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EXPERIMENTAL AND THEORETICAL STUDY OF THE RESIDUAL NUCLIDE PRODUCTION IN 40-2600 MeV PROTON-IRRADIATED THIN TARGETS OF ADS STRUCTURE MATERIALS

Prepared by

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Abstract

The Project is aimed at experimental and theoretical studying the independent and cumulative yields of residual radioactive nuclei produced in high-energy proton-irradiated structure materials intended for constructing the high-power Accelerator-Driven Systems (ADS) with a high-current proton accelerator. The Project is an extension of the researches carried out earlier under the ISTC Projects #017, #839, and #2002 which provided more 10000 residual nuclide production cross sections mainly in materials intended to use as target materials of the ADS. This Project includes 57 measurement runs carried out using the 97 targets made only of the ADS structural materials of both monoisotopic (^{56}Fe, ^{93}Nb, ^{181}Ta) and natural (^{nat}Cr, ^{nat}Ni, ^{nat}W) compositions within minutely fractionated proton energy range, namely, at 0.04, 0.07, 0.1, 0.15, 0.25, 0.4, 0.6, 0.8, 1.2, 1.6 and 2.6GeV. All the targets were irradiated using the ITEP U-10 proton synchrotron.

The experimental nuclide yields are determined by the direct γ-spectrometry and α-spectrometry methods. As a result, 3839 cumulative and independent yields of residual β-radioactive product nuclei with lifetimes range from 6 minutes to 10 years as well as 12 cumulative yields of α-radioactive ^{148}Gd whose lifetime is 74.6 years have been measured. Besides, the cross sections for the ^{27}Al(p,x)^{22}Na , ^{27}Al(p,x)^{24}Na and ^{27}Al(p,x)^{7}Be monitor reactions have been measured at the same proton energies with the use of the current transformer technique. The γ-spectrometer resolution is 1.8 keV in the 1332 keV ^{60}Co γ-line. The experimental γ-spectra were processed by the GENIE2000 code. The γ-lines were identified, and the cross sections calculated, by the ITEP-developed SIGMA code using the PCNUDAT database. The proton fluence was monitored by the ^{27}Al(p,x)^{22}Na reaction.

Measurement data have been compared with the calculation results of the BERTINI and ISABEL models of MCNPX code, CEM03.02, INCL 4.2, INCL4.5, CASCADE07, and PHITS codes. 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

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Content

1. INTRODUCTION: BRIEF DESCRIPTION OF ACTIVITY, OBJECTIVES OF THE PROJECT, EXPECTED RESULTS, TECHNICAL APPROACH

The Project is aimed at experimental and theoretical studying the independent and cumulative yields of residual radioactive nuclei produced in high-energy proton-irradiated structure materials intended for constructing the high-power Accelerator-Driven Systems (ADS) with a high-current proton accelerator

During 2006-2009 we made 57 irradiations of 97 samples made of ADS structure materials of both monoisotopic (^{56}Fe, ^{93}Nb, ^{181}Ta) and natural (^{nat}Cr, ^{nat}Ni, ^{nat}W) compositions by protons with energies 0.04 GeV, 0.07 GeV, 0.1 GeV, 0.15 GeV. 0.25 GeV, 0.4 GeV, 0.6 GeV, 0.8 GeV, 1.2 GeV, 1.6 GeV and 2.6 GeV[1]. Foils of W and Ta were additionally irradiated by 0.6, 0.8, 1.6 and 2.6GeV with a view of subsequent measurements of alpha-active ^{148}Gd ($T_{1/2}$=74,6 year).

The ITEP U-10 synhrotron was used to irradiate the targets. In total, 1841 gamma- and 25 alpha-specra were measured after irradiations which carry *unique experimental data* of about 263 Mb capacity. After the measured gamma had been identified, 3385 *independent and cumulative yields (cross-section for production) of residual radioactive product nuclei in the irradiated* samples were determined, of which 726 are independent (signed as (i)) yields; 365 sums of independent metastable and the ground state yields (i (Σmj+g)); 365 independent yields of a metastable states (i (Σmj); 2409 cumulative and supracumulative yields (c, c*).

The experimental samples were irradiated together with aluminum monitors using with the ITEP U-10 proton synchrotron beams. The experimental samples and the Al monitors of strictly identical 10.5-mm diameter were irradiated simultaneously. The ^{27}Al(p,x)^{22}Na reaction monitored the proton flux.

After irradiation, a sample-monitor sandwiches were delivered to the “Hot Laboratory”, disassembled in the manual handling box and transported then to the laboratory room, where the pre-calibrated Ge detectors measured the gamma spectra of both the sample and the monitor. The measurements of the samples from a single irradiation run lasted for about 6 months. The laboratory room were thermostatted to keep temperature constant throughout long-term measurement periods.

The measured gamma-spectra will be processed tentatively by the job-oriented GENIE2000 code in the common mode and, finally, by that same code, with inspecting each of the spectra by interactive fitting every peak. After the entire set of spectra from a given measurement run are

[1] ^{56}Fe was additionally irradiated by 0.3, 0.5, 0.75, 1.0 and 1.5 GeV protons.

processed finally, they will be combined to form a unified file used as input to the SIGMA code that identifies the spectra on the basis of the PCNUDAT nuclear database and determines the yields (cross sections for production) of the radioactive product nuclei by the techniques described in *Nucl. Instr. and Meth. A414 (1998)73-99 and in PRC C65, 064610 (2002), PRC C78, 034611 (2008)* [1-7].

The alpha-active nuclide (^{148}Gd) production was measured using the purposed, a few hours long, irradiation of Ta and W foils until a sufficient amount of ^{148}Gd is accumulated to have an appropriate statistics support of the alpha-spectra measurements. The spectra were measured on Si-detector basis.

As the gamma-, and alpha-spectra were processed, and the final data accumulated, use was made of the job-oriented database that contains information on the experimental samples and monitors, irradiation modes, the gamma-, and alpha-spectra measured, the spectrometer calibration data, and the results of processing the gamma-spectra and determining the reaction product yields.

The obtained experimental yields will be simulated by MCNPX (BERTINI, ISABEL), CEM03.02, INCL4+ABLA, INCL4.5.5+ABLA07, PHITS, CASCADE07 and partially by CAMO, GEMCAMO, CASCADO codes

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1.1 Information analysis on the of ADS facility structural material nuclear-physics characteristics

Analyzing the EXFOR database for 20-3000 MeV proton energy range has shown that

- 11 works on $^{nat,52,50}Cr$ have measured 20 excitation functions and 223 cross sections;
- 87 works on $^{nat,56,54}Fe$ have measured 256 excitation functions and 14499 cross sections;
- 84 works on $^{Nat,64,62,60,58}Ni$ have measured 19 excitation functions and 3428 cross sections; EXFOR is void of ^{61}Ni data;
- 23 works on ^{93}Nb have measured 13 excitation functions and 1952 cross sections;
- 26 works on ^{181}Ta have measured 215 excitation functions and 1487 cross sections;
- 23 works on $^{nat,186,184,183,182}W$ have measured 581 excitation functions;

As found in EXFOR, the product nuclides from Cr,Fe,Ni,Nb,Ta,W(p,x) reactions are listed in Tables 1.2.1 – 1.2.6, respectively

The works indicated as EXFOR codes in Tables 1.2.1-1.2.9 are presented in Table 1.2.10.

Table 1.2.1. The EXFOR-listed product nuclides measured in Cr(p,x) reactions.

EXFOR Code number	Energy range	Numbers of energies	Cross sections measured	Numbers of excitation functions measured	Nuclides measured	Monitor reactions	Irradiation type	Year
^{nat}Cr								
A0168	22 MeV	1	2		^{51}Cr, ^{52}Mn		stack	1981
C0336	6.3-26.91 MeV	15	15	1	^{52}Mn			1987
E1923	100-230 MeV	3	18	5	^{7}Be, ^{44m}Sc, ^{46}Sc, ^{47}Sc, ^{48}Sc, ^{48}Cr, ^{51}Cr, ^{42}K, ^{41}Ar, ^{49}Cr, ^{43}K		stack	2004
O0078	660 MeV	10	10		^{22}Na, ^{43}K, ^{47}Ca, ^{46}Sc, ^{47}Sc, ^{48}Sc, ^{48}V, ^{48}Cr, ^{51}Cr, ^{52}Mn	^{27}Al(P,X)^{22}Na	stack	1989
O0350	18.8-43.5 MeV	5	6	1	^{51}Cr, ^{52}Mn	^{27}Al(P,X)^{22}Na	stack	1976
O0412	400 MeV	1	1		^{24}Na	^{27}Al(P,X)^{22}Na, ^{27}Al(P,X)^{24}Na	stack	1967
O0771	17.39-38.08 MeV	15	134	11	^{51}Mn, ^{54}Mn, ^{52}Mn, ^{52m}Mn, ^{48}Cr, ^{49}Cr, ^{51}Cr, ^{48}V, ^{45}Ti	^{27}Al(P,X)^{22}Na, ^{27}Al(P,X)^{24}Na, Cu(P,X)^{62}Zn, Cu(P,X)^{63}Zn, Cr(P,X)^{52}Mn	stack	2000
^{50}Cr								
A0510	13.8-29.5 MeV	18	18	1	^{49}Cr	Mo(A,X)^{97}Ru, Mo(P,X)^{96}Tc		1991
^{52}Cr								
A0195	22 MeV	1	1		^{51}Cr		stack	1983
A0510	14.8-29.5 MeV	17	17	1	^{51}Cr	Mo(A,X)^{97}Ru, Mo(P,X)^{96}Tc		1991
B0050	21.5 MeV	1	1		^{51}Cr	^{63}Cu(P,X)^{63}Zn, ^{56}Fe(P,X)^{55}Co		1955

Table 1.2.2. The EXFOR-listed product nuclides measured in Fe(p,x) reactions.

EXFOR code number	Energy range	Numbers of energies	Cross sections measured	Numbers of excitation functions measured	Nuclides measured	Monitor reactions	Irradiation type	Year
^{nat}Fe								
A0100	49.3-199.8 MeV	26	257	11	^{48}Sc, ^{48}V, ^{48}Cr, ^{51}Cr, ^{52}Mn, ^{54}Mn, ^{56}Co, ^{57}Co, ^{44m}Sc, ^{46}Sc,	^{27}Al(P,X)^{22}Na	stack	1983

EXFOR code number	Energy range	Numbers of energies	Cross sections measured	Numbers of excitation functions measured	Nuclides measured	Monitor reactions	Irradiation type	Year
					^{47}Sc			
A0146	7.41-44.53 MeV	25	160	9	^{57}Co, ^{56}Co, ^{55}Co, ^{58}Co, ^{52}Fe, ^{52}Mn, ^{54}Mn, ^{51}Cr, ^{48}V	$^{197}Au(P,X)^{196}Au$	stack	1979
A0168	22 MeV	1	3		^{55}Fe, ^{56}Co, ^{57}Co		stack	1981
A0179	5.8-63.65 MeV	52	52	7	^{56}Co, ^{54}Mn, ^{57}Co, ^{58}Co, ^{48}V, ^{52}Mn, ^{51}Cr		stack	1979
A0182	15.66-38.9	80	80	3	^{56}Co, ^{52}Mn, ^{55}Co		stack	1979
A0339	7.11-64.4 MeV	70	243	5	^{48}V, ^{51}Cr, ^{52}Mn, ^{54}Mn, ^{56}Co	$^{27}Al(P,X)^{22}Na$, $^{27}Al(P,X)^{24}Na$	stack	1987
A0344	600 MeV	1	14		^{22}Na, ^{43}K, ^{44m}Sc, ^{46}Sc, ^{47}Sc, ^{48}V, ^{7}Be, ^{48}Cr, ^{51}Cr, ^{54}Mn, ^{56}Co, ^{57}Co, ^{58}Co, ^{26}Al		stack	1986
A0408	600 MeV	1	5		^{22}Na, ^{54}Mn, ^{57}Co		single target	1988
A0435	800-2600 MeV	3	43	14	^{7}Be, ^{22}Na, ^{24}Na, ^{42}K, ^{43}K, ^{44m}Sc, ^{46}Sc, ^{48}Sc, ^{48}V, ^{48}Cr, ^{51}Cr, ^{52}Mn, ^{54}Mn, ^{56}Co, ^{57}Co, ^{58}Co		stack	1989
A0479	61.7-2600 MeV	10	11		10Be, 26Al		stack	1990
A0501	1 GeV	1	21		^{57}Co, ^{56}Co, ^{55}Co, ^{52}Fe, ^{56}Mn, ^{52}Mn, ^{54}Mn, ^{51}Cr, ^{48}V, ^{48}Sc, ^{47}Sc, ^{46}Sc, ^{44}Sc, ^{44m}Sc, ^{43}Sc, ^{43}K, ^{42}K, ^{28}Mg, ^{24}Na, ^{22}Na, ^{7}Be	$^{27}Al(P,X)^{22}Na$	stack	1990
A0516	1600 MeV	1	1		^{58}Co	$^{27}Al(P,X)^{22}Na$	stack	1992
A0519	1600 MeV	1	19		^{57}Co, ^{56}Co, ^{55}Co, ^{54}Mn, ^{52}Mn, ^{51}Cr, ^{48}Cr, ^{48}V, ^{48}Sc, ^{47}Sc, ^{46}Sc, ^{44}Sc, ^{47}Ca, ^{43}K, ^{42}K, ^{28}Mg, ^{24}Na, ^{22}Na, ^{7}Be	$^{27}Al(P,X)^{22}Na$	stack	1993
A0748	650 MeV	1	19		^{24}Na, ^{41}Ar, ^{42}K, ^{43}K, ^{43}Sc, ^{44m}Sc, ^{44}Sc, ^{46}Sc, ^{48}Sc, ^{48}V, ^{48}Cr, ^{49}Cr, ^{52}Mn, ^{54}Mn, ^{52}Fe, ^{56}Co, ^{47}Sc, ^{51}Cr, ^{52}Mn	$^{27}Al(P,X)^{22}Na$, $^{27}Al(P,X)^{24}Na$, $^{27}Al(P,X)^{9}Be$		2006
A0811	1 GeV	1	1		^{17}N		single target	2007
B0073	7.1-63.1 MeV	125	125	7	^{48}V, ^{51}Cr, ^{52}Mn, ^{54}Mn, ^{56}Co, ^{55}Co, ^{52}Fe		stack	1967
B0085	590 MeV	1	62		^{56}Mn, ^{52}Fe, ^{53}Fe, ^{56}Co, ^{50}Mn, ^{54}Mn,	$^{27}Al(P,X)^{24}Na$	single target	1971

EXFOR code number	Energy range	Numbers of energies	Cross sections measured	Numbers of excitation functions measured	Nuclides measured	Monitor reactions	Irradiation type	Year
					^{48}Cr, ^{49}Cr, ^{51}Cr, ^{48}V, ^{52}V, ^{53}V, ^{43}Sc, ^{47}Sc, ^{41}Ar, ^{38}K, ^{42}K, ^{43}K, ^{34m}Cl, ^{38}Cl, ^{39}Cl, ^{24}Na, ^{28}Al, ^{29}Al, ^{44}Sc, ^{44m}Sc, ^{46}Sc, ^{46m}Sc, ^{48}Sc, ^{52}Mn, ^{52m}Mn, ^{56}Co			
C0226	730 MeV	1	11		^{10}Be, ^{54}Mn, ^{51}Cr+^{51}Mn, ^{49}V+^{49}Cr, ^{44}Ti, ^{46}Sc, ^{45}Ca, ^{40}K, ^{42}Ar, ^{32}Si	Fe(P,X)^{10}Be		1964
C0235	500-730 MeV	2	24		^{54}Mn, ^{52}Mn, ^{43}K, ^{42}K, ^{39}Cl, ^{38}Cl, ^{36}Cl, ^{34m}Cl, ^{34m}Cl+^{38}Cl, ^{26}Al, ^{22}Na, ^{7}Be			1960
C0253	100-300 MeV	3	6	2	^{22}Na, ^{24}Na	^{27}Al(P,X)^{22}Na		1970
C0272	14.1-585 MeV	10	61		^{57}Co, ^{56}Co, ^{54}Mn, ^{55}Co, ^{52}Mn, ^{51}Cr, ^{48}Cr, ^{48}V, ^{48}Sc, ^{47}Sc, ^{46}Sc, ^{44m}Sc, ^{44}Ti, ^{43}K, ^{42}K, ^{24}Na, ^{22}Na	^{27}Al(P,X)^{24}Na, Fe(P,X)^{57}Co		1971
C0275	340 MeV	1	30		^{56}Co, ^{55}Co, ^{52}Fe, ^{56}Mn, ^{54}Mn, ^{52}Mn, ^{51}Mn, ^{51}Cr, ^{49}Cr, ^{48}Cr, ^{49}V, ^{48}V, ^{47}V, ^{45}Ti, ^{48}Sc, ^{47}Sc, ^{46}Sc, ^{44}Sc, ^{47}Ca, ^{45}Ca, ^{43}K, ^{42}K, ^{39}Cl, ^{38}Cl, ^{34}Cl, ^{35}S, ^{32}P, ^{31}Si, ^{24}Na, ^{22}Na	^{27}Al(P,X)^{24}Na		1952
C0276	0.16-6.2 GeV	4	7	2	^{3}H, ^{37}Ar	^{27}Al(P,X)^{24}Na, ^{197}Au(P,X)^{149}Tb		
C0277	0.16-3 GeV	3	11	2	^{3}He, ^{4}He, ^{36}Ar, ^{37}Ar, ^{38}Ar, ^{39}Ar, ^{21}Ne	^{27}Al(P,X)^{24}Na		1959
C0293	550 MeV	1	2		^{32}P, ^{33}P	^{27}Al(P,X)^{22}Na		1970
C0401	85 MeV	1	1		^{7}Be	^{27}Al(P,X)^{24}Na	stack	1966
C0555	139.7-500 MeV	6	6	1	^{14}C			1998
C0836	450 MeV	1	1		^{1}H	^{27}Al(P,X)^{24}Na		1956
C1447	140-600 MeV	6	35	6	^{46}Sc, ^{48}V, ^{51}Cr, ^{52}Mn, ^{54}Mn, ^{56}Co	^{27}Al(P,X)^{22}Na		2006
D0260	8.95-43.8 MeV	13	31	4	^{56}Co, ^{57}Co, ^{52}Mn, ^{54}Mn		single target	1976
D4026	5-45 MeV	81	81	1	^{56}Co	^{63}Cu(P,X)^{63}Zn, ^{63}Cu(P,X)^{62}Zn, ^{65}Cu(P,X)^{65}Zn,	stack	1994
D4058	5.6-23.9 MeV	31	31	2	^{4}He, ^{56}Co			1991

EXFOR code number	Energy range	Numbers of energies	Cross sections measured	Numbers of excitation functions measured	Nuclides measured	Monitor reactions	Irradiation type	Year
D4181	42-67.2 MeV	11	80	9	^{56}Co, ^{55}Co, ^{57}Co, ^{52}Mn, ^{54}Mn, ^{48}V, ^{51}Cr, ^{48}Cr, ^{47}Sc	$^{27}Al(P,X)^{24}Na$, $^{27}Al(P,X)^{22}Na$, $Cu(P,X)^{62}Zn$, $Cu(P,X)^{65}Zn$, $Cu(P,X)^{56}Co$, $Cu(P,X)^{58}Co$	stack	2004
E1251	500 MeV	1	21		^{22}Na, ^{24}Na, ^{43}K, ^{43}Sc, ^{47}Sc, ^{48}V, ^{51}Cr, ^{56}Mn, ^{55}Co, ^{56}Co, ^{57}Co, ^{7}Be, ^{42}K, ^{44m}Sc, ^{44}Sc, ^{46}Sc, ^{48}Sc, ^{52}Mn, ^{54}Mn, ^{52}Fe		stack	1991
E1923	100-230 MeV	2	32	14	^{44m}Sc, ^{46}Sc, ^{47}Sc, ^{48}Sc, ^{54}Mn, ^{52}Fe, ^{58}Co, ^{48}Cr, ^{49}Cr, ^{51}Cr, ^{56}Mn, ^{55}Co, ^{56}Co, ^{57}Co, ^{7}Be, ^{42}K, ^{44}Sc, ^{46}Sc, ^{41}Ar, ^{43}K		stack	2004
O0073	130-396 MeV	4	28	7	^{56}Co, ^{54}Mn, ^{52}Mn, ^{51}Cr, ^{48}V, ^{32}P, ^{7}Be			1964
O0077	0.5-2.9 CeV	5	55	11	^{56}Co, ^{54}Mn, ^{52}Mn, ^{51}Cr, ^{48}Cr, ^{48}V, ^{47}Sc, ^{44m}Sc, ^{32}P, ^{24}Na, ^{7}Be		single target	1968
O0078	660 MeV	1	16		^{22}Na, ^{26}Al, ^{44m}Sc, ^{10}Be, ^{7}Be, ^{43}K, ^{46}Sc, ^{47}Sc, ^{48}V, ^{48}Cr, ^{51}Cr, ^{52}Mn, ^{54}Mn, ^{56}Co, ^{57}Co, ^{58}Co	$^{27}Al(P,X)^{22}Na$	stack	1989
O0080	57-2600 MeV	14	19	2	^{22}Na, ^{10}Be	$^{27}Al(P,X)^{22}Na$	stack	1991
O0085	0.6-21 CeV	2	28	13	^{7}Be, ^{10}Be, ^{45}Sc, ^{46}Sc, ^{49}V, ^{50}V, ^{51}V, ^{50}Cr, ^{51}Cr, ^{52}Cr, ^{53}Cr, ^{54}Cr, ^{53}Mn, ^{54}Mn, ^{55}Mn			1976
O0088	600 MeV	1	8		^{56}Co, ^{54}Mn, ^{52}Mn, ^{51}Cr, ^{48}V, ^{47}Sc, ^{46}Sc, ^{44m}Sc	$^{27}Al(P,X)^{22}Na$, $^{27}Al(P,X)^{24}Na$, $^{27}Al(P,X)^{7}Be$		1975
O0094	1-2 GeV	2	4	2	^{22}Na, ^{7}Be	$^{12}C(P,X)^{7}Be$	stack	1975
O0095	0.15-24 GeV	4	10	4	^{36}Ar, ^{38}Ar, ^{39}Ar, ^{42}Ar	$^{27}Al(P,X)^{22}Na$	stack	1979
O0098	800-2600 MeV	3	6	2	^{22}Na, ^{7}Be	$^{27}Al(P,X)^{22}Na$	stack	1990
O0103	750 MeV	1	4		^{4}He, ^{3}He	$^{27}Al(P,X)^{22}Na$		1988
O0104	108-600 MeV	4	4	1	^{41}Ca			1987
O0154	0.1383-23.9 GeV	13	13	1	^{3}H		single target	1976

EXFOR code number	Energy range	Numbers of energies	Cross sections measured	Numbers of excitation functions measured	Nuclides measured	Monitor reactions	Irradiation type	Year
O0159	660 MeV	1	30		^{57}Co, ^{56}Co, ^{55}Co, ^{52}Fe, ^{56}Mn, ^{52}Mn, ^{52m}Mn, ^{54}Mn, ^{51}Cr, ^{49}Cr, ^{48}Cr, ^{48}V, ^{48}Sc, ^{47}Sc, ^{46}Sc, ^{44}Sc, ^{44m}Sc, ^{43}Sc, ^{43}K, ^{42}K, ^{41}Ar, ^{39}Cl, ^{38}Cl, ^{34m}Cl, ^{28}Mg, ^{24}Na, ^{22}Na, ^{7}Be, ^{53}Fe	^{27}Al(P,X)^{22}Na	stack	1995
O0276	7.35-329 MeV	84	659	21	^{58}Co, ^{57}Co, ^{56}Co, ^{55}Co, ^{52}Fe, ^{52}Mn, ^{54}Mn, ^{51}Cr, ^{44}Ti, ^{48}V, ^{48}Sc, ^{47}Sc, ^{46}Sc, ^{44m}Sc, ^{43}K, ^{42}K, ^{36}Cl, ^{26}Al, ^{48}Cr, ^{10}Be, ^{7}Be	^{27}Al(P,X)^{22}Na, Cu(P,X)^{65}Zn	stack	1997
O0277	600-2600 MeV	5	106	27	^{58}Co, ^{57}Co, ^{56}Co, ^{55}Co, ^{52}Mn, ^{54}Mn, ^{51}Cr, ^{48}V, ^{48}Sc, ^{47}Sc, ^{46}Sc, ^{44m}Sc, ^{47}Ca, ^{43}K, ^{42}K, ^{36}Cl, ^{26}Al, ^{48}Cr, ^{10}Be, ^{7}Be, ^{38}Ar, ^{36}Ar, ^{28}Mg, ^{24}Na, ^{22}Na, ^{22}Ne, ^{21}Ne, ^{20}Ne, ^{4}He, ^{3}He	^{27}Al(P,X)^{22}Na	stack	1995
O0281	57.9-2600 MeV	13	14	2	^{10}Be, ^{26}Al	^{27}Al(P,X)^{22}Na	stack	1990
O0283	150 MeV	1	38		^{56}Co, ^{55}Co, ^{55}Fe, ^{53}Fe, ^{52}Fe, ^{56}Mn, ^{54}Mn, ^{52}Mn, ^{51}Mn, ^{51}Cr, ^{49}Cr, ^{48}Cr, ^{48}V, ^{47}V, ^{45}Ti, ^{47}Sc, ^{46}Sc, ^{44}Sc, ^{43}Sc, ^{47}Ca, ^{45}Ca, ^{43}K, ^{42}K, ^{39}Cl, ^{38}Cl, ^{34m}Cl, ^{38}S, ^{35}S, ^{33}P, ^{32}P, ^{31}Si, ^{28}Mg, ^{24}Na, ^{22}Na, ^{18}F, ^{11}C, ^{7}Be	^{27}Al(P,X)^{24}Na		1963
O0284	214-399 MeV	24	176	17	^{57}Co, ^{58}Co, ^{56}Co, ^{55}Co, ^{54}Mn, ^{52}Mn, ^{48}Cr, ^{48}V, ^{47}Sc, ^{46}Sc, ^{44m}Sc, ^{43}K, ^{42}K, ^{36}Cl, ^{26}Al, ^{22}Na, ^{10}Be, ^{7}Be	^{27}Al(P,X)^{22}Na, ^{27}Al(P,X)^{24}Na	stack	1996

EXFOR code number	Energy range	Numbers of energies	Cross sections measured	Numbers of excitation functions measured	Nuclides measured	Monitor reactions	Irradiation type	Year
O0299	660 MeV	1	38		^{56}Co, ^{55}Co, ^{55}Fe, ^{53}Fe, ^{52}Fe, ^{56}Mn, ^{54}Mn, ^{52}Mn, ^{51}Mn, ^{51}Cr, ^{49}Cr, ^{48}Cr, ^{48}V, ^{47}V, ^{47}V, ^{45}Ti, ^{47}Sc, ^{46}Sc, ^{44m}Sc, ^{43}Sc, ^{47}Ca, ^{45}Ca, ^{43}K, ^{42}K, ^{39}Cl, ^{38}Cl, ^{34m}Cl, ^{38}S, ^{35}S, ^{33}P, ^{32}P, ^{31}Si, ^{28}Mg, ^{24}Na, ^{22}Na, ^{18}F, ^{11}C, ^{7}Be	^{27}Al(P,X)^{24}Na		1963
O0304	130-450 MeV	2	2	1	^{3}H		stack	1967
O0305	2.05-6.2 GeV	2	2	1	^{3}H	^{27}Al(P,X)^{18}F	stack	1959
O0307	2.2 GeV	1	7		^{3}H	^{27}Al(P,X)^{24}Na	stack	1955
O0308	0.15-24 GeV	3	3	1	^{36}Cl	^{27}Al(P,X)^{22}Na	stack	1977
O0339	1.1 GeV	1	18		^{56}Mn, ^{53m}Fe, ^{53}Fe, ^{48}Cr, ^{49}Cr, ^{48}V, ^{42}K, ^{43}K, ^{38}Cl, ^{24}Na, ^{38}S, ^{41}Ar, ^{44}Sc, ^{44m}Sc, ^{47}Sc, ^{48}Sc, ^{52}Mn, ^{52m}Mn			1990
O0342	150MeV	1	1		^{3}H	^{27}Al(P,X)^{22}Na, ^{27}Al(P,X)^{24}Na, C(P,X)^{11}C, ^{12}C(P,X)^{7}Be		1962
O0353	69.8-2600 MeV	14	14		^{36}Cl	^{27}Al(P,X)^{22}Na	stack	1996
O0361	0.16-0.43 GeV	2	13	2	^{4}He, ^{3}He, ^{3}H, ^{39}Ar, ^{38}Ar, ^{37}Ar, ^{36}Ar		single target	1958
O0376	1000 MeV	1	19		^{57}Co, 5^{6}Co, ^{55}Co, ^{52}Fe, ^{56}Mn, ^{54}Mn, ^{52}Mn, ^{51}Cr, ^{48}Cr, ^{48}V, ^{48}Sc, ^{46}Sc, ^{44m}Sc, ^{43}K, ^{42}K, ^{28}Mg, ^{24}Na, ^{22}Na	^{27}Al(P,X)^{22}Na, ^{27}Al(P,X)^{7}Be		1989
O0378	1000 MeV	1	18		^{56}Co, ^{55}Co, ^{52}Fe, ^{56}Mn, ^{54}Mn, ^{52}Mn, ^{51}Cr, ^{48}Cr, ^{48}V, ^{48}Sc, ^{47}Sc, ^{46}Sc, ^{44m}Sc, ^{44}Sc, ^{43}Sc, ^{43}K, ^{42}K, ^{24}Na			1997
O0410	150-600 MeV	3	12	5	^{47}Sc, ^{46}Sc, ^{44m}Sc, ^{43}K, ^{42}K	^{27}Al(P,X)^{22}Na		1975
O0412	400 MeV	1	2		^{24}Na, ^{22}Na	^{27}Al(P,X)^{22}Na, ^{27}Al(P,X)^{24}Na	stack	1967
O0476	9.61-23.2 MeV	15	15	1	^{4}He			1960
O0498	3-30 MeV	28	174	7	^{58}Co, ^{57}Co, ^{56}Co, ^{55}Co, ^{54}Mn, ^{53}Fe, ^{52}Mn		stack	1997
O0584	0.59-18.3 GeV	2	14	2	^{45}K, ^{44}K, ^{43}K, ^{38}K, ^{42}K	^{27}Al(P,X)^{24}Na		1965

EXFOR code number	Energy range	Numbers of energies	Cross sections measured	Numbers of excitation functions measured	Nuclides measured	Monitor reactions	Irradiation type	Year
O0664	558 MeV		1072		1H, 2H			1976
O0728	86.7-352.7 MeV	17	129	9	^{55}Co, ^{48}V, ^{47}Sc, ^{44m}Sc, ^{52}Fe, ^{54}Mn, ^{52}Mn, ^{21}Cr, ^{48}Cr	^{27}Al(P,X)^{22}Na, ^{27}Al(P,X)^{24}Na, Cu(P,X)^{62}Zn	stack	1999
O0729	86.7-352.8 MeV	13	13	1	7Be	^{27}Al(P,X)^{22}Na, ^{27}Al(P,X)^{24}Na, Cu(P,X)^{62}Zn	stack	1998
O0803	17.2-1600 MeV	16	16	1	^{53}Mn		stack	2000
O1229	17.2-2600 MeV	16	17	1	^{53}Mn		stack	2000
O1305	1200 MeV	1	13		^{1}H, ^{2}H, ^{3}H, ^{3}He, ^{4}He, ^{6}He, ^{6}Li, ^{7}Li, ^{8}Li, ^{9}Li, ^{7}Be, ^{9}Be, ^{10}Be			2006
O1631	4.77-24.94 MeV	5	60	5	^{52}Cr, ^{54}Mn, ^{55}Fe, ^{56}Fe, ^{56}Co			2007
T0131	590 MeV	1	19		^{57}Co, ^{56}Co, ^{55}Co, ^{52}Fe, ^{54}Mn, ^{52}Mn, ^{51}Cr, ^{48}Cr, ^{48}V, ^{48}Sc, ^{47}Sc, ^{46}Sc, ^{44m}Sc, ^{43}K, ^{42}K, ^{28}Mg, ^{24}Na, ^{22}Na, ^{7}Be	^{27}Al(P,X)^{24}Na		1976
T0149	750 MeV	1	2		^{3}He, ^{4}He	^{27}Al(P,X)^{22}Na	stack	1988
T0276	5.8-52.7 MeV	47	49	7	^{58}Co, ^{57}Co, ^{56}Co, ^{48}V, ^{54}Mn, ^{52}Mn, ^{51}Cr	^{27}Al(P,X)^{24}Na		1979

^{54}Fe								
A0501	1 GeV	1	14		^{52}Fe, ^{52}Mn, ^{51}Cr, ^{48}Cr, ^{48}V, ^{47}Sc, ^{46}Sc, ^{44m}Sc, ^{44}Sc, ^{43}Sc, ^{43}K, ^{42}K, ^{24}Na, ^{22}Na	^{27}Al(P,X)^{22}Na	stack	1990
B0049	21.5 MeV	1	1		^{53}Fe	^{63}Cu(P,X)^{63}Zn		1955
O0166	31.33-40.54 MeV	45	45	1	1H		single target	1964
O0291	28.8-61.5 MeV	3	6630		^{1}H, ^{2}H, ^{3}H, ^{3}He, ^{4}He			1970
^{56}Fe								
A0195	22 MeV	1	1		^{55}Fe		stack	1983
B0041	15-39 MeV	11	15	2	^{55}Fe, ^{54}Mn		stack	1970
B0050	21.5 MeV	1	1		^{55}Fe	^{63}Cu(P,X)^{63}Zn, ^{56}Fe(P,X)^{55}Co	mixed monitor	1955
C0454	800 MeV	1	39		^{56}Co, ^{53}Fe, ^{54}Mn, ^{52}Mn, ^{52m}Mn, ^{50m}Mn, ^{51}Cr, ^{49}Cr, ^{48}Cr, ^{53}V, ^{48}V, ^{51}Ti, ^{48}Sc, ^{47}Sc, ^{46}Sc, ^{44}Sc, ^{44m}Sc, ^{43}Sc, ^{42}Sc, ^{42}K, ^{38m}K, ^{41}Ar, ^{39}Cl, ^{38}Cl, ^{34m}Cl, ^{32}Cl, ^{38}S, ^{35}P, ^{33}Si, ^{26}Si, ^{30}Al, ^{29}Al, ^{28}Al, ^{28}Mg, ^{27}Mg, ^{25}Na, ^{24}Na, ^{22}Na, ^{23}Ne, ^{20}F, ^{56}Fe, ^{54}Fe, ^{52}Fe, ^{54}Cr, ^{52}Cr, ^{50}Cr, ^{50}Ti, ^{48}Ti, ^{46}Ti, ^{44}Ti, ^{46}Ca, ^{44}Ca, ^{42}Ca, ^{40}Ca, ^{42}Ar, ^{40}Ar, ^{38}Ar, ^{36}Ar, ^{36}S, ^{34}S, ^{32}S, ^{30}S, ^{28}S, ^{22}Ne, ^{20}Ne, ^{14}O			1997
C0481	5.5-23.5 MeV	19	80		^{55}Fe, ^{56}Fe, ^{56}Co			1981
O0044	150 MeV	1	1		^{3}H	^{27}Al(P,X)^{24}Na, ^{12}C(P,X)^{11}C	single target	1961
O0046	600 MeV	1	5		^{1}H, ^{2}H, ^{3}H, ^{3}He, ^{4}He		single target	1975
O0096	51.9 MeV	1	1		^{3}H		single target	1974
O0097	500 MeV	1	21		^{52}Fe, 5^{4}Mn, ^{52}Mn, ^{48}Cr, ^{48}Sc, ^{46}Sc, ^{44}Sc, ^{44m}Sc, ^{19}K, ^{7}Be, ^{57}Co, ^{56}Co, ^{55}Co, ^{56}Mn, ^{51}Cr, ^{48}V, ^{47}Sc, ^{43}Sc, ^{43}K, ^{24}Na, ^{22}Na		stack	1991
O0294	61.5 MeV	1	2162		^{1}H, ^{2}H, ^{3}H, ^{3}He, ^{4}He			1969
O0807	960 MeV	1	9		^{56}Fe, ^{55}Fe, ^{54}Fe, ^{55}Mn, ^{53}Mn, ^{53}Cr, ^{52}Cr, ^{48}Ti, ^{44}Ca			1975
O1086	190 MeV	1	20		^{1}H			2004
O1307	29.9 MeV	1	739		^{1}H, ^{4}He			2005
O1591	22-1600 MeV	26	168		^{3}He, ^{4}He, ^{21}Ne, ^{22}Ne, ^{36}Ar, ^{38}Ar	^{27}Al(P,X)^{22}Na	stack	2008

Table 1.2.3. The EXFOR-listed product nuclides measured in Ni(p,x) reactions.

EXFOR code number	Energy range, MeV	Numbers of energies	Ross sections measured	Excitation functions measured	Nuclides measured	Monitor reaction	Irradiation type	Year
					^{Nat}Ni			
A0100	47.87-198.9	26	369	8	^{59}Fe, ^{55}Co, ^{56}Co, ^{57}Co, ^{58}Co, ^{60}Co, ^{56}Ni, ^{57}Ni, ^{44m}Sc, ^{46}Sc, ^{47}Sc, ^{48}V, ^{48}Cr, ^{51}Cr, ^{52}Mn, ^{54}Mn	^{27}Al(P,3N+3P)^{22}Na	stack	1983
A0168	22	1	5		^{56}Co, ^{57}Co, ^{58}Co, ^{60}Co, ^{57}Ni		stack	1981
A0344	98-600	4	16	1	^{46}Sc, ^{48}V, ^{48}Cr, ^{51}Cr, ^{52}Mn, ^{54}Mn, ^{7}Be, ^{59}Fe, ^{56}Co, ^{57}Co, ^{58}Co, ^{57}Ni, ^{26}Al, ^{41}Ca		stack	1986
A0351	11-98	10	65		^{51}Cr, ^{52}Mn, ^{56}Co, ^{57}Co, ^{58}Co, ^{56}Ni, ^{57}Ni, ^{60}Cu	^{65}Cu(P,N)^{65}Zn ^{27}Al(P,X)^{24}Na	single target	1987
A0408	600	1	3		^{22}Na, ^{54}Mn, ^{60}Co		single target	1988
A0479	57.2-2600	11	12		^{10}Be, ^{26}Al		stack	1990
A0481	800-2600	3	21	7	^{20}Ne, ^{21}Ne, ^{22}Ne, ^{36}Ar, ^{38}Ar, ^{3}He, ^{4}He		stack	1990
A0497	15.89-99.81	16	57		^{52}Fe, ^{55}Fe, ^{59}Fe		stack	1990
A0502	660	1	22		^{57}Ni, ^{42}K, ^{43}K, ^{43}Sc, ^{44m}Sc, ^{44}Sc, ^{46}Sc, ^{47}Sc, ^{48}Sc, ^{48}V, ^{48}Cr, ^{49}Cr, ^{51}Cr, ^{52}Mn, ^{54}Mn, ^{56}Mn, ^{52}Fe, ^{59}Fe, ^{55}Co, ^{56}Co, ^{57}Co, ^{58}Co	^{27}Al(P,N+3P)^{24}Na	single target	1990
A0516	1600	1	20		^{7}Be, ^{22}Na, ^{24}Na, ^{42}Ca, ^{43}Ca, ^{44}Sc, ^{46}Sc, ^{47}Sc, ^{48}V, ^{48}Cr, ^{51}Cr, ^{52}Mn, ^{54}Mn, ^{59}Fe, ^{56}Co, ^{57}Co, ^{58}Co, ^{60}Co, ^{56}Ni, ^{57}Ni	^{27}Al(P,3N+3P)^{22}Na	stack	1992
B0020	16.2-56.6	15	15		^{60}Co		stack	1972
B0083	11.9-44.72	19	109		^{61}Cu, ^{55}Co, ^{56}Co, ^{57}Co, ^{58}Co, ^{60}Co, ^{52}Mn		stack	1978

B0085	590	1	28		^{56}Ni, ^{57}Ni, ^{60}Co, ^{61}Co, ^{44}Sc, ^{44m}Sc, ^{46}Sc, ^{47}Sc, ^{48}Sc, ^{48}Cr, ^{49}Cr, ^{51}Cr, ^{56}Cr, ^{42}K, ^{43}K, ^{44m}Cl, ^{52}Mn, ^{52m}Mn, ^{54}Mn, ^{56}Mn, ^{52}Fe, ^{48}V, ^{53}V, ^{55}Co, ^{56}Co, ^{57}Co, ^{58}Co, ^{58m}Co	^{27}Al(P,X)^{24}Na	single target	1971
B0098	18.1-100	34	162		^{55}Co, ^{56}Co, ^{57}Co, ^{58}Co, ^{56}Ni, ^{57}Ni		stack	1976
C0236	2800	1	3		^{9}Li, ^{16}C, ^{17}N		single target	1965
C0253	100-300	3	6		^{22}Na, ^{24}Na		single target	1970
C0293	550	1	2		^{32}P, ^{33}P	^{27}Al(P,3N+3P)^{22}Na	single target	1970
C0401	65-85	2	2		^{7}Be		stack	1966
C0555	137.9-500	5	5		^{14}C		single target	1998
C0836	450	1	1		^{3}H	^{27}Al(P,X)^{24} Na	single target	1956
C1447	140-500	6	62		^{46}Sc, ^{48}V, ^{51}Cr, ^{52}Mn, ^{54}Mn, ^{56}Co, ^{57}Co, ^{58}Co, ^{60}Co, ^{56}Ni, ^{57}Ni, ^{59}Fe	^{27}Al (P,X)^{22} Na	single target	2006
D0303	24	1	6		^{55}Co, ^{56}Co, ^{57}Co, ^{58}Co, ^{56}Ni, ^{57}Ni	^{63}Cu(P,2N)^{62}Zn ^{65}Cu(P,N)^{65} Zn	single target	2001
D0393	12.716-28.54	17	17		^{55}Co		single target	1996
D0479	29	1	7		^{57}Ni, ^{55}Co, ^{56}Co, ^{57}Co, ^{58}Co, ^{61}Cu, ^{64}Cu		single target	2008
D4002	7.9-29.6	54	120		^{55}Co, ^{56}Co, ^{57}Co	^{63}Cu(P,N)^{63}Zn ^{63}Cu (P,2N) ^{62}Zn ^{65}Cu (P,N) ^{65}Zn	stack	1991
D4058	7.6-24.8	17	19		^{4}He, ^{57}Co		single target	1991
D4062	14.3-43.5	75	75		^{57}Ni		stack	1998
D4080	13.6-29.6	67	67		^{57}Ni		stack	1991
D4106	14.36-31.22	25	25		^{57}Ni		stack	2002
E1251	500	1	23		^{7}Be, ^{24}Na, ^{41}Ar, ^{42}K, ^{43}Sc, ^{44}Sc, ^{46}Sc, ^{47}Sc, ^{48}Cr, ^{48}V, ^{51}Cr, ^{52}Mn, ^{54}Mn, ^{56}Mn, ^{52}Fe, ^{55}Co, ^{56}Co, ^{57}Co, ^{58}Co, ^{56}Ni, ^{57}Ni		stack	1991
E1864	8.208-39.98	16	40		^{55}Fe, ^{63}Ni, ^{57}Ni, ^{56}Ni		stack	1990
E1865	8.529-29.84	17	17		^{55}Fe, ^{63}Ni		stack	1991

E1923	100	1	38		^{7}Be, ^{41}Ar, ^{42}K, ^{43}K, ^{43}Sc, ^{44}Sc, ^{46}Sc, ^{47}Sc, ^{48}Sc, ^{48}Cr, ^{49}Cr, ^{51}Cr, ^{54}Mn, ^{56}Mn, ^{52}Fe, ^{56}Co, ^{57}Co, ^{58}Co, ^{60}Co, ^{61}Co, ^{57}Ni		stack	2004
O0073	130-396	4	28		^{56}Co, ^{54}Mn, ^{52}Mn, ^{51}Cr, ^{48}V, ^{32}P, ^{7}Be	^{27}Al(P,N+3P)^{24}Na		1964
O0077	500-2900	5	40		^{56}Co, ^{54}Mn, ^{52}Mn, ^{51}Cr, ^{48}V, ^{32}P, ^{24}Na, ^{7}Be	^{27}Al(P,N+3P)^{24}Na	single target	1968
O0078	660	1	17		^{22}Na, ^{26}Al, ^{46}Sc, ^{10}Be, ^{7}Be, ^{48}V, ^{4}8Cr, ^{51}Cr, ^{52}Mn, ^{54}Mn, ^{59}Fe, ^{56}Co, ^{57}Co, ^{58}Co, ^{60}Co, ^{56}Ni, ^{57}Ni	^{27}Al(P,X)^{22}Na	stack	1989
O0080	600-2600	5	5		^{26}Al	^{27}Al(P,3N+3P)^{22}Na	stack	1991
O0088	600	1	12		^{57}Ni, ^{60}Co, ^{58}Co, ^{57}Co, ^{56}Co, ^{54}Mn, ^{52}Mn, ^{51}Cr, ^{48}V, ^{47}Sc, ^{46}Sc, ^{44m}Sc			1975
O0094	1000-2000	2	4		^{22}Na, ^{7}Be			1975
O0095	150-24000	3	12		^{36}Ar, ^{38}Ar, ^{39}Ar, ^{42}Ar	^{27}Al(P,3N+3P)^{22}Na	stack	1979
O0097	500	1	23		^{7}Be, ^{24}Na, ^{41}K, ^{42}K, ^{43}K, ^{43}Sc, ^{44}Sc, ^{47}Sc, ^{46}Sc, ^{48}V, ^{48}Cr, ^{51}Cr, ^{52}Mn, ^{54}Mn, ^{56}Mn, ^{52}Fe, ^{55}Co, ^{56}Co, ^{57}Co, ^{58}Co, ^{56}Ni, ^{57}Ni		stack	1991
O0098	800-2600	3	6		^{7}Be, ^{22}Na	^{27}Al(P,3N+3P)^{22}Na	stack	1990
O0103	750	1	2		^{3}He, ^{4}He	^{27}Al(P,X)^{22}Na		1988
O0104	98-600	4	4		^{41}Ca			1987
O0276	12.2-1600	33	466		^{7}Be, ^{10}Be, ^{22}Na, ^{36}Cl, ^{44m}Sc, ^{46}Sc, ^{44}Ti, ^{48}V, ^{48}Cr, ^{51}Cr, ^{52}Mn, ^{54}Mn, ^{55}Co, ^{56}Co, ^{57}Co, ^{58}Co, ^{60}Co, ^{56}Ni, ^{57}Ni, ^{59}Fe	^{27}Al(P,X)^{22}Na Cu(P,X)^{65}Zn	stack	1997
O0277	800-2600	4	118		^{3}He, ^{4}He, ^{7}Be, ^{10}Be, ^{20}Ne, ^{21}Ne, ^{22}Ne, ^{23}Ne, ^{22}Na, ^{24}Na, ^{26}Al, ^{36}Cr, ^{36}Ar, ^{38}Ar, ^{42}K, ^{43}K, ^{44m}Sc, ^{46}Sc, ^{47}Sc, ^{48}V, ^{48}Cr, ^{51}Cr, ^{52}Mn, ^{54}Mn, ^{59}Fe, ^{55}Co, ^{56}Co, ^{57}Co, ^{58}Co, ^{60}Co, ^{56}Ni, ^{57}Ni	^{27}Al(P,X)^{22}Na	stack	1995
O0281	53.3-2600	13	17		^{10}Be, ^{26}Al	^{27}Al(P,X)^{22}Na	stack	1990

O0284	211-385	22	233		^{7}Be, ^{10}Be, ^{22}Na, ^{36}Cl, ^{44m}Sc, ^{46}Sc, ^{48}Cr, ^{51}Cr, ^{52}Mn, ^{54}Mn, ^{56}Co, ^{57}Co, ^{58}Co, ^{60}Co, ^{56}Ni, ^{57}Ni, ^{59}Fe	^{27}Al(P,X)^{22}Na ^{27}Al(P,X)^{24}Na	stack	1996
O0353	106-2600	13	13		^{36}Cl	^{27}Al(P,X)^{22}Na	stack	1996
O0412	400	1	2		^{22}Na, ^{24}Na	^{27}Al(P,X)^{22}Na ^{27}Al(P,X)^{24}Na	stack	1967
O0476	9.64-22.99	15	15		^{4}He			1960
O0530	66	1	1		^{55}Fe		single target	1992
O0584	590-18300	2	7		^{38}K, ^{42}K, ^{43}K, ^{44}K, ^{45}K	^{27}Al(P,X)^{24}Na		1965
O0768	850	1	12		^{57}Ni, ^{55}Co, ^{52}Fe, ^{52m}Mn, ^{52}Mn, ^{49}Cr, ^{48}Cr, ^{44m}Sc, ^{44}Sc, ^{43}Sc, ^{41}Ar, ^{34m}Cl		single target	2000
O1229	33.5-2600	9	18		^{53}Mn, ^{60}Fe		stack	2000
O1305	1.3-2750	13	13		^{1}H, ^{2}H, ^{3}H, ^{3}He, ^{4}He, ^{6}He, ^{6}Li, ^{7}Li, ^{8}Li, ^{9}Li, ^{7}Be, ^{9}Be, ^{10}Be			2006
O1313	18.4-27.3	3	3		^{56}Ni	^{63}Cu(P,2N)^{62}Zn ^{65}Cu(P,N)^{65}Zn	stack	2005
O1503	5.5-27.4	42	222		^{56}Ni, ^{56}Co, ^{58}Co, ^{57}Ni, ^{57}Co, ^{55}Co, ^{60}Cu, ^{61}Cu		stack	2007
O1591	24-1590	24	130		^{3}He, ^{4}He, ^{21}Ne, ^{22}Ne, ^{36}Ar, ^{38}Ar	^{27}Al(P,3N+3P)^{22}Na	stack	2008
O1741	148-1600	8	8		^{41}Ca	^{27}Al(P,X)^{22}Na		2004
P0030	34.5-74	8	15		^{53}Fe, ^{53m}Fe	^{59}Co(P,N+P)^{58}Co		1967
T0149	750	1	2		^{3}He, ^{4}He	^{27}Al(P,X)^{22}Na		1988
^{64}Ni								
A0013	1000	1	1		17N	^{27}Al(P,X)^{17}N		1977
D6056	136	1	23		^{64}Ni, ^{63}Ni, ^{62}Ni, ^{61}Ni, ^{60}Ni, ^{59}Ni, 58Ni, ^{61}Co, ^{60}Co, ^{59}Co, ^{58}Co, ^{57}Co, ^{58}Fe, ^{57}Fe, ^{56}Fe, ^{55}Fe, ^{54}Fe, ^{55}Mn, ^{54}Mn, ^{53}Mn, ^{54}Cr, ^{53}Cr, ^{52}Cr			1977
O0132	100-136	2	2		^{54}Cr		single target	1980
^{62}Ni								
A0013	1000	1	1		^{17}N	^{27}Al(P,X)^{17}N	single target	1977

D6056	136	1	46		^{62}Ni, ^{61}Ni, ^{60}Ni, ^{59}Ni, ^{58}Ni, ^{57}Ni, 61Co, ^{60}Co, ^{59}Co, ^{58}Co, ^{57}Co, ^{56}Co, ^{55}Co,^{59}Fe, ^{58}Fe, ^{57}Fe, ^{56}Fe, ^{55}Fe, 54Fe, ^{53}Fe, ^{52}Fe, ^{56}Mn, ^{55}Mn, ^{54}Mn, ^{53}Mn, ^{52}Mn, ^{51}Mn, ^{54}Cr, ^{53}Cr, ^{52}Cr, ^{51}Cr, ^{50}Cr, ^{51}V, ^{50}V, ^{49}V, ^{48}V, ^{48}Ti			1977
^{60}Ni								
B0020	27-56.5	16	34		^{58}Co, ^{57}Ni, ^{56}Co, ^{54}Mn		stack	1972
C0478	80-164	4	82		^{61}Cu, ^{60}Cu, ^{57}Ni, ^{56}Ni, ^{61}Co, ^{60}Co, ^{58}Co, ^{57}Co, ^{56}Co, ^{55}Co, ^{59}Fe, ^{52}Fe, ^{56}Mn, ^{54}Mn, ^{52}Mn, ^{51}Cr			1980
D6056	23-28	6	28		^{60}Ni, ^{59}Ni, ^{58}Ni, ^{57}Ni, ^{59}Co, ^{58}Co, ^{57}Co, ^{56}Co, ^{54}Co, ^{58}Fe, ^{57}Fe, ^{56}Fe, ^{55}Fe, ^{54}Fe, ^{53}Fe, ^{55}Mn, ^{54}Mn, ^{53}Mn, ^{52}Mn, ^{54}Cr, ^{53}Cr, ^{52}Cr, ^{51}Cr, ^{50}Cr, ^{50}V, ^{49}V, ^{48}V			1977
E1865	16.93-40.07	8	8		^{55}Fe, ^{59}Ni		stack	1991
^{58}Ni								
A0013	1000	1	1		^{17}N	^{27}Al(P,X)^{17}N	single target	1977
A0025	1000	1	13		^{42}Ca, ^{44}Ca, ^{46}Ti, ^{48}Ti, ^{50}Cr, ^{52}Cr, ^{54}Fe		single target	1978
A0195	22	1	1		^{57}Ni		stack	1983
A0497	44.9-199.4	45	45		^{52}Fe		stack	1990
B0020	9-56.7	27	76		^{56}Ni, ^{55}Co, ^{53}Fe, ^{52}Fe, ^{56}Co, ^{52}Mn		stack	1972
B0049	21.5	1	1		^{57}Ni	^{63}Cu(P,N)^{63}Zn		1955
B0083	11.9-44.72	19	35		^{56}Ni, ^{57}Ni		stack	1978
C0478	80-164	33	39		^{57}Ni, ^{56}Ni, ^{57}Co, ^{56}Co, ^{55}Co, ^{52}Fe, ^{54}Mn, ^{52}Mn, ^{51}Cr, ^{49}Cr, ^{48}Cr, ^{48}V, ^{46}Sc, ^{44}Sc			1980
C1012	12.2-39.7	28	52		^{56}Co, ^{56}Ni, ^{57}Ni			1964
D4078	7.7-45.6	55	138	3	^{55}Co, ^{56}Co, ^{56}Ni, ^{57}Ni	Cu(P,X)^{62}Zn Cu(P,X)^{63}Zn Ti(P,X)^{48}V	stack	1998
D6056	80-164	4	98		^{58}Ni, ^{57}Ni, ^{57}Co, ^{56}Co, ^{54}Co, ^{65}Fe, ^{55}Fe, ^{54}Fe, ^{55}Mn, ^{54}Mn, ^{53}Mn, ^{52}Mn, ^{51}Mn, ^{50}Mn, ^{52}Cr, ^{51}Cr, ^{50}Cr, ^{49}Cr, ^{50}V, ^{49}V, ^{48}V, ^{49}Ti			1977
O0137	90	1	5		^{1}H, ^{2}H, ^{3}H, ^{3}He, ^{4}He		single target	1979
O0980	2600	1	38		^{57}Ni, ^{56}Ni, ^{58}Co, ^{57}Co, ^{56}Co, ^{55}Co, ^{53}Fe, ^{52}Fe, ^{54}Mn, ^{52}Mn, ^{51}Cr, ^{49}Cr, ^{48}Cr, ^{48}V, ^{48}Sc, ^{47}Sc, ^{46}Sc, ^{44}Sc, ^{43}Sc, ^{43}K, ^{42}K, ^{38}K, ^{41}Ar, ^{39}Cl, ^{38}Cl, ^{34}Cl, ^{29}Al, ^{28}Mg, ^{27}Mg, ^{24}Na, ^{22}Na, ^{7}Be	^{27}Al(P,X)^{22}Na ^{27}Al(P,X)^{24}Na ^{27}Al(P,X)^{7}Be		2001

Table 1.2.4. The EXFOR-listed product nuclides measured in ^{93}Nb(p,x) reactions.

EXFOR code number	Range, MeV	Numbers of energies	Crass sections measured	Excitation functions measured	Nuclides measured	Monitor reaction	Irradiation type	Year
A0177	20-45	4	4		^{3}H		stack	1980
A0294	12.8-22.4	27	43		^{89}Zr, ^{92m}Nb		stack	1986
A0491	800-2600	3	3		^{7}Be	^{27}Al(P,3N+3P)^{22}Na	single target	1990
A0695	12.9-29.2	18	18		^{92m}Nb	Cu(P,X)^{65}Zn	single target	1974
C0236	2.8	1	3		^{9}Li, ^{16}C, ^{17}N		single target	1965
C0293	550	1	2		^{32}P, ^{33}P	^{27}Al(P,3N+3P)^{22}Na	single target	1970
C0335	240-720	4	52	13	^{90}Nb, ^{89}Nb, ^{89}Zr, ^{88}Zr, ^{87}Zr, ^{67}Cu, ^{64}Cu, ^{61}Cu, ^{66}Ni, ^{65}Ni, ^{57}Ni, ^{24}Na, ^{22}Na	^{27}Al (P,3P+N) ^{24}Na	single target	1964
D0054	38.8-95	7	7		^{7}Be	^{27}Al (P,X) ^{24}Na ^{27}Al(P,X) ^{22}Na Cu(P,X)^{62}Zn ^{65}Cu(P,N)^{65}Zn	stack	1993
D4036	38.8-95	7	7		^{7}Be	^{27}Al (P,X) ^{24}Na ^{27}Al(P,X) ^{22}Na Cu(P,X)^{62}Zn ^{65}Cu(P,N)^{65}Zn	stack	1994
D4212	36.97-67.11	10	81		^{90}Nb, ^{91}Nb, ^{86}Zr, ^{88}Zr, ^{89}Zr, ^{85}Y, ^{87}Y, ^{87m}Y, ^{88}Y, ^{85}Sr	Cu(P,X) ^{62}Zn Cu (P,X) ^{65}Zn Cu (P,X)^{56}Co ^{27}Al (P,X) ^{24}Na ^{27}Al(P,X) ^{22}Na	stack	2008
E1936	50-390	32	345		^{1}H		single target	2005
O0098	800-2600	3	4		^{7}Be, ^{22}Na	^{27}Al (P,3N+3P) ^{22}Na	stack	1990
O0158	8.64-63.15	233	557		^{1}H, ^{2}H, ^{4}He		single target	1980
O0276	16.4-2600	53	628		^{7}Be, ^{22}Na, ^{46}Sc, ^{48}V, ^{51}Cr, ^{52}Mn, ^{54}Mn, ^{56}Co, ^{58}Co, ^{60}Co, ^{59}Fe, ^{65}Zn, ^{67}Ga, ^{68}Ge, ^{69}Ge, ^{71}As, ^{73}As, ^{74}As, ^{72}Se, ^{75}Se, ^{77}Br, ^{79}Kr, ^{83}Rb, ^{84}Rb, ^{82}Sr, ^{83}Sr, ^{85}Sr, ^{86}Y, ^{87}Y, ^{87m}Y, ^{88}Y, ^{86}Zr, ^{88}Zr, ^{89}Zr, ^{90}Nb, ^{91}Nb	^{27}Al(P,X) ^{22}Na Cu (P,X) ^{65}Zn	stack	1997
O0342	150	1	1		^{3}H	^{27}Al (P,N+3P) ^{24}Na ^{27}Al (P,3D) ^{22}Na C(P,X)^{11}C ^{12}C(P,X)^{7}Be	single target	1962
O0412	400	1	2		^{22}Na, ^{24}Na	^{27}Al (P,X) ^{24}Na ^{27}Al(P,X) ^{22}Na	stack	1967
O0466	600	1	3		^{83}Rb, ^{84}Rb, ^{86}Rb	^{27}Al(P,X) ^{22}Na	stack	1979

EXFOR code number	Range, MeV	Numbers of energies	Crass sections measured	Excitation functions measured	Nuclides measured	Monitor reaction	Irradiation type	Year
O0503	2.5-22.5	21	21		^{1}H		single target	1998
O0762	600	1	23		^{76}Sr, ^{77}Sr, ^{78}Sr, ^{79}Sr, ^{80}Sr, ^{81}Sr, ^{83}Sr, ^{85}Sr, ^{87}Sr, ^{80}Y, ^{81}Y, ^{82}Y, ^{83}Y, ^{84}Y, ^{85}Y, ^{86}Y, ^{87}Y, ^{89}Y		stack	1992
O0763	600	1	17		^{70}Br, ^{71}Br, ^{72}Br, ^{73}Br, ^{74}Br, ^{75}Br, ^{76}Br, ^{77}Br, ^{78}Br, ^{79}Br, ^{80}Br, ^{81}Br, ^{82}Br, ^{83}Br, ^{84}Br, ^{85}Br		single target	1981
O0834	600	1	31		^{74}Rb, ^{75}Rb, ^{76}Rb, ^{77}Rb, ^{78}Rb, ^{79}Rb, ^{80}Rb, ^{81}Rb, ^{82}Rb, ^{83}Rb, ^{84}Rb, ^{85}Rb, ^{86}Rb, ^{87}Rb, ^{70}Br, ^{71}Br, ^{72}Br, ^{73}Br, ^{74}Br, ^{75}Br, ^{76}Br, ^{77}Br, ^{78}Br, ^{79}Br, ^{80}Br, ^{81}Br, ^{82}Br, ^{83}Br, ^{84}Br, ^{85}Br		single target	1986
O0838	600	1	16		^{74}Rb, ^{75}Rb, ^{76}Rb, ^{77}Rb, ^{78}Rb, ^{79}Rb, ^{80}Rb, ^{81}Rb, ^{82}Rb, ^{83}Rb, ^{84}Rb, ^{85}Rb, ^{86}Rb, ^{87}Rb, ^{70}Br, ^{71}Br, ^{72}Br, ^{73}Br, ^{74}Br, ^{75}Br, ^{76}Br, ^{77}Br, ^{78}Br, ^{79}Br, ^{80}Br, ^{81}Br, ^{82}Br, ^{83}Br, ^{84}Br, ^{85}Br		single target	1984
O0981	2600	1	84		^{93}Mo, ^{90}Mo, ^{92}Nb, ^{90}Nb, ^{88}Nb, ^{89}Zr, ^{88}Zr, ^{87}Zr, ^{86}Zr, ^{84}Y, ^{85}Y, ^{86}Y, ^{87}Y, ^{88}Y, ^{90}Y, ^{85}Sr, ^{83}Sr, ^{82}Sr, ^{81}Sr, ^{84}Rb, ^{83}Rb, ^{82}Rb, ^{81}Rb, ^{79}Rb, ^{77}Kr, ^{76}Kr, ^{77}Br, ^{76}Br, ^{74}Br, ^{75}Se, ^{73}Se, ^{72}Se, ^{74}As, ^{72}As, ^{71}As, ^{70}As, ^{69}Ge, ^{67}Ge, ^{67}Ga, ^{65}Ga, ^{69}Zn, ^{65}Zn, ^{62}Zn, ^{61}Cu, ^{60}Cu, ^{57}Ni, ^{60}Co, ^{58}Co, ^{57}Co, ^{56}Co, ^{55}Co, ^{59}Fe, ^{56}Mn, ^{52}Mn, ^{51}Cr, ^{48}Cr, ^{48}V, ^{48}Sc, ^{47}Sc, ^{46}Sc, ^{44}Sc, ^{43}K, ^{42}K, ^{41}Ar, ^{39}Cl, ^{34}Cl, ^{28}Mg, ^{27}Mg, ^{24}Na, ^{7}Be	^{27}Al (P,X) ^{24}Na ^{27}Al(P,X) ^{22}Na ^{27}A (P,X)^{7}Be	single target	2001

Table 1.2.5. The EXFOR-listed product nuclides measured in ^{181}Ta(p,x) reactions.

EXFOR code number	Energy range, MeV	Numbers of energies	Cross sections measured	Numbers of Numbers of excitation functions measured	Nuclides measured	Monitor reaction	Irradiation type	Year
A0095	660	1	13		^{117m} In, ^{117} In, ^{116m} In, ^{115m} In, ^{114m} In, ^{113m} In, ^{112m} In, ^{111}In, ^{110m}In, ^{110}In, ^{109}In, ^{107}In			1981
C0236	1000	1	3		^{17}N, ^{16}C, ^{9}Li			1965
C0286	1000 - 3000	3	3	1	^{24}Na	^{27}Al(p,x)^{24}Na		1958
C0293	550	1	2		^{33}P, ^{32}P	^{27}Al(p,x)^{22}Na		1970
C0297	450	1	19		^{115m}Cd, ^{115}Cd, ^{113}Ag, ^{112}Ag, ^{111}Ag, ^{109}Pd, ^{99}Mo, ^{89}Sr, ^{86}Rb, ^{77}As, ^{76}As, ^{74}As, ^{72}As, ^{67}Cu, ^{64}Cu, ^{61}Cu, ^{66} Ni, ^{65}Ni ^{59}Fe	^{27}Al(p,x)^{24}Na		1955
C0324	580		27		^{171}Lu, ^{168}Lu, ^{166}Yb, ^{167} Tm, ^{165}Tm, ^{160}Er, ^{153} Tb, ^{152}Tb, ^{151}Tb, ^{149}Gd, ^{147}Gd, ^{146}Gd, ^{145}Eu, ^{140}Nd, ^{139}Ce, ^{137m}Ce, ^{134}Ce			1971

EXFOR code number	Energy range, MeV	Numbers of energies	Cross sections measured	Numbers of Numbers of excitation functions measured	Nuclides measured	Monitor reaction	Irradiation type	Year
C0353	340	1	62		^{178}W, ^{177}W, ^{176}W, ^{178m}Ta, ^{177}Ta, ^{175}Hf, ^{173}Hf, ^{171}Hf, ^{170}Lu, ^{169}Yb, ^{166}Yb, ^{167}Tm, ^{165}Tm, ^{160}Er, ^{135}Ce, ^{134}Ce, ^{131} Ba, ^{129m} Ba, ^{128}Ba, ^{129} Cs, ^{127}Cs, ^{121}Te, ^{119m}Te, ^{116}Te, ^{114m}In, ^{111}In, ^{110m}In, ^{109}In, ^{115m}Cd, ^{115}Cd, ^{107}Cd, ^{113}Ag, ^{112}Ag, ^{111}Ag, ^{110m}Ag, ^{105}Ag, ^{109}Pd, ^{106m}Rh, ^{105}Rh, ^{101m}Rh, ^{105}Ru, ^{103}Ru, ^{97}Ru, ^{97}Zr, ^{95}Zr, ^{91}Sr, ^{89}Sr, ^{83}Br, ^{82}Br, ^{80m}Br, ^{77}As, ^{76}As, ^{74}As, ^{73} Ga, ^{72}Ga, ^{67}Cu, ^{64}Cu, ^{66}Ni, ^{65}Ni, ^{61}Co, ^{59}Fe, ^{56}Mn, ^{52}Mn, ^{43}K, ^{42}K, ^{28}Mg, ^{24}Na			1955
C0402	24 - 84	9	68	15	^{181}W, ^{179}W, ^{178}W, ^{177}W, ^{176}W, ^{180}Ta, ^{179}Ta, ^{178m}Ta, ^{177}Ta, ^{175}Ta, ^{174}Ta, ^{173}Ta, ^{180m}Hf, ^{175}Hf, ^{173}Hf	^{65}Cu(p,x)^{64}Cu	stack	1963
E1241	500	1	44		^{176}Ta, ^{175}Ta, ^{180}Hf, ^{175}Hf, ^{173}Hf, ^{172}Hf, ^{170}Hf, ^{177}Lu, ^{174}Lu, ^{173}Lu, ^{172}Lu, ^{171}Lu, ^{169}Lu, ^{169}Yb, ^{166}Yb, ^{167}Tm, ^{166}Tm, ^{160}Tm, ^{160}Dy, ^{156}Tb, ^{155}Tb, ^{154}Tb, ^{153}Tb, ^{151}Tb, ^{149}Gd, ^{147}Gd, ^{146}Gd, ^{147}Eu, ^{146}Eu, ^{145}Eu, ^{147}Nd, ^{143}Ce, ^{139}Ce, ^{133}I, ^{131}I, ^{87}Y, ^{86}Y, ^{85}Sr, ^{83}Rb, ^{57}Co, ^{96}Tc, ^{92}Nb		stack	1985
O1305	1200	1	13		^{10}Be, ^{9}Be, ^{7}Be, ^{9}Li, ^{8}Li, ^{7}Li, ^{6}Li, ^{5}Li, ^{4}Li, ^{3}Li, ^{3}H, ^{2}H, ^{1}H			2006
A0598	100 - 500	5	52	11	^{178m}Ta, ^{180m2}Hf, ^{179m2}Hf, ^{177m2}Hf, ^{175}Hf, ^{172}Hf, ^{170}Hf, ^{177m}Lu, ^{171}Lu, ^{169}Lu, ^{167}Lu	^{27}Al(p,x)^{22}Na, ^{nat}Cu(p,x)^{62}Zn, ^{nat}W(p,x)^{181}Re, ^{197}Au(p,x)^{192}Hg	stack	2003
B0032	29.3 - 43.6	8	8	2	^{178m}Ta, ^{178}Ta	current transformer		1973
B0072	19 - 23.4	6	6	1	^{180}Ta	^{63}Cu(p,x)^{63}Zn		1954
B0098	38.9 - 83.2	21	21	1	^{175}Hf			1976
C0572	450-3000	9	9	1	^{149}Tb			1964
C1225	600, 800	2	71	33	^{182}Ta, ^{181}Hf, ^{175}Hf, ^{172}Hf, ^{174}Lu, ^{173}Lu, ^{169}Yb, ^{168}Tm, ^{153}Gd, ^{151}Gd, ^{149}Gd, ^{148}Gd, ^{147}Gd, ^{145}Gd, ^{146}Pm, ^{144}Pm, ^{139}Ce, ^{133}Ba, ^{131}Ba, ^{127}Xe, ^{131}I, ^{126}I, ^{102}Rh, ^{95}Nb, ^{88}Zr, ^{88}Y, ^{83}Rb, ^{75}Br, ^{74}Se, ^{65}Zn, ^{59}Fe, ^{54}Mn, ^{48}V, ^{46}Sc	^{27}Al(p,x)^{24}Na		2005
C1650	109.8, 195.3	2	15	7	^{171}Hf, ^{170}Hf, ^{177}Lu, ^{172}Lu, ^{171}Lu, ^{170}Lu, ^{169}Lu, ^{167}Tm	^{nat}Cu(p,x)61Cu, ^{nat}Ni(p,x)57Ni, ^{27}Al(p,x)^{24}Na	stack	2008
E1981	35.5 - 68.99	11	56	7	^{180}Ta, ^{177}Ta, ^{176}Ta, ^{175}Ta, ^{175}Hf, ^{173}Hf, ^{179}Lu	^{nat}Cu(p,x)^{58}Co	stack	2004

EXFOR code number	Energy range, MeV	Numbers of energies	Cross sections measured	Numbers of Numbers of excitation functions measured	Nuclides measured	Monitor reaction	Irradiation type	Year
O0296	500	1	42		^{176}Ta, ^{175}Ta, ^{175}Hf, ^{173}Hf, ^{172} Hf, ^{170}Hf, ^{177m}Hf, ^{174}Hf, ^{173}Hf, ^{172}Hf, ^{171}Hf, ^{169}Lu, ^{169}Yb, ^{167}Tm, ^{166}Tm, ^{165}Tm, ^{166m1}Ho, ^{160m1}Ho, ^{157}Dy, ^{156}Tb, ^{155}Tb, ^{154}Tb, ^{153}Tb, ^{151}Tb, ^{149}Gd, ^{147}Gd, ^{146}Gd, ^{147}Nd, ^{147}Eu, ^{146}Eu, ^{145}Eu, ^{143}Ce, ^{139}Ce, ^{133}I, ^{131}I, ^{96}Tc, ^{92m}Nb, ^{87}Y, ^{86}Y, ^{85}Sr, ^{83}Rb, ^{57}Co			1985
O0412	500	1	2		^{24}Na, ^{22}Na	^{27}Al(p,x)^{24}Na, ^{27}Al(p,x)^{22}Na	stack	1967
O0512	590	1	4		^{168}Tm, ^{167}Tm	^{27}Al(p,x)^{24}Na	stack	1976
O0678	1200, 1800	2	4	2	^{2}H, ^{1}H			1999
O0908	235 - 1000	7	7	1	^{149}Tb	^{27}Al(p,x)^{24}Na		2001
O1038	100 - 600	3	132	42	^{178}W, ^{181}Hf, ^{179m}Hf, ^{178m}Hf, ^{175}Hf, ^{177m} Lu, ^{174m}Lu, ^{174}Lu, ^{173}Lu, ^{172}Lu, ^{171}Lu, ^{170}Lu, ^{168}Tm, ^{167}Tm, ^{166}Dy, ^{160}Tb, ^{156}Tb, ^{155}Tb, ^{153}Gd, ^{151}Gd, ^{149}Gd, ^{146}Gd, ^{149}Eu, ^{148}Eu, ^{147}Eu, ^{146}Eu, ^{145}Eu, ^{148m}Pm, ^{148}Pm, ^{144}Pm, ^{143}Pm, ^{139}Ba, ^{140}Ba, ^{133}Ba, ^{131}Ba, ^{113}Sn, ^{136}Ce, ^{110m}Ag, ^{106m}Ag, ^{105}Ag, ^{100}Pd, ^{102m}Rh, ^{101}Rh, ^{95}Nb, ^{91m}Nb, ^{88}Zr, ^{88}Y, ^{87}Y, ^{85}Sr, ^{84}Rb, ^{83}Rb, ^{75}Se, ^{72}Se, ^{65}Zn, ^{74}As, ^{60}Co, ^{56}Co, ^{59}Fe, ^{48}V			2002
O1099	81.6 - 2590	35	798	90	^{177}Ta, ^{176}Ta, ^{175}Ta, ^{179m}Hf, ^{175}Hf, ^{173}Hf, ^{172}Hf, ^{171}Hf, ^{170}Hf, ^{177m} Lu, ^{174}Lu, ^{173}Lu, ^{172}Lu, ^{171}Lu, ^{170}Lu, ^{169}Lu, ^{169}Yb, ^{166}Yb, ^{168}Tm, ^{167}Tm, ^{165}Tm, ^{160}Er, ^{157}Dy, ^{155}Dy, ^{156}Tb, ^{155}Tb, ^{153}Tb, ^{152}Tb, ^{151}Tb, ^{153}Gd, ^{151}Gd, ^{149}Gd, ^{147}Gd, ^{146}Gd, ^{149}Eu, ^{148}Eu, ^{147}Eu, ^{146}Eu, ^{145}Eu, ^{144}Pm, ^{143}Pm, ^{139}Ce, ^{135}Ce, ^{134}Ce, ^{133}Ba, ^{131}Ba, ^{128}Ba, ^{129}Cs, ^{127}Xe, ^{121m}Te, ^{119m}Te, ^{119}Te, ^{113}Sn, ^{111}In, ^{110m}Ag, ^{106m}Ag, ^{105}Ag, ^{102m}Rh, ^{102}Rh, ^{101}Rh, ^{103}Ru, ^{96}Tc, ^{89}Zr, ^{88}Zr, ^{88}Y, ^{87}Y, ^{85}Sr, ^{82}Sr, ^{84}Rb, ^{83}Rb, ^{75}Se, ^{74}As, ^{65}Zn, ^{60}Co, ^{58}Co, ^{57}Co, ^{56}Co, ^{59}Fe, ^{54}Mn, ^{52}Mn, ^{48}V, ^{46}Sc, ^{28}Mg, ^{24}Na, ^{22}Na, ^{7}Be	^{27}Al(p,x)^{22}Na, ^{nat}Cu(p,x)^{65}Zn	stack	2002
O1733	400-2600	6	6	1	^{148}Gd	^{27}Al(p,x)^{22}Na	stack	2002

Table 1.2.6. The EXFOR-listed product nuclides measured in W(p,x) reactions.

EXFOR Code number	Energy range	Numbers of energies	Cross sections measured	Numbers of excitation functions measured	Nuclides measured	Monitor reactions	Irradiation type	Year

EXFOR Code number	Energy range	Numbers of energies	Cross sections measured	Numbers of excitation functions measured	Nuclides measured	Monitor reactions	Irradiation type	Year
					^{Nat}W			
A0179	17.9 - 57.6	15	39	2	^{184}Re, ^{183}Re	current transformer	stack	1979
A0721	2600	1	96		^{177}W, ^{176}W, ^{184}Ta, ^{183}Ta, ^{182}Ta, ^{176}Ta, ^{175}Ta, ^{174}Ta, ^{181}Hf, ^{173}Hf, ^{171}Hf, ^{170}Hf, ^{171}Lu, ^{170}Lu, ^{169}Lu, ^{167}Lu, ^{167}Yb, ^{166}Yb, ^{166}Tm, ^{165}Tm, ^{163}Tm, ^{161}Tm, ^{161}Ho, ^{160}Ho, ^{157}Ho, ^{156}Ho, ^{155}Tb, ^{153}Tb, ^{152}Tb, ^{151}Tb, ^{149}Tb, ^{147}Tb, ^{151}Gd, ^{149}Gd, ^{147}Gd, ^{146}Gd, ^{145}Gd, ^{149}Eu, ^{147}Eu, ^{146}Eu, ^{139m}Nd, ^{139}Ce, ^{135}Ce, ^{132}Ce, ^{132}La, ^{131}Ba, ^{126}Ba, ^{129}Cs, ^{127}Xe, ^{125}Xe, ^{123}Xe, ^{122}Xe, ^{121}Te, ^{119}Te, ^{117}Te, ^{115}Sb, ^{113}Sn, ^{111}In, ^{109}In, ^{105}Ag, ^{100}Pd, ^{100}Rh, ^{99m}Rh, ^{97}Ru, ^{90}Nb, ^{89}Zr, ^{88}Zr, ^{88}Y, ^{87}Y, ^{83}Sr, ^{83}Rb, ^{77}Kr, ^{75}Se, ^{73}Se, ^{51}Cr, ^{48}V, ^{43}K, ^{28}Mg, ^{24}Na	^{27}Al(p,x)^{24}Na		2000
C0236	1000, 2800	2	6	3	^{17}N, ^{16}C, ^{9}Li			1965
C1225	600, 800	2	72		^{184}Re, ^{183}Re, ^{182}Ta, ^{181}Hf, ^{175}Hf, ^{172}Hf, ^{174}Lu, ^{173}Lu, ^{169}Yb, ^{168}Yb, ^{167}Yb, ^{153}Gd, ^{151}Gd, ^{149}Gd, ^{148}Gd, ^{149}Eu, ^{148}Eu, ^{146}Pm, ^{144}Pm, ^{139}Ce, ^{133}Ba, ^{131}Ba, ^{127}Xe, ^{102}Rh, ^{95}Nb, ^{88}Zr, ^{88}Y, ^{83}Rb, ^{75}Se, ^{74}As, ^{65}Zn, ^{59}Fe, ^{54}Mn, ^{48}V, ^{46}Sc	^{27}Al(p,x)^{24}Na		2005
D0282	18.9 - 39.9	11	77	7	^{184}Re, ^{183}Re, ^{182m}Re, ^{182}Re, ^{181}Re, ^{184}Ta, ^{183}Ta	^{27}Al(p,x)^{24}Na, ^{27}Al(p,x)^{22}Na	stack	2008
D0380	19.3 - 22.2	3	18	6	^{184}Re, ^{184m}Re, ^{183}Re, ^{182m}Re, ^{182}Re, ^{181}Re	^{63}Cu(p,x)^{65}Zn, ^{63}Cu(p,x)^{62}Zn	stack	1999
D4087	20.0 - 34.7	16	16	1	^{186}Re	^{27}Al(p,x)^{24}Na	stack	1997
D4163	20.0 - 33.4	15	90	8	^{186}Re, ^{184}Re, ^{183}Re, ^{182m}Re, ^{182}Re, ^{181}Re, ^{183}Ta, ^{187}Ta	natCu(p,x)65Zn, natCu(p,x)63Zn, natCu(p,x)62Zn	stack	2006
E1241	500	1	41		^{183}Re, ^{182m}Re, ^{181}Re, ^{183}Ta, ^{177}Ta, ^{176}Ta, ^{175}Ta, ^{181}Hf, ^{180m}Hf, ^{175}Hf, ^{173}Hf, ^{172}Hf, ^{170}Hf, ^{174}Lu, ^{173}Lu, ^{172}Lu, ^{171}Lu, ^{170}Lu, ^{169}Lu, ^{169}Yb, ^{166}Tm, ^{165}Tm, ^{160m}Ho, ^{155}Tb, ^{153}Tb, ^{151}Tb, ^{149}Gd, ^{146}Gd, ^{146} Eu, ^{145}Eu, ^{148m}Pm, ^{124}Sb, ^{96}Tc, ^{88}Zr, ^{87}Y, ^{89}Sr, ^{75}Se, ^{72}As	^{27}Al(p,x)^{24}Na, ^{27}Al(p,x)^{22}Na	stack	1985
O0103	750	1	4		^{4}He, ^{3}He	^{27}Al(p,x)^{22}Na		1988
O0512	590	1	4		^{168}Tm, ^{167}Tm	^{27}Al(p,x)^{24}Na	stack	1976

EXFOR Code number	Energy range	Numbers of energies	Cross sections measured	Numbers of excitation functions measured	Nuclides measured	Monitor reactions	Irradiation type	Year
O0768	850	1	21		^{177}W, ^{176}W, ^{182m}Ta, ^{178m}Ta, ^{175}Ta, ^{174}Ta, ^{173}Ta, ^{172}Ta, ^{182m}Hf, ^{162}Yb, ^{161}Tm, ^{161}Er, ^{159}Er, ^{156}Ho			2000
O0781	2600	1	129		^{181}Re, ^{177}W, ^{176}W, ^{184} Ta, ^{183}Ta, ^{182}Ta, ^{176}Ta, ^{175}Ta, ^{174}Ta, ^{173}Ta, ^{181}Hf, ^{180}Hf, ^{175}Hf, ^{173}Hf, ^{172}Hf, ^{171}Hf, ^{170}Hf, ^{173}Lu, ^{172}Lu, ^{171}Lu, ^{170}Lu, ^{169}Lu, ^{167}Lu, ^{169}Yb, ^{167}Yb, ^{166}Yb, ^{162}Yb, ^{167}Tm, ^{166}Tm, ^{165}Tm, ^{163}Tm, ^{161}Tm, ^{160}Er, ^{159}Er, ^{157}Er, ^{156}Er, ^{160m}Ho, ^{157}Ho, ^{156}Ho, ^{157}Dy, ^{155}Dy, ^{153}Dy, ^{152}Dy, ^{155}Tb, ^{153}Tb, ^{152}Tb, ^{151}Tb, ^{150}Tb, ^{149}Tb, ^{147}Tb, ^{153}Gd, ^{151}Gd, ^{149}Gd, ^{147}Gd, ^{146}Gd, ^{145}Gd, ^{149}Eu, ^{147}Eu, ^{146}Eu, ^{145}Eu, ^{143}Pm, ^{139m}Nd, ^{139}Ce, ^{135}Ce, ^{134}Ce, ^{133}Ce, ^{132}Ce, ^{132}La, ^{133}Ba, ^{131}Ba, ^{128}Ba, ^{126}Ba, ^{129}Cs, ^{127} Xe, ^{125}Xe, ^{123}Xe, ^{122}Xe, ^{121}Te, ^{119}Te, ^{117}Te, ^{118}Sb, ^{115}Sb, ^{113}Sn, ^{111} In, ^{110} In, ^{109}In, ^{106} Ag, ^{105}Ag, ^{100}Pd, ^{100}Rh, ^{99m}Rh, ^{96}Tc, ^{90}Mo, ^{97}Ru, ^{90}Nb, ^{89}Zr, ^{88}Zr, ^{88}Y, ^{87}Sr, ^{85} Sr, ^{83}Sr, ^{84}Rb, ^{83}Rb, ^{82}Rb, ^{77}Kr, ^{74}As, ^{75}Se, ^{73}Se, ^{69}Zn, ^{59}Fe, ^{54}Mn, ^{51}Cr, ^{48}V, ^{43}K, ^{28}Mg, ^{24}Na, ^{7}Be	^{27}Al(p,x)^{24}Na, ^{27}Al(p,x)^{22}Na, ^{27}Al(p,x)7Be		2003
O0800	268 - 630	3	179	64	^{184m}Re, ^{184}Re, ^{183}Re, ^{178}W, ^{183}Ta, ^{182}Ta, ^{181}Hf, ^{179m}Hf, ^{178m} Hf, ^{175}Hf, ^{172}Hf, ^{177m}Lu, ^{174}Lu, ^{173}Lu, ^{171}Lu, ^{169}Yb, ^{168}Tm, ^{167}Tm, ^{156}Tb, ^{155}Tb, ^{156}Gd, ^{149}Gd, ^{147}Gd, ^{145}Gd, ^{149}Eu, ^{148}Eu, ^{147}Eu, ^{146}Eu, ^{145}Eu, ^{144}Eu, ^{148m}Pm, ^{143}Pm, ^{139m}Nd, ^{140}Ba, ^{133}Ba, ^{131}Ba, ^{121}Te, ^{113}Sn, ^{126}I, ^{110m}Ag, ^{106m}Ag,, ^{105}Ag,, ^{103}Ru, ^{102}Rh, ^{95}Tc, ^{95,91m}Nb, ^{95}Zr, ^{88}Zr, ^{88}Y, , ^{87}Y, ^{85}Sr, ^{84}Rb, ^{83}Rb, ^{74}As, ^{75}Se, ^{72}Se, ^{65}Zn, ^{59}Fe, ^{56}Mn, ^{54}Mn, ^{48}V, ^{22}Na, ^{7}Be			2004
O1099	764 - 2590	7	729	58	^{184m}Re, ^{183}Re, ^{182}Re, ^{181}Re, ^{178}W, ^{183}Ta, ^{182}Ta, ^{181}Hf, ^{175}Hf, ^{172}Hf, ^{170}Hf, ^{173}Lu, ^{171}Lu, ^{169}Lu, ^{169}Yb, ^{166}Yb, ^{168}Tm, ^{167}Tm, ^{160}Er, ^{155}Tb, ^{153}Tb, ^{153}Gd, ^{151}Gd, ^{149}Gd, ^{146}Gd, ^{149}Eu, ^{148}Eu, ^{147}Eu, ^{145}Eu, ^{144}Pm, ^{143}Pm, ^{139}Ce, ^{133}Ba, ^{131}Ba, ^{127}Xe, ^{121m}Te, $^{110m,\ 106m}$Ag, ^{96}Tc, ^{89}Zr, ^{88}Zr, ^{88}Y, ^{87}Y, ^{85}Sr, $^{84,\ 83}$Rb, ^{75}Se, ^{74}As, ^{65}Zn, ^{60}Co, ^{56}Co, ^{59}Fe, $^{54,\ 52}$Mn, ^{48}V, ^{22}Na, ^{7}Be	^{27}Al(p,x)^{22}Na, ^{nat}Cu(p,x)^{65}Zn,	stack	2002
O1100	52.1 - 84.2	9	130	18	^{186}Re, ^{184m}Re, ^{184}Re, ^{183}Re, ^{182m}Re, ^{182}Re, ^{181}Re, ^{178}W, ^{183}Ta, ^{182}Ta, ^{177}Ta, ^{176}Ta, ^{181}Hf, ^{179m}Hf, ^{175}Hf, ^{173}Hf, ^{177}Lu, ^{89}Y, ^{88}Zr	^{27}Al(p,x)^{22}Na	stack	2002
O1733	400 - 2600	6	6	1	^{148}Gd	^{27}Al(p,x)^{22}Na	stack	2008
T0149	750	1	2		$^{4,\ 3}$He	^{27}Al(p,x)^{22}Na		1988
T0276	17.5 - 57.4	14	29	2	^{184}Re, ^{183}Re	current transformer, ^{27}Al(p,x)^{24}Na		1979

EXFOR Code number	Energy range	Numbers of energies	Cross sections measured	Numbers of excitation functions measured	Nuclides measured	Monitor reactions	Irradiation type	Year
^{186}W								
O1021	200 - 1600	3	215	89	^{177}W, ^{184}Ta, ^{182}Ta, ^{176}Ta, ^{175}Ta, ^{174}Ta, ^{173}Ta, ^{181}Hf, ^{175}Hf, ^{172}Hf, ^{171}Hf, ^{170}Hf, ^{173}Lu, ^{172}Lu, ^{171}Lu, ^{170}Lu, ^{169}Lu, ^{167}Lu, ^{169}Yb, ^{166}Yb, ^{162}Yb, ^{167}Tm, ^{166}Tm, ^{165}Tm, ^{163}Tm, ^{161}Tm, ^{161}Er, ^{160}Er, ^{159}Er, ^{160m}Ho, ^{157}Ho, ^{157}Dy, ^{155}Dy, ^{153}Dy, ^{152}Dy, ^{155}Tb, ^{153}Tb, ^{152}Tb, ^{151}Tb, ^{150}Tb, ^{149}Tb, ^{148}Tb, ^{147}Tb, ^{153}Gd, ^{151}Gd, ^{149}Gd, ^{147}Gd, ^{146}Gd, ^{145}Gd, ^{149}Eu, ^{147}Eu, ^{146}Eu, ^{145}Eu, ^{143}Pm, ^{137}Nd, ^{136}Nd, ^{139}Ce, ^{135}Ce, ^{134}Ce, ^{132}Ce, ^{132}La, ^{133}Ba, ^{131}Ba, ^{128}Ba, ^{127}Xe, ^{125}Xe, ^{123}Xe, ^{121}Te, ^{119m}Te, ^{119}Te, ^{113}Sn, ^{105}Ag, ^{90}Nb, ^{96}Tc, ^{89}Zr, ^{88}Zr, ^{88}Y, ^{85}Sr, ^{87}Rb, ^{83}Rb, ^{75}Se, ^{59} Fe, ^{52}Fe, ^{52}Mn, ^{48}V, ^{28}Mg, ^{24}Na, ^{22}Na	^{27}Al(p,x)^{24}Na, ^{27}Al(p,x)^{22}Na, ^{27}Al(p,x)7Be		2003
O0800	268 - 630	3	180	64	^{184m}Re, ^{184}Re, ^{183}Re, ^{178}W, ^{183}Ta, ^{181}Hf, ^{179m}Hf, ^{178m}Hf, ^{175}Hf, ^{172}Hf, ^{177m}Lu, ^{174}Lu, ^{173}Lu, ^{171}Lu, ^{169}Yb, ^{168}Tm, ^{167}Tm, ^{156}Tb, ^{155}Tb, ^{156}Gd, ^{149}Gd, ^{147}Gd, ^{145}Gd, ^{149}Eu, ^{148}Eu, ^{147}Eu, ^{146}Eu, ^{145}Eu, ^{144}Eu, ^{148m}Pm, ^{143}Pm, ^{139m}Nd, ^{140}Ba, ^{133}Ba, ^{131}Ba, ^{121}Te, ^{113}Sn, ^{126}I, ^{110m}Ag, ^{106m}Ag, ^{105}Ag, ^{103}Ru, ^{102}Rh, ^{95}Tc, ^{95}Nb, ^{91m}Nb, ^{95}Zr, ^{88}Zr, ^{88}Y, ^{87}Y, ^{85}Sr, ^{84}Rb, ^{83}Rb, ^{74}As, ^{75}Se, ^{72} Se, ^{65}Zn, ^{56}Co, ^{59}Fe, ^{54}Mn, ^{48}V, ^{22}Na, ^{7}Be			2004
^{184}W								
O1020	200 - 1600	3	228	87	^{177}W, ^{184}Ta, ^{183}Ta, ^{182}Ta, ^{178m}Ta, ^{176}Ta, ^{175}Ta, ^{174}Ta, ^{173}Ta, ^{181}Hf, ^{175}Hf, ^{172}Hf, ^{171}Hf, ^{170}Hf, ^{173}Lu, ^{172}Lu, ^{171}Lu, ^{170}Lu, ^{169} Lu, ^{167}Lu, ^{169}Yb, ^{166}Yb, ^{162}Yb, ^{167}Tm, ^{166}Tm, ^{165}Tm, ^{163}Tm, ^{161}Tm, ^{161}Er, ^{160}Er, ^{159}Er, ^{160m}Ho, ^{157}Ho, ^{157}Dy, ^{155}Dy, ^{153}Dy, ^{152}Dy, ^{155}Tb, ^{153}Tb, ^{152}Tb, ^{151}Tb, ^{150}Tb, ^{149}Tb, ^{148}Tb, ^{147}Tb, ^{153}Gd, ^{151}Gd, ^{149}Gd, ^{147}Gd, ^{146}Gd, ^{145}Gd, ^{149}Eu, ^{147}Eu, ^{146}Eu, ^{145}Eu, ^{143}Pm, ^{137}Nd, ^{136}Nd, ^{139}Ce, ^{135}Ce, ^{134}Ce, ^{132}Ce, ^{132}La, ^{133}Ba, ^{131}Ba, ^{128}Ba, ^{127}Xe, ^{125}Xe, ^{123}Xe, ^{121}Te, ^{119m}Te, ^{119}Te, ^{113}Sn, ^{105}Ag, ^{90}Nb, ^{96}Tc, ^{89}Zr, ^{88}Zr, ^{88}Y, ^{85}Sr, ^{87}Rb, ^{83}Rb, ^{75}Se, ^{59}Fe, ^{52}Fe, ^{48}V, ^{28}Mg, ^{22}Na	^{27}Al(p,x)^{24}Na, ^{27}Al(p,x)^{22}Na, ^{27}Al(p,x)7Be		2003
^{182}W								

EXFOR Code number	Energy range	Numbers of energies	Cross sections measured	Numbers of excitation functions measured	Nuclides measured	Monitor reactions	Irradiation type	Year
O1019	200 - 1600	3	222	86	^{177}W, ^{182}Ta, ^{176}Ta, ^{175}Ta, ^{174}Ta, ^{173}Ta, ^{181}Hf, ^{175}Hf, ^{172}Hf, ^{171}Hf, ^{170}Hf, ^{173}Lu, ^{172}Lu, ^{171}Lu, ^{170}Lu, ^{169}Lu, ^{167}Lu, ^{169}Yb, ^{166}Yb, ^{162}Yb, ^{167}Tm, ^{166}Tm, ^{165}Tm, ^{163}Tm, ^{161}Tm, ^{161}Er, ^{160}Er, ^{159}Er, ^{160m}Ho, ^{157}Ho, ^{157}Dy, ^{155}Dy, ^{153}Dy, ^{152}Dy, ^{155}Tb, ^{153}Tb, ^{152}Tb, ^{151}Tb, ^{150}Tb, ^{149}Tb, ^{148}Tb, ^{147}Tb, ^{153}Gd, ^{151}Gd, ^{149}Gd, ^{147}Gd, ^{146}Gd, ^{145}Gd, ^{149}Eu, ^{147}Eu, ^{146}Eu, ^{145}Eu, ^{143}Pm, ^{137}Nd, ^{136}Nd, ^{139}Ce, ^{135}Ce, ^{134}Ce, ^{132}Ce, ^{132}La, ^{133}Ba, ^{131}Ba, ^{128}Ba, ^{127}Xe, ^{125}Xe, ^{123}Xe, ^{121}Te, ^{119m}Te, ^{119}Te, ^{113}Sn, ^{105}Ag, ^{90}Nb, ^{96}Tc, ^{89}Zr, ^{88}Zr, ^{88}Y, ^{85}Sr, ^{87}Rb, ^{83}Rb, ^{75}Se, ^{59}Fe, ^{52}Fe, ^{48}V, ^{28}Mg, ^{22}Na	^{27}Al(p,x)^{24}Na, ^{27}Al(p,x)^{22}Na, ^{27}Al(p,x)7Be		2003

Table 1.2.7. Identification of EXFOR code numbers.

EXFOR code number	Work
A0013	L.KH.Batist,E.E.Berlovich, K.A.Mezilev, JU.N.Novikov. Study of isotope dependence of the yield of N-17 nuclei from targets of Mg,S,Ca,Ni and Sn isotopes. Jour: Yadernaya Fizika, Vol.25, p.1140 (1977)
A0025	E.N.Vol'nin,V.T.Grachev,I.I.Gracheva,A.M.Zolotov, D.M.Seliverstov,L.A.Sliv,N.N.Smirnov. Investigation of reaction channels for spallation of Ni-58 by 1 GeV protons. Jour: Zhurnal Eksper. i Teoret. Fiz., Pisma v Redakt., Vol.28, Issue.1, p.45 (1978)
A0095	S.P.Avdeev, Joint Inst. for Nucl. Res., Dubna Reports, No.81, p.231 (1981)
A0100	R.Michel, R.Stueck, F.Peiffer. Proton-Induced Reaction on Ti,V,Mn,Fe,Co and Ni. Thesis: Stueck (1983)
A0146	R.Michel,G.Brinkmann,H.Weigel,W.Herr. Measurement and Hybrid-Model Analysis of Proton-Induced Reactions with V,Fe, and Co. Jour: Nuclear Physics, Section A, Vol.322, p.40 (1979)
A0168	P.P.Dmitriev, G.A.Molin. Radioactive nuclide yields for thick target at 22 MeV proton energy. Jour: Vop. At.Nauki i Tekhn.,Ser.Yadernye Konstanty, Vol.44, Issue.5, p.43 (1981)
A0177	M.Merkel,M.Munzel. Formation of tritium in nuclear reactions induced by deuterons and alpha-particles. Jour: Nuclear Physics, Section A, Vol.333, p.173 (1980)
A0179	N.C.Schoen,G.Orlov,R.J.McDonald. Excitation function for radioactive isotopes produced by proton bombardment of Fe, Co, and W in the energy range from 10 to 60 MeV. Jour: Physical Review, Part C, Nuclear Physics, Vol.20, p.88 (1979)
A0179	N.C.Schoen, Physical Review, Part C, Nuclear Physics, Vol.20, p.88 (1979)
A0182	M.C.Lagunas-Solar,J.A.Jungerman. Cyclotron production ofcarrier-free cobalt-55. A new positron-emitting label for bleomtcin. Jour: Applied Radiation and Isotopes, Vol.30, p.25 (1979)
A0195	P.P.Dmitriev. Systematics of nuclear reaction yields for target at 22 MeV proton energy. Jour: Vop. At.Nauki i Tekhn.,Ser.Yadernye Konstanty, Issue.2, p.57 (1983)
A0294	I.Konstantinov,P.P.Dmitriev,V.I.Bolotskikh. Activation of Zr, Nb and Ta at cyclotron. Jour: Atomnaya Energiya, Vol.60, p.332 (1986)
A0339	I.F.Barchuk,V.S.Bulkin,V.A.Kuzmenkova,P.M.Kurilo,

Yu.N.Lobach,A.F.Ogorodnik,V.S.Procopenko, V.D.Sklyarenko,V.V.Tokarev. Excitation function of the reaction induced by interaction of protons over an energy range up to 67 MeV with silicon and iron nuclei. Jour: Atomnaya Energiya, Vol.63, p.30 (1987)
A0344 R.Michel, P.Dragovitsch, P.Englert, F.Peiffer, R.Stuek, S.Theis, F.Begemann, H.Weber, P.Signer, R.Wieler, D.Filges, P.Cloth. n the depth dependence of spallation reactions in a spherical thick diorite target homogeneously irradiated by 600 MeV protons. Simulation of production of cosmogenic nuclides in small meteorites. Jour: Nucl. Instrum. Methods in Physics Res., Sect.B, Vol.16, p.61 (1986)
A0351 V.N.Aleksandrov,M.P.Semyonova,V.G. Semyonov. Excitation function for radionuclides produced by (p,x)-reactions of copper and nickel. Jour: Atomnaya Energiya, Vol.62, p.411 (1987)
A0408 B.Dittrich,U.Herpers,Th.Schiffmann. Thin-target excination function for proton produced long-lived radionuclides. Rept: Fed.Rep.Germ.report to the I.N.D.C., No.32/LN+SPECIAL, p.33 (1988)
A0435 B.Dittrich, U.Herpers, M.Lupke, R.Michel. Proton-Induced Spallation Between 600 and 2600 MeV. Rept: Fed.Rep.Germ.report to the I.N.D.C., No.34/LN+SPECIAL, p.31 (1989)
A0479 B.Dittrich, U.Herpers,R.Bodemann, M. Lupke,R.Michel, P.Signer,R.Wieler,H.J.Hofmann,W.Woelfli. Integral Excitation Functions For the Production of Long-Lived be-10 and Al-26 by Proton-Induced Reactions. Rept: Report from CEC-Countries and CEC to NEANDC, No.312,U, p.51 (1990)
A0481 B.Dittrich, U.Herpers,R.Bodemann, M. Lupke,R.Michel, P.Signer,R.Wieler,H.J.Hofmann,W.Woelfli. Production of Stable Rare Gas Isotopes by Proton Induced Spallation Between 800 and 2600 MeV. Rept: Report from CEC-Countries and CEC to NEANDC, No.312,U, p.53 (1990)
A0491 R.Wolfle,S.M.Qaim. Be-7 emission cross section in high energy proton induced reactions on V-51,Nb-93 and Au-197. Jour: Radiochimica Acta, Vol.50, p.185 (1990)
A0497 G.F.Steyn,S.J.Mills,F.M.Nortier,B.R.S.Simpson, B.R.Meyer. Production of the Fe-52 via proton-induced reactions on manganese and nickel. Jour: Applied Radiation and Isotopes, Vol.41, p.315 (1990)
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2. METHOD OF EXPERIMENTAL DETERMINING THE CROSS SECTIONS FOR RADIOACTIVE PRODUCT GENERATION WITH DUE ALLOWANCE FOR UNSTEADY PROTON PULSE AMPLITUDE DISTRIBUTION

Works [1-5,7] assumed a steady distribution of proton pulse amplitudes in proton-irradiated thin targets in case the irradiation time is sufficiently short. However, this condition is contingent upon a given accelerator operation mode, thereby necessitating a more correct allowance for unsteady state of proton beam pulse amplitude.

2.1. Method of experimental determining the production rates of radioactive products in nuclear reactions by γ-spectrometry techniques.

Given the concepts of independent nuclide production rate R_i^{ind}, when nuclear reaction generates a reaction product (Z_1,A_1), and of cumulative production rate R_i^{cum}, when a reaction product (Z_2,A_2) is generated in the course of all processes (both the reaction proper and the decays of its progenitors produced independently, Z_1,A_1 for instance), the two can be presented [3, 7] as

$$R_i^{cum/ind} = \sigma_i^{cum/ind} \cdot \Psi \qquad I = 1,2,st \tag{2.1}$$

where $\sigma_1^{cum/ind}$ and $\sigma_2^{cum/ind}$ are, respectively, cumulative or independent production cross sections for nuclides N_1 and N_2, in a proton-irradiated experimental sample [barn]; $\sigma_{st}^{cum/ind}$ are cumulative or independent monitor reaction cross sections used to calculate mean proton flux density [barn]; Ψ is the proton flux density [proton/(cm^2·s)] at instant t of time measured from start until end of irradiation.

Conforming to given irradiation mode, the function Ψ for the j-th pulse may be presented as

$$\Psi = \left\{ \begin{array}{ll} \Phi(x,y), & for \quad (j-1)\cdot T \le t < (j-1)\cdot T + \tau \\ 0, & for \quad (j-1)\cdot T + \tau \le t < j \cdot T \end{array} \right\} \tag{2.2}$$

The reaction rate definition (2.1) permits an one- or two-link radioactive transformation chain under irradiation to be described by a system of differential equations:

$$\begin{cases} \dfrac{dN_1(t)}{dt} = N_{Tag} \cdot R_1^{cum/ind} - \lambda_1 N_1(t), \\ \dfrac{dN_2(t)}{dt} = N_{Tag} \cdot R_2^{ind} + \nu_{1,2} \cdot \lambda_1 N_1(t) - \lambda_2 N_2(t), \end{cases} \tag{2.3}$$

With initial conditions $N_1(0)=N_2(0)=0$.

Here, $N_1(t)$, $N_2(t))$ is the number of nuclei produced in an irradiated experimental sample; $R_1^{cum\,/\,ind}$, R_2^{ind} are their cumulative or independent production rates, respectively; λ_1, λ_2 are decay constants; $\nu_{1,2}$ is the probability for the 1^{st} nuclide to get transformed into the 2^{nd} nuclide; N_{Tag} is the number of nuclei of element ${}^A_Z Tag$ in the experimental sample; t is current time measured from start to end of irradiation.

The given experiments make use of pulsed irradiation mode, i.e. of cyclic irradiation that consists of K pulses of different amplitudes, but with constant duration τ and repetition rate T each (see Fig. 2.1). Solution for system (2.3) at the irradiation stop moment $t_{irr}= (K-1)\cdot T+\tau$ can be described as:

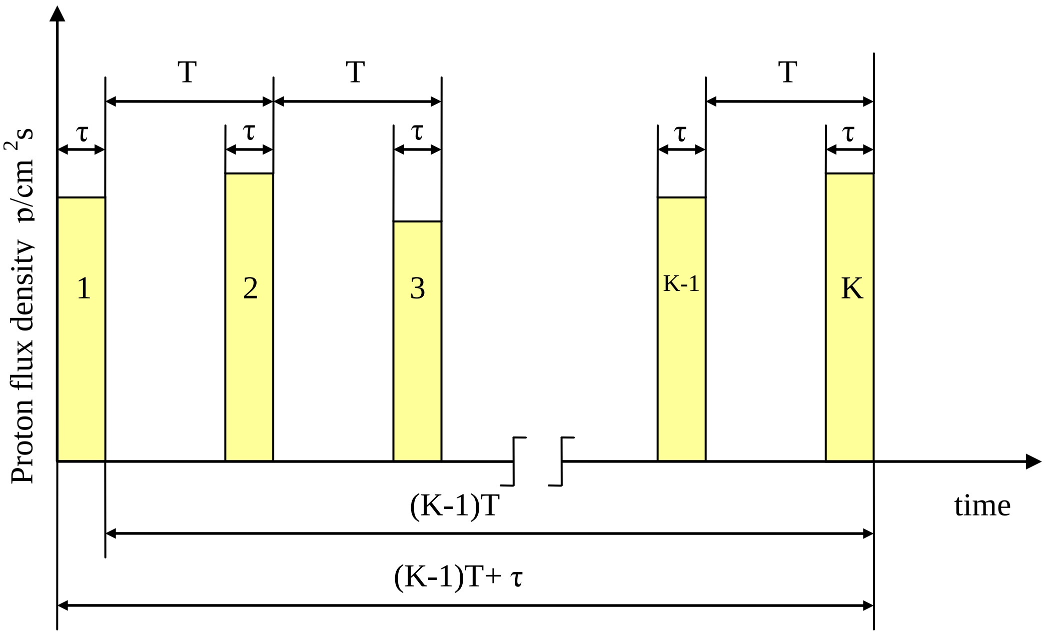


Fig. 2.1. The pulsed irradiation mode characteristics.

$$\begin{cases} N_1((K-1)\cdot T+\tau)=\dfrac{N_{Tag}\cdot \overline{\overline{R}}_1}{\lambda_1}\cdot\displaystyle\sum_{i=1}^{k}\xi\cdot e^{-\lambda_1\cdot(k-i)\cdot T} \\ N_2((K-1)\cdot T+\tau)=N_{Tag}\cdot \overline{\overline{R}}_1\cdot\nu_{1,2}\cdot\dfrac{1}{\lambda_2-\lambda_1}\cdot\displaystyle\sum_{i=1}^{k}\xi\cdot e^{-\lambda_1\cdot(k-i)\cdot T}+, \\ \qquad +\dfrac{N_{Tag}}{\lambda_2}\cdot\left[\overline{\overline{R}}_2-\dfrac{\lambda_1}{\lambda_2-\lambda_1}\cdot\nu_{1,2}\cdot\overline{\overline{R}}_1\right]\cdot\displaystyle\sum_{i=1}^{k}\xi\cdot e^{-\lambda_2\cdot(k-i)\cdot T} \end{cases} \qquad (2.4)$$

where $\overline{R}_1 = \frac{\sum_{i=1}^{K} R_{1_i}}{K}$, $\overline{R}_2 = \frac{\sum_{i=1}^{K} R_{2_i}}{K}$ are the amplitude-averaged nuclide 1 and 2 production rates**;**

$\overline{\overline{R}}_1 = \frac{\tau}{T} \cdot \overline{R}_1$, $\overline{\overline{R}}_2 = \frac{\tau}{T} \cdot \overline{R}_2$ are pulse duration-averaged production rates of nuclides 1 and 2**;**

$\xi = \frac{\Phi_i \cdot K}{\sum_{i=1}^{K} \Phi}$ is flux variation factor in each irradiation cycle. On the analogy of steady-state irradiation with a constant flux amplitude, let the time functions be introduced as

$$F_1 = \lambda_1 \cdot T \cdot \sum_{j=1}^{k} \xi_j \cdot e^{-\lambda_1 \cdot (k-j) \cdot T} \qquad F_2 = \lambda_2 \cdot T \cdot \sum_{j=1}^{k} \xi_j \cdot e^{-\lambda_2 \cdot (k-j) \cdot T} \tag{2.5}$$

Irradiation having ended, the decays of nuclides N_1 and N_2 produced are described by the set of differential equations:

$$\begin{cases} \frac{dN_1}{dt} = -\lambda_1 \cdot N_1(t) \\ \frac{dN_2}{dt} = \nu_{1,2} \cdot \lambda_1 \cdot N_1(t) - \lambda_2 \cdot N_2(t) \end{cases} \tag{2.6}$$

With initial conditions $N_1(0) = N_{1_0}$ and $N_2(0) = N_{2_0}$, where N_{1_0}, N_{2_0} is the number of nuclei produced by the "cooling" start moment (irradiation stop moment); t is the current time elapsed after the irradiation stop moment.

Solution for system (2.6) at any moment of "cooling" time t can be presented as:

$$\begin{cases} N_1(t) = N_{1_0} \cdot e^{-\lambda_1 \cdot t} \\ N_2(t) = \frac{\lambda_1}{\lambda_2 - \lambda_1} \cdot N_{1_0} \cdot \nu_{1,2} \cdot e^{-\lambda_1 \cdot t} + \left(N_{2_0} + \frac{\lambda_1}{\lambda_1 - \lambda_2} \cdot \nu_{1,2} \cdot N_{1_0} \right) \cdot e^{-\lambda_2 \cdot t} \end{cases}, \tag{2.7}$$

In the experiment, the nuclear reaction rates in the samples irradiated were determined via direct γ spectrometry without preseparating them. The nuclide 1 and 2 decay curve points measured at the "cooling" start (irradiation stop) moment were fitted by the least square technique (LST). The condition that the numbers of the 1st and 2nd nuclide nuclei be the same at the "cooling" start and at irradiation stop moments in the samples irradiated permits the required reaction rates to be obtained from (2.4) and (2.7), namely:

$$R_1^{cum/ind} = \frac{\hat{A}_1}{N_{Tag} \cdot \eta_1 \cdot \varepsilon_1} \cdot \frac{1}{F_1}, \tag{2.8}$$

$$R_1^{cum/ind} = \frac{\hat{A}_2^1}{N_{Tag} \cdot \eta_2 \cdot \varepsilon_2 \cdot \nu_{12}} \cdot \frac{\lambda_2 - \lambda_1}{\lambda_2} \cdot \frac{1}{F_1}, \quad (2.9),$$

$$R_2^{ind} = \left(\frac{\hat{A}_2^2}{F_2} + \frac{\hat{A}_2^1}{F_1} \cdot \frac{\lambda_1}{\lambda_2} \right) \cdot \frac{1}{N_{Tag} \cdot \eta_2 \cdot \varepsilon_2}, \quad (2.10),$$

$$R_2^{cum} = R_2^{ind} + \nu_{12} \cdot R_1^{cum/ind} = \left(\frac{\hat{A}_2^1}{F_1} + \frac{\hat{A}_2^2}{F_2} \right) \cdot \frac{1}{N_{Tag} \cdot \eta_2 \cdot \varepsilon_2}, \quad (2.11),$$

Where $\hat{A}_1 = A_1 \cdot k_{\mu_1}$, $\hat{A}_2^1 = A_2^1 \cdot k_{\mu_2}$ $\hat{A}_2^2 = A_2^2 \cdot k_{\mu_2}$ are parameters determined by LST-aided fitting the experimental points of the mother (subscript 1) and daughter (subscript 2) nuclide decay curve points; η_1, η_2 are absolute γ-quantum abundances; $\varepsilon_1, \varepsilon_2$ are absolute spectrometer efficiencies at γ-quantum energies E_1 (the 1st nuclide) and E_2 (the 2nd nuclide, F_1, F_2 are the functionals calculated by (2.5) formulae; t_{irr} is irradiation time; λ_1, λ_2, $\nu_{1,2}$ and N_{Tag} are the same as in (2.3).

The corrections k_μ that allow for γ-quantum absorption in an experimental sample material are determined as

$$k_{\mu_j} = \frac{k \cdot \sigma_{tot_j} \cdot h}{1 - e^{k \cdot \sigma_{tot_j} \cdot h}} \qquad \frac{\Delta k_{\mu_j}}{k_{\mu_j}} = \left(1 - k_{\mu_j} \cdot e^{-k \cdot \sigma_{tot_j} \cdot h}\right) \cdot \frac{\Delta \sigma_{tot_j}}{\sigma_{tot_j}}, \quad (2.12),$$

Where h is experimental sample thickness (g/cm^2); σ_{tot_j} is the total cross section for γ-quanta of the j-th energy to interact with matter (barn/atom); $k = \frac{N_{A_v}}{M} \cdot 10^{-24}$ is the transition coefficient from dimension [barn/atom] to dimension [cm^2/g], wherein N_{A_v} is Avogadro number and M is molecular weight. The total cross sections for γ-quanta of the j-th energy to interact with matter were borrowed from work [8]. Conforming to the recommendations made in that same work, the relative errors in the total cross sections for γ-quantum interactions with matter within the 100-2600 keV range were broken to belong to two groups of energies below and above 200 keV, wherein the error was taken to be 10% and 5%, respectively.

In some cases where the experimental dot fit fails to permit determination of factor $\hat{A}_2^1$, the concepts of supracumulative reaction rate and, respectively, of supracumulative cross section [2,3,5,6]

$$R_2^{cum*} = R_2^{ind} + \frac{\lambda_1}{\lambda_1 - \lambda_2} \cdot \nu_1 \cdot R_1^{ind} = \frac{\hat{A}_2^2}{N_{Tag} \cdot \eta_2 \cdot \varepsilon_2 \cdot F_2} \qquad (2.13)$$

are expedient to introduce.

Corrections to allow for the difference between steady and unsteady neutron fluxes may also be introduced, namely

$$\zeta_i = \frac{1 - e^{-\lambda_i \cdot t_{irr}}}{\lambda_i \cdot T \cdot \sum_{j=1}^{k} \xi_i \cdot e^{-\lambda_i \cdot (k-j) \cdot T}}_1 = \frac{1 - e^{-\lambda_i \cdot t_{irr}}}{\lambda_i \cdot t_{irr} \cdot \sum_{j=1}^{k} \Phi_j \cdot e^{-\lambda_i \cdot t_j}} \cdot \sum_{j=1}^{k} \Phi_j \ , \qquad (2.14)$$

2.2. Errors in γ-spectrometric measurements of reaction rates

Since, in further calculating the mean production rates, a few $(R_{ij}^{ind/cum} \pm \Delta R_{ij}^{ind/cum})$ values calculated for k different γ-lines $(i = 1, 2; \quad 1 < j < k)$ [9,10] may get averaged, it is expedient to introduce definitions for relative quantum yield and relative spectrometer detection effeciency that are related to their absolute values as

$$\eta_{ij} = k_{\gamma_i} \cdot \eta_{ij}^{rel} \qquad \varepsilon_{ij} = k_{\varepsilon} \cdot \varepsilon_{ij}^{rel} \qquad (2.15)$$

with the $k_{\gamma i} \pm \Delta k_{\gamma i}$ values being borrowed from [9], and the procedure of determining the $k_{\varepsilon} \pm \Delta k_{\varepsilon}$ value described in [5]. In that case, the relative production rate of each nuclide may be presented via the factors $k_{\gamma i}$ and k_{ε} introduced and the absolute reaction rate values calculated by formulas (2.8-2.11, 2.13):

$$^{rel}R_{ij}^{cum/ind} = R_{ij}^{cum/ind} \cdot k_{\gamma j} \cdot k_{\varepsilon} \cdot N_{tag} \qquad (2.16)$$

The errors in the relative reaction rates $\Delta\, ^{rel}R_1^{cum/ind}$, $\Delta\, ^{rel}R_1^{cum/ind}$, $\Delta\, ^{rel}R_2^{ind}$, $\Delta\, ^{rel}R_2^{cum}$ are calculated via the error transfer expression making allowance for errors in all cofactors entering expressions formulas (2.8-2.11, 2.13):

$$\Delta\, ^{rel}R_1^{cum/ind} = {}^{rel}R_1^{cum/ind} \cdot \sqrt{\left(\frac{\Delta A_1}{A_1}\right)^2 + \left(\frac{\Delta k_{\mu_1}}{k_{\mu_1}}\right)^2 + \left(\frac{\Delta \eta_1^{rel}}{\eta_1^{rel}}\right)^2 + \left(\frac{\Delta \varepsilon_1^{rel}}{\varepsilon_1^{rel}}\right)^2} \qquad (2.17)$$

$$\Delta\, {}^{rel}R_1^{cum/ind} = {}^{rel}R_1^{cum/ind} \cdot \sqrt{\left(\frac{\Delta A_2^1}{A_2^1}\right)^2 + \left(\frac{\Delta k_{\mu_2}}{k_{\mu_2}}\right)^2 + \left(\frac{\Delta \eta_2^{rel}}{\eta_2^{rel}}\right)^2 + \left(\frac{\Delta \varepsilon_2^{rel}}{\varepsilon_2^{rel}}\right)^2} \qquad (2.18)$$

$$\Delta\, {}^{rel}R_2^{cum/ind} = {}^{rel}R_2^{cum/ind} \cdot \sqrt{\left(\frac{\Delta G_{A_2^1}}{G_{A_2^1}}\right)^2 + \left(\frac{\Delta k_{\mu_2}}{k_{\mu_2}}\right)^2 + \left(\frac{\Delta \eta_2^{rel}}{\eta_2^{rel}}\right)^2 + \left(\frac{\Delta \varepsilon_2^{rel}}{\varepsilon_2^{rel}}\right)^2} \qquad (2.19)$$

$$\Delta\, {}^{rel}R_2^{cum} = {}^{rel}R_2^{cum} \cdot \sqrt{\left(\frac{\Delta G_{A_2^2}}{G_{A_2^2}}\right)^2 + \left(\frac{\Delta k_{\mu_2}}{k_{\mu_2}}\right)^2 + \left(\frac{\Delta \eta_2^{rel}}{\eta_2^{rel}}\right)^2 + \left(\frac{\Delta \varepsilon_2^{rel}}{\varepsilon_2^{rel}}\right)^2} \qquad (2.20)$$

The errors in the functions

$$G_{A_2^1}(\vec{A}_2) = \frac{A_2^2}{F_2} + \frac{A_2^1}{F_1} \cdot \frac{\lambda_1}{\lambda_2} \qquad (2.21)$$

$$G_{A_2^2}(\vec{A}_2) = \frac{A_2^1}{F_1} + \frac{A_2^2}{F_2} \qquad (2.22)$$

of parameters A_2^1 and A_2^2 are determined as.

$$\Delta G_{A_2^i}^2 = gradG_{A_2^i} \cdot M_{A_2}^{-1} \cdot (gradG_{A_2^i})^T, \quad i = 1, 2 \qquad (2.23)$$

$$gradG_{A_2^1} = \left\{ \frac{1}{F_1} \cdot \frac{\lambda_1}{\lambda_2}, \frac{1}{F_2} \right\} \qquad (2.24)$$

$$gradG_{A_2^2} = \left\{ \frac{1}{F_1}, \frac{1}{F_2} \right\} \qquad (2.25)$$

The mean independent production rates of the i-th nuclide derived from j γ-lines were calculated as

$$ {}^{rel}\overline{R}_i^{cum/ind} = \frac{\sum_{j=1}^{k} {}^{rel}R_{ij}^{cum/ind} \cdot {}^{rel}W_{ij}}{\sum_{j=1}^{k} {}^{rel}W_{ij}} \qquad {}^{rel}W_{ij} = \frac{1}{\left(\Delta\, {}^{rel}R_{ij}^{cum/ind}\right)^2} \tag{2.26} $$

$$ \Delta\, {}^{rel}\overline{R}_i^{cum/ind} = \max\left\{ \left(\Delta\, {}^{rel}\overline{R}_i^{cum/ind}\right)'; \left(\Delta\, {}^{rel}\overline{R}_i^{cum/ind}\right)'' \right\} \tag{2.27} $$

$$ \left(\Delta\, {}^{rel}\overline{R}_i^{cum/ind}\right)' = \sqrt{\frac{\sum_{j=1}^{k} {}^{rel}W_{ij} \left({}^{rel}\overline{R}_i^{cum/ind} - {}^{rel}\overline{R}_{ij}\right)^2}{(k-1)\sum_{j=1}^{k} {}^{rel}W_{ij}}} \tag{2.28} $$

$$ \left(\Delta\, {}^{rel}\overline{R}_i^{cum/ind}\right)'' = \sqrt{\frac{1}{\sum_{j=1}^{k} {}^{rel}W_{ij}}} \tag{2.29} $$

The mean absolute independent or cumulative *i*-th nuclide production rates and the errors therein were calculated from their relative counterparts:

$$ \overline{R}_i^{cum/ind} = \frac{{}^{rel}\overline{R}_{ij}^{cum/ind}}{k_{\gamma_i} \cdot k_{\varepsilon} \cdot N_{tag}} \tag{2.30} $$

$$ \Delta\overline{R}_i^{cum/ind} = \overline{R}_i^{cum/ind} \cdot \sqrt{\left(\frac{\Delta\, {}^{rel}\overline{R}_i^{cum/ind}}{{}^{rel}\overline{R}_i^{cum/ind}}\right)^2 + \left(\frac{\Delta k_{\gamma_i}}{k_{\gamma_i}}\right)^2 + \left(\frac{\Delta k_{\varepsilon}}{k_{\varepsilon}}\right)^2 + \left(\frac{\Delta N_{tag}}{N_{tag}}\right)^2} \tag{2.31} $$

If a single γ-line is involved in calculating a reaction rate (in such a case, that single line may be selected among *j* γ-lines, or else a nuclide may have but a single γ-line, i.e. *j*=1), then, according to (2.8-2.11, 2.13), the quantum abundance of that γ-line $(\eta_i \pm \Delta\eta_i)$ was used therein together with the absolute detection effectiveness $(\varepsilon_i \pm \Delta\varepsilon_i)$. Since

$$ \left(\frac{\Delta\eta_{ij}}{\eta_{ij}}\right)^2 = \left(\frac{\Delta k_{\gamma i}}{k_{\gamma i}}\right)^2 + \left(\frac{\Delta\eta_{ij}^{rel}}{\eta_{ij}^{rel}}\right)^2 \tag{2.32} $$

$$\left(\frac{\Delta\varepsilon_{ij}}{\varepsilon_{ij}}\right)^2 = \left(\frac{\Delta k_\varepsilon}{k_\varepsilon}\right)^2 + \left(\frac{\Delta\varepsilon_{ij}^{rel}}{\varepsilon_{ij}^{rel}}\right)^2 \qquad (2.33)$$

formula (2.31), with due allowance for formulas (2.17-2.20), gets transformed to calculate the error in the reaction rate found for but a single γ-line.

2.3. Techniques for determining the proton flux density

Here, the $^{27}Al(p,x)^{22}Na$ reaction, whose energy dependence is shown in Fig. 5.24, is used as a monitor reaction. In this case, ^{22}Na is produced via one-link chain, so the ^{22}Na production rate and the error thereof can be determined via (2.7 and (2.28), so, according to (2.1), the proton flux density and its error can be calculated as

$$\hat{\Phi}_{st} = \frac{R_{st}^{cum/ind}}{\sigma_{st}^{cum/ind}} \qquad \frac{\Delta\hat{\Phi}_{st}}{\hat{\Phi}_{st}} = \sqrt{\left(\frac{\Delta R_{st}^{cum/ind}}{R_{st}^{cum/ind}}\right)^2 + \left(\frac{\Delta\sigma_{st}^{cum/ind}}{\sigma_{st}^{cum/ind}}\right)^2} \qquad (2.34)$$

2.4. Calculating the production cross sections of nuclear reaction products and the errors therein

On determining the nuclear reaction rates in the irradiated samples via formulas (2.8-2.11, 2.13) and Al monitors-aided calculating the proton flux density, the sought production cross section of a given reaction product are calculated as

$$\sigma_i^{cum/cum^*/ind} = \frac{R_i^{cum/cum^*/ind}}{\hat{\Phi}_{st}} \qquad \frac{\Delta\sigma_i^{cum/cum^*/ind}}{\sigma_i^{cum/cum^*/ind}} = \sqrt{\left(\frac{\Delta R_i^{cum/cum^*/ind}}{R_i^{cum/cum^*/ind}}\right)^2 + \left(\frac{\Delta\hat{\Phi}_{st}}{\hat{\Phi}_{st}}\right)^2} \qquad (2.35)$$

Note that the difference between σ^{cum} and σ^{cum^*} is not indicated in many works. Actually, this has to be done because σ^{cum^*} is always greater than σ^{cum} because, irradiation having ended, the nuclei of the second nuclide keep being generated due to decay of the first nuclide, being formally equivalent to a shift of the cooling start time. The expediency of introducing σ^{cum^*} was discussed in detail in [5]

2.5. Procedure of experimental determining the production rates of nuclear reaction products by α-spectrometry techniques

Detection of ^{148}Gd ($T_{1/2}$ = 74.6 y, E_{α} = 3.183 MeV, η = 100%, [10]) free of gamma-lines, which is exclusively an α-emitter, necessitates using the α-spectrometry techniques. The above presented mathematical tool intended for determining reaction rates by λ-spectrometry techniques is also suitable in case α-spectrometry is used. However. the standard α-spectrometry techniques assume chemical extraction of a sought element from a sample irradiated. Irradiation with a ~10-nA proton beam from the ITEP U-10 accelerator restricts ^{148}Gd accumulation in a sample to 10^{-13} – 10^{-11} g. Such small Gd quantities are very difficult to separate because of very high Gd loss when concentrated on any carrier (i.e. any matter that absorbs element to be extracted). In this Project, therefore, the α-spectrometry was used without chemical separation.

The specific ^{148}Gd activity in ^{181}Ta and ^{nat}W samples can be determined by comparing between the calculated and measured α-spectra obtained given identical measurement geometries. It is assumed in this case that the count rate within a given energy spectrum is proportional to specific ^{148}Gd activity. 3183 keV α-particle ranges in ^{181}Ta and ^{nat}W are 9.88 and 10.09 mg/cm^2, correspondently [11]. Simulated counting rate for the cylindrical shape samples as a function of the sample thickness shows (Figs. 2.2 and 2.3) that the thicknesses of samples used in the experiments (0.2-0.3mm) are much above the range of α-particle emitted by ^{148}Gd.

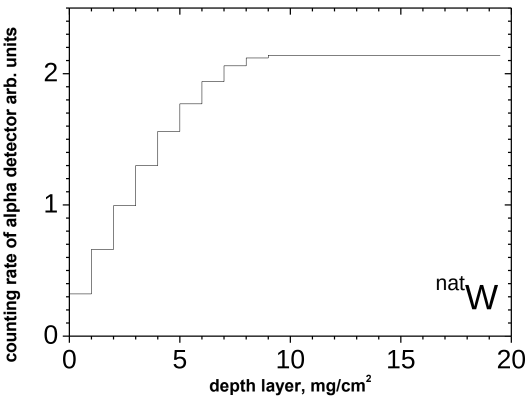


Fig. 2.2 Simulated counting rate of α-detector vs. ^{nat}W thickness.

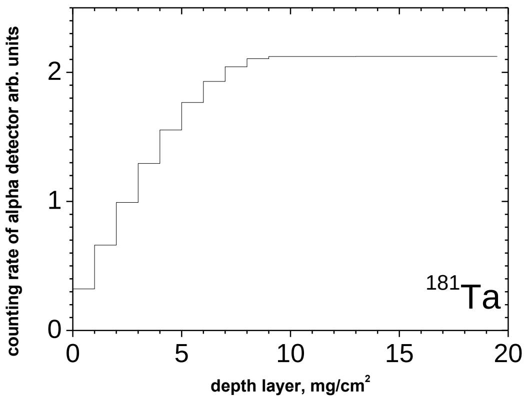


Fig. 2.3 Simulated counting rate of α-detector vs. ^{181}Ta thickness.

The above approach necessitates the following.

Not only α-particles, but also the β- and the characteristic γ-emission from the radioactive nuclides produced together with ^{148}Gd in the samples irradiated. That is why the cutoff energy E_{cutoff} has to be engaged for any α-peak detection range free of β-and γ-components to be discriminated.

In view of the above, the ^{148}Gd production rate expression (2.8) must take form

$$R = \frac{A_{cutoff} \cdot k_\alpha \cdot k_{peak}}{N_{tag} \cdot \eta_\alpha \cdot \varepsilon_\alpha} \cdot \frac{1}{F} = \frac{Q}{N_{tag}} \cdot \frac{1}{1 - e^{-\lambda \cdot t_{irr}}} , \qquad (2.36)$$

where R is the ^{148}Gd production rate; A_{cutoff} – is the α-detector count rate integral from the cutoff energy E_{cutoff} to the initial 3183 keV α-particle energy; k_α is a computational factor to allow for energy loss by an α-particle up to its stopping in the sample; k_{peak} is a computational factor to allow for the α-particle peak area ratio from the E_{disk} (80 keV) - E_{3183} (3183 keV) range and E_{cutoff} (2000 keV) and to E_{3183} (3183 keV); N_{tag} is number of target nuclei; η_α is the α particle abundance; Q – ^{148}Gd activity; λ – ^{148}Gd decay constant; t_{irr} – sample irradiation time.

Activity Q can be determined by :

$$Q = q \cdot m \tag{2.37}$$

The specific activity of ^{148}Gd of the used samples can be determined as:

$$q = K \cdot \sum_{i=N_1}^{N_2} y_i = K \cdot A_{cutoff} \tag{2.38}$$

where:

y_i – count in i-th experimental spectra channel, pulse/s;

N_1, N_2 – summing spectra range.

K – proportional factor.

Proportional factor K can be defined using the simulated α-spectra from identical sample measurement condition:

$$1 = K \cdot m \cdot \sum_{i=N_1}^{N_2} \tilde{y}_i = K \cdot m \cdot \tilde{A}_{cutoff} \tag{2.39}$$

where:

$\tilde{y}_i$ – count number in i-th channel of simulation spectra;

The (2.39) can be used to define K that is put to (2.38).

$$q = \frac{1}{m} \cdot \frac{\sum_{i=N_1}^{N_2} y_i}{\sum_{i=N_1}^{N_2} \tilde{y}_i} = \frac{1}{m} \cdot \frac{A_{cutoff}}{\tilde{A}_{cutoff}} \tag{2.40}$$

The equation (2.37) gives

$$Q = q \cdot m = \frac{\sum_{i=N_1}^{N_2} y_i}{\sum_{i=N_1}^{N_2} \tilde{y}_i} = \frac{A_{cutoff}}{\tilde{A}_{cutoff}} \tag{2.41}$$

and (2.36) provides:

$$R = \frac{Q}{N_{tag}} \cdot \frac{1}{1-e^{-\lambda T_{irr}}} = \frac{1}{N_{tag}} \cdot \frac{A_{cutoff}}{\tilde{A}_{cutoff}} \cdot \frac{1}{1-e^{-\lambda \cdot t_{irr}}} \tag{2.42}$$

3. EXPERIMENT DESIGN

Experiments to measure the ADS nuclear data may readily be made subject to using the external proton and heavy ion beams extracted from the Terawatt Accumulator (the TWA-ITEP Project), which is the unique heavy-ion acceleration-storage facility. Fig. 3.1 shows the TWA-ITEP accelerator layout. The accelerator includes

1. External ring to accelerate protons

2. Inner ring to accelerate ions

3. Proton injector, I-2

4. Laser injector of ions, I-3

5. External proton and ion bean extraction (LEH - nuclear physics, irradiations , building 102 –high energy density physics, irradiation-, building 103 – proton radiotherapy)

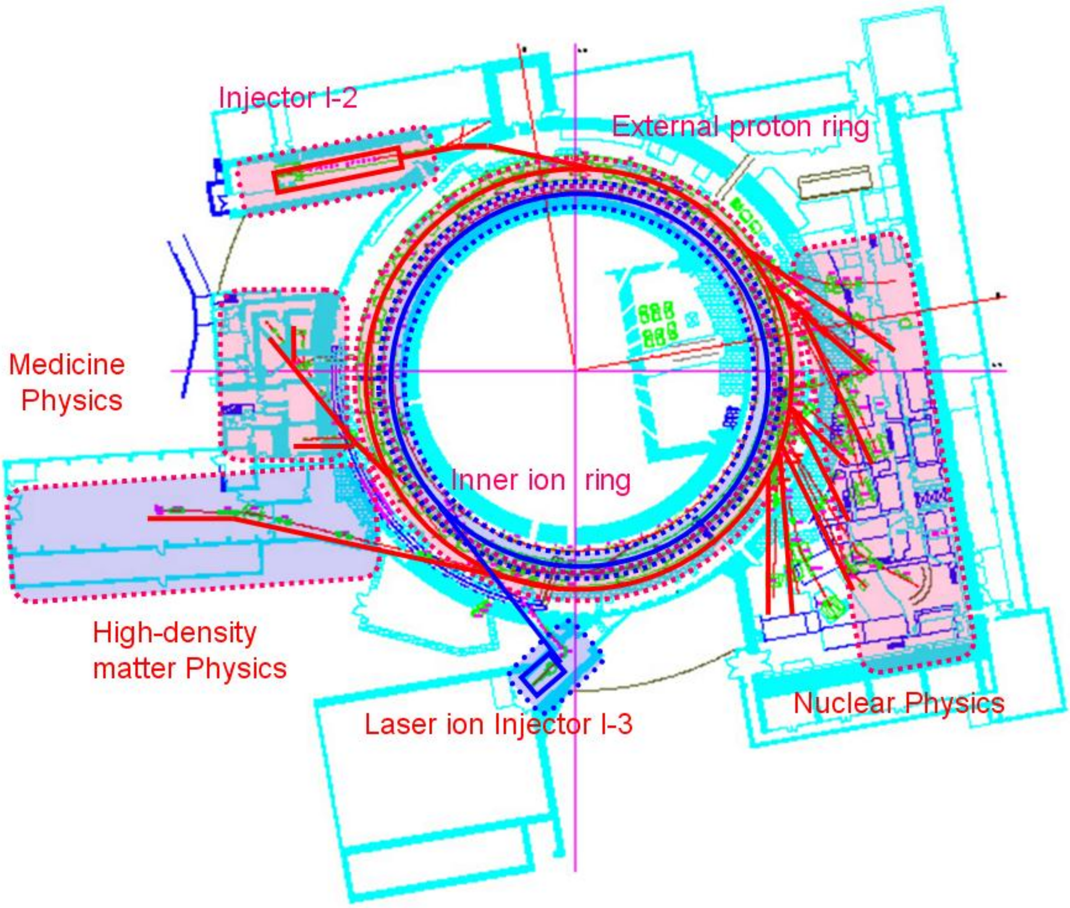


Fig. 3.1. The TWA-ITEP accelerator layout.

3.1. Preparation and irradiation of experimental samples

Experimental samples and monitors were prepared by cutting them off metal foils (^{nat}Ni, ^{93}Nb, ^{181}Ta, ^{nat}W, ^{27}Al) or by pressing fine-disperse metal powders (^{nat}Cr, ^{56}Fe). All the experimental samples and monitors were of the same 10.5-mm diameter. Table 3.1 presents the isotopic composition of the samples used in obtaining the results described below.

Table 3.1. Isotopic composition of the targets used.

Material	Certificate	Isotopic composition, %
^{nat}Cr	(*)	^{50}Cr – 4.345±0.013, ^{52}Cr – 83.789±0.018, ^{53}Cr – 9.501±0.017, ^{54}Cr – 2.365±0.007
^{56}Fe	284 STC “SI” (**)	^{54}Fe – 0.3, ^{56}Fe – 99.5±0.1, ^{57}Fe – 0.2, ^{58}Fe - < 0.05
^{nat}Ni	(*)	^{58}Ni – 68.0768±0.0089, ^{60}Ni - 26.2231±0.0077, ^{61}Ni – 1.1399±0.0006, ^{62}Ni – 3.6345±0.0017, ^{64}Ni – 0.9256±0.009.
^{93}Nb	(*)	^{93}Nb – 100.
^{181}Ta	(*)	^{180m}Ta – 0.012±0.002, ^{181}Ta – 99.988±0.002
^{nat}W	(*)	^{180}W – 0.12±0.01, ^{182}W – 26.50±0.16, ^{183}W – 14.31±0.04, ^{184}W – 30.64±0.02, ^{186}W – 28.43±0.19.

(*) – Isotopic composition was not determined; the data have been taken from [12].

(**) Quality certificate of the Scientific-Technical Center of Stable Isotopes.

As seen from Table 3.1, 50% of the materials used (^{56}Fe, ^{93}Nb, ^{181}Ta) are monoisotopic or enriched with a basic isotope. Of course, the results obtained may have been much affected by chemical admixtures (if any) in the irradiated samples. Therefore, all the materials used were strictly certified. Tables 3.2 and 3.3 present the total chemical admixture contents in all experimental samples.

The total admixture composition for ^{56}Fe is presented in conformity with the Quality Certificate issued by the Stable Isotopes Scientific and Technical Center, wherefrom ^{56}Fe was received. The admixture compositions for ^{nat}Cr, ^{nat}Ni, ^{93}Nb, and ^{181}Ta are presented conforming to the certificate issued by Alfa Aesar Co. (Jonson Matthey Company, www.alfa.com), wherefrom the materials were received. The ^{nat}W researches were made at the Mass Spectrometry and Chromatography Laboratory of the State Institute of Rare Metals (GIREDMET) via spark mass spectrometry techniques using a double-focusing mass spectrometer JMS-01-BM2. The mass spectra of a high mass-spectrum resolution were recorded on Ilford-Q photoplates. The mass spectra were quantitatively interpreted using a Joyce Loebl Co.-made MDM6 microdensitometer coupled with a NOVA-4 minicomputer. The impurity contents were calculated using the software developed at MS&GC Lab. The random error in the analysis results is characterized by a relative standard deviation of 0.15-0.30. The inert gas and transuranium element contents in a given sample have been found to be below their detection limits of 0.001 ppm. The analysis results are presented as mass parts per a million relative to metallic base (1 ppm = 0.0001%).

To be 1600 MeV and 2600 MeV proton-irradiated, an experimental sample-Al monitor "sandwich" was packed into a polyethylene bag that was fastened with a scotch to a 72x72-mm 0.1-mm thick Al plate placed normally to a proton flux. The samples and monitors were prepared to within a sufficient accuracy for them to be of identical geometric dimensions. The geometry selected has precluded any extra contribution from ^{24}Na, ^{22}Na, and ^{7}Be in the samples due to ejection of the three from the Al monitor. The Al plate was used to monitor the total proton beam intensity (see Section 5 below).

For ≤1200 MeV proton irradiations, the "sandwich" was made of two sample-monitor pairs, either of them packed in a separate polyethylene bag, namely, sample #1-monitor #1-sample #2-monitor-monitor #2. Either ^{56}Fe or ^{93}Nb, or ^{nat}W was used as sample #1, and either ^{nat}Cr or ^{nat}Ni, or ^{181}Ta[2] as sample #2.

Table 3.2. Chemical admixture contents in the ^{56}Fe, ^{nat}Cr, ^{nat}Ni, ^{93}Nb, and ^{181}Ta samples.

Admixture element	Admixture contents in				
	^{nat}Cr, %	^{56}Fe, ppm	^{nat}Ni, ppm	^{93}Nb, ppm	^{181}Ta, ppm
Al	0.0009	0.009	0.7	2	
B			0.2		
C	0.0060		<10	10	7
Ca		0.005	<0.1		
Cl		0.005	2		
Co		<0.01	0.1		
Cr	99.8100	0.013	0.07		9
Cu		0.018	0.2		2
Fe	0.1500		0.8	4	11
H	0.0200			<5	1
Hf				<1	
K			0.3		
Li			<0.01		
Mg		0.007	0.03		
Mn			0.006		
Mo			2	4	7
N	0.0500		21.5	35	10
Na		<0.001	1		

[2] The exceptions were two long irradiations of ^{nat}W and ^{181}Ta to measure ^{148}Gd at 400 and 600MeV energies. ^{181}Ta was Sample#1, ^{nat}W was Sample #2 in those irradiations.

Admixture element	Admixture contents in				
	^{nat}Cr, %	^{56}Fe, ppm	^{nat}Ni, ppm	^{93}Nb, ppm	^{181}Ta, ppm
Nb					29
Ni		0.001		1	26
O	0.6700		66	81	76
Pb			0.4		
P			0.04		
Sb		0.002			
Si	0.0010	0.02	0.9	<10	2
S	0.0270		22		
Ta				<100	
Ti				<1	1
V			0.004		
W				4	97
Zr			0.05	1	
Extra information					
Certificate No. (**)		284			
Stock No.(*)	41797		12045	10259	10353
Serial number(*)	D18R024		B13R041	A09R036	I15P25

(*) – according to the Certificate of Alfa Aesar (a Jonson Matthey Company, www.alfa.com)

(**) The Quality Certificate of the "Stable Isotopes" Scientific and Technical Center.

Table 3.3. Chemical admixtures in ^{nat}W.

Element	Content, ppm	Element	Content, ppm
Li	40	Ag	<0.9
Be	<0.01	Cd	9
B	0.4	In	<0.7
F	0.1	Sn	<2
Na	60	Sb	1
Mg	9	Te	<2
Al	20	I	<0.5
Si	20	Cs	<0.4
P	2	Ba	<1
S	40	La	<0.4
Cl	50	Ce	<0.5
K	100	Pr	<0.4
Ca	30	Nd	<0.8
Sc	<0.3	Sm	<0.9
Ti	2	Eu	<0.5
V	5	Gd	<0.8
Cr	30	Tb	<0.4
Mn	2	Dy	<0.8
Fe	2000	Ho	<0.5
Co	9	Er	<0.9
Ni	900	Tm	<0.5
Cu	10	Yb	<0.9

Element	Content, ppm	Element	Content, ppm
Zn	<1	Lu	<0.5
Ga	<0.6	Hf	<1
Ge	<0.7	Ta	<0.8
As	2	W	Base
Se	<0.5	Re	<0.9
Br	<0.8	Os	<0.8
Rb	<0.6	Ir	<0.6
Sr	<0.3	Pt	<0.8
Y	<0.4	Au	<0.6
Zr	<1	Hg	<1
Nb	<3	Tl	<0.7
Mo	100	Pb	<2
Ru	<1	Bi	<0.7
Rh	<0.5	Th	<0.9
Pd	<2	U	<0.9

All the irradiations under the projects belong to the following four groups::

1. Routine (standard) irradiations, when the above described "sandwiches" were exposed to protons for 0.5-1.0 hour; 39 irradiations of 66 samples in total;
2. High-intense (long) irradiations, when the ^{nat}W-^{181}Ta pairs were exposed for at least 4 hours to 400, 600, 800, 1200, and 1600 MeV protons to safely record ^{148}Gd; in total, five irradiations of 10 samples;
3. Additional irradiations of Fe-Cr and W-Ta pairs without polyethylene bags to 0.04, 0.07, 0.1, and 0.15 GeV protons to measure ^{7}Be yield; in total, eight irradiations of 16 samples;
4. Additional irradiations of ^{56}Fe to 0.3, 0.5, 0.75, 1.0, and 1.5 GeV protons to compare the data obtained with the GSI inverse kinematics results obtained at the respective energies; five irradiations in total.

A total of 57 irradiations of 97 samples were carried out under the Project in 2006-2009. The irradiation parameters are presented in Section 4 below.

Within 10-15 min after irradiation stop moment, the sample stacks were taken from the polyethylene bags irradiated. After that, the samples and monitors were placed into unimpaired polyethylene bags that got sealed to preclude any possible loss during the impending measurements and were then γ-spectrometered. The samples and monitors of stack #1 (sample #1-monitor #1) were measured with the GC2518 #1 γ-spectrometer purchased in 1995 when implementing ISTC Project #017, and those of stack #2 (sample #2-monitor #2) with the GC2518 #2 γ-spectrometer purchased in 2007 under the present Project.

To estimate a possible loss of radioactive recoil nuclei due to their escape from a sample under irradiation, the unsealed polyethylene bags irradiated were γ-spectrometered too. As a result, the loss level proved to be below the spectrometer detection level.

3.2. Description of the external proton beam extraction

The thin targets made from in the ADS structural materials were irradiated with 0.04-2.6 GeV proton beams from the ITEP U-10 synchrotron. The latter is a ring facility with a 25 MeV energy of proton injection into a ring and a 9.3 MeV ultimate proton acceleration energy. The proton beam accelerated up to a given energy (within 40 - 9300 MeV) and consisting of four bunches of ~250 ns duration each moves from an accelerator ring to the transport channel, wherefrom the protons are ejected, given the following parameters: a $2\cdot10^{11}$ proton/dump intensity, normal cross section shaped as an ellipsis with ~10x15-mm axes, ~1-μs total pulse duration, and ~15 pulse/min pulse repetition rate.

Fig. 3.2 shows the sample irradiation transport channel layout together with the elements of fast proton beam extraction

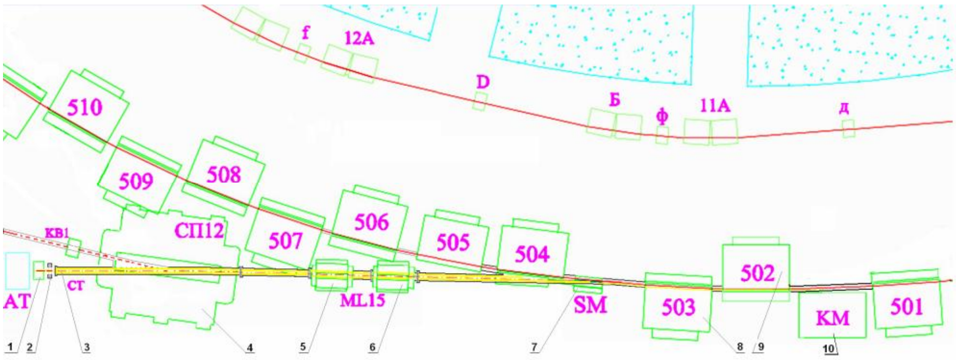


Fig. 3.2. The transport channel layout and the elements of proton beam fast extraction.

1. Support to place the positioning table together with the target to be irradiated; 2. Current transformer; 3. Outlet flange of vacuum proton guide; 4. Bending magnet; 5,6. A doublet of quadruple lenses to focus the beam; 7. Septum magnet; 8,9. Magnetic units of the accelerating ring; 10. Kicker magnet with a 15 mrad deflection angle; 11. Correction magnet (with a 20-30 mrad deflection angle).

Fig. 3.3. Place to irradiate the samples.

A proton beam goes from an accelerating ring to the transport channel, wherefrom protons of any energy within 40-2600 MeV are extracted with the fast extraction system that includes a 15 mrad deflection angle kicker magnet (with a 20-30 mrad deflection angle) and two magnetic lenses to focus the beam to take the form of an ellipsis with axes within 10-15 mm. The focusing made actually all protons hit an irradiated sample.

The beam was guided to an irradiated target using a ceramic plate that phosphoresces when proton beam-affected. The plate was placed on a task-oriented support (see Fig. 3.3.). A light flash was monitored with a camcorder. The beam having been guided to the ceramic plate center, the plate was taken from the support and replaced manually with a 0.1-mm thick 72x72 mm Al plate. The packed samples and monitors to be irradiated were fastened with a scotch to the center of the Al plate, which was so placed in the support that the proton beam would fall normally to the samples. The Al plate has a “petal” with a hole to fasten a capon cord passing through a task-oriented transport channel that connects the magnetic hall with the adjacent room (see Fig. 3.3). An irradiation run having ended, the capron cord picks the Al plate and pulls it from the support, whereupon the plate was transported without physical contact for ~1 min from the magnetic hall. In ~3-4 min, the samples were taken to the laboratory, wherein they were repacked and got monitored then with Ge detectors.

3.3. Determining the proton energies

The extracted proton beam energy has to be known because the given experiments aim to obtain the energy dependence of measured cross sections- the excitation functions for reactions analyzed in separate channels.

Under acceleration, the proton energies are measured with due allowance for the invariable length of the closed circulating proton orbit. Thus we can calculate the proton or heavy ion (charged heavy particle, CHP) energy by measuring the particle rotation frequency f_r :

$$E_0 = \frac{m\,c}{\sqrt{c^2 - L^2 f_r^2}} - m_z, \qquad (3.1)$$

where E_0 is the circulating proton kinetic energy; m is proton mass (938.26 MeV); L = 251.21m is the closed proton orbit length; $c = 2.99776\cdot10^8$ m/s is speed of light.

The f_r value is multiple to the accelerating radio frequency

$$f_a = h\cdot f_r, \qquad (3.2)$$

where h is the accelerating frequency multiplication factor relative to the beam the beam rotation frequency; f_a is the accelerating radio frequency that varies from 0.7 to 10.0 MHz The f_a signal is measured safely to within 10^{-4} accuracy or even better.

The energy measurement error if energy-dependent and can be calculated as

$$\Delta E_0 = \sqrt{\Delta E_f^2 + \Delta E_p^2}, \qquad (3.3)$$

where ΔE_f is the accelerator ring exit energy uncertainty contingent upon the space-frequency uncertainty; ΔE_p is the energy uncertainly contingent upon proton momentum spread. The ΔE_f and ΔE_p values are determined as**:**

$$\Delta E_f = E_0 \frac{\beta^2\gamma^3}{\gamma - 1}\sqrt{\left(\frac{\Delta f_a}{f_a}\right)^2 + \left(\frac{\Delta L}{L}\right)^2}, \quad (3.4) \qquad \Delta E_p = \frac{0.005\cdot p}{m_p + E_0}\sqrt{220 M\text{э}B / c\cdot p}, \quad (3.5)$$

where β is proton velocity equaling $L\cdot f_a/(h\cdot c)$; γ is a relativistic factor equaling to $\sqrt{1-\beta^2}$; p is momentum that corresponds to energy E_0**.** The L value is known to within a relativistic error of 10^{-4}.

When transported to the experimental sample irradiation place, the beam loses a portion of its energy for proton interactions with the transport channel structural materials, with air. The losses are allowed for as

$$E_{sample} = E_0 - E_{loss} \quad , \tag{3.6}$$

Here, E_{sample} is the proton beam kinetic energy in the location of a sandwich irradiated, whereas ΔE_{loss}, that is the proton energy loss for passage from transport channel to an irradiated sandwich, namely $E_{loss}= \delta E_{mem} - \delta E_{air} - \delta E_{pol} - 0.5 \cdot \delta E_{sample}$ (where δE_{mem}, δE_{air}, δE_{pol}, and δE_{sample} are, respectively, proton energy losses in the steel membrane at the transport channel outlet, in the air gap between the channel and an irradiated sandwich, in the sandwich bag polyethylene, and in the sample proper), is calculated via formula $\delta E = (dE/dx) \cdot X$, which is valid because the total structural material depth X traversed by the proton beam is insignificant, so that specific loss for ionization may well be considered constant. The energy uncertainty may be estimated as

$$\Delta E_{sample} = E_{sample} \sqrt{\Delta E_0^2 + \Delta E_{spread}^2 / 4 + \sum (\delta E_{loss})^2} \,, \tag{3.7}$$

where ΔE_{sample} is the difference between the energies when entering and leaving a sample; $\Sigma(\delta E_{loss})$ is root of the sum of dispersions of the Landau fluctuation of energy loss E_{loss} [3-Mox]; p is momentum that corresponds to energy E_0 .

Table 3.4 presents the energy uncertainties (by examples of proton-irradiated thin targets).

Table 3.4. Extracted energies and their errors.

E_0 (MeV)	40	100	800	2600
ΔE_{irr} (MeV)	< 1.4	< 1.0	2	8

Table 3.5 presents the energy loss in each irradiation run together with the resultant energies on samples and monitors.

Table 3.5. Proton beam energies in irradiating the sample-monitor “sandwiches” with due account for ionization loss in the transport channel structural materials as well as the $^{27}Al(p,x)^{22}Na$ monitor reactions cross section values at the energies calculated.

Energy (GeV)	Sample-1 Sample-2	Date	Frequency (MHz)	E0, MeV	Fe memb. hickn. (mm)	Air thickness (мм)	Sample#1 weight (g)	Monitor#1 weight (g)	Sample#2 weight (g)	Monitor#2 weight (g)	dE in membr (MeV)	dE in air (MeV)	dE in 110µm polyeth.	dE in Samp.#1 (MeV)	dE in Mon.#1 (MeV)	dE in 220µm polyeth.	dE in Samp.#2 (MeV)	dE in Mon.#2 (MeV)	dE-tot for Sample#1	dE-tot for Monitor #1	E in Sample#1 (MeV)	E in Monitor#1 (MeV)	dE-tot for Sample#2	dE-tot for Monitor #2	E in Sample#2 (MeV)	E in Monitor#1 (MeV)	^{22}Na crs for Mon#1	^{22}Na crs err for Mon#1	^{22}Na crs for Mon#2	^{22}Na crs err for Mon#2
0.04	W-Ta	30.06.08	1.471	48.00	0.1	185	0.2621	0.0481	0.3578	0.0481	0.69	0.26	0.14	1.96	0.59	0.30	2.83	0.62	2.07	3.34	**45.9**	**44.7**	5.36	7.08	**42.6**	**40.9**	43.5	2.6	41.4	2.5
0.04	W-Ta (Be)	19.03.09	1.471	48.00	0.1	185	0.138	0.0497	0.353	0.0497	0.69	0.26	0.14	1.03	0.60	0.30	2.74	0.63	1.61	2.42	**46.4**	**45.6**	4.40	6.09	**43.6**	**41.9**	42.9	2.6	42.8	2.6
0.07	W-Ta	23.06.08	1.747	69.95	0.1	185	0.2648	0.0964	0.3548	0.0498	0.52	0.19	0.10	1.50	0.86	0.21	2.05	0.46	1.56	2.74	**68**	**67.2**	4.41	5.66	**66**	**64.3**	22.6	1.4	23.7	1.4
0.07	W-Ta (Be)	19.03.09	1.747	69.95	0.1	185	0.0335	0.0493	0.127	0.0493	0.52	0.19	0.08	0.19	0.43	0.16	0.72	0.44	0.88	1.19	**69**	**68.8**	1.92	2.50	**68**	**67.4**	22.2	1.4	22.6	1.4
0.1	W-Ta	18.02.08	2.044	100.01	0.1	185	0.2770	0.0481	0.3586	0.0480	0.40	0.14	0.08	1.21	0.32	0.16	1.59	0.33	1.23	2.00	**99**	**98**	3.11	4.06	**97**	**96**	19.8	1.3	19.8	1.3
0.1	W-Ta (Be)	26.03.09	2.044	100.01	0.1	185	0.136	0.0482	0.124	0.0479	0.40	0.14	0.06	0.60	0.32	0.11	0.54	0.32	0.90	1.36	**99**	**99**	1.91	2.34	**98**	**98**	19.8	1.3	19.8	1.3
0.15	W-Ta	14.02.08	2.4187	150.06	0.1	185	0.2670	0.0584	0.3550	0.0588	0.30	0.11	0.06	0.89	0.29	0.11	1.19	0.30	0.91	1.51	**149**	**149**	2.36	3.10	**148**	**147**	17.1	1.1	17.2	1.2
0.15	W-Ta (Be)	26.03.09	2.4187	150.06	0.1	185	0.131	0.048	0.128	0.0489	0.30	0.11	0.04	0.44	0.24	0.08	0.43	0.24	0.67	1.01	**149**	**149**	1.42	1.76	**149**	**148**	17.1	1.1	17.1	1.1
0.25	W-Ta	06.12.07	2.929	250.01	0.1	185	0.2660	0.0587	0.3544	0.0585	0.22	0.08	0.04	0.65	0.21	0.08	0.87	0.21	0.66	1.10	**249**	**249**	1.71	2.25	**248**	**248**	15.0		0.9	
0.4	W-Ta	18.10.07	3.404	400.14	0.1	185	0.2680	0.0589	0.3558	0.0590	0.17	0.06	0.03	0.52	0.16	0.06	0.69	0.16	0.52	0.86	**400**	**399**	1.35	1.77	**399**	**398**	15.8		1.0	
0.4	W-Ta (Gd)	18.10.07	3.404	400.14	0.1	185	0.276	0.0588	0.353	0.0585	0.17	0.06	0.03	0.53	0.16	0.06	0.68	0.16	0.53	0.88	**400**	**399**	1.36	1.78	**399**	**398**				
0.6	W-Ta	15.10.07	3.783	600.30	0.1	185	0.2660	0.0594	0.3575	0.0591	0.15	0.05	0.03	0.44	0.14	0.05	0.59	0.14	0.44	0.73	**600**	**600**	1.15	1.51	**599**	**599**	16.0		1.0	
0.6	W-Ta (Gd)	15.10.07	3.783	600.30	0.1	185	0.267	0.0588	0.356	0.0592	0.15	0.05	0.03	0.44	0.14	0.05	0.58	0.14	0.44	0.73	**600**	**600**	1.14	1.51	**599**	**599**				
0.8	W-Ta	22.06.07	4.018	799.75	0.1	185	0.2670	0.0592	0.3575	0.0589	0.13	0.05	0.03	0.40	0.13	0.05	0.54	0.13	0.41	0.67	**799**	**799**	1.06	1.39	**799**	**798**	15.5		1.1	
0.8	W-Ta (Gd)	22.06.07	4.018	799.75	0.1	185	0.259	0.0598	0.358	0.0593	0.13	0.05	0.03	0.39	0.13	0.05	0.54	0.13	0.40	0.66	**799**	**799**	1.04	1.38	**799**	**798**				
1.2	W-Ta	21.06.07	4.289	1199.51	0.1	185	0.2650	0.0593	0.3596	0.0590	0.12	0.04	0.02	0.39	0.12	0.04	0.53	0.12	0.38	0.64	**1199**	**1199**	1.01	1.33	**1199**	**1198**	14.4		1.0	
1.2	W-Ta (Gd)	20.06.07	4.289	1199.51	0.1	185	0.269	0.0592	0.356	0.0595	0.12	0.04	0.02	0.40	0.12	0.04	0.52	0.12	0.39	0.64	**1199**	**1199**	1.01	1.33	**1198**	**1198**				
1.6	Ta	08.02.07	4.435	1599.17	0.1	185	0.3542	0.0589	0.0000	0.0000	0.12	0.04	0.02	0.49	0.11	0.04	0.00	0.00	0.43	0.73	**1599**	**1598**	0.83	0.83	**1598**	**1598**	13.2		1.0	
1.6	W	08.02.07	4.435	1599.17	0.1	185	0.2709	0.0592	0.0000	0.0000	0.12	0.04	0.02	0.37	0.11	0.04	0.00	0.00	0.37	0.61	**1599**	**1599**	0.71	0.71	**1598**	**1598**				
1.6	W-Ta (Gd)	28.03.06	4.435	1599.17	0.1	1000	0.0328	0.0226	0.124	0.0239	0.12	0.22	0.02	0.05	0.04	0.04	0.17	0.05	0.39	0.43	**1599**	**1599**	0.58	0.69	**1599**	**1598**				
2.6	Ta	27.11.06	4.603	2605.82	0.1	185	0.3598	0.0591	0.0000	0.0000	0.12	0.04	0.02	0.50	0.11	0.04	0.00	0.00	0.43	0.74	**2605**	**2605**	0.83	0.83	**2605**	**2605**	11.4		0.9	
2.6	W	27.11.06	4.603	2605.82	0.1	185	0.2566	0.0592	0.0000	0.0000	0.12	0.04	0.02	0.35	0.11	0.04	0.00	0.00	0.36	0.59	**2605**	**2605**	0.69	0.69	**2605**	**2605**				
0.04	Nb-Ni	30.06.08	1.471	48.00	0.1	185	0.1894	0.0483	0.2057	0.0480	0.69	0.26	0.14	1.75	0.58	0.30	1.99	0.61	1.97	3.14	**46.0**	**44.9**	4.73	6.03	**43.3**	**42.0**	43.4	2.6	42.9	2.6
0.07	Nb-Ni	23.06.08	1.747	69.95	0.1	185	0.1860	0.0483	0.2056	0.0498	0.52	0.19	0.10	1.29	0.42	0.21	1.46	0.45	1.46	2.32	**68**	**67.6**	3.47	4.42	**66**	**65.5**	22.5	1.4	23.2	1.4
0.1	Nb-Ni	20.02.08	2.044	100.01	0.1	185	0.1897	0.0497	0.2035	0.0485	0.40	0.14	0.08	1.01	0.33	0.16	1.09	0.33	1.13	1.80	**99**	**98**	2.66	3.37	**97**	**97**	19.8	1.3	19.8	1.3
0.15	Nb-Ni	14.02.08	2.4187	150.06	0.1	185	0.1909	0.0480	0.2066	0.0247	0.30	0.11	0.06	0.76	0.24	0.11	0.83	0.12	0.85	1.35	**149**	**149**	2.00	2.48	**148**	**148**	17.1	1.1	17.1	1.1
0.25	Nb-Ni	06.12.07	2.929	250.01	0.1	185	0.1890	0.0490	0.2065	0.0491	0.22	0.08	0.04	0.55	0.18	0.08	0.60	0.18	0.61	0.98	**249**	**249**	1.45	1.83	**249**	**248**	15.0		0.9	
0.4	Nb-Ni	18.10.07	3.404	400.14	0.1	185	0.1899	0.0583	0.2068	0.0582	0.17	0.06	0.03	0.43	0.16	0.06	0.47	0.16	0.48	0.78	**400**	**399**	1.16	1.47	**399**	**399**	15.8		1.0	

Energy (GeV)	Sample-1 Sample-2	Date	Frequency (MHz)	E0, MeV	Fe memb. hickn. (mm)	Air thickness (мм)	Sample#1 weight (g)	Monitor#1 weight (g)	Sample#2 weight (g)	Monitor#2 weight (g)	dE in membr (MeV)	dE in air (MeV)	dE in 110μm polyeth.	dE in Samp.#1 (MeV)	dE in Mon.#1 (MeV)	dE in 220μm polyeth.	dE in Samp.#2 (MeV)	dE in Mon.#2 (MeV)	dE-tot for Sample#1	dE-tot for Monitor #1	E in Sample#1 (MeV)	E in Monitor#1 (MeV)	dE-tot for Sample#2	dE-tot for Monitor #2	E in Sample#2 (MeV)	E in Monitor#1 (MeV)	^{22}Na crs for Mon#1	^{22}Na crs err for Mon#1	^{22}Na crs for Mon#2	^{22}Na crs err for Mon#2
0.6	Nb-Ni	15.10.07	3.783	600.30	0.1	185	0.1895	0.0584	0.2067	0.0588	0.15	0.05	0.03	0.37	0.14	0.05	0.40	0.14	0.41	0.66	**600**	**600**	0.98	1.25	**599**	**599**	16.0		1.0	
0.8	Nb-Ni	22.06.07	4.018	799.75	0.1	185	0.1893	0.0590	0.2054	0.0589	0.13	0.05	0.03	0.34	0.13	0.05	0.37	0.13	0.37	0.61	**799**	**799**	0.90	1.15	**799**	**799**	15.5		1.1	
1.2	Nb-Ni	21.06.07	4.289	1199.51	0.1	185	0.1901	0.0590	0.2054	0.0590	0.12	0.04	0.02	0.31	0.12	0.04	0.34	0.12	0.35	0.56	**1199**	**1199**	0.83	1.06	**1199**	**1198**	14.4		1.0	
1.6	Ni	12.02.07	4.435	1599.17	0.1	185	0.2054	0.0593	0.0000	0.0000	0.12	0.04	0.02	0.33	0.11	0.04	0.00	0.00	0.35	0.57	**1599**	**1599**	0.67	0.67	**1598**	**1598**	13.2		1.0	
1.6	Nb	12.02.07	4.435	1599.17	0.1	185	0.1859	0.0590	0.0000	0.0000	0.12	0.04	0.02	0.30	0.11	0.04	0.00	0.00	0.33	0.54	**1599**	**1599**	0.64	0.64	**1599**	**1599**				
2.6	Ni	29.11.06	4.603	2605.82	0.1	185	0.2059	0.0589	0.0000	0.0000	0.12	0.04	0.02	0.33	0.11	0.04	0.00	0.00	0.35	0.57	**2605**	**2605**	0.67	0.67	**2605**	**2605**	11.4		0.9	
2.6	Nb	29.11.06	4.603	2605.82	0.1	185	0.1892	0.0592	0.0000	0.0000	0.12	0.04	0.02	0.30	0.11	0.04	0.00	0.00	0.33	0.54	**2605**	**2605**	0.64	0.64	**2605**	**2605**				
0.04	Fe-Cr	08.07.08	1.471	48.00	0.1	185	0.2401	0.0481	0.3308	0.0476	0.69	0.26	0.14	2.53	0.59	0.30	3.74	0.65	2.36	3.92	**45.6**	**44.1**	6.39	8.58	**41.6**	**39.4**	43.6	2.6	37.2	2.2
0.04	Fe-Cr (Be)	19.03.09	1.471	48.00	0.1	185	0.4039	0.0482	0.361	0.0492	0.69	0.26	0.14	4.29	0.61	0.30	4.20	0.69	3.24	5.69	**44.8**	**42.3**	8.40	10.85	**39.6**	**37.2**	43.1	2.6	29.7	1.8
0.07	Fe-Cr	08.07.08	1.747	69.95	0.1	185	0.2396	0.0248	0.3323	0.0492	0.52	0.19	0.10	1.87	0.22	0.21	2.64	0.45	1.75	2.79	**68**	**67.2**	4.43	5.98	**66**	**64.0**	22.6	1.4	23.9	1.4
0.07	Fe-Cr (Be)	19.03.09	1.747	69.95	0.1	185	0.4776	0.0483	0.317	0.0482	0.52	0.19	0.10	3.72	0.44	0.21	2.55	0.45	2.67	4.75	**67**	**65.2**	6.46	7.96	**63**	**62.0**	23.3	1.4	25.1	1.5
0.1	Fe-Cr	20.02.08	2.044	100.01	0.1	185	0.2592	0.0488	0.3384	0.0481	0.40	0.14	0.08	1.16	0.33	0.16	2.02	0.33	1.21	1.95	**99**	**98**	3.28	4.45	**97**	**96**	19.8	1.3	19.8	1.3
0.1	Fe-Cr (Be)	26.03.09	2.044	100.01	0.1	185	0.3443	0.0481	0.351	0.0495	0.40	0.14	0.08	1.55	0.32	0.16	1.57	0.33	1.40	2.33	**99**	**98**	3.43	4.39	**97**	**96**	19.8	1.3	19.8	1.3
0.15	Fe-Cr	09.07.08	2.4187	150.06	0.1	185	0.2164	0.0498	0.3369	0.0495	0.30	0.11	0.06	0.70	0.25	0.11	1.50	0.25	0.82	1.29	**149**	**149**	2.28	3.15	**148**	**147**	17.1	1.1	17.2	1.2
0.15	Fe-Cr (Be)	26.03.09	2.4187	150.06	0.1	185	0.4015	0.0496	0.394	0.0482	0.30	0.11	0.06	1.29	0.25	0.11	1.27	0.24	1.12	1.89	**149**	**148**	2.76	3.51	**147**	**147**	17.1	1.1	1.7	1.2
0.25	Fe-Cr	13.12.07	2.929	250.01	0.1	185	0.2447	0.0479	0.3398	0.0492	0.22	0.08	0.04	0.62	0.17	0.08	0.85	0.18	0.65	1.04	**249**	**249**	1.63	2.15	**248**	**248**	15.0		0.9	
0.4	Fe-Cr	09.07.08	3.404	400.14	0.1	185	0.2704	0.0478	0.3222	0.0481	0.17	0.06	0.03	0.58	0.13	0.06	0.69	0.13	0.55	0.91	**400**	**399**	1.38	1.79	**399**	**398**	15.8		1.0	
0.6	Fe-Cr	16.10.07	3.783	600.30	0.1	185	0.2398	0.0585	0.3289	0.0583	0.15	0.05	0.03	0.47	0.14	0.05	0.64	0.14	0.46	0.76	**600**	**600**	1.20	1.59	**599**	**599**	16.0		1.0	
0.8	Fe-Cr	24.06.07	4.018	799.75	0.1	185	0.2454	0.0591	0.3374	0.0591	0.13	0.05	0.03	0.43	0.13	0.05	0.59	0.13	0.42	0.70	**799**	**799**	1.11	1.47	**799**	**798**	15.5		1.1	
1.2	Fe-Cr	21.06.07	4.289	1199.51	0.1	185	0.2430	0.0595	0.3403	0.0592	0.12	0.04	0.02	0.44	0.12	0.04	0.61	0.12	0.41	0.69	**1199**	**1199**	1.10	1.46	**1198**	**1198**	14.4		1.0	
1.6	Cr	15.02.07	4.435	1599.17	0.1	185	0.3386	0.0586	0.0000	0.0000	0.12	0.04	0.02	0.59	0.11	0.04	0.00	0.00	0.48	0.83	**1599**	**1598**	0.93	0.93	**1598**	**1598**	13.2		1.0	
1.6	Fe	15.02.07	4.435	1599.17	0.1	185	0.2474	0.0592	0.0000	0.0000	0.12	0.04	0.02	0.43	0.11	0.04	0.00	0.00	0.40	0.67	**1599**	**1598**	0.77	0.77	**1598**	**1598**				
2.6	Cr	04.12.06	4.603	2605.82	0.1	185	0.3661	0.0590	0.0000	0.0000	0.12	0.04	0.02	0.59	0.11	0.04	0.00	0.00	0.48	0.83	**2605**	**2605**	0.92	0.92	**2605**	**2605**	11.4		0.9	
2.6	Fe	04.12.06	4.603	2605.82	0.1	185	0.2433	0.0592	0.0000	0.0000	0.12	0.04	0.02	0.39	0.11	0.04	0.00	0.00	0.38	0.63	**2605**	**2605**	0.73	0.73	**2605**	**2605**				

3.4. Procedure of γ-spectrometry-based analyzing the samples irradiated

The measured γ-spectra were shown above to be explicitly much complicated. Besides, the intensity of γ-emission from the samples irradiated was sufficiently high, particularly during the decay startup. In such conditions, a possible spectrometer performance instability may not only impede obtaining and processing experimental data but also significantly distort the obtained results. Therefore, the stability of the spectrometer parameters is given particular attention to when making experiments.

The spectrometer parameters that determine the admissible measurement modes include

- temporal and temperature stability,
- cascade summation effects,
- ultimate spectrometer load,
- absolute detection efficiency at different heights and energies. Temperature stability

To ensure temperature stability, a microclimate got sustained in the laboratory measurement room.

3.4.1. Temporal stability

Temporal stability is assessed by periodic measuring the ^{152}Eu γ-emission spectrum. The many-year laboratory observations (see Fig. 2.11) have shown that the detection positions of the 121.78 keV, 778.90 keV, and 1408.01 keV γ-line photopeaks fluctuate around their means mostly within 0.1%. The observed temperature drift of the instrumental line in the measured γ-spectra is allowed for by constant calibrating the spectrometer, thereby providing a 0.1-0.3 keV error when measuring the energy of γ-emission from the samples irradiated. The procedure has led to a much decreased number of γ-lines to be considered as additional contributions when analyzing the spectra.

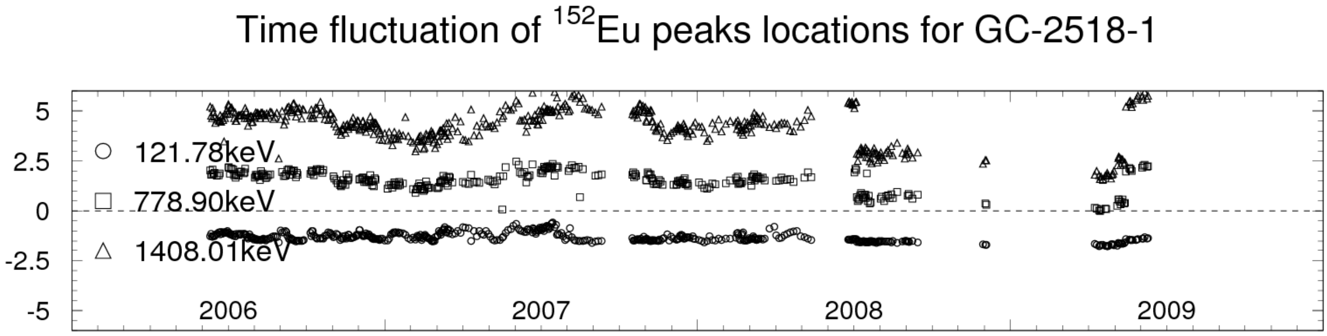


Fig. 3.4. The fluctuations of the maxima locations when detecting the 121.78 keV, 778.90 keV, and 1408.01 keV γ-line photopeaks with Canberra detector#1

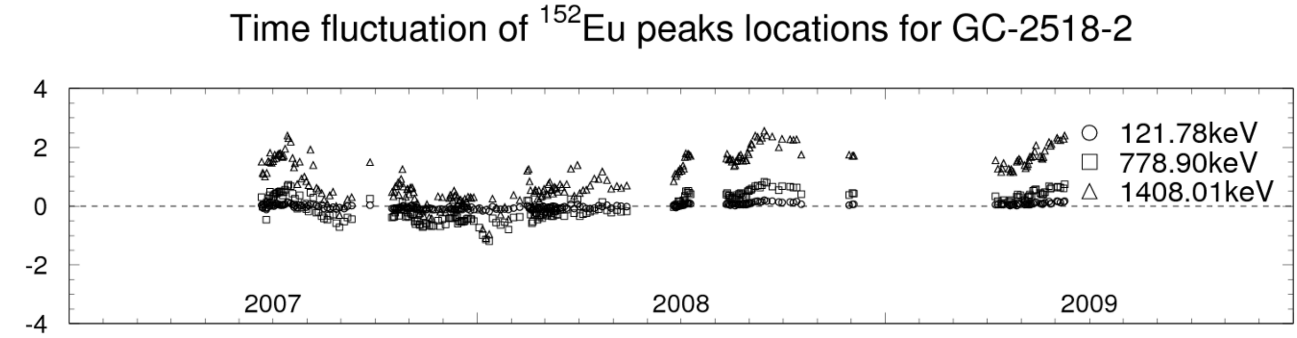


Fig. 3.5. The fluctuations of the maxima locations when detecting the 121.78 keV, 778.90 keV, and 1408.01 keV γ-line photopeaks with Canberra detector#2

3.4.2. Quantitative count loss estimation

The count loss in case of high spectrometer loads was quantitatively estimated by two-source techniques. One of the sources (10.11kBq activity ^{137}Cs) was placed at a fixed height H = 40 mm that determined the γ-source-Ge detector spacing, whereas the height of the second (50.93kBq activity ^{152}Eu) decreased as measurements went on. Position of the first source provided for a low spectrometer loading, while the second source imitated the measurement load increase by varying the height. Figs. 3.6 and 3.7 show the peak area and ^{137}Cs γ-line resolution variations vs. spectrometer load.

The results obtained were used to determine the ultimate spectrometer load, which was not found to exceed 5% in all measurement runs. To provide the conditions, the experimental samples began being monitored at heights of ~1325 mm and ~1050 mm for Canberra spectrometers #1 and #2, respectively.

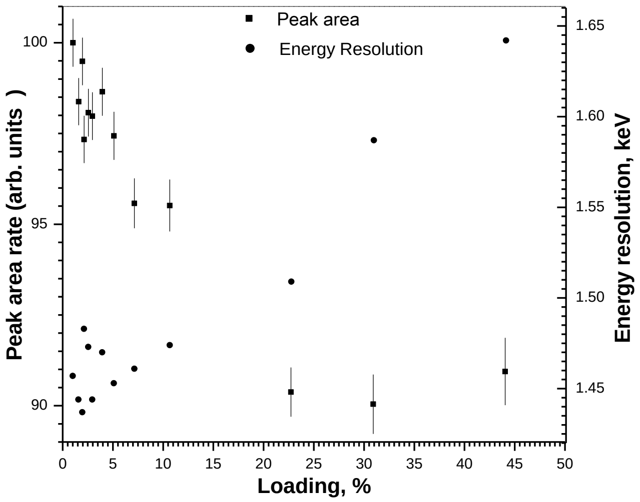


Fig. 3.6. Fig. 3.6. Detector#1 loading characteristics.

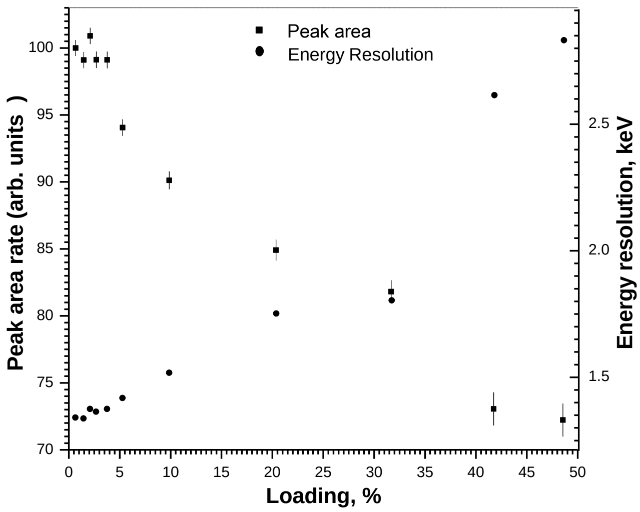


Fig. 3.7. Detector#2 loading characteristics.

3.4.3. Cascade summation.

The cascade summation effect that results in distorting the measured γ-spectra was experimentally estimated using the standard spectrometric ^{60}Co (11.76 kBq and 98.9 kBq) γ-ray sources. The main ^{60}Co 1173.2 keV and 1332.5 keV lines produce the spurious 2505.7 keV peak. The cascade summation effect was estimated to be the spurious 2505.7 keV peak-to-1173 keV peak area ratio depending on the source height above the detector. The 11.76 and 98.9 Bq sources were used for 0-150 mm and >150 mm source heights over the detector, respectively. Fig. 3.8 shows the experimental estimate, from which it follows that the cascade summation effect does not exceed 0.6% for at least a 40-mm γ-detector - sample spacing.

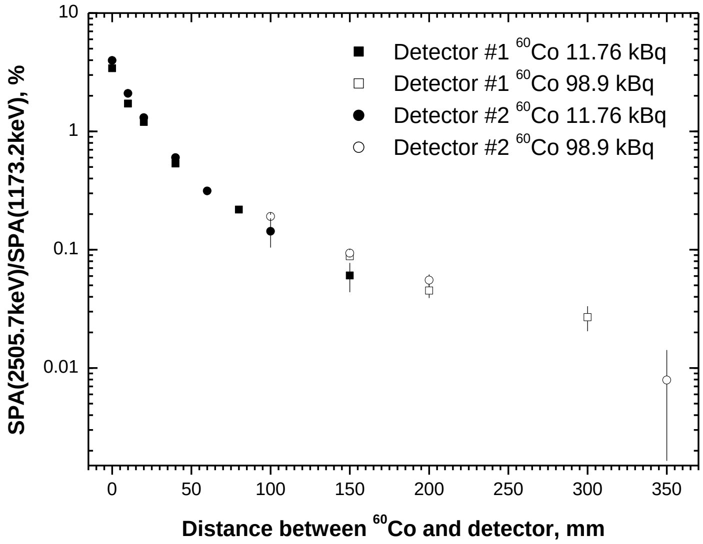


Fig. 3.8. Cascade summation effect vs. source-detector spacing**.**

3.4.4. Absolute spectrometer detection efficiency. Determining the height and energy dependences of the spectrometer detection efficiency.

The independent and cumulative reaction product yields in formulas (2.8-2.11, 2.13) were calculated in terms of absolute spectrometer efficiency, thereby attracting much attention to calculating the latter.

The absolute spectrometer efficiency for an energy that corresponds to the γ-line energy of a monitored source at a fixed height H can be presented as:

$$\varepsilon_{abs}^{E} = \frac{S_0}{A \cdot \eta}, \qquad (3.8)$$

Where S_0 is the total absorption peak count rate (pulse/s) at energy E; η is the γ-line quantum abundance; A is the attested γ-source activity reduced to the measurement moment.

Use was made of standard set of spectrometric γ-ray sources#3-1-9402, 3-1-6630, 3-2-6626 certified by the All-Russian D.I. Mendeleev Metrology Institute and comprising ^{54}Mn, ^{57}Co, ^{60}Co, ^{88}Y, ^{109}Cd, ^{113}Sn, ^{133}Ba, ^{137}Cs, ^{139}Ce, ^{152}Eu, ^{228}Th, and ^{241}Am. The radionuclide activity in the sets № 9402, № 6630 is ~10 kBq and ~100 kBq in the set № 6626. Sets with different activities were used to reduce calibration times on high heights (from 40 to 1325mm).

The source certification dates, activities, and nuclear data to be used to calculate the absolute efficiency were taken to conform to the source ratings [9,10,14-16].

Fig. 3.9 presents the results of experimental determining the absolute spectrometer efficiency at different heights. In practice, the analytical energy dependences of the absolute spectrometer efficiency should actually be known.

The absolute spectrometer detection efficiency at energy E at the fixed height H is calculated as:

$$\varepsilon(E) = \exp\left[\sum_{i=k}^{k+3} P_i \cdot (\ln E)^{i-k}\right], \tag{3.9}$$

with error:

$$\Delta_\varepsilon = \varepsilon \cdot \sqrt{\frac{\chi^2}{F}} \cdot \sqrt{\sum_{i=k}^{k+3}\sum_{j=k}^{k+3} M_{ij}^{-1} \cdot (\ln E)^{i-k} \cdot (\ln E)^{j-k}}, \tag{3.10}$$

Where

$$\begin{cases} M_{ij} = \sum_{k=1}^{N_1} W_k \cdot (\ln E)_k^{i+j-2} & \text{для } i, j = 1,\ldots,4; \\ M_{ij} = \sum_{k=1}^{N_2} W_k \cdot (\ln E)_k^{i+j-10} & \text{для } i, j = 5,\ldots,8; \end{cases} \tag{3.11}$$

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

$$\chi^2 = \sum_{i=1}^{N_1+N_2} \left[\varepsilon^{\exp}(E_i) - \varepsilon^{calc}(E_i)\right]^2 \cdot \frac{1}{\Delta_i^2}, \tag{3.12}$$

$$F = N_1 + N_2 - m_1 - m_2 + k - 3 \cdot \tag{3.13}$$

wherein $\varepsilon^{calc}(E_i)$ is calculated from (3.9); W_i - inverse square of ε_i relative error; Δ_i is absolute error in the experimental spectrometer efficiency at energy E_i; к-1 is the highest order of derivative, for which adjusting were made at point lnE_0 (E_0 = 300 keV); N_1, N_2 - numbers of experimental point to the left and to the right from the adjusting point, respectively, m_1, m_2 - polynomial degrees on the left and to the right from the adjusting point, respectively.

Thr following factors presented in tables 3.6 and 3.7 were obtained to be used in formulae (3.9) to get efficiencies of the detectors used in this work.

Table 3.6. P_i factors for Detector #1.

Height	Index i	Factors values			
		P_i	P_{i+1}	P_{i+2}	P_{i+3}
40	1	-8.0558410645E+01	4.3604387283E+01	-8.0408525467E+00	4.8303857446E-01
	5	2.7600402832E+00	-1.4625129700E+00	7.8527450562E-02	-4.2118132114E-03
60	1	-7.0631233215E+01	3.7071483612E+01	-6.7032184601E+00	3.9316287637E-01
	5	4.7654953003E+00	-2.4805488586E+00	2.1287393570E-01	-9.9528133869E-03
80	1	-7.2066257477E+01	3.7635593414E+01	-6.8136596680E+00	4.0060263872E-01
	5	-4.9985504150E-01	-2.6699829102E-01	-1.2275314331E-01	6.9065093994E-03
100	1	-7.2896057129E+01	3.7925178528E+01	-6.8706102371E+00	4.0415441990E-01
	5	8.1451416016E+00	-4.5231399536E+00	5.4054450989E-01	-2.7149021626E-02
150	1	-6.8119155884E+01	3.4526981354E+01	-6.1800374985E+00	3.5815274715E-01
	5	9.9623565674E+00	-5.6898040771E+00	7.2156286240E-01	-3.6457479000E-02
300	1	-6.5712272644E+01	3.2290397644E+01	-5.7673292160E+00	3.3325320482E-01
	5	3.4106140137E+00	-3.3897399902E+00	3.6963939667E-01	-1.8467754126E-02
450	1	-6.5289535522E+01	3.1501045227E+01	-5.5905447006E+00	3.2058292627E-01
	5	4.8513031006E+00	-4.3762130737E+00	5.2167510986E-01	-2.6225388050E-02
700	1	-6.9415992737E+01	3.3295265198E+01	-5.9383125305E+00	3.4303367138E-01
	5	1.7035522461E+00	-3.3744964600E+00	3.6154747009E-01	-1.7589986324E-02
1325	1	-6.9642684936E+01	3.3071022034E+01	-5.8766736984E+00	3.3815521002E-01
	5	-1.9138336182E+00	-1.8311080933E+00	1.1600875854E-01	-4.6740174294E-03

Table 3.7. P_i factors for Detector #2.

Height	Index i	Factors values			
		P_i	P_{i+1}	P_{i+2}	P_{i+3}
40	1	-8.0558410645E+01	4.3604387283E+01	-8.0408525467E+00	4.8303857446E-01
	5	2.7600402832E+00	-1.4625129700E+00	7.8527450562E-02	-4.2118132114E-03
60	1	-7.0631233215E+01	3.7071483612E+01	-6.7032184601E+00	3.9316287637E-01
	5	4.7654953003E+00	-2.4805488586E+00	2.1287393570E-01	-9.9528133869E-03
80	1	-7.2066257477E+01	3.7635593414E+01	-6.8136596680E+00	4.0060263872E-01
	5	-4.9985504150E-01	-2.6699829102E-01	-1.2275314331E-01	6.9065093994E-03
100	1	-7.2896057129E+01	3.7925178528E+01	-6.8706102371E+00	4.0415441990E-01
	5	8.1451416016E+00	-4.5231399536E+00	5.4054450989E-01	-2.7149021626E-02
150	1	-6.8119155884E+01	3.4526981354E+01	-6.1800374985E+00	3.5815274715E-01
	5	9.9623565674E+00	-5.6898040771E+00	7.2156286240E-01	-3.6457479000E-02
350	1	-6.5712272644E+01	3.2290397644E+01	-5.7673292160E+00	3.3325320482E-01
	5	3.4106140137E+00	-3.3897399902E+00	3.6963939667E-01	-1.8467754126E-02
500	1	-6.5289535522E+01	3.1501045227E+01	-5.5905447006E+00	3.2058292627E-01

Height	Index i	Factors values			
		P_i	P_{i+1}	P_{i+2}	P_{i+3}
	5	4.8513031006E+00	-4.3762130737E+00	5.2167510986E-01	-2.6225388050E-02
850	1	-6.9415992737E+01	3.3295265198E+01	-5.9383125305E+00	3.4303367138E-01
	5	1.7035522461E+00	-3.3744964600E+00	3.6154747009E-01	-1.7589986324E-02
1050	1	-6.9642684936E+01	3.3071022034E+01	-5.8766736984E+00	3.3815521002E-01
	5	-1.9138336182E+00	-1.8311080933E+00	1.1600875854E-01	-4.6740174294E-03;

Fig. 3.9 shows that developed technique allows description of the measured values of detector efficiencies at any heights and correct reproduction of changing of slope of the curve of energy dependence of detector efficiency on H in double logarithmic scale.

The proposed technique allows calculation the absolute efficiency in 100keV – 2600keV energy and 40mm – 1240mm height ranges with 3-10% relative uncertainty. At relatively low energies (<120keV) as well as in energy ranges with low number of experimental points the uncertainty is close to upper limit of the above values. It should be noted however that in practice the energies of the analyzed γ-lines of the nuclides produced in this work are above 100keV.

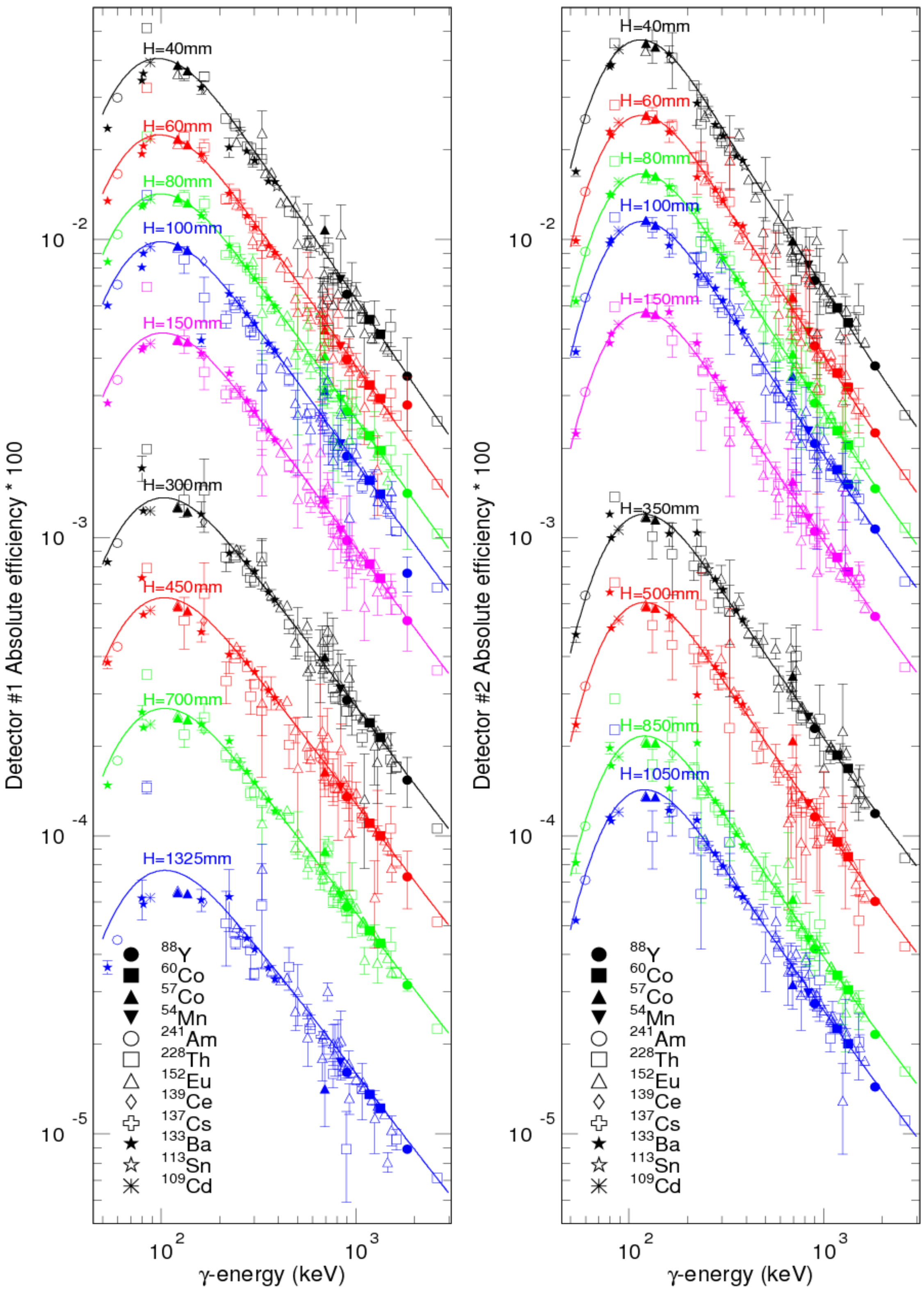


Fig. 3.9 Absolute detection efficiency of spectrometers Nos. 1 and 2 (the right- and left-hand panels, respectively) measured using the standard sources and calculated via least squares techniques..

3.4.5. Processing of γ-spectra

Figs. 3.10 – 3.21 show examples of the irradiated sample γ-spectra measured.

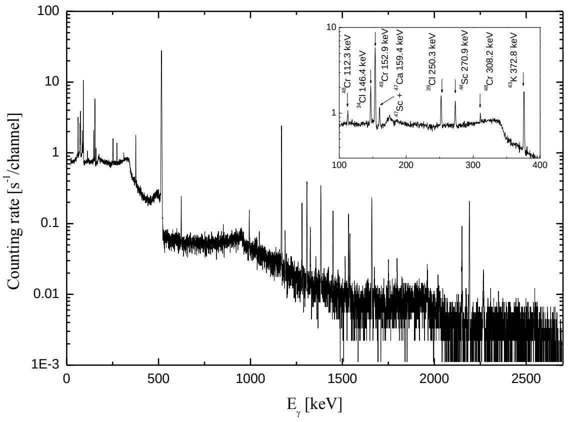


Fig. 3.10. Instance of 2600 MeV proton-irradiated ^{nat}Cr sample γ-spectrum#05 in 1.49 hour after irradiation. Measurement time is 900 s.

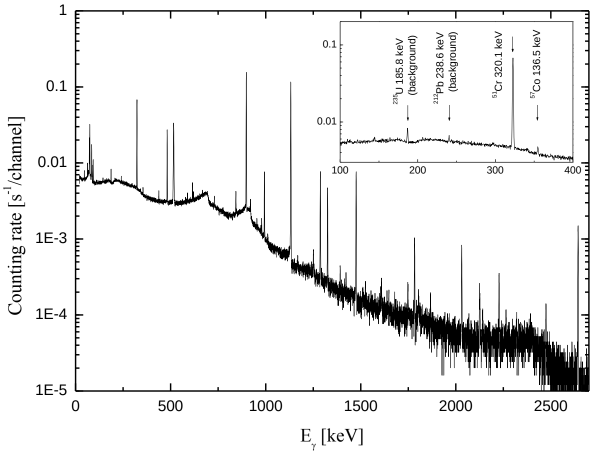


Fig. 3.11. Instance of 2600 MeV proton-irradiated ^{nat}Cr sample γ-spectrum#25 in 179.52 days after irradiation. Measurement time is 248400 s

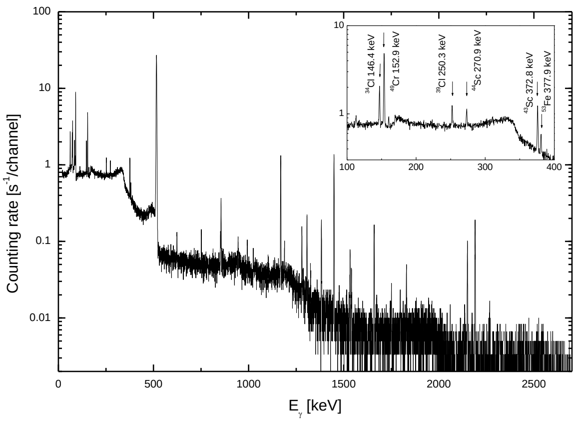


Fig. 3.12. Instance of 2600 MeV proton-irradiated ^{56}Fe sample γ-spectrum#05 in 1.88 hour after irradiation. Measurement time is 600 s.

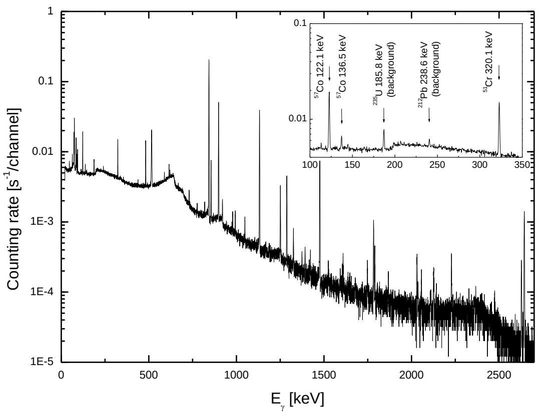


Fig. 3.13. Instance of 2600 MeV proton-irradiated ^{56}Fe sample γ-spectrum#30 in 130.47 days after irradiation. Measurement time is 248400 s.

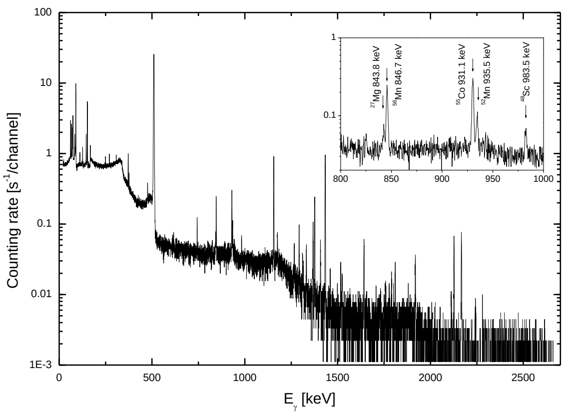


Fig. 3.14. Instance of 2600 MeV proton-irradiated ^{nat}Ni sample γ-spectrum#05 in 1.47 hour after irradiation. Measurement time is 900 s.

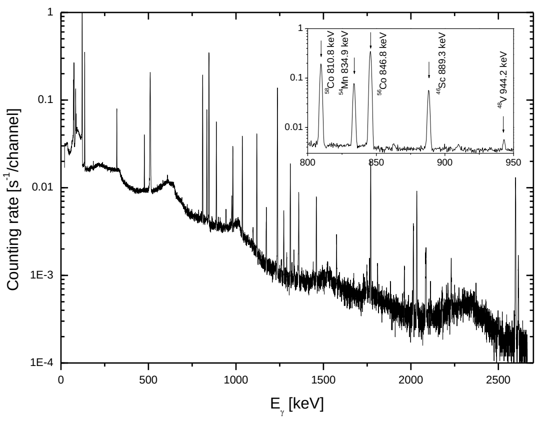


Fig. 3.15. Instance of 2600 MeV proton-irradiated ^{nat}Ni sample γ-spectrum#27 in 99.66 days after irradiation. Measurement time is 75600 s.

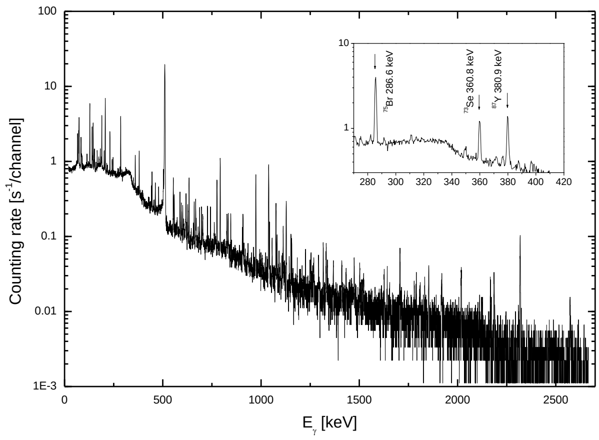


Fig. 3.16. Instance of 2600 MeV proton-irradiated ^{93}Nb sample γ-spectrum#05 in 1.61 hour after irradiation. Measurement time is 900 s.

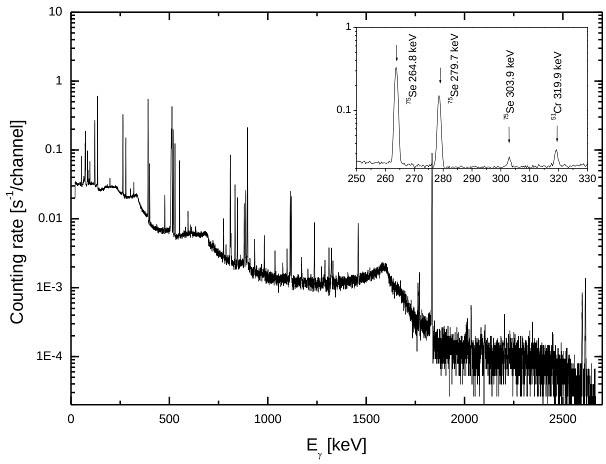


Fig. 3.17. Instance of 2600 MeV proton-irradiated ^{93}Nb sample γ-spectrum#27 in 98.84 days after irradiation. Measurement time is 75600 s.

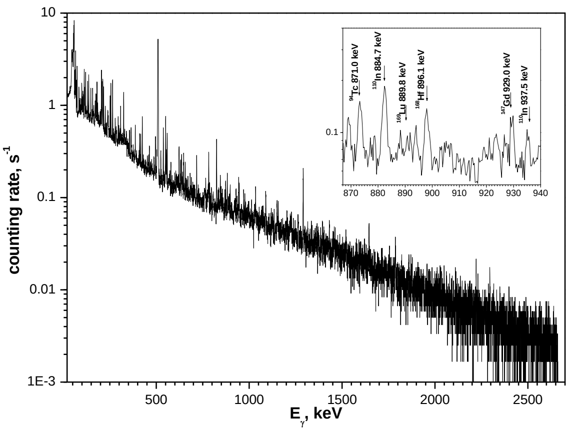


Fig. 3.18. Instance of 2600 MeV proton-irradiated ^{Nat}W sample γ-spectrum#05. Measurement time is 1200 s.

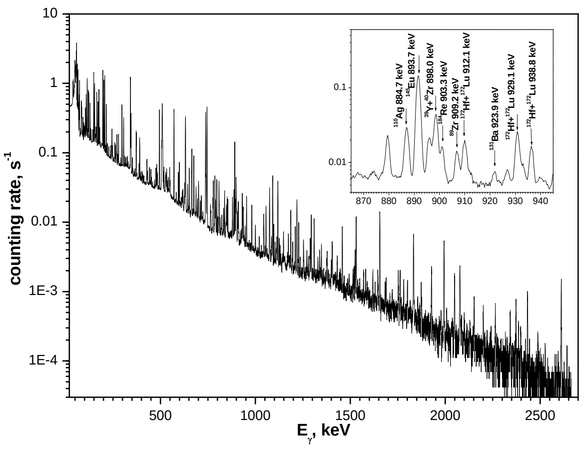


Fig. 3.19. Instance of 2600 MeV proton-irradiated ^{Nat}W sample γ-spectrum#25. Measurement time is 72000 s..

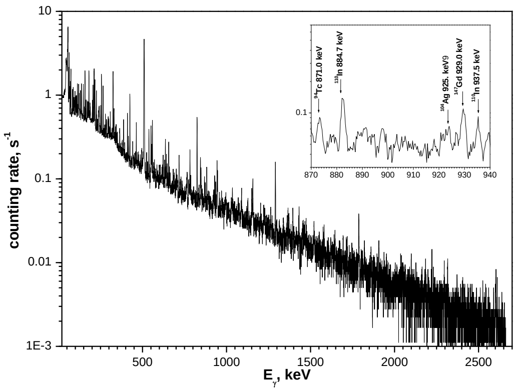


Fig. 3.20. Instance of 2600 MeV proton-irradiated ^{181}Ta sample γ-spectrum #05. Measurement time is 1800 s.

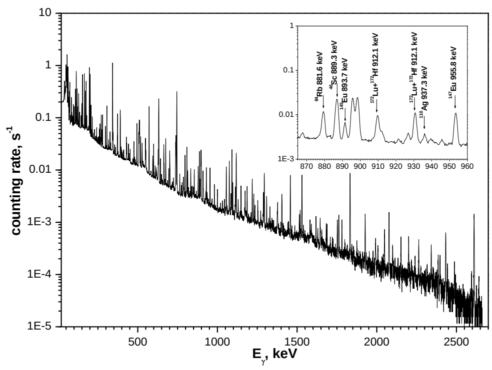


Fig. 3.21. Instance of 2600 MeV proton-irradiated ^{181}Ta sample γ-spectrum#25. Measurement time is 259200 s.

Figs. 3.22 – 3.27 show instances of automatic and interactive processing of γ-spectra.

Cr:

- Fig. 3.22-a "Automatic processing" shows the region with missed peak for ^{28}Mg γ-line (1014.44 keV, yield 28.00, $T_{1/2}$ = 9.458 min),

- Fig. 3.22-b "Interactive processing" shows that same peak added after being interactive mode-processes.

Fe:

- Fig. 3.23-a "Automatic processing" shows the region with missed peak for ^{53}Fe γ-line (377.9 keV, yield 42.00, $T_{1/2}$ = 8.51 min),

- Fig. 3.23-b "Interactive processing" shows that same peak added after being interactive mode-processes.

Ni:

- Fig. 3.24-a "Automatic processing" shows the region with missed peak for ^{53}Fe γ-line (377.9 keV, yield 42.00, $T_{1/2}$ = 8.51 min),

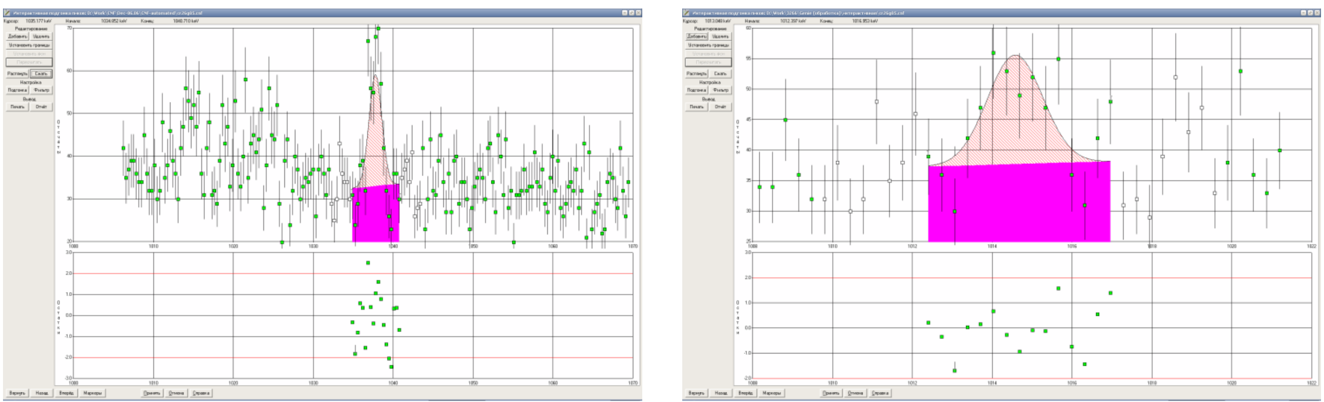
- Fig. 3.24-b "Interactive processing" shows that same peak added after being interactive mode-processes.

Nb:

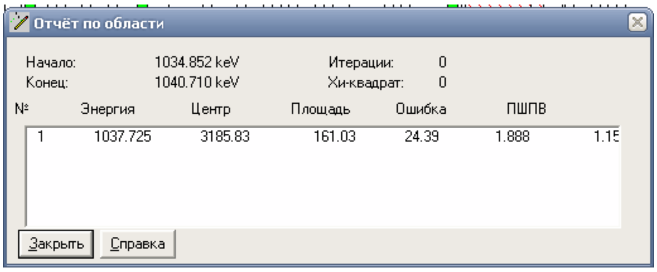
- Fig. 3.25-a "Automatic processing" shows the region with missed peak for ^{56}Mn γ-line (1810.72 keV, yield 27.00, $T_{1/2}$ = 2.5789 hours),

- Fig. 3.25-b "Interactive processing" shows that same peak added after being interactive mode-processes.

a) b)



a)



b)

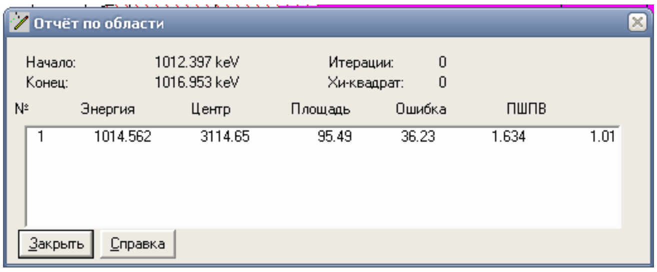
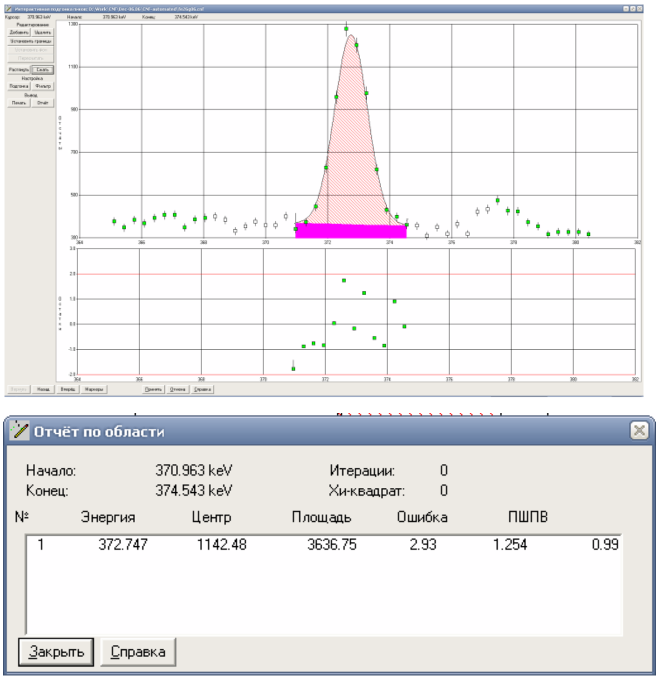


Fig. 3.22. Examples of automatic (a) and interactive (b) processing of a 2.6 GeV proton-irradiated ^{nat}Cr spectral range, spectrum No. 5.

a)



b)

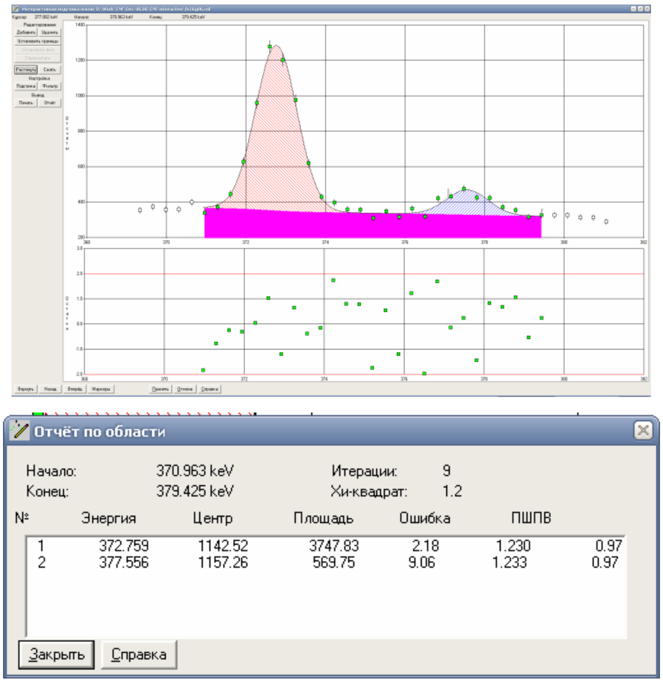
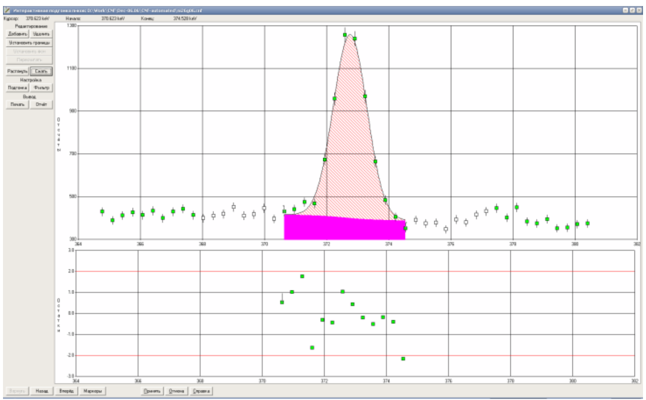
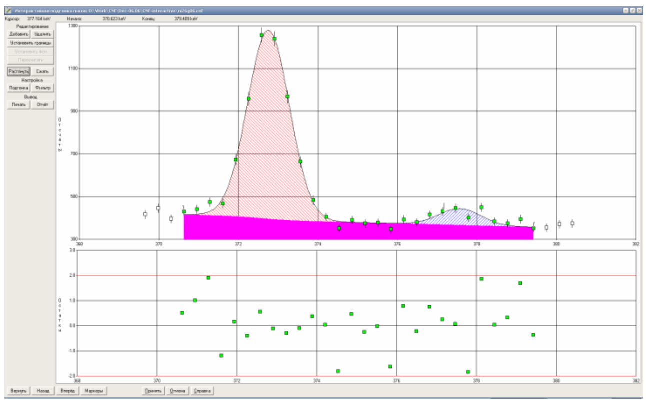


Fig. 3.23. Examples of automatic (a) and interactive (b) processing of a 2.6 GeV proton-irradiated ^{56}Fe spectral range, spectrum No. 6.

a)



b)



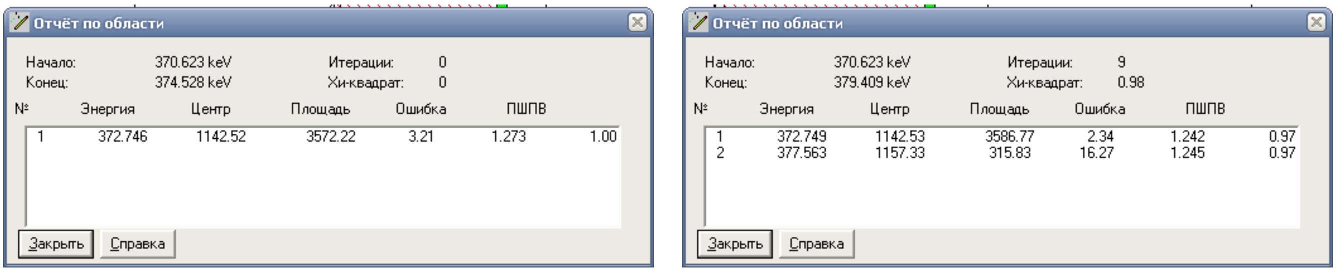


Fig. 3.24. Examples of automatic (a) and interactive (b) processing of a 2.6 GeV proton-irradiated ^{nat}Ni spectral range, spectrum No. 6.

a) b)

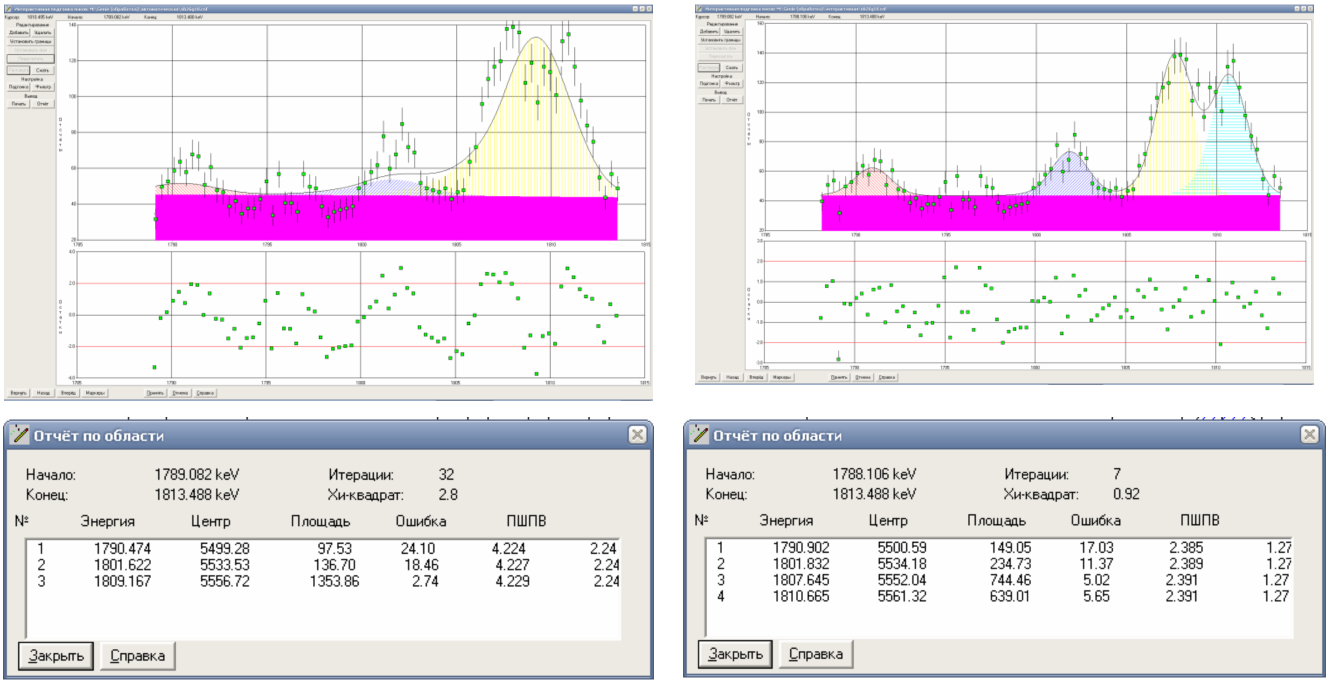
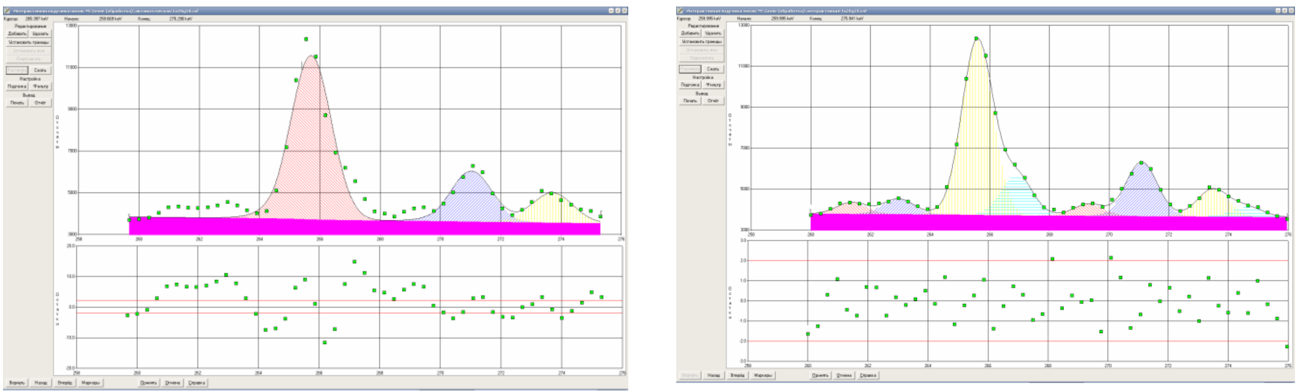


Fig. 3.25. Examples of automatic (a) and interactive (b) processing of a 2.6 GeV proton-irradiated ^{93}Nb spectral range, spectrum No. 10.

a) b)



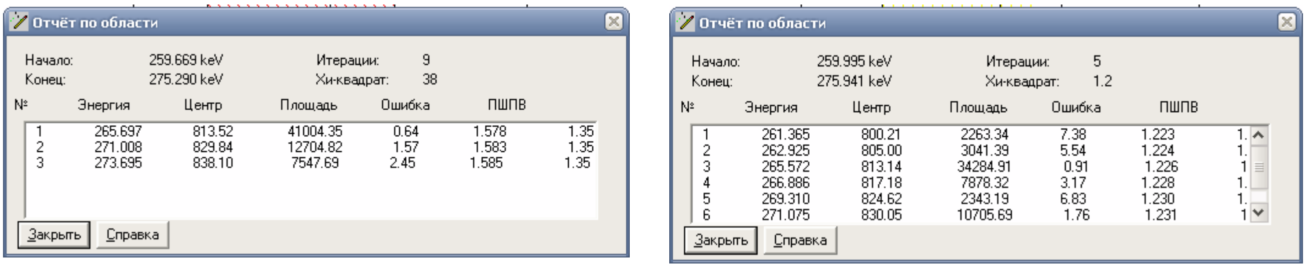


Fig. 3.26. Examples of automatic (a) and interactive (b) processing of a 2.6 GeV proton-irradiated ^{181}Ta spectral range, spectrum No. 10.

a) b)

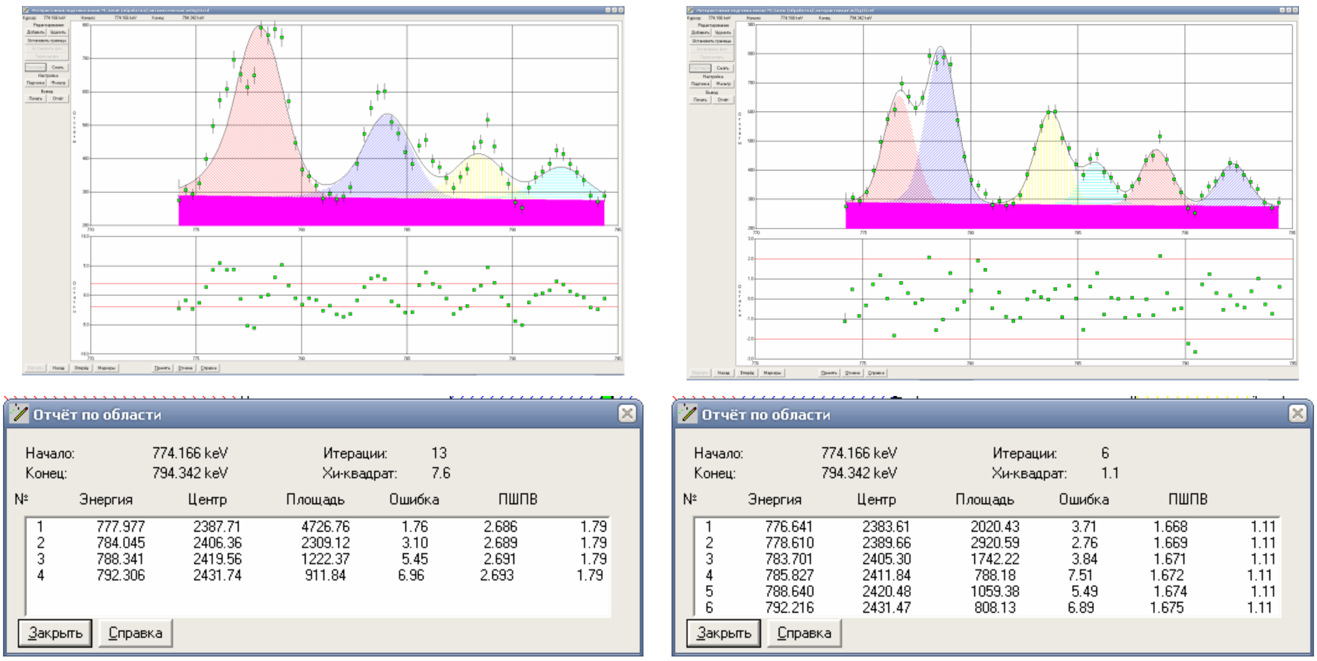


Fig. 3.27. Examples of automatic (a) and interactive (b) processing of a 2.6 GeV proton-irradiated ^{nat}W spectral range, spectrum No. 10.

3.4.6. Laboratory background

Occurrences of the background γ-lines induced in the measured γ-spectra by the natural radioactive laboratory background and by possible radioactive impurities in samples were allowed for by analyzing the γ-spectra of the intact samples monitored in the same way as the samples irradiated. Fig. 3.28 shows the laboratory 14 days-accumulated radioactive background typical of γ-spectrometry. The background is indicative of the occurrences of natural radionuclides that are members of the ^{238}U, ^{235}U, and ^{232}Th decay chains, except for the ^{137}Cs 661 keV and ^{108m}Ag 433.9, 614.9 and 722.9 keV, ^{152}Eu 244.7, 344.3, 778.9 keV, ^{22}Na 274.2 keV γ-lines. The ^{137}Cs and ^{108m}Ag occurrences arose probably from many-year heavy water reactor operations in the ITEP territory, ^{152}Eu and ^{22}Na occurrences arose from the character of the work carried out.

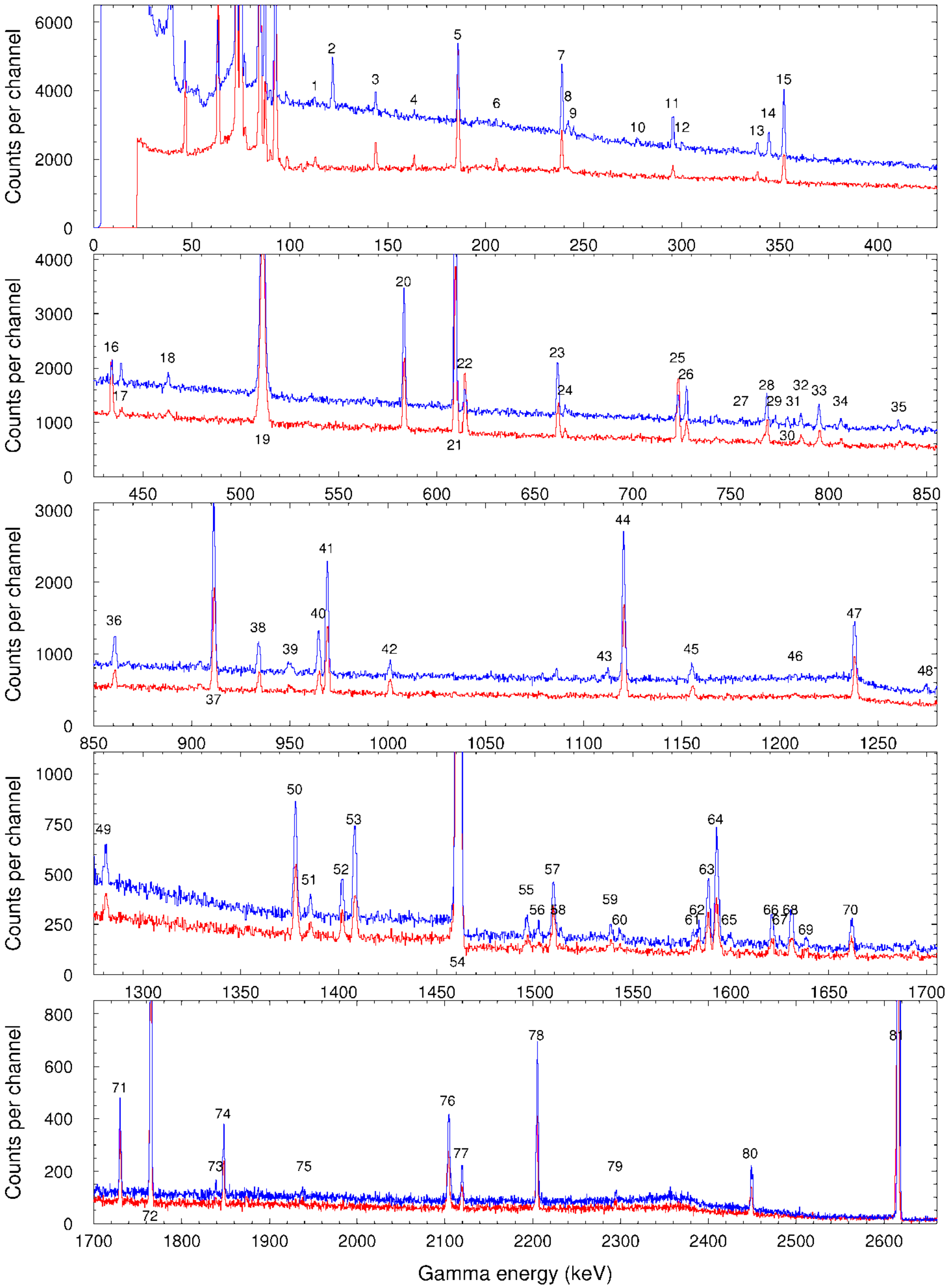


Fig. 3.28. The background spectra measured for 14 days with detectors Nos. 1 (the red lines) and 2 (the blue lines). Table 3.8 lists the lines found.

Table 3.8. List of γ-lines of the background spectra displayed in Fig. 3.28.

No. of line	E (keV)	Nulide	Counting rate, pulse/s (detector№1)	Counting rate, pulse/s (detector№2)
1	112.8	^{234}Th	8.079E-004	3.998E-004
2	121.4	^{234}U	-	4.029E-003
3	143.9	^{235}U	2.227E-003	1.592E-003
4	163.4	^{235}U+^{231}Th	8.935E-004	4.044E-004
5	185.7	^{235}U+^{226}Ra	1.090E-002	6.232E-003
6	205.4	^{235}U	9.607E-004	6.490E-004
7	238.6	^{212}Pb	3.000E-003	5.922E-003
8	241.9	^{214}Pb+^{224}Ra	-	1.317E-003
9	244.7	^{152}Eu	-	6.791E-004
10	277.4	^{208}Tl	-	6.491E-004
11	295.2	^{214}Pb	1.085E-00	2.585E-003
12	300.1	^{212}Pb+^{231}Pa	1.886E-004	6.300E-004
13	338.1	^{228}Ac	6.554E-004	1.021E-003
14	344.28	^{152}Eu	-	2.175E-003
15	351.9	^{214}Pb	3.104E-003	6.045E-003
16	433.9	^{108m}Ag	3.694E-003	8.134E-004
17	438.6	DE	3.857E-004	9.766E-004
18	462.7	^{228}Ac	8.277E-004	9.560E-004
19	510.9	AN	2.378E-002	3.225E-002
20	583.1	^{208}Tl	4.883E-003	7.176E-003
21	609.2	^{214}Bi	1.195E-002	1.611E-002
22	614.2	^{108m}Ag	4.559E-003	1.283E-003
23	661.5	^{137}Cs	2.164E-003	3.479E-003
24	665.4	^{214}Bi	5.510E-004	4.161E-004
25	722.8	^{108m}Ag	4.598E-003	1.525E-003
26	727.1	^{212}Bi	1.414E-003	2.250E-003
27	755.3	^{228}Ac	-	4.701E-004
28	768.3	^{214}Bi	1.453E-003	2.049E-003
29	772.2	^{228}Ac	-	3.258E-004
30	778.9	^{152}Eu	-	4.732E-004
31	782.1	^{228}Ac	1.129E-004	1.744E-004
32	785.6	^{214}Pb	8.008E-004	7.328E-004
33	795.1	^{228}Ac	1.130E-003	1.673E-003
34	806.1	^{214}Bi	4.869E-004	6.990E-004
35	835.7	^{228}Ac	-	3.132E-004
36	860.4	^{208}Tl	8.335E-004	1.670E-003
37	911.0	^{228}Ac	6.251E-003	3.216E-004
38	933.9	^{214}Bi	1.179E-003	9.594E-003
39	949.6	SE	4.563E-004	1.015E-003
40	964.5	^{214}Bi+^{228}Ac	1.200E-003	2.542E-003
41	968.8	^{228}Ac	3.975E-003	6.178E-003
42	1000.8	^{234m}Pa	9.645E-004	8.062E-004
43	1110.6	^{228}Ac	-	6.741E-004
44	1120.1	^{214}Bi	6.220E-003	8.896E-003
45	1154.9	^{214}Bi	9.303E-004	1.273E-003
46	1207.7	^{214}Bi	2.558E-004	1.413E-004
47	1238.0	^{214}Bi	2.628E-003	3.497E-003
48	1274.2	^{22}Na	-	4.391E-004

No. of line	E (keV)	Nulide	Counting rate, pulse/s (detector№1)	Counting rate, pulse/s (detector№2)
49	1280.1	^{214}Bi	5.443E-004	8.900E-004
50	1377.4	^{214}Bi	1.843E-003	2.737E-003
51	1384.9	^{214}Bi	3.348E-004	3.824E-004
52	1401.2	^{214}Bi	6.327E-004	8.400E-004
53	1407.7	^{214}Bi	9.781E-004	2.241E-003
54	1460.6	^{40}K	5.292E-002	8.804E-002
55	1495.7	^{228}Ac	3.179E-004	4.977E-004
56	1501.3	^{228}Ac	1.416E-004	2.675E-004
57	1509.0	^{214}Bi	9.566E-004	1.404E-003
58	1511.8	SE	-	1.806E-004
59	1538.5	^{214}Bi	2.518E-004	2.901E-004
60	1543.3	^{214}Bi	1.064E-004	2.399E-004
61	1580.5	^{228}Ac	1.482E-004	2.307E-004
62	1582.7	^{214}Bi	2.090E-004	4.106E-004
63	1587.9	^{228}Ac	9.074E-004	1.597E-003
64	1592.2	DE	1.385E-003	2.760E-003
65	1599.1	^{214}Bi	9.990E-005	1.361E-004
66	1620.5	^{212}Bi	4.932E-004	7.124E-004
67	1625.0	^{228}Ac	1.199E-004	8.628E-005
68	1630.4	^{228}Ac	6.297E-004	9.479E-004
69	1638.3	^{228}Ac	2.157E-004	1.720E-004
70	1661.1	^{214}Bi	4.560E-004	7.949E-004
71	1729.5	^{214}Bi	1.379E-003	1.989E-003
72	1764.2	^{214}Bi	7.227E-003	1.104E-002
73	1838.4	^{214}Bi	1.054E-004	1.559E-004
74	1847.2	^{214}Bi	9.197E-004	1.374E-003
75	1933.0	DE	-	1.422E-004
76	2103.1	SE	1.701E-003	2.706E-003
77	2118.3	^{214}Bi	5.340E-004	8.143E-004
78	2203.9	^{214}Bi	2.345E-003	3.508E-003
79	2293.4	^{214}Bi	1.467E-004	2.009E-004
80	2447.6	^{214}Bi	7.615E-004	1.049E-003
81	2614.8	^{208}Tl	1.217E-002	1.963E-002

AN – Annihilation peak
SE – Single ejection of annihilation γ-quanta
DE – Double ejection of annihilation γ-quanta

3.4.7. Decay curves

Figs 3.29 – 3.34 exemplify the decay curves of reaction products in the samples irradiated.

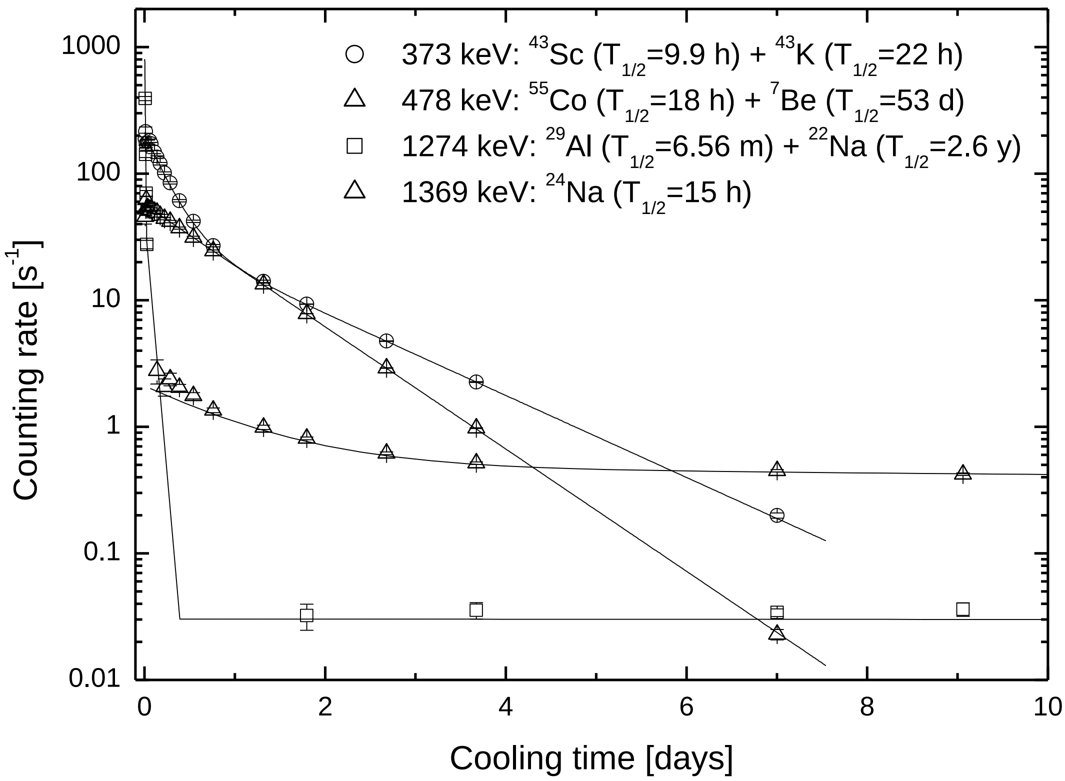


Fig. 3.29. Decay curves of reaction products in 2600 MeV proton-irradiated ^{56}Fe.

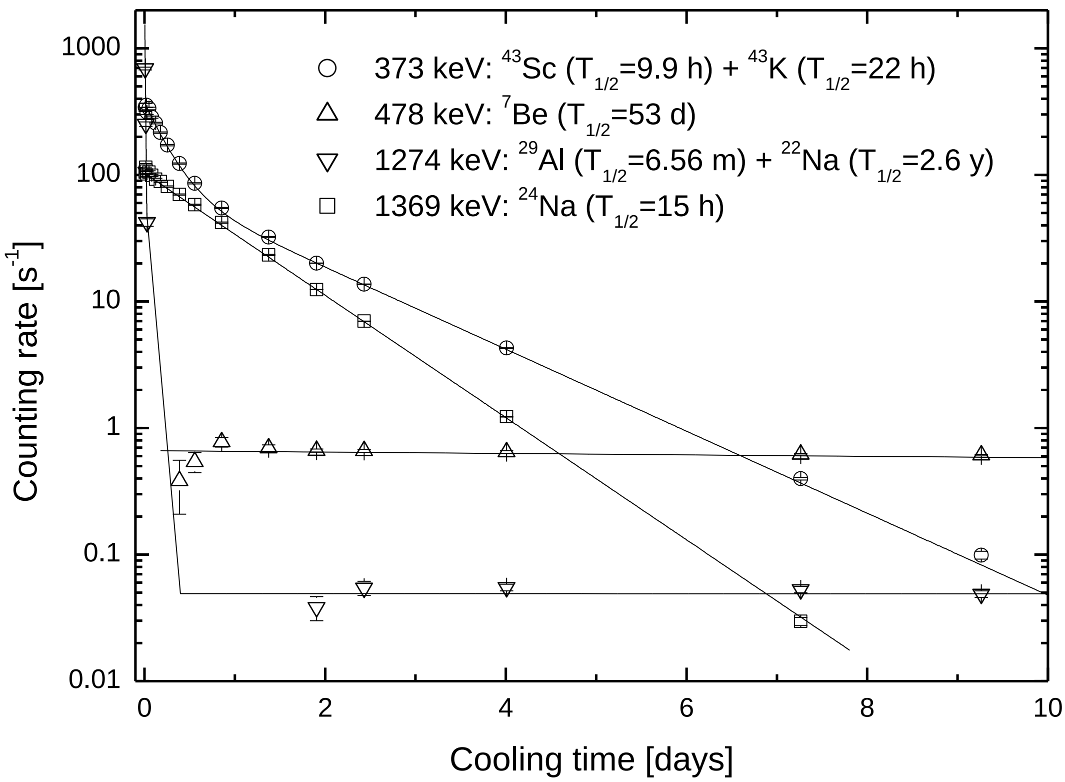


Fig. 3.30. Decay curves of reaction products in 2600 MeV proton-irradiated ^{nat}Cr.

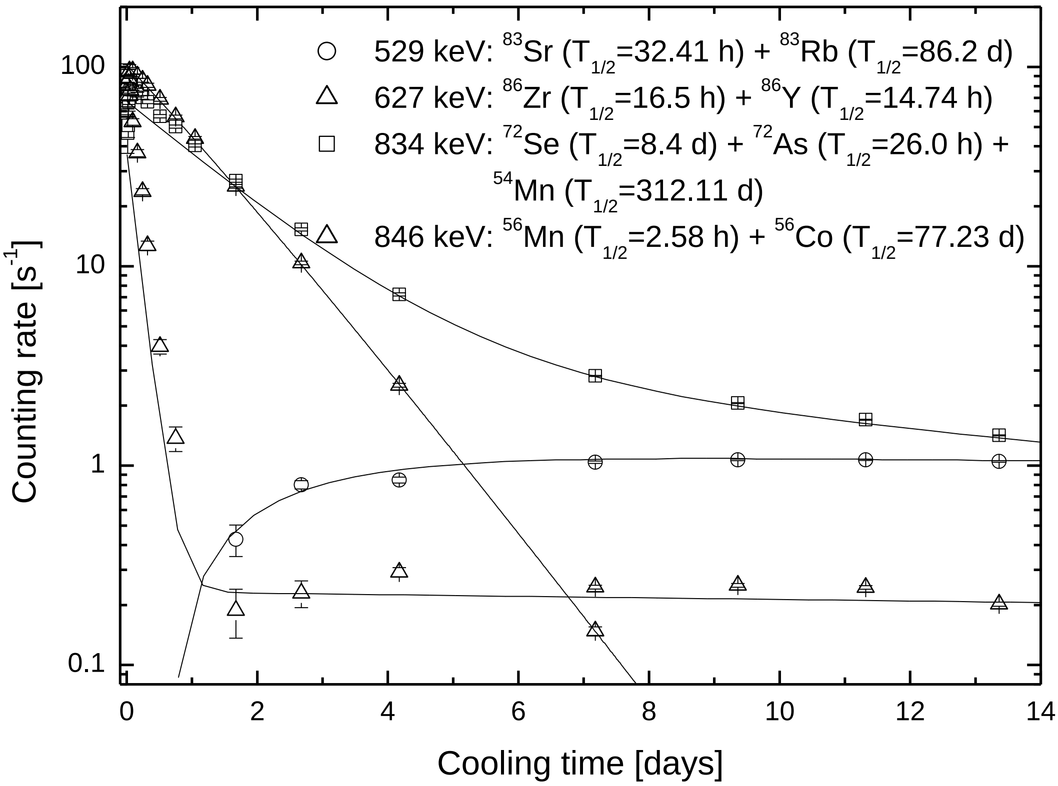


Fig. 3.31. Decay curves of reaction products in 2600 MeV proton-irradiated ^{93}Nb.

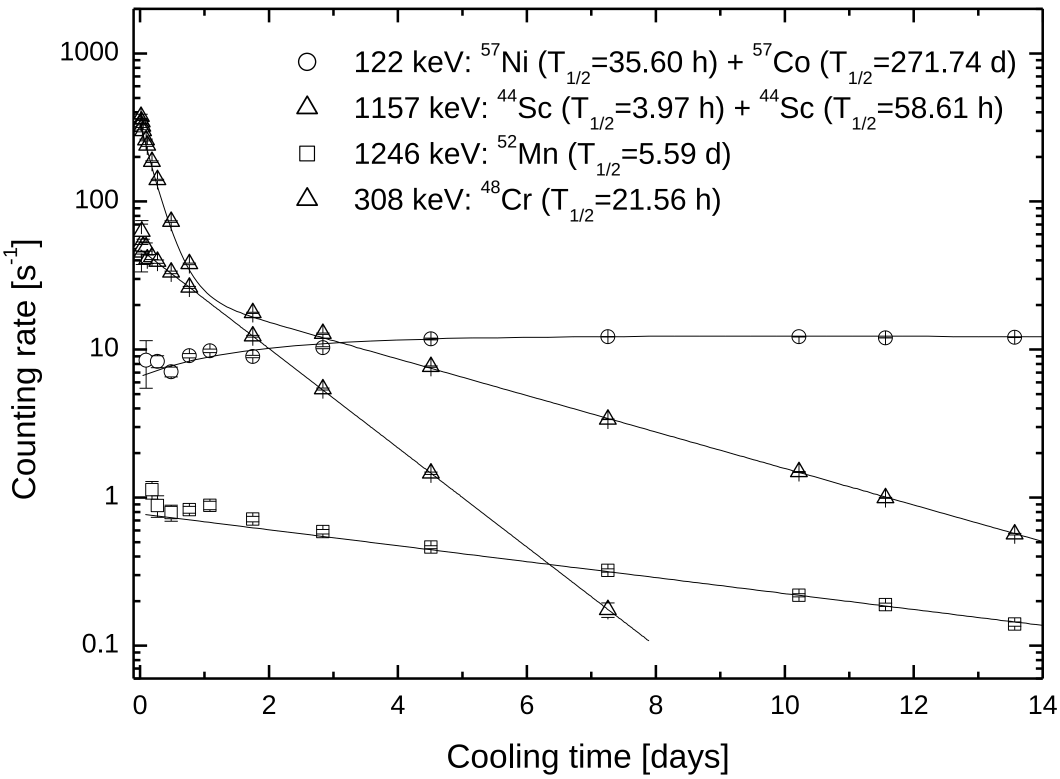


Fig. 3.32. Decay curves of reaction products in 2600 MeV proton-irradiated ^{nat}Ni.

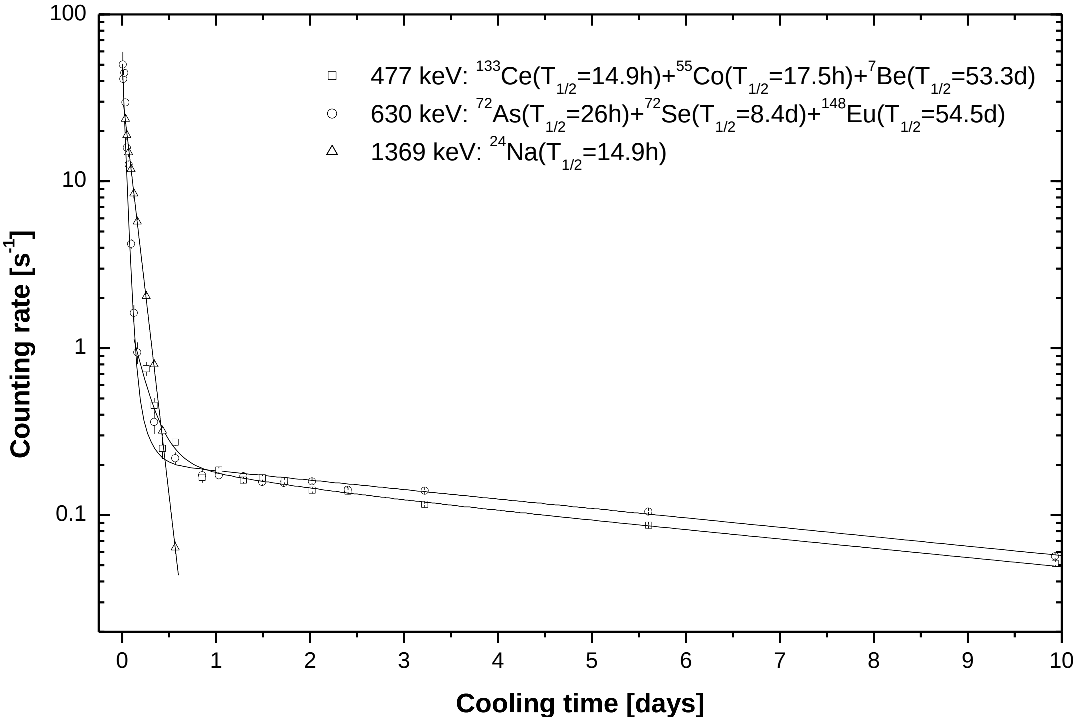


Fig. 3.33. decay curves of reaction products in 2600 MeV proton-irradiated ^{181}Ta.

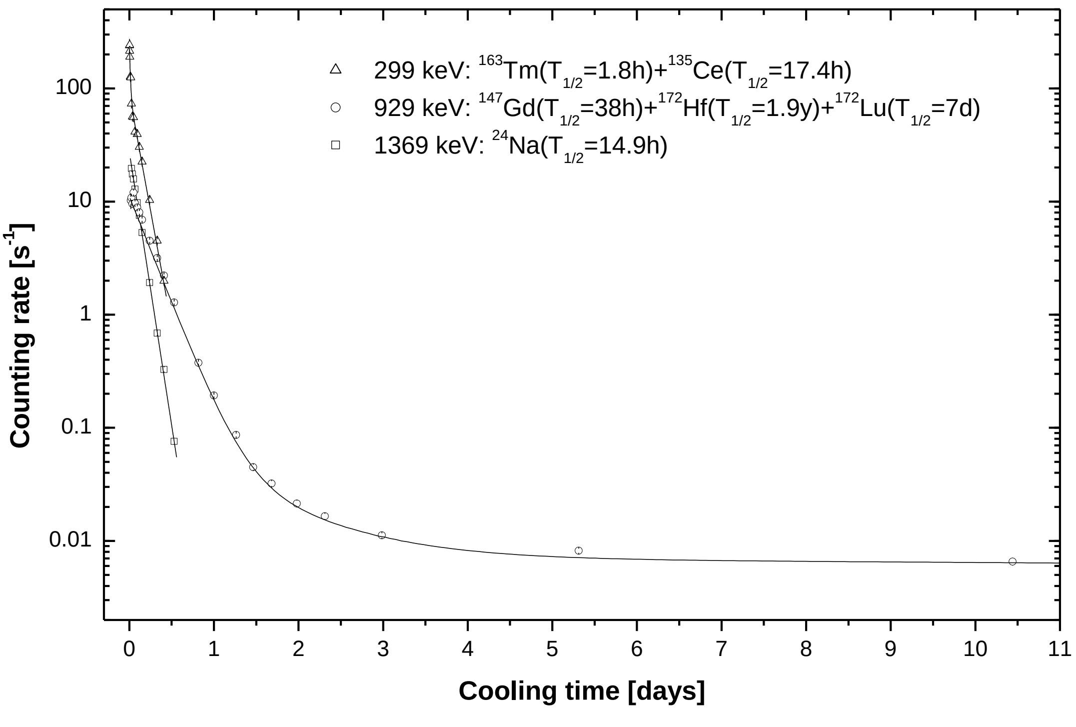


Fig. 3.34. decay curves of reaction products in 2600 MeV proton-irradiated ^{nat}W**.**

3.4.8. Neutron background

When irradiated, the samples interact with not only the primary beam protons but also secondaries, primarily the neutrons produced in interactions of primary proton beam with transport channel structural materials and with shielding. The role of the background particles, whose interactions generate identical reaction products in experimental samples, was appraised by measuring the number of ^{27}Mg nuclei, and the number ^{7}Be, ^{22}Na, and ^{24}Na nuclei, which are products of ^{27}Al(n,p)^{27}Mg, ^{27}Al(p,x)^{7}Be, ^{27}Al(p,x)^{22}Na, and ^{27}Al(p,x)^{24}Na reactions, respectively.

In that case, the mean secondary neutron flux-to-mean primary proton flux ratio can be found from the expressions [1,4,5].

The above experimental techniques was applied to all eleven proton beam energies.

Fig. 3.35 shows the measurement results. Given log-log scale, the near-linear rise of $\Phi n/\Phi p$ ratio with increasing proton energy is indicative of a correlation between neutron yield rise and neutron background increase. The relevant estimates have shown that, given even the highest $\Phi n/\Phi p$ value, the neutron component ((n,Xn) reaction) contribution is insignificant (to (p,p(X-1)n) reaction, respectively).

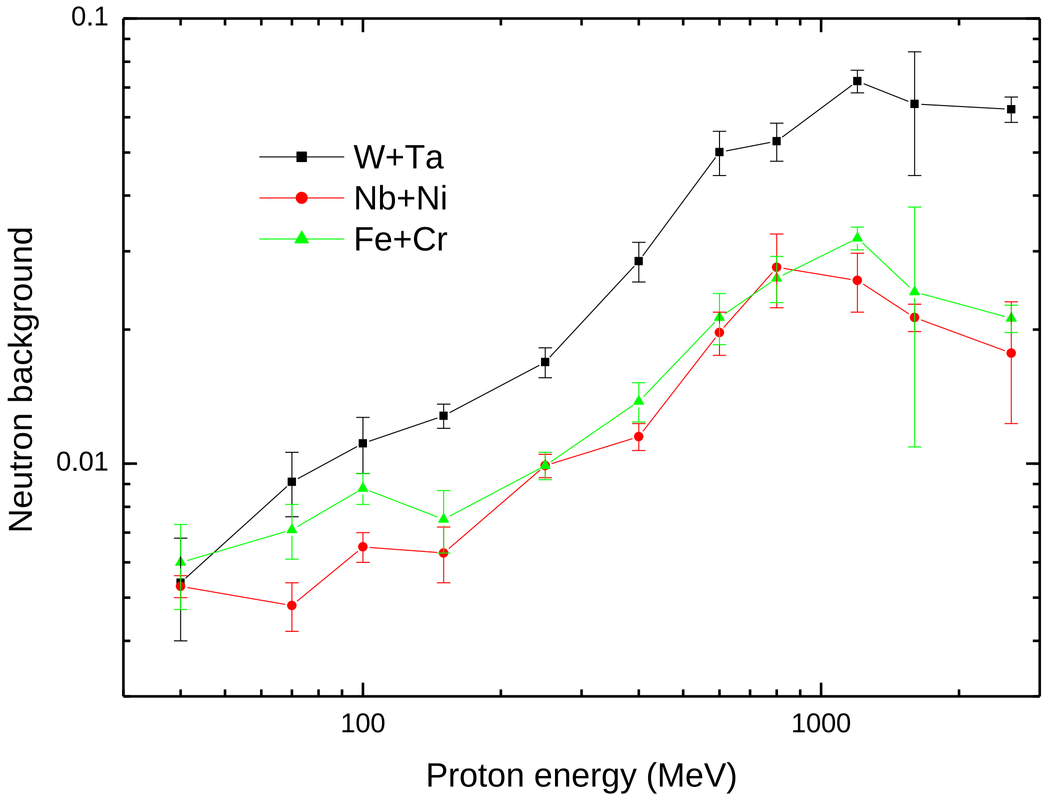


Fig. 3.35. Neutron background when irradiating different samples.

3.5. Procedure of α-spectrometric analyzing of samples irradiated

3.5.1. Energy calibration and α-spectrometer detection efficiency.

The detection efficiency of the α-spectrometer composed of an A300-17-AM detector and an ASPECT ADC 1K-B1 (2048 channels) analyzer was energy-calibrated, and its detection efficiency determined, using Set No. 665 of the Standard Spectrometry α-Sources (SSAS that consists of ^{233}U+^{238}Pu+^{239}Pu, ^{226}Ra, ^{238}Pu, and ^{239}Pu sources. Figs 3.36-3.39 are examples of the spectra measured in each of the sources.

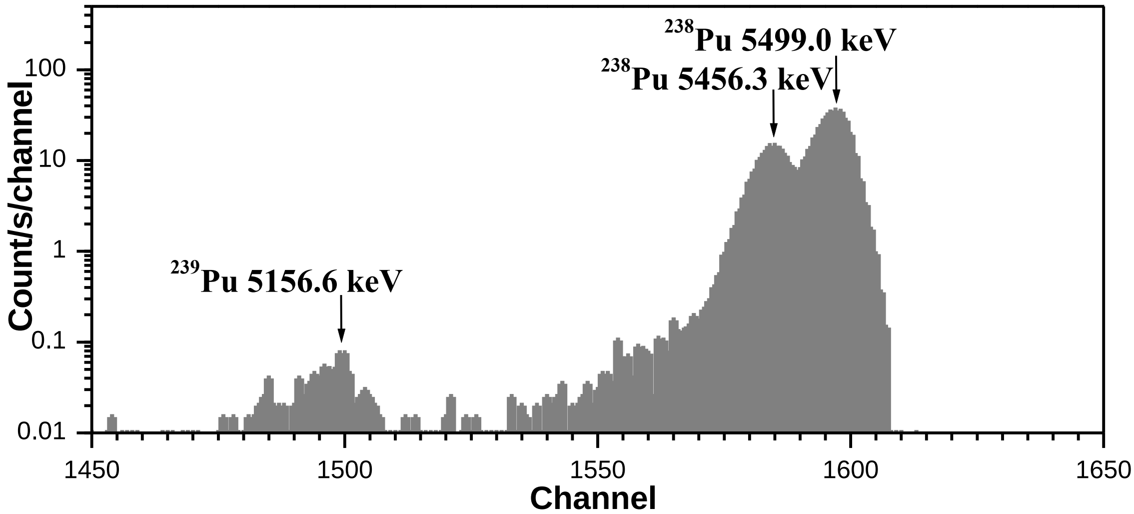


Fig. 3.36. The ^{238}Pu source spectrum measured.

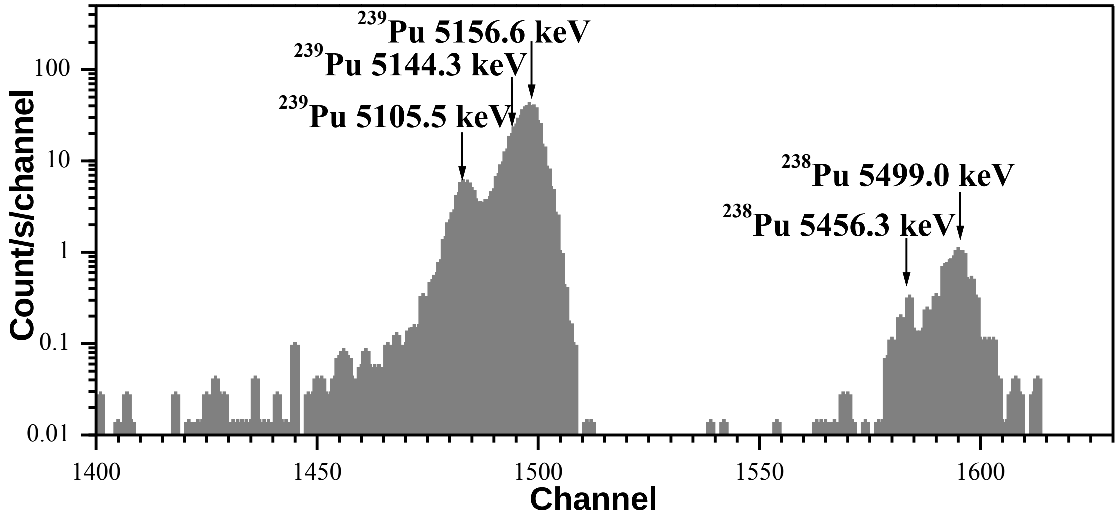


Fig. 3.37. The ^{239}Pu source spectrum measured.

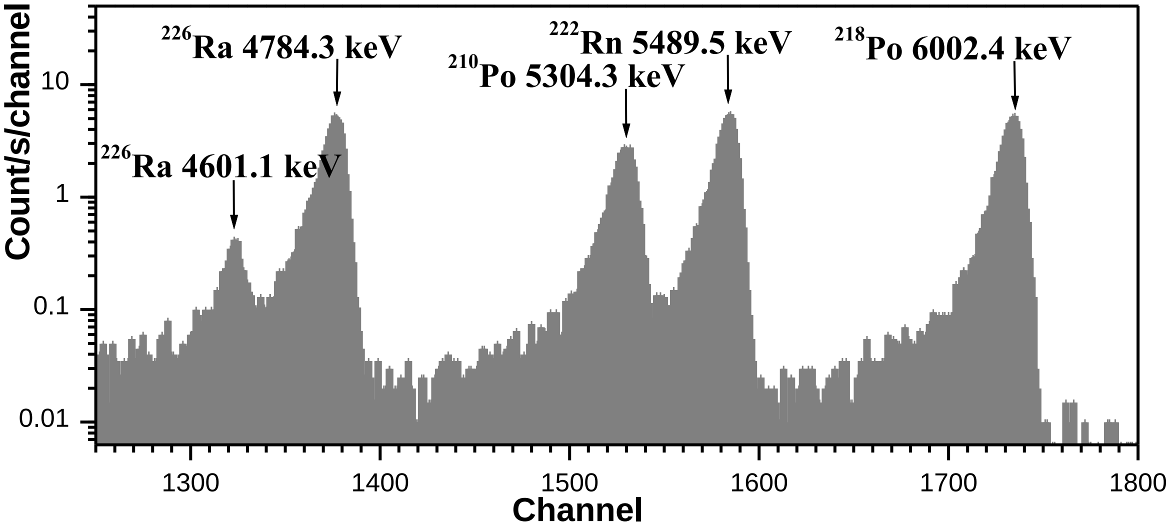


Fig. 3.38. The ^{226}Ra source spectrum measured.

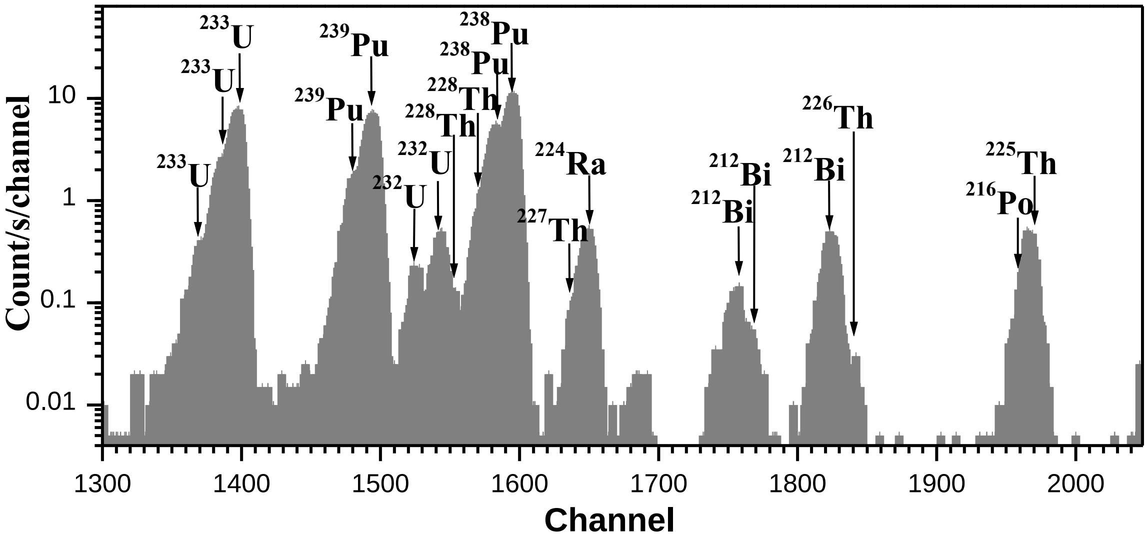


Fig. 3.39. The ^{233}U+^{238}Pu+^{239}Pu source spectrum measured.

The spectra measured were processed by α-block of the Genie-2000 program, thereby having determined the areas and center positions of the peaks together with the errors involved. From Fig. 3.40, which shows the peak center positions determined, it follows that the ^{226}Ra peak centers are shifted by some 10 channels downwards with respect to the peak positions of the rest sources. Therefore, the energies were calibrated separately for ^{226}Ra and for other sources (see Fig. 3.40). The shift of the ^{226}Ra lines may be accounted for by the difference in active layer depths of the used α-sources. This is confirmed indirectly by the elevated left-hand half of the ^{226}Ra α-line Gaussian (see Fig. 3.38). Eventually, the function E(keV) = 3.434·Ch+21, which has permitted the ^{148}Gd (3083 keV) line position at channel 921, was taken to be the energy calibration result.

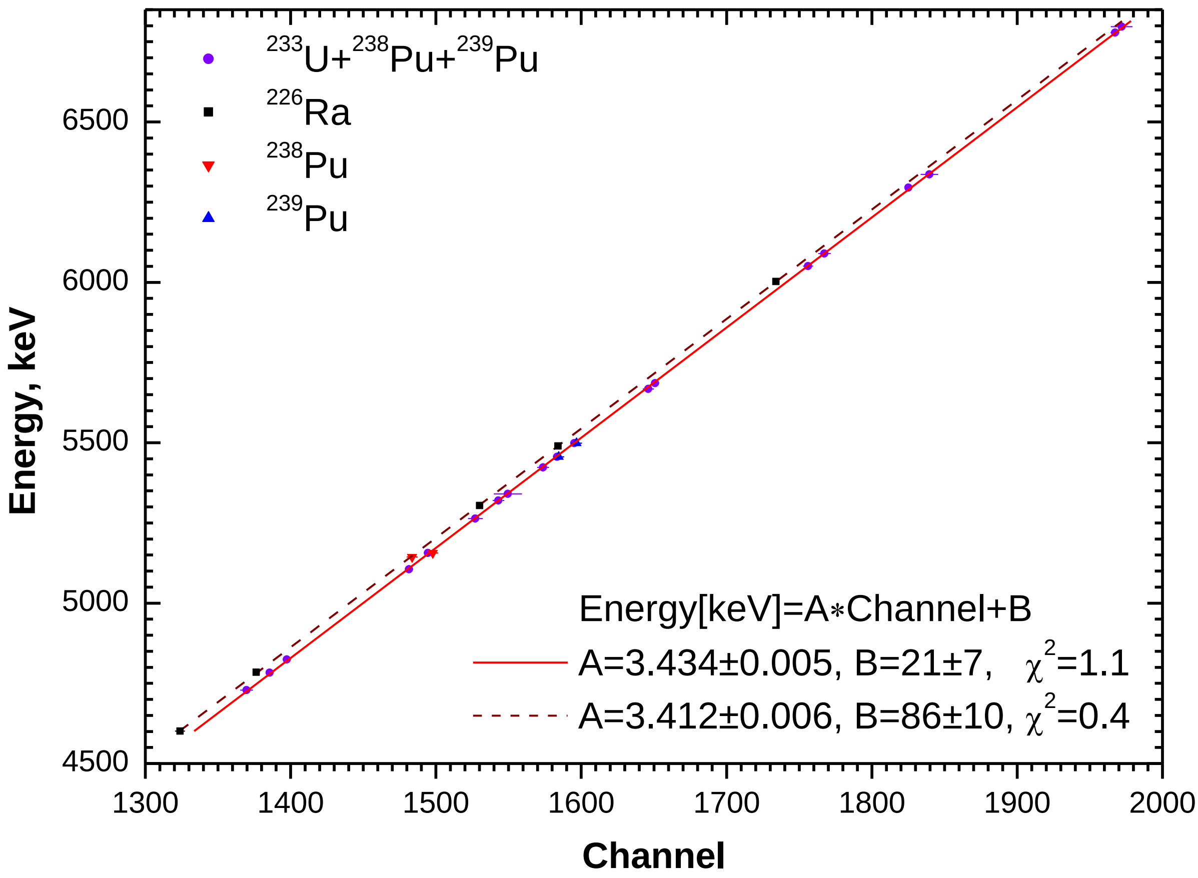


Fig. 3.40. α-energy calibration.

Fig. 3.41 shows the spectrometer detection efficiency as a function of the source-detector surface spacing measured without collimating.

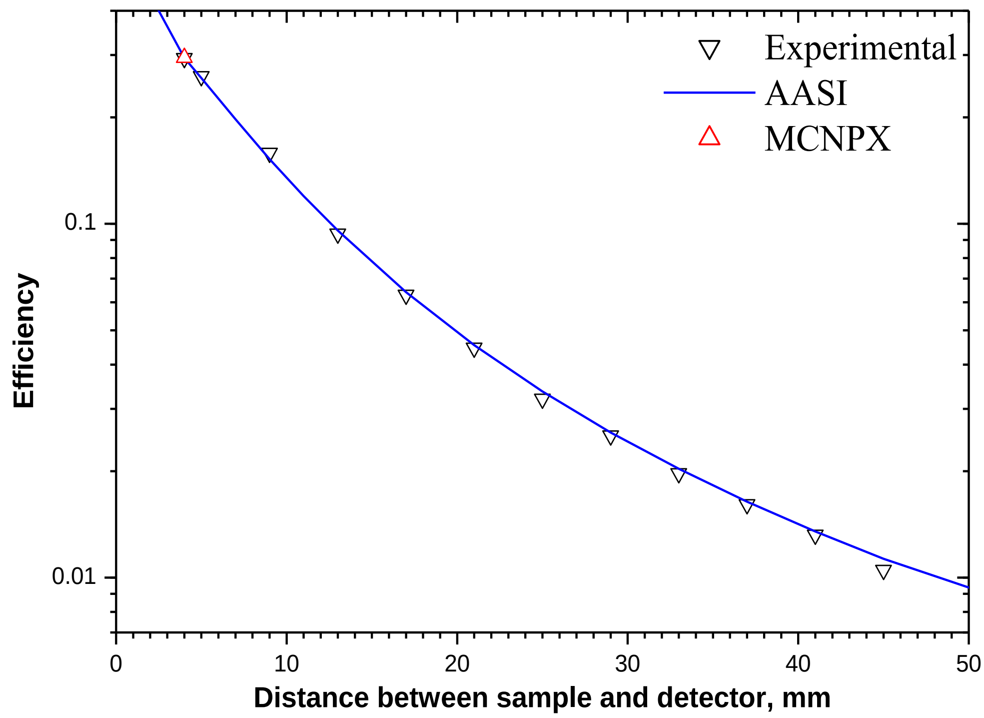


Fig. 3.41. The experimental (^{239}Pu) and calculated dependences (AASI, MCNPX) of detection efficiency on the distance to the detector. The measurement error is within a dot.

The detection efficiency measured agrees well with the values calculated via the AASI code for simulating the energy spectrum in the α-spectrometer [9]. The value was also calculated by the MCNPX code used conforming to the description in Subsection 3.5.3. Table 3.9 presents the detection efficiencies for a 4-mm source-detector surface spacing.

Table 3.9

The α-spectrometer effectiveness

Source-detector spacing, mm	Detection efficiency measured by ^{239}Pu	Detection efficiency calculated by AASI	Detection efficiency calculated by MCNPX
4	0.294(0.018)	0.2942(0.0015)	0.29485(0.00015)

The calibration measurements having ended, the α-chamber background was measured. The results are displayed in Fig. 3.42

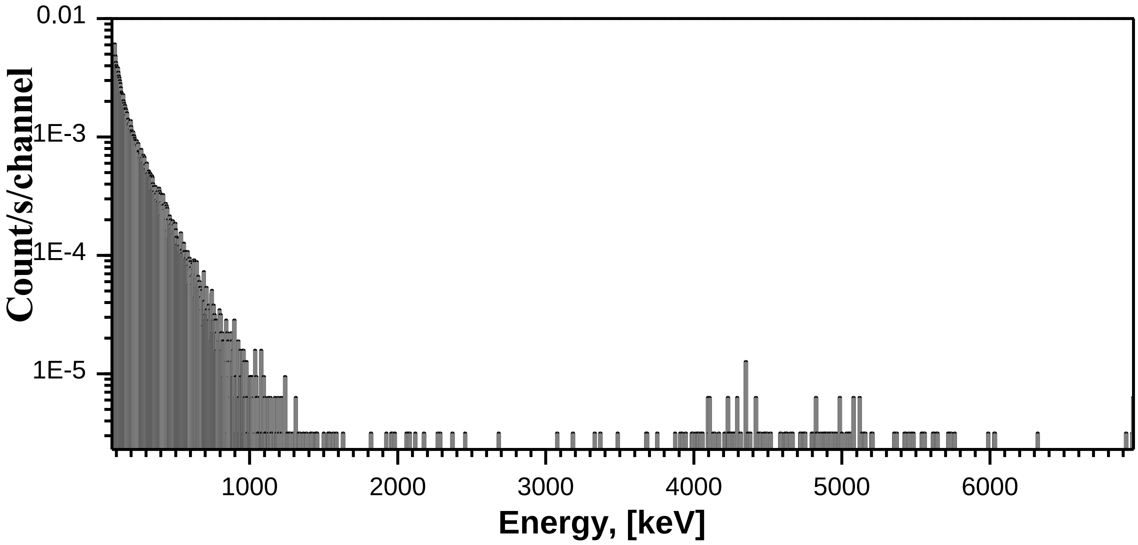


Fig. 3.42. The α-spectrometer background count rate accumulated for 105 hours.

3.5.2. Processing of α-spectra

As indicated in Subsection 2.5, the ^{148}Gd production was quantitatively determined without chemical separating the nuclide. Therefore, the shapes of the measured α-spectra of the ^{Nat}W and ^{181}Ta samples irradiated, which are shown as examples in Fig. 3.43, are much different from those of the standard spectra shown in Figs. 3.36-3.39.

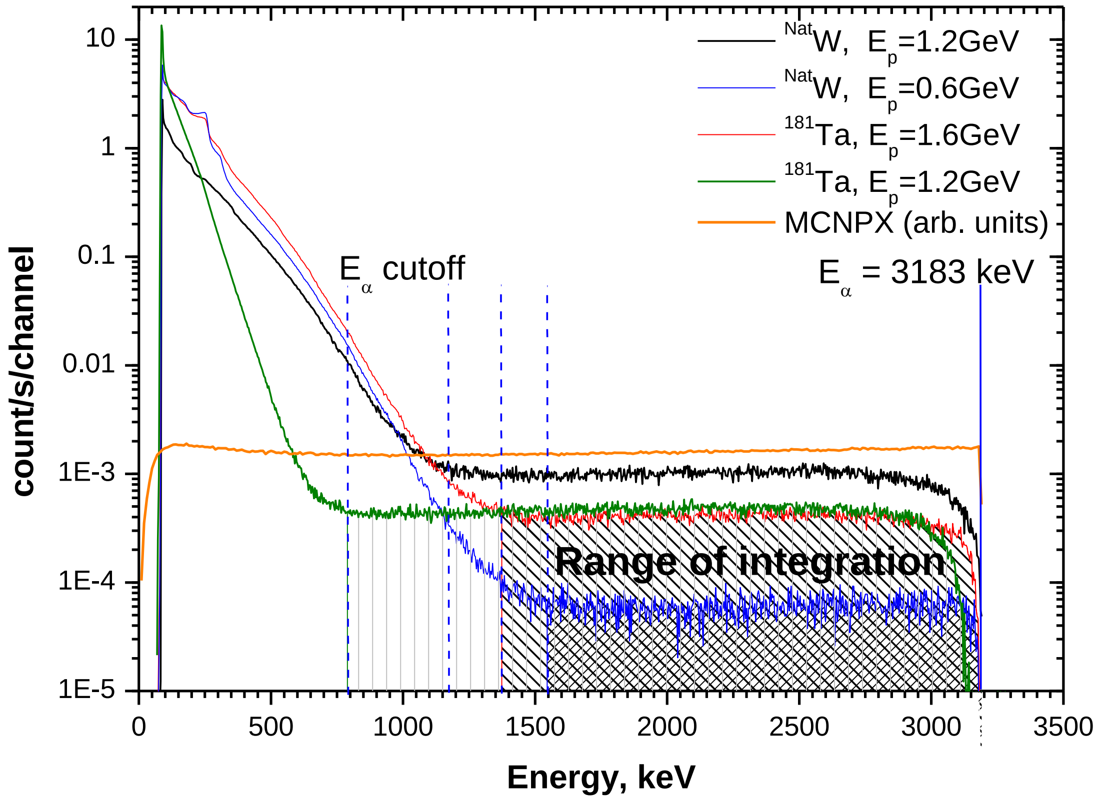


Fig. 3.43. Instances of the measured α-spectra of ^{Nat}W and ^{181}Ta samples irradiated. Shown are the feasible versions of A(E) as an integral of the measured spectrum from E_{cutoff} up to 3183 keV.

The difference in the spectra is due to the ^{148}Gd-emitted 3183 keV α-particle stoppage in an experimental sample that leads to complete smearing of ^{148}Gd monoline and to α-particle detector recording the α-particles within the range from the lower discrimination energy of the spectrometer (~80 keV) up to 3183 keV. The samples irradiated contain many β-active residual nuclides, so the spectrometer records also their summary spectrum. The differences in the excitation functions of the residual nuclides and in their irradiation and decay times results in the fact that any constant energy boundary between the β and α spectra is absent. The boundary energy E_{cutoff} were determined in additional experiments in which each experimental sample was shielded by an aluminum foil in the thickness 15 microns. As an example, the Figs 3.45 and 3.46 presents spectra of ^{nat}W and ^{181}Ta (E_p=800MeV) measured with and without 15 microns Al-foil shield. Therefore, in conformity with formula (2.42), the α-spectra measured were processed by determining the parameter A_{cutoff} that is the count rate integral from the selected discrimination energy to the ^{148}Gd α-line energy of 3183 keV. The selected discrimination energies E_{cutoff} are presented in Table 4.15 and 4.18.

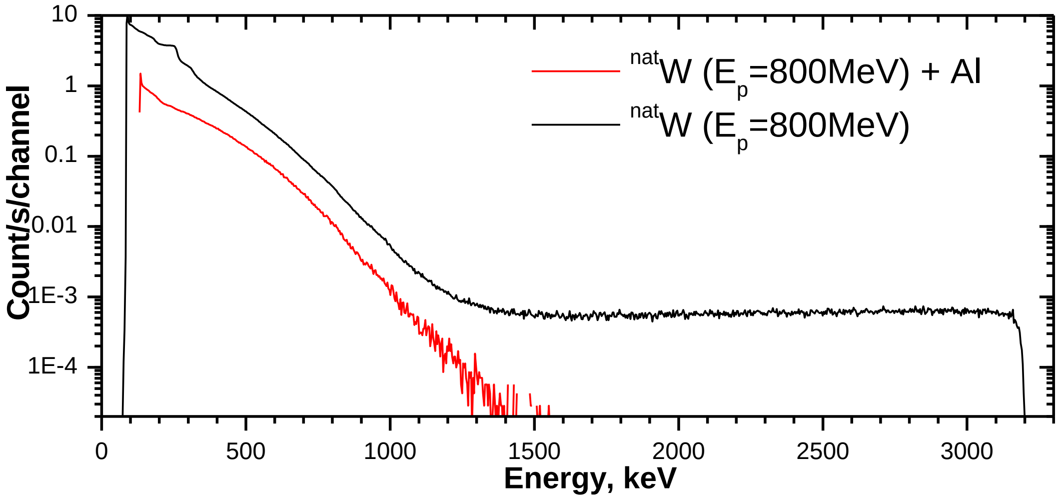


Fig. 3.45. ^{nat}W (E_p=800MeV) spectrum measured with and without 15 microns Al-foil shield.

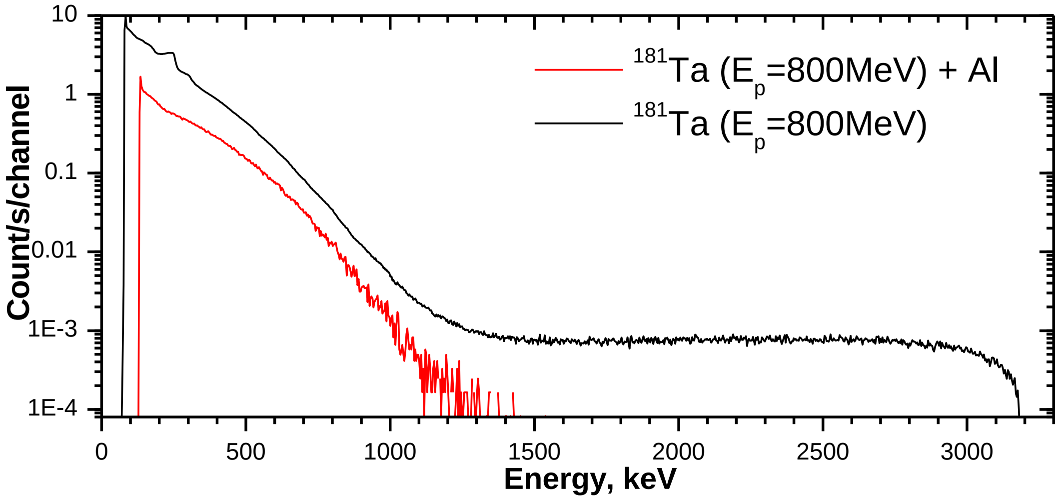


Fig. 3.46. ^{181}Ta (E_p=800MeV) spectrum measured with and without 15 microns Al-foil shield.

3.5.3. Calculations of the detection efficiency ε_α and of coefficient k_α .

The ^{148}Gd α-particle spectrum was simulated, and the coefficient k_α entering formula (2.36) determined, in terms of the MCNPX code with geometric description of the problem according to Fig. 3.46. The α-particles were taken to have energy of 3183 keV and to obey isotropic angular and uniform spatial distribution within a 10 mg/ cm^2 surface layer. The calculations assumed the source-detector surface spacing H = 4 mm, a 19.54-mm Si detector diameter, a 10.3-mm W sample diameter, and a 10.5-mm Ta sample diameter.

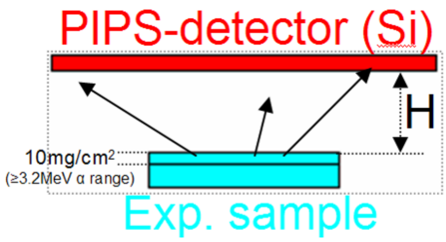


Fig. 3.46. The MCNPX model to simulate α-spectra and to calculate the parameters entering expression (2.36).

The calculation results have given $\tilde{A}(E)$ - the energy distribution of pulses created in the PIPS detector volume allowing for all the nuclear-physics processes of α-particle interactions with medium simulated by the MCNPX code. $\tilde{A}(E)$ bins correspond to the energy deposited in the detector volume by all the tracks during a single simulation history. $\tilde{A}_{cutoff}$ is calculated after E_{cutoff} energy determination.

4. RESULTS OF MEASURING OF RESIDUAL NUCLIDES PRODUCTION CROSS SECTION

The carried out experiments allowed us to determine 3865 (see Table 8.1) residual nuclides production cross section values, of them: 726 independent (signed as (i)) yields; 365 sums of independent metastable and the ground state yields (i (Σmj+g)); 365 independent yields of a metastable states (i (Σmj); 2409 cumulative and supracumulative yields (c, c*).

The formula (2.35).was used for determination values of residual nuclides production cross section values and their uncertainties. Values of residual nuclides production rates were determined with the use of formulas (2.8 – 2.11) and 2.13, and their uncertainties – with the use of (2.28-2.31). The proton fluxes and their uncertainties were determined also by use of the formula (2.34).

Results of determination of residual nuclides production cross section are presented in Tables 4.2, 4.4, 4.5, 4.7, 4.9, 4.11, 4.11a, 4.13, 4.16 and 4.19.

Since a value of reaction rate for a given nuclide can be found with the use of both one, and several γ – lines, the appendix 1 presents the detailed information on calculation of every reaction rate, both in experimental samples and in monitors..

Average uncertainty in determination of residual nuclides production cross sections are: ^{nat}Cr-10.4 %, ^{56}Fe-11.1 %, ^{nat}Ni-11.4 %, ^{93}Nb-15.2 %, ^{181}Ta-14.4 %, ^{nat}W-14.5 %.

Uncertainty distributions of reaction rates and cross sections are presented in Fig. 4.1, 4.2

4.1 Residual nuclides production cross sections in ^{nat}Cr.

Table 4.1. Parameters of ^{nat}Cr irradiations.

Proton energy (MeV)	Sample weight (mg)	Monitor weight (mg)	Weight of monitor plate (mg)	Irradiation time (min)	Average proton flux p/(cm^2•s) x10^{-10}	Number of γ-spectra measured in sample/monitor/plate	Fluence measured by current transformer, 10^{14} protons
2605±8	366.1	59.0	1452.5	33.48	5.26 ± 0.46	26/14/2	1.279
1598±4	338.6	58.6	1483.5	29.68	5.98 ± 0.50	22/12/6	1.288
1198±3	340.3	59.2	1476.1	27	6.70 ± 0.54	27/17/10	1.303
799±2	337.4	59.1	1495.1	20	6.88 ± 0.64	23/10/4	1.301
599±2	328.9	58.3	1510.1	29	6.78 ±0.52	22/15/4	1.282
399±2	322.2	48.1	1406.4	26.33	5.70 ± 0.47	20/16/3	1.240
248±1	339.8	49.2	1911.5	29	7.27 ± 0.64	23/15/7	1.290
148±1	336.9	49.5	1405.1	34.75	3.14 ± 0.27	20/17/3	1.245
97±1	338.4	48.1	1388.3	35	3.73 ± 0.28	21/18/2	1.214
66±1	332.3	24.8	1423.6	31.5	5.42 ± 0.43	22/18/4	1.218
42±1	330.8	47.6	1396.6	36	2.10 ± 0.16	23/18/4	1.225
Parameters of ^{nat}Cr irradiations by 40–150 MeV protons to measure ^{7}Be							
147±1	393.9	48.2	-	30	6.82 ± 0.53	3/2/-	1.305
97±1	350.6	49.5	-	31	5.76 ± 0.43	3/2/-	1.352
63±1	317.0	48.2	-	31	5.50 ± 0.38	3/2/-	1.225
40±1	361.3	49.2	-	46	2.42 ± 0.17	3/3/-	1.474

Table 4.2. Experimental values of residual nuclides production cross sections in ^{nat}Cr(p,x) reactions induced by 0.04-2.6GeV protons**.**

Nuclide	Type	$T_{1/2}$	Cross sections [mb] at proton energies [MeV]										
			42	66	97	148	248	399	599	799	1198	1599	2605
^{54}Mn	i	312.11d	0.996 (0.083)	0.430 (0.040)	0.346 (0.032)	0.250 (0.031)	0.167 (0.016)	0.153 (0.018)	0.185 (0.015)	0.167 (0.026)	0.205 (0.022)	0.177 (0.017)	0.155 (0.016)
^{52m}Mn	i(m)	21.1m	17.7 (1.4)	7.29 (0.65)	4.79 (0.66)	2.85 (0.30)	1.95 (0.40)	1.17 (0.13)	0.989 (0.099)	0.97 (0.12)	0.956 (0.095)	0.795 (0.097)	0.690 (0.075)
^{52}Mn	i	5.591d	9.89 (0.75)	3.35 (0.29)	2.35 (0.20)	1.64 (0.16)	0.917 (0.087)	0.665 (0.059)	0.589 (0.049)	0.543 (0.054)	0.570 (0.049)	0.432 (0.039)	0.376 (0.035)
^{51}Cr	c	27.7025d	329 (25)	152 (13)	120.0 (10.0)	89.9 (8.5)	58.8 (5.5)	53.9 (4.8)	52.4 (4.4)	47.8 (4.7)	48.2 (4.2)	38.6 (3.4)	31.7 (2.9)
^{49}Cr	c	42.3m	10.02 (0.80)	30.7 (2.8)	21.0 (1.9)	14.8 (1.6)	9.80 (0.98)	7.89 (0.73)	6.96 (0.61)	5.86 (0.61)	5.31 (0.49)	4.11 (0.48)	3.23 (0.38)

Nuclide	Type	$T_{1/2}$	Cross sections [mb] at proton energies [MeV]										
			42	66	97	148	248	399	599	799	1198	1599	2605
^{48}Cr	c	21.56h	1.65 (0.13)	1.57 (0.14)	2.44 (0.21)	1.81 (0.18)	1.21 (0.11)	1.000 (0.090)	0.869 (0.074)	0.742 (0.075)	0.628 (0.056)	0.491 (0.044)	0.367 (0.035)
^{48}V	c	15.9735d	46.3 (3.5)	33.3 (2.8)	50.9 (4.3)	42.2 (4.0)	30.1 (2.8)	27.2 (2.4)	24.6 (2.1)	21.0 (2.1)	19.2 (1.7)	16.0 (1.4)	12.1 (1.1)
^{48}Sc	i	43.67h	0.014 (0.002)	0.110 (0.011)	0.514 (0.047)	0.639 (0.065)	0.742 (0.071)	1.010 (0.090)	1.27 (0.11)	1.34 (0.14)	1.34 (0.12)	1.130 (0.100)	0.870 (0.080)
^{47}Sc	i	3.3492d	-	-	-	4.31 (0.41)	4.44 (0.42)	5.51 (0.49)	6.34 (0.53)	6.21 (0.62)	6.12 (0.53)	4.50 (0.40)	3.45 (0.32)
^{47}Sc	c	3.3492d	0.578 (0.043)	2.24 (0.19)	3.50 (0.30)	4.38 (0.42)	4.50 (0.42)	5.62 (0.50)	6.41 (0.54)	6.23 (0.62)	6.21 (0.54)	4.61 (0.41)	3.54 (0.33)
^{46}Sc	i(m+g)	83.79d	0.266 (0.023)	9.61 (0.84)	10.50 (0.90)	12.7 (1.2)	12.3 (1.2)	14.4 (1.3)	15.5 (1.3)	14.2 (1.4)	13.4 (1.2)	11.10 (1.00)	8.28 (0.79)
^{44m}Sc	i(m)	58.61h	0.154 (0.012)	1.58 (0.13)	6.48 (0.56)	7.51 (0.72)	7.72 (0.72)	8.93 (0.79)	9.79 (0.82)	8.81 (0.87)	8.11 (0.72)	6.14 (0.55)	4.49 (0.42)
^{44}Sc	i	3.97h	0.284 (0.021)	2.59 (0.22)	9.45 (0.85)	10.65 (1.00)	10.7 (1.2)	13.4 (1.2)	14.3 (1.2)	12.8 (1.3)	11.39 (1.00)	9.78 (0.87)	7.05 (0.66)
^{44}Sc	i(m+g)	3.97h	0.433 (0.038)	4.13 (0.35)	16.5 (1.6)	18.4 (1.8)	20.4 (1.9)	22.3 (2.0)	24.4 (2.0)	21.5 (2.2)	19.3 (1.7)	16.0 (1.4)	11.6 (1.1)
^{43}Sc	c	3.891h	0.124 (0.012)	1.27 (0.12)	2.46 (0.22)	4.70 (0.48)	5.50 (0.54)	6.82 (0.65)	7.43 (0.67)	6.75 (0.71)	6.08 (0.59)	4.82 (0.46)	3.47 (0.35)
^{47}Ca	c	4.536d	-	-	-	0.026 (0.008)	0.051 (0.009)	0.079 (0.013)	0.097 (0.025)	0.107 (0.040)	0.135 (0.018)	0.112 (0.011)	0.089 (0.009)
^{45}K	c	17.3m	-	-	-	-	-	0.049 (0.011)	0.091 (0.013)	0.092 (0.014)	0.098 (0.016)	0.086 (0.012)	0.074 (0.010)
^{44}K	c*	22.13m	-	-	-	-	-	0.246 (0.048)	0.362 (0.061)	0.395 (0.082)	0.444 (0.088)	0.373 (0.078)	0.304 (0.060)
^{43}K	c	22.3h	-	0.034 (0.003)	0.195 (0.017)	0.570 (0.054)	0.961 (0.090)	1.57 (0.14)	2.21 (0.18)	2.33 (0.23)	2.26 (0.20)	1.83 (0.16)	1.42 (0.13)
^{42}K	i	12.360h	-	0.021 (0.003)	1.100 (0.090)	2.08 (0.20)	3.28 (0.31)	5.31 (0.47)	7.22 (0.60)	7.32 (0.73)	6.94 (0.60)	5.89 (0.52)	4.34 (0.40)
^{38}K	i	7.636m	-	-	-	0.105 (0.024)	0.311 (0.069)	0.672 (0.069)	1.03 (0.10)	1.03 (0.11)	0.75 (0.10)	1.05 (0.13)	0.787 (0.096)
^{41}Ar	c	109.34m	-	-	0.045 (0.004)	0.155 (0.015)	0.360 (0.033)	0.714 (0.064)	1.091 (0.090)	1.18 (0.12)	1.26 (0.11)	1.130 (0.100)	0.873 (0.081)
^{39}Cl	c	55.6m	-	-	-	0.043 (0.006)	0.144 (0.014)	0.361 (0.034)	0.630 (0.054)	0.732 (0.074)	0.846 (0.075)	0.757 (0.078)	0.585 (0.062)
^{38}Cl	i(m+g)	37.24m	-	-	-	-	0.588 (0.059)	1.28 (0.12)	2.25 (0.19)	2.57 (0.26)	2.90 (0.27)	2.69 (0.25)	1.94 (0.18)
^{38}Cl	c	37.24m	-	-	0.045 (0.006)	0.171 (0.018)	0.578 (0.056)	1.30 (0.12)	2.30 (0.20)	2.64 (0.27)	2.97 (0.27)	2.77 (0.25)	2.02 (0.19)
^{34m}Cl	i(m)	32.00m	-	-	-	0.033 (0.012)	0.140 (0.017)	0.400 (0.036)	0.791 (0.067)	0.948 (0.095)	1.141 (0.099)	1.05 (0.14)	0.744 (0.085)
^{38}S	c	170.3m	-	-	-	-	0.007 (0.002)	0.024 (0.003)	0.050 (0.005)	0.072 (0.008)	0.077 (0.008)	0.081 (0.009)	0.064 (0.008)
^{29}Al	c	6.56m	-	-	-	-	-	0.389 (0.039)	1.21 (0.10)	1.86 (0.19)	2.61 (0.24)	3.15 (0.29)	2.57 (0.24)
^{28}Mg	c	20.915h	-	-	-	-	0.007 (0.001)	0.042 (0.004)	0.143 (0.012)	0.244 (0.024)	0.420 (0.037)	0.467 (0.042)	0.421 (0.039)
^{27}Mg	c	9.458m	-	-	-	-	-	0.146 (0.022)	0.559 (0.050)	0.915 (0.092)	1.35 (0.13)	1.79 (0.16)	1.57 (0.15)
^{24}Na	c	14.9590h	-	-	-	0.012 (0.002)	0.061 (0.006)	0.308 (0.027)	1.040 (0.090)	1.83 (0.18)	3.36 (0.29)	3.89 (0.35)	3.69 (0.34)
^{22}Na	c	2.6019y	-	-	-	-	-	0.216 (0.035)	0.659 (0.064)	1.09 (0.11)	2.06 (0.18)	2.55 (0.23)	2.44 (0.23)
^{7}Be	i	53.29d	0.056 (0.010)*	0.212 (0.022)**	0.297 (0.028)	0.348 (0.032)	0.676 (0.069)	1.26 (0.11)	2.39 (0.20)	3.28 (0.33)	5.38 (0.46)	6.04 (0.54)	6.58 (0.61)

* at 40 MeV

** at 63 MeV

4.2 Residual nuclides production cross sections in ^{56}Fe.

Table 4.3. Parameters of ^{56}Fe irradiations.

Proton energy (MeV)	Sample weight (mg)	Monitor weight (mg)	Weight of monitor plate (mg)	Irradiation time (min)	Average proton flux p/(cm^2•s) x10^{-10}	Number of γ-spectra measured in sample/monitor/plate	Fluence measured by current transformer, 10^{14} protons
2605±8	243.3	59.2	1479.7	35.13	4.75 ± 0.41	30/13/2	1.279
1598±4	247.4	59.2	1547.0	33.67	5.56 ± 0.47	24/12/6	1.289
1199±3	243	59.5	1476.1	27	6.62 ± 0.53	27/16/10	1.303
799±2	245.4	59.1	1495.1	20	6.97 ± 0.59	23/14/10	1.301
600±2	239.8	58.5	1510.1	29	7.99 ± 0.64	22/15/4	1.282
400±2	270.4	47.8	1406.4	26.33	6.35 ± 0.57	21/15/3	1.240
249±1	244.7	47.9	1911.5	29	7.22 ± 0.51	23/15/7	1.290
149±1	216.4	49.8	1405.1	34.75	3.44 ± 0.30	20/16/3	1.245
99±1	259.2	48.8	1388.3	35	4.07 ± 0.31	22/20/2	1.214
68±1	239.6	49.2	1423.6	31.5	5.61 ± 0.46	22/18/4	1.218
46±1	240.1	48.1	1396.6	36	3.12 ± 0.22	23/17/4	1.225
Parameters of ^{56}Fe irradiations by 40–150 MeV protons to measure							
149±1	401.5	49.6	-	30	6.85 ± 0.51	3/2/-	1.305
99±1	344.3	48.1	-	31	5.66 ± 0.42	3/2/-	1.352
67±1	477.6	48.3	-	31	5.60 ± 0.39	3/2/-	1.225
45±1	403.9	48.2	-	46	2.10 ± 0.15	3/3/-	1.474

Table 4.4. Experimental values of residual nuclides production cross sections in ^{56}Fe (p,x) reactions induced by 0.04-2.6GeV protons**.**

Nuclide	Type	$T_{1/2}$	Cross sections [mb] at proton energies [MeV]										
			46	68	99	149	249	400	600	799	1199	1599	2605
^{57}Co	i	271.74d	0.077 (0.010)	0.073 (0.007)	0.079 (0.008)	0.080 (0.010)	0.075 (0.008)	0.104 (0.020)	0.152 (0.015)	0.194 (0.019)	0.277 (0.024)	0.343 (0.031)	0.321 (0.030)
^{56}Co	i	77.233d	11.00 (0.90)	6.36 (0.56)	4.42 (0.38)	2.68 (0.25)	1.61 (0.12)	1.14 (0.11)	0.922 (0.080)	0.914 (0.084)	1.030 (0.090)	1.050 (0.100)	0.854 (0.080)
^{55}Co	i	17.53h	8.85 (0.78)	5.12 (0.47)	3.44 (0.34)	2.08 (0.23)	1.22 (0.13)	0.75 (0.10)	0.451 (0.041)	0.391 (0.038)	0.354 (0.045)	0.358 (0.041)	0.268 (0.033)
^{53}Fe	c*	8.51m	3.56 (0.40)	15.1 (1.7)	9.1 (1.1)	6.92 (0.85)	5.07 (0.54)	3.90 (0.53)	2.88 (0.34)	2.55 (0.34)	2.51 (0.30)	2.46 (0.39)	1.84 (0.20)
^{52}Fe	c	8.275h	0.035 (0.026)	0.96 (0.13)	1.09 (0.15)	0.96 (0.12)	0.76 (0.16)	0.560 (0.070)	0.392 (0.055)	0.354 (0.048)	0.294 (0.029)	0.296 (0.032)	0.229 (0.031)

^{56}Mn	c	2.5789h	0.110 (0.011)	0.128 (0.014)	0.151 (0.014)	0.150 (0.017)	0.225 (0.023)	0.393 (0.043)	0.534 (0.050)	0.714 (0.067)	0.897 (0.084)	0.921 (0.085)	0.735 (0.071)
^{54}Mn	i	312.11d	148 (12)	72.7 (6.4)	64.0 (5.6)	48.0 (4.5)	42.1 (3.3)	39.4 (3.8)	36.4 (3.2)	37.0 (3.4)	38.6 (3.3)	40.3 (3.6)	31.3 (2.9)
^{52m}Mn	i(m)	21.1m	4.54 (0.38)	13.6 (1.2)	15.8 (1.6)	13.3 (1.5)	10.3 (3.1)	8.92 (0.87)	7.81 (0.70)	7.28 (0.69)	7.39 (0.72)	6.59 (0.63)	5.18 (0.50)
^{52m}Mn	c	21.1m	4.67 (0.39)	14.4 (1.6)	17.0 (1.7)	14.4 (1.7)	11.5 (3.2)	9.57 (0.93)	8.30 (0.74)	7.70 (0.72)	7.74 (0.75)	6.95 (0.66)	5.45 (0.52)
^{52}Mn	c	5.591d	6.02 (0.50)	25.4 (2.3)	26.2 (2.3)	18.7 (1.8)	14.3 (1.1)	12.1 (1.2)	9.77 (0.94)	9.00 (0.89)	8.45 (0.78)	8.66 (0.79)	6.41 (0.60)
^{51}Cr	c	27.7025d	79.3 (6.4)	30.5 (2.7)	66.1 (5.8)	55.4 (5.3)	49.6 (3.9)	46.2 (4.4)	39.7 (3.5)	37.5 (3.4)	35.8 (3.1)	35.9 (3.2)	26.9 (2.5)
^{49}Cr	c	42.3m	0.058 (0.011)	2.73 (0.28)	6.48 (0.60)	6.90 (0.69)	7.03 (0.58)	7.11 (0.72)	6.23 (0.57)	5.75 (0.55)	5.35 (0.49)	5.08 (0.51)	3.81 (0.40)
^{48}Cr	c	21.56h	0.033 (0.004)	0.022 (0.002)	0.666 (0.060)	0.710 (0.068)	0.840 (0.066)	0.916 (0.089)	0.834 (0.074)	0.767 (0.073)	0.698 (0.063)	0.699 (0.064)	0.485 (0.047)
^{48}V	c	15.9735d	2.15 (0.18)	1.73 (0.15)	16.1 (1.4)	16.8 (1.6)	19.2 (1.5)	20.0 (1.9)	19.9 (1.7)	19.2 (1.7)	17.9 (1.5)	17.4 (1.6)	12.7 (1.2)
^{48}Sc	i	43.67h	0.033 (0.037)	0.027 (0.030)	0.084 (0.012)	0.152 (0.015)	0.261 (0.026)	0.403 (0.043)	0.490 (0.044)	0.505 (0.049)	0.558 (0.059)	0.583 (0.061)	0.417 (0.042)
^{47}Sc	i	3.3492d	-	-	-	-	1.80 (0.14)	-	3.06 (0.27)	3.27 (0.30)	3.35 (0.29)	3.40 (0.31)	2.54 (0.24)
^{47}Sc	c	3.3492d	-	0.194 (0.017)	0.400 (0.035)	1.080 (0.100)	1.81 (0.14)	-	3.11 (0.28)	3.32 (0.31)	3.41 (0.30)	3.33 (0.32)	2.58 (0.24)
^{46}Sc	i(m+g)	83.79d	0.116 (0.027)	0.083 (0.018)	1.64 (0.15)	3.20 (0.31)	5.31 (0.41)	7.81 (0.75)	8.84 (0.77)	9.33 (0.85)	9.39 (0.81)	9.39 (0.85)	6.84 (0.64)
^{44m}Sc	i(m)	58.61h	-	0.105 (0.010)	0.516 (0.046)	1.90 (0.19)	4.17 (0.33)	5.98 (0.62)	7.70 (0.68)	8.35 (0.78)	8.30 (0.73)	8.24 (0.77)	5.94 (0.57)
^{44}Sc	i	3.97h	-	0.191 (0.017)	0.645 (0.059)	2.32 (0.23)	4.56 (0.39)	6.83 (0.68)	8.61 (0.75)	9.23 (0.91)	9.61 (0.87)	9.17 (0.84)	6.50 (0.61)
^{44}Sc	i(m+g)	3.97h	-	0.290 (0.025)	1.08 (0.15)	4.16 (0.39)	8.65 (0.66)	12.4 (1.2)	16.2 (1.4)	17.5 (1.6)	17.7 (1.6)	17.1 (1.5)	12.4 (1.1)
^{43}Sc	c	3.891h	-	-	0.151 (0.019)	0.996 (0.100)	2.32 (0.20)	4.14 (0.43)	4.93 (0.47)	5.67 (0.56)	5.83 (0.55)	5.81 (0.56)	4.11 (0.41)
^{47}Ca	c	4.536d	-	-	-	-	0.013 (0.004)	0.023 (0.006)	0.032 (0.004)	0.045 (0.005)	0.052 (0.006)	0.064 (0.015)	0.038 (0.005)
^{44}K	c*	22.13m	-	-	-	-	-	0.088 (0.027)	-	-	0.185 (0.048)	-	-
^{43}K	c	22.3h	-	-	0.016 (0.003)	0.094 (0.009)	0.310 (0.024)	0.701 (0.067)	1.060 (0.090)	1.27 (0.12)	1.44 (0.12)	1.55 (0.14)	1.130 (0.100)
^{42}K	i	12.360h	-	-	0.085 (0.009)	0.302 (0.029)	1.062 (0.080)	2.43 (0.24)	3.48 (0.31)	4.33 (0.40)	4.90 (0.43)	4.97 (0.45)	3.74 (0.35)
^{38}K	i	7.636m	-	-	-	-	0.098 (0.025)	0.421 (0.069)	0.696 (0.091)	0.88 (0.12)	1.03 (0.15)	0.91 (0.18)	0.75 (0.10)
^{41}Ar	c	109.34m	-	-	-	0.024 (0.004)	0.097 (0.008)	0.288 (0.028)	0.463 (0.041)	0.645 (0.059)	0.809 (0.071)	0.858 (0.079)	0.653 (0.061)
^{39}Cl	c	55.6m	-	-	-	-	0.046 (0.014)	0.118 (0.016)	0.257 (0.024)	0.379 (0.045)	0.547 (0.050)	0.578 (0.055)	0.463 (0.046)
^{38}Cl	i(m+g)	37.24m	-	-	-	-	-	0.485 (0.056)	0.990 (0.093)	1.50 (0.14)	1.96 (0.18)	2.20 (0.22)	1.71 (0.16)
^{38}Cl	c	37.24m	-	-	-	-	0.136 (0.013)	0.528 (0.052)	1.013 (0.090)	1.53 (0.14)	2.03 (0.18)	2.24 (0.21)	1.73 (0.16)
^{34m}Cl	i(m)	32.00m	-	-	-	-	0.038 (0.023)	0.157 (0.019)	0.406 (0.037)	0.685 (0.065)	0.990 (0.090)	1.080 (0.100)	0.881 (0.084)
^{38}S	c	170.3m	-	-	-	-	-	0.009 (0.017)	0.018 (0.020)	0.042 (0.006)	0.036 (0.005)	0.055 (0.009)	0.046 (0.006)
^{29}Al	c	6.56m	-	-	-	-	-	0.093 (0.052)	0.525 (0.057)	1.05 (0.11)	2.09 (0.21)	2.18 (0.23)	2.32 (0.23)
^{28}Mg	c	20.915h	-	-	-	-	0.004 (0.001)	0.016 (0.004)	0.059 (0.005)	0.122 (0.011)	0.271 (0.024)	0.381 (0.035)	0.380 (0.035)
^{27}Mg	c	9.458m	-	-	-	-	-	-	0.232 (0.027)	0.525 (0.062)	1.034 (0.098)	1.34 (0.17)	1.38 (0.13)
^{24}Na	c	14.9590h	-	-	-	-	0.040 (0.014)	0.178 (0.019)	0.528 (0.046)	1.080 (0.100)	2.39 (0.21)	3.57 (0.32)	3.73 (0.35)
^{22}Na	c	2.6019y	-	-	-	-	-	0.120 (0.038)	0.423 (0.049)	0.769 (0.077)	1.70 (0.15)	2.56 (0.24)	2.75 (0.26)
^{7}Be	i	53.29d	0.137 (0.018)	0.206 (0.021)	0.271 (0.026)	0.329 (0.034)	0.873 (0.073)	1.29 (0.13)	2.38 (0.21)	3.54 (0.33)	6.05 (0.53)	8.33 (0.76)	9.07 (0.85)

Table 4.5. Experimental values of residual nuclides production cross sections in ^{56}Fe(p,x) reactions induced by 0.3-1.5GeV protons**.**

Nuclide	Type	$T_{1/2}$	Cross sections [mb] at proton energies [MeV]				
			0.3	0.5	0.75	1.0	1.5
^{57}Co	i	271.74d	0.091(0.008)	0.125(0.010)	0.189(0.018)	0.245(0.021)	0.314(0.029)
^{56}Co	i	77.233d	1.42(0.12)	1.02(0.08)	0.908(0.083)	0.976(0.080)	0.959(0.086)
^{55}Co	i	17.53h	1.01(0.09)	0.570(0.049)	0.404(0.041)	0.377(0.040)	0.332(0.032)
^{53}Fe	c*	8.51m	3.69(0.67)	4.38(0.95)	2.14(0.33)	2.93(0.69)	2.85(0.35)

Nuclide	Type	$T_{1/2}$	Cross sections [mb] at proton energies [MeV]				
			0.3	0.5	0.75	1.0	1.5
^{52}Fe	c	8.275h	0.630(0.061)	0.471(0.040)	0.372(0.043)	0.348(0.040)	0.302(0.039)
^{56}Mn	c	2.5789h	0.249(0.021)	0.442(0.044)	0.644(0.060)	0.791(0.066)	0.857(0.077)
^{54}Mn	i	312.11d	44.9(3.6)	42.1(3.3)	40.4(3.7)	42.4(3.5)	39.4(3.5)
^{52m}Mn	i(m)	21.1m	10.7(0.9)	9.49(0.83)	7.71(0.73)	7.36(0.64)	6.96(0.64)
^{52m}Mn	c	21.1m	11.3(1.0)	9.97(0.87)	8.16(0.81)	7.75(0.67)	7.33(0.72)
^{52}Mn	c	5.591d	14.4(1.2)	12.0(1.0)	10.0(0.9)	9.63(0.82)	8.55(0.78)
^{51}Cr	c	27.7025d	52.9(4.3)	47.7(3.8)	41.9(3.9)	41.0(3.4)	35.6(3.2)
^{49}Cr	c	42.3m	7.36(0.62)	7.31(0.61)	6.26(0.60)	5.93(0.51)	5.19(0.48)
^{48}Cr	c	21.56h	0.930(0.080)	0.973(0.078)	0.876(0.081)	0.836(0.070)	0.690(0.063)
^{48}V	c	15.9735d	21.9(1.8)	23.0(1.8)	21.1(1.9)	20.6(1.7)	17.4(1.5)
^{48}Sc	i	43.67h	0.313(0.039)	0.473(0.040)	0.553(0.053)	0.607(0.060)	0.547(0.055)
^{47}Sc	i	3.3492d	2.32(0.19)	3.26(0.26)	3.58(0.33)	3.73(0.31)	3.40(0.31)
^{47}Sc	c	3.3492d	2.36(0.19)	3.30(0.26)	3.62(0.34)	3.80(0.32)	3.44(0.31)
^{46}Sc	i(m+g)	83.79d	6.93(0.56)	9.50(0.75)	10.2(0.9)	10.6(0.9)	9.33(0.84)
^{44m}Sc	i(m)	58.61h	5.43(0.52)	8.13(0.79)	9.30(0.97)	9.63(0.95)	8.88(0.81)
^{44}Sc	i	3.97h	6.09(0.64)	9.61(1.12)	11.3(1.9)	18.9(1.5)	17.2(1.5)
^{44}Sc	i(m+g)	3.97h	10.4(0.8)	15.9(1.2)	18.8(1.7)	11.1(1.4)	7.87(1.25)
^{43}Sc	c	3.891h	3.09(0.27)	5.14(0.44)	6.07(0.59)	6.48(0.58)	5.68(0.54)
^{47}Ca	c	4.536d	0.031(0.004)	0.032(0.005)	0.045(0.006)	0.058(0.014)	0.051(0.007)
^{44}K	c*	22.13m	0.0(191314.3)	-	0.188(0.085)	0.254(0.079)	0.277(0.080)
^{43}K	c	22.3h	0.468(0.038)	0.962(0.076)	1.33(0.12)	1.53(0.14)	1.48(0.13)
^{42}K	i	12.360h	1.62(0.13)	3.28(0.26)	4.39(0.41)	5.08(0.42)	4.85(0.44)
^{41}Ar	c	109.34m	0.168(0.015)	0.416(0.034)	0.650(0.060)	0.809(0.067)	0.851(0.077)
^{39}Cl	c	55.6m	0.076(0.010)	0.226(0.022)	0.387(0.038)	0.499(0.044)	0.561(0.054)
^{38}Cl	i(m+g)	37.24m	-	-	1.44(0.14)	1.95(0.17)	2.23(0.21)
^{38}Cl	c	37.24m	0.287(0.029)	0.916(0.077)	1.48(0.14)	1.99(0.17)	2.28(0.21)
^{34m}Cl	i(m)	32.00m	0.090(0.014)	0.287(0.031)	0.653(0.063)	0.902(0.079)	1.08(0.10)
^{38}S	c	170.3m	0.0(191314.3)	-	0.029(0.004)	0.046(0.006)	0.049(0.006)
^{29}Al	c	6.56m	-	-	0.842(0.119)	1.61(0.41)	2.75(0.29)
^{28}Mg	c	20.915h	0.008(0.001)	0.048(0.007)	0.111(0.011)	0.209(0.020)	0.355(0.035)
^{27}Mg	c	9.458m	0.0(135279.6)	-	0.462(0.053)	0.593(0.109)	1.41(0.14)
^{24}Na	c	14.9590h	0.072(0.021)	0.293(0.034)	0.977(0.097)	1.80(0.16)	3.05(0.28)
^{22}Na	c	2.6019y	0.070(0.014)	0.264(0.024)	0.671(0.064)	1.35(0.11)	2.35(0.21)
^{7}Be	i	53.29d	0.891(0.076)	1.90(0.16)	3.19(0.30)	4.87(0.40)	7.30(0.66)

4.3 Residual nuclides production cross sections in ^{nat}Ni.

Table 4.6. Parameters of ^{nat}N irradiations.

Proton energy (MeV)	Sample weight (mg)	Monitor weight (mg)	Weight of monitor plate (mg)	Irradiation time (min)	Average proton flux p/(cm^2•s) x10^{-10}	Number of γ-spectra measured in sample/monitor/plate	Fluence measured by current transformer, 10^{14} protons
2605±8	205.9	58.9	1477.0	27	6.45 ± 0.56	29/12/2	1.314
1598±4	205.4	59.3	1499.9	29.25	5.30 ± 0.44	21/12/5	1.290
1199±3	205.4	59.0	1473.8	55	3.39 ± 0.27	27/18/11	1.300
799±2	205.4	58.9	1477.7	30	3.06 ± 0.26	25/14/9	1.296
599±2	206.7	58.8	1448.8	24	7.19 ± 0.68	22/15/3	1.274
399±2	206.8	58.2	1460.4	22	4.01 ± 0.38	20/11/3	1.254
249±1	206.5	49.1	1916.1	22	7.10 ± 0.55	21/17/5	1.300
148±1	206.6	24.7	1413.6	24	5.31 ± 0.45	29/23/7	1.244
97±1	203.5	48.5	1431.0	33.5	4.36 ± 0.32	19/20/3	1.211
66±1	205.6	49.8	1410.3	67.5	1.85 ± 0.14	25/21/4	1.228
43±1	205.7	48.0	1415.2	25	4.43 ± 0.32	20/15/4	1.211

Table 4.7. Experimental values of residual nuclides production cross sections in ^{nat}Ni(p,x) reactions induced by 0.04-2.6GeV protons**.**

Nuclide	Type	$T_{1/2}$	Cross sections [mb] at proton energies [MeV]										
			43	66	97	148	249	399	599	799	1199	1599	2605
^{61}Cu	i	3.333h	1.92 (0.24)	0.91 (0.15)	0.486 (0.082)	0.338 (0.060)	0.251 (0.047)	-	-	-	-	-	-
^{60}Cu	i	23.7m	5.25 (0.42)	2.24 (0.19)	1.45 (0.13)	0.814 (0.079)	0.474 (0.042)	0.340 (0.036)	0.309 (0.041)	0.252 (0.031)	0.296 (0.032)	0.211 (0.025)	0.197 (0.033)
^{57}Ni	c	35.60h	91.4 (9.4)	72.0 (8.5)	57.8 (5.8)	47.3 (5.3)	32.3 (3.2)	32.1 (3.9)	29.9 (3.4)	25.0 (2.7)	26.5 (2.6)	21.2 (2.4)	19.0 (2.3)
^{56}Ni	c	6.075d	11.70 (1.00)	7.21 (0.60)	5.98 (0.51)	4.62 (0.42)	3.16 (0.27)	2.85 (0.29)	2.57 (0.26)	2.14 (0.19)	2.10 (0.18)	1.64 (0.15)	1.44 (0.14)
^{62m}Co	i(m)	13.91m	-	-	-	-	-	-	-	0.092 (0.015)	0.106 (0.023)	0.079 (0.019)	0.079 (0.027)
^{60}Co	i(m+g)	5.2714y	1.90 (0.20)	1.64 (0.21)	1.67 (0.20)	1.68 (0.18)	2.03 (0.23)	1.93 (0.34)	2.03 (0.26)	1.73 (0.19)	1.92 (0.22)	1.79 (0.17)	1.46 (0.14)
^{58}Co	i(m+g)	70.86d	69.6 (6.4)	32.9 (2.8)	25.9 (2.5)	21.1 (2.0)	15.9 (1.5)	17.1 (1.7)	18.1 (1.9)	16.9 (1.5)	18.4 (1.7)	13.6 (1.3)	11.1 (1.2)
^{57}Co	i	271.74d	89.7 (9.1)	58.0 (6.3)	65.1 (6.4)	43.5 (4.2)	38.6 (3.8)	37.9 (4.3)	46.0 (4.8)	43.2 (4.4)	50.7 (4.9)	34.8 (8.9)	35 (11)
^{57}Co	c	271.74d	213 (17)	172 (14)	132 (11)	100.9 (9.0)	72.8 (6.1)	75.5 (7.6)	78.5 (7.8)	71.3 (6.4)	74.9 (6.4)	56.8 (5.1)	50.3 (4.6)
^{56}Co	i	77.233d	208 (17)	93.9 (7.9)	76.9 (6.9)	57.8 (5.3)	40.8 (3.5)	38.8 (3.9)	37.5 (3.8)	32.3 (2.9)	32.0 (3.5)	25.7 (2.4)	21.9 (2.2)
^{56}Co	c	77.233d	223 (18)	105.0 (8.0)	82.9 (7.0)	62.8 (5.7)	43.5 (3.6)	41.5 (4.2)	39.3 (3.9)	33.1 (3.0)	33.3 (2.8)	27.5 (2.5)	24.2 (2.2)
^{55}Co	c	17.53h	11.80 (1.00)	34.3 (2.9)	26.9 (2.4)	20.5 (1.9)	15.3 (1.3)	13.9 (1.4)	13.4 (1.5)	10.4 (1.0)	10.41 (0.90)	8.59 (0.79)	7.47 (0.71)

Nuclide	Type	$T_{1/2}$	Cross sections [mb] at proton energies [MeV]										
			43	66	97	148	249	399	599	799	1199	1599	2605
^{59}Fe	c	44.472d	0.082 (0.048)	0.155 (0.037)	0.183 (0.020)	0.210 (0.033)	0.267 (0.038)	0.309 (0.047)	0.374 (0.050)	0.342 (0.038)	0.372 (0.034)	0.298 (0.030)	0.252 (0.026)
^{53}Fe	c*	8.51m	17.1 (1.8)	8.24 (0.96)	12.8 (1.4)	10.8 (1.4)	9.2 (1.0)	10.1 (1.3)	9.6 (1.3)	8.06 (0.98)	7.75 (0.98)	5.35 (0.66)	3.44 (0.42)
^{52}Fe	c	8.275h	0.020 (0.004)	2.75 (0.24)	2.13 (0.19)	2.16 (0.21)	1.90 (0.17)	1.96 (0.20)	2.01 (0.27)	1.50 (0.14)	1.46 (0.13)	1.17 (0.21)	0.86 (0.11)
^{56}Mn	c	2.5789h	0.025 (0.006)	0.249 (0.023)	0.570 (0.051)	0.615 (0.059)	0.606 (0.053)	0.776 (0.080)	0.924 (0.095)	0.856 (0.080)	0.901 (0.080)	0.748 (0.070)	0.601 (0.058)
^{54}Mn	i	312.11d	-	22.3 (1.8)	23.6 (2.0)	21.2 (1.9)	17.1 (1.4)	18.7 (1.9)	18.8 (1.9)	16.1 (1.4)	15.8 (1.3)	12.4 (1.1)	10.39 (0.90)
^{52m}Mn	i(m)	21.1m	0.321 (0.028)	11.16 (0.93)	10.0 (1.4)	10.4 (1.3)	9.47 (0.86)	10.4 (1.1)	10.0 (1.0)	8.80 (0.91)	7.94 (0.83)	6.68 (0.62)	5.19 (0.54)
^{52m}Mn	c	21.1m	0.347 (0.030)	14.0 (1.3)	12.5 (1.4)	12.8 (1.5)	11.3 (1.0)	12.3 (1.3)	12.3 (1.3)	10.27 (1.00)	9.60 (0.95)	8.08 (0.74)	6.31 (0.64)
^{52}Mn	c	5.591d	0.631 (0.051)	20.9 (1.7)	18.2 (1.6)	19.5 (1.8)	16.8 (1.4)	18.4 (1.9)	18.2 (1.8)	15.3 (1.4)	14.6 (1.3)	11.3 (1.0)	9.11 (0.86)
^{51}Cr	c	27.7025d	0.985 (0.097)	-	31.5 (2.7)	38.0 (3.5)	36.7 (3.1)	44.2 (4.4)	45.8 (4.5)	38.7 (3.5)	36.4 (3.1)	26.8 (2.4)	21.7 (2.0)
^{49}Cr	c	42.3m	0.018 (0.013)	2.99 (0.29)	3.68 (0.34)	7.15 (0.74)	8.08 (0.75)	10.8 (1.2)	11.9 (1.3)	10.50 (1.00)	9.72 (0.92)	7.09 (0.91)	5.38 (0.73)
^{48}Cr	c	21.56h	-	0.036 (0.004)	0.483 (0.042)	0.898 (0.083)	1.19 (0.10)	1.75 (0.18)	2.08 (0.21)	1.81 (0.17)	1.80 (0.16)	1.32 (0.12)	1.070 (0.100)
^{48}V	c	15.9735d	-	0.592 (0.048)	4.69 (0.40)	10.7 (1.0)	14.7 (1.2)	22.3 (2.2)	26.4 (2.6)	23.5 (2.1)	22.5 (1.9)	18.0 (1.6)	14.3 (1.3)
^{48}Sc	i	43.67h	-	-	-	-	0.055 (0.007)	0.114 (0.015)	0.221 (0.024)	0.183 (0.045)	0.281 (0.043)	0.241 (0.025)	0.238 (0.037)
^{47}Sc	c	3.3492d	-	-	-	-	0.524 (0.045)	1.01 (0.10)	1.53 (0.15)	1.56 (0.14)	1.76 (0.15)	1.23 (0.11)	1.020 (0.090)
^{46}Sc	i(m+g)	83.79d	-	-	0.091 (0.011)	0.771 (0.092)	1.82 (0.15)	3.99 (0.40)	5.74 (0.58)	5.82 (0.54)	6.10 (0.53)	4.95 (0.46)	4.00 (0.38)
^{44m}Sc	i(m)	58.61h	-	-	0.219 (0.019)	0.868 (0.079)	2.25 (0.19)	5.28 (0.53)	8.33 (0.83)	8.56 (0.77)	9.43 (0.81)	7.08 (0.63)	5.65 (0.52)
^{44}Sc	i	3.97h	-	-	0.295 (0.042)	1.040 (0.100)	2.49 (0.21)	5.54 (0.56)	8.65 (0.90)	8.73 (0.80)	9.23 (0.83)	8.01 (0.81)	6.5 (1.0)
^{44}Sc	i(m+g)	3.97h	-	-	0.539 (0.058)	1.90 (0.19)	4.69 (0.39)	10.7 (1.1)	16.9 (1.7)	17.1 (1.5)	18.4 (1.6)	15.3 (1.4)	12.5 (1.1)
^{43}Sc	c	3.891h	-	-	-	0.581 (0.058)	1.64 (0.15)	4.00 (0.42)	6.70 (0.70)	7.09 (0.68)	7.61 (0.69)	5.87 (0.56)	4.66 (0.45)
^{47}Ca	c	4.536d	-	-	-	-	0.015 (0.004)	-	-	-	-	0.023 (0.005)	0.021 (0.005)
^{43}K	c	22.3h	-	-	-	-	0.059 (0.005)	0.230 (0.024)	0.491 (0.049)	0.563 (0.051)	0.755 (0.064)	0.651 (0.058)	0.541 (0.050)
^{42}K	i	12.360h	-	-	-	-	0.299 (0.031)	1.05 (0.11)	2.14 (0.21)	2.47 (0.22)	3.10 (0.27)	2.78 (0.25)	2.40 (0.23)
^{38}K	i	7.636m	-	-	-	-	0.071 (0.020)	0.359 (0.056)	0.771 (0.095)	1.05 (0.12)	1.39 (0.16)	1.24 (0.14)	0.85 (0.10)
^{41}Ar	c	109.34m	-	-	-	-	-	0.094 (0.011)	0.219 (0.023)	0.311 (0.029)	0.433 (0.039)	0.411 (0.037)	0.324 (0.030)
^{39}Cl	c	55.6m	-	-	-	-	-	-	0.129 (0.020)	0.192 (0.027)	0.277 (0.026)	0.281 (0.028)	0.234 (0.024)
^{38}Cl	i(m+g)	37.24m	-	-	-	-	-	-	-	-	-	1.25 (0.12)	0.972 (0.099)
^{38}Cl	c	37.24m	-	-	-	-	0.026 (0.014)	0.214 (0.025)	0.572 (0.059)	0.812 (0.074)	1.18 (0.10)	1.29 (0.12)	1.050 (0.100)
^{34m}Cl	i(m)	32.00m	-	-	-	-	0.032 (0.009)	0.214 (0.035)	0.545 (0.056)	0.804 (0.074)	1.27 (0.11)	1.15 (0.14)	1.06 (0.13)
^{38}S	c	170.3m	-	-	-	-	-	-	-	-	-	0.021 (0.009)	0.034 (0.007)
^{29}Al	c	6.56m	-	-	-	-	-	-	-	0.654 (0.075)	1.35 (0.16)	1.57 (0.17)	1.37 (0.14)
^{28}Mg	c	20.915h	-	-	-	-	-	-	0.043 (0.016)	0.065 (0.007)	0.163 (0.015)	0.190 (0.017)	0.232 (0.022)
^{27}Mg	c	9.458m	-	-	-	-	-	-	0.164 (0.025)	0.337 (0.036)	0.696 (0.067)	0.899 (0.086)	0.884 (0.085)
^{24}Na	c	14.9590h	-	-	-	-	-	-	-	1.020 (0.090)	2.14 (0.18)	2.61 (0.23)	3.08 (0.28)
^{22}Na	c	2.6019y	-	-	-	-	-	-	0.462 (0.086)	0.86 (0.10)	1.74 (0.15)	2.31 (0.21)	2.86 (0.26)
^{7}Be	i	53.29d	-	-	-	-	0.71 (0.11)	1.54 (0.20)	2.89 (0.32)	3.96 (0.38)	6.94 (0.59)	7.60 (0.68)	9.25 (0.86)

4.4 Residual nuclides production cross sections in ^{93}Nb.

Table 4.8. Parameters of ^{93}Nb irradiations..

Proton energy (MeV)	Sample weight (mg)	Monitor weight (mg)	Weight of monitor plate (mg)	Irradiation time (min)	Average proton flux p/(cm^2•s) x10^{-10}	Number of γ-spectra measured in sample/monitor/plate	Fluence measured by current transformer, 10^{14} protons
2605±8	189.2	59.2	1466.0	27.42	6.96 ± 0.61	29/14/2	1.316
1599±4	189.5	59.0	1517.6	31.37	6.00 ± 0.50	24/13/5	1.289
1199±3	190.1	59.0	1473.8	55	3.66 ± 0.29	27/17/11	1.300
799±2	189.3	59.0	1477.7	30	3.09 ± 0.27	25/14/9	1.296
600±2	189.5	58.4	1448.8	24	8.17 ± 0.75	22/15/3	1.274
400±2	189.9	58.3	1460.4	22	4.26 ± 0.40	20/11/3	1.254
249±1	189	49.0	1916.1	22	7.58 ± 0.57	23/20/5	1.300
149±1	190.9	48.0	1413.6	24	5.67 ± 0.45	25/22/7	1.244
99±1	189.7	49.7	1431.0	33.5	4.67 ± 0.35	19/20/3	1.211
68±1	186.9	48.3	1410.3	67.5	1.97 ± 0.15	24/20/4	1.228
46±1	189.4	48.3	1415.2	25	4.86 ± 0.34	20/15/4	1.211

Table 4.9. Experimental values of residual nuclides production cross sections in ^{nat}Nb (p,x) reactions induced by 0.04-2.6GeV protons. .

Nuclide	Type	$T_{1/2}$	Cross sections [mb] at proton energies [MeV]										
			46	68	99	149	249	400	600	799	1199	1599	2605
^{93m}Mo	i(m)	6.85h	1.37 (0.13)	0.845 (0.095)	0.651 (0.069)	0.392 (0.043)	0.270 (0.049)	0.222 (0.066)	0.236 (0.059)	0.228 (0.073)	0.209 (0.033)	0.216 (0.028)	0.196 (0.030)
^{91}Mo	i(m+g)	15.49m	94 (22)	-	-	-	-	-	-	-	-	-	-
^{90}Mo	i	5.56h	61.3 (5.3)	25.7 (2.4)	12.1 (1.3)	6.07 (0.60)	3.30 (0.32)	2.10 (0.24)	1.36 (0.36)	0.94 (0.10)	0.808 (0.099)	0.663 (0.095)	0.555 (0.076)
^{92m}Nb	i(m)	10.15d	54.8 (4.4)	44.0 (4.1)	33.9 (2.9)	25.0 (2.1)	18.9 (1.5)	19.9 (2.0)	20.3 (2.0)	18.6 (1.7)	19.8 (1.7)	19.1 (1.7)	17.8 (1.7)
^{91m}Nb	c	60.86d	34.9 (3.2)	22.0 (2.0)	17.6 (1.7)	11.6 (1.2)	7.63 (0.83)	8.0 (1.3)	7.5 (1.1)	5.3 (1.1)	5.1 (1.2)	5.5 (1.3)	5.44 (0.66)
^{90}Nb	i(m+g)	14.60h	302 (25)	179 (17)	108 (11)	71.4 (6.4)	44.1 (4.5)	36.7 (3.7)	30.9 (3.7)	24.4 (2.4)	21.8 (2.1)	20.2 (1.9)	18.3 (1.8)
^{90}Nb	c	14.60h	364 (29)	200 (17)	123 (11)	79.2 (6.9)	48.9 (4.3)	39.8 (4.0)	33.2 (3.4)	26.7 (2.5)	24.5 (2.2)	22.5 (2.1)	20.0 (1.9)
^{89m}Nb	i(m)	66m	0.39 (0.18)	18.0 (1.7)	9.27 (0.92)	6.41 (0.66)	4.41 (0.49)	3.78 (0.49)	3.09 (0.39)	1.88 (0.37)	2.38 (0.29)	1.94 (0.22)	1.47 (0.16)
^{89}Nb	c	2.03h	-	176 (21)	87 (11)	54.9 (6.7)	27.9 (3.4)	24.9 (3.4)	20.6 (2.8)	14.6 (2.0)	12.9 (1.7)	11.9 (1.6)	9.5 (1.3)
^{88}Nb	c*	14.5m	-	4.13 (0.38)	21.0 (2.0)	12.4 (1.2)	7.52 (0.71)	5.52 (0.65)	4.28 (0.45)	3.29 (0.33)	2.76 (0.29)	2.27 (0.27)	2.07 (0.20)
^{89}Zr	c	78.41h	12.40 (1.00)	268 (23)	164 (14)	117.0 (10.0)	81.9 (6.8)	72.7 (7.2)	61.5 (6.0)	50.8 (4.7)	47.1 (4.1)	42.7 (3.9)	37.3 (3.5)
^{88}Zr	c	83.4d	61.2 (4.8)	44.7 (3.8)	125 (11)	90.4 (7.7)	64.2 (5.2)	57.6 (5.6)	47.4 (4.6)	37.3 (3.4)	33.3 (2.9)	29.6 (2.7)	25.1 (2.3)

Nuclide	Type	$T_{1/2}$	Cross sections [mb] at proton energies [MeV]										
			46	68	99	149	249	400	600	799	1199	1599	2605
^{87}Zr	c	1.68h	7.76 (0.77)	26.9 (2.2)	73.6 (6.3)	56.6 (4.8)	43.0 (3.5)	40.3 (4.0)	31.5 (3.0)	26.6 (2.4)	20.7 (1.8)	17.6 (1.6)	14.8 (1.4)
^{86}Zr	c	16.5h	4.0 (1.0)	13.8 (1.3)	7.6 (1.4)	22.4 (2.0)	17.8 (1.5)	16.0 (1.6)	10.9 (1.4)	10.2 (1.0)	6.93 (0.71)	7.31 (0.70)	5.80 (0.55)
^{85}Zr	c	7.86m	-	-	2.94 (0.36)	-	5.76 (0.56)	7.58 (0.81)	7.86 (0.82)	7.09 (0.73)	5.31 (0.73)	-	-
^{90m}Y	i(m)	3.19h	-	0.553 (0.093)	0.635 (0.071)	0.865 (0.092)	0.90 (0.11)	1.43 (0.16)	1.81 (0.20)	1.73 (0.23)	1.86 (0.17)	1.66 (0.16)	1.45 (0.15)
^{88}Y	i	106.65d	13.4 (1.2)	7.77 (0.70)	18.1 (1.6)	17.5 (1.5)	16.0 (1.3)	18.2 (1.9)	17.8 (1.8)	15.7 (1.5)	15.4 (1.4)	14.1 (1.3)	12.1 (1.2)
^{88}Y	c	106.65d	74.6 (6.2)	53.3 (4.6)	145 (13)	110.0 (10.0)	81.3 (6.9)	76.6 (7.6)	66.8 (6.7)	53.6 (5.1)	49.0 (4.5)	44.0 (4.1)	37.6 (3.6)
^{87m}Y	i(m)	13.37h	6.56 (0.70)	20.3 (2.5)	22.3 (3.4)	27.2 (2.5)	24.3 (2.5)	24.6 (2.9)	23.2 (2.4)	18.0 (1.8)	18.1 (1.7)	16.6 (1.5)	13.8 (1.4)
^{87m}Y	c	13.37h	14.3 (1.1)	46.7 (4.0)	94.7 (8.4)	83.6 (7.2)	66.9 (5.6)	64.7 (6.4)	54.6 (5.3)	44.5 (4.1)	38.6 (3.4)	34.1 (3.1)	28.5 (2.7)
^{87}Y	c	79.8h	19.1 (1.5)	59.7 (5.1)	97.1 (8.4)	107.0 (9.0)	84.8 (6.9)	82.4 (8.1)	70.8 (6.9)	57.4 (5.3)	50.9 (4.4)	44.9 (4.1)	37.8 (3.5)
^{86m}Y	i(m)	48m	-	17.3 (1.6)	17.0 (1.6)	23.6 (2.1)	19.0 (1.9)	21.9 (2.2)	19.6 (2.0)	-	13.8 (1.2)	11.8 (1.1)	10.02 (0.99)
^{86}Y	i(m+g)	14.74h	22 (51)	32.7 (3.0)	30.4 (2.9)	41.0 (3.7)	36.0 (3.1)	39.5 (4.0)	34.4 (3.4)	27.7 (2.6)	25.0 (2.2)	18.2 (2.0)	17.6 (1.7)
^{86}Y	c	14.74h	25 (27)	46.0 (4.2)	44.9 (4.0)	63.2 (5.7)	54.0 (4.6)	56.3 (5.7)	47.4 (4.7)	38.0 (3.6)	33.2 (2.9)	27.9 (2.6)	23.3 (2.2)
^{85m}Y	c	4.86h	-	1.94 (0.39)	17.7 (1.9)	20.6 (2.0)	18.9 (2.1)	21.3 (2.3)	17.4 (2.3)	14.7 (1.9)	11.9 (1.4)	9.29 (0.96)	7.81 (0.85)
^{85}Y	c	2.68h	-	-	7.53 (0.68)	9.1 (1.0)	8.64 (0.83)	8.9 (1.1)	7.42 (0.95)	6.15 (0.66)	5.43 (0.55)	4.35 (0.43)	3.73 (0.39)
^{84}Y	c	39.5m	-	-	9.64 (0.85)	12.9 (1.2)	14.6 (1.3)	16.3 (1.7)	14.4 (1.5)	11.3 (1.1)	9.13 (0.83)	7.68 (0.73)	6.21 (0.62)
^{85m}Sr	i(m)	67.63m	-	-	1.19 (0.13)	1.51 (0.28)	1.46 (0.13)	1.84 (0.20)	2.08 (0.30)	1.82 (0.20)	1.61 (0.16)	1.46 (0.15)	1.22 (0.14)
^{85m}Sr	c	67.63m	-	0.144 (0.087)	8.54 (0.79)	10.0 (1.0)	9.90 (0.86)	10.9 (1.2)	9.6 (1.1)	7.92 (0.80)	6.93 (0.70)	5.76 (0.61)	4.89 (0.58)
^{85}Sr	c	64.84d	-	-	-	-	-	-	-	47.6 (4.9)	40.8 (3.9)	33.8 (3.4)	29.5 (3.0)
^{83}Sr	c	32.41h	-	2.4 (2.4)	3.74 (0.89)	22.2 (3.6)	28.6 (4.6)	37.6 (6.8)	31.9 (5.9)	26.1 (4.9)	25.3 (4.6)	21.8 (4.0)	17.1 (3.3)
^{82}Sr	c	25.55d	-	-	2.30 (0.20)	10.10 (0.90)	15.7 (1.3)	21.9 (2.2)	21.7 (2.1)	17.8 (1.6)	14.9 (1.3)	12.5 (1.1)	9.77 (0.91)
^{81}Sr	c	22.3m	-	-	0.44 (0.14)	2.27 (0.30)	4.18 (0.59)	7.23 (0.87)	7.47 (0.90)	6.75 (0.83)	4.94 (0.83)	3.83 (0.55)	3.29 (0.50)
^{80}Sr	c	106.3m	-	-	-	-	-	-	-	2.06 (0.78)	1.37 (0.34)	1.33 (0.30)	1.10 (0.20)
^{86}Rb	i(m+g)	18.631d	-	-	-	-	0.24 (0.12)	0.36 (0.29)	0.30 (0.37)	0.58 (0.55)	0.535 (0.087)	0.561 (0.095)	0.524 (0.071)
^{84m}Rb	i(m)	20.26m	-	-	0.71 (0.33)	1.63 (0.16)	2.05 (0.20)	3.07 (0.33)	3.34 (0.37)	3.15 (0.31)	2.95 (0.30)	2.42 (0.24)	1.98 (0.21)
^{84}Rb	i(m+g)	32.77d	-	0.554 (0.049)	1.060 (0.100)	2.38 (0.21)	3.38 (0.30)	4.98 (0.50)	5.56 (0.58)	5.00 (0.51)	4.75 (0.45)	4.22 (0.39)	3.51 (0.34)
^{83}Rb	c	86.2d	-	2.45 (0.23)	7.16 (0.71)	31.5 (3.0)	41.8 (3.8)	54.9 (5.8)	54.0 (5.6)	44.7 (4.5)	39.1 (3.7)	33.4 (3.3)	26.1 (2.7)
^{82m}Rb	i(m)	6.472h	-	-	3.39 (0.35)	7.51 (0.66)	11.4 (1.0)	17.6 (1.8)	18.8 (1.9)	16.2 (1.5)	14.1 (1.2)	12.3 (1.1)	9.82 (0.94)
^{81}Rb	c	4.576h	-	0.69 (0.18)	3.4 (1.3)	11.5 (1.3)	22.3 (2.0)	36.9 (3.7)	39.1 (3.9)	32.5 (3.3)	27.6 (2.5)	24.0 (2.3)	18.4 (1.9)
^{79}Rb	c	22.9m	-	-	-	1.46 (0.18)	3.89 (0.36)	8.15 (0.86)	10.1 (1.1)	8.9 (1.0)	8.20 (0.76)	6.33 (0.74)	5.02 (0.59)
^{79}Kr	c	35.04h	-	-	-	4.56 (0.96)	11.9 (1.1)	25.3 (2.6)	31.8 (3.3)	27.0 (2.7)	25.2 (2.3)	22.0 (2.1)	16.9 (1.7)
^{77}Kr	c	74.4m	-	-	-	0.313 (0.047)	3.07 (0.31)	8.96 (0.91)	12.2 (1.3)	12.1 (1.1)	11.2 (1.0)	8.81 (0.79)	6.65 (0.62)
^{76}Kr	c	14.8h	-	-	-	0.06 (0.61)	0.71 (0.12)	2.07 (0.31)	1.59 (0.36)	3.45 (0.48)	3.55 (0.46)	2.89 (0.31)	2.22 (0.23)
^{82}Br	i(m+g)	35.30h	-	-	0.70 (0.18)	0.43 (0.22)	0.42 (0.41)	0.60 (0.19)	0.8 (1.2)	0.48 (0.55)	0.35 (0.33)	0.35 (0.11)	0.14 (0.35)
^{77}Br	i(m+g)	57.036h	-	-	-	-	-	-	-	6.2 (8.6)	12.8 (7.2)	9.7 (4.6)	10.4 (3.2)
^{77}Br	c	57.036h	-	-	-	0.610 (0.094)	6.52 (0.55)	18.1 (1.8)	26.8 (2.7)	25.9 (2.4)	23.8 (2.2)	20.5 (1.9)	15.7 (1.5)
^{76}Br	i(m+g)	16.2h	-	-	-	0.5 (1.1)	3.17 (0.38)	10.9 (1.4)	17.0 (2.0)	17.1 (2.0)	16.3 (1.6)	13.8 (1.3)	10.50 (1.00)
^{76}Br	c	16.2h	-	-	-	0.59 (0.43)	3.95 (0.57)	13.4 (1.8)	21.3 (2.3)	20.1 (2.1)	19.9 (2.0)	16.8 (1.7)	12.5 (1.3)
^{75}Br	c	96.7m	-	-	-	0.59 (0.40)	1.9 (1.1)	8.1 (3.4)	11.4 (2.9)	13.8 (3.2)	12.8 (2.8)	10.7 (2.4)	8.0 (1.8)
^{74m}Br	i(m)	46m	-	-	-	-	1.48 (0.62)	2.11 (0.92)	3.62 (0.69)	3.74 (0.67)	3.72 (0.53)	3.51 (0.53)	2.18 (0.74)
^{74}Br	c	25.4m	-	-	-	-	-	2.40 (0.99)	1.4 (1.1)	4.7 (2.2)	4.9 (2.6)	3.1 (1.7)	2.0 (1.9)
^{75}Se	c	119.779d	-	-	-	0.416 (0.045)	4.03 (0.42)	15.5 (1.7)	27.3 (3.1)	29.2 (3.3)	28.5 (2.9)	24.9 (2.6)	19.1 (2.1)
^{73m}Se	c	39.8m	-	-	-	-	-	3.7 (1.2)	7.4 (1.5)	6.8 (1.4)	5.4 (1.7)	6.06 (0.90)	4.53 (0.81)
^{73}Se	i	7.15h	-	-	-	-	-	2.39 (0.68)	5.37 (0.89)	7.35 (0.96)	9.3 (1.2)	7.12 (0.76)	5.52 (0.65)
^{73}Se	c	7.15h	-	-	-	-	0.989 (0.092)	5.10 (0.51)	10.7 (1.1)	12.3 (1.2)	13.2 (1.2)	11.5 (1.1)	8.85 (0.84)
^{72}Se	c	8.40d	-	-	-	-	0.242 (0.023)	1.91 (0.19)	4.35 (0.42)	5.36 (0.53)	6.05 (0.54)	5.30 (0.49)	4.02 (0.38)

Nuclide	Type	$T_{1/2}$	Cross sections [mb] at proton energies [MeV]										
			46	68	99	149	249	400	600	799	1199	1599	2605
^{74}As	i	17.77d	-	-	-	0.048 (0.012)	0.427 (0.041)	2.11 (0.61)	4.1 (1.0)	4.60 (0.87)	5.10 (0.92)	4.71 (0.87)	3.66 (0.64)
^{72}As	i	26.0h	-	-	-	-	1.94 (0.18)	5.91 (0.74)	13.1 (1.5)	13.9 (1.4)	16.2 (1.6)	15.8 (1.6)	11.7 (1.3)
^{72}As	c	26.0h	-	-	-	-	2.27 (0.45)	8.0 (1.0)	17.9 (2.0)	19.9 (1.9)	22.5 (2.2)	21.4 (2.1)	15.7 (1.7)
^{71}As	c	65.28h	-	-	-	-	0.548 (0.089)	4.10 (0.46)	9.9 (1.1)	12.9 (1.2)	15.2 (1.4)	13.9 (1.4)	10.6 (1.1)
^{70}As	c*	52.6m	-	-	-	-	-	1.22 (0.22)	3.84 (0.43)	4.69 (0.51)	6.26 (0.65)	5.99 (0.63)	4.27 (0.47)
^{69}Ge	c	39.05h	-	-	-	-	0.141 (0.022)	2.22 (0.36)	6.70 (0.99)	9.0 (1.3)	11.9 (1.3)	11.1 (1.4)	9.3 (1.0)
^{67}Ge	c	18.9m	-	-	-	-	-	-	0.85 (0.11)	1.47 (0.17)	1.93 (0.25)	2.07 (0.25)	1.66 (0.20)
^{67}Ga	c	3.2612d	-	-	-	-	0.11 (0.11)	1.71 (0.18)	6.65 (0.67)	10.5 (1.1)	15.6 (1.4)	15.5 (1.4)	12.5 (1.2)
^{66}Ga	c*	9.49h	-	-	-	-	-	0.93 (0.24)	3.53 (0.76)	5.50 (0.64)	8.76 (0.91)	9.08 (0.85)	7.12 (0.84)
^{65}Ga	c	15.2m	-	-	-	-	-	-	0.74 (0.26)	1.62 (0.43)	2.49 (0.65)	2.58 (0.52)	2.28 (0.54)
^{65}Zn	c	244.26d	-	-	-	-	0.100 (0.018)	1.23 (0.13)	5.36 (0.52)	9.45 (0.88)	15.6 (1.4)	16.3 (1.5)	13.7 (1.3)
^{62}Zn	c	9.186h	-	-	-	-	-	-	-	-	0.30 (0.13)	0.83 (0.22)	0.71 (0.14)
^{67}Cu	c	61.83h	-	-	-	-	-	-	-	-	-	-	0.30 (0.17)
^{61}Cu	c	3.333h	-	-	-	-	-	0.49 (0.42)	-	2.26 (0.54)	2.31 (0.57)	3.37 (0.86)	3.43 (0.56)
^{60}Cu	c	23.7m	-	-	-	-	-	-	-	0.43 (0.17)	0.77 (0.14)	0.86 (0.11)	0.69 (0.14)
^{57}Ni	c	35.60h	-	-	-	-	-	-	-	-	0.118 (0.015)	0.182 (0.019)	0.177 (0.020)
^{62m}Co	i(m)	13.91m	-	-	-	-	-	-	-	-	0.31 (0.21)	0.198 (0.086)	0.262 (0.053)
^{60}Co	i(m+g)	5.2714y	-	-	-	-	-	-	-	0.69 (0.20)	2.56 (0.33)	3.10 (0.40)	2.97 (0.36)
^{58}Co	i(m+g)	70.86d	-	-	-	-	-	0.128 (0.014)	1.12 (0.11)	2.75 (0.25)	6.89 (0.59)	8.85 (0.80)	8.79 (0.85)
^{57}Co	c	271.74d	-	-	-	-	-	-	0.704 (0.086)	1.94 (0.18)	5.34 (0.54)	7.20 (0.70)	7.38 (0.71)
^{56}Co	c	77.233d	-	-	-	-	-	-	0.21 (0.11)	0.55 (0.12)	1.47 (0.17)	2.07 (0.21)	2.20 (0.24)
^{55}Co	c	17.53h	-	-	-	-	-	-	-	-	-	0.284 (0.076)	0.55 (0.37)
^{59}Fe	c	44.472d	-	-	-	-	-	-	0.114 (0.020)	0.233 (0.028)	0.551 (0.054)	0.723 (0.069)	0.717 (0.082)
^{53}Fe	c*	8.51m	-	-	-	-	-	-	-	-	-	0.21 (0.12)	0.47 (0.21)
^{56}Mn	c	2.5789h	-	-	-	-	-	-	-	0.327 (0.059)	1.00 (0.14)	1.31 (0.19)	1.41 (0.14)
^{54}Mn	i	312.11d	-	-	-	-	-	-	0.41 (0.13)	1.23 (0.17)	3.96 (0.35)	5.96 (0.54)	6.91 (0.65)
^{52m}Mn	c	21.1m	-	-	-	-	-	-	-	0.229 (0.096)	0.191 (0.067)	0.446 (0.076)	0.494 (0.082)
^{52}Mn	c	5.591d	-	-	-	-	-	-	0.114 (0.012)	0.356 (0.100)	1.29 (0.11)	2.07 (0.19)	2.61 (0.25)
^{51}Cr	c	27.7025d	-	-	-	-	-	-	-	0.88 (0.10)	3.48 (0.31)	5.91 (0.55)	7.42 (0.70)
^{49}Cr	c	42.3m	-	-	-	-	-	-	-	-	-	0.472 (0.082)	0.761 (0.084)
^{48}Cr	c	21.56h	-	-	-	-	-	-	-	-	-	0.066 (0.066)	0.085 (0.013)
^{48}V	c	15.9735d	-	-	-	-	-	-	0.090 (0.009)	0.309 (0.050)	1.28 (0.11)	2.28 (0.21)	3.36 (0.31)
^{48}Sc	i	43.67h	-	-	-	-	-	-	-	0.048 (0.025)	0.174 (0.029)	0.282 (0.034)	0.474 (0.063)
^{47}Sc	i	3.3492d	-	-	-	-	-	-	-	-	0.553 (0.049)	0.98 (0.10)	1.50 (0.14)
^{47}Sc	c	3.3492d	-	-	-	-	-	-	0.058 (0.008)	0.167 (0.018)	0.567 (0.050)	1.010 (0.100)	1.57 (0.15)
^{46}Sc	i(m+g)	83.79d	-	-	-	-	-	-	0.093 (0.011)	0.33 (0.10)	1.09 (0.12)	1.99 (0.19)	3.10 (0.31)
^{44m}Sc	i(m)	58.61h	-	-	-	-	-	-	0.147 (0.025)	0.27 (0.12)	0.72 (0.36)	1.26 (0.13)	2.10 (0.20)
^{44}Sc	i	3.97h	-	-	-	-	-	-	-	-	-	0.709 (0.072)	1.30 (0.12)
^{44}Sc	i(m+g)	3.97h	-	-	-	-	-	-	-	0.118 (0.044)	0.362 (0.039)	1.89 (0.17)	3.31 (0.31)
^{43}Sc	c	3.891h	-	-	-	-	-	-	-	-	0.60 (0.13)	0.76 (0.15)	1.01 (0.13)
^{47}Ca	c	4.536d	-	-	-	-	-	-	-	-	0.022 (0.008)	0.044 (0.020)	0.063 (0.008)
^{43}K	c	22.3h	-	-	-	-	-	-	-	-	0.278 (0.032)	0.526 (0.059)	0.774 (0.078)
^{42}K	i	12.360h	-	-	-	-	-	-	-	-	-	0.97 (0.13)	1.66 (0.17)
^{41}Ar	c	109.34m	-	-	-	-	-	-	-	-	-	0.294 (0.037)	0.488 (0.059)
^{39}Cl	c	55.6m	-	-	-	-	-	-	-	-	-	0.215 (0.071)	0.286 (0.047)

Nuclide	Type	$T_{1/2}$	Cross sections [mb] at proton energies [MeV]										
			46	68	99	149	249	400	600	799	1199	1599	2605
^{38}Cl	c	37.24m	-	-	-	-	-	-	-	-	0.302 (0.073)	0.521 (0.077)	0.866 (0.098)
^{29}Al	c	6.56m	-	-	-	-	-	-	-	-	-	0.393 (0.079)	1.49 (0.21)
^{28}Mg	c	20.915h	-	-	-	-	-	-	-	-	-	0.180 (0.065)	0.365 (0.050)
^{27}Mg	c	9.458m	-	-	-	-	-	-	-	-	-	0.286 (0.100)	0.61 (0.10)
^{24}Na	c	14.9590h	-	-	-	-	-	-	0.144 (0.033)	0.179 (0.027)	0.560 (0.051)	0.992 (0.092)	2.07 (0.20)
^{22}Na	c	2.6019y	-	-	-	-	-	-	-	-	0.324 (0.050)	0.364 (0.076)	0.963 (0.097)
^{7}Be	i	53.29d	-	-	-	-	0.430 (0.043)	0.84 (0.16)	1.41 (0.15)	2.13 (0.22)	4.06 (0.36)	5.73 (0.53)	8.31 (0.78)

4.5 Residual nuclides production cross sections in ^{181}Ta.

Table 4.10. Parameters of ^{181}Ta irradiations.

Proton energy (MeV)	Sample weight (mg)	Monitor weight (mg)	Weight of monitor plate (mg)	Irradiation time (min)	Average proton flux p/(cm^2•s) x10^{-10}	Number of γ-spectra measured in sample/monitor/plate	Fluence measured by current transformer, 10^{14} protons
2605±8	359.8	59.1	1463.6	24.18	7.44 ± 0.64	28/16/4	1.296
1598±4	354.2	58.9	1481.8	29.12	5.74 ± 0.48	23/12/5	1.295
1199±3	359.6	59.0	1437.1	28	6.98 ± 0.56	31/28/14	1.300
799±2	357.5	58.9	1471.0	24	6.05 ± 0.49	22/14/10	1.300
599±2	357.5	59.1	1480.9	28	4.55 ± 0.54	26/15/3	1.297
399±2	355.8	59.0	1436.3	23	4.21 ± 0.38	24/11/3	1.245
248±1	354.4	58.5	1932.5	28	8.09 ± 0.58	24/17/5	1.303
148±1	355	58.8	1439.9	27	5.17 ± 0.40	27/23/7	1.247
97±1	358.6	48.0	1417.6	38.5	3.23 ± 0.27	21/22/7	1.219
66±1	354.8	49.8	1407.7	65.5	1.81 ± 0.13	26/21/4	1.241
43±1	357.8	48.1	1400.2	25	4.57 ± 0.34	22/15/4	1.211
Parameters of ^{181}Ta irradiations by 40–150 MeV protons to measure ^{7}Be							
149±1	127.7	48.9	-	31	6.84 ± 0.50	3/2/-	1.355
98±1	123.8	47.9	-	30	5.13 ± 0.38	3/2/-	1.360
68±1	127.0	49.8	-	31	6.14 ± 0.43	3/3/-	1.286
44±1	352.5	48.1	-	45	3.67 ± 0.26	2/2/-	1.358

Table 4.11. Experimental values of residual nuclides production cross sections in ^{nat}Ta(p,x) reactions induced by 0.04-2.6GeV protons**.**

Nuclide	Type	$T_{1/2}$	Cross sections [mb] at proton energies [MeV]										
			43	66	97	148	248	399	599	799	1199	1598	2605
^{178}W	i	21.6d	690 (60)	102.0 (9.0)	57.4 (5.9)	30.7 (3.5)	16.7 (3.4)	11.2 (1.5)	9.7 (1.5)	7.3 (1.1)	8.2 (1.0)	6.1 (1.2)	-
^{177}W	i	135m	366 (48)	151 (20)	64.7 (9.0)	33.3 (4.6)	16.9 (2.2)	10.8 (1.6)	8.5 (1.4)	6.06 (0.83)	4.84 (0.70)	3.47 (0.50)	2.92 (0.43)

^{176}W	i	2.5h	-	457 (38)	95.1 (9.7)	-	-	-	15.6 (3.4)	12.5 (6.0)	5.8 (3.2)	9.2 (2.1)	4.8 (2.8)
^{174}W	i	31m	-	-	136 (17)	41.8 (5.4)	18.6 (2.2)	11.3 (2.2)	5.7 (3.0)	5.1 (1.7)	0.6 (3.1)	1.8 (1.3)	0.11 (0.77)
^{180}Ta	i	8.152h	114 (12)	80 (13)	78.1 (9.1)	54.9 (6.5)	76 (12)	40.6 (5.5)	-	-	-	-	-
^{178m}Ta	i(m)	2.36h	36.5 (3.0)	59.4 (5.3)	50.1 (4.6)	32.9 (2.9)	21.4 (2.1)	22.1 (2.2)	19.9 (2.7)	15.4 (1.5)	14.1 (1.3)	13.2 (2.3)	11.5 (1.4)
^{177}Ta	c*	56.56h	480 (62)	329 (43)	208 (28)	103 (19)	70 (17)	55 (14)	46 (12)	39.5 (9.9)	42 (10)	32.7 (8.4)	28.8 (7.2)
^{176}Ta	i	8.09h	-	73.1 (7.7)	123 (12)	-	-	-	33.8 (5.8)	25.6 (6.3)	28.3 (6.9)	17.7 (2.4)	21.2 (3.9)
^{176}Ta	c	8.09h	-	543 (45)	221 (21)	-	-	-	51.1 (7.0)	40.2 (4.2)	32.6 (4.1)	27.4 (2.7)	24.2 (2.4)
^{176}Ta	c*	8.09h	0.404 (0.036)	-	-	138 (13)	78.8 (7.1)	63.0 (6.7)	-	-	-	-	-
^{175}Ta	c	10.5h	-	224 (18)	234 (22)	137 (12)	78.6 (6.4)	61.9 (6.2)	51.3 (6.4)	32.4 (3.1)	25.9 (2.4)	20.4 (2.1)	15.6 (1.6)
^{174}Ta	i	1.14h	-	-	105 (13)	75.1 (9.4)	46.2 (5.4)	40.4 (5.7)	34.3 (7.0)	21.1 (3.6)	20.3 (5.8)	13.7 (2.5)	15.1 (2.1)
^{174}Ta	c	1.14h	-	-	241 (30)	117 (14)	64.8 (7.5)	51.7 (6.7)	39.9 (6.2)	26.2 (3.3)	20.8 (3.3)	15.5 (2.1)	15.2 (1.9)
^{173}Ta	c	3.14h	-	-	221 (23)	145 (15)	81.3 (8.9)	61.8 (7.6)	42.4 (9.2)	-	22.4 (5.1)	19.7 (4.5)	20.1 (3.2)
^{172}Ta	c*	36.8m	-	-	19.3 (6.0)	66.4 (6.4)	39.3 (3.5)	30.4 (3.4)	21.7 (2.8)	11.1 (2.1)	13.6 (1.9)	11.3 (2.3)	10.4 (1.7)
^{181}Hf	c	42.39d	-	-	-	-	-	-	-	-	-	-	0.160 (0.017)
^{180m}Hf	i(m)	5.5h	0.089 (0.014)	-	-	1.36 (0.36)	1.93 (0.35)	2.52 (0.32)	3.45 (0.51)	3.24 (0.33)	3.13 (0.28)	2.30 (0.35)	2.25 (0.23)
^{179m}Hf	i(m)	25.05d	-	0.193 (0.017)	0.379 (0.036)	0.503 (0.053)	0.570 (0.069)	0.78 (0.10)	0.95 (0.12)	0.803 (0.082)	0.790 (0.072)	0.641 (0.075)	0.518 (0.056)
^{175}Hf	c	70d	8.92 (0.88)	234 (19)	255 (24)	169 (16)	108.0 (10.0)	89.8 (9.1)	78.5 (9.9)	56.5 (5.2)	50.0 (4.8)	44.9 (5.5)	31.5 (3.1)
^{173}Hf	i	23.6h	-	-	9 (10)	-	-	-	-	-	25.0 (5.5)	18.2 (4.4)	3.6 (2.8)
^{173}Hf	c	23.6h	-	-	234 (22)	-	-	-	-	-	49.3 (4.4)	37.9 (3.6)	26.6 (3.0)
^{173}Hf	c*	23.6h	-	19.1 (1.6)	-	180 (16)	123.0 (10.0)	104 (10)	87 (11)	64.3 (5.8)	-	-	-
^{172}Hf	c	1.87y	-	2.28 (0.20)	39.7 (3.7)	122 (11)	88.9 (7.1)	78.0 (7.7)	64.5 (7.9)	44.2 (4.1)	35.4 (3.7)	28.7 (3.8)	21.0 (2.1)
^{171}Hf	c	12.1h	-	-	7 (12)	109 (12)	91.7 (8.1)	78.9 (9.9)	-	-	29.7 (5.1)	27.9 (3.2)	15.3 (4.0)
^{170}Hf	c	16.01h	-	-	12.6 (1.9)	70.9 (6.6)	78.8 (6.5)	76.1 (7.4)	57.2 (7.4)	47.6 (4.9)	33.1 (3.3)	24.7 (2.4)	16.8 (1.8)
^{168}Hf	c	25.95m	-	-	-	20.7 (5.8)	50.9 (4.5)	54.6 (5.5)	48.2 (6.0)	28.6 (2.7)	18.6 (1.9)	17.2 (2.1)	9.8 (1.5)
^{173}Lu	c	1.37y	-	18.7 (1.7)	204 (20)	152 (14)	104.9 (9.0)	95.0 (9.8)	82 (10)	56.0 (5.3)	46.2 (4.3)	39.3 (4.1)	27.4 (2.7)
^{172}Lu	i	6.70d	-	0.063 (0.006)	3.49 (0.33)	4.68 (0.42)	7.66 (0.63)	12.1 (1.2)	13.5 (1.7)	10.40 (1.00)	9.43 (0.83)	8.43 (0.79)	6.36 (0.60)
^{172}Lu	c	6.70d	-	2.35 (0.22)	42.9 (4.0)	126 (11)	96.1 (7.9)	89.3 (8.9)	78.3 (9.7)	55.5 (5.0)	45.0 (4.6)	38.7 (4.8)	27.1 (2.7)
^{171}Lu	i(m+g)	8.24d	-	-	22 (13)	13.3 (8.0)	14.6 (3.3)	23.0 (6.8)	-	-	18.1 (4.9)	11.5 (2.3)	12.8 (4.2)
^{171}Lu	c	8.24d	-	-	28.8 (2.7)	122 (11)	111.0 (9.0)	106.0 (10.0)	-	-	50.1 (4.4)	40.4 (3.7)	29.9 (2.8)
^{171}Lu	c*	8.24d	-	-	-	-	-	-	93 (11)	63.8 (5.6)	-	-	-
^{170}Lu	i(m+g)	2.012d	-	-	8.8 (2.8)	9.0 (3.2)	9.4 (2.5)	16.1 (2.1)	20.1 (3.8)	7.3 (3.9)	8.0 (2.4)	6.9 (1.4)	8.4 (1.6)
^{170}Lu	c	2.012d	-	-	20.4 (2.1)	79.7 (7.1)	88.3 (7.1)	92.0 (9.0)	78.5 (9.7)	53.4 (4.9)	43.0 (3.9)	32.9 (3.1)	25.1 (2.4)
^{169}Lu	c	34.06h	-	-	1.48 (0.16)	36.9 (3.5)	67.9 (6.0)	74.5 (7.3)	66.2 (8.2)	49.8 (4.4)	35.2 (3.2)	26.8 (2.5)	18.7 (1.9)
^{167}Lu	c	51.5m	-	-	-	21.7 (2.6)	55.0 (6.1)	81 (10)	78 (11)	49.0 (5.7)	35.0 (4.1)	24.9 (3.0)	16.8 (2.1)
^{169}Yb	c*	32.026d	-	-	-	48.2 (4.4)	88.7 (7.2)	103 (10)	95 (12)	60.2 (6.0)	48.7 (4.4)	39.7 (3.6)	24.1 (2.3)
^{167}Yb	i	17.5m	-	-	-	0.22 (0.77)	3.1 (1.0)	6.8 (1.5)	3.7 (1.4)	8.0 (1.4)	6.6 (1.2)	4.73 (0.58)	2.17 (0.68)
^{167}Yb	c	17.5m	-	-	-	22.0 (2.6)	57.9 (6.5)	89 (11)	83 (12)	57.1 (6.7)	41.7 (4.9)	29.5 (3.5)	19.0 (2.3)
^{166}Yb	c	56.7h	-	-	-	7.8 (1.3)	43.4 (3.6)	76.3 (7.6)	80 (10)	58.3 (5.4)	41.6 (3.6)	32.4 (3.0)	22.4 (2.1)
^{162}Yb	c	18.87m	-	-	-	-	9.5 (1.0)	45.9 (5.3)	62.3 (8.2)	40.7 (4.9)	27.2 (2.8)	16.7 (6.7)	10.9 (2.7)
^{168}Tm	i	93.1d	-	-	-	0.138 (0.024)	0.361 (0.041)	0.96 (0.11)	1.64 (0.25)	1.48 (0.14)	1.44 (0.15)	1.37 (0.18)	1.00 (0.11)
^{167}Tm	c	9.25d	-	-	-	19.1 (2.7)	59.0 (8.0)	90 (13)	91 (15)	63.0 (8.9)	47.0 (6.6)	38.1 (5.5)	22.8 (3.3)
^{166}Tm	i	7.70h	-	-	-	0.15 (0.35)	1.39 (0.63)	2.13 (0.93)	3.5 (1.3)	3.96 (0.94)	3.27 (0.64)	2.83 (0.42)	2.04 (0.37)
^{166}Tm	c	7.70h	-	-	-	7.8 (1.1)	45.4 (3.8)	81.2 (8.1)	86 (11)	63.1 (5.7)	46.0 (4.1)	36.7 (3.4)	24.8 (2.4)
^{165}Tm	c	30.06h	-	-	-	2.91 (0.44)	34.0 (3.0)	71.2 (7.1)	84 (11)	65.7 (6.2)	46.8 (4.8)	34.1 (3.6)	23.3 (2.4)
^{163}Tm	c*	1.810h	-	-	-	-	22.0 (3.2)	69.8 (7.1)	85 (11)	60.4 (5.5)	43.7 (4.1)	28.0 (3.3)	19.2 (3.2)
^{162}Tm	i(m+g)	21.70m	-	-	-	-	1.7 (3.0)	1.6 (2.0)	9.4 (4.0)	15.0 (3.4)	7.3 (8.3)	15.3 (3.9)	9.5 (5.2)
^{162}Tm	c	21.70m	-	-	-	-	9.6 (2.1)	50.3 (6.1)	74 (10)	54.8 (6.1)	37.1 (7.8)	25.1 (6.8)	12.7 (4.8)

^{161}Tm	c	33m	-	-	-	-	-	-	-	-	42.2 (5.6)	27.6 (4.8)	17.8 (2.9)
^{161}Er	i	3.21h	-	-	-	-	-	-	-	-	0.8 (4.0)	2.5 (3.0)	3.0 (3.1)
^{161}Er	c	3.21h	-	-	-	-	-	-	-	-	42.9 (4.6)	33.7 (3.7)	23.2 (2.6)
^{161}Er	c*	3.21h	-	-	-	-	9.61 (0.97)	52.8 (6.1)	81 (11)	61.7 (7.3)	-	-	-
^{160}Er	c	28.58h	-	-	-	-	5.32 (0.60)	39.1 (4.4)	68.5 (9.2)	61.8 (6.4)	44.4 (4.6)	36.7 (4.1)	23.8 (2.6)
^{159}Er	c*	36m	-	-	-	-	3.56 (0.56)	35.0 (4.6)	67 (10)	56.3 (7.0)	44.3 (5.5)	34.5 (4.4)	21.7 (3.2)
^{157}Er	c*	18.65m	-	-	-	-	-	23.6 (3.3)	50.4 (8.1)	44.9 (5.9)	33.6 (4.6)	31.8 (4.4)	18.7 (2.6)
^{156}Er	c	19.5m	-	-	-	-	-	13.6 (1.4)	33.7 (4.8)	35.6 (3.3)	29.2 (2.9)	25.3 (2.6)	16.5 (1.8)
^{160m}Ho	i(m)	5.02h	-	-	-	-	0.05 (0.26)	1.85 (0.54)	2.3 (1.1)	-	2.72 (0.56)	1.56 (0.68)	1.11 (0.24)
^{160m}Ho	c	5.02h	-	-	-	-	5.53 (0.85)	42.9 (5.0)	71.8 (9.9)	-	46.7 (5.1)	37.3 (4.4)	24.5 (2.8)
^{160}Ho	i(m+g)	25.6m	-	-	-	-	-	4.1 (1.2)	6.8 (1.7)	6.8 (1.7)	4.5 (1.5)	2.68 (0.51)	3.86 (0.60)
^{156}Ho	i	56m	-	-	-	-	-	0.64 (0.62)	6.0 (3.4)	4.26 (0.95)	6.6 (1.8)	2.8 (1.8)	0.20 (0.94)
^{156}Ho	c	56m	-	-	-	-	-	13.9 (1.4)	40.6 (5.0)	40.3 (3.6)	35.8 (3.2)	28.9 (3.1)	16.9 (1.7)
^{157}Dy	c	8.14h	-	-	-	-	1.25 (0.14)	21.6 (2.3)	52.7 (6.8)	53.8 (5.3)	43.7 (4.2)	34.8 (3.5)	21.2 (2.1)
^{155}Dy	c*	9.9h	-	-	-	-	-	-	40.5 (5.0)	43.6 (4.0)	40.9 (3.7)	32.3 (3.1)	18.5 (1.8)
^{152}Dy	c	2.38h	-	-	-	-	-	3.67 (0.37)	17.9 (2.2)	22.3 (1.9)	25.6 (2.2)	21.1 (2.0)	12.5 (1.2)
^{155}Tb	c*	5.32d	-	-	-	-	-	10.9 (1.4)	40.3 (5.1)	42.8 (3.9)	40.1 (3.7)	28.3 (2.9)	15.6 (1.7)
^{153}Tb	c*	2.34d	-	-	-	-	-	6.48 (0.92)	27.7 (3.7)	38.1 (3.6)	41.7 (7.8)	29.4 (3.1)	15.5 (1.6)
^{152}Tb	i(m+g)	17.5h	-	-	-	-	-	-	1.69 (0.92)	3.9 (2.3)	1.18 (0.94)	-	-
^{152}Tb	c	17.5h	-	-	-	-	-	-	20.1 (2.8)	28.4 (3.1)	28.4 (3.0)	23.2 (4.1)	15.7 (1.8)
^{151}Tb	c	17.609h	-	-	-	-	-	3.52 (0.36)	19.3 (2.5)	26.8 (2.5)	28.0 (2.5)	22.4 (2.2)	14.6 (1.5)
^{150}Tb	c	3.48h	-	-	-	-	-	1.44 (0.26)	8.8 (1.4)	13.7 (1.8)	15.2 (2.0)	11.7 (1.6)	6.82 (0.96)
^{149}Tb	c	4.118h	-	-	-	-	-	1.47 (0.26)	6.09 (0.92)	9.86 (0.92)	11.3 (1.1)	8.82 (0.91)	5.14 (0.50)
^{148}Tb	c	60m	-	-	-	-	-	2.01 (0.23)	8.2 (1.1)	11.5 (1.1)	14.1 (1.3)	11.6 (1.3)	7.54 (0.73)
^{153}Gd	c	240.4d	-	-	-	-	-	4.77 (0.74)	24.8 (3.5)	32.9 (3.7)	34.8 (3.9)	24.3 (2.8)	14.1 (2.1)
^{151}Gd	c	124d	-	-	-	-	-	3.90 (0.74)	17.4 (2.4)	23.0 (2.2)	24.9 (2.4)	20.5 (2.9)	12.7 (1.3)
^{149}Gd	c	9.28d	-	-	-	-	-	2.83 (0.29)	19.0 (2.4)	27.5 (2.6)	35.2 (3.3)	30.7 (3.0)	17.3 (1.7)
^{147}Gd	c	38.06h	-	-	-	-	-	1.44 (0.17)	12.2 (1.6)	23.5 (2.4)	31.3 (2.8)	27.7 (2.6)	16.0 (1.6)
^{146}Gd	c	48.27d	-	-	-	-	-	1.29 (0.13)	11.6 (1.4)	20.9 (1.8)	30.2 (2.6)	28.4 (2.6)	15.9 (1.5)
^{145}Gd	c	23.0m	-	-	-	-	-	-	6.0 (2.0)	9.8 (1.0)	17.0 (1.6)	15.4 (1.6)	10.1 (1.2)
^{149}Eu	i	93.1d	-	-	-	-	-	-	1.37 (0.84)	6.3 (1.2)	1.7 (2.1)	-	-
^{149}Eu	c	93.1d	-	-	-	-	-	-	20.3 (2.5)	30.9 (2.7)	37.9 (3.3)	28.2(2.9)	-
^{149}Eu	c*	93.1d	-	-	-	-	-	2.95 (0.32)	-	-	-	-	17.8 (1.7)
^{148}Eu	i	54.5d	-	-	-	-	-	-	0.70 (0.11)	1.18 (0.11)	1.73 (0.16)	1.65 (0.17)	1.18 (0.13)
^{147}Eu	i	24.1d	-	-	-	-	-	-	-	-	-	-	12.8 (4.3)
^{147}Eu	c	24.1d	-	-	-	-	0.121 (0.015)	1.78 (0.23)	15.6 (2.1)	26.8 (2.6)	38.2 (3.5)	33.4 (3.1)	20.2 (2.0)
^{146}Eu	i	4.61d	-	-	-	-	-	0.197 (0.022)	1.90 (0.43)	3.47 (0.50)	5.51 (0.73)	5.33 (0.80)	3.25 (0.47)
^{146}Eu	c	4.61d	-	-	-	-	-	1.43 (0.14)	14.3 (2.0)	25.6 (2.4)	37.2 (3.4)	33.0 (3.0)	20.4 (2.0)
^{145}Eu	c	5.93d	-	-	-	-	-	0.546 (0.074)	7.81 (0.99)	16.2 (1.5)	26.7 (2.5)	24.3 (2.3)	15.3 (1.5)
^{144}Pm	i*	363d	-	-	-	-	-	-	0.169 (0.054)	0.314 (0.032)	0.588 (0.052)	0.560 (0.063)	-
^{143}Pm	c	265d	-	-	-	-	-	-	5.16 (0.71)	12.1 (1.3)	24.3 (2.6)	25.2 (2.8)	16.4 (1.8)
^{140m}Pm	i(m)	5.95m	-	-	-	-	-	-	-	-	8.4 (1.1)	7.2 (1.3)	7.3 (1.4)
^{139m}Nd	i(m)	5.5h	-	-	-	-	-	-	-	-	2.96 (0.50)	3.62 (0.64)	2.59 (0.45)
^{136}Nd	c	50.65m	-	-	-	-	-	-	2.94 (0.42)	4.67 (0.51)	12.7 (1.5)	17.3 (1.8)	13.5 (1.3)
^{138m}Pr	i(m)	2.12h	-	-	-	-	-	-	-	-	1.53 (0.16)	1.74 (0.19)	-
^{136}Pr	i	13.1m	-	-	-	-	-	-	0.54 (0.19)	1.46 (0.22)	1.86 (0.59)	5.4 (1.2)	2.17 (0.35)
^{136}Pr	c	13.1m	-	-	-	-	-	-	3.54 (0.50)	6.13 (0.67)	14.4 (1.5)	22.1 (2.8)	15.4 (1.6)

^{134}Pr	c*	17m	-	-	-	-	-	-	-	2.39 (0.25)	10.34 (0.90)	13.8 (1.3)	12.0 (1.1)
^{139}Ce	c	137.640d	-	-	-	-	-	0.083 (0.013)	2.16 (0.26)	7.50 (0.66)	20.8 (1.8)	25.3 (2.3)	15.6 (1.4)
^{135}Ce	c	17.7h	-	-	-	-	-	-	-	-	15.5 (1.4)	20.5 (2.1)	15.5 (1.5)
^{134}Ce	c	3.16d	-	-	-	-	-	-	-	-	12.6 (1.2)	16.8 (2.2)	11.8 (1.2)
^{133m}Ce	i(m)	4.9h	-	-	-	-	-	-	-	-	2.85 (0.28)	4.59 (0.61)	3.54 (0.36)
^{132}Ce	c	3.51h	-	-	-	-	-	-	-	1.28 (0.16)	9.53 (0.92)	15.3 (1.6)	14.9 (1.6)
^{130}Ce	c	25m	-	-	-	-	-	-	-	-	5.07 (0.54)	8.44 (0.87)	7.51 (0.75)
^{132}La	i(m+g)	4.8h	-	-	-	-	-	-	-	0.359 (0.094)	0.29 (0.21)	0.28 (0.49)	0.41 (0.54)
^{132}La	c	4.8h	-	-	-	-	-	-	-	1.64 (0.20)	10.0 (1.0)	15.7 (1.7)	15.3 (1.6)
^{130}La	i	8.7m	-	-	-	-	-	-	-	-	2.39 (0.52)	4.45 (0.92)	4.8 (1.4)
^{130}La	c	8.7m	-	-	-	-	-	-	-	-	7.54 (0.84)	12.6 (1.4)	12.3 (1.9)
^{133}Ba	c	3848.9d	-	-	-	-	-	-	-	2.35 (0.33)	11.4 (1.0)	19.7 (1.8)	13.5 (1.3)
^{131}Ba	c	11.50d	-	-	-	-	-	-	0.63 (0.14)	2.03 (0.19)	10.60 (0.90)	16.8 (1.5)	13.8 (1.3)
^{128}Ba	c	2.43d	-	-	-	-	-	-	-	-	7.71 (0.77)	14.5 (1.6)	12.8 (1.4)
^{126}Ba	c	100m	-	-	-	-	-	-	-	-	2.58 (0.44)	5.22 (0.90)	6.09 (0.83)
^{129}Cs	c	32.06h	-	-	-	-	-	-	-	-	11.4 (1.5)	18.8 (1.9)	17.2 (1.7)
^{127}Cs	c	6.25h	-	-	-	-	-	-	-	-	7.60 (0.73)	13.2 (1.3)	13.0 (1.2)
^{127}Xe	c	36.4d	-	-	-	-	-	-	-	1.13 (0.11)	7.25 (0.63)	13.5 (1.2)	11.6 (1.2)
^{123}Xe	c	2.08h	-	-	-	-	-	-	-	-	6.00 (0.56)	11.3 (1.1)	11.9 (1.2)
^{122}Xe	c	20.1h	-	-	-	-	-	-	-	-	-	-	9.14 (0.93)
^{121m}Te	i(m)	154d	-	-	-	-	-	-	0.098 (0.012)	0.178 (0.076)	0.235 (0.021)	0.64 (0.11)	0.493 (0.051)
^{121}Te	i(m+g)	19.16d	-	-	-	-	-	-	0.146 (0.018)	0.453 (0.043)	3.20 (0.29)	7.78 (0.74)	10.20 (1.00)
^{121}Te	c	19.16d	-	-	-	-	-	-	0.233 (0.029)	0.675 (0.064)	3.45 (0.32)	8.35 (0.80)	10.70 (1.00)
^{119m}Te	i(m)	4.70d	-	-	-	-	-	-	-	-	0.570 (0.055)	1.28 (0.12)	1.86 (0.18)
^{119}Te	c	16.05h	-	-	-	-	-	-	-	-	2.78 (0.28)	6.09 (0.64)	9.51 (0.90)
^{117}Te	c	62m	-	-	-	-	-	-	-	-	1.34 (0.18)	5.01 (0.57)	9.03 (0.87)
^{114}Te	c	15.2m	-	-	-	-	-	-	-	-	-	1.32 (0.17)	2.82 (0.37)
^{120m}Sb	i(m)	5.76d	-	-	-	-	-	-	-	-	-	0.098 (0.010)	0.139 (0.014)
^{118m}Sb	i(m)	5.00h	-	-	-	-	-	-	-	-	0.274 (0.035)	0.665 (0.072)	0.832 (0.099)
^{115}Sb	c*	32.1m	-	-	-	-	-	-	-	-	0.49 (0.56)	3.84 (0.39)	5.09 (0.89)
^{113}Sn	i(m+g)	115.09d	-	-	-	-	-	-	-	-	-	-	6.41 (0.59)
^{111}In	c	2.8047d	-	-	-	-	-	-	-	-	1.23 (0.11)	3.50 (0.33)	6.03 (0.64)
^{110}In	i	4.9h	-	-	-	-	-	-	-	-	1.04 (0.22)	2.77 (0.26)	3.24 (0.62)
^{109}In	c	4.2h	-	-	-	-	-	-	-	-	-	1.70 (0.17)	3.84 (0.41)
^{108m}In	i(m)	58.0m	-	-	-	-	-	-	-	-	-	1.26 (0.19)	2.31 (0.36)
^{108}In	c*	39.6m	-	-	-	-	-	-	-	-	-	-	4.55 (0.57)
^{110m}Ag	i(m)	249.76d	-	-	-	-	-	-	-	-	-	0.068 (0.009)	0.130 (0.013)
^{106m}Ag	i(m)	8.28d	-	-	-	-	-	-	-	-	0.336 (0.032)	0.724 (0.073)	1.57 (0.15)
^{105}Ag	c	41.29d	-	-	-	-	-	-	-	-	0.805 (0.099)	2.27 (0.25)	4.60 (0.43)
^{100}Pd	c	3.63d	-	-	-	-	-	-	-	-	-	0.507 (0.053)	1.52 (0.16)
^{102}Rh	i(m+g)	207d	-	-	-	-	-	-	-	-	-	-	0.512 (0.079)
^{100}Rh	i(m+g)	20.8h	-	-	-	-	-	-	-	-	-	0.816 (0.098)	2.49 (0.31)
^{100}Rh	c	20.8h	-	-	-	-	-	-	-	-	-	1.32 (0.14)	3.92 (0.43)
^{99m}Rh	c	4.7h	-	-	-	-	-	-	-	-	0.446 (0.069)	0.78 (0.10)	2.11 (0.25)
^{103}Ru	c	39.26d	-	-	-	-	-	-	-	-	-	-	0.136 (0.024)
^{97}Ru	c	2.791d	-	-	-	-	-	-	-	-	-	-	3.02 (0.28)
^{96}Tc	i(m+g)	4.28d	-	-	-	-	-	0.145 (0.020)	0.188 (0.025)	0.228 (0.022)	0.445 (0.059)	0.746 (0.093)	1.63 (0.16)

^{93m}Mo	i(m)	6.85h	-	-	-	-	-	-	-	-	-	0.449 (0.097)	1.42 (0.17)
^{90}Nb	c*	14.60h	-	-	-	-	-	-	0.209 (0.033)	0.369 (0.073)	0.655 (0.080)	1.08 (0.11)	2.74 (0.25)
^{89}Zr	c	78.41h	-	-	-	-	0.086 (0.012)	0.190 (0.020)	0.293 (0.043)	0.426 (0.038)	0.850 (0.076)	1.53 (0.14)	3.17 (0.29)
^{88}Zr	c	83.4d	-	-	-	-	-	0.071 (0.008)	0.208 (0.025)	0.273 (0.024)	0.514 (0.044)	0.976 (0.087)	2.26 (0.21)
^{88}Y	i	106.65d	-	-	-	-	-	-	0.334 (0.072)	0.468 (0.042)	0.62 (0.11)	0.89 (0.13)	1.34 (0.13)
^{88}Y	c	106.65d	-	-	-	-	-	-	0.62 (0.15)	0.560 (0.051)	1.13 (0.10)	1.83 (0.17)	3.87 (0.36)
^{87m}Y	c*	13.37h	-	-	-	-	-	-	-	-	-	-	1.18 (0.40)
^{87}Y	i	79.8h	-	-	-	-	-	-	-	-	-	-	2.19 (0.49)
^{87}Y	c	79.8h	-	-	-	-	-	-	-	-	-	-	3.34 (0.32)
^{87}Y	c	79.8h	-	-	0.026 (0.004)	-	-	0.234 (0.028)	0.479 (0.060)	0.550 (0.066)	1.09 (0.15)	1.77 (0.18)	-
^{86}Y	c	14.74h	-	-	-	-	-	-	-	-	0.98 (0.57)	1.43 (0.40)	2.64 (0.36)
^{85}Sr	c	64.84d	-	-	-	-	-	-	-	-	-	-	3.07 (0.31)
^{83}Sr	c	32.41h	-	-	-	-	-	-	-	-	-	-	1.61 (0.77)
^{84}Rb	i(m+g)	32.77d	-	-	-	0.119 (0.014)	0.126 (0.011)	0.241 (0.025)	0.376 (0.048)	0.389 (0.036)	0.531 (0.048)	0.680 (0.064)	0.929 (0.088)
^{83}Rb	c	86.2d	-	-	-	-	-	0.249 (0.036)	0.350 (0.057)	0.678 (0.085)	1.15 (0.15)	1.81 (0.24)	3.05 (0.33)
^{82m}Rb	i(m)	6.472h	-	-	-	-	-	-	-	-	-	-	1.15 (0.15)
^{77}Br	c	57.036h	-	-	-	-	-	-	-	-	-	-	2.39 (0.23)
^{75}Se	c	119.779d	-	-	-	-	-	-	-	-	0.799 (0.082)	1.16 (0.12)	1.82 (0.18)
^{74}As	i	17.77d	-	-	-	-	0.056 (0.008)	0.170 (0.025)	0.345 (0.050)	0.408 (0.047)	0.619 (0.068)	0.569 (0.066)	1.08 (0.12)
^{69m}Zn	i(m)	13.76h	-	-	-	-	-	-	-	-	0.191 (0.024)	-	-
^{65}Zn	c	244.26d	-	-	-	-	-	-	-	-	0.351 (0.037)	0.646 (0.090)	1.57 (0.14)
^{60}Co	i(m+g)	5.2714y	-	-	-	-	-	-	-	-	0.78 (0.14)	1.12 (0.13)	1.24 (0.12)
^{58}Co	i(m+g)	70.86d	-	-	-	-	-	-	-	-	-	-	1.23 (0.12)
^{56}Co	c	77.233d	-	-	-	-	-	-	-	-	-	-	0.116 (0.016)
^{59}Fe	c	44.472d	-	-	-	-	-	0.143 (0.018)	0.235 (0.031)	0.234 (0.039)	0.364 (0.040)	0.540 (0.064)	0.764 (0.077)
^{54}Mn	i	312.11d	-	-	-	-	-	0.099 (0.024)	0.145 (0.025)	0.270 (0.031)	0.542 (0.050)	0.879 (0.083)	1.59 (0.15)
^{52}Mn	c	5.591d	-	-	-	-	-	-	-	-	-	-	0.271 (0.025)
^{48}V	c	15.9735d	-	-	-	-	-	-	-	-	0.100 (0.013)	0.223 (0.022)	0.475 (0.045)
^{48}Sc	i	43.67h	-	-	-	-	-	-	-	-	0.315 (0.083)	0.461 (0.048)	0.558 (0.068)
^{46}Sc	i(m+g)	83.79d	-	-	-	-	-	-	0.201 (0.034)	0.419 (0.040)	0.377 (0.035)	0.703 (0.066)	1.60 (0.15)
^{44m}Sc	i(m)	58.61h	-	-	-	-	-	-	-	-	-	-	0.458 (0.043)
^{28}Mg	c	20.915h	-	-	-	-	-	-	-	-	0.164 (0.026)	0.355 (0.035)	0.814 (0.077)
^{24}Na	c	14.9590h	-	-	-	-	-	-	-	-	1.34 (0.12)	2.03 (0.19)	4.17 (0.38)
^{22}Na	c	2.6019y	-	-	-	-	-	-	-	-	-	-	0.623 (0.062)
^{7}Be	i	53.29d	0.031 (0.007)	0.161 (0.042)*	0.259 (0.036)	0.284 (0.053)	0.240 (0.037)	0.575 (0.070)	1.05 (0.27)	1.51 (0.16)	2.55 (0.22)	3.95 (0.36)	6.70 (0.63)

*at 68 MeV

Table 4.11a. Experimental values of residual nuclides production cross sections in ^{nat}Ta(p,x) reactions including neutron contribution induced by 0.04-2.6GeV protons**.**

Nuclide	Type	$T_{1/2}$	Cross sections [mb] at proton energies [MeV]										
			43	66	97	148	248	399	599	799	1199	1598	2605
^{182}Ta	i(m1+m2+g)	114.43d	3.02 (0.29)	3.02 (0.29)	3.08 (0.32)	2.78 (0.25)	2.91 (0.23)	3.84 (0.38)	5.33 (0.67)	4.46 (0.41)	5.44 (0.48)	4.09 (0.40)	3.59 (0.33)

4.6 Residual nuclides production cross sections in ^{nat}W.

Table 4.12. Parameters of ^{nat}W irradiations..

Proton energy (MeV)	Sample weight (mg)	Monitor weight (mg)	Weight of monitor plate (mg)	Irradiation time (min)	Average proton flux p/(cm^2•s) x10^{-10}	Number of γ-spectra measured in sample/monitor/plate	Fluence measured by current transformer, 10^{14} protons
2605±8	256.6	59.2	1439.6	28.83	6.91 ± 0.60	30/17/4	1.286
1599±4	270.9	59.2	1489.7	30.68	2.93 ± 0.25	27/19/5	1.295
1199±3	265	59.3	1437.1	28	7.19 ± 0.60	32/20/14	1.300
799±2	267	59.2	1471.0	24	6.64 ± 0.58	22/15/10	1.300
600±2	266	59.4	1480.9	28	5.78 ± 0.46	26/15/3	1.297
400±2	268	58.9	1436.3	23	4.87 ± 0.42	24/11/3	1.245
249±1	266	58.7	1932.5	28	8.06 ± 0.59	26/20/5	1.303
149±1	267	58.4	1439.9	27	5.40 ± 0.42	26/23/5	1.247
99±1	277	48.1	1417.6	38.5	3.53 ± 0.25	21/22/5	1.219
68±1	264.8	96.4	1407.7	65.5	2.11 ± 0.16	25/21/4	1.241
46±1	262.1	48.0	1400.2	25	5.22 ± 0.37	22/15/4	1.211
Parameters of ^{nat}W irradiations by 40–150 MeV protons to measure ^{7}Be							
149±1	131.0	48.0	-	31	6.81 ± 0.51	3/2/-	1.355
99±1	136.0	48.2	-	30	5.21 ± 0.39	3/2/-	1.360
69±1	33.5	49.3	-	31	6.22 ± 0.46	3/3/-	1.286
46±1	138.0	49.7	-	45	3.42 ± 0.24	3/2/-	1.358

Table 4.13. Experimental values of residual nuclides production cross sections in $^{nat}W(p,x)$ reactions induced by 0.04-2.6GeV protons**.**

Nuclide	Type	$T_{1/2}$	Cross sections [mb] at proton energies [MeV]										
			46	68	99	149	249	400	600	799	1199	1599	2605
^{186}Re	i	3.7183d	3.44 (0.35)	1.95 (0.18)	0.774 (0.087)	-	-	-	-	-	-	-	-
^{184m}Re	i(m)	169d	5.89 (0.63)	2.89 (0.32)	1.60 (0.16)	1.03 (0.20)	0.82 (0.18)	-	-	-	-	-	-
^{184}Re	i(m+g)	38.0d	29.1 (2.3)	16.4 (1.3)	10.50 (0.90)	6.37 (0.59)	4.13 (0.34)	2.38 (0.23)	1.90 (0.18)	1.53 (0.15)	1.66 (0.15)	1.34 (0.13)	1.46 (0.14)
^{183}Re	i	70.0d	102.0 (9.0)	41.7 (3.4)	25.5 (2.2)	16.1 (1.5)	9.72 (0.84)	5.57 (0.57)	3.72 (0.35)	3.09 (0.30)	3.44 (0.46)	2.80 (0.27)	3.14 (0.36)

^{182m}Re	i(m)	12.7h	150 (13)	45.7 (4.5)	27.3 (2.8)	16.3 (1.6)	9.5 (1.0)	4.90 (0.59)	3.68 (0.45)	2.65 (0.39)	2.91 (0.48)	2.54 (0.39)	2.51 (0.35)
^{182}Re	i	64.0h	142 (12)	29.2 (2.4)	15.0 (1.3)	8.50 (0.76)	5.21 (0.45)	2.72 (0.29)	1.72 (0.60)	1.90 (0.55)	1.98 (0.75)	1.66 (0.51)	2.36 (0.52)
^{181}Re	i	19.9h	172 (28)	96 (17)	51.2 (7.9)	28.1 (4.4)	19.9 (3.1)	10.8 (1.8)	8.4 (1.4)	6.2 (1.1)	5.80 (0.78)	-	4.94 (0.84)
^{179}Re	i	19.5m	219 (18)	149 (12)	79.7 (7.1)	33.2 (3.3)	17.1 (2.3)	-	-	-	-	-	-
^{178}Re	i	13.2m	78.7 (7.9)	169 (16)	98.0 (9.8)	38.9 (4.5)	19.8 (2.9)	9.5 (1.4)	5.28 (0.84)	-	-	-	-
^{177}Re	i	14.0m	-	140 (11)	95.8 (7.8)	26.9 (2.3)	29 (16)	-	-	-	-	-	-
^{176}Re	i	5.3m	-	28.6 (5.2)	84.0 (8.6)	34.5 (4.0)	14.2 (1.7)	-	-	-	-	-	-
^{181}W	c	121.2d	437 (44)	377 (38)	216 (29)	-	-	-	-	-	-	-	-
^{178}W	c	21.6d	75.3 (6.6)	198 (17)	167 (15)	102.0 (10.0)	66.0 (5.8)	40.3 (4.2)	32.6 (3.3)	23.3 (2.5)	25.2 (2.6)	18.3 (2.2)	19.2 (2.1)
^{177}W	i	135m	-	8 (27)	20 (16)	37 (10)	27 (16)	-	-	-	-	-	-
^{177}W	c	135m	1.39 (0.18)	141 (18)	146 (19)	99 (13)	56.3 (7.5)	45.0 (6.5)	32.2 (4.5)	24.2 (3.5)	22.6 (3.2)	17.4 (2.5)	13.1 (1.8)
^{176}W	c	2.5h	-	35.9 (3.3)	168 (15)	127 (11)	81.0 (7.6)	46.7 (5.7)	32.6 (3.6)	25.2 (3.4)	16.1 (4.2)	17.2 (3.4)	8.8 (2.1)
^{174}W	c	31m	-	1.23 (0.44)	47.0 (5.7)	97 (13)	61.9 (7.4)	39.6 (5.4)	31.0 (4.3)	18.0 (3.1)	20.8 (3.0)	6.1 (2.0)	6.6 (1.5)
^{184}Ta	c*	8.7h	-	1.02 (0.11)	2.02 (0.18)	2.40 (0.50)	3.62 (0.36)	3.48 (0.63)	4.80 (0.56)	4.63 (0.54)	5.05 (0.69)	4.64 (0.47)	4.27 (0.53)
^{183}Ta	c	5.1d	1.10 (0.13)	2.04 (0.30)	4.57 (0.45)	6.70 (0.63)	9.5 (1.0)	10.1 (1.0)	12.3 (1.2)	11.9 (1.2)	12.4 (1.3)	9.6 (1.7)	10.9 (1.1)
^{182}Ta	i(m1+m2+g)	114.43d	1.02 (0.13)	3.09 (0.29)	6.36 (0.56)	9.22 (0.79)	11.80 (1.00)	12.3 (1.1)	14.2 (1.2)	13.8 (1.3)	15.1 (1.4)	12.9 (1.2)	12.8 (1.2)
^{178m}Ta	i(m)	2.36h	2.09 (0.18)	3.92 (0.34)	6.36 (0.72)	11.0 (1.5)	13.1 (1.2)	12.3 (1.2)	10.3 (1.1)	8.48 (0.85)	11.9 (1.1)	7.61 (0.94)	9.47 (0.92)
^{177}Ta	c*	56.56h	134 (24)	196 (25)	207 (29)	161 (25)	112 (22)	92 (23)	59 (14)	49 (12)	43 (11)	37.1 (9.1)	33.0 (8.1)
^{176}Ta	i	8.09h	-	9.3 (1.7)	4.9 (3.5)	19.4 (4.1)	25.6 (3.5)	26.2 (4.0)	28.8 (3.7)	21.7 (3.0)	26.9 (4.2)	17.4 (3.9)	24.4 (3.4)
^{176}Ta	c	8.09h	-	45.6 (3.8)	172 (15)	143 (13)	110.0 (9.0)	77.2 (8.0)	62.2 (5.9)	45.5 (4.8)	43.2 (4.2)	35.8 (3.7)	33.3 (3.3)
^{176}Ta	c*	8.09h	3.27 (0.30)	-	-	-	-	-	-	-	-	-	-
^{175}Ta	c	10.5h	-	8.88 (0.75)	123 (11)	139 (13)	109.0 (9.0)	74.1 (7.2)	59.9 (5.9)	40.9 (4.2)	34.0 (3.2)	27.6 (3.0)	27.2 (3.1)
^{174}Ta	i	1.14h	-	4.01 (0.77)	4.9 (1.4)	5.9 (4.1)	28.6 (3.8)	25.3 (4.0)	19.4 (3.7)	18.4 (3.8)	8.4 (2.6)	17.7 (3.4)	14.3 (2.5)
^{174}Ta	c	1.14h	-	5.26 (0.66)	51.7 (6.2)	103 (13)	91 (11)	64.9 (8.2)	50.2 (6.2)	36.4 (4.7)	29.2 (3.7)	23.9 (3.2)	21.0 (2.7)
^{173}Ta	c	3.14h	-	-	19.3 (2.3)	90.8 (8.6)	97.1 (8.8)	73.9 (7.8)	59.4 (6.1)	44.5 (5.2)	30.0 (4.9)	25.8 (5.1)	22.2 (3.4)
^{172}Ta	c*	36.8m	-	-	-	33.1 (4.2)	44.2 (4.0)	34.6 (3.9)	28.3 (2.9)	18.9 (2.1)	17.4 (2.4)	16.6 (2.3)	15.4 (2.2)
^{181}Hf	c	42.39d	0.043 (0.005)	0.078 (0.007)	0.157 (0.014)	0.301 (0.026)	0.629 (0.051)	-	1.23 (0.11)	-	1.40 (0.13)	1.19 (0.11)	1.23 (0.11)
^{180m}Hf	i(m)	5.5h	-	-	0.69 (0.16)	0.76 (0.10)	0.67 (0.10)	0.572 (0.090)	1.01 (0.16)	0.86 (0.10)	-	-	-
^{179m}Hf	i(m)	25.05d	-	0.045 (0.008)	0.073 (0.007)	0.116 (0.011)	0.207 (0.028)	0.259 (0.038)	0.332 (0.040)	0.326 (0.035)	-	-	-
^{175}Hf	c	70d	0.192 (0.018)	9.60 (0.85)	122 (11)	137 (12)	116.0 (10.0)	83.6 (8.3)	70.3 (6.6)	53.9 (5.4)	48.9 (4.7)	39.6 (3.9)	36.4 (3.6)
^{173}Hf	i	23.6h	-	-	-	0.5 (5.9)	3.7 (6.2)	10 (16)	5.3 (7.6)	0.5 (5.4)	15.5 (8.6)	11 (11)	13.2 (2.8)
^{173}Hf	c	23.6h	-	-	-	101 (12)	113 (13)	88 (12)	79.9 (8.1)	56.0 (6.8)	48.3 (5.1)	37.7 (3.8)	33.4 (3.6)
^{173}Hf	c*	23.6h	-	0.753 (0.084)	22.9 (2.0)	-	-	-	-	-	-	-	-
^{172}Hf	c	1.87y	-	-	11.09 (1.00)	55.2 (4.8)	80.1 (6.4)	73.1 (6.8)	62.4 (5.5)	46.3 (4.6)	39.1 (3.6)	29.3 (2.7)	24.4 (2.4)
^{171}Hf	c	12.1h	-	-	-	24 (16)	72.0 (7.8)	67.7 (9.4)	64.6 (7.4)	42.6 (5.9)	33.9 (4.1)	27.9 (3.5)	23.6 (3.1)
^{170}Hf	c	16.01h	-	-	0.6 (1.8)	18.6 (1.8)	58.1 (4.7)	62.3 (6.0)	63.7 (5.8)	44.4 (4.5)	30.1 (3.3)	25.9 (2.7)	20.9 (2.1)
^{168}Hf	c	25.95m	-	-	-	9.3 (1.2)	32.8 (3.9)	46.4 (4.6)	47.6 (4.4)	34.0 (3.4)	24.8 (2.5)	18.3 (1.9)	14.3 (1.7)
^{173}Lu	c	1.37y	-	-	18.9 (1.7)	83.7 (7.9)	98.7 (8.9)	83.0 (8.4)	73.0 (7.0)	55.4 (5.6)	43.1 (4.3)	36.4 (3.7)	31.9 (3.2)
^{172}Lu	i	6.70d	-	-	0.25 (0.12)	0.937 (0.086)	2.52 (0.21)	4.13 (0.41)	5.45 (0.50)	5.11 (0.49)	4.84 (0.44)	4.00 (0.37)	3.74 (0.37)
^{172}Lu	c	6.70d	-	-	11.6 (3.6)	55.5 (4.9)	82.4 (6.8)	77.7 (7.3)	67.7 (6.1)	51.9 (5.1)	44.1 (4.1)	33.3 (3.2)	28.4 (2.9)
^{171}Lu	i(m+g)	8.24d	-	-	-	14 (17)	9.8 (5.4)	13.3 (7.3)	10.7 (5.0)	14.5 (4.8)	13.8 (3.1)	9.0 (2.6)	8.1 (2.4)
^{171}Lu	c	8.24d	-	-	-	39.7 (3.4)	85.4 (6.9)	84.6 (7.9)	79.3 (7.0)	60.0 (5.7)	49.4 (4.5)	37.8 (3.5)	33.1 (3.1)
^{171}Lu	c*	8.24d	-	-	5.31 (0.45)	-	-	-	-	-	-	-	-
^{170}Lu	i(m+g)	2.012d	-	-	1.6 (2.6)	3.7 (1.3)	4.9 (2.3)	1.9 (2.1)	2.3 (1.8)	3.7 (2.0)	11.0 (2.5)	4.4 (2.0)	4.3 (1.4)
^{170}Lu	c	2.012d	-	-	0.79 (0.16)	22.1 (2.0)	61.7 (5.2)	64.1 (6.1)	64.7 (5.8)	48.4 (4.9)	41.9 (4.0)	31.2 (3.2)	25.9 (2.6)
^{169}Lu	c	34.06h	-	-	-	11.4 (1.1)	45.2 (3.9)	54.4 (5.4)	57.2 (5.3)	43.9 (4.2)	36.0 (3.5)	26.6 (2.6)	22.6 (2.3)
^{167}Lu	c	51.5m	-	-	-	-	28.1 (3.1)	55.3 (6.5)	61.8 (7.1)	47.1 (5.6)	36.2 (4.2)	27.2 (3.2)	21.2 (2.5)

^{169}Yb	c*	32.026d	-	-	0.403 (0.037)	14.1 (1.2)	54.9 (4.6)	73.1 (6.9)	72.6 (6.5)	58.4 (5.8)	48.1 (4.5)	36.5 (3.6)	30.3 (2.9)
^{167}Yb	i	17.5m	-	-	-	-	0.45 (0.77)	1.14 (0.53)	0.1 (2.6)	2.81 (0.91)	0.6 (1.1)	1.2 (1.1)	0.29 (0.79)
^{167}Yb	c	17.5m	-	-	-	-	28.4 (3.1)	56.9 (6.7)	62.6 (7.3)	50.0 (5.9)	36.9 (4.3)	28.5 (3.4)	21.4 (2.6)
^{166}Yb	c	56.7h	-	-	-	1.21 (0.18)	20.7 (1.7)	47.0 (4.4)	61.4 (5.4)	49.3 (4.6)	41.0 (3.7)	31.6 (2.9)	24.7 (2.3)
^{162}Yb	c	18.87m	-	-	-	-	5.31 (0.89)	13.3 (2.3)	31.9 (5.6)	28.0 (4.9)	23.4 (3.8)	13.6 (4.4)	10.5 (4.8)
^{168}Tm	i	93.1d	-	-	-	-	0.114 (0.015)	0.310 (0.044)	0.610 (0.063)	0.787 (0.081)	1.05 (0.10)	0.876 (0.099)	0.641 (0.072)
^{167}Tm	c	9.25d	-	-	-	3.31 (0.52)	32.7 (4.5)	57.6 (8.3)	73 (10)	58.0 (8.4)	48.9 (7.0)	35.0 (5.1)	28.5 (4.1)
^{166}Tm	i	7.70h	-	-	-	0.12 (0.91)	1.55 (0.60)	1.29 (0.62)	2.57 (0.90)	1.15 (0.33)	2.65 (0.71)	2.24 (0.63)	1.90 (0.50)
^{166}Tm	c	7.70h	-	-	-	1.54 (0.89)	22.6 (1.9)	48.8 (4.6)	65.3 (5.8)	51.8 (5.0)	45.3 (4.2)	34.9 (3.3)	27.8 (2.6)
^{165}Tm	c	30.06h	-	-	-	0.789 (0.083)	16.0 (1.5)	41.5 (4.1)	61.8 (5.7)	52.1 (5.2)	42.5 (4.3)	33.0 (3.4)	27.0 (2.9)
^{163}Tm	c*	1.810h	-	-	-	-	-	37.5 (4.7)	55.2 (6.5)	53.1 (6.2)	41.2 (5.1)	29.2 (3.2)	19.4 (3.5)
^{162}Tm	i(m+g)	21.70m	-	-	-	-	-	17 (11)	27.5 (4.6)	24.1 (3.6)	12.4 (3.3)	18.9 (4.2)	7.2 (5.6)
^{162}Tm	c	21.70m	-	-	-	-	-	27 (11)	56.8 (6.4)	50.2 (6.4)	34.3 (7.8)	26.9 (5.2)	18.0 (4.5)
^{161}Tm	c	33m	-	-	-	-	1.9 (1.1)	18.3 (3.4)	33.7 (6.0)	37.5 (6.7)	34.6 (6.2)	29.8 (3.4)	22.7 (3.2)
^{161}Er	i	3.21h	-	-	-	-	0.8 (1.3)	-	-	-	-	1.6 (2.0)	0.3 (2.3)
^{161}Er	c	3.21h	-	-	-	-	2.68 (0.35)	-	-	-	-	32.2 (3.6)	24.9 (2.8)
^{161}Er	c*	3.21h	-	-	-	-	-	27.6 (3.1)	57.0 (6.1)	57.1 (6.5)	50.7 (5.7)	-	-
^{160}Er	c	28.58h	-	-	-	-	2.07 (0.37)	19.3 (2.1)	46.5 (4.8)	47.1 (5.1)	46.0 (5.0)	34.1 (3.7)	25.3 (2.7)
^{159}Er	c*	36m	-	-	-	-	-	15.4 (2.0)	43.9 (5.5)	45.4 (5.9)	43.0 (5.5)	33.5 (4.3)	27.3 (3.2)
^{157}Er	c*	18.65m	-	-	-	-	-	10.8 (1.7)	33.0 (4.7)	38.2 (5.4)	39.4 (5.7)	34.0 (4.8)	23.7 (3.4)
^{156}Er	c	19.5m	-	-	-	-	-	-	23.7 (3.1)	31.6 (3.3)	33.2 (4.2)	29.2 (6.2)	22.1 (3.0)
^{160m}Ho	i(m)	5.02h	-	-	-	-	-	1.69 (0.41)	1.91 (0.51)	1.83 (0.53)	2.60 (0.43)	2.37 (0.44)	0.94 (0.34)
^{160m}Ho	c	5.02h	-	-	-	-	-	21.9 (2.5)	49.4 (5.3)	49.9 (5.7)	48.7 (5.7)	36.3 (4.1)	27.7 (3.1)
^{160}Ho	i(m+g)	25.6m	-	-	-	-	-	-	4.52 (0.72)	5.1 (1.0)	5.86 (0.91)	2.86 (0.76)	3.34 (0.60)
^{156}Ho	i	56m	-	-	-	-	-	-	0.5 (2.0)	1.4 (1.4)	1.3 (3.3)	0.4 (7.0)	0.3 (2.5)
^{156}Ho	c	56m	-	-	-	-	-	-	24.3 (3.4)	32.6 (3.2)	36.0 (4.6)	31.5 (3.4)	23.8 (2.6)
^{157}Dy	c	8.14h	-	-	-	-	0.406 (0.059)	9.7 (1.0)	33.4 (3.3)	42.6 (4.5)	44.3 (4.4)	32.8 (3.4)	25.7 (2.7)
^{155}Dy	c*	9.9h	-	-	-	-	-	5.81 (0.58)	25.3 (2.3)	34.1 (3.5)	40.2 (3.8)	30.9 (3.0)	23.9 (2.3)
^{152}Dy	c	2.38h	-	-	-	-	-	1.24 (0.12)	10.02 (0.90)	16.2 (1.5)	24.4 (2.2)	20.7 (2.0)	15.0 (1.4)
^{155}Tb	c*	5.32d	-	-	-	-	-	7.0 (1.7)	23.6 (2.2)	33.0 (3.3)	40.2 (4.2)	28.2 (3.4)	20.8 (2.7)
^{153}Tb	c*	2.34d	-	-	-	-	-	2.43 (0.35)	16.3 (1.6)	25.6 (2.7)	33.6 (3.5)	27.6 (2.9)	19.4 (2.1)
^{152}Tb	i(m+g)	17.5h	-	-	-	-	-	-	2.1 (1.4)	7.9 (2.5)	0.43 (0.91)	-	-
^{152}Tb	c	17.5h	-	-	-	-	-	-	10.7 (1.2)	20.4 (2.3)	26.6 (2.9)	27.2 (3.1)	20.3 (2.4)
^{151}Tb	c	17.609h	-	-	-	-	-	-	8.63 (0.76)	17.9 (1.7)	25.3 (2.4)	22.8 (2.5)	16.9 (1.7)
^{150}Tb	c	3.48h	-	-	-	-	-	-	4.87 (0.66)	9.4 (1.4)	14.9 (2.0)	11.6 (1.6)	8.4 (1.1)
^{149}Tb	c	4.118h	-	-	-	-	-	-	3.34 (0.38)	6.69 (0.72)	9.6 (1.1)	8.81 (0.82)	6.36 (0.59)
^{148}Tb	c	60m	-	-	-	-	-	-	4.50 (0.46)	8.85 (0.95)	13.2 (1.3)	11.1 (1.1)	8.57 (0.85)
^{147}Tb	c	1.7h	-	-	-	-	-	-	-	-	-	-	1.83 (0.26)
^{153}Gd	c	240.4d	-	-	-	-	-	-	-	-	22.8 (2.8)	23.5 (2.5)	18.7 (1.9)
^{151}Gd	c	124d	-	-	-	-	-	-	14.3 (1.7)	17.2 (1.8)	24.5 (3.0)	21.4 (3.0)	16.9 (1.7)
^{149}Gd	c	9.28d	-	-	-	-	-	1.16 (0.13)	10.6 (1.1)	20.8 (2.0)	33.8 (3.3)	28.1 (2.9)	22.1 (2.1)
^{147}Gd	c	38.06h	-	-	-	-	-	2.36 (0.27)	7.9 (1.3)	15.9 (1.7)	27.7 (2.7)	24.9 (2.4)	18.7 (2.0)
^{146}Gd	c	48.27d	-	-	-	-	-	0.479 (0.047)	6.37 (0.56)	15.1 (1.4)	30.4 (3.7)	26.0 (2.4)	20.0 (1.9)
^{145}Gd	c	23.0m	-	-	-	-	-	-	-	-	16.0 (1.7)	15.2 (1.6)	11.2 (1.3)
^{149}Eu	i	93.1d	-	-	-	-	-	-	0.1 (2.1)	0.8 (1.5)	-	-	-
^{149}Eu	c	93.1d	-	-	-	-	-	-	10.30 (1.00)	20.1 (2.2)	-	-	-
^{149}Eu	c*	93.1d	-	-	-	-	-	-	-	-	38.6 (3.7)	29.2 (2.8)	24.1 (2.4)

^{148}Eu	i	54.5d	-	-	-	-	-	-	0.322 (0.041)	0.739 (0.073)	1.51 (0.16)	1.42 (0.15)	1.32 (0.12)
^{147}Eu	i	24.1d	-	-	-	-	-	-	-	-	27 (16)	7 (16)	1.5 (7.1)
^{147}Eu	c*	24.1d	-	-	-	-	-	0.734 (0.091)	7.85 (0.94)	18.5 (1.9)	34.6 (3.3)	30.9 (3.1)	23.3 (2.3)
^{146}Eu	i	4.61d	-	-	-	-	-	0.048 (0.014)	0.738 (0.079)	2.06 (0.27)	6.07 (0.66)	5.69 (0.62)	3.74 (0.39)
^{146}Eu	c	4.61d	-	-	-	-	-	0.530 (0.053)	7.00 (0.64)	17.5 (1.7)	35.7 (3.3)	32.1 (3.0)	23.9 (2.3)
^{145}Eu	c	5.93d	-	-	-	-	-	0.359 (0.058)	4.09 (0.38)	10.9 (1.1)	23.6 (2.2)	22.7 (2.2)	18.1 (1.8)
^{144}Pm	i*	363d	-	-	-	-	-	-	-	-	0.464 (0.049)	0.552 (0.055)	0.542 (0.053)
^{143}Pm	c	265d	-	-	-	-	-	-	-	8.13 (0.91)	23.4 (2.6)	22.8 (2.5)	18.9 (2.1)
^{140m}Pm	i(m)	5.95m	-	-	-	-	-	-	-	-	5.67 (0.81)	6.61 (0.97)	4.59 (0.72)
^{139m}Nd	i(m)	5.5h	-	-	-	-	-	-	-	-	2.39 (0.42)	2.93 (0.51)	2.87 (0.50)
^{136}Nd	c	50.65m	-	-	-	-	-	-	1.22 (0.17)	3.26 (0.39)	10.1 (1.1)	15.1 (1.5)	15.4 (1.8)
^{136}Pr	i	13.1m	-	-	-	-	-	-	-	-	3.01 (0.56)	8.1 (1.3)	2.99 (0.61)
^{136}Pr	c	13.1m	-	-	-	-	-	-	-	-	13.2 (1.5)	22.6 (3.3)	17.9 (2.1)
^{134}Pr	c*	17m	-	-	-	-	-	-	-	1.33 (0.18)	-	-	13.0 (1.3)
^{139}Ce	c	137.640d	-	-	-	-	-	-	0.759 (0.069)	4.63 (0.44)	17.6 (1.6)	22.3 (2.1)	20.3 (1.9)
^{135}Ce	c	17.7h	-	-	-	-	-	-	-	-	12.7 (1.4)	17.9 (1.7)	18.3 (1.8)
^{134}Ce	c	3.16d	-	-	-	-	-	-	1.18 (0.24)	2.40 (0.37)	10.3 (1.1)	15.8 (2.1)	16.3 (1.7)
^{133m}Ce	i(m)	4.9h	-	-	-	-	-	-	-	-	2.52 (0.31)	3.71 (0.38)	3.08 (0.37)
^{132}Ce	c	3.51h	-	-	-	-	-	-	-	1.01 (0.23)	7.68 (0.84)	13.0 (1.4)	14.9 (1.5)
^{130}Ce	c	25m	-	-	-	-	-	-	-	-	3.96 (0.46)	6.50 (0.70)	7.95 (0.79)
^{132}La	i(m+g)	4.8h	-	-	-	-	-	-	-	0.28 (0.32)	0.78 (0.24)	0.73 (0.35)	0.31 (0.32)
^{132}La	c	4.8h	-	-	-	-	-	-	-	1.30 (0.22)	8.5 (1.0)	13.9 (1.6)	15.6 (1.6)
^{130}La	i	8.7m	-	-	-	-	-	-	-	-	0.53 (0.85)	5.786 (0.79)	5.02 (0.78)
^{130}La	c	8.7m	-	-	-	-	-	-	-	-	4.51 (0.86)	12.3 (1.4)	13.0 (1.5)
^{133}Ba	c	3848.9d	-	-	-	-	-	-	-	-	10.5 (1.0)	15.3 (1.5)	16.1 (1.6)
^{131}Ba	c	11.50d	-	-	-	-	-	-	-	1.47 (0.14)	8.23 (0.75)	14.0 (1.3)	16.6 (1.5)
^{128}Ba	c	2.43d	-	-	-	-	-	-	-	-	5.23 (0.55)	10.8 (1.2)	15.5 (1.7)
^{126}Ba	c	100m	-	-	-	-	-	-	-	-	-	-	7.01 (0.98)
^{129}Cs	c	32.06h	-	-	-	-	-	-	-	-	8.14 (0.85)	14.7 (1.5)	19.4 (2.0)
^{127}Cs	c	6.25h	-	-	-	-	-	-	-	-	4.68 (0.44)	9.92 (0.95)	14.4 (1.4)
^{127}Xe	c	36.4d	-	-	-	-	-	-	-	0.663 (0.075)	4.99 (0.60)	10.3 (1.3)	15.6 (1.5)
^{125}Xe	c	16.9h	-	-	-	-	-	-	-	-	3.27 (0.33)	8.92 (0.85)	14.6 (1.4)
^{123}Xe	c	2.08h	-	-	-	-	-	-	-	-	5.24 (0.53)	10.3 (1.1)	15.5 (1.5)
^{122}Xe	c	20.1h	-	-	-	-	-	-	-	-	-	-	9.7 (1.1)
^{120}Xe	c	40m	-	-	-	-	-	-	-	-	0.85 (0.35)	1.12 (0.47)	3.30 (0.44)
^{120}I	i	81.0m	-	-	-	-	-	-	-	-	0.65 (0.48)	4.23 (0.73)	7.03 (0.75)
^{120}I	c	81.0m	-	-	-	-	-	-	-	-	1.50 (0.22)	5.35 (0.54)	10.28 (1.00)
^{121m}Te	i(m)	154d	-	-	-	-	-	-	-	0.165 (0.027)	0.322 (0.064)	0.309 (0.042)	0.621 (0.063)
^{121}Te	i(m+g)	19.16d	-	-	-	-	-	-	-	0.310 (0.032)	2.53 (0.24)	6.30 (0.61)	11.7 (1.1)
^{121}Te	c	19.16d	-	-	-	-	-	-	-	0.456 (0.046)	2.82 (0.27)	6.67 (0.65)	12.3 (1.2)
^{119m}Te	i(m)	4.70d	-	-	-	-	-	-	-	-	0.475 (0.045)	1.100 (0.100)	2.03 (0.20)
^{119}Te	c	16.05h	-	-	-	-	-	-	-	-	13.6 (1.9)	11.9 (1.8)	10.6 (1.5)
^{117}Te	c	62m	-	-	-	-	-	-	-	-	-	3.83 (0.41)	9.44 (0.92)
^{114}Te	c	15.2m	-	-	-	-	-	-	-	-	-	-	2.09 (0.32)
^{120m}Sb	i(m)	5.76d	-	-	-	-	-	-	-	-	0.060 (0.010)	0.086 (0.018)	0.168 (0.020)
^{118m}Sb	i(m)	5.00h	-	-	-	-	-	-	-	-	-	0.74 (0.11)	1.06 (0.14)
^{115}Sb	c*	32.1m	-	-	-	-	-	-	-	-	-	3.08 (0.36)	9.21 (0.88)

^{113}Sn	i(m+g)	115.09d	-	-	-	-	-	-	-	-	0.71 (0.30)	3.18 (0.47)	7.53 (0.70)
^{111}In	c	2.8047d	-	-	-	-	-	-	-	-	1.32 (0.21)	1.73 (0.35)	7.4 (1.2)
^{110}In	i	4.9h	-	-	-	-	-	-	-	-	-	1.71 (0.41)	3.56 (0.68)
^{109}In	c	4.2h	-	-	-	-	-	-	-	-	-	-	4.53 (0.47)
^{108m}In	i(m)	58.0m	-	-	-	-	-	-	-	-	-	0.87 (0.17)	3.30 (0.43)
^{110m}Ag	i(m)	249.76d	-	-	-	-	-	-	-	-	-	0.108 (0.022)	0.159 (0.018)
^{106m}Ag	i(m)	8.28d	-	-	-	-	-	-	-	-	0.373 (0.055)	0.643 (0.068)	1.79 (0.17)
^{105}Ag	c	41.29d	-	-	-	-	-	-	0.291 (0.058)	0.325 (0.051)	0.92 (0.11)	1.97 (0.23)	5.21 (0.49)
^{100}Pd	c	3.63d	-	-	-	-	-	-	-	-	0.147 (0.021)	0.445 (0.048)	1.65 (0.17)
^{102m}Rh	i(m)	2.9y	-	-	-	-	-	-	-	-	-	-	1.16 (0.12)
^{100}Rh	i(m+g)	20.8h	-	-	-	-	-	-	-	-	1.22 (0.13)	1.37 (0.14)	2.33 (0.34)
^{100}Rh	c	20.8h	-	-	-	-	-	-	-	-	1.37 (0.15)	1.82 (0.18)	3.82 (0.44)
^{99m}Rh	c	4.7h	-	-	-	-	-	-	-	-	-	0.79 (0.11)	2.42 (0.29)
^{103}Ru	c	39.26d	-	-	-	-	-	-	-	-	0.089 (0.026)	0.074 (0.049)	0.167 (0.021)
^{97}Ru	c	2.791d	-	-	-	-	-	-	-	-	1.76 (0.18)	-	3.72 (0.38)
^{96}Tc	i(m+g)	4.28d	-	-	-	-	-	-	0.156 (0.016)	0.186 (0.034)	0.442 (0.046)	0.697 (0.068)	1.83 (0.18)
^{94}Tc	c	293m	-	-	-	-	-	-	-	-	-	0.632 (0.084)	2.00 (0.20)
^{93m}Mo	i(m)	6.85h	-	-	-	-	-	-	-	-	-	0.397 (0.057)	1.51 (0.21)
^{90}Nb	c*	14.60h	-	-	-	-	-	-	-	-	0.63 (0.16)	1.03 (0.11)	2.88 (0.28)
^{89}Zr	c	78.41h	-	-	-	-	-	0.096 (0.012)	0.244 (0.032)	0.367 (0.039)	0.816 (0.075)	1.23 (0.11)	3.68 (0.34)
^{88}Zr	c	83.4d	-	-	-	-	0.032 (0.033)	0.103 (0.009)	0.212 (0.018)	0.290 (0.027)	0.255 (0.023)	0.796 (0.073)	2.72 (0.25)
^{88}Y	i	106.65d	-	-	-	-	0.120 (0.015)	0.149 (0.032)	0.307 (0.030)	0.52 (0.12)	0.87 (0.15)	0.94 (0.16)	1.57 (0.19)
^{88}Y	c	106.65d	-	-	-	-	0.151 (0.025)	0.353 (0.090)	0.783 (0.085)	0.64 (0.10)	1.27 (0.12)	1.80 (0.17)	4.27 (0.40)
^{87m}Y	c*	13.37h	-	-	-	-	-	-	-	-	0.83 (0.60)	0.89 (0.29)	2.2 (1.0)
^{87}Y	i	79.8h	-	-	-	-	-	-	-	-	0.12 (0.69)	0.60 (0.32)	1.7 (1.2)
^{87}Y	c	79.8h	-	-	-	-	-	-	-	-	1.24 (0.14)	1.72 (0.21)	3.88 (0.41)
^{87}Y	c*	79.8h	-	-	-	-	-	0.178 (0.023)	0.370 (0.040)	0.587 (0.059)	-	-	-
^{86}Y	c	14.74h	-	-	-	-	-	-	-	-	-	1.16 (0.17)	3.17 (0.38)
^{85}Sr	c	64.84d	-	-	-	-	-	-	0.667 (0.070)	-	1.56 (0.16)	1.94 (0.20)	3.81 (0.39)
^{83}Sr	c	32.41h	-	-	-	-	-	-	-	-	-	-	1.58 (0.75)
^{84}Rb	i(m+g)	32.77d	-	-	-	-	0.125 (0.012)	0.230 (0.024)	0.339 (0.044)	0.425 (0.046)	0.665 (0.063)	0.796 (0.077)	1.17 (0.11)
^{83}Rb	c	86.2d	-	-	-	-	-	0.246 (0.037)	0.543 (0.070)	0.697 (0.092)	1.70 (0.68)	2.39 (0.48)	3.91 (0.45)
^{82m}Rb	i(m)	6.472h	-	-	-	-	-	-	-	-	-	-	1.45 (0.17)
^{77}Br	c	57.036h	-	-	-	-	-	-	-	-	-	-	2.66 (0.29)
^{75}Se	c	119.779d	-	-	-	-	-	-	0.324 (0.035)	0.448 (0.047)	1.020 (0.100)	1.10 (0.11)	2.54 (0.25)
^{74}As	i	17.77d	-	-	-	-	0.077 (0.009)	0.167 (0.023)	0.320 (0.036)	0.347 (0.042)	0.596 (0.070)	0.713 (0.091)	1.27 (0.15)
^{69m}Zn	i(m)	13.76h	-	-	-	-	-	-	-	-	-	-	0.359 (0.055)
^{65}Zn	c	244.26d	-	-	-	-	-	-	-	-	-	-	1.79 (0.17)
^{60}Co	i(m+g)	5.2714y	-	-	-	-	-	-	-	-	-	-	1.40 (0.15)
^{58}Co	i(m+g)	70.86d	-	-	-	-	-	-	-	-	0.347 (0.083)	0.623 (0.090)	1.53 (0.14)
^{56}Co	c	77.233d	-	-	-	-	-	-	-	-	0.094 (0.011)	-	0.213 (0.021)
^{59}Fe	c	44.472d	-	-	-	-	0.065 (0.006)	0.104 (0.013)	0.215 (0.020)	0.273 (0.027)	0.465 (0.055)	0.538 (0.068)	0.919 (0.092)
^{54}Mn	i	312.11d	-	-	-	-	-	-	-	0.395 (0.043)	0.687 (0.063)	0.89 (0.12)	1.95 (0.18)
^{52}Mn	c	5.591d	-	-	-	-	-	-	-	-	0.121 (0.012)	0.161 (0.021)	0.325 (0.031)
^{48}V	c	15.9735d	-	-	0.055 (0.005)	0.069 (0.007)	0.086 (0.007)	0.107 (0.011)	0.119 (0.013)	0.134 (0.016)	0.190 (0.017)	0.253 (0.038)	0.608 (0.058)
^{48}Sc	i	43.67h	-	-	-	-	-	-	-	-	0.277 (0.040)	0.423 (0.041)	0.726 (0.078)
^{46}Sc	i(m+g)	83.79d	-	-	-	-	-	-	-	0.377 (0.038)	0.848 (0.077)	1.10 (0.11)	1.77 (0.16)

^{44m}Sc	i(m)	58.61h	-	-	-	-	-	-	-	-	0.116 (0.018)	0.229 (0.026)	0.564 (0.056)
^{28}Mg	c	20.915h	-	-	-	-	-	-	-	-	0.170 (0.035)	0.321 (0.034)	0.932 (0.094)
^{24}Na	c	14.9590h	-	-	-	-	-	-	-	-	1.26 (0.12)	2.04 (0.19)	4.69 (0.44)
^{22}Na	c	2.6019y	-	-	-	-	-	-	-	-	-	0.487 (0.087)	0.770 (0.081)
^{7}Be	i	53.29d	-	-	0.396(0.058)	0.393(0.077)	0.425 (0.040)	0.64 (0.11)	1.04 (0.10)	1.42 (0.15)	2.69 (0.25)	3.77 (0.36)	8.31 (0.79)

i* - to ^{144}Pm contribution of alpha decay ^{148}Eu ($\nu = 9.4 \cdot 10^{-7}$%) ignored

4.7 ^{148}Gd production cross sections in ^{181}Ta and ^{nat}W.

Table 4.14. Parameters of ^{181}Ta irradiations..

Proton energy (MeV)	Sample weight (mg)	Monitor weight (mg)	Irradiation time (min)
2605	359.8	59.1	24.18
1599	123.6	23.9	1545
1198	355.0	59.5	2502
799	358.4	59.3	3022
599	355.5	59.2	759
399	353.0	58.5	1262

Table 4.15. Detailed calculation of ^{148}Gd production rate in ^{181}Ta to determine its cross section.

E_p, GeV	N_{tag}, (10^{21})	E_{cutoff}, keV	A, (10^{-2} pulse/s)	$\tilde{A}$,(10^{-3})	F, (10^{-5})	R, (10^{-15}/s)
2.6	1.2	1500	0.23±0.02	2.83±0.28	0.0439	1.55±0.19
1.6	0.41	1500	16.2±0.1	8.05±0.81	2.73	1.79±0.21
1.2	1.18	1500	37.9±0.1	2.87±0.29	4.42	1.91±0.25
0.8	1.19	1600	32.6±0.02	2.69±0.27	5.34	1.90±0.24
0.6	1.18	1700	4.8±0.5	2.55±0.26	1.34	1.18±0.18
0.4	1.17	1700	0.268±0.006	2.57±0.26	2.23	0.040±0.005

Table 4.16. Experimental values of ^{181}Ta(p,x)^{148}Gd reaction cross section in case of 0.4-2.6GeV protons**.**

E_p, GeV	R, (10^{-15}/s)	Φ, (10^{10}/cm^2/s)	σ, mb
2.6	1.55±0.19	7.44±0.65	21.4 ± 3.2
1.6	1.79±0.21	5.65±0.57	31.7 ± 4.8
1.2	1.91±0.25	5.12±0.37	27.7 ± 3.4
0.8	1.90±0.24	8.55±0.64	22.3 ± 2.8
0.6	1.18±0.18	7.97±0.57	14.8 ± 2.3
0.4	0.040±0.005	1.89±0.16	2.11 ± 0.28

Table 4.17. Parameters of ^{nat}W irradiations.

Proton energy (MeV)	Sample weight (mg)	Monitor weight (mg)	Irradiation time (min)
2605	256.6	59.2	24.18
1599	3.28	22.6	1545
1199	269.0	59.2	2502
799	259.0	59.8	3022
600	267.0	58.8	759
400	276.0	58.8	1262

Table 4.18 . Detailed calculation of ^{148}Gd production rate in ^{nat}W to determine its cross section..

E_p, GeV	N_{tag}, (10^{21})	E_{cutoff}, keV	A, $(10^{-2}$ pulse/s)	$\tilde{A}$, (10^{-3})	F, (10^{-5})	R, $(10^{-15}$/s)
2.6	8.41	1900	0.147±0.016	2.97±0.29	0.0509	1.16±0.20
1.6	1.07	1500	14.2±0.6	29.3±2.9	2.73	1.66±0.21
1.2	8.81	1600	18.2±0.7	3.63±0.36	4.42	1.78±0.22
0.8	8.48	1600	27.2±0.9	3.56±0.36	5.34	1.69±0.21
0.6	8.75	1750	2.70±0.32	3.16±0.32	1.34	0.69±0.09
0.4	9.04	1750	0.115±0.007	3.06±0.31	2.23	0.019±0.003

Table 4.19 Experimental values of $^{nat}W(p,x)^{148}Gd$ reaction cross section in case of 0.4-2.6GeV protons**.**

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E_p, GeV	R, $(10^{-15}$/s)	Φ, $(10^{10}/cm^2/s)$	σ, mb
2.6	1.16±0.20	6.91±0.62	16.8 ± 2.9
1.6	1.66±0.21	6.24±0.51	26.7 ± 3.4
1.2	1.78±0.22	5.00±0.36	25.7 ± 3.2
0.8	1.69±0.21	8.05±0.60	21.0± 3.0
0.6	0.69±0.09	7.82±0.56	8.78 ± 1.08
0.4	0.019±0.003	1.79±0.15	1.04 ± 0.15

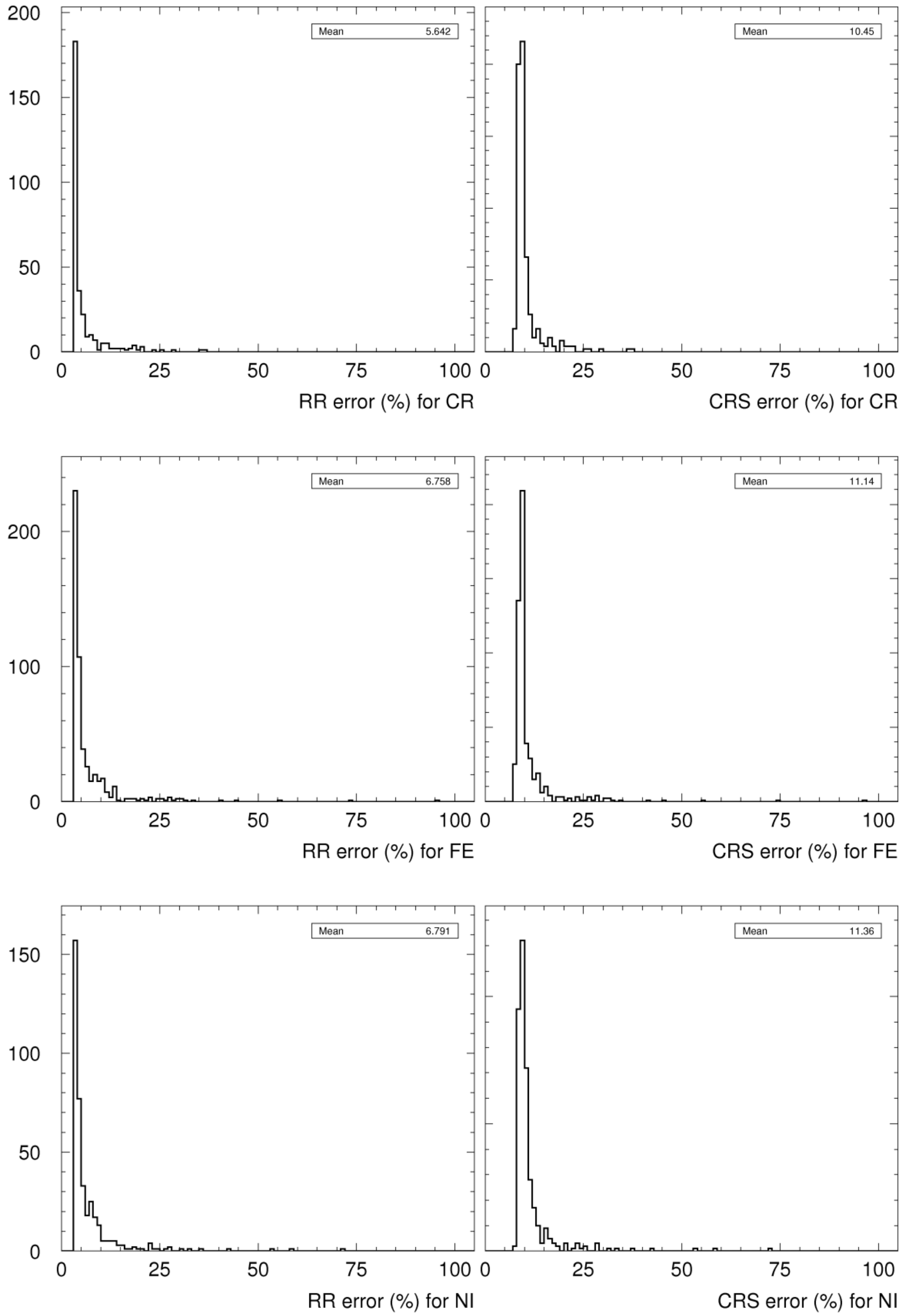

Fig. 4.1. Distributions of uncertanties of reaction rates (left) and cross sections (right) in case ^{nat}Cr, ^{56}Fe and ^{nat}N

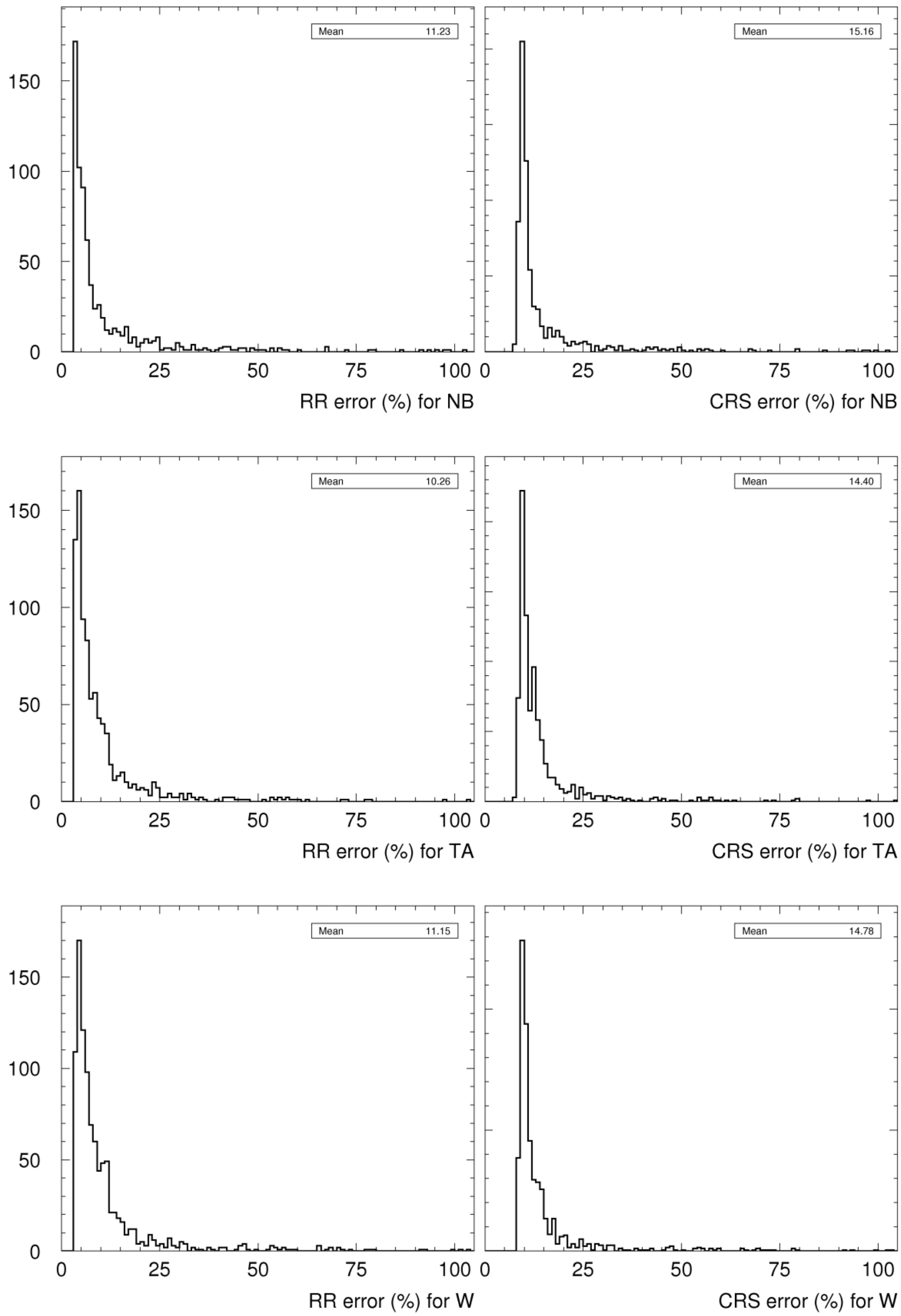

Fig. 4.2. Distributions of uncertanties of reaction rates (left) and cross sections (right) in case ^{93}Nb, ^{181}Ta and ^{nat}W.

5. DETERMINATION OF MONITOR REACTION CROSS SECTIONS

Section 2 above describes in detail the presentation formalism and, conformably, the techniques for experimental determining the cross sections of nuclear interactions-produced nuclides (the monitor reactions included) on the basis of independent measurements of reaction rates and proton flux density being determined via monitor reactions (see Subsection 2.3). In determining the cross section of monitor reaction proper, therefore, the nuclear reaction rate is also measured by γ-spectrometry techniques, whereas the proton flux density has to be determined by alternative techniques. Absolute particle flux measurements belong to the hardest experimental physics tasks. The fact is that the instruments and experimental techniques developed for the purpose are not universal. Their reliability is contingent upon the radiation source operation mode and upon experimental conditions. Any variations thereof lead to additional checkout and debugging of high-precision meters, thereby increasing time and expenditures spent to obtain the desired result. In the present work, the current transformer techniques are used as additional means to determine the proton flux density.

5.1.Determining the proton flux density by current transformer techniques

The accelerator ring-extracted proton flux density was measured with two current transformers, one (TP10) being fixed to the beam outlet circuit, while the second was a portable FCT-122-05:1-H current transformer (see Subsection 3.2 above, Fig. 3.2). According to the technical data of the latter, its frequency band upper boundary is 676 MHz, and the respective front duration 0.52 ns. The digital signal shape data of the transformers were received by a GaGe Co.-made CompuScope 85G (CS85G) board mounted on IBM PC PCI. The reference CS85G board frequency band is 500 MHz The Bergoz and CS85G frequency characteristics provide quite properly for high-quality transfer and digitization of proton bunch signals.

IBM PC together with CS85G board were housed in the accelerator control desk hall. The transformer signals are transmitted to the CS85 inputs via a few tens of meters-long coaxial cables. Fig. 5.1 is the metering equipment flowchart.

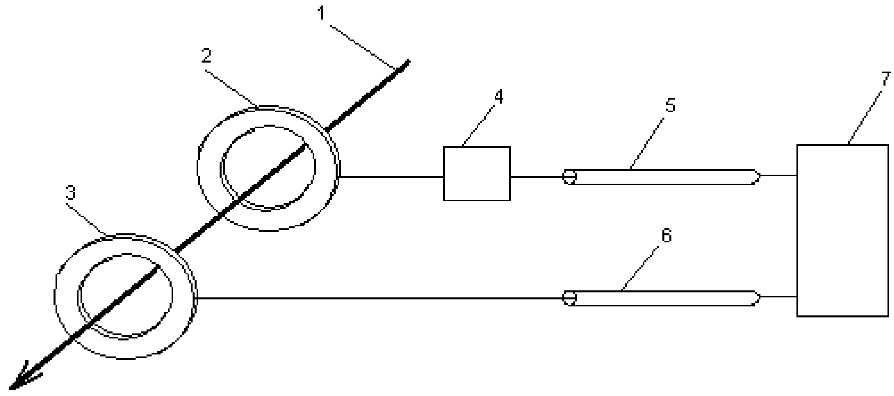

Fig. 5.1. Fast-extracted particle beam monitoring flowchart: 1 – proton beam; 2 – the fixed current transformer TP10; 3 – the FCT-122-05:1-H portable current transformer; 4 – amplifier; 5,6 – coaxial cables; 7 - CS85G board mounted into IBM PC.

Both current transformer monitoring results are presented as

1. Temporal distributions of measured current transformer readings (Figs. 5.2-5.11),
2. Summary oscillograms for each of the irradiation runs (Figs. 5.12-5.21).

The total numbers of the temporal and summary oscillograms are 52 each, which corresponds to the number of irradiation runs, although 92 samples were irradiated in total because some of the irradiation runs (40) were paired. It should be noted also that the FCT-122-05:1-H current transformer was used in far from all experiments.

The time functions F_1 and F_2 in formulas (2.8) – (2.11), (2.13) were calculated in terms of the temporal distributions of proton pulse amplitudes in each irradiation run (Figs. 5.2-5.11), while the flux density of the proton flux in irradiating each sample was calculated via summary oscillograms of each irradiation run (Figs. 5.12-5.21).

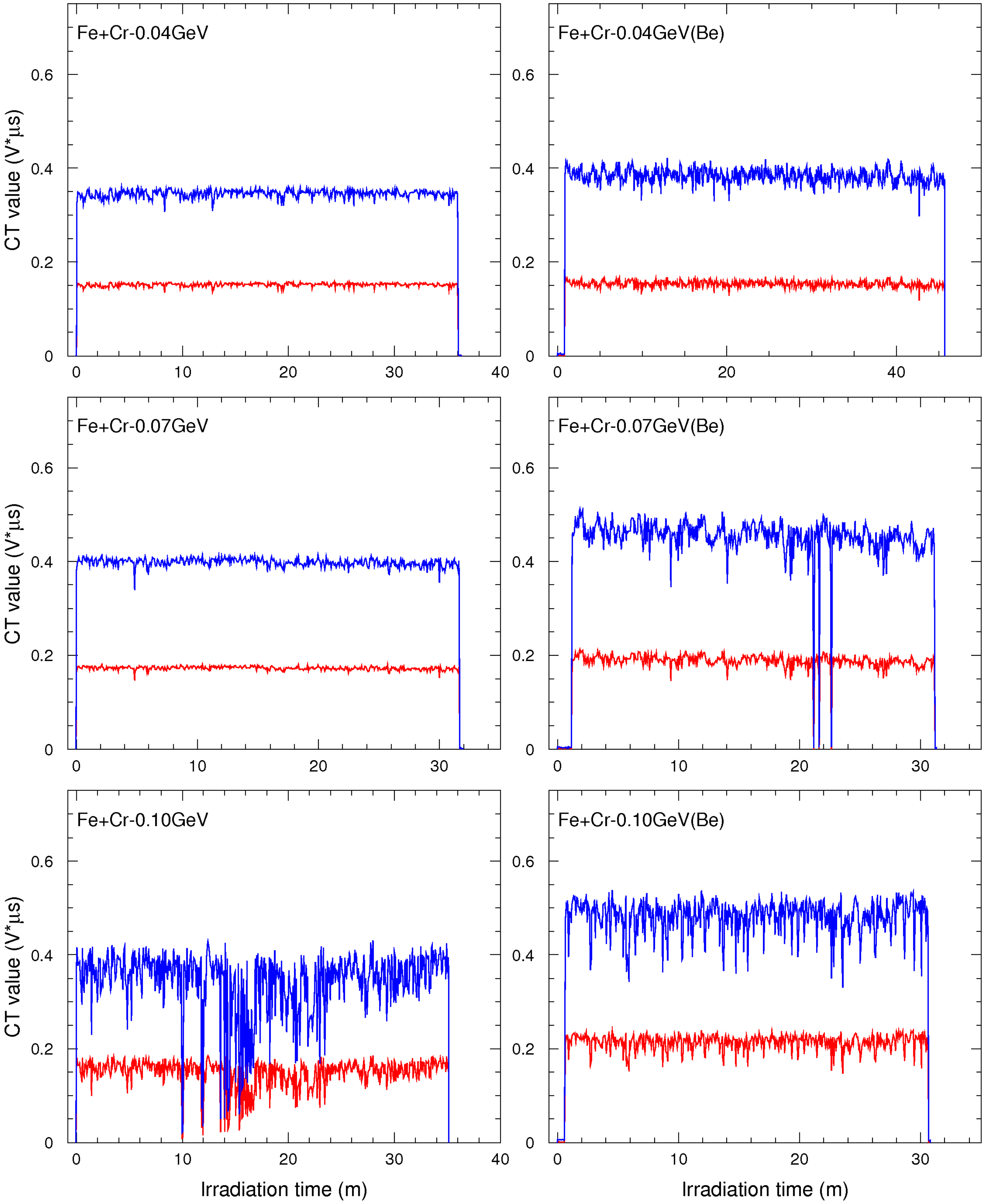

Fig. 5.2. Temporal distributions of proton beam intensity when 0.04, 0.07, and 0.1 GeV proton-irradiating Cr+Fe.

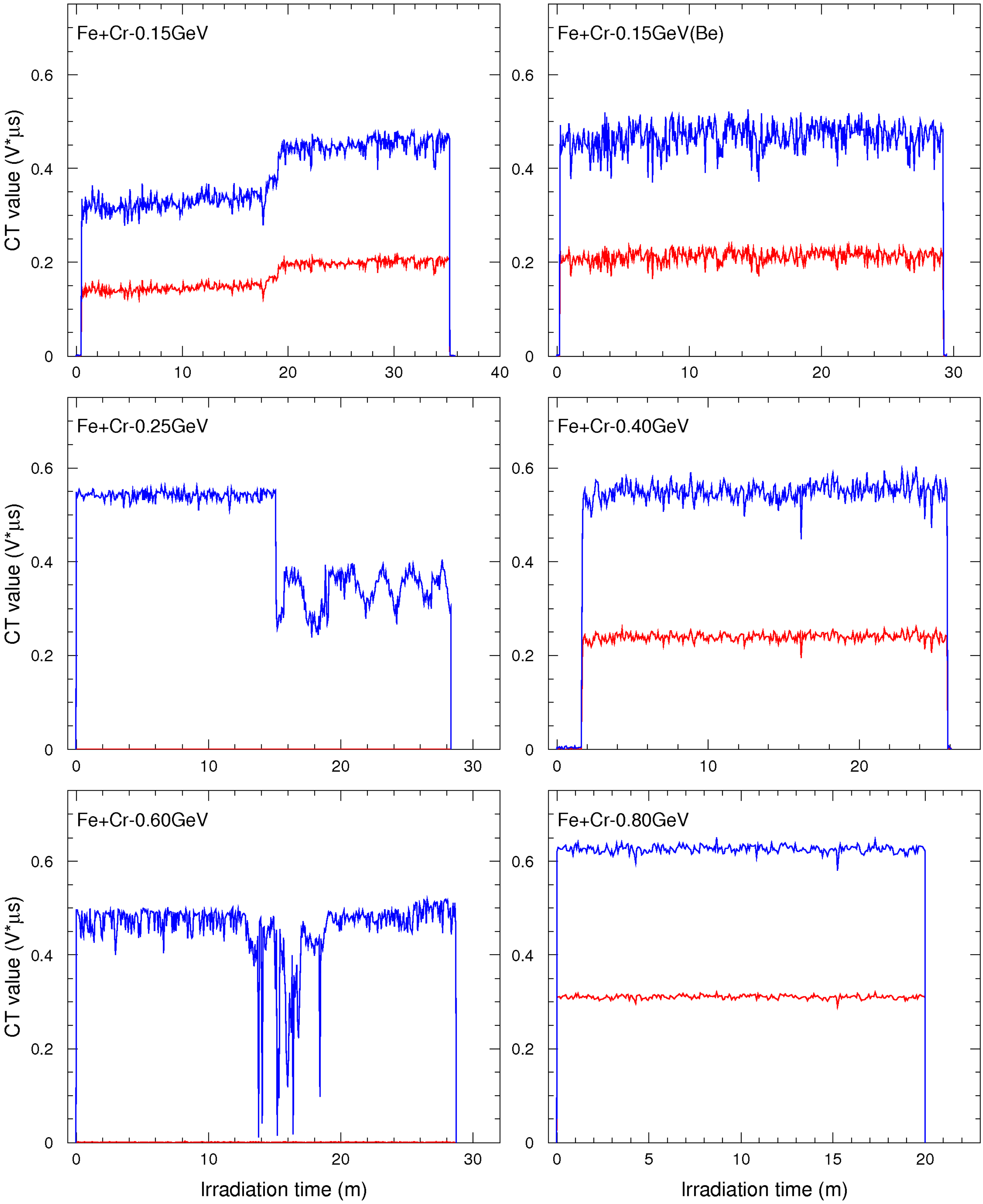

Fig. 5.3. Temporal distributions of proton beam intensity when 0.15, 0.25, 0.4, 0.6, and 0.8 GeV proton-irradiating Cr+Fe.

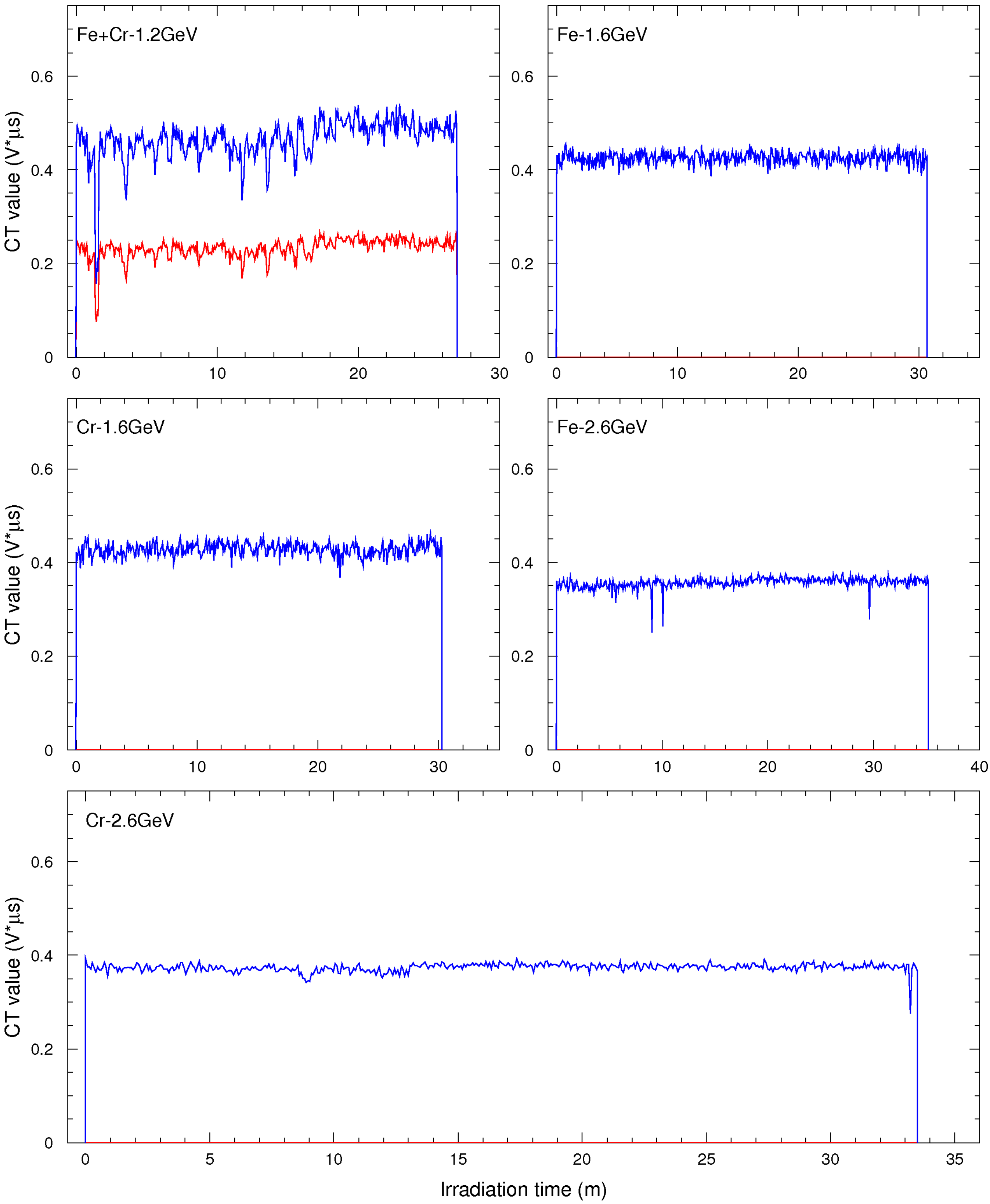

Fig. 5.4. Temporal distributions of proton beam intensity when 1.2, 1.6, and 2.6 GeV proton-irradiating Cr+Fe.

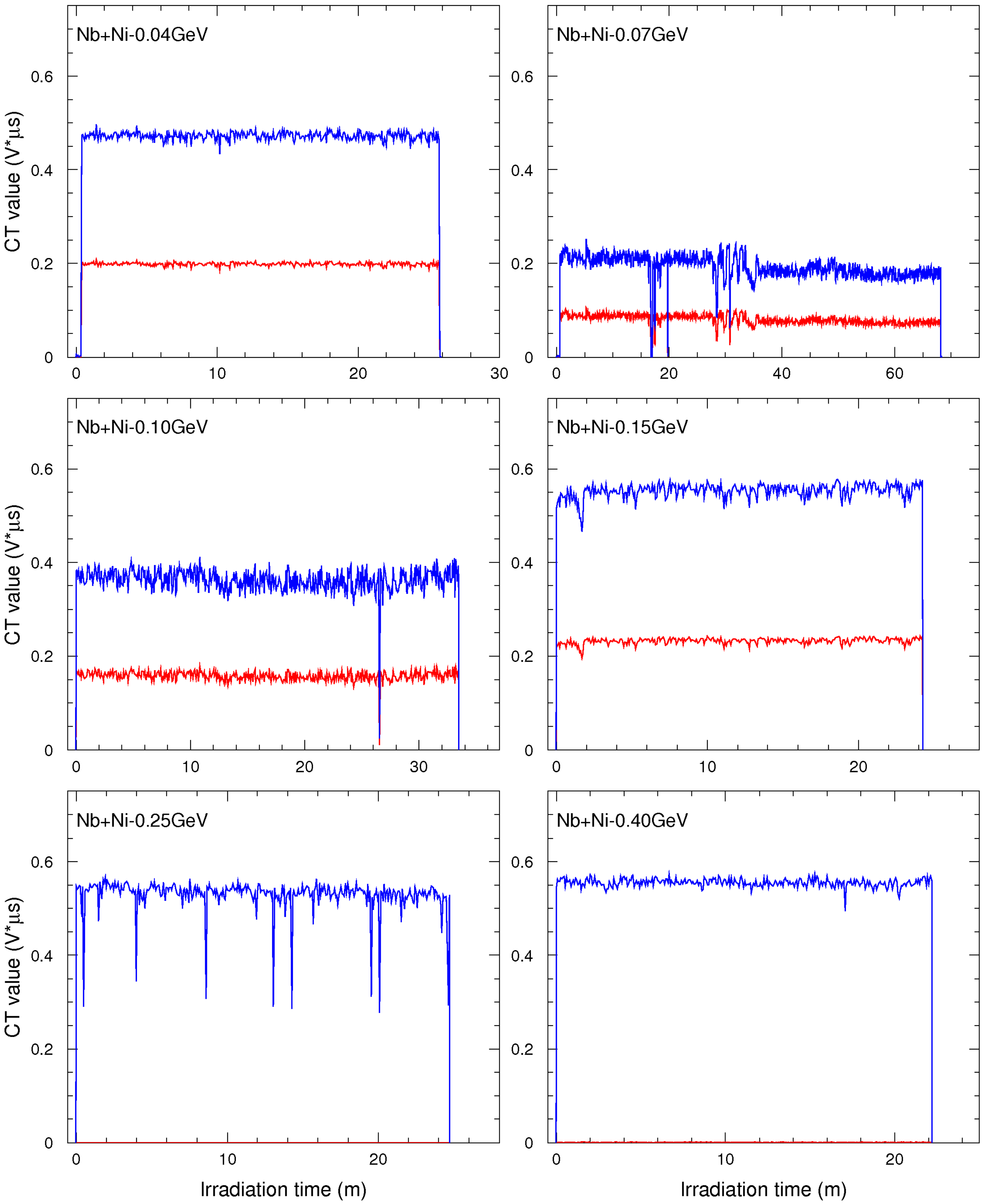

Fig. 5.5. Temporal distributions of proton beam intensity when 0.04, 0.07, 0.1, 0.15, 0.25, and 0.4 GeV proton-irradiating Ni+Nb.

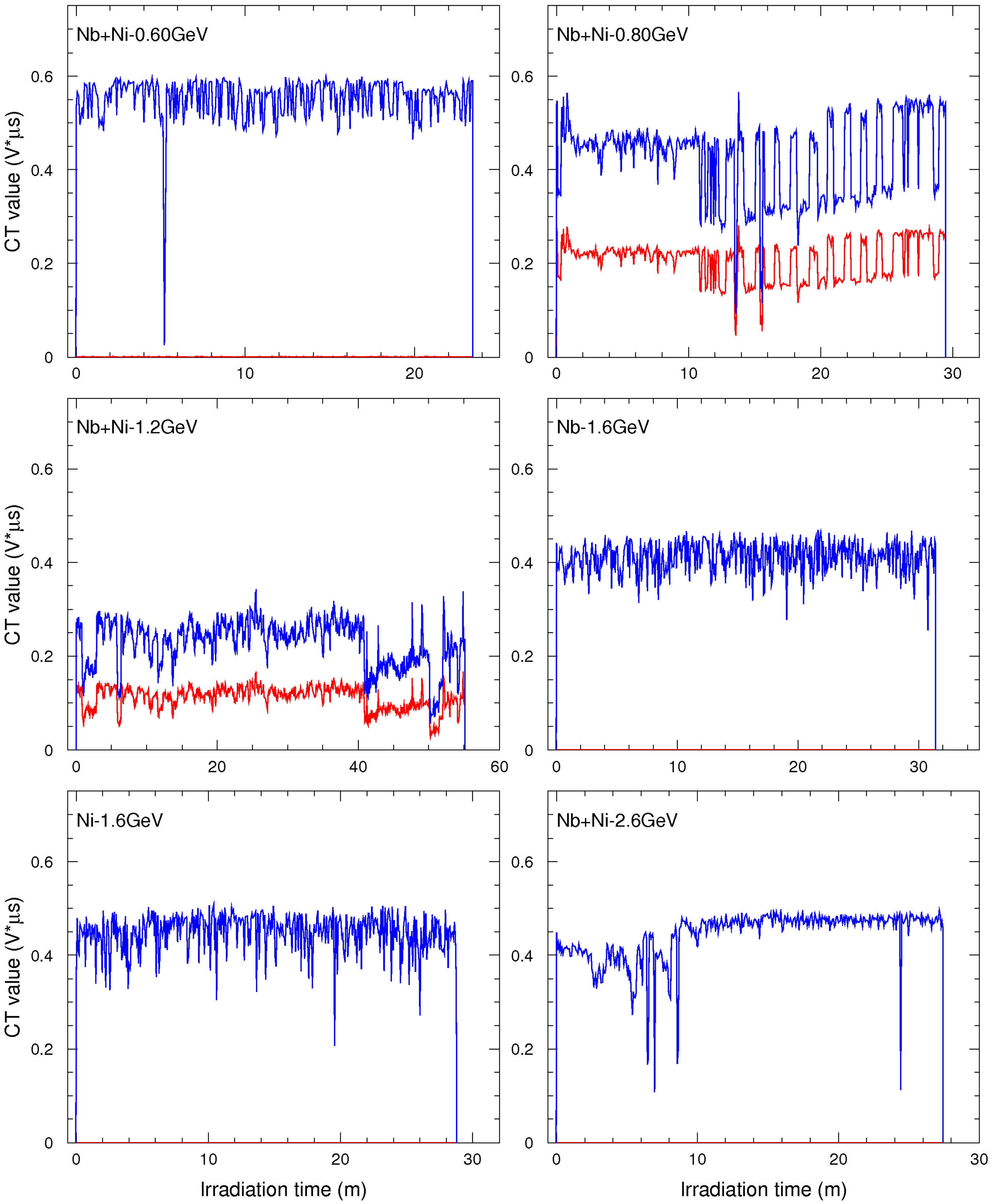

Fig. 5.6. Temporal distributions of proton beam intensity when 0.6, 0.6, 1.2, 1.6, and 2.6 GeV proton-irradiating Ni+Nb.

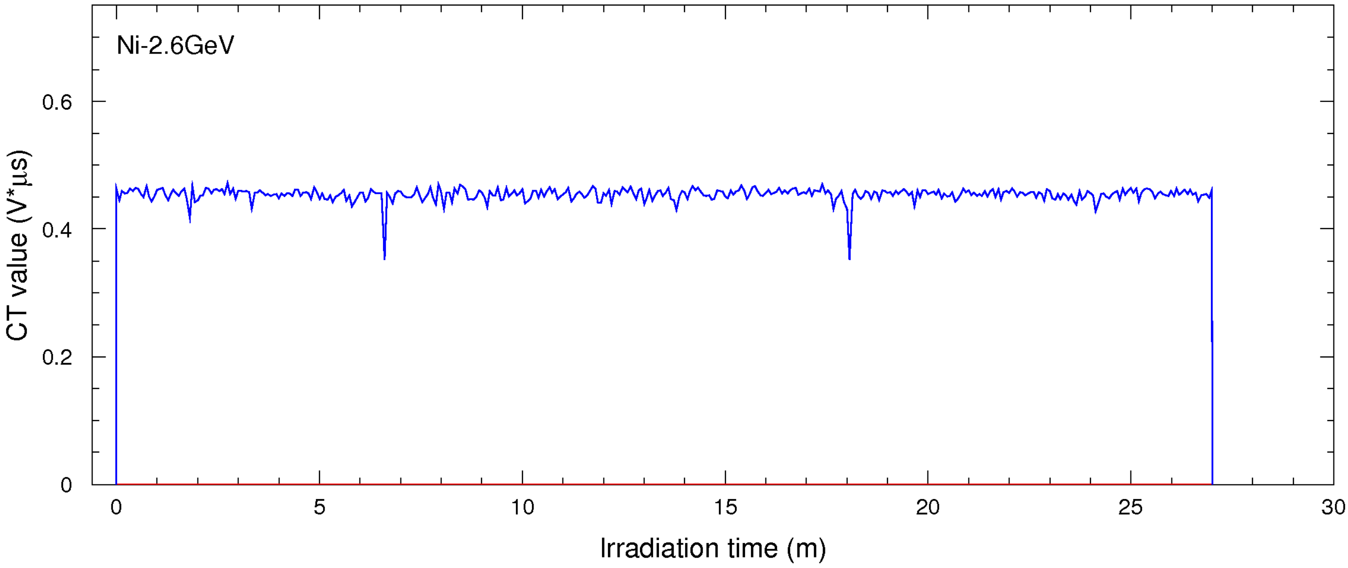

Fig. 5.7. Temporal distributions of proton beam intensity when 2.6 GeV proton-irradiating Ni.

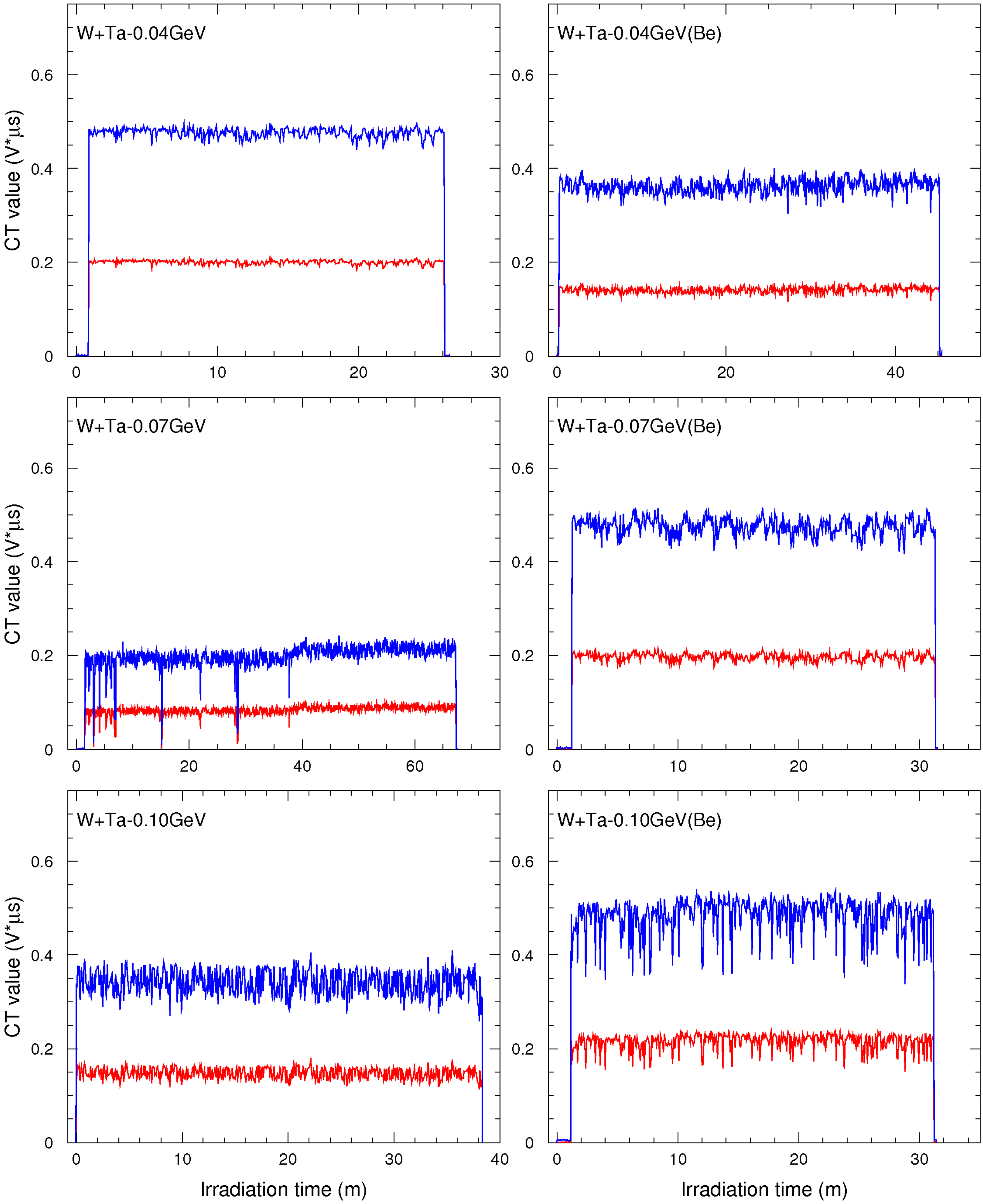

Fig. 5.8. Temporal distributions of proton beam intensity when 0.04, 0.07, and 0.01 GeV proton-irradiating Ta+W.

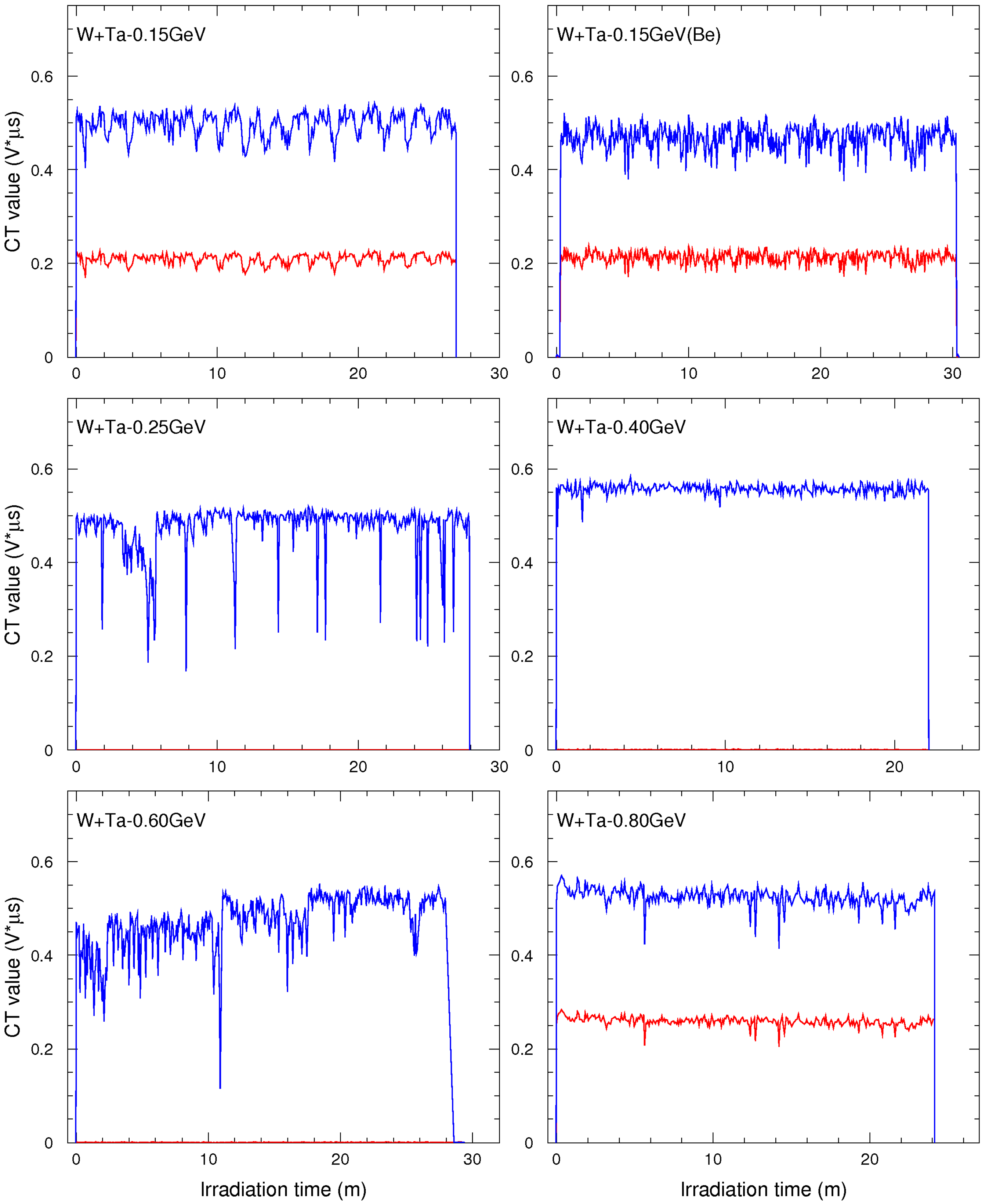

Fig. 5.9. Temporal distributions of proton beam intensity when 0.15, 0.25, 0.4, 0.6, and 0.8 GeV proton-irradiating Ta+W.

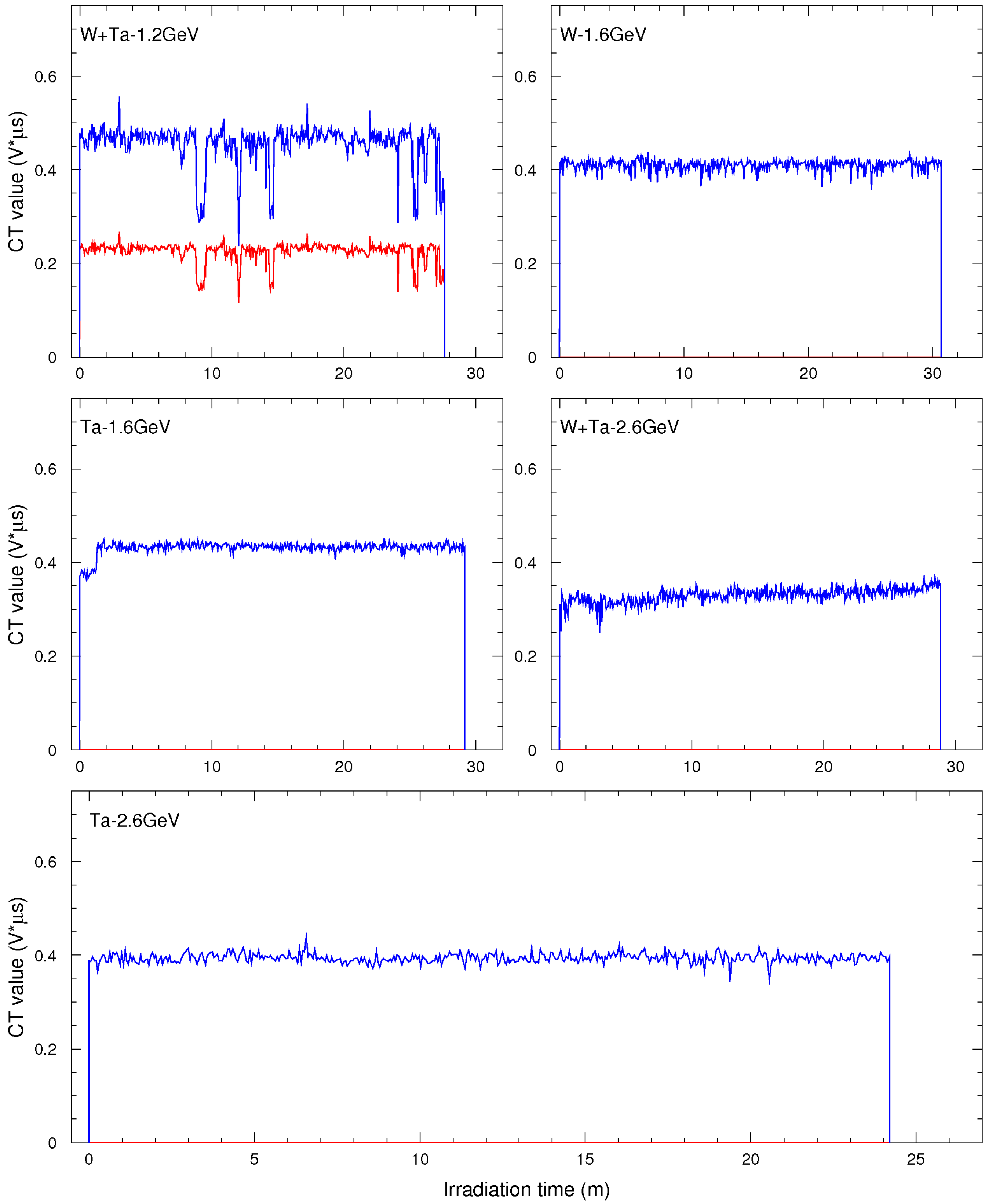

Fig. 5.10. Temporal distributions of proton beam intensity when 1.2, 1.6, and 2.6 GeV proton-irradiating Ta+W.

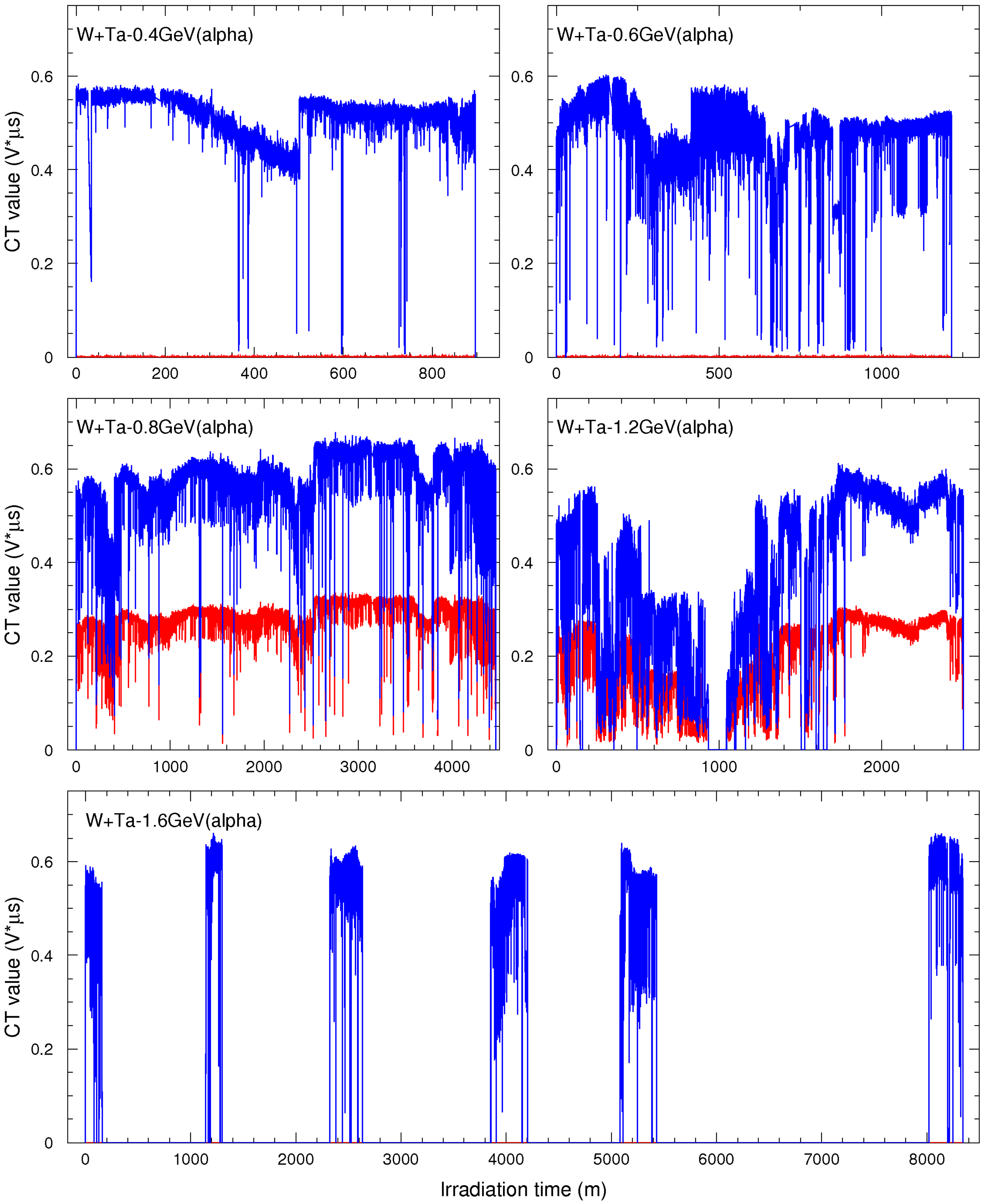

Fig. 5.11. Temporal distributions of proton beam intensity when 0.4, 0.6, 0.8, 1.2 and 1.6 GeV proton-irradiating Ta+W with a view to determine ^{148}Gd production cross sections.

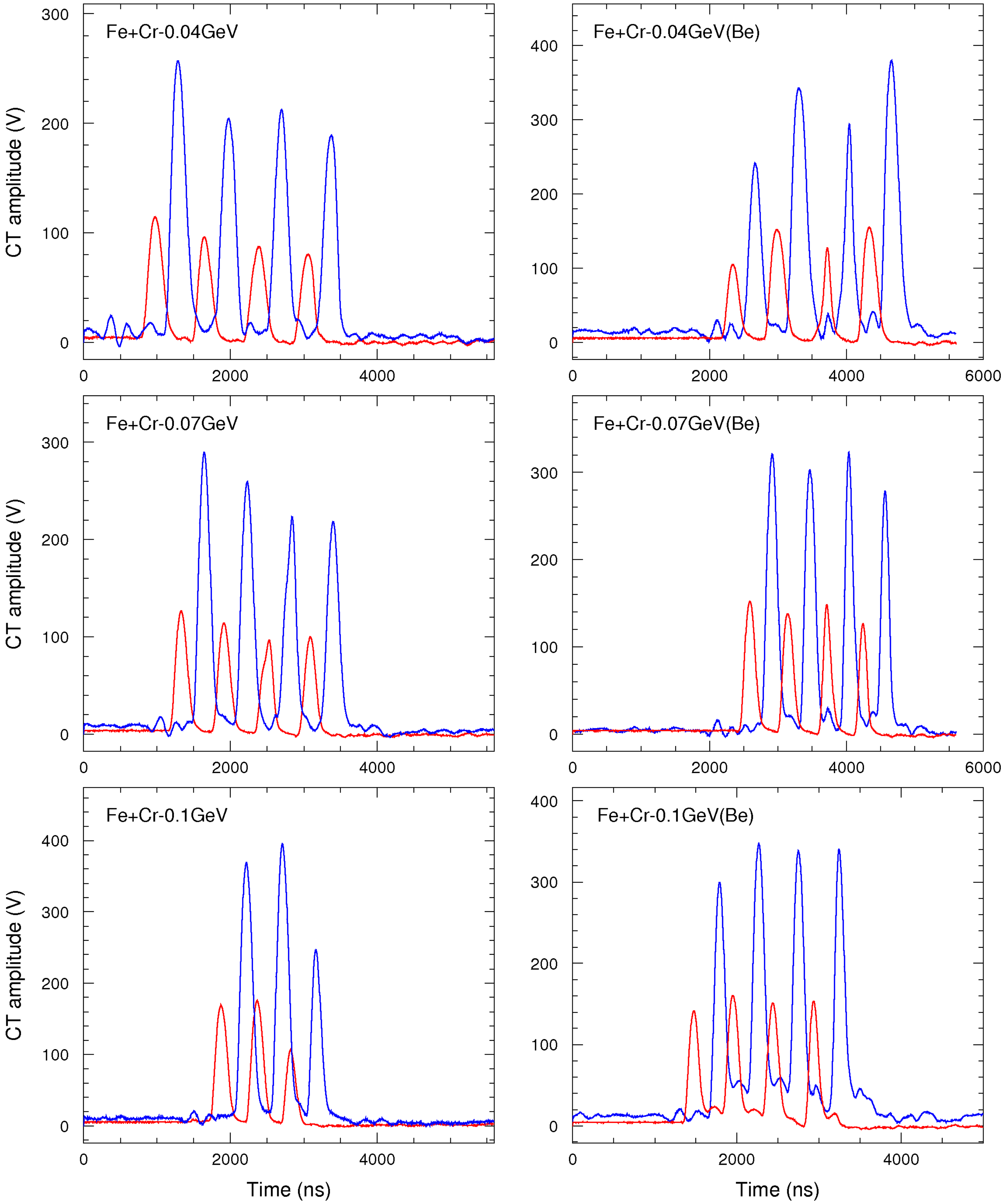

Fig. 5.12. Proton beam fine structure oscillograms when 0.04, 0.07, and 0.1 GeV proton-irradiating Cr+Fe..

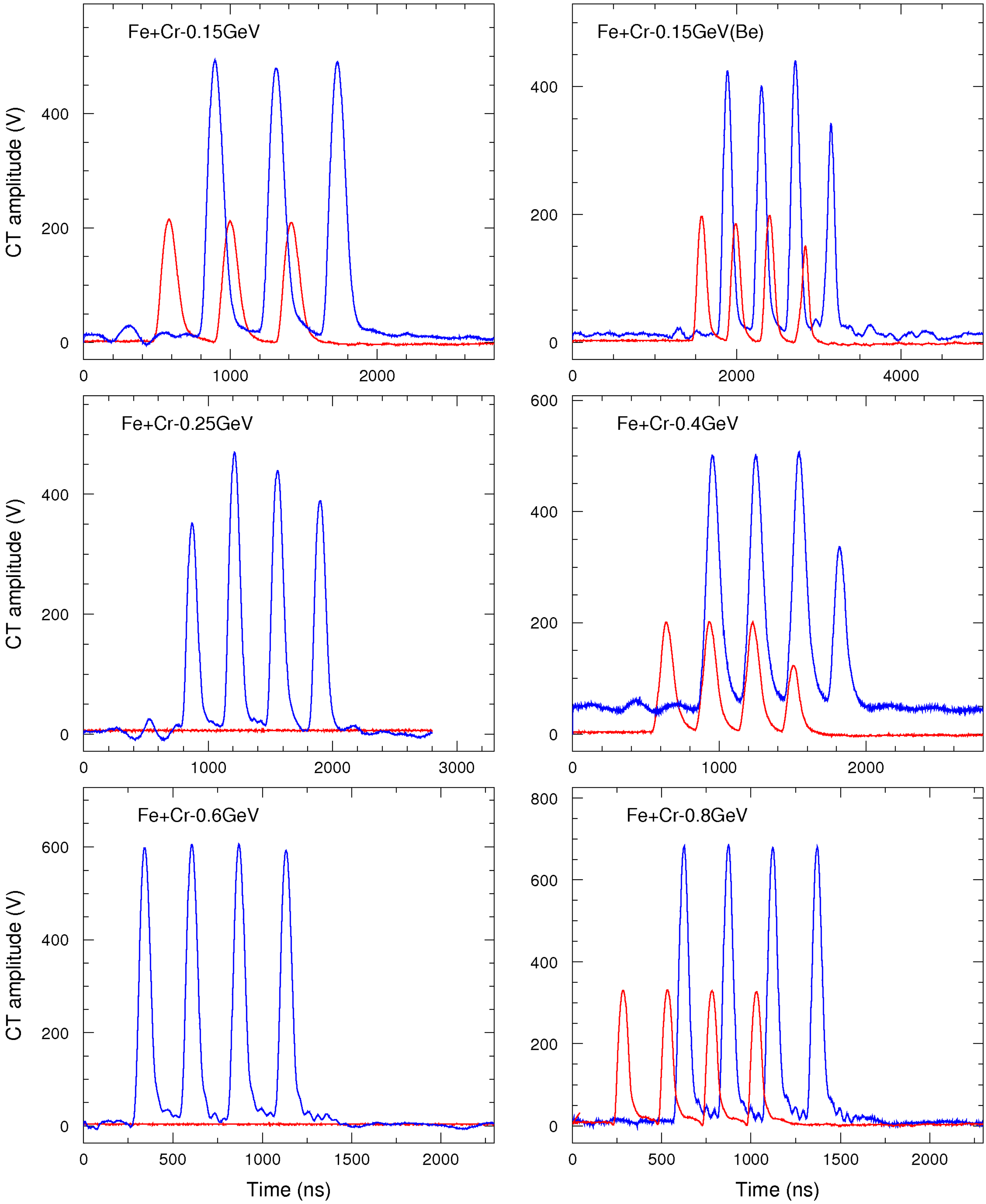

Fig. 5.13. Proton beam fine structure oscillograms when 0.15, 0.25, 0.4, 0.6, and 0.8 GeV proton-irradiating Cr+Fe.

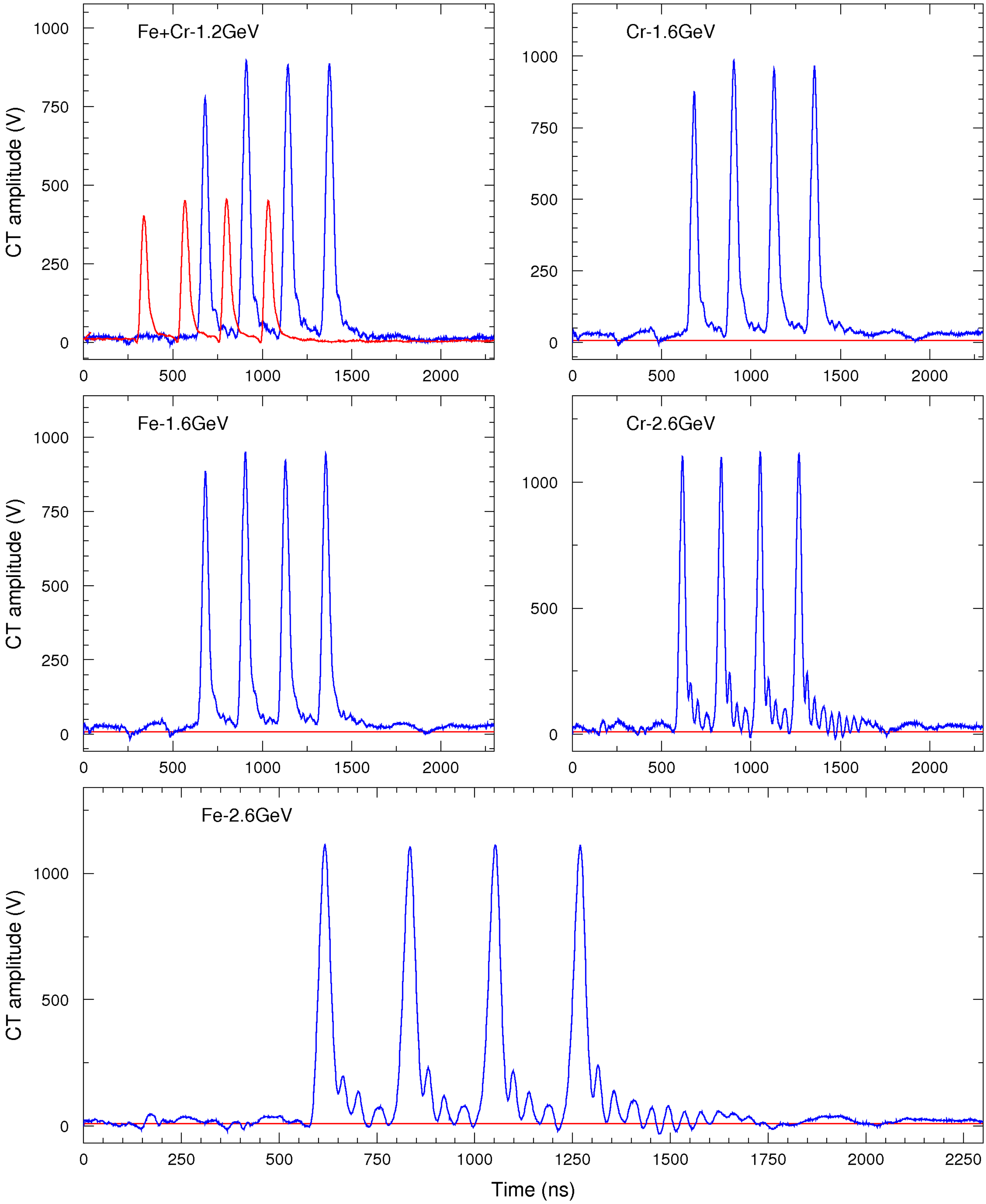

Fig. 5.14. Proton beam fine structure oscillograms when 1.6, 1.2, and 2.6 GeV proton-irradiating Cr+Fe.

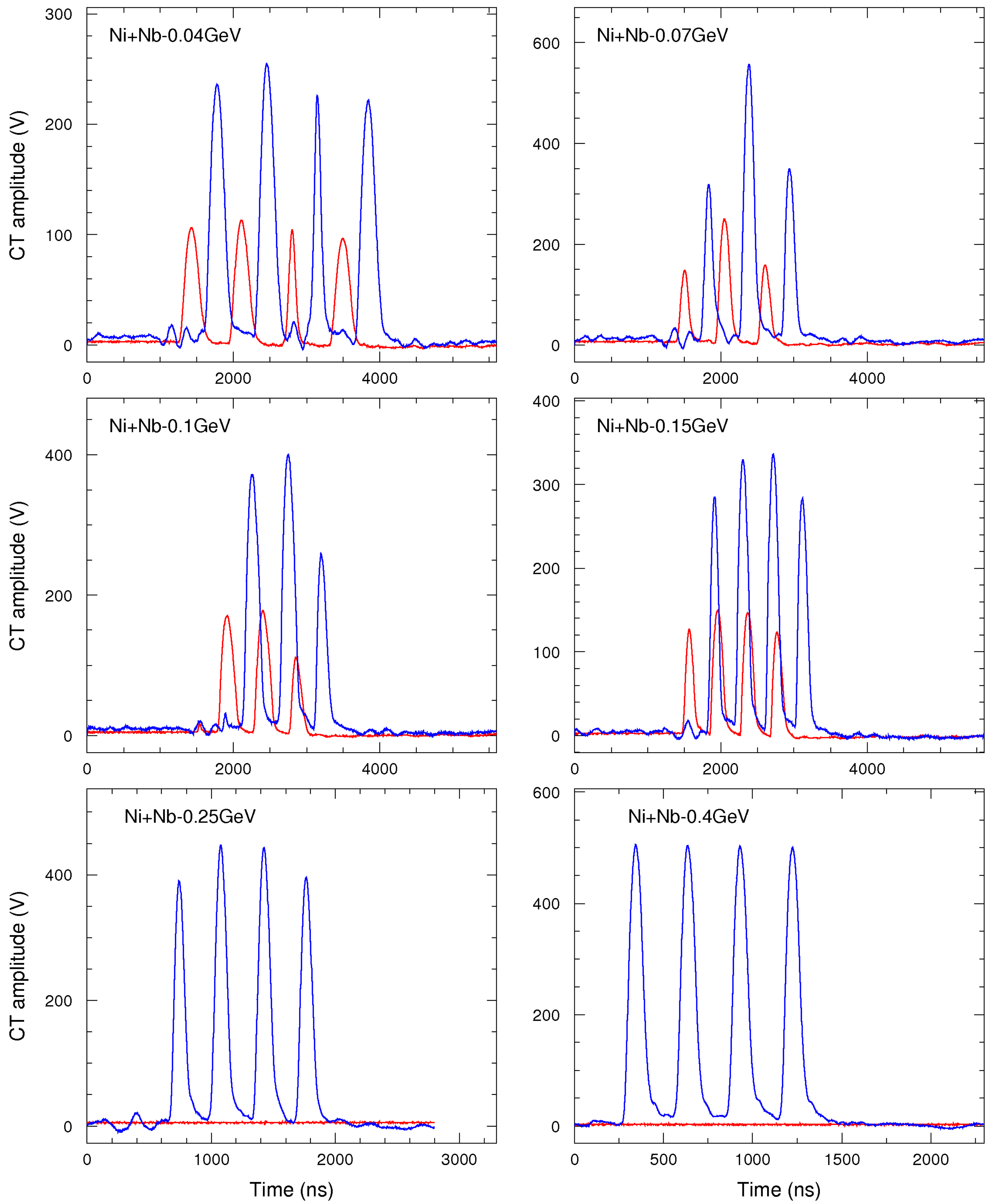

Fig. 5.15. Proton beam fine structure oscillograms when 0.04, 0.07, 0.1, 0.15, 0.25, and 0.4 GeV proton-irradiating Ni+Nb.

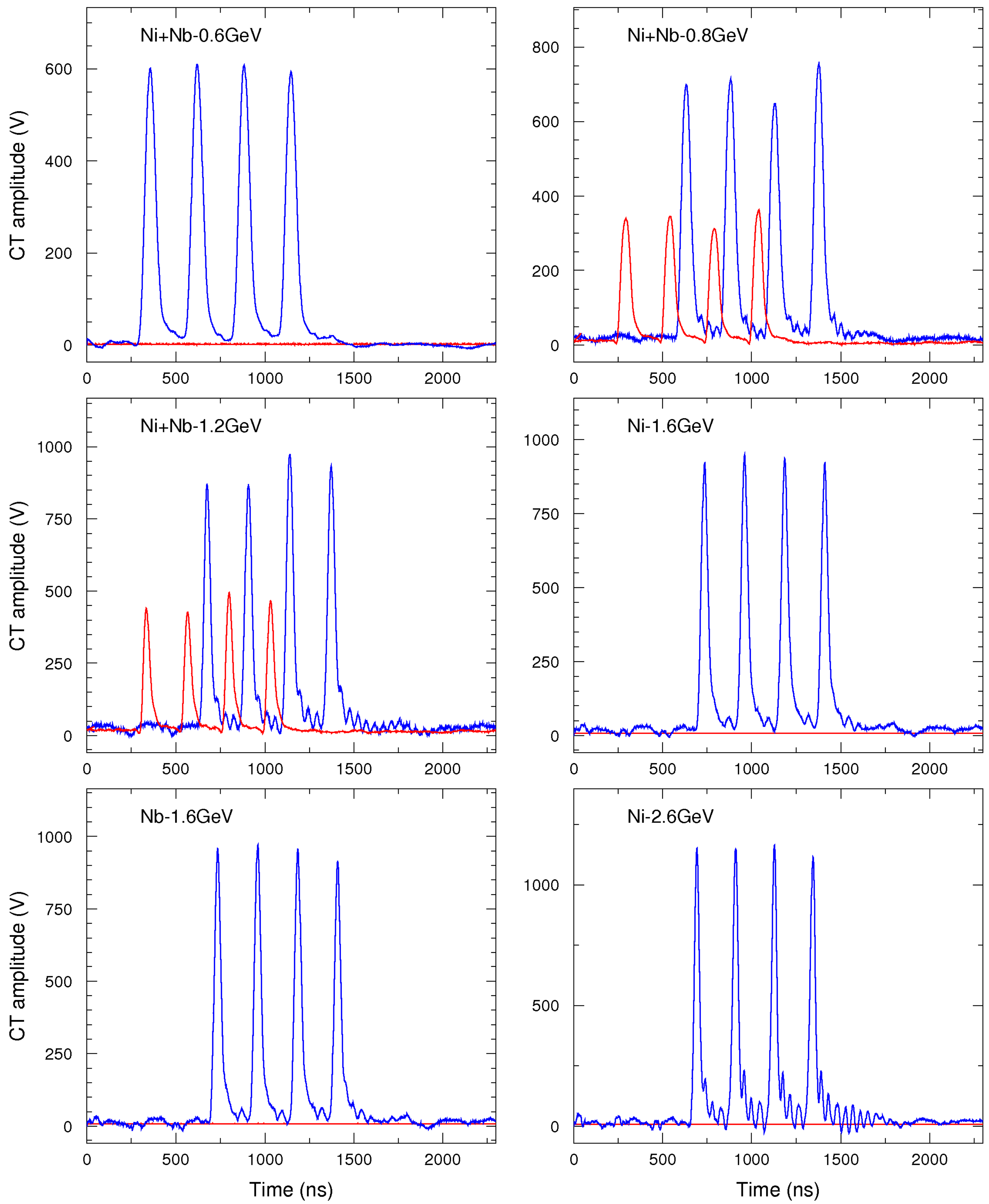

Fig. 5.16. Proton beam fine structure oscillograms when 0.6, 0.8, 1.2, 1.6, and 2.6 GeV proton-irradiating Ni+Nb.

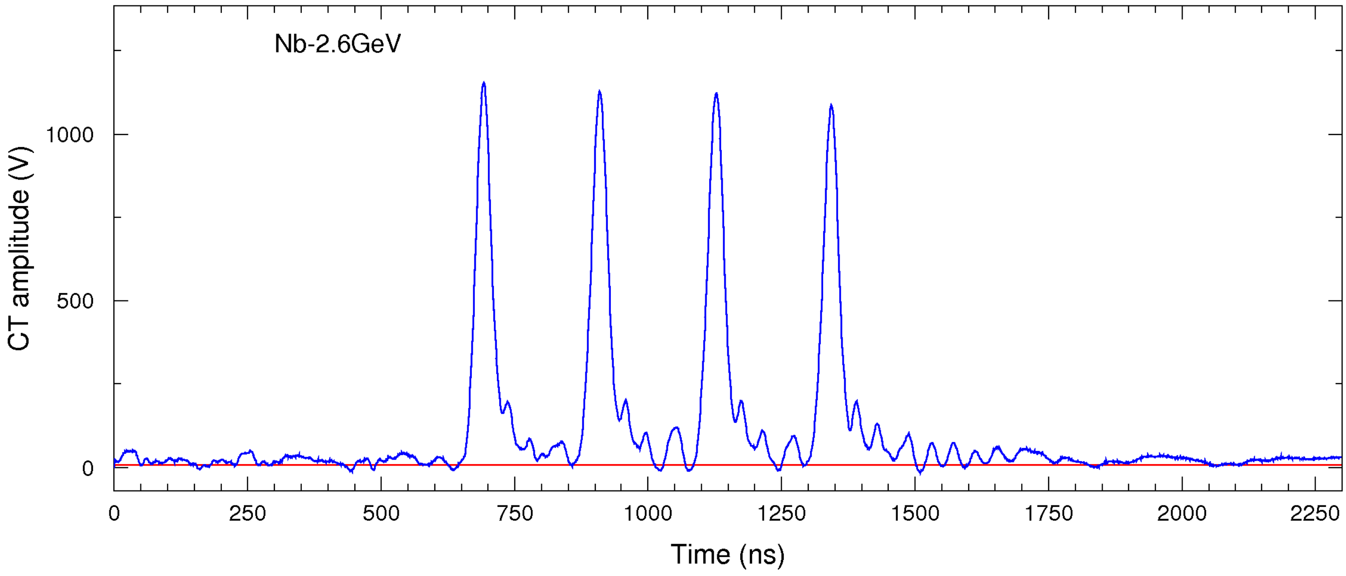

Fig. 5.17. Proton beam fine structure oscillograms when 2.6 GeV proton-irradiating Nb.

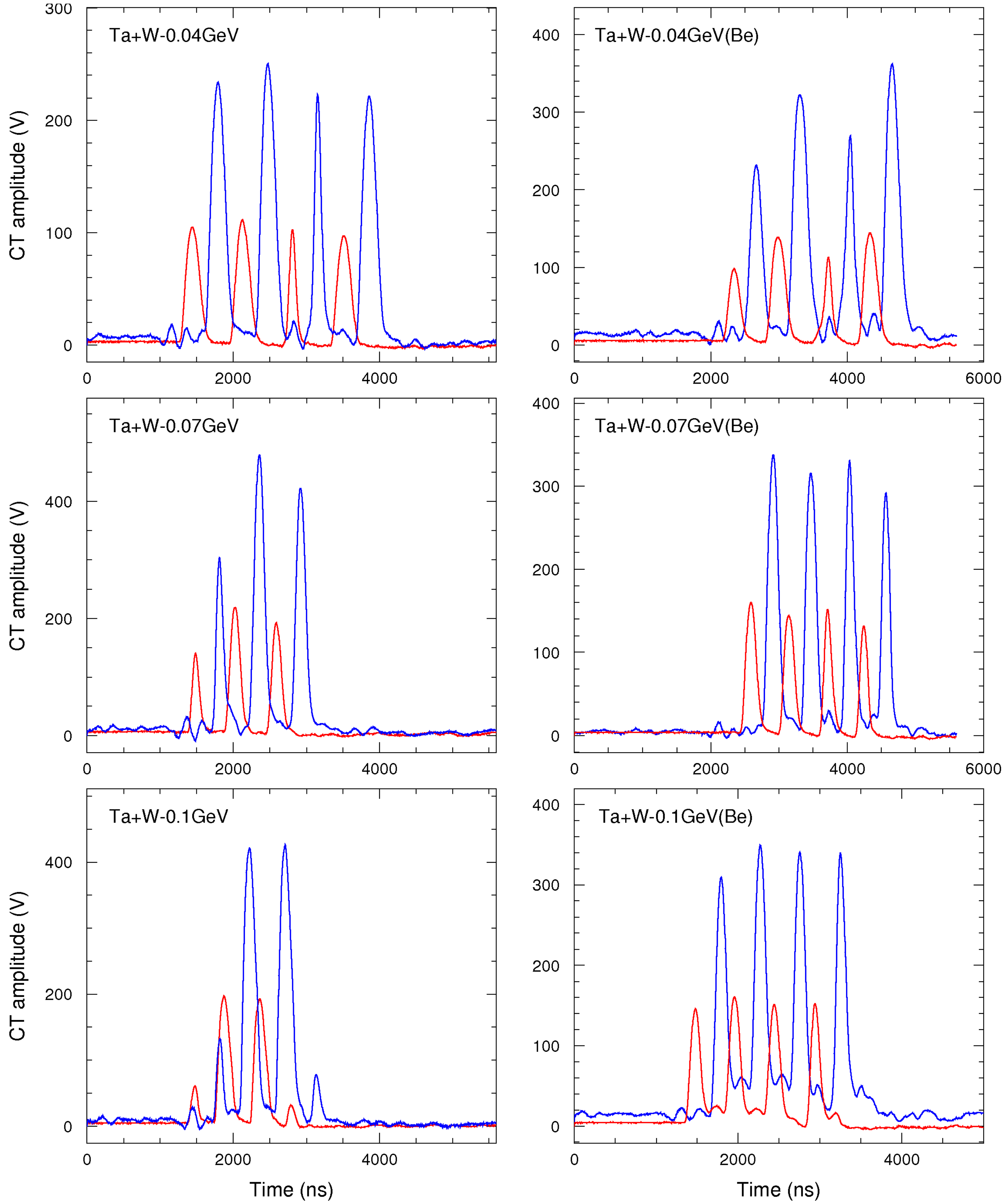

Fig. 5.18. Proton beam fine structure oscillograms when 0.04, 0.07, and 0.1 GeV proton-irradiating Ta+W.

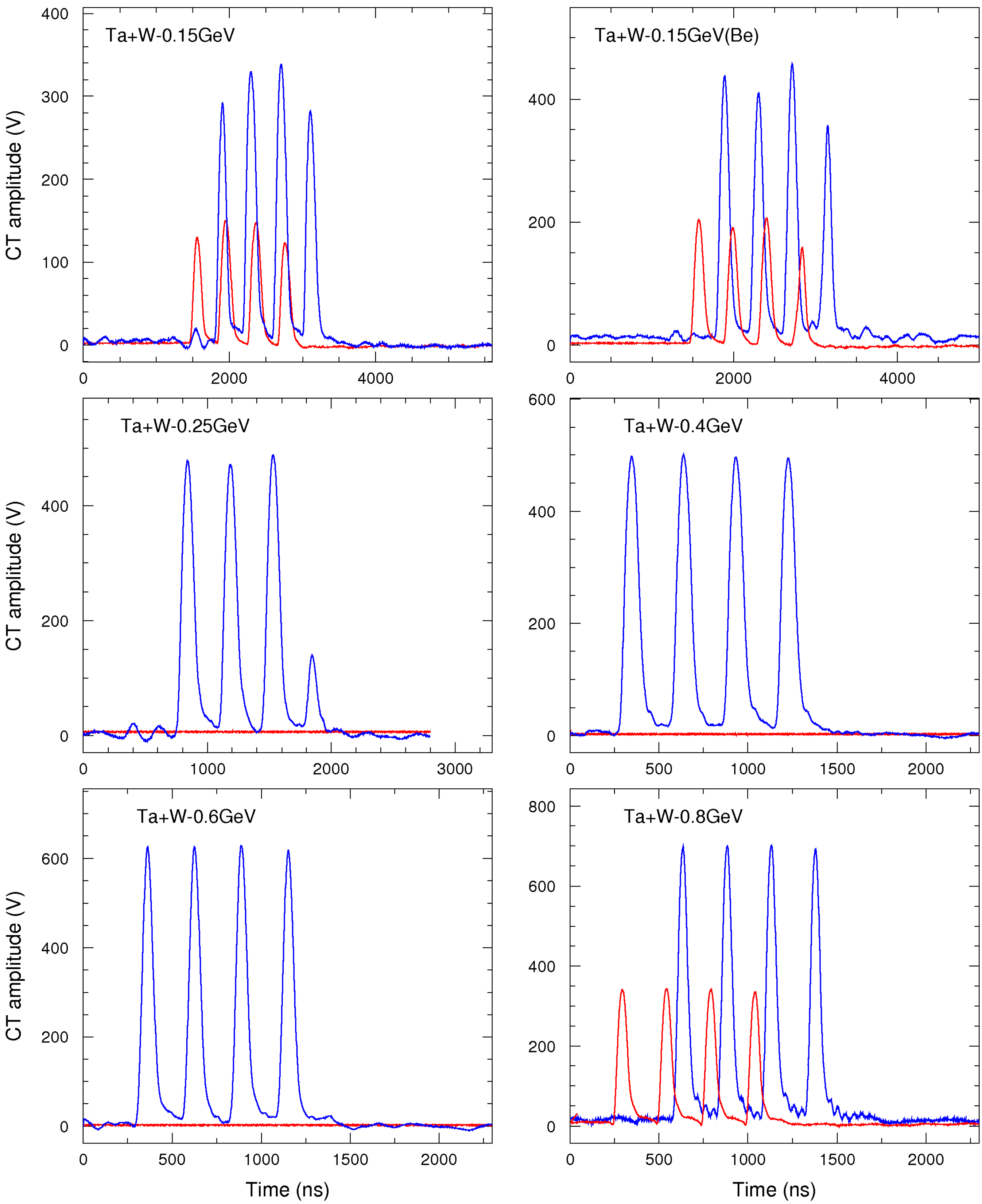

Fig. 5.19. Proton beam fine structure oscillograms when 0.15,0.25, 0.4, 0.6, and 0.8 GeV proton-irradiating Ta+W.

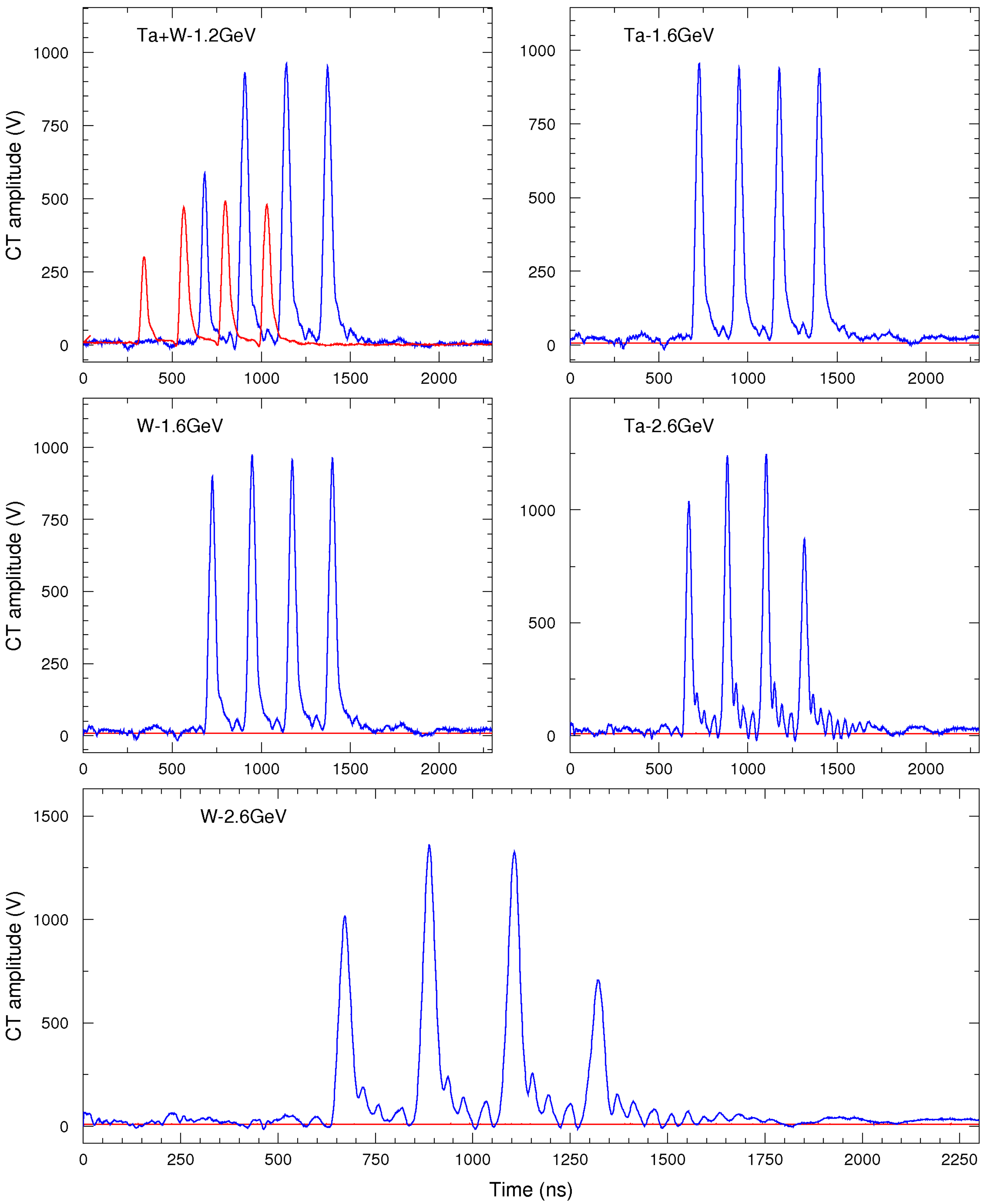

Fig. 5.20. Proton beam fine structure oscillograms when 1.2, 1.6, and 2.6 GeV proton-irradiating Ta+W.

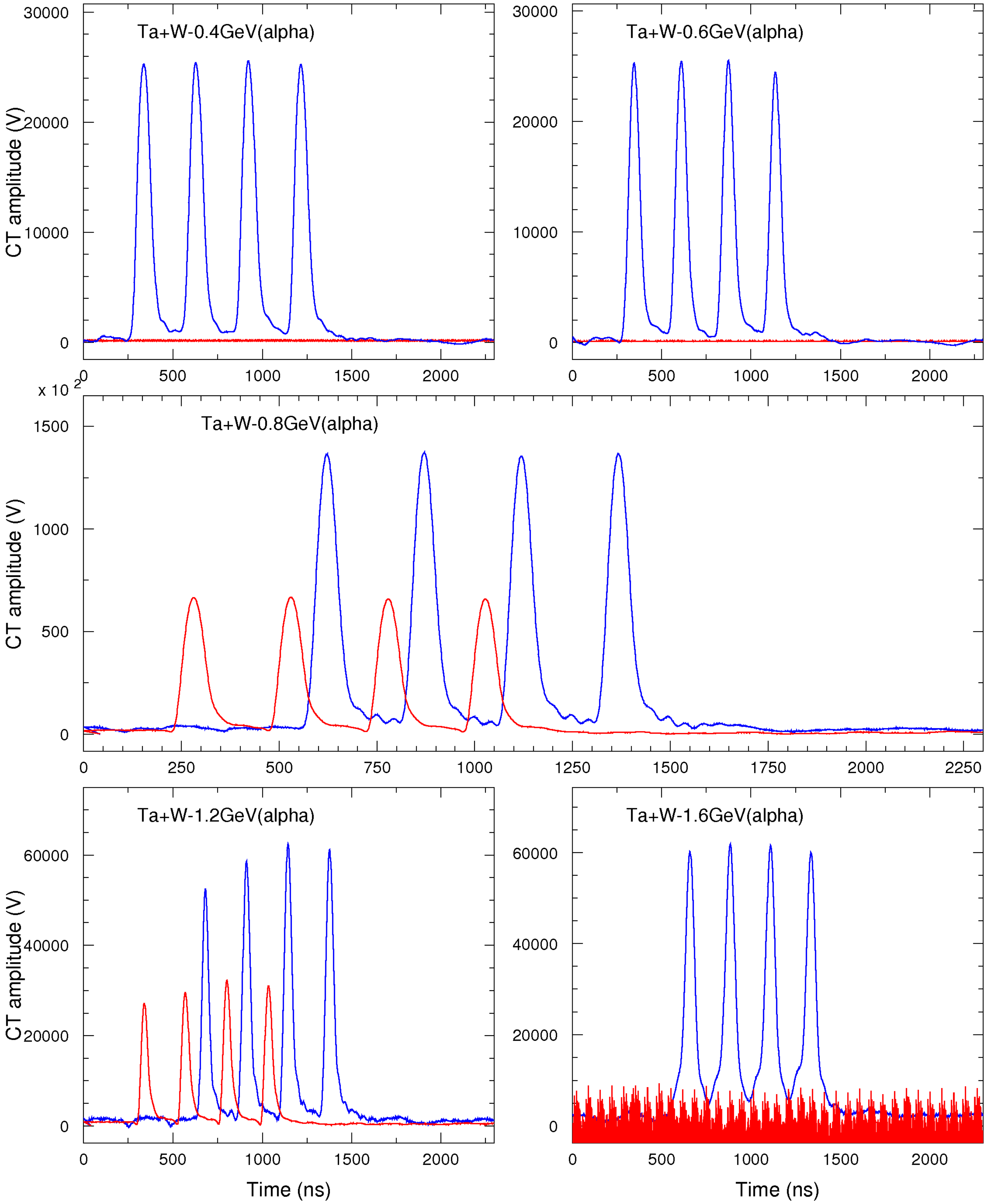

Fig. 5.21. Proton beam fine structure oscillograms when 0.4, 0.6, 0.8, 1.2, and 1.6 GeV proton-irradiating Ta+W to determine the ^{148}Gd production cross sections.

The results of summing the oscillograms of all pulses in each irradiation run were used to calculate the proton flux density as**:**

$$\Phi_{FCT} = \frac{I \cdot t \cdot k_{flux}}{K \cdot e \cdot T_{irr} \cdot S}, \tag{5.1}$$

Where *I* is the channel-by-channel sum expressed in the pulses of summary oscillograms, V: *t* is the oscillogram (digitization) channel width, s; k_{flux} is the 10.5-mm diameter monitor-traversed -to-72x72-mm plate-traversed proton number ratio; *K* is the current transformer signal conversion factor, V/A; *e* is elementary charge; T_{irr} is irradiation time, s; *S* is the monitor cross-section area, cm^2.

The flux density error was determined as

$$\frac{\Delta\Phi_{FCT}}{\Phi_{FCT}} = \sqrt{\left(\frac{\Delta I}{I}\right)^2 + \left(\frac{\Delta t}{t}\right)^2 + \left(\frac{\Delta k_{flux}}{k_{flux}}\right)^2 + \left(\frac{\Delta K}{K}\right)^2 + \left(\frac{\Delta S}{S}\right)^2}, \tag{5.2}$$

The cannel-by-channel sums were calculated as

$$I = \sum_{i=T_2+1}^{T_3-1} V_i - \sum_{i=T_1}^{T_2} V_i \frac{T_{peak}}{2 \cdot T_{left}} - \sum_{i=T_3}^{T_4} V_i \frac{T_{peak}}{2 \cdot T_{right}} \tag{5.3}$$

Where *Vi* is the oscillograph-measured amplitude within the i-th time interval; $T_{peak} = T_3 - T_2 - 1$; $T_{left} = T_2 - T_1 + 1$; $T_{right} = T_4 - T_3 + 1$; T_1, T_2, T_3, T_4 are the oscillogram partition points (see Fig. 5.2).

In calculating the channel-to-channel sums, the constant component was estimated from the left- and right-hand oscillogram sides. The error in the channel-to-channel sums is calculated as

$$\Delta I = \sqrt{\left(\frac{T_{peak}}{2 \cdot T_{left}}\right)^2 \cdot \Delta_{left}^2 + \sum_{i=T_2}^{T_3} \Delta V_i^2 + \left(\frac{T_{peak}}{2 \cdot T_{right}}\right)^2 \cdot \Delta_{right}^2} \tag{5.4}$$

$$\Delta_{left} = \sqrt{\sum_{i=T_1}^{T_2} \left(V_i - \overline{V}_{left}\right)^2} \tag{5.5}$$

$$\Delta_{ritht} = \sqrt{\sum_{i=T_3}^{T_4} \left(V_i - \overline{V}_{right}\right)^2} \tag{5.6}$$

Where Δ_{left} and Δ_{right} are the error in the left and right-hand oscillogram sides, respectively.

In this case,

$$\overline{V}_{left} = \frac{\sum_{i=T_1}^{T_2} V_i}{T_{left}} \qquad \overline{V}_{right} = \frac{\sum_{i=T_3}^{T_4} V_i}{T_{right}} \tag{5.7}$$

The charged particle flux portion through a monitor is determined by finding the ratio of the ^{24}Na production rate in the "large" monitor, where the beam cross section gets overlapped, to that in the "small" monitor, whose cross section corresponds to that of the experimental sample.

5.2. The monitor reaction cross sections and their errors

After using formulas (2.8) to determine the monitor nuclear reaction rates in Al samples irradiated and on current transformer-aided calculating the proton flux density, the sought monitor cross section and its error were calculated as

$$\sigma_{st}^{cum/ind} = \frac{R_{st}^{cum/ind}}{\hat{\Phi}_{FCT}} \qquad \frac{\Delta\sigma_{st}^{cum/ind}}{\sigma_{st}^{cum/ind}} = \sqrt{\left(\frac{\Delta R_{st}^{cum/ind}}{R_{st}^{cum/ind}}\right)^2 + \left(\frac{\Delta\hat{\Phi}_{FCT}}{\hat{\Phi}_{FCT}}\right)^2} \qquad (5.8)$$

Where $\sigma_{st}^{cum/ind}$ is the monitor reaction cross section; $R_{st}^{cum/ind}$ is the monitor reaction rate; $\hat{\Phi}_{CT}$ is the current transformer-measured proton flux density.

5.2.1. Calibration of current transformers

The calibration aimed to experimentally determine the signal transformation coefficients - *K*(V/A) for the TP10 and FCT-122-05:1-H current transformers.

The current transformers monitoring system was calibrated given the conditions closest to those of proton beam monitoring. The two transformers were placed just where they were during irradiations (when monitoring proton fluxes), while the signals therefrom are transferred via the same cables to the CS85G plate placed in the accelerator console room.

The calibration was made via the conductor passing through a current transformer ring. For the purpose, a charge pulse generator was manufactured (see Fig. 5.22). Its operations were as follows. The capacitor was charged through the charging resistor 2 up to voltage V of source 1 within less than 1 µs. As the mercury magnetically operated sealed contact 5 was circuited, the capacitor got charged within ~150 ns through resistor 4 and a conductor that transpierces the current transformers. In such a way, the charge

$$q=C\cdot U \qquad (5.9)$$

(C is the discharge capacitor capacitance) is transferred through the transformers.

The parameters of the condenser and resistor 4 were selected so that the discharge signal oscillations were avoided and the duration of discharge signal was close to that of proton bunch signals.

Fig. 5.23 shows the shapes of the pulses from discharge generator and from different-energy proton bunches.

Irradiations were made under different CS85G plate operation modes, so the calibration was made for each of the modes separately within series of a hundred discharge generator pulses each. The data obtained were online accumulated in PC and processed then via formula (5.3). After that, the sensitivity coefficient *K* was calculated for each of the CS85G operation modes as

$$K = \frac{I \cdot t}{q}, \text{ where} \qquad (5.10)$$

I is the channel-by-channel sum expressed in the pulses of summary oscillograms, as calculated via (5.3), *t* is the oscillogram (digitization) channel width, q – charge through current transformer, as calculated via (5.9),

The error *ΔK* was calculated as

$$\Delta K = \sqrt{\frac{\sum_{1}^{n}\left(I - \bar{I}\right)^2}{n(n-1)}}$$

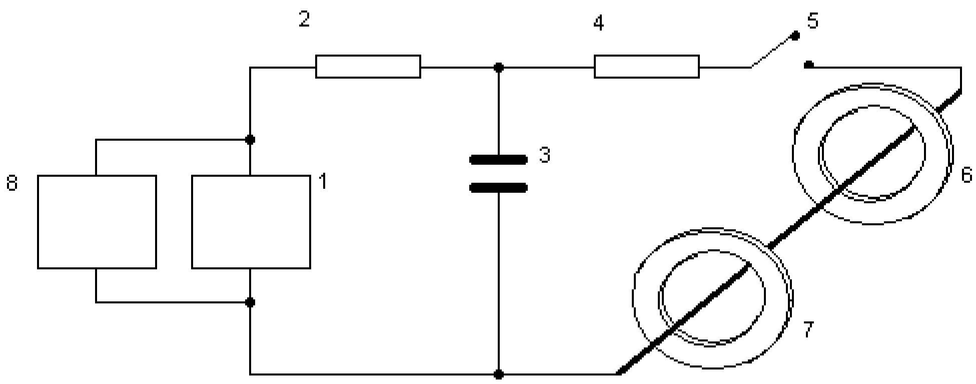

Fig. 5.22. Charge pulse generator circuit: 1 – voltage source, 2 – 300-kOhm resistor, 3 – discharge condenser C = 1357 pF, 4 – 50-Ohm resistor, 5 – mercury magnetically operated sealed contact, 6,7 – current transformers, 8 – digital voltmeter.

Table 5.1 presents the results of determining the sensitivity coefficients *K* of the current transformers for different CS85G plate operation modes. The *K* values shown in Table 5.1 were used to calculate the proton flux density from formula (5.1).

Table 5.1.

The current transformer sensitivity coefficients *K* measured (the first column shows the CS85G digitization frequency, and the second column the maximum signal in the measurement channel)

CS85G mode		FCT-122-05:1-H in channel «A»		FCT-122-05:1-H in channel «B»	
f, GHz	scale, V	**K, (V/A)**	**ΔK, (V/A)**	**K, (V/A)**	**ΔK, (V/A)**
0.5	0.2	4.186	0.003	4.219	0.002
0.5	0.5	4.207	0.004	4.224	0.003
0.5	1	4.230	0.006	4.230	0.005
1	0.2	4.159	0.002	4.190	0.002
1	0.5	4.186	0.003	4.186	0.004
1	1	4.205	0.005	4.197	0.006

CS85G mode		TP10 in channel «A»		TP10 in channel «B»	
F, GHz	scale, V	**K, (V/A)**	**ΔK, (V/A)**	**K, (V/A)**	**ΔK, (V/A)**
0.5	0.5	8.988	0.004	9.031	0.003
0.5	1	9.035	0.005	9.035	0.004
0.5	2	8.970	0.008	9.032	0.008
1	0.5	8.825	0.003	9.035	0.003
1	1	8.871	0.004	9.032	0.004
1	2	8.849	0.006	9.022	0.006

5.3. Errors in determining the proton flux density

Table 5.1 shows that, given each of the CS85G plate operation modes, the statistic fluctuations arisen from the CS85G plate noise do not exceed 0.1% of *K* values when averaged over 100 pulses. During irradiation runs, some 1000 bunches were recorded as a minimum, so the statistical fluctuations contributed but negligibly to the *K* error and were disregarded afterwards.

The *K* value determination accuracy is affected by spatial smearing of the beam in the plane normal to its axis because of its dependence on the point of current passage through the transformer ring. According to the Bergoz technical record data, the dependence of *K* on the current transverse coordinate is characterized as 0.2 %/mm. Proceeding from the 18.7x16.4-mm beam radius, the beam smearing introduces an 1% error to the *K* valu

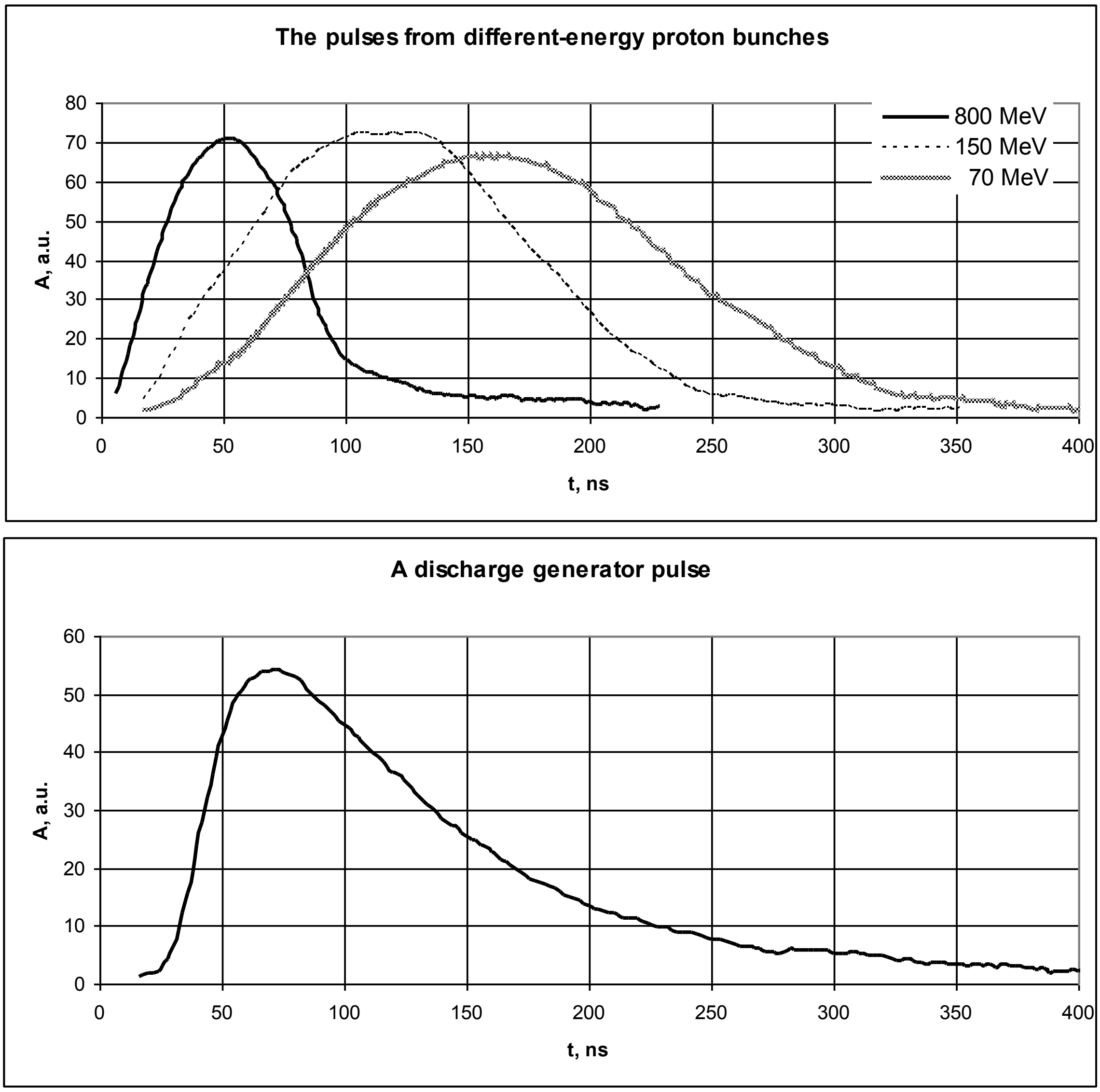

Fig. 5.23. The shapes of the CS85G-recorded single pulses. The upper panel shows the pulses from different-energy proton bunches, and the lower panel a discharge generator pulse.

5.4. Results of determining the monitor reaction cross sections

Table 5.2 and Figs. 5.24 – 5.26 present the results of determining the ^{27}Al(p,x)^{22}Na, ^{27}Al(p,x)^{24}Na, and ^{27}Al(p,x) ^{7}Be monitor reaction cross sections.

Table 5.2. $^{27}Al(p,x)^{22}Na$, $^{27}Al(p,x)^{24}Na$, and $^{27}Al(p,x)\ ^{7}Be$ monitor reaction cross sections

Energy, MeV	Monitor size, mm	Experiment	σ ^{22}Na, mb	σ ^{24}Na, mb	σ ^{7}Be, mb
2605 ± 8	72 x 72	W	10.61 ± 0.53 (0.12)	9.89 ± 0.45 (0.01)	-
		Ta	10.55 ± 0.85 (0.31)	8.96 ± 0.39 (0.05)	-
		Nb	11.01 ± 0.56 (0.14)	8.75 ± 0.40 (0.03)	-
		Ni	11.12 ± 1.25 (0.54)	8.70 ± 0.38 (0.02)	-
		Fe	10.00 ± 0.87 (0.65)	11.53 ± 0.53 (0.08)	-
		Cr	10.52 ± 0.57 (0.23)	12.13 ± 0.55 (0.03)	-
	Ø10.5	W	10.98 ± 0.58 (0.15)	10.33 ± 0.47 (0.01)	8.13 ± 0.39 (0.02)
		Ta	10.85 ± 0.53 (0.05)	10.05 ± 0.47 (0.01)	-
		Nb	11.72 ± 0.58 (0.07)	10.27 ± 0.48 (0.01)	8.87 ± 0.43 (0.01)
		Ni	11.88 ± 0.59 (0.07)	9.32 ± 0.43(0.01)	7.82 ± 0.36 (0.01)
		Fe	12.23 ± 0.62 (0.04)	10.31 ± 0.51 (0.01)	8.83 ± 0.45 (0.02)
		Cr	12.13 ± 0.59 (0.05)	10.47 ± 0.47 (0.01)	8.87 ± 0.41 (0.02)
Average:			**11.69 ± 0.55 (0.18)**	**10.22 ± 0.47 (0.11)**	**8.49 ± 0.45 (0.24)**
1598 ± 4	72 x 72	W	11.76 ± 0.62 (0.20)	10.83 ± 0.49 (0.02)	-
		Ta	12.25 ± 0.65 (0.24)	11.63 ± 0.52 (0.03)	-
		Nb	11.70 ± 0.77 (0.42)	9.49 ± 0.43 (0.03)	-
		Ni	12.25 ± 1.04 (0.78)	10.12 ± 0.46 (0.03)	-
		Fe	11.19 ± 0.80 (0.28)	10.43 ± 0.47 (0.03)	-
		Cr	12.00 ± 0.62 (0.20)	10.90 ± 0.49 (0.03)	-
	Ø10.5	W	13.15 ± 0.69 (0.14)	11.51 ± 0.55 (0.03)	7.90 ± 0.51 (0.23)
		Ta	12.75 ± 0.59 (0.03)	11.63 ± 0.53 (0.01)	7.57 ± 0.35 (0.02)
		Nb	13.42 ± 0.66 (0.06)	11.38 ± 0.53 (0.01)	8.42 ± 0.41 (0.02)
		Ni	13.04 ± 0.64 (0.06)	11.23 ± 0.51 (0.01)	7.42 ± 0.35 (0.02)
		Fe	12.76 ± 0.63 (0.05)	11.13 ± 0.54 (0.02)	8.37 ± 0.41 (0.02)
		Cr	13.88 ± 0.68 (0.05)	11.79 ± 0.56 (0.04)	8.65 ± 0.40 (0.02)
Average:			**12.98 ± 0.59 (0.14)**	**11.28 ± 0.52 (0.13)**	**8.09 ± 0.43 (0.22)**
1199 ± 3	72 x 72	W, Ta	13.11 ± 0.83 (0.43)	13.84 ± 0.61 (0.01)	-
		Nb, Ni	12.76 ± 0.69 (0.26)	11.30 ± 0.49 (0.02)	-
		Fe, Cr	13.35 ± 0.67 (0.16)	12.25 ± 0.57 (0.05)	-
	Ø10.5	W	15.81 ± 0.88 (0.29)	14.82 ± 0.68 (0.01)	8.58 ± 0.42 (0.04)
		Ta	14.41 ± 0.73 (0.17)	13.91 ± 0.62 (0.01)	7.42 ± 0.34 (0.02)
		Nb	15.38 ± 0.79 (0.14)	12.82 ± 0.60 (0.02)	8.08 ± 0.41 (0.06)
		Ni	12.99 ± 0.64 (0.11)	12.12 ± 0.54 (0.01)	6.86 ± 0.32 (0.02)
		Fe	15.37 ± 0.79 (0.13)	12.90 ± 0.61 (0.01)	7.98 ± 0.40 (0.03)
		Cr	13.44 ± 0.70 (0.17)	12.21 ± 0.56 (0.01)	6.81 ± 0.32 (0.02)
Average:			**14.13 ± 0.73 (0.38)**	**12.84 ± 0.67 (0.36)**	**7.33 ± 0.42 (0.26)**
799 ± 2	72 x 72	W, Ta	13.49 ± 0.68 (0.17)	12.09 ± 0.54 (0.02)	-
		Nb, Ni	14.85 ± 0.75 (0.18)	12.30 ± 0.55 (0.01)	-
		Fe, Cr	16.32 ± 0.92 (0.37)	13.02 ± 0.59 (0.03)	-
	Ø10.5	W	16.64 ± 1.00 (0.41)	13.01 ± 0.61 (0.01)	5.84 ± 0.32 (0.08)
		Ta	14.00 ± 0.71 (0.15)	11.99 ± 0.56 (0.03)	4.95 ± 0.26 (0.06)
		Nb	17.37 ± 1.02 (0.40)	13.27 ± 0.62 (0.02)	6.43 ± 0.33 (0.06)
		Ni	14.99 ± 0.83 (0.28)	12.28 ± 0.57 (0.03)	5.37 ± 0.27 (0.05)

Energy, MeV	Monitor size, mm	Experiment	σ ^{22}Na, mb	σ ^{24}Na, mb	σ ^{7}Be, mb
		Fe	18.22 ± 1.05 (0.35)	13.95 ± 0.66 (0.02)	6.54 ± 0.33 (0.04)
		Cr	15.75 ± 1.20 (0.77)	14.09 ± 0.65 (0.03)	5.67 ± 0.30 (0.07)
Average:			**14.73 ± 0.80 (0.46)**	**12.80 ± 0.60 (0.21)**	**5.86 ± 0.38 (0.27)**
600 ± 2	72 x 72	W, Ta	16.11 ± 0.78 (0.13)	13.46 ± 0.61 (0.03)	-
		Nb, Ni	15.90 ± 0.99 (0.50)	12.36 ± 0.56 (0.03)	-
		Fe, Cr	15.41 ± 0.76 (0.16)	12.29 ± 0.55 (0.02)	-
	Ø10.5	W	18.26 ± 1.09 (0.44)	14.48 ± 0.68 (0.01)	5.08 ± 0.28 (0.07)
		Ta	16.10 ± 0.98 (0.45)	13.56 ± 0.62 (0.01)	4.09 ± 0.22 (0.06)
		Nb	17.91 ± 1.01 (0.34)	13.16 ± 0.61 (0.01)	4.60 ± 0.25 (0.06)
		Ni	14.19 ± 1.10 (0.73)	12.31 ± 0.56 (0.02)	4.16 ± 0.22 (0.06)
		Fe	18.67 ± 1.14 (0.45)	12.92 ± 0.67 (0.05)	4.77 ± 0.26 (0.05)
		Cr	14.90 ± 0.92 (0.41)	12.51 ± 0.60 (0.05)	4.01 ± 0.22 (0.07)
Average:			**16.10 ± 0.78 (0.33)**	**13.35 ± 0.64 (0.25)**	**4.45 ± 0.26 (0.16)**
400 ± 2	72 x 72	W, Ta	14.61 ± 0.72 (0.64)	11.50 ± 0.53 (0.04)	-
		Nb, Ni	18.02 ± 0.93 (0.26)	11.66 ± 0.62 (0.19)	-
		Fe, Cr	19.15 ± 1.67 (1.15)	11.12 ± 0.50 (0.02)	-
	Ø10.5	W	16.89 ± 1.15 (0.62)	12.25 ± 0.61 (0.05)	3.29 ± 0.22 (0.09)
		Ta	14.13 ± 1.05 (0.64)	11.53 ± 0.57 (0.05)	2.36 ± 0.17 (0.09)
		Nb	18.41 ± 1.47 (0.86)	12.64 ± 0.70 (0.03)	3.37 ± 0.25 (0.11)
		Ni	16.01 ± 1.31 (0.79)	11.94 ± 0.64 (0.03)	2.57 ± 0.20 (0.10)
		Fe	16.84 ± 1.20 (0.74)	10.74 ± 0.56 (0.15)	2.86 ± 0.18 (0.08)
		Cr	16.06 ± 1.16 (0.70)	9.95 ± 0.48 (0.15)	2.18 ± 0.16 (0.10)
Average:			**17.05 ± 0.90 (0.50)**	**11.69 ± 0.56 (0.20)**	**2.76 ± 0.23 (0.19)**
249 ± 1	72 x 72	W, Ta	15.87 ± 1.09 (0.01)	10.53 ± 0.50 (0.03)	-
		Nb, Ni	18.12 ± 1.36 (0.14)	12.22 ± 0.88 (0.02)	-
		Fe, Cr	15.85 ± 0.86 (0.30)	10.66 ± 0.48 (0.02)	-
	Ø10.5	W	17.08 ± 0.93 (0.18)	11.20 ± 0.62 (0.15)	1.85 ± 0.11 (0.04)
		Ta	15.16 ± 0.81 (0.19)	10.62 ± 0.52 (0.03)	1.50 ± 0.09 (0.03)
		Nb	19.14 ± 1.52 (0.22)	13.12 ± 0.98 (0.25)	2.03 ± 0.17 (0.04)
		Ni	17.05 ± 1.40 (0.29)	12.27 ± 0.91 (0.25)	1.79 ± 0.16 (0.05)
		Fe	18.09 ± 1.06 (0.40)	11.30 ± 0.53 (0.06)	1.88 ± 0.13 (0.08)
		Cr	15.58 ± 1.13 (0.68)	10.68 ± 0.50 (0.02)	1.78 ± 0.21 (0.18)
Average:			**15.88 ± 0.70 (0.07)**	**11.08 ± 0.56 (0.25)**	**1.76 ± 0.12 (0.09)**
147.6 ± 0.4	72 x 72	W, Ta	16.22 ± 0.79 (0.14)	10.59 ± 0.47 (0.02)	-
		Nb, Ni	17.82 ± 0.98 (0.36)	10.81 ± 0.48 (0.02)	-
		Fe, Cr	19.40 ± 0.91 (0.12)	11.13 ± 0.50 (0.02)	-
	Ø10.5	W	18.01 ± 1.07 (0.42)	11.26 ± 0.53 (0.01)	1.18 ± 0.09 (0.05)
		Ta	16.50 ± 0.89 (0.26)	10.37 ± 0.48 (0.03)	0.94 ± 0.07 (0.04)
		Nb	19.62 ± 1.11 (0.35)	12.40 ± 0.59 (0.02)	1.31 ± 0.10 (0.07)
		Ni	16.99 ± 1.13 (0.56)	10.73 ± 0.54 (0.06)	1.10 ± 0.15 (0.13)
		Fe	20.26 ± 1.41 (0.76)	12.00 ± 0.58 (0.03)	1.22 ± 0.13 (0.10)
		Cr	18.28 ± 1.21 (0.61)	11.35 ± 1.87 (0.01)	1.31 ± 0.14 (0.11)
Average:			**17.99 ± 0.95 (0.53)**	**11.22 ± 0.53 (0.19)**	**1.11 ± 0.08 (0.07)**
97.2 ± 0.4	72 x 72	W, Ta	19.48 ± 0.90 (0.10)	11.39 ± 0.51 (0.02)	-
		Nb, Ni	21.41 ± 1.20 (0.46)	11.90 ± 0.59 (0.03)	-

Energy, MeV	Monitor size, mm	Experiment	σ ^{22}Na, mb	σ ^{24}Na, mb	σ ^{7}Be, mb
		Fe, Cr	19.73 ± 0.93 (0.12)	11.46 ± 0.52 (0.03)	-
	Ø10.5	W	22.15 ± 1.08 (0.11)	12.01 ± 0.56 (0.02)	0.88 ± 0.10 (0.08)
		Ta	18.92 ± 1.27 (0.50)	11.41 ± 0.61 (0.11)	0.78 ± 0.11 (0.09)
		Nb	23.33 ± 1.30 (0.38)	12.61 ± 0.66 (0.02)	1.44 ± 0.14 (0.10)
		Ni	20.62 ± 1.12 (0.33)	11.89 ± 0.56 (0.03)	0.87 ± 0.09 (0.07)
		Fe	22.19 ± 1.29 (0.37)	12.52 ± 0.60 (0.03)	0.97 ± 0.13 (0.11)
		Cr	19.34 ± 1.10 (0.34)	11.23 ± 0.59 (0.10)	0.66 ± 0.07 (0.06)
Average:			**20.44 ± 1.00 (0.44)**	**11.94 ± 0.55 (0.16)**	**0.86 ± 0.11 (0.10)**
66.0 ± 0.6	72 x 72	W, Ta	24.41 ± 1.28 (0.37)	11.70 ± 0.53 (0.03)	-
		Nb, Ni	26.85 ± 1.51 (0.60)	11.92 ± 0.53 (0.02)	-
		Fe, Cr	24.87 ± 1.44 (0.62)	11.51 ± 0.61 (0.18)	-
	Ø10.5	W	26.70 ± 1.39 (0.29)	12.68 ± 0.60 (0.01)	0.65 ± 0.06 (0.04)
		Ta	24.49 ± 1.39 (0.47)	11.52 ± 0.55 (0.04)	0.46 ± 0.08 (0.07)
		Nb	27.38 ± 1.58 (0.53)	12.72 ± 0.62 (0.04)	0.75 ± 0.09 (0.07)
		Ni	25.02 ± 1.39 (0.41)	11.91 ± 0.57 (0.05)	0.75 ± 0.10 (0.09)
		Fe	26.50 ± 1.77 (0.70)	12.05 ± 0.64 (0.02)	0.57 ± 0.09 (0.08)
		Cr	25.71 ± 1.75 (0.70)	11.28 ± 0.68 (0.06)	0.38 ± 0.21 (0.09)
Average:			**25.75 ± 1.20 (0.38)**	**12.22 ± 0.56 (0.15)**	**0.61 ± 0.06 (0.05)**
44.6 ± 0.3	Ø10.5	W	43.47 ± 2.67 (0.39)	2.52 ± 0.15 (0.02)	0.33 ± 0.11 (0.11)
		Nb	49.90 ± 3.09 (0.47)	3.10 ± 0.19 (0.01)	0.47 ± 0.13 (0.13)
		Fe	41.16 ± 2.24 (0.11)	1.93 ± 0.11 (0.01)	0.32 ± 0.07 (0.06)
Average:			**41.76 ± 2.30 (1.39)**	**2.78 ± 0.37 (0.35)**	**0.34 ± 0.05 (0.05)**
40.8 ± 0.8	Ø10.5	Ta	40.68 ± 2.59 (0.49)	1.51 ± 0.09 (0.01)	0.19 ± 0.04 (0.04)
		Ni	46.00 ± 2.92 (0.54)	1.70 ± 0.10 (0.01)	0.97 ± 0.57 (0.56)
		Cr	38.59 ± 2.04 (0.10)	1.20 ± 0.09 (0.03)	0.33 ± 0.08 (0.08)
Average:			**38.91 ± 1.96 (0.96)**	**1.55 ± 0.11 (0.09)**	**0.22 ± 0.05 (0.05)**

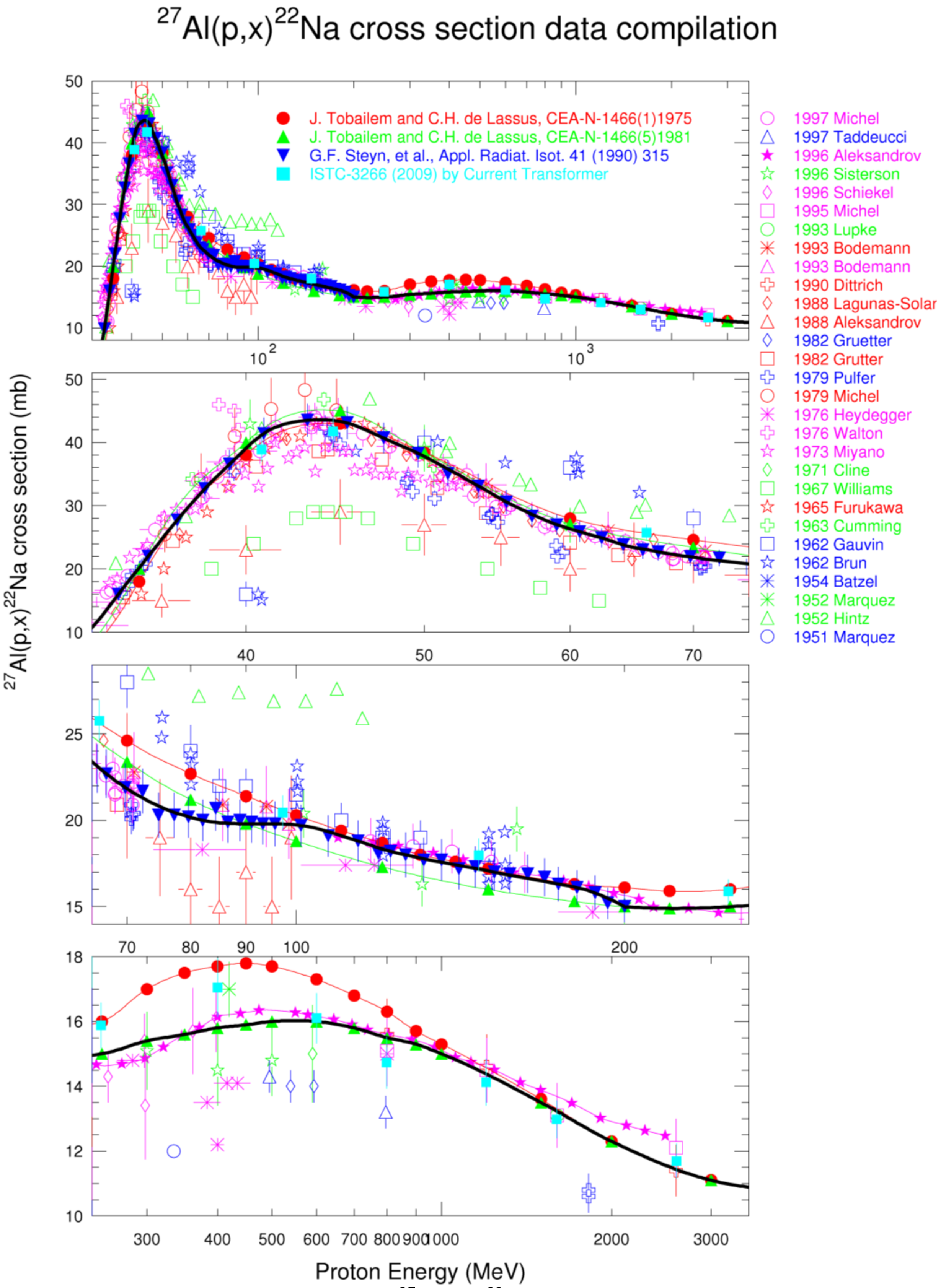

Fig. 5.24. The cross sections obtained for ^{27}Al(p,x)^{22}Na reaction as compared to the data obtained elsewhere.

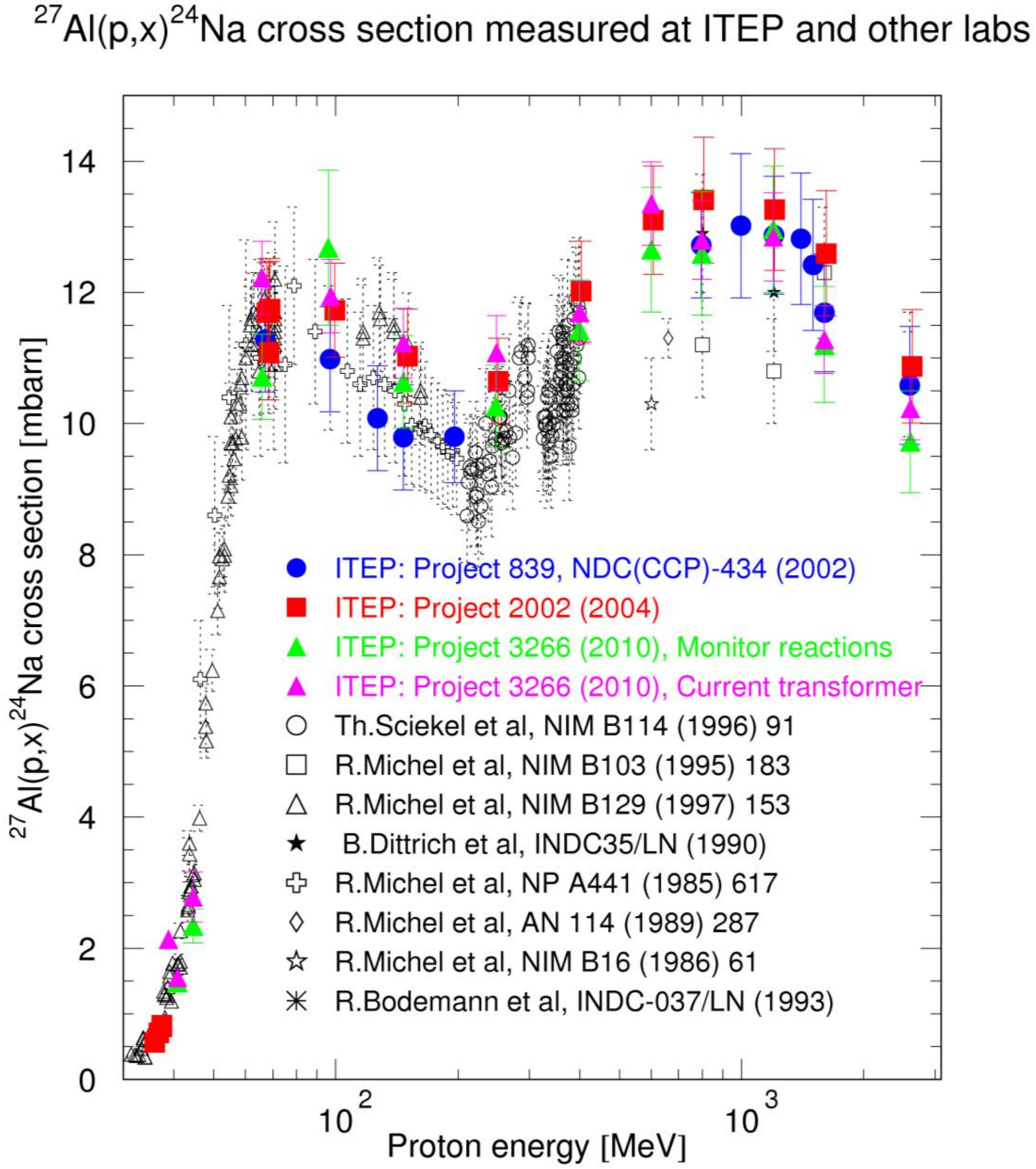

Fig. 5.25. The cross sections obtained for ^{27}Al(p,x)^{24}Na reaction as compared to the data obtained elsewhere.

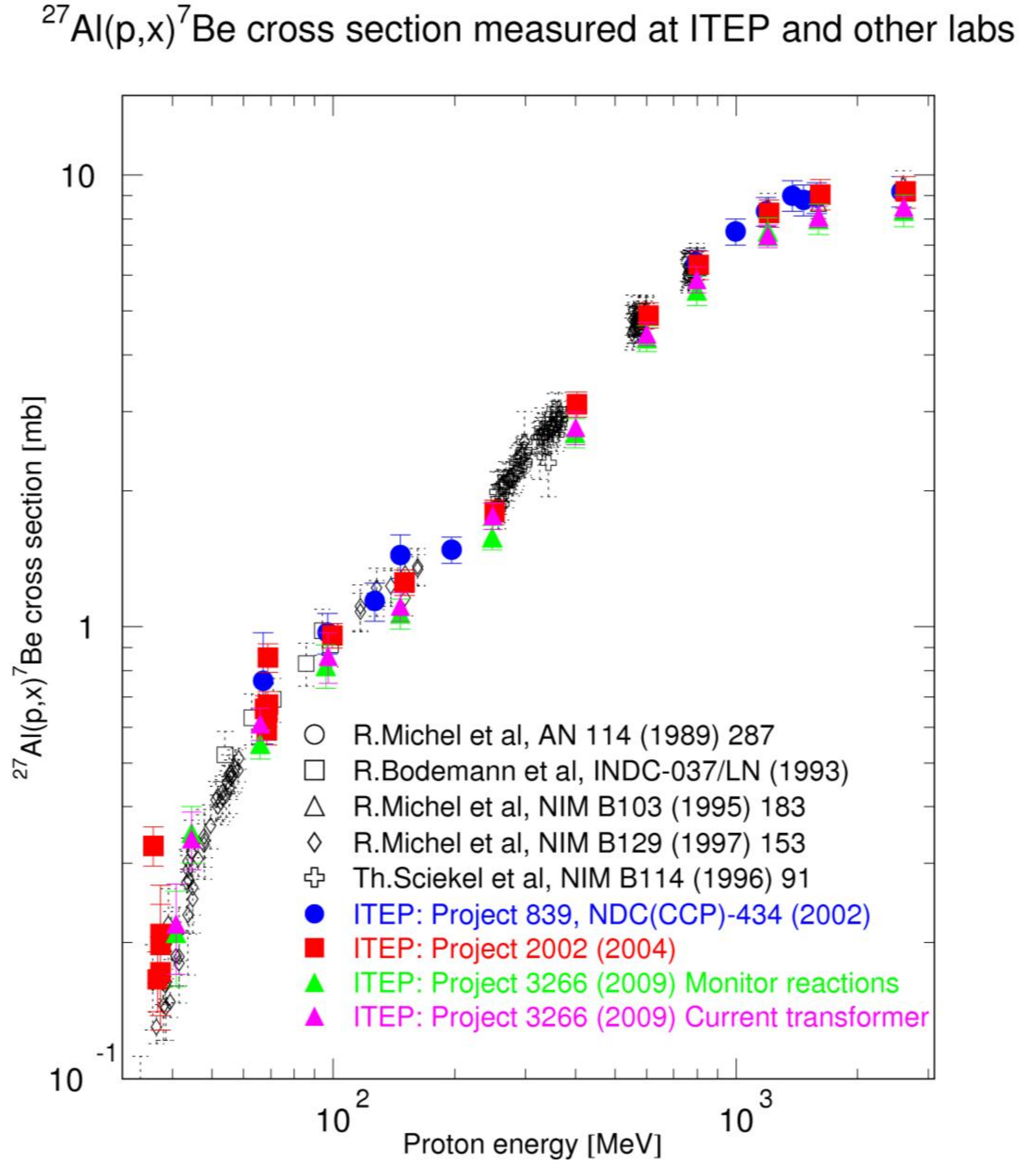

Fig. 5.26. The results obtained for $^{27}Al(p,x)^{7}Be$ reaction as compared to the data obtained elsewhere.

6. UPDATING THE MODELS AND CODES ON THE BASIS OF FRESH EXPERIMENTAL EVIDENCE

6.1. Introduction

Spallation reactions have aroused growing interest since recently because they are used to design high-intensity neutron sources for the accelerator-driven subcritical (ADS) reactors and for the physical and technology researches. Designing the subcritical ADS facilities necessitates knowing cross sections for yields of various reaction product nuclei with the view of safe predicting the number of radioactive isotopes produced in the target inside and in the nearby structural materials. Really, the short-lived isotopes may induce troubles of facility operation, while the long-lived ones can evoke a long-term increase in the system radiotoxicity. Within the last decade, copious high-precision experimental spallation and fission data have been obtained on Pb, which is considered to belong to the most promising ADS target coolant [19-23]. Despite the repeated attempts made to perfect the appropriate theoretical models, the accuracies attained in describing experimental evidence are often far from those required by technical applications [21-25]. It is still urgent, therefore, to further accumulate the experimental evidence on other feasible accelerator target materials and other structural materials for ADS facilities. Ta and W are most frequently treated as possible solid-state targets, the Fe group nuclides as the main structural material components, and the Zr-Mo group nuclides as the fuel shell materials [26]. Implementing the present Project has brought a rather large amount of new experimental data on the residual yields from the high-energy proton irradiation of the above nuclei. The feasible improvements of the modern theoretical models on the basis of these data will be discussed below.

6.2. Main approximations of the intranuclear cascade models

The spallation reactions are generally modeled as a two-stage process. In the first stage, the nucleon-nucleon collisions lead to emission of a few high-energy nucleons and to production of excited primary fragments [27-29]. This process can be continued by a preequilibrium emission of nucleons in some versions of the intranuclear cascade (INC) models [30-33]. During the second stage, the prefragments lose their excitation energy via fission or light-particle emission.

All the evaporation models are based on the well-known Weisskopf-Ewing formula [34] for the particle emission width

$$\Gamma_i(U) = \frac{(2s+1)m_i \int_0^{U-B_i} \varepsilon\sigma_i(\varepsilon)\rho_i(U-B_i-\varepsilon)d\varepsilon}{\pi^2\hbar^3\rho_c(U)} \quad , \tag{6.1}$$

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

The following approximation is widely used to estimate the absorption cross section:

$$\sigma(\varepsilon) = \begin{cases} 0 \ \text{ for } \varepsilon < \mathrm{C_{Coul}} \\ \pi R_i^2 \ \text{ for } \varepsilon \geq \mathrm{C_{Coul}} \end{cases} \quad , \tag{6.2}$$

where C_{coul} is the Coulomb barrier height determined by the standard formula; $R_i = r_i A^{1/3}$ is the nuclear radius**.** In accordance with such an approach, the relation (6.1) may be approximated as

$$\Gamma_i(U) = \frac{(2s+1)m_i r_i^2 A_i^{2/3} T_i^2 \rho_i(U-B_i-C_i)}{\pi\ \hbar^3\rho_c(U)} \quad , \tag{6.3}$$

where T_i is the nuclear temperature of residual nucleus.

More complex formula for the emission width was proposed by Dresner [35], who used the Fermi-gas model relation for the level densities to calculate the integral of Eq. (6.1) in an explicit form taking into account some small components related to the pre-exponential factors in the level density formulas. For the excitation energies above the neutron binding energy, which are important for the most of practical applications, the difference between the Dresner's approximation and the calculations based on Eq. (6.3) can be negligible.

The choice of parameter r_i and of the Coulomb barrier is much more important in the case of the simple approximation (6.2). For the initial formula (6.1) all calculations can be made in terms of the optical model without using any geometric cross section and the effective Coulomb barrier that are requiered for Eq. (6.3). The best choice of parameters r_i , which may vary for different emitted particles, corresponds to the case where relations (6.1) and (6.3) give identical results. Obviously, the complete identity of the results can only be attained at some energy only. Nevertheless, we could required an agreement between the (6.1)- and (6.3)-based calculations for the crucial energies that correspond to the averege energies of the Maxwellian spectra of evaporated particles. In the practical versions of the INC models, the effective Coulomb barrier parameters and the geometrical cross sections are usually estimated by fitting to some experimental data and the corresponding values of r_i differ essentially in various codes.

Another important evaporation model component is relevant to describing the fission widths. Usually, the well-known Bohr-Wheeler formula [36] is applied for this purpose, whose slightly simplified form is

$$\Gamma_f^{BW}(U) = \frac{T_f \rho_f (U - B_f)}{2\pi\rho_c(U)} \quad , \tag{6.4}$$

where B_f is the fission barrier height.

During the last decades, it was recognized a need of some essential modifications of the Bohr-Wheeler approach for describing the fission probability at high excitation energies. These modifications relate to the dynamics of a collective motion. Some transient time is required to create a collective motion similar to the fission process [37]. The dependence of the transient time on nucleus properties can be determined by solving the time-dependent Fokker-Planck equation for the collective degrees of freedom. In the case of the simple harmonic parameterization of the collective mode potential, the transient time for an overdamped regime can be approximated by the rather simple relation [37]

$$\tau_f = \frac{\beta}{2\omega^2} \ln \frac{10B_f}{T_f} \quad , \tag{6.5}$$

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

$$\Gamma_f(U) = \Gamma_f^{BW}(U) f_K(\beta) \exp\{-\tau_f \sum_\nu \Gamma_\nu(U)/\hbar\} \quad , \tag{6.6}$$

where $f_K = [1+(\beta/2\omega)^2 - \beta/2\omega]^{1/2}$ is the Kramers factor [38], responsible for a reduction of the fission probability due to the collective motion dissipation. The sum in (6.6) includes all decay channels competed with fission.

The main effect of factors additional to the Bohr-Wheeler formula is an obstacle to fission at times shorter than the transient time. The obstacle reduces strongly the fission widths at excitation energies that exceed the fission barrier by 100-150 MeV. The analysis of the heavy ion reactions has shown that the obstacle to fission play a crucial role for the consistent description of the total amount of neutrons and light charged particles emitted from the fissioning nuclei [39], as well as of the residual product yields observed in the fragmentation of relativistic heavy ions [40].

The fission barriers used in various computational codes are compared in Fig. 6.1 with the available experimental data for preactinide nuclei [41]. From the figure it is seen that the INC models use of fairly discrepant fission barriers. The simple liquid drop model is used in LAHET [33] and in the earlier CASCADE versions [29], whereas the present-day codes use a more complicated barrier parameterizations based on the droplet models, whose parameters are fitted to the experimental barriers [41,42]. Most of the such codes include consistently the shell corrections to fission barriers, which are very important at energies below 50 MeV for near-magic preactinide nuclei [41].

According to the liquid drop model, the fission barriers rise with decreasing mass number and reach their maxima of ~45-50 MeV for nuclei with mass number about 100-120 [43,44]. For more light nuclei the fission barriers decrease to about 30 MeV for nuclei around iron and lighter ones. These general tendencies of fission barrier variations are well confirmed by studying the nuclear fissility in heavy ion reactions, but uncertainties of experimental determining the barrier heights are still quite considerable. It is of importance to note, however, that the fission barriers for the nuclei with $Z^2/A<20$ get unstable to asymmetric deformations of nuclear shapes. In other words, the asymmetric fission on two unequal fragments is more favorable in energy than the symmetric fission into equal fragments. It was suggested by Moretto [45] that, despite instability, the corresponding asymmetric barrier configurations could be treated as the transient states of fissioning nuclei responsible for asymmetric distributions of the fission fragment masses and charges. In this case, the fragment production probability can be described by the same relations as Eq. (6.4) with the fission barriers depending on the fragment masses and charges. The Moretto model was realized in the GEMINI code [46], which was successfully used to describe the basic mechanisms of asymmetric fission of light nuclei (A<100) in heavy ion reactions [47]. Recently, the model was included into some of the INC code versions to obtain a unified description of the spallation and fission reactions for light nuclei [48, 49]. The basic parameters of the model will be discussed below in the analysis of the present Project data for the ^{56}Fe and ^{93}Nb targets.

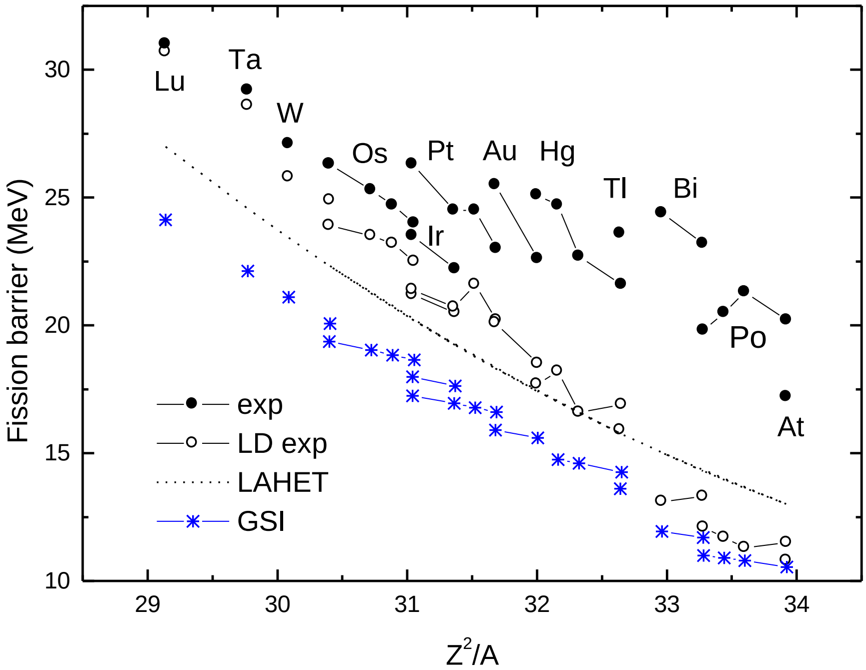

Fig. 6.1. Experimental fission barriers (dark circles) and their liquid drop components (open circles) versus the fissility parameter Z^2/A. The dotted line shows the fission barriers used in LAHET and the asterisks indicate the liquid-drop barriers used in the GSI code.

The mass and excitation energy distributions of primary fragments resulting from INC of nucleon-nucleon collisions were studied in details for the ^{208}Pb+p (1 GeV) reaction that was analyzed independently by many authors and is usually considered as a standard to test the INC models. Fig. 6.2 shows the results of calculating the fragment distributions in terms of three INC model versions: i) LAHET code [33] with default parameters including the preequilibrium particle emission, ii) INCL4 code based on the Liege INC model [30, 31] coupled to the GSI evaporation model [42], and iii) CASCADO code coupled originally to the JINR model [29, 32], but modified essentially to take into account the IPPE experience of analyzing the level densities and nuclear fission process [41]. The results of all codes exhibit fairly low excitation energies (25-50 MeV) of the primary fragments, whose masses are close to the target nucleus. The excitation energies increase up to 150-220 MeV for the most probable A~200-206 primary fragments. The A<200 range primary fragments with higher excitation energies are produced to within a relatively low probability. The distributions displayed in Fig. 6.2 may be considered as input data for the second evaporation cascade stage.

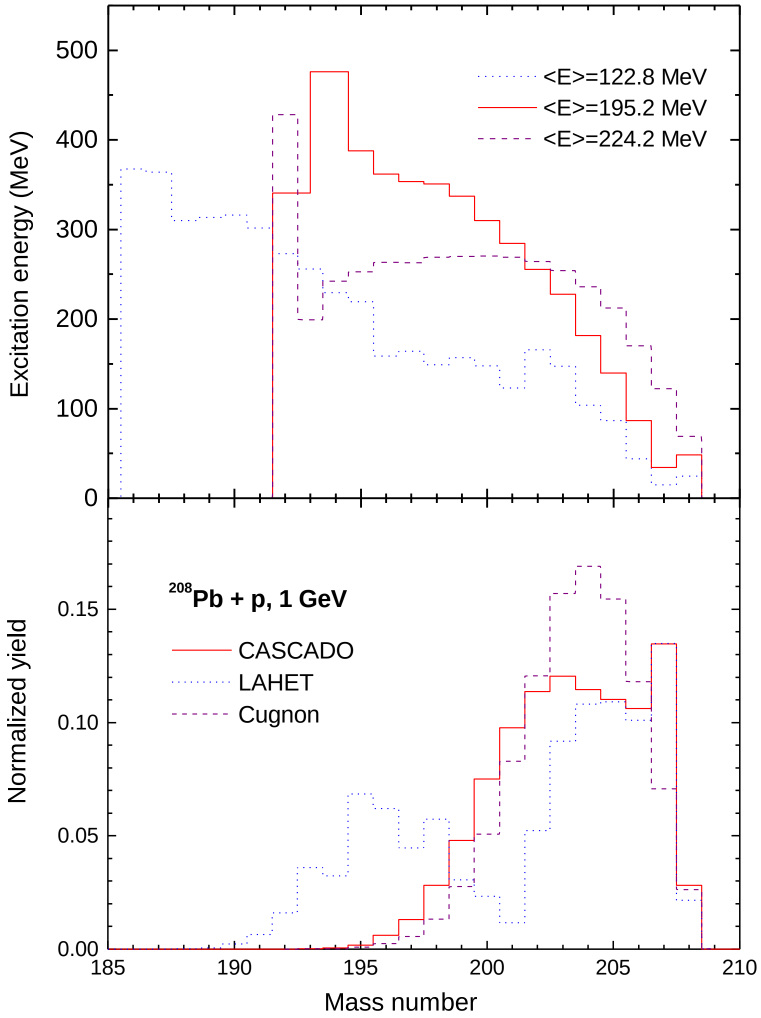

Fig. 6.2. The fragment mass and excitation energy distributions after the initial INC stage.

It should be noted that the considered distributions of the INC primary fragments for lighter nuclei is distinguished only in the corresponding shift of the target nucleus mass, whereas the excitation energies and the mass distribution widths are changed very slightly, at least for masses A>150. Thus, in the case of ^{181}Ta and ^{nat}W targets studied in the present Project, the primary fragment distributions differ from that shown in Fig. 2 by a shift in the mass scale mainly. Besides, the primary product mass and charge distributions for ^{nat}W are broadened additionally due to a natural isotope mixture in the target. The broadening effect will be discussed in more details below under analyzing the experimental data for ^{nat}W.

6.3. Analysis of the ^{56}Fe experimental data

For ^{56}Fe the experimental data on the residual product yields in a broad energy range of incident particles are accumulated in a much larger amount than for any other of light nuclei. Alongside with numerous measurements of the radioactive product yields in the high-energy proton-induced reactions, including those obtained under the present Project, the mass and charge distributions of the residual products were studied by the inverse-kinematics methods too [49]. The available data give an exhaustive representation of observed reaction product yields, so it of primary interest to compare them with the various theoretical models.

The ^{56}Fe case is also supported by precision measuring the spectra of neutrons emitted from the spallation reactions [50]. The measurements constitute an important test for the main models used in the INC codes. Figs. 6.3 and 6.4 show the differential spectra of neutrons emitted at different angles as compared with the CASCADO code calculations for 800 and 1200 MeV incident protons, respectively. The calculated spectra agree quite well with the experimental data at neutron energies above 5 MeV practically for all angles, whereas the soft part of neutron spectra at energies below 4 MeV are somewhat underestimated for the back angles. It should be noted that the calculations with the CEM and LAHET codes included in the MCNPX code system [51] give very close results to the CASCADO ones and they show also similar underestimations of the soft parts of neutron spectra. Such disagreements with experiment indicate that the contributions from the preequilibrium and evaporation processes must be somewhat redistributed in the available INC codes. However, for consistent resolving the problem more precise data on soft neutron spectra below 3 MeV are required, which, unfortunately, have not yet obtained.

The mass distributions of reaction products measured by the inverse kinematics method [49] for the proton energies cross of 300 and 1000 MeV are compared in Fig 6.5 as compared with the present Project data for the both independent or cumulative yields of certain radioactive isotopes. The independent yields for a given mass number must always be below the summary yield of all possible isotopes with the same mass. In some cases, however, the cumulative yields of certain isotopes may be sufficiently close to the total yields of given-mass isotopes. The ^{51}Cr data displayed in Fig. 6.5 are exemplify that type of yields. The presented comparison between two types of experimental data permits to conclude that the smoothed envelope of the maximal cumulative yields gives a reasonable estimation of the total mass distribution of the high-energy proton reaction products, at least in the mass range A>20. Such conclusion is important for the proton energies that are not supported by the inverse-kinematics measurements, so that the corresponding mass distributions should be evaluated on the basis of the fluctuating data of activative measurements.

Fig. 6.5 presents also the mass distributions of the reaction products calculated with the different INC codes. The calculations have been performed directly by the authors of the codes. The common publication [3] treats the main features of every code in more detail. Comparing with experimental data has shown that the Los Alamos MCNPX codes (the BERTINI, ISABEL, and CEM2k versions), as well as the IPPE-designed LAHETO and CASCADO codes, which only comprise the customary models for evaporation of nucleons and light clusters (deutons, tritons, and α-particles), cannot describe the observed production cross sections for the mass range of A<35. The deviations between calculations and experiment become especially considerable for A<20. The rise of the observed yields with decreasing the mass number in the A<20 range is evidence of some additional reaction mechanism for the products with A<35 that differs essentially from the spallation processes determining the yields of heavier products.

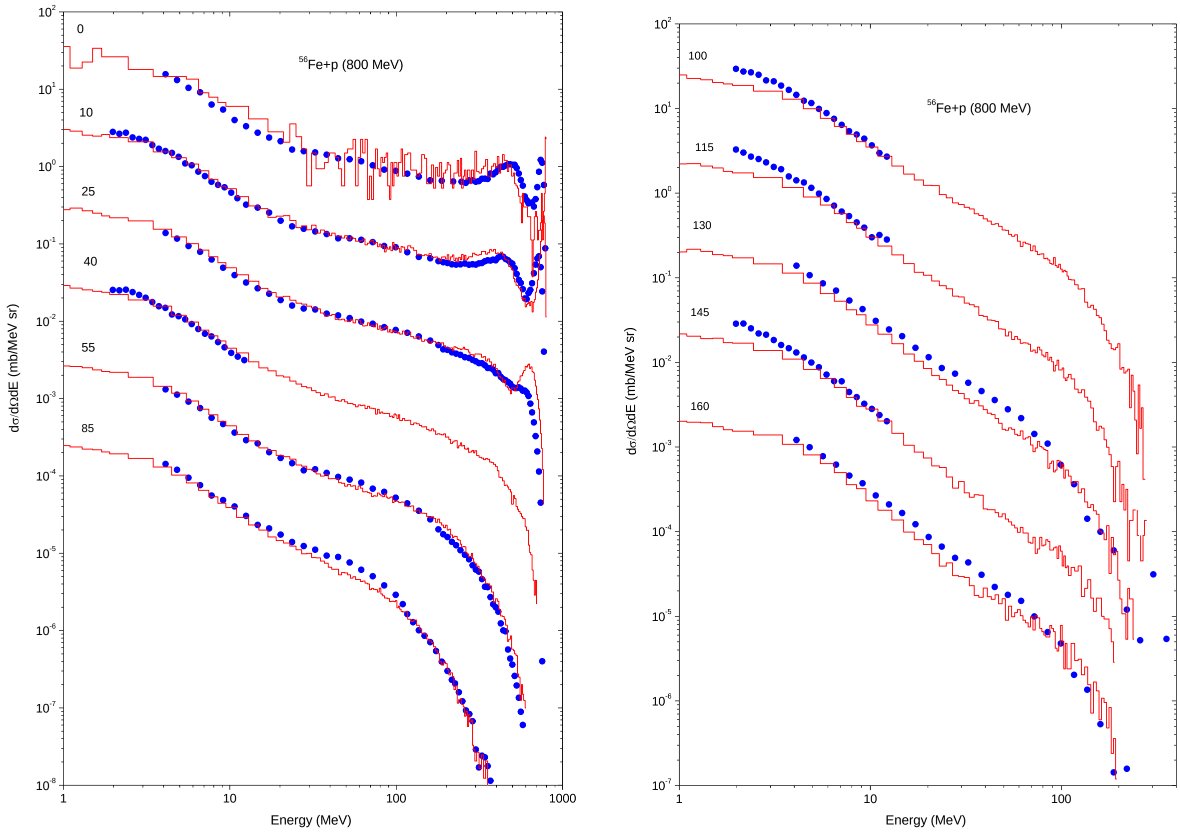

Fig. 6.3. CASCADO calculations of the ^{56}Fe(p,xn) reaction spectra for 800-MeV protons compared with experimental data [38].

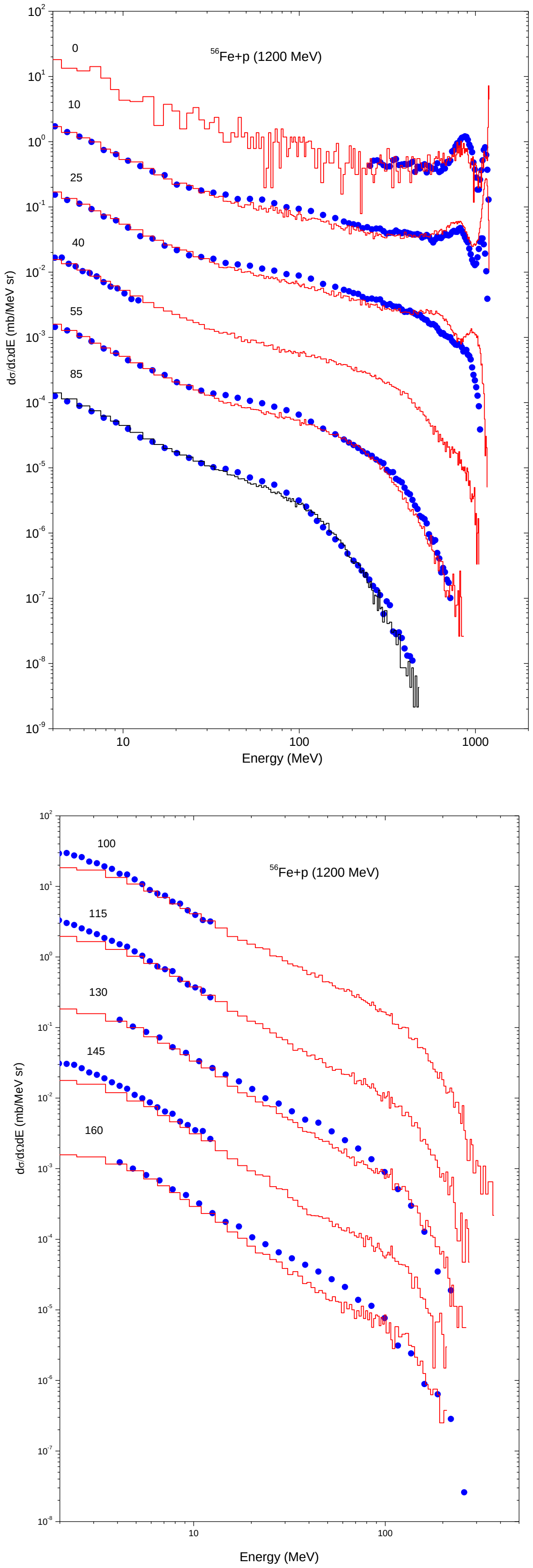

Fig. 6.4. CASCADO calculations of the ^{56}Fe(p,xn) reaction spectra for 1200-MeV protons compared with experimental data [38].

To simulate the light product yields the asymmetric fission model, developed in the GEMINI code, and the statistical multifragmentation model, proposed by Botvina et al. [53], were additionally included in the modified CEM03.G1 and CEM03.S1 codes. Extensions G1 and S1 in the above codes names designate the respective versions of the added models. Similar modifications were made also for in the LAQGSM03.G1 and LAQGSM03.S1 codes [52], which use the quark-gluon string models to describe the high-energy cascade of nucleon-nucleon collisions. The calculation results displayed in Fig. 6.5 show that the models added increase essentially the reaction product yields at the mass region $A<20$. However, the corresponding calculations are rather sensitive to some of the new model parameters fitted to the analyzed experimental data. It cannot yet be decided, which of the light nuclei production models is preferable now. Also, the optimal sets of the new model parameters are difficult to determine unambiguously on account of restricted experimental data.

The conclusion was drawn earlier from analyzing the light product yields of heavy-ion reactions that the statistical multifragmentation arises only at the excitation energies per nucleon exceeding 4-5 MeV [53, 54]. For nuclei with $A \approx 40$ this condition corresponds to the compound nucleus excitation energies above 150-200 MeV. Since the average excitation energy in the initial stage of evaporation cascade is much lower (~90-100 MeV) for the 1000 MeV incident protons, any significant contribution from the multifragmentation should be expected only at the primary proton energies above 1000 MeV. On the other hand, the fission barriers in this mass region are relatively high (~40-50 MeV) for the symmetric fission, but they reduced markedly in the case of the strongly asymmetric fission. For the excitation energies about 10-15 MeV above the barrier the fission widths get comparable with the neutron widths and the asymmetric fission should dominate over the multifragmentation at least for the incident proton energies below 800-1000 MeV. Taking into account the difficulties of simultaneous application of both models, we will concentrate the following analysis mainly on estimation of the asymmetric fission model parameters.

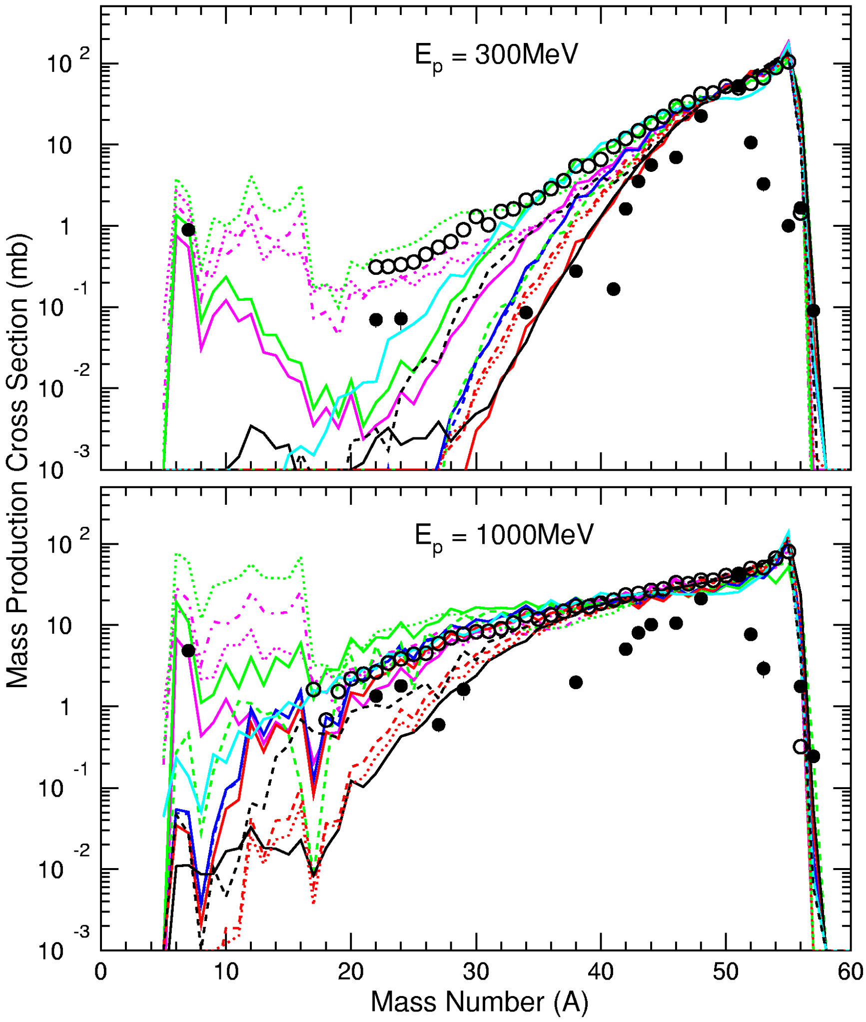

Fig. 6.5. Mass distributions of the ^{56}Fe+p reaction products measured at ITEP (black circles) and GSI (open circles) for the 300-MeV (top panel) and 1000 MeV (bottom panel) protons compared with calculations of various INC models. Black and red lines correspond to different versions of the MCNPX codes [46], the green lines indicate the GMS03.01 (solid), GMS03.S1 (dotted) and GMS03.G1 (dashed-dotted) results and the magenta lines indicate similar results for the LAQGMS versions.

The CASCADO code has been completed with the asymmetric fission model subroutines taken from the GEMINI code [46] and the modified code thus was called GEMCAMO. The high-energy collision and pre-equilibrium decay stages remained the same as in CASCADO, whereas the subsequent particle evaporation and the asymmetric fission processes are calculated in terms of the GEMINI algorithms. Fig. 6.6 compares this code results for 1000 MeV protons with the GSI experimental data and with the similar results of the GEM03.G and LAQ03.G codes, wherein the same GEMINI blocks were used. Compared with Fig. 6.5, the GSI data were completed with the recent measurements of the product yields in the range of A≤18 [54]. The additional data demonstrate directly the increase of light nuclei yields predicted by the Moretto model. Unfortunately, such experimental data has been obtained for 1000 MeV only, but not for a broader energy range that is important for a more complete testing of the light-nuclei emission models.

It should be noted that the GEMINI codes admit broad variations of the fission model parameters that are usually fixed analyzing the corresponding experimental data. In particular, the nuclearlevel densities may be calculated in terms of the standard Fermi-gas model, but can also be calculated with addition of the collective enhancement of level densities. The fission widths may be calculated in terms of not only the traditional Bohr-Wheeler formula (6.4), but also through more complicated relations that simulate the nuclear viscosity effect and the fission delay relative to the nucleon and light-cluster emissions. Three GEMCAMO code calculations shown in Fig. 6.6 demonstrate the influence of the discussed effects on the light nuclei yields. The collective enhancement of level densities leads to a 2.5-to-3-times rise of the product yields with A< 30 without sufficient changing the yields for A>40. At the same time, allowance for fission delay leads to much decreased product yields for A<20. The same yield variations can be also attained by changing the barrier heights, which are predicted by the current models for the light nuclei within very big uncertainties. The total sets of the parameters used in the Los Alamos calculations (GEM03.G and LAQ03.G) are not known exactly, but attention should be attracted to significant discrepancies between the above code calculations that use of the identical GEMINI blocks. Nevertheless, it possible to conclude on the basis of the results displayed in Fig. 6.6 that the asymmetric fission model permits to explain at least qualitatively the observed yields for the mass region A<30. However, a quantitative description of experimental data needs certainly a more careful adjustment of the model parameters.

Figs 6.7 and 6.8 show the results of the GEM03.G, LAQ03.G, and GEMCAMO calculations of reaction product yields from ^{56}Fe target exposed to 300 and 100 MeV protons, respectively. For the 300-MeV protons the experimental data in the region A<30 are very scanty, while for the 100-MeV protons the data are available for ^{7}Li yield only that was measured by the activation method. The GEMCAMO calculations were performed in the version that includes the collective enhancement of level densities, the zero-value of the fission delay time, and the same fission barriers as in case of 1000 MeV protons. The results of all three codes for the 300-MeV protons are reasonably agree with the GSI data that are obtained for A>20 only. Similar data for lighter nuclei are absent, however. In the 100-MeV proton case all calculation results agree with the “enveloping behavior” of the activation data in the region A>40, but the single experimental point for lighter nuclei does not permit to make adjustments of the theoretical model parameters.

Nevertheless, some attention should be attracted to an appreciable difference between the energy dependences of light nuclei yields in the GEM03.G and LAQ03.G results. For the 1000

MeV protons the CEMO3.G yields are about 3 times larger for 7<A<20 than the corresponding LAQ03.G yields. The differences reduce to a factor about 1.5 for the 300 MeV protons and remain of the same level for the 100 MeV protons. The differences between the LAQ03 and GEMCAMO results are smaller and fail on the average to exceed factor 2 for all proton energies considered.

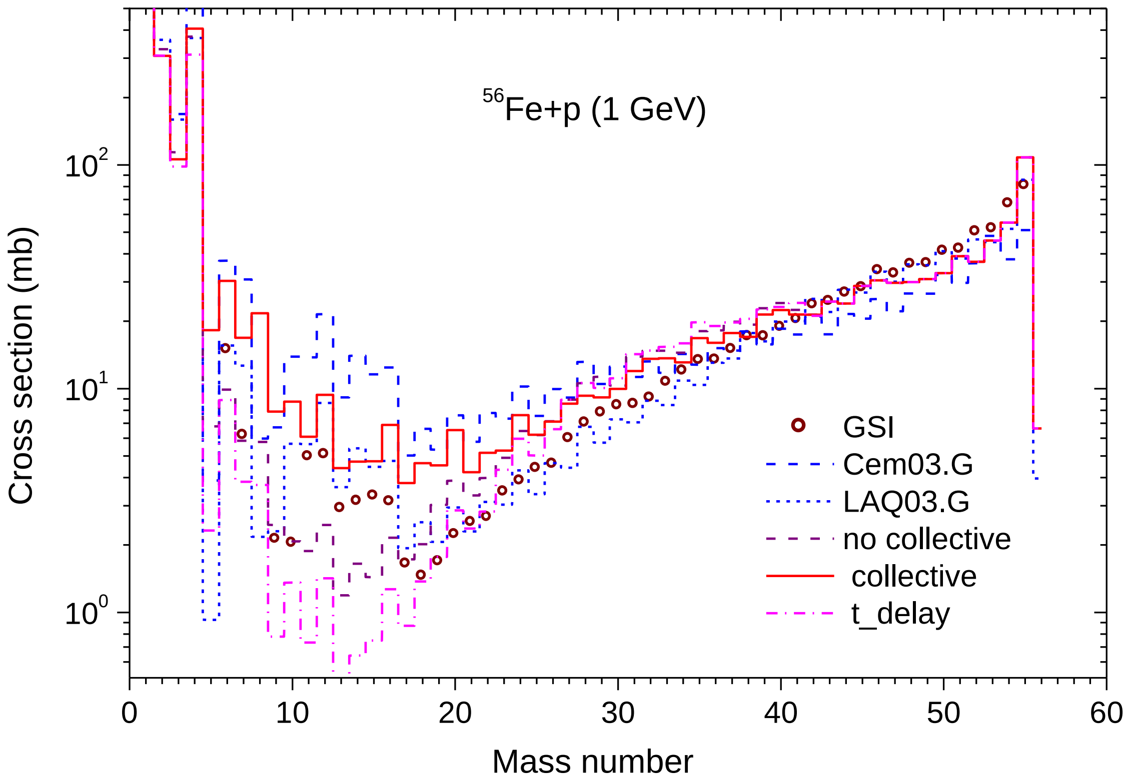

Fig. 6.6. Calculated mass distributions of the ^{56}Fe+p reaction products for 1000-MeV protons compared with the GSI experimental data. The GEMCAMO calculations are presented for three sets of parameters: without collective enhancement of the level densities (dashed line), included collective enhancement (solid line), and included fission delay t_delay = 2 10^{-21} s (dash-dotted line).

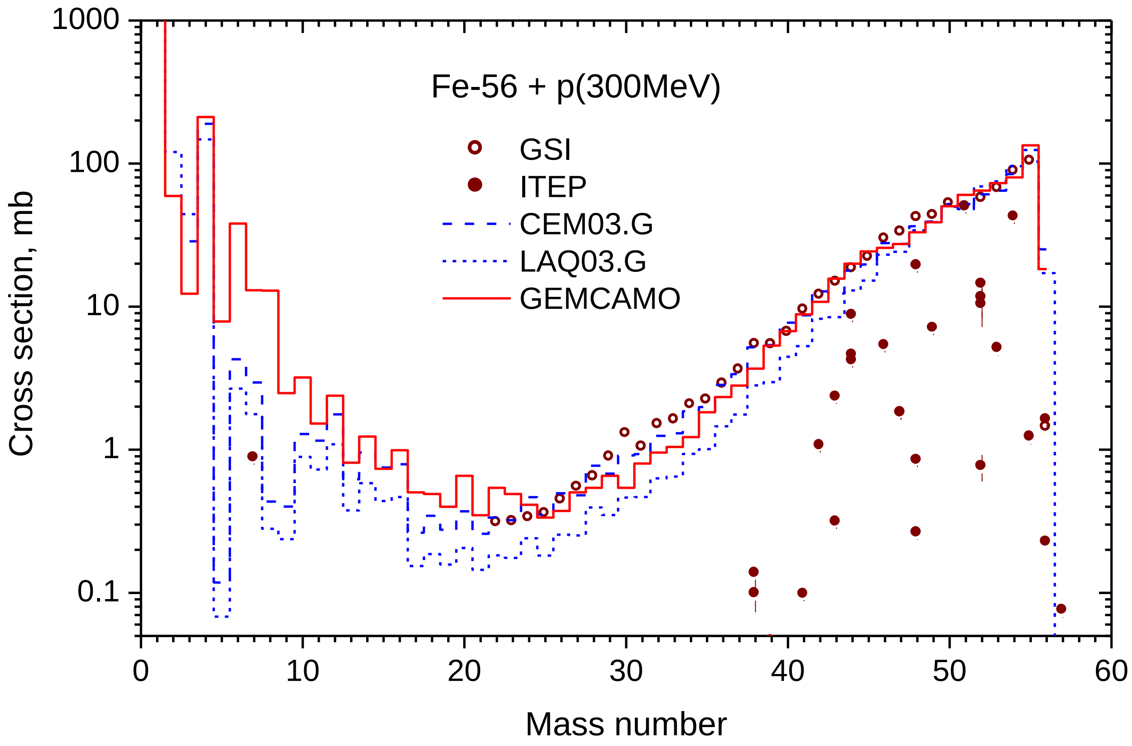

Fig. 6.7. Calculated mass distributions of the ^{56}Fe+p reaction products for 300-MeV protons compared with the GSI and ITEP experimental data.

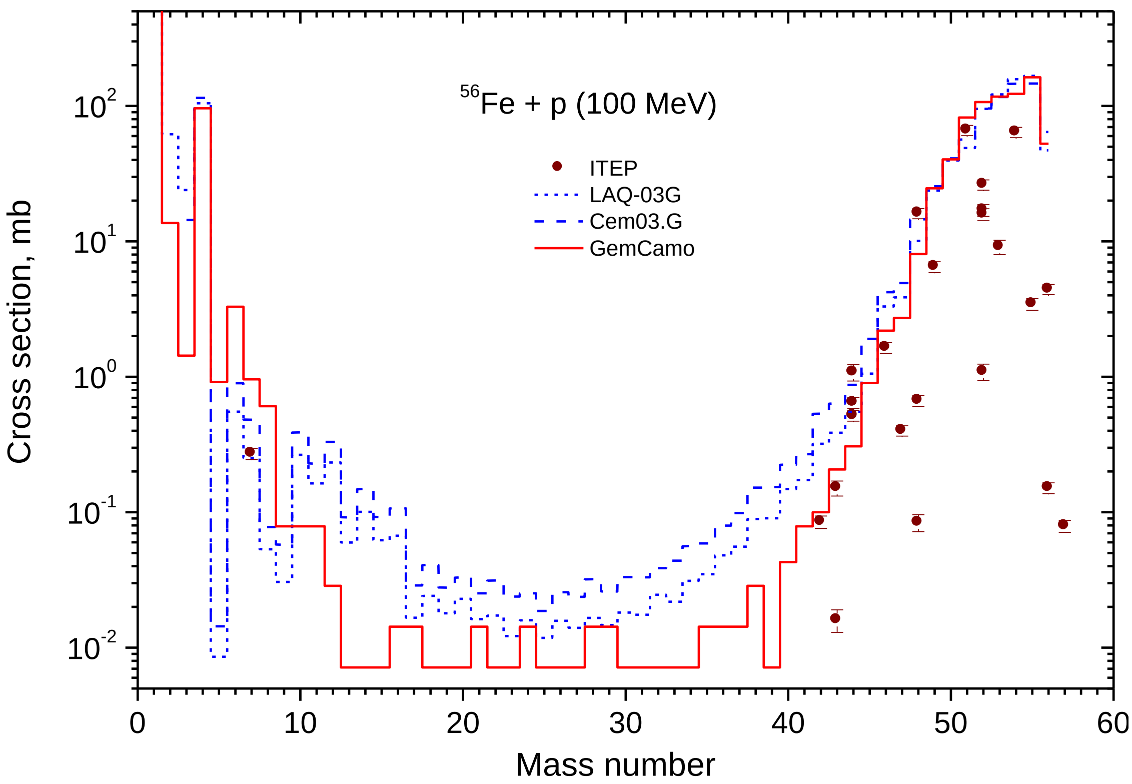

Fig. 6.8. Calculated mass distributions of the ^{56}Fe+p reaction products for 100-MeV protons compared with the experimental data of the present Project.

6.4. Analyzing the ^{nat}Cr and ^{nat}Ni target data

Fig. 6.9 shows the Project experimental data for ^{nat}Cr target irradiated with the 1200-MeV protons in comparison with analogous ^{56}Fe target data and with the GEMCAMO calculated yields for ^{nat}Cr and ^{56}Fe targets. A change of the target mass number shifts the reaction product distribution curve for A>20 towards lower masses. However, for the lighter nuclei the slight yield variations occur only without any essential shift of the relative product distribution. Generally, the calculated changes of product yields for some mass number are rather similar to those that observed on the experiment for the most of individual or cumulative yields in the corresponding mass region.

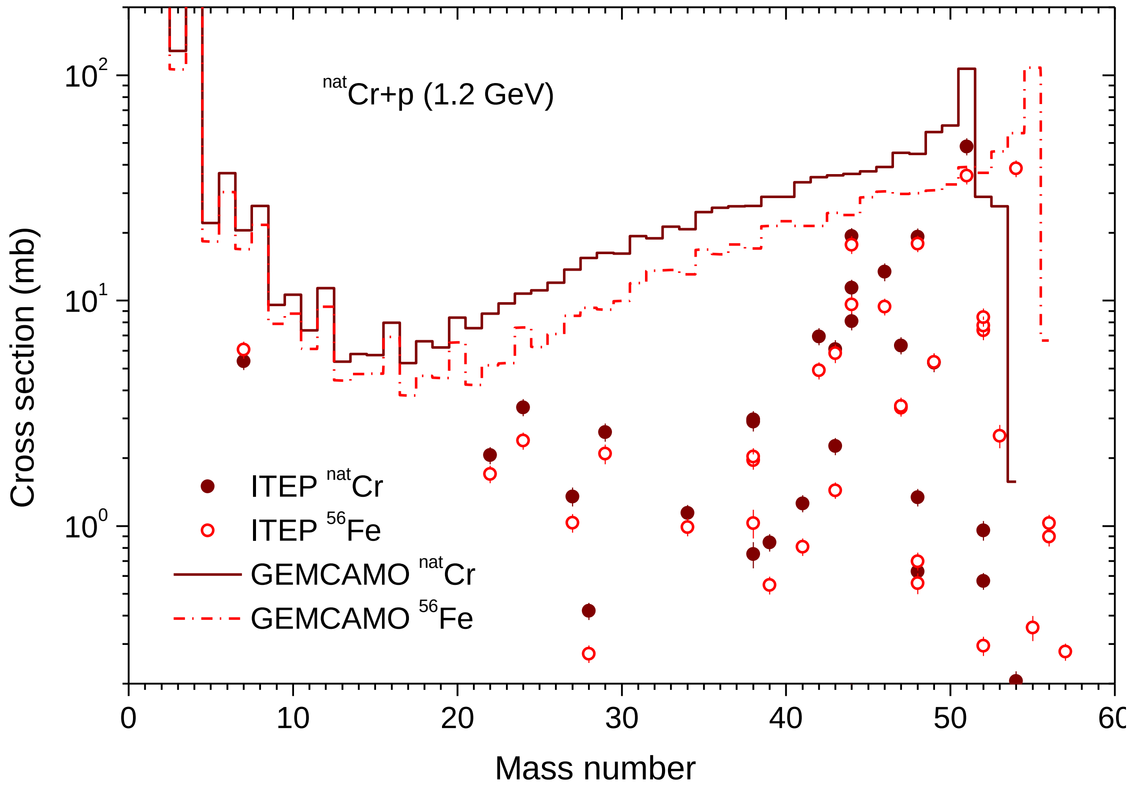

Fig. 6.9. Calculated mass distributions of the ^{nat}Cr+p reaction products for 1200-MeV protons compared with the analogous ^{56}Fe+p calculations and with the ITEP experimental data the both reactions.

Fig. 6.10 shows the analogous data for ^{nat}Ni target. As should be expected, in this case the product mass distribution shifts with respect to ^{56}Fe towards higher masses, while the A>20 yields get decreased. The trend, which is opposite to that observed in ^{nat}Cr target, is confirmed on the average by experimental data on individual and cumulative yields in ^{nat}Ni target. For the products with A<20 the differences between the yield distributions in ^{nat}Ni and ^{56}Fe targets must be quite small. It should be noted that above-stated regularities of the mass distribution variations are relate first of all to the data on cumulative yields. The independent nuclide yields are determined on the basis of both the mass and charge distributions, so the comparison of the respective data to the calculation results requires a more detailed analysis.

The considered general regularities of the mass distribution variations under target changes must be valid for other incident proton energies too. In most cases, the experimental data on cumulative yields obtained under the Project confirm this regularities. At the same time, the opposite tendencies are observed often for independent yields when changing targets. As a rule, such features occur for isotopes with very small yields when the charge distribution changes are more important compared with the mass distribution variations.

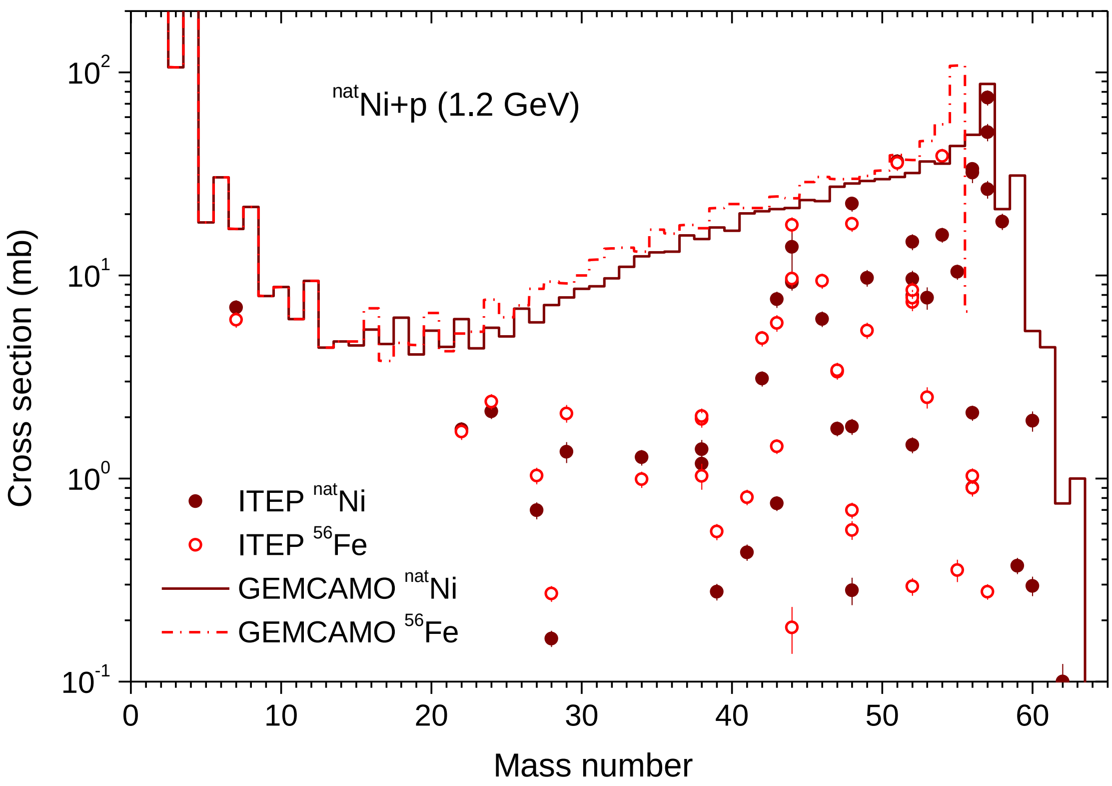

Fig. 6.10. Calculated mass distributions of the ^{nat}Ni+p reaction products for 1200-MeV protons compared with the analogous ^{56}Fe+p calculations and with the ITEP experimental data for the both reactions.

6.5. Analysis of the ^{93}Nb experimental data

Analyzing the proton induced reaction products for ^{93}Nb target is of great interest in determining the parameters of the asymmetric light nuclide fission model. In the ^{93}Nb case, the reaction product mass range is wider compared with the iron group targets, so the spallation and asymmetric fission products can be separated more effectively.

Fig. 6.11 shows the experimental data of the Project together with the GEM03.02 and GEMGAMO calculations for the 1000 MeV incident protons. Also, the results of the GAMO code that do no include the asymmetric fission model are shown as well as the results of phenomenological systematics based on the transfer of the GSI data for the 136Xe+p reaction [54] to the lighter ^{93}Nb target by shifting the spallation product distribution and preserving the light product yields as invariable for A<20. Such spallation product systematics is confirmed by the calculation results of all above codes, as well as the experimental data for nuclei with A>75, but for the light mass region the GEM03.02 and GEMGAMO calculations has failed to confirm the structure of light product yields observed for the ^{56}Fe target in the mass region A<20 (see Fig.6.6). Besides, attention attracts the significant difference between the GEM03.02 and GEMGAMO results in the mass range 15<A<30. The GEM03.02 code includes the evaporation model of light nuclei with mass numbers A<30, but do not consider the asymmetric fission and multifragmentation processes. Unfortunately, the calculations with the GEM03.G and GEM03.S codes, which include a simulation of such processes, are still not performed for ^{93}Nb target. Without such simulation the very low yields of nuclei the range of 15<A<30 look as an inevitable result. Experimental data of the project on the cumulative yields of ^{22}Na and ^{38}Cl agree reasonably with the GEMGAMO results, but the measured cumulative yield of ^{24}Na supports the phenomenological systematics and indicates that fission cross section in the GEMGAMO calculations could be increased.

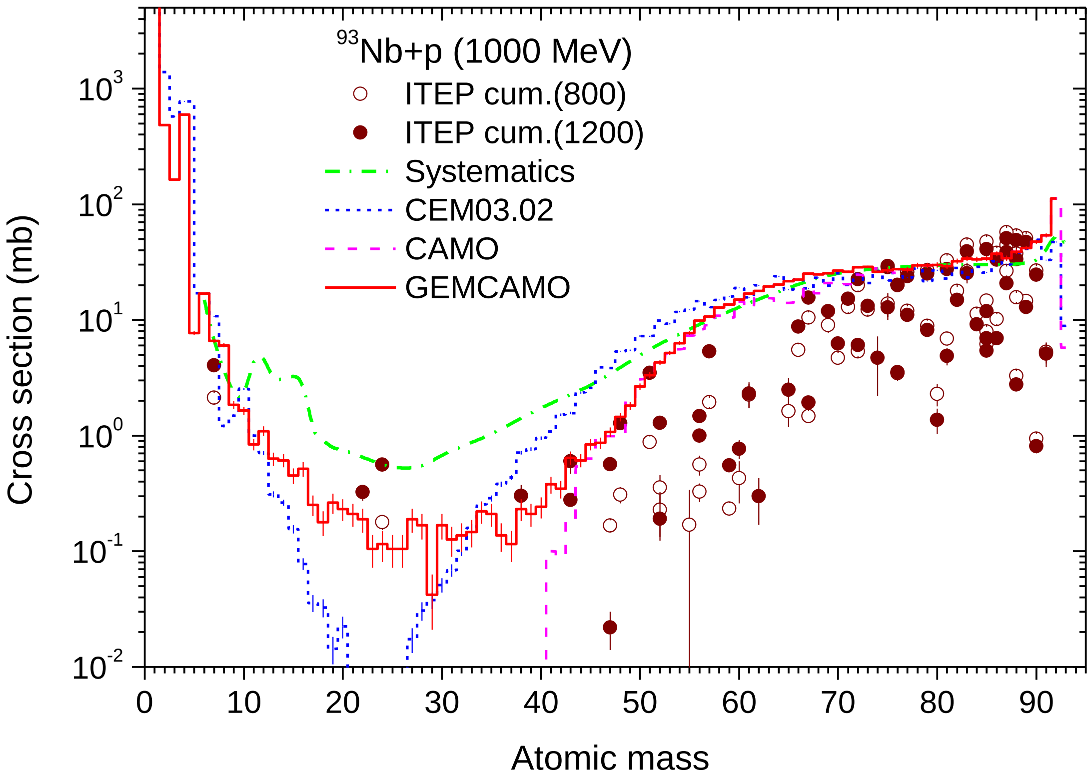

Fig. 6.11. Calculated mass distributions of the ^{93}Nb+p reaction products for 1000-MeV protons compared with the experimental data of the Project for the proton energies of 800 and 1200 MeV.

Fig. 6.12 shows the calculated mass distributions for the 300 MeV incident protons together the experimental data of the Project. Also presented is the phenomenological systematics of yields, which, however, is grounded to a lesser degree for the mass range A<50 compared with the above systematics for 1000 MeV, which is supported by the experimental data of the ^{136}Xe+p reaction [54]. The GEM03.02 and GEMGAMO calculations predict a much stronger decrease in the product yields for the mass region 15<A<60 compared to what follows from the systematics. Unfortunately, the experimental data are absent for this region. Additional experiments are needed to estimate more precisely the reaction product yields for proton energies below 250 MeV.

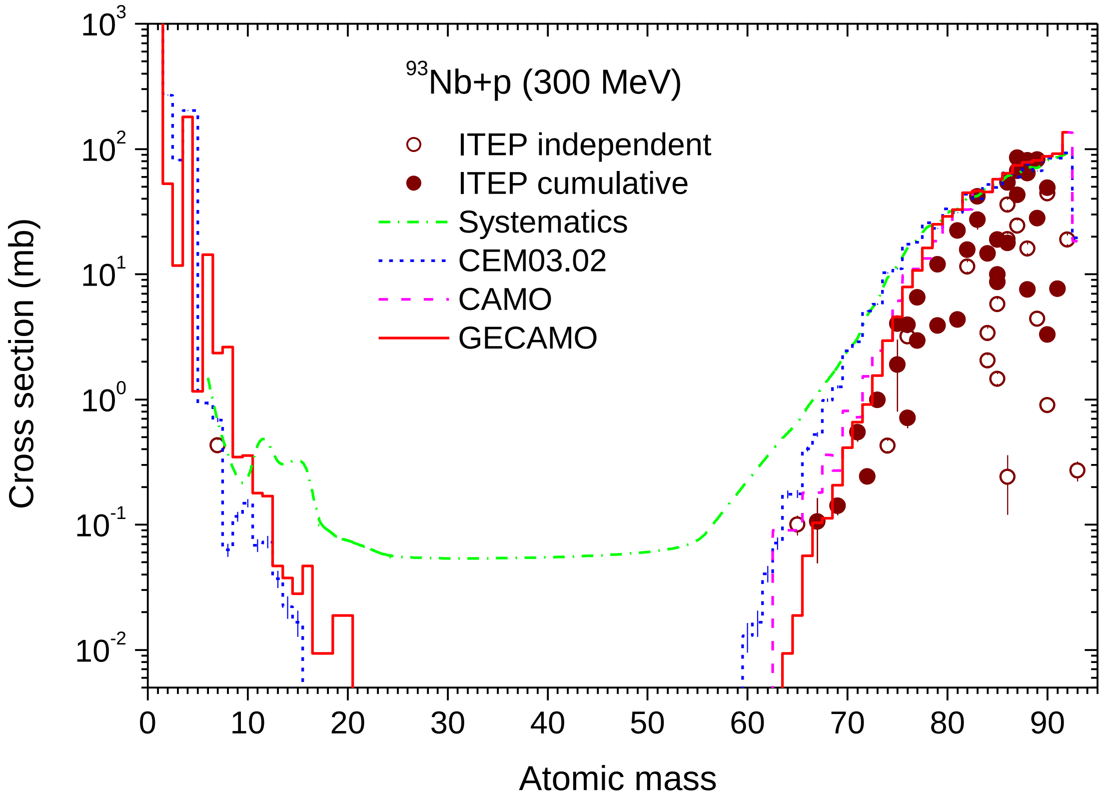

Fig. 6.12. Calculated mass distributions of the ^{93}Nb+p reaction products for 300-MeV protons compared with the experimental data of the Project for 250-MeV protons.

6.6. Analysis of the ^{181}Ta and ^{nat}W target data

The asymmetric fission model implemented in GEMINI code has to be used mainly to analyze a decay of highly excited nuclei, whose the ratio values of $Z^2/A<20$, i.e. the mass numbers below 140-150. In the case of heavier nuclei, the high-energy fission can be described properly in terms of the standard symmetric fission model. So, the Project data for ^{181}Ta and ^{nat}W targets can be analyzed in terms of the traditional INC models, in which, nevertheless, the shell corrections to the fission barriers and the level densities should be considered in the consistent way. In accordance with that the following analysis was performed with the CASCADO code that was successfully used earlier to describe the main regularities in the product yields of the proton induced reactions on lead and bismuth targets [55]. For the light nuclei with A<18 this code use the Fermi disintegration model instead the standard evaporation model usually used for all more heavy nuclei. The disintegration model parameters were tested earlier on an extensive amount of experimental data for the proton induced reactions on light nuclei [6-23].

The available experimental data on the proton-induced fission cross sections for ^{181}Ta and ^{nat}W have been collected in [56], wherein they were used to obtain the empirical systematics of the fission cross sections of these targets for the incident proton energies up to 10 GeV. In the following calculations the fission barrier parameters were always slightly adjusted to agree the calculated fission cross sections with the systematics predictions.

Fig. 6.13 shows the experimental data of the Project for ^{181}Ta target irradiated with the 1200 MeV protons together with the results of the GEM03.02 and CASCADO calculations. An attention attract the big difference in the calculated fission-product yields in the region of 20<A<100. The fission cross section calculated by CASCADO is equal to 17.8 mb that well agrees with the systematics [56]. Obviously, the GEM03.02 calculations underestimate the fission cross section by more than 3 times. The total reaction cross section estimated by these code are also too low, that reflects in the reduced yields of the nuclei, whose masses are close to the target mass. The CASCADO results agree much better with the experimental data for A>150. The reason for the calculation discrepancies in the region of 110<A<150 is still obscure.

In comparing with experimental data the main questions relate to the fission products whose yields exceed the calculated values by a factor of 1.5-2. The found disagreement may be easy removed via increasing the fission cross sections by the same factor in the corresponding calculations. However, such increasing contradicts the fission cross section systematics [56]. On the other hand, the measured yields of ^{24}Na is so high, that its description requires unjustified large fission cross section increasing. So large fission increasing can hardly be explained, so a need for more accurate experimental data looks the most of probable. However, it should be noted that a similar excess of ^{24}Na yield relative neighboring isotopes is observed also for ^{197}Au target [57]. So, the questions about ^{24}Na yields may be more difficult that it looks at once.

Fig. 6.14 shows the Project experimental data together with the calculated yields for the 250 MeV incident protons. The large difference between the GEM03.02 and CASCADO results is accounted similarly to the previous figure by the difference of the calculated fission cross sections. The CASCADO results correspond to the fission cross section of 4.2 mb that agrees with the systematics [56], whereas for GEM03.02 the much lower value of 1.9 mb has obtained. In the mass region A>150 the results of the both codes are quite similar and some differences arise only for masses near the target mass. The correct description of the fission cross section allows the CASCADO results to be considered fairly reliable throughout the whole mass range.

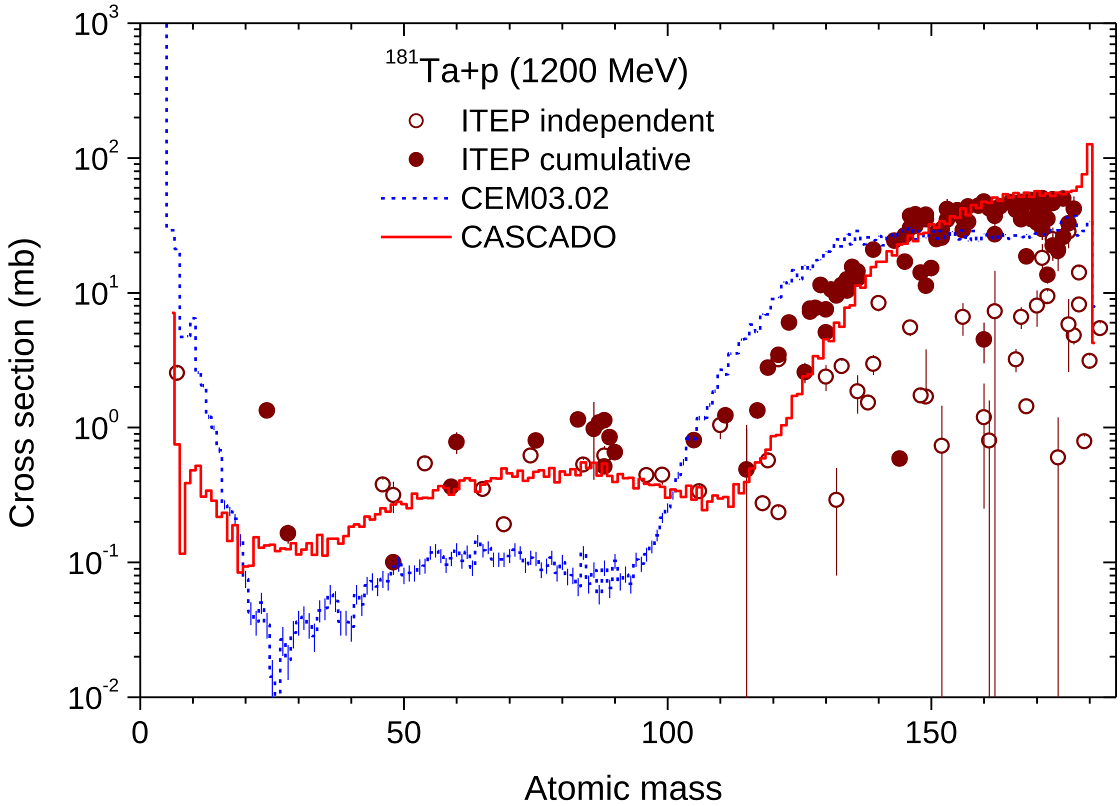

Fig. 6.13. Calculated mass distributions of the ^{181}Ta+p reaction products for 1200-MeV protons compared with the experimental data of the Project.

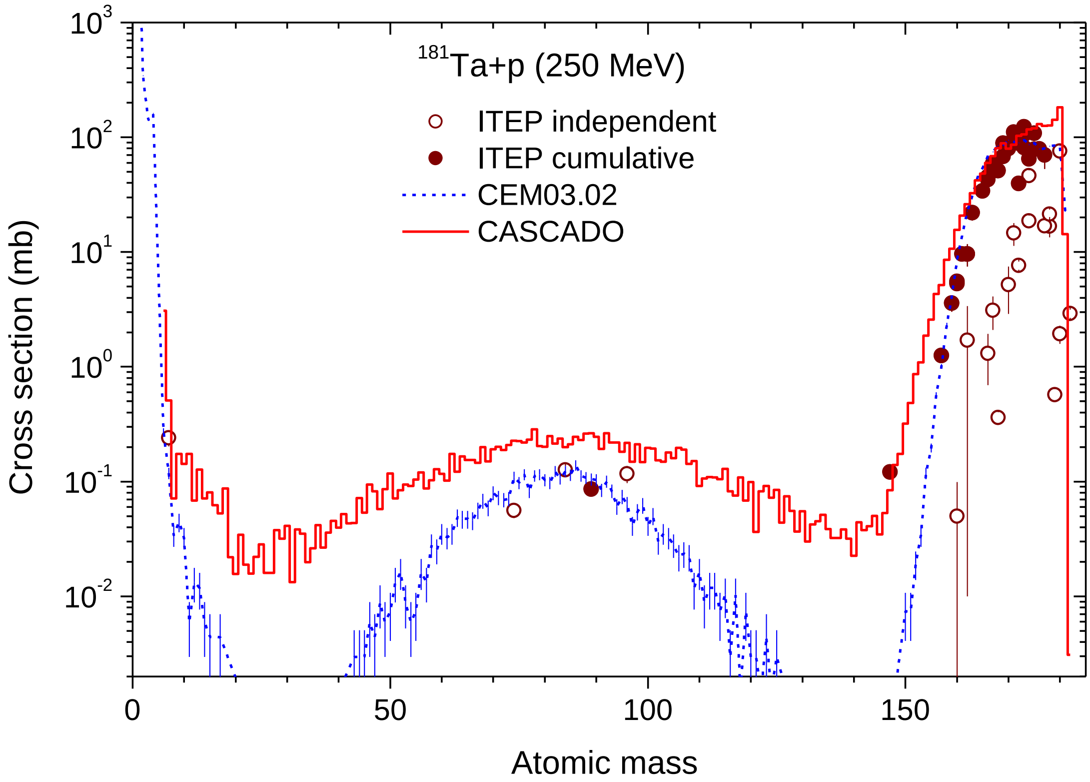

Fig. 6.14. Calculated mass distributions of the ^{181}Ta+p reaction products for 250-MeV protons compared with the experimental data of the present Project

Figs 6.15 and 6.16 show the experimental data obtained for ^{nat}W target irradiated with the 1200 and 250 MeV protons, respectively. The GEM03.02 and CASCADO code results are also presented. For the both energies the fission cross sections calculated with CASCADO are equal to 22.2 and 5.6 mb, respectively, which are in a good agreement with the systematics [56]. The GEM03.02 results for these cross sections are lower only a little and the calculated fission-product mass distributions agree for ^{nat}W target much better than in the case of ^{181}Ta target. As before, the measured cumulative yields in the region A>150 are in a good agreement with experiment. Again, the main difficulties of the experimental data description relate to the fission product yields, which are situated much above the theoretic curves.

It should be noted, however, that the systematics [56], to which were adjusted the calculated fission cross sections, can not be considered as well reliable for the incident proton energies above 1000 MeV. The experimental data used by this systematics are shown in Fig. 6.17. One can see that for the proton energy of 1000 MeV the experimental value of the fission cross section for ^{181}Ta overestimates the systematics value about 2-times and contradictions with the systemstics are ever bigger for the ^{nat}W experimental point at higher energies. The present Project data on the cumulative yields of fission products for the mass region 70<A<110 (Fig. 6.15) could be also interpreted as indication on a higher value of the fission cross section than evaluated one on the basis of the used systematics.

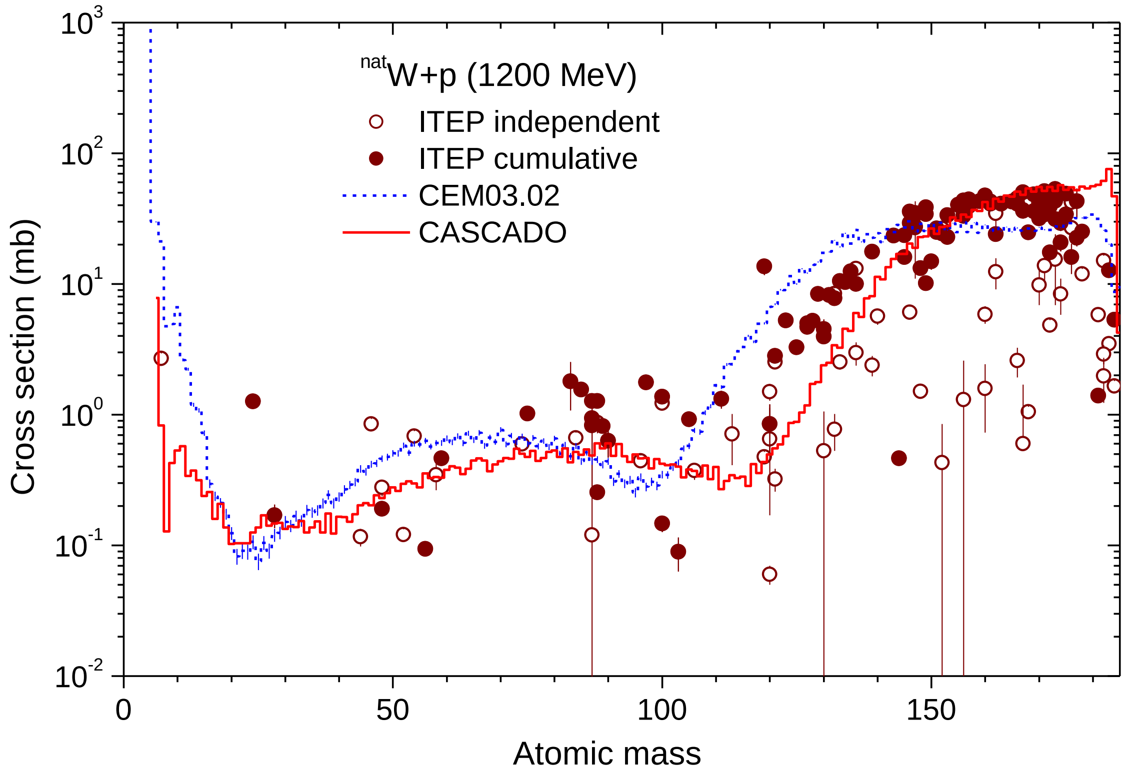

Fig. 6.15. Results of calculating the ^{nat}W+p reaction product yields for 1200-MeV protons as compared with the experimental data of the Project.

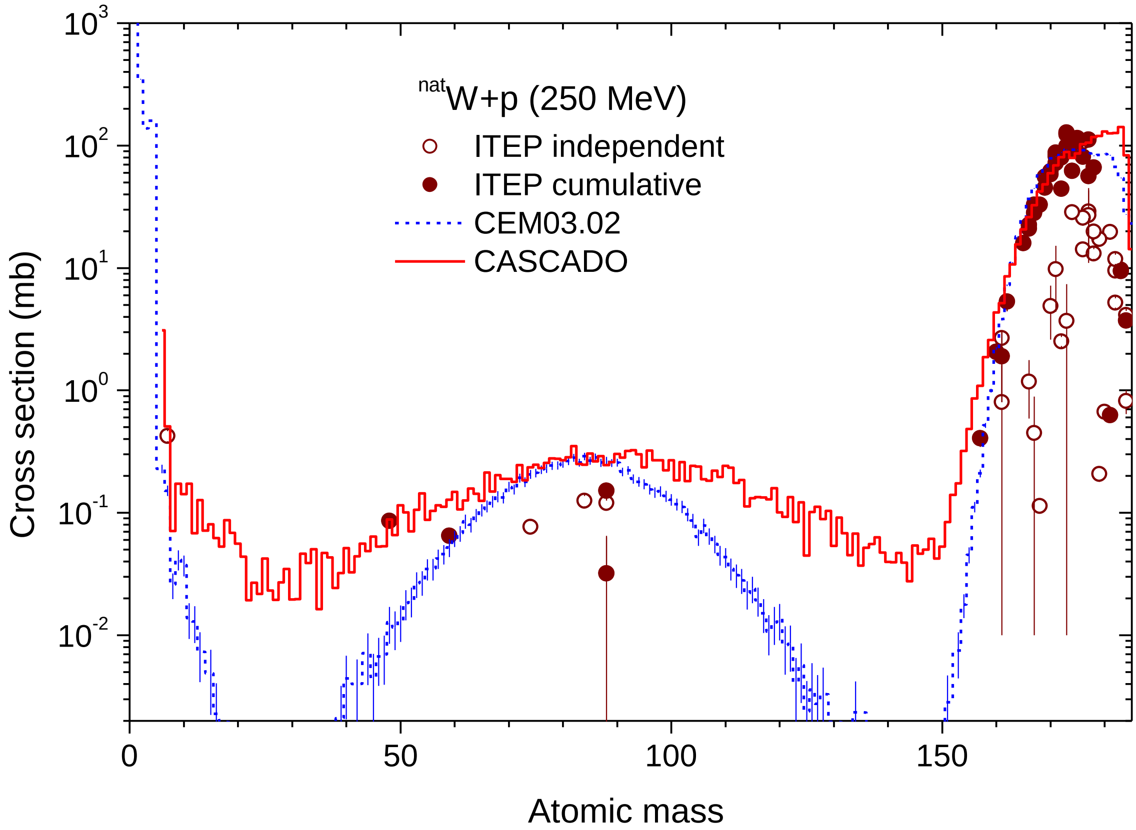

Fig. 6.16. Calculated mass distributions of the ${}^{nat}W$+p reaction products for 250-MeV protons compared with the experimental data of the Project.

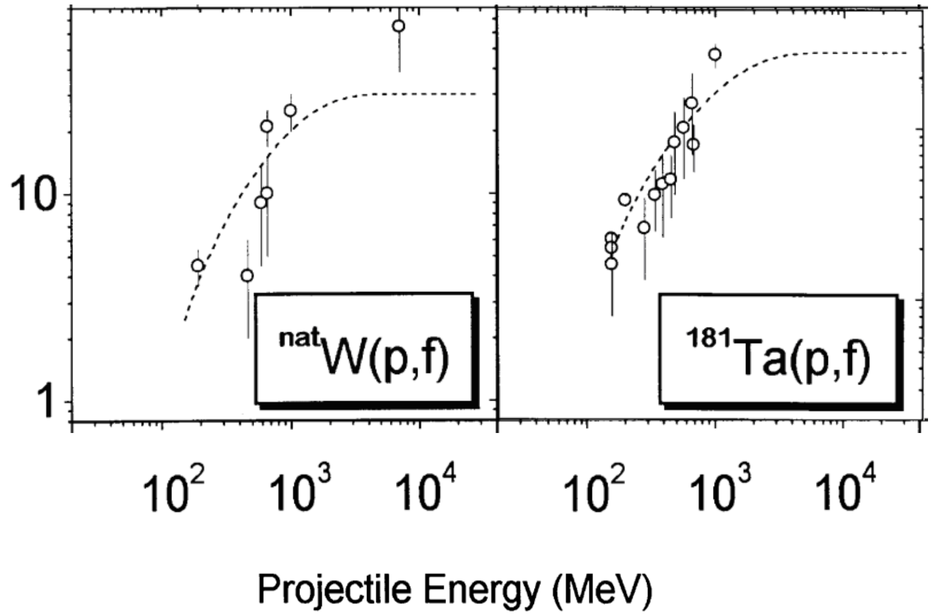

Fig. 6.17. The systematics of the proton-induced fission cross-sections for ${}^{nat}W$ and ${}^{181}Ta$ (dotted lines) compared with the available experimental data [56]

6.7. Conclusions on chapter 6.

The research results presented in this Section may be summarized as follows:

- The spallation reaction product yields have been calculated with various INC codes that simulate the high-energy intranuclear nucleon-nucleon collisions, the subsequent pre-equilibrium processes, and the final evaporative decay or fission of a highly-excited compound nucleus. The discrepancies between the results of different code simulating the product mass distributions in the proton induced reactions have been analyzed for the iron group targets, which relate to the main structure materials of the power generating facilities, for ^{93}Nb nuclide that belongs to the family of Zr-Mo nuclei, applied as important minor components of the structure materials, and of ^{181}Ta and ^{nat}W nuclei, considered as promising solid targets of high-current accelerators.
- It has been shown that the asymmetric fission model should certainly be included in the INC code simulating the mass and isotope yields of the proton induced reactions on the iron group nuclei and on the heavier nuclei related to Zr-Mo group. The experimental data obtained under the Project permit to test the main parameters of the asymmetric fission model: the fission barrier heights and the fission delay time evoked by a nuclear viscosity. Uncertainties of current model parameters are still rather big due to strong correlation between parameters. Additional experiments are needed for an accurate evaluation of the crucial model parameters.
- It has been shown that for ^{181}Ta and ^{nat}W targets a consistent estimation of the total fission cross sections plays a crucial role. The available empirical systematics of these cross sections are reasonable for the proton energies below 1000 MeV, but they are certainly needed in improvements for higher projectile energies.
- Performed simulating the mass distributions of reaction products permits to mark out the results, which suffer significant systematic uncertainties and, therefore, must be isolated in the experimental datasets or be analyzed repeatedly on the basis of improved models or empirical systematics.
- The copious experimental data obtained under the Project will facilitate further developing the INC models and the corresponding computational codes used widely in the national and international designs of promising ADS facilities.

7. THEORETICAL MODELING BY DIFFERENT CODES

7.1 The codes used to simulate the experimental results

The following five codes were used to calculate our measured cross sections:

- MCNPX [51]. This is well known code widely used in different nuclear applications. It carries out Monte-Carlo modeling of transport of nucleons, pions, muons, light ions and antinucleons in extended objects and thin targets (interactions with nuclei). The MCNPX has been developed in LANL and includes several options of models of intranuclear cascade (INC), preequilibrium, evaporation and fission. This work uses Bertini and ISABEL INC's, multistage preequilibrium model, Dresner's evaporation and Atchison's (RAL) fission models. (details can be found in [51]).

- CEM03.02 is the last, 2009, version of the improved Cascade-Exciton Model (CEM) [58], proposed initially at JINR, Dubna [32]. 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 Dubna INC [59], extended Fermi break up and coalescence models from [60], and includes an improved version of the Generalized Evaporation-fission Model (GEM2) by Furihata [61]. CEM03.02 and/or its precursors are incorporated into the MARS, MCNPX, and LAHET transport codes and are used in many applications. The above modifications of CEM03.02 and the simulations were carried out at LANL by S.G.Mashnik.

- INCL4+ABLA [62, 63] This code is based on a recent version of the Liege INC by Cugnon et al. [66] merged with the GSI evaporation/fission model ABLA by Schmidt et al. [67]. 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. This work uses both previous (INCL4+ABLA), and the last (INCL4.4.5+ABLA07) versions of the code.

- PHITS [64] **P**article and **H**eavy **I**on **T**ransport Code **S**ystem is a general purpose Monte Carlo simulation code, widely used in many fields, such as accelerator, radiotherapy and space science. To compute the production yields and characteristics of all the particles and nuclei generated in spallation reactions, the PHITS code has three kinds of first stage model/codes and one de-excitation (principally evaporation/fission) model. The Bertini model [65,66] and the **J**et **A**A **M**icroscopic Transport Model, JAM code [67], are one of

Intra-**N**uclear **C**ascade (INC) models which treats hadron-nucleus collisions. And, the **J**aeri **Q**uantum **M**olecular **D**ynamics, JQMD code [68], is one of **Q**uantum **M**olecular **D**ynamics (QMD) model which can also handle the nucleus-nucleus reactions. After retrieving information from the first stage model, the **G**eneralized **E**vaporation **M**odel, GEM code [69], simulates the evaporation and fission process which includes light nuclei up to Mg as ejectiles. In the energy region from thermal to fast neutron, PHITS can be calculated based on the Monte Carlo method using evaluated nuclear data. A new feature, Event Generator mode, considered the conservation laws of energy and momentum for one event, can be simulated event-by-event in the same way as high-energy simulation process. Note that, unlike other codes, PHITS codes considers nuclei after particle elastic scattering as residual nuclides that is easy seen below in Figs. 7.52 – 7.117 with mass distributions of reaction products.

- CASCADE07 [70] is Monte Carlo program (Intra-nuclear cascade – Preequilibrium - Evaporation/ Fission code) is used for interaction of incident proton with single nucleus. Dubna version of intranuclear cascade [60] is used with continuous density distribution of nucleus. Cross-sections of the hadron-nucleus collisions are calculated based on the compilations of the experimental data [71]. To calculate the nucleus-nucleus cross-sections we used analytical approximations with parameters defined in [72]. Criteria of transition from intra-nuclear cascade to pre-equilibrium stage are the cutoff energy (binding energy above the Fermi energy). The cut off energy has been modified in the recent work and it is reduced towards the tail of the density distribution down to 2MeV. This reduction is done due to some discontinuity in the secondary particle spectra. Pre-equilibrium stage is calculated by the method based on the Blann's model [73]. Proton, neutron, deuterium, tritium, ^{3}He and ^{4}He are considered as emitted particles in the pre-equilibrium and in the subsequent equilibrium stage. Transition from pre-equilibrium to equilibrium state of the reaction is modified in this work as described in [74]. Equilibrium stage considers the particle evaporation/fission of the thermally equilibrated nucleus which is well described in [75]. The code has been modified further which is published in [70] and some of the recent developments listed above and others are not yet published.

7.2 Simulation results comparison with experimental data

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 correct, the required cumulative yields were calculated on the base of simulated independent yields. Simulated and experimental values are compared both qualitatively (by plots) and quantitatively (by the mean simulated-to-experiment squared deviation factor <F>: $\langle F \rangle = 10^{\sqrt{\langle \log(\sigma_{cal,i}/\sigma_{\exp,i})^2 \rangle}}$).

It should be noted that a number of measured nuclides cannot be compared be compared with simulated data. It concerns the metastable products which are not modeled by the used codes: ^{184m}Re(169d), ^{178m}Ta(2.36h), ^{180m}Hf(5.5h) ^{179m}Hf(25.05d), ^{160m}Ho(5.02h), ^{140m}Pm(5.95m), ^{139m}Nd(5.5h), ^{138m}Pr(2.12h), ^{133m}Ce(4.9h), ^{121m}Te(154d), ^{119m}Te(4.70d), ^{120m}Sb(5.76d), ^{118m}Sb(5.00h), ^{108m}In(4.2h), ^{108m}Ag(249.7d), ^{106m}Ag(8.28d), ^{102m}Rh(2.9y), ^{99m}Rh(4.7h), ^{93m}Mo(6.85h), ^{92m}Nb(10.15d), ^{91m}Nb(60.86d), ^{89m}Nb(66m), ^{90m}Y(3.19h), ^{87m}Y(13.37h), ^{86m}Y(48m), ^{85m}Y(4.86h), ^{85m}Sr(67.63m), ^{84m}Rb(20.26m), ^{82m}Rb(6.472h), ^{74m}Br(46m), ^{73m}Se(39.8), ^{69m}Zn(13.76h), ^{62m}Co(13.91m), ^{52m}Mn(21.1m), ^{44m}Sc(58.61h), ^{34m}Cl(32.00m).

Moreover, a number of products, despite they are modeled by the codes, cannot be correctly compared with experimental data. Such nuclides include those that:

1) have metastable states with significant branching factor (decay by non-internal transmission mode with more than 20% probability): ^{180}Ta(8.152h), ^{162}Tm(21.70m), ^{160}Ho(25.6m), ^{152}Tb(17.5h), ^{149}Tb(4.118h), ^{148}Tb(60m), ^{147}Tb(1.7h), ^{134}Pr(17m), ^{132}La(4.8h), ^{120}I(81.0m), ^{119}Te(16.03h), ^{110}In(4.9h), ^{108}In(58.0m), ^{102}Rh(209d), ^{94}Tc(293m), ^{91}Mo(15.49m), ^{88}Nb(14.5m), ^{85}Zr(64.02m), ^{85}Y(2.68h), ^{84}Y(4.6s), ^{74}Br(25.4), ^{73}Se(7.15h), ^{52}Mn(5.591d), ^{38}K(7.636m).

2) have metastable states with lifetime significantly above the one of ground state: ^{180}Ta(8.152h), ^{44}Sc$_{(ind)}$(3.97h)

These products were excluded from accounting at <F> factor calculation despite they were modeled and plotted on the figures with EF (they are marked by “N” on the right upper corner of the EF figures). In case of ^{52}Mn, the measured yield of metastable state was added to the measured ground state (marked “○” on the figures with EF) and resultant values (marked “●” on the figures with EF) were compared with theoretical predictions.

Moreover, several simulated values with low level statistics were excluded from accounting at <F> factor calculation. A criterion of with low level statistics was accepted depending on experimental yields as:

$$\frac{\sigma_{calc}}{\sigma_{\exp}} < 10^{-R}\text{, where } R = \frac{1}{2}(\lg(\sigma_{\exp}[mb]) + 5)$$

Excluding such cases allows us to avoid unjustified high values of <F> factor due to cases when a simulated value is based only by a few events per several million simulation histories.

The technique to calculate the cumulative and supracumulative cross sections is described in [1-5]. Three set of figures were drawn for the qualitative comparison.

1. 583 figures with EF simulated by the codes and measured (Figs. 7.1 – 7.51).
2. 66 figures with mass production cross sections measured and simulated (Figs 7.52 – 7.117), 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 gamma-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. 108 figures with simulation-to-experimental ration statistics (Figs 7.118-7.135) that also can be used for the quantitative comparison.

Additionally tables 7.1 – 7.6 presents lists of nuclides with supracumulative yields, their branching factors – ν, as well as supracumulative factors which are calculated in accordance with (7.1):

$$R_n^{cum^*} = R_n^{ind} + \frac{\lambda_{n-1}}{\lambda_{n-1} - \lambda_n} \cdot \nu_{n-1,n} \cdot R_{n-1}^{cum} = R_n^{cum} + \frac{\lambda_{n-1}}{\lambda_{n-1} - \lambda_n} \cdot \nu_{n-1,n} \cdot R_{n-1}^{cum} \quad (7.1)$$

$$\Delta R_n^{cum^*} = \sqrt{\Delta\left(R_n^{cum}\right)^2 + \left(\frac{\lambda_{n-1}}{\lambda_{n-1} - \lambda_n} \cdot \nu_{n-1,n}\right)^2 \cdot \left(R_{n-1}^{cum}\right)^2} \quad (7.2)$$

Table 7.1

The list of nuclides with supracumulative yields, their lifetimes, branching factors – ν, as well as supracumulative factors in case of Cr.

№	Nuclide (2)	$T_{1/2}$ (2)	Nuclide (1)	$T_{1/2}$ (1)	type	ν_{12}	$\lambda_1/(\lambda_1-\lambda_2)$	K_{cum*}
1	^{44}K	22.13 m	^{44}Ar	11.87 m	c*	1	2.157	2.157

Table 7.2

The list of nuclides with supracumulative yields, their lifetimes, branching factors – ν, as well as supracumulative factors in case of Fe.

№	Nuclide (2)	$T_{1/2}$ (2)	Nuclide (1)	$T_{1/2}$ (1)	type	ν_{12}	$\lambda_1/(\lambda_1-\lambda_2)$	K_{cum*}
1	^{53}Fe	8.51 m	^{53m}Fe	2.526 m	c*	1	1.422	1.422
2	^{44}K	22.13 m	^{44}Ar	11.87 m	c*	1	2.157	2.157

Table 7.3

The list of nuclides with supracumulative yields, their lifetimes, branching factors – ν, as well as supracumulative factors in case of Ni

.

№	Nuclide (2)	$T_{1/2}$ (2)	Nuclide (1)	$T_{1/2}$ (1)	type	ν_{12}	$\lambda_1/(\lambda_1-\lambda_2)$	K_{cum*}
1	^{53}Fe	8.51 m	^{53m}Fe	2.526 m	c*	1	1.422	1.422

Table 7.4

The list of nuclides with supracumulative yields, their lifetimes, branching factors – ν, as well as supracumulative factors in case of Nb.

№	Nuclide (2)	$T_{1/2}$ (2)	Nuclide (1)	$T_{1/2}$ (1)	type	ν_{12}	$\lambda_1/(\lambda_1-\lambda_2)$	K_{cum*}
1	^{88}Nb	14.5 m	^{88}Mo	8 m	c*	1	2.231	2.231
2	^{70}As	52.6 m	^{70}Se	41.1 m	c*	1	4.574	4.574
3	^{66}Ga	9.49 h	^{66}Ge	2.26 h	c*	1	1.313	1.313
4	^{53}Fe	8.51 m	^{53m}Fe	2.526 m	c*	1	1.422	1.422

Table 7.5

The list of nuclides with supracumulative yields, their lifetimes, branching factors – ν, as well as supracumulative factors in case of Ta.

№	Nuclide (2)	$T_{1/2}$ (2)	Nuclide (1)	$T_{1/2}$ (1)	type	ν_{12}	$\lambda_1/(\lambda_1-\lambda_2)$	K_{cum*}
1	^{177}Ta	56.56 h	^{177}W	135 m	c*	1	1.041	1.041
2	^{176}Ta	8.09 h	^{176}W	2.5 h	c*	1	1.447	1.447
3	^{172}Ta	36.8 m	^{172}W	6.6 m	c*	1	1.219	1.219
4	^{173}Hf	23.6 h	^{173}Ta	3.14 h	c*	1	1.153	1.153
5	^{169}Yb	32.026 d	^{169}Lu	34.06 h	c*	1	1.046	1.046
6	^{163}Tm	1.81 h	^{163}Yb	11.05 m	c*	1	1.113	1.113
7	^{159}Er	36 m	^{159}Tm	9.13 m	c*	1	1.340	1.340
8	^{157}Er	18.65 m	^{157}Tm	3.63 m	c*	1	1.242	1.242
9	^{155}Dy	9.9 h	^{155}Ho	48 m	c*	1	1.088	1.088
10	^{155}Tb	5.32 d	^{155}Dy	9.9 h	c*	1	1.084	1.084
11	^{153}Tb	2.34 d	^{153}Dy	6.4 h	c*	0.9999	1.129	1.129
12	^{134}Pr	17 m	^{134}Nd	8.5 m	c*	1	2.000	2.000
13	^{115}Sb	32.1 m	^{115m}Te	6.7 m	c*	1	1.264	1.264
14	^{115}Sb	32.1 m	^{115}Te	5.8 m	c*	1	1.221	1.221

№	Nuclide (2)	$T_{1/2}$ (2)	Nuclide (1)	$T_{1/2}$ (1)	type	ν_{12}	$\lambda_1/(\lambda_1-\lambda_2)$	K_{cum*}
15	^{108}In	58 m	^{108}Sn	10.3 m	c*	1	1.216	1.216
16	^{90}Nb	14.6 h	^{90}Mb	5.56 h	c*	1	1.615	1.615
17	^{87m}Y	13.37 h	^{87}Zr	1.68 h	c*	1	1.144	1.144

Table 7.6

The list of nuclides with supracumulative yields, their lifetimes, branching factors – ν, as well as supracumulative factors in case of W.

№	Nuclide (2)	$T_{1/2}$ (2)	Nuclide (1)	$T_{1/2}$ (1)	type	ν_{12}	$\lambda_1/(\lambda_1-\lambda_2)$	K_{cum*}
1	^{184}Ta	8.7 h	^{184}Hf	4.12 h	c*	1	1.900	1.900
2	^{177}Ta	56.56 h	^{177}W	135 m	c*	1	1.041	1.041
3	^{176}Ta	8.09 h	^{176}W	2.5 h	c*	1	1.447	1.447
4	^{172}Ta	36.8 m	^{172}W	6.6 m	c*	1	1.219	1.219
5	^{173}Hf	23.6 h	^{173}Ta	3.14 h	c*	1	1.153	1.153
6	^{171}Lu	8.24 d	^{171}Hf	12.1 h	c*	1	1.065	1.065
7	^{169}Yb	32.026 d	^{169}Lu	34.06 h	c*	1	1.046	1.046
8	^{163}Tm	1.81 h	^{163}Yb	11.05 m	c*	1	1.113	1.113
9	^{161}Er	3.21 h	^{161}Tm	33 m	c*	1	1.207	1.207
10	^{159}Er	36 m	^{159}Tm	9.13 m	c*	1	1.340	1.340
11	^{157}Er	18.65 m	^{157}Tm	3.63 m	c*	1	1.242	1.242
12	^{155}Dy	9.9 h	^{155}Ho	48 m	c*	1	1.088	1.088
13	^{155}Tb	5.32 d	^{155}Dy	9.9 h	c*	1	1.084	1.084
14	^{153}Tb	2.34 d	^{153}Dy	6.4 h	c*	0.9999	1.129	1.129
15	^{149}Eu	93.1 d	^{149}Gd	9.28 d	c*	1	1.111	1.111
16	^{147}Eu	24.1 d	^{147}Gd	38.06 h	c*	1	1.070	1.070
17	^{134}Pr	17 m	^{134}Nd	8.5 m	c*	1	2.000	2.000
18	^{115}Sb	32.1 m	^{115m}Te	6.7 m	c*	1	1.264	1.264
19	^{115}Sb	32.1 m	^{115}Te	5.8 m	c*	1	1.221	1.221
20	^{90}Nb	14.6 h	^{90}Mb	5.56 h	c*	1	1.615	1.615
21	^{88}Y	106.65 d	^{88}Zr	83.4 d	c*	1	4.587	4.587
22	^{87m}Y	13.37 h	^{87}Zr	1.68 h	c*	1	1.144	1.144
23	^{87}Y	79.8 h	^{87}Zr	1.68 h	c*	1	1.022	1.022

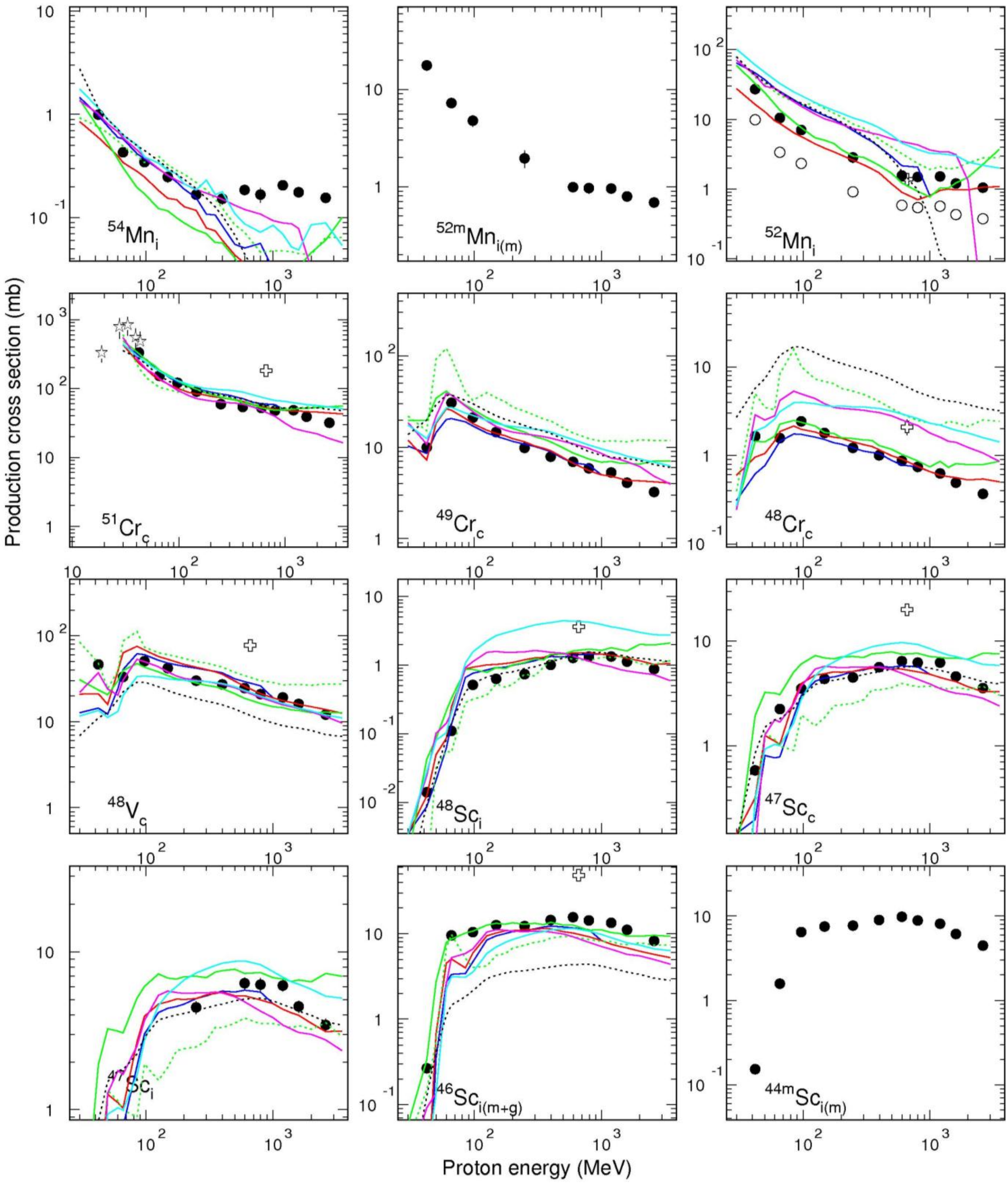

Fig. 7.1 Simulated and experimental cross sections of ^{nat}Cr(p,x) reaction. Experimental points: ● – this work, ✣ - R.Michel's works [76], ☆ - works of other laboratories. Simulations: MCNPX(BERTINI), MCNPX(ISABEL), CEM03.02, INCL4+ABLA(dots), INCL4.4.5+ABLA07, CASCADE.07(dots), PHITS.

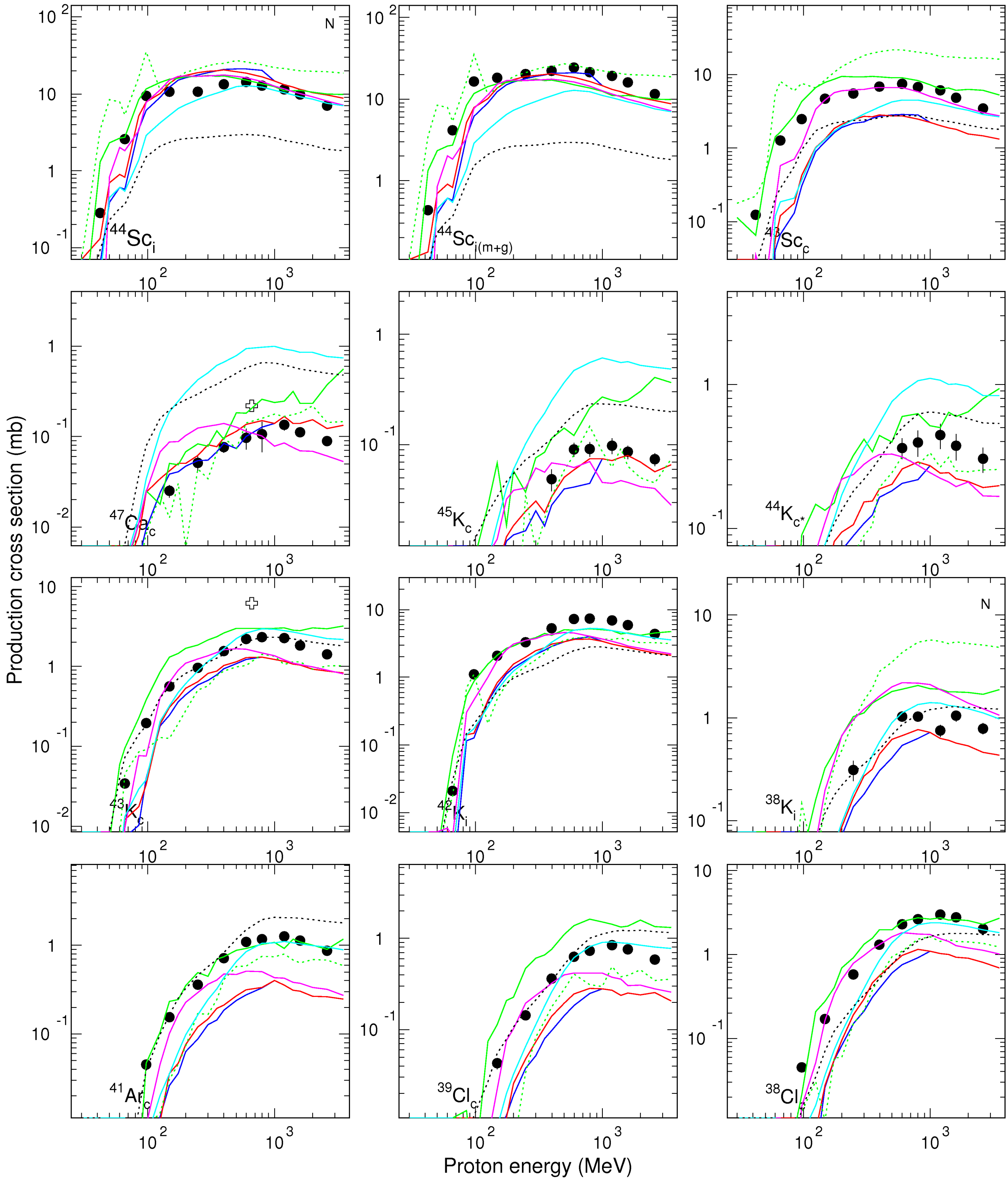

Fig. 7.2 Simulated and experimental cross sections of $^{nat}Cr(p,x)$ reaction (continuation of Fig. 7.1).

Experimental points: ● – this work, ✣ - R.Michel's works [76], ☆ - works of other laboratories. Simulations: MCNPX(BERTINI), MCNPX(ISABEL), CEM03.02, INCL4+ABLA(dots), INCL4.4.5+ABLA07, CASCADE.07(dots), PHITS.

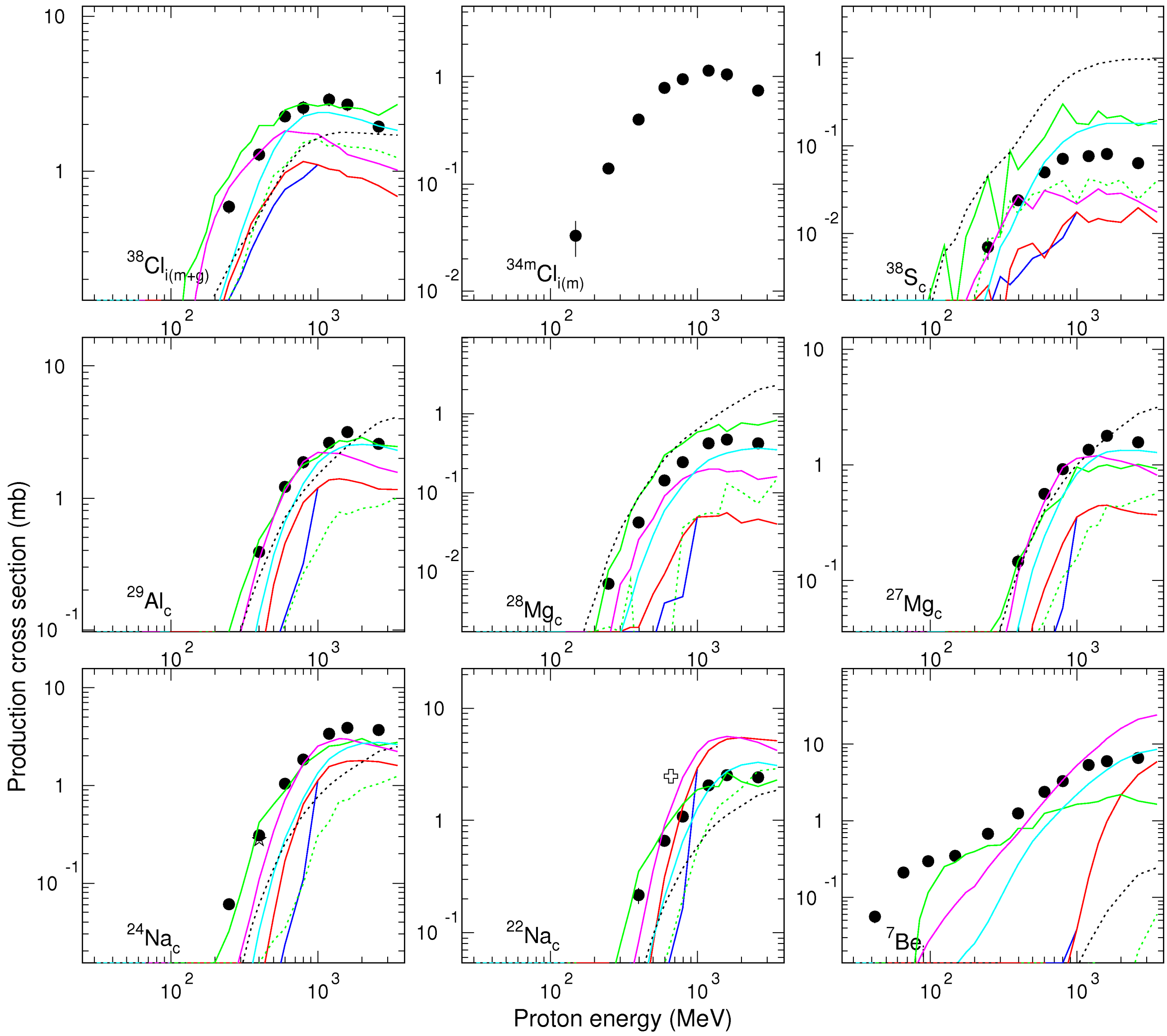

Fig. 7.3 Simulated and experimental cross sections of $^{nat}Cr(p,x)$ reaction (continuation of Fig. 7.1).

Experimental points: ● – this work, ✚ - R.Michel's works [76], ☆ - works of other laboratories. Simulations: MCNPX(BERTINI), MCNPX(ISABEL), CEM03.02, INCL4+ABLA(dots), INCL4.4.5+ABLA07, CASCADE.07(dots), PHITS.

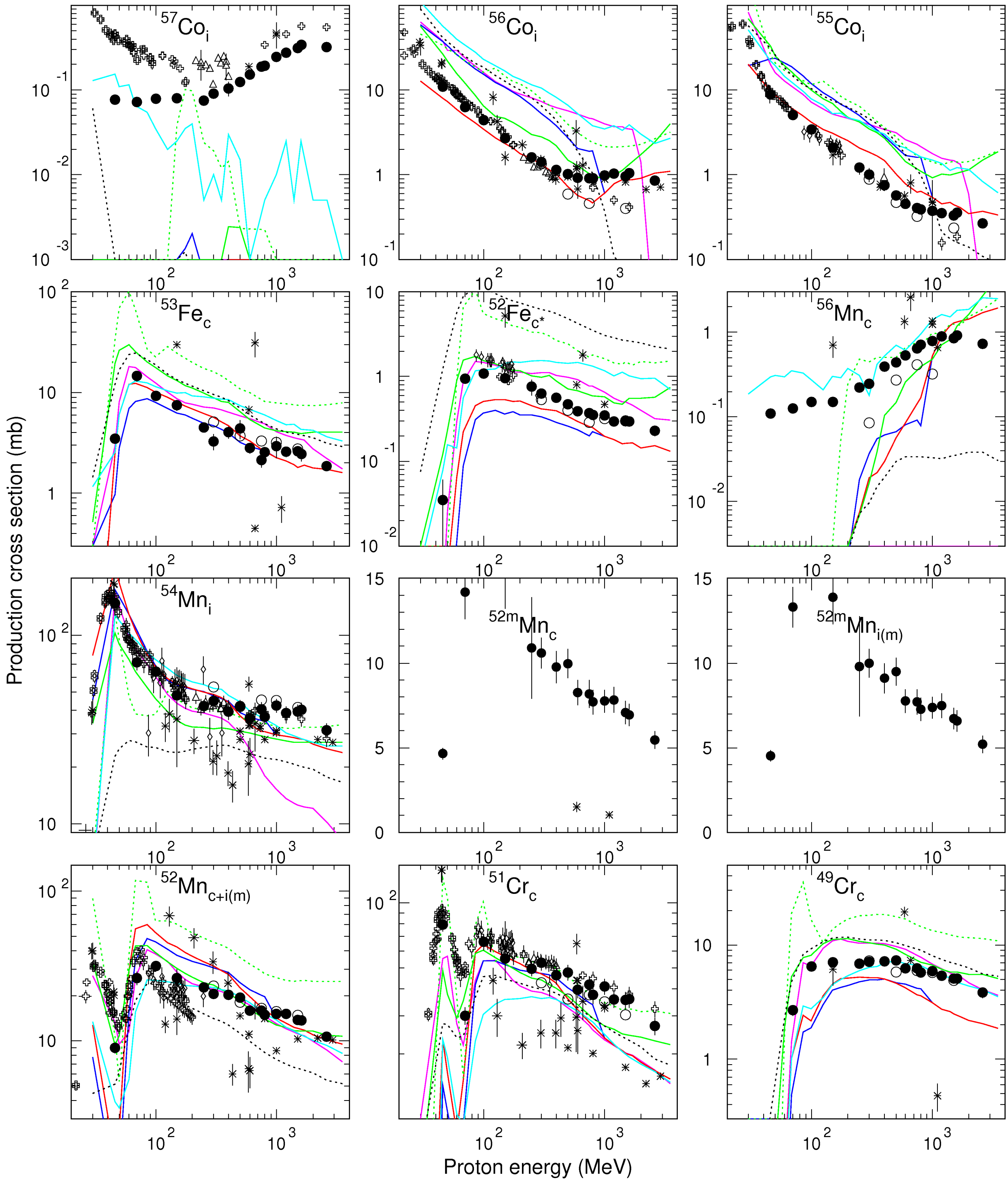

Fig. 7.4 Simulated and experimental cross sections of $^{56}Fe(p,x)$ reaction.

Experimental points: ● – this work,○ –GSI works[77], ✙ - R.Michel's works [76],],◊ - M. Fassbender's works [78], □ –W.R. Webber's works [79], * - works of other laboratories. Simulations: MCNPX(BERTINI), MCNPX(ISABEL), CEM03.02, INCL4+ABLA(dots), INCL4.4.5+ABLA07, CASCADE.07(dots), PHITS.

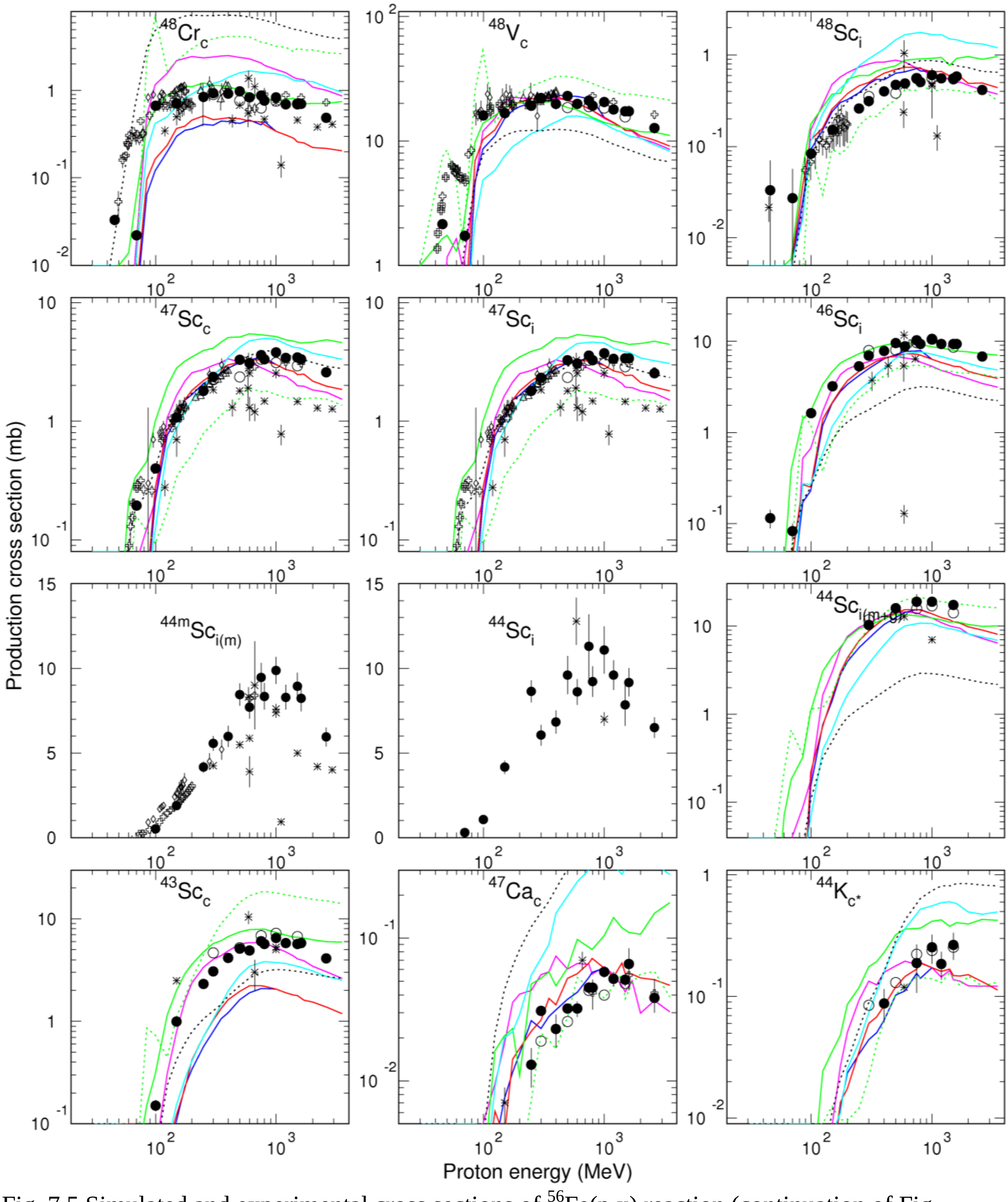

Fig. 7.5 Simulated and experimental cross sections of ^{56}Fe(p,x) reaction (continuation of Fig. 7.4).

Experimental points: ● – this work,○ –GSI works[77], ✙ - R.Michel's works [76],],◊ - M. Fassbender's works [78], □ –W.R. Webber's works [79], * - works of other laboratories.
Simulations: MCNPX(BERTINI), MCNPX(ISABEL), CEM03.02, INCL4+ABLA(dots), INCL4.4.5+ABLA07, CASCADE.07(dots), PHITS.

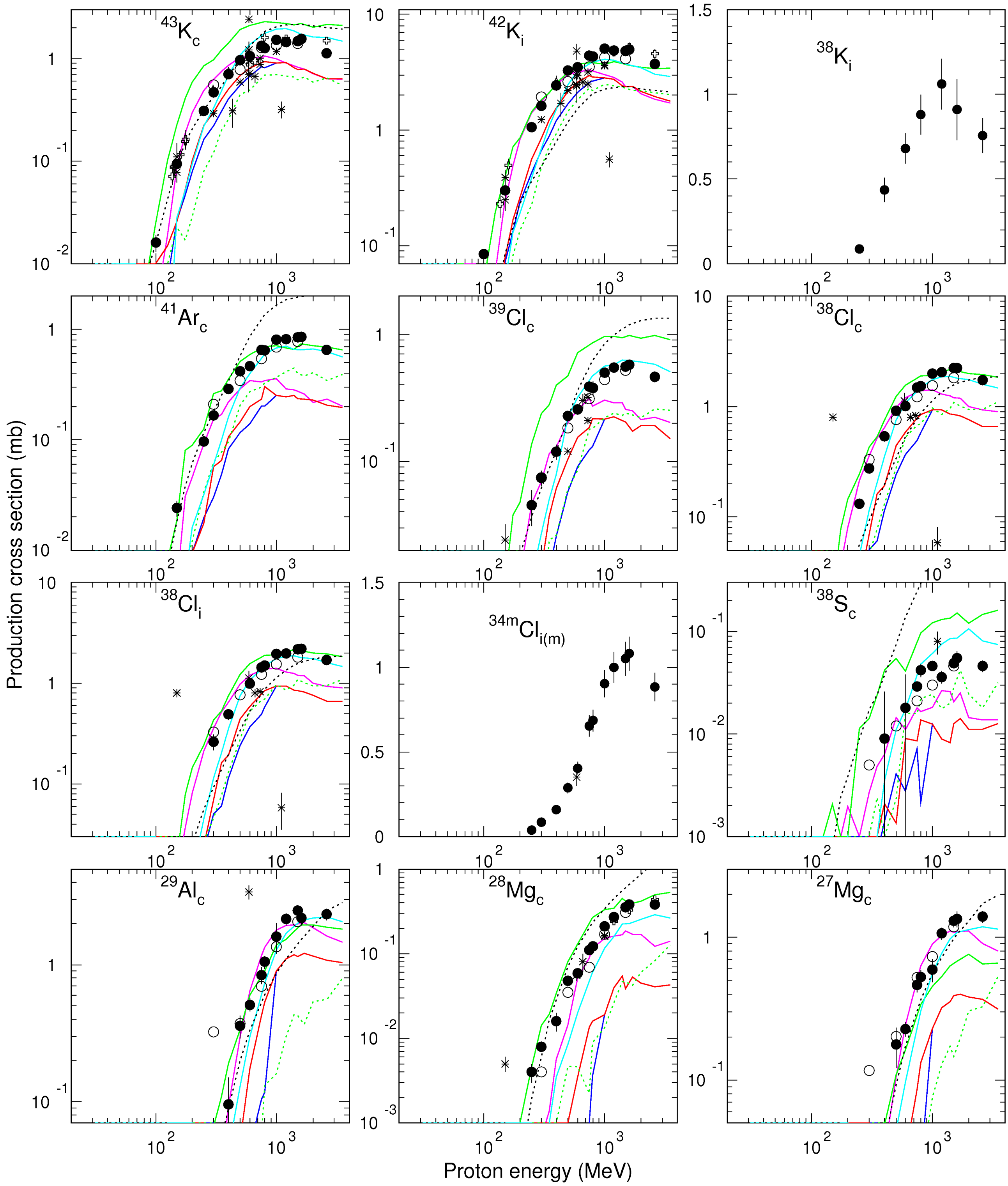

Fig. 7.6 Simulated and experimental cross sections of $^{56}Fe(p,x)$ reaction (continuation of Fig. 7.4).

Experimental points: ● – this work,○ –GSI works[77], ✙ - R.Michel's works [76],],◊ - M. Fassbender's works [78], □ –W.R. Webber's works [79], * - works of other laboratories.
Simulations: MCNPX(BERTINI), MCNPX(ISABEL), CEM03.02, INCL4+ABLA(dots), INCL4.4.5+ABLA07, CASCADE.07(dots), PHITS.

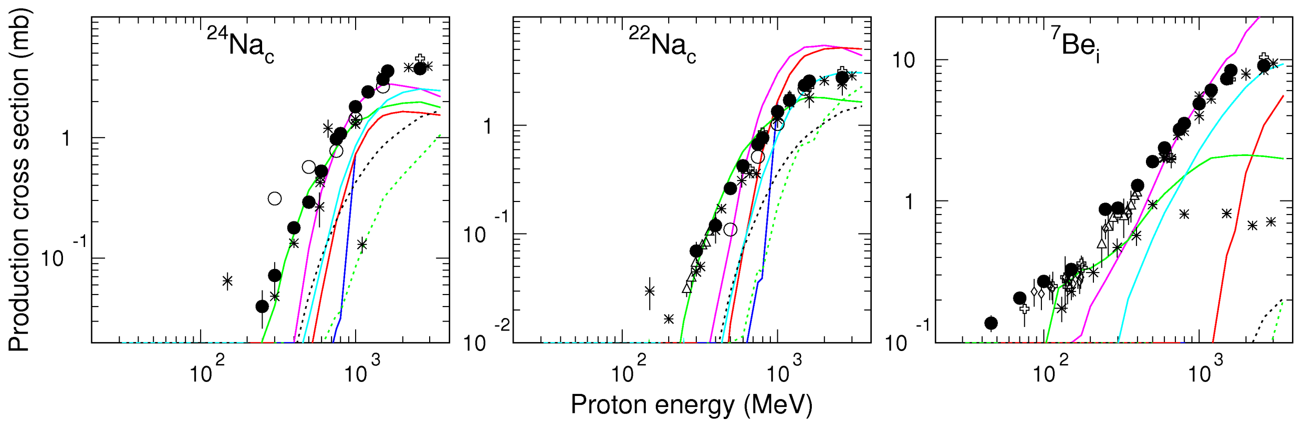

Fig. 7.7 Simulated and experimental cross sections of $^{56}Fe(p,x)$ reaction (continuation of Fig. 7.4).

Experimental points: ● – this work,○ –GSI works[77], ✙ - R.Michel's works [76],],◊ - M. Fassbender's works [78], □ –W.R. Webber's works [79], * - works of other laboratories.
Simulations: MCNPX(BERTINI), MCNPX(ISABEL), CEM03.02, INCL4+ABLA(dots), INCL4.4.5+ABLA07, CASCADE.07(dots), PHITS.

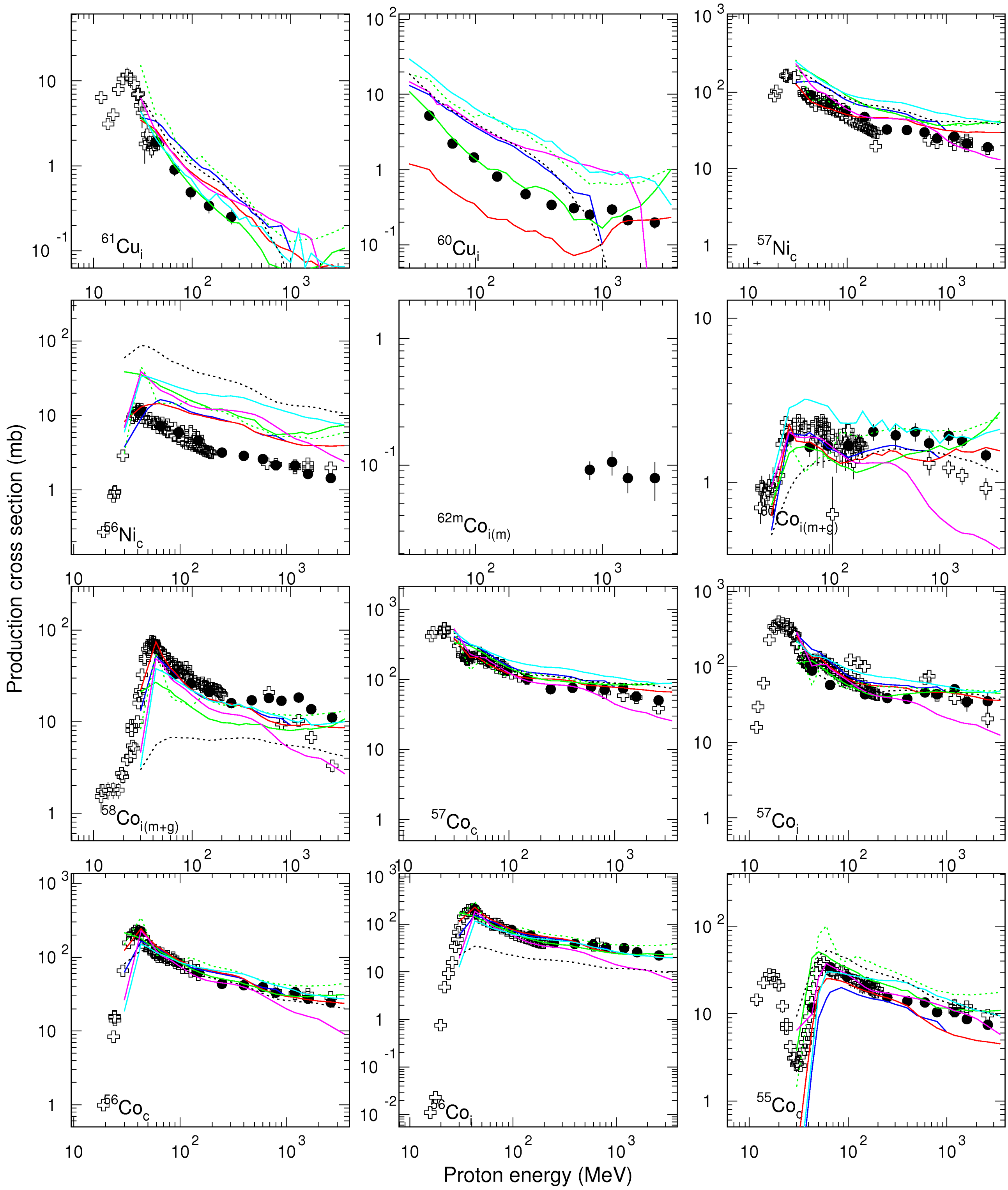

Fig. 7.8 Simulated and experimental cross sections of $^{nat}Ni(p,x)$ reaction.

Experimental points: ● – this work, ✚ - R.Michel's works [76], ☆ - works of other laboratories. Simulations: MCNPX(BERTINI), MCNPX(ISABEL), CEM03.02, INCL4+ABLA(dots), INCL4.4.5+ABLA07, CASCADE.07(dots), PHITS.

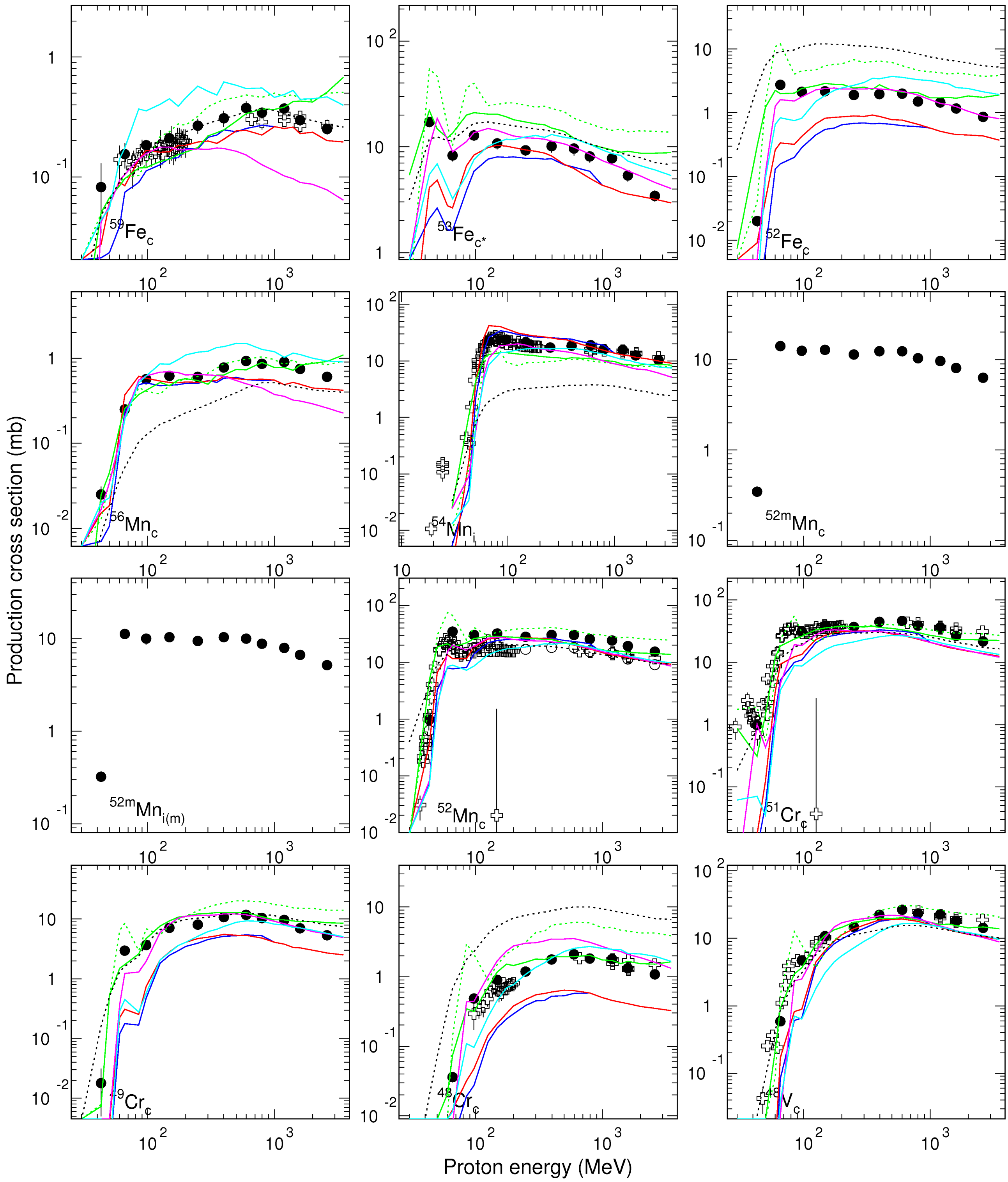

Fig. 7.9 Simulated and experimental cross sections of $^{nat}Ni(p,x)$ reaction (continuation of Fig. 7.8).

Experimental points: ● – this work, ✚ - R.Michel's works [76], ☆ - works of other laboratories. Simulations: MCNPX(BERTINI), MCNPX(ISABEL), CEM03.02, INCL4+ABLA(dots), INCL4.4.5+ABLA07, CASCADE.07(dots), PHITS.

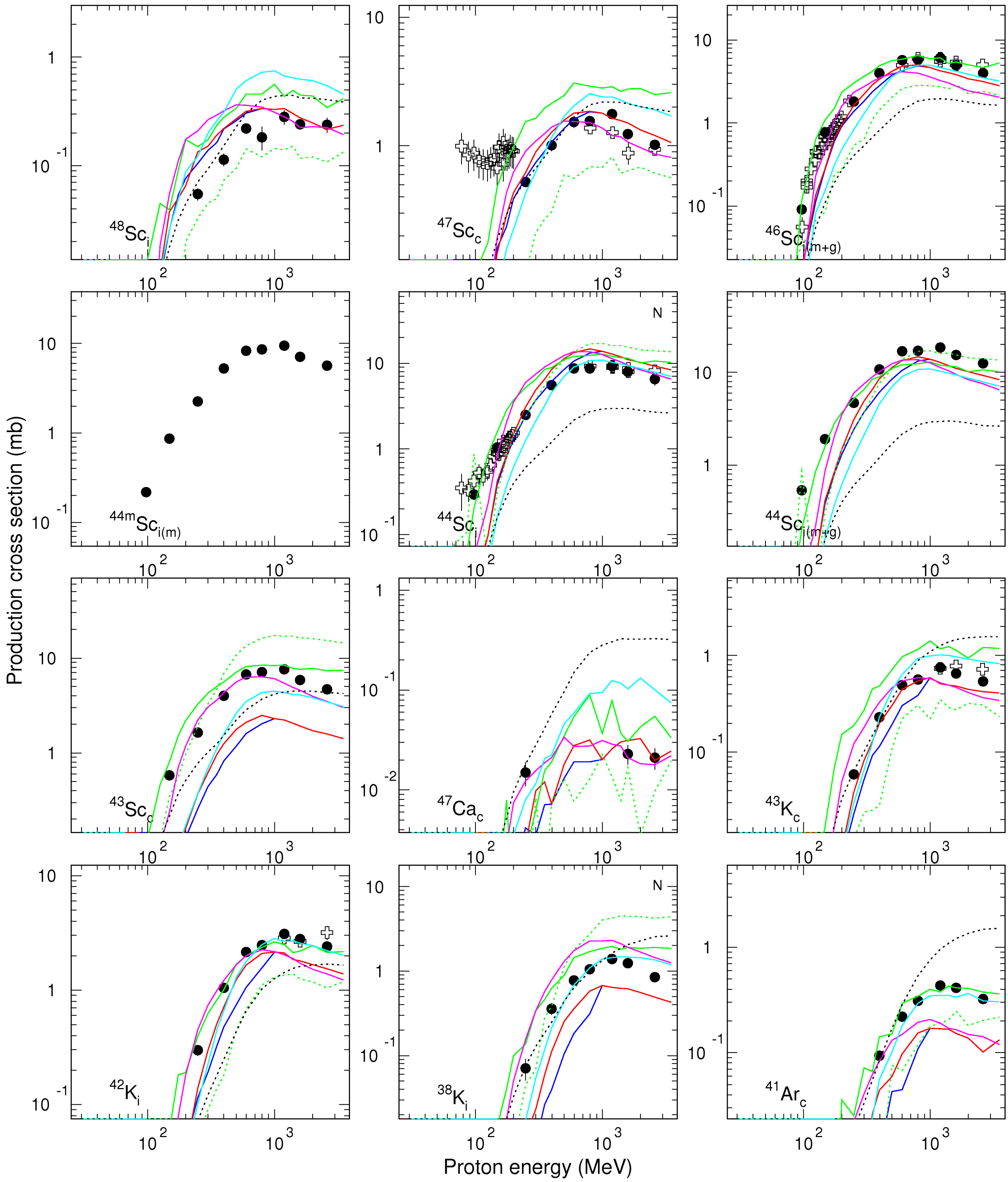

Fig. 7.10. Simulated and experimental cross sections of $^{nat}Ni(p,x)$ reaction (continuation of Fig. 7.8).

Experimental points: ● – this work, ✚ - R.Michel's works [76], ☆ - works of other laboratories. Simulations: MCNPX(BERTINI), MCNPX(ISABEL), CEM03.02, INCL4+ABLA(dots), INCL4.4.5+ABLA07, CASCADE.07(dots), PHITS.

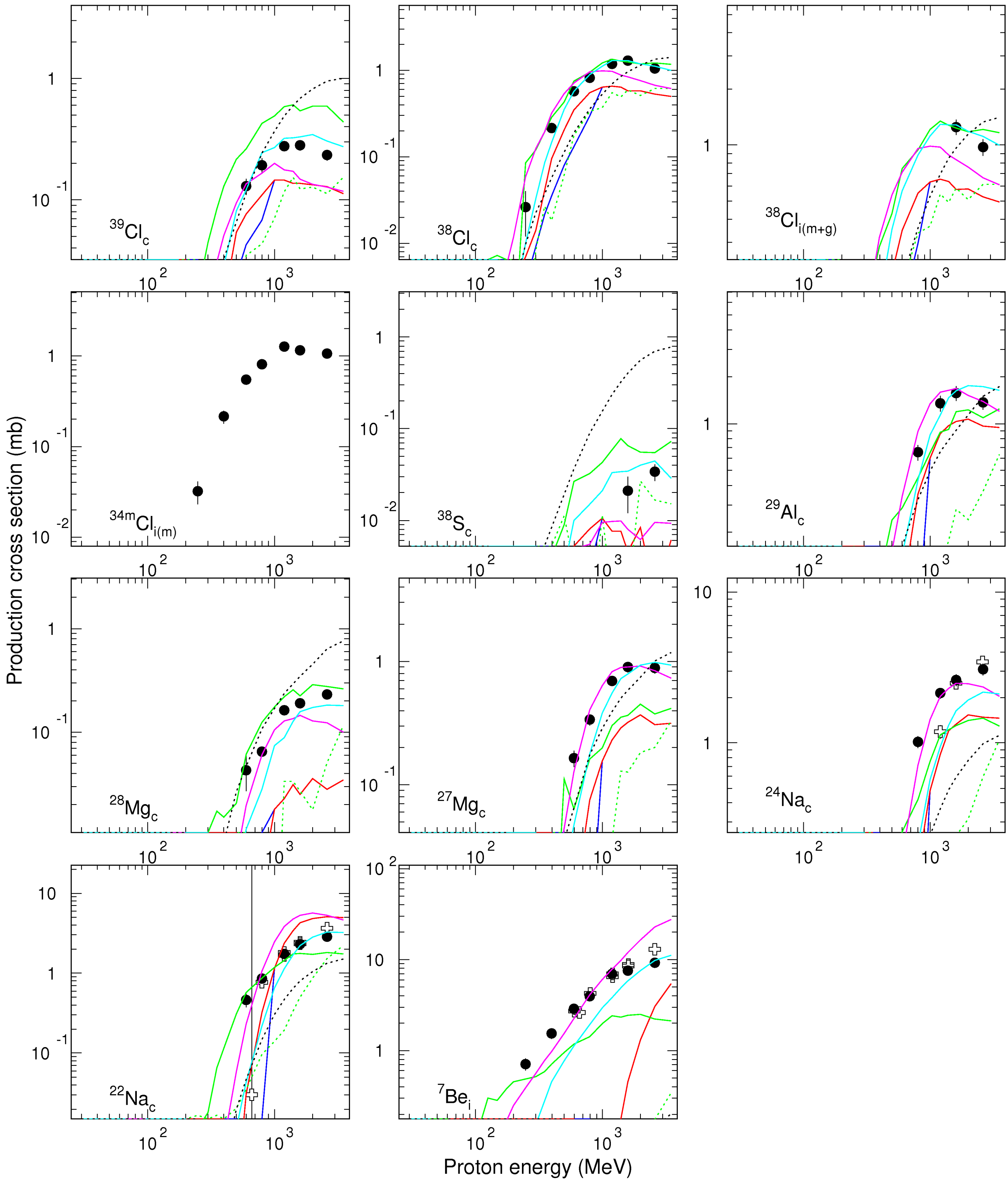

Fig. 7.11 Simulated and experimental cross sections of ^{nat}Ni(p,x) reaction (continuation of Fig. 7.8).

Experimental points: ● – this work, ✚ - R.Michel's works [76], ☆ - works of other laboratories. Simulations: MCNPX(BERTINI), MCNPX(ISABEL), CEM03.02, INCL4+ABLA(dots), INCL4.4.5+ABLA07, CASCADE.07(dots), PHITS.

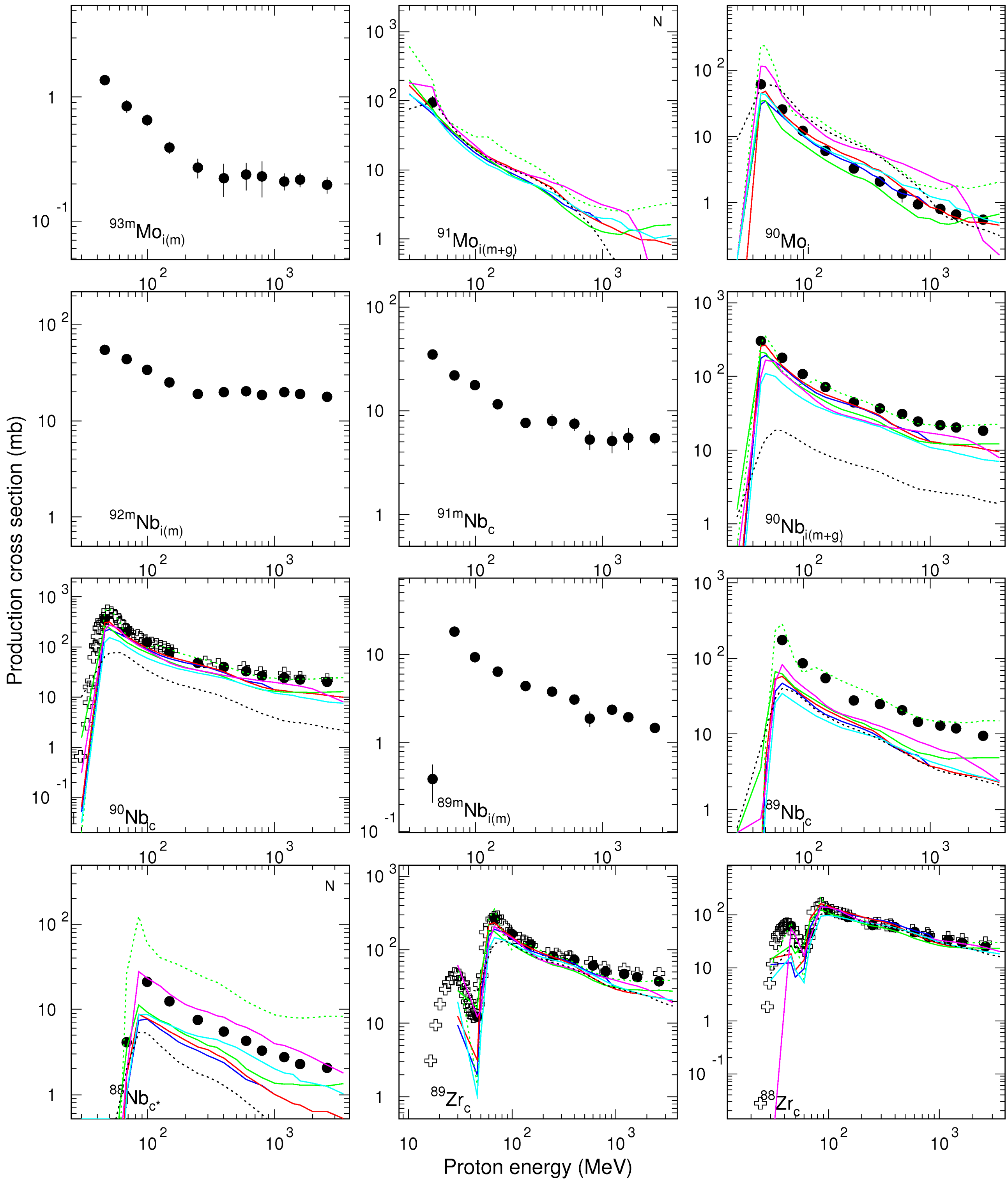

Fig. 7.12 Simulated and experimental cross sections of ^{93}Nb(p,x) reaction.

Experimental points: ● – this work, ✚ - R.Michel's works [76], ☆ - works of other laboratories. Simulations: MCNPX(BERTINI), MCNPX(ISABEL), CEM03.02, INCL4+ABLA(dots), INCL4.4.5+ABLA07, CASCADE.07(dots), PHITS.

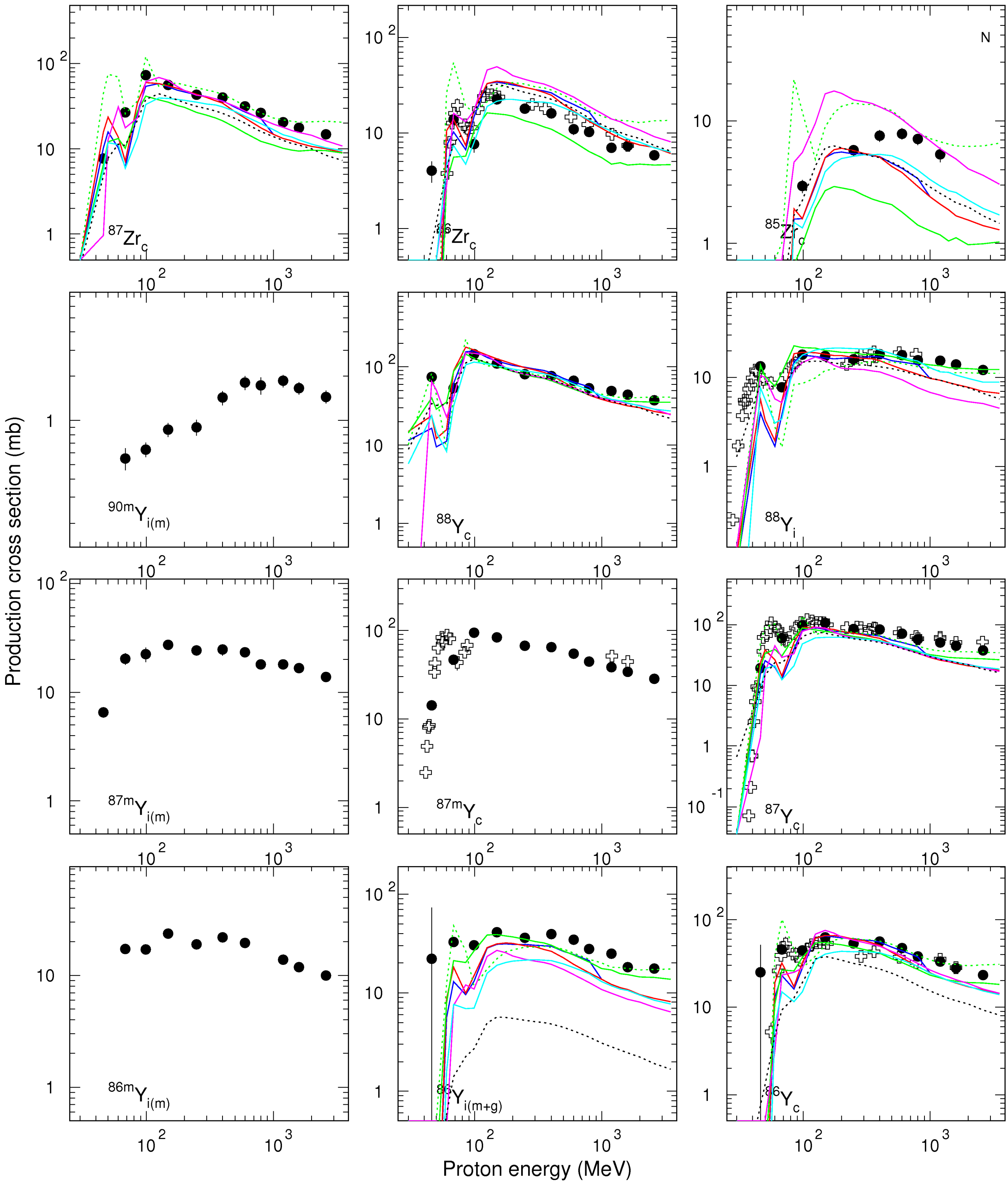

Fig. 7.13. Simulated and experimental cross sections of $^{93}Nb(p,x)$ reaction (continuation of Fig. 7.12).

Experimental points: ● – this work, ✚ - R.Michel's works [76], ☆ - works of other laboratories. Simulations: MCNPX(BERTINI), MCNPX(ISABEL), CEM03.02, INCL4+ABLA(dots), INCL4.4.5+ABLA07, CASCADE.07(dots), PHITS.

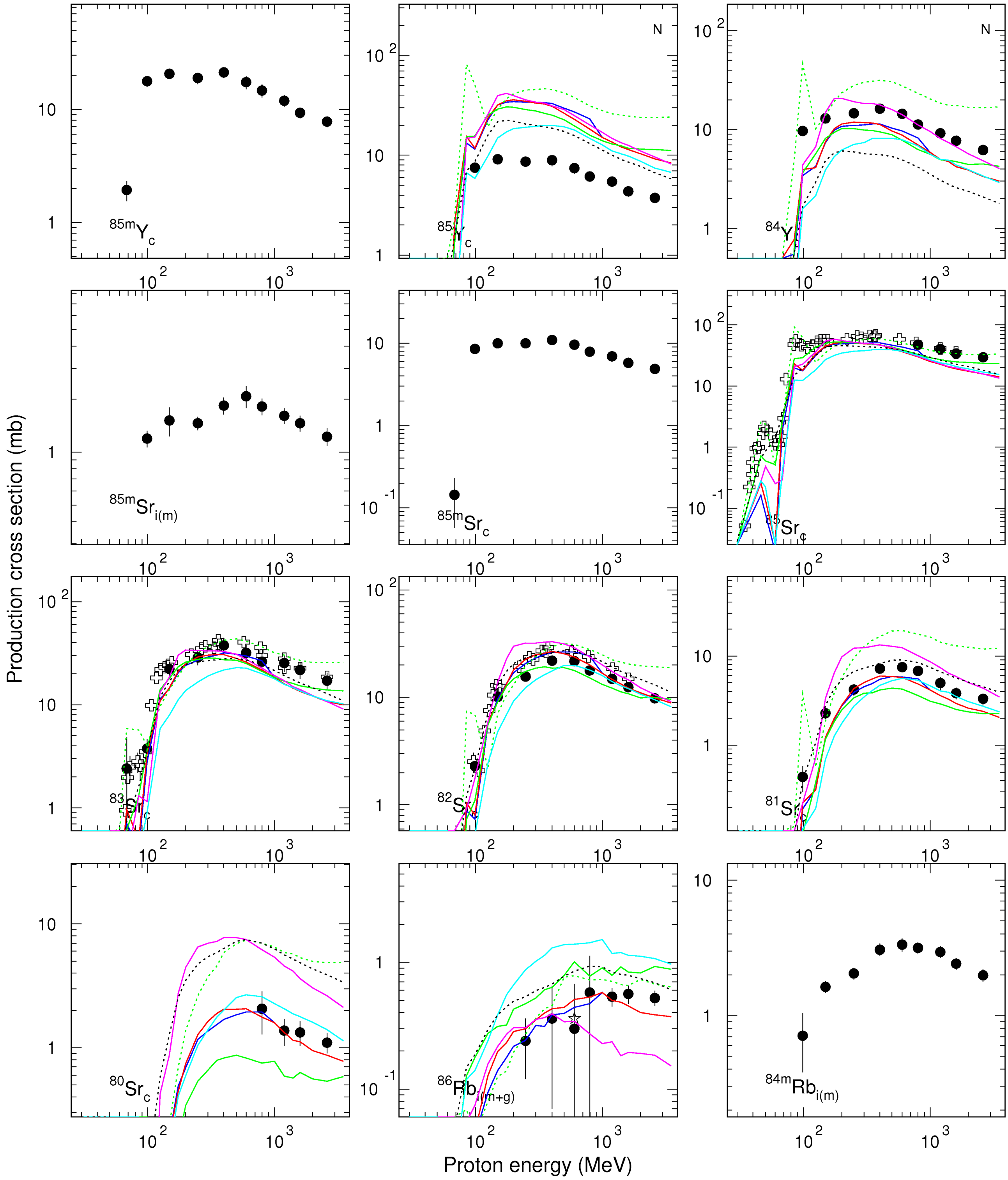

Fig. 7.14. Simulated and experimental cross sections of $^{93}Nb(p,x)$ reaction (continuation of Fig. 7.12).

Experimental points: ● – this work, ✚ - R.Michel's works [76], ☆ - works of other laboratories. Simulations: MCNPX(BERTINI), MCNPX(ISABEL), CEM03.02, INCL4+ABLA(dots), INCL4.4.5+ABLA07, CASCADE.07(dots), PHITS.

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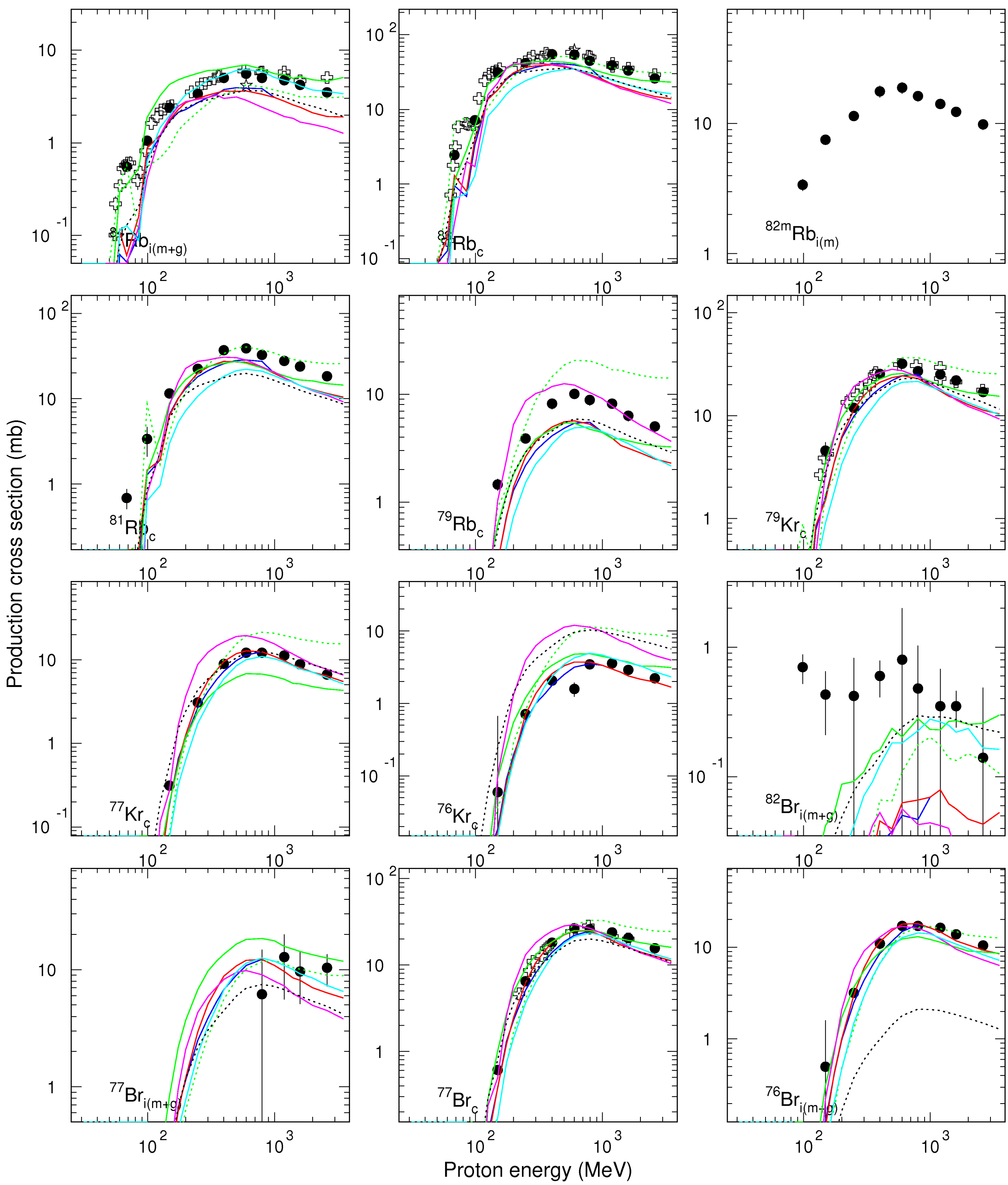

Fig. 7.15. Simulated and experimental cross sections of ^{93}Nb(p,x) reaction (continuation of Fig. 7.12).

Experimental points: ● – this work, ✠ - R.Michel's works [76], ☆ - works of other laboratories. Simulations: MCNPX(BERTINI), MCNPX(ISABEL), CEM03.02, INCL4+ABLA(dots), INCL4.4.5+ABLA07, CASCADE.07(dots), PHITS.

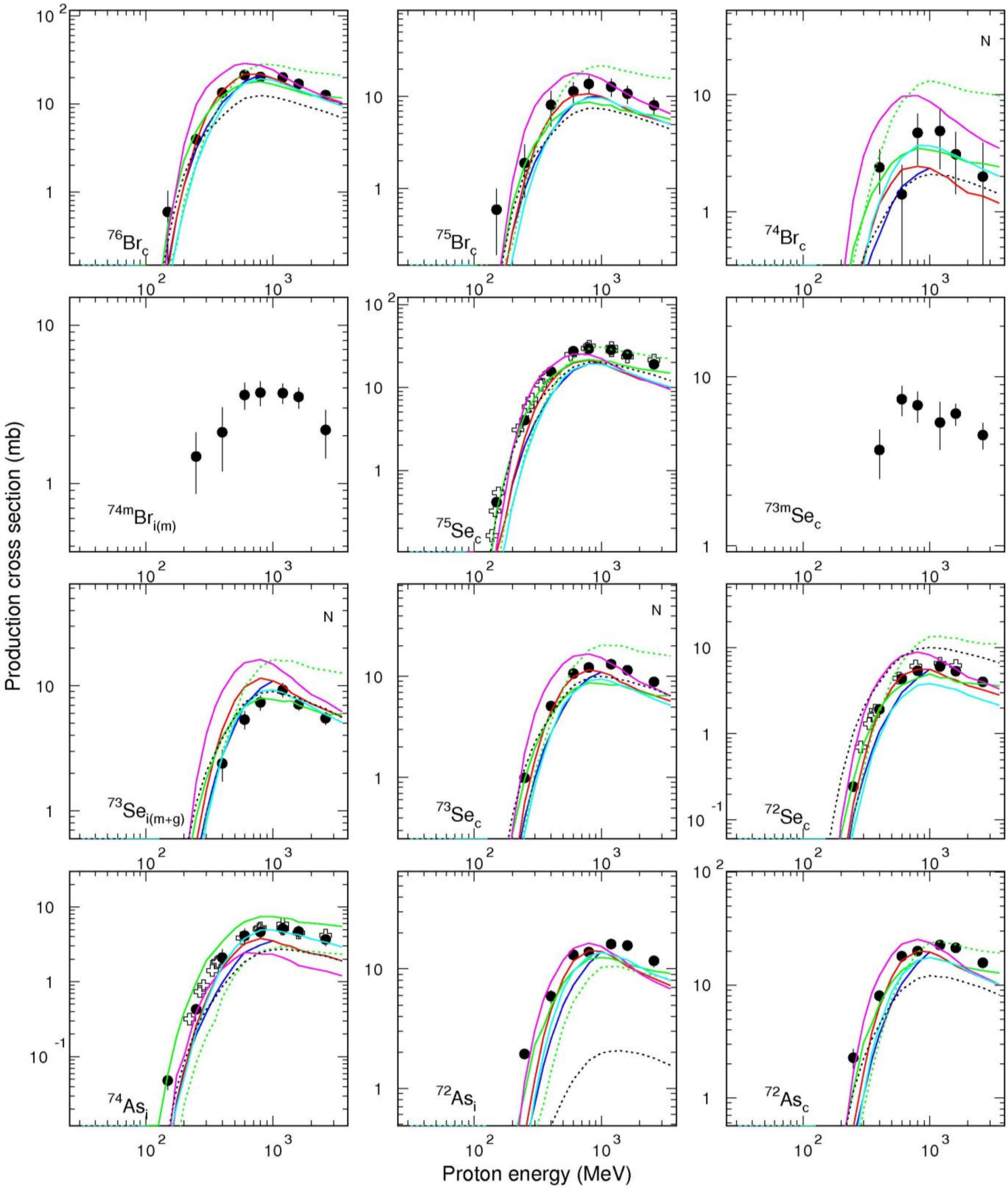

Fig. 7.16. Simulated and experimental cross sections of $^{93}Nb(p,x)$ reaction (continuation of Fig. 7.12).

Experimental points: ● – this work, ✚ - R.Michel's works [76], ☆ - works of other laboratories. Simulations: MCNPX(BERTINI), MCNPX(ISABEL), CEM03.02, INCL4+ABLA(dots), INCL4.4.5+ABLA07, CASCADE.07(dots), PHITS.

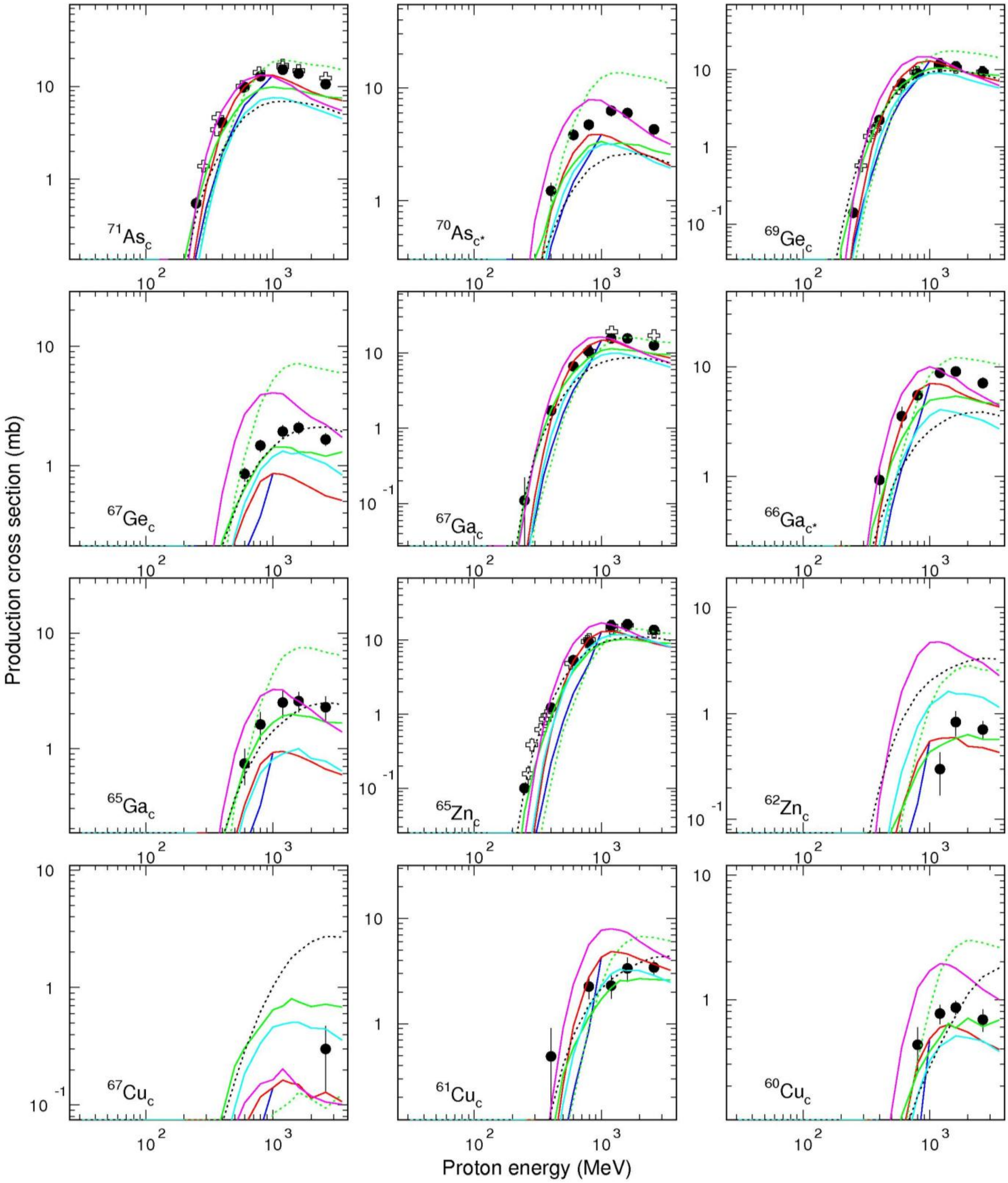

Fig. 7.17. Simulated and experimental cross sections of $^{93}Nb(p,x)$ reaction (continuation of Fig. 7.12).

Experimental points: ● – this work, ✣ - R.Michel's works [76], ☆ - works of other laboratories. Simulations: MCNPX(BERTINI), MCNPX(ISABEL), CEM03.02, INCL4+ABLA(dots), INCL4.4.5+ABLA07, CASCADE.07(dots), PHITS.

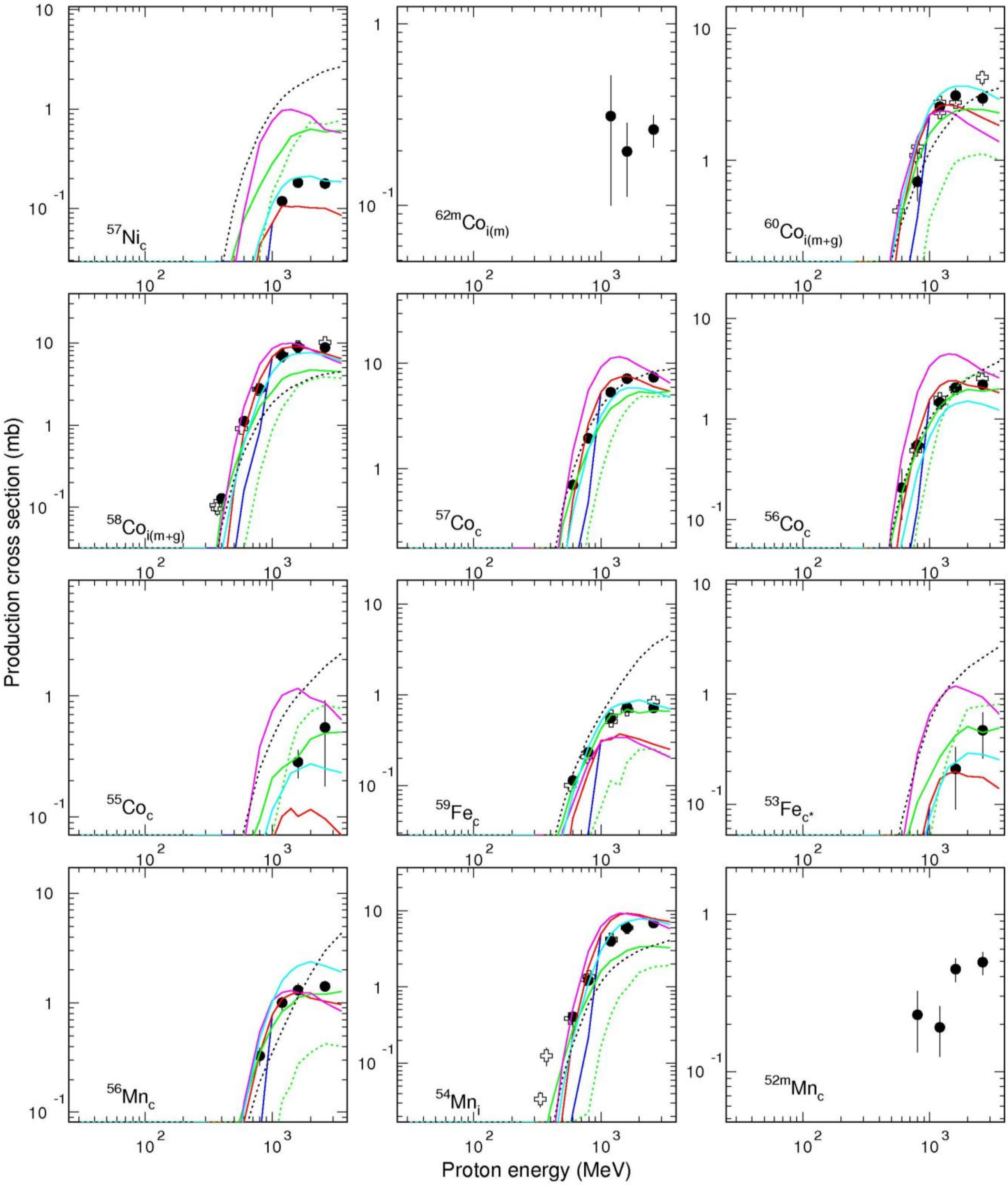

Fig. 7.18. Simulated and experimental cross sections of ^{93}Nb(p,x) reaction (continuation of Fig. 7.12).

Experimental points: ● – this work, ✣ - R.Michel's works [76], ☆ - works of other laboratories. Simulations: MCNPX(BERTINI), MCNPX(ISABEL), CEM03.02, INCL4+ABLA(dots), INCL4.4.5+ABLA07, CASCADE.07(dots), PHITS.

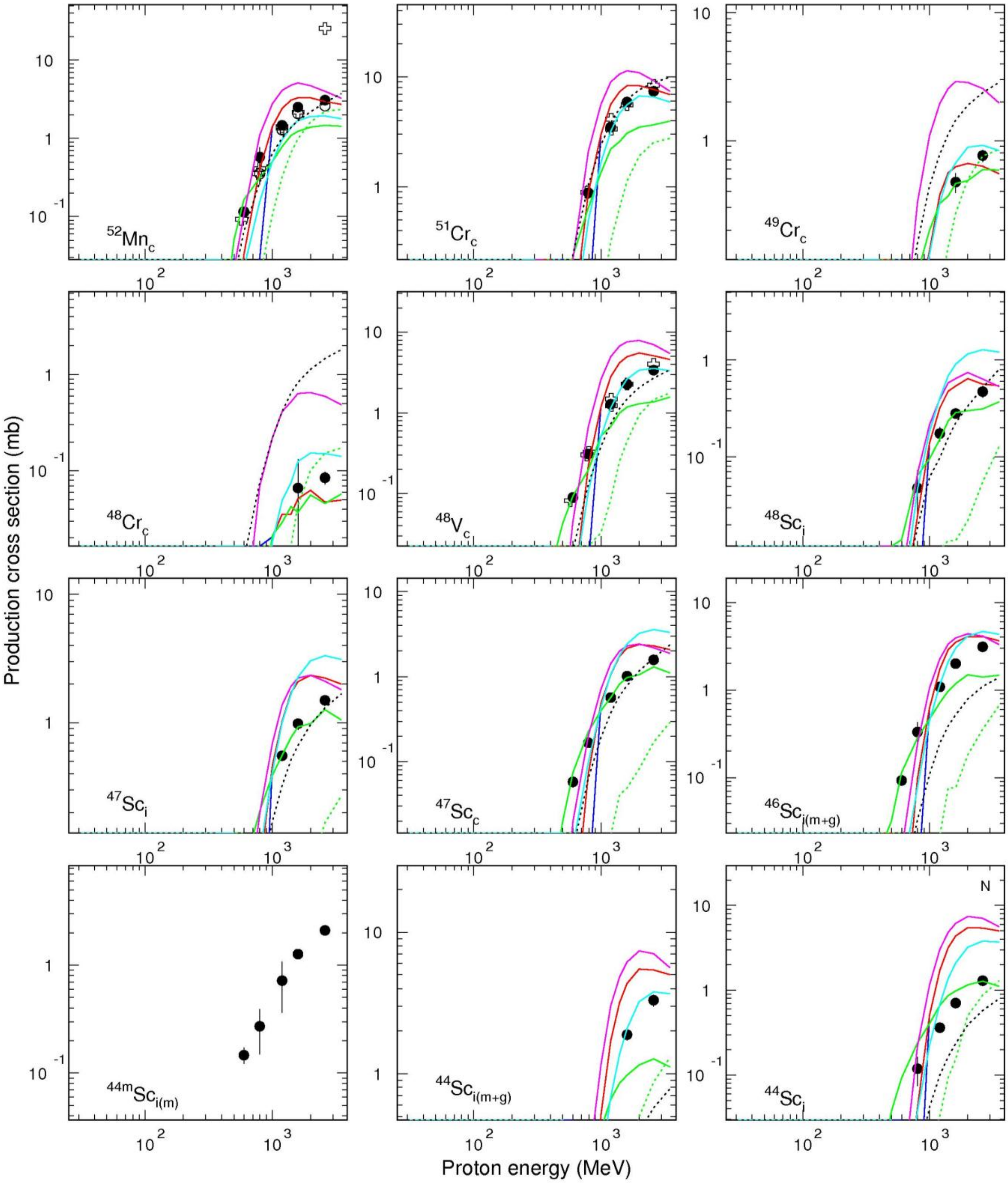

Fig. 7.19. Simulated and experimental cross sections of ^{93}Nb(p,x) reaction (continuation of Fig. 7.12).

Experimental points: ● – this work, ✙ - R.Michel's works [76], ☆ - works of other laboratories. Simulations: MCNPX(BERTINI), MCNPX(ISABEL), CEM03.02, INCL4+ABLA(dots), INCL4.4.5+ABLA07, CASCADE.07(dots), PHITS.

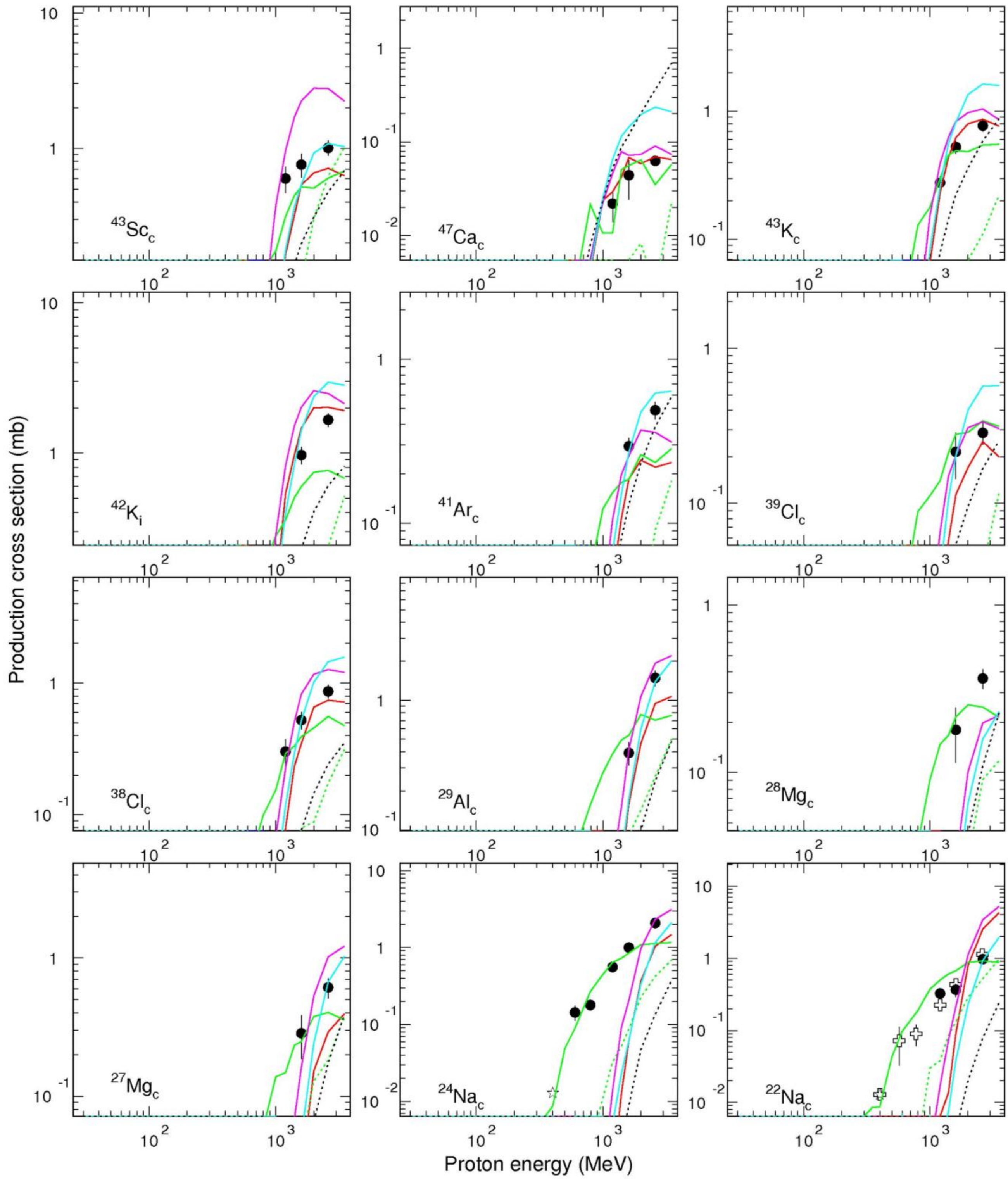

Fig. 7.20. Simulated and experimental cross sections of ^{93}Nb(p,x) reaction (continuation of Fig. 7.12).

Experimental points: ● – this work, ✠ - R.Michel's works [76], ☆ - works of other laboratories. Simulations: MCNPX(BERTINI), MCNPX(ISABEL), CEM03.02, INCL4+ABLA(dots), INCL4.4.5+ABLA07, CASCADE.07(dots), PHITS.

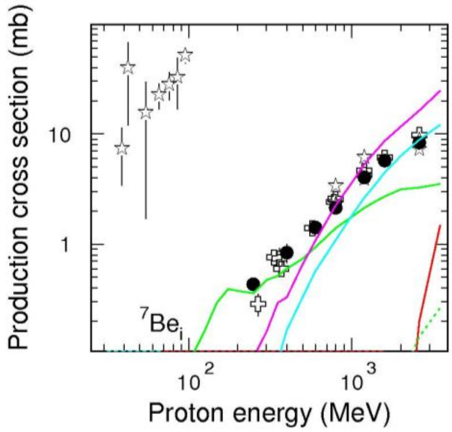

Fig. 7.20A. Simulated and experimental cross sections of ^{93}Nb(p,x) reaction (continuation of Fig. 7.12).

Experimental points: ● – this work, ✥ - R.Michel's works [76], ☆ - works of other laboratories. Simulations: MCNPX(BERTINI), MCNPX(ISABEL), CEM03.02, INCL4+ABLA(dots), INCL4.4.5+ABLA07, CASCADE.07(dots), PHITS.

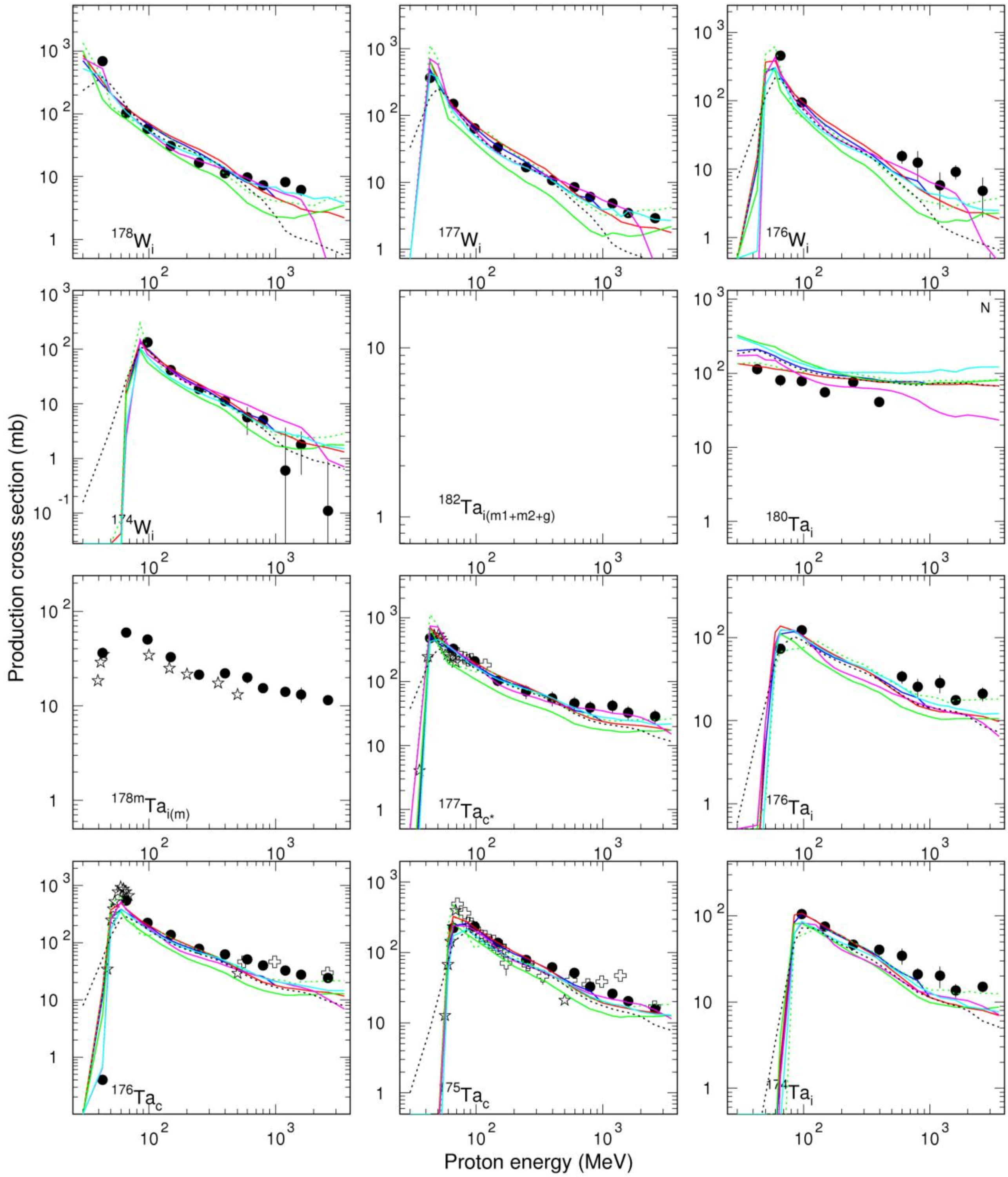

Fig. 7.21. Simulated and experimental cross sections of ^{181}Ta(p,x) reaction.

Experimental points: ● – this work, ✜ - R.Michel's works [76], ☆ - works of other laboratories. Simulations: MCNPX(BERTINI), MCNPX(ISABEL), CEM03.02, INCL4+ABLA(dots), INCL4.4.5+ABLA07, CASCADE.07(dots), PHITS.

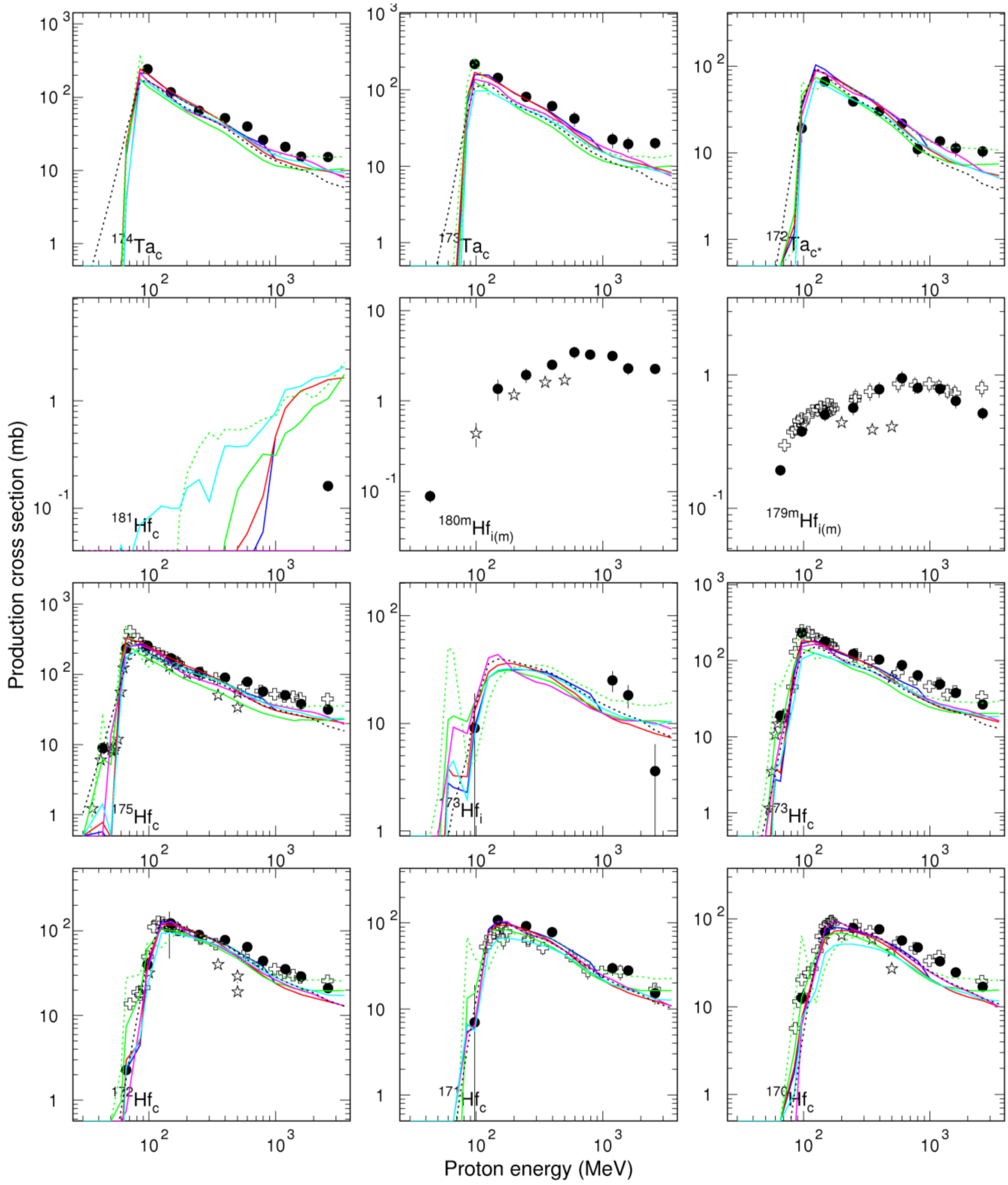

Fig. 7.22. Simulated and experimental cross sections of ^{181}Ta(p,x) reaction (continuation of Fig. 7.21).

Experimental points: ● – this work, ✚ - R.Michel's works [76], ☆ - works of other laboratories. Simulations: MCNPX(BERTINI), MCNPX(ISABEL), CEM03.02, INCL4+ABLA(dots), INCL4.4.5+ABLA07, CASCADE.07(dots), PHITS.

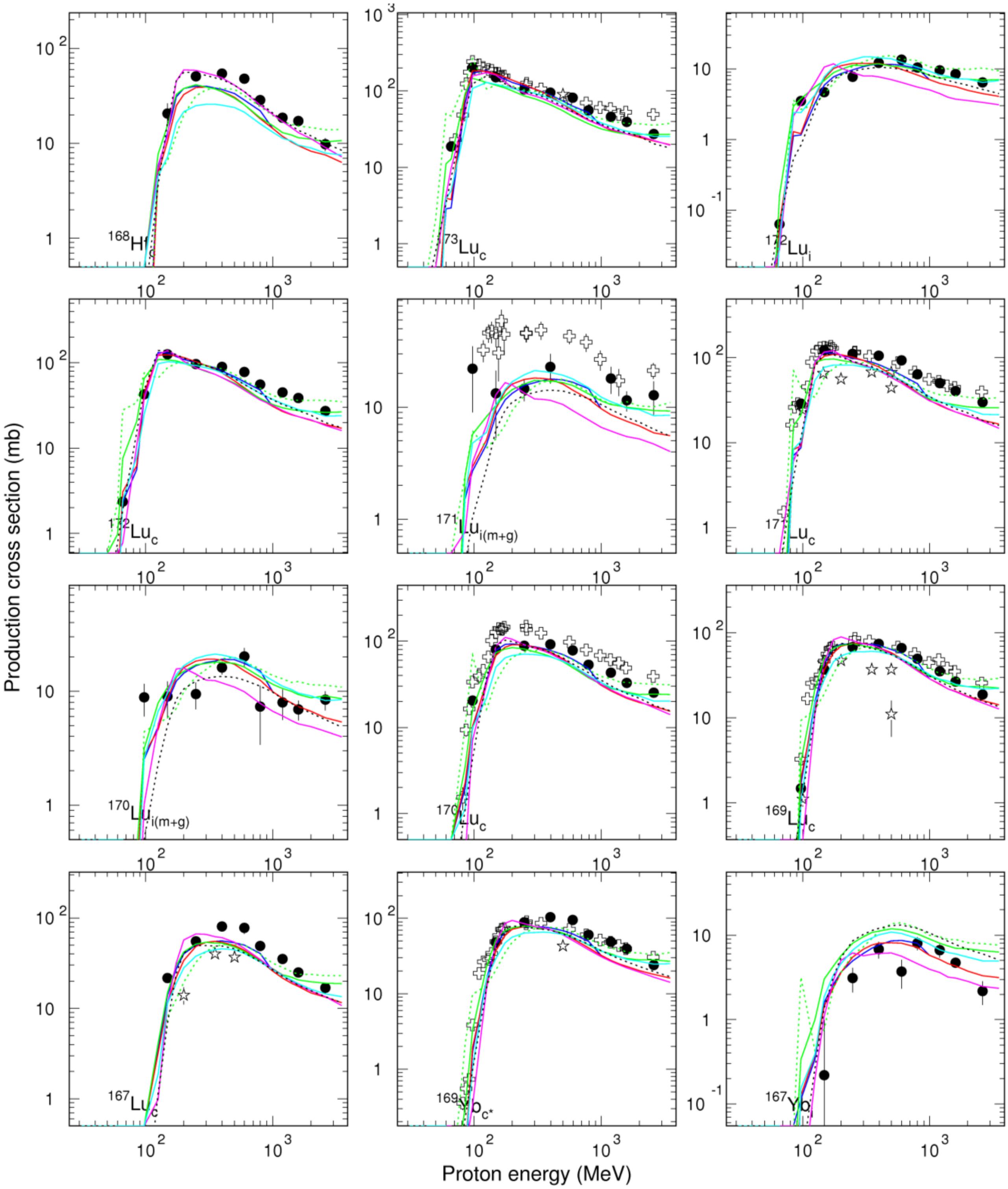

Fig. 7.23. Simulated and experimental cross sections of ^{181}Ta(p,x) reaction (continuation of Fig. 7.21).

Experimental points: ● – this work, ✚ - R.Michel's works [76], ☆ - works of other laboratories. Simulations: MCNPX(BERTINI), MCNPX(ISABEL), CEM03.02, INCL4+ABLA(dots), INCL4.4.5+ABLA07, CASCADE.07(dots), PHITS.

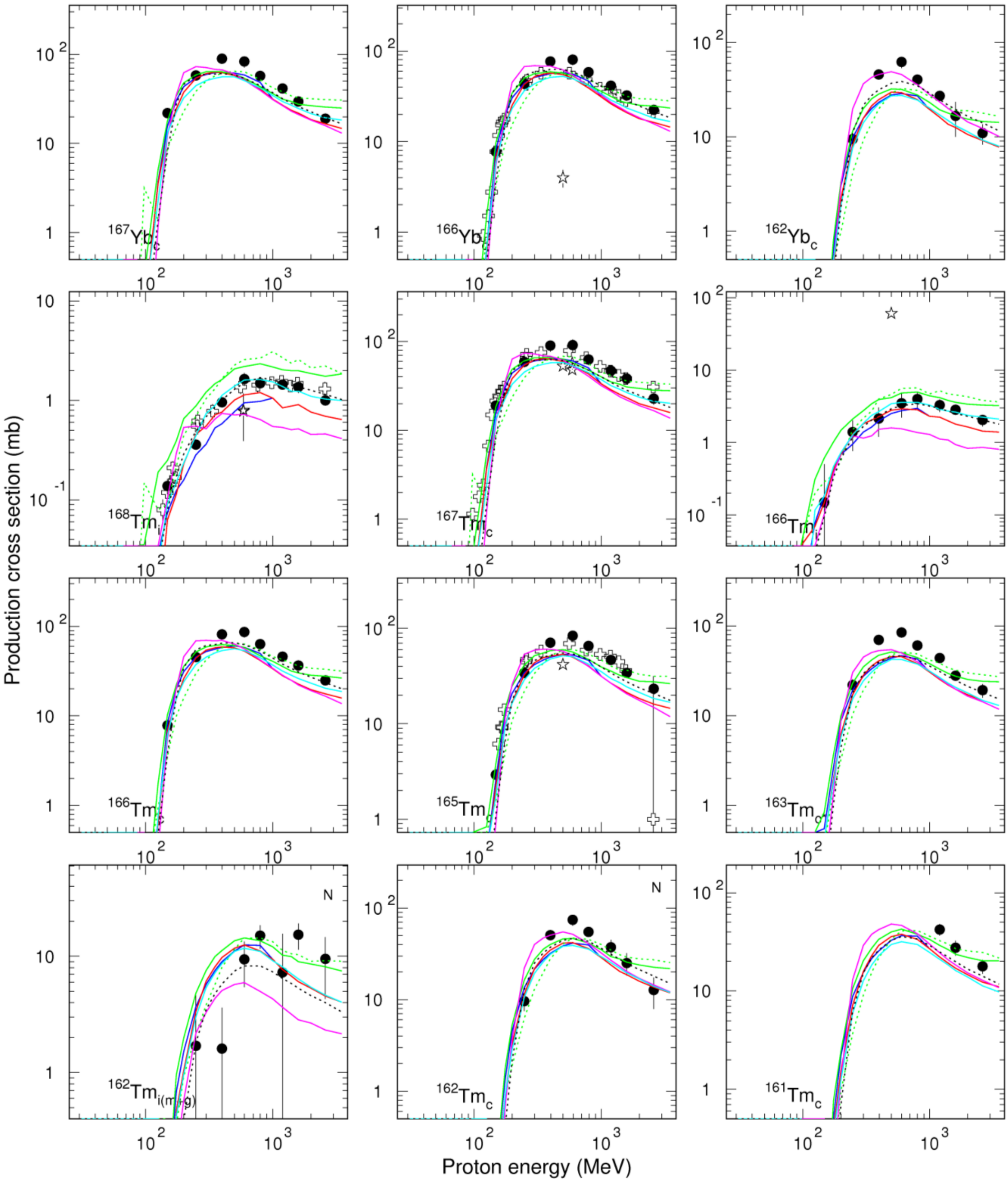

Fig. 7.24. Simulated and experimental cross sections of ^{181}Ta(p,x) reaction (continuation of Fig. 7.21).

Experimental points: ● – this work, ✚ - R.Michel's works [76], ☆ - works of other laboratories. Simulations: MCNPX(BERTINI), MCNPX(ISABEL), CEM03.02, INCL4+ABLA(dots), INCL4.4.5+ABLA07, CASCADE.07(dots), PHITS.

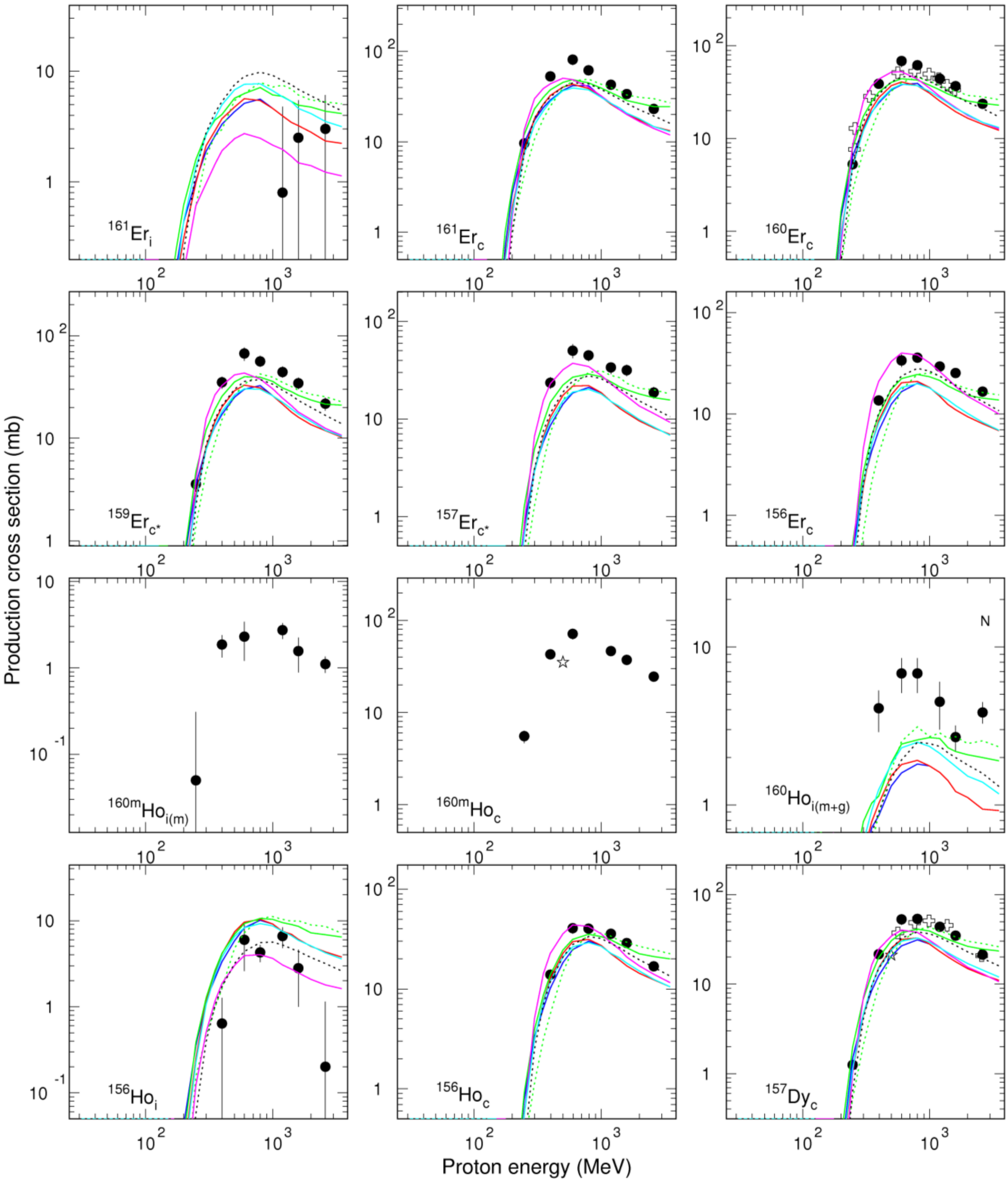

Fig. 7.25. Simulated and experimental cross sections of ^{181}Ta(p,x) reaction (continuation of Fig. 7.21).

Experimental points: ● – this work, ✚ - R.Michel's works [76], ☆ - works of other laboratories. Simulations: MCNPX(BERTINI), MCNPX(ISABEL), CEM03.02, INCL4+ABLA(dots), INCL4.4.5+ABLA07, CASCADE.07(dots), PHITS..

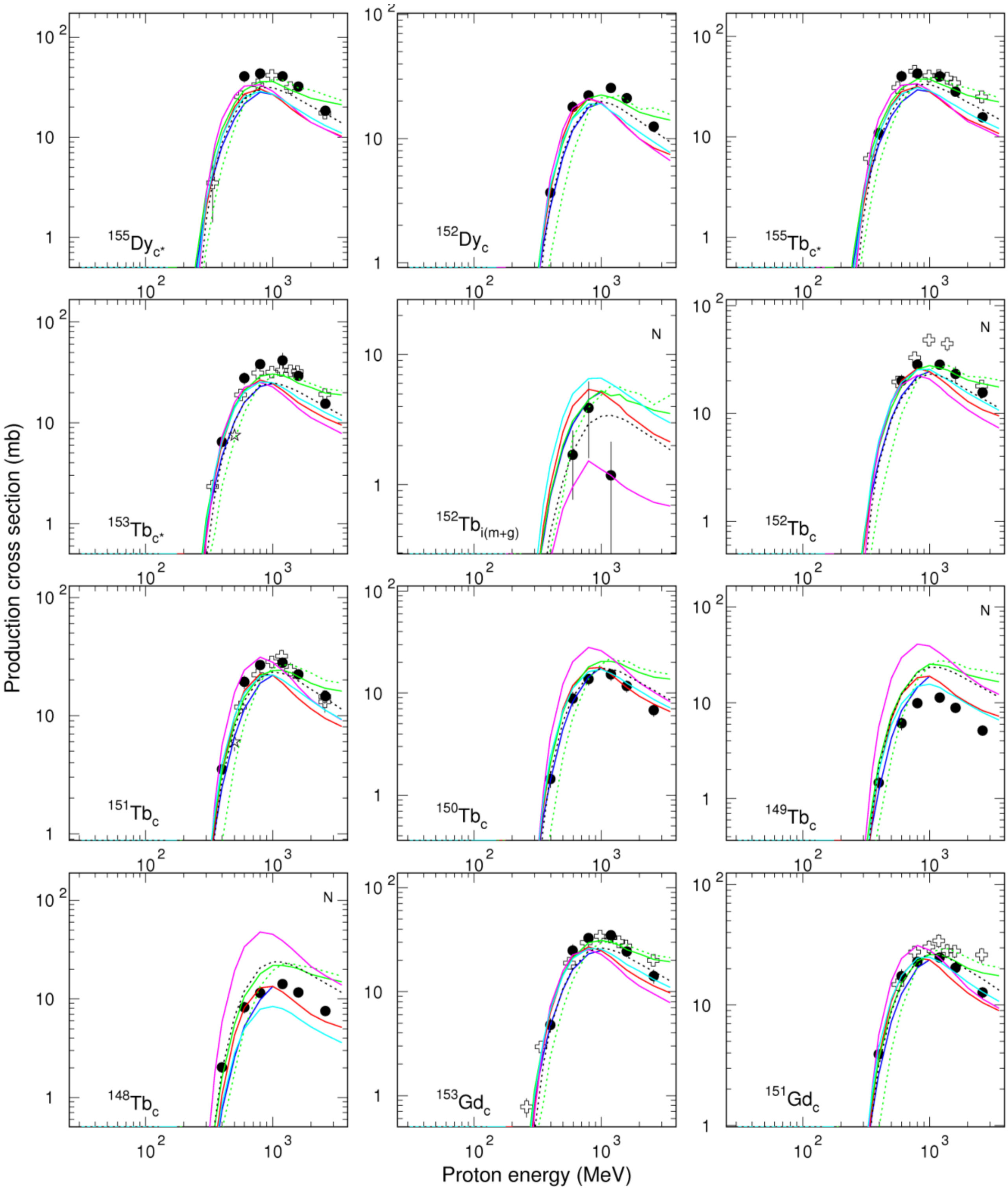

Fig. 7.26. Simulated and experimental cross sections of ^{181}Ta(p,x) reaction (continuation of Fig. 7.21).

Experimental points: ● – this work, ✢ - R.Michel's works [76], ☆ - works of other laboratories. Simulations: MCNPX(BERTINI), MCNPX(ISABEL), CEM03.02, INCL4+ABLA(dots), INCL4.4.5+ABLA07, CASCADE.07(dots), PHITS.

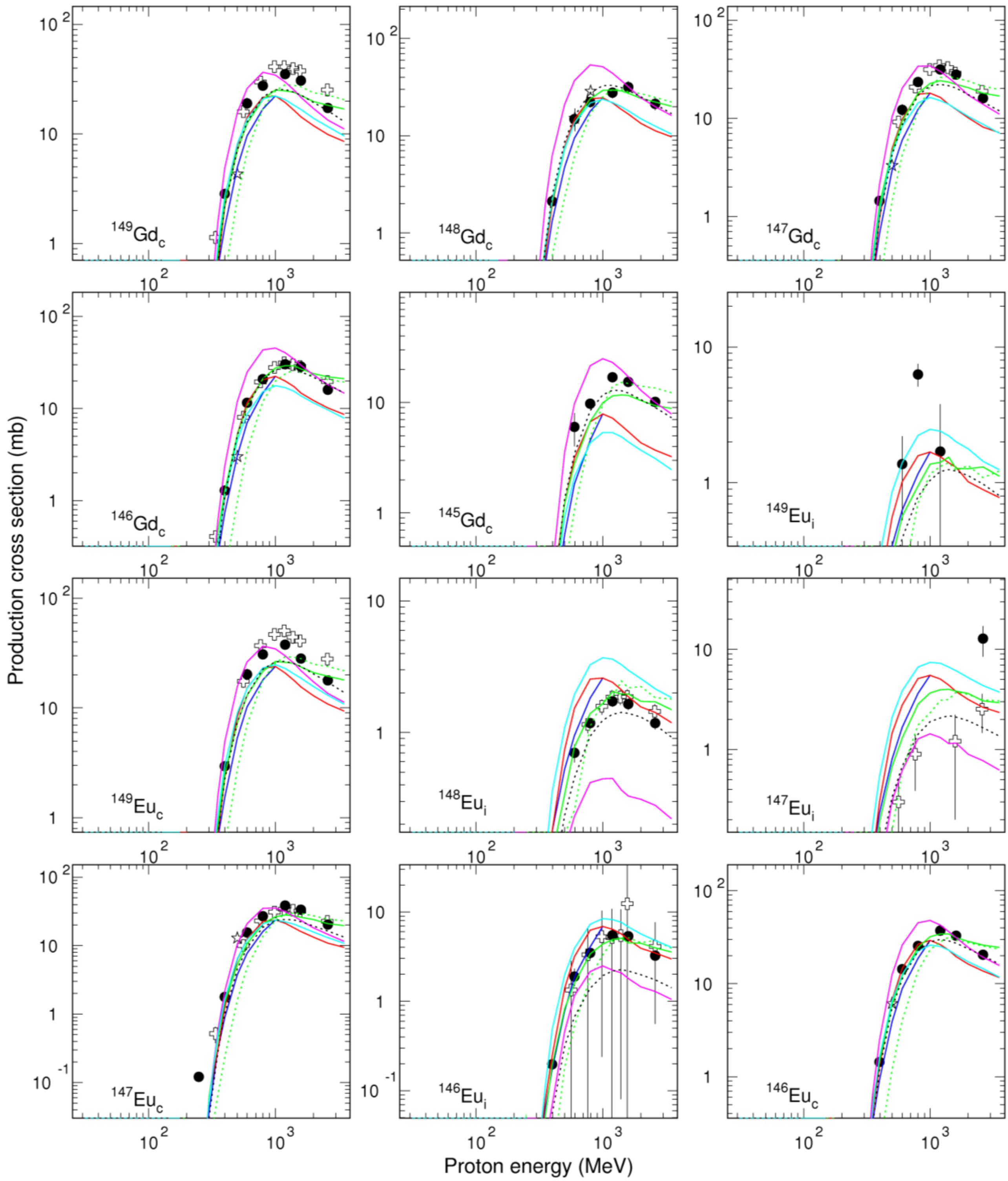

Fig. 7.27. Simulated and experimental cross sections of $^{181}Ta(p,x)$ reaction (continuation of Fig. 7.21).

Experimental points: ● – this work, ✙ - R.Michel's works [76], ☆ - works of other laboratories. Simulations: MCNPX(BERTINI), MCNPX(ISABEL), CEM03.02, INCL4+ABLA(dots), INCL4.4.5+ABLA07, CASCADE.07(dots), PHITS..

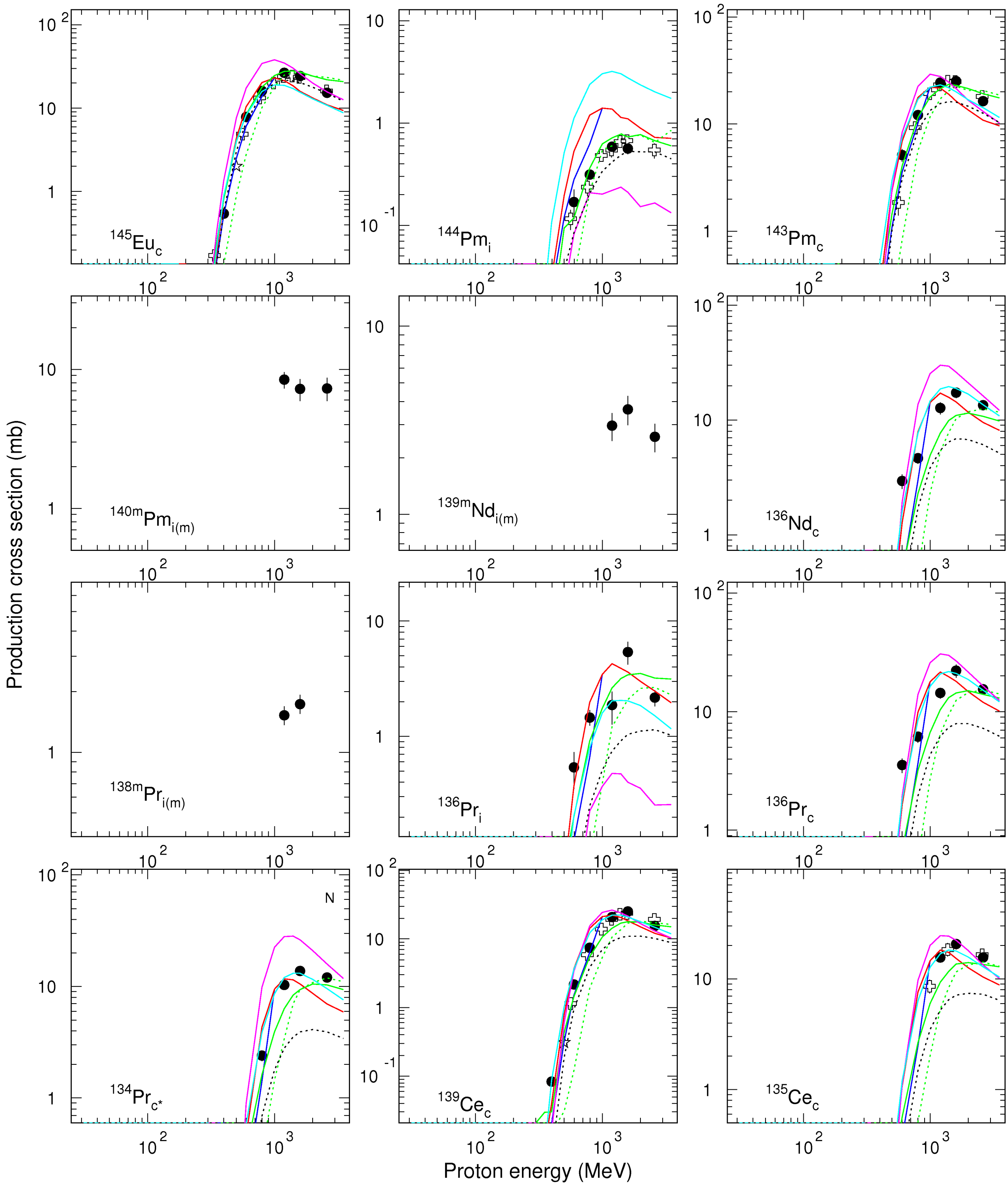

Fig. 7.28. Simulated and experimental cross sections of ^{181}Ta(p,x) reaction (continuation of Fig. 7.21).

Experimental points: ● – this work, ✚ - R.Michel's works [76], ☆ - works of other laboratories. Simulations: MCNPX(BERTINI), MCNPX(ISABEL), CEM03.02, INCL4+ABLA(dots), INCL4.4.5+ABLA07, CASCADE.07(dots), PHITS.

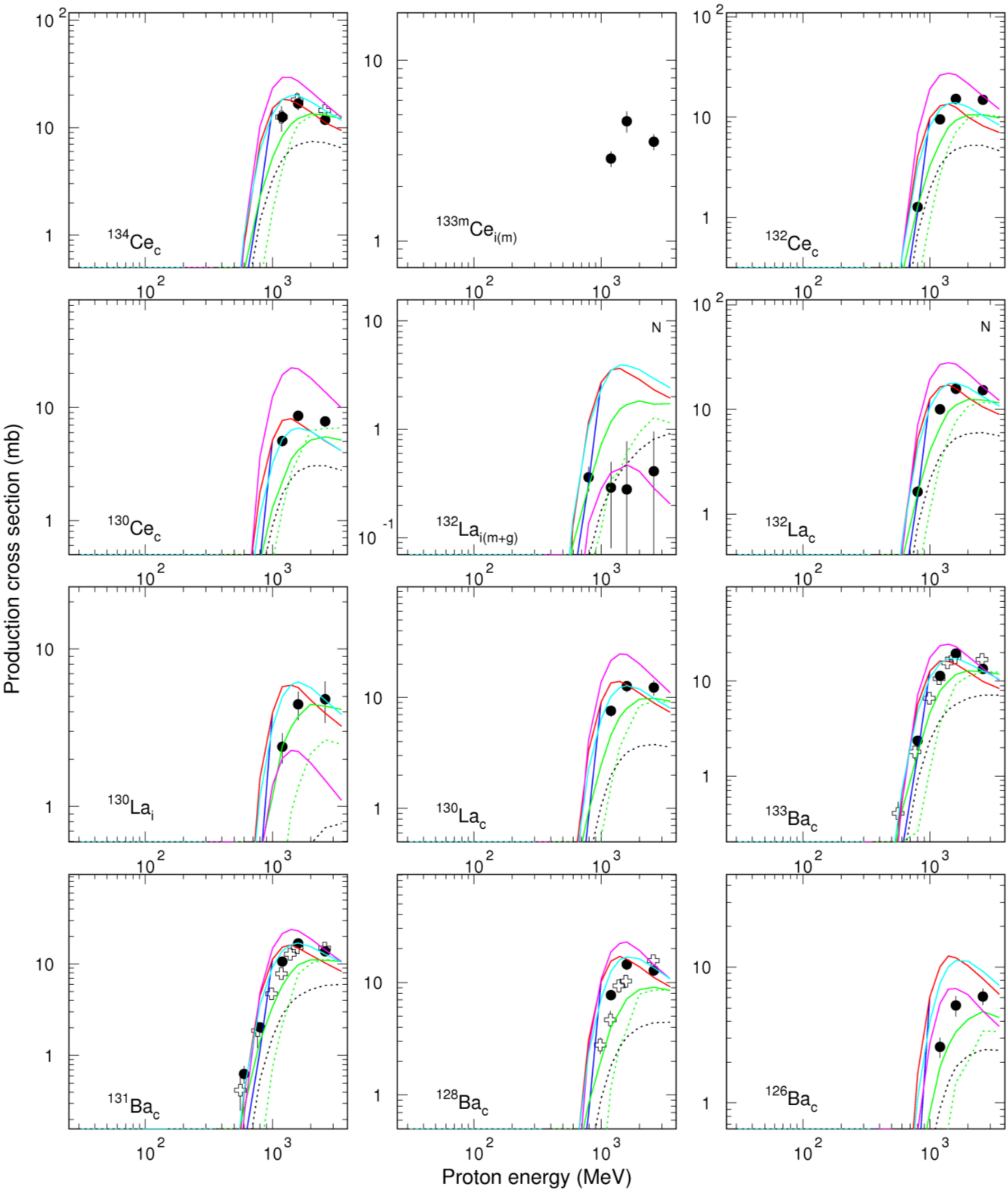

Fig. 7.29. Simulated and experimental cross sections of ^{181}Ta(p,x) reaction (continuation of Fig. 7.21).

Experimental points: ● – this work, ✚ - R.Michel's works [76], ☆ - works of other laboratories. Simulations: MCNPX(BERTINI), MCNPX(ISABEL), CEM03.02, INCL4+ABLA(dots), INCL4.4.5+ABLA07, CASCADE.07(dots), PHITS.

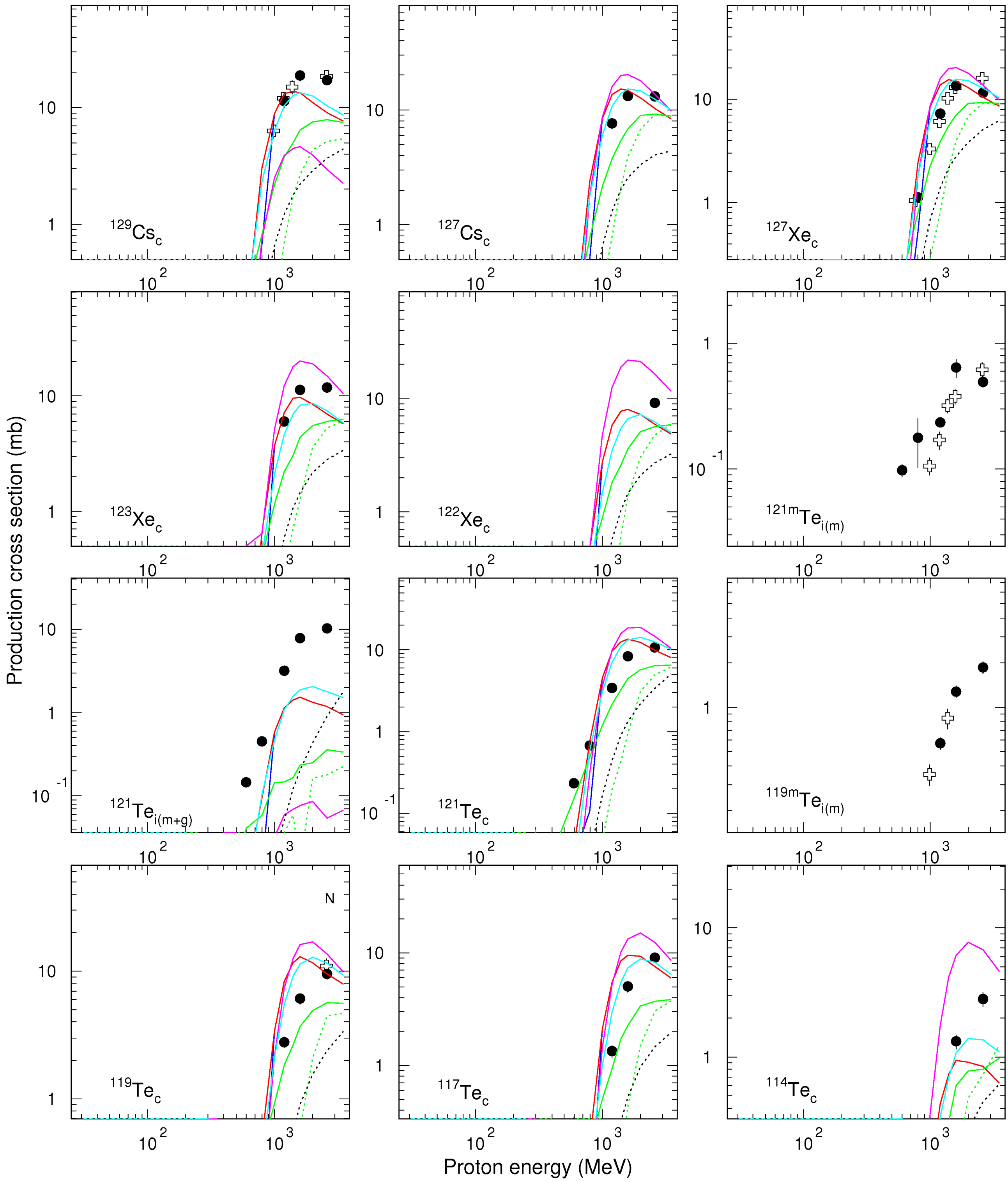

Fig. 7.30. Simulated and experimental cross sections of ^{181}Ta(p,x) reaction (continuation of Fig. 7.21).

Experimental points: ● – this work, ✣ - R.Michel's works [76], ☆ - works of other laboratories. Simulations: MCNPX(BERTINI), MCNPX(ISABEL), CEM03.02, INCL4+ABLA(dots), INCL4.4.5+ABLA07, CASCADE.07(dots), PHITS.

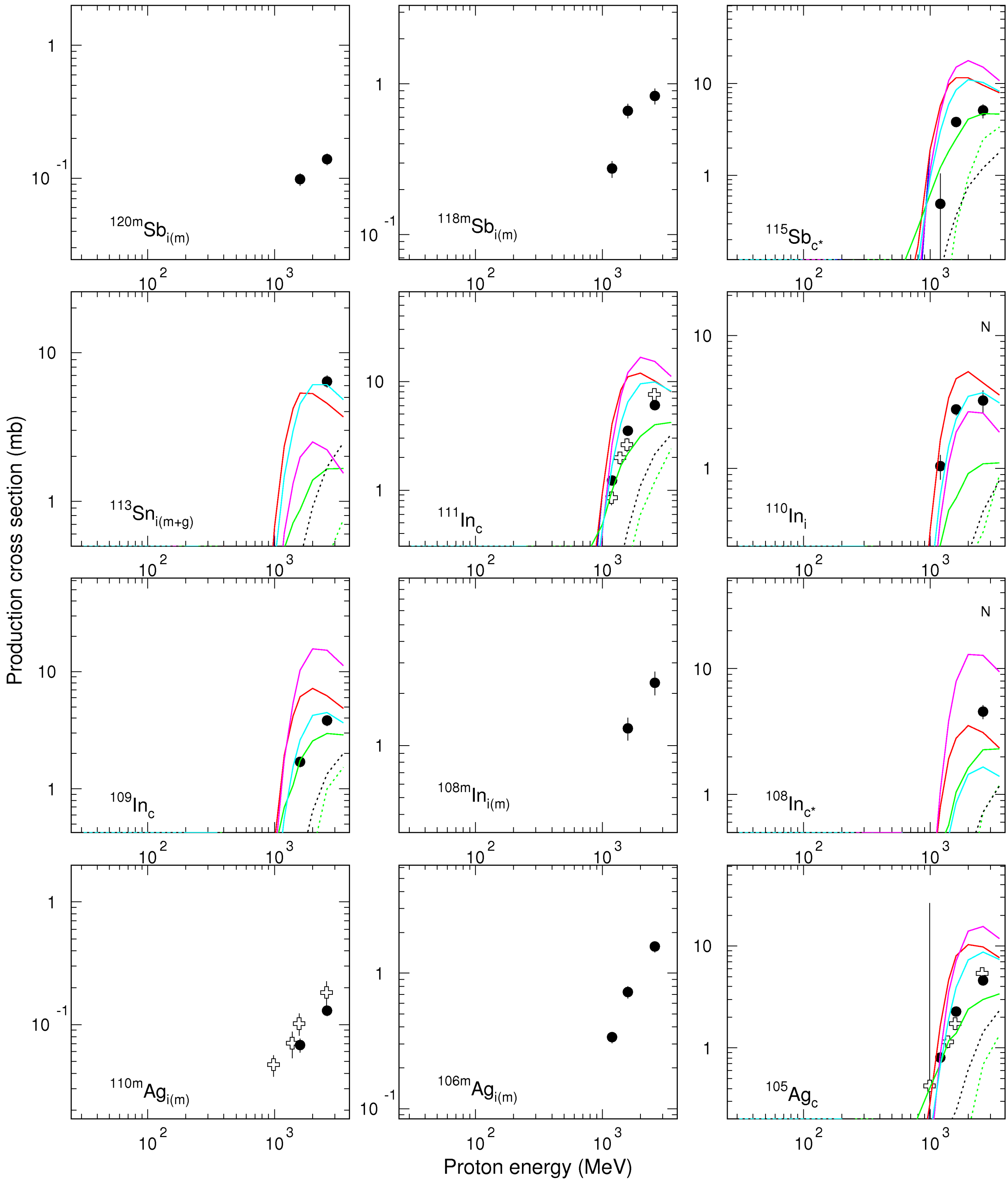

Fig. 7.31. Simulated and experimental cross sections of ^{181}Ta(p,x) reaction (continuation of Fig. 7.21).

Experimental points: ● – this work, ✙ - R.Michel's works [76], ☆ - works of other laboratories. Simulations: MCNPX(BERTINI), MCNPX(ISABEL), CEM03.02, INCL4+ABLA(dots), INCL4.4.5+ABLA07, CASCADE.07(dots), PHITS.

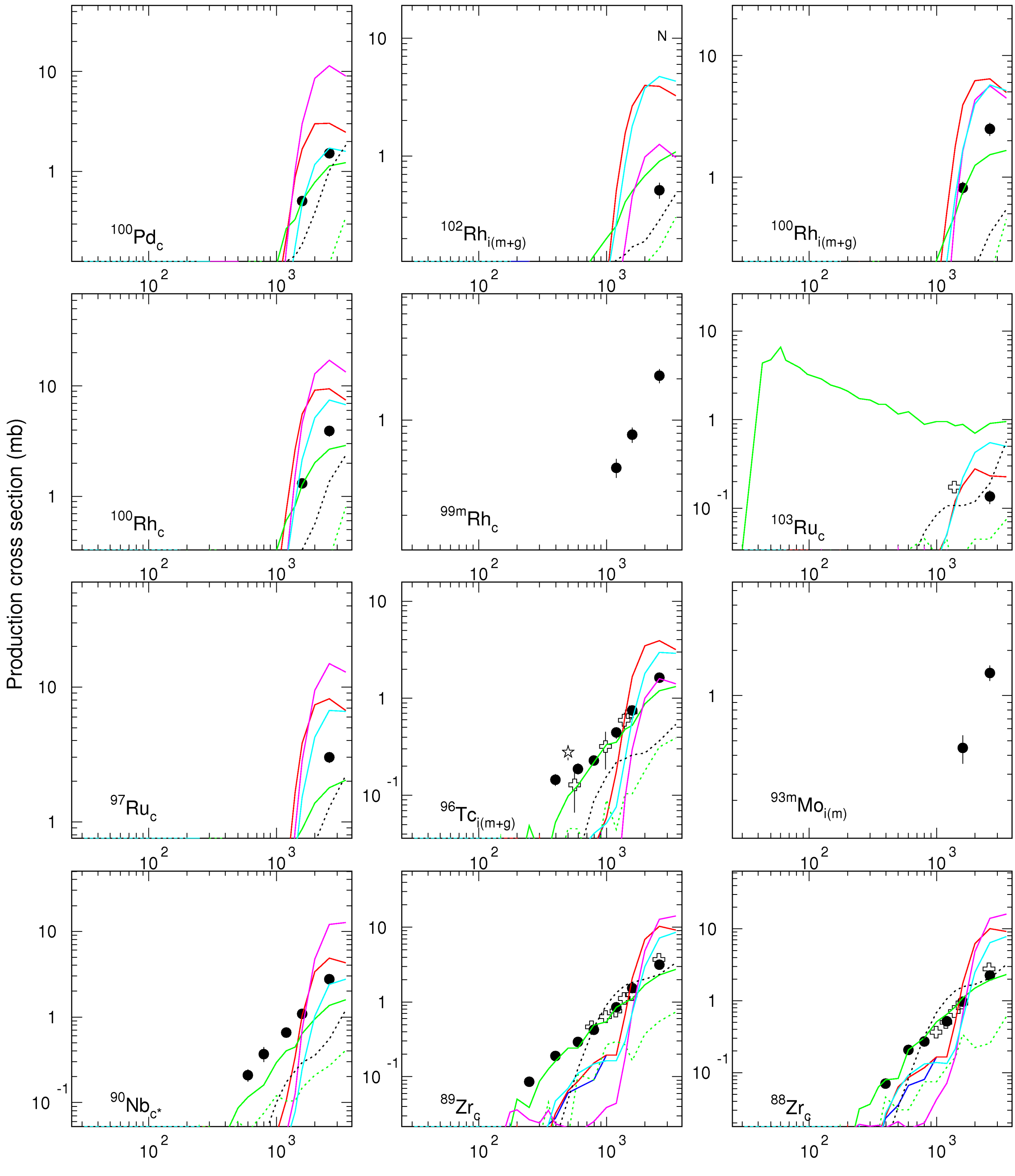

Fig. 7.32. Simulated and experimental cross sections of ^{181}Ta(p,x) reaction (continuation of Fig. 7.21).

Experimental points: ● – this work, ✚ - R.Michel's works [76], ☆ - works of other laboratories. Simulations: MCNPX(BERTINI), MCNPX(ISABEL), CEM03.02, INCL4+ABLA(dots), INCL4.4.5+ABLA07, CASCADE.07(dots), PHITS.

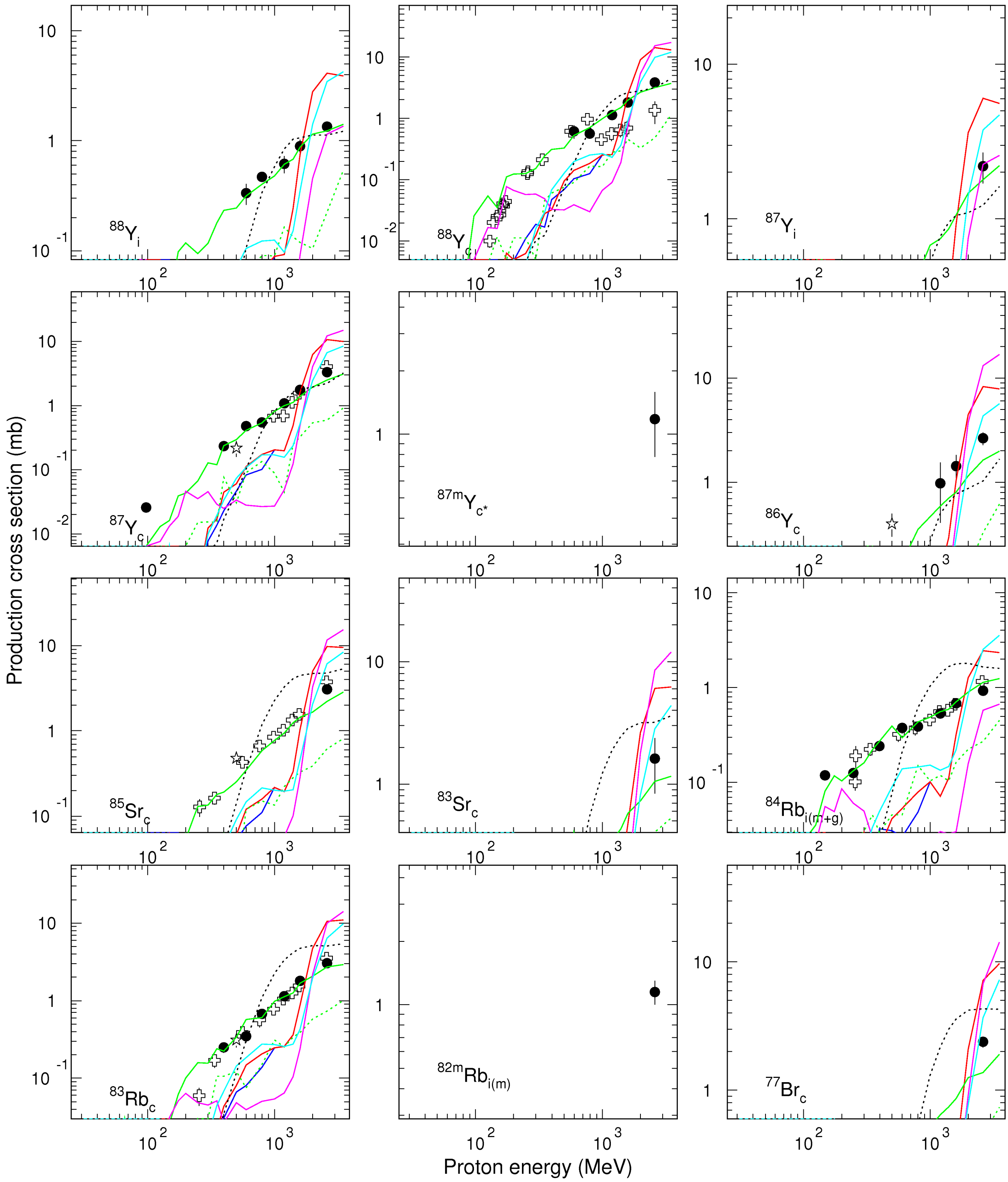

Fig. 7.33. Simulated and experimental cross sections of ^{181}Ta(p,x) reaction (continuation of Fig. 7.21).

Experimental points: ● – this work, ✚ - R.Michel's works [76], ☆ - works of other laboratories. Simulations: MCNPX(BERTINI), MCNPX(ISABEL), CEM03.02, INCL4+ABLA(dots), INCL4.4.5+ABLA07, CASCADE.07(dots), PHITS.

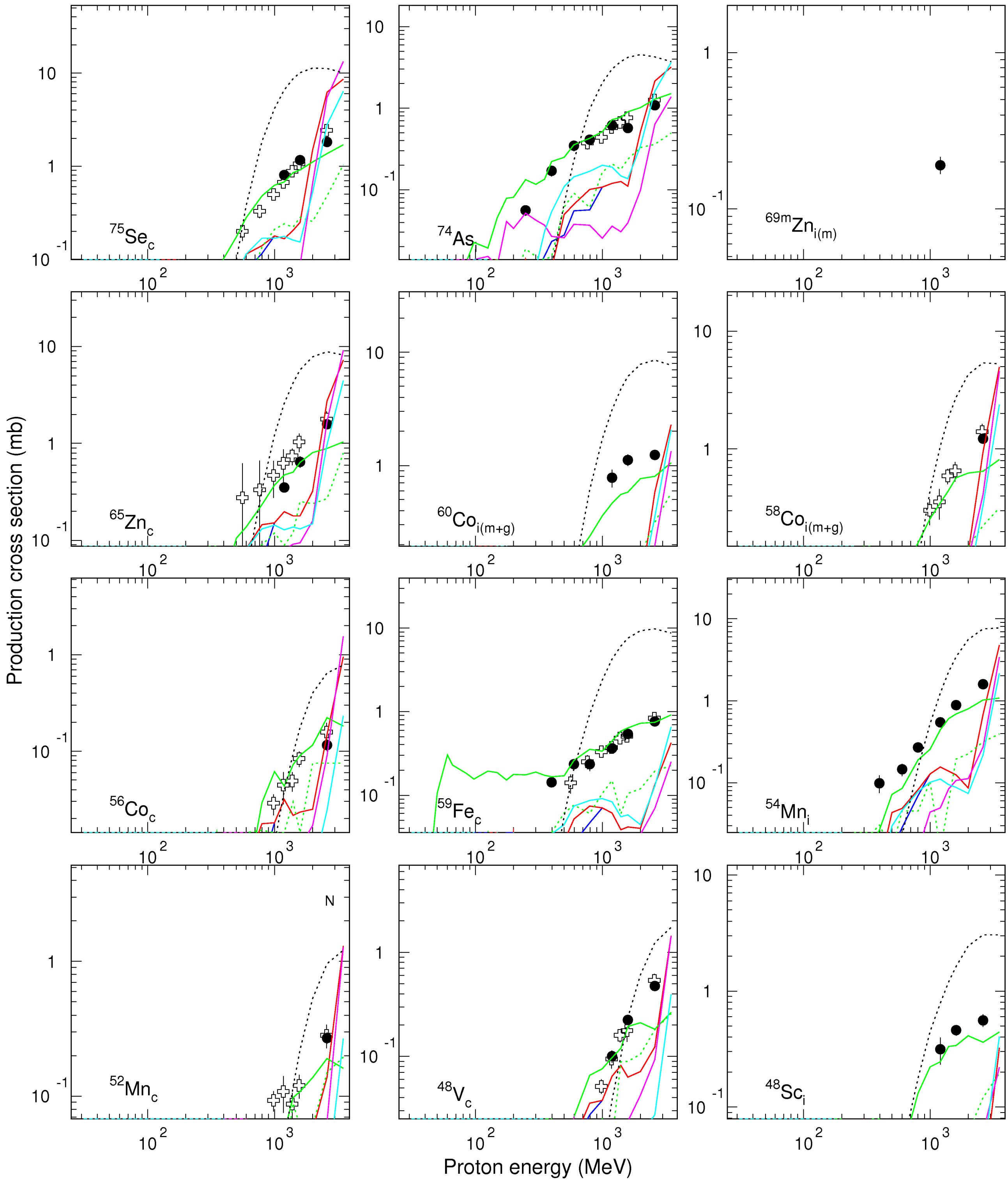

Fig. 7.34. Simulated and experimental cross sections of ^{181}Ta(p,x) reaction (continuation of Fig. 7.21).

Experimental points: ● – this work, ✚ - R.Michel's works [76], ☆ - works of other laboratories. Simulations: MCNPX(BERTINI), MCNPX(ISABEL), CEM03.02, INCL4+ABLA(dots), INCL4.4.5+ABLA07, CASCADE.07(dots), PHITS..

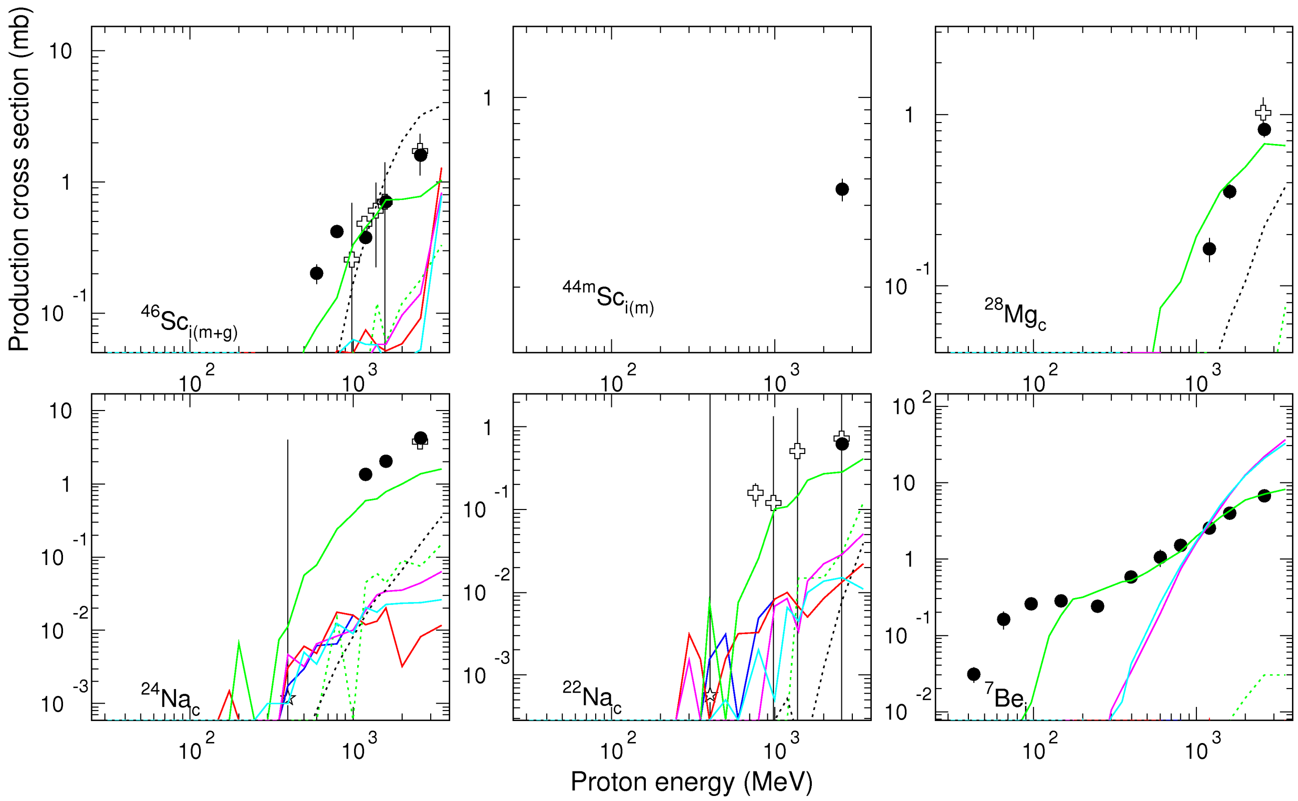

Fig. 7.35. Simulated and experimental cross sections of ^{181}Ta(p,x) reaction (continuation of Fig. 7.21).

Experimental points: ● – this work, ✚ - R.Michel's works [76], ☆ - works of other laboratories. Simulations: MCNPX(BERTINI), MCNPX(ISABEL), CEM03.02, INCL4+ABLA(dots), INCL4.4.5+ABLA07, CASCADE.07(dots), PHITS.

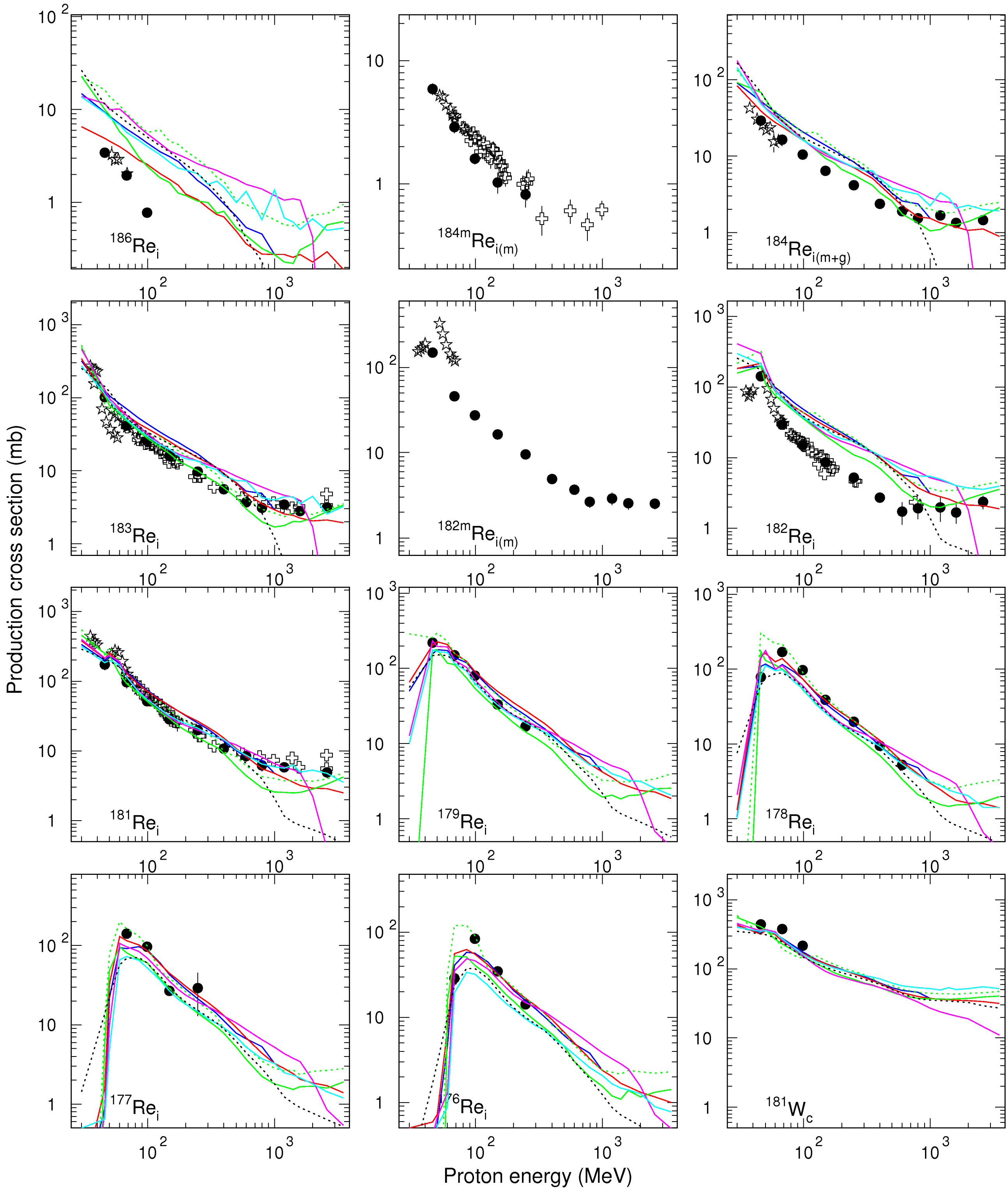

Fig. 7.36. Simulated and experimental cross sections of $^{nat}W(p,x)$ reaction.

Experimental points: ● – this work, ✠ - R.Michel's works [76], ☆ - works of other laboratories. Simulations: MCNPX(BERTINI), MCNPX(ISABEL), CEM03.02, INCL4+ABLA(dots), INCL4.4.5+ABLA07, CASCADE.07(dots), PHITS.

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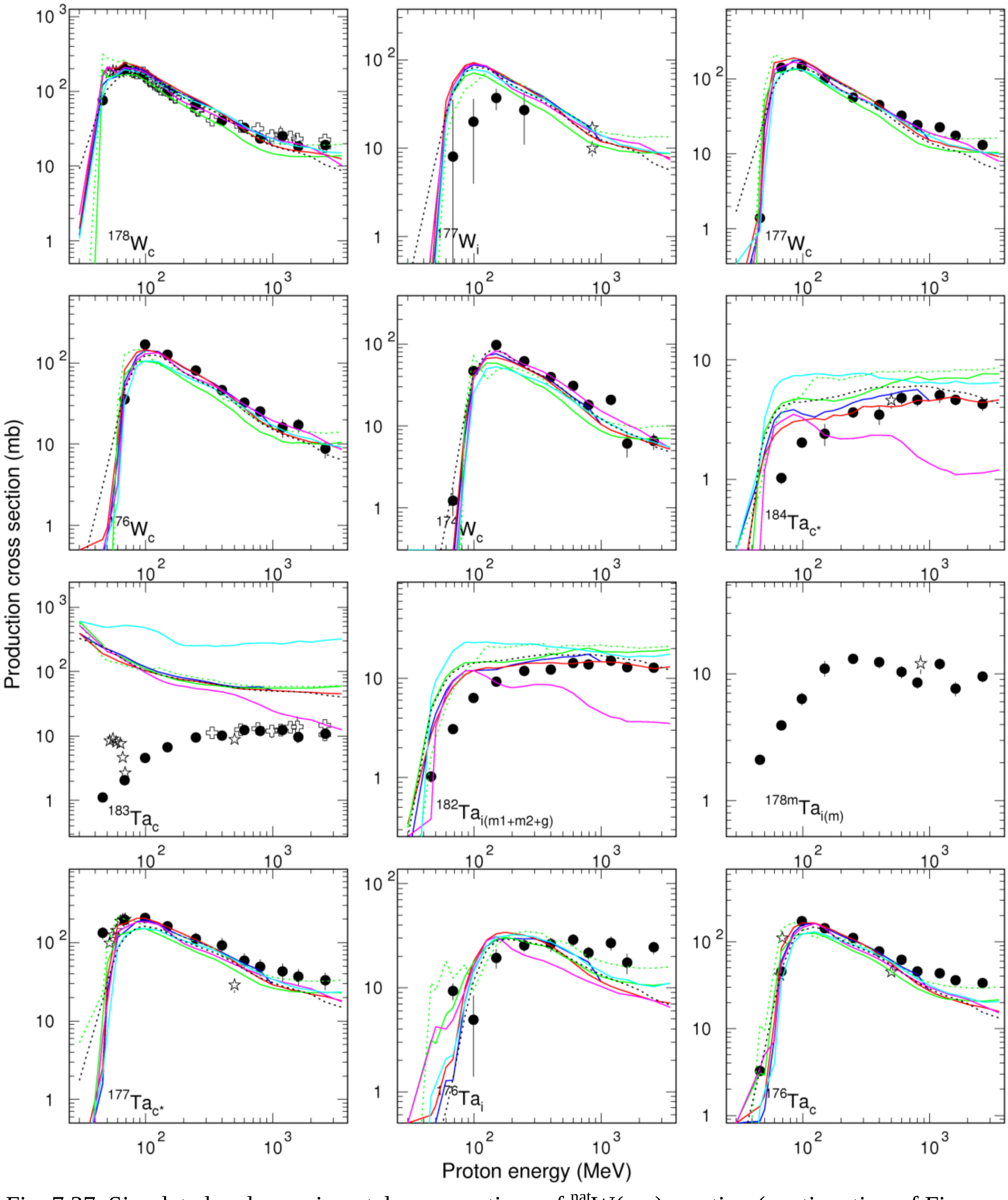

Fig. 7.37. Simulated and experimental cross sections of ^{nat}W(p,x) reaction (continuation of Fig. 7.36).

Experimental points: ● – this work, ✠ - R.Michel's works [76], ☆ - works of other laboratories. Simulations: MCNPX(BERTINI), MCNPX(ISABEL), CEM03.02, INCL4+ABLA(dots), INCL4.4.5+ABLA07, CASCADE.07(dots), PHITS.

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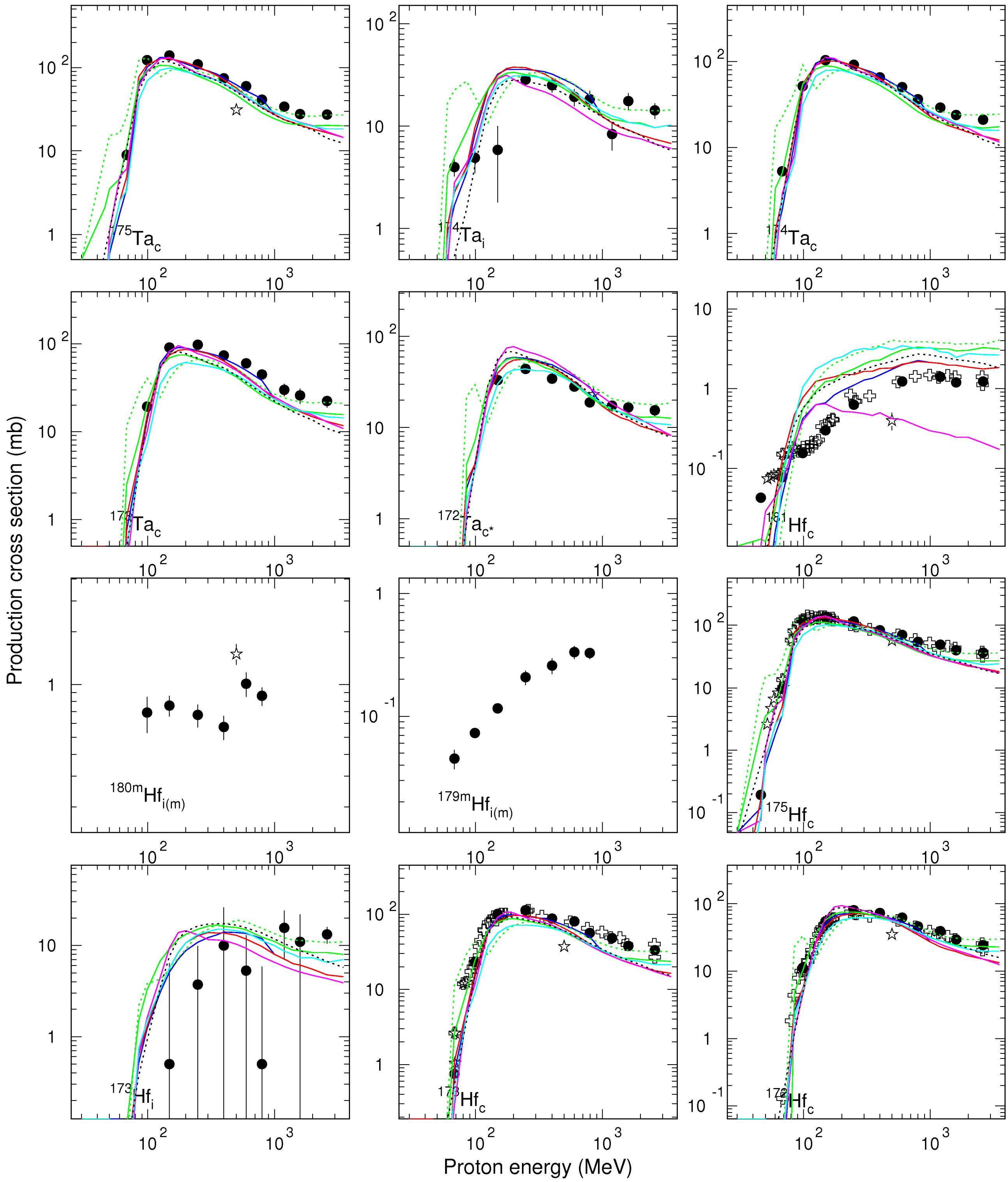

Fig. 7.38. Simulated and experimental cross sections of $^{nat}W(p,x)$ reaction (continuation of Fig. 7.36).

Experimental points: ● – this work, ✚ - R.Michel's works [76], ☆ - works of other laboratories. Simulations: MCNPX(BERTINI), MCNPX(ISABEL), CEM03.02, INCL4+ABLA(dots), INCL4.4.5+ABLA07, CASCADE.07(dots), PHITS.

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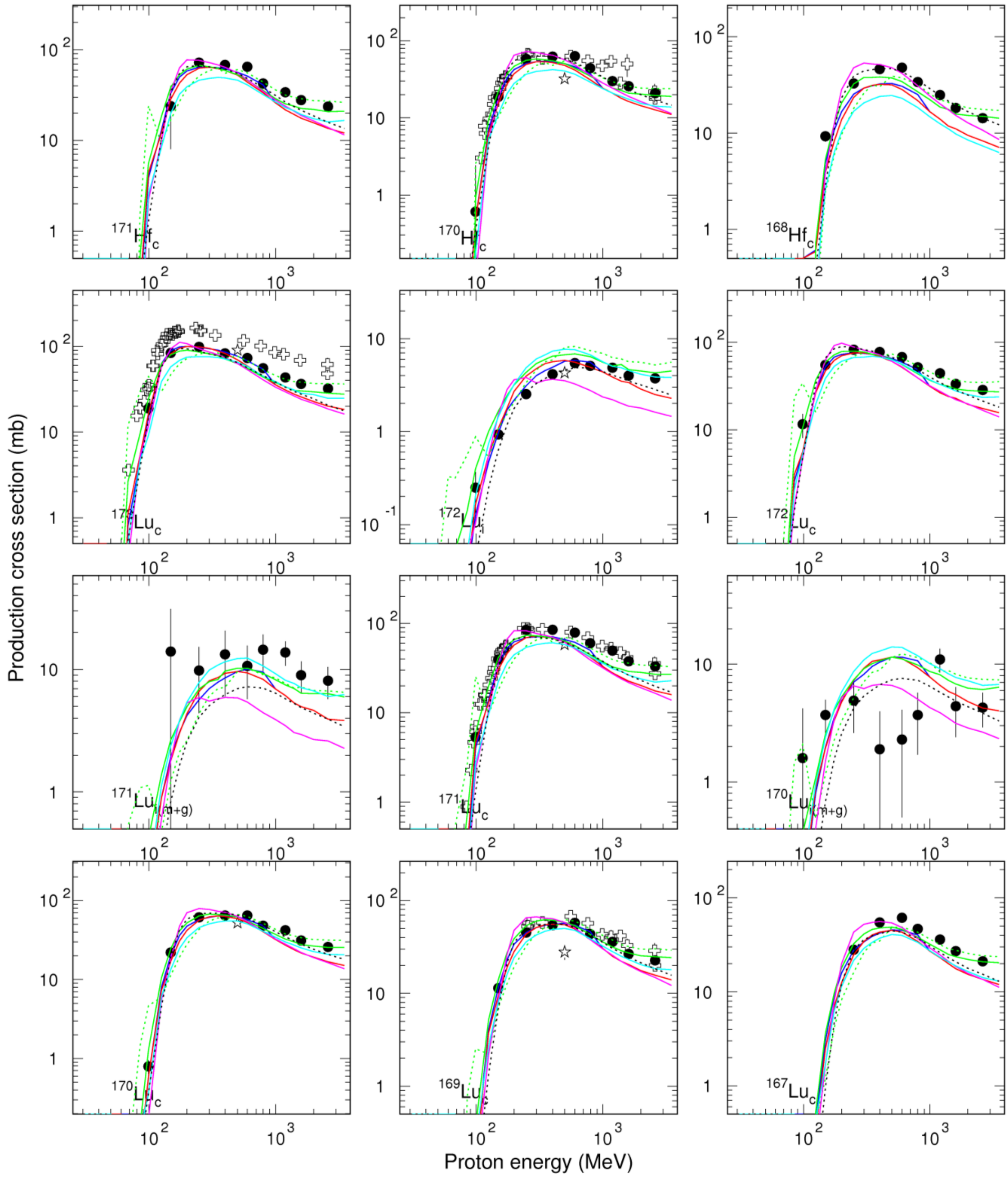

Fig. 7.39. Simulated and experimental cross sections of $^{nat}W(p,x)$ reaction (continuation of Fig. 7.36).

Experimental points: ● – this work, ✚ - R.Michel's works [76], ☆ - works of other laboratories. Simulations: MCNPX(BERTINI), MCNPX(ISABEL), CEM03.02, INCL4+ABLA(dots), INCL4.4.5+ABLA07, CASCADE.07(dots), PHITS.

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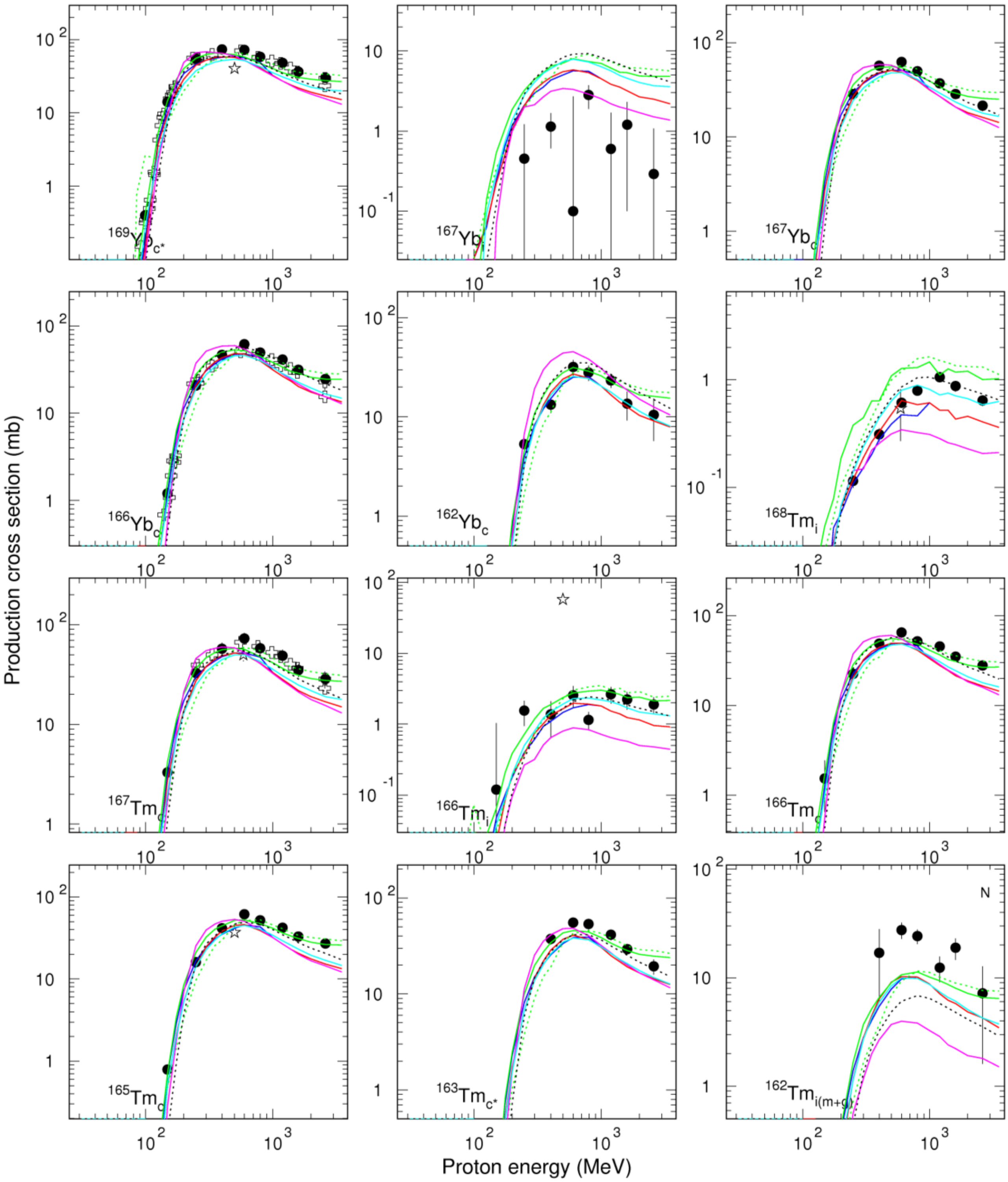

Fig. 7.40. Simulated and experimental cross sections of ^{nat}W(p,x) reaction (continuation of Fig. 7.36).

Experimental points: ● – this work, ♧ - R.Michel's works [76], ☆ - works of other laboratories. Simulations: MCNPX(BERTINI), MCNPX(ISABEL), CEM03.02, INCL4+ABLA(dots), INCL4.4.5+ABLA07, CASCADE.07(dots), PHITS.

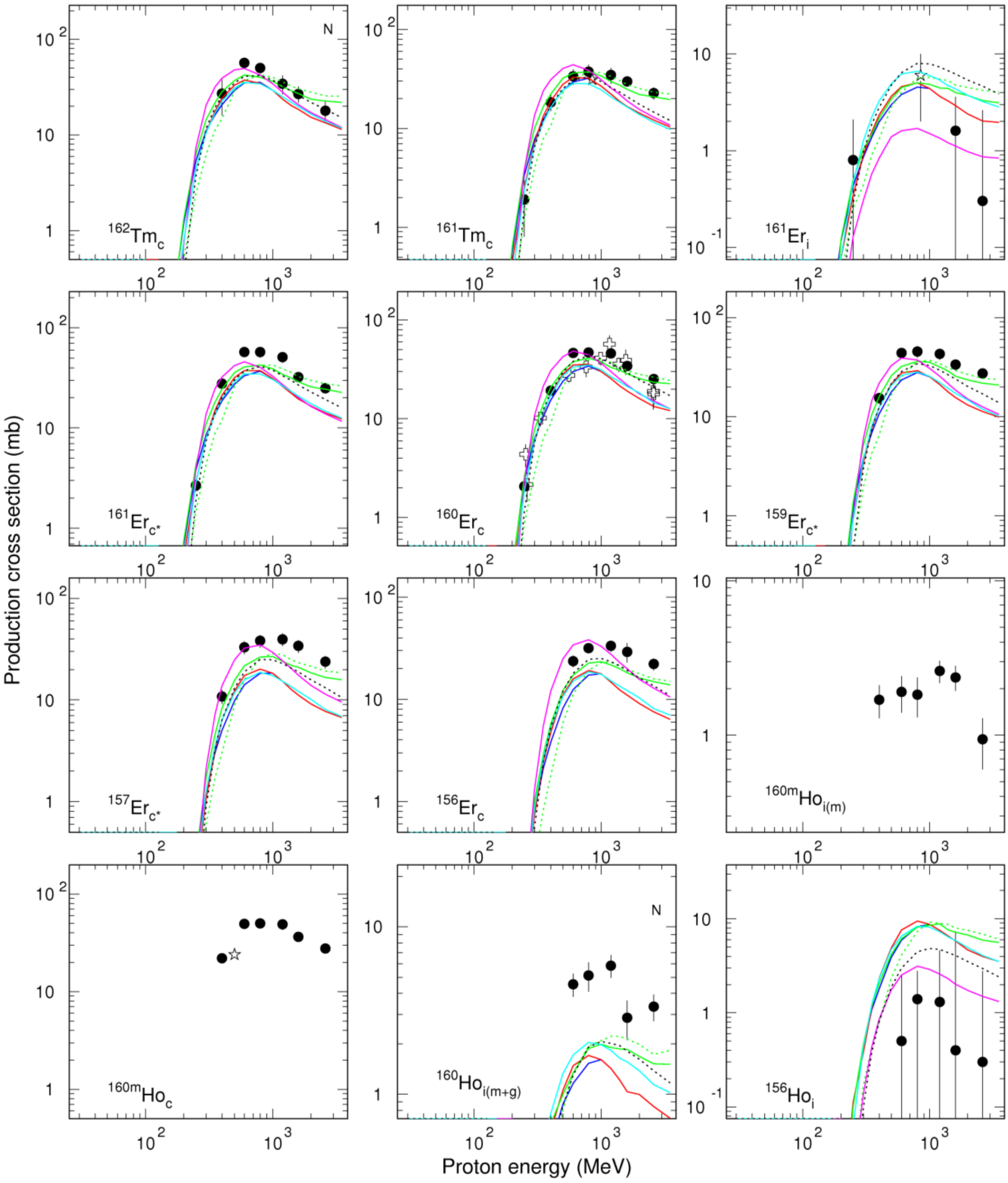

Fig. 7.41. Simulated and experimental cross sections of $^{nat}W(p,x)$ reaction (continuation of Fig. 7.36).

Experimental points: ● – this work, ✚ - R.Michel's works [76], ☆ - works of other laboratories. Simulations: MCNPX(BERTINI), MCNPX(ISABEL), CEM03.02, INCL4+ABLA(dots), INCL4.4.5+ABLA07, CASCADE.07(dots), PHITS.

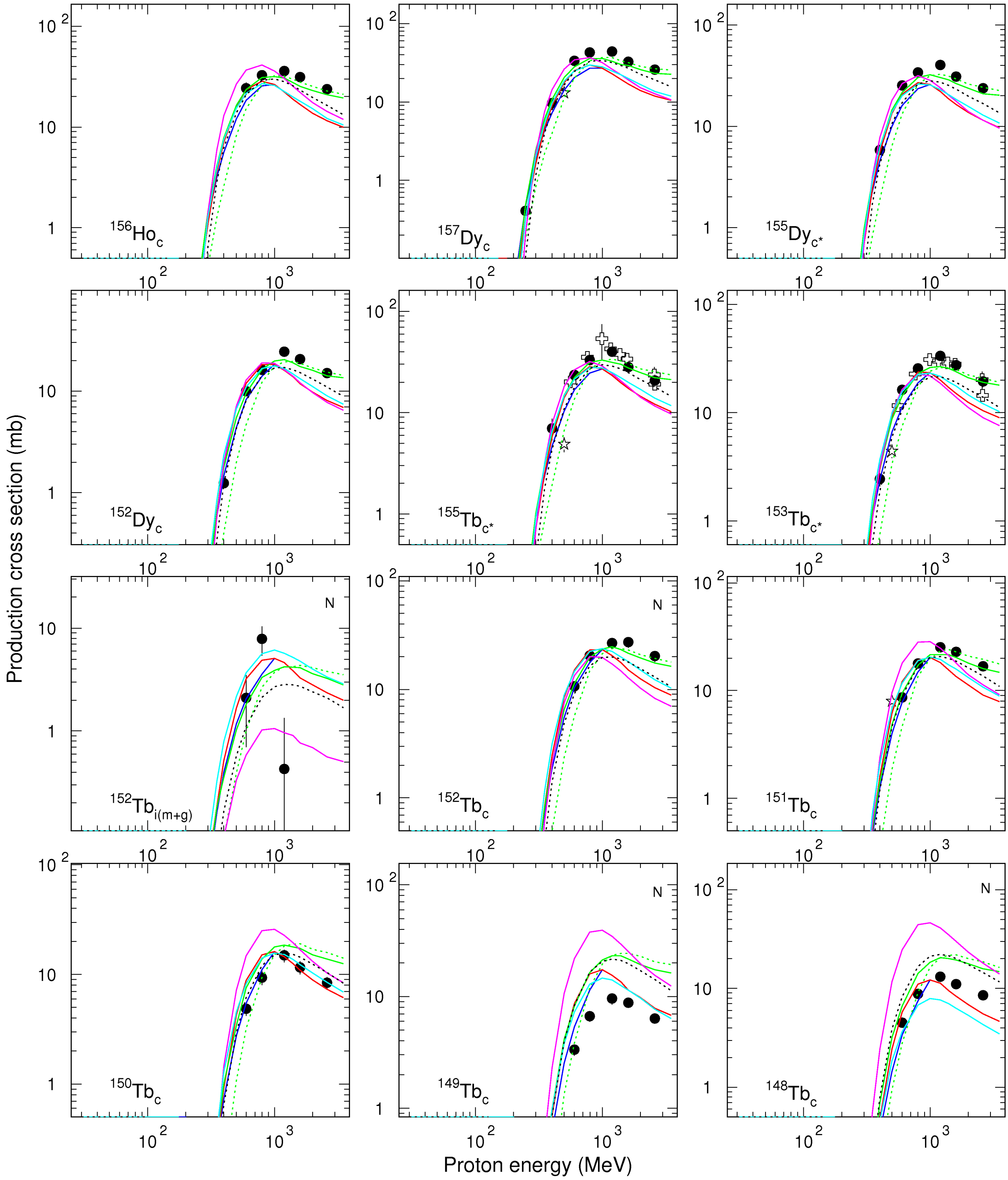

Fig. 7.42. Simulated and experimental cross sections of ^{nat}W(p,x) reaction (continuation of Fig. 7.36).

Experimental points: ● – this work, ✚ - R.Michel's works [76], ☆ - works of other laboratories. Simulations: MCNPX(BERTINI), MCNPX(ISABEL), CEM03.02, INCL4+ABLA(dots), INCL4.4.5+ABLA07, CASCADE.07(dots), PHITS.

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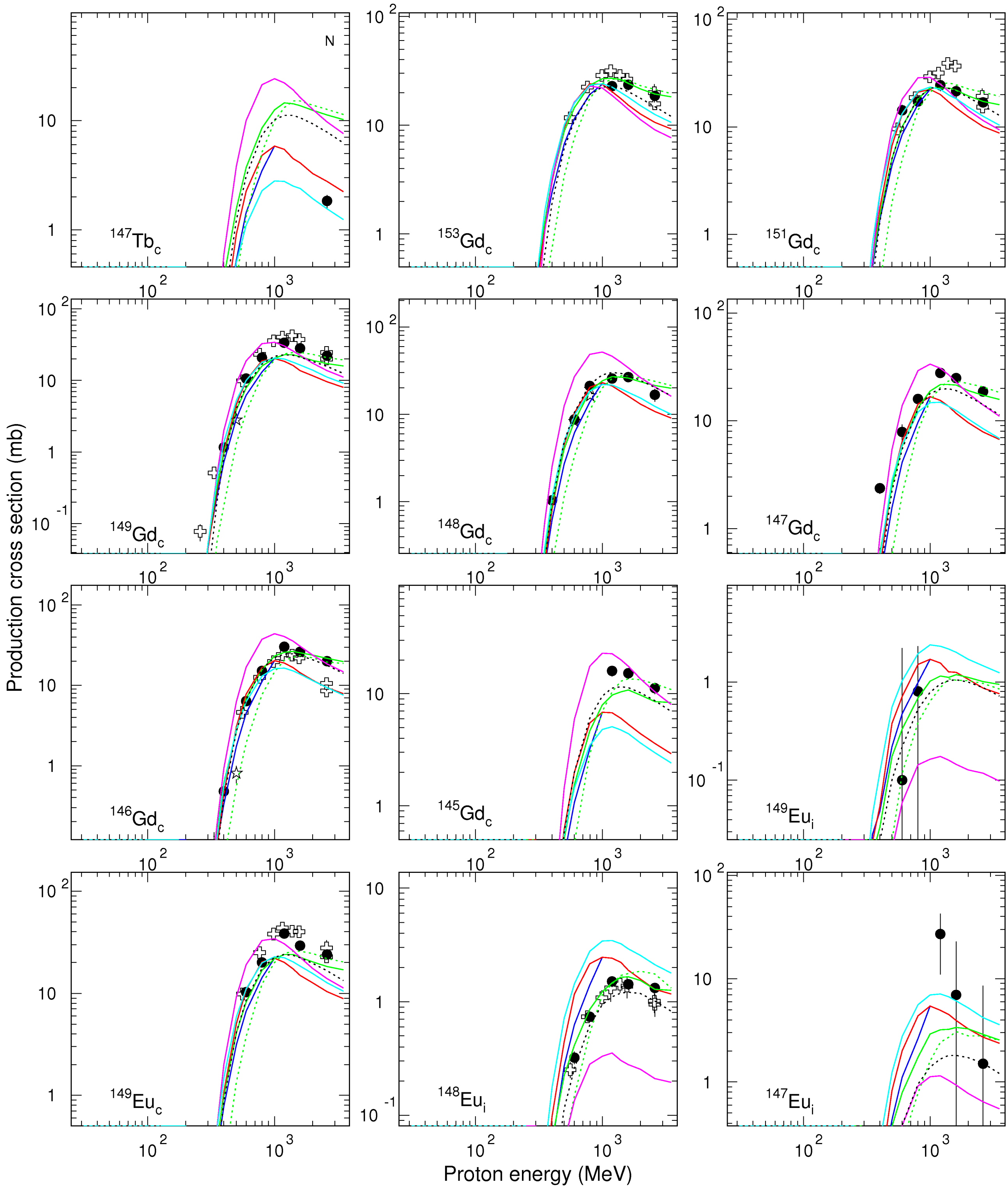

Fig. 7.43. Simulated and experimental cross sections of $^{nat}W(p,x)$ reaction (continuation of Fig. 7.36).

Experimental points: ● – this work, ✣ - R.Michel's works [76], ☆ - works of other laboratories. Simulations: MCNPX(BERTINI), MCNPX(ISABEL), CEM03.02, INCL4+ABLA(dots), INCL4.4.5+ABLA07, CASCADE.07(dots), PHITS.

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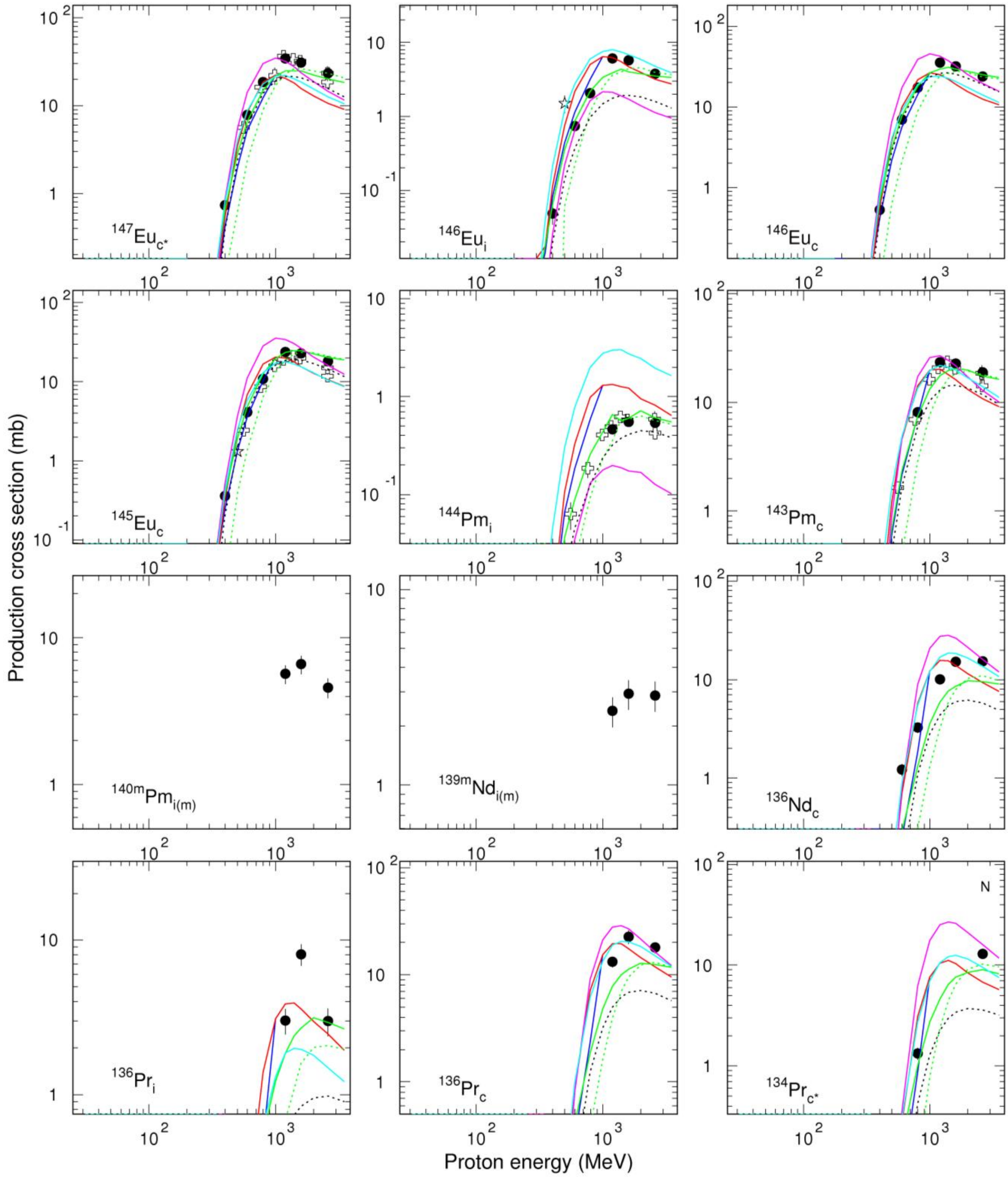

Fig. 7.44. Simulated and experimental cross sections of $^{nat}W(p,x)$ reaction (continuation of Fig. 7.36).

Experimental points: ● – this work, ✚ - R.Michel's works [76], ☆ - works of other laboratories. Simulations: MCNPX(BERTINI), MCNPX(ISABEL), CEM03.02, INCL4+ABLA(dots), INCL4.4.5+ABLA07, CASCADE.07(dots), PHITS.

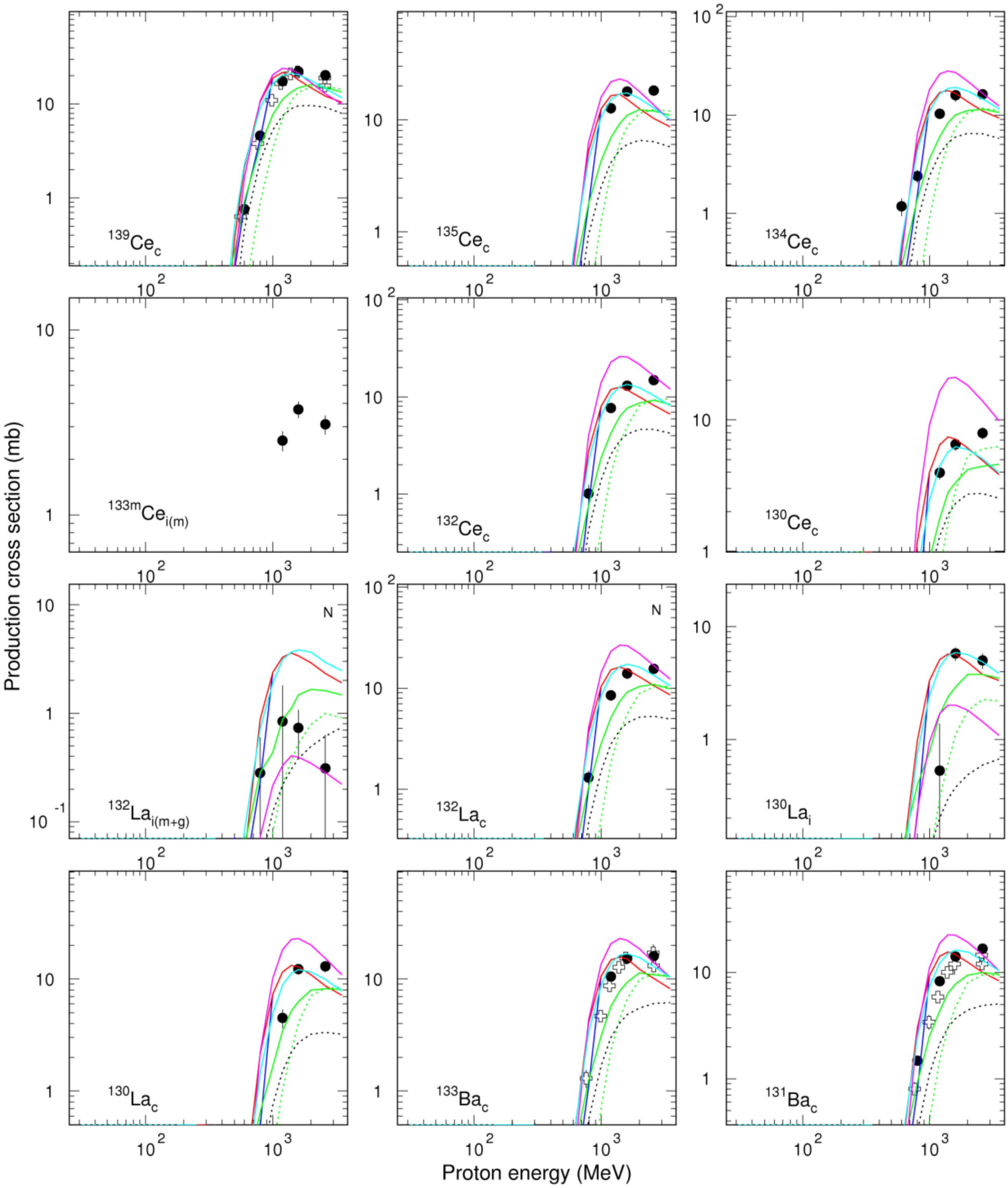

Fig. 7.45. Simulated and experimental cross sections of $^{nat}W(p,x)$ reaction (continuation of Fig. 7.36).

Experimental points: ● – this work, ✚ - R.Michel's works [76], ☆ - works of other laboratories. Simulations: MCNPX(BERTINI), MCNPX(ISABEL), CEM03.02, INCL4+ABLA(dots), INCL4.4.5+ABLA07, CASCADE.07(dots), PHITS.

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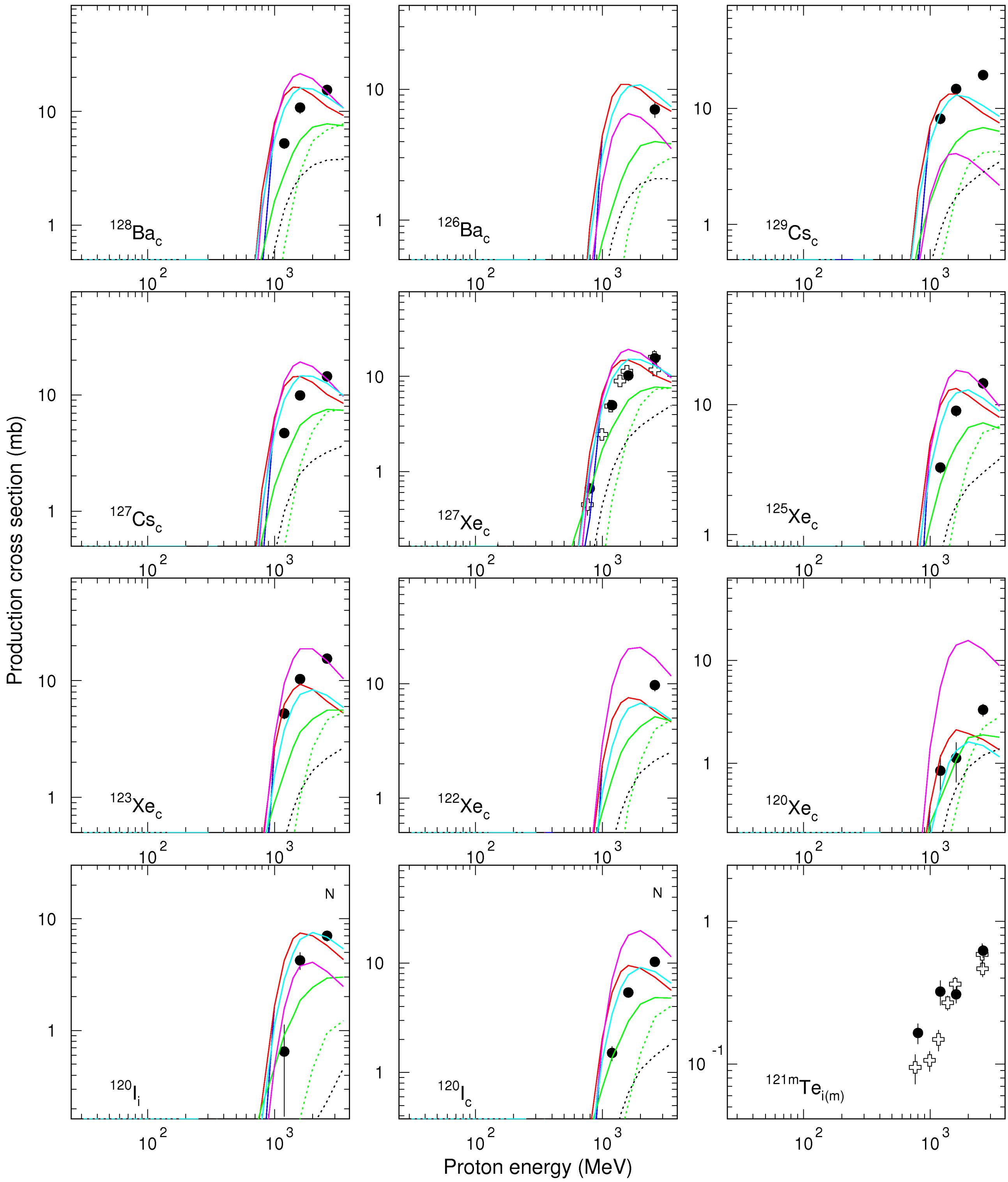

Fig. 7.46. Simulated and experimental cross sections of $^{nat}W(p,x)$ reaction (continuation of Fig. 7.36).

Experimental points: ● – this work, ✙ - R.Michel's works [76], ☆ - works of other laboratories. Simulations: MCNPX(BERTINI), MCNPX(ISABEL), CEM03.02, INCL4+ABLA(dots), INCL4.4.5+ABLA07, CASCADE.07(dots), PHITS.

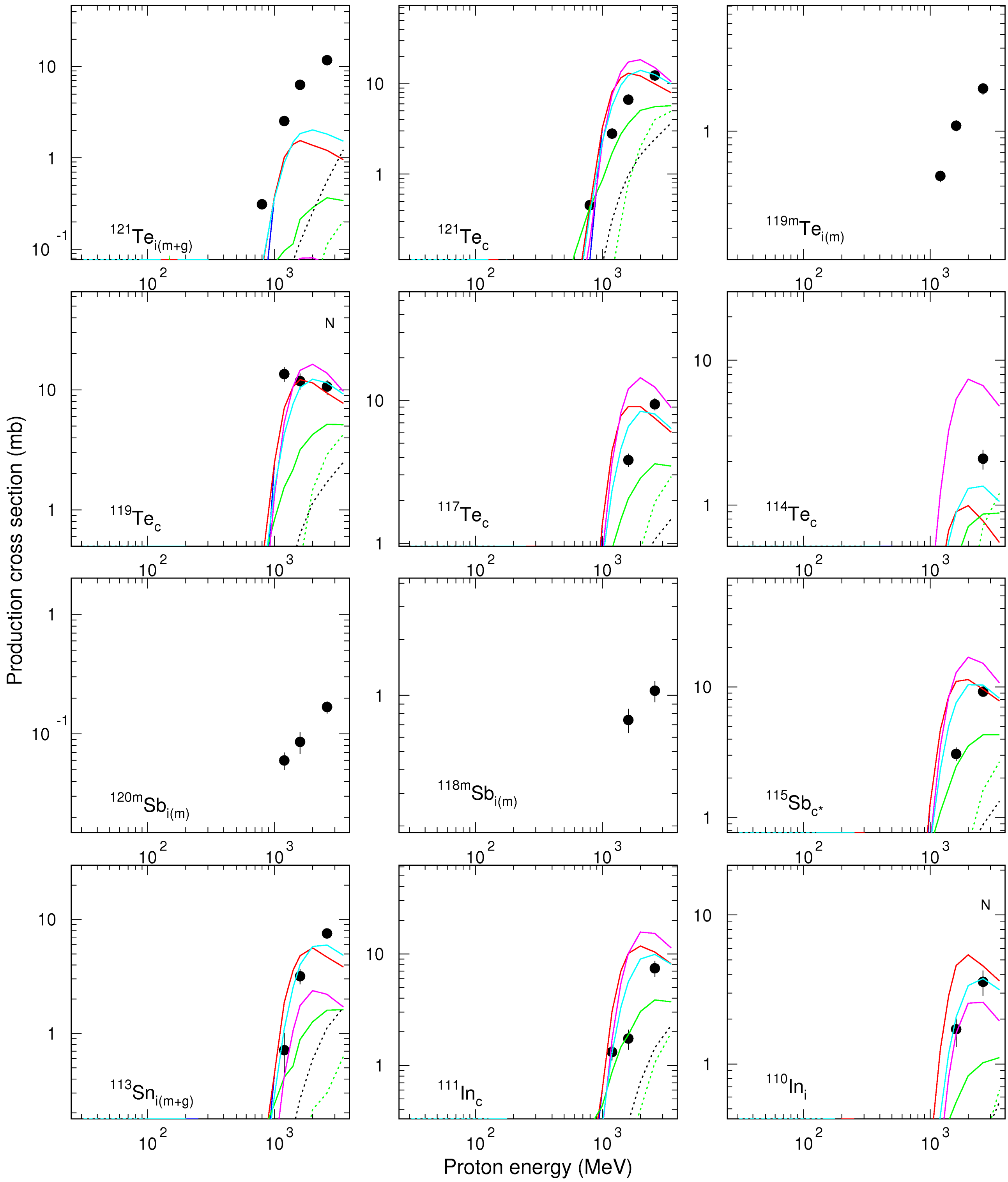

Fig. 7.47. Simulated and experimental cross sections of $^{nat}W(p,x)$ reaction (continuation of Fig. 7.36).

Experimental points: ● – this work, ✚ - R.Michel's works [76], ☆ - works of other laboratories. Simulations: MCNPX(BERTINI), MCNPX(ISABEL), CEM03.02, INCL4+ABLA(dots), INCL4.4.5+ABLA07, CASCADE.07(dots), PHITS.

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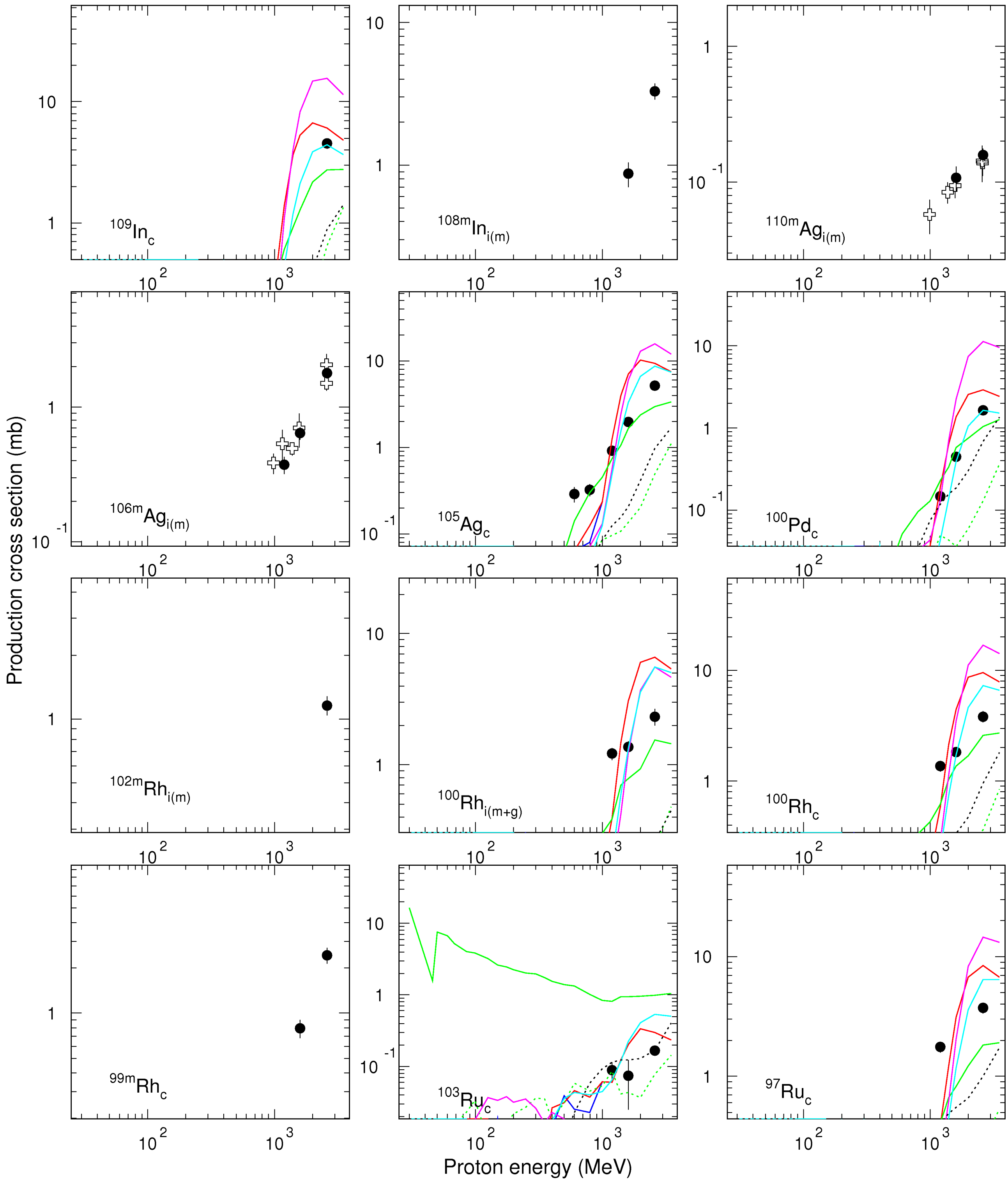

Fig. 7.48. Simulated and experimental cross sections of $^{nat}W(p,x)$ reaction (continuation of Fig. 7.36).

Experimental points: ● – this work, ✚ - R.Michel's works [76], ☆ - works of other laboratories. Simulations: MCNPX(BERTINI), MCNPX(ISABEL), CEM03.02, INCL4+ABLA(dots), INCL4.4.5+ABLA07, CASCADE.07(dots), PHITS.

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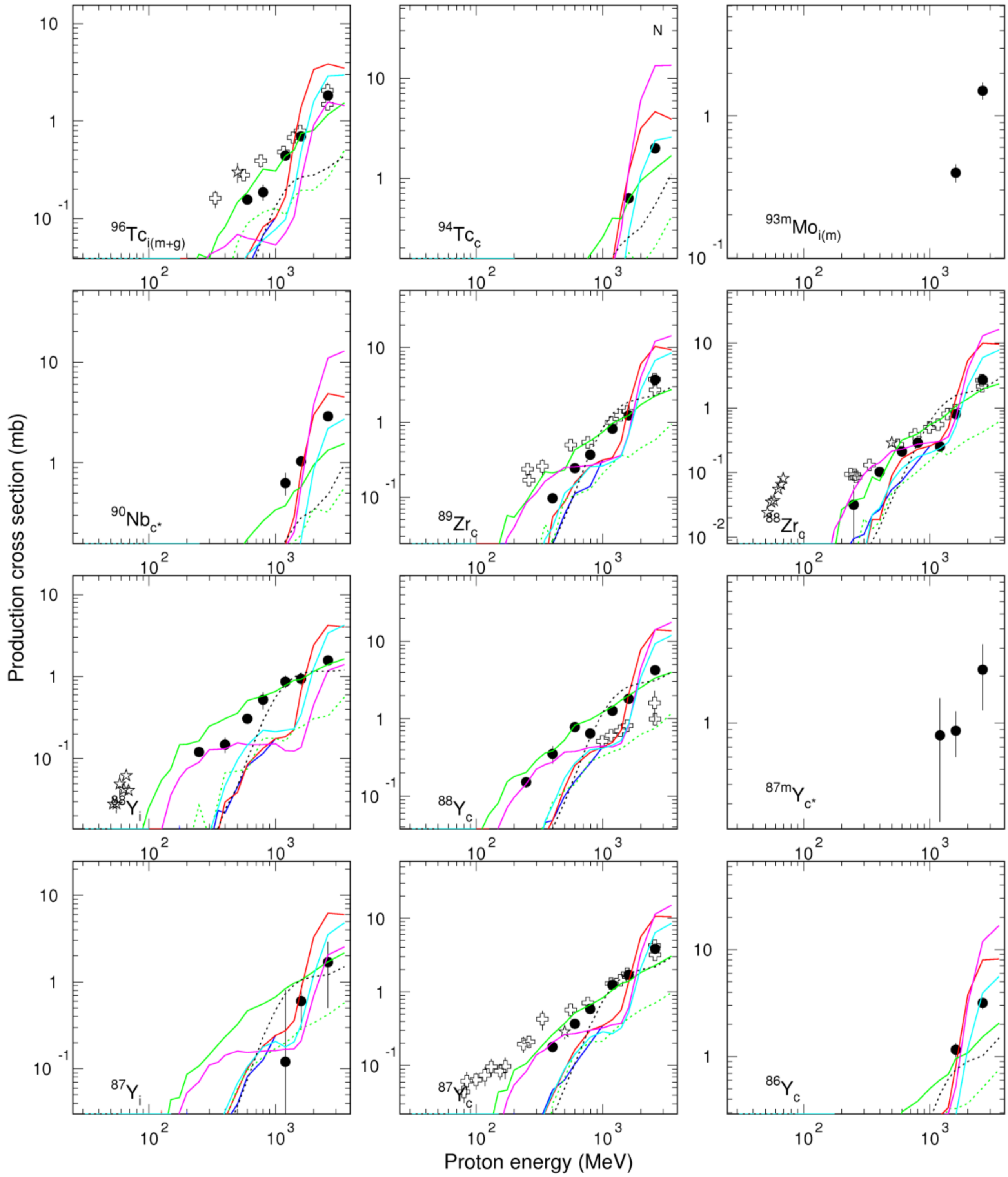

Fig. 7.49. Simulated and experimental cross sections of $^{nat}W(p,x)$ reaction (continuation of Fig. 7.36).

Experimental points: ● – this work, ✚ - R.Michel's works [76], ☆ - works of other laboratories. Simulations: MCNPX(BERTINI), MCNPX(ISABEL), CEM03.02, INCL4+ABLA(dots), INCL4.4.5+ABLA07, CASCADE.07(dots), PHITS.

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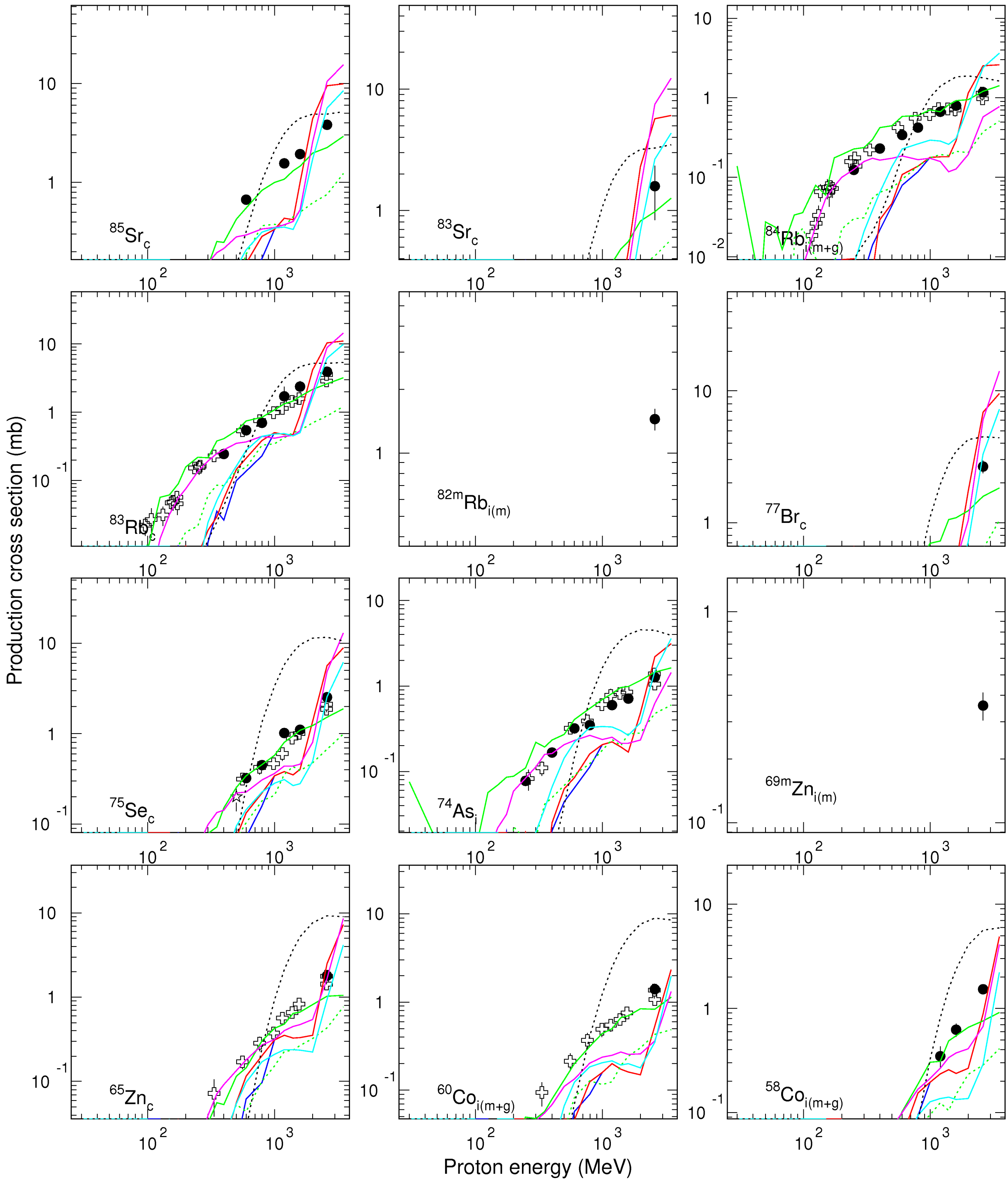

Fig. 7.50. Simulated and experimental cross sections of $^{nat}W(p,x)$ reaction (continuation of Fig. 7.36).

Experimental points: ● – this work, ✚ - R.Michel's works [76], ☆ - works of other laboratories. Simulations: MCNPX(BERTINI), MCNPX(ISABEL), CEM03.02, INCL4+ABLA(dots), INCL4.4.5+ABLA07, CASCADE.07(dots), PHITS.

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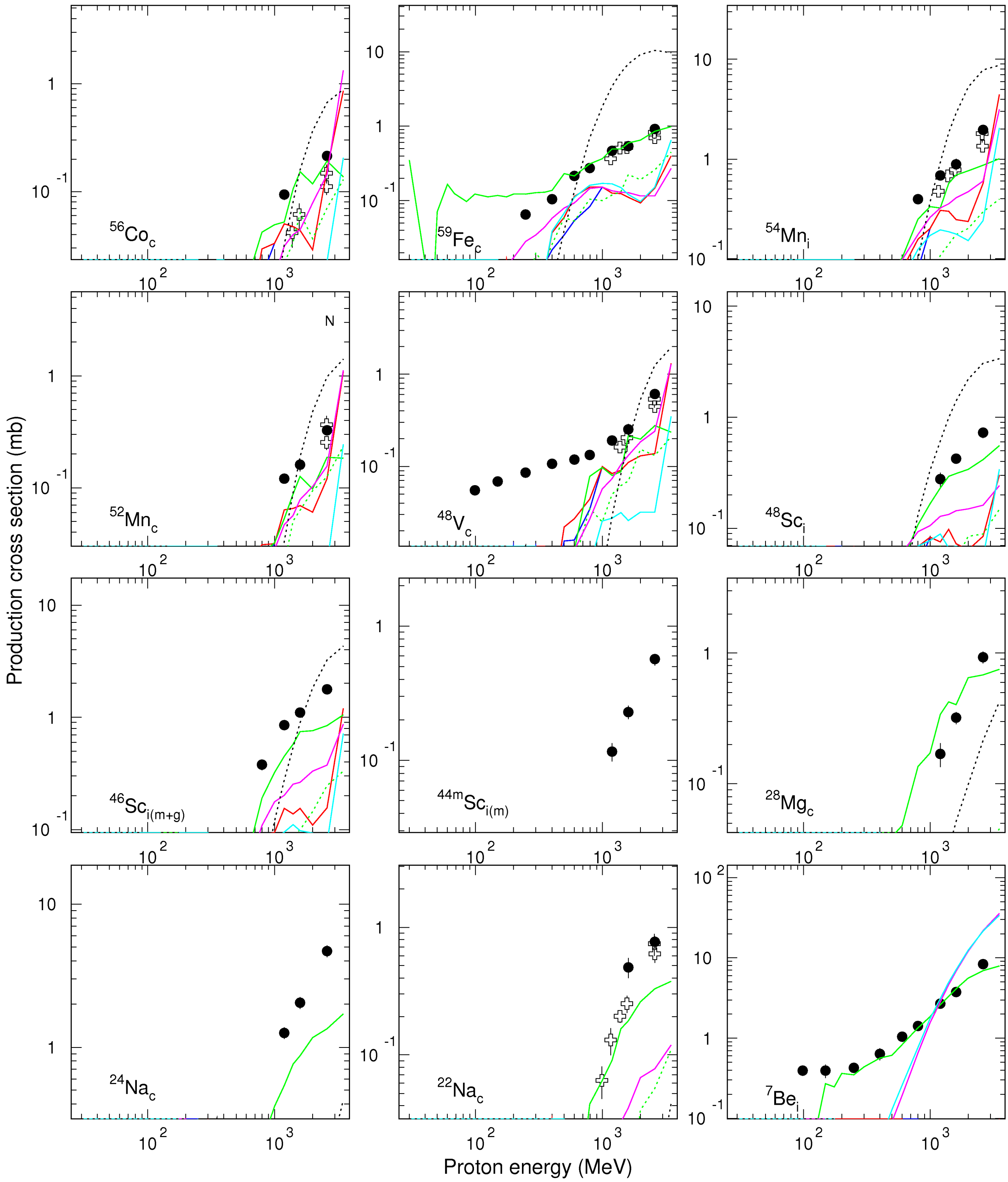

Fig. 7.51. Simulated and experimental cross sections of $^{nat}W(p,x)$ reaction (continuation of Fig. 7.36).

Experimental points: ● – this work, ✙ - R.Michel's works [76], ☆ - works of other laboratories. Simulations: MCNPX(BERTINI), MCNPX(ISABEL), CEM03.02, INCL4+ABLA(dots), INCL4.4.5+ABLA07, CASCADE.07(dots), PHITS.

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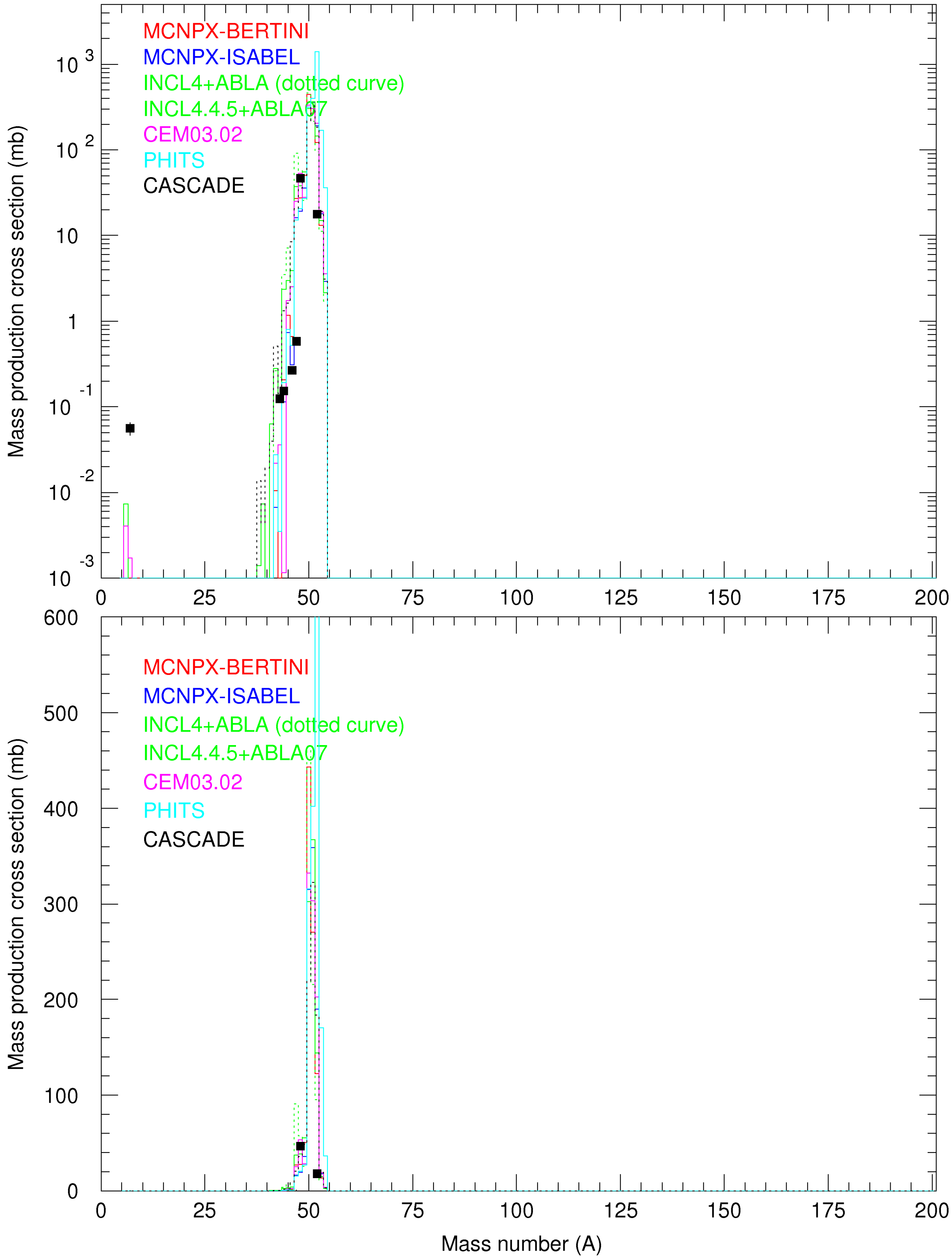

Fig. 7.52. The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{nat}Cr irradiated with 0.04 GeV protons.

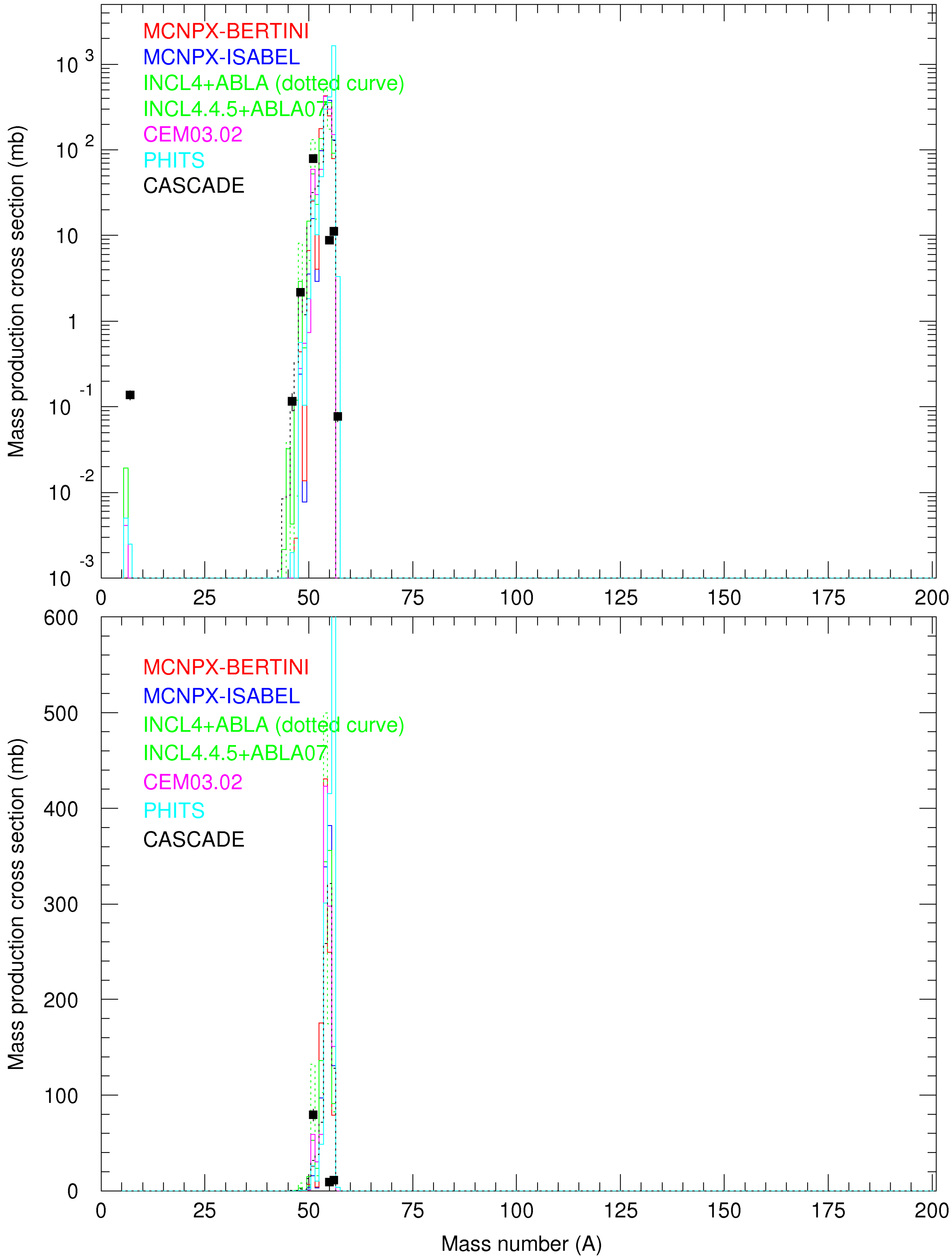

Fig. 7.53. The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{56}Fe irradiated with 0.04 GeV protons.

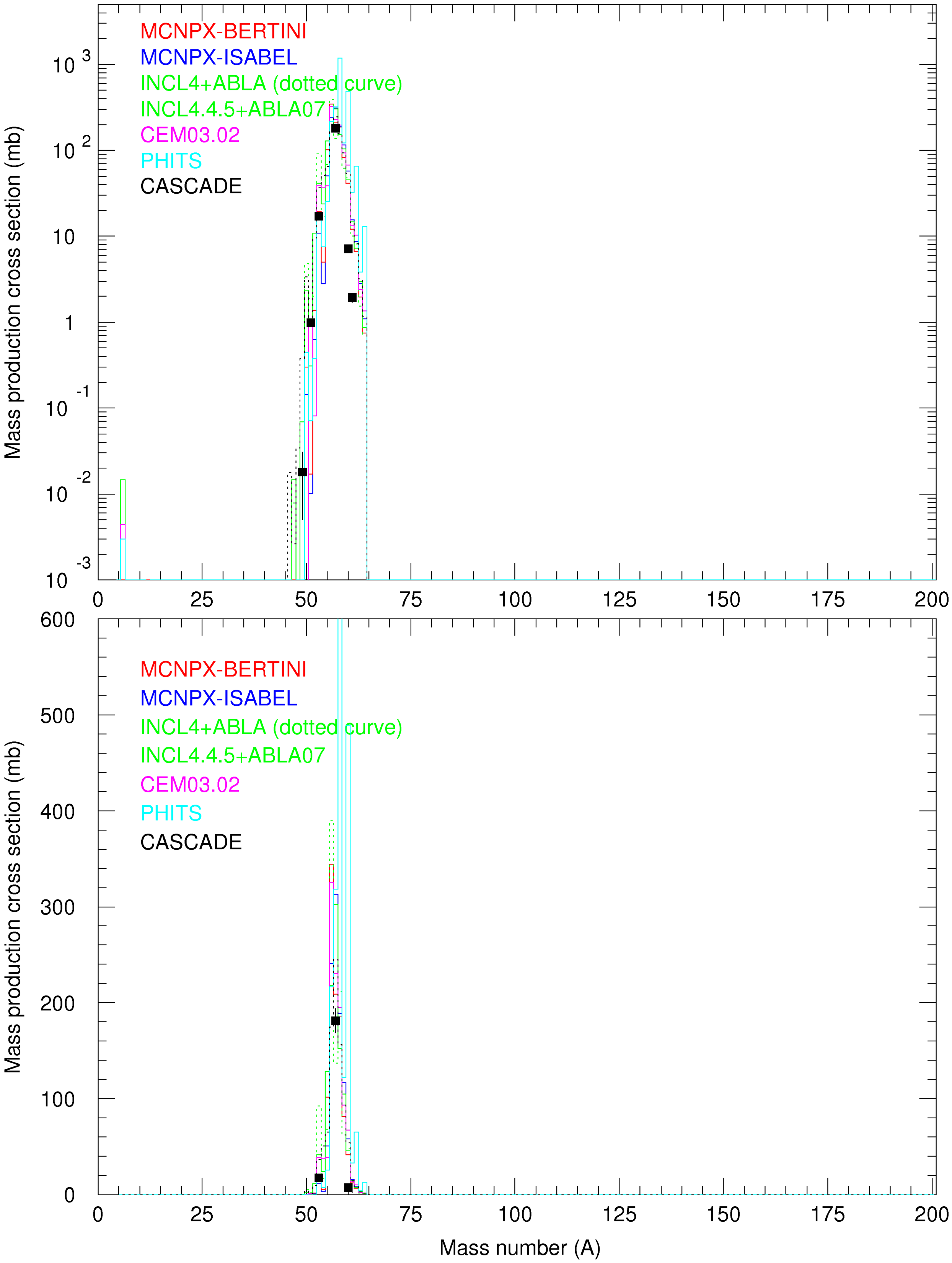

Fig. 7.54. The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{nat}Ni irradiated with 0.04 GeV protons.

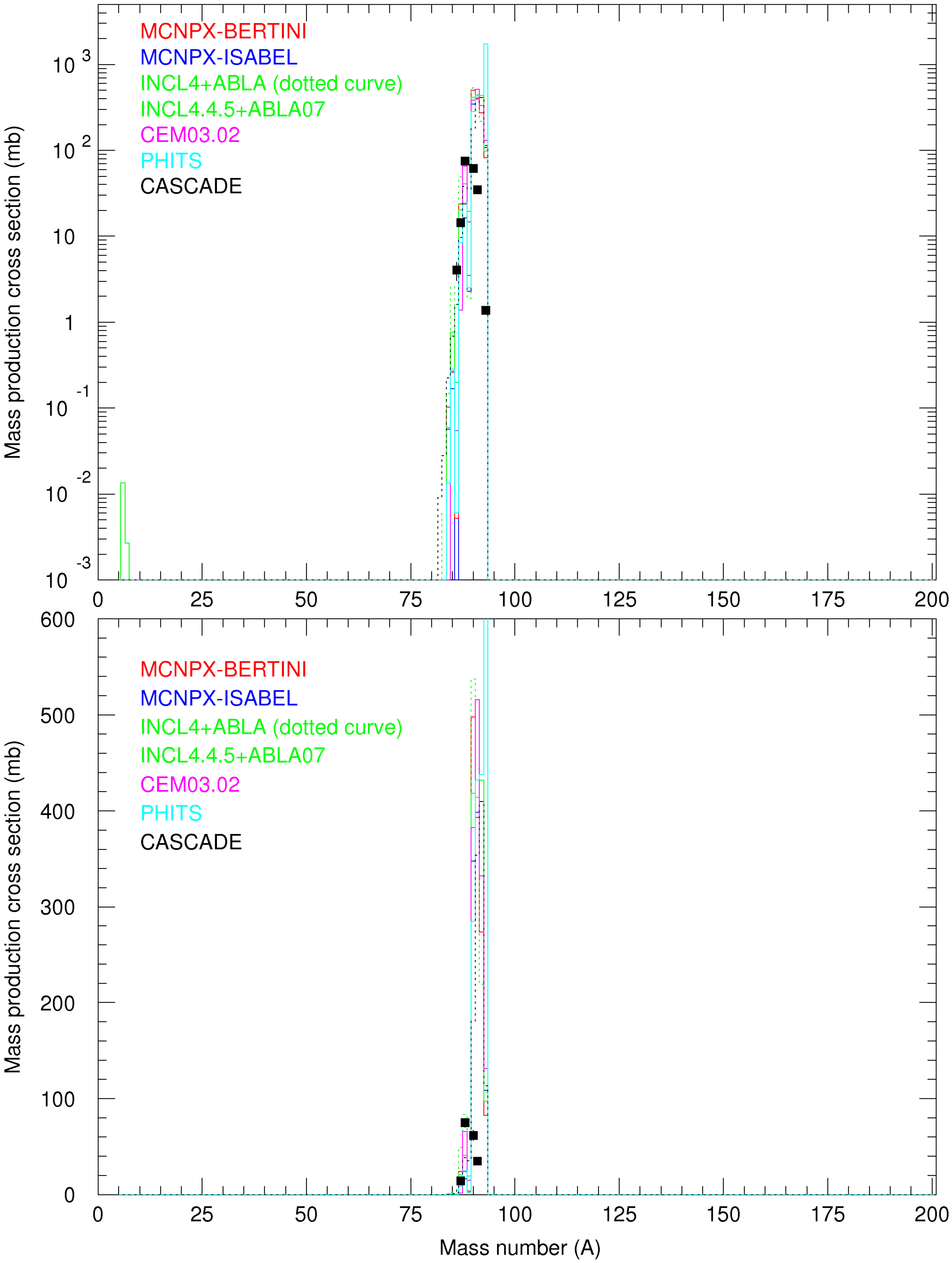

Fig. 7.55. The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{93}Nb irradiated with 0.04 GeV protons.

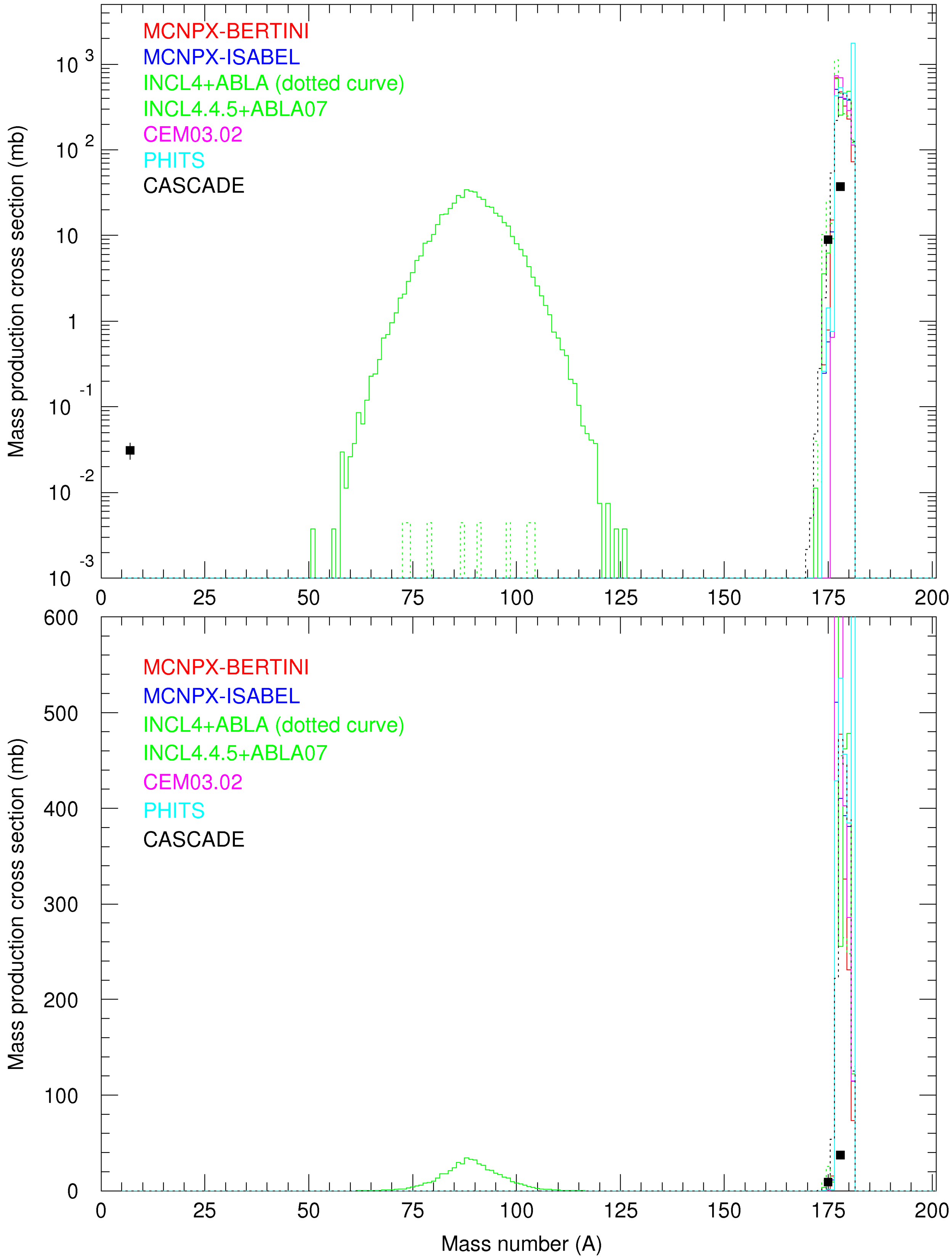

Fig. 7.56. The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{181}Ta irradiated with 0.04 GeV protons.

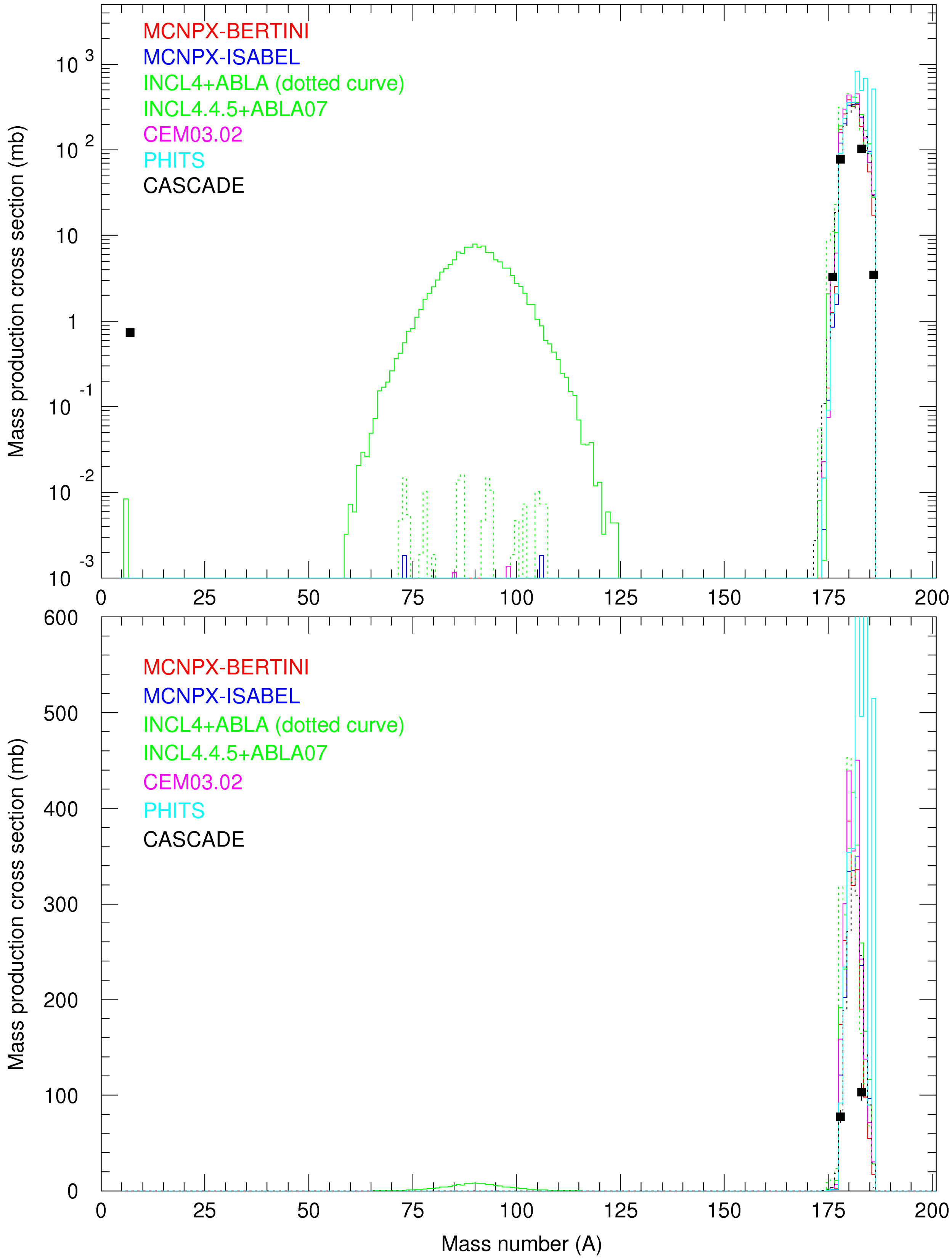

Fig. 7.57. The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{nat}W irradiated with 0.04 GeV protons.

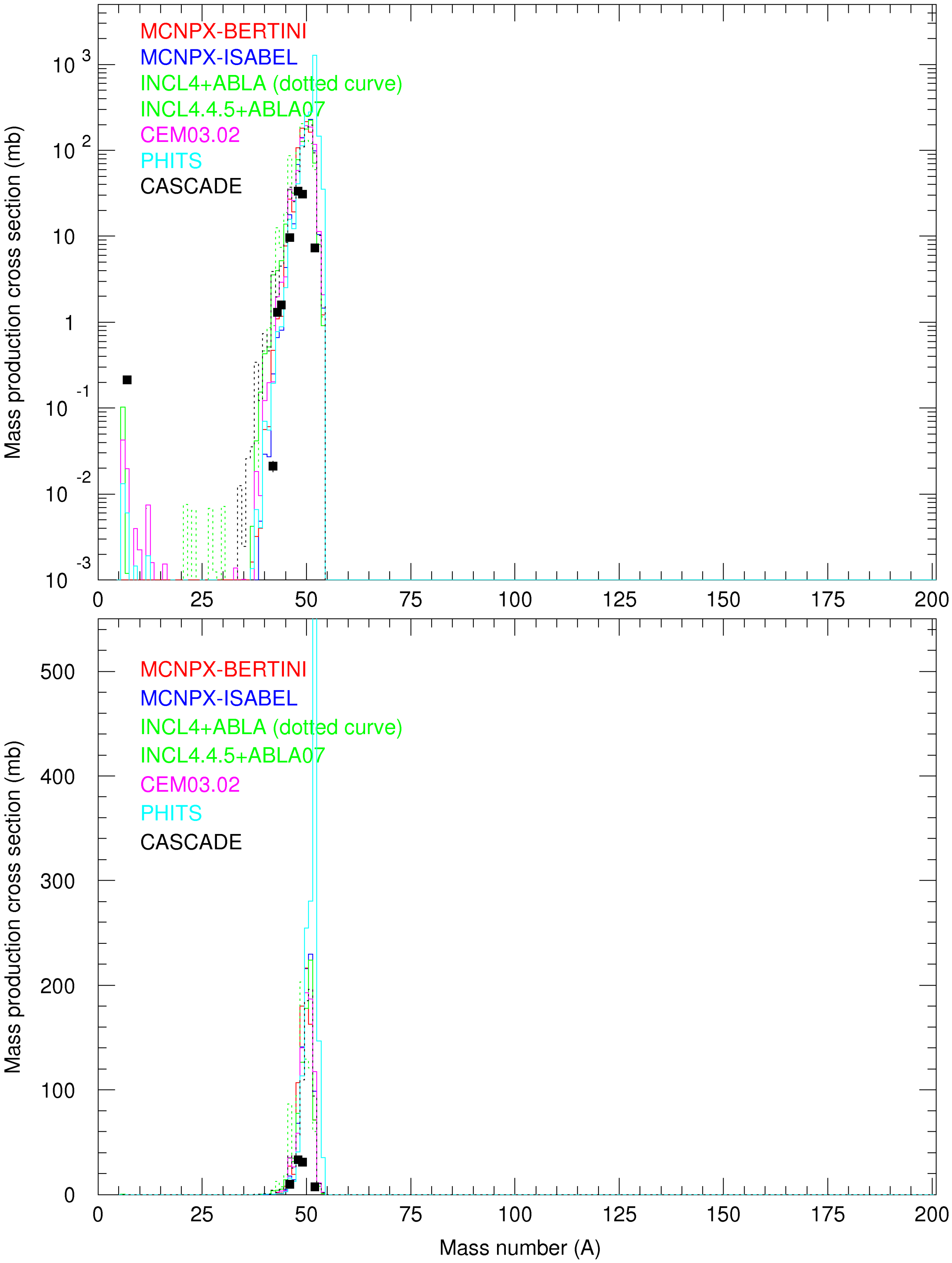

Fig. 7.58. The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{nat}Cr irradiated with 0.07 GeV protons.

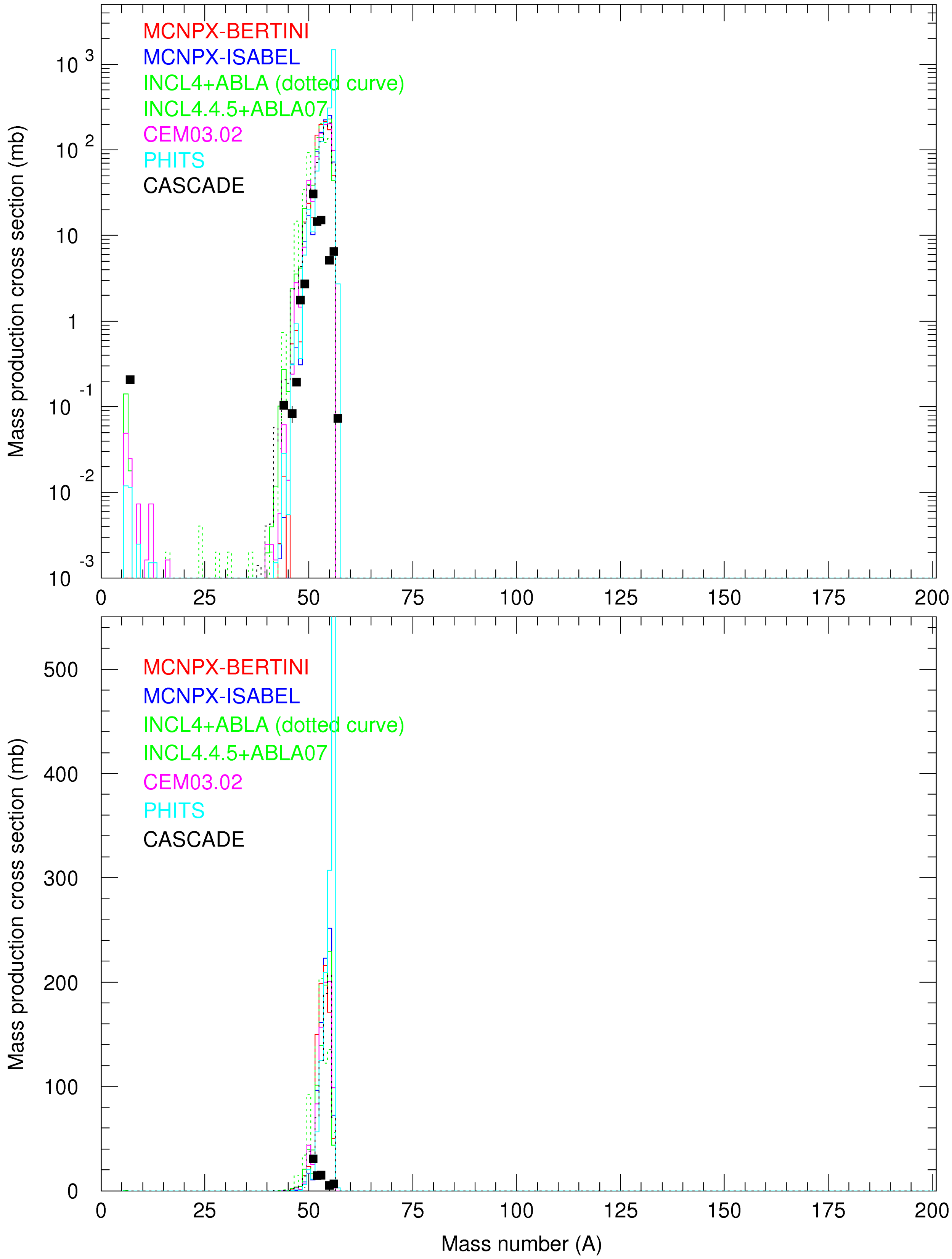

Fig. 7.59. The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{56}Fe irradiated with 0.07 GeV protons.

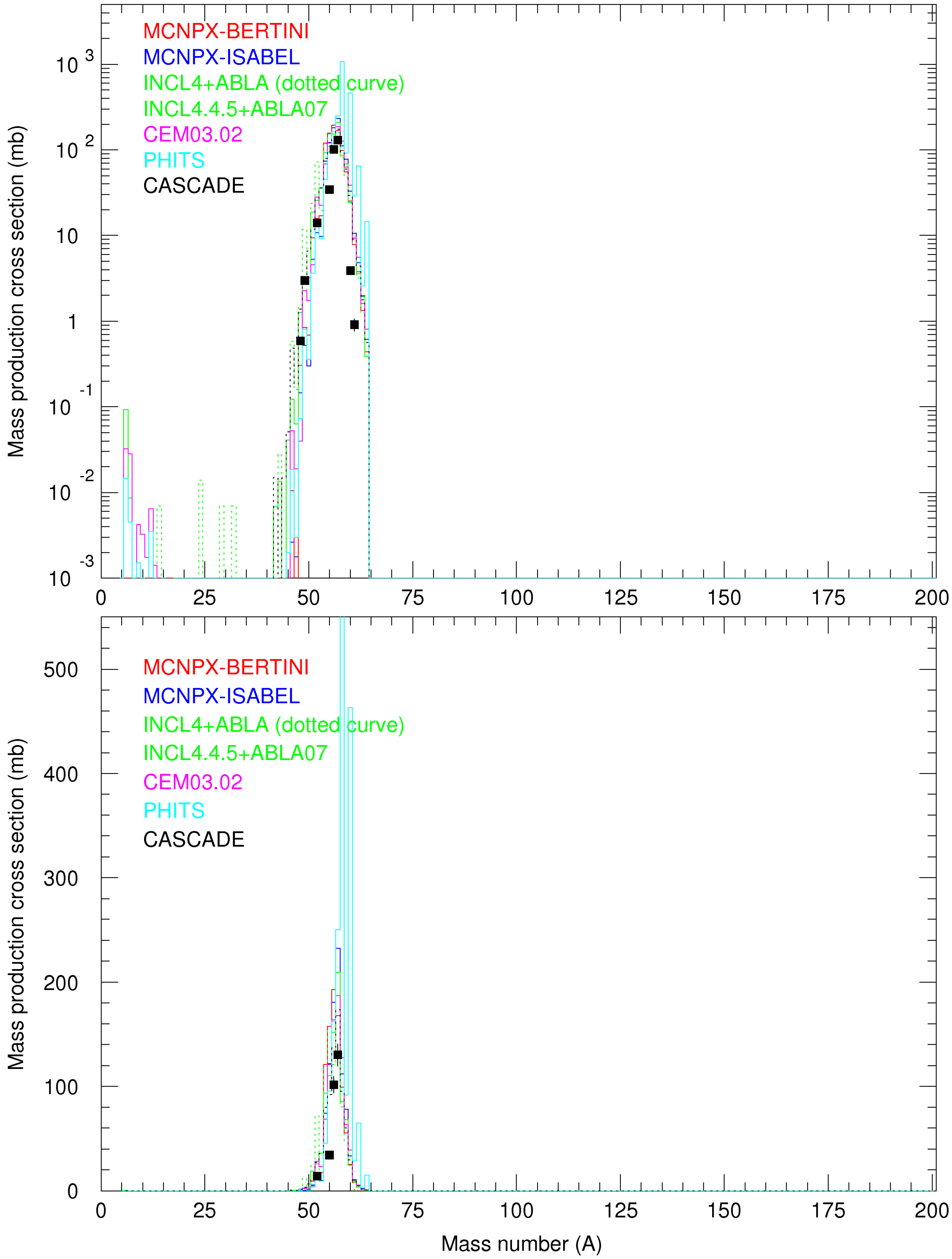

Fig. 7.60. The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{nat}Ni irradiated with 0.07 GeV protons.

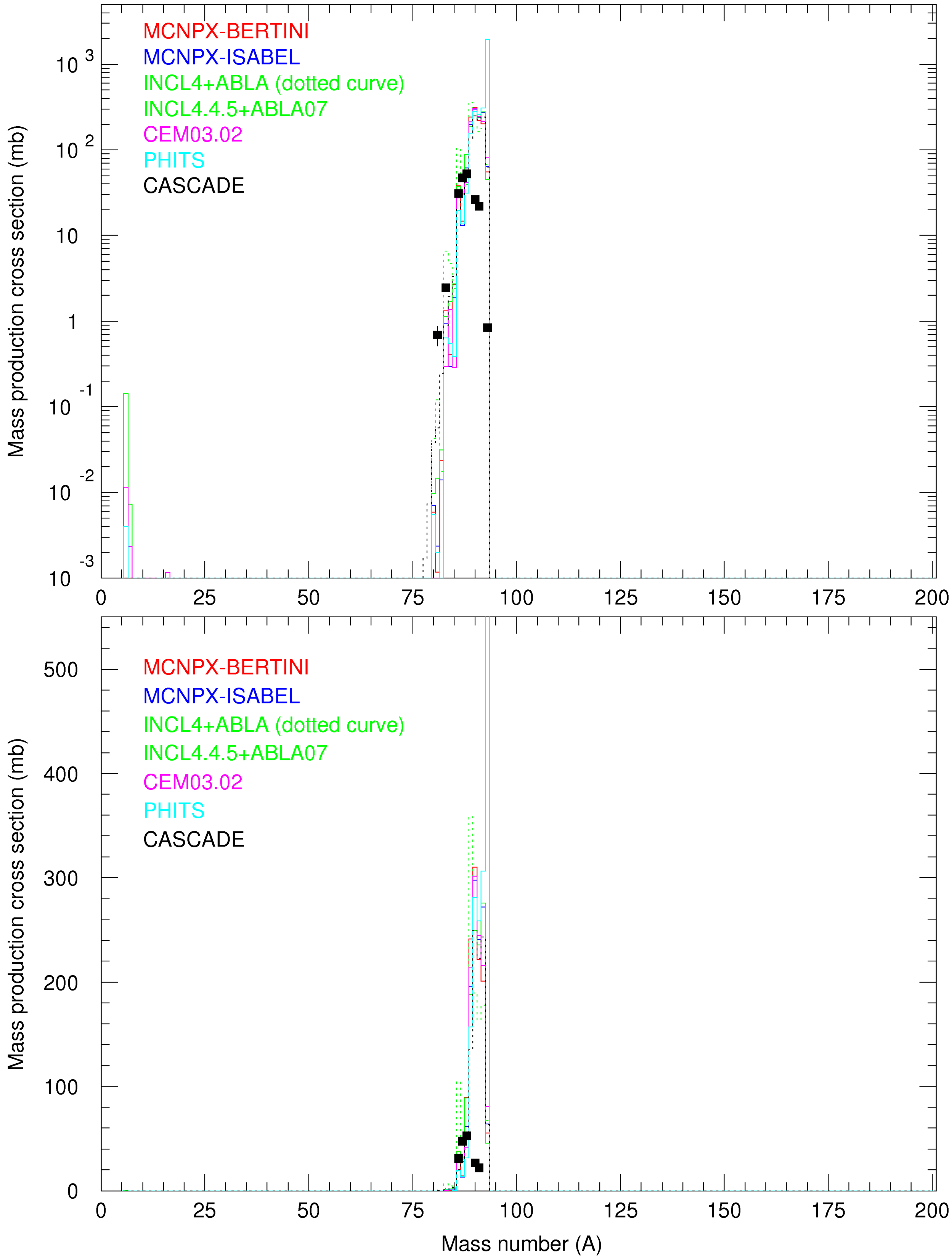

Fig. 7.61. The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{93}Nb irradiated with 0.07 GeV protons.

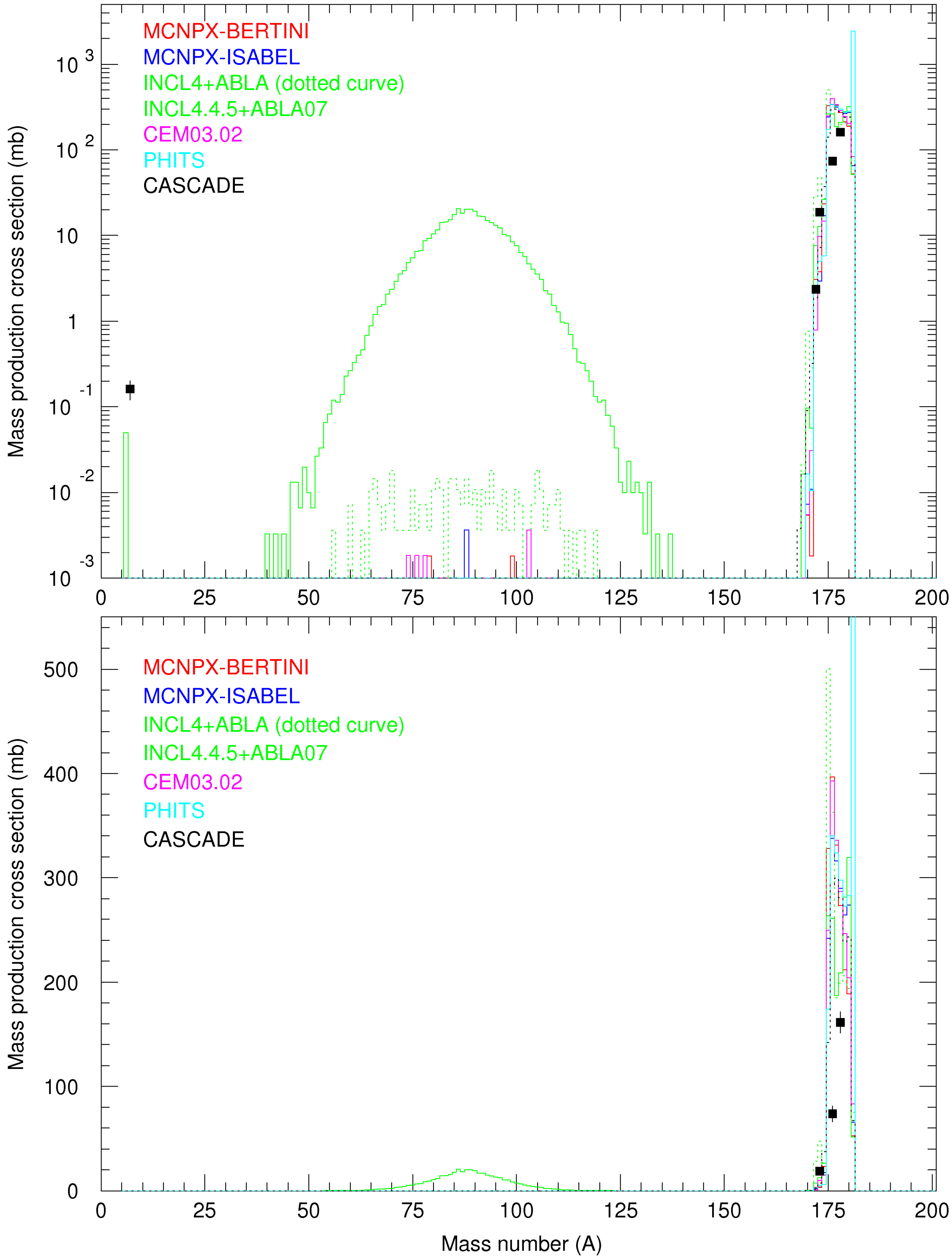

Fig. 7.62. The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{181}Ta irradiated with 0.07 GeV protons.

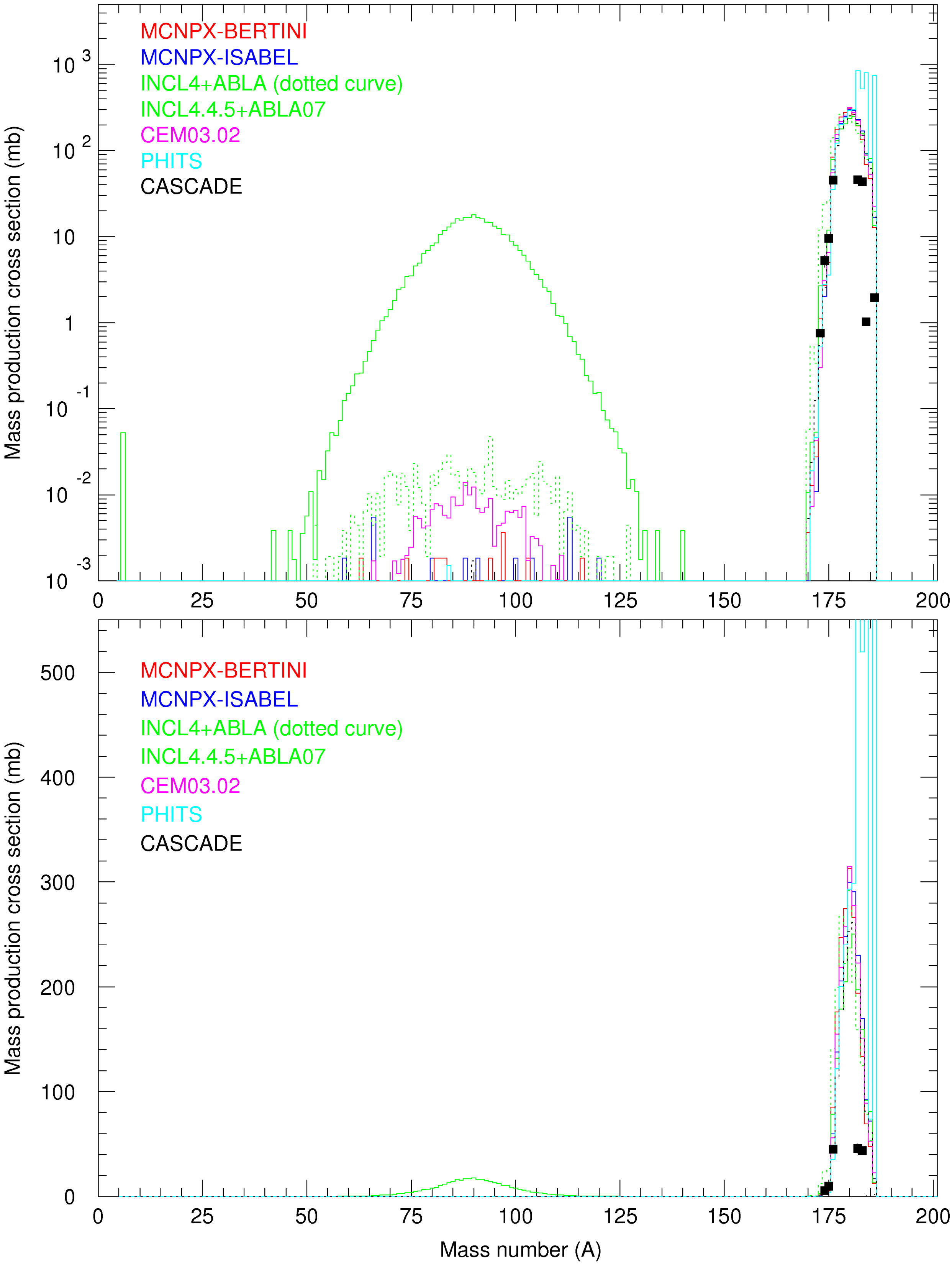

Fig. 7.63. The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{nat}W irradiated with 0.07 GeV protons.

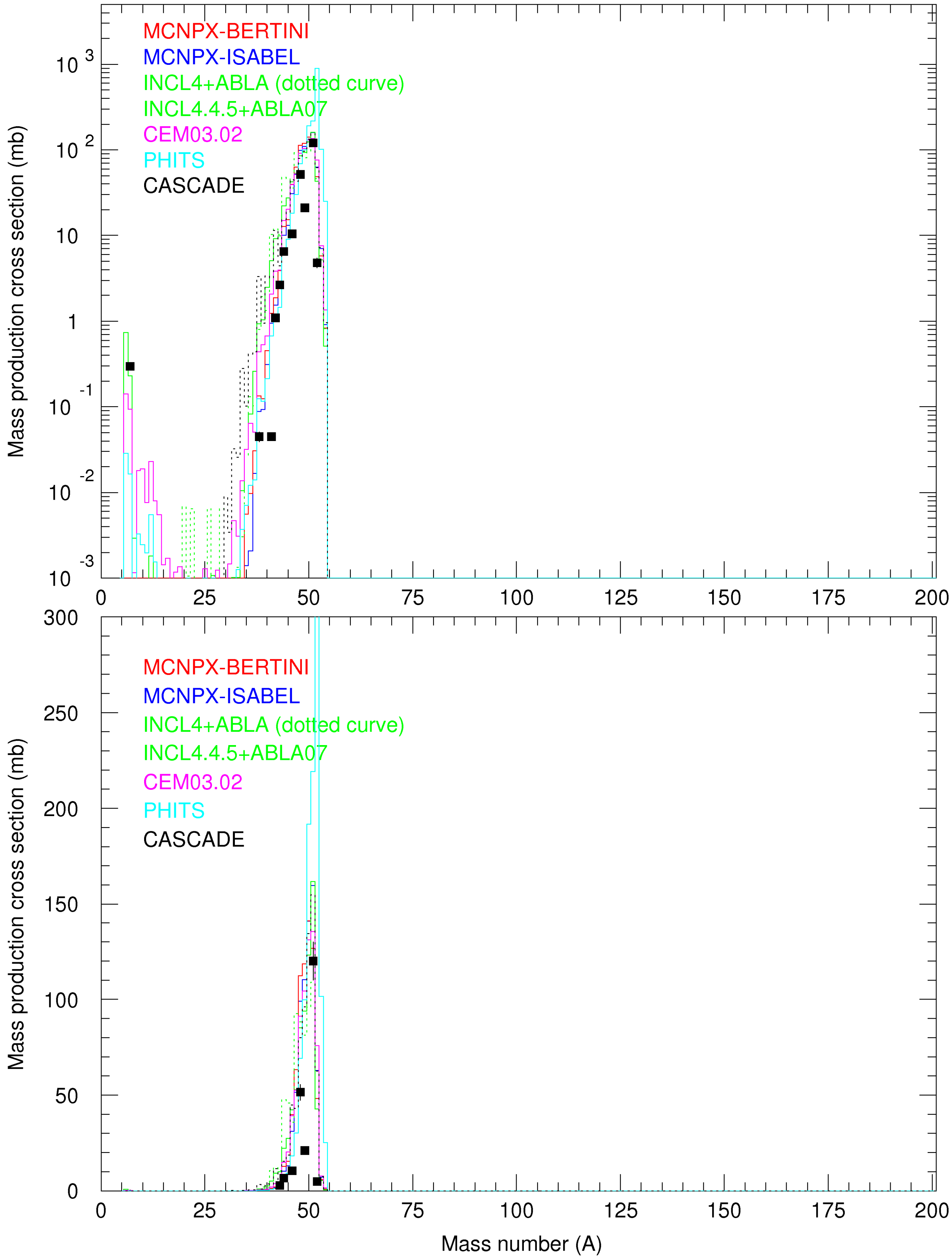

Fig. 7.64. The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{nat}Cr irradiated with 0.1 GeV protons.

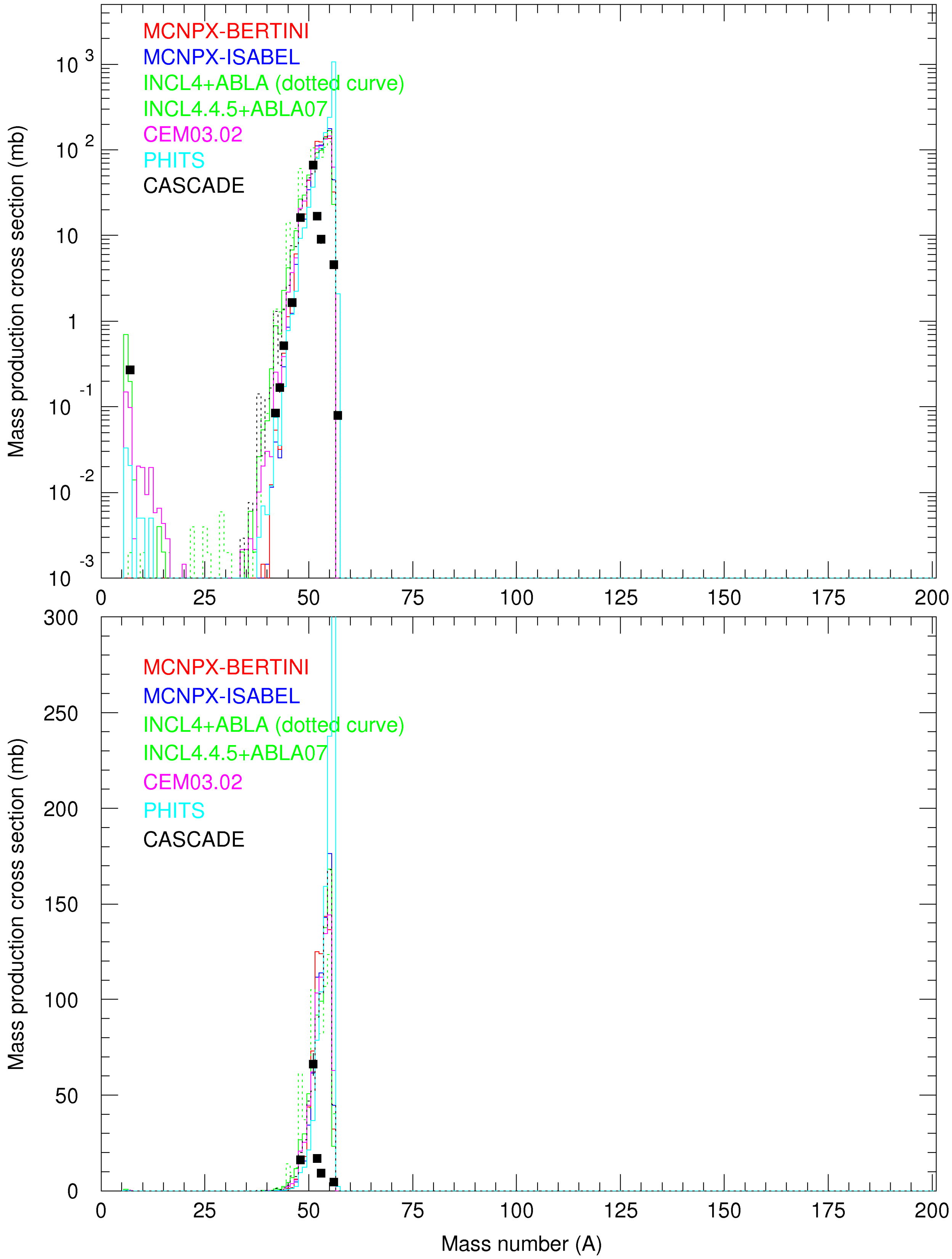

Fig. 7.65. The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{56}Fe irradiated with 0.1 GeV protons.

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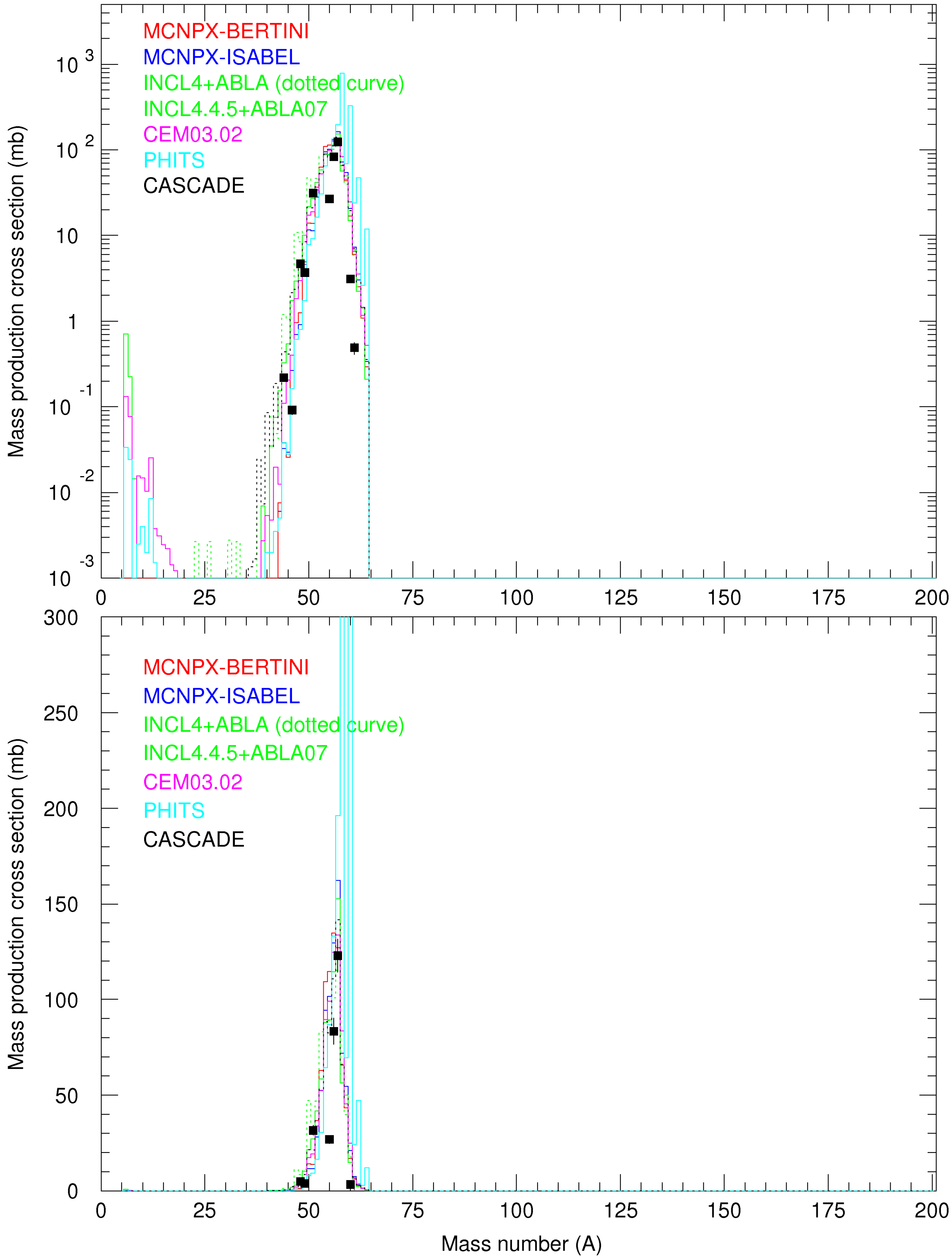

Fig. 7.66. The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{nat}Ni irradiated with 0.1 GeV protons.

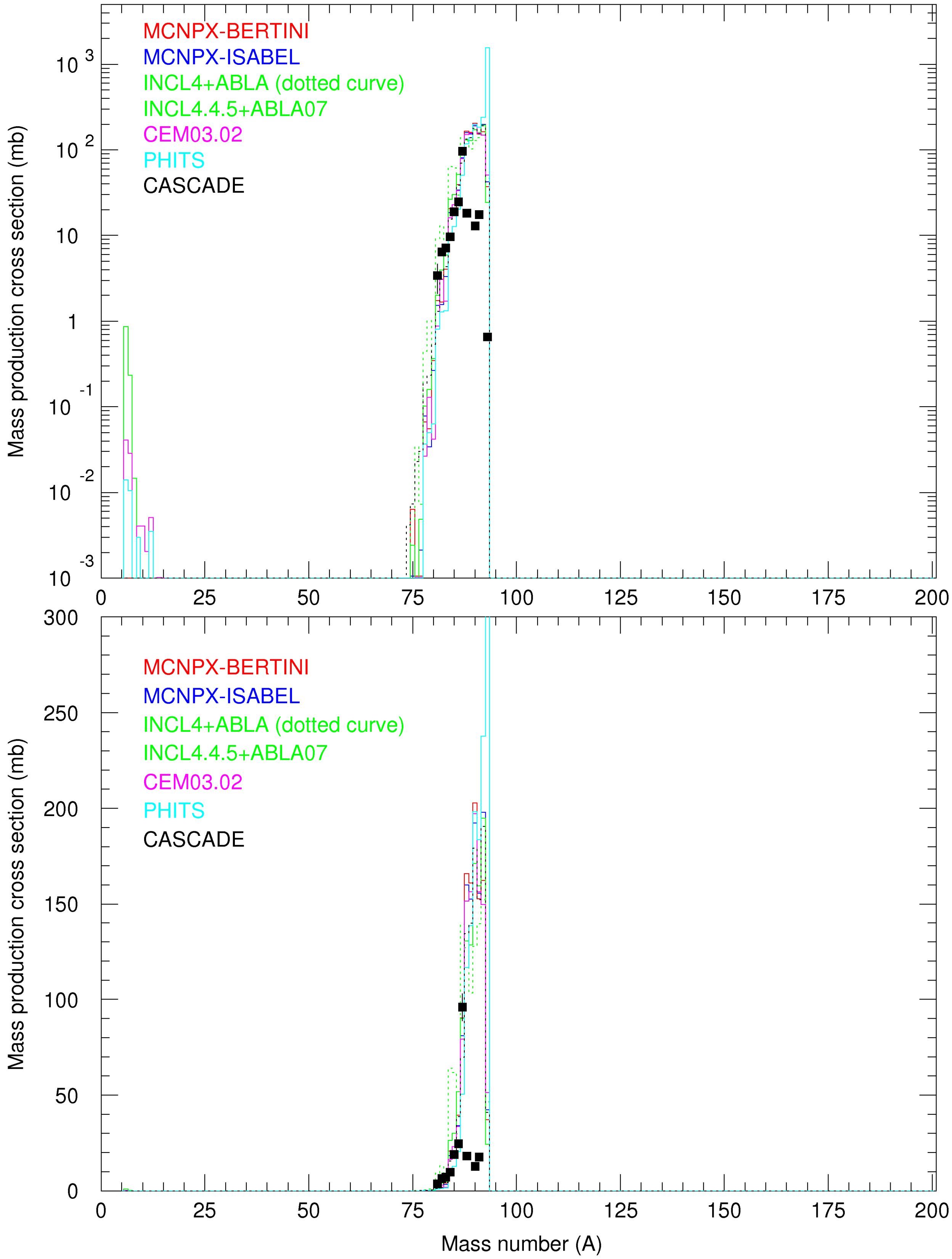

Fig. 7.67. The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{93}Nb irradiated with 0.1 GeV protons.

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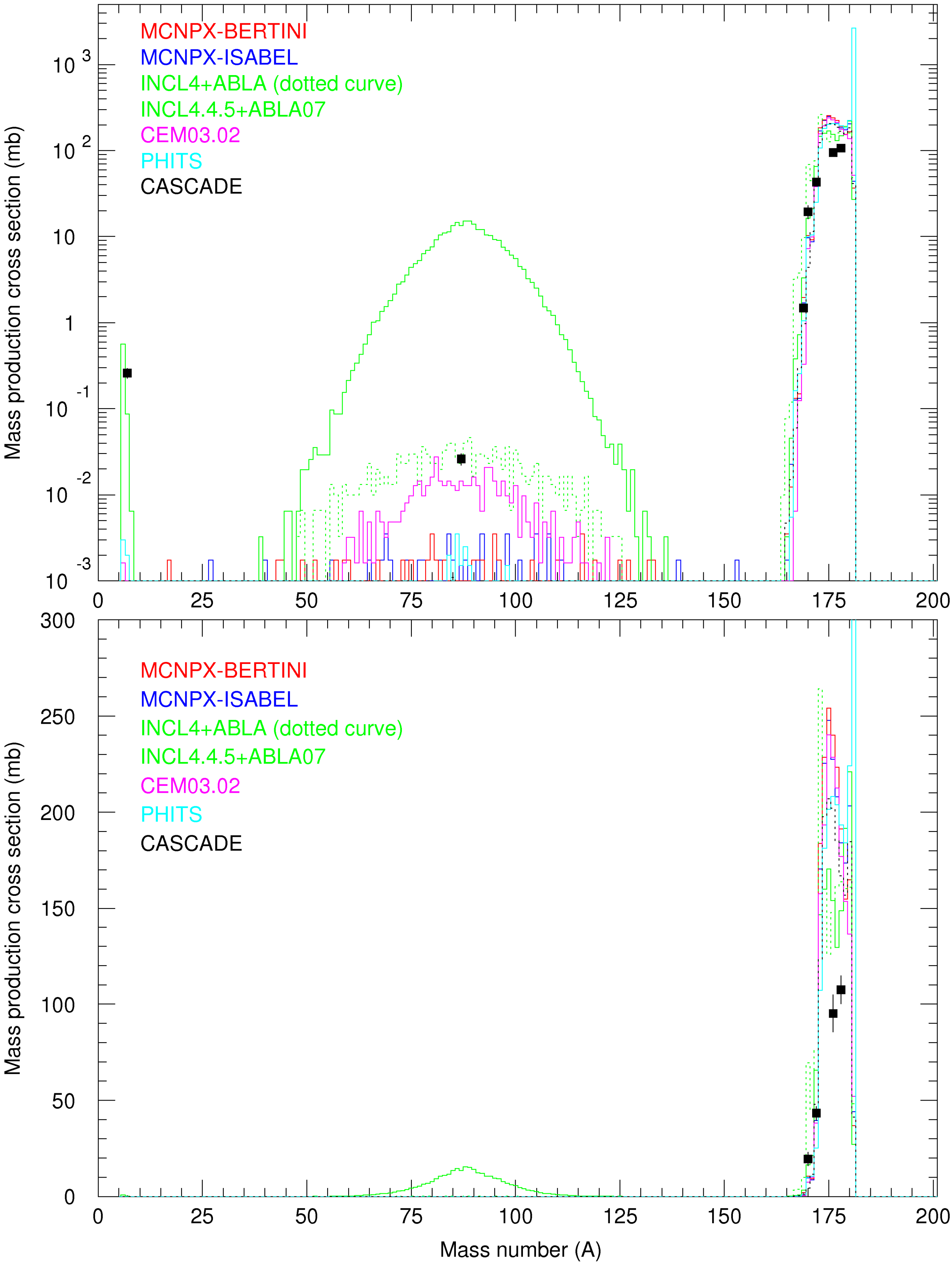

Fig. 7.68. The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{181}Ta irradiated with 0.1 GeV protons.

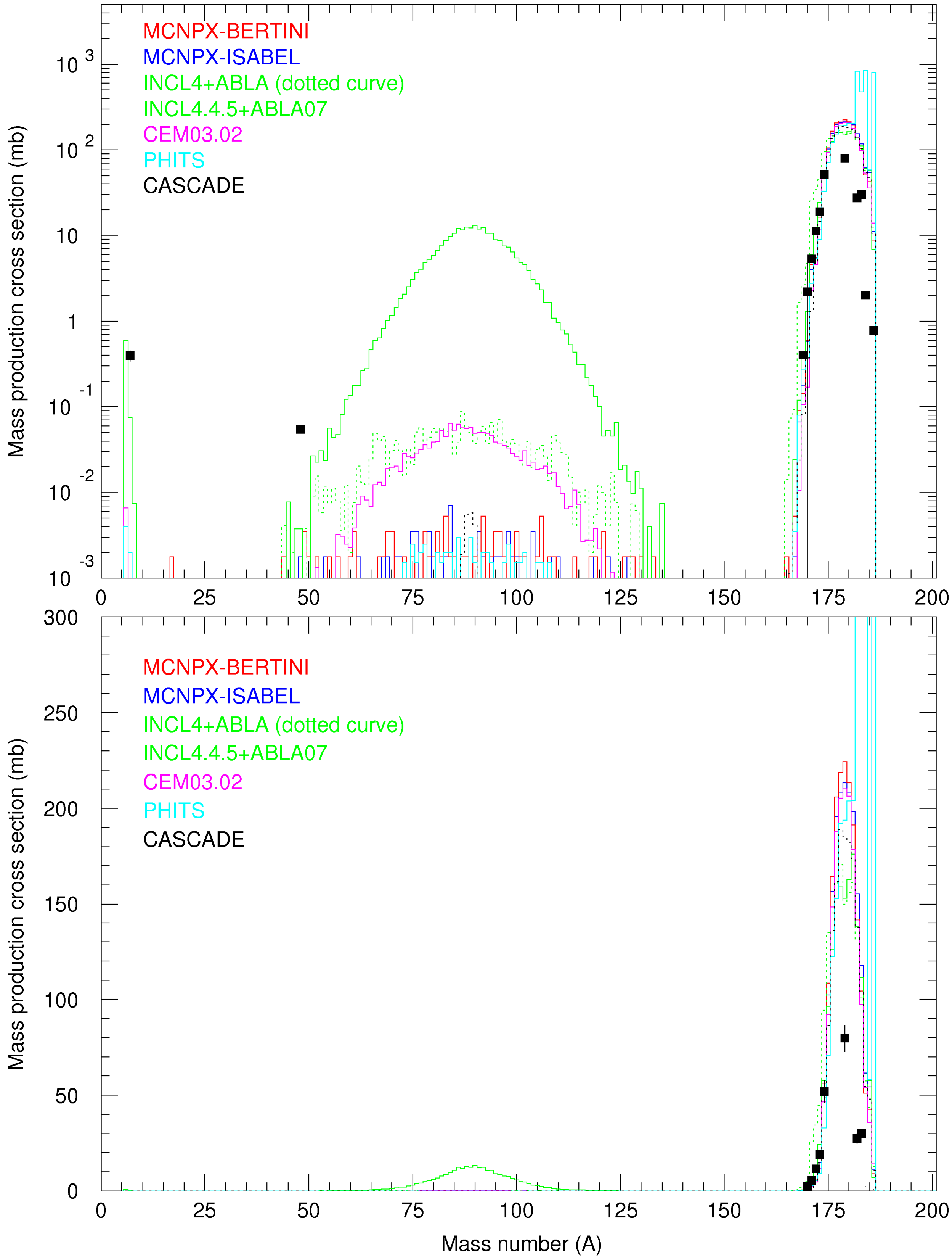

Fig. 7.69. The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{nat}W irradiated with 0.1 GeV protons.

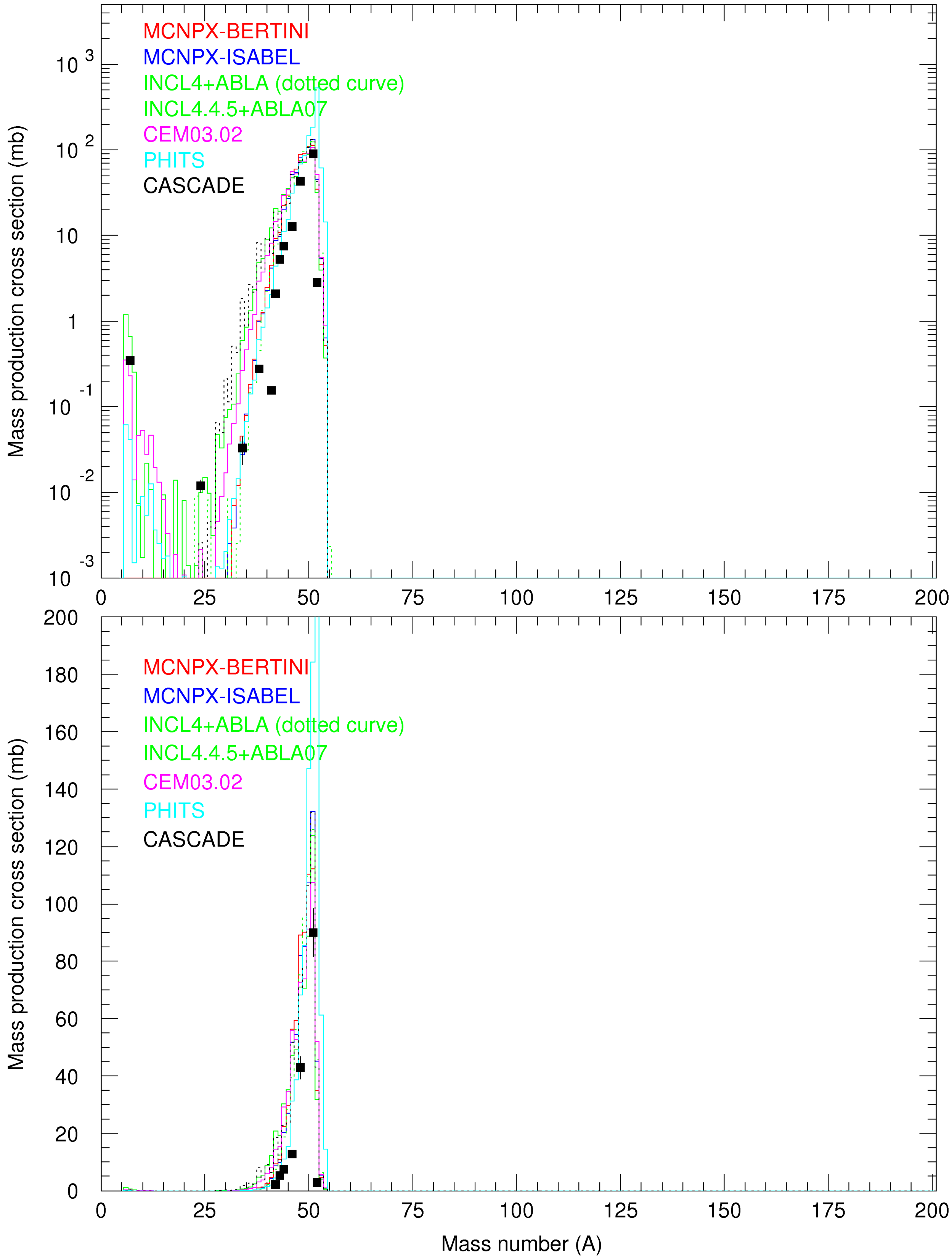

Fig. 7.70. The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{nat}Cr irradiated with 0.15 GeV protons.

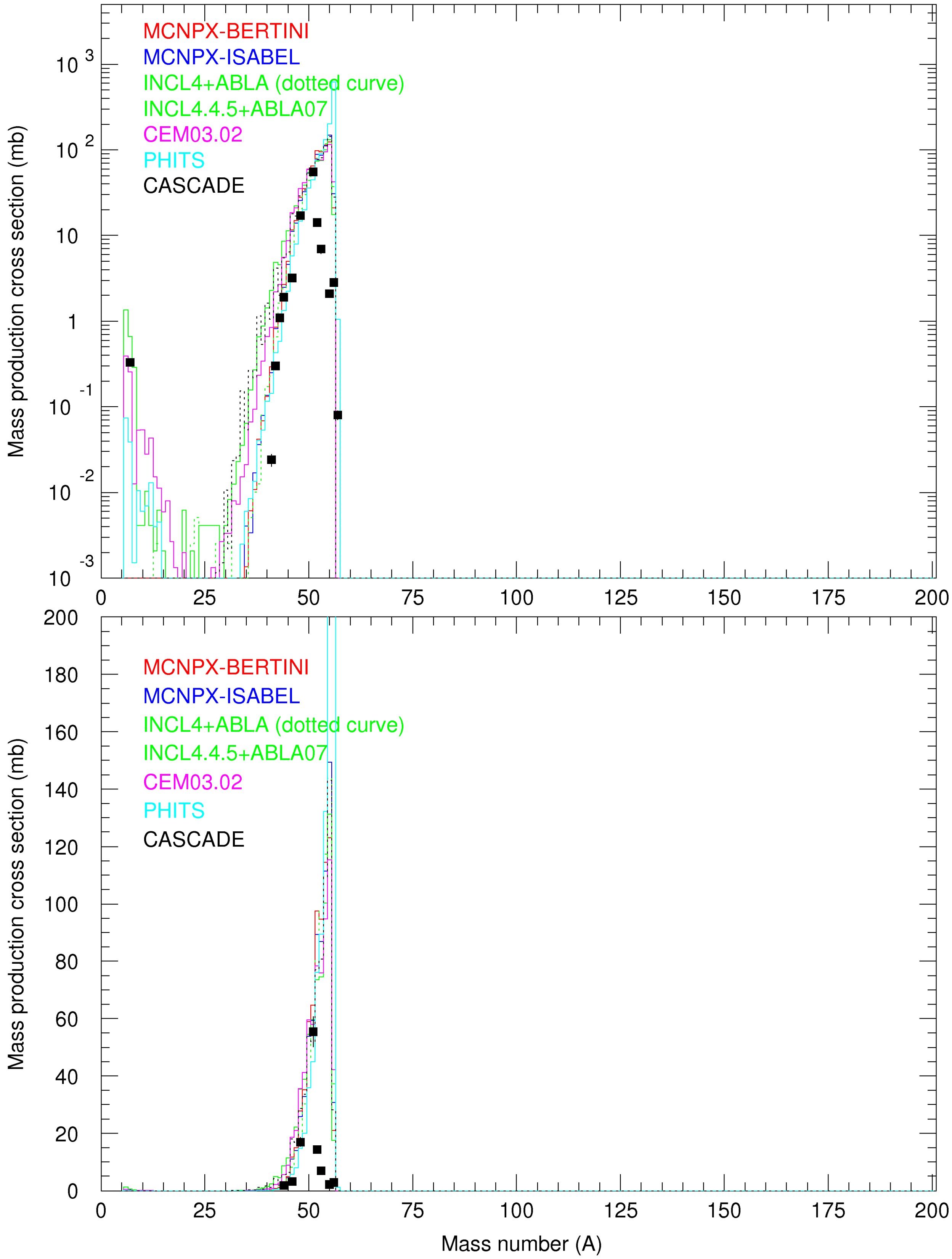

Fig. 7.71. The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{56}F irradiated with 0.15 GeV protons.

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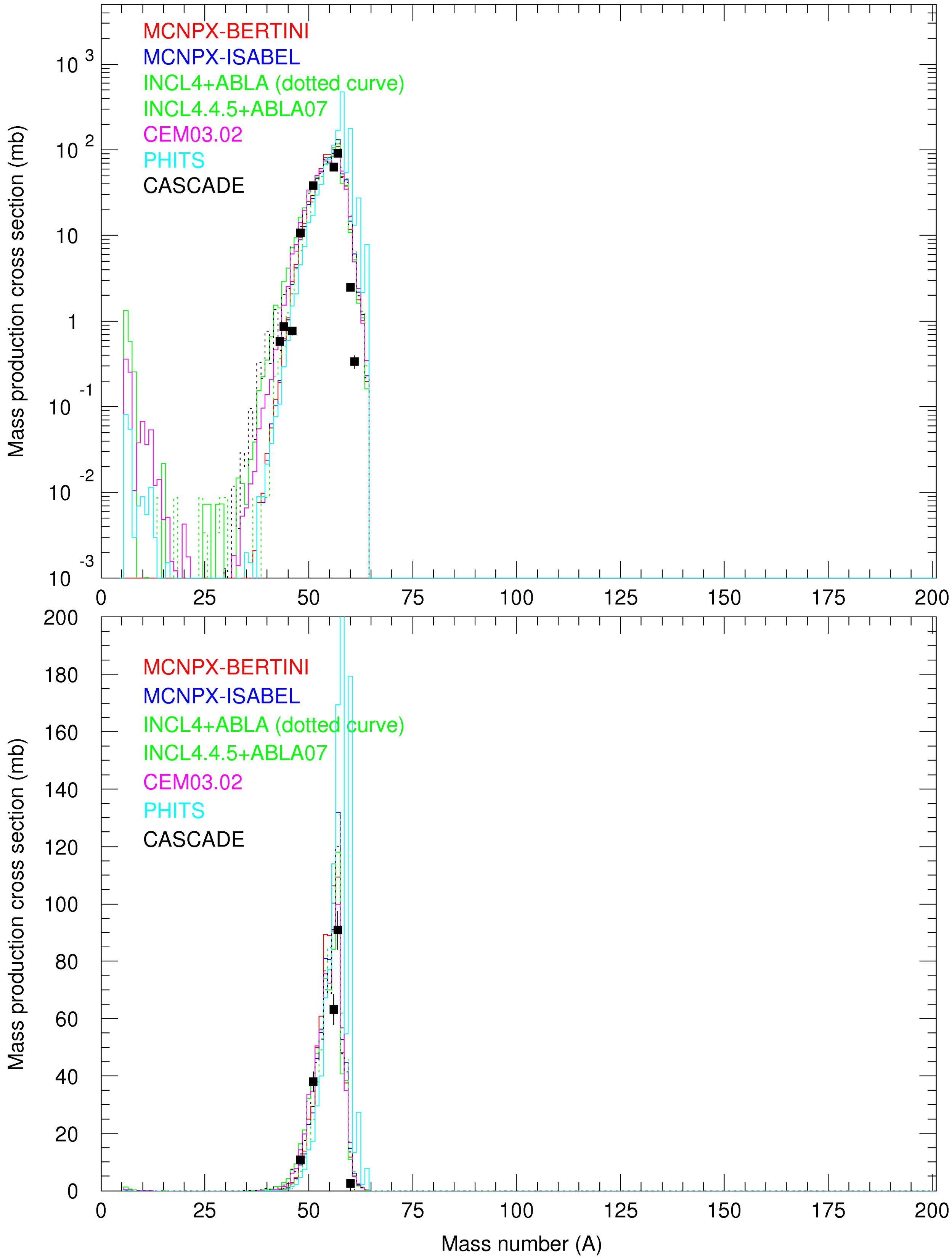

Fig. 7.72. The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{nat}Ni irradiated with 0.15 GeV protons.

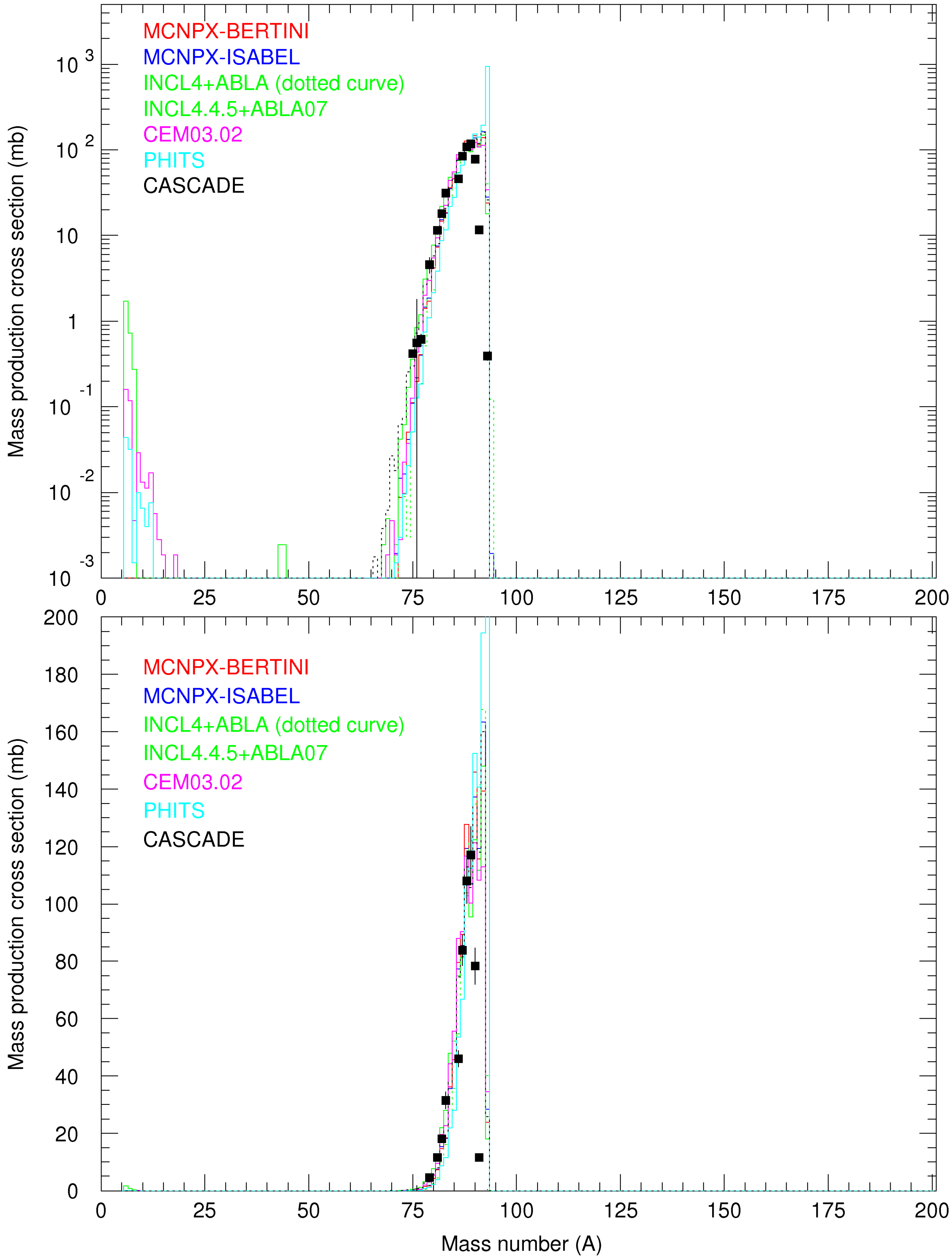

Fig. 7.73. The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{93}Nb irradiated with 0.15GeV protons.

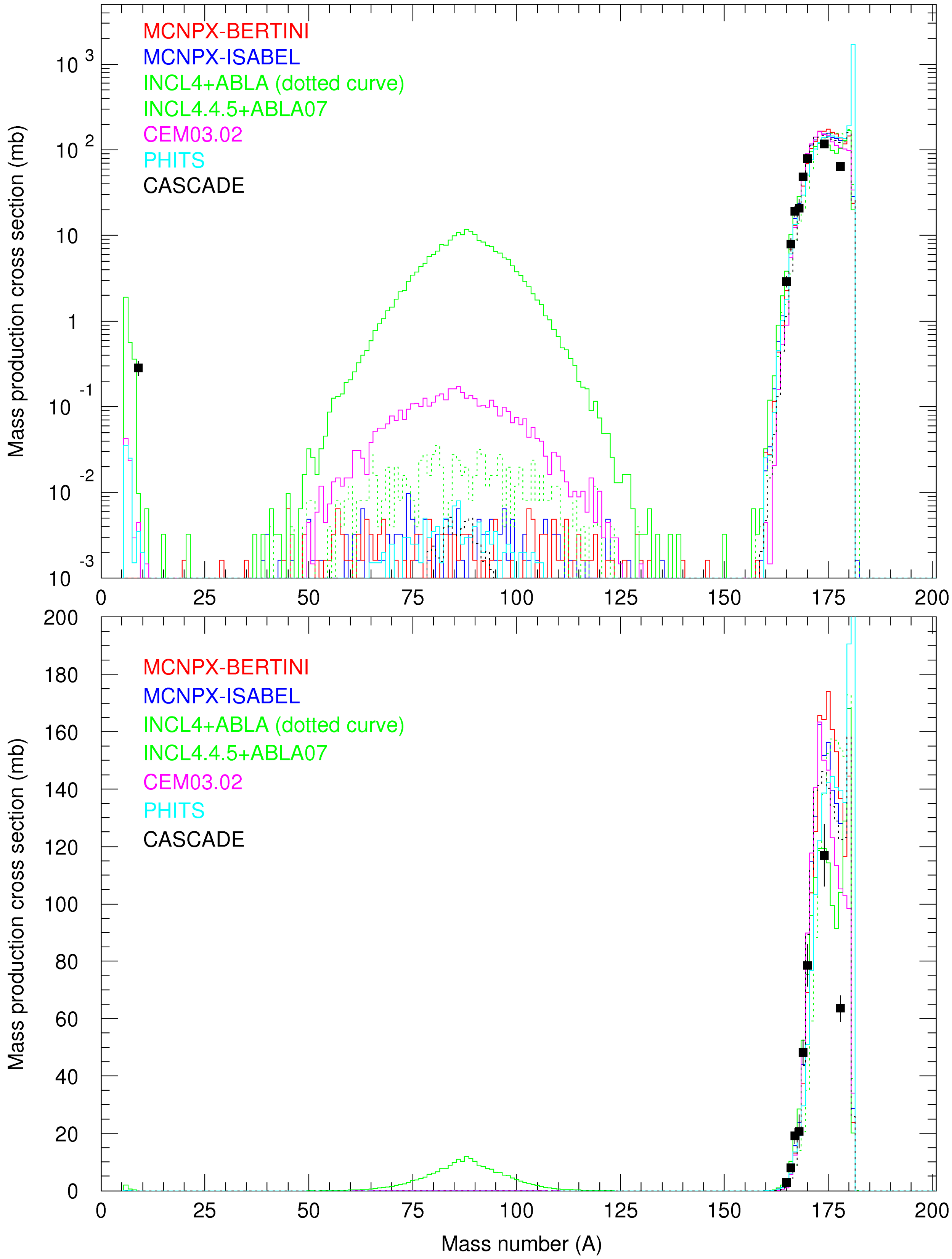

Fig. 7.74. The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{181}Ta irradiated with 0.15 GeV protons.

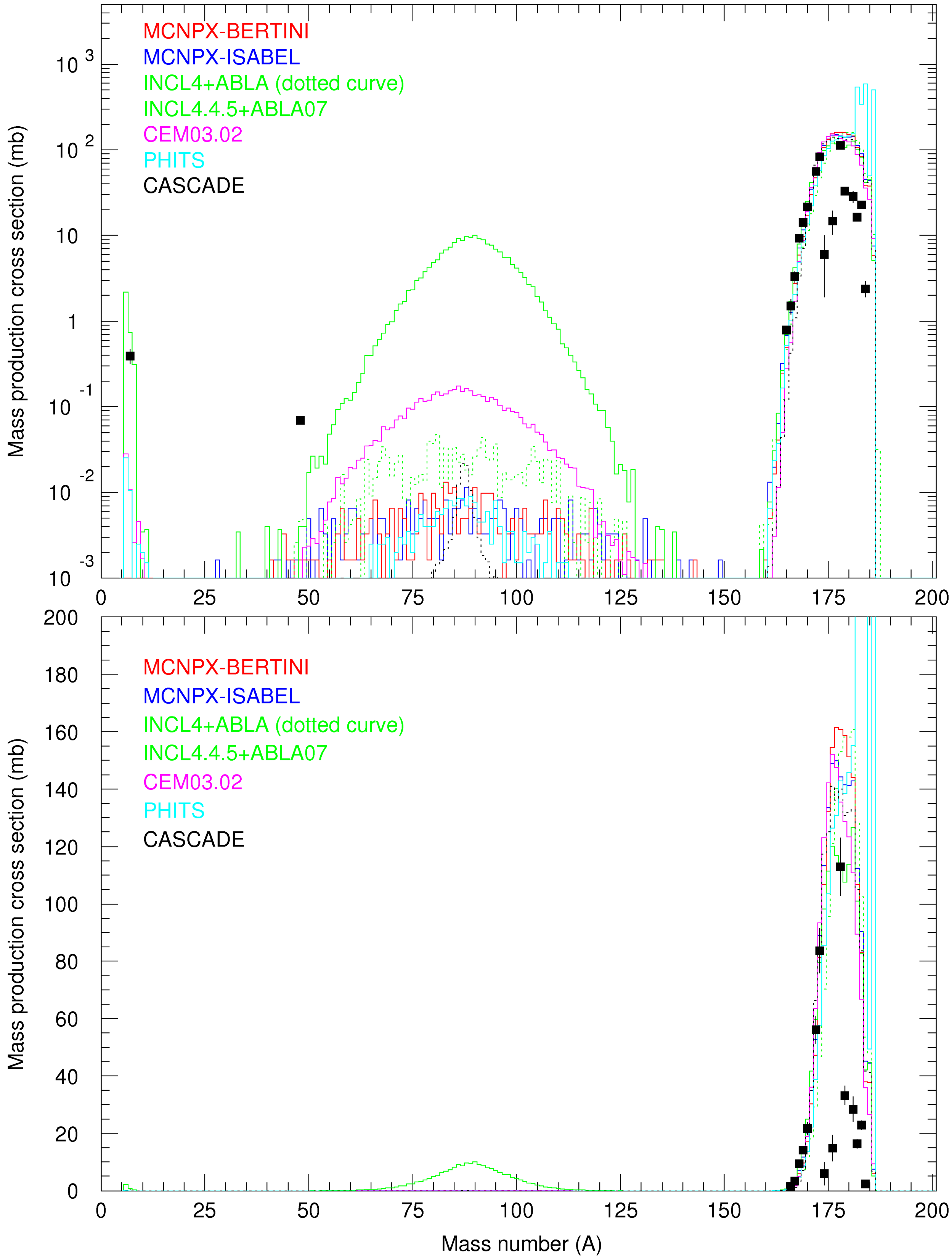

Fig. 7.75. The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{nat}W irradiated with 0.15 GeV protons.

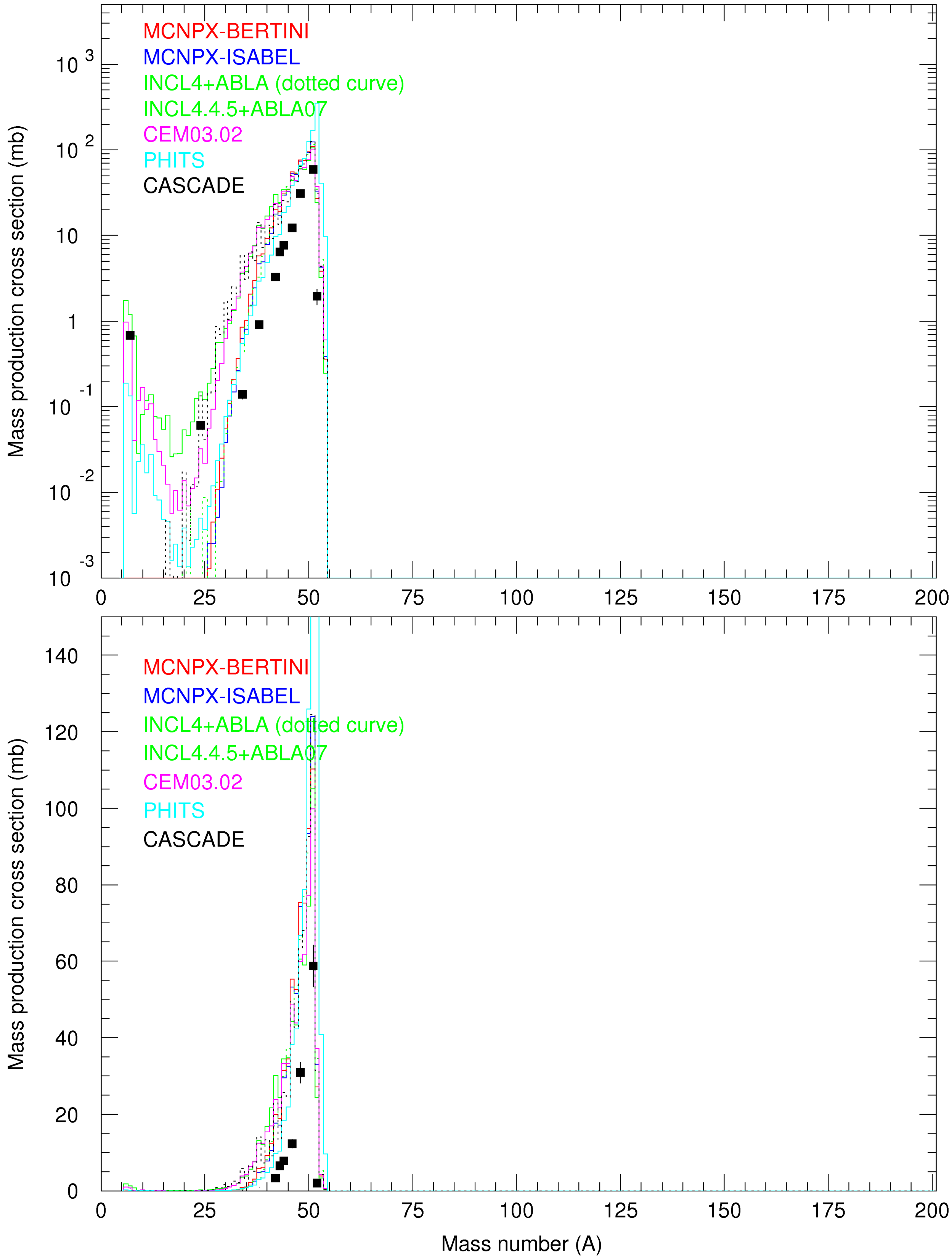

Fig. 7.76. The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{nat}Cr irradiated with 0.25 GeV protons.

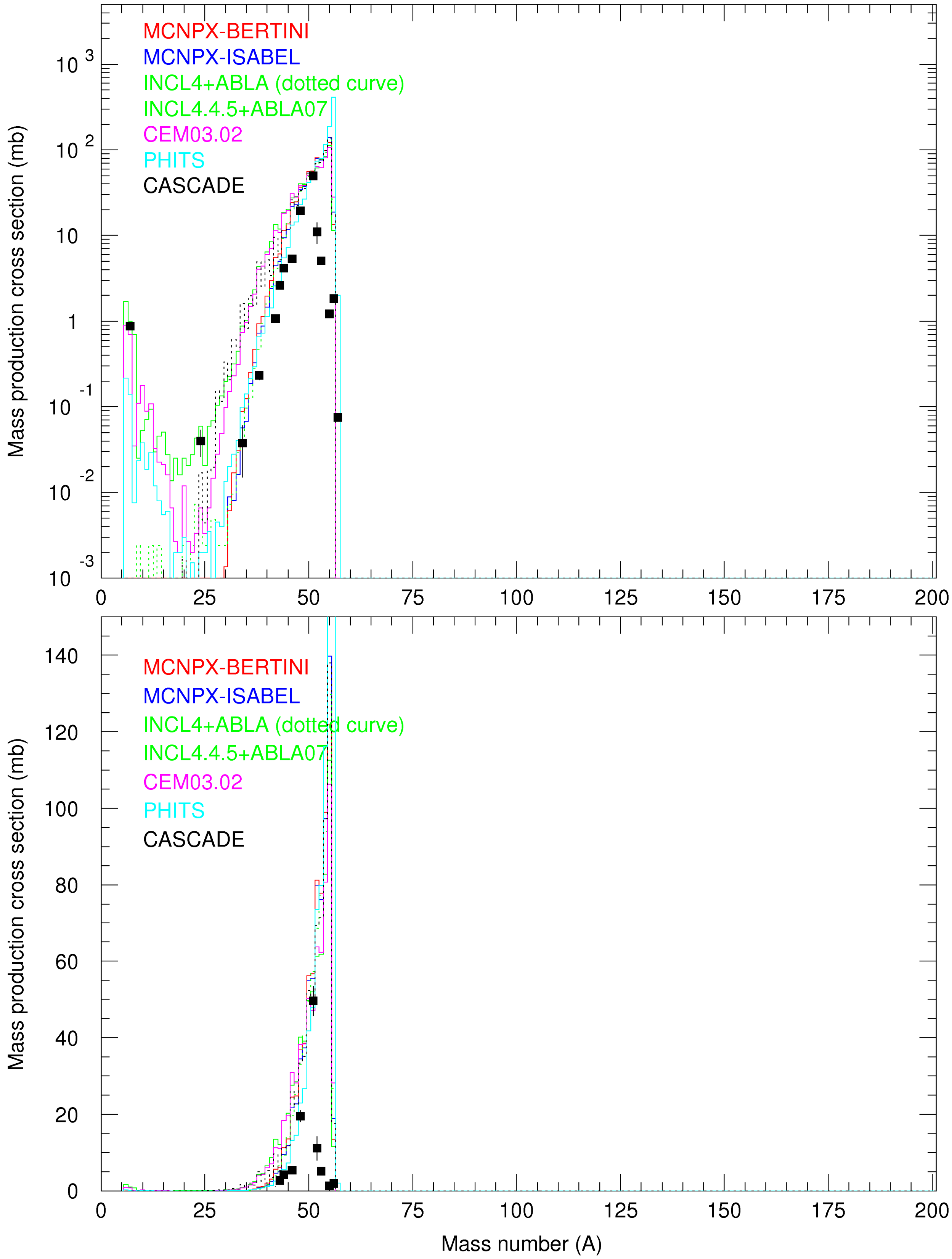

Fig. 7.77. The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{56}Fe irradiated with 0.25 GeV protons.

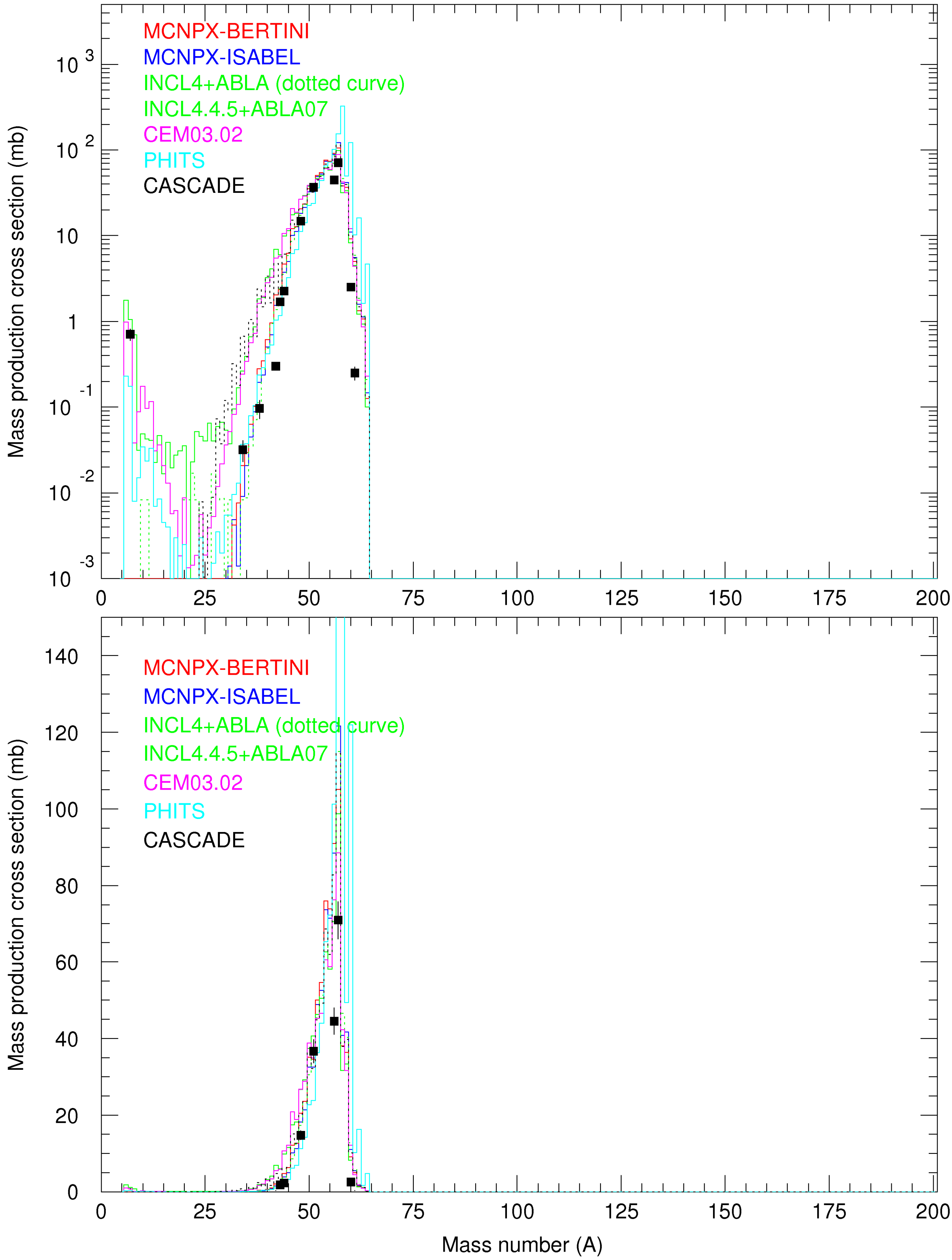

Fig. 7.78. The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{nat}Ni irradiated with 0.25 GeV protons.

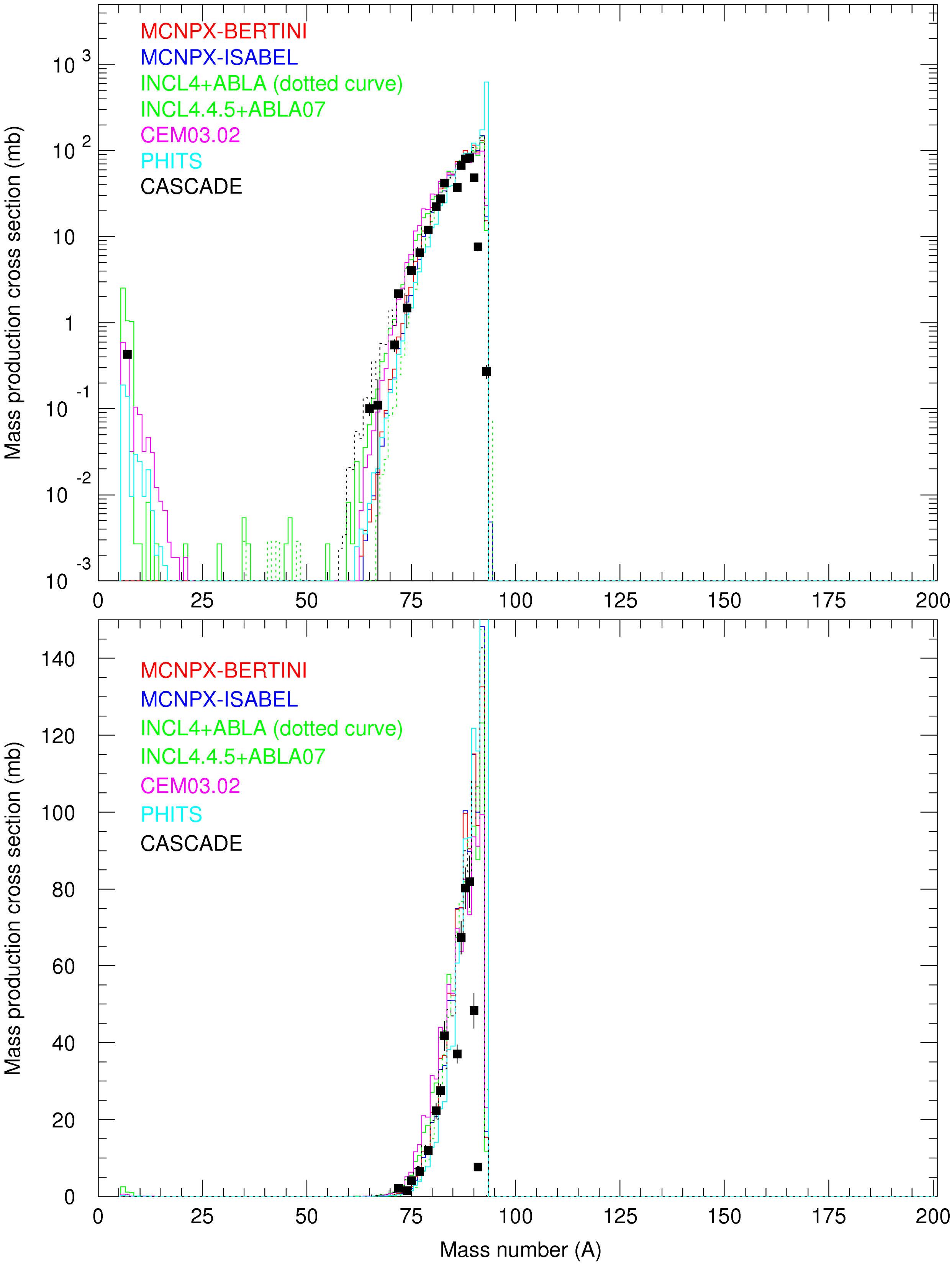

Fig. 7.79. The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{93}Nb irradiated with 0.25 GeV protons.

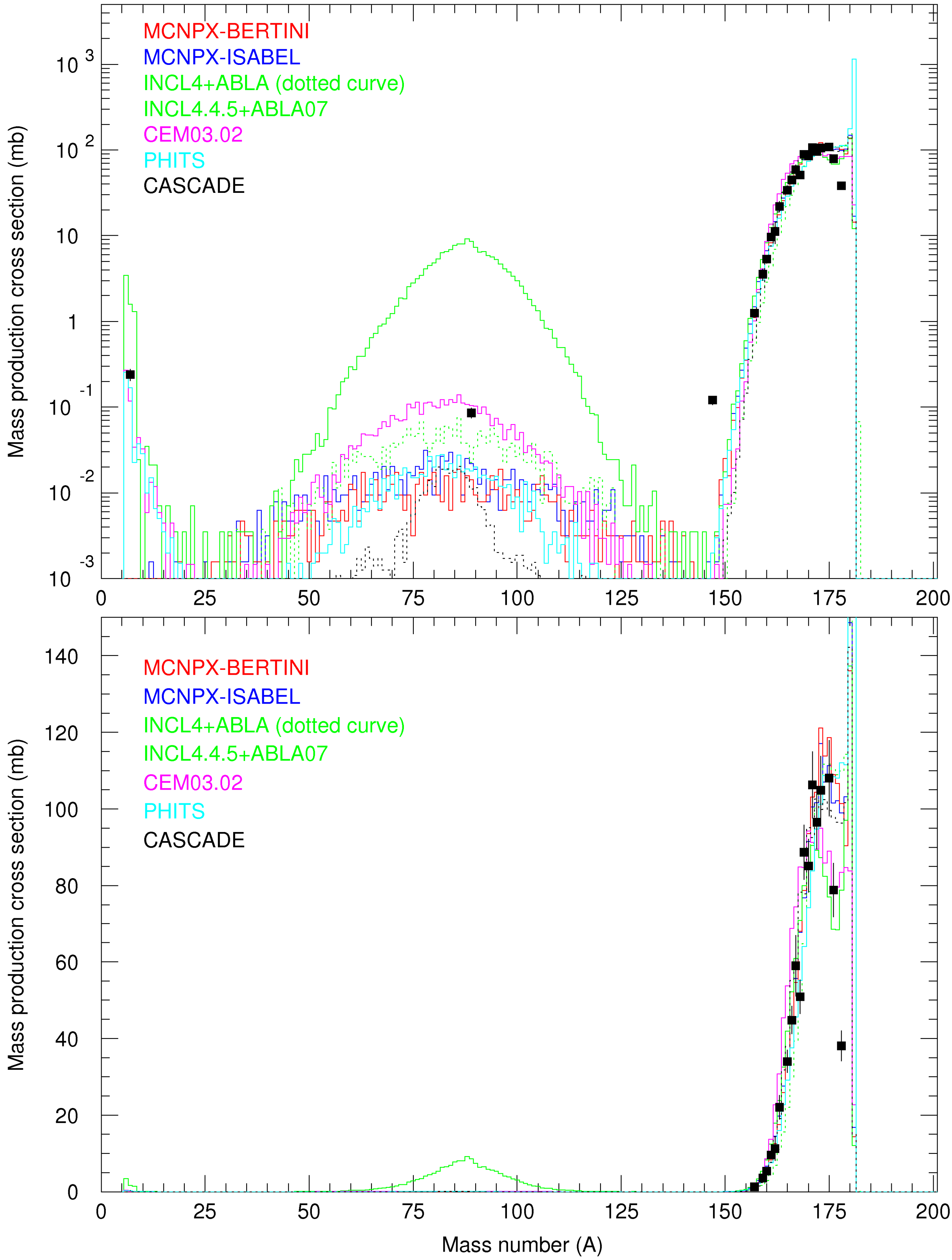

Fig. 7.80. The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{181}Ta irradiated with 0.25 GeV protons.

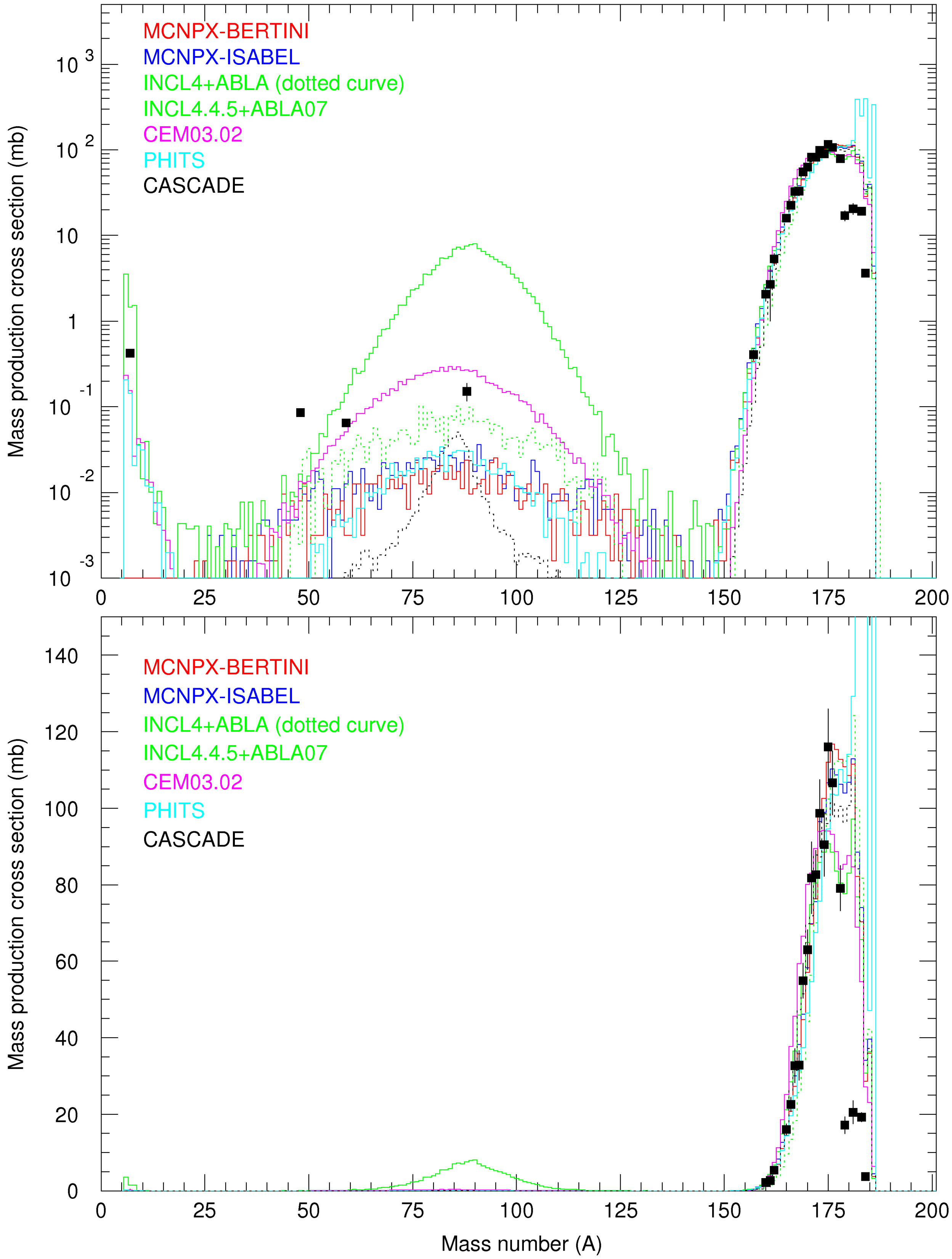

Fig. 7.81. The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{nat}W irradiated with 0.25 GeV protons.

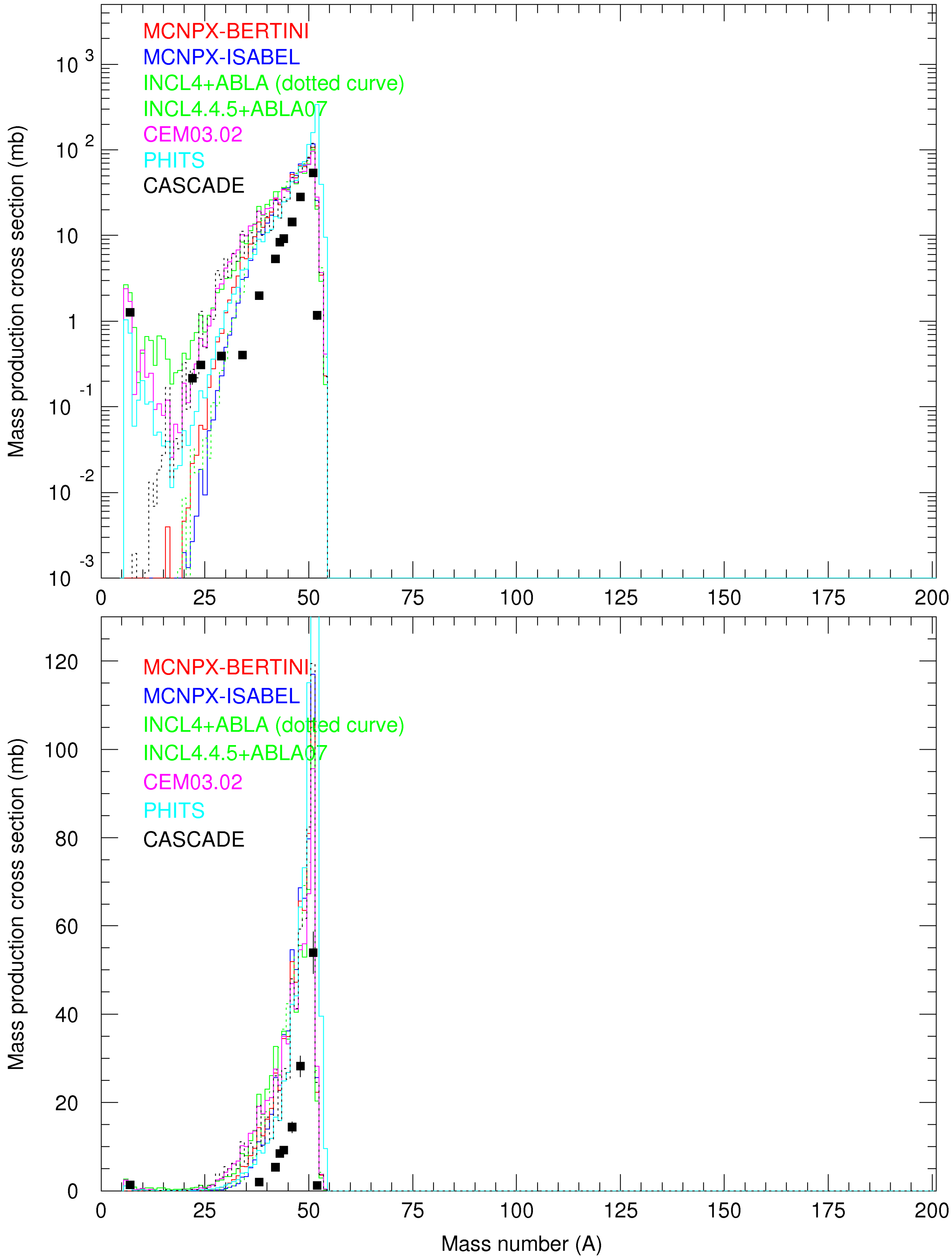

Fig. 7.82. The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{nat}Cr irradiated with 0.4 GeV protons.

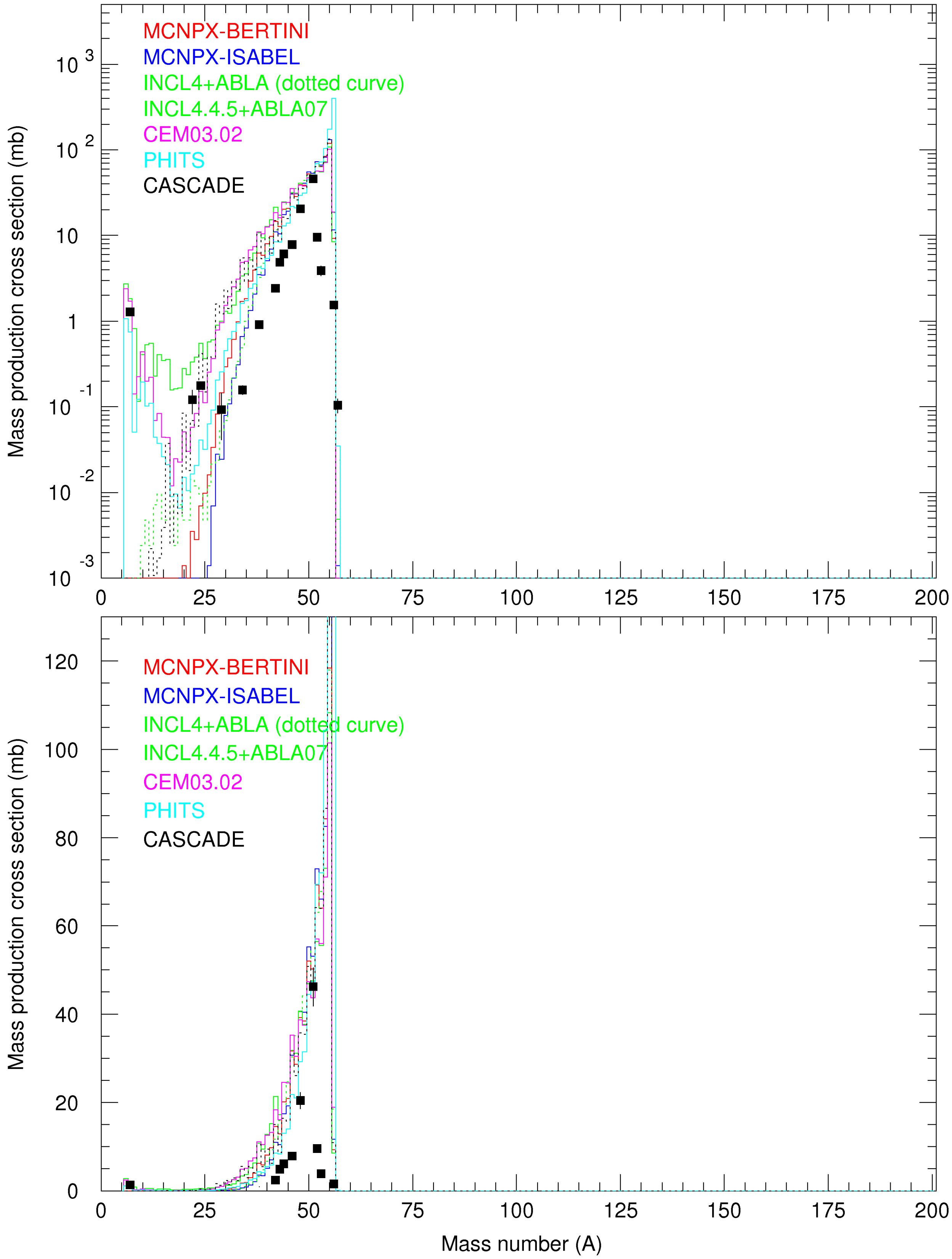

Fig. 7.83. The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{56}Fe irradiated with 0.4 GeV protons.

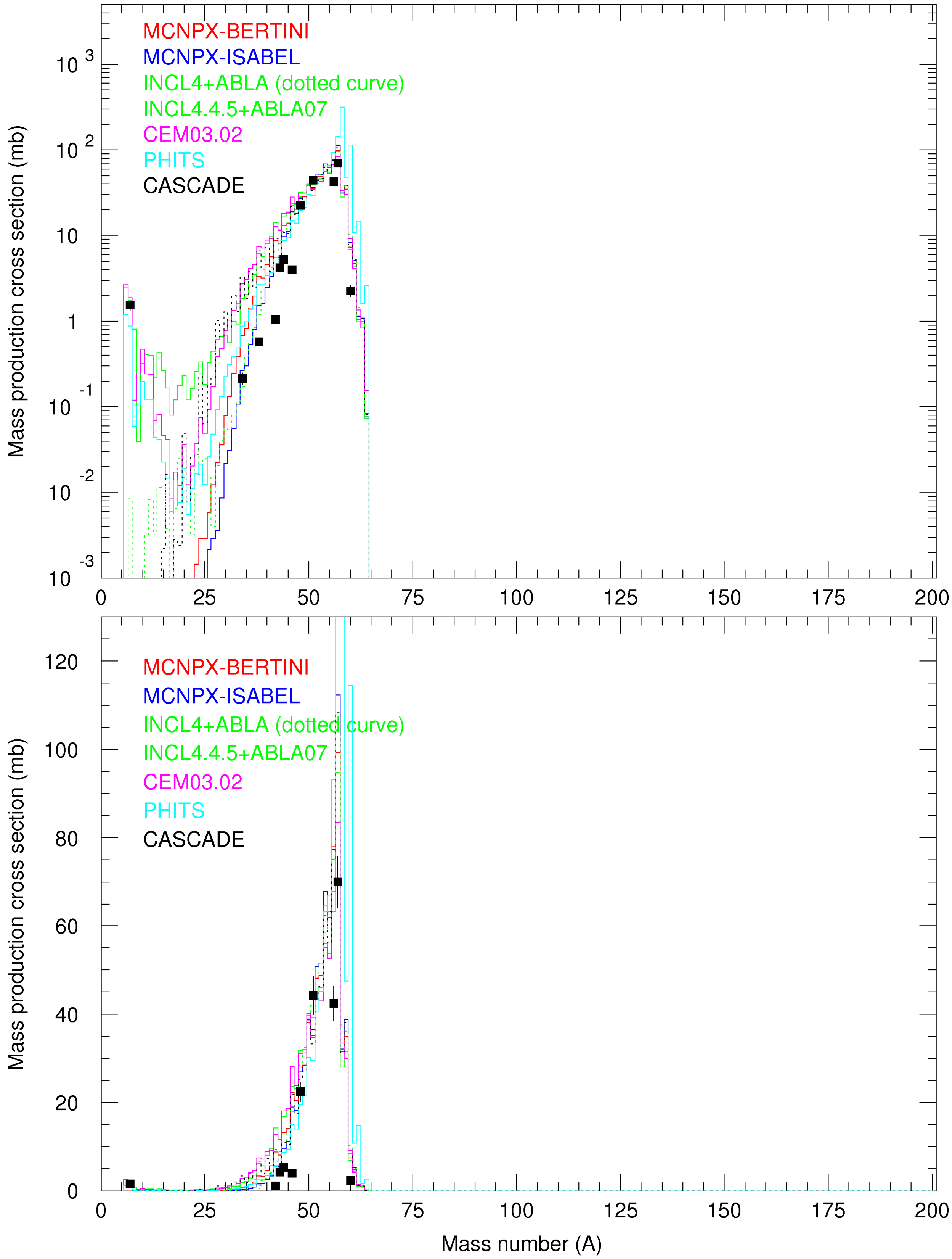

Fig. 7.84. The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{nat}Ni irradiated with 0.4 GeV protons.

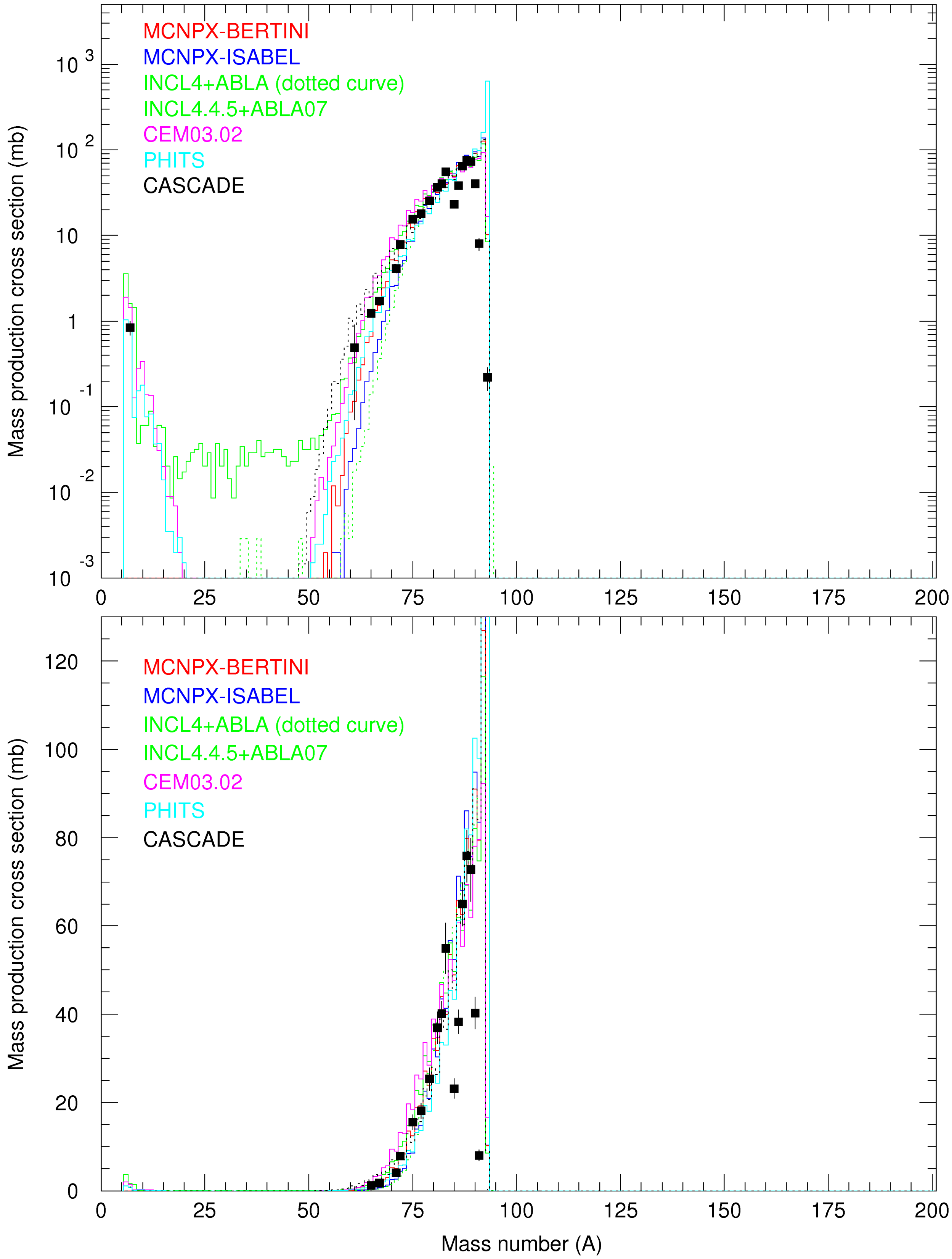

Fig. 7.85. The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{93}Nb irradiated with 0.4 GeV protons.

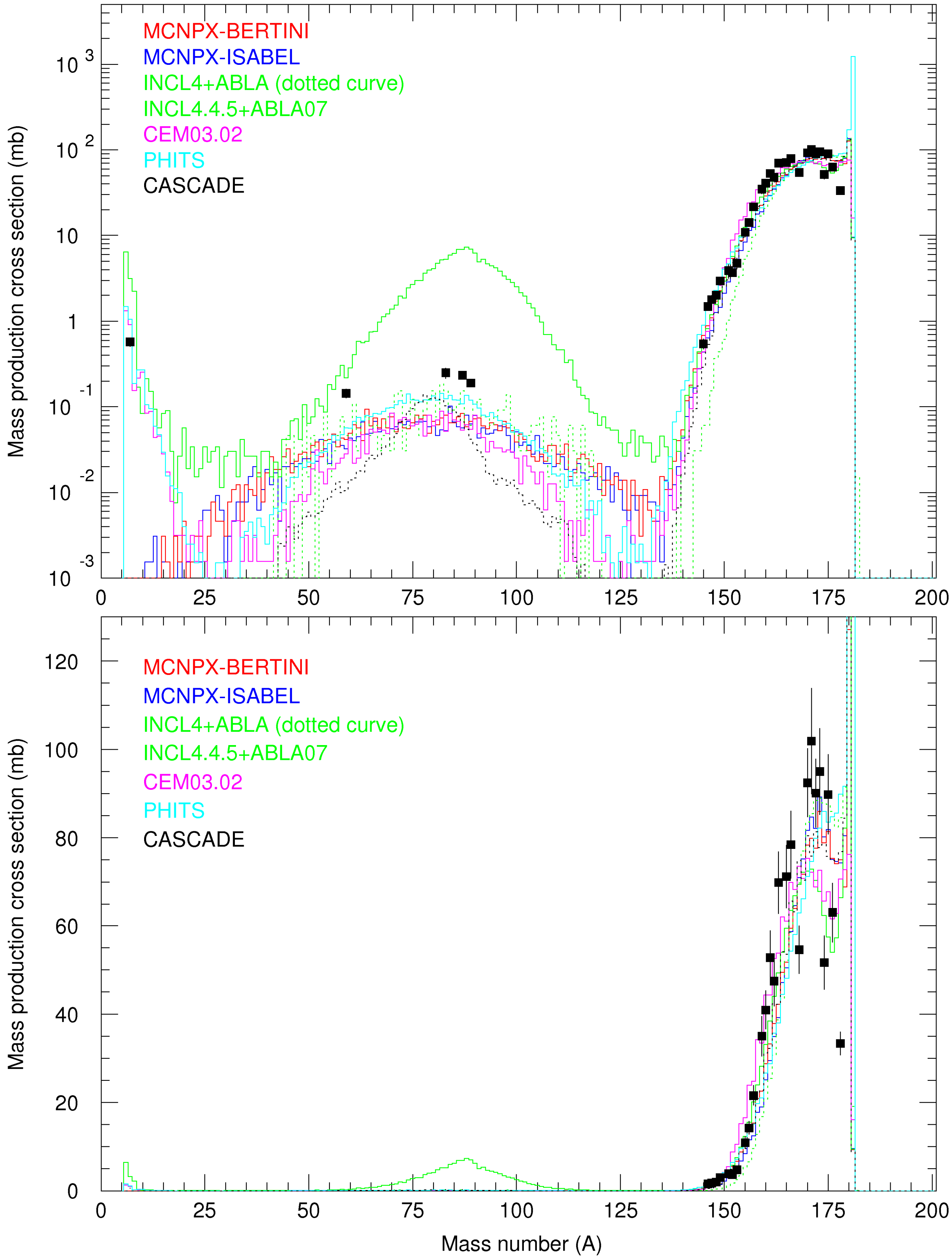

Fig. 7.86. The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{181}Ta irradiated with 0.4 GeV protons.

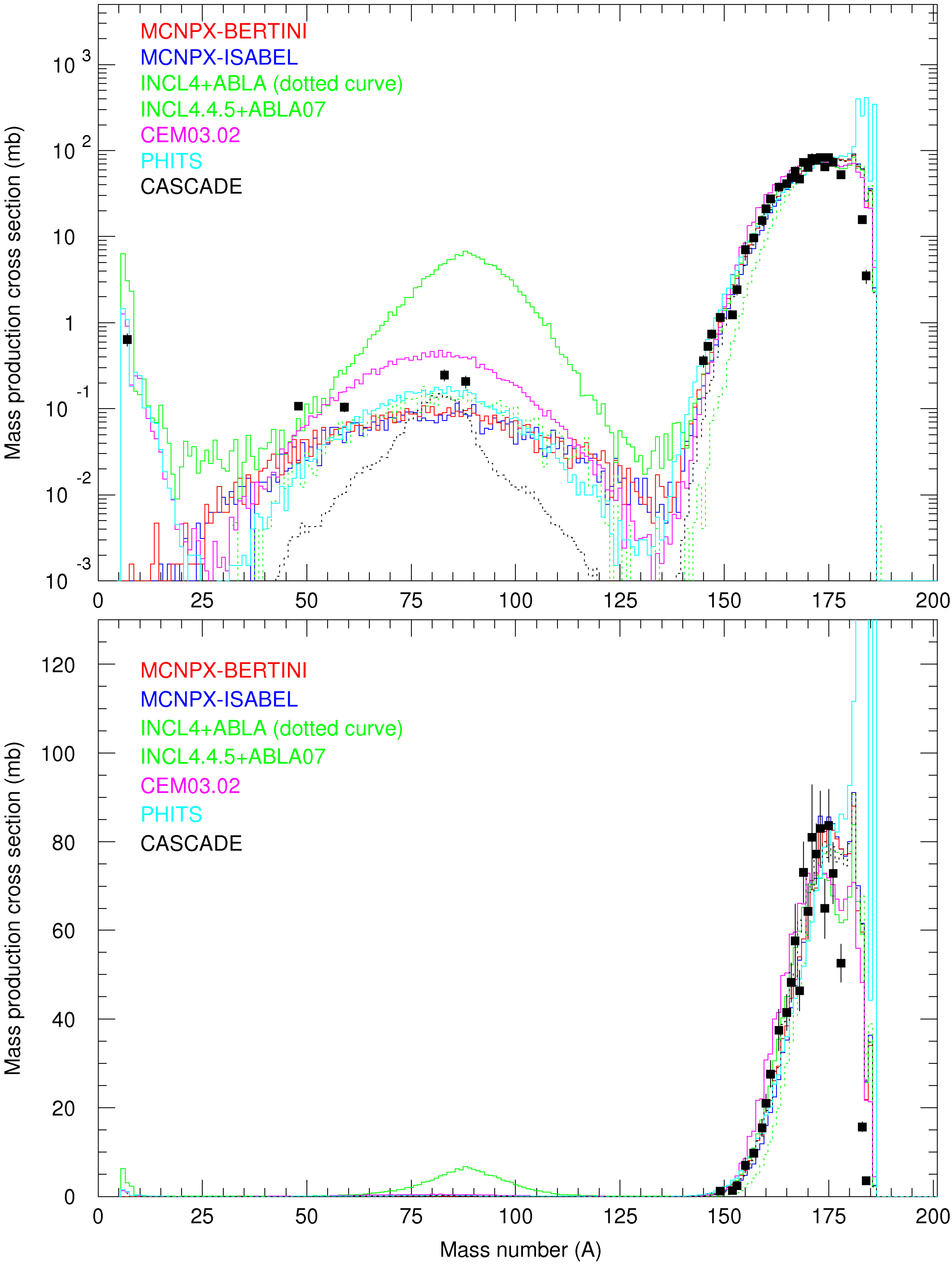

Fig. 7.87. The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{nat}W irradiated with 0.4 GeV protons.

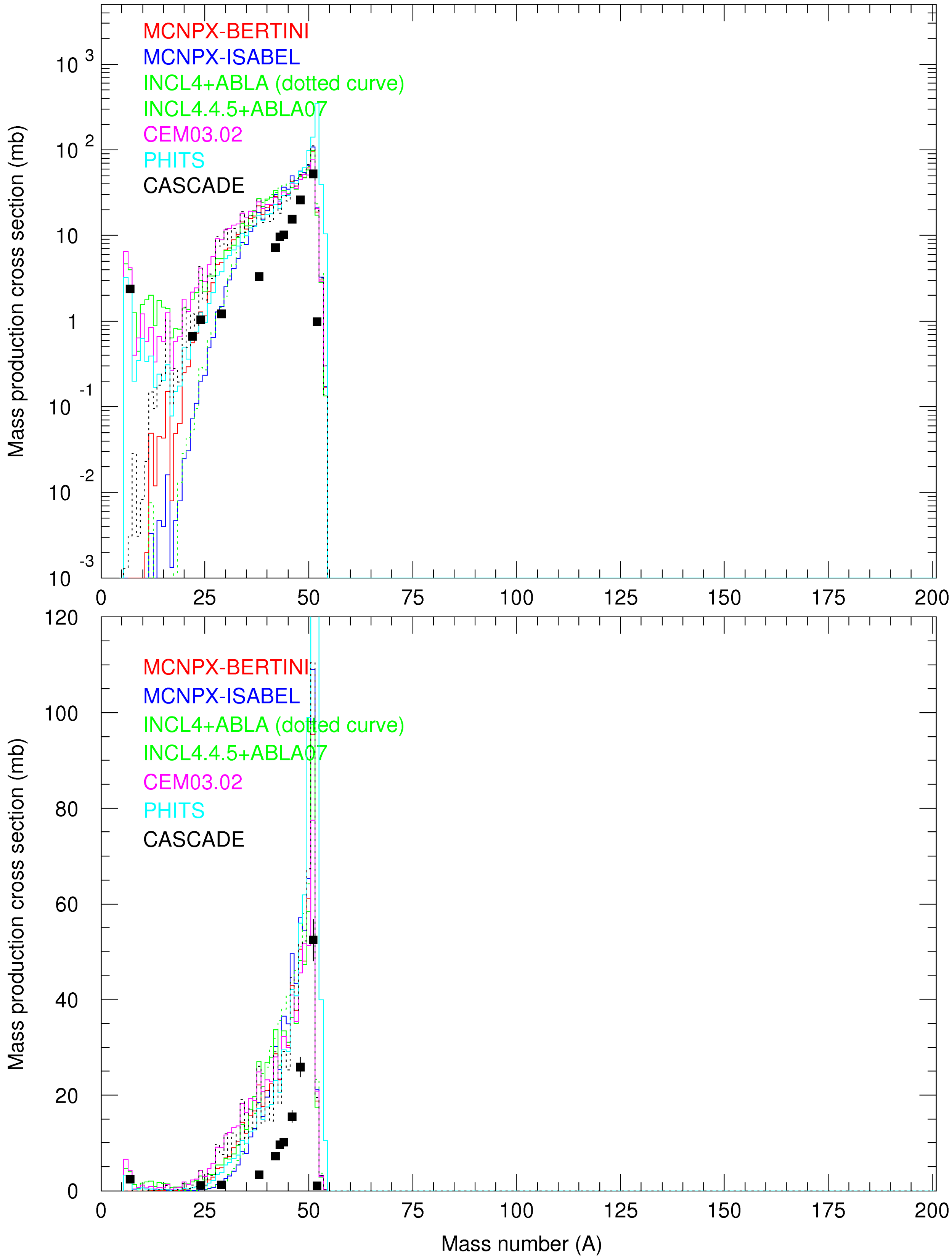

Fig. 7.88. The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{nat}Cr irradiated with 0.6 GeV protons.

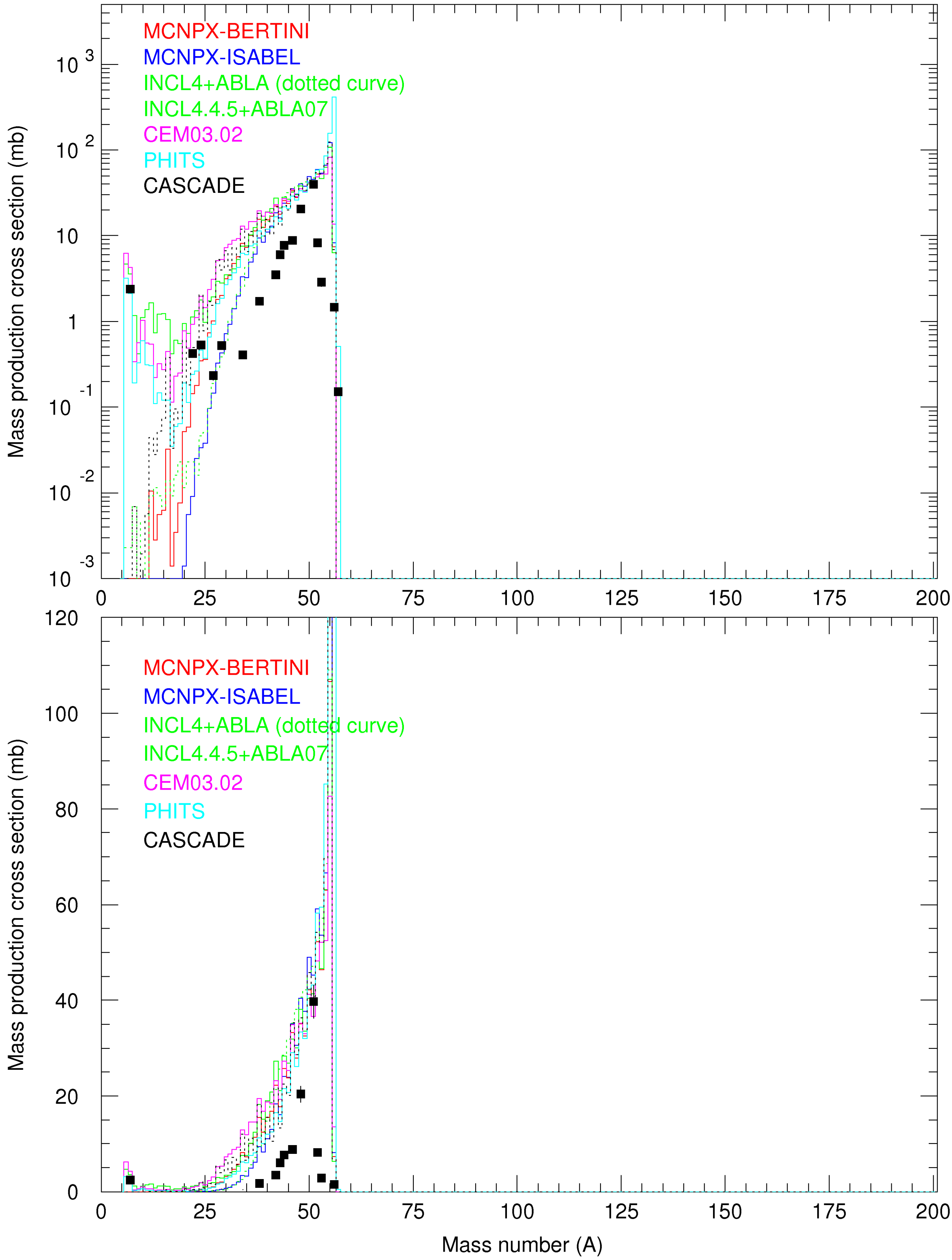

Fig. 7.89. The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{56}Fe irradiated with 0.6 GeV protons.

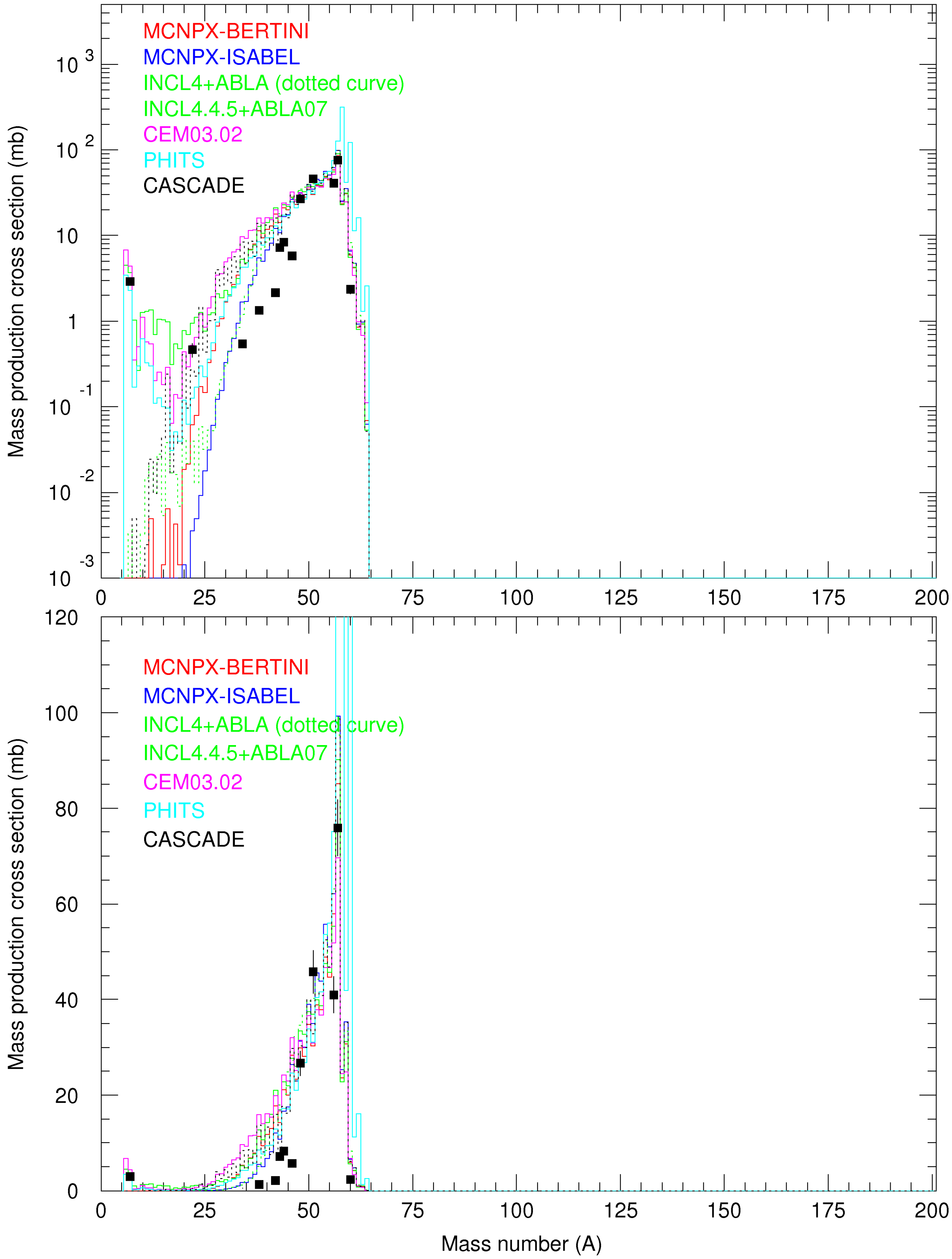

Fig. 7.90. The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{nat}Ni irradiated with 0.6 GeV protons.

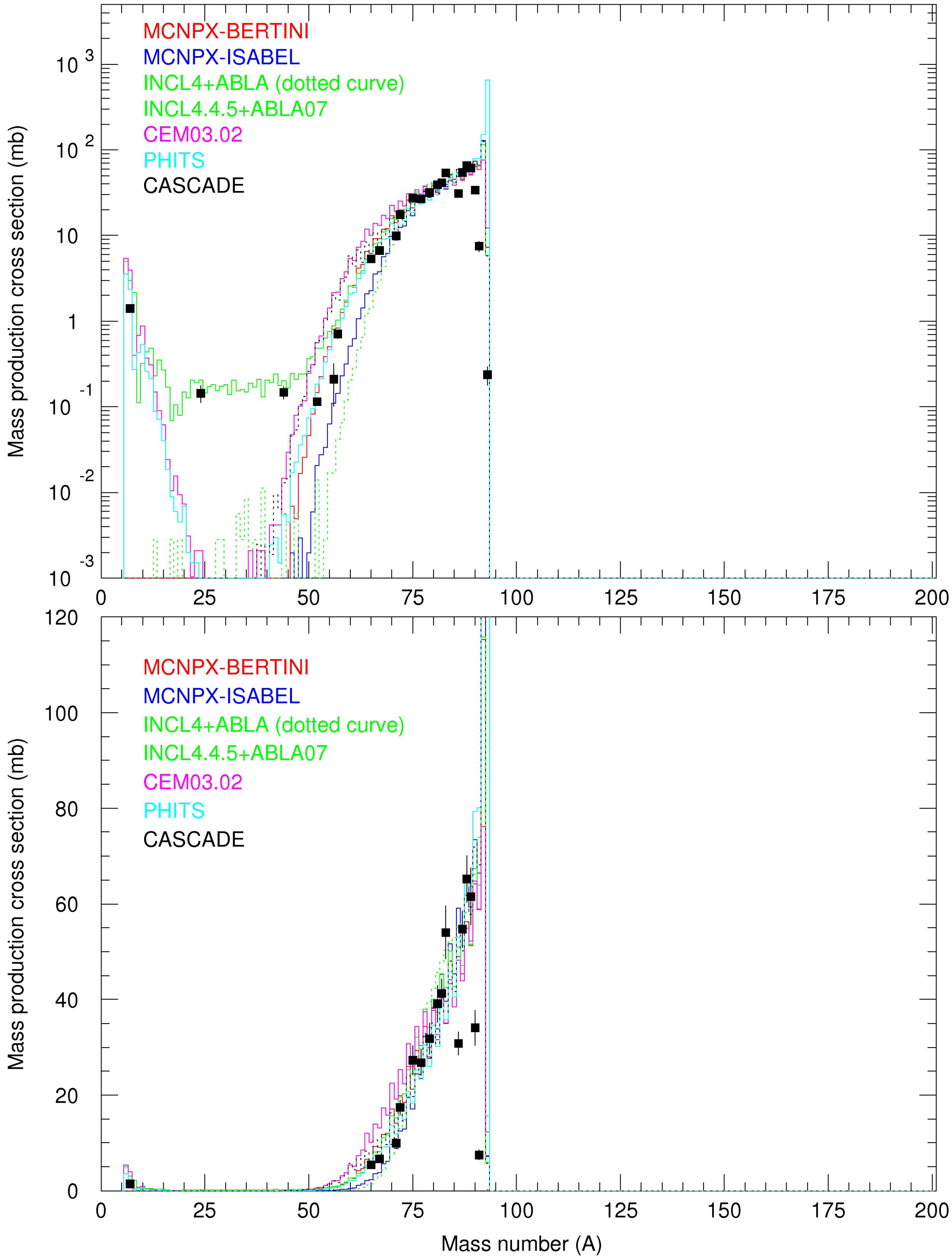

Fig. 7.91. The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{93}Nb irradiated with 0.6 GeV protons.

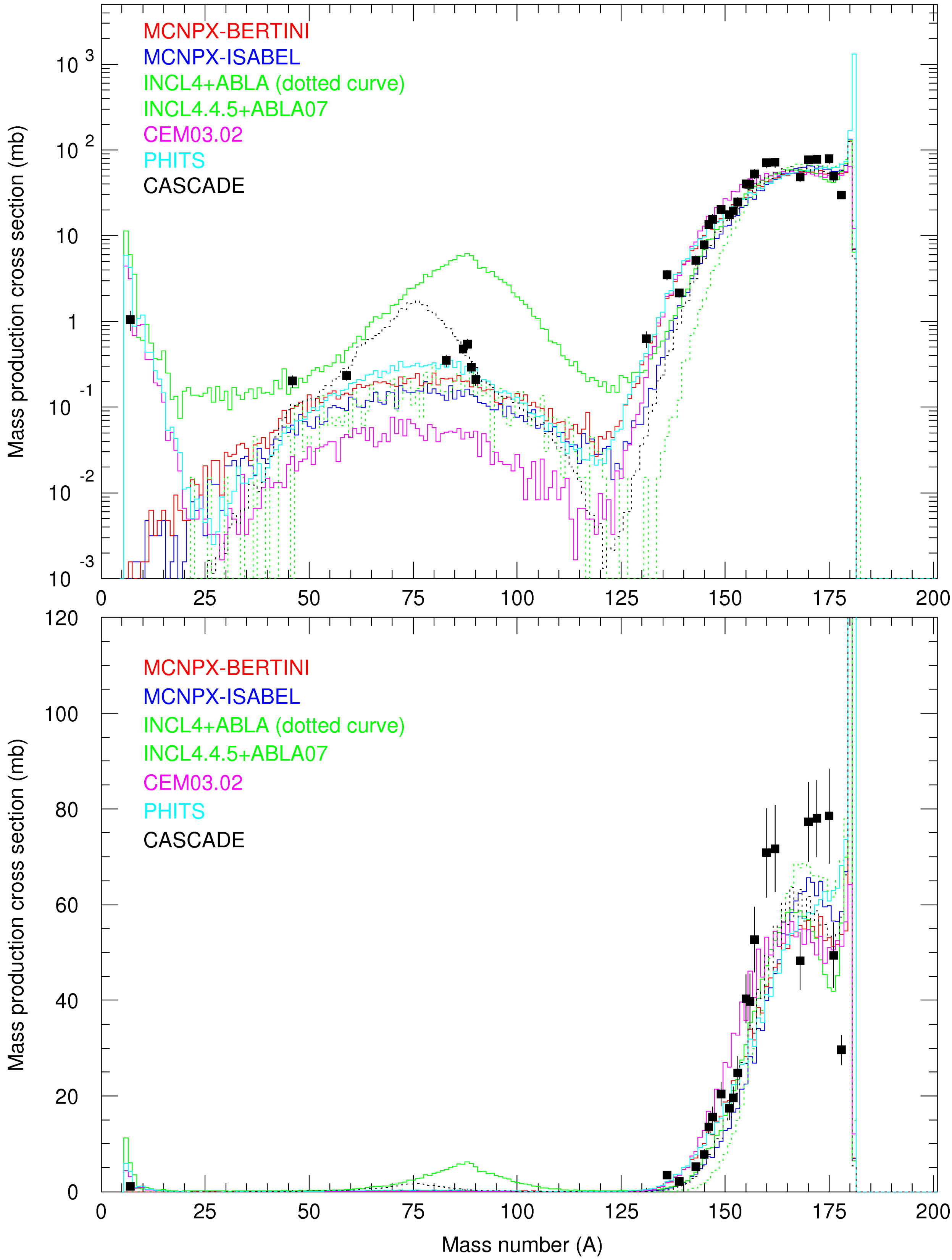

Fig. 7.92. The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{181}Ta irradiated with 0.6 GeV protons.

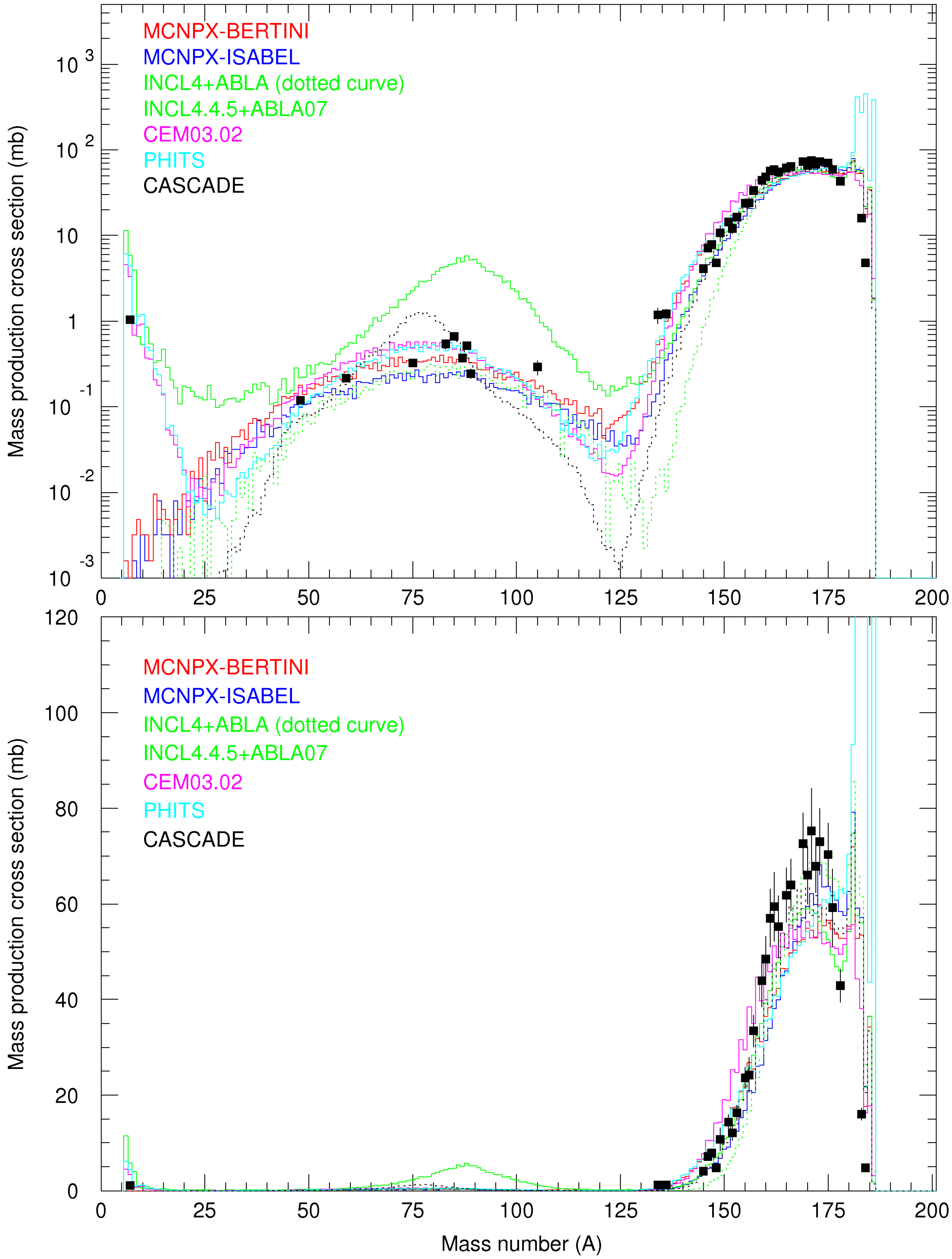

Fig. 7.93. The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{nat}W irradiated with 0.6 GeV protons.

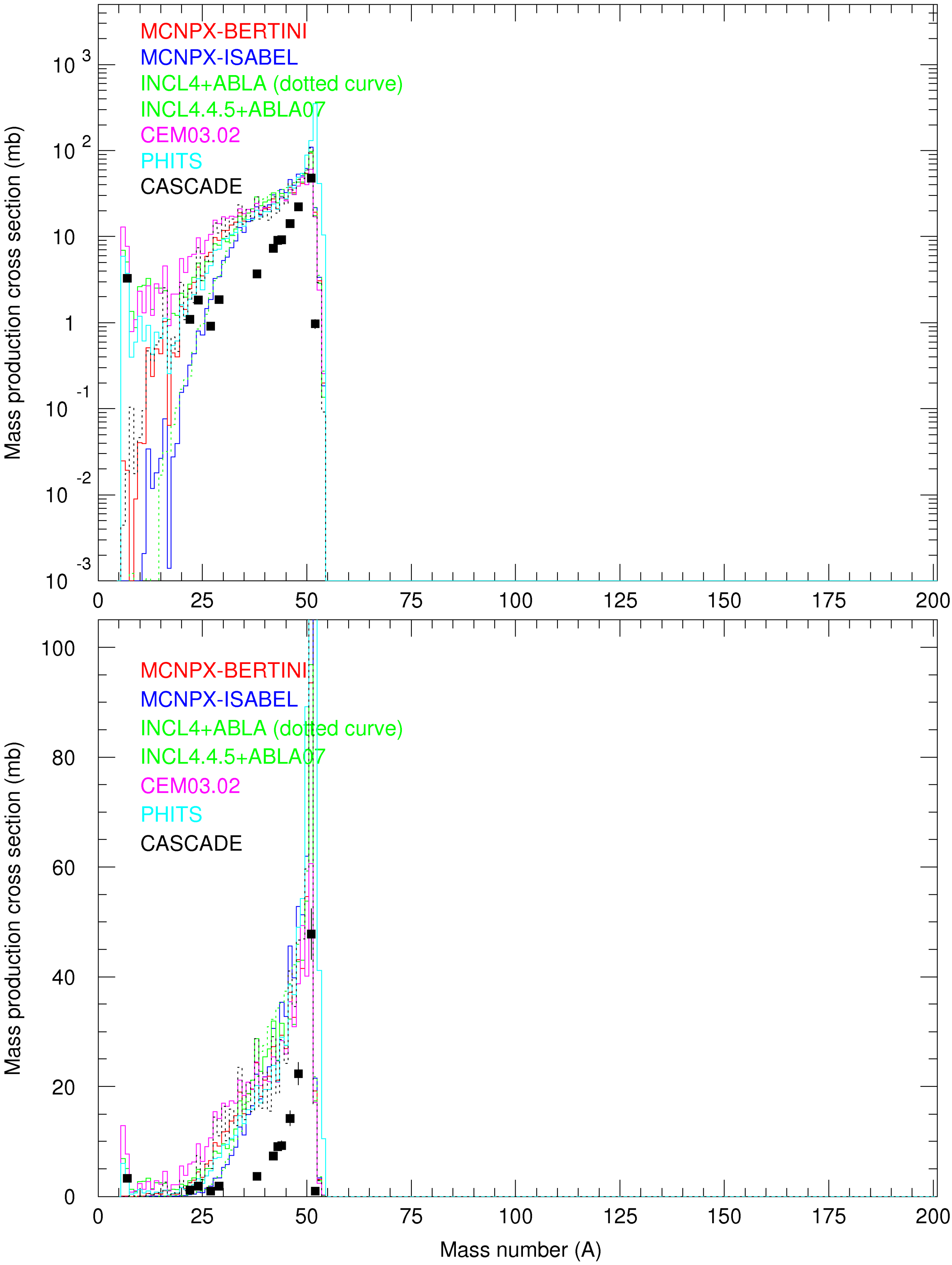

Fig. 7.94. The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{nat}Cr irradiated with 0.8 GeV protons.

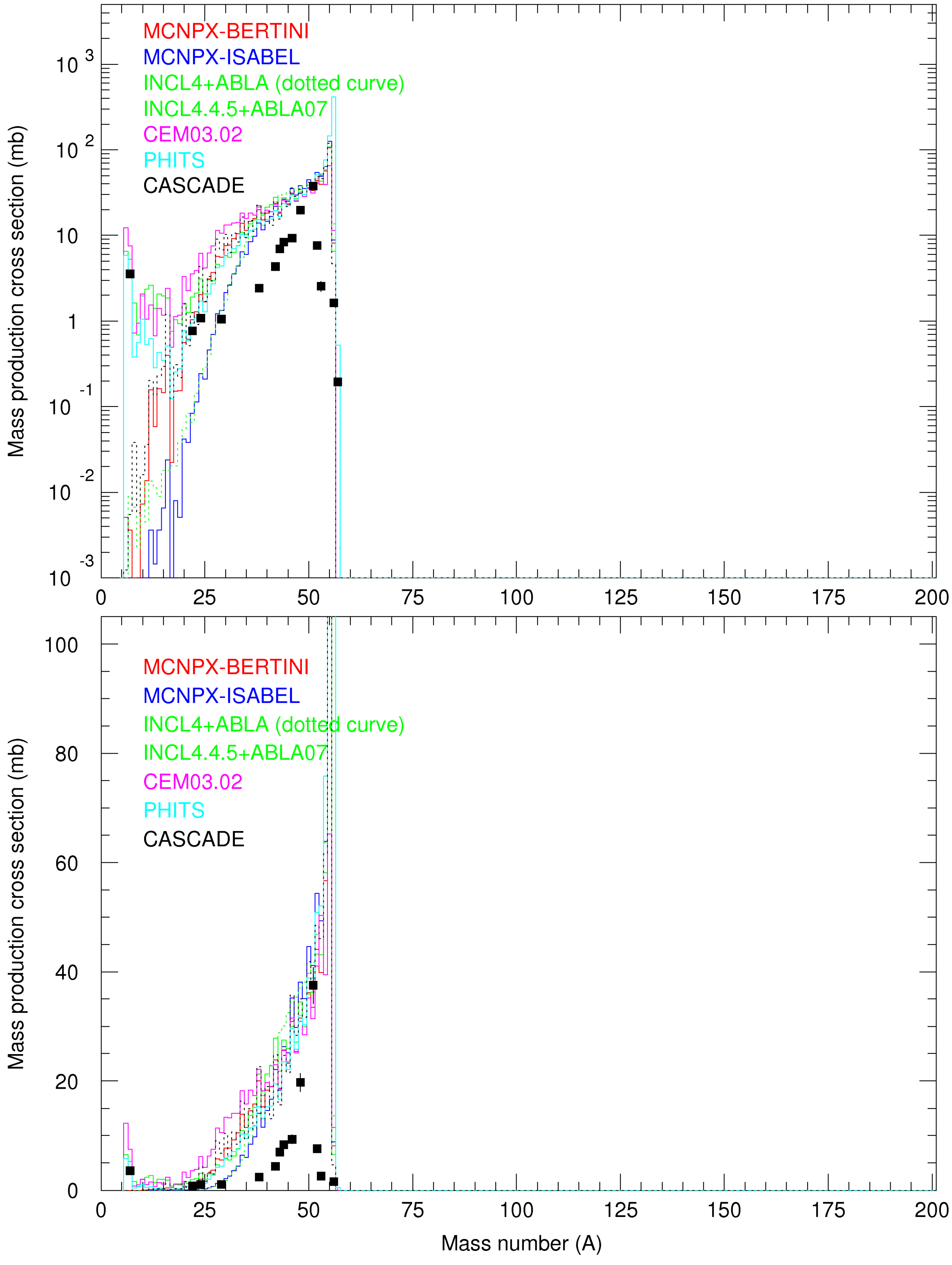

Fig. 7.95. The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{56}Fe irradiated with 0.8 GeV protons.

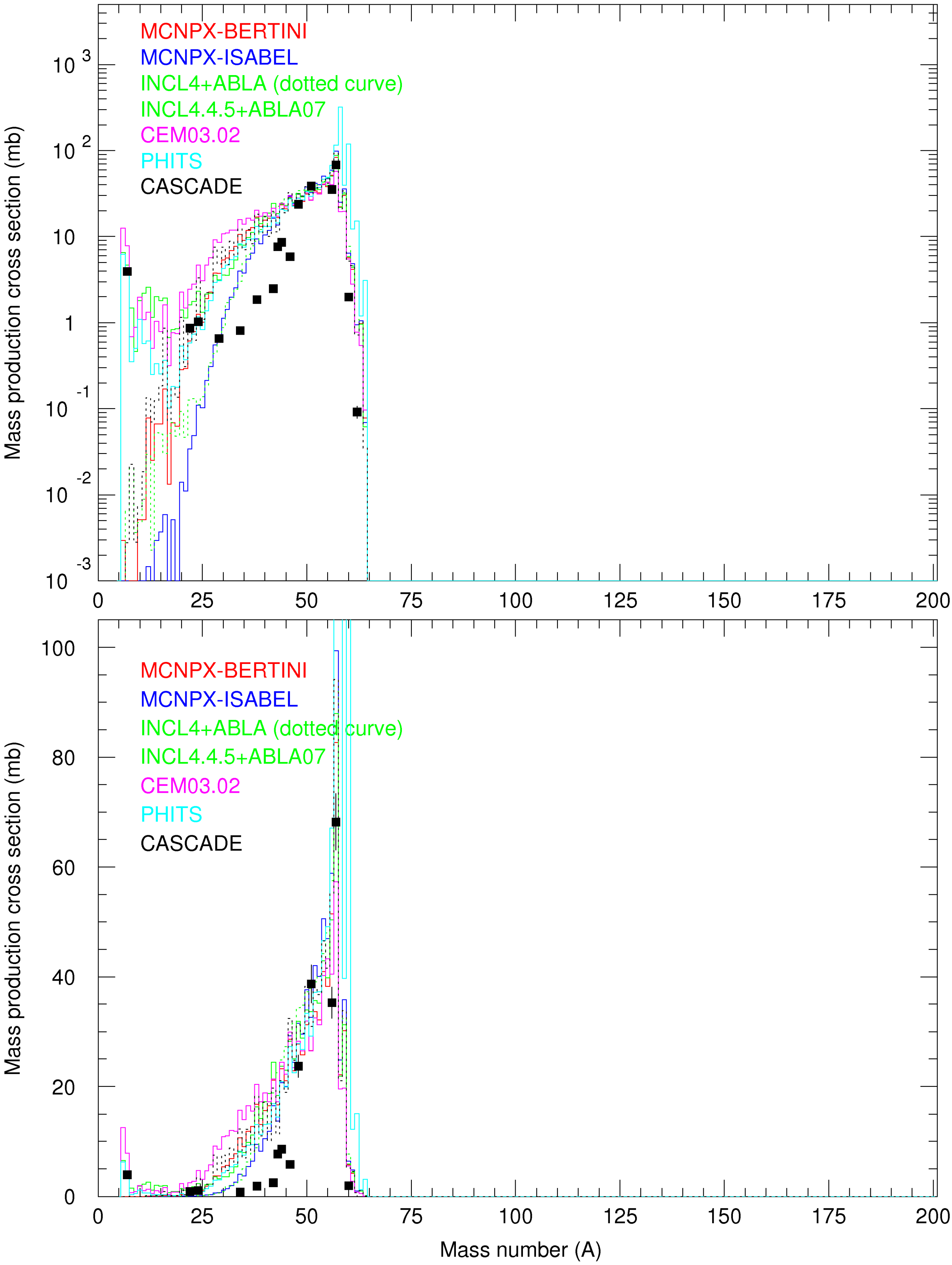

Fig. 7.96. The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{nat}Ni irradiated with 0.8 GeV protons.

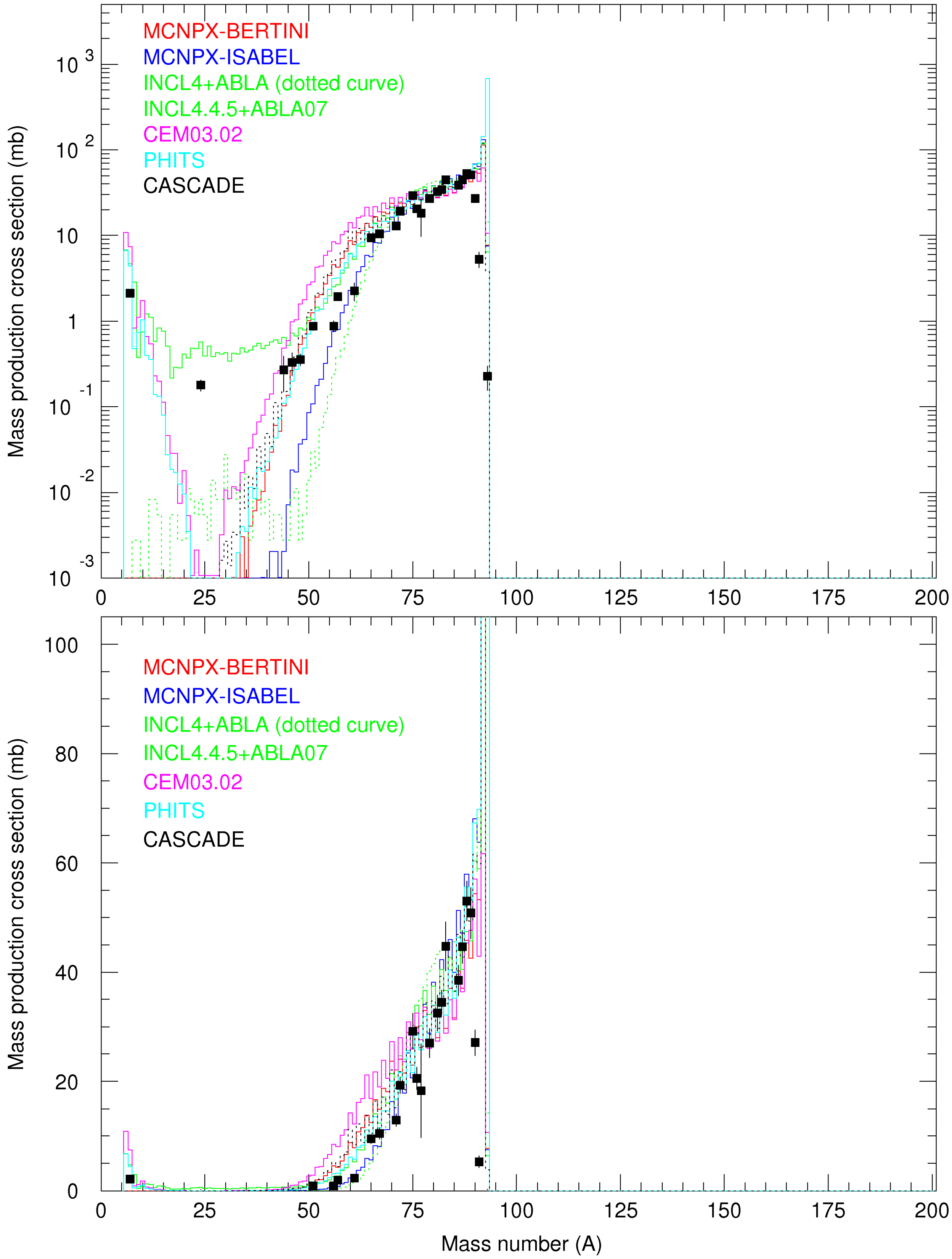

Fig. 7.97. The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{93}Nb irradiated with 0.8 GeV protons.

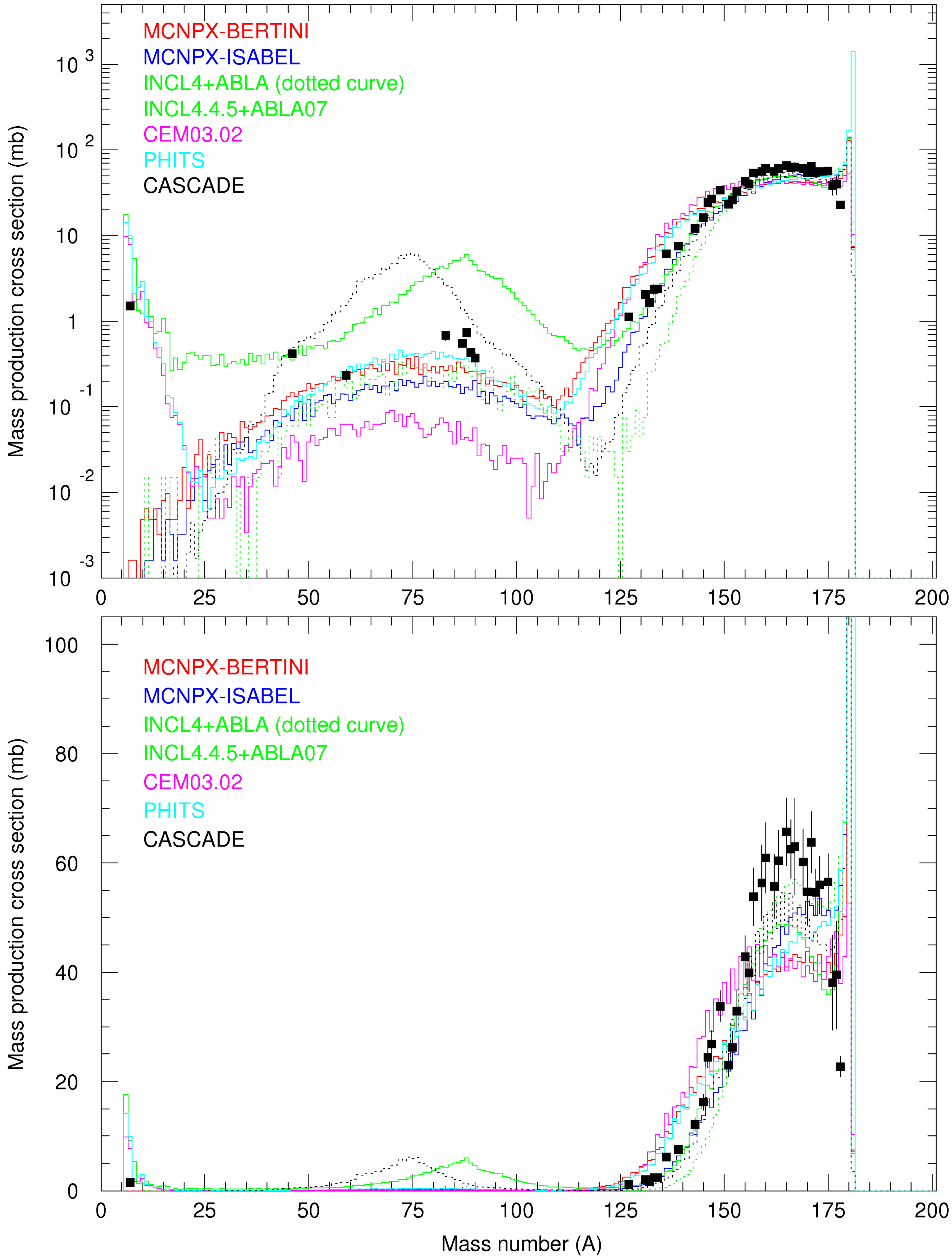

Fig. 7.98. The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{181}Ta irradiated with 0.8 GeV protons.

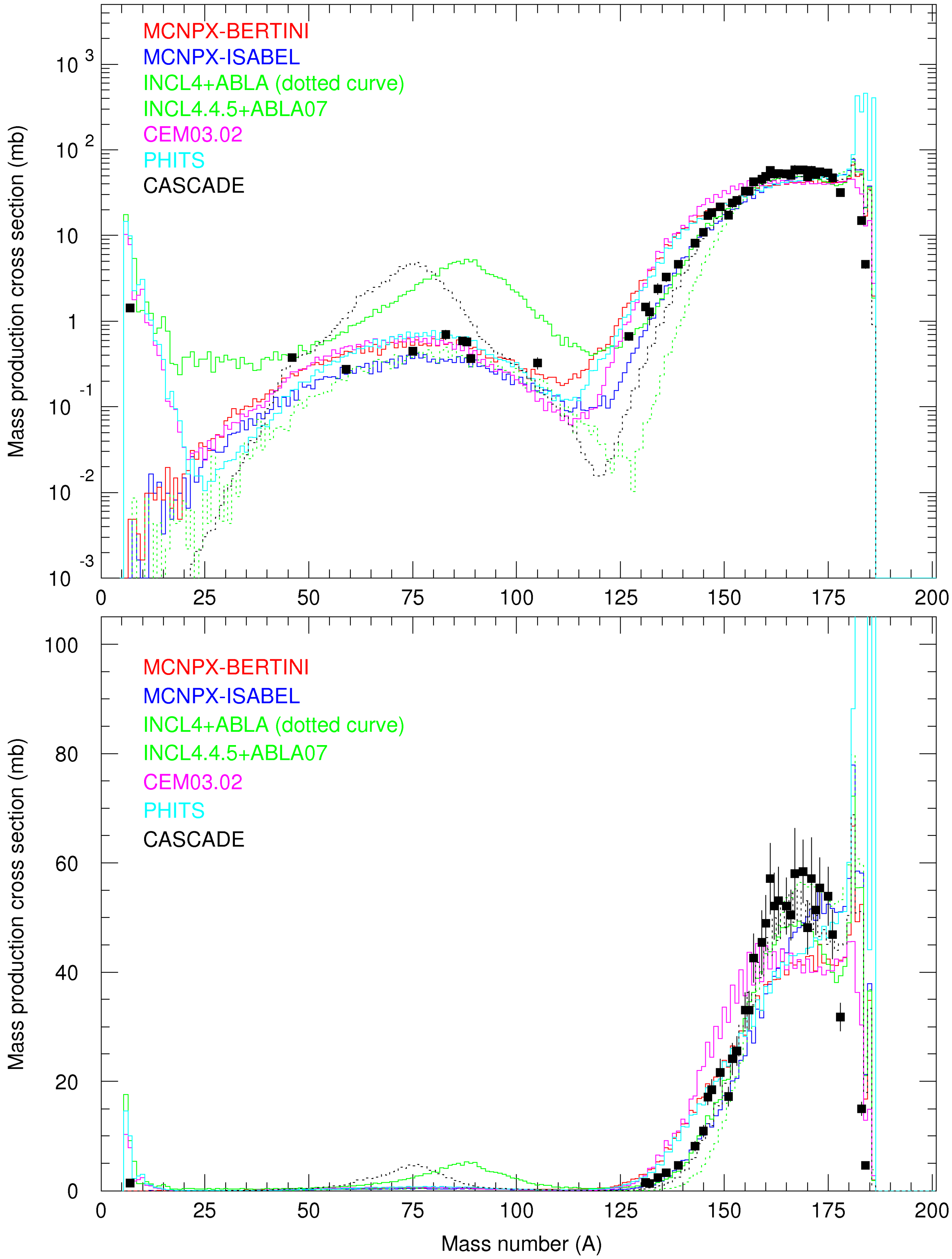

Fig. 7.99. The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{nat}W irradiated with 0.8 GeV protons.

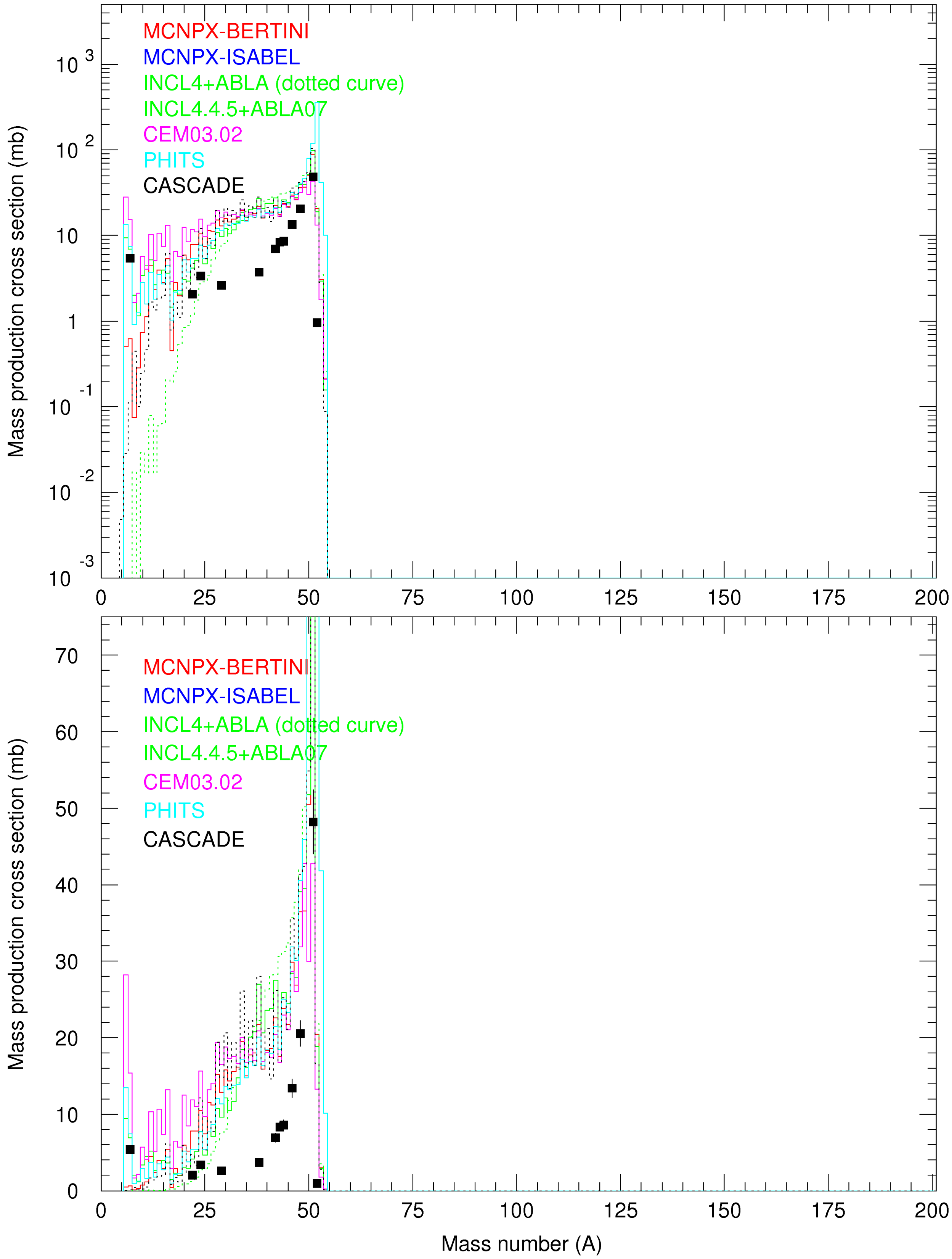

Fig. 7.100. The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{nat}Cr irradiated with 1.2 GeV protons.

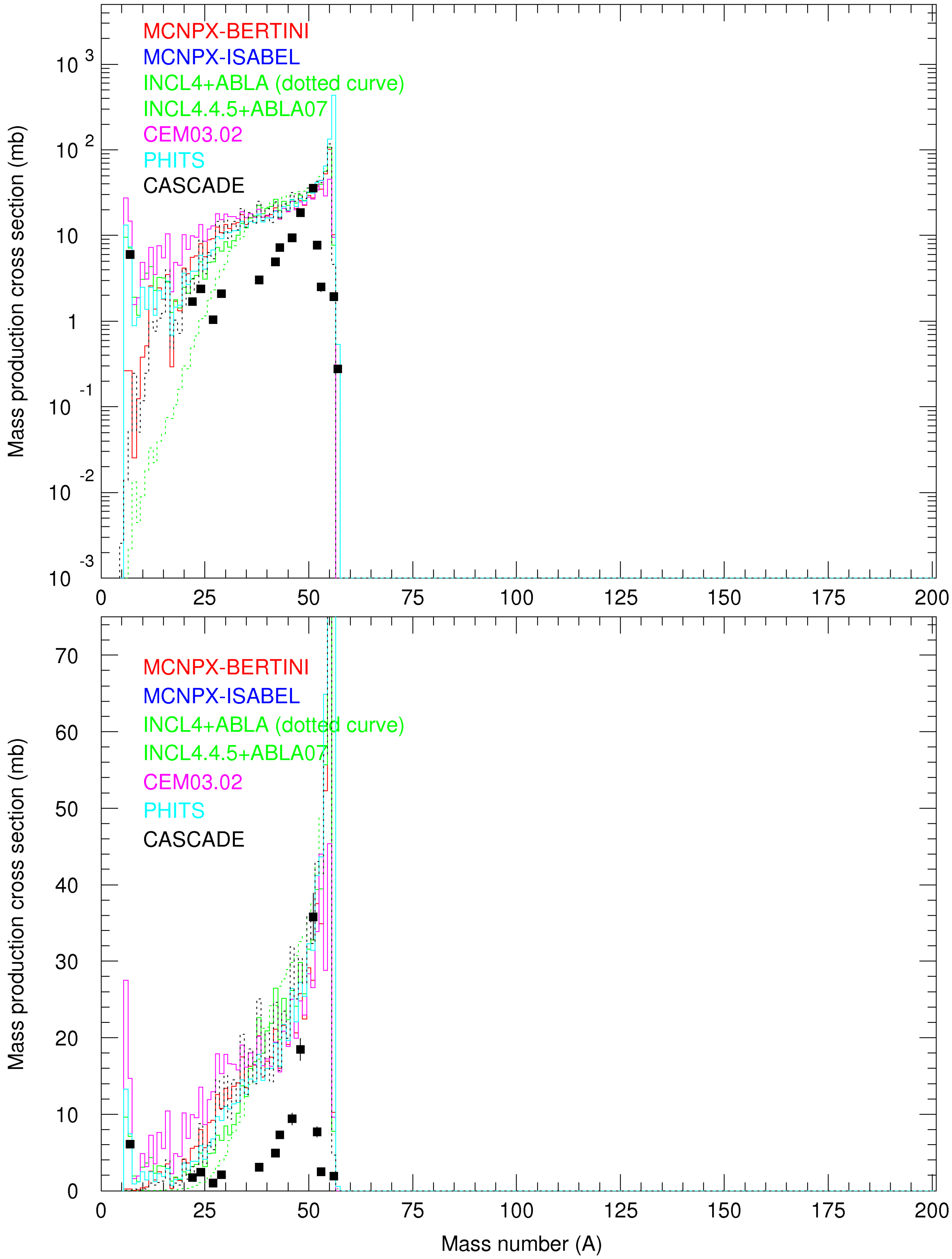

Fig. 7.101. The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{56}Fe irradiated with 1.2 GeV protons.

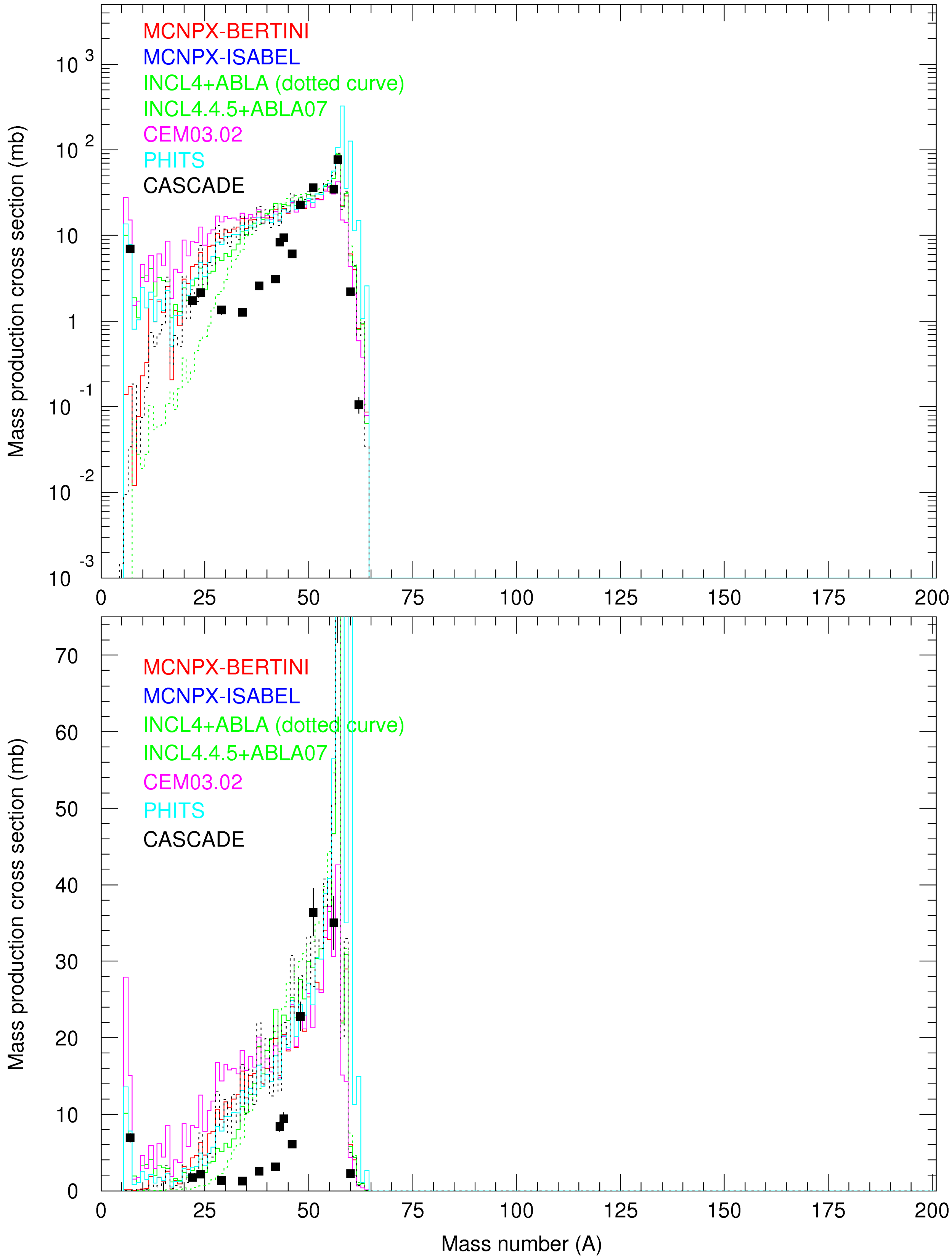

Fig. 7.102. The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{nat}Ni irradiated with 1.2 GeV protons.

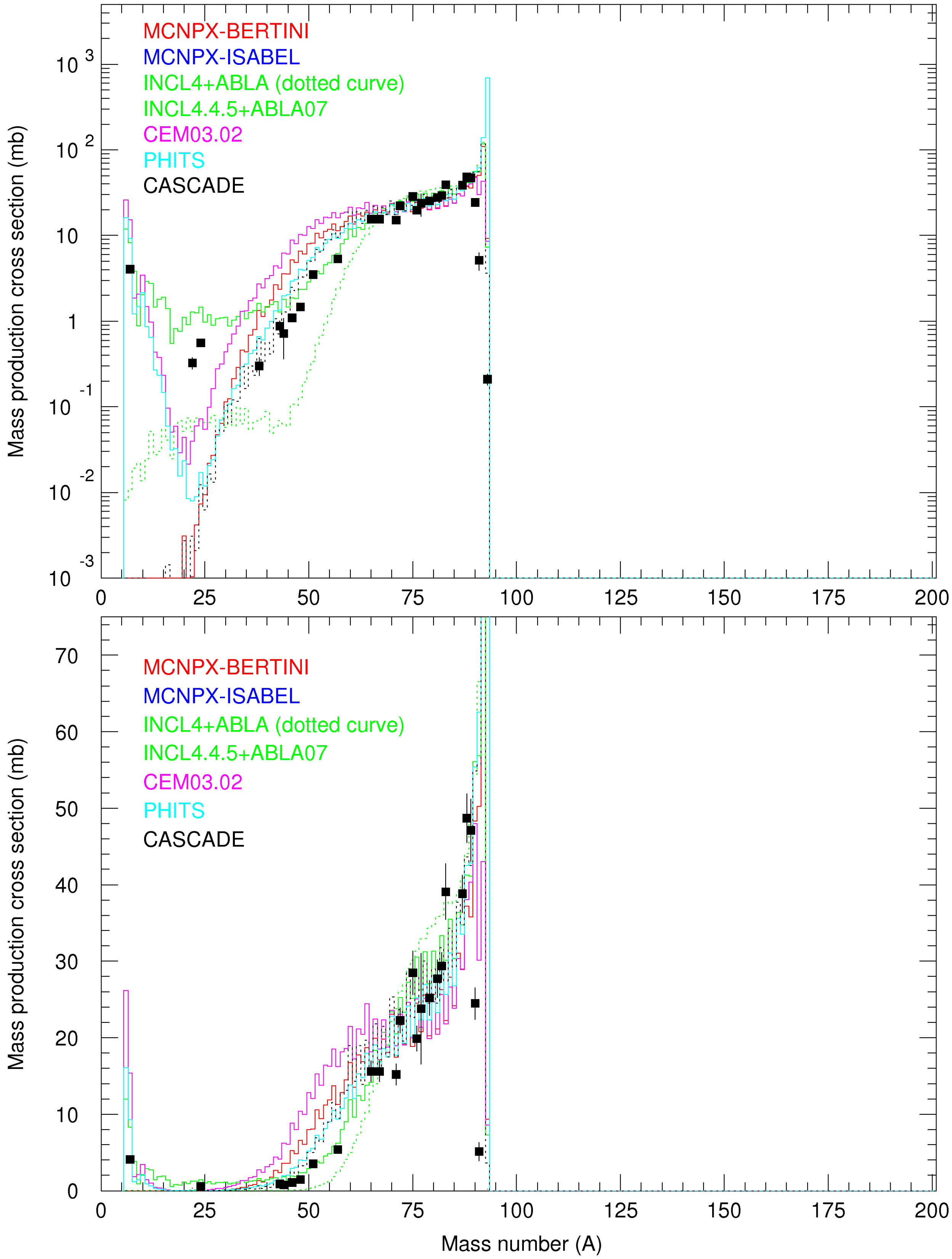

Fig. 7.103. The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{93}Nb irradiated with 1.2 GeV protons.

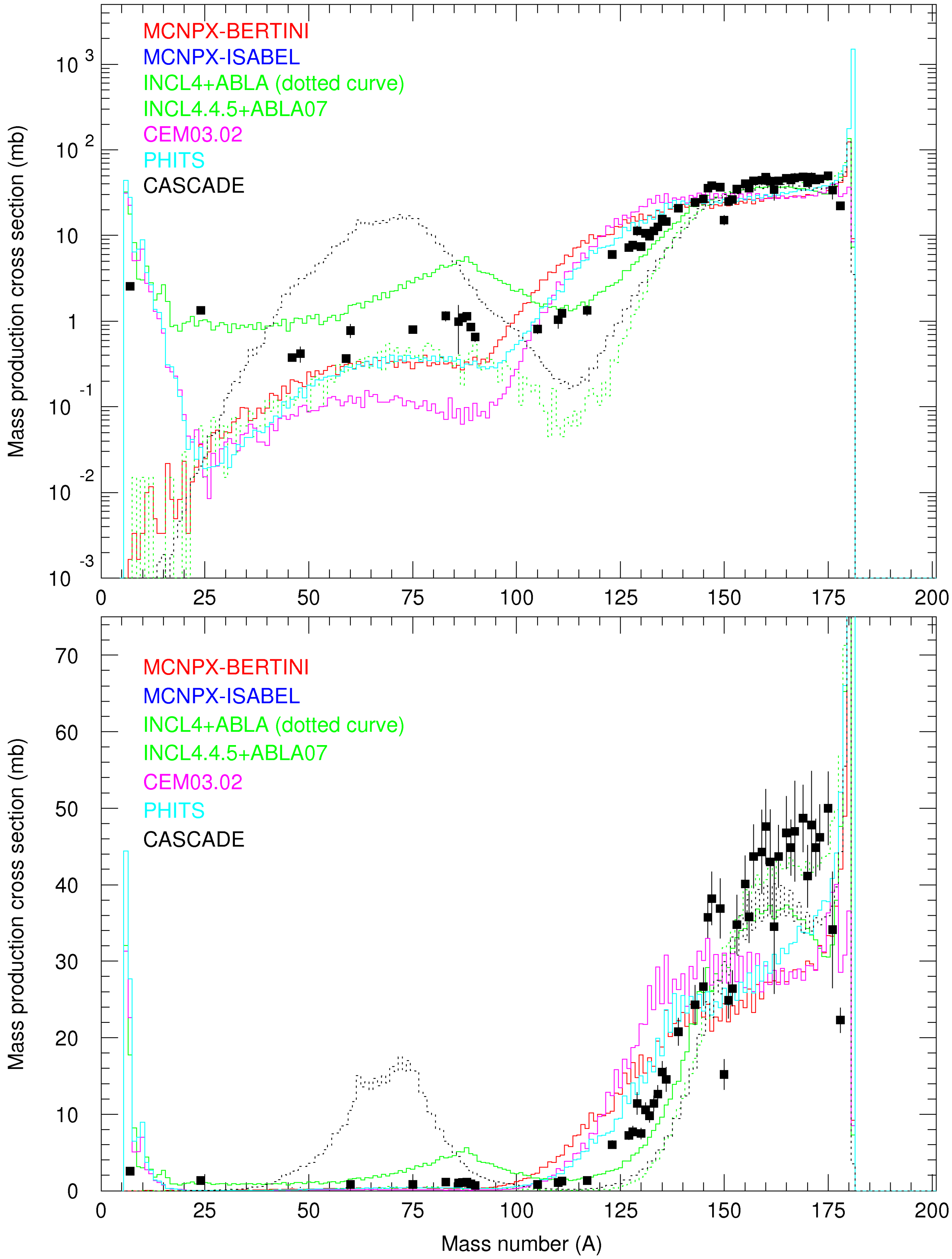

Fig. 7.104. The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{181}Ta irradiated with 1.2 GeV protons.

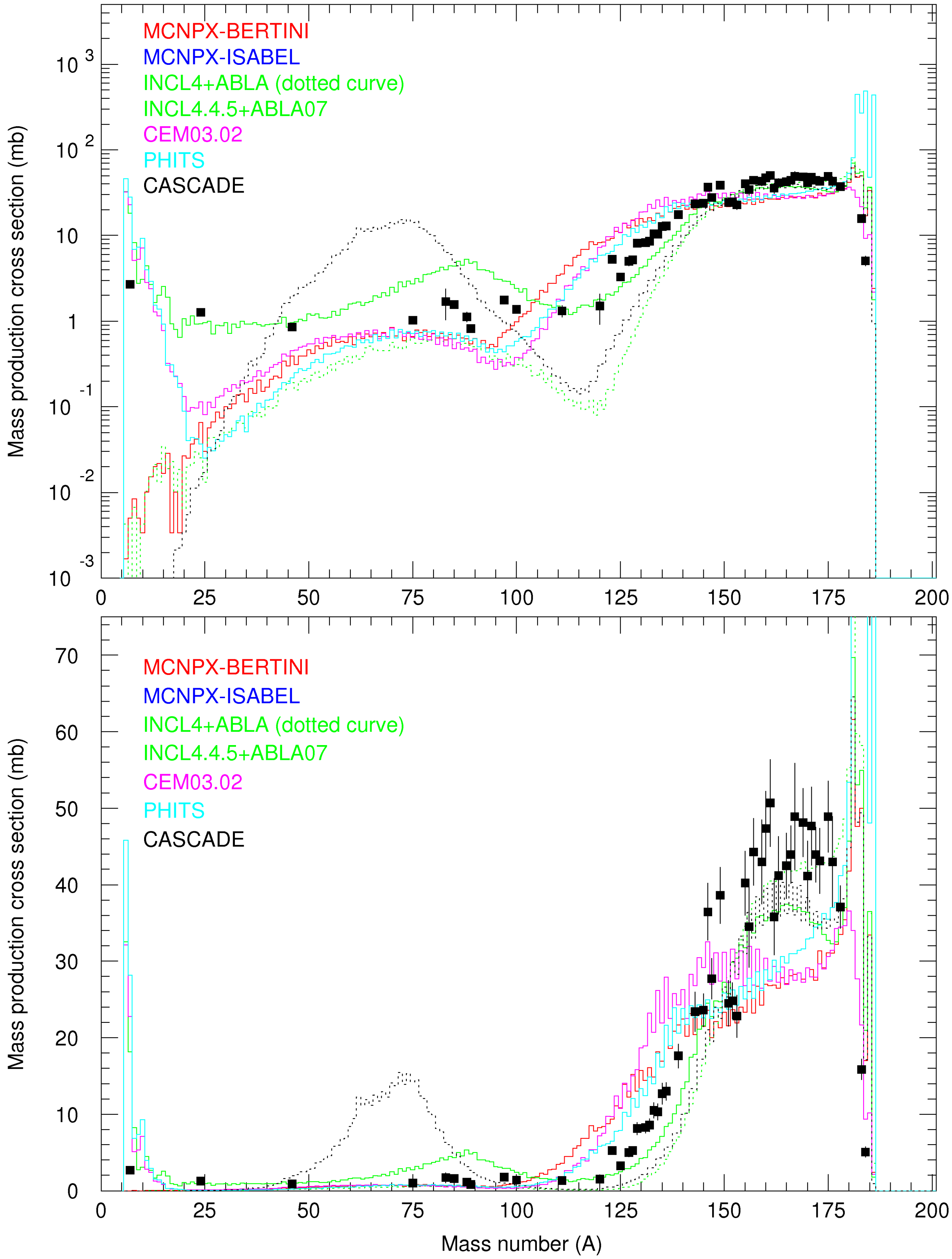

Fig. 7.105. The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{nat}W irradiated with 1.2 GeV protons.

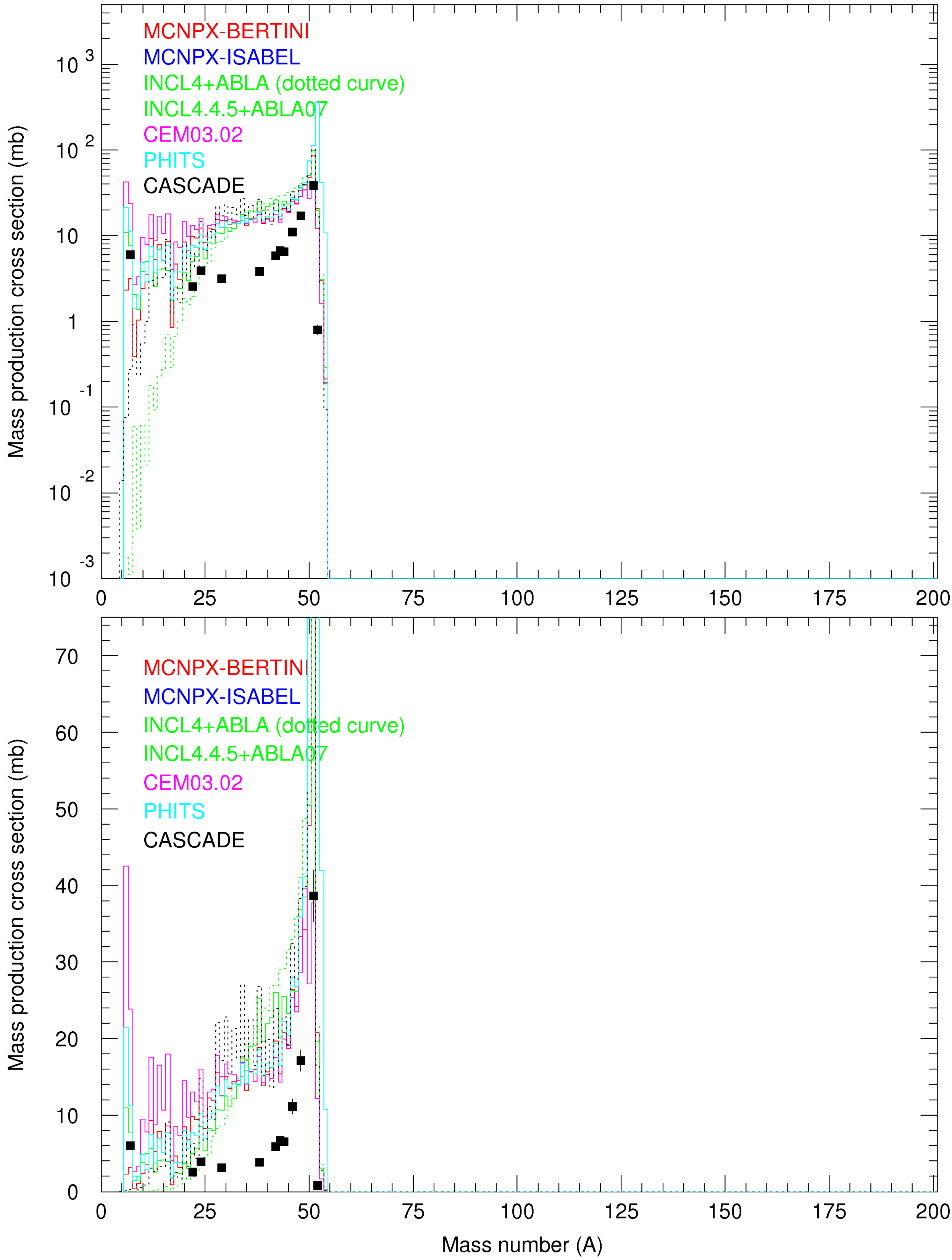

Fig. 7.106. The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{nat}Cr irradiated with 1.6 GeV protons.

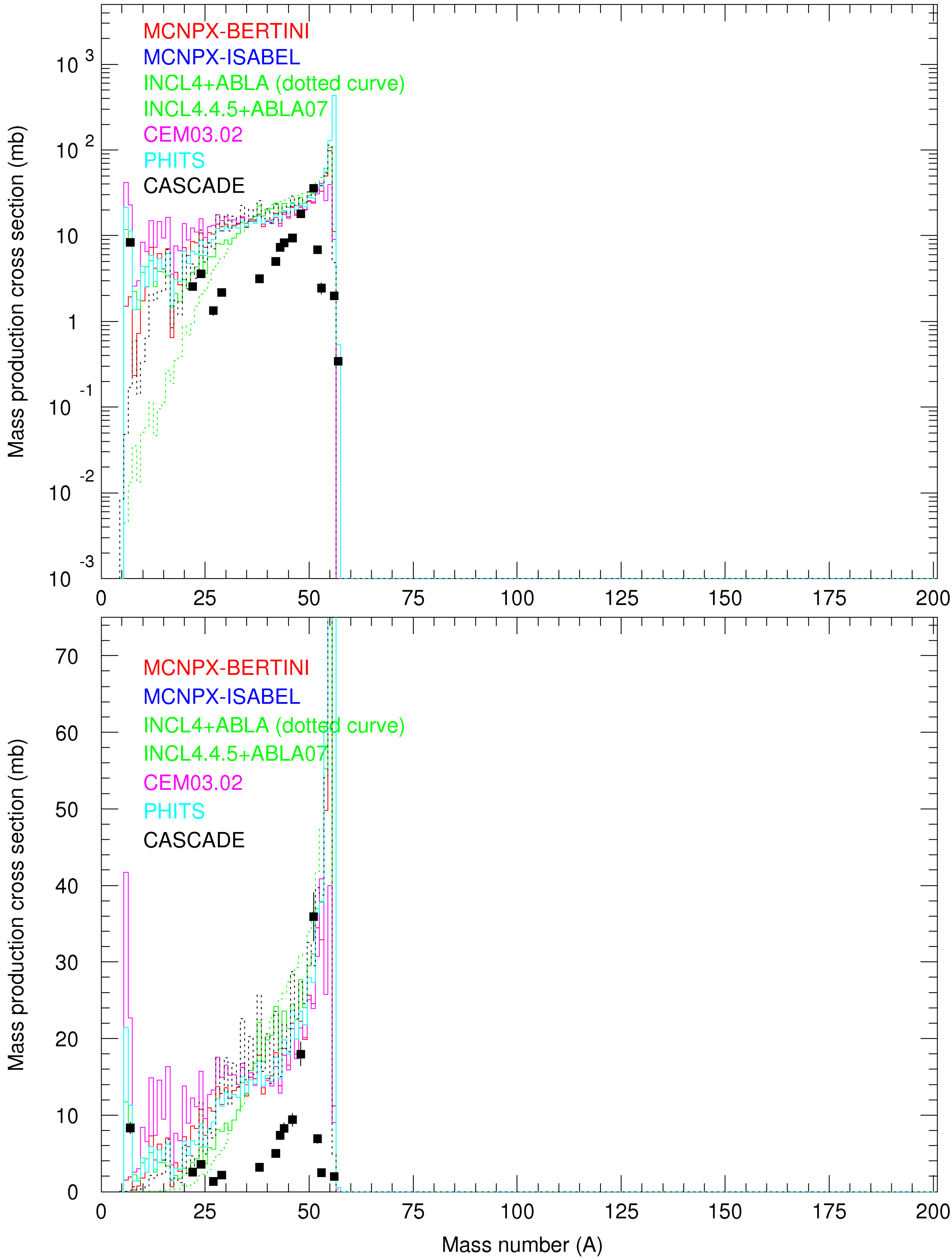

Fig. 7.107. The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{56}Fe irradiated with 1.6 GeV protons.

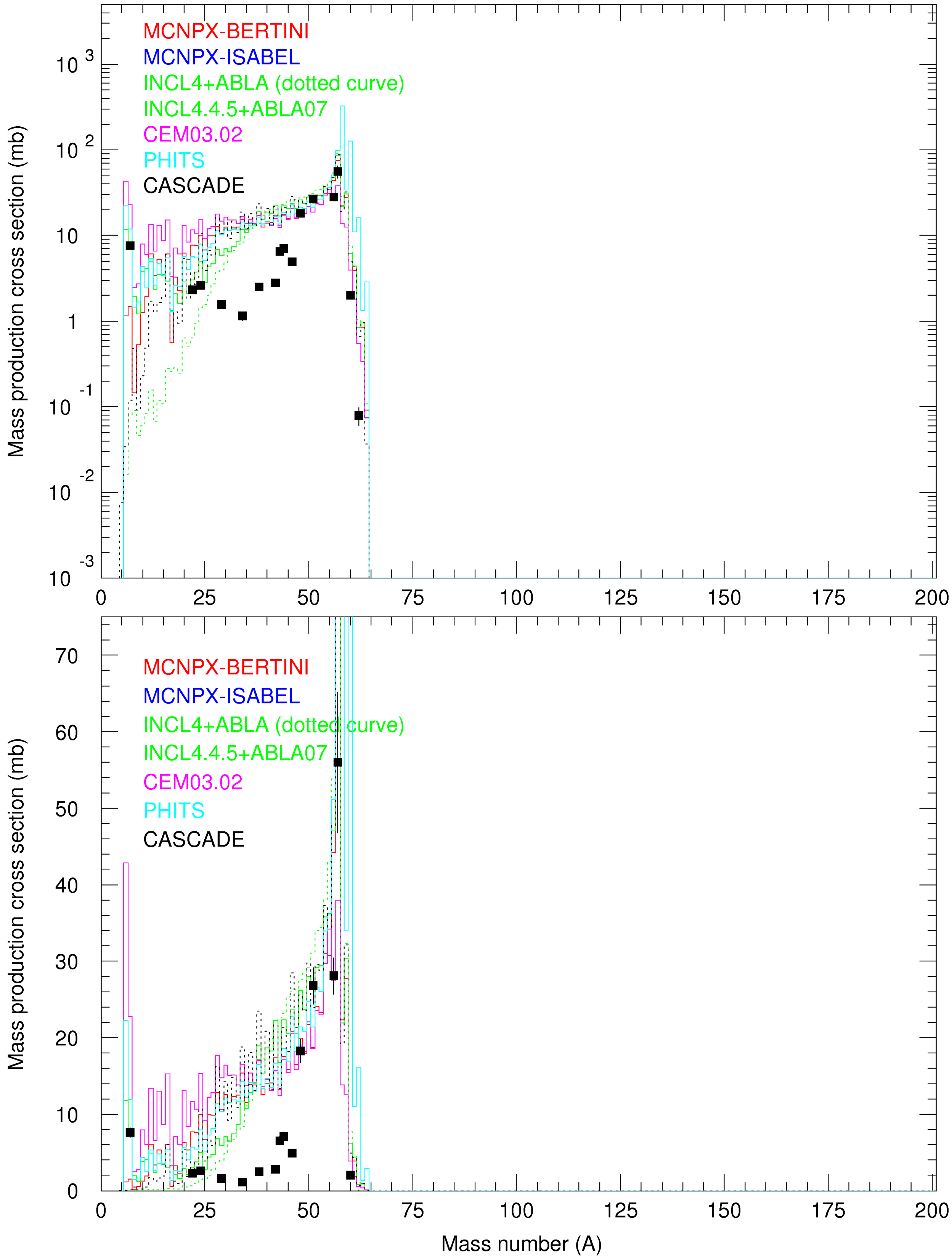

Fig. 7.108. The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{nat}Ni irradiated with 1.6 GeV protons.

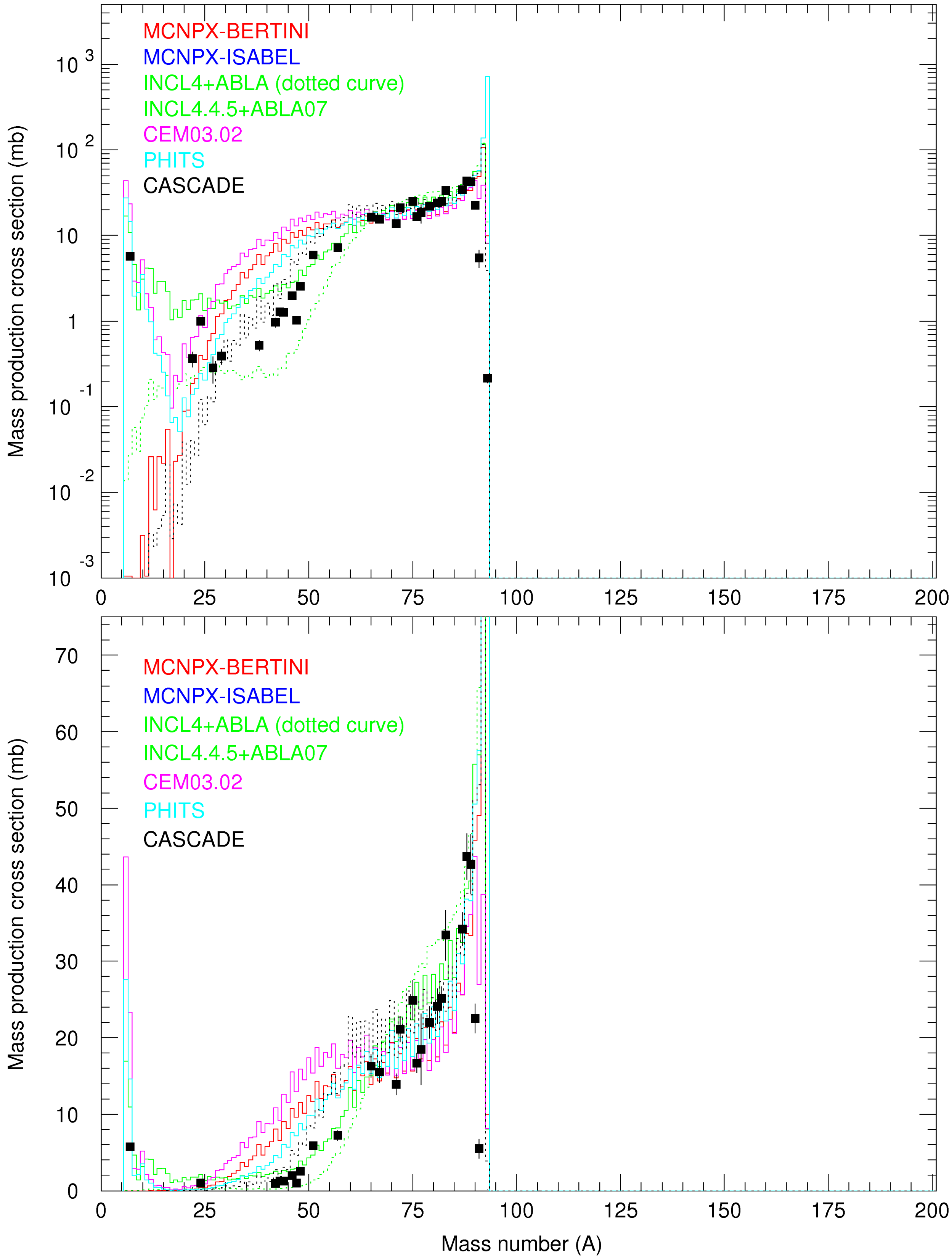

Fig. 7.109. The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{93}Nb irradiated with 1.6 GeV protons.

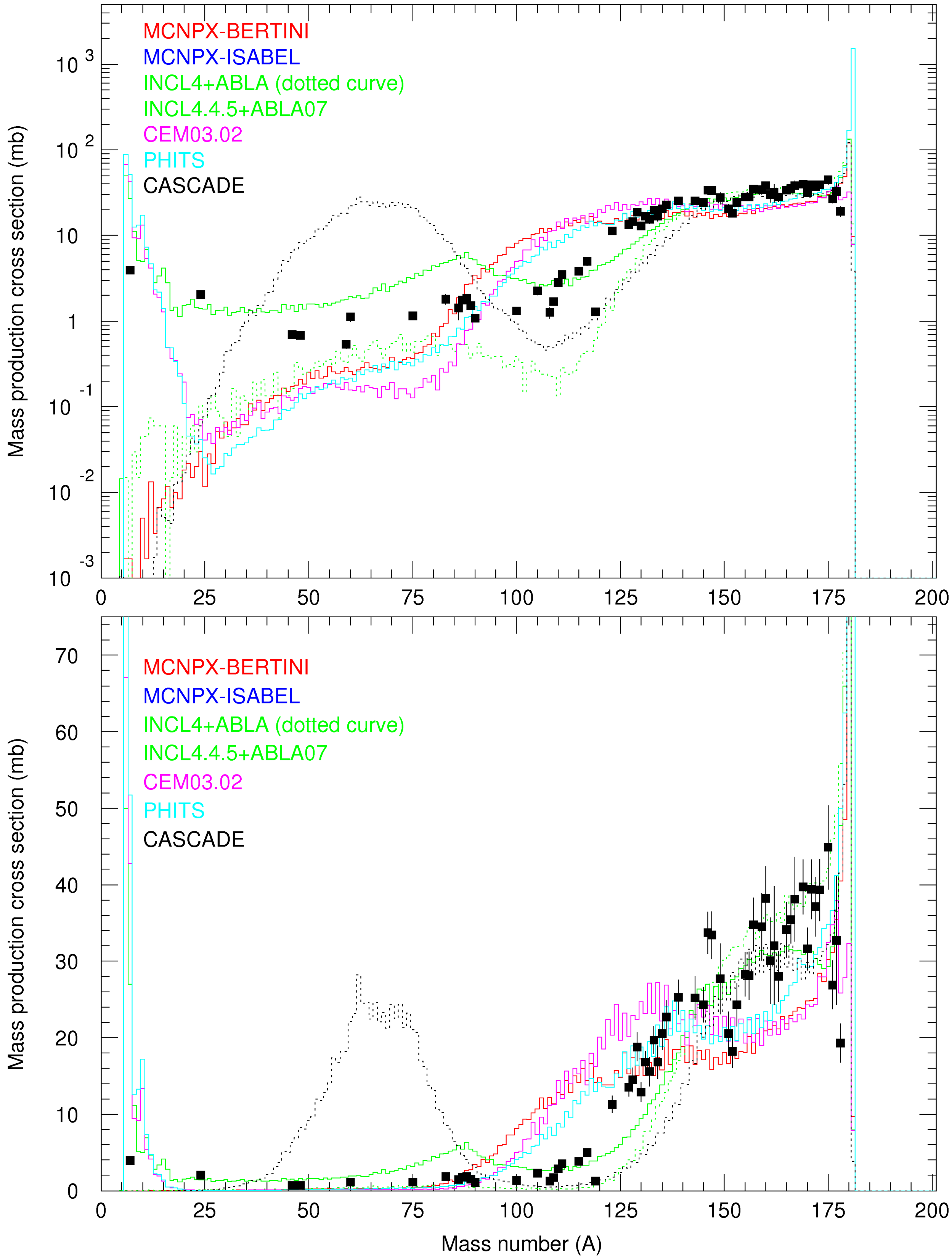

Fig. 7.110. The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{181}Ta irradiated with 1.6 GeV protons.

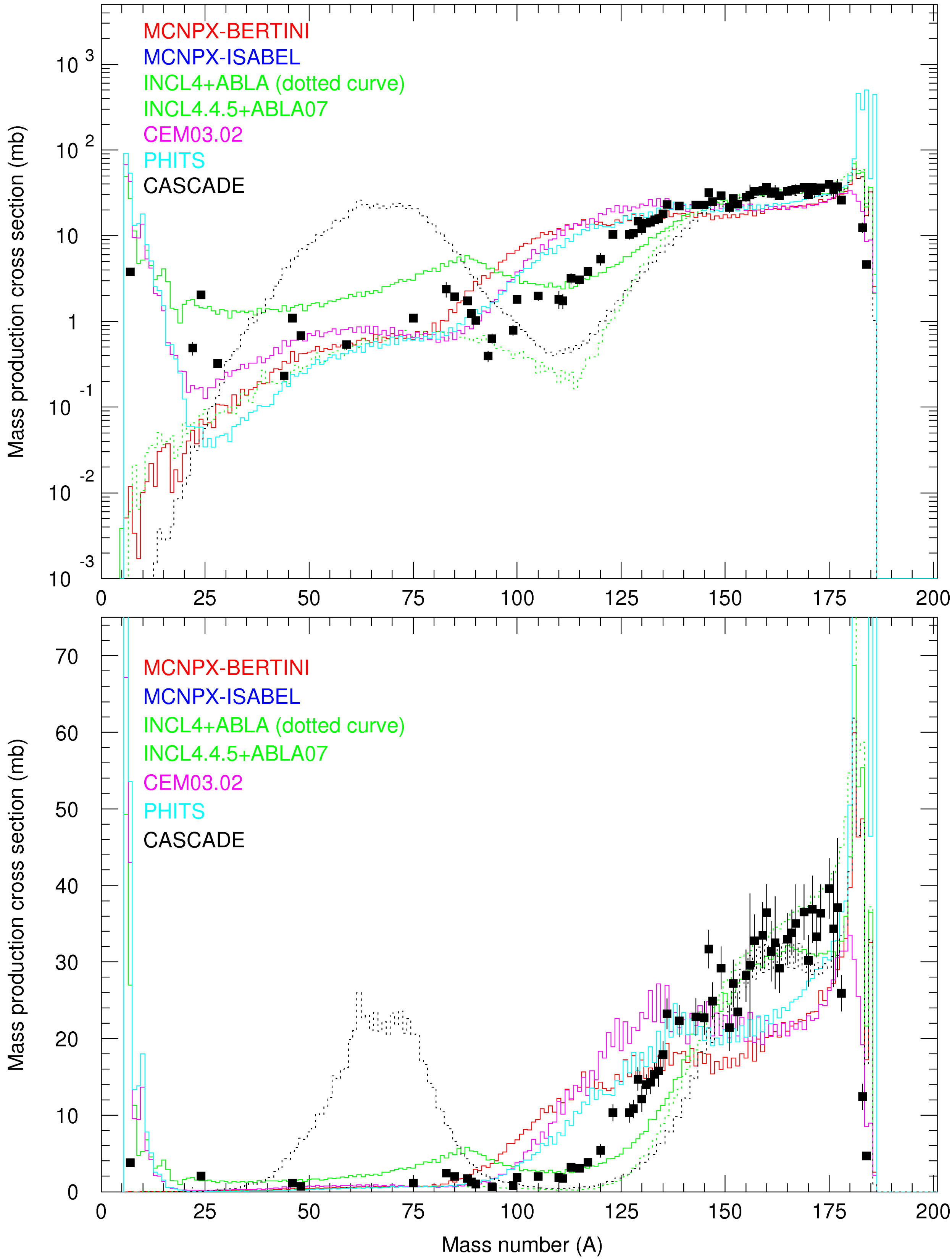

Fig. 7.111. The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{nat}W irradiated with 1.6 GeV protons.

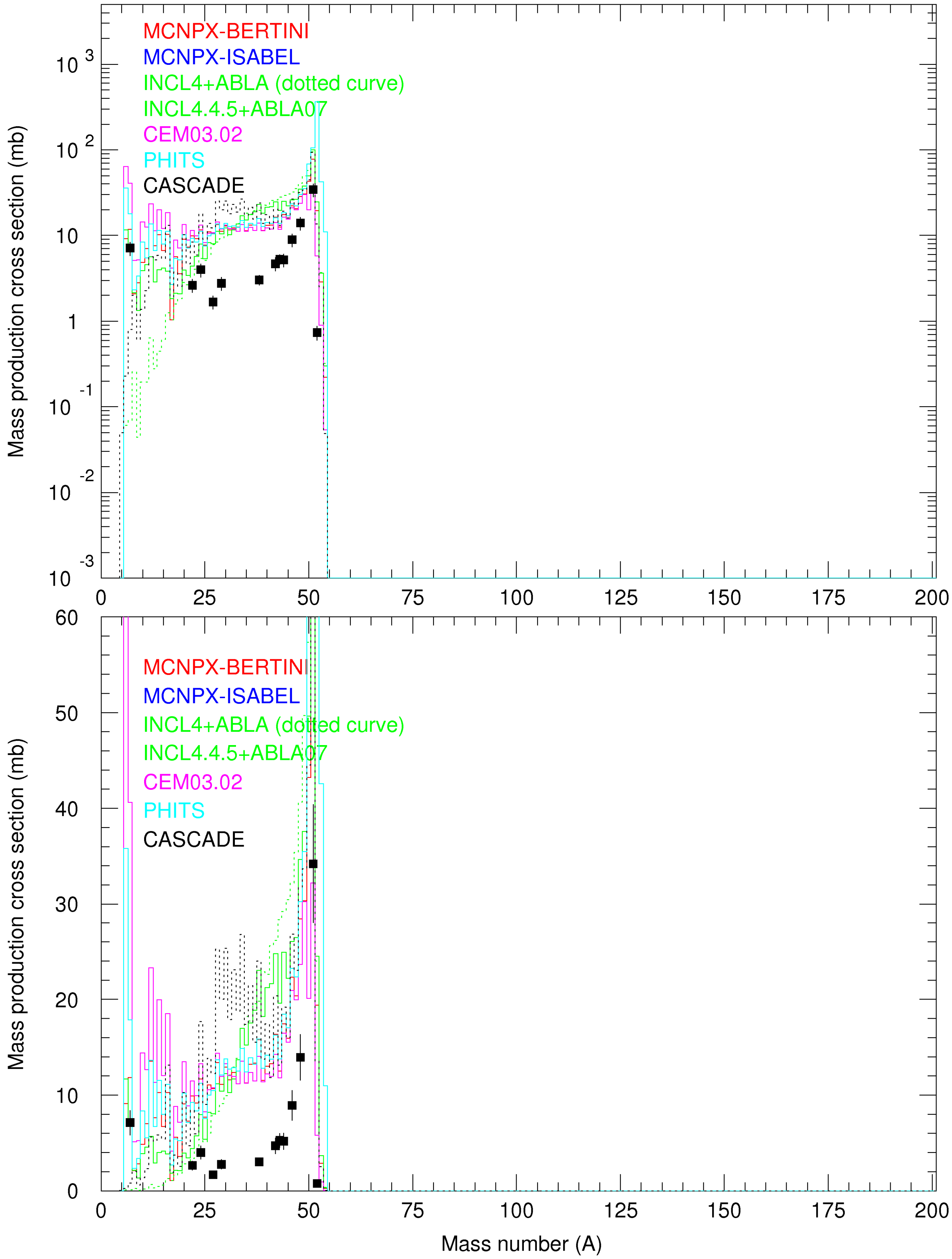

Fig. 7.112. The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{nat}Cr irradiated with 2.6 GeV protons.

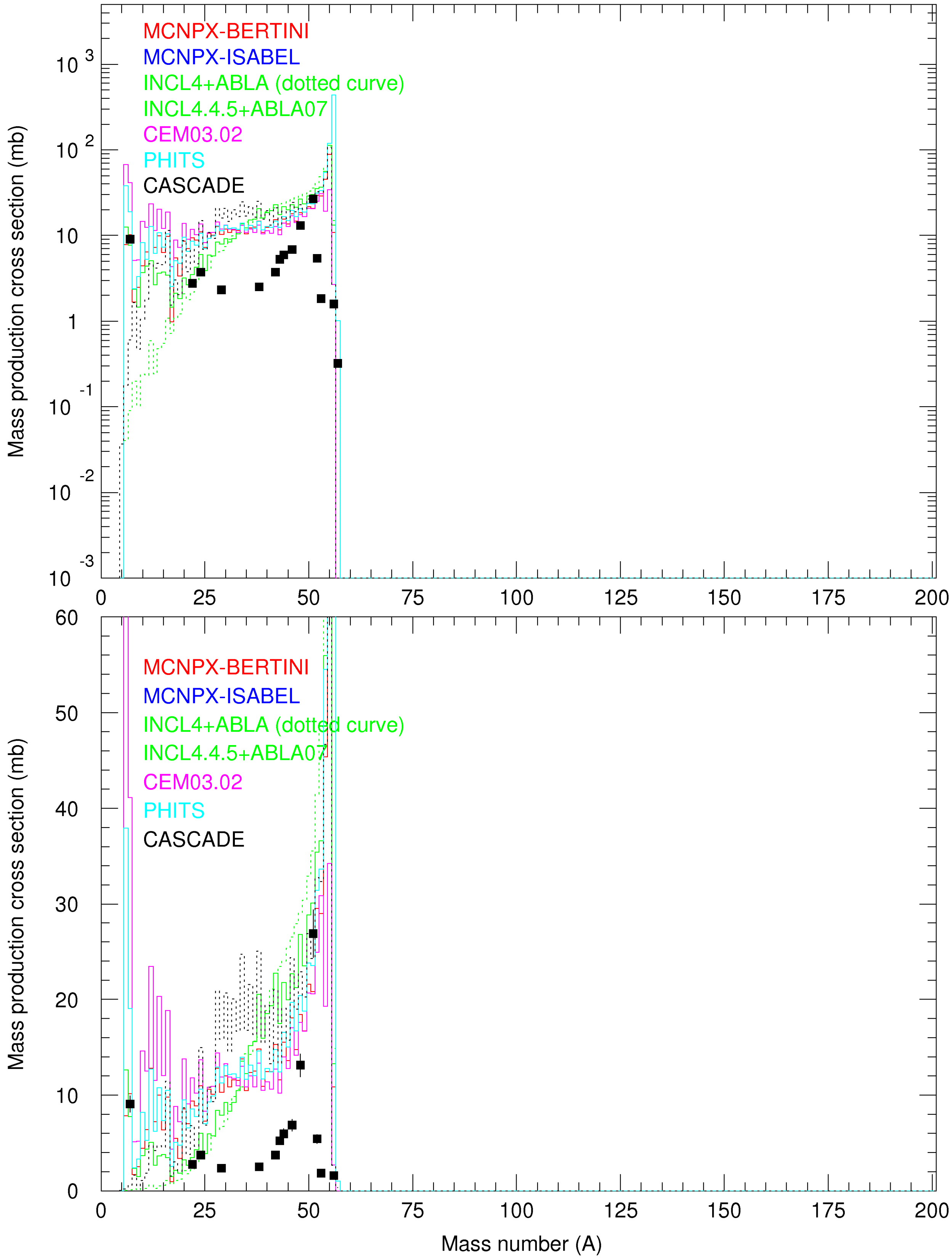

Fig. 7.113. The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{56}Fe irradiated with 2.6 GeV protons.

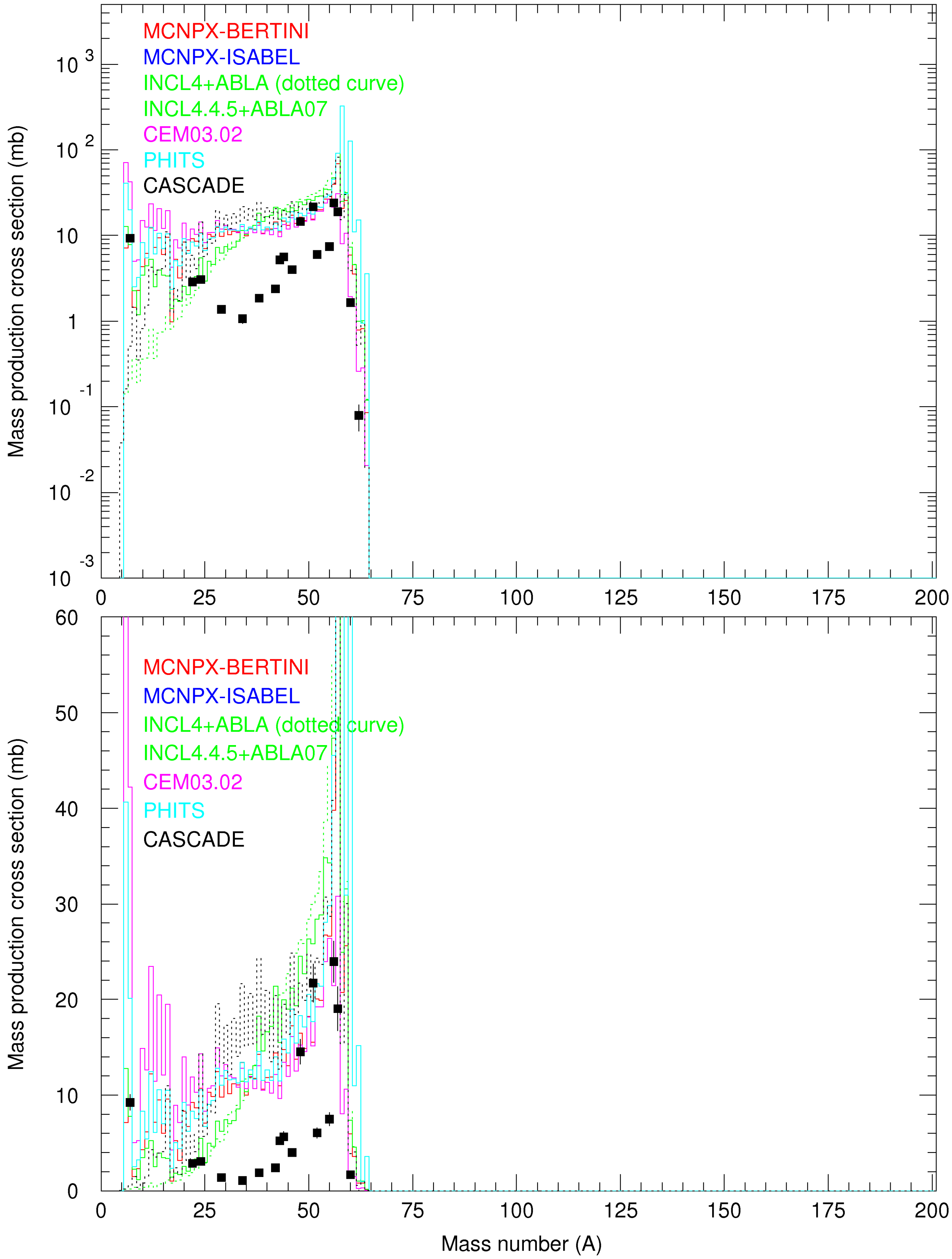

Fig. 7.114. The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{nat}Ni irradiated with 2.6 GeV protons.

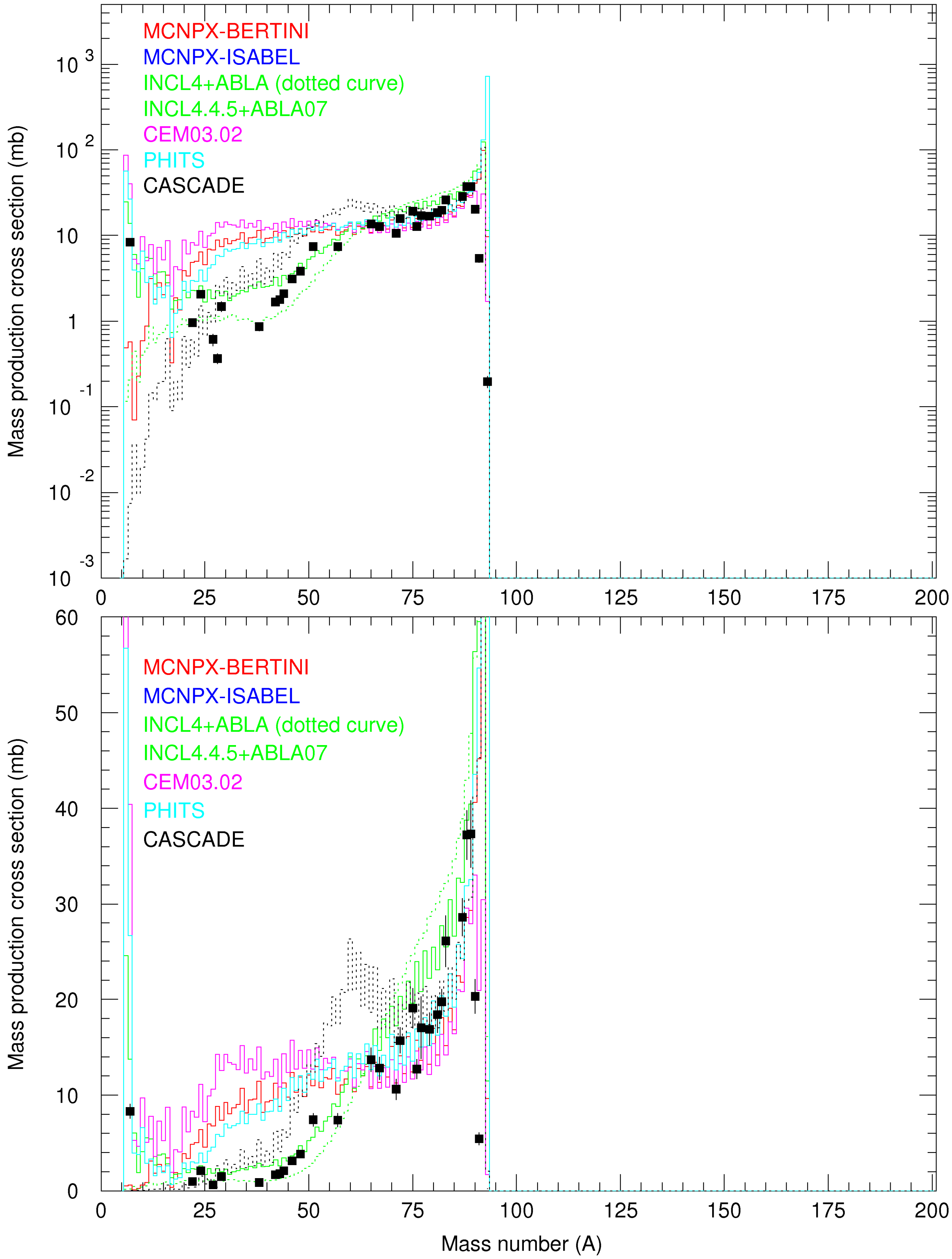

Fig. 7.115. The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{93}Nb irradiated with 2.6 GeV protons.

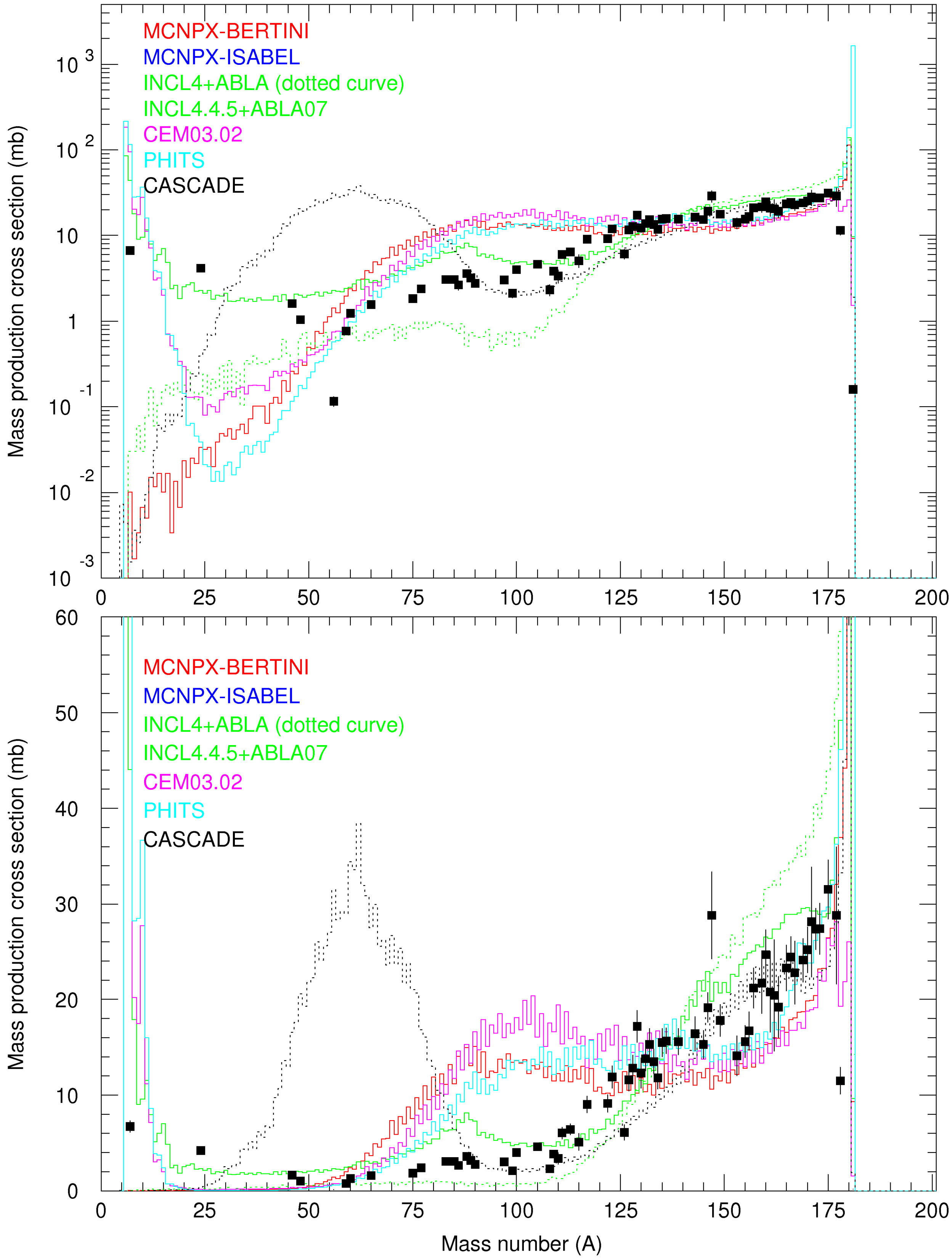

Fig. 7.116. The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{181}Ta irradiated with 2.6 GeV protons.

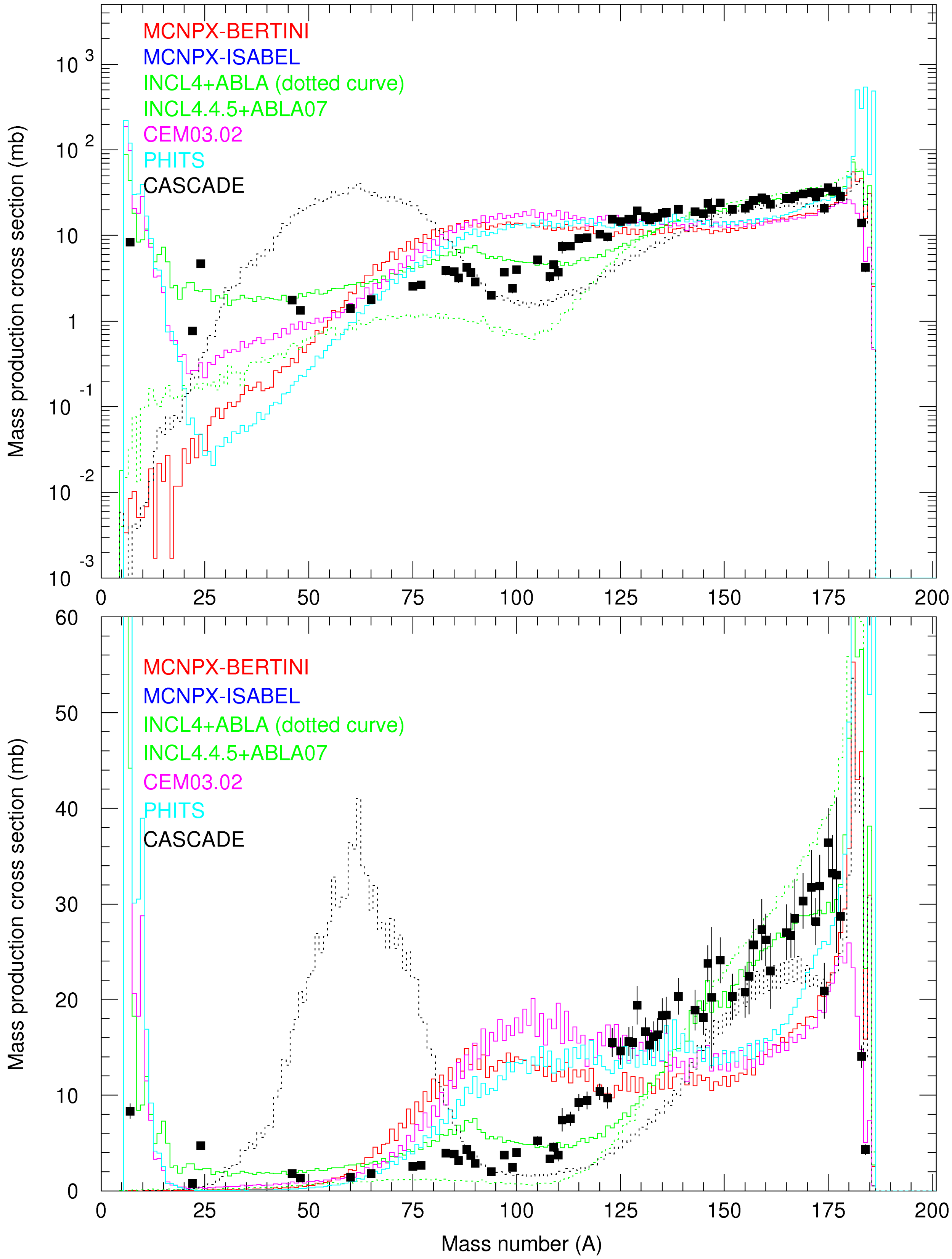

Fig. 7.117. The simulated mass distributions of reaction products together with the measured cumulative and supra-cumulative yields in ^{nat}W irradiated with 2.6 GeV protons.

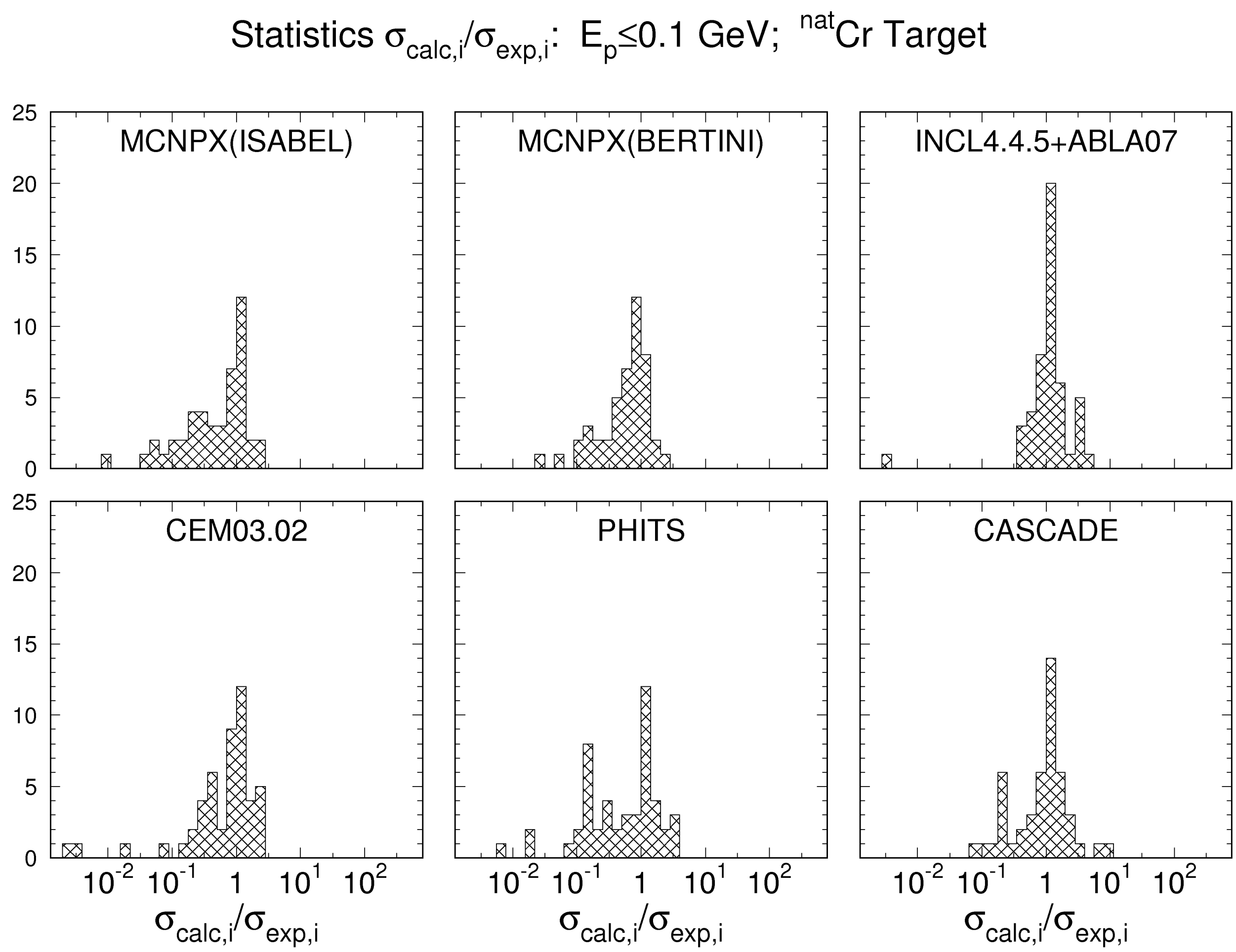

Fig. 7.118. Statistics of the simulation-to-experiment ratios for ^{nat}Cr irradiated by ≤0.1GeV protons.

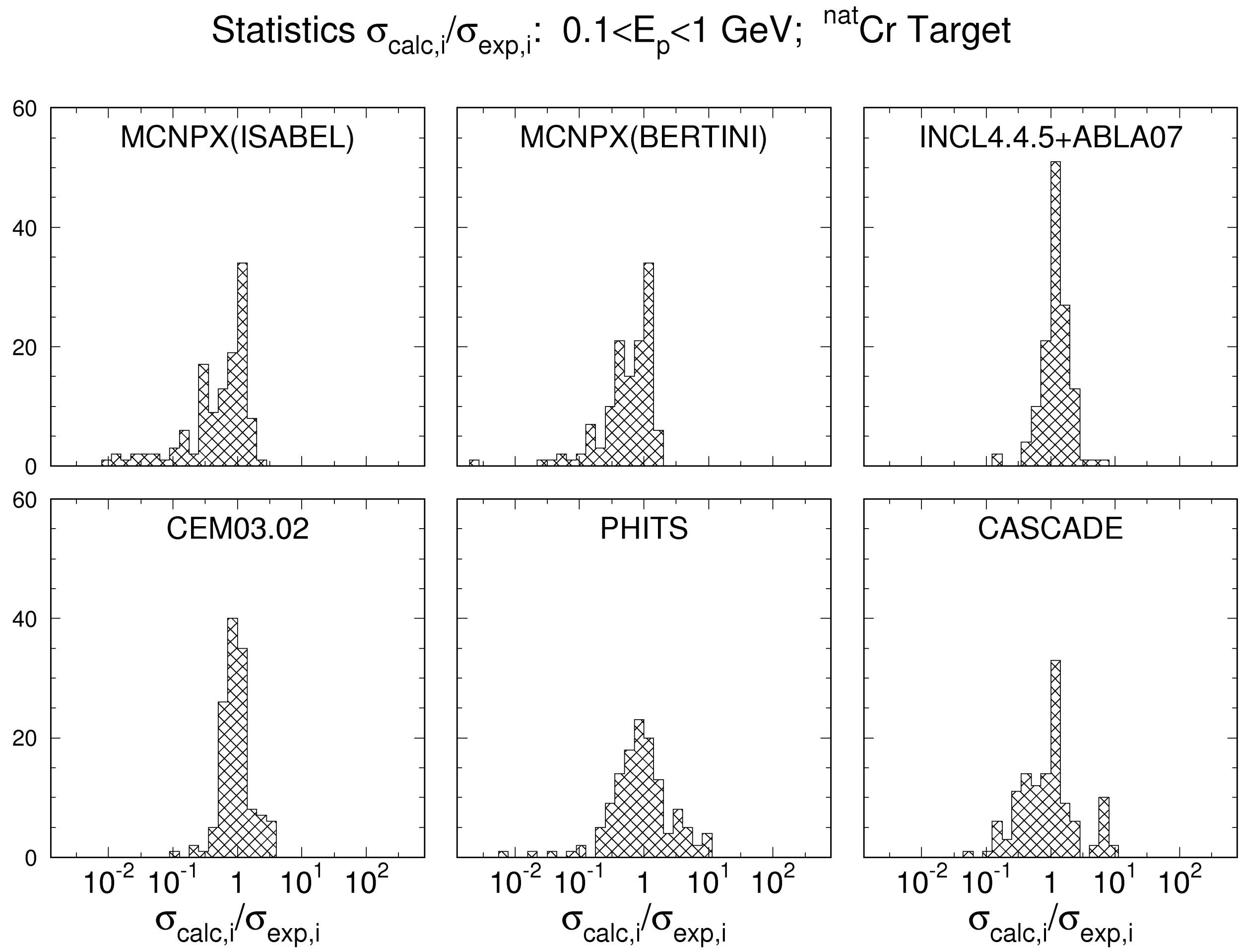

Fig. 7.119. Statistics of the simulation-to-experiment ratios for ^{nat}Cr irradiated by0.1<E_p <1GeV protons.

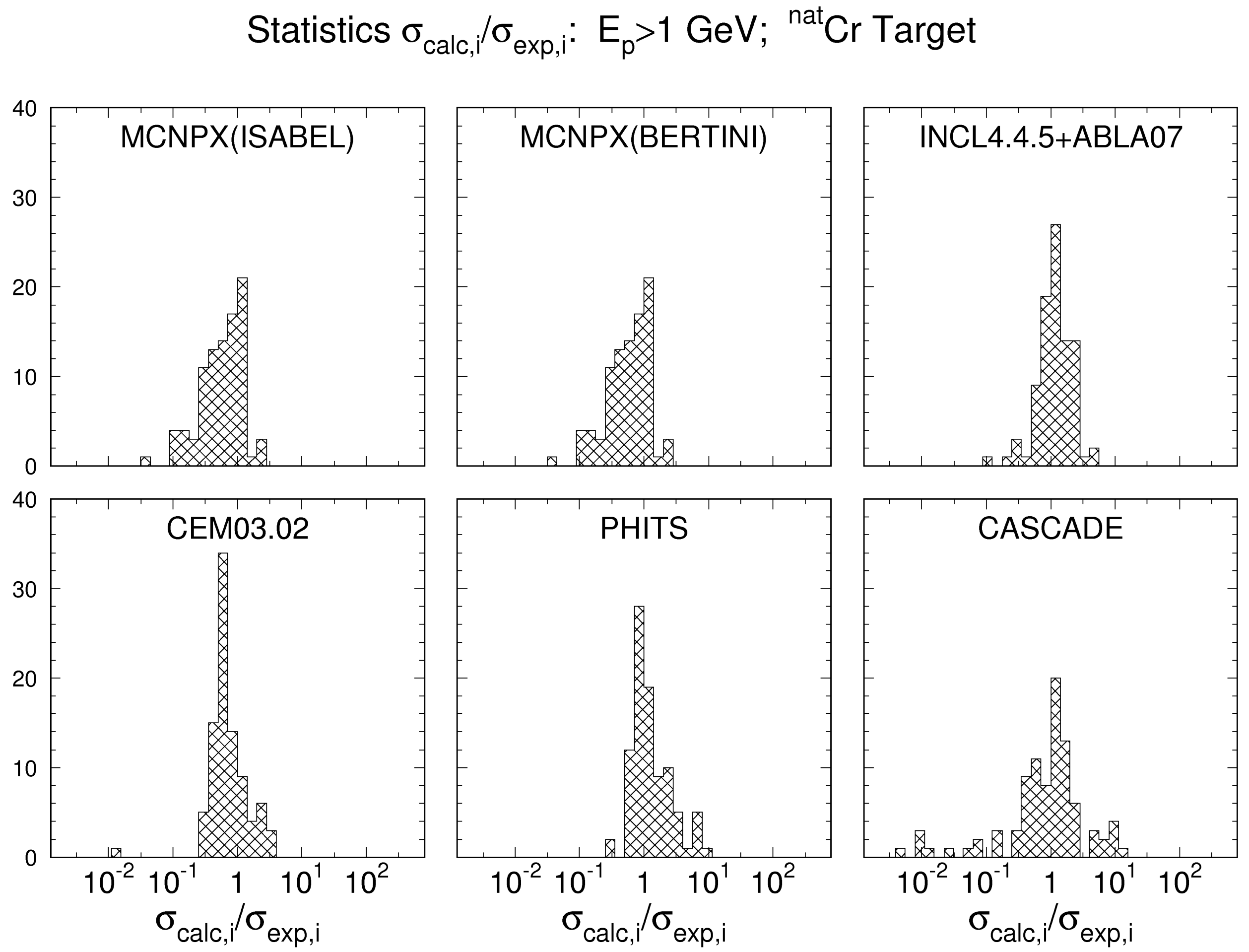

Fig. 7.120. Statistics of the simulation-to-experiment ratios for ^{nat}Cr irradiated by >1GeV protons.

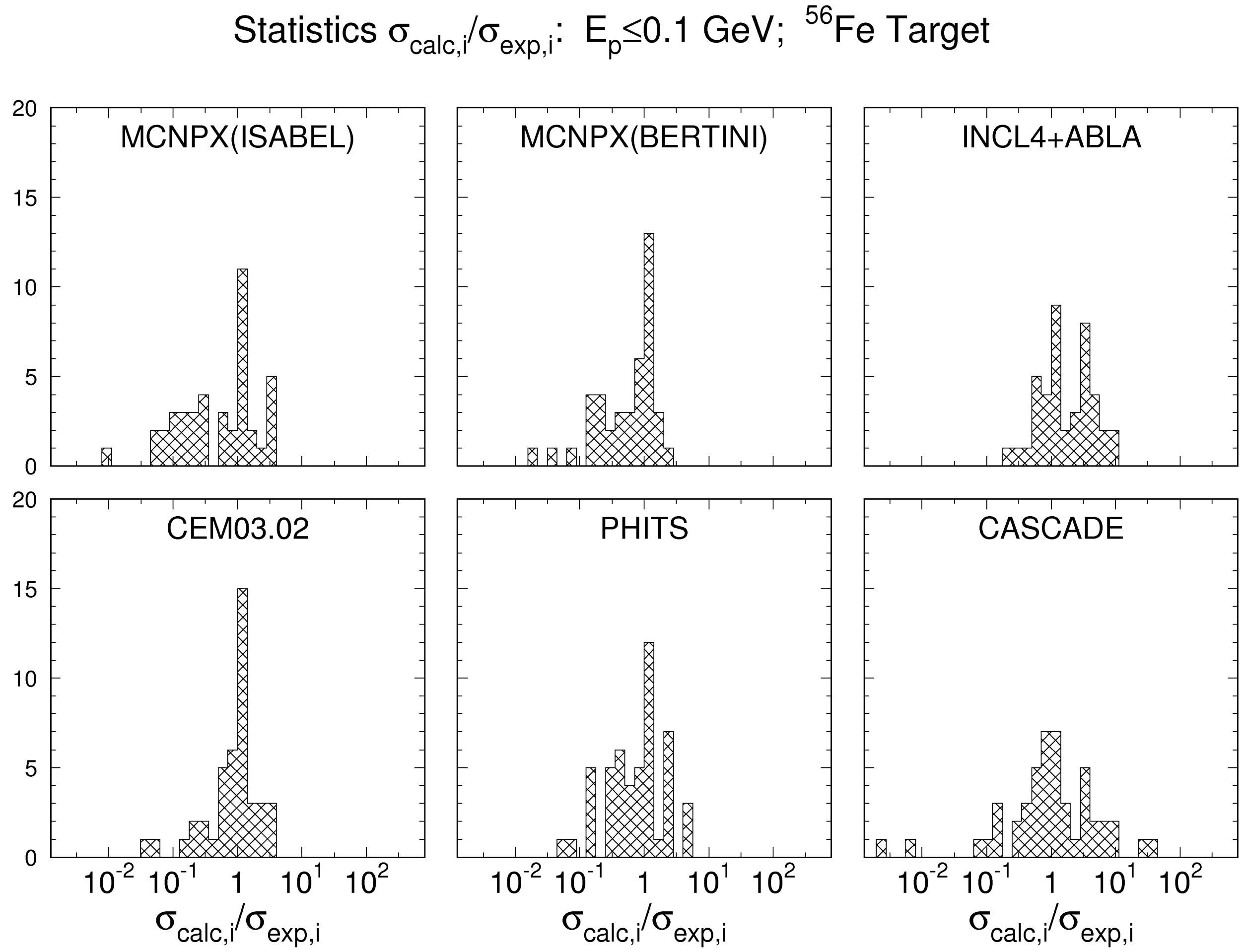

Fig. 7.121. Statistics of the simulation-to-experiment ratios for ^{56}Fe irradiated by ≤0.1GeV protons.

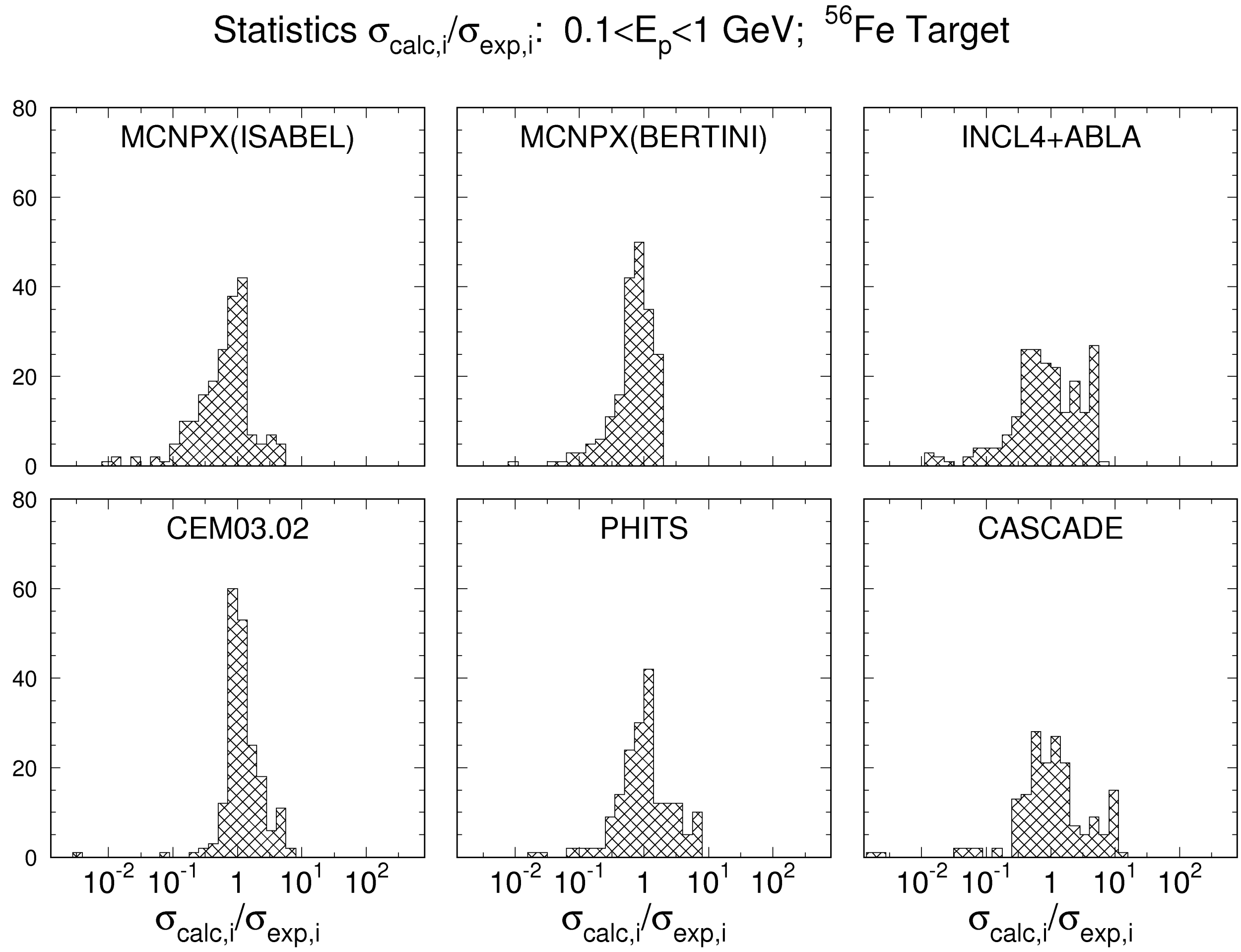

Fig. 7.122. Statistics of the simulation-to-experiment ratios for ^{56}Fe irradiated by $0.1<E_p<1$GeV protons

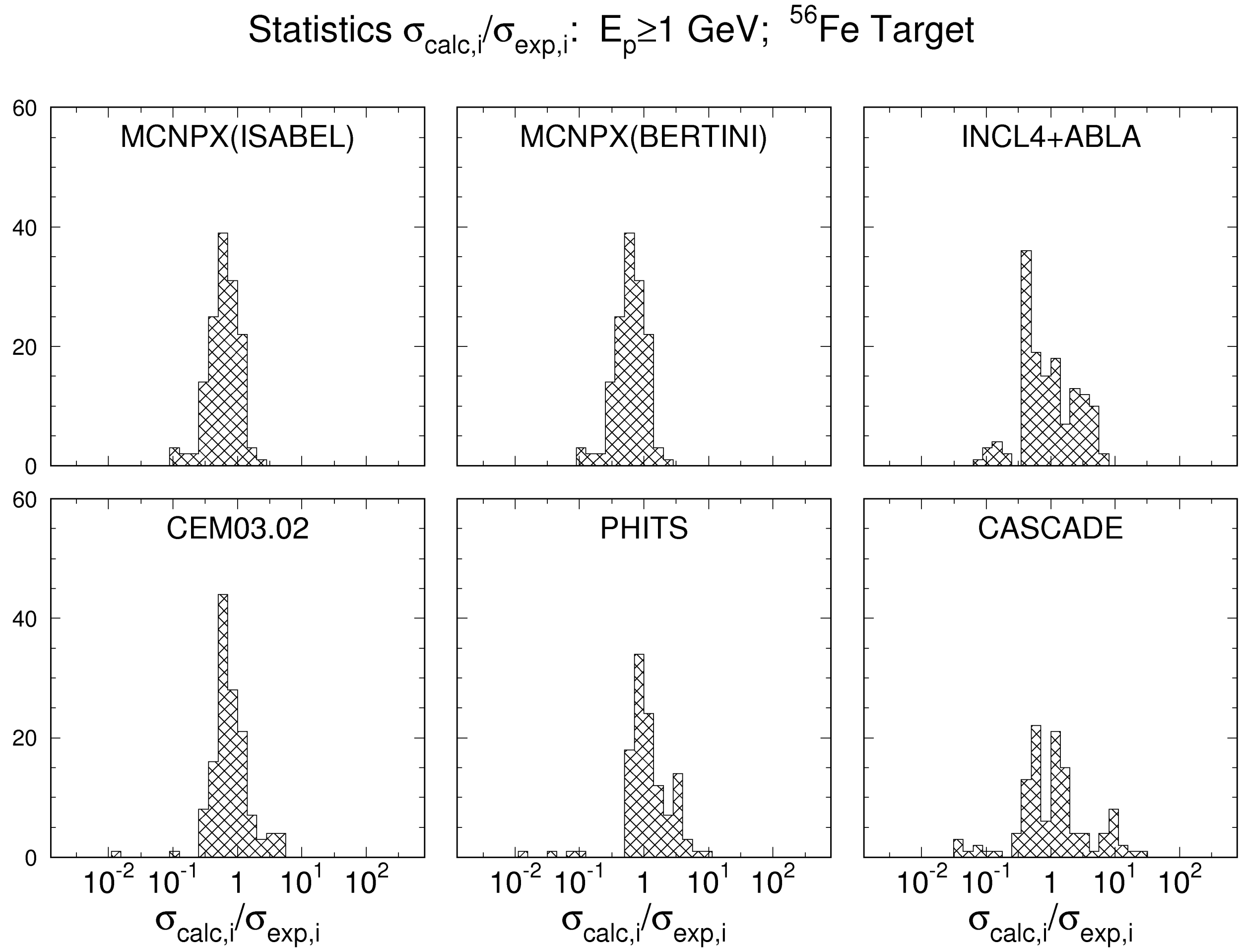

Fig. 7.123. Statistics of the simulation-to-experiment ratios for ^{56}Fe irradiated by ≥1GeV protons.

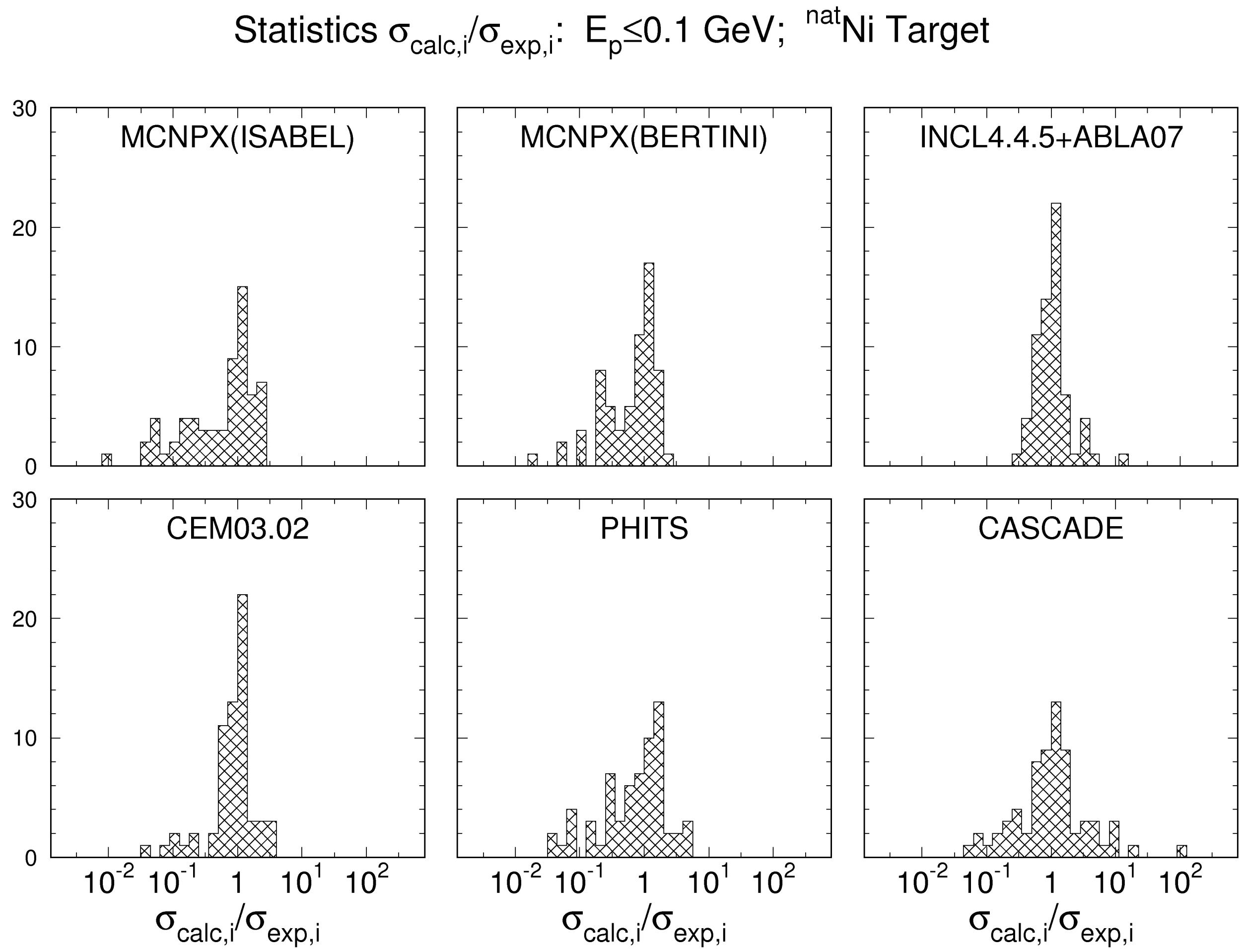

Fig. 7.124. Statistics of the simulation-to-experiment ratios for ^{nat}Cr irradiated by ≤0.1GeV protons.

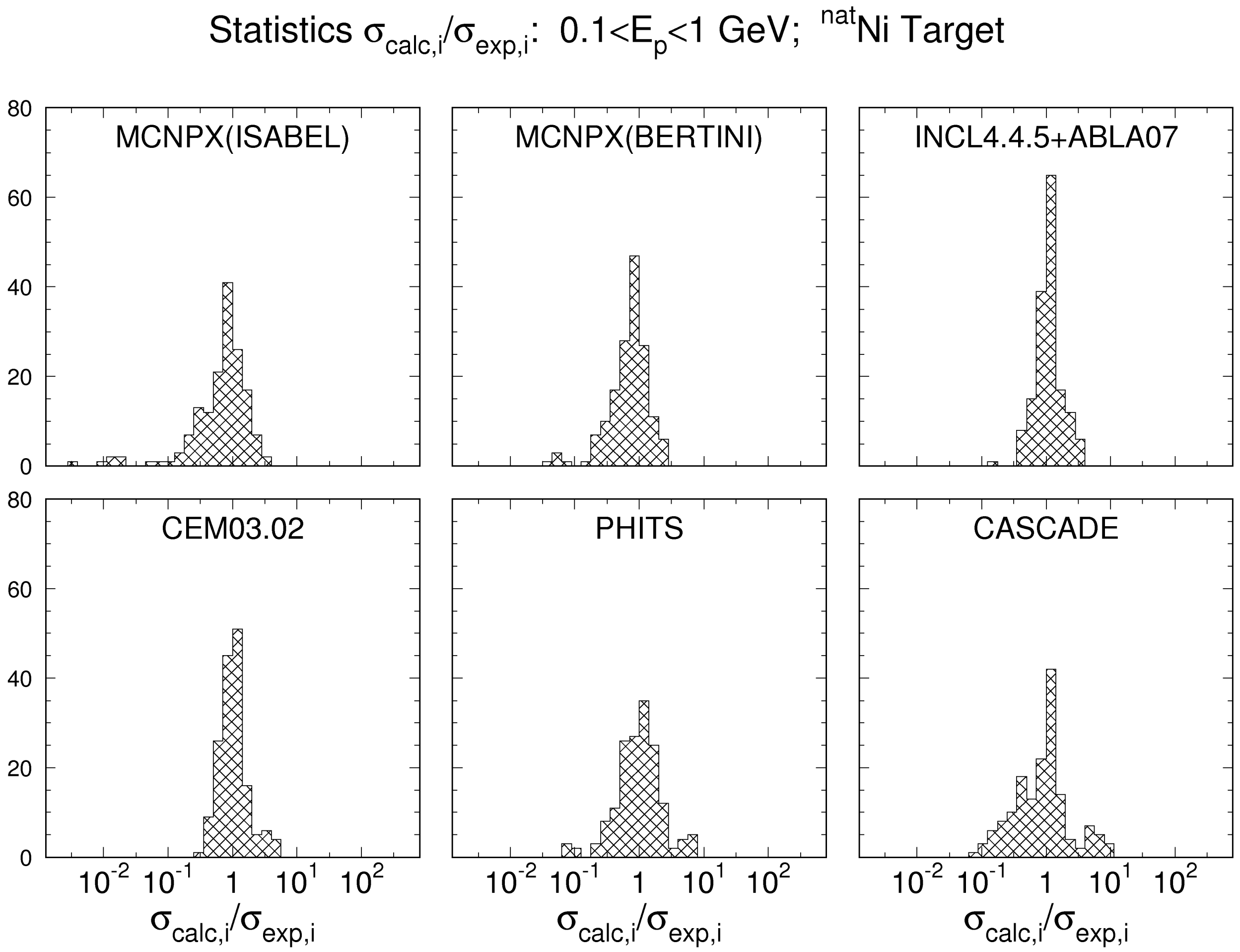

Fig. 7.125. Statistics of the simulation-to-experiment ratios for ^{nat}Ni irradiated by 0.1<E_p <1GeV protons.

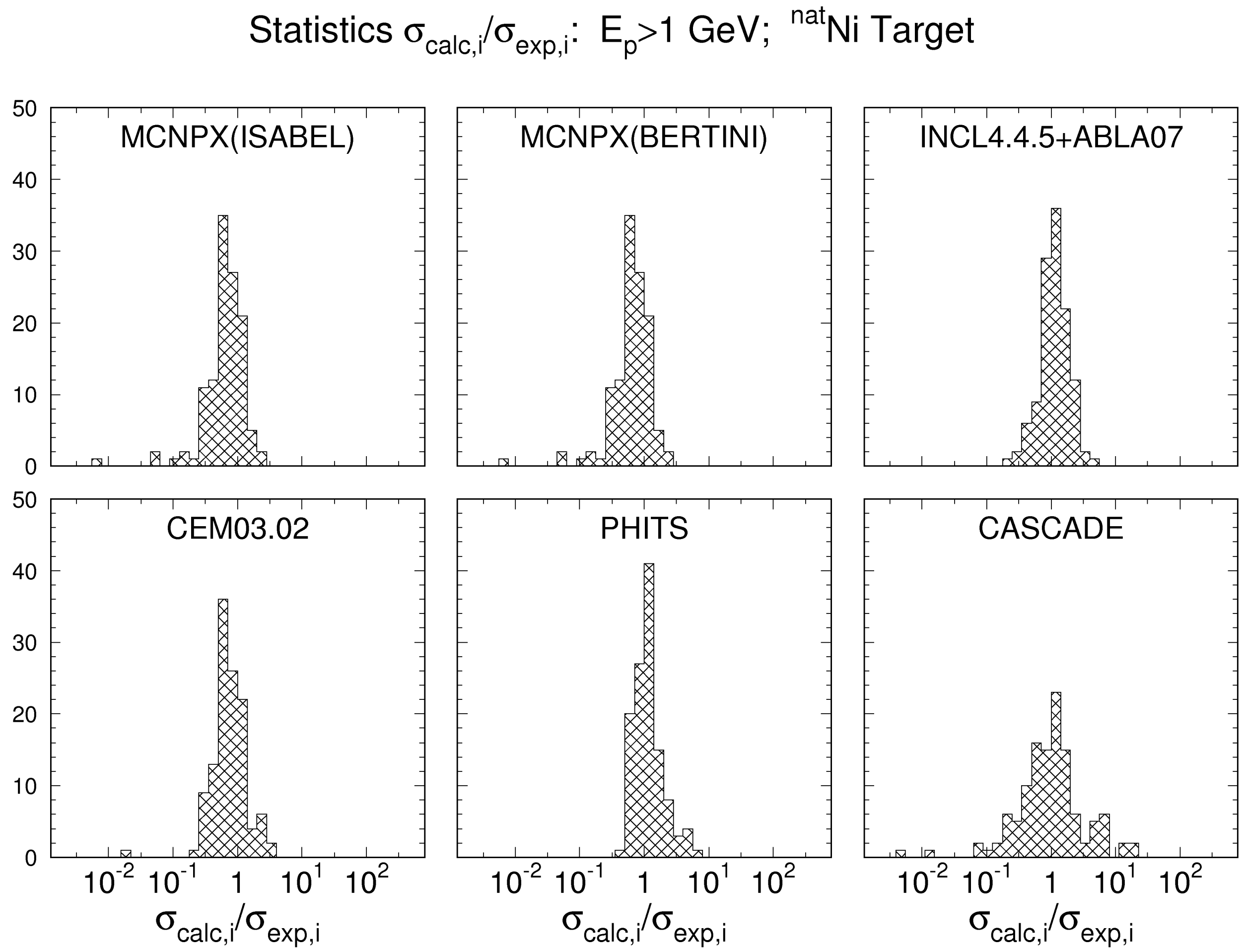

Fig. 7.126. Statistics of the simulation-to-experiment ratios for ${}^{nat}Ni$ irradiated by >1GeV protons.

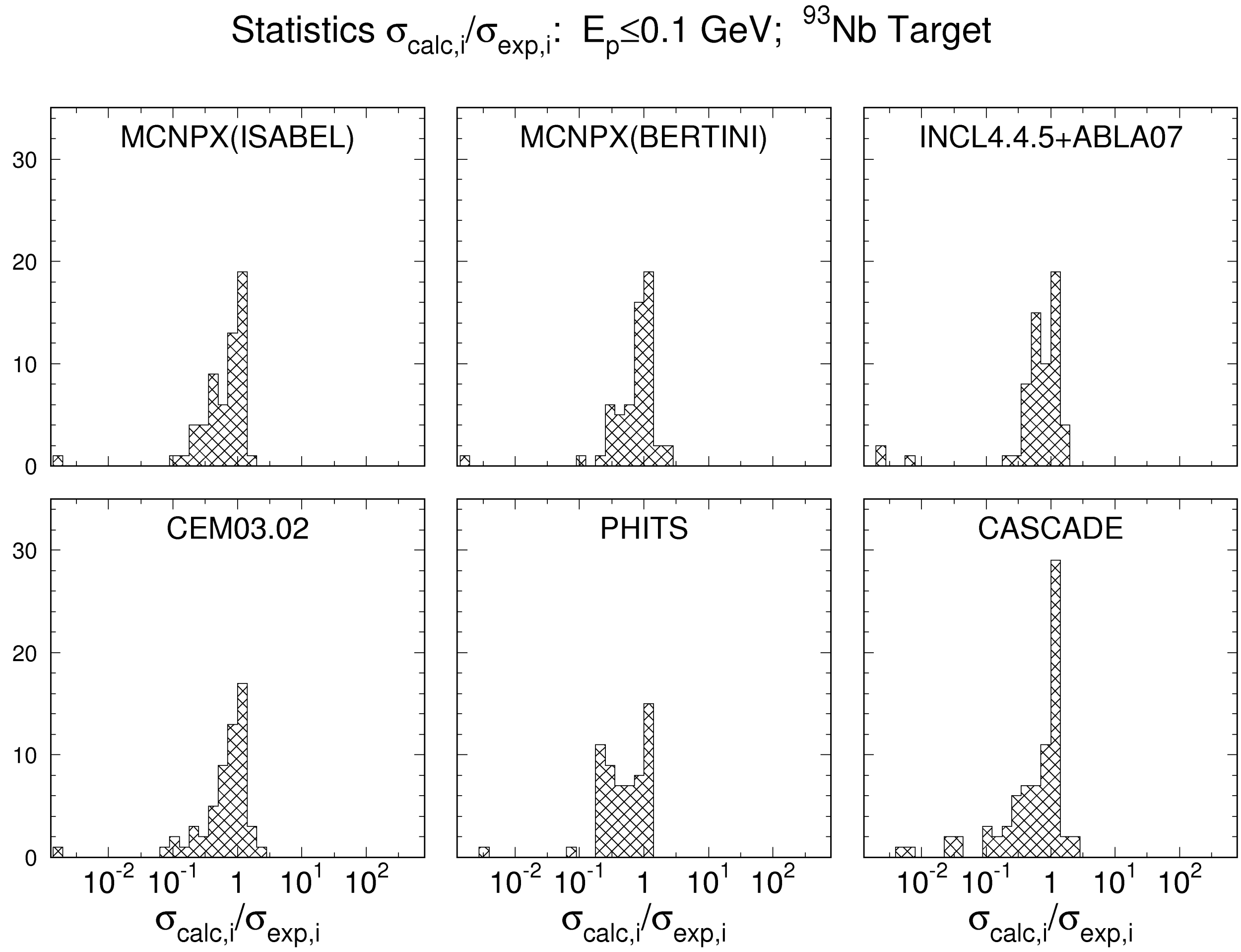

Fig. 7.127. Statistics of the simulation-to-experiment ratios for ^{93}Nb irradiated by ≤0.1GeV protons.

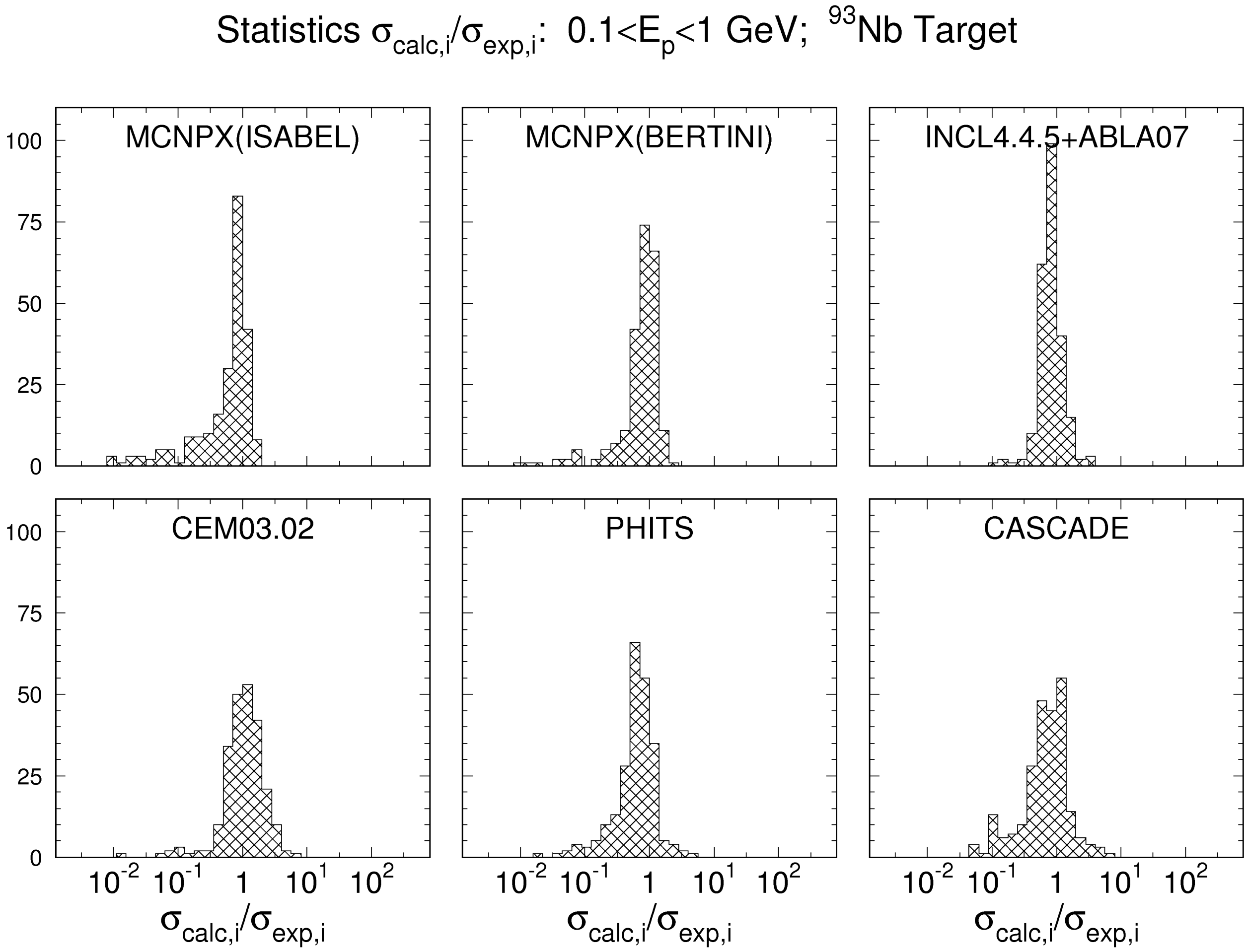

Fig. 7.128. Statistics of the simulation-to-experiment ratios for ^{93}Nb irradiated by $0.1<E_p<1$GeV protons.

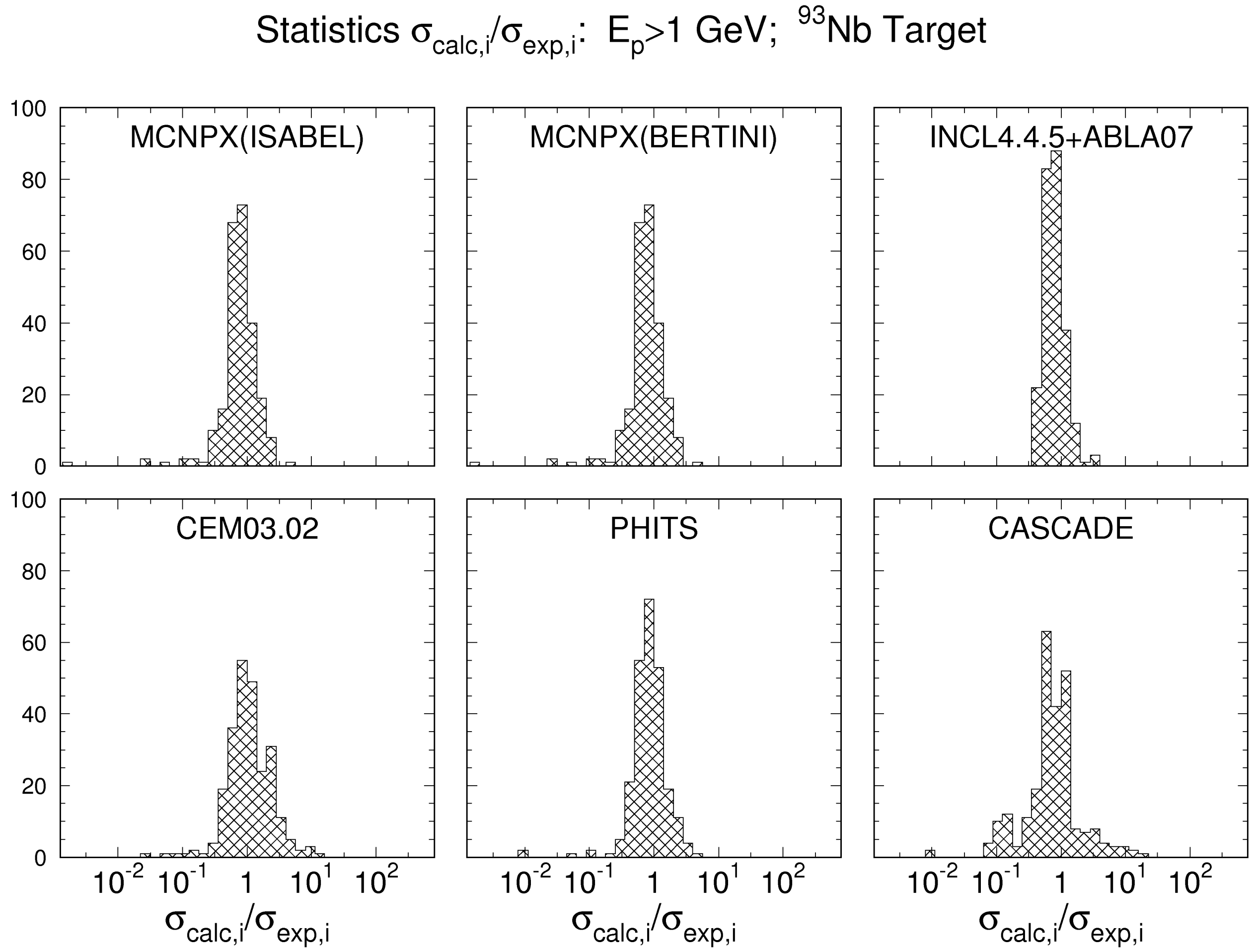

Fig. 7.129. Statistics of the simulation-to-experiment ratios for ^{93}Nb irradiated by >1GeV protons.

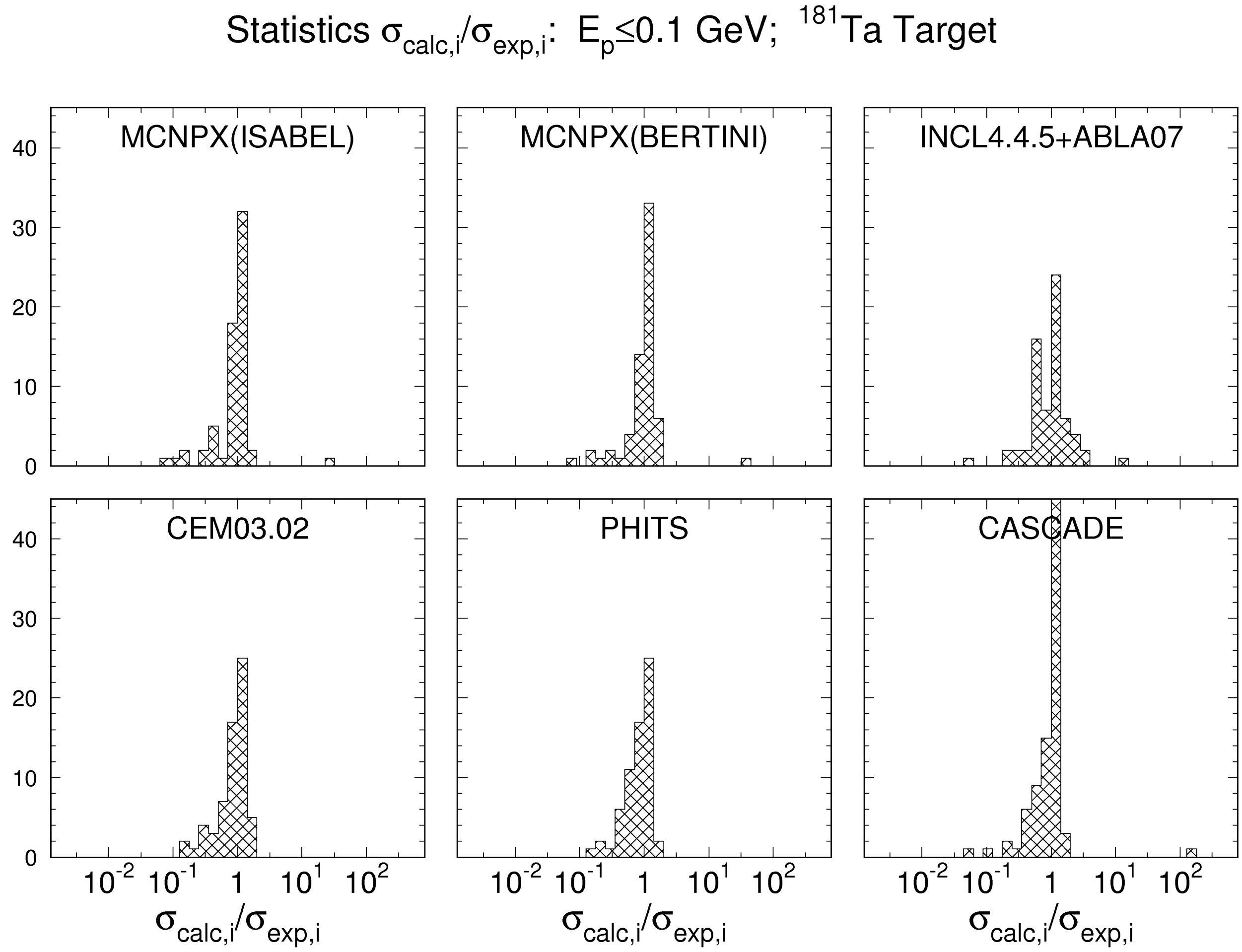

Fig. 7.130. Statistics of the simulation-to-experiment ratios for ^{181}Ta irradiated by ≤0.1GeV protons.

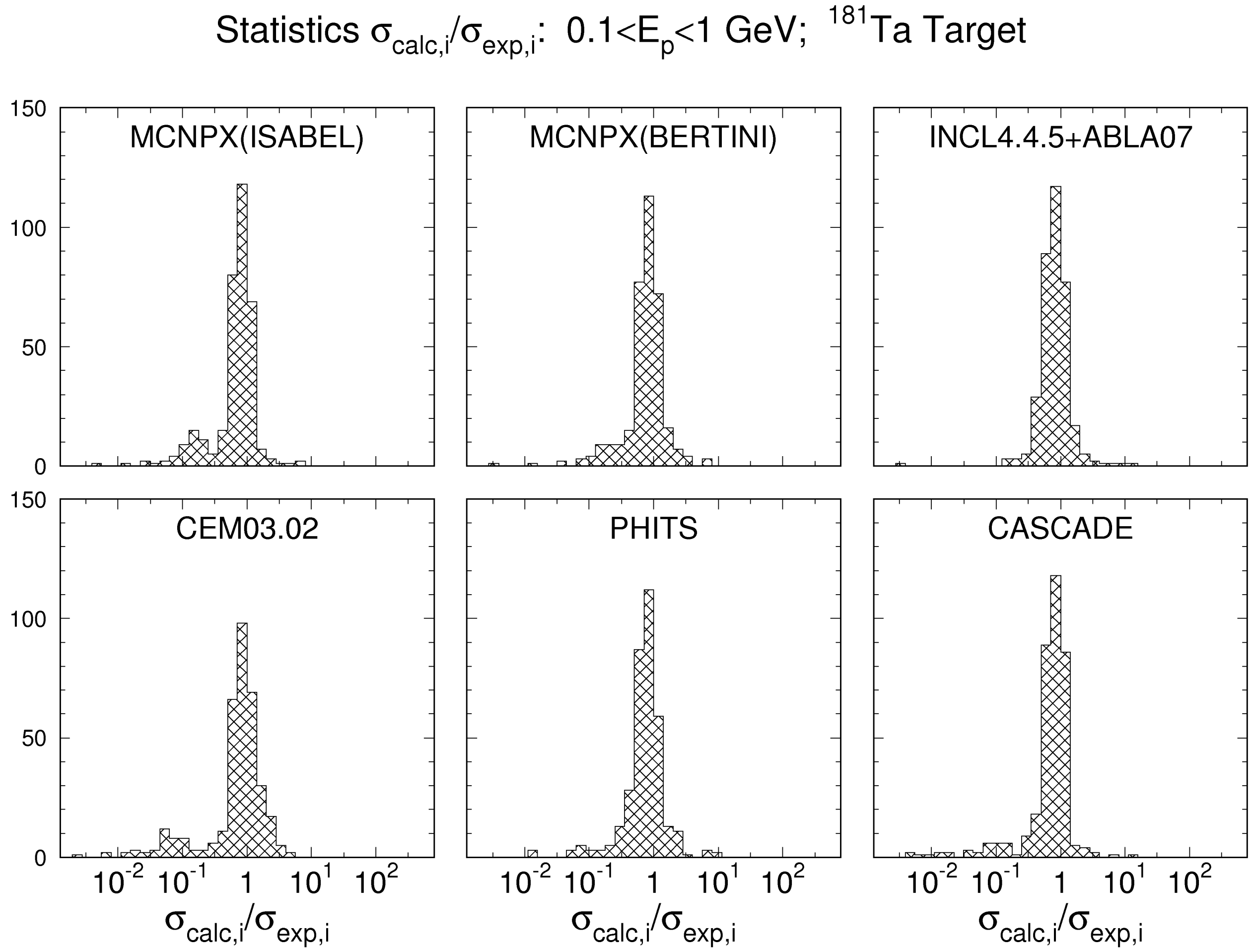

Fig. 7.131. Statistics of the simulation-to-experiment ratios for ^{181}Ta irradiated by $0.1<E_p<1$GeV protons.

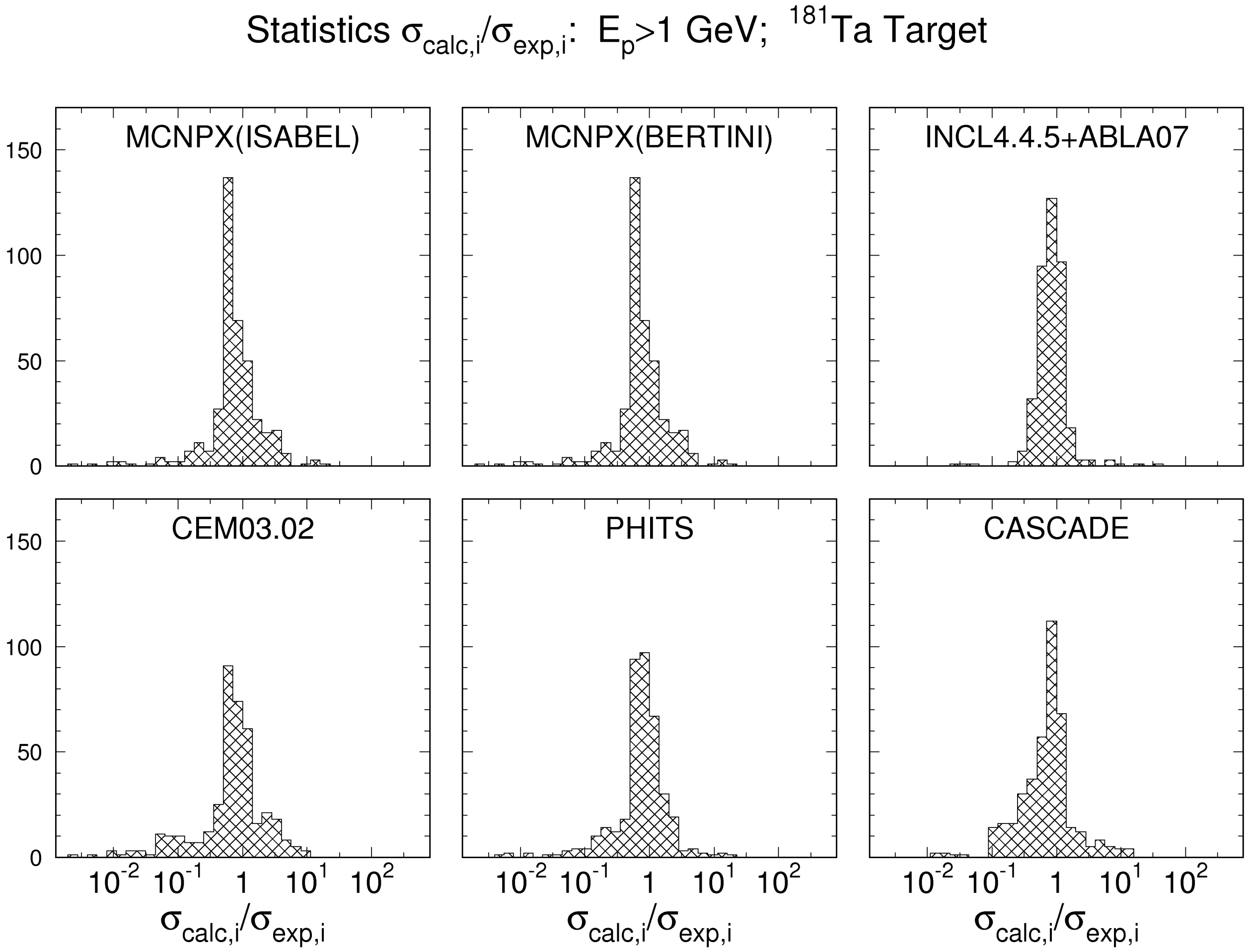

Fig. 7.132. Statistics of the simulation-to-experiment ratios for ^{181}Ta irradiated by >1GeV protons.

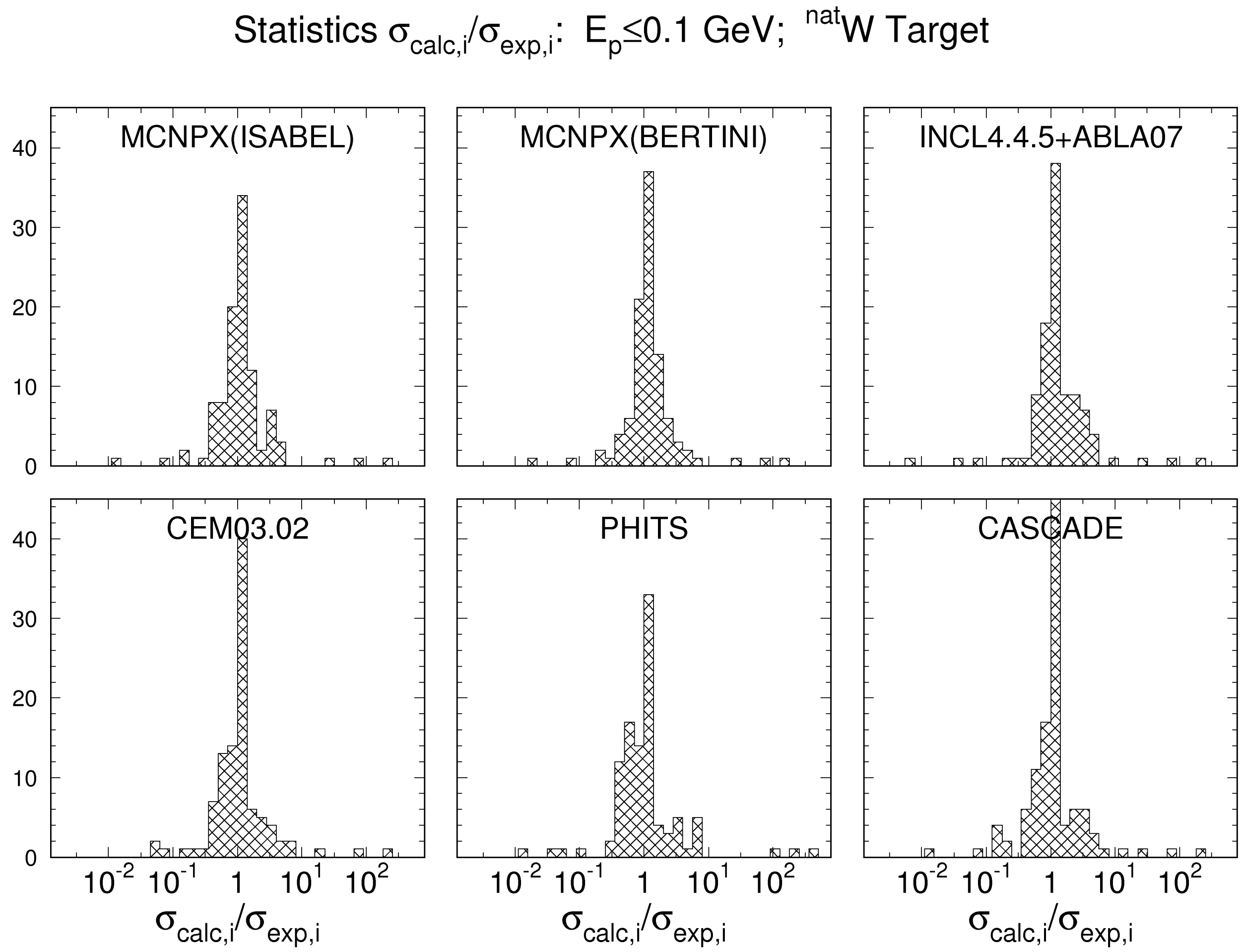

Fig. 7.133. Statistics of the simulation-to-experiment ratios for ^{nat}W irradiated by ≤0.1GeV protons.

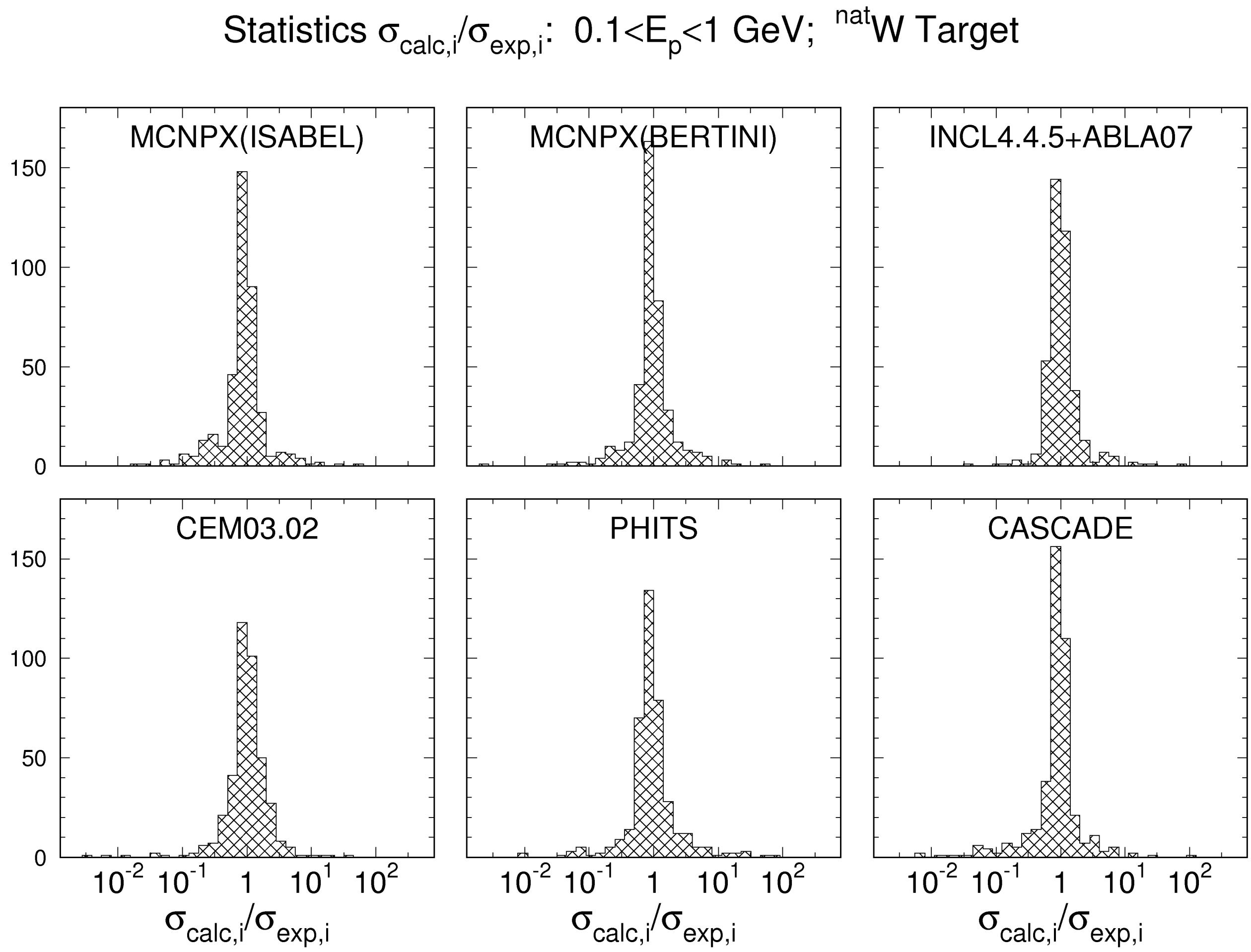

Fig. 7.134. Statistics of the simulation-to-experiment ratios for ^{nat}W irradiated by0.1< E_p <1GeV protons.

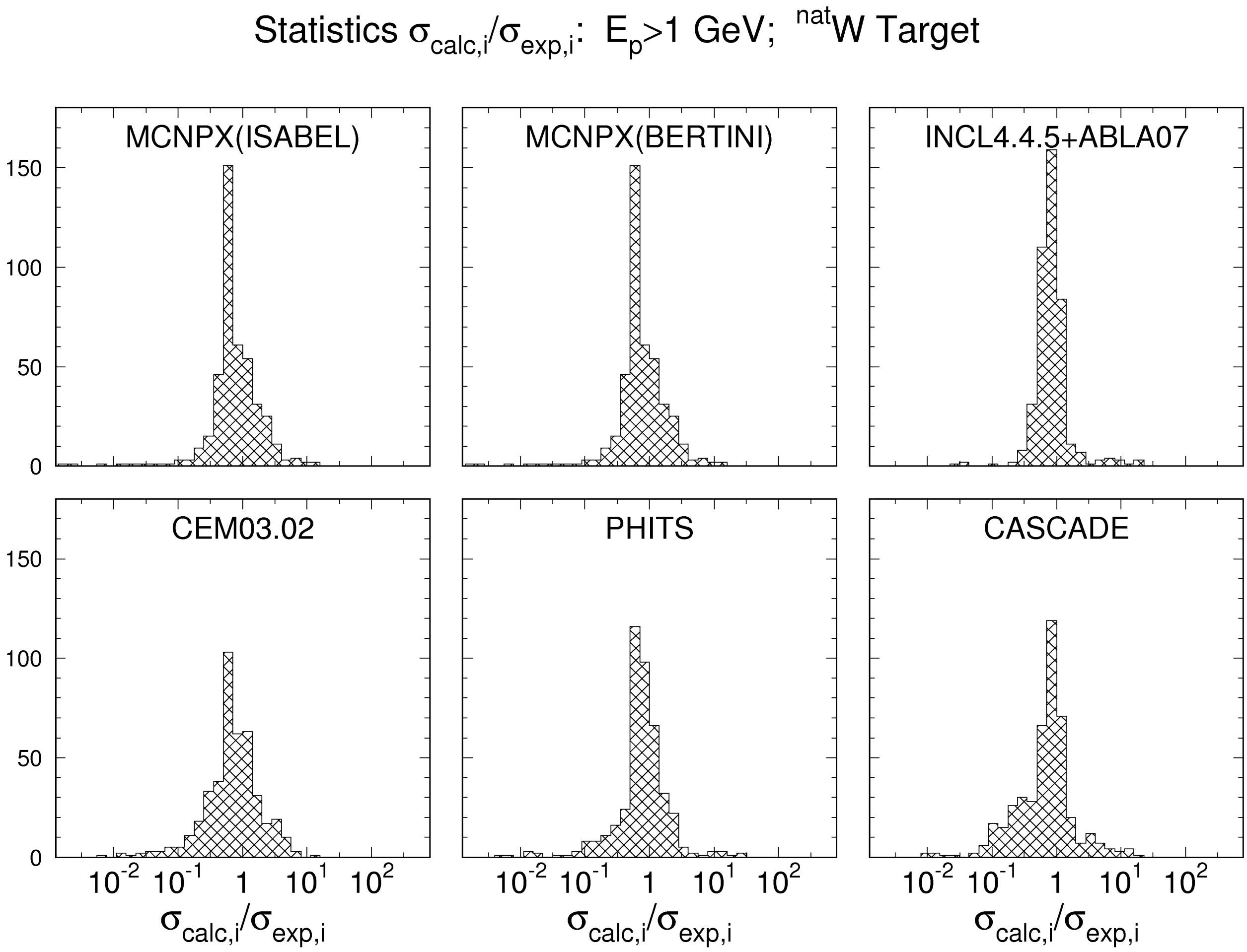

Fig. 7.135. Statistics of the simulation-to-experiment ratios for ^{nat}W irradiated by >1GeV protons.

8. CONCLUSION AND ACKNOWLEGEMENT

During 2006-2009 we made 57 irradiations of 97 samples made of ADS structure materials of both monoisotopic (^{56}Fe, ^{93}Nb, ^{181}Ta) and natural (^{nat}Cr, ^{nat}Ni, ^{nat}W) compositions by protons with energies 0.04 GeV, 0.07 GeV, 0.1 GeV, 0.15 GeV. 0.25 GeV, 0.4 GeV, 0.6 GeV, 0.8 GeV, 1.2 GeV, 1.6 GeV and 2.6 GeV[3].

The ITEP U-10 synhrotron was used to irradiate the targets. In total, 1841 gamma- and 25 alpha-specra were measured after irradiations which carry *unique experimental data* of about 263 Mb capacity. After the measured gamma had been identified, 3839 *independent and cumulative yields (cross-section for production) of residual radioactive product nuclei in the irradiated* samples were determined, of which 719 are independent (signed as (i)) yields; 363 sums of independent metastable and the ground state yields (i (Σmj+g)); 343 independent yields of a metastable states (i (Σmj); 2408 cumulative and supracumulative yields (c, c*). The quantities of different types of measured yields in each experiment are presented in Table 8.1.

Table 8.1

Quantities of different types of measured yields in each experiment.

Experiment		Yeld type (measured)						Total
		c*	C	i	i(m+g)	i(m)	i(m1+m2+g)	
^{nat}Cr	E_p=0.04 GeV	-	6	5	2	2	-	15
^{56}Fe	E_p=0.04 GeV	1	8	6	1	1	-	17
^{nat}Ni	E_p=0.04 GeV	1	12	4	2	1	-	20
^{93}Nb	E_p=0.04 GeV	-	10	2	3	4	-	19
^{181}Ta	E_p=0.04 GeV	2	1	4	-	2	-	9
^{nat}W	E_p=0.04 GeV	1	7	6	1	3	1	19
^{nat}Cr	E_p=0.07 GeV	-	7	6	2	2	-	17
^{56}Fe	E_p=0.07 GeV	1	9	7	2	2	-	21
^{nat}Ni	E_p=0.07 GeV	1	13	5	2	1	-	22
^{93}Nb	E_p=0.07 GeV	1	16	2	3	6	-	28
^{181}Ta	E_p=0.07 GeV	2	6	7	-	2	-	17
^{nat}W	E_p=0.07 GeV	2	12	11	1	4	1	31
^{nat}Cr	E_p=0.1 GeV	-	9	6	2	2	-	19
^{56}Fe	E_p=0.1 GeV	1	11	8	2	2	-	24
^{nat}Ni	E_p=0.1 GeV	1	14	6	4	2	-	27
^{93}Nb	E_p=0.1 GeV	1	21	2	4	9	-	37
^{181}Ta	E_p=0.1 GeV	2	15	10	2	2	-	31
^{nat}W	E_p=0.1 GeV	3	20	13	2	5	1	44
^{nat}Cr	E_p=0.15 GeV	-	11	8	3	3	-	25
^{56}Fe	E_p=0.15 GeV	1	12	8	2	2	-	25
^{nat}Ni	E_p=0.15 GeV	1	15	6	4	2	-	28
^{93}Nb	E_p=0.15 GeV	1	28	3	4	10	-	46
^{181}Ta	E_p=0.15 GeV	4	20	10	3	3	-	40

[3] ^{56}Fe was additionally irradiated by 0.3, 0.5, 0.75, 1.0 and 1.5 GeV protons.

^{nat}W	E_p=0.15 GeV	4	26	14	3	5	1	53
^{nat}Cr	E_p=0.25 GeV	-	14	8	3	3	-	28
^{56}Fe	E_p=0.25 GeV	1	17	10	2	3	-	33
^{nat}Ni	E_p=0.25 GeV	1	19	10	4	3	-	37
^{93}Nb	E_p=0.25 GeV	1	36	5	6	10	-	58
^{181}Ta	E_p=0.25 GeV	5	29	11	4	4	-	53
^{nat}W	E_p=0.25 GeV	5	35	19	4	5	1	69
^{nat}Cr	E_p=0.4 GeV	1	18	8	3	3	-	33
^{56}Fe	E_p=0.4 GeV	2	19	9	3	3	-	36
^{nat}Ni	E_p=0.4 GeV	1	19	9	4	3	-	36
^{93}Nb	E_p=0.4 GeV	3	39	5	8	10	-	65
^{181}Ta	E_p=0.4 GeV	8	49	14	6	4	-	81
^{nat}W	E_p=0.4 GeV	12	45	14	5	5	1	82
^{nat}Cr	E_p=0.6 GeV	1	18	8	3	3	-	33
^{56}Fe	E_p=0.6 GeV	1	21	10	3	3	-	38
^{nat}Ni	E_p=0.6 GeV	1	23	9	4	3	-	40
^{93}Nb	E_p=0.6 GeV	3	47	6	9	11	-	76
^{181}Ta	E_p=0.6 GeV	11	56	19	8	5	-	99
^{nat}W	E_p=0.6 GeV	12	61	18	8	5	1	105
^{nat}Cr	E_p=0.8 GeV	1	18	8	3	3	-	33
^{56}Fe	E_p=0.8 GeV	1	21	10	3	3	-	38
^{nat}Ni	E_p=0.8 GeV	1	25	9	4	4	-	43
^{93}Nb	E_p=0.8 GeV	3	54	7	12	10	-	86
^{181}Ta	E_p=0.8 GeV	12	57	19	9	3	-	100
^{nat}W	E_p=0.8 GeV	13	65	17	11	6	1	113
^{nat}Cr	E_p=1.2 GeV	1	18	8	3	3	-	33
^{56}Fe	E_p=1.2 GeV	1	22	10	3	3	-	39
^{nat}Ni	E_p=1.2 GeV	1	25	9	4	4	-	43
^{93}Nb	E_p=1.2 GeV	3	61	8	12	12	-	96
^{181}Ta	E_p=1.2 GeV	12	82	25	11	13	-	143
^{nat}W	E_p=1.2 GeV	14	91	24	14	11	1	155
^{nat}Cr	E_p=1.6 GeV	1	18	8	3	3	-	33
^{56}Fe	E_p=1.6 GeV	1	21	10	3	3	-	38
^{nat}Ni	E_p=1.6 GeV	1	27	9	5	4	-	46
^{93}Nb	E_p=1.6 GeV	4	69	9	12	12	-	106
^{181}Ta	E_p=1.6 GeV	12	86	23	9	16	-	146
^{nat}W	E_p=1.6 GeV	15	94	25	13	15	1	163
^{nat}Cr	E_p=2.6 GeV	1	18	8	3	3	-	33
^{56}Fe	E_p=2.6 GeV	1	21	10	3	3	-	38
^{nat}Ni	E_p=2.6 GeV	1	27	9	5	4	-	46
^{93}Nb	E_p=2.6 GeV	4	70	9	12	12	-	107
^{181}Ta	E_p=2.6 GeV	14	96	23	13	17	-	163
^{nat}W	E_p=2.6 GeV	16	104	26	14	18	1	179
^{56}Fe	E_p=0.3 GeV	2	20	9	2	3	-	36
^{56}Fe	E_p=0.5 GeV	1	18	9	2	3	-	33
^{56}Fe	E_p=0.75 GeV	2	21	9	3	3	-	38
^{56}Fe	E_p=1.0 GeV	2	21	9	3	3	-	38
^{56}Fe	E_p=1.5 GeV	2	21	9	3	3	-	38
	Total	**243**	**2165**	**719**	**338**	**363**	**11**	**3839**

All measured yields were simulated with the use of MCNPX (BERTINI, ISABEL), CEM03.02, INCL4+ABLA, INCL4.5.5+ABLA0.7, PHITS, CASCADE07 codes to determine their predictive power. (<F> factor). The values of the found predictive power of each of the code for ^{nat}Cr, ^{56}Fe, ^{nat}Ni, ^{93}Nb, ^{181}Ta and ^{nat}W at 0.04 – 2.6 GeV proton energy are presented in Table 8.2 and Figs 8.1 – 8.13. To present completed information about predictive power of each code, Table 8.3 presents also <F> factor values for ^{nat}Pb and ^{209}Bi for the same list of energies taken from the results of IST Project #2002 [5].

Table 8.2.

Predictive power of MCNPX (BERTINI, ISABEL), CEM03.02, INCL4+ABLA, INCL4.5.5+ABLA0.7, PHITS, CASCADE07 codes code for ^{nat}Cr, ^{56}Fe, ^{nat}Ni, ^{93}Nb, ^{181}Ta and ^{nat}W at 0.04 – 2.6 GeV proton energy.

Model	Sample	Proton energy, MeV											
		0.04	0.07	0.1	0.15	0.25	0.4	0.6	0.8	1.2	1.6	2.6	Total
BERTINI	Cr	3.54	3.06	3.27	2.42	1.86	4.39	2.82	4.14	2.96	2.63	2.26	3.02
	Fe	5.86	3.06	3.81	2.64	2.98	3.47	2.77	2.14	2.86	2.57	2.27	2.85
	Ni	3.36	2.65	3.48	2.53	1.95	1.71	2.86	2.29	2.90	2.25	2.24	2.51
	Nb	2.28	2.42	1.68	3.47	2.58	2.17	3.06	1.66	1.78	2.24	2.05	2.25
	Ta	7.43	2.07	1.83	1.54	2.4	2.4	2.29	2.14	2.94	2.74	3.22	2.62
	W	5.75	3.02	2.49	2.26	2.78	2.3	2.28	1.94	2.34	2.82	2.96	2.58
ISABEL	Cr	5.29	4.45	3.98	2.49	2.22	6.30	4.70	3.85	2.96	2.63	2.26	3.58
	Fe	4.94	5.21	6.15	3.23	2.90	3.66	5.07	4.77	2.86	2.57	2.27	3.71
	Ni	5.45	3.64	4.14	2.70	2.21	2.19	3.62	4.15	2.90	2.25	2.24	3.05
	Nb	3.00	2.78	1.80	3.62	2.76	2.64	4.65	3.77	1.78	2.24	2.05	2.74
	Ta	7.14	2.24	1.88	2.29	2.16	2.54	2.79	2.56	2.94	2.74	3.22	2.75
	W	6.66	3.42	2.53	2.11	2.76	2.47	2.51	2.2	2.34	2.82	2.96	2.66
CEM03.02	Cr	2.28	3.44	2.52	1.79	2.10	1.57	1.55	1.67	1.90	1.95	2.71	2.07
	Fe	3.88	3.98	2.57	2.12	2.01	2.34	1.81	1.83	1.83	1.96	2.90	2.24
	Ni	2.26	2.56	2.37	1.63	1.75	1.67	1.69	1.70	1.89	1.86	2.40	1.96
	Nb	3.36	2.59	2.08	2.84	2.26	1.94	2.09	1.94	2.67	2.30	1.92	2.25
	Ta	1.61	1.85	2.21	1.59	1.42	2.86	4.17	4.19	4.3	3.43	3.33	3.39
	W	5.52	3.22	2.88	2.5	2.32	1.99	2.13	2.29	2.87	2.86	3.31	2.72
INCL4+ABLA	Cr	3.84	2.43	2.45	4.17	2.37	2.59	3.32	2.96	2.52	2.35	3.97	2.97
	Fe	3.17	3.40	5.10	3.53	3.61	4.35	5.31	6.74	3.18	3.00	3.91	4.16
	Ni	2.01	2.08	1.97	2.52	3.44	4.11	2.28	3.41	3.01	3.48	2.92	2.95
	Nb	2.94	2.02	2.12	3.99	3.27	3.26	3.31	4.90	4.63	4.40	3.19	3.77
	Ta	5.83	3.09	2.31	2.17	2.02	2.9	3.84	3.35	3.65	3.68	3.94	3.41
	W	6.99	3.8	2.78	2.57	2.36	2.93	3.46	3.06	4.09	3.78	3.8	3.47
PHITS	Cr	5.36	3.32	4.83	3.69	3.81	3.03	2.36	2.19	2.05	2.16	2.15	2.89
	Fe	2.84	5.45	4.99	4.21	3.22	3.26	2.46	2.68	2.24	2.19	2.76	3.12
	Ni	3.68	2.95	4.11	3.16	2.45	2.05	2.12	1.96	1.67	1.74	1.76	2.35
	Nb	3.38	3.12	2.76	4.35	3.21	2.29	2.37	1.74	2.61	2.01	1.66	2.39
	Ta	2.44	1.91	1.83	2.49	3.25	2.27	2.37	2.08	2.64	2.51	2.81	2.51
	W	8.41	4.3	3.19	2.61	3.52	2.23	2.58	2.2	2.84	2.88	2.9	2.89
INCL4.5.5+ ABLA07	Cr	2.24	1.75	1.58	1.61	1.83	1.58	1.70	1.85	1.83	1.76	2.09	1.80
	Fe	2.50	3.46	1.81	1.76	2.63	2.62	1.75	1.62	1.69	1.65	2.11	2.08

	Ni	2.66	1.62	1.59	1.46	1.90	1.57	1.56	1.59	1.54	1.64	1.85	1.71
	Nb	13.78	2.05	3.45	1.98	1.55	1.65	1.63	1.56	1.59	1.55	1.58	1.93
	Ta	3.89	2.09	2.33	1.81	1.48	1.59	1.85	1.75	1.8	1.73	2.01	1.83
	W	6.05	4.34	2.66	2.14	1.73	1.84	2.11	1.76	2.03	1.89	2.01	2.13
CASCADE07	Cr	2.61	3.27	3.02	2.87	3.26	2.93	2.78	2.80	5.34	5.04	4.93	3.67
	Fe	5.92	4.23	3.33	2.93	3.57	3.96	3.35	3.24	5.47	4.90	4.54	3.98
	Ni	5.19	3.45	3.47	3.20	2.75	2.77	2.65	2.60	4.37	4.13	3.83	3.44
	Nb	9.97	4.73	4.33	3.37	2.65	2.61	2.87	2.37	2.73	3.69	3.01	3.19
	Ta	9.43	1.7	2.79	1.75	2.94	3.16	2.65	2.42	3.11	3.17	2.96	2.89
	W	6.26	3.3	3.24	2.8	2.97	2.45	2.42	2.48	3.25	3.2	3.34	3.02

Table 8.3

Predictive power of MCNPX (BERTINI, ISABEL), CEM03.02, INCL4+ABLA, INCL4.5.5+ABLA0.7, PHITS, CASCADE07 codes code for ^{nat}Pb and ^{209}Bi at 0.04 – 2.6 GeV proton energy.

Model	Sample	Proton energy, MeV											
		0.04	0.07	0.1	0.15	0.25	0.4	0.6	0.8	1.2	1.6	2.6	Total
BERTINI	Pb	8.85	3.00	2.50	2.12	2.13	2.18	1.98	1.97	1.92	1.94	2.34	2.17
	Bi	5.13	3.4	2.95	2.12	1.99	1.82	1.79	1.97	2.09	2.10	2.28	2.12
ISABEL	Pb	15.14	4.09	2.82	2.00	2.09	2.16	2.19	2.07	1.92	1.94	2.34	2.28
	Bi	5.88	4.53	3.07	1.99	2.04	1.85	1.92	2.03	2.09	2.10	2.28	2.17
CEM03.02	Pb	1.56	1.50	1.83	1.58	1.55	1.72	1.93	1.89	2.16	2.28	2.77	2.07
	Bi	4.00	1.65	1.95	1.76	1.51	1.81	1.54	1.99	2.08	2.10	2.30	1.97
INCL4+ABLA	Pb	3.57	2.74	1.88	1.60	1.67	2.35	2.70	2.18	2.17	2.37	2.29	2.27
	Bi	4.99	4.50	1.83	1.86	1.64	2.01	2.52	1.95	2.33	2.32	2.37	2.32
PHITS	Pb	2.29	3.05	2.55	1.97	2.23	2.28	2.28	1.91	1.71	1.77	1.87	2.02
	Bi	9.72	4.46	3.41	2.09	1.95	2.28	2.09	2.02	1.92	1.88	1.86	2.12
INCL4.5.5+ ABLA07	Pb	2.18	2.20	1.92	1.66	1.69	1.56	1.49	1.47	1.52	1.57	1.61	1.60
	Bi	3.71	2.62	1.87	1.61	1.63	1.61	1.48	1.56	1.56	1.58	1.60	1.63
CASCADE07	Pb	2.87	6.37	4.61	4.38	4.69	3.88	2.82	2.86	2.54	2.99	3.70	3.40
	Bi	1.63	25.53	6.14	4.97	4.48	4.84	3.35	3.39	3.09	3.02	3.38	3.84

Figs. 8.1 – 8.8 are the one-dimensional graphical representation of predictive power of MCNPX (BERTINI, ISABEL), CEM03.02, INCL4+ABLA, INCL4.5.5+ABLA0.7, PHITS, CASCADE07 codes code for ^{nat}Cr, ^{56}Fe, ^{nat}Ni, ^{93}Nb, ^{181}Ta and ^{nat}W at 0.04 – 2.6 GeV proton energy (given target nuclei in entire energy range). Figs. 8.9 – 8.13 are the two-dimensional graphical representation of predictive power of each code (all the targets in entire energy range).

The experimental results and the proposed approach for the verification of high-energy transport codes have been used in the Coordinating Research Project IAEA «Benchmark of Spallation Models» [81,82].

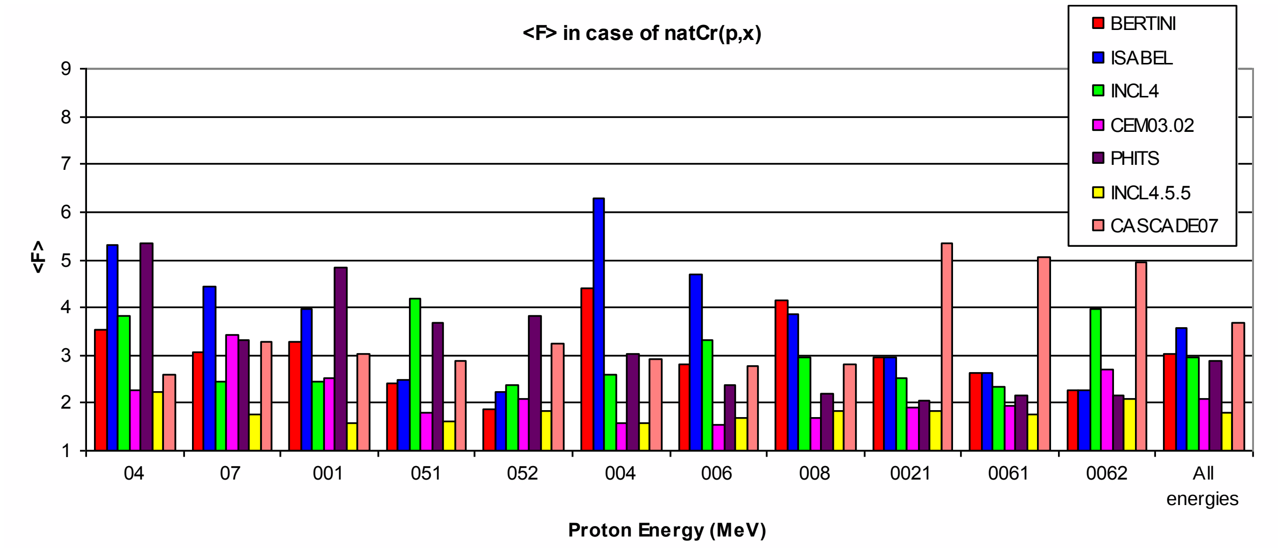

Fig. 8.1. Predictive power of BERTINI, ISABEL, CEM03.02, INCL4+ABLA, INCL4.5.5+ABLA0.7, PHITS, CASCADE07 codes code for ^{nat}Cr at 0.04 – 2.6 GeV proton energy.

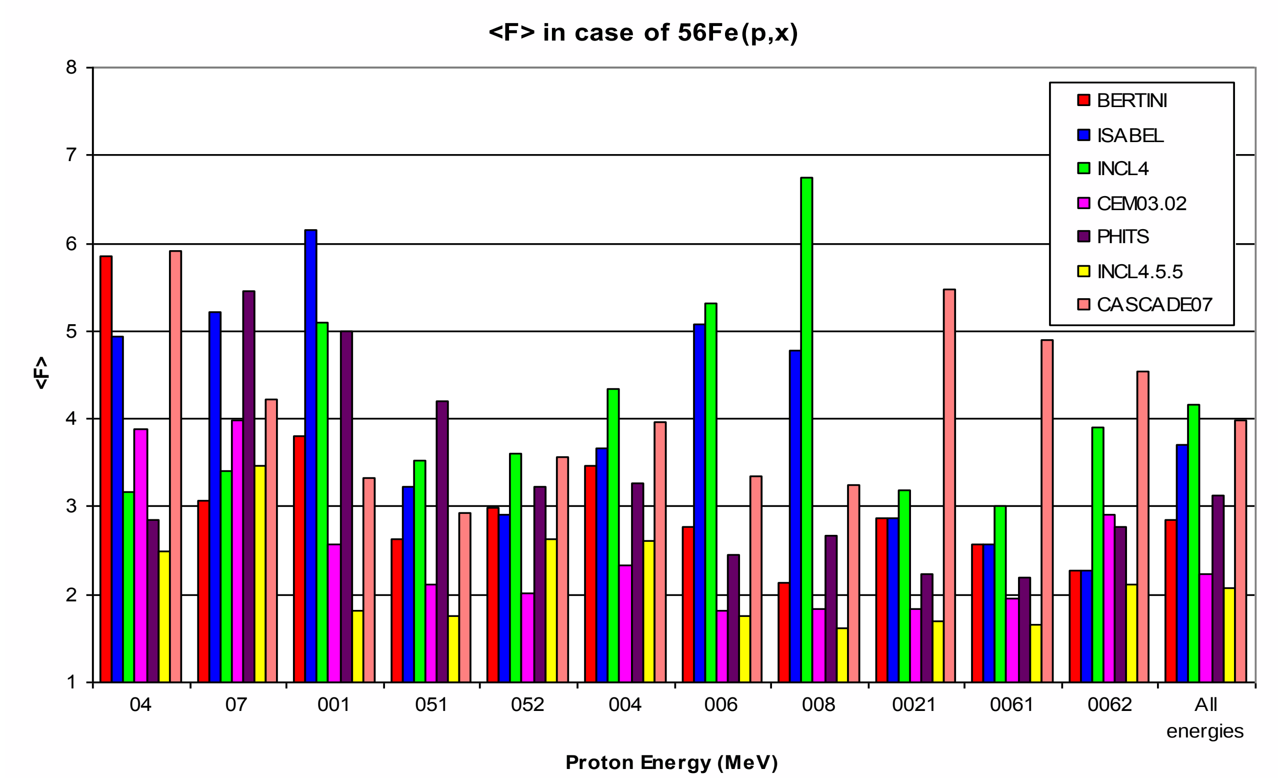

Fig. 8.2. Predictive power of BERTINI, ISABEL, CEM03.02, INCL4+ABLA, INCL4.5.5+ABLA0.7, PHITS, CASCADE07 codes code for ^{56}Fe at 0.04 – 2.6 GeV proton energy.

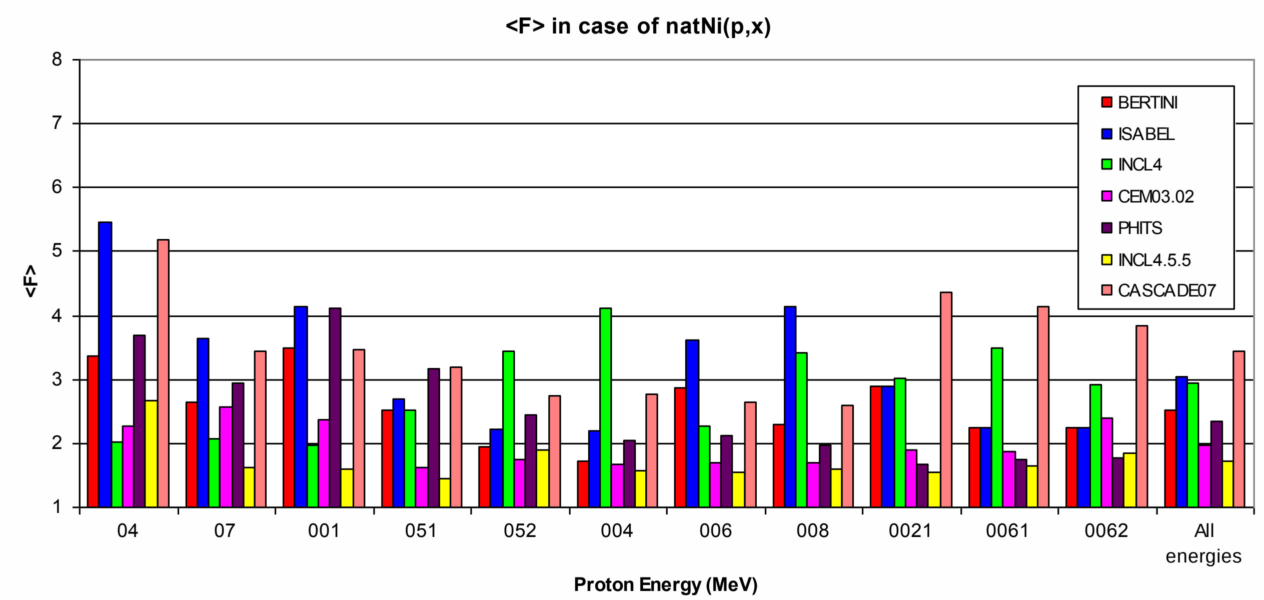

Fig. 8.3. Predictive power of BERTINI, ISABEL, CEM03.02, INCL4+ABLA, INCL4.5.5+ABLA0.7, PHITS, CASCADE07 codes code for ^{nat}Ni at 0.04 – 2.6 GeV proton energy.

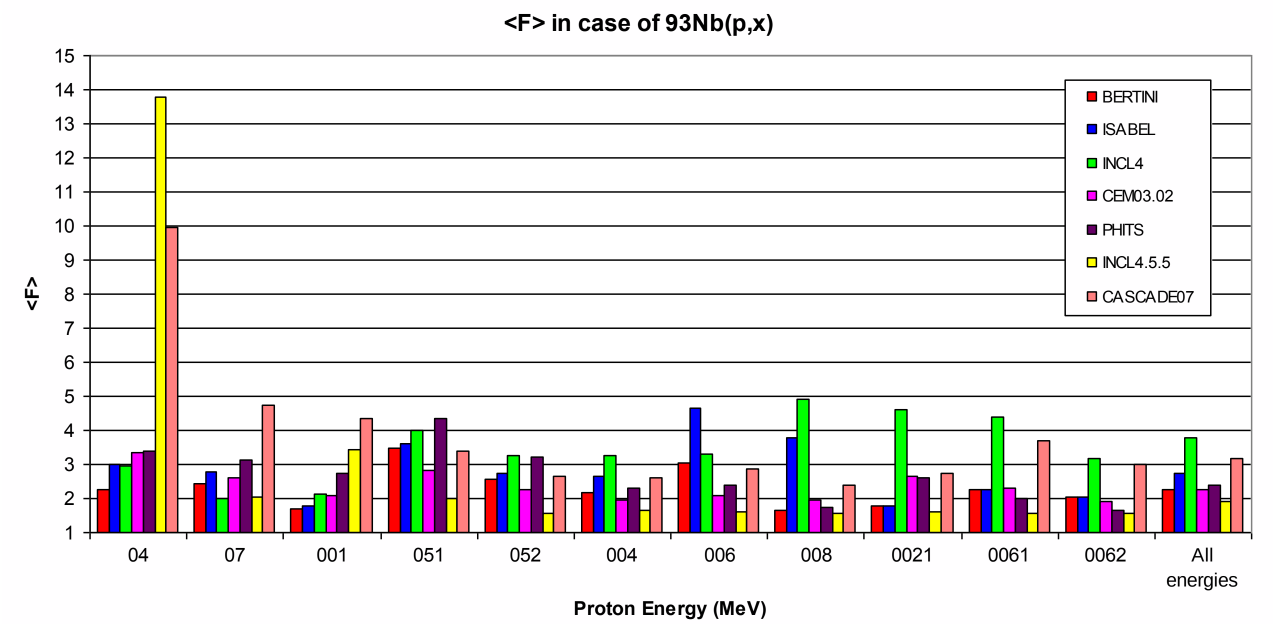

Fig. 8.4. Predictive power of BERTINI, ISABEL, CEM03.02, INCL4+ABLA, INCL4.5.5+ABLA0.7, PHITS, CASCADE07 codes code for ^{93}Nb at 0.04 – 2.6 GeV proton energy.

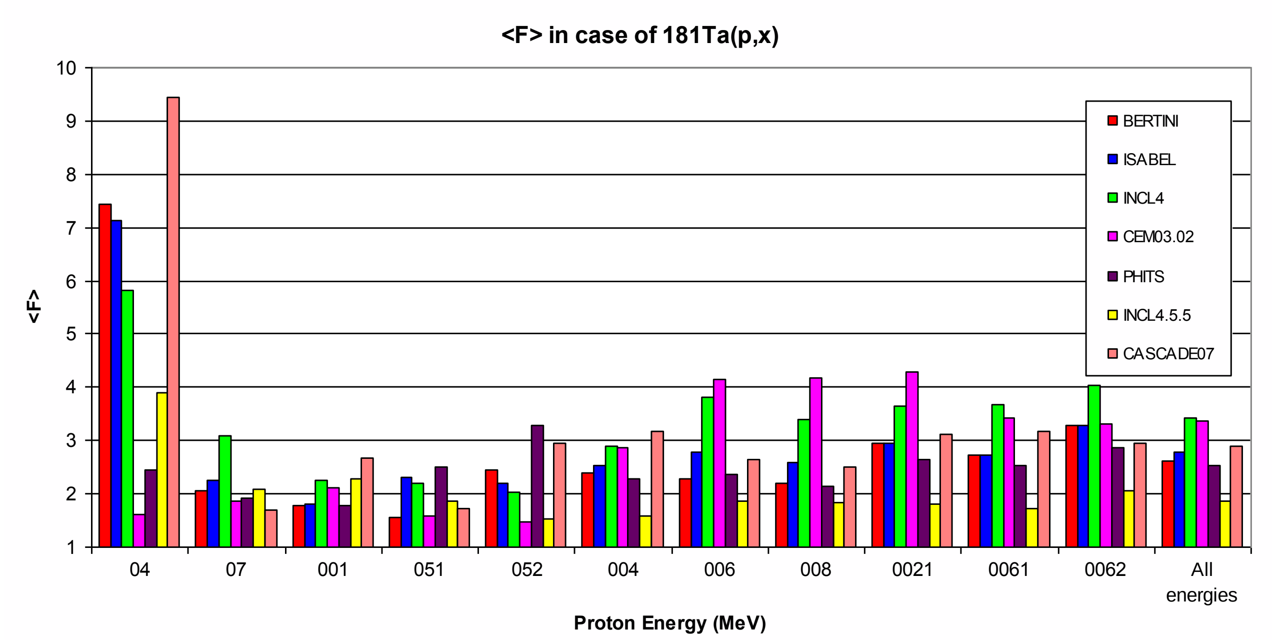

Fig. 8.5. Predictive power of BERTINI, ISABEL, CEM03.02, INCL4+ABLA, INCL4.5.5+ABLA0.7, PHITS, CASCADE07 codes code for ^{181}Ta at 0.04 – 2.6 GeV proton energy.

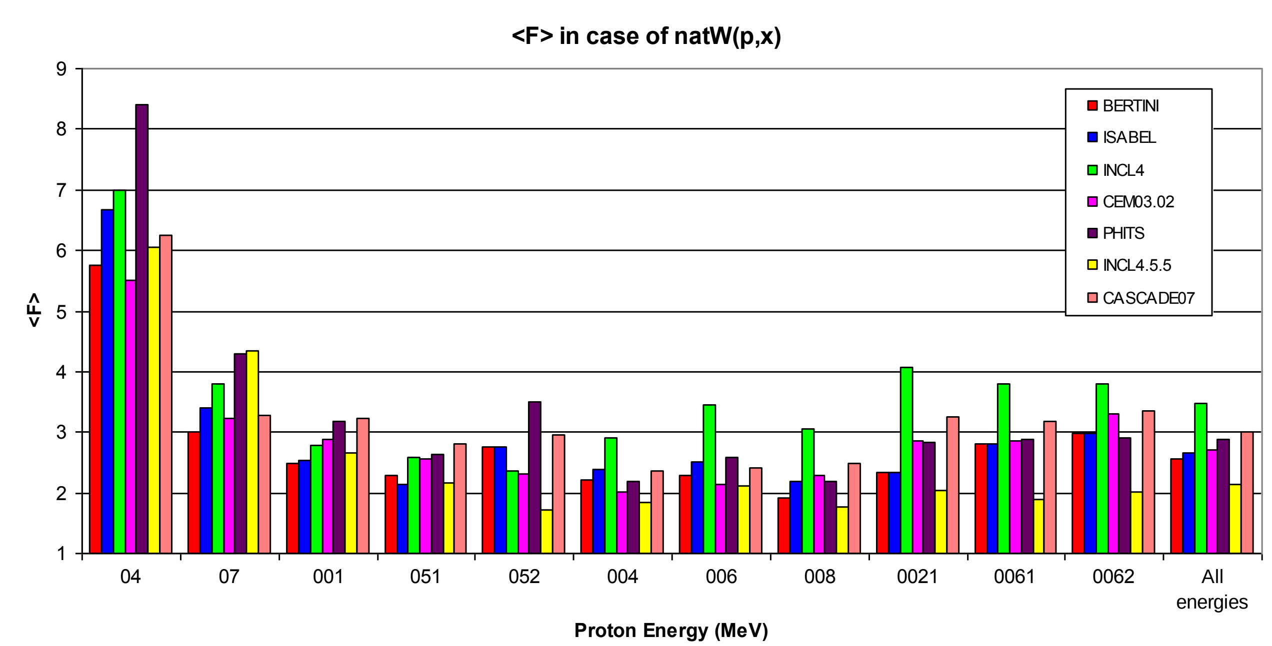

Fig. 8.6. Predictive power of BERTINI, ISABEL, CEM03.02, INCL4+ABLA, INCL4.5.5+ABLA0.7, PHITS, CASCADE07 codes code for ^{nat}W at 0.04 – 2.6 GeV proton energy.

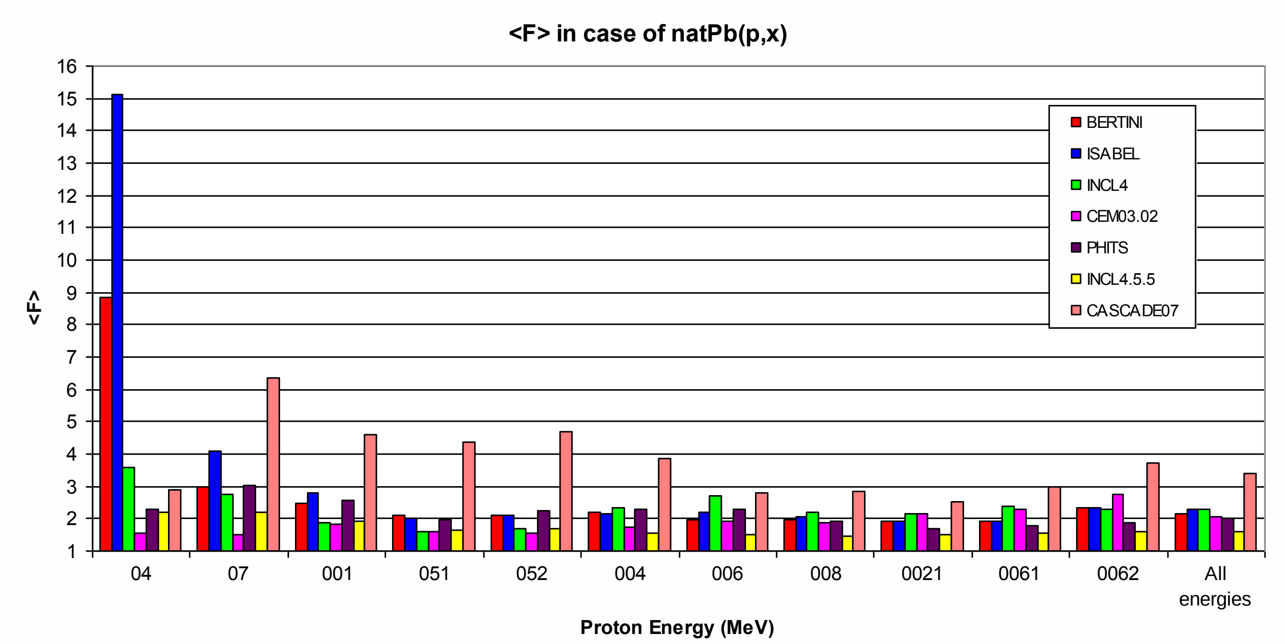

Fig. 8.7. Predictive power of BERTINI, ISABEL, CEM03.02, INCL4+ABLA, INCL4.5.5+ABLA0.7, PHITS, CASCADE07 codes code for ^{nat}Pb at 0.04 – 2.6 GeV proton energy.

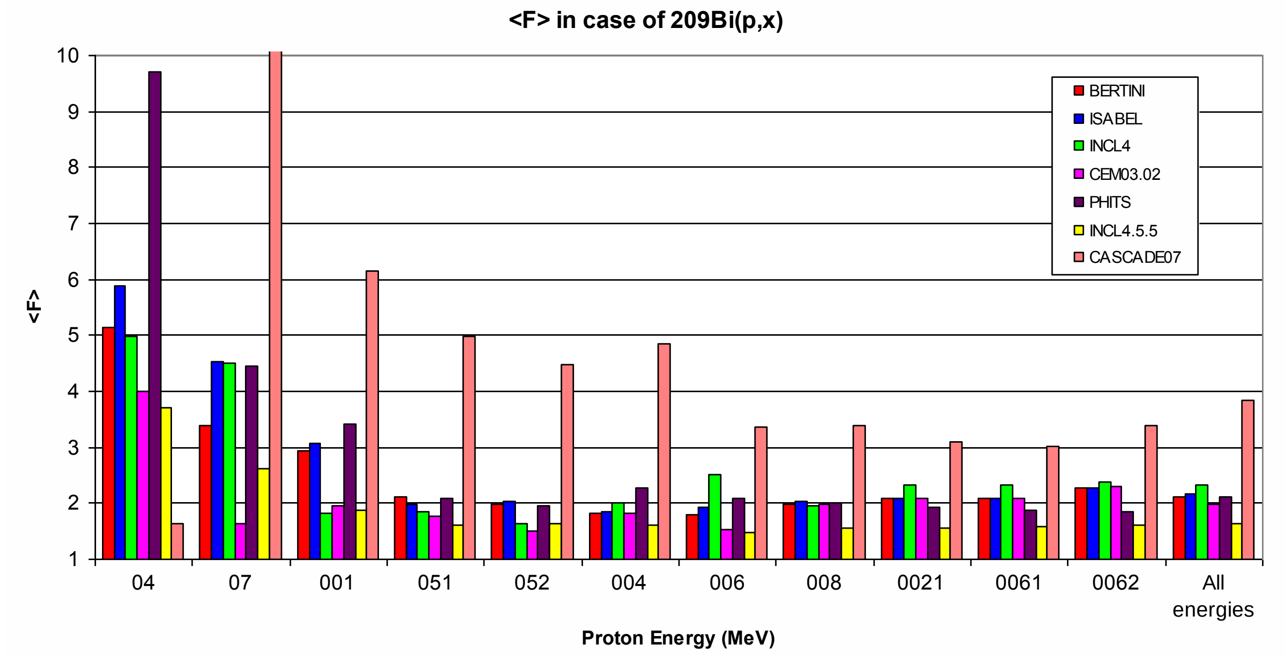

Fig. 8.8. Predictive power of BERTINI, ISABEL, CEM03.02, INCL4+ABLA, INCL4.5.5+ABLA0.7, PHITS, CASCADE07 codes code for ^{209}Bi at 0.04 – 2.6 GeV proton energy.

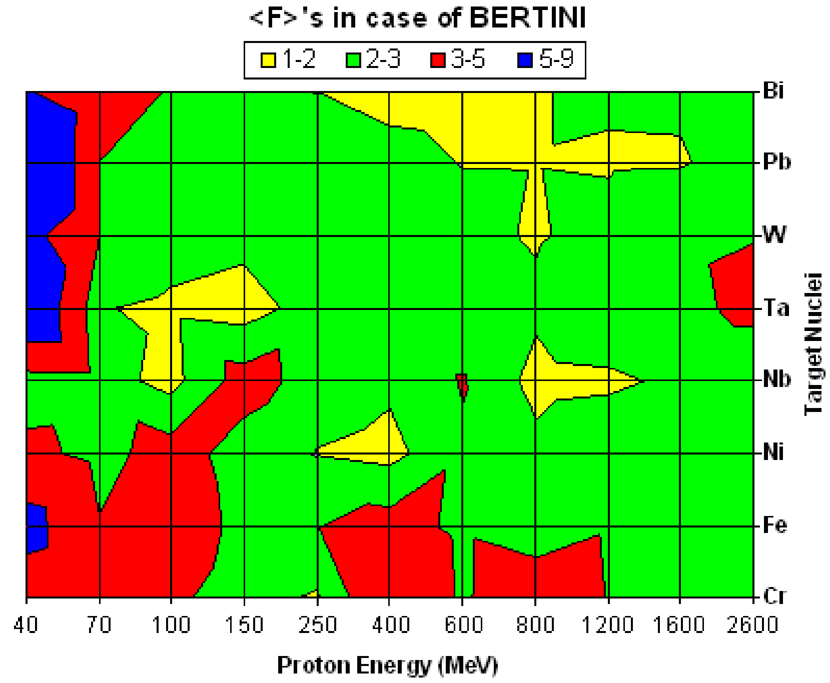

Fig. 8.9 Predictive power of BERTINI model in 0.04 – 2.6 GeV proton energy and 50-209 mass range.

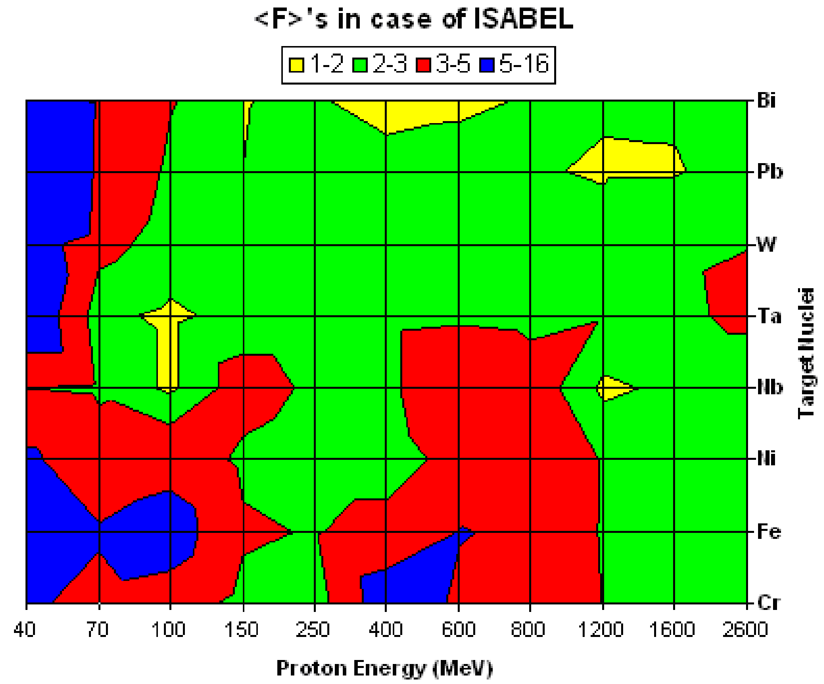

Fig. 8.10 Predictive power of ISABEL model in 0.04 – 2.6 GeV proton energy and 50-209 mass range.

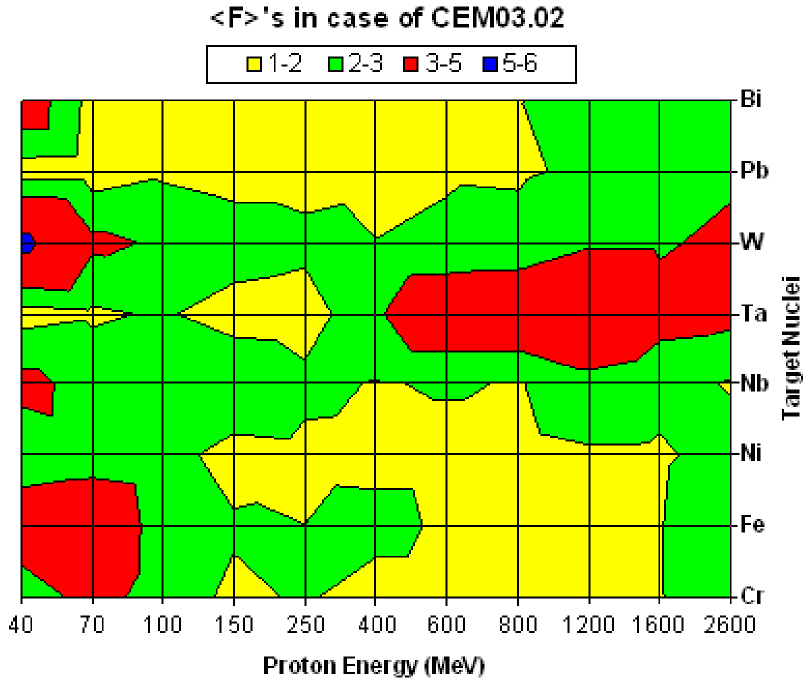

Fig. 8.11 Predictive power of CEM03.02 code in 0.04 – 2.6 GeV proton energy and 50-209 mass range.

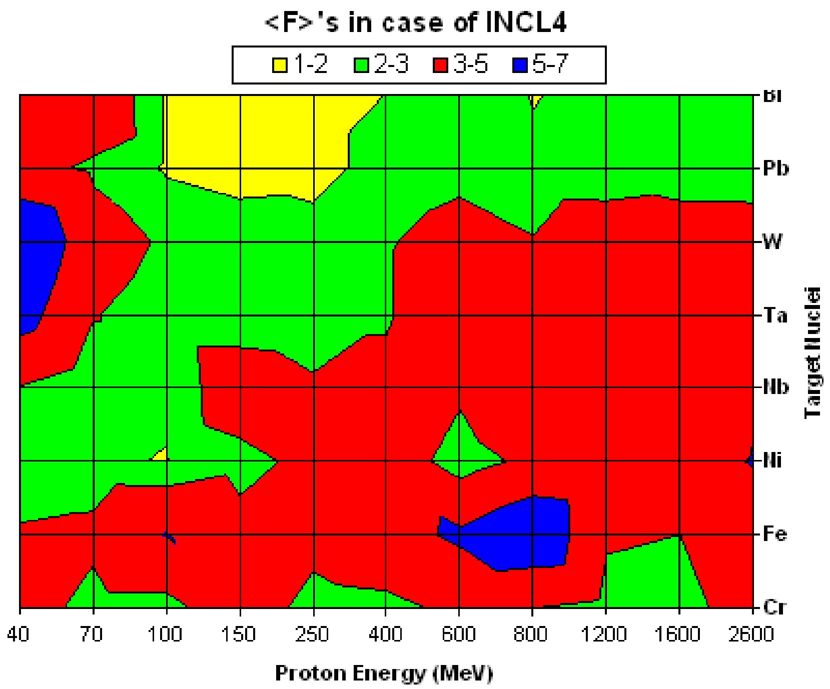

Fig. 8.12 Predictive power of INCL4 code in 0.04 – 2.6 GeV proton energy and 50-209 mass range.

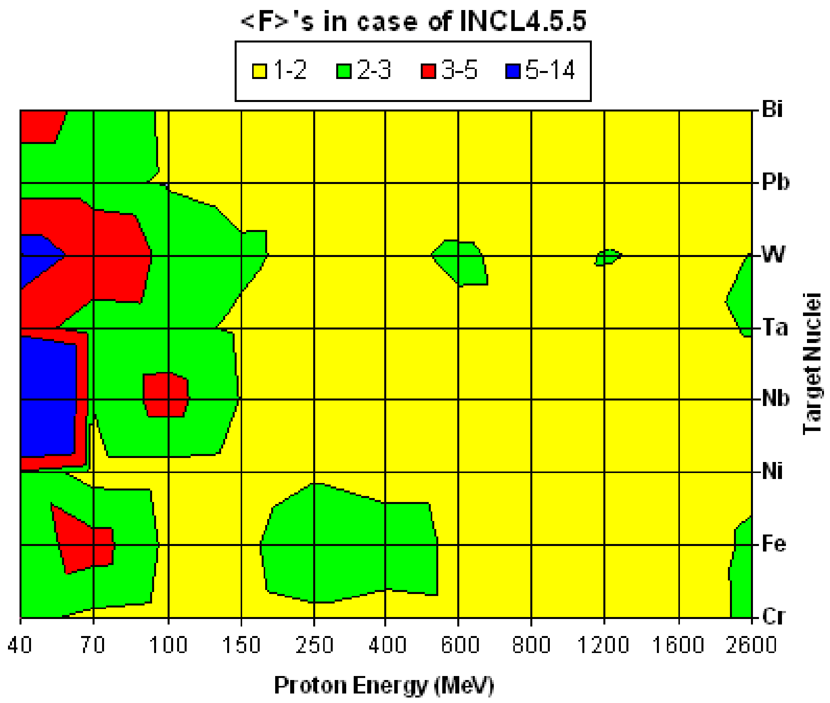

Fig. 8.13 Predictive power of INCL4.5.5+ABLA07 code in 0.04 – 2.6 GeV proton energy and 50-209 mass range.

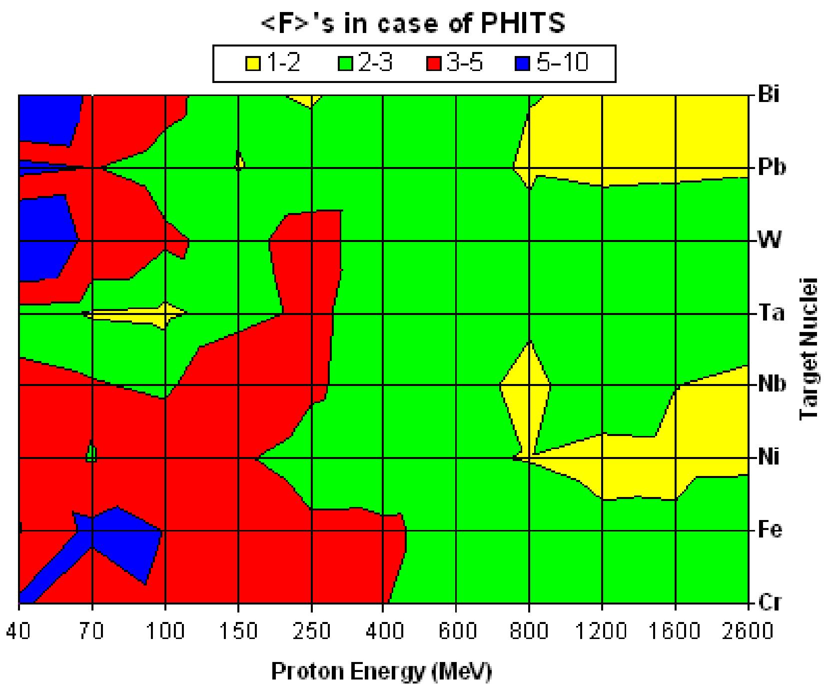

Fig. 8.14 Predictive power of PHITS code in 0.04 – 2.6 GeV proton energy and 50-209 mass range.

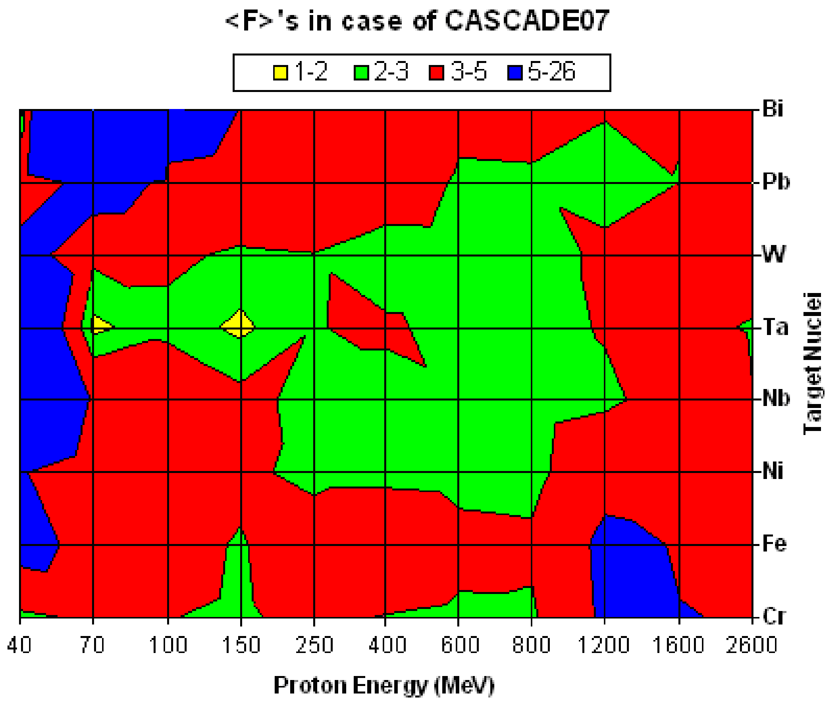

Fig. 8.15 Predictive power of CASCADE.07 code in 0.04 – 2.6 GeV proton energy and 50-209 mass range .

The obtained results proves that predictive power of the codes is bad in the following ranges of energies and masses:

Code/model	Energy range (MeV)	Mass range
	~ 2600	W, Ta
BERTINI	40 -100	Nb, Fe, Cr
	40-70	Bi, Pb, W, Ta, Nb
	2600	W, Ta
	250-1200	Ta, Nb, Ni, Fe, Cr
ISABEL	70-150	Nb, Ni, Fe, Cr
	40-70	W, Ta, Nb, Ni, Fe, Cr
	40-100	Bi, Pb
	500 -2600	W, Ta
	40 – 100	Fe, Cr
CEM03.02	40	Bi, Nb
	40-70	W
	400-2600	W,Ta
INCL4+ABLA	150-400	Nb, Ni, Fe, Cr
	40-150	Ni, Fe, Cr
	40-100	Bi, Pb, W, Ta, Nb
INCL4.4.5+ABLA07	40-70	W, Ta, Nb, Ni

Code/model	Energy range (MeV)	Mass range
PHITS	40	Bi
	40-400	Fe, Cr
	40-150	Nb, Ni
	100-250	W, Ta, Nb
	40-100	Bi, Pb, W
CASCADE07	1600-2600	Bi, Pb, W, Ta, Nb, Ni, Fe, Cr
	1200-1600	W, Ta, Nb, Ni, Fe, Cr
	250-400	Fe, Cr
	40-250	Ni, Fe, Cr
	40-150	Nb, Ni, Fe, Cr
	70-150	Bi, Pb, W
	40-70	Bi, Pb, W, Ta, Nb, Ni, Fe, Cr

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10. APPENDIX 1. REACTION RATES FOR RESIDUAL NUCLIDE PRODUCTION.

10.1 Reaction rates for residual nuclide production in ^{nat}Cr

Table 10.1: Detailed reaction rates for residual nuclide production in ^{nat}Cr at E_p=42 MeV, used to determine their production cross sections.

Nuclide	Type	$T_{1/2}$	$E_γ$, KeV	Abundance, %		Reaction rate 10^{-20} s^{-1}	
54 Mn	i	312.11D	834.8	99.98	0.00	2092	102
52 Mn	i	5.591D	1434.1	100.0	0.6	20933	663.
			1333.7	5.07	0.06	21418	721.
			1246.3	4.21	0.07	23244	830.
			935.5	94.5	1.0	20315	660.
			848.2	3.32	0.04	22308	813.
			744.2	90.0	0.9	19874	643.
					R_av	20777	725.
52mMn	i(m)	21.1M	1434.1	99.8	2.0	36911	1460
51 Cr	c	27.7025D	320.1	9.92	0.05	690380	21592
49 Cr	c	42.3M	152.9	30.3	1.1	20524	1031.
			90.6	53.2	1.9	21687	1153.
					R_av	21021	897.
48 Cr	c	21.56H	112.3	96.0	2.1	3475	136
48 V	c	15.9735D	2240.4	2.41	0.04	98452	3536.
			1312.1	97.5	0.9	97198	3148.
			983.5	100.0	0.3	94973	2930.
			944.1	7.76	0.10	95654	3192.
			928.3	0.77	0.05	96048	7005.
					R_av	97197	3118.
48 Sc	i	43.67H	1037.5	97.6	0.7	28.92	4.70
47 Sc	c	3.3492D	159.4	68.3	0.4	1214	39
46 Sc	i(m+g)	83.79D	889.3	99.98	0.00	559.0	30.9
44mSc	i(m)	58.61H	1157.0	98.61	0.01	323.9	17.5
			270.9	86.7	0.3	324.0	10.9
					R_av	324.0	10.8
44 Sc	I	3.97H	1157.0	99.9	0.5	596.1	20.1
44 Sc	i(m+g)	3.97H	1499.5	0.91	0.02	608.1	81.7
			1157.0	99.9	0.5	915.5	30.8
					R_av	909.2	51.9
43 Sc	c	3.891H	372.8	22.5	0.7	261.3	17.9

Table 10.2: Detailed reaction rates for residual nuclide production in ^{nat}Cr at E_p=66 MeV, used to determine their production cross sections.

Nuclide	Type	$T_{1/2}$	$E_γ$, KeV	Abundance, %		Reaction rate 10^{-20} s^{-1}	
54 Mn	i	312.11D	834.8	99.98	0.00	2332	116
52 Mn	i	5.591D	1434.1	100.0	0.6	18261	578.
			1333.7	5.07	0.06	18846	651.
			1246.3	4.21	0.07	20526	753.
			935.5	94.5	1.0	17763	577.
			848.2	3.32	0.04	19718	741.
			744.2	90.0	0.9	17414	563.
					R_av	18137	630.
52mMn	i(m)	21.1M	1434.1	99.8	2.0	39224	1532
51 Cr	c	27.7025D	320.1	9.92	0.05	826630	25859
49 Cr	c	42.3M	152.9	30.3	1.1	160620	7933.
			90.6	53.2	1.9	171960	8625.
					R_av	165761	7661.
48 Cr	c	21.56H	112.3	96.0	2.1	8494	332
48 V	c	15.9735D	2240.4	2.41	0.04	181950	6560.
			1437.3	0.12	0.02	159910	27836.
			1312.1	97.5	0.9	181080	5844.
			983.5	100.0	0.3	176880	5443.
			944.1	7.76	0.10	178380	5946.
			928.3	0.77	0.05	178640	13142.
					R_av	180811	5789.

48 Sc	i	43.67H	1037.5	97.6	0.7	590.0	20.5
			175.4	7.48	0.10	742.6	50.0
					R_av	596.0	35.1
47 Sc	c	3.3492D	159.4	68.3	0.4	12128	391
46 Sc	i(m+g)	83.79D	1120.6	99.99	0.00	52717	1623.
			889.3	99.98	0.00	51518	1575.
					R_av	52100	1999.
44mSc	i(m)	58.61H	2656.5	98.61	0.01	12042	1189.
			1499.5	98.61	0.01	10333	637.
			1157.0	98.61	0.01	8440	265.
			1126.1	1.20	0.07	9355	834.
			1001.8	1.20	0.07	8804	1385.
			270.9	86.7	0.3	8733	275.
					R_av	8561	279.
44 Sc	i	3.97H	2656.5	0.11	0.00	14121	1308.
			1499.5	0.91	0.02	13997	774.
			1157.0	99.9	0.5	14057	442.
					R_av	14057	442.
44 Sc	i(m+g)	3.97H	2656.5	0.11	0.00	25996	1612.
			1499.5	0.91	0.02	24187	1037.
			1157.0	99.9	0.5	22380	699.
					R_av	22380	699.
43 Sc	c	3.891H	372.8	22.5	0.7	6877	337
43 K	c	22.3H	617.5	79.2	0.7	187.9	8.3
			372.8	86.8	0.2	157.8	20.6
					R_av	185.5	10.0
42 K	i	12.360H	1525.0	18.08	0.09	111.2	12.1

Table 10.3: Detailed reaction rates for residual nuclide production in ^{nat}Cr at E_p=97 MeV, used to determine their production cross sections.

Nuclide	Type	$T_{1/2}$	E_γ, KeV	Abundance, %		Reaction rate 10^{-20} s^{-1}	
54 Mn	i	312.11D	834.8	99.98	0.00	1290	63
52 Mn	i	5.591D	1434.1	100.0	0.6	8692	358.
			1333.7	5.07	0.06	8977	328.
			1246.3	4.21	0.07	9723	385.
			935.5	94.5	1.0	8699	286.
			848.2	3.32	0.04	9933	482.
			744.2	90.0	0.9	8359	287.
					R_av	8745	322.
52mMn	i(m)	21.1M	1434.1	99.8	2.0	17922	2010
51 Cr	c	27.7025D	320.1	9.92	0.05	448510	14016
49 Cr	c	42.3M	152.9	30.3	1.1	76201	3724.
			90.6	53.2	1.9	80695	4171.
					R_av	78117	3301.
48 Cr	c	21.56H	308.2	100	2	9022	336.
			112.3	96.0	2.1	9192	359.
					R_av	9093	316.
48 V	c	15.9735D	2240.4	2.41	0.04	193360	6980.
			1437.3	0.12	0.02	184660	32318.
			1312.1	97.5	0.9	189440	6113.
			983.5	100.0	0.3	184360	5673.
			944.1	7.76	0.10	187240	6265.
			928.3	0.77	0.05	190590	13755.
					R_av	189649	6072.
48 Sc	i	43.67H	1312.1	100.1	0.7	2853	207.
			1212.9	2.38	0.05	2562	426.
			1037.5	97.6	0.7	1892	62.
			983.5	100.1	0.6	2579	208.
			175.4	7.48	0.10	2030	114.
					R_av	1915	85.
47 Sc	c	3.3492D	159.4	68.3	0.4	13031	418
46 Sc	i(m+g)	83.79D	1120.6	99.99	0.00	39641	1219.
			889.3	99.98	0.00	38602	1182.
					R_av	39105	1501.
44mSc	i(m)	58.61H	1499.5	98.61	0.01	29156	1134.
			1157.0	98.61	0.01	23354	784.
			1126.1	1.20	0.07	23461	2212.
			1001.8	1.20	0.07	26615	2079.

			270.9	86.7	0.3	24148	758.
					R_av	24157	803.
44 Sc	i	3.97H	1499.5	0.91	0.02	35238	1591.
			1157.0	99.9	0.5	35074	2107.
					R_av	35191	1465.
44 Sc	i(m+g)	3.97H	1499.5	0.91	0.02	63989	2482.
			1157.0	99.9	0.5	58103	2545.
					R_av	61606	3472.
43 Sc	c	3.891H	372.8	22.5	0.7	9167	412
43 K	c	22.3H	1022.0	1.96	0.03	2365	852.
			617.5	79.2	0.7	742.6	26.7
			593.4	11.26	0.09	718.1	50.7
			396.9	11.85	0.09	781.0	62.4
			372.8	86.8	0.2	716.8	24.1
			220.6	4.80	0.07	701.0	134.1
					R_av	725.5	24.3
42 K	i	12.360H	1525.0	18.08	0.09	4083	133
41 Ar	c	109.34M	1294.0	99.1	0.0	168.7	9.5
38 Cl	c	37.24M	2167.0	42.4	1.1	159.2	19.8
			1643.0	31.9	1.0	198.6	32.9
					R_av	169.1	17.9

Table 10.4: Detailed reaction rates for residual nuclide production in ^{nat}CR at E_p=148 MeV, used to determine their production cross sections.

Nuclide	Type	$T_{1/2}$	E_γ, KeV	Abundance, %		Reaction rate 10^{-20} s^{-1}	
54 Mn	i	312.11D	834.8	99.98	0.00	787.7	67.4
52 Mn	i	5.591D	1434.1	100.0	0.6	5239	173.
			1333.7	5.07	0.06	5323	214.
			1246.3	4.21	0.07	6242	277.
			935.5	94.5	1.0	5088	170.
			848.2	3.32	0.04	5228	306.
			744.2	90.0	0.9	5019	170.
					R_av	5170	186.
52mMn	i(m)	21.1M	1434.1	99.8	2.0	9367	514
51 Cr	c	27.7025D	320.1	9.92	0.05	282580	8841
49 Cr	c	42.3M	152.9	30.3	1.1	45917	2271.
			90.6	53.2	1.9	49714	2521.
					R_av	47587	2401.
48 Cr	c	21.56H	308.2	100	2	5588	208.
			112.3	96.0	2.1	5819	228.
					R_av	5680	210.
48 V	c	15.9735D	2240.4	2.41	0.04	134960	4891.
			1437.3	0.12	0.02	135430	23445.
			1312.1	97.5	0.9	132790	4289.
			983.5	100.0	0.3	129510	3988.
			944.1	7.76	0.10	130690	4389.
			928.3	0.77	0.05	132800	9659.
					R_av	132842	4256.
48 Sc	i	43.67H	1312.1	100.1	0.7	1400	146.
			1212.9	2.38	0.05	2933	195.
			1037.5	97.6	0.7	2012	65.
			983.5	100.1	0.6	1302	137.
			175.4	7.48	0.10	2167	94.
					R_av	2010	98.
47 Sc	i	3.3492D	159.4	68.3	0.4	13550	443
47 Sc	c	3.3492D	159.4	68.3	0.4	13781	446
46 Sc	i(m+g)	83.79D	1120.6	99.99	0.00	40435	1246.
			889.3	99.98	0.00	39482	1210.
					R_av	39945	1533.
44mSc	i(m)	58.61H	2656.5	98.61	0.01	31406	3280.
			1499.5	98.61	0.01	28781	1239.
			1157.0	98.61	0.01	22852	739.
			1126.1	1.20	0.07	27799	1941.
			1001.8	1.20	0.07	25477	1841.
			270.9	86.7	0.3	23747	749.
					R_av	23631	807.
44 Sc	i	3.97H	2656.5	0.11	0.00	29466	4448.
			1499.5	0.91	0.02	32621	1710.

Nuclide	Type	$T_{1/2}$	E_γ, KeV	Abundance, %		Reaction rate 10^{-20} s^{-1}	
			1157.0	99.9	0.5	34423	1445.
					R_av	33688	1323.
44 Sc	i(m+g)	3.97H	2656.5	0.11	0.00	60436	5361.
			1499.5	0.91	0.02	61002	2530.
			1157.0	99.9	0.5	56957	2009.
					R_av	58188	1818.
43 Sc	c	3.891H	372.8	22.5	0.7	14847	688
47 Ca	c	4.536D	1297.1	71	7	78.06	11.45
			159.4	*****************		230.9	73.7
					R_av	81.53	22.93
43 K	c	22.3H	617.5	79.2	0.7	1837	61.
			593.4	11.26	0.09	1935	87.
			396.9	11.85	0.09	1850	80.
			372.8	86.8	0.2	1773	57.
			220.6	4.80	0.07	1765	62.
					R_av	1791	59.
42 K	i	12.360H	1525.0	18.08	0.09	6546	214
38 K	i	7.636M	2167.0	99.86	0.01	362.2	75.7
41 Ar	c	109.34M	1294.0	99.1	0.0	490.2	19.3
39 Cl	c	55.6M	1518.0	39.2	1.3	126.3	18.6
			1267.0	53.6	1.3	151.0	19.2
					R_av	138.3	13.7
38 Cl	c	37.24M	2167.0	42.4	1.1	555.2	42.0
			1643.0	31.9	1.0	546.0	45.0
					R_av	551.1	29.8
34mCl	i(m)	32.00M	146.4	40.5	0.9	107.2	37.7
24 Na	c	14.9590H	1369.0	100	0	38.20	5.30

Table 10.5: Detailed reaction rates for residual nuclide production in ^{nat}Cr at E_p=248 MeV, used to determine their production cross sections.

Nuclide	Type	$T_{1/2}$	E_γ, KeV	Abundance, %		Reaction rate 10^{-20} s^{-1}	
54 Mn	i	312.11D	834.8	99.98	0.01	1233	123.
			834.8	99.98	0.00	1156	189.
					R_av	1211	38.
52 Mn	i	5.591D	1434.1	100.0	0.6	6773	277.
			1333.7	5.07	0.06	7116	301.
			1246.3	4.21	0.07	7963	339.
			935.5	94.5	1.0	6651	219.
			848.2	3.32	0.04	6960	365.
			848.2	3.32	0.04	6960	365.
			744.2	90.0	0.9	6485	213.
					R_av	6668	240.
52mMn	i(m)	21.1M	1434.1	99.8	2.0	13470	2535
51 Cr	c	27.7025D	320.1	9.92	0.05	427320	13363
49 Cr	c	42.3M	152.9	30.3	1.1	67105	3285.
			90.6	53.2	1.9	72224	3567.
					R_av	69439	3348.
48 Cr	c	21.56H	308.2	100	2	8650	328.
			112.3	96.0	2.1	8976	351.
					R_av	8792	319.
48 V	c	15.9735D	2240.4	2.41	0.04	222570	7962.
			1437.3	0.12	0.02	221400	39059.
			1312.1	97.5	0.9	218800	7056.
			983.5	100.0	0.3	213160	6555.
			944.1	7.76	0.10	215710	7187.
			928.3	0.77	0.05	222020	15993.
					R_av	218991	7007.
48 Sc	i	43.67H	1312.1	100.1	0.7	5157	236.
			1212.9	2.38	0.05	6312	318.
			1037.5	97.6	0.7	5378	176.
			983.5	100.1	0.6	5027	253.
			175.4	7.48	0.10	5880	306.
					R_av	5393	203.
47 Sc	i	3.3492D	159.4	68.3	0.4	32284	1033
47 Sc	c	3.3492D	159.4	68.3	0.4	32702	1046
46 Sc	i(m+g)	83.79D	1120.6	99.99	0.00	90726	2790.

			889.3	99.98	0.00	88556	2708.
					R_av	89609	3440.
44mSc	i(m)	58.61H	2656.5	98.61	0.01	69291	3499.
			1499.5	98.61	0.01	65053	2954.
			1157.0	98.61	0.01	54587	2052.
			1126.1	1.20	0.07	64367	4363.
			1001.8	1.20	0.07	62776	4445.
			270.9	86.7	0.3	56065	1757.
					R_av	56133	1807.
44 Sc	i	3.97H	2656.5	0.11	0.00	81470	5865.
			1499.5	0.91	0.02	80603	3847.
			1157.0	99.9	0.5	57655	7243.
					R_av	78107	5797.
44 Sc	i(m+g)	3.97H	2656.5	0.11	0.00	149790	7969.
			1499.5	0.91	0.02	144750	5849.
			1157.0	99.9	0.5	111480	7890.
					R_av	147569	4610.
43 Sc	c	3.891H	372.8	22.5	0.7	39802	1814
47 Ca	c	4.536D	1297.1	71	7	308.6	32.9
			159.4	*****************		418.9	30.9
					R_av	370.1	56.0
43 K	c	22.3H	1022.0	1.96	0.03	10762	1625.
			617.5	79.2	0.7	7073	234.
			593.4	11.26	0.09	7192	251.
			396.9	11.85	0.09	7086	244.
			372.8	86.8	0.2	6926	219.
			220.6	4.80	0.07	7199	304.
					R_av	6977	223.
42 K	i	12.360H	1525.0	18.08	0.09	23847	758
38 K	i	7.636M	2167.0	99.86	0.01	1976	404
41 Ar	c	109.34M	1294.0	99.1	0.0	2590	83
39 Cl	c	55.6M	1518.0	39.2	1.3	992.5	59.5
			1267.0	53.6	1.3	1034	55.
			250.3	46.3	2.0	1091	94.
					R_av	1025	45.
38 Cl	i(m+g)	37.24M	1643.0	31.9	1.0	4151	200
38 Cl	c	37.24M	2167.0	42.4	1.1	3979	188.
			1643.0	31.9	1.0	4188	200.
					R_av	4076	165.
34mCl	i(m)	32.00M	2127.0	42.8	0.8	983.8	84.5
			146.4	40.5	0.9	973.9	146.1
					R_av	981.5	75.4
38 S	c	170.3M	1942.0	83	3	64.27	9.44
			1643.0	*****************		37.61	12.18
					R_av	54.49	12.96
28 Mg	c	20.915H	1778.8	100.2	0.0	54.19	3.38
24 Na	c	14.9590H	1369.0	100	0	445.1	14.8
7 Be	i	53.29D	477.6	10.52	0.06	4913	252

Table 10.6: Detailed reaction rates for residual nuclide production in ^{nat}Cr at E_p=399 MeV used to determine their production cross sections.

Nuclide	Type	$T_{1/2}$	E_γ, KeV	Abundance, %		Reaction rate 10^{-20} s^{-1}	
54 Mn	i	312.11D	834.8	99.98	0.00	870.2	73.2
52 Mn	i	5.591D	1434.1	100.0	0.6	3870	139.
			1333.7	5.07	0.06	3887	196.
			1246.3	4.21	0.07	4107	230.
			935.5	94.5	1.0	3825	127.
			848.2	3.32	0.04	3745	320.
			744.2	90.0	0.9	3719	123.
					R_av	3793	123.
52mMn	i(m)	21.1M	1434.1	99.8	2.0	6757	494
51 Cr	c	27.7025D	320.1	9.92	0.05	307170	9606
49 Cr	c	42.3M	152.9	30.3	1.1	44290	2154.
			90.6	53.2	1.9	46996	2383.
					R_av	45471	1954.

48 Cr	c	21.56H	308.2	100	2	5663	215.
			112.3	96.0	2.1	5807	228.
					R_av	5725	201.
48 V	c	15.9735D	2240.4	2.41	0.04	157490	5724.
			1437.3	0.12	0.02	161000	27566.
			1312.1	97.5	0.9	155000	5014.
			983.5	100.0	0.3	151230	4664.
			944.1	7.76	0.10	153410	5144.
			928.3	0.77	0.05	155750	11420.
					R_av	155104	4974.
48 Sc	i	43.67H	1312.1	100.1	0.7	5477	327.
			1212.9	2.38	0.05	6960	349.
			1037.5	97.6	0.7	5717	184.
			983.5	100.1	0.6	5320	317.
			175.4	7.48	0.10	5979	235.
					R_av	5751	207.
47 Sc	i	3.3492D	159.4	68.3	0.4	31380	1018
47 Sc	c	3.3492D	159.4	68.3	0.4	32028	1031
46 Sc	i(m+g)	83.79D	1120.6	99.99	0.00	82927	2552.
			889.3	99.98	0.00	80999	2477.
					R_av	81935	3145.
44mSc	i(m)	58.61H	2656.5	98.61	0.01	64312	3718.
			1499.5	98.61	0.01	61208	2519.
			1157.0	98.61	0.01	50671	1585.
			1126.1	1.20	0.07	59365	4019.
			1001.8	1.20	0.07	57790	3930.
			270.9	86.7	0.3	52555	1661.
					R_av	50878	1631.
44 Sc	i	3.97H	2656.5	0.11	0.00	77159	6234.
			1499.5	0.91	0.02	71931	3798.
			1157.0	99.9	0.5	76590	2525.
					R_av	76304	2517.
44 Sc	i(m+g)	3.97H	2656.5	0.11	0.00	140570	8106.
			1499.5	0.91	0.02	132280	5524.
			1157.0	99.9	0.5	126550	4028.
					R_av	127176	3973.
43 Sc	c	3.891H	372.8	22.5	0.7	38906	1792
47 Ca	c	4.536D	1297.1	71	7	430.6	45.6
			159.4	**********	********	648.0	134.3
					R_av	451.7	66.0
45 K	c	17.3M	174.3	74	5	285.8	58.1
44 K	c*	22.13M	2150.8	23	4	1430	267.
			1499.4	7.8	1.3	1455	705.
					R_av	1433	251.
43 K	c	22.3H	1022.0	1.96	0.03	11565	1775.
			617.5	79.2	0.7	9116	297.
			593.4	11.26	0.09	9496	315.
			396.9	11.85	0.09	8957	303.
			372.8	86.8	0.2	8943	280.
			220.6	4.80	0.07	9132	383.
					R_av	8953	281.
42 K	i	12.360H	1525.0	18.08	0.09	30253	968
38 K	i	7.636M	2167.0	99.86	0.01	3969	233
41 Ar	c	109.34M	1294.0	99.1	0.0	4084	130
39 Cl	c	55.6M	1267.0	53.6	1.3	2072	91.
			250.3	46.3	2.0	2078	124.
					R_av	2073	85.
38 Cl	i(m+g)	37.24M	2167.0	42.4	1.1	7324	306.
			1643.0	31.9	1.0	7530	338.
					R_av	7409	279.
38 Cl	c	37.24M	2167.0	42.4	1.1	7475	311.
			1643.0	31.9	1.0	7658	344.
					R_av	7550	284.
34mCl	i(m)	32.00M	2127.0	42.8	0.8	2382	104.
			1177.0	14.09	0.24	2322	216.
			146.4	40.5	0.9	2231	104.
					R_av	2312	89.
38 S	c	170.3M	2167.0	**********	********	150.5	9.4
			1942.0	83	3	133.4	11.6
			1643.0	**********	********	127.4	10.8

					R_av	139.3	8.5
29 Al	c	6.56M	1273.3	90.6	0.6	2299	129
28 Mg	c	20.915H	1778.8	100.2	0.0	237.8	9.0
			1342.2	52.6	1.6	258.3	21.5
			941.5	38.3	1.0	311.6	27.3
			400.7	36.6	1.0	246.8	19.1
					R_av	242.0	11.0
27 Mg	c	9.458M	1014.4	28.0	0.4	730.5	245.5
			843.8	71.8	0.4	889.2	121.2
					R_av	859.2	109.6
24 Na	c	14.9590H	1369.0	100	0	1757	56
22 Na	c	2.6019Y	1274.5	99.94	0.01	1233	170
7 Be	i	53.29D	477.6	10.52	0.06	7206	267

Table 10.7: Detailed reaction rates for residual nuclide production in ^{nat}Cr at E_p=599 MeV used to determine their production cross sections.

Nuclide	Type	$T_{1/2}$	E_γ, KeV	Abundance, %		Reaction rate 10^{-20} s^{-1}	
54 Mn	i	312.11D	834.8	99.98	0.01	1223	100.
			834.8	99.98	0.00	1800	399.
					R_av	1253	39.
52 Mn	i	5.591D	1434.1	100.0	0.6	4057	141.
			1333.7	5.07	0.06	4461	213.
			1246.3	4.21	0.07	4359	326.
			935.5	94.5	1.0	3983	131.
			744.2	90.0	0.9	3929	130.
					R_av	3991	133.
52mMn	i(m)	21.1M	1434.1	99.8	2.0	6665	420
51 Cr	c	27.7025D	320.1	9.92	0.05	355610	11108
49 Cr	c	42.3M	152.9	30.3	1.1	45946	2223.
			90.6	53.2	1.9	48408	2380.
					R_av	47080	1928.
48 Cr	c	21.56H	308.2	100	2	5812	217.
			112.3	96.0	2.1	6013	235.
					R_av	5896	209.
48 V	c	15.9735D	2240.4	2.41	0.04	168900	6055.
			1437.3	0.12	0.02	164020	28134.
			1312.1	97.5	0.9	166630	5379.
			983.5	100.0	0.3	162520	5003.
			944.1	7.76	0.10	165310	5559.
			928.3	0.77	0.05	171180	12449.
					R_av	166748	5339.
48 Sc	i	43.67H	1312.1	100.1	0.7	9048	333.
			1212.9	2.38	0.05	9864	619.
			1037.5	97.6	0.7	8565	273.
			983.5	100.1	0.6	8742	322.
			175.4	7.48	0.10	8880	325.
					R_av	8642	284.
47 Sc	i	3.3492D	159.4	68.3	0.4	43014	1384
47 Sc	c	3.3492D	159.4	68.3	0.4	43446	1394
46 Sc	i(m+g)	83.79D	1120.6	99.99	0.00	106380	3272.
			889.3	99.98	0.00	103640	3168.
					R_av	104966	4029.
44mSc	i(m)	58.61H	2656.5	98.61	0.01	87761	5208.
			1499.5	98.61	0.01	77310	2905.
			1157.0	98.61	0.01	65361	2055.
			1126.1	1.20	0.07	76528	5140.
			1001.8	1.20	0.07	73423	4972.
			270.9	86.7	0.3	67210	2114.
					R_av	66385	2213.
44 Sc	i	3.97H	2656.5	0.11	0.00	101600	13557.
			1499.5	0.91	0.02	94856	3720.
			1157.0	99.9	0.5	97876	3495.
					R_av	96834	3311.
44 Sc	i(m+g)	3.97H	2656.5	0.11	0.00	188140	15049.
			1499.5	0.91	0.02	171090	6307.
			1157.0	99.9	0.5	162330	5327.
					R_av	165420	5168.

43 Sc	c	3.891H	372.8	22.5	0.7	50402	2329
47 Ca	c	4.536D	1297.1	71	7	777.6	81.4
			159.4	*********	*********	432.2	108.9
					R_av	659.8	165.1
45 K	c	17.3M	174.3	74	5	609.5	72.3
44 K	c*	22.13M	2150.8	23	4	2472	456.
			1499.4	7.8	1.3	2384	604.
					R_av	2440	368.
43 K	c	22.3H	1022.0	1.96	0.03	18675	1186.
			617.5	79.2	0.7	15007	483.
			593.4	11.26	0.09	15405	500.
			396.9	11.85	0.09	14410	476.
			372.8	86.8	0.2	14662	456.
			220.6	4.80	0.07	14402	577.
					R_av	14990	484.
42 K	i	12.360H	1525.0	18.08	0.09	48941	1572
38 K	i	7.636M	2167.0	99.86	0.01	6825	449
41 Ar	c	109.34M	1294.0	99.1	0.0	7398	233
39 Cl	c	55.6M	1518.0	39.2	1.3	4188	202.
			1267.0	53.6	1.3	4311	176.
			250.3	46.3	2.0	4262	242.
					R_av	4267	157.
38 Cl	i(m+g)	37.24M	2167.0	42.4	1.1	14935	639.
			1643.0	31.9	1.0	15460	705.
					R_av	15155	579.
38 Cl	c	37.24M	2167.0	42.4	1.1	15271	648.
			1643.0	31.9	1.0	15813	718.
					R_av	15496	589.
34mCl	i(m)	32.00M	2127.0	42.8	0.8	5464	219.
			1177.0	14.09	0.24	5404	261.
			146.4	40.5	0.9	5205	212.
					R_av	5346	188.
38 S	c	170.3M	2167.0	*********	*********	336.7	47.3
			1942.0	83	3	336.7	23.1
			1643.0	*********	*********	353.0	46.5
					R_av	339.1	20.3
29 Al	c	6.56M	1273.3	90.6	0.6	8020	338
28 Mg	c	20.915H	1778.8	100.2	0.0	968.9	32.0
			1372.9	4.7	0.2	1032	115.
			1342.2	52.6	1.6	984.9	45.2
			941.5	38.3	1.0	1011	48.
			400.7	36.6	1.0	906.7	41.0
					R_av	967.3	32.3
27 Mg	c	9.458M	1014.4	28.0	0.4	3888	333.
			843.8	71.8	0.4	3706	167.
					R_av	3730	161.
24 Na	c	14.9590H	1369.0	100	0	7048	221
22 Na	c	2.6019Y	1274.5	99.94	0.01	4468	260
7 Be	i	53.29D	477.6	10.52	0.06	16200	536

Table 10.8: Detailed reaction rates for residual nuclide production in ^{nat}Cr at E_p=799 MeV used to determine their production cross sections.

Nuclide	Type	$T_{1/2}$	E_γ, KeV	Abundance, %		Reaction rate 10^{-20} s^{-1}	
54 Mn	i	312.11D	834.8	99.98	0.00	1148	141
52 Mn	i	5.591D	1434.1	100.0	0.6	3812	141.
			1333.7	5.07	0.06	4148	221.
			1246.3	4.21	0.07	4058	283.
			935.5	94.5	1.0	3732	126.
			848.2	3.32	0.04	4479	932.
			744.2	90.0	0.9	3662	124.
					R_av	3734	125.
52mMn	i(m)	21.1M	1434.1	99.8	2.0	6693	531
51 Cr	c	27.7025D	320.1	9.92	0.05	328640	10281
49 Cr	c	42.3M	152.9	30.3	1.1	39116	1895.
			90.6	53.2	1.9	41759	2053.

					R_av	40318	1822.
48 Cr	c	21.56H	308.2	100	2	5003	188.
			112.3	96.0	2.1	5247	205.
					R_av	5103	200.
48 V	c	15.9735D	2240.4	2.41	0.04	147590	5447.
			1437.3	0.12	0.02	170020	29130.
			1312.1	97.5	0.9	143970	4653.
			983.5	100.0	0.3	140350	4328.
			944.1	7.76	0.10	143300	4906.
			928.3	0.77	0.05	143260	10556.
					R_av	144236	4625.
48 Sc	i	43.67H	1312.1	100.1	0.7	10429	405.
			1212.9	2.38	0.05	11244	560.
			1037.5	97.6	0.7	8947	289.
			983.5	100.1	0.6	10292	413.
			175.4	7.48	0.10	9285	358.
					R_av	9222	405.
47 Sc	i	3.3492D	159.4	68.3	0.4	42721	1405
47 Sc	c	3.3492D	159.4	68.3	0.4	42863	1389.
			159.4	68.3	0.4	42837	1387.
					R_av	42850	1364.
46 Sc	i(m+g)	83.79D	1120.6	99.99	0.00	98648	3039.
			889.3	99.98	0.00	96196	2949.
					R_av	97385	3739.
44mSc	i(m)	58.61H	1499.5	98.61	0.01	76671	3020.
			1157.0	98.61	0.01	59940	1889.
			1126.1	1.20	0.07	67122	4566.
			1001.8	1.20	0.07	68372	4637.
			270.9	86.7	0.3	60698	1902.
					R_av	60593	1982.
44 Sc	i	3.97H	1499.5	0.91	0.02	84058	4975.
			1157.0	99.9	0.5	88235	3048.
					R_av	87873	3014.
44 Sc	i(m+g)	3.97H	1499.5	0.91	0.02	159660	6952.
			1157.0	99.9	0.5	147340	4777.
					R_av	148140	5535.
43 Sc	c	3.891H	372.8	22.5	0.7	46429	2223
47 Ca	c	4.536D	1297.1	71	7	856.2	89.5
			159.4	******************		142.4	191.8
					R_av	737.9	266.3
45 K	c	17.3M	174.3	74	5	634.5	73.3
44 K	c*	22.13M	2150.8	23	4	2692	554.
			1499.4	7.8	1.3	2822	1146.
					R_av	2717	501.
43 K	c	22.3H	1022.0	1.96	0.03	19263	1118.
			617.5	79.2	0.7	16013	516.
			593.4	11.26	0.09	16385	532.
			396.9	11.85	0.09	15418	517.
			372.8	86.8	0.2	15775	492.
			220.6	4.80	0.07	15024	547.
					R_av	16016	519.
42 K	i	12.360H	1525.0	18.08	0.09	50308	1637
38 K	i	7.636M	2167.0	99.86	0.01	7110	413
41 Ar	c	109.34M	1294.0	99.1	0.0	8114	263
39 Cl	c	55.6M	1518.0	39.2	1.3	4814	228.
			1267.0	53.6	1.3	5163	212.
			250.3	46.3	2.0	5058	278.
					R_av	5032	192.
38 Cl	i(m+g)	37.24M	2167.0	42.4	1.1	17435	719.
			1643.0	31.9	1.0	17955	810.
					R_av	17638	661.
38 Cl	c	37.24M	2167.0	42.4	1.1	17980	740.
			1643.0	31.9	1.0	18419	828.
					R_av	18153	679.
34mCl	i(m)	32.00M	2127.0	42.8	0.8	6459	257.
			1177.0	14.09	0.24	6710	327.
			146.4	40.5	0.9	6507	261.
					R_av	6521	229.
38 S	c	170.3M	2167.0	******************		545.2	30.6

			1942.0	83	3	450.8	28.2
			1643.0	*********	*********	464.3	46.0
					R_av	491.8	35.4
29 Al	c	6.56M	1273.3	90.6	0.6	12813	497
28 Mg	c	20.915H	1778.8	100.2	0.0	1690	55.
			1589.4	4.2	0.2	1804	224.
			1342.2	52.6	1.6	1738	80.
			941.5	38.3	1.0	1738	74.
			400.7	36.6	1.0	1521	65.
					R_av	1681	59.
27 Mg	c	9.458M	1014.4	28.0	0.4	6117	527.
			843.8	71.8	0.4	6305	243.
					R_av	6290	239.
24 Na	c	14.9590H	1369.0	100	0	12609	395
22 Na	c	2.6019Y	1274.5	99.94	0.01	7487	304
7 Be	i	53.29D	477.6	10.52	0.06	22534	737

Table 10.9: Detailed reaction rates for residual nuclide production in ^{nat}Cr at E_p=1198 MeV used to determine their production cross sections.

Nuclide	Type	$T_{1/2}$	E_γ, KeV	Abundance, %		Reaction rate 10^{-20} s^{-1}	
54 Mn	i	312.11D	834.8	99.98	0.00	1370	95
52 Mn	i	5.591D	1434.1	100.0	0.6	3870	131.
			1333.7	5.07	0.06	3983	266.
			1246.3	4.21	0.07	3926	344.
			935.5	94.5	1.0	3839	127.
			744.2	90.0	0.9	3756	124.
					R_av	3818	122.
52mMn	i(m)	21.1M	1434.1	99.8	2.0	6478	382
51 Cr	c	27.7025D	320.1	9.92	0.05	322820	10108
49 Cr	c	42.3M	152.9	30.3	1.1	34558	1744.
			90.6	53.2	1.9	36989	1824.
					R_av	35737	1650.
48 Cr	c	21.56H	308.2	100	2	4120	158.
			112.3	96.0	2.1	4318	173.
					R_av	4203	164.
48 V	c	15.9735D	2240.4	2.41	0.04	131720	4863.
			1437.3	0.12	0.02	129880	22539.
			1312.1	97.5	0.9	128470	4160.
			983.5	100.0	0.3	125520	3878.
			944.1	7.76	0.10	126650	4247.
			928.3	0.77	0.05	126950	9302.
					R_av	128636	4129.
48 Sc	i	43.67H	1312.1	100.1	0.7	9529	428.
			1212.9	2.38	0.05	11104	559.
			1037.5	97.6	0.7	8870	286.
			983.5	100.1	0.6	9263	431.
			175.4	7.48	0.10	9118	337.
					R_av	8985	329.
47 Sc	i	3.3492D	159.4	68.3	0.4	40968	1397
47 Sc	c	3.3492D	159.4	68.3	0.4	41617	1375
46 Sc	i(m+g)	83.79D	1120.6	99.99	0.00	91188	2804.
			889.3	99.98	0.00	88987	2722.
					R_av	90055	3457.
44mSc	i(m)	58.61H	1499.5	98.61	0.01	67534	2853.
			1157.0	98.61	0.01	52792	1671.
			1126.1	1.20	0.07	56345	3891.
			1001.8	1.20	0.07	59849	4396.
			270.9	86.7	0.3	55939	1776.
					R_av	54289	1997.
44 Sc	i	3.97H	1499.5	0.91	0.02	69944	5202.
			1157.0	99.9	0.5	76612	2708.
					R_av	76164	2907.
44 Sc	i(m+g)	3.97H	1499.5	0.91	0.02	136530	6728.
			1157.0	99.9	0.5	128670	4212.
					R_av	129104	4415.
43 Sc	c	3.891H	372.8	22.5	0.7	40789	2226

47 Ca	c	4.536D	1297.1	71	7	929.0	97.1
			159.4	*********	*********	648.7	281.1
					R_av	901.5	92.4
45 K	c	17.3M	174.3	74	5	660.1	94.1
44 K	c*	22.13M	2150.8	23	4	2956	563.
			1499.4	7.8	1.3	3858	2215.
					R_av	3010	547.
43 K	c	22.3H	1022.0	1.96	0.03	17788	1537.
			617.5	79.2	0.7	15339	501.
			593.4	11.26	0.09	15613	540.
			396.9	11.85	0.09	14365	505.
			372.8	86.8	0.2	15159	481.
			220.6	4.80	0.07	14741	663.
					R_av	15166	493.
42 K	i	12.360H	1525.0	18.08	0.09	46489	1517
38 K	i	7.636M	2167.0	99.86	0.01	5162	574
41 Ar	c	109.34M	1294.0	99.1	0.0	8407	286
39 Cl	c	55.6M	1518.0	39.2	1.3	5552	267.
			1267.0	53.6	1.3	5788	237.
			250.3	46.3	2.0	5654	310.
					R_av	5694	209.
38 Cl	i(m+g)	37.24M	2167.0	42.4	1.1	19566	853
38 Cl	c	37.24M	2167.0	42.4	1.1	20057	864.
			1643.0	31.9	1.0	19958	1003.
					R_av	20021	785.
34mCl	i(m)	32.00M	2127.0	42.8	0.8	7848	316.
			1177.0	14.09	0.24	7661	360.
			146.4	40.5	0.9	7506	339.
					R_av	7699	275.
38 S	c	170.3M	2167.0	*********	*********	490.6	71.6
			1942.0	83	3	523.3	32.7
					R_av	518.7	30.9
29 Al	c	6.56M	1273.3	90.6	0.6	18058	800
28 Mg	c	20.915H	1778.8	100.2	0.0	2833	91.
			1589.4	4.2	0.2	3063	364.
			1342.2	52.6	1.6	2852	128.
			941.5	38.3	1.0	2844	123.
			400.7	36.6	1.0	2492	110.
					R_av	2812	98.
27 Mg	c	9.458M	1014.4	28.0	0.4	8939	525.
			843.8	71.8	0.4	9530	535.
					R_av	9234	427.
24 Na	c	14.9590H	1369.0	100	0	22493	704
22 Na	c	2.6019Y	1274.5	99.94	0.01	13788	472
7 Be	i	53.29D	477.6	10.52	0.06	35993	1150

Table 10.10: Detailed reaction rates for residual nuclide production in ^{nat}Cr at E_p=1598 MeV used to determine their production cross sections.

Nuclide	Type	$T_{1/2}$	E_γ, KeV	Abundance, %		Reaction rate 10^{-20} s^{-1}	
54 Mn	i	312.11D	834.8	99.98	0.00	1060	55
52 Mn	i	5.591D	1434.1	100.0	0.6	2697	95.
			1333.7	5.07	0.06	2642	142.
			1246.3	4.21	0.07	2991	219.
			935.5	94.5	1.0	2580	87.
			744.2	90.0	0.9	2493	85.
					R_av	2583	91.
52mMn	i(m)	21.1M	1434.1	99.8	2.0	4754	424
51 Cr	c	27.7025D	320.1	9.92	0.05	230970	7214
49 Cr	c	42.3M	152.9	30.3	1.1	23051	1125.
			90.6	53.2	1.9	26775	1336.
					R_av	24569	1984.
48 Cr	c	21.56H	308.2	100	2	2907	113.
			112.3	96.0	2.1	2966	117.
					R_av	2935	104.

48 V	c	15.9735D	2240.4	2.41	0.04	99452	3583.
			1437.3	0.12	0.02	103610	18759.
			1312.1	97.5	0.9	95649	3091.
			983.5	100.0	0.3	92130	2841.
			944.1	7.76	0.10	93749	3180.
			928.3	0.77	0.05	94386	7008.
					R_av	95926	3073.
48 Sc	i	43.67H	1312.1	100.1	0.7	6718	278.
			1212.9	2.38	0.05	7416	341.
			1037.5	97.6	0.7	6730	221.
			983.5	100.1	0.6	6500	285.
			175.4	7.48	0.10	6749	262.
					R_av	6747	226.
47 Sc	i	3.3492D	159.4	68.3	0.4	26882	860
47 Sc	c	3.3492D	159.4	68.3	0.4	27548	881
46 Sc	i(m+g)	83.79D	1120.6	99.99	0.00	67828	2086.
			889.3	99.98	0.00	65404	1999.
					R_av	66565	2555.
44mSc	i(m)	58.61H	2656.5	98.61	0.01	46668	2722.
			1499.5	98.61	0.01	41970	1611.
			1157.0	98.61	0.01	37575	1177.
			1126.1	1.20	0.07	44833	3022.
			1001.8	1.20	0.07	44051	3036.
			270.9	86.7	0.3	35754	1120.
					R_av	36720	1235.
44 Sc	i	3.97H	2656.5	0.11	0.00	63712	11924.
			1499.5	0.91	0.02	56935	3090.
			1157.0	99.9	0.5	58542	1958.
					R_av	58445	1946.
44 Sc	i(m+g)	3.97H	2656.5	0.11	0.00	109730	12385.
			1499.5	0.91	0.02	98321	4212.
			1157.0	99.9	0.5	95594	3062.
					R_av	95779	2992.
43 Sc	c	3.891H	372.8	22.5	0.7	28785	1375
47 Ca	c	4.536D	1297.1	71	7	707.1	73.6
			159.4	*********	********	665.7	31.7
					R_av	670.0	30.8
45 K	c	17.3M	174.3	74	5	515.3	60.7
44 K	c*	22.13M	2150.8	23	4	2101	458.
			1499.4	7.8	1.3	3160	1228.
					R_av	2229	430.
43 K	c	22.3H	1022.0	1.96	0.03	13326	738.
			617.5	79.2	0.7	11322	375.
			593.4	11.26	0.09	11655	381.
			396.9	11.85	0.09	10937	388.
			372.8	86.8	0.2	10828	340.
			220.6	4.80	0.07	10531	394.
					R_av	10942	366.
42 K	i	12.360H	1525.0	18.08	0.09	35180	1125
38 K	i	7.636M	2167.0	99.86	0.01	6246	539
41 Ar	c	109.34M	1294.0	99.1	0.0	6747	215
39 Cl	c	55.6M	1518.0	39.2	1.3	4390	225.
			1267.0	53.6	1.3	4859	205.
			250.3	46.3	2.0	4050	228.
					R_av	4527	277.
38 Cl	i(m+g)	37.24M	2167.0	42.4	1.1	15716	687.
			1643.0	31.9	1.0	16494	756.
					R_av	16051	632.
38 Cl	c	37.24M	2167.0	42.4	1.1	16292	706.
			1643.0	31.9	1.0	16931	773.
					R_av	16566	636.
34mCl	i(m)	32.00M	2127.0	42.8	0.8	6846	294.
			1177.0	14.09	0.24	7738	411.
			146.4	40.5	0.9	5473	239.
					R_av	6253	633.
38 S	c	170.3M	2167.0	*********	********	575.6	47.7
			1942.0	83	3	466.7	29.9
			1643.0	*********	********	437.1	43.5
					R_av	481.7	37.4
29 Al	c	6.56M	1273.3	90.6	0.6	18892	714

28 Mg	c	20.915H	1778.8	100.2	0.0	2810	89.
			1589.4	4.2	0.2	2860	325.
			1589.4	4.2	0.2	2724	238.
			1372.9	4.7	0.2	2632	229.
			1342.2	52.6	1.6	2742	121.
			941.5	38.3	1.0	2622	121.
			400.7	36.6	1.0	2488	106.
					R_av	2792	91.
27 Mg	c	9.458M	1014.4	28.0	0.4	10600	629.
			843.8	71.8	0.4	10685	401.
					R_av	10673	391.
24 Na	c	14.9590H	1369.0	100	0	23271	729
22 Na	c	2.6019Y	1274.5	99.94	0.01	15255	485
7 Be	i	53.29D	477.6	10.52	0.06	36111	1144

Table 10.11: Detailed reaction rates for residual nuclide production in ^{nat}Cr at E_p=2605 MeV used to determine their production cross sections.

Nuclide	Type	$T_{1/2}$	E_γ, KeV	Abundance, %		Reaction rate 10^{-20} s^{-1}	
54 Mn	i	312.11D	834.8	99.98	0.00	814.5	44.6
52 Mn	i	5.591D	1434.1	100.0	0.6	2068	70.
			1333.7	5.07	0.06	2132	109.
			1246.3	4.21	0.07	2170	203.
			935.5	94.5	1.0	1971	66.
			848.2	3.32	0.04	2096	437.
			744.2	90.0	0.9	1911	64.
					R_av	1978	69.
52mMn	i(m)	21.1M	1434.1	99.8	2.0	3638	239
51 Cr	c	27.7025D	320.1	9.92	0.05	167040	5228
49 Cr	c	42.3M	152.9	30.3	1.1	15926	786.
			90.6	53.2	1.9	18395	911.
					R_av	16976	1331.
48 Cr	c	21.56H	308.2	100	2	1897	72.
			112.3	96.0	2.1	1979	77.
					R_av	1934	73.
48 V	c	15.9735D	2240.4	2.41	0.04	65717	2380.
			1437.3	0.12	0.02	64851	11486.
			1312.1	97.5	0.9	63306	2067.
			983.5	100.0	0.3	60834	1900.
			944.1	7.76	0.10	62921	2127.
			928.3	0.77	0.05	61232	4616.
					R_av	63513	2046.
48 Sc	i	43.67H	1312.1	100.1	0.7	4771	259.
			1212.9	2.38	0.05	4714	262.
			1037.5	97.6	0.7	4572	147.
			983.5	100.1	0.6	4640	265.
			175.4	7.48	0.10	4507	194.
					R_av	4577	147.
47 Sc	i	3.3492D	159.4	68.3	0.4	18181	583
47 Sc	c	3.3492D	159.4	68.3	0.4	18643	597
46 Sc	i(m+g)	83.79D	1120.6	99.99	0.00	44452	1368.
			889.3	99.98	0.00	42777	1310.
					R_av	43578	1673.
44mSc	i(m)	58.61H	2656.5	98.61	0.01	34110	3541.
			1499.5	98.61	0.01	28669	1177.
			1157.0	98.61	0.01	23930	749.
			1126.1	1.20	0.07	27410	1924.
			1001.8	1.20	0.07	27185	1886.
			270.9	86.7	0.3	22775	715.
					R_av	23644	782.
44 Sc	i	3.97H	2656.5	0.11	0.00	44429	13396.
			1499.5	0.91	0.02	33945	2055.
			1157.0	99.9	0.5	37286	1233.
					R_av	37125	1278.
44 Sc	i(m+g)	3.97H	2656.5	0.11	0.00	78065	13623.
			1499.5	0.91	0.02	62216	2788.
			1157.0	99.9	0.5	60884	1941.
					R_av	60946	1904.
43 Sc	c	3.891H	372.8	22.5	0.7	18259	890

47 Ca	c	4.536D	1297.1	71	7	480.4	50.5
			159.4*****************			461.5	29.9
					R_av	465.8	27.2
45 K	c	17.3M	174.3	74	5	388.9	41.5
44 K	c*	22.13M	2150.8	23	4	1552	308.
			1499.4	7.8	1.3	1820	675.
					R_av	1598	281.
43 K	c	22.3H	1022.0	1.96	0.03	9280	497.
			617.5	79.2	0.7	7453	243.
			593.4	11.26	0.09	7641	251.
			396.9	11.85	0.09	7211	242.
			372.8	86.8	0.2	7114	222.
			220.6	4.80	0.07	6952	283.
					R_av	7449	248.
42 K	i	12.360H	1525.0	18.08	0.09	22848	729
38 K	i	7.636M	2167.0	99.86	0.01	4157	352
41 Ar	c	109.34M	1294.0	99.1	0.0	4595	146
39 Cl	c	55.6M	1518.0	39.2	1.3	3101	177.
			1267.0	53.6	1.3	3284	146.
			250.3	46.3	2.0	2753	155.
					R_av	3080	188.
38 Cl	i(m+g)	37.24M	2167.0	42.4	1.1	10061	434.
			1643.0	31.9	1.0	10507	500.
					R_av	10234	397.
38 Cl	c	37.24M	2167.0	42.4	1.1	10445	448.
			1643.0	31.9	1.0	10861	512.
					R_av	10607	409.
34mCl	i(m)	32.00M	2127.0	42.8	0.8	4342	186.
			1177.0	14.09	0.24	4315	245.
			146.4	40.5	0.9	3586	149.
					R_av	3922	291.
38 S	c	170.3M	2167.0*****************			384.3	25.9
			1942.0	83	3	300.6	20.3
			1643.0*****************			354.0	38.6
					R_av	335.3	29.3
29 Al	c	6.56M	1273.3	90.6	0.6	13570	519
28 Mg	c	20.915H	1778.8	100.2	0.0	2229	70.
			1589.4	4.2	0.2	2350	171.
			1372.9	4.7	0.2	1988	189.
			1342.2	52.6	1.6	2222	97.
			941.5	38.3	1.0	2037	89.
			400.7	36.6	1.0	1973	84.
					R_av	2217	73.
27 Mg	c	9.458M	1014.4	28.0	0.4	7955	455.
			843.8	71.8	0.4	8359	354.
					R_av	8245	328.
24 Na	c	14.9590H	1369.0	100	0	19398	605
22 Na	c	2.6019Y	1274.5	99.94	0.01	12839	404
7 Be	i	53.29D	477.6	10.52	0.06	34637	1100

10.2 Reaction rates for residual nuclide production in ^{56}Fe

Table 10.13: Detailed reaction rates for residual nuclide production in ^{56}Fe at E_p=46 MeV used to determine their production cross sections.

Nuclide	Type	$T_{1/2}$	E_γ, KeV	Abundance, %		Reaction rate 10^{-20} s^{-1}	
57 Co	i	271.74D	122.1	85.60	0.17	238.7	24.5
56 Co	i	77.233D	2598.5	17.3	0.3	35825.	1934.
			2212.9	0.40	0.01	39457.	3940.
			2113.1	0.38	0.01	27694.	5632.
			2034.8	7.89	0.13	33693.	1800.
			2015.2	3.04	0.05	33688.	1813.
			1963.7	0.72	0.01	37543.	2897.
			1810.8	0.64	0.01	35721.	4158.
			1771.3	15.47	0.14	35466.	1274.
			1360.2	4.29	0.04	34932.	1478.
			1238.3	66.9	0.6	34168.	1178.
			1175.1	2.29	0.02	32845.	1869.
			1037.8	14.17	0.13	33409.	1151.

			977.4	1.45	0.01	28085.	2345.
			846.8	99.94	0.03	34303.	1124.
			787.7	0.32	0.01	43309.	7302.
					R_av	34225.	1104.
55 Co	i	17.53H	2578.7	0.04	0.01	20826.	6083.
			2144.2	0.09	0.01	21056.	3062.
			1792.1	0.08	0.01	24864.	5502.
			1556.0	0.05	0.01	13353.	5137.
			1408.5	16.9	0.8	29717.	1732.
			1370.0	2.9	0.3	31367.	3422.
			1316.6	7.1	0.4	29697.	1953.
			1212.8	0.26	0.04	29427.	5314.
			931.1	75.	4.	28889.	1813.
			827.0	0.21	0.06	26650.	7996.
			803.7	1.87	0.16	28785.	3167.
			520.0	0.83	0.09	18843.	2544.
			477.2	20.2	1.7	29016.	2643.
			411.5	1.07	0.09	30136.	2948.
			385.4	0.54	0.05	22930.	3617.
					R_av	27578.	1373.
53 Fe	c*	8.51M	377.9	42.	3.	10897.	904.
52 Fe	c	8.275H	1434.1	******************		329.5	38.9
			377.7	******************		2850.	327.
			168.7	99.	3.	86.12	11.40
					R_av	108.7	80.4
56 Mn	c	2.5789H	2113.1	14.3	0.4	312.8	21.8
			1810.7	27.2	0.8	329.8	22.2
			846.8	98.9	0.3	380.5	21.7
					R_av	343.0	23.3
54 Mn	i	312.11D	834.8	99.98	0.00	460800.	15106.
52 Mn	c	5.591D	1333.7	5.07	0.06	19669.	725.
			1246.3	4.21	0.07	20739.	852.
			935.5	94.5	1.0	18332.	642.
			848.2	3.32	0.04	15041.	2506.
			744.2	90.0	0.9	17884.	702.
			647.5	0.40	0.02	19205.	7499.
			600.2	0.39	0.01	12760.	1945.
			346.0	0.98	0.01	16109.	2307.
					R_av	18753.	733.
52mMn	i(m)	21.1M	1434.1	99.8	2.0	14146.	553.
			377.7	1.68	0.05	12547.	1936.
					R_av	14098.	549.
52mMn	c	21.1M	1727.5	0.22	0.01	10398.	4837.
			1434.1	99.8	2.0	14476.	566.
			377.7	1.68	0.05	15397.	1959.
					R_av	14485.	562.
51 Cr	c	27.7025D	320.1	9.92	0.05	247020.	8480.
49 Cr	c	42.3M	152.9	30.3	1.1	236.0	32.5
			90.6	53.2	1.9	163.2	18.0
					R_av	179.9	31.2
48 Cr	c	21.56H	308.2	100.	2.	100.8	19.6
			112.3	96.0	2.1	104.0	10.5
					R_av	103.3	9.4
48 V	c	15.9735D	2240.4	2.41	0.04	5585.	562.
			1312.1	97.5	0.9	6866.	241.
			983.5	100.0	0.3	6554.	231.
			944.1	7.76	0.10	6719.	285.
			928.3	0.77	0.05	10115.	1197.
					R_av	6700.	255.
48 Sc	i	43.67H	1312.1	100.1	0.7	43.11	29.56
			983.5	100.1	0.6	327.0	58.6
					R_av	102.0	115.1
46 Sc	i(m+g)	83.79D	1120.6	99.99	0.00	360.9	79.4

Table 10.14: Detailed reaction rates for residual nuclide production in ^{56}Fe at E_p=68 MeV used to determine their production cross sections.

Nuclide	Type	$T_{1/2}$	E_γ, KeV	Abundance, %		Reaction rate 10^{-20} s^{-1}	
57 Co	i	271.74D	122.1	85.60	0.17	410.0	24.5
56 Co	i	77.233D	2598.5	17.3	0.3	36948.	2068.
			2212.9	0.40	0.01	34955.	4336.
			2113.1	0.38	0.01	39398.	4640.
			2034.8	7.89	0.13	36650.	1498.

			2015.2	3.04	0.05	36343.	1635.
			1963.7	0.72	0.01	37605.	2361.
			1810.8	0.64	0.01	37274.	2396.
			1771.3	15.47	0.14	37105.	1333.
			1360.2	4.29	0.04	37268.	1362.
			1238.3	66.9	0.6	35840.	1234.
			1175.1	2.29	0.02	33450.	1747.
			1037.8	14.17	0.13	34613.	1194.
			846.8	99.94	0.03	35528.	1169.
			787.7	0.32	0.01	49094.	7648.
					R_av	35847.	1155.
55 Co	i	17.53H	1408.5	16.9	0.8	28240.	1648.
			1370.0	2.9	0.3	31119.	3489.
			1316.6	7.1	0.4	28564.	1898.
			931.1	75.	4.	27745.	1758.
			827.0	0.21	0.06	25504.	8290.
			803.7	1.87	0.16	28730.	2707.
			520.0	0.83	0.09	29315.	3574.
			477.2	20.2	1.7	28931.	2641.
			411.5	1.07	0.09	38537.	3690.
			385.4	0.54	0.05	27989.	3190.
					R_av	28851.	1151.
53 Fe	c*	8.51M	377.9	42.	3.	83234.	6750.
52 Fe	c	8.275H	1434.1	*********	*********	6975.	420.
			377.7	*********	*********	4925.	353.
			168.7	99.	3.	5060.	258.
					R_av	5385.	565.
56 Mn	c	2.5789H	2113.1	14.3	0.4	626.8	69.4
			1810.7	27.2	0.8	707.7	41.2
			846.8	98.9	0.3	821.6	62.6
					R_av	720.0	49.3
54 Mn	i	312.11D	834.8	99.98	0.00	409300.	13413.
52 Mn	c	5.591D	1333.7	5.07	0.06	150260.	5391.
			1246.3	4.21	0.07	162580.	6144.
			935.5	94.5	1.0	140320.	4838.
			848.2	3.32	0.04	148620.	5271.
			744.2	90.0	0.9	136130.	4700.
			647.5	0.40	0.02	133260.	8860.
			600.2	0.39	0.01	137870.	6939.
			502.1	0.21	0.02	85438.	12976.
			346.0	0.98	0.01	137190.	5177.
					R_av	142850.	5482.
52mMn	i(m)	21.1M	1434.1	99.8	2.0	75649.	2951.
			377.7	1.68	0.05	77687.	6717.
					R_av	75799.	2915.
52mMn	c	21.1M	1727.5	0.22	0.01	40064.	8950.
			1434.1	99.8	2.0	82623.	3228.
			377.7	1.68	0.05	82612.	6829.
					R_av	80839.	6537.
51 Cr	c	27.7025D	320.1	9.92	0.05	171580.	5908.
49 Cr	c	42.3M	152.9	30.3	1.1	14544.	751.
			90.6	53.2	1.9	16315.	858.
					R_av	15305.	999.
48 Cr	c	21.56H	308.2	100.	2.	121.3	9.7
			112.3	96.0	2.1	129.4	7.6
					R_av	126.7	6.5
48 V	c	15.9735D	2240.4	2.41	0.04	9923.	528.
			1312.1	97.5	0.9	10024.	349.
			983.5	100.0	0.3	9654.	322.
			944.1	7.76	0.10	9612.	373.
					R_av	9765.	321.
48 Sc	i	43.67H	1312.1	100.1	0.7	80.39	39.28
			1212.9	2.38	0.05	6133.	860.
			983.5	100.1	0.6	255.4	52.3
					R_av	152.6	168.6
47 Sc	c	3.3492D	159.4	68.3	0.4	1093.	41.
46 Sc	i(m+g)	83.79D	1120.6	99.99	0.00	717.4	51.8
			889.3	99.98	0.00	431.6	21.8
					R_av	465.8	93.9
44mSc	i(m)	58.61H	1157.0	98.61	0.01	561.1	29.3
			270.9	86.7	0.3	610.1	25.7
					R_av	593.1	29.8
44 Sc	i	3.97H	1157.0	99.9	0.5	1078.	42.

44 Sc	i(m+g)	3.97H	2656.5	0.11	0.00	2489.	1678.
			1157.0	99.9	0.5	1632.	60.
					R_av	1632.	51.

Table 10.15: Detailed reaction rates for residual nuclide production in [56]Fe at E_p=99 MeV used to determine their production cross sections.

Nuclide	Type	$T_{1/2}$	E_γ, KeV	Abundance, %		Reaction rate 10^{-20} s^{-1}	
57 Co	i	271.74D	122.1	85.60	0.17	323.3	17.1
56 Co	i	77.233D	2598.5	17.3	0.3	19048.	1012.
			2034.8	7.89	0.13	18727.	775.
			2015.2	3.04	0.05	18370.	934.
			1963.7	0.72	0.01	16496.	2209.
			1810.8	0.64	0.01	18417.	1594.
			1771.3	15.47	0.14	18192.	653.
			1360.2	4.29	0.04	19444.	743.
			1238.3	66.9	0.6	18109.	621.
			1175.1	2.29	0.02	17108.	814.
			1037.8	14.17	0.13	17554.	619.
			846.8	99.94	0.03	17810.	583.
					R_av	18026.	586.
55 Co	i	17.53H	1408.5	16.9	0.8	13430.	785.
			1370.0	2.9	0.3	16158.	1776.
			1316.6	7.1	0.4	13893.	927.
			931.1	75.	4.	12942.	814.
			803.7	1.87	0.16	14924.	1437.
			477.2	20.2	1.7	13559.	1242.
			411.5	1.07	0.09	21978.	2105.
			385.4	0.54	0.05	16391.	2013.
					R_av	13999.	777.
53 Fe	c*	8.51M	377.9	42.	3.	37806.	3145.
52 Fe	c	8.275H	1434.1	*********	*********	5490.	585.
			377.7	*********	*********	3758.	220.
			168.7	99.	3.	5001.	245.
					R_av	4433.	483.
56 Mn	c	2.5789H	1810.7	27.2	0.8	618.5	36.2
			846.8	98.9	0.3	614.6	39.1
					R_av	616.8	29.8
54 Mn	i	312.11D	834.8	99.98	0.00	260900.	8500.
52 Mn	c	5.591D	1333.7	5.07	0.06	110480.	4100.
			1246.3	4.21	0.07	121090.	4594.
			935.5	94.5	1.0	105370.	3606.
			848.2	3.32	0.04	111170.	3975.
			744.2	90.0	0.9	102970.	3537.
			647.5	0.40	0.02	95516.	7940.
			600.2	0.39	0.01	85771.	6145.
			346.0	0.98	0.01	102890.	3771.
					R_av	106633.	4027.
52mMn	i(m)	21.1M	1434.1	99.8	2.0	66433.	2598.
			377.7	1.68	0.05	58259.	3431.
					R_av	64601.	3961.
52mMn	c	21.1M	1727.5	0.22	0.01	78574.	16133.
			1434.1	99.8	2.0	71924.	2836.
			377.7	1.68	0.05	62017.	3558.
					R_av	69510.	3774.
51 Cr	c	27.7025D	320.1	9.92	0.05	269390.	9230.
49 Cr	c	42.3M	152.9	30.3	1.1	25680.	1323.
			90.6	53.2	1.9	27370.	1458.
					R_av	26427.	1177.
48 Cr	c	21.56H	308.2	100.	2.	2647.	108.
			112.3	96.0	2.1	2793.	117.
					R_av	2712.	112.
48 V	c	15.9735D	2240.4	2.41	0.04	67653.	3061.
			1312.1	97.5	0.9	66995.	2322.
			983.5	100.0	0.3	65058.	2150.
			944.1	7.76	0.10	65698.	2335.
			928.3	0.77	0.05	64820.	7089.
					R_av	65786.	2114.
48 Sc	i	43.67H	1312.1	100.1	0.7	859.6	212.9
			1037.5	97.6	0.7	338.3	19.1
			983.5	100.1	0.6	927.5	240.9
					R_av	343.8	40.4
47 Sc	c	3.3492D	159.4	68.3	0.4	1630.	59.

46 Sc	i(m+g)	83.79D	1120.6	99.99	0.00	6902.	228.
			889.3	99.98	0.00	6496.	213.
					R_av	6665.	289.
44mSc	i(m)	58.61H	270.9	86.7	0.3	2102.	79.
44 Sc	i	3.97H	1157.0	99.9	0.5	2627.	111.
44 Sc	i(m+g)	3.97H	1499.5	0.91	0.02	2368.	390.
			1157.0	99.9	0.5	4529.	167.
					R_av	4419.	495.
43 Sc	c	3.891H	372.8	22.5	0.7	614.4	59.6
43 K	c	22.3H	617.5	79.2	0.7	61.26	14.45
			372.8	86.8	0.2	70.32	10.94
					R_av	67.06	8.83
42 K	i	12.360H	1525.0	18.08	0.09	344.4	22.6

Table 10.16: Detailed reaction rates for residual nuclide production in ^{56}Fe at E_p=149 MeV used to determine their production cross sections.

Nuclide	Type	$T_{1/2}$	E_γ, KeV	Abundance, %		Reaction rate 10^{-20} s^{-1}	
57 Co	i	271.74D	122.1	85.60	0.17	274.7	25.2
56 Co	i	77.233D	2598.5	17.3	0.3	9556.	515.
			2034.8	7.89	0.13	9345.	480.
			2015.2	3.04	0.05	9453.	536.
			1963.7	0.72	0.01	8927.	1722.
			1771.3	15.47	0.14	9625.	367.
			1360.2	4.29	0.04	9261.	465.
			1238.3	66.9	0.6	9203.	325.
			1175.1	2.29	0.02	7881.	879.
			1037.8	14.17	0.13	8798.	353.
			846.8	99.94	0.03	9170.	336.
					R_av	9223.	302.
55 Co	i	17.53H	1408.5	16.9	0.8	7146.	422.
			1370.0	2.9	0.3	9464.	1065.
			1316.6	7.1	0.4	7280.	490.
			931.1	75.	4.	6812.	441.
			803.7	1.87	0.16	7405.	808.
			520.0	0.83	0.09	4098.	854.
			477.2	20.2	1.7	7125.	652.
			411.5	1.07	0.09	17233.	1898.
			385.4	0.54	0.05	6878.	1081.
			91.9	1.16	0.09	7140.	659.
					R_av	7133.	482.
53 Fe	c*	8.51M	377.9	42.	3.	25822.	2194.
52 Fe	c	8.275H	1434.1	*********	********	3878.	224.
			377.7	*********	********	3047.	498.
			168.7	99.	3.	3086.	151.
					R_av	3296.	269.
56 Mn	c	2.5789H	2113.1	14.3	0.4	452.1	55.1
			1810.7	27.2	0.8	516.2	29.9
			846.8	98.9	0.3	615.4	59.1
					R_av	520.3	35.7
54 Mn	i	312.11D	834.8	99.98	0.00	164940.	5457.
52 Mn	c	5.591D	1333.7	5.07	0.06	67130.	2406.
			1246.3	4.21	0.07	73536.	2820.
			935.5	94.5	1.0	63012.	2184.
			848.2	3.32	0.04	65991.	2637.
			744.2	90.0	0.9	61577.	2135.
			647.5	0.40	0.02	61269.	4798.
			600.2	0.39	0.01	64262.	3687.
			346.0	0.98	0.01	61196.	2315.
					R_av	64193.	2405.
52mMn	i(m)	21.1M	1434.1	99.8	2.0	48351.	1892.
			377.7	1.68	0.05	30940.	5674.
					R_av	47658.	3715.
52mMn	c	21.1M	1434.1	99.8	2.0	52229.	2042.
			377.7	1.68	0.05	33987.	5702.
					R_av	51392.	4140.
51 Cr	c	27.7025D	320.1	9.92	0.05	190500.	6632.
49 Cr	c	42.3M	152.9	30.3	1.1	24159.	1240.
			90.6	53.2	1.9	24522.	1717.
					R_av	24265.	1123.

48 Cr	c	21.56H	308.2	100.	2.	2404.	102.
			112.3	96.0	2.1	2488.	108.
					R_av	2442.	92.
48 V	c	15.9735D	2240.4	2.41	0.04	59789.	2630.
			1312.1	97.5	0.9	58866.	2038.
			983.5	100.0	0.3	56690.	1886.
			944.1	7.76	0.10	57752.	2060.
			928.3	0.77	0.05	63521.	6290.
					R_av	57687.	1889.
48 Sc	i	43.67H	1312.1	100.1	0.7	773.4	179.4
			1037.5	97.6	0.7	515.0	20.7
			983.5	100.1	0.6	558.5	242.8
			175.4	7.48	0.10	629.7	53.6
					R_av	523.6	25.1
47 Sc	c	3.3492D	159.4	68.3	0.4	3707.	136.
46 Sc	i(m+g)	83.79D	1120.6	99.99	0.00	11299.	378.
			889.3	99.98	0.00	10757.	359.
					R_av	11006.	437.
44mSc	i(m)	58.61H	2656.5	98.61	0.01	5253.	365.
			1499.5	98.61	0.01	8315.	519.
			1157.0	98.61	0.01	6455.	220.
			1126.1	1.20	0.07	7386.	759.
			1001.8	1.20	0.07	6820.	885.
			270.9	86.7	0.3	6763.	256.
					R_av	6530.	279.
44 Sc	i	3.97H	2656.5	0.11	0.00	7880.	508.
			1499.5	0.91	0.02	7215.	546.
			1157.0	99.9	0.5	8122.	307.
					R_av	8008.	314.
44 Sc	i(m+g)	3.97H	2656.5	0.11	0.00	13059.	799.
			1499.5	0.91	0.02	15414.	778.
			1157.0	99.9	0.5	14487.	504.
					R_av	14353.	448.
43 Sc	c	3.891H	372.8	22.5	0.7	3445.	180.
43 K	c	22.3H	617.5	79.2	0.7	326.6	14.8
			593.4	11.26	0.09	329.6	64.7
			396.9	11.85	0.09	301.3	38.6
			372.8	86.8	0.2	322.1	16.3
			220.6	4.80	0.07	387.3	96.2
					R_av	324.2	12.9
42 K	i	12.360H	1525.0	18.08	0.09	1036.	43.
41 Ar	c	109.34M	1294.0	99.1	0.0	81.04	11.04

Table 10.17: Detailed reaction rates for residual nuclide production in ^{56}Fe at E_p=249 MeV used to determine their production cross sections.

Nuclide	Type	$T_{1/2}$	E_γ, KeV	Abundance, %		Reaction rate 10^{-20} s^{-1}	
57 Co	i	271.74D	122.1	85.60	0.17	542.8	46.7
56 Co	i	77.233D	2598.5	17.3	0.3	12309.	676.
			2034.8	7.89	0.13	12244.	552.
			2015.2	3.04	0.05	12423.	610.
			1771.3	15.47	0.14	11979.	466.
			1360.2	4.29	0.04	11537.	598.
			1238.3	66.9	0.6	11620.	402.
			1037.8	14.17	0.13	10941.	644.
			846.8	99.94	0.03	11500.	381.
					R_av	11654.	380.
55 Co	i	17.53H	1408.5	16.9	0.8	8591.	507.
			1370.0	2.9	0.3	9207.	3468.
			1316.6	7.1	0.4	8775.	591.
			931.1	75.	4.	8577.	545.
			477.2	20.2	1.7	8828.	808.
			411.5	1.07	0.09	21622.	2310.
					R_av	8832.	718.
53 Fe	c*	8.51M	377.9	42.	3.	30366.	2637.
			377.9	42.	3.	35360.	3117.
					R_av	32444.	2662.
52 Fe	c	8.275H	1434.1	******************		8234.	3758.
			377.7	******************		8655.	466.
			168.7	99.	3.	4776.	234.
					R_av	5491.	1076.

56 Mn	c	2.5789H	2657.4	0.65	0.02	7987.	1076.
			2113.1	14.3	0.4	1437.	85.
			1810.7	27.2	0.8	1533.	79.
			846.8	98.9	0.3	1663.	62.
					R_av	1609.	120.
54 Mn	i	312.11D	834.8	99.98	0.00	303930.	9901.
52 Mn	c	5.591D	1246.3	4.21	0.07	118900.	4426.
			935.5	94.5	1.0	101460.	3472.
			848.2	3.32	0.04	105820.	3732.
			744.2	90.0	0.9	99631.	3420.
			647.5	0.40	0.02	98158.	7459.
			346.0	0.98	0.01	99263.	3608.
					R_av	103023.	4089.
52mMn	i(m)	21.1M	1434.1	99.8	2.0	25349.	6329.
			377.7	1.68	0.05	80171.	3785.
					R_av	70872.	20694.
52mMn	c	21.1M	1434.1	99.8	2.0	33583.	6735.
			377.7	1.68	0.05	88825.	4153.
					R_av	79020.	21251.
51 Cr	c	27.7025D	320.1	9.92	0.05	358090.	12247.
49 Cr	c	42.3M	152.9	30.3	1.1	48155.	2470.
			90.6	53.2	1.9	51380.	2820.
					R_av	49498.	2218.
48 Cr	c	21.56H	308.2	100.	2.	6015.	245.
			112.3	96.0	2.1	6111.	259.
					R_av	6058.	222.
48 V	c	15.9735D	2240.4	2.41	0.04	141420.	6156.
			1312.1	97.5	0.9	141280.	4858.
			1312.1	97.5	0.9	140800.	4839.
			983.5	100.0	0.3	136690.	4472.
			944.1	7.76	0.10	138430.	4859.
			928.3	0.77	0.05	128810.	11924.
					R_av	138710.	4440.
48 Sc	i	43.67H	1312.1	100.1	0.7	1890.	282.
			1037.5	97.6	0.7	1827.	69.
			983.5	100.1	0.6	2051.	309.
			175.4	7.48	0.10	2704.	168.
					R_av	1886.	136.
47 Sc	i	3.3492D	159.4	68.3	0.4	12964.	464.
47 Sc	c	3.3492D	159.4	68.3	0.4	13056.	466.
			159.4	68.3	0.4	13141.	469.
					R_av	13098.	503.
46 Sc	i(m+g)	83.79D	1120.6	99.99	0.00	38946.	1278.
			889.3	99.98	0.00	37876.	1233.
					R_av	38345.	1310.
44mSc	i(m)	58.61H	2656.5	98.61	0.01	30732.	2994.
			1499.5	98.61	0.01	31653.	1648.
			1126.1	1.20	0.07	32467.	2267.
			1001.8	1.20	0.07	30722.	2310.
			270.9	86.7	0.3	29566.	1097.
					R_av	30140.	1065.
44 Sc	i	3.97H	2656.5	0.11	0.00	31490.	4539.
			1499.5	0.91	0.02	32255.	2008.
			1157.0	99.9	0.5	33721.	2198.
					R_av	32800.	1608.
44 Sc	i(m+g)	3.97H	2656.5	0.11	0.00	61795.	5647.
			1499.5	0.91	0.02	63468.	2943.
			1157.0	99.9	0.5	61080.	2793.
					R_av	62168.	1942.
43 Sc	c	3.891H	372.8	22.5	0.7	16658.	788.
47 Ca	c	4.536D	159.4	*****************		91.80	25.73
43 K	c	22.3H	617.5	79.2	0.7	2195.	86.
			593.4	11.26	0.09	2197.	116.
			396.9	11.85	0.09	2403.	114.
			372.8	86.8	0.2	2217.	81.
			220.6	4.80	0.07	2418.	181.
					R_av	2235.	78.
42 K	i	12.360H	1525.0	18.08	0.09	7625.	270.
38 K	c	7.636M	2167.0	99.86	0.01	618.7	220.4
			2167.0	99.86	0.01	618.7	220.4
					R_av	618.7	156.4

41 Ar	c	109.34M	1294.0	99.1	0.0	693.9	30.0
39 Cl	c	55.6M	1518.0	39.2	1.3	305.4	169.2
			1267.0	53.6	1.3	279.4	81.5
			250.3	46.3	2.0	861.1	278.9
					R_av	321.6	101.1
38 Cl	c	37.24M	2167.0	42.4	1.1	791.9	109.1
			2167.0	42.4	1.1	791.9	109.1
			1643.0	31.9	1.0	1021.	84.
			1643.0	31.9	1.0	1021.	84.
					R_av	950.2	68.0
34mCl	i(m)	32.00M	2127.0	42.8	0.8	203.7	56.3
			2127.0	42.8	0.8	203.7	56.3
			1177.0	14.09	0.24	3760.	652.
			146.4	40.5	0.9	1356.	267.
			146.4	40.5	0.9	1356.	267.
					R_av	265.8	157.3
28 Mg	c	20.915H	1778.8	100.2	0.0	25.35	10.28
24 Na	c	14.9590H	1369.0	100.	0.	286.8	95.7
7 Be	i	53.29D	477.6	10.52	0.06	6306.	291.

Table 10.18: Detailed reaction rates for residual nuclide production in ^{56}Fe at E_p=300 MeV used to determine their production cross sections.

Nuclide	Type	$T_{1/2}$	E_γ, KeV	Abundance, %		Reaction rate 10^{-20} s^{-1}	
57 Co	i	271.74D	136.5	10.68	0.08	821.6	370.8
			122.1	85.60	0.17	475.2	24.3
					R_av	476.2	24.3
56 Co	i	77.233D	2598.5	17.3	0.3	7733.	414.
			2034.8	7.89	0.13	7690.	340.
			2015.2	3.04	0.05	5206.	373.
			1771.3	15.47	0.14	7832.	291.
			1360.2	4.29	0.04	6950.	329.
			1238.3	66.9	0.6	7639.	263.
			1037.8	14.17	0.13	7228.	274.
			846.8	99.94	0.03	7392.	243.
					R_av	7423.	276.
55 Co	i	17.53H	1408.5	16.9	0.8	5266.	316.
			931.1	75.	4.	5196.	328.
			477.2	20.2	1.7	5386.	495.
					R_av	5256.	244.
53 Fe	c*	8.51M	377.9	42.	3.	19288.	3222.
52 Fe	c	8.275H	1434.1	*********	*********	3599.	238.
			168.7	99.	3.	3184.	160.
					R_av	3293.	209.
56 Mn	c	2.5789H	2113.1	14.3	0.4	1302.	96.
			846.8	98.9	0.3	1299.	54.
					R_av	1299.	52.
54 Mn	i	312.11D	834.8	99.98	0.00	234800.	7648.
52 Mn	c	5.591D	1434.1	100.0	0.6	76336.	2582.
			1333.7	5.07	0.06	78892.	2810.
			1246.3	4.21	0.07	84805.	3165.
			935.5	94.5	1.0	74189.	2540.
			848.2	3.32	0.04	71729.	2592.
			744.2	90.0	0.9	72897.	2506.
					R_av	75501.	2823.
52mMn	i(m)	21.1M	1434.1	99.8	2.0	55774.	2387.
52mMn	c	21.1M	1727.5	0.22	0.01	75759.	29039.
			1434.1	99.8	2.0	59373.	2506.
			377.7	1.68	0.05	44483.	17581.
					R_av	59292.	2497.
51 Cr	c	27.7025D	320.1	9.92	0.05	276580.	9489.
49 Cr	c	42.3M	152.9	30.3	1.1	38183.	1945.
			90.6	53.2	1.9	38758.	2055.
					R_av	38448.	1648.
48 Cr	c	21.56H	308.2	100.	2.	4720.	195.
			112.3	96.0	2.1	5034.	210.
					R_av	4864.	218.

48 V	c	15.9735D	1312.1	97.5	0.9	116580.	4006.
			983.5	100.0	0.3	113830.	3723.
			944.1	7.76	0.10	114890.	4035.
			928.3	0.77	0.05	115660.	8819.
					R_av	114719.	3676.
48 Sc	i	43.67H	1312.1	100.1	0.7	967.9	96.1
			1037.5	97.6	0.7	1707.	60.
			983.5	100.1	0.6	1128.	98.
			175.4	7.48	0.10	2262.	135.
					R_av	1638.	163.
47 Sc	i	3.3492D	159.4	68.3	0.4	12140.	432.
47 Sc	c	3.3492D	159.4	68.3	0.4	12319.	438.
46 Sc	i(m+g)	83.79D	1120.6	99.99	0.00	36852.	1209.
			889.3	99.98	0.00	35756.	1164.
					R_av	36234.	1256.
44mSc	i(m)	58.61H	2656.5	98.61	0.01	33019.	2335.
			1499.5	98.61	0.01	20916.	1541.
			1126.1	1.20	0.07	30670.	2447.
			1001.8	1.20	0.07	28669.	2357.
			270.9	86.7	0.3	29169.	1083.
					R_av	28388.	1740.
44 Sc	i	3.97H	2656.5	0.11	0.00	36698.	4030.
			1499.5	0.91	0.02	30886.	1968.
					R_av	31843.	2374.
44 Sc	i(m+g)	3.97H	2656.5	0.11	0.00	69258.	5306.
			1499.5	0.91	0.02	51511.	2656.
					R_av	54347.	1698.
43 Sc	c	3.891H	372.8	22.5	0.7	16145.	764.
47 Ca	c	4.536D	1297.1	71.	7.	114.2	26.6
			807.9	6.2	0.8		
0.00***************%							
			489.2	6.2	0.8		
0.00***************%							
			159.4******************			178.9	17.2
					R_av	161.0	17.5
44 K	c*	22.13M	2150.8	23.	4.	0.00*********	
43 K	c	22.3H	617.5	79.2	0.7	2443.	88.
			593.4	11.26	0.09	2514.	140.
			396.9	11.85	0.09	2328.	130.
			372.8	86.8	0.2	2453.	85.
					R_av	2445.	81.
42 K	i	12.360H	1525.0	18.08	0.09	8463.	300.
41 Ar	c	109.34M	1294.0	99.1	0.0	879.5	40.7
39 Cl	c	55.6M	1518.0	39.2	1.3	411.5	59.5
			1267.0	53.6	1.3	390.3	67.5
			250.3	46.3	2.0	354.8	112.1
					R_av	396.0	42.6
38 Cl	c	37.24M	2167.0	42.4	1.1	1424.	94.
			1643.0	31.9	1.0	1612.	111.
					R_av	1500.	103.
34mCl	i(m)	32.00M	2127.0	42.8	0.8	472.0	62.2
			1177.0	14.09	0.24		
0.00***************%							
			146.4	40.5	0.9		
0.00***************%							
					R_av	472.0	62.2
38 S	c	170.3M	1942.0	83.	3.	0.00*********	
28 Mg	c	20.915H	1778.8	100.2	0.0	40.88	6.09
27 Mg	c	9.458M	1014.4	28.0	0.4		
0.00***************%							
			843.8	71.8	0.4		
0.00***************%							
					R_av	0.00*********	
24 Na	c	14.9590H	1369.0	100.	0.	377.3	103.6
22 Na	c	2.6019Y	1274.5	99.94	0.01	364.4	66.6
7 Be	i	53.29D	477.6	10.52	0.06	4655.	205.

Table 10.19: Detailed reaction rates for residual nuclide production in ^{56}Fe at E_p=400 MeV used to determine their production cross sections.

Nuclide	Type	$T_{1/2}$	E_γ, KeV	Abundance, %		Reaction rate 10^{-20} s^{-1}	
57 Co	i	271.74D	136.5	10.68	0.08	117780.	32711.
			122.1	85.60	0.17	657.8	37.6
					R_av	657.9	115.2
56 Co	i	77.233D	2598.5	17.3	0.3	7320.	438.
			2034.8	7.89	0.13	7258.	373.
			2015.2	3.04	0.05	6440.	395.
			1771.3	15.47	0.14	7074.	290.
			1360.2	4.29	0.04	6566.	697.
			1238.3	66.9	0.6	7345.	257.
			1175.1	2.29	0.02	8230.	1803.
			1037.8	14.17	0.13	6732.	451.
			846.8	99.94	0.03	7333.	290.
					R_av	7214.	242.
55 Co	i	17.53H	1408.5	16.9	0.8	4695.	284.
			1316.6	7.1	0.4	4898.	366.
			931.1	75.	4.	4749.	302.
			477.2	20.2	1.7	4809.	450.
			411.5	1.07	0.09	70343.	11024.
			385.4	0.54	0.05	322180.	79966.
					R_av	4779.	504.
53 Fe	c*	8.51M	377.9	42.	3.	25655.	2597.
52 Fe	c	8.275H	1434.1	*********	*********	4154.	298.
			168.7	99.	3.	3420.	169.
					R_av	3561.	310.
56 Mn	c	2.5789H	2113.1	14.3	0.4	2358.	162.
			2113.1	14.3	0.4	2225.	285.
			1810.7	27.2	0.8	2432.	161.
			846.8	98.9	0.3	2942.	200.
					R_av	2502.	161.
54 Mn	i	312.11D	834.8	99.98	0.00	250590.	8205.
52 Mn	c	5.591D	1333.7	5.07	0.06	79766.	2884.
			1246.3	4.21	0.07	87980.	3342.
			935.5	94.5	1.0	76489.	2631.
			848.2	3.32	0.04	93077.	6009.
			744.2	90.0	0.9	73522.	2544.
			647.5	0.40	0.02	75584.	5824.
			600.2	0.39	0.01	69827.	4423.
			346.0	0.98	0.01	70621.	2966.
					R_av	76803.	3057.
52mMn	i(m)	21.1M	1434.1	99.8	2.0	57829.	2286.
52mMn	c	21.1M	1434.1	99.8	2.0	61983.	2447.
51 Cr	c	27.7025D	320.1	9.92	0.05	293380.	10081.
49 Cr	c	42.3M	152.9	30.3	1.1	45918.	2365.
			90.6	53.2	1.9	44890.	3654.
					R_av	45675.	2176.
48 Cr	c	21.56H	308.2	100.	2.	5821.	257.
			112.3	96.0	2.1	5819.	250.
					R_av	5820.	220.
48 V	c	15.9735D	2240.4	2.41	0.04	139270.	6116.
			2240.4	2.41	0.04	139270.	6116.
			1312.1	97.5	0.9	126230.	4348.
			983.5	100.0	0.3	122540.	4018.
			944.1	7.76	0.10	136600.	4887.
			928.3	0.77	0.05	138060.	11745.
					R_av	126908.	4814.
48 Sc	i	43.67H	1312.1	100.1	0.7	3289.	621.
			1037.5	97.6	0.7	2486.	91.
			983.5	100.1	0.6	3323.	623.
			175.4	7.48	0.10	3224.	186.
					R_av	2558.	150.
46 Sc	i(m+g)	83.79D	1120.6	99.99	0.00	50431.	1670.
			889.3	99.98	0.00	49041.	1603.
					R_av	49625.	1695.
44mSc	i(m)	58.61H	2656.5	98.61	0.01	21441.	3556.
			1499.5	98.61	0.01	42994.	2010.
			1157.0	98.61	0.01	36362.	1225.
			1126.1	1.20	0.07	48287.	3347.
			1001.8	1.20	0.07	44947.	3293.
			270.9	86.7	0.3	41572.	1550.

					R_av	38004.	1942.
44 Sc	i	3.97H	2656.5	0.11	0.00	31259.	7471.
			1499.5	0.91	0.02	43019.	3050.
			1157.0	99.9	0.5	43820.	1793.
					R_av	43445.	1850.
44 Sc	i(m+g)	3.97H	2656.5	0.11	0.00	52403.	7911.
			1499.5	0.91	0.02	85416.	4176.
			1157.0	99.9	0.5	79677.	2851.
					R_av	78665.	2458.
43 Sc	c	3.891H	372.8	22.5	0.7	26350.	1348.
47 Ca	c	4.536D	1297.1	71.	7.	147.6	33.3
44 K	c*	22.13M	2150.8	23.	4.	569.2	168.7
43 K	c	22.3H	617.5	79.2	0.7	4451.	162.
			593.4	11.26	0.09	4383.	201.
			396.9	11.85	0.09	4657.	226.
			372.8	86.8	0.2	4392.	164.
			220.6	4.80	0.07	4802.	311.
					R_av	4454.	149.
42 K	i	12.360H	1525.0	18.08	0.09	15469.	572.
38 K	c	7.636M	2167.0	99.86	0.01	2769.	380.
41 Ar	c	109.34M	1294.0	99.1	0.0	1836.	70.
39 Cl	c	55.6M	1518.0	39.2	1.3	629.4	98.0
			1267.0	53.6	1.3	873.3	127.9
			250.3	46.3	2.0	807.9	93.6
					R_av	756.6	74.5
38 Cl	i(m+g)	37.24M	2167.0	42.4	1.1	3119.	231.
38 Cl	c	37.24M	2167.0	42.4	1.1	3178.	228.
			1643.0	31.9	1.0	3503.	234.
			1643.0	31.9	1.0	3503.	234.
					R_av	3401.	151.
34mCl	i(m)	32.00M	2127.0	42.8	0.8	1101.	135.
			146.4	40.5	0.9	976.7	87.1
					R_av	1012.	76.
38 S	c	170.3M	2167.0	**********	*******	58.74	23.34
			1942.0	83.	3.	498240.	108138.
					R_av	58.77	108.32
29 Al	c	6.56M	1273.3	90.6	0.6	612.7	338.4
28 Mg	c	20.915H	1778.8	100.2	0.0	96.62	8.71
			1342.2	52.6	1.6	93.79	28.89
			941.5	38.3	1.0	397.8	58.9
			400.7	36.6	1.0	296.7	81.7
					R_av	103.7	25.7
24 Na	c	14.9590H	1369.0	100.	0.	1131.	66.
22 Na	c	2.6019Y	1274.5	99.94	0.01	763.7	232.5
7 Be	i	53.29D	477.6	10.52	0.06	8202.	350.

Table 10.20: Detailed reaction rates for residual nuclide production in ^{56}Fe at E_p=500 MeV used to determine their production cross sections.

Nuclide	Type	$T_{1/2}$	E_γ, KeV	Abundance, %		Reaction rate 10^{-20} s^{-1}	
57 Co	i	271.74D	136.5	10.68	0.08	907.8	144.0
			122.1	85.60	0.17	841.1	33.6
					R_av	842.5	33.5
56 Co	i	77.233D	2598.5	17.3	0.3	6960.	377.
			2034.8	7.89	0.13	7107.	331.
			2015.2	3.04	0.05	5042.	903.
			1771.3	15.47	0.14	6940.	266.
			1360.2	4.29	0.04	6551.	377.
			1238.3	66.9	0.6	6934.	244.
			1037.8	14.17	0.13	6696.	270.
					R_av	6877.	230.
55 Co	i	17.53H	1408.5	16.9	0.8	3896.	236.
			931.1	75.	4.	3705.	237.
			477.2	20.2	1.7	4045.	394.
					R_av	3834.	180.
53 Fe	c*	8.51M	377.9	42.	3.	29480.	6044.

52 Fe	c	8.275H	1434.1	******************		3510.	389.
			168.7	99.	3.	3133.	153.
					R_av	3167.	149.
56 Mn	c	2.5789H	2113.1	14.3	0.4	3269.	287.
			1810.7	27.2	0.8	2854.	193.
					R_av	2974.	210.
54 Mn	i	312.11D	834.8	99.98	0.00	282970.	9218.
52 Mn	c	5.591D	1434.1	100.0	0.6	81126.	2745.
			1333.7	5.07	0.06	83565.	2961.
			1246.3	4.21	0.07	91022.	3391.
			935.5	94.5	1.0	78784.	2697.
			744.2	90.0	0.9	77509.	2661.
					R_av	80904.	3144.
52mMn	i(m)	21.1M	1434.1	99.8	2.0	63787.	3171.
52mMn	c	21.1M	1434.1	99.8	2.0	67298.	3267.
			377.7	1.68	0.05	38895.	26725.
					R_av	67051.	3368.
51 Cr	c	27.7025D	320.1	9.92	0.05	320630.	11025.
49 Cr	c	42.3M	152.9	30.3	1.1	48851.	2515.
			90.6	53.2	1.9	49502.	2628.
					R_av	49157.	2116.
48 Cr	c	21.56H	308.2	100.	2.	6447.	261.
			112.3	96.0	2.1	6657.	279.
					R_av	6540.	239.
48 V	c	15.9735D	1312.1	97.5	0.9	157450.	5412.
			983.5	100.0	0.3	153900.	5034.
			944.1	7.76	0.10	154800.	5429.
			928.3	0.77	0.05	153360.	11610.
					R_av	154925.	4965.
48 Sc	i	43.67H	1312.1	100.1	0.7	2676.	235.
			1037.5	97.6	0.7	3204.	109.
			983.5	100.1	0.6	2672.	198.
			175.4	7.48	0.10	3654.	210.
					R_av	3182.	147.
47 Sc	i	3.3492D	159.4	68.3	0.4	21908.	787.
47 Sc	c	3.3492D	159.4	68.3	0.4	22186.	792.
46 Sc	i(m+g)	83.79D	1120.6	99.99	0.00	64912.	2131.
			889.3	99.98	0.00	63132.	2054.
					R_av	63906.	2183.
44mSc	i(m)	58.61H	2656.5	98.61	0.01	63335.	5143.
			1499.5	98.61	0.01	39635.	2741.
			1126.1	1.20	0.07	57117.	4074.
			1001.8	1.20	0.07	59462.	4184.
			270.9	86.7	0.3	56750.	2109.
					R_av	54659.	3642.
44 Sc	i	3.97H	2656.5	0.11	0.00	70682.	15506.
			1499.5	0.91	0.02	63703.	6321.
					R_av	64628.	5941.
44 Sc	i(m+g)	3.97H	2656.5	0.11	0.00	133130.	16704.
			1499.5	0.91	0.02	102780.	7027.
					R_av	106721.	3334.
43 Sc	c	3.891H	372.8	22.5	0.7	34573.	1647.
47 Ca	c	4.536D	1297.1	71.	7.	207.9	28.2
			159.4	******************		277.6	75.3
					R_av	216.1	26.6
43 K	c	22.3H	617.5	79.2	0.7	6481.	229.
			593.4	11.26	0.09	6627.	262.
			396.9	11.85	0.09	6169.	246.
			372.8	86.8	0.2	6521.	223.
					R_av	6472.	216.
42 K	i	12.360H	1525.0	18.08	0.09	22056.	768.
41 Ar	c	109.34M	1294.0	99.1	0.0	2796.	110.
39 Cl	c	55.6M	1518.0	39.2	1.3	1586.	131.
			1267.0	53.6	1.3	1604.	136.
			250.3	46.3	2.0	1325.	150.
					R_av	1522.	97.
38 Cl	c	37.24M	2167.0	42.4	1.1	5979.	480.

			1643.0	31.9	1.0	6216.	367.
					R_av	6159.	269.
34mCl	i(m)	32.00M	2127.0	42.8	0.8	2043.	228.
			1177.0	14.09	0.24	2527.	1259.
			146.4	40.5	0.9	1833.	201.
					R_av	1932.	156.
28 Mg	c	20.915H	1342.2	52.6	1.6	297.9	22.2
			400.7	36.6	1.0	391.9	34.1
					R_av	324.9	43.7
24 Na	c	14.9590H	1369.0	100.	0.	1972.	180.
22 Na	c	2.6019Y	1274.5	99.94	0.01	1776.	103.
7 Be	i	53.29D	477.6	10.52	0.06	12802.	549.

Table 10.21: Detailed reaction rates for residual nuclide production in ^{56}Fe at E_p=600 MeV used to determine their production cross sections.

Nuclide	Type	$T_{1/2}$	E_γ, KeV	Abundance, %		Reaction rate 10^{-20} s^{-1}	
57 Co	i	271.74D	122.1	85.60	0.17	1218.	71.
56 Co	i	77.233D	2598.5	17.3	0.3	7274.	399.
			2034.8	7.89	0.13	7390.	516.
			2015.2	3.04	0.05	7184.	454.
			1771.3	15.47	0.14	7607.	319.
			1360.2	4.29	0.04	8133.	596.
			1238.3	66.9	0.6	7221.	253.
			1037.8	14.17	0.13	6828.	425.
			846.8	99.94	0.03	7705.	312.
					R_av	7362.	250.
55 Co	i	17.53H	1408.5	16.9	0.8	3531.	224.
			1316.6	7.1	0.4	3752.	283.
			931.1	75.	4.	3537.	224.
			477.2	20.2	1.7	3765.	357.
					R_av	3603.	160.
53 Fe	c*	8.51M	377.9	42.	3.	22504.	1921.
52 Fe	c	8.275H	1434.1	******************		3870.	300.
			168.7	99.	3.	2970.	159.
					R_av	3132.	359.
56 Mn	c	2.5789H	2113.1	14.3	0.4	3979.	257.
			1810.7	27.2	0.8	4272.	247.
			846.8	98.9	0.3	4536.	264.
					R_av	4264.	206.
54 Mn	i	312.11D	834.8	99.98	0.00	290670.	9469.
52 Mn	c	5.591D	1246.3	4.21	0.07	90460.	3382.
			935.5	94.5	1.0	76649.	2626.
			848.2	3.32	0.04	103340.	4648.
			744.2	90.0	0.9	75153.	2582.
			647.5	0.40	0.02	71379.	6969.
			346.0	0.98	0.01	69591.	2977.
					R_av	78027.	4103.
52mMn	i(m)	21.1M	1434.1	99.8	2.0	61994.	2510.
52mMn	c	21.1M	1434.1	99.8	2.0	65864.	2648.
51 Cr	c	27.7025D	320.1	9.92	0.05	317250.	10849.
49 Cr	c	42.3M	152.9	30.3	1.1	48320.	2481.
			90.6	53.2	1.9	51090.	2707.
					R_av	49561.	2130.
48 Cr	c	21.56H	308.2	100.	2.	6645.	272.
			112.3	96.0	2.1	6678.	288.
					R_av	6660.	246.
48 V	c	15.9735D	2240.4	2.41	0.04	164090.	7171.
			1312.1	97.5	0.9	162160.	5571.
			983.5	100.0	0.3	157650.	5155.
			944.1	7.76	0.10	158970.	5597.
			928.3	0.77	0.05	147010.	11250.
					R_av	159108.	5123.
48 Sc	i	43.67H	1312.1	100.1	0.7	4028.	246.
			1037.5	97.6	0.7	3842.	136.
			983.5	100.1	0.6	4202.	218.
			175.4	7.48	0.10	4641.	385.
					R_av	3916.	156.

47 Sc	i	3.3492D	159.4	68.3	0.4	24441.	872.
47 Sc	c	3.3492D	159.4	68.3	0.4	24716.	880.
			159.4	68.3	0.4	24928.	891.
					R_av	24821.	954.
46 Sc	i(m+g)	83.79D	1120.6	99.99	0.00	71609.	2351.
			889.3	99.98	0.00	69818.	2273.
					R_av	70604.	2378.
44mSc	i(m)	58.61H	2656.5	98.61	0.01	73033.	8740.
			1499.5	98.61	0.01	65798.	3144.
			1157.0	98.61	0.01	59937.	2001.
			1126.1	1.20	0.07	70732.	4992.
			1001.8	1.20	0.07	67702.	5026.
			270.9	86.7	0.3	63902.	2370.
					R_av	61505.	2246.
44 Sc	i	3.97H	2656.5	0.11	0.00	75860.	20884.
			1499.5	0.91	0.02	70038.	3626.
			1157.0	99.9	0.5	68590.	2408.
					R_av	68790.	2381.
44 Sc	i(m+g)	3.97H	2656.5	0.11	0.00	147870.	22678.
			1499.5	0.91	0.02	134920.	5748.
			1157.0	99.9	0.5	127690.	4314.
					R_av	129028.	4031.
43 Sc	c	3.891H	372.8	22.5	0.7	39361.	2070.
47 Ca	c	4.536D	1297.1	71.	7.	216.6	50.4
			159.4	*********	*********	275.2	33.3
					R_av	258.0	28.2
43 K	c	22.3H	617.5	79.2	0.7	8428.	302.
			593.4	11.26	0.09	8399.	348.
			396.9	11.85	0.09	8384.	364.
			372.8	86.8	0.2	8572.	337.
			220.6	4.80	0.07	9105.	538.
					R_av	8478.	282.
42 K	i	12.360H	1525.0	18.08	0.09	27823.	985.
38 K	c	7.636M	2167.0	99.86	0.01	5427.	558.
41 Ar	c	109.34M	1294.0	99.1	0.0	3695.	144.
39 Cl	c	55.6M	1518.0	39.2	1.3	1976.	122.
			1267.0	53.6	1.3	2084.	112.
			250.3	46.3	2.0	2126.	214.
					R_av	2047.	91.
38 Cl	i(m+g)	37.24M	2167.0	42.4	1.1	7886.	393.
38 Cl	c	37.24M	2167.0	42.4	1.1	8013.	386.
			1643.0	31.9	1.0	8671.	439.
					R_av	8089.	329.
34mCl	i(m)	32.00M	2127.0	42.8	0.8	3228.	188.
			146.4	40.5	0.9	3226.	175.
					R_av	3226.	147.
38 S	c	170.3M	2167.0	*********	*********	126.7	61.4
			1942.0	83.	3.	1910.	667.
					R_av	141.8	163.2
29 Al	c	6.56M	1273.3	90.6	0.6	4081.	295.
28 Mg	c	20.915H	1778.8	100.2	0.0	453.6	19.7
			1778.8	100.2	0.0	458.2	24.7
			1342.2	52.6	1.6	472.9	31.9
			941.5	38.3	1.0	520.6	83.0
			400.7	36.6	1.0	577.5	40.9
					R_av	467.4	21.9
27 Mg	c	9.458M	843.8	71.8	0.4	1821.	161.
24 Na	c	14.9590H	1369.0	100.	0.	4215.	146.
22 Na	c	2.6019Y	1274.5	99.94	0.01	3382.	284.
7 Be	i	53.29D	477.6	10.52	0.06	18988.	690.

Table 10.22: Detailed reaction rates for residual nuclide production in ^{56}Fe at E_p=750 MeV used to determine their production cross sections.

Nuclide	Type	$T_{1/2}$	E_γ, KeV	Abundance, %		Reaction rate 10^{-20} s^{-1}	

57 Co	i	271.74D	136.5	10.68	0.08	1201.	188.
			122.1	85.60	0.17	1417.	54.
					R_av	1412.	56.
56 Co	i	77.233D	2598.5	17.3	0.3	7104.	384.
			2034.8	7.89	0.13	6618.	336.
			2015.2	3.04	0.05	6289.	740.
			1771.3	15.47	0.14	6750.	265.
			1360.2	4.29	0.04	6691.	424.
			1238.3	66.9	0.6	7018.	247.
			1037.8	14.17	0.13	6358.	276.
			846.8	99.94	0.03	6723.	227.
					R_av	6771.	224.
55 Co	i	17.53H	1408.5	16.9	0.8	3247.	222.
			931.1	75.	4.	2822.	188.
			477.2	20.2	1.7	3112.	366.
					R_av	3012.	170.
53 Fe	c*	8.51M	377.9	42.	3.	15967.	2020.
52 Fe	c	8.275H	1434.1	*****************		3102.	195.
			168.7	99.	3.	2652.	131.
					R_av	2770.	216.
56 Mn	c	2.5789H	2113.1	14.3	0.4	4941.	361.
			1810.7	27.2	0.8	4653.	248.
			846.8	98.9	0.3	4831.	192.
					R_av	4799.	179.
54 Mn	i	312.11D	834.8	99.98	0.00	301170.	9818.
52 Mn	c	5.591D	1434.1	100.0	0.6	75574.	2555.
			1333.7	5.07	0.06	78762.	2790.
			1246.3	4.21	0.07	84975.	3190.
			935.5	94.5	1.0	73542.	2516.
			848.2	3.32	0.04	68018.	2626.
			744.2	90.0	0.9	72182.	2479.
					R_av	74762.	2957.
52mMn	i(m)	21.1M	1434.1	99.8	2.0	57490.	2383.
52mMn	c	21.1M	1434.1	99.8	2.0	60592.	2494.
			377.7	1.68	0.05	83933.	15309.
					R_av	60859.	3128.
51 Cr	c	27.7025D	320.1	9.92	0.05	312150.	10719.
49 Cr	c	42.3M	152.9	30.3	1.1	46262.	2374.
			90.6	53.2	1.9	47168.	2498.
					R_av	46684.	2005.
48 Cr	c	21.56H	308.2	100.	2.	6570.	267.
			112.3	96.0	2.1	6475.	276.
					R_av	6527.	239.
48 V	c	15.9735D	1312.1	97.5	0.9	159960.	5496.
			983.5	100.0	0.3	156280.	5111.
			944.1	7.76	0.10	157880.	5533.
			928.3	0.77	0.05	156250.	12298.
					R_av	157483.	5046.
48 Sc	i	43.67H	1312.1	100.1	0.7	3774.	231.
			1037.5	97.6	0.7	4156.	143.
			983.5	100.1	0.6	3533.	262.
			175.4	7.48	0.10	5018.	345.
					R_av	4121.	186.
47 Sc	i	3.3492D	159.4	68.3	0.4	26664.	952.
47 Sc	c	3.3492D	159.4	68.3	0.4	26992.	961.
46 Sc	i(m+g)	83.79D	1120.6	99.99	0.00	76711.	2516.
			889.3	99.98	0.00	74858.	2435.
					R_av	75675.	2537.
44mSc	i(m)	58.61H	2656.5	98.61	0.01	83641.	6262.
			1499.5	98.61	0.01	47275.	4578.
			1126.1	1.20	0.07	69836.	5085.
			1001.8	1.20	0.07	77353.	5496.
			270.9	86.7	0.3	70072.	2598.
					R_av	69330.	4190.
44 Sc	i	3.97H	2656.5	0.11	0.00	101930.	15740.
			1499.5	0.91	0.02	76905.	10409.
					R_av	84451.	11784.
44 Sc	i(m+g)	3.97H	2656.5	0.11	0.00	184420.	18258.
			1499.5	0.91	0.02	123520.	11380.
					R_av	140348.	4385.

43 Sc	c	3.891H	372.8	22.5	0.7	45247.	2135.
47 Ca	c	4.536D	1297.1	71.	7.	343.5	40.9
			159.4	******************		328.0	60.6
					R_av	338.8	34.6
44 K	c*	22.13M	2150.8	23.	4.	1374.	632.
			1499.4	7.8	1.3	2330.	3751.
					R_av	1400.	624.
43 K	c	22.3H	617.5	79.2	0.7	9984.	354.
			593.4	11.26	0.09	9928.	409.
			396.9	11.85	0.09	8840.	412.
			372.8	86.8	0.2	10060.	347.
					R_av	9895.	371.
42 K	i	12.360H	1525.0	18.08	0.09	32759.	1140.
41 Ar	c	109.34M	1294.0	99.1	0.0	4843.	173.
39 Cl	c	55.6M	1518.0	39.2	1.3	2803.	180.
			1267.0	53.6	1.3	2974.	186.
			250.3	46.3	2.0	2868.	247.
					R_av	2883.	135.
38 Cl	i(m+g)	37.24M	2167.0	42.4	1.1	11038.	537.
			1643.0	31.9	1.0	10512.	515.
					R_av	10765.	441.
38 Cl	c	37.24M	2167.0	42.4	1.1	11230.	543.
			1643.0	31.9	1.0	10783.	521.
					R_av	10999.	410.
34mCl	i(m)	32.00M	2127.0	42.8	0.8	4829.	275.
			1177.0	14.09	0.24	4241.	843.
			146.4	40.5	0.9	4965.	289.
					R_av	4867.	224.
38 S	c	170.3M	2167.0	******************		191.3	29.9
			1942.0	83.	3.	242.0	51.5
			1643.0	******************		271.4	55.3
					R_av	215.9	24.0
29 Al	c	6.56M	1273.3	90.6	0.6	6276.	710.
28 Mg	c	20.915H	1342.2	52.6	1.6	825.8	49.2
			400.7	36.6	1.0	813.5	163.6
					R_av	825.0	48.1
27 Mg	c	9.458M	1014.4	28.0	0.4	3890.	1111.
			843.8	71.8	0.4	3425.	265.
					R_av	3447.	260.
24 Na	c	14.9590H	1369.0	100.	0.	7285.	367.
22 Na	c	2.6019Y	1274.5	99.94	0.01	5005.	209.
7 Be	i	53.29D	477.6	10.52	0.06	23752.	897.

Table 10.23: Detailed reaction rates for residual nuclide production in ^{56}Fe at E_p=799 MeV used to determine their production cross sections.

Nuclide	Type	$T_{1/2}$	E_γ, KeV	Abundance, %		Reaction rate 10^{-20} s^{-1}	
57 Co	i	271.74D	122.1	85.60	0.17	1354.	64.
56 Co	i	77.233D	2598.5	17.3	0.3	6468.	364.
			2034.8	7.89	0.13	6170.	344.
			2015.2	3.04	0.05	5406.	538.
			1360.2	4.29	0.04	6392.	519.
			1238.3	66.9	0.6	6429.	229.
			1037.8	14.17	0.13	6411.	441.
			846.8	99.94	0.03	6373.	248.
					R_av	6372.	214.
55 Co	i	17.53H	1408.5	16.9	0.8	2720.	206.
			1316.6	7.1	0.4	2999.	224.
			931.1	75.	4.	2641.	168.
			477.2	20.2	1.7	2589.	247.
					R_av	2726.	126.
53 Fe	c*	8.51M	377.9	42.	3.	17792.	1824.
52 Fe	c	8.275H	1434.1	******************		2909.	185.
			168.7	99.	3.	2329.	116.
					R_av	2468.	260.
56 Mn	c	2.5789H	2113.1	14.3	0.4	4760.	275.
			1810.7	27.2	0.8	4936.	251.

			846.8	98.9	0.3	5132.	241.
					R_av	4973.	194.
54 Mn	i	312.11D	834.8	99.98	0.00	258180.	8410.
52 Mn	c	5.591D	1246.3	4.21	0.07	73166.	2745.
			935.5	94.5	1.0	62157.	2127.
			848.2	3.32	0.04	84960.	4656.
			744.2	90.0	0.9	60870.	2090.
			647.5	0.40	0.02	69567.	6764.
			346.0	0.98	0.01	56074.	2302.
					R_av	62727.	3120.
52mMn	i(m)	21.1M	1434.1	99.8	2.0	50765.	2036.
52mMn	c	21.1M	1434.1	99.8	2.0	53674.	2143.
51 Cr	c	27.7025D	320.1	9.92	0.05	261620.	8948.
49 Cr	c	42.3M	152.9	30.3	1.1	39583.	2030.
			90.6	53.2	1.9	40906.	2473.
					R_av	40068.	1792.
48 Cr	c	21.56H	308.2	100.	2.	5204.	211.
			112.3	96.0	2.1	5529.	230.
					R_av	5346.	232.
48 V	c	15.9735D	2240.4	2.41	0.04	140090.	6278.
			1312.1	97.5	0.9	136190.	4679.
			983.5	100.0	0.3	132320.	4328.
			944.1	7.76	0.10	134630.	4743.
			928.3	0.77	0.05	124560.	10058.
					R_av	133892.	4335.
48 Sc	i	43.67H	1312.1	100.1	0.7	3297.	131.
			1037.5	97.6	0.7	3647.	126.
			983.5	100.1	0.6	3219.	150.
			175.4	7.48	0.10	4408.	312.
					R_av	3517.	171.
47 Sc	i	3.3492D	159.4	68.3	0.4	22771.	811.
47 Sc	c	3.3492D	159.4	68.3	0.4	23098.	822.
			159.4	68.3	0.4	23153.	828.
					R_av	23125.	889.
46 Sc	i(m+g)	83.79D	1120.6	99.99	0.00	65989.	2165.
			889.3	99.98	0.00	64299.	2092.
					R_av	65039.	2198.
44mSc	i(m)	58.61H	2656.5	98.61	0.01	72922.	4816.
			1499.5	98.61	0.01	63464.	2621.
			1157.0	98.61	0.01	56081.	1869.
			1126.1	1.20	0.07	65005.	4579.
			1126.1	1.20	0.07	64933.	4437.
			1001.8	1.20	0.07	64461.	4575.
			270.9	86.7	0.3	59936.	2223.
					R_av	58209.	2289.
44 Sc	i	3.97H	2656.5	0.11	0.00	109580.	11893.
			1499.5	0.91	0.02	62861.	2935.
			1157.0	99.9	0.5	64304.	2239.
					R_av	64341.	3252.
44 Sc	i(m+g)	3.97H	2656.5	0.11	0.00	181500.	14705.
			1499.5	0.91	0.02	125440.	5056.
			1157.0	99.9	0.5	119600.	4029.
					R_av	122296.	3821.
43 Sc	c	3.891H	372.8	22.5	0.7	39530.	1988.
47 Ca	c	4.536D	1297.1	71.	7.	281.0	39.3
			159.4	**********	********	327.5	29.2
					R_av	311.8	24.3
43 K	c	22.3H	617.5	79.2	0.7	8781.	308.
			593.4	11.26	0.09	8941.	347.
			396.9	11.85	0.09	8971.	323.
			372.8	86.8	0.2	8803.	305.
			220.6	4.80	0.07	9332.	460.
					R_av	8875.	287.
42 K	i	12.360H	1525.0	18.08	0.09	30164.	1046.
38 K	c	7.636M	2167.0	99.86	0.01	6138.	632.
41 Ar	c	109.34M	1294.0	99.1	0.0	4492.	160.
39 Cl	c	55.6M	1518.0	39.2	1.3	2262.	143.
			1267.0	53.6	1.3	2820.	141.
			250.3	46.3	2.0	2973.	203.

					R_av	2643.	223.
38 Cl	i(m+g)	37.24M	2167.0	42.4	1.1	10170.	485.
			1643.0	31.9	1.0	10796.	550.
					R_av	10430.	449.
38 Cl	c	37.24M	2167.0	42.4	1.1	10470.	497.
			1643.0	31.9	1.0	10967.	547.
					R_av	10682.	417.
34mCl	i(m)	32.00M	2127.0	42.8	0.8	4676.	254.
			1177.0	14.09	0.24	5146.	971.
			146.4	40.5	0.9	4839.	244.
					R_av	4773.	204.
38 S	c	170.3M	2167.0	******************		299.8	21.7
			1643.0	******************		171.2	66.2
					R_av	289.4	36.2
29 Al	c	6.56M	1273.3	90.6	0.6	7302.	443.
28 Mg	c	20.915H	1778.8	100.2	0.0	853.3	35.1
			1372.9	4.7	0.2	1082.	248.
			1342.2	52.6	1.6	824.7	44.8
			941.5	38.3	1.0	882.5	249.0
			400.7	36.6	1.0	917.0	65.8
					R_av	853.7	32.4
27 Mg	c	9.458M	843.8	71.8	0.4	3660.	302.
24 Na	c	14.9590H	1369.0	100.	0.	7536.	254.
22 Na	c	2.6019Y	1274.5	99.94	0.01	5359.	278.
7 Be	i	53.29D	477.6	10.52	0.06	24647.	874.

Table 10.24: Detailed reaction rates for residual nuclide production in ^{56}Fe at E_p=1000 MeV used to determine their production cross sections.

Nuclide	Type	$T_{1/2}$	E_γ, KeV	Abundance, %		Reaction rate 10^{-20} s^{-1}	
57 Co	i	271.74D	136.5	10.68	0.08	1623.	205.
			122.1	85.60	0.17	1494.	57.
					R_av	1497.	57.
56 Co	i	77.233D	2598.5	17.3	0.3	6225.	338.
			2034.8	7.89	0.13	6050.	317.
			2015.2	3.04	0.05	4811.	735.
			1771.3	15.47	0.14	6141.	241.
			1360.2	4.29	0.04	6024.	390.
			1238.3	66.9	0.6	6110.	222.
			1037.8	14.17	0.13	5781.	259.
			846.8	99.94	0.03	5833.	202.
					R_av	5964.	198.
55 Co	i	17.53H	1408.5	16.9	0.8	2391.	174.
			931.1	75.	4.	2084.	163.
			477.2	20.2	1.7	2737.	279.
					R_av	2302.	176.
53 Fe	c*	8.51M	377.9	42.	3.	17897.	3977.
52 Fe	c	8.275H	1434.1	******************		2484.	176.
			168.7	99.	3.	2046.	100.
					R_av	2130.	185.
56 Mn	c	2.5789H	2113.1	14.3	0.4	5049.	319.
			1810.7	27.2	0.8	4743.	250.
			846.8	98.9	0.3	4824.	200.
					R_av	4834.	183.
54 Mn	i	312.11D	834.8	99.98	0.00	259110.	8444.
52 Mn	c	5.591D	1434.1	100.0	0.6	59660.	2018.
			1333.7	5.07	0.06	61613.	2191.
			1246.3	4.21	0.07	66332.	2492.
			935.5	94.5	1.0	58117.	1990.
			848.2	3.32	0.04	51190.	2140.
			744.2	90.0	0.9	57065.	1961.
					R_av	58884.	2358.
52mMn	i(m)	21.1M	1434.1	99.8	2.0	45007.	1937.
52mMn	c	21.1M	1434.1	99.8	2.0	47491.	2022.
			377.7	1.68	0.05	35867.	15737.
					R_av	47403.	2017.

51 Cr	c	27.7025D	320.1	9.92	0.05	250500.	8575.
49 Cr	c	42.3M	152.9 90.6	30.3 53.2	1.1 1.9 R_av	35820. 36680. 36221.	1846. 1945. 1559.
48 Cr	c	21.56H	308.2 112.3	100. 96.0	2. 2.1 R_av	5083. 5140. 5109.	210. 219. 189.
48 V	c	15.9735D	1312.1 983.5 944.1 928.3	97.5 100.0 7.76 0.77	0.9 0.3 0.10 0.05 R_av	127740. 124760. 126050. 125390. 125737.	4395. 4082. 4429. 9525. 4030.
48 Sc	i	43.67H	1312.1 1037.5 983.5 175.4	100.1 97.6 100.1 7.48	0.7 0.7 0.6 0.10 R_av	2394. 3719. 2882. 4662. 3710.	314. 127. 249. 240. 237.
47 Sc	i	3.3492D	159.4	68.3	0.4	22772.	814.
47 Sc	c	3.3492D	159.4	68.3	0.4	23246.	828.
46 Sc	i(m+g)	83.79D	1120.6 889.3	99.99 99.98	0.00 0.00 R_av	65559. 64024. 64715.	2150. 2086. 2161.
44mSc	i(m)	58.61H	2656.5 1499.5 1126.1 1001.8 270.9	98.61 98.61 1.20 1.20 86.7	0.01 0.01 0.07 0.07 0.3 R_av	73334. 43353. 58756. 65936. 60122. 58881.	5474. 3204. 4183. 4629. 2232. 3726.
44 Sc	i	3.97H	2656.5 1499.5	0.11 0.91	0.00 0.02 R_av	70388. 67307. 67862.	14960. 7251. 6631.
44 Sc	i(m+g)	3.97H	2656.5 1499.5	0.11 0.91	0.00 0.02 R_av	142700. 110050. 115631.	16708. 8079. 3613.
43 Sc	c	3.891H	372.8	22.5	0.7	39641.	1871.
47 Ca	c	4.536D	1297.1 159.4	71. *********	7. ******** R_av	303.0 474.7 357.1	36.5 53.9 80.5
44 K	c*	22.13M	2150.8 1499.4	23. 7.8	4. 1.3 R_av	1562. 1067. 1550.	477. 3045. 471.
43 K	c	22.3H	617.5 593.4 396.9 372.8	79.2 11.26 11.85 86.8	0.7 0.09 0.09 0.2 R_av	9390. 9733. 7874. 9661. 9363.	332. 388. 352. 331. 442.
42 K	i	12.360H	1525.0	18.08	0.09	31062.	1078.
41 Ar	c	109.34M	1294.0	99.1	0.0	4945.	176.
39 Cl	c	55.6M	1518.0 1267.0 250.3	39.2 53.6 46.3	1.3 1.3 2.0 R_av	2931. 3210. 2912. 3050.	193. 189. 271. 142.
38 Cl	i(m+g)	37.24M	2167.0 1643.0	42.4 31.9	1.1 1.0 R_av	12207. 11635. 11902.	646. 608. 515.
38 Cl	c	37.24M	2167.0 1643.0	42.4 31.9	1.1 1.0 R_av	12536. 11880. 12160.	655. 612. 500.
34mCl	i(m)	32.00M	2127.0 1177.0 146.4	42.8 14.09 40.5	0.8 0.24 0.9 R_av	5651. 4990. 5501. 5513.	365. 696. 298. 254.
38 S	c	170.3M	2167.0 1942.0 1643.0	********* 83. *********	******** 3. ******** R_av	328.5 276.0 244.6 283.8	58.1 35.0 75.6 28.6
29 Al	c	6.56M	1273.3	90.6	0.6	9828.	2387.
28 Mg	c	20.915H	1342.2	52.6	1.6	1360.	67.

			941.5	38.3	1.0	1194.	69.
			400.7	36.6	1.0	1107.	164.
					R_av	1276.	75.
27 Mg	c	9.458M	843.8	71.8	0.4	3626.	608.
24 Na	c	14.9590H	1369.0	100.	0.	11003.	495.
22 Na	c	2.6019Y	1274.5	99.94	0.01	8248.	313.
7 Be	i	53.29D	477.6	10.52	0.06	29755.	1057.

Table 10.25: Detailed reaction rates for residual nuclide production in ^{56}Fe at E_p=1199 MeV used to determine their production cross sections.

Nuclide	Type	$T_{1/2}$	E_γ, KeV	Abundance, %		Reaction rate 10^{-20} s^{-1}	
57 Co	i	271.74D	136.5	10.68	0.08	2053.	254.
			122.1	85.60	0.17	1830.	68.
					R_av	1835.	68.
56 Co	i	77.233D	2598.5	17.3	0.3	6992.	383.
			2034.8	7.89	0.13	6788.	331.
			2015.2	3.04	0.05	7221.	424.
			1771.3	15.47	0.14	6934.	276.
			1360.2	4.29	0.04	6688.	767.
			1238.3	66.9	0.6	6810.	238.
			1037.8	14.17	0.13	6204.	324.
			846.8	99.94	0.03	7177.	374.
					R_av	6831.	229.
55 Co	i	17.53H	1408.5	16.9	0.8	2749.	273.
			1316.6	7.1	0.4	1697.	383.
			931.1	75.	4.	2267.	150.
			477.2	20.2	1.7	2494.	248.
			411.5	1.07	0.09	63847.	17366.
					R_av	2345.	232.
53 Fe	c*	8.51M	377.9	42.	3.	17115.	1497.
52 Fe	c	8.275H	1434.1	******************		2318.	1509.
			168.7	99.	3.	1948.	108.
					R_av	1949.	108.
56 Mn	c	2.5789H	2113.1	14.3	0.4	5750.	402.
			1810.7	27.2	0.8	6024.	384.
			846.8	98.9	0.3	6262.	626.
					R_av	5950.	293.
54 Mn	i	312.11D	834.8	99.98	0.00	255840.	8343.
52 Mn	c	5.591D	1246.3	4.21	0.07	65323.	2446.
			935.5	94.5	1.0	55719.	1911.
			848.2	3.32	0.04	187050.	40055.
			744.2	90.0	0.9	54548.	1875.
			647.5	0.40	0.02	49920.	6817.
			346.0	0.98	0.01	49465.	2263.
					R_av	55966.	2611.
52mMn	i(m)	21.1M	1434.1	99.8	2.0	49541.	2814.
52mMn	c	21.1M	1434.1	99.8	2.0	51860.	2917.
51 Cr	c	27.7025D	320.1	9.92	0.05	237110.	8119.
49 Cr	c	42.3M	152.9	30.3	1.1	34772.	1796.
			90.6	53.2	1.9	36759.	1958.
					R_av	35663.	1539.
48 Cr	c	21.56H	308.2	100.	2.	4511.	185.
			112.3	96.0	2.1	4762.	199.
					R_av	4624.	191.
48 V	c	15.9735D	2240.4	2.41	0.04	123200.	5423.
			1312.1	97.5	0.9	121080.	4163.
			983.5	100.0	0.3	117670.	3852.
			944.1	7.76	0.10	118790.	4177.
			928.3	0.77	0.05	114580.	9043.
					R_av	118896.	3813.
48 Sc	i	43.67H	1312.1	100.1	0.7	3172.	201.
			1037.5	97.6	0.7	3683.	128.
			983.5	100.1	0.6	3024.	220.
			175.4	7.48	0.10	4819.	229.
					R_av	3695.	254.
47 Sc	i	3.3492D	159.4	68.3	0.4	22209.	791.
47 Sc	c	3.3492D	159.4	68.3	0.4	22557.	803.

			159.4	68.3	0.4	22687.	812.
					R_av	22621.	870.
46 Sc	i(m+g)	83.79D	1120.6	99.99	0.00	63090.	2072.
			889.3	99.98	0.00	61548.	2003.
					R_av	62218.	2089.
44mSc	i(m)	58.61H	2656.5	98.61	0.01	65072.	5412.
			1499.5	98.61	0.01	57509.	4882.
			1157.0	98.61	0.01	53658.	1808.
			1126.1	1.20	0.07	59503.	4264.
			1001.8	1.20	0.07	61543.	4512.
			270.9	86.7	0.3	57216.	2123.
					R_av	54998.	1991.
44 Sc	i	3.97H	1499.5	0.91	0.02	63522.	4818.
			1157.0	99.9	0.5	63787.	2952.
					R_av	63735.	2788.
44 Sc	i(m+g)	3.97H	1499.5	0.91	0.02	120230.	6890.
			1157.0	99.9	0.5	116700.	4393.
					R_av	117238.	4302.
43 Sc	c	3.891H	372.8	22.5	0.7	38703.	1937.
47 Ca	c	4.536D	1297.1	71.	7.	342.7	46.0
			159.4	*****************		347.5	29.1
					R_av	346.3	25.5
44 K	c*	22.13M	2150.8	23.	4.	1238.	312.
43 K	c	22.3H	617.5	79.2	0.7	9471.	334.
			593.4	11.26	0.09	9375.	366.
			396.9	11.85	0.09	9576.	348.
			372.8	86.8	0.2	9539.	325.
			220.6	4.80	0.07	10288.	548.
					R_av	9531.	308.
42 K	i	12.360H	1525.0	18.08	0.09	32434.	1153.
38 K	c	7.636M	2167.0	99.86	0.01	7039.	805.
41 Ar	c	109.34M	1294.0	99.1	0.0	5370.	191.
39 Cl	c	55.6M	1518.0	39.2	1.3	3683.	331.
			1267.0	53.6	1.3	3632.	175.
			250.3	46.3	2.0	3623.	243.
					R_av	3635.	156.
38 Cl	i(m+g)	37.24M	2167.0	42.4	1.1	12613.	699.
			1643.0	31.9	1.0	13457.	667.
					R_av	13081.	586.
38 Cl	c	37.24M	2167.0	42.4	1.1	12926.	664.
			1643.0	31.9	1.0	13737.	674.
					R_av	13511.	557.
34mCl	i(m)	32.00M	2127.0	42.8	0.8	6969.	364.
			1177.0	14.09	0.24	6958.	636.
			146.4	40.5	0.9	6351.	299.
					R_av	6610.	298.
38 S	c	170.3M	2167.0	*****************		312.6	150.4
			1942.0	83.	3.	225.5	31.2
			1643.0	*****************		279.8	59.8
					R_av	239.2	27.6
29 Al	c	6.56M	1273.3	90.6	0.6	14282.	859.
28 Mg	c	20.915H	1778.8	100.2	0.0	1803.	66.
			1342.2	52.6	1.6	1776.	88.
			941.5	38.3	1.0	1520.	123.
			400.7	36.6	1.0	1864.	87.
					R_av	1793.	70.
27 Mg	c	9.458M	1014.4	28.0	0.4	6190.	1001.
			843.8	71.8	0.4	7050.	330.
					R_av	6999.	324.
24 Na	c	14.9590H	1369.0	100.	0.	15864.	532.
22 Na	c	2.6019Y	1274.5	99.94	0.01	11292.	443.
7 Be	i	53.29D	477.6	10.52	0.06	40069.	1396.

Table 10.26: Detailed reaction rates for residual nuclide production in ^{56}Fe at E_p=1500 MeV used to determine their production cross sections.

Nuclide	Type	$T_{1/2}$	E_γ,	Abundance,	Reaction rate

			KeV	%		10^{-20} s^{-1}	
57 Co	i	271.74D	136.5	10.68	0.08	1564.	137.
			122.1	85.60	0.17	1385.	51.
					R_av	1392.	56.
56 Co	i	77.233D	2598.5	17.3	0.3	4373.	250.
			2034.8	7.89	0.13	4320.	213.
			2015.2	3.04	0.05	4370.	261.
			1771.3	15.47	0.14	4519.	180.
			1360.2	4.29	0.04	4227.	305.
			1238.3	66.9	0.6	4342.	156.
			1037.8	14.17	0.13	4200.	197.
			846.8	99.94	0.03	4166.	138.
					R_av	4253.	140.
55 Co	i	17.53H	1408.5	16.9	0.8	1516.	113.
			931.1	75.	4.	1426.	95.
			477.2	20.2	1.7	1529.	157.
					R_av	1473.	75.
53 Fe	c*	8.51M	377.9	42.	3.	12657.	1144.
52 Fe	c	8.275H	1434.1	*********	*********	1512.	88.
			168.7	99.	3.	1250.	66.
					R_av	1339.	131.
56 Mn	c	2.5789H	2113.1	14.3	0.4	3593.	237.
			1810.7	27.2	0.8	3762.	194.
			846.8	98.9	0.3	3818.	131.
					R_av	3800.	128.
54 Mn	i	312.11D	834.8	99.98	0.00	174890.	5703.
52 Mn	c	5.591D	1434.1	100.0	0.6	38024.	1286.
			1333.7	5.07	0.06	39409.	1397.
			1246.3	4.21	0.07	42119.	1577.
			935.5	94.5	1.0	36756.	1257.
			848.2	3.32	0.04	39422.	1442.
			744.2	90.0	0.9	36026.	1237.
					R_av	37947.	1415.
52mMn	i(m)	21.1M	1434.1	99.8	2.0	30888.	1258.
52mMn	c	21.1M	1727.5	0.22	0.01	47326.	9392.
			1434.1	99.8	2.0	32400.	1313.
					R_av	32520.	1677.
51 Cr	c	27.7025D	320.1	9.92	0.05	157700.	5395.
49 Cr	c	42.3M	152.9	30.3	1.1	22521.	1155.
			90.6	53.2	1.9	23620.	1240.
					R_av	23025.	986.
48 Cr	c	21.56H	308.2	100.	2.	3007.	122.
			112.3	96.0	2.1	3130.	130.
					R_av	3062.	114.
48 V	c	15.9735D	1312.1	97.5	0.9	78578.	2699.
			983.5	100.0	0.3	76599.	2505.
			944.1	7.76	0.10	77717.	2733.
			928.3	0.77	0.05	72628.	5508.
					R_av	77244.	2479.
48 Sc	i	43.67H	1312.1	100.1	0.7	2271.	90.
			1037.5	97.6	0.7	2502.	85.
			983.5	100.1	0.6	2178.	92.
			175.4	7.48	0.10	3118.	156.
					R_av	2425.	137.
47 Sc	i	3.3492D	159.4	68.3	0.4	15065.	537.
47 Sc	c	3.3492D	159.4	68.3	0.4	15276.	544.
46 Sc	i(m+g)	83.79D	1120.6	99.99	0.00	42110.	1382.
			889.3	99.98	0.00	40826.	1328.
					R_av	41385.	1441.
44mSc	i(m)	58.61H	2656.5	98.61	0.01	41684.	3557.
			1499.5	98.61	0.01	42067.	1999.
			1126.1	1.20	0.07	40966.	2908.
			1001.8	1.20	0.07	42443.	3084.
			270.9	86.7	0.3	38196.	1417.
					R_av	39378.	1507.
44 Sc	i	3.97H	2656.5	0.11	0.00	48549.	11334.
			1499.5	0.91	0.02	33351.	3911.
					R_av	34890.	4712.
44 Sc	i(m+g)	3.97H	2656.5	0.11	0.00	89654.	12278.

			1499.5	0.91	0.02	74832.	4734.
					R_av	76403.	2387.
43 Sc	c	3.891H	372.8	22.5	0.7	25176.	1206.
47 Ca	c	4.536D	1297.1	71.	7.	256.8	29.0
			159.4	******************		210.9	22.4
					R_av	227.9	23.2
44 K	c*	22.13M	2150.8	23.	4.	1209.	346.
			1499.4	7.8	1.3	1946.	1951.
					R_av	1231.	341.
43 K	c	22.3H	617.5	79.2	0.7	6542.	228.
			593.4	11.26	0.09	6620.	251.
			396.9	11.85	0.09	6962.	258.
			372.8	86.8	0.2	6441.	218.
					R_av	6574.	229.
42 K	i	12.360H	1525.0	18.08	0.09	21509.	746.
41 Ar	c	109.34M	1294.0	99.1	0.0	3776.	132.
39 Cl	c	55.6M	1518.0	39.2	1.3	2370.	136.
			1267.0	53.6	1.3	2646.	140.
			250.3	46.3	2.0	2428.	161.
					R_av	2489.	118.
38 Cl	i(m+g)	37.24M	2167.0	42.4	1.1	9709.	493.
			1643.0	31.9	1.0	10052.	506.
					R_av	9877.	415.
38 Cl	c	37.24M	2167.0	42.4	1.1	9924.	499.
			1643.0	31.9	1.0	10292.	512.
					R_av	10122.	366.
34mCl	i(m)	32.00M	2127.0	42.8	0.8	4777.	252.
			1177.0	14.09	0.24	4892.	406.
			146.4	40.5	0.9	4751.	219.
					R_av	4774.	191.
38 S	c	170.3M	2167.0	******************		214.4	34.1
			1942.0	83.	3.	212.6	19.8
			1643.0	******************		239.8	42.6
					R_av	216.5	16.6
29 Al	c	6.56M	1273.3	90.6	0.6	12210.	777.
28 Mg	c	20.915H	1342.2	52.6	1.6	1588.	75.
			941.5	38.3	1.0	1376.	112.
			400.7	36.6	1.0	1647.	88.
					R_av	1574.	80.
27 Mg	c	9.458M	1014.4	28.0	0.4	6616.	779.
			843.8	71.8	0.4	6193.	318.
					R_av	6236.	308.
24 Na	c	14.9590H	1369.0	100.	0.	13525.	533.
22 Na	c	2.6019Y	1274.5	99.94	0.01	10433.	382.
7 Be	i	53.29D	477.6	10.52	0.06	32389.	1129.

Table 10.27: Detailed reaction rates for residual nuclide production in ^{56}Fe at E_p=1599 MeV used to determine their production cross sections.

Nuclide	Type	$T_{1/2}$	E_γ, KeV	Abundance, %		Reaction rate 10^{-20} s^{-1}	
57 Co	i	271.74D	136.5	10.68	0.08	1957.	127.
			122.1	85.60	0.17	1900.	71.
					R_av	1906.	70.
56 Co	i	77.233D	2598.5	17.3	0.3	5950.	323.
			2034.8	7.89	0.13	5981.	284.
			2015.2	3.04	0.05	5660.	419.
			1771.3	15.47	0.14	5844.	225.
			1360.2	4.29	0.04	6417.	403.
			1238.3	66.9	0.6	5895.	204.
			1037.8	14.17	0.13	5260.	487.
			846.8	99.94	0.03	5766.	208.
			411.4	0.03	0.01	1120800.	268910.
					R_av	5857.	206.
55 Co	i	17.53H	1408.5	16.9	0.8	1963.	164.
			1316.6	7.1	0.4	2032.	158.
			931.1	75.	4.	1938.	129.
			477.2	20.2	1.7	2217.	265.
			411.5	1.07	0.09	50850.	13755.
					R_av	1993.	151.

53 Fe	c*	8.51M	377.9	42.	3.	13692.	1845.
52 Fe	c	8.275H	1434.1	*****************		2046.	268.
			168.7	99.	3.	1623.	81.
					R_av	1646.	109.
56 Mn	c	2.5789H	2113.1	14.3	0.4	4896.	278.
			1810.7	27.2	0.8	5098.	255.
			846.8	98.9	0.3	5274.	238.
					R_av	5126.	196.
54 Mn	i	312.11D	834.8	99.98	0.00	224090.	7302.
52 Mn	c	5.591D	1333.7	5.07	0.06	50853.	1812.
			1246.3	4.21	0.07	55710.	2099.
			935.5	94.5	1.0	47122.	1617.
			935.5	94.5	1.0	47116.	1616.
			848.2	3.32	0.04	49373.	1834.
			744.2	90.0	0.9	46131.	1597.
			647.5	0.40	0.02	47798.	5390.
			346.0	0.98	0.01	44594.	2252.
					R_av	48175.	1807.
52mMn	i(m)	21.1M	1434.1	99.8	2.0	36653.	1663.
52mMn	c	21.1M	1434.1	99.8	2.0	38700.	1727.
51 Cr	c	27.7025D	320.1	9.92	0.05	199680.	6833.
49 Cr	c	42.3M	152.9	30.3	1.1	27219.	1408.
			90.6	53.2	1.9	29689.	1577.
					R_av	28296.	1511.
48 Cr	c	21.56H	308.2	100.	2.	3895.	160.
			112.3	96.0	2.1	3881.	165.
					R_av	3888.	143.
48 V	c	15.9735D	2240.4	2.41	0.04	99632.	4412.
			1312.1	97.5	0.9	98286.	3378.
			983.5	100.0	0.3	95470.	3123.
			944.1	7.76	0.10	98489.	3492.
			928.3	0.77	0.05	94163.	7552.
					R_av	96822.	3122.
48 Sc	i	43.67H	1312.1	100.1	0.7	2951.	167.
			1037.5	97.6	0.7	3325.	142.
			983.5	100.1	0.6	2984.	173.
			175.4	7.48	0.10	3930.	225.
					R_av	3246.	203.
47 Sc	i	3.3492D	159.4	68.3	0.4	18897.	673.
47 Sc	c	3.3492D	159.4	68.3	0.4	19234.	684.
			159.4	68.3	0.4	17940.	646.
					R_av	18551.	868.
46 Sc	i(m+g)	83.79D	1120.6	99.99	0.00	53088.	1743.
			889.3	99.98	0.00	51662.	1681.
					R_av	52279.	1780.
44mSc	i(m)	58.61H	2656.5	98.61	0.01	52805.	4457.
			1499.5	98.61	0.01	50818.	2300.
			1157.0	98.61	0.01	44165.	1482.
			1126.1	1.20	0.07	52507.	3600.
			1001.8	1.20	0.07	52971.	3754.
			270.9	86.7	0.3	47848.	1775.
					R_av	45831.	1845.
44 Sc	i	3.97H	2656.5	0.11	0.00	7490400.	5683444.
			1499.5	0.91	0.02	50522.	3787.
			1157.0	99.9	0.5	51073.	1927.
					R_av	51024.	1899.
44 Sc	i(m+g)	3.97H	2656.5	0.11	0.00	7542400.	5682507.
			1499.5	0.91	0.02	100630.	5041.
			1157.0	99.9	0.5	94624.	3276.
					R_av	95309.	2978.
43 Sc	c	3.891H	372.8	22.5	0.7	32347.	1526.
47 Ca	c	4.536D	1297.1	71.	7.	295.4	35.2
			1297.1	71.	7.	295.4	35.2
			159.4	*****************		337.4	20.7
			159.4	*****************		883.0	64.5
					R_av	354.4	76.6
43 K	c	22.3H	617.5	79.2	0.7	8510.	303.
			593.4	11.26	0.09	8748.	330.
			396.9	11.85	0.09	8768.	334.
			372.8	86.8	0.2	8573.	296.

			220.6	4.80	0.07	9132.	483.
					R_av	8637.	280.
42 K	i	12.360H	1525.0	18.08	0.09	27653.	961.
38 K	c	7.636M	2167.0	99.86	0.01	5056.	915.
41 Ar	c	109.34M	1294.0	99.1	0.0	4775.	186.
39 Cl	c	55.6M	1518.0	39.2	1.3	3047.	226.
			1267.0	53.6	1.3	3234.	189.
			250.3	46.3	2.0	3343.	219.
					R_av	3217.	146.
38 Cl	i(m+g)	37.24M	2167.0	42.4	1.1	11653.	823.
			1643.0	31.9	1.0	12649.	731.
					R_av	12241.	621.
38 Cl	c	37.24M	2167.0	42.4	1.1	11973.	793.
			1643.0	31.9	1.0	12705.	709.
					R_av	12481.	516.
34mCl	i(m)	32.00M	2127.0	42.8	0.8	6328.	359.
			1177.0	14.09	0.24	6230.	437.
			146.4	40.5	0.9	5772.	271.
					R_av	5990.	261.
38 S	c	170.3M	2167.0	******************		320.4	165.3
			1942.0	83.	3.	320.9	35.6
			1643.0	******************		55.50	149.11
					R_av	308.1	41.2
29 Al	c	6.56M	1273.3	90.6	0.6	12175.	814.
28 Mg	c	20.915H	1778.8	100.2	0.0	2110.	76.
			1589.4	4.2	0.2	1969.	454.
			1372.9	4.7	0.2	1952.	412.
			1342.2	52.6	1.6	2110.	99.
			941.5	38.3	1.0	2060.	155.
			400.7	36.6	1.0	2213.	105.
					R_av	2121.	73.
27 Mg	c	9.458M	1014.4	28.0	0.4	7473.	1298.
			843.8	71.8	0.4	7486.	767.
					R_av	7482.	676.
24 Na	c	14.9590H	1369.0	100.	0.	19873.	671.
22 Na	c	2.6019Y	1274.5	99.94	0.01	14237.	544.
7 Be	i	53.29D	477.6	10.52	0.06	46337.	1645.

Table 10.28: Detailed reaction rates for residual nuclide production in ^{56}Fe at E_p=2605 MeV used to determine their production cross sections.

Nuclide	Type	$T_{1/2}$	E_γ, KeV	Abundance, %		Reaction rate 10^{-20} s^{-1}	
57 Co	i	271.74D	136.5	10.68	0.08	1625.	108.
			122.1	85.60	0.17	1516.	54.
					R_av	1524.	56.
56 Co	i	77.233D	2598.5	17.3	0.3	4316.	236.
			2034.8	7.89	0.13	3945.	203.
			2015.2	3.04	0.05	3812.	304.
			1771.3	15.47	0.14	4089.	155.
			1360.2	4.29	0.04	3581.	268.
			1238.3	66.9	0.6	4237.	149.
			1037.8	14.17	0.13	3802.	180.
			846.8	99.94	0.03	3974.	138.
			411.4	0.03	0.01	1180800.	306156.
					R_av	4054.	147.
55 Co	i	17.53H	1408.5	16.9	0.8	1338.	88.
			1316.6	7.1	0.4	1317.	103.
			931.1	75.	4.	1181.	75.
			477.2	20.2	1.7	1262.	129.
			411.5	1.07	0.09	4845.	749.
					R_av	1274.	114.
53 Fe	c*	8.51M	377.9	42.	3.	8886.	817.
			377.9	42.	3.	8774.	757.
					R_av	8825.	588.
52 Fe	c	8.275H	1434.1	******************		1277.	80.
			168.7	99.	3.	1025.	50.
					R_av	1085.	112.
56 Mn	c	2.5789H	2113.1	14.3	0.4	3188.	176.
			1810.7	27.2	0.8	3478.	169.

			846.8	98.9	0.3	3566.	133.
					R_av	3489.	145.
54 Mn	i	312.11D	834.8	99.98	0.00	148480.	4842.
52 Mn	c	5.591D	1333.7	5.07	0.06	32166.	1172.
			1246.3	4.21	0.07	34618.	1310.
			935.5	94.5	1.0	29980.	1031.
			935.5	94.5	1.0	29980.	1031.
			848.2	3.32	0.04	30851.	1269.
			744.2	90.0	0.9	29286.	1011.
			647.5	0.40	0.02	33773.	3631.
			346.0	0.98	0.01	28314.	1256.
					R_av	30415.	1116.
52mMn	i(m)	21.1M	1434.1	99.8	2.0	24682.	976.
52mMn	c	21.1M	1434.1	99.8	2.0	25960.	1024.
51 Cr	c	27.7025D	320.1	9.92	0.05	127750.	4371.
49 Cr	c	42.3M	152.9	30.3	1.1	17336.	886.
			90.6	53.2	1.9	19165.	1005.
					R_av	18123.	1068.
48 Cr	c	21.56H	308.2	100.	2.	2237.	90.
			112.3	96.0	2.1	2391.	100.
					R_av	2302.	105.
48 V	c	15.9735D	2240.4	2.41	0.04	60486.	2763.
			1312.1	97.5	0.9	61451.	2112.
			983.5	100.0	0.3	59777.	1955.
			944.1	7.76	0.10	61035.	2163.
			928.3	0.77	0.05	56670.	4636.
					R_av	60386.	1934.
48 Sc	i	43.67H	1312.1	100.1	0.7	1842.	74.
			1037.5	97.6	0.7	2052.	70.
			983.5	100.1	0.6	1864.	70.
			175.4	7.48	0.10	2427.	121.
					R_av	1979.	100.
47 Sc	i	3.3492D	159.4	68.3	0.4	12083.	432.
			159.4	68.3	0.4	12083.	432.
					R_av	12083.	406.
47 Sc	c	3.3492D	159.4	68.3	0.4	12233.	436.
			159.4	68.3	0.4	12233.	436.
					R_av	12233.	470.
46 Sc	i(m+g)	83.79D	1120.6	99.99	0.00	33002.	1084.
			889.3	99.98	0.00	32068.	1044.
					R_av	32477.	1115.
44mSc	i(m)	58.61H	2656.5	98.61	0.01	34022.	3866.
			1499.5	98.61	0.01	32914.	1423.
			1157.0	98.61	0.01	27245.	909.
			1126.1	1.20	0.07	31319.	2168.
			1001.8	1.20	0.07	30638.	2363.
			270.9	86.7	0.3	29088.	1079.
					R_av	28192.	1158.
44 Sc	i	3.97H	2656.5	0.11	0.00	47294.	10516.
			1499.5	0.91	0.02	30318.	1827.
			1157.0	99.9	0.5	30865.	1072.
					R_av	30850.	1091.
44 Sc	i(m+g)	3.97H	2656.5	0.11	0.00	80843.	11245.
			1499.5	0.91	0.02	62775.	2783.
			1157.0	99.9	0.5	57731.	1943.
					R_av	58814.	1837.
43 Sc	c	3.891H	372.8	22.5	0.7	19507.	930.
47 Ca	c	4.536D	1297.1	71.	7.	198.9	23.3
			1297.1	71.	7.	198.9	23.3
			159.4	********	**********	149.8	30.1
			159.4	********	**********	149.8	30.1
					R_av	181.1	14.7
43 K	c	22.3H	617.5	79.2	0.7	5352.	187.
			593.4	11.26	0.09	5402.	198.
			396.9	11.85	0.09	5344.	191.
			372.8	86.8	0.2	5345.	180.
			220.6	4.80	0.07	5442.	283.
					R_av	5359.	172.
42 K	i	12.360H	1525.0	18.08	0.09	17739.	614.
38 K	c	7.636M	2167.0	99.86	0.01	3590.	390.

41 Ar	c	109.34M	1294.0	99.1	0.0	3106.	107.
39 Cl	c	55.6M	1518.0	39.2	1.3	2069.	111.
			1267.0	53.6	1.3	2304.	110.
			250.3	46.3	2.0	2232.	141.
					R_av	2203.	102.
38 Cl	i(m+g)	37.24M	2167.0	42.4	1.1	7912.	384.
			1643.0	31.9	1.0	8332.	417.
					R_av	8100.	334.
38 Cl	c	37.24M	2167.0	42.4	1.1	8131.	392.
			1643.0	31.9	1.0	8450.	417.
					R_av	8196.	286.
34mCl	i(m)	32.00M	2127.0	42.8	0.8	4242.	205.
			1177.0	14.09	0.24	4361.	312.
			146.4	40.5	0.9	4128.	182.
					R_av	4195.	161.
38 S	c	170.3M	2167.0	*********	*********	219.3	20.6
			1942.0	83.	3.	227.4	16.7
			1643.0	*********	*********	117.8	45.8
					R_av	217.5	19.9
29 Al	c	6.56M	1273.3	90.6	0.6	11122.	473.
28 Mg	c	20.915H	1778.8	100.2	0.0	1831.	65.
			1589.4	4.2	0.2	1766.	172.
			1372.9	4.7	0.2	1530.	155.
			1342.2	52.6	1.6	1803.	84.
			941.5	38.3	1.0	1740.	88.
			400.7	36.6	1.0	1794.	80.
					R_av	1803.	61.
27 Mg	c	9.458M	1014.4	28.0	0.4	7061.	518.
			843.8	71.8	0.4	6541.	259.
					R_av	6595.	260.
24 Na	c	14.9590H	1369.0	100.	0.	17692.	588.
22 Na	c	2.6019Y	1274.5	99.94	0.01	13071.	444.
7 Be	i	53.29D	477.6	10.52	0.06	43082.	1505.

10.3 Reaction rates for residual nuclide production in ^{nat}Ni

Table 10.30: Detailed reaction rates for residual nuclide production in ^{nat}Ni at E_p=43 MeV used to determine their production cross sections.

Nuclide	Type	$T_{1/2}$	E_γ, KeV	Abundance, %		Reaction rate 10^{-20} s^{-1}	
61 Cu	i	3.333H	1185.2	3.7	0.7	8614	1778.
			656.0	10.8	2.0	8242	1558.
			373.0	2.1	0.4	8535	1763.
			283.0	12.2	2.3	8695	1669.
					R_av	8508	873.
60 Cu	i	23.7M	1333.0	88	1	23258	789
57 Ni	c	35.60H	1919.5	12.3	0.4	473720	21393.
			1757.6	5.75	0.21	446300	21498.
			1377.6	81.7	2.4	385840	16465.
			136.5	*********	*********	534510	37032.
			127.2	16.7	0.5	345630	15153.
			122.1	*********	*********	554810	42550.
					R_av	404329	29113.
56 Ni	c	6.075D	2598.5	*********	*********	85709	11794.
			2034.8	*********	*********	78808	6968.
			1771.3	*********	*********	76123	5274.
			1561.8	14.0	0.6	56124	2986.
			1037.8	*********	*********	77137	8039.
			750.0	49.5	1.2	53646	2106.
			480.4	36.5	0.8	49290	1890.
			269.5	36.5	0.8	49919	1916.
			158.4	98.8	1.0	51414	1707.
					R_av	51715	2089.
60 Co	i(m+g)	5.2714Y	1332.5	99.99	0.00	8435	629
58 Co	i(m+g)	70.86D	1674.7	0.52	0.01	326470	16141.
			864.0	0.68	0.01	297000	13362.
					R_av	307944	17185.
57 Co	i	271.74D	136.5	10.68	0.08	401980	34937.
			122.1	85.60	0.17	388530	40006.
					R_av	396298	27698.

57 Co	c	271.74D	136.5	10.68	0.08	936490	30633.
			122.1	85.60	0.17	943330	30491.
					R_av	940416	29972.
56 Co	i	77.233D	2598.5	17.3	0.3	956190	36674.
			2034.8	7.89	0.13	937270	33653.
			1771.3	15.47	0.14	949680	31092.
			1037.8	14.17	0.13	880980	29101.
					R_av	921726	34524.
56 Co	c	77.233D	2598.5	17.3	0.3	1041900	38742.
			2212.9	0.40	0.01	1032400	52823.
			2113.1	0.38	0.01	985570	44331.
			2034.8	7.89	0.13	1016000	35991.
			2015.2	3.04	0.05	1013600	36113.
			1963.7	0.72	0.01	988710	39695.
			1810.8	0.64	0.01	1030700	37061.
			1771.3	15.47	0.14	1025800	33284.
			1360.2	4.29	0.04	1076600	36941.
			1238.3	66.9	0.6	981620	31524.
			1175.1	2.29	0.02	953180	31224.
			1037.8	14.17	0.13	958120	30681.
			846.8	99.94	0.03	979330	29935.
			787.7	0.32	0.01	902690	48944.
					R_av	988995	31137.
55 Co	c	17.53H	1408.5	16.9	0.8	56169	3321.
			1370.0	2.9	0.3	55138	6142.
			1316.6	7.1	0.4	49160	3202.
			827.0	0.21	0.06	65207	22206.
			803.7	1.87	0.16	53059	4935.
			477.2	20.2	1.7	48537	4381.
			411.5	1.07	0.09	51361	4830.
			385.4	0.54	0.05	50556	6113.
					R_av	52115	2191.
59 Fe	c	44.472D	1099.2	56.5	1.9	360.9	209.4
53 Fe	c*	8.51M	377.9	42	3	76217	5959
52 Fe	c	8.275H	1434.1	*********	*********	116.7	12.9
			168.7	99	3	78.36	7.77
					R_av	88.38	17.08
56 Mn	c	2.5789H	2113.1	14.3	0.4	90.41	34.51
			1810.7	27.2	0.8	132.6	35.6
					R_av	110.9	24.9
52 Mn	c	5.591D	1434.1	100.0	0.6	2877	94.
			1333.7	5.07	0.06	3043	482.
			935.5	94.5	1.0	2792	92.
			744.2	90.0	0.9	2690	89.
					R_av	2793	98.
52mMn	i(m)	21.1M	1434.1	99.8	2.0	1425	64
52mMn	c	21.1M	1434.1	99.8	2.0	1542	68
51 Cr	c	27.7025D	320.1	9.92	0.05	4358	285
49 Cr	c	42.3M	152.9	30.3	1.1	81.80	58.74

Table 10.31: Detailed reaction rates for residual nuclide production in ^{nat}Ni at E_p=66 MeV used to determine their production cross sections.

Nuclide	Type	$T_{1/2}$	E_γ, KeV	Abundance, %		Reaction rate 10^{-20} s^{-1}	
61 Cu	i	3.333H	656.0	10.8	2.0	1575	319.
			283.0	12.2	2.3	1750	345.
					R_av	1656	237.
60 Cu	i	23.7M	1333.0	88	1	4021	174.
			826.4	21.7	1.1	3816	252.
					R_av	3974	163.
57 Ni	c	35.60H	1919.5	12.3	0.4	152270	6871.
			1757.6	5.75	0.21	143040	6874.
			1377.6	81.7	2.4	123970	5291.
			136.5	*********	********	201840	14623.
			127.2	16.7	0.5	110380	4841.
			122.1	*********	********	213150	11817.
					R_av	131965	12016.
56 Ni	c	6.075D	2598.5	*********	*********	23474	2719.
			2034.8	*********	*********	19421	1714.
			2015.2	*********	*********	20328	5910.
			1771.3	*********	*********	18662	2307.
			1561.8	14.0	0.6	14532	772.
			1037.8	*********	*********	22194	1581.

			811.8	86.0	0.9	12937	421.
			750.0	49.5	1.2	13833	542.
			480.4	36.5	0.8	12685	487.
			269.5	36.5	0.8	12952	497.
			158.4	98.8	1.0	13493	449.
					R_av	13217	486.
60 Co	i(m+g)	5.2714Y	1332.5	99.99	0.00	3012	312
58 Co	i(m+g)	70.86D	1674.7	0.52	0.01	57900	4035.
			864.0	0.68	0.01	58717	3216.
			810.8	99.45	0.01	61943	1897.
					R_av	60335	2373.
57 Co	i	271.74D	136.5	10.68	0.08	112540	13383.
			122.1	85.60	0.17	102850	10156.
					R_av	106315	8406.
57 Co	c	271.74D	136.5	10.68	0.08	314390	10303.
			122.1	85.60	0.17	316010	10179.
					R_av	315381	10042.
56 Co	i	77.233D	2598.5	17.3	0.3	180270	7010.
			2034.8	7.89	0.13	177950	6445.
			2015.2	3.04	0.05	179780	8192.
			1771.3	15.47	0.14	180100	6190.
			1037.8	14.17	0.13	164520	5432.
					R_av	172073	6559.
56 Co	c	77.233D	2598.5	17.3	0.3	203740	7600.
			2212.9	0.40	0.01	208100	10938.
			2113.1	0.38	0.01	195690	9034.
			2034.8	7.89	0.13	197380	7003.
			2015.2	3.04	0.05	200100	7382.
			1963.7	0.72	0.01	185900	9404.
			1810.8	0.64	0.01	194610	7521.
			1771.3	15.47	0.14	198760	6481.
			1360.2	4.29	0.04	209070	7471.
			1238.3	66.9	0.6	192070	6171.
			1175.1	2.29	0.02	188420	6569.
			1037.8	14.17	0.13	186720	5979.
			977.4	1.45	0.01	178860	6147.
			846.8	99.94	0.03	190280	5835.
			787.7	0.32	0.01	184460	10401.
					R_av	191852	6049.
55 Co	c	17.53H	1408.5	16.9	0.8	66438	3817.
			1370.0	2.9	0.3	65048	7035.
			1316.6	7.1	0.4	59397	3839.
			931.1	75	4	62007	3816.
			827.0	0.21	0.06	74112	21585.
			803.7	1.87	0.16	64197	5872.
			477.2	20.2	1.7	57743	5210.
			411.5	1.07	0.09	66356	6102.
			385.4	0.54	0.05	64939	6447.
					R_av	62923	2483.
59 Fe	c	44.472D	1291.6	43.2	1.4	548.3	116.5
			1099.2	56.5	1.9	269.0	29.3
					R_av	284.6	64.8
53 Fe	c*	8.51M	377.9	42	3	14101	1268
52 Fe	c	8.275H	1434.1******************			5214	231.
			377.8	1.64	0.04	5435	407.
			168.7	99	3	4794	217.
					R_av	5033	229.
56 Mn	c	2.5789H	2113.1	14.3	0.4	425.5	37.6
			1810.7	27.2	0.8	466.9	31.6
			846.8	98.9	0.3	522.6	110.6
					R_av	453.6	25.7
54 Mn	i	312.11D	834.8	99.98	0.00	40897	1259
52 Mn	c	5.591D	1434.1	100.0	0.6	38841	1227.
			1333.7	5.07	0.06	40640	1384.
			1246.3	4.21	0.07	47188	1750.
			935.5	94.5	1.0	37588	1219.
			744.2	90.0	0.9	36734	1186.
			647.5	0.40	0.02	40742	3421.
			600.2	0.39	0.01	33415	2003.
			346.0	0.98	0.01	35729	1319.
					R_av	38355	1364.
52mMn	i(m)	21.1M	1434.1	99.8	2.0	19777	849
52mMn	c	21.1M	1434.1	99.8	2.0	24990	1018.
			377.7	1.68	0.05	16801	3792.
					R_av	24749	1584.

49 Cr	c	42.3M	152.9	30.3	1.1	5123	251.
			90.6	53.2	1.9	5752	285.
					R_av	5394	354.
48 Cr	c	21.56H	112.3	96.0	2.1	65.09	4.71
48 V	c	15.9735D	2240.4	2.41	0.04	1531	443.
			1312.1	97.5	0.9	1080	38.
			983.5	100.0	0.3	1087	37.
			944.1	7.76	0.10	1084	166.
					R_av	1085	36.

Table 10.32: Detailed reaction rates for residual nuclide production in ^{nat}Ni at E_p=97 MeV used to determine their production cross sections.

Nuclide	Type	$T_{1/2}$	E_γ, KeV	Abundance, %		Reaction rate 10^{-20} s^{-1}	
61 Cu	c	3.333H	656.0	10.8	2.0	1911	413.
			283.0	12.2	2.3	2402	485.
					R_av	2118	318.
60 Cu	c	23.7M	1333.0	88	1	6371	272.
			826.4	21.7	1.1	6123	486.
					R_av	6335	262.
57 Ni	i	35.60H	1757.6	5.75	0.21	293720	14141.
			1377.6	81.7	2.4	253680	10838.
			136.5	**********	*******	265440	30923.
			127.2	16.7	0.5	223770	9829.
			122.1	**********	*******	298430	18536.
					R_av	251923	15898.
56 Ni	c*	6.075D	2034.8	**********	*******	24541	2745.
			2015.2	**********	*******	17345	6650.
			1561.8	14.0	0.6	28638	1565.
			1037.8	**********	*******	28358	4099.
			811.8	86.0	0.9	25539	892.
			750.0	49.5	1.2	27259	1097.
			480.4	36.5	0.8	24794	1019.
			269.5	36.5	0.8	24749	1000.
			158.4	98.8	1.0	26656	888.
					R_av	26089	883.
60 Co	i	5.2714Y	1332.5	99.99	0.00	7271	642
58 Co	i	70.86D	1674.7	0.52	0.01	121920	7100.
			864.0	0.68	0.01	99069	6614.
			810.8	99.45	0.01	115320	3551.
					R_av	113115	6036.
57 Co	i	271.74D	136.5	10.68	0.08	307390	31404.
			122.1	85.60	0.17	276990	18136.
					R_av	283716	16625.
57 Co	c	271.74D	136.5	10.68	0.08	572820	18717.
			122.1	85.60	0.17	575430	18536.
					R_av	574375	18280.
56 Co	i	77.233D	2034.8	7.89	0.13	347140	12533.
			2015.2	3.04	0.05	356870	14147.
			1037.8	14.17	0.13	323290	11085.
					R_av	335403	14346.
56 Co	c	77.233D	2212.9	0.40	0.01	398830	20252.
			2113.1	0.38	0.01	355620	18171.
			2034.8	7.89	0.13	371680	13158.
			2015.2	3.04	0.05	374220	13309.
			1963.7	0.72	0.01	369290	13683.
			1810.8	0.64	0.01	374700	13645.
			1360.2	4.29	0.04	405780	13631.
			1238.3	66.9	0.6	360600	11642.
			1175.1	2.29	0.02	360770	11676.
			1037.8	14.17	0.13	351650	11259.
			977.4	1.45	0.01	335570	11530.
			846.8	99.94	0.03	359790	11009.
			787.7	0.32	0.01	357040	21542.
					R_av	361364	11427.
55 Co	i	17.53H	1316.6	7.1	0.4	117800	7594.
			931.1	75	4	113910	7044.
			827.0	0.21	0.06	132120	40096.
			803.7	1.87	0.16	120160	11007.
			477.2	20.2	1.7	111720	10115.
			411.5	1.07	0.09	128350	11758.
			385.4	0.54	0.05	117230	12141.
					R_av	117111	4996.
59 Fe	c	44.472D	1099.2	56.5	1.9	797.2	62.8

53 Fe	c*	8.51M	377.9	42	3	55682	4448
52 Fe	c	8.275H	1434.1	********	*********	11160	2064.
			377.8	1.64	0.04	9550	1200.
			168.7	99	3	9212	418.
					R_av	9272	410.
56 Mn	c	2.5789H	2113.1	14.3	0.4	2526	146.
			1810.7	27.2	0.8	2432	117.
			846.8	98.9	0.3	2629	201.
					R_av	2486	103.
54 Mn	i	312.11D	834.8	99.98	0.00	102840	3149
52 Mn	c	5.591D	1434.1	100.0	0.6	79361	2709.
			1333.7	5.07	0.06	83827	2997.
			1246.3	4.21	0.07	94358	4263.
			935.5	94.5	1.0	80169	2622.
			744.2	90.0	0.9	75197	2611.
			647.5	0.40	0.02	83565	8737.
			600.2	0.39	0.01	68503	5801.
			346.0	0.98	0.01	73610	3370.
					R_av	79497	2861.
52mMn	i(m)	21.1M	1434.1	99.8	2.0	43423	5289
52mMn	c	21.1M	1434.1	99.8	2.0	54584	5505.
			377.7	1.68	0.05	54318	6063.
					R_av	54465	4248.
51 Cr	c	27.7025D	320.1	9.92	0.05	137330	4298
49 Cr	c	42.3M	152.9	30.3	1.1	15488	754.
			90.6	53.2	1.9	16657	844.
					R_av	15992	765.
48 Cr	c	21.56H	308.2	100	2	2092	82.
			112.3	96.0	2.1	2125	85.
					R_av	2107	75.
48 V	c	15.9735D	2240.4	2.41	0.04	21143	910.
			1312.1	97.5	0.9	20858	675.
			983.5	100.0	0.3	20375	640.
			944.1	7.76	0.10	20658	741.
			928.3	0.77	0.05	21814	2549.
					R_av	20458	646.
46 Sc	i(m+g)	83.79D	889.3	99.98	0.00	394.6	38.0
44mSc	i(m)	58.61H	1157.0	98.61	0.01	1081	94.
			270.9	86.7	0.3	950.9	32.0
					R_av	953.2	34.4
44 Sc	i	3.97H	1157.0	99.9	0.5	1285	150
44 Sc	i(m+g)	3.97H	1157.0	99.9	0.5	2351	176

Table 10.33: Detailed reaction rates for residual nuclide production in ^{nat}Ni at E_p=148 MeV used to determine their production cross sections.

Nuclide	Type	$T_{1/2}$	E_γ, KeV	Abundance, %		Reaction rate 10^{-20} s^{-1}	
61 Cu	i	3.333H	656.0	10.8	2.0	1621	362.
			283.0	12.2	2.3	2028	428.
					R_av	1791	279.
60 Cu	i	23.7M	1333.0	88	1	4340	214.
			826.4	21.7	1.1	4279	314.
					R_av	4324	197.
57 Ni	c	35.60H	1919.5	12.3	0.4	284150	12836.
			1757.6	5.75	0.21	264170	12718.
			1377.6	81.7	2.4	229890	9840.
			136.5	********	*********	298350	19434.
			127.2	16.7	0.5	210030	9230.
			122.1	********	*********	304720	12767.
					R_av	250915	17987.
56 Ni	c	6.075D	2034.8	********	*********	30589	3487.
			2015.2	********	*********	33196	6612.
			1771.3	********	*********	30183	3072.
			1561.8	14.0	0.6	26384	1427.
			1037.8	********	*********	21815	3370.
			811.8	86.0	0.9	23905	809.
			750.0	49.5	1.2	25294	998.
			480.4	36.5	0.8	23060	905.
			269.5	36.5	0.8	23999	946.
			158.4	98.8	1.0	25230	838.
					R_av	24541	834.

60 Co	i(m+g)	5.2714Y	1332.5	99.99	0.00	8890	581
58 Co	i(m+g)	70.86D	1674.7	0.52	0.01	117360	5552.
			864.0	0.68	0.01	106130	5510.
			810.8	99.45	0.01	111770	3438.
					R_av	111930	4192.
57 Co	i	271.74D	136.5	10.68	0.08	234060	18458.
			122.1	85.60	0.17	230130	10957.
					R_av	230886	10356.
57 Co	c	271.74D	136.5	10.68	0.08	532410	17400.
			122.1	85.60	0.17	534850	17230.
					R_av	533865	16992.
56 Co	i	77.233D	2034.8	7.89	0.13	309770	11420.
			2015.2	3.04	0.05	309900	12659.
			1771.3	15.47	0.14	312460	10534.
			1037.8	14.17	0.13	299660	10152.
					R_av	306949	10156.
56 Co	c	77.233D	2212.9	0.40	0.01	331650	18858.
			2113.1	0.38	0.01	322750	16026.
			2034.8	7.89	0.13	340360	12070.
			2015.2	3.04	0.05	343090	12235.
			1963.7	0.72	0.01	344090	12769.
			1810.8	0.64	0.01	345480	13496.
			1771.3	15.47	0.14	342650	11129.
			1360.2	4.29	0.04	370310	12278.
			1238.3	66.9	0.6	329360	10711.
			1175.1	2.29	0.02	326780	11140.
			1037.8	14.17	0.13	321480	10294.
			977.4	1.45	0.01	309410	10715.
			846.8	99.94	0.03	331150	10139.
			787.7	0.32	0.01	345260	18750.
					R_av	333061	10507.
55 Co	c	17.53H	1408.5	16.9	0.8	116720	6633.
			1370.0	2.9	0.3	85933	9831.
			1316.6	7.1	0.4	110020	7100.
			931.1	75	4	105390	6502.
			827.0	0.21	0.06	128640	37638.
			803.7	1.87	0.16	114070	10503.
			477.2	20.2	1.7	102690	9263.
			411.5	1.07	0.09	118820	10843.
			385.4	0.54	0.05	106950	11132.
					R_av	108750	4530.
59 Fe	c	44.472D	1291.6	43.2	1.4	1377	161.
			1099.2	56.5	1.9	1035	90.
					R_av	1113	147.
53 Fe	c*	8.51M	377.9	42	3	57843	5493
52 Fe	c	8.275H	1434.1	*********	********	13079	1605.
			377.8	1.64	0.04	11005	2207.
			168.7	99	3	11356	542.
					R_av	11453	529.
56 Mn	c	2.5789H	2113.1	14.3	0.4	3191	184.
			1810.7	27.2	0.8	3243	168.
			846.8	98.9	0.3	3519	263.
					R_av	3266	138.
54 Mn	i	312.11D	834.8	99.98	0.00	112700	3448
52 Mn	c	5.591D	1434.1	100.0	0.6	103630	3386.
			1333.7	5.07	0.06	109430	3780.
			1246.3	4.21	0.07	125060	4754.
			935.5	94.5	1.0	103530	3365.
			744.2	90.0	0.9	100900	3268.
			647.5	0.40	0.02	104530	9836.
			600.2	0.39	0.01	91699	5768.
			346.0	0.98	0.01	97032	3695.
					R_av	103494	3714.
52mMn	i(m)	21.1M	1434.1	99.8	2.0	54939	4997
52mMn	c	21.1M	1434.1	99.8	2.0	68018	5275.
			377.7	1.68	0.05	64457	24088.
					R_av	67880	5186.
51 Cr	c	27.7025D	320.1	9.92	0.05	201830	6326
49 Cr	c	42.3M	152.9	30.3	1.1	36491	1796.
			90.6	53.2	1.9	40410	2175.
					R_av	37982	2242.
48 Cr	c	21.56H	308.2	100	2	4691	185.
			112.3	96.0	2.1	4851	193.

Nuclide	Type	$T_{1/2}$	E_γ, KeV	Abundance, %		Reaction rate 10^{-20} s^{-1}	
					R_av	4767	170.
48 V	c	15.9735D	2240.4	2.41	0.04	55887	2164.
			1312.1	97.5	0.9	57298	1865.
			983.5	100.0	0.3	56248	1756.
			944.1	7.76	0.10	55916	1924.
			928.3	0.77	0.05	54699	5589.
					R_av	56962	1836.
46 Sc	i(m+g)	83.79D	1120.6	99.99	0.00	4623	156.
			889.3	99.98	0.00	3900	127.
					R_av	4092	345.
44mSc	i(m)	58.61H	1157.0	98.61	0.01	4641	151.
			270.9	86.7	0.3	4582	148.
					R_av	4609	147.
44 Sc	i	3.97H	1157.0	99.9	0.5	5520	191
44 Sc	i	3.97H	1499.5	0.91	0.02	4369	1260.
			1157.0	99.9	0.5	10096	326.
					R_av	10070	496.
43 Sc	c	3.891H	372.8	22.5	0.7	3084	158

Table 10.34: Detailed reaction rates for residual nuclide production in ^{nat}Ni at E_p=249 MeV used to determine their production cross sections.

Nuclide	Type	$T_{1/2}$	E_γ, KeV	Abundance, %		Reaction rate 10^{-20} s^{-1}	
61 Cu	i	3.333H	656.0	10.8	2.0	1657	417.
			283.0	12.2	2.3	1926	445.
					R_av	1783	307.
60 Cu	i	23.7M	1333.0	88	1	3347	151.
			826.4	21.7	1.1	3433	583.
					R_av	3350	150.
57 Ni	c	35.60H	1919.5	12.3	0.4	270670	12216.
			1757.6	5.75	0.21	253990	12210.
			1377.6	81.7	2.4	219110	9360.
			136.5	*****************		214130	14402.
			127.2	16.7	0.5	194380	8528.
			122.1	*****************		250650	10342.
					R_av	229004	14071.
56 Ni	c	6.075D	2598.5	*****************		27250	2117.
			2034.8	*****************		24275	2327.
			2015.2	*****************		24508	3235.
			1771.3	*****************		20891	2266.
			1561.8	14.0	0.6	24795	1328.
			1037.8	*****************		26019	3203.
			811.8	86.0	0.9	22527	734.
			750.0	49.5	1.2	23638	930.
			480.4	36.5	0.8	21617	829.
			269.5	36.5	0.8	22087	853.
			158.4	98.8	1.0	22064	741.
					R_av	22432	734.
60 Co	i(m+g)	5.2714Y	1332.5	99.99	0.00	14315	1172
58 Co	i(m+g)	70.86D	1674.7	0.52	0.01	122440	5748.
			864.0	0.68	0.01	98864	5493.
			810.8	99.45	0.01	114100	3495.
					R_av	112511	6150.
57 Co	i	271.74D	136.5	10.68	0.08	300970	15853.
			122.1	85.60	0.17	266790	10671.
					R_av	274111	16431.
57 Co	c	271.74D	136.5	10.68	0.08	515100	16836.
			122.1	85.60	0.17	517440	16666.
					R_av	516500	16438.
56 Co	i	77.233D	2598.5	17.3	0.3	299720	11198.
			2034.8	7.89	0.13	292360	10502.
			2015.2	3.04	0.05	293550	10747.
			1771.3	15.47	0.14	297900	9840.
			1037.8	14.17	0.13	272110	9196.
					R_av	289194	10655.
56 Co	c	77.233D	2598.5	17.3	0.3	326980	12112.
			2212.9	0.40	0.01	322620	17276.
			2113.1	0.38	0.01	295620	16203.
			2034.8	7.89	0.13	316640	11221.
			2015.2	3.04	0.05	318050	11273.
			1963.7	0.72	0.01	304870	11615.
			1810.8	0.64	0.01	308780	12116.
			1771.3	15.47	0.14	318790	10355.

			1360.2	4.29	0.04	325610	10784.
			1238.3	66.9	0.6	305600	9841.
			1175.1	2.29	0.02	314590	11148.
			1037.8	14.17	0.13	298130	9538.
			977.4	1.45	0.01	285990	11097.
			846.8	99.94	0.03	311570	9621.
			787.7	0.32	0.01	283010	19938.
					R_av	308860	9717.
55 Co	c	17.53H	1408.5	16.9	0.8	115820	6760.
			1370.0	2.9	0.3	118120	12771.
			1316.6	7.1	0.4	105230	6810.
			931.1	75	4	103270	6364.
			827.0	0.21	0.06	122860	35890.
			803.7	1.87	0.16	111830	10372.
			477.2	20.2	1.7	100090	8999.
			411.5	1.07	0.09	113680	10361.
			385.4	0.54	0.05	104610	11170.
					R_av	108303	4292.
59 Fe	c	44.472D	1291.6	43.2	1.4	2184	231.
			1099.2	56.5	1.9	1732	176.
					R_av	1897	225.
53 Fe	c*	8.51M	377.9	42	3	64605	5155
52 Fe	c	8.275H	1434.1	*********	*********	14094	810.
			377.8	1.64	0.04	12007	842.
			168.7	99	3	13704	602.
					R_av	13479	660.
56 Mn	c	2.5789H	2113.1	14.3	0.4	4260	218.
			1810.7	27.2	0.8	4305	203.
			846.8	98.9	0.3	4596	521.
					R_av	4301	174.
54 Mn	i	312.11D	834.8	99.98	0.00	121290	3710
52 Mn	c	5.591D	1434.1	100.0	0.6	120760	3818.
			1333.7	5.07	0.06	125080	4177.
			1246.3	4.21	0.07	142400	5065.
			935.5	94.5	1.0	116740	3781.
			744.2	90.0	0.9	114040	3679.
			647.5	0.40	0.02	116720	8992.
			600.2	0.39	0.01	109760	6413.
			346.0	0.98	0.01	111390	3869.
					R_av	119129	4237.
52mMn	i(m)	21.1M	1434.1	99.8	2.0	66964	3212
52mMn	c	21.1M	1434.1	99.8	2.0	81058	3634.
			377.7	1.68	0.05	71623	8619.
					R_av	80215	3677.
51 Cr	c	27.7025D	320.1	9.92	0.05	260650	8144
49 Cr	c	42.3M	152.9	30.3	1.1	55304	2679.
			90.6	53.2	1.9	60215	3151.
					R_av	57250	2995.
48 Cr	c	21.56H	308.2	100	2	8302	312.
			112.3	96.0	2.1	8614	340.
					R_av	8430	305.
48 V	c	15.9735D	2240.4	2.41	0.04	104740	3816.
			1312.1	97.5	0.9	104550	3372.
			983.5	100.0	0.3	101930	3136.
			944.1	7.76	0.10	102690	3420.
			928.3	0.77	0.05	98222	7465.
					R_av	104302	3339.
48 Sc	i	43.67H	1037.5	97.6	0.7	386.8	41.4
47 Sc	c	3.3492D	159.4	68.3	0.4	3719	146
46 Sc	i(m+g)	83.79D	1120.6	99.99	0.00	12946	406.
			889.3	99.98	0.00	12165	377.
					R_av	12939	411.
44mSc	i(m)	58.61H	1499.5	98.61	0.01	15334	830.
			1157.0	98.61	0.01	15872	498.
			1126.1	1.20	0.07	15068	2456.
			1001.8	1.20	0.07	12317	1916.
			270.9	86.7	0.3	16156	510.
					R_av	15946	504.
44 Sc	i	3.97H	1499.5	0.91	0.02	17263	1300.
			1157.0	99.9	0.5	17705	579.
					R_av	17696	578.
44 Sc	i(m+g)	3.97H	2656.5	0.11	0.00	22763	2423.

			1499.5	0.91	0.02	32385	1662.
			1157.0	99.9	0.5	33356	1054.
					R_av	33292	1040.
43 Sc	c	3.891H	372.8	22.5	0.7	11668	539
47 Ca	c	4.536D	1297.1	71	7	105.7	29.1
43 K	c	22.3H	617.5	79.2	0.7	421.5	23.4
			372.8	86.8	0.2	420.0	24.3
					R_av	420.8	19.2
42 K	i	12.360H	1525.0	18.08	0.09	2125	142
38 K	i	7.636M	2167.0	99.86	0.01	494.2	136.1
38 Cl	c	37.24M	2167.0	42.4	1.1	185.8	99.1
34mCl	i(m)	32.00M	2127.0	42.8	0.8	224.3	60.5
7 Be	i	53.29D	477.6	10.52	0.06	5027	660

Table 10.35: Detailed reaction rates for residual nuclide production in ^{nat}Ni at E_p=399 MeV used to determine their production cross sections.

Nuclide	Type	$T_{1/2}$	E_γ, KeV	Abundance, %		Reaction rate 10^{-20} s^{-1}	
60 Cu	i	23.7M	1333.0	88	1	1365	61.
			826.4	21.7	1.1	1232	232.
					R_av	1360	60.
57 Ni	c	35.60H	1919.5	12.3	0.4	145330	6603.
			1757.6	5.75	0.21	136960	6625.
			1377.6	81.7	2.4	118000	5043.
			136.5	*****************		111660	15389.
			127.2	16.7	0.5	105720	4648.
			122.1	*****************		153300	5889.
					R_av	128736	9406.
56 Ni	c	6.075D	2598.5	*****************		16067	1950.
			2034.8	*****************		19187	3163.
			2015.2	*****************		18631	6353.
			1771.3	*****************		15117	2424.
			1561.8	14.0	0.6	12591	679.
			1037.8	*****************		6896	4208.
			811.8	86.0	0.9	10854	447.
			750.0	49.5	1.2	11991	474.
			480.4	36.5	0.8	11032	427.
			269.5	36.5	0.8	11276	437.
			158.4	98.8	1.0	11480	391.
					R_av	11428	400.
60 Co	i(m+g)	5.2714Y	1332.5	99.99	0.00	7750	1161
58 Co	i(m+g)	70.86D	1674.7	0.52	0.01	53025	5924.
			864.0	0.68	0.01	60932	9242.
			810.8	99.45	0.01	68479	2141.
					R_av	68475	2145.
57 Co	i	271.74D	136.5	10.68	0.08	189690	16155.
			122.1	85.60	0.17	149860	5761.
					R_av	151752	9709.
57 Co	c	271.74D	136.5	10.68	0.08	301360	9864.
			122.1	85.60	0.17	303170	9765.
					R_av	302455	9628.
56 Co	i	77.233D	2598.5	17.3	0.3	158930	6089.
			2034.8	7.89	0.13	151440	5996.
			2015.2	3.04	0.05	154280	7796.
			1771.3	15.47	0.14	156330	5480.
			1037.8	14.17	0.13	153640	6363.
					R_av	155431	5107.
56 Co	c	77.233D	2598.5	17.3	0.3	175000	6503.
			2212.9	0.40	0.01	174100	13603.
			2113.1	0.38	0.01	162280	9618.
			2034.8	7.89	0.13	170630	6108.
			2015.2	3.04	0.05	172920	6342.
			1963.7	0.72	0.01	172080	7732.
			1810.8	0.64	0.01	171710	9455.
			1771.3	15.47	0.14	171450	5602.
			1360.2	4.29	0.04	173200	5821.
			1238.3	66.9	0.6	163020	5297.
			1175.1	2.29	0.02	169990	6526.
			1037.8	14.17	0.13	160540	5161.
			977.4	1.45	0.01	149340	9176.
			846.8	99.94	0.03	167650	5176.
			787.7	0.32	0.01	162480	23707.

					R_av	166323	5240.
55 Co	c	17.53H	1408.5	16.9	0.8	57933	3291.
			1370.0	2.9	0.3	66693	7313.
			1316.6	7.1	0.4	54765	3539.
			931.1	75	4	53593	3302.
			803.7	1.87	0.16	58612	5450.
			477.2	20.2	1.7	52533	4725.
			411.5	1.07	0.09	62809	5775.
			385.4	0.54	0.05	47840	5528.
					R_av	55838	2300.
59 Fe	c	44.472D	1291.6	43.2	1.4	1413	107.
			1099.2	56.5	1.9	1121	87.
					R_av	1237	148.
53 Fe	c*	8.51M	377.9	42	3	40075	3466
52 Fe	c	8.275H	1434.1	******************		7963	365.
			168.7	99	3	7789	345.
					R_av	7868	305.
56 Mn	c	2.5789H	2113.1	14.3	0.4	3040	155.
			1810.7	27.2	0.8	3132	147.
			846.8	98.9	0.3	3173	189.
					R_av	3108	121.
54 Mn	i	312.11D	834.8	99.98	0.00	74900	2301
52 Mn	c	5.591D	1434.1	100.0	0.6	74540	2359.
			1333.7	5.07	0.06	77146	2599.
			1246.3	4.21	0.07	87198	3201.
			935.5	94.5	1.0	72226	2344.
			744.2	90.0	0.9	70638	2284.
			647.5	0.40	0.02	84399	7240.
			600.2	0.39	0.01	69703	5792.
			346.0	0.98	0.01	67910	2707.
					R_av	73692	2568.
52mMn	i(m)	21.1M	1434.1	99.8	2.0	41500	1731
52mMn	c	21.1M	1434.1	99.8	2.0	49463	1998
51 Cr	c	27.7025D	320.1	9.92	0.05	177260	5542
49 Cr	c	42.3M	152.9	30.3	1.1	41829	2025.
			90.6	53.2	1.9	45381	2370.
					R_av	43245	2202.
48 Cr	c	21.56H	308.2	100	2	6847	260.
			112.3	96.0	2.1	7259	286.
					R_av	7019	299.
48 V	c	15.9735D	2240.4	2.41	0.04	89657	3382.
			1312.1	97.5	0.9	89466	2886.
			983.5	100.0	0.3	87355	2689.
			944.1	7.76	0.10	87803	2942.
			928.3	0.77	0.05	92336	10763.
					R_av	89310	2862.
48 Sc	i	43.67H	1037.5	97.6	0.7	456.9	43.7
47 Sc	c	3.3492D	159.4	68.3	0.4	4028	136
46 Sc	i(m+g)	83.79D	1120.6	99.99	0.00	15982	503.
			889.3	99.98	0.00	15182	469.
					R_av	15968	510.
44mSc	i(m)	58.61H	1499.5	98.61	0.01	22679	2076.
			1157.0	98.61	0.01	21072	660.
			1126.1	1.20	0.07	23181	2758.
			1001.8	1.20	0.07	20704	3327.
			270.9	86.7	0.3	21574	686.
					R_av	21140	666.
44 Sc	i	3.97H	1499.5	0.91	0.02	20443	1866.
			1157.0	99.9	0.5	22219	714.
					R_av	22203	713.
44 Sc	i(m+g)	3.97H	2656.5	0.11	0.00	43415	4285.
			1499.5	0.91	0.02	42807	2715.
			1157.0	99.9	0.5	42998	1351.
					R_av	42998	1343.
43 Sc	c	3.891H	372.8	22.5	0.7	16015	739
43 K	c	22.3H	617.5	79.2	0.7	947.9	37.5
			396.9	11.85	0.09	1004	121.
			372.8	86.8	0.2	887.7	37.9
					R_av	923.0	36.6

42 K	i	12.360H	1525.0	18.08	0.09	4211	164
38 K	i	7.636M	2167.0	99.86	0.01	1426	176
41 Ar	c	109.34M	1294.0	99.1	0.0	375.5	22.7
38 Cl	c	37.24M	2167.0	42.4	1.1	874.7	78.1
			1643.0	31.9	1.0	833.7	87.4
					R_av	857.5	57.0
34mCl	i(m)	32.00M	2127.0	42.8	0.8	907.9	58.4
			146.4	40.5	0.9	630.4	104.7
					R_av	853.0	113.8
7 Be	i	53.29D	477.6	10.52	0.06	6178	569

Table 10.36: Detailed reaction rates for residual nuclide production in ^{nat}Ni at E_p=599 MeV used to determine their production cross sections.

Nuclide	Type	$T_{1/2}$	E_γ, KeV	Abundance, %		Reaction rate 10^{-20} s^{-1}	
60 Cu	i	23.7M	1333.0	88	1	2196	130.
			826.4	21.7	1.1	3879	943.
					R_av	2219	208.
57 Ni	c	35.60H	1919.5	12.3	0.4	255850	11607.
			1757.6	5.75	0.21	241210	11656.
			1377.6	81.7	2.4	208260	8908.
			136.5	*********	********	210570	23697.
			127.2	16.7	0.5	184530	8109.
			122.1	*********	********	239960	13356.
					R_av	214839	13674.
56 Ni	c	6.075D	2598.5	*********	********	20904	4638.
			2034.8	*********	********	20664	5377.
			2015.2	*********	********	20416	8641.
			1771.3	*********	********	18095	4145.
			1561.8	14.0	0.6	20206	1082.
			1037.8	*********	********	28850	7387.
			811.8	86.0	0.9	18493	632.
			750.0	49.5	1.2	19485	771.
			480.4	36.5	0.8	17789	695.
			269.5	36.5	0.8	18243	708.
			158.4	98.8	1.0	18331	614.
					R_av	18461	600.
60 Co	i(m+g)	5.2714Y	1332.5	99.99	0.00	14640	1256
58 Co	i(m+g)	70.86D	1674.7	0.52	0.01	134040	15192.
			864.0	0.68	0.01	129330	53780.
			810.8	99.45	0.01	129640	3974.
					R_av	129958	5655.
57 Co	i	271.74D	136.5	10.68	0.08	352010	25354.
			122.1	85.60	0.17	325280	15075.
					R_av	330411	14744.
57 Co	c	271.74D	136.5	10.68	0.08	562580	18407.
			122.1	85.60	0.17	565250	18206.
					R_av	564192	17959.
56 Co	i	77.233D	2598.5	17.3	0.3	276790	10991.
			2034.8	7.89	0.13	270460	10689.
			2015.2	3.04	0.05	272430	12368.
			1771.3	15.47	0.14	275020	9656.
			1037.8	14.17	0.13	244670	10600.
					R_av	269823	9952.
56 Co	c	77.233D	2598.5	17.3	0.3	297700	11103.
			2212.9	0.40	0.01	308020	25456.
			2113.1	0.38	0.01	289600	21952.
			2034.8	7.89	0.13	291120	10403.
			2015.2	3.04	0.05	292850	10603.
			1963.7	0.72	0.01	282840	12415.
			1810.8	0.64	0.01	291670	13523.
			1771.3	15.47	0.14	293110	9571.
			1360.2	4.29	0.04	296090	9914.
			1238.3	66.9	0.6	277380	8981.
			1175.1	2.29	0.02	279300	9572.
			1037.8	14.17	0.13	273520	8796.
			977.4	1.45	0.01	267310	10766.
			846.8	99.94	0.03	285490	8876.
					R_av	282769	8901.
55 Co	c	17.53H	1408.5	16.9	0.8	99076	5638.
			1370.0	2.9	0.3	168850	18449.
			1316.6	7.1	0.4	92741	6004.
			931.1	75	4	89931	5546.
			803.7	1.87	0.16	100860	10025.

			477.2	20.2	1.7	87886	7915.
			411.5	1.07	0.09	109390	10018.
			385.4	0.54	0.05	102540	12165.
					R_av	96530	5281.
59 Fe	c	44.472D	1291.6	43.2	1.4	3084	285.
			1099.2	56.5	1.9	2543	182.
					R_av	2691	255.
53 Fe	c*	8.51M	377.9	42	3	69093	6681
52 Fe	c	8.275H	1434.1*****************			16745	976.
			168.7	99	3	13683	631.
					R_av	14421	1385.
56 Mn	c	2.5789H	2113.1	14.3	0.4	6563	379.
			1810.7	27.2	0.8	6656	326.
			846.8	98.9	0.3	6889	655.
					R_av	6645	280.
54 Mn	i	312.11D	834.8	99.98	0.00	135280	4157
52 Mn	c	5.591D	1434.1	100.0	0.6	132250	4190.
			1333.7	5.07	0.06	137100	4606.
			1246.3	4.21	0.07	155220	5866.
			935.5	94.5	1.0	128790	4198.
			744.2	90.0	0.9	125940	4084.
			647.5	0.40	0.02	135910	11938.
			600.2	0.39	0.01	130080	10003.
			346.0	0.98	0.01	125680	4622.
					R_av	131065	4489.
52mMn	i(m)	21.1M	1434.1	99.8	2.0	71806	3403
52mMn	c	21.1M	1434.1	99.8	2.0	88551	3925
51 Cr	c	27.7025D	320.1	9.92	0.05	329100	10275
49 Cr	c	42.3M	152.9	30.3	1.1	82582	4026.
			90.6	53.2	1.9	90009	4487.
					R_av	85840	4558.
48 Cr	c	21.56H	308.2	100	2	14665	563.
			112.3	96.0	2.1	15331	603.
					R_av	14960	573.
48 V	c	15.9735D	2240.4	2.41	0.04	193940	7195.
			1312.1	97.5	0.9	189430	6110.
			983.5	100.0	0.3	184950	5701.
			944.1	7.76	0.10	186350	6206.
			928.3	0.77	0.05	176600	13118.
					R_av	189462	6068.
48 Sc	i	43.67H	1312.1	100.1	0.7	1762	133.
			1037.5	97.6	0.7	1554	80.
			983.5	100.1	0.6	1286	302.
					R_av	1588	88.
47 Sc	c	3.3492D	159.4	68.3	0.4	10971	363
46 Sc	i(m+g)	83.79D	1120.6	99.99	0.00	42027	1302.
			889.3	99.98	0.00	40531	1250.
					R_av	41249	1584.
44mSc	i(m)	58.61H	2656.5	98.61	0.01	89924	13953.
			1499.5	98.61	0.01	59279	2961.
			1157.0	98.61	0.01	59325	1872.
			1126.1	1.20	0.07	68346	5136.
			1001.8	1.20	0.07	68062	5343.
			270.9	86.7	0.3	61014	1943.
					R_av	59911	1931.
44 Sc	i	3.97H	2656.5	0.11	0.00	78626	13065.
			1499.5	0.91	0.02	55278	3580.
			1157.0	99.9	0.5	62918	2268.
					R_av	62151	2768.
44 Sc	i(m+g)	3.97H	2656.5	0.11	0.00	167300	18600.
			1499.5	0.91	0.02	113730	5174.
			1157.0	99.9	0.5	121410	3954.
					R_av	121420	3793.
43 Sc	c	3.891H	372.8	22.5	0.7	48160	2151
43 K	c	22.3H	617.5	79.2	0.7	3586	129.
			593.4	11.26	0.09	3803	405.
			396.9	11.85	0.09	3720	290.
			372.8	86.8	0.2	3516	114.
					R_av	3533	114.
42 K	i	12.360H	1525.0	18.08	0.09	15359	511

38 K	i	7.636M	2167.0	99.86	0.01	5550	443
41 Ar	c	109.34M	1294.0	99.1	0.0	1572	81
39 Cl	c	55.6M	1267.0	53.6	1.3	928.9	113.5
38 Cl	c	37.24M	2167.0	42.4	1.1	4140	283.
			1643.0	31.9	1.0	4090	257.
					R_av	4110	182.
34mCl	i(m)	32.00M	2127.0	42.8	0.8	3911	190.
			146.4	40.5	0.9	3924	233.
					R_av	3916	169.
28 Mg	c	20.915H	1778.8	100.2	0.0	232.8	18.2
			941.5	38.3	1.0	719.2	79.2
			400.7	36.6	1.0	601.6	43.0
					R_av	307.3	110.3
27 Mg	c	9.458M	843.8	71.8	0.4	1181	140
22 Na	c	2.6019Y	1274.5	99.94	0.01	3324	535
7 Be	i	53.29D	477.6	10.52	0.06	20792	1177

Table 10.37: Detailed reaction rates for residual nuclide production in ^{nat}Ni at E_p=799 MeV used to determine their production cross sections.

Nuclide	Type	$T_{1/2}$	E_γ, KeV	Abundance, %		Reaction rate 10^{-20} s^{-1}	
60 Cu	i	23.7M	1333.0	88	1	769.0	68.7
57 Ni	c	35.60H	1919.5	12.3	0.4	92771	4246.
			1757.6	5.75	0.21	86566	4202.
			1377.6	81.7	2.4	75062	3242.
			136.5	*****************		72004	12744.
			127.2	16.7	0.5	65226	2875.
			122.1	*****************		89092	6702.
					R_av	76417	5223.
56 Ni	c	6.075D	2034.8	*****************		6077	2725.
			2015.2	*****************		7304	3722.
			1771.3	*****************		5209	2307.
			1561.8	14.0	0.6	7109	458.
			1037.8	*****************		3576	3692.
			750.0	49.5	1.2	6836	274.
			480.4	36.5	0.8	6280	245.
			269.5	36.5	0.8	6590	288.
			158.4	98.8	1.0	6541	224.
					R_av	6551	216.
62mCo	i(m)	13.91M	1172.9	97.7	0.5	284.0	39.0
60 Co	i(m+g)	5.2714Y	1332.5	99.99	0.00	5213	477.
			1173.2	99.97	0.00	5433	552.
					R_av	5306	379.
58 Co	i(m+g)	70.86D	1674.7	0.52	0.01	54994	5754.
			864.0	0.68	0.01	40732	4242.
			810.8	99.45	0.01	51809	1695.
					R_av	51669	1886.
57 Co	i	271.74D	136.5	10.68	0.08	144950	13395.
			122.1	85.60	0.17	129140	7305.
					R_av	132131	7442.
57 Co	c	271.74D	136.5	10.68	0.08	216960	7108.
			122.1	85.60	0.17	218240	7041.
					R_av	217724	6936.
56 Co	i	77.233D	2034.8	7.89	0.13	98847	4380.
			2015.2	3.04	0.05	98462	5111.
			1771.3	15.47	0.14	99864	3939.
			1037.8	14.17	0.13	94866	4851.
					R_av	98558	3457.
56 Co	c	77.233D	2212.9	0.40	0.01	109550	11653.
			2113.1	0.38	0.01	98082	5247.
			2034.8	7.89	0.13	104920	3762.
			2015.2	3.04	0.05	105760	3775.
			1963.7	0.72	0.01	107570	4602.
			1810.8	0.64	0.01	106930	5065.
			1771.3	15.47	0.14	105070	3444.
			1360.2	4.29	0.04	109340	3888.
			1238.3	66.9	0.6	99489	3218.
			1175.1	2.29	0.02	102450	3797.
			1037.8	14.17	0.13	98442	3170.
			977.4	1.45	0.01	88885	3467.

			846.8	99.94	0.03	102370	3194.
			787.7	0.32	0.01	99884	13321.
					R_av	101151	3214.
55 Co	c	17.53H	1408.5	16.9	0.8	33739	1952.
			1316.6	7.1	0.4	30992	2021.
			931.1	75	4	30502	1889.
			803.7	1.87	0.16	33399	3108.
			477.2	20.2	1.7	29903	2692.
			411.5	1.07	0.09	34402	3443.
			385.4	0.54	0.05	32843	3686.
					R_av	31925	1287.
59 Fe	c	44.472D	1291.6	43.2	1.4	1109	67.
			1099.2	56.5	1.9	974.0	68.3
					R_av	1046	75.
53 Fe	c*	8.51M	377.9	42	3	25072	2233
52 Fe	c	8.275H	1434.1	**********	*******	4486	405.
			168.7	99	3	4615	207.
					R_av	4598	200.
56 Mn	c	2.5789H	2113.1	14.3	0.4	2586	137.
			1810.7	27.2	0.8	2629	124.
			846.8	98.9	0.3	2674	247.
					R_av	2617	106.
54 Mn	i	312.11D	834.8	99.98	0.00	49246	1515
52 Mn	c	5.591D	1434.1	100.0	0.6	47590	1535.
			1333.7	5.07	0.06	49456	1731.
			1246.3	4.21	0.07	56066	2170.
			935.5	94.5	1.0	45709	1497.
			744.2	90.0	0.9	44986	1478.
			647.5	0.40	0.02	72822	12640.
			600.2	0.39	0.01	58769	11624.
			346.0	0.98	0.01	44196	1914.
					R_av	46811	1694.
52mMn	i(m)	21.1M	1434.1	99.8	2.0	26955	1625
52mMn	c	21.1M	1434.1	99.8	2.0	31441	1735
51 Cr	c	27.7025D	320.1	9.92	0.05	118390	3721
49 Cr	c	42.3M	152.9	30.3	1.1	31099	1521.
			90.6	53.2	1.9	33594	1670.
					R_av	32216	1598.
48 Cr	c	21.56H	308.2	100	2	5418	206.
			112.3	96.0	2.1	5673	227.
					R_av	5521	213.
48 V	c	15.9735D	2240.4	2.41	0.04	74181	2854.
			1312.1	97.5	0.9	71831	2322.
			983.5	100.0	0.3	70133	2174.
			944.1	7.76	0.10	71067	2409.
			928.3	0.77	0.05	73315	5653.
					R_av	71949	2309.
48 Sc	i	43.67H	1312.1	100.1	0.7	99.71	81.71
			1037.5	97.6	0.7	632.5	38.0
			983.5	100.1	0.6	536.8	168.6
					R_av	559.1	128.5
47 Sc	c	3.3492D	159.4	68.3	0.4	4780	163
46 Sc	i(m+g)	83.79D	1120.6	99.99	0.00	18235	566.
			889.3	99.98	0.00	17343	541.
					R_av	17769	712.
44mSc	i(m)	58.61H	1499.5	98.61	0.01	28832	1765.
			1157.0	98.61	0.01	25786	819.
			1126.1	1.20	0.07	29622	3993.
			1001.8	1.20	0.07	26620	2362.
			270.9	86.7	0.3	26797	861.
					R_av	26154	859.
44 Sc	i	3.97H	1499.5	0.91	0.02	25774	2533.
			1157.0	99.9	0.5	26722	965.
					R_av	26685	959.
44 Sc	i(m+g)	3.97H	1499.5	0.91	0.02	54205	3084.
			1157.0	99.9	0.5	52150	1697.
					R_av	52217	1696.
43 Sc	c	3.891H	372.8	22.5	0.7	21665	982
43 K	c	22.3H	617.5	79.2	0.7	1788	61.
			593.4	11.26	0.09	1727	125.

Nuclide	Type	$T_{1/2}$	E_γ, KeV	Abundance, %		Reaction rate 10^{-20} s^{-1}	
			396.9	11.85	0.09	1648	105.
			372.8	86.8	0.2	1689	56.
					R_av	1720	60.
42 K	i	12.360H	1525.0	18.08	0.09	7559	258
38 K	i	7.636M	2167.0	99.86	0.01	3257	229
41 Ar	c	109.34M	1294.0	99.1	0.0	951.4	35.3
39 Cl	c	55.6M	1518.0	39.2	1.3	621.1	90.0
			250.3	46.3	2.0	551.3	90.6
					R_av	586.6	65.1
38 Cl	c	37.24M	2167.0	42.4	1.1	2452	141.
			1643.0	31.9	1.0	2494	130.
					R_av	2481	89.
34mCl	i(m)	32.00M	2127.0	42.8	0.8	2440	108.
			1177.0	14.09	0.24	2307	209.
			146.4	40.5	0.9	2508	112.
					R_av	2461	93.
29 Al	c	6.56M	1273.3	90.6	0.6	2056	162
28 Mg	c	20.915H	1778.8	100.2	0.0	195.0	14.2
			1342.2	52.6	1.6	195.6	23.7
			400.7	36.6	1.0	230.7	29.1
					R_av	200.0	12.1
27 Mg	c	9.458M	1014.4	28.0	0.4	854.3	182.0
			843.8	71.8	0.4	1066	67.
					R_av	1046	70.
24 Na	c	14.9590H	1369.0	100	0	3106	99
22 Na	c	2.6019Y	1274.5	99.94	0.01	2643	214
7 Be	i	53.29D	477.6	10.52	0.06	12108	538

Table 10.38: Detailed reaction rates for residual nuclide production in ^{nat}Ni at E_p=1199 MeV used to determine their production cross sections.

Nuclide	Type	$T_{1/2}$	E_γ, KeV	Abundance, %		Reaction rate 10^{-20} s^{-1}	
60 Cu	i	23.7M	1333.0	88	1	970.8	70.6
57 Ni	c	35.60H	1919.5	12.3	0.4	107460	4901.
			1757.6	5.75	0.21	100130	4886.
			1377.6	81.7	2.4	87501	3741.
			136.5	*********	*********	61173	19526.
			127.2	16.7	0.5	79766	3505.
			122.1	*********	*********	85512	7976.
					R_av	89722	5398.
56 Ni	c	6.075D	1771.3	*********	*********	2336	2326.
			1561.8	14.0	0.6	7954	432.
			1037.8	*********	*********	10431	3304.
			750.0	49.5	1.2	7450	294.
			480.4	36.5	0.8	6836	268.
			269.5	36.5	0.8	7074	320.
			158.4	98.8	1.0	7104	238.
					R_av	7130	249.
62mCo	i(m)	13.91M	1172.9	97.7	0.5	339.8	70.8
60 Co	i(m+g)	5.2714Y	1332.5	99.99	0.00	6996	337.
			1173.2	99.97	0.00	6025	313.
					R_av	6498	526.
58 Co	i(m+g)	70.86D	1674.7	0.52	0.01	68485	3770.
			864.0	0.68	0.01	59271	3227.
			810.8	99.45	0.01	61647	1884.
					R_av	62371	2709.
57 Co	i	271.74D	136.5	10.68	0.08	192000	20438.
			122.1	85.60	0.17	168730	9254.
					R_av	171792	9523.
57 Co	c	271.74D	136.5	10.68	0.08	253170	8291.
			122.1	85.60	0.17	254240	8189.
					R_av	253821	8081.
56 Co	i	77.233D	1771.3	15.47	0.14	113810	4358.
			1037.8	14.17	0.13	98085	4648.
					R_av	108432	8193.
56 Co	c	77.233D	2212.9	0.40	0.01	119360	7866.
			2113.1	0.38	0.01	113140	5467.

			2034.8	7.89	0.13	115290	4117.
			2015.2	3.04	0.05	114940	4206.
			1963.7	0.72	0.01	114810	4421.
			1810.8	0.64	0.01	118220	4798.
			1771.3	15.47	0.14	116150	3791.
			1360.2	4.29	0.04	125880	4155.
			1238.3	66.9	0.6	111900	3601.
			1175.1	2.29	0.02	111890	3843.
			1037.8	14.17	0.13	108510	3483.
			977.4	1.45	0.01	98866	3832.
			846.8	99.94	0.03	112700	3493.
			787.7	0.32	0.01	117420	12602.
					R_av	113002	3582.
55 Co	c	17.53H	1408.5	16.9	0.8	37780	2232.
			1316.6	7.1	0.4	34896	2265.
			931.1	75	4	33481	2069.
			803.7	1.87	0.16	34560	3469.
			477.2	20.2	1.7	33749	3038.
			411.5	1.07	0.09	40120	4515.
			385.4	0.54	0.05	37642	4732.
					R_av	35409	1444.
59 Fe	c	44.472D	1291.6	43.2	1.4	1257	73.
			1099.2	56.5	1.9	1264	65.
					R_av	1261	56.
53 Fe	c*	8.51M	377.9	42	3	23676	2321
52 Fe	c	8.275H	1434.1	******************		5434	647.
			168.7	99	3	4933	220.
					R_av	4963	218.
56 Mn	c	2.5789H	2113.1	14.3	0.4	3096	162.
			1810.7	27.2	0.8	3013	147.
			846.8	98.9	0.3	2921	314.
					R_av	3039	126.
54 Mn	i	312.11D	834.8	99.98	0.00	53461	1640
52 Mn	c	5.591D	1434.1	100.0	0.6	49968	1603.
			1333.7	5.07	0.06	52150	1776.
			1246.3	4.21	0.07	58321	2173.
			935.5	94.5	1.0	48445	1589.
			744.2	90.0	0.9	47225	1547.
			647.5	0.40	0.02	50526	7485.
			346.0	0.98	0.01	45950	1911.
					R_av	49396	1814.
52mMn	i(m)	21.1M	1434.1	99.8	2.0	25901	1785
52mMn	c	21.1M	1434.1	99.8	2.0	31334	1865
51 Cr	c	27.7025D	320.1	9.92	0.05	123350	3869
49 Cr	c	42.3M	152.9	30.3	1.1	31158	1509.
			90.6	53.2	1.9	33890	1676.
					R_av	32360	1692.
48 Cr	c	21.56H	308.2	100	2	5966	223.
			112.3	96.0	2.1	6329	248.
					R_av	6111	261.
48 V	c	15.9735D	2240.4	2.41	0.04	78514	2937.
			1312.1	97.5	0.9	76362	2469.
			983.5	100.0	0.3	74428	2295.
			944.1	7.76	0.10	75255	2541.
			928.3	0.77	0.05	73188	6271.
					R_av	76434	2453.
48 Sc	i	43.67H	1312.1	100.1	0.7	1056	167.
			1037.5	97.6	0.7	911.5	45.0
			983.5	100.1	0.6	1788	180.
					R_av	950.9	123.3
47 Sc	c	3.3492D	159.4	68.3	0.4	5978	198
46 Sc	i(m+g)	83.79D	1120.6	99.99	0.00	20988	649.
			889.3	99.98	0.00	20385	628.
					R_av	20677	794.
44mSc	i(m)	58.61H	1499.5	98.61	0.01	33738	1799.
			1157.0	98.61	0.01	31397	988.
			1126.1	1.20	0.07	29097	3138.
			1001.8	1.20	0.07	34922	3835.
			270.9	86.7	0.3	32919	1039.
					R_av	31980	1068.
44 Sc	i	3.97H	1499.5	0.91	0.02	23601	3623.
			1157.0	99.9	0.5	31350	1079.
					R_av	31226	1379.

44 Sc	i(m+g)	3.97H	1499.5	0.91	0.02	56870	4042.
			1157.0	99.9	0.5	62311	1997.
					R_av	62231	2052.
43 Sc	c	3.891H	372.8	22.5	0.7	25734	1157
43 K	c	22.3H	617.5	79.2	0.7	2618	92.
			593.4	11.26	0.09	2697	267.
			396.9	11.85	0.09	2579	133.
			372.8	86.8	0.2	2539	83.
					R_av	2560	83.
42 K	i	12.360H	1525.0	18.08	0.09	10520	365
38 K	i	7.636M	2167.0	99.86	0.01	4192	321
41 Ar	c	109.34M	1294.0	99.1	0.0	1459	65
39 Cl	c	55.6M	1518.0	39.2	1.3	832.5	71.1
			1267.0	53.6	1.3	969.5	54.2
			250.3	46.3	2.0	936.2	76.7
					R_av	928.4	49.4
38 Cl	c	37.24M	2167.0	42.4	1.1	3865	182.
			1643.0	31.9	1.0	4046	197.
					R_av	3946	159.
34mCl	i(m)	32.00M	2127.0	42.8	0.8	4296	175.
			146.4	40.5	0.9	4131	169.
					R_av	4211	155.
29 Al	c	6.56M	1273.3	90.6	0.6	4042	329
28 Mg	c	20.915H	1778.8	100.2	0.0	535.8	26.0
			1342.2	52.6	1.6	566.1	39.5
			941.5	38.3	1.0	614.9	75.5
			400.7	36.6	1.0	578.1	37.7
					R_av	553.4	22.9
27 Mg	c	9.458M	1014.4	28.0	0.4	2453	527.
			843.8	71.8	0.4	2133	121.
					R_av	2144	120.
24 Na	c	14.9590H	1369.0	100	0	7247	232
22 Na	c	2.6019Y	1274.5	99.94	0.01	5912	221
7 Be	i	53.29D	477.6	10.52	0.06	23509	768

Table 10.39: Detailed reaction rates for residual nuclide production in ^{nat}Ni at E_p=1598 MeV used to determine their production cross sections.

Nuclide	Type	$T_{1/2}$	E_γ, KeV	Abundance, %		Reaction rate 10^{-20} s^{-1}	
60 Cu	i	23.7M	1333.0	88	1	1116	97.
			826.4	21.7	1.1	1120	303.
					R_av	1116	93.
57 Ni	c	35.60H	1919.5	12.3	0.4	135950	6156.
			1757.6	5.75	0.21	129030	6250.
			1377.6	81.7	2.4	113010	4855.
			136.5	*********	********	58898	17340.
			127.2	16.7	0.5	94826	4185.
			122.1	*********	********	154170	14830.
					R_av	112369	8573.
56 Ni	c	6.075D	2598.5	*********	********	13170	2206.
			2034.8	*********	********	17740	3095.
			2015.2	*********	********	18877	5142.
			1561.8	14.0	0.6	9840	533.
			1037.8	*********	********	12910	4638.
			811.8	86.0	0.9	8917	300.
			750.0	49.5	1.2	9189	362.
			480.4	36.5	0.8	8545	342.
			269.5	36.5	0.8	8326	330.
			158.4	98.8	1.0	8413	286.
					R_av	8706	308.
62mCo	i(m)	13.91M	1172.9	97.7	0.5	416.2	92.7
60 Co	i(m+g)	5.2714Y	1332.5	99.99	0.00	9661	425.
			1173.2	99.97	0.00	8970	503.
					R_av	9427	440.
58 Co	i(m+g)	70.86D	1674.7	0.52	0.01	77988	3975.
			864.0	0.68	0.01	66117	4243.
			810.8	99.45	0.01	70966	2171.
					R_av	71928	3289.

57 Co	i	271.74D	136.5	10.68	0.08	239260	18961.
			122.1	85.60	0.17	148860	14809.
					R_av	184507	44553.
57 Co	c	271.74D	136.5	10.68	0.08	298160	9744.
			122.1	85.60	0.17	303040	9763.
					R_av	301038	9707.
56 Co	i	77.233D	2598.5	17.3	0.3	143650	5726.
			2034.8	7.89	0.13	134770	5636.
			2015.2	3.04	0.05	133320	6963.
			1037.8	14.17	0.13	127330	6310.
					R_av	136311	5491.
56 Co	c	77.233D	2657.4	0.02	0.01	352320	192191.
			2598.5	17.3	0.3	156820	5817.
			2212.9	0.40	0.01	157620	13140.
			2113.1	0.38	0.01	126760	8276.
			2034.8	7.89	0.13	152510	5426.
			2015.2	3.04	0.05	152200	5445.
			1963.7	0.72	0.01	152180	6433.
			1810.8	0.64	0.01	143740	6244.
			1771.3	15.47	0.14	153290	5061.
			1360.2	4.29	0.04	156180	5253.
			1238.3	66.9	0.6	144290	4665.
			1175.1	2.29	0.02	151950	6596.
			1037.8	14.17	0.13	140240	4508.
			977.4	1.45	0.01	115470	4970.
			846.8	99.94	0.03	142510	4387.
			787.7	0.32	0.01	137860	14263.
					R_av	145815	4703.
55 Co	c	17.53H	1408.5	16.9	0.8	46980	2693.
			1316.6	7.1	0.4	45095	2914.
			931.1	75	4	43845	2710.
			827.0	0.21	0.06	48664	16604.
			803.7	1.87	0.16	44934	4267.
			477.2	20.2	1.7	43231	3891.
			411.5	1.07	0.09	48769	4735.
			385.4	0.54	0.05	49337	5670.
					R_av	45531	1829.
59 Fe	c	44.472D	1291.6	43.2	1.4	1673	95.
			1099.2	56.5	1.9	1514	82.
					R_av	1581	93.
53 Fe	c*	8.51M	377.9	42	3	28265	2560
52 Fe	c	8.275H	1434.1	**********	********	7402	326.
			168.7	99	3	5465	248.
					R_av	6198	959.
56 Mn	c	2.5789H	2113.1	14.3	0.4	3911	226.
			1810.7	27.2	0.8	3972	198.
			846.8	98.9	0.3	4040	296.
					R_av	3963	165.
54 Mn	i	312.11D	834.8	99.98	0.00	65478	2004
52 Mn	c	5.591D	1434.1	100.0	0.6	61132	1935.
			1333.7	5.07	0.06	62989	2163.
			1246.3	4.21	0.07	69199	2745.
			935.5	94.5	1.0	58182	1914.
			744.2	90.0	0.9	56079	1824.
			647.5	0.40	0.02	81023	10934.
			600.2	0.39	0.01	47630	5676.
			346.0	0.98	0.01	46705	2157.
					R_av	59642	2226.
52mMn	i(m)	21.1M	1434.1	99.8	2.0	35346	1446
52mMn	c	21.1M	1434.1	99.8	2.0	42748	1698
51 Cr	c	27.7025D	320.1	9.92	0.05	141970	4436
49 Cr	c	42.3M	152.9	30.3	1.1	34622	1729.
			90.6	53.2	1.9	41738	2068.
					R_av	37566	3696.
48 Cr	c	21.56H	308.2	100	2	6997	264.
			112.3	96.0	2.1	7039	279.
					R_av	7015	246.
48 V	c	15.9735D	2240.4	2.41	0.04	98575	3628.
			1312.1	97.5	0.9	95461	3079.
			983.5	100.0	0.3	91605	2821.
			944.1	7.76	0.10	92825	3102.
			928.3	0.77	0.05	77023	7904.
					R_av	95385	3136.

48 Sc	i	43.67H	1312.1	100.1	0.7	1380	117.
			1037.5	97.6	0.7	1222	60.
			983.5	100.1	0.6	1574	187.
			175.4	7.48	0.10	1640	251.
					R_av	1275	75.
47 Sc	c	3.3492D	159.4	68.3	0.4	6528	212
46 Sc	i(m+g)	83.79D	1120.6	99.99	0.00	26925	840.
			889.3	99.98	0.00	25639	785.
					R_av	26239	1041.
44mSc	i(m)	58.61H	2656.5	98.61	0.01	37537	3199.
			1499.5	98.61	0.01	43231	2491.
			1157.0	98.61	0.01	39019	1247.
			1126.1	1.20	0.07	44848	3750.
			1001.8	1.20	0.07	43163	3518.
			270.9	86.7	0.3	37139	1167.
					R_av	37526	1233.
44 Sc	i	3.97H	2656.5	0.11	0.00	63114	5076.
			1499.5	0.91	0.02	36993	3923.
			1157.0	99.9	0.5	42214	1461.
					R_av	42435	2425.
44 Sc	i(m+g)	3.97H	2656.5	0.11	0.00	100120	6209.
			1499.5	0.91	0.02	79623	4750.
			1157.0	99.9	0.5	80690	2600.
					R_av	80928	2528.
43 Sc	c	3.891H	372.8	22.5	0.7	31091	1455
47 Ca	c	4.536D	1297.1	71	7	120.2	22.1
43 K	c	22.3H	617.5	79.2	0.7	3479	115.
			593.4	11.26	0.09	3217	165.
			396.9	11.85	0.09	3527	141.
			372.8	86.8	0.2	3370	123.
					R_av	3448	116.
42 K	i	12.360H	1525.0	18.08	0.09	14705	482
38 K	i	7.636M	2167.0	99.86	0.01	6515	485
41 Ar	c	109.34M	1294.0	99.1	0.0	2176	78
39 Cl	c	55.6M	1518.0	39.2	1.3	1405	133.
			1267.0	53.6	1.3	1550	105.
			250.3	46.3	2.0	1412	228.
					R_av	1489	85.
38 Cl	i(m+g)	37.24M	1643.0	31.9	1.0	6622	358
38 Cl	c	37.24M	2167.0	42.4	1.1	6683	343.
			1643.0	31.9	1.0	6926	345.
					R_av	6832	244.
34mCl	i(m)	32.00M	2127.0	42.8	0.8	7053	330.
			1177.0	14.09	0.24	5855	1014.
			146.4	40.5	0.9	5601	254.
					R_av	6117	524.
38 S	c	170.3M	1942.0	83	3	98.09	32.49
			1643.0	******************		304.1	138.3
					R_av	108.8	45.9
29 Al	c	6.56M	1273.3	90.6	0.6	8291	614
28 Mg	c	20.915H	1778.8	100.2	0.0	1000	35.
			1342.2	52.6	1.6	991.2	52.0
			400.7	36.6	1.0	1056	51.
					R_av	1006	34.
27 Mg	c	9.458M	1014.4	28.0	0.4	4583	541.
			843.8	71.8	0.4	4768	238.
					R_av	4748	230.
24 Na	c	14.9590H	1369.0	100	0	13828	434
22 Na	c	2.6019Y	1274.5	99.94	0.01	12264	461
7 Be	i	53.29D	477.6	10.52	0.06	40253	1295

Table 10.40: Detailed reaction rates for residual nuclide production in ^{nat}Ni at E_p=2605 MeV used to determine their production cross sections.

Nuclide	Type	$T_{1/2}$	E_γ, KeV	Abundance, %		Reaction rate 10^{-20} s^{-1}	
60 Cu	i	23.7M	1333.0	88	1	1249	88.

			826.4	21.7	1.1	2737	651.
					R_av	1271	183.
57 Ni	c	35.60H	1919.5	12.3	0.4	151810	6890.
			1757.6	5.75	0.21	142190	6929.
			1377.6	81.7	2.4	126670	5427.
			136.5	*****************		30865	25117.
			127.2	16.7	0.5	100430	4482.
			122.1	*****************		171770	26663.
					R_av	122276	10302.
56 Ni	c	6.075D	2598.5	*****************		11543	4938.
			2034.8	*****************		11834	5749.
			2015.2	*****************		30796	4644.
			1771.3	*****************		16940	4157.
			1561.8	14.0	0.6	10496	590.
			1037.8	*****************		23315	5510.
			811.8	86.0	0.9	9976	400.
			750.0	49.5	1.2	10446	529.
			480.4	36.5	0.8	9297	374.
			269.5	36.5	0.8	8994	363.
			158.4	98.8	1.0	8955	313.
					R_av	9307	372.
62mCo	i(m)	13.91M	1172.9	97.7	0.5	508.6	166.8
60 Co	i(m+g)	5.2714Y	1332.5	99.99	0.00	9124	412.
			1173.2	99.97	0.00	9793	484.
					R_av	9382	438.
58 Co	i(m+g)	70.86D	1674.7	0.52	0.01	71801	4562.
			864.0	0.68	0.01	59922	4173.
			810.8	99.45	0.01	76987	2378.
					R_av	71870	5066.
57 Co	i	271.74D	136.5	10.68	0.08	290580	26930.
			122.1	85.60	0.17	154940	26649.
					R_av	225000	68147.
57 Co	c	271.74D	136.5	10.68	0.08	321450	10505.
			122.1	85.60	0.17	326710	10533.
					R_av	324523	10465.
56 Co	i	77.233D	2598.5	17.3	0.3	155060	7491.
			2034.8	7.89	0.13	149340	7712.
			2015.2	3.04	0.05	130320	6482.
			1771.3	15.47	0.14	145560	6242.
			1037.8	14.17	0.13	125090	6926.
					R_av	140972	6975.
56 Co	c	77.233D	2657.4	0.02	0.01	454990	260458.
			2598.5	17.3	0.3	166610	6238.
			2212.9	0.40	0.01	153550	9743.
			2113.1	0.38	0.01	152390	8537.
			2034.8	7.89	0.13	161180	5816.
			2015.2	3.04	0.05	161120	5742.
			1963.7	0.72	0.01	161850	6590.
			1810.8	0.64	0.01	163390	6919.
			1771.3	15.47	0.14	162500	5325.
			1360.2	4.29	0.04	166000	5599.
			1238.3	66.9	0.6	153480	4963.
			1175.1	2.29	0.02	152320	5730.
			1037.8	14.17	0.13	148410	4784.
			977.4	1.45	0.01	123450	11455.
			846.8	99.94	0.03	151390	4666.
			787.7	0.32	0.01	138030	14907.
					R_av	155832	4937.
55 Co	c	17.53H	1408.5	16.9	0.8	49904	2968.
			1316.6	7.1	0.4	47087	3115.
			931.1	75	4	46167	2847.
			827.0	0.21	0.06	99375	38865.
			803.7	1.87	0.16	48274	5066.
			477.2	20.2	1.7	47108	4348.
			411.5	1.07	0.09	53714	5896.
			385.4	0.54	0.05	50774	7035.
					R_av	48169	1975.
59 Fe	c	44.472D	1291.6	43.2	1.4	1720	99.
			1099.2	56.5	1.9	1562	85.
					R_av	1627	93.
53 Fe	c*	8.51M	377.9	42	3	22206	1880
52 Fe	c	8.275H	1434.1	*****************		7250	613.
			168.7	99	3	5367	244.
					R_av	5533	560.
56 Mn	c	2.5789H	2113.1	14.3	0.4	3626	244.
			1810.7	27.2	0.8	3953	209.
			846.8	98.9	0.3	4047	292.

					R_av	3873	169.
54 Mn	i	312.11D	834.8	99.98	0.00	66839	2049
52 Mn	c	5.591D	1434.1	100.0	0.6	60226	1947.
			1333.7	5.07	0.06	62850	2156.
			1246.3	4.21	0.07	68981	2809.
			935.5	94.5	1.0	57888	1899.
			744.2	90.0	0.9	55010	1833.
			647.5	0.40	0.02	82550	7053.
			600.2	0.39	0.01	56096	10841.
			346.0	0.98	0.01	51164	2308.
					R_av	58766	2245.
52mMn	i(m)	21.1M	1434.1	99.8	2.0	33458	1939
52mMn	c	21.1M	1434.1	99.8	2.0	40707	2132
51 Cr	c	27.7025D	320.1	9.92	0.05	139910	4396
49 Cr	c	42.3M	152.9	30.3	1.1	31964	1558.
			90.6	53.2	1.9	38973	1926.
					R_av	34706	3588.
48 Cr	c	21.56H	308.2	100	2	6916	258.
			112.3	96.0	2.1	6804	271.
					R_av	6870	240.
48 V	c	15.9735D	2240.4	2.41	0.04	97970	4756.
			1312.1	97.5	0.9	92252	2980.
			983.5	100.0	0.3	88437	2723.
			944.1	7.76	0.10	87401	3187.
			928.3	0.77	0.05	83232	7918.
					R_av	91932	3002.
48 Sc	i	43.67H	1312.1	100.1	0.7	1621	200.
			1037.5	97.6	0.7	1376	84.
			983.5	100.1	0.6	2072	207.
			175.4	7.48	0.10	2669	287.
					R_av	1537	201.
47 Sc	c	3.3492D	159.4	68.3	0.4	6588	221
46 Sc	i(m+g)	83.79D	1120.6	99.99	0.00	26495	821.
			889.3	99.98	0.00	25146	773.
					R_av	25779	1050.
44mSc	i(m)	58.61H	2656.5	98.61	0.01	40078	2394.
			1499.5	98.61	0.01	40491	2236.
			1157.0	98.61	0.01	38741	1373.
			1126.1	1.20	0.07	44901	4585.
			1001.8	1.20	0.07	43752	3542.
			270.9	86.7	0.3	36312	1140.
					R_av	36431	1173.
44 Sc	i	3.97H	2656.5	0.11	0.00	75727	5482.
			1499.5	0.91	0.02	41762	3601.
			1157.0	99.9	0.5	40330	1708.
					R_av	42114	5410.
44 Sc	i(m+g)	3.97H	2656.5	0.11	0.00	115240	6568.
			1499.5	0.91	0.02	81690	4559.
			1157.0	99.9	0.5	78532	2755.
					R_av	80477	2514.
43 Sc	c	3.891H	372.8	22.5	0.7	30048	1345
47 Ca	c	4.536D	1297.1	71	7	133.4	31.6
43 K	c	22.3H	617.5	79.2	0.7	3547	124.
			593.4	11.26	0.09	3460	266.
			396.9	11.85	0.09	3489	246.
			372.8	86.8	0.2	3455	117.
					R_av	3489	114.
42 K	i	12.360H	1525.0	18.08	0.09	15446	634
38 K	i	7.636M	2167.0	99.86	0.01	5512	479
41 Ar	c	109.34M	1294.0	99.1	0.0	2091	78
39 Cl	c	55.6M	1518.0	39.2	1.3	1552	123.
			1267.0	53.6	1.3	1599	103.
			250.3	46.3	2.0	1353	113.
					R_av	1510	89.
38 Cl	i(m+g)	37.24M	1643.0	31.9	1.0	6266	341
38 Cl	c	37.24M	2167.0	42.4	1.1	6893	347.
			1643.0	31.9	1.0	6528	342.
					R_av	6757	275.

34mCl	i(m)	32.00M	2127.0	42.8	0.8	7611	329.
			1177.0	14.09	0.24	7096	497.
			146.4	40.5	0.9	5969	297.
					R_av	6839	590.
38 S	c	170.3M	1942.0	83	3	196.7	49.2
			1643.0	*****************		261.8	72.0
					R_av	217.4	40.9
29 Al	c	6.56M	1273.3	90.6	0.6	8804	525
28 Mg	c	20.915H	1778.8	100.2	0.0	1486	71.
			1342.2	52.6	1.6	1469	94.
			941.5	38.3	1.0	1570	140.
			400.7	36.6	1.0	1554	120.
					R_av	1499	62.
27 Mg	c	9.458M	1014.4	28.0	0.4	6233	641.
			843.8	71.8	0.4	5664	250.
					R_av	5708	246.
24 Na	c	14.9590H	1369.0	100	0	19876	630
22 Na	c	2.6019Y	1274.5	99.94	0.01	18438	606
7 Be	i	53.29D	477.6	10.52	0.06	59667	2018

10.4 Reaction rates for residual nuclide production in ^{93}Nb

Table 10.41: Detailed reaction rates for residual nuclide production in ^{93}Nb at E_p=46 MeV used to determine their production cross sections.

Nuclide	Type	$T_{1/2}$	E_γ, KeV	Abundance, %		Reaction rate 10^{-20} s^{-1}	
93mMo	i(m)	6.85H	1477.1	99.1	2.5	6213	429.
			684.7	99.7	2.0	7220	428.
			263.1	56.7	1.4	6476	538.
					R_av	6684	385.
91 Mo	i(m+g)	15.49M	1637.3	0.33	0.02	459980	100145
90 Mo	i	5.56H	2319.0	*****************		356960	20551.
			2186.2	*****************		271140	14127.
			1913.2	*****************		315640	69845.
			1716.3	*****************		421500	157409.
			1658.1	*****************		423070	206490.
			1611.8	*****************		322920	34162.
			1575.0	*****************		315880	143613.
			1454.6	1.9	0.6	272020	87093.
			1387.4	1.86	0.25	365120	52760.
			1271.3	4.1	0.5	207790	63676.
			1129.2	*****************		161860	28516.
			990.2	1.02	0.11	313240	43663.
			941.5	5.5	0.7	286070	37885.
			890.6	*****************		138830	53283.
			489.8	0.73	0.11	269840	49704.
			472.2	1.42	0.16	311080	39236.
			445.4	6.0	0.7	322420	39696.
			425.1	0.36	0.08	351190	87010.
			323.2	6.3	0.6	336570	34367.
			257.3	78	4	326870	21097.
			203.1	6.4	0.6	316110	32342.
			162.9	6.0	0.6	329100	35184.
			122.4	64	4	302770	21911.
					R_av	297767	13894.
92mNb	i(m)	10.15D	1847.5	0.85	0.04	285860	17131.
			934.4	99.07	0.04	266110	8781.
			912.6	1.78	0.10	258210	17176.
					R_av	266543	8778.
91mNb	c	60.86D	1204.7	2.0	0.3	203160	31633.
			104.6	0.58	0.02	168120	8743.
					R_av	169816	9204.
90 Nb	i(m+g)	14.60H	2319.0	82.0	0.3	1406000	63100.
			2186.2	17.96	0.17	1485800	61134.
			1913.2	1.28	0.02	1440600	105444.
			1716.3	0.50	0.02	1410900	237010.
			1658.1	0.34	0.01	1149900	288073.
			1611.8	2.38	0.07	1394700	74706.
			1575.0	0.52	0.02	1305100	198500.
			1129.2	92.7	0.5	1522900	67178.
			890.6	1.80	0.05	1683400	98854.
					R_av	1469892	53830.
90 Nb	c	14.60H	2319.0	82.0	0.3	1763000	74494.
			2222.3	0.62	0.03	1773800	110796.

			2186.2	17.96	0.17	1756900	70699.
			1984.5	0.68	0.03	1715800	125447.
			1913.2	1.28	0.02	1756300	75418.
			1843.3	0.69	0.02	1729500	94465.
			1716.3	0.50	0.02	1832400	122256.
			1658.1	0.34	0.01	1573000	133611.
			1611.8	2.38	0.07	1717700	78516.
			1575.0	0.52	0.02	1621000	105799.
			1129.2	92.7	0.5	1684800	58579.
			890.6	1.80	0.05	1822300	82450.
			827.7	1.11	0.02	1879400	79185.
			518.6	0.69	0.05	2271200	186586.
			371.3	1.80	0.07	1921800	109013.
			141.2	66.8	0.7	1859500	68014.
			132.7	4.13	0.05	1824300	75480.
					R_av	1767858	59222.
89mNb	i(m)	66M	588.0	95.1	0.5	1883	851
89 Zr	c	78.41H	1713.0	0.74	0.01	63790	4442.
			909.2	99.04	0.03	60098	1968.
					R_av	60178	1969.
88 Zr	c	83.4D	1836.1	*********	********	306170	12048.
			898.0	*********	********	291470	11837.
			392.9	97.24	0.00	296920	9987.
					R_av	297352	9290.
87 Zr	c	1.68H	380.8	99.87	0.00	37762	2541
86 Zr	c	16.5H	1163.0	*********	********	25012	9764.
			608.3	*********	********	17943	5344.
					R_av	19567	4704.
88 Y	i	106.65D	1836.1	99.2	0.3	67564	2818.
			898.0	93.7	0.3	62463	2805.
					R_av	65207	3258.
88 Y	c	106.65D	1836.1	99.2	0.3	373730	13705.
			898.0	93.7	0.3	353940	12757.
					R_av	362648	14996.
87mY	i(m)	13.37H	380.8	78.05	0.08	31894	2527
87mY	c	13.37H	380.8	78.05	0.08	69607	2386
87 Y	c	79.8H	484.8	89.7	0.7	92729	3309.
			388.5	82.1	0.5	92845	3234.
					R_av	92793	3089.
86 Y	i(m+g)	14.74H	1163.0	1.18	0.05	980410	63360.
			608.3	2.01	0.15	37223	15640.
					R_av	106803	246570.
86 Y	c	14.74H	1270.2	0.65	0.10	4285700	765869.
			1163.0	1.18	0.05	1005400	61068.
			1092.7	0.69	0.05	292730	46487.
			608.3	2.01	0.15	55166	12827.
					R_av	121706	130040.

Table 10.42: Detailed reaction rates for residual nuclide production in ^{93}Nb at E_p=68 MeV used to determine their production cross sections.

Nuclide	Type	$T_{1/2}$	E_γ, KeV	Abundance, %		Reaction rate 10^{-20} s^{-1}	
93mMo	i(m)	6.85H	684.7	99.7	2.0	1653	135
90 Mo	i	5.56H	2319.0	*********	********	40506	10620.
			2186.2	*********	********	39505	15027.
			1454.6	1.9	0.6	42370	13759.
			941.5	5.5	0.7	40351	5506.
			891.0	*********	********	2473500	2778991.
			371.3	*********	********	59275	12715.
			257.3	78	4	53293	3558.
			203.1	6.4	0.6	59553	6184.
			162.9	6.0	0.6	52277	5638.
			122.4	64	4	48200	3487.
					R_av	50167	2450.
92mNb	i(m)	10.15D	1847.5	0.85	0.04	89491	5873.
			912.6	1.78	0.10	83166	5643.
					R_av	86231	4493.
91mNb	c	60.86D	1204.7	2.0	0.3	50604	7851.
			104.6	0.58	0.02	42666	2209.
					R_av	43062	2189.
90 Nb	i(m+g)	14.60H	2319.0	82.0	0.3	336060	17669.
			2186.2	17.96	0.17	338300	21233.

			891.0	0.03	0.0320791000.20869322.		
			371.3	1.80	0.07	406100	25895.
					R_av	350660	20174.
90 Nb	c	14.60H	2319.0	82.0	0.3	376560	16938.
			2222.3	0.62	0.03	399540	32000.
			2186.2	17.96	0.17	377800	17112.
			1984.5	0.68	0.03	405690	26287.
			1843.3	0.69	0.02	395270	23329.
			1611.8	2.38	0.07	383440	19893.
			891.0	0.03	0.0323264000.23280466.		
			827.7	1.11	0.02	404180	21546.
			371.3	1.80	0.07	465370	24481.
			141.2	66.8	0.7	394530	16288.
			132.7	4.13	0.05	380500	16715.
					R_av	391566	13941.
89 Nb	c	2.03H	2612.1	0.30	0.07	269390	72482.
			2572.3	2.7	0.6	291520	68124.
			1833.4	3.3	0.7	375880	82405.
			1627.2	3.5	0.7	359970	73320.
			1511.4	1.9	0.4	396060	86223.
			1464.8	0.88	0.19	323010	72302.
			1259.0	1.2	0.3	403120	103310.
			920.5	1.4	0.4	500460	144482.
					R_av	342524	30464.
89mNb	i(m)	66M	588.0	95.1	0.5	34810	2016
88 Nb	c*	14.5M	1082.6	103	6	7874	802.
			1057.1	100	4	8070	531.
			671.2	64	4	7006	611.
			399.4	31.8	1.8	8565	903.
			271.8	30.1	1.5	7210	850.
					R_av	7725	374.
89 Zr	c	78.41H	1713.0	0.74	0.01	536260	21027.
			909.2	99.04	0.03	523630	17038.
					R_av	525185	17003.
88 Zr	c	83.4D	1836.1*****************			92114	3414.
			898.0*****************			88080	3024.
			392.9	97.24	0.00	87020	2946.
					R_av	87647	2738.
87 Zr	c	1.68H	1227.0	1.0	0.3	154450	47676.
			1210.0	0.33	0.11	107830	66918.
			380.8	99.87	0.00	51691	3865.
					R_av	52403	1637.
86 Zr	c	16.5H	2610.1*****************			32734	3938.
			1920.7*****************			29812	1591.
			1790.9*****************			28077	5946.
			1724.2*****************			52281	8690.
			1696.2*****************			36005	8578.
			1349.2*****************			29341	2053.
			1253.1*****************			28765	2049.
			1163.0*****************			22399	2741.
			1153.1*****************			27846	1418.
			1092.7*****************			43358	5656.
			1076.6*****************			28212	1390.
			1024.0*****************			26651	1958.
			955.3*****************			33218	3870.
			835.7*****************			28766	4411.
			826.0*****************			25207	1308.
			777.4*****************			27663	1314.
			740.8*****************			14955	6124.
			703.3*****************			34170	2546.
			645.9*****************			32333	4202.
			627.7*****************			27727	1566.
			612.0	5.7	0.3	28926	2158.
			608.3*****************			16024	2631.
			580.6*****************			24495	1770.
			443.1*****************			28281	1526.
			439.5*****************			50923	32736.
			382.9*****************			12518	1212.
			331.1*****************			24177	6872.
			307.0*****************			34298	2043.
			242.8	95.84	0.20	29045	1206.
					R_av	26996	1264.
90mY	i(m)	3.19H	479.5	90.74	0.05	1080	161
88 Y	i	106.65D	1836.1	99.2	0.3	15879	701.
			898.0	93.7	0.3	14829	601.
					R_av	15221	696.
88 Y	c	106.65D	1836.1	99.2	0.3	107990	3847.
			898.0	93.7	0.3	102900	3422.
					R_av	104359	3991.

87mY	i(m)	13.37H	380.8	78.05	0.08	39799	3691
87mY	c	13.37H	380.8	78.05	0.08	91422	3184
87 Y	c	79.8H	484.8	89.7	0.7	116900	4185.
			388.5	82.1	0.5	117170	4115.
					R_av	117046	3910.
86 Y	i(m+g)	14.74H	2610.1	1.24	0.08	62139	8141.
			1920.7	20.8	0.7	64977	3375.
			1790.9	1.00	0.05	89852	18270.
			1724.2	0.55	0.05	34165	16182.
			1696.2	0.64	0.02	70342	23585.
			1349.2	2.95	0.10	63287	4715.
			1253.1	1.53	0.05	65962	4684.
			1163.0	1.18	0.05	278930	16508.
			1153.1	30.5	1.0	64851	3159.
			1092.7	0.69	0.05	138180	16935.
			1076.6	82.5	0.4	63468	2560.
			1024.0	3.80	0.17	70412	5180.
			955.3	1.04	0.05	51277	10483.
			835.7	4.4	0.6	68916	10368.
			826.0	3.30	0.09	64863	3234.
			777.4	22.4	0.6	62241	2816.
			740.8	1.36	0.05	44151	9001.
			703.3	15.4	0.5	61530	3983.
			645.9	9.2	1.1	71559	9108.
			627.7	32.6	1.0	63800	3159.
			608.3	2.01	0.15	63516	6762.
			580.6	4.78	0.15	64321	3798.
			443.1	16.9	0.5	65521	3178.
			439.5	0.20	0.07	450920	165653.
			382.9	3.63	0.12	49822	3039.
			331.1	0.83	0.03	95510	11958.
			307.0	3.47	0.09	69900	3935.
					R_av	63998	3123.
86 Y	c	14.74H	2610.1	1.24	0.08	94873	9050.
			2088.1	0.25	0.03	161410	55392.
			1920.7	20.8	0.7	94789	4718.
			1801.7	1.65	0.05	113700	10004.
			1790.9	1.00	0.05	117920	15100.
			1724.2	0.55	0.05	86446	14455.
			1696.2	0.64	0.02	106340	17425.
			1415.2	0.33	0.09	134670	39636.
			1349.2	2.95	0.10	92628	5111.
			1270.2	0.65	0.10	1106700	179301.
			1253.1	1.53	0.05	94727	5135.
			1163.0	1.18	0.05	301330	17011.
			1153.1	30.5	1.0	92697	4372.
			1092.7	0.69	0.05	181540	17423.
			1076.6	82.5	0.4	91680	3296.
			1024.0	3.80	0.17	97063	5969.
			955.3	1.04	0.05	84496	9044.
			887.4	0.44	0.05	161030	31394.
			835.7	4.4	0.6	97682	13981.
			826.0	3.30	0.09	90070	4022.
			777.4	22.4	0.6	89904	3883.
			740.8	1.36	0.05	59106	6232.
			709.9	2.62	0.08	26199	9519.
			703.3	15.4	0.5	95701	4871.
			645.9	9.2	1.1	103890	12980.
			627.7	32.6	1.0	91527	4288.
			608.3	2.01	0.15	79540	7167.
			580.6	4.78	0.15	88816	4429.
			443.1	16.9	0.5	93802	4336.
			439.5	0.20	0.07	501850	178934.
			382.9	3.63	0.12	62341	3162.
			331.1	0.83	0.03	119680	8730.
			307.0	3.47	0.09	104190	4846.
			190.8	1.01	0.04	104630	15041.
					R_av	90130	4220.
86mY	i(m)	48M	208.1	93.7	0.7	33258	1597
85mY	c	4.86H	231.7	22.8	2.2	3800	697
85mSr	c	67.63M	231.9	84.4	2.2	279.3	167.6
83 Sr	c	32.41H	710.6	0.03	0.01	8564200	4174913.
			418.4	4.4	2.1	4657	2322.
					R_av	4660	4765.
84 Rb	i(m+g)	32.77D	881.6	69.0	1.6	1085	46
83 Rb	c	86.2D	552.6	16.0	1.1	4846	380.
			529.6	29.3	2.1	4823	387.
			520.4	45	4	4691	449.
					R_av	4798	262.
81 Rb	c	4.576H	190.5	64	2	1349	328

Table 10.43: Detailed reaction rates for residual nuclide production in ^{93}Nb at E_p=99 MeV used to determine their production cross sections.

Nuclide	Type	$T_{1/2}$	E_γ, KeV	Abundance, %		Reaction rate 10^{-20} s^{-1}	
93mMo	i(m)	6.85H	684.7	99.7	2.0	3039	212
90 Mo	i	5.56H	2319.0	*****************		82366	20390.
			2186.2	*****************		84845	22574.
			890.6	*****************		118560	36902.
			371.3	*****************		72382	34788.
			257.3	78	4	56864	3694.
			203.1	6.4	0.6	90357	10806.
			162.9	6.0	0.6	53235	6031.
			122.4	64	4	51179	3845.
					R_av	56466	3956.
92mNb	i(m)	10.15D	1847.5	0.85	0.04	171740	11454.
			934.4	99.07	0.04	158050	5230.
			912.6	1.78	0.10	156400	10495.
					R_av	158370	5223.
91mNb	c	60.86D	1204.7	2.0	0.3	91550	14130.
			104.6	0.58	0.02	81418	4628.
					R_av	82152	4523.
90 Nb	i(m+g)	14.60H	2319.0	82.0	0.3	484730	28173.
			2186.2	17.96	0.17	493020	30121.
			890.6	1.80	0.05	466530	50479.
			371.3	1.80	0.07	629320	49909.
					R_av	502304	30931.
90 Nb	c	14.60H	2319.0	82.0	0.3	567100	27104.
			2222.3	0.62	0.03	615250	52960.
			2186.2	17.96	0.17	577870	26422.
			1984.5	0.68	0.03	560420	64664.
			1843.3	0.69	0.02	573900	35995.
			1611.8	2.38	0.07	589370	34410.
			1129.2	92.7	0.5	568830	21796.
			890.6	1.80	0.05	585090	29188.
			371.3	1.80	0.07	701700	38178.
			141.2	66.8	0.7	560460	25793.
			132.7	4.13	0.05	544360	22093.
					R_av	572335	20305.
89 Nb	c	2.03H	2572.3	2.7	0.6	344470	79762.
			1833.4	3.3	0.7	434310	94572.
			1627.2	3.5	0.7	435300	89369.
			1511.4	1.9	0.4	415690	89869.
			1464.8	0.88	0.19	360810	80025.
			1259.0	1.2	0.3	452570	117388.
			920.5	1.4	0.4	616910	178462.
					R_av	407628	37713.
89mNb	i(m)	66M	588.0	95.1	0.5	43202	2549
88 Nb	c*	14.5M	1082.6	103	6	103010	7213.
			1057.1	100	4	99557	10020.
			671.2	64	4	92602	6911.
			399.4	31.8	1.8	115910	12369.
			271.8	30.1	1.5	89992	7889.
					R_av	97779	4838.
89 Zr	c	78.41H	1713.0	0.74	0.01	789920	39876.
			909.2	99.04	0.03	762250	24790.
					R_av	763526	24784.
88 Zr	c	83.4D	1836.1	*****************		616670	21762.
			898.0	*****************		586270	19658.
			392.9	97.24	0.00	581140	19545.
					R_av	584238	18253.
87 Zr	c	1.68H	1227.0	1.0	0.3	957580	289728.
			1210.0	0.33	0.11	971760	331982.
			380.8	99.87	0.00	338390	21392.
					R_av	342940	10714.
86 Zr	c	16.5H	2568.0	*****************		76674	9907.
			1920.7	*****************		72903	6628.
			1801.7	*****************		67806	13020.
			1349.2	*****************		9992	3718.
			1253.1	*****************		69757	14502.
			1163.0	*****************		65247	18096.
			1153.1	*****************		56206	3691.
			1092.7	*****************		81715	18910.
			1076.6	*****************		62635	5850.
			1024.0	*****************		39099	16342.
			971.4	*****************		7908	1199.

			835.7	*****************		63521	10957.
			826.0	*****************		67191	14026.
			709.9	*****************		39663	2704.
			703.3	*****************		76476	12640.
			645.9	*****************		88194	13580.
			627.7	*****************		66850	6316.
			612.0	5.7	0.3	74571	5964.
			608.3	*****************		79771	12698.
			580.6	*****************		75360	7799.
			443.1	*****************		76437	8880.
			331.1	*****************		74556	62780.
			307.0	*****************		92282	8592.
			242.8	95.84	0.20	60860	2467.
					R_av	35226	5721.
85 Zr	c	7.86M	454.3	41.4	1.0	13681	1255
90mY	i(m)	3.19H	479.5	90.74	0.05	2965	235
88 Y	i	106.65D	1836.1	99.2	0.3	87323	3322.
			898.0	93.7	0.3	81881	3087.
					R_av	84353	3780.
88 Y	c	106.65D	1836.1	99.2	0.3	703990	24613.
			898.0	93.7	0.3	668150	22063.
					R_av	678716	26771.
87mY	i(m)	13.37H	380.8	78.05	0.08	104250	13614
87mY	c	13.37H	380.8	78.05	0.08	442200	17394
87 Y	c	79.8H	484.8	89.7	0.7	452830	15826.
			388.5	82.1	0.5	453850	15597.
					R_av	453385	14953.
86 Y	i(m+g)	14.74H	2568.0	2.25	0.11	134740	14716.
			1920.7	20.8	0.7	135910	10112.
			1801.7	1.65	0.05	173840	23818.
			1349.2	2.95	0.10	149410	16789.
			1253.1	1.53	0.05	125020	21825.
			1163.0	1.18	0.05	457290	42079.
			1153.1	30.5	1.0	141970	7513.
			1092.7	0.69	0.05	272350	36730.
			1076.6	82.5	0.4	126930	8134.
			1024.0	3.80	0.17	189840	29113.
			971.4	0.27	0.04	200500	30411.
			835.7	4.4	0.6	155150	23065.
			826.0	3.30	0.09	135650	22806.
			709.9	2.62	0.08	165920	9864.
			703.3	15.4	0.5	146030	13245.
			645.9	9.2	1.1	152770	20928.
			627.7	32.6	1.0	138850	8704.
			608.3	2.01	0.15	85973	14895.
			580.6	4.78	0.15	129230	10194.
			443.1	16.9	0.5	138600	10693.
			331.1	0.83	0.03	138420	86100.
			307.0	3.47	0.09	145820	11708.
					R_av	142068	7449.
86 Y	c	14.74H	2610.1	1.24	0.08	204940	18209.
			2568.0	2.25	0.11	211420	17165.
			2088.1	0.25	0.03	453870	122658.
			1920.7	20.8	0.7	208820	12175.
			1801.7	1.65	0.05	241650	19368.
			1790.9	1.00	0.05	237150	32420.
			1724.2	0.55	0.05	200400	86918.
			1696.2	0.64	0.02	253920	68863.
			1533.2	0.22	0.04	250380	129917.
			1507.9	0.35	0.05	434680	98685.
			1415.2	0.33	0.09	172430	54068.
			1349.2	2.95	0.10	159400	14397.
			1270.2	0.65	0.10	1592500	261698.
			1253.1	1.53	0.05	194780	17090.
			1163.0	1.18	0.05	522540	38505.
			1153.1	30.5	1.0	198180	9770.
			1092.7	0.69	0.05	354070	34715.
			1076.6	82.5	0.4	189570	9389.
			1024.0	3.80	0.17	228940	24723.
			971.4	0.27	0.04	208410	31614.
			955.3	1.04	0.05	196210	31456.
			887.4	0.44	0.05	260740	45990.
			835.7	4.4	0.6	218680	31090.
			826.0	3.30	0.09	202840	16141.
			777.4	22.4	0.6	239790	10395.
			767.6	2.4	0.4	134560	28735.
			740.8	1.36	0.05	132170	24740.
			709.9	2.62	0.08	205580	10576.
			703.3	15.4	0.5	222510	13671.
			645.9	9.2	1.1	240970	30616.
			627.7	32.6	1.0	205700	10782.
			608.3	2.01	0.15	165740	15660.

			580.6	4.78	0.15	204600	10775.
			443.1	16.9	0.5	215040	12298.
			439.5	0.20	0.07	895350	320129.
			426.0	0.30	0.02	170360	73229.
			331.1	0.83	0.03	212980	48463.
			307.0	3.47	0.09	238110	12093.
			190.8	1.01	0.04	434350	68334.
			187.9	1.26	0.05	151620	18014.
					R_av	209652	8887.
86mY	i(m)	48M	208.1	93.7	0.7	79435	4169
85mY	c	4.86H	2172.1	2.27	0.21	103270	15758.
			2123.8	5.0	0.5	66116	8408.
			1261.9	0.65	0.06	147910	85845.
			1220.5	1.98	0.17	71813	12408.
			1123.2	1.78	0.16	91382	13893.
			1030.1	2.02	0.17	78166	16834.
			767.3	3.6	0.5	65468	17958.
			616.5	0.86	0.09	116030	23657.
			535.6	3.5	0.3	101750	10781.
			231.7	22.8	2.2	84130	10576.
					R_av	82783	5776.
85 Y	c	2.68H	504.4	60	4	39734	4694.
			231.9******************			34961	1739.
			151.2******************			34278	3035.
					R_av	35136	1541.
84 Y	c	39.5M	1502.9	5.8	0.6	49230	5974.
			1262.5	3.5	0.4	21214	8210.
			1255.4	6.6	0.7	42619	5126.
			1143.9	3.3	0.3	39831	7796.
			1110.4	2.9	0.3	38578	9821.
			1039.8	56	6	42624	4984.
			1000.9	2.07	0.20	55128	13105.
			994.6	3.8	0.4	33047	5710.
			974.1	75	8	43936	5161.
			793.0	98.6	1.0	45757	1666.
			680.4	5.1	0.5	36579	4628.
			660.5	15.7	1.6	42747	4753.
			602.2	8.8	0.9	47278	5481.
			462.7	9.8	1.0	53156	6496.
					R_av	44916	1711.
85mSr	i(m)	67.63M	231.9	84.4	2.2	5613	348.
			151.2	12.9	0.7	2897	1926.
					R_av	5555	431.
85mSr	c	67.63M	231.9	84.4	2.2	40574	1984.
			151.2	12.9	0.7	37174	3026.
					R_av	39793	1895.
83 Sr	c	32.41H	1562.5	1.8	0.9	12328	6650.
			1160.0	1.5	0.7	21779	10550.
			1147.3	1.3	0.6	16614	8463.
			762.7	30	14	21737	10181.
			418.4	4.4	2.1	19379	9750.
			381.2	2.5	1.2	111680	58326.
					R_av	17467	3901.
82 Sr	c	25.55D	776.5	15.08	0.00	10743	385
81 Sr	c	22.3M	147.8	30	4	2046	651
84 Rb	i(m+g)	32.77D	881.6	69.0	1.6	4966	207
84mRb	i(m)	20.26M	215.6	29.5	1.3	3287	1536
83 Rb	c	86.2D	552.6	16.0	1.1	33528	2579.
			529.6	29.3	2.1	33344	2649.
					R_av	33439	1990.
82mRb	i(m)	6.472H	1474.9	15.5	0.3	13755	1209.
			1317.4	23.7	0.6	15950	897.
			1044.1	32.07	0.08	14035	1205.
			1007.6	7.17	0.09	8195	2769.
			952.0	0.64	0.05	92712	36386.
			827.8	21.0	0.6	30262	3869.
			698.4	26.3	0.7	19523	991.
			619.1	37.98	0.10	13699	1309.
			554.3	62.4	0.9	15290	717.
					R_av	15831	1017.
81 Rb	c	4.576H	446.1	23.2	0.9	25824	2102.
			357.4	0.76	0.03	236720	40891.
			190.5	64	2	11819	1298.
					R_av	16050	6084.
82 Br	i(m+g)	35.30H	1044.0	27.2	0.4	550.1	1816.1
			952.0	0.37	0.02	31217	5386.

			827.8	24.0	0.4	18925	2260.
			698.4	28.5	0.4	3168	206.
			619.1	43.4	0.6	2649	1694.
					R_av	3274	813.

Table 10.44: Detailed reaction rates for residual nuclide production in ^{93}Nb at E_p=149 MeV used to determine their production cross sections.

Nuclide	Type	$T_{1/2}$	E_γ, KeV	Abundance, %		Reaction rate 10^{-20} s^{-1}	
93mMo	i(m)	6.85H	684.7	99.7	2.0	2222	170
90 Mo	i	5.56H	2319.0	******************		34051	2679.
			2186.2	******************		30598	6972.
			941.5	5.5	0.7	25936	4370.
			371.3	******************		124880	33132.
			323.2	6.3	0.6	41585	6143.
			257.3	78	4	36208	2358.
			203.1	6.4	0.6	46019	9116.
			122.4	64	4	33343	2427.
					R_av	34444	2071.
92mNb	i(m)	10.15D	1847.5	0.85	0.04	155260	9739.
			934.4	99.07	0.04	141440	4701.
			912.6	1.78	0.10	139960	9733.
					R_av	141859	4776.
91mNb	c	60.86D	1204.7	2.0	0.3	73949	11722.
			104.6	0.58	0.02	64645	4452.
					R_av	65636	4274.
90 Nb	i(m+g)	14.60H	2319.0	82.0	0.3	399870	17024.
			2186.2	17.96	0.17	405140	18269.
			371.3	1.80	0.07	492540	50051.
					R_av	405058	17034.
90 Nb	c	14.60H	2319.0	82.0	0.3	433920	18263.
			2222.3	0.62	0.03	465250	31698.
			2186.2	17.96	0.17	435740	17881.
			1984.5	0.68	0.03	475650	46199.
			1843.3	0.69	0.02	431910	24531.
			1611.8	2.38	0.07	458030	22015.
			1129.2	92.7	0.5	445050	15421.
			371.3	1.80	0.07	617420	35189.
			141.2	66.8	0.7	449240	17085.
			132.7	4.13	0.05	462660	19453.
					R_av	449248	16323.
89 Nb	c	2.03H	2572.3	2.7	0.6	250190	57770.
			1833.4	3.3	0.7	325440	70598.
			1627.2	3.5	0.7	343080	70050.
			1511.4	1.9	0.4	306990	67016.
			1464.8	0.88	0.19	310810	70598.
			1259.0	1.2	0.3	326920	83856.
			920.5	1.4	0.4	450530	130900.
					R_av	311501	28866.
89mNb	i(m)	66M	588.0	95.1	0.5	36348	2430
88 Nb	c*	14.5M	1082.6	103	6	68099	5753.
			1057.1	100	4	74487	6674.
			671.2	64	4	64531	4685.
			399.4	31.8	1.8	89910	8963.
			271.8	30.1	1.5	70114	4659.
					R_av	70126	3882.
89 Zr	c	78.41H	1713.0	0.74	0.01	681180	28212.
			909.2	99.04	0.03	660470	21483.
					R_av	662424	21563.
88 Zr	c	83.4D	1836.1	******************		542450	19233.
			898.0	******************		514850	17329.
			392.9	97.24	0.00	509800	17143.
					R_av	512538	16013.
87 Zr	c	1.68H	1227.0	1.0	0.3	944340	286405.
			1210.0	0.33	0.11	962020	326976.
			380.8	99.87	0.00	320240	12682.
					R_av	321074	10031.
86 Zr	c	16.5H	2610.1	******************		138050	11913.
			2568.0	******************		140360	12050.
			1920.7	******************		135760	7943.
			1801.7	******************		158320	9439.
			1790.9	******************		130130	13286.
			1724.2	******************		139430	27609.
			1696.2	******************		170910	18485.
			1415.2	******************		98740	37128.
			1349.2	******************		133660	7094.

			1270.2	*****************		176840	41233.
			1253.1	*****************		127160	10712.
			1163.0	*****************		113260	8330.
			1153.1	*****************		123910	6029.
			1092.7	*****************		148700	15544.
			1024.0	*****************		115170	10455.
			971.4	*****************		63317	21275.
			955.3	*****************		144800	12209.
			887.4	*****************		102370	46701.
			835.7	*****************		139500	19964.
			826.0	*****************		136890	8075.
			740.8	*****************		91478	8722.
			709.9	*****************		168670	19788.
			703.3	*****************		138780	7072.
			645.9	*****************		146260	18799.
			627.7	*****************		121180	5993.
			612.0	5.7	0.3	139780	9277.
			608.3	*****************		87827	9478.
			580.6	*****************		122300	7319.
			443.1	*****************		122280	5917.
			439.5	*****************		372620	142738.
			382.9	*****************		87597	5799.
			331.1	*****************		142470	48449.
			307.0	*****************		159580	8661.
			242.8	95.84	0.20	133520	5230.
					R_av	127033	5078.
90mY	i(m)	3.19H	479.5	90.74	0.05	5080	366.
			202.5	97.3	0.4	4355	606.
					R_av	4908	345.
88 Y	i	106.65D	1836.1	99.2	0.3	101940	3760.
			898.0	93.7	0.3	97615	3490.
					R_av	99426	3769.
88 Y	c	106.65D	1836.1	99.2	0.3	644400	22571.
			898.0	93.7	0.3	612470	20237.
					R_av	621859	24271.
87mY	i(m)	13.37H	380.8	78.05	0.08	154150	7652
87mY	c	13.37H	380.8	78.05	0.08	473980	16175
87 Y	c	79.8H	484.8	89.7	0.7	608540	21283.
			388.5	82.1	0.5	609770	20821.
					R_av	609234	20053.
86 Y	i(m+g)	14.74H	2610.1	1.24	0.08	242460	20972.
			2568.0	2.25	0.11	220370	19129.
			1920.7	20.8	0.7	228590	13891.
			1801.7	1.65	0.05	247850	16509.
			1790.9	1.00	0.05	297680	28961.
			1724.2	0.55	0.05	248560	56643.
			1696.2	0.64	0.02	201960	38579.
			1415.2	0.33	0.09	387090	118769.
			1349.2	2.95	0.10	244420	13145.
			1270.2	0.65	0.10	1233600	204870.
			1253.1	1.53	0.05	257260	21288.
			1163.0	1.18	0.05	455070	29419.
			1153.1	30.5	1.0	236480	11589.
			1092.7	0.69	0.05	370110	37339.
			1024.0	3.80	0.17	277840	22910.
			971.4	0.27	0.04	396940	70306.
			955.3	1.04	0.05	211900	24065.
			887.4	0.44	0.05	388760	106043.
			835.7	4.4	0.6	254250	36408.
			826.0	3.30	0.09	216610	13911.
			740.8	1.36	0.05	129340	15494.
			709.9	2.62	0.08	203890	33444.
			703.3	15.4	0.5	232890	11764.
			645.9	9.2	1.1	272910	34680.
			627.7	32.6	1.0	235160	11389.
			608.3	2.01	0.15	179780	18179.
			580.6	4.78	0.15	223040	12824.
			443.1	16.9	0.5	250320	11968.
			439.5	0.20	0.07	1151200	412050.
			382.9	3.63	0.12	181140	10635.
			331.1	0.83	0.03	310320	78573.
			307.0	3.47	0.09	264840	14459.
					R_av	232412	10659.
86 Y	c	14.74H	2610.1	1.24	0.08	380510	31548.
			2568.0	2.25	0.11	360740	26555.
			2088.1	0.25	0.03	908710	139784.
			1920.7	20.8	0.7	364360	19098.
			1801.7	1.65	0.05	406180	20480.
			1790.9	1.00	0.05	427810	30275.
			1724.2	0.55	0.05	387990	51405.
			1696.2	0.64	0.02	372870	29623.
			1533.2	0.22	0.04	290960	92782.
			1507.9	0.35	0.05	481960	86744.

			1415.2	0.33	0.09	485830	137773.
			1349.2	2.95	0.10	378090	18441.
			1270.2	0.65	0.10	1410500	226488.
			1253.1	1.53	0.05	384420	21605.
			1163.0	1.18	0.05	568330	33108.
			1153.1	30.5	1.0	360390	17024.
			1092.7	0.69	0.05	518810	44135.
			1024.0	3.80	0.17	393010	24925.
			971.4	0.27	0.04	460260	73400.
			955.3	1.04	0.05	356700	25159.
			887.4	0.44	0.05	491140	84465.
			835.7	4.4	0.6	393750	55463.
			826.0	3.30	0.09	353510	16638.
			777.4	22.4	0.6	469790	25499.
			767.6	2.4	0.4	274870	50014.
			740.8	1.36	0.05	220820	14191.
			709.9	2.62	0.08	372560	27558.
			703.3	15.4	0.5	371680	17594.
			645.9	9.2	1.1	419180	52333.
			627.7	32.6	1.0	356350	16532.
			608.3	2.01	0.15	267610	22978.
			580.6	4.78	0.15	345350	16788.
			443.1	16.9	0.5	372600	17137.
			439.5	0.20	0.07	1523900	538345.
			426.0	0.30	0.02	470930	143497.
			382.9	3.63	0.12	268740	13302.
			331.1	0.83	0.03	452800	51687.
			307.0	3.47	0.09	424420	19274.
			264.5	0.54	0.03	403830	58684.
			235.4	0.40	0.02	370170	58386.
			190.8	1.01	0.04	687420	71346.
			187.9	1.26	0.05	548560	64311.
					R_av	358465	15564.
86mY	i(m)	48M	208.1	93.7	0.7	134110	5668
85mY	c	4.86H	2172.1	2.27	0.21	108870	13511.
			2123.8	5.0	0.5	94842	12352.
			1892.2	1.78	0.18	112960	18434.
			1261.9	0.65	0.06	182310	44299.
			1220.5	1.98	0.17	116780	12674.
			1123.2	1.78	0.16	137830	18284.
			1030.1	2.02	0.17	135190	17857.
			767.3	3.6	0.5	94025	20663.
			611.9	1.08	0.10	101290	24182.
			535.6	3.5	0.3	144840	14974.
			231.7	22.8	2.2	116620	96134.
					R_av	117031	7034.
85 Y	c	2.68H	504.4	60	4	58736	4452.
			231.9	**********	********	53766	6389.
			151.2	**********	********	46993	3574.
					R_av	51905	4128.
84 Y	c	39.5M	1502.9	5.8	0.6	83090	10345.
			1453.2	1.38	0.10	94728	17443.
			1262.5	3.5	0.4	31206	6632.
			1255.4	6.6	0.7	71329	8526.
			1143.9	3.3	0.3	67556	11343.
			1110.4	2.9	0.3	73005	10883.
			1039.8	56	6	72341	8322.
			1000.9	2.07	0.20	87531	14352.
			994.6	3.8	0.4	82025	12671.
			974.1	75	8	76861	8618.
			793.0	98.6	1.0	75486	2988.
			704.5	8.5	0.9	59029	8528.
			680.4	5.1	0.5	60061	7229.
			660.5	15.7	1.6	77985	8682.
			602.2	8.8	0.9	85563	10344.
			462.7	9.8	1.0	106010	12840.
					R_av	72992	3741.
85mSr	i(m)	67.63M	231.9	84.4	2.2	8895	2002.
			151.2	12.9	0.7	8278	1982.
					R_av	8584	1417.
85mSr	c	67.63M	231.9	84.4	2.2	62661	8313.
			151.2	12.9	0.7	55271	4000.
					R_av	56500	3737.
83 Sr	c	32.41H	1952.1	0.8	0.4	129560	65615.
			1562.5	1.8	0.9	149530	75024.
			1237.7	0.21	0.10	103180	57473.
			1160.0	1.5	0.7	141590	66955.
			1147.3	1.3	0.6	130790	60667.
			1098.1	0.26	0.12	106480	50651.
			762.7	30	14	134080	62729.
			737.1	0.25	0.12	168030	87096.
			438.2	0.9	0.4	121270	55639.
			423.6	1.6	0.8	115420	57983.
			418.4	4.4	2.1	137640	65899.

			381.2	2.5	1.2	866070	416910.
			290.0	0.44	0.21	110210	57006.
					R_av	126093	18114.
82 Sr	c	25.55D	776.5	15.08	0.00	57440	2195
81 Sr	c	22.3M	188.3	15.4	2.0	8935	4082.
			153.5	34	5	12326	2018.
			147.8	30	4	14361	2058.
					R_av	12870	1380.
84 Rb	i(m+g)	32.77D	1897.8	0.74	0.03	16794	3899.
			881.6	69.0	1.6	13451	541.
					R_av	13477	541.
84mRb	i(m)	20.26M	248.0	60.2	0.8	9227	561.
			215.6	29.5	1.3	9434	976.
					R_av	9271	516.
83 Rb	c	86.2D	799.4	0.24	0.02	185040	22961.
			552.6	16.0	1.1	179220	13745.
			529.6	29.3	2.1	179240	14216.
			520.4	45	4	172610	16437.
					R_av	178376	9245.
82mRb	i(m)	6.472H	1474.9	15.5	0.3	42924	3016.
			1317.4	23.7	0.6	40486	1888.
			1081.3	1.31	0.05	65355	35135.
			1044.1	32.07	0.08	41022	1484.
			1007.6	7.17	0.09	46288	2876.
			952.0	0.64	0.05	110180	66003.
			827.8	21.0	0.6	55609	3809.
			698.4	26.3	0.7	48776	2221.
			619.1	37.98	0.10	43276	1718.
			554.3	62.4	0.9	41518	1625.
			221.5	2.07	0.05	46593	9692.
			183.3	2.13	0.05	51009	8382.
					R_av	42585	1594.
81 Rb	c	4.576H	456.7	3.02	0.12	70081	6892.
			446.1	23.2	0.9	70219	3977.
			190.5	64	2	56865	4164.
					R_av	65108	5009.
79 Rb	c	22.9M	688.1	23.1	1.2	7245	1152.
			182.8	19.2	1.1	7957	2385.
			160.8	8.6	0.5	9902	2241.
			154.8	7.9	0.5	9716	2011.
			129.7	10.7	0.6	8968	1867.
					R_av	8286	796.
79 Kr	c	35.04H	832.0	1.26	0.08	82617	9916.
			299.5	1.54	0.09	29645	5347.
			261.3	12.7	0.4	24693	1731.
			217.1	2.37	0.13	20857	3864.
			136.1	0.85	0.12	203190	46501.
					R_av	25875	5040.
77 Kr	c	74.4M	129.6	81	2	1776	227
76 Kr	c	14.8H	1853.7******************			131230	10173.
			559.1******************			256.7	228.9
					R_av	349.0	3477.1
82 Br	i(m+g)	35.30H	1044.0	27.2	0.4	1595	222.
			952.0	0.37	0.02	118910	25778.
			827.8	24.0	0.4	10886	1262.
			776.5	83.5	1.2	12199	1291.
			698.4	28.5	0.4	3496	310.
			619.1	43.4	0.6	1484	374.
			606.4	1.21	0.01	163930	12609.
					R_av	2468	1207.
77 Br	c	57.036H	520.7	22.4	0.6	1783	791.
			439.5	1.56	0.05	12780	4540.
			239.0	23.1	0.5	3563	243.
					R_av	3459	455.
76 Br	i(m+g)	16.2H	1853.7	14.7	0.9	288210	21872.
			559.1	74	2	2950	411.
					R_av	3081	6098.
76 Br	c	16.2H	2391.2	4.7	0.4	3193	1397.
			1853.7	14.7	0.9	419440	30160.
			1471.1	2.31	0.14	86522	8139.
			882.3	0.41	0.03	247640	31392.
			559.1	74	2	3207	260.
					R_av	3332	2417.
75 Br	c	96.7M	286.5	88	50	3366	2271

75 Se	c	119.779D	400.7	11.47	0.09	3492	361.
			279.5	24.99	0.14	2454	223.
			264.7	58.9	0.4	2288	261.
			136.0	58.3	0.8	2260	157.
			121.1	17.2	0.4	2183	185.
					R_av	2356	172.
74 As	i	17.77D	595.8	59	4	274.2	62.5

Table 10.45: Detailed reaction rates for residual nuclide production in ^{93}Nb at E_p=249 MeV used to determine their production cross sections.

Nuclide	Type	$T_{1/2}$	E_γ, KeV	Abundance, %		Reaction rate 10^{-20} s^{-1}	
93mMo	i(m)	6.85H	684.7	99.7	2.0	2050	340
90 Mo	i	5.56H	2319.0	*****************		47729	10567.
			2186.2	*****************		18607	6889.
			890.6	*****************		42810	23505.
			371.3	*****************		106140	36350.
			257.3	78	4	25589	1681.
			203.1	6.4	0.6	31777	13414.
			162.9	6.0	0.6	24735	3729.
			122.4	64	4	23853	1751.
					R_av	24996	1549.
92mNb	i(m)	10.15D	1847.5	0.85	0.04	155640	10109.
			934.4	99.07	0.04	142910	4649.
			912.6	1.78	0.10	140010	9230.
					R_av	143100	4662.
91mNb	c	60.86D	1204.7	2.0	0.3	69452	10872.
			104.6	0.58	0.02	56335	4211.
					R_av	57833	4547.
90 Nb	i(m+g)	14.60H	2319.0	82.0	0.3	303590	19507.
			2186.2	17.96	0.17	343520	16511.
			890.6	1.80	0.05	314570	35893.
			371.3	1.80	0.07	488080	52849.
					R_av	333980	22619.
90 Nb	c	14.60H	2319.0	82.0	0.3	351320	16047.
			2222.3	0.62	0.03	323350	39538.
			2186.2	17.96	0.17	362130	15005.
			1984.5	0.68	0.03	316330	41062.
			1843.3	0.69	0.02	369560	38673.
			1611.8	2.38	0.07	383430	19771.
			890.6	1.80	0.05	357380	19376.
			371.3	1.80	0.07	594220	34579.
			141.2	66.8	0.7	364260	14450.
			132.7	4.13	0.05	395640	18917.
					R_av	370792	17416.
89 Nb	c	2.03H	2572.3	2.7	0.6	189040	43709.
			1833.4	3.3	0.7	237940	54817.
			1627.2	3.5	0.7	252300	53478.
			1511.4	1.9	0.4	236960	52583.
			1464.8	0.88	0.19	182110	47873.
			1259.0	1.2	0.3	167520	46413.
			920.5	1.4	0.4	315080	92474.
					R_av	211322	20588.
89mNb	i(m)	66M	588.0	95.1	0.5	33373	2759
88 Nb	c*	14.5M	1082.6	103	6	56939	4432.
			1057.1	100	4	63685	4654.
			671.2	64	4	51559	4037.
			399.4	31.8	1.8	75933	10393.
			271.8	30.1	1.5	53997	3780.
					R_av	56649	3303.
89 Zr	c	78.41H	1713.0	0.74	0.01	649700	25804.
			909.2	99.04	0.03	616710	20060.
					R_av	620317	21945.
88 Zr	c	83.4D	1836.1	*****************		516960	18134.
			898.0	*****************		486730	16142.
			392.9	97.24	0.00	484500	16291.
					R_av	486299	15193.
87 Zr	c	1.68H	1227.0	1.0	0.3	988110	299769.
			1210.0	0.33	0.11	815490	278975.
			380.8	99.87	0.00	322820	17279.
					R_av	325537	10170.
86 Zr	c	16.5H	2610.1	*****************		148630	13008.
			2568.0	*****************		165430	12820.
			1920.7	*****************		144050	8004.
			1801.7	*****************		151530	11699.

			1790.9	*****************		152250	10918.
			1724.2	*****************		182540	28599.
			1696.2	*****************		125130	17341.
			1415.2	*****************		95680	29918.
			1349.2	*****************		146390	8356.
			1270.2	*****************		207820	36024.
			1253.1	*****************		142580	10740.
			1163.0	*****************		126670	15833.
			1153.1	*****************		123600	6011.
			1092.7	*****************		142360	14236.
			1076.6	*****************		130410	5063.
			1024.0	*****************		128770	9838.
			971.4	*****************		174100	42879.
			955.3	*****************		165120	16654.
			887.4	*****************		198200	26574.
			835.7	*****************		134290	19178.
			826.0	*****************		142150	6652.
			740.8	*****************		96754	8746.
			709.9	*****************		138160	8239.
			703.3	*****************		264570	13646.
			645.9	*****************		143700	19239.
			627.7	*****************		121140	6102.
			612.0	5.7	0.3	146350	10003.
			608.3	*****************		87127	8413.
			580.6	*****************		129810	7920.
			443.1	*****************		120960	5801.
			439.5	*****************		434820	201822.
			382.9	*****************		121070	16544.
			331.1	*****************		191280	19781.
			307.0	*****************		150810	9854.
			242.8	95.84	0.20	145120	5663.
			235.4	*****************		61896	11718.
					R_av	134721	5739.
85 Zr	c	7.86M	454.3	41.4	1.0	43290	2589
90mY	i(m)	3.19H	479.5	90.74	0.05	6503	622.
			202.5	97.3	0.4	7862	1086.
					R_av	6824	615.
88 Y	i	106.65D	1836.1	99.2	0.3	124770	4385.
			898.0	93.7	0.3	119220	3967.
					R_av	120971	4575.
88 Y	c	106.65D	1836.1	99.2	0.3	641730	22379.
			898.0	93.7	0.3	605950	19909.
					R_av	615879	25038.
87mY	i(m)	13.37H	380.8	78.05	0.08	184330	12706
87mY	c	13.37H	380.8	78.05	0.08	506730	18112
87 Y	c	79.8H	484.8	89.7	0.7	642090	22440.
			388.5	82.1	0.5	643070	21945.
					R_av	642643	21145.
86 Y	i(m+g)	14.74H	2610.1	1.24	0.08	283510	26796.
			2568.0	2.25	0.11	242320	21365.
			1920.7	20.8	0.7	270430	17993.
			1801.7	1.65	0.05	327580	29260.
			1790.9	1.00	0.05	316730	25395.
			1724.2	0.55	0.05	139400	63478.
			1696.2	0.64	0.02	391270	45626.
			1415.2	0.33	0.09	404970	118624.
			1349.2	2.95	0.10	258670	17236.
			1270.2	0.65	0.10	1037600	168402.
			1253.1	1.53	0.05	275100	23310.
			1163.0	1.18	0.05	401680	46470.
			1153.1	30.5	1.0	284840	14920.
			1092.7	0.69	0.05	430060	43803.
			1076.6	82.5	0.4	242910	13606.
			1024.0	3.80	0.17	306940	23886.
			971.4	0.27	0.04	304240	129821.
			955.3	1.04	0.05	252050	41102.
			887.4	0.44	0.05	294360	49681.
			835.7	4.4	0.6	312340	44674.
			826.0	3.30	0.09	252760	12984.
			740.8	1.36	0.05	168420	22407.
			709.9	2.62	0.08	274250	16524.
			703.3	15.4	0.5	220820	15960.
			645.9	9.2	1.1	337070	44202.
			627.7	32.6	1.0	281790	15016.
			608.3	2.01	0.15	226890	20777.
			580.6	4.78	0.15	272820	17785.
			443.1	16.9	0.5	304720	15438.
			439.5	0.20	0.07	1194600	474655.
			382.9	3.63	0.12	212100	19990.
			331.1	0.83	0.03	297810	35087.
			307.0	3.47	0.09	331030	17148.
			235.4	0.40	0.02	328260	27205.
					R_av	272629	11391.

86 Y	c	14.74H	2610.1	1.24	0.08	432150	37099.
			2568.0	2.25	0.11	407750	30391.
			2088.1	0.25	0.03	869860	337809.
			1920.7	20.8	0.7	414480	22900.
			1801.7	1.65	0.05	479110	29778.
			1790.9	1.00	0.05	468980	31175.
			1724.2	0.55	0.05	321940	54276.
			1696.2	0.64	0.02	516410	37846.
			1533.2	0.22	0.04	414790	172051.
			1507.9	0.35	0.05	644400	113361.
			1415.2	0.33	0.09	500650	140903.
			1349.2	2.95	0.10	405060	21486.
			1270.2	0.65	0.10	1245400	198449.
			1253.1	1.53	0.05	417690	24532.
			1163.0	1.18	0.05	528360	45069.
			1153.1	30.5	1.0	408440	19908.
			1092.7	0.69	0.05	572430	50077.
			1076.6	82.5	0.4	373320	15775.
			1024.0	3.80	0.17	435710	27381.
			971.4	0.27	0.04	478340	118969.
			955.3	1.04	0.05	417170	38756.
			887.4	0.44	0.05	492550	63484.
			835.7	4.4	0.6	446630	63021.
			826.0	3.30	0.09	394920	17663.
			777.4	22.4	0.6	604060	44689.
			767.6	2.4	0.4	448560	79014.
			740.8	1.36	0.05	265180	19954.
			709.9	2.62	0.08	412420	20155.
			703.3	15.4	0.5	485390	25023.
			645.9	9.2	1.1	480770	60766.
			627.7	32.6	1.0	402930	19554.
			608.3	2.01	0.15	314020	26548.
			580.6	4.78	0.15	402630	21124.
			443.1	16.9	0.5	425680	20145.
			439.5	0.20	0.07	1629500	594015.
			426.0	0.30	0.02	409320	60930.
			382.9	3.63	0.12	333170	19669.
			331.1	0.83	0.03	489090	33261.
			307.0	3.47	0.09	481850	22080.
			264.5	0.54	0.03	497550	63353.
			235.4	0.40	0.02	390160	26263.
			190.8	1.01	0.04	788800	61680.
			187.9	1.26	0.05	340150	23736.
					R_av	409047	16183.
86mY	i(m)	48M	208.1	93.7	0.7	143630	10048
85mY	c	4.86H	2172.1	2.27	0.21	158790	20861.
			2123.8	5.0	0.5	131050	16709.
			1892.2	1.78	0.18	148880	28710.
			1261.9	0.65	0.06	189940	80881.
			1220.5	1.98	0.17	147950	16845.
			1123.2	1.78	0.16	165050	20419.
			1030.1	2.02	0.17	161060	21354.
			816.8	0.78	0.08	121630	39210.
			767.3	3.6	0.5	66637	17713.
			616.5	0.86	0.09	314760	61568.
			611.9	1.08	0.10	122030	30838.
			535.6	3.5	0.3	169870	24741.
			231.7	22.8	2.2	174140	21252.
					R_av	143440	11494.
85 Y	c	2.68H	504.4	60	4	78770	6056.
			231.9	*********	*********	64526	3078.
			151.2	*********	*********	61480	4735.
					R_av	65505	3902.
84 Y	c	39.5M	1502.9	5.8	0.6	132110	16416.
			1453.2	1.38	0.10	65672	15744.
			1262.5	3.5	0.4	65998	11787.
			1255.4	6.6	0.7	104540	12626.
			1143.9	3.3	0.3	100240	17914.
			1110.4	2.9	0.3	130390	17571.
			1039.8	56	6	112350	12667.
			1000.9	2.07	0.20	127360	21866.
			994.6	3.8	0.4	119760	15133.
			974.1	75	8	113440	12733.
			793.0	98.6	1.0	114350	4594.
			704.5	8.5	0.9	92187	14801.
			680.4	5.1	0.5	93625	10782.
			660.5	15.7	1.6	113300	12809.
			602.2	8.8	0.9	130550	14634.
			462.7	9.8	1.0	101260	18028.
					R_av	110433	4909.
85mSr	i(m)	67.63M	231.9	84.4	2.2	11051	551.
			151.2	12.9	0.7	11381	2817.
					R_av	11057	515.
85mSr	c	67.63M	231.9	84.4	2.2	75577	3581.

			151.2	12.9	0.7	72861	5332.
					R_av	74931	3318.
83 Sr	c	32.41H	1952.1	0.8	0.4	249180	125124.
			1562.5	1.8	0.9	238570	119614.
			1160.0	1.5	0.7	214830	100507.
			1147.3	1.3	0.6	222330	102916.
			1098.1	0.26	0.12	181210	85623.
			762.7	30	14	233300	109125.
			737.1	0.25	0.12	180000	88315.
			438.2	0.9	0.4	210220	93852.
			423.6	1.6	0.8	211450	105990.
			418.4	4.4	2.1	235430	112622.
			381.5	14	7	271310	135944.
			290.0	0.44	0.21	228590	110613.
					R_av	216690	30746.
82 Sr	c	25.55D	776.5	15.08	0.00	118980	3991
81 Sr	c	22.3M	574.7	6.7	0.9	34259	7862.
			443.3	17.5	2.2	22616	3857.
			188.3	15.4	2.0	36012	5191.
			153.5	34	5	37278	6243.
			147.8	30	4	40928	6144.
					R_av	31613	3818.
86 Rb	i(m+g)	18.631D	1077.0	8.64	0.04	1825	913
84 Rb	i(m+g)	32.77D	1897.8	0.74	0.03	29446	3104.
			881.6	69.0	1.6	25437	1017.
					R_av	25613	1146.
84mRb	i(m)	20.26M	463.6	36.1	1.3	24210	4758.
			248.0	60.2	0.8	15397	812.
			215.6	29.5	1.3	14752	1650.
					R_av	15448	946.
83 Rb	c	86.2D	799.4	0.24	0.02	320030	29033.
			552.6	16.0	1.1	318830	24449.
			529.6	29.3	2.1	317840	25222.
			520.4	45	4	310320	29555.
					R_av	317114	15878.
82mRb	i(m)	6.472H	1474.9	15.5	0.3	83144	4057.
			1317.4	23.7	0.6	83079	5184.
			1081.3	1.31	0.05	49622	27660.
			1073.0	0.73	0.05	173450	24606.
			1044.1	32.07	0.08	88178	3238.
			1007.6	7.17	0.09	86015	4812.
			952.0	0.64	0.05	118130	51692.
			827.8	21.0	0.6	101900	6920.
			776.5	84.39	0.21	18364	7655.
			698.4	26.3	0.7	87467	4915.
			619.1	37.98	0.10	87192	3671.
			606.4	2.01	0.06	83634	10221.
			554.3	62.4	0.9	89286	3660.
			221.5	2.07	0.05	75599	14044.
			183.3	2.13	0.05	86635	9834.
					R_av	86472	3822.
81 Rb	c	4.576H	537.6	2.23	0.17	134150	17850.
			456.7	3.02	0.12	151960	18723.
			446.1	23.2	0.9	170510	9182.
			357.4	0.76	0.03	193610	32464.
			190.5	64	2	178780	10435.
					R_av	169246	8513.
79 Rb	c	22.9M	688.1	23.1	1.2	28961	2203.
			622.2	8.8	0.5	19910	4146.
			350.6	7.2	0.4	33113	5080.
			182.8	19.2	1.1	32073	2981.
			160.8	8.6	0.5	32670	3512.
			154.8	7.9	0.5	26755	3242.
			143.4	13.9	0.8	28868	2611.
			129.7	10.7	0.6	43769	7524.
					R_av	29430	1652.
79 Kr	c	35.04H	1115.1	0.37	0.04	55102	8885.
			832.0	1.26	0.08	110610	14894.
			397.5	9.3	0.5	88319	5788.
			306.5	2.60	0.13	91304	8030.
			299.5	1.54	0.09	96678	9192.
			261.3	12.7	0.4	93337	4623.
			217.1	2.37	0.13	97847	7229.
			136.1	0.85	0.12	71642	19598.
					R_av	90415	4937.
77 Kr	c	74.4M	276.0	2.92	0.18	40580	10382.
			146.6	37.3	1.9	19650	2677.
			129.6	81	2	23620	1336.
					R_av	23248	1620.

76 Kr	c	14.8H	2510.8	*****************		6923	1676.
			2391.2	*****************		1647	1179.
			1853.7	*****************		140870	11291.
			1471.1	*****************		10090	5071.
			1216.1	*****************		14351	2349.
			1213.1	*****************		10393	3898.
			657.0	*****************		4066	1177.
			559.1	*****************		5323	278.
			315.7	39	5	5537	1190.
			271.6	4.3	0.5	48241	25162.
					R_av	5348	842.
82 Br	i(m+g)	35.30H	1044.0	27.2	0.4	2716	175.
			952.0	0.37	0.02	72002	15957.
			827.8	24.0	0.4	8346	1629.
			776.5	83.5	1.2	13819	905.
			698.4	28.5	0.4	13082	1645.
			619.1	43.4	0.6	1494	455.
			606.4	1.21	0.01	593350	21907.
					R_av	3166	3073.
77 Br	c	57.036H	1005.0	0.92	0.03	52176	6360.
			817.8	2.08	0.07	55977	4089.
			755.3	1.67	0.05	48281	4554.
			585.5	1.57	0.05	61708	5559.
			578.9	2.96	0.10	50455	2917.
			574.6	1.19	0.04	45628	9778.
			520.7	22.4	0.6	49996	2413.
			439.5	1.56	0.05	54108	6913.
			303.8	1.18	0.04	60791	3820.
			297.2	4.16	0.21	50989	3259.
			281.6	2.29	0.07	46056	2525.
			249.8	2.98	0.10	50035	2982.
			239.0	23.1	0.5	45543	2024.
					R_av	49432	1972.
76 Br	i(m+g)	16.2H	2510.8	1.95	0.13	16466	3643.
			2391.2	4.7	0.4	28581	4306.
			1853.7	14.7	0.9	343430	29058.
			1471.1	2.31	0.14	84049	12507.
			1216.1	8.8	0.5	17605	4949.
			1213.1	1.7	0.6	26604	9978.
			657.0	15.9	0.9	23251	2649.
			559.1	74	2	23977	1078.
					R_av	24017	2282.
76 Br	c	16.2H	2601.2	0.70	0.05	24416	13340.
			2510.8	1.95	0.13	23389	2742.
			2391.2	4.7	0.4	30228	3745.
			1853.7	14.7	0.9	484310	36451.
			1471.1	2.31	0.14	94139	9783.
			1439.4	0.58	0.04	102740	25656.
			1380.5	2.52	0.15	60502	8357.
			1216.1	8.8	0.5	31956	3929.
			1213.1	1.7	0.6	36997	13296.
			882.3	0.41	0.03	250780	37679.
			657.0	15.9	0.9	27317	2294.
			563.2	3.6	0.6	37882	10041.
			559.1	74	2	29300	1285.
			472.9	1.86	0.10	37457	9390.
					R_av	29896	3720.
75 Br	c	96.7M	286.5	88	50	14671	8367
74mBr	i(m)	46M	1508.0	0.22	0.05	958580	239930.
			1269.1	8.8	0.4	10443	2397.
			634.3	16.4	2.3	11828	2254.
					R_av	11225	4606.
75 Se	c	119.779D	400.7	11.47	0.09	38713	1398.
			279.5	24.99	0.14	28707	1071.
			264.7	58.9	0.4	28163	1090.
			136.0	58.3	0.8	29046	1120.
			121.1	17.2	0.4	29211	1261.
					R_av	30570	2169.
73 Se	c	7.15H	361.2	97	1	7495	419
72 Se	c	8.40D	1475.9	*****************		12666	8846.
			834.0	*****************		1832	99.
					R_av	1832	103.
74 As	i	17.77D	634.8	15.4	1.1	3074	264.
			595.8	59	4	3391	259.
					R_av	3238	198.
72 As	i	26.0H	1475.9	0.51	0.01	19651	17100.
			834.0	79.5	1.7	14723	794.
					R_av	14729	740.

72 As	c	26.0H	2621.5	0.39	0.01	595740	164176.
			1475.9	0.51	0.01	32317	15001.
			1050.8	0.98	0.03	55733	5544.
			834.0	79.5	1.7	16555	843.
					R_av	17210	3187.
71 As	c	65.28H	1095.5	4.08	0.12	2652	441.
			174.9	82.0	2.1	4383	217.
					R_av	4156	599.
69 Ge	c	39.05H	1106.8	36	4	1128	149.
			872.0	11.9	1.6	707.0	312.5
			574.1	13.3	1.9	2269	1255.
					R_av	1066	148.
67 Ga	c	3.2612D	300.2	16.80	0.22	790.4	321.4
			208.9	2.40	0.07	37161	13685.
					R_av	810.5	854.5
65 Zn	c	244.26D	1115.6	50.60	0.24	760.2	122.4
7 Be	i	53.29D	477.6	10.52	0.06	3261	213

Table 10.46: Detailed reaction rates for residual nuclide production in ^{93}Nb at E_p=400 MeV used to determine their production cross sections.

Nuclide	Type	$T_{1/2}$	E_γ, KeV	Abundance, %		Reaction rate 10^{-20} s^{-1}	
93mMo	i(m)	6.85H	684.7	99.7	2.0	946.9	269.3
90 Mo	i	5.56H	2319.0	*********	*********	12698	1673.
			2186.2	*********	*********	6386	3730.
			257.3	78	4	8820	591.
			203.1	6.4	0.6	25769	10090.
			132.7	*********	*********	25048	12632.
			122.4	64	4	8590	651.
					R_av	8951	620.
92mNb	i(m)	10.15D	1847.5	0.85	0.04	92957	6701.
			934.4	99.07	0.04	84554	2752.
			912.6	1.78	0.10	84247	5664.
					R_av	84678	2751.
91mNb	c	60.86D	1204.7	2.0	0.3	36784	6011.
			104.6	0.58	0.02	30050	7061.
					R_av	33986	4634.
90 Nb	i(m+g)	14.60H	2319.0	82.0	0.3	154270	6855.
			2186.2	17.96	0.17	161160	8070.
			132.7	4.13	0.05	150080	18875.
					R_av	156556	6172.
90 Nb	c	14.60H	2319.0	82.0	0.3	166970	7072.
			2222.3	0.62	0.03	168480	26673.
			2186.2	17.96	0.17	167550	7018.
			1913.2	1.28	0.02	124280	12528.
			1843.3	0.69	0.02	218130	23394.
			1611.8	2.38	0.07	174450	10007.
			1129.2	92.7	0.5	169860	5936.
			890.6	1.80	0.05	173550	9177.
			371.3	1.80	0.07	237690	19482.
			141.2	66.8	0.7	169970	6829.
			132.7	4.13	0.05	175130	9195.
					R_av	169816	6181.
89 Nb	c	2.03H	2572.3	2.7	0.6	89507	20834.
			1833.4	3.3	0.7	110020	24157.
			1627.2	3.5	0.7	133310	27611.
			1511.4	1.9	0.4	118050	26617.
			1464.8	0.88	0.19	84797	23110.
			1259.0	1.2	0.3	100330	27615.
			920.5	1.4	0.4	188830	56405.
					R_av	106086	10342.
89mNb	i(m)	66M	588.0	95.1	0.5	16131	1467
88 Nb	c*	14.5M	1082.6	103	6	23310	1721.
			1057.1	100	4	26030	2175.
			671.2	64	4	20876	1827.
			399.4	31.8	1.8	35996	4294.
			271.8	30.1	1.5	22162	1796.
					R_av	23417	1714.
89 Zr	c	78.41H	1713.0	0.74	0.01	320500	12986.
			909.2	99.04	0.03	308710	10054.
					R_av	309955	10339.
88 Zr	c	83.4D	1836.1	*********	*********	253070	9518.
			898.0	*********	*********	246110	9101.

			392.9	97.24	0.00	242560	8206.
					R_av	245493	7670.
87 Zr	c	1.68H	1227.0	1.0	0.3	514260	157060.
			380.8	99.87	0.00	170920	9983.
					R_av	171918	5371.
86 Zr	c	16.5H	2610.1	*****************		92551	9379.
			2568.0	*****************		82817	6587.
			1920.7	*****************		75012	4286.
			1801.7	*****************		65870	7301.
			1790.9	*****************		76128	10609.
			1724.2	*****************		92595	54471.
			1696.2	*****************		109700	13789.
			1507.9	*****************		28000	7557.
			1415.2	*****************		42357	26261.
			1349.2	*****************		81971	4916.
			1270.2	*****************		103940	28084.
			1253.1	*****************		72099	5859.
			1163.0	*****************		51449	9301.
			1153.1	*****************		62794	3005.
			1092.7	*****************		73247	19156.
			1076.6	*****************		66505	2528.
			1024.0	*****************		64151	4575.
			955.3	*****************		73540	12172.
			887.4	*****************		60112	7832.
			835.7	*****************		63960	9218.
			826.0	*****************		75545	17448.
			767.6	*****************		32176	9495.
			740.8	*****************		41126	10711.
			709.9	*****************		60927	7833.
			703.3	*****************		66508	3353.
			644.8	*****************		311560	59331.
			627.7	*****************		58264	3092.
			612.0	5.7	0.3	80582	6766.
			608.3	*****************		22623	8520.
			580.6	*****************		134570	10057.
			443.1	*****************		63509	3199.
			331.1	*****************		96118	6378.
			307.0	*****************		86345	10601.
			242.8	95.84	0.20	74262	2893.
					R_av	67986	2933.
85 Zr	c	7.86M	454.3	41.4	1.0	32009	1697
90mY	i(m)	3.19H	479.5	90.74	0.05	6183	377.
			202.5	97.3	0.4	5837	662.
					R_av	6112	346.
88 Y	i	106.65D	1836.1	99.2	0.3	81205	2894.
			898.0	93.7	0.3	75775	2595.
					R_av	77775	3573.
88 Y	c	106.65D	1836.1	99.2	0.3	334280	12017.
			898.0	93.7	0.3	321880	11104.
					R_av	326661	11857.
87mY	i(m)	13.37H	380.8	78.05	0.08	104960	7923
87mY	c	13.37H	380.8	78.05	0.08	275660	9867
87 Y	c	79.8H	484.8	89.7	0.7	350520	12260.
			388.5	82.1	0.5	351950	12029.
					R_av	351322	11568.
86 Y	i(m+g)	14.74H	2610.1	1.24	0.08	146330	17810.
			2568.0	2.25	0.11	147430	12592.
			1920.7	20.8	0.7	160490	9762.
			1801.7	1.65	0.05	195810	15460.
			1790.9	1.00	0.05	209200	22320.
			1724.2	0.55	0.05	119960	89003.
			1696.2	0.64	0.02	168330	18974.
			1507.9	0.35	0.05	254910	38664.
			1415.2	0.33	0.09	233510	84929.
			1349.2	2.95	0.10	152950	10174.
			1270.2	0.65	0.10	567280	100265.
			1253.1	1.53	0.05	180670	13040.
			1163.0	1.18	0.05	277260	42914.
			1153.1	30.5	1.0	173000	8358.
			1092.7	0.69	0.05	253130	59606.
			1076.6	82.5	0.4	156780	6802.
			1024.0	3.80	0.17	186380	12447.
			955.3	1.04	0.05	189300	28825.
			887.4	0.44	0.05	245310	29377.
			835.7	4.4	0.6	194650	27644.
			826.0	3.30	0.09	191550	41153.
			767.6	2.4	0.4	146840	31084.
			740.8	1.36	0.05	89127	22281.
			709.9	2.62	0.08	178800	13144.
			703.3	15.4	0.5	174640	8705.
			644.8	2.2	0.4	819690	153779.

			627.7	32.6	1.0	170630	9562.
			608.3	2.01	0.15	147060	20530.
			580.6	4.78	0.15	106330	16089.
			443.1	16.9	0.5	171330	8944.
			331.1	0.83	0.03	184730	14473.
			307.0	3.47	0.09	192570	14436.
					R_av	168187	6708.
86 Y	c	14.74H	2610.1	1.24	0.08	238880	22104.
			2568.0	2.25	0.11	230250	17061.
			2088.1	0.25	0.03	558600	86273.
			1920.7	20.8	0.7	235500	12507.
			1801.7	1.65	0.05	261680	15990.
			1790.9	1.00	0.05	285330	22409.
			1724.2	0.55	0.05	212560	54981.
			1696.2	0.64	0.02	278030	15648.
			1533.2	0.22	0.04	343640	124428.
			1507.9	0.35	0.05	282910	42192.
			1415.2	0.33	0.09	275860	87632.
			1349.2	2.95	0.10	234930	12341.
			1270.2	0.65	0.10	671230	110451.
			1253.1	1.53	0.05	252770	13842.
			1163.0	1.18	0.05	328710	37500.
			1153.1	30.5	1.0	235790	11115.
			1092.7	0.69	0.05	326380	48567.
			1076.6	82.5	0.4	223290	8289.
			1024.0	3.80	0.17	250530	14826.
			955.3	1.04	0.05	262840	24911.
			887.4	0.44	0.05	305420	36199.
			835.7	4.4	0.6	258610	36406.
			826.0	3.30	0.09	267090	29538.
			777.4	22.4	0.6	309110	19137.
			767.6	2.4	0.4	179020	32911.
			740.8	1.36	0.05	130250	14333.
			709.9	2.62	0.08	239720	13310.
			703.3	15.4	0.5	241150	11464.
			644.8	2.2	0.4	1131200	210158.
			627.7	32.6	1.0	228900	11419.
			608.3	2.01	0.15	169690	18101.
			580.6	4.78	0.15	240910	15907.
			443.1	16.9	0.5	234840	11237.
			331.1	0.83	0.03	280850	15694.
			307.0	3.47	0.09	278920	15292.
			264.5	0.54	0.03	261130	29027.
			235.4	0.40	0.02	248490	38911.
			190.8	1.01	0.04	427980	33148.
			187.9	1.26	0.05	340340	29212.
					R_av	240021	9528.
86mY	i(m)	48M	208.1	93.7	0.7	93192	3865
85mY	c	4.86H	2172.1	2.27	0.21	98391	11853.
			2123.8	5.0	0.5	78041	9077.
			1892.2	1.78	0.18	107550	18366.
			1404.6	3.1	0.3	94415	10567.
			1220.5	1.98	0.17	84253	12479.
			1123.2	1.78	0.16	85121	9681.
			1030.1	2.02	0.17	109320	14817.
			816.8	0.78	0.08	86900	61465.
			535.6	3.5	0.3	79534	24725.
			231.7	22.8	2.2	97601	11422.
					R_av	90695	4765.
85 Y	c	2.68H	913.9	9.0	0.8	33239	3515.
			231.9	*********	********	40432	1960.
			151.2	*********	********	32334	2815.
					R_av	38092	2790.
84 Y	c	39.5M	1502.9	5.8	0.6	77007	8769.
			1262.5	3.5	0.4	42874	7123.
			1255.4	6.6	0.7	64297	7493.
			1143.9	3.3	0.3	71522	12624.
			1110.4	2.9	0.3	75772	12803.
			1039.8	56	6	77351	9080.
			1000.9	2.07	0.20	84828	10989.
			994.6	3.8	0.4	77154	10147.
			974.1	75	8	70498	8150.
			793.0	98.6	1.0	70539	2789.
			704.5	8.5	0.9	54898	7397.
			680.4	5.1	0.5	62932	7622.
			660.5	15.7	1.6	69567	7560.
			602.2	8.8	0.9	80901	9179.
			462.7	9.8	1.0	76531	10013.
					R_av	69539	2884.
85mSr	i(m)	67.63M	231.9	84.4	2.2	7794	416.
			151.2	12.9	0.7	9824	1852.
					R_av	7852	417.
85mSr	c	67.63M	231.9	84.4	2.2	48227	2307.
			151.2	12.9	0.7	42158	3206.

					R_av	46630	3044.
83 Sr	c	32.41H	1952.1	0.8	0.4	168510	84931.
			1562.5	1.8	0.9	171020	85853.
			1160.0	1.5	0.7	162420	76226.
			1147.3	1.3	0.6	154440	71540.
			1098.1	0.26	0.12	167020	78001.
			994.2	0.3	0.4	254720	340886.
			762.7	30	14	168090	78632.
			423.6	1.6	0.8	141260	71935.
			418.4	4.4	2.1	172020	82332.
			381.5	14	7	194110	97284.
			381.5	14	7	130190	66066.
					R_av	160126	24909.
82 Sr	c	25.55D	776.5	15.08	0.00	93344	3170
81 Sr	c	22.3M	574.7	6.7	0.9	31621	7508.
			443.3	17.5	2.2	25357	3931.
			188.3	15.4	2.0	30977	4822.
			153.5	34	5	33511	5175.
			147.8	30	4	36008	5087.
					R_av	30674	2364.
86 Rb	i(m+g)	18.631D	1077.0	8.64	0.04	1527	1212
84 Rb	i(m+g)	32.77D	1897.8	0.74	0.03	19779	4482.
			881.6	69.0	1.6	21229	850.
					R_av	21208	848.
84mRb	i(m)	20.26M	463.6	36.1	1.3	15720	2121.
			248.0	60.2	0.8	12777	782.
			215.6	29.5	1.3	12904	1244.
					R_av	13024	694.
83 Rb	c	86.2D	799.4	0.24	0.02	244080	27956.
			552.6	16.0	1.1	233190	17894.
			529.6	29.3	2.1	233980	18577.
			520.4	45	4	229770	21941.
					R_av	234091	12058.
82mRb	i(m)	6.472H	1474.9	15.5	0.3	70533	3093.
			1317.4	23.7	0.6	75565	3378.
			1081.3	1.31	0.05	91730	8481.
			1081.3	1.31	0.05	58607	25072.
			1073.0	0.73	0.05	75714	15141.
			1044.1	32.07	0.08	74722	2568.
			1007.6	7.17	0.09	76885	3380.
			952.0	0.64	0.05	63437	34582.
			827.8	21.0	0.6	92550	4598.
			776.5	84.39	0.21	48930	3838.
			698.4	26.3	0.7	79603	3750.
			619.1	37.98	0.10	73898	3099.
			606.4	2.01	0.06	57552	10532.
			554.3	62.4	0.9	76754	3055.
			183.3	2.13	0.05	106070	11067.
					R_av	74856	2956.
81 Rb	c	4.576H	977.2	0.56	0.02	145250	22810.
			456.7	3.02	0.12	161340	10199.
			446.1	23.2	0.9	149980	8245.
			190.5	64	2	163040	8558.
					R_av	157119	6439.
79 Rb	c	22.9M	688.1	23.1	1.2	32566	2248.
			622.2	8.8	0.5	26641	3470.
			350.6	7.2	0.4	37048	3973.
			182.8	19.2	1.1	35725	3464.
			160.8	8.6	0.5	35235	3458.
			154.8	7.9	0.5	37494	3498.
			143.4	13.9	0.8	37099	2852.
			129.7	10.7	0.6	48867	7051.
					R_av	34622	1785.
79 Kr	c	35.04H	1332.2	0.43	0.04	115910	15018.
			1115.1	0.37	0.04	92909	14324.
			832.0	1.26	0.08	111460	9493.
			606.1	8.1	0.4	107530	6604.
			306.5	2.60	0.13	90248	9800.
			299.5	1.54	0.09	116230	10076.
			261.3	12.7	0.4	110090	5505.
			217.1	2.37	0.13	111090	7755.
			208.5	0.77	0.06	160760	34459.
			136.1	0.85	0.12	88323	14396.
					R_av	108040	4357.
77 Kr	c	74.4M	311.9	3.7	0.5	48249	9032.
			276.0	2.92	0.18	40279	5349.
			146.6	37.3	1.9	34592	4653.
			129.6	81	2	38081	1874.
					R_av	38129	1630.

76 Kr	c	14.8H	2391.2*****************			7244	1451.
			1853.7*****************			69654	5056.
			1471.1*****************			6817	4552.
			1380.5*****************			7491	2796.
			1216.1*****************			15803	1339.
			1213.1*****************			33043	12739.
			657.0*****************			7903	1346.
			563.2*****************			13736	3300.
			559.1*****************			8271	412.
			406.5	12.1	1.4	8999	2283.
			315.7	39	5	10654	1474.
			271.6	4.3	0.5	94117	26849.
			270.2	21	3	11936	2013.
			252.0	6.2	0.9	30769	7369.
			199.8	1.17	0.14	68437	27018.
					R_av	8806	1012.
82 Br	i(m+g)	35.30H	1044.0	27.2	0.4	2202	299.
			952.0	0.37	0.02	76213	22337.
			776.5	83.5	1.2	7364	781.
			698.4	28.5	0.4	2166	331.
			619.1	43.4	0.6	1807	776.
					R_av	2542	759.
77 Br	c	57.036H	1005.0	0.92	0.03	80474	7037.
			817.8	2.08	0.07	109600	9052.
			755.3	1.67	0.05	74673	4196.
			585.5	1.57	0.05	97987	6808.
			578.9	2.96	0.10	79032	5174.
			574.6	1.19	0.04	46008	8009.
			565.9	0.43	0.02	81533	11914.
			520.7	22.4	0.6	77134	4816.
			385.0	0.84	0.03	97098	6328.
			303.8	1.18	0.04	77324	5259.
			297.2	4.16	0.21	78788	5059.
			281.6	2.29	0.07	75695	4027.
			249.8	2.98	0.10	75257	4126.
			239.0	23.1	0.5	75350	3327.
			200.4	1.21	0.06	69476	5936.
			161.8	1.10	0.03	74028	4382.
					R_av	77327	3230.
76 Br	i(m+g)	16.2H	2391.2	4.7	0.4	50479	5381.
			1853.7	14.7	0.9	265060	18976.
			1471.1	2.31	0.14	83035	10187.
			1380.5	2.52	0.15	36586	6412.
			1216.1	8.8	0.5	40469	3111.
			1213.1	1.7	0.6	6041	11061.
			657.0	15.9	0.9	46711	3964.
			563.2	3.6	0.6	33268	7094.
			559.1	74	2	46395	2077.
					R_av	46283	4214.
76 Br	c	16.2H	2510.8	1.95	0.13	71189	8755.
			2391.2	4.7	0.4	57724	5705.
			2096.7	1.36	0.09	64016	11827.
			1853.7	14.7	0.9	334710	23702.
			1471.1	2.31	0.14	89852	8292.
			1454.1	0.80	0.05	430330	206105.
			1380.5	2.52	0.15	44077	4948.
			1216.1	8.8	0.5	56272	3845.
			1213.1	1.7	0.6	39084	15335.
			1032.6	0.58	0.07	83361	22171.
			882.3	0.41	0.03	188240	25610.
			803.5	0.53	0.04	484580	80543.
			657.0	15.9	0.9	54614	3891.
			563.2	3.6	0.6	47004	8408.
			559.1	74	2	54667	2401.
			472.9	1.86	0.10	61858	9555.
					R_av	56931	5439.
75 Br	c	96.7M	377.4	3.9	2.3	35188	20997.
			286.5	88	50	34082	19407.
					R_av	34591	14272.
74 Br	c	25.4M	634.2	14.1	2.0	10168	4093
74mBr	i(m)	46M	1508.0	0.22	0.05	382100	97953.
			1249.5	6.7	0.7	9175	2665.
			728.3	35.6	1.9	5942	1169.
			634.3	16.4	2.3	38038	6268.
			219.0	5.02	0.19	20905	2923.
					R_av	9001	3849.
75 Se	c	119.779D	400.7	11.47	0.09	84933	3151.
			303.9	1.32	0.01	40168	9251.
			279.5	24.99	0.14	63147	2348.
			264.7	58.9	0.4	61601	2351.
			198.6	1.48	0.05	66453	7160.
			136.0	58.3	0.8	63819	2398.

			121.1	17.2	0.4	64773	2783.
					R_av	66221	3851.
73 Se	i(m+g)	7.15H	361.2	97	1	10175	2727
73 Se	c	7.15H	361.2	97	1	21729	836
73mSe	c	39.8M	361.2	73.00	0.01	15827	4866
72 Se	c	8.40D	2621.5	*****************		8985	1535.
			1464.0	*****************		7883	2641.
			1050.8	*****************		8856	2501.
			834.0	*****************		8079	366.
			629.9	*****************		8277	458.
					R_av	8145	306.
74 As	i	17.77D	634.8	15.4	1.1	8942	714.
			608.4	0.55	0.02	61860	7007.
			595.8	59	4	8625	655.
					R_av	8996	2471.
72 As	i	26.0H	2621.5	0.39	0.01	45559	7932.
			1464.0	1.11	0.03	42888	10430.
			1050.8	0.98	0.03	39383	6342.
			834.0	79.5	1.7	24693	1355.
			629.9	7.92	0.22	18384	4279.
					R_av	25174	2133.
72 As	c	26.0H	2621.5	0.39	0.01	54544	7543.
			1475.9	0.51	0.01	60306	13284.
			1464.0	1.11	0.03	50771	9256.
			1050.8	0.98	0.03	48239	4782.
			834.0	79.5	1.7	32773	1566.
			629.9	7.92	0.22	26662	4242.
					R_av	34149	2824.
71 As	c	65.28H	1095.5	4.08	0.12	17036	867.
			499.9	3.62	0.09	13122	1401.
			326.8	3.03	0.08	21409	2541.
			174.9	82.0	2.1	18436	823.
					R_av	17489	1112.
70 As	c*	52.6M	2020.0	17.2	1.9	8855	2270.
			1114.3	21.8	2.4	4752	788.
			1040.0	81	5	734.3	1606.2
			905.7	12.5	1.4	6032	2173.
			668.4	21.8	2.4	6225	862.
			607.6	4.0	0.5	10301	9118.
					R_av	5183	822.
69 Ge	c	39.05H	1336.6	4.5	0.7	7412	1614.
			1106.8	36	4	8907	1054.
			872.0	11.9	1.6	10359	1628.
			574.1	13.3	1.9	15467	2488.
					R_av	9473	1238.
67 Ga	c	3.2612D	300.2	16.80	0.22	6936	393.
			208.9	2.40	0.07	2238	8250.
			184.6	21.2	0.3	7570	380.
					R_av	7280	332.
66 Ga	c*	9.49H	1918.3	2.08	0.07	256100	73741.
			1039.2	36.9	1.1	3973	300.
					R_av	3977	948.
65 Zn	c	244.26D	1115.6	50.60	0.24	5261	233
61 Cu	c	3.333H	656.0	10.8	2.0	2079	1794
58 Co	i(m+g)	70.86D	810.8	99.45	0.01	547.4	31.1
7 Be	i	53.29D	477.6	10.52	0.06	3598	608

Table 10.46: Detailed reaction rates for residual nuclide production in ^{93}Nb at E_p=600 MeV used to determine their production cross sections.

Nuclide	Type	$T_{1/2}$	E_γ, KeV	Abundance, %		Reaction rate 10^{-20} s^{-1}	
93mMo	i(m)	6.85H	684.7	99.7	2.0	1925	447
90 Mo	i	5.56H	2319.0	*****************		20654	5577.
			2186.2	*****************		10655	5911.
			371.3	*****************		101560	8288.
			257.3	78	4	11145	843.
			141.2	*****************		2971	7828.
			132.7	*****************		73129	19305.
			122.4	64	4	10049	817.
					R_av	11130	2728.

92mNb	i(m)	10.15D	1847.5	0.85	0.04	184300	12017.
			934.4	99.07	0.04	165420	5381.
			912.6	1.78	0.10	162430	11241.
					R_av	165722	5506.
91mNb	c	60.86D	1204.7	2.0	0.3	66398	11061.
			104.6	0.58	0.02	57909	8910.
					R_av	61237	7067.
90 Nb	i(m+g)	14.60H	2319.0	82.0	0.3	234550	11905.
			2186.2	17.96	0.17	241350	12152.
			371.3	1.80	0.07	340010	18773.
			141.2	66.8	0.7	265950	14602.
			132.7	4.13	0.05	177780	24429.
					R_av	252497	20080.
90 Nb	c	14.60H	2319.0	82.0	0.3	255200	11198.
			2222.3	0.62	0.03	280260	38041.
			2186.2	17.96	0.17	252010	10527.
			1913.2	1.28	0.02	295610	26856.
			1843.3	0.69	0.02	361160	86640.
			1611.8	2.38	0.07	303040	19703.
			1129.2	92.7	0.5	277900	10082.
			890.6	1.80	0.05	251190	30651.
			371.3	1.80	0.07	441570	22738.
			141.2	66.8	0.7	268920	10459.
			132.7	4.13	0.05	250910	12496.
					R_av	271141	12839.
89 Nb	c	2.03H	2572.3	2.7	0.6	146040	34757.
			1833.4	3.3	0.7	183070	41485.
			1627.2	3.5	0.7	169840	35705.
			1511.4	1.9	0.4	157160	36734.
			1259.0	1.2	0.3	172850	46878.
			920.5	1.4	0.4	256220	77830.
					R_av	168188	17433.
89mNb	i(m)	66M	588.0	95.1	0.5	25211	2243
88 Nb	c*	14.5M	1082.6	103	6	34710	2635.
			1057.1	100	4	38214	3252.
			671.2	64	4	32578	2406.
			399.4	31.8	1.8	46929	7254.
			271.8	30.1	1.5	34624	5539.
					R_av	35028	1891.
89 Zr	c	78.41H	1713.0	0.74	0.01	525700	21356.
			909.2	99.04	0.03	499700	16268.
					R_av	502325	17540.
88 Zr	c	83.4D	1836.1	*****************		410770	14823.
			898.0	*****************		391930	14421.
			392.9	97.24	0.00	383480	12966.
					R_av	387412	12104.
87 Zr	c	1.68H	1227.0	1.0	0.3	737710	230067.
			380.8	99.87	0.00	256940	12280.
					R_av	257731	8052.
86 Zr	c	16.5H	2610.1	*****************		120870	16406.
			2568.0	*****************		116310	11893.
			1920.7	*****************		120790	7212.
			1801.7	*****************		123750	16678.
			1790.9	*****************		162710	43644.
			1724.2	*****************		129340	12555.
			1507.9	*****************		39623	92888.
			1415.2	*****************		11061	3039.
			1349.2	*****************		95054	11044.
			1270.2	*****************		168170	48453.
			1253.1	*****************		119840	18493.
			1153.1	*****************		96987	5081.
			1092.7	*****************		108970	21026.
			1076.6	*****************		107140	5339.
			1024.0	*****************		97125	9361.
			955.3	*****************		129300	20677.
			835.7	*****************		129250	24578.
			826.0	*****************		113580	20919.
			740.8	*****************		18907	11494.
			709.9	*****************		100520	7114.
			703.3	*****************		106120	6532.
			645.9	*****************		123710	16707.
			627.7	*****************		101850	5929.
			612.0	5.7	0.3	119960	11621.
			608.3	*****************		50587	12721.
			580.6	*****************		223650	20103.
			443.1	*****************		109790	5720.
			331.1	*****************		148390	60743.
			307.0	*****************		129540	12423.
			242.8	95.84	0.20	113960	4846.
					R_av	89184	8107.

85 Zr	c	7.86M	454.3	41.4	1.0	64279	3245
90mY	i(m)	3.19H	479.5	90.74	0.05	14112	646.
			202.5	97.3	0.4	15595	692.
					R_av	14824	874.
88 Y	i	106.65D	1836.1	99.2	0.3	151400	5331.
			898.0	93.7	0.3	142290	4857.
					R_av	145818	6360.
88 Y	c	106.65D	1836.1	99.2	0.3	562170	19803.
			898.0	93.7	0.3	534230	18285.
					R_av	545402	21856.
87mY	i(m)	13.37H	380.8	78.05	0.08	189640	9784
87mY	c	13.37H	380.8	78.05	0.08	446250	15450
87 Y	c	79.8H	484.8	89.7	0.7	577370	20203.
			388.5	82.1	0.5	579450	19836.
					R_av	578529	19061.
86 Y	i(m+g)	14.74H	2610.1	1.24	0.08	292330	35190.
			2568.0	2.25	0.11	286350	24880.
			1920.7	20.8	0.7	274730	15502.
			1801.7	1.65	0.05	297950	36957.
			1790.9	1.00	0.05	328400	99967.
			1724.2	0.55	0.05	259260	25162.
			1507.9	0.35	0.05	524220	131444.
			1415.2	0.33	0.09	527740	144967.
			1349.2	2.95	0.10	271670	20766.
			1270.2	0.65	0.10	807030	149770.
			1253.1	1.53	0.05	318140	32388.
			1153.1	30.5	1.0	290570	14478.
			1092.7	0.69	0.05	437150	54084.
			1076.6	82.5	0.4	270110	12539.
			1024.0	3.80	0.17	303540	22770.
			955.3	1.04	0.05	261890	39362.
			835.7	4.4	0.6	298000	48246.
			826.0	3.30	0.09	301950	48582.
			740.8	1.36	0.05	246550	22708.
			709.9	2.62	0.08	292090	15578.
			703.3	15.4	0.5	288510	14910.
			645.9	9.2	1.1	318520	40882.
			627.7	32.6	1.0	278590	14813.
			608.3	2.01	0.15	252400	28157.
			580.6	4.78	0.15	177220	27234.
			443.1	16.9	0.5	284070	13978.
			331.1	0.83	0.03	394710	126754.
			307.0	3.47	0.09	289190	17424.
					R_av	281347	10208.
86 Y	c	14.74H	2610.1	1.24	0.08	413210	38576.
			2568.0	2.25	0.11	402670	30128.
			1920.7	20.8	0.7	395520	20397.
			1801.7	1.65	0.05	421700	31850.
			1790.9	1.00	0.05	491110	67566.
			1724.2	0.55	0.05	388610	37717.
			1696.2	0.64	0.02	608850	61868.
			1533.2	0.22	0.04	692200	228645.
			1507.9	0.35	0.05	563850	114160.
			1415.2	0.33	0.09	538800	147985.
			1349.2	2.95	0.10	366720	20451.
			1270.2	0.65	0.10	975200	161866.
			1253.1	1.53	0.05	437990	27502.
			1163.0	1.18	0.05	503570	88302.
			1153.1	30.5	1.0	387560	18531.
			1092.7	0.69	0.05	546120	50729.
			1076.6	82.5	0.4	377260	14704.
			1024.0	3.80	0.17	400660	24719.
			955.3	1.04	0.05	391190	32531.
			887.4	0.44	0.05	668210	130845.
			835.7	4.4	0.6	427250	61442.
			826.0	3.30	0.09	415530	34939.
			777.4	22.4	0.6	555480	33760.
			767.6	2.4	0.4	327890	61808.
			740.8	1.36	0.05	265450	17151.
			709.9	2.62	0.08	392620	18442.
			703.3	15.4	0.5	394640	18898.
			645.9	9.2	1.1	442240	55421.
			627.7	32.6	1.0	380450	18492.
			608.3	2.01	0.15	302990	26893.
			580.6	4.78	0.15	400870	24226.
			443.1	16.9	0.5	393860	18335.
			382.9	3.63	0.12	286680	20175.
			331.1	0.83	0.03	543100	74884.
			307.0	3.47	0.09	418730	20421.
			264.5	0.54	0.03	461430	62961.
			235.4	0.40	0.02	328110	63340.
			190.8	1.01	0.04	681060	52942.
			187.9	1.26	0.05	465750	38188.

					R_av	387064	15368.
86mY	i(m)	48M	208.1	93.7	0.7	159990	6863
85mY	c	4.86H	2172.1	2.27	0.21	152990	19955.
			2123.8	5.0	0.5	123650	15734.
			1892.2	1.78	0.18	180990	28433.
			1404.6	3.1	0.3	175300	21270.
			1261.9	0.65	0.06	199220	42146.
			1220.5	1.98	0.17	99769	12290.
			1123.2	1.78	0.16	151020	18406.
			1030.1	2.02	0.17	121270	26828.
			787.9	1.57	0.13	223530	36049.
			767.3	3.6	0.5	97272	27416.
			616.5	0.86	0.09	976760	154995.
			611.9	1.08	0.10	48227	65456.
			535.6	3.5	0.3	166710	17471.
			231.7	22.8	2.2	168480	18792.
					R_av	142108	13365.
85 Y	c	2.68H	913.9	9.0	0.8	63233	8536.
			231.9	*****************		64928	3225.
			151.2	*****************		48292	4085.
					R_av	60584	5443.
84 Y	c	39.5M	1502.9	5.8	0.6	124170	14091.
			1453.2	1.38	0.10	153590	22291.
			1262.5	3.5	0.4	51406	12327.
			1255.4	6.6	0.7	115000	14002.
			1143.9	3.3	0.3	99064	12703.
			1110.4	2.9	0.3	120070	22165.
			1039.8	56	6	122780	16604.
			1000.9	2.07	0.20	161550	26762.
			994.6	3.8	0.4	140540	17292.
			974.1	75	8	122170	13844.
			793.0	98.6	1.0	120670	4687.
			704.5	8.5	0.9	91792	11553.
			660.5	15.7	1.6	123380	13382.
			602.2	8.8	0.9	133480	15168.
			462.7	9.8	1.0	120880	17627.
					R_av	117804	5570.
85mSr	i(m)	67.63M	231.9	84.4	2.2	16480	880.
			151.2	12.9	0.7	23529	2433.
					R_av	17018	1946.
85mSr	c	67.63M	231.9	84.4	2.2	81408	3925.
			151.2	12.9	0.7	71821	5107.
					R_av	78551	5025.
83 Sr	c	32.41H	1952.1	0.8	0.4	332710	167198.
			1562.5	1.8	0.9	287050	144157.
			1237.7	0.21	0.10	236690	124403.
			1160.0	1.5	0.7	268270	126357.
			1147.3	1.3	0.6	283470	131376.
			1054.4	0.2	0.1	322610	164485.
			762.7	30	14	305410	142794.
			423.6	1.6	0.8	162430	84251.
			418.4	4.4	2.1	312250	149494.
			381.5	14	7	356150	178520.
					R_av	260791	42272.
82 Sr	c	25.55D	776.5	15.08	0.00	177490	5941
81 Sr	c	22.3M	720.8	3.5	0.5	54316	11080.
			443.3	17.5	2.2	54519	7512.
			188.3	15.4	2.0	57925	8932.
			153.5	34	5	73303	11738.
			147.8	30	4	76080	10999.
					R_av	61118	4813.
86 Rb	i(m+g)	18.631D	1077.0	8.64	0.04	2470	3023
84 Rb	i(m+g)	32.77D	1897.8	0.74	0.03	53044	4941.
			881.6	69.0	1.6	44970	1800.
					R_av	45416	2327.
84mRb	i(m)	20.26M	463.6	36.1	1.3	34267	4230.
			248.0	60.2	0.8	25898	1579.
			215.6	29.5	1.3	28354	1991.
					R_av	27284	1754.
83 Rb	c	86.2D	799.4	0.24	0.02	429570	43808.
			552.6	16.0	1.1	446530	34239.
			529.6	29.3	2.1	445270	35351.
			520.4	45	4	437330	41688.
					R_av	441238	22441.
82mRb	i(m)	6.472H	1474.9	15.5	0.3	152780	7061.
			1317.4	23.7	0.6	158430	6881.
			1081.3	1.31	0.05	160940	23952.

			1081.3	1.31	0.05	145660	24788.
			1073.0	0.73	0.05	299960	57983.
			1044.1	32.07	0.08	154910	5636.
			1007.6	7.17	0.09	156720	10000.
			952.0	0.64	0.05	227870	72473.
			827.8	21.0	0.6	159120	7962.
			776.5	84.39	0.21	99999	7445.
			698.4	26.3	0.7	158110	7580.
			619.1	37.98	0.10	153540	6463.
			606.4	2.01	0.06	136450	17622.
			554.3	62.4	0.9	161430	7353.
			183.3	2.13	0.05	181280	12030.
					R_av	153602	6170.
81 Rb	c	4.576H	537.6	2.23	0.17	302050	27562.
			456.7	3.02	0.12	319420	21754.
			446.1	23.2	0.9	307760	16762.
			357.4	0.76	0.03	262980	60626.
			190.5	64	2	339520	17402.
					R_av	319568	13010.
79 Rb	c	22.9M	688.1	23.1	1.2	81366	5462.
			622.2	8.8	0.5	62473	5091.
			397.6	6.1	0.4	82681	23362.
			350.6	7.2	0.4	91710	7943.
			182.8	19.2	1.1	87343	6350.
			160.8	8.6	0.5	88707	6904.
			154.8	7.9	0.5	84292	7372.
			143.4	13.9	0.8	94765	6629.
			129.7	10.7	0.6	165820	34204.
					R_av	82512	4912.
79 Kr	c	35.04H	1332.2	0.43	0.04	289870	33566.
			1115.1	0.37	0.04	152140	30573.
			832.0	1.26	0.08	342240	33198.
			397.5	9.3	0.5	272370	19686.
			306.5	2.60	0.13	239400	16739.
			299.5	1.54	0.09	266160	31799.
			261.3	12.7	0.4	257190	12758.
			217.1	2.37	0.13	270960	21117.
			208.5	0.77	0.06	347110	51092.
			136.1	0.85	0.12	296150	57955.
					R_av	259770	13531.
77 Kr	c	74.4M	311.9	3.7	0.5	125050	20025.
			276.0	2.92	0.18	117100	19883.
			129.6	81	2	97926	5252.
					R_av	99497	5210.
76 Kr	c	14.8H	2391.2	********	*********	29539	6472.
			2096.7	********	*********	7581	576.
			1853.7	********	*********	129440	10121.
			1471.1	********	*********	30128	8652.
			1454.1	********	*********	114470	58471.
			1380.5	********	*********	22559	11200.
			1216.1	********	*********	46093	6893.
			1213.1	********	*********	67519	24534.
			657.0	********	*********	20786	3218.
			563.2	********	*********	50601	14132.
			559.1	********	*********	26917	1471.
			406.5	12.1	1.4	34604	4834.
			315.7	39	5	31047	4199.
			271.6	4.3	0.5	55352	15957.
			270.2	21	3	30347	4617.
			252.0	6.2	0.9	68037	10952.
			199.8	1.17	0.14	26385	19056.
					R_av	12962	2733.
82 Br	i(m+g)	35.30H	1044.0	27.2	0.4	4690	721.
			952.0	0.37	0.02	173570	35474.
			827.8	24.0	0.4	13202	1774.
			776.5	83.5	1.2	10951	1267.
			698.4	28.5	0.4	4790	1109.
			619.1	43.4	0.6	4027	1231.
			606.4	1.21	0.01	1636100	61233.
					R_av	6525	9420.
77 Br	c	57.036H	1005.0	0.92	0.03	239780	13345.
			817.8	2.08	0.07	274920	14619.
			755.3	1.67	0.05	214100	11288.
			585.5	1.57	0.05	264770	15793.
			578.9	2.96	0.10	227100	14210.
			574.6	1.19	0.04	149370	24454.
			565.9	0.43	0.02	150440	13064.
			520.7	22.4	0.6	217990	10052.
			385.0	0.84	0.03	212940	14944.
			303.8	1.18	0.04	223310	12363.
			297.2	4.16	0.21	213330	13187.
			281.6	2.29	0.07	212240	11149.
			249.8	2.98	0.10	217070	11852.
			200.4	1.21	0.06	216130	14295.

			161.8	1.10	0.03	215610	12281.
					R_av	219197	9557.
76 Br	i(m+g)	16.2H	2391.2	4.7	0.4	138880	17066.
			2096.7	1.36	0.09	168230	12788.
			1853.7	14.7	0.9	494960	36232.
			1471.1	2.31	0.14	205470	20566.
			1454.1	0.80	0.05	18884	76282.
			1380.5	2.52	0.15	141550	23536.
			1216.1	8.8	0.5	118360	12553.
			1213.1	1.7	0.6	99422	36482.
			657.0	15.9	0.9	151430	10831.
			563.2	3.6	0.6	103160	25757.
			559.1	74	2	134360	6095.
					R_av	139061	10359.
76 Br	c	16.2H	2601.2	0.70	0.05	169260	32855.
			2510.8	1.95	0.13	190650	24915.
			2391.2	4.7	0.4	168420	17524.
			2135.6	0.94	0.08	194490	41740.
			2111.2	2.49	0.14	177150	22536.
			2096.7	1.36	0.09	175810	13365.
			1853.7	14.7	0.9	624410	44595.
			1568.5	0.96	0.08	165730	21104.
			1560.0	0.46	0.03	288730	71914.
			1471.1	2.31	0.14	235590	18540.
			1454.1	0.80	0.05	133350	32180.
			1439.4	0.58	0.04	225980	30123.
			1380.5	2.52	0.15	164110	15911.
			1228.7	2.09	0.11	175900	19681.
			1216.1	8.8	0.5	164460	12275.
			1213.1	1.7	0.6	166940	59352.
			1032.6	0.58	0.07	251430	70773.
			1029.9	0.57	0.07	198750	40205.
			882.3	0.41	0.03	354290	57118.
			657.0	15.9	0.9	172220	11631.
			563.2	3.6	0.6	153760	28328.
			559.1	74	2	161280	7128.
			472.9	1.86	0.10	179710	22933.
					R_av	173907	10552.
75 Br	c	96.7M	952.1	1.7	1.0	52922	44248.
			733.9	1.5	0.9	124410	81296.
			431.8	3.9	2.3	91730	54819.
			427.8	4	3	94738	71397.
			292.9	2.7	1.6	101120	61465.
			286.5	88	50	109390	62296.
			141.2	7	4	111650	66774.
			112.1	1.7	1.0	126380	76514.
					R_av	93230	21947.
74 Br	c	25.4M	634.2	14.1	2.0	11314	8907
74mBr	i(m)	46M	1508.0	0.22	0.05	649210	172304.
			1249.5	6.7	0.7	23135	3709.
			1080.5	0.46	0.10	667850	214637.
			839.0	5.1	0.6	42032	7234.
			728.3	35.6	1.9	26686	1872.
			634.3	16.4	2.3	161920	24379.
			219.0	5.02	0.19	43471	3988.
					R_av	29550	4993.
75 Se	c	119.779D	400.7	11.47	0.09	278260	9754.
			303.9	1.32	0.01	179780	12386.
			279.5	24.99	0.14	208570	7718.
			264.7	58.9	0.4	203100	7721.
			198.6	1.48	0.05	175440	11683.
			136.0	58.3	0.8	191100	16451.
			121.1	17.2	0.4	219080	9434.
					R_av	222620	15286.
73 Se	i(m+g)	7.15H	361.2	97	1	43879	6084
73 Se	c	7.15H	361.2	97	1	87752	3217
73mSe	c	39.8M	361.2	73.00	0.01	60100	10999
72 Se	c	8.40D	2621.5	*********	********	41566	3201.
			2201.7	*********	********	34038	1891.
			2109.6	*********	********	50146	6396.
			2105.9	*********	********	44661	5380.
			1475.9	*********	********	41264	15659.
			1464.0	*********	********	43483	3665.
			1050.8	*********	********	31138	3237.
			894.3	*********	********	37892	5580.
			834.0	*********	********	35279	1392.
			629.9	*********	********	35972	1587.
					R_av	35547	1237.
74 As	i	17.77D	634.8	15.4	1.1	32702	2585.
			608.4	0.55	0.02	126180	14156.

				595.8	59	4	32078	2432.
						R_av	33682	7867.
72	As	i	26.0H	2621.5	0.39	0.01	121110	14386.
				2201.7	0.48	0.02	177350	9849.
				2109.6	0.27	0.01	244750	75657.
				2105.9	0.64	0.03	65749	41267.
				1475.9	0.51	0.01	153390	35896.
				1464.0	1.11	0.03	98022	16632.
				1050.8	0.98	0.03	195640	15310.
				894.3	0.78	0.02	67387	62203.
				834.0	79.5	1.7	102320	4369.
				629.9	7.92	0.22	97629	4806.
						R_av	106887	7871.
72	As	c	26.0H	2621.5	0.39	0.01	162680	15442.
				2507.9	0.32	0.01	379490	70999.
				2201.7	0.48	0.02	211380	11739.
				2109.6	0.27	0.01	294890	73882.
				2105.9	0.64	0.03	110400	39389.
				1991.2	0.35	0.02	753040	188757.
				1475.9	0.51	0.01	194650	31457.
				1464.0	1.11	0.03	141500	16525.
				1050.8	0.98	0.03	226780	15620.
				894.3	0.78	0.02	105270	61082.
				834.0	79.5	1.7	137590	5633.
				629.9	7.92	0.22	133600	6205.
						R_av	146391	9764.
71	As	c	65.28H	1139.5	0.80	0.02	104700	8578.
				1095.5	4.08	0.12	82784	4076.
				920.5	0.30	0.01	99019	20773.
				499.9	3.62	0.09	65756	3521.
				326.8	3.03	0.08	90509	5622.
				174.9	82.0	2.1	87291	3870.
						R_av	80936	5405.
70	As	c*	52.6M	2020.0	17.2	1.9	30681	4057.
				2007.7	3.0	0.4	55239	18435.
				1707.9	18.4	2.0	32947	4295.
				1412.5	8.8	1.0	42911	6146.
				1339.4	9.2	1.0	32402	4954.
				1114.3	21.8	2.4	27602	3510.
				1099.3	4.5	0.5	221160	136461.
				1040.0	81	5	30520	6321.
				905.7	12.5	1.4	26126	3367.
				744.8	21.5	2.4	34969	4387.
				668.4	21.8	2.4	31428	4127.
				607.6	4.0	0.5	74093	16956.
						R_av	31385	2048.
69	Ge	c	39.05H	1891.5	0.48	0.07	53431	15056.
				1336.6	4.5	0.7	41344	7108.
				1106.8	36	4	52120	6073.
				872.0	11.9	1.6	59977	8352.
				574.1	13.3	1.9	72910	11294.
				318.6	1.55	0.21	115940	21918.
						R_av	54764	6376.
67	Ge	c	18.9M	167.0	84	5	6958	648
67	Ga	c	3.2612D	393.5	4.68	0.06	50450	17525.
				300.2	16.80	0.22	52721	2168.
				208.9	2.40	0.07	44513	5658.
				184.6	21.2	0.3	56968	2334.
						R_av	54340	2340.
66	Ga	c*	9.49H	1918.3	2.08	0.07	468150	97507.
				1232.3	0.51	0.02	1239500	261161.
				1039.2	36.9	1.1	28765	1495.
						R_av	28858	5597.
65	Ga	c	15.2M	115.1	54	13	6085	2042
65	Zn	c	244.26D	1115.6	50.60	0.24	43774	1486
58	Co	i(m+g)	70.86D	810.8	99.45	0.01	9115	306
57	Co	c	271.74D	136.5	10.68	0.08	222680	166634.
				122.1	85.60	0.17	5750	374.
						R_av	5751	464.
56	Co	c	77.233D	2598.5	17.3	0.3	1391	401.
				1771.3	15.47	0.14	1917	297.
				1238.3	66.9	0.6	2086	142.
				846.8	99.94	0.03	1422	130.
				787.7	0.32	0.01	881170	51039.
						R_av	1745	856.
59	Fe	c	44.472D	1099.2	56.5	1.9	933.1	138.9

54 Mn	i	312.11D	834.8	99.98	0.00	3329	987
52 Mn	c	5.591D	1434.1	100.0	0.6	933.8	44.3
			744.2	90.0	0.9	936.9	76.9
					R_av	934.3	42.0
48 V	c	15.9735D	1312.1	97.5	0.9	775.1	56.5
			983.5	100.0	0.3	719.2	35.3
					R_av	731.6	33.2
47 Sc	c	3.3492D	159.4	68.3	0.4	476.5	45.9
46 Sc	i(m+g)	83.79D	889.3	99.98	0.00	776.0	61.8
			889.3	99.98	0.00	670.3	118.8
					R_av	755.8	56.3
44mSc	i(m)	58.61H	270.9	86.7	0.3	1199	174
24 Na	c	14.9590H	1369.0	100	0	1179	247
7 Be	i	53.29D	477.6	10.52	0.06	11546	676

Table 10.48: Detailed reaction rates for residual nuclide production in ^{93}Nb at E_p=799 MeV used to determine their production cross sections.

Nuclide	Type	$T_{1/2}$	E_γ, KeV	Abundance, %		Reaction rate 10^{-20} s^{-1}	
93mMo	i(m)	6.85H	684.7	99.7	2.0	705.5	218.5
90 Mo	i	5.56H	2319.0	******************		4115	1428.
			2186.2	******************		2670	4070.
			941.5	5.5	0.7	6714	3762.
			371.3	******************		13212	22144.
			257.3	78	4	2895	249.
			122.4	64	4	2897	239.
					R_av	2918	183.
92mNb	i(m)	10.15D	1847.5	0.85	0.04	67762	4497.
			934.4	99.07	0.04	57346	1871.
			912.6	1.78	0.10	57361	3855.
					R_av	57530	2042.
91mNb	c	60.86D	1204.7	2.0	0.3	20435	3317.
			104.6	0.58	0.02	14388	2450.
					R_av	16528	2937.
90 Nb	i(m+g)	14.60H	2319.0	82.0	0.3	75097	3549.
			2186.2	17.96	0.17	76567	5922.
			371.3	1.80	0.07	97680	30073.
					R_av	75523	3349.
90 Nb	c	14.60H	2319.0	82.0	0.3	79211	3430.
			2222.3	0.62	0.03	56472	21487.
			2186.2	17.96	0.17	79238	3752.
			1984.5	0.68	0.03	66741	7969.
			1913.2	1.28	0.02	80591	7756.
			1843.3	0.69	0.02	77905	15379.
			1611.8	2.38	0.07	78268	6012.
			1129.2	92.7	0.5	84604	2865.
			890.6	1.80	0.05	78633	7876.
			371.3	1.80	0.07	110890	11875.
			141.2	66.8	0.7	82360	3265.
			132.7	4.13	0.05	82250	4018.
					R_av	82691	2796.
89 Nb	c	2.03H	2572.3	2.7	0.6	35717	9147.
			1833.4	3.3	0.7	42410	9744.
			1627.2	3.5	0.7	54269	11407.
			1511.4	1.9	0.4	47527	11846.
			1259.0	1.2	0.3	45053	13349.
			920.5	1.4	0.4	66532	20438.
					R_av	45068	4868.
89mNb	i(m)	66M	588.0	95.1	0.5	5824	1034
88 Nb	c*	14.5M	1082.6	103	6	9954	730.
			1057.1	100	4	11291	883.
			671.2	64	4	9504	752.
			399.4	31.8	1.8	12932	2126.
			271.8	30.1	1.5	10283	899.
					R_av	10251	507.
89 Zr	c	78.41H	1713.0	0.74	0.01	164320	11257.
			909.2	99.04	0.03	157080	5127.
					R_av	157236	5128.
88 Zr	c	83.4D	1836.1	******************		122320	5071.
			898.0	******************		114990	4241.
			392.9	97.24	0.00	115190	3885.

					R_av	115518	3609.
87 Zr	c	1.68H	1227.0	1.0	0.3	213800	65634.
			1210.0	0.33	0.11	265070	97545.
			380.8	99.87	0.00	81980	3443.
					R_av	82246	2570.
86 Zr	c	16.5H	2610.1	*****************		23368	7350.
			2568.0	*****************		30316	6699.
			1920.7	*****************		35753	2641.
			1790.9	*****************		33472	6741.
			1696.2	*****************		29964	15326.
			1349.2	*****************		42636	3124.
			1253.1	*****************		29294	4600.
			1163.0	*****************		29496	4476.
			1153.1	*****************		29138	1493.
			1092.7	*****************		16528	9091.
			1076.6	*****************		27513	2557.
			1024.0	*****************		29296	2590.
			955.3	*****************		38314	9779.
			887.4	*****************		53455	19845.
			835.7	*****************		28879	4989.
			826.0	*****************		37921	2089.
			740.8	*****************		12347	7728.
			709.9	*****************		18264	7464.
			703.3	*****************		29126	2151.
			644.8	*****************		133280	25821.
			627.7	*****************		29680	1922.
			580.6	*****************		30629	4056.
			443.1	*****************		30189	1931.
			439.5	*****************		128870	116264.
			331.1	*****************		45873	4040.
			307.0	*****************		35095	4152.
			242.8	95.84	0.20	32039	1423.
			235.4	*****************		40408	12350.
					R_av	31664	1344.
85 Zr	c	7.86M	454.3	41.4	1.0	22381	1266
90mY	i(m)	3.19H	479.5	90.74	0.05	4949	221.
			202.5	97.3	0.4	5958	266.
					R_av	5361	523.
88 Y	i	106.65D	1836.1	99.2	0.3	50331	1937.
			898.0	93.7	0.3	47822	1670.
					R_av	48582	1906.
88 Y	c	106.65D	1836.1	99.2	0.3	172650	6349.
			898.0	93.7	0.3	162820	5520.
					R_av	165678	6835.
87mY	i(m)	13.37H	380.8	78.05	0.08	55771	2516
87mY	c	13.37H	380.8	78.05	0.08	137640	4698
87 Y	c	79.8H	484.8	89.7	0.7	177420	6206.
			388.5	82.1	0.5	177560	6069.
					R_av	177499	5845.
86 Y	i(m+g)	14.74H	2610.1	1.24	0.08	93116	14875.
			2568.0	2.25	0.11	68835	11950.
			1920.7	20.8	0.7	84930	5460.
			1790.9	1.00	0.05	103310	13598.
			1696.2	0.64	0.02	66183	29916.
			1349.2	2.95	0.10	72844	5670.
			1253.1	1.53	0.05	89349	9145.
			1163.0	1.18	0.05	111000	9954.
			1153.1	30.5	1.0	85337	4164.
			1092.7	0.69	0.05	115900	21740.
			1076.6	82.5	0.4	76507	5372.
			1024.0	3.80	0.17	93441	6419.
			955.3	1.04	0.05	73026	13144.
			887.4	0.44	0.05	136950	34714.
			835.7	4.4	0.6	99890	14650.
			826.0	3.30	0.09	78061	4082.
			740.8	1.36	0.05	51015	15406.
			709.9	2.62	0.08	89736	13276.
			703.3	15.4	0.5	88188	4876.
			644.8	2.2	0.4	436250	81616.
			627.7	32.6	1.0	82445	4499.
			580.6	4.78	0.15	85657	7343.
			443.1	16.9	0.5	88991	4772.
			439.5	0.20	0.07	479460	193236.
			331.1	0.83	0.03	93857	7056.
			307.0	3.47	0.09	102540	5951.
			235.4	0.40	0.02	67718	16942.
					R_av	85543	3386.
86 Y	c	14.74H	2610.1	1.24	0.08	116480	12681.
			2568.0	2.25	0.11	99150	10169.
			2088.1	0.25	0.03	300750	52600.

			1920.7	20.8	0.7	120680	6571.
			1801.7	1.65	0.05	150570	15235.
			1790.9	1.00	0.05	136780	11376.
			1724.2	0.55	0.05	107020	19299.
			1696.2	0.64	0.02	96147	18398.
			1507.9	0.35	0.05	125080	22722.
			1415.2	0.33	0.09	125280	38723.
			1349.2	2.95	0.10	115480	6275.
			1253.1	1.53	0.05	118640	7754.
			1163.0	1.18	0.05	140490	9321.
			1153.1	30.5	1.0	114470	5417.
			1092.7	0.69	0.05	132420	16040.
			1076.6	82.5	0.4	104020	5224.
			1024.0	3.80	0.17	122730	7244.
			971.4	0.27	0.04	82411	38050.
			955.3	1.04	0.05	111340	9489.
			887.4	0.44	0.05	190410	28743.
			835.7	4.4	0.6	128760	18263.
			826.0	3.30	0.09	115980	5149.
			777.4	22.4	0.6	141330	9869.
			767.6	2.4	0.4	70983	13647.
			740.8	1.36	0.05	63362	9720.
			709.9	2.62	0.08	108000	9118.
			703.3	15.4	0.5	117310	5759.
			644.8	2.2	0.4	569540	105592.
			627.7	32.6	1.0	112120	5522.
			608.3	2.01	0.15	77032	13943.
			580.6	4.78	0.15	116280	6800.
			443.1	16.9	0.5	119180	5762.
			439.5	0.20	0.07	608340	226536.
			426.0	0.30	0.02	109520	25017.
			331.1	0.83	0.03	139730	7526.
			307.0	3.47	0.09	137640	6827.
			235.4	0.40	0.02	108120	9017.
			190.8	1.01	0.04	210350	21296.
			187.9	1.26	0.05	122340	10295.
					R_av	117478	4533.
85mY	c	4.86H	2172.1	2.27	0.21	45799	6625.
			2123.8	5.0	0.5	38288	5111.
			1892.2	1.78	0.18	51018	7850.
			1220.5	1.98	0.17	36640	5991.
			1123.2	1.78	0.16	39718	10756.
			1030.1	2.02	0.17	40292	8507.
			787.9	1.57	0.13	68448	10434.
			767.3	3.6	0.5	34765	8655.
			616.5	0.86	0.09	278280	47391.
			611.9	1.08	0.10	100180	25945.
			535.6	3.5	0.3	49941	5415.
			231.7	22.8	2.2	49485	5611.
					R_av	45493	4348.
85 Y	c	2.68H	913.9	9.0	0.8	18538	2077.
			504.4	60	4	23916	2555.
			231.9	*****************		19806	1132.
			151.2	*****************		17036	1239.
					R_av	19028	1201.
84 Y	c	39.5M	1502.9	5.8	0.6	36237	4407.
			1453.2	1.38	0.10	52035	8859.
			1262.5	3.5	0.4	24519	3577.
			1255.4	6.6	0.7	29989	3549.
			1143.9	3.3	0.3	37535	7693.
			1119.7	1.68	0.20	24625	12911.
			1110.4	2.9	0.3	27972	7868.
			1039.8	56	6	34670	7936.
			1000.9	2.07	0.20	47499	8026.
			994.6	3.8	0.4	32511	4859.
			974.1	75	8	36331	4148.
			793.0	98.6	1.0	36088	1389.
			704.5	8.5	0.9	22542	3914.
			680.4	5.1	0.5	28522	3945.
			660.5	15.7	1.6	36944	4238.
			602.2	8.8	0.9	37438	4595.
			462.7	9.8	1.0	42629	5846.
					R_av	34952	1496.
85mSr	i(m)	67.63M	231.9	84.4	2.2	5458	410.
			151.2	12.9	0.7	6138	668.
					R_av	5626	360.
85mSr	c	67.63M	231.9	84.4	2.2	25264	1319.
			151.2	12.9	0.7	23174	1578.
					R_av	24507	1263.
85 Sr	c	64.84D	514.0	96	4	147250	8007
83 Sr	c	32.41H	1952.1	0.8	0.4	93948	48173.
			1562.5	1.8	0.9	93697	47054.
			1237.7	0.21	0.10	58157	30919.
			1160.0	1.5	0.7	84165	39910.

			1147.3	1.3	0.6	80655	37558.
			762.7	30	14	94515	44221.
			423.6	1.6	0.8	81304	41092.
			418.4	4.4	2.1	99160	47463.
			381.2	2.5	1.2	605380	291367.
			290.0	0.44	0.21	65996	34357.
					R_av	80625	13413.
82 Sr	c	25.55D	776.5	15.08	0.00	54950	1848
81 Sr	c	22.3M	574.7	6.7	0.9	22688	4280.
			443.3	17.5	2.2	16534	2589.
			188.3	15.4	2.0	21403	3383.
			153.5	34	5	22525	3430.
			147.8	30	4	26159	3710.
					R_av	20932	1838.
80 Sr	c	106.3M	589.0	39	5	6366	2351
86 Rb	i(m+g)	18.631D	1077.0	8.64	0.04	1778	1701
84 Rb	i(m+g)	32.77D	1897.8	0.74	0.03	20760	3096.
			881.6	69.0	1.6	15369	615.
					R_av	15455	829.
84mRb	i(m)	20.26M	463.6	36.1	1.3	11129	1514.
			248.0	60.2	0.8	9604	511.
			215.6	29.5	1.3	9911	688.
					R_av	9773	453.
83 Rb	c	86.2D	799.4	0.24	0.02	132350	15807.
			552.6	16.0	1.1	140180	10748.
			529.6	29.3	2.1	139000	11029.
			520.4	45	4	137420	13086.
					R_av	138139	7137.
82mRb	i(m)	6.472H	1474.9	15.5	0.3	46170	2892.
			1317.4	23.7	0.6	50397	2410.
			1081.3	1.31	0.05	49389	11843.
			1073.0	0.73	0.05	90686	11409.
			1044.1	32.07	0.08	50276	1731.
			1007.6	7.17	0.09	50168	2196.
			827.8	21.0	0.6	54093	2721.
			776.5	84.39	0.21	38770	2414.
			698.4	26.3	0.7	51723	2414.
			619.1	37.98	0.10	51465	1981.
			606.4	2.01	0.06	53233	6676.
			554.3	62.4	0.9	53528	2587.
			221.5	2.07	0.05	48343	6162.
			183.3	2.13	0.05	41867	3156.
					R_av	50071	1863.
81 Rb	c	4.576H	977.2	0.56	0.02	96609	14130.
			803.7	0.83	0.03	57083	12538.
			537.6	2.23	0.17	95984	9569.
			456.7	3.02	0.12	101970	7199.
			446.1	23.2	0.9	100290	5431.
			190.5	64	2	107290	5583.
					R_av	100555	5471.
79 Rb	c	22.9M	688.1	23.1	1.2	27160	1873.
			622.2	8.8	0.5	15913	1946.
			397.6	6.1	0.4	19611	5837.
			350.6	7.2	0.4	28183	3642.
			182.8	19.2	1.1	31146	2270.
			160.8	8.6	0.5	31410	2529.
			154.8	7.9	0.5	29444	2430.
			143.4	13.9	0.8	32457	2302.
			129.7	10.7	0.6	51040	10433.
					R_av	27681	2182.
79 Kr	c	35.04H	1115.1	0.37	0.04	62854	12286.
			832.0	1.26	0.08	85123	14457.
			397.5	9.3	0.5	82831	6013.
			306.5	2.60	0.13	80652	6202.
			299.5	1.54	0.09	93527	9317.
			261.3	12.7	0.4	89539	4419.
			217.1	2.37	0.13	78765	7362.
			136.1	0.85	0.12	49561	11219.
					R_av	83633	4358.
77 Kr	c	74.4M	311.9	3.7	0.5	43045	6435.
			276.0	2.92	0.18	36161	4351.
			239.0	92.5	0.0	61559	30376.
			129.6	81	2	37146	1916.
					R_av	37341	1167.
76 Kr	c	14.8H	2510.8******************			8114	5205.
			2391.2******************			9049	4286.
			2096.7******************			1686	6609.
			1853.7******************			35545	2654.

			1228.7	*****************		7178	5273.
			1216.1	*****************		14768	1830.
			1213.1	*****************		26628	9746.
			657.0	*****************		5582	1115.
			563.2	*****************		15851	3517.
			559.1	*****************		9845	589.
			451.9	9.8	1.3	12477	2269.
			406.5	12.1	1.4	9989	1454.
			355.3	4.7	0.9	10727	2555.
			315.7	39	5	11725	1590.
			271.6	4.3	0.5	14104	4252.
			270.2	21	3	12851	2064.
			252.0	6.2	0.9	20043	3222.
					R_av	10663	1169.
82 Br	i(m+g)	35.30H	1317.5	26.5	0.4	1435	253.
			1044.0	27.2	0.4	1422	132.
			952.0	0.37	0.02	86427	16772.
			827.8	24.0	0.4	1765	342.
			776.5	83.5	1.2	4473	503.
			698.4	28.5	0.4	709.6	221.4
			606.4	1.21	0.01	557500	21557.
					R_av	1469	1704.
77 Br	i(m+g)	57.036H	239.0	23.1	0.5	19195	26456
77 Br	c	57.036H	1005.0	0.92	0.03	72877	6335.
			817.8	2.08	0.07	102050	5836.
			755.3	1.67	0.05	74177	4805.
			585.5	1.57	0.05	91569	5703.
			578.9	2.96	0.10	80931	4180.
			574.6	1.19	0.04	38095	11736.
			565.9	0.43	0.02	68360	14872.
			520.7	22.4	0.6	80926	3576.
			439.5	1.56	0.05	82535	8417.
			385.0	0.84	0.03	73090	6629.
			303.8	1.18	0.04	77845	4959.
			297.2	4.16	0.21	79643	4970.
			281.6	2.29	0.07	77834	3889.
			249.8	2.98	0.10	79003	4181.
			239.0	23.1	0.5	76137	3411.
			200.4	1.21	0.06	84393	6691.
			161.8	1.10	0.03	85327	4171.
					R_av	80118	3043.
76 Br	i(m+g)	16.2H	2510.8	1.95	0.13	39771	10627.
			2391.2	4.7	0.4	44579	8431.
			2096.7	1.36	0.09	61561	13299.
			1853.7	14.7	0.9	163360	11633.
			1228.7	2.09	0.11	40758	7875.
			1216.1	8.8	0.5	51004	4179.
			1213.1	1.7	0.6	29286	11015.
			657.0	15.9	0.9	58987	4181.
			563.2	3.6	0.6	42698	8061.
			559.1	74	2	52266	2365.
					R_av	53030	3937.
76 Br	c	16.2H	2601.2	0.70	0.05	64673	7697.
			2510.8	1.95	0.13	47885	7254.
			2391.2	4.7	0.4	53628	6637.
			2135.6	0.94	0.08	78253	12630.
			2111.2	2.49	0.14	50363	9275.
			2096.7	1.36	0.09	63248	8620.
			1853.7	14.7	0.9	198910	14068.
			1568.5	0.96	0.08	66593	7729.
			1560.0	0.46	0.03	90425	18886.
			1454.1	0.80	0.05	58782	7488.
			1439.4	0.58	0.04	62814	11792.
			1380.5	2.52	0.15	60454	5402.
			1228.7	2.09	0.11	47936	4731.
			1216.1	8.8	0.5	65772	4592.
			1213.1	1.7	0.6	55914	19911.
			1032.6	0.58	0.07	76320	10835.
			1029.9	0.57	0.07	59482	14024.
			882.3	0.41	0.03	129150	15396.
			803.5	0.53	0.04	87671	14894.
			730.5	0.58	0.08	81835	14805.
			681.4	0.42	0.03	104480	20531.
			665.1	0.70	0.05	59620	9308.
			657.0	15.9	0.9	64569	4359.
			563.2	3.6	0.6	58548	10152.
			559.1	74	2	62111	2743.
			472.9	1.86	0.10	53332	4141.
					R_av	62317	3637.
75 Br	c	96.7M	952.1	1.7	1.0	44592	26614.
			733.9	1.5	0.9	44659	28022.
			427.8	4	3	37734	28393.
			377.4	3.9	2.3	41250	24431.
			292.9	2.7	1.6	41080	24651.
			286.5	88	50	43929	25015.

			141.2	7	4	41547	24322.
			112.1	1.7	1.0	47852	28706.
					R_av	42716	9310.
74 Br	c	25.4M	634.2	14.1	2.0	14505	6634
74mBr	i(m)	46M	1508.0	0.22	0.05	261270	71759.
			1249.5	6.7	0.7	10051	1409.
			1200.5	5.2	0.6	9064	2686.
			839.0	5.1	0.6	10650	2096.
			728.3	35.6	1.9	11001	784.
			634.3	16.4	2.3	63715	10121.
			219.0	5.02	0.19	20606	2252.
					R_av	11570	1824.
75 Se	c	119.779D	400.7	11.47	0.09	110450	3901.
			303.9	1.32	0.01	80026	4717.
			279.5	24.99	0.14	83309	3072.
			136.0	58.3	0.8	84628	3175.
			121.1	17.2	0.4	85275	3630.
					R_av	90424	6401.
73 Se	i(m+g)	7.15H	361.2	97	1	22732	2217
73 Se	c	7.15H	361.2	97	1	38133	1368
73mSe	c	39.8M	361.2	73.00	0.01	21098	3874
72 Se	c	8.40D	2621.5	*****************		17847	1872.
			2507.9	*****************		16280	2254.
			2248.5	*****************		19830	2036.
			2201.7	*****************		21832	1933.
			2109.6	*****************		20868	5658.
			2105.9	*****************		21877	2384.
			1991.2	*****************		39243	2843.
			1475.9	*****************		22865	8408.
			1464.0	*****************		20916	2109.
			894.3	*****************		18921	1520.
			834.0	*****************		16204	650.
			629.9	*****************		16137	743.
					R_av	16574	793.
74 As	i	17.77D	634.8	15.4	1.1	14180	1130.
			608.4	0.55	0.02	84074	15023.
			595.8	59	4	13998	1063.
					R_av	14243	2408.
72 As	i	26.0H	2621.5	0.39	0.01	32095	6453.
			2507.9	0.32	0.01	54244	6910.
			2248.5	0.32	0.01	53407	4798.
			2201.7	0.48	0.02	32005	6934.
			2109.6	0.27	0.01	158780	56979.
			2105.9	0.64	0.03	39134	9024.
			1991.2	0.35	0.02	35757	2591.
			1475.9	0.51	0.01	50539	26244.
			1464.0	1.11	0.03	29249	5317.
			894.3	0.78	0.02	50384	5362.
			834.0	79.5	1.7	45380	2053.
			629.9	7.92	0.22	42071	2158.
					R_av	42930	2067.
72 As	c	26.0H	2621.5	0.39	0.01	49942	6712.
			2507.9	0.32	0.01	70525	6917.
			2248.5	0.32	0.01	73237	5483.
			2201.7	0.48	0.02	53838	7007.
			2109.6	0.27	0.01	179650	54676.
			2105.9	0.64	0.03	61011	8959.
			1991.2	0.35	0.02	75000	5435.
			1475.9	0.51	0.01	73404	23633.
			1464.0	1.11	0.03	50165	5442.
			894.3	0.78	0.02	69305	5701.
			834.0	79.5	1.7	61585	2603.
			786.4	0.45	0.02	202180	58903.
			629.9	7.92	0.22	58208	2766.
					R_av	61546	2802.
71 As	c	65.28H	1139.5	0.80	0.02	42294	4651.
			1095.5	4.08	0.12	38433	2377.
			920.5	0.30	0.01	27127	7527.
			615.4	0.53	0.01	41967	11211.
			499.9	3.62	0.09	36614	2138.
			326.8	3.03	0.08	40357	2404.
			174.9	82.0	2.1	42196	1870.
					R_av	39876	1653.
70 As	c*	52.6M	2020.0	17.2	1.9	15671	2104.
			2007.7	3.0	0.4	23156	6130.
			1781.3	4.0	0.5	16993	3668.
			1707.9	18.4	2.0	15429	2251.
			1523.3	5.2	0.6	13701	2976.
			1412.5	8.8	1.0	16637	3048.

			1339.4	9.2	1.0	14759	2418.
			1332.2	0.63	0.13	195920	53882.
			1114.3	21.8	2.4	12943	1564.
			1099.3	4.5	0.5	14941	2718.
			1040.0	81	5	17463	4480.
			905.7	12.5	1.4	11100	1411.
			889.3	3.2	0.4	10331	7419.
			744.8	21.5	2.4	17381	2154.
			668.4	21.8	2.4	16712	2005.
					R_av	14514	959.
69 Ge	c	39.05H	1336.6	4.5	0.7	21084	3789.
			1106.8	36	4	27629	3226.
			872.0	11.9	1.6	31580	4391.
			574.1	13.3	1.9	38552	5863.
					R_av	27927	3226.
67 Ge	c	18.9M	167.0	84	5	4544	357
67 Ga	c	3.2612D	393.5	4.68	0.06	13590	4313.
			300.2	16.80	0.22	31617	1209.
			184.6	21.2	0.3	34173	1364.
					R_av	32350	2137.
66 Ga	c*	9.49H	2422.5	1.92	0.06	13689	3461.
			1918.3	2.08	0.07	120560	80771.
			1333.1	1.20	0.04	49001	14117.
			1232.3	0.51	0.02	36423	12797.
			1039.2	36.9	1.1	17012	958.
					R_av	17022	1339.
65 Ga	c	15.2M	115.1	54	13	5052	1250
65 Zn	c	244.26D	1115.6	50.60	0.24	29224	982
61 Cu	c	3.333H	283.0	12.2	2.3	7005	1551
60 Cu	c	23.7M	1791.6	45.4	2.4	1323	524
60 Co	i(m+g)	5.2714Y	1332.5	99.99	0.00	1551	1459.
			1173.2	99.97	0.00	2261	636.
					R_av	2148	584.
58 Co	i(m+g)	70.86D	810.8	99.45	0.01	8520	280
57 Co	c	271.74D	122.1	85.60	0.17	6009	231
56 Co	c	77.233D	2598.5	17.3	0.3	1624	126.
			2015.2	3.04	0.05	157990	14497.
			1963.7	0.72	0.01	235500	45956.
			1771.3	15.47	0.14	1452	96.
			1360.2	4.29	0.04	186940	10415.
			1238.3	66.9	0.6	2024	80.
			1037.8	14.17	0.13	1320	309.
			846.8	99.94	0.03	1527	62.
			787.7	0.32	0.01	270600	14563.
					R_av	1684	348.
59 Fe	c	44.472D	1291.6	43.2	1.4	786.8	57.3
			1099.2	56.5	1.9	675.9	48.3
					R_av	721.7	59.1
56 Mn	c	2.5789H	846.8	98.9	0.3	1011	162
54 Mn	i	312.11D	834.8	99.98	0.00	3818	404
52 Mn	c	5.591D	1434.1	100.0	0.6	1157	46.
			1333.7	5.07	0.06	2343	593.
			1246.3	4.21	0.07	90792	4225.
			935.5	94.5	1.0	1339	198.
			744.2	90.0	0.9	1022	44.
					R_av	1102	295.
52mMn	c	21.1M	1434.1	99.8	2.0	712.0	289.5
51 Cr	c	27.7025D	320.1	9.92	0.05	2718	204
48 V	c	15.9735D	2240.4	2.41	0.04	129600	10446.
			1312.1	97.5	0.9	964.4	44.2
			983.5	100.0	0.3	951.5	35.4
			944.1	7.76	0.10	1117	367.
					R_av	955.5	130.5
48 Sc	i	43.67H	1312.1	100.1	0.7	87.02	35.43
			1037.5	97.6	0.7	329.3	46.6
			983.5	100.1	0.6	76.71	43.41
					R_av	148.4	77.2
47 Sc	c	3.3492D	159.4	68.3	0.4	516.6	32.5
46 Sc	i(m+g)	83.79D	1120.6	99.99	0.00	1403	60.

			889.3	99.98	0.00	780.2	40.4
					R_av	1018	304.
44mSc	i(m)	58.61H	1157.0	1.20	0.07	37117	3123.
			1001.8	1.20	0.07	39242	8217.
			270.9	86.7	0.3	833.9	57.9
			270.9	86.7	0.3	810.2	105.0
					R_av	839.4	357.0
44 Sc	i	3.97H	1157.0	99.9	0.5	364.8	133.6
24 Na	c	14.9590H	1369.0	100	0	554.2	67.1
7 Be	i	53.29D	477.6	10.52	0.06	6598	374

Table 10.49: Detailed reaction rates for residual nuclide production in ^{93}Nb at E_p=1199 MeV used to determine their production cross sections.

Nuclide	Type	$T_{1/2}$	E_γ, KeV	Abundance, %		Reaction rate 10^{-20} s^{-1}	
93mMo	i(m)	6.85H	684.7	99.7	2.0	766.3	104.7
90 Mo	i	5.56H	2319.0	*********	*********	3981	838.
			2186.2	*********	*********	4891	2550.
			1611.8	*********	*********	25909	9238.
			941.5	5.5	0.7	10669	3713.
			371.3	*********	*********	26425	15660.
			257.3	78	4	2888	210.
			203.1	6.4	0.6	5842	3815.
			132.7	*********	*********	21334	6432.
			122.4	64	4	2841	271.
					R_av	2949	275.
92mNb	i(m)	10.15D	1847.5	0.85	0.04	79127	4977.
			934.4	99.07	0.04	72148	2365.
					R_av	72334	2524.
91mNb	c	60.86D	1204.7	2.0	0.3	26695	4181.
			104.6	0.58	0.02	16426	2171.
					R_av	18577	4219.
90 Nb	i(m+g)	14.60H	2319.0	82.0	0.3	81915	3583.
			2186.2	17.96	0.17	79785	4554.
			1611.8	2.38	0.07	56432	11733.
			371.3	1.80	0.07	101370	19597.
			132.7	4.13	0.05	59220	9134.
					R_av	79658	4174.
90 Nb	c	14.60H	2319.0	82.0	0.3	85897	3636.
			2222.3	0.62	0.03	108990	24886.
			2186.2	17.96	0.17	84676	3644.
			1913.2	1.28	0.02	94942	7135.
			1843.3	0.69	0.02	109100	12535.
			1611.8	2.38	0.07	82341	5742.
			1129.2	92.7	0.5	92035	3104.
			890.6	1.80	0.05	72365	8541.
			371.3	1.80	0.07	127790	9950.
			141.2	66.8	0.7	89246	3508.
			132.7	4.13	0.05	80554	4314.
					R_av	89456	3302.
89 Nb	c	2.03H	2572.3	2.7	0.6	41664	10073.
			1833.4	3.3	0.7	53896	11900.
			1627.2	3.5	0.7	53328	11126.
			1511.4	1.9	0.4	41730	10455.
			1259.0	1.2	0.3	39130	11898.
			920.5	1.4	0.4	77326	23724.
					R_av	46949	5002.
89mNb	i(m)	66M	588.0	95.1	0.5	7064	544.
			588.0	95.1	0.5	8997	373.
					R_av	8619	812.
88 Nb	c*	14.5M	1057.1	100	4	9286	792.
			671.2	64	4	9911	1130.
			399.4	31.8	1.8	10437	1401.
			271.8	30.1	1.5	8385	1643.
					R_av	9510	605.
89 Zr	c	78.41H	1713.0	0.74	0.01	182360	7719.
			909.2	99.04	0.03	171550	5586.
					R_av	172454	6163.
88 Zr	c	83.4D	1836.1	*********	*********	130120	4653.
			898.0	*********	*********	119860	4219.
			392.9	97.24	0.00	121750	4097.
					R_av	121953	3810.
87 Zr	c	1.68H	1227.0	1.0	0.3	248890	77023.

			380.8	99.87	0.00	75137	3749.
					R_av	75390	2355.
86 Zr	c	16.5H	2610.1	******************		35533	4274.
			2568.0	******************		34641	2966.
			1920.7	******************		32507	1875.
			1801.7	******************		34232	3520.
			1790.9	******************		20752	6216.
			1724.2	******************		83036	19252.
			1696.2	******************		8436	1578.
			1507.9	******************		26190	9943.
			1415.2	******************		35151	15596.
			1270.2	******************		40915	9210.
			1253.1	******************		35192	2977.
			1163.0	******************		37116	3768.
			1153.1	******************		28968	1491.
			1076.6	******************		29436	1075.
			1024.0	******************		26278	2585.
			971.4	******************		20521	3112.
			955.3	******************		26419	3141.
			887.4	******************		65566	14534.
			835.7	******************		28870	4673.
			826.0	******************		33406	3297.
			740.8	******************		7378	6128.
			709.9	******************		27312	3169.
			703.3	******************		30121	2156.
			644.8	******************		140450	26961.
			627.7	******************		29760	1552.
			612.0	5.7	0.3	30130	2396.
			443.1	******************		30518	1479.
			382.9	******************		15021	707.
			331.1	******************		48524	10323.
			307.0	******************		41795	8312.
			242.8	95.84	0.20	31819	1287.
					R_av	25348	1643.
85 Zr	c	7.86M	454.3	41.4	1.0	17361	1917
90mY	i(m)	3.19H	479.5	90.74	0.05	6649	265.
			202.5	97.3	0.4	7229	388.
					R_av	6772	318.
88 Y	i	106.65D	1836.1	99.2	0.3	57532	2030.
			898.0	93.7	0.3	55294	1888.
					R_av	56175	2068.
88 Y	c	106.65D	1836.1	99.2	0.3	187660	6573.
			898.0	93.7	0.3	175150	5832.
					R_av	179096	8069.
87mY	i(m)	13.37H	380.8	78.05	0.08	66180	3324
87mY	c	13.37H	380.8	78.05	0.08	141220	4831
87 Y	c	79.8H	484.8	89.7	0.7	185840	6501.
			388.5	82.1	0.5	186380	6368.
					R_av	186144	6129.
86 Y	i(m+g)	14.74H	2610.1	1.24	0.08	79072	9058.
			2568.0	2.25	0.11	83814	6640.
			1920.7	20.8	0.7	94000	5027.
			1801.7	1.65	0.05	101880	8338.
			1790.9	1.00	0.05	138590	20232.
			1724.2	0.55	0.05	8546	30101.
			1696.2	0.64	0.02	145200	7946.
			1507.9	0.35	0.05	126530	25554.
			1415.2	0.33	0.09	151860	50287.
			1270.2	0.65	0.10	294760	48975.
			1253.1	1.53	0.05	80564	6935.
			1163.0	1.18	0.05	109870	9540.
			1153.1	30.5	1.0	89993	4396.
			1076.6	82.5	0.4	88753	3085.
			1024.0	3.80	0.17	94962	7262.
			971.4	0.27	0.04	104020	15782.
			955.3	1.04	0.05	99646	8278.
			887.4	0.44	0.05	140120	29709.
			835.7	4.4	0.6	99824	14591.
			826.0	3.30	0.09	82388	6852.
			740.8	1.36	0.05	78835	13282.
			709.9	2.62	0.08	99259	7078.
			703.3	15.4	0.5	91492	5317.
			644.8	2.2	0.4	432810	81116.
			627.7	32.6	1.0	86745	4218.
			443.1	16.9	0.5	91169	4253.
			382.9	3.63	0.12	99750	4697.
			331.1	0.83	0.03	140810	21842.
			307.0	3.47	0.09	84405	10259.
					R_av	91596	3542.
86 Y	c	14.74H	2610.1	1.24	0.08	114600	10539.
			2568.0	2.25	0.11	118450	8584.

			2088.1	0.25	0.03	347090	71136.
			1920.7	20.8	0.7	126500	6392.
			1801.7	1.65	0.05	136110	8126.
			1790.9	1.00	0.05	159340	16536.
			1724.2	0.55	0.05	91582	20891.
			1696.2	0.64	0.02	153640	7545.
			1507.9	0.35	0.05	152720	26145.
			1415.2	0.33	0.09	187020	54818.
			1270.2	0.65	0.10	335680	54046.
			1253.1	1.53	0.05	115750	6857.
			1163.0	1.18	0.05	146980	9563.
			1153.1	30.5	1.0	118960	5636.
			1076.6	82.5	0.4	118180	3991.
			1024.0	3.80	0.17	121240	7678.
			971.4	0.27	0.04	124540	18893.
			955.3	1.04	0.05	126060	8466.
			887.4	0.44	0.05	205690	29825.
			835.7	4.4	0.6	128690	18263.
			826.0	3.30	0.09	115790	6441.
			777.4	22.4	0.6	153490	10352.
			767.6	2.4	0.4	59378	13825.
			740.8	1.36	0.05	86214	9731.
			709.9	2.62	0.08	126570	7034.
			703.3	15.4	0.5	121610	6120.
			644.8	2.2	0.4	573270	106399.
			627.7	32.6	1.0	116500	5434.
			608.3	2.01	0.15	81805	17265.
			443.1	16.9	0.5	121680	5552.
			382.9	3.63	0.12	114770	5404.
			331.1	0.83	0.03	189340	17054.
			307.0	3.47	0.09	126200	9593.
			264.5	0.54	0.03	136910	19019.
			235.4	0.40	0.02	125910	17971.
			190.8	1.01	0.04	200050	30643.
			187.9	1.26	0.05	138380	12641.
					R_av	121316	4436.
86mY	i(m)	48M	208.1	93.7	0.7	49583	2077
85mY	c	4.86H	2172.1	2.27	0.21	47284	7370.
			2123.8	5.0	0.5	45186	5231.
			1892.2	1.78	0.18	56584	8870.
			1356.3	0.53	0.05	87726	29119.
			1220.5	1.98	0.17	37865	4333.
			1123.2	1.78	0.16	42668	7278.
			1030.1	2.02	0.17	41508	6285.
			787.9	1.57	0.13	34729	6806.
			767.3	3.6	0.5	41956	8947.
			616.5	0.86	0.09	305420	44846.
			611.9	1.08	0.10	34302	8077.
			535.6	3.5	0.3	47560	5440.
			231.7	22.8	2.2	46085	5342.
					R_av	43493	3827.
85 Y	c	2.68H	504.4	60	4	22732	1933.
			231.9	*****************		20088	1047.
			151.2	*****************		17484	1418.
					R_av	19805	1250.
84 Y	c	39.5M	1502.9	5.8	0.6	36059	6933.
			1453.2	1.38	0.10	24646	12362.
			1262.5	3.5	0.4	19950	3531.
			1255.4	6.6	0.7	26521	3996.
			1143.9	3.3	0.3	31115	6516.
			1110.4	2.9	0.3	34129	8334.
			1039.8	56	6	33472	7142.
			1000.9	2.07	0.20	39007	6618.
			994.6	3.8	0.4	27875	4734.
			974.1	75	8	34130	3842.
			793.0	98.6	1.0	33717	1222.
			704.5	8.5	0.9	13907	4654.
			680.4	5.1	0.5	27184	4779.
			602.2	8.8	0.9	33887	3930.
			462.7	9.8	1.0	32670	5641.
					R_av	32761	1391.
85mSr	i(m)	67.63M	231.9	84.4	2.2	5876	416.
			151.2	12.9	0.7	5564	885.
					R_av	5830	378.
85mSr	c	67.63M	231.9	84.4	2.2	25964	1268.
			151.2	12.9	0.7	23048	1656.
					R_av	25091	1549.
85 Sr	c	64.84D	514.0	96	4	149210	8054
83 Sr	c	32.41H	1952.1	0.8	0.4	87407	44028.
			1562.5	1.8	0.9	97142	48727.
			1237.7	0.21	0.10	99104	49859.
			1160.0	1.5	0.7	97165	45484.
			1147.3	1.3	0.6	88183	40886.

			994.2	0.3	0.4	139910	187047.
			762.7	30	14	93010	43520.
			423.6	1.6	0.8	88655	44530.
			418.4	4.4	2.1	100690	48195.
			381.2	2.5	1.2	617750	297278.
			290.0	0.44	0.21	75235	39455.
					R_av	92441	14961.
82 Sr	c	25.55D	776.5	15.08	0.00	54473	1829
81 Sr	c	22.3M	574.7	6.7	0.9	27300	6435.
			443.3	17.5	2.2	12638	1944.
			188.3	15.4	2.0	19045	3444.
			153.5	34	5	21784	3449.
			147.8	30	4	23743	3489.
					R_av	17397	2560.
80 Sr	c	106.3M	589.0	39	5	4993	1178
86 Rb	i(m+g)	18.631D	1077.0	8.64	0.04	1958	278
84 Rb	i(m+g)	32.77D	1897.8	0.74	0.03	19759	1605.
			881.6	69.0	1.6	17163	687.
					R_av	17364	881.
84mRb	i(m)	20.26M	463.6	36.1	1.3	14018	2225.
			248.0	60.2	0.8	10178	606.
			215.6	29.5	1.3	9978	1423.
					R_av	10334	663.
83 Rb	c	86.2D	799.4	0.24	0.02	145780	14048.
			552.6	16.0	1.1	144030	11041.
			529.6	29.3	2.1	143350	11374.
			520.4	45	4	139290	13275.
					R_av	143177	7229.
82mRb	i(m)	6.472H	1474.9	15.5	0.3	51241	2152.
			1317.4	23.7	0.6	52857	2307.
			1081.3	1.31	0.05	52459	6957.
			1073.0	0.73	0.05	47274	9280.
			1044.1	32.07	0.08	51710	1765.
			1007.6	7.17	0.09	52529	2435.
			952.0	0.64	0.05	77529	17228.
			827.8	21.0	0.6	48264	2412.
			776.5	84.39	0.21	37790	2498.
			698.4	26.3	0.7	53677	2606.
			619.1	37.98	0.10	52399	1908.
			606.4	2.01	0.06	57562	8653.
			554.3	62.4	0.9	54469	2355.
			221.5	2.07	0.05	45986	7562.
			183.3	2.13	0.05	60977	4309.
					R_av	51623	1833.
81 Rb	c	4.576H	977.2	0.56	0.02	46807	23931.
			803.7	0.83	0.03	73710	17213.
			537.6	2.23	0.17	96328	8614.
			456.7	3.02	0.12	104880	6210.
			446.1	23.2	0.9	100130	5326.
			357.4	0.76	0.03	107720	11043.
			190.5	64	2	102520	6113.
					R_av	100673	4427.
79 Rb	c	22.9M	622.2	8.8	0.5	25928	2778.
			397.6	6.1	0.4	25134	5232.
			350.6	7.2	0.4	29615	4749.
			182.8	19.2	1.1	29612	2311.
			160.8	8.6	0.5	28386	4039.
			154.8	7.9	0.5	28055	2948.
			143.4	13.9	0.8	30592	2465.
			129.7	10.7	0.6	45651	8994.
					R_av	28989	1358.
79 Kr	c	35.04H	397.5	9.3	0.5	96771	6241.
			306.5	2.60	0.13	86679	8785.
			299.5	1.54	0.09	89428	11838.
			261.3	12.7	0.4	92369	4605.
			217.1	2.37	0.13	94851	6668.
			208.5	0.77	0.06	110120	13986.
			136.1	0.85	0.12	61888	11767.
					R_av	92276	4225.
77 Kr	c	74.4M	311.9	3.7	0.5	45036	6820.
			239.0	92.5	0.0	40579	29945.
			129.6	81	2	40508	1933.
					R_av	40645	1270.
76 Kr	c	14.8H	2510.8	*****************		23022	3888.
			2391.2	*****************		13600	2312.
			2096.7	*****************		12692	7046.
			1853.7	*****************		38293	2870.
			1568.5	*****************		19133	4371.

			1471.1	*****************		10858	1668.
			1454.1	*****************		21473	9222.
			1380.5	*****************		11389	2995.
			1216.1	*****************		20020	1704.
			1032.6	*****************		49601	14546.
			681.4	*****************		38248	2596.
			657.0	*****************		8657	1248.
			563.2	*****************		8798	2411.
			559.1	*****************		11193	620.
			472.9	*****************		8794	3370.
			451.9	9.8	1.3	13145	2297.
			406.5	12.1	1.4	11835	1571.
			355.3	4.7	0.9	11294	3758.
			315.7	39	5	13472	1851.
			271.6	4.3	0.5	9244	6183.
			270.2	21	3	18647	3046.
			252.0	6.2	0.9	24728	4365.
			199.8	1.17	0.14	4438	8412.
					R_av	12981	1343.
82 Br	i(m+g)	35.30H	1044.0	27.2	0.4	1288	100.
			952.0	0.37	0.02	43522	10670.
			827.8	24.0	0.4	3595	669.
			776.5	83.5	1.2	4653	489.
			698.4	28.5	0.4	988.8	263.8
			619.1	43.4	0.6	681.1	171.5
			606.4	1.21	0.01	575220	23567.
					R_av	1278	1195.
77 Br	i(m+g)	57.036H	239.0	23.1	0.5	46744	26208
77 Br	c	57.036H	1005.0	0.92	0.03	90623	4904.
			817.8	2.08	0.07	108370	5601.
			755.3	1.67	0.05	83966	4169.
			585.5	1.57	0.05	101160	5222.
			578.9	2.96	0.10	85880	4210.
			574.6	1.19	0.04	47086	11964.
			565.9	0.43	0.02	48337	4867.
			520.7	22.4	0.6	89691	4368.
			385.0	0.84	0.03	87845	5370.
			303.8	1.18	0.04	85602	5416.
			297.2	4.16	0.21	87980	5485.
			281.6	2.29	0.07	86976	4268.
			249.8	2.98	0.10	85978	4486.
			239.0	23.1	0.5	84280	3764.
			200.4	1.21	0.06	91046	6292.
			161.8	1.10	0.03	92512	4577.
					R_av	87003	3884.
76 Br	i(m+g)	16.2H	2510.8	1.95	0.13	30042	8173.
			2391.2	4.7	0.4	54225	6501.
			2096.7	1.36	0.09	44128	20662.
			1853.7	14.7	0.9	170150	12163.
			1568.5	0.96	0.08	47527	9205.
			1471.1	2.31	0.14	78818	6251.
			1454.1	0.80	0.05	69965	18867.
			1380.5	2.52	0.15	54271	7427.
			1216.1	8.8	0.5	52497	3997.
			1032.6	0.58	0.07	7289	34481.
			681.4	0.42	0.03	69435	4712.
			657.0	15.9	0.9	64304	4853.
			563.2	3.6	0.6	54139	9889.
			559.1	74	2	58318	2629.
			472.9	1.86	0.10	49021	7256.
					R_av	59460	3626.
76 Br	c	16.2H	2510.8	1.95	0.13	53064	6688.
			2391.2	4.7	0.4	67824	7026.
			2135.6	0.94	0.08	72228	10477.
			2111.2	2.49	0.14	61065	6545.
			2096.7	1.36	0.09	56820	14630.
			1853.7	14.7	0.9	208440	14760.
			1568.5	0.96	0.08	66660	7976.
			1560.0	0.46	0.03	100680	23059.
			1471.1	2.31	0.14	89676	6534.
			1454.1	0.80	0.05	91438	13756.
			1439.4	0.58	0.04	89705	15771.
			1380.5	2.52	0.15	65660	6177.
			1216.1	8.8	0.5	72517	4958.
			1032.6	0.58	0.07	56891	24380.
			1029.9	0.57	0.07	83929	15940.
			882.3	0.41	0.03	116720	25422.
			803.5	0.53	0.04	96966	17129.
			789.1	0.47	0.04	150460	31842.
			730.5	0.58	0.08	155900	31084.
			681.4	0.42	0.03	107680	7309.
			665.1	0.70	0.05	77570	11880.
			657.0	15.9	0.9	72962	5028.
			563.2	3.6	0.6	62938	10954.
			559.1	74	2	69511	3063.
			472.9	1.86	0.10	57814	5553.

					R_av	72922	4367.
75 Br	c	96.7M	952.1	1.7	1.0	38016	23278.
			897.6	0.5	0.3	166540	200862.
			733.9	1.5	0.9	54227	33250.
			431.8	3.9	2.3	45068	26744.
			427.8	4	3	44436	33497.
			377.4	3.9	2.3	49444	29318.
			292.9	2.7	1.6	43469	25983.
			286.5	88	50	50765	28920.
			141.2	7	4	43380	25533.
			112.1	1.7	1.0	55596	33152.
					R_av	46323	9486.
74 Br	c	25.4M	634.2	14.1	2.0	17251	9242
74mBr	i(m)	46M	1508.0	0.22	0.05	260850	75238.
			1269.1	8.8	0.4	13787	1907.
			1249.5	6.7	0.7	10769	1745.
			1080.5	0.46	0.10	48322	32512.
			839.0	5.1	0.6	14069	2480.
			728.3	35.6	1.9	13283	925.
			634.3	16.4	2.3	75384	11848.
			615.2	6.7	0.8	15716	3878.
			219.0	5.02	0.19	15674	4406.
					R_av	13387	1569.
75 Se	c	119.779D	400.7	11.47	0.09	131790	4638.
			303.9	1.32	0.01	98191	4893.
			279.5	24.99	0.14	98830	3655.
			264.7	58.9	0.4	96877	3676.
			198.6	1.48	0.05	92740	4925.
			136.0	58.3	0.8	96133	3872.
			121.1	17.2	0.4	101450	4317.
					R_av	104339	6450.
73 Se	i(m+g)	7.15H	361.2	97	1	34055	3392
73 Se	c	7.15H	361.2	97	1	48338	1737
73mSe	c	39.8M	361.2	73.00	0.01	19566	5820
72 Se	c	8.40D	2621.5	*****************		26008	1953.
			2507.9	*****************		15440	6951.
			2248.5	*****************		29974	2378.
			2201.7	*****************		26402	2695.
			2109.6	*****************		24389	2341.
			2105.9	*****************		28276	1889.
			1991.2	*****************		22653	4179.
			1475.9	*****************		29589	2863.
			1464.0	*****************		26706	1531.
			1050.8	*****************		19205	1347.
			894.3	*****************		25643	1736.
			834.0	*****************		21622	856.
			786.4	*****************		19031	2210.
			629.9	*****************		21739	961.
					R_av	22147	866.
74 As	i	17.77D	634.8	15.4	1.1	18517	1471.
			608.4	0.55	0.02	76668	13064.
			595.8	59	4	18206	1378.
					R_av	18648	2998.
72 As	i	26.0H	2621.5	0.39	0.01	50899	7173.
			2507.9	0.32	0.01	211150	37972.
			2248.5	0.32	0.01	28736	6981.
			2201.7	0.48	0.02	56053	10841.
			2109.6	0.27	0.01	183530	23212.
			2105.9	0.64	0.03	52237	5476.
			1991.2	0.35	0.02	41892	16249.
			1475.9	0.51	0.01	52653	7665.
			1464.0	1.11	0.03	55425	4720.
			1050.8	0.98	0.03	86405	5723.
			894.3	0.78	0.02	43819	6722.
			834.0	79.5	1.7	61165	2742.
			786.4	0.45	0.02	180260	72352.
			629.9	7.92	0.22	58229	2698.
					R_av	59369	3495.
72 As	c	26.0H	2621.5	0.39	0.01	76907	7734.
			2507.9	0.32	0.01	226590	35821.
			2248.5	0.32	0.01	58710	7232.
			2201.7	0.48	0.02	82455	10856.
			2109.6	0.27	0.01	207920	23406.
			2105.9	0.64	0.03	80513	6424.
			1991.2	0.35	0.02	64546	15988.
			1475.9	0.51	0.01	82242	7451.
			1464.0	1.11	0.03	82131	5217.
			1050.8	0.98	0.03	105600	6199.
			894.3	0.78	0.02	69462	6818.
			834.0	79.5	1.7	82787	3485.

			786.4	0.45	0.02	199290	71480.
			629.9	7.92	0.22	79967	3592.
					R_av	82217	4368.
71 As	c	65.28H	1139.5	0.80	0.02	59477	3120.
			1095.5	4.08	0.12	55712	2719.
			1026.5	0.31	0.01	67595	5504.
			920.5	0.30	0.01	65668	11658.
			615.4	0.53	0.01	52395	7710.
			499.9	3.62	0.09	48891	2254.
			326.8	3.03	0.08	59076	3078.
			174.9	82.0	2.1	58891	2611.
					R_av	55771	2540.
70 As	c*	52.6M	2020.0	17.2	1.9	23936	3050.
			2007.7	3.0	0.4	27211	8248.
			1781.3	4.0	0.5	25819	3972.
			1707.9	18.4	2.0	23475	2764.
			1523.3	5.2	0.6	21946	3274.
			1412.5	8.8	1.0	25430	3381.
			1339.4	9.2	1.0	24486	3126.
			1332.2	0.63	0.13	347800	89073.
			1114.3	21.8	2.4	17180	2146.
			1040.0	81	5	24028	3929.
			905.7	12.5	1.4	19807	2416.
			828.1	0.36	0.08	201350	79480.
			744.8	21.5	2.4	25330	3053.
			668.4	21.8	2.4	25381	3083.
			607.6	4.0	0.5	30932	14679.
					R_av	22619	1472.
69 Ge	c	39.05H	2023.7	0.54	0.08	36009	7166.
			1336.6	4.5	0.7	38471	6287.
			1106.8	36	4	43093	5032.
			872.0	11.9	1.6	49451	6860.
			574.1	13.3	1.9	56440	8481.
					R_av	43677	3440.
67 Ge	c	18.9M	167.0	84	5	6785	668
67 Ga	c	3.2612D	393.5	4.68	0.06	53602	3191.
			300.2	16.80	0.22	55626	2094.
			208.9	2.40	0.07	58292	3272.
			184.6	21.2	0.3	59493	2365.
					R_av	56913	2130.
66 Ga	c*	9.49H	2422.5	1.92	0.06	31368	8341.
			2189.6	5.58	0.18	29033	3456.
			1918.3	2.08	0.07	259000	71533.
			1333.1	1.20	0.04	51134	16452.
			1232.3	0.51	0.02	137010	74753.
			1039.2	36.9	1.1	32208	1570.
					R_av	32003	2147.
65 Ga	c	15.2M	115.1	54	13	8581	2119
65 Zn	c	244.26D	1115.6	50.60	0.24	57222	1925
62 Zn	c	9.186H	596.6	26	2	1107	460
61 Cu	c	3.333H	1185.2	3.7	0.7	11978	4763.
			656.0	10.8	2.0	7693	2151.
					R_av	8415	1967.
60 Cu	c	23.7M	1791.6	45.4	2.4	2719	462
57 Ni	c	35.60H	1377.6	81.7	2.4	431.9	43.3
62mCo	i(m)	13.91M	1172.9	97.7	0.5	1023	484.
			1163.5	68.0	0.9	18213	11673.
					R_av	1052	712.
60 Co	i(m+g)	5.2714Y	1332.5	99.99	0.00	7073	1304.
			1173.2	99.97	0.00	9727	584.
					R_av	9380	942.
58 Co	i(m+g)	70.86D	864.0	0.68	0.01	23118	2288.
			810.8	99.45	0.01	25213	824.
					R_av	25187	823.
57 Co	c	271.74D	136.5	10.68	0.08	65549	15327.
			122.1	85.60	0.17	19496	700.
					R_av	19520	1212.
56 Co	c	77.233D	2598.5	17.3	0.3	5573	310.
			2034.8	7.89	0.13	5506	277.
			2015.2	3.04	0.05	4709	627.
			1771.3	15.47	0.14	5610	232.
			1360.2	4.29	0.04	5730	522.
			1238.3	66.9	0.6	5479	194.
			1037.8	14.17	0.13	5162	220.

			846.8	99.94	0.03	5266	176.
			787.7	0.32	0.01	281630	14133.
					R_av	5362	429.
59 Fe	c	44.472D	1291.6	43.2	1.4	2017	112
56 Mn	c	2.5789H	2113.1	14.3	0.4	4355	1226.
			1810.7	27.2	0.8	4747	342.
			846.8	98.9	0.3	3324	189.
					R_av	3631	426.
54 Mn	i	312.11D	834.8	99.98	0.00	14490	578
52 Mn	c	5.591D	1434.1	100.0	0.6	4822	166.
			1333.7	5.07	0.06	6400	680.
			1246.3	4.21	0.07	5335	394.
			935.5	94.5	1.0	4077	413.
			744.2	90.0	0.9	4548	159.
					R_av	4703	183.
52mMn	c	21.1M	1434.1	99.8	2.0	671.7	226.8
51 Cr	c	27.7025D	320.1	9.92	0.05	12730	502
48 V	c	15.9735D	2240.4	2.41	0.04	4625	383.
			1312.1	97.5	0.9	4681	162.
			944.1	7.76	0.10	4670	223.
					R_av	4678	159.
48 Sc	i	43.67H	1312.1	100.1	0.7	492.0	38.9
			1037.5	97.6	0.7	694.1	31.4
					R_av	635.9	93.6
47 Sc	i	3.3492D	159.4	68.3	0.4	2021	81
47 Sc	c	3.3492D	159.4	68.3	0.4	2075	77
46 Sc	i(m+g)	83.79D	1120.6	99.99	0.00	4203	142.
			889.3	99.98	0.00	3703	131.
					R_av	3981	278.
44mSc	i(m)	58.61H	1157.0	1.20	0.07	195730	13441.
			270.9	86.7	0.3	2622	114.
					R_av	2630	1285.
44 Sc	i	3.97H	1157.0	99.9	0.5	1320	97
43 Sc	c	3.891H	372.8	22.5	0.7	2188	443
47 Ca	c	4.536D	1297.1	71	7	109.2	20.8
			159.4	******************		54.10	19.28
					R_av	79.88	27.62
43 K	c	22.3H	617.5	79.2	0.7	864.7	278.6
			372.8	86.8	0.2	1028	85.
					R_av	1016	82.
38 Cl	c	37.24M	2167.0	42.4	1.1	997.4	300.5
			1643.0	31.9	1.0	1261	436.
					R_av	1082	248.
24 Na	c	14.9590H	1369.0	100	0	2049	90
22 Na	c	2.6019Y	1274.5	99.94	0.01	1186	156
7 Be	i	53.29D	477.6	10.52	0.06	14870	556

Table 10.50: Detailed reaction rates for residual nuclide production in ^{93}Nb at E_p=1599 MeV used to determine their production cross sections.

Nuclide	Type	$T_{1/2}$	E_γ, KeV	Abundance, %		Reaction rate 10^{-20} s^{-1}	
93mMo	i(m)	6.85H	684.7	99.7	2.0	1293	130
90 Mo	i	5.56H	2319.0	******************		5705	900.
			2186.2	******************		8143	2406.
			1611.8	******************		7895	7092.
			941.5	5.5	0.7	14166	4846.
			371.3	******************		44527	13566.
			257.3	78	4	3785	283.
			203.1	6.4	0.6	12660	3962.
			141.2	******************		10167	4878.
			132.7	******************		51239	10216.
			122.4	64	4	3800	316.
					R_av	3977	459.
92mNb	i(m)	10.15D	1847.5	0.85	0.04	131480	9057.
			934.4	99.07	0.04	113930	3785.
			912.6	1.78	0.10	116360	8050.

					R_av	114426	4056.
91mNb	c	60.86D	1204.7	2.0	0.3	39296	6427.
			104.6	0.58	0.02	24917	7464.
					R_av	33266	7171.
90 Nb	i(m+g)	14.60H	2319.0	82.0	0.3	122770	5224.
			2186.2	17.96	0.17	121680	5568.
			1611.8	2.38	0.07	130700	10738.
			371.3	1.80	0.07	133540	17904.
			141.2	66.8	0.7	122570	7459.
			132.7	4.13	0.05	80516	12241.
					R_av	121426	5349.
90 Nb	c	14.60H	2319.0	82.0	0.3	128480	5413.
			2222.3	0.62	0.03	109730	15337.
			2186.2	17.96	0.17	129820	5319.
			1984.5	0.68	0.03	142380	19523.
			1913.2	1.28	0.02	149270	9141.
			1843.3	0.69	0.02	112220	14214.
			1611.8	2.38	0.07	138590	6818.
			1129.2	92.7	0.5	138340	4668.
			890.6	1.80	0.05	123030	7468.
			371.3	1.80	0.07	178070	10527.
			141.2	66.8	0.7	132740	5198.
			132.7	4.13	0.05	131750	6275.
					R_av	135222	4859.
89 Nb	c	2.03H	2572.3	2.7	0.6	58201	13821.
			1833.4	3.3	0.7	76351	16975.
			1627.2	3.5	0.7	80840	17360.
			1511.4	1.9	0.4	73809	16410.
			1259.0	1.2	0.3	65297	18822.
			920.5	1.4	0.4	104020	32192.
					R_av	71536	7437.
89mNb	i(m)	66M	588.0	95.1	0.5	11632	860
88 Nb	c*	14.5M	1082.6	103	6	13387	1053.
			1057.1	100	4	14927	1231.
			671.2	64	4	10191	1736.
			399.4	31.8	1.8	18813	2210.
			271.8	30.1	1.5	12524	1527.
					R_av	13697	1105.
89 Zr	c	78.41H	1713.0	0.74	0.01	277070	15422.
			909.2	99.04	0.03	255250	8324.
					R_av	255987	8917.
88 Zr	c	83.4D	1836.1	*****************		187380	6588.
			898.0	*****************		176540	6258.
			392.9	97.24	0.00	177090	5965.
					R_av	177778	5554.
87 Zr	c	1.68H	1227.0	1.0	0.3	344150	109189.
			1210.0	0.33	0.11	291510	115432.
			380.8	99.87	0.00	105520	4457.
					R_av	105828	3306.
86 Zr	c	16.5H	2610.1	*****************		42738	5693.
			2568.0	*****************		48190	4628.
			1920.7	*****************		48861	3752.
			1801.7	*****************		52885	5409.
			1790.9	*****************		43767	10082.
			1724.2	*****************		41646	23693.
			1696.2	*****************		59496	2849.
			1349.2	*****************		55861	5995.
			1270.2	*****************		38070	24776.
			1253.1	*****************		41251	4316.
			1163.0	*****************		56758	7555.
			1153.1	*****************		44102	2538.
			1092.7	*****************		27750	14085.
			1076.6	*****************		42756	1704.
			1024.0	*****************		40576	6157.
			971.4	*****************		155860	23647.
			955.3	*****************		59448	6378.
			887.4	*****************		128680	27205.
			835.7	*****************		47381	7851.
			826.0	*****************		51879	4342.
			740.8	*****************		19241	3746.
			709.9	*****************		47674	5592.
			703.3	*****************		42307	2528.
			644.8	*****************		218600	42094.
			627.7	*****************		45374	3714.
			612.0	5.7	0.3	37178	3271.
			608.3	*****************		9116	4344.
			580.6	*****************		40037	4785.
			443.1	*****************		43797	2258.
			382.9	*****************		16839	10053.
			331.1	*****************		97193	21013.
			307.0	*****************		65329	12781.

			242.8	95.84	0.20	43469	1878.
			235.4	******************		38241	10513.
					R_av	43892	2066.
90mY	i(m)	3.19H	479.5	90.74	0.05	9726	450.
			202.5	97.3	0.4	10374	520.
					R_av	9985	445.
88 Y	i	106.65D	1836.1	99.2	0.3	86834	3042.
			898.0	93.7	0.3	82562	2847.
					R_av	84417	3382.
88 Y	c	106.65D	1836.1	99.2	0.3	274220	9554.
			898.0	93.7	0.3	259100	8633.
					R_av	264166	10911.
87mY	i(m)	13.37H	380.8	78.05	0.08	99369	4073
87mY	c	13.37H	380.8	78.05	0.08	204760	6948
87 Y	c	79.8H	484.8	89.7	0.7	269750	9443.
			388.5	82.1	0.5	269030	9199.
					R_av	269343	8872.
86 Y	i(m+g)	14.74H	2610.1	1.24	0.08	135500	12916.
			2568.0	2.25	0.11	115620	9094.
			1920.7	20.8	0.7	128930	7275.
			1801.7	1.65	0.05	144600	9930.
			1790.9	1.00	0.05	163970	18641.
			1724.2	0.55	0.05	131190	35091.
			1696.2	0.64	0.02	112180	5613.
			1349.2	2.95	0.10	113760	10102.
			1270.2	0.65	0.10	383960	70527.
			1253.1	1.53	0.05	135560	8993.
			1163.0	1.18	0.05	167560	15848.
			1153.1	30.5	1.0	125850	6126.
			1092.7	0.69	0.05	154350	23981.
			1076.6	82.5	0.4	126740	4328.
			1024.0	3.80	0.17	141660	11578.
			971.4	0.27	0.04	17710	2686.
			955.3	1.04	0.05	102500	11750.
			887.4	0.44	0.05	127070	39843.
			835.7	4.4	0.6	143220	20848.
			826.0	3.30	0.09	101460	6903.
			740.8	1.36	0.05	79661	6373.
			709.9	2.62	0.08	132000	9003.
			703.3	15.4	0.5	133420	6491.
			644.8	2.2	0.4	608060	113278.
			627.7	32.6	1.0	121920	6586.
			608.3	2.01	0.15	116420	11170.
			580.6	4.78	0.15	129900	8444.
			443.1	16.9	0.5	131450	6078.
			382.9	3.63	0.12	144010	12547.
			331.1	0.83	0.03	124980	34435.
			307.0	3.47	0.09	133790	11428.
			235.4	0.40	0.02	132340	18247.
					R_av	108990	7957.
86 Y	c	14.74H	2610.1	1.24	0.08	178250	15258.
			2568.0	2.25	0.11	163820	11747.
			2088.1	0.25	0.03	324420	55667.
			1920.7	20.8	0.7	177790	9152.
			1801.7	1.65	0.05	197490	10255.
			1790.9	1.00	0.05	207730	15306.
			1724.2	0.55	0.05	172850	25464.
			1696.2	0.64	0.02	171680	7622.
			1533.2	0.22	0.04	198140	77109.
			1507.9	0.35	0.05	287020	49908.
			1415.2	0.33	0.09	179500	53930.
			1349.2	2.95	0.10	169630	9724.
			1270.2	0.65	0.10	422030	69670.
			1253.1	1.53	0.05	176820	9238.
			1163.0	1.18	0.05	224320	14470.
			1153.1	30.5	1.0	169960	8039.
			1092.7	0.69	0.05	182110	18409.
			1076.6	82.5	0.4	169500	5689.
			1024.0	3.80	0.17	182240	11310.
			971.4	0.27	0.04	173580	26330.
			955.3	1.04	0.05	161950	11542.
			887.4	0.44	0.05	255750	35939.
			835.7	4.4	0.6	190610	26954.
			826.0	3.30	0.09	153330	7243.
			783.6	0.26	0.04	251450	54673.
			777.4	22.4	0.6	215990	17652.
			767.6	2.4	0.4	116690	22553.
			740.8	1.36	0.05	98902	5642.
			709.9	2.62	0.08	179680	8985.
			703.3	15.4	0.5	175730	8267.
			644.8	2.2	0.4	826670	153122.
			627.7	32.6	1.0	167300	8197.
			608.3	2.01	0.15	125540	10789.

			580.6	4.78	0.15	169940	8768.
			443.1	16.9	0.5	175250	7970.
			426.0	0.30	0.02	165160	35824.
			382.9	3.63	0.12	160850	8968.
			331.1	0.83	0.03	222180	21414.
			307.0	3.47	0.09	199130	14407.
			264.5	0.54	0.03	175910	22342.
			235.4	0.40	0.02	170590	13674.
			190.8	1.01	0.04	271730	22499.
			187.9	1.26	0.05	167340	19179.
					R_av	167377	6452.
86mY	i(m)	48M	208.1	93.7	0.7	70802	3042
85mY	c	4.86H	2172.1	2.27	0.21	66777	12827.
			2123.8	5.0	0.5	49944	6049.
			1892.2	1.78	0.18	47092	14997.
			1892.2	1.78	0.18	39425	26746.
			1261.9	0.65	0.06	85016	39013.
			1220.5	1.98	0.17	52813	6345.
			1123.2	1.78	0.16	49366	7303.
			1030.1	2.02	0.17	50640	9680.
			816.8	0.78	0.08	84971	40760.
			787.9	1.57	0.13	57018	10550.
			767.3	3.6	0.5	41642	10693.
			616.5	0.86	0.09	228460	62050.
			611.9	1.08	0.10	58613	16574.
			535.6	3.5	0.3	63884	6404.
			231.7	22.8	2.2	68343	7949.
					R_av	55728	3339.
85 Y	c	2.68H	913.9	9.0	0.8	23199	3107.
			504.4	60	4	28155	2411.
			231.9	**********	*******	27091	1420.
			151.2	**********	*******	23496	1791.
					R_av	26086	1330.
84 Y	c	39.5M	1502.9	5.8	0.6	52979	6587.
			1453.2	1.38	0.10	69333	10183.
			1262.5	3.5	0.4	20724	6731.
			1255.4	6.6	0.7	40606	5496.
			1143.9	3.3	0.3	46971	6221.
			1119.7	1.68	0.20	67886	15415.
			1110.4	2.9	0.3	38378	7019.
			1039.8	56	6	47574	6971.
			1000.9	2.07	0.20	60879	22913.
			994.6	3.8	0.4	53553	7314.
			974.1	75	8	48715	5473.
			793.0	98.6	1.0	46966	1778.
			704.5	8.5	0.9	28638	4082.
			680.4	5.1	0.5	43701	5183.
			660.5	15.7	1.6	49556	5415.
			602.2	8.8	0.9	53659	6179.
			462.7	9.8	1.0	53749	7699.
					R_av	46132	2079.
85mSr	i(m)	67.63M	231.9	84.4	2.2	8817	512.
			151.2	12.9	0.7	8228	1252.
					R_av	8759	471.
85mSr	c	67.63M	231.9	84.4	2.2	35909	1788.
			151.2	12.9	0.7	31725	2276.
					R_av	34588	2225.
85 Sr	c	64.84D	514.0	96	4	202790	10911
83 Sr	c	32.41H	1952.1	0.8	0.4	123230	64097.
			1562.5	1.8	0.9	121510	61079.
			1237.7	0.21	0.10	99752	57059.
			1160.0	1.5	0.7	143850	67388.
			1147.3	1.3	0.6	128400	59615.
			994.2	0.3	0.4	217070	290373.
			762.7	30	14	129330	60524.
			423.6	1.6	0.8	127550	64374.
			418.4	4.4	2.1	140160	67112.
			381.2	2.5	1.2	840160	404386.
			290.0	0.44	0.21	166120	83728.
					R_av	130645	21463.
82 Sr	c	25.55D	776.5	15.08	0.00	74982	2607
81 Sr	c	22.3M	574.7	6.7	0.9	19612	4300.
			443.3	17.5	2.2	20629	2881.
			188.3	15.4	2.0	25289	4784.
			153.5	34	5	32422	4987.
					R_av	23038	2664.
80 Sr	c	106.3M	589.0	39	5	7953	1671
86 Rb	i(m+g)	18.631D	1077.0	8.64	0.04	3366	494

84 Rb	i(m+g)	32.77D	1897.8	0.74	0.03	23953	3278.
			881.6	69.0	1.6	25380	1016.
					R_av	25326	1007.
84mRb	i(m)	20.26M	463.6	36.1	1.3	15710	1966.
			248.0	60.2	0.8	13899	851.
			215.6	29.5	1.3	15902	1392.
					R_av	14515	784.
83 Rb	c	86.2D	799.4	0.24	0.02	199250	21805.
			552.6	16.0	1.1	201370	15450.
			529.6	29.3	2.1	200580	15912.
			520.4	45	4	198810	18934.
					R_av	200275	10263.
82mRb	i(m)	6.472H	1474.9	15.5	0.3	74301	3101.
			1317.4	23.7	0.6	73141	3164.
			1081.3	1.31	0.05	89145	9277.
			1044.1	32.07	0.08	73981	2507.
			1007.6	7.17	0.09	78155	3495.
			952.0	0.64	0.05	136580	37962.
			827.8	21.0	0.6	66445	3172.
			776.5	84.39	0.21	54908	3922.
			698.4	26.3	0.7	75799	3502.
			619.1	37.98	0.10	76005	2812.
			606.4	2.01	0.06	67274	8327.
			554.3	62.4	0.9	76454	3422.
			221.5	2.07	0.05	84850	8721.
			183.3	2.13	0.05	82622	4941.
					R_av	74010	2635.
81 Rb	c	4.576H	977.2	0.56	0.02	136750	32540.
			803.7	0.83	0.03	126790	27049.
			537.6	2.23	0.17	145750	16172.
			456.7	3.02	0.12	132570	8551.
			446.1	23.2	0.9	140660	7427.
			190.5	64	2	156160	7799.
					R_av	144093	6182.
79 Rb	c	22.9M	688.1	23.1	1.2	37566	2523.
			622.2	8.8	0.5	27601	2412.
			397.6	6.1	0.4	30116	5493.
			384.1	1.18	0.10	48223	28617.
			350.6	7.2	0.4	42165	4540.
			182.8	19.2	1.1	41809	3094.
			160.8	8.6	0.5	40670	4096.
			154.8	7.9	0.5	38076	3587.
			147.1	10.5	0.6	83397	8233.
			143.4	13.9	0.8	40604	2928.
			129.7	10.7	0.6	84205	10528.
					R_av	38068	3069.
79 Kr	c	35.04H	832.0	1.26	0.08	139420	16857.
			397.5	9.3	0.5	130880	8724.
			306.5	2.60	0.13	123550	16219.
			299.5	1.54	0.09	141440	22425.
			261.3	12.7	0.4	130380	6533.
			217.1	2.37	0.13	127550	10097.
			208.5	0.77	0.06	175150	28577.
			136.1	0.85	0.12	176460	30552.
					R_av	131809	5442.
77 Kr	c	74.4M	311.9	3.7	0.5	56218	8698.
			239.0	92.5	0.0	65370	31102.
			129.6	81	2	52721	2443.
					R_av	52856	1651.
76 Kr	c	14.8H	2510.8	*********	********	11225	6020.
			2391.2	*********	********	12686	2225.
			2096.7	*********	********	12933	5460.
			1853.7	*********	********	51063	5310.
			1769.9	*********	********	53208	126410.
			1471.1	*********	********	22141	5766.
			1454.1	*********	********	11063	7500.
			1439.4	*********	********	13007	22363.
			1380.5	*********	********	17057	4781.
			1228.7	*********	********	2642	10460.
			1216.1	*********	********	28241	2981.
			1213.1	*********	********	20044	11765.
			1032.6	*********	********	39833	8626.
			730.5	*********	********	3401	6374.
			681.4	*********	********	79510	25253.
			657.0	*********	********	14835	2195.
			563.2	*********	********	11226	4668.
			559.1	*********	********	16841	956.
			472.9	*********	********	25968	8841.
			451.9	9.8	1.3	15973	2436.
			406.5	12.1	1.4	16785	2358.
			355.3	4.7	0.9	9300	5005.
			315.7	39	5	18185	2426.
			271.6	4.3	0.5	74957	31909.

			270.2	21	3	21464	3295.
			252.0	6.2	0.9	30132	5266.
			199.8	1.17	0.14	16166	6697.
					R_av	17349	1168.
82 Br	i(m+g)	35.30H	1044.0	27.2	0.4	2250	233.
			952.0	0.37	0.02	85902	17847.
			827.8	24.0	0.4	5018	608.
			776.5	83.5	1.2	5278	1232.
			698.4	28.5	0.4	1733	469.
			619.1	43.4	0.6	527.0	364.6
					R_av	2110	643.
77 Br	i(m+g)	57.036H	239.0	23.1	0.5	58015	27176
77 Br	c	57.036H	1005.0	0.92	0.03	119670	8381.
			817.8	2.08	0.07	151210	9800.
			755.3	1.67	0.05	115140	6551.
			585.5	1.57	0.05	149050	8688.
			578.9	2.96	0.10	124270	6380.
			574.6	1.19	0.04	83352	18698.
			565.9	0.43	0.02	80719	24729.
			520.7	22.4	0.6	122130	5815.
			385.0	0.84	0.03	108930	9541.
			303.8	1.18	0.04	122100	11556.
			297.2	4.16	0.21	123790	7979.
			281.6	2.29	0.07	121900	7155.
			249.8	2.98	0.10	119460	6459.
			239.0	23.1	0.5	118480	5261.
			200.4	1.21	0.06	130150	9249.
			161.8	1.10	0.03	131520	9650.
					R_av	122818	4647.
76 Br	i(m+g)	16.2H	2510.8	1.95	0.13	87650	12412.
			2391.2	4.7	0.4	84841	8577.
			2096.7	1.36	0.09	81927	12249.
			1853.7	14.7	0.9	244760	18051.
			1769.9	0.21	0.21	371880	398456.
			1471.1	2.31	0.14	105300	11061.
			1454.1	0.80	0.05	82582	10720.
			1439.4	0.58	0.04	93081	37364.
			1380.5	2.52	0.15	73123	9634.
			1228.7	2.09	0.11	90956	16635.
			1216.1	8.8	0.5	74483	5784.
			1213.1	1.7	0.6	61738	24101.
			1032.6	0.58	0.07	69040	15410.
			730.5	0.58	0.08	142500	22912.
			681.4	0.42	0.03	48357	37708.
			657.0	15.9	0.9	88109	6546.
			563.2	3.6	0.6	79483	14774.
			559.1	74	2	81763	3613.
			472.9	1.86	0.10	55210	10442.
					R_av	82604	4135.
76 Br	c	16.2H	2601.2	0.70	0.05	93463	13788.
			2510.8	1.95	0.13	98874	10030.
			2391.2	4.7	0.4	97527	9475.
			2135.6	0.94	0.08	106490	13270.
			2096.7	1.36	0.09	94860	9215.
			1853.7	14.7	0.9	295830	21206.
			1769.9	0.21	0.21	425090	431488.
			1568.5	0.96	0.08	113830	11728.
			1560.0	0.46	0.03	148620	26863.
			1471.1	2.31	0.14	127440	10024.
			1454.1	0.80	0.05	93645	8093.
			1439.4	0.58	0.04	106080	21230.
			1380.5	2.52	0.15	90180	7754.
			1228.7	2.09	0.11	93598	10047.
			1216.1	8.8	0.5	102720	7013.
			1213.1	1.7	0.6	81782	29771.
			1032.6	0.58	0.07	108870	15156.
			1029.9	0.57	0.07	109610	18052.
			882.3	0.41	0.03	199690	23516.
			789.1	0.47	0.04	148770	28640.
			730.5	0.58	0.08	145900	21334.
			681.4	0.42	0.03	127860	20158.
			665.1	0.70	0.05	79752	11326.
			657.0	15.9	0.9	102940	6948.
			563.2	3.6	0.6	90709	15776.
			559.1	74	2	98605	4312.
			472.9	1.86	0.10	81177	6211.
					R_av	100779	5366.
75 Br	c	96.7M	952.1	1.7	1.0	42249	28478.
			897.6	0.5	0.3	248500	247312.
			733.9	1.5	0.9	80037	50018.
			431.8	3.9	2.3	63248	37588.
			427.8	4	3	57996	43725.
			377.4	3.9	2.3	66169	39190.
			292.9	2.7	1.6	65182	39838.
			286.5	88	50	72234	41137.

			141.2	7	4	87216	51277.
			112.1	1.7	1.0	73563	44295.
					R_av	63942	13446.
74 Br	c	25.4M	634.2	14.1	2.0	18440	9874
74mBr	i(m)	46M	1269.1	8.8	0.4	23461	2619.
			1249.5	6.7	0.7	17025	2266.
			1200.5	5.2	0.6	15252	3269.
			839.0	5.1	0.6	18098	3063.
			728.3	35.6	1.9	19206	1289.
			634.3	16.4	2.3	108740	17055.
			615.2	6.7	0.8	40100	6240.
			219.0	5.02	0.19	33264	2722.
					R_av	21055	2675.
75 Se	c	119.779D	400.7	11.47	0.09	186890	6563.
			303.9	1.32	0.01	135860	10327.
			279.5	24.99	0.14	141130	5204.
			264.7	58.9	0.4	137010	5202.
			198.6	1.48	0.05	135640	7650.
			136.0	58.3	0.8	135640	5898.
			121.1	17.2	0.4	143360	6099.
					R_av	149427	9388.
73 Se	i(m+g)	7.15H	361.2	97	1	42704	2774
73 Se	c	7.15H	361.2	97	1	69308	2448
73mSe	c	39.8M	361.2	73.00	0.01	36444	4474
72 Se	c	8.40D	2621.5	******************		39182	3334.
			2507.9	******************		34149	8719.
			2248.5	******************		34831	11996.
			2201.7	******************		37703	4478.
			2109.6	******************		28451	10664.
			2105.9	******************		43653	3012.
			1991.2	******************		25525	2469.
			1475.9	******************		39168	6041.
			1464.0	******************		42166	2783.
			1050.8	******************		30892	2041.
			894.3	******************		32858	2765.
			834.0	******************		31411	1246.
			786.4	******************		36265	8652.
			629.9	******************		31238	1391.
					R_av	31811	1206.
74 As	i	17.77D	634.8	15.4	1.1	27154	2163.
			608.4	0.55	0.02	63166	7578.
			595.8	59	4	26967	2043.
					R_av	28259	4671.
72 As	i	26.0H	2621.5	0.39	0.01	94140	10738.
			2507.9	0.32	0.01	110830	36103.
			2248.5	0.32	0.01	102020	23123.
			2201.7	0.48	0.02	131350	20983.
			2109.6	0.27	0.01	904910	99822.
			2105.9	0.64	0.03	74226	7996.
			1991.2	0.35	0.02	124710	10808.
			1475.9	0.51	0.01	96202	15147.
			1464.0	1.11	0.03	80302	6443.
			1050.8	0.98	0.03	132120	7591.
			894.3	0.78	0.02	83350	8374.
			834.0	79.5	1.7	95621	4022.
			786.4	0.45	0.02	78223	20237.
			629.9	7.92	0.22	89935	4071.
					R_av	94675	5363.
72 As	c	26.0H	2621.5	0.39	0.01	133320	12015.
			2507.9	0.32	0.01	144980	34763.
			2248.5	0.32	0.01	136850	24704.
			2201.7	0.48	0.02	169060	21361.
			2109.6	0.27	0.01	933360	100000.
			2105.9	0.64	0.03	117870	9543.
			1991.2	0.35	0.02	150240	12352.
			1475.9	0.51	0.01	135370	14539.
			1464.0	1.11	0.03	122460	7481.
			1050.8	0.98	0.03	163020	8669.
			894.3	0.78	0.02	116200	8898.
			834.0	79.5	1.7	127030	5172.
			786.4	0.45	0.02	114480	19406.
			629.9	7.92	0.22	121170	5388.
					R_av	128544	7025.
71 As	c	65.28H	1139.5	0.80	0.02	99171	7143.
			1095.5	4.08	0.12	79375	5036.
			920.5	0.30	0.01	90325	11620.
			615.4	0.53	0.01	120420	11902.
			499.9	3.62	0.09	71514	3665.
			326.8	3.03	0.08	91797	7115.
			174.9	82.0	2.1	88165	3909.

					R_av	83197	4976.
70 As	c*	52.6M	2020.0	17.2	1.9	36079	4355.
			2007.7	3.0	0.4	40399	8177.
			1781.3	4.0	0.5	37430	6365.
			1707.9	18.4	2.0	35105	4194.
			1523.3	5.2	0.6	42895	6085.
			1412.5	8.8	1.0	41265	5179.
			1339.4	9.2	1.0	34256	4298.
			1332.2	0.63	0.13	690080	163813.
			1114.3	21.8	2.4	29540	3533.
			1099.3	4.5	0.5	32713	13057.
			1040.0	81	5	36444	3866.
			905.7	12.5	1.4	29653	3713.
			828.1	0.36	0.08	234150	95180.
			744.8	21.5	2.4	37720	4560.
			668.4	21.8	2.4	39383	4595.
			607.6	4.0	0.5	53928	7537.
					R_av	35946	2253.
69 Ge	c	39.05H	1891.5	0.48	0.07	33144	18726.
			1336.6	4.5	0.7	57587	9394.
			1106.8	36	4	64965	7570.
			872.0	11.9	1.6	77450	10774.
			574.1	13.3	1.9	86665	12963.
					R_av	66412	6650.
67 Ge	c	18.9M	167.0	84	5	12448	1102
67 Ga	c	3.2612D	393.5	4.68	0.06	78943	28349.
			300.2	16.80	0.22	90020	3466.
			208.9	2.40	0.07	89063	6491.
			184.6	21.2	0.3	97267	3865.
					R_av	92755	3587.
66 Ga	c*	9.49H	2422.5	1.92	0.06	52220	6462.
			2189.6	5.58	0.18	52664	3394.
			1918.3	2.08	0.07	94723	31498.
			1333.1	1.20	0.04	56716	14222.
			1232.3	0.51	0.02	96538	33495.
			1039.2	36.9	1.1	55090	2490.
					R_av	54512	2258.
65 Ga	c	15.2M	751.8	8.1	1.6	18215	4850.
			115.1	54	13	14159	3492.
					R_av	15542	2854.
65 Zn	c	244.26D	1115.6	50.60	0.24	97638	3258
62 Zn	c	9.186H	596.6	26	2	4212	729.
			548.3	15.3	1.5	6926	1169.
					R_av	4973	1229.
61 Cu	c	3.333H	1185.2	3.7	0.7	29669	7058.
			656.0	10.8	2.0	14722	3484.
			283.0	12.2	2.3	27988	5481.
					R_av	20201	4856.
60 Cu	c	23.7M	1791.6	45.4	2.4	4955	491.
			826.4	21.7	1.1	6153	1095.
					R_av	5143	465.
57 Ni	c	35.60H	1377.6	81.7	2.4	1091	70
62mCo	i(m)	13.91M	1172.9	97.7	0.5	1787	435.
			1163.5	68.0	0.9	757.8	366.6
					R_av	1189	509.
60 Co	i(m+g)	5.2714Y	1332.5	99.99	0.00	14589	2264.
			1173.2	99.97	0.00	19325	1161.
					R_av	18535	1858.
58 Co	i(m+g)	70.86D	864.0	0.68	0.01	50248	4275.
			810.8	99.45	0.01	53148	1735.
					R_av	53102	1733.
57 Co	c	271.74D	136.5	10.68	0.08	111130	31576.
			122.1	85.60	0.17	43142	1538.
					R_av	43180	2095.
56 Co	c	77.233D	2598.5	17.3	0.3	12757	699.
			2034.8	7.89	0.13	12601	625.
			2015.2	3.04	0.05	12644	723.
			1963.7	0.72	0.01	10688	8943.
			1810.8	0.64	0.01	42843	35413.
			1771.3	15.47	0.14	12922	520.
			1360.2	4.29	0.04	13467	1254.
			1238.3	66.9	0.6	12592	450.
			1037.8	14.17	0.13	11592	519.
			846.8	99.94	0.03	12262	410.
			787.7	0.32	0.01	413770	26745.

					R_av	12407	686.
55 Co	c	17.53H	1316.6	7.1	0.4	5937	1303.
			931.1	75	4	1637	127.
			803.7	1.87	0.16	30672	5452.
			477.2	20.2	1.7	2796	911.
					R_av	1703	432.
59 Fe	c	44.472D	1291.6	43.2	1.4	4434	251.
			1099.2	56.5	1.9	4265	232.
					R_av	4341	196.
53 Fe	c*	8.51M	377.9	42	3	1268	704
56 Mn	c	2.5789H	1810.7	27.2	0.8	10649	1011.
			846.8	98.9	0.3	7559	382.
					R_av	7837	918.
54 Mn	i	312.11D	834.8	99.98	0.00	35772	1269
52 Mn	c	5.591D	1434.1	100.0	0.6	12838	451.
			1333.7	5.07	0.06	15667	1745.
			1246.3	4.21	0.07	12707	785.
			935.5	94.5	1.0	11668	1169.
			744.2	90.0	0.9	12056	425.
					R_av	12451	456.
52mMn	c	21.1M	1434.1	99.8	2.0	2684	397
51 Cr	c	27.7025D	320.1	9.92	0.05	35456	1450
49 Cr	c	42.3M	90.6	53.2	1.9	2830	433
48 Cr	c	21.56H	112.3	96.0	2.1	398.4	394.1
48 V	c	15.9735D	2240.4	2.41	0.04	14150	1035.
			1312.1	97.5	0.9	13966	485.
			983.5	100.0	0.3	13586	449.
			944.1	7.76	0.10	13565	665.
					R_av	13707	444.
48 Sc	i	43.67H	1312.1	100.1	0.7	1553	111.
			1212.9	2.38	0.05	18873	4502.
			1037.5	97.6	0.7	1780	94.
			983.5	100.1	0.6	1656	130.
					R_av	1691	143.
47 Sc	i	3.3492D	159.4	68.3	0.4	5866	347
47 Sc	c	3.3492D	159.4	68.3	0.4	6081	303
46 Sc	i(m+g)	83.79D	1120.6	99.99	0.00	12397	410.
			889.3	99.98	0.00	11491	380.
					R_av	11918	586.
44mSc	i(m)	58.61H	1157.0	98.61	0.01	7175	278.
			1001.8	1.20	0.07	8782	5730.
			270.9	86.7	0.3	8111	324.
					R_av	7548	401.
44 Sc	i	3.97H	1157.0	99.9	0.5	4252	244
44 Sc	i	3.97H	1157.0	99.9	0.5	11328	439
43 Sc	c	3.891H	372.8	22.5	0.7	4580	835
47 Ca	c	4.536D	1297.1	71	7	536.8	263.1
			159.4	******************		215.1	110.2
					R_av	263.1	114.9
43 K	c	22.3H	617.5	79.2	0.7	2164	549.
			372.8	86.8	0.2	3205	155.
					R_av	3158	237.
42 K	i	12.360H	1525.0	18.08	0.09	5848	645
41 Ar	c	109.34M	1294.0	99.1	0.0	1765	168
39 Cl	c	55.6M	1518.0	39.2	1.3	1288	412
38 Cl	c	37.24M	2167.0	42.4	1.1	3129	383
29 Al	c	6.56M	1273.3	90.6	0.6	2368	427
28 Mg	c	20.915H	1778.8	100.2	0.0	553.1	108.3
			1372.9	4.7	0.2	8954	1220.
			1342.2	52.6	1.6	1810	155.
			941.5	38.3	1.0	1224	220.
			400.7	36.6	1.0	1401	365.
					R_av	1081	381.

27 Mg	c	9.458M	843.8	71.8	0.4	1724	583
24 Na	c	14.9590H	1369.0	100	0	5954	226
22 Na	c	2.6019Y	1274.5	99.94	0.01	2179	419
7 Be	i	53.29D	477.6	10.52	0.06	34370	1313

Table 10.51: Detailed reaction rates for residual nuclide production in ^{93}Nb at E_p=2605 MeV used to determine their production cross sections.

Nuclide	Type	$T_{1/2}$	E_γ, KeV	Abundance, %		Reaction rate 10^{-20} s^{-1}	
93mMo	i(m)	6.85H	1477.1	99.1	2.5	1015	403.
			684.7	99.7	2.0	1433	183.
					R_av	1364	168.
90 Mo	i	5.56H	2319.0	*****************		3411	1959.
			2186.2	*****************		10199	4378.
			1913.2	*****************		33841	15264.
			1611.8	*****************		11471	11745.
			371.3	*****************		29833	20310.
			257.3	78	4	3864	272.
			203.1	6.4	0.6	11880	3922.
			141.2	*****************		6938	3081.
			132.7	*****************		40137	9247.
			122.4	64	4	3464	504.
					R_av	3868	409.
92mNb	i(m)	10.15D	1847.5	0.85	0.04	138040	8925.
			934.4	99.07	0.04	122720	4299.
			912.6	1.78	0.10	126160	8426.
					R_av	123767	4604.
91mNb	c	60.86D	1204.7	2.0	0.3	40923	6489.
			104.6	0.58	0.02	37013	3570.
					R_av	37873	3209.
90 Nb	i(m+g)	14.60H	2319.0	82.0	0.3	129160	5814.
			2186.2	17.96	0.17	125850	7121.
			1913.2	1.28	0.02	100320	19188.
			1611.8	2.38	0.07	131820	15735.
			371.3	1.80	0.07	144150	28233.
			141.2	66.8	0.7	132460	6240.
			132.7	4.13	0.05	91381	11521.
					R_av	127171	5646.
90 Nb	c	14.60H	2319.0	82.0	0.3	132570	5671.
			2222.3	0.62	0.03	125610	12378.
			2186.2	17.96	0.17	136050	5829.
			1984.5	0.68	0.03	118020	18688.
			1913.2	1.28	0.02	134160	7842.
			1843.3	0.69	0.02	131180	18015.
			1611.8	2.38	0.07	143290	8093.
			1129.2	92.7	0.5	142160	4800.
			890.6	1.80	0.05	97566	12206.
			371.3	1.80	0.07	173980	12040.
			141.2	66.8	0.7	139390	5235.
			132.7	4.13	0.05	131510	6215.
					R_av	138771	4860.
89 Nb	c	2.03H	2572.3	2.7	0.6	58393	13752.
			1833.4	3.3	0.7	75086	17069.
			1627.2	3.5	0.7	71488	15776.
			1511.4	1.9	0.4	59240	13488.
			1259.0	1.2	0.3	66883	20329.
			920.5	1.4	0.4	97164	29275.
					R_av	66648	7026.
89mNb	i(m)	66M	588.0	95.1	0.5	10311	624
88 Nb	c*	14.5M	1082.6	103	6	14441	1041.
			1057.1	100	4	14895	1094.
			671.2	64	4	14890	1477.
			399.4	31.8	1.8	17908	3521.
			271.8	30.1	1.5	14071	3300.
					R_av	14773	752.
89 Zr	c	78.41H	1713.0	0.74	0.01	285500	14980.
			909.2	99.04	0.03	258240	8447.
					R_av	259369	9755.
88 Zr	c	83.4D	1836.1	*****************		183730	6458.
			898.0	*****************		174760	5781.
			392.9	97.24	0.00	173890	5863.
					R_av	174679	5457.
87 Zr	c	1.68H	1227.0	1.0	0.3	312760	95661.
			1210.0	0.33	0.11	270600	94709.

			380.8	99.87	0.00	102510	5583.
					R_av	103387	3230.
86 Zr	c	16.5H	2610.1	******************		43388	8433.
			2568.0	******************		54798	5827.
			1920.7	******************		48341	3305.
			1801.7	******************		49426	6409.
			1790.9	******************		51422	12783.
			1724.2	******************		51855	15628.
			1696.2	******************		49602	10476.
			1507.9	******************		94158	29734.
			1349.2	******************		51031	6035.
			1270.2	******************		21650	11708.
			1253.1	******************		32528	7193.
			1163.0	******************		63411	11420.
			1153.1	******************		40075	2167.
			1092.7	******************		58882	6366.
			1076.6	******************		38914	1520.
			1024.0	******************		42656	5366.
			971.4	******************		34437	5223.
			955.3	******************		34290	12712.
			887.4	******************		76992	31565.
			835.7	******************		43689	6943.
			826.0	******************		43311	5030.
			740.8	******************		18116	6820.
			709.9	******************		60233	10694.
			703.3	******************		45258	2721.
			627.7	******************		40128	2236.
			612.0	5.7	0.3	32082	2479.
			608.3	******************		9664	7056.
			580.6	******************		36643	4523.
			443.1	******************		42265	2439.
			382.9	******************		27461	11928.
			331.1	******************		50839	11680.
			307.0	******************		49987	5161.
			242.8	95.84	0.20	40983	1722.
			235.4	******************		34706	5150.
					R_av	40376	1565.
90mY	i(m)	3.19H	479.5	90.74	0.05	9834	388.
			202.5	97.3	0.4	10990	541.
					R_av	10115	589.
88 Y	i	106.65D	1836.1	99.2	0.3	87293	3071.
			898.0	93.7	0.3	83321	2758.
					R_av	84488	3200.
88 Y	c	106.65D	1836.1	99.2	0.3	271020	9442.
			898.0	93.7	0.3	258080	8454.
					R_av	261576	9990.
87mY	i(m)	13.37H	380.8	78.05	0.08	95723	5018
87mY	c	13.37H	380.8	78.05	0.08	198100	6854
87 Y	c	79.8H	484.8	89.7	0.7	262570	9335.
			388.5	82.1	0.5	263700	9118.
					R_av	263209	8732.
86 Y	i(m+g)	14.74H	2610.1	1.24	0.08	108120	16325.
			2568.0	2.25	0.11	100730	9536.
			1920.7	20.8	0.7	119340	6797.
			1801.7	1.65	0.05	145150	12110.
			1790.9	1.00	0.05	98042	18742.
			1724.2	0.55	0.05	87756	21839.
			1696.2	0.64	0.02	83683	20971.
			1507.9	0.35	0.05	115100	35240.
			1349.2	2.95	0.10	105310	10965.
			1270.2	0.65	0.10	440380	71688.
			1253.1	1.53	0.05	121710	12047.
			1163.0	1.18	0.05	140340	18700.
			1153.1	30.5	1.0	121240	5853.
			1092.7	0.69	0.05	115600	12012.
			1076.6	82.5	0.4	123810	4244.
			1024.0	3.80	0.17	126470	10977.
			971.4	0.27	0.04	116770	17710.
			955.3	1.04	0.05	124080	17608.
			887.4	0.44	0.05	180500	50919.
			835.7	4.4	0.6	134300	19442.
			826.0	3.30	0.09	111430	8656.
			740.8	1.36	0.05	79247	10854.
			709.9	2.62	0.08	117600	16531.
			703.3	15.4	0.5	121800	6146.
			627.7	32.6	1.0	122670	5861.
			608.3	2.01	0.15	101000	12542.
			580.6	4.78	0.15	131750	9007.
			443.1	16.9	0.5	125910	6073.
			382.9	3.63	0.12	113490	16378.
			331.1	0.83	0.03	190390	18447.
			307.0	3.47	0.09	125770	6980.
			235.4	0.40	0.02	126610	10443.

					R_av	122250	4261.
86 Y	c	14.74H	2610.1	1.24	0.08	151510	15540.
			2568.0	2.25	0.11	155520	11746.
			2088.1	0.25	0.03	456060	205855.
			1920.7	20.8	0.7	167690	8654.
			1801.7	1.65	0.05	194580	11317.
			1790.9	1.00	0.05	149460	14624.
			1724.2	0.55	0.05	139610	18559.
			1696.2	0.64	0.02	133280	15360.
			1507.9	0.35	0.05	209260	37361.
			1415.2	0.33	0.09	219970	79614.
			1349.2	2.95	0.10	156340	10081.
			1270.2	0.65	0.10	462030	73646.
			1253.1	1.53	0.05	154240	10031.
			1163.0	1.18	0.05	203750	15075.
			1153.1	30.5	1.0	161320	7600.
			1092.7	0.69	0.05	174490	14657.
			1076.6	82.5	0.4	162720	5465.
			1024.0	3.80	0.17	169130	11002.
			971.4	0.27	0.04	151210	22933.
			955.3	1.04	0.05	158370	14076.
			887.4	0.44	0.05	257490	39071.
			835.7	4.4	0.6	177990	25173.
			826.0	3.30	0.09	154740	8015.
			783.6	0.26	0.04	253910	63310.
			777.4	22.4	0.6	184950	11788.
			767.6	2.4	0.4	107520	21671.
			740.8	1.36	0.05	97363	7858.
			709.9	2.62	0.08	177840	13398.
			703.3	15.4	0.5	167060	7938.
			627.7	32.6	1.0	162800	7536.
			608.3	2.01	0.15	110660	10537.
			580.6	4.78	0.15	168390	8981.
			443.1	16.9	0.5	168170	7763.
			426.0	0.30	0.02	184070	30583.
			382.9	3.63	0.12	140950	8895.
			331.1	0.83	0.03	241220	16672.
			307.0	3.47	0.09	175760	8702.
			264.5	0.54	0.03	182940	22723.
			235.4	0.40	0.02	161320	10045.
			190.8	1.01	0.04	272940	25368.
			187.9	1.26	0.05	161520	15108.
					R_av	161930	5935.
86mY	i(m)	48M	208.1	93.7	0.7	70092	3066
85mY	c	4.86H	2550.2	0.23	0.02	106340	49543.
			2172.1	2.27	0.21	53669	6376.
			2123.8	5.0	0.5	51601	6081.
			1892.2	1.78	0.18	39466	8581.
			1356.3	0.53	0.05	133180	27947.
			1261.9	0.65	0.06	84341	14759.
			1220.5	1.98	0.17	48608	6677.
			1123.2	1.78	0.16	56254	6873.
			1030.1	2.02	0.17	48601	9046.
			787.9	1.57	0.13	68932	10114.
			767.3	3.6	0.5	43270	11931.
			611.9	1.08	0.10	37485	10242.
			535.6	3.5	0.3	62246	6571.
			231.7	22.8	2.2	58099	6663.
					R_av	54361	3492.
85 Y	c	2.68H	913.9	9.0	0.8	22809	2949.
			504.4	60	4	29813	2863.
			231.9	*********	********	27285	1496.
			151.2	*********	********	23482	1699.
					R_av	25988	1527.
84 Y	c	39.5M	1502.9	5.8	0.6	42015	6070.
			1453.2	1.38	0.10	70822	18850.
			1262.5	3.5	0.4	21419	4936.
			1255.4	6.6	0.7	39719	5101.
			1143.9	3.3	0.3	33538	4930.
			1039.8	56	6	44666	7801.
			1000.9	2.07	0.20	52927	12402.
			994.6	3.8	0.4	40446	7018.
			974.1	75	8	44902	5067.
			793.0	98.6	1.0	45654	1822.
			704.5	8.5	0.9	31513	4799.
			680.4	5.1	0.5	37945	7345.
			660.5	15.7	1.6	46660	5207.
			602.2	8.8	0.9	49333	5684.
			462.7	9.8	1.0	57980	8956.
					R_av	43620	2120.
85mSr	i(m)	67.63M	231.9	84.4	2.2	8817	581.
			151.2	12.9	0.7	7430	1109.
					R_av	8580	587.
85mSr	c	67.63M	231.9	84.4	2.2	36102	1833.

			151.2	12.9	0.7	30912	2139.
					R_av	34210	2717.
85 Sr	c	64.84D	514.0	96	4	205260	11069
83 Sr	c	32.41H	1952.1	0.8	0.4	95313	48484.
			1562.5	1.8	0.9	114540	57543.
			1160.0	1.5	0.7	128070	60053.
			1147.3	1.3	0.6	113140	52450.
			994.2	0.3	0.4	148050	198050.
			762.7	30	14	119310	55835.
			423.6	1.6	0.8	115370	58253.
			418.4	4.4	2.1	128360	61451.
			381.2	2.5	1.2	783620	377133.
			290.0	0.44	0.21	139970	71463.
					R_av	118997	20274.
82 Sr	c	25.55D	776.5	15.08	0.00	67967	2278
81 Sr	c	22.3M	574.7	6.7	0.9	22796	6198.
			443.3	17.5	2.2	17846	2724.
			188.3	15.4	2.0	24065	4313.
			153.5	34	5	32976	5024.
			147.8	30	4	28865	4198.
					R_av	23281	2869.
80 Sr	c	106.3M	589.0	39	5	7681	1215
86 Rb	i(m+g)	18.631D	1077.0	8.64	0.04	3642	374
84 Rb	i(m+g)	32.77D	1897.8	0.74	0.03	21141	4219.
			881.6	69.0	1.6	24494	989.
					R_av	24420	983.
84mRb	i(m)	20.26M	463.6	36.1	1.3	13970	2636.
			248.0	60.2	0.8	13329	957.
			215.6	29.5	1.3	15202	1194.
					R_av	14040	789.
83 Rb	c	86.2D	799.4	0.24	0.02	158560	19586.
			552.6	16.0	1.1	186690	14321.
			529.6	29.3	2.1	186480	14798.
			520.4	45	4	183510	17480.
					R_av	181542	9416.
82mRb	i(m)	6.472H	1474.9	15.5	0.3	67735	2816.
			1317.4	23.7	0.6	66811	2907.
			1081.3	1.31	0.05	75700	6241.
			1073.0	0.73	0.05	105310	14948.
			1044.1	32.07	0.08	70864	2578.
			1007.6	7.17	0.09	68754	3129.
			952.0	0.64	0.05	92294	15598.
			952.0	0.64	0.05	134520	23627.
			827.8	21.0	0.6	68752	3632.
			776.5	84.39	0.21	55299	2783.
			698.4	26.3	0.7	71058	3180.
			619.1	37.98	0.10	69665	2444.
			606.4	2.01	0.06	53162	6640.
			554.3	62.4	0.9	72023	3414.
			221.5	2.07	0.05	22568	6722.
			183.3	2.13	0.05	73704	4503.
					R_av	68349	2691.
81 Rb	c	4.576H	977.2	0.56	0.02	106750	15103.
			803.7	0.83	0.03	117370	20111.
			537.6	2.23	0.17	121370	11397.
			456.7	3.02	0.12	131570	8022.
			446.1	23.2	0.9	125810	6663.
			357.4	0.76	0.03	82149	16031.
			190.5	64	2	139680	7150.
					R_av	127982	6383.
79 Rb	c	22.9M	688.1	23.1	1.2	34567	2446.
			622.2	8.8	0.5	21073	2755.
			397.6	6.1	0.4	30814	6581.
			350.6	7.2	0.4	35142	4990.
			182.8	19.2	1.1	38865	2980.
			160.8	8.6	0.5	44103	4357.
			154.8	7.9	0.5	40263	3487.
			143.4	13.9	0.8	37938	2774.
			129.7	10.7	0.6	82399	12978.
					R_av	35441	2818.
79 Kr	c	35.04H	832.0	1.26	0.08	111500	20682.
			397.5	9.3	0.5	125300	8224.
			306.5	2.60	0.13	114380	9657.
			299.5	1.54	0.09	115960	16188.
			261.3	12.7	0.4	117910	5942.
			217.1	2.37	0.13	113370	8705.
			208.5	0.77	0.06	171430	27289.
			136.1	0.85	0.12	74192	19041.

					R_av	117474	5342.
77 Kr	c	74.4M	311.9	3.7	0.5	50614	7959.
			239.0	92.5	0.0	37570	24096.
			129.6	81	2	46468	2283.
					R_av	46561	1455.
76 Kr	c	14.8H	2510.8	*****************		13432	4080.
			2391.2	*****************		16289	2312.
			2096.7	*****************		8523	4616.
			1853.7	*****************		49516	6678.
			1769.9	*****************		51228	91013.
			1568.5	*****************		13063	9859.
			1471.1	*****************		17922	4755.
			1454.1	*****************		20629	8177.
			1439.4	*****************		29524	17123.
			1380.5	*****************		14286	3991.
			1228.7	*****************		11592	5178.
			1216.1	*****************		25405	1782.
			1213.1	*****************		4821	7682.
			1032.6	*****************		58618	27277.
			730.5	*****************		24097	3416.
			681.4	*****************		31441	58608.
			657.0	*****************		12240	1851.
			563.2	*****************		7964	3860.
			559.1	*****************		14744	729.
			451.9	9.8	1.3	12885	2330.
			406.5	12.1	1.4	15892	2120.
			355.3	4.7	0.9	12601	3152.
			315.7	39	5	15762	2114.
			271.6	4.3	0.5	50251	11668.
			270.2	21	3	10108	2754.
			252.0	6.2	0.9	28895	4461.
			199.8	1.17	0.14	24952	8232.
					R_av	15445	897.
82 Br	i(m+g)	35.30H	1044.0	27.2	0.4	11.46	217.20
			827.8	24.0	0.4	4424	894.
			776.5	83.5	1.2	8266	771.
			698.4	28.5	0.4	2091	331.
			619.1	43.4	0.6	529.5	210.3
			606.4	1.21	0.01	733300	27559.
			554.3	70.8	1.0	527.3	495.1
			221.5	2.26	0.07	28369	5975.
					R_av	981.1	2405.1
77 Br	i(m+g)	57.036H	239.0	23.1	0.5	72283	21241
77 Br	c	57.036H	1005.0	0.92	0.03	109910	7078.
			817.8	2.08	0.07	138540	8564.
			755.3	1.67	0.05	112540	5896.
			585.5	1.57	0.05	131710	8661.
			578.9	2.96	0.10	105790	5694.
			574.6	1.19	0.04	46409	19151.
			565.9	0.43	0.02	73681	10019.
			520.7	22.4	0.6	111670	5237.
			385.0	0.84	0.03	102150	7368.
			303.8	1.18	0.04	103640	7335.
			297.2	4.16	0.21	109310	6957.
			281.6	2.29	0.07	109980	6197.
			249.8	2.98	0.10	109350	5849.
			239.0	23.1	0.5	107030	4743.
			200.4	1.21	0.06	105740	8016.
			161.8	1.10	0.03	110120	5636.
					R_av	109366	4256.
76 Br	i(m+g)	16.2H	2510.8	1.95	0.13	59602	8677.
			2391.2	4.7	0.4	69230	7127.
			2096.7	1.36	0.09	69384	9994.
			1853.7	14.7	0.9	225020	18171.
			1769.9	0.21	0.21	364170	403148.
			1568.5	0.96	0.08	75167	17000.
			1471.1	2.31	0.14	95895	9909.
			1454.1	0.80	0.05	67889	15009.
			1439.4	0.58	0.04	52736	27735.
			1380.5	2.52	0.15	71622	8120.
			1228.7	2.09	0.11	57682	9568.
			1216.1	8.8	0.5	64709	4345.
			1213.1	1.7	0.6	68228	25442.
			1032.6	0.58	0.07	41423	47686.
			730.5	0.58	0.08	64314	9119.
			681.4	0.42	0.03	169930	156883.
			657.0	15.9	0.9	78161	5872.
			563.2	3.6	0.6	68155	12765.
			559.1	74	2	73233	3205.
					R_av	72903	3299.
76 Br	c	16.2H	2601.2	0.70	0.05	57775	13452.
			2510.8	1.95	0.13	73034	7547.
			2391.2	4.7	0.4	85519	8351.
			2135.6	0.94	0.08	92616	13519.

			2096.7	1.36	0.09	77907	7777.
			1853.7	14.7	0.9	274530	20406.
			1769.9	0.21	0.21	415400	429281.
			1568.5	0.96	0.08	88230	12201.
			1560.0	0.46	0.03	87284	24540.
			1471.1	2.31	0.14	113810	9061.
			1454.1	0.80	0.05	88519	10676.
			1439.4	0.58	0.04	82261	14906.
			1380.5	2.52	0.15	85908	7016.
			1228.7	2.09	0.11	69274	6739.
			1216.1	8.8	0.5	90114	5945.
			1213.1	1.7	0.6	73049	26531.
			1032.6	0.58	0.07	100040	28578.
			1029.9	0.57	0.07	73424	19962.
			882.3	0.41	0.03	150770	45774.
			789.1	0.47	0.04	113350	23586.
			730.5	0.58	0.08	88411	12534.
			681.4	0.42	0.03	201370	121350.
			665.1	0.70	0.05	88925	15088.
			657.0	15.9	0.9	90401	6150.
			563.2	3.6	0.6	76119	13327.
			559.1	74	2	87977	3827.
			472.9	1.86	0.10	69039	7164.
					R_av	86675	4576.
75 Br	c	96.7M	952.1	1.7	1.0	48410	30135.
			897.6	0.5	0.3	196160	170901.
			733.9	1.5	0.9	51741	32477.
			431.8	3.9	2.3	51870	31029.
			427.8	4	3	51291	38641.
			377.4	3.9	2.3	51993	30889.
			292.9	2.7	1.6	57810	34943.
			286.5	88	50	63930	36411.
			141.2	7	4	72720	42406.
			112.1	1.7	1.0	59514	35835.
					R_av	56034	11480.
74 Br	c	25.4M	634.2	14.1	2.0	14274	13097
74mBr	i(m)	46M	1508.0	0.22	0.05	365960	98255.
			1269.1	8.8	0.4	5060	3722.
			1249.5	6.7	0.7	15804	2420.
			839.0	5.1	0.6	19339	4509.
			634.3	16.4	2.3	100690	16794.
			219.0	5.02	0.19	16512	3681.
					R_av	15283	5065.
75 Se	c	119.779D	400.7	11.47	0.09	167370	5841.
			303.9	1.32	0.01	125360	6182.
			279.5	24.99	0.14	125750	4630.
			264.7	58.9	0.4	122560	4653.
			198.6	1.48	0.05	114370	6612.
			136.0	58.3	0.8	124800	4866.
			121.1	17.2	0.4	127590	5439.
					R_av	133096	8275.
73 Se	i(m+g)	7.15H	361.2	97	1	38457	3002
73 Se	c	7.15H	361.2	97	1	61651	2187
73mSe	c	39.8M	361.2	73.00	0.01	31772	4993
72 Se	c	8.40D	2621.5	*****************		32464	2411.
			2507.9	*****************		34864	4133.
			2248.5	*****************		25502	3724.
			2201.7	*****************		41208	4970.
			2109.6	*****************		28016	7535.
			2105.9	*****************		30590	2622.
			1991.2	*****************		22802	3421.
			1475.9	*****************		31380	2545.
			1464.0	*****************		33655	2412.
			1050.8	*****************		33358	3249.
			894.3	*****************		26087	2862.
			834.0	*****************		27542	1103.
			786.4	*****************		37214	6132.
			629.9	*****************		27184	1233.
					R_av	27928	1012.
74 As	i	17.77D	634.8	15.4	1.1	25026	1998.
			608.4	0.55	0.02	72951	11274.
			595.8	59	4	24730	1880.
					R_av	25480	3895.
72 As	i	26.0H	2621.5	0.39	0.01	74187	10205.
			2507.9	0.32	0.01	118670	23195.
			2248.5	0.32	0.01	111190	21490.
			2201.7	0.48	0.02	87309	18417.
			2109.6	0.27	0.01	800460	73069.
			2105.9	0.64	0.03	66066	9130.
			1991.2	0.35	0.02	59848	11007.
			1475.9	0.51	0.01	95857	59350.

			1464.0	1.11	0.03	68822	7413.
			1050.8	0.98	0.03	85615	8829.
			894.3	0.78	0.02	68542	9709.
			834.0	79.5	1.7	85141	3904.
			786.4	0.45	0.02	50424	26304.
			629.9	7.92	0.22	80393	3841.
					R_av	81405	5519.
72	As	c	26.0H	2621.5	0.39	0.01	106650	10996.
			2507.9	0.32	0.01	153540	23270.
			2248.5	0.32	0.01	136690	21524.
			2201.7	0.48	0.02	128510	19054.
			2109.6	0.27	0.01	828470	73876.
			2105.9	0.64	0.03	96656	9923.
			1991.2	0.35	0.02	82651	11061.
			1475.9	0.51	0.01	127230	57966.
			1464.0	1.11	0.03	102470	7948.
			1050.8	0.98	0.03	118970	9535.
			894.3	0.78	0.02	94629	9829.
			834.0	79.5	1.7	112680	4836.
			786.4	0.45	0.02	87638	26212.
			629.9	7.92	0.22	107570	4935.
					R_av	109036	7179.
71 As	c	65.28H	1139.5	0.80	0.02	82188	6920.
			1095.5	4.08	0.12	74157	4217.
			1026.5	0.31	0.01	69948	14404.
			920.5	0.30	0.01	138430	29068.
			615.4	0.53	0.01	62932	10040.
			499.9	3.62	0.09	64517	3213.
			326.8	3.03	0.08	78530	4098.
			174.9	82.0	2.1	79262	3516.
					R_av	73821	3604.
70 As	c*	52.6M	2020.0	17.2	1.9	30535	3798.
			2007.7	3.0	0.4	37438	12361.
			1781.3	4.0	0.5	22445	4867.
			1707.9	18.4	2.0	31744	3772.
			1523.3	5.2	0.6	33185	4706.
			1412.5	8.8	1.0	32818	4380.
			1339.4	9.2	1.0	28021	3489.
			1332.2	0.63	0.13	722100	166515.
			1114.3	21.8	2.4	24870	2982.
			1099.3	4.5	0.5	29271	5290.
			1040.0	81	5	34774	4562.
			905.7	12.5	1.4	25147	3099.
			828.1	0.36	0.08	101120	136034.
			744.8	21.5	2.4	34304	4351.
			668.4	21.8	2.4	36098	4461.
			607.6	4.0	0.5	51320	9115.
					R_av	29938	1978.
69 Ge	c	39.05H	2023.7	0.54	0.08	71262	20263.
			1336.6	4.5	0.7	52726	8641.
			1106.8	36	4	60887	7110.
			872.0	11.9	1.6	70111	9735.
			872.0	11.9	1.6	70110	9735.
			574.1	13.3	1.9	80743	12183.
					R_av	64726	4362.
67 Ge	c	18.9M	167.0	84	5	11749	977
67 Ga	c	3.2612D	393.5	4.68	0.06	74416	7612.
			300.2	16.80	0.22	84562	3186.
			208.9	2.40	0.07	83564	5371.
			184.6	21.2	0.3	91761	3642.
			184.6	21.2	0.3	88251	3997.
					R_av	86898	3315.
66 Ga	c*	9.49H	2422.5	1.92	0.06	36158	4453.
			2189.6	5.58	0.18	45786	3011.
			1918.3	2.08	0.07	103380	15945.
			1333.1	1.20	0.04	53915	14262.
			1039.2	36.9	1.1	52889	2460.
					R_av	49530	3966.
65 Ga	c	15.2M	751.8	8.1	1.6	22810	9787.
			115.1	54	13	15287	3769.
					R_av	16249	3528.
65 Zn	c	244.26D	1115.6	50.60	0.24	95008	3158
62 Zn	c	9.186H	596.6	26	2	3813	1242.
			548.3	15.3	1.5	5567	921.
					R_av	4955	850.
67 Cu	c	61.83H	184.6	48.7	0.3	2075	1144
61 Cu	c	3.333H	1185.2	3.7	0.7	26823	6196.
			656.0	10.8	2.0	19393	4243.
			283.0	12.2	2.3	29617	5739.

					R_av	23902	3322.
60 Cu	c	23.7M	1791.6	45.4	2.4	4631	608.
			826.4	21.7	1.1	8303	2270.
					R_av	4866	912.
57 Ni	c	35.60H	1377.6	81.7	2.4	1233	92
62mCo	i(m)	13.91M	1172.9	97.7	0.5	2069	403.
			1163.5	68.0	0.9	1434	591.
					R_av	1870	335.
60 Co	i(m+g)	5.2714Y	1332.5	99.99	0.00	16909	1701.
			1173.2	99.97	0.00	21399	975.
					R_av	20673	1775.
58 Co	i(m+g)	70.86D	864.0	0.68	0.01	50111	4302.
			810.8	99.45	0.01	61346	2004.
					R_av	61110	2497.
57 Co	c	271.74D	136.5	10.68	0.08	69624	12969.
			122.1	85.60	0.17	51239	1844.
					R_av	51333	2070.
56 Co	c	77.233D	2598.5	17.3	0.3	15806	886.
			2598.5	17.3	0.3	15790	864.
			2034.8	7.89	0.13	15625	714.
			2015.2	3.04	0.05	16382	952.
			1810.8	0.64	0.01	14319000	.12677280.
			1771.3	15.47	0.14	15110	598.
			1360.2	4.29	0.04	15894	1445.
			1238.3	66.9	0.6	15475	553.
			1037.8	14.17	0.13	14233	750.
			846.8	99.94	0.03	15108	513.
			787.7	0.32	0.01	373970	20939.
					R_av	15294	988.
55 Co	c	17.53H	1316.6	7.1	0.4	7430	1268.
			803.7	1.87	0.16	27938	6423.
			477.2	20.2	1.7	1863	823.
					R_av	3828	2573.
59 Fe	c	44.472D	1291.6	43.2	1.4	4879	257.
			1099.2	56.5	1.9	5060	245.
			142.6	1.02	0.05	28788	7270.
					R_av	4987	365.
53 Fe	c*	8.51M	377.9	42	3	3382	1513
56 Mn	c	2.5789H	2113.1	14.3	0.4	9597	926.
			1810.7	27.2	0.8	10378	1927.
			846.8	98.9	0.3	9842	585.
					R_av	9812	522.
54 Mn	i	312.11D	834.8	99.98	0.00	48067	1684
52 Mn	c	5.591D	1434.1	100.0	0.6	18490	635.
			1333.7	5.07	0.06	20753	1432.
			1246.3	4.21	0.07	19700	933.
			935.5	94.5	1.0	21057	2345.
			744.2	90.0	0.9	17481	610.
					R_av	18186	687.
52mMn	c	21.1M	1434.1	99.8	2.0	3501	489
51 Cr	c	27.7025D	320.1	9.92	0.05	51618	1897
49 Cr	c	42.3M	90.6	53.2	1.9	5339	366
48 Cr	c	21.56H	112.3	96.0	2.1	592.8	72.1
48 V	c	15.9735D	2240.4	2.41	0.04	23775	1358.
			1312.1	97.5	0.9	23557	820.
			983.5	100.0	0.3	23016	767.
			944.1	7.76	0.10	24154	888.
					R_av	23382	771.
48 Sc	i	43.67H	1312.1	100.1	0.7	3094	249.
			1212.9	2.38	0.05	21557	3637.
			1037.5	97.6	0.7	3363	164.
			983.5	100.1	0.6	3132	346.
					R_av	3299	334.
47 Sc	i	3.3492D	159.4	68.3	0.4	10464	387
47 Sc	c	3.3492D	159.4	68.3	0.4	10904	394
46 Sc	i(m+g)	83.79D	1120.6	99.99	0.00	22423	747.
			889.3	99.98	0.00	20784	695.
					R_av	21564	1060.

44mSc	i(m)	58.61H	1157.0	98.61	0.01	14240	485.
			1001.8	1.20	0.07	17265	3737.
			270.9	86.7	0.3	15335	630.
					R_av	14608	553.
44 Sc	i	3.97H	1157.0	99.9	0.5	9038	353
44 Sc	i(m+g)	3.97H	1157.0	99.9	0.5	23080	792
43 Sc	c	3.891H	372.8	22.5	0.7	7019	694
47 Ca	c	4.536D	1297.1	71	7	441.3	51.2
			159.4	*****************		439.7	46.6
					R_av	440.4	35.8
43 K	c	22.3H	617.5	79.2	0.7	5181	222.
			372.8	86.8	0.2	5608	237.
					R_av	5384	271.
42 K	i	12.360H	1525.0	18.08	0.09	11520	678
41 Ar	c	109.34M	1294.0	99.1	0.0	3408	280
39 Cl	c	55.6M	1518.0	39.2	1.3	2004	279
38 Cl	c	37.24M	2167.0	42.4	1.1	6450	499.
			1643.0	31.9	1.0	5666	525.
					R_av	6090	434.
29 Al	c	6.56M	1273.3	90.6	0.6	10830	1186
28 Mg	c	20.915H	1778.8	100.2	0.0	2154	133.
			1372.9	4.7	0.2	13082	2493.
			1342.2	52.6	1.6	2952	173.
			941.5	38.3	1.0	2768	243.
			400.7	36.6	1.0	2830	301.
					R_av	2538	266.
27 Mg	c	9.458M	843.8	71.8	0.4	4399	610
24 Na	c	14.9590H	1369.0	100	0	14405	510
22 Na	c	2.6019Y	1274.5	99.94	0.01	6701	336
7 Be	i	53.29D	477.6	10.52	0.06	57773	2084

10.5 Reaction rates for residual nuclide production in ^{181}Ta

Table 10.52: Detailed reaction rates for residual nuclide production in ^{181}Ta at E_p=43 MeV used to determine their production cross sections.

Nuclide	Type	$T_{1/2}$	E_γ, KeV	Abundance, %		Reaction rate 10^{-20} s^{-1}	
178 W	i	21.6D	1496.0	0.27	0.02	3240200	306237.
			1402.9	0.48	0.04	3119700	277649.
			1350.6	1.18	0.11	3085600	303177.
			1340.8	1.03	0.09	3072700	284924.
			1183.4	0.17	0.01	3162600	297438.
			1106.1	0.54	0.05	3084200	301070.
			93.1	6.6	1.9	3589000	1071424.
					R_av	3131042	148404.
177 W	i	135M	115.7	59.6	5.3	1661300	181574
182 Ta	i(m1+m2+g)	114.43D	1231.0	11.44	0.20	13850	711.
			1221.4	27.0	0.5	12774	486.
			1121.3	34.9	0.6	15904	604.
			152.4	6.93	0.13	13042	592.
			100.1	14.1	0.3	10958	913.
					R_av	13692	838.
180 Ta	i	8.152H	103.6	0.81	0.24	502630	153741.
			103.6	0.81	0.24	492080	150725.
			93.4	4.51	0.16	474460	48620.
			93.4	4.51	0.16	621780	71303.
					R_av	517872	40737.
178mTa	i(m)	2.36H	331.6	31.2	0.5	165400	6334.
			325.6	94.1	1.7	168020	6354.
			93.2	17.2	0.4	169850	19836.
			93.2	17.2	0.4	137160	13750.
					R_av	165718	6136.
177 Ta	c*	56.56H	1057.8	0.29	0.07	2276500	553926.
			745.9	0.21	0.05	2313700	555553.
			424.6	0.10	0.02	2226500	480664.
			208.4	0.94	0.20	2120200	456255.
			112.9	7.2	1.6	2025800	468856.

					R_av	2177961	230742.
176 Ta	c*	8.09H	1862.7	4.0	0.3	1896	229.
			1823.7	4.5	0.4	1937	237.
			1696.6	4.6	0.4	1799	228.
			1643.4	2.40	0.18	1747	236.
			1633.7	2.93	0.22	1713	222.
			1584.0	5.3	0.4	1818	223.
			1555.1	4.0	0.3	1727	226.
			1159.3	24.7	1.9	1950	175.
					R_av	1834	94.
180mHf	i(m)	5.5H	443.2	81.9	1.3	389.8	30.2
			332.3	94.1	1.2	877.3	135.1
			215.4	81.3	1.1	391.5	37.6
					R_av	403.3	56.7
175 Hf	c	70D	433.0	1.44	0.06	44218	2607.
			343.4	84	3	38985	1845.
					R_av	40461	2673.

Table 10.53: Detailed reaction rates for residual nuclide production in ^{181}Ta at E_p=66 MeV used to determine their production cross sections.

Nuclide	Type	$T_{1/2}$	E_γ, KeV	Abundance, %		Reaction rate 10^{-20} s^{-1}	
178 W	i	21.6D	1496.0	0.27	0.02	195390	18655.
			1402.9	0.48	0.04	188560	16810.
			1350.6	1.18	0.11	183400	18040.
			1340.8	1.03	0.09	181130	16964.
			1183.4	0.17	0.01	188430	17972.
			1106.1	0.54	0.05	182800	17891.
			93.1	6.6	1.9	197870	59099.
					R_av	186611	8883.
177 W	i	135M	115.7	59.6	5.3	278500	30699
176 W	i	2.5H	2044.9	*********	********	783930	73817.
			1977.8	*********	********	802930	88780.
			1862.7	*********	********	831640	74097.
			1823.7	*********	********	812050	84709.
			1704.7	*********	********	936280	89046.
			1696.6	*********	********	952570	89590.
			1643.4	*********	********	764170	73145.
			1633.7	*********	********	910310	79479.
			1584.0	*********	********	832900	78598.
			1555.1	*********	********	855120	72397.
			1341.3	*********	********	692130	71033.
			1252.9	*********	********	803740	84302.
			1190.2	*********	********	695690	83142.
			1159.3	*********	********	902630	75811.
			1023.1	*********	********	911030	79505.
			710.5	*********	********	822160	67414.
					R_av	843214	30052.
182 Ta	i(m1+m2+g)	114.43D	1231.0	11.44	0.20	5050	211.
			1221.4	27.0	0.5	4993	189.
			1189.1	16.2	0.3	5896	250.
			1121.3	34.9	0.6	6325	234.
			152.4	6.93	0.13	5815	376.
					R_av	5511	337.
180 Ta	i	8.152H	93.4	4.51	0.16	130760	14270.
			93.4	4.51	0.16	175810	19670.
					R_av	146245	21879.
178mTa	i(m)	2.36H	331.6	31.2	0.5	103110	4018.
			325.6	94.1	1.7	115400	4418.
			93.2	17.2	0.4	131950	12646.
			93.2	17.2	0.4	113980	10805.
					R_av	109492	5231.
177 Ta	c*	56.56H	1057.8	0.29	0.07	609640	148332.
			745.9	0.21	0.05	622360	149371.
			424.6	0.10	0.02	601250	129760.
			208.4	0.94	0.20	587620	126435.
			112.9	7.2	1.6	594230	137461.
					R_av	601623	63665.
176 Ta	i	8.09H	2044.9	1.35	0.10	175300	49848.
			1977.8	0.87	0.07	127820	71263.
			1862.7	4.0	0.3	166440	38773.
			1823.7	4.5	0.4	134240	45588.
			1704.7	1.40	0.11	78044	52462.
			1696.6	4.6	0.4	104840	20275.
			1643.4	2.40	0.18	162260	49560.
			1633.7	2.93	0.22	73250	34141.
			1584.0	5.3	0.4	169400	50327.
			1555.1	4.0	0.3	123030	24282.

			1341.3	3.34	0.25	301100	60251.
			1252.9	3.08	0.23	174750	68012.
			1190.2	4.5	0.4	298980	70533.
			1159.3	24.7	1.9	125990	14917.
			1023.1	2.67	0.20	102510	36071.
			710.5	5.4	0.4	157870	19785.
					R_av	133973	10051.
176 Ta	c	8.09H	2405.2	0.49	0.04	1322900	124306.
			2044.9	1.35	0.10	959230	78663.
			1977.8	0.87	0.07	930750	83328.
			1862.7	4.0	0.3	998080	82105.
			1823.7	4.5	0.4	946300	90470.
			1704.7	1.40	0.11	1014300	87454.
			1696.6	4.6	0.4	1057400	97940.
			1643.4	2.40	0.18	926440	76917.
			1633.7	2.93	0.22	983560	80717.
			1584.0	5.3	0.4	1002300	83455.
			1555.1	4.0	0.3	978150	79838.
			1341.3	3.34	0.25	993230	82275.
			1252.9	3.08	0.23	978490	82107.
			1190.2	4.5	0.4	994670	95920.
			1159.3	24.7	1.9	1028600	85437.
			1023.1	2.67	0.20	1013500	82860.
			710.5	5.4	0.4	980030	78791.
					R_av	993430	36487.
175 Ta	c	10.5H	1887.9	0.38	0.08	356100	76599.
			1826.1	1.24	0.22	481640	87077.
			1793.1	4.6	0.7	406410	63344.
			1744.8	1.36	0.19	437930	62809.
			1736.7	0.92	0.14	456040	71001.
			1711.8	1.16	0.19	413060	69159.
			1659.2	1.08	0.15	490690	69986.
			1618.2	1.32	0.19	243280	36047.
			1293.3	0.44	0.08	439020	82518.
			1249.8	2.4	0.7	499440	146568.
			1249.8	2.4	0.7	497920	146066.
			998.3	2.6	0.4	371710	58404.
			857.7	3.2	0.4	420030	54186.
			436.4	3.8	0.4	396000	43532.
			393.2	2.12	0.23	419060	47311.
			348.5	12.0	1.1	440250	42618.
			348.5	12.0	1.1	440170	42608.
			288.9	1.48	0.20	417770	58244.
			266.9	10.52	0.16	410850	14422.
			207.4	14.0	1.4	439230	46199.
			104.3	3.1	0.5	308160	54116.
					R_av	408507	14382.
179mHf	i(m)	25.05D	453.6	68	4	366.0	25.1
			362.5	39.5	1.5	348.5	19.1
			315.9	20.2	0.7	349.0	29.1
					R_av	353.3	16.0
175 Hf	c	70D	433.0	1.44	0.06	431600	22507.
			433.0	1.44	0.06	429860	22395.
			353.3	0.23	0.02	395640	35352.
			343.4	84	3	424920	20107.
			318.9	0.17	0.05	432680	127960.
			229.6	0.68	0.03	440150	24166.
					R_av	428350	15815.
173 Hf	c*	23.6H	311.2	10.7	0.5	34300	2003.
			306.6	6.4	0.3	34004	2123.
			139.6	12.7	0.6	36115	2451.
			123.7	83	5	37213	3121.
					R_av	34836	1352.
172 Hf	c	1.87Y	1093.6	**********	********	4212	253.
			181.5	**********	********	4058	425.
			125.8	11.3	0.9	3725	552.
					R_av	4167	180.
173 Lu	c	1.37Y	272.1	21.2	0.8	34147	1709
172 Lu	i(m+g)	6.70D	1093.6	63	3	113.1	7.4
			181.5	20.6	1.0	139.6	18.6
					R_av	114.9	7.7
172 Lu	c	6.70D	1093.6	63	3	4325	259.
			181.5	20.6	1.0	4198	426.
					R_av	4296	236.

Table 10.54: Detailed reaction rates for residual nuclide production in ^{181}Ta at E_p=97 MeV used to determine their production cross sections.

Nuclide	Type	$T_{1/2}$	E_γ, KeV	Abundance, %		Reaction rate 10^{-20} s^{-1}	

178 W	i	21.6D	1496.0	0.27	0.02	179320	17212.
			1402.9	0.48	0.04	201420	18249.
			1350.6	1.18	0.11	167970	16632.
			1183.4	0.17	0.01	226060	21944.
			1106.1	0.54	0.05	170190	16862.
			93.1	6.6	1.9	179660	53691.
					R_av	185105	10582.
177 W	i	135M	115.7	59.6	5.3	208850	22990
176 W	i	2.5H	2044.9	*********	*********	331380	66013.
			1862.7	*********	*********	309770	37461.
			1823.7	*********	*********	299740	37688.
			1696.6	*********	*********	384040	51242.
			1643.4	*********	*********	365270	67703.
			1633.7	*********	*********	297110	66173.
			1555.1	*********	*********	246200	43255.
			1190.2	*********	*********	373790	46405.
			1159.3	*********	*********	290760	30926.
			710.5	*********	*********	227880	50683.
					R_av	306754	16850.
174 W	i	31M	206.5	*********	*********	437560	40071
182 Ta	i(m1+m2+g)	114.43D	1231.0	11.44	0.20	8943	373.
			1221.4	27.0	0.5	9392	352.
			1189.1	16.2	0.3	10202	385.
			1121.3	34.9	0.6	11389	432.
					R_av	9929	589.
180 Ta	i	8.152H	93.4	4.51	0.16	239250	29089.
			93.4	4.51	0.16	261100	24970.
					R_av	252092	19639.
178mTa	i(m)	2.36H	331.6	31.2	0.5	157990	5824.
			325.6	94.1	1.7	166350	6258.
			93.2	17.2	0.4	170140	18172.
			93.2	17.2	0.4	161230	14500.
					R_av	161802	5607.
177 Ta	c*	56.56H	1057.8	0.29	0.07	738330	179869.
			745.9	0.21	0.05	663850	159746.
			424.6	0.10	0.02	642270	139438.
			208.4	0.94	0.20	686340	148336.
			112.9	7.2	1.6	643510	148956.
					R_av	669946	71169.
176 Ta-i	i	8.09H	2044.9	1.35	0.10	285770	85173.
			1862.7	4.0	0.3	405070	49059.
			1823.7	4.5	0.4	380060	48752.
			1696.6	4.6	0.4	372300	59017.
			1643.4	2.40	0.18	274980	85061.
			1633.7	2.93	0.22	399590	89199.
			1555.1	4.0	0.3	448620	62018.
			1190.2	4.5	0.4	334560	50870.
			1159.3	24.7	1.9	424610	41808.
			710.5	5.4	0.4	439140	71799.
					R_av	396112	18867.
176 Ta	c	8.09H	2405.2	0.49	0.04	741080	70621.
			2044.9	1.35	0.10	617140	54990.
			1977.8	0.87	0.07	756190	66894.
			1862.7	4.0	0.3	714840	59070.
			1823.7	4.5	0.4	679800	64812.
			1704.7	1.40	0.11	909390	77922.
			1696.6	4.6	0.4	756340	71306.
			1643.4	2.40	0.18	640240	56862.
			1633.7	2.93	0.22	696710	61275.
			1555.1	4.0	0.3	694820	58304.
			1252.9	3.08	0.23	870520	71630.
			1190.2	4.5	0.4	708350	67683.
			1159.3	24.7	1.9	715380	59766.
			710.5	5.4	0.4	667020	56708.
					R_av	713486	29852.
175 Ta	c	10.5H	1887.9	0.38	0.08	688290	147849.
			1826.1	1.24	0.22	854080	154342.
			1793.1	4.6	0.7	733580	114436.
			1744.8	1.36	0.19	764970	109727.
			1736.7	0.92	0.14	816000	127276.
			1711.8	1.16	0.19	745400	124524.
			1659.2	1.08	0.15	888350	127320.
			1618.2	1.32	0.19	467080	69213.
			1293.3	0.44	0.08	900480	167690.
			1249.8	2.4	0.7	940350	276145.
			998.3	2.6	0.4	695020	109503.
			857.7	3.2	0.4	797470	102822.
			436.4	3.8	0.4	778230	85952.
			393.2	2.12	0.23	774530	87685.
			348.5	12.0	1.1	856030	82889.
			288.9	1.48	0.20	728600	101570.

			266.9	10.52	0.16	755760	27269.
			266.9	10.52	0.16	754400	27212.
			207.4	14.0	1.4	798410	84093.
			125.9	9.0	1.3	1085700	169361.
			104.3	3.1	0.5	673500	118535.
					R_av	754363	25525.
174 Ta-i	i	1.14H	206.5	60	5	338940	31809
174 Ta	c	1.14H	206.5	60	5	776500	69500
173 Ta	c	3.14H	1208.2	2.7	0.4	883900	134245.
			180.6	2.22	0.24	690090	81174.
			172.2	17.5	1.8	723600	78924.
			160.4	4.9	0.8	743470	124711.
			139.6	*****************		676010	108610.
			123.7	*****************		692620	66091.
					R_av	714024	39949.
172 Ta	c*	36.8M	1330.4	8.1	0.8	74300	8813.
			1085.6	8.1	0.8	99123	11154.
			214.1	55	5	34616	6644.
					R_av	62145	18661.
179mHf	i(m)	25.05D	453.6	68	4	1228	82.
			362.5	39.5	1.5	1197	68.
			315.9	20.2	0.7	1242	67.
					R_av	1222	52.
175 Hf	c	70D	433.0	1.44	0.06	842810	44279.
			353.3	0.23	0.02	739860	66221.
			343.4	84	3	808740	38467.
			318.9	0.17	0.05	823430	243755.
			229.6	0.68	0.03	859800	47143.
					R_av	823554	31692.
173 Hf-i	i	23.6H	139.6	12.7	0.6	27817	113003.
			123.7	83	5	28265	35370.
					R_av	28225	33744.
173 Hf	c	23.6H	311.2	10.7	0.5	784840	44661.
			306.6	6.4	0.3	756660	43042.
			139.6	12.7	0.6	703830	50260.
			123.7	83	5	720890	60918.
					R_av	754192	29080.
172 Hf	c	1.87Y	1584.1	*****************		135970	8079.
			1488.9	*****************		123540	10994.
			1093.6	*****************		130410	7430.
			1022.4	*****************		117300	7535.
			810.1	*****************		129590	7545.
			181.5	*****************		125490	7533.
			125.8	11.3	0.9	129170	12772.
					R_av	128225	4582.
171 Hf	c	12.1H	739.8	*****************		21556	38145
170 Hf	c	16.01H	2126.1	*****************		58620	16227.
			2040.0	*****************		48831	9824.
			1405.2	*****************		40965	13476.
			1364.6	*****************		51447	5800.
			1280.2	*****************		40867	5783.
			1054.3	*****************		23040	4838.
			620.7	18	5	75624	21162.
			501.6	3.7	1.0	75395	20883.
			164.7	26	8	68196	21109.
					R_av	40638	5073.
173 Lu	c	1.37Y	272.1	21.2	0.8	657320	32449
172 Lu-i	i	6.70D	1584.1	2.64	0.12	11890	810.
			1488.9	1.15	0.05	10922	1061.
			1093.6	63	3	11771	673.
			1022.4	1.41	0.07	9245	757.
			810.1	16.6	0.8	11447	672.
			181.5	20.6	1.0	10934	655.
					R_av	11269	470.
172 Lu	c	6.70D	1584.1	2.64	0.12	147860	8635.
			1488.9	1.15	0.05	134460	11118.
			1093.6	63	3	142180	8091.
			1022.4	1.41	0.07	126550	7958.
			810.1	16.6	0.8	141040	8179.
			181.5	20.6	1.0	136420	8153.
					R_av	138306	5300.
171 Lu-i	i(m+g)	8.24D	739.8	47.8	1.2	71071	40576
171 Lu	c	8.24D	853.0	2.55	0.07	93172	4149.
			780.7	4.36	0.11	92406	3831.
			739.8	47.8	1.2	92627	4437.

			739.8	47.8	1.2	93445	3770.
			712.7	1.13	0.03	94606	4068.
			689.3	2.37	0.06	92097	3955.
			667.4	11.0	0.3	92517	3943.
					R_av	92986	3083.
170 Lu-i	i(m+g)	2.012D	2126.1	5.1	0.3	3749	21608.
			2040.0	2.62	0.14	14359	12517.
			1405.2	2.61	0.14	29776	18571.
			1364.6	4.62	0.18	8563	7197.
			1280.2	8.2	0.4	24919	7479.
			1054.3	4.76	0.24	54632	7167.
					R_av	28542	8559.
170 Lu	c	2.012D	2126.1	5.1	0.3	62369	7445.
			2040.0	2.62	0.14	63190	5425.
			1405.2	2.61	0.14	70740	6966.
			1364.6	4.62	0.18	60010	3630.
			1280.2	8.2	0.4	65786	4358.
			1054.3	4.76	0.24	77672	4944.
					R_av	65749	3482.
169 Lu	c	34.06H	960.6	23.4	0.7	4449	410.
			889.8	5.36	0.17	3355	697.
			191.2	20.6	0.6	4968	267.
					R_av	4761	331.
87 Y	c	79.8H	388.5	82.1	0.5	83.37	10.36

Table 10.55: Detailed reaction rates for residual nuclide production in ^{181}Ta at E_p=148 MeV used to determine their production cross sections.

Nuclide	Type	$T_{1/2}$	E_γ, KeV	Abundance, %		Reaction rate 10^{-20} s^{-1}	
178 W	i	21.6D	1496.0	0.27	0.02	172190	16937.
			1350.6	1.18	0.11	145670	14399.
			93.1	6.6	1.9	225080	67280.
					R_av	158390	12690.
177 W	i	135M	115.7	59.6	5.3	172210	19044
174 W	i	31M	206.5	*****************		216060	21291
182 Ta	i(m1+m2+g)	114.43D	1231.0	11.44	0.20	13775	556.
			1221.4	27.0	0.5	14182	529.
			1189.1	16.2	0.3	15038	574.
					R_av	14337	571.
180 Ta	i	8.152H	93.4	4.51	0.16	304820	51528.
			93.4	4.51	0.16	278190	26679.
					R_av	283450	24151.
178mTa	i(m)	2.36H	331.6	31.2	0.5	165130	6023.
			325.6	94.1	1.7	175810	6663.
			93.2	17.2	0.4	188200	17156.
			93.2	17.2	0.4	168410	25721.
					R_av	169841	6285.
177 Ta	c*	56.56H	745.9	0.21	0.05	721540	173754.
			424.6	0.10	0.02	424820	100263.
			112.9	7.2	1.6	615640	142502.
					R_av	530536	87366.
176 Ta	c	8.09H	2513.8	0.67	0.05	627750	55286.
			1862.7	4.0	0.3	801690	66436.
			1823.7	4.5	0.4	702060	67215.
			1696.6	4.6	0.4	783010	73372.
			1252.9	3.08	0.23	745330	61229.
			1159.3	24.7	1.9	731360	61282.
			710.5	5.4	0.4	665690	53915.
					R_av	713037	32575.
175 Ta	c	10.5H	1793.1	4.6	0.7	648610	100875.
			1744.8	1.36	0.19	658850	94637.
			266.9	10.52	0.16	708860	25460.
			125.9	9.0	1.3	1025400	159495.
					R_av	708885	26264.
174 Ta-i	i	1.14H	206.5	60	5	387710	36692
174 Ta	c	1.14H	206.5	60	5	603780	54178
173 Ta	c	3.14H	1208.2	2.7	0.4	892800	135474.
			180.6	2.22	0.24	766070	88796.
			172.2	17.5	1.8	711460	77411.
			160.4	4.9	0.8	697620	116889.
					R_av	747902	50471.
172 Ta	c*	36.8M	1330.4	8.1	0.8	336510	37119.

			1109.3	14.9	1.5	326470	34806.
			1085.6	8.1	0.8	376750	39578.
			214.1	55	5	339390	33771.
					R_av	343108	17254.
180mHf	i(m)	5.5H	443.2	81.9	1.3	5771	329.
			332.3	94.1	1.2	9446	483.
					R_av	7021	1755.
179mHf	i(m)	25.05D	453.6	68	4	2546	172.
			362.5	39.5	1.5	2433	126.
			315.9	20.2	0.7	2954	167.
					R_av	2597	175.
175 Hf	c	70D	433.0	1.44	0.06	941910	49170.
			353.3	0.23	0.02	786480	70637.
			343.4	84	3	824700	38963.
			318.9	0.17	0.05	889310	263156.
			229.6	0.68	0.03	927720	50995.
					R_av	872796	40246.
173 Hf	c	23.6H	311.2	10.7	0.5	916530	52029.
			139.6	12.7	0.6	930480	63405.
			123.7	83	5	994360	83435.
					R_av	929662	37927.
172 Hf	c	1.87Y	1093.6	*****************		641870	36383.
			1022.4	*****************		624960	37998.
			912.1	*****************		624790	34438.
			810.1	*****************		637800	36455.
			181.5	*****************		613210	36134.
					R_av	629051	21007.
171 Hf	c	12.1H	739.8	*****************		564590	44416
170 Hf	c	16.01H	2691.4	*****************		408850	30184.
			2663.9	*****************		395970	34059.
			2496.1	*****************		349900	42167.
			2275.4	*****************		364140	43301.
			2191.1	*****************		406500	70828.
			2126.1	*****************		409260	34789.
			1512.5	*****************		267130	21769.
			1455.2	*****************		420820	61999.
			1364.6	*****************		393310	23783.
			1280.2	*****************		383790	24724.
			1054.3	*****************		341390	22212.
			985.1	*****************		375970	28075.
			620.7	18	5	515750	144133.
			501.6	3.7	1.0	509280	138943.
			164.7	26	8	464540	143777.
			120.2	15	5	550820	186733.
					R_av	366395	16283.
168 Hf	c	25.95M	1136.8	16.1	2.9	89486	17853.
			979.2	26.1	0.7	143740	8414.
			896.1	20.1	2.6	58904	8637.
					R_av	106835	28697.
173 Lu	c	1.37Y	272.1	21.2	0.8	772280	37929.
			179.4	1.38	0.06	805120	45797.
					R_av	784397	33778.
172 Lu-i	i	6.70D	1093.6	63	3	26055	1484.
			1022.4	1.41	0.07	24380	2425.
			912.1	15.3	0.7	23449	1319.
			810.1	16.6	0.8	24349	1407.
			181.5	20.6	1.0	22756	1384.
					R_av	24163	955.
172 Lu	c	6.70D	1093.6	63	3	667930	37858.
			1022.4	1.41	0.07	649340	39263.
			912.1	15.3	0.7	648230	35726.
			810.1	16.6	0.8	662150	37834.
			181.5	20.6	1.0	635960	37454.
					R_av	652688	24791.
171 Lu-i	i(m+g)	8.24D	739.8	47.8	1.2	68542	40732
171 Lu	c	8.24D	853.0	2.55	0.07	619220	25742.
			839.9	3.04	0.08	637900	25811.
			780.7	4.36	0.11	641390	26492.
			739.8	47.8	1.2	633140	25252.
			689.3	2.37	0.06	613560	26483.
					R_av	629625	21068.
170 Lu-i	i(m+g)	2.012D	2691.4	2.29	0.13	3354	17790.
			2663.9	1.26	0.07	665.4	29620.0
			2496.1	0.76	0.04	75763	47175.
			2275.4	0.90	0.05	17157	46273.
			2191.1	1.64	0.08	12436	90471.
			2126.1	5.1	0.3	8389	27527.

			1512.5	2.55	0.13	161360	21453.
			1455.2	1.18	0.06	1740	76370.
			1364.6	4.62	0.18	564.5	17560.0
			1280.2	8.2	0.4	10460	11634.
			1054.3	4.76	0.24	103310	13919.
			985.1	5.5	0.3	64069	20689.
					R_av	46696	16207.
170 Lu	c	2.012D	2691.4	2.29	0.13	412210	27650.
			2663.9	1.26	0.07	396640	26967.
			2496.1	0.76	0.04	425660	29101.
			2275.4	0.90	0.05	381290	27556.
			2191.1	1.64	0.08	418930	35163.
			2126.1	5.1	0.3	417650	29195.
			1512.5	2.55	0.13	428490	26157.
			1455.2	1.18	0.06	422560	33002.
			1364.6	4.62	0.18	393880	20327.
			1280.2	8.2	0.4	394250	22952.
			1054.3	4.76	0.24	444700	26511.
			985.1	5.5	0.3	440040	28192.
					R_av	411869	14520.
169 Lu	c	34.06H	1466.8	3.32	0.11	213890	10928.
			1463.4	1.51	0.05	202620	10558.
			960.6	23.4	0.7	196880	8518.
			889.8	5.36	0.17	188060	8448.
			191.2	20.6	0.6	185040	8301.
			165.0	1.97	0.05	130610	11970.
					R_av	190843	9524.
167 Lu	c	51.5M	113.3	*****************		112240	9950
169 Yb	c*	32.026D	307.7	10.05	0.19	251440	9154.
			130.5	11.31	0.21	235270	13476.
					R_av	249054	9666.
167 Yb-i	i	17.5M	113.3	55	3	1151	3965
167 Yb	c	17.5M	113.3	55	3	113390	9995
166 Yb	c	56.7H	2092.1	*****************		63786	4814.
			2079.5	*****************		37424	2809.
			1374.2	*****************		46477	4131.
			691.2	8.56	0.58	33772	2549.
					R_av	39945	5621.
168 Tm	i	93.1D	447.5	23.7	0.8	714.4	111.5
167 Tm	c	9.25D	531.5	1.61	0.22	100400	14399.
			207.8	42	8	95673	18484.
					R_av	98639	11551.
166 Tm-i	i	7.70H	2092.1	1.56	0.09	4439	11961.
			2079.5	6.3	0.4	616.9	1860.1
			1374.2	5.6	0.4	3616	13790.
					R_av	758.0	1821.7
166 Tm	c	7.70H	2092.1	1.56	0.09	68225	12370.
			2079.5	6.3	0.4	38041	3159.
			1374.2	5.6	0.4	50093	14299.
					R_av	40089	5115.
165 Tm	c	30.06H	806.4	9.5	0.6	12391	1211.
			242.9	35.5	1.7	16359	955.
					R_av	15046	1925.
84 Rb	i(m+g)	32.77D	881.6	69.0	1.6	616.4	51.1

Table 10.56: Detailed reaction rates for residual nuclide production in ^{181}Ta at E_p=248 MeV used to determine their production cross sections.

Nuclide	Type	$T_{1/2}$	E_γ, KeV	Abundance, %		Reaction rate 10^{-20} s^{-1}	
178 W	i	21.6D	1350.6	1.18	0.11	132550	13089.
			93.1	6.6	1.9	350820	104830.
					R_av	135552	25772.
177 W	i	135M	115.7	59.6	5.3	136700	14944
174 W	i	31M	206.5	*****************		150680	14170
182 Ta	i(m1+m2+g)	114.43D	1231.0	11.44	0.20	23775	1069.
			1221.4	27.0	0.5	23067	856.
			1189.1	16.2	0.3	23996	887.
					R_av	23559	798.
180 Ta	i	8.152H	93.4	4.51	0.16	611820	88856
178mTa	i(m)	2.36H	331.6	31.2	0.5	169440	6351.

			325.6	94.1	1.7	184670	7098.
			93.2	17.2	0.4	83984	14865.
			93.2	17.2	0.4	184130	26942.
					R_av	172957	11608.
177 Ta	c*	56.56H	112.9	7.2	1.6	565530	131003
176 Ta	c	8.09H	2513.8	0.67	0.05	553760	48720.
			1862.7	4.0	0.3	760870	62833.
			1823.7	4.5	0.4	640090	61001.
			1696.6	4.6	0.4	729660	68938.
			1252.9	3.08	0.23	643060	53313.
			1159.3	24.7	1.9	663330	56033.
			710.5	5.4	0.4	580480	47321.
					R_av	637735	33933.
175 Ta	c	10.5H	1793.1	4.6	0.7	599740	93272.
			1744.8	1.36	0.19	574140	83652.
			266.9	10.52	0.16	636480	22638.
			125.9	9.0	1.3	951550	148470.
					R_av	636508	23694.
174 Ta-i	i	1.14H	206.5	60	5	374260	33922
174 Ta	c	1.14H	206.5	60	5	524950	46959
173 Ta	c	3.14H	1208.2	2.7	0.4	766910	116887.
			180.6	2.22	0.24	637600	74430.
			160.4	4.9	0.8	614080	102962.
					R_av	657770	54020.
172 Ta	c*	36.8M	1330.4	8.1	0.8	296920	32957.
			1109.3	14.9	1.5	299200	32446.
			1085.6	8.1	0.8	360070	38132.
			214.1	55	5	326510	31892.
					R_av	318870	16875.
180mHf	i(m)	5.5H	443.2	81.9	1.3	13135	717.
			332.3	94.1	1.2	18250	836.
					R_av	15594	2602.
179mHf	i(m)	25.05D	453.6	68	4	4332	291.
			362.5	39.5	1.5	4238	224.
			315.9	20.2	0.7	5658	314.
					R_av	4610	447.
175 Hf	c	70D	353.3	0.23	0.02	782350	72684.
			343.4	84	3	853510	40323.
			318.9	0.17	0.05	994700	294416.
			229.6	0.68	0.03	974490	55716.
					R_av	877153	45515.
173 Hf	c	23.6H	311.2	10.7	0.5	979960	57374.
			139.6	12.7	0.6	1001600	69438.
			123.7	83	5	1074500	90197.
					R_av	998627	41727.
172 Hf	c	1.87Y	1093.6	*****************		729390	41396.
			1022.4	*****************		674230	47077.
			912.1	*****************		723310	41147.
			810.1	*****************		738780	43784.
			181.5	*****************		700300	43842.
					R_av	720000	24569.
171 Hf	c	12.1H	739.8	*****************		742390	37380
170 Hf	c	16.01H	2691.4	*****************		655110	48299.
			2496.1	*****************		684320	58267.
			2275.4	*****************		499890	34897.
			2191.1	*****************		709970	48659.
			2126.1	*****************		704250	49677.
			1512.5	*****************		522500	60515.
			1455.2	*****************		791830	128613.
			1364.6	*****************		651700	35683.
			1280.2	*****************		652060	40472.
			1054.3	*****************		673300	48006.
			985.1	*****************		614280	42062.
			620.7	18	5	842920	235661.
			501.6	3.7	1.0	856520	233120.
			164.7	26	8	770490	238722.
			120.2	15	5	874700	296663.
					R_av	637639	26015.
168 Hf	c	25.95M	1136.8	16.1	2.9	418620	76893.
			979.2	26.1	0.7	420100	18645.
			896.1	20.1	2.6	335880	44788.
					R_av	413123	20842.
173 Lu	c	1.37Y	272.1	21.2	0.8	853240	41898
172 Lu-i	i	6.70D	1093.6	63	3	65685	3727.

			1022.4	1.41	0.07	67458	4829.
			912.1	15.3	0.7	58546	3333.
			810.1	16.6	0.8	62277	3663.
			181.5	20.6	1.0	60215	3710.
					R_av	61973	2479.
172 Lu	c	6.70D	1093.6	63	3	795070	45103.
			1022.4	1.41	0.07	741690	49574.
			912.1	15.3	0.7	781860	44147.
			810.1	16.6	0.8	801060	47093.
			181.5	20.6	1.0	760510	46964.
					R_av	777946	30048.
171 Lu-i	i(m+g)	8.24D	739.8	47.8	1.2	118030	24992
171 Lu	c	8.24D	853.0	2.55	0.07	912270	37584.
			839.9	3.04	0.08	935430	37938.
			780.7	4.36	0.11	901340	35766.
			739.8	47.8	1.2	860430	34105.
			689.3	2.37	0.06	885300	35404.
					R_av	896288	30736.
170 Lu-i	i(m+g)	2.012D	2691.4	2.29	0.13	55564	27590.
			2496.1	0.76	0.04	15139	51802.
			2275.4	0.90	0.05	169080	21079.
			2191.1	1.64	0.08	38445	35199.
			2126.1	5.1	0.3	33027	20933.
			1512.5	2.55	0.13	196640	69531.
			1455.2	1.18	0.06	37772	171804.
			1364.6	4.62	0.18	37305	19372.
			1280.2	8.2	0.4	27576	19458.
			1054.3	4.76	0.24	60420	36006.
			985.1	5.5	0.3	162350	25038.
					R_av	76253	19307.
170 Lu	c	2.012D	2691.4	2.29	0.13	710670	47601.
			2496.1	0.76	0.04	699450	45915.
			2275.4	0.90	0.05	668970	43142.
			2191.1	1.64	0.08	748410	44707.
			2126.1	5.1	0.3	737280	49649.
			1512.5	2.55	0.13	719140	48234.
			1455.2	1.18	0.06	829600	73361.
			1364.6	4.62	0.18	689000	34875.
			1280.2	8.2	0.4	679640	39791.
			1054.3	4.76	0.24	733720	44809.
			985.1	5.5	0.3	776620	49126.
					R_av	714654	25216.
169 Lu	c	34.06H	1466.8	3.32	0.11	617480	30723.
			1463.4	1.51	0.05	674270	37150.
			960.6	23.4	0.7	558970	24115.
			889.8	5.36	0.17	525340	23432.
			191.2	20.6	0.6	529370	23840.
			165.0	1.97	0.05	462790	30752.
					R_av	550003	27509.
167 Lu	c	51.5M	113.3	*****************		445780	37964
169 Yb	c*	32.026D	307.7	10.05	0.19	724180	26276.
			130.5	11.31	0.21	680200	38902.
					R_av	717848	27228.
167 Yb-i	i	17.5M	113.3	55	3	24874	7970
167 Yb	c	17.5M	113.3	55	3	470650	40070
166 Yb	c	56.7H	2092.1	*****************		400830	26808.
			2079.5	*****************		363450	25807.
			2052.4	*****************		373420	24715.
			1867.9	*****************		359900	24372.
			1374.2	*****************		366890	28824.
			1273.5	*****************		333310	22674.
			1176.7	*****************		332250	23653.
			785.9	*****************		315770	21931.
			691.2	8.56	0.58	311460	23195.
					R_av	351461	14818.
162 Yb	c	18.87M	163.4	40	5	79597	10427.
			118.7	34	4	81592	10947.
			102.0	*****************		64503	13193.
					R_av	77301	5996.
168 Tm	i	93.1D	447.5	23.7	0.8	2920	253
167 Tm	c	9.25D	531.5	1.61	0.22	485700	68078.
			207.8	42	8	463530	89546.
					R_av	477705	55125.
166 Tm-i	i	7.70H	2092.1	1.56	0.09	14539	10369.
			2079.5	6.3	0.4	-94.71	3496.00
			2052.4	17.2	1.0	1890	4867.

			1867.9	4.04	0.24	29051	4448.
			1374.2	5.6	0.4	15627	11220.
			1273.5	14.9	0.9	3452	5146.
			1176.7	9.5	0.6	41668	9451.
			785.9	9.9	0.6	18511	8236.
					R_av	11236	5075.
166 Tm	c	7.70H	2092.1	1.56	0.09	415370	29157.
			2079.5	6.3	0.4	363360	25969.
			2052.4	17.2	1.0	375310	25303.
			1867.9	4.04	0.24	388950	26471.
			1374.2	5.6	0.4	382510	31784.
			1273.5	14.9	0.9	336760	23439.
			1176.7	9.5	0.6	373920	27712.
			785.9	9.9	0.6	334280	24196.
					R_av	367825	14964.
165 Tm	c	30.06H	806.4	9.5	0.6	278080	19685.
			242.9	35.5	1.7	273320	16087.
					R_av	275097	13797.
163 Tm	c*	1.810H	1434.4	8.0	0.3	164740	10388.
			1397.5	7.03	0.24	218560	11723.
			104.3	18.6	0.7	142360	11949.
					R_av	177811	22755.
162 Tm-i	i(m+g)	21.70M	102.0	17.5	1.5	13520	24043
162 Tm	c	21.70M	102.0	17.5	1.5	78023	16042
161 Er	c	3.21H	826.6	64	4	77820	5521
160 Er	c	28.58H	879.4******************			44369	5855.
			872.0	6.8	1.1	37643	6447.
			728.2	34	5	47669	7198.
					R_av	43103	3690.
159 Er	c*	36M	624.5	33	4	28888	3987
160mHo-i	i(m)	5.02H	879.4	18.6	2.3	425.1	2102.0
160mHo	c	5.02H	879.4	18.6	2.3	44794	6082
157 Dy	c	8.14H	326.2	92	4	10109	827
147 Eu	c	24.1D	121.2	22.9	1.3	977.0	100.3
89 Zr	c	78.41H	909.2	99.04	0.03	697.2	87.0
84 Rb	i(m+g)	32.77D	881.6	69.0	1.6	1022	50
74 As	i	17.77D	595.8	59	4	453.4	52.0
7 Be	i	53.29D	477.6	10.52	0.06	1942	265

Table 10.57: Detailed reaction rates for residual nuclide production in ^{181}Ta at E_p=399 MeV used to determine their production cross sections.

Nuclide	Type	$T_{1/2}$	E_γ, KeV	Abundance, %		Reaction rate 10^{-20} s^{-1}	
178 W	i	21.6D	1350.6	1.18	0.11	47001	4783
177 W	i	135M	115.7	59.6	5.3	45493	5054
174 W	i	31M	206.5******************			47791	8179
182 Ta	i(m1+m2+g)	114.43D	1231.0	11.44	0.20	15600	698.
			1221.4	27.0	0.5	16768	759.
			1189.1	16.2	0.3	16324	743.
					R_av	16191	613.
180 Ta	i	8.152H	93.4	4.51	0.16	171080	17022
178mTa	i(m)	2.36H	331.6	31.2	0.5	94705	3831.
			325.6	94.1	1.7	91631	3576.
			93.2	17.2	0.4	96491	10632.
					R_av	93059	3313.
177 Ta	c*	56.56H	112.9	7.2	1.6	231130	53809
176 Ta	c	8.09H	2513.8	0.67	0.05	244750	26325.
			1862.7	4.0	0.3	304100	25041.
			1823.7	4.5	0.4	253320	24422.
			1696.6	4.6	0.4	311840	29086.
			1252.9	3.08	0.23	279750	23164.
			1159.3	24.7	1.9	275130	23151.
			710.5	5.4	0.4	227590	18626.
					R_av	265639	14462.

175 Ta	c	10.5H	1793.1	4.6	0.7	238990	37364.
			1744.8	1.36	0.19	200000	29751.
			266.9	10.52	0.16	261800	9322.
			125.9	9.0	1.3	404290	63018.
					R_av	260893	10929.
174 Ta-i	i	1.14H	206.5	60	5	169650	18369
174 Ta	c	1.14H	206.5	60	5	217440	19852
173 Ta	c	3.14H	1208.2	2.7	0.4	305390	49053.
			180.6	2.22	0.24	248950	28950.
			160.4	4.9	0.8	253920	42685.
					R_av	260483	21635.
172 Ta	c*	36.8M	1330.4	8.1	0.8	151760	20824.
			1109.3	14.9	1.5	136910	15822.
			1085.6	8.1	0.8	136790	14800.
			214.1	55	5	114340	11332.
					R_av	127653	8631.
180mHf	i(m)	5.5H	443.2	81.9	1.3	9953	481.
			332.3	94.1	1.2	11821	617.
					R_av	10616	953.
179mHf	i(m)	25.05D	453.6	68	4	3039	206.
			362.5	39.5	1.5	3018	155.
			315.9	20.2	0.7	3876	194.
					R_av	3291	298.
175 Hf	c	70D	353.3	0.23	0.02	370360	35608.
			343.4	84	3	378810	17908.
			318.9	0.17	0.05	466760	138311.
					R_av	378377	17155.
173 Hf	c	23.6H	311.2	10.7	0.5	430080	24434.
			139.6	12.7	0.6	438780	30038.
			123.7	83	5	466220	39181.
					R_av	436765	17847.
172 Hf	c	1.87Y	1093.6	******************		331670	18876.
			1022.4	******************		260740	31991.
			912.1	******************		335960	19054.
			810.1	******************		341460	20355.
			181.5	******************		314220	18510.
					R_av	328884	12541.
171 Hf	c	12.1H	739.8	******************		332500	28521
170 Hf	c	16.01H	2698.8	******************		355440	63935.
			2691.4	******************		324310	23444.
			2663.9	******************		348700	34790.
			2496.1	******************		335700	36362.
			2364.1	******************		308060	25895.
			2275.4	******************		289150	32991.
			2191.1	******************		350620	24016.
			2126.1	******************		336870	23359.
			1512.5	******************		277120	22363.
			1455.2	******************		306580	104306.
			1364.6	******************		345800	23226.
			1280.2	******************		305980	19806.
			1054.3	******************		316250	24668.
			985.1	******************		303920	22848.
			620.7	18	5	417810	116775.
			501.6	3.7	1.0	385220	104839.
			164.7	26	8	380850	118054.
			120.2	15	5	438520	148783.
					R_av	320607	11523.
168 Hf	c	25.95M	1136.8	16.1	2.9	256420	47477.
			979.2	26.1	0.7	228340	10089.
			896.1	20.1	2.6	228560	30598.
					R_av	228956	9913.
173 Lu	c	1.37Y	272.1	21.2	0.8	400480	19738
172 Lu-i	i	6.70D	1093.6	63	3	52561	2983.
			1022.4	1.41	0.07	59323	4693.
			912.1	15.3	0.7	49969	2787.
			810.1	16.6	0.8	49358	2878.
			181.5	20.6	1.0	50796	2984.
					R_av	50931	1867.
172 Lu	c	6.70D	1093.6	63	3	384230	21831.
			1022.4	1.41	0.07	320060	32548.
			912.1	15.3	0.7	385930	21689.
			810.1	16.6	0.8	390810	22994.
			181.5	20.6	1.0	365020	21472.
					R_av	376222	15175.
171 Lu-i	i(m+g)	8.24D	739.8	47.8	1.2	96763	27116

171 Lu	c	8.24D	853.0	2.55	0.07	456680	19004.
			839.9	3.04	0.08	464580	18863.
			780.7	4.36	0.11	449960	18048.
			739.8	47.8	1.2	429270	17093.
			689.3	2.37	0.06	447380	17990.
					R_av	448346	15258.
170 Lu-i	i(m+g)	2.012D	2698.8	0.61	0.04	18026	79032.
			2691.4	2.29	0.13	60572	13572.
			2663.9	1.26	0.07	26976	35999.
			2496.1	0.76	0.04	81719	39436.
			2364.1	1.50	0.08	93198	23805.
			2275.4	0.90	0.05	61500	35408.
			2191.1	1.64	0.08	79977	17951.
			2126.1	5.1	0.3	58050	9182.
			1512.5	2.55	0.13	104220	20678.
			1455.2	1.18	0.06	77822	139100.
			1364.6	4.62	0.18	27072	21325.
			1280.2	8.2	0.4	60655	12483.
			1054.3	4.76	0.24	84967	22455.
			985.1	5.5	0.3	108510	18587.
					R_av	67753	6081.
170 Lu	c	2.012D	2698.8	0.61	0.04	373470	35485.
			2691.4	2.29	0.13	384890	25620.
			2663.9	1.26	0.07	375680	26424.
			2496.1	0.76	0.04	417420	28247.
			2364.1	1.50	0.08	401260	25889.
			2275.4	0.90	0.05	350650	24865.
			2191.1	1.64	0.08	430600	25486.
			2126.1	5.1	0.3	394920	26461.
			1512.5	2.55	0.13	381340	23529.
			1455.2	1.18	0.06	384400	46580.
			1364.6	4.62	0.18	372870	19679.
			1280.2	8.2	0.4	366630	21505.
			1054.3	4.76	0.24	401210	24622.
			985.1	5.5	0.3	412430	26337.
					R_av	387765	13500.
169 Lu	c	34.06H	1466.8	3.32	0.11	335160	16019.
			1463.4	1.51	0.05	307290	15847.
			960.6	23.4	0.7	325680	14002.
			889.8	5.36	0.17	313200	13883.
			191.2	20.6	0.6	302150	13280.
			165.0	1.97	0.05	279440	20074.
					R_av	314024	11593.
167 Lu	c	51.5M	113.3	*********	********	341270	29026
169 Yb	c*	32.026D	307.7	10.05	0.19	438110	15970.
			130.5	11.31	0.21	409520	23472.
					R_av	433855	16949.
167 Yb-i	i	17.5M	113.3	55	3	28517	5504
167 Yb	c	17.5M	113.3	55	3	369780	31423
166 Yb	c	56.7H	2092.1	*********	********	360120	24330.
			2079.5	*********	********	336210	23875.
			2052.4	*********	********	339640	22455.
			1867.9	*********	********	332840	22497.
			1374.2	*********	********	330140	25788.
			1273.5	*********	********	310440	21187.
			1176.7	*********	********	306850	21645.
			785.9	*********	********	293510	20002.
			691.2	8.56	0.58	281150	20953.
					R_av	321347	13008.
162 Yb	c	18.87M	798.7	*********	********	212870	19713.
			163.4	40	5	168000	23233.
			118.7	34	4	165650	22077.
			102.0	*********	********	181370	24853.
					R_av	192218	13767.
168 Tm	i	93.1D	447.5	23.7	0.8	4037	276
167 Tm	c	9.25D	531.5	1.61	0.22	387220	54307.
			207.8	42	8	362600	70050.
					R_av	378118	43660.
166 Tm-i	i	7.70H	2092.1	1.56	0.09	17783	12831.
			2079.5	6.3	0.4	761.6	3471.1
			2052.4	17.2	1.0	4179	1695.
			1867.9	4.04	0.24	28223	4437.
			1374.2	5.6	0.4	25994	8190.
			1273.5	14.9	0.9	17745	5866.
			1176.7	9.5	0.6	51942	9845.
			785.9	9.9	0.6	11434	3849.
					R_av	8994	3842.

166 Tm	c	7.70H	2092.1	1.56	0.09	377910	27916.
			2079.5	6.3	0.4	336970	24121.
			2052.4	17.2	1.0	343820	22779.
			1867.9	4.04	0.24	361060	24594.
			1374.2	5.6	0.4	356130	28805.
			1273.5	14.9	0.9	328190	22985.
			1176.7	9.5	0.6	358790	26733.
			785.9	9.9	0.6	304940	21052.
					R_av	342035	13516.
165 Tm	c	30.06H	806.4	9.5	0.6	303200	21780.
			389.4	2.82	0.14	316060	19152.
			356.5	2.75	0.15	282780	18420.
			242.9	35.5	1.7	299570	17255.
					R_av	300000	12448.
163 Tm	c*	1.810H	1434.4	8.0	0.3	292340	18783.
			1397.5	7.03	0.24	304140	15267.
			1374.3	4.28	0.16	303580	21106.
			104.3	18.6	0.7	257250	21055.
					R_av	293676	13343.
162 Tm-i	i(m+g)	21.70M	798.7	8.4	0.7	6341	8678.
			102.0	17.5	1.5	10163	32671.
					R_av	6592	8377.
162 Tm	c	21.70M	798.7	8.4	0.7	219210	19889.
			102.0	17.5	1.5	191540	28858.
					R_av	210789	16909.
161 Er	c	3.21H	826.6	64	4	222390	15545
160 Er	c	28.58H	966.2	*********	********	173660	23202.
			962.4	*********	********	168170	22006.
			879.4	*********	********	165890	21163.
			872.0	6.8	1.1	140280	23165.
			728.2	*********	********	176020	25757.
					R_av	164769	10688.
159 Er	c*	36M	649.1	23	3	150580	20289.
			624.5	33	4	143930	18229.
					R_av	146888	13940.
157 Er	c*	18.65M	391.3	14.2	1.4	98805	10622
156 Er	c	19.5M	266.5	*********	********	56996	3615.
			137.8	*********	********	56338	4393.
					R_av	56752	2978.
160mHo-i	i(m)	5.02H	966.2	15.4	2.0	5734	2371.
			962.4	16.6	2.1	22403	6206.
			879.4	18.6	2.3	5518	1993.
			728.2	28	4	10388	2222.
					R_av	7792	2148.
160mHo	c	5.02H	966.2	15.4	2.0	179400	24030.
			962.4	16.6	2.1	190570	25324.
			879.4	18.6	2.3	171410	21912.
			728.2	28	4	186410	27299.
					R_av	180891	13143.
160 Ho	i(m+g)	25.6M	728.2	46.9	1.7	17207	4723
156 Ho-i	i	56M	266.5	54.7	1.1	788.3	3508.1
			137.8	51.1	0.8	4999	3898.
					R_av	2675	2608.
156 Ho	c	56M	266.5	54.7	1.1	57785	2376.
			137.8	51.1	0.8	61337	3358.
					R_av	58634	2377.
157 Dy	c	8.14H	326.2	92	4	91020	4932
152 Dy	c	2.38H	256.9	97.50	0.07	15454	630
155 Tb	c*	5.32D	180.1	7.5	0.5	50963	3822.
			163.3	4.44	0.24	42976	3035.
					R_av	46012	4135.
153 Tb	c*	2.34D	212.0	31.0	1.9	29193	2069.
			102.2	6.4	0.5	22949	2819.
					R_av	27313	2989.
151 Tb	c	17.609H	479.4	15.4	0.7	15307	992.
			251.9	26.3	1.2	14368	956.
					R_av	14828	703.
150 Tb	c	3.48H	638.0	72	10	6053	928
149 Tb	c	4.118H	352.2	29.4	0.9	6215	932

148 Tb	c	60M	784.4	84.0	1.6	8462	598
153 Gd	c	240.4D	103.2	21.1	0.7	20079	2533
151 Gd	c	124D	243.3	5.6	0.4	12967	1617.
			174.7	2.96	0.21	23578	2353.
			153.6	6.2	0.4	16443	1565.
					R_av	16452	2713.
149 Gd	c	9.28D	788.9	7.3	0.4	12034	898.
			346.6	23.9	1.3	11977	765.
			298.6	28.6	1.7	11366	895.
			149.7	48	3	12348	938.
					R_av	11930	539.
147 Gd	c	38.06H	229.3	63	4	6074	454
146 Gd	c	48.27D	747.2	*****************		5203	226.
			154.6	46.6	0.5	5587	210.
					R_av	5451	250.
149 Eu	c	93.1D	327.5	4.03	0.12	13157	815.
			277.1	3.56	0.06	11840	722.
					R_av	12416	760.
147 Eu	c	24.1D	955.8	3.84	0.20	6567	615.
			933.0	3.44	0.18	9911	716.
			677.5	9.8	0.5	7420	464.
			121.2	22.9	1.3	6754	569.
					R_av	7490	681.
146 Eu-i	i	4.61D	747.2	99	3	832.0	55.8
146 Eu	c	4.61D	747.2	99	3	6035	262
145 Eu	c	5.93D	893.7	66	5	2301	233
139 Ce	c	137.640D	165.9	79.89	0.01	349.4	46.6
96 Tc	i(m+g)	4.28D	849.9	98	4	613.1	60.8
89 Zr	c	78.41H	909.2	99.04	0.03	802.0	43.2
88 Zr	c	83.4D	392.9	97.24	0.00	301.3	21.1
87 Y	c	79.8H	388.5	82.1	0.5	986.3	78.9
84 Rb	i(m+g)	32.77D	881.6	69.0	1.6	1017	49
83 Rb	c	86.2D	520.4	45	4	1051	119
74 As	i	17.77D	595.8	59	4	718.4	81.6
59 Fe	c	44.472D	1099.2	56.5	1.9	603.2	54.9
54 Mn	i	312.11D	834.8	99.98	0.00	415.3	91.8
7 Be	i	53.29D	477.6	10.52	0.06	2424	194

Table 10.58: Detailed reaction rates for residual nuclide production in ^{181}Ta at E_p=599 MeV used to determine their production cross sections.

Nuclide	Type	$T_{1/2}$	E_γ, KeV	Abundance, %		Reaction rate 10^{-20} s^{-1}	
178 W	i	21.6D	1350.6	1.18	0.11	43932	4467
177 W	i	135M	115.7	59.6	5.3	38772	4344
176 W	i	2.5H	1862.7	*****************		131430	110071.
			1823.7	*****************		102510	17197.
			1159.3	*****************		54859	11419.
			710.5	*****************		74939	50370.
					R_av	70959	13166.
174 W	i	31M	206.5	*****************		25611	13132
182 Ta	i(m1+m2+g)	114.43D	1231.0	11.44	0.20	22416	981.
			1221.4	27.0	0.5	24909	923.
			1189.1	16.2	0.3	24558	930.
					R_av	24241	1022.
178mTa	i(m)	2.36H	331.6	31.2	0.5	90648	5842
177 Ta	c*	56.56H	112.9	7.2	1.6	209070	48795
176 Ta-i	i	8.09H	1862.7	4.0	0.3	121910	143647.
			1823.7	4.5	0.4	112980	21252.
			1159.3	24.7	1.9	178910	20302.
			710.5	5.4	0.4	98219	69463.

					R_av	153609	19372.
176 Ta	c	8.09H	1862.7	4.0	0.3	253420	43273.
			1823.7	4.5	0.4	215500	20867.
			1696.6	4.6	0.4	263640	24871.
			1252.9	3.08	0.23	268270	22807.
			1159.3	24.7	1.9	233770	19766.
			710.5	5.4	0.4	173160	24058.
					R_av	232483	15931.
175 Ta	c	10.5H	1793.1	4.6	0.7	193070	30289.
			1744.8	1.36	0.19	171950	27380.
			1736.7	0.92	0.14	221550	41407.
			266.9	10.52	0.16	234870	8488.
			125.9	9.0	1.3	350360	54670.
					R_av	233292	9821.
174 Ta-i	i	1.14H	206.5	60	5	155590	25865
174 Ta	c	1.14H	206.5	60	5	181210	18659
173 Ta	c	3.14H	1208.2	2.7	0.4	192630	35267
172 Ta	c*	36.8M	1330.4	8.1	0.8	108170	13797.
			1109.3	14.9	1.5	95002	12490.
			1085.6	8.1	0.8	95564	11474.
			214.1	55	5	98084	10098.
					R_av	98502	5599.
180mHf	i(m)	5.5H	332.3	94.1	1.2	15690	1384
179mHf	i(m)	25.05D	453.6	68	4	4009	272.
			362.5	39.5	1.5	4178	247.
			315.9	20.2	0.7	4669	247.
					R_av	4324	241.
175 Hf	c	70D	353.3	0.23	0.02	358540	33797.
			343.4	84	3	356420	16840.
			318.9	0.17	0.05	424630	126642.
					R_av	357293	16167.
173 Hf	c	23.6H	311.2	10.7	0.5	398010	22678.
			139.6	12.7	0.6	386810	26523.
			123.7	83	5	396590	33354.
					R_av	394710	16165.
172 Hf	c	1.87Y	1093.6	*****************		292270	16672.
			1022.4	*****************		287340	31666.
			929.1	*****************		300200	19806.
			912.1	*****************		294880	16977.
			810.1	*****************		313630	19273.
			181.5	*****************		278180	16514.
					R_av	293436	10320.
170 Hf	c	16.01H	2691.4	*****************		301140	30785.
			2663.9	*****************		286730	31950.
			2496.1	*****************		225230	43212.
			2275.4	*****************		140400	25698.
			2191.1	*****************		238460	24536.
			2126.1	*****************		304560	23039.
			1512.5	*****************		292550	30481.
			1455.2	*****************		325000	58548.
			1364.6	*****************		256500	29830.
			1280.2	*****************		243750	18920.
			1054.3	*****************		251000	31814.
			985.1	*****************		276740	32624.
			620.7	18	5	386240	107924.
			501.6	3.7	1.0	354330	96537.
			164.7	26	8	342410	105999.
			120.2	15	5	386240	130914.
					R_av	260251	14316.
168 Hf	c	25.95M	1136.8	16.1	2.9	244510	45979.
			983.8	16	4	226830	57435.
			979.2	26.1	0.7	213850	9172.
			896.1	20.1	2.6	250510	33640.
			896.1	20.1	2.6	246280	33232.
					R_av	216856	9034.
173 Lu	c	1.37Y	272.1	21.2	0.8	371520	18344
172 Lu-i	i	6.70D	1093.6	63	3	63924	3628.
			1022.4	1.41	0.07	72988	4953.
			929.1	3.04	0.14	62515	3756.
			912.1	15.3	0.7	59255	3286.
			810.1	16.6	0.8	59575	3480.
			181.5	20.6	1.0	61378	3620.
					R_av	61640	2380.
172 Lu	c	6.70D	1093.6	63	3	356200	20266.
			1022.4	1.41	0.07	360330	33228.

			929.1	3.04	0.14	362720	22453.
			912.1	15.3	0.7	354130	20064.
			810.1	16.6	0.8	373200	22364.
			181.5	20.6	1.0	339550	20059.
					R_av	356402	13529.
171 Lu	c	8.24D	853.0	2.55	0.07	430590	17975.
			839.9	3.04	0.08	435350	17750.
			780.7	4.36	0.11	421920	16822.
			739.8	47.8	1.2	423690	16783.
			689.3	2.37	0.06	416720	16738.
					R_av	425085	14142.
170 Lu-i	i(m+g)	2.012D	2691.4	2.29	0.13	44611	31708.
			2663.9	1.26	0.07	67581	33561.
			2496.1	0.76	0.04	177050	53872.
			2275.4	0.90	0.05	209260	34172.
			2191.1	1.64	0.08	131970	27289.
			2126.1	5.1	0.3	60312	14821.
			1512.5	2.55	0.13	48765	32303.
			1455.2	1.18	0.06	5744	72460.
			1364.6	4.62	0.18	95615	36752.
			1280.2	8.2	0.4	105310	17921.
			1054.3	4.76	0.24	111500	38814.
			985.1	5.5	0.3	106100	37595.
					R_av	91473	13248.
170 Lu	c	2.012D	2691.4	2.29	0.13	345750	24476.
			2663.9	1.26	0.07	354310	24668.
			2496.1	0.76	0.04	402280	29110.
			2275.4	0.90	0.05	349670	24040.
			2191.1	1.64	0.08	370430	22697.
			2126.1	5.1	0.3	364870	24725.
			1512.5	2.55	0.13	341320	22300.
			1455.2	1.18	0.06	330740	27820.
			1364.6	4.62	0.18	352110	20475.
			1280.2	8.2	0.4	349060	20799.
			1054.3	4.76	0.24	362500	24317.
			985.1	5.5	0.3	382850	26291.
					R_av	357351	12710.
169 Lu	c	34.06H	1466.8	3.32	0.11	320550	15091.
			1463.4	1.51	0.05	276900	13721.
			960.6	23.4	0.7	309070	13493.
			889.8	5.36	0.17	303310	13962.
			191.2	20.6	0.6	296080	13525.
					R_av	301436	11597.
167 Lu	c	51.5M	113.3	**********	*******	353560	30073
169 Yb	c*	32.026D	307.7	10.05	0.19	437560	15949.
			130.5	11.31	0.21	403540	23199.
					R_av	432421	18192.
167 Yb-i	i	17.5M	113.3	55	3	16738	5872
167 Yb	c	17.5M	113.3	55	3	370300	31541
166 Yb	c	56.7H	2092.1	**********	*******	405000	26981.
			2079.5	**********	*******	377530	26819.
			2052.4	**********	*******	380520	25239.
			1867.9	**********	*******	376490	25471.
			1374.2	**********	*******	359660	28233.
			1273.5	**********	*******	361570	25149.
			1176.7	**********	*******	343600	24785.
			785.9	**********	*******	336270	23027.
			691.2	8.56	0.58	317770	23784.
					R_av	365108	14503.
162 Yb	c	18.87M	798.7	**********	*******	306660	30443.
			163.4	40	5	277950	36252.
			118.7	34	4	253880	34804.
			102.0	**********	*******	247260	34019.
					R_av	279558	17083.
168 Tm	i	93.1D	720.4	12.0	0.4	8478	549.
			447.5	23.7	0.8	6988	387.
					R_av	7444	725.
167 Tm	c	9.25D	531.5	1.61	0.22	419920	58971.
			207.8	42	8	397680	76832.
					R_av	411801	47584.
166 Tm-i	i	7.70H	2092.1	1.56	0.09	3677	26020.
			2079.5	6.3	0.4	5855	4769.
			2052.4	17.2	1.0	11368	4204.
			1867.9	4.04	0.24	43284	9346.
			1374.2	5.6	0.4	10196	13114.
			1273.5	14.9	0.9	43617	8915.
			1176.7	9.5	0.6	88206	27727.
			785.9	9.9	0.6	12505	7837.

				R_av	15948	5584.
166 Tm	c	7.70H	2092.1	1.56	0.09	408680	36388.
			2079.5	6.3	0.4	383380	27546.
			2052.4	17.2	1.0	391890	26241.
			1867.9	4.04	0.24	419770	29340.
			1374.2	5.6	0.4	369850	31461.
			1273.5	14.9	0.9	405190	28955.
			1176.7	9.5	0.6	431800	40024.
			785.9	9.9	0.6	348780	24950.
					R_av	389869	15469.
165 Tm	c	30.06H	806.4	9.5	0.6	369020	26657.
			356.5	2.75	0.15	415010	26612.
			242.9	35.5	1.7	366170	21679.
					R_av	380771	19342.
163 Tm	c*	1.810H	1434.4	8.0	0.3	371840	20501.
			1397.5	7.03	0.24	384560	20777.
			1374.3	4.28	0.16	430800	37826.
			104.3	18.6	0.7	395930	31625.
					R_av	385212	16012.
162 Tm-i	i(m+g)	21.70M	798.7	8.4	0.7	36050	19959.
			102.0	17.5	1.5	64450	37011.
					R_av	42442	17450.
162 Tm	c	21.70M	798.7	8.4	0.7	342710	31684.
			102.0	17.5	1.5	311710	39192.
					R_av	330881	25628.
161 Er	c	3.21H	826.6	64	4	368810	27843
160 Er	c	28.58H	966.2	**********	*******	317160	42479.
			962.4	**********	*******	307920	40303.
			879.4	**********	*******	322210	41171.
			872.0	6.8	1.1	282150	46703.
			728.2	**********	*******	325540	47749.
					R_av	311791	20231.
159 Er	c*	36M	649.1	23	3	303880	42773.
			624.5	33	4	299480	37968.
					R_av	301406	29155.
157 Er	c*	18.65M	391.3	14.2	1.4	226290	24903
156 Er	c	19.5M	266.5	**********	*******	142470	8534.
			137.8	**********	*******	165120	10655.
					R_av	150953	11934.
160mHo-i	i(m)	5.02H	966.2	15.4	2.0	3835	6189.
			962.4	16.6	2.1	2292	11250.
			879.4	18.6	2.3	9674	5229.
			728.2	28	4	25540	7644.
					R_av	10466	4650.
160mHo	c	5.02H	966.2	15.4	2.0	320990	43285.
			962.4	16.6	2.1	310210	41877.
			879.4	18.6	2.3	331890	42600.
			728.2	28	4	351080	51743.
					R_av	326429	23887.
160 Ho	i(m+g)	25.6M	728.2	46.9	1.7	30687	6616
156 Ho-i	i	56M	266.5	54.7	1.1	43335	7987.
			137.8	51.1	0.8	13017	7459.
					R_av	27391	15163.
156 Ho	c	56M	266.5	54.7	1.1	185810	7249.
			137.8	51.1	0.8	178130	9510.
					R_av	183962	6881.
157 Dy	c	8.14H	326.2	92	4	239950	12888
155 Dy	c*	9.9H	226.9	68.4	1.6	184350	7359
152 Dy	c	2.38H	344.3	99.9	0.0	83987	7070.
			256.9	97.50	0.07	81302	2797.
					R_av	81385	2543.
155 Tb	c*	5.32D	340.7	1.18	0.07	187780	12941.
			180.1	7.5	0.5	179710	13375.
			163.3	4.44	0.24	182860	11918.
					R_av	183526	8691.
153 Tb	c*	2.34D	212.0	31.0	1.9	128100	8900.
			102.2	6.4	0.5	121080	12768.
					R_av	126106	7491.
152 Tb-i	i(m+g)	17.5H	344.3	65	4	7677	4097

152 Tb	c	17.5H	344.3	65	4	91580	6382
151 Tb	c	17.609H	731.2	8.32	0.04	88291	3380.
			616.6	10.4	0.5	107840	6301.
			479.4	15.4	0.7	83889	4747.
			251.9	26.3	1.2	82258	4675.
			108.1	24.3	1.1	80864	6812.
					R_av	87759	4570.
150 Tb	c	3.48H	638.0	72	10	40140	5778.
			496.2	14.6	2.0	39628	6217.
					R_av	39904	4322.
149 Tb	c	4.118H	817.1	11.6	0.4	23016	2554.
			352.2	29.4	0.9	29168	1737.
					R_av	27652	2613.
148 Tb	c	60M	784.4	84.0	1.6	37969	1586.
			489.0	19.7	0.5	32750	2708.
					R_av	37188	2195.
153 Gd	c	240.4D	103.2	21.1	0.7	112740	8968
151 Gd	c	124D	243.3	5.6	0.4	81588	6702.
			174.7	2.96	0.21	88107	7012.
			153.6	6.2	0.4	72104	5551.
					R_av	79207	5356.
149 Gd	c	9.28D	788.9	7.3	0.4	89038	5603.
			534.3	3.07	0.17	103460	6883.
			346.6	23.9	1.3	83307	5225.
			327.5	*****************		87995	5468.
			298.6	28.6	1.7	82452	5558.
			277.1	*****************		87662	19241.
			272.3	3.21	0.19	79816	5521.
			149.7	48	3	86886	6581.
					R_av	86679	3622.
147 Gd	c	38.06H	929.0	20.2	1.2	54640	3728.
			861.7	1.75	0.10	58304	5155.
			625.2	4.7	0.4	45600	4980.
			370.0	17.2	0.9	54332	3494.
			229.3	63	4	63485	4580.
					R_av	55521	2830.
146 Gd	c	48.27D	2436.7	*****************		53994	4514.
			1533.7	*****************		54626	2450.
			747.2	*****************		54250	2361.
			154.6	46.6	0.5	52074	1873.
					R_av	52984	1806.
145 Gd	c	23.0M	1880.6	32.6	1.9	14239	3837.
			1757.9	34.2	2.0	32147	2918.
					R_av	26830	8225.
149 Eu-i	i	93.1D	327.5	4.03	0.12	6409	3838.
			277.1	3.56	0.06	2468	18610.
					R_av	6248	3759.
149 Eu	c	93.1D	327.5	4.03	0.12	94404	4092.
			277.1	3.56	0.06	90130	3937.
					R_av	92201	3586.
148 Eu	i	54.5D	725.7	12.7	0.4	4272	264.
			611.3	20.5	0.7	2837	186.
			550.3	99	3	3109	140.
					R_av	3188	316.
147 Eu	c	24.1D	955.8	3.84	0.20	66527	4106.
			798.7	4.8	0.3	85307	6015.
			677.5	9.8	0.5	70893	4255.
			121.2	22.9	1.3	66995	5542.
					R_av	70891	4292.
146 Eu-i	i	4.61D	2436.7	0.93	0.03	45939	8254.
			1533.7	6.08	0.19	12138	911.
			747.2	99	3	7772	458.
					R_av	8627	1666.
146 Eu	c	4.61D	2436.7	0.93	0.03	99934	8710.
			1533.7	6.08	0.19	66764	2994.
			747.2	99	3	62022	2692.
					R_av	65113	5004.
145 Eu	c	5.93D	1997.0	7.2	0.5	37205	2896.
			1804.3	1.07	0.07	42532	7481.
			1658.5	14.9	1.0	34983	2619.
			893.7	66	5	34602	2831.
			653.5	15	1	34888	2595.
					R_av	35559	1656.

144 Pm	i	363D	618.0	98.6	1.0	769.5	227.1
143 Pm	c	265D	742.0	38.5	2.4	23482	1659
136 Nd	c	50.65M	552.2	*****************		13333	1083
136 Pr-i	i	13.1M	552.2	76	5	2404	771
136 Pr	c	13.1M	552.2	76	5	15737	1237
139 Ce	c	137.640D	165.9	79.89	0.01	9813	335
131 Ba	c	11.50D	216.1	19.66	0.25	2862	517
121 Te-i	i(m+g)	19.16D	573.1	80.3	2.5	665.4	29.2
121 Te	c	19.16D	573.1	80.3	2.5	1058	46
121mTe	i(m)	154D	573.1	88.6	0.1	443.2	20.8
			212.2	81.4	1.1	648.2	247.1
					R_av	444.1	20.8
96 Tc	i(m+g)	4.28D	849.9	98	4	854.4	53.4
90 Nb	c*	14.60H	2319.0	82.0	0.3	952.8	101.4
89 Zr	c	78.41H	909.2	99.04	0.03	1333	119
88 Zr	c	83.4D	1836.1	*****************		1321	853.
			392.9	97.24	0.00	943.8	101.5
					R_av	948.6	29.6
88 Y -i	i	106.65D	1836.1	99.2	0.3	1520	277
88 Y	c	106.65D	1836.1	99.2	0.3	2841	599
87 Y	c	79.8H	484.8	89.7	0.7	1977	220.
			388.5	82.1	0.5	2198	93.
					R_av	2180	91.
84 Rb	i(m+g)	32.77D	881.6	69.0	1.6	1712	82
83 Rb	c	86.2D	520.4	45	4	1592	177
74 As	i	17.77D	595.8	59	4	1571	132
59 Fe	c	44.472D	1099.2	56.5	1.9	1069	61
54 Mn	i	312.11D	834.8	99.98	0.00	658.5	84.3
46 Sc	i(m+g)	83.79D	889.3	99.98	0.00	913.2	109.2
7 Be	i	53.29D	477.6	10.52	0.06	4771	1098

Table 10.59: Detailed reaction rates for residual nuclide production in ^{181}Ta at E_p=799 MeV used to determine their production cross sections.

Nuclide	Type	$T_{1/2}$	E_γ, KeV	Abundance, %		Reaction rate 10^{-20} s^{-1}	
178 W	i	21.6D	1350.6	1.18	0.11	44444	5283
177 W	i	135M	115.7	59.6	5.3	36656	4049
176 W	i	2.5H	1862.7	*****************		168420	23275.
			1823.7	*****************		28776	40419.
			1159.3	*****************		49453	11337.
					R_av	75461	35869.
174 W	i	31M	206.5	*****************		30915	10212
182 Ta	i(m1+m2+g)	114.43D	1231.0	11.44	0.20	25813	1045.
			1221.4	27.0	0.5	26936	1025.
			1189.1	16.2	0.3	28527	1138.
					R_av	27025	1122.
178mTa	i(m)	2.36H	331.6	31.2	0.5	93221	5058
177 Ta	c*	56.56H	112.9	7.2	1.6	239260	56428
176 Ta-i	i	8.09H	1862.7	4.0	0.3	60991	24718.
			1823.7	4.5	0.4	183200	53792.
			1159.3	24.7	1.9	181470	19765.
					R_av	154901	35722.
176 Ta	c	8.09H	1862.7	4.0	0.3	229410	19523.
			1823.7	4.5	0.4	211970	23738.
			1696.6	4.6	0.4	277870	27066.
			1252.9	3.08	0.23	295060	26172.
			1159.3	24.7	1.9	230930	19465.

					R_av	243176	16235.
175 Ta	c	10.5H	1793.1	4.6	0.7	160220	26038.
			1744.8	1.36	0.19	138600	23461.
			1736.7	0.92	0.14	206110	38470.
			266.9	10.52	0.16	198580	7958.
			125.9	9.0	1.3	310090	48314.
					R_av	196032	10528.
174 Ta-i	i	1.14H	206.5	60	5	127640	19059
174 Ta	c	1.14H	206.5	60	5	158550	15393
172 Ta	c*	36.8M	1330.4	8.1	0.8	73910	12292.
			1109.3	14.9	1.5	95691	13050.
			1085.6	8.1	0.8	81717	14154.
			214.1	55	5	46906	8038.
					R_av	66956	11561.
180mHf	i(m)	5.5H	332.3	94.1	1.2	19609	1233
179mHf	i(m)	25.05D	453.6	68	4	4531	310.
			362.5	39.5	1.5	4617	242.
			315.9	20.2	0.7	5369	275.
					R_av	4859	304.
175 Hf	c	70D	353.3	0.23	0.02	347170	36153.
			343.4	84	3	340460	16088.
			318.9	0.17	0.05	465870	138407.
					R_av	342041	15592.
173 Hf	c	23.6H	311.2	10.7	0.5	389120	22453.
			139.6	12.7	0.6	376420	26172.
			123.7	83	5	419850	35509.
					R_av	389332	16137.
172 Hf	c	1.87Y	1093.6	*****************		258310	14673.
			1022.4	*****************		291700	43979.
			929.1	*****************		310150	22996.
			912.1	*****************		279930	17034.
			810.1	*****************		296360	17497.
			181.5	*****************		246510	14481.
					R_av	268378	12403.
170 Hf	c	16.01H	2275.4	*****************		247510	65393.
			2191.1	*****************		259060	185763.
			2126.1	*****************		283330	34649.
			1512.5	*****************		298130	90195.
			1455.2	*****************		304360	505183.
			1364.6	*****************		298360	50224.
			1280.2	*****************		249200	38925.
			1054.3	*****************		307310	35711.
			620.7	18	5	335570	93941.
			501.6	3.7	1.0	335690	91983.
			164.7	26	8	323850	100570.
			120.2	15	5	339130	115051.
					R_av	287886	18275.
168 Hf	c	25.95M	1136.8	16.1	2.9	206080	38628.
			983.8	16	4	211130	53606.
			979.2	26.1	0.7	171080	8134.
					R_av	172465	8075.
173 Lu	c	1.37Y	272.1	21.2	0.8	338250	16793
172 Lu-i	i	6.70D	1093.6	63	3	66301	3760.
			1022.4	1.41	0.07	76751	6561.
			929.1	3.04	0.14	48209	4104.
			912.1	15.3	0.7	59957	3413.
			810.1	16.6	0.8	65298	3818.
			181.5	20.6	1.0	63782	3749.
					R_av	62922	2973.
172 Lu	c	6.70D	1093.6	63	3	324610	18416.
			1022.4	1.41	0.07	368450	44766.
			929.1	3.04	0.14	358360	24738.
			912.1	15.3	0.7	339890	19970.
			810.1	16.6	0.8	361660	21077.
			181.5	20.6	1.0	310290	18218.
					R_av	336095	13784.
171 Lu	c	8.24D	853.0	2.55	0.07	400150	16974.
			839.9	3.04	0.08	397760	16448.
			780.7	4.36	0.11	383140	15374.
			739.8	47.8	1.2	381550	15130.
			689.3	2.37	0.06	375350	15146.
					R_av	386218	12929.
170 Lu-i	i(m+g)	2.012D	2275.4	0.90	0.05	62597	91349.
			2191.1	1.64	0.08	89223	268813.
			2126.1	5.1	0.3	58021	41417.

			1512.5	2.55	0.13	17353	126901.
			1455.2	1.18	0.06	38737	736401.
			1364.6	4.62	0.18	3919	68980.
			1280.2	8.2	0.4	87520	51876.
			1054.3	4.76	0.24	10810	44231.
					R_av	44161	23109.
170 Lu	c	2.012D	2275.4	0.90	0.05	310110	35115.
			2191.1	1.64	0.08	348290	86265.
			2126.1	5.1	0.3	341350	26471.
			1512.5	2.55	0.13	315480	44322.
			1455.2	1.18	0.06	343100	232928.
			1364.6	4.62	0.18	302280	26848.
			1280.2	8.2	0.4	336720	25662.
			1054.3	4.76	0.24	318120	23468.
					R_av	323133	14641.
169 Lu	c	34.06H	1466.8	3.32	0.11	311630	19823.
			1463.4	1.51	0.05	298390	25353.
			960.6	23.4	0.7	298080	15614.
			889.8	5.36	0.17	294620	14173.
			191.2	20.6	0.6	305330	13366.
					R_av	301326	10651.
167 Lu	c	51.5M	113.3	*****************		295740	25222
169 Yb	c*	32.026D	307.5	0.3	0.313451000.13456052.		
			130.5	11.31	0.21	364390	20983.
					R_av	364412	20983.
167 Yb-i	i	17.5M	113.3	55	3	48320	7676
167 Yb	c	17.5M	113.3	55	3	344060	29486
166 Yb	c	56.7H	2092.1	*****************		390450	25989.
			2052.4	*****************		380050	25680.
			1867.9	*****************		376070	26321.
			1374.2	*****************		342430	27454.
			1273.5	*****************		337120	23308.
			1176.7	*****************		341770	25200.
			785.9	*****************		321540	22016.
			691.2	8.56	0.58	309120	24336.
					R_av	353059	15372.
162 Yb	c	18.87M	798.7	*****************		291840	29681.
			163.4	40	5	258040	34500.
			118.7	34	4	237460	31944.
			102.0	*****************		204230	23667.
					R_av	244969	22445.
168 Tm	i	93.1D	720.4	12.0	0.4	9384	594.
			447.5	23.7	0.8	8744	431.
					R_av	8932	403.
167 Tm	c	9.25D	531.5	1.61	0.22	389130	54671.
			207.8	42	8	367940	71082.
					R_av	381374	44081.
166 Tm-i	i	7.70H	2092.1	1.56	0.09	27880	18139.
			2052.4	17.2	1.0	11849	9073.
			1867.9	4.04	0.24	26977	15891.
			1374.2	5.6	0.4	38657	27065.
			1273.5	14.9	0.9	45725	9698.
			1176.7	9.5	0.6	56162	28300.
			785.9	9.9	0.6	17120	6135.
					R_av	23999	5352.
166 Tm	c	7.70H	2092.1	1.56	0.09	418330	32824.
			2052.4	17.2	1.0	391900	27690.
			1867.9	4.04	0.24	403050	31706.
			1374.2	5.6	0.4	381080	40277.
			1273.5	14.9	0.9	382840	27758.
			1176.7	9.5	0.6	397930	39717.
			785.9	9.9	0.6	338660	23834.
					R_av	381766	16141.
165 Tm	c	30.06H	806.4	9.5	0.6	372250	26398.
			356.5	2.75	0.15	429410	29871.
			242.9	35.5	1.7	397850	22999.
					R_av	397633	19323.
163 Tm	c*	1.810H	1434.4	8.0	0.3	368220	20224.
			1397.5	7.03	0.24	355360	21058.
			1374.3	4.28	0.16	388470	50338.
			104.3	18.6	0.7	369930	29673.
					R_av	364761	15734.
162 Tm-i	i(m+g)	21.70M	798.7	8.4	0.7	60338	22872.
			102.0	17.5	1.5	102060	16222.
					R_av	90109	19071.

162 Tm	c	21.70M	798.7	8.4	0.7	352180	32978.
			102.0	17.5	1.5	306290	34477.
					R_av	330687	25122.
161 Er	c	3.21H	826.6	64	4	373720	32430
160 Er	c	28.58H	966.2	*********	********	383770	51308.
			962.4	*********	********	370450	48364.
			879.4	*********	********	388740	49746.
			872.0	6.8	1.1	327330	54276.
			728.2	*********	********	398640	58319.
					R_av	374272	24283.
159 Er	c*	36M	649.1	23	3	346810	46791.
			624.5	33	4	335430	42120.
					R_av	340499	32189.
157 Er	c*	18.65M	391.3	14.2	1.4	270440	28566
156 Er	c	19.5M	266.5	*********	********	212710	11781.
			137.8	*********	********	217640	12509.
					R_av	214971	9505.
160 Ho	i(m+g)	25.6M	728.2	46.9	1.7	41017	9977
156 Ho-i	i	56M	266.5	54.7	1.1	31325	10154.
			137.8	51.1	0.8	23629	6257.
					R_av	25738	5345.
156 Ho	c	56M	266.5	54.7	1.1	244030	9522.
			137.8	51.1	0.8	241270	12704.
					R_av	243375	9090.
157 Dy	c	8.14H	326.2	92	4	325830	18232
155 Dy	c*	9.9H	226.9	68.4	1.6	263950	11231
152 Dy	c	2.38H	344.3	99.9	0.0	148800	16727.
			256.9	97.50	0.07	134630	4772.
					R_av	134903	4215.
155 Tb	c*	5.32D	340.7	1.18	0.07	256300	17608.
			180.1	7.5	0.5	253060	18838.
			163.3	4.44	0.24	268880	18205.
			163.3	4.44	0.24	257160	16557.
					R_av	258863	11294.
153 Tb	c*	2.34D	212.0	31.0	1.9	236320	16410.
			212.0	31.0	1.9	227960	17088.
			102.2	6.4	0.5	220360	24085.
					R_av	230409	11728.
152 Tb-i	i(m+g)	17.5H	344.3	65	4	23558	13698
152 Tb	c	17.5H	344.3	65	4	172220	12153
151 Tb	c	17.609H	731.2	8.32	0.04	154410	5978.
			616.6	10.4	0.5	176140	10419.
			479.4	15.4	0.7	188850	12748.
			479.4	15.4	0.7	157920	12883.
			251.9	26.3	1.2	159470	9146.
			108.1	24.3	1.1	175180	14329.
					R_av	162307	7116.
150 Tb	c	3.48H	638.0	72	10	79218	11430.
			496.2	14.6	2.0	87967	13128.
					R_av	82984	8812.
149 Tb	c	4.118H	817.1	11.6	0.4	52389	5363.
			352.2	29.4	0.9	60395	2875.
					R_av	59706	2743.
148 Tb	c	60M	784.4	84.0	1.6	68494	2693.
			489.0	19.7	0.5	74597	3898.
					R_av	69807	3323.
153 Gd	c	240.4D	103.2	21.1	0.7	199450	15483
151 Gd	c	124D	243.3	5.6	0.4	139350	11209.
			174.7	2.96	0.21	147970	12682.
			153.6	6.2	0.4	132800	10517.
					R_av	139044	7454.
149 Gd	c	9.28D	788.9	7.3	0.4	176360	11094.
			534.3	3.07	0.17	203160	12971.
			346.6	23.9	1.3	163590	10326.
			327.5	*********	********	149970	13700.
			298.6	28.6	1.7	163200	10961.
			277.1	*********	********	148350	9521.
			272.3	3.21	0.19	164610	11270.
			149.7	48	3	172590	13051.

					R_av	166296	7768.
147 Gd	c	38.06H	929.0	20.2	1.2	140050	9540.
			861.7	1.75	0.10	176780	12691.
			625.2	4.7	0.4	155370	14348.
			370.0	17.2	0.9	129670	8058.
			229.3	63	4	151000	10760.
					R_av	142280	8755.
146 Gd	c	48.27D	2436.7*****************			130530	6210.
			1533.7*****************			131340	5796.
			747.2*****************			127900	5512.
			154.6	46.6	0.5	124040	4472.
					R_av	126700	4330.
145 Gd	c	23.0M	1880.6	32.6	1.9	55548	5080.
			1757.9	34.2	2.0	62662	5049.
					R_av	59349	4004.
149 Eu-i	i	93.1D	327.5	4.03	0.12	40241	12220.
			277.1	3.56	0.06	37376	8225.
					R_av	38263	6869.
149 Eu	c	93.1D	327.5	4.03	0.12	190220	8396.
			277.1	3.56	0.06	185730	6679.
					R_av	186795	6511.
148 Eu	i	54.5D	725.7	12.7	0.4	7268	378.
			630.0	71.9	2.3	7518	380.
			611.3	20.5	0.7	6658	331.
			550.3	99	3	7238	328.
					R_av	7142	288.
147 Eu	c	24.1D	955.8	3.84	0.20	159100	9668.
			798.7	4.8	0.3	187700	13102.
			677.5	9.8	0.5	158430	9560.
			121.2	22.9	1.3	149640	12494.
					R_av	161991	8533.
146 Eu-i	i	4.61D	2436.7	0.93	0.03	39169	3776.
			1533.7	6.08	0.19	24210	1238.
			747.2	99	3	19286	856.
					R_av	21035	2501.
146 Eu	c	4.61D	2436.7	0.93	0.03	169710	8257.
			1533.7	6.08	0.19	155550	6872.
			747.2	99	3	147190	6343.
					R_av	154843	7704.
145 Eu	c	5.93D	1997.0	7.2	0.5	96103	7375.
			1804.3	1.07	0.07	117210	9812.
			1658.5	14.9	1.0	96266	7144.
			893.7	66	5	94681	7745.
			653.5	15	1	95992	7085.
					R_av	98346	4636.
144 Pm	i	363D	618.0	98.6	1.0	1903	114
143 Pm	c	265D	742.0	38.5	2.4	73238	5109
136 Nd	c	50.65M	552.2*****************			28197	2126
136 Pr-i	i	13.1M	552.2	76	5	8748	1105
136 Pr	c	13.1M	552.2	76	5	36946	2768
134 Pr	c*	17M	409.2	87.1	0.0	14416	954
139 Ce	c	137.640D	165.9	79.89	0.01	45417	1537
132 Ce	c	3.51H	464.5*****************			7725	761
132 La-i	i(m+g)	4.8H	464.5	76	6	2175	541
132 La	c	4.8H	464.5	76	6	9900	871
133 Ba	c	3848.9D	356.0	62.05	0.19	14116	1631
131 Ba	c	11.50D	216.1	19.66	0.25	12303	576
127 Xe	c	36.4D	375.0	17.2	0.6	6851	340
121 Te-i	i(m+g)	19.16D	573.1	80.3	2.5	2743	134
121 Te	c	19.16D	573.1	80.3	2.5	4087	204
121mTe	i(m)	154D	573.1	88.6	0.1	1517	186.
			212.2	81.4	1.1	621.3	183.2
					R_av	1075	449.
96 Tc	i(m+g)	4.28D	849.9	98	4	1376	78.

			812.5	82	4	1389	158.
					R_av	1378	74.
90 Nb	c*	14.60H	2319.0	82.0	0.3	2231	402
89 Zr	c	78.41H	909.2	99.04	0.03	2579	103
88 Zr	c	83.4D	1836.1	********	*********	558.3	164.9
			392.9	97.24	0.00	1807	83.
					R_av	1655	52.
88 Y -i	i	106.65D	1836.1	99.2	0.3	2832	110
88 Y	c	106.65D	1836.1	99.2	0.3	3390	148
87 Y	c	79.8H	484.8	89.7	0.7	3121	140.
			388.5	82.1	0.5	3698	177.
					R_av	3329	296.
84 Rb	i(m+g)	32.77D	881.6	69.0	1.6	2357	104
83 Rb	c	86.2D	520.4	45	4	4102	397
74 As	i	17.77D	595.8	59	4	2468	201
59 Fe	c	44.472D	1099.2	56.5	1.9	1416	210
54 Mn	i	312.11D	834.8	99.98	0.00	1634	131
46 Sc	i(m+g)	83.79D	889.3	99.98	0.00	2536	123
7 Be	i	53.29D	477.6	10.52	0.06	9126	602

Table 10.60: Detailed reaction rates for residual nuclide production in ^{181}Ta at E_p=1199 MeV used to determine their production cross sections.

Nuclide	Type	$T_{1/2}$	E_γ, KeV	Abundance, %		Reaction rate 10^{-20} s^{-1}	
178 W	i	21.6D	1402.9	0.48	0.04	61613	13091.
			1350.6	1.18	0.11	56318	5799.
					R_av	57124	5350.
177 W	i	135M	115.7	59.6	5.3	33805	4100
176 W	i	2.5H	1862.7	********	*********	129840	62262.
			1823.7	********	*********	44981	31879.
			1252.9	********	*********	107.9	33850.0
			1159.3	********	*********	2055	31010.
			710.5	********	*********	96354	35438.
					R_av	40414	21955.
174 W	i	31M	206.5	********	*********	3968	21610
182 Ta	i(m1+m2+g)	114.43D	1231.0	11.44	0.20	37824	1443.
			1221.4	27.0	0.5	36875	1352.
			1189.1	16.2	0.3	39549	1486.
					R_av	37953	1423.
178mTa	i(m)	2.36H	331.6	31.2	0.5	98088	4111
177 Ta	c*	56.56H	112.9	7.2	1.6	291260	68291
176 Ta-i	i	8.09H	1862.7	4.0	0.3	101430	79538.
			1823.7	4.5	0.4	164770	43969.
			1252.9	3.08	0.23	312850	48909.
			1159.3	24.7	1.9	255150	45853.
			710.5	5.4	0.4	73213	44105.
					R_av	197839	45588.
176 Ta	c	8.09H	1862.7	4.0	0.3	231280	26707.
			1823.7	4.5	0.4	209750	22191.
			1696.6	4.6	0.4	263190	25846.
			1252.9	3.08	0.23	312950	26761.
			1159.3	24.7	1.9	257210	23682.
			710.5	5.4	0.4	169570	17018.
					R_av	227636	22478.
175 Ta	c	10.5H	1793.1	4.6	0.7	192240	30000.
			1744.8	1.36	0.19	153800	25393.
			1736.7	0.92	0.14	184820	29849.
			266.9	10.52	0.16	180170	7302.
			125.9	9.0	1.3	310620	48366.
					R_av	180790	8500.
174 Ta-i	i	1.14H	206.5	60	5	141560	38614
174 Ta	c	1.14H	206.5	60	5	145530	20168
173 Ta	c	3.14H	123.7	********	*********	156550	33580

172 Ta	c*	36.8M	214.1	55	5	94811	10647
180mHf	i(m)	5.5H	332.3	94.1	1.2	21841	861
179mHf	i(m)	25.05D	453.6	68	4	5274	361.
			362.5	39.5	1.5	5374	275.
			315.9	20.2	0.7	5810	298.
					R_av	5515	236.
175 Hf	c	70D	353.3	0.23	0.02	397390	40734.
			343.4	84	3	344270	16401.
					R_av	349180	18861.
173 Hf-i	i	23.6H	123.7	83	5	174500	35993
173 Hf	c	23.6H	311.2	10.7	0.5	350890	20149.
			139.6	12.7	0.6	336570	24388.
			123.7	83	5	331060	28375.
					R_av	344226	14344.
172 Hf	c	1.87Y	1402.5	*****************		169580	30645.
			1093.6	*****************		233660	13272.
			1022.4	*****************		275370	21981.
			912.1	*****************		247200	14056.
			810.1	*****************		332210	19585.
			181.5	*****************		224230	13211.
					R_av	246896	16744.
171 Hf	c	12.1H	739.8	*****************		207600	31737
170 Hf	c	16.01H	2191.1	*****************		199490	35971.
			2126.1	*****************		250180	20178.
			1512.5	*****************		216710	32732.
			1455.2	*****************		211630	38191.
			1364.6	*****************		179600	16807.
			1280.2	*****************		199790	15284.
			1054.3	*****************		282820	19619.
			985.1	*****************		274880	21025.
			620.7	18	5	287820	80554.
			501.6	3.7	1.0	252110	68966.
			164.7	26	8	264020	81824.
			120.2	15	5	307130	104308.
					R_av	231406	14079.
168 Hf	c	25.95M	1136.8	16.1	2.9	182400	35139.
			983.8	16	4	156050	39925.
			979.2	26.1	0.7	126270	6080.
			896.1	20.1	2.6	180170	25255.
					R_av	129372	8155.
173 Lu	c	1.37Y	272.1	21.2	0.8	322690	16049
172 Lu-i	i	6.70D	1402.5	0.72	0.04	46376	14845.
			1093.6	63	3	67901	3853.
			1022.4	1.41	0.07	57638	24172.
			912.1	15.3	0.7	62925	3514.
			810.1	16.6	0.8	69393	4098.
			181.5	20.6	1.0	65544	4064.
					R_av	65829	2428.
172 Lu	c	6.70D	1402.5	0.72	0.04	215960	41657.
			1093.6	63	3	301560	17108.
			1022.4	1.41	0.07	333000	28986.
			912.1	15.3	0.7	310120	17397.
			810.1	16.6	0.8	401600	23383.
			181.5	20.6	1.0	289770	17069.
					R_av	313876	20175.
171 Lu-i	i(m+g)	8.24D	739.8	47.8	1.2	126420	32919
171 Lu	c	8.24D	853.0	2.55	0.07	367540	15399.
			839.9	3.04	0.08	362960	14899.
			780.7	4.36	0.11	348750	14162.
			739.8	47.8	1.2	334020	13420.
			689.3	2.37	0.06	344150	13994.
					R_av	349877	12514.
170 Lu-i	i(m+g)	2.012D	2191.1	1.64	0.08	174940	46696.
			2126.1	5.1	0.3	38979	14876.
			1512.5	2.55	0.13	70665	41294.
			1455.2	1.18	0.06	101980	50044.
			1364.6	4.62	0.18	119210	20238.
			1280.2	8.2	0.4	88979	14017.
			1054.3	4.76	0.24	3559	13900.
			985.1	5.5	0.3	31008	15757.
					R_av	55491	16145.
170 Lu	c	2.012D	2191.1	1.64	0.08	374430	25534.
			2126.1	5.1	0.3	289160	19873.
			1512.5	2.55	0.13	287370	21065.

			1455.2	1.18	0.06	313620	24489.
			1364.6	4.62	0.18	298820	16039.
			1280.2	8.2	0.4	288770	17149.
			1054.3	4.76	0.24	286380	17460.
			985.1	5.5	0.3	305890	19831.
					R_av	300047	12495.
169 Lu	c	34.06H	1466.8	3.32	0.11	281750	15214.
			1463.4	1.51	0.05	219230	12390.
			960.6	23.4	0.7	243450	10587.
			889.8	5.36	0.17	241260	11274.
			191.2	20.6	0.6	253880	11445.
					R_av	245831	10797.
167 Lu	c	51.5M	113.3	*****************		243550	20974
169 Yb	c*	32.026D	307.7	10.05	0.19	343610	12508.
			130.5	11.31	0.21	319370	18418.
					R_av	340054	13653.
167 Yb-i	i	17.5M	113.3	55	3	46154	7815
167 Yb	c	17.5M	113.3	55	3	289700	25027
166 Yb	c	56.7H	2092.1	*****************		312370	21356.
			2079.5	*****************		298560	21368.
			2052.4	*****************		300900	19967.
			1895.1	*****************		307470	102914.
			1867.9	*****************		303320	20599.
			1374.2	*****************		281820	22138.
			1273.5	*****************		295780	21297.
			1176.7	*****************		285060	20526.
			785.9	*****************		269940	18542.
			691.2	8.56	0.58	256490	19309.
			594.4	*****************		280290	21016.
					R_av	290251	10431.
162 Yb	c	18.87M	798.7	*****************		177470	24515.
			163.4	40	5	197320	25730.
			118.7	34	4	177950	25349.
			102.0	*****************		203200	25208.
					R_av	189371	11845.
168 Tm	i	93.1D	720.4	12.0	0.4	10761	594.
			447.5	23.7	0.8	9564	488.
					R_av	10021	660.
167 Tm	c	9.25D	531.5	1.61	0.22	335190	47634.
			207.8	42	8	316060	61071.
					R_av	328058	38200.
166 Tm-i	i	7.70H	2092.1	1.56	0.09	27970	262201.
			2079.5	6.3	0.4	10852	3644.
			2052.4	17.2	1.0	17623	3460.
			1895.1	1.2	0.4	67515	332206.
			1867.9	4.04	0.24	27579	3580.
			1374.2	5.6	0.4	61952	8606.
			1273.5	14.9	0.9	42030	21777.
			1176.7	9.5	0.6	47455	132208.
			785.9	9.9	0.6	34464	7270.
			594.4	3.46	0.20	3362	108500.
					R_av	22831	4088.
166 Tm	c	7.70H	2092.1	1.56	0.09	340340	261100.
			2079.5	6.3	0.4	309420	22267.
			2052.4	17.2	1.0	318520	21312.
			1895.1	1.2	0.4	374980	353379.
			1867.9	4.04	0.24	330900	22525.
			1374.2	5.6	0.4	343770	27711.
			1273.5	14.9	0.9	337810	31448.
			1176.7	9.5	0.6	332520	132975.
			785.9	9.9	0.6	304400	21768.
			594.4	3.46	0.20	283650	107737.
					R_av	320837	13266.
165 Tm	c	30.06H	806.4	9.5	0.6	308220	21862.
			356.5	2.75	0.15	345130	22424.
					R_av	326643	21089.
163 Tm	c*	1.810H	1434.4	8.0	0.3	302570	16326.
			1397.5	7.03	0.24	332970	23762.
			1374.3	4.28	0.16	312460	25524.
			104.3	18.6	0.7	256420	28797.
					R_av	304770	15522.
162 Tm-i	i(m+g)	21.70M	798.7	8.4	0.7	140120	33773.
			102.0	17.5	1.5	13764	20574.
					R_av	50649	57469.
162 Tm	c	21.70M	798.7	8.4	0.7	317600	32116.
			102.0	17.5	1.5	216970	26531.

					R_av	258587	50212.
161 Tm	c	33M	826.6******************			293990	31433
161 Er-i	i	3.21H	826.6	64	4	5487	27890
161 Er	c	3.21H	826.6	64	4	299480	21434
160 Er	c	28.58H	966.2******************			290880	41293.
			962.4******************			285830	40215.
			879.4******************			334510	42745.
			872.0	6.8	1.1	318850	52676.
			728.2******************			332160	48642.
					R_av	310044	20658.
159 Er	c*	36M	649.1	23	3	328310	44533.
			624.5	33	4	295010	37315.
					R_av	308678	29391.
157 Er	c*	18.65M	391.3	14.2	1.4	233600	25771
156 Er	c	19.5M	266.5******************			215060	17391.
			137.8******************			192890	15668.
					R_av	202834	12717.
160mHo-i	i(m)	5.02H	966.2	15.4	2.0	10059	17799.
			962.4	16.6	2.1	21155	21962.
			879.4	18.6	2.3	12976	4759.
			728.2	28	4	25047	4729.
					R_av	19002	3569.
160mHo	c	5.02H	966.2	15.4	2.0	301040	44095.
			962.4	16.6	2.1	306980	45355.
			879.4	18.6	2.3	347490	44479.
			728.2	28	4	357210	52300.
					R_av	326192	24737.
160 Ho	i(m+g)	25.6M	966.2	21.9	1.2	48631	8378.
			728.2	46.9	1.7	25234	4850.
					R_av	31137	10208.
156 Ho-i	i	56M	266.5	54.7	1.1	37168	18673.
			137.8	51.1	0.8	51891	14921.
					R_av	46189	11683.
156 Ho	c	56M	266.5	54.7	1.1	252230	10662.
			137.8	51.1	0.8	244780	13426.
					R_av	250014	9861.
157 Dy	c	8.14H	326.2	92	4	305380	16489
155 Dy	c*	9.9H	226.9	68.4	1.6	285700	11400
152 Dy	c	2.38H	344.3	99.9	0.0	190500	14927.
			256.9	97.50	0.07	178680	5950.
					R_av	178942	5590.
155 Tb	c*	5.32D	340.7	1.18	0.07	275150	18988.
			180.1	7.5	0.5	304060	22886.
			163.3	4.44	0.24	270810	17900.
					R_av	280167	13361.
153 Tb	c*	2.34D	212.0	31.0	1.9	334560	24400.
			102.2	6.4	0.5	237200	25100.
					R_av	291309	49225.
152 Tb-i	i(m+g)	17.5H	344.3	65	4	8238	6694
152 Tb	c	17.5H	344.3	65	4	198550	13765
151 Tb	c	17.609H	731.2	8.32	0.04	183260	6711.
			616.6	10.4	0.5	220510	12853.
			479.4	15.4	0.7	205110	11461.
			287.4	28.3	1.2	201380	10763.
			251.9	26.3	1.2	204530	11416.
			108.1	24.3	1.1	189720	17284.
					R_av	195518	8308.
150 Tb	c	3.48H	638.0	72	10	104190	14921.
			496.2	14.6	2.0	108300	15504.
					R_av	106166	11004.
149 Tb	c	4.118H	817.1	11.6	0.4	74324	4452.
			352.2	29.4	0.9	81226	4082.
					R_av	78952	4075.
148 Tb	c	60M	784.4	84.0	1.6	100920	4035.
			489.0	19.7	0.5	93323	4474.
					R_av	98222	4758.
153 Gd	c	240.4D	103.2	21.1	0.7	242800	18789

151 Gd	c	124D	243.3	5.6	0.4	186790	14672.
			174.7	2.96	0.21	162430	12785.
			153.6	6.2	0.4	174670	13058.
					R_av	173563	8927.
149 Gd	c	9.28D	788.9	7.3	0.4	243900	15391.
			534.3	3.07	0.17	311510	20202.
			346.6	23.9	1.3	231430	14755.
			327.5	******************		252930	23149.
			298.6	28.6	1.7	228760	15359.
			277.1	******************		252320	20936.
			272.3	3.21	0.19	234010	16164.
			149.7	48	3	243340	18446.
					R_av	245409	11568.
147 Gd	c	38.06H	929.0	20.2	1.2	217650	14825.
			861.7	1.75	0.10	212660	15340.
			625.2	4.7	0.4	209590	19388.
			370.0	17.2	0.9	219520	13838.
			229.3	63	4	227360	16233.
					R_av	218346	8209.
146 Gd	c	48.27D	2436.7	******************		223150	10287.
			1756.1	******************		225980	12726.
			1533.7	******************		215250	9541.
			747.2	******************		210580	9091.
			154.6	46.6	0.5	205290	7379.
					R_av	210991	7479.
145 Gd	c	23.0M	1880.6	32.6	1.9	115950	8562.
			1757.9	34.2	2.0	120370	8675.
					R_av	118176	5817.
149 Eu-i	i	93.1D	327.5	4.03	0.12	10866	21013.
			277.1	3.56	0.06	12668	19484.
					R_av	11835	14289.
149 Eu	c	93.1D	327.5	4.03	0.12	263800	11551.
			277.1	3.56	0.06	264990	9661.
					R_av	264663	9293.
148 Eu	i	54.5D	725.7	12.7	0.4	13257	806.
			630.0	71.9	2.3	12354	578.
			611.3	20.5	0.7	10931	572.
			550.3	99	3	12245	535.
					R_av	12062	557.
147 Eu	c	24.1D	955.8	3.84	0.20	254100	15373.
			798.7	4.8	0.3	295220	20583.
			677.5	9.8	0.5	257530	15355.
			121.2	22.9	1.3	286390	24290.
					R_av	266490	12707.
146 Eu-i	i	4.61D	2436.7	0.93	0.03	46257	4021.
			1756.1	0.92	0.04	58317	12166.
			1533.7	6.08	0.19	49183	2813.
			747.2	99	3	34132	1669.
					R_av	38456	4065.
146 Eu	c	4.61D	2436.7	0.93	0.03	269410	12600.
			1756.1	0.92	0.04	284300	18556.
			1533.7	6.08	0.19	264430	11749.
			747.2	99	3	244710	10565.
					R_av	259470	10965.
145 Eu	c	5.93D	1997.0	7.2	0.5	190870	14581.
			1804.3	1.07	0.07	217620	16552.
			1658.5	14.9	1.0	180050	13425.
			893.7	66	5	177860	14544.
			653.5	15	1	176890	13075.
					R_av	186556	9082.
144 Pm	i	363D	618.0	98.6	1.0	4108	157
143 Pm	c	265D	742.0	38.5	2.4	169910	12042
140mPm	i(m)	5.95M	1028.2	100	2	60821	11219.
			773.7	100	5	57545	6300.
					R_av	58298	5604.
139mNd	i(m)	5.5H	738.2	35	5	20673	3044
136 Nd	c	50.65M	1092.3	******************		81970	7354.
			574.8	10.4	1.1	125960	17835.
			552.2	******************		89240	6707.
					R_av	88378	7301.
138mPr	i(m)	2.12H	1037.8	101	5	11354	778.
			788.7	100	5	10169	687.
					R_av	10687	676.

136 Pr-i	i	13.1M	1092.3	18.5	1.2	11935	11236.
			552.2	76	5	13094	4313.
					R_av	12948	4009.
136 Pr	c	13.1M	1092.3	18.5	1.2	93905	11947.
			552.2	76	5	102330	8318.
					R_av	99757	7119.
134 Pr	c*	17M	409.2	87.1	0.0	71992	2711
139 Ce	c	137.640D	165.9	79.89	0.01	145420	4904
135 Ce	c	17.7H	783.6	10.6	0.4	114180	6277.
			606.8	18.8	0.7	103000	5059.
			577.1	5.14	0.19	97773	7037.
			300.1	23.5	0.6	110560	4695.
			206.5	7.77	0.25	112070	7635.
					R_av	107963	4254.
134 Ce	c	3.16D	604.7	5.04	0.20	87651	5109
133mCe	i(m)	4.9H	477.2	39.2	1.2	19872	1140
132 Ce	c	3.51H	2102.8	******************		69936	7216.
			1909.9	******************		68795	8587.
			464.5	******************		64345	5565.
					R_av	66530	3638.
130 Ce	c	25M	544.5	******************		23328	8361.
			357.4	******************		35773	2321.
					R_av	35355	2498.
132 La-i	i(m+g)	4.8H	2102.8	5.9	0.5	3102	5513.
			1909.9	9.0	0.8	4314	8510.
			464.5	76	6	1842	1544.
					R_av	2004	1462.
132 La	c	4.8H	2102.8	5.9	0.5	73038	7021.
			1909.9	9.0	0.8	73109	7684.
			464.5	76	6	66188	5676.
					R_av	69873	4212.
130 La-i	i	8.7M	544.5	16.2	1.8	38941	28004.
			357.4	81	4	16184	3482.
					R_av	16515	3407.
130 La	c	8.7M	544.5	16.2	1.8	62269	23534.
			357.4	81	4	51957	4043.
					R_av	52208	4004.
133 Ba	c	3848.9D	356.0	62.05	0.19	79635	2907
131 Ba	c	11.50D	496.3	46.8	0.2	73107	2443.
			486.5	2.09	0.02	78574	2746.
			373.2	14.04	0.20	77767	2731.
			216.1	19.66	0.25	69200	2425.
			123.8	29.0	0.3	64790	4337.
					R_av	73903	2965.
128 Ba	c	2.43D	273.4	14.5	0.7	53843	3188
126 Ba	c	100M	233.6	19.6	1.8	17998	2693
129 Cs	c	32.06H	411.5	22.3	1.3	90325	6890.
			371.9	30.6	1.7	74047	5227.
					R_av	79865	8190.
127 Cs	c	6.25H	412.0	62.8	1.0	53068	2891
127 Xe	c	36.4D	375.0	17.2	0.6	49723	2332.
			202.9	68.3	0.5	50756	1747.
					R_av	50600	1719.
123 Xe	c	2.08H	148.9	48.9	0.6	41858	1982
121 Te-i	i(m+g)	19.16D	573.1	80.3	2.5	22329	1008
121 Te	c	19.16D	573.1	80.3	2.5	24061	1126
121mTe	i(m)	154D	573.1	88.6	0.1	1955	718.
			212.2	81.4	1.1	1642	67.
					R_av	1643	67.
119 Te	c	16.05H	644.0	84.0	0.5	19409	1182
119mTe	i(m)	4.70D	1212.7	66.2	0.3	4042	157.
			153.6	66	3	3519	272.
					R_av	3978	212.
117 Te	c	62M	719.7	64.7	1.4	9374	974

118mSb	i(m)	5.00H	1050.7	97	5	1916	194
115 Sb	c*	32.1M	497.3	97.9	0.4	3399	3921
111 In	c	2.8047D	245.4	94	1	8592	378
110 In	i	4.9H	657.8	98.3	2.0	6793	362.
			641.7	25.9	0.6	11610	991.
					R_av	7237	1412.
106mAg	i(m)	8.28D	1527.7	16.3	1.4	2315	237.
			1128.0	11.8	0.6	2292	254.
			804.3	12.4	0.6	2870	264.
			717.3	28.9	0.8	2330	138.
			616.2	21.6	0.7	2048	189.
			451.0	28.2	0.8	2487	221.
					R_av	2344	118.
105 Ag	c	41.29D	443.4	10.5	0.6	5622	524
99mRh	c	4.7H	340.8	70	5	3116	414
96 Tc	i(m+g)	4.28D	849.9	98	4	2887	160.
			812.5	82	4	3558	220.
					R_av	3106	329.
90 Nb	c*	14.60H	2319.0	82.0	0.3	4573	427
89 Zr	c	78.41H	909.2	99.04	0.03	5935	234
88 Zr	c	83.4D	1836.1	*********	*********	3802	175.
			898.0	*********	*********	2010	265.
			392.9	97.24	0.00	3587	121.
					R_av	3587	112.
88 Y -i	i	106.65D	1836.1	99.2	0.3	4060	136.
			898.0	93.7	0.3	5940	217.
					R_av	4353	695.
88 Y	c	106.65D	1836.1	99.2	0.3	7863	261.
			898.0	93.7	0.3	7950	286.
					R_av	7887	257.
87 Y	c	79.8H	484.8	89.7	0.7	7009	280.
			388.5	82.1	0.5	8622	352.
					R_av	7609	815.
86 Y	c	14.74H	1920.7	20.8	0.7	14898	1334.
			1854.4	17.2	0.5	4930	627.
					R_av	6836	3925.
84 Rb	i(m+g)	32.77D	881.6	69.0	1.6	3706	154
83 Rb	c	86.2D	520.4	45	4	8021	829
75 Se	c	119.779D	136.0	58.3	0.8	5581	357
74 As	i	17.77D	595.8	59	4	4319	331
69mZn	i(m)	13.76H	438.6	94.77	0.20	1334	129
65 Zn	c	244.26D	1115.6	50.60	0.24	2451	171
60 Co	i(m+g)	5.2714Y	1173.2	99.97	0.00	5462	839
59 Fe	c	44.472D	1099.2	56.5	1.9	2543	188
54 Mn	i	312.11D	834.8	99.98	0.00	3782	179
48 V	c	15.9735D	1312.1	97.5	0.9	741.8	34.3
			983.5	100.0	0.3	601.9	43.3
					R_av	700.3	67.6
48 Sc	i	43.67H	1312.1	100.1	0.7	3272	232.
			1037.5	97.6	0.7	1947	179.
			983.5	100.1	0.6	1234	248.
					R_av	2198	549.
46 Sc	i(m+g)	83.79D	889.3	99.98	0.00	2634	122
28 Mg	c	20.915H	1778.8	*********	*********	1142	156
24 Na	c	14.9590H	1369.0	100	0	9381	389
7 Be	i	53.29D	477.6	10.52	0.06	17776	654

Table 10.61: Detailed reaction rates for residual nuclide production in ^{181}Ta at E_p=1598 MeV used to determine their production cross sections.

Nuclide	Type	$T_{1/2}$	E_γ, KeV	Abundance, %		Reaction rate 10^{-20} s^{-1}	
178 W	i	21.6D	1350.6	1.18	0.11	45390	6302.
			1340.8	1.03	0.09	31484	3713.
					R_av	35003	6144.
177 W	i	135M	115.7	59.6	5.3	19914	2355
176 W	i	2.5H	1862.7	*********	********	85926	14304.
			1823.7	*********	********	14369	25244.
			1252.9	*********	********	47102	48161.
			1159.3	*********	********	44263	8957.
			710.5	*********	********	11869	43061.
					R_av	52791	11043.
174 W	i	31M	206.5	*********	********	10475	7474
182 Ta	i(m1+m2+g)	114.43D	1231.0	11.44	0.20	24318	1122.
			1221.4	27.0	0.5	21977	889.
			1189.1	16.2	0.3	24671	976.
					R_av	23458	1163.
178mTa	i(m)	2.36H	331.6	31.2	0.5	75930	11586
177 Ta	c*	56.56H	112.9	7.2	1.6	187570	45718
176 Ta-i	i	8.09H	1862.7	4.0	0.3	74842	16920.
			1823.7	4.5	0.4	146220	36931.
			1252.9	3.08	0.23	104200	67113.
			1159.3	24.7	1.9	107900	14077.
			710.5	5.4	0.4	149240	54594.
					R_av	101455	10665.
176 Ta	c	8.09H	1862.7	4.0	0.3	160770	13791.
			1823.7	4.5	0.4	160590	18026.
			1696.6	4.6	0.4	156380	16645.
			1252.9	3.08	0.23	151300	23081.
			1159.3	24.7	1.9	152160	13092.
			710.5	5.4	0.4	161120	18165.
					R_av	157087	7975.
175 Ta	c	10.5H	1793.1	4.6	0.7	110990	17529.
			1744.8	1.36	0.19	91521	14502.
			1736.7	0.92	0.14	97712	21848.
			266.9	10.52	0.16	118390	5353.
			125.9	9.0	1.3	209640	33064.
					R_av	116873	7151.
174 Ta-i	i	1.14H	206.5	60	5	78679	12819
174 Ta	c	1.14H	206.5	60	5	89154	9165
173 Ta	c	3.14H	123.7	*********	********	113360	24002
172 Ta	c*	36.8M	214.1	55	5	64607	11879
180mHf	i(m)	5.5H	332.3	94.1	1.2	13195	1648
179mHf	i(m)	25.05D	453.6	68	4	4083	280.
			362.5	39.5	1.5	3289	201.
			315.9	20.2	0.7	4058	267.
					R_av	3683	299.
175 Hf	c	70D	353.3	0.23	0.02	332440	34934.
			343.4	84	3	208100	10586.
					R_av	215440	30068.
173 Hf-i	i	23.6H	123.7	83	5	104510	23619
173 Hf	c	23.6H	311.2	10.7	0.5	221920	14972.
			139.6	12.7	0.6	212320	15108.
			123.7	83	5	217870	19225.
					R_av	217455	9904.
172 Hf	c	1.87Y	1093.6	*********	********	158550	9189.
			1022.4	*********	********	192490	12424.
			912.1	*********	********	185530	12947.
			810.1	*********	********	285050	19541.
			181.5	*********	********	138490	8575.
					R_av	164966	16936.
171 Hf	c	12.1H	739.8	*********	********	159900	12830
170 Hf	c	16.01H	2191.1	*********	********	145440	39124.
			2126.1	*********	********	152320	12069.
			1512.5	*********	********	131840	26299.
			1455.2	*********	********	125810	21839.
			1364.6	*********	********	123160	13601.
			1280.2	*********	********	126020	10146.
			1054.3	*********	********	171440	13526.

			985.1	*****************		102000	54845.
			620.7	18	5	198830	55959.
			501.6	3.7	1.0	151560	41569.
			164.7	26	8	182570	56655.
			120.2	15	5	194250	66267.
					R_av	141828	7406.
168 Hf	c	25.95M	1136.8	16.1	2.9	103520	19667.
			983.8	16	4	105840	28935.
			979.2	26.1	0.7	88997	11913.
			896.1	20.1	2.6	111360	16277.
					R_av	98649	8658.
173 Lu	c	1.37Y	272.1	21.2	0.8	225700	13735
172 Lu-i	i	6.70D	1093.6	63	3	49134	2842.
			1022.4	1.41	0.07	44561	2793.
			912.1	15.3	0.7	46822	2906.
			810.1	16.6	0.8	51745	3471.
			181.5	20.6	1.0	51621	3197.
					R_av	48405	1995.
172 Lu	c	6.70D	1093.6	63	3	207690	12012.
			1022.4	1.41	0.07	237060	14801.
			912.1	15.3	0.7	232350	14927.
			810.1	16.6	0.8	336790	21873.
			181.5	20.6	1.0	190110	11739.
					R_av	222398	20292.
171 Lu-i	i(m+g)	8.24D	739.8	47.8	1.2	66274	11996
171 Lu	c	8.24D	853.0	2.55	0.07	227880	11776.
			839.9	3.04	0.08	245740	10371.
			780.7	4.36	0.11	230970	9990.
			739.8	47.8	1.2	226180	9383.
			689.3	2.37	0.06	228910	9817.
					R_av	231932	8083.
170 Lu-i	i(m+g)	2.012D	2191.1	1.64	0.08	86028	44675.
			2126.1	5.1	0.3	38007	6930.
			1512.5	2.55	0.13	49308	29148.
			1455.2	1.18	0.06	65251	27340.
			1364.6	4.62	0.18	78822	14031.
			1280.2	8.2	0.4	42207	8189.
			1054.3	4.76	0.24	7605	10323.
			985.1	5.5	0.3	121750	65083.
					R_av	39789	7544.
170 Lu	c	2.012D	2191.1	1.64	0.08	231480	18512.
			2126.1	5.1	0.3	190330	13479.
			1512.5	2.55	0.13	181160	13429.
			1455.2	1.18	0.06	191070	13615.
			1364.6	4.62	0.18	201990	10921.
			1280.2	8.2	0.4	168230	10132.
			1054.3	4.76	0.24	179050	11062.
			985.1	5.5	0.3	223760	21695.
					R_av	188621	8756.
169 Lu	c	34.06H	1466.8	3.32	0.11	165620	8236.
			1463.4	1.51	0.05	142060	10309.
			960.6	23.4	0.7	151030	7669.
			889.8	5.36	0.17	150870	7890.
			191.2	20.6	0.6	153420	9543.
					R_av	153998	6026.
167 Lu	c	51.5M	113.3	*****************		142690	12168
169 Yb	c*	32.026D	307.7	10.05	0.19	234960	9320.
			177.2	22.2	0.5	220450	9688.
			130.5	11.31	0.21	222100	13110.
					R_av	228012	8694.
167 Yb-i	i	17.5M	113.3	55	3	27241	2458
167 Yb	c	17.5M	113.3	55	3	169930	14487
166 Yb	c	56.7H	2092.1	*****************		209930	15379.
			2079.5	*****************		189000	14348.
			2052.4	*****************		189880	13256.
			1895.1	*****************		194330	65430.
			1867.9	*****************		197560	14470.
			1374.2	*****************		188930	15438.
			1273.5	*****************		184350	13953.
			1176.7	*****************		177960	13473.
			785.9	*****************		182030	12839.
			691.2	8.56	0.58	164050	12601.
			594.4	*****************		183050	13106.
					R_av	185969	6763.
162 Yb	c	18.87M	798.7	*****************		83832	21885.
			163.4	40	5	159240	21439.

			102.0	******************		36710	18513.
					R_av	95955	37498.
168 Tm	i	93.1D	720.4	12.0	0.4	6762	539.
			447.5	23.7	0.8	8383	433.
					R_av	7855	798.
167 Tm	c	9.25D	531.5	1.61	0.22	218450	30981.
			207.8	42	8	219180	42610.
					R_av	218699	25475.
166 Tm-i	i	7.70H	2092.1	1.56	0.09	13904	15229.
			2079.5	6.3	0.4	14619	3868.
			2052.4	17.2	1.0	13695	1869.
			1895.1	1.2	0.4	34627	26660.
			1867.9	4.04	0.24	20354	9081.
			1374.2	5.6	0.4	33141	7374.
			1273.5	14.9	0.9	37971	8530.
			1176.7	9.5	0.6	33686	24361.
			785.9	9.9	0.6	20866	4411.
			594.4	3.46	0.20	19915	14512.
					R_av	16248	1966.
166 Tm	c	7.70H	2092.1	1.56	0.09	223830	19756.
			2079.5	6.3	0.4	203620	15440.
			2052.4	17.2	1.0	203580	14182.
			1895.1	1.2	0.4	228960	79776.
			1867.9	4.04	0.24	217910	16924.
			1374.2	5.6	0.4	222070	18604.
			1273.5	14.9	0.9	222320	17325.
			1176.7	9.5	0.6	211640	26803.
			785.9	9.9	0.6	202890	14527.
			594.4	3.46	0.20	202960	19163.
					R_av	210910	8426.
165 Tm	c	30.06H	806.4	9.5	0.6	189620	13624.
			356.5	2.75	0.15	214270	21723.
					R_av	196044	12434.
163 Tm	c*	1.810H	1434.4	8.0	0.3	188100	11894.
			1397.5	7.03	0.24	153980	11307.
			1374.3	4.28	0.16	166170	21866.
			104.3	18.6	0.7	134810	12058.
					R_av	160748	13124.
162 Tm-i	i(m+g)	21.70M	798.7	8.4	0.7	101670	31578.
			102.0	17.5	1.5	74797	30064.
					R_av	87749	21413.
162 Tm	c	21.70M	798.7	8.4	0.7	185510	21541.
			102.0	17.5	1.5	111500	18613.
					R_av	143854	36986.
161 Tm	c	33M	1648.1	20	3	131210	21169.
			826.6	******************		179190	19553.
					R_av	158369	24289.
161 Er-i	i	3.21H	826.6	64	4	14583	17206
161 Er	c	3.21H	826.6	64	4	193770	13994
160 Er	c	28.58H	966.2	******************		201420	27209.
			879.4	******************		207910	26689.
			872.0	6.8	1.1	247170	41134.
			728.2	******************		207860	30602.
					R_av	210853	15269.
159 Er	c*	36M	649.1	23	3	210100	28906.
			624.5	33	4	189390	24051.
					R_av	197815	18988.
157 Er	c*	18.65M	391.3	14.2	1.4	183270	19876
156 Er	c	19.5M	266.5	******************		146030	12222.
			137.8	******************		146060	11479.
					R_av	146046	8817.
160mHo-i	i(m)	5.02H	966.2	15.4	2.0	5708	3947.
			879.4	18.6	2.3	5287	2432.
			728.2	28	4	17221	3282.
					R_av	8955	3844.
160mHo	c	5.02H	966.2	15.4	2.0	207130	28028.
			879.4	18.6	2.3	213200	27368.
			728.2	28	4	225080	33096.
					R_av	214059	17707.
160 Ho	i(m+g)	25.6M	728.2	46.9	1.7	15379	2619
156 Ho-i	i	56M	266.5	54.7	1.1	28016	11391.
			137.8	51.1	0.8	7477	9737.

					R_av	16182	10162.
156 Ho	c	56M	266.5	54.7	1.1	174050	8070.
			137.8	51.1	0.8	153530	8710.
					R_av	165797	11317.
157 Dy	c	8.14H	326.2	92	4	199700	11266
155 Dy	c*	9.9H	226.9	68.4	1.6	185680	8715
152 Dy	c	2.38H	256.9	97.50	0.07	121030	4915
155 Tb	c*	5.32D	340.7	1.18	0.07	152270	10945.
			180.1	7.5	0.5	182570	14024.
			163.3	4.44	0.24	161240	11181.
					R_av	162664	9640.
153 Tb	c*	2.34D	212.0	31.0	1.9	166420	12162.
			102.2	6.4	0.5	175570	19158.
					R_av	168734	10485.
152 Tb	c	17.5H	344.3	65	4	133120	21013
151 Tb	c	17.609H	731.2	8.32	0.04	121970	5554.
			616.6	10.4	0.5	168980	11480.
			479.4	15.4	0.7	147650	9308.
			287.4	28.3	1.2	139010	8757.
			251.9	26.3	1.2	140210	8530.
			108.1	24.3	1.1	126420	11522.
					R_av	128386	6601.
150 Tb	c	3.48H	638.0	72	10	65461	9442.
			496.2	14.6	2.0	69395	10371.
					R_av	67241	7138.
149 Tb	c	4.118H	817.1	11.6	0.4	55145	3280.
			352.2	29.4	0.9	49048	2476.
					R_av	50611	3096.
148 Tb	c	60M	784.4	84.0	1.6	69069	3511.
			489.0	19.7	0.5	58454	5309.
					R_av	66566	4963.
153 Gd	c	240.4D	103.2	21.1	0.7	139430	10923
151 Gd	c	124D	243.3	5.6	0.4	129970	10799.
			174.7	2.96	0.21	94798	9531.
			153.6	6.2	0.4	134830	11122.
					R_av	117864	13499.
149 Gd	c	9.28D	788.9	7.3	0.4	176180	11264.
			534.3	3.07	0.17	209520	13768.
			346.6	23.9	1.3	165780	10633.
			298.6	28.6	1.7	163250	11288.
			272.3	3.21	0.19	174500	14554.
			149.7	48	3	181240	13925.
					R_av	176203	8524.
147 Gd	c	38.06H	929.0	20.2	1.2	158410	11516.
			861.7	1.75	0.10	149720	13556.
			625.2	4.7	0.4	148720	13782.
			370.0	17.2	0.9	156680	9904.
			229.3	63	4	183380	13840.
					R_av	159078	7129.
146 Gd	c	48.27D	2436.7*****************			157740	9740.
			1756.1*****************			164190	9764.
			1533.7*****************			161150	7439.
			747.2*****************			159510	7183.
			154.6	46.6	0.5	163020	6538.
			115.5	44.0	0.7	178370	11821.
			114.7	44.0	0.7	172730	11584.
					R_av	162920	5616.
145 Gd	c	23.0M	1880.6	32.6	1.9	86248	7358.
			1757.9	34.2	2.0	90664	7155.
					R_av	88615	4942.
149 Eu	c	93.1D	327.5	4.03	0.12	161800	9310
148 Eu	i	54.5D	725.7	12.7	0.4	11453	659.
			630.0	71.9	2.3	9106	444.
			611.3	20.5	0.7	8439	467.
			550.3	99	3	9950	461.
					R_av	9489	609.
147 Eu	c	24.1D	955.8	3.84	0.20	188100	11683.
			798.7	4.8	0.3	209010	14840.
			677.5	9.8	0.5	187670	11468.
			121.2	22.9	1.3	188890	15792.
					R_av	191950	8298.

146 Eu-i	i	4.61D	2436.7	0.93	0.03	25711	8579.
			1756.1	0.92	0.04	31419	7706.
			1533.7	6.08	0.19	36702	2089.
			747.2	99	3	23736	2020.
					R_av	30607	3789.
146 Eu	c	4.61D	2436.7	0.93	0.03	183450	12398.
			1756.1	0.92	0.04	195610	12591.
			1533.7	6.08	0.19	197860	9129.
			747.2	99	3	183260	8318.
					R_av	189715	7168.
145 Eu	c	5.93D	1997.0	7.2	0.5	137930	10869.
			1804.3	1.07	0.07	154570	12224.
			1658.5	14.9	1.0	136570	10293.
			893.7	66	5	136700	11272.
			653.5	15	1	134650	10057.
					R_av	139233	6221.
144 Pm	i	363D	618.0	98.6	1.0	3213	242
143 Pm	c	265D	742.0	38.5	2.4	144900	10224
140mPm	i(m)	5.95M	1028.2	100	2	35346	7172.
			773.7	100	5	49023	8106.
					R_av	41393	6915.
139mNd	i(m)	5.5H	738.2	35	5	20812	3262
136 Nd	c	50.65M	1092.3	**********	*******	99569	13583.
			574.8	10.4	1.1	96754	11783.
			552.2	**********	*******	100470	8085.
					R_av	99500	5977.
138mPr	i(m)	2.12H	1037.8	101	5	10019	1037.
			788.7	100	5	10006	788.
					R_av	10011	662.
136 Pr-i	i	13.1M	1092.3	18.5	1.2	4468	24180.
			552.2	76	5	32647	6027.
					R_av	31103	6485.
136 Pr	c	13.1M	1092.3	18.5	1.2	104030	20805.
			552.2	76	5	133120	10889.
					R_av	127493	12161.
134 Pr	c*	17M	409.2	87.1	0.0	79256	3848
139 Ce	c	137.640D	165.9	79.89	0.01	145180	5443
135 Ce	c	17.7H	783.6	10.6	0.4	130640	7364.
			606.8	18.8	0.7	109480	5603.
			577.1	5.14	0.19	120020	6361.
			300.1	23.5	0.6	127200	7291.
			206.5	7.77	0.25	89169	11350.
					R_av	117922	6498.
134 Ce	c	3.16D	604.7	5.04	0.20	96323	9498
133mCe	i(m)	4.9H	477.2	39.2	1.2	26369	2728
132 Ce	c	3.51H	1909.9	**********	*******	85509	10673.
			464.5	**********	*******	89043	8113.
					R_av	88002	5748.
130 Ce	c	25M	544.5	**********	*******	47486	6006.
			357.4	**********	*******	48783	3618.
					R_av	48529	2887.
132 La-i	i(m+g)	4.8H	1909.9	9.0	0.8	4555	10071.
			464.5	76	6	1331	2936.
					R_av	1584	2818.
132 La	c	4.8H	1909.9	9.0	0.8	90064	9608.
			464.5	76	6	90374	7982.
					R_av	90251	6443.
130 La-i	i	8.7M	544.5	16.2	1.8	33123	7564.
			357.4	81	4	22623	4866.
					R_av	25683	4839.
130 La	c	8.7M	544.5	16.2	1.8	80610	10697.
			357.4	81	4	71406	5525.
					R_av	73166	5088.
133 Ba	c	3848.9D	356.0	62.05	0.19	113270	4544
131 Ba	c	11.50D	496.3	46.8	0.2	94539	3512.
			486.5	2.09	0.02	91609	4303.
			373.2	14.04	0.20	97699	3579.

			216.1	19.66	0.25	102290	4651.
			123.8	29.0	0.3	96977	5874.
					R_av	96312	3344.
128 Ba	c	2.43D	273.4	14.5	0.7	83314	5992
126 Ba	c	100M	233.6	19.6	1.8	29994	4521
129 Cs	c	32.06H	411.5	22.3	1.3	111550	8210.
			371.9	30.6	1.7	105390	6925.
					R_av	107865	5793.
127 Cs	c	6.25H	412.0	62.8	1.0	75836	4009
127 Xe	c	36.4D	375.0	17.2	0.6	80094	3893.
			202.9	68.3	0.5	76493	3188.
					R_av	77694	2976.
123 Xe	c	2.08H	148.9	48.9	0.6	65062	3719
121 Te-i	i(m+g)	19.16D	573.1	80.3	2.5	44644	2056
121 Te	c	19.16D	573.1	80.3	2.5	47924	2223
121mTe	i(m)	154D	573.1	88.6	0.1	3702	525
119 Te	c	16.05H	644.0	84.0	0.5	34954	2216
119mTe	i(m)	4.70D	1212.7	66.2	0.3	7335	283.
			1136.8	7.66	0.08	8695	2008.
			153.6	66	3	7354	483.
					R_av	7345	276.
117 Te	c	62M	719.7	64.7	1.4	28772	2203
114 Te	c	15.2M	1299.9	128.1	1.0	7600	754
120mSb	i(m)	5.76D	1171.7******************			562.6	36.7
118mSb	i(m)	5.00H	1229.7	100	5	3955	330.
			1050.7	97	5	3626	380.
					R_av	3818	262.
115 Sb	c*	32.1M	497.3	97.9	0.4	22123	1258
111 In	c	2.8047D	245.4	94	1	20070	850
110 In	i	4.9H	657.8	98.3	2.0	16002	768.
			641.7	25.9	0.6	15443	1247.
					R_av	15888	719.
109 In	c	4.2H	203.5	73.5	0.5	9764	553
108mIn	i(m)	58.0M	875.4	100	11	6701	1037.
			632.9	100	7	8360	1551.
					R_av	7208	875.
110mAg	i(m)	249.76D	657.8	94.3	0.3	388.1	43.7
106mAg	i(m)	8.28D	1527.7	16.3	1.4	4630	477.
			1128.0	11.8	0.6	4045	724.
			717.3	28.9	0.8	3918	178.
			616.2	21.6	0.7	3986	438.
			451.0	28.2	0.8	4808	268.
					R_av	4158	230.
105 Ag	c	41.29D	443.4	10.5	0.6	13018	919
100 Pd	c	3.63D	2376.0******************			2913	181
100 Rh-i	i(m+g)	20.8H	2376.0	32.6	0.4	4683	400
100 Rh	c	20.8H	2376.0	32.6	0.4	7597	473
99mRh	c	4.7H	340.8	70	5	4461	443
96 Tc	i(m+g)	4.28D	849.9	98	4	3947	271.
			812.5	82	4	4692	305.
					R_av	4282	394.
93mMo	i(m)	6.85H	1477.1	99.1	2.5	2198	222.
			684.7	99.7	2.0	3247	296.
					R_av	2580	511.
90 Nb	c*	14.60H	2319.0	82.0	0.3	6212	383
89 Zr	c	78.41H	909.2	99.04	0.03	8794	349
88 Zr	c	83.4D	1836.1******************			6015	396.
			898.0******************			4556	463.
			392.9	97.24	0.00	5615	260.

					R_av	5604	175.
88 Y -i	i	106.65D	1836.1	99.2	0.3	4610	203.
			898.0	93.7	0.3	5805	250.
					R_av	5103	609.
88 Y	c	106.65D	1836.1	99.2	0.3	10625	432.
			898.0	93.7	0.3	10361	452.
					R_av	10510	389.
87 Y	c	79.8H	484.8	89.7	0.7	9678	423.
			388.5	82.1	0.5	10669	449.
					R_av	10164	588.
86 Y	c	14.74H	1920.7	20.8	0.7	14705	987.
			1854.4	17.2	0.5	11329	770.
			1076.6	82.5	0.4	6178	411.
					R_av	8183	2220.
84 Rb	i(m+g)	32.77D	881.6	69.0	1.6	3906	170
83 Rb	c	86.2D	520.4	45	4	10379	1052
75 Se	c	119.779D	136.0	58.3	0.8	6659	380
74 As	i	17.77D	595.8	59	4	3266	263
65 Zn	c	244.26D	1115.6	50.60	0.24	3706	415
60 Co	i(m+g)	5.2714Y	1173.2	99.97	0.00	6449	514
59 Fe	c	44.472D	1291.6	43.2	1.4	3407	180.
			1099.2	56.5	1.9	2910	146.
					R_av	3099	260.
54 Mn	i	312.11D	834.8	99.98	0.00	5044	223
48 V	c	15.9735D	1312.1	97.5	0.9	1269	81.
			983.5	100.0	0.3	1293	84.
					R_av	1281	65.
48 Sc	i	43.67H	1312.1	100.1	0.7	2316	329.
			1037.5	97.6	0.7	2657	141.
			983.5	100.1	0.6	3758	688.
					R_av	2647	167.
46 Sc	i(m+g)	83.79D	889.3	99.98	0.00	4038	167
28 Mg	c	20.915H	1778.8	**********	********	2041	107
24 Na	c	14.9590H	1369.0	100	0	11680	434
7 Be	i	53.29D	477.6	10.52	0.06	22674	880

Table 10.62: Detailed reaction rates for residual nuclide production in ^{181}Ta at E_p=2605 MeV used to determine their production cross sections.

Nuclide	Type	$T_{1/2}$	E_γ, KeV	Abundance, %		Reaction rate 10^{-20} s^{-1}	
177 W	i	135M	115.7	59.6	5.3	21716	2554
176 W	i	2.5H	1862.7	**********	********	77532	23336.
			1823.7	**********	********	10368	34561.
			1696.6	**********	********	1296	24490.
			1252.9	**********	********	19746	77362.
					R_av	36015	20794.
174 W	i	31M	206.5	**********	********	827.4	5745.1
182 Ta	i(m1+m2+g)	114.43D	1231.0	11.44	0.20	26032	1136.
			1221.4	27.0	0.5	26342	1004.
			1189.1	16.2	0.3	27517	1056.
					R_av	26703	945.
178mTa	i(m)	2.36H	331.6	31.2	0.5	79492	3994.
			325.6	94.1	1.7	93052	4549.
					R_av	85515	7248.
177 Ta	c*	56.56H	112.9	7.2	1.6	213870	50033
176 Ta-i	i	8.09H	1862.7	4.0	0.3	110010	31802.
			1823.7	4.5	0.4	170650	49237.
			1696.6	4.6	0.4	209030	37311.
			1252.9	3.08	0.23	152700	102602.
					R_av	157882	25922.
176 Ta	c	8.09H	1862.7	4.0	0.3	187550	17461.
			1823.7	4.5	0.4	181020	21342.
			1696.6	4.6	0.4	210330	21048.

			1252.9	3.08	0.23	172450	30443.
			1159.3	24.7	1.9	177350	15258.
			710.5	5.4	0.4	164500	14252.
					R_av	179848	8993.
175 Ta	c	10.5H	1793.1	4.6	0.7	121160	19413.
			266.9	10.52	0.16	115570	4590.
			125.9	9.0	1.3	190710	30109.
					R_av	116296	6018.
174 Ta-i	i	1.14H	206.5	60	5	112160	12136
174 Ta	c	1.14H	206.5	60	5	112990	10346
173 Ta	c	3.14H	139.6	*****************		151440	21906.
			123.7	*****************		136890	58614.
					R_av	149812	20040.
172 Ta	c*	36.8M	214.1	55	5	77202	10918
181 Hf	c	42.39D	482.2	80.5	0.5	1193	79
180mHf	i(m)	5.5H	332.3	94.1	1.2	16725	891
179mHf	i(m)	25.05D	453.6	68	4	4273	286.
			362.5	39.5	1.5	3545	186.
			315.9	20.2	0.7	4095	223.
					R_av	3854	251.
175 Hf	c	70D	343.4	84	3	234510	11084
173 Hf-i	i	23.6H	139.6	12.7	0.6	23695	21802.
			123.7	83	5	51607	64129.
					R_av	26584	20632.
173 Hf	c	23.6H	311.2	10.7	0.5	214350	12176.
			139.6	12.7	0.6	175140	12181.
			123.7	83	5	188500	17556.
					R_av	197920	14291.
172 Hf	c	1.87Y	1093.6	*****************		157200	8947.
			1022.4	*****************		138730	14577.
			912.1	*****************		174240	9702.
			810.1	*****************		156920	10189.
			181.5	*****************		137090	8146.
					R_av	156387	8638.
171 Hf	c	12.1H	739.8	*****************		114040	28427
170 Hf	c	16.01H	2191.1	*****************		87244	19675.
			2126.1	*****************		148540	13932.
			1512.5	*****************		164340	82917.
			1455.2	*****************		156420	62536.
			1364.6	*****************		123440	8245.
			1280.2	*****************		118130	12993.
			1054.3	*****************		164550	19225.
			985.1	*****************		64179	20083.
			620.7	18	5	178400	49898.
			501.6	3.7	1.0	131860	36445.
			164.7	26	8	173940	54132.
			120.2	15	5	155650	52767.
					R_av	125160	7421.
168 Hf	c	25.95M	1136.8	16.1	2.9	97060	20399.
			983.8	16	4	74347	21486.
			979.2	26.1	0.7	63081	7140.
			896.1	20.1	2.6	102330	14655.
					R_av	72833	9424.
173 Lu	c	1.37Y	272.1	21.2	0.8	203540	10160
172 Lu-i	i	6.70D	1093.6	63	3	51152	2906.
			1022.4	1.41	0.07	36744	28811.
			912.1	15.3	0.7	46969	2608.
			810.1	16.6	0.8	46952	2739.
			181.5	20.6	1.0	44241	2620.
					R_av	47331	1886.
172 Lu	c	6.70D	1093.6	63	3	208360	11827.
			1022.4	1.41	0.07	175480	29415.
			912.1	15.3	0.7	221210	12253.
			810.1	16.6	0.8	203880	12735.
			181.5	20.6	1.0	181340	10713.
					R_av	201680	10009.
171 Lu-i	i(m+g)	8.24D	739.8	47.8	1.2	95229	30056
171 Lu	c	8.24D	853.0	2.55	0.07	229030	9562.
			839.9	3.04	0.08	230200	9355.
			780.7	4.36	0.11	226990	9177.
			739.8	47.8	1.2	209280	8510.

			689.3	2.37	0.06	219560	8898.
					R_av	222313	8020.
170 Lu-i	i(m+g)	2.012D	2191.1	1.64	0.08	130830	26908.
			2126.1	5.1	0.3	38115	13518.
			1512.5	2.55	0.13	9342	118300.
			1455.2	1.18	0.06	18025	87322.
			1364.6	4.62	0.18	67689	8128.
			1280.2	8.2	0.4	50707	14898.
			1054.3	4.76	0.24	6443	22861.
			985.1	5.5	0.3	145810	29714.
					R_av	62136	10765.
170 Lu	c	2.012D	2191.1	1.64	0.08	218070	14723.
			2126.1	5.1	0.3	186660	13097.
			1512.5	2.55	0.13	173680	37890.
			1455.2	1.18	0.06	174450	28387.
			1364.6	4.62	0.18	191140	9756.
			1280.2	8.2	0.4	168840	10638.
			1054.3	4.76	0.24	170990	12155.
			985.1	5.5	0.3	209990	16067.
					R_av	186711	8438.
169 Lu	c	34.06H	1466.8	3.32	0.11	161210	9175.
			1463.4	1.51	0.05	137770	10642.
			960.6	23.4	0.7	146180	6379.
			889.8	5.36	0.17	134560	6884.
			191.2	20.6	0.6	122050	6471.
					R_av	139130	7376.
167 Lu	c	51.5M	113.3*****************			125280	10833
169 Yb	c*	32.026D	307.5	0.3	0.3	6658700	6661996.
			177.2	22.2	0.5	178100	7146.
			130.5	11.31	0.21	185040	10680.
					R_av	179488	6895.
167 Yb-i	i	17.5M	113.3	55	3	16158	4874
167 Yb	c	17.5M	113.3	55	3	141440	12549
166 Yb	c	56.7H	2092.1*****************			177540	14336.
			2079.5*****************			176190	12620.
			2052.4*****************			175790	11679.
			1867.9*****************			171970	11726.
			1374.2*****************			160120	12666.
			1273.5*****************			158860	10865.
			1176.7*****************			164920	12262.
			785.9*****************			159110	10929.
			691.2	8.56	0.58	150580	11956.
					R_av	166441	6006.
162 Yb	c	18.87M	798.7*****************			82845	79349.
			163.4	40	5	121600	15972.
			118.7	34	4	76363	10532.
			102.0*****************			9247	19582.
					R_av	80761	19132.
168 Tm	i	93.1D	720.4	12.0	0.4	6876	440.
			447.5	23.7	0.8	7755	391.
					R_av	7412	487.
167 Tm	c	9.25D	531.5	1.61	0.22	170470	24050.
			207.8	42	8	168020	32493.
					R_av	169616	19658.
166 Tm-i	i	7.70H	2092.1	1.56	0.09	25975	48916.
			2079.5	6.3	0.4	11908	3692.
			2052.4	17.2	1.0	10291	2953.
			1867.9	4.04	0.24	22909	4792.
			1374.2	5.6	0.4	32872	7059.
			1273.5	14.9	0.9	17749	4675.
			1176.7	9.5	0.6	24169	19424.
			785.9	9.9	0.6	13497	5260.
					R_av	15203	2428.
166 Tm	c	7.70H	2092.1	1.56	0.09	203510	49786.
			2079.5	6.3	0.4	188090	13797.
			2052.4	17.2	1.0	186080	12577.
			1867.9	4.04	0.24	194880	13809.
			1374.2	5.6	0.4	192990	16349.
			1273.5	14.9	0.9	176620	12817.
			1176.7	9.5	0.6	189090	22913.
			785.9	9.9	0.6	172610	12712.
					R_av	184702	7529.
165 Tm	c	30.06H	806.4	9.5	0.6	173130	12400.
			356.5	2.75	0.15	174190	12960.
					R_av	173632	9745.
163 Tm	c*	1.810H	1434.4	8.0	0.3	185560	13665.

			1397.5	7.03	0.24	168100	11271.
			1374.3	4.28	0.16	152520	21864.
			104.3	18.6	0.7	103320	9050.
					R_av	142883	20754.
162 Tm-i	i(m+g)	21.70M	798.7	8.4	0.7	85692	119028.
			102.0	17.5	1.5	68978	40393.
					R_av	70682	38010.
162 Tm	c	21.70M	798.7	8.4	0.7	168540	50822.
			102.0	17.5	1.5	78225	24055.
					R_av	94760	35053.
161 Tm	c	33M	1648.1	20	3	115790	20842.
			826.6*****************			150670	22097.
					R_av	132514	17910.
161 Er-i	i	3.21H	826.6	64	4	21961	22830
161 Er	c	3.21H	826.6	64	4	172640	12603
160 Er	c	28.58H	966.2*****************			172810	23187.
			962.4*****************			171450	22379.
			879.4*****************			179190	22880.
			872.0	6.8	1.1	188000	31263.
			728.2*****************			178300	26094.
					R_av	176709	11458.
159 Er	c*	36M	649.1	23	3	185880	25214.
			624.5	33	4	147080	19155.
					R_av	161235	19345.
157 Er	c*	18.65M	391.3	14.2	1.4	139350	15475
156 Er	c	19.5M	266.5*****************			128690	9537.
			137.8*****************			132300	14446.
			137.8*****************			106560	11888.
					R_av	123040	8391.
160mHo-i	i(m)	5.02H	966.2	15.4	2.0	3442	6307.
			962.4	16.6	2.1	8490	3160.
			879.4	18.6	2.3	7604	3848.
			728.2	28	4	9032	2490.
					R_av	8225	1677.
160mHo	c	5.02H	966.2	15.4	2.0	175880	24173.
			962.4	16.6	2.1	179940	23596.
			879.4	18.6	2.3	186790	24032.
			728.2	28	4	187330	27451.
					R_av	182181	13286.
160 Ho	i(m+g)	25.6M	728.2	46.9	1.7	28713	3713
156 Ho-i	i	56M	266.5	54.7	1.1	279.5	9517.0
			137.8	51.1	0.8	3917	13501.
			137.8	51.1	0.8	1641	16000.
					R_av	1517	6996.
156 Ho	c	56M	266.5	54.7	1.1	128970	5285.
			137.8	51.1	0.8	133940	8418.
			137.8	51.1	0.8	110480	6805.
					R_av	125636	6990.
157 Dy	c	8.14H	326.2	92	4	158280	8635.
			326.2	92	4	157330	8727.
					R_av	157814	7059.
155 Dy	c*	9.9H	226.9	68.4	1.6	137830	5526
152 Dy	c	2.38H	256.9	97.50	0.07	93072	3285
155 Tb	c*	5.32D	340.7	1.18	0.07	104980	7588.
			180.1	7.5	0.5	132610	9889.
			163.3	4.44	0.24	117500	7871.
					R_av	116029	8299.
153 Tb	c*	2.34D	212.0	31.0	1.9	112770	8237.
			102.2	6.4	0.5	124170	13889.
					R_av	115357	7209.
152 Tb	c	17.5H	344.3	65	4	116550	8604
151 Tb	c	17.609H	616.6	10.4	0.5	152830	9553.
			479.4	15.4	0.7	109920	6303.
			287.4	28.3	1.2	104540	5578.
			251.9	26.3	1.2	104700	5891.
			108.1	24.3	1.1	98132	8072.
			108.1	24.3	1.1	100200	8238.
					R_av	108496	6753.
150 Tb	c	3.48H	638.0	72	10	49335	7247.

			496.2	14.6	2.0	52697	8637.
					R_av	50716	5661.
149 Tb	c	4.118H	817.1	11.6	0.4	40464	2804.
			352.2	29.4	0.9	36880	1879.
					R_av	38216	1804.
148 Tb	c	60M	784.4	84.0	1.6	56184	2563.
			489.0	19.7	0.5	55114	7402.
					R_av	56117	2518.
153 Gd	c	240.4D	103.2	21.1	0.7	105110	12833
151 Gd	c	124D	243.3	5.6	0.4	89766	7115.
			174.7	2.96	0.21	95842	7937.
			153.6	6.2	0.4	97862	7742.
					R_av	94185	4988.
149 Gd	c	9.28D	788.9	7.3	0.4	140620	8844.
			534.3	3.07	0.17	150580	9640.
			346.6	23.9	1.3	121880	7637.
			298.6	28.6	1.7	119100	7989.
			272.3	3.21	0.19	123790	8730.
			149.7	48	3	122840	9486.
					R_av	128755	6415.
147 Gd	c	38.06H	929.0	20.2	1.2	127780	8599.
			861.7	1.75	0.10	100790	8052.
			677.5	*****************		49910	28739.
			625.2	4.7	0.4	115860	11203.
			370.0	17.2	0.9	121900	7492.
			229.3	63	4	126250	9041.
					R_av	119348	6150.
146 Gd	c	48.27D	2436.7	*****************		133090	6302.
			1756.1	*****************		134940	7624.
			1686.4	*****************		117450	6207.
			1533.7	*****************		130850	5829.
			747.2	*****************		122790	5313.
			154.6	46.6	0.5	109150	3979.
			115.5	44.0	0.7	126750	8300.
			114.7	44.0	0.7	120440	7948.
					R_av	118532	5206.
145 Gd	c	23.0M	1880.6	32.6	1.9	82961	8817.
			1757.9	34.2	2.0	70391	6713.
					R_av	74806	6439.
149 Eu	c	93.1D	327.5	4.03	0.12	128960	6100.
			277.1	3.56	0.06	133620	4975.
					R_av	132414	4748.
148 Eu	i	54.5D	725.7	12.7	0.4	10135	475.
			630.0	71.9	2.3	8921	401.
			611.3	20.5	0.7	7660	372.
			550.3	99	3	8900	390.
					R_av	8785	546.
147 Eu-i	i	24.1D	677.5	9.8	0.5	95418	31032
147 Eu	c	24.1D	955.8	3.84	0.20	150900	9152.
			798.7	4.8	0.3	165780	11663.
			677.5	9.8	0.5	145320	8894.
			121.2	22.9	1.3	140330	11610.
					R_av	149911	6677.
146 Eu-i	i	4.61D	2436.7	0.93	0.03	31082	3921.
			1756.1	0.92	0.04	17907	5835.
			1686.4	0.63	0.02	17262	7232.
			1533.7	6.08	0.19	32310	1953.
			747.2	99	3	20537	1259.
					R_av	24154	2857.
146 Eu	c	4.61D	2436.7	0.93	0.03	164180	8079.
			1756.1	0.92	0.04	152850	9626.
			1686.4	0.63	0.02	134720	8559.
			1533.7	6.08	0.19	163170	7285.
			747.2	99	3	143330	6231.
					R_av	151760	7246.
145 Eu	c	5.93D	1997.0	7.2	0.5	116740	8958.
			1804.3	1.07	0.07	123440	11834.
			1658.5	14.9	1.0	114180	8495.
			893.7	66	5	111940	9149.
			653.5	15	1	108110	7951.
					R_av	113683	5129.
143 Pm	c	265D	742.0	38.5	2.4	122300	8507
140mPm	i(m)	5.95M	1028.2	100	2	45939	5906.
			773.7	100	5	63822	6432.

					R_av	54299	9082.
139mNd	i(m)	5.5H	738.2	35	5	19244	2893
136 Nd	c	50.65M	1092.3*****************			105300	8064.
			1092.3*****************			103400	8562.
			574.8	10.4	1.1	90663	11681.
			552.2*****************			97758	7147.
					R_av	100534	4601.
136 Pr-i	i	13.1M	1092.3	18.5	1.2	8098	8040.
			1092.3	18.5	1.2	12669	10077.
			552.2	76	5	16925	2390.
					R_av	16124	2176.
136 Pr	c	13.1M	1092.3	18.5	1.2	116070	11700.
			1092.3	18.5	1.2	113400	10499.
			552.2	76	5	114680	8512.
					R_av	114627	6428.
134 Pr	c*	17M	409.2	87.1	0.0	89267	3130
139 Ce	c	137.640D	165.9	79.89	0.01	115830	3905
135 Ce	c	17.7H	783.6	10.6	0.4	125970	6542.
			606.8	18.8	0.7	117990	5817.
			577.1	5.14	0.19	112450	7286.
			300.1	23.5	0.6	117490	4865.
			206.5	7.77	0.25	97708	6094.
					R_av	115448	5448.
134 Ce	c	3.16D	604.7	5.04	0.20	88112	5257
133mCe	i(m)	4.9H	477.2	39.2	1.2	26315	1433
132 Ce	c	3.51H	2102.8*****************			117340	13845.
			1909.9*****************			114850	13468.
			464.5*****************			107010	9937.
					R_av	111091	6535.
130 Ce	c	25M	544.5*****************			58872	9800.
			357.4*****************			55648	3608.
					R_av	55846	2904.
132 La-i	i(m+g)	4.8H	2102.8	5.9	0.5	244.4	14150.0
			1909.9	9.0	0.8	1212	12580.
			464.5	76	6	3574	4411.
					R_av	3072	3991.
132 La	c	4.8H	2102.8	5.9	0.5	117580	12709.
			1909.9	9.0	0.8	116060	12553.
			464.5	76	6	110580	9860.
					R_av	113935	7213.
130 La-i	i	8.7M	544.5	16.2	1.8	80392	30785.
			357.4	81	4	33126	6976.
					R_av	35352	10074.
130 La	c	8.7M	544.5	16.2	1.8	139260	29359.
			357.4	81	4	88773	7702.
					R_av	91687	12117.
133 Ba	c	3848.9D	356.0	62.05	0.19	99498	3651
131 Ba	c	11.50D	496.3	46.8	0.2	103000	3271.
			486.5	2.09	0.02	102280	3516.
			373.2	14.04	0.20	106490	3665.
			216.1	19.66	0.25	100260	3479.
			123.8	29.0	0.3	104810	6247.
					R_av	103003	3297.
128 Ba	c	2.43D	273.4	14.5	0.7	95131	5869
126 Ba	c	100M	233.6	19.6	1.8	45272	4746
129 Cs	c	32.06H	411.5	22.3	1.3	129710	8768.
			371.9	30.6	1.7	125900	8096.
					R_av	127626	6579.
127 Cs	c	6.25H	412.0	62.8	1.0	96796	3741
127 Xe	c	36.4D	375.0	17.2	0.6	102330	4783.
			202.9	68.3	0.5	84545	2837.
					R_av	85933	5475.
123 Xe	c	2.08H	148.9	48.9	0.6	88546	4162
122 Xe	c	20.1H	350.1	7.80	0.17	67994	3760
121 Te-i	i(m+g)	19.16D	573.1	80.3	2.5	75667	3323

121 Te	c	19.16D	573.1	80.3	2.5	79386	3488
121mTe	i(m)	154D	573.1	88.6	0.1	4198	296.
			212.2	81.4	1.1	3604	145.
					R_av	3667	216.
119 Te	c	16.05H	1749.7	3.9	0.3	92803	10699.
			644.0	84.0	0.5	70559	2367.
					R_av	70714	2882.
119mTe	i(m)	4.70D	1212.7	66.2	0.3	13992	459.
			1136.8	7.66	0.08	14437	1093.
			153.6	66	3	11397	668.
					R_av	13853	608.
117 Te	c	62M	719.7	64.7	1.4	67198	2936
114 Te	c	15.2M	1299.9	128.1	1.0	21012	2106
120mSb	i(m)	5.76D	1171.7*****************			1033	50.
			1023.3	99.4	0.3	1239	449.
					R_av	1035	50.
118mSb	i(m)	5.00H	1229.7	100	5	6658	482.
			1050.7	97	5	5721	470.
					R_av	6189	507.
115 Sb	c*	32.1M	497.3	97.9	0.4	37832	5731
113 Sn	i(m+g)	115.09D	391.7	64.97	0.17	47645	1497
111 In	c	2.8047D	245.4	94	1	46827	1579.
			171.3	90.2	1.0	41739	1504.
					R_av	44865	2846.
110 In	i	4.9H	937.5	68.4	1.4	20783	1157.
			884.7	92.9	1.9	21818	868.
			657.8	98.3	2.0	46032	2018.
			641.7	25.9	0.6	25085	1596.
					R_av	24087	4093.
109 In	c	4.2H	203.5	73.5	0.5	28595	1857
108mIn	i(m)	58.0M	875.4	100	11	17158	2208
108 In	c*	39.6M	632.9	76.4	0.6	33818	3129
110mAg	i(m)	249.76D	884.7	72.7	0.4	1140	192.
			657.8	94.3	0.3	940.5	51.1
			657.8	94.3	0.3	1032	88.
					R_av	966.1	47.4
106mAg	i(m)	8.28D	1572.3	6.6	0.6	11392	1251.
			1527.7	16.3	1.4	13394	1246.
			1045.8	29.6	1.0	13006	617.
			824.7	15.3	0.5	12671	609.
			804.3	12.4	0.6	10773	759.
			717.3	28.9	0.8	10864	461.
			616.2	21.6	0.7	10660	528.
			451.0	28.2	0.8	12390	533.
					R_av	11699	514.
105 Ag	c	41.29D	644.5	11.1	0.6	34480	2176.
			443.4	10.5	0.6	36119	2386.
			344.5	41.4	0.6	34044	1197.
					R_av	34199	1185.
100 Pd	c	3.63D	2376.0*****************			11235	404.
			1553.3*****************			13079	488.
			1362.2*****************			11428	457.
			822.7*****************			10435	377.
					R_av	11296	631.
102 Rh	i(m+g)	207D	475.1	46	5	3807	485
100 Rh-i	i(m+g)	20.8H	2376.0	32.6	0.4	20944	887.
			1553.3	20.67	0.18	14766	2790.
			1362.2	15.39	0.13	19062	1115.
			822.7	21.09	0.17	15024	835.
					R_av	18502	1650.
100 Rh	c	20.8H	2376.0	32.6	0.4	32179	1212.
			1553.3	20.67	0.18	27845	2820.
			1362.2	15.39	0.13	30490	1329.
			822.7	21.09	0.17	25459	1050.
					R_av	29177	1969.
99mRh	c	4.7H	340.8	70	5	15690	1275
103 Ru	c	39.26D	497.1	91.0	1.3	1011	158

97 Ru	c	2.791D	215.7	85.6	0.0	22462	861
96 Tc	i(m+g)	4.28D	849.9	98	4	11755	623.
			812.5	82	4	12675	735.
					R_av	12121	588.
93mMo	i(m)	6.85H	1477.1	99.1	2.5	11307	585.
			684.7	99.7	2.0	9744	594.
					R_av	10595	846.
90 Nb	c*	14.60H	2319.0	82.0	0.3	20380	727.
			1129.2	92.7	0.5	20326	746.
					R_av	20356	687.
89 Zr	c	78.41H	909.2	99.04	0.03	23576	733
88 Zr	c	83.4D	1836.1	*********	*********	19251	649.
			898.0	*********	*********	17083	563.
			392.9	97.24	0.00	16761	546.
					R_av	16784	524.
88 Y -i	i	106.65D	1836.1	99.2	0.3	9616	329.
			898.0	93.7	0.3	10130	332.
					R_av	9941	397.
88 Y	c	106.65D	1836.1	99.2	0.3	28868	917.
			898.0	93.7	0.3	27213	845.
					R_av	28809	949.
87mY	c*	13.37H	484.8	98.4	0.1	8740	2917
87 Y -i	i	79.8H	484.8	89.7	0.7	16269	3395
87 Y	c	79.8H	484.8	89.7	0.7	24869	979
86 Y	c	14.74H	1920.7	20.8	0.7	26254	2237.
			1854.4	17.2	0.5	26096	2173.
			1076.6	82.5	0.4	18416	849.
					R_av	19631	2086.
85 Sr	c	64.84D	514.0	96	4	22842	1191
83 Sr	c	32.41H	762.7	30	14	11954	5604
84 Rb	i(m+g)	32.77D	881.6	69.0	1.6	6910	269
83 Rb	c	86.2D	529.6	29.3	2.1	23028	1815.
			520.4	45	4	22158	2096.
					R_av	22667	1458.
82mRb	i(m)	6.472H	554.3	62.4	0.9	8586	883
77 Br	c	57.036H	520.7	22.4	0.6	17809	841
75 Se	c	119.779D	264.7	58.9	0.4	13351	480.
			136.0	58.3	0.8	15065	818.
					R_av	13543	687.
74 As	i	17.77D	595.8	59	4	8000	600
65 Zn	c	244.26D	1115.6	50.60	0.24	11688	388
60 Co	i(m+g)	5.2714Y	1332.5	99.99	0.00	8681	683.
			1173.2	99.97	0.00	9523	466.
					R_av	9316	465.
58 Co	i(m+g)	70.86D	810.8	99.45	0.01	9186	355
56 Co	c	77.233D	846.8	99.94	0.03	859.6	89.6
59 Fe	c	44.472D	1291.6	43.2	1.4	5939	276.
			1099.2	56.5	1.9	5464	253.
					R_av	5680	296.
54 Mn	i	312.11D	834.8	99.98	0.00	11826	393
52 Mn	c	5.591D	1434.1	100.0	0.6	2014	72
48 V	c	15.9735D	1312.1	97.5	0.9	3632	121.
			983.5	100.0	0.3	3469	114.
					R_av	3533	136.
48 Sc	i	43.67H	1312.1	100.1	0.7	4304	195.
			1037.5	97.6	0.7	4557	231.
			983.5	100.1	0.6	3265	235.
					R_av	4154	363.
46 Sc	i(m+g)	83.79D	889.3	99.98	0.00	11921	371
44mSc	i(m)	58.61H	1157.0	108.4	0.5	3404	126

28 Mg	c	20.915H	1778.8	*****************		6054	245
24 Na	c	14.9590H	1369.0	100	0	30981	1008
22 Na	c	2.6019Y	1274.5	99.94	0.01	4627	236
7 Be	i	53.29D	477.6	10.52	0.06	49805	1911

10.6 Reaction rates for residual nuclide production in ^{nat}W

Table 10.64: Detailed reaction rates for residual nuclide production in ^{nat}W at E_p=46 MeV used to determine their production cross sections.

Nuclide	Type	$T_{1/2}$	E_γ, KeV	Abundance, %		Reaction rate 10^{-20} s^{-1}	
186 Re	i	3.7183D	137.2	9.42	0.06	17928	1290
184 Re	i(m+g)	38.0D	903.3	37.9	1.1	154990	6793.
			894.8	15.6	0.5	153170	7064.
			792.1	37.5	1.1	146540	6473.
					R_av	151335	5488.
184mRe	i(m)	169D	216.6	12.2	0.6	30642	2399
183 Re	i	70.0D	354.0	0.54	0.01	503540	22459.
			291.7	3.05	0.18	517660	35686.
			208.8	2.95	0.09	590450	29668.
			162.3	23.3	0.7	559940	26527.
			107.9	2.17	0.07	424120	39723.
					R_av	529656	27804.
182 Re	i	64.0H	1427.3	9.8	0.6	682880	48227.
			1294.0	1.61	0.10	872370	63394.
			1257.5	1.06	0.07	872880	68226.
			1231.0	14.9	0.9	696740	49400.
			1221.4	17.4	1.1	693550	50113.
			1189.0	9.0	0.6	751770	57700.
			1076.2	10.5	0.7	714960	55050.
			351.1	10.3	1.0	733610	75987.
			342.0	1.05	0.10	738360	76737.
			256.5	9.5	1.0	753560	85850.
			191.4	6.7	0.7	769310	86612.
					R_av	739473	30558.
182mRe	i(m)	12.7H	1257.3	1.4	0.1	800120	67633.
			1221.5	24.8	1.6	790900	60902.
			1189.2	15	1	803650	65294.
			470.3	2.00	0.14	739810	61709.
					R_av	782461	38238.
181 Re	i	19.9H	805.2	3.1	1.6	1451500	753060.
			661.8	3.0	0.7	1057200	250020.
			639.0	6.4	1.4	1210100	269457.
			365.5	56	8	1042200	158220.
			360.7	20	5	583990	147941.
					R_av	893031	130085.
179 Re	i	19.5M	1680.3	13.0	1.1	1117600	107844.
			1560.4	3.2	0.3	1203500	130494.
			832.6	3.0	0.3	1155900	125006.
			498.3	5.7	0.5	1089000	105135.
			477.3	9.2	0.8	1138400	108230.
			430.2	28.0	1.8	1163000	88682.
			415.4	10.6	0.9	1167400	118398.
			401.8	7.2	0.6	1149600	106726.
			296.3	8.9	0.8	1159800	114800.
			290.0	26.9	2.3	1139400	107860.
					R_av	1146347	48464.
178 Re	i	13.2M	1110.8	2.7	0.6	431150	108474.
			976.6	3.6	0.7	409680	87983.
			777.9	3.8	0.6	488620	84107.
			237.3	45	5	402190	53976.
			105.9	23	3	388880	61654.
					R_av	412964	29318.
181 W	c	121.2D	136.3	0.03	0.00	2276000	161087
178 W	c	21.6D	1496.0	0.27	0.02	396190	38719.
			1402.9	0.48	0.04	408540	37103.
			1350.6	1.18	0.11	382320	37993.
			1340.8	1.03	0.09	387140	36393.
			1183.4	0.17	0.01	403570	39844.
			1106.1	0.54	0.05	376580	37636.
					R_av	392270	18981.
177 W	c	135M	115.7	59.6	5.3	7236	802
183 Ta	c	5.1D	354.0	11.2	0.7	5744	514

182 Ta	i(m1+m2+g)	114.43D	1231.0	11.44	0.20	5464	1679.
			1221.4	27.0	0.5	4745	623.
			1189.1	16.2	0.3	6382	879.
					R_av	5304	550.
178mTa	i(m)	2.36H	325.6	94.1	1.7	10881	488
177 Ta	c*	56.56H	208.4	0.94	0.20	685970	154675.
			112.9	7.2	1.6	709170	162796.
					R_av	696973	113184.
176 Ta	c*	8.09H	2044.9	1.35	0.10	18995	3541.
			1862.7	4.0	0.3	16239	2012.
			1823.7	4.5	0.4	14585	1681.
			1696.6	4.6	0.4	22292	2426.
			1633.7	2.93	0.22	16559	2292.
			1584.0	5.3	0.4	17167	1719.
			1555.1	4.0	0.3	14437	1581.
			1159.3	24.7	1.9	19400	1708.
			710.5	5.4	0.4	17999	2410.
					R_av	17000	972.
181 Hf	c	42.39D	482.2	80.5	0.5	222.9	18.8
175 Hf	c	70D	343.4	84	3	998.8	55.8

Table 10.65: Detailed reaction rates for residual nuclide production in ^{nat}W at E_p=68 MeV used to determine their production cross sections.

Nuclide	Type	$T_{1/2}$	E_γ, KeV	Abundance, %		Reaction rate 10^{-20} s^{-1}	
186 Re	i	3.7183D	137.2	9.42	0.06	4131	235
184 Re	i(m+g)	38.0D	1022.6	0.52	0.04	36042	4549.
			903.3	37.9	1.1	35289	1543.
			894.8	15.6	0.5	35069	1645.
			792.1	37.5	1.1	33593	1493.
					R_av	34634	1256.
184mRe	i(m)	169D	216.6	12.2	0.6	6110	492
183 Re	i	70.0D	354.0	0.54	0.01	87630	4548.
			291.7	3.05	0.18	84798	5878.
			246.1	1.31	0.05	92908	5318.
			208.8	2.95	0.09	89175	4431.
			162.3	23.3	0.7	90268	4288.
			107.9	2.17	0.07	80801	5690.
					R_av	88374	3201.
182 Re	i	64.0H	1427.3	9.8	0.6	57690	4041.
			1294.0	1.61	0.10	62837	4502.
			1257.5	1.06	0.07	69258	5335.
			1231.0	14.9	0.9	59943	4154.
			1221.4	17.4	1.1	59438	4274.
			1189.0	9.0	0.6	64156	4796.
			1121.3	22.0	1.4	59294	4280.
			1076.2	10.5	0.7	62910	4775.
			351.1	10.3	1.0	61719	6346.
			256.5	9.5	1.0	63445	7142.
			191.4	6.7	0.7	64134	7143.
			107.1	1.41	0.13	76816	9700.
					R_av	61861	2341.
182mRe	i(m)	12.7H	1257.3	1.4	0.1	105840	9084.
			1221.5	24.8	1.6	95070	7444.
			1189.2	15	1	118300	9219.
			1121.4	31.8	1.6	85653	6055.
			470.3	2.00	0.14	96892	9985.
					R_av	96946	6378.
181 Re	i	19.9H	805.2	3.1	1.6	346920	179702.
			661.8	3.0	0.7	250050	59296.
			639.0	6.4	1.4	272340	60861.
			365.5	56	8	245860	36170.
			360.7	20	5	127850	32358.
					R_av	202412	32397.
179 Re	i	19.5M	1680.3	13.0	1.1	305590	28599.
			1560.4	3.2	0.3	299890	33308.
			832.6	3.0	0.3	303630	35760.
			498.3	5.7	0.5	350590	33684.
			477.3	9.2	0.8	333330	31623.
			430.2	28.0	1.8	346130	25537.
			415.4	10.6	0.9	341210	31926.
			401.8	7.2	0.6	331490	30516.
			296.3	8.9	0.8	342200	33597.
			290.0	26.9	2.3	337360	31642.
					R_av	330294	13882.

178 Re	i	13.2M	1110.8	2.7	0.6	361060	85787.
			976.6	3.6	0.7	353210	71697.
			777.9	3.8	0.6	365710	61142.
			351.9	2.6	0.6	431580	103612.
			237.3	45	5	394250	46925.
			105.9	23	3	361440	53344.
					R_av	378058	23358.
177 Re	i	14.0M	708.1	2.5	0.5	259440	60810.
			209.8	2.8	0.5	255120	54134.
			196.9	8.4	0.0	319790	16963.
			115.7	*****************		283870	61453.
			94.9	3.9	0.9	344750	90572.
					R_av	313297	9788.
176 Re	i	5.3M	240.1	47.7	2.3	64895	10846
181 W	c	121.2D	136.3	0.03	0.00	797810	53744
178 W	c	21.6D	1496.0	0.27	0.02	458030	44257.
			1402.9	0.48	0.04	425000	38304.
			1350.6	1.18	0.11	413120	40941.
			1340.8	1.03	0.09	411620	38580.
			1183.4	0.17	0.01	400610	39246.
			1106.1	0.54	0.05	409850	40540.
			93.1	6.6	1.9	425590	126247.
					R_av	418619	20077.
177 W -i	i	135M	115.7	59.6	5.3	16620	57822
177 W	c	135M	115.7	59.6	5.3	300490	32140
176 W	c	2.5H	2044.9	*****************		81178	11980.
			1977.8	*****************		83982	36677.
			1862.7	*****************		82272	13812.
			1823.7	*****************		70190	13278.
			1704.7	*****************		85045	13444.
			1696.6	*****************		88505	18690.
			1643.4	*****************		73589	12693.
			1633.7	*****************		84891	15747.
			1584.0	*****************		83438	11789.
			1555.1	*****************		76603	12533.
			1341.3	*****************		108020	21051.
			1252.9	*****************		59571	14243.
			1159.3	*****************		86737	8313.
			1023.1	*****************		30918	17485.
			710.5	*****************		65960	6842.
					R_av	76614	3949.
174 W	c	31M	206.5	*****************		2697	940
184 Ta	c*	8.7H	920.9	32.0	1.6	2401	175.
			414.0	72	3	2072	118.
					R_av	2164	162.
183 Ta	c	5.1D	354.0	11.2	0.7	5113	382.
			291.7	3.73	0.23	3006	509.
			246.1	27	4	4622	710.
			107.9	11.0	0.8	3529	623.
					R_av	4312	540.
182 Ta	i(m1+m2+g)	114.43D	1231.0	11.44	0.20	5972	587.
			1221.4	27.0	0.5	5790	401.
			1189.1	16.2	0.3	6722	341.
			1121.3	34.9	0.6	7283	437.
					R_av	6545	380.
178mTa	i(m)	2.36H	325.6	94.1	1.7	8367	374
177 Ta	c*	56.56H	1057.8	0.29	0.07	439930	107315.
			745.9	0.21	0.05	404100	97447.
			424.6	0.10	0.02	362600	78596.
			208.4	0.94	0.20	463700	100280.
			112.9	7.2	1.6	438560	100683.
					R_av	414440	44097.
176 Ta-i	i	8.09H	2044.9	1.35	0.10	8470	13622.
			1977.8	0.87	0.07	3112	49790.
			1862.7	4.0	0.3	17948	16129.
			1823.7	4.5	0.4	24992	15278.
			1704.7	1.40	0.11	5600	15671.
			1696.6	4.6	0.4	15008	22404.
			1643.4	2.40	0.18	14694	15056.
			1633.7	2.93	0.22	8920	18692.
			1584.0	5.3	0.4	8472	12623.
			1555.1	4.0	0.3	14940	14597.
			1341.3	3.34	0.25	7283	23781.
			1252.9	3.08	0.23	52253	18566.
			1159.3	24.7	1.9	14002	4940.
			1023.1	2.67	0.20	74376	24462.

			710.5	5.4	0.4	30766	6135.
					R_av	19828	3263.
176 Ta	c	8.09H	2044.9	1.35	0.10	89648	8376.
			1977.8	0.87	0.07	87094	16172.
			1862.7	4.0	0.3	100220	9388.
			1823.7	4.5	0.4	95181	10044.
			1704.7	1.40	0.11	90645	9056.
			1696.6	4.6	0.4	103510	11574.
			1643.4	2.40	0.18	88283	8436.
			1633.7	2.93	0.22	93812	9302.
			1584.0	5.3	0.4	91910	8380.
			1555.1	4.0	0.3	91542	8566.
			1341.3	3.34	0.25	115300	11017.
			1252.9	3.08	0.23	111820	10470.
			1159.3	24.7	1.9	100730	8551.
			1023.1	2.67	0.20	105290	11003.
			710.5	5.4	0.4	96726	7986.
					R_av	96667	3800.
175 Ta	c	10.5H	1826.1	1.24	0.22	19587	4205.
			1793.1	4.6	0.7	17802	2814.
			1744.8	1.36	0.19	24397	3680.
			1736.7	0.92	0.14	14698	2698.
			1711.8	1.16	0.19	13625	2585.
			857.7	3.2	0.4	18113	2474.
			348.5	12.0	1.1	20760	2064.
			348.5	12.0	1.1	20678	2054.
			266.9	10.52	0.16	18793	962.
			125.9	9.0	1.3	28515	4418.
					R_av	18852	745.
174 Ta-i	i	1.14H	206.5	60	5	8638	1526
174 Ta	c	1.14H	206.5	60	5	11335	1146
181 Hf	c	42.39D	482.2	80.5	0.5	164.9	9.1
179mHf	i(m)	25.05D	453.6	68	4	96.12	15.45
175 Hf	c	70D	343.4	84	3	20336	997
173 Hf	c	23.6H	123.7	83	5	1598	134

Table 10.66: Detailed reaction rates for residual nuclide production in ^{nat}W at E_p=99 MeV used to determine their production cross sections.

Nuclide	Type	$T_{1/2}$	E_γ, KeV	Abundance, %		Reaction rate 10^{-20} s^{-1}	
186 Re	i	3.7183D	137.2	9.42	0.06	2735	226
184 Re	i(m+g)	38.0D	903.3	37.9	1.1	38059	1661.
			894.8	15.6	0.5	37518	1727.
			792.1	37.5	1.1	36032	1588.
					R_av	37156	1345.
184mRe	i(m)	169D	216.6	12.2	0.6	5646	393
183 Re	i	70.0D	208.8	2.95	0.09	86380	4516.
			162.3	23.3	0.7	91624	4367.
			107.9	2.17	0.07	94178	6720.
					R_av	89938	3607.
182 Re	i	64.0H	1294.0	1.61	0.10	51458	4293.
			1189.0	9.0	0.6	55148	4252.
			1121.3	22.0	1.4	50225	3653.
			1076.2	10.5	0.7	52568	3950.
			351.1	10.3	1.0	53085	5576.
			256.5	9.5	1.0	54558	6128.
			191.4	6.7	0.7	58205	6510.
					R_av	52839	2302.
182mRe	i(m)	12.7H	1121.4	31.8	1.6	96549	6795
181 Re	i	19.9H	365.5	56	8	177020	26028.
			331.9	1.3	0.4	205740	64158.
					R_av	180954	24294.
179 Re	i	19.5M	1680.3	13.0	1.1	253970	24239.
			832.6	3.0	0.3	263080	34193.
			477.3	9.2	0.8	264300	25856.
			430.2	28.0	1.8	344500	25608.
			415.4	10.6	0.9	275830	26087.
			401.8	7.2	0.6	270770	26820.
			296.3	8.9	0.8	284080	28599.
			290.0	26.9	2.3	278230	26319.
					R_av	280788	13766.
178 Re	i	13.2M	1110.8	2.7	0.6	416050	97036.

			976.6	3.6	0.7	358460	78777.
			351.9	2.6	0.6	435460	104520.
			237.3	45	5	347530	41540.
			105.9	23	3	312800	45674.
					R_av	344903	22766.
177 Re	i	14.0M	708.1	2.5	0.5	227070	54071.
			209.8	2.8	0.5	314960	59752.
			196.9	8.4	0.0	338260	15738.
			115.7	*****************		445410	70950.
					R_av	337411	10541.
176 Re	i	5.3M	240.1	47.7	2.3	294720	20117
181 W	c	121.2D	136.3	0.03	0.00	761910	84009
178 W	c	21.6D	1496.0	0.27	0.02	613680	59082.
			1402.9	0.48	0.04	605610	54526.
			1350.6	1.18	0.11	582360	57660.
			1340.8	1.03	0.09	578250	54353.
			1183.4	0.17	0.01	575000	55090.
			93.1	6.6	1.9	586910	174391.
					R_av	590502	29649.
177 W -i	i	135M	115.7	59.6	5.3	69335	54929
177 W	c	135M	115.7	59.6	5.3	514740	54983
176 W	c	2.5H	1861.2	*****************		553100	68510.
			1823.7	*****************		520630	58446.
			1696.6	*****************		663160	68350.
			1555.1	*****************		542370	87575.
			1252.9	*****************		590800	79979.
			1159.3	*****************		619700	54584.
			710.5	*****************		548260	59950.
					R_av	592440	26293.
174 W	c	31M	206.5	*****************		165650	15906
184 Ta	c*	8.7H	920.9	32.0	1.6	7074	545.
			414.0	72	3	7190	405.
					R_av	7153	357.
183 Ta	c	5.1D	354.0	11.2	0.7	15738	1197.
			313.3	7.52	0.55	18378	1511.
			246.1	27	4	17204	2636.
			107.9	11.0	0.8	14313	1431.
					R_av	16130	1008.
182 Ta	i(m1+m2+g)	114.43D	1231.0	11.44	0.20	21296	864.
			1221.4	27.0	0.5	21339	831.
			1189.1	16.2	0.3	24330	985.
			1121.3	34.9	0.6	23874	968.
					R_av	22467	1060.
178mTa	i(m)	2.36H	331.6	31.2	0.5	16199	2229.
			325.6	94.1	1.7	22983	948.
					R_av	22472	1923.
177 Ta	c*	56.56H	745.9	0.21	0.05	718960	173645.
			424.6	0.10	0.02	698630	152150.
			208.4	0.94	0.20	775420	167919.
			112.9	7.2	1.6	743530	170961.
					R_av	732423	85083.
176 Ta-i	i	8.09H	1862.7	4.0	0.3	64337	61840.
			1823.7	4.5	0.4	64085	38168.
			1696.6	4.6	0.4	4131	31490.
			1555.1	4.0	0.3	44537	96429.
			1252.9	3.08	0.23	26283	80604.
			1159.3	24.7	1.9	7995	15442.
			710.5	5.4	0.4	22037	49934.
					R_av	17145	12107.
176 Ta	c	8.09H	1862.7	4.0	0.3	617440	54269.
			1823.7	4.5	0.4	584720	56939.
			1696.6	4.6	0.4	667290	63128.
			1555.1	4.0	0.3	586910	53982.
			1252.9	3.08	0.23	617090	54924.
			1159.3	24.7	1.9	627700	53101.
			710.5	5.4	0.4	570300	48461.
					R_av	606936	27060.
175 Ta	c	10.5H	1793.1	4.6	0.7	397740	62333.
			1744.8	1.36	0.19	429220	62295.
			1736.7	0.92	0.14	426930	67447.
			857.7	3.2	0.4	444110	57709.
			348.5	12.0	1.1	475340	46567.
			266.9	10.52	0.16	427890	18965.
			125.9	9.0	1.3	634760	97753.
					R_av	434157	17701.

174 Ta-i	i	1.14H	206.5	60	5	17120	4669
174 Ta	c	1.14H	206.5	60	5	182770	16895
173 Ta	c	3.14H	172.2	17.5	1.8	68570	7674.
			160.4	4.9	0.8	66681	12215.
					R_av	68084	6348.
181 Hf	c	42.39D	482.2	80.5	0.5	556.4	25.6
180mHf	i(m)	5.5H	332.3	94.1	1.2	2454	535
179mHf	i(m)	25.05D	453.6	68	4	261.6	21.4
			362.5	39.5	1.5	253.3	19.5
					R_av	257.0	15.5
175 Hf	c	70D	433.0	1.44	0.06	440000	23730.
			343.4	84	3	424390	20786.
					R_av	430735	18253.
173 Hf	c	23.6H	311.2	10.7	0.5	81219	4756.
			139.6	12.7	0.6	77636	5677.
			123.7	83	5	85195	6875.
					R_av	80918	3402.
172 Hf	c	1.87Y	1093.6	*********	*********	39171	2290.
			810.1	*********	*********	41980	2506.
			181.5	*********	*********	35794	2330.
					R_av	39188	2053.
170 Hf	c	16.01H	1280.2	*********	*********	2246	6463
173 Lu	c	1.37Y	272.1	21.2	0.8	66755	3541
172 Lu-i	i	6.70D	1093.6	63	3	820.5	56.5
			810.1	16.6	0.8	1009	79.
			432.5	1.64	0.08	35305	2292.
			181.5	20.6	1.0	758.5	75.3
					R_av	865.1	406.5
172 Lu	c	6.70D	1093.6	63	3	39992	2335.
			810.1	16.6	0.8	42989	2560.
			432.5	1.64	0.08	390610	23249.
			181.5	20.6	1.0	36553	2366.
					R_av	41025	12343.
171 Lu	c	8.24D	853.0	2.55	0.07	21337	1513.
			839.9	3.04	0.08	19642	949.
			780.7	4.36	0.11	18275	847.
			739.8	47.8	1.2	18575	779.
			689.3	2.37	0.06	18053	937.
					R_av	18750	709.
170 Lu-i	i(m+g)	2.012D	1280.2	8.2	0.4	5699	9208
170 Lu	c	2.012D	2126.1	5.1	0.3	2720	292.
			1280.2	8.2	0.4	7946	2809.
					R_av	2772	523.
169 Yb	c*	32.026D	307.7	10.05	0.19	1262	177.
			177.2	22.2	0.5	1444	77.
					R_av	1423	73.
48 V	c	15.9735D	1312.1	97.5	0.9	194.1	11.1
7 Be	i	53.29D	477.6	10.52	0.06	2061.	258.

Table 10.67: Detailed reaction rates for residual nuclide production in ^{nat}W at E_p=149 MeV used to determine their production cross sections.

Nuclide	Type	$T_{1/2}$	E_γ, KeV	Abundance, %		Reaction rate 10^{-20} s^{-1}	
184 Re	i(m+g)	38.0D	903.3	37.9	1.1	36037	1576.
			894.8	15.6	0.5	31889	1507.
			792.1	37.5	1.1	35145	1595.
					R_av	34373	1661.
184mRe	i(m)	169D	216.6	12.2	0.6	5535	977
183 Re	i	70.0D	162.3	23.3	0.7	87241	4155.
			107.9	2.17	0.07	84835	7590.
					R_av	86849	3949.
182 Re	i	64.0H	1189.0	9.0	0.6	44711	3685.
			1121.3	22.0	1.4	45197	3342.
			1121.3	22.0	1.4	45180	3354.
			1076.2	10.5	0.7	48025	3649.
			351.1	10.3	1.0	44798	4658.

			256.5	9.5	1.0	46090	5217.
			191.4	6.7	0.7	49836	6530.
					R_av	45870	2005.
182mRe	i(m)	12.7H	1121.4	31.8	1.6	88152	6204.
			1121.4	31.8	1.6	88118	6111.
					R_av	88135	4769.
181 Re	i	19.9H	365.5	56	8	146010	21432.
			331.9	1.3	0.4	206280	64070.
					R_av	151881	20453.
179 Re	i	19.5M	1680.3	13.0	1.1	177870	18880.
			477.3	9.2	0.8	162900	17180.
			415.4	10.6	0.9	188990	19034.
			401.8	7.2	0.6	193810	21260.
					R_av	179237	10630.
178 Re	i	13.2M	976.6	3.6	0.7	212910	50010.
			237.3	45	5	210200	25977.
					R_av	210557	18037.
177 Re	i	14.0M	196.9	8.4	0.0	138770	11761.
			115.7	*****************		329910	57656.
					R_av	145616	4549.
176 Re	i	5.3M	240.1	47.7	2.3	187510	16114
178 W	c	21.6D	1496.0	0.27	0.02	559110	53858.
			1402.9	0.48	0.04	555900	50220.
			1350.6	1.18	0.11	535540	53204.
			1340.8	1.03	0.09	545670	51122.
			1183.4	0.17	0.01	555820	53685.
					R_av	550441	27833.
177 W -i	i	135M	115.7	59.6	5.3	202220	52204
177 W	c	135M	115.7	59.6	5.3	532130	56445
176 W	c	2.5H	1861.2	*****************		743400	82983.
			1823.7	*****************		684160	128845.
			1696.6	*****************		739250	104872.
			1555.1	*****************		680290	102257.
			1252.9	*****************		729290	91096.
			1159.3	*****************		680760	61764.
			710.5	*****************		631940	70487.
					R_av	687374	29379.
174 W	c	31M	206.5	*****************		523790	53873
184 Ta	c*	8.7H	920.9	32.0	1.6	10700	770.
			414.0	72	3	15702	907.
					R_av	12963	2522.
183 Ta	c	5.1D	354.0	11.2	0.7	35514	2565.
			313.3	7.52	0.55	36000	2975.
			246.1	27	4	38443	5899.
			107.9	11.0	0.8	37016	3630.
					R_av	36157	1893.
182 Ta	i(m1+m2+g)	114.43D	1231.0	11.44	0.20	49282	1910.
			1221.4	27.0	0.5	48230	1848.
			1189.1	16.2	0.3	52779	2303.
			1121.3	34.9	0.6	50218	1950.
			1121.3	34.9	0.6	49945	1942.
					R_av	49742	1684.
178mTa	i(m)	2.36H	331.6	31.2	0.5	52417	2573.
			325.6	94.1	1.7	64828	2675.
					R_av	59408	6429.
177 Ta	c*	56.56H	745.9	0.21	0.05	824660	201127.
			424.6	0.10	0.02	961270	214448.
			112.9	7.2	1.6	832290	191138.
					R_av	867782	118460.
176 Ta-i	i	8.09H	1862.7	4.0	0.3	67603	71149.
			1823.7	4.5	0.4	61277	153101.
			1696.6	4.6	0.4	134850	101780.
			1555.1	4.0	0.3	11373	113901.
			1252.9	3.08	0.23	58957	84778.
			1159.3	24.7	1.9	118980	26868.
			710.5	5.4	0.4	93458	60155.
					R_av	104550	20577.
176 Ta	c	8.09H	1862.7	4.0	0.3	811010	69976.
			1823.7	4.5	0.4	745440	82980.
			1696.6	4.6	0.4	874100	85996.
			1555.1	4.0	0.3	691660	65266.
			1252.9	3.08	0.23	788250	69046.
			1159.3	24.7	1.9	799750	67657.

			710.5	5.4	0.4	725400	61125.
					R_av	769279	34621.
175 Ta	c	10.5H	1793.1	4.6	0.7	687630	107498.
			1744.8	1.36	0.19	700940	101737.
			1736.7	0.92	0.14	742540	116647.
			266.9	10.52	0.16	765510	31934.
			125.9	9.0	1.3	1079000	165791.
			104.3	3.1	0.5	491750	85867.
					R_av	750624	39627.
174 Ta-i	i	1.14H	206.5	60	5	31634	21761
174 Ta	c	1.14H	206.5	60	5	555430	52087
173 Ta	c	3.14H	1208.2	2.7	0.4	548280	89121.
			1030.0	1.42	0.23	562960	95476.
			700.6	1.16	0.15	580310	86294.
			180.6	2.22	0.24	496230	58767.
			172.2	17.5	1.8	473100	51947.
			160.4	4.9	0.8	457990	78275.
			139.6	*********	********	466970	41477.
					R_av	490079	26230.
172 Ta	c*	36.8M	1330.4	8.1	0.8	199520	22154.
			1109.3	14.9	1.5	158070	17158.
			1085.6	8.1	0.8	240510	26857.
			214.1	55	5	160860	17922.
					R_av	178698	17833.
181 Hf	c	42.39D	482.2	80.5	0.5	1625	65
180mHf	i(m)	5.5H	332.3	94.1	1.2	4111	447
179mHf	i(m)	25.05D	453.6	68	4	628.8	47.2
			362.5	39.5	1.5	628.4	42.7
					R_av	628.6	34.5
175 Hf	c	70D	433.0	1.44	0.06	745580	40239.
			343.4	84	3	732350	35851.
					R_av	737832	31265.
173 Hf-i	i	23.6H	139.6	12.7	0.6	2835	31600
173 Hf	c	23.6H	311.2	10.7	0.5	596890	34758.
			139.6	12.7	0.6	469810	31115.
			123.7	83	5	600850	48170.
					R_av	544702	47737.
172 Hf	c	1.87Y	1093.6	*********	********	296960	17232.
			1022.4	*********	********	270140	18177.
			912.1	*********	********	316640	18060.
			810.1	*********	********	295680	17452.
			181.5	*********	********	290580	17923.
					R_av	297370	11582.
171 Hf	c	12.1H	739.8	*********	********	128600	83929
170 Hf	c	16.01H	2126.1	*********	********	89608	44082.
			1512.5	*********	********	106680	12574.
			1364.6	*********	********	90521	13193.
			1280.2	*********	********	101710	11319.
			1054.3	*********	********	79673	13582.
			985.1	*********	********	105430	13234.
			620.7	18	5	144840	40544.
			501.6	3.7	1.0	131850	36575.
			164.7	26	8	137280	42590.
			120.2	15	5	143080	48401.
					R_av	100254	5920.
168 Hf	c	25.95M	979.2	26.1	0.7	50153	4996
173 Lu	c	1.37Y	272.1	21.2	0.8	451520	23875
172 Lu-i	i	6.70D	1093.6	63	3	5092	314.
			1022.4	1.41	0.07	2853	802.
			912.1	15.3	0.7	5310	377.
			810.1	16.6	0.8	5306	404.
			181.5	20.6	1.0	4789	351.
					R_av	5055	246.
172 Lu	c	6.70D	1093.6	63	3	302050	17525.
			1022.4	1.41	0.07	273000	18197.
			912.1	15.3	0.7	321950	18339.
			810.1	16.6	0.8	300990	17749.
			181.5	20.6	1.0	295370	18202.
					R_av	299236	12084.
171 Lu-i	i(m+g)	8.24D	739.8	47.8	1.2	76296	89109
171 Lu	c	8.24D	853.0	2.55	0.07	221410	10091.

			839.9	3.04	0.08	214690	9717.
			780.7	4.36	0.11	215830	9544.
			739.8	47.8	1.2	204900	10182.
			689.3	2.37	0.06	213450	9368.
					R_av	214336	7407.
170 Lu-i	i(m+g)	2.012D	2126.1	5.1	0.3	35673	62691.
			1512.5	2.55	0.13	5307	13391.
			1364.6	4.62	0.18	28470	16652.
			1280.2	8.2	0.4	13066	13186.
			1054.3	4.76	0.24	51705	18156.
			985.1	5.5	0.3	18013	15849.
					R_av	20136	6723.
170 Lu	c	2.012D	2126.1	5.1	0.3	125280	21176.
			1512.5	2.55	0.13	111980	7540.
			1364.6	4.62	0.18	118990	7698.
			1280.2	8.2	0.4	114780	7829.
			1054.3	4.76	0.24	131370	9562.
			985.1	5.5	0.3	123440	9180.
					R_av	118996	4932.
169 Lu	c	34.06H	960.6	23.4	0.7	63857	2879.
			889.8	5.36	0.17	62830	3552.
			191.2	20.6	0.6	53171	3744.
					R_av	61727	3411.
169 Yb	c*	32.026D	307.7	10.05	0.19	78629	3097.
			177.2	22.2	0.5	73805	3221.
			130.5	11.31	0.21	73235	3897.
					R_av	76047	2967.
166 Yb	c	56.7H	1176.7	******************		7675	757.
			691.2	8.56	0.58	6007	553.
					R_av	6550	808.
167 Tm	c	9.25D	531.5	1.61	0.22	17844	3268.
			207.8	42	8	17836	3573.
					R_av	17840	2443.
166 Tm-i	i	7.70H	1176.7	9.5	0.6	626.8	4895.0
166 Tm	c	7.70H	1176.7	9.5	0.6	8302	4775
165 Tm	c	30.06H	242.9	35.5	1.7	4259	299
48 V	c	15.9735D	1312.1	97.5	0.9	371.0	22.7
7 Be	i	53.29D	477.6	10.52	0.06	2678.	484.

Table 10.68: Detailed reaction rates for residual nuclide production in ^{nat}W at E_p=249 MeV used to determine their production cross sections.

Nuclide	Type	$T_{1/2}$	E_γ, KeV	Abundance, %		Reaction rate 10^{-20} s^{-1}	
			792.1	37.5	1.1	33442	1533.
					R_av	33337	1285.
184mRe	i(m)	169D	216.6	12.2	0.6	6586	1370
183 Re	i	70.0D	162.3	23.3	0.7	78384	3737
182 Re	i	64.0H	1189.0	9.0	0.6	43640	3527.
			1121.3	22.0	1.4	43353	3445.
			1076.2	10.5	0.7	41644	3322.
			351.1	10.3	1.0	36862	3819.
			256.5	9.5	1.0	45579	5158.
					R_av	42023	2030.
182mRe	i(m)	12.7H	1121.4	31.8	1.6	76591	6276
181 Re	i	19.9H	365.5	56	8	155660	23028.
			331.9	1.3	0.4	193220	61812.
					R_av	160095	21722.
179 Re	i	19.5M	1680.3	13.0	1.1	110440	16251.
			430.2	28.0	1.8	135000	14008.
			415.4	10.6	0.9	158740	17366.
			401.8	7.2	0.6	239150	45460.
					R_av	137934	15971.
178 Re	i	13.2M	237.3	45	5	160260	20268
177 Re	i	14.0M	115.7	******************		233730	125496
176 Re	i	5.3M	240.1	47.7	2.3	114950	10890
178 W	c	21.6D	1496.0	0.27	0.02	557200	53413.
			1402.9	0.48	0.04	554290	50591.

			1350.6	1.18	0.11	530240	52517.
			1340.8	1.03	0.09	539050	50509.
			1183.4	0.17	0.01	486390	47849.
					R_av	532021	27002.
177 W -i	i	135M	115.7	59.6	5.3	220510	129769
177 W	c	135M	115.7	59.6	5.3	454240	50715
176 W	c	2.5H	1861.2	********	*********	774850	85587.
			1823.7	********	*********	699870	70032.
			1696.6	********	*********	706770	89702.
			1252.9	********	*********	313130	134030.
			1159.3	********	*********	675640	57613.
			710.5	********	*********	543410	53571.
					R_av	653254	38877.
174 W	c	31M	206.5	********	*********	499870	47632
184 Ta	c*	8.7H	920.9	32.0	1.6	26924	1982.
			414.0	72	3	30478	1677.
					R_av	29157	1944.
183 Ta	c	5.1D	354.0	11.2	0.7	72382	5180.
			313.3	7.52	0.55	70560	5745.
			246.1	27	4	78874	12074.
			162.3	4.9	0.3	104830	8323.
			107.9	11.0	0.8	72848	6916.
					R_av	76613	6071.
182 Ta	i(m1+m2+g)	114.43D	1231.0	11.44	0.20	94153	3601.
			1221.4	27.0	0.5	93691	3553.
			1189.1	16.2	0.3	99892	3787.
			1121.3	34.9	0.6	94081	3543.
					R_av	95326	3307.
178mTa	i(m)	2.36H	331.6	31.2	0.5	100340	4516.
			325.6	94.1	1.7	109680	4474.
					R_av	105577	5689.
177 Ta	c*	56.56H	745.9	0.21	0.05	905480	263902.
			112.9	7.2	1.6	897240	206066.
					R_av	900347	163561.
176 Ta-i	i	8.09H	1862.7	4.0	0.3	84752	72025.
			1823.7	4.5	0.4	138280	29315.
			1696.6	4.6	0.4	253400	80072.
			1252.9	3.08	0.23	672250	183710.
			1159.3	24.7	1.9	212730	21470.
			710.5	5.4	0.4	294040	45670.
					R_av	206600	23785.
176 Ta	c	8.09H	1862.7	4.0	0.3	859600	73615.
			1823.7	4.5	0.4	838150	80241.
			1696.6	4.6	0.4	960180	91949.
			1252.9	3.08	0.23	985390	93819.
			1159.3	24.7	1.9	888370	74425.
			710.5	5.4	0.4	837450	68680.
					R_av	883277	40832.
175 Ta	c	10.5H	1793.1	4.6	0.7	792740	124100.
			1744.8	1.36	0.19	828740	120297.
			1736.7	0.92	0.14	843020	134205.
			266.9	10.52	0.16	884210	36802.
			125.9	9.0	1.3	1256700	193018.
			104.3	3.1	0.5	663500	115922.
					R_av	874926	39091.
174 Ta-i	i	1.14H	206.5	60	5	230770	25498
174 Ta	c	1.14H	206.5	60	5	730640	67309
173 Ta	c	3.14H	1208.2	2.7	0.4	845550	135005.
			1030.0	1.42	0.23	924850	158054.
			700.6	1.16	0.15	901500	137094.
			180.6	2.22	0.24	811190	104960.
			172.2	17.5	1.8	731710	81126.
			160.4	4.9	0.8	760140	128047.
			139.6	********	*********	753930	67841.
					R_av	783006	42580.
172 Ta	c*	36.8M	1330.4	8.1	0.8	354120	42586.
			1109.3	14.9	1.5	349360	40239.
			1085.6	8.1	0.8	370840	44687.
			214.1	55	5	356980	36812.
					R_av	357142	19529.
181 Hf	c	42.39D	482.2	80.5	0.5	5073	180
180mHf	i(m)	5.5H	332.3	94.1	1.2	5428	730

179mHf	i(m)	25.05D	453.6	68	4	1934	134.
			362.5	39.5	1.5	1540	97.
					R_av	1669	192.
175 Hf	c	70D	433.0	1.44	0.06	932730	50193.
			343.4	84	3	930470	45562.
					R_av	931429	39439.
173 Hf-i	i	23.6H	139.6	12.7	0.6	29880	50278
173 Hf	c	23.6H	311.2	10.7	0.5	992610	58376.
			139.6	12.7	0.6	783810	51920.
			123.7	83	5	1032600	82757.
					R_av	908863	81814.
172 Hf	c	1.87Y	1093.6	*****************		653810	37789.
			1022.4	*****************		607960	38433.
			912.1	*****************		650320	36577.
			810.1	*****************		654590	38126.
			181.5	*****************		648550	39774.
					R_av	645892	21894.
171 Hf	c	12.1H	739.8	*****************		580190	46788
170 Hf	c	16.01H	2126.1	*****************		520420	39699.
			1512.5	*****************		465930	35930.
			1364.6	*****************		461500	32479.
			1280.2	*****************		460100	30779.
			1054.3	*****************		472680	30568.
			985.1	*****************		445960	31213.
			620.7	18	5	640380	179233.
			501.6	3.7	1.0	608500	166106.
			164.7	26	8	585800	181652.
			120.2	15	5	691480	234519.
					R_av	468789	17341.
168 Hf	c	25.95M	1136.8	16.1	2.9	237470	49525.
			983.8	16	4	185130	48588.
			979.2	26.1	0.7	293000	17171.
			896.1	20.1	2.6	204800	27739.
					R_av	265610	25129.
173 Lu	c	1.37Y	272.1	21.2	0.8	796530	42107
172 Lu-i	i	6.70D	1093.6	63	3	21172	1227.
			1022.4	1.41	0.07	23458	2042.
			912.1	15.3	0.7	19166	1100.
			810.1	16.6	0.8	20392	1207.
			181.5	20.6	1.0	20827	1297.
					R_av	20343	806.
172 Lu	c	6.70D	1093.6	63	3	674990	39008.
			1022.4	1.41	0.07	631420	39560.
			912.1	15.3	0.7	669490	37645.
			810.1	16.6	0.8	674980	39307.
			181.5	20.6	1.0	669370	41039.
					R_av	664529	25549.
171 Lu-i	i(m+g)	8.24D	739.8	47.8	1.2	79209	42896
171 Lu	c	8.24D	853.0	2.55	0.07	706270	30150.
			839.9	3.04	0.08	722770	30437.
			780.7	4.36	0.11	688950	28691.
			739.8	47.8	1.2	659390	27387.
			689.3	2.37	0.06	676410	28352.
					R_av	688678	24197.
170 Lu-i	i(m+g)	2.012D	2126.1	5.1	0.3	2405	21470.
			1512.5	2.55	0.13	345.6	29280.0
			1364.6	4.62	0.18	31982	31595.
			1280.2	8.2	0.4	4812	20631.
			1054.3	4.76	0.24	43976	16303.
			985.1	5.5	0.3	110950	19585.
					R_av	39832	18276.
170 Lu	c	2.012D	2126.1	5.1	0.3	522820	37262.
			1512.5	2.55	0.13	466280	29806.
			1364.6	4.62	0.18	493480	27176.
			1280.2	8.2	0.4	464910	28183.
			1054.3	4.76	0.24	516660	31454.
			985.1	5.5	0.3	556910	35851.
					R_av	497413	20724.
169 Lu	c	34.06H	1466.8	3.32	0.11	418660	21273.
			1463.4	1.51	0.05	387820	21948.
			960.6	23.4	0.7	363130	16319.
			889.8	5.36	0.17	334730	16387.
			191.2	20.6	0.6	355650	17618.
					R_av	364740	17346.
167 Lu	c	51.5M	113.3	*****************		226260	18314

169 Yb	c*	32.026D	307.7	10.05	0.19	459590	18063.
			177.2	22.2	0.5	427380	18589.
			130.5	11.31	0.21	427000	22560.
					R_av	442792	17941.
167 Yb-i	i	17.5M	113.3	55	3	3620	6185
167 Yb	c	17.5M	113.3	55	3	229880	18828
166 Yb	c	56.7H	2052.4	*****************		182770	12650.
			1867.9	*****************		175540	12169.
			1374.2	*****************		190730	15235.
			1273.5	*****************		158240	11015.
			1176.7	*****************		163380	11824.
			785.9	*****************		156990	11063.
			691.2	8.56	0.58	154570	11799.
					R_av	166841	7037.
162 Yb	c	18.87M	163.4	40	5	42926	6446
168 Tm	i	93.1D	447.5	23.7	0.8	915.8	99.5
167 Tm	c	9.25D	531.5	1.61	0.22	266070	37763.
			207.8	42	8	258330	50202.
					R_av	263315	30686.
166 Tm-i	i	7.70H	2052.4	17.2	1.0	1830	3331.
			1867.9	4.04	0.24	23683	3736.
			1374.2	5.6	0.4	2063	13970.
			1273.5	14.9	0.9	2243	6700.
			1176.7	9.5	0.6	21997	6638.
			785.9	9.9	0.6	20868	11048.
					R_av	12475	4770.
166 Tm	c	7.70H	2052.4	17.2	1.0	184600	13162.
			1867.9	4.04	0.24	199220	14118.
			1374.2	5.6	0.4	192800	20464.
			1273.5	14.9	0.9	160490	12846.
			1176.7	9.5	0.6	185380	14693.
			785.9	9.9	0.6	177860	16364.
					R_av	182041	8168.
165 Tm	c	30.06H	806.4	9.5	0.6	130970	11117.
			242.9	35.5	1.7	128500	8353.
					R_av	129326	7214.
161 Tm	c	33M	826.6	*****************		15355	8864
161 Er-i	i	3.21H	826.6	64	4	6256	10462
161 Er	c*	3.21H	826.6	64	4	21611	2299
160 Er	c	28.58H	728.2	34	5	16711	2684
157 Dy	c	8.14H	326.2	92	4	3275	416
88 Zr	c	83.4D	1836.1	*****************		254.8	263.9
88 Y -i	i	106.65D	1836.1	99.2	0.3	964.3	102.2
88 Y	c	106.65D	1836.1	99.2	0.3	1219	177
84 Rb	i(m+g)	32.77D	881.6	69.0	1.6	1008	61
74 As	i	17.77D	595.8	59	4	623.0	61.8
59 Fe	c	44.472D	1099.2	56.5	1.9	520.4	33.0
48 V	c	15.9735D	1312.1	97.5	0.9	692.2	29.5
7 Be	i	53.29D	477.6	10.52	0.06	3430	204

Table 10.69: Detailed reaction rates for residual nuclide production in ^{nat}W at E_p=400 MeV used to determine their production cross sections.

Nuclide	Type	$T_{1/2}$	E_γ, KeV	Abundance, %		Reaction rate 10^{-20} s^{-1}	
184 Re	i(m+g)	38.0D	903.3	37.9	1.1	11599	524
183 Re	i	70.0D	291.7	3.05	0.18	29030	2808.
			162.3	23.3	0.7	26597	1640.
					R_av	27134	1509.
182 Re	i	64.0H	1189.0	9.0	0.6	12347	1066.
			1121.3	22.0	1.4	15331	1352.
			1076.2	10.5	0.7	12526	1046.
			351.1	10.3	1.0	14051	1562.
					R_av	13242	797.

182mRe	i(m)	12.7H	1121.4	31.8	1.6	23848	2008
181 Re	i	19.9H	365.5	56	8	52701	7770
178 Re	i	13.2M	237.3	45	5	45695	5580
178 W	c	21.6D	1496.0	0.27	0.02	213660	21679.
			1350.6	1.18	0.11	192180	19149.
			1340.8	1.03	0.09	204250	19612.
			1183.4	0.17	0.01	179480	19162.
					R_av	196433	11175.
177 W	c	135M	115.7	51	5	219320	25339
176 W	c	2.5H	1862.7	******************		248500	41102.
			1823.7	******************		280010	36072.
			1696.6	******************		153210	75760.
			1159.3	******************		240220	22013.
			710.5	******************		160730	23070.
					R_av	227516	19551.
174 W	c	31M	206.5	******************		192000	20419
184 Ta	c*	8.7H	920.9	32.0	1.6	14309	1017.
			414.0	72	3	19567	1090.
					R_av	16969	2682.
183 Ta	c	5.1D	354.0	11.2	0.7	48956	3496.
			313.3	7.52	0.55	46287	3820.
			246.1	27	4	49925	7651.
			162.3	4.9	0.3	62167	8569.
			107.9	11.0	0.8	50695	4853.
					R_av	49248	2490.
182 Ta	i(m1+m2+g)	114.43D	1231.0	11.44	0.20	59214	2359.
			1221.4	27.0	0.5	58228	2232.
			1189.1	16.2	0.3	61519	2409.
			1121.3	34.9	0.6	61146	2343.
					R_av	59960	2036.
178mTa	i(m)	2.36H	331.6	31.2	0.5	59719	2766
177 Ta	c*	56.56H	745.9	0.21	0.05	630690	154860.
			112.9	7.2	1.6	389280	89416.
					R_av	449534	105416.
176 Ta-i	i	8.09H	1862.7	4.0	0.3	130580	46874.
			1823.7	4.5	0.4	63498	30490.
			1696.6	4.6	0.4	271100	99812.
			1159.3	24.7	1.9	123010	14440.
			710.5	5.4	0.4	183450	28085.
					R_av	127754	16245.
176 Ta	c	8.09H	1862.7	4.0	0.3	379080	33546.
			1823.7	4.5	0.4	343500	33714.
			1696.6	4.6	0.4	424310	46718.
			1252.9	3.08	0.23	466100	39591.
			1159.3	24.7	1.9	363240	30550.
			710.5	5.4	0.4	344180	28608.
					R_av	376122	21722.
175 Ta	c	10.5H	1793.1	4.6	0.7	341970	53738.
			1744.8	1.36	0.19	313290	48078.
			1736.7	0.92	0.14	301480	54161.
			266.9	10.52	0.16	363800	15602.
			125.9	9.0	1.3	519900	81006.
					R_av	360965	16685.
174 Ta-i	i	1.14H	206.5	60	5	123350	16276
174 Ta	c	1.14H	206.5	60	5	315360	29366
173 Ta	c	3.14H	1208.2	2.7	0.4	412720	64058.
			1030.0	1.42	0.23	441530	79748.
			700.6	1.16	0.15	404480	56762.
			180.6	2.22	0.24	330150	38641.
			172.2	17.5	1.8	347120	38332.
			160.4	4.9	0.8	371010	62332.
			139.6	******************		301920	70633.
					R_av	359916	21656.
172 Ta	c*	36.8M	1330.4	8.1	0.8	160150	21465.
			1109.3	14.9	1.5	154910	17875.
			1085.6	8.1	0.8	210870	24028.
			214.1	55	5	162480	17205.
					R_av	167872	12398.
180mHf	i(m)	5.5H	332.3	94.1	1.2	2784	370
179mHf	i(m)	25.05D	453.6	68	4	1514	109.

			362.5	39.5	1.5	1081	79.
			315.9	20.2	0.7	1429	144.
					R_av	1260	148.
175 Hf	c	70D	343.4	84	3	407110	19938
173 Hf-i	i	23.6H	139.6	12.7	0.6	48359	78103
173 Hf	c	23.6H	311.2	10.7	0.5	470020	27767.
			139.6	12.7	0.6	350280	25241.
			123.7	83	5	493530	39593.
					R_av	426896	45444.
172 Hf	c	1.87Y	1093.6	*********	********	343810	20004.
			1022.4	*********	********	381360	27867.
			912.1	*********	********	365530	20805.
			810.1	*********	********	356960	20910.
			181.5	*********	********	348270	21788.
					R_av	356110	12352.
171 Hf	c	12.1H	739.8	*********	********	329450	35821
170 Hf	c	16.01H	2126.1	*********	********	329640	41515.
			1512.5	*********	********	293520	36498.
			1364.6	*********	********	306430	19998.
			1280.2	*********	********	289210	19937.
			1054.3	*********	********	325730	48985.
			985.1	*********	********	297210	47907.
			620.7	18	5	420930	117779.
			501.6	3.7	1.0	382810	104533.
			481.3	3.7	1.0	414670	113285.
			164.7	26	8	362310	112725.
			120.2	15	5	450520	152500.
					R_av	303141	12647.
168 Hf	c	25.95M	1136.8	16.1	2.9	228350	43286.
			983.8	16	4	191490	48660.
			979.2	26.1	0.7	230770	12081.
			896.1	20.1	2.6	192190	25988.
					R_av	224815	11188.
173 Lu	c	1.37Y	272.1	21.2	0.8	404250	21390
172 Lu-i	i	6.70D	1093.6	63	3	20938	1233.
			1022.4	1.41	0.07	30729	3416.
			912.1	15.3	0.7	19127	1114.
			810.1	16.6	0.8	19280	1167.
			181.5	20.6	1.0	21595	1373.
					R_av	20120	975.
172 Lu	c	6.70D	1093.6	63	3	364750	21193.
			1022.4	1.41	0.07	412090	28456.
			912.1	15.3	0.7	384660	21838.
			810.1	16.6	0.8	376240	22005.
			181.5	20.6	1.0	369870	23056.
					R_av	378455	14703.
171 Lu-i	i(m+g)	8.24D	739.8	47.8	1.2	64911	35334
171 Lu	c	8.24D	853.0	2.55	0.07	418680	18062.
			839.9	3.04	0.08	429220	18058.
			780.7	4.36	0.11	409420	16977.
			739.8	47.8	1.2	394360	16457.
					R_av	411728	14878.
170 Lu-i	i(m+g)	2.012D	2126.1	5.1	0.3	5309	47940.
			1512.5	2.55	0.13	11154	44921.
			1364.6	4.62	0.18	9771	16433.
			1280.2	8.2	0.4	7741	14222.
			1054.3	4.76	0.24	2513	63500.
			985.1	5.5	0.3	42514	62573.
					R_av	9302	9960.
170 Lu	c	2.012D	2126.1	5.1	0.3	334950	27865.
			1512.5	2.55	0.13	304670	23077.
			1364.6	4.62	0.18	316200	17002.
			1280.2	8.2	0.4	296960	18034.
			1054.3	4.76	0.24	328240	27802.
			985.1	5.5	0.3	339720	29150.
					R_av	314422	12606.
169 Lu	c	34.06H	1466.8	3.32	0.11	276710	15483.
			1463.4	1.51	0.05	263500	13684.
			960.6	23.4	0.7	277910	12366.
			889.8	5.36	0.17	244430	11406.
			191.2	20.6	0.6	286880	13951.
			165.0	1.97	0.05	173020	24907.
					R_av	265091	12814.
167 Lu	c	51.5M	113.3	*********	********	268990	21511

169 Yb	c*	32.026D	307.7	10.05	0.19	368630	14486.
			177.2	22.2	0.5	345050	15018.
			130.5	11.31	0.21	342910	18180.
					R_av	356102	14063.
167 Yb-i	i	17.5M	113.3	55	3	5479	2546
167 Yb	c	17.5M	113.3	55	3	274470	21897
166 Yb	c	56.7H	2079.5	*****************		239720	17898.
			2052.4	*****************		249670	17224.
			1867.9	*****************		236010	16479.
			1374.2	*****************		237650	19398.
			1273.5	*****************		220810	15281.
			1176.7	*****************		216800	15664.
			785.9	*****************		212350	14702.
			691.2	8.56	0.58	210570	16193.
					R_av	226458	8770.
162 Yb	c	18.87M	798.7	*****************		58437	5766.
			163.4	40	5	119720	15998.
			118.7	34	4	103360	13803.
			102.0	*****************		59361	6864.
					R_av	64233	9528.
168 Tm	i	93.1D	447.5	23.7	0.8	1511	168
167 Tm	c	9.25D	531.5	1.61	0.22	275740	38880.
			207.8	42	8	290440	56447.
					R_av	280393	32545.
166 Tm-i	i	7.70H	2079.5	6.3	0.4	521.1	6562.0
			2052.4	17.2	1.0	446.6	3073.0
			1867.9	4.04	0.24	12186	4809.
			1374.2	5.6	0.4	47602	24202.
			1273.5	14.9	0.9	582.1	5415.0
			1176.7	9.5	0.6	19523	7045.
			785.9	9.9	0.6	18681	5370.
					R_av	6704	3469.
166 Tm	c	7.70H	2079.5	6.3	0.4	240240	18954.
			2052.4	17.2	1.0	250120	17509.
			1867.9	4.04	0.24	248190	17793.
			1374.2	5.6	0.4	285250	32709.
			1273.5	14.9	0.9	221390	16185.
			1176.7	9.5	0.6	236330	18281.
			785.9	9.9	0.6	231030	16760.
					R_av	239213	9799.
165 Tm	c	30.06H	806.4	9.5	0.6	199510	14339.
			356.5	2.75	0.15	191190	13926.
			242.9	35.5	1.7	213950	13573.
					R_av	202123	9550.
163 Tm	c*	1.810H	1434.4	8.0	0.3	201930	12497.
			1397.5	7.03	0.24	195830	11293.
			1374.3	4.28	0.16	227190	40094.
			104.3	18.6	0.7	140300	11918.
					R_av	182502	16682.
162 Tm-i	i(m+g)	21.70M	798.7	8.4	0.7	158780	14703.
			102.0	17.5	1.5	43833	6851.
					R_av	83851	54821.
162 Tm	c	21.70M	798.7	8.4	0.7	217220	19567.
			102.0	17.5	1.5	103190	11254.
					R_av	132451	49975.
161 Tm	c	33M	1648.1	20	3	88547	14702
161 Er	c*	3.21H	826.6	64	4	134230	9573
160 Er	c	28.58H	966.2	*****************		102750	13818.
			962.4	*****************		94767	12439.
			879.4	*****************		99525	12822.
			872.0	6.8	1.1	77827	13001.
			728.2	*****************		95729	14145.
					R_av	94150	6157.
159 Er	c*	36M	649.1	23	3	72185	11152.
			624.5	33	4	76259	9791.
					R_av	74505	7535.
157 Er	c*	18.65M	391.3	14.2	1.4	52257	6805
160mHo-i	i(m)	5.02H	966.2	15.4	2.0	8510	2351.
			962.4	16.6	2.1	4042	3459.
			879.4	18.6	2.3	15471	4680.
			728.2	28	4	7574	4057.
					R_av	8238	1886.

160mHo	c	5.02H	966.2	15.4	2.0	111260	15035.
			962.4	16.6	2.1	98809	13353.
			879.4	18.6	2.3	114990	15294.
			728.2	28	4	103300	15620.
					R_av	106572	7913.
157 Dy	c	8.14H	326.2	92	4	47010	2912
155 Dy	c*	9.9H	226.9	68.4	1.6	28286	1407
152 Dy	c	2.38H	256.9	97.50	0.07	6051	284
155 Tb	c*	5.32D	340.7	1.18	0.07	29197	2782.
			163.3	4.44	0.24	46542	4587.
					R_av	33837	7750.
153 Tb	c*	2.34D	212.0	31.0	1.9	11171	847.
			102.2	6.4	0.5	14546	1612.
					R_av	11816	1378.
149 Gd	c	9.28D	346.6	23.9	1.3	6240	423.
			298.6	28.6	1.7	5268	412.
			149.7	48	3	5270	489.
					R_av	5635	377.
147 Gd	c	38.06H	370.0	17.2	0.9	11487	898
146 Gd	c	48.27D	747.2	*********	*********	2344	113.
			154.6	46.6	0.5	2201	310.
					R_av	2333	110.
147 Eu	c*	24.1D	677.5	9.8	0.5	3574	316
146 Eu-i	i	4.61D	747.2	99	3	235.2	63.0
146 Eu	c	4.61D	747.2	99	3	2579	129
145 Eu	c	5.93D	893.7	66	5	1749	236
89 Zr	c	78.41H	909.2	99.04	0.03	467.0	39.3
88 Zr	c	83.4D	1836.1	*********	*********	1368	502.
			898.0	*********	*********	622.9	27.4
			392.9	97.24	0.00	387.7	30.1
					R_av	501.0	15.7
88 Y -i	i	106.65D	1836.1	99.2	0.3	759.0	201.3
			898.0	93.7	0.3	688.0	201.1
					R_av	723.5	143.1
88 Y	c	106.65D	1836.1	99.2	0.3	2128	504.
			898.0	93.7	0.3	1311	502.
					R_av	1720	412.
87 Y	c	79.8H	484.8	89.7	0.7	864.6	81.0
84 Rb	i(m+g)	32.77D	881.6	69.0	1.6	1121	62
83 Rb	c	86.2D	520.4	45	4	1197	146
74 As	i	17.77D	595.8	59	4	813.5	88.1
59 Fe	c	44.472D	1291.6	43.2	1.4	451.4	49.0
			1099.2	56.5	1.9	540.2	38.6
					R_av	508.7	45.3
48 V	c	15.9735D	1312.1	97.5	0.9	522.4	31.8
7 Be	i	53.29D	477.6	10.52	0.06	3130	467

Table 10.70: Detailed reaction rates for residual nuclide production in ^{nat}W at E_p=600 MeV used to determine their production cross sections.

Nuclide	Type	$T_{1/2}$	E_γ, KeV	Abundance, %		Reaction rate 10^{-20} s^{-1}	
184 Re	i(m+g)	38.0D	903.3	37.9	1.1	11006	534
183 Re	i	70.0D	291.7	3.05	0.18	19488	1788.
			162.3	23.3	0.7	23307	1682.
			162.3	23.3	0.7	21488	1121.
					R_av	21529	1074.
182 Re	i	64.0H	1189.0	9.0	0.6	11259	1359.
			1121.3	22.0	1.4	16664	1496.
			1076.2	10.5	0.7	5103	1093.
					R_av	9964	3378.
182mRe	i(m)	12.7H	1121.4	31.8	1.6	21284	1958

181 Re	i	19.9H	365.5	56	8	48804	7201
178 Re	i	13.2M	237.3	45	5	29855	4122
178 W	c	21.6D	1496.0	0.27	0.02	188380	19334.
			1350.6	1.18	0.11	186140	18627.
			1340.8	1.03	0.09	191750	18450.
					R_av	188797	11788.
177 W	c	135M	115.7	51	5	185460	21309
176 W	c	2.5H	1862.7	********	*********	243360	51678.
			1823.7	********	*********	176080	60561.
			1696.6	********	*********	155970	61010.
			1159.3	********	*********	190240	22602.
			710.5	********	*********	177810	29408.
					R_av	188723	14067.
174 W	c	31M	206.5	********	*********	177740	20631
184 Ta	c*	8.7H	920.9	32.0	1.6	24756	1960.
			414.0	72	3	29369	1615.
					R_av	27744	2368.
183 Ta	c	5.1D	354.0	11.2	0.7	71541	5106.
			313.3	7.52	0.55	65435	5413.
			246.1	27	4	74402	11391.
			162.3	4.9	0.3	79479	6535.
			107.9	11.0	0.8	70487	6713.
					R_av	71344	3427.
182 Ta	i(m1+m2+g)	114.43D	1231.0	11.44	0.20	78987	3391.
			1221.4	27.0	0.5	81035	3123.
			1189.1	16.2	0.3	83341	3307.
			1121.3	34.9	0.6	84287	3186.
					R_av	82181	2806.
178mTa	i(m)	2.36H	331.6	31.2	0.5	59300	4307
177 Ta	c*	56.56H	112.9	7.2	1.6	341460	78412
176 Ta-i	i	8.09H	1862.7	4.0	0.3	123390	61891.
			1823.7	4.5	0.4	191070	78652.
			1696.6	4.6	0.4	260110	81893.
			1159.3	24.7	1.9	169600	24612.
			710.5	5.4	0.4	151370	35561.
					R_av	166847	16893.
176 Ta	c	8.09H	1862.7	4.0	0.3	366760	34047.
			1823.7	4.5	0.4	367150	40352.
			1696.6	4.6	0.4	416080	44007.
			1159.3	24.7	1.9	359830	30654.
			710.5	5.4	0.4	329190	28168.
					R_av	359605	18185.
175 Ta	c	10.5H	1793.1	4.6	0.7	325540	51318.
			1744.8	1.36	0.19	248170	39901.
			1736.7	0.92	0.14	281920	55755.
			266.9	10.52	0.16	353280	14961.
			125.9	9.0	1.3	505450	77674.
					R_av	346538	19479.
174 Ta-i	i	1.14H	206.5	60	5	111370	19597
174 Ta	c	1.14H	206.5	60	5	289110	27295
173 Ta	c	3.14H	1208.2	2.7	0.4	373200	60112.
			1030.0	1.42	0.23	418340	74219.
			700.6	1.16	0.15	289130	50629.
			172.2	17.5	1.8	315550	34975.
			160.4	4.9	0.8	351990	60154.
			139.6	********	*********	387560	47117.
					R_av	343028	21853.
172 Ta	c*	36.8M	1330.4	8.1	0.8	158280	22595.
			1109.3	14.9	1.5	189630	22937.
			1085.6	8.1	0.8	169040	24364.
			214.1	55	5	146700	17144.
					R_av	162295	10838.
181 Hf	c	42.39D	482.2	80.5	0.5	7093	263
180mHf	i(m)	5.5H	332.3	94.1	1.2	5836	799
179mHf	i(m)	25.05D	453.6	68	4	2106	150.
			362.5	39.5	1.5	1650	131.
			315.9	20.2	0.7	2106	159.
					R_av	1922	169.
175 Hf	c	70D	343.4	84	3	406890	19927

173 Hf-i	i	23.6H	139.6	12.7	0.6	30532	43710
173 Hf	c	23.6H	311.2	10.7	0.5	482910	28351.
			139.6	12.7	0.6	418090	28033.
			123.7	83	5	507480	40862.
					R_av	462241	28585.
172 Hf	c	1.87Y	1093.6	*****************		350150	20316.
			1022.4	*****************		332190	33115.
			912.1	*****************		375610	22021.
			810.1	*****************		379180	22930.
			181.5	*****************		348490	21494.
					R_av	361180	13482.
171 Hf	c	12.1H	739.8	*****************		373920	30824
170 Hf	c	16.01H	2126.1	*****************		387630	30033.
			1512.5	*****************		299780	34377.
			1455.2	*****************		387130	102262.
			1364.6	*****************		360710	27287.
			1280.2	*****************		329590	30762.
			1054.3	*****************		380980	28979.
			985.1	*****************		408780	33254.
			620.7	18	5	470060	131558.
			501.6	3.7	1.0	427140	116507.
			481.3	3.7	1.0	491990	134313.
			164.7	26	8	444810	137947.
			120.2	15	5	446920	151096.
					R_av	368504	15595.
168 Hf	c	25.95M	1136.8	16.1	2.9	267310	50086.
			983.8	16	4	272300	69025.
			979.2	26.1	0.7	270660	14045.
			896.1	20.1	2.6	296120	41014.
					R_av	272282	13455.
173 Lu	c	1.37Y	272.1	21.2	0.8	422440	22606
172 Lu-i	i	6.70D	1093.6	63	3	33059	1917.
			1022.4	1.41	0.07	35471	3640.
			912.1	15.3	0.7	28928	1719.
			810.1	16.6	0.8	31807	1986.
			181.5	20.6	1.0	32789	2037.
					R_av	31540	1359.
172 Lu	c	6.70D	1093.6	63	3	383210	22216.
			1022.4	1.41	0.07	367670	33215.
			912.1	15.3	0.7	404540	23523.
			810.1	16.6	0.8	410990	24629.
			181.5	20.6	1.0	381270	23475.
					R_av	391864	15482.
171 Lu-i	i(m+g)	8.24D	739.8	47.8	1.2	62001	28431
171 Lu	c	8.24D	853.0	2.55	0.07	463430	20031.
			839.9	3.04	0.08	474050	19949.
			780.7	4.36	0.11	466590	19398.
			739.8	47.8	1.2	435920	18125.
					R_av	458681	16770.
170 Lu-i	i(m+g)	2.012D	2126.1	5.1	0.3	16273	17037.
			1512.5	2.55	0.13	58631	39489.
			1455.2	1.18	0.06	16486	135501.
			1364.6	4.62	0.18	7263	26851.
			1280.2	8.2	0.4	6934	32761.
			1054.3	4.76	0.24	7257	24741.
			985.1	5.5	0.3	278.9	28690.0
					R_av	13264	10366.
170 Lu	c	2.012D	2126.1	5.1	0.3	403900	28839.
			1512.5	2.55	0.13	358410	24775.
			1455.2	1.18	0.06	403620	46736.
			1364.6	4.62	0.18	367970	20480.
			1280.2	8.2	0.4	336520	22430.
			1054.3	4.76	0.24	388240	24540.
			985.1	5.5	0.3	409060	27446.
					R_av	374102	15430.
169 Lu	c	34.06H	1466.8	3.32	0.11	373510	18595.
			1463.4	1.51	0.05	329580	17042.
			960.6	23.4	0.7	332960	14829.
			889.8	5.36	0.17	316960	14669.
			191.2	20.6	0.6	349830	16840.
			165.0	1.97	0.05	264490	18516.
					R_av	330808	15657.
167 Lu	c	51.5M	113.3	*****************		355590	29198
169 Yb	c*	32.026D	307.5	0.3	0.3	15203000	.15216837.
			177.2	22.2	0.5	418170	18218.
			130.5	11.31	0.21	423920	22384.

					R_av	420081	16735.
167 Yb-i	i	17.5M	113.3	55	3	770.2	14720.0
167 Yb	c	17.5M	113.3	55	3	356360	30430
166 Yb	c	56.7H	2092.1******************			365880	27634.
			2079.5******************			375890	27827.
			2052.4******************			377230	26038.
			1867.9******************			366450	25330.
			1374.2******************			360200	28526.
			1273.5******************			346340	24095.
			1176.7******************			342080	24639.
			785.9******************			344850	23851.
			691.2	8.56	0.58	322380	24491.
					R_av	355000	12539.
162 Yb	c	18.87M	798.7******************			219410	31525.
			163.4	40	5	234760	31381.
			118.7	34	4	221320	29098.
			102.0******************			129820	18788.
					R_av	181714	28114.
168 Tm	i	93.1D	447.5	23.7	0.8	3527	226
167 Tm	c	9.25D	531.5	1.61	0.22	431870	60924.
			207.8	42	8	405100	78734.
					R_av	421995	49004.
166 Tm-i	i	7.70H	2092.1	1.56	0.09	5013	24340.
			2079.5	6.3	0.4	789.2	4966.1
			2052.4	17.2	1.0	2677	3411.
			1867.9	4.04	0.24	30684	4501.
			1374.2	5.6	0.4	18377	9389.
			1273.5	14.9	0.9	24053	7305.
			1176.7	9.5	0.6	33561	8222.
			785.9	9.9	0.6	24313	7354.
					R_av	14892	5049.
166 Tm	c	7.70H	2092.1	1.56	0.09	370890	34787.
			2079.5	6.3	0.4	376680	28212.
			2052.4	17.2	1.0	379900	26397.
			1867.9	4.04	0.24	397140	27640.
			1374.2	5.6	0.4	378570	31182.
			1273.5	14.9	0.9	370400	26557.
			1176.7	9.5	0.6	375640	27971.
			785.9	9.9	0.6	369170	26405.
					R_av	377527	14877.
165 Tm	c	30.06H	806.4	9.5	0.6	364580	26320.
			356.5	2.75	0.15	346580	23290.
			242.9	35.5	1.7	361670	22394.
					R_av	357213	16478.
163 Tm	c*	1.810H	1434.4	8.0	0.3	375760	22334.
			1397.5	7.03	0.24	314930	17643.
			1374.3	4.28	0.16	365870	32349.
			104.3	18.6	0.7	257470	19734.
					R_av	318997	27599.
162 Tm-i	i(m+g)	21.70M	798.7	8.4	0.7	128930	39122.
			102.0	17.5	1.5	172220	30471.
					R_av	157307	22746.
162 Tm	c	21.70M	798.7	8.4	0.7	348340	35885.
			102.0	17.5	1.5	302040	34636.
					R_av	324594	25932.
161 Tm	c	33M	1648.1	20	3	193150	31016
161 Er	c*	3.21H	826.6	64	4	329330	23516
160 Er	c	28.58H	966.2******************			271440	36432.
			962.4******************			272370	35698.
			879.4******************			274240	35253.
			872.0	6.8	1.1	238960	39585.
			728.2******************			283650	41668.
					R_av	268737	17484.
159 Er	c*	36M	649.1	23	3	252390	34482.
			624.5	33	4	252510	32291.
					R_av	252454	24218.
157 Er	c*	18.65M	391.3	14.2	1.4	187920	22053
156 Er	c	19.5M	266.5******************			154120	18246.
			137.8******************			125840	13288.
					R_av	135482	14058.
160mHo-i	i(m)	5.02H	966.2	15.4	2.0	5290	3910.
			962.4	16.6	2.1	19067	4964.

			879.4	18.6	2.3	7193	5723.
			728.2	28	4	12698	3273.
					R_av	11072	2838.
160mHo	c	5.02H	966.2	15.4	2.0	276730	37266.
			962.4	16.6	2.1	291440	38311.
			879.4	18.6	2.3	281430	36442.
			728.2	28	4	296350	43547.
					R_av	285625	20793.
160 Ho	i(m+g)	25.6M	728.2	46.9	1.7	25879	3537
156 Ho-i	i	56M	266.5	54.7	1.1	5129	19131.
			137.8	51.1	0.8	1331	14370.
					R_av	2701	11490.
156 Ho	c	56M	266.5	54.7	1.1	159250	8792.
			137.8	51.1	0.8	127170	7189.
					R_av	140189	16351.
157 Dy	c	8.14H	326.2	92	4	193010	11015
155 Dy	c*	9.9H	226.9	68.4	1.6	146380	6816
152 Dy	c	2.38H	344.3	99.9	0.0	50074	8800.
			256.9	97.50	0.07	58298	2411.
					R_av	58033	1813.
155 Tb	c*	5.32D	340.7	1.18	0.07	130420	9249.
			180.1	7.5	0.5	134430	10346.
			163.3	4.44	0.24	144810	9536.
					R_av	136665	6581.
153 Tb	c*	2.34D	212.0	31.0	1.9	94502	6877.
			102.2	6.4	0.5	94118	9554.
					R_av	94384	5743.
152 Tb-i	i(m+g)	17.5H	344.3	65	4	11844	8303
152 Tb	c	17.5H	344.3	65	4	61868	4559
151 Tb	c	17.609H	616.6	10.4	0.5	49381	3556.
			604.8	3.28	0.15	54062	5179.
			479.4	15.4	0.7	62103	3959.
			287.4	28.3	1.2	57600	3408.
			251.9	26.3	1.2	59499	3853.
			108.1	24.3	1.1	53799	4803.
					R_av	49898	1817.
150 Tb	c	3.48H	638.0	72	10	29548	4294.
			496.2	14.6	2.0	26765	4218.
					R_av	28137	3072.
149 Tb	c	4.118H	352.2	29.4	0.9	19332	1551
148 Tb	c	60M	784.4	84.0	1.6	25921	1647
151 Gd	c	124D	243.3	5.6	0.4	82448	7361
149 Gd	c	9.28D	788.9	7.3	0.4	64974	4163.
			534.3	3.07	0.17	82928	6210.
			346.6	23.9	1.3	60459	3936.
			298.6	28.6	1.7	58302	4050.
			277.1*****************			59625	12281.
			272.3	3.21	0.19	50675	4254.
			149.7	48	3	62092	4662.
					R_av	61322	3704.
147 Gd	c	38.06H	929.0	20.2	1.2	34679	2726.
			370.0	17.2	0.9	52213	3421.
			229.3	63	4	54561	4138.
					R_av	45428	6551.
146 Gd	c	48.27D	747.2*****************			36222	1629.
			154.6	46.6	0.5	37214	1447.
					R_av	36866	1345.
149 Eu-i	i	93.1D	277.1	3.56	0.06	747.8	12110.0
149 Eu	c	93.1D	327.5	4.03	0.12	54131	5133.
			277.1	3.56	0.06	60373	2699.
					R_av	59518	2840.
148 Eu	i	54.5D	630.0	71.9	2.3	1985	109.
			550.3	99	3	1609	136.
					R_av	1861	186.
147 Eu	c*	24.1D	955.8	3.84	0.20	42291	2763.
			798.7	4.8	0.3	62706	4601.
			677.5	9.8	0.5	46191	2910.
			121.2	22.9	1.3	40447	3173.

					R_av	45420	4070.
146 Eu-i	i	4.61D	747.2	99	3	4268	301
146 Eu	c	4.61D	747.2	99	3	40490	1821
145 Eu	c	5.93D	1997.0	7.2	0.5	26184	2250.
			1804.3	1.07	0.07	24232	3215.
			1658.5	14.9	1.0	22329	1711.
			893.7	66	5	23302	1948.
			653.5	15	1	23806	1873.
					R_av	23680	1127.
136 Nd	c	50.65M	552.2	99	7	6995	812
139 Ce	c	137.640D	165.9	79.89	0.01	4390	191
134 Ce	c	3.16D	604.7	5.04	0.20	6840	1255
105 Ag	c	41.29D	443.4	10.5	0.6	1683	309
96 Tc	i(m+g)	4.28D	849.9	98	4	870.5	57.6
			812.5	82	4	976.1	79.8
					R_av	904.4	56.9
89 Zr	c	78.41H	909.2	99.04	0.03	1409	144
88 Zr	c	83.4D	1836.1******************			2984	104.
			898.0******************			2133	164.
			392.9	97.24	0.00	1203	80.
			392.9	97.24	0.00	1178	57.
					R_av	1226	38.
88 Y -i	i	106.65D	1836.1	99.2	0.3	1735	60.
			898.0	93.7	0.3	1928	78.
					R_av	1777	97.
88 Y	c	106.65D	1836.1	99.2	0.3	4718	164.
			898.0	93.7	0.3	4061	170.
					R_av	4531	329.
87 Y	c	79.8H	484.8	89.7	0.7	2139	157
85 Sr	c	64.84D	514.0	96	4	3857	264
84 Rb	i(m+g)	32.77D	881.6	69.0	1.6	1963	201
83 Rb	c	86.2D	520.4	45	4	3143	316
75 Se	c	119.779D	136.0	58.3	0.8	1875	134
74 As	i	17.77D	595.8	59	4	1852	149
59 Fe	c	44.472D	1291.6	43.2	1.4	1201	76.
			1099.2	56.5	1.9	1296	86.
					R_av	1242	63.
48 V	c	15.9735D	1312.1	97.5	0.9	685.8	47.4
7 Be	i	53.29D	477.6	10.52	0.06	6235	391.

Table 10.71: Detailed reaction rates for residual nuclide production in ^{nat}W at E_p=799 MeV used to determine their production cross sections.

Nuclide	Type	$T_{1/2}$	E_γ, KeV	Abundance, %		Reaction rate 10^{-20} s^{-1}	
184 Re	i(m+g)	38.0D	903.3	37.9	1.1	9855	454.
			792.1	37.5	1.1	10439	474.
					R_av	10139	431.
183 Re	i	70.0D	291.7	3.05	0.18	19721	2196.
			162.3	23.3	0.7	20696	1100.
			162.3	23.3	0.7	20487	991.
					R_av	20515	849.
182 Re	i	64.0H	1189.0	9.0	0.6	8969	1367.
			1121.3	22.0	1.4	15917	1364.
					R_av	12622	3492.
182mRe	i(m)	12.7H	1121.4	31.8	1.6	17621	2107
181 Re	i	19.9H	365.5	56	8	41161	6082
178 W	c	21.6D	1496.0	0.27	0.02	139960	17191.
			1350.6	1.18	0.11	165470	16848.
			1340.8	1.03	0.09	157010	15627.
					R_av	154648	10248.
177 W	c	135M	115.7	51	5	160450	18459

176 W	c	2.5H	1159.3	*****************		173100	22682.
			710.5	*****************		126400	47482.
					R_av	167039	17505.
174 W	c	31M	206.5	*****************		119730	17610
184 Ta	c*	8.7H	920.9	32.0	1.6	27932	2193.
			414.0	72	3	32412	1840.
					R_av	30762	2365.
183 Ta	c	5.1D	354.0	11.2	0.7	81351	5788.
			313.3	7.52	0.55	70743	5770.
			246.1	27	4	83885	12849.
			162.3	4.9	0.3	86403	6456.
			107.9	11.0	0.8	77056	7348.
					R_av	79016	3837.
182 Ta	i(m1+m2+g)	114.43D	1231.0	11.44	0.20	88627	3607.
			1221.4	27.0	0.5	88922	3464.
			1189.1	16.2	0.3	92497	3641.
			1121.3	34.9	0.6	95066	3541.
					R_av	91526	3269.
178mTa	i(m)	2.36H	331.6	31.2	0.5	56249	2826
177 Ta	c*	56.56H	112.9	7.2	1.6	324080	74537
176 Ta-i	i	8.09H	1862.7	4.0	0.3	161320	29806.
			1159.3	24.7	1.9	132790	22082.
			710.5	5.4	0.4	161470	60783.
					R_av	143771	15816.
176 Ta	c	8.09H	1862.7	4.0	0.3	310770	26635.
			1159.3	24.7	1.9	305890	26500.
			710.5	5.4	0.4	287870	28348.
					R_av	302231	17447.
175 Ta	c	10.5H	1793.1	4.6	0.7	250800	40200.
			266.9	10.52	0.16	270100	14863.
			125.9	9.0	1.3	403310	62551.
					R_av	271415	14568.
174 Ta-i	i	1.14H	206.5	60	5	122190	22787
174 Ta	c	1.14H	206.5	60	5	241930	23451
173 Ta	c	3.14H	1208.2	2.7	0.4	345340	55545.
			172.2	17.5	1.8	259330	28964.
			160.4	4.9	0.8	335730	57194.
			139.6	*****************		324070	39214.
					R_av	295605	23186.
172 Ta	c*	36.8M	1330.4	8.1	0.8	150780	21540.
			1109.3	14.9	1.5	133220	17707.
			1085.6	8.1	0.8	109520	15268.
			214.1	55	5	123820	13165.
					R_av	125375	8177.
180mHf	i(m)	5.5H	332.3	94.1	1.2	5713	482
179mHf	i(m)	25.05D	453.6	68	4	2254	172.
			362.5	39.5	1.5	2332	147.
			315.9	20.2	0.7	1950	137.
					R_av	2162	140.
175 Hf	c	70D	343.4	84	3	358150	17537
173 Hf-i	i	23.6H	139.6	12.7	0.6	3355	35750
173 Hf	c	23.6H	311.2	10.7	0.5	400750	25343.
			139.6	12.7	0.6	327430	22255.
			123.7	83	5	428510	34671.
					R_av	371814	31431.
172 Hf	c	1.87Y	1093.6	*****************		300740	17436.
			1022.4	*****************		331370	32117.
			912.1	*****************		318050	164577.
			810.1	*****************		338260	19979.
			181.5	*****************		287690	17662.
					R_av	308384	13976.
171 Hf	c	12.1H	739.8	*****************		282970	30639
170 Hf	c	16.01H	2126.1	*****************		324070	29602.
			1512.5	*****************		226940	53773.
			1364.6	*****************		269380	23879.
			1280.2	*****************		270340	21842.
			985.1	*****************		348370	29887.
			620.7	18	5	411810	116059.
			501.6	3.7	1.0	362100	99336.

			481.3	3.7	1.0	390440	108932.
			164.7	26	8	367650	114134.
			120.2	15	5	368470	124492.
					R_av	294846	15727.
168 Hf	c	25.95M	1136.8	16.1	2.9	243910	45334.
			983.8	16	4	229110	58108.
			979.2	26.1	0.7	223520	11207.
			896.1	20.1	2.6	235680	32635.
					R_av	225136	10818.
173 Lu	c	1.37Y	272.1	21.2	0.8	367280	19518
172 Lu-i	i	6.70D	1093.6	63	3	33583	1950.
			1022.4	1.41	0.07	41552	4251.
			912.1	15.3	0.7	30659	2169.
			810.1	16.6	0.8	34908	2118.
			181.5	20.6	1.0	34828	2171.
					R_av	33940	1408.
172 Lu	c	6.70D	1093.6	63	3	334330	19361.
			1022.4	1.41	0.07	372920	32788.
			912.1	15.3	0.7	348710	166030.
			810.1	16.6	0.8	373170	21958.
			181.5	20.6	1.0	322520	19796.
					R_av	344432	15292.
171 Lu-i	i(m+g)	8.24D	739.8	47.8	1.2	96545	30408
171 Lu	c	8.24D	853.0	2.55	0.07	407490	17693.
			839.9	3.04	0.08	409070	17617.
			780.7	4.36	0.11	402250	16808.
			739.8	47.8	1.2	379510	15796.
					R_av	398083	14351.
170 Lu-i	i(m+g)	2.012D	2126.1	5.1	0.3	20867	26567.
			1512.5	2.55	0.13	125980	72359.
			1364.6	4.62	0.18	56480	27802.
			1280.2	8.2	0.4	12017	20813.
			985.1	5.5	0.3	827.3	28570.0
					R_av	24242	13053.
170 Lu	c	2.012D	2126.1	5.1	0.3	344940	25696.
			1512.5	2.55	0.13	352920	31446.
			1364.6	4.62	0.18	325860	18887.
			1280.2	8.2	0.4	282360	18016.
			985.1	5.5	0.3	349200	23988.
					R_av	321394	17104.
169 Lu	c	34.06H	1466.8	3.32	0.11	291780	19103.
			1463.4	1.51	0.05	280860	22433.
			960.6	23.4	0.7	289320	12955.
			889.8	5.36	0.17	266010	14361.
			191.2	20.6	0.6	317650	15261.
			165.0	1.97	0.05	313550	25610.
					R_av	291752	12082.
167 Lu	c	51.5M	113.3	**********	*******	311880	25146
169 Yb	c*	32.026D	307.7	10.05	0.19	407270	15987.
			177.2	22.2	0.5	369560	16177.
			130.5	11.31	0.21	370680	19625.
					R_av	387691	17904.
167 Yb-i	i	17.5M	113.3	55	3	18577	5850
167 Yb	c	17.5M	113.3	55	3	330460	26597
166 Yb	c	56.7H	2079.5	**********	*******	346520	25624.
			2052.4	**********	*******	357950	24706.
			1867.9	**********	*******	339590	23774.
			1374.2	**********	*******	333230	26452.
			1273.5	**********	*******	317150	21886.
			1176.7	**********	*******	322150	23308.
			1152.3	**********	*******	327240	25977.
			785.9	**********	*******	322600	22399.
			691.2	8.56	0.58	309350	23758.
			594.4	**********	*******	302720	21656.
					R_av	327069	11624.
162 Yb	c	18.87M	798.7	**********	*******	232950	30171.
			163.4	40	5	259400	34616.
			118.7	34	4	208110	27683.
			102.0	**********	*******	138300	18160.
					R_av	185429	28306.
168 Tm	i	93.1D	720.4	12.0	0.4	5335	417.
			447.5	23.7	0.8	5158	342.
					R_av	5226	288.
167 Tm	c	9.25D	531.5	1.61	0.22	391140	55299.

			207.8	42	8	374940	72863.
					R_av	385309	44795.
166 Tm-i	i	7.70H	2079.5	6.3	0.4	7302	5845.
			2052.4	17.2	1.0	4895	2977.
			1867.9	4.04	0.24	11782	7525.
			1374.2	5.6	0.4	7071	10862.
			1273.5	14.9	0.9	12950	4644.
			1176.7	9.5	0.6	38113	16560.
			1152.3	1.55	0.10	12729	44082.
			785.9	9.9	0.6	315.5	7554.0
			594.4	3.46	0.20	22096	47615.
					R_av	7614	2056.
166 Tm	c	7.70H	2079.5	6.3	0.4	353820	26691.
			2052.4	17.2	1.0	362840	25184.
			1867.9	4.04	0.24	351370	25455.
			1374.2	5.6	0.4	340300	28940.
			1273.5	14.9	0.9	330100	23218.
			1176.7	9.5	0.6	360260	30368.
			1152.3	1.55	0.10	339970	50295.
			785.9	9.9	0.6	322920	23527.
			594.4	3.46	0.20	324820	52522.
					R_av	343668	13757.
165 Tm	c	30.06H	806.4	9.5	0.6	336990	24375.
			356.5	2.75	0.15	336010	31383.
			242.9	35.5	1.7	356050	22024.
					R_av	345624	16847.
163 Tm	c*	1.810H	1434.4	8.0	0.3	364660	21579.
			1397.5	7.03	0.24	319980	18977.
			1374.3	4.28	0.16	419800	30365.
					R_av	352617	27711.
162 Tm-i	i(m+g)	21.70M	798.7	8.4	0.7	131860	38752.
			102.0	17.5	1.5	168260	25348.
					R_av	159039	19467.
162 Tm	c	21.70M	798.7	8.4	0.7	364810	38249.
			102.0	17.5	1.5	306570	33853.
					R_av	332290	30728.
161 Tm	c	33M	1648.1	20	3	248580	39039
161 Er	c*	3.21H	826.6	64	4	378920	27901
160 Er	c	28.58H	966.2******************			316910	42546.
			962.4******************			310200	40572.
			879.4******************			323760	41551.
			872.0	6.8	1.1	276140	45943.
			728.2******************			337520	49849.
					R_av	313015	20383.
159 Er	c*	36M	649.1	23	3	308500	42500.
			624.5	33	4	294890	38685.
					R_av	301038	29367.
157 Er	c*	18.65M	391.3	14.2	1.4	252040	28260
156 Er	c	19.5M	266.5******************			210570	12876.
			137.8******************			203270	24598.
					R_av	209347	11650.
160mHo-i	i(m)	5.02H	966.2	15.4	2.0	9370	9295.
			962.4	16.6	2.1	10898	4295.
			879.4	18.6	2.3	4600	7588.
			728.2	28	4	22280	6674.
					R_av	12176	3341.
160mHo	c	5.02H	966.2	15.4	2.0	326280	44500.
			962.4	16.6	2.1	321090	42126.
			879.4	18.6	2.3	328360	42595.
			728.2	28	4	359800	53197.
					R_av	331322	24222.
160 Ho	i(m+g)	25.6M	728.2	46.9	1.7	33824	5984
156 Ho-i	i	56M	266.5	54.7	1.1	10635	10005.
			137.8	51.1	0.8	287.6	28320.0
					R_av	9488	9433.
156 Ho	c	56M	266.5	54.7	1.1	221200	9778.
			137.8	51.1	0.8	203560	12451.
					R_av	216004	10498.
157 Dy	c	8.14H	326.2	92	4	282990	16725
155 Dy	c*	9.9H	226.9	68.4	1.6	226400	11967
152 Dy	c	2.38H	344.3	99.9	0.0	82896	16143.

			256.9	97.50	0.07	108220	4479.
					R_av	107387	3355.
155 Tb	c*	5.32D	340.7	1.18	0.07	210620	14878.
			180.1	7.5	0.5	215270	16552.
			163.3	4.44	0.24	235350	17333.
					R_av	219213	10867.
153 Tb	c*	2.34D	212.0	31.0	1.9	167500	12139.
			102.2	6.4	0.5	175710	17990.
					R_av	169791	10327.
152 Tb-i	i(m+g)	17.5H	344.3	65	4	52673	16128
152 Tb	c	17.5H	344.3	65	4	135480	10051
151 Tb	c	17.609H	616.6	10.4	0.5	115150	8799.
			604.8	3.28	0.15	126160	16053.
			479.4	15.4	0.7	119720	8137.
			287.4	28.3	1.2	122670	7063.
			251.9	26.3	1.2	121970	7587.
			108.1	24.3	1.1	119280	10970.
					R_av	118557	4265.
150 Tb	c	3.48H	638.0	72	10	62545	9222.
			496.2	14.6	2.0	62816	12819.
					R_av	62636	7600.
149 Tb	c	4.118H	352.2	29.4	0.9	44442	2846
148 Tb	c	60M	784.4	84.0	1.6	59784	2502.
			489.0	19.7	0.5	49204	5163.
					R_av	58701	3694.
151 Gd	c	124D	243.3	5.6	0.4	113760	9295.
			174.7	2.96	0.21	115050	9552.
					R_av	114386	7125.
149 Gd	c	9.28D	788.9	7.3	0.4	142770	9199.
			534.3	3.07	0.17	165740	10860.
			346.6	23.9	1.3	133540	8584.
			327.5	*****************		137970	15937.
			298.6	28.6	1.7	131900	9128.
			277.1	*****************		122950	14053.
			272.3	3.21	0.19	128990	9278.
			149.7	48	3	140650	10583.
					R_av	138255	6095.
147 Gd	c	38.06H	929.0	20.2	1.2	94748	6546.
			625.2	4.7	0.4	102940	10504.
			370.0	17.2	0.9	107840	6835.
			229.3	63	4	124380	9268.
					R_av	105316	6536.
146 Gd	c	48.27D	2436.7	*****************		103250	6415.
			1533.7	*****************		101120	4698.
			747.2	*****************		98916	4418.
			154.6	46.6	0.5	99554	3805.
			114.7	44.0	0.7	101100	5997.
					R_av	100084	3455.
149 Eu-i	i	93.1D	327.5	4.03	0.12	5910	15821.
			277.1	3.56	0.06	4706	13391.
					R_av	5209	10222.
149 Eu	c	93.1D	327.5	4.03	0.12	143880	6676.
			277.1	3.56	0.06	127650	5403.
					R_av	133377	8804.
148 Eu	i	54.5D	630.0	71.9	2.3	4779	227.
			611.3	20.5	0.7	4615	294.
			550.3	99	3	5186	240.
					R_av	4908	224.
147 Eu	c*	24.1D	955.8	3.84	0.20	118550	7339.
			798.7	4.8	0.3	142920	10417.
			677.5	9.8	0.5	122180	7488.
			121.2	22.9	1.3	115520	9091.
					R_av	122824	6370.
146 Eu-i	i	4.61D	2436.7	0.93	0.03	7853	8302.
			1533.7	6.08	0.19	22776	2263.
			747.2	99	3	13307	600.
					R_av	13661	1378.
146 Eu	c	4.61D	2436.7	0.93	0.03	111100	9371.
			1533.7	6.08	0.19	123890	5911.
			747.2	99	3	112220	5013.
					R_av	116256	5410.
145 Eu	c	5.93D	1997.0	7.2	0.5	76536	6152.

Nuclide	Type	$T_{1/2}$	E_γ, KeV	Abundance,	%	Reaction rate 10^{-20} s^{-1}	
			1804.3	1.07	0.07	81334	8880.
			1658.5	14.9	1.0	69274	5290.
			893.7	66	5	69513	5749.
			653.5	15	1	70956	5378.
					R_av	72133	3339.
143 Pm	c	265D	742.0	38.5	2.4	53994	3827
136 Nd	c	50.65M	552.2	99	7	21591	1811
134 Pr	c*	17M	409.2	87.1	0.0	8735	944
139 Ce	c	137.640D	165.9	79.89	0.01	30759	1135
134 Ce	c	3.16D	604.7	5.04	0.20	15926	2017
132 Ce	c	3.51H	464.5******************			6736	1417
132 La-i	i(m+g)	4.8H	464.5	76	6	1867	2096
132 La	c	4.8H	464.5	76	6	8603	1265
131 Ba	c	11.50D	216.1	19.66	0.25	9780	439
127 Xe	c	36.4D	375.0	17.2	0.6	4404	322
121 Te-i	i(m+g)	19.16D	573.1	80.3	2.5	2056	115
121 Te	c	19.16D	573.1	80.3	2.5	3027	157
121mTe	i(m)	154D	573.1	88.6	0.1	1097	155
105 Ag	c	41.29D	443.4	10.5	0.6	2160	280
96 Tc	i(m+g)	4.28D	849.9	98	4	1149	75.
			812.5	82	4	1702	166.
					R_av	1232	201.
89 Zr	c	78.41H	909.2	99.04	0.03	2435	154
88 Zr	c	83.4D	1836.1******************			735.6	500.5
			898.0******************			862.5	500.7
			392.9	97.24	0.00	2025	124.
					R_av	1924	60.
88 Y -i	i	106.65D	1836.1	99.2	0.3	3336	1005.
			898.0	93.7	0.3	3522	1006.
					R_av	3429	715.
88 Y	c	106.65D	1836.1	99.2	0.3	4071	809.
			898.0	93.7	0.3	4385	811.
					R_av	4228	580.
87 Y	c	79.8H	484.8	89.7	0.7	3837	160.
			388.5	82.1	0.5	4311	305.
					R_av	3899	201.
84 Rb	i(m+g)	32.77D	881.6	69.0	1.6	2820	179
83 Rb	c	86.2D	520.4	45	4	4630	454
75 Se	c	119.779D	136.0	58.3	0.8	2975	179
74 As	i	17.77D	595.8	59	4	2303	193
59 Fe	c	44.472D	1291.6	43.2	1.4	1871	110.
			1099.2	56.5	1.9	1767	103.
					R_av	1815	85.
54 Mn	i	312.11D	834.8	99.98	0.00	2623	170
48 V	c	15.9735D	1312.1	97.5	0.9	892.5	69.0
46 Sc	i(m+g)	83.79D	889.3	99.98	0.00	2505	132
7 Be	i	53.29D	477.6	10.52	0.06	9420	550

Table 10.72: Detailed reaction rates for residual nuclide production in ^{nat}W at E_p=1199 MeV used to determine their production cross sections.

Nuclide	Type	$T_{1/2}$	E_γ, KeV	Abundance,	%	Reaction rate 10^{-20} s^{-1}	
184 Re	i(m+g)	38.0D	903.3	37.9	1.1	11904	557.
			792.1	37.5	1.1	12474	633.
			792.1	37.5	1.1	11396	638.
					R_av	11940	471.
183 Re	i	70.0D	291.7	3.05	0.18	19185	2262.
			162.3	23.3	0.7	25843	1272.

					R_av	24720	2610.
182 Re	i	64.0H	1189.0	9.0	0.6	8794	2782.
			1121.3	22.0	1.4	19336	2766.
					R_av	14198	5288.
182mRe	i(m)	12.7H	1121.4	31.8	1.6	20945	2973
181 Re	i	19.9H	365.5	56	8	41842	6156.
			365.5	56	8	41607	6124.
					R_av	41724	4438.
178 W	c	21.6D	1496.0	0.27	0.02	192850	21108.
			1402.9	0.48	0.04	176760	18842.
			1350.6	1.18	0.11	190870	19366.
			1340.8	1.03	0.09	171680	16248.
					R_av	181406	10457.
177 W	c	135M	115.7	51	5	162440	18667
176 W	c	2.5H	1862.7*****************			262100	51020.
			1823.7*****************			97861	40078.
			1696.6*****************			138510	77701.
			1252.9*****************			53869	63371.
			1159.3*****************			137730	28125.
			710.5*****************			48156	29735.
					R_av	115675	28887.
174 W	c	31M	206.5*****************			149390	17571
184 Ta	c*	8.7H	920.9	32.0	1.6	32409	2140.
			414.0	72	3	39923	2194.
					R_av	36329	3921.
183 Ta	c	5.1D	354.0	11.2	0.7	100490	7147.
			313.3	7.52	0.55	83694	6858.
			246.1	27	4	99857	15453.
			107.9	11.0	0.8	80019	7735.
					R_av	89367	5925.
182 Ta	i(m1+m2+g)	114.43D	1231.0	11.44	0.20	105350	4112.
			1221.4	27.0	0.5	106740	4241.
			1189.1	16.2	0.3	113190	4317.
					R_av	108478	4180.
178mTa	i(m)	2.36H	331.6	31.2	0.5	85559	4206
177 Ta	c*	56.56H	112.9	7.2	1.6	309770	71159
176 Ta-i	i	8.09H	1862.7	4.0	0.3	56720	59304.
			1823.7	4.5	0.4	226970	54705.
			1696.6	4.6	0.4	196350	102769.
			1252.9	3.08	0.23	282090	79532.
			1159.3	24.7	1.9	181120	36882.
			710.5	5.4	0.4	223300	40764.
					R_av	193677	25655.
176 Ta	c	8.09H	1862.7	4.0	0.3	318820	30328.
			1823.7	4.5	0.4	324830	33336.
			1696.6	4.6	0.4	334860	40670.
			1252.9	3.08	0.23	335960	31980.
			1159.3	24.7	1.9	318860	28381.
			710.5	5.4	0.4	271460	23712.
					R_av	310533	15136.
175 Ta	c	10.5H	1793.1	4.6	0.7	236780	37303.
			1744.8	1.36	0.19	206840	32684.
			266.9	10.52	0.16	244090	12304.
			125.9	9.0	1.3	394540	61137.
					R_av	244095	10167.
174 Ta-i	i	1.14H	206.5	60	5	60170	18001
174 Ta	c	1.14H	206.5	60	5	209570	20431
173 Ta	c	3.14H	1208.2	2.7	0.4	284100	50987.
			172.2	17.5	1.8	226570	25108.
			160.4	4.9	0.8	306160	54095.
			139.6*****************			155210	19825.
			123.7*****************			297390	32364.
					R_av	215774	30248.
172 Ta	c*	36.8M	214.1	55	5	124860	13654
181 Hf	c	42.39D	482.2	80.5	0.5	10086	354
175 Hf	c	70D	343.4	84	3	351160	17227
173 Hf-i	i	23.6H	139.6	12.7	0.6	163970	21598.
			123.7	83	5	39769	23540.
					R_av	111321	61476.

173 Hf	c	23.6H	311.2	10.7	0.5	381730	23525.
			139.6	12.7	0.6	319190	21036.
			123.7	83	5	337160	27442.
					R_av	346878	22895.
172 Hf	c	1.87Y	1093.6******************			271510	15775.
			912.1******************			293040	16803.
			810.1******************			281840	19301.
					R_av	282044	11260.
171 Hf	c	12.1H	780.7******************			204670	376850.
			739.8******************			243900	21616.
					R_av	243794	20979.
170 Hf	c	16.01H	2191.1******************			233230	32903.
			2126.1******************			284380	26406.
			1512.5******************			227990	28891.
			1364.6******************			225390	18864.
			1280.2******************			178220	15033.
			620.7	18	5	359780	100680.
			501.6	3.7	1.0	288240	79760.
			164.7	26	8	369180	115333.
			120.2	15	5	343090	116257.
					R_av	216284	15750.
168 Hf	c	25.95M	1136.8	16.1	2.9	211360	39946.
			983.8	16	4	164110	43042.
			979.2	26.1	0.7	172890	10312.
			896.1	20.1	2.6	212690	28893.
					R_av	177451	9778.
173 Lu	c	1.37Y	272.1	21.2	0.8	310160	16885
172 Lu-i	i	6.70D	1093.6	63	3	36023	2097.
			912.1	15.3	0.7	33635	1948.
			810.1	16.6	0.8	34890	2073.
					R_av	34770	1297.
172 Lu	c	6.70D	1093.6	63	3	307540	17841.
			912.1	15.3	0.7	326670	18627.
			810.1	16.6	0.8	316730	21235.
					R_av	316754	13632.
171 Lu-i	i(m+g)	8.24D	780.7	4.36	0.11	142710	401223.
			739.8	47.8	1.2	98824	20743.
					R_av	98937	20614.
171 Lu	c	8.24D	853.0	2.55	0.07	363640	16078.
			839.9	3.04	0.08	371640	15775.
			780.7	4.36	0.11	347390	28401.
			739.8	47.8	1.2	342720	14231.
			689.3	2.37	0.06	350670	14653.
					R_av	355405	12434.
170 Lu-i	i(m+g)	2.012D	2191.1	1.64	0.08	120790	40971.
			2126.1	5.1	0.3	10167	24102.
			1512.5	2.55	0.13	84465	36009.
			1364.6	4.62	0.18	74613	20135.
			1280.2	8.2	0.4	101360	15658.
					R_av	79177	17005.
170 Lu	c	2.012D	2191.1	1.64	0.08	354030	25607.
			2126.1	5.1	0.3	294540	21920.
			1512.5	2.55	0.13	312460	21997.
			1364.6	4.62	0.18	300000	16601.
			1280.2	8.2	0.4	279580	17107.
					R_av	301489	14301.
169 Lu	c	34.06H	1466.8	3.32	0.11	278610	14128.
			1463.4	1.51	0.05	251090	15696.
			960.6	23.4	0.7	253110	11328.
			889.8	5.36	0.17	234380	11458.
			191.2	20.6	0.6	293290	14117.
					R_av	259034	13167.
167 Lu	c	51.5M	113.3******************			259280	21180
169 Yb	c*	32.026D	307.7	10.05	0.19	361590	14390.
			177.2	22.2	0.5	328170	14386.
			130.5	11.31	0.21	339210	18052.
					R_av	345607	15316.
167 Yb-i	i	17.5M	113.3	55	3	4459	7669
167 Yb	c	17.5M	113.3	55	3	263740	21769
166 Yb	c	56.7H	2079.5******************			311130	23265.
			2052.4******************			315960	21799.
			1867.9******************			302520	21038.
			1374.2******************			295780	23472.

			1273.5*****************			297390	20719.
			1176.7*****************			281640	20347.
			785.9*****************			288820	19977.
			691.2	8.56	0.58	269280	20398.
			594.4*****************			290790	19931.
					R_av	294832	10271.
162 Yb	c	18.87M	798.7*****************			219410	36951.
			163.4	40	5	224480	30103.
			118.7	34	4	170480	22470.
			102.0*****************			123700	19654.
					R_av	167795	23694.
168 Tm	i	93.1D	447.5	23.7	0.8	7532	407
167 Tm	c	9.25D	531.5	1.61	0.22	364720	51711.
			207.8	42	8	330050	64159.
					R_av	351262	40951.
166 Tm-i	i	7.70H	2079.5	6.3	0.4	2534	9130.
			2052.4	17.2	1.0	9847	2330.
			1867.9	4.04	0.24	19995	4460.
			1374.2	5.6	0.4	46427	9423.
			1273.5	14.9	0.9	38383	5343.
			1176.7	9.5	0.6	34785	10104.
			785.9	9.9	0.6	36425	5745.
			594.4	3.46	0.20	7534	140900.
					R_av	19043	4834.
166 Tm	c	7.70H	2079.5	6.3	0.4	313660	24795.
			2052.4	17.2	1.0	325810	22558.
			1867.9	4.04	0.24	322520	22660.
			1374.2	5.6	0.4	342200	28326.
			1273.5	14.9	0.9	335780	23689.
			1176.7	9.5	0.6	316430	24587.
			785.9	9.9	0.6	325250	23002.
			594.4	3.46	0.20	298320	141084.
					R_av	325359	13061.
165 Tm	c	30.06H	806.4	9.5	0.6	311820	22324.
			356.5	2.75	0.15	296600	26038.
					R_av	305652	18197.
163 Tm	c*	1.810H	1434.4	8.0	0.3	350590	20435.
			1397.5	7.03	0.24	297730	17811.
			1374.3	4.28	0.16	320630	34268.
			104.3	18.6	0.7	232980	18677.
					R_av	296071	27429.
162 Tm-i	i(m+g)	21.70M	798.7	8.4	0.7	100610	48893.
			102.0	17.5	1.5	86256	25611.
					R_av	89241	22189.
162 Tm	c	21.70M	798.7	8.4	0.7	320030	36283.
			102.0	17.5	1.5	209960	25151.
					R_av	245891	52181.
161 Tm	c	33M	1648.1	20	3	247930	39212
161 Er	c*	3.21H	826.6	64	4	364090	27943
160 Er	c	28.58H	962.4*****************			321600	42188.
			879.4*****************			336490	43089.
			872.0	6.8	1.1	322910	53730.
			728.2*****************			341920	50219.
					R_av	330594	23675.
159 Er	c*	36M	649.1	23	3	321620	44138.
			624.5	33	4	297330	39208.
					R_av	308016	30087.
157 Er	c*	18.65M	391.3	14.2	1.4	281790	33998
156 Er	c	19.5M	266.5*****************			238240	23027
160mHo-i	i(m)	5.02H	962.4	16.6	2.1	14385	5316.
			879.4	18.6	2.3	20925	4380.
			728.2	28	4	19329	4569.
					R_av	18703	2708.
160mHo	c	5.02H	962.4	16.6	2.1	335980	44185.
			879.4	18.6	2.3	357420	45832.
			728.2	28	4	361250	53098.
					R_av	350228	28701.
160 Ho	i(m+g)	25.6M	728.2	46.9	1.7	42006	5505
156 Ho-i	i	56M	266.5	54.7	1.1	9523	23772
156 Ho	c	56M	266.5	54.7	1.1	247760	12410.
			137.8	51.1	0.8	311240	23486.

					R_av	258598	25215.
157 Dy	c	8.14H	326.2	92	4	318170	17872
155 Dy	c*	9.9H	226.9	68.4	1.6	288690	13696
152 Dy	c	2.38H	344.3	99.9	0.0	188190	14855.
			256.9	97.50	0.07	174110	6923.
					R_av	175373	5479.
155 Tb	c*	5.32D	340.7	1.18	0.07	270990	19015.
			180.1	7.5	0.5	280180	21492.
			163.3	4.44	0.24	322500	22325.
					R_av	288929	17991.
153 Tb	c*	2.34D	212.0	31.0	1.9	237580	17233.
			102.2	6.4	0.5	253070	25764.
					R_av	241856	14700.
152 Tb-i	i(m+g)	17.5H	344.3	65	4	3116	6515
152 Tb	c	17.5H	344.3	65	4	191120	13489
151 Tb	c	17.609H	731.2	8.32	0.04	175120	7757.
			616.6	10.4	0.5	210630	12877.
			479.4	15.4	0.7	206420	12363.
			287.4	28.3	1.2	194680	12059.
			251.9	26.3	1.2	212120	12960.
			108.1	24.3	1.1	201170	17063.
					R_av	182159	8187.
150 Tb	c	3.48H	638.0	72	10	106370	15287.
			496.2	14.6	2.0	108200	15543.
					R_av	107270	11153.
149 Tb	c	4.118H	817.1	11.6	0.4	63489	4156.
			352.2	29.4	0.9	75137	3545.
					R_av	69308	5085.
148 Tb	c	60M	784.4	84.0	1.6	97620	4946.
			489.0	19.7	0.5	89100	6130.
					R_av	94748	4998.
153 Gd	c	240.4D	103.2	21.1	0.7	163870	14659
151 Gd	c	124D	243.3	5.6	0.4	162290	14201.
			174.7	2.96	0.21	192500	15645.
					R_av	176113	16025.
149 Gd	c	9.28D	788.9	7.3	0.4	250310	16001.
			534.3	3.07	0.17	295680	19477.
			346.6	23.9	1.3	235010	15080.
			298.6	28.6	1.7	229240	15832.
			272.3	3.21	0.19	220420	16228.
			149.7	48	3	240970	18106.
					R_av	242622	12428.
147 Gd	c	38.06H	955.8	*****************		48265	106010.
			929.0	20.2	1.2	180620	12523.
			861.7	1.75	0.10	190620	14065.
			625.2	4.7	0.4	200120	20709.
			370.0	17.2	0.9	208000	13093.
			229.3	63	4	233490	17420.
					R_av	199460	10128.
146 Gd	c	48.27D	2436.7	*****************		206900	12000.
			1756.1	*****************		213350	12709.
			1533.7	*****************		213210	9802.
			747.2	*****************		208700	9343.
			154.6	46.6	0.5	203890	8515.
			115.5	44.0	0.7	418100	24702.
			114.7	44.0	0.7	418510	24691.
					R_av	218226	19532.
145 Gd	c	23.0M	1880.6	32.6	1.9	109340	11843.
			1757.9	34.2	2.0	118010	10465.
					R_av	114498	7607.
149 Eu	c	93.1D	327.5	4.03	0.12	289270	13816.
			277.1	3.56	0.06	270620	11744.
					R_av	277675	12532.
148 Eu	i	54.5D	725.7	12.7	0.4	12420	624.
			630.0	71.9	2.3	9815	458.
			611.3	20.5	0.7	10471	569.
			550.3	99	3	11485	535.
					R_av	10847	659.
147 Eu-i	i	24.1D	955.8	3.84	0.20	192750	113747
147 Eu	c*	24.1D	955.8	3.84	0.20	241010	16472.

			798.7	4.8	0.3	277470	19614.
			677.5	9.8	0.5	245030	14995.
			121.2	22.9	1.3	239550	18863.
					R_av	248962	11156.
146 Eu-i	i	4.61D	2436.7	0.93	0.03	60434	6872.
			1756.1	0.92	0.04	51790	10079.
			1533.7	6.08	0.19	39200	2162.
			747.2	99	3	46056	2179.
					R_av	43599	3004.
146 Eu	c	4.61D	2436.7	0.93	0.03	267340	15789.
			1756.1	0.92	0.04	265140	16943.
			1533.7	6.08	0.19	252410	11608.
			747.2	99	3	254760	11405.
					R_av	256949	9494.
145 Eu	c	5.93D	1997.0	7.2	0.5	172060	13515.
			1804.3	1.07	0.07	180940	15427.
			1658.5	14.9	1.0	168280	12669.
			893.7	66	5	167230	13823.
			653.5	15	1	165170	12348.
					R_av	169947	7652.
144 Pm	i	363D	618.0	98.6	1.0	3338	212
143 Pm	c	265D	742.0	38.5	2.4	168350	11868
140mPm	i(m)	5.95M	1028.2	100	2	44927	4813.
			773.7	100	5	35999	4540.
					R_av	40260	4633.
139mNd	i(m)	5.5H	738.2	35	5	17184	2647
136 Nd	c	50.65M	1092.3	**********	********	64123	30680.
			552.2	**********	********	72568	5465.
					R_av	72410	4753.
136 Pr-i	i	13.1M	1092.3	18.5	1.2	16146	117201.
			552.2	76	5	21517	3674.
					R_av	21512	3589.
136 Pr	c	13.1M	1092.3	18.5	1.2	80268	101129.
			552.2	76	5	94085	7513.
					R_av	94021	7498.
139 Ce	c	137.640D	165.9	79.89	0.01	126680	4818
135 Ce	c	17.7H	783.6	10.6	0.4	99775	6870.
			606.8	18.8	0.7	84494	4459.
			300.1	23.5	0.6	102190	6952.
					R_av	91184	6415.
134 Ce	c	3.16D	604.7	5.04	0.20	73699	4838
133mCe	i(m)	4.9H	477.2	39.2	1.2	18085	1687
132 Ce	c	3.51H	1909.9	**********	********	49057	18210.
			464.5	**********	********	55486	4971.
					R_av	55234	3954.
130 Ce	c	25M	357.4	**********	********	28387	2272
132 La-i	i(m+g)	4.8H	1909.9	9.0	0.8	11110	26362.
			464.5	76	6	5577	1705.
					R_av	5600	1676.
132 La	c	4.8H	1909.9	9.0	0.8	60161	109315.
			464.5	76	6	61063	5313.
					R_av	61061	5308.
130 La-i	i	8.7M	357.4	81	4	3743	6052
130 La	c	8.7M	357.4	81	4	32130	5475
133 Ba	c	3848.9D	356.0	62.05	0.19	75607	3664
131 Ba	c	11.50D	496.3	46.8	0.2	59064	2218.
			486.5	2.09	0.02	65729	3475.
			373.2	14.04	0.20	60646	2289.
			216.1	19.66	0.25	55601	2385.
			123.8	29.0	0.3	57275	3082.
					R_av	59181	2235.
128 Ba	c	2.43D	273.4	14.5	0.7	37610	2426
129 Cs	c	32.06H	411.5	22.3	1.3	55330	3962.
			371.9	30.6	1.7	61639	4043.
					R_av	58494	3646.
127 Cs	c	6.25H	412.0	62.8	1.0	33675	1462

127 Xe	c	36.4D	375.0 202.9	17.2 68.3	0.6 0.5 R_av	39914 33746 35880	1954. 1519. 3141.
125 Xe	c	16.9H	188.4	54.0	0.3	23492	1393
123 Xe	c	2.08H	148.9	48.9	0.6	37651	2119
120 Xe	c	40M	560.4******************			6095	2441
120 I -i	i	81.0M	560.4	73	0	4690	3440
120 I	c	81.0M	560.4	73	0	10785	1312
121 Te-i	i(m+g)	19.16D	573.1	80.3	2.5	18208	850
121 Te	c	19.16D	573.1	80.3	2.5	20258	960
121mTe	i(m)	154D	573.1	88.6	0.1	2314	416
119 Te	c	16.05H	1749.7	3.9	0.3	97890	11009
119mTe	i(m)	4.70D	1212.7	66.2	0.3	3414	158
120mSb	i(m)	5.76D	1171.7******************			429.3	59.3
113 Sn	i(m+g)	115.09D	391.7	64.97	0.17	5102	2127
111 In	c	2.8047D	245.4	94	1	9516	1287
106mAg	i(m)	8.28D	1527.7	16.3	1.4	2682	325
105 Ag	c	41.29D	443.4	10.5	0.6	6642	543
100 Pd	c	3.63D	2376.0******************			1058	125
100 Rh-i	i(m+g)	20.8H	2376.0	32.6	0.4	8795	630
100 Rh	c	20.8H	2376.0	32.6	0.4	9853	661
103 Ru	c	39.26D	497.1	91.0	1.3	642.2	180.6
97 Ru	c	2.791D	215.7	85.6	0.0	12649	708
96 Tc	i(m+g)	4.28D	849.9 812.5	98 82	4 4 R_av	3026 3377 3180	192. 217. 200.
90 Nb	c*	14.60H	2319.0	82.0	0.3	4547	1093
89 Zr	c	78.41H	909.2	99.04	0.03	5865	235
88 Zr	c	83.4D	1836.1****************** 898.0****************** 392.9	 97.24	 0.00 R_av	4769 2183 715.4 1830	483. 242. 1173.2 57.
88 Y -i	i	106.65D	1836.1 898.0	99.2 93.7	0.3 0.3 R_av	4698 6843 6281	258. 248. 963.
88 Y	c	106.65D	1836.1 898.0	99.2 93.7	0.3 0.3 R_av	9467 9026 9116	429. 323. 336.
87mY	c*	13.37H	484.8	98.4	0.1	5994	4289
87 Y -i	i	79.8H	484.8	89.7	0.7	838.5	4961.1
87 Y	c	79.8H	484.8 388.5	89.7 82.1	0.7 0.5 R_av	6736 9110 8925	857. 374. 695.
85 Sr	c	64.84D	514.0	96	4	11230	662
84 Rb	i(m+g)	32.77D	881.6	69.0	1.6	4778	217
83 Rb	c	86.2D	552.6 520.4	16.0 45	1.1 4 R_av	20062 9371 12227	1656. 971. 4746.
75 Se	c	119.779D	136.0	58.3	0.8	7304	414
74 As	i	17.77D	595.8	59	4	4281	358
58 Co	i(m+g)	70.86D	810.8	99.45	0.01	2493	562
56 Co	c	77.233D	846.8	99.94	0.03	677.5	54.6
59 Fe	c	44.472D	1291.6	43.2	1.4	3700	200.

			1099.2	56.5	1.9	3145	156.
					R_av	3344	286.
54 Mn	i	312.11D	834.8	99.98	0.00	4936	193
52 Mn	c	5.591D	1434.1	100.0	0.6	867.2	51.4
48 V	c	15.9735D	1312.1	97.5	0.9	1373	54.
			983.5	100.0	0.3	1346	60.
					R_av	1363	50.
48 Sc	i	43.67H	1037.5	97.6	0.7	1988	235
46 Sc	i(m+g)	83.79D	889.3	99.98	0.00	6096	215
44mSc	i(m)	58.61H	1157.0	108.4	0.5	833.0	112.2
28 Mg	c	20.915H	1778.8	*****************		1219	228
24 Na	c	14.9590H	1369.0	100	0	9026	373
7 Be	i	53.29D	477.6	10.52	0.06	19354	785

Table 10.73: Detailed reaction rates for residual nuclide production in ^{nat}W at E_p=1599 MeV used to determine their production cross sections.

Nuclide	Type	$T_{1/2}$	E_γ, KeV	Abundance, %		Reaction rate 10^{-20} s^{-1}	
184 Re	i(m+g)	38.0D	903.3	37.9	1.1	4011	190.
			792.1	37.5	1.1	3745	216.
					R_av	3908	178.
183 Re	i	70.0D	162.3	23.3	0.7	8255	495.
			162.3	23.3	0.7	8133	437.
					R_av	8184	373.
182 Re	i	64.0H	1189.0	9.0	0.6	3442	767.
			1121.3	22.0	1.4	6304	790.
					R_av	4862	1439.
182mRe	i(m)	12.7H	1121.4	31.8	1.6	7436	962
178 W	c	21.6D	1402.9	0.48	0.04	52537	9649.
			1350.6	1.18	0.11	56936	7069.
			1340.8	1.03	0.09	50912	6527.
					R_av	53470	4478.
177 W	c	135M	115.7	51	5	50887	5876
176 W	c	2.5H	1862.7	*****************		74672	23179.
			1823.7	*****************		13884	11727.
			1696.6	*****************		23377	21421.
			1252.9	*****************		36340	29020.
			1159.3	*****************		61444	7909.
			710.5	*****************		52801	16974.
					R_av	50462	8810.
174 W	c	31M	206.5	*****************		17950	5673
184 Ta	c*	8.7H	920.9	32.0	1.6	12798	903.
			414.0	72	3	14024	768.
					R_av	13561	730.
183 Ta	c	5.1D	354.0	11.2	0.7	35042	2522.
			313.3	7.52	0.55	31088	2629.
			246.1	27	4	40410	6293.
			107.9	11.0	0.8	18992	2128.
					R_av	28080	4383.
182 Ta	i(m1+m2+g)	114.43D	1231.0	11.44	0.20	36545	1493.
			1221.4	27.0	0.5	37613	1455.
			1189.1	16.2	0.3	39499	1616.
					R_av	37785	1431.
178mTa	i(m)	2.36H	331.6	31.2	0.5	22266	1979
177 Ta	c*	56.56H	112.9	7.2	1.6	108570	25033
176 Ta-i	i	8.09H	1862.7	4.0	0.3	37747	30303.
			1823.7	4.5	0.4	94263	18053.
			1696.6	4.6	0.4	96910	29812.
			1252.9	3.08	0.23	83800	38542.
			1159.3	24.7	1.9	38800	8519.
			710.5	5.4	0.4	37488	21220.
					R_av	51001	10433.
176 Ta	c	8.09H	1862.7	4.0	0.3	112420	12359.
			1823.7	4.5	0.4	108140	11171.
			1696.6	4.6	0.4	120280	13540.

			1252.9	3.08	0.23	120140	13944.
			1159.3	24.7	1.9	100240	8665.
			710.5	5.4	0.4	90289	9000.
					R_av	104654	5788.
175 Ta	c	10.5H	1793.1	4.6	0.7	74853	11825.
			1744.8	1.36	0.19	61408	9594.
			1736.7	0.92	0.14	71168	12366.
			266.9	10.52	0.16	82707	5044.
			125.9	9.0	1.3	128330	19975.
					R_av	80602	5441.
174 Ta-i	i	1.14H	206.5	60	5	51824	9050
174 Ta	c	1.14H	206.5	60	5	69774	7053
173 Ta	c	3.14H	1208.2	2.7	0.4	88996	14744.
			172.2	17.5	1.8	76341	8728.
			160.4	4.9	0.8	94567	18568.
			139.6	*****************		9353	13613.
			123.7	*****************		92473	9826.
					R_av	75568	13383.
172 Ta	c*	36.8M	214.1	55	5	48667	5323
181 Hf	c	42.39D	482.2	80.5	0.5	3467	129
175 Hf	c	70D	343.4	84	3	115730	5677
173 Hf-i	i	23.6H	139.6	12.7	0.6	100320	16585.
			123.7	83	5	19090	7303.
					R_av	33092	30699.
173 Hf	c	23.6H	139.6	12.7	0.6	109680	7490.
			123.7	83	5	111560	9033.
					R_av	110354	5650.
172 Hf	c	1.87Y	1093.6	*****************		85522	5000.
			912.1	*****************		86274	21199.
			810.1	*****************		82755	6528.
			181.5	*****************		86904	5467.
					R_av	85600	3237.
171 Hf	c	12.1H	780.7	*****************		86249	52094.
			739.8	*****************		81612	7690.
					R_av	81696	7439.
170 Hf	c	16.01H	2191.1	*****************		63422	11400.
			2126.1	*****************		89894	8113.
			1512.5	*****************		80613	12712.
			1364.6	*****************		69386	6799.
			1280.2	*****************		72385	5975.
			620.7	18	5	115390	32346.
			501.6	3.7	1.0	81300	22254.
			164.7	26	8	133140	41373.
			120.2	15	5	98809	33392.
					R_av	75853	4264.
168 Hf	c	25.95M	1136.8	16.1	2.9	66641	13034.
			983.8	16	4	51621	13271.
			979.2	26.1	0.7	52088	3195.
			896.1	20.1	2.6	67995	10353.
					R_av	53649	3180.
173 Lu	c	1.37Y	272.1	21.2	0.8	106480	5690
172 Lu-i	i	6.70D	1093.6	63	3	12031	703.
			912.1	15.3	0.7	11225	676.
			810.1	16.6	0.8	11890	1021.
			181.5	20.6	1.0	11864	819.
					R_av	11697	427.
172 Lu	c	6.70D	1093.6	63	3	97554	5684.
			912.1	15.3	0.7	97499	21431.
			810.1	16.6	0.8	94645	7283.
			181.5	20.6	1.0	98768	6174.
					R_av	97328	4352.
171 Lu-i	i(m+g)	8.24D	780.7	4.36	0.11	20921	55184.
			739.8	47.8	1.2	26520	7413.
					R_av	26423	7328.
171 Lu	c	8.24D	853.0	2.55	0.07	107760	5282.
			839.9	3.04	0.08	119130	5094.
			780.7	4.36	0.11	107170	5565.
			739.8	47.8	1.2	108130	4499.
			689.3	2.37	0.06	109700	4733.
					R_av	110589	4104.
170 Lu-i	i(m+g)	2.012D	2191.1	1.64	0.08	48935	13768.
			2126.1	5.1	0.3	3922	6684.

			1512.5	2.55	0.13	12376	14775.
			1364.6	4.62	0.18	21521	7522.
			1280.2	8.2	0.4	8635	5506.
					R_av	12980	5701.
170 Lu	c	2.012D	2191.1	1.64	0.08	112350	7871.
			2126.1	5.1	0.3	93816	6854.
			1512.5	2.55	0.13	92989	6721.
			1364.6	4.62	0.18	90907	5088.
			1280.2	8.2	0.4	81019	5038.
					R_av	91145	5323.
169 Lu	c	34.06H	1466.8	3.32	0.11	88489	4823.
			1463.4	1.51	0.05	75117	4951.
			960.6	23.4	0.7	76846	3470.
			889.8	5.36	0.17	70606	4524.
			191.2	20.6	0.6	78950	4117.
					R_av	77905	3468.
167 Lu	c	51.5M	113.3*****************			79690	6502
169 Yb	c*	32.026D	307.7	10.05	0.19	113660	4927.
			177.2	22.2	0.5	102720	4586.
			130.5	11.31	0.21	102390	5482.
					R_av	106735	5043.
167 Yb-i	i	17.5M	113.3	55	3	3621	3311
167 Yb	c	17.5M	113.3	55	3	83311	7086
166 Yb	c	56.7H	2092.1*****************			98549	6853.
			2079.5*****************			93829	7037.
			2052.4*****************			94617	6560.
			1867.9*****************			94034	6667.
			1374.2*****************			91471	7375.
			1273.5*****************			93057	6797.
			1176.7*****************			91411	6720.
			785.9*****************			88992	6179.
			691.2	8.56	0.58	83847	6478.
			594.4*****************			92621	6478.
					R_av	92478	3128.
162 Yb	c	18.87M	798.7*****************			50866	14520.
			163.4	40	5	79160	12066.
			118.7	34	4	45929	6326.
			102.0*****************			12619	6624.
					R_av	39928	12346.
168 Tm	i	93.1D	447.5	23.7	0.8	2561	187
167 Tm	c	9.25D	531.5	1.61	0.22	106020	15060.
			207.8	42	8	96878	18905.
					R_av	102522	11979.
166 Tm-i	i	7.70H	2092.1	1.56	0.09	5474	3651.
			2079.5	6.3	0.4	2924	2000.
			2052.4	17.2	1.0	2464	1211.
			1867.9	4.04	0.24	11007	2597.
			1374.2	5.6	0.4	21419	5061.
			1273.5	14.9	0.9	12419	3658.
			1176.7	9.5	0.6	9819	2509.
			785.9	9.9	0.6	13187	2281.
			594.4	3.46	0.20	9022	22442.
					R_av	6539	1766.
166 Tm	c	7.70H	2092.1	1.56	0.09	104020	7910.
			2079.5	6.3	0.4	96753	7391.
			2052.4	17.2	1.0	97080	6798.
			1867.9	4.04	0.24	105040	7598.
			1374.2	5.6	0.4	112880	9977.
			1273.5	14.9	0.9	105470	8178.
			1176.7	9.5	0.6	101230	7553.
			785.9	9.9	0.6	102170	7318.
			594.4	3.46	0.20	101640	22626.
					R_av	102176	4030.
165 Tm	c	30.06H	806.4	9.5	0.6	95814	6895.
			356.5	2.75	0.15	97105	7164.
					R_av	96431	5405.
163 Tm	c*	1.810H	1434.4	8.0	0.3	96009	6896.
			1397.5	7.03	0.24	79924	5241.
			1374.3	4.28	0.16	82482	13341.
					R_av	85402	5907.
162 Tm-i	i(m+g)	21.70M	798.7	8.4	0.7	48486	23405.
			102.0	17.5	1.5	57425	13451.
					R_av	55350	11265.
162 Tm	c	21.70M	798.7	8.4	0.7	99351	15078.
			102.0	17.5	1.5	70044	9791.

					R_av	78689	13589.
161 Tm	c	33M	1648.1	20	3	79662	12658.
			826.6	******************		89526	8055.
					R_av	87084	6622.
161 Er-i	i	3.21H	826.6	64	4	4692	5771
161 Er	c*	3.21H	826.6	64	4	94217	6701
160 Er	c	28.58H	966.2	******************		96852	13028.
			962.4	******************		97602	12780.
			879.4	******************		98993	12731.
			872.0	6.8	1.1	106740	17653.
			728.2	******************		102260	15046.
					R_av	99615	6479.
159 Er	c*	36M	649.1	23	3	107190	14852.
			624.5	33	4	92293	11790.
					R_av	98018	9478.
157 Er	c*	18.65M	391.3	14.2	1.4	99507	11022
156 Er	c	19.5M	266.5	******************		85462	16649
160mHo-i	i(m)	5.02H	966.2	15.4	2.0	4134	2285.
			962.4	16.6	2.1	7950	2192.
			879.4	18.6	2.3	10853	3091.
			728.2	28	4	6678	1648.
					R_av	6941	1145.
160mHo	c	5.02H	966.2	15.4	2.0	100980	13689.
			962.4	16.6	2.1	105550	13896.
			879.4	18.6	2.3	109840	14285.
			728.2	28	4	108940	16046.
					R_av	106057	7747.
160 Ho	i(m+g)	25.6M	728.2	46.9	1.7	8364	2091
156 Ho-i	i	56M	266.5	54.7	1.1	1216	20440
156 Ho	c	56M	266.5	54.7	1.1	86678	6289.
			137.8	51.1	0.8	97608	6350.
					R_av	92246	6177.
157 Dy	c	8.14H	326.2	92	4	95864	5471
155 Dy	c*	9.9H	226.9	68.4	1.6	90335	4351
152 Dy	c	2.38H	256.9	97.50	0.07	60612	2490
155 Tb	c*	5.32D	340.7	1.18	0.07	71738	5213.
			180.1	7.5	0.5	92470	7110.
			163.3	4.44	0.24	89532	5956.
					R_av	82545	7161.
153 Tb	c*	2.34D	212.0	31.0	1.9	80843	5860.
			102.2	6.4	0.5	80666	8215.
					R_av	80789	4907.
152 Tb	c	17.5H	344.3	65	4	79657	6033
151 Tb	c	17.609H	731.2	8.32	0.04	55821	3032.
			616.6	10.4	0.5	76688	4796.
			479.4	15.4	0.7	72474	4316.
			287.4	28.3	1.2	73808	4274.
			251.9	26.3	1.2	72265	4480.
			108.1	24.3	1.1	71599	5971.
					R_av	66662	4413.
150 Tb	c	3.48H	638.0	72	10	34112	4963.
			496.2	14.6	2.0	33988	5012.
					R_av	34051	3606.
149 Tb	c	4.118H	817.1	11.6	0.4	25461	1728.
			352.2	29.4	0.9	26033	1318.
					R_av	25767	965.
148 Tb	c	60M	784.4	84.0	1.6	32692	1411.
			489.0	19.7	0.5	32112	2353.
					R_av	32592	1349.
153 Gd	c	240.4D	103.2	21.1	0.7	68788	5993.
			97.4	29.0	0.8	68702	5026.
					R_av	68736	4130.
151 Gd	c	124D	243.3	5.6	0.4	56847	5050.
			174.7	2.96	0.21	69855	5683.
					R_av	62675	6759.
149 Gd	c	9.28D	788.9	7.3	0.4	85304	5503.

			534.3	3.07	0.17	103420	6766.
			346.6	23.9	1.3	80254	5148.
			298.6	28.6	1.7	78218	5424.
			272.3	3.21	0.19	71339	5316.
			149.7	48	3	82461	6197.
					R_av	82242	4758.
147 Gd	c	38.06H	955.8	*****************		62508	44060.
			929.0	20.2	1.2	75207	5267.
			861.7	1.75	0.10	67356	4812.
			625.2	4.7	0.4	76197	7142.
			370.0	17.2	0.9	70971	4636.
			229.3	63	4	80850	6029.
					R_av	72756	3013.
146 Gd	c	48.27D	2436.7	*****************		79447	5085.
			1756.1	*****************		75990	4618.
			1686.4	*****************		77028	3556.
			1533.7	*****************		76910	3647.
			747.2	*****************		78185	3555.
			154.6	46.6	0.5	73961	2883.
					R_av	76099	2606.
145 Gd	c	23.0M	1880.6	32.6	1.9	47152	3887.
			1757.9	34.2	2.0	42141	3577.
					R_av	44478	2860.
149 Eu	c	93.1D	327.5	4.03	0.12	85166	4398.
			277.1	3.56	0.06	85868	4068.
					R_av	85564	3529.
148 Eu	i	54.5D	725.7	12.7	0.4	5453	435.
			630.0	71.9	2.3	3918	210.
			611.3	20.5	0.7	3717	268.
			550.3	99	3	4329	209.
					R_av	4148	273.
147 Eu-i	i	24.1D	955.8	3.84	0.20	21714	46735
147 Eu	c*	24.1D	955.8	3.84	0.20	84222	5957.
			798.7	4.8	0.3	98621	6979.
			677.5	9.8	0.5	90281	5526.
					R_av	90286	4749.
146 Eu-i	i	4.61D	2436.7	0.93	0.03	19294	3450.
			1756.1	0.92	0.04	6195	4435.
			1686.4	0.63	0.02	20622	2103.
			1533.7	6.08	0.19	16003	1644.
			747.2	99	3	16432	898.
					R_av	16659	1120.
146 Eu	c	4.61D	2436.7	0.93	0.03	98741	6316.
			1756.1	0.92	0.04	82184	5815.
			1686.4	0.63	0.02	97650	4646.
			1533.7	6.08	0.19	92913	4423.
			747.2	99	3	94616	4282.
					R_av	93959	3709.
145 Eu	c	5.93D	1997.0	7.2	0.5	66352	5241.
			1804.3	1.07	0.07	77767	7398.
			1658.5	14.9	1.0	65430	4939.
			893.7	66	5	65869	5512.
			653.5	15	1	63212	4768.
					R_av	66367	3032.
144 Pm	i	363D	618.0	98.6	1.0	1615	83
143 Pm	c	265D	742.0	38.5	2.4	66638	4705
140mPm	i(m)	5.95M	1028.2	100	2	19356	5687.
			773.7	100	5	19305	2483.
					R_av	19313	2296.
139mNd	i(m)	5.5H	738.2	35	5	8583	1294
136 Nd	c	50.65M	1092.3	*****************		43361	4284.
			574.8	10.4	1.1	41714	9523.
			552.2	*****************		44584	3354.
					R_av	44066	2491.
136 Pr-i	i	13.1M	1092.3	18.5	1.2	2605	14560.
			552.2	76	5	24265	2465.
					R_av	23793	3250.
136 Pr	c	13.1M	1092.3	18.5	1.2	45966	13391.
			552.2	76	5	68850	5314.
					R_av	66160	7654.
139 Ce	c	137.640D	165.9	79.89	0.01	65263	2488
135 Ce	c	17.7H	783.6	10.6	0.4	56338	2911.

			606.8	18.8	0.7	49939	2693.
			300.1	23.5	0.6	51179	4154.
			206.5	7.77	0.25	50717	3974.
					R_av	52423	2334.
134 Ce	c	3.16D	604.7	5.04	0.20	46108	4634
133mCe	i(m)	4.9H	477.2	39.2	1.2	10854	625
132 Ce	c	3.51H	2102.8	************	******	41204	12402.
			1909.9	************	******	30339	11715.
			464.5	************	******	38164	3391.
					R_av	37953	2640.
130 Ce	c	25M	357.4	************	******	19012	1224
132 La-i	i(m+g)	4.8H	2102.8	5.9	0.5	1806	17272.
			1909.9	9.0	0.8	11584	20293.
			464.5	76	6	2108	1028.
					R_av	2131	1019.
132 La	c	4.8H	2102.8	5.9	0.5	43009	7807.
			1909.9	9.0	0.8	41923	11270.
			464.5	76	6	40273	3507.
					R_av	40776	3175.
130 La-i	i	8.7M	357.4	81	4	16894	1808
130 La	c	8.7M	357.4	81	4	35906	2485
133 Ba	c	3848.9D	356.0	62.05	0.19	45104	2360
131 Ba	c	11.50D	496.3	46.8	0.2	40358	1419.
			486.5	2.09	0.02	37680	1980.
			373.2	14.04	0.20	41486	1520.
			216.1	19.66	0.25	42527	1751.
			123.8	29.0	0.3	41035	2235.
					R_av	40839	1403.
128 Ba	c	2.43D	273.4	14.5	0.7	31689	2041
129 Cs	c	32.06H	411.5	22.3	1.3	41608	2872.
			371.9	30.6	1.7	44356	2923.
					R_av	42976	2258.
127 Cs	c	6.25H	412.0	62.8	1.0	29028	1221
127 Xe	c	36.4D	375.0	17.2	0.6	33513	1636.
			202.9	68.3	0.5	28421	1296.
					R_av	30258	2622.
125 Xe	c	16.9H	188.4	54.0	0.3	26091	1065
123 Xe	c	2.08H	148.9	48.9	0.6	30268	1832
120 Xe	c	40M	560.4	************	******	3273	1357
120 I -i	i	81.0M	560.4	73	0	12369	1868
120 I	c	81.0M	560.4	73	0	15642	851
121 Te-i	i(m+g)	19.16D	573.1	80.3	2.5	18424	854
121 Te	c	19.16D	573.1	80.3	2.5	19505	914
121mTe	i(m)	154D	573.1	88.6	0.1	1219	250.
			212.2	81.4	1.1	877.3	75.9
					R_av	903.2	94.7
119 Te	c	16.05H	1749.7	3.9	0.3	34874	4182
119mTe	i(m)	4.70D	1212.7	66.2	0.3	3222	122
117 Te	c	62M	719.7	64.7	1.4	11197	734
120mSb	i(m)	5.76D	1171.7	************	******	251.6	49.4
118mSb	i(m)	5.00H	1229.7	100	5	2333	191.
			1050.7	97	5	1744	288.
					R_av	2167	273.
115 Sb	c*	32.1M	497.3	97.9	0.4	8997	704
113 Sn	i(m+g)	115.09D	391.7	64.97	0.17	9298	1114
111 In	c	2.8047D	245.4	94	1	5047	915
110 In	i	4.9H	884.7	92.9	1.9	3925	266.
			657.8	98.3	2.0	6146	309.
					R_av	5006	1121.

108mIn	i(m)	58.0M	875.4	100	11	2556	441
110mAg	i(m)	249.76D	657.8	94.3	0.3	317.1	58.8
106mAg	i(m)	8.28D	1527.7	16.3	1.4	1820	230.
			824.7	15.3	0.5	2197	183.
			717.3	28.9	0.8	1872	119.
			616.2	21.6	0.7	1565	170.
			451.0	28.2	0.8	2068	248.
					R_av	1882	115.
105 Ag	c	41.29D	443.4	10.5	0.6	5750	444
100 Pd	c	3.63D	2376.0******************			1300	83
100 Rh-i	i(m+g)	20.8H	2376.0	32.6	0.4	4016	232
100 Rh	c	20.8H	2376.0	32.6	0.4	5316	274
99mRh	c	4.7H	340.8	70	5	2315	248
103 Ru	c	39.26D	497.1	91.0	1.3	216.8	142.8
96 Tc	i(m+g)	4.28D	849.9	98	4	2034	114.
			812.5	82	4	2044	125.
					R_av	2038	95.
94 Tc	c	293M	871.0	99.9	0.0	1848	186
93mMo	i(m)	6.85H	684.7	99.7	2.0	1161	133
90 Nb	c*	14.60H	2319.0	82.0	0.3	3020	201
89 Zr	c	78.41H	909.2	99.04	0.03	3600	130
88 Zr	c	83.4D	1836.1******************			2943	169.
			898.0******************			2136	132.
			392.9	97.24	0.00	2031	618.
					R_av	2329	73.
88 Y -i	i	106.65D	1836.1	99.2	0.3	2330	118.
			898.0	93.7	0.3	3126	131.
					R_av	2750	406.
88 Y	c	106.65D	1836.1	99.2	0.3	5273	203.
			898.0	93.7	0.3	5261	187.
					R_av	5265	179.
87mY	c*	13.37H	484.8	98.4	0.1	2597	809
87 Y -i	i	79.8H	484.8	89.7	0.7	1756	926
87 Y	c	79.8H	484.8	89.7	0.7	4311	217.
			388.5	82.1	0.5	5273	191.
					R_av	5041	440.
86 Y	c	14.74H	1854.4	17.2	0.5	4385	395.
			1076.6	82.5	0.4	3241	183.
					R_av	3407	417.
85 Sr	c	64.84D	514.0	96	4	5679	316
84 Rb	i(m+g)	32.77D	881.6	69.0	1.6	2328	101
83 Rb	c	86.2D	552.6	16.0	1.1	7942	702.
			529.6	29.3	2.1	9595	852.
			520.4	45	4	5235	552.
					R_av	6987	1280.
75 Se	c	119.779D	136.0	58.3	0.8	3207	185
74 As	i	17.77D	595.8	59	4	2086	199
58 Co	i(m+g)	70.86D	810.8	99.45	0.01	1824	213
59 Fe	c	44.472D	1291.6	43.2	1.4	1761	99.
			1099.2	56.5	1.9	1472	76.
					R_av	1574	146.
54 Mn	i	312.11D	834.8	99.98	0.00	2593	278
52 Mn	c	5.591D	1434.1	100.0	0.6	472.0	45.2
48 V	c	15.9735D	1312.1	97.5	0.9	845.2	43.7
			983.5	100.0	0.3	669.3	35.6
					R_av	740.8	89.4
48 Sc	i	43.67H	1312.1	100.1	0.7	1138	106.
			1037.5	97.6	0.7	1253	56.
					R_av	1237	56.

46 Sc	i(m+g)	83.79D	889.3	99.98	0.00	3204	173
44mSc	i(m)	58.61H	1157.0	108.4	0.5	669.4	50.7
28 Mg	c	20.915H	1778.8******************			938.2	60.1
24 Na	c	14.9590H	1369.0	100	0	5959	215
22 Na	c	2.6019Y	1274.5	99.94	0.01	1425	223
7 Be	i	53.29D	477.6	10.52	0.06	11023	441

Table 10.74: Detailed reaction rates for residual nuclide production in ^{nat}W at E_p=2605 MeV used to determine their production cross sections.

Nuclide	Type	$T_{1/2}$	E_γ, KeV	Abundance, %		Reaction rate 10^{-20} s^{-1}	
184 Re	i(m+g)	38.0D	903.3	37.9	1.1	9880	498.
			903.3	37.9	1.1	9664	505.
			792.1	37.5	1.1	10838	547.
					R_av	10094	471.
183 Re	i	70.0D	291.7	3.05	0.18	18653	1788.
			162.3	23.3	0.7	22404	1097.
					R_av	21654	1645.
182 Re	i	64.0H	1189.0	9.0	0.6	12810	1803.
			1121.3	22.0	1.4	19300	1747.
					R_av	16282	3277.
182mRe	i(m)	12.7H	1121.4	31.8	1.6	17325	1910
181 Re	i	19.9H	365.5	56	8	34111	5022
178 W	c	21.6D	1402.9	0.48	0.04	139520	15179.
			1350.6	1.18	0.11	131350	13622.
			1340.8	1.03	0.09	129240	13269.
					R_av	132850	8682.
177 W	c	135M	115.7	59.6	5.3	90687	9968
176 W	c	2.5H	1862.7******************			143810	52368.
			1823.7******************			87208	33602.
			1696.6******************			75437	58864.
			1252.9******************			55970	69010.
			1159.3******************			46851	22504.
			710.5******************			43676	23487.
					R_av	60701	13383.
174 W	c	31M	206.5******************			45879	9442
184 Ta	c*	8.7H	920.9	32.0	1.6	26684	1828.
			414.0	72	3	31715	1745.
					R_av	29510	2661.
183 Ta	c	5.1D	354.0	11.2	0.7	83821	5983.
			313.3	7.52	0.55	71915	5959.
			246.1	27	4	69512	11137.
			107.9	11.0	0.8	69843	6657.
					R_av	75269	4296.
182 Ta	i(m1+m2+g)	114.43D	1231.0	11.44	0.20	85821	3454.
			1221.4	27.0	0.5	87202	3317.
			1189.1	16.2	0.3	91621	3517.
					R_av	88253	3245.
178mTa	i(m)	2.36H	331.6	31.2	0.5	65598	3150.
			325.6	94.1	1.7	64926	5196.
					R_av	65464	2959.
177 Ta	c*	56.56H	112.9	7.2	1.6	228090	52399
176 Ta-i	i	8.09H	1862.7	4.0	0.3	91599	68985.
			1823.7	4.5	0.4	118610	44642.
			1696.6	4.6	0.4	185580	78338.
			1252.9	3.08	0.23	172370	92854.
			1159.3	24.7	1.9	184720	32496.
			710.5	5.4	0.4	187350	34382.
					R_av	168475	18263.
176 Ta	c	8.09H	1862.7	4.0	0.3	235410	26768.
			1823.7	4.5	0.4	205820	22706.
			1696.6	4.6	0.4	261020	31334.
			1252.9	3.08	0.23	228340	30636.
			1159.3	24.7	1.9	231570	20861.
			710.5	5.4	0.4	231030	20413.
					R_av	229653	11867.
175 Ta	c	10.5H	1793.1	4.6	0.7	170420	27048.

			1744.8	1.36	0.19	117990	19642.
			1736.7	0.92	0.14	184470	33204.
			266.9	10.52	0.16	195090	8997.
			125.9	9.0	1.3	260820	40277.
					R_av	187659	13672.
174 Ta-i	i	1.14H	206.5	60	5	98856	15124
174 Ta	c	1.14H	206.5	60	5	144730	13991
173 Ta	c	3.14H	172.2	17.5	1.8	175430	19658.
			160.4	4.9	0.8	210470	37486.
			139.6	**********	*******	108220	24100.
			123.7	**********	*******	137290	24055.
					R_av	153639	19562.
172 Ta	c*	36.8M	214.1	55	5	106890	12373
181 Hf	c	42.39D	482.2	80.5	0.5	8464	302
175 Hf	c	70D	343.4	84	3	251240	12320
173 Hf-i	i	23.6H	139.6	12.7	0.6	104150	26525.
			123.7	83	5	81570	23080.
					R_av	91338	17372.
173 Hf	c	23.6H	311.2	10.7	0.5	251550	15040.
			139.6	12.7	0.6	212380	14235.
			123.7	83	5	218870	17944.
					R_av	230616	14935.
172 Hf	c	1.87Y	1093.6	**********	*******	176170	10185.
			1022.4	**********	*******	150420	11779.
			912.1	**********	*******	132150	18500.
			810.1	**********	*******	164900	9880.
			181.5	**********	*******	173520	10684.
					R_av	168351	7256.
171 Hf	c	12.1H	780.7	**********	*******	115000	231826.
			739.8	**********	*******	163360	16256.
					R_av	163157	15861.
170 Hf	c	16.01H	2191.1	**********	*******	139500	31212.
			1512.5	**********	*******	157370	23333.
			1455.2	**********	*******	156170	13115.
			1364.6	**********	*******	165130	15247.
			1280.2	**********	*******	125260	11105.
			1054.3	**********	*******	121060	81061.
			985.1	**********	*******	113630	20791.
			620.7	18	5	208280	58405.
			501.6	3.7	1.0	145110	39888.
			164.7	26	8	201320	62443.
			120.2	15	5	190600	64434.
					R_av	144161	7757.
168 Hf	c	25.95M	1136.8	16.1	2.9	110440	21823.
			983.8	16	4	111160	30821.
			979.2	26.1	0.7	90952	9252.
			896.1	20.1	2.6	119930	16731.
					R_av	99630	7746.
173 Lu	c	1.37Y	272.1	21.2	0.8	220300	11836
172 Lu-i	i	6.70D	1093.6	63	3	27511	1591.
			1022.4	1.41	0.07	90689	24025.
			912.1	15.3	0.7	24814	1453.
			810.1	16.6	0.8	24192	1469.
			181.5	20.6	1.0	27485	1721.
					R_av	25860	1231.
172 Lu	c	6.70D	1093.6	63	3	203680	11770.
			1022.4	1.41	0.07	241120	26968.
			912.1	15.3	0.7	156960	19051.
			810.1	16.6	0.8	189090	11295.
			181.5	20.6	1.0	201010	12352.
					R_av	196004	10110.
171 Lu-i	i(m+g)	8.24D	780.7	4.36	0.11	112780	246823.
			739.8	47.8	1.2	55605	15898.
					R_av	55837	15824.
171 Lu	c	8.24D	853.0	2.55	0.07	234820	10114.
			839.9	3.04	0.08	238320	10229.
			780.7	4.36	0.11	227780	17804.
			739.8	47.8	1.2	218970	9106.
			689.3	2.37	0.06	226850	9661.
					R_av	228764	8068.
170 Lu-i	i(m+g)	2.012D	2191.1	1.64	0.08	92318	38739.
			1512.5	2.55	0.13	15933	28864.
			1455.2	1.18	0.06	7163	11602.

			1364.6	4.62	0.18	21570	16733.
			1280.2	8.2	0.4	41016	11059.
			1054.3	4.76	0.24	86403	116629.
			985.1	5.5	0.3	80010	27844.
					R_av	29493	9241.
170 Lu	c	2.012D	2191.1	1.64	0.08	231820	18312.
			1512.5	2.55	0.13	173310	13557.
			1455.2	1.18	0.06	163340	10424.
			1364.6	4.62	0.18	186700	10786.
			1280.2	8.2	0.4	166280	10339.
			1054.3	4.76	0.24	207470	38102.
			985.1	5.5	0.3	193650	15001.
					R_av	178860	9299.
169 Lu	c	34.06H	1466.8	3.32	0.11	172000	8963.
			1463.4	1.51	0.05	139950	9785.
			960.6	23.4	0.7	151760	6881.
			889.8	5.36	0.17	138810	7579.
			191.2	20.6	0.6	180180	9084.
					R_av	155842	9005.
167 Lu	c	51.5M	113.3	*****************		146930	11869
169 Yb	c*	32.026D	307.7	10.05	0.19	219110	8652.
			177.2	22.2	0.5	203360	8840.
			130.5	11.31	0.21	196920	10285.
					R_av	209444	9268.
167 Yb-i	i	17.5M	113.3	55	3	1998	5503
167 Yb	c	17.5M	113.3	55	3	148930	12468
166 Yb	c	56.7H	2092.1	*****************		178820	12690.
			2079.5	*****************		174690	13049.
			2052.4	*****************		180960	12527.
			1895.1	*****************		187730	63431.
			1867.9	*****************		183150	12854.
			1374.2	*****************		177780	14126.
			1273.5	*****************		167090	11771.
			1176.7	*****************		10793000.44701172.	
			785.9	*****************		171820	11967.
			691.2	8.56	0.58	153840	11846.
			594.4	*****************		150800	10850.
					R_av	170560	6404.
162 Yb	c	18.87M	798.7	*****************		146400	15793.
			163.4	40	5	136160	18068.
			118.7	34	4	82858	11209.
			102.0	*****************		9026	8037.
					R_av	73264	32603.
168 Tm	i	93.1D	720.4	12.0	0.4	4216	425.
			447.5	23.7	0.8	4631	426.
					R_av	4425	317.
167 Tm	c	9.25D	531.5	1.61	0.22	197000	28020.
			207.8	42	8	196670	38277.
					R_av	196887	22985.
166 Tm-i	i	7.70H	2092.1	1.56	0.09	3650	14050.
			2079.5	6.3	0.4	6628	3267.
			2052.4	17.2	1.0	8310	2139.
			1895.1	1.2	0.4	79306	39053.
			1867.9	4.04	0.24	13467	4249.
			1374.2	5.6	0.4	32082	5481.
			1273.5	14.9	0.9	26526	4387.
			1176.7	9.5	0.6	5636	6698.
			785.9	9.9	0.6	26132	11926.
			594.4	3.46	0.20	54451	13138.
					R_av	13116	3292.
166 Tm	c	7.70H	2092.1	1.56	0.09	182470	18193.
			2079.5	6.3	0.4	181320	13706.
			2052.4	17.2	1.0	189260	13212.
			1895.1	1.2	0.4	267040	93693.
			1867.9	4.04	0.24	196620	14166.
			1374.2	5.6	0.4	209870	17194.
			1273.5	14.9	0.9	193620	13983.
			1176.7	9.5	0.6	180490	14351.
			785.9	9.9	0.6	197960	17800.
			594.4	3.46	0.20	205250	18231.
					R_av	191969	7590.
165 Tm	c	30.06H	806.4	9.5	0.6	184750	13765.
			356.5	2.75	0.15	191210	23355.
					R_av	186265	12386.
163 Tm	c*	1.810H	1434.4	8.0	0.3	191050	16770.
			1397.5	7.03	0.24	171660	11830.
			1374.3	4.28	0.16	121050	15220.

			104.3	18.6	0.7	101090	8651.
					R_av	134123	21345.
162 Tm-i	i(m+g)	21.70M	798.7	8.4	0.7	13842	15566.
			102.0	17.5	1.5	91782	18140.
					R_av	49972	38898.
162 Tm	c	21.70M	798.7	8.4	0.7	160240	16458.
			102.0	17.5	1.5	100800	13367.
					R_av	124996	29462.
161 Tm	c	33M	1648.1	20	3	135610	23308.
			826.6	*****************		169670	18216.
					R_av	157733	16981.
161 Er-i	i	3.21H	826.6	64	4	2274	15590
161 Er	c*	3.21H	826.6	64	4	171940	12385
160 Er	c	28.58H	966.2	*****************		181610	24455.
			962.4	*****************		176720	23194.
			879.4	*****************		189970	24376.
			872.0	6.8	1.1	214660	35686.
			728.2	*****************		190790	28080.
			197.0	15.5	1.8	144060	18317.
					R_av	174405	11131.
159 Er	c*	36M	649.1	23	3	199570	27636.
			624.5	33	4	185410	23663.
			624.5	33	4	184340	24717.
					R_av	188939	15311.
157 Er	c*	18.65M	391.3	14.2	1.4	165200	18631
156 Er	c	19.5M	266.5	*****************		154240	15526
160mHo-i	i(m)	5.02H	966.2	15.4	2.0	2063	3749.
			962.4	16.6	2.1	14401	4324.
			879.4	18.6	2.3	4300	3595.
			728.2	28	4	6955	2805.
					R_av	6529	2301.
160mHo	c	5.02H	966.2	15.4	2.0	183680	24849.
			962.4	16.6	2.1	191130	25230.
			879.4	18.6	2.3	194270	25047.
			728.2	28	4	197740	29121.
					R_av	191246	13941.
160 Ho	i(m+g)	25.6M	728.2	46.9	1.7	23226	3591
156 Ho-i	i	56M	266.5	54.7	1.1	2020	17300
156 Ho	c	56M	266.5	54.7	1.1	156260	8023.
			137.8	51.1	0.8	175440	8954.
					R_av	164835	10838.
157 Dy	c	8.14H	326.2	92	4	177360	10231
155 Dy	c*	9.9H	226.9	68.4	1.6	164750	7685
152 Dy	c	2.38H	256.9	97.50	0.07	103590	4460
155 Tb	c*	5.32D	340.7	1.18	0.07	122440	9136.
			180.1	7.5	0.5	163650	12513.
			163.3	4.44	0.24	156720	10540.
					R_av	143508	13849.
153 Tb	c*	2.34D	212.0	31.0	1.9	130280	9586.
			102.2	6.4	0.5	146480	15419.
					R_av	134294	8320.
152 Tb	c	17.5H	344.3	65	4	140310	11192
151 Tb	c	17.609H	805.5	0.79	0.04	27881	77615.
			731.2	8.32	0.04	103800	5416.
			616.6	10.4	0.5	158820	11231.
			479.4	15.4	0.7	126620	7422.
			479.4	15.4	0.7	118130	7004.
			287.4	28.3	1.2	117330	6870.
			251.9	26.3	1.2	131270	8062.
			108.1	24.3	1.1	111360	9485.
					R_av	116855	6247.
150 Tb	c	3.48H	638.0	72	10	61916	8988.
			496.2	14.6	2.0	54499	8159.
					R_av	57855	6175.
149 Tb	c	4.118H	817.1	11.6	0.4	43836	3217.
			352.2	29.4	0.9	43911	2676.
					R_av	43909	1404.

148 Tb	c	60M	784.4	84.0	1.6	60304	3243.
			489.0	19.7	0.5	57537	4071.
					R_av	59355	2831.
147 Tb	c	1.7H	1152.2	100	8	12609	1431
153 Gd	c	240.4D	103.2	21.1	0.7	133360	9347.
			97.4	29.0	0.8	124730	9486.
					R_av	129188	7242.
151 Gd	c	124D	307.5	1.04	0.08	108140	11401.
			243.3	5.6	0.4	110980	9546.
			174.7	2.96	0.21	123450	10059.
			153.6	6.2	0.4	122640	9420.
					R_av	117002	5918.
149 Gd	c	9.28D	788.9	7.3	0.4	155690	9960.
			534.3	3.07	0.17	170990	11489.
			346.6	23.9	1.3	146740	9387.
			298.6	28.6	1.7	143580	9907.
			272.3	3.21	0.19	150860	11397.
			149.7	48	3	153550	11512.
					R_av	152720	6103.
147 Gd	c	38.06H	955.8*****************			152200	90026.
			929.0	20.2	1.2	130860	8976.
			861.7	1.75	0.10	110260	8736.
			677.5*****************			141510	53997.
			625.2	4.7	0.4	102190	10622.
			370.0	17.2	0.9	135340	8616.
			229.3	63	4	160190	11949.
					R_av	128949	7797.
146 Gd	c	48.27D	2436.7*****************			145510	9369.
			1756.1*****************			146800	8901.
			1686.4*****************			130000	6931.
			1533.7*****************			143710	6760.
			747.2*****************			138500	6201.
			154.6	46.6	0.5	135260	5153.
			115.5	44.0	0.7	146460	8608.
			114.7	44.0	0.7	138940	8121.
					R_av	138396	4716.
145 Gd	c	23.0M	1880.6	32.6	1.9	72088	7123.
			1757.9	34.2	2.0	82954	7029.
					R_av	77936	5939.
149 Eu	c	93.1D	327.5	4.03	0.12	173120	8108.
			277.1	3.56	0.06	161670	7094.
					R_av	166305	7654.
148 Eu	i	54.5D	725.7	12.7	0.4	9567	640.
			630.0	71.9	2.3	9074	423.
			611.3	20.5	0.7	8781	505.
			550.3	99	3	9197	426.
					R_av	9114	340.
147 Eu-i	i	24.1D	955.8	3.84	0.20	4019	95590.
			677.5	9.8	0.5	12215	56841.
					R_av	10074	48855.
147 Eu	c*	24.1D	955.8	3.84	0.20	156220	11416.
			798.7	4.8	0.3	188980	13399.
			677.5	9.8	0.5	153720	10046.
			197.3	26.5	1.1	158470	9050.
			121.2	22.9	1.3	157390	12247.
					R_av	160675	7422.
146 Eu-i	i	4.61D	2436.7	0.93	0.03	38438	7518.
			1756.1	0.92	0.04	23169	7371.
			1686.4	0.63	0.02	15835	6554.
			1533.7	6.08	0.19	29370	2544.
			747.2	99	3	25255	1262.
					R_av	25815	1487.
146 Eu	c	4.61D	2436.7	0.93	0.03	183950	11950.
			1756.1	0.92	0.04	169970	11243.
			1686.4	0.63	0.02	145830	8622.
			1533.7	6.08	0.19	173080	8178.
			747.2	99	3	163760	7334.
					R_av	165350	7541.
145 Eu	c	5.93D	1997.0	7.2	0.5	126590	9957.
			1804.3	1.07	0.07	149050	15164.
			1658.5	14.9	1.0	121920	9173.
			893.7	66	5	124580	10301.
			653.5	15	1	119680	8946.
					R_av	125089	5721.
144 Pm	i	363D	618.0	98.6	1.0	3741	179

143 Pm	c	265D	742.0	38.5	2.4	130870	9228
140mPm	i(m)	5.95M	1028.2	100	2	35093	5458.
			773.7	100	5	28491	6567.
					R_av	32431	4254.
139mNd	i(m)	5.5H	738.2	35	5	19809	3005
136 Nd	c	50.65M	1092.3*****************			129430	13817.
			574.8	10.4	1.1	104290	19907.
			552.2*****************			101320	7609.
					R_av	106335	8144.
136 Pr-i	i	13.1M	1092.3	18.5	1.2	23552	31418.
			552.2	76	5	20903	3967.
					R_av	20942	3866.
136 Pr	c	13.1M	1092.3	18.5	1.2	152980	29707.
			552.2	76	5	122220	9588.
					R_av	124759	9319.
134 Pr	c*	17M	409.2	87.1	0.0	90155	4476
139 Ce	c	137.640D	165.9	79.89	0.01	140130	5143
135 Ce	c	17.7H	783.6	10.6	0.4	139990	7599.
			606.8	18.8	0.7	120780	6240.
			606.8	18.8	0.7	119700	6158.
			577.1	5.14	0.19	111180	6447.
			300.1	23.5	0.6	135010	6170.
			206.5	7.77	0.25	141350	8954.
					R_av	126397	6152.
134 Ce	c	3.16D	604.7	5.04	0.20	112740	6356
133mCe	i(m)	4.9H	477.2	39.2	1.2	21261	1751
132 Ce	c	3.51H	2102.8*****************			97719	10892.
			1909.9*****************			103260	10756.
			464.5*****************			105760	9339.
					R_av	103013	5611.
130 Ce	c	25M	544.5*****************			52940	7443.
			357.4*****************			55487	3434.
					R_av	55269	2675.
132 La-i	i(m+g)	4.8H	2102.8	5.9	0.5	11744	10166.
			1909.9	9.0	0.8	3074	6198.
			464.5	76	6	1479	2419.
					R_av	2162	2200.
132 La	c	4.8H	2102.8	5.9	0.5	109460	11240.
			1909.9	9.0	0.8	106330	10535.
			464.5	76	6	107240	9315.
					R_av	107561	6525.
130 La-i	i	8.7M	544.5	16.2	1.8	59581	19173.
			357.4	81	4	34410	3794.
					R_av	35198	4520.
130 La	c	8.7M	544.5	16.2	1.8	112520	20332.
			357.4	81	4	89897	6021.
					R_av	91391	6303.
133 Ba	c	3848.9D	356.0	62.05	0.19	111780	4918
131 Ba	c	11.50D	496.3	46.8	0.2	113620	3919.
			486.5	2.09	0.02	112060	4159.
			373.2	14.04	0.20	118520	4329.
			216.1	19.66	0.25	118630	4960.
			123.8	29.0	0.3	114770	6036.
					R_av	114934	3820.
128 Ba	c	2.43D	273.4	14.5	0.7	107140	6757
126 Ba	c	100M	233.6	19.6	1.8	48493	5272
129 Cs	c	32.06H	411.5	22.3	1.3	129280	8839.
			371.9	30.6	1.7	138520	9085.
					R_av	133827	6991.
127 Cs	c	6.25H	412.0	62.8	1.0	99782	3988
127 Xe	c	36.4D	375.0	17.2	0.6	113470	5494.
			202.9	68.3	0.5	105330	4138.
					R_av	107473	4912.
125 Xe	c	16.9H	188.4	54.0	0.3	100710	4043
123 Xe	c	2.08H	148.9	48.9	0.6	107370	5252

122 Xe	c	20.1H	350.1	7.80	0.17	67155	4435
120 Xe	c	40M	560.4*****************			22828	2273
120 I -i	i	81.0M	560.4	73	0	48626	2974
120 I	c	81.0M	560.4	73	0	71454	2559
121 Te-i	i(m+g)	19.16D	573.1	80.3	2.5	80984	3726
121 Te	c	19.16D	573.1	80.3	2.5	84914	3909
121mTe	i(m)	154D	573.1	88.6	0.1	4437	347.
			212.2	81.4	1.1	4220	257.
					R_av	4290	225.
119 Te	c	16.05H	1749.7	3.9	0.3	101380	9589.
			644.0	84.0	0.5	71233	3367.
					R_av	73413	8138.
119mTe	i(m)	4.70D	1212.7	66.2	0.3	14231	495.
			1136.8	7.66	0.08	13879	1228.
			153.6	66	3	12173	757.
					R_av	14023	612.
117 Te	c	62M	719.7	64.7	1.4	65314	2973
114 Te	c	15.2M	1299.9	128.1	1.0	14573	1777
120mSb	i(m)	5.76D	1171.7*****************			1169	53.
			1023.3	99.4	0.3	116.9	489.6
					R_av	1162	91.
118mSb	i(m)	5.00H	1229.7	100	5	7795	555.
			1050.7	97	5	6316	721.
					R_av	7292	737.
115 Sb	c*	32.1M	497.3	97.9	0.4	63949	2548
113 Sn	i(m+g)	115.09D	391.7	64.97	0.17	52017	1786
111 In	c	2.8047D	245.4	94	1	65379	3263.
			171.3	90.2	1.0	48190	1916.
					R_av	51251	6769.
110 In	i	4.9H	937.5	68.4	1.4	23407	1167.
			884.7	92.9	1.9	22000	1085.
			657.8	98.3	2.0	45697	2144.
			641.7	25.9	0.6	20709	1275.
					R_av	24573	4211.
109 In	c	4.2H	203.5	73.5	0.5	31289	1847
108mIn	i(m)	58.0M	875.4	100	11	20144	2498.
			632.9	100	7	24514	2053.
					R_av	22840	2241.
110mAg	i(m)	249.76D	884.7	72.7	0.4	1039	108.
			657.8	94.3	0.3	1156	105.
					R_av	1100	79.
106mAg	i(m)	8.28D	1572.3	6.6	0.6	11008	1196.
			1527.7	16.3	1.4	13419	1251.
			1128.0	11.8	0.6	11972	824.
			1045.8	29.6	1.0	13769	668.
			824.7	15.3	0.5	13637	667.
			804.3	12.4	0.6	10514	727.
			717.3	28.9	0.8	11683	526.
			616.2	21.6	0.7	12028	671.
			451.0	28.2	0.8	12409	716.
					R_av	12330	530.
105 Ag	c	41.29D	644.5	11.1	0.6	38498	2522.
			443.4	10.5	0.6	38460	2596.
			344.5	41.4	0.6	35448	1334.
					R_av	35989	1392.
100 Pd	c	3.63D	2376.0*****************			11235	529.
			1553.3*****************			13237	600.
			1362.2*****************			10801	497.
			822.7*****************			10909	487.
					R_av	11405	635.
102mRh	i(m)	2.9Y	475.1	95	4	8021	464
100 Rh-i	i(m+g)	20.8H	2376.0	32.6	0.4	18734	1077.
			1553.3	20.67	0.18	9313	7315.
			1362.2	15.39	0.13	16586	1646.
			822.7	21.09	0.17	11914	1163.
					R_av	16065	1859.

100 Rh	c	20.8H	2376.0	32.6	0.4	29969	1499.
			1553.3	20.67	0.18	22550	7168.
			1362.2	15.39	0.13	27388	1733.
			822.7	21.09	0.17	22823	1306.
					R_av	26387	2022.
99mRh	c	4.7H	340.8	70	5	16684	1397
103 Ru	c	39.26D	497.1	91.0	1.3	1156	105
97 Ru	c	2.791D	215.7	85.6	0.0	25685	1434
96 Tc	i(m+g)	4.28D	849.9	98	4	12353	653.
			812.5	82	4	13143	775.
					R_av	12662	570.
94 Tc	c	293M	871.0	99.9	0.0	13807	706
93mMo	i(m)	6.85H	1477.1	99.1	2.5	11649	606.
			684.7	99.7	2.0	9440	534.
					R_av	10451	1148.
90 Nb	c*	14.60H	2319.0	82.0	0.3	19323	906.
			1129.2	92.7	0.5	20421	939.
					R_av	19862	828.
89 Zr	c	78.41H	909.2	99.04	0.03	25417	839
88 Zr	c	83.4D	1836.1******************			19779	698.
			898.0******************			17369	632.
			392.9	97.24	0.00	18790	654.
					R_av	18778	587.
88 Y -i	i	106.65D	1836.1	99.2	0.3	10150	363.
			898.0	93.7	0.3	11880	434.
					R_av	10812	906.
88 Y	c	106.65D	1836.1	99.2	0.3	29929	1043.
			898.0	93.7	0.3	29249	973.
					R_av	29482	976.
87mY	c*	13.37H	484.8	98.4	0.1	12960	8196.
			388.5	98.4	0.1	20712	13085.
					R_av	15145	6954.
87 Y -i	i	79.8H	484.8	89.7	0.7	13983	9505.
			388.5	82.1	0.5	6580	15171.
					R_av	11899	8057.
87 Y	c	79.8H	484.8	89.7	0.7	26735	1836.
			388.5	82.1	0.5	26961	2693.
					R_av	26801	1612.
86 Y	c	14.74H	1920.7	20.8	0.7	29969	1815.
			1854.4	17.2	0.5	22253	1694.
			1076.6	82.5	0.4	21147	813.
					R_av	21924	1805.
85 Sr	c	64.84D	514.0	96	4	26297	1424
83 Sr	c	32.41H	762.7	30	14	10912	5126
84 Rb	i(m+g)	32.77D	881.6	69.0	1.6	8054	335
83 Rb	c	86.2D	552.6	16.0	1.1	31102	2432.
			529.6	29.3	2.1	25621	2047.
			520.4	45	4	24819	2370.
					R_av	27003	2069.
82mRb	i(m)	6.472H	554.3	62.4	0.9	9994	787
77 Br	c	57.036H	520.7	22.4	0.6	18399	1188
75 Se	c	119.779D	136.0	58.3	0.8	17565	859
74 As	i	17.77D	595.8	59	4	8791	679
69mZn	i(m)	13.76H	438.6	94.77	0.20	2482	310
65 Zn	c	244.26D	1115.6	50.60	0.24	12360	506
60 Co	i(m+g)	5.2714Y	1332.5	99.99	0.00	9927	549.
			1173.2	99.97	0.00	8578	680.
			1173.2	99.97	0.00	10399	750.
					R_av	9675	572.
58 Co	i(m+g)	70.86D	810.8	99.45	0.01	10542	365
56 Co	c	77.233D	1238.3	66.9	0.6	1558	156.
			846.8	99.94	0.03	1462	64.
					R_av	1470	63.

59 Fe	c	44.472D	1291.6	43.2	1.4	6635	324.
			1099.2	56.5	1.9	6113	297.
					R_av	6350	327.
54 Mn	i	312.11D	834.8	99.98	0.00	13498	467
52 Mn	c	5.591D	1434.1	100.0	0.6	2247	93
48 V	c	15.9735D	1312.1	97.5	0.9	4274	152.
			983.5	100.0	0.3	4023	166.
					R_av	4197	175.
48 Sc	i	43.67H	1312.1	100.1	0.7	5294	241.
			1037.5	97.6	0.7	4884	252.
			983.5	100.1	0.6	3935	439.
					R_av	5011	316.
46 Sc	i(m+g)	83.79D	889.3	99.98	0.00	12242	411
44mSc	i(m)	58.61H	1157.0	108.4	0.5	3898	194
28 Mg	c	20.915H	1778.8	*****************		6434	336
24 Na	c	14.9590H	1369.0	100	0	32411	1124
22 Na	c	2.6019Y	1274.5	99.94	0.01	5317	321
7 Be	i	53.29D	477.6	10.52	0.06	57388	2210

10.7 Reaction rates for residual nuclide production in ^{27}Al

Table 10.75: Detailed calculations of reaction rates for nuclide productions in ^{27}Al monitors irradiated with ^{nat}Cr.

Sample	Energy of protons on monitor, MeV	^{27}Al(p,x)^{27}Mg reaction rate [10^{-20} s^{-1}]	^{27}Al(p,x)^{24}Na reaction rate [10^{-20} s^{-1}]	^{27}Al(p,x)^{22}Na reaction rate [10^{-20} s^{-1}]	^{27}Al(p,x)^{7}Be reaction rate [10^{-20} s^{-1}]
Cr	39	452(37)	2900(160)	78200(2600)	670(160)
	64	1175(81)	60400(2200)	139400(600)	3200(1200)
	96	866(45)	65200(2800)	111400(5100)	3990(420)
	147	658(38)	33500(1100)	58300(3400)	3880(380)
	248	2130(150)	80700(2700)	117300(7700)	14200(1600)
	398	2091(82)	63800(2200)	90200(4800)	14000(910)
	599	4220(190)	97000(3700)	117400(6200)	33400(1500)
	798	5180(210)	102900(3600)	114900(7900)	43700(1900)
	1198	5520(230)	94400(3200)	103700(4300)	55700(2000)
	1598	5900(3200)	71200(2500)	84400(3000)	52300(1900)
	2605	2780(200)	52200(1700)	60100(2200)	43900(1600)

Table 10.76: Detailed calculations of reaction rates for nuclide productions in ^{27}Al monitors irradiated with ^{56}Fe.

Sample	Energy of protons on monitor, MeV	^{27}Al(p,x)^{27}Mg reaction rate [10^{-20} s^{-1}]	^{27}Al(p,x)^{24}Na reaction rate [10^{-20} s^{-1}]	^{27}Al(p,x)^{22}Na reaction rate [10^{-20} s^{-1}]	^{27}Al(p,x)^{7}Be reaction rate [10^{-20} s^{-1}]
Fe	44	431(23)	33200(1200)	132600(4700)	1030(210)
	67	919(56)	57900(2000)	127100(6800)	2750(400)
	98	765(90)	62900(2200)	111200(5100)	4840(610)
	149	517(41)	34900(1200)	58800(3600)	3520(350)
	249	1830(240)	72300(2400)	115500(5700)	12010(770)
	399	1900(100)	70100(2400)	100600(6500)	17080(910)
	600	3750(210)	88500(3200)	127900(6500)	32300(1400)
	799	4220(240)	82800(2800)	108000(5100)	38800(1500)
	1198	4980(240)	80100(2700)	95200(3700)	49600(1800)
	1598	2880(170)	64500(2200)	73600(2600)	48500(1700)
	2605	2430(150)	46000(1500)	54000(1900)	39100(1400)

Table 10.77: Detailed calculations of reaction rates for nuclide productions in 72x72mm ^{27}Al monitors irradiated with ^{nat}Cr and ^{56}Fe.

Sample	Energy of protons on monitor, MeV	^{27}Al(p,x)^{27}Mg reaction rate [10^{-20} s^{-1}]	^{27}Al(p,x)^{24}Na reaction rate [10^{-20} s^{-1}]	^{27}Al(p,x)^{22}Na reaction rate [10^{-20} s^{-1}]	^{27}Al(p,x)^{7}Be reaction rate [10^{-20} s^{-1}]

Sample	Energy of protons on monitor, MeV	$^{27}Al(p,x)^{27}Mg$ reaction rate [10^{-20} s^{-1}]	$^{27}Al(p,x)^{24}Na$ reaction rate [10^{-20} s^{-1}]	$^{27}Al(p,x)^{22}Na$ reaction rate [10^{-20} s^{-1}]	$^{27}Al(p,x)^{7}Be$ reaction rate [10^{-20} s^{-1}]
Cr+Fe (72x72)	39	14.6(2.6)	244(11)	4350(160)	-
	64	32.8(3.4)	1459(64)	-	-
	96	28.9(2.8)	1352(47)	-	-
	147	22.5(3.2)	1327(46)	3020(900)	-
	248	47(3.9)	1192(41)	-	-
	398	67.4(5.9)	1737(60)	2370(110)	1340(790)
	599	132.2(7.1)	1702(58)	-	-
	798	264(15)	2654(92)	-	-
	1198	210(13)	1874(68)	-	-
Cr (72x72)	1598	93.4(5.4)	1493(52)	-	1090(220)
	2605	-	1114(36)	-	3620(240)
Fe (72x72)	1598	68(4.1)	1329(47)	-	-
	2605	-	1115(42)	-	-

Table 10.78: Detailed calculations of reaction rates for nuclide productions in ^{27}Al monitors irradiated with ^{nat}Ni.

Sample	Energy of protons on monitor, MeV	$^{27}Al(p,x)^{27}Mg$ reaction rate [10^{-20} s^{-1}]	$^{27}Al(p,x)^{24}Na$ reaction rate [10^{-20} s^{-1}]	$^{27}Al(p,x)^{22}Na$ reaction rate [10^{-20} s^{-1}]	$^{27}Al(p,x)^{7}Be$ reaction rate [10^{-20} s^{-1}]
Ni	42	624(32)	7010(260)	165000(20000)	4000(2400)
	66	272(47)	19950(680)	45200(2000)	1250(160)
	97	720(93)	49700(1600)	141500(6300)	3630(370)
	148	990(62)	57300(2000)	106700(6100)	5860(750)
	248	1830(110)	76600(2600)	106400(5200)	11170(630)
	399	1283(87)	46700(1500)	63400(4500)	10040(640)
	599	4000(180)	99700(3200)	120300(8800)	33700(1400)
	799	1941(85)	38800(1300)	51000(2400)	16960(640)
	1198	2810(160)	45600(1400)	52600(2000)	25770(870)
	1599	2780(180)	60400(1900)	69800(2400)	42900(1400)
	2605	2490(260)	62200(2000)	79100(2900)	52200(1700)

Table 10.79: Detailed calculations of reaction rates for nuclide productions in ^{27}Al monitors irradiated with ^{93}Nb.

Sample	Energy of protons on monitor, MeV	$^{27}Al(p,x)^{27}Mg$ reaction rate [10^{-20} s^{-1}]	$^{27}Al(p,x)^{24}Na$ reaction rate [10^{-20} s^{-1}]	$^{27}Al(p,x)^{22}Na$ reaction rate [10^{-20} s^{-1}]	$^{27}Al(p,x)^{7}Be$ reaction rate [10^{-20} s^{-1}]
Nb	45	606(35)	68800(2400)	211200(8600)	1970(550)
	68	237(38)	20490(720)	41000(2800)	1200(140)
	98	661(87)	76500(2600)	140500(6300)	5700(500)
	149	778(68)	61300(2100)	105800(4900)	6480(470)
	249	1910(140)	77900(2800)	113700(5100)	12080(660)
	399	1175(78)	46200(1600)	62700(5400)	78100(4700)
	600	3720(190)	100100(3400)	136200(6300)	35000(1500)
	799	1790(120)	36600(1200)	47900(2400)	17750(720)
	1199	3100(230)	43900(1500)	52600(2100)	27700(1100)
	1599	3360(210)	67200(2300)	79400(2900)	49700(1800)
	2605	4570(290)	69400(2300)	79300(3000)	60000(2100)

Table 10.80: Detailed calculations of reaction rates for nuclide productions in 72x72mm ^{27}Al monitors irradiated with ^{nat}Ni and ^{93}Nb.

Sample	Energy of protons on monitor, MeV	$^{27}Al(p,x)^{27}Mg$ reaction rate [10^{-20} s^{-1}]	$^{27}Al(p,x)^{24}Na$ reaction rate [10^{-20} s^{-1}]	$^{27}Al(p,x)^{22}Na$ reaction rate [10^{-20} s^{-1}]	$^{27}Al(p,x)^{7}Be$ reaction rate [10^{-20} s^{-1}]
Ni+Nb (72x72)	39	-	2112(94)	-	-
	64	8.5(2.7)	722(25)	-	-
	96	27(3.3)	1427(50)	-	-
	147	30.5(2.6)	1839(63)	-	-
	248	42.3(3.0)	1572(55)	2332(95)	-
	398	20.9(3.2)	410(15)	-	-

Sample	Energy of protons on monitor, MeV	$^{27}Al(p,x)^{27}Mg$ reaction rate [10^{-20} s^{-1}]	$^{27}Al(p,x)^{24}Na$ reaction rate [10^{-20} s^{-1}]	$^{27}Al(p,x)^{22}Na$ reaction rate [10^{-20} s^{-1}]	$^{27}Al(p,x)^{7}Be$ reaction rate [10^{-20} s^{-1}]
	599	120(15)	2172(75)	-	-
	798	-	1715(58)	-	-
	1198	90(13)	848(27)	-	-
Ni (72x72)	1598	66.9(4.1)	1343(44)	-	1190(200)
	2605	-	1338(43)	-	-
Nb (72x72)	1598	80.1(5.0)	1342(47)	-	-
	2605	-	1475(53)	-	-

Table 10.81: Detailed calculations of reaction rates for nuclide productions in ^{27}Al monitors irradiated with ^{181}Ta.

Sample	Energy of protons on monitor, MeV	$^{27}Al(p,x)^{27}Mg$ reaction rate [10^{-20} s^{-1}]	$^{27}Al(p,x)^{24}Na$ reaction rate [10^{-20} s^{-1}]	$^{27}Al(p,x)^{22}Na$ reaction rate [10^{-20} s^{-1}]	$^{27}Al(p,x)^{7}Be$ reaction rate [10^{-20} s^{-1}]
Ta	41	863(34)	6960(250)	165000(20000)	880(200)
	64	493(45)	20350(690)	46600(2200)	820(130)
	96	1081(78)	38100(1500)	97200(5200)	2610(350)
	147	1781(99)	55800(1800)	95800(4200)	5090(330)
	248	3540(300)	85000(3000)	130800(5500)	12050(570)
	398	3510(180)	54300(1900)	252000(16000)	11100(680)
	599	7190(280)	74400(2400)	78300(7900)	22420(960)
	798	8960(340)	80300(2600)	101100(4100)	33200(1300)
	1198	13180(560)	97000(3100)	108500(4500)	51800(1700)
	1599	7910(310)	67900(2100)	74700(2400)	44200(1500)
	2605	12440(730)	78600(2500)	85000(2900)	135000(4400)

Table 10.82: Detailed calculations of reaction rates for nuclide productions in ^{27}Al monitors irradiated with ^{nat}W.

Sample	Energy of protons on monitor, MeV	$^{27}Al(p,x)^{27}Mg$ reaction rate [10^{-20} s^{-1}]	$^{27}Al(p,x)^{24}Na$ reaction rate [10^{-20} s^{-1}]	$^{27}Al(p,x)^{22}Na$ reaction rate [10^{-20} s^{-1}]	$^{27}Al(p,x)^{7}Be$ reaction rate [10^{-20} s^{-1}]
W	45	569(31)	69800(2400)	226200(9200)	1720(560)
	67	386(30)	22690(770)	47800(1900)	1158(94)
	98	869(65)	54200(1900)	70000(2600)	2770(290)
	149	1610(100)	56200(1900)	89900(4500)	5880(380)
	249	3090(170)	79400(3400)	120900(4900)	13140(640)
	399	3140(200)	55800(2000)	77000(4500)	14980(830)
	600	7100(310)	73400(2500)	92400(4600)	25800(1100)
	799	8070(350)	80500(2700)	102900(5200)	36100(1600)
	1199	12640(520)	97100(3300)	103700(4700)	56200(2100)
	1599	4800(2200)	33800(1200)	38700(1600)	23200(1300)
	2605	10290(430)	74400(2500)	79100(3400)	58600(2100)

Table 10.83: Detailed calculations of reaction rates for nuclide productions in 72x72mm ^{27}Al monitors irradiated with ^{181}Ta and ^{nat}W.

Sample	Energy of protons on monitor, MeV	$^{27}Al(p,x)^{27}Mg$ reaction rate [10^{-20} s^{-1}]	$^{27}Al(p,x)^{24}Na$ reaction rate [10^{-20} s^{-1}]	$^{27}Al(p,x)^{22}Na$ reaction rate [10^{-20} s^{-1}]	$^{27}Al(p,x)^{7}Be$ reaction rate [10^{-20} s^{-1}]
Ta+W (72x72)	39	20.3(1.7)	359(13)	7250(810)	-
	64	16.9(2.0)	736(26)	620(400)	-
	96	36(2.7)	1196(41)	2480(910)	-
	147	54.7(3.6)	1594(55)	2260(470)	-
	248	85.6(5.3)	1192(44)	2120(620)	1100(320)
	398	136.5(7.1)	2193(78)	-	-
	599	153(16)	1906(66)	-	-
	798	230(13)	2139(73)	2450(370)	1070(100)
	1198	375(26)	2110(71)	-	-
Ta (72x72)	1598	192(16)	1524(50)	-	-
	2605	283(12)	1729(60)	-	-
W (72x72)	1598	89.9(4.5)	1436(50)	-	-

Sample	Energy of protons on monitor, MeV	$^{27}Al(p,x)^{27}Mg$ reaction rate $[10^{-20}\ s^{-1}]$	$^{27}Al(p,x)^{24}Na$ reaction rate $[10^{-20}\ s^{-1}]$	$^{27}Al(p,x)^{22}Na$ reaction rate $[10^{-20}\ s^{-1}]$	$^{27}Al(p,x)^{7}Be$ reaction rate $[10^{-20}\ s^{-1}]$
	2605	229.4(9.8)	1527(51)	-	1300(120)

10.8 Reaction rates for residual nuclide production in additional irradiations

Table 10.84: Calculations of reaction rates for ^{7}Be productionsin ^{nat}Cr, ^{56}Fe, ^{181}Ta and ^{nat}W in additional irradiations.

Sample	Energy of protons on monitor, MeV	$^{27}Al\ (p,x)\ ^{7}Be$ reaction rate $[10^{-20}\ s^{-1}]$
Cr	40	134.3 (21.6)
	66	1162 (90)
	97	1709 (100)
	148	2376 (119)
Fe	45	287.9 (31.5)
	67	1152 (86)
	99	1537 (96)
	149	2256 (162)
Ta	44	113.9 (25.9)
	67	989.0 (248.5)
	98	1328 (158)
	148	1942 (332)
W	99	2061 (258)
	149	2678 (484)

Table 10.85: Calculations of reaction rates for ^{22}Na productionsin ^{nat}Cr, ^{56}Fe, ^{181}Ta and ^{nat}W in additional irradiations.

Sample	Energy of protons on monitor, MeV	$^{27}Al(p,x)^{27}Mg$ reaction rate $[10^{-20}\ s^{-1}]$	$^{27}Al(p,x)^{24}Na$ reaction rate $[10^{-20}\ s^{-1}]$	$^{27}Al(p,x)^{22}Na$ reaction rate $[10^{-20}\ s^{-1}]$	$^{27}Al(p,x)^{7}Be$ reaction rate $[10^{-20}\ s^{-1}]$
Cr (Be)	37	-	-	71700(2500)	-
	62	-	-	137900(4700)	-
	96	-	-	114300(3900)	-
	147	-	-	117200(4200)	-
Fe (Be)	42	-	-	90500(3100)	-
	65	-	-	130500(4500)	-
	98	-	-	112200(3900)	-
	148	-	-	117000(4300)	-
Ta (Be)	42	-	-	156900(5400)	-
	67	-	-	139200(4600)	4300(160)
	98	-	-	101600(3600)	-
	148	-	-	117000(4200)	-
W (Be)	46	-	-	146700(5000)	-
	69	-	-	135100(5500)	4020(150)
	99	-	-	103200(3600)	-
	149	-	-	116500(4400)	-

11. APPENDIX 2. RADIOACTIVE DECAY CHAINS USED IN THE SIMULATIONS.

11.1 Decay chains of ^{nat}Cr products.

Table 11.1: Chain of $^{54}_{25}Mn-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
25054	0						

Table 11.2: Chain of $^{52}_{25}Mn-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
25052	0						

Table 11.3: Chain of $^{51}_{24}Cr-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
24051	1	1.	25051				
25051	0						

Table 11.4: Chain of $^{49}_{24}Cr-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
24051	1	1.	25049				
25051	0						

Table 11.5: Chain of $^{48}_{24}Cr-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
24051	1	0.99719	25048				
25051	0						

Table 11.6: Chain of $^{48}_{23}V-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
23048	1	1.	24048				
24048	1	0.99719	25048				
25048	0						

Table 11.7: Chain of $^{48}_{21}Sc-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
21048	0						

Table 11.8: Chain of $^{47}_{21}Sc-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
21047	0						

Table 11.9: Chain of ${}^{47}_{21}Sc-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
21047	1	1.	20047				
20047	2	1.	19047	0.0114	19048		
19047	1	0.99	18047				
19048	0						
18047	1	1.	17047				
17047	0						

Table 11.10: Chain of ${}^{46}_{21}Sc-i(m+g)$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
21046	0						

Table 11.11: Chain of ${}^{44}_{21}Sc-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
21044	0						

Table 11.12: Chain of ${}^{44}_{21}Sc-i(m+g)$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
21044	0						

Table 11.13: Chain of ${}^{43}_{21}Sc-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
21043	1	1.	22043				
22043	2	1.	23043	0.07	24044		
23043	2	0.71	24043	0.07	25044		
24044	2	0.93	25044	1.	25045		
24043	0						
25044	0						
25045	0						

Table 11.14: Chain of ${}^{47}_{20}Ca-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
20047	2	1.	19047	0.0114	19048		
19047	1	0.99	18047				
19048	0						
18047	1	1.	17047				
17047	0						

Table 11.15: Chain of ${}^{45}_{19}K-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)

19045	1	1.	18045				
18045	2	0.76	17045	0.6	17046		
17045	0						
17046	0						

Table 11.16: Chain of ${}^{44}_{19}K-c*$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
19044	1	1.	18044				
18044	2	0.92	17044	0.24	17045		
17044	0						
17045	0						

Table 11.17: Chain of ${}^{43}_{19}K-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
19043	1	1.	18043				
18043	2	1.	17043	0.08	17044		
17043	0						
17044	0						

Table 11.18: Chain of ${}^{42}_{19}K-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
19042	0						

Table 11.19: Chain of ${}^{38}_{19}K-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
19038	0						

Table 11.20: Chain of ${}^{41}_{18}Ar-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
18041	1	1.	17041				
17041	0						

Table 11.21: Chain of ${}^{39}_{17}Cl-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
17039	0						

Table 11.22: Chain of ${}^{38}_{17}Cl-i(m+g)$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
17038	0						

Table 11.23: Chain of ${}^{38}_{17}Cl-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
17038	0						

Table 11.24: Chain of $^{38}_{16}S-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
16038	2	0.9	15038	0.26	15039		
15038	0						
15039	2	1.	14039	1.	14040		
14039	2	1.	13039	1.	13040		
14040	0						
13039	0						
13040	0						

Table 11.25: Chain of $^{29}_{13}Al-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
13029	1	1.	12029				
12029	2	0.785	11029	0.3	11030		
11029	2	0.73	10029	0.26	10030		
11030	1	0.74	10030				
10029	0						
10030	0						

Table 11.26: Chain of $^{28}_{12}Mg-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching 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 11.27: Chain of $^{27}_{12}Mg-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
12027	2	0.9987	11027	0.0058	11028		
11027	2	0.98	10027	0.16	10028		
11028	2	0.84	10028	0.27	10029		
10027	1	0.23	9027				
10028	1	1.	9029				
10029	0						
9027	1	1.	9028				
9029	0						
9028	0						

Table 11.28: Chain of ${}^{24}_{11}Na-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching 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 11.29: Chain of ${}^{22}_{11}Na-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
11022	2	1.	12022	0.011	13023		
12022	2	0.3879	13022	0.73	14023		
13023	1	0.27	14023				
13022	1	0.68	14022				
14023	0						
14022	0						

Table 11.30: Chain of ${}^{7}_{4}Be-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
4007	0						

11.2. Decay chains of ^{56}Fe products.

Table 11.31 Chain of ${}^{57}_{27}Co-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
27057	0						

Table 11.32 Chain of ${}^{56}_{27}Co-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
27056	0						

Table 11.33 Chain of ${}^{55}_{27}Co-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
27055	0						

Table 11.34 Chain of ${}^{53}_{26}Fe-c*$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
26053	1	1.	27053				
27053	0						

Table 11.35 Chain of $^{52}_{26}Fe-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
26052	1	1.	27052				
27052	0						

Table 11.36 Chain of $^{56}_{25}Mn-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
25056	1	1.	24056				
24056	1	1.	23056				
23056	1	1.	22056				
22056	1	1.	21056				
21056	1	1.	20056				
20056	1	0.5	21057				
21057	0						

Table 11.37 Chain of $^{54}_{25}Mn-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
25054	0						

Table 11.38 Chain of $^{52}_{25}Mn-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
25052	1	1.	26052				
26052	1	1.	27052				
27052	0						

Table 11.39 Chain of $^{51}_{24}Cr-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
24051	1	1.	25051				
25051	1	1.	26051				
26051	1	1.	27051				
27051	0						

Table 11.40 Chain of $^{49}_{24}Cr-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
24049	1	1.	25049				
25049	2	0.48	26049	0.54	27050		
26049	1	0.5	27049				
27050	0						
27049	0						

Table 11.41 Chain of $^{48}_{24}Cr-c$

(Z,A)	N. of	Branching	(Z,A)	Branching	(Z,A)	Branching	(Z,A)

	entries	factor		factor		factor	
24048	2	0.99719	25048	0.52	26049		
25048	1	0.964	26048				
26049	1	0.5	27049				
26048	1	0.5	27049				
27049	0						

Table 11.42 Chain of ${}^{48}_{23}V-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching 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	0						

Table 11.43 Chain of ${}^{48}_{21}Sc-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
21048	0						

Table 11.44 Chain of ${}^{47}_{21}Sc-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
21047	0						

Table 11.45 Chain of ${}^{47}_{21}Sc-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
21047	1	1.	20047				
20047	2	1.	19047	0.0114	19048		
19047	1	0.99	18047				
19048	0						
18047	1	1.	17047				
17047	0						

Table 11.46 Chain of ${}^{46}_{21}Sc-i(m+g)$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
21046	0						

Table 11.47 Chain of ${}^{44}_{21}Sc-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
21044	0						

Table 11.48 Chain of ${}^{44}_{21}Sc-i(m+g)$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
21044	0						

Table 11.49 Chain of $^{43}_{21}Sc-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
21043	1	1.	22043				
22043	2	1.	23043	0.07	24044		
23043	2	0.71	24043	0.07	25044		
24044	2	0.93	25044	1.	25045		
24043	0						
25044	1	1.	26045				
25045	0						
26045	0						

Table 11.50 Chain of $^{47}_{20}Ca-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
20047	2	1.	19047	0.0114	19048		
19047	1	0.99	18047				
19048	0						
18047	1	1.	17047				
17047	0						

Table 11.51 Chain of $^{44}_{19}K-c*$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
19044	1	1.	18044				
18044	2	0.92	17044	0.24	17045		
17044	0						
17045	0						

Table 11.52 Chain of $^{43}_{19}K-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
19043	1	1.	18043				
18043	2	1.	17043	0.08	17044		
17043	0						
17044	0						

Table 11.53 Chain of $^{42}_{19}K-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
19042	0						

Table 11.54 Chain of $^{38}_{19}K-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)

19038	0						

Table 11.55 Chain of ${}^{41}_{18}Ar-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
18041	1	1.	17041				
17041	0						

Table 11.56 Chain of ${}^{39}_{17}Cl-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
17039	0						

Table 11.57 Chain of ${}^{38}_{17}Cl-i(m+g)$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
17038	0						

Table 11.58 Chain of ${}^{38}_{17}Cl-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
17038	0						

Table 11.59 Chain of ${}^{38}_{16}S-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
16038	2	0.9	15038	0.26	15039		
15038	0						
15039	2	1.	14039	1.	14040		
14039	2	1.	13039	1.	13040		
14040	0						
13039	0						
13040	0						

Table 11.60 Chain of ${}^{29}_{13}Al-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
13029	1	1.	12029				
12029	2	0.785	11029	0.3	11030		
11029	2	0.73	10029	0.26	10030		
11030	1	0.74	10030				
10029	0						
10030	0						

Table 11.61 Chain of ${}^{28}_{12}Mg-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching 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 11.62 Chain of ${}^{27}_{12}Mg-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
12027	2	0.9987	11027	0.0058	11028		
11027	2	0.98	10027	0.16	10028		
11028	2	0.84	10028	0.27	10029		
10027	1	0.23	9027				
10028	1	1.	9029				
10029	0						
9027	1	1.	9028				
9029	0						
9028	0						

Table 11.63 Chain of ${}^{24}_{11}Na-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching 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 11.64 Chain of ${}^{22}_{11}Na-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
11022	2	1.	12022	0.011	13023		
12022	2	0.3879	13022	0.73	14023		
13023	1	0.27	14023				
13022	1	0.68	14022				
14023	0						
14022	0						

Table 11.65 Chain of ${}^{7}_{4}Be-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
4007	0						

11.3 Decay chains of ^{nat}Ni products.

Table 11.66: Chain of ${}^{61}_{29}Cu-i$

(Z,A)	N. of	Branching	(Z,A)	Branching	(Z,A)	Branching

	entries	factor		factor		factor
29060	0					

Table 11.67: Chain of $^{60}_{29}Cu-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor
29060	0					

Table 11.68: Chain of $^{57}_{28}Ni-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor
28057	0					

Table 11.69: Chain of $^{56}_{28}Ni-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor
28056	0					

Table 11.70: Chain of $^{60}_{27}Co-i(m+g)$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor
27060	0					

Table 11.71: Chain of $^{58}_{27}Co-i(m+g)$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor
27058	0					

Table 11.72: Chain of $^{57}_{27}Co-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor
27057	0					

Table 11.73: Chain of $^{57}_{27}Co-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor
27057	1	1.	28057			
28057	1	1.	29057			
29057	0					

Table 11.74: Chain of $^{56}_{27}Co-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor
27056	0					

Table 11.75: Chain of $^{56}_{27}Co-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor

27056	1	1.	28057			
28059	1	1.	29057			

Table 11.76: Chain of $^{55}_{27}Co-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor
27055	1	1.	28055			
28055	1	1.	29055			
29055	0					

Table 11.77: Chain of $^{59}_{26}Fe-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor
26059	1	1.	25059			
25059	1	1.	24059			
24059	1	1.	23059			
23059	1	1.	22059			
22059	0					

Table 11.78: Chain of $^{53}_{26}Fe-c*$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor
26053	1	1.	27053			
27053	1	0.55	28053			
28053	2	0.5	29053	1.	29054	
29053	0					
29054	0					

Table 11.79: Chain of $^{52}_{26}Fe-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor
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	0					
29052	0					

Table 11.80: Chain of $^{56}_{25}Mn-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor
25056	1	1.	24056			
24056	1	1.	23056			
23056	1	1.	22056			
22056	1	1.	21056			
21056	1	1.	20056			
20056	1	0.5	21057			
21057	1	0.65	23058			

23058	0					

Table 11.81: Chain of ${}^{54}_{25}Mn-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor
25054	0					

Table 11.82: Chain of ${}^{52}_{25}Mn-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor
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	0					
29052	0					

Table 11.83: Chain of ${}^{51}_{24}Cr-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor
24051	1	1.	25051			
25051	1	1.	26051			
26051	2	1.	27051	0.17	28052	
27051	2	1.	28051	0.17	29052	
28052	2	0.83	29052	0.5	29053	
28051	0					
29052	0					
29053	0					

Table 11.84: Chain of ${}^{49}_{24}Cr-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor
24049	1	1.	25049			
25049	2	0.48	26049	0.54	27050	
26049	1	0.5	27049			
27050	1	1.	28050			
27049	1	0.5	28049			
28050	0					
28049	0					

Table 11.85: Chain of ${}^{48}_{24}Cr-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor
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 11.86: Chain of $^{48}_{23}V-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor
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 11.87: Chain of $^{48}_{21}Sc-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor
21048	0					

Table 11.88: Chain of $^{47}_{21}Sc-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor
21047	1	1.	20047			
20047	2	1.	19047	0.0114	19048	
19047	1	0.99	18047			
19048	0					
18047	1	1.	17047			
17047	0					

Table 11.89: Chain of $^{46}_{21}Sc-i(m+g)$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor
21046	0					

Table 11.90: Chain of $^{44}_{21}Sc-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor
21044	0					

Table 11.91: Chain of $^{44}_{21}Sc-i(m+g)$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor
21044	0					

Table 11.92: Chain of $^{43}_{21}Sc-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor
21043	1	1.	22043			

22043	2	1.	23043	0.07	24044	
23043	2	0.71	24043	0.07	25044	
24044	2	0.93	25044	1.	25045	
24043	0					
25044	1	1.	26045			
25045	0					
26045	0					

Table 11.93: Chain of ${}^{47}_{20}Ca-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor
20047	2	1.	19047	0.0114	19048	
19047	1	0.99	18047			
19048	0					
18047	1	1.	17047			
17047	0					

Table 11.94: Chain of ${}^{43}_{19}K-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor
19043	1	1.	18043			
18043	2	1.	17043	0.08	17044	
17043	0					
17044	0					

Table 11.95: Chain of ${}^{42}_{19}K-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor
19042	0					

Table 11.96: Chain of ${}^{38}_{19}K-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor
19038	0					

Table 11.97: Chain of ${}^{41}_{18}Ar-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor
18041	1	1.	17041			
17041	0					

Table 11.98: Chain of ${}^{39}_{17}Cl-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor
17039	0					

Table 11.99: Chain of ${}^{38}_{17}Cl-i(m+g)$

(Z,A)	N. of	Branching	(Z,A)	Branching	(Z,A)	Branching

	entries	factor		factor		factor
17038	0					

Table 11.100: Chain of ${}^{38}_{17}Cl-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor
17038	0					

Table 11.101: Chain of ${}^{38}_{16}S-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor
16038	2	0.9	15038	0.26	15039	
15038	0					
15039	2	1.	14039	1.	14040	
14039	2	1.	13039	1.	13040	
14040	0					
13039	0					
13040	0					

Table 11.102: Chain of ${}^{29}_{13}Al-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor
13029	1	1.	12029			
12029	2	0.785	11029	0.3	11030	
11029	2	0.73	10029	0.26	10030	
11030	1	0.74	10030			
10029	0					
10030	0					

Table 11.103: Chain of ${}^{28}_{12}Mg-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor
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 11.104: Chain of ${}^{27}_{12}Mg-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor
12027	2	0.9987	11027	0.0058	11028	
11027	2	0.98	10027	0.16	10028	
11028	2	0.84	10028	0.27	10029	
10027	1	0.23	9027			
10028	1	1.	9029			

10029	0					
9027	1	1.	9028			
9029	0					
9028	0					

Table 11.105: Chain of $^{24}_{11}Na-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor
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 11.106: Chain of $^{22}_{11}Na-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor
11022	2	1.	12022	0.011	13023	
12022	2	0.3879	13022	0.73	14023	
13023	1	0.27	14023			
13022	1	0.68	14022			
14023	0					
14022	0					

Table 11.107: Chain of $^{7}_{4}Be-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor
4007	0					

11.4 Decay chains of ^{93}Nb products.

Table 11.108: Chain of $^{91}_{42}Mo-i(m+g)$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
42091	0						

Table 11.109: Chain of $^{90}_{42}Mo-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
42090	0						

Table 11.110: Chain of $^{90}_{41}Nb-i(m+g)$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
41090	0						

Table 11.111: Chain of $^{90}_{41}Nb-c$

(Z,A)	N. of	Branching	(Z,A)	Branching	(Z,A)	Branching	(Z,A)

	entries	factor		factor		factor	
41090	1	1.	42090				
42090	0						

Table 11.112: Chain of $^{89}_{41}Nb-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
41089	1	1.	42089				
42089	0						

Table 11.113: Chain of $^{88}_{41}Nb-c*$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
41088	1	1.	42088				
42088	0						

Table 11.114: Chain of $^{89}_{40}Zr-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
40089	1	1.	41089				
41089	1	1.	42089				
42089	0						

Table 11.115: Chain of $^{88}_{40}Zr-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
40088	1	1.	41088				
41088	1	1.	42088				
42088	0						

Table 11.116: Chain of $^{87}_{40}Zr-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
40087	1	1.	41087				
41087	1	0.85	42087				
42087	0						

Table 11.117: Chain of $^{86}_{40}Zr-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
40086	2	1.	41086	0.15	42087		
41086	1	1.	42086				
42087	0						
42086	0						

Table 11.118: Chain of $^{85}_{40}Zr-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)

40085	1	1.	41085				
41085	1	1.	42085				
42085	0						

Table 11.119: Chain of $^{88}_{39}Y-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
39088	0						

Table 11.120: Chain of $^{88}_{39}Y-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
39088	1	1.	40088				
40088	1	1.	41088				
41088	1	1.	42088				
42088	0						

Table 11.121: Chain of $^{87}_{39}Y-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
39087	1	1.	40087				
40087	1	1.	41087				
41087	1	0.85	42087				
42087	0						

Table 11.122: Chain of $^{86}_{39}Y-i(m+g)$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
39086	0						

Table 11.123: Chain of $^{86}_{39}Y-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
39086	1	1.	40086				
40086	2	1.	41086	0.15	42087		
41086	1	1.	42086				
42087	0						
42086	0						

Table 11.124: Chain of $^{85}_{39}Y-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
39085	1	1.	40085				
40085	1	1.	41085				
41085	1	1.	42085				
42085	0						

Table 11.125: Chain of $^{85}_{38}Sr-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
38085	1	1.	39085				
39085	1	1.	40085				
40085	1	1.	41085				
41085	1	1.	42085				
42085	0						

Table 11.126: Chain of $^{83}_{38}Sr-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
38083	1	1.	39083				
39083	1	1.	40083				
40083	1	1.	41083				
41083	1	1.	42083				
42083	0						

Table 11.127: Chain of $^{82}_{38}Sr-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
38082	1	1.	39082				
39082	1	1.	40082				
40082	1	1.	41082				
41082	0						

Table 11.128: Chain of $^{81}_{38}Sr-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
38081	1	1.	39081				
39081	1	0.9988	40081				
40081	0						

Table 11.128: Chain of $^{80}_{38}Sr-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
38080	2	1.	39080	0.0012	40081		
39080	0						
40081	0						

Table 11.130: Chain of $^{86}_{37}Rb-i(m+g)$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
37086	0						

Table 11.131: Chain of $^{84}_{37}Rb-i(m+g)$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
37084	0						

Table 11.132: Chain of ${}^{83}_{37}Rb-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching 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 11.133: Chain of ${}^{81}_{37}Rb-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
37081	1	1.	38081				
38081	1	1.	39081				
39081	1	0.9988	40081				
40081	0						

Table 11.134: Chain of ${}^{79}_{37}Rb-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
37079	1	1.	38079				
38079	1	1.	39079				
39079	0						

Table 11.135: Chain of ${}^{79}_{36}Kr-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
36079	1	1.	37079				
37079	1	1.	38079				
38079	1	1.	39079				
39079	0						

Table 11.136: Chain of ${}^{77}_{36}Kr-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
36077	1	1.	37077				
37077	1	0.9975	38077				
38077	1	0.9975	39077				
39077	0						

Table 11.137: Chain of ${}^{76}_{36}Kr-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
36076	2	1.	37076	0.0025	38077		
37076	2	1.	38076	0.0025	39077		
38077	1	0.9975	39077				
38076	0						
39077	0						

Table 11.138: Chain of ${}^{82}_{35}Br - i(m+g)$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
35082	0						

Table 11.139: Chain of ${}^{77}_{35}Br - i(m+g)$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
35077	1	1.	36077				
36077	1	1.	37077				
37077	1	0.9975	38077				
38077	1	0.9975	39077				
39077	0						

Table 11.140: Chain of ${}^{77}_{35}Br - c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
35077	1	1.	36077				
36077	1	1.	37077				
37077	1	0.9975	38077				
38077	1	0.9975	39077				
39077	0						

Table 11.141: Chain of ${}^{76}_{35}Br - i(m+g)$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
35076	0						

Table 11.142: Chain of ${}^{76}_{35}Br - c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
35076	1	1.	36076				
36076	2	1.	37076	0.0025	38077		
37076	2	1.	38076	0.0025	39077		
38077	1	0.9975	39077				
38076	0						
39077	0						

Table 11.143: Chain of ${}^{75}_{35}Br - c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
35075	1	1.	36075				
36075	1	1.	37075				
37075	1	0.935	38075				
38075	0						

Table 11.144: Chain of ${}^{74}_{35}Br - c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
35074	1	1.	36074				
36074	2	1.	37074	0.065	38075		
37074	1	1.	38074				
38075	0						
38074	0						

Table 11.145: Chain of $^{75}_{34}Se-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
34075	1	1.	35075				
35075	1	1.	36075				
36075	1	1.	37075				
37075	1	0.935	38075				
38075	0						
34073	0						

Table 11.146: Chain of $^{73}_{34}Se-i(m+g)$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
34073	0						

Table 11.147: Chain of $^{73}_{34}Se-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
34073	1	1.	35073				
35073	1	0.9975	36073				
36073	1	1.	37073				
37073	1	1.	38073				
38073	0						

Table 11.148: Chain of $^{72}_{34}Se-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
34072	3	1.	35072	0.25E-02	36073	0.38E-08	37076
35072	1	1.	36072				
36073	1	1.	37073				
37076	2	1.	38076	0.0025	39077		
36072	0						
37073	1	1.	38073				
38076	0						
39077	0						
38073	0						

Table 11.149: Chain of $^{74}_{33}As-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
33074	0						

Table 11.150: Chain of ${}^{72}_{33}As-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
33072	0						

Table 11.151: Chain of ${}^{72}_{33}As-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
33072	1	1.	34072				
34072	3	1.	35072	0.25E-02	36073	0.38E-08	37076
35072	1	1.	36072				
36073	1	1.	37073				
37076	2	1.	38076	0.0025	39077		
36072	0						
37073	1	1.	38073				
38076	0						
39077	0						
38073	0						

Table 11.152: Chain of ${}^{71}_{33}As-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
33071	1	1.	34071				
34071	1	1.	35071				
35071	1	0.948	36071				
36071	1	1.	37072				
37072	0						

Table 11.153: Chain of ${}^{70}_{33}As-c*$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
33070	1	1.	34070				
34070	2	1.	35070	0.052	36071		
35070	1	0.987	36070				
36071	1	1.	37072				
36070	0						
37072	0						

Table 11.154: Chain of ${}^{69}_{32}Ge-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
32069	1	1.	33069				
33069	1	0.99955	34069				
34069	1	0.013	36070				
36070	0						

Table 11.155: Chain of ${}^{67}_{32}Ge-c$

(Z,A)	N. of	Branching	(Z,A)	Branching	(Z,A)	Branching	(Z,A)

	entries	factor		factor		factor	
32067	1	1.	33067				
33067	1	0.995	34067				
34067	0						

Table 11.156: Chain of $^{67}_{31}Ga-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
31067	1	1.	32067				
32067	1	1.	33067				
33067	1	0.995	34067				
34067	0						

Table 11.157: Chain of $^{66}_{31}Ga-c*$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
31066	1	1.	32066				
32066	2	1.	33066	0.005	34067		
33066	1	1.	34066				
34067	0						
34066	0						

Table 11.158: Chain of $^{65}_{31}Ga-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
31065	1	1.	32065				
32065	1	1.	33065				
33065	1	1.	34065				
34065	0						

Table 11.159: Chain of $^{65}_{30}Zn-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
30065	1	1.	31065				
31065	1	1.	32065				
32065	1	1.	33065				
33065	1	1.	34065				
34065	0	0					

Table 11.160: Chain of $^{62}_{30}Zn-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
30062	1	1.	31062				
31062	0						

Table 11.161: Chain of $^{67}_{29}Cu-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
29067	1	1.	28067				

28067	1	1.	27067				
27067	1	1.	26067				
26067	2	1.	25067	0.005	25068		
25067	0						
25068	0						

Table 11.162: Chain of $^{61}_{29}Cu-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
29061	1	1.	30061				
30061	1	1.	31061				
31061	1	0.2	32061				
32061	0						

Table 11.163: Chain of $^{60}_{29}Cu-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
29060	1	1.	30060				
30060	2	0.96777	31060	0.8	32061		
31060	0						
32061	0						

Table 11.164: Chain of $^{57}_{28}Ni-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
28057	1	1.	29057				
29057	1	0.35	30057				
30057	0						

Table 11.165: Chain of $^{60}_{27}Co-i(m+g)$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
27060	0						

Table 11.166: Chain of $^{58}_{27}Co-i(m+g)$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
27058	0						

Table 11.167: Chain of $^{57}_{27}Co-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
27057	1	1.	28057				
28057	1	1.	29057				
29057	1	0.35	30057				
30057	0						

Table 11.168: Chain of $^{56}_{27}Co-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
27056	1	1.	28056				
28056	2	0.65	30057	0.00023	31060		
30057	0						
31060	0						

Table 11.169: Chain of $^{55}_{27}Co-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
27055	1	1.	28055				
28055	1	1.	29055				
29055	2	0.5	30055	0.5	30056		
30055	0						
30056	0						

Table 11.170: Chain of $^{59}_{26}Fe-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
26059	1	1.	25059				
25059	1	1.	24059				
24059	1	1.	23059				
23059	1	1.	22059				
22059	0						

Table 11.171: Chain of $^{53}_{26}Fe-c*$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
26053	1	1.	27053				
27053	1	0.55	28053				
28053	2	0.5	29053	1.	29054		
29053	0						
29054	1	0.5	30055				
30055	0						

Table 11.172: Chain of $^{56}_{25}Mn-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
25056	1	1.	24056				
24056	1	1.	23056				
23056	1	1.	22056				
22056	1	1.	21056				
21056	1	1.	20056				
20056	1	0.5	21057				
21057	1	0.65	23058				
23058	0						

Table 11.173: Chain of $^{54}_{25}Mn-i$

(Z,A)	N. of	Branching	(Z,A)	Branching	(Z,A)	Branching	(Z,A)

	entries	factor		factor		factor	
25054	0						

Table 11.174: Chain of ${}^{52}_{25}Mn-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching 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 11.175: Chain of ${}^{51}_{24}Cr-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
24051	1	1.	25051				
25051	1	1.	26051				
26051	2	1.	27051	0.17	28052		
27051	2	1.	28051	0.17	29052		
28052	2	0.83	29052	0.5	29053		
28051	0						
29052	0						
29053	0						

Table 11.176: Chain of ${}^{49}_{24}Cr-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
24049	1	1.	25049				
25049	2	0.48	26049	0.54	27050		
26049	1	0.5	27049				
27050	1	1.	28050				
27049	1	0.5	28049				
28050	0						
28049	0						

Table 11.177: Chain of ${}^{48}_{24}Cr-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
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 11.178: Chain of ${}^{48}_{23}V-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching 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 11.179: Chain of ${}^{48}_{21}Sc-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
21048	0						

Table 11.180: Chain of ${}^{47}_{21}Sc-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
21047	0						

Table 11.181: Chain of ${}^{47}_{21}Sc-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
21047	1	1.	20047				
20047	2	1.	19047	0.0114	19048		
19047	1	0.99	18047				
19048	0						
18047	1	1.	17047				
17047	0						

Table 11.182: Chain of ${}^{46}_{21}Sc-i(m+g)$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
21046	0						

Table 11.183: Chain of ${}^{44}_{21}Sc-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
21044	0						

Table 11.184: Chain of ${}^{44}_{21}Sc-i(m+g)$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
21044	0						

Table 11.185: Chain of ${}^{43}_{21}Sc-c$

(Z,A)	N. of	Branching	(Z,A)	Branching	(Z,A)	Branching	(Z,A)

	entries	factor		factor		factor	
21043	1	1.	22043				
22043	2	1.	23043	0.07	24044		
23043	2	0.71	24043	0.07	25044		
24044	2	0.93	25044	1.	25045		
24043	0						
25044	1	1.	26045				
25045	0						
26045	0						

Table 11.186: Chain of ${}^{47}_{20}Ca-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
20047	2	1.	19047	0.0114	19048		
19047	1	0.99	18047				
19048	0						
18047	1	1.	17047				
17047	0						

Table 11.187: Chain of ${}^{43}_{19}K-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
19043	1	1.	18043				
18043	2	1.	17043	0.08	17044		
17043	0						
17044	0						

Table 11.188: Chain of ${}^{42}_{19}K-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
19042	0						

Table 11.189: Chain of ${}^{41}_{18}Ar-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
18041	1	1.	17041				
17041	0						

Table 11.190: Chain of ${}^{39}_{17}Cl-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
17039	0						

Table 11.191: Chain of ${}^{38}_{17}Cl-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
17038	0						

Table 11.192: Chain of $^{29}_{13}Al-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
13029	1	1.	12029				
12029	2	0.785	11029	0.3	11030		
11029	2	0.73	10029	0.26	10030		
11030	1	0.74	10030				
10029	0						
10030	0						

Table 11.193: Chain of $^{28}_{12}Mg-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching 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 11.194: Chain of $^{27}_{12}Mg-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
12027	2	0.9987	11027	0.0058	11028		
11027	2	0.98	10027	0.16	10028		
11028	2	0.84	10028	0.27	10029		
10027	1	0.23	9027				
10028	1	1.	9029				
10029	0						
9027	1	1.	9028				
9029	0						
9028	0						

Table 11.195: Chain of $^{24}_{11}Na-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching 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 11.196: Chain of $^{22}_{11}Na-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
11022	2	1.	12022	0.011	13023		
12022	2	0.3879	13022	0.73	14023		

13023	1	0.27	14023				
13022	1	0.68	14022				
14023	0						
14022	0						

Table 11.197: Chain of ${}^{7}_{4}Be-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
4007	0						

11.5 Decay chains of ^{181}Ta products.

Table 11.198: Chain of ${}^{178}_{74}W-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
74178	0						

Table 11.199: Chain of ${}^{177}_{74}W-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
74177	0						

Table 11.200: Chain of ${}^{176}_{74}W-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
74176	0						

Table 11.201: Chain of ${}^{174}_{74}W-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
74174	0						

Table 11.202: Chain of ${}^{180}_{73}Ta-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
73176	0						

Table 11.203: Chain of ${}^{177}_{73}Ta-c*$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
73177	1	1.	74177				
74177	0						

Table 11.204: Chain of ${}^{176}_{73}Ta-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
73176	0						

Table 11.205: Chain of $^{176}_{73}Ta-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
73176	1	1.	74175				
74176							

Table 11.206: Chain of $^{176}_{73}Ta-c*$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
73176	1	1.	74175				
74176							

Table 11.207: Chain of $^{175}_{73}Ta-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
73175	1	1.	74175				
74175	0						

Table 11.208: Chain of $^{174}_{73}Ta-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
73174	0						

Table 11.209: Chain of $^{174}_{73}Ta-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
73174	1	1.	74174				
74174	0						

Table 11.210: Chain of $^{173}_{73}Ta-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
73173	1	1.	74173				
74173	0						

Table 11.211: Chain of $^{172}_{73}Ta-c*$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
73172	1	1.	74172				
74172	0						

Table 11.212: Chain of $^{181}_{72}Hf-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
72181	1	1.	71181				
71181	0						

Table 11.213: Chain of $^{175}_{72}Hf-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
72175	1	1.	73175				
73175	1	1.	74175				
74175	0						

Table 11.214: Chain of $^{173}_{72}Hf-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
72173	0						

Table 11.215: Chain of $^{173}_{72}Hf-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
72173	1	1.	73173				
73173	1	1.	74173				
74173	0						

Table 11.216: Chain of $^{173}_{72}Hf-c*$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
72173	1	1.	73173				
73173	1	1.	74173				
74173	0						

Table 11.217: Chain of $^{172}_{72}Hf-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
72172	1	1.	73172				
73172	1	1.	74172				
74172	0						

Table 11.218: Chain of $^{171}_{72}Hf-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
72171	1	1.	73171				
73171	1	1.	74171				
74171	0						

Table 11.219: Chain of $^{170}_{72}Hf-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
72170	1	1.	73170				
73170	1	1.	74170				
74170	0	0					

Table 11.220: Chain of $^{168}_{72}Hf-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
72168	1	1.	73168				
73168	1	1.	74168				
74168	0						

Table 11.221: Chain of $^{173}_{71}Lu-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
71173	1	1.	72173				
72173	1	1.	73173				
73173	1	1.	74173				
74173	0						

Table 11.222: Chain of $^{172}_{71}Lu-i(m+g)$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
71172	0						

Table 11.223: Chain of $^{172}_{71}Lu-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
71172	1	1.	72172				
72172	1	1.	73172				
73172	1	1.	74172				
74172	0						

Table 11.224: Chain of $^{171}_{71}Lu-i(m+g)$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
71171	0						

Table 11.225: Chain of $^{171}_{71}Lu-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
71171	1	1.	72171				
72171	1	1.	73171				
73171	1	1.	74171				
74171	0						

Table 11.226: Chain of $^{170}_{71}Lu-i(m+g)$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
71170	0						

Table 11.227: Chain of $^{170}_{71}Lu-c$

(Z,A)	N. of	Branching	(Z,A)	Branching	(Z,A)	Branching	(Z,A)

	entries	factor		factor		factor	
71170	1	1.	72170				
72170	1	1.	73170				
73170	1	1.	74170				
74170	0						

Table 11.228: Chain of $^{169}_{71}Lu-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
71169	1	1.	72169				
72169	1	1.	73169				
73169	1	1.	74169				
74169	0						

Table 11.229: Chain of $^{167}_{71}Lu-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
71167	1	1.	72167				
72167	1	1.	73167				
73167	1	0.9996	74167				
74167	0						

Table 11.230: Chain of $^{169}_{70}Yb-c*$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
70169	1	1.	71169				
71169	1	1.	72169				
72169	1	1.	73169				
73169	1	1.	74169				
74169	0						

Table 11.231: Chain of $^{167}_{70}Yb-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
70167	0						

Table 11.232: Chain of $^{167}_{70}Yb-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
70167	1	1.	71167				
71167	1	1.	72167				
72167	1	1.	73167				
73167	1	0.9996	74167				
74167	0						

Table 11.233: Chain of $^{166}_{70}Yb-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
70166	1	1.	71166				

71166	1	1.	72166				
72166	1	1.	73166				
73166	1	0.99965	74166				
74166	0						

Table 11.234: Chain of $^{162}_{70}Yb-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
70162	1	1.	71162				
71162	1	0.99992	72162				
72162	2	0.99926	73162	0.00035	74166		
73162	1	0.548	74162				
74166	0						
74162	0						

Table 11.235: Chain of $^{168}_{69}Tm-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
69168	0						

Table 11.236: Chain of $^{167}_{69}Tm-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching 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	0						

Table 11.237: Chain of $^{166}_{69}Tm-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
69166	0						

Table 11.238: Chain of $^{166}_{69}Tm-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
69166	1	1.	70166				
70166	1	1.	71166				
71166	1	1.	72166				
72166	1	1.	73166				
73166	1	0.99965	74166				
74166	0						

Table 11.239: Chain of $^{165}_{69}Tm-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
69165	1	1.	70165				

70165	1	1.	71165				
71165	1	1.	72165				
72165	1	1.	73165				
73165	1	1.	74165				
74165	0						

Table 11.240: Chain of ${}^{163}_{69}Tm-c*$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
69163	1	1.	70163				
70163	1	1.	71163				
71163	1	1.	72163				
72163	2	0.998	73163	0.0004	74167		
73163	1	0.87	74163				
74167	0						
74163	0						

Table 11.241: Chain of ${}^{162}_{69}Tm-i(m+g)$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
69162	0						

Table 11.242: Chain of ${}^{162}_{69}Tm-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
69162	1	1.	70162				
70162	1	1.	71162				
71162	1	0.99992	72162				
72162	2	0.99926	73162	0.00035	74166		
73162	1	0.548	74162				
74166	0						
74162	0						

Table 11.243: Chain of ${}^{161}_{69}Tm-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
69161	1	1.	70161				
70161	1	1.	71161				
71161	1	0.9987	72161				
72161	2	0.955	73161	0.002	74165		
73161	1	0.27	74161				
74165	0						
74161	0						

Table 11.244: Chain of ${}^{161}_{68}Er-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
68161	0						

Table 11.245: Chain of ${}^{161}_{68}Er-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
68161	1	1.	69161				
69161	1	1.	70161				
70161	1	1.	71161				
71161	1	0.9987	72161				
72161	2	0.955	73161	0.002	74165		
73161	1	0.27	74161				
74165	0						
74161	0						

Table 11.246: Chain of ${}^{160}_{68}Er-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching 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	1	0.13	74160				
74164	0						
74160	0						

Table 11.247: Chain of ${}^{159}_{68}Er-c*$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
68159	1	1.	69159				
69159	1	1.	70159				
70159	2	1.	71159	0.1E-05	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	1	0.87	74163				
74167	0						
73159	1	0.001	74159				
74163	0						
74159	0						

Table 11.248: Chain of ${}^{157}_{68}Er-c*$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
68157	1	1.	69157				
69157	1	0.995	70157				
70157	1	0.0013	72161				
72161	2	0.955	73161	0.002	74165		
73161	1	0.27	74161				
74165	0						
74161	0						

Table 11.249: Chain of ${}^{156}_{68}Er-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
68156	1	0.99936	69156				
69156	2	0.9	70156	0.1E-05	71160		
70156	2	0.05	71156	0.007	72160		
71160	1	0.993	73160				
71156	1	0.34	73160				
72160	2	0.66	73160	0.038	74164		
73160	1	0.13	74160				
74164	0						
74160	0						

Table 11.250: Chain of ${}^{160}_{67}Ho-i(m+g)$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
67160	0						

Table 11.251: Chain of ${}^{156}_{67}Ho-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
67156	0						

Table 11.252: Chain of ${}^{156}_{67}Ho-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
67156	1	1.	68156				
68156	1	0.99936	69156				
69156	2	0.9	70156	0.1E-05	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	1	0.13	74160				
74164	0						
74160	0						

Table 11.253: Chain of ${}^{157}_{66}Dy-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching 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	1	0.27	74161				
74165	0						

74161	0						

Table 11.254: Chain of $^{155}_{66}Dy-c*$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
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	1	0.87	74163				
72155	2	1.	73156	0.999	74159		
73159	1	0.001	74159				
74163	0						
73156	0						
74159	0						

Table 11.255: Chain of $^{152}_{66}Dy-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
66152	2	0.88	67152	0.17E-06	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	0.1E-05	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	1	0.13	74160				
74164	0						
73157	0						
74160	0						

Table 11.256: Chain of $^{155}_{65}Tb-c*$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
65155	1	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	1	0.87	74163				
72155	2	1.	73156	0.999	74159		
73159	1	0.001	74159				
74163	0						
73156	0						
74159	0						

Table 11.257: Chain of ${}^{153}_{65}Tb-c*$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
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	1	0.27	74161				
74165	0						
73157	0						
74161	0						

Table 11.258: Chain of ${}^{152}_{65}Tb-i(m+g)$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
65152	0						

Table 11.259: Chain of ${}^{152}_{65}Tb-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
65152	1	0.999	66152				
66152	2	0.88	67152	0.17E-06	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	0.1E-05	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	1	0.13	74160				
74164	0						
73157	0						
74160	0						

Table 11.260: Chain of ${}^{151}_{65}Tb-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching 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	1	0.87	74163				
72155	2	1.	73156	0.999	74159		
73159	1	0.001	74159				
74163	0						
73156	0						
74159	0						

Table 11.261: Chain of ${}^{150}_{65}Tb-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching 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	0.21E-04	70158		
68150	2	1.	69150	0.926	70154		
69154	2	0.074	70154	0.0091	71158		
70158	2	0.9909	71158	0.8E-04	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	1	0.548	74162				
74166	0						
73158	0						
74162	0						

Table 11.262: Chain of ${}^{149}_{65}Tb-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching 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	1	0.27	74161				
74165	0						
73157	0						
74161	0						

Table 11.263: Chain of ${}^{148}_{65}Tb-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching 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	0.1E-05	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	0						
71152	0						
72156	2	0.034	73157				

73160	1	0.13	74160				
74164	0						
74160	0						

Table 11.264: Chain of ${}^{153}_{64}Gd-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching 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	1	0.27	74161				
74165	0						
73157	0						
74161	0						

Table 11.265: Chain of ${}^{151}_{64}Gd-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching 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	1	0.87	74163	0.01	75167		
72155	2	1.	73156	0.999	74159		
73159	1	0.001	74159				
74163	0						
73156	0						
74159	0						

Table 11.266: Chain of ${}^{149}_{64}Gd-c$

(Z,A)	N. of	Branching	(Z,A)	Branching	(Z,A)	Branching	(Z,A)

	entries	factor		factor		factor	
64149	2	0.833	65149	0.94E-04	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	1	0.27	74161				
74165	0						
73157	0						
74161	0						

Table 11.267: Chain of ${}^{148}_{64}Gd-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
64148	2	1	65148	0.001	66152		
65148	2	1	66148	0.12	67152		
66152	2	0.88	67152	1.70E-07	68156		
66148	3	1	67148	0.07	68149	0.9	68152
67152	2	0.1	68152	0.00064	69156		
68156	1	0.99936	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 11.268: Chain of $^{147}_{64}Gd-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching 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	1	0.87	74163				
72155	2	1.	73156	0.999	74159		
73159	1	0.001	74159				
74163	0						
73156	0						

74159	0						

Table 11.269: Chain of $^{146}_{64}Gd-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching 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	0.21E-04	70158		
67146	0						
68150	2	1.	69150	0.926	70154		
69154	2	0.074	70154	0.0091	71158		
70158	2	0.9909	71158	0.8E-04	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	1	0.548	74162				
74166	0						
73158	0						
74162	0						

Table 11.270: Chain of $^{145}_{64}Gd-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
64145	1	1.	65145				
65145	1	1.	66145				
66145	1	1.	67145				
67145	1	1.	68145				
68145	1	0.5	69146				
69146	0						

Table 11.271: Chain of $^{149}_{63}Eu-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
63149	0						

Table 11.272: Chain of $^{149}_{63}Eu-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
63149	1	1.	64149				
64149	2	0.833	65149	0.94E-04	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	1	0.27	74161				
74165	0						
73157	0						
74161	0						

Table 11.273: Chain of $^{148}_{63}Eu-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
63148	0						

Table 11.274: Chain of $^{147}_{63}Eu-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
63147	0						

Table 11.275: Chain of $^{147}_{63}Eu-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
63147	2	1.	64147	0.95E-04	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	1	0.87	74163	0.01	75167		

72155	2	1.	73156	0.999	74159		
73159	1	0.001	74159	0.32	75163		
74163	0						
73156	0						
74159	0						

Table 11.276: Chain of ${}^{146}_{63}Eu-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
63146	0						

Table 11.277: Chain of ${}^{146}_{63}Eu-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching 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	0.21E-04	70158		
67146	0						
68150	2	1.	69150	0.926	70154		
69154	2	0.074	70154	0.0091	71158		
70158	2	0.9909	71158	0.8E-04	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	1	0.548	74162				
74166	0						
73158	0						
74162	0						

Table 11.278: Chain of ${}^{145}_{63}Eu-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching 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	0.86	72157		
70153	2	0.3	71153	0.045	73161		
71157	2	0.14	72157	0.002	74165		
72161	2	0.955	73161				
69146	0						
71153	1	0.966	73157				
72157	1	0.73	74161				
73161	1	0.27	74161				
74165	0						
73157	0						
74161	0						

Table 11.279: Chain of $^{144}_{61}Pm-i*$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
61144	0						

Table 11.280: Chain of $^{143}_{61}Pm-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
61143	2	1.	62143	0.22E-04	63147		
62143	1	1.	63143				
63147	2	1.	64147	0.95E-04	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	1	0.87	74163				
72155	2	1.	73156	0.999	74159		
73159	1	0.001	74159				
74163	0						
73156	0						
74159	0						

Table 11.281: Chain of $^{136}_{60}Nd-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
60136	1	1.	61136				
61136	1	1.	62136				
62136	1	0.9991	63136				
63136	0						

Table 11.282: Chain of $^{136}_{59}\mathrm{Pr}-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
60136	0						

Table 11.283: Chain of $^{136}_{59}\mathrm{Pr}-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
59136	1	1.	60136				
60136	1	1.	61136				
61136	1	1.	62136				
62136	1	0.9991	63136				
63136	0						

Table 11.284: Chain of $^{134}_{59}\mathrm{Pr}-c*$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
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 11.285: Chain of $^{139}_{58}Ce-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching 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 11.286: Chain of $^{135}_{58}Ce-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching 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 11.287: Chain of $^{134}_{58}Ce-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching 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 11.288: Chain of $^{132}_{58}Ce-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
58132	1	1.	59132				
59132	1	1.	60132				
60132	1	1.	61132				
61132	1	1.	62132				
62132	0						

Table 11.289: Chain of $^{130}_{58}Ce-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching 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 11.290: Chain of ${}^{132}_{57}La-i(m+g)$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
57140	0						

Table 11.291: Chain of ${}^{132}_{57}La-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching 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 11.292: Chain of ${}^{130}_{57}La-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
57140	0						

Table 11.293: Chain of ${}^{130}_{57}La-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
57130	1	1.	58130				
58130	1	1.	59130				
59130	1	1.	60130				
60130	1	1.	61130				
61130	1	1.	62130				
62130	1	0.879	63131				
63131	0						

Table 11.294: Chain of ${}^{133}_{56}Ba-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching 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 11.295: Chain of ${}^{131}_{56}Ba-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)

56131	1	1.	57131				
57131	1	1.	58131				
58131	1	1.	59131				
59131	2	1.	60131	0.5E-06	61132		
60131	0						
61132	1	1.	62132				
62132	0						

Table 11.296: Chain of $^{128}_{56}Ba-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching 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 11.297: Chain of $^{126}_{56}Ba-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
56126	1	0.01	57126				
57126	1	1.	58126				
58126	1	1.	59126				
59126	0						

Table 11.298: Chain of $^{129}_{55}Cs-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching 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 11.299: Chain of $^{127}_{55}Cs-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
55127	1	1.	56127				
56127	1	1.	57127				
57127	1	1.	58127				
58127	1	1.	59127				
59127	1	1.	60127				
60127	0						

Table 11.300: Chain of $^{127}_{54}Xe-c$

(Z,A)	N. of	Branching	(Z,A)	Branching	(Z,A)	Branching	(Z,A)

	entries	factor		factor		factor	
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 11.301: Chain of ${}^{123}_{54}Xe-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
54123	1	1.	55123				
55123	1	1.	56123				
56123	1	1.	57123				
57123	1	1.	58123				
58123	0						

Table 11.302: Chain of ${}^{122}_{54}Xe-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
54122	1	1.	55122				
55122	1	1.	56122				
56122	1	1.	57122				
57122	0						

Table 11.303: Chain of ${}^{121}_{52}Te-i(m+g)$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
52119	0						

Table 11.304: Chain of ${}^{121}_{52}Te-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching 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 11.305: Chain of ${}^{119}_{52}Te-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
52119	1	1.	53119				
53119	2	1.	54119	0.7E-07	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 11.306: Chain of ${}^{117}_{52}Te-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
52117	1	1.	53117				
53117	2	0.99997	54117	0.00042	55118		
54117	1	1.	55117				
55118	1	1.	56118				
55117	1	1.	56117				
56118	0						
56117	1	0.061	57117				
57117	0						

Table 11.307: Chain of ${}^{114}_{52}Te-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
53114	3	1.	53114	0.34E-02	54115	0.24E-04	55118
53114	2	1.	54114	0.0007	55115		
54115	2	0.9993	55115	0.03	56116		
55118	1	1.	56118				
54114	1	0.9111	55114				
55115	1	1.	56115				
56116	1	0.939	57117				
56118	0						
55114	0						
56115	0						
57117	0						

Table 11.308: Chain of ${}^{115}_{51}Sb-c*$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
51115	1	1.	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 11.309: Chain of ${}^{113}_{50}Sn-i(m+g)$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
50113	0						

Table 11.310: Chain of ${}^{111}_{49}In-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching 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 11.311: Chain of ${}^{110}_{49}In-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
49110	0						

Table 11.312: Chain of ${}^{109}_{49}In-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
49109	1	1.	50109						
50109	1	1.	51109						
51109	4	0.86695	52109	0.11	53110	0.7E-04	54113	0.331E-08	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 11.313: Chain of ${}^{108}_{49}In-c*$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
49108	1	1.	50108				
50108	2	1.	51108	0.094	52109		
51108	2	0.486	52108	0.12E-04	53112		
52109	2	0.11	54110	0.00011	54113		
52108	2	0.09	53108	1.	53109		
53112	1	0.9916	54112				
54110	0						
54113	0						
53108	0						
53109	0						
54112	1	55133					
55113	0						

Table 11.314: Chain of ${}^{105}_{47}Ag-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
47105	1	1.	48105				
48105	1	1.	49105				
49105	2	1.	50105	0.5E-04	52109		
50105	2	0.99	51105	0.039	52109		
52109	2	0.11	54110	0.00011	54113		
51105	0						
54110	0						
54113	0						

Table 11.315: Chain of ${}^{100}_{46}Pd-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching 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 11.316: Chain of ${}^{102}_{45}Rh-i(m+g)$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
45102	0						

Table 11.317: Chain of ${}^{100}_{45}Rh-i(m+g)$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
45100	0						

Table 11.318: Chain of ${}^{100}_{45}Rh-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching 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 11.319: Chain of ${}^{99m}_{45}Rh-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
45099	1	1.	46099				
46099	1	1.	47099				
47099	2	1.	48099	0.039	49100		
48099	2	1.	49099	0.17	50100		

49100	1	0.83	50100				
49099	0						
50100	0						

Table 11.320: Chain of $^{103}_{44}Ru-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching 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 11.321: Chain of $^{97}_{44}Ru-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
44097	1	1.	45097				
45097	2	1.	46097	0.11E-04	47098		
46097	2	1.	47097	0.00025	48098		
47098	1	0.99975	48098				
47097	0						
48098	0						

Table 11.322: Chain of $^{96}_{43}Tc-i(m+g)$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
43096	0						

Table 11.323: Chain of $^{90}_{41}Nb-c*$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
41090	1	1.	42090				
42090	1	1.	43090				
43090	1	1.	44090				
44090	0						

Table 11.324: Chain of $^{89}_{40}Zr-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching 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 11.325: Chain of $^{88}_{40}Zr-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching 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 11.326: Chain of $^{88}_{39}Y-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
39088	0						

Table 11.327: Chain of $^{88}_{39}Y-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching 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 11.328: Chain of $^{87m}_{39}Y-c*$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
39087	1	1.	40087				
40087	1	1.	41087				
41087	1	0.85	42087				
42087	1	1.	43087				
43087	0						

Table 11.329: Chain of $^{87}_{39}Y-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
39087	0						

Table 11.330: Chain of $^{87}_{39}Y-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
39087	1	1.	40087				
40087	1	1.	41087				
41087	1	0.85	42087				
42087	1	1.	43087				
43087	0						

Table 11.331: Chain of ${}^{86}_{39}Y-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
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						

Table 11.332: Chain of ${}^{85}_{38}Sr-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
38085	1	1.	39085				
39085	1	1.	40085				
40085	1	1.	41085				
41085	1	1.	42085				
42085	0						

Table 11.333: Chain of ${}^{83}_{38}Sr-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
38083	1	1.	39083				
39083	1	1.	40083				
40083	1	1.	41083				
41083	1	1.	42083				
42083	0						

Table 11.334: Chain of ${}^{84}_{37}Rb-i(m+g)$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
37084	0						

Table 11.335: Chain of ${}^{83}_{37}Rb-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching 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 11.336: Chain of ${}^{77}_{35}Br-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
35077	1	1.	36077				

36077	1	1.	37077				
37077	1	0.9975	38077				
38077	1	0.9975	39077				
39077	0						

Table 11.337: Chain of $^{75}_{34}Se-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
34075	1	1.	35075				
35075	1	1.	36075				
36075	1	1.	37075				
37075	1	0.935	38075				
38075	0						

Table 11.338: Chain of $^{74}_{33}As-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
33074	0						

Table 11.339: Chain of $^{65}_{30}Zn-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
30065	1	1.	31065				
31065	1	1.	32056				
32065	1	1.	33065				
33065	1	1.	34065				
34065	0						

Table 11.340: Chain of $^{60}_{27}Co-i(m+g)$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
27060	0						

Table 11.341: Chain of $^{58}_{27}Co-i(m+g)$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
27058	0						

Table 11.342: Chain of $^{56}_{27}Co-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
27056	1	1.	28056				
28056	2	0.65	30057	0.00023	31060		
30057	0						
31060	0						

Table 11.343: Chain of $^{59}_{26}Fe-c$

(Z,A)	N. of	Branching	(Z,A)	Branching	(Z,A)	Branching	(Z,A)

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
26059	1	1.	25059				
25059	1	1.	24059				
24059	1	1.	23059				
23059	1	1.	22059				
22059	0						

Table 11.344: Chain of $^{54}_{25}Mn-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
25054	0						

Table 11.345: Chain of $^{52}_{25}Mn-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching 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 11.346: Chain of $^{48}_{23}V-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching 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 11.347: Chain of $^{48}_{21}Sc-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
21048	0						

Table 11.348: Chain of $^{46}_{21}Sc-i(m+g)$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
21046	0						

Table 11.349: Chain of $^{28}_{12}Mg-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching 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 11.350: Chain of $^{24}_{11}Na-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching 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 11.351: Chain of $^{22}_{11}Na-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
11022	2	1.	12022	0.011	13023		
12022	2	0.3879	13022	0.73	14023		
13023	1	0.27	14023				
13022	1	0.68	14022				
14023	0						
14022	0						

Table 11.352: Chain of $^{7}_{4}Be-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
4007	0						

11.6 Decay chains of ^{nat}W products.

Table 11.353: Chain of $^{186}_{75}\mathrm{Re}-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
75186	0						

Table 11.354: Chain of $^{184}_{75}\mathrm{Re}-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
75184	0						

Table 11.355: Chain of $^{183}_{75}\mathrm{Re}-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
75183	0						

Table 11.356: Chain of $^{182}_{75}\text{Re}-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
75182	0						

Table 11.357: Chain of $^{181}_{75}\text{Re}-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
75181	0						

Table 11.358: Chain of $^{179}_{75}\text{Re}-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
75179	0						

Table 11.359: Chain of $^{178}_{75}\text{Re}-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
75178	0						

Table 11.360: Chain of $^{177}_{75}\text{Re}-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
75177	0						

Table 11.361: Chain of $^{176}_{75}\text{Re}-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
75176	0						

Table 11.362: Chain of $^{181}_{74}W-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
74181	1	1.	75181				
75181	0						

Table 11.363: Chain of $^{178}_{74}W-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
74178	1	1.	75178				
75178	0						

Table 11.364: Chain of $^{177}_{74}W-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
74177	0						

Table 11.365: Chain of ${}^{177}_{74}W-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
74177	1	1.	75177				
75177	0						

Table 11.366: Chain of ${}^{176}_{74}W-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
74176	1	1.	75176				
75176	0						

Table 11.367: Chain of ${}^{174}_{74}W-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
74174	1	1.	75174				
75174	0						

Table 11.368: Chain of ${}^{184}_{73}Ta-c*$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
73184	1	1.	72184				
72184	1	1.	71184				
71184	0						

Table 11.369: Chain of ${}^{183}_{73}Ta-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
73183	3	1.	72183	1.	74183	0.1E-05	75187
72183	1	1.	71183				
74183	2	1.	73183	1.	75183		
75187	1	1.	74187				
71183	0						
75183	0						
74187	0						

Table 11.370: Chain of ${}^{182}_{73}Ta-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
73182	0						

Table 11.371: Chain of ${}^{177}_{73}Ta-c*$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
73177	1	1.	74177				
74177	1	1.	75177				
75177	0						

Table 11.372: Chain of ${}^{176}_{73}Ta-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
73176	0						

Table 11.373: Chain of ${}^{176}_{73}Ta-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
73176	1	1.	74176				
74176	1	1.	75176				
75176	0						

Table 11.374: Chain of ${}^{176}_{73}Ta-c*$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
73176	1	1.	74176				
74176	1	1.	75176				
75176	0						

Table 11.375: Chain of ${}^{175}_{73}Ta-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
73175	1	1.	74175				
74175	1	1.	75175				
75175	0						

Table 11.376: Chain of ${}^{174}_{73}Ta-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
73174	0						

Table 11.377: Chain of ${}^{174}_{73}Ta-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
73174	1	1.	74174				
74174	1	1.	75174				
75174	0						

Table 11.378: Chain of ${}^{173}_{73}Ta-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
73173	1	1.	74173				
74173	1	1.	75173				
75173	0						

Table 11.379: Chain of ${}^{172}_{73}Ta-c*$

(Z,A)	N. of	Branching	(Z,A)	Branching	(Z,A)	Branching	(Z,A)

	entries	factor		factor		factor	
73172	1	1.	74172				
74172	1	1.	75172				
75172	0						

Table 11.380: Chain of ${}^{181}_{72}Hf-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
72181	1	1.	71181				
71181	0						

Table 11.381: Chain of ${}^{175}_{72}Hf-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
72175	1	1.	73175				
73175	1	1.	74175				
74175	1	1.	75175				
75175	0						

Table 11.382: Chain of ${}^{173}_{72}Hf-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
72173	0						

Table 11.383: Chain of ${}^{173}_{72}Hf-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
72173	1	1.	73173				
73173	1	1.	74173				
74173	1	1.	75173				
75173	0						

Table 11.384: Chain of ${}^{173}_{72}Hf-c*$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
72173	1	1.	73173				
73173	1	1.	74173				
74173	1	1.	75173				
75173	0						

Table 11.385: Chain of ${}^{172}_{72}Hf-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
72172	1	1.	73172				
73172	1	1.	74172				
74172	1	1.	75172				
75172	0						

Table 11.386: Chain of $^{171}_{72}Hf-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
72171	1	1.	73171				
73171	1	1.	74171				
74171	1	1.	75171				
75171	0						

Table 11.387: Chain of $^{170}_{72}Hf-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
72170	1	1.	73170				
73170	1	1.	74170				
74170	1	1.	75170				
75170	0						

Table 11.388: Chain of $^{168}_{72}Hf-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
72168	1	1.	73168				
73168	1	1.	74168				
74168	1	1.	75168				
75168	0						

Table 11.389: Chain of $^{173}_{71}Lu-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
71173	1	1.	72173				
72173	1	1.	73173				
73173	1	1.	74173				
74173	1	1.	75173				
75173	0						

Table 11.390: Chain of $^{172}_{71}Lu-i(m+g)$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
71172	0						

Table 11.391: Chain of $^{172}_{71}Lu-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
71172	1	1.	72172				
72172	1	1.	73172				
73172	1	1.	74172				
74172	1	1.	75172				
75172	0						

Table 11.392: Chain of $^{171}_{71}Lu-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
71171	0						

Table 11.393: Chain of $^{171}_{71}Lu-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
71171	1	1.	72171				
72171	1	1.	73171				
73171	1	1.	74171				
74171	1	1.	75171				
75171	0						

Table 11.394: Chain of $^{171}_{71}Lu-c*$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
71171	1	1.	72171				
72171	1	1.	73171				
73171	1	1.	74171				
74171	1	1.	75171				
75171	0						

Table 11.395: Chain of $^{170}_{71}Lu-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
71170	0						

Table 11.396: Chain of $^{170}_{71}Lu-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
71170	1	1.	72170				
72170	1	1.	73170				
73170	1	1.	74170				
74170	1	1.	75170				
75170	0						

Table 11.397: Chain of $^{169}_{71}Lu-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
71169	1	1.	72169				
72169	1	1.	73169				
73169	1	1.	74169				
74169	1	0.5	75169				
75169	0						

Table 11.398: Chain of $^{167}_{71}Lu-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
71167	1	1.	72167				

72167	1	1.	73167				
73167	1	0.9996	74167				
74167	1	0.99	75167				
75167	0						

Table 11.399: Chain of $^{169}_{70}Yb-c*$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
70169	1	1.	71169				
71169	1	1.	72169				
72169	1	1.	73169				
73169	1	1.	74169				
74169	1	0.5	75169				
75169	0						

Table 11.400: Chain of $^{167}_{70}Yb-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
70167	0						

Table 11.401: Chain of $^{167}_{70}Yb-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
70167	1	1.	71167				
71167	1	1.	72167				
72167	1	1.	73167				
73167	1	0	74167				
74167	1	0	75167				
75167	0						

Table 11.402: Chain of $^{166}_{70}Yb-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
70166	1	1.	71166				
71166	1	1.	72166				
72166	1	1.	73166				
73166	1	0.99965	74166				
74166	1	0.92	75166				
75166	0						

Table 11.403: Chain of $^{162}_{70}Yb-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching 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	1	0.92	75166				
74162	1	0.06	75162				

75166	0						
75162	0						

Table 11.404: Chain of ${}^{168}_{69}Tm-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
69168	0						

Table 11.405: Chain of ${}^{167}_{69}Tm-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching 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	1	0.99	75167				
75167	0						

Table 11.406: Chain of ${}^{166}_{69}Tm-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
69166	0						

Table 11.407: Chain of ${}^{166}_{69}Tm-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
69166	1	1.	70166				
70166	1	1.	71166				
71166	1	1.	72166				
72166	1	1.	73166				
73166	1	0.99965	74166				
74166	1	0.92	75166				
75166	0						

Table 11.408: Chain of ${}^{165}_{69}Tm-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching 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	1	1.	75165				
75169	0						
75165	0						

Table 11.409: Chain of ${}^{163}_{69}Tm-c*$

(Z,A)	N. of	Branching	(Z,A)	Branching	(Z,A)	Branching	(Z,A)

	entries	factor		factor		factor	
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	1	0.99	75167				
74163	1	0.68	75163				
75167	0						
75163	0						

Table 11.410: Chain of ${}^{162}_{69}Tm-i(m+g)$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
69162	0						

Table 11.411: Chain of ${}^{162}_{69}Tm-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
69162	1	1.	70162				
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	1	0.92	75166				
74162	1	0.06	75162				
75166	0						
75162	0						

Table 11.412: Chain of ${}^{161}_{69}Tm-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
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	1	1.	75161				
74161	0						
75165	0						

Table 11.413: Chain of ${}^{161}_{68}Er-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
68161	0						

Table 11.414: Chain of ${}^{161}_{68}Er-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)

68161	1	1.	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	1	1.	75165				
74161	0						
75165	0						

Table 11.415: Chain of $^{161}_{68}Er - c*$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
68161	1	1.	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	1	1.	75165				
74161	0						
75165	0						

Table 11.416: Chain of $^{160}_{68}Er - c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching 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	1	0.42	75164				
74160	1	1.	75161				
75164	0						
75161	0						

Table 11.417: Chain of $^{159}_{68}Er - c*$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
68159	1	1.	69159				
69159	1	1.	70159				
70159	2	1.	71159	0.1E-05	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	1	0.99	75167				
73159	2	0.001	74159	0.32	75163		
74163	1	0.68	75163				

75167	0						
74159	1	0.91	75160				
75163	0						
75160	0						

Table 11.418: Chain of ${}^{157}_{68}Er-c*$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
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	1	1.		75165			
74161	0						
75165	0						

Table 11.419: Chain of ${}^{156}_{68}Er-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
68156	1	0.99936	69156	0.1E-05	71160		
69156	2	0.9	70156	0.007	72160		
70156	2	0.05	71156				
71160	1	0.993	72160				
71156	1	0.34	73160	0.038	74164		
72160	2	0.66	73160	0.58	75164		
73160	2	0.13	74160				
74164	1	0.42	75164				
74160	1	1.	75161				
75164	0						
75161	0						

Table 11.420: Chain of ${}^{160m}_{67}Ho-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
67160	0						

Table 11.421: Chain of ${}^{160}_{67}Ho-i(m+g)$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
67160	0						

Table 11.422: Chain of ${}^{156}_{67}Ho-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
67156	0						

Table 11.423: Chain of ${}^{156}_{67}Ho-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
67156	1	1.	68156				
68156	1	0.99936	69156				
69156	2	0.9	70156	0.1E-05	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	1	0.42	75164				
74160	1	1.	75161				
75164	0						
75161	0						

Table 11.424: Chain of ${}^{157}_{66}Dy-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching 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	1	1.	75165				
74161	0						
75165	0						

Table 11.425: Chain of ${}^{155}_{66}Dy-c*$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
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	1	0.68	75163				
75167	0						
73156	1	0.09	75160				
74159	1	0.91	75160				
75163	0						
75160	0						

Table 11.426: Chain of $^{152}_{66}Dy-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
66152	2	0.88	67152	0.17E-06	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	0.1E-05	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	1	0.42	75164				
73157	0						
74160	1	1.	75161				
75164	0						
75161	0						

Table 11.427: Chain of $^{155}_{65}Tb-c*$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
65155	1	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	1	0.68	75163				
75167	0						
73156	1	0.09	75160				
74159	1	0.91	75160				
75163	0						
75160	0						

Table 11.428: Chain of $^{153}_{65}Tb-c*$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
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	1	1.	75165					
73157	0							
74161	0							
75165	0							

Table 11.429: Chain of ${}^{152}_{65}Tb-i(m+g)$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
65152	0						

Table 11.430: Chain of ${}^{152}_{65}Tb-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
65152	1	0.999	66152				
66152	2	0.88	67152	0.17E-06	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	0.1E-05	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	1	0.42	75164				
73157	0						
74160	1	1.	75161				
75164	0						
75161	0						

Table 11.431: Chain of ${}^{152}_{65}Tb-c*$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
65152	1	0.999	66152				

66152	2	0.88	67152	0.17E-06	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	0.1E-05	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	1	0.42	75164				
73157	0						
74160	1	1.	75161				
75164	0						
75161	0						

Table 11.432: Chain of $^{151}_{65}Tb-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching 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	1	0.68	75163				
75167	0						
73156	1	0.09	75160				
74159	1	0.91	75160				
75163	0						
75160	0						

Table 11.433: Chain of $^{150}_{65}Tb-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching 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	0.21E-04	70158		
68150	2	1.	69150	0.926	70154		
69154	2	0.074	70154	0.0091	71158		
70158	2	0.9909	71158	0.8E-04	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	1	0.92	75166				
73158	1	0.94	75162				
74162	1	0.06	75162				
75166	0						
75162	0						

Table 11.434: Chain of $^{149}_{65}Tb-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching 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	1	1.	75165				
73157	0						
74161	0						
75165	0						

Table 11.435: Chain of $^{148}_{65}Tb-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching 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	0.1E-05	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	0						
71152	0						
72156	2	0.034	73157	0.87	74160		
73160	2	0.13	74160	0.58	75164		
74164	1	0.42	75164				
74160	1	1.		75161			
75164	0						
75161	0						

Table 11.436: Chain of $^{147}_{65}Tb-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
65147	2	1.	66147	0.22	67151		
66147	1	1.	67147				
67151	2	1.	68151	0.0089	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	1	0.68	75163				
75167	0						

73156	1	0.09	75160				
74159	1	0.91	75160				
75163	0						
75160	0						

Table 11.437: Chain of ${}^{153}_{64}Gd-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching 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	1	1.	75165				
73157	0						
74161	0						
75165	0						

Table 11.438: Chain of ${}^{151}_{64}Gd-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching 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	1	0.68	75163				
75167	0						
73156	1	0.09	75160				
74159	1	0.91	75160				

75163	0						
75160	0						

Table 11.439: Chain of $^{149}_{64}Gd-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
64149	2	0.833	65149	0.94E-04	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	1	1.	75165				
73157	0						
74161	0						
75165	0						

Table 11.440: Chain of $^{148}_{64}Gd-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
64148	2	1	65148	0.001	66152		
65148	2	1	66148	0.12	67152		
66152	2	0.88	67152	1.70E-07	68156		
66148	3	1	67148	0.07	68149	0.9	68152
67152	2	0.1	68152	0.00064	69156		
68156	1	0.99936	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 11.441: Chain of $^{147}_{64}Gd-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching 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	1	0.68	75163				
75167	0						
73156	1	0.09	75160				
74159	1	0.91	75160				
75163	0						
75160	0						

Table 11.442: Chain of $^{146}_{64}Gd-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching 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	0.21E-04	70158		
67146	0						
68150	2	1.	69150	0.926	70154		
69154	2	0.074	70154	0.0091	71158		
70158	2	0.9909	71158	0.8E-04	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	1	0.92	75166				
73158	1	0.94	75162				
74162	1	0.06	75162				
75166	0						
75162	0						

Table 11.443: Chain of $^{145}_{64}Gd-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
64145	1	1.	65145				
65145	1	1.	66145				
66145	1	1.	67145				
67145	1	1.	68145				
68145	1	0.5	69146				
69146	0						

Table 11.444: Chain of $^{149}_{63}Eu-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
63149	0						

Table 11.445: Chain of ${}^{149}_{63}Eu-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
63149	1	1.	64149				
64149	2	0.833	65149	0.94E-04	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	1	1.	75165				
73157	0						
74161	0						
75165	0						

Table 11.446: Chain of ${}^{149}_{63}Eu-c*$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
63149	1	1.	64149				
64149	2	0.833	65149	0.94E-04	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	1	1.	75165				
73157	0						

74161	0						
75165	0						

Table 11.447: Chain of ${}^{148}_{63}Eu-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
63148	0						

Table 11.448: Chain of ${}^{147}_{63}Eu-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
63147	0						

Table 11.449: Chain of ${}^{147}_{63}Eu-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
63147	2	1.	64147	0.95E-04	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	1	0.68	75163				
75167	0						
73156	1	0.09	75160				
74159	1	0.91	75160				
75163	0						
75160	0						

Table 11.450: Chain of ${}^{147}_{63}Eu-c*$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)

63147	2	1.	64147	0.95E-04	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	1	0.68	75163				
75167	0						
73156	1	0.09	75160				
74159	1	0.91	75160				
75163	0						
75160	0						

Table 11.451: Chain of $^{146}_{63}Eu-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
63146	0						

Table 11.452: Chain of $^{146}_{63}Eu-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching 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	0.21E-04	70158		
67146	0						
68150	2	1.	69150	0.926	70154		
69154	2	0.074	70154	0.0091		71158	

70158	2	0.9909	71158	0.8E-04	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	1	0.92	75166				
73158	1	0.94	75162				
74162	1	0.06	75162				
75166	0						
75162	0						

Table 11.453: Chain of $^{145}_{63}Eu-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching 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	1	1.	75165				
73157	0						
74161	0						
75165	0						

Table 11.454: Chain of $^{144}_{61}Pm-i*$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
61144	0						

Table 11.455: Chain of $^{143}_{61}Pm-c$

(Z,A)	N. of	Branching	(Z,A)	Branching	(Z,A)	Branching	(Z,A)

	entries	factor		factor		factor	
61143	2	1.	62143	0.22E-04	63147		
62143	1	1.	63143				
63147	2	1.	64147	0.95E-04	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	1	0.68	75163				
75167	0						
73156	1	0.09	75160				
74159	1	0.91	75160				
75163	0						
75160	0						

Table 11.456: Chain of $^{136}_{60}Nd-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
60136	1	1.	61136				
61136	1	1.	62136				
62136	1	0.9991	63136				
63136	0						

Table 11.457: Chain of $^{136}_{59}\mathrm{Pr}-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)

59136	0						

Table 11.458: Chain of $^{136}_{59}\mathrm{Pr}-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
59136	1	1.	60136				
60136	1	1.	61136				
61136	1	1.	62136				
62136	1	0.9991	63136				
63136	0						

Table 11.459: Chain of $^{134}_{59}\mathrm{Pr}-c*$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
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 11.460: Chain of $^{139}_{58}Ce-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching 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 11.461: Chain of $^{135}_{58}Ce-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching 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 11.462: Chain of $^{134}_{58}Ce-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching 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 11.463: Chain of $^{132}_{58}Ce-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
58132	1	1.	59132				
59132	1	1.	60132				
60132	1	1.	61132				
61132	1	1.	62132				
62132	0						

Table 11.464: Chain of $^{130}_{58}Ce-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching 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 11.465: Chain of $^{132}_{57}La-i(m+g)$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
57132	0						

Table 11.466: Chain of $^{132}_{57}La-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching 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 11.467: Chain of $^{130}_{57}La-i$

(Z,A)	N. of	Branching	(Z,A)	Branching	(Z,A)	Branching	(Z,A)

	entries	factor		factor		factor	
57130	0						

Table 11.468: Chain of $^{130}_{57}La-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
57130	1	1.	58130				
58130	1	1.	59130				
59130	1	1.	60130				
60130	1	1.	61130				
61130	1	1.	62130				
62130	1	0.879	63131				
63131	0						

Table 11.469: Chain of $^{133}_{56}Ba-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching 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 11.470: Chain of $^{131}_{56}Ba-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
56131	1	1.	57131				
57131	1	1.	58131				
58131	1	1.	59131				
59131	2	1.	60131	0.5E-06	61132		
60131	0						
61132	1	1.	62132				
62132	0						

Table 11.471: Chain of $^{128}_{56}Ba-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching 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 11.472: Chain of $^{126}_{56}Ba-c$

(Z,A)	N. of	Branching	(Z,A)	Branching	(Z,A)	Branching	(Z,A)

	entries	factor		factor		factor	
65126	1	0.01	57126				
57126	1	1.	59126				
58126	1	1.	59126				
59126	0						

Table 11.473: Chain of $^{129}_{55}Cs-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching 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 11.474: Chain of $^{127}_{55}Cs-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
55127	1	1.	56127				
56127	1	1.	57127				
57127	1	1.	58127				
58127	1	1.	59127				
59127	1	1.	60127				
60127	0						

Table 11.475: Chain of $^{127}_{54}Xe-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching 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 11.476: Chain of $^{125}_{54}Xe-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching 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 11.477: Chain of $^{123}_{54}Xe-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
54123	1	1.	55123				
55123	1	1.	56123				
56123	1	1.	57123				
57123	1	1.	58123				
58123	0						

Table 11.478: Chain of $^{122}_{54}Xe-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
54122	1	1.	55122				
55122	1	1.	56122				
56122	1	1.	57122				
57122	0						

Table 11.479: Chain of $^{120}_{54}Xe-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
54120	1	1.	55120				
55120	1	1.	56120				
56120	2	1.	57120	0.01	58121		
57120	0						
58121	0						

Table 11.480: Chain of $^{120}_{53}I-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
53120							

Table 11.481: Chain of $^{120}_{53}I-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
53120	1	1.	54120				
54120	1	1.	55120				
55120	1	1.	56120				
56120	2	1.	57120	0.01	58121		
57120	0						
58212	0						

Table 11.482: Chain of $^{121}_{52}Te-i(m+g)$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
52121							

Table 11.483: Chain of $^{121}_{52}Te-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching 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 11.484: Chain of ${}^{119}_{52}Te-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
52119	1	1.	53119				
53119	2	1.	54119	0.7E-07	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 11.485: Chain of ${}^{117}_{52}Te-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
52117	1	1.	53117				
53117	2	0.99997	54117	0.00042	55118		
54117	1	1.	55117				
55118	1	1.	56118				
55117	1	1.	56117				
56118	0						
56117	1	0.061	57117				
57117	0						

Table 11.486: Chain of ${}^{114}_{52}Te-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
52114	3	1.	53114	0.34E-02	54115	0.24E-04	55118
53114	2	1.	54114	0.0007	55115		
54115	2	0.993	55115	0.03	56116		
55118	1	1.	56118				
54114	1	0.9111	55114				
55115	1	1.	56115				
56116	1	0.939	57117				
56118	0						
55114	0						
56115	0						
57117	0						

Table 11.487: Chain of ${}^{115}_{51}Sb-c*$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
51115	1	1.	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 11.488: Chain of $^{113}_{50}Sn-i(m+g)$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
50113	0						

Table 11.489: Chain of $^{111}_{49}In-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching 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 11.490: Chain of $^{110}_{49}In-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
49110	0						

Table 11.491: Chain of $^{109}_{49}In-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
49109	1	1.	50109						
50109	1	1.	51109						
51109	4	0.86695	52109	0.11	53110	0.7E-04	54113	0.331E-08	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 11.492: Chain of $^{105}_{47}Ag-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
47105	1	1.	48105				

48105	1	1.	49105				
49105	2	1.	50105	0.5E-04	52109		
50105	2	0.99	51105	0.039	52109		
52109	2	0.11	54110	0.00011	54113		
51105	0						
54110	0						
54113	0						

Table 11.493: Chain of $^{100}_{46}Pd-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching 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 11.494: Chain of $^{100}_{45}Rh-i(m+g)$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
45100	0						

Table 11.495: Chain of $^{100}_{45}Rh-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching 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 11.496: Chain of $^{99m}_{45}Rh-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
45099	1	1.	46099				
46099	1	1.	47099				
47099	2	1.	48099	0.039	49100		
48099	2	1.	49099	0.17	50100		
49100	1	0.83	50100				
49099	0						
50100	0						

Table 11.497: Chain of $^{103}_{44}Ru-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching 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 11.498: Chain of $^{97}_{44}Ru-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
44097	1	1.	45097				
45097	2	1.	46097	0.11E-04	47098		
46097	2	1.	47097	0.00025	48098		
47098	1	0.99975	48098				
47097	0						
48098	0						

Table 11.499: Chain of $^{96}_{43}Tc-i(m+g)$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
43096	0						

Table 11.500: Chain of $^{94}_{43}Tc-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
43094	1	1.	44094				
44094	2	1.	45094	0.009	46095		
45094	1	1.	46094				
46095	0						
46094	1	1.	47094				
47094	0						

Table 11.501: Chain of $^{90}_{41}Nb-c*$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
41090	1	1.	42090				
42090	1	1.	43090				
43090	1	1.	44090				
44090	0						

Table 11.502: Chain of $^{89}_{40}Zr-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching 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 11.503: Chain of ${}^{88}_{40}Zr-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching 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 11.504: Chain of ${}^{88}_{39}Y-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
39088	0						

Table 11.505: Chain of ${}^{87m}_{39}Y-c*$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
39087	1	1.	40087				
40087	1	1.	41087				
41087	1	0.85	42087				
42087	1	1.	43087				
43087	0						

Table 11.506: Chain of ${}^{87}_{39}Y-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
39087	0						

Table 11.507: Chain of ${}^{87}_{39}Y-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
39087	1	1.	40087				
40087	1	1.	41087				
41087	1	0.85	42087				
42087	1	1.	43087				
43087	0						

Table 11.508: Chain of ${}^{87}_{39}Y-c*$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
39087	1	1.	40087				
40087	1	1.	41087				
41087	1	0.85	42087				
42087	1	1.	43087				
43087	0						

Table 11.509: Chain of ${}^{86}_{39}Y-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
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						

Table 11.510: Chain of ${}^{85}_{38}Sr-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
38085	1	1.	39085				
39085	1	1.	40085				
40085	1	1.	41085				
41085	1	1.	42085				
42085	0						

Table 11.511: Chain of ${}^{83}_{38}Sr-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
38083	1	1.	39083				
39083	1	1.	40083				
40083	1	1.	41083				
41083	1	1.	42083				
42083	0						

Table 11.512: Chain of ${}^{84}_{37}Rb-i(m+g)$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
37084	0						

Table 11.513: Chain of ${}^{83}_{37}Rb-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching 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 11.514: Chain of ${}^{77}_{35}Br-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)

35077	1	1.	36077				
36077	1	1.	37077				
37077	1	0.9975	38077				
38077	1	0.9975	39077				
39077	0						

Table 11.515: Chain of $^{75}_{34}Se-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
34075	1	1.	35075				
35075	1	1.	36075				
36075	1	1.	37075				
37075	1	0.935	38075				
38075	0						

Table 11.516: Chain of $^{74}_{33}As-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
33074	0						

Table 11.517: Chain of $^{65}_{30}Zn-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
30065	1	1.	31065				
31065	1	1.	32065				
32065	1	1.	33065				
33065	1	1.	34065				
34065	0						

Table 11.518: Chain of $^{60}_{27}Co-i(m+g)$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
27060							

Table 11.519: Chain of $^{58}_{27}Co-i(m+g)$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
27058	0						

Table 11.520: Chain of $^{56}_{27}Co-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
27056	1	1.	28056				
28056	2	0.65	30057	0.00023	31060		
30057	0						
31060	0						

Table 11.521: Chain of $^{59}_{26}Fe-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
26059	1	1.	25059				
25059	1	1.	24059				
24059	1	1.	23059				
23059	1	1.	22059				
22059	0						

Table 11.522: Chain of $^{54}_{25}Mn-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
25054	0						

Table 11.523: Chain of $^{52}_{25}Mn-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching 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 11.524: Chain of $^{48}_{23}V-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching 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 11.525: Chain of $^{48}_{21}Sc-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
21048	0						

Table 11.526: Chain of $^{46}_{21}Sc-i(m+g)$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
21046	0						

Table 11.527: Chain of $^{28}_{12}Mg-c$

(Z,A)	N. of	Branching	(Z,A)	Branching	(Z,A)	Branching	(Z,A)

	entries	factor		factor		factor	
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 11.528: Chain of $^{24}_{11}Na-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching 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 11.529: Chain of $^{22}_{11}Na-c$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
11022	2	1.	12022	0.011	13023		
12022	2	0.3879	13022	0.73	14023		
13023	1	0.27	14023				
13022	1	0.68	14022				
14023	0						
14022	0						

Table 11.530: Chain of $^{7}_{4}Be-i$

(Z,A)	N. of entries	Branching factor	(Z,A)	Branching factor	(Z,A)	Branching factor	(Z,A)
4007	0						

12. APPENDIX 3. LIST OF PUBLISHED PAPERS.

1. Yury E. Titarenko, Viacheslav F. Batyaev, Ruslan D. Mulambetov, Valery M. Zhivun, Vladilen S. Barashenkov, Stepan G. Mashnik, Yury N. Shubin, Anatoly V. Ignatyuk, Excitation Functions of Product Nuclei from 40-2600 MeV Proton-Irradiated $^{206,207,208,nat}Pb$ and ^{209}Bi, The Seventh International Topical Meeting on Nuclear Applications of Accelerator Technology (AccApp05), 29 August - 1 September 2005, Venice, Italy. Nucl. Instrum & Methods in Phys Res. A562(2006) 801-805.
2. Yu. E. Titarenko, V. F. Batyaev, A. Yu. Titarenko, M. A. Butko, K. V. Pavlov, R. S. Tikhonov, S. N. Florya, S. G. Mashnik, A. V. Ignatyuk, W. Gudowski, Residual nuclide formation in $^{206,207,208,nat}Pb$ and ^{209}Bi induced by 0.04-2.6 GeV Protons as well as in ^{56}Fe Induced by 0.3-2.6 GeV Protons, International Conference on Nuclear Data, Nice Acropolis, 22 - 27 April 2007, pp. 1099- 1102.
3. Yu. E. Titarenko, V. F. Batyaev, A. Yu. Titarenko, M. A. Butko, K. V. Pavlov, R. S. Tikhonov, S. N. Florya, S. G. Mashnik, W. Gudowski, High Energy Threshold Reaction Rates on 0.8 GeV proton-irradiated thick Pb-target, International Conference on Nuclear Data, Nice Acropolis, 22 - 27 April 2007, pp. 1209 - 1212.
4. Excitation Functions of Residual Nuclei Production from 40-2600 MeV Proton-irradiated 206,207,208,natPb and 209Bi - ITEP Experimental ADS Activities , Workshop on Physics for ADS for Energy and Transmutation, University of Rajasthan, Jaipur, India , 23–26 January 2006, Pramana journal of physics, vol. 68, No.2, February 2007, pp.289-295
5. V.F.Batyaev, M.A. Butko, K.V. Pavlov, et al. Analysis of general nuclear-physical features of proton beam interaction with heavy metal targets, Atomic Energy, v. 104.4, April 2008, pp. 242-249 (in Russian).
6. Yu. E. Titarenko, V. F. Batyaev, A. Yu. Titarenko, M. A. Butko, K. V. Pavlov, S. N. Florya, R. S. Tikhonov, S. G. Mashnik, A. V. Ignatyuk, N. N. Titarenko, W. Gudowski, M. Tesınsky, C.-M. L. Persson, H. Ait Abderrahim, H. Kumawat, and H. Duarte, Cross sections for nuclide production in a ^{56}Fe target irradiated by 300, 500, 750, 1000, 1500, and 2600 MeV protons compared with data on a hydrogen target irradiated by 300, 500, 750, 1000, and 1500 MeV/nucleon ^{56}Fe ions, PHYSICAL REVIEW C 78, 034611 (2008)
7. Yu. E. Titarenko, V. F. Batyaev, A. Yu. Titarenko, M. A. Butko, K. V. Pavlov, R. S. Tikhonov, S. N., Florya, S. G. Mashnik, W. Gudowski, ^{148}Gd formation in thin ^{nat}W and ^{181}Ta targets induced with 0.4-2.6 GeV protons, PSI Proceedings 09-01, January 2009, ISSN 1019-0643, 68-74.
8. Yury Titarenko, Viacheslav Batyaev, Alexey Titarenko, Michael Butko, Kirill Pavlov, Sergey Florya, Roman Tikhonov, Nikolai Sobolevsky, Stepan Mashnik, Waclaw Gudowski, Radioactive Nuclide Formation in Proton-Irradiated Extended Lead-Target, PSI Proceedings 09-01, January 2009, 119-127.

13. APPENDIX 4. LIST OF CONTRIBUTIONS AT DIFFERENT CONFERENCES AND WORKSHOPS.

Contributions at ND2007:

1) Residual nuclide formation in ^{206,207,208,nat}Pb and ^{209}Bi induced by 0.04-2.6 GeV Protons as well as in ^{56}Fe Induced by 0.3-2.6 GeV Protons

2) Threshold Reaction Rates on 0.8 GeV proton-irradiated thick Pb-target

Contributions at NUFRA2007.

1. Fragmentation Products from Lead isotopes, Lead and Bismuth Induced by 0.04-2.6 GeV Protons
2. Rates of High Energy Threshold Reactions on Extended Lead target induced by 0.8 GeV protons
3. Nuclear Data requirements for Accelerator-Driven Systems
4. Fragmentation products from ^{56}Fe Induced by 0.3-2.6 GeV Protons

Contributions at conference-session of physical science department of Russian cademy of science "Physics of fundamental interactions" ».

1. Integral experiment with extended Pb target irradiated with 0.8GeV protons (in Russian).
2. Reaction products in ^{93}Nb and ^{nat}Ni irradiated with 0.8 – 2.6 GeV protons (in Russian).
3. Yields of ^{148}Gd and fragmentation products via 0.8-2.6GeV protons interactions with ^{nat}W and ^{181}Ta (in Russian).
4. Reaction products from ^{56}Fe and ^{nat}Cr irradiated with 0.3-2.6GeV energies (in Russian).

Contributions at the scientific session NIYaU-MEPhI-2010 , section #1 – nuclear physics and energy, topic: "experimental nuclear data", 25-31 january 2010:

1. Experimental study of residual nuclide cross sections for production in thin ^{56}Fe and ^{nat}Cr targets irradiated with 40 - 2600 MeV protons *(in Russian).*
2. Experimental study of residual nuclide cross sections for production in ^{nat}W and ^{181}Ta irradiated with 40 - 2600 MeV protons *(in Russian).*
3. Experimental study of radioactive residual nuclide production cross sections in ^{93}Nb and ^{nat}Ni induced by 0.04-2.6 GeV protons *(in Russian).*

Contributions at ICRS-11 & RPSD-2008 (11th International Conference on Radiation Shielding (ICRS-11) & 15th Topical Meeting of the Radiation Protection & Shielding Division of ANS (RPSD-2008), April 13-18, 2008 Callaway Gardens, Pine Mountain, Georgia, USA)

1. Beam dump and local shielding layout around the ITEP radiation test facility
2. Residual radioactive nuclide formation in 0.8-gev proton-irradiated extended pb-target

Contributions at ARIA'08 (First International Workshop on Accelerator Radiation Induced Activation (ARIA'08), PSI, 13-17 October 2008)).:

1. "^{148}Gd formation in thin ^{nat}W and ^{181}Ta targets induced with 0.4-2.6GeV protons"
2. "Radioactive nuclide formation in proton- irradiated extended lead- target"

Contributions at Technical Meeting (TM) on "Analytical and Experimental Benchmark Analyses of Accelerator Driven Systems (ADS)", Mumbai, India, 22 - 26 February 2010:

1. ITEP contribution to the CRP "Analitycal and experimental benchmark analyses on ADS

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