



**The Abdus Salam  
International Centre for Theoretical Physics**



**1944-25**

**Joint ICTP-IAEA Workshop on Nuclear Reaction Data for Advanced  
Reactor Technologies**

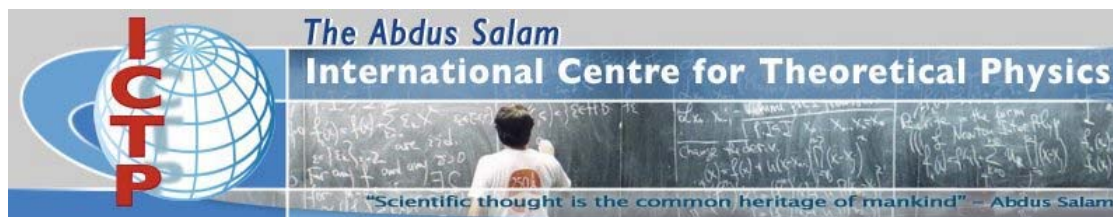
*19 - 30 May 2008*

**Nuclear Data Libraries: Where? How?**

MENGONI Alberto  
*ENEA  
Applied Physics Section  
V. Don Fiammelli, 2  
40128 Bologna  
ITALY*



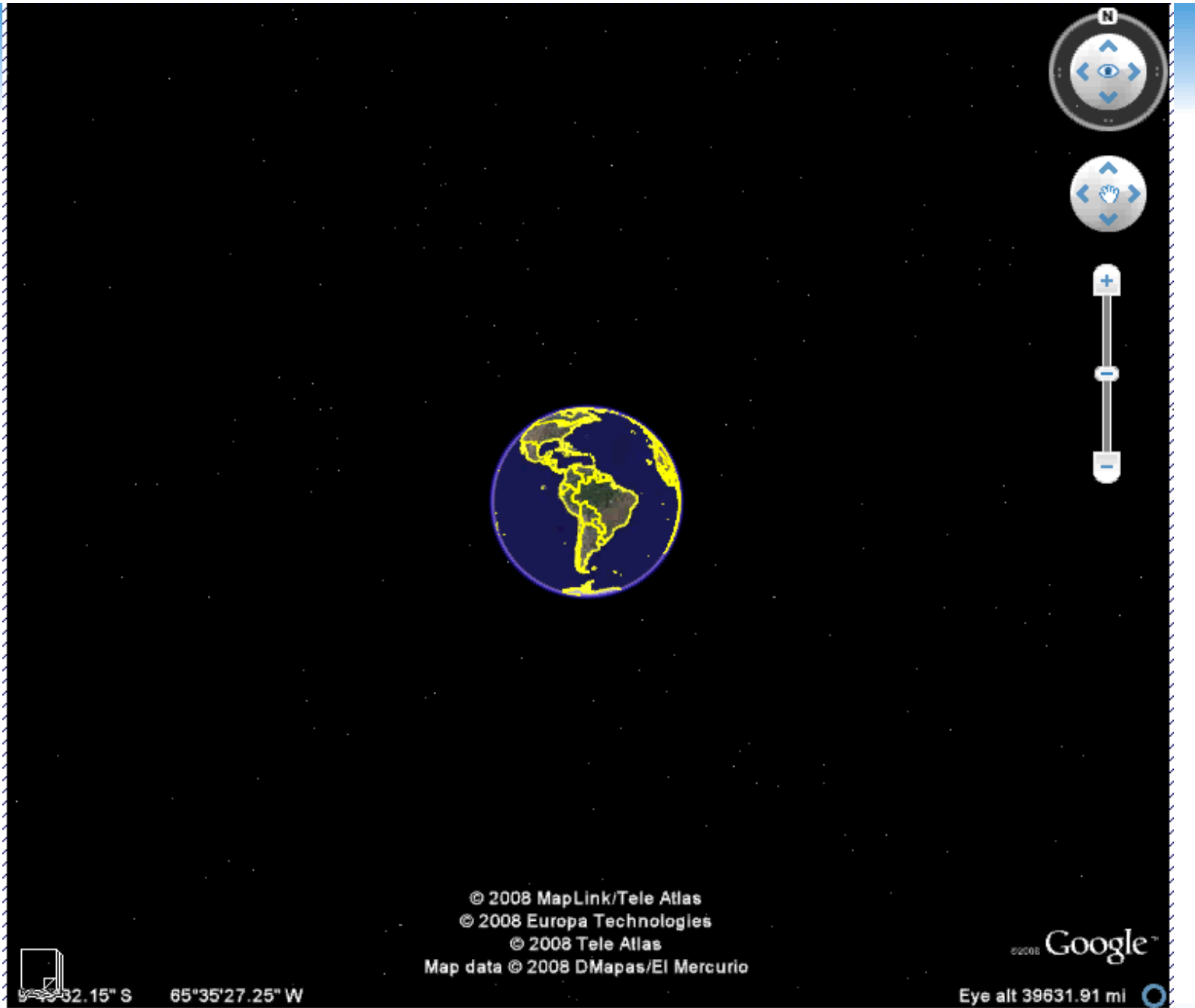
**International Atomic Energy Agency**

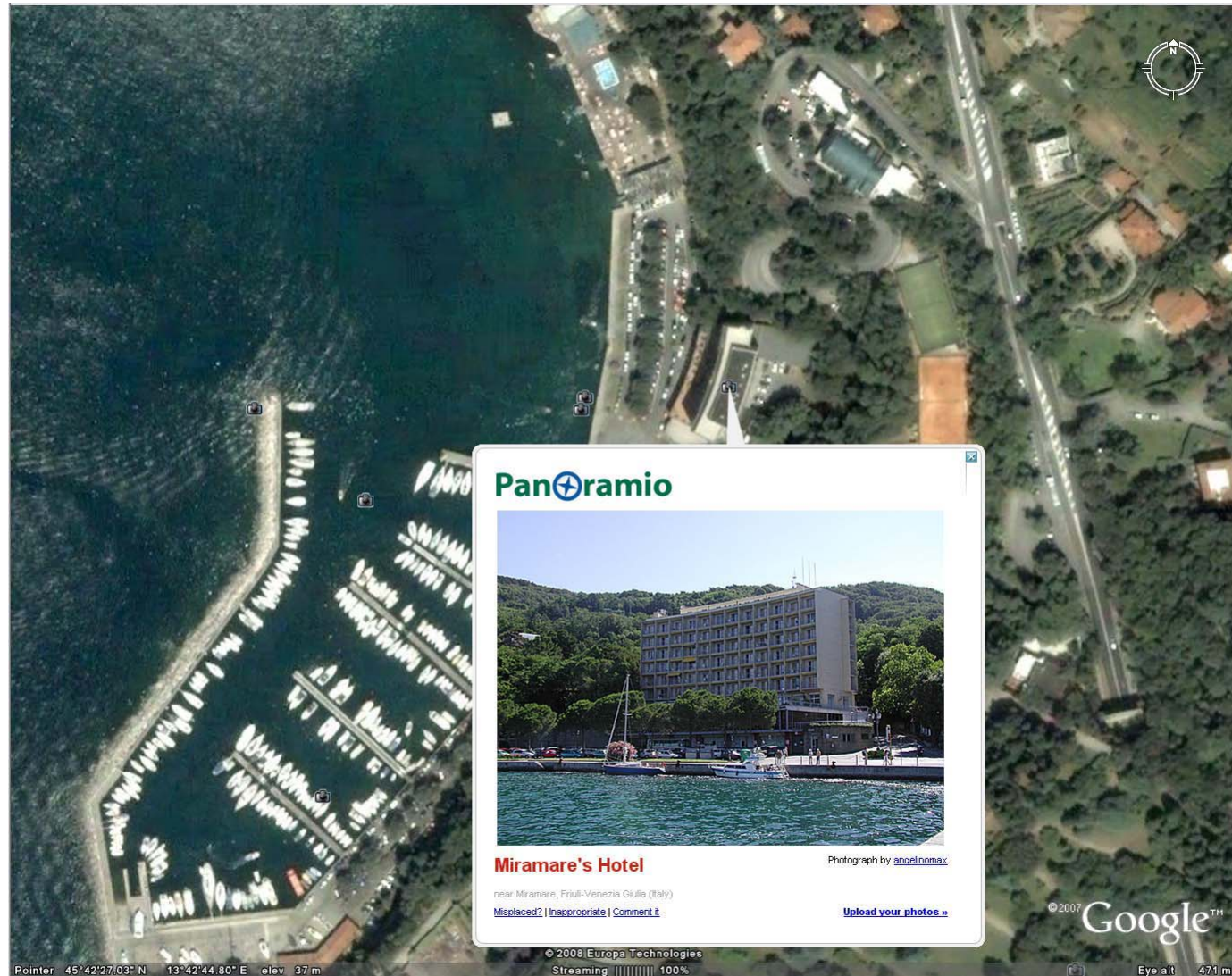


**Joint IAEA-ICTP Workshop on  
Nuclear Reaction Data  
for Advanced Reactor Technologies**

**Welcome!**

Alberto Mengoni  
IAEA, Vienna





# Joint IAEA-ICTP Workshop on Nuclear Reaction Data for Advanced Reactor Technologies

Yahoo! Meteo - Trieste

°C °F





Meteo > Italia > Trieste

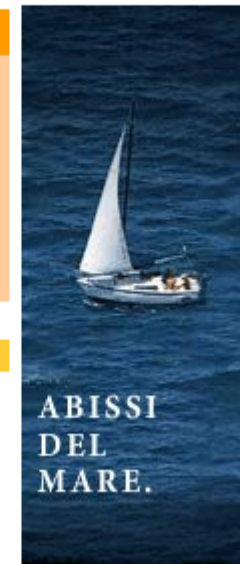
**Oggi**

|                                |  |                    |
|--------------------------------|--|--------------------|
| <b>17°</b><br>5:55 CEST<br>lun | <br>Parzialmente nuvoloso | <b>Massime 20°</b> |
|                                |  | <b>Minime 16°</b>  |

<-10 -10 -5 0 5 10 15 20 25 30 35+

|                         |             |
|-------------------------|-------------|
| Umidità:                | 100%        |
| Vento:                  | Nord/0 km/h |
| Visibilità:             | 9.99 km     |
| Punto di condensazione: | 17°         |
| Barometro:              | Sconosciuto |
| Alba:                   | 5:29        |
| Tramonto:               | 20:34       |

| mar  | mer  | gio  | ven  |
|--|--|--|--|
|  |  |  |  |
| Pioggia<br>Massime 17<br>Minime 15   | Aquazzoni<br>Massime 20<br>Minime 15   | Aquazzoni<br>Massime 21<br>Minime 15   | Aquazzoni<br>Massime 22<br>Minime 16   |



# Rationale for a Workshop on Nuclear Reaction Data for Advanced Reactor Technologies

Both the development and maintenance of nuclear technologies rely on the availability of atomic, molecular and nuclear data to provide accurate numerical representations of the underlying physical processes.

Essential data include energy-dependent reaction probabilities (cross sections), the energy and angular distributions of reaction products for many combinations of target and projectile, and the atomic and nuclear properties of excited states, and their radioactive decay data.

source: IAEA, Division of Physical & Chemical Sciences website



# **Nuclear Reaction Data for Advanced Reactor Technologies**

## **Topics**

- **facilities and instrumentation for nuclear reaction data measurements**
- **experimental techniques for measurements of nuclear reaction data**
- **modern theoretical nuclear structure and reaction models**
- **evaluation of nuclear data and creation of evaluated nuclear reaction data libraries**
- **simulation tools for design studies of advanced nuclear systems**
- **overview of strategies for advanced nuclear technologies**



Joint IAEA-ICTP Workshop on

# Nuclear Reaction Data

## for Advanced Reactor Technologies

14

mathematics

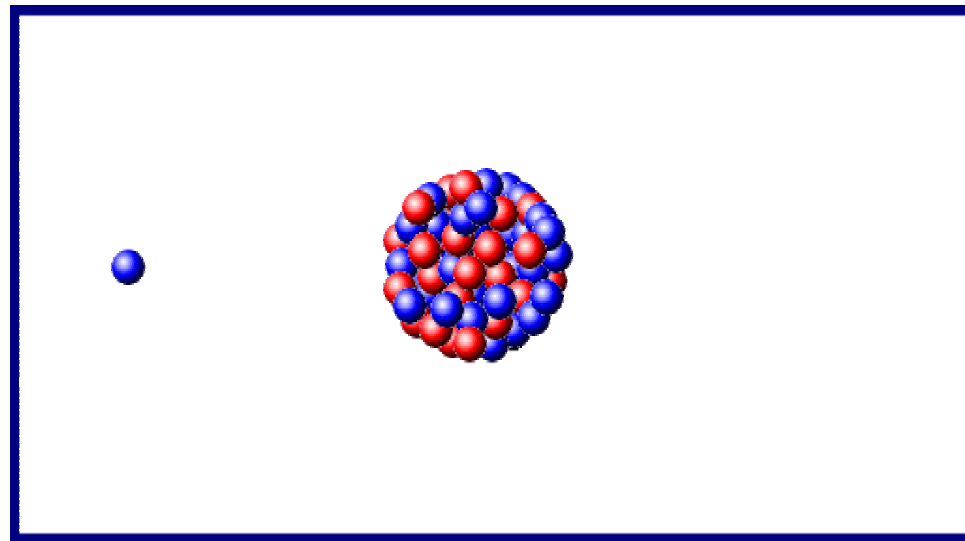
14 MeV

nuclear physics



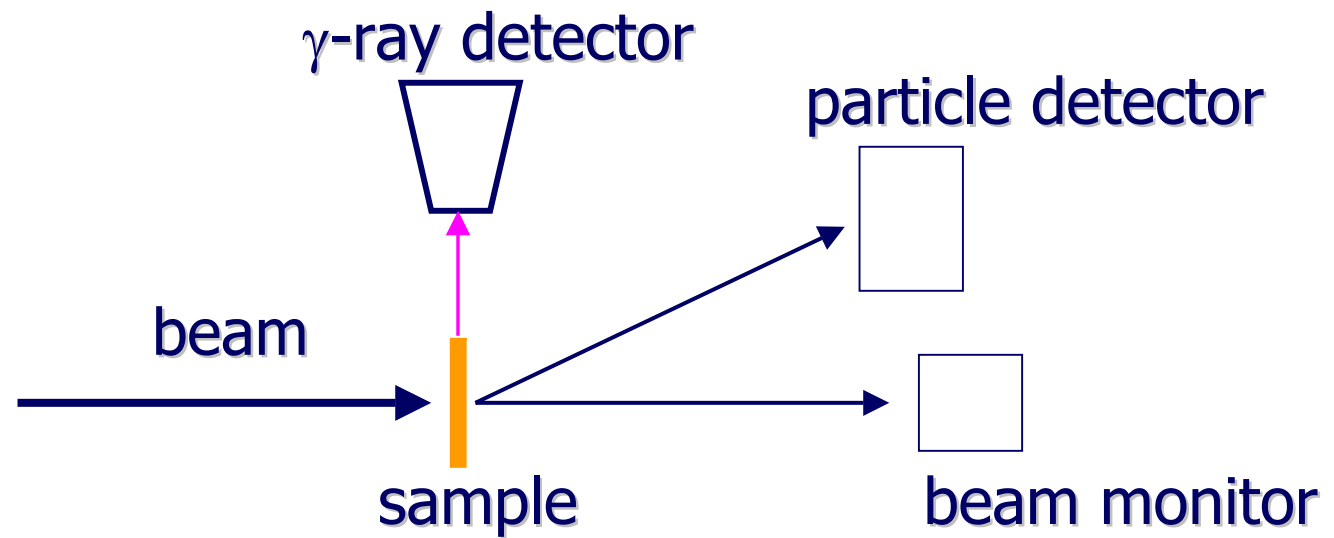


# Nuclear Reactions

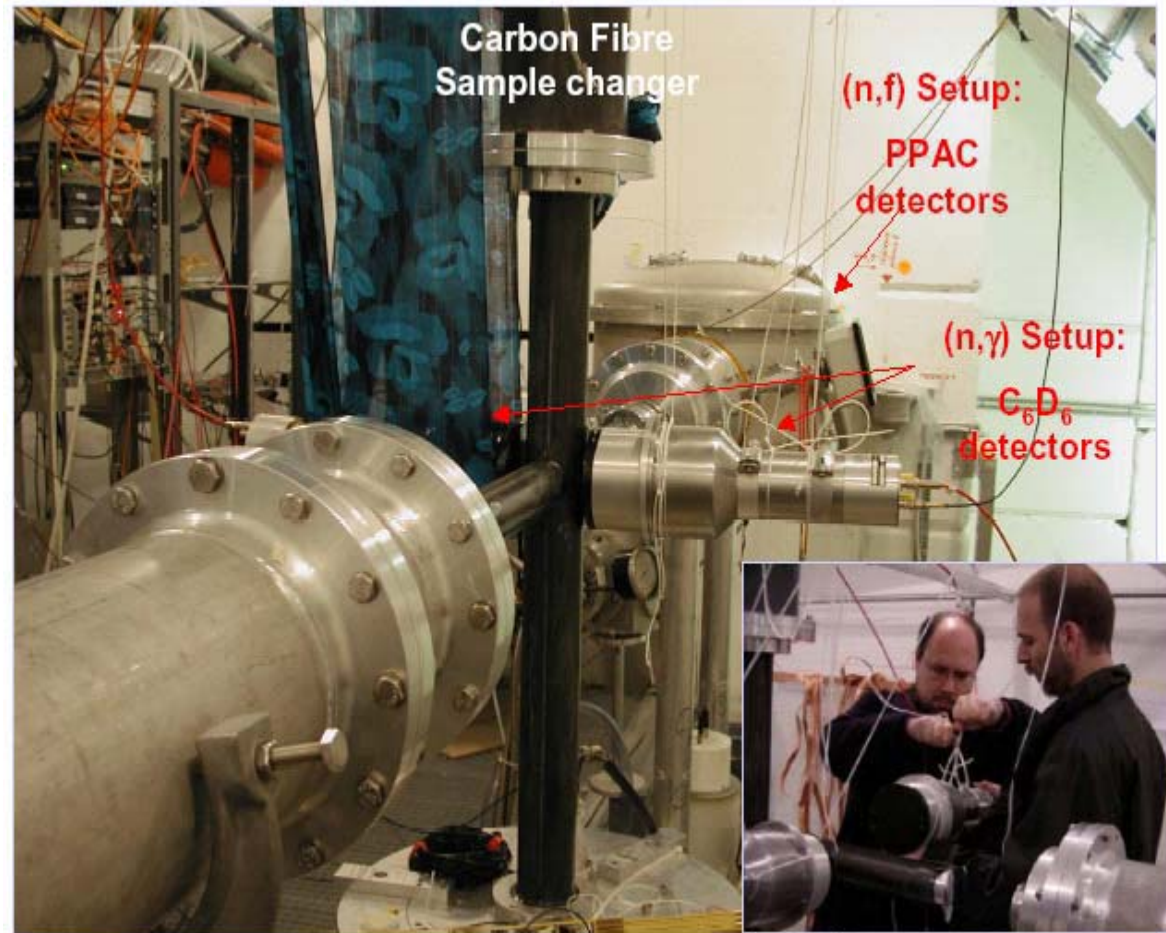


source: the Internet

# Nuclear Reaction

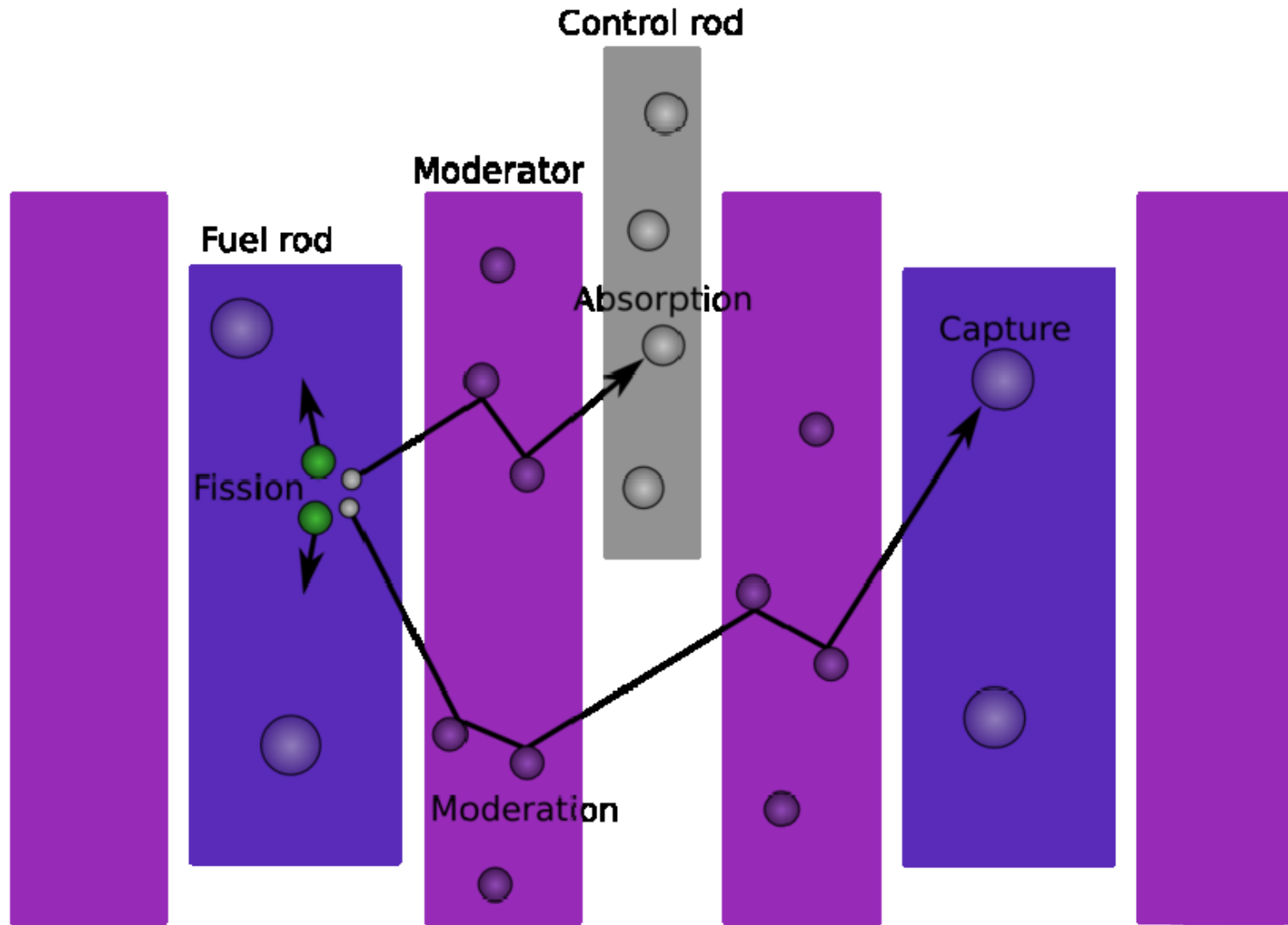


# Nuclear Reactions: Measurement



source: The n\_TOF Collaboration

# Nuclear Reactions in Reactors



source: wikipedia.org

a.mengoni@iaea.org

International Atomic Energy Agency



# Nuclear reactions in Reactors

|                                    |                   |                  |                                     |                                     |                    |                   |                                     |                   |                                    |
|------------------------------------|-------------------|------------------|-------------------------------------|-------------------------------------|--------------------|-------------------|-------------------------------------|-------------------|------------------------------------|
|                                    | Cm 238<br>2,4 h   | Cm 239<br>3 h    | Cm 240<br>27 d                      | Cm 241<br>32,8 d                    | Cm 242<br>162,94 d | Cm 243<br>29,1 a  | Cm 244<br>18,10 a                   | Cm 245<br>8500 a  | Cm 246<br>4730 a                   |
| Am 236 ?<br>3,7 m                  | Am 237<br>73,0 m  | Am 238<br>1,63 h | Am 239<br>11,9 h                    | Am 240<br>50,8 h                    | Am 241<br>432,2 a  | Am 242<br>141 a   | Am 243<br>7370 a                    | Am 244<br>26 m    | Am 245<br>2,05 h                   |
| Pu 235<br>25,3 m                   | Pu 236<br>2,858 a | Pu 237<br>45,2 d | Pu 238<br>87,74 a                   | Pu 239<br>2,411 · 10 <sup>4</sup> a | Pu 240<br>6563 a   | Pu 241<br>14,35 a | Pu 242<br>3,750 · 10 <sup>5</sup> a | Pu 243<br>4,956 h | Pu 244<br>6,00 · 10 <sup>7</sup> a |
| Np 234<br>4,4 d                    | Np 235<br>396,1 d | Np 236<br>22,5 h | Np 237<br>2,144 · 10 <sup>6</sup> a | Np 238<br>2,117 d                   | Np 239<br>2,355 d  | Np 240<br>722 m   | Np 241<br>13,9 m                    | Np 242<br>2,2 m   | Np 243<br>1,85 m                   |
| U 233<br>1,592 · 10 <sup>5</sup> a | U 234<br>0,0055   | U 235<br>0,7200  | U 236<br>2,342 · 10 <sup>7</sup> a  | U 237<br>6,75 d                     | U 238<br>99,2745   | U 239<br>23,5 m   | U 240<br>14,1 h                     |                   | U 242<br>16,8 m                    |
| Pa 232<br>1,31 d                   | Pa 233<br>27,0 d  | Pa 234<br>1,17 m | Pa 235<br>24,2 m                    | Pa 236<br>9,1 m                     | Pa 237<br>8,7 m    | Pa 238<br>2,3 m   |                                     | 148               | 150                                |
| Th 231<br>25,5 h                   | Th 232<br>100     | Th 233<br>22,3 m | Th 234<br>24,10 d                   | Th 235<br>7,1 m                     | Th 236<br>37,5 m   | Th 237<br>5,0 m   |                                     |                   |                                    |

LLFP



# Th/U fuel cycle

|   |                          |  |  |  |                           |                              |  |                              |   |  |
|---|--------------------------|--|--|--|---------------------------|------------------------------|--|------------------------------|---|--|
|   | <b>Cm 238</b><br>2,4 h   | <b>Cm 239</b><br>3 h                             | <b>Cm 240</b><br>27 d                            | <b>Cm 241</b><br>32,8 d                    | <b>Cm 242</b><br>162,94 d | <b>Cm 243</b><br>29,1 a      | <b>Cm 244</b><br>18,10 a                   | <b>Cm 245</b><br>8500 a      | <b>Cm 246</b><br>4730 a                   |  |
| <b>Am 236 ?</b><br>3,7 m                  | <b>Am 237</b><br>73,0 m  | <b>Am 238</b><br>1,63 h                          | <b>Am 239</b><br>11,9 h                          | <b>Am 240</b><br>50,8 h                    | <b>Am 241</b><br>432,2 a  | <b>Am 242</b><br>141 a 16 h  | <b>Am 243</b><br>7370 a                    | <b>Am 244</b><br>26 m 10,1 h | <b>Am 245</b><br>2,05 h                   |  |
| <b>Pu 235</b><br>25,3 m                   | <b>Pu 236</b><br>2,858 a | <b>Pu 237</b><br>45,2 d                          | <b>Pu 238</b><br>87,74 a                         | <b>Pu 239</b><br>2,411 · 10 <sup>4</sup> a | <b>Pu 240</b><br>6563 a   | <b>Pu 241</b><br>14,35 a     | <b>Pu 242</b><br>3,750 · 10 <sup>5</sup> a | <b>Pu 243</b><br>4,956 h     | <b>Pu 244</b><br>6,00 · 10 <sup>7</sup> a |  |
| <b>Np 234</b><br>4,4 d                    | <b>Np 235</b><br>396,1 d | <b>Np 236</b><br>22,5 h 1,54 · 10 <sup>3</sup> a | <b>Np 237</b><br>2,144 · 10 <sup>6</sup> a       | <b>Np 238</b><br>2,117 d                   | <b>Np 239</b><br>2,355 d  | <b>Np 240</b><br>7,22 m 65 m | <b>Np 241</b><br>13,9 m                    | <b>Np 242</b><br>2,2 m 3,5 m | <b>Np 243</b><br>1,85 m                   |  |
| <b>U 233</b><br>1,592 · 10 <sup>5</sup> a | <b>U 234</b><br>0,0055   | <b>U 235</b><br>0,7200                           | <b>U 236</b><br>120 ns 2,342 · 10 <sup>7</sup> a | <b>U 237</b><br>6,75 d                     | <b>U 238</b><br>99,2745   | <b>U 239</b><br>23,5 m       | <b>U 240</b><br>14,1 h                     |                              | <b>U 242</b><br>16,8 m                    |  |
| <b>Pa 232</b><br>1,31 d                   | <b>Pa 233</b><br>27,0 d  | <b>Pa 234</b><br>1,17 m 6,70 h                   | <b>Pa 235</b><br>24,2 m                          | <b>Pa 236</b><br>9,1 m                     | <b>Pa 237</b><br>8,7 m    | <b>Pa 238</b><br>2,3 m       | 148  |                              | 150                                       |  |
| <b>Th 231</b><br>25,5 h                   | <b>Th 232</b><br>100     | <b>Th 233</b><br>22,3 m                          | <b>Th 234</b><br>24,10 d                         | <b>Th 235</b><br>7,1 m                     | <b>Th 236</b><br>37,5 m   | <b>Th 237</b><br>5,0 m       |  |                              |   |  |



# Nucleosynthesis: the s-process

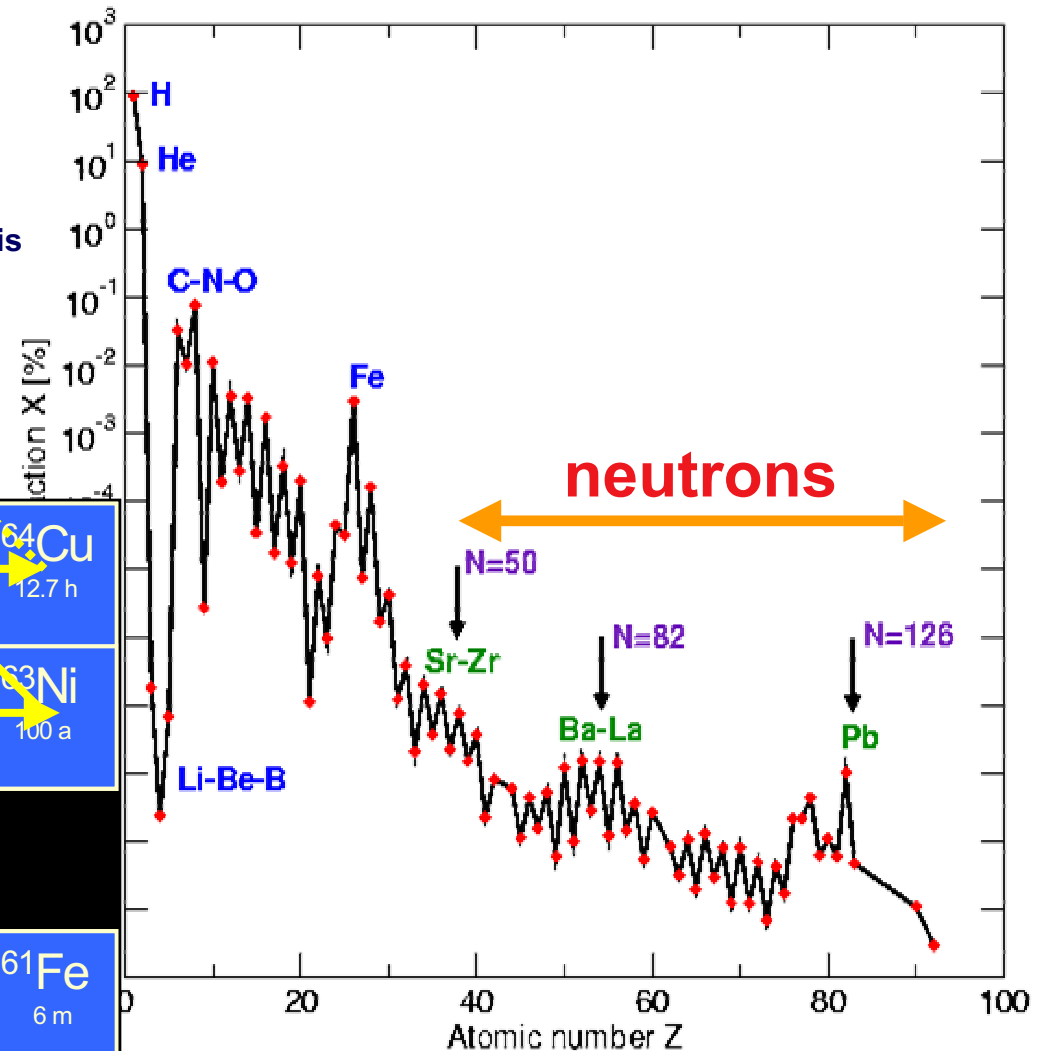
- 1/2 of the elements above Fe are produced by the s-process
- The astrophysical sites of the s-process are:
  - He burning in intermediate/massive stars
  - Low-mass AGB's
- There exists a direct correlation between the neutron capture cross section and the abundance ( $\sigma(n,\gamma) \cdot N = const.$ )
- The neutron capture cross sections are key ingredients for s-process nucleosynthesis

Solar system elemental abundances

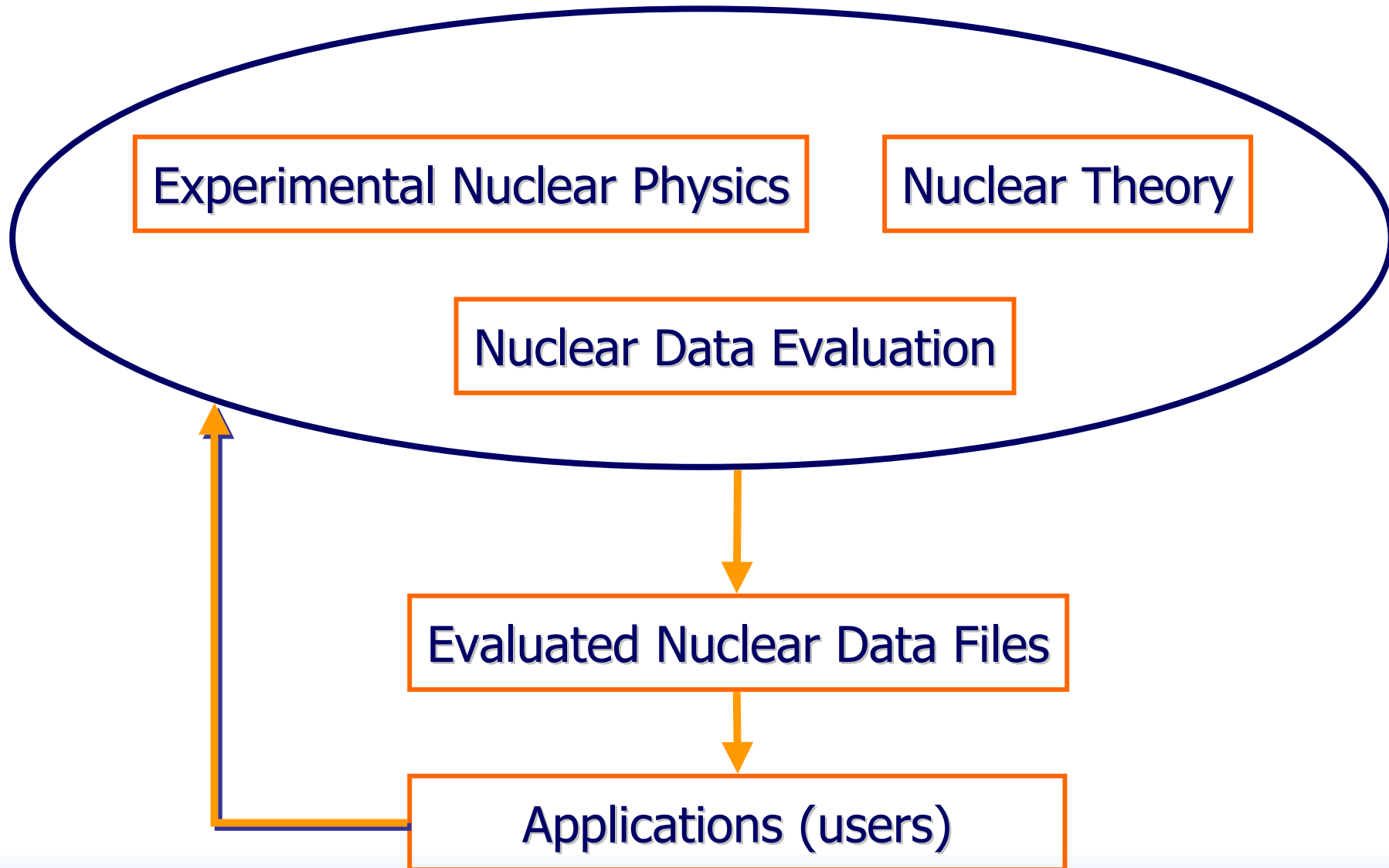
## The canonical s-process

|    |                 |               |                 |                  |                               |             |
|----|-----------------|---------------|-----------------|------------------|-------------------------------|-------------|
| Cu |                 |               | 62Cu<br>9.74 m  | 63Cu<br>69.7     | 64Cu<br>12.7 h                |             |
| Ni |                 | 60Ni<br>26.23 | 61Ni<br>1.140   | 62Ni<br>3.634    | 63Ni<br>100 a                 |             |
| Co | 58Co<br>70.86 d | 59Co<br>1     | 60Co<br>5.272 a | 61Co<br>1.65 h   |                               |             |
| Fe | 56Fe<br>91.72   | 57Fe<br>2.2   | 58Fe<br>0.28    | 59Fe<br>44.503 d | 60Fe<br>1.5 10 <sup>6</sup> a | 61Fe<br>6 m |

Yellow arrows indicate the s-process path from Fe to Cu. Red boxes highlight the unstable parent nuclei: 58Co, 59Fe, 60Co, 61Ni, and 64Cu.



# Nuclear Reactions & Nuclear Data Libraries





Joint IAEA-ICTP Workshop on

# **Nuclear Reaction Data for Advanced Reactor Technologies**

1. Nuclear Data Measurements
2. Theory/Modeling/Evaluation of Nuclear Data
3. Applications: Advanced Reactor Systems



**Q. Where to get Nuclear Data?**

**A. The Internet**

**Example:**

what is the capture cross section  
of Zr-91 at  $E_n = 30$  keV ?



# Nuclear Data Online

www-nds.iaea.org

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

File Edit View History Bookmarks Develop Window Help

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

NDS

IAEA.org  
International Atomic Energy Agency

**Welcome to the IAEA Nuclear Data Centre**  
**Nuclear Data Services**

Search NDS

**NDS Mirror Sites**  
India Brazil

**Navigation**  
Content Browser  
Quick Links  
ADS-Lib  
AMDC  
CINDA  
DROSG-2000  
ENDF  
ENSDF  
ENSDF ASCII Files  
EXFOR  
FENDL-2.1  
IBANDL  
INDL/TSL  
IRDf-2002  
Masses 2003  
Medical Radioisotopes Production  
MIRD  
Minsk Actinides  
NGATLAS  
NuDat 2.1  
NSR  
PADF Proton Activation Data File  
PGAA-IAEA  
Photonuclear  
Photon+Electron Interaction  
POINT2007  
POINT2004  
Q-values, Thresholds  
RIPL  
RNAL  
Safeguards data  
SigmaCalc  
Standards  
Stopping Power Data  
Thermal Neutron Capture Gamma Rays  
Thorium-Uranium Fuel Cycle

**Major Databases**  
CINDA - neutron reaction data bibliography  
ENDF - evaluated nuclear reaction cross section libraries  
EXFOR - experimental nuclear reaction data  
ENSDF - evaluated nuclear structure and decay data (Includes XUNDL)  
NSR - Nuclear Science References  
NuDat 2.2 - selected evaluated nuclear data

**Nuclear Databases and Files**  
**General**  
Atomic Mass Data Center - 2003 atomic mass evaluation, NUBASE, PC-NUCLEUS, etc.  
Q-values, Thresholds - atomic masses, Q-values and threshold energies  
RIPL - reference parameters for nuclear model calculations  
Thermal neutron capture gamma rays - by target and by energy  
Wallet cards - ground and metastable state properties

**Other evaluated data libraries in ENDF format**  
IAEA Photonuclear Data Library - cross sections and spectra up to 140MeV  
INDL/TSL - IAEA Evaluated Nuclear Data Library / Thermal Scattering Law  
IRDf-2002 - International Reactor Dosimetry File  
Minsk Actinides Library - evaluated neutron reaction data (Maslov et al.)  
NGATLAS - atlas of neutron capture cross sections (old-version is here)  
PADF 2007 - Proton Activation Data File  
POINT2007 - Pointwise data of ENDF/B-VII.0 processed into temperature dependent form  
POINT2004 - Pointwise data of ENDF/B-VI Release 8 at 8 temperatures  
RNAL - Reference Neutron Activation Library  
Standards - Neutron Cross-section Standards 2006  
Th-U - Evaluated nuclear data for the Thorium-Uranium fuel cycle

**Evaluated libraries in different formats**  
ADS-Lib Application test library in ACE and MATXS format for ADS neutronics design  
Charged-particle cross section database for medical radioisotope production  
FENDL-2.1 - Fusion Evaluated Nuclear Data Library, Version 2.1  
IAEA-NDS-0 - Index to IAEA NDS documentation series  
IBANDL - Ion Beam Analysis Nuclear Data Library  
MIRD - medical internal radiation dose tables  
Nuclear Data for Safeguards - recommendations, 2007  
PGAA-IAEA - database of prompt gamma rays from slow neutron capture  
Photon and Electron Interaction Data - EPDL, EADL, EEDL, EXDL and ASF  
SigmaCalc - Evaluated (recommended) differential cross sections for Ion Beam Analysis  
Stopping Power Data for Light Ions - Graphs, data, programs, compiled by H. Paul  
X and Gamma-rays standards - Decay data standards for detector calibration  
WIMSD-IAEA Library - multigroup data library for the WIMS-D code  
Various Specialized Evaluated Data Libraries in ENDF and other formats

**NDS Events**  
Meetings & Workshops  
Joint ICTP-IAEA Workshop on Nuclear Structure and Decay Data: Theory and Evaluation  
28 April - 9 May, 2008  
ICTP, Trieste, Italy  
Joint ICTP-IAEA Workshop on Nuclear Reaction Data for Advanced Reactor Technologies  
18 - 30 May, 2008  
ICTP, Trieste, Italy  
13th International Symposium on Reactor Dosimetry  
25 - 30 May, 2008  
Alkmaar, Netherlands

a.mengoni@iaea.org

# Nuclear Data Online

The screenshot shows a web browser window with the URL <http://www-nds.iaea.org/exfor/endl.htm>. The page title is "Evaluated Nuclear Data File (ENDF)" and the database version is "Database Version of March 28, 2008". A "News & History" section lists four new and updated libraries from 2008/04: 1) JENDL/AC-2008: JENDL Actinoid File 2008, 2) JENDL/AN-2005: (Alpha,n) Reaction Data File 2005, 3) JENDL/G-2005: Photoreaction Data File 2004, and 4) JENDL/HE-2004: High Energy File 2004. Below this is a "Standard Request" form with fields for Target, Reaction, and Quantity, and a "Libraries" section with radio buttons for Major Libraries (including ENDF/B-VII.0, JEFF-3.1, JENDL-3.3, BROND-2.2, and CENDL-2) and Special Libraries (Archival and Derived). There are also "Options" for sorting by Reactions or Evaluations, and buttons for "Clone Request" (EXFOR, CINDA) and "Feedback" (Comments/Questions?). A "Note" section provides search criteria details, and a footer contains contact information for the Database Manager, Web and Database Programming, and Data Source.

ENDF: Evaluated Nuclear Data File

File Edit View History Bookmarks Develop Window Help

http://www-nds.iaea.org/exfor/endl.htm

## Evaluated Nuclear Data File (ENDF)

Database Version of March 28, 2008  
Software Version of 2008.03.31 Old interface is [here]

### News & History

2008/04 New and updated libraries:

- 1) JENDL/AC-2008: JENDL Actinoid File 2008 [page]
- 2) JENDL/AN-2005: (Alpha,n) Reaction Data File 2005 [page]
- 3) JENDL/G-2005: Photoreaction Data File 2004 [page]
- 4) JENDL/HE-2004: High Energy File 2004 [page]

Core nuclear reaction database contain recommended, evaluated cross sections, spectra, angular distributions, fission product yields, photo-atomic and thermal scattering law data, with emphasis on neutron induced reactions. The data were analyzed by experienced nuclear physicists to produce recommended libraries for one of the national nuclear data projects (USA, Europe, Japan, Russia and China). All data are stored in the internationally-adopted ENDF-6 format maintained by CSEWG.

### Standard Request (example); Go to: Advanced Request

Parameters:

Target

Reaction

Quantity

[More Parameters...](#)

Libraries:  All  Selected

Major Libraries  Special Libraries

- 1) ENDF/B-VII.0 (USA,2006)  Archival
- 2) JEFF-3.1 (Europe,2005)  Derived
- 3) JENDL-3.3 (Japan,2002)
- 4) BROND-2.2 (Russia,1992)
- 5) CENDL-2 (China,1991)

Options:

Sort by:  Reactions  Evaluations

Clone Request:

Feedback:

**Note:**

- all criteria are optional (selected by checking )
- selected criteria are combined for search with logical AND
- criteria separated in a field by ";" are combined with logical OR
- wildcards and intervals are available
- pointwise libraries contain reconstructed resonances using parameters from MF=2 and applied Doppler broadening at a given temperature.

Extensive temperature dependent pointwise libraries: [Point-2004 \(ENDFB-VI.8\)](#), [Point-2007 \(ENDFB-VII.0\)](#)

Database Manager: Viktor Zerkin, NDS, International Atomic Energy Agency ([V.Zerkin@iaea.org](mailto:V.Zerkin@iaea.org))  
Web and Database Programming: Viktor Zerkin, NDS, International Atomic Energy Agency ([V.Zerkin@iaea.org](mailto:V.Zerkin@iaea.org))  
Data Source: Nuclear Energy Agency International Working Party on Evaluation Cooperation (<http://www.nea.fr/html/science/wpec/>) and Cross Section Evaluation Working Group (<http://www.nndc.bnl.gov/csewg/>)

# Nuclear Data Online

The screenshot shows a web browser window with the URL <http://www-nds.iaea.org/exfor/endl.htm>. The page title is "Evaluated Nuclear Data File (ENDF)" and the database version is "Database Version of March 28, 2008". A "News & History" section lists recent updates, including JENDL/AC-2008, JENDL/AN-2005, JENDL/G-2005, and JENDL/HE-2004. A "Standard Request" form is visible, with fields for Target (Zr-91), Reaction (n,g), and Quantity (cs). A blue arrow points to the "Submit" button. The form also includes options for library selection (Major Libraries, Special Libraries, Archival, Derived) and sorting (Reactions, Evaluations). A "Note" section provides search criteria details, and a footer contains contact information for the Database Manager, Viktor Zerkin, and the Nuclear Energy Agency International Working Party on Evaluation Cooperation.

ENDF: Evaluated Nuclear Data File

File Edit View History Bookmarks Develop Window Help

http://www-nds.iaea.org/exfor/endl.htm

## Evaluated Nuclear Data File (ENDF)

Database Version of March 28, 2008  
Software Version of 2008.03.31 Old interface is [here]

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- 4) JENDL/HE-2004: High Energy File 2004 [page]

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### Standard Request (example); Go to: Advanced Request

Parameters:

Target  Zr-91

Reaction  n,g

Quantity  cs

[More Parameters...](#)

Libraries:  All  Selected

Major Libraries  Special Libraries

- 1) ENDF/B-VII.0 (USA,2006)  Archival
- 2) JEFF-3.1 (Europe,2005)  Derived
- 3) JENDL-3.3 (Japan,2002)
- 4) BROND-2.2 (Russia,1992)
- 5) CENDL-2 (China,1991)

Options:  
Sort by:  Reactions  Evaluations

Clone Request:

**Note:**

- all criteria are optional (selected by checking )
- selected criteria are combined for search with logical AND
- criteria separated in a field by ";" are combined with logical OR
- wildcards and intervals are available
- pointwise libraries contain reconstructed resonances using parameters from MF=2 and applied Doppler broadening at a given temperature.

Extensive temperature dependent pointwise libraries: [Point-2004 \(ENDFB-VI.8\)](#), [Point-2007 \(ENDFB-VII.0\)](#)

Database Manager: Viktor Zerkin, NDS, International Atomic Energy Agency ([V.Zerkin@iaea.org](mailto:V.Zerkin@iaea.org))  
Web and Database Programming: Viktor Zerkin, NDS, International Atomic Energy Agency ([V.Zerkin@iaea.org](mailto:V.Zerkin@iaea.org))  
Data Source: Nuclear Energy Agency International Working Party on Evaluation Cooperation (<http://www.nea.fr/html/science/wpec/>)  
and Cross Section Evaluation Working Group (<http://www.nndc.bnl.gov/csewg/>)

# Nuclear Data Online

E4/Servlet: Select

File Edit View History Bookmarks Develop Window Help

http://www-nds.iaea.org/exfor/servlet/E4sSearch2

Request #1402

### ENDF Data Selection

Retrieve Plot  Selected  Unselected  All

Plotting options:  Quick plot (cross-sections only:  $\sigma$ )  MF3-Plot  
 Universal plot ( $\sigma \pm \Delta\sigma$ ,  $\alpha\sigma/\Omega$ ,  $\alpha\sigma/\epsilon$ ,  $\alpha^2\sigma/\epsilon/\Omega$ ) *beta version*

Sorted by: [Reactions] Reorder by: [Libraries] View:  basic  extended

1) ZR-91 (N, G) ZR-92, SIG MT-102 MF-3 NSUB=10

|    | ENDF-6                              | Interpreted                         | $\sigma$                            | Plot                                |               |           |               |                        |  |
|----|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|---------------|-----------|---------------|------------------------|--|
| 1  | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | ENDF/B-VII.0  | E=20MeV   | Lab=JNDC, BNL | Date=DIS-T-DEC06       | JNDC FPND W.G., Mughabghab             |
| 2  | <input type="checkbox"/>            | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | JEFF-3.1      | E=20MeV   | Lab=JNDC      | Date=050504            | JNDC FP NUCLEAR DATA W.G.              |
| 3  | <input type="checkbox"/>            | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | JENDL-3.3     | E=20MeV   | Lab=JNDC      | Date=20010810          | JNDC FP NUCLEAR DATA W.G.              |
| 4  | <input type="checkbox"/>            | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | JENDL-3.3     | E=20MeV   | Lab=JNDC      | Date=20010810 T=300    | JNDC FP NUCLEAR DATA W.G.              |
| 5  | <input type="checkbox"/>            | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | ENDF/B-VI     | E=20MeV   | Lab=SAI, BNL  | Date=20011108          | M. DRAKE, D. SARGIS, T. MAUNG, P. ROSE |
| 6  | <input type="checkbox"/>            | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | ENDF/B-VI     | E=20MeV   | Lab=SAI, BNL  | Date=20010926 T=300    | M. DRAKE, D. SARGIS, T. MAUNG, P. ROSE |
| 7  | <input type="checkbox"/>            | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | BROND-2.2     |           | Lab=CJD+IATE  | Date=REV1-SEP9         | GRUDZEVICH O. T. ET. AL.               |
| 8  | <input type="checkbox"/>            | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | JEFF-3.1/A    | E=20MeV   | Lab=UKAEA     | Date=DIS-T-JUL03 T=293 | Forrest, Kopecky, Sublet, Koning       |
| 9  | <input type="checkbox"/>            | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | JEFF-2.2      |           | Lab=NEA       | Date=920101            | H. GRUPPELAAR, E. MENAPACE             |
| 10 | <input type="checkbox"/>            | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | JEFF-3.0      | E=20MeV   | Lab=JNDC      | Date=DIS-T-APR02       | JNDC FP NUCLEAR DATA W.G.              |
| 11 | <input type="checkbox"/>            | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | JENDL/HE-2004 | E=3000MeV | Lab=KYUSHU    | Date=REV1-             | S. KUNIEDA, N. SHIGYO, K. ISHIBASHI    |

\*Plotting options:

**MF3-Plot** cross section from file MF3 as is. Quick, but sometimes presents only "background" data (without resonances in low energy region)

**Cross section** includes reconstructed resonances and applied Doppler broadening at the temperature 293°K =20°C

**Other plots**

- $\alpha\sigma/\Omega$  - angular distributions,
- $\alpha\sigma/\epsilon$  - energy distributions,
- $\alpha^2\sigma/\epsilon/\Omega$  - double differential cross sections,
- $\sigma \pm \Delta\sigma$  - cross sections with uncertainties (if given)

[Glossary]: meaning of abbreviations and variables  
[About]: a few words on ENDF-6 format

Page generated: 2008/04/17, 16:24:02 by E4-Servlet on www-nds.iaea.org  
Project: "Multi-platform EXFOR-CINDA-ENDF", V.Zerkin, IAEA-nds, 1999-2008  
Request from: pc32330.iaea.org (161.5.149.213)

Attention: Data for Output: changed to "Selected"

# Nuclear Data Online

E4/Servlet: Output

File Edit View History Bookmarks Develop Window Help

http://www-nds.iaea.org/exfor/servlet/E4sMakeE4

E4/Servlet: Output

ENDF Request #1402 (974)

**Output Data**

|        |                       |
|--------|-----------------------|
| Format | Data (Size)           |
| ENDF   | Text (31Kb) ZIP (8Kb) |

**Cross Section**

Note: The data shown on this plot were converted to the pointwise presentation (T=293K).

ENDF Request 1402, 2008-Apr-17,16:26:41

EXFOR Find and add to the plot experimental data

- 1) ENDF/B-VII.0: ZR-91(N,G)ZR-92
- 2) Use my data [example]

Columns: x y [dx]

Type:  Curve  Points

Title: My data

Multiply by: X: 1 Y: 1

See: [plotted data \(556Kb\)](#)

Log: [XY](#) [X](#) [Y](#) Lin: [XY](#) [X](#) [Y](#) Auto-range: [XY](#) [X](#) [Y](#) Page: [>>](#) [<<](#) Zoom: [<>](#) [>>](#) Grid: [VH](#) [0](#) [V](#) [H](#) Pts: [Txt](#) [Box](#) [PL](#) [Print](#)

Reset  Legend  Authors  Info+ [PostScript](#) Manual options: [+]

Data for plotting: [ZVD \(536Kb\)](#), [send to ZVView](#); download [ZVView](#)

Note. Zoom and other interactive plotting features were tested under Web-browsers:  
MS-Internet Explorer 5.5, Firefox 2.0, Safari, Opera 9.1, Netscape v-7.2

Page generated: 2008/04/17,16:26:42 by E4-Servlet on www-nds.iaea.org  
Project: "Multi-platform EXFOR-CINDA-ENDF", V.Zerkin, IAEA-nds, 1999-2008  
Request from: pc32330.iaea.org (161.5.149.213)

# Nuclear Data Online

$^{91}\text{Zr}$  capture cross  
section  
at  $E_n=30$  keV:  
61.8 mb

http://www-nds.iaea.org/exfor/servlet/X4sShowData?db=x4&op=get\_plotdata&req=-1&ii=1782&File=E4R1403\_e4.zvd.dat.txt

|           |             |
|-----------|-------------|
| 0.0199106 | 0.000390432 |
| 0.0199155 | 0.000369768 |
| 0.0199205 | 0.000351134 |
| 0.0199255 | 0.000334264 |
| 0.0199322 | 0.00031413  |
| 0.0199388 | 0.000296292 |
| 0.0199455 | 0.000280398 |
| 0.0199521 | 0.000266161 |
| 0.0199588 | 0.000253345 |
| 0.0199654 | 0.000241757 |
| 0.0199721 | 0.000231236 |
| 0.0199814 | 0.000218046 |
| 0.0199894 | 0.000208008 |
| 0.019996  | 0.000200599 |
| 0.0199987 | 0.000198266 |
| 0.02      | 0.000197403 |
| 0.02      | 0.0873264   |
| 0.0211287 | 0.0833562   |
| 0.02125   | 0.0829294   |
| 0.0224492 | 0.0791402   |
| 0.0225    | 0.0789797   |
| 0.02375   | 0.075413    |
| 0.025     | 0.072177    |
| 0.02625   | 0.0692284   |
| 0.0275    | 0.0665312   |
| 0.03      | 0.0617753   |
| 0.0325    | 0.0577238   |
| 0.03375   | 0.0559146   |
| 0.035     | 0.0542306   |
| 0.0369752 | 0.0518289   |
| 0.0375    | 0.0511907   |
| 0.0396162 | 0.0489335   |
| 0.04      | 0.0485241   |
| 0.0422573 | 0.0463834   |
| 0.0425    | 0.0461532   |
| 0.0448984 | 0.0441314   |
| 0.045     | 0.0440457   |
| 0.0475    | 0.0421616   |
| 0.05      | 0.0404684   |
| 0.0525    | 0.0389799   |
| 0.055     | 0.0376286   |
| 0.0575    | 0.0363968   |
| 0.06      | 0.0352696   |
| 0.0625    | 0.0342185   |
| 0.065     | 0.0332504   |
| 0.0675    | 0.0323559   |
| 0.07      | 0.0315268   |
| 0.0739503 | 0.0303623   |
| 0.075     | 0.0300529   |
| 0.0792325 | 0.028963    |
| 0.08      | 0.0287654   |
| 0.0845146 | 0.0277695   |
| 0.085     | 0.0276625   |
| 0.0897968 | 0.0267198   |
| 0.09      | 0.0266798   |
| 0.095     | 0.0257972   |
| 0.1       | 0.0249984   |
| 0.1       | 0.0250719   |
| 0.110668  | 0.0238083   |
| 0.122863  | 0.0225713   |
| 0.13194   | 0.0217648   |
| 0.14686   | 0.0206101   |
| 0.15      | 0.0203853   |



# Nuclear Data Online

How about experimental data?

The screenshot shows a web browser window titled "E4/Servlet: Output" with the URL <http://www-nds.iaea.org/exfor/servlet/E4sMakeE4>. The page displays "Output Data" for "ENDF Request #1402 (974)". Below this, there is a "Cross Section" plot for "ENDF Request 1402, 2008-Apr-17,16:26:41". The plot is a log-log graph of Cross Section (barns) versus Incident Energy (MeV). The y-axis ranges from  $10^{-4}$  to  $10^2$  barns, and the x-axis ranges from  $10^{-10}$  to  $10^0$  MeV. The plot shows a smooth curve that exhibits a complex, oscillatory structure between approximately 0.1 MeV and 1 MeV. To the right of the plot is an "EXFOR" panel with a search button and a list of data entries. The first entry is checked: "1) ENDF/B-VII.0: ZR-91(N,G)ZR-92". Below the list, there are options for "Type" (Curve selected, Points unselected), "Title" (My data), and "Multiply by" (X: 1, Y: 1). At the bottom of the panel, it says "See: plotted data (556Kb)".

Output Data

|        |                       |
|--------|-----------------------|
| Format | Data (Size)           |
| ENDF   | Text (31Kb) ZIP (8Kb) |

**Cross Section**

Note: The data shown on this plot were converted to the pointwise presentation (T=293K).

ENDF Request 1402, 2008-Apr-17,16:26:41

Cross Section (barns)

Incident Energy (MeV)

EXFOR Find and add to the plot experimental data

- 1) ENDF/B-VII.0: ZR-91(N,G)ZR-92
- 2) Use my data [example]

Columns: x y [dy [dx]]

Type:  Curve  Points

Title: My data

Multiply by: X: 1 Y: 1

See: plotted data (556Kb)

Log: [XY](#) [X](#) [Y](#) Lin: [XY](#) [X](#) [Y](#) Auto-range: [XY](#) [X](#) [Y](#) Page: [>>](#) [<<](#) Zoom: [<>](#) [>>](#) Grid: [VH](#) [0](#) [V](#) [H](#) Pts: [Txt](#) [Box](#) [PL](#) [Print](#)

Reset  Legend  Authors  Info+ [PostScript](#) Manual options: [+]

Data for plotting: [ZVD](#) (536Kb), [send](#) to ZVView; download [ZVView](#)

Note. Zoom and other interactive plotting features were tested under Web-browsers: MS-Internet Explorer 5.5, Firefox 2.0, Safari, Opera 9.1, Netscape v-7.2

Page generated: 2008/04/17,16:26:42 by E4-Servlet on [www-nds.iaea.org](http://www-nds.iaea.org)  
Project: "Multi-platform EXFOR-CINDA-ENDF", V.Zerkin, IAEA-nds, 1999-2008  
Request from: pc32330.iaea.org (161.5.149.213)

# Nuclear Data Online

X4/Servlet: Select

File Edit View History Bookmarks Develop Window Help

http://www-nds.iaea.org/exfor/servlet/X4sMakeX4

X4/Servlet: Select

EXFOR Request #2157/823 (following ENDF Request #1402)

### Output Data

| Format       | Data (Size)  |
|--------------|--|
| EXFOR        | <a href="#">Text (32Kb)</a> <a href="#">ZIP (8Kb)</a>    |
| Bibliography | <a href="#">html (10Kb)</a> <a href="#">BibTeX (4Kb)</a> |

ENDF Request 1402, 2008-Apr-17, 16:26:41  
EXFOR Request: 2157/1, 2008-Apr-17 16:41:31

Log: [XY](#) [X](#) [Y](#) Lin: [XY](#) [X](#) [Y](#) Auto-range: [XY](#) [X](#) [Y](#) Page: [>>](#) [<<](#) Zoom: [>](#) [<](#) Grid: [VH](#) [0](#) [V](#) [H](#) Pts: [Txt](#) [Box](#) [PL](#) [Print](#)

[Reset](#) [Repaint](#)  Legend  Authors  Info+ [PostScript](#) Manual options: [\[+\]](#)

Data for plotting: [ZVD \(544Kb\)](#), [send to ZVView](#); [download ZVView](#)

Note. Zoom and other interactive plotting features were tested under Web-browsers:  
MS-Internet Explorer 5.5, Firefox 2.0, Safari, Opera 9.1, Netscape v-7.2

Page generated: 2008/04/17, 16:41:32 by X4-Servlet on www-nds.iaea.org  
Project: "Multi-platform EXFOR-CINDA-ENDF", V.Zerkin, IAEA-NDS, 1999-2008  
Request from: pc32330.iaea.org (161.5.149.213)

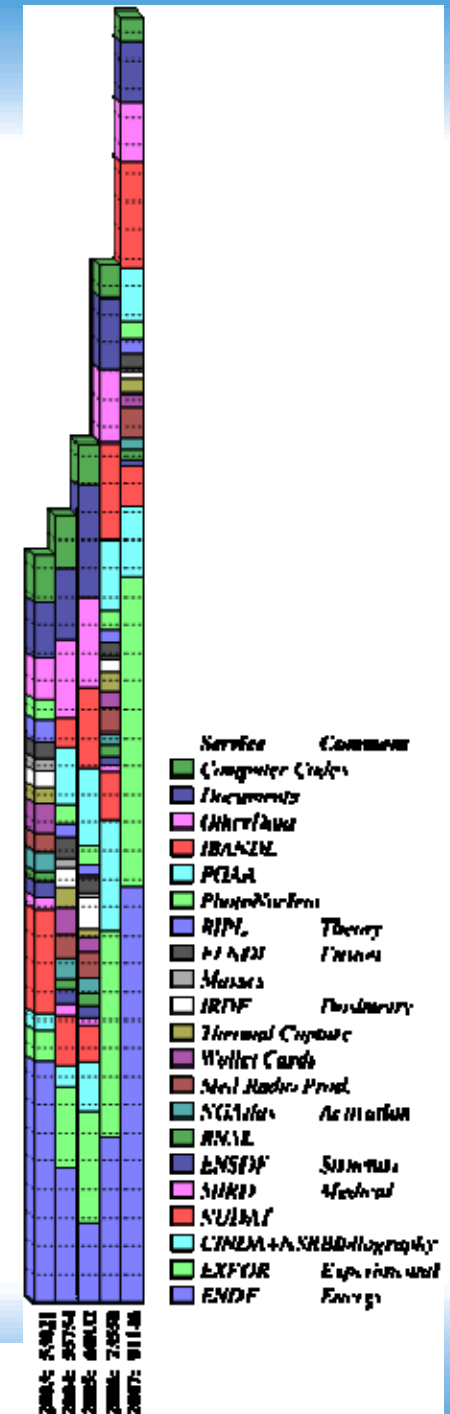
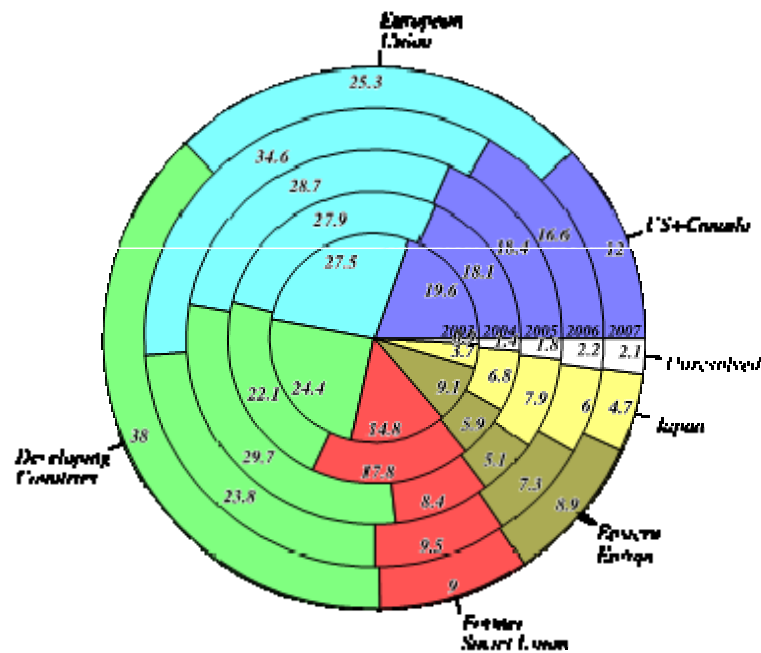
1) 40-ZR-91(N,G)40-ZR-92,,SIG

2) ENDF/B-VII.0: ZR-91(N,G)ZR-92

3) Use my data [\[example\]](#)

See: [plotted\\_data \(563Kb\)](#)

# Providing On-line Services: Access Statistics



source: NDS report to the INDC (2008)

Joint IAEA-ICTP Workshop on

# **Nuclear Reaction Data for Advanced Reactor Technologies**

**1. Nuclear Data Measurements**

**2. Theory/Modeling/Evaluation of Nuclear Data**

**3. Applications: Advanced Reactor Systems**



# 1. Nuclear Data Measurements

| facility          |                                | driver and energy         | repetition rate  | n source                         | n energy range                     | flight path length |
|-------------------|--------------------------------|---------------------------|------------------|----------------------------------|------------------------------------|--------------------|
| FZK<br>TIT<br>... | Karlsruhe<br>Tokyo<br>...      | varii in the MeV range    | MHz              | ${}^7\text{Li}(p,n)$<br>& others | few keV up to 1 MeV<br>monoE above | 10s cm             |
| GELINA            | EC-JRC<br>Geel                 | electron linac<br>150 MeV | 800 Hz           | photo-n<br>photo-f               | 10 meV – 20 MeV                    | 10m to 400m        |
| LANSCE            | Los Alamos National Laboratory | proton linac<br>800 MeV   | 20 Hz            | spallation                       | < 500 keV (DANCE)                  | 20m                |
| n_TOF             | CERN                           | PS<br>20 GeV              | 0.4 Hz (average) | spallation                       | 10 meV – 250 MeV (or wider)        | 200m               |

World scene for tof measurements



# 1. Nuclear Data Measurements

## **Franz Käppeler**

Forschungszentrum Karlsruhe, GERMANY  
*Capture Cross Section Measurements*



## **Nicola Colonna**

INFN, Sezione di Bari, ITALY  
*Fission Measurements*

## **Peter Schillebeeckx**

EC-JRC-IRMM, Geel, BELGIUM  
*Cross Section Measurements and Uncertainties of Cross Section Data*

## **Frank Gunsing**

CEA, Saclay, FRANCE  
*TBA*



# 1. Nuclear Data Measurements

**Alessandro Borella**

EC-JRC-IRMM, Geel, BELGIUM

*Cross Section Measurements and Uncertainties of Cross Section Data*

**Stefano Marrone**

INFN, Sezione di Bari, ITALY

*Capture Cross Sections: Data Analysis*



# **Nuclear Reaction Data for Advanced Reactor Technologies**

1. Nuclear Data Measurements

2. Theory/Modeling/Evaluation of Nuclear Data

3. Applications: Advanced Reactor Systems





## 2. Theory/Evaluation/Modeling Nuclear Data

### **Stephane Hilaire**

CEA, Bruyeres-le-Chatel, FRANCE

*Statistical Modeling and Calculation (TALYS code)*

### **Pierre Descouvemont**

Université Libre de Bruxelles, BELGIUM

*R-matrix theory of nuclear reactions*

### **Anatoly Ignatyuk**

Institute of Physics and Power Engineering, Obninsk, RUSSIAN FEDERATION

*Evaluation of Nuclear Reaction Data*

### **Giuseppe Palmiotti**

Argonne National Laboratory, Chicago, USA

*Sensitivity and Uncertainty Analysis*

*for the Neutronic Design of Advanced Nuclear Systems*



# **Nuclear Reaction Data for Advanced Reactor Technologies**

1. Nuclear Data Measurements

2. Theory/Modeling/Evaluation of Nuclear Data

3. Applications: Advanced Reactor Systems

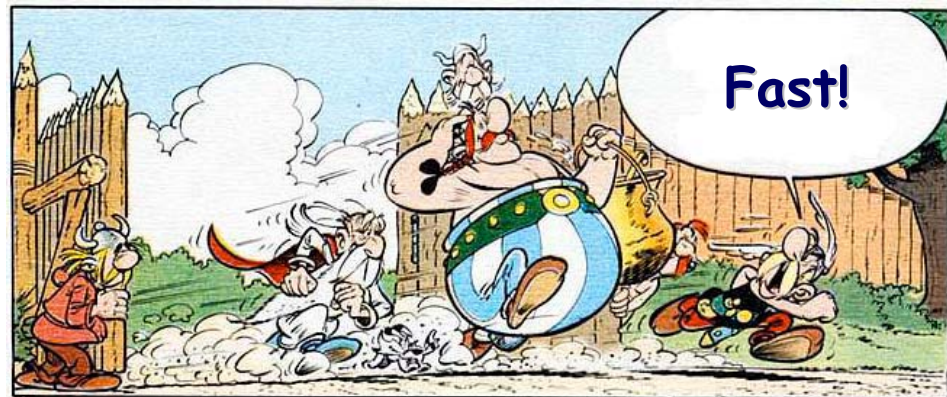


# 3. Applications: Advanced Reactor Systems

**Alex Stanculescu**

IAEA, Vienna, AUSTRIA

*Advanced Fast Reactors*



# 3. Applications: Advanced Reactor Systems

**Jim Kendall**

Global Virtual LLCC, Prescott, AZ, USA

*High Temperature Advanced Reactors*

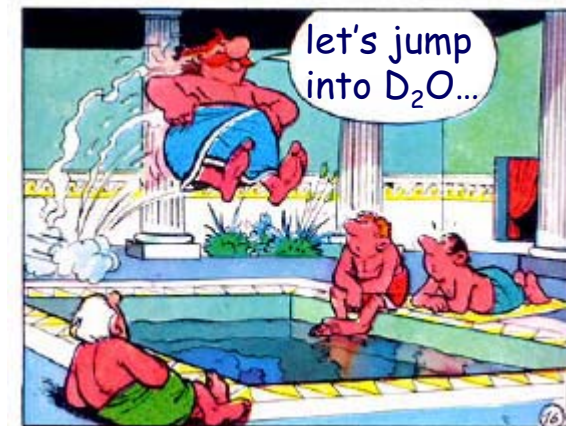


# 3. Applications: Advanced Reactor Systems

**Blair Bromley**

AECL, Deep River, ON, CANADA

*Heavy Water Reactors*

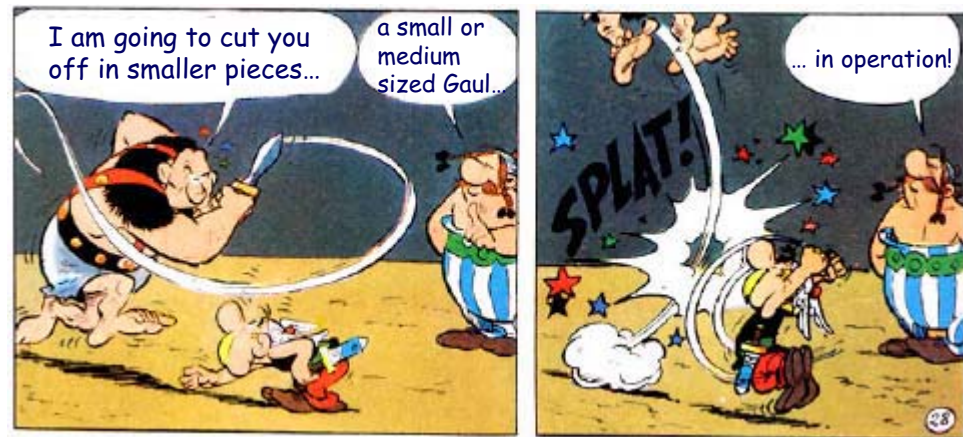


# 3. Applications: Advanced Reactor Systems

**Vladimir Kuznetsov**

IAEA, Vienna, AUSTRIA

*Small and Medium Sized Advanced Reactors*



# Joint IAEA-ICTP Workshop on Nuclear Reaction Data for Advanced Reactor Technologies

## PROGRAM layout

| Week 1        | Monday, 19   | Tuesday, 20                 | Wednesday, 21               | Thursday, 22          | Friday, 23            | Weekend |
|---------------|--|-----------------------------|-----------------------------|-----------------------|-----------------------|---------|
| 8:30 – 10:00  | registration   | P Schillebeeckx             | P Schillebeeckx             | TBA                   | TBA                   |         |
| 10:00 – 10:30 | <i>Break</i>   |                             |                             |                       |                       |         |
| 10:30 – 12:00 | Welcome & Introduction   | N Colonna                   | N Colonna                   | A Borella             | F Gunsing             |         |
| 12:00 – 14:00 | <i>Lunch</i>   |                             |                             |                       |                       |         |
| 14:00 – 15:30 | A Stanculescu  | J Kendall                   | J Kendall                   | V Kuznetsov           | V Kuznetsov           |         |
| 15:30 – 16:00 | <i>Break</i>   |                             |                             |                       |                       |         |
| 16:00 – 17:30 | Introduction to computational facilities and computer software | exercise<br>P Schillebeeckx | exercise<br>P Schillebeeckx | exercise<br>A Borella | exercise<br>S Marrone |         |



# Joint IAEA-ICTP Workshop on Nuclear Reaction Data for Advanced Reactor Technologies

## PROGRAM layout

| Week 2        | Monday, 26                 | Tuesday, 27                | Wednesday, 28          | Thursday, 29            | Friday, 30              | Weekend |
|---------------|----------------------------|----------------------------|------------------------|-------------------------|-------------------------|---------|
| 8:30 – 10:00  | P Descouvemont             | P Descouvemont             | S Hilaire              | S Hilaire               | A Mengoni               |         |
| 10:00 – 10:30 | <i>Break</i>               |                            |                        |                         |                         |         |
| 10:30 – 12:00 | G Palmiotti                | G Palmiotti                | A Ignatyuk             | A Ignatyuk              | TBA                     |         |
| 12:00 – 14:00 | <i>Lunch</i>               |                            |                        |                         |                         |         |
| 14:00 – 15:30 | BP Bromley                 | BP Bromley                 | Student's presentation | Student's presentations | Student's presentations |         |
| 15:30 – 16:00 | <i>Break</i>               |                            |                        |                         |                         |         |
| 16:00 – 17:30 | exercise<br>P Descouvemont | exercise<br>P Descouvemont | exercise<br>S Hilaire  | exercise<br>S Hilaire   | Closing                 |         |





# Exercises

**J. Grassberger / K. McLaughlin**

ICTP, Trieste / IAEA, Vienna, Austria

Introduction to computational facilities and computer software



# Student's presentations

- 2<sup>nd</sup> week: Wednesday, Thursday & Friday, from 2:00PM to 3:30PM
- typically 20min for each presentation

Please sign up to make a presentation on a topic (any), on which you are working!



# Reception

Today, 19:00 hrs  
Adriatico Cafeteria  
in the terrace, ground floor  
(or inside if bad weather...)



# Practical Infos

**DIRECTORS:** office no. 4, tel.ext. 954

**LECTURERS/SPEAKERS:** United Nations Room, tel.ext. 643

**SECRETARIAT:** Mrs. Ave Lusenti, office no. 2, tel.ext. 544

**MAIL BOX AND E-MAIL ACCOUNT:** A mail box has been prepared for you on the Lower Level 1, near Eklund Informatics Laboratory, Adriatico Guest House. An ICTP e-mail account has been created. Your login information will be given to you in a sealed envelope during registration. During your stay please check your mail box and e-mail account regularly, as these are the main channels of communication within the Campus and the only means of notifying you of urgent messages or correspondence which may arrive during your stay

**FOLDER & NAME BADGE:** In the Mail Box you will receive a conference Folder, containing information on the activity, Upon registration you will also receive a Name Badge, which you are kindly requested to wear, and which is required to borrow books from the Library.

**ADMINISTRATIVE INFORMATION** is posted on the notice boards situated in the reception areas of the Leonardo Building, Adriatico and Galileo Guest Houses. In-house information is sent through the Info Point by means of an automatic e-mail delivery service (ICTP Community Link Digest) available to all holders of an e-mail account at ICTP. There is also a mailing list (Trieste Scientific News Digest), which gives details of in-house scientific activities as well as those taking place in ICTP's neighbouring scientific institutes, like SISSA.

**INFO POINT** (located to the left of the main entrance hall of the Leonardo da Vinci Building) provides general information about the Centre, its activities and offices, as well as details about the city and its surroundings. Tel. Ext: 433; e-mail: [info\\_pt@ictp.it](mailto:info_pt@ictp.it)



# Practical Infos

**ITALIAN PERMIT OF STAY:** Your new ICTP e-mail account contains an important comprehensive message regarding the rules to be observed related to the permit of stay in Italy. The message is especially important to those whose stay exceeds 8 days and are not accommodated in the ICTP Guesthouses, and the deadlines mentioned are imperative! Questions on permit of stay issues can be raised with the ICTP Passport and Visa Information Office (room T4, E. Fermi Building 09:00 - 12:30 14:00 - 15:00).

**MEAL COUPONS** (*for participants whose subsistence costs are covered by the Centre*). Meal coupons are issued by the Operations Office (Fermi Building), upon presentation of the completed Registration form.

**ICTP STAFF WORKING HOURS** Monday to Friday, from 8.30 to 16.48

**CERTIFICATES OF ATTENDANCE** Unless already foreseen by the Activity itself, certificates can be requested via e-mail to the account: Attendance.Certificates@ictp.it Requests should be made well in advance of your departure date.

**END OF STAY** Only in exceptional cases of authorized anticipated departure and **always** for Associates and Affiliates the clearance is requested. For details please see the End-of-Stay Clearance Terms to be found on the last page of the Pre-arrival Information Booklet: <http://www.ictp.it/pages/info/visiting.html>

**PLEASE SEE THE REVERSE SIDE FOR A SUMMARY OF INFORMATION ON ICTP OFFICES AND SERVICES**  
For more details, we draw your kind attention to the "**Visitor's Guide**" booklet, to be found in your conference folder. Special attention should be given to the sections regarding PASSPORTS AND VISAS and HEALTH INSURANCE.

# Practical Infos

---

## **HOUSING OFFICE**

08.30 - 12.00 and 13.30 - 14.30 (Mon - Fri)

*E. Fermi Building* - Rooms T1/T2 (ground floor).

---

## **OPERATIONS/TRAVEL CLAIMS OFFICE**

08.30 - 12.00 and 13.30 - 14.30 (Mon-Fri)

*E. Fermi Building* - Room T17 (ground floor) - For daily allowances/travel reimbursements. *Note:* reimbursements of over Euro 200 are done via bank cheque, cashed at UniCredit Banca (see timetable below).

---

## **PASSPORT & VISA INFORMATION OFFICE**

09.00 - 12.30 and 14.00 - 15.00 (Mon-Fri)

*E. Fermi Building* - Room T4 (ground floor)

---

## **BANK (UniCredit Banca)** 08.30 - 12.30 (Mon-Fri)

*E. Fermi Building* - Main Entrance (ground floor) - Kindly note that for all banking transactions you are required to exhibit your **passport** (or equivalent valid identification document).

---

## **TRAVEL AGENCY (Carlson Wagonlit Travel)**

08.30 - 12.30 and 13.00 - 15.00 (Mon-Fri)

*E. Fermi Building* - Main Entrance (ground floor) (Tel.ext. 584)

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## **MEDICAL SERVICE**

09.00 - 12.00 and 15.00 - 16.30 (Mon-Fri)

*E. Fermi Building* - Main Entrance (Room T9/T10 - ground floor) (**Tel. ext. 500 and 600**).

Appointments with the Doctor should be arranged through the Nurse.

---

## **HEALTH INSURANCE (Lloyd Adriatico Ins. Co.)**

08.30 - 12.30 (Tuesday and Thursday)

*E. Fermi Building* - Main Entrance (ground floor)

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# Practical Infos

**COMPUTERS** Computers are located in the Leonardo da Vinci Building (1S level) and the Adriatico (Lower Level 1) and Galileo (near reception) guesthouses, running Windows XP and Linux. As mentioned before, your login information will be given to you in a sealed envelope during registration. It is also needed for our wireless network. For more information, please see <http://icts.ictp.it/>. Computer help is available on workdays 10:30-12:00 and 13:30-15:00 in the Leonardo Building, Information and Communication Technology Section (ICTS), entrance level, room 2, or via internal phone 999. Diskettes, CD-Rs, network cables and printer transparencies can be bought at the Mail Counters (see below). Network cables can also be bought from the vending machines at the Adriatico and Galileo Guesthouses at the same price as at the Mail Counters (Euro 4.50)

**STATIONERY and MAIL COUNTERS** (Photographic services: **only** E. Fermi Bldg, Mail Office counter).

**Leonardo Building** - (1S Level, right-hand side) 13.30 - 15.30 (Mon-Fri)

**E. Fermi Building** - (Lower Level) 08.30 - 12.00 (Mon-Fri)

Basic stationery is included in the conference folder. Additional items can be requested from the above offices.

**PHOTOCOPYING (SELF-SERVICE)** Five self-service photocopying machines are available: two inside the ICTP Library, one at the AGH (Lower Level, inside the Eklund Informatic Lab.), one at the Galileo GH, one at the Enrico Fermi Building (outside the Associate area). The machines are operated by magnetic cards, obtainable from an automatic distributor outside the Library entrance, at a cost of Euro 1 (deposit for the card + 10 copies). These cards may be re-charged at Euro 0,03 per copy. The deposit (Euro 0,80) will be reimbursed if the card is returned, undamaged, to the mail counters. Exceptionally, cards are also available from the Mail Counters and at weekends from the AGH Reception.

**TYPEWRITERS** Available for the use of Visitors at: **E. Fermi Building** Lower Level, corridor.

**Leonardo Building**: right-hand side, Level 2S

## **TELEFAX**

**Leonardo Building**:

**Adriatico G.H.:**

**E. Fermi Building**:

Private messages can be sent, on payment, through:

Reception Desk (08.30 - 16.00, Mon-Fri)

Reception Desk

Mail Counter (08.30 - 12.00, Mon-Fri)

## **LIBRARY**

**Leonardo Building**

08.30 - 20.00 (Mon-Fri)

09.00 - 20.00 (Sat & Sun)

first floor All first-time users must register at the loan desk.



# Practical Infos

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## **SHUTTLE BUS SERVICE:**

|                     |                         |                 |                     |
|---------------------|-------------------------|-----------------|---------------------|
| 08:30 Galileo/Fermi | 08.35 Leonardo Building | 08:40 Adriatico | 08:45 Galileo/Fermi |
| 08:50 Galileo/Fermi | 08:55 Leonardo Building | 09:00 Adriatico | 09:05 Galileo/Fermi |
| 10:00 Galileo/Fermi | 10:05 Leonardo Building | 10:10 Adriatico | 10:15 Galileo/Fermi |
| 11:55 Galileo/Fermi | 12:00 Leonardo Building | 12:05 Adriatico | 12:10 Galileo/Fermi |
| 12:15 Galileo/Fermi | 12:20 Leonardo Building | 12:25 Adriatico | 12:30 Galileo/Fermi |
| 13:00 Galileo/Fermi | 13:05 Leonardo Building | 13:10 Adriatico | 13:15 Galileo/Fermi |
| 13:40 Galileo/Fermi | 13:45 Leonardo Building | 13:50 Adriatico | 13:55 Galileo/Fermi |
| 15:00 Galileo/Fermi | 15:05 Leonardo Building | 15:10 Adriatico | 15:15 Galileo/Fermi |
| 16:30 Galileo/Fermi | 16:35 Leonardo Building | 16:40 Adriatico | 16:45 Galileo/Fermi |





Joint IAEA-ICTP Workshop on

# **Nuclear Reaction Data for Advanced Reactor Technologies**

## **Directors**

Alberto Mengoni (IAEA, Vienna)

Alex Stanculescu (IAEA, Vienna)

## **Local Organizer**

Claudio Tuniz (ICTP, Trieste)

## **Secretariat**

Ave Lusenti (ICTP, Trieste)



# The End

# Title

to cover:

- information on the location
- exercises
- student's presentations



# Fast neutrons!

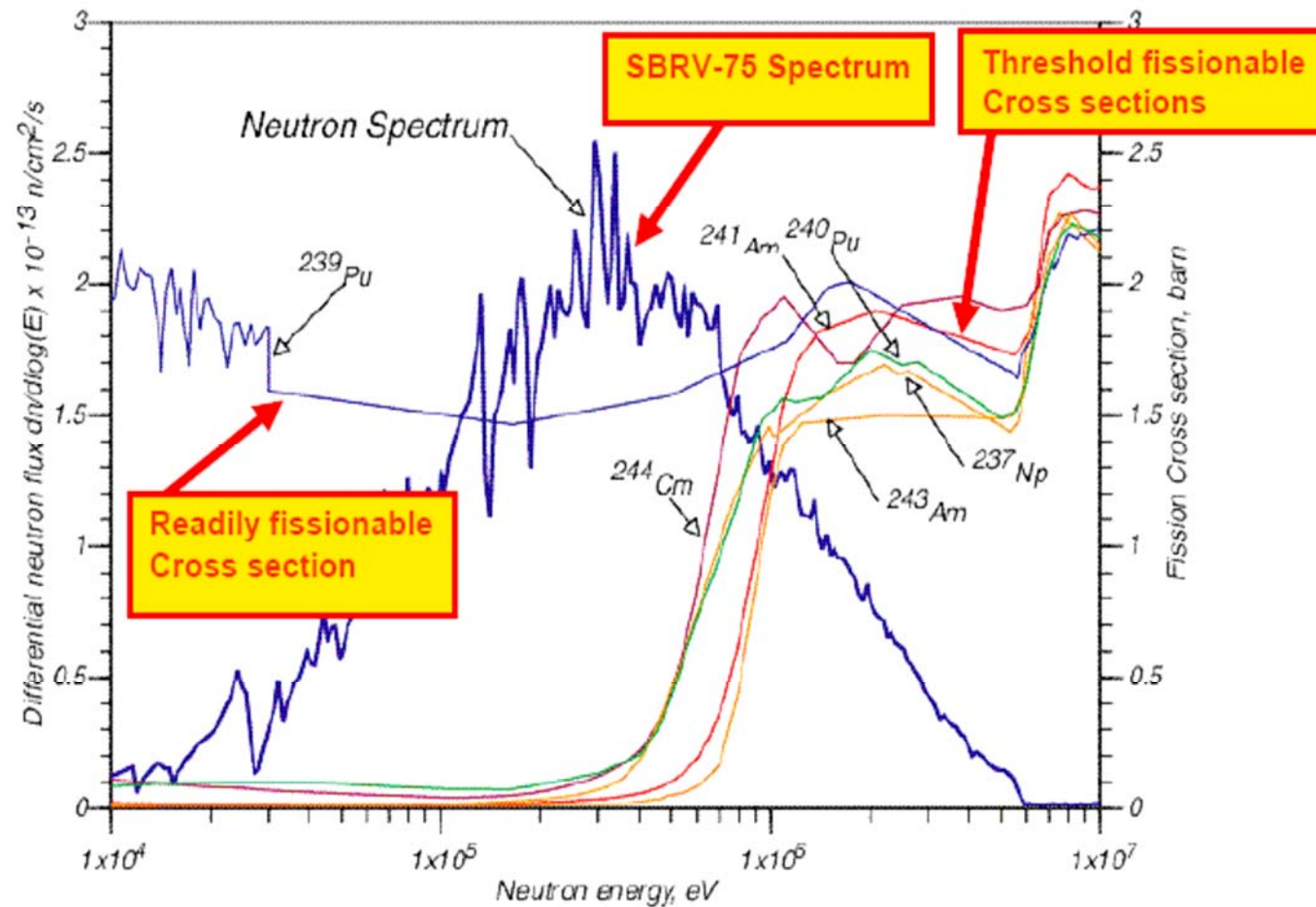


Figure 1: Simulation of the neutron spectrum in the SBRV-75 reactor [2], loaded with the Spiro MA fuel mixture (1/2 of  $^{241}\text{Am}$ , 1/4 of  $^{243}\text{Am}$  and 1/4 of equal amount of  $^{244}\text{Cm}$  and  $^{237}\text{Np}$ ). The fission cross sections of several MA in consideration here are shown. The fission cross section of  $^{239}\text{Pu}$  is also shown for a direct comparison with a non-threshold fission case.

# Neutron cross sections data are needed!

$^{243}\text{Am}(n,f)$

