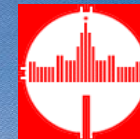




International Atomic Energy Agency
Nuclear Data Services
Provided by the Nuclear Data Section

IAEA Technical Meeting of
International Network
of Nuclear Reaction Data Centres
(NRDC) 6 - 9 May 2014, Congress
Centre Smolenice, Slovakia

*Centre for
Photonuclear
Experiments
Data*



*Lomonosov Moscow State University
Skobeltsyn Institute of Nuclear Physics*

Vladimir Varlamov

5/15/2014

1
Title

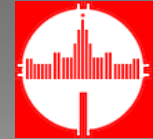


The CDFE progress report on new photonuclear data compilations and old data corrections for 2013 - 2014

V.V.Varlamov, N.E.Gorskikh, S.Yu.Komarov, M.A.Makarov, N.N.Peskov, M.E.Stepanov

***Progress Report to the IAEA Technical Meeting
on International Network of Nuclear Reaction Data Centres (NRDC)
6 - 9 May 2014, Congress Centre Smolenice, Slovakia***

The report contains short review of the main results obtained at the Centre for Photonuclear Experiments Data (Centr Danykh Fotoyadernykh Eksperimentov – CDFE) of the Lomonosov Moscow State University Skobeltsyn Institute of Nuclear Physics (MSU SINP) concern nuclear data processing, analysis and evaluation for the period of time from the IAEA’s Technical Meeting On International Network of Nuclear Reaction Data Centers” (NRDC), 23 – 25 April 2012, IAEA’s Headquarters, Vienna, Austria till the spring of 2014.

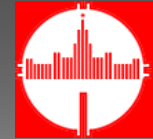


General

The CDFE provides scientific and educational institutes and organizations of Russian Academy of Science with nuclear data for basic research, education and various applications. CDFE activities include the compilation, verification, evaluation and dissemination of modern international nuclear data. CDFE maintains several international and specially developed nuclear databases available through the CDFE Web-site – <http://cdfe.sinp.msu.ru>.

Organization

The CDFE has a status of laboratory (Nuclear Data Analysis Laboratory) within the MSU SINP. The total permanent staff includes 5 professional (the Centre head Vladimir Varlamov, Sergei Komarov, Nikolay Peskov, Mikhail Stepanov, Valery Viazovsky), 2 general service officers and several students of the MSU Physics Faculty.



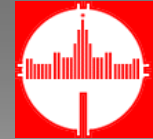
Main fields of nuclear data activity

EXFOR Compilations

Photonuclear Data Evaluations

Nuclear Structure Data Evaluations

Nuclear Database Service



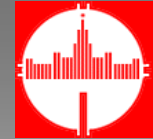
EXFOR Compilations

6 new CDFE EXFOR trances **TRANS.M067 - 072** have been produced and transmitted to the IAEA NDS. In the reported period of time all trances in addition to number of new ENTRYs contain primarily old ENTRYs corrected in accordance with the NRDC Network experts comments and recommendations.

The main subjects of corrections were:

- English translation additions for REFERENCE (YF <-> SNP, YF <-> PAN, ZET <-> JET, ZEP <-> JEL, IZV <-> BAS, DOK <-> SPD);
- REACTION SF8 corrections BRA <-> BRS;
- REACTION SF8 corrections ST2 <-> SN2;
- deleting of some ENTRYs because data duplications.

On the whole contents new CDFE trances have been produced in the reported period contain 164 corrected ENTRYs and 15 new ENTRYs.



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 Centre Smolenice, Slovakia

CDFE as participant of NRDC

International Network of Nuclear Reaction Data Centres - Mozilla Firefox

www-nds.iaea.org/nrdc/

International Atomic Energy Agency
Nuclear Data Services
 Sección Datos Nucleares, OIEA

Databases » EXFOR | ENDF | CINDA | IBANDL | Medical | PGAA | NGATlas | RIPL | FENDL | IRDF-2002 | IRDF

Databases

- EXFOR
- What is EXFOR?
- EXFOR News
- Feedback
- Feedback (SG30)
- Articles in compilation
- CINDA
- What is CINDA?
- Feedback
- ENDF
- What is ENDF?
- ENDF Citation

NRDC Centres

- NNDC (USA)
- NEADB (France)
- NDS (Austria)
- CJD (Russia)
- CNDC (China)
- ATOMKI (Hungary)
- NDPCI (India)
- JAEA (Japan)
- JCPRG (Japan)
- KAERI (Korea)
- CAJaD (Russia)
- CDFE (Russia)
- CNPD (Russia)
- UkrNDC (Ukraine)

Contacts

- N.Otsuka
- V.Semkova
- S.Simakov
- V.Zerkin

Links

- NRDC
- Nuclear Data Services
- Nuclear Data Section

International Network of Nuclear Reaction Data Centres (NRDC)

(To previous [NRDC Home](#) / [NRDC Internal Archive](#) / [Cite map](#))

What is NRDC?

The International Network of Nuclear Reaction Data Centres (NRDC) constitutes a worldwide cooperation of nuclear data centres under the auspices of the International Atomic Energy Agency. The Network was established to coordinate the world-wide collection, compilation and dissemination of nuclear reaction data.

Objectives and Tasks

The primary goal of the Network is the dissemination of nuclear reaction data and associated documentation to users. The following specific tasks must be carried out in order to accomplish this important aim:

- Compilation of relevant bibliographic information (CINDA),
- Compilation of experimental nuclear reaction data (EXFOR),
- Collection of evaluated nuclear reaction data (ENDF),
- Exchange of nuclear reaction data of all types,
- Promotion of the development of special purpose evaluated data files,
- Development of common formats for computerized exchange of nuclear data,
- Coordinated development of computer software for managing and disseminating nuclear data,
- Coordination of the development and dissemination of end user software for both on line and local access to nuclear data,
- Documentation of current and future data needs in order to be able to meet changing user demands.

Core Centres | **Specialized Centres** | **Discontinued Centres**

Regional, national and specialized data centres provide essential complementary functions to the core data centres by assuming particular responsibility for the collection and dissemination of data of a specialized type or application.

Country	Centre	Joined
China	Chinese Nuclear Data Center (CNDC) China Institute of Atomic Energy Beijing	1987
Hungary	Nuclear Data Group ATOMKI, Debrecen	1992
India	Nuclear Data Physics Centre of India BARC, Trombay, Mumbai	2008
Japan	Nuclear Data Center Japan Atomic Energy Agency, Tokai-mura, Naka-gun, Ibaraki	1991
Japan	Japan Nuclear Reaction Data Centre (JCPRG) Hokkaido University, Sapporo	1975
Korea	Nuclear Data Center Korea Atomic Energy Research Institute, Yuseong, Daejeon	2000
Russia	Nuclear Structure and Nuclear Reaction Data Centre (CAJaD) Kurchatov Institute, Moscow	1974
Russia	Centre for Experimental Photonuclear Data (CDFE) Moscow State University, Moscow	1982
Russia	Center for Nuclear Physics Data (CNPD) All Russian Scientific Research Institute of Experimental Physics, Sarov	1997
Ukraine	Ukrainian Nuclear Data Center (UkrNDC) Institute for Nuclear Research, Kyiv	1998

Documents

- Network Document
- EXFOR Basics (pdf)
- EXFOR Basics (html)
- EXFOR Formats
- LEXFOR Protocol
- Dictionary
- Short Guide
- CINDA2001
- ENDF-6 Formats
- More Documents

Codes

- Codes
- Comments on ZCHEX

NRDC Meetings

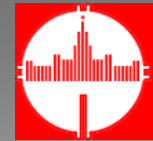
- 2014 (Smolenice)
- 2013 (Vienna)
- 2012 (Paris)
- 2011 (Vienna)
- 2010 (Sapporo)
- 2009 (Vienna)
- 2008 (Obninsk)
- 2007 (Vienna)
- 2006 (Vienna)
- 2005 (Vienna)
- 2004 (Brookhaven)
- 2003 (Vienna)
- 2002 (Paris)
- 2001 (Vienna)
- 2000 (Obninsk)
- 1999 (Vienna)
- All meetings

Other Events

- Workshop 2013
- Workshop 2011
- Workshop 2010
- Workshop 2003
- More Meetings

Memos

- 4C-1 (NNDC)
- 4C-2 (NEA-DB)
- 4C-3 (NDS)
- 4C-4 (CJD)
- CP-A (CAJaD)
- CP-B (KaChaPaG)
- CP-C (NNDC)
- CP-D (NDS)
- CP-E (JCPRG)
- CP-F (CNPD)
- CP-M (CDFE)
- CP-N (NEA-DB)



LOMONOSOV MOSCOW STATE UNIVERSITY, SKOBELTSYN INSTITUTE OF NUCLEAR PHYSICS,
CENTRE FOR PHOTONUCLEAR EXPERIMENTS DATA
 CENTR. DANNYKH FOTUYADERNYKH EKSPERIMENTOV

CDFE: Home Page

Welcome to the CDFE Website.

Online Services available at CDFE:

What are you looking for?

Database

All known about atomic nuclei and nuclear reactions. Numerical data, graphics, and bibliography

Abundances, atomic masses, mass excesses, binding energies, spin-parities, moments, deformations, decay modes of ground and metastable states, energies of first isobar-analog states

Parameters and features of various nuclear reactions with incident photons, neutrons, charge particles, and heavy ions from the international EXFOR data fund

Nucleus state parameters: Energies, spin-parities half-times (decay modes), metastabilities, isospins, angular momenta, spectroscopic strengths, etc.; α -, β -, γ -transition parameters: Energies, intensities, multipolarities, branching ratios, mixing ratios, etc.

Quadrupole deformation parameters; quadrupole moments; charge radii

Reference-bibliography information on articles concern physics of atomic nuclei and nuclear reactions: Author, title, year, full reference, keywords etc...

Energies, amplitudes, widths, integrated cross sections and moments of Giant Dipole Resonances

Nuclear, reactions, energies, angles, abstracts (in codes), references, authors

Nuclei and Reactions Unified Digital Information System
[\[description\]](#)
 Last updated: November 6th, 2012

Nucleus Ground and Isomeric State Parameters
[\[description\]](#)
 Last updated: June 15th, 2011

Nuclear Reaction Database (EXFOR)
[\[description\]](#)
 Last updated: November 6th, 2012

Complete Nuclear Spectroscopy Database "Relational ENSDF"
[\[description\]](#)
 Last updated: April 29th, 2013

Chart of Nucleus Shape and Size Parameters
[\[description\]](#)
 Last updated: April 4th, 2008

Nuclear Physics Publications ("NSR" Database)
[\[description\]](#)
 Last updated: March 1th, 2014

Chart of Giant Dipole Resonance Main Parameters
[\[description\]](#)
[\[guide \(in Russian\)\]](#)
 Last updated: September 27th, 2011

Photonuclear Data Index since 1955
[\[description\]](#)
 Last updated: June 2nd, 2005

CDFE - Centre for Photonuclear Experiments Data - Home page - Mozilla Firefox

cdfe.sinp.msu.ru

Reaction energy, threshold, binding energy, decays

Calculator and Graph Engine for Atomic Nuclei Parameters and Nuclear Reactions and Radioactive Decays Features
[\[description\]](#)
 Last updated: March 22th, 2010

$T_{1/2}$, decay mode

Chart of Atomic Nuclei
 Last updated: March 19th, 2013
Atomic Nuclei, Main Characteristics (in Russian)

Low energy isomer transition internal conversion probabilities

Low Energy Isomer Transition Internal Conversion Probabilities
[\[description\]](#)
 Last updated: May 15th, 2002

p -, d -, t -, ^3He -, α -, and HI-induced reactions yields and cross sections

CAJAD Charged Particle Reaction Cross Sections Catalogue
[\[description\]](#)
 Last updated: December 28th, 2000
 Contains obsolete data. Please use EXFOR instead.

Together with SINP Division of the atomic nuclear physics (DANP)

Wave functions of atoms and ions, He-like, Li-like, excited states, cross sections, variational method, matrix elements, single and double ionization, charge transfer, two bound electrons, hydrogenic wave functions, minimum of the energy, Hylleraas, Slater, Hartree - Fock, one-electron amplitude

Wave Function Value Database
[\[description\]](#)
 Last updated: April 9th, 2013

Charge-Changing Cross Sections, Electron Capture Cross Section, Electron Loss Cross Sections.

Charge-Changing Cross Sections in Ion-Atom Collisions
[\[description\]](#)
 Last updated: December 25th, 2013

Together with SINP Division of space and nuclear research (DSNR)

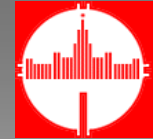
Animation

Dynamic atomic nuclei deformation
 Last updated: April 26th, 2006

3 CDFE databases (EXFOR, ENSDF, NSR) are based on the international data sources but have original Search Engines.

Other databases are based on the CDFE own data collections.

5/15/2014

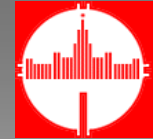


Nuclear Database Service

Some of the CDFE DB that are available through the CDFE Web-site (<http://cdfe.sinp.msu.ru>) were based on the international sources and funds of data produced and maintained by Nuclear Reaction Data Centres Network and by USA NNDC and NSDD:

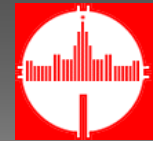
- **“Nuclear Reaction Database (EXFOR)”**: many data for reactions induced by photons, neutrons, charge particles and heavy ions;
- **“Complete Nuclear Spectroscopy Database “Relational ENSDF”** contains many nuclear spectroscopy data for all known (~3200) nuclides from the well-known international fund ENSDF (Evaluated Nuclear Structure Data File);
- **“Nuclear Physics Publications (“NSR” Database”** is the really relational DB based on the data fund of NSR (Nuclear Science References).

Those databases used international sources of information but CDFE-developed powerful and flexible original Search Engines.



Other databases are CDFE-produced and maintained:

- digital **“Chart of Giant Dipole Resonance Main Parameters”** contains data on main parameters (energy position, amplitude, width, integrated cross section) of GDR for many nuclei;
- digital **“Chart of Nucleus Shape and Size Parameters”** contains data on quadrupole moments, parameters of quadrupole deformation and charge radii for many nuclei;
- **“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);
- **“Calculator and Graph Engine for Atomic Nuclei Parameters and Nuclear Reactions and Radiative Decays Features** combines many useful data for “Nucleus Binding Energies”, “Nucleons and Nuclei Separation Energies”, “Decays Energies”, “Decays Energies”, “Nuclei fission”.



EXFOR Database

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 Centre Smolenice, Slovakia

CDFE => Online Services => EXFOR Search Engine - Mozilla Firefox

LOMONOSOV MOSCOW STATE UNIVERSITY, SKOBELTSYN INSTITUTE OF NUCLEAR PHYSICS

CENTRE FOR PHOTONUCLEAR EXPERIMENTS

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CDFE => Online Services

Nuclear Reaction Database (EXFOR)
 [Direct Geometry]
[Inverse Geometry](#)

The source of data is the EXFOR fund prepared and maintained by the [Nuclear Reaction Data Centres Network](#).

Each field in this form is optional - may be blank.

Number ENTRY / SUBENTRY	<input type="text"/>	M0025 - M0025 A0075002 - A0075002 C0128, L00128
Reaction		
Target Nucleus : Z (digits) or Chemical symbol (letters) and Mass number (digits)	Z or Symbol : <input type="text"/>	A : <input type="text"/>
Incident Particle :	<input type="text"/> any <input type="checkbox"/> No incident particle - spontaneous decay <input type="checkbox"/> A Alphas <input type="checkbox"/> D Deuterons <input type="checkbox"/> E Electrons or Ions <input type="text"/> Sequence : Be-8, Pb-208, Li-7	
Inc-Source : Source of the incident particle beam	<input type="text"/> any <input type="checkbox"/> A-BE Alpha-Beryllium <input type="checkbox"/> APAD Annihilation radiation <input type="checkbox"/> ATOMI Atomic beam source <input type="checkbox"/> BRST Bremsstrahlung	
Outgoing Particle / Process :	<input type="text"/> any <input type="checkbox"/> No outgoing particle <input type="checkbox"/> A Alphas <input type="checkbox"/> B- Decay Beta- <input type="checkbox"/> D Deuterons / <input type="text"/> any <input type="checkbox"/> ABS Absorption <input type="checkbox"/> EL Elastic scattering <input type="checkbox"/> F Fission <input type="checkbox"/> INL Inelastic scattering or Sum (e.g., n + p) <input type="text"/>	
Product Nucleus : Z (digits) or Chemical symbol (letters) and Mass number (digits)	Z or Symbol : <input type="text"/>	A : <input type="text"/>

CDFE => Online Services => EXFOR Search Engine - Mozilla Firefox

cdfe.sinp.msu.ru/exfor/index.php

Angular correlation

Angular distributions, general

Angular distributions, partial reactions

Double differential data

Energy/momentum/mass correlation (photoneuclear data)

Fission fragment data

Fitting coefficients

Quantity :
Reaction parameter

Energy / Angle range :
Low High

Status :
Various types of information
 any
 APF
 COF
 CPX
 CUP

CDFE => Online Services => EXFOR Search Engine - Mozilla Firefox

cdfe.sinp.msu.ru/exfor/index.php

Methodic

Method : Experimental technique(s) employed in the experiment	<input type="text"/> any ABSFY Absolute fission yield measurement ACTIV Activation AMS Accelerator mass spectrometry ASEP Separation by mass-separator
Facility : Main apparatus used in the experiment	<input type="text"/> any BETAT Betatron CCW Cockcroft-Walton accelerator CHOPF Fast chopper CHOPS Slow chopper
Detector : Detector(s) used in the experiment	<input type="text"/> any BF3 Boron Trifluoride neutron detector BGO Bismuth-Germanate crystal detector BPAIR Electron-pair spectrometer CEREN Cerenkov detector

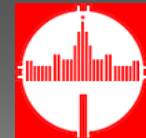
Bibliography

Reference : Type, code and year of publication	Type : <input type="text"/> any <input type="checkbox"/> B Book <input type="checkbox"/> C Conference Code : <input type="text"/> Year : <input type="text"/> 1999 <input type="text"/> 1965 <input type="text"/> 1975 <input type="text"/> 1948,1985,1997
Author : Name of any author of publication	<input type="text"/>
Institute : Institute(s) at which experiment was performed	<input type="text"/> help
Number of subentrys founded / page	<input type="text"/> 50

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If you have any questions, comments, and/or suggestions, please, contact
 CDFE Head: [Vladimir V. Varlamov](#)



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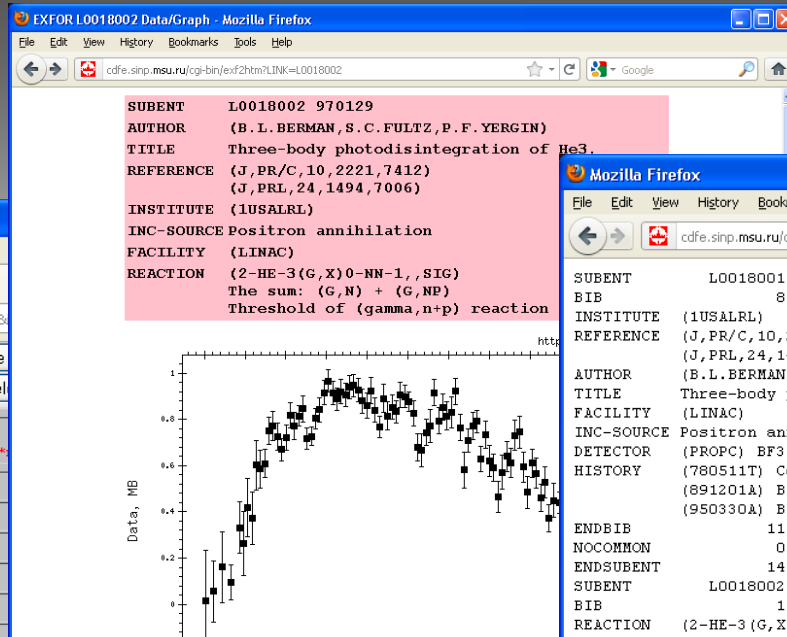
CDFE search engine. - Mozilla Firefox

CDFE => Online Services => EXFOR Sea... x CDCE search engine.

cdfe.sinp.msu.ru/cgi-bin/exfv3.cgi?entry=&ztarg=&atarg=&

Save
 Look through sel

Subent	First Author	Reference (+NSR)	Target Nucleus	
<input type="checkbox"/>	L0152002	Y.Ilieva+	J.EP/A.43.261.2010	1-H-2
<input type="checkbox"/>	L0152003	Y.Ilieva+	J.EP/A.43.261.2010	1-H-2
<input type="checkbox"/>	L0152004	Y.Ilieva+	J.EP/A.43.261.2010	1-H-2
<input type="checkbox"/>	L0152005	Y.Ilieva+	J.EP/A.43.261.2010	1-H-2
<input type="checkbox"/>	L0152006	Y.Ilieva+	J.EP/A.43.261.2010	1-H-2
<input type="checkbox"/>	L0052002	D.D.Faul+	J.EP/A.43.261.2010	1-H-2
<input type="checkbox"/>	L0052004	D.D.Faul+	J.EP/A.43.261.2010	1-H-2
<input type="checkbox"/>	L0052007	D.D.Faul+	J.EP/A.43.261.2010	1-H-2
<input type="checkbox"/>	L0052003	D.D.Faul+	J.EP/A.43.261.2010	1-H-2
<input type="checkbox"/>	L0052008	D.D.Faul+	J.EP/A.43.261.2010	1-H-2
<input type="checkbox"/>	L0157002	R.Nasserip	J.EP/A.43.261.2010	1-H-2
<input type="checkbox"/>	L0157003	R.Nasserip	J.EP/A.43.261.2010	1-H-2
<input type="checkbox"/>	L0018002	B.L.BERMAN	J.EP/A.43.261.2010	1-H-2
<input type="checkbox"/>	L0149002	M.Karlsson	J.EP/A.43.261.2010	1-H-2
<input type="checkbox"/>	M0469002	B.L.BERMAN	J.EP/A.43.261.2010	1-H-2
<input type="checkbox"/>	M0478002	B.L.BERMAN	J.EP/A.43.261.2010	1-H-2
<input type="checkbox"/>	L0052005	D.D.Faul+	J.EP/A.43.261.2010	1-H-2
<input type="checkbox"/>	L0052006	D.D.Faul+	J.EP/A.43.261.2010	1-H-2
<input type="checkbox"/>	M0469003	B.L.BERMAN	J.EP/A.43.261.2010	1-H-2
<input type="checkbox"/>	L0023002	B.L.BERMAN	J.EP/A.43.261.2010	1-H-2
<input type="checkbox"/>	M0520002	M.MACCO	J.EP/A.43.261.2010	1-H-2
<input type="checkbox"/>	M0546002	M.MACCO	J.EP/A.43.261.2010	1-H-2
<input type="checkbox"/>	L0051002	B.L.BERMAN	J.EP/A.43.261.2010	1-H-2
<input type="checkbox"/>	L0051003	B.L.BERMAN+	J.PR/C.22.2273.8012	2-HE-4 (G,N)* 2-HE-3 [INT]
<input type="checkbox"/>	M0327002	J.D.IRISH+	J.CJP.53.802.75	2-HE-4 (G,N) 2-HE-3 [DA/T]
<input type="checkbox"/>	M0327003	J.D.IRISH+	J.CJP.53.802.75	2-HE-4 (G,N) 2-HE-3 [DA/T]



Mozilla Firefox

cdfe.sinp.msu.ru/cgi-bin/exf2htm?LINK=L0018002&SOURCE=ON

SUBENT	L0018001	970129	L0018	1	1C
BIB	8	11	L0018	1	2
INSTITUTE	(1USALRL)		L0018	1	3
REFERENCE	(J, PR/C, 10, 2221, 7412)		L0018	1	4
	(J, PRL, 24, 1494, 7006)		L0018	1	5
AUTHOR	(B.L.BERMAN, S.C.FULTZ, P.F.YERGIN)		L0018	1	6
TITLE	Three-body photodisintegration of He3.		L0018	1	7
FACILITY	(LINAC)		L0018	1	8
INC-SOURCE	Positron annihilation		L0018	1	9
DETECTOR	(PROPC) BF3 counters in polyethylene moderator		L0018	1	10
HISTORY	(780511T) Converted from Berman compilation		L0018	1	11
	(891201A) BIB Updated		L0018	1	12
	(950330A) BIB Updated		L0018	1	13 I
ENDBIB	11	0	L0018	1	14
NOCOMMON	0	0	L0018	1	15
ENDSUBENT	14	0	L0018	1	199999
SUBENT	L0018002	970129	L0018	2	1C
BIB	1	3	L0018	2	2C
REACTION	(2-HE-3(G, X) 0-NN-1, , SIG)		L0018	2	3
			L0018	2	4I
			L0018	2	5I
			L0018	2	6

reaction is 7.7 MeV.

Nucleus Ground and Isomeric States Parameters - results - Mozilla Firefox

cdfe.sinp.msu.ru/cgi-bin/gsearch.cgi?z=2&a=3&dataset=all&met=excluid&12=8&fields=abn&fields=am&fields=ip&fields=dam&fields=if&fields=meif

Return to the CDCE Online Services Main Menu

Nucleus Ground and Isomeric States Parameters - results

2He

The source of data is the current version of [Nuclear Wallet Cards](#) database prepared and maintained by the USA NNDC

[See description]

A	JP	T _{1/2} , G, Abundance	Atomic Mass M, Micro-U	Atomic Mass M, MeV	D _{A.M.} , Micro-U	Mass Excess M.A., MeV	Atomic Mass, MeV	D _{M.E.} keV
3	1/2+	0.000137%	3.016029	2809.413		14.931	2808.391	

CDCE search engine. - Mozilla Firefox

cdfe.sinp.msu.ru/cgi-bin/hessy/current/hessy.cgi?Msd=11&ch=6&clch=0&nlms=11&clen=0&clsp=0&lls=Y&clN=0&fls=Y&fls=Y

Get all data

ENSDF Source	Nucleus	Level energy	Spin-parity	Half-life
11.55	6-C-11	0	3/2-	20.39 M (2)
11.55	6-C-11	2000.0 (5)	1/2-	7.1 FS (5)
11.55	6-C-11	4318.8 (12)	5/2-	< 8.3 FS
11.55	6-C-11	4804.2 (12)	3/2-	< 7.6 FS
11.55	6-C-11	6339.2 (14)	1/2+	< 76.2 FS
11.55	6-C-11	6478.2 (13)	7/2-	< 6 FS
11.55	6-C-11	6904.8 (14)	5/2+	< 48 FS
11.55	6-C-11	7499.7 (15)	3/2+	< 63 FS
11.55	6-C-11	8104.5 (17)	3/2-	0.04 FS (3)
11.55	6-C-11	8420 (2)	5/2-	0.030 FS (8)
11.55	6-C-11	8655 (8)	7/2+	<= 5 KEV

V, measured |s(E,En),

5/15/2014

NSR - 2-HE-3 (G,X) 0-NN-1



Photonuclear Data Evaluations

Main direction:

investigations of reliability and authenticity of data for partial photonuclear reaction cross sections

Main results:

- **many experimental data data for partial photonuclear reaction cross sections from various experiments were analyzed;**
- **new simple objective and absolute criteria were found out for investigation of data reliability and authenticity;**
- **that was shown that majority of experimental data on partial photonuclear reaction cross section data are not reliable and authentic;**
 - **new method for evaluation of reliable and authentic data were proposed**
 - **many new data were evaluated**

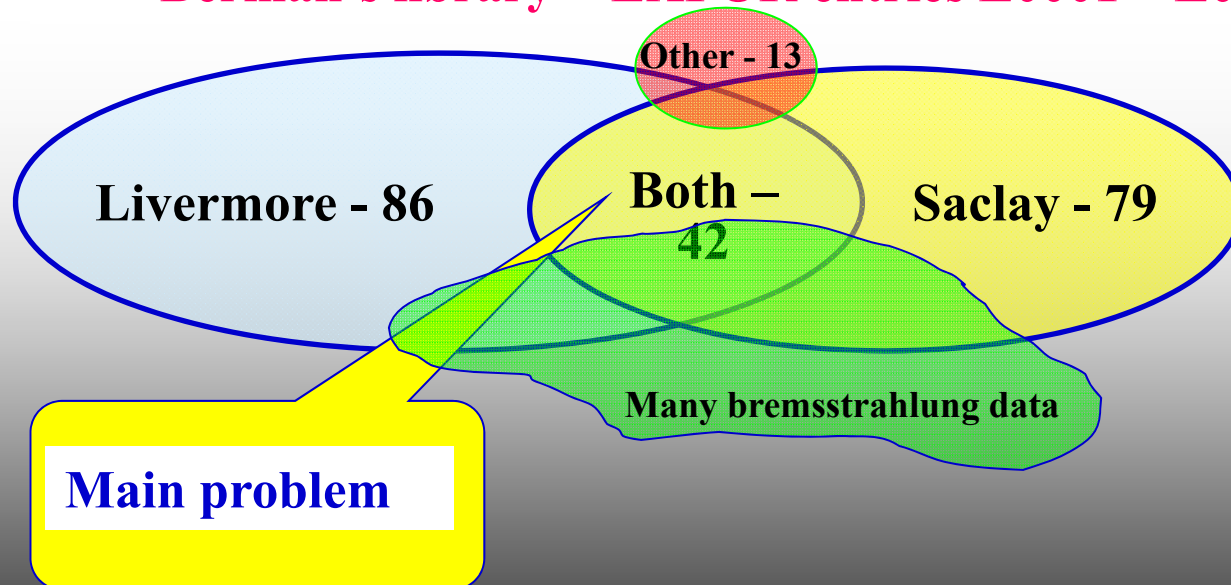


Main problem:

- many experimental data data for partial photonuclear reaction cross sections are published (majority was obtained at Livermore and Saclay):

Atlas of Photoneutron cross sections obtained with monoenergetic photons
 (S.S.Dietrich, B.L.Berman. *Atom. Data and Nucl. Data Tables*, 38 (1988) 199;

Berman's library - EXFOR entries L0001 – L0059 (~ 180 nuclei sets)



For each nucleus – cross sections:

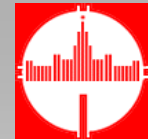
$(\gamma,3n)$

$(\gamma,2n)$

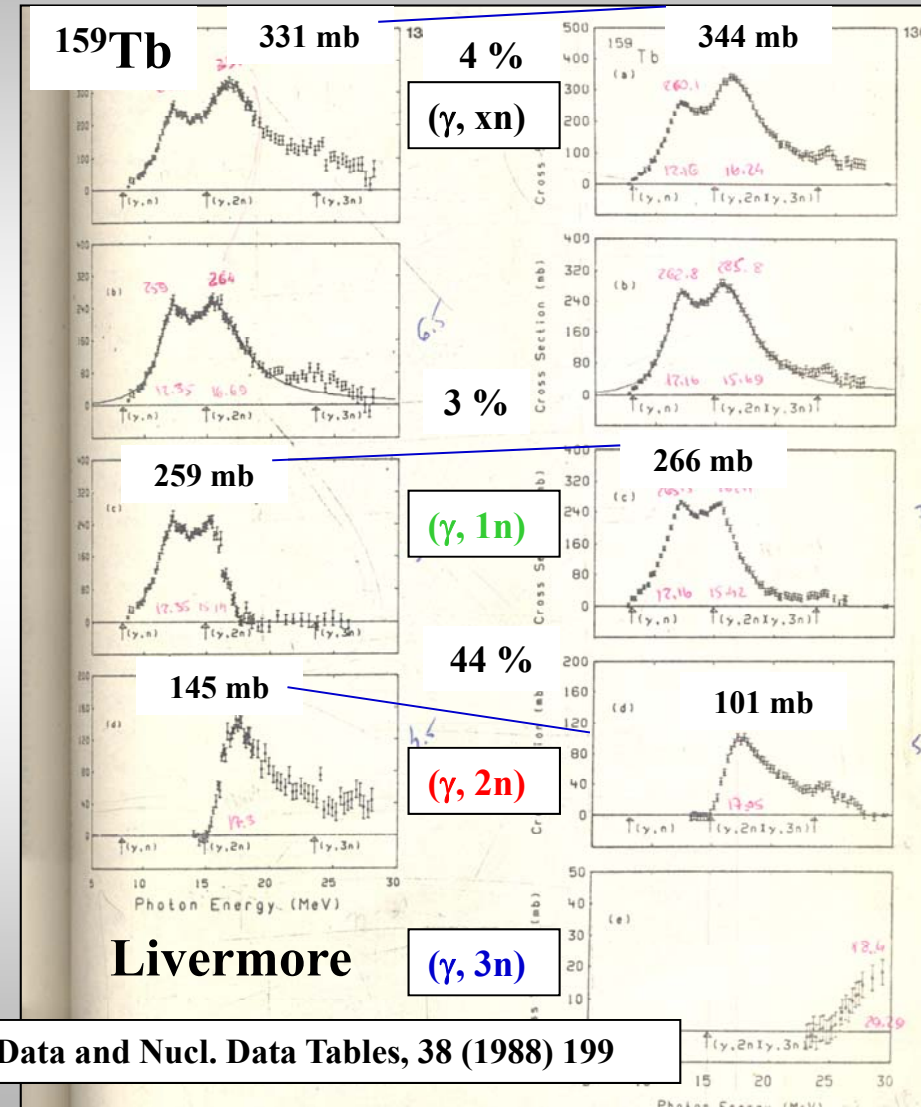
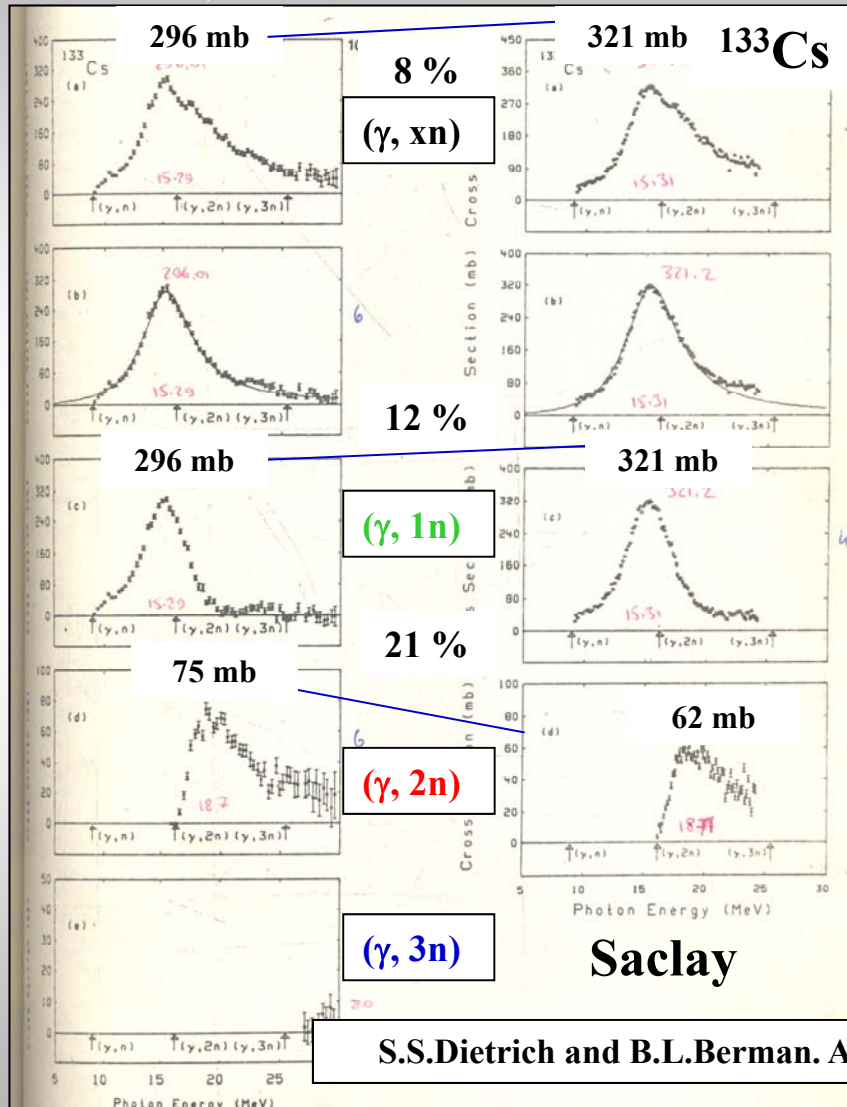
(γ,n)

$(\gamma,sn) = + (\gamma,n) + (\gamma,2n) + (\gamma,3n)$

$\gamma,xn) = + (\gamma,n) + 2(\gamma,2n) + 3(\gamma,3n)$



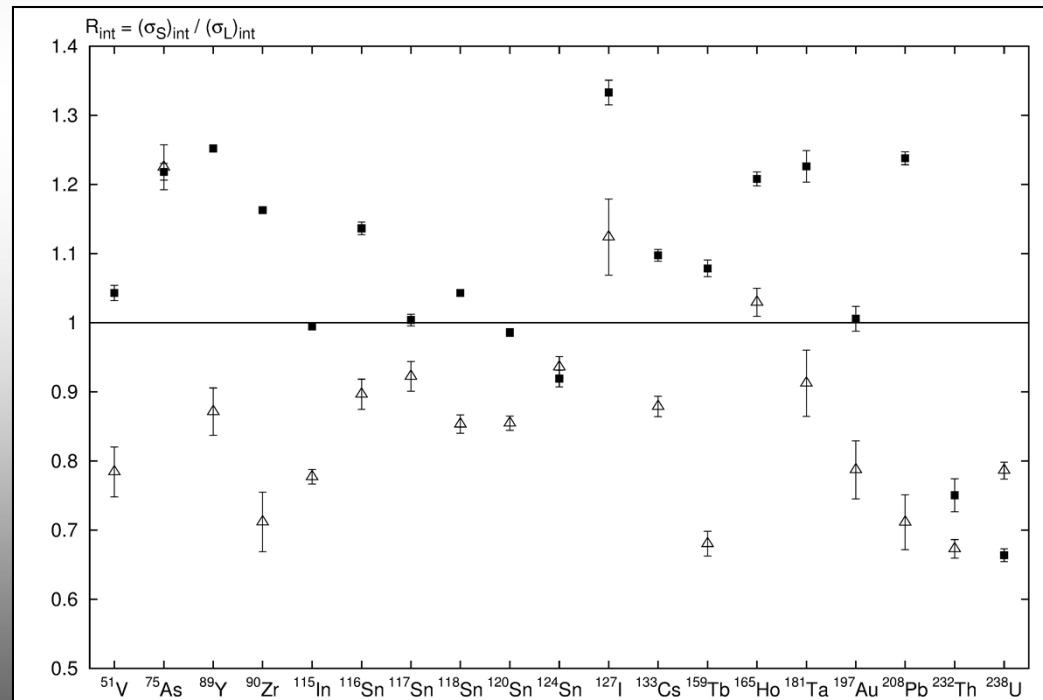
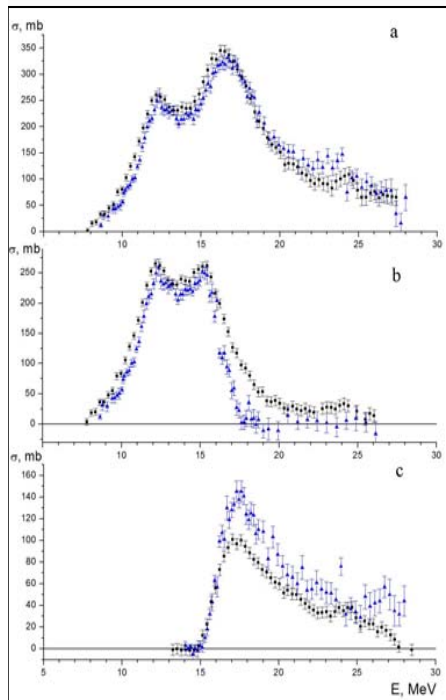
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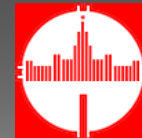
Main problem: many significant (till 100 %!) disagreements were found out between data from two laboratories;

**$(\gamma,n) - (\gamma,2n)$ disagreements between Saclay and Livermore data –
 ratios of integrated cross sections**
 ^{159}Tb



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

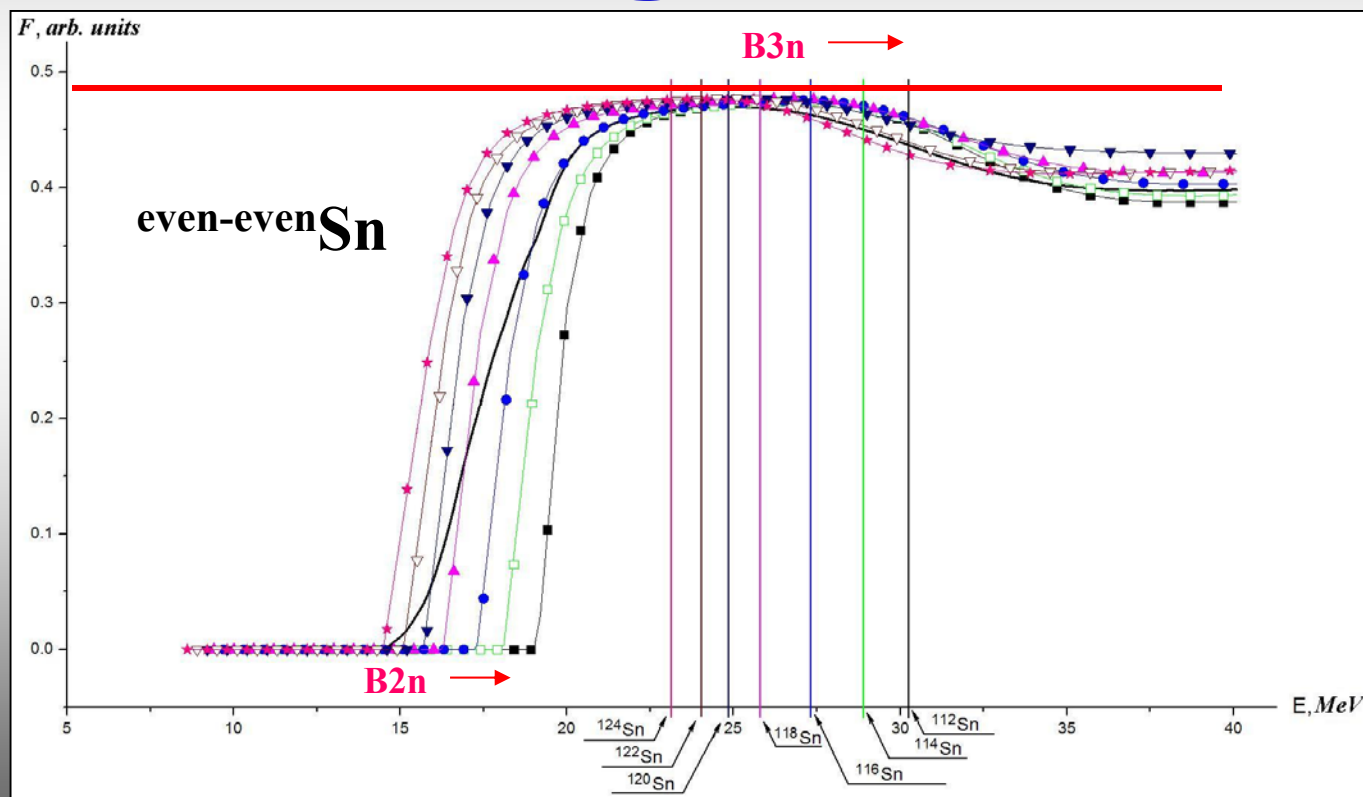
**Triangles - △ -
 ratios for $(\gamma,2n)$
 reactions – are
 smaller than 1.0.**

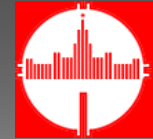


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*Objective absolute criterium of
 “correct” reliable data*

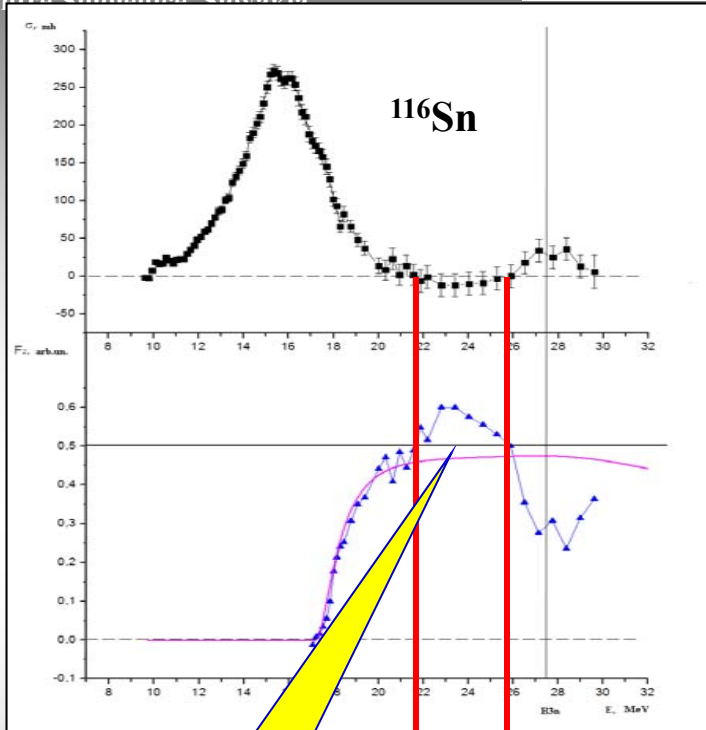
$$F_2 = \frac{\sigma(\gamma, 2n)}{\sigma(\gamma, n) + 2\sigma(\gamma, 2n) + 3\sigma(\gamma, 3n) + \dots} < 0.5 (!)$$





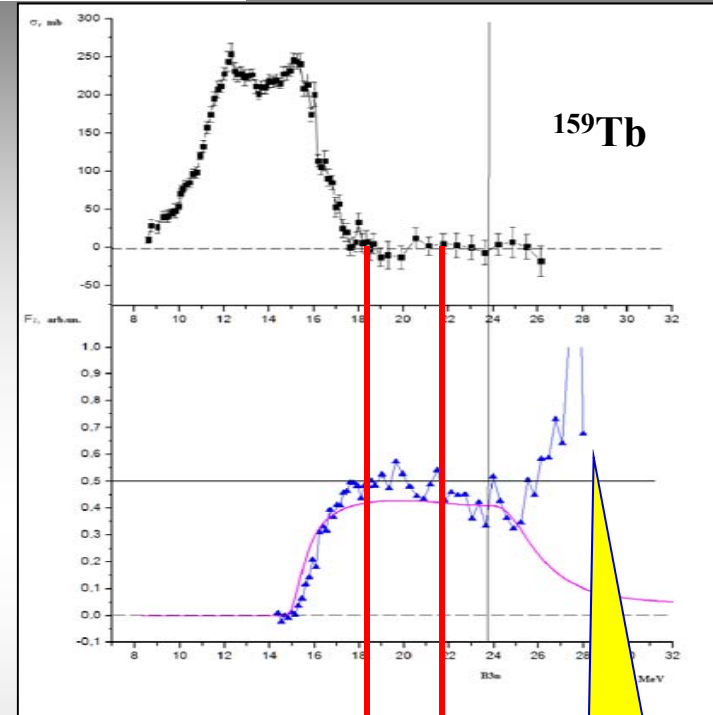
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Some examples of "correct"
 Livermore data



$\sigma(\gamma, n)$

F_2



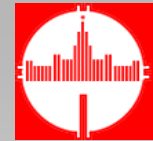
^{159}Tb

**Dramatic
 disagreements:
 $F_2 > 0.5!$**

$$F_2 = \frac{\sigma(\gamma, 2n)}{\sigma(\gamma, n) + 2\sigma(\gamma, 2n) + 3\sigma(\gamma, 3n) + \dots} < 0.5 (!)$$

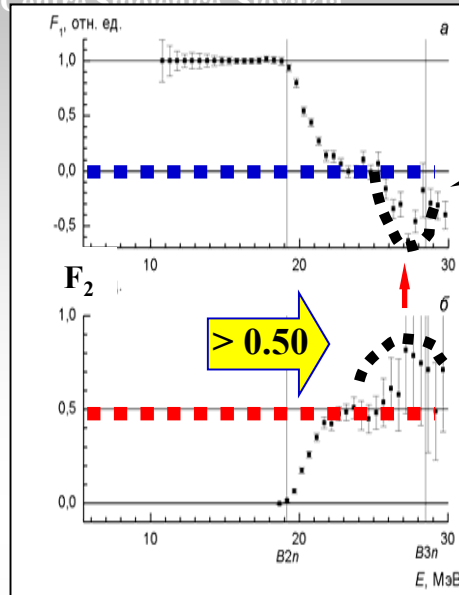
**But physically not reliable negative cross section values
 are correlated with physically forbidden values $F_2 > 0.5$**

**Dramatic
 disagreements:
 $F_2 = 1.5 - 2.0!$**

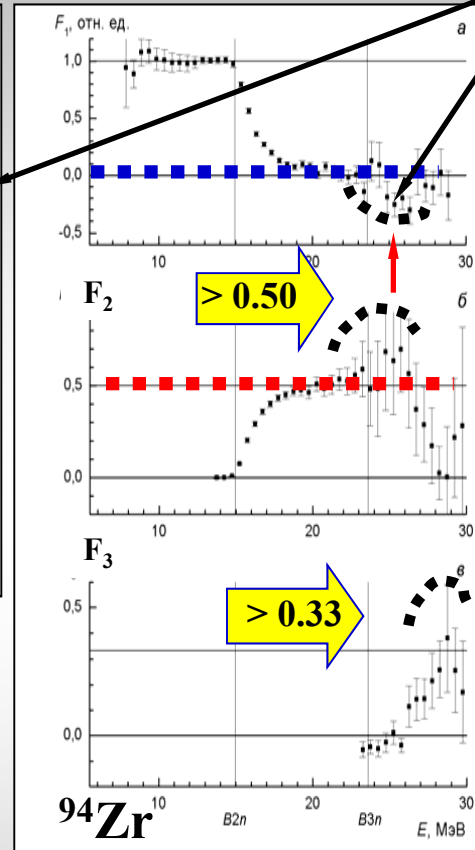


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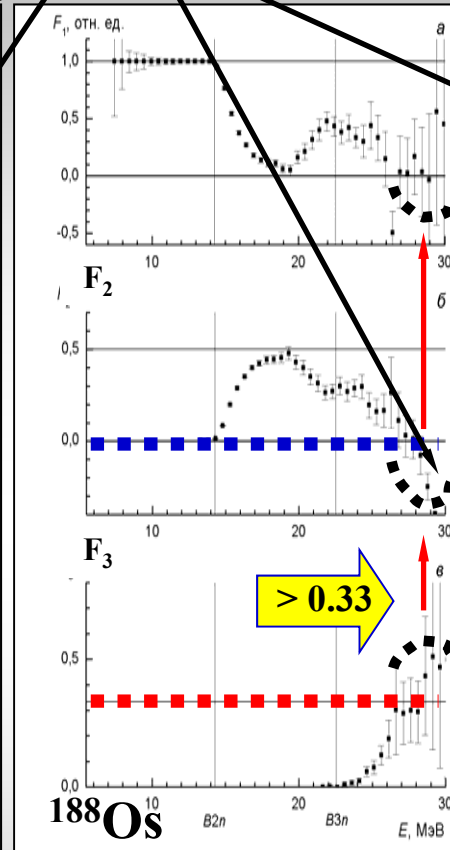
**Physically forbidden
 negative values**



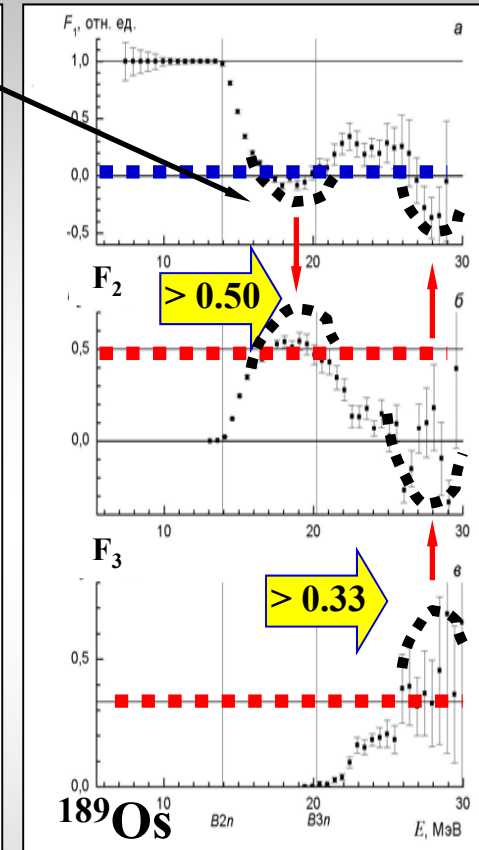
⁹¹Zr



⁹⁴Zr



¹⁸⁸Os



¹⁸⁹Os

The reliability of many data is doubtful.

Many data should be reanalyzed and reevaluated!

There are additional physically natural criteria:

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

$$F_3 = \sigma(\gamma, 3n) / \sigma(\gamma, xn) < 0.33 \text{ etc.}$$



New experimentally-theoretical method of evaluation

using modern model of photonuclear reactions:

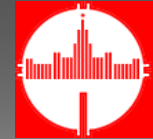
- initial data – experimental (γ, xn) reaction cross section;**
- sorting neutrons for multiplicity based on theoretical model.**

Theoretically calculated transitional multiplicity functions

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

are used for cross section evaluation by following way

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



$\sigma(\gamma, xn)$

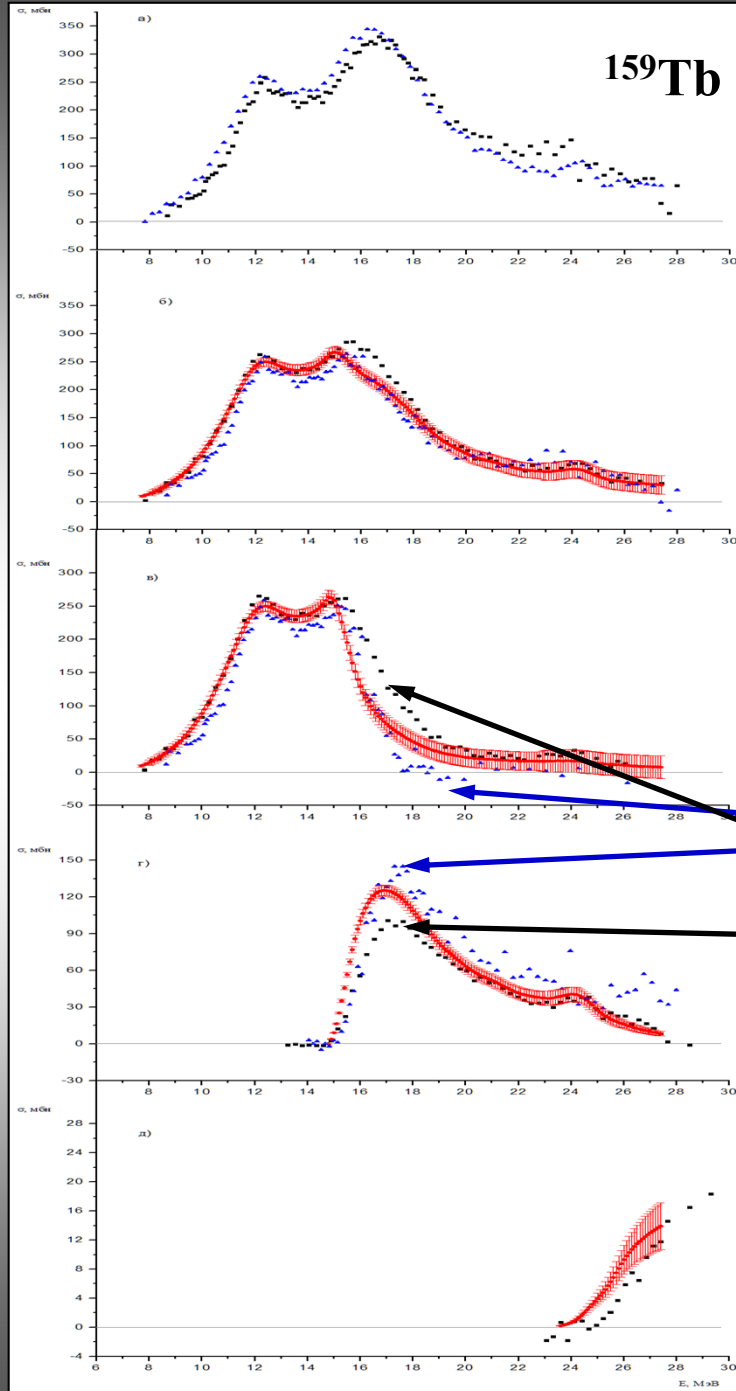
$\sigma(\gamma, sn)$

$\sigma(\gamma, n)$

$\sigma(\gamma, 2n)$

$\sigma(\gamma, 3n)$

^{159}Tb



$^{63}\text{Cu}, ^{89}\text{Y}, ^{90}\text{Zr}, ^{115}\text{In},$
 $^{112}, ^{114}, ^{116}, ^{117}, ^{118}, ^{119}, ^{120}, ^{122}, ^{124}\text{Sn},$
 $^{165}\text{Ho}, ^{197}\text{Au}, ^{181}\text{Ta}, ^{208}\text{Pb}$

Livermore
 data are
 "bad"

Saclay
 data are
 "bad"

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xn-sn-n-2n-3n



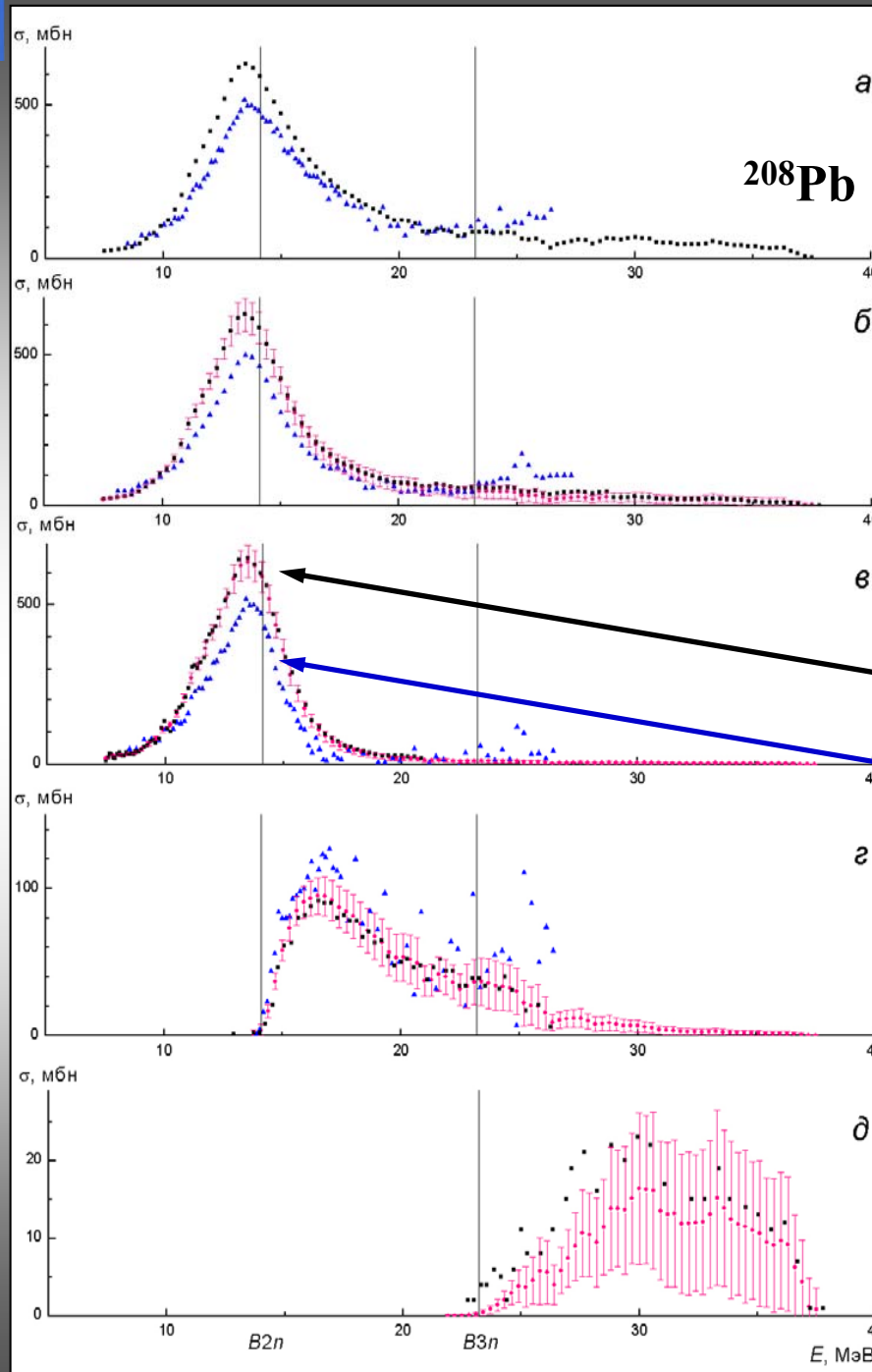
$\sigma(\gamma, xn)$

$\sigma(\gamma, sn)$

$\sigma(\gamma, n)$

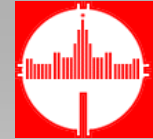
$\sigma(\gamma, 2n)$

$\sigma(\gamma, 3n)$



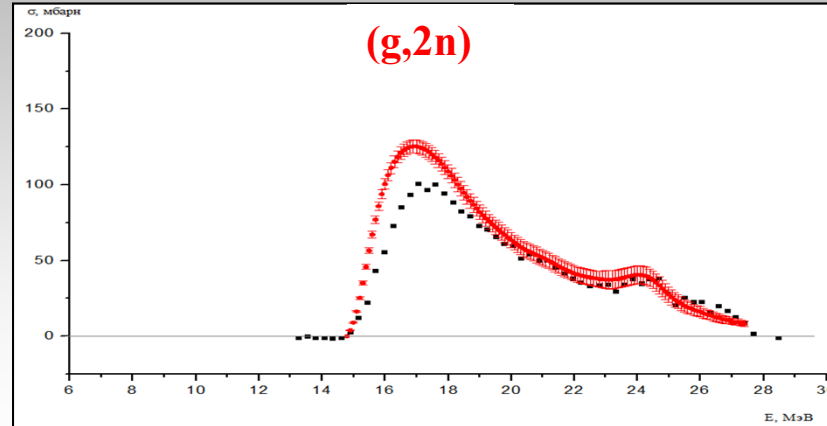
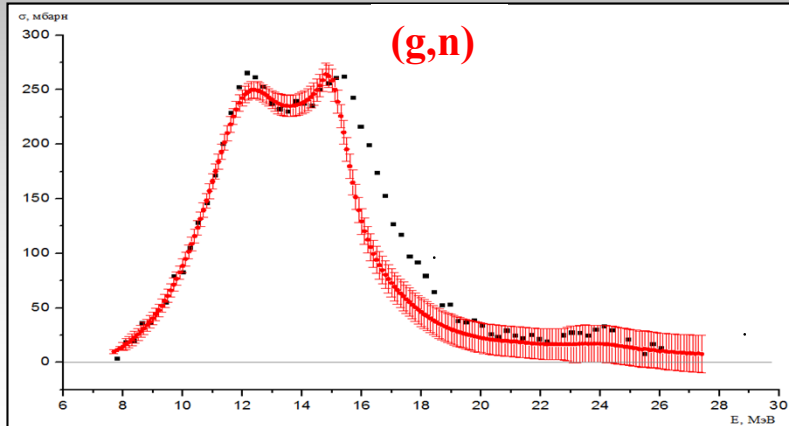
Saclay
 data are
 "good"

Livermore
 data are
 "bad"



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¹⁵⁹Tb



Reaction	Center of gravity E ^{c.g.} , MeV	Integrated cross section σ^{int} , MeV•mb	Integrated cross section σ^{int} , MeV•mb	Center of gravity E ^{c.g.} , MeV
	New evaluated data		Saclay data	
(γ ,xn) *)	16.84	3200	3200	16.84
(γ ,sn)	15.78	2383 <	2557	
(γ ,n)	14.04	1642 <	1950	14.6
(γ ,2n)	19.04	714 >	610	19.9
(γ ,3n)	26.29	26	16	26.8

$\sigma^{int}(\gamma,2n)/\sigma^{int}(\gamma,n)$
 decreased for 27 %.

Decrease for 9 %!

Decrease for 19 %!

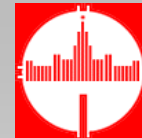
Increase for 15 %!



*) Initial Saclay data

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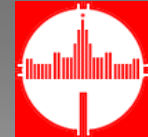
GEANT, TALYS, EMPIRE,...corrections?



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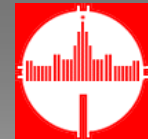
^{181}Ta

Ratios	Experiments			Evaluation
	Saclay	Livermore	Activity	$F_{1,2,3}$
of cross sections $\sigma(\gamma,2n)/\sigma(\gamma,n)$	0.36 (797.4/2189.5)	0.67 (887.0/1315.7)		0.49 (958.3/1956.3)
of yields $Y(\gamma,2n)/Y(\gamma,n)$	0.24	0.42	0.34 ± 0.07	0.33^*
of cross sections $\sigma(\gamma,3n)/\sigma(\gamma,n)$	0.063 (137.4/2189.5)			0.055 (107.3/1956.3)
of yields $Y(\gamma,3n)/Y(\gamma,n)$	0.02		$0.023 - 0.025^{**}$	0.018^*



Photonuclear Data Evaluations

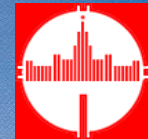
In accordance with CDFE program of investigation of reliability of experimental data for photonuclear total and partial reaction cross sections obtained using various methods the correspondent analysis and evaluations were continued. Using specially proposed objective criteria of data reliability and new experimental-theoretical method for evaluation many new reliable and data for neutron yield reaction $(\gamma, xn) = (\gamma, n) + 2(\gamma, 2n) + 3(\gamma, 3n)$, total photoneutron reaction $(\gamma, sn) = (\gamma, n) + (\gamma, 2n) + (\gamma, 3n)$ and partial (γ, n) , $(\gamma, 2n)$, $(\gamma, 3n)$ reactions cross sections were obtained for many nuclei ($^{63,65}\text{Cu}$, $^{91,94}\text{Zr}$, $^{186,188,189,190,192}\text{Os}$, ^{207}Pb) in addition to those investigated before (^{89}Y , ^{90}Zr , ^{115}In , $^{116,117,118,119,120,122,124}\text{Sn}$, ^{159}Tb , ^{165}Ho , ^{181}Ta , ^{197}Au , ^{208}Pb). New reliable evaluated data were presented at the International Meetings on Nuclear Spectroscopy and Nuclear Structure (NUCLEUS 2013 and NUCLEUS 2014) and included into the EXFOR database.



Short-term (2013/2014) Program

The main items of CDFE (2013/2014) program, main priorities and most important tasks are traditional and the following:

- continuation of photonuclear data compilation using EXFOR format, new TRANSes (M073, M074, 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 of total and partial photonuclear reaction cross sections obtained using various methods in experiments with quasimonoeenergetic annihilation and bremsstrahlung photons;
- upgrading (corrections and additions) of all databases put upon the CDFE Web-site (<http://cdfe.sinp.msu.ru>).



Vladimir Varlamov

**THANKS A LOT
FOR ATTENTION!**

5/15/2014

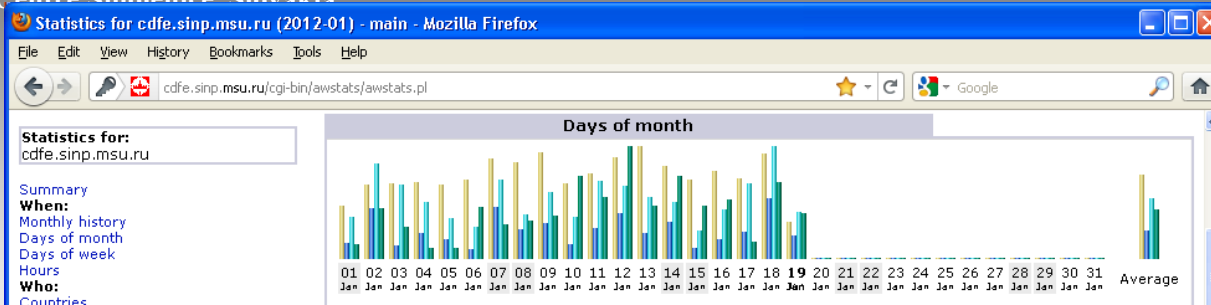
26

Thanks!

CDFE services statistics: January 2012

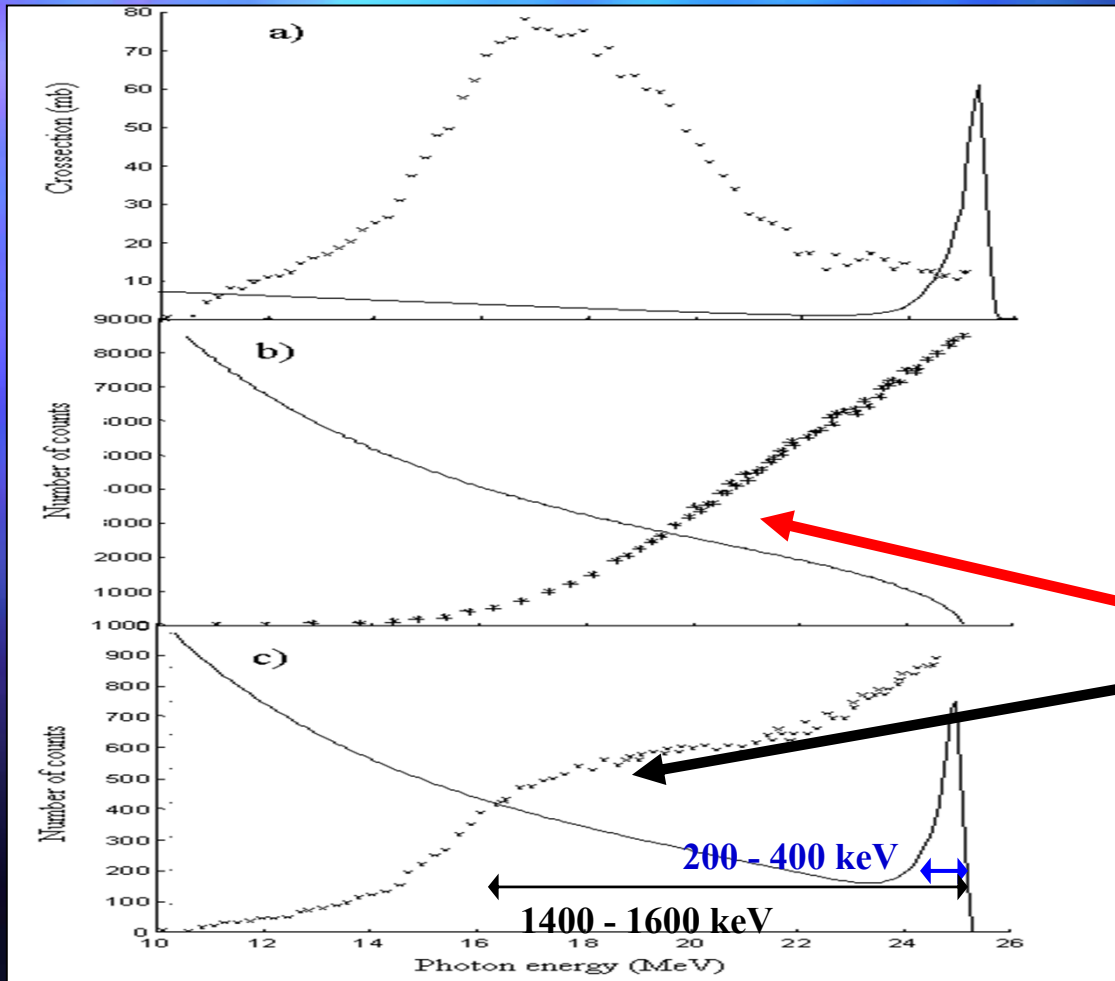
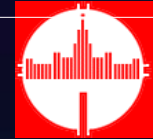


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Countries	Pages	Hits	Bandwidth
Russian Federation ru	1841	4080	323.01 MB
Ukraine ua	338	563	20.10 MB
United States us	325	431	47.87 MB
Kazakhstan kz	101	437	4.50 MB
Germany de	74	108	3.60 MB
China cn	67	100	2.23 MB
Japan jp	66	163	2.76 MB
Poland pl	65	71	964.64 KB
Canada ca	41	73	3.02 MB
South Korea kr	37	37	3.59 MB
Vietnam vn	35	103	515.38 KB
Iraq iq	31	55	4.41 MB
India in	30	111	15.89 MB
Great Britain gb	28	97	17.99 MB
France fr	27	35	12.03 MB
Belgium be	25	27	72.76 KB
Netherlands nl	22	25	1.35 MB
Italy it	20	21	1.61 MB
Turkey tr	16	55	843.44 KB
Thailand th	16	39	456.50 KB
Others	124	425	40.92 MB

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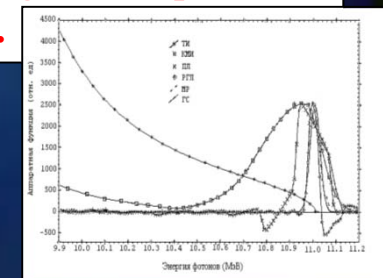


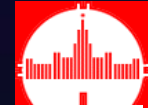
Simple subtraction QMA-procedure gives to one possibility to delete bremsstrahlung tail but does not - to obtain higher energy resolution!

Difference of the yields is not cross section but only yield again:
 $\int W_1 \sigma dE - \int W_2 \sigma dE = \int (W_1 - W_2) \sigma dE$
 only for $\sigma = \text{const!}$

That procedure is subtraction of result obtained with **very bad** resolution from the result obtained with **bad** resolution!

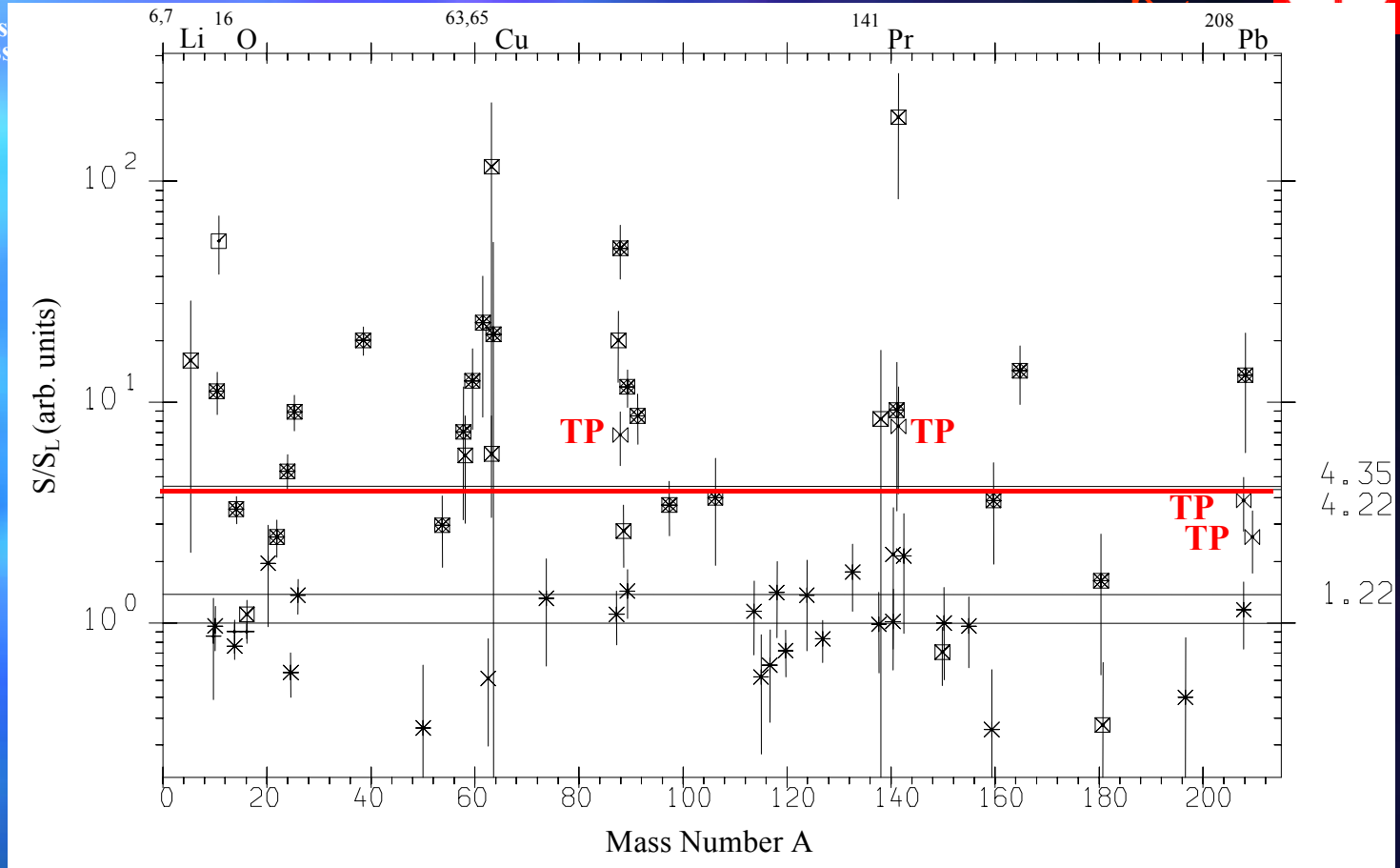
Additional processing for real photon spectrum is needed.





$$S = \frac{1}{N} \frac{\sum_{i=1}^N (\sigma_i - \langle \sigma_i \rangle)^2}{\langle \langle \sigma \rangle \rangle^2}$$

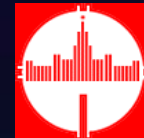
S/S_L are presented, where S were calculated for various laboratories data and S_L - for Livermore QMA-data.



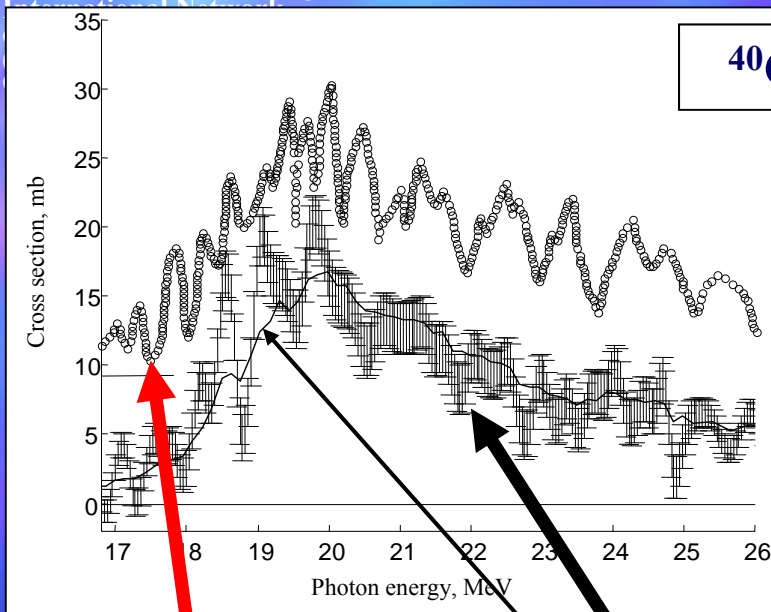
“Structureless” S/S_L ratios for (γ,xn) reaction cross section data:

- squares - BR-data (Moscow, Melbourne (Australia), other) - $\langle S/S_L \rangle = 4.35$;
- crosses - QMA-data (Saclay (France), Giessen (Germany), other) - $\langle S/S_L \rangle = 1.22$;
- bows - Tagged Photons-data (Illinois (USA)) - $\langle S/S_L \rangle = 4.22$.

Structure systematic

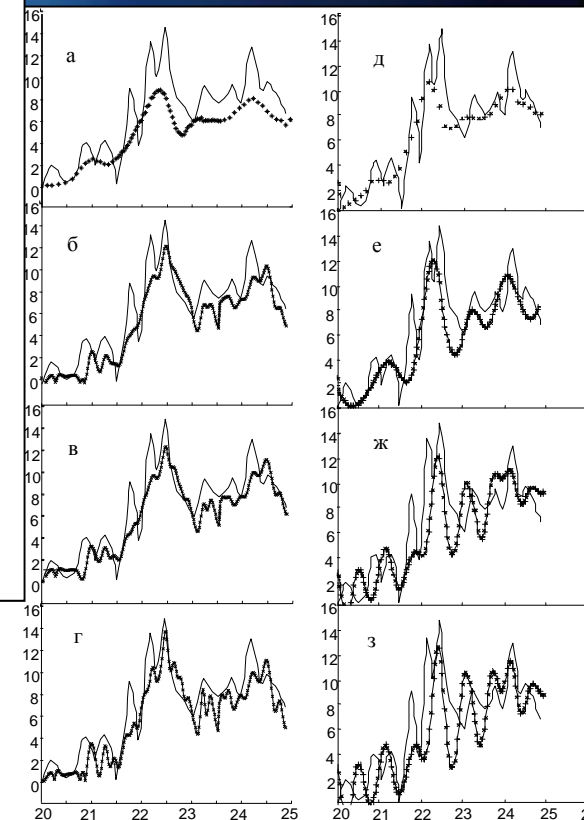
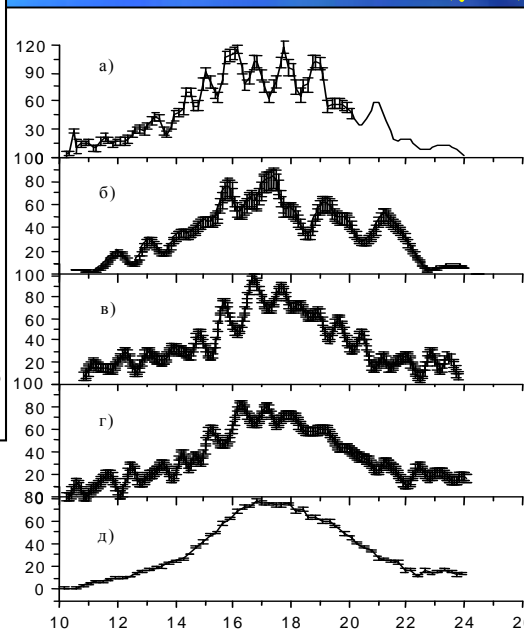


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$^{40}\text{Ca}(\gamma,n)^{39}\text{Ca}$

$^{63}\text{Cu}(\gamma,n)^{62}\text{Cu}$



Result of bremsstrahlung experiment

**Cross section restoration
 from QMA-experiment result**

**Real energy resolution of QMA-experiments is 4 - 6 times
 worse in comparison to its estimation based upon calculated
 photon spectrum annihilation line width.**

$^{16}\text{O}(\gamma,xn)$



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Well-known data under discussion:

E.G.Fuller, H.Gerstenberg. Photonuclear Data - Abstracts Sheets 1955 - 1982. NBSIR 83-2742. U.S.A. National Bureau of Standards, 1986.

S.S.Dietrich, B.L.Berman. Atlas of Photoneutron Cross Sections Obtained with Monoenergetic Photons. Atomic Data and Nuclear Data Tables, 38 (1988) 199.

A.V.Varlamov, V.V.Varlamov, D.S.Rudenko, M.E.Stepanov. Atlas of Giant Dipole Resonances. Parameters and Graphs of Photonuclear Reaction Cross Sections. INDC(NDS)-394, IAEA NDS, Vienna, Austria, 1999.

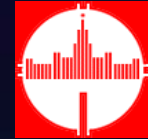
V.V.Varlamov, V.V.Sapunenko, M.E.Stepanov. Photonuclear Data 1976 - 1995. Index. Moscow State University. Moscow, 1996 (bibliographic database URL (<http://depni.sinp.msu.ru/cdfe/services/pnisearch.html>)).

International nuclear (including photonuclear) reaction data relational database (EXFOR):

I.N.Boboshin, V.V.Varlamov, E.M.Ivanov, S.V.Ivanov, N.N.Peskov, M.E.Stepanov, V.V.Chesnokov. Relational Nuclear Databases Upon the MSU INP CDFE Web-site and Nuclear Data Centres Network CDFE Activities. Report on the IAEA Consultant's Meeting on the Co-ordination of Nuclear Reaction Data Centres (Technical Aspects), 28 - 30 May 2001, Vienna, Austria. INDC(NDS)-427, IAEA NDS, Vienna, Austria, 2001, p. 49.

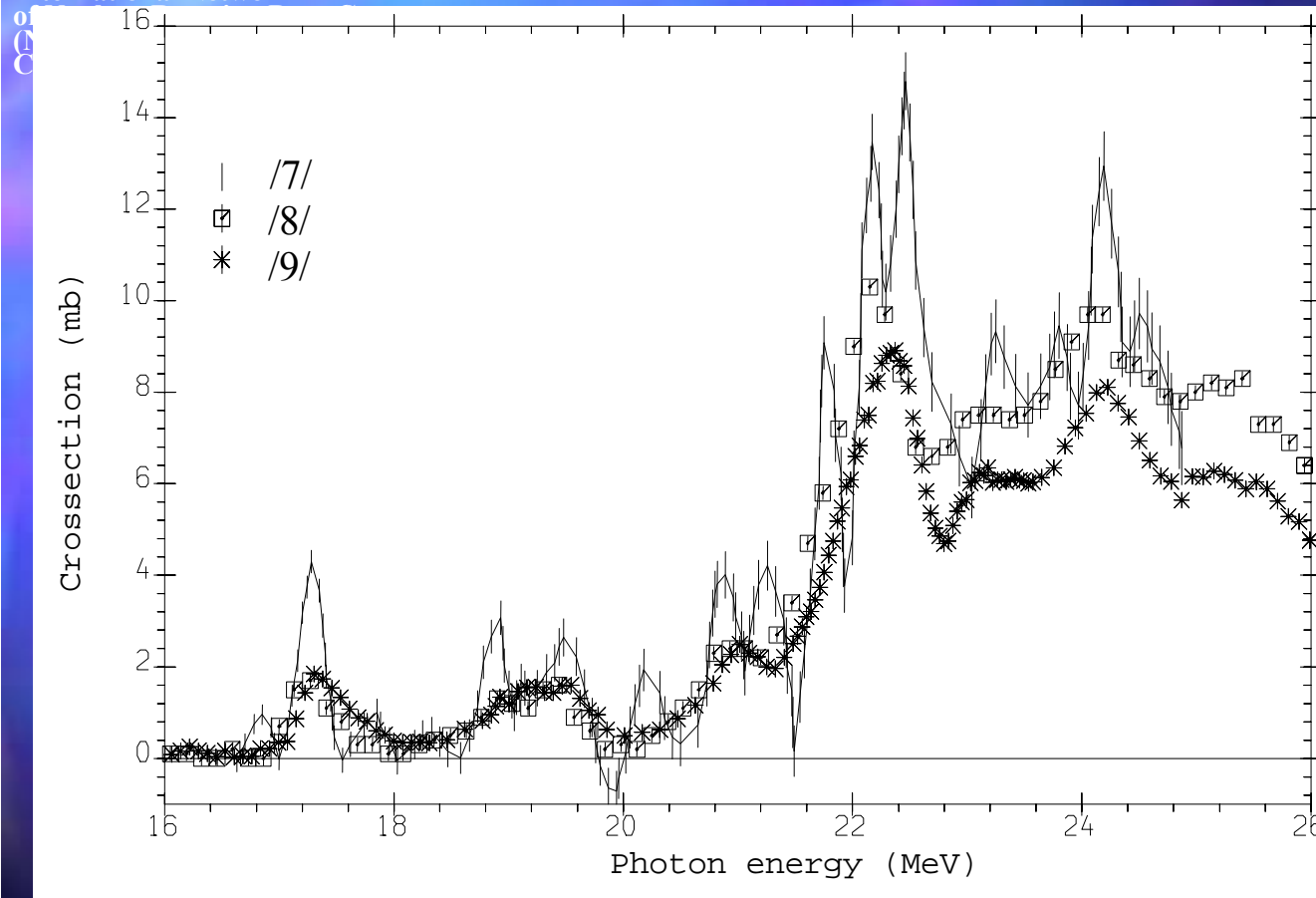
All data for quasimonoenergetic photons and many data for bremsstrahlung are included: URL (<http://depni.sinp.msu.ru/cdfe/exfor/index.php>):

EXFOR
database



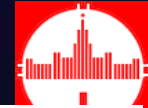
$^{16}\text{O}(\gamma, xn)$

In details:
 quasimonoenergetic
 data look like
 smoothed
 bremsstrahlung
 ones.



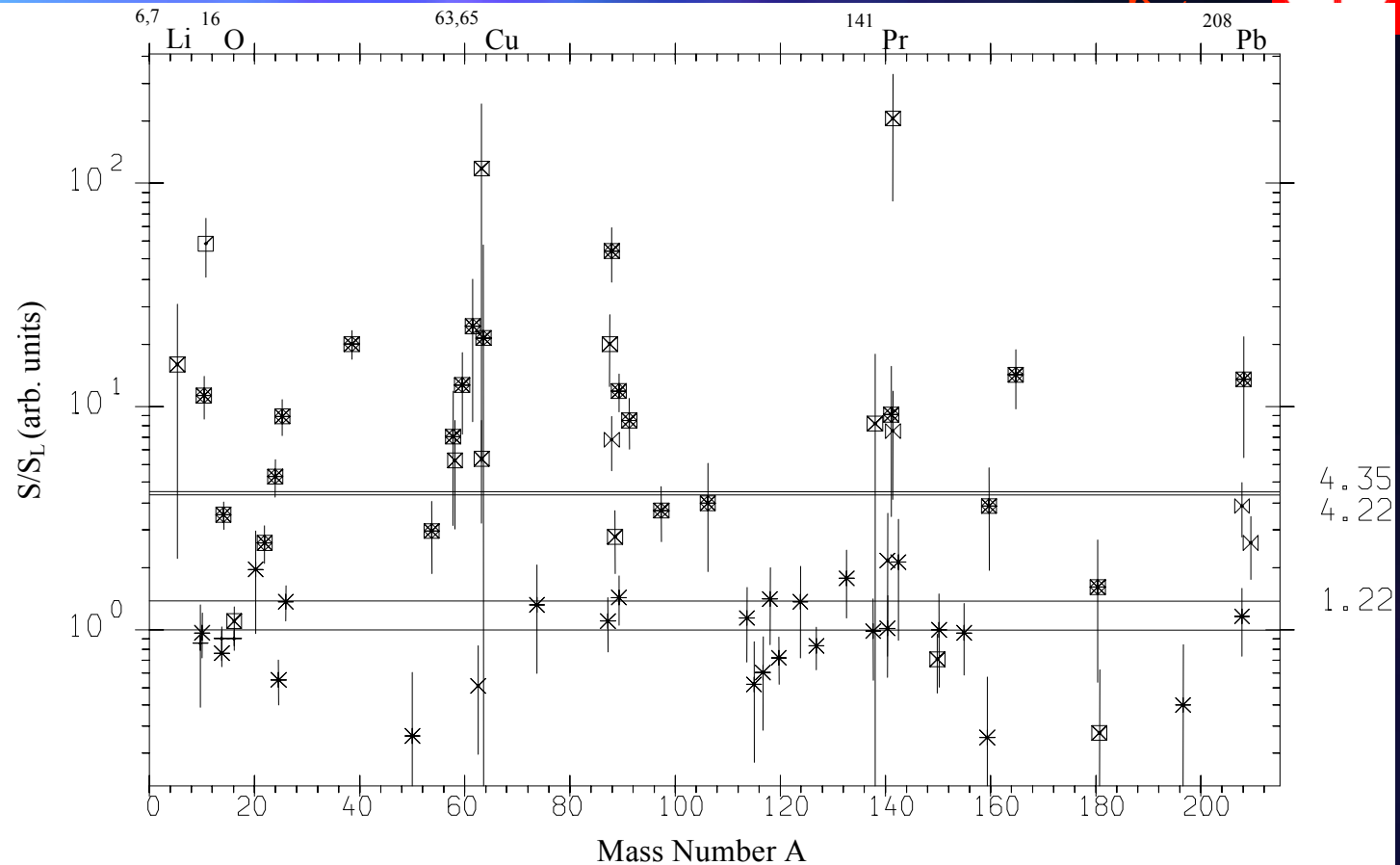
σ_{BR}^{int} (MSU - error bars) = 36.9 MeV•mb
 σ_{QMA}^{int} (Saclay - squares) = 34.6 MeV•mb
 σ_{QMA}^{int} (Livermore - crosses) = 32.1 (27.6 • 1.12) MeV•mb

BR - QMA



$$S = \frac{1}{N} \sum_{i=1}^N \frac{(\sigma_i - \langle \sigma_i \rangle)^2}{\langle \sigma \rangle^2}$$

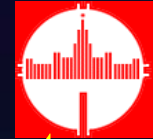
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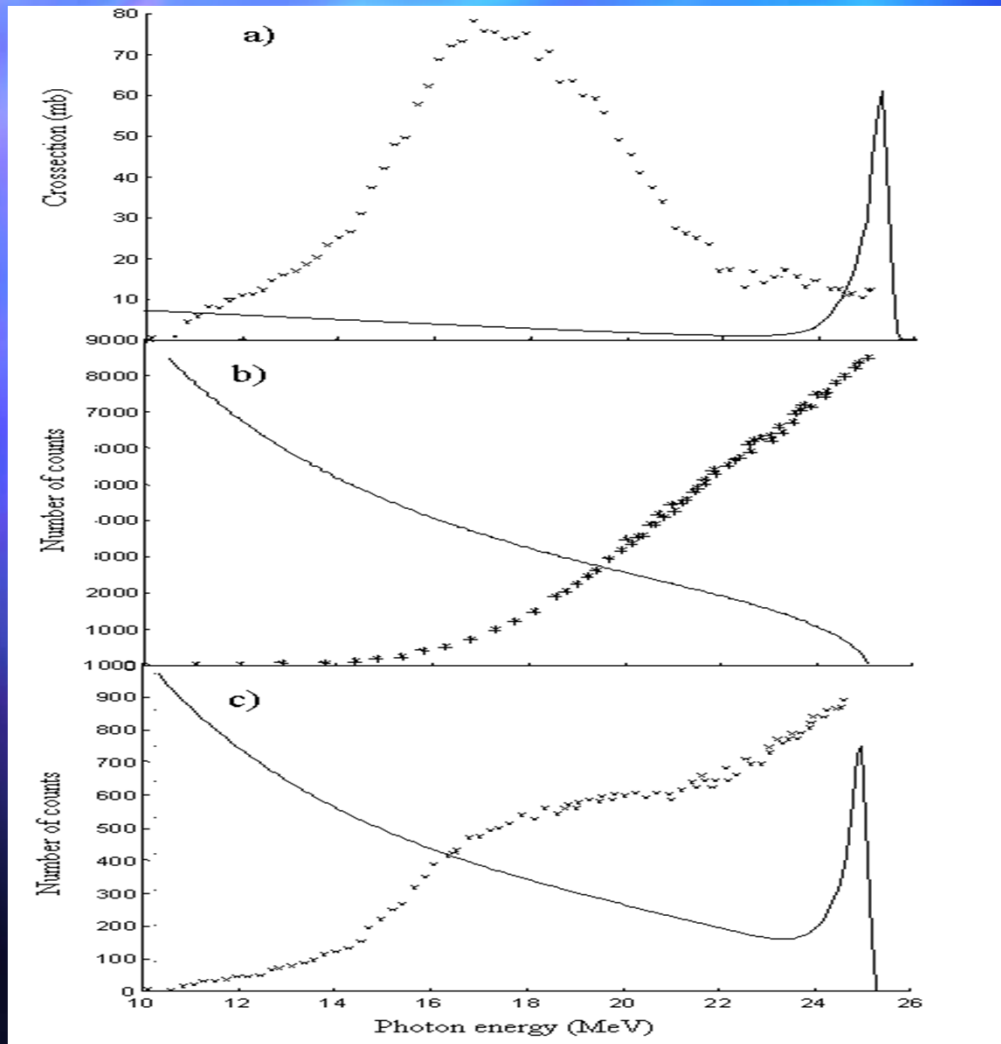
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Structure
 systematic

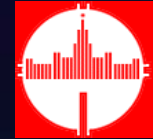


Concerning $^{63}\text{Cu}(\gamma, n)^{62}\text{Cu}$ reaction cross section in 3 steps QMA-experiment



- $\sigma(k) \approx Y(E_j) = Y_{e^+}(E_j) - Y_{e^-}(E_j)$;
 must be additionally processed **taking into account real apparatus function is needed** ;
- $Y_{e^-}(E_j)$ measured using electron bremsstrahlung must be processed by one of methods traditional for BR-experiments;
- $Y_{e^+}(E_j)$ measured using photons from sum of positrons annihilation and bremsstrahlung must be processed also using appropriate apparatus function.

$^{63}\text{Cu}(\gamma, n)^{62}\text{Cu}$



Disagreements (Saclay/Livermore) of amplitudes – absolute values – integrated cross sections

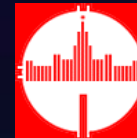
5 clear cases (from “Atlas...” of S.S.Dietrich and B.L.Berman, Atomic Data and Nuclear Data Tables, 38 (1988) 199) of σ^{int} disagreements for appropriate integration energy limits E_{γ}^{max} :

Nucleus	⁵¹ V	⁷⁵ As	⁹⁰ Zr	¹³³ Cs	¹⁶⁵ Ho
$E_{\gamma}^{\text{int-max}}$ (MeV)	27.8 27.8	26.2 29.5	25.9 27.6	24.2 29.5	26.8 28.9
$\sigma^{\text{int}}_{\text{S}}/\sigma^{\text{int}}_{\text{L}}$	689/654 = 1.06	1306/1130 \geq 1.16	1309/1158 \geq 1.13	2484/2505 \approx 1	3667/3385 \geq 1.08

The values obtained at Saclay are higher than that obtained at Livermore for about 6 – 16 %.

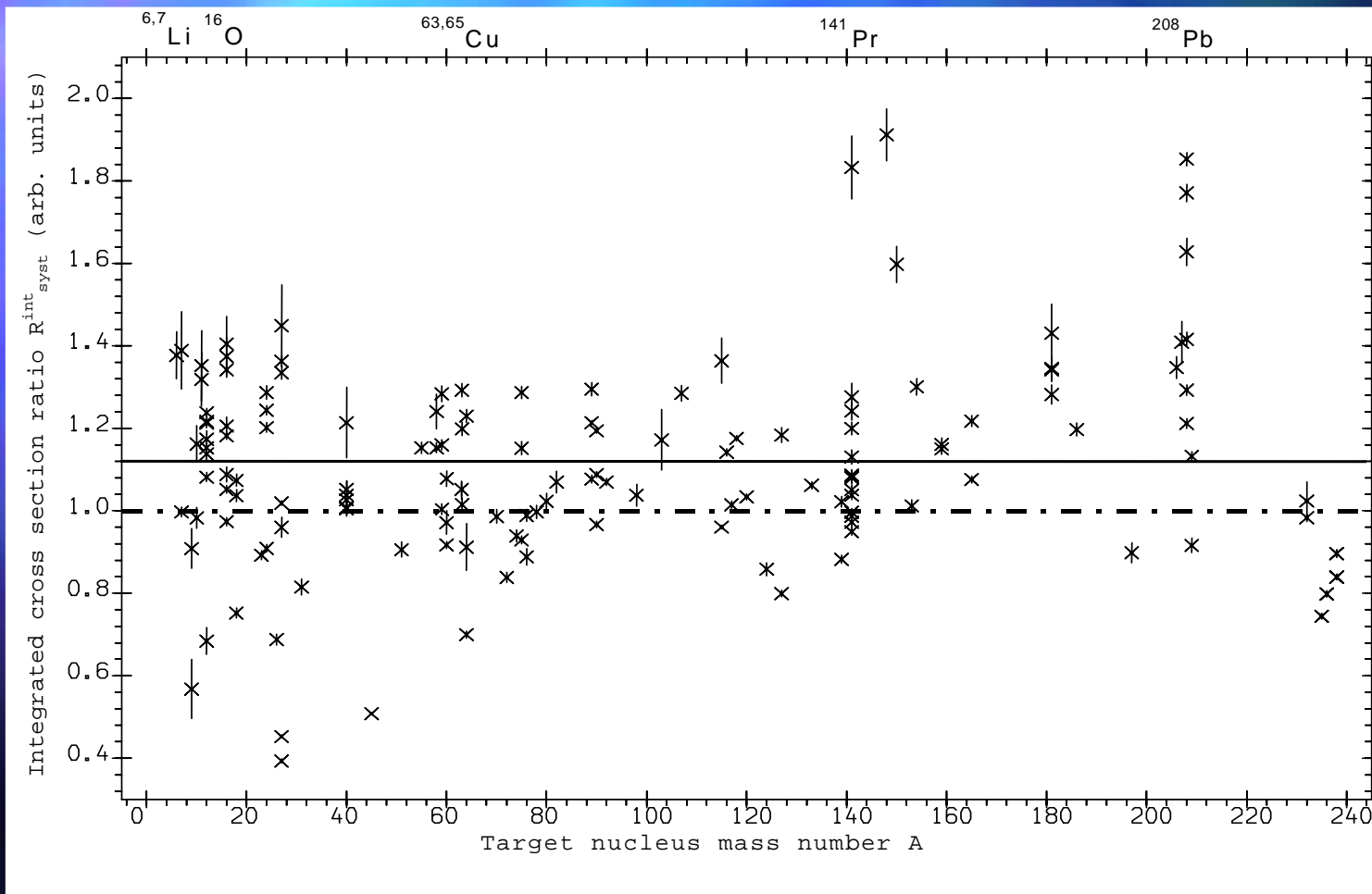
Explanation of the reasons (B.L.Berman, et al., Phys.Rev., C36 (1987) 1286): “... an Livermore experiments error either in the photon flux determination or in the neutron detection efficiency or in both”.

5 nuclei “S/L”



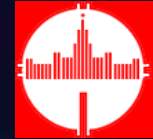
IAEA Technical Meeting of
 International Network
 of Nuclear Reaction Data Centres
 (NRDC) 6-9 May 2014, Congress
 Centre Simolnice, Slovakia

**Systematic of integrated cross section ratios “All other/Livermore” for about 500 total
 photoneutron reaction (γ, xn) cross sections.**



$R_{syst}^{int} = 1.12$

Int. cross. sect.
 ratios



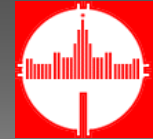
Significant disagreements for partial reaction (γ,n) and ($\gamma,2n$) cross section between Saclay and Livermore data (integrated cross section ratios are presented).

Nucleus	n	$2n$	xn			
	$\sigma_{s(\gamma,n)}^{int} / \sigma_{L(\gamma,n)}^{int}$, /1, 25/ (= arb. units)	$\sigma_{s(\gamma,2n)}^{int} / \sigma_{L(\gamma,2n)}^{int}$, /1, 25/ (= arb. units)	$R^{int}(\gamma,xn)$ /25/ (arb. units)	$\sigma_{s(\gamma,n)}^{int} / \sigma_{L(\gamma,n)}^{int}$, /26/ (arb. units)	$\sigma_{s(\gamma,2n)}^{int} / \sigma_{L(\gamma,2n)}^{int}$, /26/ (arb. units)	$R^{int}(\gamma,xn)$ /26/ (arb. units)
⁵¹ V				1.07	0.79	1.07
⁷⁵ As				1.21	1.22	1.21
⁸⁹ Y	1279/960 = 1.33	74/99 = 0.75	1.26	1.25	0.87	1.25
⁹⁰ Zr				1.26	0.73	1.26
¹¹⁵ In	1470/1354 = 1.09	278/508 = 0.55	0.94	0.97	0.76	0.97
¹¹⁶ Sn				1.10	0.92	1.10
¹¹⁷ Sn	1334/1380 = 0.97	220/476 = 0.46	1.01	1.02	0.93	1.02
¹¹⁸ Sn	1377/1302 = 1.06	258/531 = 0.59	1.06	1.07	0.86	1.07
¹²⁰ Sn	1371/1389 = 0.98	399/673 = 0.75	0.99	1.00	0.86	1.00
¹²⁴ Sn	1056/1285 = 0.82	502/670 = 0.75	0.93	0.93	0.94	0.93
¹²⁷ I				1.34	1.07	1.34
¹³³ Cs	1828/1475 = 1.24	328/503 = 0.65	1.11	1.10	0.88	1.10
¹⁵⁹ Tb	1936/1413 = 1.37	605/887 = 0.68	1.06	1.07	0.71	1.07
¹⁶⁵ Ho	2090/1735 = 1.20	766/744 = 1.03	1.14	1.20	1.05	1.20
¹⁸¹ Ta	2180/1300 = 1.68	790/881 = 0.90	1.22	1.25	0.89	1.25
¹⁹⁷ Au	2588/2190 = 1.18	479/777 = 0.62	1.00	1.00	0.69	1.00
²⁰⁸ Pb	2731/1776 = 1.54	328/860 = 0.38	1.30	1.21	0.77	1.21
²³² Th				0.84	0.69	0.84
²³⁸ U				0.76	0.79	0.76

more higher more lower $\langle R \rangle \approx 1.12$

**While (γ,n)
 Saclay data
 are more
 higher than
 those from
 Livermore,
 ($\gamma,2n$) data are,
 vice versa,
 more lower.**

“(γ,n) – ($\gamma,2n$)”
 discrepancies



Important results:

- **clear data discrepancies** force one to use data existed strongly individually;
- **quasimonoenergetic photons-data** are strongly (**3 – 4 times**) over-smoothed and must be additionally reprocessed to take into account real shape of apparatus function (effective photon spectrum);
- **Livermore** total photoneutron reaction (γ, xn) cross sections have in general absolute values **smaller** than that obtained at various other laboratories; the reason: “... an Livermore experiments error either in the photon flux determination or in the neutron detection efficiency or in both”; therefore **Livermore** (γ, xn) cross sections data of for 19 nuclei studied specially must be multiplied by appropriate coefficients $R^{int}(\gamma, xn)$ and for others – by $\langle R^{int}_{syst} \rangle = 1.12$ at least;
- **Saclay** partial photoneutron reactions (γ, n) and ($\gamma, 2n$) cross sections **are not correct** and consistent each other because of incorrect neutron multiplicity sorting procedure used and **must be recalculated**;
- **Livermore** neutron multiplicity sorting procedure at the same time **is correct** and therefore Livermore (γ, n) and ($\gamma, 2n$) cross sections are in consistence with each other and with (γ, xn) cross sections and both can be used but again only multiplied by coefficients $R^{int}(\gamma, xn)$ or $\langle R^{int}_{syst} \rangle$.

Important
results



3 important physical consequences:

- **GDR structure** (resonances with width \sim hundreds of keV) **exists**; BR-data look like preferable for GDR structure detailed study because QMA-data are strongly over-smoothed;
- **E1 GDR decays dominantly statistically** - Saclay interpretation of high-energy tails of (γ, n) reaction cross sections as contributions of high-energy neutrons from GDR nonstatistical direct decay (those contributions evaluated to be about 17 - 30 %) because of small decreasing of (γ, n) reaction cross sections for energies higher than $(\gamma, 2n)$ reaction threshold $B(2n)$ looks like as very doubtful; **Saclay (γ, n) data corrections** described decrease those and **put them into accordance with Livermore data**: direct decay contributions are not more than **10 - 12 %**;
- **big extra integrated cross section** $\sigma^{\text{int}}(\gamma, \text{abs}) \approx 1.3 - 1.5 60NZ/A$ (MeV \cdot mb) became doubtfully being all due to effective mass of nucleon changing because of the effect of exchange forces; Saclay data correction described affects photoabsorption cross section evaluation using cross section data combinations $(\gamma, \text{abs}) = (\gamma, \text{sn}) + (\gamma, \text{p})$ and $(\gamma, \text{sn}) = (\gamma, \text{xn}) - (\gamma, 2n)$; **mistake in $(\gamma, 2n)$ reaction data produces the mistakes in both (γ, sn) and (γ, abs) reaction data**; correction described do them noticeably smaller.



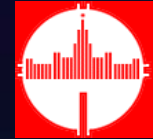
Neutron multiplicity sorting procedure test:

Twice measurement of $^{181}\text{Ta}(e,2n)^{180}\text{Ta}$ cross section $s(e,2n) = \frac{1}{2}(s(e,xn) - s(e,n))$:

1. $\sigma_1(e,n)$ – neutron multiplicity sorting measurement;
2. $\sigma_2(e,n)$ – measurement of induced activity (decay $^{180}\text{Ta} \rightarrow ^{180}\text{Hf}$, 93.3 keV, Ge-Li).

Mean-square ratio $\langle \sigma_1(e,n)/\sigma_2(e,n) \rangle = 1.057 \pm 0.023$ means high reliability of multiplicity sorting procedure.

Comparison of (e,n) and (γ ,n) data show that Saclay data for ($\gamma,2n$) reaction are **underestimated** and correspondingly that for (γ,n) reaction – vice versa **overestimated**.



Nucleus	$\sigma_{s(\gamma,n)}^{int}/\sigma_{L(\gamma,n)}^{int}$, both—MeV*mb		$\sigma_{s(\gamma,2n)}^{int}/\sigma_{L(\gamma,2n)}^{int}$, both—MeV*mb	
	Before [6]	After	Before [6]	After
⁸⁹ Y	1279/960 = 1.33	1205.3/1206.1 = 1.00	74/99 = 0.75	112.6/107.3 = 1.05
¹¹⁵ In	1470/1354 = 1.09	1298.0/1298.2 = 1.00	278/508 = 0.55	364.6/358.3 = 1.02
¹¹⁷ Sn	1334/1380 = 0.97	1261.6/1261.4 = 1.00	220/476 = 0.46	234.1/243.6 = 0.96
¹¹⁸ Sn	1377/1302 = 1.06	1281.3/1281.4 = 1.00	258/531 = 0.49	298.9/320.4 = 0.93
¹²⁰ Sn	1371/1389 = 0.99	1282.7/1282.6 = 1.00	399/673 = 0.59	444.5/460.2 = 0.97
¹²⁴ Sn	1056/1285 = 0.82	1042.5/1042.4 = 1.00	502/670 = 0.75	511.5/502.6 = 1.02
¹³³ Cs	1828/1475 = 1.24	1619.5/1618.5 = 1.00	328/503 = 0.65	431.8/413.7 = 1.04
¹⁵⁹ Tb	1936/1413 = 1.37	1485.3/1485.4 = 1.00	605/887 = 0.68	633.9/675.7 = 0.94
¹⁶⁶ Hb	2090/1735 = 1.20	2040.7/2040.7 = 1.00	766/744 = 1.03	825.6/803.4 = 1.03
¹⁸¹ Ta	2180/1300 = 1.68	1616.4/1615.7 = 1.00	790/881 = 0.90	520.1/559.9 = 0.93
¹⁹⁷ Au	2588/2190 = 1.18	2144.6/2142.4 = 1.00	479/777 = 0.62	367.0/345.0 = 1.06
²⁰⁸ Pb	2731/1776 = 1.54	2274.5/2273.8 = 1.00	328/860 = 0.38	611.0/626.0 = 0.98

**The effect of joint Saclay and Livermore data correction:
 agreement for both (γ,n) and ($\gamma,2n$) reaction cross sections is quite well.**

Correction
 (table)



Nucleus	Laboratory	Factor F /23/ (arb. units)	Factor 1/F (arb. units)
^{nat} Rb	S	0.85 ± 0.03	
^{nat} Sr	S	0.85 ± 0.03	1.18
⁸⁹ Y	S	0.82	1.22
⁸⁹ Y	L	1.0	
⁹⁰ Zr	S	0.88	1.14
⁹⁰ Zr	L	1.0	
⁹¹ Zr	L	1.0	
⁹² Zr	L	1.0	
⁹³ Nb	S	0.85 ± 0.03	1.18
⁹⁴ Zr	L	1.0	
¹²⁷ I	S	0.80	1.25
¹⁹⁷ Au	S	0.93	1.08
²⁰⁶ Pb	L	1.22	
²⁰⁷ Pb	L	1.22	
²⁰⁸ Pb	L	1.22	
²⁰⁸ Pb	S	0.93	1.08
²⁰⁸ Bi	L	1.22	

Factor "F"