Database of continuum gamma-ray data

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4th Oslo Workshop on Level Densities and Gamma Strength, 30 May 2013

International Atomic Energy Agency

- Vienna, Austria
- 157 member states
- Over 2000 employees

International Atomic Energy Agency

- Mandate to promote and support the safe, secure and peaceful application of nuclear technologies

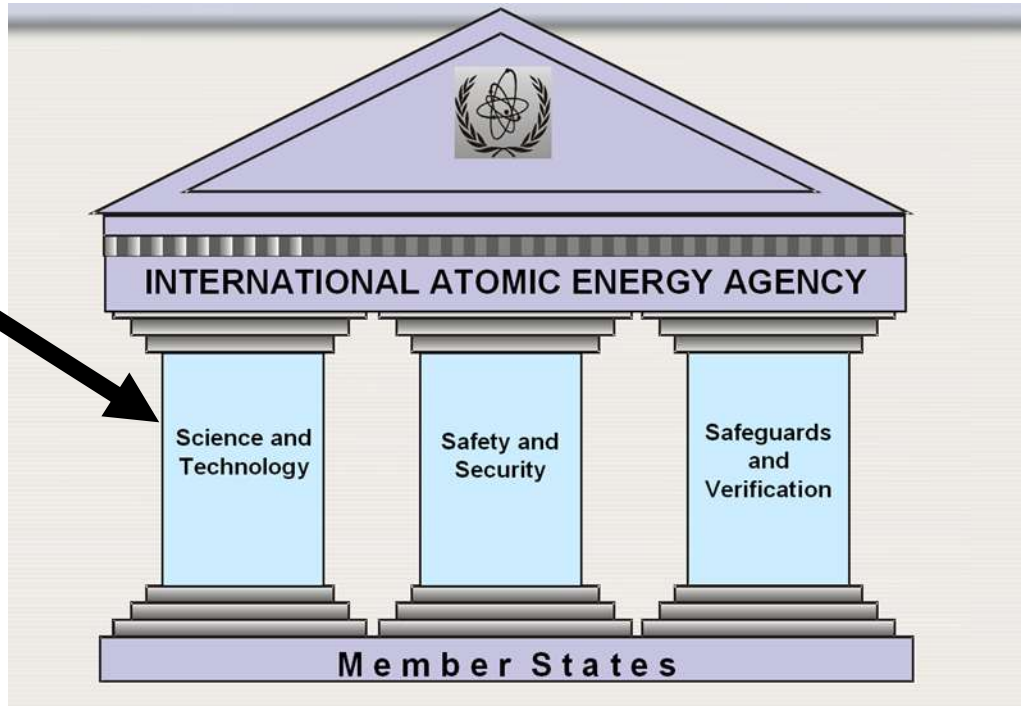
Nuclear Sciences and Applications:
Physical and Chemical Sciences

Isotope Hydrology

Radioisotopes and
Radiation Technology

Physics

Nuclear Data



Nuclear Data Section

- is responsible for the development and dissemination of atomic and nuclear data for applications through specific actions such as

-Data compilation and evaluation

-Data services, Data Networks and User Support

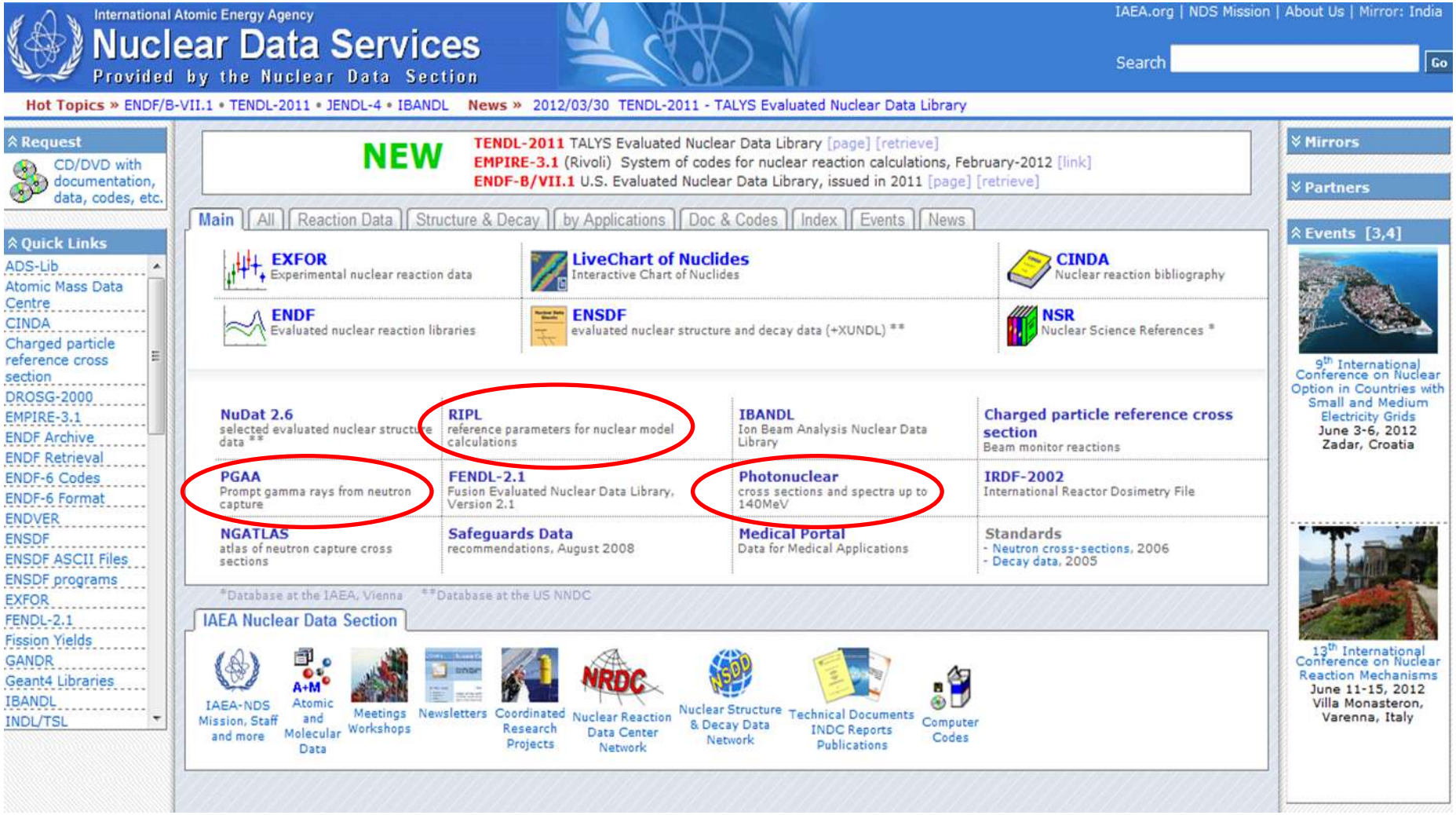
(documents, CDs)

-Nuclear Data Standards and Evaluation Methods

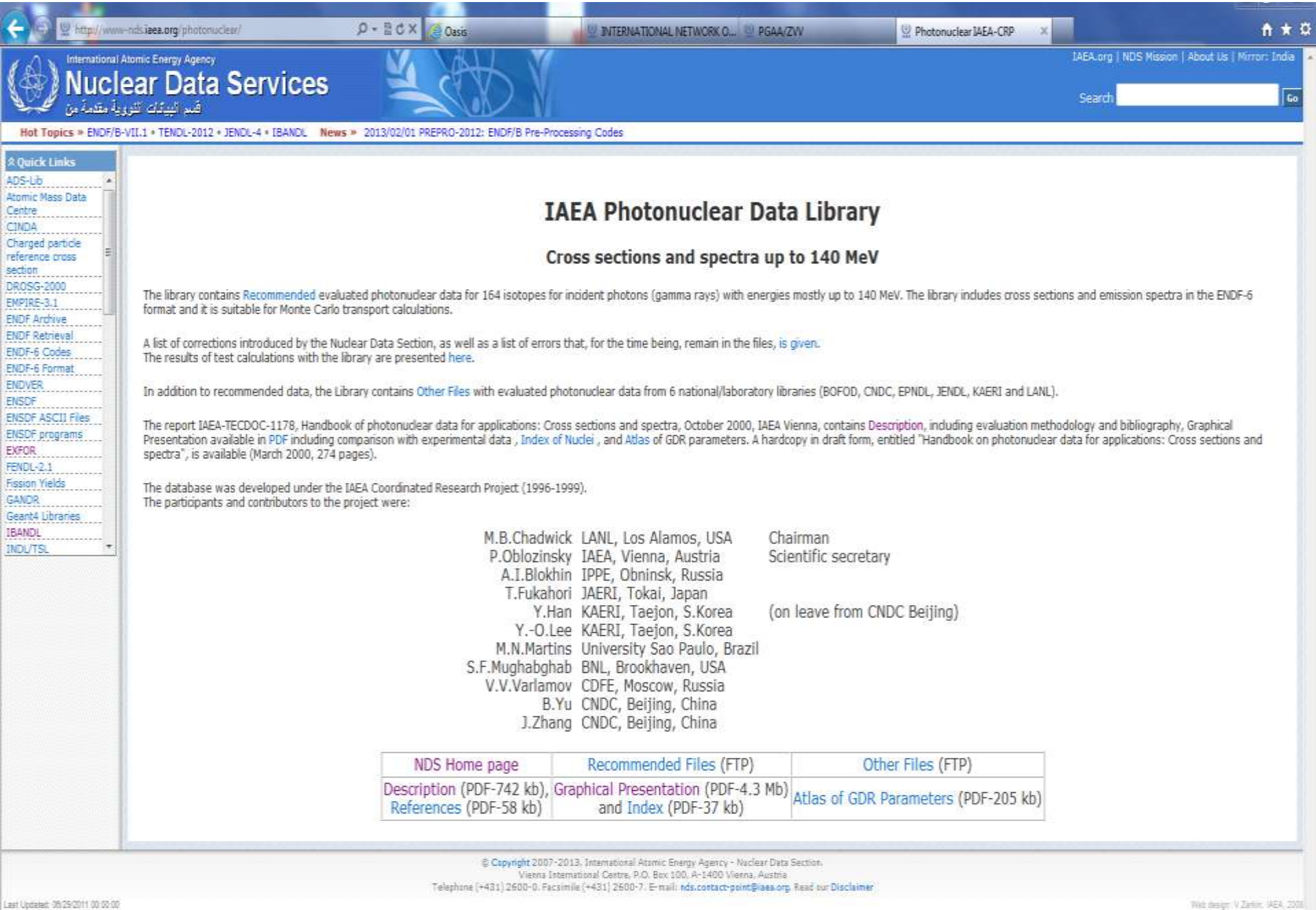
Data :

- **energy-dependent reaction probabilities (cross sections)**
- **energy and angular distributions of reaction products for many combinations of target and projectile**
- **atomic and nuclear properties of excited states**
- **nuclear structure and radioactive decay data**

Nuclear Data Services Webpage
http://www-nds.iaea.org/



http://www-nds.iaea.org/photonuclear/



International Atomic Energy Agency
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- EMPIRE-3.1
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- ENDF-6 Format
- ENDVER
- ENSDF
- ENSDF ASCII Files
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- EXFOR
- FENDL-2.1
- Fission Yields
- GANDR
- Geant4 Libraries
- IBANDL
- INDL/TSL

IAEA Photonuclear Data Library

Cross sections and spectra up to 140 MeV

The library contains Recommended evaluated photonuclear data for 164 isotopes for incident photons (gamma rays) with energies mostly up to 140 MeV. The library includes cross sections and emission spectra in the ENDF-6 format and it is suitable for Monte Carlo transport calculations.

A list of corrections introduced by the Nuclear Data Section, as well as a list of errors that, for the time being, remain in the files, is given.
The results of test calculations with the library are presented here.

In addition to recommended data, the Library contains Other Files with evaluated photonuclear data from 6 national/laboratory libraries (BOFOD, CNDC, EPNDL, JENDL, KAERI and LANL).

The report IAEA-TECDOC-1178, Handbook of photonuclear data for applications: Cross sections and spectra, October 2000, IAEA Vienna, contains Description, including evaluation methodology and bibliography, Graphical Presentation available in PDF including comparison with experimental data , Index of Nuclei , and Atlas of GDR parameters. A hardcopy in draft form, entitled "Handbook on photonuclear data for applications: Cross sections and spectra", is available (March 2000, 274 pages).

The database was developed under the IAEA Coordinated Research Project (1996-1999).
The participants and contributors to the project were:

M.B.Chadwick	LANL, Los Alamos, USA	Chairman
P.Oblozinsky	IAEA, Vienna, Austria	Scientific secretary
A.I.Blokhin	IPPE, Obninsk, Russia	
T.Fukahori	JAERI, Tokai, Japan	
Y.Han	KAERI, Taejon, S.Korea	(on leave from CNDC Beijing)
Y.-O.Lee	KAERI, Taejon, S.Korea	
M.N.Martins	University Sao Paulo, Brazil	
S.F.Mughabghab	BNL, Brookhaven, USA	
V.V.Varlamov	CDFE, Moscow, Russia	
B.Yu	CNDC, Beijing, China	
J.Zhang	CNDC, Beijing, China	

NDS Home page	Recommended Files (FTP)	Other Files (FTP)
Description (PDF-742 kb), References (PDF-58 kb)	Graphical Presentation (PDF-4.3 Mb) and Index (PDF-37 kb)	Atlas of GDR Parameters (PDF-205 kb)

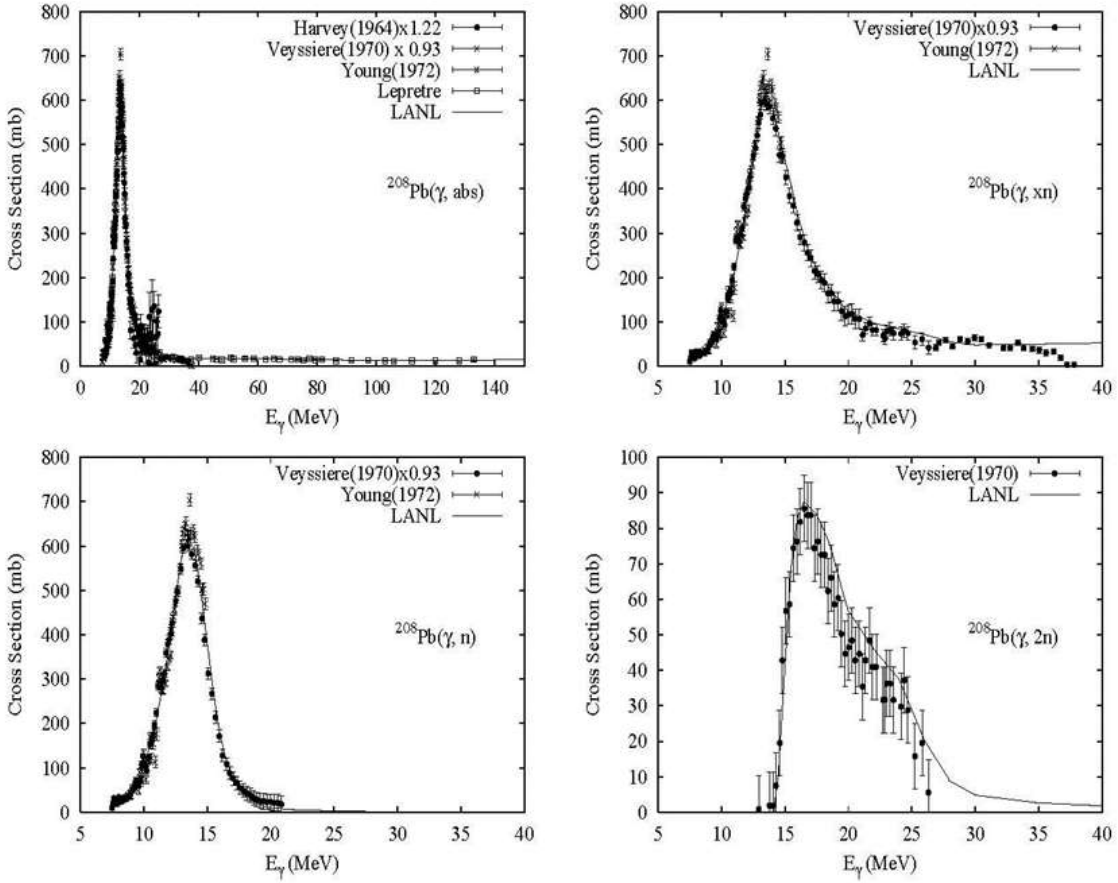
Last Updated: 06/29/2011 00:00:00

Web design: V.Zerkin, IAEA, 2008

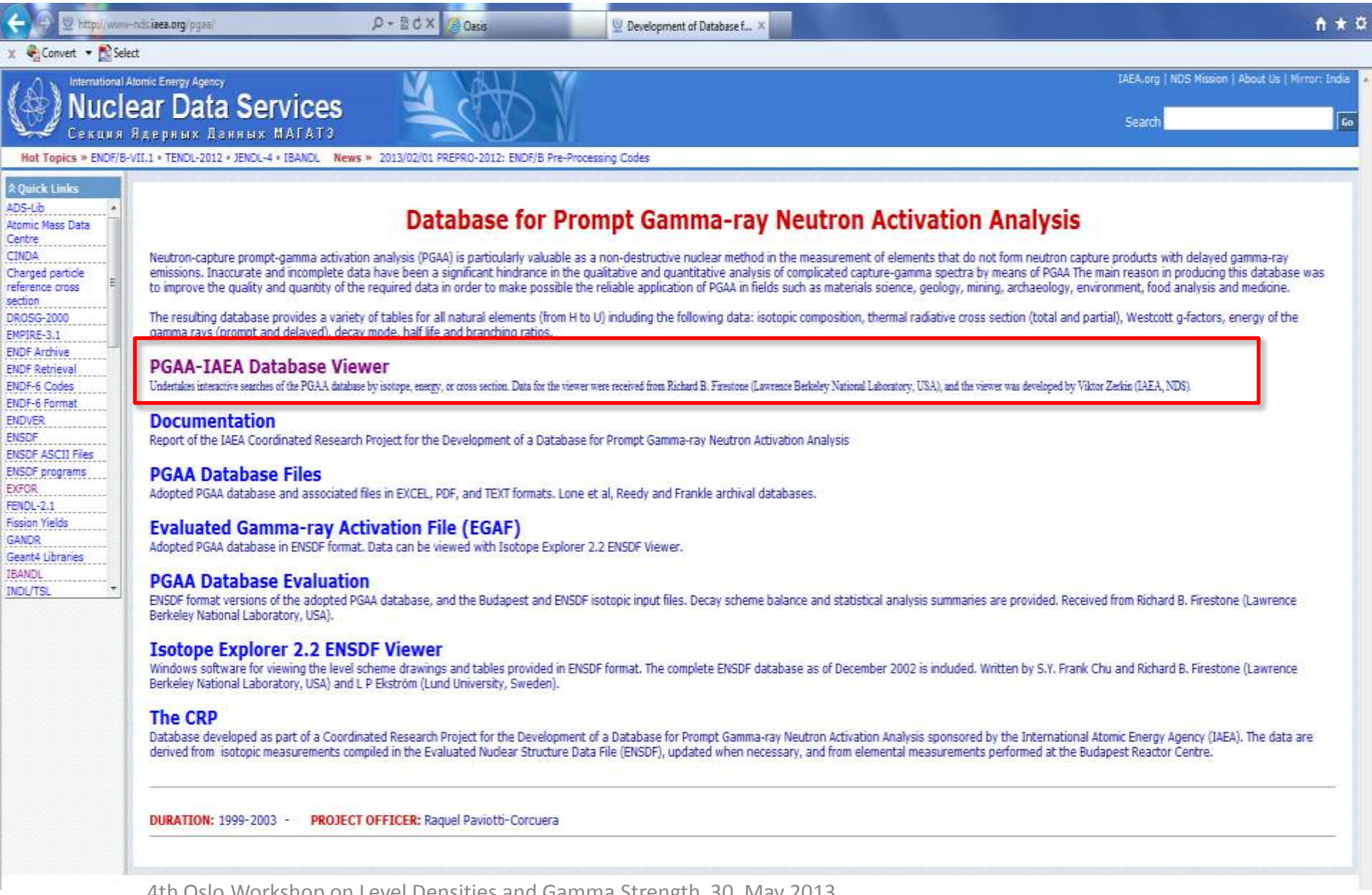
IAEA Photonuclear Data Library

$\gamma + {}^{208}\mathbf{Pb}$

Abundance (%)	Threshold Energies (MeV)								
	γ,n	γ,p	γ,t	γ,He-3	γ,α	γ,2n	γ,np	γ,2p	γ,3n
52.40	7.37	8.01	12.88	14.39	-0.52	14.11	14.85	15.38	22.19



www-nds.iaea.org/pgaa/



International Atomic Energy Agency

P G A A

Prompt Gamma-ray Neutron Activation Analysis

This database has been developed as part of a Coordinated Research Project for the Development of a Database for Prompt Gamma-ray Neutron Activation Analysis sponsored by the International Atomic Energy Agency (IAEA). The data are derived from the isotopic measurements compiled in the Evaluated Nuclear Structure Data File (ENSDF), updated when necessary, and from elemental measurements performed at the Budapest Reactor Center. The data were received from Richard B. Firestone (Lawrence Berkeley National Laboratory, USA). The program "Viewer" was developed by Viktor Zerkin (IAEA, NDS).

Selected Element
1-Hydrogen (2)
H-1 (1)
H-2 (1)

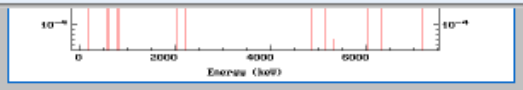
* Lanthanides
** Actinides

Database Search:
- from smaller version of database
- from full database
(see: limitations)

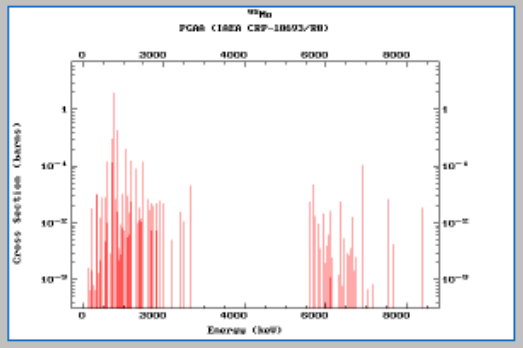
Display:
- Table of elements
- Table of elements & isotopes

Download:
- PGAA data as plain text
- Adopted Gamma Rays for Elements
- Most Intense Gamma Rays

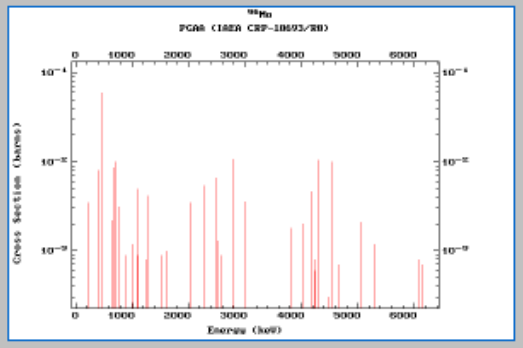
Web design: V.Zerkin, IAEA, August 2002
Last updated: 05/22/2012 12:24:13



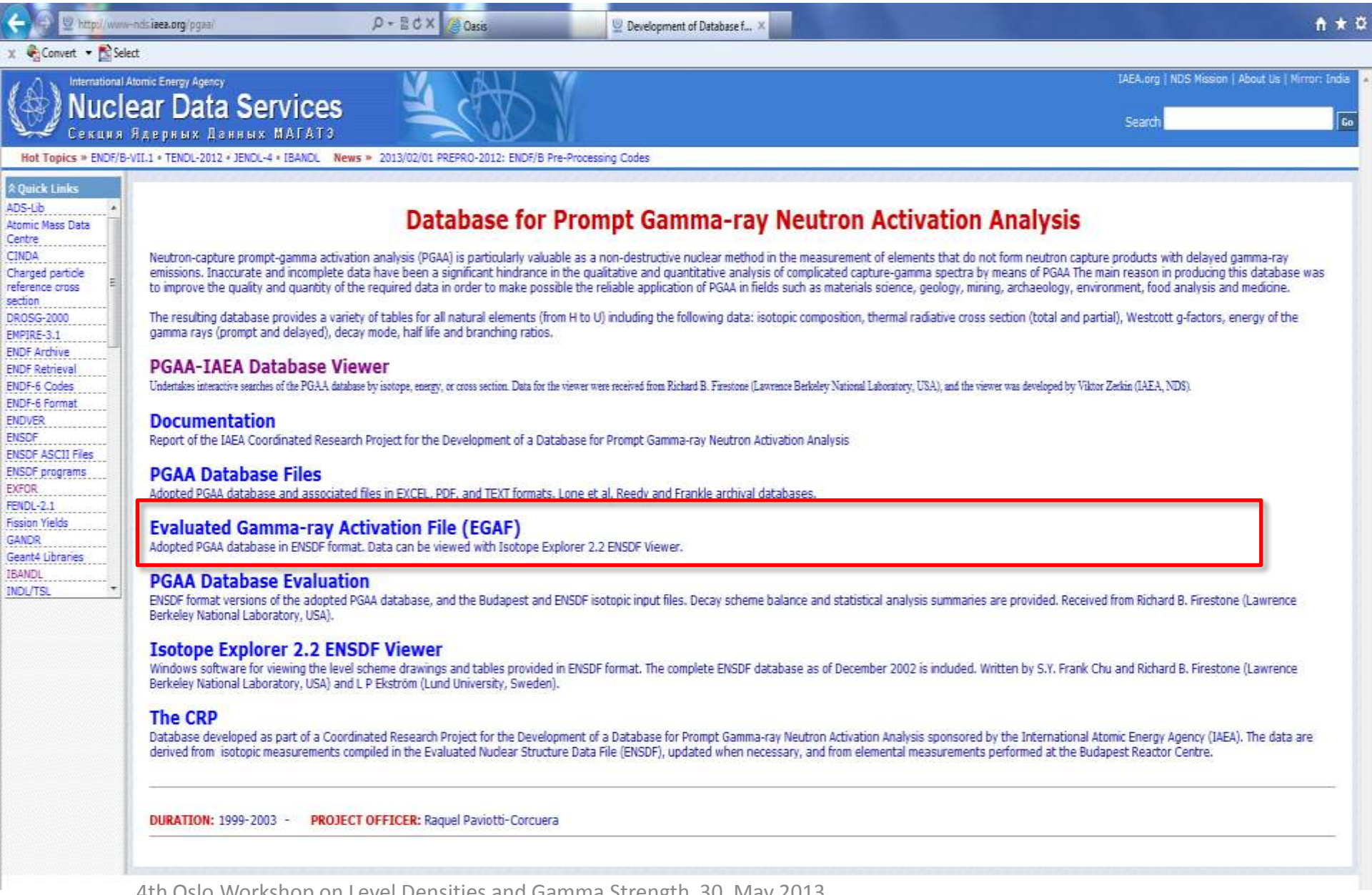
Mo-95



Mo-96



www-nds.iaea.org/pgaa/



http://www-nds.iaea.org/pgaa/EGAF/97RU_EGAF.ens

Oasis

iaea.org

Convert Select

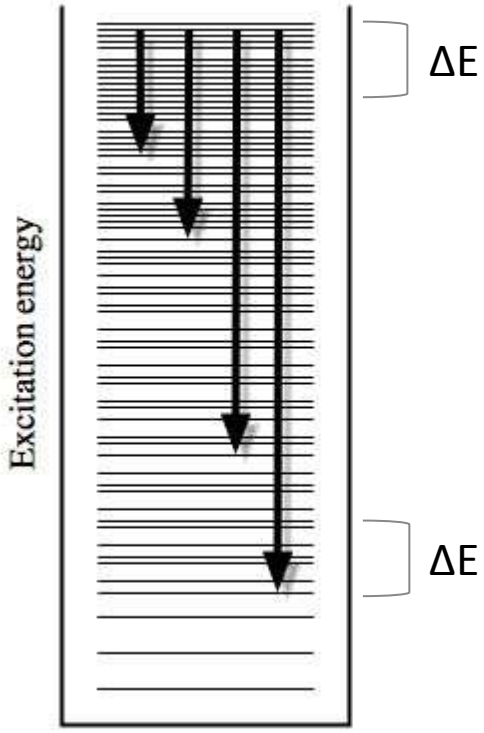
```
97RU    96RU(N,G) E=THERMAL: {~EGAF}
97RU c  Evaluated Gamma-ray Activation File (EGAF).
97RU2c  Evaluated by R.B. Firestone (LBNL), December 2003.
97RU c  BR$|s{-0}=0.29 2 (1981MuZQ)
97RU cG RI$Elemental |s(|g) assuming %Abundance=5.54 14
97RU  N 18.1      5
97RU PN                                                          C
97RU2PN Thermal cross section in barns.
97RU cN NR$Isotopic |s(|g)=NR*RI.
97RU2cN Divide by |s{-0} for intensity per neutron capture.
97RU  L 0           5/2+
97RU  L 189.24     43/2+
97RU  G 189.24     4 0.0099 11
97RU  L 527.48    21 3/2+
97RU  G 527.48    21 0.0045 12
97RU  L 8112       3 1/2+

97RU    96RU(N,G) E=THERMAL:^BUDAPEST
97RU c  Budapest Reactor data measured with thermal beam.
97RU cG RI$Elemental |s(|g) assuming %Abundance=5.54 14
97RU  N 18.1      2
97RU PN                                                          C
97RU2PN Thermal cross section in barns.
97RU  L 0           5/2+
97RU  L 189.2       3/2+
97RU  G 189.24     4 0.0099 11
97RU CG E$ALSO PLACED IN 102RU
97RU  L 527.8       3/2+
97RU  G 527.48    21 0.0045 12
97RU  L 8112       3 1/2+
```

IAEA Coordinated Research Projects

- An important IAEA mechanism for organizing international research work to achieve specific research objectives
- Bring together researchers in both developing and developed countries to address a problem of common interest
- CRPs are initiated upon advice and suggestions of expert scientists “consultants” who participate in a Consultant’s Meeting
- A proposal is formed and submitted for approval to the IAEA Committee for Coordinated Research Activities (CCRA)
- Following approval there is a call for submission of research proposals by interested researchers
- **3 Research Coordination Meetings are held to define objectives, outputs & methodology, outline actions to be taken, monitor progress and prepare final report (TEC DOC)**
- Duration is normally 3 to 5 years
- Results are available in online databases or on CDs

Continuum γ-ray data

- statistical properties of nuclei: γ-ray strength functions, level densities
- are directly related to partial decay widths and reduced transition probabilities
- are used to describe de-excitation of nucleus in the continuum
- are input data to statistical model calculations of nuclear reaction cross sections



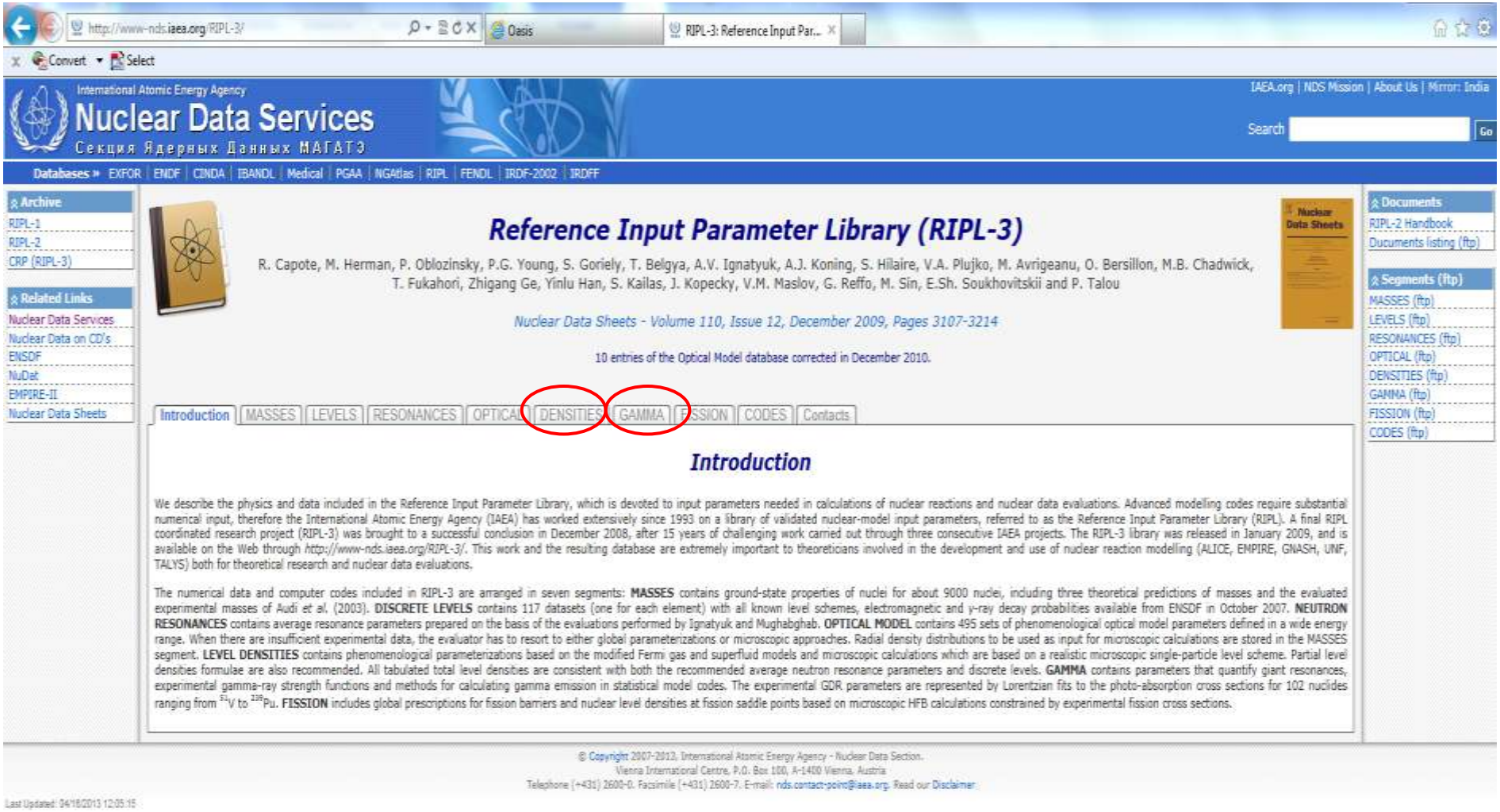
Applications

- Reactor and ADS technologies
  - actinide build-up (neutron-induced cross sections)
  - criticality safety (delayed neutrons)
  - monitoring of reactors (beta-decay/antineutrino spectra)

- Medical applications, materials analysis

- Nuclear astrophysics (heavy-element nucleosynthesis)

Reference Input Parameter Library (RIPL) : model calculations of γ-ray strength functions + level densities (http://www-nds.iaea.org/ripl3/



Level Densities Segment

Total Level Densities

Back-Shifted Fermi Gas Model (BSFG)

Level density parameters for the BSFG model obtained by fitting the Fermi-gas model formula to the recommended spacings of s-wave neutron resonances and to the cumulative number of low-lying levels.

Data File (34.3kB) README File (2.2kB)

Gilbert-Cameron Model

Level density parameters for the Gilbert-Cameron model obtained by fitting the Fermi-gas model formula to the recommended spacings of s-wave neutron resonances and by matching the corresponding level density to discrete levels.

Data File (42.8kB) README File (2.4kB)

Enhanced Generalized Superfluid Model (EGSM)

Level density parameters for the Enhanced Generalized Superfluid Model (EGSM), which takes into account collective enhancement of the nuclear level density in addition to shell and superfluid effects. The parameters were obtained by fitting the corresponding model formulas to the recommended spacings of s-wave neutron resonances and by matching level densities to discrete levels.

Data File (26.1kB) README File (2.4kB)

Z Systematics:
Data File (1.3kB) README File (1.3kB)

Retrieval of Total Level Density Parameters

Atomic number (Z)
Mass number (A)
(blank for all mass numbers)
retrieve reset

Plot of Total Level Density Parameters (a-parameters)

Select one of below and input no.:
Atomic number (Z)
Mass number (A)
Neutron number (N)
X-axis: A
plot reset

Plot of Total Level Densities

Atomic number (Z)
Mass number (A)
plot reset

HFB Total Level Densities

The files contains the HFB plus combinatorial nuclear level densities at ground state deformations[1]. The nuclear level density is coherently obtained on the basis of the single-particle level scheme and pairing energy derived at the saddle point deformation or shape isomer deformation. The same BSk14 Skyrme force[2] is used to estimate the fission saddle and isomeric points.

References:
[1] S. Goriely, S. Hilaire, A.J. Koning, Phys. Rev. C (2008) in press
[2] S. Goriely, M. Samyn, J.M. Pearson, Phys. Rev. C75 (2007) 064312

Data Files (total 486.6MB) README File (3.1kB)

Retrieval of HFB Total Level Densities

Atomic number (Z)
Mass number (A)
retrieve reset

Shell Correction prescriptions

Shell corrections calculated with the **Myers-Swiatecki** mass formula[1].

References:
[1] W.D. Myers and W.J. Swiatecki, Ark. Fizik. 36, 343 (1967).

Data File (280kB) README File (2.1kB)

Retrieval of Level Densities Data and Shell Corrections

Atomic number (Z)
Mass number (A)

Reference Input Parameter Library (RIPL-3)

R. Capote, M. Herman, P. Oblozinsky, P.G. Young, S. Goriely, T. Belgya, A.V. Ignatyuk, A.J. Koning, S. Hilaire, V.A. Plujko, M. Avrigeanu, O. Bersillon, M.B. Chadwick, T. Fukahori, Zhigang Ge, Yinlu Han, S. Kailas, J. Kopecky, V.M. Maslov, G. Reffo, M. Sin, E.Sh. Soukhovitskii and P. Talou

Nuclear Data Sheets - Volume 110, Issue 12, December 2009, Pages 3107-3214

10 entries of the Optical Model database corrected in December 2010.

Gamma-ray Segment

Experimental Giant Dipole Resonance (GDR) Parameters

The values and errors of giant dipole resonance (GDR) parameters are presented which were obtained by a fit of the theoretical photoabsorption cross sections to the experimental data for 121 nuclides from 12-C through 239-Pu. The values and errors of the shape parameters of the Lorentzian-like curves corresponding to the giant dipole resonance excitation are presented.[1-8]

References

[1] J. Kopecky, in Handbook for calculations of nuclear reaction data. Reference Input Parameter Library (RIPL), IAEA-TEDOC-1034, 1998, Ch.6
[2] T. Belgya, O. Bersillon, R. Capote, T. Fukahori, G. Zhigang, S. Goriely, M. Herman, A.V. Ignatyuk, S. Kailas. A. Koning, P. Oblozinsky, V. Plujko, P. Young. Handbook for calculations of nuclear reaction data: Reference Input Parameter Library-2, IAEA-TECDOC-1506, Vienna, 2006, Ch.7.
[3] V.A. Plujko, I.M. Kadenko, E.V. Kulich, S. Goriely, O.I. Davidovskaya, O.M. Gorbachenko, in Proceeding of Workshop on Photon Strength Functions and Related Topics, Prague, Czech Republic, June 17-20, 2007, Proceedings of Science, PSF07, 2008
[4] S.S.Dietrich, B.L.Berman; At. Data Nucl. Data Tables., 199, 38(1988).
[5] M.B. Chadwick, P. Oblozinsky, P.E. Hodgson, G. Reffo. Phys.Rev. C44(1991)814.
[6] M.B.Chadwick, P.Oblozinsky, A.I.Blokhin, T.Fukahori, Y.Han, Y. O.Lee, M.N.Martins, S.F.Mughabghab, V.V.Varlamov, B.Yu, J.Zhang. Handbook on photonuclear data for application. Cross sections and spectra. IAEA TECDOC 1178, Vienna, 2000
[7] Experimental Nuclear Reaction Data Library EXFOR
[8] CERN Program Library, MINUIT (D506), Function Minimization and Error Analysis

README File (16kB)
Standard Lorentzian model (SLO) (22,3kB) Modified Lorentzian model (MLO) (22,0kB)

Retrieval of GDR Parameters

Atomic number (Z)
Mass number (A)
(blank for all mass numbers)
retrieve reset

Theoretical GDR Parameters

Predictions of the GDR energies and widths using Goldhaber-Teller model for about 6000 nuclei with 14<=Z<=110 lying between the proton and the neutron driplines.

Data File (281kB) README File (3.5kB)

Microscopic E1 Photoabsorption Strength-Functions

Predictions of the E1-strength functions for 3317 nuclei with 8<=Z<=84 lying between the proton and the neutron driplines. The E1-strength functions are determined within the QRPA model based on the SLy4 Skyrme force[1,2].

References

[1] S. Goriely, E. Khan, Nucl. Phys. A706, 217 (2002).
[2] E. Khan et al., Nucl. Phys. A694 (2001) 103.

README File (2.0kB)

Retrieval of Microscopic E1 Photoabsorption Strength-Functions

Atomic number (Z)
Mass number (A)
retrieve reset

γ-ray strength data

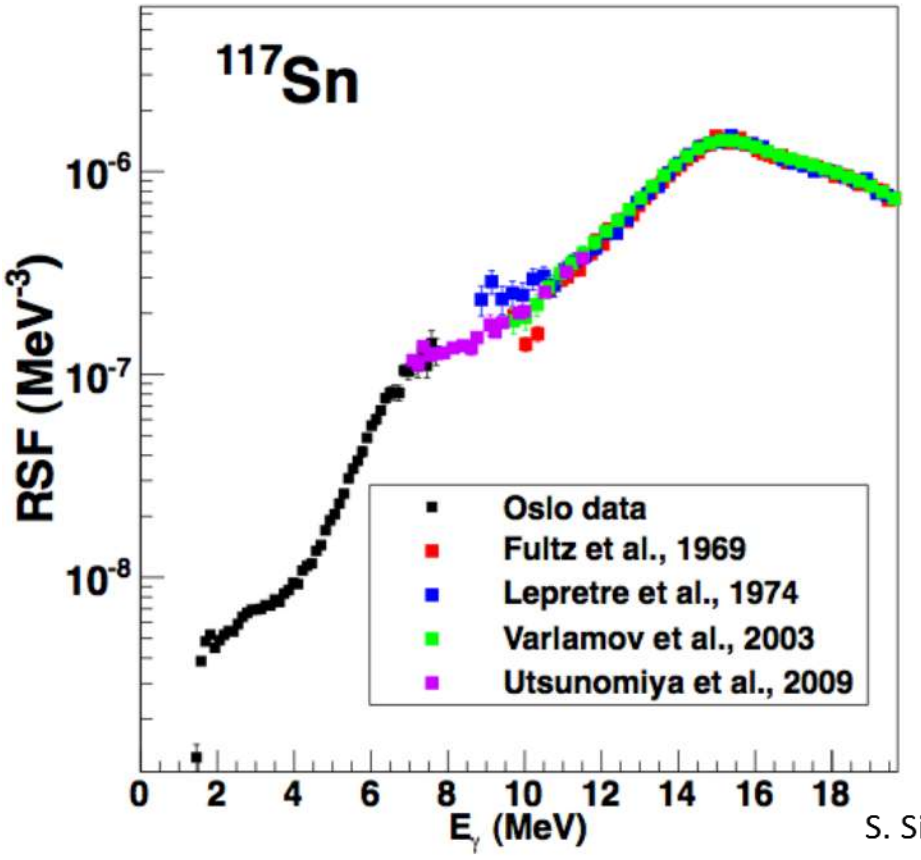
- Photonuclear reactions
- Primary gamma transitions from neutron capture
- Nuclear resonance fluorescence (γ, γ'), electron scattering, proton scattering
- Two-step & multi-step γ cascades following neutron capture
- Scattering with polarized beams
- Particle-γ coincidence measurements

Lots of data have been measured over the past decades BUT

there is no database where they are all compiled and evaluated

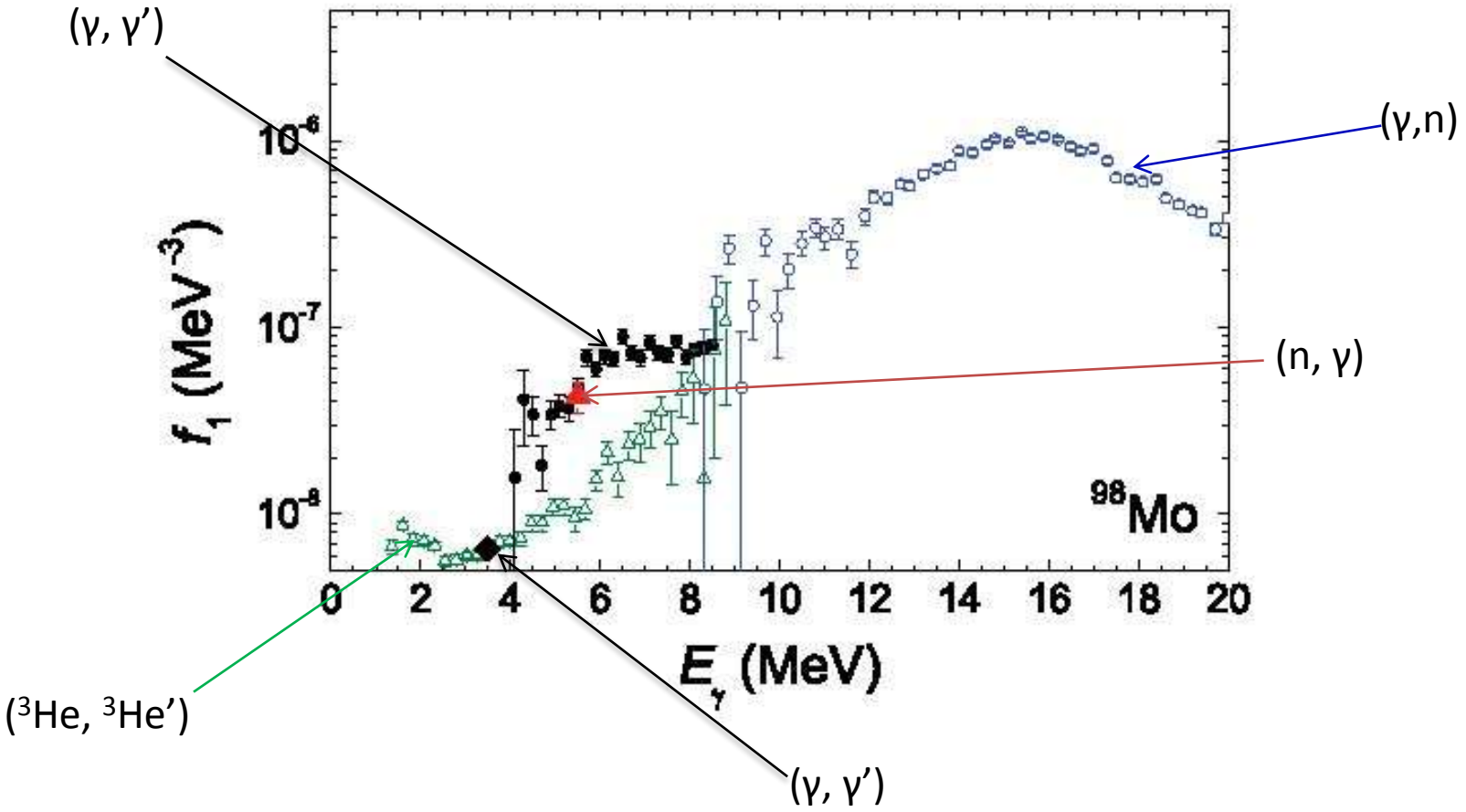
Different approaches

probing different energy regions above or below B_n : data should match smoothly



S. Siem, 20th NSDD Meeting, Kuwait, 27-31 Jan 2013

Complementarity of different measurements



Database…dedicated to continuum γ-ray data

Compilation of all existing data

easily accessible
user-friendly retrieval system
on-the-fly plotter-viewer

Evaluation of available data

Assessment of data and uncertainties
Resolve discrepancies between different types of measurements
Ensure continuity-consistency of different types of data
Provide recommended data for applications → RIPL

Priority list for new measurements

How to proceed…

an initiative of S. Siem and R. Firestone

- Consultant's Meeting to be held at IAEA

  meeting of experts (experiment, theory, evaluation) to:

  - define problem – data needs
  - set objectives
  - outline methodology
  - propose best way to achieve goals: coordinated effort

- Coordinated effort

  - IAEA Coordinated Research Project or
  - IAEA Data Development Project

- The outcome of the CM would be of importance for a future RIPL-4 effort