International Atomic Energy Agency
Nuclear Data Services
Provided by the Nuclear Data Section

Technical Meeting on the International Network of Nuclear Reaction Data Centres

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

The CDFE photonuclear data Compilations.and evaluations in 2015 – 2016

Vladimir Varlamov,
Aleksandr Davydov,
Sergei Komarov,
Nikolai Peskov,
Mikhail Stepanov

The CDFE photonuclear data compilations and evaluations in 2015 – 2016.

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 at the Nuclear Data Centre, Atomic Energy of China (CAEA), Beijing, China, 7 – 10 June 2016

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) concern nuclear data compilation and correction, analysis and evaluation for the period of time from the IAEA's Technical Meeting On International Network of Nuclear Reaction Data Centers" (NRDC), 21 – 23 April 2015, IAEA's Headquarters, Vienna, Austria till the summer of 2016.

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

The CDFE total permanent stuff includes now five professional, three general service officers and several 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, edication and various applications. The CDFE maintains several nuclear databases available through the CDFE Web-site – http://cdfe.sinp.msu.ru.

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CDFE EXFOR Compilation

Five new CDFE EXFOR **TRANS.M078 - 082** and **one PRELIM.M083** transes have been produced and transmitted to the IAEA NDS. All TRANSes are prepared in addition to a number of new ENTRYs contain many old ENTRYs corrected in accordance with the NRDC Network experts comments and recommendations.

On the whole new CDFE trances have been produced in the reported period contain **121** corrected and **19** new ENTRYs:

TRANS	Old	New	Total
m078	5	7	12
m079	7	3	10
m080	3	5	8
m081	33	3	36
m082	57	1	58
prelim.m083	16	0	16
All	121	19	140

The majority of prepared ENTRYs contains old photonuclear data corrected in accordance with new EXFOR format rules.

I would like to acknowledge very much Svetlana Dunaeva for great help and assistance in finding mistakes and doing corrections and Naohiko Otsuka and Oscar Cabellos for many very important and useful comments.

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CDFE Photonuclear Data Evaluation

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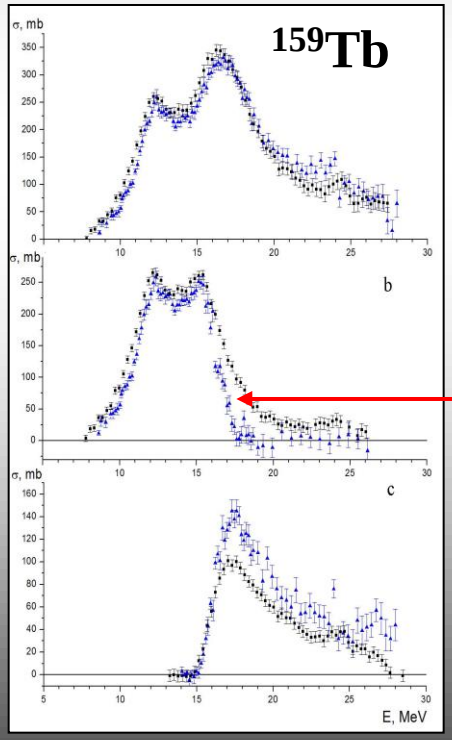
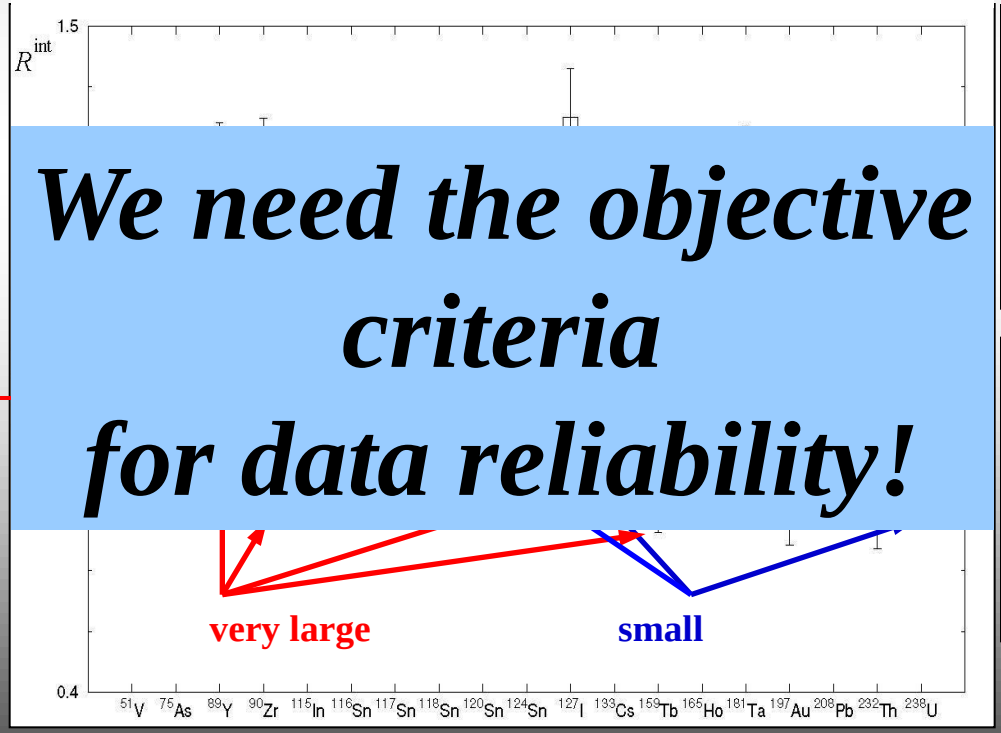
Main problem for 19 nuclei investigated in both Labs:

(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 $R^{int} = \sigma^{int}_S / \sigma^{int}_L$



We need the objective criteria for data reliability!

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.

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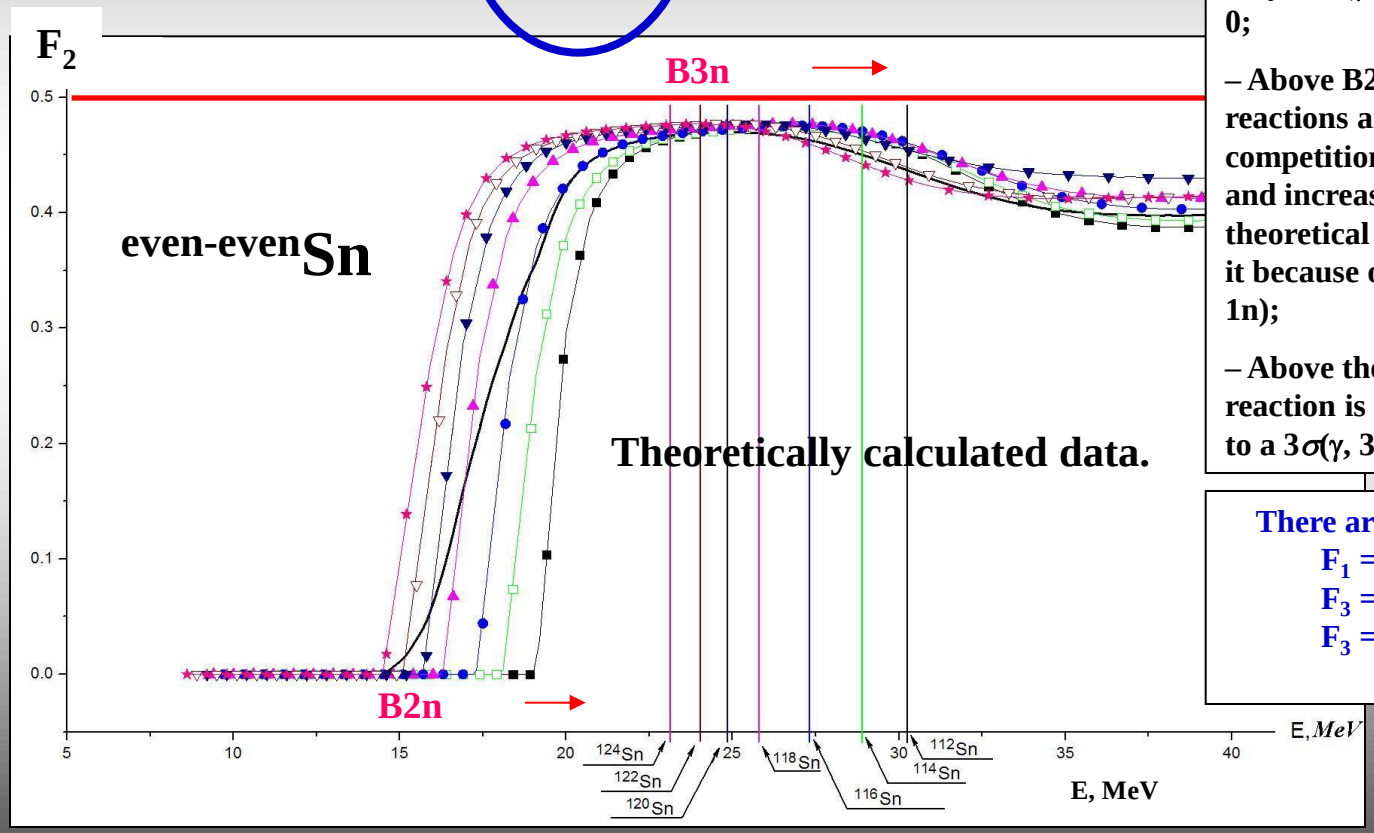
Main objective physical criterion for data reliability

$$F_2 = \frac{\sigma(\gamma, 2n)}{\sigma(\gamma, 1n) + 2\sigma(\gamma, 2n) + 3\sigma(\gamma, 3n) + \ldots} < 0.50\ (!)$$



The natural and physically reliable energy dependence of F_2 should be following:

– Below the (γ, 2n) reaction threshold B2n only the (γ, 1n) reaction is possible: $F_2 = 0$;

– Above B2n both (γ, 1n) and (γ, 2n) reactions are possible, F_2 increases due to competition between decreasing $\sigma(\gamma, 1n)$ and increasing $\sigma(\gamma, 2n)$, going to the theoretical limit of 0.50, but never reach it because of a high–energy part in $\sigma(\gamma, 1n)$;

– Above the B3n threshold the (γ, 3n) reaction is also possible, F_2 decreases due to a $3\sigma(\gamma, 3n)$.

There are additional physical criteria:

$F_1 = \sigma(\gamma, 1n) / \sigma(\gamma, xn) < 1.00$

$F_3 = \sigma(\gamma, 3n) / \sigma(\gamma, xn) < 0.33$

$F_3 = \sigma(\gamma, 4n) / \sigma(\gamma, xn) < 0.25$

etc.

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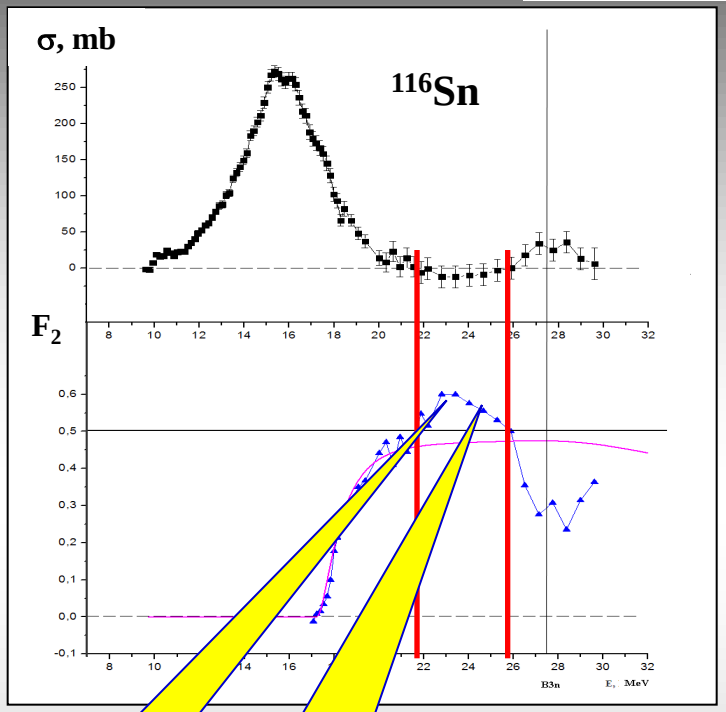
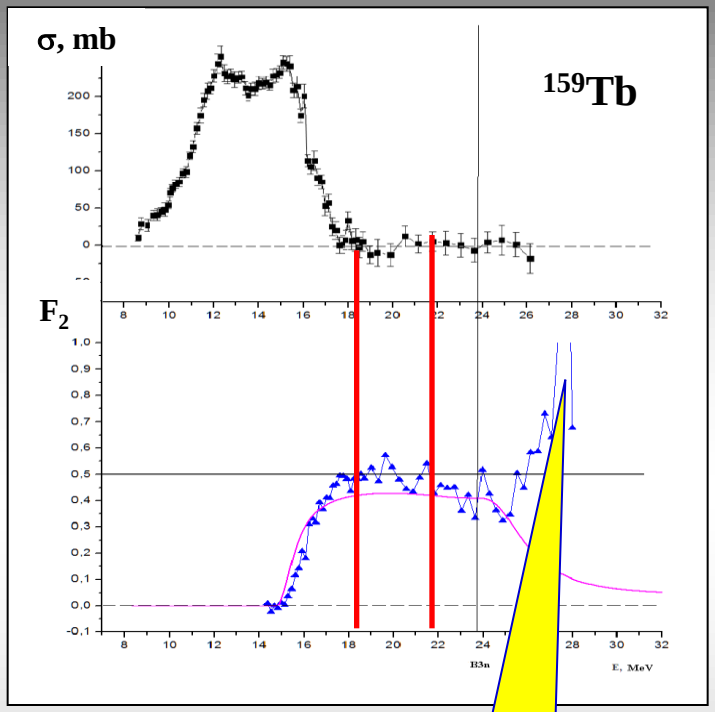
Some examples of Livermore data



$\sigma(\gamma, 1n)$

negative values

$F_2 > 0.50$



$F_2 > 0.50$!

Decrease before B3n

$F_2 \approx 2.00$?!

$$F_2 = \frac{\sigma(\gamma, 2n)}{\sigma(\gamma, 1n) + 2\sigma(\gamma, 2n) + 3\sigma(\gamma, 3n) + \ldots} < 0.50\ (!)$$

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

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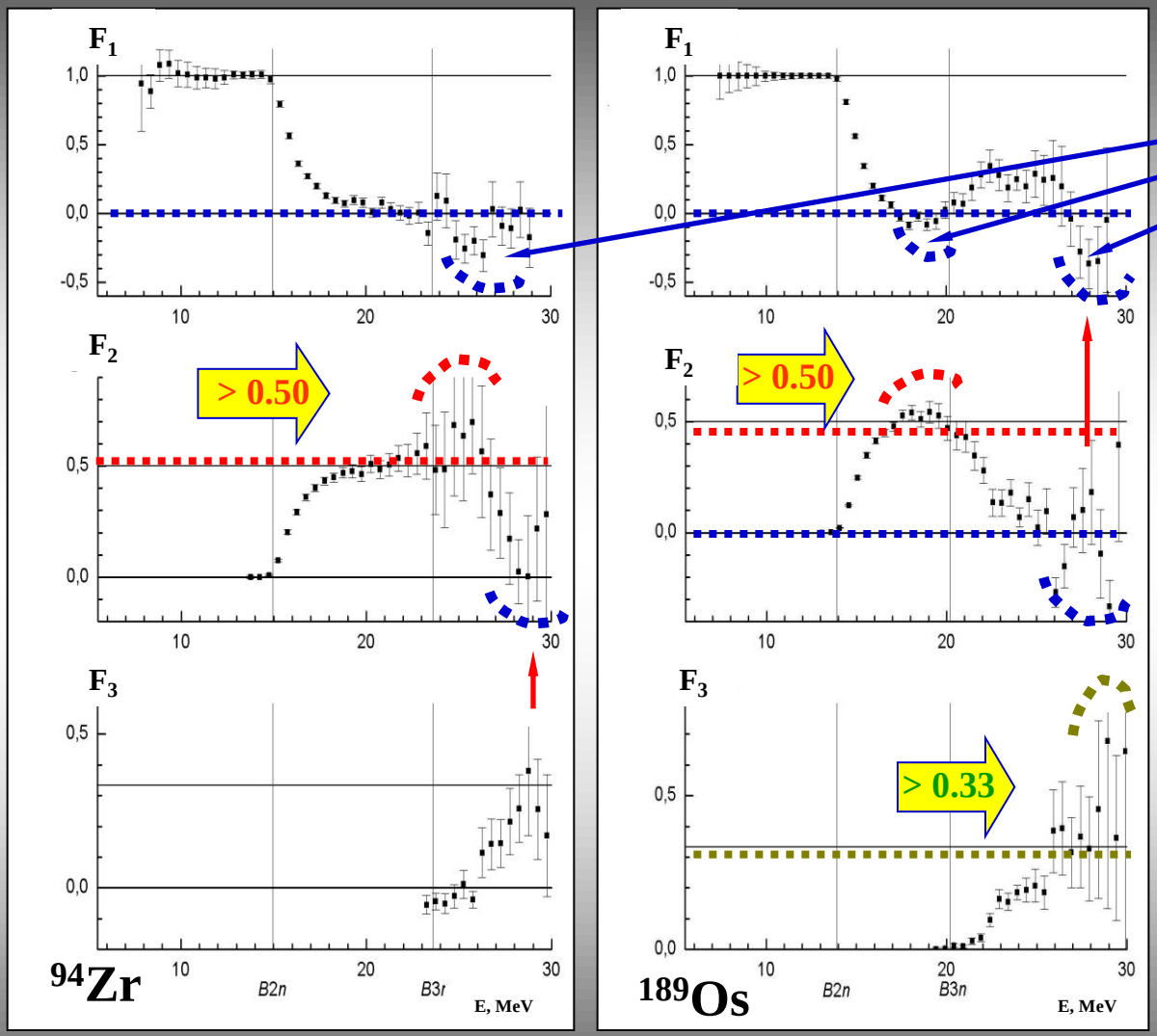

Physically forbidden negative values

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 (γ,Sn) reaction cross section;

- competition of partial reactions based on theoretical model.

Theoretically calculated transitional multiplicity functions

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

are used for cross section evaluation by following way

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

Such evaluation method means that competition of partial reactions is described by model and their correspondent sum is equal to the experimental (γ,Sn) reaction cross section.

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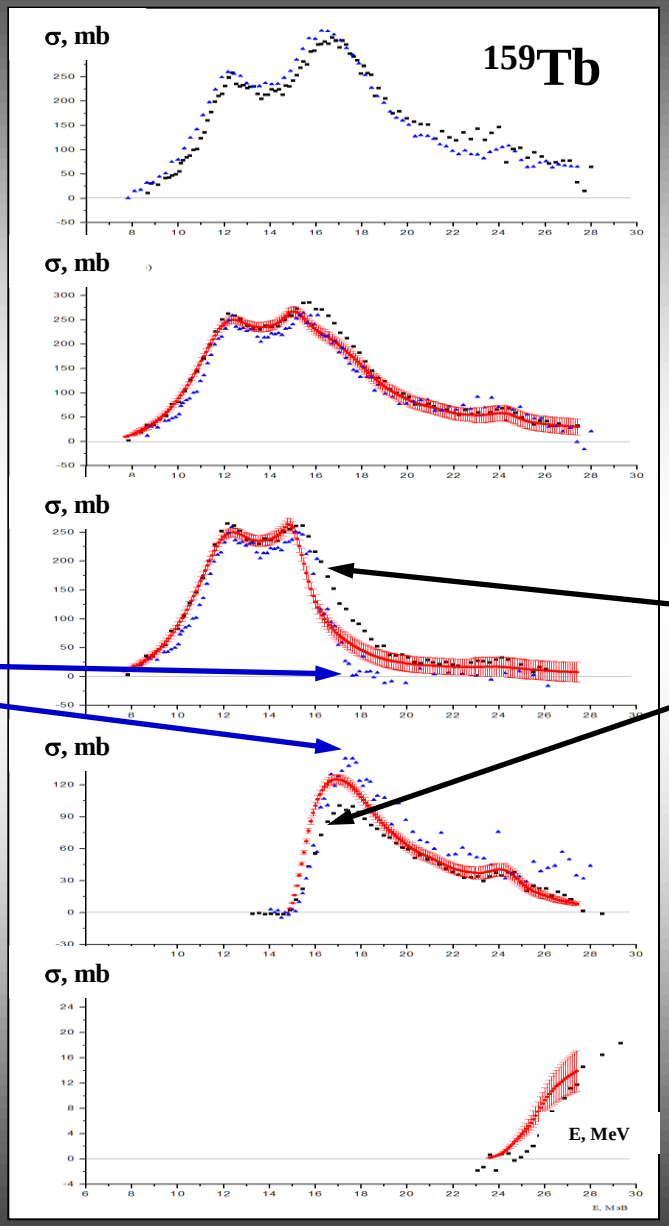
σ(γ, xn)

σ(γ, Sn)

σ(γ, 1n)

σ(γ, 2n)

σ(γ, 3n)

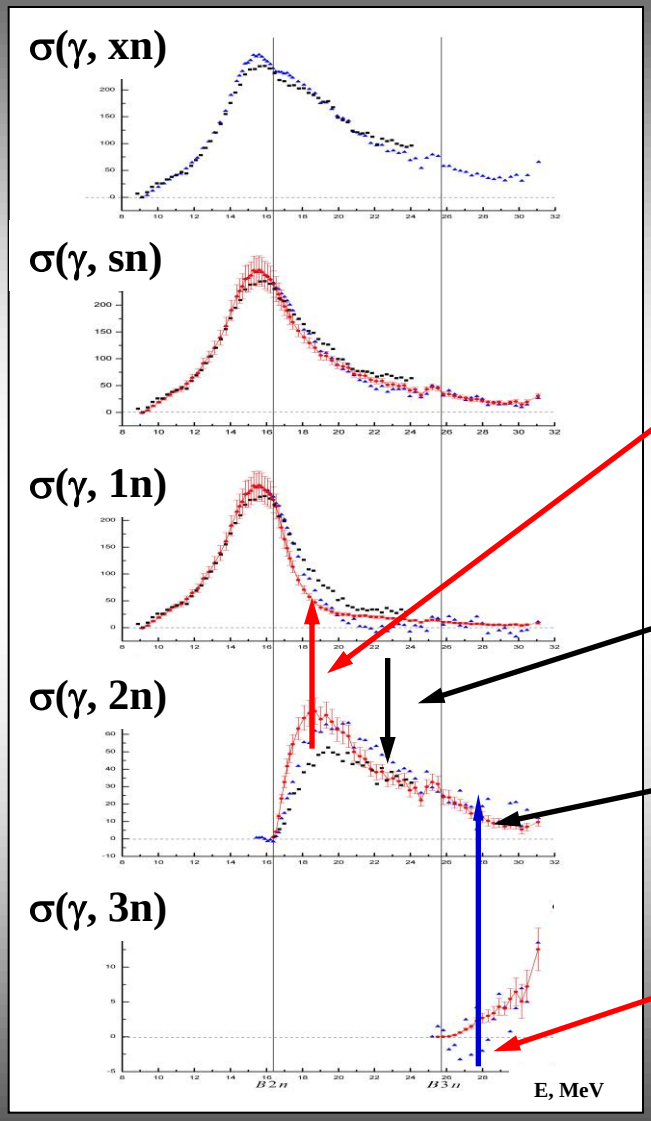


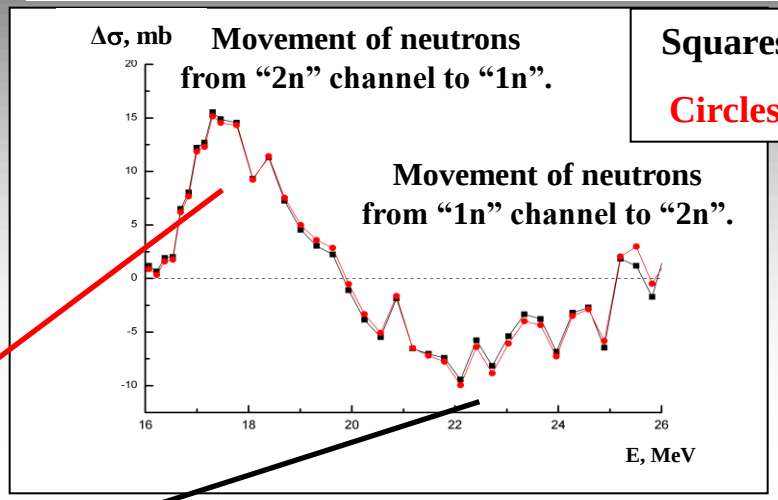
Livermore data

Saclay data

^{91,94}Zr, ^{15}In, $^{116-124}$Sn, ^{159}Tb, $^{186-192}$Os, ^{181}Ta, ^{197}Au, ^{208}Pb, ^{209}Bi

Comparison of evaluated and experimental (Saclay, Livermore) reaction cross sections for ^{115}In.



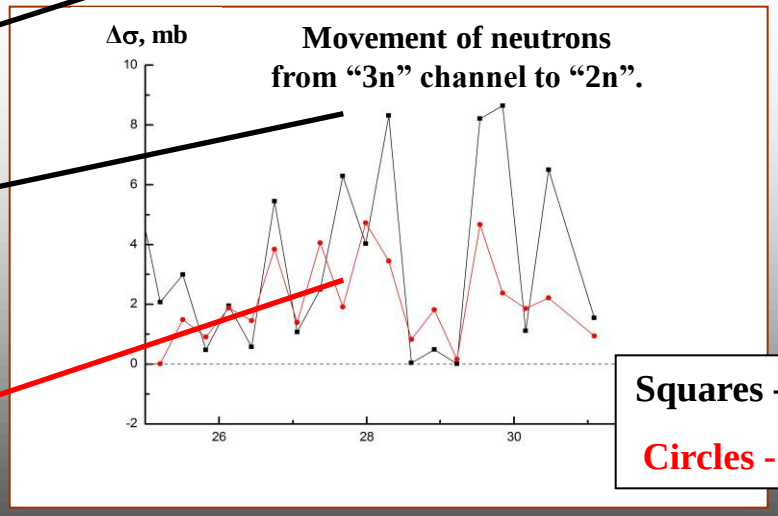


Squares - $[\sigma^{exp}(\gamma, 1n) - \sigma^{eval}(\gamma, 1n)]$

Circles - $[\sigma^{eval}(\gamma, 2n) - \sigma^{exp}(\gamma, 2n)]$

That means that erroneous moving some number of neutrons from "1n" channel to "2n" decrease (γ, 1n) cross section down to physically forbidden negative values and at the same time increase F_2 up to not reliable values "> 0.50".

The analogous is the situation for "2n" and "3n" channels.



Squares - $[\sigma^{exp}(\gamma, 2n) - \sigma^{eval}(\gamma, 2n)]$

Circles - $[\sigma^{eval}(\gamma, 3n) - \sigma^{exp}(\gamma, 3n)]$

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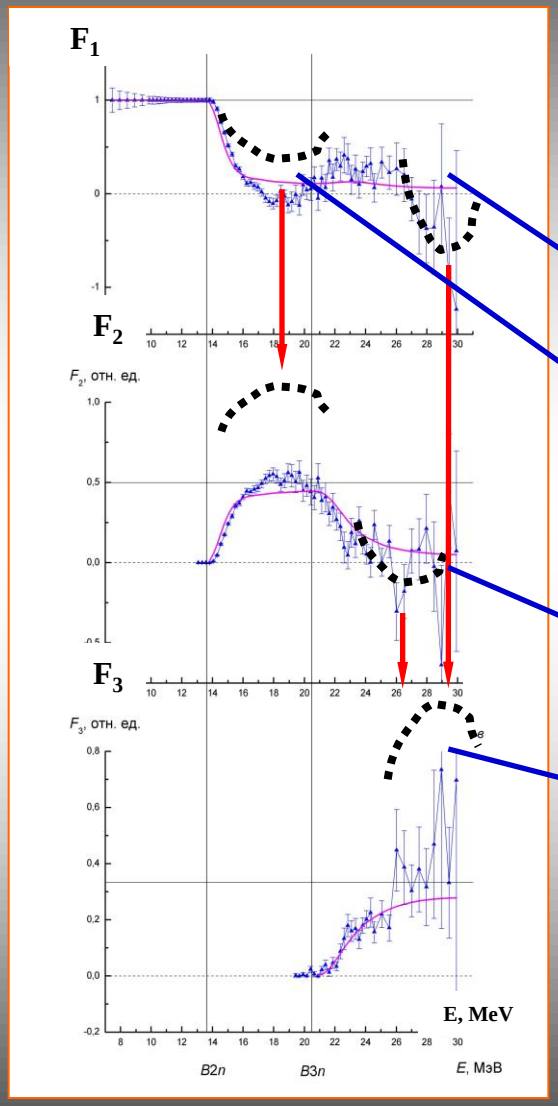

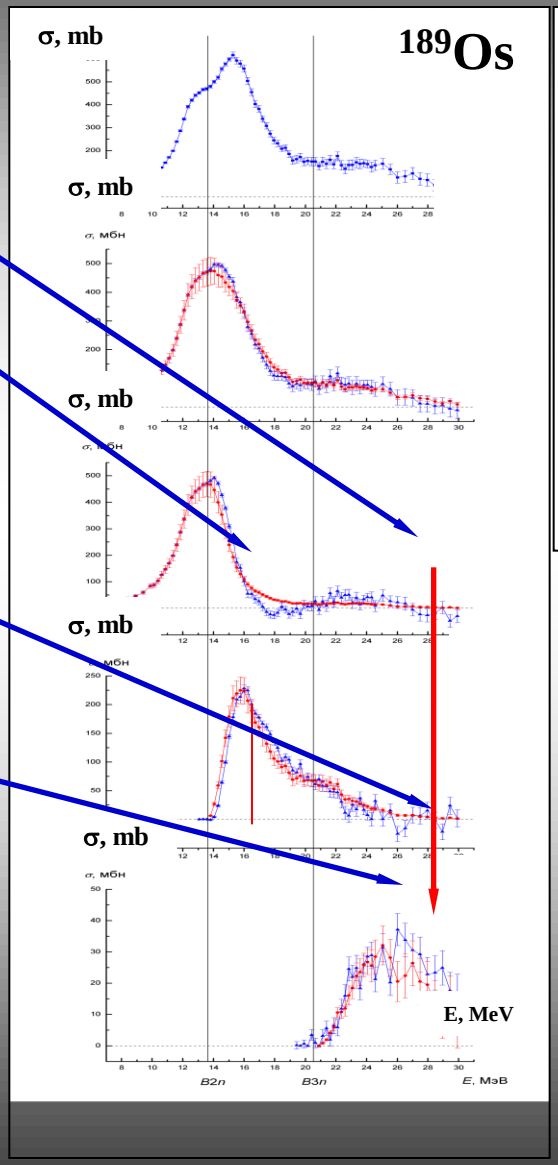

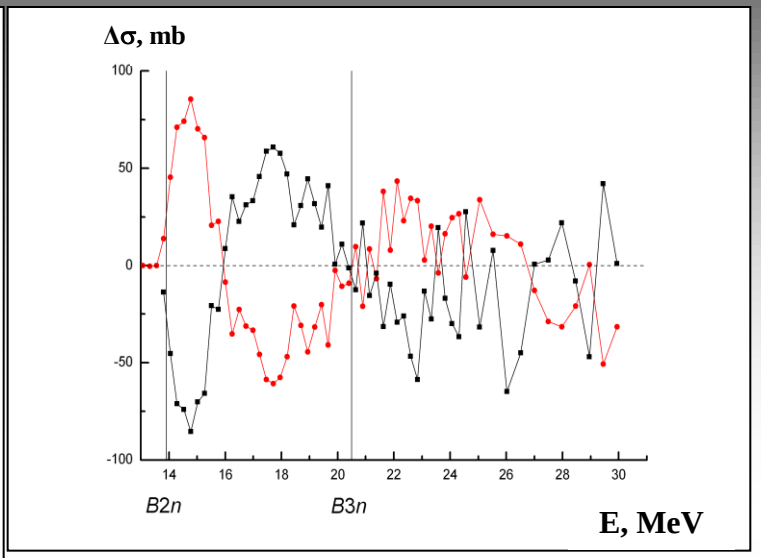

Analogous erroneous moving some number of neutrons from one decay channel to another.

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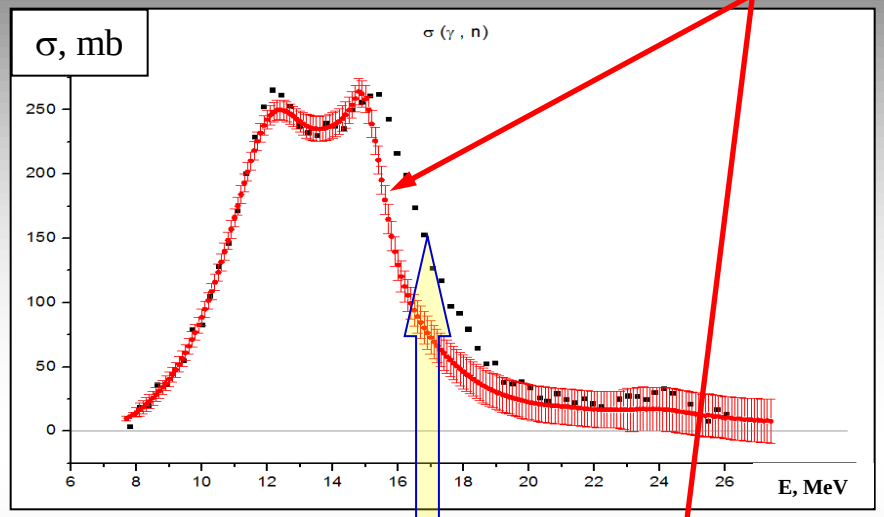
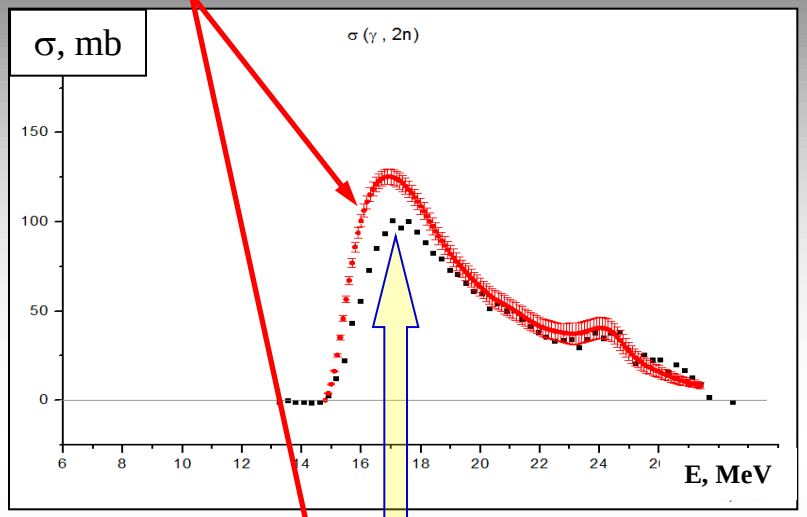
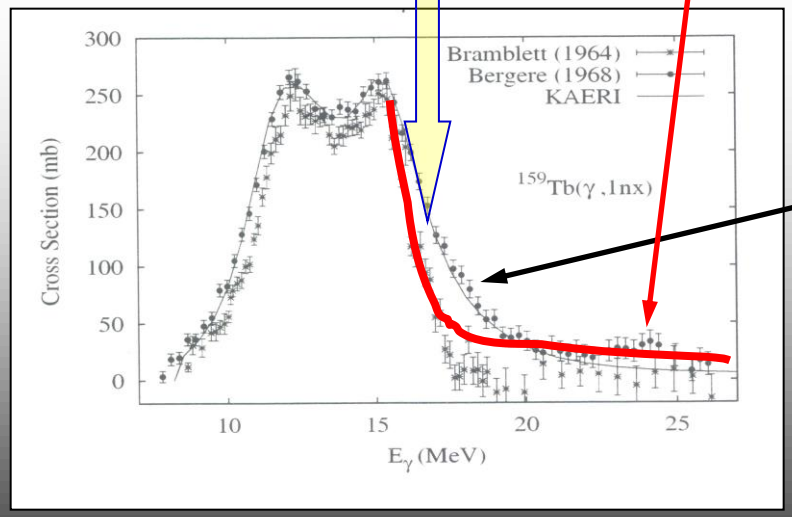
IAEA CRP (1996 – 1999) evaluations are quite different from our evaluations based on F-functions

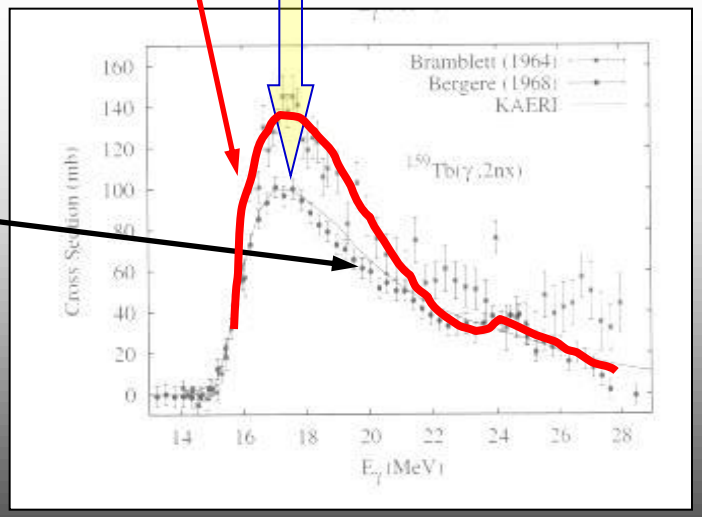


^{159}Tb





CRP evaluations have been done using GUNF and GNASH codes in order to model accurately Saclay (γ, tot) data.



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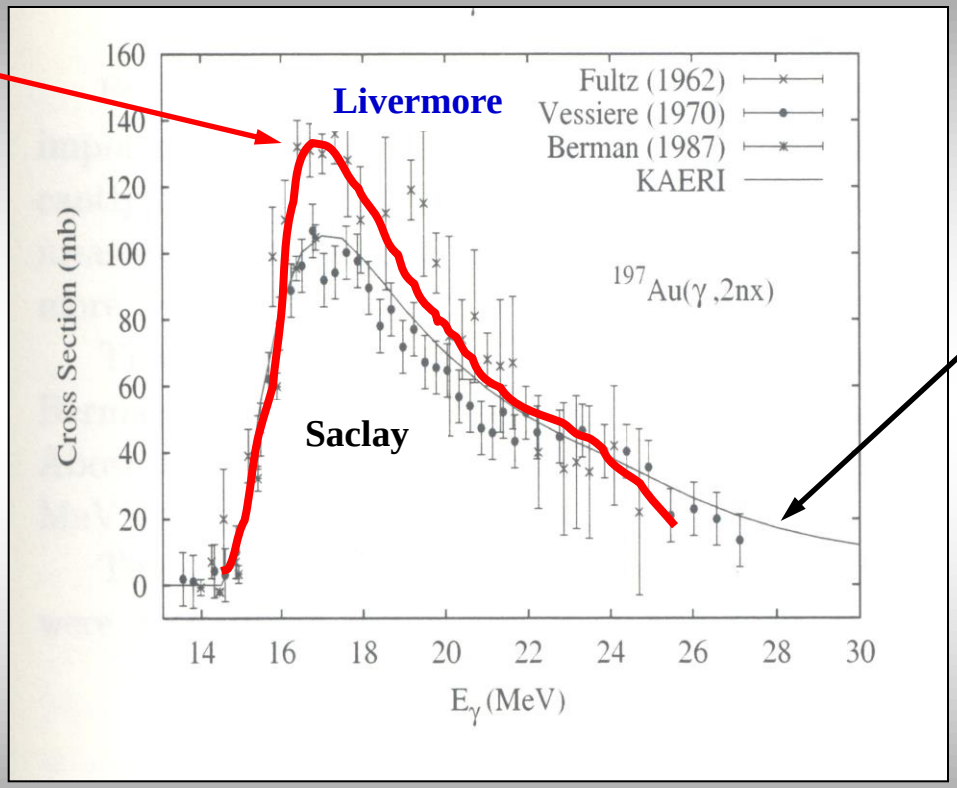
^{197}Au (γ, 2n)

Our evaluations based on F-functions:

Livermore data are much more reliable.



Previous CRP evaluation has been done using GUNF and GNASH codes in order to model accurately Saclay (γ, tot) data.

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The CDFE has the program of investigation of reliability of experimental photonuclear total and partial reaction cross sections data obtained using various methods.

The correspondent analysis and evaluations were carried out for many nuclei:

^{91,94}Zr, ^{115}In, $^{116-124}$Sn, ^{181}Ta, $^{186-192}$Os, ^{197}Au, ^{208}Pb, ^{209}Bi.

Those will be continued for other nuclei in the frame of the IAEA Coordinated Research Project N F41032 (Research Contract N 20501).

Evaluated data will be presented at the International Conference on Nuclear Data for Science and Technology (Bruges, Belgium, 11-16 September, 2016) .

Evaluated data are included into the EXFOR database.

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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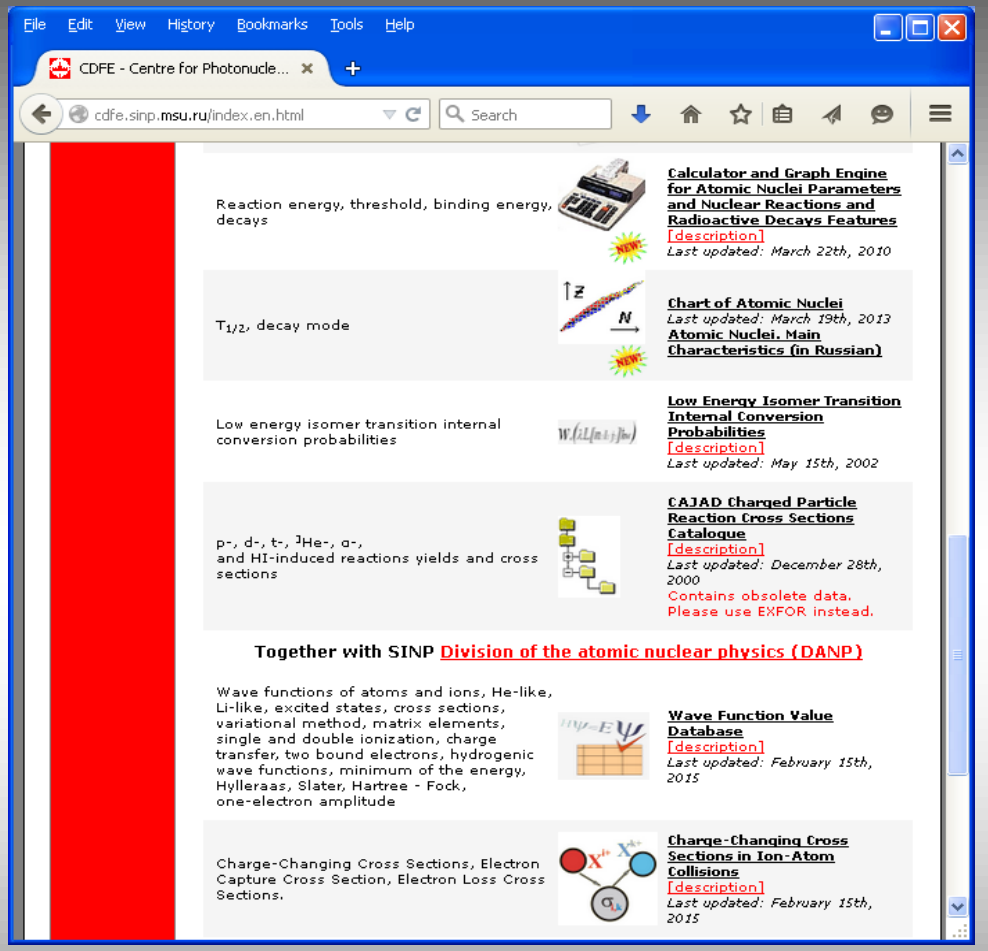

EXFOR, ENSDF, and NSR databases are based on the international data sources (USA NNDC and NSDD) but have original Search Engines.

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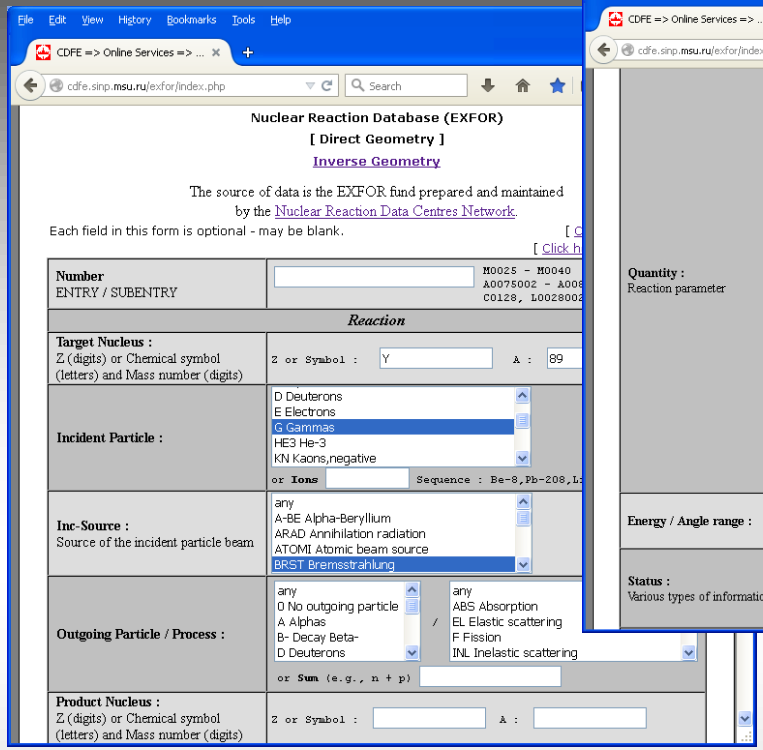

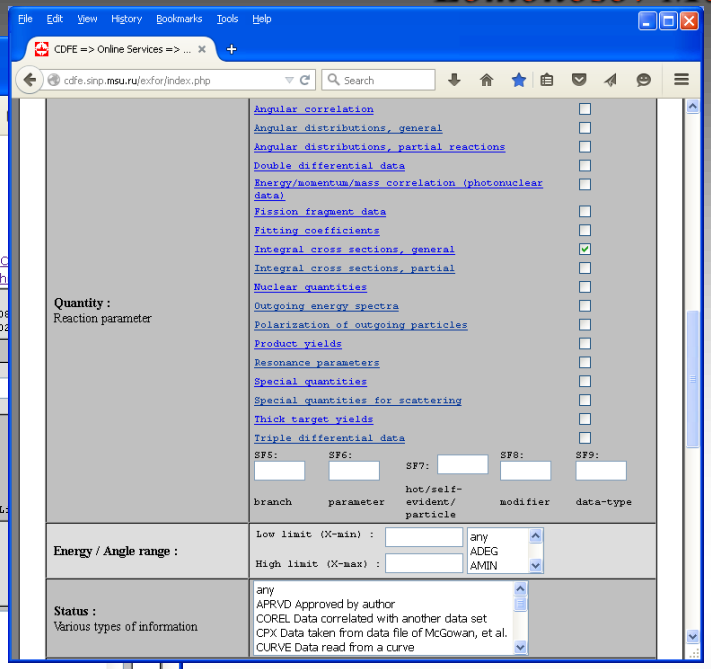

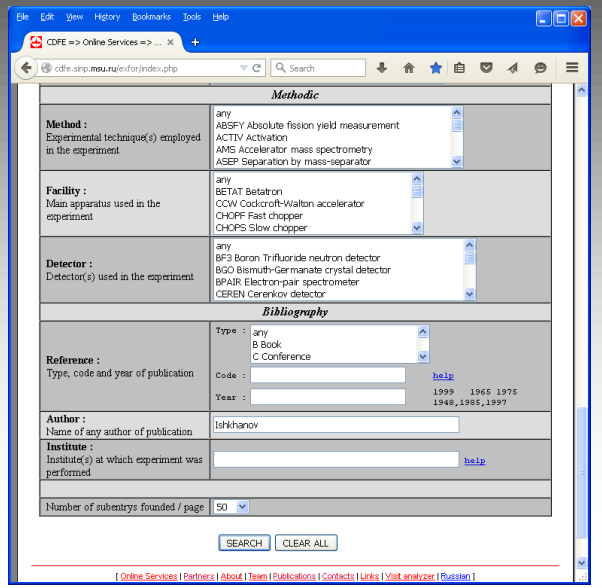

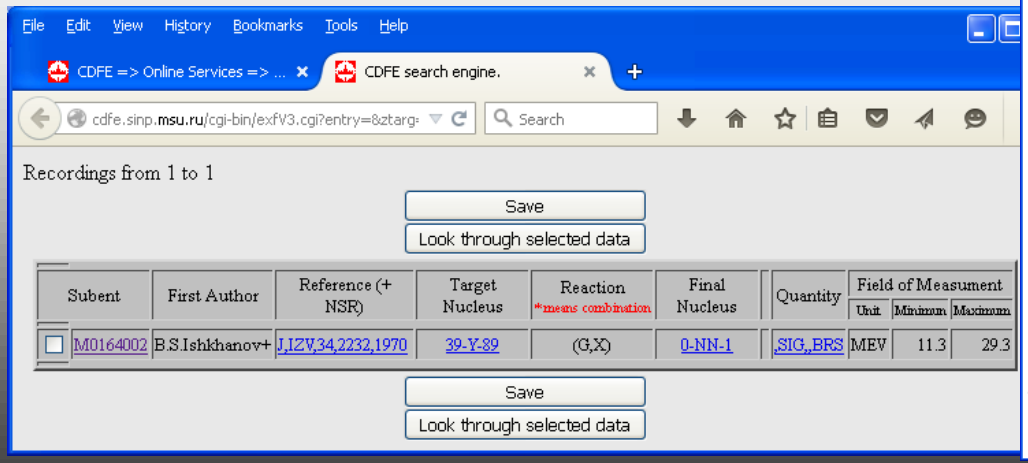

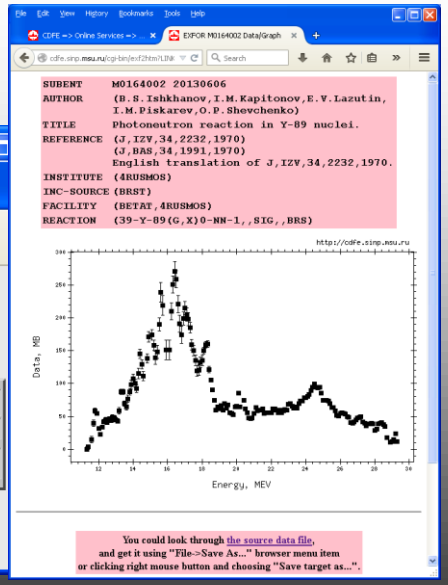

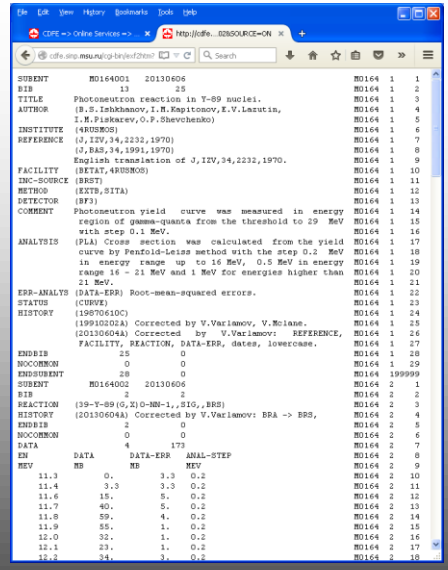

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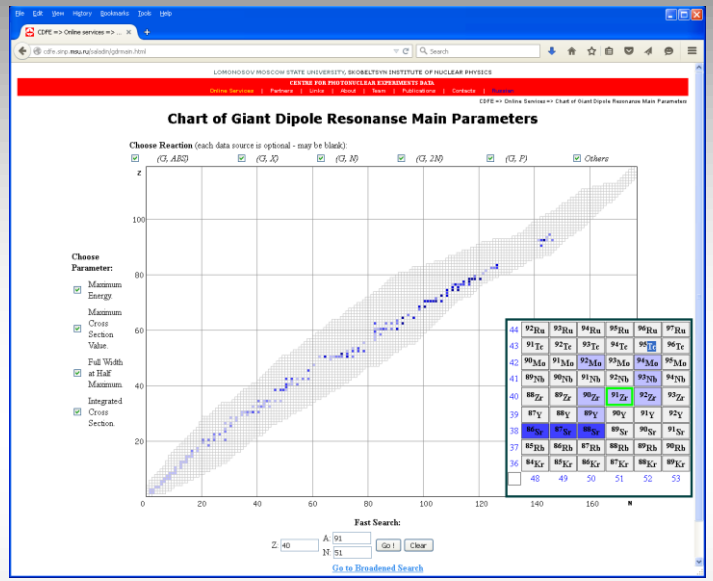
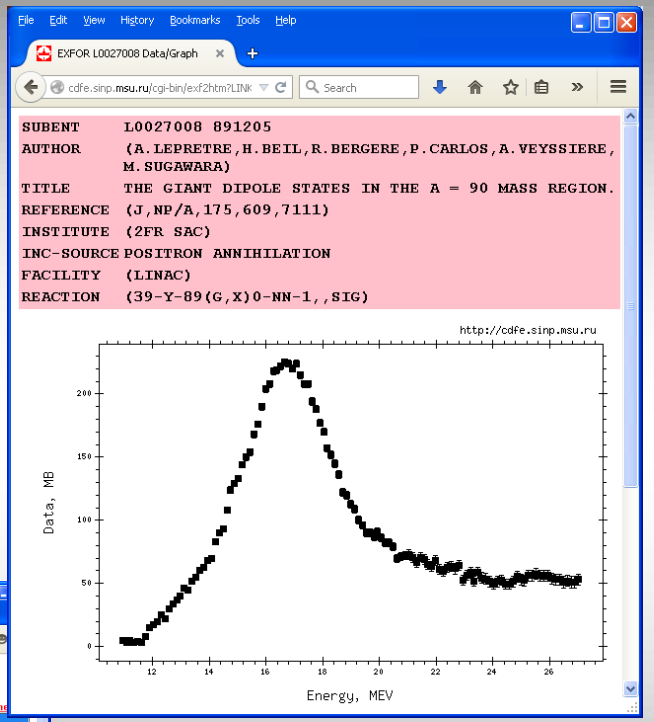
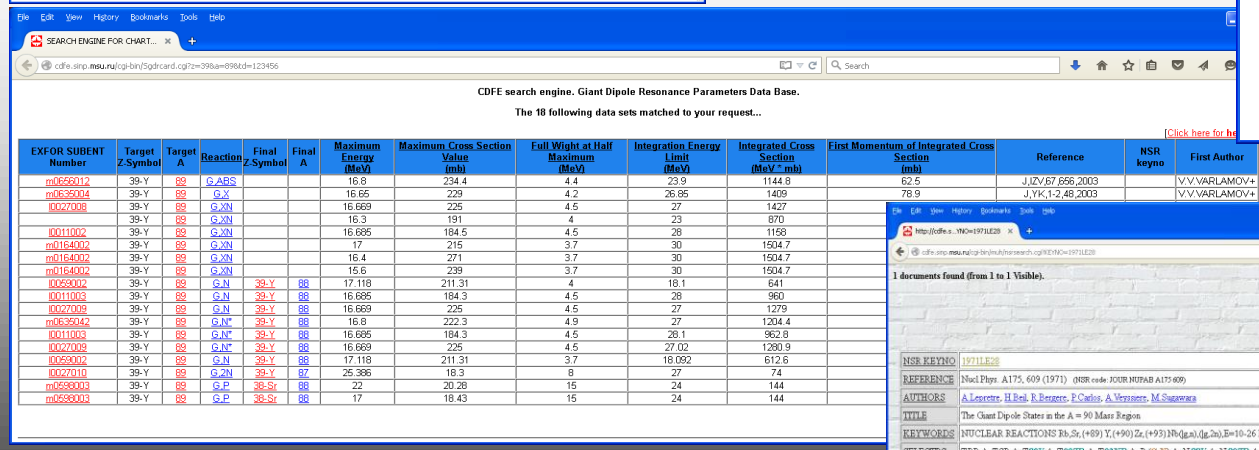
"Chart of Giant Dipole Resonance Main Parameters":

data on main parameters (energy position, amplitude, width, integrated cross section) of GDR

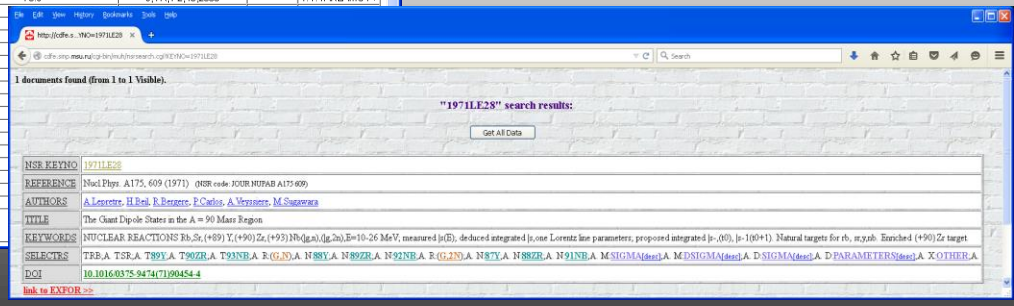


^{89}Y





EXFOR SUBENT Number	Target Z-Symbol	Target A	Reaction	Final Z-Symbol	Final A	Maximum Energy (MeV)	Maximum Cross Section Value (mb)	Full Wight at Half Maximum (MeV)	Integration Energy Limit (MeV)	Integrated Cross Section (MeV.* mb)	First Momentum of Integrated Cross Section (mb)	Reference	NSR keyno	First Author
m0656012	39-Y	89	G,ABS			16.8	234.4	4.4	23.9	1144.8	62.5	J,JZV,67,656,2003		V.V.VARLAMOV+
m0635004	39-Y	89	G,X			16.65	229	4.2	26.85	1409	78.9	J,YK,1-2,48,2003		V.V.VARLAMOV+
I0027008	39-Y	89	G,XN			16.669	225	4.5	27	1427				
	39-Y	89	G,XN			16.3	191	4	23	870				
I0011002	39-Y	89	G,XN			16.685	184.5	4.5	28	1158				
m0164002	39-Y	89	G,XN			17	215	3.7	30	1504.7				
m0164002	39-Y	89	G,XN			16.4	271	3.7	30	1504.7				
m0164002	39-Y	89	G,XN			15.6	239	3.7	30	1504.7				
I0059002	39-Y	89	G,N	39-Y	88	17.118	211.31	4	18.1	641				
I0011003	39-Y	89	G,N	39-Y	88	16.685	184.3	4.5	28	960				
I0027009	39-Y	89	G,N	39-Y	88	16.669	225	4.5	27	1279				
m0635042	39-Y	89	G,N*	39-Y	88	16.8	222.3	4.9	27	1204.4				
I0011003	39-Y	89	G,N*	39-Y	88	16.685	184.3	4.5	28.1	962.8				
I0027009	39-Y	89	G,N*	39-Y	88	16.669	225	4.5	27.02	1280.9				
I0059002	39-Y	89	G,N	39-Y	88	17.118	211.31	3.7	18.092	612.6				
I0027010	39-Y	89	G,2N	39-Y	87	25.386	18.3	8	27	74				
m0598003	39-Y	89	G,P	38-Sr	88	22	20.28	15	24	144				
m0598003	39-Y	89	G,P	38-Sr	88	17	18.43	15	24	144				



6/13/2016

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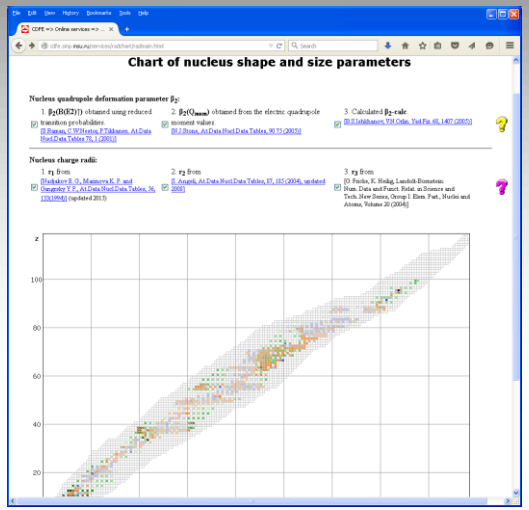
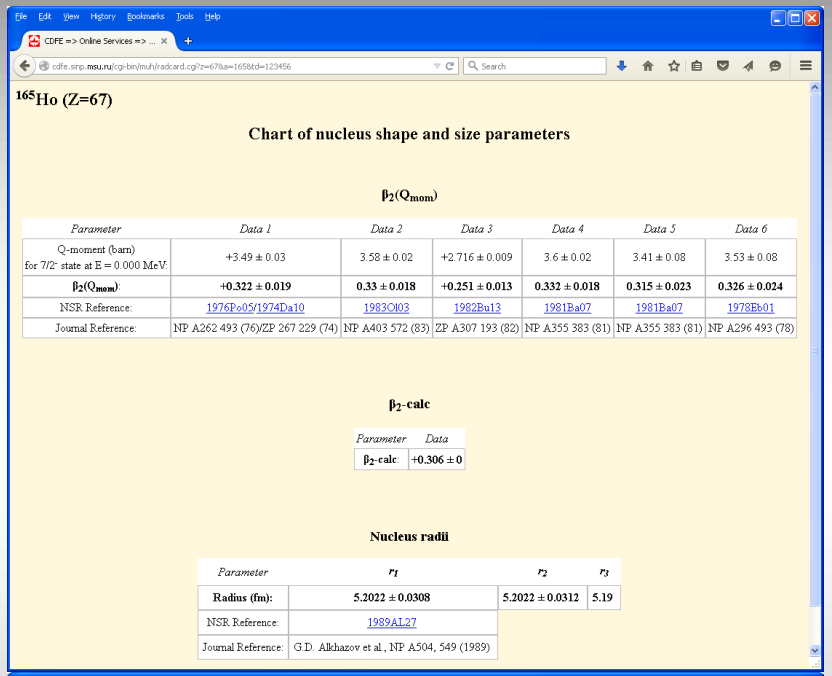
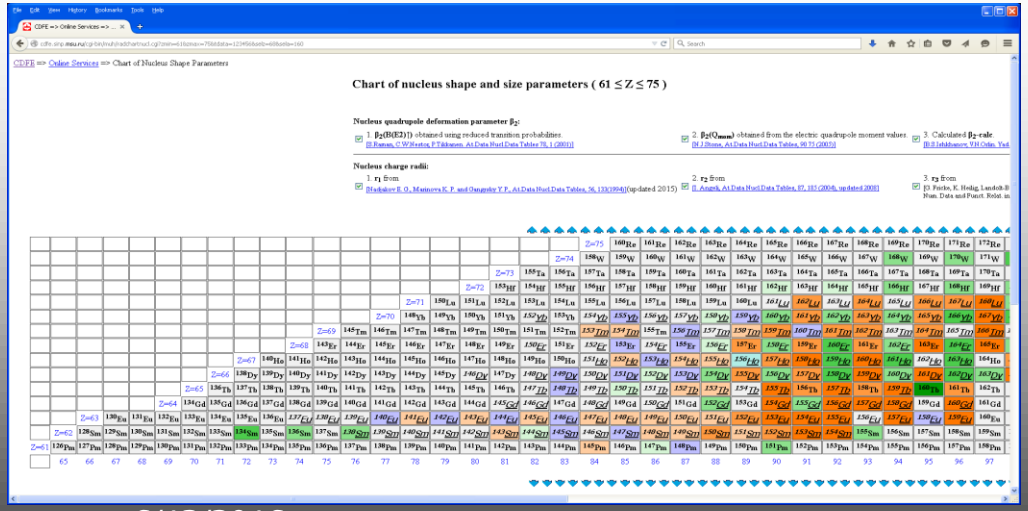
"Chart of Nucleus Shape and Size Parameters":

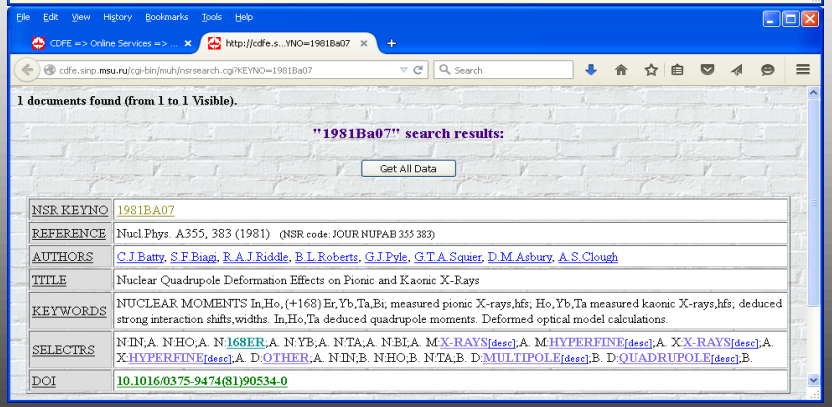
data on quadrupole moments, parameters of quadrupole deformation and charge radii



^{165}Ho



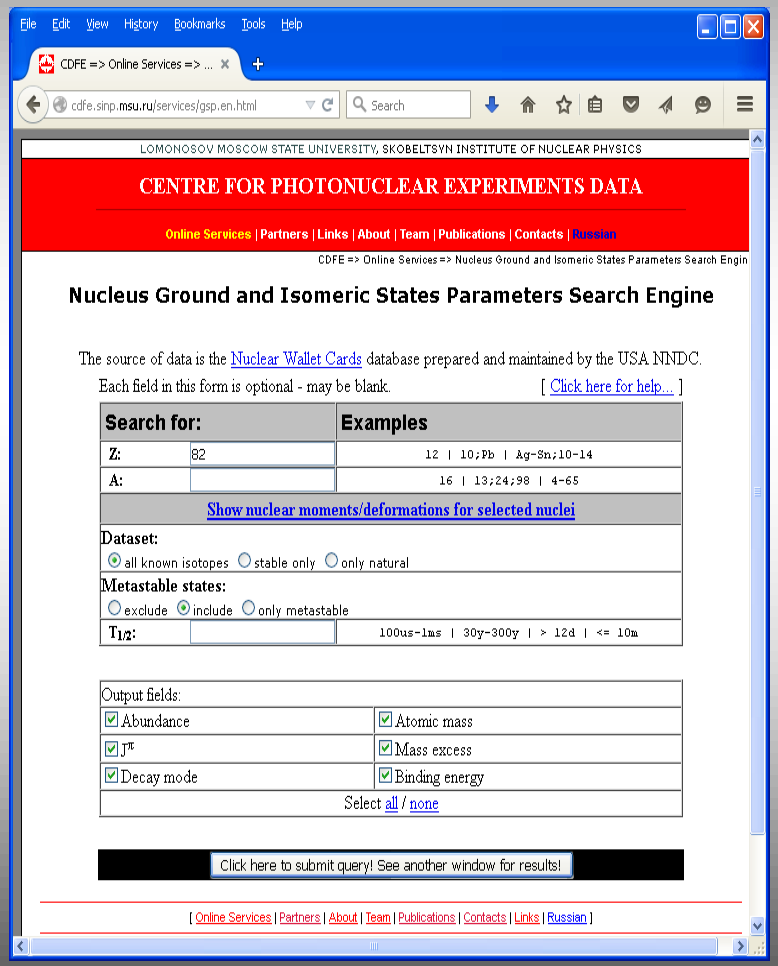


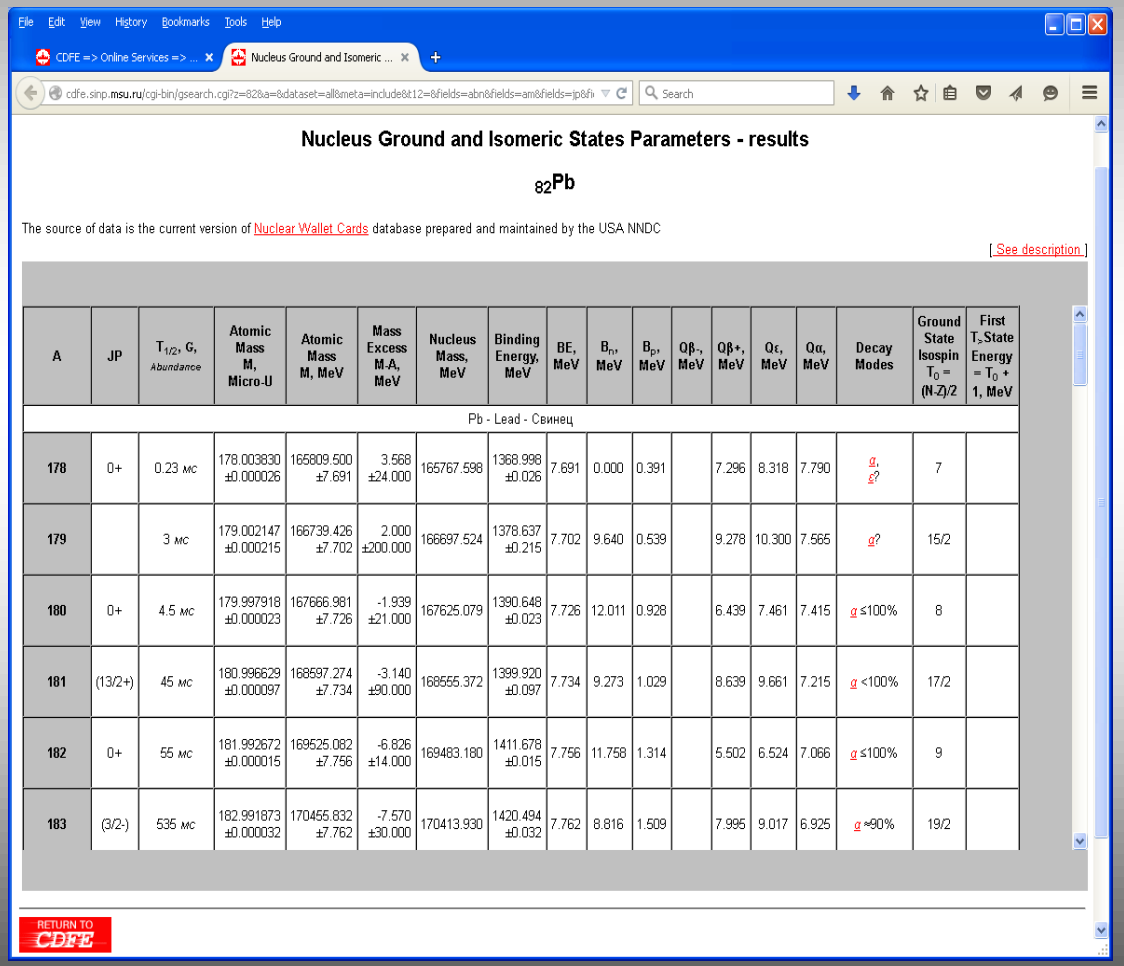


6/13/2016

"Nucleus Ground and Isomeric State Parameters":

combines many useful information on the nucleus as whole and its ground and isomeric states properties (masses, binding energy, nucleon separation energy, decay mode, energy of various decays, etc)





A	JP	$T_{1/2}$, G, Abundance	Atomic Mass M, Micro-U	Atomic Mass M, MeV	Mass Excess M-A, MeV	Nucleus Mass, MeV	Binding Energy, MeV	BE, MeV	B_n, MeV	B_p, MeV	Qβ-, MeV	Qβ+, MeV	Qε, MeV	Qα, MeV	Decay Modes	Ground State Isospin T_0 = (N-Z)/2	First T_0 State Energy = T_0 + 1, MeV
Pb - Lead - Свинец																	
178	0+	0.23 мс	178.003830 ±0.000026	165809.500 ±7.691	3.568 ±24.000	165767.598	1368.998 ±0.026	7.691	0.000	0.391		7.296	8.318	7.790	α, ε?	7	
179		3 мс	179.002147 ±0.000215	166739.426 ±7.702	2.000 ±200.000	166697.524	1378.637 ±0.215	7.702	9.640	0.539		9.278	10.300	7.565	α?	15/2	
180	0+	4.5 мс	179.997918 ±0.000023	167666.981 ±7.726	-1.939 ±21.000	167625.079	1390.648 ±0.023	7.726	12.011	0.928		6.439	7.461	7.415	α ≤100%	8	
181	(13/2+)	45 мс	180.996629 ±0.000097	168597.274 ±7.734	-3.140 ±90.000	168555.372	1399.920 ±0.097	7.734	9.273	1.029		8.639	9.661	7.215	α <100%	17/2	
182	0+	55 мс	181.992672 ±0.000015	169525.082 ±7.756	-6.826 ±14.000	169483.180	1411.678 ±0.015	7.756	11.758	1.314		5.502	6.524	7.066	α ≤100%	9	
183	(3/2-)	535 мс	182.991873 ±0.000032	170455.832 ±7.762	-7.570 ±30.000	170413.930	1420.494 ±0.032	7.762	8.816	1.509		7.995	9.017	6.925	α ≈90%	19/2	

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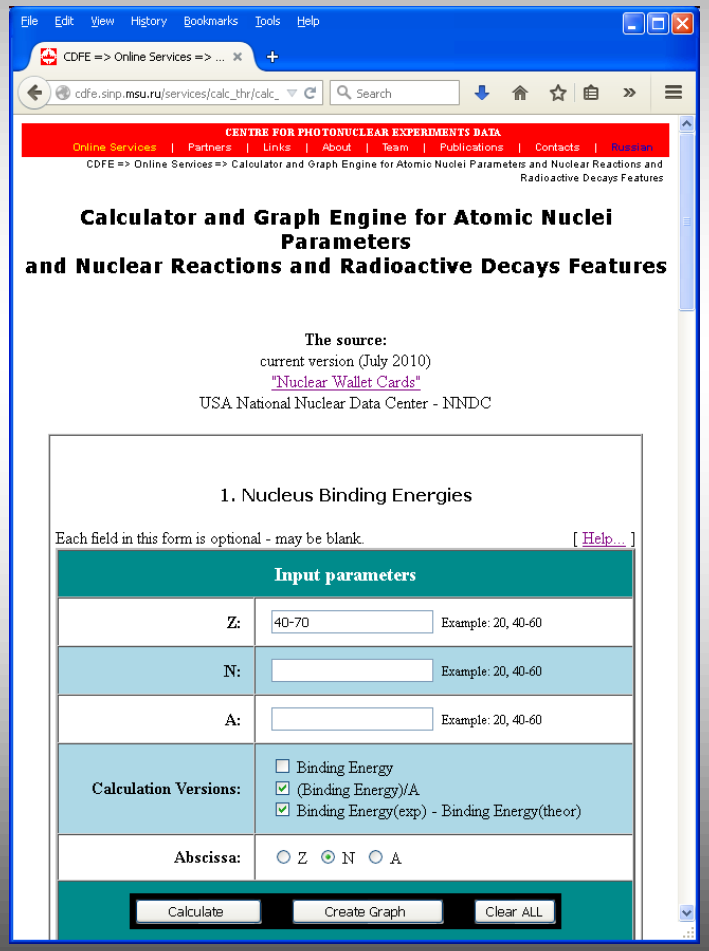
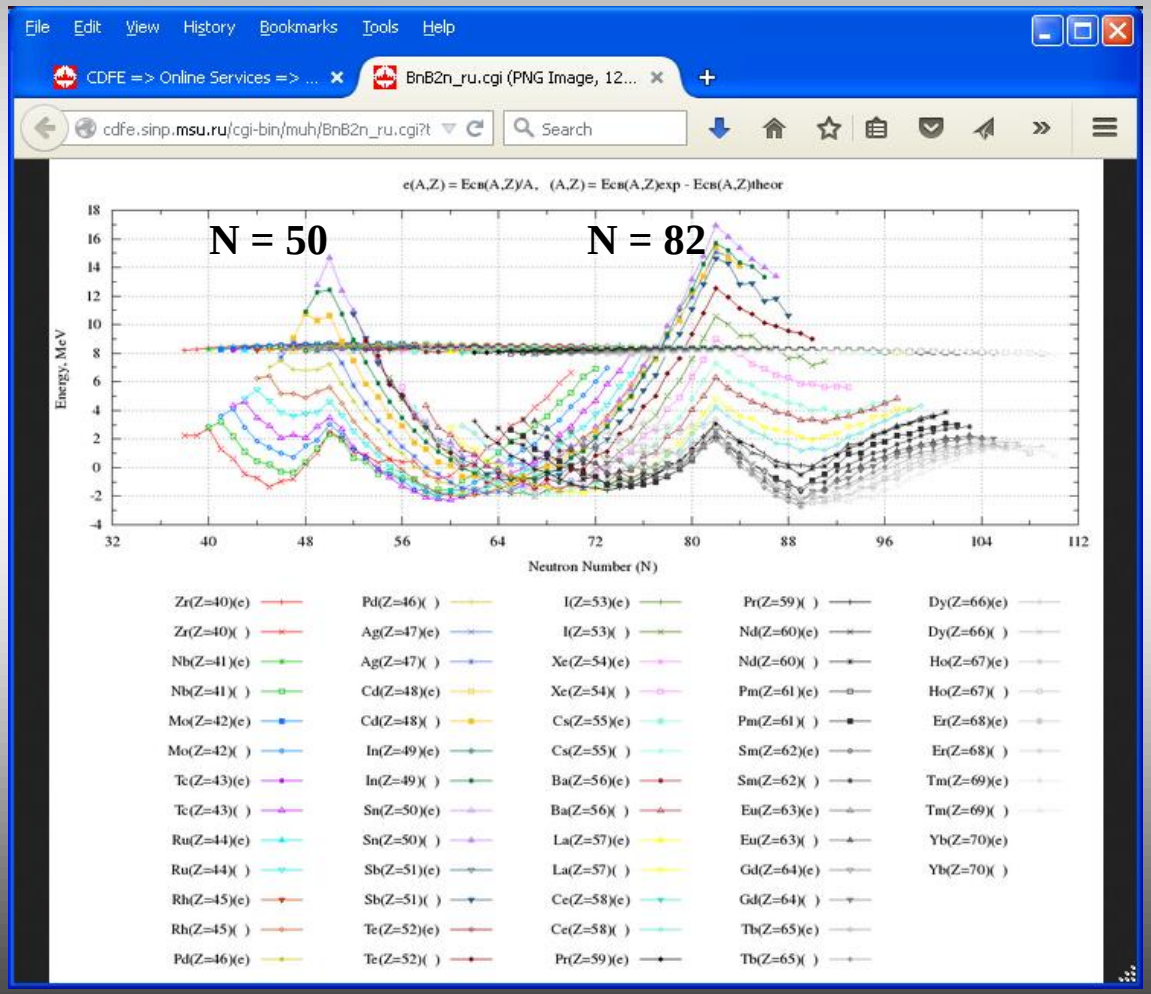
"Calculator and Graph Engine for Atomic Nuclei Parameters and Nuclear Reactions and Radiative Decays Features:

many useful data for "Nucleus Binding Energies", "Nucleons and Nuclei Separation Energies", "Decays Energies", "Decays Energies", "Nuclei fission".





"Calculator and Graph Engine for Atomic Nuclei Parameters and Nuclear Reactions and Radiative Decays

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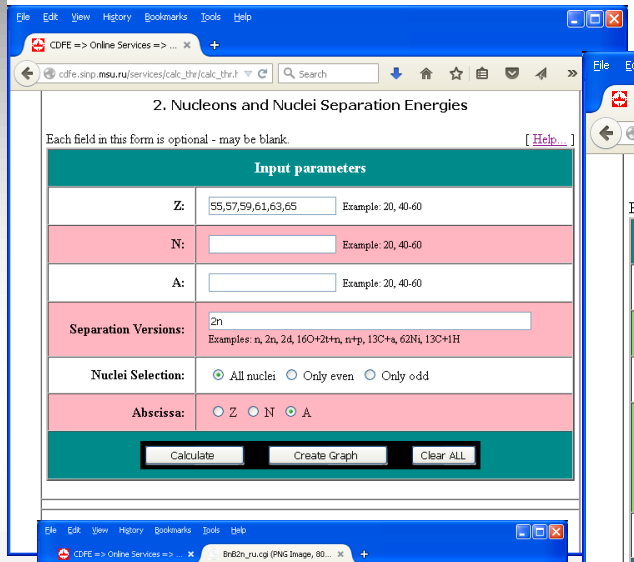

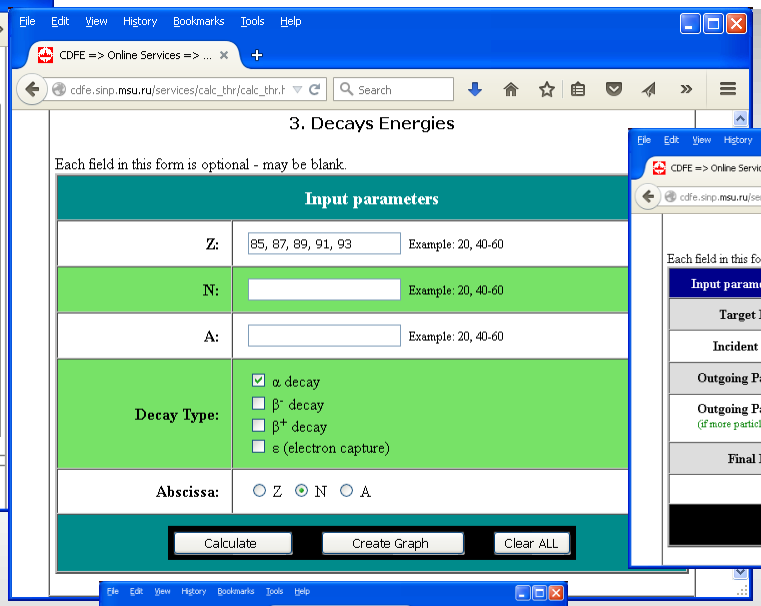

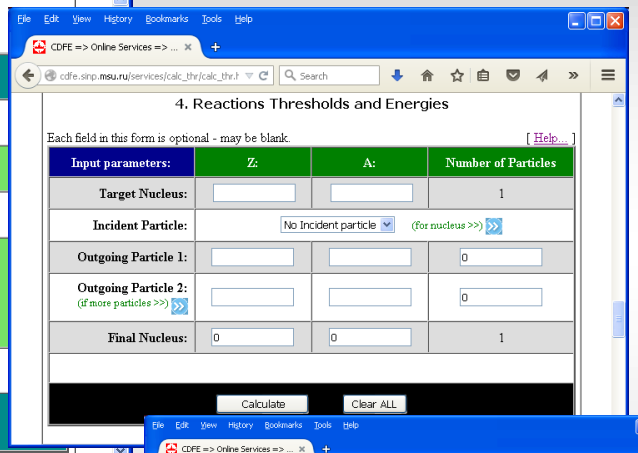

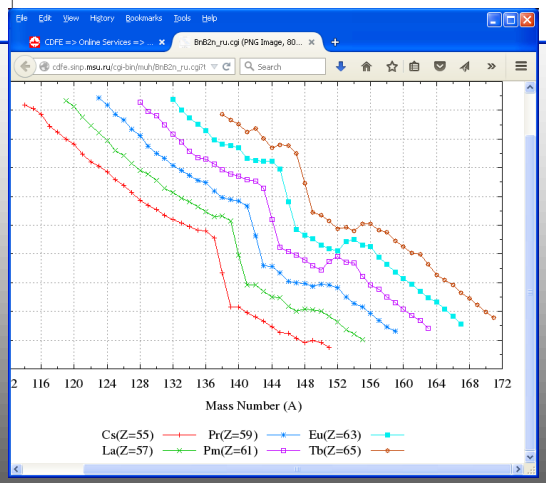

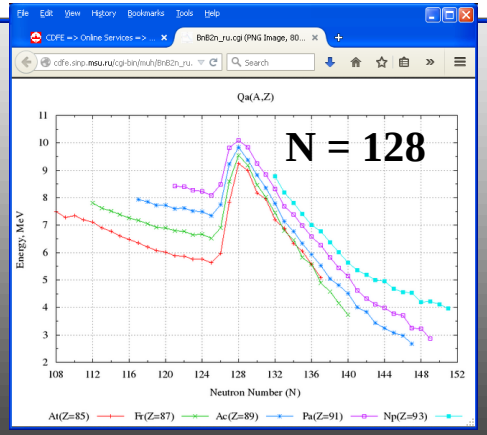

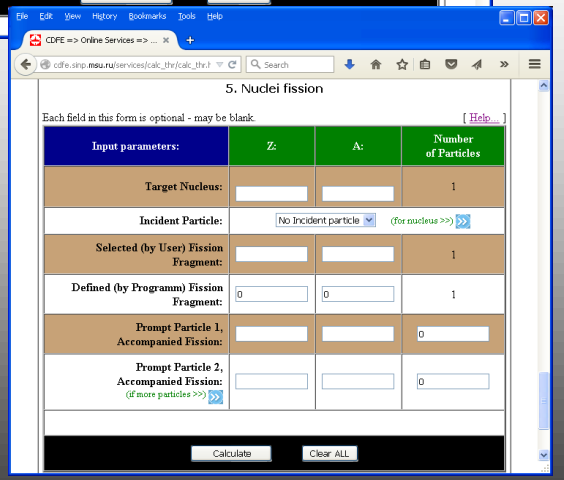

6/13/2016

Short-term (2016/2017) CDFE Program

The main items of the CDFE (2016/2017) program, main priorities and most important tasks are traditional:

- continuation of photonuclear data compilation using EXFOR format, new TRANSes (M084, M085, etc.) production;
- correction of old ENTRYs in accordance with new EXFOR coding rule changes and the NRDC Network experts comments and recommendations;
- continuation of joint 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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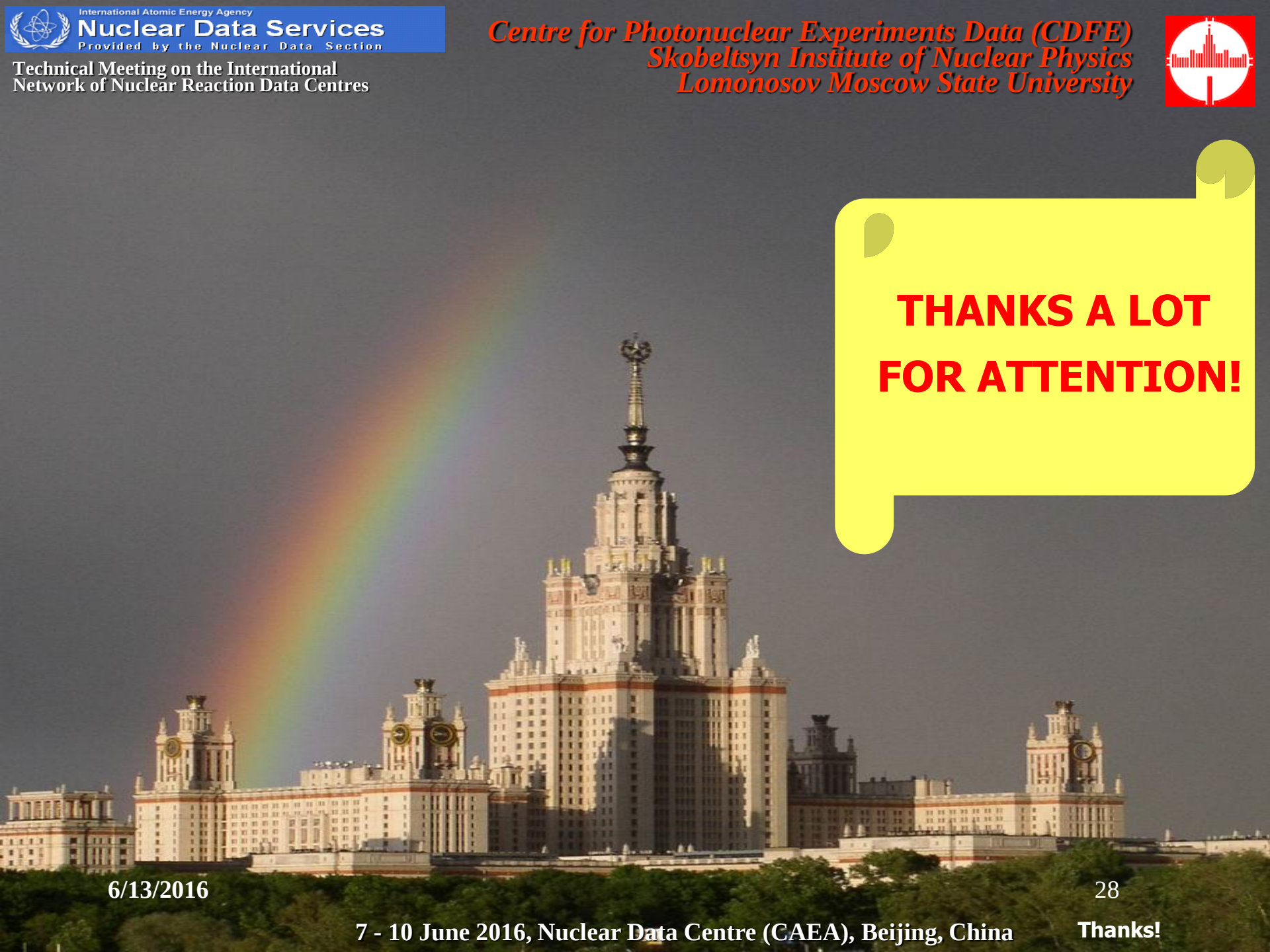

THANKS A LOT

FOR ATTENTION!

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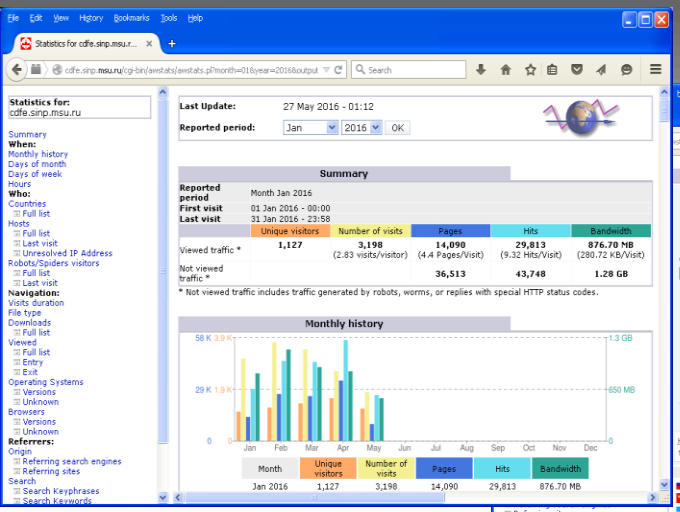
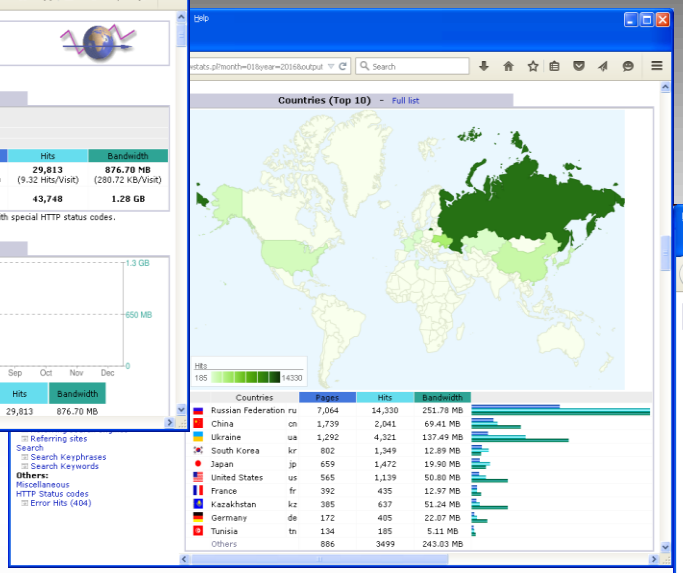
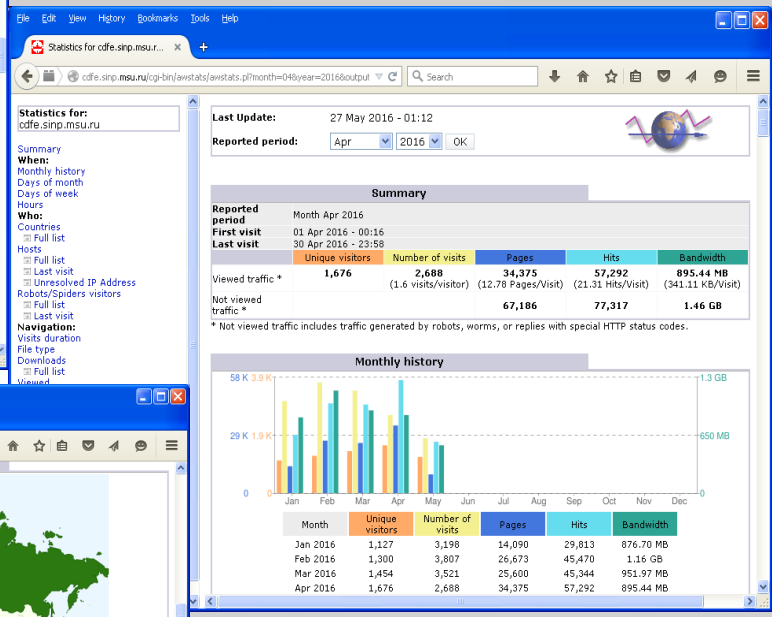
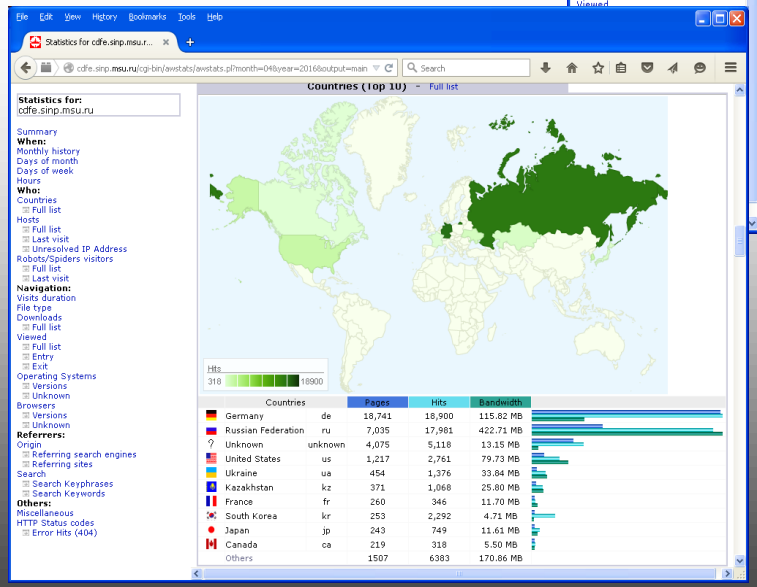
AWSTATS – Advanced Web Statistics





January 2016





April 2016

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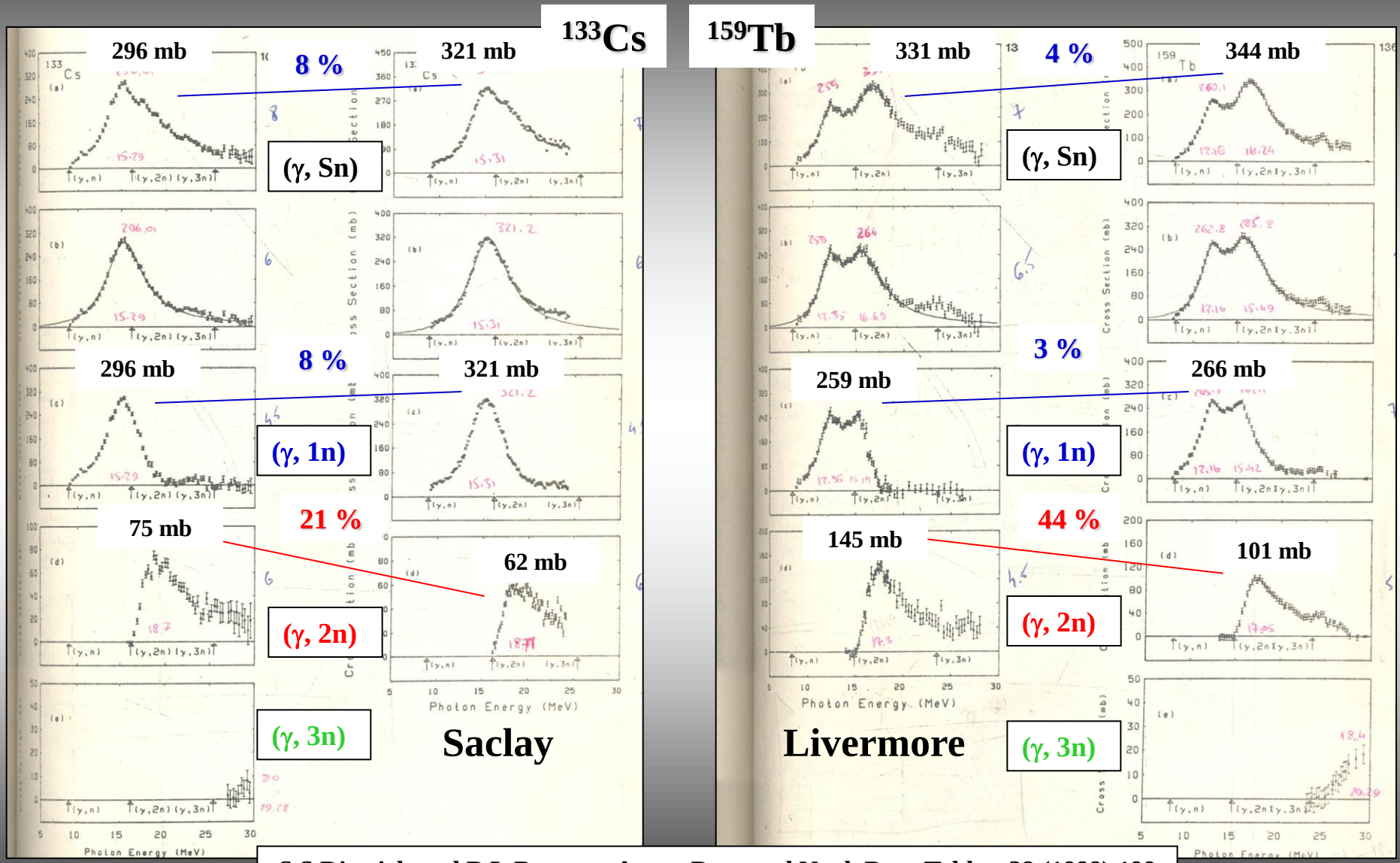

S.S.Dietrich and B.L.Berman. Atom. Data and Nucl. Data Tables, 38 (1988) 199