.5	5.76 ± 0.09	52.31 ± 2.92
			537.5	30.5 ± 0.5	48.63 ± 1.97
			516.2	40.7 ± 0.6	50.89 ± 1.95
			497.1	15.31 ± 0.22	47.38 ± 2.16
			398.0	10.74 ± 0.15	48.96 ± 1.87
			343.5	23.4 ± 0.4	49.50 ± 1.95
			184.0	15.8 ± 0.4	60.70 ± 2.94
				RR_{mean} =	**51.87 ± 1.93**
^{205}Bi	i	15.31D	1861.7	6.17 ± 0.10	78.91 ± 3.88
			1775.8	3.99 ± 0.08	74.75 ± 3.76
			1764.3	32.5 ± 0.7	79.72 ± 3.27
			1614.3	2.28 ± 0.04	83.85 ± 5.95
			1190.0	2.26 ± 0.07	78.23 ± 5.75
			1043.8	7.51 ± 0.10	69.96 ± 2.91
			703.5	31.1 ± 0.1	74.11 ± 2.48
			570.6	4.34 ± 0.07	76.71 ± 4.15
				RR_{mean} =	**74.83 ± 2.56**
^{204}Bi	i	11.22H	984.0	59 ± 4	70.65 ± 5.38
			918.3	10.8 ± 0.9	85.33 ± 8.15
			899.2	98 ± 9	67.04 ± 2.26
			670.7	11.4 ± 0.9	70.74 ± 6.31
			374.8	82 ± 5	73.40 ± 15.35
				RR_{mean} =	**67.33 ± 2.08**
^{203}Bi	i(m+g)	11.76H	1893.0	8.2 ± 0.6	75.21 ± 7.34
			1847.3	11.4 ± 0.8	79.29 ± 6.60
			1679.6	8.8 ± 0.7	78.34 ± 7.81
			896.8	13.1 ± 0.7	81.72 ± 5.96
			820.2	29.6 ± 1.5	78.41 ± 5.08
				RR_{mean} =	**78.93 ± 2.88**
^{202}Bi	i	1.72H	960.7	99.28 ± 0.02	57.88 ± 3.41
			422.1	83.7 ± 2.5	60.87 ± 5.21
				RR_{mean} =	**58.67 ± 3.08**
^{204m}Pb$_i$	i(m)	67.2M	899.2	99.17 ± 0.02	106.2 ± 3.9
			374.7	89 ± 15	129.8 ± 22.5
				RR_{mean} =	**106.5 ± 4.0**
^{204m}Pb$_c$	c	67.2M	899.2	99.17 ± 0.02	116.3 ± 4.2
			374.7	89 ± 15	139.1 ± 24.0
				RR_{mean} =	**116.5 ± 4.2**
^{203}Pb	c*	51.873H	401.3	3.35 ± 0.07	334.2 ± 14.7
			279.2	80.8 ± 0.2	352.2 ± 12.9
				RR_{mean} =	**346.8 ± 13.5**
^{202m}Pb	i(m)	3.53H	960.7	92 ± 8	108.3 ± 10.3
			459.7	8.6 ± 0.7	113.5 ± 11.5
			422.1	86 ± 5	123.8 ± 8.8
				RR_{mean} =	**118.9 ± 5.9**
^{201}Pb	c*	9.33H	1277.1	1.63 ± 0.12	348.2 ± 32.7
			1238.8	1.18 ± 0.08	299.8 ± 30.2
			1098.5	1.83 ± 0.12	308.9 ± 35.7
			946.0	7.4 ± 0.6	296.0 ± 26.4
			907.6	5.7 ± 0.4	341.8 ± 28.1

Continuation of Table 77.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			692.4	4.27 ± 0.16	296.0 ± 16.0
			331.2	79 ± 5	332.9 ± 23.9
				RR_{mean} =	**311.3 ± 12.7**
^{200}Pb	c	21.5H	1514.9	*	227.7 ± 22.7
			1407.6	*	276.0 ± 34.2
			1362.9	*	250.9 ± 31.3
			1225.5	*	242.8 ± 18.5
			1205.7	*	259.4 ± 18.2
			828.3	*	235.1 ± 20.7
			701.6	*	214.4 ± 26.1
			579.3	*	200.6 ± 15.7
			367.9	*	246.6 ± 8.6
			147.6	37.7 ± 1.4	269.9 ± 14.7
				RR_{mean} =	**246.6 ± 7.6**
^{199}Pb	c*	90M	1135.0	7.8 ± 1.2	416.4 ± 70.4
			366.9	44 ± 7	426.1 ± 70.2
			353.4	9.5 ± 1.5	466.9 ± 80.6
				RR_{mean} =	**432.4 ± 24.7**
^{198}Pb	c	2.4H	365.4	19 ± 5	508.3 ± 135.9
			865.3	5.9 ± 1.2	271.5 ± 58.4
			173.4	18 ± 3	373.2 ± 64.3
				RR_{mean} =	**365.3 ± 25.9**
^{197m}Pb	c*	43M	387.7	25 ± 6	275.9 ± 67.0
			385.9	74 ± 15	248.5 ± 51.2
			222.8	25 ± 6	226.1 ± 55.2
				RR_{mean} =	**248.2 ± 11.6**
^{196}Pb	c*	37M	502.1	26 ± 3	**262.9 ± 32.2**
^{195m}Pb	i(m)	15.0M	394.2	44 ± 8	136.4 ± 25.6
			383.6	107 ± 20	133.6 ± 25.5
				RR_{mean} =	**135.4 ± 5.7**
^{202}Tl	c	12.23D	439.6	91.4 ± 1.0	**149.9 ± 5.4**
^{201}Tl	c*	72.912H	167.4	10.00 ± 0.06	**538.5 ± 20.0**
^{200}Tl$_i$	i	26.1H	1514.9	4.0 ± 0.3	268.9 ± 28.8
			1407.6	1.45 ± 0.13	320.8 ± 50.8
			1362.9	3.4 ± 0.4	282.6 ± 36.4
			1225.5	3.36 ± 0.21	245.2 ± 21.3
			1205.7	29.9 ± 1.8	208.1 ± 16.3
			828.3	10.8 ± 0.7	318.0 ± 28.2
			701.6	1.29 ± 0.10	284.6 ± 42.2
			579.3	13.8 ± 0.7	311.5 ± 30.7
			367.9	87.2 ± 0.4	213.2 ± 9.0
				RR_{mean} =	**226.9 ± 13.0**
^{200}Tl$_c$	c	26.1H	1514.9	4.0 ± 0.3	496.6 ± 41.9
			1407.6	1.45 ± 0.13	596.8 ± 61.3
			1362.9	3.4 ± 0.4	533.5 ± 65.5
			1225.5	3.36 ± 0.21	488.0 ± 35.2
			1205.7	29.9 ± 1.8	467.5 ± 32.5
			828.3	10.8 ± 0.7	553.1 ± 40.9
			701.6	1.29 ± 0.10	498.9 ± 46.0
			579.3	13.8 ± 0.7	512.1 ± 34.5
			367.9	87.2 ± 0.4	459.8 ± 15.9

Continuation of Table 77.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
				RR_{mean} =	**469.5 ± 16.8**
^{199}Tl	c*	7.42H	247.3	9.3 ± 1.1	518.6 ± 65.2
			208.2	12.3 ± 1.4	558.9 ± 68.0
			158.4	5.0 ± 0.6	679.2 ± 90.0
				RR_{mean} =	**564.0 ± 43.6**
^{198m}Tl	i(m)	1.87H	587.2	52.5 ± 2.0	184.8 ± 13.7
			282.8	28 ± 3	211.9 ± 24.4
				RR_{mean} =	**189.7 ± 12.0**
^{197}Tl	c*	2.84H	1411.3	4.5 ± 1.5	471.7 ± 159.8
			152.2	7.3 ± 2.3	722.9 ± 229.8
			134.0	2.0 ± 0.7	690.9 ± 254.9
				RR_{mean} =	**627.9 ± 86.7**
^{196m}Tl	i(m)	1.41H	695.4	41 ± 7	**364.3 ± 63.6**
^{195}Tl	c*	1.16H	884.5	10.0 ± 1.1	**356.7 ± 45.3**
^{203}Hg	c	46.612D	279.2	81.46 ± 0.13	**21.45 ± 0.81**
^{197}Hg	c*	64.14H	191.4	0.63 ± 0.02	**654.5 ± 37.9**
^{197m}Hg	i(m)	23.8H	134.0	33.5 ± 0.4	**87.66 ± 3.98**
^{195m}Hg	i(m)	41.6H	779.8	54.2 ± 0.1	91.10 ± 18.71
			560.3	7.0 ± 0.6	102.3 ± 9.9
			261.8	31 ± 4	113.1 ± 15.2
				RR_{mean} =	**101.7 ± 3.1**
^{195}Hg$_c$	c	9.9H	779.8	6.8 ± 0.7	**471.6 ± 52.0**
^{193m}Hg	i(m)	11.8H	573.2	26 ± 4	82.34 ± 13.09
			407.6	32 ± 6	113.5 ± 21.7
				RR_{mean} =	**90.59 ± 14.03**
^{192}Hg	c	4.85H	2335.7	*	335.7 ± 77.0
			2236.9	*	342.1 ± 58.8
			316.5	*	420.3 ± 53.0
			296.0	*	394.7 ± 56.7
			274.8	50.2 ± 2.5	325.5 ± 20.7
				RR_{mean} =	**335.0 ± 10.3**
^{190}Hg	c*	20.0M	301.8	*	207.0 ± 32.9
			295.8	*	222.3 ± 18.7
			142.6	68 ± 10	218.2 ± 33.5
				RR_{mean} =	**219.8 ± 6.8**
^{198m}Au	i(m)	2.27D	204.1	40.8 ± 2.4	4.006 ± 0.334
			411.8	*	4.092 ± 0.247
				RR_{mean} =	**4.065 ± 0.125**
^{198}Au$_i$	i	2.69517D	411.8	95.58 ± 0.12	**7.137 ± 0.405**
^{198}Au$_c$	i(m+g)	2.69517D	411.8	95.58 ± 0.12	**11.23 ± 0.41**
^{196}Au	i(m1+m2+g)	6.183D	426.1	6.6 ± 0.8	21.78 ± 2.87
			355.7	87.0 ± 0.8	21.21 ± 0.75
			333.0	22.9 ± 0.6	20.51 ± 1.02
				RR_{mean} =	**21.12 ± 0.71**
^{195}Au	c	186.098D	129.8	0.82 ± 0.05	**600.3 ± 48.3**
^{194}Au	i(m1+m2+g)	38.02H	328.5	61 ± 5	37.66 ± 3.35
			293.6	10.4 ± 0.8	36.38 ± 3.27
				RR_{mean} =	**37.01 ± 2.11**
^{192}Au$_i$	i(m+g)	4.94H	2236.9	5.6 ± 0.9	49.66 ± 31.02
			316.5	58 ± 7	58.37 ± 8.88

Continuation of Table 77.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			296.0	22 ± 3	111.7 ± 29.4
				RR_{mean} =	**60.15 ± 7.53**
$^{192}Au_c$	c	4.94H	2236.9	5.6 ± 0.9	391.8 ± 67.4
			316.5	58 ± 7	478.6 ± 60.2
			296.0	22 ± 3	506.4 ± 72.9
				RR_{mean} =	**475.9 ± 22.0**
^{191}Au	c*	3.18H	586.4	17 ± 0	313.1 ± 20.5
			293.5	2.84 ± 0.19	349.9 ± 37.8
			166.5	3.32 ± 0.24	486.0 ± 52.5
				RR_{mean} =	**336.0 ± 37.1**
$^{190}Au_c$	c	42.8M	301.8	23.4 ± 1.5	275.2 ± 23.5
			295.8	71 ± 5	269.8 ± 21.4
				RR_{mean} =	**271.9 ± 12.9**
^{191}Pt	c	2.802D	538.9	13.7 ± 1.6	328.6 ± 40.1
			456.5	3.4 ± 0.4	293.8 ± 36.2
			409.4	8.0 ± 0.9	292.4 ± 34.4
			351.2	3.4 ± 0.4	360.6 ± 45.1
			172.2	3.5 ± 0.4	319.1 ± 38.4
				RR_{mean} =	**312.7 ± 15.0**
^{189}Pt	c	10.87H	721.4	9.3 ± 0.8	367.6 ± 34.6
			607.6	8.10 ± 0.16	284.4 ± 13.4
			568.8	7.1 ± 0.6	305.0 ± 29.3
			544.9	5.8 ± 0.5	302.4 ± 29.2
			243.5	7.0 ± 1.2	276.2 ± 48.7
				RR_{mean} =	**293.4 ± 14.0**
^{188}Pt	c	10.2D	1209.8	*	246.5 ± 26.3
			634.9	*	243.9 ± 40.0
			633.0	*	257.8 ± 43.8
			478.0	*	231.6 ± 12.5
			423.3	4.4 ± 0.3	238.1 ± 18.3
			381.4	7.5 ± 0.5	225.9 ± 16.9
			322.9	*	202.3 ± 20.3
			195.1	18.6 ± 1.2	228.5 ± 17.1
			187.6	19.4 ± 1.2	235.4 ± 17.0
			155.1	*	243.5 ± 25.9
			140.4	2.33 ± 0.15	252.8 ± 20.0
				RR_{mean} =	**233.0 ± 7.2**
^{187}Pt	c	2.35H	304.8	4.3 ± 1.0	175.4 ± 44.8
			106.4	8.8 ± 1.8	160.5 ± 35.1
				RR_{mean} =	**163.0 ± 12.0**
^{186}Pt	c	2.08H	689.4	70 ± 15	**148.8 ± 32.4**
^{184}Pt	c	17.3M	548.3	23 ± 4	**103.9 ± 19.3**
^{192}Ir	i(m1+g)	73.827D	316.5	82.71 ± 0.21	**0.4294 ± 0.1154**
^{190}Ir	i(m1+g)	11.78D	605.1	39.9 ± 1.9	**2.172 ± 0.271**
^{189}Ir	c	13.2D	275.9	0.54 ± 0.07	238.7 ± 33.0
			245.1	6.0 ± 0.6	242.0 ± 26.0
				RR_{mean} =	**241.7 ± 9.5**
$^{188}Ir_i$	i	41.5H	633.0	18 ± 3	17.01 ± 3.33
			478.0	14.7 ± 0.6	9.148 ± 3.084
			155.1	30 ± 3	7.416 ± 1.612

Continuation of Table 77.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
				RR_{mean} =	**9.238 ± 2.442**
$^{188}Ir_c$	c	41.5H	634.9	5.0 ± 0.8	250.8 ± 41.2
			633.0	18 ± 3	274.8 ± 46.7
			478.0	14.7 ± 0.6	240.7 ± 13.1
			322.9	1.62 ± 0.15	204.2 ± 20.9
			155.1	30 ± 3	250.9 ± 26.7
				RR_{mean} =	**239.5 ± 8.7**
^{187}Ir	c*	10.5H	977.5	3.14 ± 0.11	**242.4 ± 14.0**
^{186}Ir	c	16.64H	773.3	8.9 ± 0.5	72.96 ± 5.25
			434.8	33.9 ± 1.1	80.16 ± 3.93
			137.2	41.4 ± 0.7	88.31 ± 4.04
				RR_{mean} =	**82.46 ± 4.73**
^{185}Ir	c	14.4H	1829.0	10.1 ± 1.5	109.2 ± 16.8
			254.2	13.3 ± 2.4	97.76 ± 18.23
				RR_{mean} =	**107.2 ± 5.8**
^{184}Ir	c*	3.09H	841.3	8.0 ± 0.8	87.33 ± 16.67
			264.0	68 ± 4	116.5 ± 8.3
			119.8	31 ± 3	120.1 ± 13.1
				RR_{mean} =	**115.6 ± 5.5**
^{183}Ir	c	57M	392.5	10.4 ± 2.4	**116.9 ± 29.7**
^{185}Os	c	93.6D	880.5	5.17 ± 0.21	139.9 ± 8.9
			874.8	6.29 ± 0.25	144.8 ± 8.2
			717.4	3.94 ± 0.16	143.4 ± 8.6
			646.1	78 ± 3	137.4 ± 7.1
				RR_{mean} =	**139.4 ± 4.6**
^{183m}Os	c*	9.9H	1107.9	22.4 ± 0.6	55.69 ± 2.79
			1101.9	49.0 ± 1.3	54.71 ± 2.54
				RR_{mean} =	**55.08 ± 2.00**
^{182}Os	c	22.10H	1221.5	*	85.97 ± 6.36
			1189.2	*	87.53 ± 6.82
			1121.4	*	81.99 ± 5.12
			180.2	33.5 ± 1.7	81.16 ± 5.26
				RR_{mean} =	**82.73 ± 2.55**
^{180}Os	c	21.5M	902.8(D)	101.5 ± 3.4	**41.30 ± 2.51**
^{183}Re	c	70.0D	291.7	3.05 ± 0.18	90.40 ± 7.62
			208.8	2.95 ± 0.09	89.06 ± 5.76
			162.3	23.3 ± 0.7	97.01 ± 4.64
				RR_{mean} =	**94.34 ± 3.87**
$^{182m}Re_c$	c	12.7H	1221.5	24.8 ± 1.6	82.16 ± 6.33
			1189.2	15 ± 1	85.70 ± 7.01
			1121.4	31.8 ± 1.6	96.06 ± 6.10
				RR_{mean} =	**89.81 ± 5.26**
^{181}Re	c*	19.9H	639.0	6.4 ± 1.4	53.36 ± 12.12
			365.5	56 ± 8	56.72 ± 8.39
				RR_{mean} =	**55.81 ± 6.06**
^{175}Hf	c	70D	343.4	84 ± 3	**8.525 ± 0.455**
^{173}Lu	c	1.37Y	272.1	21.2 ± 0.8	**4.787 ± 0.760**
^{171}Lu	c*	8.24D	739.8	47.8 ± 1.2	**2.166 ± 0.291**
^{139}Ce	c	137.640D	165.9	79.89 ± 0.01	**0.9961 ± 0.0753**
^{127}Xe	c	36.4D	202.9	68.3 ± 0.5	2.638 ± 0.124

Continuation of Table 77.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			172.1	25.5 ± 0.8	2.701 ± 0.269
				$RR_{mean} =$	**2.646 ± 0.119**
^{124}Sb	i(m1+m2+g)	60.20D	602.7	98.3 ± 0.4	**0.7831 ± 0.0811**
^{123m}Te	i(m)	119.7D	159.0	84.0 ± 0.4	**2.222 ± 0.105**
^{121m}Te	i(m)	154D	212.2	81.4 ± 1.1	1.903 ± 0.114
			573.1	88.6 ± 0.1	2.168 ± 0.305
				$RR_{mean} =$	**1.929 ± 0.060**
^{121}Te$_c$	c	19.16D	573.1	80.3 ± 2.5	**3.007 ± 0.258**
^{120m}Sb	i(m)	5.76D	1023.3	99.4 ± 0.3	2.519 ± 0.126
			197.3	87.0 ± 1.1	3.063 ± 0.158
				$RR_{mean} =$	**2.724 ± 0.277**
^{114m}In	i(m)	49.51D	190.3	15.56 ± 0.16	**6.535 ± 0.381**
^{110m}Ag	i(m)	249.76D	937.5	34.2 ± 0.6	7.413 ± 0.476
			884.7	72.7 ± 0.4	7.322 ± 0.321
			657.8	94.3 ± 0.3	7.592 ± 0.301
				$RR_{mean} =$	**7.475 ± 0.268**
^{106m}Ag	i(m)	8.28D	1045.8	29.6 ± 1.0	1.868 ± 0.221
			717.3	28.9 ± 0.8	1.351 ± 0.380
				$RR_{mean} =$	**1.744 ± 0.228**
^{105}Rh	c	35.36H	318.9	19.1 ± 0.6	**30.12 ± 1.50**
^{102}Rh	i	207D	475.1	46 ± 5	**2.557 ± 0.370**
^{101m}Rh	c	4.34D	306.9	81 ± 5	**2.906 ± 0.229**
^{103}Ru	c	39.26D	497.1	91.0 ± 1.3	**30.05 ± 1.16**
^{96}Tc	i(m+g)	4.28D	849.9	98 ± 4	1.626 ± 0.118
			812.5	82 ± 4	2.443 ± 0.212
				$RR_{mean} =$	**1.809 ± 0.345**
^{99}Mo	c	65.94H	140.5	90.27 ± 0.33	**29.48 ± 1.22**
^{96}Nb	i	23.35H	1091.3	48.5 ± 1.6	17.59 ± 0.98
			778.2	96.45 ± 0.22	16.89 ± 0.69
			568.9	58.0 ± 0.3	14.38 ± 0.74
			460.0	26.62 ± 0.20	15.99 ± 0.68
				$RR_{mean} =$	**16.14 ± 0.78**
^{95}Nb$_i$	i(m+g)	34.975D	765.8	99.81 ± 0.03	**17.96 ± 0.64**
^{95}Nb$_c$	c	34.975D	765.8	99.81 ± 0.03	**36.44 ± 1.23**
^{92m}Nb	i(m)	10.15D	934.4	99.07 ± 0.04	**1.968 ± 0.141**
^{97}Zr	c	16.744H	743.4	93.06 ± 0.16	**6.119 ± 0.281**
^{95}Zr	c	64.02D	765.8	*	18.65 ± 0.72
			756.7	54.46 ± 0.10	18.51 ± 0.74
			724.2	44.17 ± 0.16	19.06 ± 0.92
				$RR_{mean} =$	**18.66 ± 0.58**
^{89}Zr	c	78.41H	909.2	99.04 ± 0.03	**3.931 ± 0.216**
^{88}Zr	c	83.4D	1836.1	*	0.07931 ± 0.41611
			392.9	97.24 ± 0.00	1.180 ± 0.092
				$RR_{mean} =$	**1.137 ± 0.035**
^{90m} Y	i(m)	3.19H	479.5	90.74 ± 0.05	**19.37 ± 1.03**
^{88} Y$_i$	i	106.65D	1836.1	99.2 ± 0.3	10.46 ± 0.50
			898.0	93.7 ± 0.3	9.507 ± 0.600
				$RR_{mean} =$	**10.12 ± 0.55**
^{88} Y$_c$	c	106.65D	1836.1	99.2 ± 0.3	10.54 ± 0.44
			898.0	93.7 ± 0.3	10.09 ± 0.46

Continuation of Table 77.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
				RR_{mean} =	**10.35 ± 0.39**
^{87}Y	c*	79.8H	484.8	89.7 ± 0.7	**4.795 ± 0.195**
^{85}Sr	c	64.84D	514.0	96 ± 4	**6.274 ± 0.358**
^{86}Rb	i(m+g)	18.631D	1077.0	8.64 ± 0.04	**24.25 ± 1.21**
^{84}Rb	i(m+g)	32.77D	881.6	69.0 ± 1.6	**15.64 ± 1.19**
^{83}Rb	c	86.2D	552.6	16.0 ± 1.1	8.228 ± 0.820
			529.6	29.3 ± 2.1	7.088 ± 0.612
			520.4	45 ± 4	7.271 ± 0.754
				RR_{mean} =	**7.395 ± 0.397**
^{82}Br	i(m+g)	35.30H	1317.5	26.5 ± 0.4	12.06 ± 1.05
			776.5	83.5 ± 1.2	11.86 ± 0.47
			698.4	28.5 ± 0.4	11.37 ± 0.60
			554.3	70.8 ± 1.0	10.99 ± 0.62
				RR_{mean} =	**11.63 ± 0.42**
^{75}Se	c	119.779D	264.7	58.9 ± 0.4	1.512 ± 0.175
			136.0	58.3 ± 0.8	1.755 ± 0.173
				RR_{mean} =	**1.637 ± 0.132**
^{74}As	i	17.77D	595.8	59 ± 4	**3.886 ± 0.390**
^{72}Ga$_i$	i	14.10H	2201.7	25.9 ± 0.5	**6.416 ± 1.270**
^{72}Ga$_c$	c	14.10H	2201.7	25.9 ± 0.5	**8.561 ± 1.145**
^{72}Zn	c	46.5H	2201.7	*	**2.145 ± 0.371**
^{59}Fe	c	44.472D	1291.6	43.2 ± 1.4	1.880 ± 0.302
			1099.2	56.5 ± 1.9	1.658 ± 0.369
				RR_{mean} =	**1.792 ± 0.236**

12.6.4 Nuclide production rates for ^{nat}Pb

Table 78: Detailed calculation of nuclide production rates for ^{nat}Pb for $E_p = 0.4$ GeV, used to determine the cross sections for their production.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{207}Bi	i	31.55Y	569.7	97.74 ± 0.03	**27.86 ± 2.42**
^{206}Bi	i	6.243D	1718.7	31.8 ± 0.6	44.47 ± 1.78
			1098.3	13.50 ± 0.21	41.82 ± 1.83
			895.1	15.66 ± 0.23	47.79 ± 1.80
			881.0	66.2 ± 1.0	45.55 ± 1.66
			803.1	98.9 ± 1.4	42.20 ± 1.55
			620.5	5.76 ± 0.09	42.75 ± 1.88
			537.5	30.5 ± 0.5	39.79 ± 1.57
			516.2	40.7 ± 0.6	41.25 ± 1.57
			497.1	15.31 ± 0.22	40.38 ± 1.80
			398.0	10.74 ± 0.15	41.17 ± 1.62
			343.5	23.4 ± 0.4	41.24 ± 1.65
			184.0	15.8 ± 0.4	46.49 ± 2.24
				RR_{mean} =	**42.80 ± 1.51**
^{205}Bi	i	15.31D	1764.3	32.5 ± 0.7	74.12 ± 3.08
			1614.3	2.28 ± 0.04	79.67 ± 4.10
			1190.0	2.26 ± 0.07	70.65 ± 3.78
			1043.8	7.51 ± 0.10	66.18 ± 2.70

Continuation of Table 78.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			703.5	31.1 ± 0.1	69.47 ± 2.35
			570.6	4.34 ± 0.07	69.57 ± 3.20
				RR_{mean} =	**70.02 ± 2.53**
^{204}Bi	i	11.22H	984.0	59 ± 4	74.68 ± 5.79
			918.3	10.8 ± 0.9	91.91 ± 9.38
			899.2	98 ± 9	69.36 ± 2.32
			670.7	11.4 ± 0.9	75.27 ± 6.87
			374.8	82 ± 5	78.84 ± 16.47
				RR_{mean} =	**69.67 ± 2.15**
^{203}Bi	i(m+g)	11.76H	1893.0	8.2 ± 0.6	85.39 ± 8.07
			1847.3	11.4 ± 0.8	85.64 ± 7.27
			1679.6	8.8 ± 0.7	81.78 ± 7.52
			896.8	13.1 ± 0.7	90.85 ± 6.22
			820.2	29.6 ± 1.5	84.17 ± 5.22
				RR_{mean} =	**85.28 ± 2.92**
^{202}Bi	i	1.72H	960.7	99.28 ± 0.02	64.43 ± 3.88
			422.1	83.7 ± 2.5	69.04 ± 8.21
				RR_{mean} =	**65.12 ± 3.67**
$^{204m}Pb_i$	i(m)	67.2M	899.2	99.17 ± 0.02	111.3 ± 3.9
			374.7	89 ± 15	132.3 ± 22.8
				RR_{mean} =	**111.5 ± 3.9**
$^{204m}Pb_c$	c	67.2M	899.2	99.17 ± 0.02	121.7 ± 4.2
			374.7	89 ± 15	142.2 ± 24.5
				RR_{mean} =	**121.9 ± 4.2**
^{203}Pb	c*	51.873H	401.3	3.35 ± 0.07	403.4 ± 16.7
			279.2	80.8 ± 0.2	406.0 ± 14.9
				RR_{mean} =	**405.1 ± 14.1**
^{202m}Pb	i(m)	3.53H	960.7	92 ± 8	111.4 ± 10.7
			459.7	8.6 ± 0.7	112.9 ± 12.5
			422.1	86 ± 5	122.5 ± 9.5
				RR_{mean} =	**117.7 ± 5.7**
^{201}Pb	c*	9.33H	1277.1	1.63 ± 0.12	369.7 ± 37.5
			1238.8	1.18 ± 0.08	382.7 ± 38.6
			1098.5	1.83 ± 0.12	376.9 ± 36.6
			946.0	7.4 ± 0.6	342.4 ± 30.4
			907.6	5.7 ± 0.4	396.1 ± 32.6
			692.4	4.27 ± 0.16	348.2 ± 21.5
			331.2	79 ± 5	384.3 ± 27.7
				RR_{mean} =	**366.6 ± 15.4**
^{200}Pb	c	21.5H	1514.9	*	286.0 ± 26.8
			1407.6	*	306.4 ± 36.6
			1362.9	*	321.4 ± 40.7
			1225.5	*	287.5 ± 21.9
			1205.7	*	312.3 ± 21.6
			828.3	*	308.1 ± 23.8
			701.6	*	269.3 ± 25.7
			579.3	*	287.7 ± 18.5
			367.9	*	283.1 ± 10.3
			147.6	37.7 ± 1.4	315.6 ± 18.5
				RR_{mean} =	**289.0 ± 8.9**
^{199}Pb	c*	90M	1135.0	7.8 ± 1.2	480.8 ± 77.7

Continuation of Table 78.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			366.9	44 ± 7	537.2 ± 88.9
			353.4	9.5 ± 1.5	505.4 ± 86.3
				RR_{mean} =	**503.3 ± 27.3**
^{198}Pb	c	2.4H	865.3	5.9 ± 1.2	343.7 ± 74.4
			365.4	19 ± 5	482.4 ± 129.4
			173.4	18 ± 3	441.6 ± 76.1
				RR_{mean} =	**434.3 ± 23.6**
^{197m}Pb	c*	43M	387.7	25 ± 6	306.6 ± 74.5
			385.9	74 ± 15	294.9 ± 60.9
			222.8	25 ± 6	259.9 ± 64.4
				RR_{mean} =	**292.7 ± 14.3**
^{196}Pb	c*	37M	502.1	26 ± 3	**293.0 ± 37.0**
^{195m}Pb	i(m)	15.0M	394.2	44 ± 8	160.4 ± 29.9
			383.6	107 ± 20	141.7 ± 27.2
				RR_{mean} =	**155.3 ± 9.6**
^{202}Tl	c	12.23D	439.6	91.4 ± 1.0	**156.9 ± 5.6**
^{201}Tl	c*	72.912H	167.4	10.00 ± 0.06	**617.1 ± 23.3**
^{200}Tl$_i$	i	26.1H	1514.9	4.0 ± 0.3	269.9 ± 29.5
			1407.6	1.45 ± 0.13	344.5 ± 55.9
			1362.9	3.4 ± 0.4	243.3 ± 35.4
			1225.5	3.36 ± 0.21	254.6 ± 23.2
			1205.7	29.9 ± 1.8	208.6 ± 14.8
			828.3	10.8 ± 0.7	296.2 ± 24.3
			701.6	1.29 ± 0.10	344.0 ± 36.9
			579.3	13.8 ± 0.7	252.2 ± 17.8
			367.9	87.2 ± 0.4	233.9 ± 10.8
				RR_{mean} =	**242.3 ± 12.6**
^{200}Tl$_c$	c	26.1H	1514.9	4.0 ± 0.3	555.8 ± 46.7
			1407.6	1.45 ± 0.13	650.9 ± 67.7
			1362.9	3.4 ± 0.4	564.7 ± 69.8
			1225.5	3.36 ± 0.21	542.1 ± 39.2
			1205.7	29.9 ± 1.8	520.9 ± 35.8
			828.3	10.8 ± 0.7	604.4 ± 44.2
			701.6	1.29 ± 0.10	613.3 ± 53.1
			579.3	13.8 ± 0.7	539.9 ± 33.3
			367.9	87.2 ± 0.4	517.0 ± 18.2
				RR_{mean} =	**528.1 ± 18.7**
^{199}Tl	c*	7.42H	247.3	9.3 ± 1.1	609.4 ± 76.4
			208.2	12.3 ± 1.4	636.0 ± 77.6
			158.4	5.0 ± 0.6	774.9 ± 101.5
				RR_{mean} =	**651.9 ± 47.3**
^{198m}Tl	i(m)	1.87H	587.2	52.5 ± 2.0	155.0 ± 14.2
			282.8	28 ± 3	231.8 ± 26.7
				RR_{mean} =	**170.4 ± 31.2**
^{197}Tl	c*	2.84H	1411.3	4.5 ± 1.5	545.4 ± 185.5
			152.2	7.3 ± 2.3	814.6 ± 259.3
			134.0	2.0 ± 0.7	791.1 ± 289.0
				RR_{mean} =	**717.7 ± 92.6**
^{196m}Tl	i(m)	1.41H	695.4	41 ± 7	**401.9 ± 70.2**
^{195}Tl	c*	1.16H	884.5	10.0 ± 1.1	**375.4 ± 45.7**

Continuation of Table 78.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{203}Hg	c	46.612D	279.2	81.46 ± 0.13	**17.60 ± 0.65**
^{197}Hg	c*	64.14H	191.4	0.63 ± 0.02	**715.8 ± 38.9**
^{197m}Hg	i(m)	23.8H	134.0	33.5 ± 0.4	**89.05 ± 4.84**
^{195m}Hg	i(m)	41.6H	779.8	54.2 ± 0.1	106.2 ± 21.7
			560.3	7.0 ± 0.6	113.8 ± 10.8
			261.8	31 ± 4	119.2 ± 16.1
				RR_{mean} =	**113.3 ± 3.5**
^{195}Hg$_c$	c	9.9H	779.8	6.8 ± 0.7	**522.4 ± 57.8**
^{193m}Hg	i(m)	11.8H	573.2	26 ± 4	89.52 ± 14.18
			407.6	32 ± 6	124.1 ± 23.7
			258.0	49 ± 7	183.1 ± 27.3
				RR_{mean} =	**112.6 ± 24.6**
^{192}Hg	c	4.85H	2335.7	*	505.9 ± 97.7
			2236.9	*	402.3 ± 68.2
			316.5	*	483.0 ± 60.8
			296.0	*	484.0 ± 68.6
			274.8	50.2 ± 2.5	382.2 ± 24.2
				RR_{mean} =	**393.5 ± 12.1**
^{190}Hg	c*	20.0M	301.8	*	327.4 ± 52.4
			295.8	*	261.1 ± 30.7
			142.6	68 ± 10	256.4 ± 40.2
				RR_{mean} =	**268.2 ± 8.3**
^{198m}Au	i(m)	2.27D	204.1	40.8 ± 2.4	3.997 ± 0.378
			411.8	*	3.121 ± 0.167
				RR_{mean} =	**3.231 ± 0.100**
^{198}Au$_i$	i	2.69517D	411.8	95.58 ± 0.12	**7.597 ± 0.363**
^{198}Au$_c$	i(m+g)	2.69517D	411.8	95.58 ± 0.12	**10.72 ± 0.39**
^{196}Au	i(m1+m2+g)	6.183D	426.1	6.6 ± 0.8	20.42 ± 2.73
			355.7	87.0 ± 0.8	20.39 ± 0.71
			333.0	22.9 ± 0.6	20.40 ± 0.90
				RR_{mean} =	**20.39 ± 0.68**
^{195}Au	c	186.098D	129.8	0.82 ± 0.05	769.5 ± 62.7
			98.9	10.9 ± 0.9	710.1 ± 75.9
				RR_{mean} =	**751.9 ± 40.6**
^{194}Au	i(m1+m2+g)	38.02H	328.5	61 ± 5	39.83 ± 3.54
			293.6	10.4 ± 0.8	37.96 ± 3.34
				RR_{mean} =	**38.83 ± 2.19**
^{192}Au$_i$	i(m+g)	4.94H	2236.9	5.6 ± 0.9	50.47 ± 27.49
			316.5	58 ± 7	58.60 ± 8.30
			296.0	22 ± 3	93.99 ± 20.56
				RR_{mean} =	**60.34 ± 6.06**
^{192}Au$_c$	c	4.94H	2236.9	5.6 ± 0.9	452.8 ± 76.9
			316.5	58 ± 7	541.6 ± 68.0
			296.0	22 ± 3	578.0 ± 82.0
				RR_{mean} =	**540.0 ± 24.0**
^{191}Au	c*	3.18H	586.4	17 ± 0	436.5 ± 32.8
			293.5	2.84 ± 0.19	381.4 ± 35.4
			166.5	3.32 ± 0.24	477.8 ± 45.3
				RR_{mean} =	**426.0 ± 28.9**
^{190}Au$_c$	c	42.8M	301.8	23.4 ± 1.5	299.2 ± 31.1

Continuation of Table 78.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			295.8	71 ± 5	316.4 ± 26.7
				RR_{mean} =	**310.7 ± 17.0**
^{191}Pt	c	2.802D	538.9	13.7 ± 1.6	395.8 ± 48.2
			456.5	3.4 ± 0.4	359.3 ± 44.3
			409.4	8.0 ± 0.9	358.3 ± 42.2
			351.2	3.4 ± 0.4	411.7 ± 50.6
			172.2	3.5 ± 0.4	398.2 ± 48.2
				RR_{mean} =	**380.7 ± 16.1**
^{189}Pt	c	10.87H	721.4	9.3 ± 0.8	406.9 ± 37.9
			607.6	8.10 ± 0.16	351.7 ± 14.5
			568.8	7.1 ± 0.6	370.4 ± 35.6
			544.9	5.8 ± 0.5	368.5 ± 34.7
			243.5	7.0 ± 1.2	356.5 ± 62.8
				RR_{mean} =	**357.1 ± 13.8**
^{188}Pt	c	10.2D	1209.8	*	290.5 ± 31.0
			634.9	*	298.3 ± 48.8
			633.0	*	308.0 ± 52.4
			478.0	*	275.8 ± 14.8
			423.3	4.4 ± 0.3	284.4 ± 21.7
			381.4	7.5 ± 0.5	271.6 ± 20.3
			322.9	*	258.0 ± 25.8
			195.1	18.6 ± 1.2	277.1 ± 20.8
			187.6	19.4 ± 1.2	284.0 ± 20.6
			155.1	*	294.5 ± 31.4
			140.4	2.33 ± 0.15	312.7 ± 25.3
				RR_{mean} =	**279.8 ± 8.6**
^{187}Pt	c	2.35H	304.8	4.3 ± 1.0	166.6 ± 40.9
			106.4	8.8 ± 1.8	199.9 ± 44.3
				RR_{mean} =	**188.1 ± 16.9**
^{186}Pt	c	2.08H	689.4	70 ± 15	**177.9 ± 38.6**
^{184}Pt	c	17.3M	548.3	23 ± 4	**126.8 ± 24.3**
^{192}Ir	i(m1+g)	73.827D	316.5	82.71 ± 0.21	**0.5063 ± 0.0520**
^{190}Ir	i(m1+g)	11.78D	605.1	39.9 ± 1.9	1.606 ± 0.157
			518.5	34.0 ± 1.6	1.643 ± 0.204
				RR_{mean} =	**1.619 ± 0.124**
^{189}Ir	c	13.2D	275.9	0.54 ± 0.07	279.7 ± 39.1
			245.1	6.0 ± 0.6	314.1 ± 34.1
				RR_{mean} =	**310.2 ± 14.5**
^{188}Ir$_i$	i	41.5H	633.0	18 ± 3	15.23 ± 3.21
			478.0	14.7 ± 0.6	29.45 ± 2.30
			155.1	30 ± 3	18.80 ± 2.44
				RR_{mean} =	**23.80 ± 4.34**
^{188}Ir$_c$	c	41.5H	1209.8	6.9 ± 0.7	291.6 ± 31.2
			634.9	5.0 ± 0.8	308.6 ± 50.6
			633.0	18 ± 3	323.3 ± 55.0
			478.0	14.7 ± 0.6	305.3 ± 16.3
			322.9	1.62 ± 0.15	288.8 ± 29.9
			155.1	30 ± 3	313.3 ± 33.4
				RR_{mean} =	**304.8 ± 10.4**
^{187}Ir	c*	10.5H	977.5	3.14 ± 0.11	**308.1 ± 19.3**

Continuation of Table 78.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{186}Ir	c	16.64H	773.3	8.9 ± 0.5	109.6 ± 7.8
			434.8	33.9 ± 1.1	92.42 ± 4.62
			137.2	41.4 ± 0.7	110.3 ± 5.9
				RR_{mean} =	**100.4 ± 6.9**
^{185}Ir	c	14.4H	1829.0	10.1 ± 1.5	139.8 ± 21.6
			254.2	13.3 ± 2.4	115.6 ± 21.6
				RR_{mean} =	**134.8 ± 10.6**
^{184}Ir	c*	3.09H	841.3	8.0 ± 0.8	187.3 ± 24.0
			264.0	68 ± 4	152.9 ± 11.1
			119.8	31 ± 3	156.1 ± 18.0
				RR_{mean} =	**154.8 ± 7.0**
^{183}Ir	c	57M	392.5	10.4 ± 2.4	**118.3 ± 29.9**
^{185}Os	c	93.6D	880.5	5.17 ± 0.21	179.4 ± 9.9
			874.8	6.29 ± 0.25	171.8 ± 9.0
			717.4	3.94 ± 0.16	172.1 ± 9.6
			646.1	78 ± 3	171.9 ± 8.8
				RR_{mean} =	**172.8 ± 5.6**
^{183m}Os	c*	9.9H	1107.9	22.4 ± 0.6	68.67 ± 3.32
			1101.9	49.0 ± 1.3	70.02 ± 3.06
				RR_{mean} =	**69.59 ± 2.41**
^{182}Os	c	22.10H	1221.5	*	116.5 ± 8.6
			1189.2	*	116.4 ± 8.8
			1121.4	*	116.8 ± 7.2
			180.2	33.5 ± 1.7	106.7 ± 6.9
				RR_{mean} =	**112.0 ± 3.5**
^{180}Os	c	21.5M	902.8(D)	101.5 ± 3.4	**54.31 ± 3.64**
^{183}Re	c	70.0D	291.7	3.05 ± 0.18	111.8 ± 7.9
			208.8	2.95 ± 0.09	117.1 ± 6.4
			162.3	23.3 ± 0.7	125.2 ± 6.0
				RR_{mean} =	**120.4 ± 5.2**
^{182m}Re$_c$	c	12.7H	1221.5	24.8 ± 1.6	98.25 ± 7.54
			1189.2	15 ± 1	115.3 ± 8.9
			1121.4	31.8 ± 1.6	108.6 ± 7.7
				RR_{mean} =	**106.6 ± 5.8**
^{181}Re	c*	19.9H	639.0	6.4 ± 1.4	61.37 ± 14.22
			365.5	56 ± 8	77.44 ± 11.42
				RR_{mean} =	**72.16 ± 7.88**
^{175}Hf	c	70D	343.4	84 ± 3	**12.69 ± 0.64**
^{172}Hf	c	1.87Y	1093.6	*	**4.838 ± 0.395**
^{173}Lu	c	1.37Y	272.1	21.2 ± 0.8	**6.065 ± 0.499**
^{172}Lu$_c$	c	6.70D	1093.6	63 ± 3	**5.385 ± 0.420**
^{171}Lu	c*	8.24D	739.8	47.8 ± 1.2	**2.884 ± 0.198**
^{139}Ce	c	137.640D	165.9	79.89 ± 0.01	**1.249 ± 0.093**
^{127}Xe	c	36.4D	202.9	68.3 ± 0.5	3.183 ± 0.164
			172.1	25.5 ± 0.8	2.947 ± 0.283
				RR_{mean} =	**3.138 ± 0.151**
^{124}Sb	i(m1+m2+g)	60.20D	602.7	98.3 ± 0.4	**0.7493 ± 0.1054**
^{123m}Te	i(m)	119.7D	159.0	84.0 ± 0.4	**2.612 ± 0.113**
^{121m}Te	i(m)	154D	212.2	81.4 ± 1.1	2.868 ± 0.132
			573.1	88.6 ± 0.1	2.672 ± 0.164

Continuation of Table 78.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
				$RR_{mean} =$	**2.805 ± 0.087**
$^{121}Te_c$	c	19.16D	573.1	80.3 ± 2.5	**3.420 ± 0.175**
^{120m}Sb	i(m)	5.76D	1023.3	99.4 ± 0.3	3.461 ± 0.161
			197.3	87.0 ± 1.1	3.912 ± 0.191
				$RR_{mean} =$	**3.641 ± 0.247**
^{113}Sn	c	115.09D	391.7	64.97 ± 0.17	**1.482 ± 0.120**
^{114m}In	i(m)	49.51D	190.3	15.56 ± 0.16	**8.380 ± 0.550**
^{110m}Ag	i(m)	249.76D	937.5	34.2 ± 0.6	9.550 ± 0.478
			884.7	72.7 ± 0.4	9.034 ± 0.368
			657.8	94.3 ± 0.3	9.324 ± 0.335
				$RR_{mean} =$	**9.266 ± 0.314**
^{106m}Ag	i(m)	8.28D	1045.8	29.6 ± 1.0	2.448 ± 0.200
			717.3	28.9 ± 0.8	3.350 ± 0.364
			451.0	28.2 ± 0.8	2.161 ± 0.180
				$RR_{mean} =$	**2.409 ± 0.265**
^{105}Rh	c	35.36H	318.9	19.1 ± 0.6	**34.33 ± 1.73**
^{102}Rh	i	207D	475.1	46 ± 5	**2.705 ± 0.483**
^{101m}Rh	c	4.34D	306.9	81 ± 5	**3.704 ± 0.276**
^{103}Ru	c	39.26D	497.1	91.0 ± 1.3	**34.26 ± 1.28**
^{96}Tc	i(m+g)	4.28D	849.9	98 ± 4	3.243 ± 0.194
			812.5	82 ± 4	3.392 ± 0.232
				$RR_{mean} =$	**3.301 ± 0.165**
^{99}Mo	c	65.94H	140.5	90.27 ± 0.33	**32.90 ± 1.60**
^{96}Nb	i	23.35H	1091.3	48.5 ± 1.6	21.45 ± 1.05
			849.9	20.45 ± 0.20	24.81 ± 1.47
			778.2	96.45 ± 0.22	21.14 ± 0.77
			460.0	26.62 ± 0.20	20.50 ± 0.90
				$RR_{mean} =$	**21.25 ± 0.86**
$^{95}Nb_i$	i(m+g)	34.975D	765.8	99.81 ± 0.03	**21.90 ± 0.73**
$^{95}Nb_c$	c	34.975D	765.8	99.81 ± 0.03	**42.57 ± 1.40**
^{92m}Nb	i(m)	10.15D	934.4	99.07 ± 0.04	**1.798 ± 0.080**
^{97}Zr	c	16.744H	743.4	93.06 ± 0.16	**6.569 ± 0.405**
^{95}Zr	c	64.02D	765.8	*	20.86 ± 0.70
			756.7	54.46 ± 0.10	20.29 ± 0.71
			724.2	44.17 ± 0.16	21.80 ± 0.86
				$RR_{mean} =$	**20.83 ± 0.64**
^{89}Zr	c	78.41H	909.2	99.04 ± 0.03	**5.663 ± 0.228**
^{88}Zr	c	83.4D	1836.1	*	1.583 ± 0.383
			392.9	97.24 ± 0.00	1.993 ± 0.183
				$RR_{mean} =$	**1.922 ± 0.059**
^{90m}Y	i(m)	3.19H	479.5	90.74 ± 0.05	**25.76 ± 1.49**
$^{88}Y_i$	i	106.65D	1836.1	99.2 ± 0.3	12.48 ± 0.57
			898.0	93.7 ± 0.3	12.24 ± 0.47
				$RR_{mean} =$	**12.31 ± 0.45**
$^{88}Y_c$	c	106.65D	1836.1	99.2 ± 0.3	14.06 ± 0.53
			898.0	93.7 ± 0.3	13.59 ± 0.48
				$RR_{mean} =$	**13.76 ± 0.48**
^{87}Y	c*	79.8H	484.8	89.7 ± 0.7	**7.096 ± 0.274**
^{85}Sr	c	64.84D	514.0	96 ± 4	**7.686 ± 0.423**
^{86}Rb	i(m+g)	18.631D	1077.0	8.64 ± 0.04	**25.52 ± 1.27**

Continuation of Table 78.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{84}Rb	i(m+g)	32.77D	881.6	69.0 ± 1.6	**14.26 ± 0.70**
^{83}Rb	c	86.2D	552.6	16.0 ± 1.1	9.561 ± 0.840
			529.6	29.3 ± 2.1	8.814 ± 0.742
			520.4	45 ± 4	8.638 ± 0.902
				RR_{mean} =	**9.018 ± 0.439**
^{82}Br	i(m+g)	35.30H	1317.5	26.5 ± 0.4	15.40 ± 0.79
			776.5	83.5 ± 1.2	15.14 ± 0.57
			698.4	28.5 ± 0.4	15.29 ± 0.67
			554.3	70.8 ± 1.0	14.65 ± 0.63
				RR_{mean} =	**15.08 ± 0.51**
^{75}Se	c	119.779D	264.7	58.9 ± 0.4	2.137 ± 0.150
			136.0	58.3 ± 0.8	2.508 ± 0.154
				RR_{mean} =	**2.324 ± 0.199**
^{74}As	i	17.77D	595.8	59 ± 4	**5.222 ± 0.405**
^{72}Ga$_i$	i	14.10H	2201.7	25.9 ± 0.5	**6.592 ± 0.661**
^{72}Ga$_c$	c	14.10H	2201.7	25.9 ± 0.5	**9.136 ± 0.668**
^{72}Zn	c	46.5H	2201.7	*	**2.543 ± 0.173**
^{59}Fe	c	44.472D	1291.6	43.2 ± 1.4	2.708 ± 0.197
			1099.2	56.5 ± 1.9	1.939 ± 0.193
				RR_{mean} =	**2.345 ± 0.391**

12.6.5 Nuclide production rates for ^{209}Bi

Table 79: Detailed calculation of nuclide production rates for ^{209}Bi for $E_p = 0.4$ GeV, used to determine the cross sections for their production.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{207}Po	i(m+g)	5.80H	992.3	59.3 ± 0.9	**64.22 ± 2.47**
^{206}Po	i	8.8D	1878.7	*	73.27 ± 7.35
			1718.7	*	77.22 ± 3.56
			1595.3	*	59.28 ± 4.60
			1098.3	*	65.34 ± 6.60
			1032.3	33 ± 5	75.33 ± 11.69
			1007.2	3.1 ± 0.4	66.11 ± 8.96
			980.2	7.1 ± 0.9	79.38 ± 10.46
			895.1	*	76.11 ± 3.66
			807.4	23 ± 3	72.91 ± 9.81
			803.1	*	72.59 ± 2.67
			620.5	*	59.58 ± 4.54
			537.5	*	65.84 ± 2.86
			522.5	15.7 ± 2.0	72.62 ± 9.62
			516.2	*	70.78 ± 2.70
			497.1	*	72.19 ± 3.31
			398.0	*	73.26 ± 4.64
			343.5	*	75.99 ± 3.28
			338.4	19.2 ± 2.5	77.10 ± 10.39
			286.4	24 ± 3	77.31 ± 10.06
			184.0	*	81.45 ± 3.89
				RR_{mean} =	**72.01 ± 2.22**

Continuation of Table 79.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{205}Po	i	1.66H	1001.2	28.8 ± 2.2	85.26 ± 7.83
			872.4	37 ± 2	98.01 ± 6.75
			849.8	25.5 ± 2.1	77.56 ± 7.84
				RR_{mean} =	**92.79 ± 6.29**
^{204}Po	i	3.53H	1016.3	24.1 ± 1.0	78.71 ± 5.63
			884.0	29.9 ± 1.2	92.90 ± 6.10
				RR_{mean} =	**85.71 ± 7.57**
^{207}Bi	c	31.55Y	1063.7	74.5 ± 0.2	452.5 ± 16.1
			569.7	97.74 ± 0.03	432.2 ± 15.1
				RR_{mean} =	**440.9 ± 16.9**
^{206}Bi$_i$	i	6.243D	1878.7	2.01 ± 0.05	300.4 ± 14.8
			1718.7	31.8 ± 0.6	290.3 ± 11.9
			1098.3	13.50 ± 0.21	283.9 ± 14.0
			895.1	15.66 ± 0.23	291.7 ± 11.2
			881.0	66.2 ± 1.0	275.1 ± 10.4
			803.1	98.9 ± 1.4	272.2 ± 9.7
			620.5	5.76 ± 0.09	289.2 ± 12.5
			537.5	30.5 ± 0.5	255.5 ± 10.0
			516.2	40.7 ± 0.6	262.1 ± 9.8
			497.1	15.31 ± 0.22	252.5 ± 9.7
			343.5	23.4 ± 0.4	255.9 ± 10.1
			184.0	15.8 ± 0.4	307.6 ± 14.1
			398.0	10.74 ± 0.15	240.3 ± 10.7
				RR_{mean} =	**269.9 ± 9.7**
^{206}Bi$_c$	c	6.243D	1878.7	2.01 ± 0.05	369.7 ± 16.8
			1718.7	31.8 ± 0.6	363.2 ± 14.3
			1098.3	13.50 ± 0.21	345.6 ± 14.1
			895.1	15.66 ± 0.23	363.7 ± 13.2
			881.0	66.2 ± 1.0	361.5 ± 13.1
			803.1	98.9 ± 1.4	340.8 ± 12.1
			620.5	5.76 ± 0.09	345.5 ± 13.5
			537.5	30.5 ± 0.5	317.7 ± 12.1
			516.2	40.7 ± 0.6	329.0 ± 12.2
			497.1	15.31 ± 0.22	320.7 ± 12.0
			398.0	10.74 ± 0.15	309.5 ± 11.9
			343.5	23.4 ± 0.4	327.7 ± 12.5
			184.0	15.8 ± 0.4	384.6 ± 17.7
				RR_{mean} =	**339.6 ± 12.0**
^{205}Bi	c	15.31D	1861.7	6.17 ± 0.10	387.5 ± 15.3
			1775.8	3.99 ± 0.08	397.6 ± 16.4
			1764.3	32.5 ± 0.7	399.0 ± 16.1
			1614.3	2.28 ± 0.04	418.0 ± 17.0
			1551.0	0.97 ± 0.03	399.6 ± 19.8
			1351.5	1.06 ± 0.04	398.8 ± 22.6
			1190.0	2.26 ± 0.07	393.8 ± 18.3
			1043.8	7.51 ± 0.10	354.1 ± 13.0
			1014.3	0.91 ± 0.02	395.2 ± 16.9
			987.7	16.13 ± 0.17	388.9 ± 13.4
			872.0	0.42 ± 0.01	352.8 ± 19.3
			759.1	1.04 ± 0.05	408.0 ± 24.6
			703.5	31.1 ± 0.1	360.5 ± 12.1

Continuation of Table 79.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			579.8	5.44 ± 0.07	349.3 ± 12.9
			570.6	4.34 ± 0.07	351.6 ± 13.4
			549.8	2.95 ± 0.04	342.6 ± 12.8
			284.1	1.69 ± 0.02	365.5 ± 15.3
			260.5	1.09 ± 0.04	377.5 ± 21.9
				RR_{mean} =	**370.6 ± 12.6**
^{204}Bi	c*	11.22H	1274.8	2.14 ± 0.25	378.0 ± 48.0
			1211.7	3.0 ± 0.4	306.8 ± 44.1
			984.0	59 ± 4	350.1 ± 26.5
			918.3	10.8 ± 0.9	401.9 ± 36.4
			899.2	98 ± 9	327.8 ± 11.6
			670.7	11.4 ± 0.9	361.2 ± 31.1
			374.8	82 ± 5	388.8 ± 81.2
				RR_{mean} =	**331.4 ± 10.2**
^{203}Bi	c	11.76H	1893.0	8.2 ± 0.6	334.1 ± 27.7
			1888.0	1.94 ± 0.10	317.8 ± 21.8
			1847.3	11.4 ± 0.8	335.0 ± 26.5
			1679.6	8.8 ± 0.7	332.2 ± 29.1
			1536.5	7.5 ± 0.6	333.8 ± 30.0
			1506.7	3.7 ± 0.3	354.2 ± 33.1
			1034.0	8.8 ± 0.5	347.4 ± 23.9
			896.8	13.1 ± 0.7	334.8 ± 21.2
			866.5	1.49 ± 0.08	318.9 ± 28.7
			847.2	8.5 ± 0.5	354.1 ± 24.2
			825.2	14.6 ± 1.1	378.9 ± 31.4
			820.2	29.6 ± 1.5	343.6 ± 20.9
			816.3	4.03 ± 0.21	320.8 ± 20.8
			279.2	*	367.8 ± 13.7
				RR_{mean} =	**363.0 ± 11.2**
^{202}Bi	c*	1.72H	960.7	99.28 ± 0.02	307.2 ± 11.8
			422.1	83.7 ± 2.5	327.4 ± 16.0
				RR_{mean} =	**312.1 ± 12.9**
^{204m}Pb$_i$	i(m)	67.2M	899.2	99.17 ± 0.02	62.22 ± 5.69
			374.7	89 ± 15	78.53 ± 14.10
				RR_{mean} =	**64.33 ± 5.82**
^{204m}Pb$_c$	c	67.2M	899.2	99.17 ± 0.02	111.4 ± 6.3
			374.7	89 ± 15	127.3 ± 22.2
				RR_{mean} =	**112.2 ± 6.2**
^{203}Pb$_i$	i(m1+m2+g)	51.873H	279.2	80.8 ± 0.2	**167.4 ± 6.8**
^{203}Pb$_c$	c	51.873H	279.2	80.8 ± 0.2	**535.2 ± 19.6**
^{202m}Pb	i(m)	3.53H	960.7	92 ± 8	105.1 ± 10.4
			422.1	86 ± 5	95.53 ± 7.50
				RR_{mean} =	**97.98 ± 5.16**
^{201}Pb	c*	9.33H	1277.1	1.63 ± 0.12	590.7 ± 55.4
			946.0	7.4 ± 0.6	518.1 ± 45.7
			907.6	5.7 ± 0.4	566.0 ± 47.0
			692.4	4.27 ± 0.16	548.1 ± 31.3
			361.3	9.9 ± 0.5	600.2 ± 37.4
			331.2	79 ± 5	595.7 ± 42.9
				RR_{mean} =	**568.0 ± 23.0**
^{200}Pb	c	21.5H	1604.5	*	411.0 ± 45.8

Continuation of Table 79.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			1514.9	*	438.5 ± 38.0
			1362.9	*	493.9 ± 61.1
			1225.5	*	417.3 ± 30.6
			1205.7	*	471.7 ± 32.5
			579.3	*	462.2 ± 30.1
			450.5	3.33 ± 0.08	520.9 ± 23.4
			367.9	*	456.2 ± 16.5
			257.2	4.46 ± 0.17	429.1 ± 26.7
			235.6	4.30 ± 0.17	562.4 ± 31.9
			147.6	37.7 ± 1.4	493.2 ± 30.2
				RR_{mean} =	**457.7 ± 14.1**
^{199}Pb	c*	90M	1502.0	2.1 ± 0.4	779.9 ± 159.7
			1135.0	7.8 ± 1.2	952.1 ± 155.8
			366.9	44 ± 7	927.4 ± 157.5
			353.4	9.5 ± 1.5	1077 ± 180
				RR_{mean} =	**950.1 ± 59.1**
^{198}Pb	c	2.4H	2040.2	*	421.6 ± 67.4
			1447.0	*	455.4 ± 74.2
			1420.6	*	606.8 ± 114.8
			865.3	5.9 ± 1.2	421.4 ± 88.3
			675.8	*	473.3 ± 51.5
			575.0	3.1 ± 0.7	543.4 ± 126.0
			365.4	19 ± 5	643.6 ± 171.1
			259.5	5.8 ± 1.2	558.2 ± 118.3
			173.4	18 ± 3	644.0 ± 110.3
			259.5	5.8 ± 1.2	558.2 ± 118.3
				RR_{mean} =	**483.4 ± 14.9**
^{197m}Pb	c*	43M	387.7	25 ± 6	393.6 ± 95.7
			385.9	74 ± 15	423.7 ± 87.3
			222.8	25 ± 6	324.0 ± 83.0
				RR_{mean} =	**412.7 ± 23.8**
^{196}Pb	c*	37M	502.1	26 ± 3	**401.5 ± 49.1**
^{195m}Pb	i(m)	15.0M	383.6	107 ± 20	**232.9 ± 45.5**
^{202}Tl	c	12.23D	439.6	91.4 ± 1.0	**48.92 ± 1.78**
^{201}Tl	c*	72.912H	167.4	10.00 ± 0.06	**670.2 ± 26.1**
^{200}Tl$_i$	i	26.1H	1205.7	29.9 ± 1.8	81.48 ± 6.86
			579.3	13.8 ± 0.7	89.10 ± 15.13
			367.9	87.2 ± 0.4	84.46 ± 6.70
				RR_{mean} =	**83.51 ± 4.96**
^{200}Tl$_c$	c	26.1H	1604.5	1.17 ± 0.10	571.0 ± 58.7
			1514.9	4.0 ± 0.3	567.4 ± 47.5
			1362.9	3.4 ± 0.4	588.2 ± 72.4
			1225.5	3.36 ± 0.21	601.0 ± 43.1
			1205.7	29.9 ± 1.8	553.2 ± 38.0
			579.3	13.8 ± 0.7	551.3 ± 34.2
			367.9	87.2 ± 0.4	540.6 ± 18.7
				RR_{mean} =	**545.7 ± 18.3**
^{199}Tl	c*	7.42H	455.5	12.4 ± 1.4	615.7 ± 73.3
			247.3	9.3 ± 1.1	641.6 ± 81.1
			208.2	12.3 ± 1.4	665.2 ± 80.5

Continuation of Table 79.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
				RR_{mean} =	**638.3 ± 31.6**
^{198m}Tl	i(m)	1.87H	587.2	52.5 ± 2.0	92.06 ± 12.08
			282.8	28 ± 3	116.9 ± 13.6
				RR_{mean} =	**103.3 ± 12.8**
^{197}Tl	c*	2.84H	1411.3	4.5 ± 1.5	505.5 ± 170.7
			152.2	7.3 ± 2.3	864.6 ± 274.6
				RR_{mean} =	**701.0 ± 180.2**
^{196m}Tl	i(m)	1.41H	695.4	41 ± 7	**241.6 ± 42.5**
^{195}Tl	c*	1.16H	884.5	10.0 ± 1.1	**404.4 ± 51.3**
^{203}Hg	c	46.612D	279.2	81.46 ± 0.13	**1.519 ± 0.125**
^{197}Hg	c*	64.14H	191.4	0.63 ± 0.02	**576.1 ± 33.1**
^{197m}Hg	i(m)	23.8H	134.0	33.5 ± 0.4	**35.31 ± 2.99**
^{195m}Hg	i(m)	41.6H	261.8	31 ± 4	51.99 ± 7.39
			779.8	54.2 ± 0.1	57.43 ± 12.14
				RR_{mean} =	**53.44 ± 1.65**
^{195}Hg$_c$	c	9.9H	779.8	6.8 ± 0.7	**453.7 ± 49.7**
^{193m}Hg	i(m)	11.8H	573.2	26 ± 4	50.08 ± 8.21
			407.6	32 ± 6	67.91 ± 13.04
			258.0	49 ± 7	109.6 ± 16.5
				RR_{mean} =	**63.37 ± 14.91**
^{192}Hg	c	4.85H	2319.4	*	389.8 ± 83.0
			316.5	*	386.5 ± 48.6
			296.0	*	377.2 ± 53.6
			274.8	50.2 ± 2.5	296.2 ± 18.7
				RR_{mean} =	**305.9 ± 9.4**
^{190}Hg	c*	20.0M	295.8	*	214.5 ± 36.0
			142.6	68 ± 10	210.6 ± 36.8
				RR_{mean} =	**212.6 ± 6.6**
^{198}Au	i	2.69517D	411.8	95.58 ± 0.12	**2.508 ± 0.119**
^{196}Au	i(m1+m2+g)	6.183D	355.7	87.0 ± 0.8	**4.781 ± 0.182**
^{195}Au	c	186.098D	98.9	10.9 ± 0.9	**464.8 ± 51.9**
^{194}Au	i(m1+m2+g)	38.02H	328.5	61 ± 5	**11.10 ± 1.01**
^{192}Au$_i$	i(m+g)	4.94H	316.5	58 ± 7	**28.20 ± 5.23**
^{192}Au$_c$	c	4.94H	2319.4	1.6 ± 0.3	364.2 ± 75.2
			316.5	58 ± 7	414.7 ± 52.1
			296.0	22 ± 3	429.6 ± 61.0
				RR_{mean} =	**414.9 ± 16.2**
^{191}Au	c*	3.18H	586.4	17 ± 0	306.6 ± 21.7
			277.9	7.2 ± 0.5	288.2 ± 24.6
				RR_{mean} =	**298.9 ± 17.5**
^{191}Pt	c	2.802D	538.9	13.7 ± 1.6	271.8 ± 33.1
			456.5	3.4 ± 0.4	245.5 ± 30.4
			409.4	8.0 ± 0.9	244.5 ± 29.0
			359.9	6.0 ± 0.7	256.6 ± 31.2
			351.2	3.4 ± 0.4	288.4 ± 35.5
			172.2	3.5 ± 0.4	247.9 ± 31.4
			129.4	3.2 ± 0.5	274.5 ± 46.4
				RR_{mean} =	**257.5 ± 10.3**
^{189}Pt	c	10.87H	607.6	8.10 ± 0.16	254.0 ± 11.8
			568.8	7.1 ± 0.6	258.9 ± 26.1

Continuation of Table 79.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			544.9	5.8 ± 0.5	253.3 ± 24.7
			243.5	7.0 ± 1.2	231.9 ± 41.5
				RR_{mean} =	**253.7 ± 10.8**
^{188}Pt	c	10.2D	634.9	*	221.5 ± 36.3
			633.0	*	255.9 ± 43.6
			478.0	*	180.2 ± 9.7
			423.3	4.4 ± 0.3	179.2 ± 13.8
			381.4	7.5 ± 0.5	181.7 ± 13.6
			322.9	*	190.4 ± 18.9
			195.1	18.6 ± 1.2	184.1 ± 13.8
			187.6	19.4 ± 1.2	186.3 ± 13.6
			155.1	*	194.3 ± 20.8
			140.4	2.33 ± 0.15	212.9 ± 18.3
				RR_{mean} =	**183.8 ± 5.7**
^{186}Pt	c	2.08H	689.4	70 ± 15	**129.6 ± 28.2**
^{189}Ir	c	13.2D	275.9	0.54 ± 0.07	188.6 ± 26.5
			245.1	6.0 ± 0.6	203.0 ± 22.0
				RR_{mean} =	**201.6 ± 8.3**
^{188}Ir$_c$	c	41.5H	634.9	5.0 ± 0.8	236.8 ± 39.0
			633.0	18 ± 3	309.0 ± 54.4
			478.0	14.7 ± 0.6	207.8 ± 11.4
			322.9	1.62 ± 0.15	200.3 ± 20.3
			155.1	30 ± 3	205.3 ± 22.0
				RR_{mean} =	**208.2 ± 7.6**
^{187}Ir	c*	10.5H	977.5	3.14 ± 0.11	**161.8 ± 12.1**
^{186}Ir	c	16.64H	434.8	33.9 ± 1.1	61.46 ± 3.09
			296.9	62.3 ± 1.9	61.71 ± 3.54
			137.2	41.4 ± 0.7	72.36 ± 4.67
				RR_{mean} =	**63.43 ± 3.49**
^{185}Ir	c	14.4H	1829.0	10.1 ± 1.5	90.21 ± 13.86
			254.2	13.3 ± 2.4	75.87 ± 14.59
				RR_{mean} =	**87.80 ± 6.01**
^{184}Ir	c*	3.09H	264.0	68 ± 4	86.13 ± 6.66
			119.8	31 ± 3	101.2 ± 12.3
				RR_{mean} =	**87.75 ± 5.40**
^{185}Os	c	93.6D	874.8	6.29 ± 0.25	109.9 ± 5.8
			717.4	3.94 ± 0.16	110.1 ± 7.7
			646.1	78 ± 3	106.7 ± 5.5
			592.1	1.32 ± 0.06	100.1 ± 6.6
				RR_{mean} =	**107.3 ± 3.6**
^{183m}Os	c*	9.9H	1107.9	22.4 ± 0.6	41.28 ± 2.45
			1101.9	49.0 ± 1.3	40.59 ± 2.01
				RR_{mean} =	**40.80 ± 1.62**
^{182}Os	c	22.10H	1221.5	*	66.04 ± 4.89
			1189.2	*	67.64 ± 5.48
			1121.4	*	66.46 ± 4.17
			180.2	33.5 ± 1.7	55.17 ± 3.64
				RR_{mean} =	**60.78 ± 1.87**
^{181}Os	c	105M	238.8	44 ± 5	**24.62 ± 3.42**
^{183}Re	c	70.0D	291.7	3.05 ± 0.18	67.59 ± 5.01

Continuation of Table 79.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			208.8	2.95 ± 0.09	68.74 ± 4.10
			162.3	23.3 ± 0.7	71.39 ± 3.49
			109.7	2.87 ± 0.09	74.66 ± 6.10
			107.9	2.17 ± 0.07	67.78 ± 6.26
				RR_{mean} =	**70.27 ± 2.66**
$^{182m}Re_c$	c	12.7H	1221.5	24.8 ± 1.6	64.34 ± 5.13
			1189.2	15 ± 1	77.10 ± 7.47
			1121.4	31.8 ± 1.6	73.86 ± 4.87
				RR_{mean} =	**71.13 ± 4.09**
^{181}Re	c*	19.9H	365.5	56 ± 8	**43.05 ± 6.34**
^{175}Hf	c	70D	343.4	84 ± 3	**6.420 ± 0.358**
^{173}Hf	c*	23.6H	123.7	83 ± 5	**4.168 ± 0.503**
^{172}Hf	c	1.87Y	1093.6	*	**1.762 ± 0.380**
^{173}Lu	c	1.37Y	272.1	21.2 ± 0.8	**2.749 ± 0.415**
$^{172}Lu_c$	c	6.70D	1093.6	63 ± 3	**2.329 ± 0.529**
^{139}Ce	c	137.640D	165.9	79.89 ± 0.01	**1.776 ± 0.080**
^{131}Ba	c	11.50D	123.8	29.0 ± 0.3	**2.888 ± 0.357**
^{129}Cs	c	32.06H	371.9	30.6 ± 1.7	**7.344 ± 0.577**
^{127}Xe	c	36.4D	375.0	17.2 ± 0.6	5.695 ± 0.425
			202.9	68.3 ± 0.5	5.575 ± 0.240
			172.1	25.5 ± 0.8	5.269 ± 0.312
				RR_{mean} =	**5.514 ± 0.214**
^{126}I	i	13.11D	666.3	33.1 ± 2.5	3.864 ± 0.445
			388.6	34 ± 3	2.965 ± 0.354
				RR_{mean} =	**3.327 ± 0.453**
^{124}I	i	4.1760D	602.7	62.9 ± 0.6	**4.625 ± 0.243**
^{123m}Te	i(m)	119.7D	159.0	84.0 ± 0.4	**4.799 ± 0.199**
^{121m}Te	i(m)	154D	212.2	81.4 ± 1.1	5.014 ± 0.216
			573.1	88.6 ± 0.1	5.020 ± 0.250
				RR_{mean} =	**5.016 ± 0.155**
$^{121}Te_c$	c	19.16D	573.1	80.3 ± 2.5	**6.511 ± 0.306**
^{119m}Te	i(m)	4.70D	1212.7	66.2 ± 0.3	**2.293 ± 0.143**
^{124}Sb	i(m1+m2+g)	60.20D	602.7	98.3 ± 0.4	**1.411 ± 0.098**
^{120m}Sb	i(m)	5.76D	1171.7	100 ± 0	6.866 ± 0.241
			197.3	87.0 ± 1.1	7.056 ± 0.310
				RR_{mean} =	**6.907 ± 0.236**
^{118m}Sb	i(m)	5.00H	1050.7	97 ± 5	**7.343 ± 0.652**
^{117m}Sn	i(m)	13.60D	158.6	86.4 ± 0.4	**10.52 ± 0.41**
^{113}Sn	c	115.09D	391.7	64.97 ± 0.17	**2.710 ± 0.170**
^{114m}In	i(m)	49.51D	190.3	15.56 ± 0.16	**13.28 ± 0.67**
^{111}In	c	2.8047D	245.4	94 ± 1	**4.292 ± 0.325**
^{115}Cd	c	53.46H	336.2	45.9 ± 1.0	**4.617 ± 0.302**
^{110m}Ag	i(m)	249.76D	1505.0	13.60 ± 0.19	16.92 ± 1.11
			937.5	34.2 ± 0.6	16.50 ± 0.71
			884.7	72.7 ± 0.4	16.24 ± 0.59
			763.9	22.62 ± 0.21	15.49 ± 0.75
			687.0	6.44 ± 0.06	16.93 ± 1.52
			657.8	94.3 ± 0.3	16.01 ± 0.55
			446.8	3.62 ± 0.04	16.38 ± 1.77
				RR_{mean} =	**16.13 ± 0.52**

Continuation of Table 79.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{106m}Ag	i(m)	8.28D	451.0	28.2 ± 0.8	**3.351 ± 0.411**
^{105}Ag	c	41.29D	280.4	30.2 ± 1.8	**2.310 ± 1.001**
^{105}Rh	c	35.36H	318.9	19.1 ± 0.6	**61.29 ± 2.97**
^{102m}Rh	i(m)	2.9Y	631.3	56 ± 2	6.567 ± 0.600
			1046.6	34 ± 2	7.384 ± 0.933
			475.1	95 ± 4	8.502 ± 1.784
				RR_{mean} =	**6.914 ± 0.509**
^{101m}Rh	c	4.34D	306.9	81 ± 5	**5.579 ± 0.465**
^{101}Rh	c	3.3Y	127.2	68 ± 6	**2.278 ± 0.361**
^{103}Ru	c	39.26D	610.3	5.76 ± 0.07	56.55 ± 3.52
			497.1	91.0 ± 1.3	57.67 ± 2.14
				RR_{mean} =	**57.53 ± 2.09**
^{96}Tc	i(m+g)	4.28D	849.9	98 ± 4	4.462 ± 0.260
			812.5	82 ± 4	5.284 ± 0.351
				RR_{mean} =	**4.738 ± 0.415**
^{99}Mo	c	65.94H	140.5	90.27 ± 0.33	**52.97 ± 2.86**
^{96}Nb	i	23.35H	1091.3	48.5 ± 1.6	34.88 ± 1.68
			778.2	96.45 ± 0.22	34.16 ± 1.19
			460.0	26.62 ± 0.20	33.82 ± 1.39
				RR_{mean} =	**34.17 ± 1.14**
$^{95}Nb_i$	i(m+g)	34.975D	765.8	99.81 ± 0.03	**36.13 ± 1.20**
$^{95}Nb_c$	c	34.975D	765.8	99.81 ± 0.03	**70.08 ± 2.30**
^{92m}Nb	i(m)	10.15D	934.4	99.07 ± 0.04	**2.066 ± 0.142**
^{90}Nb	c*	14.60H	2319.0	82.0 ± 0.3	**1.727 ± 0.342**
^{97}Zr	c	16.744H	743.4	93.06 ± 0.16	**9.486 ± 0.516**
^{95}Zr	c	64.02D	765.8	*	34.26 ± 1.15
			756.7	54.46 ± 0.10	33.76 ± 1.13
			724.2	44.17 ± 0.16	35.91 ± 1.26
				RR_{mean} =	**34.30 ± 1.06**
^{89}Zr	c	78.41H	909.2	99.04 ± 0.03	**8.030 ± 0.297**
^{88}Zr	c	83.4D	1836.1	*	1.566 ± 0.182
			898.0	*	1.955 ± 0.602
			392.9	97.24 ± 0.00	2.060 ± 0.117
				RR_{mean} =	**1.943 ± 0.060**
^{90m}Y	i(m)	3.19H	479.5	90.74 ± 0.05	36.88 ± 3.19
			202.5	97.3 ± 0.4	38.00 ± 2.07
				RR_{mean} =	**37.72 ± 1.88**
$^{88}Y_i$	i	106.65D	1836.1	99.2 ± 0.3	20.75 ± 0.74
			898.0	93.7 ± 0.3	18.63 ± 0.78
				RR_{mean} =	**20.06 ± 1.17**
$^{88}Y_c$	c	106.65D	1836.1	99.2 ± 0.3	22.32 ± 0.78
			898.0	93.7 ± 0.3	20.59 ± 0.74
				RR_{mean} =	**21.50 ± 1.09**
^{87}Y	c*	79.8H	484.8	89.7 ± 0.7	10.37 ± 0.38
			388.5	82.1 ± 0.5	11.39 ± 0.43
				RR_{mean} =	**10.78 ± 0.60**
^{85}Sr	c	64.84D	514.0	96 ± 4	**11.31 ± 0.63**
^{86}Rb	i(m+g)	18.631D	1077.0	8.64 ± 0.04	**42.89 ± 1.62**
^{83}Rb	c	86.2D	552.6	16.0 ± 1.1	13.11 ± 1.05
			529.6	29.3 ± 2.1	13.59 ± 1.10

Continuation of Table 79.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			520.4	45 ± 4	13.40 ± 1.30
				RR_{mean} =	**13.35 ± 0.60**
^{82}Br	i(m+g)	35.30H	1474.9	16.32 ± 0.23	23.23 ± 1.39
			776.5	83.5 ± 1.2	22.06 ± 0.82
			698.4	28.5 ± 0.4	20.91 ± 1.00
			554.3	70.8 ± 1.0	20.86 ± 0.91
				RR_{mean} =	**21.67 ± 0.78**
^{75}Se	c	119.779D	400.7	11.47 ± 0.09	4.207 ± 0.363
			400.7	11.47 ± 0.09	4.207 ± 0.363
			264.7	58.9 ± 0.4	3.028 ± 0.202
			136.0	58.3 ± 0.8	3.345 ± 0.205
				RR_{mean} =	**3.408 ± 0.276**
^{76}As	i	1.0778D	559.1	45 ± 2	**16.29 ± 1.17**
^{74}As	i	17.77D	595.8	59 ± 4	**7.246 ± 0.562**
$^{72}Ga_i$	i	14.10H	2507.8	12.78 ± 0.23	11.18 ± 1.28
			2201.7	25.9 ± 0.5	8.549 ± 0.814
				RR_{mean} =	**9.288 ± 1.215**
$^{72}Ga_c$	c	14.10H	2507.8	12.78 ± 0.23	14.64 ± 1.29
			2201.7	25.9 ± 0.5	11.91 ± 0.84
				RR_{mean} =	**12.69 ± 1.29**
^{72}Zn	c	46.5H	2507.8	*	3.463 ± 0.278
			2201.7	*	3.360 ± 0.208
				RR_{mean} =	**3.394 ± 0.181**
^{59}Fe	c	44.472D	1291.6	43.2 ± 1.4	2.958 ± 0.388
			1099.2	56.5 ± 1.9	3.743 ± 0.418
				RR_{mean} =	**3.328 ± 0.405**
^{46}Sc	i(m+g)	83.79D	889.3	99.98 ± 0.00	**0.3080 ± 0.0471**
^{7}Be	i	53.29D	477.6	10.52 ± 0.06	**8.181 ± 0.642**

12.6.6 Nuclide production rates for ^{27}Al

Table 80: Detailed calculation of nuclide production rates for in ^{27}Al-monitors and ^{27}Al-plates for E_p = 0.4 GeV, used for calculating proton flux (including total over the plate area), cross sections for production of ^{7}Be, ^{24}Naand neutron background.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
		^{27}Al-monitor for ^{206}Pb			
^{7}Be	i	53.29D	477.6	10.52 ± 0.06	**20.32 ± 1.35**
^{27}Mg	c	9.458M	843.8	71.8 ± 0.4	2.076 ± 0.108
			1014.4	28.0 ± 0.4	2.098 ± 0.174
				RR_{mean} =	**2.081 ± 0.100**
^{22}Na	c	2.6019Y	1274.5	99.94 ± 0.01	**105.8 ± 3.7**
^{24}Na	c	14.9590H	1369.0	100 ± 0	**81.30 ± 2.71**
		^{27}Al-plate for ^{206}Pb			
^{24}Na	c	14.9590H	1368.0	100 ± 0	**2.781 ± 0.094**
		^{27}Al-monitor for ^{207}Pb			
^{7}Be	i	53.29D	477.6	10.52 ± 0.06	**13.88 ± 0.56**
^{27}Mg	c	9.458M	843.8	71.8 ± 0.4	1.331 ± 0.068

Continuation of Table 80.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			1014.4	28.0 ± 0.4	1.283 ± 0.106
				RR_{mean} =	**1.320 ± 0.062**
^{22}Na	c	2.6019Y	1274.5	99.94 ± 0.01	**70.32 ± 2.44**
^{24}Na	c	14.9590H	1369.0	100 ± 0	**54.09 ± 1.80**
^{27}Al-plate for ^{207}Pb					
^{24}Na	c	14.9590H	1369.0	100 ± 0	**1.820 ± 0.062**
^{27}Al-monitor for ^{207}Pb					
^{7}Be	i	53.29D	477.6	10.52 ± 0.06	**18.83 ± 0.70**
^{27}Mg	c	9.458M	843.8	71.8 ± 0.4	2.028 ± 0.100
			1014.4	28.0 ± 0.4	2.061 ± 0.242
				RR_{mean} =	**2.031 ± 0.097**
^{22}Na	c	2.6019Y	1274.5	99.94 ± 0.01	**98.64 ± 3.46**
^{24}Na	c	14.9590H	1369.0	100 ± 0	**74.32 ± 2.47**
^{27}Al-plate for ^{207}Pb					
^{24}Na	c	14.9590H	1369.0	100 ± 0	**2.634 ± 0.088**
^{27}Al-monitor for ^{nat}Pb					
^{7}Be	i	53.29D	477.6	10.52 ± 0.06	**20.52 ± 0.76**
^{27}Mg	c	9.458M	843.8	71.8 ± 0.4	2.851 ± 0.130
			1014.4	28.0 ± 0.4	2.922 ± 0.210
				RR_{mean} =	**2.865 ± 0.123**
^{22}Na	c	2.6019Y	1274.5	99.94 ± 0.01	**105.3 ± 3.6**
^{24}Na	c	14.9590H	1369.0	100 ± 0	**79.65 ± 2.65**
^{27}Al-plate for ^{nat}Pb					
^{24}Na	c	14.9590H	1369.0	100 ± 0	**2.658 ± 0.089**
^{27}Al-monitor for ^{209}Bi					
^{7}Be	i	53.29D	477.6	10.52 ± 0.06	**21.52 ± 0.79**
^{27}Mg	c	9.458M	843.8	71.8 ± 0.4	2.611 ± 0.120
			1014.4	28.0 ± 0.4	2.601 ± 0.353
				RR_{mean} =	**2.610 ± 0.118**
^{22}Na	c	2.6019Y	1274.5	99.94 ± 0.01	**104.9 ± 3.6**
^{24}Na	c	14.9590H	1369.0	100 ± 0	**79.20 ± 2.64**
^{27}Al-plate for ^{209}Bi					
^{24}Na	c	14.9590H	1369.0	100 ± 0	**2.703 ± 0.091**

12.7 Detailed calculation of nuclide production rates for ^{206}Pb, ^{207}Pb, ^{208}Pb, ^{nat}Pb and ^{209}Bi for $E_p = 0.6$ GeV

12.7.1 Nuclide production rates for ^{206}Pb

Table 81: Detailed calculation of nuclide production rates for ^{206}Pb for $E_p = 0.6$ GeV, used to determine the cross sections for their production.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{206}Bi	i	6.243D	803.1	98.9 ± 1.4	7.778 ± 0.305
			537.5	30.5 ± 0.5	7.779 ± 0.429
			497.1	15.31 ± 0.22	8.319 ± 0.909
			343.5	23.4 ± 0.4	6.950 ± 0.647
				RR_{mean} =	**7.741 ± 0.286**
^{205}Bi	i	15.31D	1861.7	6.17 ± 0.10	26.67 ± 1.58
			1764.3	32.5 ± 0.7	25.56 ± 1.21
			703.5	31.1 ± 0.1	24.67 ± 0.86
				RR_{mean} =	**24.92 ± 0.86**
^{204}Bi	i	11.22H	984.0	59 ± 4	32.92 ± 2.55
			899.2	98 ± 9	31.36 ± 1.19
			670.7	11.4 ± 0.9	39.82 ± 4.09
			374.8	82 ± 5	34.14 ± 7.13
				RR_{mean} =	**31.54 ± 0.97**
^{203}Bi	i(m+g)	11.76H	1893.0	8.2 ± 0.6	36.97 ± 4.53
			1847.3	11.4 ± 0.8	35.97 ± 3.56
			820.2	29.6 ± 1.5	40.63 ± 2.57
				RR_{mean} =	**40.07 ± 1.61**
^{202}Bi	i	1.72H	960.7	99.28 ± 0.02	25.80 ± 3.09
			422.1	83.7 ± 2.5	45.70 ± 3.34
				RR_{mean} =	**35.60 ± 10.01**
^{204m}Pb$_i$	i(m)	67.2M	899.2	99.17 ± 0.02	69.40 ± 2.64
			374.7	89 ± 15	76.19 ± 13.14
				RR_{mean} =	**69.50 ± 2.64**
^{204m}Pb$_c$	c	67.2M	899.2	99.17 ± 0.02	74.10 ± 2.77
			374.7	89 ± 15	80.48 ± 13.87
				RR_{mean} =	**74.18 ± 2.76**
^{203}Pb	c*	51.873H	279.2	80.8 ± 0.2	**258.6 ± 9.4**
^{202m}Pb	i(m)	3.53H	960.7	92 ± 8	67.96 ± 6.86
			422.1	86 ± 5	63.71 ± 4.68
				RR_{mean} =	**64.52 ± 3.11**
^{201}Pb	c*	9.33H	692.4	4.27 ± 0.16	221.8 ± 13.1
			331.2	79 ± 5	227.6 ± 16.5
				RR_{mean} =	**223.9 ± 11.2**
^{200}Pb	c	21.5H	1514.9	*	167.0 ± 15.0
			1205.7	*	172.8 ± 12.0
			579.3	*	154.3 ± 10.0
			367.9	*	163.3 ± 5.7
			147.6	37.7 ± 1.4	170.8 ± 9.3
				RR_{mean} =	**163.9 ± 5.1**
^{199}Pb	c*	90M	366.9	44 ± 7	**328.9 ± 54.7**
^{198}Pb	c	2.4H	173.4	18 ± 3	**229.0 ± 39.5**

Continuation of Table 81.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{197m}Pb	c*	43M	385.9	74 ± 15	161.0 ± 33.3
			222.8	25 ± 6	150.4 ± 36.8
				RR_{mean} =	**160.0 ± 8.0**
^{196}Pb	c*	37M	502.1	26 ± 3	**155.9 ± 19.2**
^{195m}Pb	i(m)	15.0M	383.6	107 ± 20	**89.64 ± 17.44**
^{202}Tl	c	12.23D	439.6	91.4 ± 1.0	**109.2 ± 4.0**
^{201}Tl	c*	72.912H	167.4	10.00 ± 0.06	**372.8 ± 13.8**
^{200}Tl$_i$	i	26.1H	1514.9	4.0 ± 0.3	159.5 ± 17.0
			1205.7	29.9 ± 1.8	142.1 ± 10.7
			579.3	13.8 ± 0.7	162.5 ± 12.3
			367.9	87.2 ± 0.4	142.9 ± 6.5
				RR_{mean} =	**146.0 ± 6.1**
^{200}Tl$_c$	c	26.1H	1514.9	4.0 ± 0.3	326.5 ± 27.5
			1205.7	29.9 ± 1.8	315.0 ± 21.8
			579.3	13.8 ± 0.7	316.8 ± 19.8
			367.9	87.2 ± 0.4	306.2 ± 10.7
				RR_{mean} =	**308.0 ± 10.5**
^{199}Tl$_c$	c	7.42H	455.5	12.4 ± 1.4	279.1 ± 33.4
			208.2	12.3 ± 1.4	335.6 ± 42.2
				RR_{mean} =	**298.0 ± 28.2**
^{199}Tl	c*	7.42H	455.5	12.4 ± 1.4	343.3 ± 40.8
			208.2	12.3 ± 1.4	375.4 ± 46.4
				RR_{mean} =	**355.7 ± 19.8**
^{198m}Tl	i(m)	1.87H	282.8	28 ± 3	**129.4 ± 17.0**
^{197}Tl	c*	2.84H	1411.3	4.5 ± 1.5	**282.2 ± 96.0**
^{196m}Tl	i(m)	1.41H	695.4	41 ± 7	**252.6 ± 44.1**
^{195}Tl	c*	1.16H	884.5	10.0 ± 1.1	**259.3 ± 33.4**
^{203}Hg	c	46.612D	279.2	81.46 ± 0.13	**8.439 ± 0.323**
^{197m}Hg	i(m)	23.8H	134.0	33.5 ± 0.4	**50.49 ± 2.30**
^{195}Hg$_c$	c	9.9H	779.8	6.8 ± 0.7	**328.2 ± 35.8**
^{195m}Hg	i(m)	41.6H	560.3	7.0 ± 0.6	73.97 ± 7.11
			261.8	31 ± 4	80.17 ± 10.78
				RR_{mean} =	**75.11 ± 4.43**
^{193m}Hg	i(m)	11.8H	407.6	32 ± 6	98.00 ± 18.71
			258.0	49 ± 7	131.5 ± 20.5
				RR_{mean} =	**113.3 ± 17.1**
^{192}Hg	c	4.85H	316.5	*	354.8 ± 44.7
			274.8	50.2 ± 2.5	279.8 ± 17.7
				RR_{mean} =	**288.2 ± 8.9**
^{190}Hg	c*	20.0M	142.6	68 ± 10	**223.5 ± 34.2**
^{198m}Au	i(m)	2.27D	204.1	40.8 ± 2.4	2.188 ± 0.194
			411.8	*	1.922 ± 0.244
				RR_{mean} =	**2.090 ± 0.064**
^{198}Au$_i$	i	2.69517D	411.8	95.58 ± 0.12	**5.150 ± 0.457**
^{198}Au$_c$	i(m+g)	2.69517D	411.8	95.58 ± 0.12	**7.072 ± 0.315**
^{196}Au	i(m1+m2+g)	6.183D	426.1	6.6 ± 0.8	13.79 ± 1.83
			355.7	87.0 ± 0.8	14.45 ± 0.51
			333.0	22.9 ± 0.6	16.11 ± 0.80
				RR_{mean} =	**14.60 ± 0.57**
^{195}Au	c	186.098D	98.9	10.9 ± 0.9	**299.0 ± 29.3**

Continuation of Table 81.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{194}Au	i(m1+m2+g)	38.02H	328.5	61 ± 5	29.90 ± 2.66
			293.6	10.4 ± 0.8	28.10 ± 2.51
				RR_{mean} =	**28.95 ± 1.65**
$^{192}Au_i$	i(m+g)	4.94H	316.5	58 ± 7	**42.34 ± 6.31**
$^{192}Au_c$	c	4.94H	316.5	58 ± 7	**397.1 ± 49.9**
^{191}Au	c*	3.18H	586.4	17 ± 0	389.6 ± 16.2
			166.5	3.32 ± 0.24	328.3 ± 29.8
				RR_{mean} =	**381.5 ± 23.9**
$^{190}Au_c$	c	42.8M	301.8	23.4 ± 1.5	**286.9 ± 26.1**
^{191}Pt	c	2.802D	538.9	13.7 ± 1.6	313.4 ± 38.2
			456.5	3.4 ± 0.4	283.0 ± 34.7
			409.4	8.0 ± 0.9	276.9 ± 32.6
			351.2	3.4 ± 0.4	319.0 ± 39.4
			172.2	3.5 ± 0.4	267.8 ± 32.3
				RR_{mean} =	**287.7 ± 13.1**
^{189}Pt	c	10.87H	721.4	9.3 ± 0.8	351.7 ± 32.7
			607.6	8.10 ± 0.16	309.4 ± 12.8
			568.8	7.1 ± 0.6	317.8 ± 29.8
			544.9	5.8 ± 0.5	359.3 ± 33.7
			243.5	7.0 ± 1.2	335.2 ± 59.5
				RR_{mean} =	**315.5 ± 12.2**
^{188}Pt	c	10.2D	633.0	*	317.0 ± 53.9
			478.0	*	281.9 ± 15.1
			423.3	4.4 ± 0.3	291.6 ± 22.3
			381.4	7.5 ± 0.5	282.3 ± 21.1
			195.1	18.6 ± 1.2	281.6 ± 21.0
			187.6	19.4 ± 1.2	289.1 ± 20.9
			155.1	*	298.1 ± 31.7
				RR_{mean} =	**284.2 ± 8.8**
^{187}Pt	c	2.35H	106.4	8.8 ± 1.8	**255.2 ± 54.5**
^{186}Pt	c	2.08H	689.4	70 ± 15	**228.2 ± 49.5**
^{184}Pt	c	17.3M	548.3	23 ± 4	**193.4 ± 35.0**
^{192}Ir	i(m1+g)	73.827D	316.5	82.71 ± 0.21	**0.5142 ± 0.0888**
^{190}Ir	i(m1+g)	11.78D	605.1	39.9 ± 1.9	1.674 ± 0.148
			518.5	34.0 ± 1.6	2.044 ± 0.172
				RR_{mean} =	**1.833 ± 0.192**
^{189}Ir	c	13.2D	275.9	0.54 ± 0.07	285.1 ± 39.7
			245.1	6.0 ± 0.6	274.4 ± 29.5
				RR_{mean} =	**275.1 ± 10.6**
$^{188}Ir_i$	i	41.5H	633.0	18 ± 3	8.265 ± 1.804
			478.0	14.7 ± 0.6	11.79 ± 1.48
			155.1	30 ± 3	9.476 ± 2.038
				RR_{mean} =	**10.24 ± 1.14**
$^{188}Ir_c$	c	41.5H	1209.8	6.9 ± 0.7	297.5 ± 31.8
			633.0	18 ± 3	325.3 ± 55.3
			478.0	14.7 ± 0.6	293.6 ± 15.7
			155.1	30 ± 3	307.6 ± 32.7
				RR_{mean} =	**294.3 ± 10.1**
^{187}Ir	c*	10.5H	977.5	3.14 ± 0.11	**306.4 ± 17.0**
^{186}Ir	c	16.64H	773.3	8.9 ± 0.5	127.5 ± 8.8

Continuation of Table 81.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			434.8	33.9 ± 1.1	120.6 ± 5.8
				RR_{mean} =	**122.2 ± 5.4**
^{185}Ir	c	14.4H	1829.0	10.1 ± 1.5	192.9 ± 29.6
			254.2	13.3 ± 2.4	176.1 ± 32.8
				RR_{mean} =	**190.2 ± 10.1**
^{184}Ir	c*	3.09H	841.3	8.0 ± 0.8	216.7 ± 24.9
			390.4	25.9 ± 2.4	208.8 ± 21.1
			264.0	68 ± 4	230.2 ± 16.4
			119.8	31 ± 3	242.2 ± 26.3
				RR_{mean} =	**227.4 ± 9.0**
^{183}Ir	c	57M	392.5	10.4 ± 2.4	**203.8 ± 48.5**
^{185}Os	c	93.6D	874.8	6.29 ± 0.25	251.0 ± 13.2
			717.4	3.94 ± 0.16	257.7 ± 13.8
			646.1	78 ± 3	248.3 ± 12.7
				RR_{mean} =	**250.9 ± 8.1**
^{183m}Os	c*	9.9H	1107.9	22.4 ± 0.6	135.4 ± 6.1
			1101.9	49.0 ± 1.3	125.6 ± 6.1
				RR_{mean} =	**131.4 ± 6.3**
^{182}Os	c	22.10H	1121.4	*	239.3 ± 14.6
			180.2	33.5 ± 1.7	208.8 ± 13.2
				RR_{mean} =	**222.7 ± 6.9**
^{181}Os	c	105M	238.8	44 ± 5	**73.23 ± 9.13**
^{180}Os	c	21.5M	902.8(D)	101.5 ± 3.4	**166.6 ± 8.5**
^{183}Re	c	70.0D	291.7	3.05 ± 0.18	208.2 ± 14.6
			162.3	23.3 ± 0.7	231.6 ± 10.9
				RR_{mean} =	**226.4 ± 12.0**
^{182m}Re$_c$	c	12.7H	1221.5	24.8 ± 1.6	220.5 ± 16.2
			1189.2	15 ± 1	255.1 ± 19.9
			1121.4	31.8 ± 1.6	229.8 ± 14.5
				RR_{mean} =	**231.5 ± 10.8**
^{181}Re	c*	19.9H	639.0	6.4 ± 1.4	193.2 ± 43.1
			365.5	56 ± 8	159.2 ± 23.6
				RR_{mean} =	**165.7 ± 18.0**
^{179}Re	c*	19.5M	430.2	28.0 ± 1.8	208.9 ± 15.9
			290.0	26.9 ± 2.3	180.7 ± 17.8
				RR_{mean} =	**204.0 ± 12.4**
^{178}Re	c*	13.2M	237.3	45 ± 5	**181.3 ± 22.3**
^{178} W	c	21.6D	1350.6(D)	1.18 ± 0.11	126.4 ± 15.4
			1340.8(D)	1.03 ± 0.09	98.92 ± 11.02
				RR_{mean} =	**106.8 ± 12.9**
^{177} W	c	135M	115.7	51 ± 5	**104.2 ± 11.5**
^{176} W	c	2.5H	1159.3	*	**38.01 ± 14.79**
^{177}Ta	c*	56.56H	112.9	7.2 ± 1.6	**111.5 ± 25.4**
^{176}Ta$_c$	c	8.09H	1159.3	24.7 ± 1.9	**118.0 ± 11.2**
^{175}Ta	c	10.5H	348.5	12.0 ± 1.1	97.42 ± 10.09
			266.9	10.52 ± 0.16	91.89 ± 4.27
				RR_{mean} =	**92.42 ± 4.12**
^{173}Ta	c	3.14H	172.2	17.5 ± 1.8	**69.28 ± 8.04**
^{175}Hf	c	70D	343.4	84 ± 3	**88.09 ± 4.33**
^{173}Hf	c*	23.6H	311.2	10.7 ± 0.5	**74.80 ± 4.59**

Continuation of Table 81.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{172}Hf	c	1.87Y	1093.6	*	47.73 ± 2.87
			900.7	*	49.48 ± 2.91
			181.5	*	46.71 ± 3.05
			125.8	11.3 ± 0.9	50.86 ± 5.20
				RR_{mean} =	**48.60 ± 1.50**
^{170}Hf	c	16.01H	164.7	26 ± 8	43.07 ± 13.36
			120.2	15 ± 5	32.45 ± 11.06
				RR_{mean} =	**37.90 ± 5.44**
^{173}Lu	c	1.37Y	272.1	21.2 ± 0.8	**62.08 ± 3.46**
^{172}Lu$_c$	c	6.70D	1093.6	63 ± 3	47.80 ± 2.86
			900.7	29.8 ± 1.3	50.88 ± 2.97
			181.5	20.6 ± 1.0	47.99 ± 3.12
				RR_{mean} =	**49.07 ± 1.84**
^{171}Lu	c*	8.24D	739.8	47.8 ± 1.2	**48.53 ± 2.03**
^{170}Lu	c*	2.012D	2126.1	5.1 ± 0.3	46.96 ± 3.79
			1280.2	8.2 ± 0.4	48.49 ± 3.36
				RR_{mean} =	**47.90 ± 2.37**
^{169}Lu	c	34.06H	960.6	23.4 ± 0.7	**26.81 ± 1.31**
^{169}Yb	c*	32.026D	198.0	35.8 ± 0.7	30.91 ± 1.36
			177.2	22.2 ± 0.5	28.22 ± 1.25
			130.5	11.31 ± 0.21	30.16 ± 1.95
				RR_{mean} =	**29.54 ± 1.29**
^{166}Yb	c	56.7H	2052.4	*	**14.77 ± 1.07**
^{167}Tm	c	9.25D	207.8	42 ± 8	**20.51 ± 3.99**
^{165}Tm	c	30.06H	242.9	35.5 ± 1.7	**10.90 ± 0.81**
^{149}Gd	c	9.28D	149.7	48 ± 3	**1.263 ± 0.131**
^{139}Ce	c	137.640D	165.9	79.89 ± 0.01	**1.311 ± 0.099**
^{127}Xe	c	36.4D	202.9	68.3 ± 0.5	4.139 ± 0.175
			172.1	25.5 ± 0.8	4.165 ± 0.323
				RR_{mean} =	**4.143 ± 0.167**
^{123m}Te	i(m)	119.7D	159.0	84.0 ± 0.4	**2.140 ± 0.107**
^{121m}Te	i(m)	154D	573.1	88.6 ± 0.1	3.042 ± 0.206
			212.2	81.4 ± 1.1	2.997 ± 0.146
				RR_{mean} =	**3.010 ± 0.093**
^{121}Te$_c$	c	19.16D	573.1	80.3 ± 2.5	**5.756 ± 0.282**
^{119m}Te	i(m)	4.70D	1212.7	66.2 ± 0.3	**2.332 ± 0.111**
^{120m}Sb	i(m)	5.76D	1023.3	99.4 ± 0.3	**2.727 ± 0.107**
^{113}Sn	c	115.09D	391.7	64.97 ± 0.17	**2.972 ± 0.230**
^{114m}In	i(m)	49.51D	190.3	15.56 ± 0.16	**9.033 ± 0.456**
^{110m}Ag	i(m)	249.76D	1384.3	24.9 ± 0.8	9.126 ± 0.728
			937.5	34.2 ± 0.6	9.011 ± 0.460
			884.7	72.7 ± 0.4	8.315 ± 0.337
				RR_{mean} =	**8.542 ± 0.355**
^{106m}Ag	i(m)	8.28D	1045.8	29.6 ± 1.0	4.676 ± 0.265
			717.3	28.9 ± 0.8	4.255 ± 0.259
			451.0	28.2 ± 0.8	4.657 ± 0.250
				RR_{mean} =	**4.538 ± 0.194**
^{105}Rh	c	35.36H	318.9	19.1 ± 0.6	**30.28 ± 1.48**
^{102}Rh	i	207D	475.1	46 ± 5	**4.612 ± 0.600**
^{101m}Rh	c	4.34D	306.9	81 ± 5	**6.362 ± 0.480**

Continuation of Table 81.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{103}Ru	c	39.26D	497.1	91.0 ± 1.3	**27.34 ± 1.04**
^{96}Tc	i(m+g)	4.28D	849.9	98 ± 4	6.034 ± 0.332
			812.5	82 ± 4	6.220 ± 0.372
				RR_{mean} =	**6.113 ± 0.281**
^{96}Nb	i	23.35H	1091.3	48.5 ± 1.6	17.30 ± 0.86
			568.9	58.0 ± 0.3	16.85 ± 0.69
				RR_{mean} =	**16.99 ± 0.65**
^{95}Nb$_i$	i(m+g)	34.975D	765.8	99.81 ± 0.03	**21.44 ± 0.72**
^{95}Nb$_c$	c	34.975D	765.8	99.81 ± 0.03	**36.69 ± 1.22**
^{92m}Nb	i(m)	10.15D	934.4	99.07 ± 0.04	**1.978 ± 0.137**
^{97}Zr	c	16.744H	743.4	93.06 ± 0.16	**3.716 ± 0.232**
^{95}Zr	c	64.02D	765.8	*	15.40 ± 0.56
			756.7	54.46 ± 0.10	14.89 ± 0.54
			724.2	44.17 ± 0.16	15.48 ± 0.57
				RR_{mean} =	**15.27 ± 0.47**
^{89}Zr	c	78.41H	909.2	99.04 ± 0.03	**9.923 ± 0.335**
^{88}Zr	c	83.4D	1836.1	*	4.317 ± 0.420
			392.9	97.24 ± 0.00	3.807 ± 0.165
				RR_{mean} =	**3.847 ± 0.119**
^{90m} Y	i(m)	3.19H	479.5	90.74 ± 0.05	**19.33 ± 0.85**
^{88} Y$_i$	i	106.65D	1836.1	99.2 ± 0.3	18.65 ± 0.72
			898.0	93.7 ± 0.3	18.70 ± 0.71
				RR_{mean} =	**18.67 ± 0.65**
^{88} Y$_c$	c	106.65D	1836.1	99.2 ± 0.3	22.96 ± 0.83
			898.0	93.7 ± 0.3	21.72 ± 0.76
				RR_{mean} =	**22.21 ± 0.92**
^{87} Y	c*	79.8H	484.8	89.7 ± 0.7	13.71 ± 0.49
			388.5	82.1 ± 0.5	15.07 ± 0.52
				RR_{mean} =	**14.45 ± 0.81**
^{85}Sr	c	64.84D	514.0	96 ± 4	**14.49 ± 0.80**
^{86}Rb	i(m+g)	18.631D	1077.0	8.64 ± 0.04	**26.38 ± 1.09**
^{83}Rb	c	86.2D	552.6	16.0 ± 1.1	16.49 ± 1.38
			529.6	29.3 ± 2.1	16.98 ± 1.38
			520.4	45 ± 4	16.08 ± 1.56
				RR_{mean} =	**16.60 ± 0.76**
^{82}Br	i(m+g)	35.30H	1317.5	26.5 ± 0.4	13.95 ± 0.70
			776.5	83.5 ± 1.2	13.65 ± 0.52
			698.4	28.5 ± 0.4	14.52 ± 0.60
			554.3	70.8 ± 1.0	12.90 ± 0.52
				RR_{mean} =	**13.65 ± 0.54**
^{75}Se	c	119.779D	264.7	58.9 ± 0.4	4.964 ± 0.217
			136.0	58.3 ± 0.8	5.297 ± 0.283
				RR_{mean} =	**5.067 ± 0.219**
^{74}As	i	17.77D	595.8	59 ± 4	**8.866 ± 0.679**
^{72}Ga$_i$	i	14.10H	2201.7	25.9 ± 0.5	**7.423 ± 0.634**
^{72}Ga$_c$	c	14.10H	2201.7	25.9 ± 0.5	**9.578 ± 0.636**
^{72}Zn	c	46.5H	2201.7	*	**2.155 ± 0.205**
^{59}Fe	c	44.472D	1291.6	43.2 ± 1.4	3.723 ± 0.245
			1099.2	56.5 ± 1.9	3.970 ± 0.236
				RR_{mean} =	**3.858 ± 0.182**

Continuation of Table 81.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{46}Sc	i(m+g)	83.79D	889.3	99.98 ± 0.00	**0.5948 ± 0.0736**
^{7}Be	i	53.29D	477.6	10.52 ± 0.06	**5.899 ± 0.971**

12.7.2 Nuclide production rates for ^{207}Pb

Table 82: Detailed calculation of nuclide production rates for ^{207}Pb for $E_p = 0.6$ GeV, used to determine the cross sections for their production.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{206}Bi	i	6.243D	803.1	98.9 ± 1.4	17.27 ± 0.62
			537.5	30.5 ± 0.5	17.15 ± 0.71
			343.5	23.4 ± 0.4	16.28 ± 0.86
			497.1	15.31 ± 0.22	18.64 ± 1.12
				RR_{mean} =	**17.21 ± 0.60**
^{205}Bi	i	15.31D	1764.3	32.5 ± 0.7	34.99 ± 1.46
			703.5	31.1 ± 0.1	33.47 ± 1.14
			1861.7	6.17 ± 0.10	34.44 ± 1.94
				RR_{mean} =	**33.80 ± 1.12**
^{204}Bi	i	11.22H	899.2	98 ± 9	32.90 ± 1.17
			374.8	82 ± 5	35.93 ± 7.51
			984.0	59 ± 4	34.13 ± 2.68
			670.7	11.4 ± 0.9	37.19 ± 3.49
				RR_{mean} =	**33.08 ± 1.02**
^{203}Bi	i(m+g)	11.76H	820.2	29.6 ± 1.5	37.73 ± 2.75
			1847.3	11.4 ± 0.8	36.37 ± 3.71
			1893.0	8.2 ± 0.6	30.37 ± 3.28
				RR_{mean} =	**35.97 ± 2.34**
^{202}Bi	i	1.72H	960.7	99.28 ± 0.02	25.51 ± 2.28
			422.1	83.7 ± 2.5	39.07 ± 3.50
				RR_{mean} =	**29.55 ± 6.27**
^{204m}Pb$_i$	i(m)	67.2M	899.2	99.17 ± 0.02	67.80 ± 2.40
			374.7	89 ± 15	78.75 ± 13.58
				RR_{mean} =	**67.88 ± 2.40**
^{204m}Pb$_c$	c	67.2M	899.2	99.17 ± 0.02	72.73 ± 2.55
			374.7	89 ± 15	83.25 ± 14.35
				RR_{mean} =	**72.81 ± 2.55**
^{203}Pb	c*	51.873H	279.2	80.8 ± 0.2	**222.7 ± 8.1**
^{202m}Pb	i(m)	3.53H	960.7	92 ± 8	65.23 ± 6.36
			422.1	86 ± 5	65.83 ± 4.95
				RR_{mean} =	**65.67 ± 3.24**
^{201}Pb	c*	9.33H	331.2	79 ± 5	197.7 ± 14.3
			692.4	4.27 ± 0.16	186.5 ± 11.2
				RR_{mean} =	**190.4 ± 9.6**
^{200}Pb	c	21.5H	1205.7	*	154.3 ± 10.8
			1514.9	*	159.4 ± 14.2
			579.3	*	128.6 ± 8.6
			367.9	*	142.3 ± 4.9
			147.6	37.7 ± 1.4	148.1 ± 8.1
				RR_{mean} =	**143.2 ± 4.4**

Continuation of Table 82.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{199}Pb	c*	90M	366.9	44 ± 7	**284.3 ± 47.9**
^{198}Pb	c	2.4H	173.4	18 ± 3	**197.5 ± 34.1**
^{197m}Pb	c*	43M	385.9	74 ± 15	137.9 ± 28.4
			222.8	25 ± 6	135.3 ± 33.2
				RR_{mean} =	**137.8 ± 6.6**
^{196}Pb	c*	37M	502.1	26 ± 3	**133.6 ± 16.9**
^{195m}Pb	i(m)	15.0M	383.6	107 ± 20	**69.95 ± 13.39**
^{202}Tl	c	12.23D	439.6	91.4 ± 1.0	**102.8 ± 3.7**
^{201}Tl	c*	72.912H	167.4	10.00 ± 0.06	**331.0 ± 12.2**
^{200}Tl$_i$	i	26.1H	367.9	87.2 ± 0.4	135.1 ± 5.4
			1205.7	29.9 ± 1.8	123.2 ± 9.6
			579.3	13.8 ± 0.7	158.5 ± 12.4
			1514.9	4.0 ± 0.3	101.1 ± 14.7
				RR_{mean} =	**133.9 ± 7.1**
^{200}Tl$_c$	c	26.1H	367.9	87.2 ± 0.4	277.4 ± 9.6
			1205.7	29.9 ± 1.8	277.6 ± 19.3
			579.3	13.8 ± 0.7	287.1 ± 18.2
			1514.9	4.0 ± 0.3	260.5 ± 22.6
				RR_{mean} =	**277.4 ± 9.3**
^{199}Tl$_c$	c	7.42H	455.5	12.4 ± 1.4	245.5 ± 29.9
			208.2	12.3 ± 1.4	293.2 ± 38.5
				RR_{mean} =	**260.5 ± 23.5**
^{199}Tl	c*	7.42H	455.5	12.4 ± 1.4	309.4 ± 36.8
			208.2	12.3 ± 1.4	319.9 ± 39.2
				RR_{mean} =	**313.9 ± 17.3**
^{198m}Tl	i(m)	1.87H	282.8	28 ± 3	**126.4 ± 15.5**
^{197}Tl	c*	2.84H	1411.3	4.5 ± 1.5	**272.4 ± 92.9**
^{196m}Tl	i(m)	1.41H	695.4	41 ± 7	**232.5 ± 40.8**
^{195}Tl	c*	1.16H	884.5	10.0 ± 1.1	**194.3 ± 23.5**
^{203}Hg	c	46.612D	279.2	81.46 ± 0.13	**13.90 ± 0.56**
^{197m}Hg	i(m)	23.8H	134.0	33.5 ± 0.4	**55.49 ± 2.49**
^{195}Hg$_c$	c	9.9H	779.8	6.8 ± 0.7	**290.4 ± 31.6**
^{195m}Hg	i(m)	41.6H	560.3	7.0 ± 0.6	76.90 ± 7.41
			261.8	31 ± 4	82.60 ± 11.10
				RR_{mean} =	**77.98 ± 4.62**
^{193m}Hg	i(m)	11.8H	407.6	32 ± 6	92.74 ± 17.71
			258.0	49 ± 7	123.0 ± 18.5
				RR_{mean} =	**107.3 ± 15.5**
^{192}Hg	c	4.85H	316.5	*	318.3 ± 40.1
			274.8	50.2 ± 2.5	247.7 ± 15.8
				RR_{mean} =	**255.6 ± 7.9**
^{190}Hg	c*	20.0M	142.6	68 ± 10	**192.0 ± 29.4**
^{198m}Au	i(m)	2.27D	204.1	40.8 ± 2.4	2.840 ± 0.228
			411.8	*	2.536 ± 0.170
				RR_{mean} =	**2.638 ± 0.081**
^{198}Au$_i$	i	2.69517D	411.8	95.58 ± 0.12	**6.566 ± 0.352**
^{198}Au$_c$	i(m+g)	2.69517D	411.8	95.58 ± 0.12	**9.102 ± 0.338**
^{196}Au	i(m1+m2+g)	6.183D	426.1	6.6 ± 0.8	17.17 ± 2.22
			355.7	87.0 ± 0.8	16.94 ± 0.61
			333.0	22.9 ± 0.6	18.56 ± 0.82

Continuation of Table 82.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, $10^{-17}\ s^{-1}$
				RR_{mean} =	**17.23 ± 0.69**
^{195}Au	c	186.098D	98.9	10.9 ± 0.9	**341.6 ± 33.6**
^{194}Au	i(m1+m2+g)	38.02H	328.5	61 ± 5	33.16 ± 2.95
			293.6	10.4 ± 0.8	32.69 ± 2.82
				RR_{mean} =	**32.91 ± 1.83**
^{192}Au$_i$	i(m+g)	4.94H	316.5	58 ± 7	**52.86 ± 7.37**
^{192}Au$_c$	c	4.94H	316.5	58 ± 7	**371.2 ± 46.6**
^{191}Au	c*	3.18H	586.4	17 ± 0	342.7 ± 15.9
			166.5	3.32 ± 0.24	353.7 ± 32.6
				RR_{mean} =	**344.1 ± 15.3**
^{190}Au$_c$	c	42.8M	301.8	23.4 ± 1.5	**269.3 ± 21.8**
^{191}Pt	c	2.802D	538.9	13.7 ± 1.6	288.9 ± 35.2
			456.5	3.4 ± 0.4	262.8 ± 32.2
			409.4	8.0 ± 0.9	255.1 ± 30.0
			351.2	3.4 ± 0.4	296.8 ± 36.6
			172.2	3.5 ± 0.4	247.9 ± 30.0
				RR_{mean} =	**266.1 ± 12.2**
^{189}Pt	c	10.87H	721.4	9.3 ± 0.8	318.4 ± 29.7
			607.6	8.10 ± 0.16	278.1 ± 11.3
			568.8	7.1 ± 0.6	299.3 ± 28.0
			544.9	5.8 ± 0.5	324.8 ± 30.7
			243.5	7.0 ± 1.2	305.4 ± 53.9
				RR_{mean} =	**284.3 ± 11.2**
^{188}Pt	c	10.2D	1209.8	*	269.5 ± 28.8
			633.0	*	287.6 ± 48.9
			478.0	*	255.4 ± 13.7
			423.3	4.4 ± 0.3	266.1 ± 20.3
			381.4	7.5 ± 0.5	254.5 ± 19.0
			195.1	18.6 ± 1.2	256.8 ± 19.2
			187.6	19.4 ± 1.2	262.7 ± 19.0
			155.1	*	271.5 ± 28.8
				RR_{mean} =	**258.0 ± 8.0**
^{187}Pt	c	2.35H	106.4	8.8 ± 1.8	**215.7 ± 47.0**
^{186}Pt	c	2.08H	689.4	70 ± 15	**199.7 ± 43.4**
^{184}Pt	c	17.3M	548.3	23 ± 4	**160.4 ± 29.0**
^{192}Ir	i(m1+g)	73.827D	316.5	82.71 ± 0.21	**0.5344 ± 0.0885**
^{190}Ir	i(m1+g)	11.78D	605.1	39.9 ± 1.9	2.019 ± 0.186
			518.5	34.0 ± 1.6	2.220 ± 0.156
				RR_{mean} =	**2.147 ± 0.118**
^{189}Ir	c	13.2D	275.9	0.54 ± 0.07	255.5 ± 34.9
			245.1	6.0 ± 0.6	249.3 ± 26.8
				RR_{mean} =	**249.7 ± 9.6**
^{188}Ir$_i$	i	41.5H	633.0	18 ± 3	11.15 ± 2.26
			478.0	14.7 ± 0.6	13.78 ± 1.49
			155.1	30 ± 3	9.997 ± 2.102
				RR_{mean} =	**12.36 ± 1.23**
^{188}Ir$_c$	c	41.5H	1209.8	6.9 ± 0.7	272.6 ± 29.2
			633.0	18 ± 3	298.8 ± 50.8
			478.0	14.7 ± 0.6	269.2 ± 14.4
			155.1	30 ± 3	281.4 ± 29.9

Continuation of Table 82.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
				RR_{mean} =	**269.8** ± **9.3**
^{187}Ir	c*	10.5H	977.5	3.14 ± 0.11	**264.7** ± **16.1**
^{186}Ir	c	16.64H	773.3	8.9 ± 0.5	107.3 ± 8.2
			434.8	33.9 ± 1.1	114.2 ± 5.6
				RR_{mean} =	**112.5** ± **5.1**
^{185}Ir	c	14.4H	1829.0	10.1 ± 1.5	170.4 ± 26.1
			254.2	13.3 ± 2.4	156.8 ± 29.1
				RR_{mean} =	**168.2** ± **8.8**
^{184}Ir	c*	3.09H	841.3	8.0 ± 0.8	199.9 ± 22.9
			390.4	25.9 ± 2.4	179.1 ± 18.0
			264.0	68 ± 4	202.6 ± 14.4
			119.8	31 ± 3	212.0 ± 23.0
				RR_{mean} =	**200.1** ± **7.9**
^{183}Ir	c	57M	392.5	10.4 ± 2.4	**183.0** ± **43.3**
^{185}Os	c	93.6D	874.8	6.29 ± 0.25	236.0 ± 12.4
			717.4	3.94 ± 0.16	232.4 ± 12.7
			646.1	78 ± 3	221.9 ± 11.3
				RR_{mean} =	**227.1** ± **8.3**
^{183m}Os	c*	9.9H	1107.9	22.4 ± 0.6	116.7 ± 5.1
			1101.9	49.0 ± 1.3	105.7 ± 5.2
				RR_{mean} =	**112.9** ± **6.3**
^{182}Os	c	22.10H	1121.4	*	208.6 ± 12.6
			180.2	33.5 ± 1.7	184.4 ± 11.6
				RR_{mean} =	**195.8** ± **6.0**
^{181}Os	c	105M	238.8	44 ± 5	**57.69** ± **7.23**
^{180}Os	c	21.5M	902.8(D)	101.5 ± 3.4	**131.1** ± **6.5**
^{183}Re	c	70.0D	291.7	3.05 ± 0.18	192.6 ± 13.9
			162.3	23.3 ± 0.7	203.1 ± 9.5
				RR_{mean} =	**201.2** ± **8.1**
^{182m}Re$_c$	c	12.7H	1221.5	24.8 ± 1.6	189.9 ± 14.2
			1189.2	15 ± 1	224.1 ± 17.3
			1121.4	31.8 ± 1.6	198.1 ± 12.1
				RR_{mean} =	**200.2** ± **9.9**
^{181}Re	c*	19.9H	639.0	6.4 ± 1.4	159.1 ± 35.8
			365.5	56 ± 8	137.2 ± 20.3
				RR_{mean} =	**141.6** ± **15.4**
^{179}Re	c*	19.5M	430.2	28.0 ± 1.8	176.0 ± 13.6
			290.0	26.9 ± 2.3	131.2 ± 13.2
				RR_{mean} =	**165.0** ± **20.0**
^{178}Re	c*	13.2M	237.3	45 ± 5	**140.2** ± **17.3**
^{178} W	c	21.6D	1350.6(D)	1.18 ± 0.11	122.2 ± 18.7
			1340.8(D)	1.03 ± 0.09	85.09 ± 9.22
				RR_{mean} =	**89.05** ± **11.79**
^{177} W	c	135M	115.7	51 ± 5	**85.01** ± **9.53**
^{176} W	c	2.5H	1159.3	*	**41.82** ± **15.07**
^{177}Ta	c*	56.56H	112.9	7.2 ± 1.6	**101.9** ± **23.3**
^{176}Ta$_c$	c	8.09H	1159.3	24.7 ± 1.9	**91.79** ± **9.44**
^{175}Ta	c	10.5H	348.5	12.0 ± 1.1	77.46 ± 7.80
			266.9	10.52 ± 0.16	74.39 ± 3.53
				RR_{mean} =	**74.73** ± **3.38**

Continuation of Table 82.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{173}Ta	c	3.14H	172.2	17.5 ± 1.8	**56.73 ± 6.68**
^{175}Hf	c	70D	343.4	84 ± 3	**70.93 ± 3.49**
^{173}Hf	c*	23.6H	311.2	10.7 ± 0.5	**57.94 ± 3.62**
^{172}Hf	c	1.87Y	1093.6	*	36.93 ± 2.21
			900.7	*	39.03 ± 2.37
			181.5	*	37.31 ± 2.55
			125.8	11.3 ± 0.9	38.92 ± 3.96
				RR_{mean} =	**37.95 ± 1.17**
^{170}Hf	c	16.01H	164.7	26 ± 8	34.04 ± 10.56
			120.2	15 ± 5	23.80 ± 8.15
				RR_{mean} =	**28.74 ± 5.19**
^{173}Lu	c	1.37Y	272.1	21.2 ± 0.8	**49.17 ± 3.10**
^{172}Lu$_c$	c	6.70D	1093.6	63 ± 3	37.26 ± 2.23
			900.7	29.8 ± 1.3	40.05 ± 2.41
			181.5	20.6 ± 1.0	39.42 ± 2.65
				RR_{mean} =	**38.70 ± 1.50**
^{171}Lu	c*	8.24D	739.8	47.8 ± 1.2	**37.30 ± 1.56**
^{170}Lu	c*	2.012D	2126.1	5.1 ± 0.3	33.70 ± 2.97
			1280.2	8.2 ± 0.4	39.95 ± 2.65
				RR_{mean} =	**37.83 ± 3.18**
^{169}Lu	c	34.06H	960.6	23.4 ± 0.7	**20.04 ± 1.18**
^{169}Yb	c*	32.026D	198.0	35.8 ± 0.7	24.05 ± 1.06
			177.2	22.2 ± 0.5	21.77 ± 1.01
			130.5	11.31 ± 0.21	24.02 ± 1.30
				RR_{mean} =	**23.13 ± 1.06**
^{166}Yb	c	56.7H	2052.4	*	**10.96 ± 0.85**
^{167}Tm	c	9.25D	207.8	42 ± 8	**15.63 ± 3.05**
^{165}Tm	c	30.06H	242.9	35.5 ± 1.7	**8.040 ± 0.568**
^{149}Gd	c	9.28D	149.7	48 ± 3	**1.150 ± 0.113**
^{139}Ce	c	137.640D	165.9	79.89 ± 0.01	**1.056 ± 0.072**
^{127}Xe	c	36.4D	202.9	68.3 ± 0.5	3.498 ± 0.156
			172.1	25.5 ± 0.8	3.443 ± 0.266
				RR_{mean} =	**3.488 ± 0.147**
^{124}Sb	i(m1+m2+g)	60.20D	602.7	98.3 ± 0.4	**0.5043 ± 0.0629**
^{123m}Te	i(m)	119.7D	159.0	84.0 ± 0.4	**1.976 ± 0.120**
^{121m}Te	i(m)	154D	573.1	88.6 ± 0.1	2.279 ± 0.195
			212.2	81.4 ± 1.1	2.710 ± 0.136
				RR_{mean} =	**2.599 ± 0.080**
^{121}Te$_c$	c	19.16D	573.1	80.3 ± 2.5	**4.447 ± 0.233**
^{119m}Te	i(m)	4.70D	1212.7	66.2 ± 0.3	**1.711 ± 0.152**
^{120m}Sb	i(m)	5.76D	1023.3	99.4 ± 0.3	**2.478 ± 0.090**
^{113}Sn	c	115.09D	391.7	64.97 ± 0.17	**2.539 ± 0.263**
^{114m}In	i(m)	49.51D	190.3	15.56 ± 0.16	**8.976 ± 0.459**
^{110m}Ag	i(m)	249.76D	1384.3	24.9 ± 0.8	9.019 ± 0.788
			937.5	34.2 ± 0.6	7.208 ± 0.419
			884.7	72.7 ± 0.4	7.320 ± 0.309
				RR_{mean} =	**7.389 ± 0.365**
^{106m}Ag	i(m)	8.28D	1045.8	29.6 ± 1.0	3.557 ± 0.211
			717.3	28.9 ± 0.8	3.121 ± 0.240
			451.0	28.2 ± 0.8	3.672 ± 0.238

Continuation of Table 82.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
				RR_{mean} =	**3.471 ± 0.190**
^{105}Rh	c	35.36H	318.9	19.1 ± 0.6	**26.42 ± 1.38**
^{102}Rh	i	207D	475.1	46 ± 5	**3.565 ± 0.523**
^{101m}Rh	c	4.34D	306.9	81 ± 5	**4.763 ± 0.361**
^{103}Ru	c	39.26D	497.1	91.0 ± 1.3	**23.98 ± 0.92**
^{96}Tc	i(m+g)	4.28D	849.9	98 ± 4	4.445 ± 0.247
			812.5	82 ± 4	4.536 ± 0.281
				RR_{mean} =	**4.483 ± 0.209**
^{96}Nb	i	23.35H	1091.3	48.5 ± 1.6	15.29 ± 0.78
			568.9	58.0 ± 0.3	14.07 ± 0.61
				RR_{mean} =	**14.46 ± 0.72**
^{95}Nb$_i$	i(m+g)	34.975D	765.8	99.81 ± 0.03	**18.42 ± 0.64**
^{95}Nb$_c$	c	34.975D	765.8	99.81 ± 0.03	**32.65 ± 1.12**
^{92m}Nb	i(m)	10.15D	934.4	99.07 ± 0.04	**1.671 ± 0.091**
^{97}Zr	c	16.744H	743.4	93.06 ± 0.16	**3.928 ± 0.259**
^{95}Zr	c	64.02D	765.8	*	14.36 ± 0.63
			756.7	54.46 ± 0.10	14.07 ± 0.66
			724.2	44.17 ± 0.16	13.89 ± 0.54
				RR_{mean} =	**14.06 ± 0.43**
^{89}Zr	c	78.41H	909.2	99.04 ± 0.03	**7.545 ± 0.261**
^{88}Zr	c	83.4D	1836.1	*	3.400 ± 0.433
			392.9	97.24 ± 0.00	2.840 ± 0.133
				RR_{mean} =	**2.869 ± 0.089**
^{90m} Y	i(m)	3.19H	479.5	90.74 ± 0.05	**16.08 ± 0.78**
^{88} Y$_i$	i	106.65D	1836.1	99.2 ± 0.3	14.82 ± 0.60
			898.0	93.7 ± 0.3	14.22 ± 0.53
				RR_{mean} =	**14.45 ± 0.53**
^{88} Y$_c$	c	106.65D	1836.1	99.2 ± 0.3	18.22 ± 0.69
			898.0	93.7 ± 0.3	17.02 ± 0.59
				RR_{mean} =	**17.41 ± 0.78**
^{87} Y	c*	79.8H	484.8	89.7 ± 0.7	10.28 ± 0.37
			388.5	82.1 ± 0.5	11.56 ± 0.40
				RR_{mean} =	**10.92 ± 0.72**
^{85}Sr	c	64.84D	514.0	96 ± 4	**11.27 ± 0.62**
^{86}Rb	i(m+g)	18.631D	1077.0	8.64 ± 0.04	**21.20 ± 1.21**
^{83}Rb	c	86.2D	552.6	16.0 ± 1.1	11.87 ± 1.25
			529.6	29.3 ± 2.1	12.09 ± 1.05
			520.4	45 ± 4	12.40 ± 1.21
				RR_{mean} =	**12.12 ± 0.63**
^{82}Br	i(m+g)	35.30H	1317.5	26.5 ± 0.4	12.34 ± 0.58
			776.5	83.5 ± 1.2	12.01 ± 0.48
			698.4	28.5 ± 0.4	12.75 ± 0.57
			554.3	70.8 ± 1.0	11.14 ± 0.45
				RR_{mean} =	**11.87 ± 0.50**
^{75}Se	c	119.779D	264.7	58.9 ± 0.4	4.063 ± 0.211
			136.0	58.3 ± 0.8	4.298 ± 0.245
				RR_{mean} =	**4.158 ± 0.184**
^{74}As	i	17.77D	595.8	59 ± 4	**7.001 ± 0.540**
^{72}Ga$_i$	i	14.10H	2201.7	25.9 ± 0.5	**5.592 ± 1.022**
^{72}Ga$_c$	c	14.10H	2201.7	25.9 ± 0.5	**7.697 ± 0.963**

Continuation of Table 82.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{72}Zn	c	46.5H	2201.7	*	**2.105 ± 0.265**
^{59}Fe	c	44.472D	1291.6	43.2 ± 1.4	3.236 ± 0.295
			1099.2	56.5 ± 1.9	3.135 ± 0.403
				RR_{mean} =	**3.203 ± 0.243**
^{46}Sc	i(m+g)	83.79D	889.3	99.98 ± 0.00	**0.5059 ± 0.0631**
^{7}Be	i	53.29D	477.6	10.52 ± 0.06	**4.316 ± 0.918**

12.7.3 Nuclide production rates for ^{208}Pb

Table 83: Detailed calculation of nuclide production rates for ^{208}Pb for E_p = 0.6 GeV, used to determine the cross sections for their production.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{207}Bi	i	31.55Y	569.7	97.74 ± 0.03	**20.58 ± 3.59**
^{206}Bi	i	6.243D	803.1	98.9 ± 1.4	23.75 ± 0.86
			537.5	30.5 ± 0.5	22.48 ± 0.89
			497.1	15.31 ± 0.22	21.63 ± 1.16
			343.5	23.4 ± 0.4	22.86 ± 0.98
				RR_{mean} =	**23.03 ± 0.82**
^{205}Bi	i	15.31D	1861.7	6.17 ± 0.10	35.62 ± 1.92
			1764.3	32.5 ± 0.7	35.11 ± 1.49
			703.5	31.1 ± 0.1	33.64 ± 1.16
				RR_{mean} =	**34.07 ± 1.17**
^{204}Bi	i	11.22H	984.0	59 ± 4	30.57 ± 2.35
			899.2	98 ± 9	29.63 ± 1.01
			670.7	11.4 ± 0.9	32.76 ± 3.49
			374.8	82 ± 5	32.38 ± 6.77
				RR_{mean} =	**29.72 ± 0.92**
^{203}Bi	i(m+g)	11.76H	1893.0	8.2 ± 0.6	27.08 ± 3.14
			1847.3	11.4 ± 0.8	25.78 ± 2.37
			820.2	29.6 ± 1.5	32.73 ± 2.09
				RR_{mean} =	**31.35 ± 2.13**
^{202}Bi	i	1.72H	960.7	99.28 ± 0.02	23.34 ± 2.76
			422.1	83.7 ± 2.5	28.38 ± 2.71
				RR_{mean} =	**25.95 ± 2.64**
^{204m}Pb$_i$	i(m)	67.2M	899.2	99.17 ± 0.02	61.31 ± 2.16
			374.7	89 ± 15	74.35 ± 12.84
				RR_{mean} =	**61.40 ± 2.18**
^{204m}Pb$_c$	c	67.2M	899.2	99.17 ± 0.02	65.75 ± 2.29
			374.7	89 ± 15	78.42 ± 13.53
				RR_{mean} =	**65.83 ± 2.30**
^{203}Pb	c*	51.873H	279.2	80.8 ± 0.2	**182.8 ± 6.7**
^{202m}Pb	i(m)	3.53H	960.7	92 ± 8	55.77 ± 5.50
			422.1	86 ± 5	62.76 ± 4.45
				RR_{mean} =	**61.20 ± 3.47**
^{201}Pb	c*	9.33H	692.4	4.27 ± 0.16	143.3 ± 8.8
			331.2	79 ± 5	164.0 ± 11.8
				RR_{mean} =	**150.3 ± 10.8**

Continuation of Table 83.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{200}Pb	c	21.5H	1514.9	*	117.6 ± 11.9
			1205.7	*	128.7 ± 8.9
			579.3	*	107.4 ± 7.1
			367.9	*	117.3 ± 4.1
			147.6	37.7 ± 1.4	125.7 ± 6.9
				RR_{mean} =	**118.2 ± 3.6**
^{199}Pb	c*	90M	366.9	44 ± 7	**233.6 ± 39.2**
^{198}Pb	c	2.4H	173.4	18 ± 3	**162.1 ± 28.0**
^{197m}Pb	c*	43M	385.9	74 ± 15	115.6 ± 23.8
			222.8	25 ± 6	111.1 ± 27.2
				RR_{mean} =	**115.3 ± 5.6**
^{196}Pb	c*	37M	502.1	26 ± 3	**108.8 ± 13.5**
^{195m}Pb	i(m)	15.0M	383.6	107 ± 20	**62.51 ± 12.17**
^{202}Tl	c	12.23D	439.6	91.4 ± 1.0	**92.48 ± 3.42**
^{201}Tl	c*	72.912H	167.4	10.00 ± 0.06	**282.4 ± 10.4**
^{200}Tl$_i$	i	26.1H	1514.9	4.0 ± 0.3	127.5 ± 16.9
			1205.7	29.9 ± 1.8	114.8 ± 8.3
			579.3	13.8 ± 0.7	146.4 ± 10.8
			367.9	87.2 ± 0.4	123.1 ± 5.2
				RR_{mean} =	**124.1 ± 5.9**
^{200}Tl$_c$	c	26.1H	1514.9	4.0 ± 0.3	245.1 ± 21.4
			1205.7	29.9 ± 1.8	243.6 ± 16.8
			579.3	13.8 ± 0.7	253.8 ± 15.9
			367.9	87.2 ± 0.4	240.4 ± 8.4
				RR_{mean} =	**241.5 ± 8.2**
^{199}Tl$_c$	c	7.42H	455.5	12.4 ± 1.4	227.2 ± 27.4
			208.2	12.3 ± 1.4	256.2 ± 31.9
				RR_{mean} =	**238.5 ± 15.9**
^{199}Tl	c*	7.42H	455.5	12.4 ± 1.4	268.4 ± 31.9
			208.2	12.3 ± 1.4	293.5 ± 35.8
				RR_{mean} =	**278.8 ± 15.4**
^{198m}Tl	i(m)	1.87H	282.8	28 ± 3	**107.8 ± 13.3**
^{197}Tl	c*	2.84H	1411.3	4.5 ± 1.5	**235.8 ± 80.2**
^{196m}Tl	i(m)	1.41H	695.4	41 ± 7	**208.2 ± 36.3**
^{195}Tl	c*	1.16H	884.5	10.0 ± 1.1	**155.9 ± 19.1**
^{203}Hg	c	46.612D	279.2	81.46 ± 0.13	**17.66 ± 0.66**
^{197m}Hg	i(m)	23.8H	134.0	33.5 ± 0.4	**55.83 ± 2.50**
^{195}Hg$_c$	c	9.9H	779.8	6.8 ± 0.7	**240.8 ± 26.3**
^{195m}Hg	i(m)	41.6H	560.3	7.0 ± 0.6	71.07 ± 6.64
			261.8	31 ± 4	79.20 ± 10.65
				RR_{mean} =	**72.31 ± 4.05**
^{193m}Hg	i(m)	11.8H	407.6	32 ± 6	81.70 ± 15.62
			258.0	49 ± 7	109.5 ± 16.6
				RR_{mean} =	**94.86 ± 14.19**
^{192}Hg	c	4.85H	316.5	*	273.2 ± 34.3
			274.8	50.2 ± 2.5	211.0 ± 13.3
				RR_{mean} =	**217.8 ± 6.7**
^{190}Hg	c*	20.0M	142.6	68 ± 10	**165.4 ± 25.3**
^{198m}Au	i(m)	2.27D	204.1	40.8 ± 2.4	3.191 ± 0.281
			411.8	*	3.308 ± 0.178

Continuation of Table 83.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
				RR_{mean} =	**3.280 ± 0.101**
$^{198}Au_i$	i	2.69517D	411.8	95.58 ± 0.12	**6.924 ± 0.331**
$^{198}Au_c$	i(m+g)	2.69517D	411.8	95.58 ± 0.12	**10.23 ± 0.36**
^{196}Au	i(m1+m2+g)	6.183D	355.7	87.0 ± 0.8	18.36 ± 0.65
			333.0	22.9 ± 0.6	20.04 ± 0.96
				RR_{mean} =	**18.57 ± 0.79**
^{195}Au	c	186.098D	98.9	10.9 ± 0.9	**293.7 ± 28.7**
^{194}Au	i(m1+m2+g)	38.02H	328.5	61 ± 5	34.54 ± 3.06
			293.6	10.4 ± 0.8	32.02 ± 2.76
				RR_{mean} =	**33.12 ± 1.84**
$^{192}Au_i$	i(m+g)	4.94H	316.5	58 ± 7	**44.87 ± 6.01**
$^{192}Au_c$	c	4.94H	316.5	58 ± 7	**318.1 ± 39.9**
^{191}Au	c*	3.18H	586.4	17 ± 0	291.2 ± 14.3
			166.5	3.32 ± 0.24	297.6 ± 26.8
				RR_{mean} =	**292.3 ± 13.6**
$^{190}Au_c$	c	42.8M	301.8	23.4 ± 1.5	**226.9 ± 17.3**
^{191}Pt	c	2.802D	538.9	13.7 ± 1.6	252.2 ± 30.7
			456.5	3.4 ± 0.4	228.4 ± 28.1
			409.4	8.0 ± 0.9	222.6 ± 26.2
			351.2	3.4 ± 0.4	255.7 ± 31.5
			172.2	3.5 ± 0.4	221.1 ± 27.1
				RR_{mean} =	**233.3 ± 10.1**
^{189}Pt	c	10.87H	721.4	9.3 ± 0.8	271.2 ± 25.3
			607.6	8.10 ± 0.16	243.6 ± 10.0
			568.8	7.1 ± 0.6	232.5 ± 22.9
			544.9	5.8 ± 0.5	279.1 ± 26.2
			243.5	7.0 ± 1.2	267.6 ± 47.2
				RR_{mean} =	**246.6 ± 9.5**
^{188}Pt	c	10.2D	1209.8	*	230.5 ± 24.7
			633.0	*	247.3 ± 42.0
			478.0	*	217.3 ± 11.7
			423.3	4.4 ± 0.3	220.8 ± 16.9
			381.4	7.5 ± 0.5	218.0 ± 16.3
			195.1	18.6 ± 1.2	217.6 ± 16.3
			187.6	19.4 ± 1.2	224.2 ± 16.2
			155.1	*	228.5 ± 24.3
				RR_{mean} =	**219.1 ± 6.8**
^{187}Pt	c	2.35H	106.4	8.8 ± 1.8	**171.7 ± 36.7**
^{186}Pt	c	2.08H	689.4	70 ± 15	**167.4 ± 36.4**
^{184}Pt	c	17.3M	548.3	23 ± 4	**130.7 ± 23.9**
^{192}Ir	i(m1+g)	73.827D	316.5	82.71 ± 0.21	**0.6971 ± 0.0603**
^{190}Ir	i(m1+g)	11.78D	605.1	39.9 ± 1.9	1.793 ± 0.151
			518.5	34.0 ± 1.6	2.352 ± 0.179
				RR_{mean} =	**2.039 ± 0.284**
^{189}Ir	c	13.2D	275.9	0.54 ± 0.07	231.5 ± 32.1
			245.1	6.0 ± 0.6	220.5 ± 23.7
				RR_{mean} =	**221.2 ± 8.6**
$^{188}Ir_i$	i	41.5H	633.0	18 ± 3	11.74 ± 2.20
			478.0	14.7 ± 0.6	12.47 ± 1.58
			155.1	30 ± 3	13.05 ± 1.54

Continuation of Table 83.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
				RR_{mean} =	**12.58 ± 0.98**
$^{188}Ir_c$	c	41.5H	1209.8	6.9 ± 0.7	236.5 ± 25.3
			633.0	18 ± 3	259.1 ± 44.1
			478.0	14.7 ± 0.6	229.7 ± 12.3
			155.1	30 ± 3	241.5 ± 25.6
				RR_{mean} =	**230.4 ± 8.0**
^{187}Ir	c*	10.5H	977.5	3.14 ± 0.11	**212.8 ± 12.0**
^{186}Ir	c	16.64H	773.3	8.9 ± 0.5	95.33 ± 6.60
			434.8	33.9 ± 1.1	94.89 ± 4.56
				RR_{mean} =	**95.00 ± 4.17**
^{185}Ir	c	14.4H	1829.0	10.1 ± 1.5	141.2 ± 21.7
			254.2	13.3 ± 2.4	131.7 ± 24.5
				RR_{mean} =	**139.6 ± 7.5**
^{184}Ir	c*	3.09H	841.3	8.0 ± 0.8	148.9 ± 17.1
			390.4	25.9 ± 2.4	149.9 ± 15.2
			264.0	68 ± 4	171.6 ± 12.2
			119.8	31 ± 3	172.6 ± 18.7
				RR_{mean} =	**167.0 ± 7.4**
^{183}Ir	c	57M	392.5	10.4 ± 2.4	**141.9 ± 33.9**
^{185}Os	c	93.6D	874.8	6.29 ± 0.25	193.0 ± 10.1
			717.4	3.94 ± 0.16	193.4 ± 10.5
			646.1	78 ± 3	186.1 ± 9.5
				RR_{mean} =	**189.2 ± 6.3**
^{183m}Os	c*	9.9H	1107.9	22.4 ± 0.6	93.49 ± 4.33
			1101.9	49.0 ± 1.3	80.46 ± 3.86
				RR_{mean} =	**86.76 ± 7.04**
^{182}Os	c	22.10H	1121.4	*	171.6 ± 10.4
			180.2	33.5 ± 1.7	158.4 ± 10.1
				RR_{mean} =	**164.9 ± 5.1**
^{181}Os	c	105M	238.8	44 ± 5	**47.72 ± 5.90**
^{180}Os	c	21.5M	902.8(D)	101.5 ± 3.4	**104.5 ± 5.7**
^{183}Re	c	70.0D	291.7	3.05 ± 0.18	153.9 ± 10.8
			162.3	23.3 ± 0.7	167.2 ± 7.9
				RR_{mean} =	**164.4 ± 7.4**
$^{182m}Re_c$	c	12.7H	1221.5	24.8 ± 1.6	153.3 ± 11.4
			1189.2	15 ± 1	181.0 ± 14.5
			1121.4	31.8 ± 1.6	155.6 ± 9.6
				RR_{mean} =	**158.6 ± 8.1**
^{181}Re	c*	19.9H	639.0	6.4 ± 1.4	128.1 ± 28.9
			365.5	56 ± 8	117.2 ± 17.5
				RR_{mean} =	**119.6 ± 13.1**
^{179}Re	c*	19.5M	430.2	28.0 ± 1.8	129.7 ± 10.2
			290.0	26.9 ± 2.3	115.8 ± 12.2
				RR_{mean} =	**127.0 ± 6.8**
^{178}Re	c*	13.2M	237.3	45 ± 5	**117.1 ± 14.6**
^{178}W	c	21.6D	1350.6(D)	1.18 ± 0.11	90.68 ± 11.56
			1340.8(D)	1.03 ± 0.09	66.71 ± 12.50
				RR_{mean} =	**82.00 ± 11.80**
^{177}W	c	135M	115.7	51 ± 5	**66.00 ± 7.37**
^{176}W	c	2.5H	1159.3	*	**37.53 ± 8.93**

Continuation of Table 83.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{177}Ta	c*	56.56H	112.9	7.2 ± 1.6	**79.71 ± 18.71**
^{176}Ta$_c$	c	8.09H	1159.3	24.7 ± 1.9	**68.09 ± 6.39**
^{175}Ta	c	10.5H	348.5	12.0 ± 1.1	60.26 ± 6.13
			266.9	10.52 ± 0.16	56.02 ± 3.12
				RR_{mean} =	**56.71 ± 2.93**
^{173}Ta	c	3.14H	172.2	17.5 ± 1.8	**47.29 ± 6.03**
^{175}Hf	c	70D	343.4	84 ± 3	**54.33 ± 2.67**
^{173}Hf	c*	23.6H	311.2	10.7 ± 0.5	**41.65 ± 2.60**
^{172}Hf	c	1.87Y	1093.6	*	26.63 ± 1.61
			900.7	*	28.11 ± 1.96
			181.5	*	27.83 ± 1.82
			125.8	11.3 ± 0.9	27.72 ± 2.94
				RR_{mean} =	**27.36 ± 0.84**
^{170}Hf	c	16.01H	164.7	26 ± 8	23.55 ± 7.32
			120.2	15 ± 5	20.77 ± 7.16
				RR_{mean} =	**22.44 ± 2.89**
^{173}Lu	c	1.37Y	272.1	21.2 ± 0.8	**37.03 ± 2.05**
^{172}Lu$_c$	c	6.70D	1093.6	63 ± 3	26.78 ± 1.61
			900.7	29.8 ± 1.3	29.66 ± 2.02
			181.5	20.6 ± 1.0	29.80 ± 1.93
				RR_{mean} =	**28.22 ± 1.36**
^{171}Lu	c*	8.24D	739.8	47.8 ± 1.2	**27.04 ± 1.15**
^{170}Lu	c*	2.012D	2126.1	5.1 ± 0.3	23.88 ± 1.88
			1280.2	8.2 ± 0.4	28.59 ± 2.22
				RR_{mean} =	**25.86 ± 2.46**
^{169}Lu	c	34.06H	960.6	23.4 ± 0.7	**15.96 ± 0.91**
^{169}Yb	c*	32.026D	198.0	35.8 ± 0.7	17.29 ± 0.80
			177.2	22.2 ± 0.5	15.47 ± 0.76
			130.5	11.31 ± 0.21	18.42 ± 1.22
				RR_{mean} =	**16.63 ± 0.92**
^{166}Yb	c	56.7H	2052.4	*	**7.528 ± 0.566**
^{167}Tm	c	9.25D	207.8	42 ± 8	**10.89 ± 2.13**
^{165}Tm	c	30.06H	242.9	35.5 ± 1.7	**4.914 ± 0.396**
^{149}Gd	c	9.28D	149.7	48 ± 3	**0.6018 ± 0.0920**
^{139}Ce	c	137.640D	165.9	79.89 ± 0.01	**1.085 ± 0.103**
^{127}Xe	c	36.4D	202.9	68.3 ± 0.5	2.708 ± 0.146
			172.1	25.5 ± 0.8	2.369 ± 0.350
				RR_{mean} =	**2.672 ± 0.138**
^{124}Sb	i(m1+m2+g)	60.20D	602.7	98.3 ± 0.4	**0.5347 ± 0.0672**
^{123m}Te	i(m)	119.7D	159.0	84.0 ± 0.4	**1.832 ± 0.150**
^{121m}Te	i(m)	154D	573.1	88.6 ± 0.1	1.834 ± 0.164
			212.2	81.4 ± 1.1	2.039 ± 0.114
				RR_{mean} =	**1.982 ± 0.061**
^{121}Te$_c$	c	19.16D	573.1	80.3 ± 2.5	**3.500 ± 0.191**
^{119m}Te	i(m)	4.70D	1212.7	66.2 ± 0.3	**1.109 ± 0.081**
^{120m}Sb	i(m)	5.76D	1023.3	99.4 ± 0.3	**2.009 ± 0.095**
^{113}Sn	c	115.09D	391.7	64.97 ± 0.17	**1.606 ± 0.155**
^{114m}In	i(m)	49.51D	190.3	15.56 ± 0.16	**6.490 ± 0.469**
^{110m}Ag	i(m)	249.76D	1384.3	24.9 ± 0.8	7.393 ± 0.565
			937.5	34.2 ± 0.6	6.093 ± 0.374

Continuation of Table 83.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			884.7	72.7 ± 0.4	5.998 ± 0.269
				RR_{mean} =	**6.152 ± 0.342**
^{106m}Ag	i(m)	8.28D	1045.8	29.6 ± 1.0	2.071 ± 0.196
			717.3	28.9 ± 0.8	2.032 ± 0.225
			451.0	28.2 ± 0.8	2.419 ± 0.230
				RR_{mean} =	**2.162 ± 0.136**
^{105}Rh	c	35.36H	318.9	19.1 ± 0.6	**22.73 ± 1.12**
^{102}Rh	i	207D	475.1	46 ± 5	**2.910 ± 0.421**
^{101m}Rh	c	4.34D	306.9	81 ± 5	**3.415 ± 0.283**
^{103}Ru	c	39.26D	497.1	91.0 ± 1.3	**21.01 ± 0.81**
^{96}Tc	i(m+g)	4.28D	849.9	98 ± 4	3.206 ± 0.180
			812.5	82 ± 4	3.294 ± 0.204
				RR_{mean} =	**3.243 ± 0.152**
^{96}Nb	i	23.35H	1091.3	48.5 ± 1.6	12.04 ± 0.65
			568.9	58.0 ± 0.3	13.91 ± 0.61
				RR_{mean} =	**13.14 ± 1.00**
^{95}Nb$_i$	i(m+g)	34.975D	765.8	99.81 ± 0.03	**14.59 ± 0.52**
^{95}Nb$_c$	c	34.975D	765.8	99.81 ± 0.03	**27.20 ± 0.93**
^{92m}Nb	i(m)	10.15D	934.4	99.07 ± 0.04	**1.427 ± 0.080**
^{97}Zr	c	16.744H	743.4	93.06 ± 0.16	**3.752 ± 0.173**
^{95}Zr	c	64.02D	765.8	*	12.72 ± 0.52
			756.7	54.46 ± 0.10	11.74 ± 0.87
			724.2	44.17 ± 0.16	12.57 ± 0.48
				RR_{mean} =	**12.57 ± 0.39**
^{89}Zr	c	78.41H	909.2	99.04 ± 0.03	**5.034 ± 0.185**
^{88}Zr	c	83.4D	1836.1	*	2.056 ± 0.307
			392.9	97.24 ± 0.00	2.036 ± 0.119
				RR_{mean} =	**2.038 ± 0.063**
^{90m} Y	i(m)	3.19H	479.5	90.74 ± 0.05	**14.34 ± 0.64**
^{88} Y$_i$	i	106.65D	1836.1	99.2 ± 0.3	10.90 ± 0.46
			898.0	93.7 ± 0.3	10.75 ± 0.39
				RR_{mean} =	**10.79 ± 0.37**
^{88} Y$_c$	c	106.65D	1836.1	99.2 ± 0.3	12.96 ± 0.49
			898.0	93.7 ± 0.3	12.39 ± 0.42
				RR_{mean} =	**12.55 ± 0.46**
^{87} Y	c*	79.8H	484.8	89.7 ± 0.7	7.291 ± 0.265
			388.5	82.1 ± 0.5	8.754 ± 0.308
				RR_{mean} =	**7.994 ± 0.771**
^{85}Sr	c	64.84D	514.0	96 ± 4	**7.920 ± 0.437**
^{86}Rb	i(m+g)	18.631D	1077.0	8.64 ± 0.04	**17.90 ± 1.13**
^{83}Rb	c	86.2D	552.6	16.0 ± 1.1	10.01 ± 0.88
			529.6	29.3 ± 2.1	9.103 ± 0.788
			520.4	45 ± 4	8.723 ± 0.865
				RR_{mean} =	**9.292 ± 0.465**
^{82}Br	i(m+g)	35.30H	1317.5	26.5 ± 0.4	9.425 ± 0.563
			776.5	83.5 ± 1.2	9.894 ± 0.382
			698.4	28.5 ± 0.4	10.53 ± 0.48
			554.3	70.8 ± 1.0	9.448 ± 0.397
				RR_{mean} =	**9.828 ± 0.374**
^{75}Se	c	119.779D	264.7	58.9 ± 0.4	2.567 ± 0.145

Continuation of Table 83.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			136.0	58.3 ± 0.8	2.648 ± 0.158
				RR_{mean} =	**2.603 ± 0.121**
^{74}As	i	17.77D	595.8	59 ± 4	**4.894 ± 0.390**
^{72}Ga$_i$	i	14.10H	2201.7	25.9 ± 0.5	**4.679 ± 0.849**
^{72}Ga$_c$	c	14.10H	2201.7	25.9 ± 0.5	**6.291 ± 0.780**
^{72}Zn	c	46.5H	2201.7	*	**1.612 ± 0.170**
^{59}Fe	c	44.472D	1291.6	43.2 ± 1.4	2.195 ± 0.194
			1099.2	56.5 ± 1.9	2.302 ± 0.180
				RR_{mean} =	**2.254 ± 0.137**
^{46}Sc	i(m+g)	83.79D	889.3	99.98 ± 0.00	**0.4787 ± 0.0629**
^{7}Be	i	53.29D	477.6	10.52 ± 0.06	**4.866 ± 0.870**

12.7.4 Nuclide production rates for ^{nat}Pb

Table 84: Detailed calculation of nuclide production rates for ^{nat}Pb for $E_p = 0.6$ GeV, used to determine the cross sections for their production.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{207}Bi	i	31.55Y	569.7	97.74 ± 0.03	**18.95 ± 3.61**
^{206}Bi	i	6.243D	1718.7	31.8 ± 0.6	22.10 ± 0.94
			803.1	98.9 ± 1.4	20.93 ± 0.75
			537.5	30.5 ± 0.5	20.55 ± 0.83
			497.1	15.31 ± 0.22	21.76 ± 1.22
			343.5	23.4 ± 0.4	19.22 ± 0.90
				RR_{mean} =	**20.83 ± 0.76**
^{205}Bi	i	15.31D	1764.3	32.5 ± 0.7	37.00 ± 1.56
			1861.7	6.17 ± 0.10	34.81 ± 1.93
			703.5	31.1 ± 0.1	35.59 ± 1.24
				RR_{mean} =	**35.80 ± 1.20**
^{204}Bi	i	11.22H	984.0	59 ± 4	38.57 ± 3.00
			899.2	98 ± 9	34.88 ± 1.28
			670.7	11.4 ± 0.9	38.30 ± 3.99
			374.8	82 ± 5	38.60 ± 8.06
				RR_{mean} =	**35.20 ± 1.09**
^{203}Bi	i(m+g)	11.76H	1893.0	8.2 ± 0.6	32.45 ± 3.40
			1847.3	11.4 ± 0.8	35.99 ± 3.19
			820.2	29.6 ± 1.5	40.87 ± 2.59
				RR_{mean} =	**39.56 ± 2.26**
^{202}Bi	i	1.72H	960.7	99.28 ± 0.02	30.59 ± 4.30
			422.1	83.7 ± 2.5	41.88 ± 3.42
				RR_{mean} =	**37.78 ± 5.55**
^{204m}Pb$_i$	i(m)	67.2M	899.2	99.17 ± 0.02	75.82 ± 2.95
			374.7	89 ± 15	83.06 ± 14.37
				RR_{mean} =	**75.94 ± 2.94**
^{204m}Pb$_c$	c	67.2M	899.2	99.17 ± 0.02	81.06 ± 3.08
			374.7	89 ± 15	87.90 ± 15.19
				RR_{mean} =	**81.15 ± 3.08**
^{203}Pb	c*	51.873H	279.2	80.8 ± 0.2	**242.7 ± 8.9**

Continuation of Table 84.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{202m}Pb	i(m)	3.53H	960.7	92 ± 8	67.27 ± 7.46
			422.1	86 ± 5	68.77 ± 5.01
				RR_{mean} =	**68.52 ± 3.32**
^{201}Pb	c*	9.33H	331.2	79 ± 5	215.4 ± 15.5
			692.4	4.27 ± 0.16	203.6 ± 11.2
				RR_{mean} =	**207.2 ± 10.0**
^{200}Pb	c	21.5H	1205.7	*	161.4 ± 11.2
			1514.9	*	175.3 ± 15.4
			579.3	*	146.3 ± 9.5
			367.9	*	153.6 ± 5.3
			147.6	37.7 ± 1.4	163.2 ± 9.1
				RR_{mean} =	**154.9 ± 4.8**
^{199}Pb	c*	90M	366.9	44 ± 7	**284.7 ± 47.0**
^{198}Pb	c	2.4H	173.4	18 ± 3	**207.3 ± 35.6**
^{197m}Pb	c*	43M	385.9	74 ± 15	153.7 ± 31.7
			222.8	25 ± 6	147.3 ± 36.4
				RR_{mean} =	**153.2 ± 7.5**
^{196}Pb	c*	37M	502.1	26 ± 3	**168.0 ± 21.0**
^{195m}Pb	i(m)	15.0M	383.6	107 ± 20	**86.92 ± 18.35**
^{202}Tl	c	12.23D	439.6	91.4 ± 1.0	**112.7 ± 4.1**
^{201}Tl	c*	72.912H	167.4	10.00 ± 0.06	**359.8 ± 13.3**
$^{200}Tl_i$	i	26.1H	1205.7	29.9 ± 1.8	148.1 ± 10.6
			1514.9	4.0 ± 0.3	133.5 ± 14.7
			367.9	87.2 ± 0.4	143.4 ± 5.8
			579.3	13.8 ± 0.7	164.8 ± 11.9
				RR_{mean} =	**145.3 ± 5.9**
$^{200}Tl_c$	c	26.1H	1205.7	29.9 ± 1.8	309.4 ± 21.3
			1514.9	4.0 ± 0.3	308.8 ± 25.9
			579.3	13.8 ± 0.7	311.2 ± 19.3
			367.9	87.2 ± 0.4	296.9 ± 10.3
				RR_{mean} =	**298.7 ± 10.1**
$^{199}Tl_c$	c	7.42H	455.5	12.4 ± 1.4	283.8 ± 34.9
			208.2	12.3 ± 1.4	319.1 ± 39.8
				RR_{mean} =	**298.7 ± 19.7**
^{199}Tl	c*	7.42H	455.5	12.4 ± 1.4	338.0 ± 40.1
			208.2	12.3 ± 1.4	360.3 ± 43.9
				RR_{mean} =	**347.5 ± 19.1**
^{198m}Tl	i(m)	1.87H	282.8	28 ± 3	**126.4 ± 15.5**
^{197}Tl	c*	2.84H	1411.3	4.5 ± 1.5	**369.4 ± 125.0**
^{196m}Tl	i(m)	1.41H	695.4	41 ± 7	**261.0 ± 45.5**
^{195}Tl	c*	1.16H	884.5	10.0 ± 1.1	**225.0 ± 29.0**
^{203}Hg	c	46.612D	279.2	81.46 ± 0.13	**16.35 ± 0.64**
^{197m}Hg	i(m)	23.8H	134.0	33.5 ± 0.4	**62.07 ± 3.10**
$^{195}Hg_c$	c	9.9H	779.8	6.8 ± 0.7	**311.4 ± 34.1**
^{195m}Hg	i(m)	41.6H	560.3	7.0 ± 0.6	82.89 ± 7.85
			261.8	31 ± 4	90.48 ± 12.19
				RR_{mean} =	**84.17 ± 4.84**
^{193m}Hg	i(m)	11.8H	258.0	49 ± 7	132.1 ± 19.8
			407.6	32 ± 6	100.6 ± 19.2
				RR_{mean} =	**116.1 ± 16.2**

Continuation of Table 84.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{192}Hg	c	4.85H	316.5	*	340.7 ± 42.8
			274.8	50.2 ± 2.5	267.4 ± 16.7
				RR_{mean} =	**275.5 ± 8.5**
^{190}Hg	c*	20.0M	142.6	68 ± 10	**215.2 ± 33.0**
^{198m}Au	i(m)	2.27D	204.1	40.8 ± 2.4	3.632 ± 0.299
			411.8	*	3.052 ± 0.215
				RR_{mean} =	**3.241 ± 0.100**
^{198}Au$_i$	i	2.69517D	411.8	95.58 ± 0.12	**7.484 ± 0.426**
^{198}Au$_c$	i(m+g)	2.69517D	411.8	95.58 ± 0.12	**10.53 ± 0.40**
^{196}Au	i(m1+m2+g)	6.183D	426.1	6.6 ± 0.8	20.51 ± 2.65
			355.7	87.0 ± 0.8	19.43 ± 0.68
			333.0	22.9 ± 0.6	20.38 ± 0.92
				RR_{mean} =	**19.57 ± 0.65**
^{195}Au	c	186.098D	98.9	10.9 ± 0.9	**386.3 ± 38.2**
^{194}Au	i(m1+m2+g)	38.02H	328.5	61 ± 5	37.34 ± 3.32
			293.6	10.4 ± 0.8	35.30 ± 3.05
				RR_{mean} =	**36.22 ± 2.02**
^{192}Au$_i$	i(m+g)	4.94H	316.5	58 ± 7	**59.19 ± 7.65**
^{192}Au$_c$	c	4.94H	316.5	58 ± 7	**399.9 ± 50.2**
^{191}Au	c*	3.18H	586.4	17 ± 0	377.7 ± 14.6
			166.5	3.32 ± 0.24	360.7 ± 31.2
				RR_{mean} =	**376.2 ± 14.4**
^{190}Au$_c$	c	42.8M	301.8	23.4 ± 1.5	257.9 ± 28.2
			295.8	71 ± 5	278.0 ± 23.0
				RR_{mean} =	**272.2 ± 14.8**
^{191}Pt	c	2.802D	538.9	13.7 ± 1.6	315.2 ± 38.4
			456.5	3.4 ± 0.4	282.0 ± 34.6
			409.4	8.0 ± 0.9	274.1 ± 32.2
			351.2	3.4 ± 0.4	316.7 ± 39.1
			172.2	3.5 ± 0.4	265.3 ± 32.0
				RR_{mean} =	**285.9 ± 13.4**
^{189}Pt	c	10.87H	721.4	9.3 ± 0.8	343.5 ± 31.8
			607.6	8.10 ± 0.16	296.9 ± 12.6
			568.8	7.1 ± 0.6	325.9 ± 30.4
			544.9	5.8 ± 0.5	343.7 ± 32.2
			243.5	7.0 ± 1.2	320.8 ± 56.6
				RR_{mean} =	**305.0 ± 12.5**
^{188}Pt	c	10.2D	1209.8	*	286.3 ± 30.6
			633.0	*	309.2 ± 52.6
			478.0	*	271.4 ± 14.6
			322.9	*	267.9 ± 26.7
			155.1	*	290.3 ± 30.8
			187.6	19.4 ± 1.2	281.1 ± 20.3
			195.1	18.6 ± 1.2	274.3 ± 20.5
			423.3	4.4 ± 0.3	276.0 ± 21.1
			381.4	7.5 ± 0.5	268.9 ± 20.1
				RR_{mean} =	**273.7 ± 8.4**
^{187}Pt	c	2.35H	106.4	8.8 ± 1.8	**219.2 ± 46.7**
^{186}Pt	c	2.08H	689.4	70 ± 15	212.2 ± 46.1
			137.1	*	183.8 ± 26.2

Continuation of Table 84.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
				RR_{mean} =	**190.6 ± 5.9**
^{184}Pt	c	17.3M	548.3	23 ± 4	**179.5 ± 33.2**
^{192}Ir	i(m1+g)	73.827D	316.5	82.71 ± 0.21	**0.6374 ± 0.0717**
^{190}Ir	i(m1+g)	11.78D	605.1	39.9 ± 1.9	2.145 ± 0.170
			518.5	34.0 ± 1.6	2.549 ± 0.199
				RR_{mean} =	**2.318 ± 0.212**
^{189}Ir	c	13.2D	245.1	6.0 ± 0.6	270.0 ± 29.0
			275.9	0.54 ± 0.07	278.7 ± 38.3
				RR_{mean} =	**270.6 ± 10.5**
$^{188}Ir_i$	i	41.5H	633.0	18 ± 3	11.12 ± 2.53
			478.0	14.7 ± 0.6	14.19 ± 2.41
			155.1	30 ± 3	12.84 ± 2.25
				RR_{mean} =	**12.79 ± 1.38**
$^{188}Ir_c$	c	41.5H	1209.8	6.9 ± 0.7	289.1 ± 30.9
			633.0	18 ± 3	320.4 ± 54.5
			478.0	14.7 ± 0.6	285.6 ± 15.4
			322.9	1.62 ± 0.15	264.4 ± 27.1
			155.1	30 ± 3	303.1 ± 32.2
				RR_{mean} =	**285.6 ± 9.9**
^{187}Ir	c*	10.5H	977.5	3.14 ± 0.11	**276.2 ± 14.8**
^{186}Ir	c	16.64H	434.8	33.9 ± 1.1	122.1 ± 5.9
			773.3	8.9 ± 0.5	116.5 ± 8.0
			137.2	41.4 ± 0.7	125.7 ± 5.9
				RR_{mean} =	**122.8 ± 4.8**
^{185}Ir	c	14.4H	1829.0	10.1 ± 1.5	182.4 ± 28.0
			254.2	13.3 ± 2.4	171.9 ± 32.0
				RR_{mean} =	**180.8 ± 9.6**
^{184}Ir	c*	3.09H	264.0	68 ± 4	213.8 ± 15.1
			841.3	8.0 ± 0.8	175.1 ± 19.9
			390.4	25.9 ± 2.4	192.8 ± 19.2
			119.8	31 ± 3	230.6 ± 25.1
				RR_{mean} =	**208.7 ± 10.2**
^{183}Ir	c	57M	392.5	10.4 ± 2.4	**181.5 ± 44.3**
^{185}Os	c	93.6D	646.1	78 ± 3	237.1 ± 12.1
			874.8	6.29 ± 0.25	246.3 ± 12.9
			717.4	3.94 ± 0.16	238.9 ± 12.9
				RR_{mean} =	**239.9 ± 7.9**
^{183m}Os	c*	9.9H	1101.9	49.0 ± 1.3	119.6 ± 5.3
			1107.9	22.4 ± 0.6	118.0 ± 5.3
				RR_{mean} =	**118.8 ± 4.1**
^{182}Os	c	22.10H	1221.5	*	208.0 ± 15.4
			180.2	33.5 ± 1.7	204.9 ± 13.1
				RR_{mean} =	**206.1 ± 6.4**
^{181}Os	c	105M	238.8	44 ± 5	**66.19 ± 8.15**
^{180}Os	c	21.5M	902.8(D)	101.5 ± 3.4	**133.7 ± 7.0**
^{183}Re	c	70.0D	291.7	3.05 ± 0.18	206.0 ± 14.5
			162.3	23.3 ± 0.7	214.0 ± 10.1
				RR_{mean} =	**212.4 ± 8.6**
$^{182m}Re_c$	c	12.7H	1221.5	24.8 ± 1.6	202.1 ± 15.0
			1189.2	15 ± 1	232.3 ± 18.0

Continuation of Table 84.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			1121.4	31.8 ± 1.6	201.7 ± 13.0
				RR_{mean} =	**207.4 ± 10.5**
^{181}Re	c*	19.9H	639.0	6.4 ± 1.4	164.4 ± 36.8
			365.5	56 ± 8	159.4 ± 24.1
				RR_{mean} =	**160.7 ± 17.8**
^{179}Re	c*	19.5M	430.2	28.0 ± 1.8	190.3 ± 15.3
			290.0	26.9 ± 2.3	165.6 ± 16.8
				RR_{mean} =	**184.1 ± 12.2**
^{178}Re	c*	13.2M	237.3	45 ± 5	**159.1 ± 20.5**
^{178} W	c	21.6D	1340.8(D)	1.03 ± 0.09	87.25 ± 10.45
			1350.6(D)	1.18 ± 0.11	103.4 ± 19.2
				RR_{mean} =	**89.62 ± 7.04**
^{177} W	c	135M	115.7	51 ± 5	**95.71 ± 10.61**
^{176} W	c	2.5H	1159.3	*	**77.21 ± 13.27**
^{177}Ta	c*	56.56H	112.9	7.2 ± 1.6	**113.1 ± 25.8**
^{176}Ta$_c$	c	8.09H	1159.3	24.7 ± 1.9	**89.84 ± 8.49**
^{175}Ta	c	10.5H	266.9	10.52 ± 0.16	79.45 ± 3.92
			348.5	12.0 ± 1.1	84.43 ± 8.40
				RR_{mean} =	**80.07 ± 3.74**
^{173}Ta	c	3.14H	172.2	17.5 ± 1.8	**56.86 ± 6.53**
^{175}Hf	c	70D	343.4	84 ± 3	**75.62 ± 3.71**
^{173}Hf	c*	23.6H	311.2	10.7 ± 0.5	**64.05 ± 3.85**
^{172}Hf	c	1.87Y	1093.6	*	37.40 ± 2.33
			900.7	*	42.80 ± 3.05
			181.5	*	36.23 ± 2.43
			125.8	11.3 ± 0.9	59.48 ± 6.74
				RR_{mean} =	**40.33 ± 1.24**
^{170}Hf	c	16.01H	164.7	26 ± 8	36.79 ± 11.44
			120.2	15 ± 5	25.18 ± 8.71
				RR_{mean} =	**30.73 ± 5.88**
^{173}Lu	c	1.37Y	272.1	21.2 ± 0.8	**51.92 ± 2.93**
^{172}Lu$_c$	c	6.70D	1093.6	63 ± 3	37.70 ± 2.33
			900.7	29.8 ± 1.3	44.46 ± 3.08
			181.5	20.6 ± 1.0	37.17 ± 2.48
				RR_{mean} =	**38.84 ± 2.30**
^{171}Lu	c*	8.24D	739.8	47.8 ± 1.2	**39.29 ± 1.67**
^{170}Lu	c*	2.012D	1280.2	8.2 ± 0.4	45.61 ± 3.43
			2126.1	5.1 ± 0.3	39.29 ± 3.80
				RR_{mean} =	**43.18 ± 3.35**
^{169}Lu	c	34.06H	960.6	23.4 ± 0.7	**22.14 ± 1.57**
^{169}Yb	c*	32.026D	198.0	35.8 ± 0.7	25.27 ± 1.11
			177.2	22.2 ± 0.5	23.10 ± 1.02
			130.5	11.31 ± 0.21	25.12 ± 1.56
				RR_{mean} =	**24.23 ± 1.06**
^{166}Yb	c	56.7H	2052.4	*	**12.54 ± 1.01**
^{167}Tm	c	9.25D	207.8	42 ± 8	**16.63 ± 3.26**
^{165}Tm	c	30.06H	242.9	35.5 ± 1.7	**8.297 ± 0.619**
^{149}Gd	c	9.28D	149.7	48 ± 3	**0.8612 ± 0.1055**
^{139}Ce	c	137.640D	165.9	79.89 ± 0.01	**1.367 ± 0.125**
^{127}Xe	c	36.4D	202.9	68.3 ± 0.5	3.617 ± 0.155

Continuation of Table 84.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			172.1	25.5 ± 0.8	3.384 ± 0.259
				RR_{mean} =	**3.578 ± 0.146**
^{124}Sb	i(m1+m2+g)	60.20D	602.7	98.3 ± 0.4	**0.7733 ± 0.0932**
^{123m}Te	i(m)	119.7D	159.0	84.0 ± 0.4	**1.926 ± 0.154**
^{121m}Te	i(m)	154D	573.1	88.6 ± 0.1	2.386 ± 0.203
			212.2	81.4 ± 1.1	2.672 ± 0.156
				RR_{mean} =	**2.578 ± 0.080**
^{121}Te$_c$	c	19.16D	573.1	80.3 ± 2.5	**4.912 ± 0.252**
^{119m}Te	i(m)	4.70D	1212.7	66.2 ± 0.3	**2.042 ± 0.118**
^{120m}Sb	i(m)	5.76D	1023.3	99.4 ± 0.3	**2.576 ± 0.137**
^{113}Sn	c	115.09D	391.7	64.97 ± 0.17	**2.080 ± 0.190**
^{114m}In	i(m)	49.51D	190.3	15.56 ± 0.16	**8.575 ± 0.816**
^{110m}Ag	i(m)	249.76D	884.7	72.7 ± 0.4	7.797 ± 0.404
			1384.3	24.9 ± 0.8	8.824 ± 0.855
			937.5	34.2 ± 0.6	7.177 ± 0.735
				RR_{mean} =	**7.820 ± 0.386**
^{106m}Ag	i(m)	8.28D	1045.8	29.6 ± 1.0	3.594 ± 0.235
			717.3	28.9 ± 0.8	3.575 ± 0.279
			451.0	28.2 ± 0.8	3.188 ± 0.228
				RR_{mean} =	**3.435 ± 0.173**
^{105}Rh	c	35.36H	318.9	19.1 ± 0.6	**28.74 ± 1.55**
^{102}Rh	i	207D	475.1	46 ± 5	**3.500 ± 0.525**
^{101m}Rh	c	4.34D	306.9	81 ± 5	**5.158 ± 0.394**
^{103}Ru	c	39.26D	497.1	91.0 ± 1.3	**26.12 ± 0.99**
^{96}Tc	i(m+g)	4.28D	849.9	98 ± 4	4.763 ± 0.275
			812.5	82 ± 4	4.884 ± 0.296
				RR_{mean} =	**4.818 ± 0.227**
^{96}Nb	i	23.35H	1091.3	48.5 ± 1.6	16.31 ± 0.87
			568.9	58.0 ± 0.3	15.03 ± 0.67
				RR_{mean} =	**15.43 ± 0.76**
^{95}Nb$_i$	i(m+g)	34.975D	765.8	99.81 ± 0.03	**19.67 ± 0.66**
^{95}Nb$_c$	c	34.975D	765.8	99.81 ± 0.03	**34.97 ± 1.16**
^{92m}Nb	i(m)	10.15D	934.4	99.07 ± 0.04	**1.721 ± 0.095**
^{97}Zr	c	16.744H	743.4	93.06 ± 0.16	**4.533 ± 0.210**
^{95}Zr	c	64.02D	765.8	*	15.43 ± 0.56
			756.7	54.46 ± 0.10	14.84 ± 0.54
			724.2	44.17 ± 0.16	14.98 ± 0.56
				RR_{mean} =	**15.09 ± 0.47**
^{89}Zr	c	78.41H	909.2	99.04 ± 0.03	**8.113 ± 0.284**
^{88}Zr	c	83.4D	1836.1	*	2.612 ± 0.375
			392.9	97.24 ± 0.00	2.851 ± 0.137
				RR_{mean} =	**2.833 ± 0.087**
^{90m} Y	i(m)	3.19H	479.5	90.74 ± 0.05	**18.07 ± 0.78**
^{88} Y$_i$	i	106.65D	1836.1	99.2 ± 0.3	16.09 ± 0.60
			898.0	93.7 ± 0.3	16.01 ± 0.52
				RR_{mean} =	**16.03 ± 0.52**
^{88} Y$_c$	c	106.65D	1836.1	99.2 ± 0.3	18.71 ± 0.68
			898.0	93.7 ± 0.3	17.92 ± 0.59
				RR_{mean} =	**18.09 ± 0.65**
^{87} Y	c*	79.8H	484.8	89.7 ± 0.7	11.09 ± 0.40

Continuation of Table 84.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			388.5	82.1 ± 0.5	11.45 ± 0.48
				RR_{mean} =	**11.19 ± 0.38**
^{85}Sr	c	64.84D	514.0	96 ± 4	**11.81 ± 0.67**
^{86}Rb	i(m+g)	18.631D	1077.0	8.64 ± 0.04	**19.98 ± 1.34**
^{83}Rb	c	86.2D	552.6	16.0 ± 1.1	14.07 ± 1.27
			529.6	29.3 ± 2.1	13.49 ± 1.16
			520.4	45 ± 4	13.54 ± 1.41
				RR_{mean} =	**13.69 ± 0.68**
^{82}Br	i(m+g)	35.30H	1317.5	26.5 ± 0.4	13.25 ± 0.61
			776.5	83.5 ± 1.2	12.86 ± 0.50
			698.4	28.5 ± 0.4	13.93 ± 0.61
			554.3	70.8 ± 1.0	12.28 ± 0.52
				RR_{mean} =	**12.96 ± 0.51**
^{75}Se	c	119.779D	264.7	58.9 ± 0.4	4.180 ± 0.197
			136.0	58.3 ± 0.8	4.268 ± 0.223
				RR_{mean} =	**4.216 ± 0.173**
^{74}As	i	17.77D	595.8	59 ± 4	**7.219 ± 0.556**
$^{72}Ga_i$	i	14.10H	2201.7	25.9 ± 0.5	**6.004 ± 0.487**
$^{72}Ga_c$	c	14.10H	2201.7	25.9 ± 0.5	**7.798 ± 0.497**
^{72}Zn	c	46.5H	2201.7	*	**1.793 ± 0.141**
^{59}Fe	c	44.472D	1291.6	43.2 ± 1.4	3.164 ± 0.224
			1099.2	56.5 ± 1.9	3.416 ± 0.230
				RR_{mean} =	**3.289 ± 0.170**
^{46}Sc	i(m+g)	83.79D	889.3	99.98 ± 0.00	**0.7309 ± 0.1024**
^{7}Be	i	53.29D	477.6	10.52 ± 0.06	**5.916 ± 1.052**

12.7.5 Nuclide production rates for ^{209}Bi

Table 85: Detailed calculation of nuclide production rates for ^{209}Bi for E_p = 0.6 GeV, used to determine the cross sections for their production.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{207}Po	i(m+g)	5.80H	992.3	59.3 ± 0.9	**25.10 ± 1.05**
^{206}Po	i	8.8D	1718.7	*	28.69 ± 1.38
			1595.3	*	17.84 ± 5.14
			1098.3	*	24.16 ± 1.80
			1032.3	33 ± 5	28.99 ± 4.50
			980.2	7.1 ± 0.9	32.87 ± 4.38
			895.1	*	32.42 ± 1.48
			807.4	23 ± 3	29.35 ± 3.97
			803.1	*	28.61 ± 1.09
			620.5	*	25.61 ± 2.11
			537.5	*	26.79 ± 1.34
			522.5	15.7 ± 2.0	27.33 ± 3.62
			516.2	*	27.76 ± 1.42
			497.1	*	28.51 ± 2.13
			398.0	*	26.74 ± 1.55
			343.5	*	29.38 ± 1.59
			338.4	19.2 ± 2.5	29.69 ± 4.00

Continuation of Table 85.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			286.4	24 ± 3	29.35 ± 3.83
			184.0	*	26.84 ± 1.72
				RR_{mean} =	**28.24 ± 0.87**
^{205}Po	i	1.66H	872.4	37 ± 2	**31.80 ± 3.81**
^{204}Po	i	3.53H	884.0	29.9 ± 1.2	**35.43 ± 2.36**
^{207}Bi	c	31.55Y	1063.7	74.5 ± 0.2	254.9 ± 13.2
			569.7	97.74 ± 0.03	224.0 ± 10.1
				RR_{mean} =	**233.9 ± 16.2**
^{206}Bi$_i$	i	6.243D	1718.7	31.8 ± 0.6	147.6 ± 5.8
			1595.3	5.01 ± 0.08	164.6 ± 7.7
			1098.3	13.50 ± 0.21	137.1 ± 5.2
			895.1	15.66 ± 0.23	146.4 ± 5.3
			881.0	66.2 ± 1.0	143.6 ± 5.3
			803.1	98.9 ± 1.4	138.5 ± 4.9
			620.5	5.76 ± 0.09	139.1 ± 5.7
			537.5	30.5 ± 0.5	128.1 ± 5.0
			516.2	40.7 ± 0.6	132.6 ± 5.0
			497.1	15.31 ± 0.22	127.9 ± 5.0
			398.0	10.74 ± 0.15	127.8 ± 4.8
			343.5	23.4 ± 0.4	132.4 ± 5.1
			184.0	15.8 ± 0.4	169.7 ± 8.0
				RR_{mean} =	**137.6 ± 5.0**
^{206}Bi$_c$	c	6.243D	1718.7	31.8 ± 0.6	174.7 ± 6.8
			1595.3	5.01 ± 0.08	181.4 ± 7.6
			1098.3	13.50 ± 0.21	159.9 ± 5.9
			895.1	15.66 ± 0.23	177.1 ± 6.4
			881.0	66.2 ± 1.0	181.0 ± 6.5
			803.1	98.9 ± 1.4	165.5 ± 5.9
			620.5	5.76 ± 0.09	163.3 ± 6.2
			537.5	30.5 ± 0.5	153.5 ± 5.9
			516.2	40.7 ± 0.6	158.8 ± 5.9
			497.1	15.31 ± 0.22	154.8 ± 5.8
			398.0	10.74 ± 0.15	153.1 ± 5.6
			343.5	23.4 ± 0.4	160.2 ± 6.1
			184.0	15.8 ± 0.4	195.1 ± 9.0
				RR_{mean} =	**164.8 ± 5.9**
^{205}Bi	c	15.31D	1861.7	6.17 ± 0.10	180.7 ± 7.2
			1775.8	3.99 ± 0.08	179.6 ± 7.7
			1764.3	32.5 ± 0.7	181.8 ± 7.4
			1614.3	2.28 ± 0.04	182.2 ± 8.6
			1190.0	2.26 ± 0.07	182.6 ± 10.1
			1043.8	7.51 ± 0.10	168.3 ± 6.1
			987.7	16.13 ± 0.17	185.6 ± 6.8
			759.1	1.04 ± 0.05	173.4 ± 11.2
			703.5	31.1 ± 0.1	169.7 ± 5.7
			579.8	5.44 ± 0.07	159.9 ± 6.1
			570.6	4.34 ± 0.07	159.8 ± 6.9
			549.8	2.95 ± 0.04	160.9 ± 6.5
			284.1	1.69 ± 0.02	171.4 ± 7.8
				RR_{mean} =	**171.4 ± 5.8**
^{204}Bi	c*	11.22H	1211.7	3.0 ± 0.4	143.3 ± 20.6

Continuation of Table 85.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			984.0	59 ± 4	150.3 ± 11.4
			918.3	10.8 ± 0.9	172.1 ± 15.7
			899.2	98 ± 9	142.1 ± 4.9
			374.8	82 ± 5	164.5 ± 34.4
				RR_{mean} =	**142.9 ± 4.4**
^{203}Bi	c	11.76H	1893.0	8.2 ± 0.6	133.7 ± 11.2
			1888.0	1.94 ± 0.10	114.7 ± 9.9
			1847.3	11.4 ± 0.8	141.7 ± 11.4
			1679.6	8.8 ± 0.7	142.1 ± 13.2
			1536.5	7.5 ± 0.6	161.0 ± 14.5
			896.8	13.1 ± 0.7	138.9 ± 9.1
			847.2	8.5 ± 0.5	144.5 ± 10.9
			825.2	14.6 ± 1.1	157.6 ± 13.3
			820.2	29.6 ± 1.5	143.1 ± 9.0
			816.3	4.03 ± 0.21	148.2 ± 11.0
			279.2	*	127.5 ± 7.3
			264.2	5.2 ± 0.4	180.7 ± 21.5
				RR_{mean} =	**132.9 ± 4.1**
^{202}Bi	c*	1.72H	960.7	99.28 ± 0.02	114.8 ± 4.7
			422.1	83.7 ± 2.5	130.6 ± 7.3
				RR_{mean} =	**118.1 ± 7.4**
^{204m}Pb$_i$	i(m)	67.2M	899.2	99.17 ± 0.02	40.44 ± 2.13
			374.7	89 ± 15	51.67 ± 9.06
				RR_{mean} =	**40.84 ± 2.44**
^{204m}Pb$_c$	c	67.2M	899.2	99.17 ± 0.02	61.74 ± 2.59
			374.7	89 ± 15	72.31 ± 12.55
				RR_{mean} =	**61.95 ± 2.58**
^{203}Pb$_i$	i(m1+m2+g)	51.873H	279.2	80.8 ± 0.2	**115.4 ± 8.3**
^{203}Pb$_c$	c	51.873H	279.2	80.8 ± 0.2	**242.8 ± 9.0**
^{202m}Pb	i(m)	3.53H	960.7	92 ± 8	53.62 ± 5.41
			422.1	86 ± 5	54.15 ± 4.23
				RR_{mean} =	**54.00 ± 2.82**
^{201}Pb	c*	9.33H	946.0	7.4 ± 0.6	231.5 ± 20.7
			907.6	5.7 ± 0.4	275.4 ± 23.6
			692.4	4.27 ± 0.16	237.7 ± 16.1
			361.3	9.9 ± 0.5	252.9 ± 17.7
			331.2	79 ± 5	257.7 ± 18.6
				RR_{mean} =	**248.9 ± 10.8**
^{200}Pb	c	21.5H	1514.9	*	193.7 ± 17.9
			1362.9	*	206.8 ± 26.3
			1205.7	*	189.3 ± 13.1
			450.5	3.33 ± 0.08	212.0 ± 10.3
			367.9	*	182.6 ± 6.3
			235.6	4.30 ± 0.17	223.5 ± 13.2
			147.6	37.7 ± 1.4	195.6 ± 12.7
				RR_{mean} =	**186.3 ± 5.7**
^{199}Pb	c*	90M	1135.0	7.8 ± 1.2	312.9 ± 54.3
			366.9	44 ± 7	389.4 ± 65.0
				RR_{mean} =	**348.6 ± 39.7**
^{198}Pb	c	2.4H	2040.2	*	190.4 ± 30.7
			1447.0	*	189.1 ± 41.5

Continuation of Table 85.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			1420.6	*	216.6 ± 44.2
			865.3	5.9 ± 1.2	174.5 ± 37.3
			675.8	*	177.6 ± 28.8
			365.4	19 ± 5	287.1 ± 76.9
			259.5	5.8 ± 1.2	220.8 ± 47.3
			173.4	18 ± 3	271.2 ± 46.6
				RR_{mean} =	**198.6 ± 6.1**
^{197m}Pb	c*	43M	387.7	25 ± 6	180.9 ± 44.0
			385.9	74 ± 15	181.2 ± 37.3
			222.8	25 ± 6	152.5 ± 37.2
				RR_{mean} =	**178.6 ± 8.3**
^{196}Pb	c*	37M	502.1	26 ± 3	**194.2 ± 23.9**
^{195m}Pb	i(m)	15.0M	383.6	107 ± 20	**100.0 ± 19.1**
^{202}Tl	c	12.23D	439.6	91.4 ± 1.0	**29.38 ± 1.07**
^{201}Tl	c*	72.912H	167.4	10.00 ± 0.06	**300.1 ± 11.6**
^{200}Tl$_i$	i	26.1H	1205.7	29.9 ± 1.8	57.55 ± 5.27
			367.9	87.2 ± 0.4	54.95 ± 4.04
				RR_{mean} =	**55.87 ± 3.41**
^{200}Tl$_c$	c	26.1H	1205.7	29.9 ± 1.8	246.9 ± 17.1
			579.3	13.8 ± 0.7	252.2 ± 15.8
			367.9	87.2 ± 0.4	237.5 ± 8.4
				RR_{mean} =	**239.1 ± 8.2**
^{199}Tl	c*	7.42H	455.5	12.4 ± 1.4	284.2 ± 34.1
			247.3	9.3 ± 1.1	303.1 ± 38.0
			208.2	12.3 ± 1.4	341.4 ± 42.5
				RR_{mean} =	**303.9 ± 18.7**
^{198m}Tl	i(m)	1.87H	587.2	52.5 ± 2.0	51.89 ± 6.51
			282.8	28 ± 3	76.08 ± 9.63
				RR_{mean} =	**59.47 ± 11.37**
^{197}Tl	c*	2.84H	1411.3	4.5 ± 1.5	275.8 ± 93.1
			152.2	7.3 ± 2.3	418.9 ± 133.2
				RR_{mean} =	**360.6 ± 71.2**
^{196m}Tl	i(m)	1.41H	695.4	41 ± 7	**131.4 ± 23.4**
^{195}Tl	c*	1.16H	884.5	10.0 ± 1.1	**179.2 ± 22.5**
^{197}Hg	c*	64.14H	191.4	0.63 ± 0.02	**214.8 ± 27.1**
^{197m}Hg	i(m)	23.8H	134.0	33.5 ± 0.4	**21.99 ± 1.56**
^{195}Hg	c	9.9H	779.8	6.8 ± 0.7	**228.8 ± 25.3**
^{195m}Hg	i(m)	41.6H	261.8	31 ± 4	**36.48 ± 4.93**
^{193m}Hg	i(m)	11.8H	573.2	26 ± 4	43.99 ± 7.02
			407.6	32 ± 6	47.73 ± 9.13
				RR_{mean} =	**45.37 ± 5.64**
^{192}Hg	c	4.85H	316.5	*	234.8 ± 29.6
			296.0	*	246.5 ± 34.9
			274.8	50.2 ± 2.5	193.2 ± 12.2
				RR_{mean} =	**198.4 ± 6.1**
^{190}Hg	c*	20.0M	301.8	*	192.1 ± 28.9
			295.8	*	166.4 ± 13.8
			142.6	68 ± 10	152.2 ± 24.1
				RR_{mean} =	**165.3 ± 5.1**
^{198m}Au	i(m)	2.27D	411.8	*	**0.2199 ± 0.1553**

Continuation of Table 85.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
$^{198}Au_i$	i	2.69517D	411.8	95.58 ± 0.12	**1.752 ± 0.262**
$^{198}Au_c$	i(m+g)	2.69517D	411.8	95.58 ± 0.12	**1.972 ± 0.130**
^{196}Au	i(m1+m2+g)	6.183D	355.7	87.0 ± 0.8	**3.779 ± 0.141**
^{195}Au	c	186.098D	98.9	10.9 ± 0.9	**245.1 ± 27.7**
^{194}Au	i(m1+m2+g)	38.02H	328.5	61 ± 5	**9.801 ± 0.879**
$^{192}Au_i$	i(m+g)	4.94H	316.5	58 ± 7	**22.39 ± 4.89**
$^{192}Au_c$	c	4.94H	316.5	58 ± 7	**257.2 ± 32.3**
^{191}Au	c*	3.18H	586.4	17 ± 0	212.0 ± 12.1
			277.9	7.2 ± 0.5	213.0 ± 18.4
				RR_{mean} =	**212.3 ± 11.0**
$^{190}Au_c$	c	42.8M	301.8	23.4 ± 1.5	164.7 ± 16.4
			295.8	71 ± 5	184.0 ± 14.6
				RR_{mean} =	**177.8 ± 10.5**
^{191}Pt	c	2.802D	538.9	13.7 ± 1.6	189.0 ± 23.0
			456.5	3.4 ± 0.4	167.3 ± 20.7
			409.4	8.0 ± 0.9	171.9 ± 20.3
			359.9	6.0 ± 0.7	169.5 ± 20.6
			351.2	3.4 ± 0.4	194.7 ± 24.5
			172.2	3.5 ± 0.4	170.3 ± 20.8
			129.4	3.2 ± 0.5	182.9 ± 30.7
				RR_{mean} =	**175.6 ± 7.0**
^{189}Pt	c	10.87H	721.4	9.3 ± 0.8	271.0 ± 25.2
			607.6	8.10 ± 0.16	186.4 ± 9.1
			568.8	7.1 ± 0.6	192.5 ± 19.1
			544.9	5.8 ± 0.5	219.2 ± 20.7
			243.5	7.0 ± 1.2	215.0 ± 38.1
				RR_{mean} =	**195.9 ± 12.4**
^{188}Pt	c	10.2D	478.0	*	163.6 ± 8.8
			423.3	4.4 ± 0.3	169.7 ± 13.1
			381.4	7.5 ± 0.5	164.6 ± 12.6
			322.9	*	171.1 ± 17.1
			195.1	18.6 ± 1.2	165.3 ± 12.4
			187.6	19.4 ± 1.2	169.2 ± 12.3
			155.1	*	176.0 ± 18.8
				RR_{mean} =	**165.5 ± 5.1**
^{187}Pt	c	2.35H	106.4	8.8 ± 1.8	**112.5 ± 26.5**
^{186}Pt	c	2.08H	689.4	70 ± 15	135.3 ± 29.4
			630.3	*	96.09 ± 14.09
				RR_{mean} =	**103.3 ± 3.2**
^{184}Pt	c	17.3M	548.3	23 ± 4	**121.3 ± 22.5**
^{189}Ir	c	13.2D	275.9	0.54 ± 0.07	127.8 ± 23.4
			245.1	6.0 ± 0.6	157.0 ± 17.0
				RR_{mean} =	**155.6 ± 7.9**
$^{188}Ir_c$	c	41.5H	478.0	14.7 ± 0.6	160.7 ± 8.7
			322.9	1.62 ± 0.15	160.4 ± 16.6
			155.1	30 ± 3	180.1 ± 19.3
				RR_{mean} =	**161.2 ± 5.6**
^{187}Ir	c*	10.5H	977.5	3.14 ± 0.11	**145.9 ± 9.3**
^{186}Ir	c	16.64H	773.3	8.9 ± 0.5	63.87 ± 5.51
			434.8	33.9 ± 1.1	65.46 ± 3.42

Continuation of Table 85.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, $10^{-17}\ s^{-1}$
			296.9	62.3 ± 1.9	80.01 ± 4.71
			137.2	41.4 ± 0.7	75.59 ± 4.61
				RR_{mean} =	**70.50 ± 4.31**
^{185}Ir	c	14.4H	1829.0	10.1 ± 1.5	106.0 ± 16.4
			1668.0	3.6 ± 0.6	94.75 ± 16.74
			254.2	13.3 ± 2.4	95.93 ± 18.02
				RR_{mean} =	**102.2 ± 5.3**
^{184}Ir	c*	3.09H	390.4	25.9 ± 2.4	117.2 ± 11.8
			264.0	68 ± 4	129.9 ± 9.4
			119.8	31 ± 3	146.4 ± 17.3
				RR_{mean} =	**128.9 ± 6.1**
^{185}Os	c	93.6D	874.8	6.29 ± 0.25	146.4 ± 7.9
			717.4	3.94 ± 0.16	135.9 ± 7.6
			646.1	78 ± 3	136.2 ± 6.9
			592.1	1.32 ± 0.06	124.2 ± 9.3
				RR_{mean} =	**137.5 ± 5.1**
^{183m}Os	c*	9.9H	1107.9	22.4 ± 0.6	65.61 ± 3.18
			1101.9	49.0 ± 1.3	66.59 ± 2.98
				RR_{mean} =	**66.23 ± 2.33**
^{182}Os	c	22.10H	1221.5	*	127.3 ± 9.4
			1189.2	*	127.7 ± 9.8
			1121.4	*	122.6 ± 7.4
			180.2	33.5 ± 1.7	108.0 ± 6.9
			130.8	3.30 ± 0.17	115.0 ± 9.9
				RR_{mean} =	**116.4 ± 3.6**
^{181}Os	c	105M	238.8	44 ± 5	**40.37 ± 5.45**
^{180}Os	c	21.5M	902.8(D)	101.5 ± 3.4	84.62 ± 4.57
			103.5(D)	25.0 ± 0.8	75.92 ± 7.37
				RR_{mean} =	**82.67 ± 4.43**
^{183}Re	c	70.0D	291.7	3.05 ± 0.18	113.3 ± 8.1
			208.8	2.95 ± 0.09	117.0 ± 6.7
			162.3	23.3 ± 0.7	122.0 ± 5.9
			109.7	2.87 ± 0.09	109.3 ± 9.9
			107.9	2.17 ± 0.07	117.0 ± 9.8
				RR_{mean} =	**118.2 ± 4.4**
$^{182m}Re_c$	c	12.7H	1221.5	24.8 ± 1.6	121.1 ± 9.3
			1189.2	15 ± 1	131.8 ± 10.5
			1121.4	31.8 ± 1.6	126.6 ± 7.8
				RR_{mean} =	**126.2 ± 5.1**
^{181}Re	c*	19.9H	639.0	6.4 ± 1.4	97.74 ± 21.96
			365.5	56 ± 8	97.50 ± 14.36
				RR_{mean} =	**97.56 ± 10.51**
^{179}Re	c*	19.5M	430.2	28.0 ± 1.8	95.29 ± 8.73
			290.0	26.9 ± 2.3	81.10 ± 8.93
				RR_{mean} =	**89.70 ± 7.47**
^{178}Re	c*	13.2M	237.3	45 ± 5	**91.07 ± 11.22**
^{178} W	c	21.6D	1340.8(D)	1.03 ± 0.09	**91.68 ± 15.56**
^{177} W	c	135M	115.7	51 ± 5	**57.41 ± 7.02**
^{177}Ta	c*	56.56H	112.9	7.2 ± 1.6	**62.48 ± 14.66**
^{176}Ta	c*	8.09H	1159.3	24.7 ± 1.9	**62.31 ± 5.66**

Continuation of Table 85.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{175}Ta	c	10.5H	348.5	12.0 ± 1.1	41.90 ± 4.49
			266.9	10.52 ± 0.16	43.18 ± 2.67
				RR_{mean} =	**42.89 ± 2.42**
^{173}Ta	c	3.14H	172.2	17.5 ± 1.8	**38.38 ± 4.83**
^{175}Hf	c	70D	343.4	84 ± 3	**39.27 ± 1.95**
^{173}Hf	c*	23.6H	306.6	6.4 ± 0.3	13.16 ± 4.03
			311.2	10.7 ± 0.5	25.26 ± 2.19
			297.0	33.9 ± 1.4	18.82 ± 2.48
			123.7	83 ± 5	33.81 ± 3.00
				RR_{mean} =	**24.34 ± 3.70**
^{172}Hf	c	1.87Y	1093.6	*	20.39 ± 1.41
			900.7	*	19.96 ± 1.11
			181.5	*	18.83 ± 1.35
			125.8	11.3 ± 0.9	27.46 ± 3.22
				RR_{mean} =	**20.41 ± 0.63**
^{170}Hf	c	16.01H	620.7	18 ± 5	17.84 ± 5.18
			164.7	26 ± 8	18.49 ± 5.79
				RR_{mean} =	**18.04 ± 1.69**
^{173}Lu	c	1.37Y	272.1	21.2 ± 0.8	**26.46 ± 1.53**
$^{172}Lu_c$	c	6.70D	1093.6	63 ± 3	20.67 ± 1.41
			900.7	29.8 ± 1.3	20.52 ± 1.15
			181.5	20.6 ± 1.0	19.26 ± 1.82
				RR_{mean} =	**20.45 ± 0.76**
^{171}Lu	c*	8.24D	739.8	47.8 ± 1.2	**20.28 ± 0.88**
^{170}Lu	c*	2.012D	2126.1	5.1 ± 0.3	18.91 ± 2.07
			1280.2	8.2 ± 0.4	21.67 ± 1.61
				RR_{mean} =	**20.86 ± 1.41**
^{169}Lu	c	34.06H	1449.7	9.9 ± 0.3	11.00 ± 1.12
			191.2	20.6 ± 0.6	11.25 ± 1.27
				RR_{mean} =	**11.11 ± 0.86**
^{169}Yb	c*	32.026D	198.0	35.8 ± 0.7	11.93 ± 0.56
			177.2	22.2 ± 0.5	11.62 ± 0.58
				RR_{mean} =	**11.79 ± 0.46**
^{165}Tm	c	30.06H	242.9	35.5 ± 1.7	**3.185 ± 0.360**
^{139}Ce	c	137.640D	165.9	79.89 ± 0.01	**1.251 ± 0.075**
^{129}Cs	c	32.06H	371.9	30.6 ± 1.7	**4.782 ± 0.532**
^{127}Xe	c	36.4D	375.0	17.2 ± 0.6	4.331 ± 0.454
			202.9	68.3 ± 0.5	4.322 ± 0.187
			172.1	25.5 ± 0.8	4.236 ± 0.260
				RR_{mean} =	**4.303 ± 0.171**
^{126} I	i	13.11D	388.6	34 ± 3	**1.498 ± 0.221**
^{124} I	i	4.1760D	602.7	62.9 ± 0.6	**3.693 ± 0.212**
^{123m}Te	i(m)	119.7D	159.0	84.0 ± 0.4	**2.635 ± 0.176**
^{121m}Te	i(m)	154D	573.1	88.6 ± 0.1	3.265 ± 0.300
			212.2	81.4 ± 1.1	3.393 ± 0.193
				RR_{mean} =	**3.362 ± 0.104**
$^{121}Te_c$	c	19.16D	573.1	80.3 ± 2.5	**5.448 ± 0.344**
^{119m}Te	i(m)	4.70D	1212.7	66.2 ± 0.3	**1.948 ± 0.100**
^{124}Sb	i(m1+m2+g)	60.20D	602.7	98.3 ± 0.4	**0.6108 ± 0.0624**
^{120m}Sb	i(m)	5.76D	1171.7	100 ± 0	3.994 ± 0.203

Continuation of Table 85.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			197.3	87.0 ± 1.1	4.772 ± 0.290
				RR_{mean} =	**4.223 ± 0.378**
^{117m}Sn	i(m)	13.60D	158.6	86.4 ± 0.4	**6.561 ± 0.302**
^{113}Sn	c	115.09D	391.7	64.97 ± 0.17	**2.386 ± 0.163**
^{114m}In	i(m)	49.51D	190.3	15.56 ± 0.16	**8.579 ± 0.549**
^{111}In	c	2.8047D	245.4	94 ± 1	4.375 ± 0.229
			171.3	90.2 ± 1.0	4.842 ± 0.233
				RR_{mean} =	**4.618 ± 0.273**
^{115}Cd	c	53.46H	336.2	45.9 ± 1.0	**2.295 ± 0.136**
^{110m}Ag	i(m)	249.76D	1505.0	13.60 ± 0.19	8.224 ± 1.139
			1384.3	24.9 ± 0.8	11.17 ± 0.72
			937.5	34.2 ± 0.6	10.10 ± 0.54
			884.7	72.7 ± 0.4	10.15 ± 0.41
			763.9	22.62 ± 0.21	8.497 ± 0.698
			657.8	94.3 ± 0.3	10.10 ± 0.41
				RR_{mean} =	**10.05 ± 0.39**
^{106m}Ag	i(m)	8.28D	717.3	28.9 ± 0.8	4.890 ± 0.378
			451.0	28.2 ± 0.8	3.436 ± 0.272
				RR_{mean} =	**3.933 ± 0.701**
^{105}Ag	c	41.29D	280.4	30.2 ± 1.8	**3.471 ± 0.364**
^{105}Rh	c	35.36H	318.9	19.1 ± 0.6	**31.77 ± 1.58**
^{102m}Rh	i(m)	2.9Y	475.1	95 ± 4	**7.283 ± 3.045**
^{101m}Rh	c	4.34D	306.9	81 ± 5	**6.172 ± 0.461**
^{103}Ru	c	39.26D	610.3	5.76 ± 0.07	28.81 ± 5.25
			497.1	91.0 ± 1.3	32.04 ± 1.22
				RR_{mean} =	**31.98 ± 1.21**
^{96}Tc	i(m+g)	4.28D	849.9	98 ± 4	5.274 ± 0.311
			812.5	82 ± 4	5.364 ± 0.352
				RR_{mean} =	**5.312 ± 0.260**
^{99}Mo	c	65.94H	140.5	90.27 ± 0.33	**29.77 ± 1.65**
^{96}Nb	i	23.35H	1091.3	48.5 ± 1.6	18.08 ± 0.89
			849.9	20.45 ± 0.20	19.55 ± 1.93
			778.2	96.45 ± 0.22	21.06 ± 0.79
			568.9	58.0 ± 0.3	18.44 ± 0.77
			460.0	26.62 ± 0.20	20.03 ± 0.81
				RR_{mean} =	**19.68 ± 0.85**
^{95}Nb$_i$	i(m+g)	34.975D	765.8	99.81 ± 0.03	**22.69 ± 0.76**
^{95}Nb$_c$	c	34.975D	765.8	99.81 ± 0.03	**41.87 ± 1.38**
^{92m}Nb	i(m)	10.15D	934.4	99.07 ± 0.04	**1.691 ± 0.078**
^{97}Zr	c	16.744H	743.4	93.06 ± 0.16	**4.299 ± 0.264**
^{95}Zr	c	64.02D	765.8	*	19.35 ± 0.66
			724.2	44.17 ± 0.16	19.54 ± 0.89
				RR_{mean} =	**19.38 ± 0.60**
^{89}Zr	c	78.41H	909.2	99.04 ± 0.03	**9.011 ± 0.342**
^{88}Zr	c	83.4D	898.0	*	2.815 ± 0.361
			392.9	97.24 ± 0.00	3.129 ± 0.139
				RR_{mean} =	**3.105 ± 0.096**
^{90m} Y	i(m)	3.19H	479.5	90.74 ± 0.05	22.94 ± 1.10
			202.5	97.3 ± 0.4	28.64 ± 1.66
				RR_{mean} =	**24.45 ± 2.62**

Continuation of Table 85.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
$^{88}Y_i$	i	106.65D	898.0	93.7 ± 0.3	**16.98 ± 0.63**
$^{88}Y_c$	c	106.65D	898.0	93.7 ± 0.3	**19.79 ± 0.67**
^{87}Y	c*	79.8H	484.8	89.7 ± 0.7	11.76 ± 0.43
			388.5	82.1 ± 0.5	12.31 ± 0.43
				RR_{mean} =	**12.06 ± 0.46**
^{85}Sr	c	64.84D	514.0	96 ± 4	**12.79 ± 0.70**
^{86}Rb	i(m+g)	18.631D	1077.0	8.64 ± 0.04	**25.88 ± 1.17**
^{83}Rb	c	86.2D	552.6	16.0 ± 1.1	14.47 ± 1.23
			529.6	29.3 ± 2.1	14.48 ± 1.23
			520.4	45 ± 4	14.50 ± 1.40
				RR_{mean} =	**14.48 ± 0.69**
^{82}Br	i(m+g)	35.30H	1474.9	16.32 ± 0.23	16.19 ± 0.83
			1317.5	26.5 ± 0.4	14.90 ± 0.79
			776.5	83.5 ± 1.2	14.34 ± 0.54
			698.4	28.5 ± 0.4	12.85 ± 0.68
			554.3	70.8 ± 1.0	13.14 ± 0.54
				RR_{mean} =	**14.01 ± 0.63**
^{75}Se	c	119.779D	279.5	24.99 ± 0.14	5.812 ± 0.758
			264.7	58.9 ± 0.4	4.064 ± 0.192
			136.0	58.3 ± 0.8	5.079 ± 0.362
				RR_{mean} =	**4.280 ± 0.352**
^{76}As	i	1.0778D	559.1	45 ± 2	**10.28 ± 0.72**
^{74}As	i	17.77D	595.8	59 ± 4	**7.744 ± 0.611**
$^{72}Ga_i$	i	14.10H	2507.8	12.78 ± 0.23	10.80 ± 3.55
			2201.7	25.9 ± 0.5	7.549 ± 0.627
				RR_{mean} =	**7.635 ± 0.621**
$^{72}Ga_c$	c	14.10H	2507.8	12.78 ± 0.23	12.71 ± 3.40
			2201.7	25.9 ± 0.5	9.207 ± 0.621
				RR_{mean} =	**9.298 ± 0.626**
^{72}Zn	c	46.5H	2507.8	*	1.909 ± 0.400
			2201.7	*	1.658 ± 0.154
				RR_{mean} =	**1.687 ± 0.146**
^{59}Fe	c	44.472D	1291.6	43.2 ± 1.4	3.893 ± 0.313
			1099.2	56.5 ± 1.9	3.245 ± 0.262
				RR_{mean} =	**3.512 ± 0.337**
^{46}Sc	i(m+g)	83.79D	889.3	99.98 ± 0.00	**0.3610 ± 0.0749**
^{7}Be	i	53.29D	477.6	10.52 ± 0.06	**6.609 ± 0.891**

12.7.6 Nuclide production rates for ^{27}Al

Table 86: Detailed calculation of nuclide production rates for in ^{27}Al-monitors and ^{27}Al-plates for E_p = 0.6 GeV, used for calculating proton flux (including total over the plate area), cross sections for production of ^{7}Be, ^{24}Naand neutron background.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{27}Al-monitor for ^{206}Pb					
^{7}Be	i	53.29D	477.6	10.52 ± 0.06	**25.13 ± 1.04**
^{27}Mg	c	9.458M	843.8	71.8 ± 0.4	2.447 ± 0.119
			1014.4	28.0 ± 0.4	2.163 ± 0.198

Continuation of Table 86.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
				RR_{mean} =	**2.391 ± 0.135**
^{22}Na	c	2.6019Y	1274.5	99.94 ± 0.01	**82.21 ± 2.81**
^{24}Na	c	14.9590H	1369.0	100 ± 0	**66.92 ± 2.22**
			^{27}Al-plate for ^{206}Pb		
^{24}Na	c	14.9590H	1369.0	100 ± 0	**3.144 ± 0.106**
			^{27}Al-monitor for ^{207}Pb		
^{7}Be	i	53.29D	477.6	10.52 ± 0.06	**23.41 ± 0.86**
^{27}Mg	c	9.458M	843.8	71.8 ± 0.4	2.271 ± 0.109
			1014.4	28.0 ± 0.4	2.420 ± 0.183
				RR_{mean} =	**2.301 ± 0.103**
^{22}Na	c	2.6019Y	1274.5	99.94 ± 0.01	**75.25 ± 2.57**
^{24}Na	c	14.9590H	1369.0	100 ± 0	**61.26 ± 2.04**
			^{27}Al-plate for ^{207}Pb		
^{24}Na	c	14.9590H	1369.0	100 ± 0	**2.868 ± 0.096**
			^{27}Al-monitor for ^{207}Pb		
^{7}Be	i	53.29D	477.6	10.52 ± 0.06	**20.80 ± 0.76**
^{27}Mg	c	9.458M	843.8	71.8 ± 0.4	1.901 ± 0.097
			1014.4	28.0 ± 0.4	2.327 ± 0.166
				RR_{mean} =	**1.990 ± 0.184**
^{22}Na	c	2.6019Y	1274.5	99.94 ± 0.01	**68.24 ± 2.35**
^{24}Na	c	14.9590H	1369.0	100 ± 0	**55.95 ± 1.86**
			^{27}Al-plate for ^{207}Pb		
^{24}Na	c	14.9590H	1369.0	100 ± 0	**2.497 ± 0.083**
			^{27}Al-monitor for ^{nat}Pb		
^{7}Be	i	53.29D	477.6	10.52 ± 0.06	**25.17 ± 0.92**
^{27}Mg	c	9.458M	843.8	71.8 ± 0.4	2.338 ± 0.123
			1014.4	28.0 ± 0.4	2.880 ± 0.229
				RR_{mean} =	**2.437 ± 0.222**
^{22}Na	c	2.6019Y	1274.5	99.94 ± 0.01	**82.45 ± 2.83**
^{24}Na	c	14.9590H	1369.0	100 ± 0	**67.39 ± 2.24**
			^{27}Al-plate for ^{nat}Pb		
^{24}Na	c	14.9590H	1369.0	100 ± 0	**2.879 ± 0.096**
			^{27}Al-monitor for ^{209}Bi		
^{7}Be	i	53.29D	477.6	10.52 ± 0.06	**18.51 ± 0.71**
^{27}Mg	c	9.458M	843.8	71.8 ± 0.4	2.486 ± 0.111
			1014.4	28.0 ± 0.4	2.652 ± 0.190
				RR_{mean} =	**2.516 ± 0.107**
^{22}Na	c	2.6019Y	1274.5	99.94 ± 0.01	**61.40 ± 2.11**
^{24}Na	c	14.9590H	1369.0	100 ± 0	**50.81 ± 1.69**
			^{27}Al-plate for ^{209}Bi		
^{24}Na	c	14.9590H	1369.0	100 ± 0	**2.077 ± 0.070**

12.8 Detailed calculation of nuclide production rates for ^{206}Pb, ^{207}Pb, ^{208}Pb, ^{nat}Pb and ^{209}Bi for $E_p = 0.8$ GeV

12.8.1 Nuclide production rates for ^{206}Pb

Table 87: Detailed calculation of nuclide production rates for ^{206}Pb for $E_p = 0.8$ GeV, used to determine the cross sections for their production.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{206}Bi	i	6.243D	1718.7	31.8 ± 0.6	7.008 ± 0.436
			803.1	98.9 ± 1.4	6.560 ± 0.246
			537.5	30.5 ± 0.5	6.448 ± 0.339
			343.5	23.4 ± 0.4	5.811 ± 0.719
				RR_{mean} =	**6.561 ± 0.234**
^{205}Bi	i	15.31D	1861.7	6.17 ± 0.10	22.89 ± 2.96
			1764.3	32.5 ± 0.7	19.54 ± 0.85
			703.5	31.1 ± 0.1	19.71 ± 0.72
				RR_{mean} =	**19.70 ± 0.69**
^{204}Bi	i	11.22H	984.0	59 ± 4	23.44 ± 1.91
			899.2	98 ± 9	24.44 ± 0.90
			670.7	11.4 ± 0.9	27.32 ± 2.88
			374.8	82 ± 5	24.90 ± 5.21
				RR_{mean} =	**24.45 ± 0.75**
^{203}Bi	i(m+g)	11.76H	820.2	29.6 ± 1.5	**27.33 ± 1.94**
^{202}Bi	i	1.72H	422.1	83.7 ± 2.5	**33.75 ± 2.85**
^{204m}Pb$_i$	i(m)	67.2M	899.2	99.17 ± 0.02	62.62 ± 2.58
			374.7	89 ± 15	66.62 ± 11.52
				RR_{mean} =	**62.71 ± 2.56**
^{204m}Pb$_c$	c	67.2M	899.2	99.17 ± 0.02	66.29 ± 2.66
			374.7	89 ± 15	69.74 ± 12.05
				RR_{mean} =	**66.36 ± 2.65**
^{203}Pb	c*	51.873H	279.2	80.8 ± 0.2	**224.0 ± 8.2**
^{202m}Pb	i(m)	3.53H	422.1	86 ± 5	**53.99 ± 3.97**
^{201}Pb	c*	9.33H	331.2	79 ± 5	**182.0 ± 13.1**
^{200}Pb	c	21.5H	1205.7	*	140.0 ± 9.7
			1514.9	*	133.1 ± 12.1
			828.3	*	120.5 ± 12.0
			579.3	*	124.6 ± 8.0
			450.5	3.33 ± 0.08	153.2 ± 8.1
			367.9	*	128.9 ± 4.5
			147.6	37.7 ± 1.4	134.2 ± 7.3
				RR_{mean} =	**129.5 ± 4.0**
^{199}Pb	c*	90M	366.9	44 ± 7	**232.1 ± 38.0**
^{198}Pb	c	2.4H	173.4	18 ± 3	**169.6 ± 29.1**
^{197m}Pb	c*	43M	385.9	74 ± 15	125.7 ± 25.9
			222.8	25 ± 6	122.4 ± 30.1
				RR_{mean} =	**125.4 ± 6.2**
^{195m}Pb	i(m)	15.0M	383.6	107 ± 20	**66.99 ± 12.92**
^{202}Tl	c	12.23D	439.6	91.4 ± 1.0	**100.7 ± 3.7**
^{201}Tl	c*	72.912H	167.4	10.00 ± 0.06	**307.5 ± 11.3**
^{200}Tl$_i$	i	26.1H	1514.9	4.0 ± 0.3	103.4 ± 12.6

Continuation of Table 87.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			579.3	13.8 ± 0.7	128.2 ± 9.3
			1205.7	29.9 ± 1.8	121.2 ± 8.8
			367.9	87.2 ± 0.4	121.9 ± 4.8
				RR_{mean} =	**121.6 ± 4.6**
$^{200}Tl_c$	c	26.1H	1205.7	29.9 ± 1.8	261.2 ± 18.0
			1514.9	4.0 ± 0.3	236.5 ± 20.1
			579.3	13.8 ± 0.7	252.8 ± 15.7
			367.9	87.2 ± 0.4	250.8 ± 8.6
				RR_{mean} =	**250.9 ± 8.5**
$^{199}Tl_c$	c	7.42H	455.5	12.4 ± 1.4	**224.6 ± 27.5**
^{199}Tl	c*	7.42H	455.5	12.4 ± 1.4	**285.8 ± 33.9**
^{198m}Tl	i(m)	1.87H	282.8	28 ± 3	**117.6 ± 14.2**
^{196m}Tl	i(m)	1.41H	695.4	41 ± 7	**196.8 ± 34.4**
^{203}Hg	c	46.612D	279.2	81.46 ± 0.13	**9.031 ± 0.362**
^{197m}Hg	i(m)	23.8H	134.0	33.5 ± 0.4	**45.95 ± 2.21**
^{195m}Hg	i(m)	41.6H	560.3	7.0 ± 0.6	63.54 ± 6.11
			261.8	31 ± 4	68.00 ± 9.16
				RR_{mean} =	**64.38 ± 3.80**
^{193m}Hg	i(m)	11.8H	407.6	32 ± 6	76.68 ± 14.63
			258.0	49 ± 7	114.8 ± 17.1
				RR_{mean} =	**92.94 ± 19.07**
^{192}Hg	c	4.85H	316.5	*	269.9 ± 33.9
			274.8	50.2 ± 2.5	213.9 ± 13.5
				RR_{mean} =	**220.3 ± 6.8**
^{190}Hg	c*	20.0M	142.6	68 ± 10	**169.8 ± 26.2**
^{198m}Au	i(m)	2.27D	204.1	40.8 ± 2.4	1.805 ± 0.185
			411.8	*	1.720 ± 0.132
				RR_{mean} =	**1.747 ± 0.054**
$^{198}Au_i$	i	2.69517D	411.8	95.58 ± 0.12	**5.771 ± 0.301**
$^{198}Au_c$	i(m+g)	2.69517D	411.8	95.58 ± 0.12	**7.491 ± 0.280**
^{196}Au	i(m1+m2+g)	6.183D	426.1	6.6 ± 0.8	12.93 ± 1.75
			355.7	87.0 ± 0.8	14.13 ± 0.50
			333.0	22.9 ± 0.6	15.68 ± 0.73
				RR_{mean} =	**14.31 ± 0.58**
^{195}Au	c	186.098D	98.9	10.9 ± 0.9	**255.5 ± 26.0**
^{194}Au	i(m1+m2+g)	38.02H	328.5	61 ± 5	28.22 ± 2.51
			293.6	10.4 ± 0.8	25.81 ± 2.34
				RR_{mean} =	**26.95 ± 1.55**
$^{192}Au_i$	i(m+g)	4.94H	316.5	58 ± 7	**43.96 ± 5.65**
$^{192}Au_c$	c	4.94H	316.5	58 ± 7	**313.8 ± 39.4**
^{191}Au	c*	3.18H	674.2	6.8 ± 0.5	337.4 ± 28.0
			586.4	17 ± 0	310.0 ± 14.1
			166.5	3.32 ± 0.24	288.4 ± 27.4
				RR_{mean} =	**310.7 ± 13.2**
$^{190}Au_c$	c	42.8M	301.8	23.4 ± 1.5	222.3 ± 21.2
			295.8	71 ± 5	243.1 ± 23.0
				RR_{mean} =	**232.0 ± 13.5**
^{191}Pt	c	2.802D	538.9	13.7 ± 1.6	256.3 ± 31.2
			456.5	3.4 ± 0.4	239.8 ± 29.5
			409.4	8.0 ± 0.9	223.2 ± 26.2

Continuation of Table 87.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			351.2	3.4 ± 0.4	259.3 ± 31.9
			172.2	3.5 ± 0.4	215.0 ± 26.1
				RR_{mean} =	**234.7 ± 11.3**
^{189}Pt	c	10.87H	721.4	9.3 ± 0.8	288.3 ± 26.8
			607.6	8.10 ± 0.16	255.2 ± 10.7
			568.8	7.1 ± 0.6	257.2 ± 24.4
			544.9	5.8 ± 0.5	276.9 ± 26.1
			243.5	7.0 ± 1.2	281.2 ± 49.9
				RR_{mean} =	**259.1 ± 10.1**
^{188}Pt	c	10.2D	1209.8	*	251.3 ± 26.9
			633.0	*	273.3 ± 46.5
			195.1	18.6 ± 1.2	244.0 ± 18.2
			478.0	*	238.8 ± 12.8
			423.3	4.4 ± 0.3	242.8 ± 18.5
			381.4	7.5 ± 0.5	240.4 ± 18.1
			187.6	19.4 ± 1.2	246.5 ± 17.8
				RR_{mean} =	**241.3 ± 7.4**
^{187}Pt	c	2.35H	106.4	8.8 ± 1.8	**191.7 ± 42.0**
^{186}Pt	c	2.08H	689.4	70 ± 15	**203.1 ± 44.1**
^{184}Pt	c	17.3M	548.3	23 ± 4	**190.1 ± 36.7**
^{192}Ir	i(m1+g)	73.827D	316.5	82.71 ± 0.21	**0.6050 ± 0.0570**
^{190}Ir	i(m1+g)	11.78D	605.1	39.9 ± 1.9	1.729 ± 0.142
			569.3	28.5 ± 1.3	1.349 ± 0.181
				RR_{mean} =	**1.603 ± 0.186**
^{189}Ir	c	13.2D	275.9	0.54 ± 0.07	242.9 ± 33.3
			245.1	6.0 ± 0.6	226.3 ± 24.3
				RR_{mean} =	**227.3 ± 8.8**
$^{188}Ir_i$	i	41.5H	633.0	18 ± 3	10.40 ± 1.89
			478.0	14.7 ± 0.6	15.19 ± 1.50
				RR_{mean} =	**13.60 ± 2.30**
$^{188}Ir_c$	c	41.5H	1209.8	6.9 ± 0.7	254.6 ± 27.3
			633.0	18 ± 3	283.7 ± 48.2
			478.0	14.7 ± 0.6	254.0 ± 13.6
				RR_{mean} =	**254.2 ± 8.7**
^{187}Ir	c*	10.5H	977.5	3.14 ± 0.11	**272.1 ± 17.1**
^{186}Ir	c	16.64H	434.8	33.9 ± 1.1	111.3 ± 5.6
			773.3	8.9 ± 0.5	110.9 ± 7.8
				RR_{mean} =	**111.2 ± 5.1**
^{185}Ir	c	14.4H	1829.0	10.1 ± 1.5	181.3 ± 27.8
			254.2	13.3 ± 2.4	159.9 ± 30.4
				RR_{mean} =	**177.9 ± 9.5**
^{184}Ir	c*	3.09H	264.0	68 ± 4	230.6 ± 16.3
			841.3	8.0 ± 0.8	194.2 ± 22.9
			390.4	25.9 ± 2.4	200.3 ± 19.9
			119.8	31 ± 3	236.8 ± 25.6
				RR_{mean} =	**224.4 ± 10.4**
^{183}Ir	c	57M	392.5	10.4 ± 2.4	**220.8 ± 53.1**
^{185}Os	c	93.6D	874.8	6.29 ± 0.25	245.3 ± 12.9
			717.4	3.94 ± 0.16	238.6 ± 12.9
			646.1	78 ± 3	235.0 ± 12.0

Continuation of Table 87.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
				RR_{mean} =	**238.4 ± 8.0**
^{183m}Os	c*	9.9H	1107.9	22.4 ± 0.6	139.4 ± 6.2
			1101.9	49.0 ± 1.3	132.0 ± 5.8
				RR_{mean} =	**135.3 ± 5.6**
^{182}Os	c	22.10H	263.3	6.71 ± 0.25	209.6 ± 11.8
			180.2	33.5 ± 1.7	228.0 ± 14.4
				RR_{mean} =	**216.3 ± 11.1**
^{181}Os	c	105M	238.8	44 ± 5	**82.80 ± 10.30**
^{180}Os	c	21.5M	902.8(D)	101.5 ± 3.4	**191.2 ± 11.0**
^{183}Re	c	70.0D	291.7	3.05 ± 0.18	226.8 ± 16.3
			162.3	23.3 ± 0.7	238.7 ± 11.4
				RR_{mean} =	**236.3 ± 9.6**
^{182m}Re$_c$	c	12.7H	1221.5	24.8 ± 1.6	235.9 ± 17.4
			1189.2	15 ± 1	269.0 ± 22.6
			1121.4	31.8 ± 1.6	258.1 ± 15.8
				RR_{mean} =	**253.4 ± 11.3**
^{181}Re	c*	19.9H	639.0	6.4 ± 1.4	225.1 ± 50.1
			365.5	56 ± 8	217.0 ± 32.1
				RR_{mean} =	**219.0 ± 23.7**
^{179}Re	c*	19.5M	430.2	28.0 ± 1.8	262.8 ± 21.3
			290.0	26.9 ± 2.3	227.5 ± 22.5
				RR_{mean} =	**252.4 ± 17.9**
^{178}Re	c*	13.2M	237.3	45 ± 5	**278.6 ± 35.7**
^{178} W	c	21.6D	1350.6(D)	1.18 ± 0.11	159.0 ± 17.5
			1340.8(D)	1.03 ± 0.09	128.8 ± 13.7
				RR_{mean} =	**139.3 ± 15.0**
^{177} W	c	135M	115.7	51 ± 5	**156.9 ± 17.2**
^{176} W	c	2.5H	1823.7	*	123.0 ± 31.1
			1159.3	*	125.5 ± 18.3
			710.5	*	128.0 ± 36.4
				RR_{mean} =	**125.4 ± 13.2**
^{177}Ta	c*	56.56H	112.9	7.2 ± 1.6	**172.2 ± 39.4**
^{176}Ta$_c$	c	8.09H	1823.7	4.5 ± 0.4	162.3 ± 18.4
			1159.3	24.7 ± 1.9	158.8 ± 14.3
			710.5	5.4 ± 0.4	171.4 ± 18.8
				RR_{mean} =	**161.5 ± 7.2**
^{175}Ta	c	10.5H	1793.1	4.6 ± 0.7	120.5 ± 19.3
			348.5	12.0 ± 1.1	169.3 ± 16.7
			266.9	10.52 ± 0.16	157.2 ± 6.7
				RR_{mean} =	**156.2 ± 7.8**
^{174}Ta$_c$	c	1.14H	206.5	60 ± 5	**125.7 ± 11.8**
^{173}Ta	c	3.14H	172.2	17.5 ± 1.8	**139.6 ± 15.4**
^{172}Ta	c*	36.8M	214.1	55 ± 5	**68.35 ± 7.02**
^{175}Hf	c	70D	343.4	84 ± 3	**147.8 ± 7.2**
^{173}Hf	c*	23.6H	123.7	83 ± 5	157.2 ± 11.9
			311.2	10.7 ± 0.5	153.4 ± 9.1
			306.6	6.4 ± 0.3	170.4 ± 11.3
			139.6	12.7 ± 0.6	169.4 ± 11.2
				RR_{mean} =	**160.8 ± 6.7**
^{172}Hf	c	1.87Y	1093.6	*	101.7 ± 5.9

Continuation of Table 87.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			900.7	*	105.3 ± 5.9
			181.5	*	103.7 ± 6.6
			125.8	11.3 ± 0.9	97.39 ± 10.27
				RR_{mean} =	**102.7 ± 3.2**
^{170}Hf	c	16.01H	620.7	18 ± 5	117.1 ± 32.8
			164.7	26 ± 8	110.8 ± 34.4
			120.2	15 ± 5	116.7 ± 39.3
				RR_{mean} =	**115.9 ± 8.2**
^{173}Lu	c	1.37Y	272.1	21.2 ± 0.8	**122.7 ± 6.6**
^{172}Lu$_c$	c	6.70D	1093.6	63 ± 3	102.1 ± 6.0
			900.7	29.8 ± 1.3	106.3 ± 5.9
			181.5	20.6 ± 1.0	105.2 ± 6.7
				RR_{mean} =	**104.7 ± 3.7**
^{171}Lu	c*	8.24D	853.0	2.55 ± 0.07	114.9 ± 5.2
			780.7	4.36 ± 0.11	126.4 ± 7.0
			689.3	2.37 ± 0.06	117.0 ± 5.2
			667.4	11.0 ± 0.3	114.3 ± 5.0
				RR_{mean} =	**116.4 ± 4.1**
^{170}Lu	c*	2.012D	1280.2	8.2 ± 0.4	**125.9 ± 7.7**
^{169}Lu	c	34.06H	960.6	23.4 ± 0.7	**69.63 ± 3.36**
^{167}Lu	c	51.5M	176.2	*	**45.98 ± 3.76**
^{169}Yb	c*	32.026D	198.0	35.8 ± 0.7	84.74 ± 3.63
			177.2	22.2 ± 0.5	80.54 ± 3.56
			130.5	11.31 ± 0.21	85.59 ± 4.17
				RR_{mean} =	**83.33 ± 3.00**
^{166}Yb	c	56.7H	2079.5	*	52.96 ± 4.14
			2052.4	*	56.98 ± 3.97
			1374.2	*	53.96 ± 4.41
			785.9	*	52.07 ± 3.95
			691.2(D)	8.56 ± 0.58	50.21 ± 3.97
				RR_{mean} =	**53.24 ± 1.64**
^{167}Tm	c	9.25D	207.8	42 ± 8	**66.84 ± 12.99**
^{165}Tm	c	30.06H	806.4	9.5 ± 0.6	50.74 ± 3.80
			242.9	35.5 ± 1.7	46.53 ± 2.89
				RR_{mean} =	**47.58 ± 2.34**
^{161}Er	c*	3.21H	826.6	64 ± 4	**46.78 ± 3.66**
^{160}Er	c	28.58H	966.2	*	25.98 ± 3.57
			962.4	*	25.02 ± 3.44
			728.2(D)	34 ± 5	24.89 ± 3.77
				RR_{mean} =	**25.29 ± 0.78**
^{160m}Ho$_c$	c	5.02H	966.2	15.4 ± 2.0	31.00 ± 6.07
			962.4	16.6 ± 2.1	15.20 ± 14.42
				RR_{mean} =	**28.78 ± 5.56**
^{157}Dy	c	8.14H	326.2	92 ± 4	**13.50 ± 0.83**
^{155}Dy	c*	9.9H	226.9	68.4 ± 1.6	**8.661 ± 0.551**
^{155}Tb	c*	5.32D	105.3	25.1 ± 1.3	**9.481 ± 0.701**
^{153}Tb	c*	2.34D	212.0	31.0 ± 1.9	**6.215 ± 0.516**
^{153}Gd	c	240.4D	103.2	21.1 ± 0.7	5.541 ± 0.672
			97.4	29.0 ± 0.8	5.893 ± 0.531
				RR_{mean} =	**5.765 ± 0.426**

Continuation of Table 87.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{149}Gd	c	9.28D	346.6	23.9 ± 1.3	4.054 ± 0.429
			298.6	28.6 ± 1.7	3.740 ± 0.336
			149.7	48 ± 3	4.471 ± 0.393
				RR_{mean} =	**4.055 ± 0.258**
^{146}Gd	c	48.27D	747.2	*	**2.484 ± 0.136**
$^{146}Eu_i$	i	4.61D	747.2	99 ± 3	**0.4627 ± 0.1421**
$^{146}Eu_c$	c	4.61D	747.2	99 ± 3	**2.947 ± 0.187**
^{139}Ce	c	137.640D	165.9	79.89 ± 0.02	**2.428 ± 0.136**
^{131}Ba	c	11.50D	123.8	29.0 ± 0.3	**2.942 ± 0.428**
^{127}Xe	c	36.4D	375.0	17.2 ± 0.6	4.249 ± 0.299
			202.9	68.3 ± 0.5	4.722 ± 0.217
			172.1	25.5 ± 0.8	4.474 ± 0.495
				RR_{mean} =	**4.591 ± 0.201**
^{124}Sb	i(m1+m2+g)	60.20D	602.7	98.3 ± 0.4	**0.4929 ± 0.0659**
^{123m}Te	i(m)	119.7D	159.0	84.0 ± 0.4	**1.999 ± 0.099**
^{121m}Te	i(m)	154D	212.2	81.4 ± 1.1	2.788 ± 0.155
			573.1	88.6 ± 0.1	2.643 ± 0.211
				RR_{mean} =	**2.744 ± 0.085**
$^{121}Te_c$	c	19.16D	573.1	80.3 ± 2.5	**5.984 ± 0.298**
^{119m}Te	i(m)	4.70D	1212.7	66.2 ± 0.3	**2.582 ± 0.131**
^{120m}Sb	i(m)	5.76D	1023.3	99.4 ± 0.3	**2.235 ± 0.095**
^{113}Sn	c	115.09D	391.7	64.97 ± 0.17	**3.790 ± 0.210**
^{114m}In	i(m)	49.51D	190.3	15.56 ± 0.16	**8.180 ± 0.424**
^{111}In	c	2.8047D	245.4	94 ± 1	5.383 ± 0.272
			171.3	90.2 ± 1.0	5.847 ± 0.262
				RR_{mean} =	**5.649 ± 0.288**
^{110m}Ag	i(m)	249.76D	1384.3	24.9 ± 0.8	7.278 ± 0.641
			884.7	72.7 ± 0.4	7.259 ± 0.292
			937.5	34.2 ± 0.6	7.115 ± 0.471
			657.8	94.3 ± 0.3	6.749 ± 0.259
				RR_{mean} =	**6.976 ± 0.258**
^{106m}Ag	i(m)	8.28D	1045.8	29.6 ± 1.0	5.420 ± 0.354
			717.3	28.9 ± 0.8	5.037 ± 0.305
			451.0	28.2 ± 0.8	5.434 ± 0.276
				RR_{mean} =	**5.305 ± 0.220**
^{100}Pd	c	3.63D	2376.0	*	**0.4127 ± 0.0374**
^{105}Rh	c	35.36H	318.9	19.1 ± 0.6	**28.13 ± 1.49**
^{102}Rh	i	207D	475.1	46 ± 5	**6.750 ± 0.830**
^{101m}Rh	c	4.34D	306.9	81 ± 5	**7.569 ± 0.566**
$^{100}Rh_i$	i(m+g)	20.8H	2376.0	32.6 ± 0.4	**3.661 ± 0.179**
$^{100}Rh_c$	c	20.8H	2376.0	32.6 ± 0.4	**4.074 ± 0.190**
^{103}Ru	c	39.26D	497.1	91.0 ± 1.3	**22.49 ± 0.84**
^{96}Tc	i(m+g)	4.28D	849.9	98 ± 4	7.294 ± 0.391
			812.5	82 ± 4	7.401 ± 0.440
				RR_{mean} =	**7.339 ± 0.333**
^{99}Mo	c	65.94H	140.5	90.27 ± 0.33	**18.99 ± 0.84**
^{96}Nb	i	23.35H	1091.3	48.5 ± 1.6	15.20 ± 0.75
			568.9	58.0 ± 0.3	14.64 ± 0.65
				RR_{mean} =	**14.85 ± 0.59**
$^{95}Nb_i$	i(m+g)	34.975D	765.8	99.81 ± 0.03	**19.53 ± 0.66**

Continuation of Table 87.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
$^{95}Nb_c$	c	34.975D	765.8	99.81 ± 0.03	**32.47 ± 1.08**
^{92m}Nb	i(m)	10.15D	934.4	99.07 ± 0.04	**2.021 ± 0.086**
^{97}Zr	c	16.744H	743.4	93.06 ± 0.16	**3.518 ± 0.250**
^{95}Zr	c	64.02D	765.8	*	13.06 ± 0.48
			756.7	54.46 ± 0.10	11.67 ± 0.46
			724.2	44.17 ± 0.16	12.70 ± 0.49
				RR_{mean} =	**12.89 ± 0.40**
^{89}Zr	c	78.41H	909.2	99.04 ± 0.03	**12.56 ± 0.42**
^{88}Zr	c	83.4D	1836.1	*	4.911 ± 0.443
			898.0	*	5.367 ± 0.509
			392.9	97.24 ± 0.00	5.572 ± 0.216
				RR_{mean} =	**5.503 ± 0.170**
^{90m}Y	i(m)	3.19H	479.5	90.74 ± 0.05	**18.35 ± 0.77**
$^{88}Y_i$	i	106.65D	1836.1	99.2 ± 0.3	21.67 ± 0.81
			898.0	93.7 ± 0.3	19.94 ± 0.75
				RR_{mean} =	**20.75 ± 1.07**
$^{88}Y_c$	c	106.65D	1836.1	99.2 ± 0.3	26.58 ± 0.96
			898.0	93.7 ± 0.3	25.31 ± 0.87
				RR_{mean} =	**25.79 ± 1.00**
^{87}Y	c*	79.8H	484.8	89.7 ± 0.7	17.14 ± 0.60
			388.5	82.1 ± 0.5	18.91 ± 0.66
				RR_{mean} =	**17.98 ± 1.04**
^{85}Sr	c	64.84D	514.0	96 ± 4	**17.73 ± 0.97**
^{86}Rb	i(m+g)	18.631D	1077.0	8.64 ± 0.04	**24.92 ± 1.12**
^{83}Rb	c	86.2D	552.6	16.0 ± 1.1	21.10 ± 1.67
			529.6	29.3 ± 2.1	20.54 ± 1.69
			520.4	45 ± 4	20.34 ± 1.95
				RR_{mean} =	**20.74 ± 0.93**
^{82m}Rb	i(m)	6.472H	776.5	84.39 ± 0.21	7.061 ± 0.538
			554.3	62.4 ± 0.9	8.214 ± 0.895
				RR_{mean} =	**7.347 ± 0.547**
^{82}Br	i(m+g)	35.30H	1317.5	26.5 ± 0.4	12.34 ± 0.58
			776.5	83.5 ± 1.2	12.69 ± 0.50
			554.3	70.8 ± 1.0	11.74 ± 0.50
				RR_{mean} =	**12.30 ± 0.48**
^{75}Se	c	119.779D	264.7	58.9 ± 0.4	7.603 ± 0.305
			136.0	58.3 ± 0.8	7.780 ± 0.357
				RR_{mean} =	**7.665 ± 0.284**
^{74}As	i	17.77D	595.8	59 ± 4	**10.95 ± 0.83**
$^{72}Ga_i$	i	14.10H	2201.7	25.9 ± 0.5	**6.418 ± 0.828**
$^{72}Ga_c$	c	14.10H	2201.7	25.9 ± 0.5	**8.471 ± 0.781**
^{72}Zn	c	46.5H	2201.7	*	**2.053 ± 0.202**
^{59}Fe	c	44.472D	1291.6	43.2 ± 1.4	3.906 ± 0.265
			1099.2	56.5 ± 1.9	4.033 ± 0.250
				RR_{mean} =	**3.975 ± 0.194**
^{54}Mn	i	312.11D	834.8	99.98 ± 0.00	**1.837 ± 0.174**
^{46}Sc	i(m+g)	83.79D	889.3	99.98 ± 0.00	**0.9286 ± 0.0913**
^{7}Be	i	53.29D	477.6	10.52 ± 0.06	**7.210 ± 1.191**

12.8.2 Nuclide production rates for ^{207}Pb

Table 88: Detailed calculation of nuclide production rates for ^{207}Pb for E_p = 80 MэB, used to determine the cross sections for their production.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{206}Bi	i	6.243D	1718.7	31.8 ± 0.6	14.66 ± 0.66
			803.1	98.9 ± 1.4	14.63 ± 0.53
			537.5	30.5 ± 0.5	14.07 ± 0.57
			343.5	23.4 ± 0.4	12.03 ± 0.87
				RR_{mean} =	**14.31 ± 0.57**
^{205}Bi	i	15.31D	1861.7	6.17 ± 0.10	27.55 ± 1.74
			1764.3	32.5 ± 0.7	28.21 ± 1.20
			703.5	31.1 ± 0.1	27.01 ± 0.93
				RR_{mean} =	**27.26 ± 0.91**
^{204}Bi	i	11.22H	984.0	59 ± 4	25.74 ± 2.02
			899.2	98 ± 9	26.61 ± 0.98
			670.7	11.4 ± 0.9	26.73 ± 2.76
			374.8	82 ± 5	28.34 ± 5.92
				RR_{mean} =	**26.57 ± 0.82**
^{203}Bi	i(m+g)	11.76H	820.2	29.6 ± 1.5	**28.56 ± 1.93**
^{202}Bi	i	1.72H	422.1	83.7 ± 2.5	**26.18 ± 2.69**
^{204m}Pb$_i$	i(m)	67.2M	899.2	99.17 ± 0.02	64.31 ± 2.62
			374.7	89 ± 15	71.72 ± 12.38
				RR_{mean} =	**64.46 ± 2.61**
^{204m}Pb$_c$	c	67.2M	899.2	99.17 ± 0.02	68.31 ± 2.72
			374.7	89 ± 15	75.27 ± 12.99
				RR_{mean} =	**68.43 ± 2.71**
^{203}Pb	c*	51.873H	279.2	80.8 ± 0.2	**190.8 ± 7.0**
^{202m}Pb	i(m)	3.53H	422.1	86 ± 5	**57.06 ± 4.23**
^{201}Pb	c*	9.33H	331.2	79 ± 5	**163.2 ± 11.7**
^{200}Pb	c	21.5H	1205.7	*	120.0 ± 8.4
			1514.9	*	117.6 ± 10.5
			828.3	*	115.7 ± 9.2
			579.3	*	102.6 ± 7.1
			450.5	3.33 ± 0.08	127.5 ± 6.2
			367.9	*	111.1 ± 3.9
			147.6	37.7 ± 1.4	116.5 ± 6.4
				RR_{mean} =	**112.1 ± 3.5**
^{199}Pb	c*	90M	366.9	44 ± 7	**215.2 ± 35.4**
^{198}Pb	c	2.4H	173.4	18 ± 3	**143.6 ± 24.9**
^{197m}Pb	c*	43M	385.9	74 ± 15	111.6 ± 23.1
			222.8	25 ± 6	114.5 ± 28.1
				RR_{mean} =	**111.8 ± 5.9**
^{195m}Pb	i(m)	15.0M	383.6	107 ± 20	**54.21 ± 10.59**
^{202}Tl	c	12.23D	439.6	91.4 ± 1.0	**94.46 ± 3.40**
^{201}Tl	c*	72.912H	167.4	10.00 ± 0.06	**276.7 ± 10.2**
^{200}Tl$_i$	i	26.1H	1514.9	4.0 ± 0.3	101.9 ± 11.1
			579.3	13.8 ± 0.7	134.4 ± 10.8
			367.9	87.2 ± 0.4	121.4 ± 4.9
			1205.7	29.9 ± 1.8	116.0 ± 8.6
				RR_{mean} =	**120.5 ± 5.2**

Continuation of Table 88.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
$^{200}Tl_c$	c	26.1H	1514.9	4.0 ± 0.3	219.5 ± 18.5
			579.3	13.8 ± 0.7	237.0 ± 15.1
			367.9	87.2 ± 0.4	232.4 ± 8.0
			1205.7	29.9 ± 1.8	236.1 ± 16.3
				RR_{mean} =	**232.4 ± 7.9**
$^{199}Tl_c$	c	7.42H	455.5	12.4 ± 1.4	**209.6 ± 25.4**
^{199}Tl	c*	7.42H	455.5	12.4 ± 1.4	**246.0 ± 29.3**
^{198m}Tl	i(m)	1.87H	282.8	28 ± 3	**114.5 ± 14.4**
^{196m}Tl	i(m)	1.41H	695.4	41 ± 7	**178.8 ± 31.4**
^{203}Hg	c	46.612D	279.2	81.46 ± 0.13	**15.00 ± 0.57**
^{197m}Hg	i(m)	23.8H	134.0	33.5 ± 0.4	**50.74 ± 2.40**
^{195m}Hg	i(m)	41.6H	560.3	7.0 ± 0.6	66.47 ± 6.30
			261.8	31 ± 4	71.33 ± 9.60
				RR_{mean} =	**67.32 ± 3.88**
^{193m}Hg	i(m)	11.8H	407.6	32 ± 6	77.88 ± 14.87
			258.0	49 ± 7	111.5 ± 16.7
				RR_{mean} =	**92.86 ± 16.95**
^{192}Hg	c	4.85H	316.5	*	252.8 ± 31.7
			274.8	50.2 ± 2.5	197.8 ± 12.7
				RR_{mean} =	**204.1 ± 6.3**
^{190}Hg	c*	20.0M	142.6	68 ± 10	**149.5 ± 23.1**
^{198m}Au	i(m)	2.27D	204.1	40.8 ± 2.4	2.689 ± 0.228
			411.8	*	3.050 ± 0.143
				RR_{mean} =	**2.976 ± 0.092**
$^{198}Au_i$	i	2.69517D	411.8	95.58 ± 0.12	**6.113 ± 0.276**
$^{198}Au_c$	i(m+g)	2.69517D	411.8	95.58 ± 0.12	**9.163 ± 0.323**
^{196}Au	i(m1+m2+g)	6.183D	426.1	6.6 ± 0.8	18.43 ± 2.58
			355.7	87.0 ± 0.8	17.02 ± 0.59
			333.0	22.9 ± 0.6	18.33 ± 0.81
				RR_{mean} =	**17.23 ± 0.63**
^{195}Au	c	186.098D	98.9	10.9 ± 0.9	**321.3 ± 32.0**
^{194}Au	i(m1+m2+g)	38.02H	328.5	61 ± 5	32.30 ± 2.87
			293.6	10.4 ± 0.8	30.96 ± 2.69
				RR_{mean} =	**31.58 ± 1.77**
$^{192}Au_i$	i(m+g)	4.94H	316.5	58 ± 7	**48.21 ± 6.34**
$^{192}Au_c$	c	4.94H	316.5	58 ± 7	**301.0 ± 37.8**
^{191}Au	c*	3.18H	674.2	6.8 ± 0.5	297.9 ± 25.6
			586.4	17 ± 0	270.0 ± 14.1
			166.5	3.32 ± 0.24	282.4 ± 26.3
				RR_{mean} =	**276.2 ± 12.8**
$^{190}Au_c$	c	42.8M	301.8	23.4 ± 1.5	220.6 ± 18.3
			295.8	71 ± 5	217.2 ± 21.2
				RR_{mean} =	**219.5 ± 11.5**
^{191}Pt	c	2.802D	538.9	13.7 ± 1.6	246.9 ± 30.1
			456.5	3.4 ± 0.4	226.9 ± 27.9
			409.4	8.0 ± 0.9	214.3 ± 25.2
			351.2	3.4 ± 0.4	251.8 ± 31.0
			172.2	3.5 ± 0.4	200.9 ± 24.3
				RR_{mean} =	**223.5 ± 11.6**
^{189}Pt	c	10.87H	721.4	9.3 ± 0.8	282.1 ± 26.2

Continuation of Table 88.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			607.6	8.10 ± 0.16	248.0 ± 10.3
			568.8	7.1 ± 0.6	262.0 ± 24.9
			544.9	5.8 ± 0.5	257.9 ± 24.4
			243.5	7.0 ± 1.2	276.1 ± 49.1
				RR_{mean} =	**252.0 ± 9.8**
^{188}Pt	c	10.2D	1209.8	*	242.4 ± 25.9
			633.0	*	260.9 ± 44.4
			195.1	18.6 ± 1.2	233.6 ± 17.5
			478.0	*	229.5 ± 12.2
			423.3	4.4 ± 0.3	237.8 ± 18.2
			381.4	7.5 ± 0.5	228.1 ± 17.1
			187.6	19.4 ± 1.2	238.9 ± 17.3
				RR_{mean} =	**232.1 ± 7.2**
^{187}Pt	c	2.35H	106.4	8.8 ± 1.8	**158.7 ± 35.2**
^{186}Pt	c	2.08H	689.4	70 ± 15	**187.9 ± 40.8**
^{184}Pt	c	17.3M	548.3	23 ± 4	**158.7 ± 29.0**
^{192}Ir	i(m1+g)	73.827D	316.5	82.71 ± 0.21	**0.9040 ± 0.1115**
^{190}Ir	i(m1+g)	11.78D	605.1	39.9 ± 1.9	**2.261 ± 0.156**
^{189}Ir	c	13.2D	275.9	0.54 ± 0.07	211.9 ± 32.6
			245.1	6.0 ± 0.6	220.4 ± 23.7
				RR_{mean} =	**220.0 ± 8.5**
^{188}Ir$_i$	i	41.5H	633.0	18 ± 3	12.38 ± 2.28
			478.0	14.7 ± 0.6	15.21 ± 1.00
				RR_{mean} =	**15.00 ± 0.87**
^{188}Ir$_c$	c	41.5H	1209.8	6.9 ± 0.7	242.9 ± 25.9
			633.0	18 ± 3	273.3 ± 46.5
			478.0	14.7 ± 0.6	244.7 ± 13.0
				RR_{mean} =	**244.9 ± 8.3**
^{187}Ir	c*	10.5H	977.5	3.14 ± 0.11	**252.5 ± 17.1**
^{186}Ir	c	16.64H	434.8	33.9 ± 1.1	106.2 ± 5.6
			773.3	8.9 ± 0.5	101.1 ± 7.0
				RR_{mean} =	**104.4 ± 4.9**
^{185}Ir	c	14.4H	1829.0	10.1 ± 1.5	169.7 ± 26.0
			254.2	13.3 ± 2.4	153.9 ± 29.3
				RR_{mean} =	**167.3 ± 8.9**
^{184}Ir	c*	3.09H	264.0	68 ± 4	214.6 ± 15.2
			841.3	8.0 ± 0.8	196.2 ± 22.3
			390.4	25.9 ± 2.4	197.8 ± 19.8
			119.8	31 ± 3	220.8 ± 24.0
				RR_{mean} =	**211.6 ± 8.3**
^{183}Ir	c	57M	392.5	10.4 ± 2.4	**225.8 ± 53.1**
^{185}Os	c	93.6D	874.8	6.29 ± 0.25	236.4 ± 12.3
			717.4	3.94 ± 0.16	233.3 ± 12.8
			646.1	78 ± 3	226.4 ± 11.6
				RR_{mean} =	**230.5 ± 7.8**
^{183m}Os	c*	9.9H	1107.9	22.4 ± 0.6	129.6 ± 5.7
			1101.9	49.0 ± 1.3	122.0 ± 5.4
				RR_{mean} =	**125.4 ± 5.4**
^{182}Os	c	22.10H	263.3	6.71 ± 0.25	208.4 ± 11.5
			180.2	33.5 ± 1.7	208.4 ± 13.2

Continuation of Table 88.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
				RR_{mean} =	**208.4 ± 9.3**
^{181}Os	c	105M	238.8	44 ± 5	**78.21 ± 10.59**
^{180}Os	c	21.5M	902.8(D)	101.5 ± 3.4	**169.5 ± 8.5**
^{183}Re	c	70.0D	291.7	3.05 ± 0.18	221.9 ± 17.9
			162.3	23.3 ± 0.7	226.5 ± 10.9
				RR_{mean} =	**225.8 ± 9.3**
$^{182m}Re_c$	c	12.7H	1221.5	24.8 ± 1.6	224.0 ± 16.6
			1189.2	15 ± 1	240.7 ± 19.0
			1121.4	31.8 ± 1.6	233.2 ± 14.8
				RR_{mean} =	**232.1 ± 9.6**
^{181}Re	c*	19.9H	639.0	6.4 ± 1.4	206.6 ± 45.9
			365.5	56 ± 8	204.6 ± 30.2
				RR_{mean} =	**205.1 ± 22.1**
^{179}Re	c*	19.5M	430.2	28.0 ± 1.8	233.9 ± 18.0
			290.0	26.9 ± 2.3	200.8 ± 19.8
				RR_{mean} =	**227.2 ± 15.0**
^{178}Re	c*	13.2M	237.3	45 ± 5	**234.1 ± 28.7**
^{178} W	c	21.6D	1350.6(D)	1.18 ± 0.11	154.5 ± 16.9
			1340.8(D)	1.03 ± 0.09	121.5 ± 14.0
				RR_{mean} =	**136.3 ± 17.0**
^{177} W	c	135M	115.7	51 ± 5	**144.4 ± 15.9**
^{176} W	c	2.5H	1159.3	*	84.56 ± 21.48
			710.5	*	135.4 ± 43.7
				RR_{mean} =	**94.15 ± 20.11**
^{177}Ta	c*	56.56H	112.9	7.2 ± 1.6	**156.4 ± 35.7**
$^{176}Ta_c$	c	8.09H	1159.3	24.7 ± 1.9	148.5 ± 14.7
			710.5	5.4 ± 0.4	147.4 ± 20.5
				RR_{mean} =	**148.3 ± 8.9**
^{175}Ta	c	10.5H	1793.1	4.6 ± 0.7	115.0 ± 18.4
			348.5	12.0 ± 1.1	152.6 ± 15.0
			266.9	10.52 ± 0.16	137.1 ± 6.3
				RR_{mean} =	**137.3 ± 6.4**
$^{174}Ta_c$	c	1.14H	206.5	60 ± 5	**113.4 ± 10.9**
^{173}Ta	c	3.14H	172.2	17.5 ± 1.8	**122.1 ± 13.6**
^{172}Ta	c*	36.8M	214.1	55 ± 5	**55.95 ± 5.85**
^{175}Hf	c	70D	343.4	84 ± 3	**135.0 ± 6.6**
^{173}Hf	c*	23.6H	123.7	83 ± 5	137.3 ± 10.3
			311.2	10.7 ± 0.5	132.1 ± 7.8
			306.6	6.4 ± 0.3	151.9 ± 9.8
			139.6	12.7 ± 0.6	148.1 ± 9.4
				RR_{mean} =	**140.5 ± 6.5**
^{172}Hf	c	1.87Y	1093.6	*	92.50 ± 5.54
			900.7	*	89.47 ± 4.92
			181.5	*	89.87 ± 5.65
			125.8	11.3 ± 0.9	94.54 ± 9.06
				RR_{mean} =	**91.01 ± 2.81**
^{170}Hf	c	16.01H	620.7	18 ± 5	103.0 ± 28.9
			164.7	26 ± 8	97.32 ± 30.16
			120.2	15 ± 5	102.0 ± 34.4
				RR_{mean} =	**101.8 ± 7.3**

Continuation of Table 88.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{173}Lu	c	1.37Y	272.1	21.2 ± 0.8	**110.1 ± 5.9**
^{172}Lu$_c$	c	6.70D	1093.6	63 ± 3	92.94 ± 5.56
			900.7	29.8 ± 1.3	91.64 ± 5.03
			181.5	20.6 ± 1.0	90.65 ± 5.69
				RR_{mean} =	**91.77 ± 3.19**
^{171}Lu	c*	8.24D	853.0	2.55 ± 0.07	100.9 ± 4.6
			780.7	4.36 ± 0.11	106.5 ± 4.9
			689.3	2.37 ± 0.06	103.6 ± 4.8
			667.4	11.0 ± 0.3	99.43 ± 4.31
				RR_{mean} =	**102.1 ± 3.5**
^{170}Lu	c*	2.012D	1280.2	8.2 ± 0.4	**111.7 ± 7.4**
^{169}Lu	c	34.06H	960.6	23.4 ± 0.7	**60.45 ± 2.81**
^{167}Lu	c	51.5M	176.2	*	**40.32 ± 2.75**
^{169}Yb	c*	32.026D	198.0	35.8 ± 0.7	72.58 ± 3.11
			177.2	22.2 ± 0.5	68.97 ± 3.02
			130.5	11.31 ± 0.21	72.06 ± 3.45
				RR_{mean} =	**71.08 ± 2.49**
^{166}Yb	c	56.7H	2079.5	*	43.92 ± 3.34
			2052.4	*	47.90 ± 3.34
			1374.2	*	48.70 ± 4.18
			785.9	*	44.19 ± 3.21
			691.2(D)	8.56 ± 0.58	41.27 ± 3.19
				RR_{mean} =	**44.85 ± 1.38**
^{167}Tm	c	9.25D	207.8	42 ± 8	**56.59 ± 10.99**
^{165}Tm	c	30.06H	806.4	9.5 ± 0.6	40.28 ± 3.04
			242.9	35.5 ± 1.7	38.70 ± 2.42
				RR_{mean} =	**39.13 ± 1.66**
^{161}Er	c*	3.21H	826.6	64 ± 4	**38.54 ± 3.05**
^{160}Er	c	28.58H	966.2	*	20.86 ± 2.88
			962.4	*	21.32 ± 2.89
			728.2(D)	34 ± 5	20.97 ± 3.17
				RR_{mean} =	**21.05 ± 0.65**
^{160m}Ho$_c$	c	5.02H	966.2	15.4 ± 2.0	22.41 ± 7.94
			962.4	16.6 ± 2.1	16.38 ± 11.18
				RR_{mean} =	**20.41 ± 6.45**
^{157}Dy	c	8.14H	326.2	92 ± 4	**10.27 ± 0.69**
^{155}Dy	c*	9.9H	226.9	68.4 ± 1.6	**7.086 ± 0.475**
^{155}Tb	c*	5.32D	105.3	25.1 ± 1.3	**7.389 ± 0.585**
^{153}Tb	c*	2.34D	212.0	31.0 ± 1.9	**5.242 ± 0.487**
^{153}Gd	c	240.4D	103.2	21.1 ± 0.7	5.227 ± 0.566
			97.4	29.0 ± 0.8	4.338 ± 0.428
				RR_{mean} =	**4.656 ± 0.450**
^{149}Gd	c	9.28D	346.6	23.9 ± 1.3	2.881 ± 0.349
			298.6	28.6 ± 1.7	2.859 ± 0.228
			149.7	48 ± 3	3.509 ± 0.265
				RR_{mean} =	**3.128 ± 0.245**
^{146}Gd	c	48.27D	747.2	*	**1.923 ± 0.104**
^{146}Eu$_i$	i	4.61D	747.2	99 ± 3	**0.2365 ± 0.0746**
^{146}Eu$_c$	c	4.61D	747.2	99 ± 3	**2.160 ± 0.119**
^{139}Ce	c	137.640D	165.9	79.89 ± 0.02	**1.977 ± 0.133**

Continuation of Table 88.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{131}Ba	c	11.50D	123.8	29.0 ± 0.3	**2.742 ± 0.311**
^{127}Xe	c	36.4D	375.0	17.2 ± 0.6	4.048 ± 0.426
			202.9	68.3 ± 0.5	3.889 ± 0.190
			172.1	25.5 ± 0.8	5.038 ± 0.343
				RR_{mean} =	**4.095 ± 0.325**
^{123m}Te	i(m)	119.7D	159.0	84.0 ± 0.4	**1.833 ± 0.136**
^{121m}Te	i(m)	154D	212.2	81.4 ± 1.1	2.591 ± 0.201
			573.1	88.6 ± 0.1	2.223 ± 0.170
				RR_{mean} =	**2.376 ± 0.073**
^{121}Te$_c$	c	19.16D	573.1	80.3 ± 2.5	**4.978 ± 0.247**
^{119m}Te	i(m)	4.70D	1212.7	66.2 ± 0.3	**1.833 ± 0.178**
^{120m}Sb	i(m)	5.76D	1023.3	99.4 ± 0.3	**2.204 ± 0.094**
^{113}Sn	c	115.09D	391.7	64.97 ± 0.17	**2.729 ± 0.245**
^{114m}In	i(m)	49.51D	190.3	15.56 ± 0.16	**8.330 ± 0.505**
^{111}In	c	2.8047D	245.4	94 ± 1	4.426 ± 0.208
			171.3	90.2 ± 1.0	4.667 ± 0.215
				RR_{mean} =	**4.545 ± 0.185**
^{110m}Ag	i(m)	249.76D	884.7	72.7 ± 0.4	6.837 ± 0.312
			937.5	34.2 ± 0.6	7.132 ± 0.452
			657.8	94.3 ± 0.3	6.380 ± 0.276
				RR_{mean} =	**6.639 ± 0.285**
^{106m}Ag	i(m)	8.28D	1045.8	29.6 ± 1.0	4.545 ± 0.250
			717.3	28.9 ± 0.8	4.027 ± 0.268
			451.0	28.2 ± 0.8	4.347 ± 0.234
				RR_{mean} =	**4.332 ± 0.194**
^{105}Rh	c	35.36H	318.9	19.1 ± 0.6	**25.11 ± 1.29**
^{102}Rh	i	207D	475.1	46 ± 5	**5.019 ± 0.667**
^{101m}Rh	c	4.34D	306.9	81 ± 5	**5.900 ± 0.436**
^{103}Ru	c	39.26D	497.1	91.0 ± 1.3	**21.66 ± 0.82**
^{96}Tc	i(m+g)	4.28D	849.9	98 ± 4	6.081 ± 0.325
			812.5	82 ± 4	6.077 ± 0.362
				RR_{mean} =	**6.080 ± 0.275**
^{99}Mo	c	65.94H	140.5	90.27 ± 0.33	**17.69 ± 0.77**
^{96}Nb	i	23.35H	1091.3	48.5 ± 1.6	13.59 ± 0.68
			568.9	58.0 ± 0.3	12.56 ± 0.60
				RR_{mean} =	**12.99 ± 0.65**
^{95}Nb$_i$	i(m+g)	34.975D	765.8	99.81 ± 0.03	**17.52 ± 0.60**
^{95}Nb$_c$	c	34.975D	765.8	99.81 ± 0.03	**30.41 ± 1.02**
^{92m}Nb	i(m)	10.15D	934.4	99.07 ± 0.04	**1.850 ± 0.075**
^{97}Zr	c	16.744H	743.4	93.06 ± 0.16	**3.421 ± 0.231**
^{95}Zr	c	64.02D	765.8	*	13.00 ± 0.52
			756.7	54.46 ± 0.10	12.05 ± 0.48
			724.2	44.17 ± 0.16	11.91 ± 0.50
				RR_{mean} =	**12.32 ± 0.38**
^{89}Zr	c	78.41H	909.2	99.04 ± 0.03	**10.23 ± 0.35**
^{88}Zr	c	83.4D	898.0	*	4.332 ± 0.148
			1836.1	*	4.474 ± 0.309
			392.9	97.24 ± 0.00	4.242 ± 0.196
				RR_{mean} =	**4.325 ± 0.133**
^{90m} Y	i(m)	3.19H	479.5	90.74 ± 0.05	**16.60 ± 0.78**

Continuation of Table 88.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{88} Y_i	i	106.65D	1836.1	99.2 ± 0.3	17.32 ± 0.64
			898.0	93.7 ± 0.3	16.97 ± 0.56
				RR_{mean} =	**17.05 ± 0.55**
^{88} Y_c	c	106.65D	1836.1	99.2 ± 0.3	21.79 ± 0.78
			898.0	93.7 ± 0.3	21.31 ± 0.70
				RR_{mean} =	**21.43 ± 0.69**
^{87} Y	c*	79.8H	484.8	89.7 ± 0.7	13.88 ± 0.49
			388.5	82.1 ± 0.5	15.43 ± 0.54
				RR_{mean} =	**14.61 ± 0.89**
^{85}Sr	c	64.84D	514.0	96 ± 4	**14.69 ± 0.80**
^{86}Rb	i(m+g)	18.631D	1077.0	8.64 ± 0.04	**22.37 ± 1.05**
^{83}Rb	c	86.2D	552.6	16.0 ± 1.1	16.60 ± 1.47
			529.6	29.3 ± 2.1	16.10 ± 1.32
			520.4	45 ± 4	16.64 ± 1.63
				RR_{mean} =	**16.38 ± 0.78**
^{82m}Rb	i(m)	6.472H	776.5	84.39 ± 0.21	6.671 ± 0.642
			554.3	62.4 ± 0.9	6.206 ± 0.688
				RR_{mean} =	**6.458 ± 0.490**
^{82}Br	i(m+g)	35.30H	1317.5	26.5 ± 0.4	11.66 ± 0.52
			776.5	83.5 ± 1.2	11.80 ± 0.46
			554.3	70.8 ± 1.0	11.13 ± 0.44
				RR_{mean} =	**11.49 ± 0.42**
^{75}Se	c	119.779D	264.7	58.9 ± 0.4	6.283 ± 0.317
			136.0	58.3 ± 0.8	6.577 ± 0.313
				RR_{mean} =	**6.438 ± 0.263**
^{74}As	i	17.77D	595.8	59 ± 4	**9.227 ± 0.708**
^{72}Ga$_i$	i	14.10H	2201.7	25.9 ± 0.5	**6.714 ± 0.671**
^{72}Ga$_c$	c	14.10H	2201.7	25.9 ± 0.5	**8.882 ± 0.668**
^{72}Zn	c	46.5H	2201.7	*	**2.168 ± 0.189**
^{59}Fe	c	44.472D	1291.6	43.2 ± 1.4	3.748 ± 0.255
			1099.2	56.5 ± 1.9	4.333 ± 0.309
				RR_{mean} =	**3.981 ± 0.311**
^{54}Mn	i	312.11D	834.8	99.98 ± 0.00	**1.847 ± 0.221**
^{46}Sc	i(m+g)	83.79D	889.3	99.98 ± 0.00	**1.107 ± 0.298**
^{7}Be	i	53.29D	477.6	10.52 ± 0.06	**6.646 ± 2.382**

12.8.3 Nuclide production rates for ^{208}Pb

Table 89: Detailed calculation of nuclide production rates for ^{208}Pb for E_p = 0.8 GeV, used to determine the cross sections for their production.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{207}Bi	i	31.55Y	569.7	97.74 ± 0.03	**27.32 ± 3.74**
^{206}Bi	i	6.243D	1718.7	31.8 ± 0.6	23.01 ± 0.96
			803.1	98.9 ± 1.4	21.50 ± 0.77
			537.5	30.5 ± 0.5	20.65 ± 0.85
			343.5	23.4 ± 0.4	19.39 ± 1.14
				RR_{mean} =	**21.38 ± 0.87**

Continuation of Table 89.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{205}Bi	i	15.31D	1861.7	6.17 ± 0.10	32.95 ± 1.84
			1764.3	32.5 ± 0.7	31.38 ± 1.41
			703.5	31.1 ± 0.1	30.22 ± 1.02
				RR_{mean} =	**30.53 ± 1.07**
^{204}Bi	i	11.22H	984.0	59 ± 4	26.19 ± 2.08
			899.2	98 ± 9	26.39 ± 1.00
			670.7	11.4 ± 0.9	27.48 ± 2.91
			374.8	82 ± 5	27.90 ± 5.84
				RR_{mean} =	**26.43 ± 0.82**
^{203}Bi	i(m+g)	11.76H	820.2	29.6 ± 1.5	**25.43 ± 1.87**
^{202}Bi	i	1.72H	422.1	83.7 ± 2.5	**24.99 ± 2.80**
^{204m}Pb$_i$	i(m)	67.2M	899.2	99.17 ± 0.02	65.75 ± 2.70
			374.7	89 ± 15	69.52 ± 12.10
				RR_{mean} =	**65.83 ± 2.68**
^{204m}Pb$_c$	c	67.2M	899.2	99.17 ± 0.02	69.71 ± 2.79
			374.7	89 ± 15	73.02 ± 12.69
				RR_{mean} =	**69.77 ± 2.78**
^{203}Pb	c*	51.873H	279.2	80.8 ± 0.2	**174.0 ± 6.4**
^{202m}Pb	i(m)	3.53H	422.1	86 ± 5	**57.00 ± 4.12**
^{201}Pb	c*	9.33H	331.2	79 ± 5	**150.2 ± 10.8**
^{200}Pb	c	21.5H	579.3	*	94.25 ± 6.13
			1514.9	*	107.5 ± 10.1
			1205.7	*	109.1 ± 7.6
			828.3	*	94.79 ± 9.11
			450.5	3.33 ± 0.08	131.7 ± 6.7
			367.9	*	102.3 ± 3.6
			147.6	37.7 ± 1.4	108.4 ± 5.9
				RR_{mean} =	**102.3 ± 3.2**
^{199}Pb	c*	90M	366.9	44 ± 7	**216.0 ± 35.7**
^{198}Pb	c	2.4H	173.4	18 ± 3	**135.0 ± 23.3**
^{197m}Pb	c*	43M	385.9	74 ± 15	102.1 ± 21.1
			222.8	25 ± 6	95.81 ± 24.12
				RR_{mean} =	**101.6 ± 5.2**
^{195m}Pb	i(m)	15.0M	383.6	107 ± 20	**47.21 ± 9.23**
^{202}Tl	c	12.23D	439.6	91.4 ± 1.0	**94.99 ± 3.44**
^{201}Tl	c*	72.912H	167.4	10.00 ± 0.06	**264.3 ± 9.7**
^{200}Tl$_i$	i	26.1H	1514.9	4.0 ± 0.3	108.9 ± 13.0
			1205.7	29.9 ± 1.8	120.7 ± 8.7
			579.3	13.8 ± 0.7	138.8 ± 9.6
			367.9	87.2 ± 0.4	122.2 ± 4.7
				RR_{mean} =	**122.9 ± 4.9**
^{200}Tl$_c$	c	26.1H	1514.9	4.0 ± 0.3	216.4 ± 18.5
			1205.7	29.9 ± 1.8	229.8 ± 15.9
			579.3	13.8 ± 0.7	233.1 ± 14.5
			367.9	87.2 ± 0.4	224.5 ± 7.7
				RR_{mean} =	**225.0 ± 7.6**
^{199}Tl$_c$	c	7.42H	455.5	12.4 ± 1.4	**206.2 ± 24.8**
^{199}Tl	c*	7.42H	455.5	12.4 ± 1.4	**247.6 ± 29.5**
^{198m}Tl	i(m)	1.87H	282.8	28 ± 3	**113.4 ± 13.4**
^{196m}Tl	i(m)	1.41H	695.4	41 ± 7	**187.8 ± 32.8**

Continuation of Table 89.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{203}Hg	c	46.612D	279.2	81.46 ± 0.13	**21.08 ± 0.79**
^{197m}Hg	i(m)	23.8H	134.0	33.5 ± 0.4	**56.18 ± 2.54**
^{195m}Hg	i(m)	41.6H	560.3	7.0 ± 0.6	76.16 ± 7.16
			261.8	31 ± 4	77.54 ± 10.43
				RR_{mean} =	**76.41 ± 4.34**
^{193m}Hg	i(m)	11.8H	407.6	32 ± 6	78.86 ± 15.10
			258.0	49 ± 7	114.4 ± 17.1
				RR_{mean} =	**94.65 ± 17.92**
^{192}Hg	c	4.85H	316.5	*	242.2 ± 30.5
			274.8	50.2 ± 2.5	189.1 ± 12.3
				RR_{mean} =	**195.4 ± 6.0**
^{190}Hg	c*	20.0M	142.6	68 ± 10	**140.6 ± 21.7**
^{198m}Au	i(m)	2.27D	204.1	40.8 ± 2.4	3.680 ± 0.331
			411.8	*	4.259 ± 0.197
				RR_{mean} =	**4.153 ± 0.128**
^{198}Au$_i$	i	2.69517D	411.8	95.58 ± 0.12	**7.433 ± 0.348**
^{198}Au$_c$	i(m+g)	2.69517D	411.8	95.58 ± 0.12	**11.69 ± 0.41**
^{196}Au	i(m1+m2+g)	6.183D	426.1	6.6 ± 0.8	21.36 ± 2.74
			355.7	87.0 ± 0.8	20.73 ± 0.72
			333.0	22.9 ± 0.6	22.33 ± 1.01
				RR_{mean} =	**20.95 ± 0.75**
^{195}Au	c	186.098D	98.9	10.9 ± 0.9	**305.6 ± 30.1**
^{194}Au	i(m1+m2+g)	38.02H	328.5	61 ± 5	37.82 ± 3.36
			293.6	10.4 ± 0.8	36.59 ± 3.19
				RR_{mean} =	**37.17 ± 2.08**
^{192}Au$_i$	i(m+g)	4.94H	316.5	58 ± 7	**60.31 ± 7.97**
^{192}Au$_c$	c	4.94H	316.5	58 ± 7	**302.5 ± 38.0**
^{191}Au	c*	3.18H	674.2	6.8 ± 0.5	296.5 ± 25.5
			586.4	17 ± 0	296.3 ± 14.9
			166.5	3.32 ± 0.24	268.6 ± 26.4
				RR_{mean} =	**292.2 ± 13.2**
^{190}Au$_c$	c	42.8M	301.8	23.4 ± 1.5	222.6 ± 19.4
			295.8	71 ± 5	205.2 ± 19.5
				RR_{mean} =	**214.6 ± 11.7**
^{191}Pt	c	2.802D	538.9	13.7 ± 1.6	246.0 ± 29.9
			456.5	3.4 ± 0.4	227.3 ± 27.9
			409.4	8.0 ± 0.9	213.4 ± 25.1
			351.2	3.4 ± 0.4	260.1 ± 31.9
			172.2	3.5 ± 0.4	204.6 ± 24.9
				RR_{mean} =	**225.4 ± 11.9**
^{189}Pt	c	10.87H	721.4	9.3 ± 0.8	283.7 ± 26.5
			607.6	8.10 ± 0.16	244.7 ± 9.9
			568.8	7.1 ± 0.6	253.3 ± 24.8
			544.9	5.8 ± 0.5	261.2 ± 24.7
			243.5	7.0 ± 1.2	279.3 ± 49.6
				RR_{mean} =	**248.6 ± 9.5**
^{188}Pt	c	10.2D	1209.8	*	235.8 ± 25.2
			633.0	*	260.2 ± 44.2
			195.1	18.6 ± 1.2	231.6 ± 17.3
			478.0	*	229.9 ± 12.3

Continuation of Table 89.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			423.3	4.4 ± 0.3	240.0 ± 18.4
			381.4	7.5 ± 0.5	226.8 ± 17.0
			187.6	19.4 ± 1.2	237.3 ± 17.1
				RR_{mean} =	**231.8 ± 7.2**
^{187}Pt	c	2.35H	106.4	8.8 ± 1.8	**180.5 ± 39.3**
^{186}Pt	c	2.08H	689.4	70 ± 15	**186.7 ± 40.5**
^{184}Pt	c	17.3M	548.3	23 ± 4	**157.4 ± 28.9**
^{192}Ir	i(m1+g)	73.827D	316.5	82.71 ± 0.21	**0.7820 ± 0.0891**
^{190}Ir	i(m1+g)	11.78D	605.1	39.9 ± 1.9	2.656 ± 0.191
			569.3	28.5 ± 1.3	2.597 ± 0.314
				RR_{mean} =	**2.643 ± 0.158**
^{189}Ir	c	13.2D	275.9	0.54 ± 0.07	243.2 ± 35.6
			245.1	6.0 ± 0.6	224.2 ± 24.0
				RR_{mean} =	**225.0 ± 8.7**
$^{188}Ir_i$	i	41.5H	633.0	18 ± 3	14.55 ± 2.74
			478.0	14.7 ± 0.6	18.88 ± 1.66
				RR_{mean} =	**17.97 ± 1.85**
$^{188}Ir_c$	c	41.5H	1209.8	6.9 ± 0.7	242.6 ± 25.9
			633.0	18 ± 3	274.8 ± 46.7
			478.0	14.7 ± 0.6	248.8 ± 13.3
				RR_{mean} =	**248.8 ± 8.5**
^{187}Ir	c*	10.5H	977.5	3.14 ± 0.11	**234.9 ± 13.8**
^{186}Ir	c	16.64H	434.8	33.9 ± 1.1	110.6 ± 5.6
			773.3	8.9 ± 0.5	113.5 ± 7.7
				RR_{mean} =	**111.5 ± 5.0**
^{185}Ir	c	14.4H	1829.0	10.1 ± 1.5	173.8 ± 26.6
			254.2	13.3 ± 2.4	157.9 ± 29.3
				RR_{mean} =	**171.3 ± 9.0**
^{184}Ir	c*	3.09H	264.0	68 ± 4	208.0 ± 14.9
			841.3	8.0 ± 0.8	177.2 ± 21.0
			390.4	25.9 ± 2.4	190.0 ± 19.1
			119.8	31 ± 3	218.7 ± 23.9
				RR_{mean} =	**203.8 ± 8.8**
^{183}Ir	c	57M	392.5	10.4 ± 2.4	**200.3 ± 47.2**
^{185}Os	c	93.6D	874.8	6.29 ± 0.25	234.8 ± 12.3
			717.4	3.94 ± 0.16	233.5 ± 12.5
			646.1	78 ± 3	225.5 ± 11.5
				RR_{mean} =	**229.4 ± 7.7**
^{183m}Os	c*	9.9H	1107.9	22.4 ± 0.6	123.2 ± 5.7
			1101.9	49.0 ± 1.3	120.2 ± 5.3
				RR_{mean} =	**121.4 ± 4.2**
^{182}Os	c	22.10H	263.3	6.71 ± 0.25	205.8 ± 11.5
			180.2	33.5 ± 1.7	205.0 ± 13.0
				RR_{mean} =	**205.5 ± 9.3**
^{181}Os	c	105M	238.8	44 ± 5	**77.08 ± 10.09**
^{180}Os	c	21.5M	902.8(D)	101.5 ± 3.4	**165.4 ± 8.6**
^{183}Re	c	70.0D	291.7	3.05 ± 0.18	212.7 ± 16.0
			161.4	0.61 ± 0.14	270.3 ± 63.8
				RR_{mean} =	**215.3 ± 15.0**
$^{182m}Re_c$	c	12.7H	1221.5	24.8 ± 1.6	219.6 ± 16.4

Continuation of Table 89.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			1189.2	15 ± 1	235.6 ± 18.7
			1121.4	31.8 ± 1.6	220.1 ± 13.9
				RR_{mean} =	**222.8 ± 9.2**
^{181}Re	c*	19.9H	639.0	6.4 ± 1.4	203.4 ± 45.2
			365.5	56 ± 8	197.4 ± 29.1
				RR_{mean} =	**198.9 ± 21.4**
^{179}Re	c*	19.5M	430.2	28.0 ± 1.8	230.6 ± 18.0
			290.0	26.9 ± 2.3	180.5 ± 18.6
				RR_{mean} =	**219.1 ± 22.1**
^{178}Re	c*	13.2M	237.3	45 ± 5	**216.3 ± 27.2**
^{178} W	c	21.6D	1350.6(D)	1.18 ± 0.11	154.1 ± 16.7
			1340.8(D)	1.03 ± 0.09	126.4 ± 13.7
				RR_{mean} =	**137.6 ± 14.2**
^{177} W	c	135M	115.7	51 ± 5	**134.3 ± 14.8**
^{176} W	c	2.5H	1159.3	*	83.17 ± 16.41
			710.5	*	97.84 ± 30.50
				RR_{mean} =	**86.19 ± 13.62**
^{177}Ta	c*	56.56H	112.9	7.2 ± 1.6	**150.1 ± 34.3**
$^{176}Ta_c$	c	8.09H	1159.3	24.7 ± 1.9	142.3 ± 13.2
			710.5	5.4 ± 0.4	153.1 ± 17.0
				RR_{mean} =	**145.0 ± 7.3**
^{175}Ta	c	10.5H	1793.1	4.6 ± 0.7	100.4 ± 16.2
			348.5	12.0 ± 1.1	143.1 ± 14.2
			266.9	10.52 ± 0.16	128.9 ± 5.7
				RR_{mean} =	**128.4 ± 6.7**
$^{174}Ta_c$	c	1.14H	206.5	60 ± 5	**104.3 ± 9.7**
^{173}Ta	c	3.14H	172.2	17.5 ± 1.8	**111.9 ± 12.7**
^{172}Ta	c*	36.8M	214.1	55 ± 5	**48.70 ± 5.81**
^{175}Hf	c	70D	343.4	84 ± 3	**126.1 ± 6.2**
^{173}Hf	c*	23.6H	123.7	83 ± 5	127.3 ± 9.5
			311.2	10.7 ± 0.5	122.1 ± 7.3
			306.6	6.4 ± 0.3	142.8 ± 9.2
			139.6	12.7 ± 0.6	137.4 ± 9.0
				RR_{mean} =	**130.6 ± 6.4**
^{172}Hf	c	1.87Y	1093.6	*	81.82 ± 4.76
			900.7	*	84.82 ± 4.66
			181.5	*	79.66 ± 5.35
			125.8	11.3 ± 0.9	86.15 ± 9.37
				RR_{mean} =	**83.53 ± 2.58**
^{170}Hf	c	16.01H	620.7	18 ± 5	91.76 ± 25.70
			164.7	26 ± 8	86.85 ± 26.94
			120.2	15 ± 5	75.67 ± 25.59
				RR_{mean} =	**88.71 ± 6.28**
^{173}Lu	c	1.37Y	272.1	21.2 ± 0.8	**102.8 ± 5.6**
$^{172}Lu_c$	c	6.70D	1093.6	63 ± 3	82.53 ± 4.80
			900.7	29.8 ± 1.3	86.67 ± 4.76
			181.5	20.6 ± 1.0	81.65 ± 5.42
				RR_{mean} =	**84.59 ± 3.05**
^{171}Lu	c*	8.24D	853.0	2.55 ± 0.07	85.29 ± 5.13
			780.7	4.36 ± 0.11	103.2 ± 5.2

Continuation of Table 89.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			689.3	2.37 ± 0.06	95.14 ± 4.54
			667.4	11.0 ± 0.3	92.49 ± 4.02
				RR_{mean} =	**94.01 ± 4.06**
^{170}Lu	c*	2.012D	1280.2	8.2 ± 0.4	**98.97 ± 6.09**
^{169}Lu	c	34.06H	960.6	23.4 ± 0.7	**53.08 ± 2.53**
^{167}Lu	c	51.5M	176.2	*	**48.54 ± 5.77**
^{169}Yb	c*	32.026D	198.0	35.8 ± 0.7	65.93 ± 2.84
			177.2	22.2 ± 0.5	61.77 ± 2.68
			130.5	11.31 ± 0.21	67.03 ± 3.17
				RR_{mean} =	**64.49 ± 2.56**
^{166}Yb	c	56.7H	2079.5	*	38.18 ± 2.88
			2052.4	*	41.34 ± 2.89
			1374.2	*	41.82 ± 3.63
			785.9	*	38.96 ± 2.84
			691.2(D)	8.56 ± 0.58	35.60 ± 2.81
				RR_{mean} =	**38.94 ± 1.20**
^{167}Tm	c	9.25D	207.8	42 ± 8	**50.77 ± 9.87**
^{165}Tm	c	30.06H	806.4	9.5 ± 0.6	37.21 ± 2.87
			242.9	35.5 ± 1.7	33.10 ± 2.07
				RR_{mean} =	**34.02 ± 2.01**
^{161}Er	c*	3.21H	826.6	64 ± 4	**34.07 ± 3.09**
^{160}Er	c	28.58H	966.2	*	16.64 ± 2.29
			962.4	*	18.54 ± 2.48
			728.2(D)	34 ± 5	17.21 ± 2.62
				RR_{mean} =	**17.42 ± 0.54**
^{160m}Ho$_c$	c	5.02H	966.2	15.4 ± 2.0	19.44 ± 5.89
			962.4	16.6 ± 2.1	15.33 ± 10.01
				RR_{mean} =	**18.40 ± 5.04**
^{157}Dy	c	8.14H	326.2	92 ± 4	**8.727 ± 0.525**
^{155}Dy	c*	9.9H	226.9	68.4 ± 1.6	**6.058 ± 0.494**
^{155}Tb	c*	5.32D	105.3	25.1 ± 1.3	**5.959 ± 0.450**
^{153}Tb	c*	2.34D	212.0	31.0 ± 1.9	**4.391 ± 0.425**
^{153}Gd	c	240.4D	97.4	29.0 ± 0.8	4.135 ± 0.691
			103.2	21.1 ± 0.7	3.451 ± 0.401
				RR_{mean} =	**3.616 ± 0.350**
^{149}Gd	c	9.28D	346.6	23.9 ± 1.3	2.417 ± 0.214
			298.6	28.6 ± 1.7	2.394 ± 0.206
			149.7	48 ± 3	3.088 ± 0.240
				RR_{mean} =	**2.633 ± 0.242**
^{146}Gd	c	48.27D	747.2	*	**1.459 ± 0.105**
^{146}Eu$_i$	i	4.61D	747.2	99 ± 3	**0.4969 ± 0.1061**
^{146}Eu$_c$	c	4.61D	747.2	99 ± 3	**1.956 ± 0.138**
^{139}Ce	c	137.640D	165.9	79.89 ± 0.02	**1.870 ± 0.092**
^{131}Ba	c	11.50D	123.8	29.0 ± 0.3	**2.463 ± 0.213**
^{127}Xe	c	36.4D	375.0	17.2 ± 0.6	3.789 ± 0.278
			202.9	68.3 ± 0.5	3.716 ± 0.168
			172.1	25.5 ± 0.8	4.019 ± 0.406
				RR_{mean} =	**3.751 ± 0.156**
^{124}Sb	i(m1+m2+g)	60.20D	602.7	98.3 ± 0.4	**0.3624 ± 0.0587**
^{123m}Te	i(m)	119.7D	159.0	84.0 ± 0.4	**1.523 ± 0.121**

Continuation of Table 89.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{121m}Te	i(m)	154D	212.2	81.4 ± 1.1	2.304 ± 0.175
			573.1	88.6 ± 0.1	2.185 ± 0.175
				RR_{mean} =	**2.245 ± 0.069**
^{121}Te$_c$	c	19.16D	573.1	80.3 ± 2.5	**4.482 ± 0.226**
^{119m}Te	i(m)	4.70D	1212.7	66.2 ± 0.3	**1.893 ± 0.115**
^{120m}Sb	i(m)	5.76D	1023.3	99.4 ± 0.3	**2.252 ± 0.111**
^{113}Sn	c	115.09D	391.7	64.97 ± 0.17	**2.642 ± 0.161**
^{114m}In	i(m)	49.51D	190.3	15.56 ± 0.16	**7.578 ± 0.511**
^{111}In	c	2.8047D	245.4	94 ± 1	3.594 ± 0.182
			171.3	90.2 ± 1.0	4.217 ± 0.216
				RR_{mean} =	**3.851 ± 0.329**
^{110m}Ag	i(m)	249.76D	884.7	72.7 ± 0.4	6.295 ± 0.263
			657.8	94.3 ± 0.3	6.309 ± 0.272
			937.5	34.2 ± 0.6	7.070 ± 0.409
				RR_{mean} =	**6.396 ± 0.266**
^{106m}Ag	i(m)	8.28D	1045.8	29.6 ± 1.0	3.709 ± 0.219
			717.3	28.9 ± 0.8	3.366 ± 0.223
			451.0	28.2 ± 0.8	3.619 ± 0.222
				RR_{mean} =	**3.571 ± 0.156**
^{105}Rh	c	35.36H	318.9	19.1 ± 0.6	**24.96 ± 1.38**
^{102}Rh	i	207D	475.1	46 ± 5	**5.135 ± 0.661**
^{101m}Rh	c	4.34D	306.9	81 ± 5	**5.184 ± 0.387**
^{103}Ru	c	39.26D	497.1	91.0 ± 1.3	**21.15 ± 0.80**
^{96}Tc	i(m+g)	4.28D	849.9	98 ± 4	4.842 ± 0.261
			812.5	82 ± 4	5.057 ± 0.303
				RR_{mean} =	**4.929 ± 0.224**
^{99}Mo	c	65.94H	140.5	90.27 ± 0.33	**18.20 ± 0.79**
^{96}Nb	i	23.35H	1091.3	48.5 ± 1.6	13.43 ± 0.66
			568.9	58.0 ± 0.3	12.35 ± 0.69
				RR_{mean} =	**12.96 ± 0.67**
^{95}Nb$_i$	i(m+g)	34.975D	765.8	99.81 ± 0.03	**16.36 ± 0.55**
^{95}Nb$_c$	c	34.975D	765.8	99.81 ± 0.03	**28.97 ± 0.95**
^{92m}Nb	i(m)	10.15D	934.4	99.07 ± 0.04	**1.505 ± 0.069**
^{97}Zr	c	16.744H	743.4	93.06 ± 0.16	**3.079 ± 0.166**
^{95}Zr	c	64.02D	765.8	*	12.72 ± 0.44
			756.7	54.46 ± 0.10	12.28 ± 0.49
			724.2	44.17 ± 0.16	12.39 ± 0.47
				RR_{mean} =	**12.54 ± 0.39**
^{89}Zr	c	78.41H	909.2	99.04 ± 0.03	**8.491 ± 0.285**
^{88}Zr	c	83.4D	1836.1	*	3.890 ± 0.304
			392.9	97.24 ± 0.00	3.570 ± 0.149
				RR_{mean} =	**3.606 ± 0.111**
^{90m} Y	i(m)	3.19H	479.5	90.74 ± 0.05	**15.25 ± 0.85**
^{88} Y$_i$	i	106.65D	898.0	93.7 ± 0.3	15.63 ± 0.53
			1836.1	99.2 ± 0.3	15.37 ± 0.57
				RR_{mean} =	**15.54 ± 0.51**
^{88} Y$_c$	c	106.65D	898.0	93.7 ± 0.3	17.81 ± 0.59
			1836.1	99.2 ± 0.3	19.26 ± 0.69
				RR_{mean} =	**18.24 ± 0.87**
^{87} Y	c*	79.8H	484.8	89.7 ± 0.7	11.86 ± 0.42

Continuation of Table 89.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			388.5	82.1 ± 0.5	13.18 ± 0.48
				RR_{mean} =	**12.39 ± 0.75**
^{85}Sr	c	64.84D	514.0	96 ± 4	**12.22 ± 0.66**
^{86}Rb	i(m+g)	18.631D	1077.0	8.64 ± 0.04	**21.54 ± 1.09**
^{83}Rb	c	86.2D	552.6	16.0 ± 1.1	14.49 ± 1.21
			529.6	29.3 ± 2.1	14.34 ± 1.18
			520.4	45 ± 4	14.65 ± 1.41
				RR_{mean} =	**14.46 ± 0.67**
^{82m}Rb	i(m)	6.472H	776.5	84.39 ± 0.21	4.702 ± 0.550
			554.3	62.4 ± 0.9	5.651 ± 0.797
				RR_{mean} =	**5.003 ± 0.468**
^{82}Br	i(m+g)	35.30H	1317.5	26.5 ± 0.4	11.29 ± 0.49
			776.5	83.5 ± 1.2	11.34 ± 0.44
			698.4	28.5 ± 0.4	11.89 ± 0.60
			554.3	70.8 ± 1.0	10.88 ± 0.44
				RR_{mean} =	**11.24 ± 0.39**
^{75}Se	c	119.779D	264.7	58.9 ± 0.4	4.979 ± 0.221
			136.0	58.3 ± 0.8	5.097 ± 0.273
				RR_{mean} =	**5.019 ± 0.202**
^{74}As	i	17.77D	595.8	59 ± 4	**8.116 ± 0.625**
^{72}Ga$_i$	i	14.10H	2201.7	25.9 ± 0.5	**7.234 ± 0.690**
^{72}Ga$_c$	c	14.10H	2201.7	25.9 ± 0.5	**8.886 ± 0.673**
^{72}Zn	c	46.5H	2201.7	*	**1.652 ± 0.178**
^{59}Fe	c	44.472D	1099.2	56.5 ± 1.9	4.215 ± 0.257
			1291.6	43.2 ± 1.4	3.778 ± 0.242
				RR_{mean} =	**3.990 ± 0.251**
^{54}Mn	i	312.11D	834.8	99.98 ± 0.00	**1.570 ± 0.135**
^{46}Sc	i(m+g)	83.79D	889.3	99.98 ± 0.00	**0.9722 ± 0.1855**
^{7}Be	i	53.29D	477.6	10.52 ± 0.06	**7.217 ± 0.949**

12.8.4 Nuclide production rates for ^{nat}Pb

Table 90: Detailed calculation of nuclide production rates for ^{nat}Pb for $E_p = 0.8$ GeV, used to determine the cross sections for their production.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{207}Bi	i	31.55Y	569.7	97.74 ± 0.03	**15.51 ± 2.68**
^{206}Bi	i	6.243D	1718.7	31.8 ± 0.6	15.99 ± 0.79
			803.1	98.9 ± 1.4	15.67 ± 0.59
			537.5	30.5 ± 0.5	15.38 ± 0.69
			343.5	23.4 ± 0.4	14.77 ± 1.16
				RR_{mean} =	**15.60 ± 0.54**
^{205}Bi	i	15.31D	1861.7	6.17 ± 0.10	24.63 ± 1.58
			1861.7	6.17 ± 0.10	24.63 ± 1.58
			1764.3	32.5 ± 0.7	26.65 ± 1.14
			703.5	31.1 ± 0.1	26.03 ± 0.96
				RR_{mean} =	**25.96 ± 0.89**
^{204}Bi	i	11.22H	984.0	59 ± 4	25.34 ± 2.02
			899.2	98 ± 9	25.78 ± 0.97

Continuation of Table 90.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			670.7	11.4 ± 0.9	28.31 ± 2.98
			374.8	82 ± 5	27.10 ± 5.67
				RR_{mean} =	**25.83 ± 0.80**
^{203}Bi	i(m+g)	11.76H	820.2	29.6 ± 1.5	**26.36 ± 1.79**
^{202}Bi	i	1.72H	422.1	83.7 ± 2.5	**27.76 ± 2.27**
^{204m}Pb$_i$	i(m)	67.2M	899.2	99.17 ± 0.02	57.71 ± 2.26
			374.7	89 ± 15	66.42 ± 11.46
				RR_{mean} =	**57.84 ± 2.26**
^{204m}Pb$_c$	c	67.2M	899.2	99.17 ± 0.02	61.57 ± 2.36
			374.7	89 ± 15	69.82 ± 12.04
				RR_{mean} =	**61.69 ± 2.36**
^{203}Pb	c*	51.873H	279.2	80.8 ± 0.2	**187.4 ± 6.9**
^{202m}Pb	i(m)	3.53H	422.1	86 ± 5	**52.74 ± 3.83**
^{201}Pb	c*	9.33H	331.2	79 ± 5	**154.8 ± 11.2**
^{200}Pb	c	21.5H	1514.9	*	114.6 ± 10.4
			1205.7	*	115.9 ± 8.2
			828.3	*	111.4 ± 9.6
			450.5	3.33 ± 0.08	121.9 ± 6.2
			367.9	*	107.3 ± 3.7
			147.6	37.7 ± 1.4	119.3 ± 6.7
				RR_{mean} =	**109.7 ± 3.4**
^{199}Pb	c*	90M	366.9	44 ± 7	**203.8 ± 33.7**
^{198}Pb	c	2.4H	173.4	18 ± 3	**136.7 ± 23.6**
^{197m}Pb	c*	43M	385.9	74 ± 15	**108.0 ± 22.3**
^{195m}Pb	i(m)	15.0M	383.6	107 ± 20	**53.94 ± 10.38**
^{202}Tl	c	12.23D	439.6	91.4 ± 1.0	**91.70 ± 3.31**
^{201}Tl	c*	72.912H	167.4	10.00 ± 0.06	**267.9 ± 10.0**
^{200}Tl$_i$	i	26.1H	1514.9	4.0 ± 0.3	93.00 ± 10.43
			1205.7	29.9 ± 1.8	109.3 ± 8.1
			579.3	13.8 ± 0.7	129.7 ± 11.5
			367.9	87.2 ± 0.4	115.7 ± 4.6
				RR_{mean} =	**114.2 ± 5.3**
^{200}Tl$_c$	c	26.1H	1514.9	4.0 ± 0.3	207.6 ± 17.4
			1205.7	29.9 ± 1.8	225.2 ± 15.6
			579.3	13.8 ± 0.7	228.2 ± 14.7
			367.9	87.2 ± 0.4	223.0 ± 7.7
				RR_{mean} =	**222.8 ± 7.6**
^{199}Tl$_c$	c	7.42H	455.5	12.4 ± 1.4	**194.2 ± 23.1**
^{199}Tl	c*	7.42H	455.5	12.4 ± 1.4	**243.4 ± 29.2**
^{198m}Tl	i(m)	1.87H	282.8	28 ± 3	**108.9 ± 13.9**
^{196m}Tl	i(m)	1.41H	695.4	41 ± 7	**183.5 ± 32.0**
^{203}Hg	c	46.612D	279.2	81.46 ± 0.13	**15.52 ± 0.58**
^{197m}Hg	i(m)	23.8H	134.0	33.5 ± 0.4	**50.79 ± 2.54**
^{195m}Hg	i(m)	41.6H	560.3	7.0 ± 0.6	66.16 ± 6.36
			261.8	31 ± 4	72.41 ± 9.79
				RR_{mean} =	**67.28 ± 3.97**
^{193m}Hg	i(m)	11.8H	407.6	32 ± 6	72.85 ± 13.92
			258.0	49 ± 7	107.9 ± 16.2
				RR_{mean} =	**87.90 ± 17.56**
^{192}Hg	c	4.85H	316.5	*	242.4 ± 30.4

Continuation of Table 90.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			274.8	50.2 ± 2.5	188.3 ± 11.9
				RR_{mean} =	**194.2 ± 6.0**
^{190}Hg	c*	20.0M	142.6	68 ± 10	**155.2 ± 24.1**
^{198m}Au	i(m)	2.27D	204.1	40.8 ± 2.4	2.788 ± 0.255
			411.8	*	2.673 ± 0.201
				RR_{mean} =	**2.715 ± 0.084**
^{198}Au$_i$	i	2.69517D	411.8	95.58 ± 0.12	**6.934 ± 0.444**
^{198}Au$_c$	i(m+g)	2.69517D	411.8	95.58 ± 0.12	**9.608 ± 0.386**
^{196}Au	i(m1+m2+g)	6.183D	426.1	6.6 ± 0.8	17.31 ± 2.29
			355.7	87.0 ± 0.8	17.26 ± 0.60
			333.0	22.9 ± 0.6	18.40 ± 0.89
				RR_{mean} =	**17.39 ± 0.59**
^{195}Au	c	186.098D	98.9	10.9 ± 0.9	**279.6 ± 28.7**
^{194}Au	i(m1+m2+g)	38.02H	328.5	61 ± 5	32.47 ± 2.89
			293.6	10.4 ± 0.8	31.79 ± 2.92
				RR_{mean} =	**32.14 ± 1.86**
^{192}Au$_i$	i(m+g)	4.94H	316.5	58 ± 7	**46.44 ± 5.87**
^{192}Au$_c$	c	4.94H	316.5	58 ± 7	**288.8 ± 36.2**
^{191}Au	c*	3.18H	674.2	6.8 ± 0.5	287.0 ± 24.1
			586.4	17 ± 0	284.2 ± 13.4
			166.5	3.32 ± 0.24	261.2 ± 24.1
				RR_{mean} =	**281.4 ± 12.2**
^{190}Au$_c$	c	42.8M	301.8	23.4 ± 1.5	207.3 ± 15.4
			295.8	71 ± 5	205.7 ± 17.2
				RR_{mean} =	**206.8 ± 9.0**
^{191}Pt	c	2.802D	538.9	13.7 ± 1.6	237.8 ± 29.0
			456.5	3.4 ± 0.4	215.9 ± 26.7
			409.4	8.0 ± 0.9	202.1 ± 23.8
			351.2	3.4 ± 0.4	249.0 ± 31.9
			172.2	3.5 ± 0.4	204.1 ± 25.0
				RR_{mean} =	**216.3 ± 10.8**
^{189}Pt	c	10.87H	721.4	9.3 ± 0.8	269.2 ± 25.0
			607.6	8.10 ± 0.16	230.8 ± 9.7
			568.8	7.1 ± 0.6	242.7 ± 23.7
			544.9	5.8 ± 0.5	258.1 ± 24.8
			243.5	7.0 ± 1.2	235.2 ± 42.5
				RR_{mean} =	**235.6 ± 9.3**
^{188}Pt	c	10.2D	1209.8	*	228.6 ± 24.4
			633.0	*	250.3 ± 42.5
			195.1	18.6 ± 1.2	223.4 ± 16.7
			478.0	*	219.1 ± 11.7
			423.3	4.4 ± 0.3	224.1 ± 17.1
			381.4	7.5 ± 0.5	216.2 ± 16.2
			187.6	19.4 ± 1.2	227.3 ± 16.5
				RR_{mean} =	**221.0 ± 6.8**
^{187}Pt	c	2.35H	106.4	8.8 ± 1.8	**169.6 ± 36.6**
^{186}Pt	c	2.08H	689.4	70 ± 15	**186.0 ± 40.4**
^{184}Pt	c	17.3M	548.3	23 ± 4	**157.7 ± 28.6**
^{192}Ir	i(m1+g)	73.827D	316.5	82.71 ± 0.21	**0.6950 ± 0.0583**
^{190}Ir	i(m1+g)	11.78D	605.1	39.9 ± 1.9	2.073 ± 0.149

Continuation of Table 90.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			569.3	28.5 ± 1.3	1.996 ± 0.209
				RR_{mean} =	**2.051 ± 0.119**
^{189}Ir	c	13.2D	275.9	0.54 ± 0.07	214.9 ± 29.9
			245.1	6.0 ± 0.6	210.8 ± 22.6
				RR_{mean} =	**211.1 ± 8.2**
^{188}Ir$_i$	i	41.5H	633.0	18 ± 3	12.05 ± 2.26
			478.0	14.7 ± 0.6	15.45 ± 1.22
				RR_{mean} =	**14.92 ± 1.31**
^{188}Ir$_c$	c	41.5H	1209.8	6.9 ± 0.7	237.7 ± 25.4
			633.0	18 ± 3	262.4 ± 44.6
			478.0	14.7 ± 0.6	234.5 ± 12.5
				RR_{mean} =	**234.8 ± 8.0**
^{187}Ir	c*	10.5H	977.5	3.14 ± 0.11	**240.6 ± 16.4**
^{186}Ir	c	16.64H	434.8	33.9 ± 1.1	105.1 ± 5.3
			773.3	8.9 ± 0.5	107.5 ± 7.4
				RR_{mean} =	**105.7 ± 4.8**
^{185}Ir	c	14.4H	1829.0	10.1 ± 1.5	159.4 ± 24.6
			254.2	13.3 ± 2.4	147.6 ± 27.8
				RR_{mean} =	**157.3 ± 8.8**
^{184}Ir	c*	3.09H	264.0	68 ± 4	210.8 ± 15.0
			390.4	25.9 ± 2.4	183.1 ± 18.3
			119.8	31 ± 3	215.8 ± 24.2
				RR_{mean} =	**207.2 ± 9.5**
^{183}Ir	c	57M	392.5	10.4 ± 2.4	**203.5 ± 47.8**
^{185}Os	c	93.6D	874.8	6.29 ± 0.25	226.5 ± 12.3
			717.4	3.94 ± 0.16	218.4 ± 11.8
			646.1	78 ± 3	215.7 ± 11.0
				RR_{mean} =	**218.2 ± 7.3**
^{183m}Os	c*	9.9H	1107.9	22.4 ± 0.6	120.4 ± 5.3
			1101.9	49.0 ± 1.3	119.8 ± 5.2
				RR_{mean} =	**120.0 ± 4.0**
^{182}Os	c	22.10H	263.3	6.71 ± 0.25	196.3 ± 11.4
			180.2	33.5 ± 1.7	207.5 ± 13.2
				RR_{mean} =	**200.8 ± 9.3**
^{181}Os	c	105M	238.8	44 ± 5	**70.25 ± 8.98**
^{180}Os	c	21.5M	902.8(D)	101.5 ± 3.4	**160.3 ± 8.4**
^{183}Re	c	70.0D	291.7	3.05 ± 0.18	207.3 ± 14.8
			161.4	0.61 ± 0.14	253.4 ± 59.3
			161.4	0.61 ± 0.14	209.6 ± 14.5
				RR_{mean} =	**209.5 ± 10.8**
^{182m}Re$_c$	c	12.7H	1221.5	24.8 ± 1.6	210.2 ± 15.5
			1189.2	15 ± 1	218.4 ± 19.8
			1121.4	31.8 ± 1.6	208.5 ± 13.1
				RR_{mean} =	**210.2 ± 8.8**
^{181}Re	c*	19.9H	639.0	6.4 ± 1.4	200.3 ± 44.5
			365.5	56 ± 8	191.6 ± 28.3
				RR_{mean} =	**193.7 ± 20.9**
^{179}Re	c*	19.5M	430.2	28.0 ± 1.8	226.5 ± 20.0
			290.0	26.9 ± 2.3	188.0 ± 18.3
				RR_{mean} =	**208.3 ± 20.3**

Continuation of Table 90.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{178}Re	c*	13.2M	237.3	45 ± 5	**246.7 ± 29.7**
^{178} W	c	21.6D	1350.6(D)	1.18 ± 0.11	143.6 ± 15.4
			1340.8(D)	1.03 ± 0.09	119.9 ± 12.1
				RR_{mean} =	**127.3 ± 11.6**
^{177} W	c	135M	115.7	51 ± 5	**134.1 ± 15.2**
^{176} W	c	2.5H	1823.7	*	108.8 ± 44.9
			1159.3	*	111.2 ± 12.9
			710.5	*	108.5 ± 31.9
				RR_{mean} =	**110.8 ± 9.4**
^{177}Ta	c*	56.56H	112.9	7.2 ± 1.6	**158.8 ± 37.3**
^{176}Ta$_c$	c	8.09H	1823.7	4.5 ± 0.4	135.1 ± 19.3
			1159.3	24.7 ± 1.9	136.2 ± 11.8
			710.5	5.4 ± 0.4	151.5 ± 16.6
				RR_{mean} =	**138.1 ± 5.9**
^{175}Ta	c	10.5H	1793.1	4.6 ± 0.7	99.31 ± 16.15
			348.5	12.0 ± 1.1	151.0 ± 15.0
			266.9	10.52 ± 0.16	130.4 ± 5.8
				RR_{mean} =	**130.1 ± 7.7**
^{174}Ta$_c$	c	1.14H	206.5	60 ± 5	**101.3 ± 9.5**
^{173}Ta	c	3.14H	172.2	17.5 ± 1.8	**120.6 ± 13.5**
^{172}Ta	c*	36.8M	214.1	55 ± 5	**51.25 ± 5.23**
^{175}Hf	c	70D	343.4	84 ± 3	**125.8 ± 6.2**
^{173}Hf	c*	23.6H	123.7	83 ± 5	131.7 ± 10.4
			311.2	10.7 ± 0.5	126.4 ± 7.7
			306.6	6.4 ± 0.3	143.8 ± 9.3
			139.6	12.7 ± 0.6	145.0 ± 9.7
				RR_{mean} =	**135.1 ± 6.4**
^{172}Hf	c	1.87Y	1093.6	*	84.40 ± 4.99
			900.7	*	85.41 ± 4.88
			181.5	*	89.49 ± 5.68
			125.8	11.3 ± 0.9	88.82 ± 8.97
				RR_{mean} =	**86.35 ± 2.66**
^{170}Hf	c	16.01H	620.7	18 ± 5	98.92 ± 27.72
			164.7	26 ± 8	92.24 ± 28.59
			120.2	15 ± 5	95.56 ± 32.45
				RR_{mean} =	**97.27 ± 6.92**
^{173}Lu	c	1.37Y	272.1	21.2 ± 0.8	**106.2 ± 5.9**
^{172}Lu$_c$	c	6.70D	1093.6	63 ± 3	85.14 ± 5.03
			900.7	29.8 ± 1.3	86.90 ± 4.92
			181.5	20.6 ± 1.0	90.96 ± 5.75
				RR_{mean} =	**87.09 ± 3.09**
^{171}Lu	c*	8.24D	853.0	2.55 ± 0.07	98.05 ± 4.73
			780.7	4.36 ± 0.11	99.91 ± 4.66
			689.3	2.37 ± 0.06	98.12 ± 4.48
			667.4	11.0 ± 0.3	96.94 ± 4.23
				RR_{mean} =	**98.08 ± 3.29**
^{170}Lu	c*	2.012D	1280.2	8.2 ± 0.4	**104.2 ± 6.9**
^{169}Lu	c	34.06H	960.6	23.4 ± 0.7	**56.73 ± 2.62**
^{167}Lu	c	51.5M	176.2	*	**46.86 ± 3.53**
^{169}Yb	c*	32.026D	198.0	35.8 ± 0.7	69.83 ± 3.01

Continuation of Table 90.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			177.2	22.2 ± 0.5	66.84 ± 2.94
			130.5	11.31 ± 0.21	69.63 ± 3.60
				RR_{mean} =	**68.58 ± 2.40**
^{166}Yb	c	56.7H	2079.5	*	40.50 ± 3.10
			2052.4	*	41.20 ± 2.87
			1374.2	*	47.45 ± 4.21
			785.9	*	44.18 ± 3.30
			691.2(D)	8.56 ± 0.58	38.36 ± 3.12
				RR_{mean} =	**41.73 ± 1.29**
^{167}Tm	c	9.25D	207.8	42 ± 8	**53.54 ± 10.40**
^{165}Tm	c	30.06H	806.4	9.5 ± 0.6	37.25 ± 2.91
			242.9	35.5 ± 1.7	39.34 ± 2.52
				RR_{mean} =	**38.68 ± 1.70**
^{161}Er	c*	3.21H	826.6	64 ± 4	**35.93 ± 2.87**
^{160}Er	c	28.58H	966.2	*	20.64 ± 2.93
			962.4	*	18.61 ± 2.48
			728.2(D)	34 ± 5	19.29 ± 2.96
				RR_{mean} =	**19.40 ± 0.60**
^{160m}Ho$_c$	c	5.02H	966.2	15.4 ± 2.0	23.21 ± 9.05
			962.4	16.6 ± 2.1	26.48 ± 6.19
				RR_{mean} =	**25.46 ± 5.05**
^{157}Dy	c	8.14H	326.2	92 ± 4	**10.82 ± 0.66**
^{155}Dy	c*	9.9H	226.9	68.4 ± 1.6	**7.299 ± 0.521**
^{155}Tb	c*	5.32D	105.3	25.1 ± 1.3	**6.587 ± 0.552**
^{153}Tb	c*	2.34D	212.0	31.0 ± 1.9	**3.794 ± 0.381**
^{153}Gd	c	240.4D	103.2	21.1 ± 0.7	4.093 ± 0.425
			97.4	29.0 ± 0.8	4.588 ± 0.395
				RR_{mean} =	**4.367 ± 0.298**
^{149}Gd	c	9.28D	346.6	23.9 ± 1.3	3.006 ± 0.287
			298.6	28.6 ± 1.7	2.900 ± 0.253
			149.7	48 ± 3	3.695 ± 0.289
				RR_{mean} =	**3.221 ± 0.277**
^{146}Gd	c	48.27D	747.2	*	**1.757 ± 0.087**
^{146}Eu$_i$	i	4.61D	747.2	99 ± 3	**0.5386 ± 0.0547**
^{146}Eu$_c$	c	4.61D	747.2	99 ± 3	**2.296 ± 0.116**
^{139}Ce	c	137.640D	165.9	79.89 ± 0.02	**2.129 ± 0.102**
^{131}Ba	c	11.50D	123.8	29.0 ± 0.3	**2.489 ± 0.207**
^{127}Xe	c	36.4D	375.0	17.2 ± 0.6	3.837 ± 0.269
			202.9	68.3 ± 0.5	3.946 ± 0.180
			172.1	25.5 ± 0.8	3.686 ± 0.322
				RR_{mean} =	**3.892 ± 0.160**
^{124}Sb	i(m1+m2+g)	60.20D	602.7	98.3 ± 0.4	**0.5406 ± 0.0582**
^{123m}Te	i(m)	119.7D	159.0	84.0 ± 0.4	**1.739 ± 0.149**
^{121m}Te	i(m)	154D	212.2	81.4 ± 1.1	2.400 ± 0.142
			573.1	88.6 ± 0.1	2.382 ± 0.580
				RR_{mean} =	**2.399 ± 0.074**
^{121}Te$_c$	c	19.16D	573.1	80.3 ± 2.5	**5.043 ± 0.424**
^{119m}Te	i(m)	4.70D	1212.7	66.2 ± 0.3	**1.957 ± 0.187**
^{120m}Sb	i(m)	5.76D	1023.3	99.4 ± 0.3	**2.157 ± 0.091**
^{113}Sn	c	115.09D	391.7	64.97 ± 0.17	**2.940 ± 0.182**

Continuation of Table 90.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{114m}In	i(m)	49.51D	190.3	15.56 ± 0.16	**8.245 ± 0.402**
^{111}In	c	2.8047D	245.4	94 ± 1	4.349 ± 0.240
			171.3	90.2 ± 1.0	4.298 ± 0.226
				RR_{mean} =	**4.321 ± 0.186**
^{110m}Ag	i(m)	249.76D	1384.3	24.9 ± 0.8	6.974 ± 0.559
			884.7	72.7 ± 0.4	6.344 ± 0.251
			657.8	94.3 ± 0.3	6.130 ± 0.234
			937.5	34.2 ± 0.6	6.262 ± 0.358
				RR_{mean} =	**6.252 ± 0.216**
^{106m}Ag	i(m)	8.28D	1045.8	29.6 ± 1.0	4.042 ± 0.288
			717.3	28.9 ± 0.8	3.688 ± 0.267
			451.0	28.2 ± 0.8	3.799 ± 0.229
				RR_{mean} =	**3.829 ± 0.176**
^{105}Rh	c	35.36H	318.9	19.1 ± 0.6	**24.30 ± 1.31**
^{102}Rh	i	207D	475.1	46 ± 5	**6.255 ± 0.762**
^{101m}Rh	c	4.34D	306.9	81 ± 5	**5.924 ± 0.451**
^{103}Ru	c	39.26D	497.1	91.0 ± 1.3	**20.49 ± 0.78**
^{96}Tc	i(m+g)	4.28D	849.9	98 ± 4	5.450 ± 0.302
			812.5	82 ± 4	5.558 ± 0.346
				RR_{mean} =	**5.494 ± 0.257**
^{99}Mo	c	65.94H	140.5	90.27 ± 0.33	**17.64 ± 0.82**
^{96}Nb	i	23.35H	1091.3	48.5 ± 1.6	13.57 ± 0.70
			568.9	58.0 ± 0.3	11.87 ± 0.62
				RR_{mean} =	**12.64 ± 0.93**
^{95}Nb$_i$	i(m+g)	34.975D	765.8	99.81 ± 0.03	**16.51 ± 0.57**
^{95}Nb$_c$	c	34.975D	765.8	99.81 ± 0.03	**28.48 ± 0.95**
^{92m}Nb	i(m)	10.15D	934.4	99.07 ± 0.04	**1.640 ± 0.103**
^{97}Zr	c	16.744H	743.4	93.06 ± 0.16	**3.143 ± 0.187**
^{95}Zr	c	64.02D	765.8	*	12.07 ± 0.47
			756.7	54.46 ± 0.10	11.52 ± 0.44
			724.2	44.17 ± 0.16	11.96 ± 0.47
				RR_{mean} =	**11.85 ± 0.37**
^{89}Zr	c	78.41H	909.2	99.04 ± 0.03	**9.446 ± 0.323**
^{88}Zr	c	83.4D	898.0	*	3.840 ± 0.223
			1836.1	*	3.691 ± 0.187
			392.9	97.24 ± 0.00	4.159 ± 0.168
				RR_{mean} =	**3.967 ± 0.122**
^{90m}Y	i(m)	3.19H	479.5	90.74 ± 0.05	**14.92 ± 0.76**
^{88}Y$_i$	i	106.65D	898.0	93.7 ± 0.3	15.49 ± 0.53
			1836.1	99.2 ± 0.3	16.81 ± 0.59
				RR_{mean} =	**15.98 ± 0.80**
^{88}Y$_c$	c	106.65D	898.0	93.7 ± 0.3	19.34 ± 0.64
			1836.1	99.2 ± 0.3	20.50 ± 0.72
				RR_{mean} =	**19.72 ± 0.82**
^{87}Y	c*	79.8H	484.8	89.7 ± 0.7	13.35 ± 0.48
			388.5	82.1 ± 0.5	14.14 ± 0.53
				RR_{mean} =	**13.66 ± 0.57**
^{85}Sr	c	64.84D	514.0	96 ± 4	**13.67 ± 0.75**
^{86}Rb	i(m+g)	18.631D	1077.0	8.64 ± 0.04	**23.95 ± 1.05**
^{83}Rb	c	86.2D	552.6	16.0 ± 1.1	16.10 ± 1.32

Continuation of Table 90.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			529.6	29.3 ± 2.1	15.49 ± 1.26
			520.4	45 ± 4	15.80 ± 1.55
				RR_{mean} =	**15.78 ± 0.72**
^{82m}Rb	i(m)	6.472H	776.5	84.39 ± 0.21	5.394 ± 0.514
			554.3	62.4 ± 0.9	6.062 ± 0.961
				RR_{mean} =	**5.534 ± 0.464**
^{82}Br	i(m+g)	35.30H	1317.5	26.5 ± 0.4	10.77 ± 0.58
			776.5	83.5 ± 1.2	11.69 ± 0.46
			698.4	28.5 ± 0.4	11.56 ± 0.72
			554.3	70.8 ± 1.0	11.27 ± 0.49
				RR_{mean} =	**11.41 ± 0.40**
^{75}Se	c	119.779D	264.7	58.9 ± 0.4	5.491 ± 0.251
			136.0	58.3 ± 0.8	5.923 ± 0.323
				RR_{mean} =	**5.632 ± 0.267**
^{74}As	i	17.77D	595.8	59 ± 4	**8.516 ± 0.651**
^{72}Ga$_i$	i	14.10H	2201.7	25.9 ± 0.5	**7.405 ± 0.674**
^{72}Ga$_c$	c	14.10H	2201.7	25.9 ± 0.5	**8.783 ± 0.652**
^{72}Zn	c	46.5H	2201.7	*	**1.378 ± 0.160**
^{59}Fe	c	44.472D	1099.2	56.5 ± 1.9	3.891 ± 0.328
			1291.6	43.2 ± 1.4	4.237 ± 0.245
				RR_{mean} =	**4.135 ± 0.205**
^{54}Mn	i	312.11D	834.8	99.98 ± 0.00	**1.640 ± 0.123**
^{46}Sc	i(m+g)	83.79D	889.3	99.98 ± 0.00	**1.089 ± 0.067**
^{7}Be	i	53.29D	477.6	10.52 ± 0.06	**6.155 ± 0.790**

12.8.5 Nuclide production rates for ^{209}Bi

Table 91: Detailed calculation of nuclide production rates for ^{209}Bi for E_p = 0.8 GeV, used to determine the cross sections for their production.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{207}Po	i(m+g)	5.80H	992.3	59.3 ± 0.9	**25.02 ± 1.11**
^{206}Po	i	8.8D	1718.7	*	27.63 ± 1.62
			1595.3	*	26.58 ± 3.47
			1032.3	33 ± 5	27.83 ± 4.33
			1007.2	3.1 ± 0.4	29.01 ± 4.44
			980.2	7.1 ± 0.9	30.39 ± 4.06
			807.4	23 ± 3	29.12 ± 3.96
			803.1	*	27.01 ± 1.14
			657.2	*	21.96 ± 4.66
			620.5	*	26.40 ± 2.09
			537.5	*	25.55 ± 1.06
			522.5	15.7 ± 2.0	26.12 ± 3.50
			516.2	*	27.42 ± 1.11
			398.0	*	26.05 ± 1.56
			343.5	*	27.44 ± 1.29
			338.4	19.2 ± 2.5	28.27 ± 3.82
			286.4	24 ± 3	28.82 ± 3.77
				RR_{mean} =	**26.75 ± 0.82**

Continuation of Table 91.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{207}Bi	c	31.55Y	1063.7	74.5 ± 0.2	265.5 ± 12.7
			569.7	97.74 ± 0.03	256.4 ± 9.4
				RR_{mean} =	**258.4 ± 9.2**
^{206}Bi$_i$	i	6.243D	1718.7	31.8 ± 0.6	162.4 ± 6.6
			1595.3	5.01 ± 0.08	164.6 ± 8.2
			881.0	66.2 ± 1.0	161.4 ± 5.9
			803.1	98.9 ± 1.4	151.5 ± 5.5
			657.2	1.91 ± 0.04	134.1 ± 8.0
			620.5	5.76 ± 0.09	145.8 ± 6.2
			537.5	30.5 ± 0.5	139.7 ± 5.3
			516.2	40.7 ± 0.6	144.5 ± 5.4
			398.0	10.74 ± 0.15	141.1 ± 5.5
			343.5	23.4 ± 0.4	145.3 ± 5.5
				RR_{mean} =	**148.5 ± 5.4**
^{206}Bi$_c$	c	6.243D	1718.7	31.8 ± 0.6	188.5 ± 7.5
			1595.3	5.01 ± 0.08	189.8 ± 8.0
			881.0	66.2 ± 1.0	197.2 ± 7.1
			803.1	98.9 ± 1.4	177.0 ± 6.3
			620.5	5.76 ± 0.09	170.7 ± 6.7
			537.5	30.5 ± 0.5	163.9 ± 6.2
			516.2	40.7 ± 0.6	170.4 ± 6.3
			398.0	10.74 ± 0.15	165.7 ± 6.2
			343.5	23.4 ± 0.4	171.2 ± 6.5
				RR_{mean} =	**175.7 ± 6.6**
^{205}Bi	c	15.31D	1861.7	6.17 ± 0.10	182.6 ± 7.5
			1775.8	3.99 ± 0.08	190.9 ± 8.1
			1764.3	32.5 ± 0.7	189.0 ± 7.7
			1614.3	2.28 ± 0.04	180.7 ± 7.6
			1190.0	2.26 ± 0.07	180.9 ± 8.9
			1043.8	7.51 ± 0.10	164.6 ± 6.4
			987.7	16.13 ± 0.17	189.6 ± 6.9
			759.1	1.04 ± 0.05	183.4 ± 11.9
			703.5	31.1 ± 0.1	173.1 ± 5.9
			579.8	5.44 ± 0.07	166.4 ± 6.4
			570.6	4.34 ± 0.07	155.5 ± 6.3
			549.8	2.95 ± 0.04	167.4 ± 6.4
			284.1	1.69 ± 0.02	173.6 ± 8.3
				RR_{mean} =	**174.3 ± 6.1**
^{204}Bi	c*	11.22H	984.0	59 ± 4	144.8 ± 11.0
			918.3	10.8 ± 0.9	168.2 ± 15.7
			899.2	98 ± 9	140.6 ± 5.0
			670.7	11.4 ± 0.9	159.3 ± 14.4
			374.8	82 ± 5	165.8 ± 34.6
				RR_{mean} =	**141.8 ± 4.4**
^{203}Bi	c	11.76H	1893.0	8.2 ± 0.6	126.4 ± 10.6
			1847.3	11.4 ± 0.8	128.1 ± 10.7
			1679.6	8.8 ± 0.7	117.4 ± 10.7
			847.2	8.5 ± 0.5	153.7 ± 11.0
			820.2	29.6 ± 1.5	138.1 ± 8.4
			279.2	*	127.0 ± 6.3
			264.2	5.2 ± 0.4	187.1 ± 24.1

Continuation of Table 91.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
				RR_{mean} =	**130.0 ± 4.0**
^{202}Bi	c*	1.72H	960.7	99.28 ± 0.02	114.1 ± 4.6
			422.1	83.7 ± 2.5	120.0 ± 6.2
				RR_{mean} =	**115.7 ± 4.4**
^{204m}Pb$_i$	i(m)	67.2M	899.2	99.17 ± 0.02	48.96 ± 2.51
			374.7	89 ± 15	50.56 ± 8.88
				RR_{mean} =	**49.04 ± 2.47**
^{204m}Pb$_c$	c	67.2M	899.2	99.17 ± 0.02	70.04 ± 2.94
			374.7	89 ± 15	71.36 ± 12.39
				RR_{mean} =	**70.08 ± 2.93**
^{203}Pb$_i$	i(m1+m2+g)	51.873H	279.2	80.8 ± 0.2	**120.1 ± 7.0**
^{203}Pb$_c$	c	51.873H	279.2	80.8 ± 0.2	**247.1 ± 9.2**
^{202m}Pb	i(m)	3.53H	960.7	92 ± 8	71.97 ± 7.11
			422.1	86 ± 5	60.54 ± 4.49
				RR_{mean} =	**62.55 ± 4.76**
^{201}Pb	c*	9.33H	946.0	7.4 ± 0.6	221.2 ± 20.6
			361.3	9.9 ± 0.5	277.1 ± 18.1
			331.2	79 ± 5	249.9 ± 18.0
				RR_{mean} =	**252.9 ± 17.4**
^{200}Pb	c	21.5H	1514.9	*	163.2 ± 14.6
			1205.7	*	180.2 ± 12.4
			579.3	*	165.0 ± 11.6
			450.5	3.33 ± 0.08	206.6 ± 10.1
			367.9	*	170.5 ± 6.0
			147.6	37.7 ± 1.4	188.3 ± 12.4
				RR_{mean} =	**172.8 ± 5.3**
^{199}Pb	c*	90M	1135.0	7.8 ± 1.2	271.3 ± 44.5
			455.5	*	225.6 ± 36.0
			366.9	44 ± 7	369.8 ± 61.5
				RR_{mean} =	**244.0 ± 7.5**
^{198}Pb	c	2.4H	173.4	18 ± 3	**240.7 ± 41.3**
^{197m}Pb	c*	43M	385.9	74 ± 15	167.3 ± 34.4
			222.8	25 ± 6	140.8 ± 34.4
				RR_{mean} =	**164.8 ± 9.3**
^{195m}Pb	i(m)	15.0M	383.6	107 ± 20	**89.13 ± 17.07**
^{202}Tl	c	12.23D	439.6	91.4 ± 1.0	**33.43 ± 1.21**
^{201}Tl	c*	72.912H	167.4	10.00 ± 0.06	**295.5 ± 11.4**
^{200}Tl$_i$	i	26.1H	1514.9	4.0 ± 0.3	69.91 ± 11.49
			1205.7	29.9 ± 1.8	67.43 ± 4.91
			579.3	13.8 ± 0.7	73.67 ± 9.42
			367.9	87.2 ± 0.4	65.47 ± 4.58
				RR_{mean} =	**67.26 ± 3.46**
^{200}Tl$_c$	c	26.1H	1514.9	4.0 ± 0.3	233.1 ± 19.8
			1205.7	29.9 ± 1.8	247.7 ± 17.0
			579.3	13.8 ± 0.7	238.6 ± 15.2
			367.9	87.2 ± 0.4	235.9 ± 8.5
				RR_{mean} =	**236.8 ± 8.2**
^{199}Tl	c*	7.42H	455.5	12.4 ± 1.4	279.2 ± 33.3
			247.3	9.3 ± 1.1	290.4 ± 36.5
				RR_{mean} =	**283.6 ± 16.1**

Continuation of Table 91.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{198m}Tl	i(m)	1.87H	282.8	28 ± 3	**82.16 ± 10.33**
^{197}Tl	c*	2.84H	1411.3	4.5 ± 1.5	223.1 ± 75.9
			152.2	7.3 ± 2.3	374.5 ± 119.5
				RR_{mean} =	**303.9 ± 76.1**
^{196m}Tl	i(m)	1.41H	695.4	41 ± 7	**164.1 ± 28.7**
^{197m}Hg	i(m)	23.8H	134.0	33.5 ± 0.4	**24.50 ± 1.63**
^{195m}Hg	i(m)	41.6H	261.8	31 ± 4	**44.07 ± 6.20**
^{193m}Hg	i(m)	11.8H	407.6	32 ± 6	51.96 ± 9.94
			258.0	49 ± 7	74.32 ± 11.35
				RR_{mean} =	**61.75 ± 11.26**
^{192}Hg	c	4.85H	316.5	*	238.6 ± 30.0
			274.8	50.2 ± 2.5	196.6 ± 12.4
				RR_{mean} =	**201.7 ± 6.2**
^{190}Hg	c*	20.0M	597.7	*	170.6 ± 26.5
			301.8	*	188.9 ± 26.1
			295.8	*	158.1 ± 13.2
			142.6	68 ± 10	161.9 ± 25.3
				RR_{mean} =	**162.5 ± 5.0**
^{198m}Au	i(m)	2.27D	411.8	*	**0.1457 ± 0.0682**
^{198}Au$_i$	i	2.69517D	411.8	95.58 ± 0.12	**2.740 ± 0.156**
^{198}Au$_c$	i(m+g)	2.69517D	411.8	95.58 ± 0.12	**2.886 ± 0.116**
^{196}Au	i(m1+m2+g)	6.183D	355.7	87.0 ± 0.8	**4.819 ± 0.188**
^{195}Au	c	186.098D	98.9	10.9 ± 0.9	**230.1 ± 25.7**
^{194}Au	i(m1+m2+g)	38.02H	328.5	61 ± 5	**11.88 ± 1.11**
^{192}Au$_i$	i(m+g)	4.94H	316.5	58 ± 7	**27.10 ± 4.00**
^{192}Au$_c$	c	4.94H	316.5	58 ± 7	**265.7 ± 33.4**
^{191}Au	c*	3.18H	586.4	17 ± 0	266.3 ± 12.3
			277.9	7.2 ± 0.5	221.6 ± 18.8
			166.5	3.32 ± 0.24	243.2 ± 25.8
				RR_{mean} =	**255.4 ± 14.9**
^{190}Au$_c$	c	42.8M	597.7	9.4 ± 0.9	167.7 ± 19.2
			301.8	23.4 ± 1.5	197.3 ± 17.8
			295.8	71 ± 5	184.4 ± 14.6
				RR_{mean} =	**185.1 ± 8.8**
^{191}Pt	c	2.802D	538.9	13.7 ± 1.6	202.0 ± 24.7
			456.5	3.4 ± 0.4	177.7 ± 22.1
			409.4	8.0 ± 0.9	180.1 ± 21.3
			359.9	6.0 ± 0.7	181.9 ± 22.2
			351.2	3.4 ± 0.4	207.5 ± 25.6
			172.2	3.5 ± 0.4	178.7 ± 22.0
			129.4	3.2 ± 0.5	187.8 ± 31.7
				RR_{mean} =	**186.3 ± 7.4**
^{189}Pt	c	10.87H	721.4	9.3 ± 0.8	230.6 ± 23.7
			607.6	8.10 ± 0.16	212.2 ± 9.3
			568.8	7.1 ± 0.6	227.7 ± 24.3
			544.9	5.8 ± 0.5	223.3 ± 21.5
				RR_{mean} =	**215.2 ± 8.8**
^{188}Pt	c	10.2D	1209.8	*	201.9 ± 21.5
			633.0	*	228.8 ± 38.9
			478.0	*	193.2 ± 10.3

Continuation of Table 91.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			423.3	4.4 ± 0.3	193.4 ± 14.8
			381.4	7.5 ± 0.5	189.5 ± 14.3
			195.1	18.6 ± 1.2	192.3 ± 14.5
			187.6	19.4 ± 1.2	195.1 ± 14.2
			155.1	*	204.6 ± 21.9
			140.4	2.33 ± 0.15	219.9 ± 18.9
				RR_{mean} =	**194.7 ± 6.0**
^{187}Pt	c	2.35H	106.4	8.8 ± 1.8	**147.0 ± 33.1**
^{186}Pt	c	2.08H	689.4	70 ± 15	170.8 ± 37.1
			630.3	*	119.4 ± 14.0
				RR_{mean} =	**125.6 ± 3.9**
^{184}Pt	c	17.3M	548.3	23 ± 4	**144.2 ± 27.0**
^{189}Ir	c	13.2D	275.9	0.54 ± 0.07	**202.9 ± 28.4**
^{188}Ir$_c$	c	41.5H	1209.8	6.9 ± 0.7	203.5 ± 21.7
			633.0	18 ± 3	242.6 ± 41.4
			478.0	14.7 ± 0.6	201.4 ± 10.8
			155.1	30 ± 3	212.9 ± 22.8
				RR_{mean} =	**202.0 ± 7.0**
^{187}Ir	c*	10.5H	977.5	3.14 ± 0.11	192.5 ± 13.7
			400.8	3.94 ± 0.14	217.5 ± 18.2
				RR_{mean} =	**201.2 ± 13.4**
^{186}Ir	c	16.64H	773.3	8.9 ± 0.5	81.08 ± 5.79
			434.8	33.9 ± 1.1	85.98 ± 4.21
			296.9	62.3 ± 1.9	99.96 ± 7.62
			137.2	41.4 ± 0.7	93.94 ± 5.47
				RR_{mean} =	**88.39 ± 4.32**
^{185}Ir	c	14.4H	1829.0	10.1 ± 1.5	137.1 ± 21.1
			1668.0	3.6 ± 0.6	129.2 ± 23.0
			254.2	13.3 ± 2.4	126.9 ± 23.9
				RR_{mean} =	**134.3 ± 6.9**
^{184}Ir	c*	3.09H	1105.3	5.3 ± 0.7	145.6 ± 21.4
			390.4	25.9 ± 2.4	152.2 ± 15.2
			264.0	68 ± 4	176.6 ± 12.8
			119.8	31 ± 3	193.2 ± 22.6
				RR_{mean} =	**171.5 ± 8.9**
^{183}Ir	c	57M	392.5	10.4 ± 2.4	**164.8 ± 39.3**
^{185}Os	c	93.6D	874.8	6.29 ± 0.25	196.4 ± 10.4
			717.4	3.94 ± 0.16	182.5 ± 9.8
			646.1	78 ± 3	182.2 ± 9.3
			592.1	1.32 ± 0.06	178.1 ± 11.8
				RR_{mean} =	**185.1 ± 6.7**
^{183m}Os	c*	9.9H	1107.9	22.4 ± 0.6	106.9 ± 5.4
			1101.9	49.0 ± 1.3	101.9 ± 4.8
				RR_{mean} =	**103.8 ± 4.0**
^{182}Os	c	22.10H	1221.5	*	195.9 ± 14.6
			1189.2	*	199.2 ± 15.4
			1121.4	*	193.0 ± 12.2
			180.2	33.5 ± 1.7	171.5 ± 11.1
				RR_{mean} =	**183.5 ± 5.7**
^{181}Os	c	105M	238.8	44 ± 5	**56.81 ± 7.19**

Continuation of Table 91.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{180}Os	c	21.5M	902.8(D)	101.5 ± 3.4	148.6 ± 7.4
			103.5(D)	25.0 ± 0.8	128.6 ± 12.4
				RR_{mean} =	**144.6 ± 9.2**
^{183}Re	c	70.0D	291.7	3.05 ± 0.18	172.3 ± 12.1
			208.8	2.95 ± 0.09	175.1 ± 8.9
			162.3	23.3 ± 0.7	179.6 ± 8.7
			161.4	0.61 ± 0.14	223.6 ± 52.6
			109.7	2.87 ± 0.09	170.7 ± 15.0
				RR_{mean} =	**176.6 ± 6.5**
^{182m}Re$_c$	c	12.7H	1221.5	24.8 ± 1.6	187.7 ± 14.1
			1189.2	15 ± 1	215.9 ± 16.6
			1121.4	31.8 ± 1.6	187.9 ± 11.8
				RR_{mean} =	**192.7 ± 9.6**
^{181}Re	c*	19.9H	953.6	3.6 ± 1.0	170.6 ± 48.2
			639.0	6.4 ± 1.4	162.6 ± 36.4
			365.5	56 ± 8	159.4 ± 23.6
				RR_{mean} =	**161.4 ± 16.4**
^{179}Re	c*	19.5M	430.2	28.0 ± 1.8	192.9 ± 15.6
			290.0	26.9 ± 2.3	154.8 ± 16.2
				RR_{mean} =	**182.3 ± 18.0**
^{178}Re	c*	13.2M	237.3	45 ± 5	**190.2 ± 23.0**
^{178} W	c	21.6D	1340.8(D)	1.03 ± 0.09	129.1 ± 17.8
			1106.1(D)	0.54 ± 0.05	157.5 ± 18.4
				RR_{mean} =	**145.2 ± 14.7**
^{177} W	c	135M	115.7	51 ± 5	**115.0 ± 13.8**
^{177}Ta	c*	56.56H	112.9	7.2 ± 1.6	**125.9 ± 29.7**
^{176}Ta	c*	8.09H	1823.7	4.5 ± 0.4	137.8 ± 14.8
			1584.0	5.3 ± 0.4	118.1 ± 11.0
			1555.1	4.0 ± 0.3	133.3 ± 15.1
			1159.3	24.7 ± 1.9	149.8 ± 12.8
				RR_{mean} =	**137.1 ± 9.1**
^{175}Ta	c	10.5H	1793.1	4.6 ± 0.7	79.63 ± 13.19
			348.5	12.0 ± 1.1	109.4 ± 11.0
			266.9	10.52 ± 0.16	112.1 ± 5.8
				RR_{mean} =	**108.6 ± 7.5**
^{174}Ta$_c$	c	1.14H	206.5	60 ± 5	**84.89 ± 7.84**
^{173}Ta	c	3.14H	172.2	17.5 ± 1.8	**97.86 ± 11.01**
^{172}Ta	c*	36.8M	214.1	55 ± 5	**46.41 ± 5.09**
^{175}Hf	c	70D	343.4	84 ± 3	**100.3 ± 4.9**
^{173}Hf	c*	23.6H	311.2	10.7 ± 0.5	95.85 ± 5.80
			306.6	6.4 ± 0.3	92.49 ± 10.03
			297.0	33.9 ± 1.4	107.1 ± 8.8
			139.6	12.7 ± 0.6	116.2 ± 9.9
			123.7	83 ± 5	100.9 ± 8.9
				RR_{mean} =	**99.88 ± 4.65**
^{172}Hf	c	1.87Y	1093.6	*	68.64 ± 4.00
			929.1	*	70.49 ± 4.15
			900.7	*	68.52 ± 3.85
			181.5	*	69.18 ± 4.29
			125.8	11.3 ± 0.9	73.29 ± 7.59

Continuation of Table 91.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
				RR_{mean} =	**69.70 ± 2.15**
^{170}Hf	c	16.01H	1280.2	*	49.37 ± 8.55
			620.7	18 ± 5	77.11 ± 21.67
			164.7	26 ± 8	68.56 ± 21.29
			120.2	15 ± 5	63.67 ± 21.69
				RR_{mean} =	**52.90 ± 1.63**
^{173}Lu	c	1.37Y	272.1	21.2 ± 0.8	83.48 ± 4.48
			171.4	2.90 ± 0.15	88.90 ± 7.03
			100.7	5.24 ± 0.20	71.59 ± 7.78
				RR_{mean} =	**83.14 ± 3.86**
^{172}Lu$_c$	c	6.70D	1093.6	63 ± 3	69.38 ± 4.05
			929.1	3.04 ± 0.14	79.29 ± 5.79
			900.7	29.8 ± 1.3	70.90 ± 3.98
			181.5	20.6 ± 1.0	69.33 ± 4.31
				RR_{mean} =	**70.73 ± 2.61**
^{171}Lu	c*	8.24D	853.0	2.55 ± 0.07	73.90 ± 4.51
			839.9	3.04 ± 0.08	83.20 ± 4.28
			780.7	4.36 ± 0.11	76.19 ± 3.83
			739.8	47.8 ± 1.2	73.73 ± 3.12
			712.7	1.13 ± 0.03	71.08 ± 5.88
			667.4	11.0 ± 0.3	77.78 ± 3.46
				RR_{mean} =	**75.99 ± 2.71**
^{170}Lu	c*	2.012D	2126.1	5.1 ± 0.3	75.69 ± 6.62
			1280.2	8.2 ± 0.4	78.38 ± 4.91
				RR_{mean} =	**77.76 ± 3.55**
^{169}Lu	c	34.06H	1449.7	9.9 ± 0.3	38.94 ± 2.28
			960.6	23.4 ± 0.7	41.67 ± 2.05
				RR_{mean} =	**40.63 ± 1.83**
^{167}Lu	c	51.5M	106.2	*	22.52 ± 6.85
			113.3	*	40.57 ± 3.71
				RR_{mean} =	**36.81 ± 7.42**
^{169}Yb	c*	32.026D	307.7	10.05 ± 0.19	58.03 ± 2.37
			198.0	35.8 ± 0.7	54.75 ± 2.40
			177.2	22.2 ± 0.5	51.80 ± 2.32
			130.5	11.31 ± 0.21	55.70 ± 3.53
			109.8	17.5 ± 0.4	52.16 ± 4.05
				RR_{mean} =	**55.15 ± 2.12**
^{166}Yb	c	56.7H	2079.5	*	32.58 ± 2.61
			2052.4	*	32.71 ± 2.32
			1374.2	*	32.70 ± 3.15
			1176.7	*	31.87 ± 2.38
			691.2(D)	8.56 ± 0.58	29.95 ± 2.48
				RR_{mean} =	**31.92 ± 0.98**
^{167}Tm	c	9.25D	207.8	42 ± 8	**39.97 ± 7.77**
^{165}Tm	c	30.06H	242.9	35.5 ± 1.7	**28.69 ± 1.90**
^{160}Er	c	28.58H	728.2(D)	34 ± 5	**15.19 ± 2.35**
^{157}Dy	c	8.14H	326.2	92 ± 4	**7.267 ± 0.496**
^{155}Tb	c*	5.32D	105.3	25.1 ± 1.3	**5.177 ± 0.531**
^{149}Gd	c	9.28D	346.6	23.9 ± 1.3	2.339 ± 0.277
			298.6	28.6 ± 1.7	2.340 ± 0.222

Continuation of Table 91.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			149.7	48 ± 3	3.970 ± 0.326
				RR_{mean} =	**2.803 ± 0.527**
^{146}Gd	c	48.27D	747.2	*	**1.560 ± 0.106**
^{146}Eu$_i$	i	4.61D	747.2	99 ± 3	**0.9859 ± 0.3827**
^{146}Eu$_c$	c	4.61D	747.2	99 ± 3	**2.546 ± 0.372**
^{139}Ce	c	137.640D	165.9	79.89 ± 0.01	**2.347 ± 0.110**
^{131}Ba	c	11.50D	123.8	29.0 ± 0.3	**3.556 ± 0.389**
^{129}Cs	c	32.06H	371.9	30.6 ± 1.7	**7.371 ± 0.596**
^{127}Xe	c	36.4D	375.0	17.2 ± 0.6	5.936 ± 0.373
			202.9	68.3 ± 0.5	5.809 ± 0.242
			172.1	25.5 ± 0.8	6.222 ± 0.356
				RR_{mean} =	**5.905 ± 0.222**
^{126} I	i	13.11D	388.6	34 ± 3	**1.690 ± 0.232**
^{124} I	i	4.1760D	602.7	62.9 ± 0.6	**4.230 ± 0.208**
^{121} I	c*	2.12H	212.2	84.3 ± 0.3	**10.07 ± 0.74**
^{123m}Te	i(m)	119.7D	159.0	84.0 ± 0.4	**2.781 ± 0.175**
^{121m}Te	i(m)	154D	212.2	81.4 ± 1.1	3.991 ± 0.205
			573.1	88.6 ± 0.1	3.796 ± 0.209
				RR_{mean} =	**3.900 ± 0.120**
^{121}Te$_c$	c	19.16D	573.1	80.3 ± 2.5	**7.167 ± 0.338**
^{119m}Te	i(m)	4.70D	1212.7	66.2 ± 0.3	**3.350 ± 0.171**
^{120m}Sb	i(m)	5.76D	1171.7	100 ± 0	4.089 ± 0.171
			1023.3	99.4 ± 0.3	3.472 ± 0.174
				RR_{mean} =	**3.835 ± 0.326**
^{118m}Sb	i(m)	5.00H	1050.7	97 ± 5	**5.040 ± 0.564**
^{117m}Sn	i(m)	13.60D	158.6	86.4 ± 0.4	**6.927 ± 0.284**
^{113}Sn	c	115.09D	391.7	64.97 ± 0.17	**4.554 ± 0.238**
^{114m}In	i(m)	49.51D	190.3	15.56 ± 0.16	**11.06 ± 0.54**
^{111}In	c	2.8047D	245.4	94 ± 1	6.799 ± 0.377
			171.3	90.2 ± 1.0	7.076 ± 0.331
				RR_{mean} =	**6.972 ± 0.285**
^{110m}Ag	i(m)	249.76D	1505.0	13.60 ± 0.19	10.32 ± 0.87
			937.5	34.2 ± 0.6	10.19 ± 0.48
			884.7	72.7 ± 0.4	10.61 ± 0.44
			657.8	94.3 ± 0.3	10.29 ± 0.37
				RR_{mean} =	**10.35 ± 0.35**
^{106m}Ag	i(m)	8.28D	717.3	28.9 ± 0.8	5.885 ± 0.358
			451.0	28.2 ± 0.8	5.724 ± 0.332
			406.2	13.4 ± 0.4	5.438 ± 0.595
				RR_{mean} =	**5.756 ± 0.263**
^{105}Ag	c	41.29D	280.4	30.2 ± 1.8	**4.766 ± 0.445**
^{100}Pd	c	3.63D	2376.0	*	**0.2871 ± 0.1612**
^{105}Rh	c	35.36H	318.9	19.1 ± 0.6	**39.26 ± 1.92**
^{102m}Rh	i(m)	2.9Y	631.3	56 ± 2	9.092 ± 1.125
			1046.6	34 ± 2	7.320 ± 1.269
			475.1	95 ± 4	8.556 ± 1.609
				RR_{mean} =	**8.375 ± 0.773**
^{102}Rh	i	207D	475.1	46 ± 5	**1.909 ± 0.915**
^{101m}Rh	c	4.34D	306.9	81 ± 5	**8.521 ± 0.654**
^{100}Rh$_i$	i(m+g)	20.8H	2376.0	32.6 ± 0.4	**4.692 ± 0.381**

Continuation of Table 91.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
$^{100}Rh_c$	c	20.8H	2376.0	32.6 ± 0.4	**4.979 ± 0.317**
^{103}Ru	c	39.26D	497.1	91.0 ± 1.3	**33.38 ± 1.26**
^{96}Tc	i(m+g)	4.28D	849.9	98 ± 4	8.344 ± 0.449
			812.5	82 ± 4	8.379 ± 0.504
				RR_{mean} =	**8.359 ± 0.381**
^{99}Mo	c	65.94H	140.5	90.27 ± 0.33	**28.19 ± 1.57**
^{93m}Mo	i(m)	6.85H	684.7	99.7 ± 2.0	**4.776 ± 0.490**
^{96}Nb	i	23.35H	1091.3	48.5 ± 1.6	20.06 ± 1.06
			849.9	20.45 ± 0.20	22.32 ± 1.45
			568.9	58.0 ± 0.3	20.61 ± 0.99
				RR_{mean} =	**20.69 ± 0.84**
$^{95}Nb_i$	i(m+g)	34.975D	765.8	99.81 ± 0.03	**25.96 ± 0.86**
$^{95}Nb_c$	c	34.975D	765.8	99.81 ± 0.03	**44.05 ± 1.45**
^{92m}Nb	i(m)	10.15D	934.4	99.07 ± 0.04	**1.819 ± 0.111**
^{90}Nb	c*	14.60H	2319.0	82.0 ± 0.3	**3.897 ± 0.354**
^{97}Zr	c	16.744H	743.4	93.06 ± 0.16	**5.092 ± 0.271**
^{95}Zr	c	64.02D	765.8	*	18.26 ± 0.63
			756.7	54.46 ± 0.10	17.92 ± 0.70
			724.2	44.17 ± 0.16	17.68 ± 0.69
				RR_{mean} =	**18.05 ± 0.56**
^{89}Zr	c	78.41H	909.2	99.04 ± 0.03	**13.43 ± 0.46**
^{88}Zr	c	83.4D	1836.1	*	5.549 ± 0.746
			898.0	*	4.742 ± 0.327
			392.9	97.24 ± 0.00	5.518 ± 0.215
				RR_{mean} =	**5.399 ± 0.167**
^{90m}Y	i(m)	3.19H	479.5	90.74 ± 0.05	**23.82 ± 1.00**
$^{88}Y_i$	i	106.65D	1836.1	99.2 ± 0.3	24.31 ± 1.06
			898.0	93.7 ± 0.3	23.26 ± 0.79
				RR_{mean} =	**23.44 ± 0.82**
$^{88}Y_c$	c	106.65D	1836.1	99.2 ± 0.3	29.86 ± 1.12
			898.0	93.7 ± 0.3	28.00 ± 0.93
				RR_{mean} =	**28.43 ± 1.17**
^{87}Y	c*	79.8H	388.5	82.1 ± 0.5	**19.40 ± 0.68**
^{85}Sr	c	64.84D	514.0	96 ± 4	**18.90 ± 1.03**
^{86}Rb	i(m+g)	18.631D	1077.0	8.64 ± 0.04	**30.19 ± 1.19**
^{83}Rb	c	86.2D	552.6	16.0 ± 1.1	21.69 ± 1.71
			529.6	29.3 ± 2.1	22.13 ± 1.78
			520.4	45 ± 4	21.83 ± 2.09
				RR_{mean} =	**21.88 ± 0.97**
^{82m}Rb	i(m)	6.472H	1474.9	15.5 ± 0.3	14.29 ± 7.15
			554.3	62.4 ± 0.9	7.491 ± 1.165
				RR_{mean} =	**7.661 ± 1.152**
^{82}Br	i(m+g)	35.30H	1474.9	16.32 ± 0.23	15.86 ± 0.93
			698.4	28.5 ± 0.4	15.57 ± 0.81
			554.3	70.8 ± 1.0	15.33 ± 0.62
				RR_{mean} =	**15.46 ± 0.56**
^{75}Se	c	119.779D	400.7	11.47 ± 0.09	9.916 ± 0.879
			264.7	58.9 ± 0.4	7.583 ± 0.333
			136.0	58.3 ± 0.8	8.372 ± 0.483
				RR_{mean} =	**7.906 ± 0.489**

Continuation of Table 91.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{76}As	i	1.0778D	559.1	45 ± 2	**13.93 ± 1.01**
^{74}As	i	17.77D	595.8	59 ± 4	**11.92 ± 0.91**
$^{72}Ga_i$	i	14.10H	2201.7	25.9 ± 0.5	**9.219 ± 0.580**
$^{72}Ga_c$	c	14.10H	2201.7	25.9 ± 0.5	**11.20 ± 0.60**
^{72}Zn	c	46.5H	2201.7	*	**1.982 ± 0.146**
^{59}Fe	c	44.472D	1291.6	43.2 ± 1.4	**4.904 ± 0.301**
^{54}Mn	i	312.11D	834.8	99.98 ± 0.00	**1.778 ± 0.206**
^{48}Sc	i	43.67H	1037.5	97.6 ± 0.7	**1.374 ± 0.136**
^{46}Sc	i(m+g)	83.79D	1120.6	99.99 ± 0.00	1.420 ± 0.125
			889.3	99.98 ± 0.00	1.305 ± 0.210
				RR_{mean} =	**1.392 ± 0.111**
^{7}Be	i	53.29D	477.6	10.52 ± 0.06	**8.730 ± 0.837**

12.8.6 Nuclide production rates for ^{27}Al

Table 92: Detailed calculation of nuclide production rates for in ^{27}Al-monitors and ^{27}Al-plates for E_p = 0.8 GeV, used for calculating proton flux (including total over the plate area), cross sections for production of ^{7}Be, ^{24}Naand neutron background.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
		^{27}Al-monitor for ^{206}Pb			
^{7}Be	i	53.29D	477.6	10.52 ± 0.06	**32.26 ± 1.17**
^{27}Mg	c	9.458M	843.8	71.8 ± 0.4	2.821 ± 0.138
			1014.4	28.0 ± 0.4	3.614 ± 0.273
				RR_{mean} =	**2.944 ± 0.302**
^{22}Na	c	2.6019Y	1274.5	99.94 ± 0.01	**79.81 ± 2.75**
^{24}Na	c	14.9590H	1369.0	100 ± 0	**67.79 ± 2.25**
		^{27}Al-plate for ^{206}Pb			
^{24}Na	c	14.9590H	1369.0	100 ± 0	**2.870 ± 0.099**
		^{27}Al-monitor for ^{207}Pb			
^{7}Be	i	53.29D	477.6	10.52 ± 0.06	**29.70 ± 1.08**
^{27}Mg	c	9.458M	843.8	71.8 ± 0.4	2.786 ± 0.162
			1014.4	28.0 ± 0.4	3.023 ± 0.296
				RR_{mean} =	**2.832 ± 0.151**
^{22}Na	c	2.6019Y	1274.5	99.94 ± 0.01	**72.50 ± 2.49**
^{24}Na	c	14.9590H	1369.0	100 ± 0	**62.69 ± 2.09**
		^{27}Al-plate for ^{207}Pb			
^{24}Na	c	14.9590H	1369.0	100 ± 0	**2.179 ± 0.073**
		^{27}Al-monitor for ^{207}Pb			
^{7}Be	i	53.29D	477.6	10.52 ± 0.06	**30.39 ± 1.11**
^{27}Mg	c	9.458M	843.8	71.8 ± 0.4	2.700 ± 0.129
			1014.4	28.0 ± 0.4	2.809 ± 0.202
				RR_{mean} =	**2.725 ± 0.121**
^{22}Na	c	2.6019Y	1274.5	99.94 ± 0.01	**73.29 ± 2.53**
^{24}Na	c	14.9590H	1369.0	100 ± 0	**64.20 ± 2.14**
		^{27}Al-plate for ^{207}Pb			
^{24}Na	c	14.9590H	1369.0	100 ± 0	**2.324 ± 0.080**
		^{27}Al-monitor for ^{nat}Pb			

Continuation of Table 92.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{7}Be	i	53.29D	477.6	10.52 ± 0.06	**28.85 ± 1.05**
^{27}Mg	c	9.458M	843.8	71.8 ± 0.4	3.583 ± 0.163
			1014.4	28.0 ± 0.4	3.510 ± 0.254
				RR_{mean} =	**3.568 ± 0.153**
^{22}Na	c	2.6019Y	1274.5	99.94 ± 0.01	**71.00 ± 2.46**
^{24}Na	c	14.9590H	1369.0	100 ± 0	**60.22 ± 2.01**
^{27}Al-plate for ^{nat}Pb					
^{24}Na	c	14.9590H	1369.0	100 ± 0	**2.133 ± 0.072**
^{27}Al-monitor for ^{209}Bi					
^{7}Be	i	53.29D	477.6	10.52 ± 0.06	**27.28 ± 1.04**
^{27}Mg	c	9.458M	843.8	71.8 ± 0.4	3.882 ± 0.183
			1014.4	28.0 ± 0.4	4.302 ± 0.303
				RR_{mean} =	**3.968 ± 0.209**
^{22}Na	c	2.6019Y	1274.5	99.94 ± 0.01	**67.25 ± 2.28**
^{24}Na	c	14.9590H	1369.0	100 ± 0	**59.57 ± 1.99**
^{27}Al-plate for ^{209}Bi					
^{24}Na	c	14.9590H	1369.0	100 ± 0	**2.177 ± 0.073**

12.9 Detailed calculation of nuclide production rates for ^{206}Pb, ^{207}Pb, ^{208}Pb, ^{nat}Pb and ^{209}Bi for $E_p = 1.2$ GeV

12.9.1 Nuclide production rates for ^{206}Pb

Table 93: Detailed calculation of nuclide production rates for ^{206}Pb for $E_p = 1.2$ GeV, used to determine the cross sections for their production.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{206}Bi	i	6.243D	1718.7	31.8 ± 0.6	8.497 ± 0.531
			803.1	98.9 ± 1.4	8.882 ± 0.384
			537.5	30.5 ± 0.5	8.472 ± 0.491
				RR_{mean} =	**8.710 ± 0.337**
^{205}Bi	i	15.31D	1861.7	6.17 ± 0.10	20.79 ± 1.52
			1764.3	32.5 ± 0.7	24.30 ± 1.10
				RR_{mean} =	**23.42 ± 1.69**
^{204}Bi	i	11.22H	984.0	59 ± 4	30.76 ± 2.80
			899.2	98 ± 9	26.83 ± 1.25
			374.8	82 ± 5	27.02 ± 5.67
				RR_{mean} =	**27.26 ± 0.84**
^{203}Bi	i(m+g)	11.76H	820.2	29.6 ± 1.5	**32.69 ± 2.29**
^{202}Bi	i	1.72H	422.1	83.7 ± 2.5	**42.49 ± 3.34**
^{204m}Pb$_i$	i(m)	67.2M	899.2	99.17 ± 0.02	80.17 ± 4.52
			374.7	89 ± 15	85.94 ± 14.92
				RR_{mean} =	**80.53 ± 4.42**
^{204m}Pb$_c$	c	67.2M	899.2	99.17 ± 0.02	84.19 ± 4.58
			374.7	89 ± 15	89.33 ± 15.50
				RR_{mean} =	**84.49 ± 4.50**
^{203}Pb	c*	51.873H	279.2	80.8 ± 0.2	**274.6 ± 10.0**
^{202m}Pb	i(m)	3.53H	422.1	86 ± 5	**58.82 ± 4.47**
^{201}Pb	c*	9.33H	331.2	79 ± 5	**209.2 ± 15.1**
^{200}Pb	c	21.5H	1205.7	*	152.6 ± 10.6
			367.9	*	140.7 ± 5.0
			257.2	4.46 ± 0.17	150.7 ± 13.9
			147.6	37.7 ± 1.4	159.4 ± 8.8
				RR_{mean} =	**143.7 ± 4.4**
^{199}Pb	c*	90M	366.9	44 ± 7	**289.1 ± 47.8**
^{198}Pb	c	2.4H	173.4	18 ± 3	**206.3 ± 35.7**
^{197m}Pb	c*	43M	385.9	74 ± 15	**128.3 ± 26.5**
^{195m}Pb	i(m)	15.0M	383.6	107 ± 20	**60.84 ± 11.71**
^{202}Tl	c	12.23D	439.6	91.4 ± 1.0	**128.8 ± 4.6**
^{201}Tl	c*	72.912H	167.4	10.00 ± 0.06	**358.9 ± 13.3**
^{200}Tl$_i$	i	26.1H	1205.7	29.9 ± 1.8	151.1 ± 11.1
			579.3	13.8 ± 0.7	174.6 ± 13.5
			367.9	87.2 ± 0.4	150.3 ± 6.2
				RR_{mean} =	**152.4 ± 6.7**
^{200}Tl$_c$	c	26.1H	1205.7	29.9 ± 1.8	303.7 ± 21.0
			579.3	13.8 ± 0.7	307.2 ± 19.5
			367.9	87.2 ± 0.4	290.9 ± 10.1
				RR_{mean} =	**292.6 ± 10.0**
^{199}Tl$_c$	c	7.42H	455.5	12.4 ± 1.4	**263.3 ± 31.7**

Continuation of Table 93.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{199}Tl	c*	7.42H	455.5	12.4 ± 1.4	**305.0 ± 36.4**
^{198m}Tl	i(m)	1.87H	282.8	28 ± 3	**129.4 ± 15.4**
^{196m}Tl	i(m)	1.41H	695.4	41 ± 7	**218.8 ± 38.3**
^{203}Hg	c	46.612D	279.2	81.46 ± 0.13	**12.99 ± 0.53**
^{197m}Hg	i(m)	23.8H	134.0	33.5 ± 0.4	**58.09 ± 2.77**
^{195m}Hg	i(m)	41.6H	261.8	31 ± 4	**89.99 ± 12.32**
^{193m}Hg	i(m)	11.8H	258.0	49 ± 7	122.5 ± 18.6
			407.6	32 ± 6	78.11 ± 14.99
				RR_{mean} =	**95.75 ± 21.93**
^{192}Hg	c	4.85H	316.5	*	263.0 ± 33.1
			274.8	50.2 ± 2.5	221.7 ± 14.1
				RR_{mean} =	**227.0 ± 7.0**
^{190}Hg	c*	20.0M	142.6	68 ± 10	**164.8 ± 25.3**
^{198m}Au	i(m)	2.27D	204.1	40.8 ± 2.4	2.940 ± 0.300
			411.8	*	2.201 ± 0.225
				RR_{mean} =	**2.467 ± 0.076**
^{198}Au$_i$	i	2.69517D	411.8	95.58 ± 0.12	**8.150 ± 0.514**
^{198}Au$_c$	i(m+g)	2.69517D	411.8	95.58 ± 0.12	**10.35 ± 0.42**
^{196}Au	i(m1+m2+g)	6.183D	355.7	87.0 ± 0.8	18.14 ± 0.65
			426.1	6.6 ± 0.8	17.77 ± 2.37
			333.0	22.9 ± 0.6	19.71 ± 0.93
				RR_{mean} =	**18.36 ± 0.69**
^{195}Au	c	186.098D	98.9	10.9 ± 0.9	**234.0 ± 23.1**
^{194}Au	i(m1+m2+g)	38.02H	328.5	61 ± 5	**34.35 ± 3.07**
^{192}Au$_i$	i(m+g)	4.94H	316.5	58 ± 7	**61.18 ± 8.59**
^{192}Au$_c$	c	4.94H	316.5	58 ± 7	**324.2 ± 40.7**
^{191}Au	c*	3.18H	674.2	6.8 ± 0.5	**323.7 ± 31.7**
^{190}Au$_c$	c	42.8M	597.7	9.4 ± 0.9	168.1 ± 23.5
			301.8	23.4 ± 1.5	233.8 ± 18.8
			295.8	71 ± 5	242.3 ± 20.0
				RR_{mean} =	**228.0 ± 18.5**
^{191}Pt	c	2.802D	538.9	13.7 ± 1.6	281.5 ± 34.4
			456.5	3.4 ± 0.4	224.2 ± 27.6
			409.4	8.0 ± 0.9	223.3 ± 26.3
				RR_{mean} =	**236.1 ± 18.3**
^{189}Pt	c	10.87H	544.9	5.8 ± 0.5	282.2 ± 29.0
			721.4	9.3 ± 0.8	283.9 ± 27.2
			607.6	8.10 ± 0.16	272.8 ± 12.6
			568.8	7.1 ± 0.6	292.3 ± 29.2
			243.5	7.0 ± 1.2	322.6 ± 60.5
				RR_{mean} =	**277.0 ± 11.6**
^{188}Pt	c	10.2D	1209.8	*	254.5 ± 27.3
			478.0	*	269.4 ± 14.4
			423.3	4.4 ± 0.3	249.2 ± 19.2
			381.4	7.5 ± 0.5	241.4 ± 18.1
			195.1	18.6 ± 1.2	251.6 ± 18.8
			187.6	19.4 ± 1.2	249.8 ± 18.1
				RR_{mean} =	**258.2 ± 8.0**
^{186}Pt	c	2.08H	689.4	70 ± 15	**206.8 ± 45.0**
^{184}Pt	c	17.3M	548.3	23 ± 4	**203.4 ± 37.2**

Continuation of Table 93.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{192}Ir	i(m1+g)	73.827D	316.5	82.71 ± 0.21	**0.7425 ± 0.1006**
^{190}Ir	i(m1+g)	11.78D	605.1	39.9 ± 1.9	2.734 ± 0.226
			569.3	28.5 ± 1.3	2.636 ± 0.309
				RR_{mean} =	**2.704 ± 0.180**
^{189}Ir	c	13.2D	245.1	6.0 ± 0.6	**221.9 ± 24.2**
^{188}Ir$_i$	i	41.5H	478.0	14.7 ± 0.6	**20.95 ± 4.39**
^{188}Ir$_c$	c	41.5H	1209.8	6.9 ± 0.7	262.3 ± 28.2
			478.0	14.7 ± 0.6	290.4 ± 15.9
				RR_{mean} =	**289.0 ± 10.8**
^{187}Ir	c*	10.5H	977.5	3.14 ± 0.11	**247.3 ± 21.6**
^{186}Ir	c	16.64H	434.8	33.9 ± 1.1	116.5 ± 5.8
			137.2	41.4 ± 0.7	128.4 ± 6.3
				RR_{mean} =	**121.8 ± 7.0**
^{185}Ir	c	14.4H	1829.0	10.1 ± 1.5	196.9 ± 30.4
			254.2	13.3 ± 2.4	177.9 ± 33.1
				RR_{mean} =	**193.4 ± 10.6**
^{184}Ir	c*	3.09H	264.0	68 ± 4	231.1 ± 16.8
			390.4	25.9 ± 2.4	246.8 ± 24.7
			119.8	31 ± 3	263.7 ± 29.6
				RR_{mean} =	**235.5 ± 9.9**
^{185}Os	c	93.6D	646.1	78 ± 3	252.1 ± 12.9
			874.8	6.29 ± 0.25	265.6 ± 13.9
			717.4	3.94 ± 0.16	258.6 ± 14.4
				RR_{mean} =	**256.8 ± 8.9**
^{183m}Os	c*	9.9H	1101.9	49.0 ± 1.3	146.4 ± 6.5
			1107.9	22.4 ± 0.6	155.7 ± 7.4
				RR_{mean} =	**149.6 ± 6.4**
^{182}Os	c	22.10H	263.3	6.71 ± 0.25	253.6 ± 15.5
			180.2	33.5 ± 1.7	250.9 ± 16.3
				RR_{mean} =	**252.4 ± 12.0**
^{180}Os	c	21.5M	902.8(D)	101.5 ± 3.4	**217.9 ± 11.2**
^{183}Re	c	70.0D	162.3	23.3 ± 0.7	270.4 ± 12.7
			291.7	3.05 ± 0.18	250.2 ± 17.7
				RR_{mean} =	**266.3 ± 11.6**
^{182m}Re$_c$	c	12.7H	1221.5	24.8 ± 1.6	277.9 ± 20.6
			1189.2	15 ± 1	273.9 ± 23.2
				RR_{mean} =	**276.3 ± 14.4**
^{181}Re	c*	19.9H	365.5	56 ± 8	219.6 ± 32.4
			639.0	6.4 ± 1.4	257.4 ± 57.2
				RR_{mean} =	**227.1 ± 24.5**
^{179}Re	c*	19.5M	430.2	28.0 ± 1.8	335.3 ± 25.8
			290.0	26.9 ± 2.3	280.5 ± 27.3
				RR_{mean} =	**323.9 ± 24.4**
^{178}Re	c*	13.2M	237.3	45 ± 5	**342.5 ± 41.1**
^{178} W	c	21.6D	1350.6(D)	1.18 ± 0.11	217.2 ± 24.2
			1340.8(D)	1.03 ± 0.09	175.2 ± 23.9
				RR_{mean} =	**200.6 ± 21.4**
^{177} W	c	135M	115.7	51 ± 5	**223.6 ± 24.8**
^{176} W	c	2.5H	1159.3	*	186.5 ± 38.1
			1823.7	*	243.6 ± 114.0

Continuation of Table 93.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			710.5	*	181.8 ± 129.5
				RR_{mean} =	**190.9 ± 32.9**
^{177}Ta	c*	56.56H	112.9	7.2 ± 1.6	**241.0 ± 54.8**
^{176}Ta$_c$	c	8.09H	1159.3	24.7 ± 1.9	247.0 ± 23.9
			1823.7	4.5 ± 0.4	206.2 ± 44.6
			710.5	5.4 ± 0.4	240.5 ± 53.7
				RR_{mean} =	**243.0 ± 14.4**
^{175}Ta	c	10.5H	1793.1	4.6 ± 0.7	193.8 ± 31.6
			348.5	12.0 ± 1.1	279.4 ± 27.6
			266.9	10.52 ± 0.16	234.4 ± 10.3
				RR_{mean} =	**235.4 ± 12.5**
^{174}Ta$_c$	c	1.14H	206.5	60 ± 5	**233.3 ± 21.5**
^{173}Ta	c	3.14H	172.2	17.5 ± 1.8	**239.9 ± 26.7**
^{172}Ta	c*	36.8M	214.1	55 ± 5	**119.1 ± 12.3**
^{175}Hf	c	70D	343.4	84 ± 3	**232.4 ± 11.4**
^{173}Hf	c*	23.6H	123.7	83 ± 5	283.0 ± 21.3
			311.2	10.7 ± 0.5	269.9 ± 15.9
			139.6	12.7 ± 0.6	286.6 ± 18.2
				RR_{mean} =	**277.3 ± 10.9**
^{172}Hf	c	1.87Y	1093.6	*	200.0 ± 11.6
			1002.7(D)	5.55 ± 0.38	176.9 ± 18.8
			181.5	*	194.0 ± 12.2
			125.8	11.3 ± 0.9	199.9 ± 18.9
				RR_{mean} =	**195.8 ± 6.0**
^{171}Hf	c	12.1H	739.8	*	**214.3 ± 15.5**
^{170}Hf	c	16.01H	620.7	18 ± 5	262.1 ± 73.4
			164.7	26 ± 8	253.4 ± 78.5
			120.2	15 ± 5	250.5 ± 84.6
				RR_{mean} =	**259.3 ± 18.3**
^{173}Lu	c	1.37Y	272.1	21.2 ± 0.8	**225.7 ± 12.1**
^{172}Lu$_i$	i(m+g)	6.70D	1093.6	63 ± 3	0.9509 ± 0.1307
			181.5	20.6 ± 1.0	2.936 ± 0.732
				RR_{mean} =	**1.006 ± 0.329**
^{172}Lu$_c$	c	6.70D	1093.6	63 ± 3	200.9 ± 11.7
			181.5	20.6 ± 1.0	197.0 ± 12.3
				RR_{mean} =	**199.4 ± 7.6**
^{171}Lu$_c$	c	8.24D	739.8	47.8 ± 1.2	**219.9 ± 9.1**
^{171}Lu	c*	8.24D	853.0	2.55 ± 0.07	235.1 ± 10.5
			780.7	4.36 ± 0.11	250.3 ± 10.8
			667.4	11.0 ± 0.3	236.2 ± 10.3
				RR_{mean} =	**240.7 ± 8.9**
^{170}Lu$_c$	c	2.012D	1280.2	8.2 ± 0.4	191.8 ± 14.5
			2126.1	5.1 ± 0.3	174.1 ± 16.8
			1054.3	4.76 ± 0.24	167.6 ± 16.2
			985.1	5.5 ± 0.3	201.9 ± 21.6
				RR_{mean} =	**183.1 ± 9.1**
^{169}Lu	c	34.06H	960.6	23.4 ± 0.7	164.3 ± 7.5
			191.2	20.6 ± 0.6	176.7 ± 8.6
				RR_{mean} =	**169.1 ± 8.0**
^{167}Lu	c	51.5M	176.2	*	151.8 ± 9.5

Continuation of Table 93.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			113.3	*	181.6 ± 14.0
				RR_{mean} =	**160.4 ± 14.4**
^{169}Yb	c*	32.026D	198.0	35.8 ± 0.7	195.1 ± 8.5
			177.2	22.2 ± 0.5	196.3 ± 8.5
			130.5	11.31 ± 0.21	199.0 ± 9.3
				RR_{mean} =	**196.6 ± 6.8**
^{166}Yb	c	56.7H	2079.5	*	166.8 ± 12.7
			2052.4	*	180.3 ± 12.8
			1867.9	*	173.7 ± 12.7
			1374.2	*	171.7 ± 14.1
			1176.7	*	164.8 ± 11.9
			785.9	*	172.0 ± 12.2
			705.3	*	155.7 ± 11.2
			691.2(D)	8.56 ± 0.58	147.5 ± 11.4
				RR_{mean} =	**165.6 ± 5.1**
^{167}Tm	c	9.25D	207.8	42 ± 8	**190.1 ± 36.9**
^{165}Tm	c	30.06H	806.4	9.5 ± 0.6	156.5 ± 11.7
			242.9	35.5 ± 1.7	163.3 ± 10.1
				RR_{mean} =	**161.3 ± 6.7**
^{161}Er	c*	3.21H	826.6	64 ± 4	**161.4 ± 11.7**
^{160}Er	c	28.58H	966.2	*	124.5 ± 16.8
			962.4	*	123.3 ± 16.2
			872.0(D)	6.8 ± 1.1	111.8 ± 18.8
			728.2(D)	34 ± 5	131.2 ± 19.8
				RR_{mean} =	**122.6 ± 3.8**
^{159}Er	c*	36M	624.5	33 ± 4	133.3 ± 17.3
			132.0	*	151.9 ± 11.8
				RR_{mean} =	**146.5 ± 4.5**
^{160m}Ho$_c$	c	5.02H	966.2	15.4 ± 2.0	130.1 ± 18.5
			962.4	16.6 ± 2.1	128.9 ± 19.5
				RR_{mean} =	**129.6 ± 13.0**
^{156}Ho	c*	56M	266.5	54.7 ± 1.1	**97.26 ± 4.89**
^{157}Dy	c	8.14H	326.2	92 ± 4	**92.27 ± 5.21**
^{155}Dy	c*	9.9H	226.9	68.4 ± 1.6	**72.88 ± 3.45**
^{152}Dy	c	2.38H	256.9	97.50 ± 0.07	**33.96 ± 1.85**
^{155}Tb	c*	5.32D	180.1	7.5 ± 0.5	64.84 ± 5.24
			105.3	25.1 ± 1.3	75.56 ± 5.47
				RR_{mean} =	**70.93 ± 5.74**
^{153}Tb	c*	2.34D	212.0	31.0 ± 1.9	**53.60 ± 3.96**
^{152}Tb	c*	17.5H	344.3	65 ± 4	**51.29 ± 3.72**
^{151}Tb	c	17.609H	479.4	15.4 ± 0.7	**35.42 ± 2.63**
^{153}Gd	c	240.4D	103.2	21.1 ± 0.7	51.24 ± 3.28
			97.4	29.0 ± 0.8	49.88 ± 3.08
				RR_{mean} =	**50.50 ± 2.39**
^{151}Gd	c	124D	243.3	5.6 ± 0.4	**38.31 ± 3.60**
^{149}Gd	c	9.28D	149.7	48 ± 3	48.15 ± 3.55
			788.9	7.3 ± 0.4	53.32 ± 3.74
			346.6	23.9 ± 1.3	42.91 ± 2.80
			298.6	28.6 ± 1.7	43.51 ± 3.05
				RR_{mean} =	**45.31 ± 2.59**

Continuation of Table 93.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{147}Gd	c	38.06H	929.0	20.2 ± 1.2	36.14 ± 2.77
			396.0	34.3 ± 2.1	33.39 ± 2.38
				RR_{mean} =	**34.48 ± 1.71**
^{146}Gd	c	48.27D	747.2	*	**32.90 ± 1.48**
^{149}Eu	c*	93.1D	327.5	4.03 ± 0.12	**60.79 ± 3.47**
^{147}Eu	c*	24.1D	677.5	9.8 ± 0.5	40.32 ± 2.72
			955.8	3.84 ± 0.20	40.83 ± 2.96
			798.7	4.8 ± 0.3	47.51 ± 4.13
			601.5	5.9 ± 0.3	40.66 ± 2.82
			121.2	22.9 ± 1.3	37.09 ± 2.74
				RR_{mean} =	**40.34 ± 1.76**
$^{146}Eu_i$	i	4.61D	747.2	99 ± 3	**4.319 ± 0.236**
$^{146}Eu_c$	c	4.61D	747.2	99 ± 3	**37.22 ± 1.67**
^{145}Eu	c	5.93D	1658.5	14.9 ± 1.0	21.95 ± 1.84
			653.5	15 ± 1	24.51 ± 1.89
				RR_{mean} =	**23.26 ± 1.47**
^{143}Pm	c	265D	742.0	38.5 ± 2.4	**21.00 ± 1.56**
^{139}Ce	c	137.640D	165.9	79.89 ± 0.02	**15.10 ± 0.56**
^{131}Ba	c	11.50D	123.8	29.0 ± 0.3	**8.262 ± 0.599**
^{128}Ba	c	2.43D	442.9	26.8 ± 1.4	**4.821 ± 0.624**
^{127}Xe	c	36.4D	375.0	17.2 ± 0.6	9.237 ± 0.564
			202.9	68.3 ± 0.5	9.046 ± 0.371
				RR_{mean} =	**9.083 ± 0.351**
^{123m}Te	i(m)	119.7D	159.0	84.0 ± 0.4	**1.785 ± 0.177**
^{121m}Te	i(m)	154D	212.2	81.4 ± 1.1	3.346 ± 0.306
			573.1	88.6 ± 0.1	3.406 ± 0.318
				RR_{mean} =	**3.375 ± 0.104**
$^{121}Te_c$	c	19.16D	573.1	80.3 ± 2.5	**10.40 ± 0.51**
^{119m}Te	i(m)	4.70D	1212.7	66.2 ± 0.3	**4.005 ± 0.198**
^{120m}Sb	i(m)	5.76D	1171.7	100 ± 0	2.872 ± 0.164
			1023.3	99.4 ± 0.3	2.464 ± 0.115
				RR_{mean} =	**2.579 ± 0.200**
^{113}Sn	c	115.09D	391.7	64.97 ± 0.17	**7.575 ± 0.369**
^{114m}In	i(m)	49.51D	190.3	15.56 ± 0.16	**11.21 ± 0.72**
^{111}In	c	2.8047D	171.3	90.2 ± 1.0	9.909 ± 0.418
			245.4	94 ± 1	9.993 ± 0.462
			171.3	90.2 ± 1.0	9.886 ± 0.422
				RR_{mean} =	**9.922 ± 0.347**
^{110m}Ag	i(m)	249.76D	884.7	72.7 ± 0.4	7.345 ± 0.363
			657.8	94.3 ± 0.3	7.612 ± 0.322
				RR_{mean} =	**7.512 ± 0.289**
^{106m}Ag	i(m)	8.28D	451.0	28.2 ± 0.8	8.422 ± 0.471
			1045.8	29.6 ± 1.0	9.101 ± 0.821
			717.3	28.9 ± 0.8	7.702 ± 0.460
				RR_{mean} =	**8.181 ± 0.419**
^{105}Ag	c	41.29D	443.4	10.5 ± 0.6	9.837 ± 1.067
			280.4	30.2 ± 1.8	8.866 ± 0.699
				RR_{mean} =	**9.137 ± 0.605**
^{100}Pd	c	3.63D	2376.0	*	**1.301 ± 0.150**
^{105}Rh	c	35.36H	318.9	19.1 ± 0.6	**33.37 ± 1.85**

Continuation of Table 93.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{102}Rh	i	207D	475.1	46 ± 5	**7.096 ± 0.922**
^{101m}Rh	c	4.34D	306.9	81 ± 5	**12.75 ± 0.95**
^{100}Rh$_i$	i(m+g)	20.8H	2376.0	32.6 ± 0.4	**7.206 ± 0.480**
^{100}Rh$_c$	c	20.8H	2376.0	32.6 ± 0.4	**8.506 ± 0.480**
^{103}Ru	c	39.26D	497.1	91.0 ± 1.3	**23.81 ± 0.95**
^{96}Tc	i(m+g)	4.28D	849.9	98 ± 4	11.53 ± 0.61
			812.5	82 ± 4	11.92 ± 0.72
				RR_{mean} =	**11.68 ± 0.53**
^{99}Mo	c	65.94H	140.5	90.27 ± 0.33	**21.02 ± 0.93**
^{96}Nb	i	23.35H	1091.3	48.5 ± 1.6	16.81 ± 1.08
			568.9	58.0 ± 0.3	14.44 ± 0.90
				RR_{mean} =	**15.40 ± 1.26**
^{95}Nb$_i$	i(m+g)	34.975D	765.8	99.81 ± 0.03	**23.23 ± 0.81**
^{95}Nb$_c$	c	34.975D	765.8	99.81 ± 0.03	**35.56 ± 1.21**
^{90}Nb	c*	14.60H	2319.0	82.0 ± 0.3	6.745 ± 0.571
			1129.2	92.7 ± 0.5	7.718 ± 0.485
				RR_{mean} =	**7.342 ± 0.525**
^{95}Zr	c	64.02D	765.8	*	12.45 ± 0.64
			756.7	54.46 ± 0.10	11.99 ± 0.56
				RR_{mean} =	**12.18 ± 0.38**
^{89}Zr	c	78.41H	909.2	99.04 ± 0.03	**21.01 ± 0.70**
^{88}Zr	c	83.4D	1836.1	*	12.05 ± 1.34
			898.0	*	9.530 ± 0.390
			392.9	97.24 ± 0.00	10.13 ± 0.37
				RR_{mean} =	**10.05 ± 0.31**
^{88} Y$_i$	i	106.65D	1836.1	99.2 ± 0.3	27.80 ± 1.29
			898.0	93.7 ± 0.3	27.44 ± 0.91
				RR_{mean} =	**27.48 ± 0.90**
^{88} Y$_c$	c	106.65D	1836.1	99.2 ± 0.3	39.86 ± 1.59
			898.0	93.7 ± 0.3	36.97 ± 1.22
				RR_{mean} =	**37.41 ± 1.55**
^{87} Y	c*	79.8H	484.8	89.7 ± 0.7	**28.77 ± 1.02**
^{86} Y$_c$	c	14.74H	1076.6	82.5 ± 0.4	**12.02 ± 0.71**
^{85}Sr	c	64.84D	514.0	96 ± 4	**28.48 ± 1.73**
^{83}Rb	c	86.2D	552.6	16.0 ± 1.1	33.61 ± 2.72
			529.6	29.3 ± 2.1	30.99 ± 2.74
			520.4	45 ± 4	32.26 ± 3.09
				RR_{mean} =	**32.40 ± 1.52**
^{82m}Rb	i(m)	6.472H	776.5	84.39 ± 0.21	13.51 ± 1.23
			554.3	62.4 ± 0.9	16.36 ± 1.68
				RR_{mean} =	**14.48 ± 1.43**
^{82}Br	i(m+g)	35.30H	554.3	70.8 ± 1.0	**13.01 ± 0.61**
^{75}Se	c	119.779D	264.7	58.9 ± 0.4	13.38 ± 0.53
			136.0	58.3 ± 0.8	14.74 ± 0.65
			121.1	17.2 ± 0.4	15.02 ± 1.31
				RR_{mean} =	**13.90 ± 0.64**
^{74}As	i	17.77D	595.8	59 ± 4	**17.56 ± 1.35**
^{71}As	c	65.28H	174.9	82.0 ± 2.1	**2.400 ± 0.153**
^{72}Ga$_i$	i	14.10H	2201.7	25.9 ± 0.5	**7.121 ± 0.997**
^{72}Ga$_c$	c	14.10H	2201.7	25.9 ± 0.5	**10.05 ± 0.98**

Continuation of Table 93.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{72}Zn	c	46.5H	2201.7	*	**2.926 ± 0.248**
^{59}Fe	c	44.472D	1291.6	43.2 ± 1.4	7.479 ± 0.455
			1099.2	56.5 ± 1.9	8.137 ± 0.431
				RR_{mean} =	**7.857 ± 0.406**
^{54}Mn	i	312.11D	834.8	99.98 ± 0.00	**5.066 ± 0.515**
^{48} V	c	15.9735D	1312.1	97.5 ± 0.9	0.6186 ± 0.0678
			983.5	100.0 ± 0.3	0.6929 ± 0.1627
				RR_{mean} =	**0.6290 ± 0.0634**
^{48}Sc	i	43.67H	1037.5	97.6 ± 0.7	**2.940 ± 0.207**
^{46}Sc	i(m+g)	83.79D	889.3	99.98 ± 0.00	4.021 ± 0.210
			1120.6	99.99 ± 0.00	3.914 ± 0.291
				RR_{mean} =	**3.990 ± 0.188**
^{7}Be	i	53.29D	477.6	10.52 ± 0.06	**17.54 ± 1.83**

12.9.2 Nuclide production rates for ^{207}Pb

Table 94: Detailed calculation of nuclide production rates for ^{207}Pb for $E_p = 1.2$ GeV, used to determine the cross sections for their production.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{206}Bi	i	6.243D	1718.7	31.8 ± 0.6	16.57 ± 0.75
			803.1	98.9 ± 1.4	15.79 ± 0.60
			537.5	30.5 ± 0.5	14.91 ± 0.82
				RR_{mean} =	**15.83 ± 0.61**
^{205}Bi	i	15.31D	1861.7	6.17 ± 0.10	26.32 ± 2.05
			1764.3	32.5 ± 0.7	26.57 ± 1.35
				RR_{mean} =	**26.51 ± 1.24**
^{204}Bi	i	11.22H	984.0	59 ± 4	29.49 ± 2.43
			899.2	98 ± 9	25.64 ± 1.00
			374.8	82 ± 5	26.05 ± 5.48
				RR_{mean} =	**25.91 ± 0.80**
^{203}Bi	i(m+g)	11.76H	820.2	29.6 ± 1.5	**23.84 ± 2.69**
^{202}Bi	i	1.72H	422.1	83.7 ± 2.5	**25.97 ± 3.49**
^{204m}Pb$_i$	i(m)	67.2M	899.2	99.17 ± 0.02	65.33 ± 3.08
			374.7	89 ± 15	77.81 ± 13.50
				RR_{mean} =	**65.70 ± 3.06**
^{204m}Pb$_c$	c	67.2M	899.2	99.17 ± 0.02	69.17 ± 3.15
			374.7	89 ± 15	81.08 ± 14.06
				RR_{mean} =	**69.50 ± 3.13**
^{203}Pb	c*	51.873H	279.2	80.8 ± 0.2	**201.6 ± 7.4**
^{202m}Pb	i(m)	3.53H	422.1	86 ± 5	**58.60 ± 4.88**
^{201}Pb	c*	9.33H	331.2	79 ± 5	**157.4 ± 11.4**
^{200}Pb	c	21.5H	1205.7	*	121.0 ± 8.4
			367.9	*	106.3 ± 3.9
			257.2	4.46 ± 0.17	136.8 ± 12.3
			147.6	37.7 ± 1.4	115.6 ± 6.7
				RR_{mean} =	**109.4 ± 3.4**
^{199}Pb	c*	90M	366.9	44 ± 7	**212.5 ± 35.0**

Continuation of Table 94.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{198}Pb	c	2.4H	173.4	18 ± 3	**149.6 ± 25.8**
^{197m}Pb	c*	43M	385.9	74 ± 15	**95.07 ± 19.67**
^{195m}Pb	i(m)	15.0M	383.6	107 ± 20	**45.31 ± 8.74**
^{202}Tl	c	12.23D	439.6	91.4 ± 1.0	**104.9 ± 3.8**
^{201}Tl	c*	72.912H	167.4	10.00 ± 0.06	**287.4 ± 10.6**
^{200}Tl$_i$	i	26.1H	1205.7	29.9 ± 1.8	122.2 ± 8.6
			579.3	13.8 ± 0.7	150.8 ± 11.2
			367.9	87.2 ± 0.4	124.2 ± 5.9
				RR_{mean} =	**127.2 ± 7.5**
^{200}Tl$_c$	c	26.1H	1205.7	29.9 ± 1.8	243.2 ± 16.7
			579.3	13.8 ± 0.7	245.0 ± 15.4
			367.9	87.2 ± 0.4	230.5 ± 8.3
				RR_{mean} =	**232.4 ± 8.1**
^{199}Tl$_c$	c	7.42H	455.5	12.4 ± 1.4	**233.3 ± 28.3**
^{199}Tl	c*	7.42H	455.5	12.4 ± 1.4	**244.3 ± 29.2**
^{198m}Tl	i(m)	1.87H	282.8	28 ± 3	**137.4 ± 16.6**
^{196m}Tl	i(m)	1.41H	695.4	41 ± 7	**186.5 ± 32.5**
^{203}Hg	c	46.612D	279.2	81.46 ± 0.13	**18.39 ± 0.70**
^{197m}Hg	i(m)	23.8H	134.0	33.5 ± 0.4	**52.42 ± 2.68**
^{195m}Hg	i(m)	41.6H	261.8	31 ± 4	**80.14 ± 10.95**
^{193m}Hg	i(m)	11.8H	258.0	49 ± 7	98.11 ± 14.85
			407.6	32 ± 6	69.19 ± 13.21
				RR_{mean} =	**82.09 ± 14.60**
^{192}Hg	c	4.85H	316.5	*	216.0 ± 27.4
			274.8	50.2 ± 2.5	184.6 ± 11.9
				RR_{mean} =	**188.8 ± 5.8**
^{190}Hg	c*	20.0M	142.6	68 ± 10	**134.7 ± 20.7**
^{198m}Au	i(m)	2.27D	204.1	40.8 ± 2.4	3.422 ± 0.312
			411.8	*	2.716 ± 0.114
				RR_{mean} =	**2.761 ± 0.085**
^{198}Au$_i$	i	2.69517D	411.8	95.58 ± 0.12	**9.049 ± 0.330**
^{198}Au$_c$	i(m+g)	2.69517D	411.8	95.58 ± 0.12	**11.77 ± 0.40**
^{196}Au	i(m1+m2+g)	6.183D	355.7	87.0 ± 0.8	18.94 ± 0.67
			426.1	6.6 ± 0.8	17.83 ± 2.40
			333.0	22.9 ± 0.6	20.02 ± 0.92
				RR_{mean} =	**19.10 ± 0.66**
^{195}Au	c	186.098D	98.9	10.9 ± 0.9	**263.2 ± 26.6**
^{194}Au	i(m1+m2+g)	38.02H	328.5	61 ± 5	**33.91 ± 3.02**
^{192}Au$_i$	i(m+g)	4.94H	316.5	58 ± 7	**50.19 ± 7.68**
^{192}Au$_c$	c	4.94H	316.5	58 ± 7	**266.2 ± 33.5**
^{191}Au	c*	3.18H	674.2	6.8 ± 0.5	**266.4 ± 25.4**
^{190}Au$_c$	c	42.8M	597.7	9.4 ± 0.9	165.2 ± 22.2
			301.8	23.4 ± 1.5	211.7 ± 16.7
			295.8	71 ± 5	217.7 ± 17.8
				RR_{mean} =	**208.3 ± 13.2**
^{191}Pt	c	2.802D	538.9	13.7 ± 1.6	242.2 ± 29.6
			456.5	3.4 ± 0.4	182.0 ± 22.7
			409.4	8.0 ± 0.9	190.1 ± 22.4
				RR_{mean} =	**198.5 ± 17.3**
^{189}Pt	c	10.87H	544.9	5.8 ± 0.5	231.7 ± 23.6

Continuation of Table 94.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			721.4	9.3 ± 0.8	245.6 ± 23.1
			607.6	8.10 ± 0.16	231.8 ± 11.4
			568.8	7.1 ± 0.6	225.7 ± 22.1
			243.5	7.0 ± 1.2	248.5 ± 51.9
				RR_{mean} =	**232.9 ± 10.1**
^{188}Pt	c	10.2D	1209.8	*	217.6 ± 23.3
			478.0	*	228.2 ± 12.2
			423.3	4.4 ± 0.3	216.1 ± 16.7
			381.4	7.5 ± 0.5	204.1 ± 15.3
			195.1	18.6 ± 1.2	213.3 ± 16.0
			187.6	19.4 ± 1.2	212.6 ± 15.4
				RR_{mean} =	**219.5 ± 6.8**
^{186}Pt	c	2.08H	689.4	70 ± 15	**175.4 ± 38.1**
^{184}Pt	c	17.3M	548.3	23 ± 4	**142.5 ± 28.3**
^{192}Ir	i(m1+g)	73.827D	316.5	82.71 ± 0.21	**0.8643 ± 0.0873**
^{190}Ir	i(m1+g)	11.78D	605.1	39.9 ± 1.9	2.709 ± 0.283
			569.3	28.5 ± 1.3	2.123 ± 0.332
				RR_{mean} =	**2.477 ± 0.297**
^{189}Ir	c	13.2D	245.1	6.0 ± 0.6	**202.1 ± 21.8**
^{188}Ir$_i$	i	41.5H	478.0	14.7 ± 0.6	**16.72 ± 1.64**
^{188}Ir$_c$	c	41.5H	1209.8	6.9 ± 0.7	230.0 ± 24.7
			478.0	14.7 ± 0.6	244.9 ± 13.1
				RR_{mean} =	**244.5 ± 8.4**
^{187}Ir	c*	10.5H	977.5	3.14 ± 0.11	**226.5 ± 18.0**
^{186}Ir	c	16.64H	434.8	33.9 ± 1.1	103.0 ± 5.4
			137.2	41.4 ± 0.7	106.1 ± 6.5
				RR_{mean} =	**104.2 ± 4.7**
^{185}Ir	c	14.4H	1829.0	10.1 ± 1.5	159.0 ± 24.6
			254.2	13.3 ± 2.4	156.3 ± 29.1
				RR_{mean} =	**158.6 ± 8.9**
^{184}Ir	c*	3.09H	264.0	68 ± 4	204.8 ± 14.6
			390.4	25.9 ± 2.4	197.0 ± 19.7
			119.8	31 ± 3	221.0 ± 24.1
				RR_{mean} =	**205.1 ± 8.3**
^{185}Os	c	93.6D	646.1	78 ± 3	217.9 ± 11.1
			874.8	6.29 ± 0.25	226.2 ± 12.4
			717.4	3.94 ± 0.16	215.8 ± 12.0
				RR_{mean} =	**219.1 ± 7.2**
^{183m}Os	c*	9.9H	1101.9	49.0 ± 1.3	126.2 ± 5.5
			1107.9	22.4 ± 0.6	136.5 ± 6.6
				RR_{mean} =	**128.9 ± 6.0**
^{182}Os	c	22.10H	263.3	6.71 ± 0.25	205.8 ± 13.1
			180.2	33.5 ± 1.7	217.3 ± 14.3
				RR_{mean} =	**211.0 ± 10.3**
^{180}Os	c	21.5M	902.8(D)	101.5 ± 3.4	**185.2 ± 11.0**
^{183}Re	c	70.0D	162.3	23.3 ± 0.7	229.4 ± 11.0
			291.7	3.05 ± 0.18	220.0 ± 16.9
				RR_{mean} =	**227.7 ± 9.4**
^{182m}Re$_c$	c	12.7H	1221.5	24.8 ± 1.6	232.6 ± 17.3
			1189.2	15 ± 1	225.9 ± 19.4

Continuation of Table 94.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
				RR_{mean} =	**229.9 ± 12.1**
^{181}Re	c*	19.9H	365.5	56 ± 8	191.3 ± 28.6
			639.0	6.4 ± 1.4	218.4 ± 48.8
				RR_{mean} =	**197.1 ± 21.6**
^{179}Re	c*	19.5M	430.2	28.0 ± 1.8	288.8 ± 25.0
			290.0	26.9 ± 2.3	264.5 ± 25.5
				RR_{mean} =	**279.0 ± 14.7**
^{178}Re	c*	13.2M	237.3	45 ± 5	**280.3 ± 33.7**
^{178} W	c	21.6D	1350.6(D)	1.18 ± 0.11	177.9 ± 19.9
			1340.8(D)	1.03 ± 0.09	170.9 ± 22.6
				RR_{mean} =	**175.5 ± 11.2**
^{177} W	c	135M	115.7	51 ± 5	**195.2 ± 21.4**
^{176} W	c	2.5H	1159.3	*	189.3 ± 25.9
			1823.7	*	201.8 ± 51.7
			710.5	*	146.4 ± 43.6
				RR_{mean} =	**183.4 ± 18.4**
^{177}Ta	c*	56.56H	112.9	7.2 ± 1.6	**214.8 ± 48.9**
^{176}Ta$_c$	c	8.09H	1159.3	24.7 ± 1.9	201.0 ± 18.2
			1823.7	4.5 ± 0.4	185.9 ± 23.8
			710.5	5.4 ± 0.4	230.0 ± 23.7
				RR_{mean} =	**205.1 ± 11.7**
^{175}Ta	c	10.5H	1793.1	4.6 ± 0.7	163.4 ± 26.1
			348.5	12.0 ± 1.1	227.2 ± 22.4
			266.9	10.52 ± 0.16	198.5 ± 8.7
				RR_{mean} =	**198.8 ± 9.8**
^{174}Ta$_c$	c	1.14H	206.5	60 ± 5	**192.9 ± 17.7**
^{173}Ta	c	3.14H	172.2	17.5 ± 1.8	**210.1 ± 23.2**
^{172}Ta	c*	36.8M	214.1	55 ± 5	**102.6 ± 10.5**
^{175}Hf	c	70D	343.4	84 ± 3	**196.1 ± 9.7**
^{173}Hf	c*	23.6H	123.7	83 ± 5	237.8 ± 17.9
			311.2	10.7 ± 0.5	230.0 ± 13.6
			139.6	12.7 ± 0.6	229.1 ± 15.3
				RR_{mean} =	**231.1 ± 9.2**
^{172}Hf	c	1.87Y	1093.6	*	170.8 ± 10.0
			1002.7(D)	5.55 ± 0.38	163.4 ± 16.2
			181.5	*	166.6 ± 10.4
			125.8	11.3 ± 0.9	163.5 ± 15.6
				RR_{mean} =	**167.6 ± 5.2**
^{171}Hf	c	12.1H	739.8	*	**167.2 ± 14.2**
^{170}Hf	c	16.01H	620.7	18 ± 5	221.7 ± 62.1
			164.7	26 ± 8	212.8 ± 65.9
			120.2	15 ± 5	211.5 ± 71.5
				RR_{mean} =	**219.0 ± 15.5**
^{173}Lu	c	1.37Y	272.1	21.2 ± 0.8	**184.5 ± 9.9**
^{172}Lu$_i$	i(m+g)	6.70D	1093.6	63 ± 3	0.8738 ± 0.1482
			181.5	20.6 ± 1.0	2.088 ± 0.515
				RR_{mean} =	**0.9624 ± 0.3172**
^{172}Lu$_c$	c	6.70D	1093.6	63 ± 3	171.7 ± 10.1
			181.5	20.6 ± 1.0	168.7 ± 10.6
				RR_{mean} =	**170.5 ± 6.6**

Continuation of Table 94.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
$^{171}Lu_c$	c	8.24D	739.8	47.8 ± 1.2	**183.7 ± 7.6**
^{171}Lu	c*	8.24D	853.0	2.55 ± 0.07	201.9 ± 9.7
			780.7	4.36 ± 0.11	215.6 ± 10.3
			667.4	11.0 ± 0.3	197.6 ± 8.6
				RR_{mean} =	**202.9 ± 8.1**
$^{170}Lu_c$	c	2.012D	1280.2	8.2 ± 0.4	165.3 ± 11.3
			2126.1	5.1 ± 0.3	153.1 ± 12.6
			1054.3	4.76 ± 0.24	150.7 ± 11.8
			985.1	5.5 ± 0.3	169.4 ± 21.2
				RR_{mean} =	**158.4 ± 7.0**
^{169}Lu	c	34.06H	960.6	23.4 ± 0.7	139.3 ± 6.5
			191.2	20.6 ± 0.6	144.3 ± 7.0
				RR_{mean} =	**141.5 ± 5.4**
^{167}Lu	c	51.5M	176.2	*	122.6 ± 9.0
			113.3	*	156.2 ± 11.8
				RR_{mean} =	**134.8 ± 16.7**
^{169}Yb	c*	32.026D	198.0	35.8 ± 0.7	160.1 ± 7.2
			177.2	22.2 ± 0.5	160.6 ± 7.0
			130.5	11.31 ± 0.21	161.1 ± 8.0
				RR_{mean} =	**160.5 ± 5.6**
^{166}Yb	c	56.7H	2079.5	*	138.2 ± 10.4
			2052.4	*	147.1 ± 10.2
			1867.9	*	131.8 ± 9.3
			1374.2	*	137.8 ± 11.2
			1176.7	*	134.5 ± 9.8
			785.9	*	134.8 ± 9.9
			705.3	*	130.5 ± 9.5
			691.2(D)	8.56 ± 0.58	118.5 ± 9.4
				RR_{mean} =	**133.7 ± 4.1**
^{167}Tm	c	9.25D	207.8	42 ± 8	**155.3 ± 30.2**
^{165}Tm	c	30.06H	806.4	9.5 ± 0.6	132.4 ± 9.6
			242.9	35.5 ± 1.7	131.5 ± 8.2
				RR_{mean} =	**131.8 ± 5.5**
^{161}Er	c*	3.21H	826.6	64 ± 4	**141.5 ± 10.4**
^{160}Er	c	28.58H	966.2	*	99.53 ± 13.51
			962.4	*	95.86 ± 12.60
			872.0(D)	6.8 ± 1.1	95.69 ± 16.91
			728.2(D)	34 ± 5	103.4 ± 15.6
				RR_{mean} =	**98.52 ± 3.04**
^{159}Er	c*	36M	624.5	33 ± 4	111.3 ± 14.6
			132.0	*	112.9 ± 11.3
				RR_{mean} =	**112.3 ± 3.5**
$^{160m}Ho_c$	c	5.02H	966.2	15.4 ± 2.0	101.1 ± 14.7
			962.4	16.6 ± 2.1	113.2 ± 16.3
				RR_{mean} =	**106.6 ± 10.6**
^{156}Ho	c*	56M	266.5	54.7 ± 1.1	**77.70 ± 4.23**
^{157}Dy	c	8.14H	326.2	92 ± 4	**74.56 ± 4.21**
^{155}Dy	c*	9.9H	226.9	68.4 ± 1.6	**57.13 ± 2.71**
^{152}Dy	c	2.38H	256.9	97.50 ± 0.07	**27.95 ± 1.36**
^{155}Tb	c*	5.32D	180.1	7.5 ± 0.5	50.01 ± 4.19

Continuation of Table 94.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			105.3	25.1 ± 1.3	61.29 ± 4.50
				RR_{mean} =	**56.31 ± 5.87**
^{153}Tb	c*	2.34D	212.0	31.0 ± 1.9	**44.36 ± 3.23**
^{152}Tb	c*	17.5H	344.3	65 ± 4	**37.81 ± 2.95**
^{151}Tb	c	17.609H	479.4	15.4 ± 0.7	**24.17 ± 2.87**
^{153}Gd	c	240.4D	103.2	21.1 ± 0.7	43.28 ± 3.34
			97.4	29.0 ± 0.8	38.40 ± 2.46
				RR_{mean} =	**39.96 ± 2.59**
^{151}Gd	c	124D	243.3	5.6 ± 0.4	**30.01 ± 3.13**
^{149}Gd	c	9.28D	149.7	48 ± 3	36.41 ± 2.70
			788.9	7.3 ± 0.4	42.24 ± 3.09
			346.6	23.9 ± 1.3	33.10 ± 2.14
			298.6	28.6 ± 1.7	34.05 ± 2.38
				RR_{mean} =	**34.68 ± 1.93**
^{147}Gd	c	38.06H	929.0	20.2 ± 1.2	27.24 ± 2.65
			396.0	34.3 ± 2.1	25.94 ± 1.87
				RR_{mean} =	**26.29 ± 1.42**
^{146}Gd	c	48.27D	747.2	*	**24.29 ± 1.10**
^{149}Eu	c*	93.1D	327.5	4.03 ± 0.12	**42.87 ± 4.53**
^{147}Eu	c*	24.1D	677.5	9.8 ± 0.5	32.01 ± 2.28
			955.8	3.84 ± 0.20	31.29 ± 2.99
			798.7	4.8 ± 0.3	39.08 ± 3.48
			601.5	5.9 ± 0.3	27.73 ± 3.52
			121.2	22.9 ± 1.3	28.42 ± 2.20
				RR_{mean} =	**31.16 ± 1.88**
^{146}Eu$_i$	i	4.61D	747.2	99 ± 3	**3.988 ± 0.229**
^{146}Eu$_c$	c	4.61D	747.2	99 ± 3	**28.27 ± 1.28**
^{145}Eu	c	5.93D	1658.5	14.9 ± 1.0	17.66 ± 1.51
			653.5	15 ± 1	17.47 ± 1.44
				RR_{mean} =	**17.56 ± 1.00**
^{143}Pm	c	265D	742.0	38.5 ± 2.4	**14.77 ± 1.16**
^{139}Ce	c	137.640D	165.9	79.89 ± 0.02	**11.89 ± 0.49**
^{131}Ba	c	11.50D	123.8	29.0 ± 0.3	**6.769 ± 0.441**
^{128}Ba	c	2.43D	442.9	26.8 ± 1.4	**4.767 ± 0.482**
^{127}Xe	c	36.4D	375.0	17.2 ± 0.6	7.880 ± 0.538
			202.9	68.3 ± 0.5	6.539 ± 0.300
				RR_{mean} =	**6.770 ± 0.547**
^{123m}Te	i(m)	119.7D	159.0	84.0 ± 0.4	**1.901 ± 0.258**
^{121m}Te	i(m)	154D	212.2	81.4 ± 1.1	2.746 ± 0.174
			573.1	88.6 ± 0.1	2.377 ± 0.311
				RR_{mean} =	**2.671 ± 0.082**
^{121}Te$_c$	c	19.16D	573.1	80.3 ± 2.5	**8.420 ± 0.447**
^{119m}Te	i(m)	4.70D	1212.7	66.2 ± 0.3	**3.815 ± 0.236**
^{120m}Sb	i(m)	5.76D	1171.7	100 ± 0	2.589 ± 0.152
			1023.3	99.4 ± 0.3	2.176 ± 0.117
				RR_{mean} =	**2.323 ± 0.210**
^{113}Sn	c	115.09D	391.7	64.97 ± 0.17	**5.233 ± 0.402**
^{114m}In	i(m)	49.51D	190.3	15.56 ± 0.16	**8.631 ± 0.836**
^{111}In	c	2.8047D	171.3	90.2 ± 1.0	7.079 ± 0.410
			245.4	94 ± 1	7.156 ± 0.344

Continuation of Table 94.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			171.3	90.2 ± 1.0	7.571 ± 0.367
				RR_{mean} =	**7.287 ± 0.277**
^{110m}Ag	i(m)	249.76D	884.7	72.7 ± 0.4	6.659 ± 0.331
			657.8	94.3 ± 0.3	5.928 ± 0.345
				RR_{mean} =	**6.337 ± 0.412**
^{106m}Ag	i(m)	8.28D	451.0	28.2 ± 0.8	5.699 ± 0.370
			1045.8	29.6 ± 1.0	6.655 ± 0.387
			717.3	28.9 ± 0.8	5.915 ± 0.382
				RR_{mean} =	**6.091 ± 0.347**
^{105}Ag	c	41.29D	443.4	10.5 ± 0.6	7.160 ± 0.858
			280.4	30.2 ± 1.8	6.444 ± 0.598
				RR_{mean} =	**6.668 ± 0.504**
^{100}Pd	c	3.63D	2376.0	*	**0.6339 ± 0.2199**
^{105}Rh	c	35.36H	318.9	19.1 ± 0.6	**23.70 ± 1.47**
^{102}Rh	i	207D	475.1	46 ± 5	**5.310 ± 0.736**
^{101m}Rh	c	4.34D	306.9	81 ± 5	**9.368 ± 0.688**
^{100}Rh$_i$	i(m+g)	20.8H	2376.0	32.6 ± 0.4	**4.902 ± 0.492**
^{100}Rh$_c$	c	20.8H	2376.0	32.6 ± 0.4	**5.536 ± 0.430**
^{103}Ru	c	39.26D	497.1	91.0 ± 1.3	**20.03 ± 0.77**
^{96}Tc	i(m+g)	4.28D	849.9	98 ± 4	8.405 ± 0.473
			812.5	82 ± 4	8.623 ± 0.518
				RR_{mean} =	**8.501 ± 0.395**
^{99}Mo	c	65.94H	140.5	90.27 ± 0.33	**17.10 ± 0.77**
^{96}Nb	i	23.35H	1091.3	48.5 ± 1.6	12.89 ± 0.74
			568.9	58.0 ± 0.3	12.87 ± 0.74
				RR_{mean} =	**12.88 ± 0.59**
^{95}Nb$_i$	i(m+g)	34.975D	765.8	99.81 ± 0.03	**18.81 ± 0.76**
^{95}Nb$_c$	c	34.975D	765.8	99.81 ± 0.03	**29.66 ± 1.06**
^{90}Nb	c*	14.60H	2319.0	82.0 ± 0.3	4.805 ± 0.597
			1129.2	92.7 ± 0.5	6.189 ± 0.395
				RR_{mean} =	**5.825 ± 0.635**
^{95}Zr	c	64.02D	765.8	*	10.95 ± 0.70
			756.7	54.46 ± 0.10	11.05 ± 0.51
				RR_{mean} =	**11.02 ± 0.34**
^{89}Zr	c	78.41H	909.2	99.04 ± 0.03	**15.63 ± 0.53**
^{88}Zr	c	83.4D	1836.1	*	5.817 ± 0.814
			898.0	*	6.373 ± 0.481
			392.9	97.24 ± 0.00	7.562 ± 0.350
				RR_{mean} =	**7.146 ± 0.220**
^{88}Y$_i$	i	106.65D	1836.1	99.2 ± 0.3	23.17 ± 1.05
			898.0	93.7 ± 0.3	22.07 ± 0.79
				RR_{mean} =	**22.30 ± 0.82**
^{88}Y$_c$	c	106.65D	1836.1	99.2 ± 0.3	28.98 ± 1.09
			898.0	93.7 ± 0.3	28.44 ± 0.96
				RR_{mean} =	**28.60 ± 0.94**
^{87}Y	c*	79.8H	484.8	89.7 ± 0.7	**21.28 ± 0.76**
^{86}Y$_c$	c	14.74H	1076.6	82.5 ± 0.4	**8.320 ± 0.701**
^{85}Sr	c	64.84D	514.0	96 ± 4	**21.39 ± 1.17**
^{83}Rb	c	86.2D	552.6	16.0 ± 1.1	25.95 ± 2.17
			529.6	29.3 ± 2.1	24.02 ± 1.98

Continuation of Table 94.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			520.4	45 ± 4	24.20 ± 2.33
				RR_{mean} =	**24.72 ± 1.15**
^{82m}Rb	i(m)	6.472H	776.5	84.39 ± 0.21	9.686 ± 0.787
			554.3	62.4 ± 0.9	10.62 ± 1.30
				RR_{mean} =	**9.920 ± 0.700**
^{82}Br	i(m+g)	35.30H	554.3	70.8 ± 1.0	**11.08 ± 0.60**
^{75}Se	c	119.779D	264.7	58.9 ± 0.4	9.854 ± 0.446
			136.0	58.3 ± 0.8	10.84 ± 0.49
			121.1	17.2 ± 0.4	11.96 ± 1.61
				RR_{mean} =	**10.34 ± 0.50**
^{74}As	i	17.77D	595.8	59 ± 4	**12.98 ± 1.02**
^{71}As	c	65.28H	174.9	82.0 ± 2.1	**1.102 ± 0.215**
^{72}Ga$_i$	i	14.10H	2201.7	25.9 ± 0.5	**9.090 ± 0.786**
^{72}Ga$_c$	c	14.10H	2201.7	25.9 ± 0.5	**10.87 ± 0.75**
^{72}Zn	c	46.5H	2201.7	*	**1.776 ± 0.276**
^{59}Fe	c	44.472D	1291.6	43.2 ± 1.4	6.163 ± 0.448
			1099.2	56.5 ± 1.9	6.531 ± 0.390
				RR_{mean} =	**6.387 ± 0.312**
^{54}Mn	i	312.11D	834.8	99.98 ± 0.00	**3.819 ± 0.436**
^{48} V	c	15.9735D	1312.1	97.5 ± 0.9	0.4082 ± 0.0816
			983.5	100.0 ± 0.3	0.5207 ± 0.1267
				RR_{mean} =	**0.4410 ± 0.0692**
^{48}Sc	i	43.67H	1037.5	97.6 ± 0.7	**2.532 ± 0.228**
^{46}Sc	i(m+g)	83.79D	889.3	99.98 ± 0.00	3.220 ± 0.164
			1120.6	99.99 ± 0.00	2.286 ± 0.308
				RR_{mean} =	**3.072 ± 0.354**
^{7}Be	i	53.29D	477.6	10.52 ± 0.06	**11.60 ± 0.70**

12.9.3 Nuclide production rates for ^{208}Pb

Table 95: Detailed calculation of nuclide production rates for ^{208}Pb for E_p = 1.2 GeV, used to determine the cross sections for their production.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{206}Bi	i	6.243D	1718.7	31.8 ± 0.6	19.93 ± 0.86
			803.1	98.9 ± 1.4	18.71 ± 0.68
			537.5	30.5 ± 0.5	17.99 ± 0.82
				RR_{mean} =	**18.82 ± 0.73**
^{205}Bi	i	15.31D	1861.7	6.17 ± 0.10	23.90 ± 1.44
			1764.3	32.5 ± 0.7	25.18 ± 1.20
				RR_{mean} =	**24.72 ± 1.06**
^{204}Bi	i	11.22H	984.0	59 ± 4	24.49 ± 1.98
			899.2	98 ± 9	22.15 ± 1.00
			374.8	82 ± 5	21.88 ± 4.59
				RR_{mean} =	**22.46 ± 0.69**
^{203}Bi	i(m+g)	11.76H	820.2	29.6 ± 1.5	**19.69 ± 1.54**
^{202}Bi	i	1.72H	422.1	83.7 ± 2.5	**22.40 ± 3.16**
^{204m}Pb$_i$	i(m)	67.2M	899.2	99.17 ± 0.02	50.46 ± 3.30
			374.7	89 ± 15	65.41 ± 11.32

Continuation of Table 95.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, $10^{-17}\ s^{-1}$
				$RR_{mean} =$	**51.42 ± 3.98**
$^{204m}Pb_c$	c	67.2M	899.2	99.17 ± 0.02	53.78 ± 3.33
			374.7	89 ± 15	68.16 ± 11.79
				$RR_{mean} =$	**54.62 ± 3.76**
^{203}Pb	c*	51.873H	279.2	80.8 ± 0.2	**152.6 ± 5.6**
^{202m}Pb	i(m)	3.53H	422.1	86 ± 5	**48.46 ± 4.05**
^{201}Pb	c*	9.33H	331.2	79 ± 5	**120.4 ± 8.7**
^{200}Pb	c	21.5H	1205.7	*	86.26 ± 6.59
			367.9	*	83.80 ± 3.16
			257.2	4.46 ± 0.17	90.98 ± 7.35
			147.6	37.7 ± 1.4	89.25 ± 4.98
				$RR_{mean} =$	**85.00 ± 2.62**
^{199}Pb	c*	90M	366.9	44 ± 7	**168.6 ± 27.7**
^{198}Pb	c	2.4H	173.4	18 ± 3	**118.2 ± 20.6**
^{195m}Pb	i(m)	15.0M	383.6	107 ± 20	**34.48 ± 6.82**
^{197m}Pb	c*	43M	385.9	74 ± 15	**75.23 ± 15.52**
^{202}Tl	c	12.23D	439.6	91.4 ± 1.0	**87.65 ± 3.13**
^{201}Tl	c*	72.912H	167.4	10.00 ± 0.06	**222.6 ± 8.2**
$^{200}Tl_i$	i	26.1H	1205.7	29.9 ± 1.8	109.5 ± 9.5
			579.3	13.8 ± 0.7	128.5 ± 10.5
			367.9	87.2 ± 0.4	100.5 ± 5.0
				$RR_{mean} =$	**105.2 ± 7.3**
$^{200}Tl_c$	c	26.1H	1205.7	29.9 ± 1.8	195.8 ± 13.9
			579.3	13.8 ± 0.7	197.2 ± 12.8
			367.9	87.2 ± 0.4	184.3 ± 6.7
				$RR_{mean} =$	**186.1 ± 6.5**
$^{199}Tl_c$	c	7.42H	455.5	12.4 ± 1.4	**168.4 ± 20.9**
^{199}Tl	c*	7.42H	455.5	12.4 ± 1.4	**190.6 ± 23.0**
^{198m}Tl	i(m)	1.87H	282.8	28 ± 3	**95.21 ± 11.42**
^{196m}Tl	i(m)	1.41H	695.4	41 ± 7	**154.3 ± 27.0**
^{203}Hg	c	46.612D	279.2	81.46 ± 0.13	**21.25 ± 0.80**
^{197m}Hg	i(m)	23.8H	134.0	33.5 ± 0.4	**50.76 ± 2.40**
^{195m}Hg	i(m)	41.6H	261.8	31 ± 4	**63.53 ± 8.70**
^{193m}Hg	i(m)	11.8H	258.0	49 ± 7	92.88 ± 13.95
			407.6	32 ± 6	60.67 ± 11.60
				$RR_{mean} =$	**73.98 ± 16.02**
^{192}Hg	c	4.85H	316.5	*	177.1 ± 22.3
			274.8	50.2 ± 2.5	149.3 ± 9.4
				$RR_{mean} =$	**152.8 ± 4.7**
^{190}Hg	c*	20.0M	142.6	68 ± 10	**113.1 ± 17.4**
^{198m}Au	i(m)	2.27D	204.1	40.8 ± 2.4	3.781 ± 0.307
			411.8	*	3.301 ± 0.407
				$RR_{mean} =$	**3.617 ± 0.112**
$^{198}Au_i$	i	2.69517D	411.8	95.58 ± 0.12	**9.237 ± 0.744**
$^{198}Au_c$	i(m+g)	2.69517D	411.8	95.58 ± 0.12	**12.54 ± 0.53**
^{196}Au	i(m1+m2+g)	6.183D	355.7	87.0 ± 0.8	19.49 ± 0.69
			426.1	6.6 ± 0.8	17.63 ± 2.38
			333.0	22.9 ± 0.6	20.24 ± 0.90
				$RR_{mean} =$	**19.60 ± 0.66**
^{195}Au	c	186.098D	98.9	10.9 ± 0.9	**237.2 ± 23.3**

Continuation of Table 95.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{194}Au	i(m1+m2+g)	38.02H	328.5	61 ± 5	**33.08 ± 2.95**
^{192}Au$_i$	i(m+g)	4.94H	316.5	58 ± 7	**49.24 ± 6.55**
^{192}Au$_c$	c	4.94H	316.5	58 ± 7	**226.4 ± 28.4**
^{191}Au	c*	3.18H	674.2	6.8 ± 0.5	**227.3 ± 20.2**
^{190}Au$_c$	c	42.8M	301.8	23.4 ± 1.5	182.0 ± 14.2
			295.8	71 ± 5	184.3 ± 15.1
				RR_{mean} =	**183.0 ± 8.3**
^{191}Pt	c	2.802D	538.9	13.7 ± 1.6	198.2 ± 24.2
			456.5	3.4 ± 0.4	171.3 ± 21.4
			409.4	8.0 ± 0.9	163.0 ± 19.2
				RR_{mean} =	**173.9 ± 11.4**
^{189}Pt	c	10.87H	544.9	5.8 ± 0.5	189.4 ± 18.8
			721.4	9.3 ± 0.8	214.1 ± 20.8
			607.6	8.10 ± 0.16	198.6 ± 8.8
			568.8	7.1 ± 0.6	212.4 ± 21.0
			243.5	7.0 ± 1.2	243.7 ± 45.5
				RR_{mean} =	**200.6 ± 8.2**
^{188}Pt	c	10.2D	1209.8	*	183.5 ± 19.7
			478.0	*	191.9 ± 10.3
			423.3	4.4 ± 0.3	179.3 ± 13.7
			381.4	7.5 ± 0.5	172.1 ± 12.9
			195.1	18.6 ± 1.2	181.0 ± 13.6
			187.6	19.4 ± 1.2	181.3 ± 13.1
				RR_{mean} =	**184.9 ± 5.7**
^{186}Pt	c	2.08H	689.4	70 ± 15	**143.6 ± 31.2**
^{184}Pt	c	17.3M	548.3	23 ± 4	**127.3 ± 23.5**
^{192}Ir	i(m1+g)	73.827D	316.5	82.71 ± 0.21	**1.053 ± 0.080**
^{190}Ir	i(m1+g)	11.78D	605.1	39.9 ± 1.9	2.860 ± 0.215
			569.3	28.5 ± 1.3	2.833 ± 0.296
				RR_{mean} =	**2.852 ± 0.171**
^{189}Ir	c	13.2D	245.1	6.0 ± 0.6	**175.5 ± 19.2**
^{188}Ir$_i$	i	41.5H	478.0	14.7 ± 0.6	**22.42 ± 2.36**
^{188}Ir$_c$	c	41.5H	1209.8	6.9 ± 0.7	191.5 ± 20.6
			478.0	14.7 ± 0.6	214.3 ± 11.5
				RR_{mean} =	**213.5 ± 7.9**
^{187}Ir	c*	10.5H	977.5	3.14 ± 0.11	**181.5 ± 14.0**
^{186}Ir	c	16.64H	434.8	33.9 ± 1.1	89.65 ± 4.41
			137.2	41.4 ± 0.7	90.90 ± 5.67
				RR_{mean} =	**90.05 ± 3.94**
^{185}Ir	c	14.4H	1829.0	10.1 ± 1.5	143.9 ± 22.1
			254.2	13.3 ± 2.4	131.6 ± 24.5
				RR_{mean} =	**141.8 ± 7.6**
^{184}Ir	c*	3.09H	264.0	68 ± 4	181.9 ± 12.9
			390.4	25.9 ± 2.4	177.9 ± 17.8
			119.8	31 ± 3	181.8 ± 19.9
				RR_{mean} =	**181.4 ± 7.3**
^{185}Os	c	93.6D	646.1	78 ± 3	188.1 ± 9.6
			874.8	6.29 ± 0.25	193.3 ± 10.2
			717.4	3.94 ± 0.16	190.1 ± 10.5
				RR_{mean} =	**189.7 ± 6.1**

Continuation of Table 95.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{183m}Os	c*	9.9H	1101.9	49.0 ± 1.3	103.4 ± 4.5
			1107.9	22.4 ± 0.6	109.3 ± 5.0
				RR_{mean} =	**105.5 ± 4.3**
^{182}Os	c	22.10H	263.3	6.71 ± 0.25	171.7 ± 10.9
			180.2	33.5 ± 1.7	174.7 ± 12.0
				RR_{mean} =	**173.0 ± 8.6**
^{180}Os	c	21.5M	902.8(D)	101.5 ± 3.4	**161.2 ± 9.5**
^{183}Re	c	70.0D	162.3	23.3 ± 0.7	201.4 ± 9.5
			291.7	3.05 ± 0.18	189.2 ± 13.5
				RR_{mean} =	**199.0 ± 8.0**
^{182m}Re$_c$	c	12.7H	1221.5	24.8 ± 1.6	201.0 ± 15.3
			1189.2	15 ± 1	189.2 ± 19.1
				RR_{mean} =	**197.2 ± 11.1**
^{181}Re	c*	19.9H	365.5	56 ± 8	165.0 ± 24.3
			639.0	6.4 ± 1.4	189.1 ± 42.1
				RR_{mean} =	**169.9 ± 18.3**
^{179}Re	c*	19.5M	430.2	28.0 ± 1.8	229.9 ± 19.2
			290.0	26.9 ± 2.3	215.9 ± 21.0
				RR_{mean} =	**225.3 ± 10.7**
^{178}Re	c*	13.2M	237.3	45 ± 5	**236.8 ± 30.5**
^{178} W	c	21.6D	1350.6(D)	1.18 ± 0.11	170.5 ± 21.1
			1340.8(D)	1.03 ± 0.09	107.4 ± 12.2
				RR_{mean} =	**120.8 ± 26.1**
^{177} W	c	135M	115.7	51 ± 5	**168.9 ± 18.5**
^{176} W	c	2.5H	1159.3	*	151.9 ± 32.9
			1823.7	*	192.1 ± 57.8
			710.5	*	67.88 ± 82.94
				RR_{mean} =	**152.3 ± 25.9**
^{177}Ta	c*	56.56H	112.9	7.2 ± 1.6	**175.6 ± 39.9**
^{176}Ta$_c$	c	8.09H	1159.3	24.7 ± 1.9	169.8 ± 17.9
			1823.7	4.5 ± 0.4	158.4 ± 24.8
			710.5	5.4 ± 0.4	197.0 ± 35.0
				RR_{mean} =	**170.0 ± 11.0**
^{175}Ta	c	10.5H	1793.1	4.6 ± 0.7	148.5 ± 24.9
			348.5	12.0 ± 1.1	209.9 ± 21.0
			266.9	10.52 ± 0.16	164.5 ± 7.4
				RR_{mean} =	**166.7 ± 9.7**
^{174}Ta$_c$	c	1.14H	206.5	60 ± 5	**163.7 ± 15.2**
^{173}Ta	c	3.14H	172.2	17.5 ± 1.8	**172.8 ± 19.2**
^{172}Ta	c*	36.8M	214.1	55 ± 5	**85.51 ± 9.25**
^{175}Hf	c	70D	343.4	84 ± 3	**168.5 ± 8.3**
^{173}Hf	c*	23.6H	123.7	83 ± 5	201.0 ± 15.1
			311.2	10.7 ± 0.5	188.1 ± 11.2
			139.6	12.7 ± 0.6	200.3 ± 13.2
				RR_{mean} =	**194.0 ± 7.8**
^{172}Hf	c	1.87Y	1093.6	*	139.7 ± 8.2
			1002.7(D)	5.55 ± 0.38	120.4 ± 12.0
			181.5	*	139.3 ± 9.5
			125.8	11.3 ± 0.9	144.5 ± 13.4
				RR_{mean} =	**138.3 ± 4.3**

Continuation of Table 95.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{171}Hf	c	12.1H	739.8	*	**139.6 ± 15.0**
^{170}Hf	c	16.01H	620.7	18 ± 5	175.8 ± 49.2
			164.7	26 ± 8	175.8 ± 54.5
			120.2	15 ± 5	181.4 ± 61.1
				RR_{mean} =	**176.3 ± 12.5**
^{173}Lu	c	1.37Y	272.1	21.2 ± 0.8	**159.7 ± 8.5**
^{172}Lu$_i$	i(m+g)	6.70D	1093.6	63 ± 3	1.049 ± 0.122
			181.5	20.6 ± 1.0	2.158 ± 0.934
				RR_{mean} =	**1.064 ± 0.134**
^{172}Lu$_c$	c	6.70D	1093.6	63 ± 3	140.7 ± 8.2
			181.5	20.6 ± 1.0	141.5 ± 9.5
				RR_{mean} =	**140.9 ± 5.6**
^{171}Lu$_c$	c	8.24D	739.8	47.8 ± 1.2	**154.1 ± 6.4**
^{171}Lu	c*	8.24D	853.0	2.55 ± 0.07	155.1 ± 7.7
			780.7	4.36 ± 0.11	181.2 ± 7.8
			667.4	11.0 ± 0.3	161.0 ± 7.0
				RR_{mean} =	**167.1 ± 9.3**
^{170}Lu$_c$	c	2.012D	1280.2	8.2 ± 0.4	128.4 ± 8.5
			2126.1	5.1 ± 0.3	121.2 ± 10.0
			1054.3	4.76 ± 0.24	127.2 ± 13.9
			985.1	5.5 ± 0.3	159.3 ± 19.8
				RR_{mean} =	**127.9 ± 6.1**
^{169}Lu	c	34.06H	960.6	23.4 ± 0.7	112.6 ± 5.2
			191.2	20.6 ± 0.6	114.9 ± 5.6
				RR_{mean} =	**113.6 ± 4.3**
^{167}Lu	c	51.5M	176.2	*	94.75 ± 6.07
			113.3	*	125.2 ± 9.5
				RR_{mean} =	**103.1 ± 14.0**
^{169}Yb	c*	32.026D	198.0	35.8 ± 0.7	137.8 ± 5.9
			177.2	22.2 ± 0.5	135.0 ± 5.9
			130.5	11.31 ± 0.21	138.2 ± 6.5
				RR_{mean} =	**136.8 ± 4.7**
^{166}Yb	c	56.7H	2079.5	*	112.0 ± 8.6
			2052.4	*	117.7 ± 8.2
			1867.9	*	107.8 ± 7.8
			1374.2	*	112.1 ± 8.9
			1176.7	*	107.3 ± 7.8
			785.9	*	115.7 ± 8.1
			705.3	*	102.9 ± 7.4
			691.2(D)	8.56 ± 0.58	99.13 ± 7.59
				RR_{mean} =	**108.9 ± 3.4**
^{167}Tm	c	9.25D	207.8	42 ± 8	**128.7 ± 25.0**
^{165}Tm	c	30.06H	806.4	9.5 ± 0.6	107.0 ± 8.0
			242.9	35.5 ± 1.7	106.6 ± 6.6
				RR_{mean} =	**106.7 ± 4.4**
^{161}Er	c*	3.21H	826.6	64 ± 4	**113.9 ± 8.5**
^{160}Er	c	28.58H	966.2	*	77.56 ± 10.44
			962.4	*	77.61 ± 10.27
			872.0(D)	6.8 ± 1.1	68.51 ± 11.53
			728.2(D)	34 ± 5	80.68 ± 12.20

Continuation of Table 95.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
				RR_{mean} =	**76.07 ± 2.35**
^{159}Er	c*	36M	624.5	33 ± 4	69.98 ± 9.67
			132.0	*	97.99 ± 8.90
				RR_{mean} =	**85.63 ± 2.64**
^{160m}Ho$_c$	c	5.02H	966.2	15.4 ± 2.0	86.95 ± 14.93
			962.4	16.6 ± 2.1	87.60 ± 47.12
				RR_{mean} =	**87.01 ± 13.79**
^{156}Ho	c*	56M	266.5	54.7 ± 1.1	**57.86 ± 3.43**
^{157}Dy	c	8.14H	326.2	92 ± 4	**56.08 ± 3.24**
^{155}Dy	c*	9.9H	226.9	68.4 ± 1.6	**44.79 ± 2.15**
^{152}Dy	c	2.38H	256.9	97.50 ± 0.07	**20.98 ± 1.15**
^{155}Tb	c*	5.32D	180.1	7.5 ± 0.5	42.35 ± 3.92
			105.3	25.1 ± 1.3	47.85 ± 3.47
				RR_{mean} =	**46.21 ± 2.90**
^{153}Tb	c*	2.34D	212.0	31.0 ± 1.9	**34.53 ± 2.53**
^{152}Tb	c*	17.5H	344.3	65 ± 4	**31.29 ± 2.60**
^{151}Tb	c	17.609H	479.4	15.4 ± 0.7	**21.34 ± 1.83**
^{153}Gd	c	240.4D	103.2	21.1 ± 0.7	32.47 ± 2.23
			97.4	29.0 ± 0.8	31.43 ± 1.88
				RR_{mean} =	**31.83 ± 1.52**
^{151}Gd	c	124D	243.3	5.6 ± 0.4	**27.44 ± 2.72**
^{149}Gd	c	9.28D	149.7	48 ± 3	27.91 ± 2.06
			788.9	7.3 ± 0.4	31.52 ± 2.21
			346.6	23.9 ± 1.3	24.14 ± 1.56
			298.6	28.6 ± 1.7	25.71 ± 1.83
				RR_{mean} =	**25.94 ± 1.69**
^{147}Gd	c	38.06H	929.0	20.2 ± 1.2	18.44 ± 1.59
			396.0	34.3 ± 2.1	18.15 ± 1.33
				RR_{mean} =	**18.26 ± 0.97**
^{146}Gd	c	48.27D	747.2	*	**17.75 ± 0.80**
^{149}Eu	c*	93.1D	327.5	4.03 ± 0.12	**39.27 ± 4.99**
^{147}Eu	c*	24.1D	677.5	9.8 ± 0.5	21.29 ± 1.46
			955.8	3.84 ± 0.20	24.94 ± 2.14
			798.7	4.8 ± 0.3	28.59 ± 3.59
			601.5	5.9 ± 0.3	22.17 ± 1.99
			121.2	22.9 ± 1.3	22.06 ± 1.68
				RR_{mean} =	**22.38 ± 1.09**
^{146}Eu$_i$	i	4.61D	747.2	99 ± 3	**3.402 ± 0.168**
^{146}Eu$_c$	c	4.61D	747.2	99 ± 3	**21.15 ± 0.95**
^{145}Eu	c	5.93D	1658.5	14.9 ± 1.0	11.74 ± 0.98
			653.5	15 ± 1	12.49 ± 1.08
				RR_{mean} =	**12.07 ± 0.70**
^{143}Pm	c	265D	742.0	38.5 ± 2.4	**11.05 ± 0.95**
^{139}Ce	c	137.640D	165.9	79.89 ± 0.02	**9.311 ± 0.355**
^{131}Ba	c	11.50D	123.8	29.0 ± 0.3	**5.770 ± 0.535**
^{128}Ba	c	2.43D	442.9	26.8 ± 1.4	**3.382 ± 0.500**
^{127}Xe	c	36.4D	375.0	17.2 ± 0.6	5.902 ± 0.511
			202.9	68.3 ± 0.5	5.523 ± 0.235
				RR_{mean} =	**5.560 ± 0.227**
^{123m}Te	i(m)	119.7D	159.0	84.0 ± 0.4	**1.785 ± 0.177**

Continuation of Table 95.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{121m}Te	i(m)	154D	212.2	81.4 ± 1.1	1.988 ± 0.165
			573.1	88.6 ± 0.1	1.851 ± 0.334
				RR_{mean} =	**1.964 ± 0.061**
^{121}Te$_c$	c	19.16D	573.1	80.3 ± 2.5	**6.230 ± 0.363**
^{119m}Te	i(m)	4.70D	1212.7	66.2 ± 0.3	**2.510 ± 0.196**
^{120m}Sb	i(m)	5.76D	1171.7	100 ± 0	2.097 ± 0.116
			1023.3	99.4 ± 0.3	1.852 ± 0.114
				RR_{mean} =	**1.977 ± 0.137**
^{113}Sn	c	115.09D	391.7	64.97 ± 0.17	**4.094 ± 0.246**
^{114m}In	i(m)	49.51D	190.3	15.56 ± 0.16	**6.711 ± 0.335**
^{111}In	c	2.8047D	171.3	90.2 ± 1.0	5.379 ± 0.251
			245.4	94 ± 1	5.479 ± 0.320
			171.3	90.2 ± 1.0	5.379 ± 0.251
				RR_{mean} =	**5.398 ± 0.202**
^{110m}Ag	i(m)	249.76D	884.7	72.7 ± 0.4	5.370 ± 0.303
			657.8	94.3 ± 0.3	4.977 ± 0.254
				RR_{mean} =	**5.129 ± 0.248**
^{106m}Ag	i(m)	8.28D	451.0	28.2 ± 0.8	4.755 ± 0.393
			1045.8	29.6 ± 1.0	5.082 ± 0.338
			717.3	28.9 ± 0.8	4.735 ± 0.334
				RR_{mean} =	**4.870 ± 0.237**
^{105}Ag	c	41.29D	443.4	10.5 ± 0.6	6.076 ± 0.901
			280.4	30.2 ± 1.8	4.210 ± 0.458
				RR_{mean} =	**4.579 ± 0.756**
^{100}Pd	c	3.63D	2376.0	*	**0.6796 ± 0.1174**
^{105}Rh	c	35.36H	318.9	19.1 ± 0.6	**21.83 ± 1.31**
^{102}Rh	i	207D	475.1	46 ± 5	**4.347 ± 0.670**
^{101m}Rh	c	4.34D	306.9	81 ± 5	**6.930 ± 0.536**
^{100}Rh$_i$	i(m+g)	20.8H	2376.0	32.6 ± 0.4	**3.993 ± 0.274**
^{100}Rh$_c$	c	20.8H	2376.0	32.6 ± 0.4	**4.672 ± 0.261**
^{103}Ru	c	39.26D	497.1	91.0 ± 1.3	**17.32 ± 0.67**
^{96}Tc	i(m+g)	4.28D	849.9	98 ± 4	6.432 ± 0.381
			812.5	82 ± 4	6.636 ± 0.402
				RR_{mean} =	**6.527 ± 0.311**
^{99}Mo	c	65.94H	140.5	90.27 ± 0.33	**15.65 ± 0.66**
^{96}Nb	i	23.35H	1091.3	48.5 ± 1.6	9.521 ± 0.540
			568.9	58.0 ± 0.3	9.875 ± 0.588
				RR_{mean} =	**9.679 ± 0.450**
^{95}Nb$_i$	i(m+g)	34.975D	765.8	99.81 ± 0.03	**14.93 ± 0.54**
^{95}Nb$_c$	c	34.975D	765.8	99.81 ± 0.03	**25.00 ± 0.85**
^{90}Nb	c*	14.60H	2319.0	82.0 ± 0.3	3.582 ± 0.403
			1129.2	92.7 ± 0.5	4.497 ± 0.277
				RR_{mean} =	**4.243 ± 0.430**
^{95}Zr	c	64.02D	765.8	*	10.16 ± 0.47
			756.7	54.46 ± 0.10	9.616 ± 0.394
				RR_{mean} =	**9.814 ± 0.303**
^{89}Zr	c	78.41H	909.2	99.04 ± 0.03	**11.86 ± 0.42**
^{88}Zr	c	83.4D	1836.1	*	6.305 ± 0.441
			898.0	*	5.423 ± 0.238
			392.9	97.24 ± 0.00	5.576 ± 0.218

Continuation of Table 95.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
				RR_{mean} =	**5.573 ± 0.172**
^{88} Y_i	i	106.65D	1836.1	99.2 ± 0.3	16.82 ± 0.63
			898.0	93.7 ± 0.3	16.76 ± 0.56
				RR_{mean} =	**16.78 ± 0.55**
^{88} Y_c	c	106.65D	1836.1	99.2 ± 0.3	23.12 ± 0.84
			898.0	93.7 ± 0.3	22.18 ± 0.73
				RR_{mean} =	**22.42 ± 0.80**
^{87} Y	c*	79.8H	484.8	89.7 ± 0.7	**15.93 ± 0.57**
^{86} Y_c	c	14.74H	1076.6	82.5 ± 0.4	**6.538 ± 0.951**
^{85}Sr	c	64.84D	514.0	96 ± 4	**16.14 ± 0.88**
^{83}Rb	c	86.2D	552.6	16.0 ± 1.1	20.90 ± 1.80
			529.6	29.3 ± 2.1	18.85 ± 1.63
			520.4	45 ± 4	18.47 ± 1.79
				RR_{mean} =	**19.42 ± 0.95**
^{82m}Rb	i(m)	6.472H	776.5	84.39 ± 0.21	7.842 ± 0.855
			554.3	62.4 ± 0.9	7.100 ± 1.731
				RR_{mean} =	**7.704 ± 0.777**
^{82}Br	i(m+g)	35.30H	554.3	70.8 ± 1.0	**9.499 ± 0.471**
^{75}Se	c	119.779D	264.7	58.9 ± 0.4	7.445 ± 0.349
			136.0	58.3 ± 0.8	8.549 ± 0.395
			121.1	17.2 ± 0.4	6.371 ± 1.272
				RR_{mean} =	**7.899 ± 0.484**
^{74}As	i	17.77D	595.8	59 ± 4	**10.47 ± 0.80**
^{71}As	c	65.28H	174.9	82.0 ± 2.1	**0.7159 ± 0.1128**
^{72}Ga_i	i	14.10H	2201.7	25.9 ± 0.5	**6.801 ± 0.654**
^{72}Ga_c	c	14.10H	2201.7	25.9 ± 0.5	**8.499 ± 0.617**
^{72}Zn	c	46.5H	2201.7	*	**1.698 ± 0.224**
^{59}Fe	c	44.472D	1291.6	43.2 ± 1.4	4.977 ± 0.290
			1099.2	56.5 ± 1.9	5.294 ± 0.372
				RR_{mean} =	**5.084 ± 0.243**
^{54}Mn	i	312.11D	834.8	99.98 ± 0.00	**2.912 ± 0.211**
^{48} V	c	15.9735D	1312.1	97.5 ± 0.9	0.3978 ± 0.0652
			983.5	100.0 ± 0.3	0.5224 ± 0.0567
				RR_{mean} =	**0.4701 ± 0.0632**
^{48}Sc	i	43.67H	1037.5	97.6 ± 0.7	**2.175 ± 0.126**
^{46}Sc	i(m+g)	83.79D	889.3	99.98 ± 0.00	2.140 ± 0.152
			1120.6	99.99 ± 0.00	2.712 ± 0.272
				RR_{mean} =	**2.264 ± 0.246**
^{7}Be	i	53.29D	477.6	10.52 ± 0.06	**14.45 ± 1.85**

12.9.4 Nuclide production rates for ^{nat}Pb

Table 96: Detailed calculation of nuclide production rates for ^{nat}Pb for $E_p = 1.2$ GeV, used to determine the cross sections for their production.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{207}Bi	i	31.55Y	569.7	97.74 ± 0.03	**26.86 ± 4.47**
^{206}Bi	i	6.243D	1718.7	31.8 ± 0.6	23.75 ± 1.07
			803.1	98.9 ± 1.4	22.81 ± 0.82

Continuation of Table 96.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			537.5	30.5 ± 0.5	21.89 ± 0.90
				RR_{mean} =	**22.70 ± 0.82**
^{205}Bi	i	15.31D	1861.7	6.17 ± 0.10	36.01 ± 1.82
			1764.3	32.5 ± 0.7	36.88 ± 1.53
				RR_{mean} =	**36.59 ± 1.40**
^{204}Bi	i	11.22H	984.0	59 ± 4	41.04 ± 3.44
			899.2	98 ± 9	34.12 ± 1.39
			374.8	82 ± 5	33.33 ± 7.00
				RR_{mean} =	**34.61 ± 1.07**
^{203}Bi	i(m+g)	11.76H	820.2	29.6 ± 1.5	**32.07 ± 2.17**
^{202}Bi	i	1.72H	422.1	83.7 ± 2.5	**30.01 ± 3.52**
^{204m}Pb$_i$	i(m)	67.2M	899.2	99.17 ± 0.02	89.79 ± 4.59
			374.7	89 ± 15	99.46 ± 17.38
				RR_{mean} =	**90.22 ± 4.53**
^{204m}Pb$_c$	c	67.2M	899.2	99.17 ± 0.02	94.91 ± 4.68
			374.7	89 ± 15	103.6 ± 18.1
				RR_{mean} =	**95.26 ± 4.63**
^{203}Pb	c*	51.873H	279.2	80.8 ± 0.2	**261.8 ± 9.6**
^{202m}Pb	i(m)	3.53H	422.1	86 ± 5	**73.73 ± 5.43**
^{201}Pb	c*	9.33H	331.2	79 ± 5	**201.7 ± 14.6**
^{200}Pb	c	21.5H	1205.7	*	144.7 ± 10.2
			367.9	*	127.7 ± 5.4
			257.2	4.46 ± 0.17	136.0 ± 13.2
			147.6	37.7 ± 1.4	145.3 ± 8.1
				RR_{mean} =	**136.4 ± 4.2**
^{199}Pb	c*	90M	366.9	44 ± 7	**251.3 ± 41.8**
^{198}Pb	c	2.4H	173.4	18 ± 3	**184.4 ± 31.8**
^{197m}Pb	c*	43M	385.9	74 ± 15	**120.7 ± 24.9**
^{195m}Pb	i(m)	15.0M	383.6	107 ± 20	**61.09 ± 12.11**
^{202}Tl	c	12.23D	439.6	91.4 ± 1.0	**135.4 ± 4.9**
^{201}Tl	c*	72.912H	167.4	10.00 ± 0.06	**357.2 ± 13.2**
^{200}Tl$_i$	i	26.1H	1205.7	29.9 ± 1.8	161.6 ± 12.1
			579.3	13.8 ± 0.7	181.6 ± 12.9
			367.9	87.2 ± 0.4	170.1 ± 10.4
				RR_{mean} =	**170.6 ± 7.9**
^{200}Tl$_c$	c	26.1H	1205.7	29.9 ± 1.8	306.3 ± 21.2
			579.3	13.8 ± 0.7	304.3 ± 19.0
			367.9	87.2 ± 0.4	297.8 ± 11.7
				RR_{mean} =	**299.6 ± 11.1**
^{199}Tl$_c$	c	7.42H	455.5	12.4 ± 1.4	**258.6 ± 32.7**
^{199}Tl	c*	7.42H	455.5	12.4 ± 1.4	**312.3 ± 37.7**
^{198m}Tl	i(m)	1.87H	282.8	28 ± 3	**151.2 ± 21.3**
^{196m}Tl	i(m)	1.41H	695.4	41 ± 7	**229.4 ± 40.1**
^{203}Hg	c	46.612D	279.2	81.46 ± 0.13	**25.10 ± 0.94**
^{197m}Hg	i(m)	23.8H	134.0	33.5 ± 0.4	**68.89 ± 3.35**
^{195m}Hg	i(m)	41.6H	261.8	31 ± 4	**99.03 ± 13.58**
^{193m}Hg	i(m)	11.8H	258.0	49 ± 7	123.8 ± 18.5
			407.6	32 ± 6	86.07 ± 16.43
				RR_{mean} =	**102.9 ± 19.0**
^{192}Hg	c	4.85H	316.5	*	273.0 ± 34.4

Continuation of Table 96.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			274.8	50.2 ± 2.5	226.4 ± 14.4
				RR_{mean} =	**232.2 ± 7.2**
^{190}Hg	c*	20.0M	142.6	68 ± 10	**168.9 ± 26.2**
^{198m}Au	i(m)	2.27D	204.1	40.8 ± 2.4	4.418 ± 0.360
			411.8	*	4.709 ± 0.447
				RR_{mean} =	**4.529 ± 0.140**
^{198}Au$_i$	i	2.69517D	411.8	95.58 ± 0.12	**9.860 ± 0.913**
^{198}Au$_c$	i(m+g)	2.69517D	411.8	95.58 ± 0.12	**14.57 ± 0.67**
^{196}Au	i(m1+m2+g)	6.183D	355.7	87.0 ± 0.8	25.28 ± 0.89
			426.1	6.6 ± 0.8	21.64 ± 2.85
			333.0	22.9 ± 0.6	25.96 ± 1.16
				RR_{mean} =	**25.34 ± 0.86**
^{195}Au	c	186.098D	98.9	10.9 ± 0.9	**325.3 ± 32.5**
^{194}Au	i(m1+m2+g)	38.02H	328.5	61 ± 5	**44.65 ± 3.97**
^{192}Au$_i$	i(m+g)	4.94H	316.5	58 ± 7	**67.62 ± 9.17**
^{192}Au$_c$	c	4.94H	316.5	58 ± 7	**340.6 ± 42.8**
^{191}Au	c*	3.18H	674.2	6.8 ± 0.5	**324.1 ± 28.4**
^{190}Au$_c$	c	42.8M	597.7	9.4 ± 0.9	172.5 ± 26.4
			301.8	23.4 ± 1.5	246.4 ± 21.4
			295.8	71 ± 5	266.9 ± 22.5
				RR_{mean} =	**243.6 ± 23.7**
^{191}Pt	c	2.802D	538.9	13.7 ± 1.6	292.4 ± 35.7
			456.5	3.4 ± 0.4	244.2 ± 30.1
			409.4	8.0 ± 0.9	234.8 ± 27.7
				RR_{mean} =	**250.6 ± 17.9**
^{189}Pt	c	10.87H	544.9	5.8 ± 0.5	298.4 ± 28.7
			721.4	9.3 ± 0.8	307.8 ± 28.9
			607.6	8.10 ± 0.16	291.1 ± 12.3
			568.8	7.1 ± 0.6	302.3 ± 31.3
			243.5	7.0 ± 1.2	372.5 ± 68.8
				RR_{mean} =	**294.4 ± 11.6**
^{188}Pt	c	10.2D	1209.8	*	277.3 ± 29.6
			478.0	*	285.8 ± 15.2
			423.3	4.4 ± 0.3	263.2 ± 20.1
			381.4	7.5 ± 0.5	253.9 ± 19.1
			195.1	18.6 ± 1.2	265.5 ± 19.9
			187.6	19.4 ± 1.2	264.6 ± 19.1
				RR_{mean} =	**273.3 ± 8.4**
^{186}Pt	c	2.08H	689.4	70 ± 15	**225.9 ± 49.1**
^{184}Pt	c	17.3M	548.3	23 ± 4	**233.6 ± 45.2**
^{192}Ir	i(m1+g)	73.827D	316.5	82.71 ± 0.21	**1.271 ± 0.073**
^{190}Ir	i(m1+g)	11.78D	605.1	39.9 ± 1.9	2.910 ± 0.272
			569.3	28.5 ± 1.3	3.120 ± 0.380
				RR_{mean} =	**2.976 ± 0.219**
^{189}Ir	c	13.2D	245.1	6.0 ± 0.6	**253.9 ± 27.7**
^{188}Ir$_i$	i	41.5H	478.0	14.7 ± 0.6	**29.27 ± 3.65**
^{188}Ir$_c$	c	41.5H	1209.8	6.9 ± 0.7	286.1 ± 30.6
			478.0	14.7 ± 0.6	315.1 ± 17.0
				RR_{mean} =	**314.0 ± 11.2**
^{187}Ir	c*	10.5H	977.5	3.14 ± 0.11	**274.2 ± 15.9**

Continuation of Table 96.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{186}Ir	c	16.64H	434.8	33.9 ± 1.1	136.6 ± 6.8
			137.2	41.4 ± 0.7	144.3 ± 6.9
				RR_{mean} =	**140.5 ± 5.8**
^{185}Ir	c	14.4H	1829.0	10.1 ± 1.5	203.5 ± 31.3
			254.2	13.3 ± 2.4	201.6 ± 37.3
				RR_{mean} =	**203.2 ± 10.9**
^{184}Ir	c*	3.09H	264.0	68 ± 4	270.7 ± 19.3
			390.4	25.9 ± 2.4	262.7 ± 26.2
			119.8	31 ± 3	278.2 ± 30.7
				RR_{mean} =	**270.3 ± 10.9**
^{185}Os	c	93.6D	646.1	78 ± 3	274.3 ± 14.0
			874.8	6.29 ± 0.25	281.7 ± 14.6
			717.4	3.94 ± 0.16	283.3 ± 15.6
				RR_{mean} =	**278.0 ± 9.0**
^{183m}Os	c*	9.9H	1101.9	49.0 ± 1.3	159.5 ± 7.1
			1107.9	22.4 ± 0.6	170.1 ± 8.0
				RR_{mean} =	**163.3 ± 7.1**
^{182}Os	c	22.10H	263.3	6.71 ± 0.25	261.5 ± 15.2
			180.2	33.5 ± 1.7	270.6 ± 17.5
				RR_{mean} =	**265.1 ± 12.3**
^{180}Os	c	21.5M	902.8(D)	101.5 ± 3.4	**218.1 ± 14.6**
^{183}Re	c	70.0D	162.3	23.3 ± 0.7	291.9 ± 13.8
			291.7	3.05 ± 0.18	266.7 ± 18.6
				RR_{mean} =	**286.3 ± 13.7**
^{182m}Re$_c$	c	12.7H	1221.5	24.8 ± 1.6	287.2 ± 21.2
			1189.2	15 ± 1	298.4 ± 23.3
				RR_{mean} =	**292.0 ± 14.7**
^{181}Re	c*	19.9H	365.5	56 ± 8	237.3 ± 35.4
			639.0	6.4 ± 1.4	267.6 ± 59.7
				RR_{mean} =	**243.9 ± 26.6**
^{179}Re	c*	19.5M	430.2	28.0 ± 1.8	362.0 ± 34.9
			290.0	26.9 ± 2.3	305.7 ± 30.7
				RR_{mean} =	**331.5 ± 29.9**
^{178}Re	c*	13.2M	237.3	45 ± 5	**380.5 ± 46.9**
^{178} W	c	21.6D	1350.6(D)	1.18 ± 0.11	224.0 ± 23.1
			1340.8(D)	1.03 ± 0.09	184.5 ± 18.4
				RR_{mean} =	**197.9 ± 19.6**
^{177} W	c	135M	115.7	51 ± 5	**257.1 ± 28.1**
^{176} W	c	2.5H	1159.3	*	178.6 ± 25.3
			1823.7	*	316.8 ± 93.2
			710.5	*	155.3 ± 100.4
				RR_{mean} =	**184.5 ± 22.3**
^{177}Ta	c*	56.56H	112.9	7.2 ± 1.6	**260.9 ± 59.4**
^{176}Ta$_c$	c	8.09H	1159.3	24.7 ± 1.9	270.8 ± 23.9
			1823.7	4.5 ± 0.4	230.8 ± 39.3
			710.5	5.4 ± 0.4	302.2 ± 46.2
				RR_{mean} =	**269.7 ± 12.4**
^{175}Ta	c	10.5H	1793.1	4.6 ± 0.7	196.8 ± 31.4
			348.5	12.0 ± 1.1	301.1 ± 29.6
			266.9	10.52 ± 0.16	255.0 ± 10.9

Continuation of Table 96.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
				RR_{mean} =	**254.8 ± 14.6**
$^{174}Ta_c$	c	1.14H	206.5	60 ± 5	**244.4 ± 22.6**
^{173}Ta	c	3.14H	172.2	17.5 ± 1.8	**264.9 ± 29.4**
^{172}Ta	c*	36.8M	214.1	55 ± 5	**139.1 ± 15.2**
^{175}Hf	c	70D	343.4	84 ± 3	**247.7 ± 12.2**
^{173}Hf	c*	23.6H	123.7	83 ± 5	299.5 ± 22.6
			311.2	10.7 ± 0.5	285.9 ± 17.0
			139.6	12.7 ± 0.6	290.1 ± 19.1
				RR_{mean} =	**289.6 ± 11.6**
^{172}Hf	c	1.87Y	1093.6	*	211.8 ± 12.3
			1002.7(D)	5.55 ± 0.38	224.2 ± 20.3
			181.5	*	205.3 ± 12.9
			125.8	11.3 ± 0.9	217.6 ± 20.8
				RR_{mean} =	**212.2 ± 6.5**
^{171}Hf	c	12.1H	739.8	*	**216.1 ± 22.5**
^{170}Hf	c	16.01H	620.7	18 ± 5	275.4 ± 77.1
			164.7	26 ± 8	260.8 ± 80.8
			120.2	15 ± 5	263.1 ± 88.7
				RR_{mean} =	**271.4 ± 19.1**
^{173}Lu	c	1.37Y	272.1	21.2 ± 0.8	**235.2 ± 12.5**
$^{172}Lu_i$	i(m+g)	6.70D	1093.6	63 ± 3	1.396 ± 0.138
			181.5	20.6 ± 1.0	1.915 ± 0.770
				RR_{mean} =	**1.408 ± 0.125**
$^{172}Lu_c$	c	6.70D	1093.6	63 ± 3	213.2 ± 12.4
			181.5	20.6 ± 1.0	207.2 ± 13.0
				RR_{mean} =	**210.9 ± 8.1**
$^{171}Lu_c$	c	8.24D	739.8	47.8 ± 1.2	**229.6 ± 9.6**
^{171}Lu	c*	8.24D	853.0	2.55 ± 0.07	242.5 ± 10.8
			780.7	4.36 ± 0.11	269.8 ± 11.5
			667.4	11.0 ± 0.3	246.8 ± 10.7
				RR_{mean} =	**253.4 ± 11.5**
$^{170}Lu_c$	c	2.012D	1280.2	8.2 ± 0.4	188.9 ± 12.0
			2126.1	5.1 ± 0.3	184.5 ± 13.9
			1054.3	4.76 ± 0.24	193.6 ± 14.4
			985.1	5.5 ± 0.3	212.3 ± 19.9
				RR_{mean} =	**191.0 ± 7.7**
^{169}Lu	c	34.06H	960.6	23.4 ± 0.7	172.0 ± 7.7
			191.2	20.6 ± 0.6	176.8 ± 8.8
				RR_{mean} =	**173.8 ± 6.6**
^{167}Lu	c	51.5M	176.2	*	144.4 ± 10.4
			113.3	*	200.9 ± 15.5
				RR_{mean} =	**161.5 ± 26.4**
^{169}Yb	c*	32.026D	198.0	35.8 ± 0.7	201.7 ± 8.7
			177.2	22.2 ± 0.5	202.1 ± 8.7
			130.5	11.31 ± 0.21	208.0 ± 9.7
				RR_{mean} =	**203.4 ± 7.0**
^{166}Yb	c	56.7H	2079.5	*	169.3 ± 12.7
			2052.4	*	179.9 ± 12.6
			1867.9	*	168.4 ± 12.0
			1374.2	*	173.7 ± 14.0

Continuation of Table 96.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			1176.7	*	168.2 ± 12.1
			785.9	*	174.8 ± 12.2
			705.3	*	1622 ± 369
			691.2(D)	8.56 ± 0.58	148.9 ± 11.3
				RR_{mean} =	**164.1 ± 5.1**
^{167}Tm	c	9.25D	207.8	42 ± 8	**194.7 ± 37.8**
^{165}Tm	c	30.06H	806.4	9.5 ± 0.6	165.7 ± 12.1
			242.9	35.5 ± 1.7	163.5 ± 10.1
				RR_{mean} =	**164.2 ± 6.8**
^{161}Er	c*	3.21H	826.6	64 ± 4	**178.9 ± 13.0**
^{160}Er	c	28.58H	966.2	*	123.4 ± 16.6
			962.4	*	121.0 ± 15.9
			872.0(D)	6.8 ± 1.1	115.7 ± 19.4
			728.2(D)	34 ± 5	127.8 ± 19.3
				RR_{mean} =	**122.0 ± 3.8**
^{159}Er	c*	36M	624.5	33 ± 4	147.4 ± 19.4
			132.0	*	158.0 ± 9.2
				RR_{mean} =	**156.5 ± 4.8**
^{160m}Ho$_c$	c	5.02H	966.2	15.4 ± 2.0	141.7 ± 19.8
			962.4	16.6 ± 2.1	128.6 ± 19.6
				RR_{mean} =	**135.2 ± 13.6**
^{156}Ho	c*	56M	266.5	54.7 ± 1.1	**92.09 ± 5.16**
^{157}Dy	c	8.14H	326.2	92 ± 4	**92.54 ± 5.19**
^{155}Dy	c*	9.9H	226.9	68.4 ± 1.6	**72.81 ± 3.44**
^{152}Dy	c	2.38H	256.9	97.50 ± 0.07	**35.47 ± 1.96**
^{155}Tb	c*	5.32D	180.1	7.5 ± 0.5	57.73 ± 4.66
			105.3	25.1 ± 1.3	75.50 ± 5.46
				RR_{mean} =	**66.79 ± 9.12**
^{153}Tb	c*	2.34D	212.0	31.0 ± 1.9	**53.38 ± 3.91**
^{152}Tb	c*	17.5H	344.3	65 ± 4	**51.30 ± 3.74**
^{151}Tb	c	17.609H	479.4	15.4 ± 0.7	**38.75 ± 2.75**
^{153}Gd	c	240.4D	103.2	21.1 ± 0.7	53.08 ± 3.41
			97.4	29.0 ± 0.8	49.44 ± 3.02
				RR_{mean} =	**50.99 ± 2.41**
^{151}Gd	c	124D	243.3	5.6 ± 0.4	**42.06 ± 3.81**
^{149}Gd	c	9.28D	149.7	48 ± 3	45.54 ± 3.35
			788.9	7.3 ± 0.4	52.33 ± 3.51
			346.6	23.9 ± 1.3	41.54 ± 2.69
			298.6	28.6 ± 1.7	41.94 ± 2.90
				RR_{mean} =	**44.17 ± 2.75**
^{147}Gd	c	38.06H	929.0	20.2 ± 1.2	36.18 ± 2.80
			396.0	34.3 ± 2.1	28.98 ± 2.08
				RR_{mean} =	**31.35 ± 3.51**
^{146}Gd	c	48.27D	747.2	*	**30.27 ± 1.37**
^{149}Eu	c*	93.1D	327.5	4.03 ± 0.12	**49.74 ± 3.47**
^{147}Eu	c*	24.1D	677.5	9.8 ± 0.5	37.10 ± 2.34
			955.8	3.84 ± 0.20	34.73 ± 2.46
			798.7	4.8 ± 0.3	45.55 ± 3.48
			601.5	5.9 ± 0.3	36.43 ± 2.64
			121.2	22.9 ± 1.3	36.08 ± 2.65

Continuation of Table 96.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
				RR_{mean} =	**37.08 ± 1.83**
$^{146}Eu_i$	i	4.61D	747.2	99 ± 3	**5.047 ± 0.274**
$^{146}Eu_c$	c	4.61D	747.2	99 ± 3	**35.32 ± 1.59**
^{145}Eu	c	5.93D	1658.5	14.9 ± 1.0	20.88 ± 1.72
			653.5	15 ± 1	21.96 ± 1.66
				RR_{mean} =	**21.46 ± 1.15**
^{143}Pm	c	265D	742.0	38.5 ± 2.4	**18.80 ± 1.44**
^{139}Ce	c	137.640D	165.9	79.89 ± 0.02	**14.84 ± 0.57**
^{131}Ba	c	11.50D	123.8	29.0 ± 0.3	**9.247 ± 0.655**
^{128}Ba	c	2.43D	442.9	26.8 ± 1.4	**5.045 ± 0.492**
^{127}Xe	c	36.4D	375.0	17.2 ± 0.6	9.390 ± 0.692
			202.9	68.3 ± 0.5	8.203 ± 0.341
				RR_{mean} =	**8.335 ± 0.453**
^{123m}Te	i(m)	119.7D	159.0	84.0 ± 0.4	**2.170 ± 0.226**
^{121m}Te	i(m)	154D	212.2	81.4 ± 1.1	3.478 ± 0.272
			573.1	88.6 ± 0.1	3.380 ± 0.332
				RR_{mean} =	**3.440 ± 0.106**
$^{121}Te_c$	c	19.16D	573.1	80.3 ± 2.5	**10.05 ± 0.51**
^{119m}Te	i(m)	4.70D	1212.7	66.2 ± 0.3	**3.803 ± 0.192**
^{120m}Sb	i(m)	5.76D	1171.7	100 ± 0	3.011 ± 0.175
			1023.3	99.4 ± 0.3	2.821 ± 0.107
				RR_{mean} =	**2.849 ± 0.111**
^{113}Sn	c	115.09D	391.7	64.97 ± 0.17	**6.634 ± 0.341**
^{114m}In	i(m)	49.51D	190.3	15.56 ± 0.16	**9.833 ± 0.493**
^{111}In	c	2.8047D	171.3	90.2 ± 1.0	9.125 ± 0.398
			245.4	94 ± 1	9.318 ± 0.481
			171.3	90.2 ± 1.0	9.058 ± 0.384
				RR_{mean} =	**9.132 ± 0.325**
^{110m}Ag	i(m)	249.76D	884.7	72.7 ± 0.4	8.160 ± 0.329
			657.8	94.3 ± 0.3	7.791 ± 0.313
				RR_{mean} =	**7.965 ± 0.307**
^{106m}Ag	i(m)	8.28D	451.0	28.2 ± 0.8	7.313 ± 0.378
			1045.8	29.6 ± 1.0	8.094 ± 0.457
			717.3	28.9 ± 0.8	6.592 ± 0.501
				RR_{mean} =	**7.398 ± 0.443**
^{105}Ag	c	41.29D	443.4	10.5 ± 0.6	12.11 ± 1.04
			280.4	30.2 ± 1.8	8.260 ± 0.648
				RR_{mean} =	**9.301 ± 1.733**
^{100}Pd	c	3.63D	2376.0	*	**0.7719 ± 0.2139**
^{105}Rh	c	35.36H	318.9	19.1 ± 0.6	**31.27 ± 2.09**
^{102}Rh	i	207D	475.1	46 ± 5	**7.706 ± 0.942**
^{101m}Rh	c	4.34D	306.9	81 ± 5	**11.55 ± 0.84**
$^{100}Rh_i$	i(m+g)	20.8H	2376.0	32.6 ± 0.4	**7.853 ± 0.726**
$^{100}Rh_c$	c	20.8H	2376.0	32.6 ± 0.4	**8.625 ± 0.683**
^{103}Ru	c	39.26D	497.1	91.0 ± 1.3	**25.84 ± 0.97**
^{96}Tc	i(m+g)	4.28D	849.9	98 ± 4	10.66 ± 0.58
			812.5	82 ± 4	10.94 ± 0.66
				RR_{mean} =	**10.78 ± 0.49**
^{99}Mo	c	65.94H	140.5	90.27 ± 0.33	**22.32 ± 0.97**
^{96}Nb	i	23.35H	1091.3	48.5 ± 1.6	16.67 ± 0.88

Continuation of Table 96.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			568.9	58.0 ± 0.3	15.53 ± 1.06
				RR_{mean} =	**16.25 ± 0.76**
$^{95}Nb_i$	i(m+g)	34.975D	765.8	99.81 ± 0.03	**22.80 ± 0.82**
$^{95}Nb_c$	c	34.975D	765.8	99.81 ± 0.03	**37.37 ± 1.27**
^{90}Nb	c*	14.60H	2319.0	82.0 ± 0.3	6.765 ± 0.409
			1129.2	92.7 ± 0.5	7.977 ± 0.381
				RR_{mean} =	**7.485 ± 0.638**
^{95}Zr	c	64.02D	765.8	*	14.70 ± 0.67
			756.7	54.46 ± 0.10	14.68 ± 0.53
				RR_{mean} =	**14.68 ± 0.45**
^{89}Zr	c	78.41H	909.2	99.04 ± 0.03	**20.13 ± 0.70**
^{88}Zr	c	83.4D	1836.1	*	10.44 ± 0.44
			898.0	*	8.679 ± 0.596
			392.9	97.24 ± 0.00	9.447 ± 0.359
				RR_{mean} =	**9.490 ± 0.293**
$^{88}Y_i$	i	106.65D	1836.1	99.2 ± 0.3	27.40 ± 0.97
			898.0	93.7 ± 0.3	27.27 ± 0.95
				RR_{mean} =	**27.34 ± 0.90**
$^{88}Y_c$	c	106.65D	1836.1	99.2 ± 0.3	37.84 ± 1.32
			898.0	93.7 ± 0.3	35.95 ± 1.22
				RR_{mean} =	**36.70 ± 1.46**
^{87}Y	c*	79.8H	484.8	89.7 ± 0.7	**26.53 ± 0.94**
$^{86}Y_c$	c	14.74H	1076.6	82.5 ± 0.4	**10.94 ± 0.62**
^{85}Sr	c	64.84D	514.0	96 ± 4	**26.48 ± 1.44**
^{83}Rb	c	86.2D	552.6	16.0 ± 1.1	33.63 ± 2.63
			529.6	29.3 ± 2.1	28.85 ± 2.35
			520.4	45 ± 4	30.57 ± 2.92
				RR_{mean} =	**31.02 ± 1.80**
^{82m}Rb	i(m)	6.472H	776.5	84.39 ± 0.21	12.98 ± 0.87
			554.3	62.4 ± 0.9	13.78 ± 1.27
				RR_{mean} =	**13.21 ± 0.76**
^{82}Br	i(m+g)	35.30H	554.3	70.8 ± 1.0	**15.03 ± 0.63**
^{75}Se	c	119.779D	264.7	58.9 ± 0.4	12.50 ± 0.49
			136.0	58.3 ± 0.8	14.05 ± 0.68
			121.1	17.2 ± 0.4	15.10 ± 1.16
				RR_{mean} =	**13.03 ± 0.71**
^{74}As	i	17.77D	595.8	59 ± 4	**16.95 ± 1.29**
^{71}As	c	65.28H	174.9	82.0 ± 2.1	**1.545 ± 0.099**
$^{72}Ga_i$	i	14.10H	2201.7	25.9 ± 0.5	**10.12 ± 1.21**
$^{72}Ga_c$	c	14.10H	2201.7	25.9 ± 0.5	**13.08 ± 1.17**
^{72}Zn	c	46.5H	2201.7	*	**2.959 ± 0.296**
^{59}Fe	c	44.472D	1291.6	43.2 ± 1.4	8.325 ± 0.420
			1099.2	56.5 ± 1.9	8.688 ± 0.449
				RR_{mean} =	**8.490 ± 0.339**
^{54}Mn	i	312.11D	834.8	99.98 ± 0.00	**4.578 ± 0.397**
^{48}V	c	15.9735D	1312.1	97.5 ± 0.9	0.5147 ± 0.0677
			983.5	100.0 ± 0.3	0.6894 ± 0.0603
				RR_{mean} =	**0.6154 ± 0.0884**
^{48}Sc	i	43.67H	1037.5	97.6 ± 0.7	**3.066 ± 0.180**
^{46}Sc	i(m+g)	83.79D	889.3	99.98 ± 0.00	4.186 ± 0.300

Continuation of Table 96.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			1120.6	99.99 ± 0.00	4.179 ± 0.287
				RR_{mean} =	**4.182 ± 0.227**
^{7}Be	i	53.29D	477.6	10.52 ± 0.06	**16.97 ± 1.65**

12.9.5 Nuclide production rates for ^{209}Bi

Table 97: Detailed calculation of nuclide production rates for ^{209}Bi for $E_p = 1.2$ GeV, used to determine the cross sections for their production.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{207}Po	i(m+g)	5.80H	992.3	59.3 ± 0.9	**24.58 ± 1.24**
^{206}Po	i	8.8D	1718.7	*	25.70 ± 1.33
			1595.3	*	26.28 ± 3.69
			1032.3	33 ± 5	26.75 ± 4.15
			1007.2	3.1 ± 0.4	23.58 ± 3.63
			980.2	7.1 ± 0.9	31.84 ± 4.25
			881.0	*	13.09 ± 3.20
			807.4	23 ± 3	26.82 ± 3.63
			803.1	*	25.69 ± 1.06
			620.5	*	17.96 ± 2.22
			537.5	*	22.80 ± 1.17
			522.5	15.7 ± 2.0	25.56 ± 3.39
			516.2	*	24.43 ± 1.10
			398.0	*	23.45 ± 2.56
			343.5	*	24.60 ± 2.15
			338.4	19.2 ± 2.5	26.21 ± 3.54
			311.6	4.2 ± 0.6	32.87 ± 5.02
			286.4	24 ± 3	26.88 ± 3.52
				RR_{mean} =	**24.44 ± 0.75**
^{207}Bi	c	31.55Y	1063.7	74.5 ± 0.2	297.7 ± 11.2
			569.7	97.74 ± 0.03	295.6 ± 11.3
				RR_{mean} =	**296.7 ± 10.2**
^{206}Bi$_i$	i	6.243D	1718.7	31.8 ± 0.6	176.3 ± 7.0
			1595.3	5.01 ± 0.08	187.9 ± 8.3
			881.0	66.2 ± 1.0	185.4 ± 6.9
			803.1	98.9 ± 1.4	165.1 ± 6.0
			620.5	5.76 ± 0.09	165.7 ± 7.0
			537.5	30.5 ± 0.5	156.3 ± 6.1
			516.2	40.7 ± 0.6	160.9 ± 6.0
			398.0	10.74 ± 0.15	154.0 ± 6.4
			343.5	23.4 ± 0.4	158.8 ± 6.4
				RR_{mean} =	**166.3 ± 6.4**
^{206}Bi$_c$	c	6.243D	1718.7	31.8 ± 0.6	200.6 ± 7.8
			1595.3	5.01 ± 0.08	212.7 ± 8.3
			881.0	66.2 ± 1.0	197.7 ± 7.2
			803.1	98.9 ± 1.4	189.4 ± 6.8
			620.5	5.76 ± 0.09	182.6 ± 7.1
			537.5	30.5 ± 0.5	177.9 ± 6.8
			516.2	40.7 ± 0.6	184.0 ± 6.9

Continuation of Table 97.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			398.0	10.74 ± 0.15	176.2 ± 6.6
			343.5	23.4 ± 0.4	182.1 ± 7.0
				RR_{mean} =	**187.7 ± 6.8**
^{205}Bi	c	15.31D	1861.7	6.17 ± 0.10	186.8 ± 8.0
			1775.8	3.99 ± 0.08	196.2 ± 7.9
			1764.3	32.5 ± 0.7	193.2 ± 7.8
			1614.3	2.28 ± 0.04	193.9 ± 9.1
			1190.0	2.26 ± 0.07	193.4 ± 9.2
			1043.8	7.51 ± 0.10	174.5 ± 6.8
			987.7	16.13 ± 0.17	186.6 ± 6.5
			759.1	1.04 ± 0.05	197.0 ± 12.7
			703.5	31.1 ± 0.1	182.3 ± 6.1
			579.8	5.44 ± 0.07	167.9 ± 6.3
			570.6	4.34 ± 0.07	167.7 ± 6.8
			549.8	2.95 ± 0.04	190.9 ± 7.6
			284.1	1.69 ± 0.02	180.6 ± 7.6
				RR_{mean} =	**182.6 ± 6.2**
^{204}Bi	c*	11.22H	984.0	59 ± 4	153.1 ± 11.9
			918.3	10.8 ± 0.9	178.1 ± 16.4
			899.2	98 ± 9	138.2 ± 4.8
			670.7	11.4 ± 0.9	150.7 ± 13.4
			374.8	82 ± 5	162.1 ± 33.8
				RR_{mean} =	**139.5 ± 4.3**
^{203}Bi	c	11.76H	1893.0	8.2 ± 0.6	136.7 ± 12.0
			1847.3	11.4 ± 0.8	119.5 ± 9.5
			1679.6	8.8 ± 0.7	116.7 ± 10.6
			847.2	8.5 ± 0.5	140.9 ± 10.2
			820.2	29.6 ± 1.5	130.6 ± 8.1
			279.2	*	122.1 ± 6.2
				RR_{mean} =	**124.7 ± 3.8**
^{202}Bi	c*	1.72H	960.7	99.28 ± 0.02	104.7 ± 4.4
			422.1	83.7 ± 2.5	112.0 ± 5.8
				RR_{mean} =	**106.9 ± 4.7**
$^{204m}Pb_i$	i(m)	67.2M	899.2	99.17 ± 0.02	52.59 ± 2.92
			374.7	89 ± 15	54.09 ± 9.39
				RR_{mean} =	**52.69 ± 2.86**
$^{204m}Pb_c$	c	67.2M	899.2	99.17 ± 0.02	73.32 ± 3.32
			374.7	89 ± 15	74.43 ± 12.86
				RR_{mean} =	**73.35 ± 3.29**
$^{203}Pb_i$	i(m1+m2+g)	51.873H	279.2	80.8 ± 0.2	**122.8 ± 7.1**
$^{203}Pb_c$	c	51.873H	279.2	80.8 ± 0.2	**244.9 ± 9.1**
^{202m}Pb	i(m)	3.53H	960.7	92 ± 8	68.41 ± 7.00
			422.1	86 ± 5	57.43 ± 4.26
				RR_{mean} =	**59.20 ± 4.43**
^{201}Pb	c*	9.33H	946.0	7.4 ± 0.6	227.2 ± 21.1
			361.3	9.9 ± 0.5	269.5 ± 18.7
			331.2	79 ± 5	233.2 ± 16.9
				RR_{mean} =	**244.3 ± 15.1**
^{200}Pb	c	21.5H	1514.9	*	146.6 ± 13.4
			1205.7	*	166.9 ± 11.5
			579.3	*	156.5 ± 10.8

Continuation of Table 97.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			450.5	3.33 ± 0.08	183.4 ± 9.0
			367.9	*	159.4 ± 5.5
			147.6	37.7 ± 1.4	175.3 ± 11.0
				RR_{mean} =	**161.9 ± 5.0**
^{199}Pb	c*	90M	1135.0	7.8 ± 1.2	269.9 ± 43.6
			366.9	44 ± 7	303.3 ± 49.6
				RR_{mean} =	**283.7 ± 18.6**
^{198}Pb	c	2.4H	173.4	18 ± 3	**222.7 ± 38.3**
^{197m}Pb	c*	43M	385.9	74 ± 15	143.0 ± 29.4
			222.8	25 ± 6	137.4 ± 34.4
				RR_{mean} =	**142.6 ± 6.8**
^{195m}Pb	i(m)	15.0M	383.6	107 ± 20	**69.42 ± 13.35**
^{202}Tl	c	12.23D	439.6	91.4 ± 1.0	**35.71 ± 1.29**
^{201}Tl	c*	72.912H	167.4	10.00 ± 0.06	**279.3 ± 10.8**
^{200}Tl$_i$	i	26.1H	1205.7	29.9 ± 1.8	67.05 ± 4.96
			579.3	13.8 ± 0.7	68.78 ± 8.87
			367.9	87.2 ± 0.4	61.21 ± 3.21
				RR_{mean} =	**63.05 ± 2.91**
^{200}Tl$_c$	c	26.1H	1514.9	4.0 ± 0.3	227.4 ± 19.4
			1205.7	29.9 ± 1.8	233.9 ± 16.1
			579.3	13.8 ± 0.7	225.3 ± 14.3
			367.9	87.2 ± 0.4	220.6 ± 7.7
				RR_{mean} =	**221.7 ± 7.5**
^{199}Tl	c*	7.42H	455.5	12.4 ± 1.4	273.8 ± 33.6
			247.3	9.3 ± 1.1	289.8 ± 36.3
				RR_{mean} =	**280.9 ± 16.5**
^{198m}Tl	i(m)	1.87H	282.8	28 ± 3	**62.08 ± 8.10**
^{197}Tl	c*	2.84H	1411.3	4.5 ± 1.5	167.1 ± 58.3
			152.2	7.3 ± 2.3	329.7 ± 105.2
				RR_{mean} =	**252.2 ± 81.6**
^{196m}Tl	i(m)	1.41H	695.4	41 ± 7	**147.7 ± 25.8**
^{197m}Hg	i(m)	23.8H	134.0	33.5 ± 0.4	**23.67 ± 1.46**
^{195m}Hg	i(m)	41.6H	261.8	31 ± 4	**36.62 ± 4.97**
^{193m}Hg	i(m)	11.8H	407.6	32 ± 6	46.23 ± 8.83
			258.0	49 ± 7	69.51 ± 10.44
				RR_{mean} =	**56.05 ± 11.63**
^{192}Hg	c	4.85H	316.5	*	201.6 ± 25.4
			274.8	50.2 ± 2.5	171.5 ± 10.8
				RR_{mean} =	**175.4 ± 5.4**
^{190}Hg	c*	20.0M	301.8	*	122.5 ± 17.7
			142.6	68 ± 10	131.8 ± 20.7
				RR_{mean} =	**126.4 ± 3.9**
^{196}Au	i(m1+m2+g)	6.183D	355.7	87.0 ± 0.8	5.760 ± 0.247
			333.0	22.9 ± 0.6	6.077 ± 0.309
				RR_{mean} =	**5.861 ± 0.233**
^{195}Au	c	186.098D	98.9	10.9 ± 0.9	**200.6 ± 22.6**
^{194}Au	i(m1+m2+g)	38.02H	328.5	61 ± 5	**13.16 ± 1.17**
^{192}Au$_i$	i(m+g)	4.94H	316.5	58 ± 7	**24.24 ± 3.59**
^{192}Au$_c$	c	4.94H	316.5	58 ± 7	**225.8 ± 28.4**
^{191}Au	c*	3.18H	277.9	7.2 ± 0.5	**162.5 ± 14.9**

Continuation of Table 97.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, $10^{-17}\ s^{-1}$
$^{190}Au_c$	c	42.8M	301.8	23.4 ± 1.5	185.0 ± 15.8
			295.8	71 ± 5	181.4 ± 15.3
				RR_{mean} =	**183.1 ± 9.1**
^{191}Pt	c	2.802D	538.9	13.7 ± 1.6	183.7 ± 22.4
			456.5	3.4 ± 0.4	153.7 ± 19.1
			409.4	8.0 ± 0.9	152.2 ± 17.9
			359.9	6.0 ± 0.7	158.0 ± 19.3
			351.2	3.4 ± 0.4	184.6 ± 22.8
			129.4	3.2 ± 0.5	167.9 ± 28.3
				RR_{mean} =	**163.3 ± 7.9**
^{189}Pt	c	10.87H	721.4	9.3 ± 0.8	223.6 ± 21.6
			607.6	8.10 ± 0.16	185.4 ± 8.0
			568.8	7.1 ± 0.6	201.0 ± 19.7
			544.9	5.8 ± 0.5	203.5 ± 19.4
				RR_{mean} =	**190.0 ± 8.3**
^{188}Pt	c	10.2D	478.0	*	167.6 ± 9.1
			423.3	4.4 ± 0.3	170.3 ± 13.0
			195.1	18.6 ± 1.2	174.8 ± 13.1
			187.6	19.4 ± 1.2	173.8 ± 12.7
			155.1	*	180.1 ± 19.3
			140.4	2.33 ± 0.15	191.0 ± 16.1
				RR_{mean} =	**171.5 ± 5.3**
^{186}Pt	c	2.08H	689.4	70 ± 15	**154.9 ± 33.6**
^{184}Pt	c	17.3M	548.3	23 ± 4	**142.3 ± 26.3**
^{189}Ir	c	13.2D	275.9	0.54 ± 0.07	156.7 ± 22.3
			245.1	6.0 ± 0.6	159.5 ± 17.2
				RR_{mean} =	**159.3 ± 6.4**
$^{188}Ir_c$	c	41.5H	478.0	14.7 ± 0.6	182.0 ± 10.0
			155.1	30 ± 3	186.4 ± 20.0
				RR_{mean} =	**182.2 ± 6.7**
^{187}Ir	c*	10.5H	977.5	3.14 ± 0.11	**178.1 ± 12.4**
^{186}Ir	c	16.64H	773.3	8.9 ± 0.5	78.46 ± 5.85
			434.8	33.9 ± 1.1	78.23 ± 3.94
			296.9	62.3 ± 1.9	79.09 ± 7.35
				RR_{mean} =	**78.39 ± 3.47**
^{185}Ir	c	14.4H	1829.0	10.1 ± 1.5	127.0 ± 19.6
			1668.0	3.6 ± 0.6	125.2 ± 21.6
			254.2	13.3 ± 2.4	117.2 ± 22.1
				RR_{mean} =	**125.3 ± 6.4**
^{184}Ir	c*	3.09H	1105.3	5.3 ± 0.7	157.8 ± 22.9
			390.4	25.9 ± 2.4	157.4 ± 15.9
			264.0	68 ± 4	181.3 ± 13.0
			119.8	31 ± 3	184.1 ± 21.8
				RR_{mean} =	**176.6 ± 7.8**
^{183}Ir	c	57M	392.5	10.4 ± 2.4	**170.4 ± 40.3**
^{185}Os	c	93.6D	874.8	6.29 ± 0.25	182.3 ± 9.5
			717.4	3.94 ± 0.16	180.5 ± 9.6
			646.1	78 ± 3	175.9 ± 9.0
			592.1	1.32 ± 0.06	167.8 ± 10.5
				RR_{mean} =	**177.9 ± 5.9**

Continuation of Table 97.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{183m}Os	c*	9.9H	1107.9	22.4 ± 0.6	109.5 ± 4.8
			1101.9	49.0 ± 1.3	103.9 ± 4.6
				RR_{mean} =	**106.5 ± 4.3**
^{182}Os	c	22.10H	1221.5	*	213.4 ± 15.7
			1189.2	*	222.7 ± 16.9
			1121.4	*	218.2 ± 13.5
			180.2	33.5 ± 1.7	190.1 ± 12.4
				RR_{mean} =	**204.6 ± 6.3**
^{181}Os	c	105M	238.8	44 ± 5	**63.98 ± 8.24**
^{180}Os	c	21.5M	902.8(D)	101.5 ± 3.4	160.7 ± 8.6
			103.5(D)	25.0 ± 0.8	169.3 ± 15.6
				RR_{mean} =	**162.3 ± 8.1**
^{183}Re	c	70.0D	291.7	3.05 ± 0.18	176.1 ± 12.2
			208.8	2.95 ± 0.09	162.4 ± 8.9
			162.3	23.3 ± 0.7	185.8 ± 9.0
			107.9	2.17 ± 0.07	191.2 ± 15.6
				RR_{mean} =	**176.9 ± 8.4**
^{182m}Re$_c$	c	12.7H	1221.5	24.8 ± 1.6	198.5 ± 14.7
			1189.2	15 ± 1	210.1 ± 17.8
			1121.4	31.8 ± 1.6	191.8 ± 12.7
				RR_{mean} =	**196.9 ± 8.4**
^{181}Re	c*	19.9H	953.6	3.6 ± 1.0	175.8 ± 49.5
			639.0	6.4 ± 1.4	187.8 ± 41.7
			365.5	56 ± 8	177.1 ± 26.0
				RR_{mean} =	**179.0 ± 18.0**
^{179}Re	c*	19.5M	430.2	28.0 ± 1.8	236.7 ± 18.5
			290.0	26.9 ± 2.3	213.0 ± 21.4
				RR_{mean} =	**232.0 ± 11.9**
^{178}Re	c*	13.2M	237.3	45 ± 5	**247.7 ± 30.0**
^{178} W	c	21.6D	1340.8(D)	1.03 ± 0.09	133.2 ± 17.4
			1106.1(D)	0.54 ± 0.05	150.3 ± 17.6
				RR_{mean} =	**142.6 ± 9.6**
^{177} W	c	135M	115.7	51 ± 5	**165.6 ± 19.8**
^{177}Ta	c*	56.56H	112.9	7.2 ± 1.6	**181.9 ± 42.6**
^{176}Ta	c*	8.09H	1823.7	4.5 ± 0.4	221.7 ± 24.7
			1584.0	5.3 ± 0.4	200.7 ± 19.0
			1555.1	4.0 ± 0.3	206.8 ± 18.1
			1159.3	24.7 ± 1.9	223.0 ± 19.0
				RR_{mean} =	**213.6 ± 8.5**
^{175}Ta	c	10.5H	1793.1	4.6 ± 0.7	124.6 ± 19.8
			348.5	12.0 ± 1.1	176.2 ± 17.7
			266.9	10.52 ± 0.16	161.8 ± 7.6
				RR_{mean} =	**160.5 ± 9.1**
^{174}Ta$_c$	c	1.14H	206.5	60 ± 5	**154.5 ± 14.3**
^{173}Ta	c	3.14H	172.2	17.5 ± 1.8	**178.4 ± 19.8**
^{172}Ta	c*	36.8M	214.1	55 ± 5	**94.34 ± 9.64**
^{175}Hf	c	70D	343.4	84 ± 3	**161.4 ± 7.9**
^{173}Hf	c*	23.6H	311.2	10.7 ± 0.5	182.8 ± 10.8
			306.6	6.4 ± 0.3	182.8 ± 13.1
			297.0	33.9 ± 1.4	256.0 ± 16.7

Continuation of Table 97.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			139.6	12.7 ± 0.6	208.5 ± 15.0
			123.7	83 ± 5	193.3 ± 17.0
				RR_{mean} =	**197.5 ± 13.9**
^{172}Hf	c	1.87Y	1093.6	*	133.0 ± 7.7
			1002.7(D)	5.55 ± 0.38	132.4 ± 12.1
			929.1	*	121.5 ± 7.7
			900.7	*	134.6 ± 7.4
			125.8	11.3 ± 0.9	138.3 ± 14.1
				RR_{mean} =	**132.4 ± 4.1**
^{170}Hf	c	16.01H	620.7	18 ± 5	180.1 ± 50.5
			481.3	3.7 ± 1.0	158.3 ± 43.5
			164.7	26 ± 8	170.9 ± 53.0
			120.2	15 ± 5	178.4 ± 60.7
				RR_{mean} =	**164.7 ± 8.2**
^{173}Lu	c	1.37Y	272.1	21.2 ± 0.8	151.8 ± 8.2
			171.4	2.90 ± 0.15	143.7 ± 14.4
			100.7	5.24 ± 0.20	140.6 ± 14.7
				RR_{mean} =	**150.0 ± 6.1**
^{172}Lu$_c$	c	6.70D	1093.6	63 ± 3	134.2 ± 7.8
			929.1	3.04 ± 0.14	123.1 ± 7.7
			900.7	29.8 ± 1.3	136.2 ± 7.5
				RR_{mean} =	**132.9 ± 5.5**
^{171}Lu	c*	8.24D	853.0	2.55 ± 0.07	159.7 ± 7.2
			839.9	3.04 ± 0.08	168.2 ± 7.4
			780.7	4.36 ± 0.11	164.9 ± 7.2
			739.8	47.8 ± 1.2	157.5 ± 6.5
			712.7	1.13 ± 0.03	153.5 ± 8.6
			667.4	11.0 ± 0.3	165.5 ± 7.2
				RR_{mean} =	**161.9 ± 5.4**
^{170}Lu	c*	2.012D	2126.1	5.1 ± 0.3	187.5 ± 13.5
			1280.2	8.2 ± 0.4	175.5 ± 10.8
			1054.3	4.76 ± 0.24	183.8 ± 11.6
				RR_{mean} =	**180.8 ± 7.0**
^{169}Lu	c	34.06H	1449.7	9.9 ± 0.3	108.4 ± 5.2
			960.6	23.4 ± 0.7	108.0 ± 4.9
			889.8	5.36 ± 0.17	104.1 ± 5.2
			191.2	20.6 ± 0.6	119.2 ± 5.8
				RR_{mean} =	**109.4 ± 4.5**
^{167}Lu	c	51.5M	239.0	0.9 ± 0.5	1472 ± 841
			113.3	*	124.7 ± 11.0
			106.2	*	104.5 ± 11.7
				RR_{mean} =	**115.6 ± 3.6**
^{169}Yb	c*	32.026D	307.7	10.05 ± 0.19	142.6 ± 5.6
			198.0	35.8 ± 0.7	132.5 ± 5.8
			177.2	22.2 ± 0.5	131.4 ± 5.8
			130.5	11.31 ± 0.21	137.1 ± 8.4
			118.2	1.87 ± 0.04	136.4 ± 10.2
			109.8	17.5 ± 0.4	128.6 ± 9.7
				RR_{mean} =	**136.7 ± 4.8**
^{166}Yb	c	56.7H	2079.5	*	104.7 ± 7.9
			1374.2	*	110.5 ± 8.9

Continuation of Table 97.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			1176.7	*	105.5 ± 7.7
			785.9	*	119.9 ± 9.1
			691.2(D)	8.56 ± 0.58	100.3 ± 7.7
				RR_{mean} =	**107.3 ± 3.3**
^{162}Yb	c	18.87M	163.4	40 ± 5	**82.41 ± 11.05**
^{167}Tm	c	9.25D	531.5	1.61 ± 0.22	120.7 ± 17.2
			207.8	42 ± 8	121.2 ± 23.6
				RR_{mean} =	**120.8 ± 6.2**
^{165}Tm	c	30.06H	806.4	9.5 ± 0.6	103.9 ± 7.7
			242.9	35.5 ± 1.7	109.0 ± 6.8
				RR_{mean} =	**107.3 ± 4.5**
^{163}Tm	c	1.810H	104.3	18.6 ± 0.7	**78.93 ± 7.50**
^{161}Er	c*	3.21H	826.6	64 ± 4	**83.73 ± 6.51**
^{160}Er	c	28.58H	966.2	*	78.47 ± 10.57
			962.4	*	76.70 ± 10.06
			879.4(D)	22.6 ± 2.8	78.18 ± 10.08
			872.0(D)	6.8 ± 1.1	71.18 ± 11.86
			728.2(D)	34 ± 5	82.00 ± 12.38
				RR_{mean} =	**77.31 ± 2.38**
^{159}Er	c*	36M	649.1	23 ± 3	98.54 ± 13.78
			624.5	33 ± 4	83.43 ± 11.21
			121.0	*	72.15 ± 7.25
				RR_{mean} =	**78.54 ± 2.42**
^{160m}Ho$_c$	c	5.02H	966.2	15.4 ± 2.0	81.16 ± 14.46
			962.4	16.6 ± 2.1	105.3 ± 15.1
				RR_{mean} =	**93.07 ± 12.39**
^{156}Ho	c*	56M	266.5	54.7 ± 1.1	**58.23 ± 3.26**
^{157}Dy	c	8.14H	326.2	92 ± 4	**55.97 ± 3.13**
^{155}Dy	c*	9.9H	226.9	68.4 ± 1.6	**43.13 ± 2.22**
^{155}Tb	c*	5.32D	180.1	7.5 ± 0.5	41.65 ± 3.48
			163.3	4.44 ± 0.24	40.47 ± 3.26
			148.6	2.65 ± 0.14	52.52 ± 4.68
			105.3	25.1 ± 1.3	44.92 ± 4.04
				RR_{mean} =	**43.43 ± 2.71**
^{153}Tb	c*	2.34D	212.0	31.0 ± 1.9	32.68 ± 2.40
			102.2	6.4 ± 0.5	22.94 ± 2.70
				RR_{mean} =	**29.08 ± 4.78**
^{150}Tb	c	3.48H	638.0	72 ± 10	**12.85 ± 2.21**
^{153}Gd	c	240.4D	103.2	21.1 ± 0.7	30.85 ± 2.56
			97.4	29.0 ± 0.8	27.61 ± 2.22
				RR_{mean} =	**28.99 ± 1.84**
^{151}Gd	c	124D	243.3	5.6 ± 0.4	23.75 ± 2.14
			153.6	6.2 ± 0.4	24.93 ± 2.47
				RR_{mean} =	**24.19 ± 1.28**
^{149}Gd	c	9.28D	346.6	23.9 ± 1.3	24.54 ± 1.65
			298.6	28.6 ± 1.7	25.72 ± 1.79
			149.7	48 ± 3	29.37 ± 2.30
				RR_{mean} =	**25.58 ± 1.35**
^{147}Gd	c	38.06H	929.0	20.2 ± 1.2	20.76 ± 1.57
			396.0	34.3 ± 2.1	20.68 ± 1.51

Continuation of Table 97.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			370.0	17.2 ± 0.9	17.65 ± 1.16
			229.3	63 ± 4	20.39 ± 1.57
				RR_{mean} =	**19.33 ± 1.04**
^{146}Gd	c	48.27D	1533.7	*	17.56 ± 1.29
			1297.0	*	18.79 ± 1.38
			747.2	*	18.54 ± 0.83
			154.6	46.6 ± 0.5	19.44 ± 1.09
			115.5	44.0 ± 0.7	21.56 ± 1.51
			114.7	44.0 ± 0.7	21.29 ± 1.50
				RR_{mean} =	**19.01 ± 0.59**
^{149}Eu	c*	93.1D	327.5	4.03 ± 0.12	35.67 ± 2.24
			277.1	3.56 ± 0.06	34.60 ± 2.72
				RR_{mean} =	**35.26 ± 1.89**
^{147}Eu	c*	24.1D	798.7	4.8 ± 0.3	24.38 ± 1.88
			677.5	9.8 ± 0.5	24.78 ± 1.77
			601.5	5.9 ± 0.3	23.28 ± 1.89
			121.2	22.9 ± 1.3	21.56 ± 1.89
				RR_{mean} =	**23.68 ± 1.01**
^{146}Eu$_i$	i	4.61D	747.2	99 ± 3	**2.957 ± 0.152**
^{146}Eu$_c$	c	4.61D	747.2	99 ± 3	**21.50 ± 0.96**
^{145}Eu	c	5.93D	1997.0	7.2 ± 0.5	13.27 ± 1.15
			1658.5	14.9 ± 1.0	12.35 ± 0.99
			893.7	66 ± 5	11.44 ± 1.00
			653.5	15 ± 1	13.22 ± 1.06
			542.6	4.5 ± 0.4	15.12 ± 2.03
				RR_{mean} =	**12.64 ± 0.60**
^{143}Pm	c	265D	742.0	38.5 ± 2.4	**11.50 ± 1.29**
^{139}Ce	c	137.640D	165.9	79.89 ± 0.01	**9.801 ± 0.382**
^{132}La$_c$	c	4.8H	464.5	76 ± 6	**3.500 ± 0.783**
^{133}Ba	c	3848.9D	356.0	62.05 ± 0.19	**7.594 ± 3.614**
^{131}Ba	c	11.50D	373.2	14.04 ± 0.20	7.293 ± 0.374
			123.8	29.0 ± 0.3	6.957 ± 0.569
				RR_{mean} =	**7.212 ± 0.341**
^{128}Ba	c	2.43D	442.9	26.8 ± 1.4	**4.193 ± 0.431**
^{129}Cs	c	32.06H	371.9	30.6 ± 1.7	**11.36 ± 0.83**
^{127}Xe	c	36.4D	375.0	17.2 ± 0.6	8.468 ± 0.475
			202.9	68.3 ± 0.5	9.053 ± 0.379
			172.1	25.5 ± 0.8	8.578 ± 0.534
				RR_{mean} =	**8.833 ± 0.332**
^{123}Xe	c	2.08H	148.9	48.9 ± 0.6	**11.98 ± 1.30**
^{126} I	i	13.11D	388.6	34 ± 3	**1.293 ± 0.236**
^{123m}Te	i(m)	119.7D	159.0	84.0 ± 0.4	**2.835 ± 0.186**
^{121m}Te	i(m)	154D	212.2	81.4 ± 1.1	3.587 ± 0.185
			573.1	88.6 ± 0.1	3.788 ± 0.208
				RR_{mean} =	**3.672 ± 0.113**
^{121}Te$_c$	c	19.16D	573.1	80.3 ± 2.5	**9.642 ± 0.450**
^{119m}Te	i(m)	4.70D	1212.7	66.2 ± 0.3	**4.075 ± 0.175**
^{116}Te	c	2.49H	1293.6	95 ± 8	**7.002 ± 1.113**
^{120m}Sb	i(m)	5.76D	1171.7	100 ± 0	3.260 ± 0.210
			1023.3	99.4 ± 0.3	3.152 ± 0.114

Continuation of Table 97.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
				RR_{mean} =	**3.162 ± 0.113**
^{118m}Sb	i(m)	5.00H	1050.7	97 ± 5	**4.533 ± 0.493**
^{117m}Sn	i(m)	13.60D	158.6	86.4 ± 0.4	**6.166 ± 0.287**
^{113}Sn	c	115.09D	391.7	64.97 ± 0.17	**6.679 ± 0.262**
^{114m}In	i(m)	49.51D	190.3	15.56 ± 0.16	**11.47 ± 0.63**
^{111}In	c	2.8047D	245.4	94 ± 1	9.868 ± 0.428
			171.3	90.2 ± 1.0	9.538 ± 0.437
				RR_{mean} =	**9.716 ± 0.365**
^{110m}Ag	i(m)	249.76D	1505.0	13.60 ± 0.19	9.355 ± 0.880
			1384.3	24.9 ± 0.8	9.503 ± 0.675
			937.5	34.2 ± 0.6	8.763 ± 0.502
			884.7	72.7 ± 0.4	9.263 ± 0.354
			657.8	94.3 ± 0.3	9.287 ± 0.374
				RR_{mean} =	**9.232 ± 0.317**
^{106m}Ag	i(m)	8.28D	1045.8	29.6 ± 1.0	7.738 ± 0.400
			717.3	28.9 ± 0.8	6.973 ± 0.368
			451.0	28.2 ± 0.8	6.993 ± 0.370
				RR_{mean} =	**7.212 ± 0.331**
^{105}Ag	c	41.29D	443.4	10.5 ± 0.6	8.904 ± 0.718
			280.4	30.2 ± 1.8	8.484 ± 0.692
				RR_{mean} =	**8.687 ± 0.526**
^{100}Pd	c	3.63D	2376.0	*	**0.8521 ± 0.1601**
^{105}Rh	c	35.36H	318.9	19.1 ± 0.6	**33.30 ± 1.75**
^{102m}Rh	i(m)	2.9Y	1046.6	34 ± 2	10.20 ± 1.35
			631.3	56 ± 2	8.497 ± 1.770
				RR_{mean} =	**9.590 ± 1.089**
^{101m}Rh	c	4.34D	306.9	81 ± 5	**11.79 ± 0.88**
^{100}Rh$_i$	i(m+g)	20.8H	2376.0	32.6 ± 0.4	**6.420 ± 0.523**
^{100}Rh$_c$	c	20.8H	2376.0	32.6 ± 0.4	**7.272 ± 0.502**
^{103}Ru	c	39.26D	497.1	91.0 ± 1.3	**28.78 ± 1.08**
^{96}Tc	i(m+g)	4.28D	849.9	98 ± 4	10.82 ± 0.59
			812.5	82 ± 4	10.71 ± 0.65
				RR_{mean} =	**10.77 ± 0.49**
^{99}Mo	c	65.94H	140.5	90.27 ± 0.33	**26.05 ± 1.40**
^{93m}Mo	i(m)	6.85H	684.7	99.7 ± 2.0	**4.988 ± 0.460**
^{96}Nb	i	23.35H	1091.3	48.5 ± 1.6	19.14 ± 1.01
			568.9	58.0 ± 0.3	18.70 ± 0.75
				RR_{mean} =	**18.82 ± 0.71**
^{95}Nb$_i$	i(m+g)	34.975D	765.8	99.81 ± 0.03	**24.57 ± 0.82**
^{95}Nb$_c$	c	34.975D	765.8	99.81 ± 0.03	**39.95 ± 1.32**
^{92m}Nb	i(m)	10.15D	934.4	99.07 ± 0.04	**2.134 ± 0.191**
^{90}Nb	c*	14.60H	2319.0	82.0 ± 0.3	**6.391 ± 0.348**
^{97}Zr	c	16.744H	743.4	93.06 ± 0.16	**5.115 ± 0.261**
^{95}Zr	c	64.02D	765.8	*	15.52 ± 0.56
			756.7	54.46 ± 0.10	15.76 ± 0.55
			724.2	44.17 ± 0.16	16.96 ± 0.59
				RR_{mean} =	**15.67 ± 0.48**
^{89}Zr	c	78.41H	909.2	99.04 ± 0.03	**19.34 ± 0.65**
^{88}Zr	c	83.4D	898.0	*	9.613 ± 0.523
			392.9	97.24 ± 0.00	9.121 ± 0.321

Continuation of Table 97.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
				RR_{mean} =	**9.177 ± 0.283**
^{90m}Y	i(m)	3.19H	479.5	90.74 ± 0.05	**21.62 ± 0.94**
$^{88}Y_i$	i	106.65D	898.0	93.7 ± 0.3	**26.15 ± 0.90**
$^{88}Y_c$	c	106.65D	898.0	93.7 ± 0.3	**35.76 ± 1.20**
^{87}Y	c*	79.8H	388.5	82.1 ± 0.5	**26.76 ± 0.94**
^{85}Sr	c	64.84D	514.0	96 ± 4	**25.68 ± 1.39**
^{86}Rb	i(m+g)	18.631D	1077.0	8.64 ± 0.04	**26.98 ± 1.32**
^{84}Rb	i(m+g)	32.77D	881.6	69.0 ± 1.6	**26.82 ± 1.37**
^{83}Rb	c	86.2D	552.6	16.0 ± 1.1	30.46 ± 2.43
			529.6	29.3 ± 2.1	29.28 ± 2.36
			520.4	45 ± 4	29.19 ± 2.80
				RR_{mean} =	**29.73 ± 1.33**
^{82m}Rb	i(m)	6.472H	554.3	62.4 ± 0.9	**11.51 ± 1.32**
^{82}Br	i(m+g)	35.30H	1474.9	16.32 ± 0.23	17.64 ± 1.18
			1317.5	26.5 ± 0.4	17.65 ± 0.74
			554.3	70.8 ± 1.0	14.90 ± 0.60
				RR_{mean} =	**16.04 ± 1.08**
^{75}Se	c	119.779D	264.7	58.9 ± 0.4	11.61 ± 0.46
			136.0	58.3 ± 0.8	13.21 ± 0.77
			121.1	17.2 ± 0.4	14.43 ± 1.29
				RR_{mean} =	**12.00 ± 0.67**
^{76}As	i	1.0778D	559.1	45 ± 2	**22.67 ± 1.45**
^{74}As	i	17.77D	595.8	59 ± 4	**16.07 ± 1.22**
^{71}As	c	65.28H	174.9	82.0 ± 2.1	**1.860 ± 0.110**
$^{72}Ga_i$	i	14.10H	2201.7	25.9 ± 0.5	**10.27 ± 0.79**
$^{72}Ga_c$	c	14.10H	2201.7	25.9 ± 0.5	**12.19 ± 0.78**
^{72}Zn	c	46.5H	2201.7	*	**1.917 ± 0.214**
^{65}Zn	c	244.26D	1115.6	50.60 ± 0.24	**5.482 ± 0.380**
^{59}Fe	c	44.472D	1291.6	43.2 ± 1.4	7.048 ± 0.366
			1099.2	56.5 ± 1.9	7.430 ± 0.391
				RR_{mean} =	**7.224 ± 0.294**
^{54}Mn	i	312.11D	834.8	99.98 ± 0.00	**3.991 ± 0.177**
^{48}V	c	15.9735D	983.5	100.0 ± 0.3	**0.6538 ± 0.0526**
^{48}Sc	i	43.67H	1312.1	100.1 ± 0.7	**2.863 ± 0.130**
^{46}Sc	i(m+g)	83.79D	1120.6	99.99 ± 0.00	3.070 ± 0.192
			889.3	99.98 ± 0.00	2.837 ± 0.154
				RR_{mean} =	**2.922 ± 0.144**
^{24}Na	c	14.9590H	1369.0	100 ± 0	**4.377 ± 0.261**
^{7}Be	i	53.29D	477.6	10.52 ± 0.06	**19.08 ± 1.19**

12.9.6 Nuclide production rates for ^{27}Al

Table 98: Detailed calculation of nuclide production rates for in ^{27}Al-monitors and ^{27}Al-plates for E_p = 1.2 GeV, used for calculating proton flux (including total over the plate area), cross sections for production of ^{7}Be, ^{24}Naand neutron background.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{27}Al-monitor for ^{206}Pb					

Continuation of Table 98.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{7}Be	i	53.29D	477.6	10.52 ± 0.06	**56.82 ± 2.03**
^{27}Mg	c	9.458M	843.8	71.8 ± 0.4	4.922 ± 0.212
			1014.4	28.0 ± 0.4	5.028 ± 0.324
				RR_{mean} =	**4.945 ± 0.201**
^{22}Na	c	2.6019Y	1274.5	99.94 ± 0.01	**98.46 ± 3.33**
^{24}Na	c	14.9590H	1369.0	100 ± 0	**90.26 ± 3.01**
		^{27}Al-plate for ^{206}Pb			
^{24}Na	c	14.9590H	1369.0	100 ± 0	**3.554 ± 0.119**
		^{27}Al-monitor for ^{207}Pb			
^{7}Be	i	53.29D	477.6	10.52 ± 0.06	**48.64 ± 1.72**
^{27}Mg	c	9.458M	843.8	71.8 ± 0.4	4.249 ± 0.186
			1014.4	28.0 ± 0.4	4.480 ± 0.299
				RR_{mean} =	**4.296 ± 0.178**
^{22}Na	c	2.6019Y	1274.5	99.94 ± 0.01	**86.18 ± 2.91**
^{24}Na	c	14.9590H	1369.0	100 ± 0	**77.37 ± 2.58**
		^{27}Al-plate for ^{207}Pb			
^{24}Na	c	14.9590H	1369.0	100 ± 0	**2.828 ± 0.095**
		^{27}Al-monitor for ^{207}Pb			
^{7}Be	i	53.29D	477.6	10.52 ± 0.06	**41.71 ± 1.49**
^{27}Mg	c	9.458M	843.8	71.8 ± 0.4	3.673 ± 0.167
			1014.4	28.0 ± 0.4	3.493 ± 0.236
				RR_{mean} =	**3.627 ± 0.154**
^{22}Na	c	2.6019Y	1274.5	99.94 ± 0.01	**72.17 ± 2.46**
^{24}Na	c	14.9590H	1369.0	100 ± 0	**65.88 ± 2.19**
		^{27}Al-plate for ^{207}Pb			
^{24}Na	c	14.9590H	1369.0	100 ± 0	**2.647 ± 0.088**
		^{27}Al-monitor for ^{nat}Pb			
^{7}Be	i	53.29D	477.6	10.52 ± 0.06	**63.18 ± 2.25**
^{27}Mg	c	9.458M	843.8	71.8 ± 0.4	8.077 ± 0.333
			1014.4	28.0 ± 0.4	8.114 ± 0.458
				RR_{mean} =	**8.086 ± 0.314**
^{22}Na	c	2.6019Y	1274.5	99.94 ± 0.01	**111.8 ± 3.8**
^{24}Na	c	14.9590H	1369.0	100 ± 0	**104.7 ± 3.5**
		^{27}Al-plate for ^{nat}Pb			
^{24}Na	c	14.9590H	1369.0	100 ± 0	**3.889 ± 0.130**
		^{27}Al-monitor for ^{209}Bi			
^{7}Be	i	53.29D	477.6	10.52 ± 0.06	**41.85 ± 1.50**
^{27}Mg	c	9.458M	843.8	71.8 ± 0.4	5.538 ± 0.242
			1014.4	28.0 ± 0.4	5.378 ± 0.435
				RR_{mean} =	**5.514 ± 0.232**
^{22}Na	c	2.6019Y	1274.5	99.94 ± 0.01	**72.84 ± 2.47**
^{24}Na	c	14.9590H	1369.0	100 ± 0	**68.59 ± 2.28**
		^{27}Al-plate for ^{209}Bi			
^{24}Na	c	14.9590H	1369.0	100 ± 0	**2.992 ± 0.100**

12.10 Detailed calculation of nuclide production rates for ^{206}Pb, ^{207}Pb, ^{208}Pb, ^{nat}Pb and ^{209}Bi for E_p = 1.6 GeV

12.10.1 Nuclide production rates for ^{206}Pb

Table 99: Detailed calculation of nuclide production rates for ^{206}Pb for E_p = 1.6 GeV, used to determine the cross sections for their production.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{206}Bi	i	6.243D	1718.7	31.8 ± 0.6	4.992 ± 0.383
			803.1	98.9 ± 1.4	5.433 ± 0.213
			537.5	30.5 ± 0.5	6.232 ± 0.374
			497.1	15.31 ± 0.22	16.80 ± 5.85
				RR_{mean} =	**5.493 ± 0.281**
^{205}Bi	i	15.31D	1861.7	6.17 ± 0.10	11.24 ± 1.24
			1764.3	32.5 ± 0.7	14.16 ± 0.66
				RR_{mean} =	**13.73 ± 1.12**
^{204}Bi	i	11.22H	984.0	59 ± 4	13.56 ± 1.20
			899.2	98 ± 9	16.11 ± 0.58
			374.8	82 ± 5	15.25 ± 3.20
				RR_{mean} =	**15.94 ± 0.49**
^{203}Bi	i(m+g)	11.76H	820.2	29.6 ± 1.5	**17.47 ± 1.33**
^{202}Bi	i	1.72H	422.1	83.7 ± 2.5	**12.97 ± 1.52**
^{204m}Pb$_i$	i(m)	67.2M	899.2	99.17 ± 0.02	43.99 ± 1.71
			374.7	89 ± 15	49.88 ± 8.63
				RR_{mean} =	**44.08 ± 1.71**
^{204m}Pb$_c$	c	67.2M	899.2	99.17 ± 0.02	46.41 ± 1.77
			374.7	89 ± 15	51.79 ± 8.95
				RR_{mean} =	**46.48 ± 1.77**
^{203}Pb	c*	51.873H	279.2	80.8 ± 0.2	**153.1 ± 5.6**
^{202m}Pb	i(m)	3.53H	960.7	92 ± 8	30.34 ± 3.43
			422.1	86 ± 5	38.16 ± 2.74
				RR_{mean} =	**36.53 ± 3.37**
^{201}Pb	c*	9.33H	331.2	79 ± 5	**110.5 ± 8.0**
^{200}Pb	c	21.5H	1205.7	*	75.59 ± 5.36
			579.3	*	70.96 ± 5.88
			450.5	3.33 ± 0.08	82.56 ± 4.95
			367.9	*	75.96 ± 2.66
			147.6	37.7 ± 1.4	80.89 ± 4.50
				RR_{mean} =	**76.47 ± 2.36**
^{199}Pb	c*	90M	366.9	44 ± 7	**134.3 ± 22.0**
^{198}Pb	c	2.4H	173.4	18 ± 3	**99.87 ± 17.17**
^{197m}Pb	c*	43M	385.9	74 ± 15	**64.22 ± 13.25**
^{195m}Pb	i(m)	15.0M	383.6	107 ± 20	**27.95 ± 5.50**
^{202}Tl	c	12.23D	439.6	91.4 ± 1.0	**71.54 ± 2.59**
^{201}Tl	c*	72.912H	167.4	10.00 ± 0.06	**191.5 ± 7.1**
^{200}Tl$_i$	i	26.1H	1205.7	29.9 ± 1.8	82.75 ± 5.97
			579.3	13.8 ± 0.7	87.18 ± 8.45
			367.9	87.2 ± 0.4	78.57 ± 3.15
				RR_{mean} =	**79.48 ± 3.05**
^{200}Tl$_c$	c	26.1H	1205.7	29.9 ± 1.8	158.3 ± 10.9

Continuation of Table 99.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			579.3	13.8 ± 0.7	158.1 ± 10.3
			367.9	87.2 ± 0.4	154.5 ± 5.3
				RR_{mean} =	**154.9 ± 5.2**
$^{199}Tl_c$	c	7.42H	455.5	12.4 ± 1.4	**134.5 ± 16.3**
^{199}Tl	c*	7.42H	455.5	12.4 ± 1.4	**157.2 ± 18.7**
^{198m}Tl	i(m)	1.87H	282.8	28 ± 3	**66.04 ± 7.67**
^{196m}Tl	i(m)	1.41H	695.4	41 ± 7	**115.6 ± 20.2**
^{203}Hg	c	46.612D	279.2	81.46 ± 0.13	**7.378 ± 0.297**
^{197m}Hg	i(m)	23.8H	134.0	33.5 ± 0.4	**29.83 ± 1.48**
^{195m}Hg	i(m)	41.6H	261.8	31 ± 4	**46.84 ± 7.13**
^{193m}Hg	i(m)	11.8H	258.0	49 ± 7	**59.51 ± 8.91**
^{192}Hg	c	4.85H	316.5	*	127.5 ± 16.1
			274.8	50.2 ± 2.5	109.1 ± 6.9
				RR_{mean} =	**111.5 ± 3.4**
^{190}Hg	c*	20.0M	142.6	68 ± 10	**74.90 ± 11.56**
^{198m}Au	i(m)	2.27D	411.8	*	**1.551 ± 0.128**
$^{198}Au_i$	i	2.69517D	411.8	95.58 ± 0.12	**3.560 ± 0.261**
$^{198}Au_c$	i(m+g)	2.69517D	411.8	95.58 ± 0.12	**5.111 ± 0.212**
^{196}Au	i(m1+m2+g)	6.183D	355.7	87.0 ± 0.8	9.774 ± 0.365
			333.0	22.9 ± 0.6	10.66 ± 0.56
				RR_{mean} =	**9.910 ± 0.442**
^{195}Au	c	186.098D	98.9	10.9 ± 0.9	**180.2 ± 17.6**
^{194}Au	i(m1+m2+g)	38.02H	328.5	61 ± 5	**18.40 ± 1.66**
$^{192}Au_i$	i(m+g)	4.94H	316.5	58 ± 7	**25.44 ± 3.89**
$^{192}Au_c$	c	4.94H	316.5	58 ± 7	**152.9 ± 19.2**
^{191}Au	c*	3.18H	674.2	6.8 ± 0.5	**164.6 ± 14.2**
$^{190}Au_c$	c	42.8M	301.8	23.4 ± 1.5	110.7 ± 9.5
			295.8	71 ± 5	128.7 ± 11.7
				RR_{mean} =	**117.3 ± 9.4**
^{191}Pt	c	2.802D	538.9	13.7 ± 1.6	136.3 ± 16.7
			456.5	3.4 ± 0.4	117.6 ± 14.6
			409.4	8.0 ± 0.9	108.2 ± 12.8
				RR_{mean} =	**117.3 ± 8.6**
^{189}Pt	c	10.87H	721.4	9.3 ± 0.8	139.3 ± 13.0
			607.6	8.10 ± 0.16	144.5 ± 6.5
			568.8	7.1 ± 0.6	124.9 ± 13.0
			544.9	5.8 ± 0.5	125.9 ± 12.3
			243.5	7.0 ± 1.2	143.9 ± 30.6
				RR_{mean} =	**140.2 ± 5.8**
^{188}Pt	c	10.2D	1209.8	*	119.2 ± 12.8
			423.3	4.4 ± 0.3	117.0 ± 9.1
			381.4	7.5 ± 0.5	115.4 ± 8.6
			195.1	18.6 ± 1.2	117.6 ± 8.8
			187.6	19.4 ± 1.2	117.2 ± 8.5
				RR_{mean} =	**117.2 ± 3.6**
^{186}Pt	c	2.08H	689.4	70 ± 15	**99.27 ± 21.55**
^{184}Pt	c	17.3M	548.3	23 ± 4	**92.64 ± 17.40**
^{192}Ir	i(m1+g)	73.827D	316.5	82.71 ± 0.21	**0.4885 ± 0.0828**
^{190}Ir	i(m1+g)	11.78D	569.3	28.5 ± 1.3	**1.512 ± 0.272**
^{189}Ir	c	13.2D	245.1	6.0 ± 0.6	**103.4 ± 11.4**

Continuation of Table 99.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
$^{188}Ir_c$	c	41.5H	1209.8	6.9 ± 0.7	**115.7 ± 12.6**
^{187}Ir	c*	10.5H	977.5	3.14 ± 0.11	**122.5 ± 7.5**
^{186}Ir	c	16.64H	434.8	33.9 ± 1.1	52.71 ± 3.05
			137.2	41.4 ± 0.7	56.75 ± 4.16
				RR_{mean} =	**53.99 ± 2.69**
^{185}Ir	c	14.4H	1829.0	10.1 ± 1.5	91.04 ± 14.27
			254.2	13.3 ± 2.4	77.51 ± 14.65
				RR_{mean} =	**87.84 ± 6.36**
^{184}Ir	c*	3.09H	390.4	25.9 ± 2.4	113.7 ± 11.3
			264.0	68 ± 4	111.2 ± 8.0
			119.8	31 ± 3	109.8 ± 12.1
				RR_{mean} =	**111.4 ± 4.6**
^{185}Os	c	93.6D	874.8	6.29 ± 0.25	129.6 ± 6.9
			717.4	3.94 ± 0.16	117.3 ± 7.0
			646.1	78 ± 3	117.6 ± 6.0
				RR_{mean} =	**120.5 ± 5.2**
^{183m}Os	c*	9.9H	1107.9	22.4 ± 0.6	75.24 ± 3.40
			1101.9	49.0 ± 1.3	66.61 ± 2.97
				RR_{mean} =	**70.17 ± 4.77**
^{182}Os	c	22.10H	263.3	6.71 ± 0.25	125.9 ± 7.7
			180.2	33.5 ± 1.7	121.2 ± 7.8
				RR_{mean} =	**123.6 ± 5.9**
^{180}Os	c	21.5M	902.8(D)	101.5 ± 3.4	**97.59 ± 5.71**
^{183}Re	c	70.0D	291.7	3.05 ± 0.18	120.3 ± 8.8
			162.3	23.3 ± 0.7	126.1 ± 6.0
				RR_{mean} =	**125.0 ± 5.1**
$^{182m}Re_c$	c	12.7H	1221.5	24.8 ± 1.6	126.6 ± 9.3
			1189.2	15 ± 1	124.2 ± 10.6
				RR_{mean} =	**125.7 ± 6.5**
^{181}Re	c*	19.9H	639.0	6.4 ± 1.4	119.1 ± 26.6
			365.5	56 ± 8	112.0 ± 16.8
				RR_{mean} =	**113.7 ± 12.5**
^{179}Re	c*	19.5M	430.2	28.0 ± 1.8	177.9 ± 16.5
			290.0	26.9 ± 2.3	139.0 ± 14.4
				RR_{mean} =	**158.2 ± 20.1**
^{178}Re	c*	13.2M	237.3	45 ± 5	**169.6 ± 20.5**
^{178}W	c	21.6D	1350.6(D)	1.18 ± 0.11	96.23 ± 10.51
			1340.8(D)	1.03 ± 0.09	83.42 ± 9.09
				RR_{mean} =	**88.86 ± 6.90**
^{177}W	c	135M	115.7	51 ± 5	**101.8 ± 11.2**
^{177}Ta	c*	56.56H	112.9	7.2 ± 1.6	**114.3 ± 26.0**
$^{176}Ta_c$	c	8.09H	1823.7	4.5 ± 0.4	81.93 ± 14.81
			1159.3	24.7 ± 1.9	107.5 ± 9.3
			710.5	5.4 ± 0.4	153.9 ± 15.2
				RR_{mean} =	**112.0 ± 12.7**
^{175}Ta	c	10.5H	1793.1	4.6 ± 0.7	93.39 ± 14.99
			348.5	12.0 ± 1.1	133.5 ± 13.2
			266.9	10.52 ± 0.16	116.0 ± 5.2
				RR_{mean} =	**116.1 ± 6.1**
$^{174}Ta_c$	c	1.14H	206.5	60 ± 5	**118.4 ± 11.0**

Continuation of Table 99.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{173}Ta	c	3.14H	172.2	17.5 ± 1.8	**125.6 ± 13.9**
^{172}Ta	c*	36.8M	214.1	55 ± 5	**72.84 ± 7.66**
^{175}Hf	c	70D	343.4	84 ± 3	**114.8 ± 5.6**
^{173}Hf	c*	23.6H	311.2	10.7 ± 0.5	136.9 ± 8.6
			139.6	12.7 ± 0.6	135.8 ± 8.8
			123.7	83 ± 5	142.3 ± 10.7
				RR_{mean} =	**137.6 ± 5.6**
^{172}Hf	c	1.87Y	1093.6	*	100.2 ± 5.9
			1002.7(D)	5.55 ± 0.38	99.51 ± 9.47
			181.5	*	102.3 ± 6.4
			125.8	11.3 ± 0.9	104.6 ± 9.8
				RR_{mean} =	**101.3 ± 3.1**
^{171}Hf	c	12.1H	739.8	*	**100.0 ± 12.5**
^{170}Hf	c	16.01H	620.7	18 ± 5	142.7 ± 40.0
			164.7	26 ± 8	132.6 ± 41.1
			120.2	15 ± 5	137.0 ± 46.2
				RR_{mean} =	**140.2 ± 9.9**
^{173}Lu	c	1.37Y	272.1	21.2 ± 0.8	**115.1 ± 6.3**
^{172}Lu$_i$	i(m+g)	6.70D	1093.6	63 ± 3	**0.3884 ± 0.0917**
^{172}Lu$_c$	c	6.70D	1093.6	63 ± 3	**100.6 ± 5.9**
^{171}Lu	c*	8.24D	853.0	2.55 ± 0.07	116.9 ± 6.8
			780.7	4.36 ± 0.11	136.8 ± 6.2
			667.4	11.0 ± 0.3	125.3 ± 5.5
				RR_{mean} =	**127.9 ± 6.4**
^{171}Lu$_c$	c	8.24D	739.8	47.8 ± 1.2	**117.0 ± 4.9**
^{170}Lu$_c$	c	2.012D	2126.1	5.1 ± 0.3	102.3 ± 8.2
			1280.2	8.2 ± 0.4	100.1 ± 6.7
			1054.3	4.76 ± 0.24	89.42 ± 6.67
				RR_{mean} =	**96.82 ± 4.90**
^{169}Lu	c	34.06H	960.6	23.4 ± 0.7	91.70 ± 4.20
			191.2	20.6 ± 0.6	101.0 ± 4.9
				RR_{mean} =	**95.30 ± 5.40**
^{167}Lu	c	51.5M	176.2	*	86.80 ± 4.85
			113.3	*	107.5 ± 7.8
				RR_{mean} =	**91.89 ± 9.36**
^{169}Yb	c*	32.026D	198.0	35.8 ± 0.7	111.4 ± 5.1
			177.2	22.2 ± 0.5	108.7 ± 4.7
			130.5	11.31 ± 0.21	113.0 ± 5.3
				RR_{mean} =	**110.7 ± 3.9**
^{166}Yb	c	56.7H	2079.5	*	96.05 ± 7.30
			2052.4	*	104.0 ± 7.3
			1867.9	*	104.0 ± 7.5
			1374.2	*	102.5 ± 8.3
			1176.7	*	100.1 ± 7.3
			785.9	*	104.1 ± 7.5
			691.2(D)	8.56 ± 0.58	92.96 ± 7.23
				RR_{mean} =	**100.4 ± 3.1**
^{167}Tm	c	9.25D	207.8	42 ± 8	**112.6 ± 21.9**
^{165}Tm	c	30.06H	806.4	9.5 ± 0.6	105.2 ± 7.7
			242.9	35.5 ± 1.7	104.1 ± 6.5

Continuation of Table 99.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
				RR_{mean} =	**104.4 ± 4.3**
^{161}Er	c*	3.21H	826.6	64 ± 4	**111.1 ± 8.2**
^{160}Er	c	28.58H	966.2	*	96.18 ± 12.95
			962.4	*	94.27 ± 12.37
			879.4(D)	22.6 ± 2.8	102.7 ± 13.3
			872.0(D)	6.8 ± 1.1	102.1 ± 17.1
			728.2(D)	34 ± 5	101.9 ± 15.4
				RR_{mean} =	**99.05 ± 3.06**
^{159}Er	c*	36M	624.5	33 ± 4	111.9 ± 14.3
			132.0	*	126.7 ± 8.7
				RR_{mean} =	**123.2 ± 3.8**
^{160m}Ho$_c$	c	5.02H	966.2	15.4 ± 2.0	99.08 ± 13.41
			962.4	16.6 ± 2.1	93.34 ± 12.93
				RR_{mean} =	**96.12 ± 9.01**
^{156}Ho	c*	56M	266.5	54.7 ± 1.1	**102.7 ± 4.9**
^{157}Dy	c	8.14H	326.2	92 ± 4	**84.88 ± 4.72**
^{155}Dy	c*	9.9H	226.9	68.4 ± 1.6	**73.73 ± 3.43**
^{152}Dy	c	2.38H	256.9	97.50 ± 0.07	**41.93 ± 1.76**
^{155}Tb	c*	5.32D	180.1	7.5 ± 0.5	64.82 ± 5.12
			105.3	25.1 ± 1.3	75.44 ± 5.47
				RR_{mean} =	**70.56 ± 5.72**
^{153}Tb	c*	2.34D	212.0	31.0 ± 1.9	**57.99 ± 4.24**
^{152}Tb	c*	17.5H	344.3	65 ± 4	**51.67 ± 3.67**
^{151}Tb	c	17.609H	479.4	15.4 ± 0.7	46.30 ± 3.00
			251.9	26.3 ± 1.2	41.02 ± 2.68
				RR_{mean} =	**43.38 ± 2.95**
^{149}Tb	c	4.118H	165.0	26.4 ± 0.9	**18.01 ± 1.84**
^{148}Tb	c	60M	784.4	84.0 ± 1.6	**27.74 ± 1.35**
^{153}Gd	c	240.4D	103.2	21.1 ± 0.7	54.89 ± 3.36
			97.4	29.0 ± 0.8	52.29 ± 3.02
				RR_{mean} =	**53.40 ± 2.41**
^{151}Gd	c	124D	243.3	5.6 ± 0.4	**47.38 ± 4.03**
^{149}Gd	c	9.28D	788.9	7.3 ± 0.4	62.34 ± 4.15
			346.6	23.9 ± 1.3	54.43 ± 3.49
			298.6	28.6 ± 1.7	55.41 ± 3.84
			149.7	48 ± 3	60.56 ± 4.44
				RR_{mean} =	**56.98 ± 2.62**
^{147}Gd	c	38.06H	929.0	20.2 ± 1.2	46.86 ± 3.60
			396.0	34.3 ± 2.1	43.26 ± 3.05
			370.0	17.2 ± 0.9	46.43 ± 3.00
				RR_{mean} =	**45.43 ± 1.90**
^{146}Gd	c	48.27D	747.2	*	46.74 ± 2.09
			154.6	46.6 ± 0.5	48.62 ± 2.28
				RR_{mean} =	**47.56 ± 1.47**
^{149}Eu	c*	93.1D	327.5	4.03 ± 0.12	**67.41 ± 3.70**
^{147}Eu	c*	24.1D	955.8	3.84 ± 0.20	53.93 ± 3.81
			798.7	4.8 ± 0.3	61.81 ± 4.50
			677.5	9.8 ± 0.5	57.50 ± 3.56
			601.5	5.9 ± 0.3	57.79 ± 3.63
			121.2	22.9 ± 1.3	52.66 ± 3.84

Continuation of Table 99.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
				RR_{mean} =	**56.71 ± 2.21**
$^{146}Eu_i$	i	4.61D	747.2	99 ± 3	**6.290 ± 0.306**
$^{146}Eu_c$	c	4.61D	747.2	99 ± 3	**53.03 ± 2.37**
^{145}Eu	c	5.93D	1997.0	7.2 ± 0.5	38.05 ± 3.22
			1658.5	14.9 ± 1.0	34.59 ± 2.69
			893.7	66 ± 5	37.14 ± 3.11
			653.5	15 ± 1	35.49 ± 2.68
				RR_{mean} =	**36.04 ± 1.59**
^{143}Pm	c	265D	742.0	38.5 ± 2.4	**31.58 ± 2.28**
^{139}Ce	c	137.640D	165.9	79.89 ± 0.01	**27.74 ± 1.01**
^{135}Ce	c	17.7H	265.6	41.8 ± 1.5	**17.11 ± 1.05**
^{132}Ce	c	3.51H	182.1	77.4 ± 0.5	**12.01 ± 0.76**
$^{132}La_c$	c	4.8H	464.5	76 ± 6	**12.46 ± 1.13**
^{133}Ba	c	3848.9D	356.0	62.05 ± 0.19	**17.29 ± 1.79**
^{131}Ba	c	11.50D	496.3	46.8 ± 0.2	13.09 ± 1.46
			373.2	14.04 ± 0.20	15.43 ± 0.64
			123.8	29.0 ± 0.3	14.43 ± 0.73
				RR_{mean} =	**14.97 ± 0.65**
^{128}Ba	c	2.43D	442.9	26.8 ± 1.4	9.553 ± 0.819
			273.4	14.5 ± 0.7	10.36 ± 0.91
				RR_{mean} =	**9.906 ± 0.552**
^{129}Cs	c	32.06H	371.9	30.6 ± 1.7	**17.09 ± 1.20**
^{127}Xe	c	36.4D	375.0	17.2 ± 0.6	13.47 ± 0.73
			202.9	68.3 ± 0.5	12.20 ± 0.48
				RR_{mean} =	**12.45 ± 0.63**
^{123}Xe	c	2.08H	148.9	48.9 ± 0.6	**13.38 ± 1.26**
^{123m}Te	i(m)	119.7D	159.0	84.0 ± 0.4	**1.100 ± 0.076**
^{121m}Te	i(m)	154D	212.2	81.4 ± 1.1	1.876 ± 0.150
			573.1	88.6 ± 0.1	1.837 ± 0.305
				RR_{mean} =	**1.869 ± 0.058**
$^{121}Te_c$	c	19.16D	573.1	80.3 ± 2.5	**9.819 ± 0.504**
^{119m}Te	i(m)	4.70D	1212.7	66.2 ± 0.3	**2.832 ± 0.185**
^{120m}Sb	i(m)	5.76D	1171.7	100 ± 0	1.523 ± 0.082
			1023.3	99.4 ± 0.3	1.349 ± 0.070
				RR_{mean} =	**1.420 ± 0.096**
^{113}Sn	c	115.09D	391.7	64.97 ± 0.17	**5.696 ± 0.263**
^{114m}In	i(m)	49.51D	190.3	15.56 ± 0.16	**4.773 ± 0.966**
^{111}In	c	2.8047D	245.4	94 ± 1	7.971 ± 0.377
			171.3	90.2 ± 1.0	6.877 ± 0.333
				RR_{mean} =	**7.367 ± 0.590**
^{110m}Ag	i(m)	249.76D	884.7	72.7 ± 0.4	3.539 ± 0.239
			657.8	94.3 ± 0.3	3.577 ± 0.175
				RR_{mean} =	**3.566 ± 0.159**
^{106m}Ag	i(m)	8.28D	1045.8	29.6 ± 1.0	4.920 ± 0.317
			717.3	28.9 ± 0.8	4.923 ± 0.365
			451.0	28.2 ± 0.8	4.402 ± 0.267
				RR_{mean} =	**4.681 ± 0.233**
^{105}Ag	c	41.29D	443.4	10.5 ± 0.6	8.083 ± 0.957
			280.4	30.2 ± 1.8	6.427 ± 0.505
				RR_{mean} =	**6.754 ± 0.692**

Continuation of Table 99.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{100}Pd	c	3.63D	2376.0	*	**1.174 ± 0.178**
^{102}Rh	i	207D	475.1	46 ± 5	**3.616 ± 0.469**
^{101m}Rh	c	4.34D	306.9	81 ± 5	**8.156 ± 0.729**
^{100}Rh$_i$	i(m+g)	20.8H	2376.0	32.6 ± 0.4	**5.280 ± 0.513**
^{100}Rh$_c$	c	20.8H	2376.0	32.6 ± 0.4	**6.454 ± 0.491**
^{103}Ru	c	39.26D	497.1	91.0 ± 1.3	**11.16 ± 0.46**
^{96}Tc	i(m+g)	4.28D	849.9	98 ± 4	6.682 ± 0.365
			812.5	82 ± 4	7.222 ± 0.433
				RR_{mean} =	**6.896 ± 0.339**
^{99}Mo	c	65.94H	140.5	90.27 ± 0.33	**9.574 ± 0.413**
^{93m}Mo	i(m)	6.85H	684.7	99.7 ± 2.0	**4.434 ± 0.273**
^{96}Nb	i	23.35H	1091.3	48.5 ± 1.6	7.537 ± 0.543
			568.9	58.0 ± 0.3	7.023 ± 0.555
				RR_{mean} =	**7.291 ± 0.420**
^{95}Nb$_i$	i(m+g)	34.975D	765.8	99.81 ± 0.03	**10.53 ± 0.40**
^{95}Nb$_c$	c	34.975D	765.8	99.81 ± 0.03	**16.86 ± 0.58**
^{90}Nb	c*	14.60H	2319.0	82.0 ± 0.3	5.816 ± 0.403
			1129.2	92.7 ± 0.5	5.802 ± 0.337
				RR_{mean} =	**5.808 ± 0.287**
^{95}Zr	c	64.02D	765.8	*	6.391 ± 0.322
			756.7	54.46 ± 0.10	5.492 ± 0.296
				RR_{mean} =	**5.922 ± 0.183**
^{89}Zr	c	78.41H	909.2	99.04 ± 0.03	**13.04 ± 0.45**
^{88}Zr	c	83.4D	1836.1	*	7.525 ± 0.395
			898.0	*	7.049 ± 0.645
			392.9	97.24 ± 0.00	7.156 ± 0.278
				RR_{mean} =	**7.227 ± 0.223**
^{88} Y$_i$	i	106.65D	1836.1	99.2 ± 0.3	14.99 ± 0.56
			898.0	93.7 ± 0.3	15.09 ± 0.65
				RR_{mean} =	**15.02 ± 0.53**
^{88} Y$_c$	c	106.65D	1836.1	99.2 ± 0.3	22.52 ± 0.80
			898.0	93.7 ± 0.3	22.14 ± 0.80
				RR_{mean} =	**22.34 ± 0.75**
^{87} Y	c*	79.8H	484.8	89.7 ± 0.7	**17.63 ± 0.64**
^{86} Y$_c$	c	14.74H	1076.6	82.5 ± 0.4	**7.776 ± 0.374**
^{85}Sr	c	64.84D	514.0	96 ± 4	**17.16 ± 0.94**
^{84}Rb	i(m+g)	32.77D	881.6	69.0 ± 1.6	**15.49 ± 0.79**
^{83}Rb	c	86.2D	552.6	16.0 ± 1.1	21.06 ± 1.67
			529.6	29.3 ± 2.1	19.52 ± 1.59
			520.4	45 ± 4	19.47 ± 1.88
				RR_{mean} =	**20.11 ± 0.90**
^{82m}Rb	i(m)	6.472H	554.3	62.4 ± 0.9	**7.895 ± 0.787**
^{82}Br	i(m+g)	35.30H	554.3	70.8 ± 1.0	**6.713 ± 0.329**
^{75}Se	c	119.779D	264.7	58.9 ± 0.4	8.818 ± 0.352
			136.0	58.3 ± 0.8	9.767 ± 0.431
			121.1	17.2 ± 0.4	10.94 ± 0.97
				RR_{mean} =	**9.213 ± 0.487**
^{74}As	i	17.77D	595.8	59 ± 4	**10.60 ± 0.81**
^{71}As	c	65.28H	174.9	82.0 ± 2.1	**1.983 ± 0.158**
^{72}Ga$_i$	i	14.10H	2201.7	25.9 ± 0.5	**4.589 ± 0.945**

Continuation of Table 99.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
$^{72}Ga_c$	c	14.10H	2201.7	25.9 ± 0.5	**6.070 ± 0.872**
^{72}Zn	c	46.5H	2201.7	*	**1.481 ± 0.386**
^{58}Co	i(m+g)	70.86D	810.8	99.45 ± 0.01	**3.501 ± 0.299**
^{59}Fe	c	44.472D	1291.6	43.2 ± 1.4	4.739 ± 0.257
			1099.2	56.5 ± 1.9	4.709 ± 0.256
				RR_{mean} =	**4.724 ± 0.199**
^{54}Mn	i	312.11D	834.8	99.98 ± 0.00	**4.318 ± 0.214**
^{48}V	c	15.9735D	1312.1	97.5 ± 0.9	0.6487 ± 0.0798
			983.5	100.0 ± 0.3	0.7455 ± 0.0504
				RR_{mean} =	**0.7211 ± 0.0476**
^{48}Sc	i	43.67H	1312.1	100.1 ± 0.7	2.399 ± 0.227
			1037.5	97.6 ± 0.7	2.166 ± 0.127
				RR_{mean} =	**2.213 ± 0.118**
^{46}Sc	i(m+g)	83.79D	1120.6	99.99 ± 0.00	3.646 ± 0.230
			889.3	99.98 ± 0.00	4.247 ± 0.163
				RR_{mean} =	**4.135 ± 0.267**
^{28}Mg	c	20.915H	1778.8	100.2 ± 0.0	**1.872 ± 0.200**
^{24}Na	c	14.9590H	1369.0	100 ± 0	**6.214 ± 0.294**
^{7}Be	i	53.29D	477.6	10.52 ± 0.06	**17.40 ± 1.21**

12.10.2 Nuclide production rates for ^{207}Pb

Table 100: Detailed calculation of nuclide production rates for ^{207}Pb for $E_p = 1.6$ GeV, used to determine the cross sections for their production.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{206}Bi	i	6.243D	1718.7	31.8 ± 0.6	7.396 ± 0.371
			803.1	98.9 ± 1.4	7.301 ± 0.269
			537.5	30.5 ± 0.5	7.304 ± 0.418
			497.1	15.31 ± 0.22	10.00 ± 2.43
				RR_{mean} =	**7.325 ± 0.257**
^{205}Bi	i	15.31D	1861.7	6.17 ± 0.10	9.488 ± 0.801
			1764.3	32.5 ± 0.7	10.79 ± 0.52
				RR_{mean} =	**10.49 ± 0.63**
^{204}Bi	i	11.22H	984.0	59 ± 4	13.96 ± 1.31
			899.2	98 ± 9	11.01 ± 0.46
			374.8	82 ± 5	10.09 ± 2.12
				RR_{mean} =	**11.16 ± 0.34**
^{203}Bi	i(m+g)	11.76H	820.2	29.6 ± 1.5	**11.84 ± 0.84**
^{202}Bi	i	1.72H	422.1	83.7 ± 2.5	**8.699 ± 1.023**
$^{204m}Pb_i$	i(m)	67.2M	899.2	99.17 ± 0.02	27.35 ± 1.48
			374.7	89 ± 15	30.94 ± 5.38
				RR_{mean} =	**27.53 ± 1.46**
$^{204m}Pb_c$	c	67.2M	899.2	99.17 ± 0.02	29.00 ± 1.51
			374.7	89 ± 15	32.21 ± 5.60
				RR_{mean} =	**29.15 ± 1.49**
^{203}Pb	c*	51.873H	279.2	80.8 ± 0.2	**80.19 ± 2.93**
^{202m}Pb	i(m)	3.53H	960.7	92 ± 8	21.91 ± 2.37
			422.1	86 ± 5	23.64 ± 1.75

Continuation of Table 100.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
				RR_{mean} =	**23.27 ± 1.15**
^{201}Pb	c*	9.33H	331.2	79 ± 5	**59.97 ± 4.36**
^{200}Pb	c	21.5H	579.3	*	37.87 ± 3.25
			1205.7	*	42.10 ± 3.31
			450.5	3.33 ± 0.08	49.34 ± 4.15
			367.9	*	40.75 ± 1.46
			257.2	4.46 ± 0.17	33.29 ± 4.80
			147.6	37.7 ± 1.4	45.02 ± 2.45
				RR_{mean} =	**40.86 ± 1.26**
^{199}Pb	c*	90M	366.9	44 ± 7	**78.89 ± 13.06**
^{198}Pb	c	2.4H	173.4	18 ± 3	**58.67 ± 10.16**
^{197m}Pb	c*	43M	385.9	74 ± 15	**35.49 ± 7.40**
^{195m}Pb	i(m)	15.0M	383.6	107 ± 20	**15.45 ± 3.14**
^{202}Tl	c	12.23D	439.6	91.4 ± 1.0	**42.47 ± 1.54**
^{201}Tl	c*	72.912H	167.4	10.00 ± 0.06	**111.0 ± 4.1**
^{200}Tl$_i$	i	26.1H	1205.7	29.9 ± 1.8	50.71 ± 4.30
			579.3	13.8 ± 0.7	54.21 ± 5.68
			367.9	87.2 ± 0.4	47.01 ± 1.93
				RR_{mean} =	**47.67 ± 1.94**
^{200}Tl$_c$	c	26.1H	1205.7	29.9 ± 1.8	92.82 ± 6.52
			579.3	13.8 ± 0.7	92.08 ± 6.17
			367.9	87.2 ± 0.4	87.76 ± 3.03
				RR_{mean} =	**88.22 ± 2.99**
^{199}Tl$_c$	c	7.42H	455.5	12.4 ± 1.4	**66.98 ± 9.12**
^{199}Tl	c*	7.42H	455.5	12.4 ± 1.4	**87.15 ± 10.70**
^{198m}Tl	i(m)	1.87H	282.8	28 ± 3	**44.42 ± 5.39**
^{196m}Tl	i(m)	1.41H	695.4	41 ± 7	**70.00 ± 12.24**
^{203}Hg	c	46.612D	279.2	81.46 ± 0.13	**7.470 ± 0.283**
^{197m}Hg	i(m)	23.8H	134.0	33.5 ± 0.4	**21.72 ± 1.07**
^{195m}Hg	i(m)	41.6H	261.8	31 ± 4	**30.30 ± 4.40**
^{193m}Hg	i(m)	11.8H	258.0	49 ± 7	**41.11 ± 6.13**
^{192}Hg	c	4.85H	316.5	*	73.95 ± 9.40
			274.8	50.2 ± 2.5	63.87 ± 4.05
				RR_{mean} =	**65.19 ± 2.01**
^{190}Hg	c*	20.0M	142.6	68 ± 10	**46.19 ± 7.23**
^{198m}Au	i(m)	2.27D	411.8	*	**1.230 ± 0.184**
^{198}Au$_i$	i	2.69517D	411.8	95.58 ± 0.12	**3.095 ± 0.346**
^{198}Au$_c$	i(m+g)	2.69517D	411.8	95.58 ± 0.12	**4.325 ± 0.229**
^{196}Au	i(m1+m2+g)	6.183D	355.7	87.0 ± 0.8	7.420 ± 0.281
			333.0	22.9 ± 0.6	7.851 ± 0.368
				RR_{mean} =	**7.521 ± 0.295**
^{195}Au	c	186.098D	98.9	10.9 ± 0.9	**85.75 ± 8.46**
^{194}Au	i(m1+m2+g)	38.02H	328.5	61 ± 5	**12.82 ± 1.14**
^{192}Au$_i$	i(m+g)	4.94H	316.5	58 ± 7	**18.43 ± 2.85**
^{192}Au$_c$	c	4.94H	316.5	58 ± 7	**92.38 ± 11.64**
^{191}Au	c*	3.18H	674.2	6.8 ± 0.5	**99.53 ± 9.80**
^{190}Au$_c$	c	42.8M	301.8	23.4 ± 1.5	67.23 ± 7.19
			295.8	71 ± 5	71.11 ± 9.87
				RR_{mean} =	**68.40 ± 5.25**
^{191}Pt	c	2.802D	538.9	13.7 ± 1.6	87.95 ± 11.01

Continuation of Table 100.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			456.5	3.4 ± 0.4	65.75 ± 8.23
			409.4	8.0 ± 0.9	68.11 ± 8.03
				RR_{mean} =	**70.97 ± 6.14**
^{189}Pt	c	10.87H	721.4	9.3 ± 0.8	83.26 ± 7.89
			607.6	8.10 ± 0.16	84.41 ± 4.55
			568.8	7.1 ± 0.6	85.16 ± 9.36
			544.9	5.8 ± 0.5	76.18 ± 7.58
			243.5	7.0 ± 1.2	107.1 ± 22.5
				RR_{mean} =	**83.42 ± 3.82**
^{188}Pt	c	10.2D	1209.8	*	73.19 ± 7.89
			423.3	4.4 ± 0.3	71.12 ± 5.52
			381.4	7.5 ± 0.5	68.50 ± 5.18
			195.1	18.6 ± 1.2	69.12 ± 5.17
			187.6	19.4 ± 1.2	71.12 ± 5.19
				RR_{mean} =	**70.44 ± 2.17**
^{186}Pt	c	2.08H	689.4	70 ± 15	**59.68 ± 12.96**
^{184}Pt	c	17.3M	548.3	23 ± 4	**56.17 ± 12.30**
^{192}Ir	i(m1+g)	73.827D	316.5	82.71 ± 0.21	**0.4604 ± 0.0992**
^{190}Ir	i(m1+g)	11.78D	569.3	28.5 ± 1.3	**1.083 ± 0.191**
^{189}Ir	c	13.2D	245.1	6.0 ± 0.6	**71.11 ± 8.11**
$^{188}Ir_c$	c	41.5H	1209.8	6.9 ± 0.7	**74.83 ± 8.12**
^{187}Ir	c*	10.5H	977.5	3.14 ± 0.11	**73.55 ± 5.24**
^{186}Ir	c	16.64H	434.8	33.9 ± 1.1	35.23 ± 1.74
			137.2	41.4 ± 0.7	35.97 ± 3.30
				RR_{mean} =	**35.35 ± 1.64**
^{185}Ir	c	14.4H	1829.0	10.1 ± 1.5	54.71 ± 8.56
			254.2	13.3 ± 2.4	45.70 ± 11.06
				RR_{mean} =	**53.75 ± 3.32**
^{184}Ir	c*	3.09H	390.4	25.9 ± 2.4	68.43 ± 6.87
			264.0	68 ± 4	69.55 ± 4.93
			119.8	31 ± 3	69.13 ± 7.63
				RR_{mean} =	**69.39 ± 2.76**
^{185}Os	c	93.6D	874.8	6.29 ± 0.25	75.94 ± 4.12
			717.4	3.94 ± 0.16	76.03 ± 4.54
			646.1	78 ± 3	73.22 ± 3.74
				RR_{mean} =	**74.10 ± 2.46**
^{183m}Os	c*	9.9H	1107.9	22.4 ± 0.6	44.69 ± 2.56
			1101.9	49.0 ± 1.3	42.12 ± 1.87
				RR_{mean} =	**42.58 ± 1.64**
^{182}Os	c	22.10H	263.3	6.71 ± 0.25	74.60 ± 5.74
			180.2	33.5 ± 1.7	78.50 ± 5.12
				RR_{mean} =	**76.89 ± 4.03**
^{180}Os	c	21.5M	902.8(D)	101.5 ± 3.4	**61.23 ± 3.21**
^{183}Re	c	70.0D	291.7	3.05 ± 0.18	70.55 ± 5.09
			162.3	23.3 ± 0.7	77.35 ± 3.66
				RR_{mean} =	**75.94 ± 3.62**
$^{182m}Re_c$	c	12.7H	1221.5	24.8 ± 1.6	81.11 ± 6.21
			1189.2	15 ± 1	64.20 ± 5.84
				RR_{mean} =	**73.03 ± 8.74**
^{181}Re	c*	19.9H	639.0	6.4 ± 1.4	73.16 ± 16.34

Continuation of Table 100.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			365.5	56 ± 8	68.11 ± 10.03
				RR_{mean} =	**69.24 ± 7.45**
^{179}Re	c*	19.5M	430.2	28.0 ± 1.8	96.53 ± 7.84
			290.0	26.9 ± 2.3	80.28 ± 9.38
				RR_{mean} =	**93.22 ± 7.15**
^{178}Re	c*	13.2M	237.3	45 ± 5	**102.5 ± 12.6**
^{178} W	c	21.6D	1350.6(D)	1.18 ± 0.11	71.24 ± 8.05
			1340.8(D)	1.03 ± 0.09	51.92 ± 6.03
				RR_{mean} =	**59.23 ± 9.55**
^{177} W	c	135M	115.7	51 ± 5	**70.20 ± 7.80**
^{177}Ta	c*	56.56H	112.9	7.2 ± 1.6	**77.67 ± 17.74**
^{176}Ta$_c$	c	8.09H	1823.7	4.5 ± 0.4	73.96 ± 11.24
			1159.3	24.7 ± 1.9	70.70 ± 6.03
			710.5	5.4 ± 0.4	78.30 ± 10.47
				RR_{mean} =	**71.25 ± 2.94**
^{175}Ta	c	10.5H	1793.1	4.6 ± 0.7	63.40 ± 10.24
			348.5	12.0 ± 1.1	85.88 ± 8.81
			266.9	10.52 ± 0.16	72.67 ± 3.38
				RR_{mean} =	**73.18 ± 3.72**
^{174}Ta$_c$	c	1.14H	206.5	60 ± 5	**74.24 ± 6.92**
^{173}Ta	c	3.14H	172.2	17.5 ± 1.8	**82.51 ± 9.29**
^{172}Ta	c*	36.8M	214.1	55 ± 5	**49.95 ± 5.21**
^{175}Hf	c	70D	343.4	84 ± 3	**71.60 ± 3.53**
^{173}Hf	c*	23.6H	311.2	10.7 ± 0.5	86.21 ± 5.18
			139.6	12.7 ± 0.6	89.12 ± 5.97
			123.7	83 ± 5	86.86 ± 6.55
				RR_{mean} =	**87.18 ± 3.52**
^{172}Hf	c	1.87Y	1093.6	*	61.23 ± 3.59
			1002.7(D)	5.55 ± 0.38	57.88 ± 7.44
			181.5	*	61.71 ± 3.93
			125.8	11.3 ± 0.9	65.22 ± 6.22
				RR_{mean} =	**61.75 ± 1.90**
^{171}Hf	c	12.1H	739.8	*	**64.00 ± 6.13**
^{170}Hf	c	16.01H	620.7	18 ± 5	87.22 ± 24.57
			164.7	26 ± 8	84.05 ± 26.07
			120.2	15 ± 5	85.00 ± 28.66
				RR_{mean} =	**86.32 ± 6.38**
^{173}Lu	c	1.37Y	272.1	21.2 ± 0.8	**70.51 ± 3.80**
^{172}Lu$_i$	i(m+g)	6.70D	1093.6	63 ± 3	**0.5557 ± 0.0910**
^{172}Lu$_c$	c	6.70D	1093.6	63 ± 3	**61.79 ± 3.62**
^{171}Lu	c*	8.24D	853.0	2.55 ± 0.07	76.52 ± 3.73
			780.7	4.36 ± 0.11	82.54 ± 3.72
			667.4	11.0 ± 0.3	77.47 ± 3.48
				RR_{mean} =	**78.95 ± 3.06**
^{171}Lu$_c$	c	8.24D	739.8	47.8 ± 1.2	**72.35 ± 3.02**
^{170}Lu$_c$	c	2.012D	2126.1	5.1 ± 0.3	66.19 ± 5.33
			1280.2	8.2 ± 0.4	63.61 ± 4.49
			1054.3	4.76 ± 0.24	59.80 ± 4.14
				RR_{mean} =	**62.49 ± 2.71**
^{169}Lu	c	34.06H	960.6	23.4 ± 0.7	55.99 ± 2.63

Continuation of Table 100.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			191.2	20.6 ± 0.6	60.79 ± 3.00
				RR_{mean} =	**57.94 ± 2.96**
^{167}Lu	c	51.5M	176.2	*	58.37 ± 3.42
			113.3	*	66.51 ± 5.03
				RR_{mean} =	**60.70 ± 4.13**
^{169}Yb	c*	32.026D	198.0	35.8 ± 0.7	65.22 ± 2.93
			177.2	22.2 ± 0.5	67.00 ± 2.92
			130.5	11.31 ± 0.21	66.21 ± 3.13
				RR_{mean} =	**66.17 ± 2.31**
^{166}Yb	c	56.7H	2079.5	*	63.60 ± 4.78
			2052.4	*	62.94 ± 4.44
			1867.9	*	62.27 ± 4.71
			1374.2	*	66.99 ± 5.58
			1176.7	*	62.01 ± 4.66
			785.9	*	67.71 ± 4.94
			691.2(D)	8.56 ± 0.58	58.04 ± 4.50
				RR_{mean} =	**63.07 ± 1.95**
^{167}Tm	c	9.25D	207.8	42 ± 8	**68.17 ± 13.25**
^{165}Tm	c	30.06H	806.4	9.5 ± 0.6	68.34 ± 5.24
			242.9	35.5 ± 1.7	63.06 ± 3.92
				RR_{mean} =	**64.29 ± 2.99**
^{161}Er	c*	3.21H	826.6	64 ± 4	**68.60 ± 5.02**
^{160}Er	c	28.58H	966.2	*	59.35 ± 7.98
			962.4	*	58.26 ± 7.70
			879.4(D)	22.6 ± 2.8	62.42 ± 8.06
			872.0(D)	6.8 ± 1.1	57.66 ± 9.63
			728.2(D)	34 ± 5	60.03 ± 9.07
				RR_{mean} =	**59.67 ± 1.84**
^{159}Er	c*	36M	624.5	33 ± 4	63.86 ± 8.37
			132.0	*	69.34 ± 4.50
				RR_{mean} =	**68.29 ± 2.11**
$^{160m}Ho_c$	c	5.02H	966.2	15.4 ± 2.0	59.64 ± 8.17
			962.4	16.6 ± 2.1	51.32 ± 7.70
				RR_{mean} =	**55.30 ± 5.44**
^{156}Ho	c*	56M	266.5	54.7 ± 1.1	**60.05 ± 3.00**
^{157}Dy	c	8.14H	326.2	92 ± 4	**51.38 ± 2.88**
^{155}Dy	c*	9.9H	226.9	68.4 ± 1.6	**42.69 ± 1.99**
^{152}Dy	c	2.38H	256.9	97.50 ± 0.07	**25.05 ± 1.14**
^{155}Tb	c*	5.32D	180.1	7.5 ± 0.5	40.25 ± 3.23
			105.3	25.1 ± 1.3	44.20 ± 3.26
				RR_{mean} =	**42.46 ± 2.36**
^{153}Tb	c*	2.34D	212.0	31.0 ± 1.9	**35.86 ± 2.62**
^{152}Tb	c*	17.5H	344.3	65 ± 4	**32.57 ± 2.42**
^{151}Tb	c	17.609H	479.4	15.4 ± 0.7	26.27 ± 1.84
			251.9	26.3 ± 1.2	25.06 ± 1.72
				RR_{mean} =	**25.61 ± 1.27**
^{149}Tb	c	4.118H	165.0	26.4 ± 0.9	**10.06 ± 1.84**
^{148}Tb	c	60M	784.4	84.0 ± 1.6	**13.99 ± 0.78**
^{153}Gd	c	240.4D	103.2	21.1 ± 0.7	32.47 ± 2.13
			97.4	29.0 ± 0.8	30.56 ± 1.81

Continuation of Table 100.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
				RR_{mean} =	**31.31** ± **1.47**
^{151}Gd	c	124D	243.3	5.6 ± 0.4	**26.87** ± **2.59**
^{149}Gd	c	9.28D	788.9	7.3 ± 0.4	37.35 ± 2.48
			346.6	23.9 ± 1.3	31.93 ± 2.05
			298.6	28.6 ± 1.7	31.71 ± 2.19
			149.7	48 ± 3	34.68 ± 2.55
				RR_{mean} =	**33.38** ± **1.67**
^{147}Gd	c	38.06H	929.0	20.2 ± 1.2	26.57 ± 1.85
			396.0	34.3 ± 2.1	24.75 ± 1.77
			370.0	17.2 ± 0.9	26.51 ± 1.74
				RR_{mean} =	**25.98** ± **1.07**
^{146}Gd	c	48.27D	747.2	*	26.70 ± 1.20
			154.6	46.6 ± 0.5	26.66 ± 1.07
				RR_{mean} =	**26.67** ± **0.82**
^{149}Eu	c*	93.1D	327.5	4.03 ± 0.12	**38.14** ± **2.50**
^{147}Eu	c*	24.1D	955.8	3.84 ± 0.20	33.02 ± 2.21
			798.7	4.8 ± 0.3	38.21 ± 2.86
			677.5	9.8 ± 0.5	32.19 ± 2.01
			601.5	5.9 ± 0.3	31.78 ± 2.06
			121.2	22.9 ± 1.3	30.45 ± 2.26
				RR_{mean} =	**32.54** ± **1.40**
$^{146}Eu_i$	i	4.61D	747.2	99 ± 3	**3.933** ± **0.192**
$^{146}Eu_c$	c	4.61D	747.2	99 ± 3	**30.63** ± **1.37**
^{145}Eu	c	5.93D	1997.0	7.2 ± 0.5	18.79 ± 1.65
			1658.5	14.9 ± 1.0	20.76 ± 1.61
			893.7	66 ± 5	21.62 ± 1.82
			653.5	15 ± 1	20.44 ± 1.58
				RR_{mean} =	**20.38** ± **0.91**
^{143}Pm	c	265D	742.0	38.5 ± 2.4	**19.41** ± **1.41**
^{139}Ce	c	137.640D	165.9	79.89 ± 0.01	**15.66** ± **0.57**
^{135}Ce	c	17.7H	265.6	41.8 ± 1.5	**10.43** ± **0.59**
^{132}Ce	c	3.51H	182.1	77.4 ± 0.5	**8.335** ± **0.442**
$^{132}La_c$	c	4.8H	464.5	76 ± 6	**7.420** ± **0.743**
^{133}Ba	c	3848.9D	356.0	62.05 ± 0.19	**10.91** ± **1.31**
^{131}Ba	c	11.50D	496.3	46.8 ± 0.2	8.819 ± 1.069
			373.2	14.04 ± 0.20	8.684 ± 0.374
			123.8	29.0 ± 0.3	8.325 ± 0.453
				RR_{mean} =	**8.578** ± **0.336**
^{128}Ba	c	2.43D	442.9	26.8 ± 1.4	5.584 ± 0.696
			273.4	14.5 ± 0.7	6.133 ± 0.669
				RR_{mean} =	**5.881** ± **0.458**
^{129}Cs	c	32.06H	371.9	30.6 ± 1.7	**9.773** ± **0.707**
^{127}Xe	c	36.4D	375.0	17.2 ± 0.6	6.973 ± 0.413
			202.9	68.3 ± 0.5	6.903 ± 0.273
				RR_{mean} =	**6.916** ± **0.260**
^{123}Xe	c	2.08H	148.9	48.9 ± 0.6	**7.230** ± **0.640**
^{123m}Te	i(m)	119.7D	159.0	84.0 ± 0.4	**0.5598** ± **0.0961**
^{121m}Te	i(m)	154D	212.2	81.4 ± 1.1	1.165 ± 0.116
			573.1	88.6 ± 0.1	1.125 ± 0.131
				RR_{mean} =	**1.148** ± **0.035**

Continuation of Table 100.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
$^{121}Te_c$	c	19.16D	573.1	80.3 ± 2.5	**5.705 ± 0.274**
^{119m}Te	i(m)	4.70D	1212.7	66.2 ± 0.3	**2.002 ± 0.100**
^{120m}Sb	i(m)	5.76D	1171.7	100 ± 0	0.9399 ± 0.0546
			1023.3	99.4 ± 0.3	0.7830 ± 0.0549
				RR_{mean} =	**0.8665 ± 0.0827**
^{113}Sn	c	115.09D	391.7	64.97 ± 0.17	**2.511 ± 0.228**
^{114m}In	i(m)	49.51D	190.3	15.56 ± 0.16	**2.411 ± 0.355**
^{111}In	c	2.8047D	245.4	94 ± 1	4.044 ± 0.215
			171.3	90.2 ± 1.0	4.210 ± 0.229
				RR_{mean} =	**4.121 ± 0.178**
^{110m}Ag	i(m)	249.76D	884.7	72.7 ± 0.4	2.395 ± 0.203
			657.8	94.3 ± 0.3	2.068 ± 0.163
				RR_{mean} =	**2.194 ± 0.173**
^{106m}Ag	i(m)	8.28D	1045.8	29.6 ± 1.0	2.750 ± 0.203
			717.3	28.9 ± 0.8	2.640 ± 0.221
			451.0	28.2 ± 0.8	2.838 ± 0.194
				RR_{mean} =	**2.754 ± 0.137**
^{105}Ag	c	41.29D	443.4	10.5 ± 0.6	4.081 ± 0.795
			280.4	30.2 ± 1.8	3.260 ± 0.283
				RR_{mean} =	**3.342 ± 0.267**
^{100}Pd	c	3.63D	2376.0	*	**0.6424 ± 0.0700**
^{102}Rh	i	207D	475.1	46 ± 5	**2.096 ± 0.306**
^{101m}Rh	c	4.34D	306.9	81 ± 5	**4.573 ± 0.370**
$^{100}Rh_i$	i(m+g)	20.8H	2376.0	32.6 ± 0.4	**3.048 ± 0.260**
$^{100}Rh_c$	c	20.8H	2376.0	32.6 ± 0.4	**3.691 ± 0.249**
^{103}Ru	c	39.26D	497.1	91.0 ± 1.3	**6.537 ± 0.303**
^{96}Tc	i(m+g)	4.28D	849.9	98 ± 4	3.862 ± 0.219
			812.5	82 ± 4	4.189 ± 0.253
				RR_{mean} =	**3.998 ± 0.203**
^{99}Mo	c	65.94H	140.5	90.27 ± 0.33	**5.835 ± 0.310**
^{93m}Mo	i(m)	6.85H	684.7	99.7 ± 2.0	**2.603 ± 0.166**
^{96}Nb	i	23.35H	1091.3	48.5 ± 1.6	4.569 ± 0.284
			568.9	58.0 ± 0.3	4.128 ± 0.366
				RR_{mean} =	**4.419 ± 0.250**
$^{95}Nb_i$	i(m+g)	34.975D	765.8	99.81 ± 0.03	**6.462 ± 0.238**
$^{95}Nb_c$	c	34.975D	765.8	99.81 ± 0.03	**10.39 ± 0.36**
^{90}Nb	c*	14.60H	2319.0	82.0 ± 0.3	2.949 ± 0.208
			1129.2	92.7 ± 0.5	3.477 ± 0.259
				RR_{mean} =	**3.152 ± 0.275**
^{95}Zr	c	64.02D	765.8	*	3.969 ± 0.198
			756.7	54.46 ± 0.10	3.813 ± 0.186
				RR_{mean} =	**3.885 ± 0.120**
^{89}Zr	c	78.41H	909.2	99.04 ± 0.03	**7.288 ± 0.265**
^{88}Zr	c	83.4D	1836.1	*	4.740 ± 0.378
			898.0	*	3.585 ± 0.371
			392.9	97.24 ± 0.00	3.633 ± 0.156
				RR_{mean} =	**3.651 ± 0.113**
$^{88}Y_i$	i	106.65D	1836.1	99.2 ± 0.3	8.057 ± 0.334
			898.0	93.7 ± 0.3	8.520 ± 0.358
				RR_{mean} =	**8.268 ± 0.344**

Continuation of Table 100.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
$^{88}Y_c$	c	106.65D	1836.1	99.2 ± 0.3	12.80 ± 0.51
			898.0	93.7 ± 0.3	12.10 ± 0.46
				RR_{mean} =	**12.39 ± 0.51**
^{87}Y	c*	79.8H	484.8	89.7 ± 0.7	**9.681 ± 0.345**
$^{86}Y_c$	c	14.74H	1076.6	82.5 ± 0.4	**3.958 ± 0.433**
^{85}Sr	c	64.84D	514.0	96 ± 4	**9.703 ± 0.531**
^{84}Rb	i(m+g)	32.77D	881.6	69.0 ± 1.6	**9.951 ± 0.514**
^{83}Rb	c	86.2D	552.6	16.0 ± 1.1	13.54 ± 1.10
			529.6	29.3 ± 2.1	11.78 ± 1.01
			520.4	45 ± 4	10.89 ± 1.05
				RR_{mean} =	**12.15 ± 0.85**
^{82m}Rb	i(m)	6.472H	554.3	62.4 ± 0.9	**4.481 ± 0.472**
^{82}Br	i(m+g)	35.30H	554.3	70.8 ± 1.0	**4.142 ± 0.210**
^{75}Se	c	119.779D	264.7	58.9 ± 0.4	4.906 ± 0.208
			136.0	58.3 ± 0.8	5.246 ± 0.262
			121.1	17.2 ± 0.4	6.320 ± 0.970
				RR_{mean} =	**5.036 ± 0.221**
^{74}As	i	17.77D	595.8	59 ± 4	**5.883 ± 0.451**
^{71}As	c	65.28H	174.9	82.0 ± 2.1	**1.128 ± 0.083**
$^{72}Ga_i$	i	14.10H	2201.7	25.9 ± 0.5	**3.124 ± 0.327**
$^{72}Ga_c$	c	14.10H	2201.7	25.9 ± 0.5	**3.991 ± 0.291**
^{72}Zn	c	46.5H	2201.7	*	**0.8669 ± 0.1267**
^{58}Co	i(m+g)	70.86D	810.8	99.45 ± 0.01	**1.818 ± 0.153**
^{59}Fe	c	44.472D	1291.6	43.2 ± 1.4	3.265 ± 0.194
			1099.2	56.5 ± 1.9	2.752 ± 0.145
				RR_{mean} =	**2.915 ± 0.256**
^{54}Mn	i	312.11D	834.8	99.98 ± 0.00	**2.734 ± 0.154**
^{48}V	c	15.9735D	1312.1	97.5 ± 0.9	0.3750 ± 0.0389
			983.5	100.0 ± 0.3	0.4377 ± 0.0412
				RR_{mean} =	**0.4049 ± 0.0337**
^{48}Sc	i	43.67H	1312.1	100.1 ± 0.7	1.421 ± 0.146
			1037.5	97.6 ± 0.7	1.428 ± 0.087
				RR_{mean} =	**1.427 ± 0.079**
^{46}Sc	i(m+g)	83.79D	1120.6	99.99 ± 0.00	2.280 ± 0.152
			889.3	99.98 ± 0.00	2.240 ± 0.111
				RR_{mean} =	**2.252 ± 0.101**
^{28}Mg	c	20.915H	1778.8	100.2 ± 0.0	**0.8296 ± 0.0681**
^{24}Na	c	14.9590H	1369.0	100 ± 0	**4.564 ± 0.300**
^{7}Be	i	53.29D	477.6	10.52 ± 0.06	**8.210 ± 0.763**

12.10.3 Nuclide production rates for ^{208}Pb

Table 101: Detailed calculation of nuclide production rates for ^{208}Pb for $E_p = 1.6$ GeV, used to determine the cross sections for their production.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{207}Bi	i	31.55Y	569.7	97.74 ± 0.03	**16.88 ± 3.06**
^{206}Bi	i	6.243D	1718.7	31.8 ± 0.6	13.49 ± 0.64

Continuation of Table 101.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			803.1	98.9 ± 1.4	13.41 ± 0.48
			537.5	30.5 ± 0.5	13.05 ± 0.58
			497.1	15.31 ± 0.22	15.02 ± 2.90
				RR_{mean} =	**13.35 ± 0.46**
^{205}Bi	i	15.31D	1861.7	6.17 ± 0.10	16.11 ± 1.49
			1764.3	32.5 ± 0.7	17.96 ± 0.82
				RR_{mean} =	**17.67 ± 0.86**
^{204}Bi	i	11.22H	984.0	59 ± 4	13.96 ± 1.14
			899.2	98 ± 9	15.14 ± 0.59
			374.8	82 ± 5	14.86 ± 3.11
				RR_{mean} =	**15.01 ± 0.46**
^{203}Bi	i(m+g)	11.76H	820.2	29.6 ± 1.5	**13.89 ± 1.04**
^{202}Bi	i	1.72H	422.1	83.7 ± 2.5	**10.05 ± 1.37**
^{204m}Pb$_i$	i(m)	67.2M	899.2	99.17 ± 0.02	44.46 ± 1.90
			374.7	89 ± 15	42.93 ± 7.41
				RR_{mean} =	**44.41 ± 1.88**
^{204m}Pb$_c$	c	67.2M	899.2	99.17 ± 0.02	46.73 ± 1.95
			374.7	89 ± 15	44.80 ± 7.73
				RR_{mean} =	**46.67 ± 1.93**
^{203}Pb	c*	51.873H	279.2	80.8 ± 0.2	**98.69 ± 3.62**
^{202m}Pb	i(m)	3.53H	960.7	92 ± 8	29.03 ± 3.19
			422.1	86 ± 5	31.38 ± 2.33
				RR_{mean} =	**30.90 ± 1.54**
^{201}Pb	c*	9.33H	331.2	79 ± 5	**76.13 ± 5.49**
^{200}Pb	c	21.5H	1205.7	*	51.97 ± 4.14
			450.5	3.33 ± 0.08	63.09 ± 3.74
			367.9	*	58.09 ± 2.41
			147.6	37.7 ± 1.4	55.54 ± 3.03
				RR_{mean} =	**57.44 ± 1.77**
^{199}Pb	c*	90M	366.9	44 ± 7	**93.56 ± 15.51**
^{198}Pb	c	2.4H	173.4	18 ± 3	**73.13 ± 12.71**
^{197m}Pb	c*	43M	385.9	74 ± 15	**45.62 ± 9.46**
^{195m}Pb	i(m)	15.0M	383.6	107 ± 20	**19.67 ± 3.90**
^{202}Tl	c	12.23D	439.6	91.4 ± 1.0	**56.84 ± 2.05**
^{201}Tl	c*	72.912H	167.4	10.00 ± 0.06	**138.8 ± 5.6**
^{200}Tl$_i$	i	26.1H	1205.7	29.9 ± 1.8	67.94 ± 6.03
			579.3	13.8 ± 0.7	74.16 ± 6.14
			367.9	87.2 ± 0.4	59.40 ± 3.19
				RR_{mean} =	**62.84 ± 4.39**
^{200}Tl$_c$	c	26.1H	1205.7	29.9 ± 1.8	119.9 ± 8.5
			579.3	13.8 ± 0.7	119.8 ± 7.7
			367.9	87.2 ± 0.4	117.5 ± 4.3
				RR_{mean} =	**117.9 ± 4.2**
^{199}Tl$_c$	c	7.42H	455.5	12.4 ± 1.4	**80.09 ± 11.03**
^{199}Tl	c*	7.42H	455.5	12.4 ± 1.4	**116.0 ± 14.0**
^{198m}Tl	i(m)	1.87H	282.8	28 ± 3	**53.16 ± 7.19**
^{196m}Tl	i(m)	1.41H	695.4	41 ± 7	**92.05 ± 16.09**
^{203}Hg	c	46.612D	279.2	81.46 ± 0.13	**14.32 ± 0.56**
^{197m}Hg	i(m)	23.8H	134.0	33.5 ± 0.4	**31.17 ± 1.50**
^{195m}Hg	i(m)	41.6H	261.8	31 ± 4	**44.12 ± 6.11**

Continuation of Table 101.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, $10^{-17}\ s^{-1}$
^{193m}Hg	i(m)	11.8H	258.0	49 ± 7	**51.98 ± 7.87**
^{192}Hg	c	4.85H	316.5	*	97.89 ± 12.46
			274.8	50.2 ± 2.5	83.51 ± 5.31
				RR_{mean} =	**85.36 ± 2.63**
^{190}Hg	c*	20.0M	142.6	68 ± 10	**53.97 ± 8.38**
^{198m}Au	i(m)	2.27D	411.8	*	**2.685 ± 0.169**
^{198}Au$_i$	i	2.69517D	411.8	95.58 ± 0.12	**4.700 ± 0.335**
^{198}Au$_c$	i(m+g)	2.69517D	411.8	95.58 ± 0.12	**7.385 ± 0.303**
^{196}Au	i(m1+m2+g)	6.183D	355.7	87.0 ± 0.8	12.20 ± 0.43
			333.0	22.9 ± 0.6	12.99 ± 0.61
				RR_{mean} =	**12.31 ± 0.47**
^{195}Au	c	186.098D	98.9	10.9 ± 0.9	**135.9 ± 13.4**
^{194}Au	i(m1+m2+g)	38.02H	328.5	61 ± 5	**19.90 ± 1.78**
^{192}Au$_i$	i(m+g)	4.94H	316.5	58 ± 7	**29.06 ± 4.40**
^{192}Au$_c$	c	4.94H	316.5	58 ± 7	**127.0 ± 16.0**
^{191}Au	c*	3.18H	674.2	6.8 ± 0.5	**127.3 ± 12.7**
^{190}Au$_c$	c	42.8M	301.8	23.4 ± 1.5	86.20 ± 8.77
			295.8	71 ± 5	96.27 ± 8.00
				RR_{mean} =	**92.67 ± 5.61**
^{191}Pt	c	2.802D	538.9	13.7 ± 1.6	118.4 ± 14.6
			456.5	3.4 ± 0.4	98.88 ± 12.71
			409.4	8.0 ± 0.9	91.22 ± 10.75
				RR_{mean} =	**99.04 ± 8.18**
^{189}Pt	c	10.87H	721.4	9.3 ± 0.8	115.8 ± 10.9
			607.6	8.10 ± 0.16	113.5 ± 5.5
			568.8	7.1 ± 0.6	116.2 ± 11.3
			544.9	5.8 ± 0.5	107.0 ± 10.5
			243.5	7.0 ± 1.2	121.0 ± 25.7
				RR_{mean} =	**113.4 ± 4.9**
^{188}Pt	c	10.2D	1209.8	*	99.56 ± 10.67
			423.3	4.4 ± 0.3	98.71 ± 7.64
			381.4	7.5 ± 0.5	93.72 ± 7.14
			195.1	18.6 ± 1.2	98.41 ± 7.37
			187.6	19.4 ± 1.2	97.75 ± 7.08
				RR_{mean} =	**97.49 ± 3.01**
^{186}Pt	c	2.08H	689.4	70 ± 15	**79.78 ± 17.34**
^{184}Pt	c	17.3M	548.3	23 ± 4	**73.69 ± 13.82**
^{192}Ir	i(m1+g)	73.827D	316.5	82.71 ± 0.21	**0.6928 ± 0.0846**
^{190}Ir	i(m1+g)	11.78D	569.3	28.5 ± 1.3	**1.746 ± 0.193**
^{189}Ir	c	13.2D	245.1	6.0 ± 0.6	**88.77 ± 10.40**
^{188}Ir$_i$	i	41.5H	1209.8	6.9 ± 0.7	**9.455 ± 1.662**
^{188}Ir$_c$	c	41.5H	1209.8	6.9 ± 0.7	**109.0 ± 11.7**
^{187}Ir	c*	10.5H	977.5	3.14 ± 0.11	**102.8 ± 7.7**
^{186}Ir	c	16.64H	434.8	33.9 ± 1.1	51.26 ± 2.56
			137.2	41.4 ± 0.7	47.17 ± 4.42
				RR_{mean} =	**50.51 ± 2.37**
^{185}Ir	c	14.4H	1829.0	10.1 ± 1.5	76.82 ± 11.91
			254.2	13.3 ± 2.4	51.06 ± 11.17
				RR_{mean} =	**71.99 ± 10.30**
^{184}Ir	c*	3.09H	390.4	25.9 ± 2.4	95.47 ± 9.58

Continuation of Table 101.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			264.0	68 ± 4	94.11 ± 6.68
			119.8	31 ± 3	83.76 ± 9.88
				RR_{mean} =	**93.39 ± 3.74**
^{185}Os	c	93.6D	874.8	6.29 ± 0.25	107.9 ± 5.7
			717.4	3.94 ± 0.16	107.0 ± 6.3
			646.1	78 ± 3	101.7 ± 5.2
				RR_{mean} =	**104.0 ± 3.8**
^{183m}Os	c*	9.9H	1107.9	22.4 ± 0.6	60.87 ± 2.76
			1101.9	49.0 ± 1.3	57.98 ± 2.57
				RR_{mean} =	**59.21 ± 2.32**
^{182}Os	c	22.10H	263.3	6.71 ± 0.25	93.81 ± 5.55
			180.2	33.5 ± 1.7	104.4 ± 7.0
				RR_{mean} =	**97.59 ± 5.89**
^{180}Os	c	21.5M	902.8(D)	101.5 ± 3.4	**89.06 ± 4.77**
^{183}Re	c	70.0D	291.7	3.05 ± 0.18	95.59 ± 6.88
			162.3	23.3 ± 0.7	111.1 ± 5.3
				RR_{mean} =	**107.5 ± 7.3**
^{182m}Re$_c$	c	12.7H	1221.5	24.8 ± 1.6	106.8 ± 8.2
			1189.2	15 ± 1	111.1 ± 9.9
				RR_{mean} =	**108.4 ± 5.9**
^{181}Re	c*	19.9H	639.0	6.4 ± 1.4	103.1 ± 23.0
			365.5	56 ± 8	94.31 ± 13.91
				RR_{mean} =	**96.25 ± 10.37**
^{179}Re	c*	19.5M	430.2	28.0 ± 1.8	133.3 ± 11.0
			290.0	26.9 ± 2.3	118.0 ± 11.7
				RR_{mean} =	**128.4 ± 8.2**
^{178}Re	c*	13.2M	237.3	45 ± 5	**148.5 ± 18.1**
^{178} W	c	21.6D	1350.6(D)	1.18 ± 0.11	85.61 ± 9.58
			1340.8(D)	1.03 ± 0.09	60.78 ± 8.89
				RR_{mean} =	**75.56 ± 12.41**
^{177} W	c	135M	115.7	51 ± 5	**89.72 ± 10.00**
^{177}Ta	c*	56.56H	112.9	7.2 ± 1.6	**103.2 ± 23.6**
^{176}Ta$_c$	c	8.09H	1823.7	4.5 ± 0.4	95.77 ± 16.88
			1159.3	24.7 ± 1.9	99.60 ± 8.52
			710.5	5.4 ± 0.4	120.3 ± 16.4
				RR_{mean} =	**100.4 ± 4.4**
^{175}Ta	c	10.5H	1793.1	4.6 ± 0.7	76.63 ± 12.83
			348.5	12.0 ± 1.1	117.9 ± 11.8
			266.9	10.52 ± 0.16	100.1 ± 5.0
				RR_{mean} =	**100.1 ± 6.9**
^{174}Ta$_c$	c	1.14H	206.5	60 ± 5	**100.3 ± 9.3**
^{173}Ta	c	3.14H	172.2	17.5 ± 1.8	**103.8 ± 11.6**
^{172}Ta	c*	36.8M	214.1	55 ± 5	**63.86 ± 6.63**
^{175}Hf	c	70D	343.4	84 ± 3	**99.30 ± 4.90**
^{173}Hf	c*	23.6H	311.2	10.7 ± 0.5	118.9 ± 7.2
			139.6	12.7 ± 0.6	124.0 ± 7.9
			123.7	83 ± 5	120.0 ± 9.1
				RR_{mean} =	**120.8 ± 4.8**
^{172}Hf	c	1.87Y	1093.6	*	87.20 ± 5.06
			1002.7(D)	5.55 ± 0.38	83.49 ± 8.51

Continuation of Table 101.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			181.5	*	89.34 ± 5.63
			125.8	11.3 ± 0.9	85.72 ± 7.96
				RR_{mean} =	**87.09 ± 2.69**
^{171}Hf	c	12.1H	739.8	*	**82.83 ± 7.17**
^{170}Hf	c	16.01H	620.7	18 ± 5	119.1 ± 33.4
			164.7	26 ± 8	115.4 ± 35.8
			120.2	15 ± 5	109.1 ± 36.8
				RR_{mean} =	**117.3 ± 8.3**
^{173}Lu	c	1.37Y	272.1	21.2 ± 0.8	**97.96 ± 5.24**
$^{172}Lu_i$	i(m+g)	6.70D	1093.6	63 ± 3	**0.9549 ± 0.0732**
$^{172}Lu_c$	c	6.70D	1093.6	63 ± 3	**88.15 ± 5.12**
^{171}Lu	c*	8.24D	853.0	2.55 ± 0.07	105.8 ± 5.0
			780.7	4.36 ± 0.11	117.3 ± 5.0
			667.4	11.0 ± 0.3	108.3 ± 4.7
				RR_{mean} =	**111.0 ± 4.9**
$^{171}Lu_c$	c	8.24D	739.8	47.8 ± 1.2	**99.92 ± 4.15**
$^{170}Lu_c$	c	2.012D	2126.1	5.1 ± 0.3	84.95 ± 6.41
			1280.2	8.2 ± 0.4	87.97 ± 6.07
			1054.3	4.76 ± 0.24	86.63 ± 6.95
				RR_{mean} =	**86.65 ± 3.83**
^{169}Lu	c	34.06H	960.6	23.4 ± 0.7	78.32 ± 3.54
			191.2	20.6 ± 0.6	82.45 ± 4.01
				RR_{mean} =	**79.94 ± 3.18**
^{167}Lu	c	51.5M	176.2	*	67.60 ± 4.32
			113.3	*	86.91 ± 6.62
				RR_{mean} =	**73.03 ± 8.97**
^{169}Yb	c*	32.026D	198.0	35.8 ± 0.7	92.40 ± 4.26
			177.2	22.2 ± 0.5	91.08 ± 4.00
			130.5	11.31 ± 0.21	94.42 ± 4.46
				RR_{mean} =	**92.39 ± 3.24**
^{166}Yb	c	56.7H	2079.5	*	89.53 ± 6.70
			2052.4	*	91.42 ± 6.36
			1867.9	*	91.00 ± 6.67
			1374.2	*	90.15 ± 7.53
			1176.7	*	85.65 ± 6.23
			785.9	*	89.96 ± 6.69
			691.2(D)	8.56 ± 0.58	79.51 ± 6.23
				RR_{mean} =	**87.96 ± 2.71**
^{167}Tm	c	9.25D	207.8	42 ± 8	**94.72 ± 18.40**
^{165}Tm	c	30.06H	806.4	9.5 ± 0.6	87.23 ± 6.33
			242.9	35.5 ± 1.7	85.39 ± 5.28
				RR_{mean} =	**85.93 ± 3.56**
^{161}Er	c*	3.21H	826.6	64 ± 4	**88.29 ± 6.63**
^{160}Er	c	28.58H	966.2	*	79.74 ± 10.74
			962.4	*	77.76 ± 10.20
			879.4(D)	22.6 ± 2.8	79.28 ± 10.30
			872.0(D)	6.8 ± 1.1	73.56 ± 12.53
			728.2(D)	34 ± 5	79.79 ± 12.04
				RR_{mean} =	**78.20 ± 2.41**
^{159}Er	c*	36M	624.5	33 ± 4	88.75 ± 11.64

Continuation of Table 101.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			132.0	*	92.30 ± 5.94
				RR_{mean} =	**91.68 ± 2.83**
$^{160m}Ho_c$	c	5.02H	966.2	15.4 ± 2.0	82.81 ± 11.57
			962.4	16.6 ± 2.1	73.27 ± 10.19
				RR_{mean} =	**77.44 ± 7.41**
^{156}Ho	c*	56M	266.5	54.7 ± 1.1	**82.44 ± 4.08**
^{157}Dy	c	8.14H	326.2	92 ± 4	**68.57 ± 3.83**
^{155}Dy	c*	9.9H	226.9	68.4 ± 1.6	**58.70 ± 2.75**
^{152}Dy	c	2.38H	256.9	97.50 ± 0.07	**31.02 ± 1.64**
^{155}Tb	c*	5.32D	180.1	7.5 ± 0.5	55.65 ± 4.58
			105.3	25.1 ± 1.3	59.84 ± 4.40
				RR_{mean} =	**58.17 ± 2.72**
^{153}Tb	c*	2.34D	212.0	31.0 ± 1.9	**47.48 ± 3.44**
^{152}Tb	c*	17.5H	344.3	65 ± 4	**41.74 ± 2.98**
^{151}Tb	c	17.609H	479.4	15.4 ± 0.7	34.37 ± 2.24
			251.9	26.3 ± 1.2	31.28 ± 2.13
				RR_{mean} =	**32.78 ± 1.85**
^{149}Tb	c	4.118H	165.0	26.4 ± 0.9	**9.848 ± 2.683**
^{148}Tb	c	60M	784.4	84.0 ± 1.6	**17.96 ± 1.35**
^{153}Gd	c	240.4D	103.2	21.1 ± 0.7	44.33 ± 2.84
			97.4	29.0 ± 0.8	42.11 ± 2.48
				RR_{mean} =	**43.02 ± 1.99**
^{151}Gd	c	124D	243.3	5.6 ± 0.4	**36.31 ± 3.38**
^{149}Gd	c	9.28D	788.9	7.3 ± 0.4	47.95 ± 3.18
			346.6	23.9 ± 1.3	40.83 ± 2.62
			298.6	28.6 ± 1.7	41.10 ± 2.85
			149.7	48 ± 3	44.92 ± 3.31
				RR_{mean} =	**42.88 ± 2.16**
^{147}Gd	c	38.06H	929.0	20.2 ± 1.2	36.07 ± 2.51
			396.0	34.3 ± 2.1	31.42 ± 2.24
			370.0	17.2 ± 0.9	33.72 ± 2.17
				RR_{mean} =	**33.62 ± 1.62**
^{146}Gd	c	48.27D	747.2	*	33.20 ± 1.49
			154.6	46.6 ± 0.5	34.30 ± 1.41
				RR_{mean} =	**33.83 ± 1.04**
^{149}Eu	c*	93.1D	327.5	4.03 ± 0.12	**54.05 ± 3.13**
^{147}Eu	c*	24.1D	955.8	3.84 ± 0.20	40.45 ± 2.88
			798.7	4.8 ± 0.3	47.86 ± 3.50
			677.5	9.8 ± 0.5	41.77 ± 2.60
			601.5	5.9 ± 0.3	44.13 ± 2.83
			121.2	22.9 ± 1.3	39.69 ± 2.92
				RR_{mean} =	**42.45 ± 1.79**
$^{146}Eu_i$	i	4.61D	747.2	99 ± 3	**5.606 ± 0.275**
$^{146}Eu_c$	c	4.61D	747.2	99 ± 3	**38.81 ± 1.74**
^{145}Eu	c	5.93D	1997.0	7.2 ± 0.5	27.00 ± 2.31
			1658.5	14.9 ± 1.0	27.11 ± 2.29
			893.7	66 ± 5	25.32 ± 2.16
			653.5	15 ± 1	26.81 ± 2.02
				RR_{mean} =	**26.55 ± 1.20**
^{143}Pm	c	265D	742.0	38.5 ± 2.4	**24.19 ± 1.76**

Continuation of Table 101.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{139}Ce	c	137.640D	165.9	79.89 ± 0.01	**20.38 ± 0.75**
^{135}Ce	c	17.7H	265.6	41.8 ± 1.5	**12.55 ± 0.79**
^{132}Ce	c	3.51H	182.1	77.4 ± 0.5	**8.819 ± 0.536**
$^{132}La_c$	c	4.8H	464.5	76 ± 6	**9.867 ± 0.926**
^{133}Ba	c	3848.9D	356.0	62.05 ± 0.19	**12.33 ± 1.44**
^{131}Ba	c	11.50D	496.3	46.8 ± 0.2	11.19 ± 1.02
			373.2	14.04 ± 0.20	11.19 ± 0.47
			123.8	29.0 ± 0.3	10.65 ± 0.61
				RR_{mean} =	**11.05 ± 0.43**
^{128}Ba	c	2.43D	442.9	26.8 ± 1.4	8.117 ± 0.639
			273.4	14.5 ± 0.7	6.157 ± 0.558
				RR_{mean} =	**7.120 ± 1.004**
^{129}Cs	c	32.06H	371.9	30.6 ± 1.7	**12.05 ± 0.89**
^{127}Xe	c	36.4D	375.0	17.2 ± 0.6	9.189 ± 0.534
			202.9	68.3 ± 0.5	8.797 ± 0.355
				RR_{mean} =	**8.873 ± 0.337**
^{123}Xe	c	2.08H	148.9	48.9 ± 0.6	**9.991 ± 0.851**
^{123m}Te	i(m)	119.7D	159.0	84.0 ± 0.4	**0.9792 ± 0.0690**
^{121m}Te	i(m)	154D	212.2	81.4 ± 1.1	1.561 ± 0.087
			573.1	88.6 ± 0.1	1.755 ± 0.195
				RR_{mean} =	**1.586 ± 0.049**
$^{121}Te_c$	c	19.16D	573.1	80.3 ± 2.5	**7.481 ± 0.372**
^{119m}Te	i(m)	4.70D	1212.7	66.2 ± 0.3	**2.383 ± 0.146**
^{120m}Sb	i(m)	5.76D	1171.7	100 ± 0	1.197 ± 0.072
			1023.3	99.4 ± 0.3	1.231 ± 0.065
				RR_{mean} =	**1.216 ± 0.055**
^{113}Sn	c	115.09D	391.7	64.97 ± 0.17	**4.230 ± 0.207**
^{114m}In	i(m)	49.51D	190.3	15.56 ± 0.16	**4.408 ± 0.443**
^{111}In	c	2.8047D	245.4	94 ± 1	5.196 ± 0.305
			171.3	90.2 ± 1.0	5.291 ± 0.243
				RR_{mean} =	**5.261 ± 0.216**
^{110m}Ag	i(m)	249.76D	884.7	72.7 ± 0.4	3.136 ± 0.169
			657.8	94.3 ± 0.3	3.008 ± 0.152
				RR_{mean} =	**3.063 ± 0.131**
^{106m}Ag	i(m)	8.28D	1045.8	29.6 ± 1.0	3.663 ± 0.272
			717.3	28.9 ± 0.8	3.729 ± 0.306
			451.0	28.2 ± 0.8	3.924 ± 0.216
				RR_{mean} =	**3.813 ± 0.174**
^{105}Ag	c	41.29D	443.4	10.5 ± 0.6	5.010 ± 0.578
			280.4	30.2 ± 1.8	4.063 ± 0.335
				RR_{mean} =	**4.284 ± 0.422**
^{100}Pd	c	3.63D	2376.0	*	**0.4434 ± 0.3190**
^{102}Rh	i	207D	475.1	46 ± 5	**3.104 ± 0.394**
^{101m}Rh	c	4.34D	306.9	81 ± 5	**5.748 ± 0.440**
$^{100}Rh_i$	i(m+g)	20.8H	2376.0	32.6 ± 0.4	**3.681 ± 0.436**
$^{100}Rh_c$	c	20.8H	2376.0	32.6 ± 0.4	**4.125 ± 0.284**
^{103}Ru	c	39.26D	497.1	91.0 ± 1.3	**9.143 ± 0.392**
^{96}Tc	i(m+g)	4.28D	849.9	98 ± 4	4.854 ± 0.272
			812.5	82 ± 4	5.214 ± 0.314
				RR_{mean} =	**5.004 ± 0.235**

Continuation of Table 101.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{99}Mo	c	65.94H	140.5	90.27 ± 0.33	**8.171 ± 0.396**
^{93m}Mo	i(m)	6.85H	684.7	99.7 ± 2.0	**3.080 ± 0.206**
^{96}Nb	i	23.35H	1091.3	48.5 ± 1.6	6.737 ± 0.395
			568.9	58.0 ± 0.3	5.483 ± 0.330
				RR_{mean} =	**6.003 ± 0.645**
^{95}Nb$_i$	i(m+g)	34.975D	765.8	99.81 ± 0.03	**8.809 ± 0.346**
^{95}Nb$_c$	c	34.975D	765.8	99.81 ± 0.03	**14.16 ± 0.50**
^{90}Nb	c*	14.60H	2319.0	82.0 ± 0.3	3.769 ± 0.254
			1129.2	92.7 ± 0.5	4.337 ± 0.409
				RR_{mean} =	**3.914 ± 0.275**
^{95}Zr	c	64.02D	765.8	*	5.395 ± 0.298
			756.7	54.46 ± 0.10	5.437 ± 0.233
				RR_{mean} =	**5.424 ± 0.167**
^{89}Zr	c	78.41H	909.2	99.04 ± 0.03	**8.853 ± 0.300**
^{88}Zr	c	83.4D	1836.1	*	4.444 ± 0.233
			898.0	*	4.695 ± 0.219
			392.9	97.24 ± 0.00	4.625 ± 0.179
				RR_{mean} =	**4.608 ± 0.142**
^{88} Y$_i$	i	106.65D	1836.1	99.2 ± 0.3	11.00 ± 0.40
			898.0	93.7 ± 0.3	10.84 ± 0.37
				RR_{mean} =	**10.89 ± 0.36**
^{88} Y$_c$	c	106.65D	1836.1	99.2 ± 0.3	15.44 ± 0.55
			898.0	93.7 ± 0.3	15.53 ± 0.52
				RR_{mean} =	**15.50 ± 0.50**
^{87} Y	c*	79.8H	484.8	89.7 ± 0.7	**11.76 ± 0.42**
^{86} Y$_c$	c	14.74H	1076.6	82.5 ± 0.4	**4.822 ± 0.271**
^{85}Sr	c	64.84D	514.0	96 ± 4	**11.92 ± 0.65**
^{84}Rb	i(m+g)	32.77D	881.6	69.0 ± 1.6	**11.82 ± 0.64**
^{83}Rb	c	86.2D	552.6	16.0 ± 1.1	16.30 ± 1.32
			529.6	29.3 ± 2.1	13.88 ± 1.22
			520.4	45 ± 4	13.48 ± 1.32
				RR_{mean} =	**14.69 ± 1.00**
^{82m}Rb	i(m)	6.472H	554.3	62.4 ± 0.9	**5.897 ± 0.732**
^{82}Br	i(m+g)	35.30H	554.3	70.8 ± 1.0	**5.675 ± 0.280**
^{75}Se	c	119.779D	264.7	58.9 ± 0.4	6.152 ± 0.250
			136.0	58.3 ± 0.8	6.736 ± 0.325
			121.1	17.2 ± 0.4	7.670 ± 0.786
				RR_{mean} =	**6.369 ± 0.318**
^{74}As	i	17.77D	595.8	59 ± 4	**7.518 ± 0.582**
^{71}As	c	65.28H	174.9	82.0 ± 2.1	**1.339 ± 0.097**
^{72}Ga$_i$	i	14.10H	2201.7	25.9 ± 0.5	**4.937 ± 0.563**
^{72}Ga$_c$	c	14.10H	2201.7	25.9 ± 0.5	**6.276 ± 0.523**
^{72}Zn	c	46.5H	2201.7	*	**1.339 ± 0.184**
^{58}Co	i(m+g)	70.86D	810.8	99.45 ± 0.01	**2.816 ± 0.273**
^{59}Fe	c	44.472D	1291.6	43.2 ± 1.4	4.112 ± 0.231
			1099.2	56.5 ± 1.9	4.281 ± 0.251
				RR_{mean} =	**4.187 ± 0.184**
^{54}Mn	i	312.11D	834.8	99.98 ± 0.00	**3.210 ± 0.234**
^{48} V	c	15.9735D	1312.1	97.5 ± 0.9	0.5543 ± 0.0520
			983.5	100.0 ± 0.3	0.4954 ± 0.0488

Continuation of Table 101.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
				RR_{mean} =	**0.5231 ± 0.0374**
^{48}Sc	i	43.67H	1312.1	100.1 ± 0.7	2.143 ± 0.156
			1037.5	97.6 ± 0.7	2.043 ± 0.109
				RR_{mean} =	**2.071 ± 0.098**
^{46}Sc	i(m+g)	83.79D	1120.6	99.99 ± 0.00	2.745 ± 0.203
			889.3	99.98 ± 0.00	3.034 ± 0.125
				RR_{mean} =	**2.986 ± 0.142**
^{28}Mg	c	20.915H	1778.8	100.2 ± 0.0	**1.386 ± 0.099**
^{24}Na	c	14.9590H	1369.0	100 ± 0	**6.403 ± 0.382**
^{7}Be	i	53.29D	477.6	10.52 ± 0.06	**19.60 ± 1.80**

12.10.4 Nuclide production rates for ^{nat}Pb

Table 102: Detailed calculation of nuclide production rates for ^{nat}Pb for $E_p = 1.6$ GeV, used to determine the cross sections for their production.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{207}Bi	i	31.55Y	569.7	97.74 ± 0.03	**19.85 ± 4.30**
^{206}Bi	i	6.243D	1718.7	31.8 ± 0.6	18.39 ± 0.87
			803.1	98.9 ± 1.4	16.70 ± 0.61
			537.5	30.5 ± 0.5	16.96 ± 0.77
			497.1	15.31 ± 0.22	20.00 ± 2.30
				RR_{mean} =	**17.04 ± 0.65**
^{205}Bi	i	15.31D	1861.7	6.17 ± 0.10	22.05 ± 1.76
			1764.3	32.5 ± 0.7	25.21 ± 1.12
				RR_{mean} =	**24.59 ± 1.47**
^{204}Bi	i	11.22H	984.0	59 ± 4	28.85 ± 2.91
			899.2	98 ± 9	25.16 ± 1.03
			374.8	82 ± 5	20.97 ± 4.42
				RR_{mean} =	**25.27 ± 0.78**
^{203}Bi	i(m+g)	11.76H	820.2	29.6 ± 1.5	**27.56 ± 2.03**
^{202}Bi	i	1.72H	422.1	83.7 ± 2.5	**14.56 ± 2.17**
^{204m}Pb$_i$	i(m)	67.2M	899.2	99.17 ± 0.02	60.50 ± 3.29
			374.7	89 ± 15	69.44 ± 12.02
				RR_{mean} =	**60.95 ± 3.24**
^{204m}Pb$_c$	c	67.2M	899.2	99.17 ± 0.02	64.28 ± 3.35
			374.7	89 ± 15	72.07 ± 12.47
				RR_{mean} =	**64.64 ± 3.31**
^{203}Pb	c*	51.873H	279.2	80.8 ± 0.2	**178.7 ± 6.5**
^{202m}Pb	i(m)	3.53H	960.7	92 ± 8	41.78 ± 4.69
			422.1	86 ± 5	51.90 ± 3.72
				RR_{mean} =	**49.85 ± 4.35**
^{201}Pb	c*	9.33H	331.2	79 ± 5	**130.6 ± 9.4**
^{200}Pb	c	21.5H	1205.7	*	93.93 ± 6.66
			579.3	*	84.53 ± 6.58
			450.5	3.33 ± 0.08	89.22 ± 6.71
			367.9	*	89.08 ± 3.17
			257.2	4.46 ± 0.17	114.1 ± 10.5
			147.6	37.7 ± 1.4	90.68 ± 5.19

Continuation of Table 102.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
				RR_{mean} =	**89.34 ± 2.76**
^{199}Pb	c*	90M	366.9	44 ± 7	**187.7 ± 30.7**
^{198}Pb	c	2.4H	173.4	18 ± 3	**117.1 ± 20.7**
^{197m}Pb	c*	43M	385.9	74 ± 15	**76.66 ± 15.82**
^{195m}Pb	i(m)	15.0M	383.6	107 ± 20	**31.14 ± 6.08**
^{202}Tl	c	12.23D	439.6	91.4 ± 1.0	**91.72 ± 3.33**
^{201}Tl	c*	72.912H	167.4	10.00 ± 0.06	**234.3 ± 8.8**
^{200}Tl$_i$	i	26.1H	1205.7	29.9 ± 1.8	99.43 ± 7.77
			579.3	13.8 ± 0.7	104.8 ± 10.8
			367.9	87.2 ± 0.4	98.11 ± 4.21
				RR_{mean} =	**98.71 ± 4.00**
^{200}Tl$_c$	c	26.1H	1205.7	29.9 ± 1.8	193.4 ± 13.5
			579.3	13.8 ± 0.7	189.3 ± 12.7
			367.9	87.2 ± 0.4	187.2 ± 6.5
				RR_{mean} =	**187.6 ± 6.4**
^{199}Tl$_c$	c	7.42H	455.5	12.4 ± 1.4	**160.4 ± 21.0**
^{199}Tl	c*	7.42H	455.5	12.4 ± 1.4	**194.6 ± 23.8**
^{198m}Tl	i(m)	1.87H	282.8	28 ± 3	**82.02 ± 9.99**
^{196m}Tl	i(m)	1.41H	695.4	41 ± 7	**147.3 ± 25.8**
^{203}Hg	c	46.612D	279.2	81.46 ± 0.13	**17.59 ± 0.67**
^{197m}Hg	i(m)	23.8H	134.0	33.5 ± 0.4	**47.23 ± 2.56**
^{195m}Hg	i(m)	41.6H	261.8	31 ± 4	**66.55 ± 9.21**
^{193m}Hg	i(m)	11.8H	258.0	49 ± 7	**88.96 ± 13.33**
^{192}Hg	c	4.85H	316.5	*	155.7 ± 19.7
			274.8	50.2 ± 2.5	134.8 ± 8.5
				RR_{mean} =	**137.6 ± 4.2**
^{190}Hg	c*	20.0M	142.6	68 ± 10	**87.27 ± 13.68**
^{198m}Au	i(m)	2.27D	411.8	*	**3.551 ± 0.396**
^{198}Au$_i$	i	2.69517D	411.8	95.58 ± 0.12	**6.017 ± 0.735**
^{198}Au$_c$	i(m+g)	2.69517D	411.8	95.58 ± 0.12	**9.569 ± 0.491**
^{196}Au	i(m1+m2+g)	6.183D	355.7	87.0 ± 0.8	16.76 ± 0.59
			333.0	22.9 ± 0.6	18.49 ± 0.83
				RR_{mean} =	**17.02 ± 0.81**
^{195}Au	c	186.098D	98.9	10.9 ± 0.9	**209.6 ± 21.8**
^{194}Au	i(m1+m2+g)	38.02H	328.5	61 ± 5	**28.11 ± 2.50**
^{192}Au$_i$	i(m+g)	4.94H	316.5	58 ± 7	**43.48 ± 6.12**
^{192}Au$_c$	c	4.94H	316.5	58 ± 7	**199.2 ± 25.1**
^{191}Au	c*	3.18H	674.2	6.8 ± 0.5	**186.0 ± 17.6**
^{190}Au$_c$	c	42.8M	301.8	23.4 ± 1.5	154.1 ± 14.0
			295.8	71 ± 5	170.5 ± 14.0
				RR_{mean} =	**163.4 ± 9.6**
^{191}Pt	c	2.802D	538.9	13.7 ± 1.6	188.6 ± 23.0
			456.5	3.4 ± 0.4	150.8 ± 18.9
			409.4	8.0 ± 0.9	144.4 ± 17.0
				RR_{mean} =	**155.9 ± 13.3**
^{189}Pt	c	10.87H	721.4	9.3 ± 0.8	177.4 ± 16.8
			607.6	8.10 ± 0.16	198.5 ± 10.3
			568.8	7.1 ± 0.6	173.1 ± 17.3
			544.9	5.8 ± 0.5	174.1 ± 17.6
			243.5	7.0 ± 1.2	245.3 ± 45.9

Continuation of Table 102.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
				$RR_{mean} =$	**189.5 ± 9.1**
^{188}Pt	c	10.2D	1209.8	*	155.2 ± 16.7
			423.3	4.4 ± 0.3	147.9 ± 11.5
			381.4	7.5 ± 0.5	152.6 ± 11.6
			195.1	18.6 ± 1.2	150.9 ± 11.3
			187.6	19.4 ± 1.2	153.9 ± 11.2
				$RR_{mean} =$	**152.0 ± 4.7**
^{186}Pt	c	2.08H	689.4	70 ± 15	**124.0 ± 26.9**
^{184}Pt	c	17.3M	548.3	23 ± 4	**106.2 ± 22.6**
^{192}Ir	i(m1+g)	73.827D	316.5	82.71 ± 0.21	**0.6652 ± 0.0758**
^{190}Ir	i(m1+g)	11.78D	569.3	28.5 ± 1.3	**1.802 ± 0.479**
^{189}Ir	c	13.2D	245.1	6.0 ± 0.6	**164.7 ± 17.8**
$^{188}Ir_i$	i	41.5H	1209.8	6.9 ± 0.7	**8.195 ± 2.951**
$^{188}Ir_c$	c	41.5H	1209.8	6.9 ± 0.7	**163.4 ± 17.6**
^{187}Ir	c*	10.5H	977.5	3.14 ± 0.11	**142.0 ± 17.7**
^{186}Ir	c	16.64H	434.8	33.9 ± 1.1	75.81 ± 4.02
			137.2	41.4 ± 0.7	77.33 ± 4.01
				$RR_{mean} =$	**76.58 ± 3.27**
^{185}Ir	c	14.4H	1829.0	10.1 ± 1.5	118.2 ± 18.9
			254.2	13.3 ± 2.4	105.9 ± 21.3
				$RR_{mean} =$	**115.6 ± 7.6**
^{184}Ir	c*	3.09H	390.4	25.9 ± 2.4	156.5 ± 15.6
			264.0	68 ± 4	149.8 ± 10.7
			119.8	31 ± 3	150.3 ± 17.0
				$RR_{mean} =$	**150.5 ± 6.0**
^{185}Os	c	93.6D	874.8	6.29 ± 0.25	165.1 ± 9.2
			717.4	3.94 ± 0.16	159.9 ± 9.5
			646.1	78 ± 3	160.3 ± 8.3
				$RR_{mean} =$	**161.3 ± 5.3**
^{183m}Os	c*	9.9H	1107.9	22.4 ± 0.6	95.19 ± 4.41
			1101.9	49.0 ± 1.3	85.74 ± 3.76
				$RR_{mean} =$	**88.93 ± 5.24**
^{182}Os	c	22.10H	263.3	6.71 ± 0.25	154.5 ± 10.1
			180.2	33.5 ± 1.7	158.4 ± 10.5
				$RR_{mean} =$	**156.4 ± 7.8**
^{180}Os	c	21.5M	902.8(D)	101.5 ± 3.4	**142.1 ± 7.1**
^{183}Re	c	70.0D	291.7	3.05 ± 0.18	154.0 ± 10.8
			162.3	23.3 ± 0.7	169.0 ± 8.0
				$RR_{mean} =$	**165.7 ± 8.1**
$^{182m}Re_c$	c	12.7H	1221.5	24.8 ± 1.6	160.7 ± 12.2
			1189.2	15 ± 1	142.5 ± 15.4
				$RR_{mean} =$	**155.2 ± 9.6**
^{181}Re	c*	19.9H	639.0	6.4 ± 1.4	147.9 ± 33.1
			365.5	56 ± 8	142.8 ± 21.1
				$RR_{mean} =$	**144.0 ± 15.5**
^{179}Re	c*	19.5M	430.2	28.0 ± 1.8	211.5 ± 16.6
			290.0	26.9 ± 2.3	191.2 ± 19.5
				$RR_{mean} =$	**207.6 ± 10.3**
^{178}Re	c*	13.2M	237.3	45 ± 5	**219.9 ± 27.5**
^{178}W	c	21.6D	1350.6(D)	1.18 ± 0.11	135.3 ± 16.5

Continuation of Table 102.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			1340.8(D)	1.03 ± 0.09	112.3 ± 13.8
				RR_{mean} =	**121.8 ± 11.9**
^{177}W	c	135M	115.7	51 ± 5	**146.0 ± 16.9**
^{177}Ta	c*	56.56H	112.9	7.2 ± 1.6	**174.0 ± 40.0**
^{176}Ta$_c$	c	8.09H	1823.7	4.5 ± 0.4	129.8 ± 21.5
			1159.3	24.7 ± 1.9	148.4 ± 14.0
			710.5	5.4 ± 0.4	231.9 ± 30.0
				RR_{mean} =	**152.6 ± 17.5**
^{175}Ta	c	10.5H	1793.1	4.6 ± 0.7	151.7 ± 30.5
			348.5	12.0 ± 1.1	177.6 ± 17.8
			266.9	10.52 ± 0.16	148.8 ± 6.8
				RR_{mean} =	**151.1 ± 7.2**
^{174}Ta$_c$	c	1.14H	206.5	60 ± 5	**160.3 ± 15.1**
^{173}Ta	c	3.14H	172.2	17.5 ± 1.8	**185.3 ± 21.0**
^{172}Ta	c*	36.8M	214.1	55 ± 5	**94.07 ± 11.00**
^{175}Hf	c	70D	343.4	84 ± 3	**156.6 ± 7.7**
^{173}Hf	c*	23.6H	311.2	10.7 ± 0.5	183.8 ± 10.8
			139.6	12.7 ± 0.6	192.8 ± 13.0
			123.7	83 ± 5	195.4 ± 15.6
				RR_{mean} =	**187.9 ± 7.5**
^{172}Hf	c	1.87Y	1093.6	*	133.1 ± 7.8
			1002.7(D)	5.55 ± 0.38	146.4 ± 13.1
			181.5	*	139.8 ± 8.9
			125.8	11.3 ± 0.9	136.4 ± 13.5
				RR_{mean} =	**137.1 ± 4.2**
^{171}Hf	c	12.1H	739.8	*	**122.7 ± 18.7**
^{170}Hf	c	16.01H	620.7	18 ± 5	188.2 ± 52.7
			164.7	26 ± 8	182.2 ± 56.5
			120.2	15 ± 5	183.2 ± 61.9
				RR_{mean} =	**186.6 ± 13.3**
^{173}Lu	c	1.37Y	272.1	21.2 ± 0.8	**154.5 ± 8.5**
^{172}Lu$_i$	i(m+g)	6.70D	1093.6	63 ± 3	**1.182 ± 0.134**
^{172}Lu$_c$	c	6.70D	1093.6	63 ± 3	**134.3 ± 7.8**
^{171}Lu$_c$	c	8.24D	739.8	47.8 ± 1.2	**154.7 ± 6.5**
^{171}Lu	c*	8.24D	853.0	2.55 ± 0.07	157.9 ± 8.2
			780.7	4.36 ± 0.11	179.6 ± 8.1
			667.4	11.0 ± 0.3	165.0 ± 7.1
				RR_{mean} =	**168.1 ± 7.8**
^{170}Lu$_c$	c	2.012D	2126.1	5.1 ± 0.3	129.6 ± 12.7
			1280.2	8.2 ± 0.4	127.6 ± 23.2
				RR_{mean} =	**129.2 ± 10.6**
^{169}Lu	c	34.06H	960.6	23.4 ± 0.7	119.8 ± 5.4
			191.2	20.6 ± 0.6	129.4 ± 6.2
				RR_{mean} =	**123.6 ± 6.0**
^{167}Lu	c	51.5M	176.2	*	121.5 ± 7.8
			113.3	*	144.9 ± 11.7
				RR_{mean} =	**128.3 ± 11.3**
^{169}Yb	c*	32.026D	198.0	35.8 ± 0.7	144.5 ± 6.5
			177.2	22.2 ± 0.5	146.5 ± 6.4
			130.5	11.31 ± 0.21	152.6 ± 8.1

Continuation of Table 102.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
				RR_{mean} =	**146.8 ± 5.2**
^{166}Yb	c	56.7H	2079.5	*	134.1 ± 10.0
			2052.4	*	136.7 ± 9.5
			1867.9	*	137.9 ± 10.5
			1374.2	*	133.4 ± 10.6
			1176.7	*	126.7 ± 9.2
			785.9	*	134.2 ± 9.6
			691.2(D)	8.56 ± 0.58	121.7 ± 9.3
				RR_{mean} =	**131.8 ± 4.1**
^{167}Tm	c	9.25D	207.8	42 ± 8	**144.2 ± 28.0**
^{165}Tm	c	30.06H	806.4	9.5 ± 0.6	134.9 ± 9.7
			242.9	35.5 ± 1.7	135.0 ± 8.3
				RR_{mean} =	**134.9 ± 5.6**
^{161}Er	c*	3.21H	826.6	64 ± 4	**145.5 ± 10.8**
^{160}Er	c	28.58H	966.2	*	121.6 ± 16.3
			962.4	*	118.7 ± 15.6
			879.4(D)	22.6 ± 2.8	133.3 ± 17.1
			872.0(D)	6.8 ± 1.1	114.5 ± 19.0
			728.2(D)	34 ± 5	124.0 ± 18.7
				RR_{mean} =	**122.6 ± 3.8**
^{159}Er	c*	36M	624.5	33 ± 4	133.3 ± 17.5
			132.0	*	153.3 ± 14.6
				RR_{mean} =	**145.4 ± 4.5**
$^{160m}Ho_c$	c	5.02H	966.2	15.4 ± 2.0	125.2 ± 17.1
			962.4	16.6 ± 2.1	116.4 ± 17.4
				RR_{mean} =	**120.9 ± 11.8**
^{156}Ho	c*	56M	266.5	54.7 ± 1.1	**133.7 ± 6.2**
^{157}Dy	c	8.14H	326.2	92 ± 4	**106.9 ± 6.0**
^{155}Dy	c*	9.9H	226.9	68.4 ± 1.6	**88.39 ± 4.35**
^{152}Dy	c	2.38H	256.9	97.50 ± 0.07	**53.22 ± 2.59**
^{155}Tb	c*	5.32D	180.1	7.5 ± 0.5	89.14 ± 7.34
			105.3	25.1 ± 1.3	95.42 ± 7.66
				RR_{mean} =	**92.24 ± 4.57**
^{153}Tb	c*	2.34D	212.0	31.0 ± 1.9	**69.37 ± 5.05**
^{152}Tb	c*	17.5H	344.3	65 ± 4	**65.55 ± 4.73**
^{151}Tb	c	17.609H	479.4	15.4 ± 0.7	59.18 ± 3.95
			251.9	26.3 ± 1.2	50.60 ± 3.27
				RR_{mean} =	**54.00 ± 4.51**
^{149}Tb	c	4.118H	165.0	26.4 ± 0.9	**23.45 ± 3.63**
^{148}Tb	c	60M	784.4	84.0 ± 1.6	**31.31 ± 2.85**
^{153}Gd	c	240.4D	103.2	21.1 ± 0.7	71.03 ± 5.03
			97.4	29.0 ± 0.8	64.67 ± 4.37
				RR_{mean} =	**67.35 ± 3.77**
^{151}Gd	c	124D	243.3	5.6 ± 0.4	**55.19 ± 4.77**
^{149}Gd	c	9.28D	788.9	7.3 ± 0.4	75.42 ± 4.95
			346.6	23.9 ± 1.3	67.02 ± 4.29
			298.6	28.6 ± 1.7	67.65 ± 4.68
			149.7	48 ± 3	74.63 ± 5.61
				RR_{mean} =	**69.95 ± 3.08**
^{147}Gd	c	38.06H	929.0	20.2 ± 1.2	50.30 ± 3.62

Continuation of Table 102.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			396.0	34.3 ± 2.1	50.53 ± 3.55
			370.0	17.2 ± 0.9	54.08 ± 3.41
				RR_{mean} =	**51.97 ± 2.12**
^{146}Gd	c	48.27D	747.2	*	56.11 ± 2.51
			154.6	46.6 ± 0.5	57.88 ± 2.31
				RR_{mean} =	**57.19 ± 1.76**
^{149}Eu	c*	93.1D	327.5	4.03 ± 0.12	**88.88 ± 5.28**
^{147}Eu	c*	24.1D	955.8	3.84 ± 0.20	68.49 ± 4.82
			798.7	4.8 ± 0.3	77.07 ± 5.67
			677.5	9.8 ± 0.5	65.18 ± 4.03
			601.5	5.9 ± 0.3	67.42 ± 4.47
			121.2	22.9 ± 1.3	65.66 ± 5.13
				RR_{mean} =	**67.63 ± 2.74**
^{146}Eu$_i$	i	4.61D	747.2	99 ± 3	**7.972 ± 0.376**
^{146}Eu$_c$	c	4.61D	747.2	99 ± 3	**64.08 ± 2.87**
^{145}Eu	c	5.93D	1997.0	7.2 ± 0.5	47.22 ± 3.85
			1658.5	14.9 ± 1.0	44.39 ± 3.44
			893.7	66 ± 5	45.94 ± 3.94
			653.5	15 ± 1	41.65 ± 3.13
				RR_{mean} =	**44.32 ± 1.95**
^{143}Pm	c	265D	742.0	38.5 ± 2.4	**37.94 ± 2.90**
^{139}Ce	c	137.640D	165.9	79.89 ± 0.01	**33.84 ± 1.26**
^{135}Ce	c	17.7H	265.6	41.8 ± 1.5	**21.29 ± 1.27**
^{132}Ce	c	3.51H	182.1	77.4 ± 0.5	**18.86 ± 1.24**
^{132}La$_c$	c	4.8H	464.5	76 ± 6	**15.89 ± 2.13**
^{133}Ba	c	3848.9D	356.0	62.05 ± 0.19	**18.80 ± 1.82**
^{131}Ba	c	11.50D	496.3	46.8 ± 0.2	18.73 ± 1.20
			373.2	14.04 ± 0.20	18.52 ± 0.79
			123.8	29.0 ± 0.3	17.82 ± 1.08
				RR_{mean} =	**18.41 ± 0.71**
^{128}Ba	c	2.43D	442.9	26.8 ± 1.4	11.59 ± 0.83
			273.4	14.5 ± 0.7	11.89 ± 0.89
				RR_{mean} =	**11.72 ± 0.53**
^{129}Cs	c	32.06H	371.9	30.6 ± 1.7	**20.89 ± 1.41**
^{127}Xe	c	36.4D	375.0	17.2 ± 0.6	15.62 ± 0.82
			202.9	68.3 ± 0.5	14.49 ± 0.59
				RR_{mean} =	**14.76 ± 0.67**
^{123}Xe	c	2.08H	148.9	48.9 ± 0.6	**18.34 ± 2.42**
^{123m}Te	i(m)	119.7D	159.0	84.0 ± 0.4	**1.351 ± 0.123**
^{121m}Te	i(m)	154D	212.2	81.4 ± 1.1	2.538 ± 0.184
			573.1	88.6 ± 0.1	2.538 ± 0.154
				RR_{mean} =	**2.538 ± 0.078**
^{121}Te$_c$	c	19.16D	573.1	80.3 ± 2.5	**12.15 ± 0.56**
^{119m}Te	i(m)	4.70D	1212.7	66.2 ± 0.3	**3.765 ± 0.184**
^{120m}Sb	i(m)	5.76D	1171.7	100 ± 0	2.178 ± 0.115
			1023.3	99.4 ± 0.3	1.765 ± 0.090
				RR_{mean} =	**1.921 ± 0.208**
^{113}Sn	c	115.09D	391.7	64.97 ± 0.17	**6.881 ± 0.316**
^{114m}In	i(m)	49.51D	190.3	15.56 ± 0.16	**8.121 ± 3.527**
^{111}In	c	2.8047D	245.4	94 ± 1	8.373 ± 0.375

Continuation of Table 102.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			171.3	90.2 ± 1.0	9.046 ± 0.380
				RR_{mean} =	**8.732 ± 0.430**
^{110m}Ag	i(m)	249.76D	884.7	72.7 ± 0.4	5.052 ± 0.256
			657.8	94.3 ± 0.3	4.683 ± 0.218
				RR_{mean} =	**4.828 ± 0.234**
^{106m}Ag	i(m)	8.28D	1045.8	29.6 ± 1.0	6.615 ± 0.367
			717.3	28.9 ± 0.8	5.509 ± 0.480
			451.0	28.2 ± 0.8	5.472 ± 0.370
				RR_{mean} =	**5.975 ± 0.437**
^{105}Ag	c	41.29D	443.4	10.5 ± 0.6	7.469 ± 0.909
			280.4	30.2 ± 1.8	7.347 ± 0.610
				RR_{mean} =	**7.382 ± 0.521**
^{100}Pd	c	3.63D	2376.0	*	**1.430 ± 0.322**
^{102}Rh	i	207D	475.1	46 ± 5	**4.877 ± 0.598**
^{101m}Rh	c	4.34D	306.9	81 ± 5	**9.336 ± 0.691**
^{100}Rh$_i$	i(m+g)	20.8H	2376.0	32.6 ± 0.4	**5.953 ± 1.112**
^{100}Rh$_c$	c	20.8H	2376.0	32.6 ± 0.4	**7.382 ± 0.938**
^{103}Ru	c	39.26D	497.1	91.0 ± 1.3	**14.28 ± 0.61**
^{96}Tc	i(m+g)	4.28D	849.9	98 ± 4	7.901 ± 0.458
			812.5	82 ± 4	8.148 ± 0.486
				RR_{mean} =	**8.016 ± 0.376**
^{99}Mo	c	65.94H	140.5	90.27 ± 0.33	**12.66 ± 0.63**
^{93m}Mo	i(m)	6.85H	684.7	99.7 ± 2.0	**6.671 ± 0.659**
^{96}Nb	i	23.35H	1091.3	48.5 ± 1.6	9.054 ± 0.623
			568.9	58.0 ± 0.3	8.770 ± 0.610
				RR_{mean} =	**8.910 ± 0.477**
^{95}Nb$_i$	i(m+g)	34.975D	765.8	99.81 ± 0.03	**14.02 ± 0.49**
^{95}Nb$_c$	c	34.975D	765.8	99.81 ± 0.03	**22.24 ± 0.75**
^{90}Nb	c*	14.60H	2319.0	82.0 ± 0.3	6.265 ± 0.530
			1129.2	92.7 ± 0.5	6.024 ± 0.361
				RR_{mean} =	**6.092 ± 0.322**
^{95}Zr	c	64.02D	765.8	*	8.290 ± 0.331
			756.7	54.46 ± 0.10	7.812 ± 0.397
				RR_{mean} =	**8.144 ± 0.251**
^{89}Zr	c	78.41H	909.2	99.04 ± 0.03	**14.65 ± 0.49**
^{88}Zr	c	83.4D	1836.1	*	6.820 ± 0.366
			898.0	*	7.279 ± 0.571
			392.9	97.24 ± 0.00	7.964 ± 0.314
				RR_{mean} =	**7.591 ± 0.234**
^{88} Y$_i$	i	106.65D	1836.1	99.2 ± 0.3	19.85 ± 0.72
			898.0	93.7 ± 0.3	17.67 ± 0.68
				RR_{mean} =	**18.83 ± 1.23**
^{88} Y$_c$	c	106.65D	1836.1	99.2 ± 0.3	26.67 ± 0.94
			898.0	93.7 ± 0.3	24.95 ± 0.87
				RR_{mean} =	**25.73 ± 1.17**
^{87} Y	c*	79.8H	484.8	89.7 ± 0.7	**19.51 ± 0.70**
^{86} Y$_c$	c	14.74H	1076.6	82.5 ± 0.4	**9.980 ± 0.582**
^{85}Sr	c	64.84D	514.0	96 ± 4	**20.06 ± 1.09**
^{84}Rb	i(m+g)	32.77D	881.6	69.0 ± 1.6	**18.57 ± 0.84**
^{83}Rb	c	86.2D	552.6	16.0 ± 1.1	23.39 ± 1.97

Continuation of Table 102.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			529.6	29.3 ± 2.1	23.95 ± 2.03
			520.4	45 ± 4	22.63 ± 2.18
				RR_{mean} =	**23.40 ± 1.10**
^{82m}Rb	i(m)	6.472H	554.3	62.4 ± 0.9	**11.72 ± 0.94**
^{82}Br	i(m+g)	35.30H	554.3	70.8 ± 1.0	**8.296 ± 0.359**
^{75}Se	c	119.779D	264.7	58.9 ± 0.4	10.45 ± 0.42
			136.0	58.3 ± 0.8	11.54 ± 0.69
			121.1	17.2 ± 0.4	12.78 ± 1.14
				RR_{mean} =	**10.75 ± 0.55**
^{74}As	i	17.77D	595.8	59 ± 4	**12.67 ± 0.97**
^{71}As	c	65.28H	174.9	82.0 ± 2.1	**2.823 ± 0.144**
$^{72}Ga_i$	i	14.10H	2201.7	25.9 ± 0.5	**4.785 ± 0.209**
$^{72}Ga_c$	c	14.10H	2201.7	25.9 ± 0.5	**5.954 ± 0.261**
^{72}Zn	c	46.5H	2201.7	*	**1.168 ± 0.051**
^{58}Co	i(m+g)	70.86D	810.8	99.45 ± 0.01	**4.068 ± 0.297**
^{59}Fe	c	44.472D	1291.6	43.2 ± 1.4	6.723 ± 0.370
			1099.2	56.5 ± 1.9	6.559 ± 0.366
				RR_{mean} =	**6.641 ± 0.284**
^{54}Mn	i	312.11D	834.8	99.98 ± 0.00	**5.259 ± 0.277**
^{48} V	c	15.9735D	1312.1	97.5 ± 0.9	0.9196 ± 0.0649
			983.5	100.0 ± 0.3	0.7943 ± 0.1501
				RR_{mean} =	**0.9027 ± 0.0610**
^{48}Sc	i	43.67H	1312.1	100.1 ± 0.7	2.362 ± 0.205
			1037.5	97.6 ± 0.7	2.958 ± 0.216
				RR_{mean} =	**2.653 ± 0.309**
^{46}Sc	i(m+g)	83.79D	1120.6	99.99 ± 0.00	3.586 ± 0.394
			889.3	99.98 ± 0.00	4.539 ± 0.204
				RR_{mean} =	**4.413 ± 0.351**
^{24}Na	c	14.9590H	1369.0	100 ± 0	**10.22 ± 0.52**
^{7}Be	i	53.29D	477.6	10.52 ± 0.06	**19.15 ± 1.11**

12.10.5 Nuclide production rates for ^{209}Bi

Table 103: Detailed calculation of nuclide production rates for ^{209}Bi for $E_p = 1.6$ GeV, used to determine the cross sections for their production.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{207}Po	i(m+g)	5.80H	992.3	59.3 ± 0.9	**15.34 ± 0.71**
^{206}Po	i	8.8D	1032.3	33 ± 5	17.05 ± 2.65
			286.4	24 ± 3	18.25 ± 2.38
			807.4	23 ± 3	18.45 ± 2.51
			338.4	19.2 ± 2.5	16.88 ± 2.28
			522.5	15.7 ± 2.0	15.81 ± 2.10
			980.2	7.1 ± 0.9	19.65 ± 2.68
			311.6	4.2 ± 0.6	22.19 ± 3.37
			1007.2	3.1 ± 0.4	15.54 ± 2.40
			803.1	*	16.62 ± 0.65
			1718.7	*	16.34 ± 0.93
			1595.3	*	16.02 ± 1.41

Continuation of Table 103.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			657.2	*	12.47 ± 3.95
			620.5	*	15.49 ± 1.91
			537.5	*	14.44 ± 0.66
			516.2	*	15.38 ± 0.64
			343.5	*	16.10 ± 1.20
				RR_{mean} =	**15.74 ± 0.49**
^{207}Bi	c	31.55Y	1063.7	74.5 ± 0.2	204.0 ± 8.2
			569.7	97.74 ± 0.03	202.0 ± 7.5
				RR_{mean} =	**202.8 ± 7.1**
^{206}Bi$_i$	i	6.243D	803.1	98.9 ± 1.4	109.0 ± 3.9
			1718.7	31.8 ± 0.6	116.9 ± 4.7
			516.2	40.7 ± 0.6	105.2 ± 3.9
			537.5	30.5 ± 0.5	102.8 ± 3.9
			343.5	23.4 ± 0.4	105.8 ± 4.1
			620.5	5.76 ± 0.09	106.0 ± 4.9
			1595.3	5.01 ± 0.08	118.9 ± 4.7
			657.2	1.91 ± 0.04	114.9 ± 6.4
				RR_{mean} =	**108.6 ± 3.9**
^{206}Bi$_c$	c	6.243D	803.1	98.9 ± 1.4	124.7 ± 4.4
			1718.7	31.8 ± 0.6	132.4 ± 5.2
			516.2	40.7 ± 0.6	119.7 ± 4.5
			537.5	30.5 ± 0.5	116.4 ± 4.4
			343.5	23.4 ± 0.4	121.1 ± 4.6
			620.5	5.76 ± 0.09	120.6 ± 4.8
			1595.3	5.01 ± 0.08	134.0 ± 5.1
			657.2	1.91 ± 0.04	126.7 ± 5.7
				RR_{mean} =	**123.7 ± 4.4**
^{205}Bi	c	15.31D	1764.3	32.5 ± 0.7	124.1 ± 5.1
			987.7	16.13 ± 0.17	120.0 ± 4.4
			1861.7	6.17 ± 0.10	118.2 ± 4.7
			1043.8	7.51 ± 0.10	108.3 ± 4.3
			703.5	31.1 ± 0.1	114.4 ± 4.0
			1775.8	3.99 ± 0.08	117.7 ± 5.1
			1190.0	2.26 ± 0.07	116.5 ± 6.2
			579.8	5.44 ± 0.07	103.2 ± 3.9
			759.1	1.04 ± 0.05	125.7 ± 9.6
			1614.3	2.28 ± 0.04	120.7 ± 5.0
			284.1	1.69 ± 0.02	112.6 ± 5.2
			872.0	0.42 ± 0.01	95.27 ± 10.18
				RR_{mean} =	**114.5 ± 4.0**
^{204}Bi	c*	11.22H	899.2	98 ± 9	86.23 ± 3.14
			374.8	82 ± 5	100.5 ± 21.0
			984.0	59 ± 4	88.77 ± 7.27
			670.7	11.4 ± 0.9	89.65 ± 7.90
			918.3	10.8 ± 0.9	100.2 ± 9.2
				RR_{mean} =	**86.93 ± 2.68**
^{203}Bi	c	11.76H	820.2	29.6 ± 1.5	79.74 ± 4.91
			1847.3	11.4 ± 0.8	70.74 ± 5.98
			1679.6	8.8 ± 0.7	68.90 ± 6.41
			1893.0	8.2 ± 0.6	74.18 ± 6.82
			279.2	*	80.04 ± 7.31

Continuation of Table 103.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
				$RR_{mean}=$	**78.70 ± 2.43**
^{202}Bi	c*	1.72H	422.1	83.7 ± 2.5	66.04 ± 3.58
			960.7	99.28 ± 0.02	69.48 ± 3.43
				$RR_{mean}=$	**67.93 ± 2.88**
^{204m}Pb$_i$	i(m)	67.2M	374.7	89 ± 15	35.68 ± 6.21
			899.2	99.17 ± 0.02	35.16 ± 2.57
				$RR_{mean}=$	**35.23 ± 2.43**
^{204m}Pb$_c$	c	67.2M	374.7	89 ± 15	48.29 ± 8.35
			899.2	99.17 ± 0.02	48.09 ± 2.74
				$RR_{mean}=$	**48.10 ± 2.67**
^{203}Pb$_i$	i(m1+m2+g)	51.873H	279.2	80.8 ± 0.2	**67.20 ± 8.93**
^{203}Pb$_c$	c	51.873H	279.2	80.8 ± 0.2	**147.2 ± 5.7**
^{202m}Pb	i(m)	3.53H	960.7	92 ± 8	39.58 ± 4.43
			422.1	86 ± 5	34.99 ± 2.79
				$RR_{mean}=$	**35.87 ± 2.12**
^{201}Pb	c*	9.33H	331.2	79 ± 5	**134.4 ± 9.7**
^{200}Pb	c	21.5H	147.6	37.7 ± 1.4	103.5 ± 7.2
			450.5	3.33 ± 0.08	100.4 ± 6.3
			1205.7	*	92.57 ± 6.39
			579.3	*	89.23 ± 5.80
			367.9	*	93.10 ± 3.27
				$RR_{mean}=$	**93.62 ± 2.89**
^{199}Pb	c*	90M	366.9	44 ± 7	158.4 ± 26.4
			353.4	9.5 ± 1.5	172.0 ± 29.9
			1135.0	7.8 ± 1.2	124.7 ± 20.4
				$RR_{mean}=$	**142.6 ± 14.7**
^{198}Pb	c	2.4H	173.4	18 ± 3	**128.2 ± 22.3**
^{197m}Pb	c*	43M	385.9	74 ± 15	81.32 ± 16.75
			222.8	25 ± 6	72.66 ± 18.09
				$RR_{mean}=$	**80.63 ± 3.88**
^{195m}Pb	i(m)	15.0M	383.6	107 ± 20	**41.40 ± 8.01**
^{202}Tl	c	12.23D	439.6	91.4 ± 1.0	**22.54 ± 0.82**
^{201}Tl	c*	72.912H	167.4	10.00 ± 0.06	**158.7 ± 6.3**
^{200}Tl$_i$	i	26.1H	1205.7	29.9 ± 1.8	45.08 ± 3.36
			579.3	13.8 ± 0.7	34.61 ± 4.15
			367.9	87.2 ± 0.4	35.49 ± 2.66
				$RR_{mean}=$	**38.35 ± 3.45**
^{200}Tl$_c$	c	26.1H	1205.7	29.9 ± 1.8	137.6 ± 9.5
			579.3	13.8 ± 0.7	123.8 ± 7.9
			367.9	87.2 ± 0.4	128.6 ± 4.6
				$RR_{mean}=$	**128.7 ± 4.5**
^{199}Tl	c*	7.42H	455.5	12.4 ± 1.4	148.8 ± 18.0
			247.3	9.3 ± 1.1	160.0 ± 20.1
				$RR_{mean}=$	**153.3 ± 8.9**
^{198m}Tl	i(m)	1.87H	282.8	28 ± 3	**32.90 ± 4.95**
^{197}Tl	c*	2.84H	152.2	7.3 ± 2.3	**178.1 ± 56.8**
^{196m}Tl	i(m)	1.41H	695.4	41 ± 7	**81.61 ± 14.27**
^{197m}Hg	i(m)	23.8H	134.0	33.5 ± 0.4	**14.23 ± 1.10**
^{193m}Hg	i(m)	11.8H	407.6	32 ± 6	**25.77 ± 4.93**
^{192}Hg	c	4.85H	274.8	50.2 ± 2.5	90.13 ± 5.84

Continuation of Table 103.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			316.5	*	104.3 ± 13.1
				RR_{mean} =	**92.11 ± 2.84**
^{190}Hg	c*	20.0M	142.6	68 ± 10	66.91 ± 10.64
			295.8	*	43.10 ± 8.56
			597.7	*	65.89 ± 16.44
			301.8	*	98.23 ± 13.96
				RR_{mean} =	**65.12 ± 2.01**
^{196}Au	i(m1+m2+g)	6.183D	355.7	87.0 ± 0.8	3.624 ± 0.135
			333.0	22.9 ± 0.6	4.079 ± 0.235
				RR_{mean} =	**3.673 ± 0.182**
^{195}Au	c	186.098D	98.9	10.9 ± 0.9	**104.8 ± 12.3**
^{194}Au	i(m1+m2+g)	38.02H	328.5	61 ± 5	**7.676 ± 0.720**
^{192}Au$_i$	i(m+g)	4.94H	316.5	58 ± 7	**15.56 ± 2.31**
^{192}Au$_c$	c	4.94H	316.5	58 ± 7	**119.9 ± 15.1**
^{191}Au	c*	3.18H	277.9	7.2 ± 0.5	**84.10 ± 10.41**
^{190}Au$_c$	c	42.8M	295.8	71 ± 5	100.8 ± 8.7
			301.8	23.4 ± 1.5	79.75 ± 8.81
			597.7	9.4 ± 0.9	73.45 ± 10.23
				RR_{mean} =	**88.55 ± 8.86**
^{191}Pt	c	2.802D	538.9	13.7 ± 1.6	96.50 ± 11.76
			409.4	8.0 ± 0.9	81.92 ± 9.67
			359.9	6.0 ± 0.7	84.92 ± 10.45
			129.4	3.2 ± 0.5	91.57 ± 15.76
				RR_{mean} =	**86.73 ± 4.32**
^{189}Pt	c	10.87H	568.8	7.1 ± 0.6	104.2 ± 14.6
			544.9	5.8 ± 0.5	122.9 ± 13.7
			607.6	8.10 ± 0.16	105.1 ± 5.7
				RR_{mean} =	**106.8 ± 5.3**
^{188}Pt	c	10.2D	195.1	18.6 ± 1.2	91.40 ± 6.91
			187.6	19.4 ± 1.2	90.34 ± 6.61
			381.4	7.5 ± 0.5	86.89 ± 6.54
			423.3	4.4 ± 0.3	87.78 ± 6.77
			478.0	*	89.29 ± 4.85
				RR_{mean} =	**89.18 ± 2.75**
^{186}Pt	c	2.08H	689.4	70 ± 15	**82.58 ± 17.94**
^{184}Pt	c	17.3M	548.3	23 ± 4	**84.01 ± 16.84**
^{189}Ir	c	13.2D	245.1	6.0 ± 0.6	**89.18 ± 9.74**
^{188}Ir$_c$	c	41.5H	478.0	14.7 ± 0.6	**92.91 ± 5.29**
^{187}Ir	c*	10.5H	977.5	3.14 ± 0.11	**83.03 ± 7.47**
^{186}Ir	c	16.64H	296.9	62.3 ± 1.9	42.73 ± 3.45
			434.8	33.9 ± 1.1	42.11 ± 2.19
				RR_{mean} =	**42.26 ± 2.01**
^{185}Ir	c	14.4H	254.2	13.3 ± 2.4	52.57 ± 10.34
			1829.0	10.1 ± 1.5	64.27 ± 9.98
			1668.0	3.6 ± 0.6	66.33 ± 11.79
				RR_{mean} =	**62.75 ± 3.73**
^{184}Ir	c*	3.09H	264.0	68 ± 4	89.24 ± 6.40
			119.8	31 ± 3	97.43 ± 12.12
			390.4	25.9 ± 2.4	83.48 ± 8.53
			1105.3	5.3 ± 0.7	98.99 ± 14.64

Continuation of Table 103.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
				RR_{mean} =	**89.24** ± **3.63**
^{185}Os	c	93.6D	646.1	78 ± 3	93.40 ± 4.77
			874.8	6.29 ± 0.25	92.54 ± 4.97
			717.4	3.94 ± 0.16	94.54 ± 5.14
			592.1	1.32 ± 0.06	94.43 ± 6.49
				RR_{mean} =	**93.46** ± **3.03**
^{183m}Os	c*	9.9H	1101.9	49.0 ± 1.3	55.62 ± 2.63
			1107.9	22.4 ± 0.6	58.91 ± 3.57
				RR_{mean} =	**56.35** ± **2.21**
^{182}Os	c	22.10H	180.2	33.5 ± 1.7	91.86 ± 6.19
			1221.5	*	120.9 ± 9.1
			1189.2	*	110.5 ± 9.2
			1121.4	*	116.1 ± 7.5
				RR_{mean} =	**103.3** ± **3.2**
^{181}Os	c	105M	238.8	44 ± 5	**27.10** ± **3.86**
^{180}Os	c	21.5M	902.8(D)	101.5 ± 3.4	**92.67** ± **4.95**
^{183}Re	c	70.0D	162.3	23.3 ± 0.7	98.85 ± 4.93
			291.7	3.05 ± 0.18	89.01 ± 6.44
			208.8	2.95 ± 0.09	92.32 ± 5.17
			107.9	2.17 ± 0.07	87.76 ± 8.14
				RR_{mean} =	**94.33** ± **3.82**
^{182m}Re$_c$	c	12.7H	1221.5	24.8 ± 1.6	99.33 ± 7.62
			1121.4	31.8 ± 1.6	108.7 ± 7.4
			1189.2	15 ± 1	98.07 ± 8.57
				RR_{mean} =	**103.2** ± **4.7**
^{181}Re	c*	19.9H	365.5	56 ± 8	96.89 ± 14.27
			639.0	6.4 ± 1.4	91.89 ± 21.74
				RR_{mean} =	**95.66** ± **10.44**
^{179}Re	c*	19.5M	290.0	26.9 ± 2.3	130.1 ± 13.7
			430.2	28.0 ± 1.8	136.0 ± 10.7
				RR_{mean} =	**135.0** ± **5.9**
^{178}Re	c*	13.2M	237.3	45 ± 5	**131.6** ± **16.3**
^{178} W	c	21.6D	1340.8(D)	1.03 ± 0.09	85.05 ± 9.15
			1106.1(D)	0.54 ± 0.05	88.02 ± 11.81
				RR_{mean} =	**85.80** ± **5.18**
^{177} W	c	135M	115.7	51 ± 5	**95.12** ± **11.99**
^{177}Ta	c*	56.56H	112.9	7.2 ± 1.6	**98.04** ± **23.13**
^{176}Ta	c*	8.09H	1159.3	24.7 ± 1.9	123.2 ± 10.5
			1823.7	4.5 ± 0.4	125.1 ± 17.3
			1584.0	5.3 ± 0.4	106.2 ± 10.3
				RR_{mean} =	**119.1** ± **6.4**
^{175}Ta	c	10.5H	348.5	12.0 ± 1.1	100.7 ± 10.0
			1793.1	4.6 ± 0.7	71.54 ± 11.66
				RR_{mean} =	**88.74** ± **14.58**
^{174}Ta$_c$	c	1.14H	206.5	60 ± 5	**96.58** ± **9.18**
^{173}Ta	c	3.14H	172.2	17.5 ± 1.8	**110.9** ± **12.6**
^{172}Ta	c*	36.8M	214.1	55 ± 5	**60.44** ± **6.20**
^{175}Hf	c	70D	343.4	84 ± 3	**93.48** ± **4.59**
^{173}Hf	c*	23.6H	123.7	83 ± 5	117.2 ± 10.7
			297.0	33.9 ± 1.4	157.6 ± 9.7

Continuation of Table 103.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			139.6	12.7 ± 0.6	117.6 ± 9.8
			311.2	10.7 ± 0.5	108.1 ± 6.5
			306.6	6.4 ± 0.3	129.3 ± 8.4
				RR_{mean} =	**123.3 ± 9.8**
^{172}Hf	c	1.87Y	125.8	11.3 ± 0.9	82.64 ± 8.87
			1002.7(D)	5.55 ± 0.38	82.55 ± 7.06
			1093.6	*	83.35 ± 4.85
			929.1	*	89.71 ± 7.69
			912.1	*	91.84 ± 5.70
			697.3	*	119.6 ± 7.6
			181.5	*	84.64 ± 5.35
				RR_{mean} =	**85.96 ± 2.65**
^{170}Hf	c	16.01H	164.7	26 ± 8	99.89 ± 31.01
			620.7	18 ± 5	110.1 ± 30.9
			120.2	15 ± 5	119.1 ± 40.6
				RR_{mean} =	**108.6 ± 7.8**
^{168}Hf	c	25.95M	979.2	22.3 ± 5.6	**85.22 ± 22.25**
^{173}Lu	c	1.37Y	272.1	21.2 ± 0.8	**91.74 ± 4.96**
^{172}Lu$_i$	i(m+g)	6.70D	1093.6	63 ± 3	**0.5030 ± 0.0802**
^{172}Lu$_c$	c	6.70D	1093.6	63 ± 3	83.85 ± 4.88
			181.5	20.6 ± 1.0	86.12 ± 5.44
			912.1	15.3 ± 0.7	91.39 ± 9.40
				RR_{mean} =	**85.02 ± 3.24**
^{171}Lu	c*	8.24D	739.8	47.8 ± 1.2	99.64 ± 4.13
			667.4	11.0 ± 0.3	105.2 ± 4.6
			780.7	4.36 ± 0.11	101.3 ± 5.2
			839.9	3.04 ± 0.08	110.8 ± 5.0
			853.0	2.55 ± 0.07	99.27 ± 4.61
			689.3	2.37 ± 0.06	92.57 ± 4.33
			712.7	1.13 ± 0.03	103.6 ± 5.7
				RR_{mean} =	**101.3 ± 3.8**
^{170}Lu	c*	2.012D	1280.2	8.2 ± 0.4	115.7 ± 7.5
			2126.1	5.1 ± 0.3	119.2 ± 8.8
			1054.3	4.76 ± 0.24	127.7 ± 8.1
				RR_{mean} =	**120.9 ± 5.3**
^{169}Lu	c	34.06H	960.6	23.4 ± 0.7	71.56 ± 3.36
			191.2	20.6 ± 0.6	79.93 ± 3.93
			1449.7	9.9 ± 0.3	68.21 ± 3.56
			889.8	5.36 ± 0.17	71.12 ± 3.88
				RR_{mean} =	**72.54 ± 3.30**
^{167}Lu	c	51.5M	113.3	*	89.63 ± 8.47
			106.2	*	72.03 ± 8.83
				RR_{mean} =	**81.41 ± 9.13**
^{169}Yb	c*	32.026D	198.0	35.8 ± 0.7	89.38 ± 3.97
			177.2	22.2 ± 0.5	89.45 ± 4.01
			130.5	11.31 ± 0.21	92.94 ± 6.18
			307.7	10.05 ± 0.19	95.29 ± 3.83
			118.2	1.87 ± 0.04	84.85 ± 6.85
				RR_{mean} =	**91.91 ± 3.24**
^{166}Yb	c	56.7H	2052.4	*	76.40 ± 5.44
			2079.5	*	82.43 ± 6.47

Continuation of Table 103.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			1374.2	*	80.31 ± 6.48
			1176.7	*	77.02 ± 5.55
			785.9	*	82.61 ± 5.87
			691.2(D)	*	71.73 ± 5.46
				RR_{mean} =	**77.99 ± 3.24**
^{162}Yb	c	18.87M	163.4	40 ± 5	**76.93 ± 10.37**
^{167}Tm	c	9.25D	207.8	42 ± 8	88.39 ± 17.19
			531.5	1.61 ± 0.22	86.66 ± 12.80
				RR_{mean} =	**86.91 ± 5.39**
^{165}Tm	c	30.06H	242.9	35.5 ± 1.7	82.74 ± 5.14
			806.4	9.5 ± 0.6	89.59 ± 7.26
				RR_{mean} =	**84.12 ± 3.78**
^{163}Tm	c	1.810H	104.3	18.6 ± 0.7	**68.44 ± 7.31**
^{161}Er	c*	3.21H	826.6	64 ± 4	**79.16 ± 6.08**
^{160}Er	c	28.58H	728.2(D)	34 ± 5	77.64 ± 11.77
			879.4(D)	22.6 ± 2.8	70.42 ± 9.25
			645.4(D)	18.0 ± 2.3	86.08 ± 11.63
			872.0(D)	6.8 ± 1.1	72.01 ± 12.01
			966.2	*	75.62 ± 10.20
			962.4	*	69.79 ± 9.22
				RR_{mean} =	**74.56 ± 2.30**
^{159}Er	c*	36M	624.5	33 ± 4	78.70 ± 10.09
			649.1	23 ± 3	89.87 ± 12.54
			309.6	*	79.83 ± 8.61
			132.0	*	77.93 ± 11.38
			121.0	*	79.23 ± 8.24
				RR_{mean} =	**80.25 ± 2.48**
^{160m}Ho$_c$	c	5.02H	962.4	16.6 ± 2.1	74.85 ± 10.96
			966.2	15.4 ± 2.0	76.03 ± 10.54
				RR_{mean} =	**75.47 ± 7.37**
^{156}Ho	c*	56M	266.5	54.7 ± 1.1	**71.80 ± 3.46**
^{157}Dy	c	8.14H	326.2	92 ± 4	**61.62 ± 3.57**
^{155}Dy	c*	9.9H	226.9	68.4 ± 1.6	**50.86 ± 2.45**
^{152}Dy	c	2.38H	256.9	97.50 ± 0.07	**30.29 ± 1.38**
^{155}Tb	c*	5.32D	105.3	25.1 ± 1.3	54.14 ± 5.19
			180.1	7.5 ± 0.5	52.36 ± 4.17
			163.3	4.44 ± 0.24	49.66 ± 4.17
			148.6	2.65 ± 0.14	56.65 ± 4.95
				RR_{mean} =	**52.67 ± 2.28**
^{153}Tb	c*	2.34D	212.0	31.0 ± 1.9	42.01 ± 3.07
			102.2	6.4 ± 0.5	31.47 ± 4.27
				RR_{mean} =	**39.20 ± 4.82**
^{152}Tb	c*	17.5H	344.3	65 ± 4	**39.34 ± 3.02**
^{151}Tb	c	17.609H	287.4	28.3 ± 1.2	33.96 ± 1.99
			108.1	24.3 ± 1.1	30.06 ± 3.05
			587.5	15.6 ± 0.7	37.38 ± 2.66
			479.4	15.4 ± 0.7	31.09 ± 2.21
			395.4	10.8 ± 0.5	35.07 ± 3.32
				RR_{mean} =	**33.48 ± 1.59**
^{150}Tb	c	3.48H	638.0	72 ± 10	**17.97 ± 2.74**

Continuation of Table 103.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{149}Tb	c	4.118H	165.0	26.4 ± 0.9	17.19 ± 2.25
			352.2	29.4 ± 0.9	17.12 ± 1.32
				RR_{mean} =	**17.14 ± 1.12**
^{148}Tb	c	60M	784.4	84.0 ± 1.6	**23.90 ± 1.50**
^{153}Gd	c	240.4D	97.4	29.0 ± 0.8	34.97 ± 2.95
			103.2	21.1 ± 0.7	39.58 ± 3.46
				RR_{mean} =	**36.89 ± 2.54**
^{151}Gd	c	124D	243.3	5.6 ± 0.4	35.81 ± 3.05
			153.6	6.2 ± 0.4	32.30 ± 2.71
			174.7	2.96 ± 0.21	35.41 ± 3.06
				RR_{mean} =	**34.25 ± 1.57**
^{149}Gd	c	9.28D	149.7	48 ± 3	45.03 ± 3.61
			298.6	28.6 ± 1.7	40.60 ± 2.82
			346.6	23.9 ± 1.3	40.35 ± 2.60
			788.9	7.3 ± 0.4	45.32 ± 2.96
				RR_{mean} =	**42.17 ± 1.87**
^{147}Gd	c	38.06H	229.3	63 ± 4	34.76 ± 2.61
			396.0	34.3 ± 2.1	29.37 ± 2.09
			929.0	20.2 ± 1.2	31.96 ± 2.23
			370.0	17.2 ± 0.9	32.99 ± 2.15
				RR_{mean} =	**32.01 ± 1.46**
^{146}Gd	c	48.27D	154.6	46.6 ± 0.5	34.83 ± 1.45
			747.2	*	33.12 ± 1.48
			1533.7	*	30.27 ± 1.91
			1297.0	*	32.52 ± 1.89
				RR_{mean} =	**33.35 ± 1.03**
^{149}Eu	c*	93.1D	327.5	4.03 ± 0.12	54.16 ± 2.86
			277.1	3.56 ± 0.06	50.15 ± 2.29
				RR_{mean} =	**51.53 ± 2.48**
^{147}Eu	c*	24.1D	121.2	22.9 ± 1.3	39.46 ± 3.56
			677.5	9.8 ± 0.5	41.44 ± 2.61
			798.7	4.8 ± 0.3	41.19 ± 3.07
			601.5	5.9 ± 0.3	42.68 ± 2.79
			955.8	3.84 ± 0.20	43.33 ± 2.95
			933.0	3.44 ± 0.18	40.32 ± 3.06
			856.9	2.70 ± 0.14	36.75 ± 2.57
				RR_{mean} =	**40.85 ± 1.54**
$^{146}Eu_i$	i	4.61D	747.2	99 ± 3	**4.581 ± 0.217**
$^{146}Eu_c$	c	4.61D	747.2	99 ± 3	**37.70 ± 1.69**
^{145}Eu	c	5.93D	893.7	66 ± 5	26.10 ± 2.18
			1658.5	14.9 ± 1.0	24.72 ± 1.90
			653.5	15 ± 1	25.72 ± 2.04
			1997.0	7.2 ± 0.5	26.76 ± 2.30
			542.6	4.5 ± 0.4	30.10 ± 3.05
				RR_{mean} =	**26.07 ± 1.13**
^{143}Pm	c	265D	742.0	38.5 ± 2.4	**22.86 ± 1.64**
^{139}Ce	c	137.640D	165.9	79.89 ± 0.01	**19.82 ± 0.77**
^{135}Ce	c	17.7H	265.6	41.8 ± 1.5	**12.59 ± 0.75**
^{132}Ce	c	3.51H	182.1	77.4 ± 0.5	10.71 ± 0.59
			464.5	*	9.136 ± 0.859

Continuation of Table 103.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
				RR_{mean} =	**10.30 ± 0.32**
$^{132}La_c$	c	4.8H	464.5	76 ± 6	**8.982 ± 0.805**
^{133}Ba	c	3848.9D	356.0	62.05 ± 0.19	**12.28 ± 0.97**
^{131}Ba	c	11.50D	123.8	29.0 ± 0.3	10.98 ± 0.78
			373.2	14.04 ± 0.20	11.33 ± 0.48
				RR_{mean} =	**11.27 ± 0.45**
^{128}Ba	c	2.43D	442.9	26.8 ± 1.4	7.158 ± 0.696
			273.4	14.5 ± 0.7	7.301 ± 0.614
				RR_{mean} =	**7.245 ± 0.419**
^{129}Cs	c	32.06H	371.9	30.6 ± 1.7	**14.44 ± 1.10**
^{127}Xe	c	36.4D	172.1	25.5 ± 0.8	10.72 ± 0.61
			375.0	17.2 ± 0.6	10.47 ± 0.55
			202.9	68.3 ± 0.5	10.40 ± 0.43
				RR_{mean} =	**10.47 ± 0.38**
^{125}Xe	c	16.9H	188.4	54.0 ± 0.3	**12.84 ± 0.81**
^{123}Xe	c	2.08H	148.9	48.9 ± 0.6	**12.80 ± 1.16**
^{126} I	i	13.11D	388.6	34 ± 3	**0.8295 ± 0.1390**
^{121} I	c*	2.12H	212.2	84.3 ± 0.3	**9.868 ± 0.769**
^{123m}Te	i(m)	119.7D	159.0	84.0 ± 0.4	**1.389 ± 0.072**
^{121m}Te	i(m)	154D	212.2	81.4 ± 1.1	2.316 ± 0.112
			573.1	88.6 ± 0.1	2.439 ± 0.205
				RR_{mean} =	**2.336 ± 0.072**
$^{121}Te_c$	c	19.16D	573.1	80.3 ± 2.5	**8.736 ± 0.434**
^{119m}Te	i(m)	4.70D	1212.7	66.2 ± 0.3	**2.928 ± 0.190**
^{116}Te	c	2.49H	1293.6	95 ± 8	**4.386 ± 0.763**
^{120m}Sb	i(m)	5.76D	1023.3	99.4 ± 0.3	1.843 ± 0.095
			1171.7	100 ± 0	1.910 ± 0.095
				RR_{mean} =	**1.877 ± 0.079**
^{115}Sb	c*	32.1M	497.3	97.9 ± 0.4	**7.780 ± 0.726**
^{117m}Sn	i(m)	13.60D	158.6	86.4 ± 0.4	**3.768 ± 0.158**
^{113}Sn	c	115.09D	391.7	64.97 ± 0.17	**5.437 ± 0.236**
^{114m}In	i(m)	49.51D	190.3	15.56 ± 0.16	**5.474 ± 0.574**
^{111}In	c	2.8047D	245.4	94 ± 1	7.370 ± 0.328
			171.3	90.2 ± 1.0	6.986 ± 0.327
				RR_{mean} =	**7.187 ± 0.293**
^{110m}Ag	i(m)	249.76D	1384.3	24.9 ± 0.8	5.508 ± 0.443
			937.5	34.2 ± 0.6	5.073 ± 0.362
			884.7	72.7 ± 0.4	4.780 ± 0.216
			657.8	94.3 ± 0.3	4.922 ± 0.189
				RR_{mean} =	**4.916 ± 0.175**
^{106m}Ag	i(m)	8.28D	1045.8	29.6 ± 1.0	5.087 ± 0.281
			717.3	28.9 ± 0.8	4.704 ± 0.255
			451.0	28.2 ± 0.8	5.004 ± 0.273
			406.2	13.4 ± 0.4	4.564 ± 0.314
				RR_{mean} =	**4.856 ± 0.190**
^{105}Ag	c	41.29D	280.4	30.2 ± 1.8	6.275 ± 0.469
			443.4	10.5 ± 0.6	6.857 ± 0.785
				RR_{mean} =	**6.413 ± 0.415**
^{100}Pd	c	3.63D	2376.0	*	**0.8840 ± 0.1013**
^{105}Rh	c	35.36H	318.9	19.1 ± 0.6	**16.89 ± 1.13**

Continuation of Table 103.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{102}Rh	i	207D	475.1	46 ± 5	**4.597 ± 0.553**
^{101m}Rh	c	4.34D	306.9	81 ± 5	**8.328 ± 0.612**
^{100}Rh$_i$	i(m+g)	20.8H	2376.0	32.6 ± 0.4	**5.068 ± 0.455**
^{100}Rh$_c$	c	20.8H	2376.0	32.6 ± 0.4	**5.952 ± 0.455**
^{103}Ru	c	39.26D	497.1	91.0 ± 1.3	**15.16 ± 0.57**
^{96}Tc	i(m+g)	4.28D	849.9	98 ± 4	6.990 ± 0.380
			812.5	82 ± 4	7.323 ± 0.446
				RR_{mean} =	**7.123 ± 0.327**
^{99}Mo	c	65.94H	140.5	90.27 ± 0.33	**13.14 ± 0.78**
^{93m}Mo	i(m)	6.85H	684.7	99.7 ± 2.0	**3.603 ± 0.502**
^{96}Nb	i	23.35H	1091.3	48.5 ± 1.6	10.11 ± 0.55
			568.9	58.0 ± 0.3	10.26 ± 0.88
				RR_{mean} =	**10.15 ± 0.51**
^{95}Nb$_i$	i(m+g)	34.975D	765.8	99.81 ± 0.03	**13.40 ± 0.53**
^{95}Nb$_c$	c	34.975D	765.8	99.81 ± 0.03	**22.10 ± 0.77**
^{90}Nb	c*	14.60H	2319.0	82.0 ± 0.3	**4.971 ± 0.332**
^{95}Zr	c	64.02D	724.2	44.17 ± 0.16	9.112 ± 0.355
			756.7	54.46 ± 0.10	8.377 ± 0.295
			765.8	*	8.780 ± 0.414
				RR_{mean} =	**8.696 ± 0.268**
^{89}Zr	c	78.41H	909.2	99.04 ± 0.03	**12.68 ± 0.43**
^{88}Zr	c	83.4D	1836.1	*	7.358 ± 0.414
			898.0	*	6.754 ± 0.506
			392.9	97.24 ± 0.00	6.715 ± 0.240
				RR_{mean} =	**6.779 ± 0.209**
^{90m}Y	i(m)	3.19H	479.5	90.74 ± 0.05	**11.33 ± 0.70**
^{88}Y$_i$	i	106.65D	1836.1	99.2 ± 0.3	16.16 ± 0.62
			898.0	93.7 ± 0.3	15.98 ± 0.62
				RR_{mean} =	**16.07 ± 0.56**
^{88}Y$_c$	c	106.65D	1836.1	99.2 ± 0.3	23.51 ± 0.83
			898.0	93.7 ± 0.3	22.73 ± 0.79
				RR_{mean} =	**23.06 ± 0.81**
^{87}Y	c*	79.8H	388.5	82.1 ± 0.5	**17.77 ± 0.62**
^{85}Sr	c	64.84D	514.0	96 ± 4	**17.30 ± 0.94**
^{84}Rb	i(m+g)	32.77D	881.6	69.0 ± 1.6	**16.05 ± 0.77**
^{83}Rb	c	86.2D	520.4	45 ± 4	19.37 ± 1.85
			529.6	29.3 ± 2.1	19.01 ± 1.52
			552.6	16.0 ± 1.1	20.24 ± 1.58
				RR_{mean} =	**19.58 ± 0.86**
^{82m}Rb	i(m)	6.472H	554.3	62.4 ± 0.9	**9.318 ± 0.967**
^{82}Br	i(m+g)	35.30H	554.3	70.8 ± 1.0	**7.439 ± 0.351**
^{75}Se	c	119.779D	136.0	58.3 ± 0.8	9.758 ± 0.625
			264.7	58.9 ± 0.4	9.404 ± 0.376
			400.7	11.47 ± 0.09	10.94 ± 0.78
				RR_{mean} =	**9.591 ± 0.429**
^{76}As	i	1.0778D	559.1	45 ± 2	**16.51 ± 1.73**
^{74}As	i	17.77D	595.8	59 ± 4	**10.41 ± 0.80**
^{71}As	c	65.28H	174.9	82.0 ± 2.1	**1.657 ± 0.105**
^{72}Ga$_i$	i	14.10H	2201.7	25.9 ± 0.5	**4.155 ± 0.413**
^{72}Ga$_c$	c	14.10H	2201.7	25.9 ± 0.5	**6.125 ± 0.426**

Continuation of Table 103.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{72}Zn	c	46.5H	2201.7	*	**1.971 ± 0.146**
^{65}Zn	c	244.26D	1115.6	50.60 ± 0.24	**4.446 ± 0.256**
^{58}Co	i(m+g)	70.86D	810.8	99.45 ± 0.01	**3.269 ± 0.232**
^{59}Fe	c	44.472D	1099.2	56.5 ± 1.9	5.213 ± 0.315
			1291.6	43.2 ± 1.4	5.051 ± 0.255
				RR_{mean} =	**5.105 ± 0.214**
^{54}Mn	i	312.11D	834.8	99.98 ± 0.00	**3.967 ± 0.305**
^{48} V	c	15.9735D	1312.1	97.5 ± 0.9	0.5116 ± 0.0447
			983.5	100.0 ± 0.3	0.5830 ± 0.1014
				RR_{mean} =	**0.5222 ± 0.0418**
^{48}Sc	i	43.67H	1312.1	100.1 ± 0.7	1.953 ± 0.125
			1037.5	97.6 ± 0.7	1.938 ± 0.113
			983.5	100.1 ± 0.6	2.111 ± 0.505
				RR_{mean} =	**1.948 ± 0.093**
^{46}Sc	i(m+g)	83.79D	1120.6	99.99 ± 0.00	3.473 ± 0.257
			889.3	99.98 ± 0.00	3.364 ± 0.128
				RR_{mean} =	**3.374 ± 0.126**
^{28}Mg	c	20.915H	1778.8	100.2 ± 0.0	**1.242 ± 0.111**
^{24}Na	c	14.9590H	1369.0	100 ± 0	**6.112 ± 0.372**
^{7}Be	i	53.29D	477.6	10.52 ± 0.06	**18.01 ± 0.83**

12.10.6 Nuclide production rates for ^{27}Al

Table 104: Detailed calculation of nuclide production rates for in ^{27}Al-monitors and ^{27}Al-plates for E_p = 1.6 GeV, used for calculating proton flux (including total over the plate area), cross sections for production of ^{7}Be, ^{24}Naand neutron background.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
		^{27}Al-monitor for ^{206}Pb			
^{7}Be	i	53.29D	477.6	10.52 ± 0.06	**36.30 ± 1.39**
^{27}Mg	c	9.458M	1014.4	28.0 ± 0.4	4.023 ± 0.246
			843.8	71.8 ± 0.4	3.568 ± 0.162
				RR_{mean} =	**3.677 ± 0.225**
^{22}Na	c	2.6019Y	1274.5	99.94 ± 0.01	**53.78 ± 1.86**
^{24}Na	c	14.9590H	1369.0	100 ± 0	**50.81 ± 1.69**
^{24}Ne	c	3.38M	472.2	100 ± 0	**2.102 ± 1.394**
		^{27}Al-plate for ^{206}Pb			
^{24}Na	c	14.9590H	1369.0	100 ± 0	**1.685 ± 0.056**
		^{27}Al-monitor for ^{207}Pb			
^{7}Be	i	53.29D	477.6	10.52 ± 0.06	**20.94 ± 0.77**
^{27}Mg	c	9.458M	1014.4	28.0 ± 0.4	2.125 ± 0.184
			843.8	71.8 ± 0.4	1.998 ± 0.129
				RR_{mean} =	**2.037 ± 0.114**
^{22}Na	c	2.6019Y	1274.5	99.94 ± 0.01	**29.94 ± 1.07**
^{24}Na	c	14.9590H	1369.0	100 ± 0	**28.92 ± 0.96**
		^{27}Al-plate for ^{207}Pb			
^{24}Na	c	14.9590H	1369.0	100 ± 0	**0.9596 ± 0.0328**
		^{27}Al-monitor for ^{207}Pb			

Continuation of Table 104.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{7}Be	i	53.29D	477.6	10.52 ± 0.06	**31.45 ± 1.15**
^{27}Mg	c	9.458M	1014.4	28.0 ± 0.4	3.119 ± 0.206
			843.8	71.8 ± 0.4	3.049 ± 0.141
				RR_{mean} =	**3.067 ± 0.131**
^{22}Na	c	2.6019Y	1274.5	99.94 ± 0.01	**44.89 ± 1.58**
^{24}Na	c	14.9590H	1369.0	100 ± 0	**42.61 ± 1.42**
^{24}Ne	c	3.38M	472.2	100 ± 0	**3.488 ± 0.731**
^{27}Al-plate for ^{207}Pb					
^{24}Na	c	14.9590H	1369.0	100 ± 0	**1.500 ± 0.051**
^{27}Al-monitor for ^{nat}Pb					
^{7}Be	i	53.29D	477.6	10.52 ± 0.06	**48.76 ± 1.74**
^{27}Mg	c	9.458M	1014.4	28.0 ± 0.4	6.077 ± 0.383
			843.8	71.8 ± 0.4	6.097 ± 0.271
				RR_{mean} =	**6.092 ± 0.252**
^{22}Na	c	2.6019Y	1274.5	99.94 ± 0.01	**71.57 ± 2.47**
^{24}Na	c	14.9590H	1369.0	100 ± 0	**67.18 ± 2.23**
^{27}Al-plate for ^{nat}Pb					
^{24}Na	c	14.9590H	1369.0	100 ± 0	**2.391 ± 0.080**
^{27}Al-monitor for ^{209}Bi					
^{7}Be	i	53.29D	477.6	10.52 ± 0.06	**30.22 ± 1.11**
^{27}Mg	c	9.458M	843.8	71.8 ± 0.4	5.237 ± 0.223
			1014.4	28.0 ± 0.4	5.071 ± 0.385
				RR_{mean} =	**5.210 ± 0.214**
^{22}Na	c	2.6019Y	1274.5	99.94 ± 0.01	**44.63 ± 1.57**
^{24}Na	c	14.9590H	1369.0	100 ± 0	**43.56 ± 1.45**
^{27}Al-plate for ^{209}Bi					
^{24}Na	c	14.9590H	1369.0	100 ± 0	**1.518 ± 0.051**

12.11 Detailed calculation of nuclide production rates for ^{206}Pb, ^{207}Pb, ^{208}Pb, ^{nat}Pb and ^{209}Bi for E_p = 2.6 GeV

12.11.1 Nuclide production rates for ^{206}Pb

Table 105: Detailed calculation of nuclide production rates for ^{206}Pb for $E_p = 2.6$ GeV, used to determine the cross sections for their production.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{206}Bi	i	6.243D	1718.7	31.8 ± 0.6	1.969 ± 0.108
			803.1	98.9 ± 1.4	1.797 ± 0.081
			537.5	30.5 ± 0.5	1.839 ± 0.109
				RR_{mean} =	**1.846 ± 0.075**
^{205}Bi	i	15.31D	1764.3	32.5 ± 0.7	4.144 ± 0.226
			987.7	16.13 ± 0.17	5.935 ± 0.307
				RR_{mean} =	**4.797 ± 0.875**
^{204}Bi	i	11.22H	374.8	82 ± 5	4.392 ± 0.919
			899.2	98 ± 9	4.388 ± 0.163
			984.0	59 ± 4	3.658 ± 0.375
				RR_{mean} =	**4.344 ± 0.134**
^{203}Bi	i(m+g)	11.76H	820.2	29.6 ± 1.5	**4.388 ± 0.340**
^{202}Bi	i	1.72H	422.1	83.7 ± 2.5	**3.272 ± 0.505**
^{204m}Pb$_i$	i(m)	67.2M	374.7	89 ± 15	14.48 ± 2.50
			899.2	99.17 ± 0.02	14.44 ± 0.58
				RR_{mean} =	**14.44 ± 0.58**
^{204m}Pb$_c$	c	67.2M	374.7	89 ± 15	15.09 ± 2.61
			899.2	99.17 ± 0.02	15.18 ± 0.60
				RR_{mean} =	**15.17 ± 0.60**
^{203}Pb	c*	51.873H	279.2	80.8 ± 0.2	**41.85 ± 1.53**
^{202m}Pb	i(m)	3.53H	960.7	92 ± 8	11.45 ± 1.18
			422.1	86 ± 5	10.07 ± 0.76
				RR_{mean} =	**10.32 ± 0.62**
^{201}Pb	c*	9.33H	331.2	79 ± 5	**28.96 ± 2.08**
^{200}Pb	c	21.5H	1205.7	*	19.38 ± 1.46
			579.3	*	18.83 ± 1.27
			367.9	*	18.42 ± 0.74
			147.6	37.7 ± 1.4	19.26 ± 1.07
				RR_{mean} =	**18.69 ± 0.58**
^{199}Pb	c*	90M	366.9	44 ± 7	**37.62 ± 6.16**
^{198}Pb	c	2.4H	173.4	18 ± 3	**28.20 ± 4.88**
^{197m}Pb	c*	43M	385.9	74 ± 15	**15.75 ± 3.26**
^{202}Tl	c	12.23D	439.6	91.4 ± 1.0	**19.28 ± 0.70**
^{201}Tl	c*	72.912H	167.4	10.00 ± 0.06	**49.95 ± 1.96**
^{200}Tl$_i$	i	26.1H	1205.7	29.9 ± 1.8	21.14 ± 1.65
			579.3	13.8 ± 0.7	21.93 ± 1.57
			367.9	87.2 ± 0.4	20.99 ± 1.05
				RR_{mean} =	**21.21 ± 0.92**
^{200}Tl$_c$	c	26.1H	1205.7	29.9 ± 1.8	40.51 ± 2.81
			579.3	13.8 ± 0.7	40.76 ± 2.52
			367.9	87.2 ± 0.4	39.41 ± 1.39
				RR_{mean} =	**39.58 ± 1.36**

Continuation of Table 105.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
$^{199}Tl_c$	c	7.42H	455.5	12.4 ± 1.4	**32.72 ± 4.16**
^{199}Tl	c*	7.42H	455.5	12.4 ± 1.4	**42.80 ± 5.24**
^{198m}Tl	i(m)	1.87H	282.8	28 ± 3	**18.39 ± 2.30**
^{196m}Tl	i(m)	1.41H	695.4	41 ± 7	**29.91 ± 5.26**
^{203}Hg	c	46.612D	279.2	81.46 ± 0.13	**1.857 ± 0.141**
^{197m}Hg	i(m)	23.8H	134.0	33.5 ± 0.4	**7.568 ± 0.341**
^{195m}Hg	i(m)	41.6H	261.8	31 ± 4	**13.25 ± 1.78**
^{193m}Hg	i(m)	11.8H	258.0	49 ± 7	**15.64 ± 2.33**
^{192}Hg	c	4.85H	2236.9	*	24.28 ± 4.18
			316.5	*	28.36 ± 3.57
			274.8	50.2 ± 2.5	24.90 ± 1.60
				RR_{mean} =	**25.34 ± 0.78**
^{190}Hg	c*	20.0M	142.6	68 ± 10	**15.82 ± 2.51**
$^{198}Au_c$	i(m+g)	2.69517D	411.8	95.58 ± 0.12	**1.398 ± 0.161**
^{196}Au	i(m1+m2+g)	6.183D	355.7	87.0 ± 0.8	**2.609 ± 0.094**
^{195}Au	c	186.098D	98.9	10.9 ± 0.9	**32.87 ± 3.21**
^{194}Au	i(m1+m2+g)	38.02H	328.5	61 ± 5	**4.488 ± 0.404**
$^{192}Au_i$	i(m+g)	4.94H	316.5	58 ± 7	**7.928 ± 1.079**
$^{192}Au_c$	c	4.94H	316.5	58 ± 7	**36.28 ± 4.56**
$^{190}Au_c$	c	42.8M	295.8	71 ± 5	**33.47 ± 3.53**
^{191}Pt	c	2.802D	409.4	8.0 ± 0.9	**24.49 ± 2.89**
^{189}Pt	c	10.87H	721.4	9.3 ± 0.8	33.35 ± 3.17
			568.8	7.1 ± 0.6	29.37 ± 3.00
			544.9	5.8 ± 0.5	29.90 ± 2.99
				RR_{mean} =	**30.79 ± 1.92**
^{188}Pt	c	10.2D	423.3	4.4 ± 0.3	23.33 ± 1.91
			195.1	18.6 ± 1.2	25.46 ± 1.91
				RR_{mean} =	**24.45 ± 1.31**
^{186}Pt	c	2.08H	689.4	70 ± 15	**22.52 ± 4.89**
^{189}Ir	c	13.2D	245.1	6.0 ± 0.6	**26.60 ± 3.10**
$^{188}Ir_c$	c	41.5H	1209.8	6.9 ± 0.7	**27.12 ± 2.96**
^{187}Ir	c*	10.5H	977.5	3.14 ± 0.11	**28.02 ± 2.23**
^{186}Ir	c	16.64H	434.8	33.9 ± 1.1	11.47 ± 0.60
			137.2	41.4 ± 0.7	11.88 ± 0.53
				RR_{mean} =	**11.72 ± 0.47**
^{185}Ir	c	14.4H	1829.0	10.1 ± 1.5	20.02 ± 3.10
			254.2	13.3 ± 2.4	15.83 ± 2.98
				RR_{mean} =	**19.07 ± 1.85**
^{184}Ir	c*	3.09H	264.0	68 ± 4	25.01 ± 1.78
			119.8	31 ± 3	24.47 ± 2.66
				RR_{mean} =	**24.96 ± 1.03**
^{185}Os	c	93.6D	874.8	6.29 ± 0.25	26.07 ± 1.48
			646.1	78 ± 3	25.73 ± 1.32
				RR_{mean} =	**25.80 ± 0.86**
^{183m}Os	c*	9.9H	1101.9	49.0 ± 1.3	**13.97 ± 0.66**
^{182}Os	c	22.10H	180.2	33.5 ± 1.7	**24.43 ± 1.57**
^{180}Os	c	21.5M	902.8(D)	101.5 ± 3.4	**23.07 ± 1.43**
^{183}Re	c	70.0D	162.3	23.3 ± 0.7	**26.18 ± 1.24**
$^{182m}Re_c$	c	12.7H	1221.5	24.8 ± 1.6	29.64 ± 2.23
			1189.2	15 ± 1	27.97 ± 2.35

Continuation of Table 105.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
				RR_{mean} =	**28.91 ± 1.52**
^{181}Re	c*	19.9H	639.0	6.4 ± 1.4	24.51 ± 5.44
			365.5	56 ± 8	24.01 ± 3.56
				RR_{mean} =	**24.13 ± 2.61**
^{179}Re	c*	19.5M	430.2	28.0 ± 1.8	37.59 ± 3.59
			290.0	26.9 ± 2.3	42.03 ± 4.99
				RR_{mean} =	**38.76 ± 2.37**
^{178}Re	c*	13.2M	237.3	45 ± 5	**38.08 ± 5.05**
^{177} W	c	135M	115.7	51 ± 5	**22.66 ± 2.47**
^{177}Ta	c*	56.56H	112.9	7.2 ± 1.6	**26.42 ± 6.08**
^{176}Ta$_c$	c	8.09H	1823.7	4.5 ± 0.4	24.30 ± 3.63
			1159.3	24.7 ± 1.9	24.41 ± 2.12
			710.5	5.4 ± 0.4	29.95 ± 5.81
				RR_{mean} =	**24.52 ± 1.09**
^{175}Ta	c	10.5H	348.5	12.0 ± 1.1	28.84 ± 2.85
			266.9	10.52 ± 0.16	24.23 ± 1.09
				RR_{mean} =	**24.57 ± 1.43**
^{174}Ta$_c$	c	1.14H	206.5	60 ± 5	**25.46 ± 2.37**
^{173}Ta	c	3.14H	172.2	17.5 ± 1.8	**28.17 ± 3.35**
^{172}Ta	c*	36.8M	214.1	55 ± 5	**17.20 ± 1.83**
^{175}Hf	c	70D	343.4	84 ± 3	**23.48 ± 1.15**
^{173}Hf	c*	23.6H	311.2	10.7 ± 0.5	28.19 ± 1.66
			123.7	83 ± 5	28.10 ± 2.08
				RR_{mean} =	**28.17 ± 1.20**
^{172}Hf	c	1.87Y	1093.6	*	20.60 ± 1.25
			125.8	11.3 ± 0.9	21.50 ± 2.11
				RR_{mean} =	**20.80 ± 0.64**
^{171}Hf	c	12.1H	739.8	*	**17.42 ± 2.63**
^{170}Hf	c	16.01H	620.7	18 ± 5	28.65 ± 8.03
			164.7	26 ± 8	27.05 ± 8.38
			120.2	15 ± 5	27.02 ± 9.09
				RR_{mean} =	**28.17 ± 1.99**
^{173}Lu	c	1.37Y	272.1	21.2 ± 0.8	**22.39 ± 1.26**
^{172}Lu$_i$	i(m+g)	6.70D	1093.6	63 ± 3	**0.2067 ± 0.0332**
^{172}Lu$_c$	c	6.70D	1093.6	63 ± 3	**20.81 ± 1.26**
^{171}Lu$_c$	c	8.24D	739.8	47.8 ± 1.2	**24.58 ± 1.03**
^{171}Lu	c*	8.24D	739.8	47.8 ± 1.2	**25.63 ± 1.07**
^{170}Lu$_c$	c	2.012D	2126.1	5.1 ± 0.3	20.56 ± 1.65
			1280.2	8.2 ± 0.4	21.56 ± 1.41
			985.1	5.5 ± 0.3	23.45 ± 1.92
				RR_{mean} =	**21.65 ± 0.96**
^{169}Lu	c	34.06H	960.6	23.4 ± 0.7	19.29 ± 0.89
			191.2	20.6 ± 0.6	20.05 ± 0.99
				RR_{mean} =	**19.60 ± 0.75**
^{167}Lu	c	51.5M	176.2	*	21.53 ± 1.37
			113.3	*	21.45 ± 1.59
				RR_{mean} =	**21.50 ± 1.14**
^{169}Yb	c*	32.026D	198.0	35.8 ± 0.7	23.40 ± 1.06
			177.2	22.2 ± 0.5	22.81 ± 0.99
			130.5	11.31 ± 0.21	23.43 ± 1.09

Continuation of Table 105.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
				RR_{mean} =	**23.16 ± 0.81**
^{166}Yb	c	56.7H	2079.5	*	21.50 ± 1.81
			2052.4	*	23.00 ± 1.64
			1867.9	*	22.82 ± 1.73
			1176.7	*	20.53 ± 1.49
			785.9	*	24.77 ± 1.78
			691.2(D)	8.56 ± 0.58	19.37 ± 1.53
				RR_{mean} =	**21.76 ± 0.67**
^{167}Tm	c	9.25D	207.8	42 ± 8	**24.25 ± 4.71**
^{165}Tm	c	30.06H	806.4	9.5 ± 0.6	22.89 ± 1.68
			242.9	35.5 ± 1.7	24.16 ± 1.53
				RR_{mean} =	**23.71 ± 1.01**
^{161}Er	c*	3.21H	826.6	64 ± 4	**29.73 ± 2.17**
^{160}Er	c	28.58H	966.2	*	23.58 ± 3.16
			879.4(D)	22.6 ± 2.8	24.51 ± 3.17
			872.0(D)	6.8 ± 1.1	24.73 ± 4.12
			728.2(D)	*	24.62 ± 3.61
				RR_{mean} =	**24.31 ± 0.75**
^{159}Er	c*	36M	624.5	33 ± 4	28.54 ± 3.84
			309.6	*	29.79 ± 3.27
			132.0	*	26.78 ± 2.89
				RR_{mean} =	**28.21 ± 0.87**
$^{160m}Ho_c$	c	5.02H	966.2	15.4 ± 2.0	25.67 ± 3.52
			728.2	28 ± 4	26.33 ± 3.88
				RR_{mean} =	**25.96 ± 2.53**
^{156}Ho	c*	56M	266.5	54.7 ± 1.1	**27.81 ± 1.30**
^{157}Dy	c	8.14H	326.2	92 ± 4	**22.39 ± 1.25**
^{155}Dy	c*	9.9H	226.9	68.4 ± 1.6	**20.51 ± 0.98**
^{152}Dy	c	2.38H	256.9	97.50 ± 0.07	**13.94 ± 0.61**
^{155}Tb	c*	5.32D	180.1	7.5 ± 0.5	19.62 ± 1.55
			105.3	25.1 ± 1.3	20.61 ± 1.46
				RR_{mean} =	**20.24 ± 0.88**
^{153}Tb	c*	2.34D	212.0	31.0 ± 1.9	**17.74 ± 1.30**
$^{152}Tb_c$	c	17.5H	344.3	65 ± 4	**14.26 ± 1.03**
^{151}Tb	c	17.609H	479.4	15.4 ± 0.7	15.55 ± 0.96
			251.9	26.3 ± 1.2	15.93 ± 0.96
				RR_{mean} =	**15.74 ± 0.69**
^{149}Tb	c	4.118H	352.2	29.4 ± 0.9	8.181 ± 0.627
			165.0	26.4 ± 0.9	9.404 ± 0.725
				RR_{mean} =	**8.703 ± 0.662**
^{148}Tb	c	60M	784.4	84.0 ± 1.6	**10.35 ± 0.47**
^{153}Gd	c	240.4D	103.2	21.1 ± 0.7	14.98 ± 0.93
			97.4	29.0 ± 0.8	15.18 ± 0.88
				RR_{mean} =	**15.09 ± 0.68**
^{151}Gd	c	124D	243.3	5.6 ± 0.4	**14.84 ± 1.30**
^{149}Gd	c	9.28D	788.9	7.3 ± 0.4	21.94 ± 1.50
			346.6	23.9 ± 1.3	18.85 ± 1.21
			298.6	28.6 ± 1.7	19.15 ± 1.32
			149.7	48 ± 3	20.83 ± 1.52
				RR_{mean} =	**19.66 ± 0.92**

Continuation of Table 105.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{147}Gd	c	38.06H	929.0	20.2 ± 1.2	16.71 ± 1.15
			396.0	34.3 ± 2.1	14.99 ± 1.07
			370.0	17.2 ± 0.9	16.79 ± 1.07
				RR_{mean} =	**16.21 ± 0.76**
^{146}Gd	c	48.27D	747.2	*	18.14 ± 0.81
			154.6	46.6 ± 0.5	17.58 ± 0.67
				RR_{mean} =	**17.75 ± 0.55**
^{149}Eu	c*	93.1D	327.5	4.03 ± 0.12	**24.59 ± 1.33**
^{147}Eu	c*	24.1D	955.8	3.84 ± 0.20	22.68 ± 1.53
			798.7	4.8 ± 0.3	25.32 ± 1.89
			677.5	9.8 ± 0.5	21.75 ± 1.37
			601.5	5.9 ± 0.3	22.38 ± 1.44
				RR_{mean} =	**22.57 ± 0.93**
^{146}Eu$_i$	i	4.61D	747.2	99 ± 3	**2.488 ± 0.119**
^{146}Eu$_c$	c	4.61D	747.2	99 ± 3	**20.63 ± 0.92**
^{145}Eu	c	5.93D	1997.0	7.2 ± 0.5	15.89 ± 1.28
			1658.5	14.9 ± 1.0	15.59 ± 1.22
			893.7	66 ± 5	15.59 ± 1.29
			653.5	15 ± 1	14.93 ± 1.13
				RR_{mean} =	**15.45 ± 0.68**
^{143}Pm	c	265D	742.0	38.5 ± 2.4	**15.02 ± 1.11**
^{136}Nd	c	50.65M	539.8(D)	70.7 ± 2.6	**10.65 ± 0.91**
^{139}Ce	c	137.640D	165.9	79.89 ± 0.01	**15.61 ± 0.57**
^{135}Ce	c	17.7H	783.6	10.6 ± 0.4	15.36 ± 1.17
			265.6	41.8 ± 1.5	13.42 ± 0.70
				RR_{mean} =	**13.69 ± 0.79**
^{134}Ce	c	3.16D	604.7	5.04 ± 0.20	**11.77 ± 0.88**
^{132}Ce	c	3.51H	464.5	*	10.59 ± 0.95
			182.1	77.4 ± 0.5	10.13 ± 0.59
				RR_{mean} =	**10.24 ± 0.32**
^{132}La$_c$	c	4.8H	464.5	76 ± 6	**10.73 ± 0.94**
^{133}Ba	c	3848.9D	356.0	62.05 ± 0.19	**10.91 ± 1.02**
^{131}Ba	c	11.50D	373.2	14.04 ± 0.20	11.58 ± 0.46
			216.1	19.66 ± 0.25	12.26 ± 0.56
			123.8	29.0 ± 0.3	11.42 ± 0.51
				RR_{mean} =	**11.69 ± 0.42**
^{128}Ba	c	2.43D	442.9	26.8 ± 1.4	8.351 ± 0.590
			273.4	14.5 ± 0.7	10.07 ± 0.65
				RR_{mean} =	**9.324 ± 0.902**
^{129}Cs	c	32.06H	371.9	30.6 ± 1.7	**12.98 ± 0.87**
^{127}Xe	c	36.4D	375.0	17.2 ± 0.6	10.89 ± 0.58
			202.9	68.3 ± 0.5	10.33 ± 0.40
			172.1	25.5 ± 0.8	9.937 ± 0.499
				RR_{mean} =	**10.33 ± 0.38**
^{123}Xe	c	2.08H	148.9	48.9 ± 0.6	**9.929 ± 0.473**
^{123m}Te	i(m)	119.7D	159.0	84.0 ± 0.4	**0.2571 ± 0.0809**
^{121m}Te	i(m)	154D	573.1	88.6 ± 0.1	0.6365 ± 0.1124
			212.2	81.4 ± 1.1	0.6616 ± 0.0558
				RR_{mean} =	**0.6571 ± 0.0203**
^{121}Te$_c$	c	19.16D	573.1	80.3 ± 2.5	**8.048 ± 0.377**

Continuation of Table 105.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{119m}Te	i(m)	4.70D	1212.7	66.2 ± 0.3	**1.696 ± 0.072**
^{120m}Sb	i(m)	5.76D	1171.7	100 ± 0	0.3323 ± 0.0345
			1023.3	99.4 ± 0.3	0.4389 ± 0.0230
				RR_{mean} =	**0.4133 ± 0.0473**
^{113}Sn	c	115.09D	391.7	64.97 ± 0.17	**4.898 ± 0.206**
^{114m}In	i(m)	49.51D	190.3	15.56 ± 0.16	**1.585 ± 0.115**
^{111}In	c	2.8047D	245.4	94 ± 1	5.116 ± 0.214
			171.3	90.2 ± 1.0	5.038 ± 0.200
				RR_{mean} =	**5.071 ± 0.179**
^{110}In	i	4.9H	937.5	68.4 ± 1.4	3.443 ± 0.195
			884.7	92.9 ± 1.9	3.155 ± 0.186
				RR_{mean} =	**3.293 ± 0.176**
^{109}In	c	4.2H	203.5	73.5 ± 0.5	**4.690 ± 0.328**
^{110m}Ag	i(m)	249.76D	884.7	72.7 ± 0.4	0.8498 ± 0.0887
			657.8	94.3 ± 0.3	0.7624 ± 0.0639
				RR_{mean} =	**0.7912 ± 0.0544**
^{106m}Ag	i(m)	8.28D	1527.7	16.3 ± 1.4	1.955 ± 0.232
			1045.8	29.6 ± 1.0	1.970 ± 0.128
			717.3	28.9 ± 0.8	1.910 ± 0.150
			451.0	28.2 ± 0.8	2.014 ± 0.141
				RR_{mean} =	**1.967 ± 0.091**
^{105}Ag	c	41.29D	443.4	10.5 ± 0.6	4.132 ± 0.405
			344.5	41.4 ± 0.6	3.800 ± 0.190
				RR_{mean} =	**3.839 ± 0.177**
^{100}Pd	c	3.63D	2376.0	*	**0.8674 ± 0.0638**
^{102}Rh	i	207D	475.1	46 ± 5	**1.086 ± 0.162**
^{101m}Rh	c	4.34D	306.9	81 ± 5	**3.993 ± 0.301**
^{100}Rh$_i$	i(m+g)	20.8H	2376.0	32.6 ± 0.4	**2.172 ± 0.155**
^{100}Rh$_c$	c	20.8H	2376.0	32.6 ± 0.4	**3.039 ± 0.174**
^{103}Ru	c	39.26D	497.1	91.0 ± 1.3	**2.636 ± 0.123**
^{96}Tc	i(m+g)	4.28D	849.9	98 ± 4	2.399 ± 0.133
			812.5	82 ± 4	2.509 ± 0.151
				RR_{mean} =	**2.445 ± 0.113**
^{99}Mo	c	65.94H	140.5	90.27 ± 0.33	**2.480 ± 0.115**
^{93m}Mo	i(m)	6.85H	684.7	99.7 ± 2.0	**1.741 ± 0.099**
^{96}Nb	i	23.35H	568.9	58.0 ± 0.3	1.504 ± 0.123
			1091.3	48.5 ± 1.6	1.614 ± 0.102
				RR_{mean} =	**1.572 ± 0.085**
^{95}Nb$_c$	c	34.975D	765.8	99.81 ± 0.03	**3.795 ± 0.133**
^{90}Nb	c*	14.60H	2319.0	82.0 ± 0.3	**3.033 ± 0.149**
^{95}Zr	c	64.02D	756.7	54.46 ± 0.10	**1.382 ± 0.079**
^{89}Zr	c	78.41H	909.2	99.04 ± 0.03	**4.746 ± 0.162**
^{88}Zr	c	83.4D	1836.1	*	3.864 ± 0.316
			898.0	*	3.222 ± 0.400
			392.9	97.24 ± 0.00	3.043 ± 0.114
				RR_{mean} =	**3.067 ± 0.095**
^{88} Y$_i$	i	106.65D	1836.1	99.2 ± 0.3	3.585 ± 0.195
			898.0	93.7 ± 0.3	3.739 ± 0.249
				RR_{mean} =	**3.638 ± 0.171**
^{88} Y$_c$	c	106.65D	1836.1	99.2 ± 0.3	7.449 ± 0.306

Continuation of Table 105.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			898.0	93.7 ± 0.3	6.961 ± 0.311
				RR_{mean} =	**7.231 ± 0.330**
^{87} Y	c*	79.8H	484.8	89.7 ± 0.7	**6.063 ± 0.223**
^{86} Y_c	c	14.74H	1076.6	82.5 ± 0.4	**3.166 ± 0.126**
^{85}Sr	c	64.84D	514.0	96 ± 4	**5.745 ± 0.314**
^{84}Rb	i(m+g)	32.77D	881.6	69.0 ± 1.6	**3.869 ± 0.205**
^{83}Rb	c	86.2D	529.6	29.3 ± 2.1	6.592 ± 0.574
			520.4	45 ± 4	6.013 ± 0.615
				RR_{mean} =	**6.358 ± 0.368**
^{82m}Rb	i(m)	6.472H	554.3	62.4 ± 0.9	**2.732 ± 0.167**
^{82}Br	i(m+g)	35.30H	554.3	70.8 ± 1.0	**1.532 ± 0.068**
^{75}Se	c	119.779D	264.7	58.9 ± 0.4	**3.322 ± 0.140**
^{74}As	i	17.77D	595.8	59 ± 4	**2.985 ± 0.239**
^{71}As	c	65.28H	174.9	82.0 ± 2.1	**0.9602 ± 0.0639**
^{58}Co	i(m+g)	70.86D	810.8	99.45 ± 0.01	**1.743 ± 0.162**
^{59}Fe	c	44.472D	1099.2	56.5 ± 1.9	**1.712 ± 0.109**
^{54}Mn	i	312.11D	834.8	99.98 ± 0.00	**2.220 ± 0.111**
^{48} V	c	15.9735D	1312.1	97.5 ± 0.9	0.5192 ± 0.0347
			983.5	100.0 ± 0.3	0.5225 ± 0.0305
				RR_{mean} =	**0.5211 ± 0.0255**
^{48}Sc	i	43.67H	1312.1	100.1 ± 0.7	1.150 ± 0.059
			1037.5	97.6 ± 0.7	1.004 ± 0.048
				RR_{mean} =	**1.060 ± 0.078**
^{46}Sc	i(m+g)	83.79D	889.3	99.98 ± 0.00	**2.271 ± 0.083**
^{28}Mg	c	20.915H	1778.8	100.2 ± 0.0	**1.264 ± 0.052**
^{24}Na	c	14.9590H	1369.0	100 ± 0	**5.471 ± 0.192**
^{7}Be	i	53.29D	477.6	10.52 ± 0.06	**8.407 ± 0.768**

12.11.2 Nuclide production rates for ^{207}Pb

Table 106: Detailed calculation of nuclide production rates for ^{207}Pb for E_p = 2.6 GeV, used to determine the cross sections for their production.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{206}Bi	i	6.243D	1718.7	31.8 ± 0.6	1.094 ± 0.057
			803.1	98.9 ± 1.4	0.9988 ± 0.0394
			537.5	30.5 ± 0.5	1.080 ± 0.067
				RR_{mean} =	**1.027 ± 0.043**
^{205}Bi	i	15.31D	1764.3	32.5 ± 0.7	1.545 ± 0.087
			987.7	16.13 ± 0.17	1.779 ± 0.098
				RR_{mean} =	**1.649 ± 0.127**
^{204}Bi	i	11.22H	374.8	82 ± 5	1.250 ± 0.262
			899.2	98 ± 9	1.256 ± 0.046
			984.0	59 ± 4	1.290 ± 0.123
				RR_{mean} =	**1.257 ± 0.039**
^{203}Bi	i(m+g)	11.76H	820.2	29.6 ± 1.5	**1.197 ± 0.084**
^{202}Bi	i	1.72H	422.1	83.7 ± 2.5	**1.077 ± 0.288**
^{204m}Pb_i	i(m)	67.2M	374.7	89 ± 15	4.446 ± 0.774

Continuation of Table 106.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			899.2	99.17 ± 0.02	4.161 ± 0.200
				RR_{mean} =	**4.172 ± 0.198**
$^{204m}Pb_c$	c	67.2M	374.7	89 ± 15	4.620 ± 0.804
			899.2	99.17 ± 0.02	4.370 ± 0.204
				RR_{mean} =	**4.379 ± 0.202**
^{203}Pb	c*	51.873H	279.2	80.8 ± 0.2	**10.28 ± 0.38**
^{202m}Pb	i(m)	3.53H	960.7	92 ± 8	4.012 ± 0.410
			422.1	86 ± 5	2.894 ± 0.248
				RR_{mean} =	**3.142 ± 0.475**
^{201}Pb	c*	9.33H	331.2	79 ± 5	**7.399 ± 0.533**
^{200}Pb	c	21.5H	1205.7	*	5.528 ± 0.404
			579.3	*	5.053 ± 0.372
			367.9	*	5.013 ± 0.183
			147.6	37.7 ± 1.4	5.117 ± 0.284
				RR_{mean} =	**5.056 ± 0.156**
^{199}Pb	c*	90M	366.9	44 ± 7	**10.19 ± 1.68**
^{198}Pb	c	2.4H	173.4	18 ± 3	**7.597 ± 1.313**
^{197m}Pb	c*	43M	385.9	74 ± 15	**4.355 ± 0.912**
^{202}Tl	c	12.23D	439.6	91.4 ± 1.0	**5.320 ± 0.195**
^{201}Tl	c*	72.912H	167.4	10.00 ± 0.06	**12.95 ± 0.52**
$^{200}Tl_i$	i	26.1H	1205.7	29.9 ± 1.8	5.345 ± 0.407
			579.3	13.8 ± 0.7	5.512 ± 0.449
			367.9	87.2 ± 0.4	5.337 ± 0.229
				RR_{mean} =	**5.357 ± 0.214**
$^{200}Tl_c$	c	26.1H	1205.7	29.9 ± 1.8	10.87 ± 0.75
			579.3	13.8 ± 0.7	10.56 ± 0.66
			367.9	87.2 ± 0.4	10.35 ± 0.36
				RR_{mean} =	**10.39 ± 0.35**
$^{199}Tl_c$	c	7.42H	455.5	12.4 ± 1.4	**8.579 ± 1.143**
^{199}Tl	c*	7.42H	455.5	12.4 ± 1.4	**10.58 ± 1.27**
^{198m}Tl	i(m)	1.87H	282.8	28 ± 3	**4.352 ± 0.569**
^{196m}Tl	i(m)	1.41H	695.4	41 ± 7	**9.033 ± 1.589**
^{203}Hg	c	46.612D	279.2	81.46 ± 0.13	**0.8400 ± 0.0388**
^{197m}Hg	i(m)	23.8H	134.0	33.5 ± 0.4	**2.578 ± 0.122**
^{195m}Hg	i(m)	41.6H	261.8	31 ± 4	**3.790 ± 0.515**
^{193m}Hg	i(m)	11.8H	258.0	49 ± 7	**4.487 ± 0.667**
^{192}Hg	c	4.85H	2236.9	*	6.119 ± 1.125
			316.5	*	7.764 ± 0.979
			274.8	50.2 ± 2.5	7.167 ± 0.457
				RR_{mean} =	**7.235 ± 0.223**
^{190}Hg	c*	20.0M	142.6	68 ± 10	**6.387 ± 1.102**
$^{198}Au_c$	i(m+g)	2.69517D	411.8	95.58 ± 0.12	**0.7404 ± 0.1490**
^{196}Au	i(m1+m2+g)	6.183D	355.7	87.0 ± 0.8	0.9142 ± 0.0367
			333.0	22.9 ± 0.6	0.9577 ± 0.0529
				RR_{mean} =	**0.9232 ± 0.0346**
^{195}Au	c	186.098D	98.9	10.9 ± 0.9	**10.45 ± 1.07**
^{194}Au	i(m1+m2+g)	38.02H	328.5	61 ± 5	**1.548 ± 0.139**
$^{192}Au_i$	i(m+g)	4.94H	316.5	58 ± 7	**2.272 ± 0.323**
$^{192}Au_c$	c	4.94H	316.5	58 ± 7	**10.04 ± 1.26**
$^{190}Au_c$	c	42.8M	295.8	71 ± 5	**10.24 ± 0.98**

Continuation of Table 106.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{191}Pt	c	2.802D	409.4	8.0 ± 0.9	**7.185 ± 0.849**
^{189}Pt	c	10.87H	721.4	9.3 ± 0.8	9.130 ± 0.874
			568.8	7.1 ± 0.6	9.208 ± 1.268
			544.9	5.8 ± 0.5	8.623 ± 0.879
				RR_{mean} =	**8.940 ± 0.597**
^{188}Pt	c	10.2D	423.3	4.4 ± 0.3	7.467 ± 0.592
			195.1	18.6 ± 1.2	7.564 ± 0.567
			187.6	19.4 ± 1.2	7.614 ± 0.552
				RR_{mean} =	**7.555 ± 0.345**
^{186}Pt	c	2.08H	689.4	70 ± 15	**6.617 ± 1.439**
^{189}Ir	c	13.2D	245.1	6.0 ± 0.6	**6.423 ± 0.762**
$^{188}Ir_c$	c	41.5H	1209.8	6.9 ± 0.7	**8.125 ± 0.886**
^{187}Ir	c*	10.5H	977.5	3.14 ± 0.11	**9.177 ± 0.597**
^{186}Ir	c	16.64H	434.8	33.9 ± 1.1	3.640 ± 0.182
			137.2	41.4 ± 0.7	3.562 ± 0.209
				RR_{mean} =	**3.609 ± 0.157**
^{185}Ir	c	14.4H	1829.0	10.1 ± 1.5	5.590 ± 0.874
			254.2	13.3 ± 2.4	4.253 ± 0.858
				RR_{mean} =	**5.302 ± 0.573**
^{184}Ir	c*	3.09H	264.0	68 ± 4	7.854 ± 0.562
			119.8	31 ± 3	7.794 ± 0.889
				RR_{mean} =	**7.848 ± 0.328**
^{185}Os	c	93.6D	874.8	6.29 ± 0.25	8.141 ± 0.552
			646.1	78 ± 3	7.639 ± 0.392
				RR_{mean} =	**7.678 ± 0.273**
^{183m}Os	c*	9.9H	1101.9	49.0 ± 1.3	**4.240 ± 0.190**
^{182}Os	c	22.10H	180.2	33.5 ± 1.7	**7.576 ± 0.493**
^{180}Os	c	21.5M	902.8(D)	101.5 ± 3.4	**7.962 ± 0.475**
^{183}Re	c	70.0D	162.3	23.3 ± 0.7	**8.337 ± 0.404**
$^{182m}Re_c$	c	12.7H	1221.5	24.8 ± 1.6	8.450 ± 0.630
			1189.2	15 ± 1	8.431 ± 0.758
				RR_{mean} =	**8.443 ± 0.452**
^{181}Re	c*	19.9H	639.0	6.4 ± 1.4	7.379 ± 1.646
			365.5	56 ± 8	7.134 ± 1.055
				RR_{mean} =	**7.193 ± 0.777**
^{179}Re	c*	19.5M	430.2	28.0 ± 1.8	13.93 ± 1.62
			290.0	26.9 ± 2.3	14.90 ± 1.98
				RR_{mean} =	**14.29 ± 1.11**
^{178}Re	c*	13.2M	237.3	45 ± 5	**14.41 ± 1.87**
^{177} W	c	135M	115.7	51 ± 5	**7.119 ± 0.788**
^{177}Ta	c*	56.56H	112.9	7.2 ± 1.6	**8.066 ± 1.874**
$^{176}Ta_c$	c	8.09H	1823.7	4.5 ± 0.4	7.055 ± 1.437
			1159.3	24.7 ± 1.9	6.977 ± 0.629
			710.5	5.4 ± 0.4	9.457 ± 1.247
				RR_{mean} =	**7.166 ± 0.511**
^{175}Ta	c	10.5H	348.5	12.0 ± 1.1	8.182 ± 0.819
			266.9	10.52 ± 0.16	6.954 ± 0.328
				RR_{mean} =	**7.064 ± 0.412**
$^{174}Ta_c$	c	1.14H	206.5	60 ± 5	**7.483 ± 0.741**
^{173}Ta	c	3.14H	172.2	17.5 ± 1.8	**8.766 ± 0.981**

Continuation of Table 106.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{172}Ta	c*	36.8M	214.1	55 ± 5	**6.319 ± 0.796**
^{175}Hf	c	70D	343.4	84 ± 3	**7.041 ± 0.348**
^{173}Hf	c*	23.6H	311.2	10.7 ± 0.5	7.918 ± 0.475
			123.7	83 ± 5	8.761 ± 0.657
				RR_{mean} =	**8.126 ± 0.441**
^{172}Hf	c	1.87Y	1093.6	*	6.235 ± 0.418
			125.8	11.3 ± 0.9	6.967 ± 0.785
				RR_{mean} =	**6.378 ± 0.197**
^{171}Hf	c	12.1H	739.8	*	**4.490 ± 0.428**
^{170}Hf	c	16.01H	620.7	18 ± 5	8.554 ± 2.396
			164.7	26 ± 8	8.039 ± 2.492
			120.2	15 ± 5	8.561 ± 2.887
				RR_{mean} =	**8.455 ± 0.598**
^{173}Lu	c	1.37Y	272.1	21.2 ± 0.8	**6.809 ± 0.402**
$^{172}Lu_i$	i(m+g)	6.70D	1093.6	63 ± 3	**0.06450 ± 0.02071**
$^{172}Lu_c$	c	6.70D	1093.6	63 ± 3	**6.300 ± 0.418**
$^{171}Lu_c$	c	8.24D	739.8	47.8 ± 1.2	**7.264 ± 0.302**
^{171}Lu	c*	8.24D	739.8	47.8 ± 1.2	**7.511 ± 0.313**
$^{170}Lu_c$	c	2.012D	2126.1	5.1 ± 0.3	5.814 ± 0.425
			1280.2	8.2 ± 0.4	6.758 ± 0.443
				RR_{mean} =	**6.322 ± 0.509**
^{169}Lu	c	34.06H	960.6	23.4 ± 0.7	5.782 ± 0.285
			191.2	20.6 ± 0.6	5.975 ± 0.296
				RR_{mean} =	**5.874 ± 0.231**
^{167}Lu	c	51.5M	176.2	*	7.565 ± 0.698
			113.3	*	7.030 ± 0.519
				RR_{mean} =	**7.212 ± 0.443**
^{169}Yb	c*	32.026D	198.0	35.8 ± 0.7	6.917 ± 0.320
			177.2	22.2 ± 0.5	6.924 ± 0.301
			130.5	11.31 ± 0.21	7.111 ± 0.334
				RR_{mean} =	**6.973 ± 0.244**
^{166}Yb	c	56.7H	2079.5	*	6.013 ± 0.477
			2052.4	*	6.381 ± 0.459
			1867.9	*	6.694 ± 0.515
			785.9	*	7.104 ± 0.556
			691.2(D)	8.56 ± 0.58	5.284 ± 0.651
				RR_{mean} =	**6.359 ± 0.196**
^{167}Tm	c	9.25D	207.8	42 ± 8	**7.104 ± 1.381**
^{165}Tm	c	30.06H	806.4	9.5 ± 0.6	6.534 ± 0.494
			242.9	35.5 ± 1.7	7.389 ± 0.463
				RR_{mean} =	**7.099 ± 0.460**
^{161}Er	c*	3.21H	826.6	64 ± 4	**8.488 ± 0.630**
^{160}Er	c	28.58H	966.2	*	6.983 ± 0.940
			879.4(D)	22.6 ± 2.8	7.459 ± 0.966
			872.0(D)	6.8 ± 1.1	7.662 ± 1.279
			728.2(D)	*	7.260 ± 1.066
				RR_{mean} =	**7.309 ± 0.225**
^{159}Er	c*	36M	624.5	33 ± 4	8.885 ± 1.209
			309.6	*	10.65 ± 0.98
			132.0	*	11.53 ± 1.16

Continuation of Table 106.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
				RR_{mean} =	**10.45 ± 0.32**
$^{160m}Ho_c$	c	5.02H	966.2	15.4 ± 2.0	7.458 ± 1.025
			728.2	28 ± 4	7.176 ± 1.066
				RR_{mean} =	**7.324 ± 0.717**
^{156}Ho	c*	56M	266.5	54.7 ± 1.1	**9.179 ± 0.495**
^{157}Dy	c	8.14H	326.2	92 ± 4	**6.796 ± 0.378**
^{155}Dy	c*	9.9H	226.9	68.4 ± 1.6	**6.076 ± 0.285**
^{152}Dy	c	2.38H	256.9	97.50 ± 0.07	**4.209 ± 0.179**
^{155}Tb	c*	5.32D	180.1	7.5 ± 0.5	5.936 ± 0.484
			105.3	25.1 ± 1.3	6.567 ± 0.475
				RR_{mean} =	**6.318 ± 0.365**
^{153}Tb	c*	2.34D	212.0	31.0 ± 1.9	**5.149 ± 0.378**
$^{152}Tb_c$	c	17.5H	344.3	65 ± 4	**4.261 ± 0.344**
^{151}Tb	c	17.609H	479.4	15.4 ± 0.7	4.708 ± 0.291
			251.9	26.3 ± 1.2	4.418 ± 0.272
				RR_{mean} =	**4.553 ± 0.203**
^{149}Tb	c	4.118H	352.2	29.4 ± 0.9	2.555 ± 0.187
			165.0	26.4 ± 0.9	2.389 ± 0.187
				RR_{mean} =	**2.474 ± 0.134**
^{148}Tb	c	60M	784.4	84.0 ± 1.6	**2.914 ± 0.186**
^{153}Gd	c	240.4D	103.2	21.1 ± 0.7	4.829 ± 0.320
			97.4	29.0 ± 0.8	5.003 ± 0.333
				RR_{mean} =	**4.912 ± 0.245**
^{151}Gd	c	124D	243.3	5.6 ± 0.4	**4.628 ± 0.651**
^{149}Gd	c	9.28D	788.9	7.3 ± 0.4	5.990 ± 0.429
			346.6	23.9 ± 1.3	5.388 ± 0.348
			298.6	28.6 ± 1.7	5.406 ± 0.375
			149.7	48 ± 3	6.063 ± 0.446
				RR_{mean} =	**5.559 ± 0.235**
^{147}Gd	c	38.06H	929.0	20.2 ± 1.2	5.239 ± 0.364
			396.0	34.3 ± 2.1	4.485 ± 0.320
			370.0	17.2 ± 0.9	4.864 ± 0.306
				RR_{mean} =	**4.841 ± 0.248**
^{146}Gd	c	48.27D	747.2	*	5.150 ± 0.232
			154.6	46.6 ± 0.5	4.878 ± 0.205
				RR_{mean} =	**4.989 ± 0.154**
^{149}Eu	c*	93.1D	327.5	4.03 ± 0.12	**6.937 ± 0.934**
^{147}Eu	c*	24.1D	955.8	3.84 ± 0.20	5.770 ± 0.436
			798.7	4.8 ± 0.3	6.651 ± 0.517
			677.5	9.8 ± 0.5	6.114 ± 0.405
			601.5	5.9 ± 0.3	5.962 ± 0.402
				RR_{mean} =	**6.070 ± 0.242**
$^{146}Eu_i$	i	4.61D	747.2	99 ± 3	**0.7714 ± 0.0403**
$^{146}Eu_c$	c	4.61D	747.2	99 ± 3	**5.922 ± 0.266**
^{145}Eu	c	5.93D	1997.0	7.2 ± 0.5	4.380 ± 0.363
			1658.5	14.9 ± 1.0	4.121 ± 0.323
			893.7	66 ± 5	4.472 ± 0.377
			653.5	15 ± 1	4.321 ± 0.328
				RR_{mean} =	**4.305 ± 0.190**
^{143}Pm	c	265D	742.0	38.5 ± 2.4	**4.432 ± 0.342**

Continuation of Table 106.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{136}Nd	c	50.65M	539.8(D)	70.7 ± 2.6	**3.092 ± 0.318**
^{139}Ce	c	137.640D	165.9	79.89 ± 0.01	**4.621 ± 0.170**
^{135}Ce	c	17.7H	783.6	10.6 ± 0.4	4.236 ± 0.574
			265.6	41.8 ± 1.5	3.723 ± 0.199
				RR_{mean} =	**3.744 ± 0.161**
^{134}Ce	c	3.16D	604.7	5.04 ± 0.20	**3.669 ± 0.355**
^{132}Ce	c	3.51H	464.5	*	2.910 ± 0.256
			182.1	77.4 ± 0.5	3.409 ± 0.158
				RR_{mean} =	**3.312 ± 0.102**
$^{132}La_c$	c	4.8H	464.5	76 ± 6	**2.963 ± 0.259**
^{133}Ba	c	3848.9D	356.0	62.05 ± 0.19	**3.137 ± 0.721**
^{131}Ba	c	11.50D	373.2	14.04 ± 0.20	3.146 ± 0.160
			216.1	19.66 ± 0.25	3.535 ± 0.178
			123.8	29.0 ± 0.3	3.424 ± 0.159
				RR_{mean} =	**3.361 ± 0.153**
^{128}Ba	c	2.43D	442.9	26.8 ± 1.4	2.649 ± 0.174
			273.4	14.5 ± 0.7	2.837 ± 0.182
				RR_{mean} =	**2.746 ± 0.126**
^{129}Cs	c	32.06H	371.9	30.6 ± 1.7	**3.709 ± 0.251**
^{127}Xe	c	36.4D	375.0	17.2 ± 0.6	2.949 ± 0.167
			202.9	68.3 ± 0.5	2.899 ± 0.116
			172.1	25.5 ± 0.8	2.875 ± 0.146
				RR_{mean} =	**2.901 ± 0.105**
^{123}Xe	c	2.08H	148.9	48.9 ± 0.6	**3.021 ± 0.164**
^{123m}Te	i(m)	119.7D	159.0	84.0 ± 0.4	**0.08314 ± 0.01494**
^{121m}Te	i(m)	154D	573.1	88.6 ± 0.1	0.1340 ± 0.0459
			212.2	81.4 ± 1.1	0.2269 ± 0.0169
				RR_{mean} =	**0.2174 ± 0.0067**
$^{121}Te_c$	c	19.16D	573.1	80.3 ± 2.5	**2.219 ± 0.106**
^{119m}Te	i(m)	4.70D	1212.7	66.2 ± 0.3	**0.5598 ± 0.0331**
^{120m}Sb	i(m)	5.76D	1171.7	100 ± 0	0.1364 ± 0.0130
			1023.3	99.4 ± 0.3	0.1041 ± 0.0124
				RR_{mean} =	**0.1198 ± 0.0165**
^{113}Sn	c	115.09D	391.7	64.97 ± 0.17	**1.295 ± 0.062**
^{114m}In	i(m)	49.51D	190.3	15.56 ± 0.16	**0.3592 ± 0.0783**
^{111}In	c	2.8047D	245.4	94 ± 1	1.459 ± 0.060
			171.3	90.2 ± 1.0	1.427 ± 0.059
				RR_{mean} =	**1.442 ± 0.051**
^{110}In	i	4.9H	937.5	68.4 ± 1.4	0.9625 ± 0.0885
			884.7	92.9 ± 1.9	0.6816 ± 0.0646
				RR_{mean} =	**0.7798 ± 0.1361**
^{109}In	c	4.2H	203.5	73.5 ± 0.5	**1.153 ± 0.062**
^{110m}Ag	i(m)	249.76D	884.7	72.7 ± 0.4	0.2391 ± 0.0564
			657.8	94.3 ± 0.3	0.2805 ± 0.0451
				RR_{mean} =	**0.2646 ± 0.0356**
^{106m}Ag	i(m)	8.28D	1527.7	16.3 ± 1.4	0.7134 ± 0.0810
			1045.8	29.6 ± 1.0	0.6229 ± 0.0464
			717.3	28.9 ± 0.8	0.6435 ± 0.0548
			451.0	28.2 ± 0.8	0.4446 ± 0.0508
				RR_{mean} =	**0.5891 ± 0.0563**

Continuation of Table 106.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{105}Ag	c	41.29D	443.4	10.5 ± 0.6	0.9235 ± 0.0977
			344.5	41.4 ± 0.6	0.9931 ± 0.0677
				RR_{mean} =	**0.9732 ± 0.0579**
^{100}Pd	c	3.63D	2376.0	*	**0.2101 ± 0.0362**
^{102}Rh	i	207D	475.1	46 ± 5	**0.3654 ± 0.0650**
^{101m}Rh	c	4.34D	306.9	81 ± 5	**1.211 ± 0.094**
^{100}Rh$_i$	i(m+g)	20.8H	2376.0	32.6 ± 0.4	**0.5102 ± 0.0539**
^{100}Rh$_c$	c	20.8H	2376.0	32.6 ± 0.4	**0.7203 ± 0.0482**
^{103}Ru	c	39.26D	497.1	91.0 ± 1.3	**0.8004 ± 0.0464**
^{96}Tc	i(m+g)	4.28D	849.9	98 ± 4	0.6412 ± 0.0379
			812.5	82 ± 4	0.6766 ± 0.0428
				RR_{mean} =	**0.6563 ± 0.0317**
^{99}Mo	c	65.94H	140.5	90.27 ± 0.33	**0.6331 ± 0.0359**
^{93m}Mo	i(m)	6.85H	684.7	99.7 ± 2.0	**0.5394 ± 0.0311**
^{96}Nb	i	23.35H	568.9	58.0 ± 0.3	0.2993 ± 0.1400
			1091.3	48.5 ± 1.6	0.5004 ± 0.0380
				RR_{mean} =	**0.4887 ± 0.0494**
^{95}Nb$_c$	c	34.975D	765.8	99.81 ± 0.03	**1.070 ± 0.037**
^{90}Nb	c*	14.60H	2319.0	82.0 ± 0.3	0.7378 ± 0.0489
			1129.2	92.7 ± 0.5	0.7518 ± 0.0371
				RR_{mean} =	**0.7475 ± 0.0333**
^{95}Zr	c	64.02D	756.7	54.46 ± 0.10	**0.4509 ± 0.0288**
^{89}Zr	c	78.41H	909.2	99.04 ± 0.03	**1.261 ± 0.043**
^{88}Zr	c	83.4D	1836.1	*	0.7643 ± 0.2738
			898.0	*	0.7706 ± 0.1101
			392.9	97.24 ± 0.00	0.8869 ± 0.0406
				RR_{mean} =	**0.8772 ± 0.0271**
^{88} Y$_i$	i	106.65D	1836.1	99.2 ± 0.3	1.131 ± 0.099
			898.0	93.7 ± 0.3	1.135 ± 0.063
				RR_{mean} =	**1.134 ± 0.058**
^{88} Y$_c$	c	106.65D	1836.1	99.2 ± 0.3	1.895 ± 0.203
			898.0	93.7 ± 0.3	1.906 ± 0.092
				RR_{mean} =	**1.905 ± 0.089**
^{87} Y	c*	79.8H	484.8	89.7 ± 0.7	**1.598 ± 0.058**
^{86} Y$_c$	c	14.74H	1076.6	82.5 ± 0.4	**0.8110 ± 0.0339**
^{85}Sr	c	64.84D	514.0	96 ± 4	**1.606 ± 0.089**
^{84}Rb	i(m+g)	32.77D	881.6	69.0 ± 1.6	**1.223 ± 0.116**
^{83}Rb	c	86.2D	529.6	29.3 ± 2.1	1.760 ± 0.162
			520.4	45 ± 4	1.779 ± 0.173
				RR_{mean} =	**1.768 ± 0.105**
^{82m}Rb	i(m)	6.472H	554.3	62.4 ± 0.9	**0.7715 ± 0.0494**
^{82}Br	i(m+g)	35.30H	554.3	70.8 ± 1.0	**0.4060 ± 0.0200**
^{75}Se	c	119.779D	264.7	58.9 ± 0.4	**0.9088 ± 0.0418**
^{74}As	i	17.77D	595.8	59 ± 4	**0.8459 ± 0.0693**
^{71}As	c	65.28H	174.9	82.0 ± 2.1	**0.2710 ± 0.0225**
^{58}Co	i(m+g)	70.86D	810.8	99.45 ± 0.01	**0.5976 ± 0.0993**
^{59}Fe	c	44.472D	1099.2	56.5 ± 1.9	**0.5009 ± 0.0349**
^{54}Mn	i	312.11D	834.8	99.98 ± 0.00	**0.6343 ± 0.0796**
^{48} V	c	15.9735D	1312.1	97.5 ± 0.9	0.1258 ± 0.0102
			983.5	100.0 ± 0.3	0.1418 ± 0.0135

Continuation of Table 106.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
				RR_{mean} =	**0.1314 ± 0.0086**
^{48}Sc	i	43.67H	1312.1	100.1 ± 0.7	0.2914 ± 0.0151
			1037.5	97.6 ± 0.7	0.3010 ± 0.0171
				RR_{mean} =	**0.2954 ± 0.0130**
^{46}Sc	i(m+g)	83.79D	889.3	99.98 ± 0.00	**0.6668 ± 0.0340**
^{28}Mg	c	20.915H	1778.8	100.2 ± 0.0	**0.3659 ± 0.0201**
^{24}Na	c	14.9590H	1369.0	100 ± 0	**1.536 ± 0.058**
^{7}Be	i	53.29D	477.6	10.52 ± 0.06	**3.307 ± 0.218**

12.11.3 Nuclide production rates for ^{208}Pb

Table 107: Detailed calculation of nuclide production rates for ^{208}Pb for E_p = 2.6 GeV, used to determine the cross sections for their production.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{207}Bi	i	31.55Y	569.7	97.74 ± 0.03	**6.104 ± 1.284**
^{206}Bi	i	6.243D	1718.7	31.8 ± 0.6	3.234 ± 0.144
			803.1	98.9 ± 1.4	3.090 ± 0.113
			537.5	30.5 ± 0.5	3.013 ± 0.152
				RR_{mean} =	**3.108 ± 0.108**
^{205}Bi	i	15.31D	1764.3	32.5 ± 0.7	3.992 ± 0.211
			987.7	16.13 ± 0.17	4.982 ± 0.228
				RR_{mean} =	**4.495 ± 0.514**
^{204}Bi	i	11.22H	374.8	82 ± 5	3.227 ± 0.675
			899.2	98 ± 9	3.412 ± 0.136
			984.0	59 ± 4	3.057 ± 0.265
				RR_{mean} =	**3.371 ± 0.104**
^{203}Bi	i(m+g)	11.76H	820.2	29.6 ± 1.5	**3.154 ± 0.213**
^{202}Bi	i	1.72H	422.1	83.7 ± 2.5	**2.024 ± 0.380**
^{204m}Pb$_i$	i(m)	67.2M	374.7	89 ± 15	10.45 ± 1.80
			899.2	99.17 ± 0.02	10.31 ± 0.44
				RR_{mean} =	**10.32 ± 0.44**
^{204m}Pb$_c$	c	67.2M	374.7	89 ± 15	10.90 ± 1.88
			899.2	99.17 ± 0.02	10.88 ± 0.45
				RR_{mean} =	**10.88 ± 0.45**
^{203}Pb	c*	51.873H	279.2	80.8 ± 0.2	**23.16 ± 0.85**
^{202m}Pb	i(m)	3.53H	960.7	92 ± 8	8.587 ± 0.887
			422.1	86 ± 5	7.554 ± 0.547
				RR_{mean} =	**7.709 ± 0.439**
^{201}Pb	c*	9.33H	331.2	79 ± 5	**16.73 ± 1.20**
^{200}Pb	c	21.5H	1205.7	*	10.97 ± 0.79
			579.3	*	11.37 ± 0.87
			367.9	*	11.61 ± 0.43
			147.6	37.7 ± 1.4	11.80 ± 0.65
				RR_{mean} =	**11.57 ± 0.36**
^{199}Pb	c*	90M	366.9	44 ± 7	**21.04 ± 3.49**
^{198}Pb	c	2.4H	173.4	18 ± 3	**14.94 ± 2.59**
^{197m}Pb	c*	43M	385.9	74 ± 15	**9.967 ± 2.066**

Continuation of Table 107.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{202}Tl	c	12.23D	439.6	91.4 ± 1.0	**13.70 ± 0.49**
^{201}Tl	c*	72.912H	167.4	10.00 ± 0.06	**31.34 ± 1.17**
$^{200}Tl_i$	i	26.1H	1205.7	29.9 ± 1.8	15.20 ± 1.10
			579.3	13.8 ± 0.7	15.05 ± 1.24
			367.9	87.2 ± 0.4	13.57 ± 0.57
				RR_{mean} =	**13.90 ± 0.62**
$^{200}Tl_c$	c	26.1H	1205.7	29.9 ± 1.8	26.17 ± 1.80
			579.3	13.8 ± 0.7	26.42 ± 1.66
			367.9	87.2 ± 0.4	25.18 ± 0.87
				RR_{mean} =	**25.30 ± 0.85**
$^{199}Tl_c$	c	7.42H	455.5	12.4 ± 1.4	**22.56 ± 3.32**
^{199}Tl	c*	7.42H	455.5	12.4 ± 1.4	**25.47 ± 3.05**
^{198m}Tl	i(m)	1.87H	282.8	28 ± 3	**12.07 ± 1.45**
^{196m}Tl	i(m)	1.41H	695.4	41 ± 7	**20.63 ± 3.61**
^{203}Hg	c	46.612D	279.2	81.46 ± 0.13	**3.401 ± 0.133**
^{197m}Hg	i(m)	23.8H	134.0	33.5 ± 0.4	**6.705 ± 0.355**
^{195m}Hg	i(m)	41.6H	261.8	31 ± 4	**10.64 ± 1.44**
^{193m}Hg	i(m)	11.8H	258.0	49 ± 7	**11.19 ± 1.66**
^{192}Hg	c	4.85H	2236.9	*	17.47 ± 3.50
			316.5	*	19.11 ± 2.41
			274.8	50.2 ± 2.5	17.05 ± 1.10
				RR_{mean} =	**17.35 ± 0.54**
^{190}Hg	c*	20.0M	142.6	68 ± 10	**14.90 ± 2.50**
$^{198}Au_c$	i(m+g)	2.69517D	411.8	95.58 ± 0.12	**1.361 ± 0.226**
^{196}Au	i(m1+m2+g)	6.183D	355.7	87.0 ± 0.8	2.867 ± 0.102
			333.0	22.9 ± 0.6	2.972 ± 0.143
				RR_{mean} =	**2.882 ± 0.097**
^{195}Au	c	186.098D	98.9	10.9 ± 0.9	**28.86 ± 2.82**
^{194}Au	i(m1+m2+g)	38.02H	328.5	61 ± 5	**4.475 ± 0.400**
$^{192}Au_i$	i(m+g)	4.94H	316.5	58 ± 7	**7.621 ± 1.006**
$^{192}Au_c$	c	4.94H	316.5	58 ± 7	**26.73 ± 3.36**
$^{190}Au_c$	c	42.8M	295.8	71 ± 5	**24.67 ± 2.30**
^{191}Pt	c	2.802D	409.4	8.0 ± 0.9	**18.71 ± 2.21**
^{189}Pt	c	10.87H	721.4	9.3 ± 0.8	23.02 ± 2.20
			568.8	7.1 ± 0.6	21.50 ± 2.36
			544.9	5.8 ± 0.5	23.98 ± 2.34
				RR_{mean} =	**22.86 ± 1.44**
^{188}Pt	c	10.2D	423.3	4.4 ± 0.3	19.97 ± 1.55
			195.1	18.6 ± 1.2	20.02 ± 1.50
			187.6	19.4 ± 1.2	19.95 ± 1.45
				RR_{mean} =	**19.98 ± 0.91**
^{186}Pt	c	2.08H	689.4	70 ± 15	**16.24 ± 3.53**
^{189}Ir	c	13.2D	245.1	6.0 ± 0.6	**20.38 ± 2.27**
$^{188}Ir_c$	c	41.5H	1209.8	6.9 ± 0.7	**20.90 ± 2.29**
^{187}Ir	c*	10.5H	977.5	3.14 ± 0.11	**20.42 ± 1.62**
^{186}Ir	c	16.64H	434.8	33.9 ± 1.1	8.911 ± 0.454
			137.2	41.4 ± 0.7	9.795 ± 0.448
				RR_{mean} =	**9.393 ± 0.527**
^{185}Ir	c	14.4H	1829.0	10.1 ± 1.5	15.12 ± 2.34
			254.2	13.3 ± 2.4	11.83 ± 2.21

Continuation of Table 107.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
				RR_{mean} =	**14.33 ± 1.47**
^{184}Ir	c*	3.09H	264.0	68 ± 4	18.81 ± 1.33
			119.8	31 ± 3	19.32 ± 2.11
				RR_{mean} =	**18.85 ± 0.77**
^{185}Os	c	93.6D	874.8	6.29 ± 0.25	19.98 ± 1.13
			646.1	78 ± 3	20.35 ± 1.04
				RR_{mean} =	**20.28 ± 0.67**
^{183m}Os	c*	9.9H	1101.9	49.0 ± 1.3	**10.99 ± 0.50**
^{182}Os	c	22.10H	180.2	33.5 ± 1.7	**19.30 ± 1.32**
^{180}Os	c	21.5M	902.8(D)	101.5 ± 3.4	**18.00 ± 1.02**
^{183}Re	c	70.0D	162.3	23.3 ± 0.7	**21.68 ± 1.04**
^{182m}Re$_c$	c	12.7H	1221.5	24.8 ± 1.6	22.15 ± 1.68
			1189.2	15 ± 1	21.19 ± 1.73
				RR_{mean} =	**21.71 ± 1.13**
^{181}Re	c*	19.9H	639.0	6.4 ± 1.4	18.19 ± 4.05
			365.5	56 ± 8	18.93 ± 2.79
				RR_{mean} =	**18.73 ± 2.02**
^{179}Re	c*	19.5M	430.2	28.0 ± 1.8	25.82 ± 2.67
			290.0	26.9 ± 2.3	33.11 ± 3.53
				RR_{mean} =	**28.38 ± 3.59**
^{178}Re	c*	13.2M	237.3	45 ± 5	**30.84 ± 3.94**
^{177} W	c	135M	115.7	51 ± 5	**17.68 ± 1.93**
^{177}Ta	c*	56.56H	112.9	7.2 ± 1.6	**19.76 ± 4.51**
^{176}Ta$_c$	c	8.09H	1823.7	4.5 ± 0.4	19.17 ± 4.30
			1159.3	24.7 ± 1.9	19.09 ± 1.69
			710.5	5.4 ± 0.4	25.82 ± 2.47
				RR_{mean} =	**20.54 ± 2.05**
^{175}Ta	c	10.5H	348.5	12.0 ± 1.1	21.14 ± 2.11
			266.9	10.52 ± 0.16	17.86 ± 0.82
				RR_{mean} =	**18.13 ± 1.05**
^{174}Ta$_c$	c	1.14H	206.5	60 ± 5	**19.65 ± 1.82**
^{173}Ta	c	3.14H	172.2	17.5 ± 1.8	**22.43 ± 2.52**
^{172}Ta	c*	36.8M	214.1	55 ± 5	**14.48 ± 1.52**
^{175}Hf	c	70D	343.4	84 ± 3	**18.60 ± 0.91**
^{173}Hf	c*	23.6H	311.2	10.7 ± 0.5	21.97 ± 1.29
			123.7	83 ± 5	22.42 ± 1.66
				RR_{mean} =	**22.09 ± 0.94**
^{172}Hf	c	1.87Y	1093.6	*	16.77 ± 1.12
			125.8	11.3 ± 0.9	17.17 ± 1.68
				RR_{mean} =	**16.89 ± 0.52**
^{171}Hf	c	12.1H	739.8	*	**16.01 ± 1.76**
^{170}Hf	c	16.01H	620.7	18 ± 5	22.16 ± 6.21
			164.7	26 ± 8	20.63 ± 6.40
			120.2	15 ± 5	20.79 ± 7.00
				RR_{mean} =	**21.72 ± 1.53**
^{173}Lu	c	1.37Y	272.1	21.2 ± 0.8	**18.08 ± 1.01**
^{172}Lu$_i$	i(m+g)	6.70D	1093.6	63 ± 3	**0.1972 ± 0.0535**
^{172}Lu$_c$	c	6.70D	1093.6	63 ± 3	**16.97 ± 1.12**
^{171}Lu$_c$	c	8.24D	739.8	47.8 ± 1.2	**19.25 ± 0.80**
^{171}Lu	c*	8.24D	739.8	47.8 ± 1.2	**20.18 ± 0.84**

Continuation of Table 107.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
$^{170}Lu_c$	c	2.012D	2126.1	5.1 ± 0.3	15.48 ± 1.20
			1280.2	8.2 ± 0.4	17.67 ± 1.27
			985.1	5.5 ± 0.3	17.84 ± 2.36
				RR_{mean} =	**16.69 ± 0.93**
^{169}Lu	c	34.06H	960.6	23.4 ± 0.7	15.20 ± 0.70
			191.2	20.6 ± 0.6	15.79 ± 0.76
				RR_{mean} =	**15.45 ± 0.58**
^{167}Lu	c	51.5M	176.2	*	15.98 ± 1.27
			113.3	*	17.52 ± 1.31
				RR_{mean} =	**16.74 ± 0.98**
^{169}Yb	c*	32.026D	198.0	35.8 ± 0.7	18.96 ± 0.85
			177.2	22.2 ± 0.5	17.86 ± 0.77
			130.5	11.31 ± 0.21	18.34 ± 0.85
				RR_{mean} =	**18.33 ± 0.65**
^{166}Yb	c	56.7H	2079.5	*	17.82 ± 1.34
			2052.4	*	16.71 ± 1.19
			1867.9	*	16.66 ± 1.29
			1176.7	*	15.98 ± 1.19
			1176.7	*	15.98 ± 1.19
			785.9	*	18.27 ± 1.29
			691.2(D)	8.56 ± 0.58	14.23 ± 1.16
				RR_{mean} =	**16.43 ± 0.51**
^{167}Tm	c	9.25D	207.8	42 ± 8	**19.17 ± 3.73**
^{165}Tm	c	30.06H	806.4	9.5 ± 0.6	17.41 ± 1.26
			242.9	35.5 ± 1.7	19.61 ± 1.23
				RR_{mean} =	**18.79 ± 1.21**
^{161}Er	c*	3.21H	826.6	64 ± 4	**22.35 ± 1.62**
^{160}Er	c	28.58H	966.2	*	18.08 ± 2.43
			879.4(D)	22.6 ± 2.8	19.34 ± 2.49
			872.0(D)	6.8 ± 1.1	19.81 ± 3.30
			728.2(D)	*	18.92 ± 2.78
				RR_{mean} =	**18.96 ± 0.58**
^{159}Er	c*	36M	624.5	33 ± 4	19.99 ± 2.73
			309.6	*	20.81 ± 2.18
			132.0	*	20.09 ± 1.57
				RR_{mean} =	**20.27 ± 0.63**
$^{160m}Ho_c$	c	5.02H	966.2	15.4 ± 2.0	18.85 ± 2.59
			728.2	28 ± 4	18.93 ± 2.81
				RR_{mean} =	**18.88 ± 1.85**
^{156}Ho	c*	56M	266.5	54.7 ± 1.1	**20.81 ± 0.99**
^{157}Dy	c	8.14H	326.2	92 ± 4	**17.55 ± 0.98**
^{155}Dy	c*	9.9H	226.9	68.4 ± 1.6	**16.11 ± 0.76**
^{152}Dy	c	2.38H	256.9	97.50 ± 0.07	**10.38 ± 0.43**
^{155}Tb	c*	5.32D	180.1	7.5 ± 0.5	16.15 ± 1.28
			105.3	25.1 ± 1.3	17.26 ± 1.24
				RR_{mean} =	**16.81 ± 0.75**
^{153}Tb	c*	2.34D	212.0	31.0 ± 1.9	**13.73 ± 1.01**
$^{152}Tb_c$	c	17.5H	344.3	65 ± 4	**11.51 ± 0.99**
^{151}Tb	c	17.609H	479.4	15.4 ± 0.7	11.54 ± 0.70
			251.9	26.3 ± 1.2	10.79 ± 0.66

Continuation of Table 107.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
				RR_{mean} =	**11.14 ± 0.51**
^{149}Tb	c	4.118H	352.2	29.4 ± 0.9	5.177 ± 0.332
			165.0	26.4 ± 0.9	6.125 ± 0.517
				RR_{mean} =	**5.404 ± 0.437**
^{148}Tb	c	60M	784.4	84.0 ± 1.6	**7.171 ± 0.386**
^{153}Gd	c	240.4D	103.2	21.1 ± 0.7	13.28 ± 0.80
			97.4	29.0 ± 0.8	12.68 ± 0.76
				RR_{mean} =	**12.96 ± 0.59**
^{151}Gd	c	124D	243.3	5.6 ± 0.4	**11.78 ± 1.01**
^{149}Gd	c	9.28D	788.9	7.3 ± 0.4	15.84 ± 1.12
			346.6	23.9 ± 1.3	13.84 ± 0.90
			298.6	28.6 ± 1.7	14.11 ± 0.98
			149.7	48 ± 3	15.42 ± 1.13
				RR_{mean} =	**14.42 ± 0.64**
^{147}Gd	c	38.06H	929.0	20.2 ± 1.2	12.55 ± 0.88
			396.0	34.3 ± 2.1	11.63 ± 0.82
			370.0	17.2 ± 0.9	12.30 ± 0.77
				RR_{mean} =	**12.17 ± 0.49**
^{146}Gd	c	48.27D	747.2	*	12.98 ± 0.58
			154.6	46.6 ± 0.5	12.42 ± 0.49
				RR_{mean} =	**12.60 ± 0.39**
^{149}Eu	c*	93.1D	327.5	4.03 ± 0.12	**18.01 ± 1.73**
^{147}Eu	c*	24.1D	955.8	3.84 ± 0.20	15.55 ± 1.08
			798.7	4.8 ± 0.3	16.81 ± 1.26
			677.5	9.8 ± 0.5	15.65 ± 0.99
			601.5	5.9 ± 0.3	15.87 ± 1.04
				RR_{mean} =	**15.85 ± 0.60**
^{146}Eu$_i$	i	4.61D	747.2	99 ± 3	**2.274 ± 0.108**
^{146}Eu$_c$	c	4.61D	747.2	99 ± 3	**15.25 ± 0.68**
^{145}Eu	c	5.93D	1997.0	7.2 ± 0.5	11.35 ± 0.93
			1658.5	14.9 ± 1.0	11.21 ± 0.86
			893.7	66 ± 5	11.30 ± 0.95
			653.5	15 ± 1	10.76 ± 0.82
				RR_{mean} =	**11.12 ± 0.49**
^{143}Pm	c	265D	742.0	38.5 ± 2.4	**11.14 ± 0.81**
^{136}Nd	c	50.65M	539.8(D)	70.7 ± 2.6	**5.560 ± 0.500**
^{139}Ce	c	137.640D	165.9	79.89 ± 0.01	**11.73 ± 0.43**
^{135}Ce	c	17.7H	783.6	10.6 ± 0.4	10.75 ± 0.74
			265.6	41.8 ± 1.5	9.539 ± 0.516
				RR_{mean} =	**9.802 ± 0.585**
^{134}Ce	c	3.16D	604.7	5.04 ± 0.20	**10.27 ± 0.72**
^{132}Ce	c	3.51H	464.5	*	7.272 ± 0.646
			182.1	77.4 ± 0.5	8.208 ± 0.379
				RR_{mean} =	**8.042 ± 0.248**
^{132}La$_c$	c	4.8H	464.5	76 ± 6	**7.427 ± 0.648**
^{133}Ba	c	3848.9D	356.0	62.05 ± 0.19	**10.90 ± 0.84**
^{131}Ba	c	11.50D	373.2	14.04 ± 0.20	8.361 ± 0.326
			216.1	19.66 ± 0.25	9.730 ± 0.411
			123.8	29.0 ± 0.3	8.608 ± 0.394
				RR_{mean} =	**8.768 ± 0.486**

Continuation of Table 107.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{128}Ba	c	2.43D	442.9	26.8 ± 1.4	6.278 ± 0.428
			273.4	14.5 ± 0.7	7.462 ± 0.512
				RR_{mean} =	**6.756 ± 0.617**
^{129}Cs	c	32.06H	371.9	30.6 ± 1.7	**9.540 ± 0.638**
^{127}Xe	c	36.4D	375.0	17.2 ± 0.6	7.833 ± 0.391
			202.9	68.3 ± 0.5	7.636 ± 0.298
			172.1	25.5 ± 0.8	7.400 ± 0.368
				RR_{mean} =	**7.622 ± 0.270**
^{123}Xe	c	2.08H	148.9	48.9 ± 0.6	**7.315 ± 0.352**
^{123m}Te	i(m)	119.7D	159.0	84.0 ± 0.4	**0.2197 ± 0.0326**
^{121m}Te	i(m)	154D	573.1	88.6 ± 0.1	0.6339 ± 0.1580
			212.2	81.4 ± 1.1	0.7184 ± 0.0530
				RR_{mean} =	**0.7111 ± 0.0219**
^{121}Te$_c$	c	19.16D	573.1	80.3 ± 2.5	**5.809 ± 0.287**
^{119m}Te	i(m)	4.70D	1212.7	66.2 ± 0.3	**1.336 ± 0.052**
^{120m}Sb	i(m)	5.76D	1171.7	100 ± 0	0.3371 ± 0.0199
			1023.3	99.4 ± 0.3	0.3305 ± 0.0237
				RR_{mean} =	**0.3345 ± 0.0168**
^{113}Sn	c	115.09D	391.7	64.97 ± 0.17	**3.308 ± 0.153**
^{114m}In	i(m)	49.51D	190.3	15.56 ± 0.16	**1.152 ± 0.168**
^{111}In	c	2.8047D	245.4	94 ± 1	3.592 ± 0.146
			171.3	90.2 ± 1.0	3.459 ± 0.139
				RR_{mean} =	**3.521 ± 0.127**
^{110}In	i	4.9H	937.5	68.4 ± 1.4	2.339 ± 0.119
			884.7	92.9 ± 1.9	1.964 ± 0.113
				RR_{mean} =	**2.154 ± 0.199**
^{109}In	c	4.2H	203.5	73.5 ± 0.5	**2.996 ± 0.148**
^{110m}Ag	i(m)	249.76D	884.7	72.7 ± 0.4	0.5702 ± 0.0578
			657.8	94.3 ± 0.3	0.7269 ± 0.0564
				RR_{mean} =	**0.6535 ± 0.0807**
^{106m}Ag	i(m)	8.28D	1527.7	16.3 ± 1.4	1.133 ± 0.149
			1045.8	29.6 ± 1.0	1.429 ± 0.086
			717.3	28.9 ± 0.8	1.304 ± 0.084
			451.0	28.2 ± 0.8	1.395 ± 0.100
				RR_{mean} =	**1.352 ± 0.065**
^{105}Ag	c	41.29D	443.4	10.5 ± 0.6	2.551 ± 0.289
			344.5	41.4 ± 0.6	2.321 ± 0.144
				RR_{mean} =	**2.357 ± 0.132**
^{100}Pd	c	3.63D	2376.0	*	**0.5725 ± 0.0377**
^{102}Rh	i	207D	475.1	46 ± 5	**0.6472 ± 0.1045**
^{101m}Rh	c	4.34D	306.9	81 ± 5	**2.721 ± 0.200**
^{100}Rh$_i$	i(m+g)	20.8H	2376.0	32.6 ± 0.4	**1.564 ± 0.102**
^{100}Rh$_c$	c	20.8H	2376.0	32.6 ± 0.4	**2.137 ± 0.114**
^{103}Ru	c	39.26D	497.1	91.0 ± 1.3	**1.940 ± 0.093**
^{96}Tc	i(m+g)	4.28D	849.9	98 ± 4	1.588 ± 0.091
			812.5	82 ± 4	1.685 ± 0.102
				RR_{mean} =	**1.630 ± 0.077**
^{99}Mo	c	65.94H	140.5	90.27 ± 0.33	**1.771 ± 0.083**
^{93m}Mo	i(m)	6.85H	684.7	99.7 ± 2.0	**1.310 ± 0.076**
^{96}Nb	i	23.35H	1091.3	48.5 ± 1.6	1.412 ± 0.092

Continuation of Table 107.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			568.9	58.0 ± 0.3	1.091 ± 0.160
				RR_{mean} =	**1.344 ± 0.137**
$^{95}Nb_c$	c	34.975D	765.8	99.81 ± 0.03	**2.817 ± 0.102**
^{90}Nb	c*	14.60H	2319.0	82.0 ± 0.3	1.604 ± 0.106
			1129.2	92.7 ± 0.5	1.643 ± 0.071
				RR_{mean} =	**1.635 ± 0.067**
^{95}Zr	c	64.02D	756.7	54.46 ± 0.10	**1.191 ± 0.069**
^{89}Zr	c	78.41H	909.2	99.04 ± 0.03	**3.004 ± 0.103**
^{88}Zr	c	83.4D	1836.1	*	1.466 ± 0.144
			898.0	*	1.518 ± 0.252
			392.9	97.24 ± 0.00	1.967 ± 0.075
				RR_{mean} =	**1.910 ± 0.059**
$^{88}Y_i$	i	106.65D	1836.1	99.2 ± 0.3	2.989 ± 0.123
			898.0	93.7 ± 0.3	2.887 ± 0.169
				RR_{mean} =	**2.964 ± 0.116**
$^{88}Y_c$	c	106.65D	1836.1	99.2 ± 0.3	4.455 ± 0.176
			898.0	93.7 ± 0.3	4.405 ± 0.195
				RR_{mean} =	**4.436 ± 0.162**
^{87}Y	c*	79.8H	484.8	89.7 ± 0.7	**4.084 ± 0.145**
$^{86}Y_c$	c	14.74H	1076.6	82.5 ± 0.4	**1.968 ± 0.086**
^{85}Sr	c	64.84D	514.0	96 ± 4	**3.820 ± 0.209**
^{84}Rb	i(m+g)	32.77D	881.6	69.0 ± 1.6	**2.642 ± 0.154**
^{83}Rb	c	86.2D	552.6	16.0 ± 1.1	4.886 ± 0.405
			529.6	29.3 ± 2.1	3.871 ± 0.345
			520.4	45 ± 4	3.983 ± 0.387
				RR_{mean} =	**4.240 ± 0.350**
^{82m}Rb	i(m)	6.472H	554.3	62.4 ± 0.9	**2.064 ± 0.127**
^{82}Br	i(m+g)	35.30H	554.3	70.8 ± 1.0	**1.022 ± 0.050**
^{75}Se	c	119.779D	264.7	58.9 ± 0.4	**2.196 ± 0.095**
^{74}As	i	17.77D	595.8	59 ± 4	**2.062 ± 0.160**
^{71}As	c	65.28H	174.9	82.0 ± 2.1	**0.5843 ± 0.0339**
^{58}Co	i(m+g)	70.86D	810.8	99.45 ± 0.01	**1.151 ± 0.207**
^{59}Fe	c	44.472D	1099.2	56.5 ± 1.9	**1.313 ± 0.106**
^{54}Mn	i	312.11D	834.8	99.98 ± 0.00	**1.670 ± 0.082**
^{48}V	c	15.9735D	1312.1	97.5 ± 0.9	0.2897 ± 0.0234
			983.5	100.0 ± 0.3	0.3120 ± 0.0188
				RR_{mean} =	**0.3041 ± 0.0159**
^{48}Sc	i	43.67H	1312.1	100.1 ± 0.7	0.7548 ± 0.0375
			1037.5	97.6 ± 0.7	0.7685 ± 0.0337
				RR_{mean} =	**0.7630 ± 0.0299**
^{46}Sc	i(m+g)	83.79D	889.3	99.98 ± 0.00	**1.581 ± 0.069**
^{28}Mg	c	20.915H	1778.8	100.2 ± 0.0	**0.9869 ± 0.0445**
^{24}Na	c	14.9590H	1369.0	100 ± 0	**3.946 ± 0.143**
^{7}Be	i	53.29D	477.6	10.52 ± 0.06	**5.466 ± 0.331**

12.11.4 Nuclide production rates for ^{nat}Pb

Table 108: Detailed calculation of nuclide production rates for ^{nat}Pb for $E_p = 2.6$ GeV, used to determine the cross sections for their production.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{207}Bi	i	31.55Y	1063.7	74.5 ± 0.2	**55.38 ± 5.13**
^{206}Bi	i	6.243D	1718.7	31.8 ± 0.6	23.89 ± 0.96
			803.1	98.9 ± 1.4	22.09 ± 0.86
			537.5	30.5 ± 0.5	23.17 ± 0.93
				RR_{mean} =	**22.96 ± 0.89**
^{205}Bi	i	15.31D	1861.7	6.17 ± 0.10	33.24 ± 1.64
			1764.3	32.5 ± 0.7	33.30 ± 1.39
			987.7	16.13 ± 0.17	37.68 ± 2.07
				RR_{mean} =	**33.99 ± 1.56**
^{204}Bi	i	11.22H	899.2	98 ± 9	28.75 ± 1.06
			374.8	82 ± 5	27.97 ± 5.85
			984.0	59 ± 4	28.14 ± 2.43
				RR_{mean} =	**28.71 ± 0.89**
^{203}Bi	i(m+g)	11.76H	820.2	29.6 ± 1.5	**29.51 ± 1.92**
^{202}Bi	i	1.72H	422.1	83.7 ± 2.5	**24.25 ± 2.90**
^{204m}Pb$_i$	i(m)	67.2M	899.2	99.17 ± 0.02	82.91 ± 3.32
			374.7	89 ± 15	79.80 ± 13.79
				RR_{mean} =	**82.84 ± 3.30**
^{204m}Pb$_c$	c	67.2M	899.2	99.17 ± 0.02	87.22 ± 3.43
			374.7	89 ± 15	83.31 ± 14.39
				RR_{mean} =	**87.14 ± 3.41**
^{203}Pb	c*	51.873H	279.2	80.8 ± 0.2	**218.2 ± 8.0**
^{202m}Pb	i(m)	3.53H	960.7	92 ± 8	56.73 ± 5.83
			422.1	86 ± 5	57.12 ± 4.40
				RR_{mean} =	**57.03 ± 2.94**
^{201}Pb	c*	9.33H	331.2	79 ± 5	**146.0 ± 10.5**
^{200}Pb	c	21.5H	1205.7	*	103.6 ± 7.3
			828.3	*	90.87 ± 7.37
			579.3	*	91.98 ± 6.06
			367.9	*	101.5 ± 4.2
			147.6	37.7 ± 1.4	96.44 ± 5.79
				RR_{mean} =	**98.52 ± 3.04**
^{199}Pb	c*	90M	455.5	*	171.3 ± 32.3
			366.9	44 ± 7	180.2 ± 30.1
				RR_{mean} =	**176.1 ± 5.4**
^{198}Pb	c	2.4H	173.4	18 ± 3	**131.3 ± 22.6**
^{197m}Pb	c*	43M	385.9	74 ± 15	**70.15 ± 14.72**
^{202}Tl	c	12.23D	439.6	91.4 ± 1.0	**108.0 ± 3.9**
^{201}Tl	c*	72.912H	167.4	10.00 ± 0.06	**268.2 ± 10.0**
^{200}Tl$_i$	i	26.1H	1205.7	29.9 ± 1.8	117.0 ± 8.7
			579.3	13.8 ± 0.7	128.9 ± 9.0
			367.9	87.2 ± 0.4	116.7 ± 4.9
				RR_{mean} =	**118.2 ± 4.6**
^{200}Tl$_c$	c	26.1H	1205.7	29.9 ± 1.8	220.6 ± 15.3
			579.3	13.8 ± 0.7	220.9 ± 13.8
			367.9	87.2 ± 0.4	218.1 ± 7.6
				RR_{mean} =	**218.5 ± 7.4**
^{199}Tl	c*	7.42H	455.5	12.4 ± 1.4	174.0 ± 21.3

Continuation of Table 108.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			455.5	12.4 ± 1.4	213.7 ± 25.5
				RR_{mean} =	**190.3 ± 5.9**
^{198m}Tl	i(m)	1.87H	282.8	28 ± 3	**80.49 ± 9.51**
^{196m}Tl	i(m)	1.41H	695.4	41 ± 7	**165.0 ± 28.8**
^{203}Hg	c	46.612D	279.2	81.46 ± 0.13	**20.98 ± 0.77**
^{197m}Hg	i(m)	23.8H	134.0	33.5 ± 0.4	**49.04 ± 2.51**
^{195m}Hg	i(m)	41.6H	261.8	31 ± 4	**81.69 ± 11.14**
^{193m}Hg	i(m)	11.8H	258.0	49 ± 7	**94.24 ± 14.03**
^{192}Hg	c	4.85H	2236.9	*	123.0 ± 23.2
			316.5	*	150.7 ± 19.0
			274.8	50.2 ± 2.5	132.6 ± 8.4
				RR_{mean} =	**134.8 ± 4.2**
^{190}Hg	c*	20.0M	142.6	68 ± 10	**84.25 ± 14.05**
^{198}Au$_c$	i(m+g)	2.69517D	411.8	95.58 ± 0.12	**10.04 ± 0.73**
^{196}Au	i(m1+m2+g)	6.183D	426.1	6.6 ± 0.8	15.81 ± 2.06
			355.7	87.0 ± 0.8	18.89 ± 0.67
			333.0	22.9 ± 0.6	18.94 ± 1.22
				RR_{mean} =	**18.84 ± 0.65**
^{195}Au	c	186.098D	98.9	10.9 ± 0.9	**233.8 ± 24.3**
^{194}Au	i(m1+m2+g)	38.02H	328.5	61 ± 5	**32.22 ± 2.90**
^{192}Au$_i$	i(m+g)	4.94H	316.5	58 ± 7	**48.85 ± 6.59**
^{192}Au$_c$	c	4.94H	316.5	58 ± 7	**199.5 ± 25.1**
^{190}Au$_c$	c	42.8M	295.8	71 ± 5	**188.4 ± 16.8**
^{191}Pt	c	2.802D	456.5	3.4 ± 0.4	150.1 ± 18.7
			409.4	8.0 ± 0.9	138.1 ± 16.4
			351.2	3.4 ± 0.4	165.9 ± 20.5
				RR_{mean} =	**148.0 ± 9.1**
^{189}Pt	c	10.87H	721.4	9.3 ± 0.8	185.1 ± 17.4
			607.6	8.10 ± 0.16	134.1 ± 14.7
			568.8	7.1 ± 0.6	188.1 ± 18.6
			544.9	5.8 ± 0.5	182.0 ± 17.4
				RR_{mean} =	**168.7 ± 14.7**
^{188}Pt	c	10.2D	1209.8	*	151.4 ± 16.2
			478.0	*	143.6 ± 7.7
			423.3	4.4 ± 0.3	146.3 ± 11.2
			381.4	7.5 ± 0.5	142.7 ± 10.7
			195.1	18.6 ± 1.2	143.2 ± 10.7
			187.6	19.4 ± 1.2	143.1 ± 10.4
			140.4	2.33 ± 0.15	142.9 ± 11.8
				RR_{mean} =	**143.7 ± 4.4**
^{186}Pt	c	2.08H	689.4	70 ± 15	**121.2 ± 26.3**
^{192}Ir	i(m1+g)	73.827D	316.5	82.71 ± 0.21	**1.107 ± 0.057**
^{190}Ir	i(m1+g)	11.78D	569.3	28.5 ± 1.3	**2.716 ± 0.234**
^{189}Ir	c	13.2D	245.1	6.0 ± 0.6	**151.3 ± 16.3**
^{188}Ir$_c$	c	41.5H	1209.8	6.9 ± 0.7	157.0 ± 16.9
			478.0	14.7 ± 0.6	159.1 ± 8.8
				RR_{mean} =	**159.0 ± 5.8**
^{187}Ir	c*	10.5H	977.5	3.14 ± 0.11	**126.1 ± 10.5**
^{186}Ir	c	16.64H	434.8	33.9 ± 1.1	74.94 ± 3.62
			137.2	41.4 ± 0.7	76.96 ± 4.16

Continuation of Table 108.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
				RR_{mean} =	**75.74 ± 3.16**
^{185}Ir	c	14.4H	1829.0	10.1 ± 1.5	110.8 ± 17.1
			254.2	13.3 ± 2.4	71.79 ± 13.93
				RR_{mean} =	**100.6 ± 17.4**
^{184}Ir	c*	3.09H	390.4	25.9 ± 2.4	133.6 ± 13.5
			264.0	68 ± 4	135.8 ± 9.7
			119.8	31 ± 3	148.8 ± 16.9
				RR_{mean} =	**136.3 ± 5.5**
^{185}Os	c	93.6D	874.8	6.29 ± 0.25	155.2 ± 8.0
			717.4	3.94 ± 0.16	159.1 ± 8.5
			646.1	78 ± 3	150.1 ± 7.7
				RR_{mean} =	**153.5 ± 5.4**
^{183m}Os	c*	9.9H	1101.9	49.0 ± 1.3	**84.25 ± 3.74**
^{182}Os	c	22.10H	1221.5	*	172.1 ± 13.6
			1189.2	*	181.1 ± 14.2
			263.3	6.71 ± 0.25	176.3 ± 10.4
			180.2	33.5 ± 1.7	157.8 ± 10.5
				RR_{mean} =	**171.9 ± 5.3**
^{180}Os	c	21.5M	902.8(D)	101.5 ± 3.4	**111.3 ± 5.7**
^{183}Re	c	70.0D	291.7	3.05 ± 0.18	143.0 ± 10.0
			162.3	23.3 ± 0.7	157.1 ± 7.5
				RR_{mean} =	**153.9 ± 7.6**
^{182m}Re$_c$	c	12.7H	1221.5	24.8 ± 1.6	168.7 ± 13.2
			1189.2	15 ± 1	150.7 ± 12.4
				RR_{mean} =	**159.5 ± 10.3**
^{181}Re	c*	19.9H	639.0	6.4 ± 1.4	147.1 ± 32.7
			365.5	56 ± 8	146.4 ± 21.6
				RR_{mean} =	**146.6 ± 15.8**
^{179}Re	c*	19.5M	430.2	28.0 ± 1.8	189.0 ± 23.4
			290.0	26.9 ± 2.3	132.4 ± 18.1
				RR_{mean} =	**154.8 ± 28.1**
^{178}Re	c*	13.2M	237.3	45 ± 5	**173.3 ± 22.2**
^{178} W	c	21.6D	1350.6(D)	1.18 ± 0.11	121.2 ± 12.5
			1340.8(D)	1.03 ± 0.09	99.47 ± 10.67
				RR_{mean} =	**109.8 ± 11.3**
^{177} W	c	135M	115.7	51 ± 5	**133.2 ± 15.1**
^{177}Ta	c*	56.56H	112.9	7.2 ± 1.6	**151.4 ± 34.9**
^{176}Ta$_c$	c	8.09H	1823.7	4.5 ± 0.4	157.3 ± 18.4
			1159.3	24.7 ± 1.9	146.4 ± 12.7
			710.5	5.4 ± 0.4	215.8 ± 26.4
				RR_{mean} =	**151.2 ± 11.9**
^{175}Ta	c	10.5H	348.5	12.0 ± 1.1	169.7 ± 16.7
			266.9	10.52 ± 0.16	129.2 ± 5.9
				RR_{mean} =	**131.8 ± 10.8**
^{174}Ta$_c$	c	1.14H	206.5	60 ± 5	**145.4 ± 14.4**
^{173}Ta	c	3.14H	172.2	17.5 ± 1.8	**159.9 ± 17.8**
^{172}Ta	c*	36.8M	214.1	55 ± 5	**93.21 ± 9.68**
^{175}Hf	c	70D	343.4	84 ± 3	**138.2 ± 6.8**
^{173}Hf	c*	23.6H	139.6	12.7 ± 0.6	171.2 ± 11.4
			123.7	83 ± 5	168.6 ± 13.6

Continuation of Table 108.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
				RR_{mean} =	**170.3 ± 8.3**
^{172}Hf	c	1.87Y	1093.6	*	124.4 ± 7.2
			1002.7(D)	5.55 ± 0.38	123.7 ± 10.3
			181.5	*	119.5 ± 7.5
			125.8	11.3 ± 0.9	130.0 ± 12.4
				RR_{mean} =	**123.4 ± 3.8**
^{171}Hf	c	12.1H	739.8	*	**125.8 ± 13.2**
^{170}Hf	c	16.01H	620.7	18 ± 5	178.0 ± 49.8
			164.7	26 ± 8	146.0 ± 45.3
			120.2	15 ± 5	162.4 ± 54.9
				RR_{mean} =	**168.9 ± 12.0**
^{173}Lu	c	1.37Y	272.1	21.2 ± 0.8	**128.7 ± 6.9**
^{172}Lu$_i$	i(m+g)	6.70D	1093.6	63 ± 3	**1.514 ± 0.099**
^{172}Lu$_c$	c	6.70D	1093.6	63 ± 3	125.9 ± 7.3
			181.5	20.6 ± 1.0	122.5 ± 7.7
				RR_{mean} =	**124.6 ± 4.8**
^{171}Lu$_c$	c	8.24D	739.8	47.8 ± 1.2	**141.5 ± 5.9**
^{171}Lu	c*	8.24D	739.8	47.8 ± 1.2	**149.7 ± 6.2**
^{170}Lu$_c$	c	2.012D	2126.1	5.1 ± 0.3	118.4 ± 8.9
			1280.2	8.2 ± 0.4	126.6 ± 10.8
				RR_{mean} =	**121.4 ± 6.5**
^{169}Lu	c	34.06H	960.6	23.4 ± 0.7	110.3 ± 5.0
			191.2	20.6 ± 0.6	128.0 ± 6.2
				RR_{mean} =	**116.2 ± 9.1**
^{167}Lu	c	51.5M	176.2	*	101.0 ± 6.5
			113.3	*	121.4 ± 10.9
				RR_{mean} =	**105.9 ± 9.3**
^{169}Yb	c*	32.026D	198.0	35.8 ± 0.7	137.1 ± 6.0
			177.2	22.2 ± 0.5	134.2 ± 5.9
			130.5	11.31 ± 0.21	142.1 ± 7.5
				RR_{mean} =	**136.7 ± 4.8**
^{166}Yb	c	56.7H	2079.5	*	120.6 ± 9.6
			2052.4	*	135.8 ± 9.4
			1867.9	*	135.8 ± 9.6
			1374.2	*	130.2 ± 10.5
			1176.7	*	123.8 ± 9.0
			785.9	*	131.8 ± 9.3
			691.2(D)	8.56 ± 0.58	119.1 ± 9.1
				RR_{mean} =	**128.0 ± 3.9**
^{167}Tm	c	9.25D	207.8	42 ± 8	**137.2 ± 26.7**
^{165}Tm	c	30.06H	806.4	9.5 ± 0.6	128.5 ± 9.3
			242.9	35.5 ± 1.7	132.9 ± 8.4
				RR_{mean} =	**131.4 ± 5.5**
^{161}Er	c*	3.21H	826.6	64 ± 4	**165.7 ± 11.9**
^{160}Er	c	28.58H	966.2	*	132.3 ± 17.8
			962.4	*	129.9 ± 17.0
			879.4(D)	22.6 ± 2.8	149.2 ± 19.2
			872.0(D)	6.8 ± 1.1	143.5 ± 23.8
			728.2(D)	*	142.3 ± 20.9
				RR_{mean} =	**138.9 ± 4.3**

Continuation of Table 108.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{159}Er	c*	36M	624.5	33 ± 4	155.4 ± 20.6
			309.6	*	183.9 ± 13.0
			132.0	*	184.8 ± 14.6
				RR_{mean} =	**179.6 ± 5.5**
^{160m}Ho$_c$	c	5.02H	966.2	15.4 ± 2.0	138.2 ± 18.8
			962.4	16.6 ± 2.1	130.2 ± 17.5
			728.2	28 ± 4	141.7 ± 20.9
				RR_{mean} =	**136.0 ± 10.9**
^{156}Ho	c*	56M	266.5	54.7 ± 1.1	**155.6 ± 7.4**
^{157}Dy	c	8.14H	326.2	92 ± 4	**129.4 ± 7.2**
^{155}Dy	c*	9.9H	226.9	68.4 ± 1.6	**114.7 ± 5.4**
^{152}Dy	c	2.38H	256.9	97.50 ± 0.07	**78.14 ± 3.33**
^{155}Tb	c*	5.32D	180.1	7.5 ± 0.5	114.9 ± 8.9
			105.3	25.1 ± 1.3	124.3 ± 9.9
				RR_{mean} =	**118.9 ± 5.9**
^{153}Tb	c*	2.34D	212.0	31.0 ± 1.9	**100.6 ± 7.3**
^{152}Tb$_c$	c	17.5H	344.3	65 ± 4	**86.01 ± 6.20**
^{151}Tb	c	17.609H	479.4	15.4 ± 0.7	93.38 ± 5.80
			395.4	10.8 ± 0.5	99.07 ± 8.72
			251.9	26.3 ± 1.2	75.94 ± 4.88
				RR_{mean} =	**85.25 ± 7.25**
^{149}Tb	c	4.118H	352.2	29.4 ± 0.9	34.97 ± 2.28
			165.0	26.4 ± 0.9	43.34 ± 4.60
				RR_{mean} =	**36.20 ± 3.16**
^{148}Tb	c	60M	784.4	84.0 ± 1.6	**52.29 ± 2.51**
^{153}Gd	c	240.4D	103.2	21.1 ± 0.7	100.1 ± 7.0
			97.4	29.0 ± 0.8	88.17 ± 5.88
				RR_{mean} =	**93.00 ± 6.53**
^{151}Gd	c	124D	243.3	5.6 ± 0.4	**87.62 ± 7.36**
^{149}Gd	c	9.28D	788.9	7.3 ± 0.4	118.8 ± 7.7
			346.6	23.9 ± 1.3	105.0 ± 6.7
			298.6	28.6 ± 1.7	106.7 ± 7.4
			149.7	48 ± 3	116.6 ± 8.7
				RR_{mean} =	**110.2 ± 5.0**
^{147}Gd	c	38.06H	929.0	20.2 ± 1.2	96.20 ± 6.58
			396.0	34.3 ± 2.1	88.21 ± 6.24
			370.0	17.2 ± 0.9	95.63 ± 6.08
				RR_{mean} =	**93.56 ± 3.81**
^{146}Gd	c	48.27D	747.2	*	100.1 ± 4.5
			154.6	46.6 ± 0.5	105.0 ± 4.1
				RR_{mean} =	**103.2 ± 3.2**
^{149}Eu	c*	93.1D	327.5	4.03 ± 0.12	**146.2 ± 6.7**
^{147}Eu	c*	24.1D	955.8	3.84 ± 0.20	120.7 ± 7.6
			798.7	4.8 ± 0.3	136.2 ± 9.7
			677.5	9.8 ± 0.5	122.7 ± 7.6
			601.5	5.9 ± 0.3	122.8 ± 7.5
			121.2	22.9 ± 1.3	112.7 ± 8.9
				RR_{mean} =	**122.6 ± 4.7**
^{146}Eu$_i$	i	4.61D	747.2	99 ± 3	**15.91 ± 0.73**
^{146}Eu$_c$	c	4.61D	747.2	99 ± 3	**116.0 ± 5.2**

Continuation of Table 108.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{145}Eu	c	5.93D	1997.0	7.2 ± 0.5	86.65 ± 6.86
			1658.5	14.9 ± 1.0	84.97 ± 6.40
			893.7	66 ± 5	81.76 ± 6.80
			653.5	15 ± 1	81.75 ± 6.11
				RR_{mean} =	**83.70 ± 3.61**
^{143}Pm	c	265D	742.0	38.5 ± 2.4	**86.21 ± 6.11**
^{136}Nd	c	50.65M	539.8(D)	70.7 ± 2.6	**47.45 ± 4.21**
^{139}Ce	c	137.640D	165.9	79.89 ± 0.01	**88.78 ± 3.28**
^{135}Ce	c	17.7H	783.6	10.6 ± 0.4	82.37 ± 4.71
			606.8	18.8 ± 0.7	75.32 ± 6.08
			265.6	41.8 ± 1.5	76.64 ± 4.47
				RR_{mean} =	**78.84 ± 3.23**
^{134}Ce	c	3.16D	604.7	5.04 ± 0.20	**75.38 ± 5.33**
^{132}Ce	c	3.51H	464.5	*	56.59 ± 5.02
			182.1	77.4 ± 0.5	64.86 ± 2.90
				RR_{mean} =	**63.49 ± 1.96**
$^{132}La_c$	c	4.8H	464.5	76 ± 6	**58.01 ± 5.07**
^{133}Ba	c	3848.9D	356.0	62.05 ± 0.19	**72.86 ± 2.93**
^{131}Ba	c	11.50D	496.3	46.8 ± 0.2	61.57 ± 2.20
			373.2	14.04 ± 0.20	63.72 ± 2.36
			216.1	19.66 ± 0.25	73.86 ± 3.08
			123.8	29.0 ± 0.3	66.05 ± 3.50
				RR_{mean} =	**64.19 ± 3.02**
^{128}Ba	c	2.43D	442.9	26.8 ± 1.4	46.79 ± 4.44
			273.4	14.5 ± 0.7	50.89 ± 3.48
				RR_{mean} =	**49.94 ± 2.31**
^{129}Cs	c	32.06H	371.9	30.6 ± 1.7	**72.14 ± 4.88**
^{127}Xe	c	36.4D	375.0	17.2 ± 0.6	61.20 ± 3.02
			202.9	68.3 ± 0.5	56.47 ± 2.22
			172.1	25.5 ± 0.8	56.78 ± 2.89
				RR_{mean} =	**57.45 ± 2.20**
^{123}Xe	c	2.08H	148.9	48.9 ± 0.6	**53.29 ± 2.82**
^{123m}Te	i(m)	119.7D	159.0	84.0 ± 0.4	**1.518 ± 0.105**
^{121m}Te	i(m)	154D	573.1	88.6 ± 0.1	4.920 ± 0.319
			212.2	81.4 ± 1.1	4.232 ± 0.243
				RR_{mean} =	**4.471 ± 0.138**
$^{121}Te_c$	c	19.16D	573.1	80.3 ± 2.5	**45.03 ± 2.07**
$^{119m}Te_i$	i(m)	4.70D	1212.7	66.2 ± 0.3	**9.880 ± 0.338**
^{120m}Sb	i(m)	5.76D	1171.7	100 ± 0	2.373 ± 0.183
			1023.3	99.4 ± 0.3	2.316 ± 0.116
				RR_{mean} =	**2.329 ± 0.108**
^{113}Sn	c	115.09D	391.7	64.97 ± 0.17	**26.17 ± 0.92**
^{114m}In	i(m)	49.51D	190.3	15.56 ± 0.16	**9.006 ± 0.605**
^{111}In	c	2.8047D	245.4	94 ± 1	28.05 ± 1.13
			171.3	90.2 ± 1.0	28.38 ± 1.12
				RR_{mean} =	**28.22 ± 0.98**
^{110}In	i	4.9H	937.5	68.4 ± 1.4	18.63 ± 1.06
			884.7	92.9 ± 1.9	14.76 ± 1.13
				RR_{mean} =	**16.99 ± 1.98**
^{109}In	c	4.2H	203.5	73.5 ± 0.5	**23.72 ± 1.14**

Continuation of Table 108.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{110m}Ag	i(m)	249.76D	884.7	72.7 ± 0.4	5.147 ± 0.206
			657.8	94.3 ± 0.3	4.902 ± 0.216
				RR_{mean} =	**5.044 ± 0.197**
^{106m}Ag	i(m)	8.28D	1527.7	16.3 ± 1.4	11.82 ± 1.12
			1045.8	29.6 ± 1.0	11.82 ± 0.58
			717.3	28.9 ± 0.8	11.04 ± 0.49
			451.0	28.2 ± 0.8	10.55 ± 0.51
				RR_{mean} =	**11.11 ± 0.45**
^{105}Ag	c	41.29D	443.4	10.5 ± 0.6	22.81 ± 1.78
			344.5	41.4 ± 0.6	20.32 ± 0.77
			280.4	30.2 ± 1.8	21.96 ± 1.55
				RR_{mean} =	**20.52 ± 0.77**
^{100}Pd	c	3.63D	2376.0	*	**5.277 ± 0.271**
^{102}Rh	i	207D	475.1	46 ± 5	**5.279 ± 0.680**
^{101m}Rh	c	4.34D	306.9	81 ± 5	**22.50 ± 1.61**
^{100}Rh$_i$	i(m+g)	20.8H	2376.0	32.6 ± 0.4	**13.56 ± 0.96**
^{100}Rh$_c$	c	20.8H	2376.0	32.6 ± 0.4	**18.84 ± 1.11**
^{103}Ru	c	39.26D	497.1	91.0 ± 1.3	**14.00 ± 0.56**
^{96}Tc	i(m+g)	4.28D	849.9	98 ± 4	13.09 ± 0.71
			812.5	82 ± 4	13.05 ± 0.78
				RR_{mean} =	**13.07 ± 0.60**
^{99}Mo	c	65.94H	140.5	90.27 ± 0.33	**12.95 ± 0.65**
^{93m}Mo	i(m)	6.85H	684.7	99.7 ± 2.0	**9.883 ± 0.660**
^{96}Nb	i	23.35H	1091.3	48.5 ± 1.6	9.658 ± 0.947
			568.9	58.0 ± 0.3	6.980 ± 0.697
				RR_{mean} =	**7.923 ± 1.302**
^{95}Nb$_c$	c	34.975D	765.8	99.81 ± 0.03	**21.20 ± 0.71**
^{90}Nb	c*	14.60H	2319.0	82.0 ± 0.3	13.00 ± 0.68
			1129.2	92.7 ± 0.5	13.94 ± 0.61
				RR_{mean} =	**13.58 ± 0.62**
^{95}Zr	c	64.02D	765.8	*	8.409 ± 0.482
			756.7	54.46 ± 0.10	7.846 ± 0.291
				RR_{mean} =	**7.923 ± 0.244**
^{89}Zr	c	78.41H	909.2	99.04 ± 0.03	**25.14 ± 0.90**
^{88}Zr	c	83.4D	1836.1	*	17.41 ± 1.28
			898.0	*	15.71 ± 1.19
			392.9	97.24 ± 0.00	15.39 ± 0.53
				RR_{mean} =	**15.47 ± 0.48**
^{88} Y$_i$	i	106.65D	1836.1	99.2 ± 0.3	21.27 ± 0.97
			898.0	93.7 ± 0.3	21.33 ± 0.90
				RR_{mean} =	**21.31 ± 0.80**
^{88} Y$_c$	c	106.65D	1836.1	99.2 ± 0.3	38.69 ± 1.47
			898.0	93.7 ± 0.3	37.04 ± 1.35
				RR_{mean} =	**37.73 ± 1.42**
^{87} Y	c*	79.8H	484.8	89.7 ± 0.7	31.03 ± 1.25
			388.5	82.1 ± 0.5	29.95 ± 6.92
				RR_{mean} =	**31.01 ± 1.23**
^{86} Y	c	14.74H	1076.6	82.5 ± 0.4	**18.35 ± 0.93**
^{85}Sr	c	64.84D	514.0	96 ± 4	**29.89 ± 1.64**
^{84}Rb	i(m+g)	32.77D	881.6	69.0 ± 1.6	**21.56 ± 0.90**

Continuation of Table 108.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{83}Rb	c	86.2D	552.6	16.0 ± 1.1	41.61 ± 3.28
			529.6	29.3 ± 2.1	33.49 ± 2.73
			520.4	45 ± 4	32.54 ± 3.12
				RR_{mean} =	**35.94 ± 3.03**
^{82m}Rb	i(m)	6.472H	554.3	62.4 ± 0.9	**16.88 ± 1.04**
^{82}Br	i(m+g)	35.30H	554.3	70.8 ± 1.0	**8.674 ± 0.410**
^{75}Se	c	119.779D	264.7	58.9 ± 0.4	**17.57 ± 0.69**
^{74}As	i	17.77D	595.8	59 ± 4	**16.72 ± 1.27**
^{71}As	c	65.28H	174.9	82.0 ± 2.1	**6.052 ± 0.285**
^{72}Ga$_i$	i	14.10H	2201.7	25.9 ± 0.5	**8.310 ± 1.380**
^{72}Ga$_c$	c	14.10H	2201.7	25.9 ± 0.5	**9.896 ± 1.362**
^{72}Zn	c	46.5H	2201.7	*	**1.586 ± 0.260**
^{58}Co	i(m+g)	70.86D	810.8	99.45 ± 0.01	**8.787 ± 0.458**
^{56}Co	c	77.233D	846.8	99.94 ± 0.03	**0.7364 ± 0.0442**
^{59}Fe	c	44.472D	1291.6	43.2 ± 1.4	10.38 ± 0.51
			1099.2	56.5 ± 1.9	9.979 ± 0.485
				RR_{mean} =	**10.16 ± 0.39**
^{54}Mn	i	312.11D	834.8	99.98 ± 0.00	**11.73 ± 0.50**
^{48} V	c	15.9735D	1312.1	97.5 ± 0.9	2.726 ± 0.112
			983.5	100.0 ± 0.3	2.572 ± 0.122
				RR_{mean} =	**2.666 ± 0.111**
^{48}Sc	i	43.67H	1312.1	100.1 ± 0.7	6.587 ± 0.279
			1037.5	97.6 ± 0.7	6.218 ± 0.239
				RR_{mean} =	**6.349 ± 0.264**
^{46}Sc	i(m+g)	83.79D	1120.6	99.99 ± 0.00	12.69 ± 0.92
			889.3	99.98 ± 0.00	13.01 ± 0.44
				RR_{mean} =	**12.99 ± 0.44**
^{28}Mg	c	20.915H	1778.8	100.2 ± 0.0	**7.222 ± 0.325**
^{24}Na	c	14.9590H	1369.0	100 ± 0	**31.49 ± 1.12**
^{7}Be	i	53.29D	477.6	10.52 ± 0.06	**49.27 ± 1.82**

12.11.5 Nuclide production rates for ^{209}Bi

Table 109: Detailed calculation of nuclide production rates for ^{209}Bi for $E_p = 2.6$ GeV, used to determine the cross sections for their production.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{207}Po	i(m+g)	5.80H	992.3	59.3 ± 0.9	**4.224 ± 0.173**
^{206}Po	i	8.8D	1032.3	33 ± 5	4.265 ± 0.664
			980.2	7.1 ± 0.9	4.652 ± 0.633
			807.4	23 ± 3	4.288 ± 0.589
			522.5	15.7 ± 2.0	4.083 ± 0.542
			338.4	19.2 ± 2.5	4.439 ± 0.604
			311.6	4.2 ± 0.6	4.841 ± 0.875
			286.4	24 ± 3	4.417 ± 0.581
			1718.7	*	4.106 ± 0.208
			803.1	*	4.008 ± 0.158
			620.5	*	4.101 ± 0.535
			516.2	*	3.773 ± 0.218

Continuation of Table 109.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			343.5	*	4.623 ± 0.290
				RR_{mean} =	**4.053 ± 0.125**
^{207}Bi	c	31.55Y	1063.7	74.5 ± 0.2	56.58 ± 2.33
			569.7	97.74 ± 0.03	52.08 ± 4.37
				RR_{mean} =	**56.01 ± 2.28**
^{206}Bi$_i$	i	6.243D	1718.7	31.8 ± 0.6	29.80 ± 1.17
			881.0	66.2 ± 1.0	29.00 ± 1.05
			803.1	98.9 ± 1.4	27.93 ± 1.00
			657.2	1.91 ± 0.04	29.32 ± 1.59
			620.5	5.76 ± 0.09	29.78 ± 1.30
			537.5	30.5 ± 0.5	26.33 ± 1.02
			516.2	40.7 ± 0.6	27.44 ± 1.04
			343.5	23.4 ± 0.4	26.73 ± 1.03
				RR_{mean} =	**28.01 ± 0.97**
^{206}Bi$_c$	c	6.243D	1718.7	31.8 ± 0.6	33.68 ± 1.31
			881.0	66.2 ± 1.0	34.93 ± 1.26
			803.1	98.9 ± 1.4	31.71 ± 1.13
			657.2	1.91 ± 0.04	30.01 ± 1.36
			620.5	5.76 ± 0.09	33.66 ± 1.32
			537.5	30.5 ± 0.5	29.75 ± 1.14
			516.2	40.7 ± 0.6	31.00 ± 1.16
			343.5	23.4 ± 0.4	31.10 ± 1.18
				RR_{mean} =	**32.00 ± 1.18**
^{205}Bi	c	15.31D	1861.7	6.17 ± 0.10	29.63 ± 1.21
			1775.8	3.99 ± 0.08	30.73 ± 1.28
			1764.3	32.5 ± 0.7	30.99 ± 1.27
			1614.3	2.28 ± 0.04	30.21 ± 1.29
			1190.0	2.26 ± 0.07	27.65 ± 1.35
			1043.8	7.51 ± 0.10	27.54 ± 1.09
			987.7	16.13 ± 0.17	29.59 ± 1.07
			703.5	31.1 ± 0.1	28.54 ± 0.96
			579.8	5.44 ± 0.07	26.58 ± 1.04
			284.1	1.69 ± 0.02	27.84 ± 1.18
				RR_{mean} =	**28.75 ± 0.98**
^{204}Bi	c*	11.22H	918.3	10.8 ± 0.9	23.90 ± 2.18
			899.2	98 ± 9	21.09 ± 0.72
			670.7	11.4 ± 0.9	22.11 ± 1.97
			374.8	82 ± 5	24.36 ± 5.09
				RR_{mean} =	**21.19 ± 0.65**
^{203}Bi	c	11.76H	1893.0	8.2 ± 0.6	18.50 ± 1.62
			1847.3	11.4 ± 0.8	17.10 ± 1.45
			1679.6	8.8 ± 0.7	17.16 ± 1.61
			896.8	13.1 ± 0.7	18.34 ± 1.23
			820.2	29.6 ± 1.5	18.62 ± 1.15
			279.2	*	16.83 ± 1.16
				RR_{mean} =	**17.68 ± 0.55**
^{202}Bi	c*	1.72H	960.7	99.28 ± 0.02	14.79 ± 0.64
			422.1	83.7 ± 2.5	14.52 ± 0.77
				RR_{mean} =	**14.70 ± 0.58**
^{204m}Pb$_i$	i(m)	67.2M	899.2	99.17 ± 0.02	8.900 ± 0.505
			374.7	89 ± 15	8.575 ± 1.497

Continuation of Table 109.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
				RR_{mean} =	**8.875 ± 0.491**
$^{204m}Pb_c$	c	67.2M	899.2	99.17 ± 0.02	12.06 ± 0.56
			374.7	89 ± 15	11.63 ± 2.02
				RR_{mean} =	**12.04 ± 0.56**
$^{203}Pb_i$	i(m1+m2+g)	51.873H	279.2	80.8 ± 0.2	**19.08 ± 1.44**
$^{203}Pb_c$	c	51.873H	279.2	80.8 ± 0.2	**35.91 ± 1.35**
^{202m}Pb	i(m)	3.53H	960.7	92 ± 8	10.02 ± 0.99
			422.1	86 ± 5	9.228 ± 0.680
				RR_{mean} =	**9.383 ± 0.452**
^{201}Pb	c*	9.33H	946.0	7.4 ± 0.6	31.62 ± 2.86
			331.2	79 ± 5	31.70 ± 2.29
				RR_{mean} =	**31.67 ± 1.91**
^{200}Pb	c	21.5H	1205.7	*	21.68 ± 1.54
			828.3	*	21.33 ± 2.17
			579.3	*	20.17 ± 1.42
			367.9	*	21.00 ± 0.74
			257.2	4.46 ± 0.17	26.19 ± 1.82
			235.6	4.30 ± 0.17	27.09 ± 1.95
			147.6	37.7 ± 1.4	22.50 ± 1.58
				RR_{mean} =	**21.16 ± 0.65**
^{199}Pb	c*	90M	1135.0	7.8 ± 1.2	30.93 ± 5.26
			366.9	44 ± 7	41.66 ± 6.86
			353.4	9.5 ± 1.5	48.12 ± 8.08
				RR_{mean} =	**38.07 ± 5.08**
^{198}Pb	c	2.4H	173.4	18 ± 3	**29.53 ± 5.09**
^{197m}Pb	c*	43M	385.9	74 ± 15	17.38 ± 3.59
			222.8	25 ± 6	15.43 ± 3.81
				RR_{mean} =	**17.18 ± 0.87**
^{195m}Pb	i(m)	15.0M	383.6	107 ± 20	**8.821 ± 1.736**
^{202}Tl	c	12.23D	439.6	91.4 ± 1.0	**5.584 ± 0.202**
^{201}Tl	c*	72.912H	167.4	10.00 ± 0.06	**37.60 ± 1.45**
$^{200}Tl_i$	i	26.1H	1205.7	29.9 ± 1.8	9.471 ± 0.907
			579.3	13.8 ± 0.7	10.01 ± 1.66
			367.9	87.2 ± 0.4	8.781 ± 0.637
				RR_{mean} =	**9.075 ± 0.537**
$^{200}Tl_c$	c	26.1H	1205.7	29.9 ± 1.8	31.15 ± 2.17
			579.3	13.8 ± 0.7	30.18 ± 2.06
			367.9	87.2 ± 0.4	29.78 ± 1.07
				RR_{mean} =	**29.90 ± 1.05**
^{199}Tl	c*	7.42H	455.5	12.4 ± 1.4	34.18 ± 4.09
			247.3	9.3 ± 1.1	37.28 ± 4.69
				RR_{mean} =	**35.35 ± 2.02**
^{198m}Tl	i(m)	1.87H	282.8	28 ± 3	**9.298 ± 1.164**
^{197}Tl	c*	2.84H	1411.3	4.5 ± 1.5	**23.42 ± 8.05**
^{196m}Tl	i(m)	1.41H	695.4	41 ± 7	**18.40 ± 3.22**
^{197m}Hg	i(m)	23.8H	134.0	33.5 ± 0.4	**3.489 ± 0.268**
^{193m}Hg	i(m)	11.8H	407.6	32 ± 6	**5.360 ± 1.031**
^{192}Hg	c	4.85H	316.5	*	21.45 ± 2.70
			274.8	50.2 ± 2.5	18.88 ± 1.21
				RR_{mean} =	**19.24 ± 0.59**

Continuation of Table 109.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{190}Hg	c*	20.0M	142.6	68 ± 10	**15.04 ± 2.41**
^{196}Au	i(m1+m2+g)	6.183D	355.7	87.0 ± 0.8	0.8301 ± 0.0370
			333.0	22.9 ± 0.6	0.9385 ± 0.0837
				RR_{mean} =	**0.8407 ± 0.0413**
^{195}Au	c	186.098D	98.9	10.9 ± 0.9	**23.89 ± 2.71**
^{194}Au	i(m1+m2+g)	38.02H	328.5	61 ± 5	**1.874 ± 0.170**
^{192}Au$_i$	i(m+g)	4.94H	316.5	58 ± 7	**3.969 ± 0.567**
^{192}Au$_c$	c	4.94H	316.5	58 ± 7	**25.42 ± 3.19**
^{191}Au	c*	3.18H	277.9	7.2 ± 0.5	**19.99 ± 1.97**
^{190}Au$_c$	c	42.8M	295.8	71 ± 5	**24.64 ± 2.35**
^{191}Pt	c	2.802D	538.9	13.7 ± 1.6	22.69 ± 2.77
			409.4	8.0 ± 0.9	17.14 ± 2.02
			359.9	6.0 ± 0.7	16.83 ± 2.07
			129.4	3.2 ± 0.5	17.75 ± 3.00
				RR_{mean} =	**18.10 ± 1.38**
^{189}Pt	c	10.87H	721.4	9.3 ± 0.8	24.47 ± 2.55
			568.8	7.1 ± 0.6	25.55 ± 2.78
			544.9	5.8 ± 0.5	24.74 ± 2.47
				RR_{mean} =	**24.88 ± 1.62**
^{188}Pt	c	10.2D	423.3	4.4 ± 0.3	18.27 ± 1.42
			381.4	7.5 ± 0.5	17.45 ± 1.31
			195.1	18.6 ± 1.2	18.08 ± 1.37
			187.6	19.4 ± 1.2	18.09 ± 1.32
				RR_{mean} =	**17.96 ± 0.76**
^{186}Pt	c	2.08H	689.4	70 ± 15	**16.42 ± 3.57**
^{189}Ir	c	13.2D	245.1	6.0 ± 0.6	**18.18 ± 1.98**
^{187}Ir	c*	10.5H	977.5	3.14 ± 0.11	**16.61 ± 1.33**
^{186}Ir	c	16.64H	434.8	33.9 ± 1.1	8.183 ± 0.422
			296.9	62.3 ± 1.9	8.446 ± 0.692
				RR_{mean} =	**8.239 ± 0.390**
^{185}Ir	c	14.4H	1829.0	10.1 ± 1.5	12.49 ± 1.96
			254.2	13.3 ± 2.4	10.38 ± 1.97
				RR_{mean} =	**11.98 ± 0.98**
^{184}Ir	c*	3.09H	390.4	25.9 ± 2.4	16.40 ± 1.65
			264.0	68 ± 4	17.79 ± 1.28
			119.8	31 ± 3	17.91 ± 2.15
				RR_{mean} =	**17.60 ± 0.72**
^{185}Os	c	93.6D	874.8	6.29 ± 0.25	19.20 ± 1.03
			717.4	3.94 ± 0.16	19.12 ± 1.12
			646.1	78 ± 3	18.00 ± 0.92
				RR_{mean} =	**18.40 ± 0.69**
^{183m}Os	c*	9.9H	1101.9	49.0 ± 1.3	**10.47 ± 0.47**
^{182}Os	c	22.10H	1221.5	*	22.57 ± 1.72
			1189.2	*	21.54 ± 1.61
			1121.4	*	22.78 ± 1.46
			180.2	33.5 ± 1.7	18.18 ± 1.19
				RR_{mean} =	**20.19 ± 0.62**
^{181}Os	c	105M	238.8	44 ± 5	**7.198 ± 0.991**
^{180}Os	c	21.5M	902.8(D)	101.5 ± 3.4	**18.39 ± 1.53**
^{183}Re	c	70.0D	291.7	3.05 ± 0.18	18.12 ± 1.29

Continuation of Table 109.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			162.3	23.3 ± 0.7	19.32 ± 0.95
				RR_{mean} =	**19.03 ± 0.80**
$^{182m}Re_c$	c	12.7H	1221.5	24.8 ± 1.6	20.46 ± 1.64
			1189.2	15 ± 1	21.13 ± 1.67
			1121.4	31.8 ± 1.6	20.16 ± 1.76
				RR_{mean} =	**20.61 ± 0.99**
^{181}Re	c*	19.9H	639.0	6.4 ± 1.4	17.04 ± 3.80
			365.5	56 ± 8	16.77 ± 2.52
				RR_{mean} =	**16.84 ± 1.85**
^{179}Re	c*	19.5M	290.0	26.9 ± 2.3	**24.52 ± 2.72**
^{178}Re	c*	13.2M	237.3	45 ± 5	**27.99 ± 3.64**
^{178}W	c	21.6D	1340.8(D)	1.03 ± 0.09	16.15 ± 2.15
			1106.1(D)	0.54 ± 0.05	22.20 ± 3.08
				RR_{mean} =	**18.05 ± 2.86**
^{177}W	c	135M	115.7	51 ± 5	**18.02 ± 2.17**
^{177}Ta	c*	56.56H	112.9	7.2 ± 1.6	**19.08 ± 4.46**
^{176}Ta	c*	8.09H	1584.0	5.3 ± 0.4	20.93 ± 1.92
			1159.3	24.7 ± 1.9	23.07 ± 2.00
				RR_{mean} =	**22.24 ± 1.25**
^{175}Ta	c	10.5H	1793.1	4.6 ± 0.7	13.57 ± 2.24
			348.5	12.0 ± 1.1	18.56 ± 1.88
				RR_{mean} =	**16.57 ± 2.50**
$^{174}Ta_c$	c	1.14H	206.5	60 ± 5	**18.18 ± 1.74**
^{173}Ta	c	3.14H	172.2	17.5 ± 1.8	**23.53 ± 2.63**
^{172}Ta	c*	36.8M	214.1	55 ± 5	**13.96 ± 1.46**
^{175}Hf	c	70D	343.4	84 ± 3	**17.35 ± 0.85**
^{173}Hf	c*	23.6H	306.6	6.4 ± 0.3	25.87 ± 1.83
			297.0	33.9 ± 1.4	30.82 ± 1.88
			139.6	12.7 ± 0.6	24.84 ± 1.84
			123.7	83 ± 5	22.52 ± 1.96
				RR_{mean} =	**26.73 ± 1.98**
^{172}Hf	c	1.87Y	1093.6	*	15.97 ± 0.93
			181.5	*	14.80 ± 0.98
			125.8	11.3 ± 0.9	15.68 ± 1.77
				RR_{mean} =	**15.58 ± 0.48**
^{170}Hf	c	16.01H	620.7	18 ± 5	22.23 ± 6.24
			164.7	26 ± 8	19.13 ± 5.94
			120.2	15 ± 5	22.30 ± 7.59
				RR_{mean} =	**21.52 ± 1.56**
^{168}Hf	c	25.95M	979.2	22.3 ± 5.6	**18.39 ± 4.80**
^{173}Lu	c	1.37Y	272.1	21.2 ± 0.8	**16.50 ± 0.94**
$^{172}Lu_i$	i(m+g)	6.70D	1093.6	63 ± 3	**0.1544 ± 0.0182**
$^{172}Lu_c$	c	6.70D	1093.6	63 ± 3	**16.12 ± 0.94**
^{171}Lu	c*	8.24D	853.0	2.55 ± 0.07	19.86 ± 0.99
			839.9	3.04 ± 0.08	22.99 ± 1.25
			780.7	4.36 ± 0.11	19.46 ± 0.86
			739.8	47.8 ± 1.2	19.25 ± 0.80
			667.4	11.0 ± 0.3	20.45 ± 0.91
				RR_{mean} =	**19.83 ± 0.76**
^{170}Lu	c*	2.012D	2126.1	5.1 ± 0.3	24.02 ± 1.83

Continuation of Table 109.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			1280.2	8.2 ± 0.4	23.73 ± 1.43
			1138.7	3.60 ± 0.18	23.86 ± 1.56
			1054.3	4.76 ± 0.24	24.21 ± 1.51
				RR_{mean} =	**23.93 ± 0.88**
$^{170}Lu_c$	c	2.012D	2126.1	5.1 ± 0.3	14.85 ± 1.70
			1280.2	8.2 ± 0.4	14.46 ± 1.11
			1138.7	3.60 ± 0.18	17.28 ± 3.54
			985.1	5.5 ± 0.3	17.80 ± 3.23
				RR_{mean} =	**14.84 ± 0.84**
^{169}Lu	c	34.06H	1449.7	9.9 ± 0.3	15.29 ± 0.74
			960.6	23.4 ± 0.7	14.53 ± 0.66
			191.2	20.6 ± 0.6	15.59 ± 0.77
				RR_{mean} =	**15.03 ± 0.57**
^{167}Lu	c	51.5M	113.3	*	16.94 ± 1.58
			106.2	*	18.15 ± 1.97
				RR_{mean} =	**17.41 ± 1.29**
^{169}Yb	c*	32.026D	307.7	10.05 ± 0.19	19.23 ± 0.77
			198.0	35.8 ± 0.7	17.42 ± 0.78
			177.2	22.2 ± 0.5	17.48 ± 0.78
			130.5	11.31 ± 0.21	18.80 ± 1.19
				RR_{mean} =	**18.29 ± 0.76**
^{166}Yb	c	56.7H	2079.5	*	17.74 ± 1.37
			2052.4	*	14.78 ± 1.05
			1374.2	*	16.89 ± 1.36
			1176.7	*	15.82 ± 1.14
			785.9	*	17.05 ± 1.35
			691.2(D)	*	15.12 ± 1.18
				RR_{mean} =	**16.02 ± 0.69**
^{162}Yb	c	18.87M	163.4	40 ± 5	**18.40 ± 2.64**
^{167}Tm	c	9.25D	531.5	1.61 ± 0.22	17.75 ± 2.59
			207.8	42 ± 8	17.34 ± 3.37
				RR_{mean} =	**17.70 ± 1.04**
^{165}Tm	c	30.06H	806.4	9.5 ± 0.6	16.25 ± 1.25
			242.9	35.5 ± 1.7	18.53 ± 1.15
				RR_{mean} =	**17.83 ± 1.19**
^{163}Tm	c	1.810H	104.3	18.6 ± 0.7	**15.94 ± 1.48**
^{161}Er	c*	3.21H	826.6	64 ± 4	**19.57 ± 1.45**
^{160}Er	c	28.58H	966.2	*	17.02 ± 2.29
			962.4	*	16.84 ± 2.21
			879.4(D)	22.6 ± 2.8	18.67 ± 2.41
			872.0(D)	6.8 ± 1.1	19.91 ± 3.34
			728.2(D)	34 ± 5	18.77 ± 2.83
				RR_{mean} =	**18.00 ± 0.56**
^{159}Er	c*	36M	649.1	23 ± 3	24.02 ± 3.55
			624.5	33 ± 4	21.77 ± 2.86
			309.6	*	21.68 ± 2.05
			132.0	*	23.21 ± 1.69
			121.0	*	19.73 ± 1.87
				RR_{mean} =	**21.86 ± 0.67**
$^{160m}Ho_c$	c	5.02H	966.2	15.4 ± 2.0	17.68 ± 2.55

Continuation of Table 109.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			962.4	16.6 ± 2.1	16.80 ± 2.31
				RR_{mean} =	**17.19 ± 1.66**
^{156}Ho	c*	56M	266.5	54.7 ± 1.1	**22.10 ± 1.02**
^{157}Dy	c	8.14H	326.2	92 ± 4	**16.80 ± 0.94**
^{155}Dy	c*	9.9H	226.9	68.4 ± 1.6	**15.40 ± 0.74**
^{152}Dy	c	2.38H	256.9	97.50 ± 0.07	**10.60 ± 0.44**
^{155}Tb	c*	5.32D	180.1	7.5 ± 0.5	14.69 ± 1.16
			163.3	4.44 ± 0.24	14.17 ± 1.01
			105.3	25.1 ± 1.3	15.98 ± 1.44
				RR_{mean} =	**14.59 ± 0.63**
^{153}Tb	c*	2.34D	212.0	31.0 ± 1.9	13.23 ± 0.96
			102.2	6.4 ± 0.5	11.42 ± 1.28
				RR_{mean} =	**12.70 ± 0.91**
^{152}Tb	c*	17.5H	344.3	65 ± 4	**12.46 ± 0.97**
^{151}Tb	c	17.609H	731.2	8.32 ± 0.04	10.21 ± 0.47
			587.5	15.6 ± 0.7	12.09 ± 1.06
			479.4	15.4 ± 0.7	11.49 ± 0.71
			395.4	10.8 ± 0.5	12.48 ± 1.44
			287.4	28.3 ± 1.2	11.06 ± 0.64
			251.9	26.3 ± 1.2	11.49 ± 0.71
			108.1	24.3 ± 1.1	11.49 ± 1.04
				RR_{mean} =	**10.94 ± 0.44**
^{150}Tb	c	3.48H	638.0	72 ± 10	**5.917 ± 0.859**
^{149}Tb	c	4.118H	352.2	29.4 ± 0.9	5.664 ± 0.324
			165.0	26.4 ± 0.9	6.501 ± 0.586
				RR_{mean} =	**5.792 ± 0.350**
^{148}Tb	c	60M	784.4	84.0 ± 1.6	**6.817 ± 0.454**
^{153}Gd	c	240.4D	103.2	21.1 ± 0.7	12.03 ± 1.00
			97.4	29.0 ± 0.8	11.05 ± 0.89
				RR_{mean} =	**11.48 ± 0.69**
^{151}Gd	c	124D	243.3	5.6 ± 0.4	11.24 ± 0.94
			174.7	2.96 ± 0.21	11.12 ± 0.96
				RR_{mean} =	**11.19 ± 0.50**
^{149}Gd	c	9.28D	788.9	7.3 ± 0.4	16.30 ± 1.06
			346.6	23.9 ± 1.3	14.00 ± 0.90
			298.6	28.6 ± 1.7	14.03 ± 0.97
			272.3	3.21 ± 0.19	14.69 ± 1.18
			149.7	48 ± 3	15.64 ± 1.22
				RR_{mean} =	**14.80 ± 0.68**
^{147}Gd	c	38.06H	929.0	20.2 ± 1.2	12.28 ± 0.87
			396.0	34.3 ± 2.1	11.45 ± 0.81
			370.0	17.2 ± 0.9	12.63 ± 0.80
			229.3	63 ± 4	13.67 ± 1.02
				RR_{mean} =	**12.40 ± 0.56**
^{146}Gd	c	48.27D	1533.7	*	13.19 ± 0.71
			1297.0	*	13.68 ± 0.80
			747.2	*	13.18 ± 0.59
			154.6	46.6 ± 0.5	14.01 ± 0.56
			115.5	44.0 ± 0.7	15.47 ± 1.08
			114.7	44.0 ± 0.7	14.87 ± 1.04

Continuation of Table 109.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
				RR_{mean} =	**13.67 ± 0.42**
^{149}Eu	c*	93.1D	327.5	4.03 ± 0.12	18.19 ± 0.94
			277.1	3.56 ± 0.06	18.40 ± 0.81
				RR_{mean} =	**18.33 ± 0.73**
^{147}Eu	c*	24.1D	955.8	3.84 ± 0.20	16.14 ± 1.11
			933.0	3.44 ± 0.18	19.63 ± 1.38
			856.9	2.70 ± 0.14	14.66 ± 0.97
			798.7	4.8 ± 0.3	16.75 ± 1.22
			677.5	9.8 ± 0.5	15.66 ± 0.98
			601.5	5.9 ± 0.3	15.81 ± 1.02
			121.2	22.9 ± 1.3	15.46 ± 1.35
				RR_{mean} =	**15.99 ± 0.71**
$^{146}Eu_i$	i	4.61D	1533.7	6.08 ± 0.19	3.725 ± 1.370
			1297.0	5.39 ± 0.15	3.525 ± 1.433
			747.2	99 ± 3	1.815 ± 0.086
				RR_{mean} =	**1.823 ± 0.101**
$^{146}Eu_c$	c	4.61D	1533.7	6.08 ± 0.19	16.92 ± 1.48
			1297.0	5.39 ± 0.15	17.20 ± 1.37
			747.2	99 ± 3	14.99 ± 0.67
				RR_{mean} =	**15.44 ± 0.77**
^{145}Eu	c	5.93D	1997.0	7.2 ± 0.5	10.79 ± 0.88
			1658.5	14.9 ± 1.0	10.49 ± 0.81
			893.7	66 ± 5	11.14 ± 0.93
			653.5	15 ± 1	10.68 ± 0.80
			542.6	4.5 ± 0.4	10.13 ± 1.08
				RR_{mean} =	**10.67 ± 0.45**
^{143}Pm	c	265D	742.0	38.5 ± 2.4	**11.19 ± 0.80**
^{136}Nd	c	50.65M	539.8(D)	70.7 ± 2.6	**7.627 ± 0.718**
^{134}Pr	c*	17M	409.2	87.1 ± 0.0	**6.763 ± 0.554**
^{139}Ce	c	137.640D	165.9	79.89 ± 0.01	**11.47 ± 0.44**
^{135}Ce	c	17.7H	783.6	10.6 ± 0.4	11.09 ± 0.71
			300.1	23.5 ± 0.6	10.62 ± 0.58
			265.6	41.8 ± 1.5	9.361 ± 0.503
				RR_{mean} =	**10.11 ± 0.60**
^{134}Ce	c	3.16D	604.7	5.04 ± 0.20	**9.418 ± 0.587**
^{132}Ce	c	3.51H	464.5	*	7.287 ± 0.651
			182.1	77.4 ± 0.5	8.728 ± 0.377
				RR_{mean} =	**8.500 ± 0.262**
^{130}Ce	c	25M	357.4	*	**4.952 ± 0.453**
$^{132}La_c$	c	4.8H	567.1	15.7 ± 1.5	6.236 ± 0.770
			464.5	76 ± 6	7.398 ± 0.645
				RR_{mean} =	**7.024 ± 0.584**
^{133}Ba	c	3848.9D	356.0	62.05 ± 0.19	**8.986 ± 0.747**
^{131}Ba	c	11.50D	373.2	14.04 ± 0.20	8.378 ± 0.314
			249.4	2.81 ± 0.03	9.426 ± 0.504
			216.1	19.66 ± 0.25	8.911 ± 0.386
			133.6	2.12 ± 0.03	7.889 ± 0.735
			123.8	29.0 ± 0.3	8.641 ± 0.551
				RR_{mean} =	**8.612 ± 0.324**
^{128}Ba	c	2.43D	442.9	26.8 ± 1.4	6.318 ± 0.422

Continuation of Table 109.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			273.4	14.5 ± 0.7	7.193 ± 0.453
				RR_{mean} =	**6.809 ± 0.482**
^{129}Cs	c	32.06H	371.9	30.6 ± 1.7	**9.559 ± 0.636**
^{127}Xe	c	36.4D	375.0	17.2 ± 0.6	7.831 ± 0.383
			202.9	68.3 ± 0.5	7.498 ± 0.299
			172.1	25.5 ± 0.8	7.333 ± 0.383
				RR_{mean} =	**7.538 ± 0.270**
^{125}Xe	c	16.9H	188.4	54.0 ± 0.3	**7.829 ± 0.353**
^{123}Xe	c	2.08H	148.9	48.9 ± 0.6	**7.173 ± 0.394**
^{121} I	c*	2.12H	212.2	84.3 ± 0.3	**6.893 ± 0.366**
^{123m}Te	i(m)	119.7D	159.0	84.0 ± 0.4	**0.3091 ± 0.0287**
^{121m}Te	i(m)	154D	212.2	81.4 ± 1.1	0.6717 ± 0.0319
			573.1	88.6 ± 0.1	0.5587 ± 0.0657
			507.6	88.6 ± 0.1	0.9740 ± 0.2882
				RR_{mean} =	**0.6650 ± 0.0205**
^{121}Te$_c$	c	19.16D	573.1	80.3 ± 2.5	5.828 ± 0.270
			507.6	17.7 ± 0.6	6.393 ± 0.357
				RR_{mean} =	**5.975 ± 0.309**
^{119m}Te	i(m)	4.70D	1212.7	66.2 ± 0.3	**1.331 ± 0.050**
^{119}Te	c	16.05H	644.0	84.0 ± 0.5	**3.533 ± 0.166**
^{116}Te	c	2.49H	1293.6	95 ± 8	**3.627 ± 0.374**
^{120m}Sb	i(m)	5.76D	1171.7	100 ± 0	0.4037 ± 0.0217
			1023.3	99.4 ± 0.3	0.3995 ± 0.0172
				RR_{mean} =	**0.4008 ± 0.0159**
^{118m}Sb	i(m)	5.00H	1050.7	97 ± 5	**1.014 ± 0.081**
^{115}Sb	c*	32.1M	497.3	97.9 ± 0.4	**5.459 ± 0.324**
^{117m}Sn	i(m)	13.60D	158.6	86.4 ± 0.4	**0.8139 ± 0.0421**
^{113}Sn	c	115.09D	391.7	64.97 ± 0.17	**3.468 ± 0.129**
^{114m}In	i(m)	49.51D	190.3	15.56 ± 0.16	**1.505 ± 0.080**
^{111}In	c	2.8047D	245.4	94 ± 1	3.995 ± 0.162
			171.3	90.2 ± 1.0	4.016 ± 0.168
				RR_{mean} =	**4.004 ± 0.143**
^{109}In	c	4.2H	203.5	73.5 ± 0.5	**3.309 ± 0.214**
^{110m}Ag	i(m)	249.76D	937.5	34.2 ± 0.6	1.007 ± 0.080
			884.7	72.7 ± 0.4	1.054 ± 0.048
			657.8	94.3 ± 0.3	0.9622 ± 0.0451
				RR_{mean} =	**1.006 ± 0.044**
^{106m}Ag	i(m)	8.28D	1045.8	29.6 ± 1.0	1.699 ± 0.093
			717.3	28.9 ± 0.8	1.564 ± 0.086
			451.0	28.2 ± 0.8	1.695 ± 0.083
				RR_{mean} =	**1.654 ± 0.067**
^{105}Ag	c	41.29D	443.4	10.5 ± 0.6	2.957 ± 0.220
			344.5	41.4 ± 0.6	2.541 ± 0.161
			331.5	4.10 ± 0.22	3.010 ± 0.283
				RR_{mean} =	**2.727 ± 0.174**
^{100}Pd	c	3.63D	2376.0	*	**0.6411 ± 0.0408**
^{102}Rh	i	207D	475.1	46 ± 5	**1.012 ± 0.123**
^{101m}Rh	c	4.34D	306.9	81 ± 5	**3.373 ± 0.244**
^{100}Rh$_i$	i(m+g)	20.8H	2376.0	32.6 ± 0.4	**1.633 ± 0.134**
^{100}Rh$_c$	c	20.8H	2376.0	32.6 ± 0.4	**2.274 ± 0.144**

Continuation of Table 109.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{99m}Rh	c	4.7H	340.8	70 ± 5	**1.577 ± 0.143**
^{103}Ru	c	39.26D	497.1	91.0 ± 1.3	**3.261 ± 0.137**
^{96}Tc	i(m+g)	4.28D	849.9	98 ± 4	2.069 ± 0.113
			812.5	82 ± 4	2.138 ± 0.128
				RR_{mean} =	**2.098 ± 0.096**
^{99}Mo	c	65.94H	140.5	90.27 ± 0.33	**2.915 ± 0.162**
^{93m}Mo	i(m)	6.85H	1477.1	99.1 ± 2.5	1.437 ± 0.080
			684.7	99.7 ± 2.0	1.314 ± 0.079
				RR_{mean} =	**1.376 ± 0.075**
^{96}Nb	i	23.35H	1091.3	48.5 ± 1.6	1.720 ± 0.135
			568.9	58.0 ± 0.3	1.613 ± 0.139
				RR_{mean} =	**1.669 ± 0.103**
^{95}Nb$_i$	i(m+g)	34.975D	765.8	99.81 ± 0.03	**2.730 ± 0.097**
^{95}Nb$_c$	c	34.975D	765.8	99.81 ± 0.03	**4.396 ± 0.147**
^{90}Nb	c*	14.60H	2319.0	82.0 ± 0.3	1.926 ± 0.099
			1129.2	92.7 ± 0.5	2.101 ± 0.086
				RR_{mean} =	**2.042 ± 0.104**
^{95}Zr	c	64.02D	765.8	*	1.681 ± 0.076
			756.7	54.46 ± 0.10	1.684 ± 0.072
				RR_{mean} =	**1.683 ± 0.052**
^{89}Zr	c	78.41H	909.2	99.04 ± 0.03	**4.008 ± 0.132**
^{88}Zr	c	83.4D	898.0	*	2.709 ± 0.206
			392.9	97.24 ± 0.00	2.420 ± 0.087
				RR_{mean} =	**2.435 ± 0.075**
^{90m} Y	i(m)	3.19H	479.5	90.74 ± 0.05	**2.175 ± 0.130**
^{88} Y$_i$	i	106.65D	898.0	93.7 ± 0.3	**3.522 ± 0.149**
^{88} Y$_c$	c	106.65D	1836.1	99.2 ± 0.3	5.916 ± 0.211
			898.0	93.7 ± 0.3	6.231 ± 0.232
				RR_{mean} =	**6.044 ± 0.242**
^{87} Y	c*	79.8H	388.5	82.1 ± 0.5	**5.449 ± 0.192**
^{85}Sr	c	64.84D	514.0	96 ± 4	**4.804 ± 0.261**
^{84}Rb	i(m+g)	32.77D	881.6	69.0 ± 1.6	**3.539 ± 0.242**
^{83}Rb	c	86.2D	552.6	16.0 ± 1.1	5.663 ± 0.444
			529.6	29.3 ± 2.1	5.278 ± 0.429
			520.4	45 ± 4	5.307 ± 0.507
				RR_{mean} =	**5.441 ± 0.242**
^{82m}Rb	i(m)	6.472H	554.3	62.4 ± 0.9	**2.921 ± 0.239**
^{82}Br	i(m+g)	35.30H	554.3	70.8 ± 1.0	**1.622 ± 0.081**
^{75}Se	c	119.779D	400.7	11.47 ± 0.09	3.775 ± 0.171
			264.7	58.9 ± 0.4	2.874 ± 0.112
			136.0	58.3 ± 0.8	3.086 ± 0.178
				RR_{mean} =	**3.084 ± 0.267**
^{76}As	i	1.0778D	559.1	45 ± 2	**2.989 ± 0.302**
^{74}As	i	17.77D	595.8	59 ± 4	**2.691 ± 0.206**
^{71}As	c	65.28H	174.9	82.0 ± 2.1	**0.8262 ± 0.0414**
^{72}Ga$_i$	i	14.10H	2201.7	25.9 ± 0.5	**1.382 ± 0.088**
^{72}Ga$_c$	c	14.10H	2201.7	25.9 ± 0.5	**1.564 ± 0.087**
^{72}Zn	c	46.5H	2201.7	*	**0.1822 ± 0.0249**
^{65}Zn	c	244.26D	1115.6	50.60 ± 0.24	**1.962 ± 0.085**
^{58}Co	i(m+g)	70.86D	810.8	99.45 ± 0.01	**1.303 ± 0.154**

Continuation of Table 109.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{56}Co	c	77.233D	846.8	99.94 ± 0.03	**0.07337 ± 0.01595**
^{59}Fe	c	44.472D	1291.6	43.2 ± 1.4	1.500 ± 0.086
			1099.2	56.5 ± 1.9	1.591 ± 0.084
				RR_{mean} =	**1.549 ± 0.066**
^{54}Mn	i	312.11D	834.8	99.98 ± 0.00	**1.750 ± 0.068**
^{52}Mn	c	5.591D	1434.1	100.0 ± 0.6	**0.1936 ± 0.0192**
^{48} V	c	15.9735D	1312.1	97.5 ± 0.9	0.4129 ± 0.0191
			983.5	100.0 ± 0.3	0.3320 ± 0.0186
				RR_{mean} =	**0.3759 ± 0.0419**
^{48}Sc	i	43.67H	1312.1	100.1 ± 0.7	0.7165 ± 0.0355
			1037.5	97.6 ± 0.7	0.8134 ± 0.0326
				RR_{mean} =	**0.7791 ± 0.0522**
^{46}Sc	i(m+g)	83.79D	889.3	99.98 ± 0.00	**1.834 ± 0.064**
^{28}Mg	c	20.915H	1778.8	100.2 ± 0.0	**1.015 ± 0.045**
^{24}Na	c	14.9590H	1369.0	100 ± 0	**4.277 ± 0.154**
^{7}Be	i	53.29D	477.6	10.52 ± 0.06	**8.000 ± 0.318**

12.11.6 Nuclide production rates for ^{27}Al

Table 110: Detailed calculation of nuclide production rates for in ^{27}Al-monitors and ^{27}Al-plates for E_p = 2.6 GeV, used for calculating proton flux (including total over the plate area), cross sections for production of ^{7}Be, ^{24}Naand neutron background.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
			^{27}Al-monitor for ^{206}Pb		
^{7}Be	i	53.29D	477.6	10.52 ± 0.06	**11.11 ± 0.40**
^{27}Mg	c	9.458M	843.8	71.8 ± 0.4	1.066 ± 0.056
			1014.4	28.0 ± 0.4	1.094 ± 0.076
				RR_{mean} =	**1.074 ± 0.050**
^{22}Na	c	2.6019Y	1274.5	99.94 ± 0.01	**13.68 ± 0.48**
^{24}Na	c	14.9590H	1369.0	100 ± 0	**12.89 ± 0.43**
			^{27}Al-plate for ^{206}Pb		
^{24}Na	c	14.9590H	1369.0	100 ± 0	**1.356 ± 0.045**
			^{27}Al-monitor for ^{207}Pb		
^{7}Be	i	53.29D	477.6	10.52 ± 0.06	**3.645 ± 0.129**
^{27}Mg	c	9.458M	843.8	71.8 ± 0.4	0.5042 ± 0.0229
			1014.4	28.0 ± 0.4	0.5045 ± 0.0341
				RR_{mean} =	**0.5042 ± 0.0214**
^{22}Na	c	2.6019Y	1274.5	99.94 ± 0.01	**4.516 ± 0.162**
^{24}Na	c	14.9590H	1369.0	100 ± 0	**4.246 ± 0.141**
			^{27}Al-plate for ^{207}Pb		
^{24}Na	c	14.9590H	1369.0	100 ± 0	**0.4794 ± 0.0161**
			^{27}Al-monitor for ^{207}Pb		
^{7}Be	i	53.29D	477.6	10.52 ± 0.06	**9.278 ± 0.327**
^{27}Mg	c	9.458M	843.8	71.8 ± 0.4	0.9817 ± 0.0434
			1014.4	28.0 ± 0.4	1.014 ± 0.066
				RR_{mean} =	**0.9888 ± 0.0410**
^{22}Na	c	2.6019Y	1274.5	99.94 ± 0.01	**11.44 ± 0.39**

Continuation of Table 110.

Nuclide	Type	$T_{1/2}$	E_γ, keV	γ-yield, %	Reaction Rate, 10^{-17} s^{-1}
^{24}Na	c	14.9590H	1369.0	100 ± 0	**10.96 ± 0.36**
			^{27}Al-plate for ^{207}Pb		
^{24}Na	c	14.9590H	1369.0	100 ± 0	**0.7769 ± 0.0263**
			^{27}Al-monitor for ^{nat}Pb		
^{7}Be	i	53.29D	477.6	10.52 ± 0.06	**64.65 ± 2.27**
^{27}Mg	c	9.458M	843.8	71.8 ± 0.4	0.09826 ± 0.00388
			1014.4	28.0 ± 0.4	0.09976 ± 0.00514
				RR_{mean} =	**0.09864 ± 0.00369**
^{22}Na	c	2.6019Y	1274.5	99.94 ± 0.01	**79.54 ± 2.72**
^{24}Na	c	14.9590H	1369.0	100 ± 0	**74.95 ± 2.50**
			^{27}Al-plate for ^{nat}Pb		
^{24}Na	c	14.9590H	1369.0	100 ± 0	**3.614 ± 0.125**
			^{27}Al-monitor for ^{209}Bi		
^{7}Be	i	53.29D	477.6	10.52 ± 0.06	**8.745 ± 0.307**
^{27}Mg	c	9.458M	843.8	71.8 ± 0.4	1.506 ± 0.063
			1014.4	28.0 ± 0.4	1.505 ± 0.097
				RR_{mean} =	**1.506 ± 0.060**
^{22}Na	c	2.6019Y	1274.5	99.94 ± 0.01	**11.14 ± 0.38**
^{24}Na	c	14.9590H	1369.0	100 ± 0	**10.93 ± 0.36**
			^{27}Al-plate for ^{209}Bi		
^{24}Na	c	14.9590H	1369.0	100 ± 0	**0.7347 ± 0.0246**

13 Appendix 2. Radioactive decay chains ised in simulation.

The analyzed decay chains presented in the Tables are broken, for convenience, into

- the ^{208,207,206,nat}Pb decay chains (the left-hand or upper sides of the Tables)
- the ^{209}Bi decay chains (the righ-hand or bottom sides of the Tables)

In cases the ^{208,207,206,nat}Pb and ^{209}Bi chains are the same they are According to the decay chain fragments presented, the measured nuclides for both Pb and Bi have been classified to be the independent yields of ground sttes **i**, the independent yields of metastable states $\mathbf{i}(\Sigma m_j)$, the sums of the independent yields of metastable and ground states $\mathbf{i(}\Sigma m_j\mathbf{+g)}$, the cumulative yields of metastable and ground states **c**, and the supracumulative yields of metastable and ground states c^*

Table 111: Chain for $^{207}_{84}Po - i(m{+}g)$

Pb						Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)
						84207	0				

Table 112: Chain of $^{206}_{84}Po - i$

Pb						Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)
						84206	0				

Table 113: Chain of $^{205}_{84}Po - i$

Pb						Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)
						84205	0				

Table 114: Chain of $^{204}_{84}Po - i$

Pb						Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)
						84204	0				

Table 115: Chain of ${}^{203}_{84}Po - i(m+g)$

Pb						Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)
						84203	0				

Table 116: Chain of ${}^{202}_{84}Po - i$

Pb						Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)
						84202	0				

Table 117: Chain of ${}^{201}_{84}Po - i(m+g)$

Pb						Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)
						84201	0				

Table 118: Chain of ${}^{207}_{83}Bi - i, c$

Pb						Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)
83207	0					83207	1	0.99979	84207		
						84207	0				

Table 119: Chain of ${}^{206}_{83}Bi - i$

Pb						Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)
83206	0					83206	0				

Table 120: Chain of ${}^{206}_{83}Bi - c$

Pb						Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)
						83206	1	0.9455	84206		
						84206	0				

Table 121: Chain of $^{205}_{83}Bi - i, c$

Pb						Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)
83205	0					83205	1	0.9996	84205		
						84205	0				

Table 122: Chain of $^{204}_{83}Bi - i$

Pb						Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)
83204	0					83204	0				

Table 123: Chain of $^{204}_{83}Bi - c$

Pb						Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)
						83204	1	0.9934	84204		
						84204	0				

Table 124: Chain of $^{204}_{83}Bi - c^{*}$

Pb						Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)
						83204	1	1.44937	84204		
						84204	0				

Table 125: Chain of $^{203}_{83}Bi - i(m+g), c$

Pb						Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)
83203	0					83203	1	0.9989	84203		
						84203	0				

Table 126: Chain of $^{202}_{83}Bi - i$

Pb						Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)
83202	0					83202	0				

Table 127: Chain of $^{202}_{83}Bi - c$

Pb						Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)
						83202	1	0.9808	84202		
						84202	0				

Table 128: Chain of $^{202}_{83}Bi - c^{*}$

Pb						Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)
						83202	1	1.73023	84202		
						84202	0				

Table 129: Chain of $^{201}_{83}Bi - i, c^{*}$

Pb						Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)
83201	0					83201	1	1.14636	84201		
						84201	0				

Table 130: Chain of $^{199}_{83}Bi - i, c^{*}$

Pb						Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)
83199	0					83199	1	1.11398	84199		
						84199	0				

Table 131: Chain of $^{203}_{82}Pb - i(m1 + m2 + g)$

Pb						Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)
82203	0					82203	0				

Table 132: Chain of $^{203}_{82}Pb - c$

Pb						Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)
82203	1	1	83203			82203	2	1	83203	0.00021	84207
83203	0					83203	1	0.9989	84203		
						84207	0				
						84203	0				

Table 133: Chain of $^{201}_{82}Pb - i(m+g)$

Pb						Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)
82201	0										

Table 134: Chain of $^{201}_{82}Pb - c$

Pb						Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)
82201	1	1	83201			82201	2	1	83201	0.0004	84205
83201	0					83201	1	0.984	84201		
						84205	0				
						84201	0				

Table 135: Chain of $^{201}_{82}Pb - c^{*}$

Pb						Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)
82201	1	1.239	83201			82201	2	1.239	83201	0.0004	84205
83201	0					83201	1	0.984	84201		
						84205	0				
						84201	0				

Table 136: Chain of $^{200}_{82}Pb - c$

Pb						Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)
82200	1	1	83200			82200	2	1	83200	0.0066	84204
83200	0					83200	1	0.889	84200		
						84204	0				
						84200	0				

Table 137: Chain of ${}^{199}_{82}Pb - c^{*}$

Pb						Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)
82199	1	1.4286	83199			82199	2	1.4286	83199	0.0011	84203
83199	0					83199	1	0.925	84199		
						84203	0				
						84199	0				

Table 138: Chain of ${}^{198}_{82}Pb - c$

Pb						Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)
82198	1	1	83198			82198	2	1	83198	0.0192	84202
83198	0					83198	1	0.43	84198		
						84202	0				
						84198	0				

Table 139: Chain of ${}^{196}_{82}Pb - c^{*}$

Pb						Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)
82196	1	1.1611	83196			82196	2	1.1611	83196	0.111	84200
83196	0					83196	1	0.02	84196		
						84200	0				
						84196	0				

Table 140: Chain of ${}^{202}_{81}Tl - i$

Pb						Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)
81202	0					81202	0				

Table 141: Chain of $^{202}_{81}Tl - c$

Pb						Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)
						81202	1	1	82202		
						82202	2	1	83202	0.0545	84206
						83202	1	0.9808	84202		
						84206	0				
						84202	0				

Table 142: Chain of $^{201}_{81}Tl - c$

Pb						Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)
81201	1	1	82201			81201	1	1	82201		
82201	1	1	83201			82201	2	1	83201	0.0004	84205
83201	0					83201	1	0.984	84201		
						84205	0				
						84201	0				

Table 143: Chain of $^{200}_{81}Tl - i$

Pb						Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)
81200	0					81200	0				

Table 144: Chain of $^{200}_{81}Tl - c$

Pb						Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)
81200	1	1	82200			81200	1	1	82200		
82200	1	1	83200			82200	2	1	83200	0.0066	84204
83200	0					83200	1	0.889	84200		
						84204	0				
						84200	0				

Table 145: Chain of ${}^{199}_{81}Tl - c$

Pb						Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)
81199	2	1.2534	82199	1.0E-07	83203	81199	2	1	82199	1.0E-07	83203
82199	1	1	83199			82199	2	1	83199	0.0011	84203
83203	0					83203	1	0.9989	84203		
83199	0					83199	1	0.925	84199		
						84203	0				
						84199	0				

Table 146: Chain of ${}^{197}_{81}Tl - c$

Pb						Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)
81197	2	1	82197	1.0E-06	83201	81197	2	1	82197	1.0E-06	83201
82197	1	1	83197			82197	2	1	83197	0.016	84201
83201	0					83201	1	0.984	84201		
83197	0					83197	1	0.56	84197		
						84201	0				
						84197	0				

Table 147: Chain of ${}^{195}_{81}Tl - c^{*}$

Pb						Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)
81195	1	1.2747	82195			81195	1	1.2747	82195		
82195	1	0.9997	83195			82195	2	0.9997	83195	0.075	84199
83195	0					83195	1	0.25	84195		
						84199	0				
						84195	0				

Table 148: Chain of ${}^{203}_{80}Hg - c$

Pb						Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)
80203	1	1	79203			80203	1	1	79203		
79203	0					79203	0				

Table 149: Chain of $^{197}_{80}Hg - c^{*}$

Pb						Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)
80197	1	1.0463	81197			80197	1	1.0463	81197		
81197	2	1	82197	1.0E-06	83201	81197	2	1	82197	1.0E-06	83201
82197	1	1	83197			82197	2	1	83197	0.016	84201
83201	0					83201	1	0.984	84201		
83197	0					83197	1	0.56	84197		
						84201	0				
						84197	0				

Table 150: Chain of $^{195}_{80}Hg - c_t$

Pb						Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)
80195	1	1	81195			80195	1	1	81195		
81195	1	1	82195			81195	1	1	82195		
82195	1	0.9997	83195			82195	2	0.9997	83195	0.075	84199
83195	0					83195	1	0.25	84195		
						84199	0				
						84195	0				

Table 151: Chain of $^{192}_{80}Hg - c$

Pb						Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)
80192	2	1	81192	3.00E-07	82196	80192	2	1	81192	3.00E-07	82196
81192	2	0.99994	82192	1.15E-05	83196	81192	2	0.99994	82192	1.15E-05	83196
82196	1	1	83196			82196	2	1	83196	0.111	84200
82192	1	0.88	83192			82192	2	0.88	83192	0.98	84196
83196	0					83196	1	0.02	84196		
83192	0					84200	0				
						83192	1	0.005	84192		
						84196	0				
						84192	0				

Table 152: Chain of $^{190}_{80}Hg - c^{*}$

Pb						Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)
80190	2	1.227	81190	7.30E-08	82194	80190	2	1.227	81190	7.30E-08	82194
81190	2	0.996	82190	0.0046	83194	81190	2	0.996	82190	0.0046	83194
82194	1	0.9954	83194			82194	2	0.9954	83194	0.57	84198
82190	1	0.1	83190			82190	2	0.1	83190	1	84194
83194	0					83194	0				
83190	0					84198	0				
						83190	0				
						84194	0				

Table 153: Chain of $^{198}_{79}Au - i(m+g)$

Pb						Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)
79198	0					79198	0				

Table 154: Chain of $^{196}_{79}Au - i(m1+m2+g)$

Pb						Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)
79196	0					79196	0				

Table 155: Chain of $^{195}_{79}Au - c$

Pb						Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)
79195	1	1	80195			79195	1	1	80195		
80195	1	1	81195			80195	1	1	81195		
81195	1	1	82195			81195	1	1	82195		
82195	1	0.9997	83195			82195	2	0.9997	83195	0.075	84199
83195	0					83195	1	0.25	84195		
						84199	0				
						84195	0				

Table 156: Chain of $^{194}_{79}Au - i(m1+m2+g)$

Pb						Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)
79194	0					79194	0				

Table 157: Chain of $^{192}_{79}Au - i(m+g)$

Pb						Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)
79192	0					79192	0				

Table 158: Chain of ${}^{192}_{79}Au - c$

Pb						Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)
79192	1	1	80192			79192	1	1	80192		
80192	2	1	81192	3.00E-07	82196	80192	2	1	81192	3.00E-07	82196
81192	2	0.99994	82192	1.15E-05	83196	81192	2	0.99994	82192	1.15E-05	83196
82196	1	1	83196			82196	2	1	83196	0.111	84200
82192	1	0.88	83192			82192	2	0.88	83192	0.98	84196
83196	0					83196	1	0.02	84196		
83192	0					84200	0				
						83192	1	0.005	84192		
						84196	0				
						84192	0				

Table 159: Chain of ${}^{191}_{79}Au - c^{*}$

Pb						Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)
79191	1	1.3456	80191			79191	1	1.3456	80191		
80191	1	1	81191			80191	1	1	81191		
81191	2	0.99987	82191	0.0003	83195	81191	2	0.99987	82191	0.0003	83195
82191	1	0.4	83191			82191	2	0.4	83191	0.75	84195
83195	0					83195	1	0.25	84195		
83191	0					83191	0				
						84195	0				

Table 160: Chain of ${}^{190}_{79}Au - c$

Pb						Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)
79190	2	1	80190	1.00E-09	81194	79190	2	1	80190	1.00E-09	81194
80190	2	1	81190	7.30E-08	82194	80190	2	1	81190	7.30E-08	82194
81194	1	1	82194			81194	1	1	82194		
81190	2	0.996	82190	0.0046	83194	81190	2	0.996	82190	0.0046	83194
82194	1	0.9954	83194			82194	2	0.9954	83194	0.57	84198
82190	1	0.1	83190			82190	2	0.1	83190	1	84194
83194	0					83194	0				
83190	0					84198	0				
						83190	0				
						84194	0				

Table 161: Chain of $^{191}_{78}Pt - c$

Pb						Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)
78191	1	1	79191			78191	1	1	79191		
79191	1	1	80191			79191	1	1	80191		
80191	1	1	81191			80191	1	1	81191		
81191	2	0.99987	82191	0.0003	83195	81191	2	0.99987	82191	0.0003	83195
82191	1	0.4	83191			82191	2	0.4	83191	0.75	84195
83195	0					83195	1	0.25	84195		
83191	0					83191	0				
						84195	0				

Table 162: Chain of $^{189}_{78}Pt - c$

Pb						Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)
78189	1	1	79189			78189	1	1	79189		
79189	1	1	80189			79189	1	1	80189		
80189	1	1	81189			80189	1	1	81189		
81189	2	0.006	82189	0.035	83193	81189	2	0.006	82189	0.035	83193
82189	1	0.5	83189			82189	2	0.5	83189	1	84193
83193	0					83193	0				
83189	0					83189	0				
						84193	0				

Table 163: Chain of $^{188}_{78}Pt - c$

Pb						Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)
78188	1	1	79188			78188	1	1	79188		
79188	1	1	80188			79188	1	1	80188		
80188	2	1	81188	5.90E-05	82192	80188	2	1	81188	5.90E-05	82192
81188	2	0.907	82188	0.12	83192	81188	2	0.907	82188	0.12	83192
82192	1	0.88	83192			82192	2	0.88	83192	0.98	84196
82188	1	1	83188			82188	2	1	83188	0.995	84192
83192	0					83192	1	0.005	84192		
83188	0					84196	0				
						83188	1	1	84188		
						84192	0				
						84188	0				

Table 164: Chain of ${}^{187}_{78}Pt-c$

Pb						Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)
78187	1	1	79187			78187	1	1	79187		
79187	1	1	80187			79187	1	1	80187		
80187	2	1	81187	0.00013	82191	80187	2	1	81187	0.00013	82191
81187	2	0.93	82187	0.6	83191	81187	2	0.93	82187	0.6	83191
82191	1	0.4	83191			82191	2	0.4	83191	0.75	84195
82187	1	0.5	83187			82187	2	0.5	83187	1	84191
83191	0					83191	0				
83187	0					84195	0				
						83187	0				
						84191	0				

Table 165: Chain of ${}^{186}_{78}Pt-c$

Pb						Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)
78186	2	1	79186	3.40E-09	80190	78186	2	1	79186	3.40E-09	80190
79186	1	0.99984	80186			79186	1	0.99984	80186		
80190	2	1	81190	7.30E-08	82194	80190	2	1	81190	7.30E-08	82194
80186	2	1	81186	0.004	82190	80186	2	1	81186	0.004	82190
81190	2	0.996	82190	0.0046	83194	81190	2	0.996	82190	0.0046	83194
82194	1	0.9954	83194			82194	2	0.9954	83194	0.57	84198
81186	2	0.6	82186	0.9	83190	81186	2	0.6	82186	0.9	83190
82190	1	0.1	83190			82190	2	0.1	83190	1	84194
83194	0					83194	0				
82186	0					84198	0				
83190	0					82186	1	1	84190		
						83190	0				
						84194	0				
						84190	0				

Table 166: Chain of ${}^{184}_{78}Pt-c$

Pb						Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)
78184	2	0.99984	79184	3.70E-07	80188	78184	2	0.99984	79184	3.70E-07	80188
79184	1	0.9889	80184			79184	1	0.9889	80184		
80188	2	1	81188	5.90E-05	82192	80188	2	1	81188	5.90E-05	82192
80184	2	0.979	81184	0.093	82188	80184	2	0.979	81184	0.093	82188
81188	2	0.907	82188	0.12	83192	81188	2	0.907	82188	0.12	83192
82192	1	0.88	83192			82192	2	0.88	83192	0.98	84196
81184	1	0.77	82184			81184	1	0.77	82184		
82188	1	1	83188			82188	2	1	83188	0.995	84192
83192	0					83192	1	0.005	84192		
82184	1	0.85	83185			84196	0				
83188	0					82184	1	0.85	83185		
83185	0					83188	1	1	84188		
						84192	0				
						83185	0				
						84188	0				

Table 167: Chain of ${}^{192}_{77}Ir - i(m1+g)$

Pb						Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)
77192	0										

Table 168: Chain of ${}^{190}_{77}Ir - i(m1+g)$

Pb						Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)
77190	0										

Table 169: Chain of ${}^{189}_{77}Ir - c$

Pb						Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)
77189	1	1	78189			77189	1	1	78189		
78189	1	1	79189			78189	1	1	79189		
79189	1	1	80189			79189	1	1	80189		
80189	1	1	81189			80189	1	1	81189		
81189	2	0.006	82189	0.035	83193	81189	2	0.006	82189	0.035	83193
82189	1	0.5	83189			82189	2	0.5	83189	1	84193
83193	0					83193	0				
83189	0					83189	0				
						84193	0				

Table 170: Chain of ${}^{188}_{77}Ir - i$

Pb						Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)
77188	0										

Table 171: Chain of $^{188}_{77}Ir - c$

Pb						Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)
77188	1	1	78188			77188	1	1	78188		
78188	1	1	79188			78188	1	1	79188		
79188	1	1	80188			79188	1	1	80188		
80188	2	1	81188	5.90E-05	82192	80188	2	1	81188	5.90E-05	82192
81188	2	0.907	82188	0.12	83192	81188	2	0.907	82188	0.12	83192
82192	1	0.88	83192			82192	2	0.88	83192	0.98	84196
82188	1	1	83188			82188	2	1	83188	0.995	84192
83192	0					83192	1	0.005	84192		
83188	0					84196	0				
						83188	1	1	84188		
						84192	0				
						84188	0				

Table 172: Chain of $^{187}_{77}Ir - c^{*}$

Pb						Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)
77187	1	1.2883	78187			77187	1	1.2883	78187		
78187	1	1	79187			78187	1	1	79187		
79187	1	1	80187			79187	1	1	80187		
80187	2	1	81187	0.00013	82191	80187	2	1	81187	0.00013	82191
81187	2	0.93	82187	0.6	83191	81187	2	0.93	82187	0.6	83191
82191	1	0.4	83191			82191	2	0.4	83191	0.75	84195
82187	1	0.5	83187			82187	2	0.5	83187	1	84191
83191	0					83191	0				
83187	0					84195	0				
						83187	0				
						84191	0				

Table 173: Chain of $^{186}_{77}Ir - c$

Pb						Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)
77186	2	1	78186	1.00E-08	79190	77186	2	1	78186	1.00E-08	79190
78186	2	1	79186	3.40E-09	80190	78186	2	1	79186	3.40E-09	80190
79190	2	1	80190	1.00E-09	81194	79190	2	1	80190	1.00E-09	81194
79186	1	0.99984	80186			79186	1	0.99984	80186		
80190	2	1	81190	7.30E-08	82194	80190	2	1	81190	7.30E-08	82194
81194	1	1	82194			81194	1	1	82194		
80186	2	1	81186	0.004	82190	80186	2	1	81186	0.004	82190
81190	2	0.996	82190	0.0046	83194	81190	2	0.996	82190	0.0046	83194
82194	1	0.9954	83194			82194	2	0.9954	83194	0.57	84198
81186	2	0.6	82186	0.9	83190	81186	2	0.6	82186	0.9	83190
82190	1	0.1	83190			82190	2	0.1	83190	1	84194
83194	0					83194	0				
82186	0					84198	0				
83190	0					82186	1	1	84190		
						83190	0				
						84194	0				
						84190	0				

Table 174: Chain of ${}^{185}_{77}Ir - c$

Pb						Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)
77185	2	1	78185	3.00E-07	79189	77185	2	1	78185	3.00E-07	79189
78185	2	0.9974	79185	3.00E-07	80189	78185	2	0.9974	79185	3.00E-07	80189
79189	1	1	80189			79189	1	1	80189		
79185	1	0.94	80185			79185	1	0.94	80185		
80189	1	1	81189			80189	1	1	81189		
80185	2	1	81185	0.004	82189	80185	2	1	81185	0.004	82189
81189	2	0.006	82189	0.035	83193	81189	2	0.006	82189	0.035	83193
81185	1	0.5	83189			81185	1	0.5	83189		
82189	1	0.5	83189			82189	2	0.5	83189	1	84193
83193	0					83193	0				
83189	0					83189	0				
						84193	0				

Table 175: Chain of ${}^{184}_{77}Ir - c^{*}$

Pb						Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)
77184	1	1.1029	78184			77184	1	1.1029	78184		
78184	2	0.99984	79184	3.70E-07	80188	78184	2	0.99984	79184	3.70E-07	80188
79184	1	0.9889	80184			79184	1	0.9889	80184		
80188	2	1	81188	5.90E-05	82192	80188	2	1	81188	5.90E-05	82192
80184	2	0.979	81184	0.093	82188	80184	2	0.979	81184	0.093	82188
81188	2	0.907	82188	0.12	83192	81188	2	0.907	82188	0.12	83192
82192	1	0.88	83192			82192	2	0.88	83192	0.98	84196
81184	1	0.77	82184			81184	1	0.77	82184		
82188	1	1	83188			82188	2	1	83188	0.995	84192
83192	0					83192	1	0.005	84192		
82184	1	0.85	83185			84196	0				
83188	0					82184	1	0.85	83185		
83185	0					83188	1	1	84188		
						84192	0				
						83185	0				
						84188	0				

Table 176: Chain of ${}^{183}_{77}Ir - c$

Pb						Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)
77183	2	1	78183	3.00E-05	79187	77183	2	1	78183	3.00E-05	79187
78183	2	0.9945	79183	1.20E-06	80187	78183	2	0.9945	79183	1.20E-06	80187
79187	1	1	80187			79187	1	1	80187		
79183	1	0.883	80183			79183	1	0.883	80183		
80187	2	1	81187	0.00013	82191	80187	2	1	81187	0.00013	82191
80183	2	1	81183	0.07	82187	80183	2	1	81183	0.07	82187
81187	2	0.93	82187	0.6	83191	81187	2	0.93	82187	0.6	83191
82191	1	0.4	83191			82191	2	0.4	83191	0.75	84195
81183	2	0.1	82183	0.5	83187	81183	2	0.1	82183	0.5	83187
82187	1	0.5	83187			82187	2	0.5	83187	1	84191
83191	0					83191	0				
82183	0					84195	0				
83187	0					82183	0				
						83187	0				
						84191	0				

Table 177: Chain of ${}^{185}_{76}Os - c$

Pb						Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)
76185	1	1	77185			76185	1	1	77185		
77185	2	1	78185	3.00E-07	79189	77185	2	1	78185	3.00E-07	79189
78185	2	0.9974	79185	3.00E-07	80189	78185	2	0.9974	79185	3.00E-07	80189
79189	1	1	80189			79189	1	1	80189		
79185	1	0.94	80185			79185	1	0.94	80185		
80189	1	1	81189			80189	1	1	81189		
80185	2	1	81185	0.004	82189	80185	2	1	81185	0.004	82189
81189	2	0.006	82189	0.035	83193	81189	2	0.006	82189	0.035	83193
81185	1	0.5	83189			81185	1	0.5	83189		
82189	1	0.5	83189			82189	2	0.5	83189	1	84193
83193	0					83193	0				
83189	0					83189	0				
						84193	0				

Table 178: Chain of ${}^{182}_{76}Os - c$

Pb

(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
76182	2	1	77182	1.40E-06	78186				
77182	2	0.99962	78182	8.00E-06	79186				
78186	2	1	79186	3.40E-09	80190				
78182	3	0.9987	79182	2.60E-06	80183	1.60E-04	80186		
79186	1	0.99984	80186						
80190	2	1	81190	7.30E-08	82194				
79182	2	0.848	80182	6.00E-05	81186				
80183	2	1	81183	0.07	82187				
80186	2	1	81186	0.004	82190				
81190	2	0.996	82190	0.0046	83194				
82194	1	0.9954	83194						
80182	2	0.96	81182	0.4	82186				
81186	2	0.6	82186	0.9	83190				
81183	2	0.1	82183	0.5	83187				
82187	1	0.5	83187						
82190	1	0.1	83190						
83194	0								
81182	1	1	83186						
82186	0								
83190	0								
82183	0								
83187	0								
83186	0								

Bi

(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
76182	2	1	77182	1.40E-06	78186				
77182	2	0.99962	78182	8.00E-06	79186				
78186	2	1	79186	3.40E-09	80190				
78182	3	0.9987	79182	2.60E-06	80183	1.60E-04	80186		
79186	1	0.99984	80186						
80190	2	1	81190	7.30E-08	82194				
79182	2	0.848	80182	6.00E-05	81186				
80183	2	1	81183	0.07	82187				
80186	2	1	81186	0.004	82190				
81190	2	0.996	82190	0.0046	83194				
82194	2	0.9954	83194	0.57	84198				
80182	2	0.96	81182	0.4	82186				
81186	2	0.6	82186	0.9	83190				
81183	2	0.1	82183	0.5	83187				
82187	2	0.5	83187	1	84191				
82190	2	0.1	83190	1	84194				
83194	0								
84198	0								
81182	1	1	83186						
82186	1	1	84190						
83190	0								
82183	0								
83187	0								
84191	0								
84194	0								
83186	0								
84190	0								

Table 179: Chain of ${}^{181}_{76}Os-c$

Pb

(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)
76181	1	1	77181		
77181	2	1	78181	0.0026	79185
78181	2	0.973	79181	0.06	80185
79185	1	0.94	80185		
79181	1	0.68984	80181		
80185	2	1	81185	0.004	82189
80181	2	0.5	81181	1	82185
81185	1	0.5	83189		
82189	1	0.5	83189		
81181	1	0.15	83185		
82185	0				
83189	0				
83185	0				

Bi

(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)
76181	1	1	77181		
77181	2	1	78181	0.0026	79185
78181	2	0.973	79181	0.06	80185
79185	1	0.94	80185		
79181	1	0.68984	80181		
80185	2	1	81185	0.004	82189
80181	2	0.5	81181	1	82185
81185	1	0.5	83189		
82189	2	0.5	83189	1	84193
81181	1	0.15	83185		
82185	0				
83189	0				
84193	0				
83185	0				

Table 180: Chain of $^{180}_{76}Os - c$

(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
Pb									
76180	2	1	77180	1.00E-05	78184				
77180	2	1	78180	0.00016	79184				
78184	2	0.99984	79184	3.70E-07	80188				
78180	3	0.982	79180	0.00016	80181	0.0111	80184		
79184	1	0.9889	80184						
80188	2	1	81188	5.90E-05	82192				
79180	2	0.52	80180	0.021	81184				
80181	2	0.5	81181	1	82185				
80184	2	0.979	81184	0.093	82188				
81188	2	0.907	82188	0.12	83192				
82192	1	0.88	83192						
80180	2	0.93	81180	0.23	82184				
81184	1	0.77	82184						
81181	1	0.15	83185						
82185	0								
82188	1	1	83188						
83192	0								
81180	1	1	83184						
82184	1	0.85	83185						
83185	0								
83188	0								
83184	0								
Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
76180	2	1	77180	1.00E-05	78184				
77180	2	1	78180	0.00016	79184				
78184	2	0.99984	79184	3.70E-07	80188				
78180	3	0.982	79180	0.00016	80181	0.0111	80184		
79184	1	0.9889	80184						
80188	2	1	81188	5.90E-05	82192				
79180	2	0.52	80180	0.021	81184				
80181	2	0.5	81181	1	82185				
80184	2	0.979	81184	0.093	82188				
81188	2	0.907	82188	0.12	83192				
82192	2	0.88	83192	0.98	84196				
80180	2	0.93	81180	0.23	82184				
81184	1	0.77	82184						
81181	1	0.15	83185						
82185	0								
82188	2	1	83188	0.995	84192				
83192	1	0.005	84192						
84196	0								
81180	1	1	83184						
82184	1	0.85	83185						
83185	0								
83188	1	1	84188						
84192	0								
83184	0								
84188	0								

Table 181: Chain of $^{183}_{75}Re - c$

Pb						Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)
75183	1	1	76183			75183	1	1	76183		
76183	1	1	77183			76183	1	1	77183		
77183	2	1	78183	3.00E-05	79187	77183	2	1	78183	3.00E-05	79187
78183	2	0.9945	79183	1.20E-06	80187	78183	2	0.9945	79183	1.20E-06	80187
79187	1	1	80187			79187	1	1	80187		
79183	1	0.883	80183			79183	1	0.883	80183		
80187	2	1	81187	0.00013	82191	80187	2	1	81187	0.00013	82191
80183	2	1	81183	0.07	82187	80183	2	1	81183	0.07	82187
81187	2	0.93	82187	0.6	83191	81187	2	0.93	82187	0.6	83191
82191	1	0.4	83191			82191	2	0.4	83191	0.75	84195
81183	2	0.1	82183	0.5	83187	81183	2	0.1	82183	0.5	83187
82187	1	0.5	83187			82187	2	0.5	83187	1	84191
83191	0					83191	0				
82183	0					84195	0				
83187	0					82183	0				
						83187	0				
						84191	0				

Table 182: Chain of $^{181}_{75}Re - c$

Pb						Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)
75181	1	1	76181			75181	1	1	76181		
76181	1	1	77181			76181	1	1	77181		
77181	2	1	78181	0.0026	79185	77181	2	1	78181	0.0026	79185
78181	2	0.973	79181	0.06	80185	78181	2	0.973	79181	0.06	80185
79185	1	0.94	80185			79185	1	0.94	80185		
79181	1	0.68984	80181			79181	1	0.68984	80181		
80185	2	1	81185	0.004	82189	80185	2	1	81185	0.004	82189
80181	2	0.5	81181	1	82185	80181	2	0.5	81181	1	82185
81185	1	0.5	83189			81185	1	0.5	83189		
82189	1	0.5	83189			82189	2	0.5	83189	1	84193
81181	1	0.15	83185			81181	1	0.15	83185		
82185	0					82185	0				
83189	0					83189	0				
83185	0					84193	0				
						83185	0				

Table 183: Chain of ${}^{179}_{75}Re - c^{*}$

Pb						Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)
75179	1	1.5	76179			75179	1	1.5	76179		
76179	2	1	77179	1.30E-05	78183	76179	2	1	77179	1.30E-05	78183
77179	2	0.9976	78179	0.0055	79183	77179	2	0.9976	78179	0.0055	79183
78183	2	0.9945	79183	1.20E-06	80187	78183	2	0.9945	79183	1.20E-06	80187
78179	2	0.78	79179	0.117	80183	78179	2	0.78	79179	0.117	80183
79183	1	0.883	80183			79183	1	0.883	80183		
80187	2	1	81187	0.00013	82191	80187	2	1	81187	0.00013	82191
79179	2	0.4685	80179	1	81183	79179	2	0.4685	80179	1	81183
80183	2	1	81183	0.07	82187	80183	2	1	81183	0.07	82187
81187	2	0.93	82187	0.6	83191	81187	2	0.93	82187	0.6	83191
82191	1	0.4	83191			82191	2	0.4	83191	0.75	84195
80179	1	0.9	82183			80179	1	0.9	82183		
81183	2	0.1	82183	0.5	83187	81183	2	0.1	82183	0.5	83187
82187	1	0.5	83187			82187	2	0.5	83187	1	84191
83191	0					83191	0				
82183	0					84195	0				
83187	0					82183	0				
						83187	0				
						84191	0				

Table 184: Chain of ${}^{178}_{75}Re - c^{*}$

(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
Pb									
75178	1	1.6098	76178						
76178	2	1	77178	0.00038	78182				
77178	2	0.923	78178	0.0013	79182				
78182	3	0.9987	79182	2.60E-06	80183	1.60E-04	80186		
78178	3	0.6	79178	0.0015	80179	0.152	80182		
79182	2	0.848	80182	6.00E-05	81186				
80183	2	1	81183	0.07	82187				
80186	2	1	81186	0.004	82190				
79178	2	0.3	80178	0.04	81182				
80179	1	0.9	82183						
80182	2	0.96	81182	0.4	82186				
81186	2	0.6	82186	0.9	83190				
81183	2	0.1	82183	0.5	83187				
82187	1	0.5	83187						
82190	1	0.1	83190						
80178	1	1	82182						
81182	1	1	83186						
82183	0								
82186	0								
83190	0								
83187	0								
82182	0								
83186	0								

(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
Bi									
75178	1	1.6098	76178						
76178	2	1	77178	0.00038	78182				
77178	2	0.923	78178	0.0013	79182				
78182	3	0.9987	79182	2.60E-06	80183	1.60E-04	80186		
78178	3	0.6	79178	0.0015	80179	0.152	80182		
79182	2	0.848	80182	6.00E-05	81186				
80183	2	1	81183	0.07	82187				
80186	2	1	81186	0.004	82190				
79178	2	0.3	80178	0.04	81182				
80179	1	0.9	82183						
80182	2	0.96	81182	0.4	82186				
81186	2	0.6	82186	0.9	83190				
81183	2	0.1	82183	0.5	83187				
82187	2	0.5	83187	1	84191				
82190	2	0.1	83190	1	84194				
80178	1	1	82182						
81182	1	1	83186						
82183	0								
82186	1	1	84190						
83190	0								
83187	0								
84191	0								
84194	0								
82182	0								
83186	0								
84190	0								

Table 185: Chain of ${}^{178}_{74}W-c$

Pb

(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
74178	1	1	75178						
75178	1	1	76178						
76178	2	1	77178	0.00038	78182				
77178	2	0.923	78178	0.0013	79182				
78182	3	0.9987	79182	2.60E-06	80183	1.60E-04	80186		
78178	3	0.6	79178	0.0015	80179	0.152	80182		
79182	2	0.848	80182	6.00E-05	81186				
80183	2	1	81183	0.07	82187				
80186	2	1	81186	0.004	82190				
79178	2	0.3	80178	0.04	81182				
80179	1	0.9	82183						
80182	2	0.96	81182	0.4	82186				
81186	2	0.6	82186	0.9	83190				
81183	2	0.1	82183	0.5	83187				
82187	1	0.5	83187						
82190	1	0.1	83190						
80178	1	1	82182						
81182	1	1	83186						
82183	0								
82186	0								
83190	0								
83187	0								
82182	0								
83186	0								

Bi

(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
74178	1	1	75178						
75178	1	1	76178						
76178	2	1	77178	0.00038	78182				
77178	2	0.923	78178	0.0013	79182				
78182	3	0.9987	79182	2.60E-06	80183	1.60E-04	80186		
78178	3	0.6	79178	0.0015	80179	0.152	80182		
79182	2	0.848	80182	6.00E-05	81186				
80183	2	1	81183	0.07	82187				
80186	2	1	81186	0.004	82190				
79178	2	0.3	80178	0.04	81182				
80179	1	0.9	82183						
80182	2	0.96	81182	0.4	82186				
81186	2	0.6	82186	0.9	83190				
81183	2	0.1	82183	0.5	83187				
82187	2	0.5	83187	1	84191				
82190	2	0.1	83190	1	84194				
80178	1	1	82182						
81182	1	1	83186						
82183	0								
82186	1	1	84190						
83190	0								
83187	0								
84191	0								
84194	0								
82182	0								
83186	0								
84190	0								

Table 186: Chain of $^{177}_{74}W-c$

(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
Pb									
74177	1	1	75177						
75177	1	1	76177						
76177	2	0.9994	77177	0.0008	78181				
77177	3	0.943	78177	1.10E-07	80181	2.70E-02	79181		
78181	2	0.973	79181	0.06	80185				
78177	1	0.31	80181						
80181	2	0.5	81181	1	82185				
79181	1	0.68984	80181						
80185	2	1	81185	0.004	82189				
81181	1	0.15	83185						
82185	0								
81185	1	0.5	83189						
82189	1	0.5	83189						
83185	0								
83189	0								

(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
Bi									
74177	1	1	75177						
75177	1	1	76177						
76177	2	0.9994	77177	0.0008	78181				
77177	3	0.943	78177	1.10E-07	80181	2.70E-02	79181		
78181	2	0.973	79181	0.06	80185				
78177	1	0.31	80181						
80181	2	0.5	81181	1	82185				
79181	1	0.68984	80181						
80185	2	1	81185	0.004	82189				
81181	1	0.15	83185						
82185	0								
81185	1	0.5	83189						
82189	2	0.5	83189	1	84193				
83185	0								
83189	0								
84193	0								

Table 187: Chain of ${}^{176}_{74}W - c$

Pb									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
74176	1	1	75176						
75176	1	1	76176						
76176	2	0.969	77176	0.003	78180				
77176	2	0.62	78176	0.018	79180				
78180	3	0.982	79180	0.00016	80181	0.0111	80184		
78176	2	0.5	79176	0.48	80180				
79180	2	0.52	80180	0.021	81184				
80181	2	0.5	81181	1	82185				
80184	2	0.979	81184	0.093	82188				
79176	1	0.07	81180						
80180	2	0.93	81180	0.23	82184				
81184	1	0.77	82184						
81181	1	0.15	83185						
82185	0								
82188	1	1	83188						
81180	1	1	83184						
82184	1	0.85	83185						
83185	0								
83188	0								
83184	0								

Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)

Table 188: Chain of $^{177}_{73}Ta - c$

Pb									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
73176	1	1	74176						
74176	1	1	75176						
75176	1	1	76176						
76176	2	0.969	77176	0.003	78180				
77176	2	0.62	78176	0.018	79180				
78180	3	0.982	79180	0.00016	80181	0.0111	80184		
78176	2	0.5	79176	0.48	80180				
79180	2	0.52	80180	0.021	81184				
80181	2	0.5	81181	1	82185				
80184	2	0.979	81184	0.093	82188				
79176	1	0.07	81180						
80180	2	0.93	81180	0.23	82184				
81184	1	0.77	82184						
81181	1	0.15	83185						
82185	0								
82188	1	1	83188						
81180	1	1	83184						
82184	1	0.85	83185						
83185	0								
83188	0								
83184	0								

Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
73176	1	1.4472	74176						
74176	1	1	75176						
75176	1	1	76176						
76176	2	0.969	77176	0.003	78180				
77176	2	0.62	78176	0.018	79180				
78180	3	0.982	79180	0.00016	80181	0.0111	80184		
78176	2	0.5	79176	0.48	80180				
79180	2	0.52	80180	0.021	81184				
80181	2	0.5	81181	1	82185				
80184	2	0.979	81184	0.093	82188				
79176	1	0.07	81180						
80180	2	0.93	81180	0.23	82184				
81184	1	0.77	82184						
81181	1	0.15	83185						
82185	0								
82188	2	1	83188	0.995	84192				
81180	1	1	83184						
82184	1	0.85	83185						
83185	0								
83188	1	1	84188						
84192	0								
83184	0								
84188	0								

Table 189: Chain of $^{176}_{73}Ta - c$

Pb									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
73177	1	1	74177						
74177	1	1	75177						
75177	1	1	76177						
76177	2	0.9994	77177	0.0008	78181				
77177	3	0.943	78177	1.10E-07	80181	2.70E-02	79181		
78181	2	0.973	79181	0.06	80185				
78177	1	0.31	80181						
80181	2	0.5	81181	1	82185				
79181	1	0.68984	80181						
80185	2	1	81185	0.004	82189				
81181	1	0.15	83185						
82185	0								
81185	1	0.5	83189						
82189	1	0.5	83189						
83185	0								
83189	0								

Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
73177	1	1	74177						
74177	1	1	75177						
75177	1	1	76177						
76177	2	0.9994	77177	0.0008	78181				
77177	3	0.943	78177	1.10E-07	80181	2.70E-02	79181		
78181	2	0.973	79181	0.06	80185				
78177	1	0.31	80181						
80181	2	0.5	81181	1	82185				
79181	1	0.68984	80181						
80185	2	1	81185	0.004	82189				
81181	1	0.15	83185						
82185	0								
81185	1	0.5	83189						
82189	2	0.5	83189	1	84193				
83185	0								
83189	0								
84193	0								

Table 190: Chain of $^{175}_{73}Ta - c$

Pb						Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)
73175	1	1	74175			73175	1	1	74175		
74175	1	1	75175			74175	1	1	75175		
75175	1	1	76175			75175	1	1	76175		
76175	2	0.9915	77175	0.0024	78179	76175	2	0.9915	77175	0.0024	78179
77175	2	0.36	78175	0.22	79179	77175	2	0.36	78175	0.22	79179
78179	2	0.78	79179	0.117	80183	78179	2	0.78	79179	0.117	80183
78175	2	0.06	79175	0.53	80179	78175	2	0.06	79175	0.53	80179
79179	2	0.4685	80179	1	81183	79179	2	0.4685	80179	1	81183
80183	2	1	81183	0.07	82187	80183	2	1	81183	0.07	82187
79175	1	1	81179			79175	1	1	81179		
80179	1	0.9	82183			80179	1	0.9	82183		
81183	2	0.1	82183	0.5	83187	81183	2	0.1	82183	0.5	83187
82187	1	0.5	83187			82187	2	0.5	83187	1	84191
81179	0					81179	0				
82183	0					82183	0				
83187	0					83187	0				
						84191	0				

Table 191: Chain of ${}^{174}_{73}Ta-c$

Pb									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
73174	1	1	74174						
74174	1	1	75174						
75174	1	0.9998	76174						
76174	2	0.995	77174	0.077	78178				
77174	2	0.24	78174	0.4	79178				
78178	3	0.6	79178	0.0015	80179	0.152	80182		
78174	1	0.7	80178						
79178	2	0.3	80178	0.04	81182				
80179	1	0.9	82183						
80182	2	0.96	81182	0.4	82186				
80178	1	1	82182						
81182	1	1	83186						
82183	0								
82186	0								
82182	0								
83186	0								

Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
73174	1	1	74174						
74174	1	1	75174						
75174	1	0.9998	76174						
76174	2	0.995	77174	0.077	78178				
77174	2	0.24	78174	0.4	79178				
78178	3	0.6	79178	0.0015	80179	0.152	80182		
78174	1	0.7	80178						
79178	2	0.3	80178	0.04	81182				
80179	1	0.9	82183						
80182	2	0.96	81182	0.4	82186				
80178	1	1	82182						
81182	1	1	83186						
82183	0								
82186	1	1	84190						
82182	0								
83186	0								
84190	0								

Table 192: Chain of $^{173}_{73}Ta - c$

				Pb, Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
73173	1	1	74173						
74173	1	1	75173						
75173	2	0.99979	76173	0.0006	77177				
76173	2	0.93	77173	0.057	78177				
77177	3	0.943	78177	1.10E-07	80181	2.70E-02	79181		
77173	2	0.16	78173	1	79177				
78177	1	0.31	80181						
80181	2	0.5	81181	1	82185				
79181	1	0.68984	80181						
78173	2	0.06	79173	0.85	80177				
79177	2	0.15	80177	0.5	81181				
81181	1	0.15	83185						
82185	0								
79173	1	0.73	81177						
80177	1	1	82181						
83185	0								
81177	0								
82181	0								

Table 193: Chain of $^{172}_{73}Ta - c^{*}$

				Pb, Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
73172	1	1.2185	74172						
74172	1	1	75172						
75172	2	0.998	76172	0.031	77176				
76172	2	0.98	77172	0.38	78176				
77176	2	0.62	78176	0.018	79180				
77172	2	0.06	78172	0.5	79176				
78176	2	0.5	79176	0.48	80180				
79180	2	0.52	80180	0.021	81184				
78172	2	0.03	79173	1	80176				
79176	1	0.07	81180						
80180	2	0.93	81180	0.23	82184				
81184	1	0.77	82184						
79173	1	0.73	81177						
80176	2	0.27	81177	1	82180				
81180	1	1	83184						
82184	1	0.85	83185						
81177	0								
82180	0								
83184	0								
83185	0								

Table 194: Chain of ${}^{175}_{72}Hf - c$

Pb						Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)
72175	1	1	73175			72175	1	1	73175		
73175	1	1	74175			73175	1	1	74175		
74175	1	1	75175			74175	1	1	75175		
75175	1	1	76175			75175	1	1	76175		
76175	2	0.9915	77175	0.0024	78179	76175	2	0.9915	77175	0.0024	78179
77175	2	0.36	78175	0.22	79179	77175	2	0.36	78175	0.22	79179
78179	2	0.78	79179	0.117	80183	78179	2	0.78	79179	0.117	80183
78175	2	0.06	79175	0.53	80179	78175	2	0.06	79175	0.53	80179
79179	2	0.4685	80179	1	81183	79179	2	0.4685	80179	1	81183
80183	2	1	81183	0.07	82187	80183	2	1	81183	0.07	82187
79175	1	1	81179			79175	1	1	81179		
80179	1	0.9	82183			80179	1	0.9	82183		
81183	2	0.1	82183	0.5	83187	81183	2	0.1	82183	0.5	83187
82187	1	0.5	83187			82187	2	0.5	83187	1	84191
81179	0					81179	0				
82183	0					82183	0				
83187	0					83187	0				
						84191	0				

Table 195: Chain of ${}^{173}_{72}Hf - c$

Pb, Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
72173	1	1	73173						
73173	1	1	74173						
74173	1	1	75173						
75173	2	0.99979	76173	0.0006	77177				
76173	2	0.93	77173	0.057	78177				
77177	3	0.943	78177	1.10E-07	80181	2.70E-02	79181		
77173	2	0.16	78173	1	79177				
78177	1	0.31	80181						
80181	2	0.5	81181	1	82185				
79181	1	0.68984	80181						
78173	2	0.06	79173	0.85	80177				
79177	2	0.15	80177	0.5	81181				
81181	1	0.15	83185						
82185	0								
79173	1	0.73	81177						
80177	1	1	82181						
83185	0								
81177	0								
82181	0								

Table 196: Chain of ${}^{172}_{72}Hf-c$

Pb, Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
72172	1	1	73172						
73172	1	1	74172						
74172	1	1	75172						
75172	2	0.998	76172	0.031	77176				
76172	2	0.98	77172	0.38	78176				
77176	2	0.62	78176	0.018	79180				
77172	2	0.06	78172	0.5	79176				
78176	2	0.5	79176	0.48	80180				
79180	2	0.52	80180	0.021	81184				
78172	2	0.03	79173	1	80176				
79176	1	0.07	81180						
80180	2	0.93	81180	0.23	82184				
81184	1	0.77	82184						
79173	1	0.73	81177						
80176	2	0.27	81177	1	82180				
81180	1	1	83184						
82184	1	0.85	83185						
81177	0								
82180	0								
83184	0								
83185	0								

Table 197: Chain of ${}^{171}_{72}Hf-c$

Pb									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
72171	1	1	73171						
73171	1	1	74171						
74171	1	1	75171						
75171	2	0.982	76171	0.0085	77175				
76171	2	0.5	77171	0.64	78175				
77175	2	0.36	78175	0.22	79179				
77171	2	0.02	78171	0.94	79175				
78175	2	0.06	79175	0.53	80179				
79179	2	0.4685	80179	1	81183				
78171	2	0.02	79172	1	80175				
79175	1	1	81179						
80179	1	0.9	82183						
81183	2	0.1	82183	0.5	83187				
79172	0								
80175	0								
81179	0								
82183	0								
83187	0								
Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)

Table 198: Chain of $^{170}_{72}Hf-c$

Pb									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
72170	1	1	73170						
73170	1	1	74170						
74170	2	1	75170	0.0002	76174				
75170	2	0.914	76170	0.005	77174				
76174	2	0.995	77174	0.077	78178				
76170	3	0.948	77170	0.5	77171	0.76	78174		
77174	2	0.24	78174	0.4	79178				
78178	3	0.6	79178	0.0015	80179	0.152	80182		
77170	2	0.02	78170	0.01	79174				
77171	2	0.02	78171	0.94	79175				
78174	1	0.7	80178						
79178	2	0.3	80178	0.04	81182				
80179	1	0.9	82183						
80182	2	0.96	81182	0.4	82186				
78170	2	1	79171	0.996	80174				
79174	1	0.004	80174						
78171	2	0.02	79172	1	80175				
79175	1	1	81179						
80178	1	1	82182						
81182	1	1	83186						
82183	0								
82186	0								
79171	0								
80174	0								
79172	0								
80175	0								
81179	0								
82182	0								
83186	0								

Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
72170	1	1	73170						
73170	1	1	74170						
74170	2	1	75170	0.0002	76174				
75170	2	0.914	76170	0.005	77174				
76174	2	0.995	77174	0.077	78178				
76170	3	0.948	77170	0.5	77171	0.76	78174		
77174	2	0.24	78174	0.4	79178				
78178	3	0.6	79178	0.0015	80179	0.152	80182		
77170	2	0.02	78170	0.01	79174				
77171	2	0.02	78171	0.94	79175				
78174	1	0.7	80178						
79178	2	0.3	80178	0.04	81182				
80179	1	0.9	82183						
80182	2	0.96	81182	0.4	82186				
78170	2	1	79171	0.996	80174				
79174	1	0.004	80174						
78171	2	0.02	79172	1	80175				
79175	1	1	81179						
80178	1	1	82182						
81182	1	1	83186						
82183	0								
82186	1	1	84190						
79171	0								
80174	0								
79172	0								
80175	0								
81179	0								
82182	0								
83186	0								
84190	0								

Table 199: Chain of ${}^{168}_{72}Hf-c$

Pb						Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)
						72168	1	1	73168		
						73168	1	1	74168		
						74168	2	1	75168	0.002	76172
						75168	2	0.51	76168	0.02	77172
						76172	2	0.98	77172	0.38	78176
						76168	2	0.51	77168	0.94	78172
						77172	2	0.06	78172	0.5	79176
						78176	2	0.5	79176	0.48	80180
						77168	1	1	79172		
						78172	2	0.03	79173	1	80176
						79176	1	0.07	81180		
						80180	2	0.93	81180	0.23	82184
						79172	0				
						79173	1	0.73	81177		
						80176	2	0.27	81177	1	82180
						81180	1	1	83184		
						82184	1	0.85	83185		
						81177	0				
						82180	0				
						83184	0				
						83185	0				

Table 200: Chain of ${}^{173}_{71}Lu-c$

Pb, Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
71173	1	1	72173						
72173	1	1	73173						
73173	1	1	74173						
74173	1	1	75173						
75173	2	0.99979	76173	0.0006	77177				
76173	2	0.93	77173	0.057	78177				
77177	3	0.943	78177	1.10E-07	80181	2.70E-02	79181		
77173	2	0.16	78173	1	79177				
78177	1	0.31	80181						
80181	2	0.5	81181	1	82185				
79181	1	0.68984	80181						
78173	2	0.06	79173	0.85	80177				
79177	2	0.15	80177	0.5	81181				
81181	1	0.15	83185						
82185	0								
79173	1	0.73	81177						
80177	1	1	82181						
83185	0								
81177	0								
82181	0								

Table 201: Chain of ${}^{172}_{71}Lu - i(m+g)$

Pb, Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
71172	0								

Table 202: Chain of ${}^{172}_{71}Lu - c$

Pb, Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
71172	1	1	72172						
72172	1	1	73172						
73172	1	1	74172						
74172	1	1	75172						
75172	2	0.998	76172	0.031	77176				
76172	2	0.98	77172	0.38	78176				
77176	2	0.62	78176	0.018	79180				
77172	2	0.06	78172	0.5	79176				
78176	2	0.5	79176	0.48	80180				
79180	2	0.52	80180	0.021	81184				
78172	2	0.03	79173	1	80176				
79176	1	0.07	81180						
80180	2	0.93	81180	0.23	82184				
81184	1	0.77	82184						
79173	1	0.73	81177						
80176	2	0.27	81177	1	82180				
81180	1	1	83184						
82184	1	0.85	83185						
81177	0								
82180	0								
83184	0								
83185	0								

Table 203: Chain of $^{171}_{71}Lu - c$

Pb, Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
71171	1	1	72171						
72171	1	1	73171						
73171	1	1	74171						
74171	1	1	75171						
75171	2	0.982	76171	0.0085	77175				
76171	2	0.5	77171	0.64	78175				
77175	2	0.36	78175	0.22	79179				
77171	2	0.02	78171	0.94	79175				
78175	2	0.06	79175	0.53	80179				
79179	2	0.4685	80179	1	81183				
78171	2	0.02	79172	1	80175				
79175	1	1	81179						
80179	1	0.9	82183						
81183	2	0.1	82183	0.5	83187				
79172	0								
80175	0								
81179	0								
82183	0								
83187	0								

Table 204: Chain of ${}^{170}_{71}Lu-c$

Pb									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
71170	1	1	72170						
72170	1	1	73170						
73170	1	1	74170						
74170	2	1	75170	0.0002	76174				
75170	2	0.914	76170	0.005	77174				
76174	2	0.995	77174	0.077	78178				
76170	3	0.948	77170	0.5	77171	0.76	78174		
77174	2	0.24	78174	0.4	79178				
78178	3	0.6	79178	0.0015	80179	0.152	80182		
77170	2	0.02	78170	0.01	79174				
77171	2	0.02	78171	0.94	79175				
78174	1	0.7	80178						
79178	2	0.3	80178	0.04	81182				
80179	1	0.9	82183						
80182	2	0.96	81182	0.4	82186				
78170	2	1	79171	0.996	80174				
79174	1	0.004	80174						
78171	2	0.02	79172	1	80175				
79175	1	1	81179						
80178	1	1	82182						
81182	1	1	83186						
82183	0								
82186	0								
79171	0								
80174	0								
79172	0								
80175	0								
81179	0								
82182	0								
83186	0								

Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
71170	1	1	72170						
72170	1	1	73170						
73170	1	1	74170						
74170	2	1	75170	0.0002	76174				
75170	2	0.914	76170	0.005	77174				
76174	2	0.995	77174	0.077	78178				
76170	3	0.948	77170	0.5	77171	0.76	78174		
77174	2	0.24	78174	0.4	79178				
78178	3	0.6	79178	0.0015	80179	0.152	80182		
77170	2	0.02	78170	0.01	79174				
77171	2	0.02	78171	0.94	79175				
78174	1	0.7	80178						
79178	2	0.3	80178	0.04	81182				
80179	1	0.9	82183						
80182	2	0.96	81182	0.4	82186				
78170	2	1	79171	0.996	80174				
79174	1	0.004	80174						
78171	2	0.02	79172	1	80175				
79175	1	1	81179						
80178	1	1	82182						
81182	1	1	83186						
82183	0								
82186	1	1	84190						
79171	0								
80174	0								
79172	0								
80175	0								
81179	0								
82182	0								
83186	0								
84190	0								

Table 205: Chain of ${}^{169}_{71}Lu - c$

Pb, Bi										
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
71169	1	1	72169						
72169	1	1	73169						
73169	1	1	74169						
74169	2	0.5	75169	0.00021	76173				
75169	2	0.89	76169	0.07	77173				
76173	2	0.93	77173	0.057	78177				
76169	1	0.84	78173						
77173	2	0.16	78173	1	79177				
78177	1	0.31	80181						
78173	2	0.06	79173	0.85	80177				
79177	2	0.15	80177	0.5	81181				
80181	2	0.5	81181	1	82185				
79173	1	0.73	81177						
80177	1	1	82181						
81181	1	0.15	83185						
82185	0								
81177	0								
82181	0								
83185	0								

Table 206: Chain of ${}^{167}_{71}Lu - c$

Pb, Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
71167	1	1	72167						
72167	1	1	73167						
73167	1	0.9996	74167						
74167	2	0.99	75167	0.018	76171				
75167	1	0.43	76167						
76171	2	0.5	77171	0.64	78175				
76167	2	0.2	77167	0.98	78171				
77171	2	0.02	78171	0.94	79175				
78175	2	0.06	79175	0.53	80179				
77167	0								
78171	2	0.02	79172	1	80175				
79175	1	1	81179						
80179	1	0.9	82183						
79172	0								
80175	0								
81179	0								
82183	0								

Table 207: Chain of ${}^{169}_{70}Yb - c$

Pb, Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
70169	1	1	71169						
71169	1	1	72169						
72169	1	1	73169						
73169	1	1	74169						
74169	2	0.5	75169	0.00021	76173				
75169	2	0.89	76169	0.07	77173				
76173	2	0.93	77173	0.057	78177				
76169	1	0.84	78173						
77173	2	0.16	78173	1	79177				
78177	1	0.31	80181						
78173	2	0.06	79173	0.85	80177				
79177	2	0.15	80177	0.5	81181				
80181	2	0.5	81181	1	82185				
79173	1	0.73	81177						
80177	1	1	82181						
81181	1	0.15	83185						
82185	0								
81177	0								
82181	0								
83185	0								

Table 208: Chain of ${}^{166}_{70}Yb - c$

Pb, Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
70166	1	1	71166						
71166	1	1	72166						
72166	1	1	73166						
73166	1	0.99965	74166						
74166	2	0.92	75166	0.086	76170				
75166	2	0.1	76166	0.052	77170				
76170	3	0.948	77170	0.5	77171	0.76	78174		
76166	2	0.32	77167	0.98	78170				
77170	2	0.02	78170	0.01	79174				
77171	2	0.02	78171	0.94	79175				
78174	1	0.7	80178						
77167	0								
78170	2	1	79171	0.996	80174				
79174	1	0.004	80174						
78171	2	0.02	79172	1	80175				
79175	1	1	81179						
80178	1	1	82182						
79171	0								
80174	0								
79172	0								
80175	0								
81179	0								
82182	0								

Table 209: Chain of $^{162}_{70}Yb-c$

Pb									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)

Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
70162	1	1	71162						
71162	1	0.99992	72162						
72162	2	0.99926	73162	0.00035	74166				
73162	2	0.548	74162	0.08	75166				
74166	2	0.92	75166	0.086	76170				
74162	2	0.06	75162	0.72	76166				
75166	2	0.1	76166	0.052	77170				
76170	3	0.948	77170	0.5	77171	0.76	78174		
75162	1	0.931	77166						
76166	2	0.32	77167	0.98	78170				
77170	2	0.02	78170	0.01	79174				
77171	2	0.02	78171	0.94	79175				
78174	1	0.7	80178						
77166	1	0.15	79170						
77167	0								
78170	2	1	79171	0.996	80174				
79174	1	0.004	80174						
78171	2	0.02	79172	1	80175				
79175	1	1	81179						
80178	1	1	82182						
79170	0								
79171	0								
80174	0								
79172	0								
80175	0								
81179	0								
82182	0								

Table 210: Chain of $^{167}_{69}Tm-c$

Pb, Bi										
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	
69167	1	1	70167							
70167	1	1	71167							
71167	1	1	72167							
72167	1	1	73167							
73167	1	0.9996	74167							
74167	2	0.99	75167	0.018	76171					
75167	1	0.43	76167							
76171	2	0.5	77171	0.64	78175					
76167	2	0.2	77167	0.98	78171					
77171	2	0.02	78171	0.94	79175					
78175	2	0.06	79175	0.53	80179					
77167	0									
78171	2	0.02	79172	1	80175					
79175	1	1	81179							
80179	1	0.9	82183							
79172	0									
80175	0									
81179	0									
82183	0									

Table 211: Chain of $^{165}_{69}Tm-c$

Pb, Bi										
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	
69165	1	1	70165							
70165	1	1	71165							
71165	1	1	72165							
72165	1	1	73165							
73165	2	1	74165	0.5	75169					
74165	2	1	75165	0.11	76169					
75169	2	0.89	76169	0.07	77173					
75165	2	0.4	76165	1	77169					
76169	1	0.84	78173							
77173	2	0.16	78173	1	79177					
76165	2	0.069	77166	1	78169					
77169	1	0.94	79173							
78173	2	0.06	79173	0.85	80177					
79177	2	0.15	80177	0.5	81181					
77166	1	0.15	79170							
78169	2	0.85	79170	1	80173					
79173	1	0.73	81177							
80177	1	1	82181							
81181	1	0.15	83185							
79170	0									
80173	0									
81177	0									
82181	0									
83185	0									

Table 212: Chain of $^{163}_{69}Tm - c$

Pb

(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)

Bi

(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
69163	1	1	70163						
70163	1	1	71163						
71163	1	1	72163						
72163	2	0.998	73163	0.0004	74167				
73163	2	0.87	74163	0.01	75167				
74167	2	0.99	75167	0.018	76171				
74163	2	0.68	75163	0.57	76167				
75167	1	0.43	76167						
76171	2	0.5	77171	0.64	78175				
75163	1	0.48	77167						
76167	2	0.2	77167	0.98	78171				
77171	2	0.02	78171	0.94	79175				
78175	2	0.06	79175	0.53	80179				
77167	0								
78171	2	0.02	79172	1	80175				
79175	1	1	81179						
80179	1	0.9	82183						
79172	0								
80175	0								
81179	0								
82183	0								

Table 213: Chain of $^{161}_{68}Er - c^{*}$

Pb, Bi

(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
68161	1	1.2068	69161						
69161	1	1	70161						
70161	1	1	71161						
71161	1	0.9987	72161						
72161	2	0.955	73161	0.002	74165				
73161	2	0.27	74161	0.002	75165				
74165	2	1	75165	0.11	76169				
74161	1	0.6	76165						
75165	2	0.4	76165	1	77169				
76169	1	0.84	78173						
76165	2	0.069	77166	1	78169				
77169	1	0.94	79173						
78173	2	0.06	79173	0.85	80177				
77166	1	0.15	79170						
78169	2	0.85	79170	1	80173				
79173	1	0.73	81177						
80177	1	1	82181						
79170	0								
80173	0								
81177	0								
82181	0								

Table 214: Chain of ${}^{160}_{68}Er - c$

				Pb, Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
68160	1	1	69160						
69160	1	1	70160						
70160	1	1	71160						
71160	1	0.993	72160						
72160	2	0.66	73160	0.038	74164				
73160	2	0.13	74160	0.58	75164				
74164	2	0.42	75164	0.49	76168				
74160	2	1	75161	0.98	76164				
75164	2	0.02	76164	0.49	77168				
76168	2	0.51	77168	0.94	78172				
75161	0								
76164	1	1	78168						
77168	1	1	79172						
78172	2	0.03	79173	1	80176				
78168	0								
79172	0								
79173	1	0.73	81177						
80176	2	0.27	81177	1	82180				
81177	0								
82180	0								

Table 215: Chain of ${}^{159}_{68}Er - c^{*}$

Pb, Bi										
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
68159	1	1.3398	69159						
69159	1	1	70159						
70159	2	1	71159	1.00E-06	72163				
71159	2	0.65	72159	0.002	73163				
72163	2	0.998	73163	0.0004	74167				
72159	2	0.66	73159	0.13	74163				
73163	2	0.87	74163	0.01	75167				
74167	2	0.99	75167	0.018	76171				
73159	2	0.001	74159	0.32	75163				
74163	2	0.68	75163	0.57	76167				
75167	1	0.43	76167						
76171	2	0.5	77171	0.64	78175				
74159	2	0.91	75160	1	76163				
75163	1	0.48	77167						
76167	2	0.2	77167	0.98	78171				
77171	2	0.02	78171	0.94	79175				
78175	2	0.06	79175	0.53	80179				
75160	0								
76163	2	1	77164	1	78167				
77167	0								
78171	2	0.02	79172	1	80175				
79175	1	1	81179						
80179	1	0.9	82183						
77164	0								
78167	1	1	80171						
79172	0								
80175	0								
81179	0								
82183	0								
80171	0								

Table 216: Chain of ${}^{156}_{67}Ho - c^{*}$

				Pb, Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
67156	1	1.5342	68156						
68156	1	0.99936	69156						
69156	2	0.9	70156	1.00E-06	71160				
70156	2	0.05	71156	0.007	72160				
71160	1	0.993	72160						
71156	1	0.34	73160						
72160	2	0.66	73160	0.038	74164				
73160	2	0.13	74160	0.58	75164				
74164	2	0.42	75164	0.49	76168				
74160	2	1	75161	0.98	76164				
75164	2	0.02	76164	0.49	77168				
76168	2	0.51	77168	0.94	78172				
75161	0								
76164	1	1	78168						
77168	1	1	79172						
78172	2	0.03	79173	1	80176				
78168	0								
79172	0								
79173	1	0.73	81177						
80176	2	0.27	81177	1	82180				
81177	0								
82180	0								

Table 217: Chain of ${}^{157}_{66}Dy - c$

				Pb, Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
66157	1	1	67157						
67157	1	1	68157						
68157	1	1	69157						
69157	1	0.995	70157						
70157	1	0.0013	72161						
72161	2	0.955	73161	0.002	74165				
73161	2	0.27	74161	0.002	75165				
74165	2	1	75165	0.11	76169				
74161	1	0.6	76165						
75165	2	0.4	76165	1	77169				
76169	1	0.84	78173						
76165	2	0.069	77166	1	78169				
77169	1	0.94	79173						
78173	2	0.06	79173	0.85	80177				
77166	1	0.15	79170						
78169	2	0.85	79170	1	80173				
79173	1	0.73	81177						
80177	1	1	82181						
79170	0								
80173	0								
81177	0								
82181	0								

Table 218: Chain of ${}^{155}_{66}Dy - c^{*}$

				Pb, Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
66155	1	1.0879	67155						
67155	1	0.99978	68155						
68155	1	0.9911	69155						
69155	2	0.11	70155	0.001	71159				
70155	2	0.1	71155	0.35	72159				
71159	2	0.65	72159	0.002	73163				
71155	2	1	72155	0.34	73159				
72159	2	0.66	73159	0.13	74163				
73163	2	0.87	74163	0.01	75167				
72155	2	1	73156	0.999	74159				
73159	2	0.001	74159	0.32	75163				
74163	2	0.68	75163	0.57	76167				
75167	1	0.43	76167						
73156	1	0.09	75160						
74159	2	0.91	75160	1	76163				
75163	1	0.48	77167						
76167	2	0.2	77167	0.98	78171				
75160	0								
76163	2	1	77164	1	78167				
77167	0								
78171	2	0.02	79172	1	80175				
77164	0								
78167	1	1	80171						
79172	0								
80175	0								
80171	0								

Table 219: Chain of $^{152}_{66}Dy - c$

Pb, Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
66152	2	0.88	67152	1.70E-07	68156				
67152	2	0.1	68152	0.00064	69156				
68156	1	0.99936	69156						
68152	2	1	69152	0.1	70156				
69156	2	0.9	70156	1.00E-06	71160				
69152	2	1	70152	0.95	71156				
70156	2	0.05	71156	0.007	72160				
71160	1	0.993	72160						
70152	2	0.85	71152	1	72156				
71156	1	0.34	73160						
72160	2	0.66	73160	0.038	74164				
71152	0								
72156	2	0.034	73157	0.87	74160				
73160	2	0.13	74160	0.58	75164				
74164	2	0.42	75164	0.49	76168				
73157	0								
74160	2	1	75161	0.98	76164				
75164	2	0.02	76164	0.49	77168				
76168	2	0.51	77168	0.94	78172				
75161	0								
76164	1	1	78168						
77168	1	1	79172						
78172	2	0.03	79173	1	80176				
78168	0								
79172	0								
79173	1	0.73	81177						
80176	2	0.27	81177	1	82180				
81177	0								
82180	0								

Table 220: Chain of $^{155}_{65}Tb - c^{*}$

				Pb, Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
65155	1.0841	1	66155						
66155	1	1	67155						
67155	1	0.99978	68155						
68155	1	0.9911	69155						
69155	2	0.11	70155	0.001	71159				
70155	2	0.1	71155	0.35	72159				
71159	2	0.65	72159	0.002	73163				
71155	2	1	72155	0.34	73159				
72159	2	0.66	73159	0.13	74163				
73163	2	0.87	74163	0.01	75167				
72155	2	1	73156	0.999	74159				
73159	2	0.001	74159	0.32	75163				
74163	2	0.68	75163	0.57	76167				
75167	1	0.43	76167						
73156	1	0.09	75160						
74159	2	0.91	75160	1	76163				
75163	1	0.48	77167						
76167	2	0.2	77167	0.98	78171				
75160	0								
76163	2	1	77164	1	78167				
77167	0								
78171	2	0.02	79172	1	80175				
77164	0								
78167	1	1	80171						
79172	0								
80175	0								
80171	0								

Table 221: Chain of ${}^{153}_{65}Tb - c^{*}$

Pb, Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
65153	1	1.04771	66153						
66153	1	0.99949	67153						
67153	1	0.47	68153						
68153	2	0.09	69153	0.005	70157				
69153	2	0.5	70153	0.01	71157				
70157	1	0.0013	72161						
70153	2	0.3	71153	0.86	72157				
71157	2	0.14	72157	0.045	73161				
72161	2	0.955	73161	0.002	74165				
71153	1	0.966	73157						
72157	1	0.73	74161						
73161	2	0.27	74161	0.002	75165				
74165	2	1	75165	0.11	76169				
73157	0								
74161	1	0.6	76165						
75165	2	0.4	76165	1	77169				
76169	1	0.84	78173						
76165	2	0.069	77166	1	78169				
77169	1	0.94	79173						
78173	2	0.06	79173	0.85	80177				
77166	1	0.15	79170						
78169	2	0.85	79170	1	80173				
79173	1	0.73	81177						
80177	1	1	82181						
79170	0								
80173	0								
81177	0								
82181	0								

Table 222: Chain of ${}^{152}_{65}Tb - c$

Pb, Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
65152	1	0.999	66152						
66152	2	0.88	67152	1.70E-07	68156				
67152	2	0.1	68152	0.00064	69156				
68156	1	0.99936	69156						
68152	2	1	69152	0.1	70156				
69156	2	0.9	70156	1.00E-06	71160				
69152	2	1	70152	0.95	71156				
70156	2	0.05	71156	0.007	72160				
71160	1	0.993	72160						
70152	2	0.85	71152	1	72156				
71156	1	0.34	73160						
72160	2	0.66	73160	0.038	74164				
71152	0								
72156	2	0.034	73157	0.87	74160				
73160	2	0.13	74160	0.58	75164				
74164	2	0.42	75164	0.49	76168				
73157	0								
74160	2	1	75161	0.98	76164				
75164	2	0.02	76164	0.49	77168				
76168	2	0.51	77168	0.94	78172				
75161	0								
76164	1	1	78168						
77168	1	1	79172						
78172	2	0.03	79173	1	80176				
78168	0								
79172	0								
79173	1	0.73	81177						
80176	2	0.27	81177	1	82180				
81177	0								
82180	0								

Table 223: Chain of ${}^{151}_{65}Tb - c$

Pb, Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
65151	1	0.944	66151						
66151	2	0.78	67151	0.00022	68155				
67151	2	1	68151	0.0089	69155				
68155	1	0.9911	69155						
68151	2	1	69151	0.89	70155				
69155	2	0.11	70155	0.001	71159				
69151	3	1	70151	0.15	71152	0.9	71155		
70155	2	0.1	71155	0.35	72159				
71159	2	0.65	72159	0.002	73163				
70151	0								
71152	0								
71155	2	1	72155	0.34	73159				
72159	2	0.66	73159	0.13	74163				
73163	2	0.87	74163	0.01	75167				
72155	2	1	73156	0.999	74159				
73159	2	0.001	74159	0.32	75163				
74163	2	0.68	75163	0.57	76167				
75167	1	0.43	76167						
73156	1	0.09	75160						
74159	2	0.91	75160	1	76163				
75163	1	0.48	77167						
76167	2	0.2	77167	0.98	78171				
75160	0								
76163	2	1	77164	1	78167				
77167	0								
78171	2	0.02	79172	1	80175				
77164	0								
78167	1	1	80171						
79172	0								
80175	0								
80171	0								

Table 224: Chain of $^{150}_{65}Tb - c$

Pb									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)

Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
65150	2	0.64	66150	0.00019	67154				
66150	2	1	67150	0.0047	68154				
67154	1	0.9953	68154						
67150	2	1	68150	0.54	69154				
68154	2	0.46	69154	2.10E-05	70158				
68150	2	1	69150	0.926	70154				
69154	2	0.074	70154	0.0091	71158				
70158	2	0.9909	71158	8.00E-05	72162				
69150	0								
70154	1	0.443	72158						
71158	2	0.557	72158	0.00074	73162				
72162	2	0.99926	73162	0.00035	74166				
72158	2	0.09	73158	0.452	74162				
73162	2	0.548	74162	0.08	75166				
74166	2	0.92	75166	0.086	76170				
73158	1	0.94	75162						
74162	2	0.06	75162	0.72	76166				
75166	2	0.1	76166	0.052	77170				
76170	3	0.948	77170	0.5	77171	0.76	78174		
75162	1	0.931	77166						
76166	2	0.32	77167	0.98	78170				
77170	2	0.02	78170	0.01	79174				
77171	2	0.02	78171	0.94	79175				
78174	1	0.7	80178						
77166	1	0.15	79170						
77167	0								
78170	2	1	79171	0.996	80174				
79174	1	0.004	80174						
78171	2	0.02	79172	1	80175				
79175	1	1	81179						
80178	1	1	82182						
79170	0								
79171	0								
80174	0								
79172	0								
80175	0								
81179	0								
82182	0								

Table 225: Chain of $^{149}_{65}Tb - c$

Pb, Bi										
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
65149	2	1	66149	0.00051	67153				
66149	2	1	67149	0.53	68153				
67153	1	0.47	68153						
67149	2	0.93	68149	0.91	69153				
68153	2	0.09	69153	0.005	70157				
68149	2	0.998	69149	0.5	70153				
69153	2	0.5	70153	0.01	71157				
70157	1	0.0013	72161						
69149	1	0.7	71153						
70153	2	0.3	71153	0.86	72157				
71157	2	0.14	72157	0.045	73161				
72161	2	0.955	73161	0.002	74165				
71153	1	0.966	73157						
72157	1	0.73	74161						
73161	2	0.27	74161	0.002	75165				
74165	2	1	75165	0.11	76169				
73157	0								
74161	1	0.6	76165						
75165	2	0.4	76165	1	77169				
76169	1	0.84	78173						
76165	2	0.069	77166	1	78169				
77169	1	0.94	79173						
78173	2	0.06	79173	0.85	80177				
77166	1	0.15	79170						
78169	2	0.85	79170	1	80173				
79173	1	0.73	81177						
80177	1	1	82181						
79170	0								
80173	0								
81177	0								
82181	0								

Table 226: Chain of $^{148}_{65}Tb-c$

Pb, Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
65148	2	1	66148	0.12	67152				
66148	3	1	67148	0.07	68149	0.9	68152		
67152	2	0.1	68152	0.00064	69156				
67148	2	1	68148	0.002	69149				
68149	2	0.998	69149	0.5	70153				
68152	2	1	69152	0.1	70156				
69156	2	0.9	70156	1.00E-06	71160				
68148	2	1	69148	1	70149				
69149	1	0.7	71153						
70153	2	0.3	71153	0.86	72157				
69152	2	1	70152	0.95	71156				
70156	2	0.05	71156	0.007	72160				
71160	1	0.993	72160						
69148	0								
70149	1	0.7	71150						
71153	1	0.966	73157						
72157	1	0.73	74161						
70152	2	0.85	71152	1	72156				
71156	1	0.34	73160						
72160	2	0.66	73160	0.038	74164				
71150	0								
73157	0								
74161	1	0.6	76165						
71152	0								
72156	2	0.034	73157	0.87	74160				
73160	2	0.13	74160	0.58	75164				
74164	2	0.42	75164	0.49	76168				
76165	2	0.069	77166	1	78169				
74160	2	1	75161	0.98	76164				
75164	2	0.02	76164	0.49	77168				
76168	2	0.51	77168	0.94	78172				
77166	1	0.15	79170						
78169	2	0.85	79170	1	80173				
75161	0								
76164	1	1	78168						
77168	1	1	79172						
78172	2	0.03	79173	1	80176				
79170	0								
80173	0								
78168	0								
79172	0								
79173	1	0.73	81177						
80176	2	0.27	81177	1	82180				
81177	0								
82180	0								

Table 227: Chain of ${}^{153}_{64}Gd - c$

				Pb, Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
64153	1	1	65153						
65153	1	0.99991	66153						
66153	1	0.99949	67153						
67153	1	0.47	68153						
68153	2	0.09	69153	0.005	70157				
69153	2	0.5	70153	0.01	71157				
70157	1	0.0013	72161						
70153	2	0.3	71153	0.86	72157				
71157	2	0.14	72157	0.045	73161				
72161	2	0.955	73161	0.002	74165				
71153	1	0.966	73157						
72157	1	0.73	74161						
73161	2	0.27	74161	0.002	75165				
74165	2	1	75165	0.11	76169				
73157	0								
74161	1	0.6	76165						
75165	2	0.4	76165	1	77169				
76169	1	0.84	78173						
76165	2	0.069	77166	1	78169				
77169	1	0.94	79173						
78173	2	0.06	79173	0.85	80177				
77166	1	0.15	79170						
78169	2	0.85	79170	1	80173				
79173	1	0.73	81177						
80177	1	1	82181						
79170	0								
80173	0								
81177	0								
82181	0								

Table 228: Chain of ${}^{151}_{64}Gd - c$

Pb, Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
64151	1	1	65151						
65151	1	0.944	66151						
66151	2	0.78	67151	0.00022	68155				
67151	2	1	68151	0.0089	69155				
68155	1	0.9911	69155						
68151	2	1	69151	0.89	70155				
69155	2	0.11	70155	0.001	71159				
69151	3	1	70151	0.15	71152	0.9	71155		
70155	2	0.1	71155	0.35	72159				
71159	2	0.65	72159	0.002	73163				
70151	0								
71152	0								
71155	2	1	72155	0.34	73159				
72159	2	0.66	73159	0.13	74163				
73163	2	0.87	74163	0.01	75167				
72155	2	1	73156	0.999	74159				
73159	2	0.001	74159	0.32	75163				
74163	2	0.68	75163	0.57	76167				
75167	1	0.43	76167						
73156	1	0.09	75160						
74159	2	0.91	75160	1	76163				
75163	1	0.48	77167						
76167	2	0.2	77167	0.98	78171				
75160	0								
76163	2	1	77164	1	78167				
77167	0								
78171	2	0.02	79172	1	80175				
77164	0								
78167	1	1	80171						
79172	0								
80175	0								
80171	0								

Table 229: Chain of ${}^{149}_{64}Gd - c$

				Pb, Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
64149	2	0.833	65149	9.40E-05	66153				
65149	2	1	66149	0.00051	67153				
66153	1	0.99949	67153						
66149	2	1	67149	0.53	68153				
67153	1	0.47	68153						
67149	2	0.93	68149	0.91	69153				
68153	2	0.09	69153	0.005	70157				
68149	2	0.998	69149	0.5	70153				
69153	2	0.5	70153	0.01	71157				
70157	1	0.0013	72161						
69149	1	0.7	71153						
70153	2	0.3	71153	0.86	72157				
71157	2	0.14	72157	0.045	73161				
72161	2	0.955	73161	0.002	74165				
71153	1	0.966	73157						
72157	1	0.73	74161						
73161	2	0.27	74161	0.002	75165				
74165	2	1	75165	0.11	76169				
73157	0								
74161	1	0.6	76165						
75165	2	0.4	76165	1	77169				
76169	1	0.84	78173						
76165	2	0.069	77166	1	78169				
77169	1	0.94	79173						
78173	2	0.06	79173	0.85	80177				
77166	1	0.15	79170						
78169	2	0.85	79170	1	80173				
79173	1	0.73	81177						
80177	1	1	82181						
79170	0								
80173	0								
81177	0								
82181	0								

Table 230: Chain of $^{147}_{64}Gd - c$

Pb, Bi										
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
64147	2	1	65147	0.056	66151				
65147	2	1	66147	0.22	67151				
66151	2	0.78	67151	0.00022	68155				
66147	1	1	67147						
67151	2	1	68151	0.0089	69155				
68155	1	0.9911	69155						
67147	1	1	68147						
68151	2	1	69151	0.89	70155				
69155	2	0.11	70155	0.001	71159				
68147	1	0.85	69147						
69151	3	1	70151	0.15	71152	0.9	71155		
70155	2	0.1	71155	0.35	72159				
71159	2	0.65	72159	0.002	73163				
69147	0								
70151	0								
71152	0								
71155	2	1	72155	0.34	73159				
72159	2	0.66	73159	0.13	74163				
73163	2	0.87	74163	0.01	75167				
72155	2	1	73156	0.999	74159				
73159	2	0.001	74159	0.32	75163				
74163	2	0.68	75163	0.57	76167				
75167	1	0.43	76167						
73156	1	0.09	75160						
74159	2	0.91	75160	1	76163				
75163	1	0.48	77167						
76167	2	0.2	77167	0.98	78171				
75160	0								
76163	2	1	77164	1	78167				
77167	0								
78171	2	0.02	79172	1	80175				
77164	0								
78167	1	1	80171						
79172	0								
80175	0								
80171	0								

Table 231: Chain of ${}^{146}_{64}Gd - c$

Pb, Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
64146	2	1	65146	0.36	66150				
65146	1	1	66146						
66150	2	1	67150	0.0047	68154				
66146	1	1	67146						
67150	2	1	68150	0.54	69154				
68154	2	0.46	69154	2.10E-05	70158				
67146	0								
68150	2	1	69150	0.926	70154				
69154	2	0.074	70154	0.0091	71158				
70158	2	0.9909	71158	8.00E-05	72162				
69150	0								
70154	1	0.443	72158						
71158	2	0.557	72158	0.00074	73162				
72162	2	0.99926	73162	0.00035	74166				
72158	2	0.09	73158	0.452	74162				
73162	2	0.548	74162	0.08	75166				
74166	2	0.92	75166	0.086	76170				
73158	1	0.94	75162						
74162	2	0.06	75162	0.72	76166				
75166	2	0.1	76166	0.052	77170				
76170	3	0.948	77170	0.5	77171	0.76	78174		
75162	1	0.931	77166						
76166	2	0.32	77167	0.98	78170				
77170	2	0.02	78170	0.01	79174				
77171	2	0.02	78171	0.94	79175				
78174	1	0.7	80178						
77166	1	0.15	79170						
77167	0								
78170	2	1	79171	0.996	80174				
79174	1	0.004	80174						
78171	2	0.02	79172	1	80175				
79175	1	1	81179						
80178	1	1	82182						
79170	0								
79171	0								
80174	0								
79172	0								
80175	0								
81179	0								
82182	0								

Table 232: Chain of ${}^{149}_{63}Eu - c$

Pb, Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
63149	1	1	64149						
64149	2	0.833	65149	9.40E-05	66153				
65149	2	1	66149	0.00051	67153				
66153	1	0.99949	67153						
66149	2	1	67149	0.53	68153				
67153	1	0.47	68153						
67149	2	0.93	68149	0.91	69153				
68153	2	0.09	69153	0.005	70157				
68149	2	0.998	69149	0.5	70153				
69153	2	0.5	70153	0.01	71157				
70157	1	0.0013	72161						
69149	1	0.7	71153						
70153	2	0.3	71153	0.86	72157				
71157	2	0.14	72157	0.045	73161				
72161	2	0.955	73161	0.002	74165				
71153	1	0.966	73157						
72157	1	0.73	74161						
73161	2	0.27	74161	0.002	75165				
74165	2	1	75165	0.11	76169				
73157	0								
74161	1	0.6	76165						
75165	2	0.4	76165	1	77169				
76169	1	0.84	78173						
76165	2	0.069	77166	1	78169				
77169	1	0.94	79173						
78173	2	0.06	79173	0.85	80177				
77166	1	0.15	79170						
78169	2	0.85	79170	1	80173				
79173	1	0.73	81177						
80177	1	1	82181						
79170	0								
80173	0								
81177	0								
82181	0								

Table 233: Chain of $^{147}_{63}Eu - c$

Pb, Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
63147	2	1	64147	9.50E-05	65151				
64147	2	1	65147	0.056	66151				
65151	1	0.944	66151						
65147	2	1	66147	0.22	67151				
66151	2	0.78	67151	0.00022	68155				
66147	1	1	67147						
67151	2	1	68151	0.0089	69155				
68155	1	0.9911	69155						
67147	1	1	68147						
68151	2	1	69151	0.89	70155				
69155	2	0.11	70155	0.001	71159				
68147	1	0.85	69147						
69151	3	1	70151	0.15	71152	0.9	71155		
70155	2	0.1	71155	0.35	72159				
71159	2	0.65	72159	0.002	73163				
69147	0								
70151	0								
71152	0								
71155	2	1	72155	0.34	73159				
72159	2	0.66	73159	0.13	74163				
73163	2	0.87	74163	0.01	75167				
72155	2	1	73156	0.999	74159				
73159	2	0.001	74159	0.32	75163				
74163	2	0.68	75163	0.57	76167				
75167	1	0.43	76167						
73156	1	0.09	75160						
74159	2	0.91	75160	1	76163				
75163	1	0.48	77167						
76167	2	0.2	77167	0.98	78171				
75160	0								
76163	2	1	77164	1	78167				
77167	0								
78171	2	0.02	79172	1	80175				
77164	0								
78167	1	1	80171						
79172	0								
80175	0								
80171	0								

Table 234: Chain of $^{146}_{63}Eu - i$

Pb, Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
63146	0								

Table 235: Chain of $^{146}_{63}Eu - c$

Pb, Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
63146	2	1	64146	0.0005	65150				
64146	2	1	65146	0.36	66150				
65150	2	0.64	66150	0.00019	67154				
65146	1	1	66146						
66150	2	1	67150	0.0047	68154				
67154	1	0.9953	68154						
66146	1	1	67146						
67150	2	1	68150	0.54	69154				
68154	2	0.46	69154	2.10E-05	70158				
67146	0								
68150	2	1	69150	0.926	70154				
69154	2	0.074	70154	0.0091	71158				
70158	2	0.9909	71158	8.00E-05	72162				
69150	0								
70154	1	0.443	72158						
71158	2	0.557	72158	0.00074	73162				
72162	2	0.99926	73162	0.00035	74166				
72158	2	0.09	73158	0.452	74162				
73162	2	0.548	74162	0.08	75166				
74166	2	0.92	75166	0.086	76170				
73158	1	0.94	75162						
74162	2	0.06	75162	0.72	76166				
75166	2	0.1	76166	0.052	77170				
76170	3	0.948	77170	0.5	77171	0.76	78174		
75162	1	0.931	77166						
76166	2	0.32	77167	0.98	78170				
77170	2	0.02	78170	0.01	79174				
77171	2	0.02	78171	0.94	79175				
78174	1	0.7	80178						
77166	1	0.15	79170						
77167	0								
78170	2	1	79171	0.996	80174				
79174	1	0.004	80174						
78171	2	0.02	79172	1	80175				
79175	1	1	81179						
80178	1	1	82182						
79170	0								
79171	0								
80174	0								
79172	0								
80175	0								
81179	0								
82182	0								

Table 236: Chain of $^{145}_{63}Eu - c$

Pb, Bi										
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	
63145	2	1	64145	0.167	65149					
64145	1	1	65145							
65149	2	1	66149	0.00051	67153					
65145	1	1	66145							
66149	2	1	67149	0.53	68153					
67153	1	0.47	68153							
66145	1	1	67145							
67149	2	0.93	68149	0.91	69153					
68153	2	0.09	69153	0.005	70157					
67145	1	1	68145							
68149	2	0.998	69149	0.5	70153					
69153	2	0.5	70153	0.01	71157					
70157	1	0.0013	72161							
68145	1	0.5	69146							
69149	1	0.7	71153							
70153	2	0.3	71153	0.86	72157					
71157	2	0.14	72157	0.045	73161					
72161	2	0.955	73161	0.002	74165					
69146	0									
71153	1	0.966	73157							
72157	1	0.73	74161							
73161	2	0.27	74161	0.002	75165					
74165	2	1	75165	0.11	76169					
73157	0									
74161	1	0.6	76165							
75165	2	0.4	76165	1	77169					
76169	1	0.84	78173							
76165	2	0.069	77166	1	78169					
77169	1	0.94	79173							
78173	2	0.06	79173	0.85	80177					
77166	1	0.15	79170							
78169	2	0.85	79170	1	80173					
79173	1	0.73	81177							
80177	1	1	82181							
79170	0									
80173	0									
81177	0									
82181	0									

Table 237: Chain of ${}^{143}_{61}Pm - c$

				Pb, Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
61143	2	1	62143	2.20E-05	63147				
62143	1	1	63143						
63147	2	1	64147	9.50E-05	65151				
63143	1	1	64143						
64147	2	1	65147	0.056	66151				
65151	1	0.944	66151						
64143	1	1	65143						
65147	2	1	66147	0.22	67151				
66151	2	0.78	67151	0.00022	68155				
65143	2	1	66143	1	67144				
66147	1	1	67147						
67151	2	1	68151	0.0089	69155				
68155	1	0.9911	69155						
66143	1	1	67143						
67144	0								
67147	1	1	68147						
68151	2	1	69151	0.89	70155				
69155	2	0.11	70155	0.001	71159				
67143	0								
68147	1	0.85	69147						
69151	3	1	70151	0.15	71152	0.9	71155		
70155	2	0.1	71155	0.35	72159				
71159	2	0.65	72159	0.002	73163				
69147	0								
70151	0								
71152	0								
71155	2	1	72155	0.34	73159				
72159	2	0.66	73159	0.13	74163				
73163	2	0.87	74163	0.01	75167				
72155	2	1	73156	0.999	74159				
73159	2	0.001	74159	0.32	75163				
74163	2	0.68	75163	0.57	76167				
75167	1	0.43	76167						
73156	1	0.09	75160						
74159	2	0.91	75160	1	76163				
75163	1	0.48	77167						
76167	2	0.2	77167	0.98	78171				
75160	0								
76163	2	1	77164	1	78167				
77167	0								
78171	2	0.02	79172	1	80175				
77164	0								
78167	1	1	80171						
79172	0								
80175	0								
80171	0								

Table 238: Chain of ${}^{136}_{60}Nd - c$

				Pb, Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
60136	1	1	61136						
61136	1	1	62136						
62136	1	0.9991	63136						
63136	0								

Table 239: Chain of ${}^{134}_{59}Pr - c^{*}$

				Pb					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)

				Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
59134	1	2	60134						
60134	2	1	61134	0.0002	62135				
61134	1	1	62134						
62135	1	1	63135						
62134	2	1	63134	0.02	64135				
63135	1	0.98	64135						
63134	0								
64135	0								

Table 240: Chain of ${}^{139}_{58}Ce - c$

				Pb, Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
58139	1	1	59139						
59139	1	1	60139						
60139	1	1	61139						
61139	1	1	62139						
62139	1	1	63139						
63139	2	0.005	64139	0.0026	65140				
64139	1	0.0026	66140						
65140	1	0.9974	66140						
66140	1	1	67141						
67141	0								

Table 241: Chain of ${}^{135}_{58}Ce - c$

				Pb, Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
58135	1	1	59135						
59135	1	1	60135						
60135	1	1	61135						
61135	2	0.9998	62135	0.0009	63136				
62135	1	1	63135						
63136	0								
63135	1	0.98	64135						
64135	0								

Table 242: Chain of $^{134}_{58}Ce - c$

Pb, Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
58134	1	1	59134						
59134	1	1	60134						
60134	2	1	61134	0.0002	62135				
61134	1	1	62134						
62135	1	1	63135						
62134	2	1	63134	0.02	64135				
63135	1	0.98	64135						
63134	0								
64135	0								

Table 243: Chain of $^{132}_{58}Ce - c$

Pb, Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
58132	1	1	59132						
59132	1	1	60132						
60132	1	1	61132						
61132	1	1	62132						
62132	0								

Table 244: Chain of $^{130}_{58}Ce - c$

Pb									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)

Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
58130	1	1	59130						
59130	1	1	60130						
60130	1	1	61130						
61130	1	1	62130						
62130	1	0.879	63131						
63131	0								

Table 245: Chain of $^{132}_{57}La - c$

Pb, Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
57132	1	1	58132						
58132	1	1	59132						
59132	1	1	60132						
60132	1	1	61132						
61132	1	1	62132						
62132	0								

Table 246: Chain of $^{133}_{56}Ba-c$

Pb, Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
56133	1	1	57133						
57133	1	1	58133						
58133	1	1	59133						
59133	1	1	60133						
60133	1	1	61133						
61133	1	1	62133						
62133	0								

Table 247: Chain of $^{131}_{56}Ba-c$

Pb, Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
56131	1	1	57131						
57131	1	1	58131						
58131	1	1	59131						
59131	2	1	60131	5.00E-07	61132				
60131	0								
61132	1	1	62132						
62132	0								

Table 248: Chain of $^{128}_{56}Ba-c$

Pb, Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
56128	1	1	57128						
57128	1	1	58128						
58128	2	1	59128	0.005	60129				
59128	1	1	60128						
60129	0								
60128	1	1	61128						
61128	0								

Table 249: Chain of $^{129}_{55}Cs-c$

Pb, Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
55129	1	1	56129						
56129	1	1	57129						
57129	1	0.01	58129						
58129	1	0.01	59129						
59129	1	0.005	60129						
60129	0								

Table 250: Chain of ${}^{127}_{54}Xe-c$

Pb, Bi										
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
54127	1	1	55127						
55127	1	1	56127						
56127	1	1	57127						
57127	1	1	58127						
58127	1	1	59127						
59127	1	1	60127						
60127	0								

Table 251: Chain of ${}^{125}_{54}Xe-c$

Pb									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)

Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
54125	1	1	55125						
55125	1	1	56125						
56125	1	1	57125						
57125	1	1	58125						
58125	1	1	59125						
59125	1	1	60125						
60125	0								

Table 252: Chain of ${}^{123}_{54}Xe-c$

Pb, Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
54123	1	1	55123						
55123	1	1	56123						
56123	1	1	57123						
57123	1	1	58123						
58123	0								

Table 253: Chain of ${}^{126}_{53}I-i$

Pb									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)

Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
53126	0								

Table 254: Chain of ${}^{124}_{53}I - i$

Pb									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)

Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
53124	0								

Table 255: Chain of ${}^{121}_{53}I - c^{*}$

Pb									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)

Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
53121	1	1.4604	54121						
54121	1	1	55121						
55121	1	1	56121						
56121	1	1	57121						
57121	1	0.99	58121						
58121	0								

Table 256: Chain of ${}^{121}_{52}Te - c$

Pb, Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
52121	1	1	53121						
53121	1	1	54121						
54121	1	1	55121						
55121	1	1	56121						
56121	1	1	57121						
57121	1	0.99	58121						
58121	0								

Table 257: Chain of $^{119}_{52}Te-c$

Pb									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)

Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
52119	1	1	53119						
53119	2	1	54119	7.00E-08	55120				
54119	1	1	55119						
55120	1	1	56120						
55119	1	0.75	56119						
56120	2	1	57120	0.01	58121				
56119	0								
57120	0								
58121	0								

Table 258: Chain of $^{116}_{52}Te-c$

Pb									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)

Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
52116	3	1	53116	2.90E-05	54117	2.00E-07	55120		
53116	1	1	54116						
54117	1	1	55117						
55120	1	1	56120						
54116	1	1	55116						
55117	1	1	56117						
56120	2	1	57120	0.01	58121				
55116	1	0.97	56116						
56117	1	0.061	57117						
57120	0								
58121	0								
56116	1	0.939	57117						
57117	0								

Table 259: Chain of $^{124}_{51}Sb-i(m1+m2+g)$

Pb, Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
51124	0								

Table 260: Chain of $^{122}_{51}Sb-i(m+g)$

Pb									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)

Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
51122	0								

Table 261: Chain of $^{115}_{51}Sb-c^{*}$

Pb									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)

Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
51115	1	1.2205	52115						
52115	1	1	53115						
53115	1	0.9966	54115						
54115	2	0.9993	55115	0.03	56116				
55115	1	1	56115						
56116	1	0.939	57117						
56115	0								
57117	0								

Table 262: Chain of $^{113}_{50}Sn-c$

Pb, Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
50113	1	1	51113						
51113	1	1	52113						
52113	1	1	53113						
53113	2	0.92993	54113	0.087	55114				
54113	0								
55114	0								

Table 263: Chain of $^{111}_{49}In-c$

Pb, Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
49111	1	1	50111						
50111	1	1	51111						
51111	1	1	52111						
52111	1	0.999	53111						
53111	1	0.92	54111						
54111	1	1	55112						
55112	0								

Table 264: Chain of $^{110}_{49}In-i$

Pb									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
49110	0								

Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)

Table 265: Chain of $^{109}_{49}In - c$

Pb, Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
49109	1	1	50109						
50109	1	1	51109						
51109	4	0.86695	52109	0.11	53110	7.00E-05	54113	3.31E-09	53113
52109	2	0.11	54110	0.00011	54113				
53110	2	0.709	54110	0.00018	55114				
54113	0								
53113	2	0.92993	54113	0.087	55114				
54110	0								
55114	0								

Table 266: Chain of $^{115}_{48}Cd - c$

Pb									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)

Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
48115	1	1	47115						
47115	1	1	46115						
46115	1	1	45115						
45115	1	1	44115						
44115	0								

Table 267: Chain of $^{105}_{47}Ag - c$

Pb, Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
47105	1	1	48105						
48105	1	1	49105						
49105	2	1	50105	5.00E-05	52109				
50105	2	0.99	51105	0.039	52109				
52109	2	0.11	54110	0.00011	54113				
51105	0								
54110	0								
54113	0								

Table 268: Chain of $^{100}_{46}Pd - c$

Pb, Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
46100	1	1	47100						
47100	1	1	48100						
48100	2	0.961	49100	1	50101				
49100	1	0.83	50100						
50101	0								
50100	0								

Table 269: Chain of $^{107}_{45}Rh - c$

Pb									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)

Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
45107	1	1	44107						
44107	1	1	43107						
43107	1	1	42107						
42107	2	1	41107	0.062	41108				
41107	2	1	40107	1	40108				
41108	0								
40107	2	1	39107	1	39108				
40108	0								
39107	0								
39108	1	0.01	40109						
40109	0								

Table 270: Chain of $^{105}_{45}Rh - c$

Pb, Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
45105	1	1	44105						
44105	1	1	43105						
43105	1	1	42105						
42105	1	1	41105						
41105	1	1	40105						
40105	0								

Table 271: Chain of $^{102}_{45}Rh - i$

Pb, Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
45102	0								

Table 272: Chain of $^{101}_{45}Rh-c$

Pb									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)

Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
45101	1	1	46101						
46101	1	1	47101						
47101	2	1	48101	9.30E-05	49102				
48101	1	1	49101						
49102	1	1	50102						
49101	0								
50102	1	1	52106						
52106	1	0.17	54110						
54110	0								

Table 273: Chain of $^{100}_{45}Rh-i(m+g)$

Pb, Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
45100	0								

Table 274: Chain of $^{100}_{45}Rh-c$

Pb, Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
45100	1	1	46100						
46100	1	1	47100						
47100	1	1	48100						
48100	2	0.961	49100	1	50101				
49100	1	0.83	50100						
50101	0								
50100	0								

Table 275: Chain of ${}^{106}_{44}Ru - c$

Pb									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
44106	1	1	43106						
43106	1	1	42106						
42106	1	1	41106						
41106	0								

Table 276: Chain of ${}^{103}_{44}Ru - c$

Pb, Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
44103	1	1	43103						
43103	1	1	42103						
42103	2	1	41103	0.0006	41104				
41103	1	1	40103						
41104	1	1	40104						
40103	1	0.92	39103						
40104	0								
39103	1	1	38103						
38103	0								

Table 277: Chain of ${}^{96}_{43}Tc - i(m+g)$

Pb, Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
43096	0								

Table 278: Chain of ${}^{99}_{42}Mo - c$

Pb, Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
42099	1	1	41099						
41099	1	1	40099						
40099	2	0.981	39099	0.0092	39100				
39099	2	0.999	38099	0.0078	38100				
39100	2	0.9922	38100	0.0237	38101				
38099	2	0.841	37099	0.06	37100				
38100	2	0.94	37100	0.28	37101				
38101	2	0.72	37101	0.18	37102				
37099	1	1	36099						
37100	1	1	36100						
37101	0								
37102	0								
36099	0								
36100	0								

Table 279: Chain of ${}^{96}_{41}Nb - i$

				Pb, Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
41096	0								

Table 280: Chain of ${}^{95}_{41}Nb - i(m+g)$

				Pb, Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
41095	0								

Table 281: Chain of ${}^{95}_{41}Nb - c$

				Pb, Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
41095	1	1	40095						
40095	1	1	39095						
39095	1	1	38095						
38095	2	0.9127	37095	0.14	37096				
37095	1	1	36095						
37096	0								
36095	1	1	35095						
35095	0								

Table 282: Chain of ${}^{90}_{41}Nb - c^{*}$

				Pb, Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
41090	1	1.615	42090						
42090	1	1	43090						
43090	1	1	44090						
44090	0								

Table 283: Chain of $^{97}_{40}Zr - c$

Pb, Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
40097	2	0.99945	39097	0.00331	39098				
39097	2	0.9995	38097	0.0025	38098				
39098	2	0.9975	38098	0.001	38099				
38097	2	0.749	37097	0.138	37098				
38098	2	0.862	37098	0.159	37099				
38099	2	0.841	37099	0.06	37100				
37097	1	0.005	36098						
37098	1	0.005	36098						
37099	1	1	36099						
37100	1	1	36100						
36098	0								
36099	0								
36100	0								

Table 284: Chain of $^{95}_{40}Zr - c$

Pb, Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
40095	1	1	39095						
39095	1	1	38095						
38095	2	0.9127	37095	0.14	37096				
37095	1	1	36095						
37096	0								
36095	1	1	35095						
35095	0								

Table 285: Chain of $^{89}_{40}Zr - c$

Pb, Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
40089	1	1	41089						
41089	1	1	42089						
42089	1	1	43089						
43089	1	0.9985	44089						
44089	1	1	45089						
45089	0								

Table 286: Chain of $^{88}_{40}Zr - c$

Pb, Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
40088	1	1	41088						
41088	1	1	42088						
42088	2	1	43088	0.0015	44089				
43088	0								
44089	1	1	45089						
45089	0								

Table 287: Chain of $^{88}_{39}Y - i$

Pb, Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
39088	0								

Table 288: Chain of $^{88}_{39}Y - c$

Pb, Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
39088	1	1	40088						
40088	1	1	41088						
41088	1	1	42088						
42088	2	1	43088	0.0015	44089				
43088	0								
44089	1	1	45089						
45089	0								

Table 289: Chain of $^{86}_{39}Y - c$

(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
Pb									
39086	1	1	40086						
40086	2	1	41086	0.15	42087				
41086	1	1	42086						
42087	1	1	43087						
42086	1	1	43086						
43087	0								
43086	0								
Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)

Table 290: Chain of $^{85}_{38}Sr - c$

(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
Pb, Bi									
38085	1	1	39085						
39085	1	1	40085						
40085	1	1	41085						
41085	1	1	42085						
42085	0								

Table 291: Chain of $^{86}_{37}Rb - i(m+g)$

(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
Pb, Bi									
37086	0								

Table 292: Chain of $^{84}_{37}Rb - i(m+g)$

(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
Pb, Bi									
37084	0								

Table 293: Chain of $^{83}_{37}Rb-c$

Pb, Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
37083	1	1	38083						
38083	1	1	39083						
39083	1	1	40083						
40083	1	1	41083						
41083	1	1	42083						
42083	0								

Table 294: Chain of $^{82}_{35}Br-i(m+g)$

Pb, Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
35082	0								

Table 295: Chain of $^{75}_{34}Se-c$

Pb, Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
34075	1	1	35075						
35075	1	1	36075						
36075	1	1	37075						
37075	1	0.935	38075						
38075	0								

Table 296: Chain of $^{76}_{33}As-i$

Pb									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)

Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
33076	0								

Table 297: Chain of $^{74}_{33}As-i$

Pb, Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
33074	0								

Table 298: Chain of $^{71}_{33}As - c$

Pb, Bi										
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
33071	1	1	34071						
34071	1	1	35071						
35071	1	0.948	36071						
36071	1	1	37072						
37072	0								

Table 299: Chain of $^{72}_{31}Ga - i$

Pb, Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
31072	0								

Table 300: Chain of $^{72}_{31}Ga - c$

Pb, Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
31072	1	1	30072						
30072	1	1	29072						
29072	1	1	28072						
28072	0								

Table 301: Chain of $^{72}_{30}Zn - c$

Pb, Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
30072	1	1	29072						
29072	1	1	28072						
28072	0								

Table 302: Chain of $^{65}_{30}Zn - c$

Pb									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
30065	1	1	31065						
31065	1	1	32065						
32065	1	1	33065						
33065	1	1	34065						
34065	0								

Table 303: Chain of $^{58}_{27}Co - i(m+g)$

Pb, Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
27058	0								

Table 304: Chain of $^{56}_{27}Co - c$

Pb, Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
27056	1	1	28056						
28056	2	0.65	30057	0.00023	31060				
30057	0								
31060	0								

Table 305: Chain of $^{59}_{26}Fe - c$

Pb, Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
26059	1	1	25059						
25059	1	1	24059						
24059	1	1	23059						
23059	1	1	22059						
22059	0								

Table 306: Chain of $^{54}_{25}Mn - i$

Pb, Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
25054	0								

Table 307: Chain of $^{52}_{25}Mn - c$

Pb									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)

Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
25052	1	1	26052						
26052	2	1	27052	0.45	28053				
27052	1	0.83	28052						
28053	2	0.5	29053	1	29054				
28052	2	0.83	29052	0.5	29053				
29053	0								
29054	1	0.5	30055						
29052	0								
30055	0								

Table 308: Chain of $^{48}_{23}V - c$

Pb, Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
23048	1	1	24048						
24048	2	0.99719	25048	0.52	26049				
25048	1	0.964	26048						
26049	1	0.5	27049						
26048	1	0.5	27049						
27049	1	0.5	28049						
28049	0								

Table 309: Chain of $^{48}_{21}Sc - i$

Pb, Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
21048	0								

Table 310: Chain of $^{46}_{21}Sc - i(m+g)$

Pb, Bi									
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
21046	0								

Table 311: Chain of $^{28}_{12}Mg - c$

				Pb, Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
12028	2	0.9942	11028	0.215	11029				
11028	2	0.84	10028	0.27	10029				
11029	2	0.73	10029	0.26	10030				
10028	1	1	9029						
10029	0								
10030	0								
9029	0								

Table 312: Chain of $^{24}_{11}Na - c$

				Pb, Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
11024	1	1	10024						
10024	2	0.941	9024	0.14	9025				
9024	1	0.82	8024						
9025	0								
8024	1	1	8025						
8025	0								

Table 313: Chain of $^{7}_{4}Be - i$

				Pb, Bi					
(Z, A)	Number of entries	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)	Branch. factor	(Z, A)
4007	0								

14 Appendix 3. The changes introduced into the LAHET code

The main change in the pre-equilibrium model was to substitute the value $g = A/12$ for the level density parameter of single-particle state nuclei with g $= 6a/\pi^2$ (the nuclear level density parameter of the Pb group nuclei is a $\cong$ 9).

In the end of the routine

$Function\ getg(e, iz, in, mode, is, getg0)$

$Getg = a/12$ was replaced with $Getg0 = a/12$

This means that, in the case of the proton interactions of interest with the PB and Bi isotopes, the LAHETO-estimated pre-equilibrium mechanism contribution is about two times as small as the LAHET code calculation data. The resulting value of the parameter g is close to the value $g = A/13$ used in the GHASH code to calculate nuclear reactions in the range of scattered particle energies below 0.2 GeV. It is this particular choice of the single-particle state density that permits the integral particle spectra to be quite properly described by the LAHETO code The LAHET code Coulomb barrier parameters that define the charged particle evaporation widths were modified with a view of constructing a sufficiently reliable evaporation model.

In the LAHET subroutine

$Subroutine\ CLECT(a, z, ja, jz, u, kfiss)$

the line

$Coulef = 0.846927^*d0^*flkcou(j)^*flz(j)^*zz/(rmass(mm) + rho(j))$

in the section

$C/////RALchannelprobabilitysection//////$

has been replaced with

$Coulef = 0.846927^*d0^*flkcou(j)^*flz(j)^*zz/(rmass(mm)^*0.9^*d0 + rho(j))$

An updated fission-channel parametrization procedure has been adopted. The cross sections for fission of high-energy proton-irradiated Pb and Bi are known to rise with incresing particle energies up to 400-600 MeV, to reach saturation afterwards. This type energy dependence of the fission cross section at the proton-scattered proton energies of 50-200 MeV can well be described in terms of the LAHETO code mainly by introducing the energy function in the relation a_f/a_n.

The common block $common/comon/apr, cosks, cosphi, costh, d, delsig, dkwt, emax,$
has been introduced to the routine $Functionfprob(z, a, u)$,
while the line

$af = an^*(c1 + c2^*af^*af)$

is replaced with

$acorre = dmax1(0.006^*d0, 0.000012^*d0 * emax)$

$af = an^*(c1 + c2^*af^*af + acorre)$

Besides, the fission barriers have been corrected with a view of getting a fission cross section that would agree with experimental data or with the Prokofiev approximation.

In the routine

$Functionfprob(z, a, u)$,

the line

$ef = x^*(a1^*x - a2) + a3 + se$

has been replaced with

$$ef = x^*(a1^*x - a2) + a3 + se - 0.7^*d0.$$

The parameters of the fission fragment mass distribution have been also specified.

In the subroiutine $Subroutine\ fissed(ja, jz, u, erec)$,
the line

$$sigmas = 0.425^*d0^*(upr^*(dp1 - 0.005^*d0^*upr) + 9.35^*d0)$$

has been replaced with

$$sigmas = 0.300^*d0^*(upr^*(dp1 - 0.005^*d0^*upr) + 9.35^*d0)$$

Nuclear Data Section
International Atomic Energy Agency
Vienna International Centre, P.O. Box 100
A-1400 Vienna
Austria

e-mail: services@iaeand.iaea.org
fax: (43-1) 26007
telephone: (43-1) 2600-21710
Web: http://www-nds.iaea.org