Technical Meeting on the International Network of Nuclear Reaction Data Centres (NRDC)

Centre for Photonuclear Experiments Data (CDFE)
Skobeltsyn Institute of Nuclear Physics
Lomonosov Moscow State University

The CDFE photonuclear data compilations and evaluation activity. 2016/2017 Progress Report.

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23 - 26 May 2017, NDS, IAEA, Vienna, Austria

The CDFE photonuclear data compilation and evaluation activity. 2016/2017 Progress Report.

***V.V.Varlamov**, A.I.Davydov, S.Yu.Komarov, N.N.Peskov, M.E.Stepanov*

Progress Report to the Technical Meeting on the International Network of Nuclear Reaction Data Centres (NRDC) at the IAEA Headquarters in Vienna, Austria, from 23 to 26 May 2017.

This short report contains review of the main results obtained at the Russia Lomonosov Moscow State University Skobeltsyn Institute of Nuclear Physics Centre for Photonuclear Experiments Data (Centr Dannykh Fotoyadernykh Eksperimentov – CDFE) for the period of time from the IAEA's Technical Meeting on the International Network of Nuclear Reaction Data Centres at the Nuclear Data Centre, Atomic Energy of China (CAEA), Beijing, China, from 7 to 10 June 2016 concern new photonuclear data compilations and old data corrections, analysis and evaluation of photonuclear data obtained in various experiments and nuclear data service in the whole.

The main CDFE responsibility in the NRDC Network is compilation and processing of photonuclear data. The main CDFE scientific activity is joint evaluating of photonuclear data obtained in various experiments.

The CDFE total permanent stuff includes now four professional, three general service officers and three students of the MSU Physics Faculty.

The CDFE nuclear data activities in the whole are dissemination of international nuclear data for providing Lomonosov Moscow State University (Skobeltsyn Institute of Nuclear Physics, primarily) and scientific and educational institutes and organizations of Russian Academy of Science for basic research, education and various applications. The CDFE maintains several nuclear databases available through the CDFE Web-site – http://cdfe.sinp.msu.ru.

CDFE EXFOR Compilation

5 new CDFE EXFOR **trans.m083 - m087** transes and the ***prelim.m088*** have been produced and transmitted to the IAEA NDS.

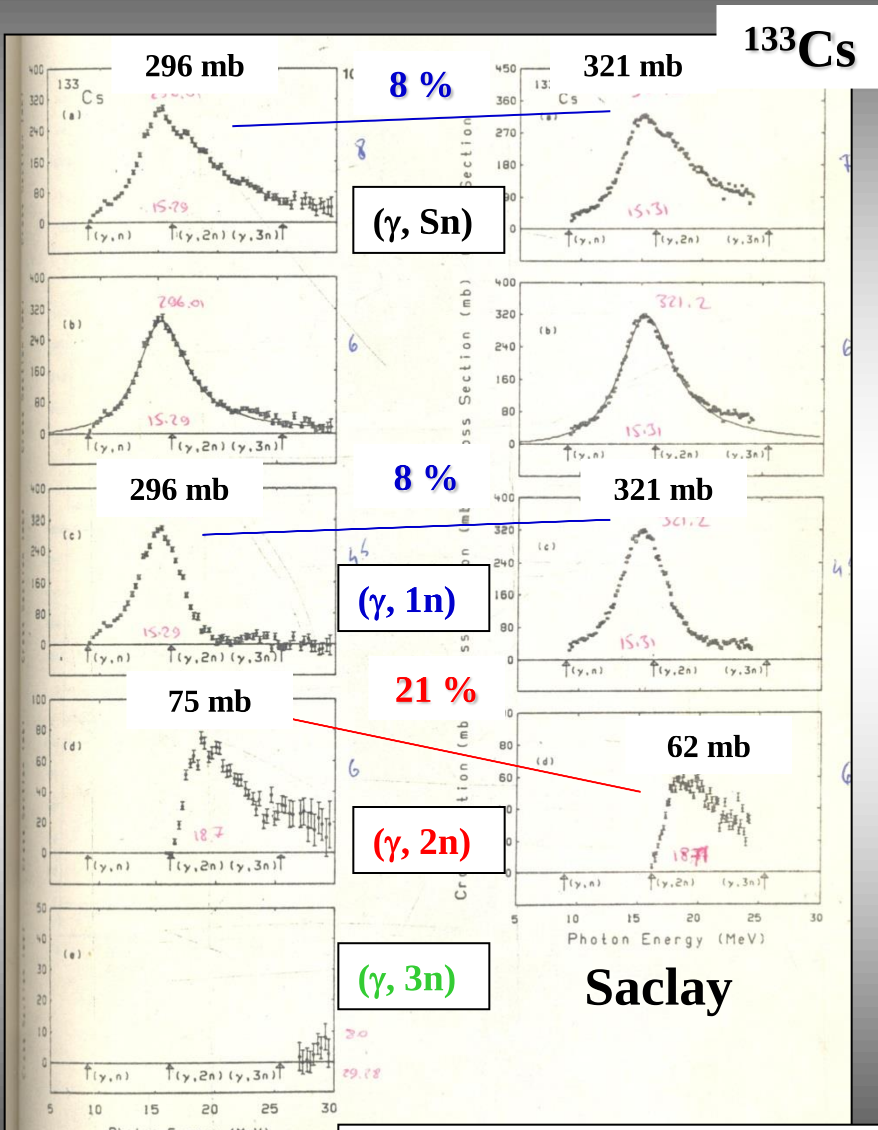
All TRANSes contain both **14** new ENTRYs and **87** old ENTRYs corrected in accordance with the new EXFOR format rules and the NRDC experts, first of all Naohiko Otsuka and Oscar Cabellos, comments and recommendations.

On the whole new CDFE trances have been produced in the reported period:

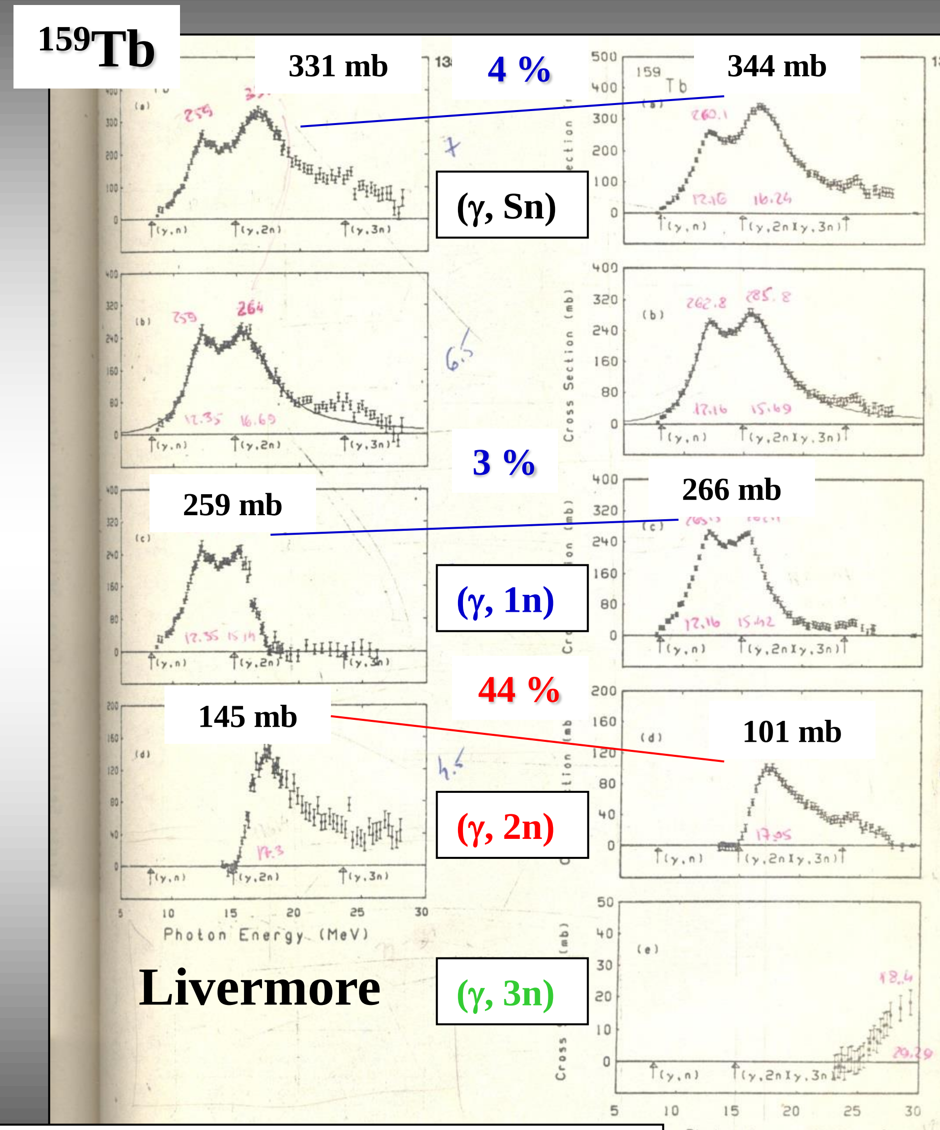
TRANS	Old	New	Total
m083	16	0	16
m084	16	3	19
m085	15	1	16
m086	15	3	18
m087	7	3	10
prelim.m088	18	4	22
All	87	14	101

CDFE Photonuclear Data Evaluation

^{133}Cs



^{159}Tb

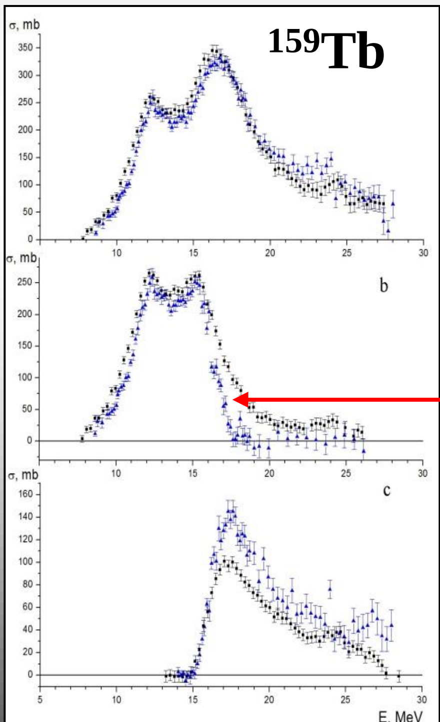


S.S.Dietrich and B.L.Berman. Atom. Data and Nucl. Data Tables, 38 (1988) 199

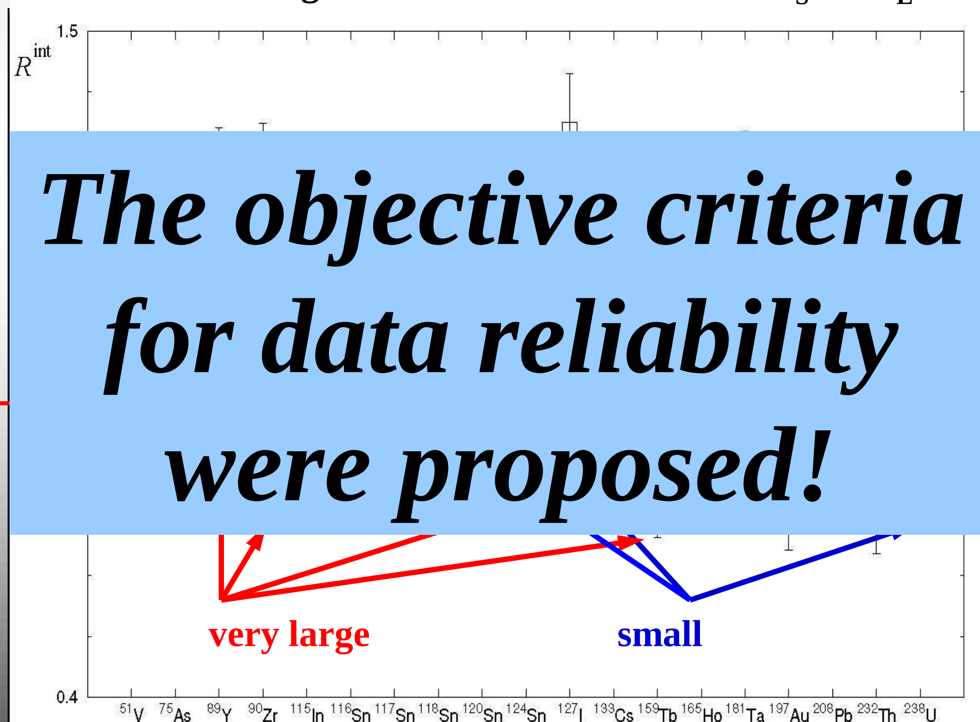
Main problem for 19 nuclei investigated in both Labs:

(γ, 1n) cross sections are larger at Saclay but those for (γ, 2n) - at Livermore.

V.V.Varlamov, N.N.Peskov, D.S.Rudenko, M.E.Stepanov. Consistent Evaluation of Photoneutron Reaction Cross Sections Using Data Obtained in Experiments with Quasimonoenergetic Annihilation Photon Beams at Livermore (USA) and Saclay (France). INDC(CCP)-440, IAEA NDS, Vienna, Austria, 2004, p. 37.



Ratios of integrated cross sections $R^{int} = \sigma^{int}_S / \sigma^{int}_L$



The objective criteria for data reliability were proposed!

Squares - ■ - ratios for (γ, 1n) reactions – are larger than 1.0:

<R> ~ 1.07.

Triangles - △ - ratios for (γ, 2n) reactions – are smaller than 1.0:

<R> ~ 0.84.

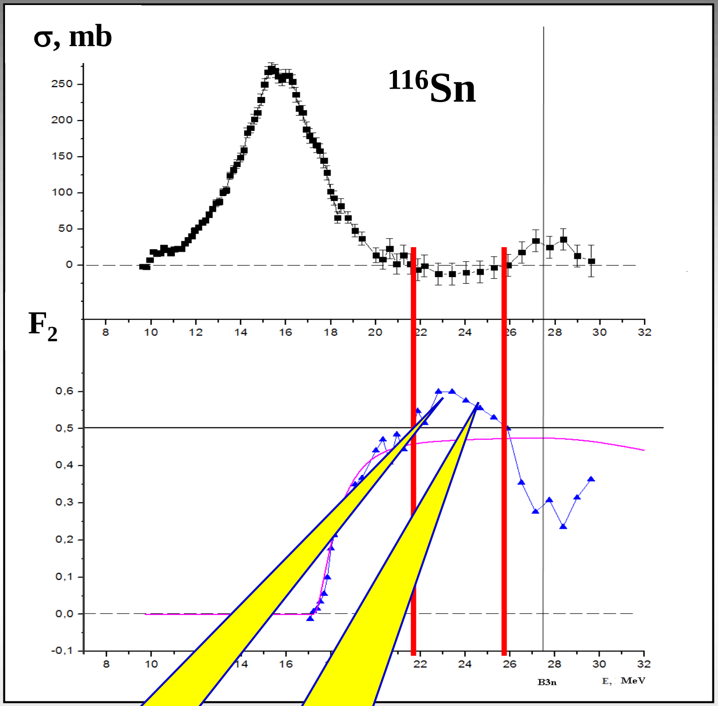
Very simple and convenient for using
objective physical criteria of data reliability
not dependent on the methods of their obtaining were proposed.

The most interesting is F_2 – effective tool for investigation of competition between three partial photoneutron reactions under discussion - (γ, 1n), (γ, 2n) and (γ, 3n).

$$F_2 = \frac{\sigma(\gamma, 2n)}{\sigma(\gamma, 1n) + 2\sigma(\gamma, 2n) + 3\sigma(\gamma, 3n) + \ldots}$$

In accordance with definition: $F_2 < 1.00$; $F_2 < 0.50$; $F_3 < 0.33$; $F_4 < 0.25$, $F_5 < 0.20$ …;

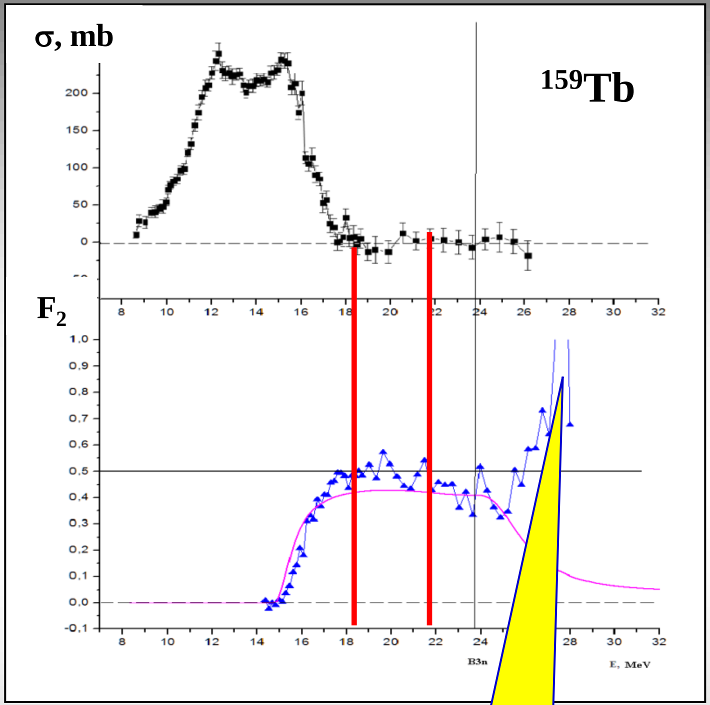
Some examples of Livermore data



$\sigma(\gamma, 1n)$

negative values

$F_2 > 0.50$



$F_2 > 0.50$!

Decrease before B3n

$F_2 \approx$ 2.00?!

Physically not reliable negative cross section values are correlated with physically forbidden values $F_2 > 0.50$

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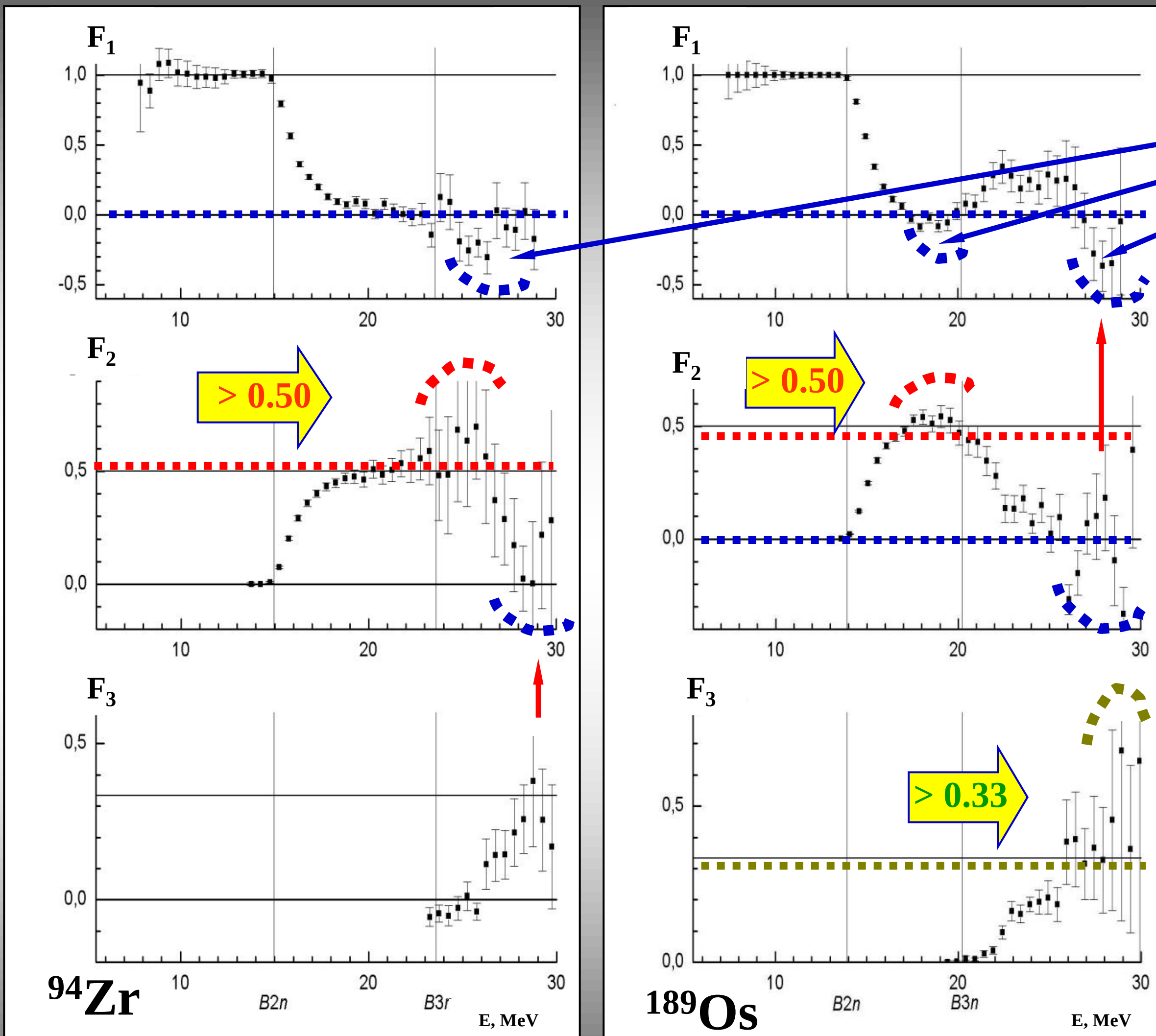


Physically forbidden negative values

Physically unreliable values:
$F_2 > 0.50$

Physically forbidden negative values

Physically unreliable values:
$F_3 > 0.33$

The reliability of many data is doubtful.

Many data should be reanalyzed and reevaluated!

New experimentally-theoretical method of evaluation

using combined model of photonuclear reactions:

- initial data – experimental cross section for the neutron yield reaction

$$(\gamma, Sn) = (\gamma, 1n) + 2(\gamma, 2n) + 3(\gamma, 3n) + \ldots$$

- competition of partial reactions based on theoretical model.

Theoretically calculated in the combined model of photonuclear reactions transitional multiplicity functions

$$F_i^{theor} = \sigma^{theor}(\gamma, in)/\sigma^{theor}(\gamma, Sn)$$

are used for cross section evaluation by following way

$$\sigma^{eval}(\gamma, in) = F_i^{theor}(\gamma, in) \bullet \sigma^{exp}(\gamma, Sn).$$

The evaluation method means that competition of partial reactions is described by the model and their correspondent sum $\sigma^{eval}(\gamma, Sn)$ is equal to the experimental $\sigma^{exp}(\gamma, Sn)$ reaction cross section.

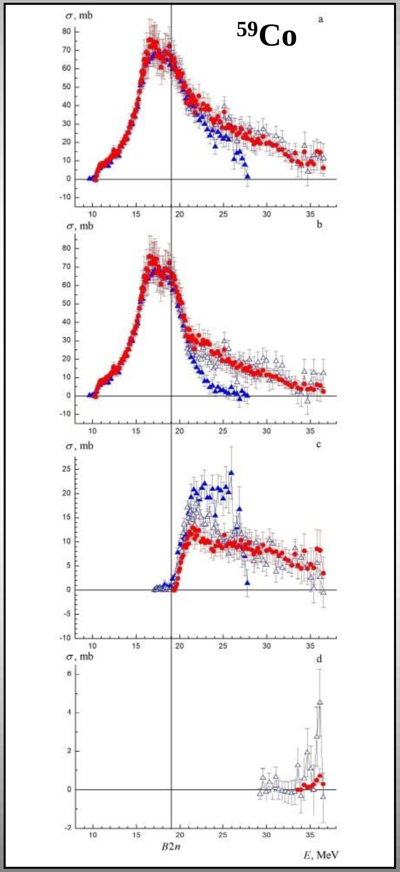
In addition to activity in photonuclear data compilation and the CDFE continues the program of investigation of reliability partial photoneutron reaction cross sections obtained in various experiments using specially proposed objective physical criteria of data reliability.

In addition to many nuclei investigated before (for example, ^{91,94}Zr, ^{115}In, $^{116\text{-}124}$Sn, ^{159}Tb, ^{181}Ta, ^{186,188,190,192}Os, ^{197}Au, ^{208}Pb, ^{209}Bi) in the frame of the IAEA Coordinated Research Project N F41032 "Updating the Photonuclear Data Library and generating a reference database for Photon Strenght Functions" (Research Contract N 20501 "Evaluation of Partial and Total Photoneutron Reactions Cross Sections Using New Objective Physical Data Reliability Criteria") 9 new nuclei were investigated (^{63,65}Cu, ^{80}Se, ^{89}Y, ^{133}Cs, ^{138}Ba, ^{141}Pr, ^{165}Ho, ^{186}W).

For all 9 nuclei using experimental-theoretical method for evaluation of reliable partial ((γ, 1n), (γ, 2n), (γ, 3n)) and total photoneutron reaction (γ, tot) = (γ, 1n) + (γ, 2n) + (γ, 3n) reactions cross sections were obtained.

New reliable evaluated data were included into the EXFOR database.

(γ, tot) = (γ,1n) + (γ,2n) + (γ,3n)

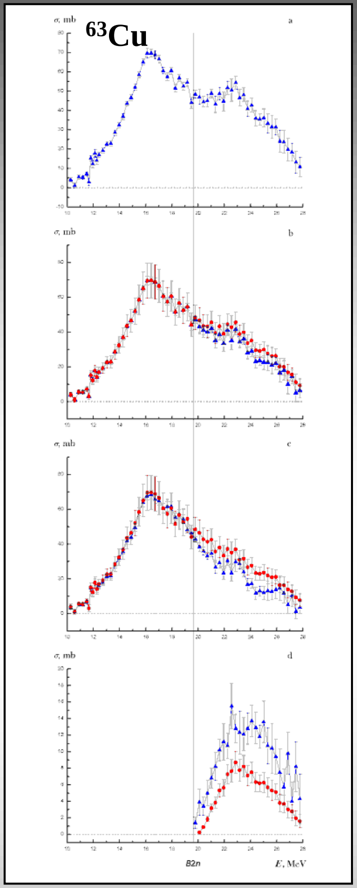


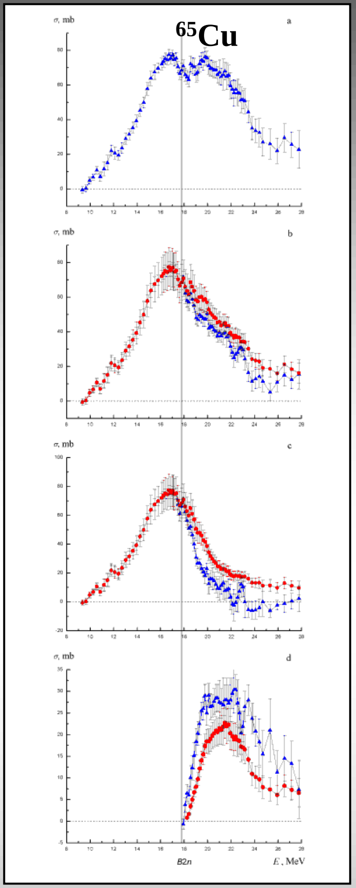
σ(γ, tot)

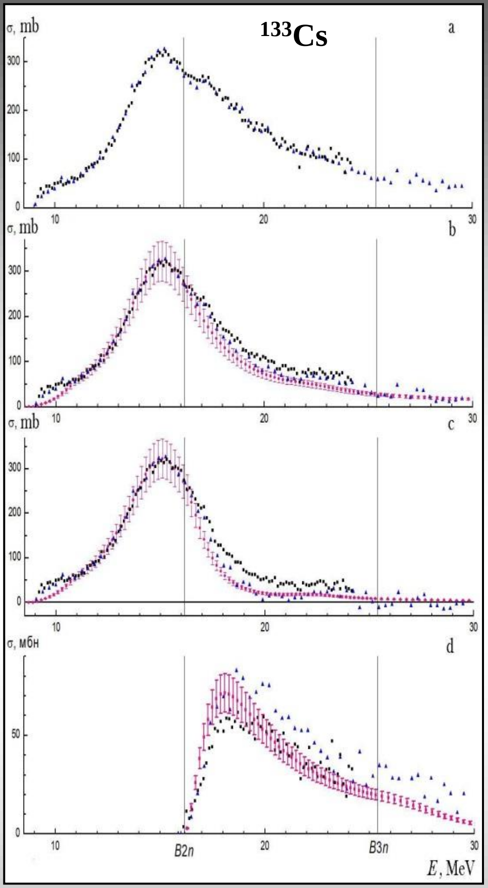
σ(γ, 1n)

σ(γ, 2n)

σ(γ, 3n)

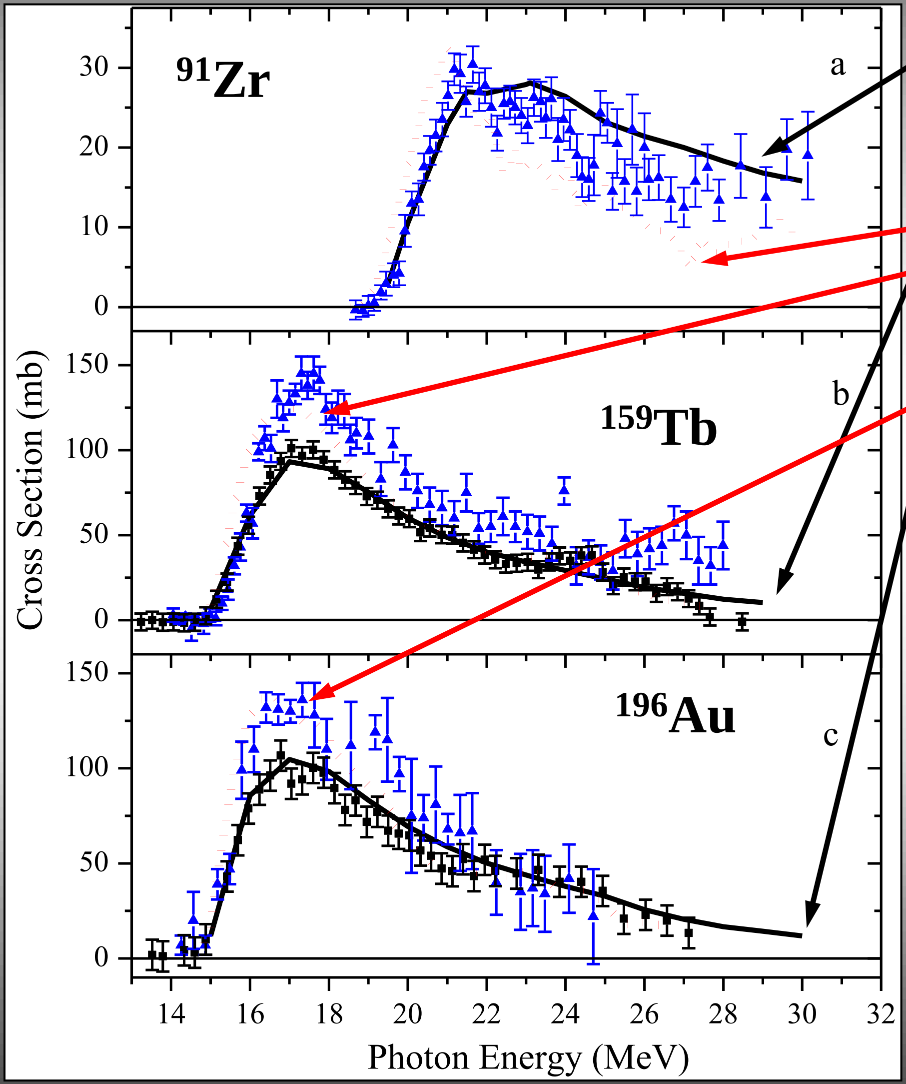






The evaluated cross sections noticeably differ from the experimental once.

σ(γ, 2n)



IAEA CRP (1996 – 1999) evaluations (GUNF and GNASH codes)

are quite different from our evaluations based on F-functions

Previous CRP evaluation has been done to model accurately Saclay (γ, tot) data.

The possible reason for new and old evaluations disagreements:

Because at energies below B3n
σ(γ, tot) ≈ σ(γ, Sn) - σ(γ, 2n)
large systematic errors in σ(γ, 2n) can lead to systematic errors in σ(γ, tot)
and correspondingly
to those in data for partial reaction cross sections evaluated on the base of using σ(γ, tot).

The correspondent talks were presented at:

- **the 66 International Conference on the problems of nuclear spectroscopy and structure of atomic nucleus «Nucleus 2016». 10 – 14 October 2016, Sarov, Russia, FGUP «RFYAC-VNIIEF»**
- **the International Conference on Nuclear Data for Science and Technology (Bruges, Belgium, 11-16 September, 2016).**

The correspondent articles are prepared for the journals:

- **Physical Review C,**
- **European Journal of Physics A,**
- **EPJ Web of Conference,**
- **Physics of Atomic Nuclei ,**
- **Bulletin of the Russian Academy of Sciences.**

Main Publications

1. V. Varlamov, B. Ishkhanov, V. Orlin. Reliability of (γ, 1n), (γ, 2n), and (γ, 3n) cross-section data on ^{159}Tb. Phys. Rev. C95, N5 (2017) 054607.

2. B.S.Ishkhanov, V.N.Orlin, N.N.Peskov, V.V.Varlamov. Photoneutron reactions in the range of Giant Dipole Resonance. Physics of Particles and Nuclei, 48, N1 (2017) 76 - 83.

3. V.V.Varlamov, B.S.Ishkhanov, V.N.Orlin, N.N.Peskov. Data on photoneutron reactions from various experiments for ^{133}Cs, ^{138}Ba and ^{209}Bi nuclei. Physics of Atomic Nuclei, 79, N4 (2016) 501 – 513.

4. V.V.Varlamov, A.I.Davydov, M.A.Makarov, V.N.Orlin, N.N.Peskov. Reliability of the data on the cross sections of the partial photoneutron reaction for ^{63,65}Cu and ^{80}Se nuclei. Bulletin of the Russian Academy of Sciences, Physics, 80, №3 (2016) 317 - 324.

5. Vladimir Varlamov, Boris Ishkhanov, Vadim Orlin, Nikolai Peskov, Mikhail Stepanov. Photoneutron reaction cross sections from various experiments – analysis and evaluation using physical criteria of data reliability. EPJ Web of Conferences (2017), in print.

6. Varlamov VV, Ishkhanov BS, Orlin VN, Peskov NN, Stepanov ME. Photoneutron reaction cross sections from various experiments – analysis and evaluation using physical criteria of data reliability. ND2016 Programme & Abstract Book, 11-16 September, Brugges, Belgium, Joint Research Centre, European Commission, 2016, p. 266.

7. Gheorgine I., Filipescu D., Katayama S., Utsunomiya H., Belyshev S.S., Varlamov V.V., Shima T., Amano S., Miyamoto S. Partial photoneutron cross section measurements on ^{209}Bi. ND2016 Programme & Abstract Book, 11-16 September, Bruges, Belgium, Joint Research Centre, European Commission, 2016, p. 307.

8. V.V.Varlamov, A.I.Davydov, V.N.Orlin, N.N.Peskov. Photodisintegration of ^{89}Y and physical criteria of data reliability. 66 International Conference on the problems of nuclear spectroscopy and structure of atomic nucleus «Nucleus 2016». 10 – 14 October 2016, Sarov, Russia. Abstracts. FGUP «RFYAC-VNIIEF», 2016, p. 145.

9. V.V.Varlamov, V.N.Orlin, N.N.Peskov. Evaluation of partial photoneutron reactionn cross sections for ^{141}Pr and ^{186}W using physical criteria of data reliability. 66 International Conference on the problems of nuclear spectroscopy and structure of atomic nucleus «Nucleus 2016». 10 – 14 October 2016, Sarov, Russia. Abstracts. FGUP «RFYAC-VNIIEF», 2016, pp. 146 - 147.

10. V.V.Varlamov, B.S.Ishkhanov. Modern status of photonuclear data. 66 International Conference on problems of nuclear spectroscopy and structure of atomic nucleus «Nucleus 2016». 10 – 14 October 2016, Sarov, Russia. Abstracts. FGUP «RFYAC-VNIIEF», 2016, pp. 148 - 149.

CDFE Nuclear Database Service

The main CDFE nuclear database service activities are dissemination of modern international nuclear data for providing

Lomonosov Moscow State University (Skobeltsyn Institute of Nuclear Physics, primarily) staff and students

and also scientific and educational institutes and organizations of Russian Academy of Science with nuclear data for basic research, education and various applications.

Nuclear Database Service

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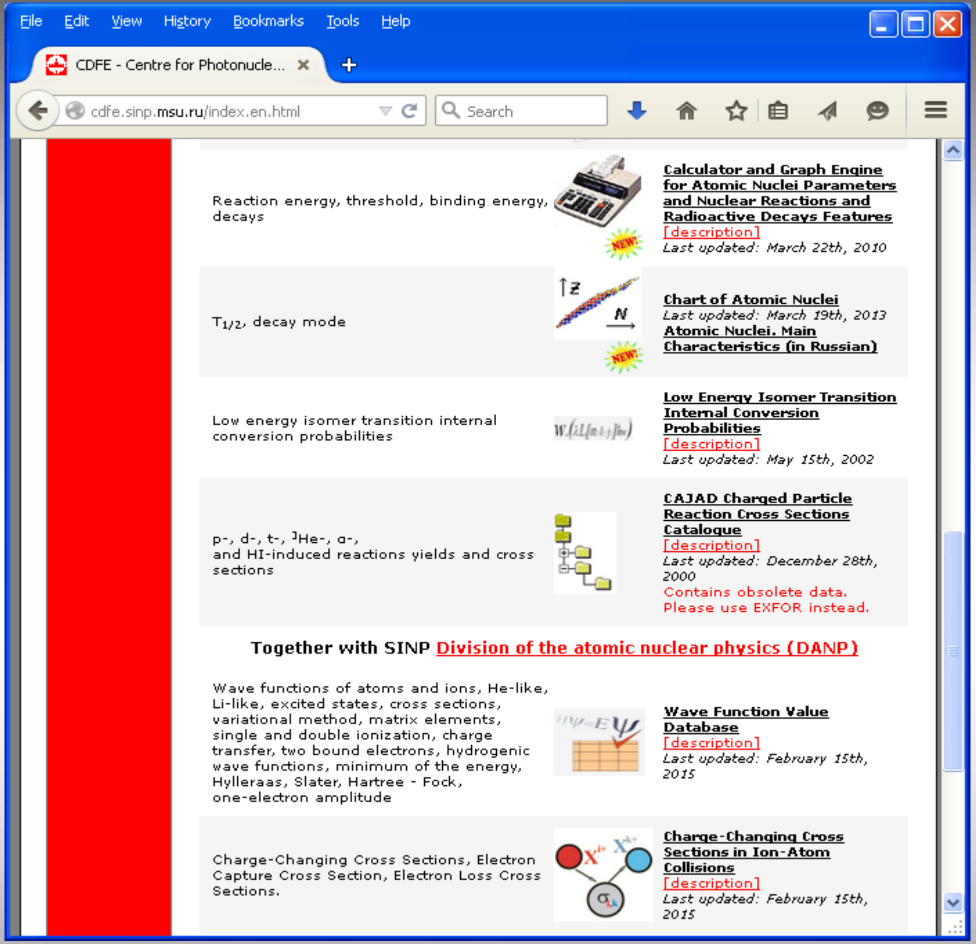

EXFOR, ENSDF, and NSR databases are based on the international data sources (USA NNDC and NSDD) but have original Search Engines.

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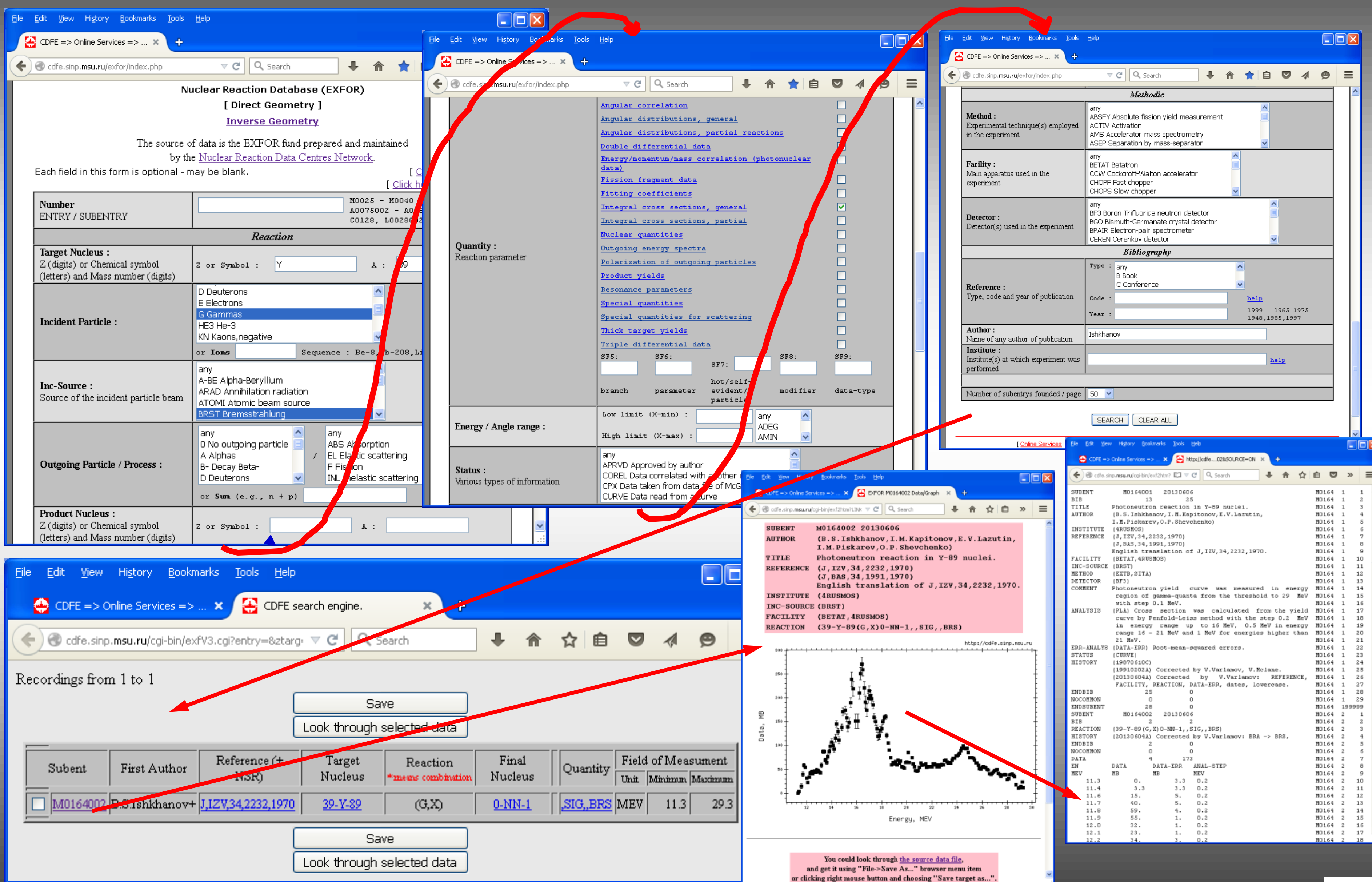
The main database: EXFOR



Short-term (2017/2018) CDFE Program

The main items of the CDFE (2017/2018) program, main priorities and most important tasks are traditional and the following:

- continuation of new photonuclear data compilation using EXFOR format, new TRANSes (M089, M090, etc.) production;
- correction of old ENTRYs in accordance with new EXFOR coding rule changes and the NRDC Network experts comments and recommendations;
- continuation of analysis and evaluation using objective physical criteria of total and partial photonuclear reaction cross sections obtained in various experiments;
- upgrading of all databases put upon the CDFE Web-site http://cdfe.sinp.msu.ru).

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THANKS A LOT FOR ATTENTION!