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International Atomic Energy Agency

2257-28

Joint ICTP-IAEA School of Nuclear Energy Management

8 - 26 August 2011

Nuclear Data

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International Atomic Energy Agency

Nuclear Data

Robin Forrest

ICTP, Trieste, Italy, 10 August 2011

Outline

- **IAEA Nuclear Data Section (NDS)**
- **Nuclear Technology**
- **Nuclear Data**
  - Cross sections
  - Decay data
  - Where to find data?
- **NDS Activities**
  - Example databases
  - Coordinated Research Projects
- **Conclusions**

NAPC: Physics and Nuclear Data Sections

Physics Section

Research Reactors

Accelerators

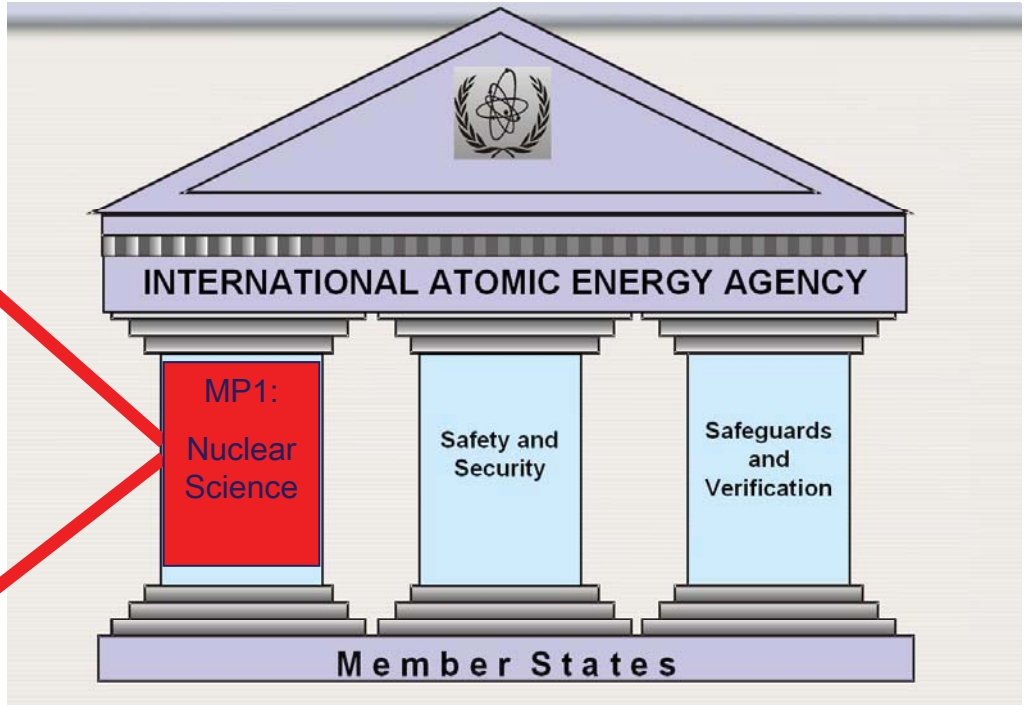
Instrumentation

Fusion

Nuclear Data Section

Nuclear Data

Atomic and Molecular Data



IAEA Nuclear Data Section

Section Head: **R.A. Forrest**
Nuclear Data Physicist
(21709/21710)

Deputy Section Head: **D. Abriola**
Nuclear Data Physicist
(21712/21711)

Section Secretary: **L. Vrapcenjak**
(21710)

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J. Roberts Nuclear Data Services Assistant (21725)		**K. Sheikh** Database Assistant (21730)
A. Oechs Clerk (21716)		**A. Vasaros** IT Systems Engineer (temp.) (21724)

Three Units

17 staff

IAEA Nuclear Data Section

Role

- Provision of atomic and nuclear data services to scientists worldwide (data libraries, bibliographies, documents) through the internet, CD and other media
- Coordination of three international atomic and nuclear data networks
- Production of new databases through Coordinated Research Projects (CRPs) and Data Development projects
- Assist developing countries through technology transfer activities

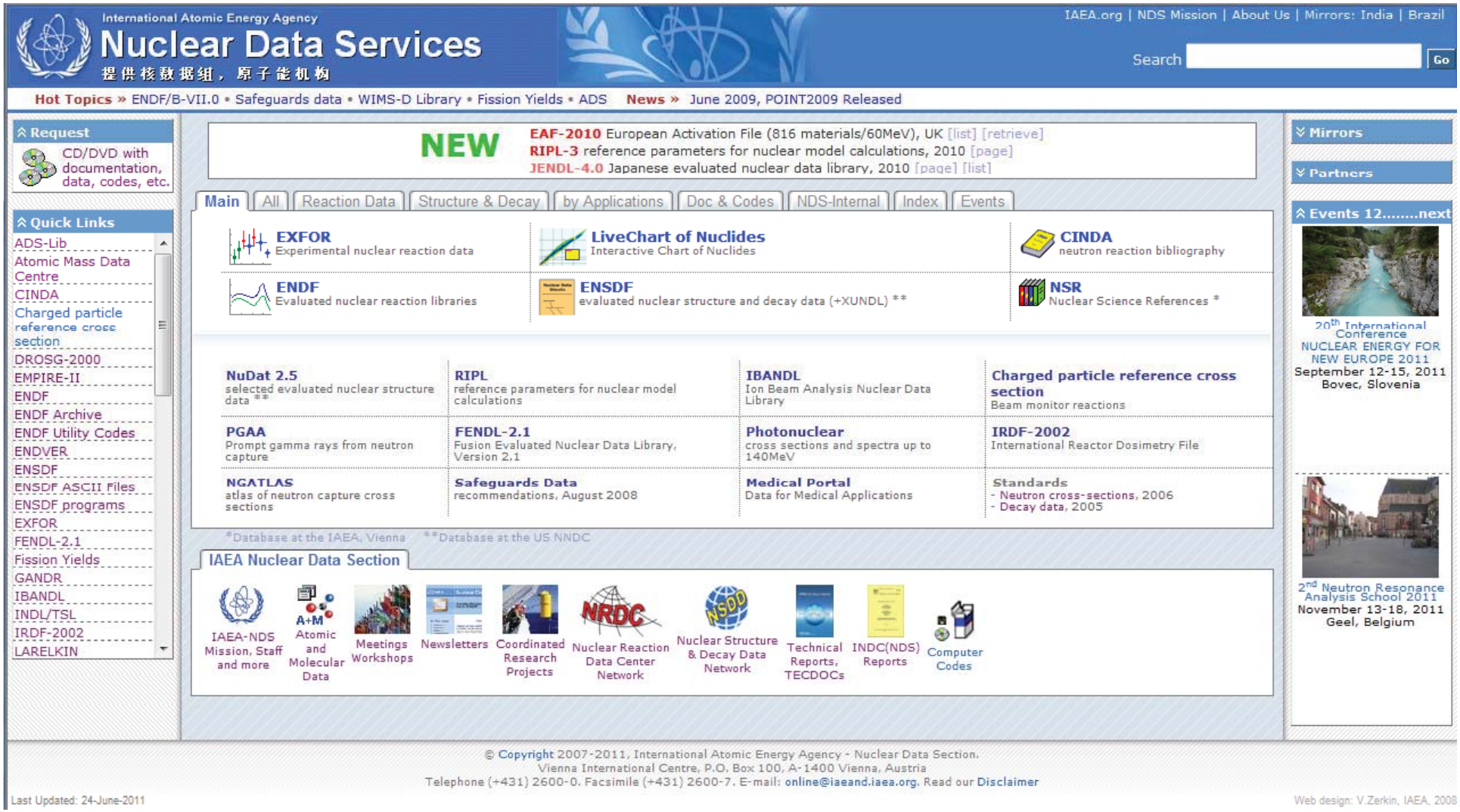
IAEA Nuclear Data Section

The development and maintenance of nuclear technologies rely on the availability of atomic, molecular and nuclear data

Essential data include:

- Energy-dependent reaction probabilities (cross sections)
- Energy and angular distributions of reaction products
- Atomic and nuclear properties of excited states
- Radioactive decay data

NDS Web site


International Atomic Energy Agency
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Search
Go
Hot Topics » ENDF/B-VII.0 • Safeguards data • WIMS-D Library • Fission Yields • ADS
News » June 2009, POINT2009 Released
Request
CD/DVD with documentation, data, codes, etc.
Quick Links
ADS-Lib
Atomic Mass Data Centre
CINDA
Charged particle reference cross section
DROSG-2000
EMPIRE-II
ENDF
ENDF Archive
ENDF Utility Codes
ENDVER
ENSDF
ENSDF ASCII Files
ENSDF programs
EXFOR
FENDL-2.1
Fission Yields
GANDR
IBANDL
INDL/TSL
IRDF-2002
LARELKIN
NEW
EAF-2010 European Activation File (816 materials/60MeV), UK [list] [retrieve]
RIPL-3 reference parameters for nuclear model calculations, 2010 [page]
JENDL-4.0 Japanese evaluated nuclear data library, 2010 [page] [list]
Main
All
Reaction Data
Structure & Decay
by Applications
Doc & Codes
NDS-Internal
Index
Events
EXFOR
Experimental nuclear reaction data
LiveChart of Nuclides
Interactive Chart of Nuclides
CINDA
neutron reaction bibliography
ENDF
Evaluated nuclear reaction libraries
ENSDF
evaluated nuclear structure and decay data (+XUNDL) **
NSR
Nuclear Science References *
NuDat 2.5
selected evaluated nuclear structure data **
RIPL
reference parameters for nuclear model calculations
IBANDL
Ion Beam Analysis Nuclear Data Library
Charged particle reference cross section
Beam monitor reactions
PGAA
Prompt gamma rays from neutron capture
FENDL-2.1
Fusion Evaluated Nuclear Data Library, Version 2.1
Photonuclear
cross sections and spectra up to 140MeV
IRDF-2002
International Reactor Dosimetry File
NGATLAS
atlas of neutron capture cross sections
Safeguards Data
recommendations, August 2008
Medical Portal
Data for Medical Applications
Standards
- Neutron cross-sections, 2006
- Decay data, 2005
*Database at the IAEA, Vienna
**Database at the US NNDC
IAEA Nuclear Data Section
IAEA-NDS Mission, Staff and more
A+M
Atomic and Molecular Data
Meetings Workshops
Newsletters
Coordinated Research Projects
NRDC
Nuclear Reaction Data Center Network
NSDD
Nuclear Structure & Decay Data Network
Technical Reports, TECDOCs
INDC(NDS) Reports
Computer Codes
Mirrors
Partners
Events 12.....next
20th International Conference
NUCLEAR ENERGY FOR NEW EUROPE 2011
September 12-15, 2011
Bovec, Slovenia
2nd Neutron Resonance Analysis School 2011
November 13-18, 2011
Geel, Belgium
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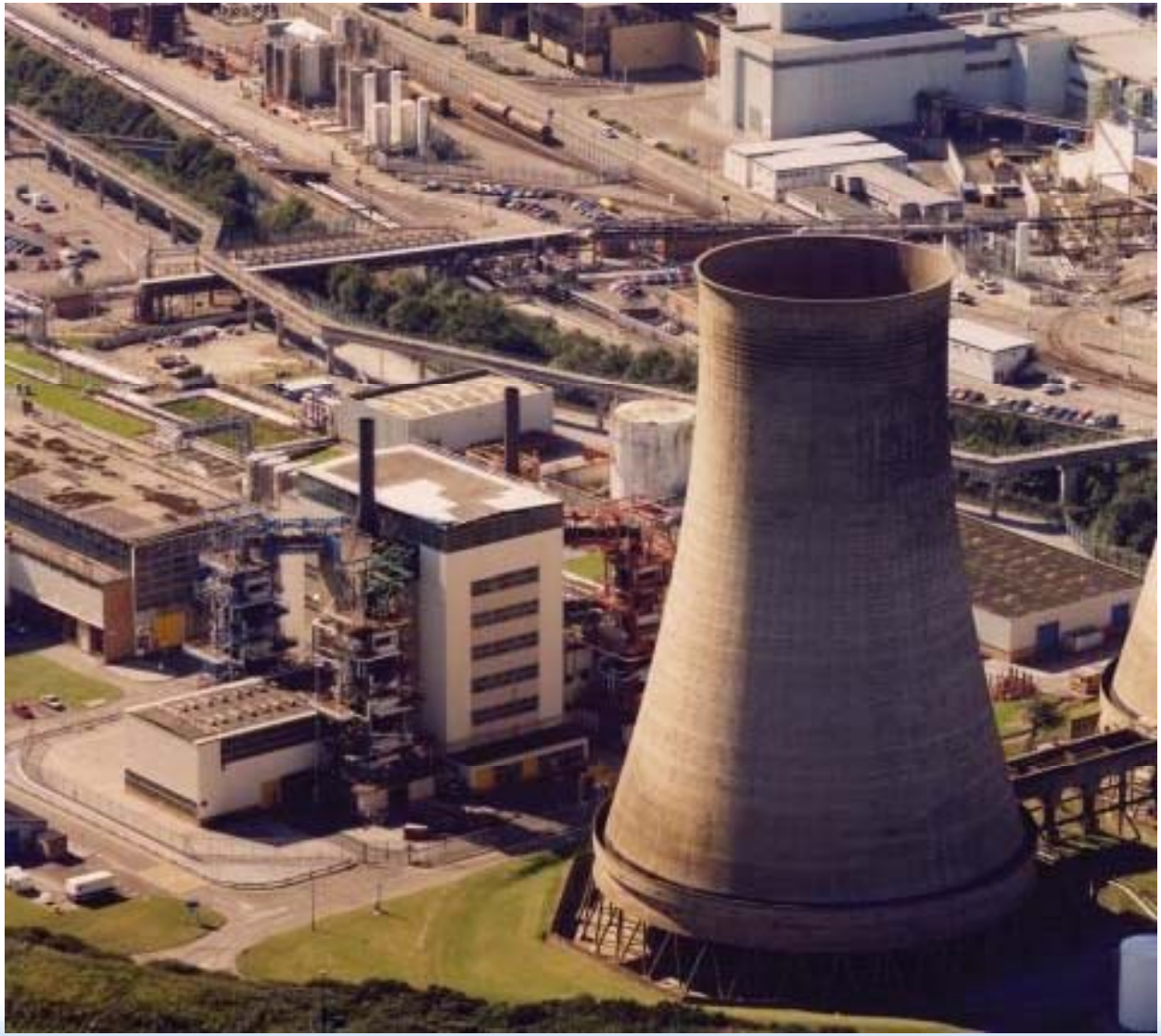
Publications

Nuclear Technology

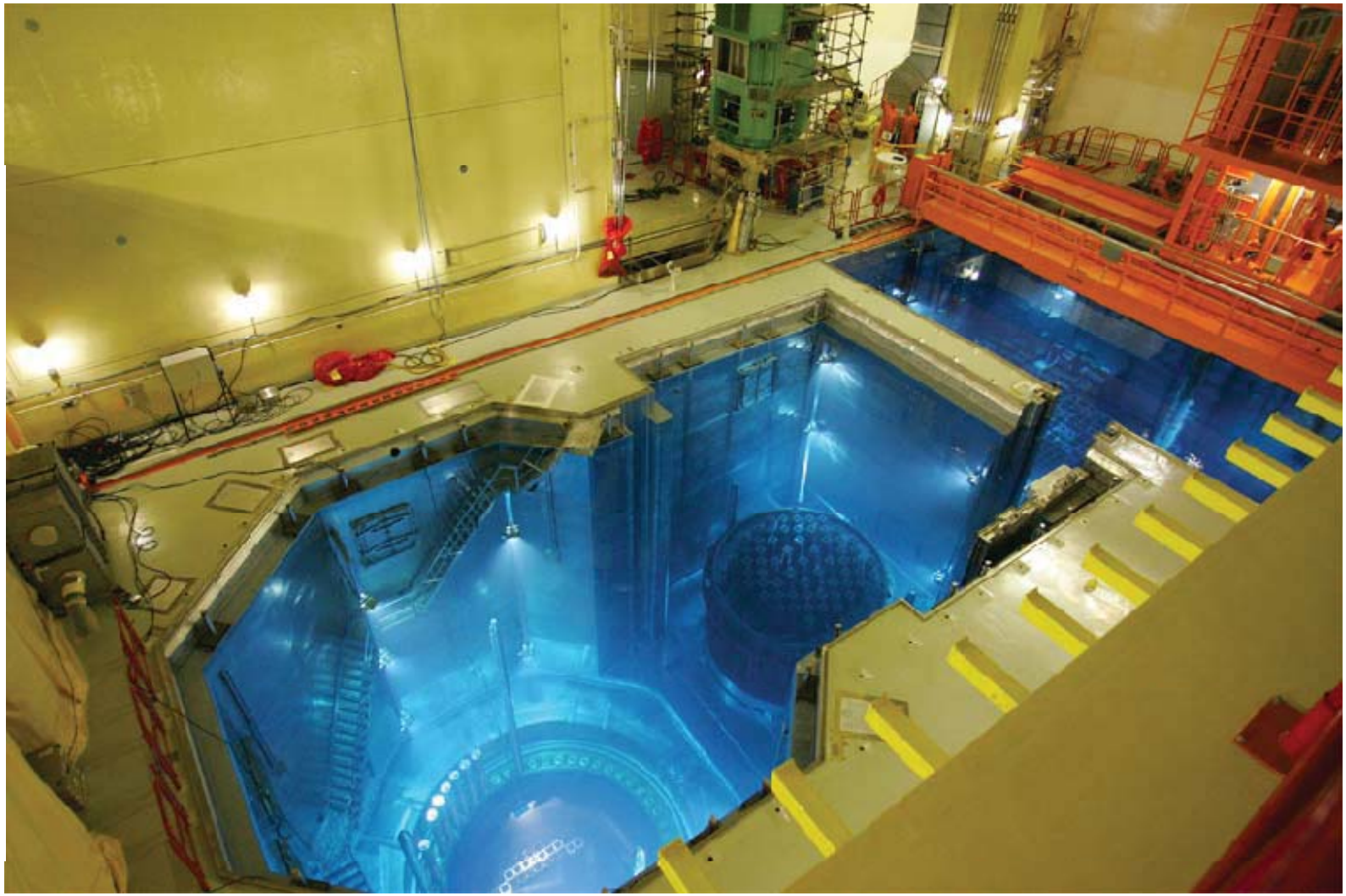
- Essential in the modern world
  - Fission power plants
  - Medical applications
  - Analytical techniques
  - Future energy production – Fusion
- To apply these safely and efficiently need to have accurate and well tested values for many physical quantities

Fission Power Plants

Fission Power Plants

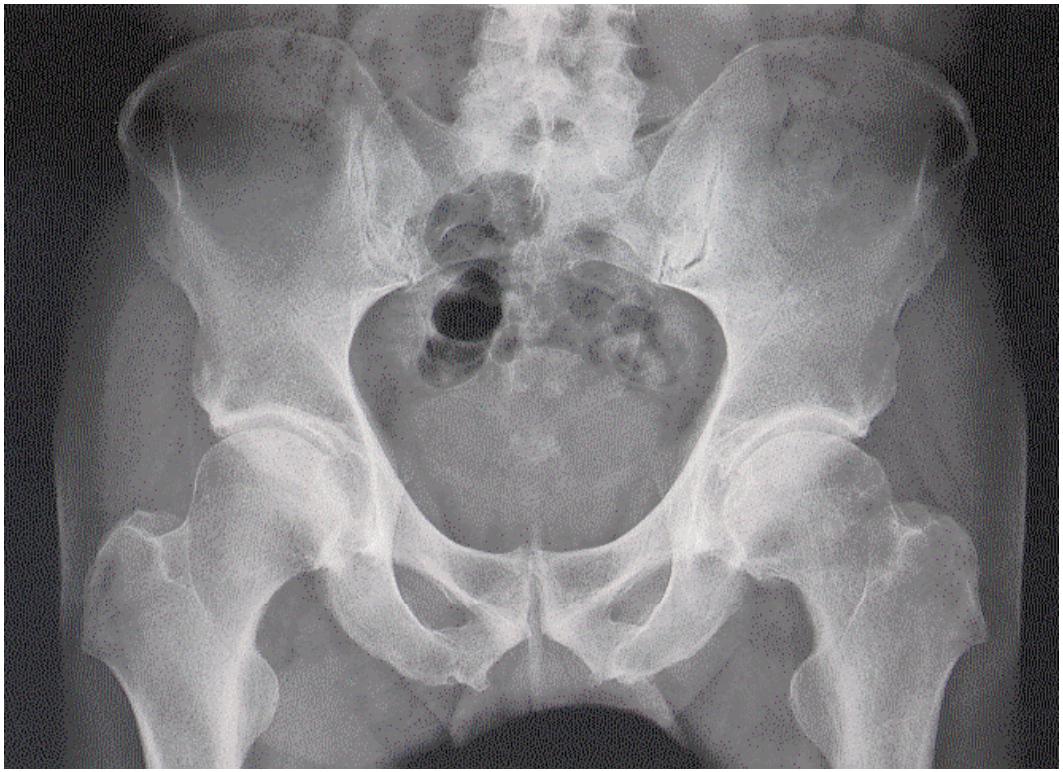


Fission Power Plants



Medical - diagnosis

The left hand of Mrs Röntgen (1895)

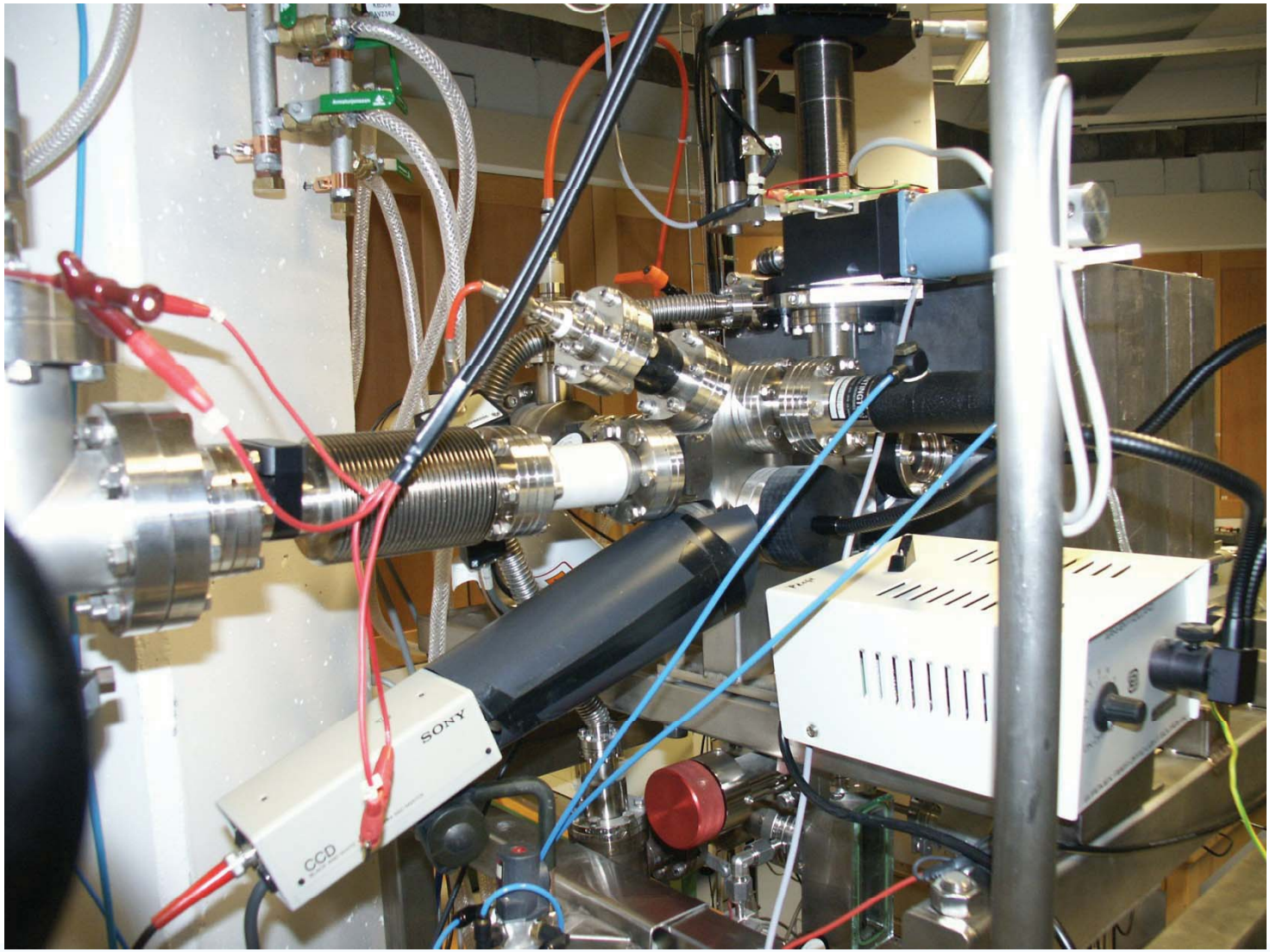


Modern pelvic X-ray examination using digital techniques

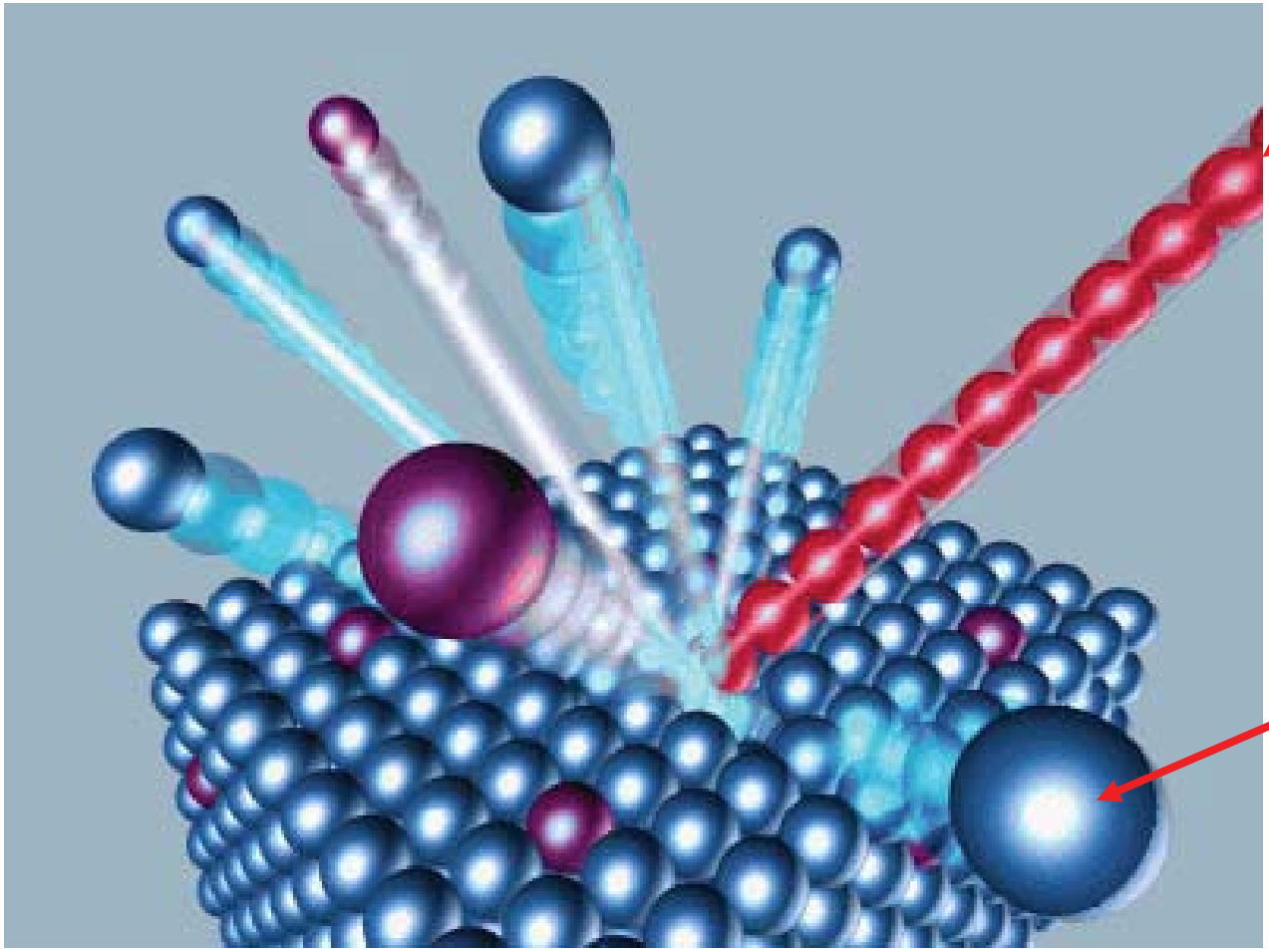
Medical - diagnosis

Medical - therapy

Analytical techniques



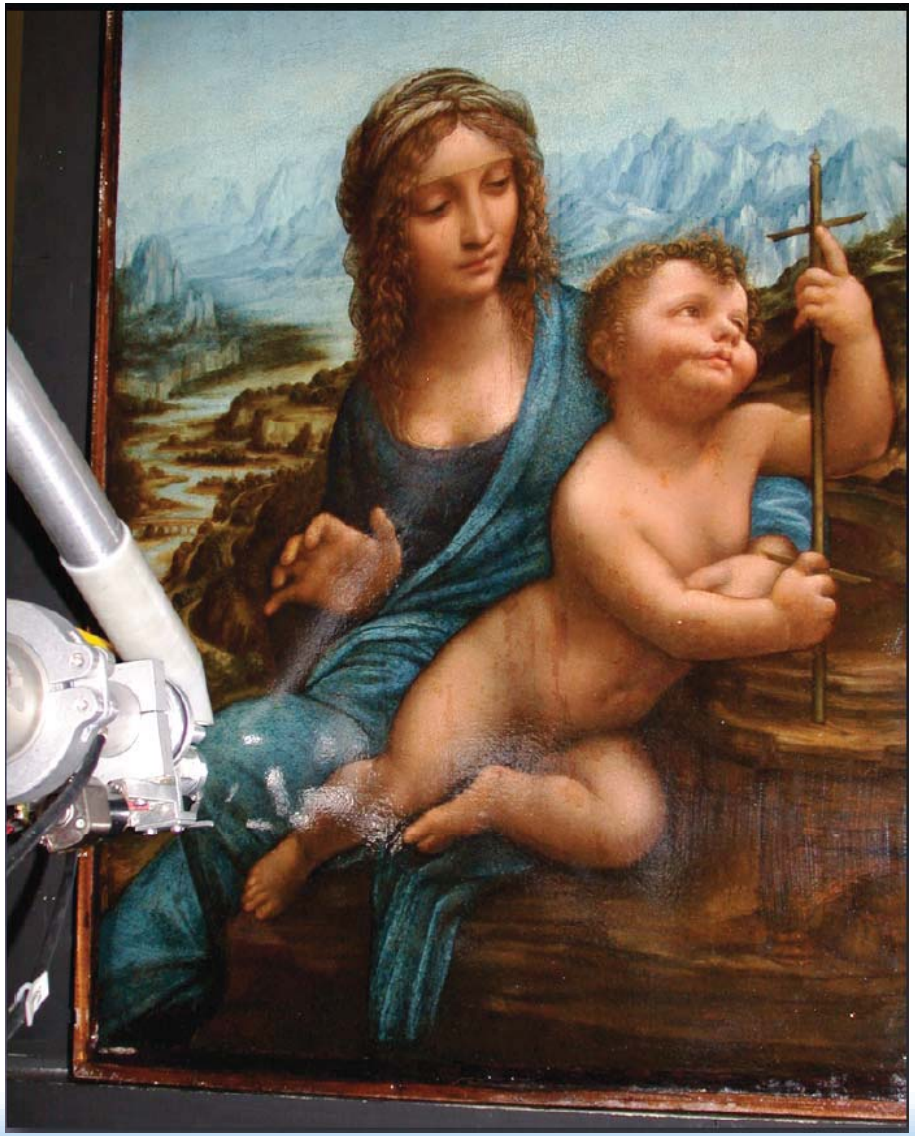
Analytical techniques



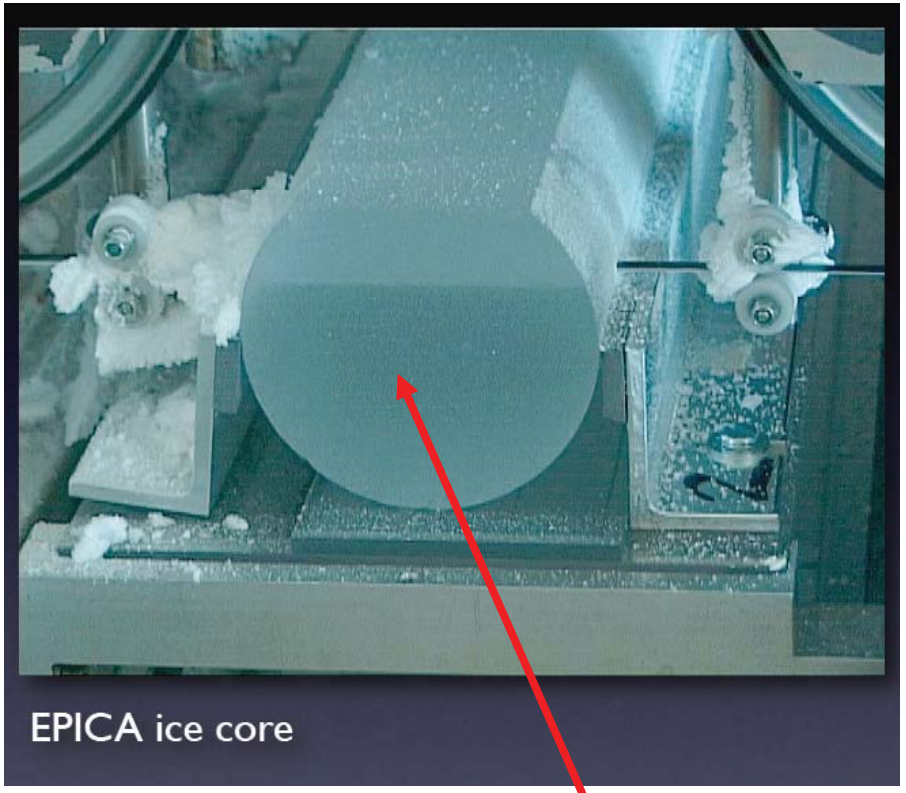
Analytical techniques

PIXE

Particle induced X-ray emission



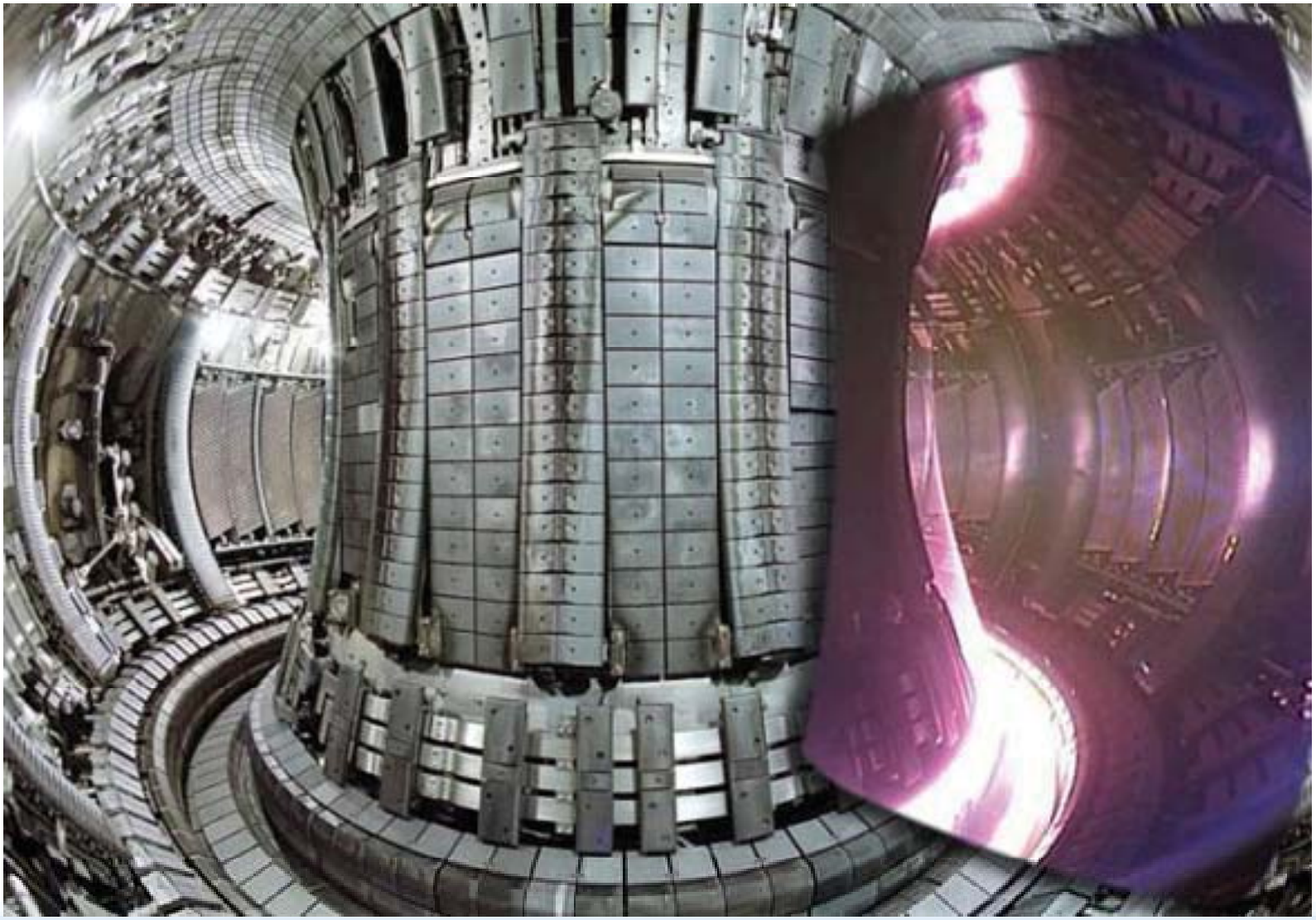
Analytical techniques



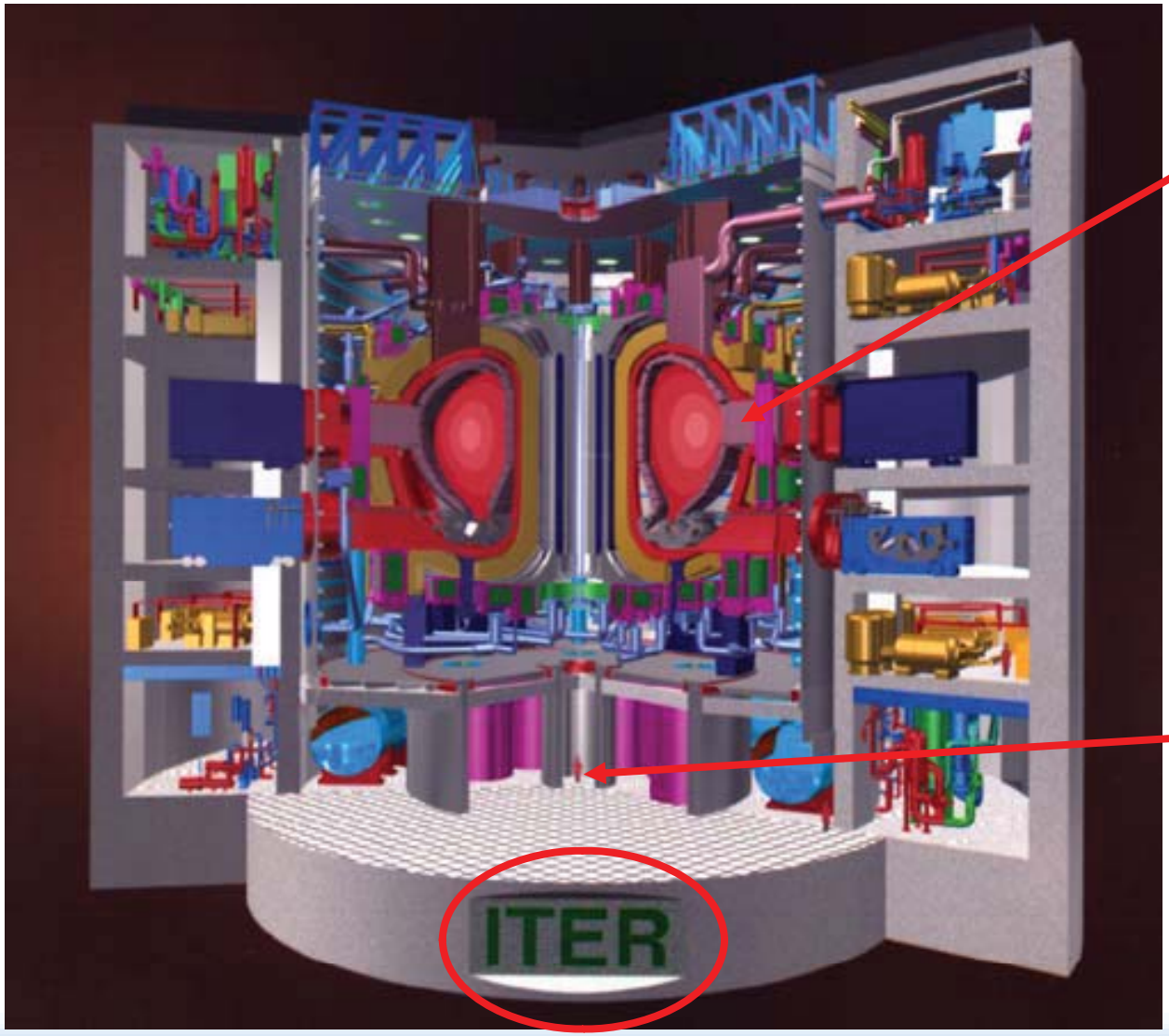
Dust evolution studies

IBA of dust in ice core

Fusion



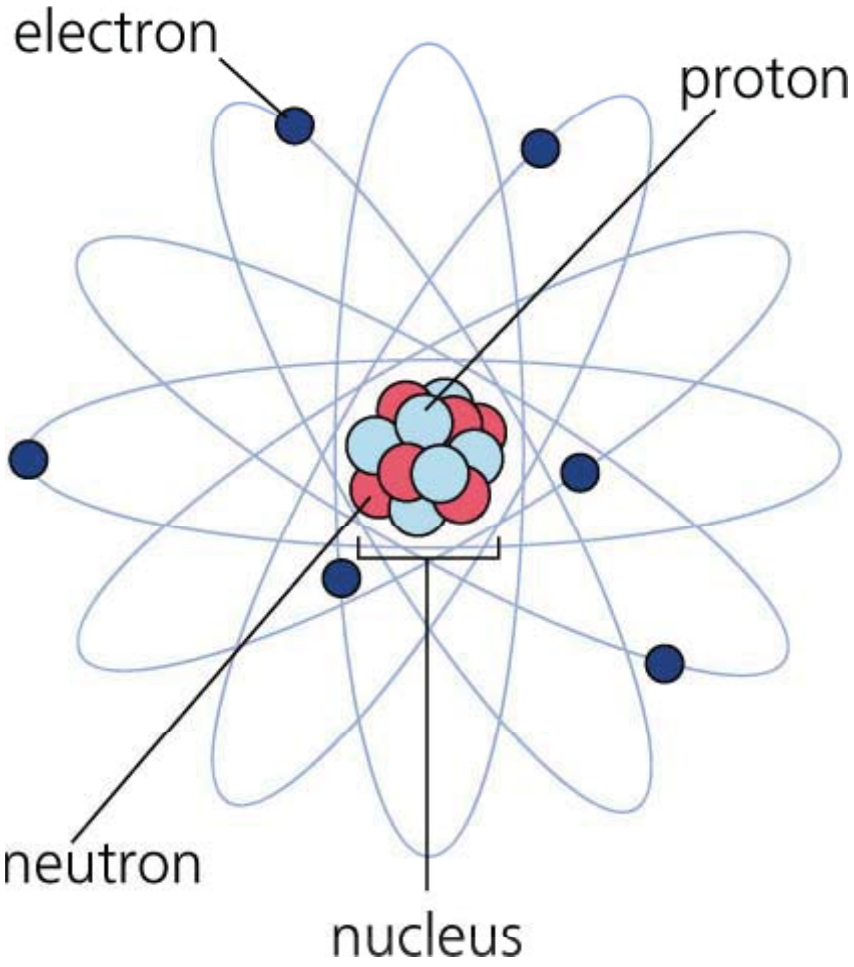
Fusion



Plasma

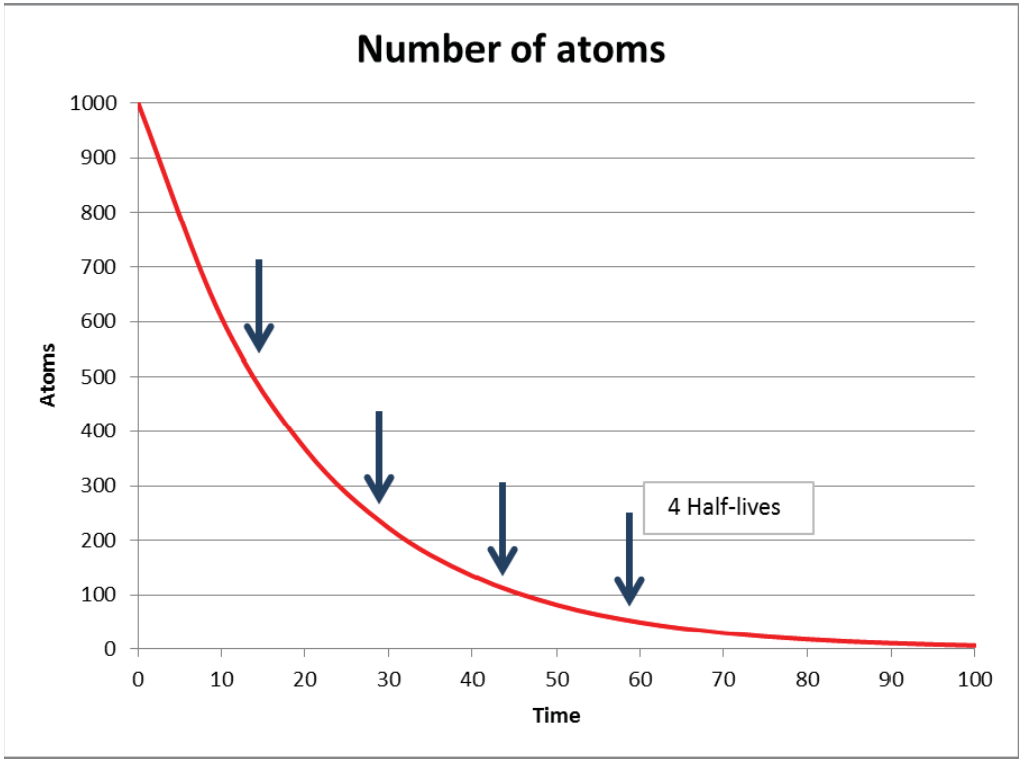
Person

Technical terms



- **Chemistry and atomic physics – electrons**
- **Nuclear physics – interact with nucleus with neutrons or protons**

Decay



- Radioactive atoms decay
- After 4 half-lives only 1/16 left
- Compare to chemical toxicity – lasts forever!

Natural Radioactivity

- We are all ‘radioactive’ because of the ^{14}C and ^{40}K in our bodies
- Actinides such as Thorium and Uranium occur naturally, when we burn coal radioactivity is released from the stack
- Carbon dating relies on ^{14}C being formed in the atmosphere
- We are constantly irradiated by radiation from rocks and cosmic rays

Reaction cross sections

- Production of ^{14}C and the fusion in the sun are examples of nuclear reactions
- Note a nucleus is shown as $^{A}_{Z}X$ or ^{A}X
- When a particle e.g. neutron ‘hits’ a nucleus it can react
- Many types of reaction are possible
- Write as Target(Incoming,Outgoing)Product
- $^{56}Fe(n,2n)^{55}Fe$

(n,2n) reaction

n

n

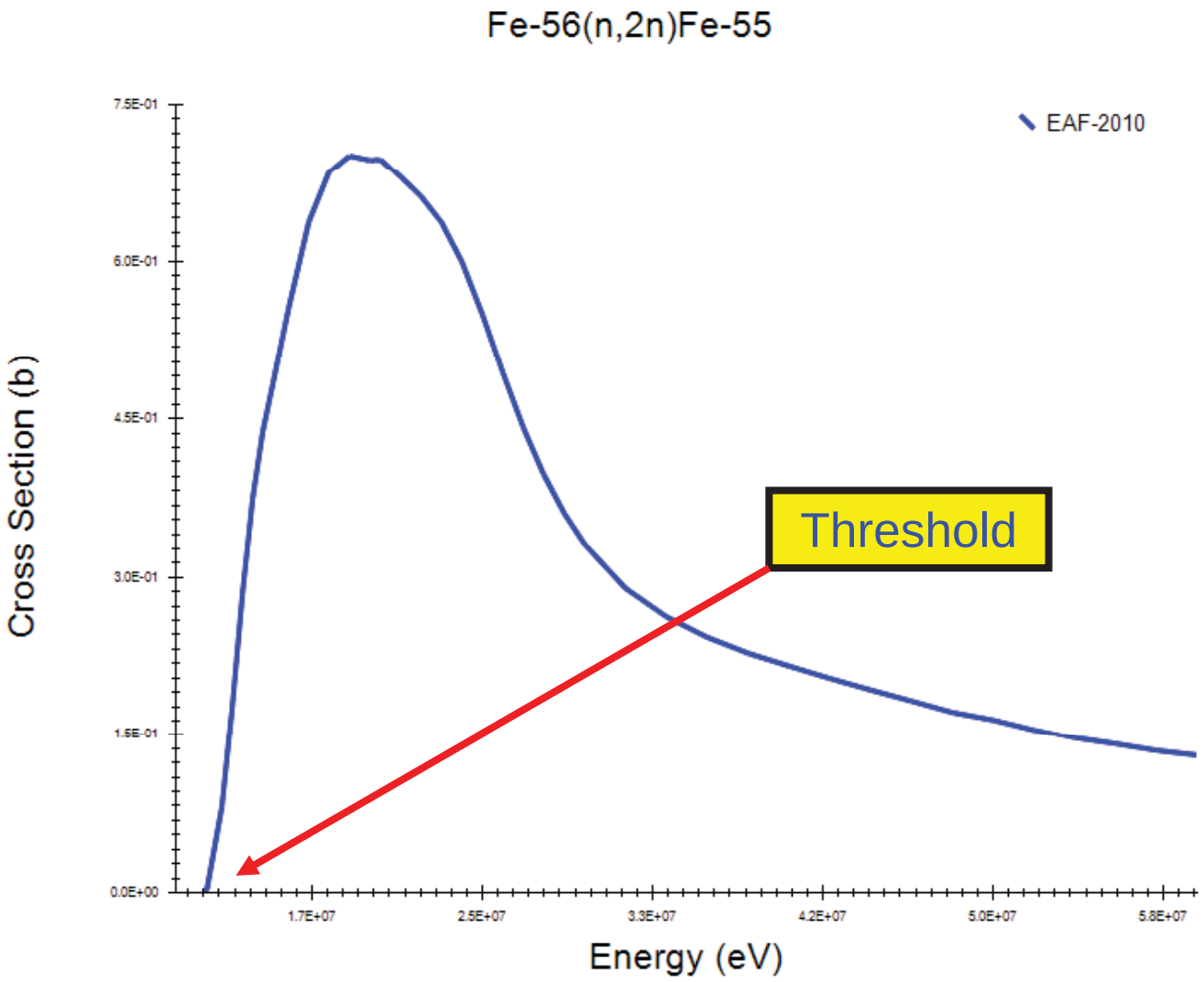
n

$^{A}_{Z}X(n,2n)^{A-1}_{Z}X$

Cross section

- Cross section ≈ Probability of reaction
- Depends on energy (E) of incident particle
- Units barns (b) = 1 10^{-28} m^2
- For a nucleus 1 b cross section is ‘as big as a barn door’!!
- $\sigma(E)$

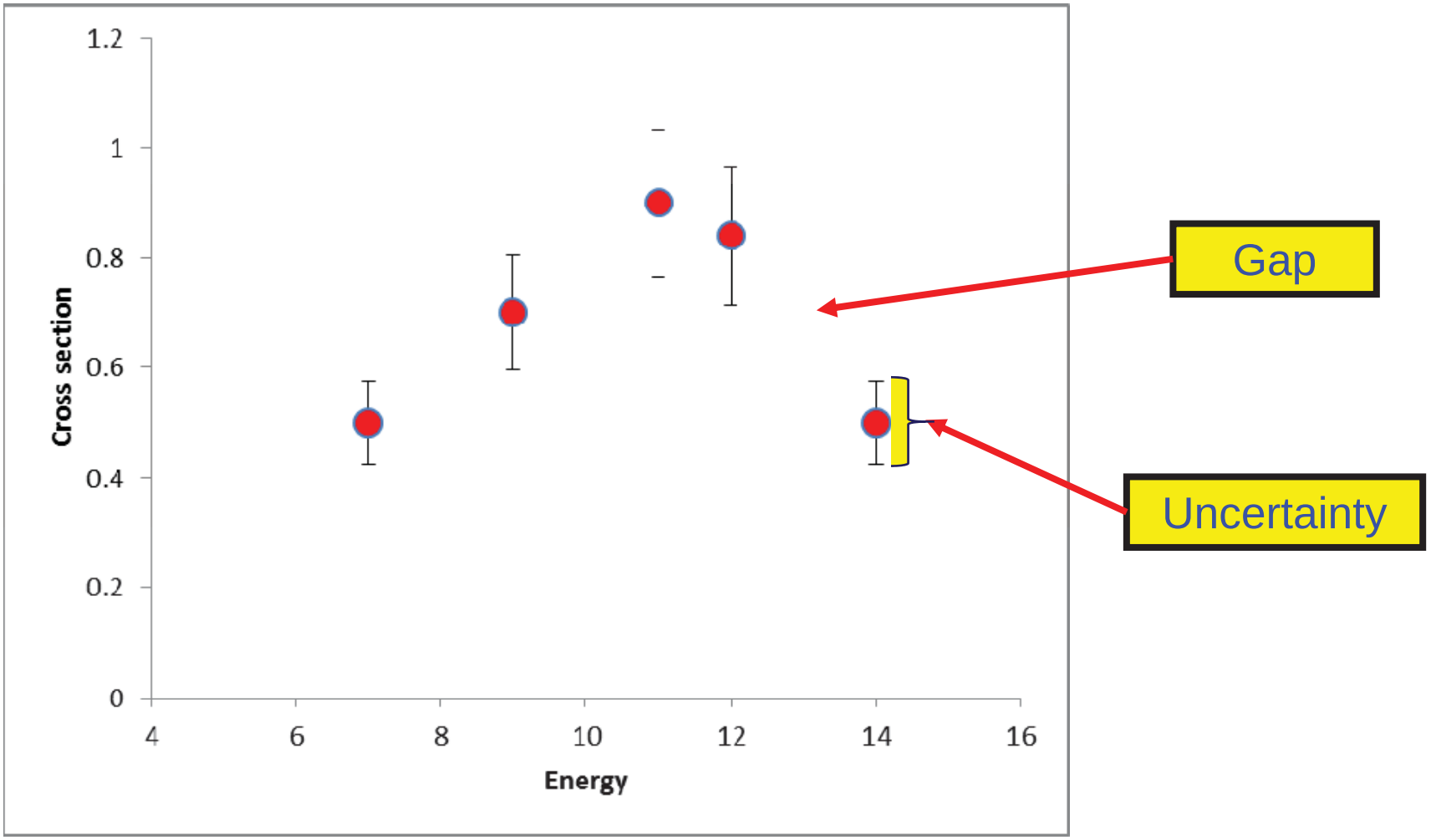
Cross section



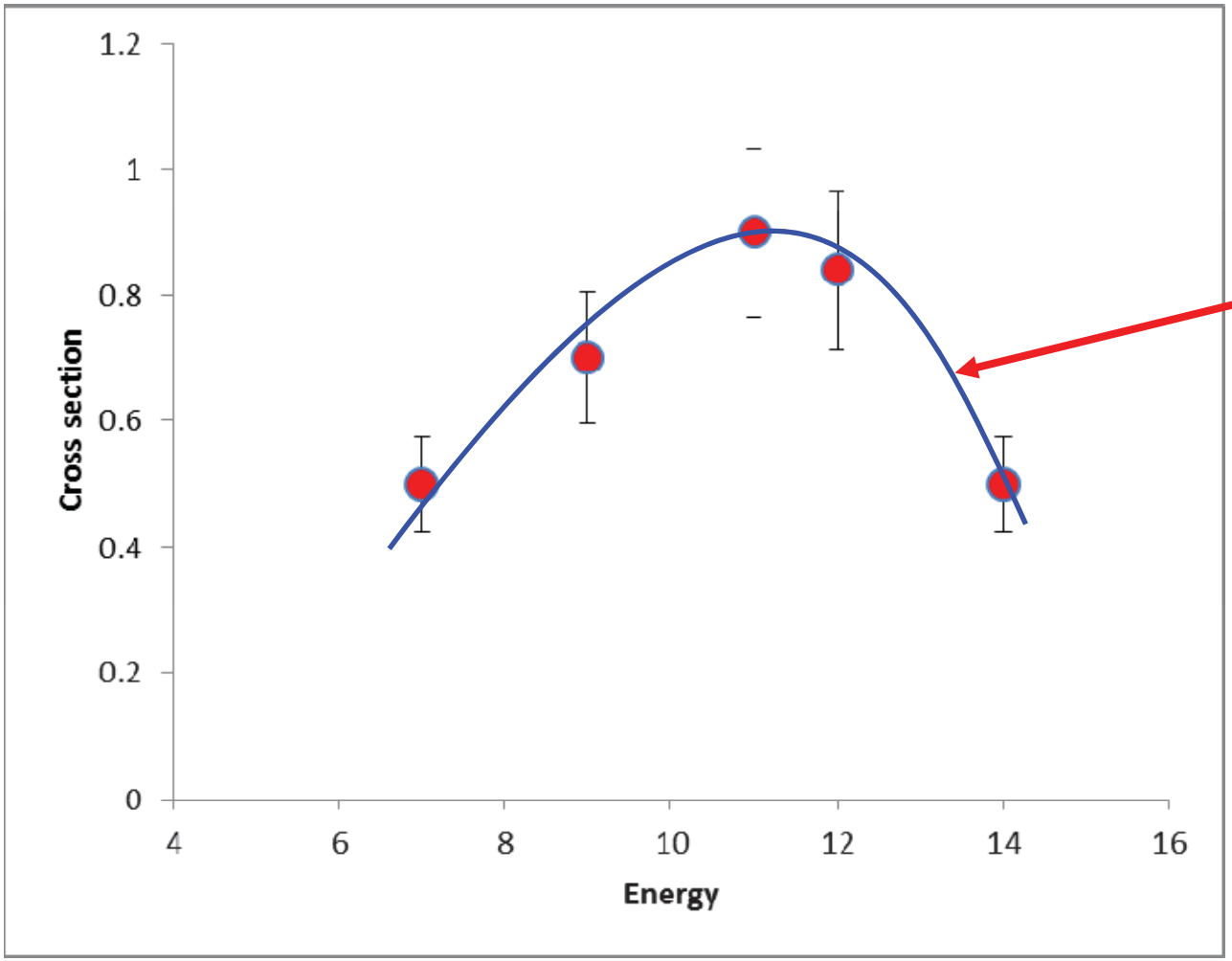
Experiments

- How do we know the values of a cross section?
- Measurements are made at particular energies
- Note that we actually measure a quantity like ‘counts’ and then infer the cross section
- Measurements are not exact

Data


1.2
1
0.8
0.6
0.4
0.2
0
Cross section
4
6
8
10
12
14
16
Energy
Gap
Uncertainty

Data

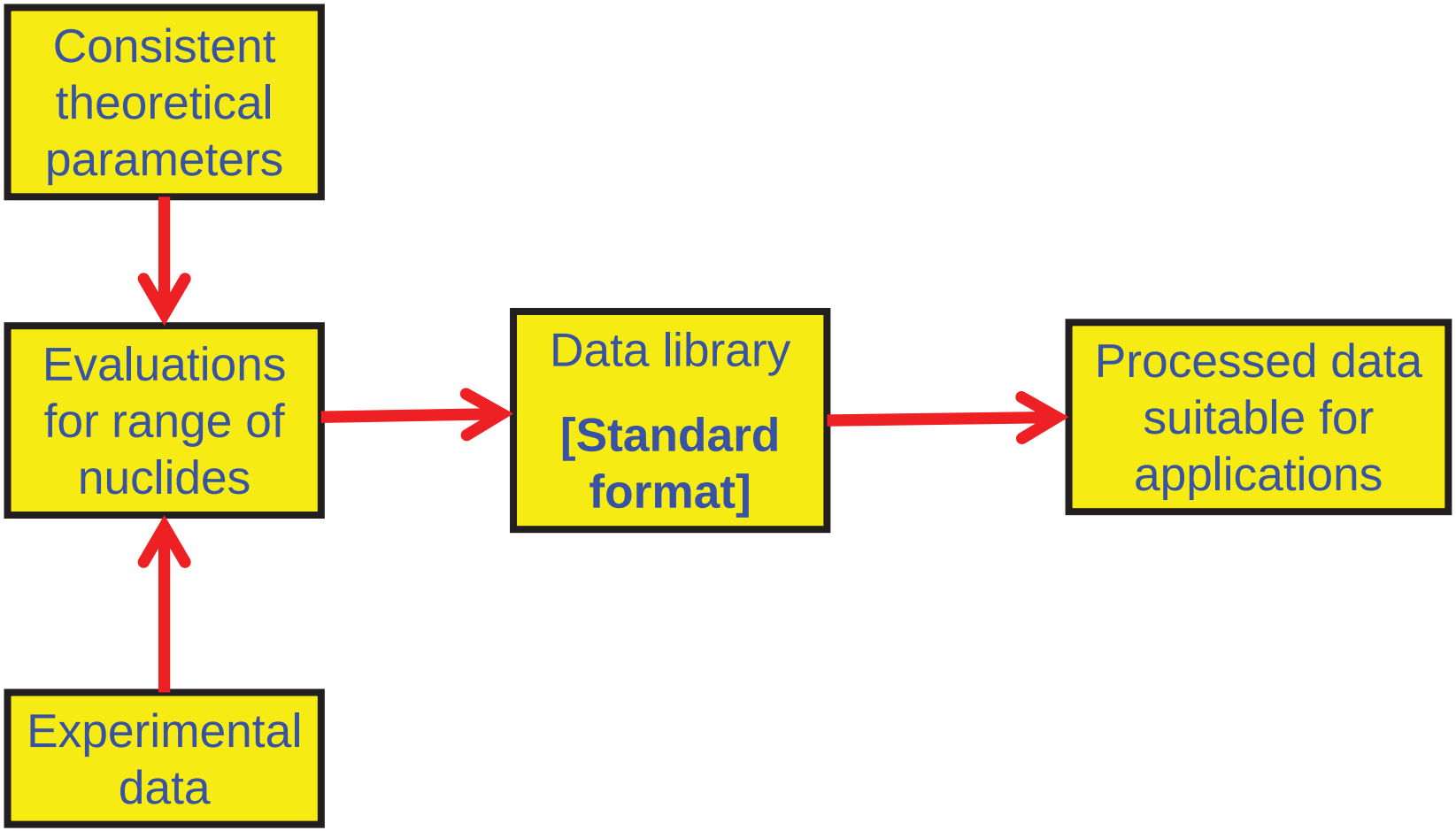


Theory

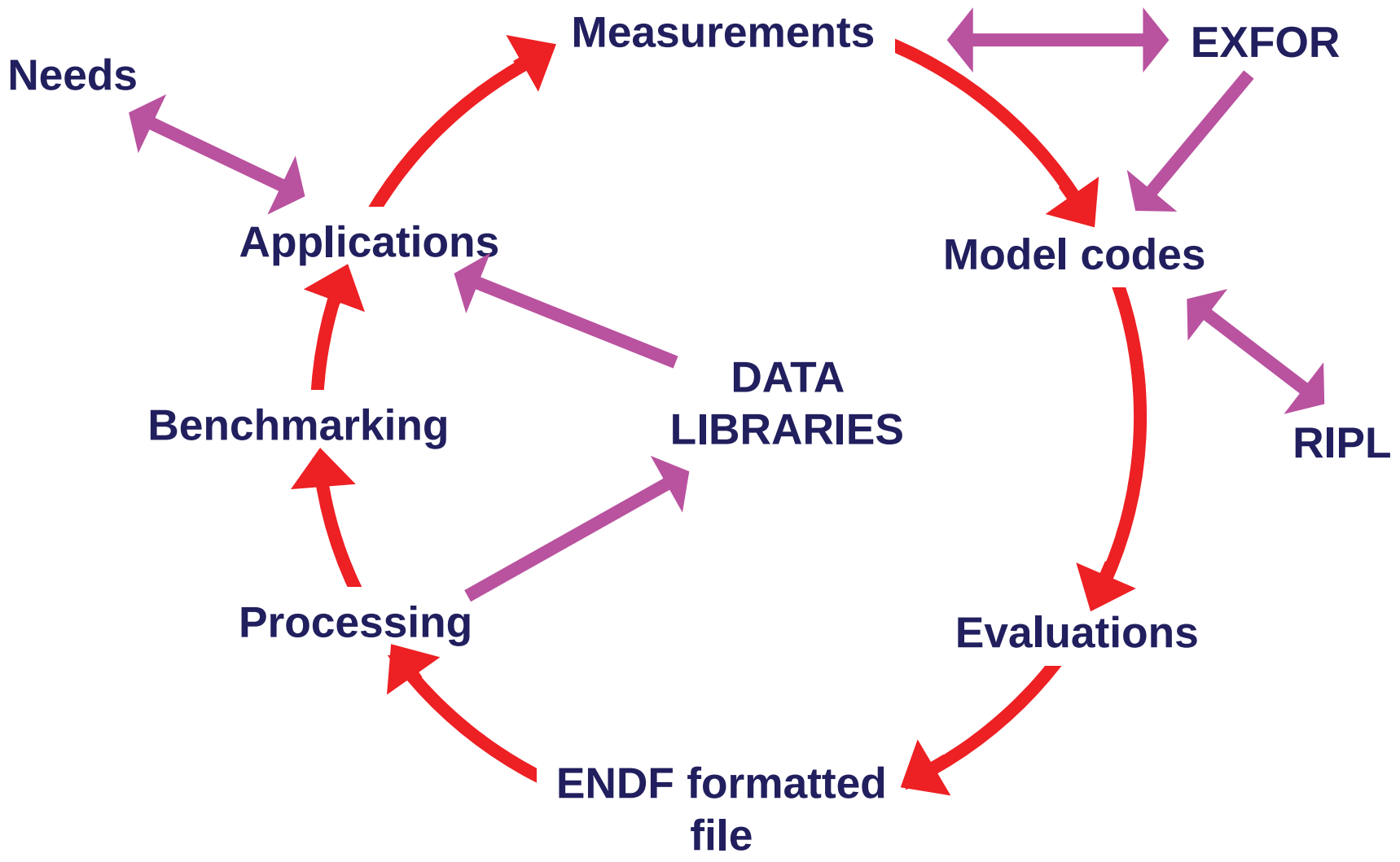
Evaluations

- If the same theory is used for all reactions on the target and fits made to all data
- Theory gives a ‘complete’ description of all reactions
- Put in standard format (ENDF)
- Gives a first evaluation
- Test under wide range of conditions
- Iterate

Data library

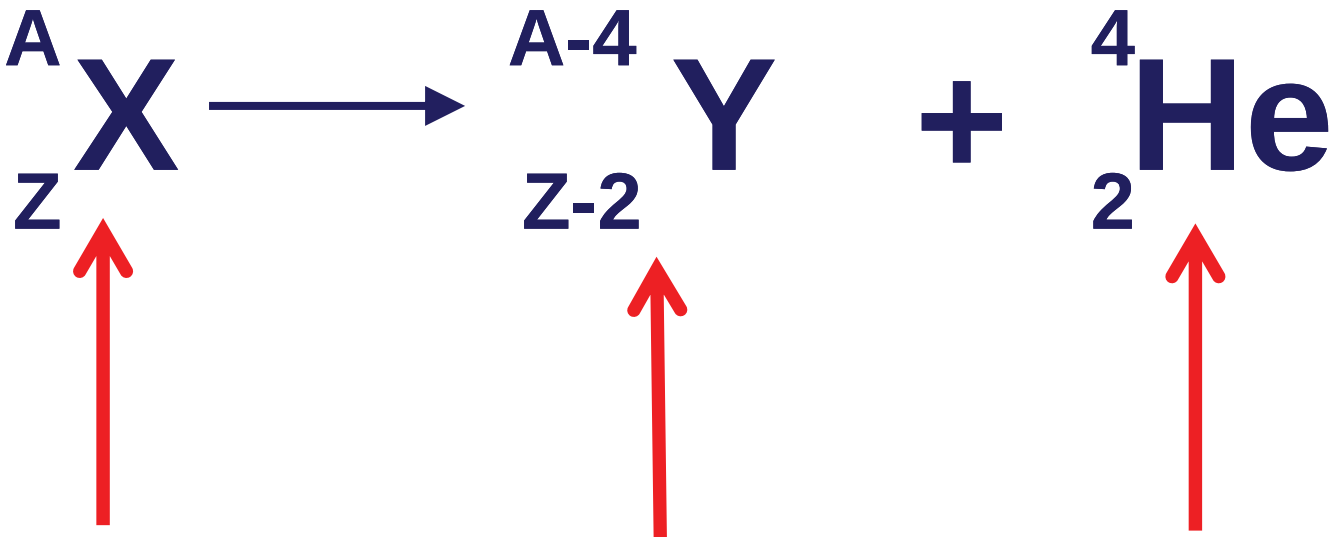


Nuclear data

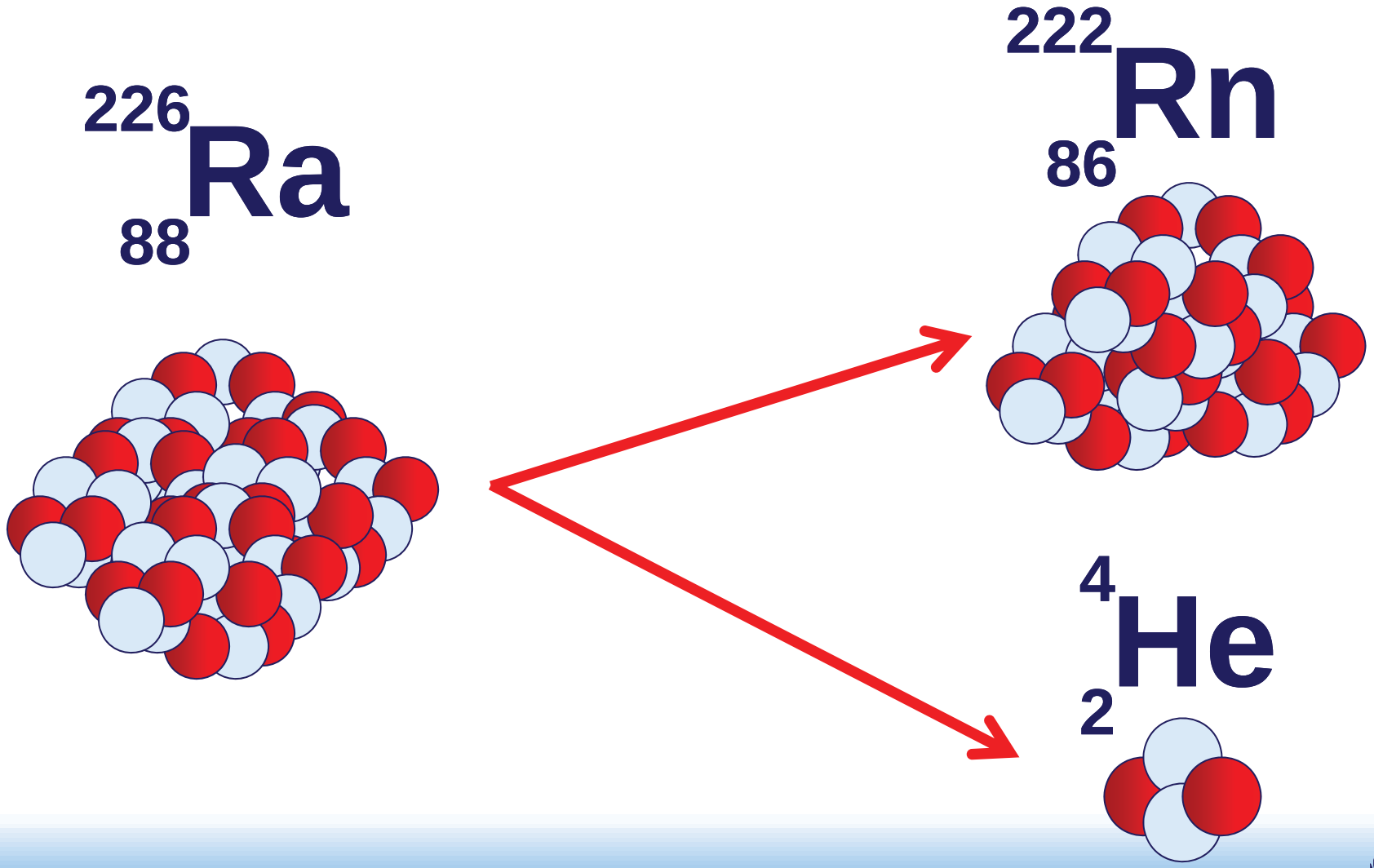


Nuclear structure and decay

Alpha Decay

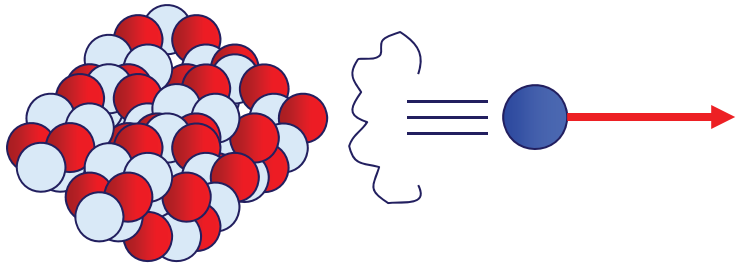


Alpha Decay



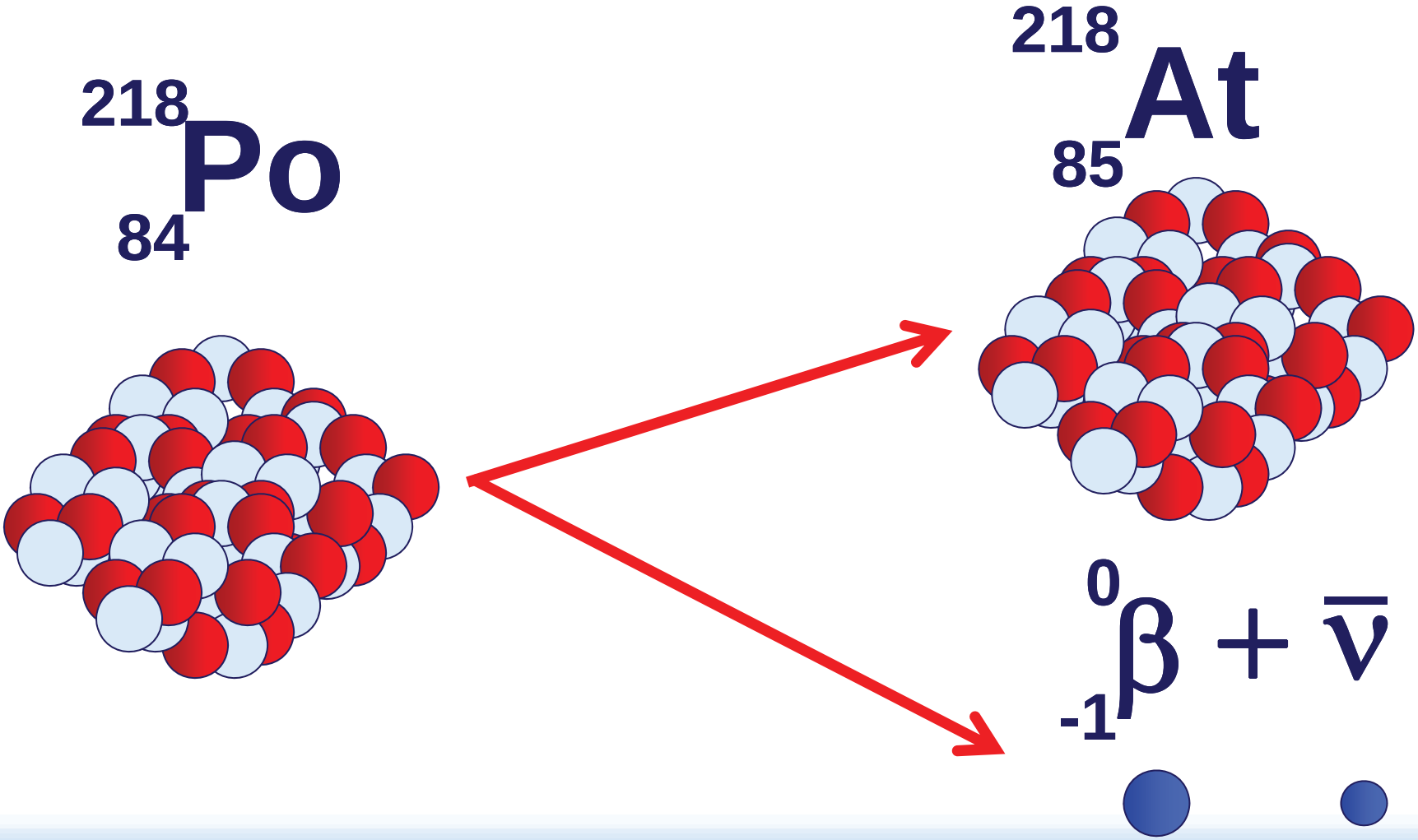
Beta Decay

A beta particle is a fast moving electron which is emitted from the nucleus of an atom undergoing radioactive decay

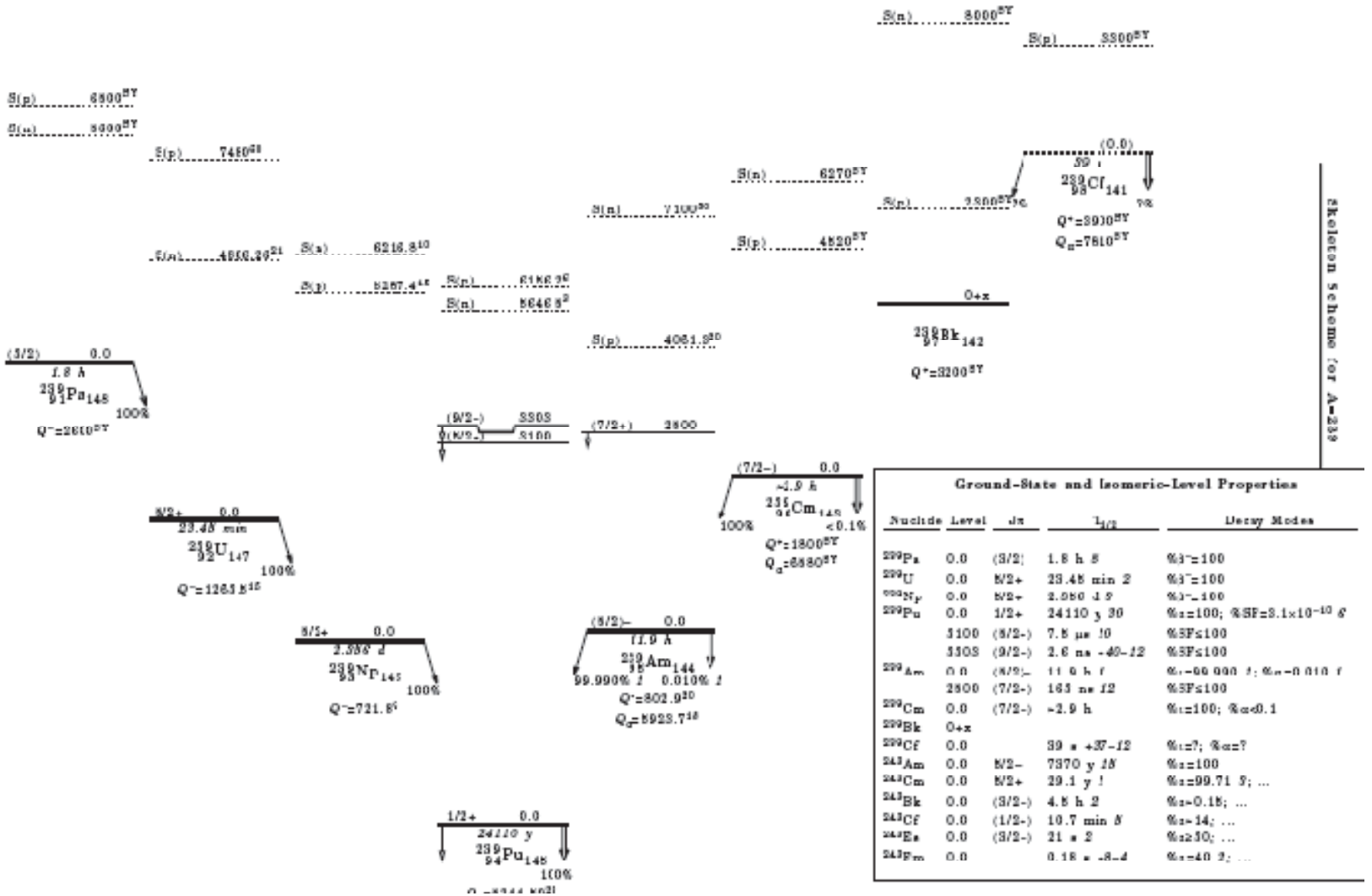


Beta decay occurs when a neutron changes into a proton, an electron and an anti-neutrino

Beta Decay



Nuclear structure and decay



Nuclear Data

- Nuclear Data is a separate field of study from Nuclear Physics
- Not research
- Aim is produce complete, accurate, tested and reliable databases suitable for a range of applications
- Thus Nuclear Data forms the basis for many other studies

Perceptions

- Most ‘non-Nuclear Data specialists’ assume that the data exists and are adequate in the same way as a telephone directory exists
- Data are ‘free’
- Available for all applications particularly ‘new’ ones
- If data exist for fission studies then they should also be available for fusion!

Reality

- Data are not ‘free’
- Require extension and improvement as new applications arise
- Since measurement usually made relative to a standard, as these improve then original data need to be recalculated
- Rather few experts – International collaboration essential
- Core role for a body such as IAEA

Obtaining Nuclear Data

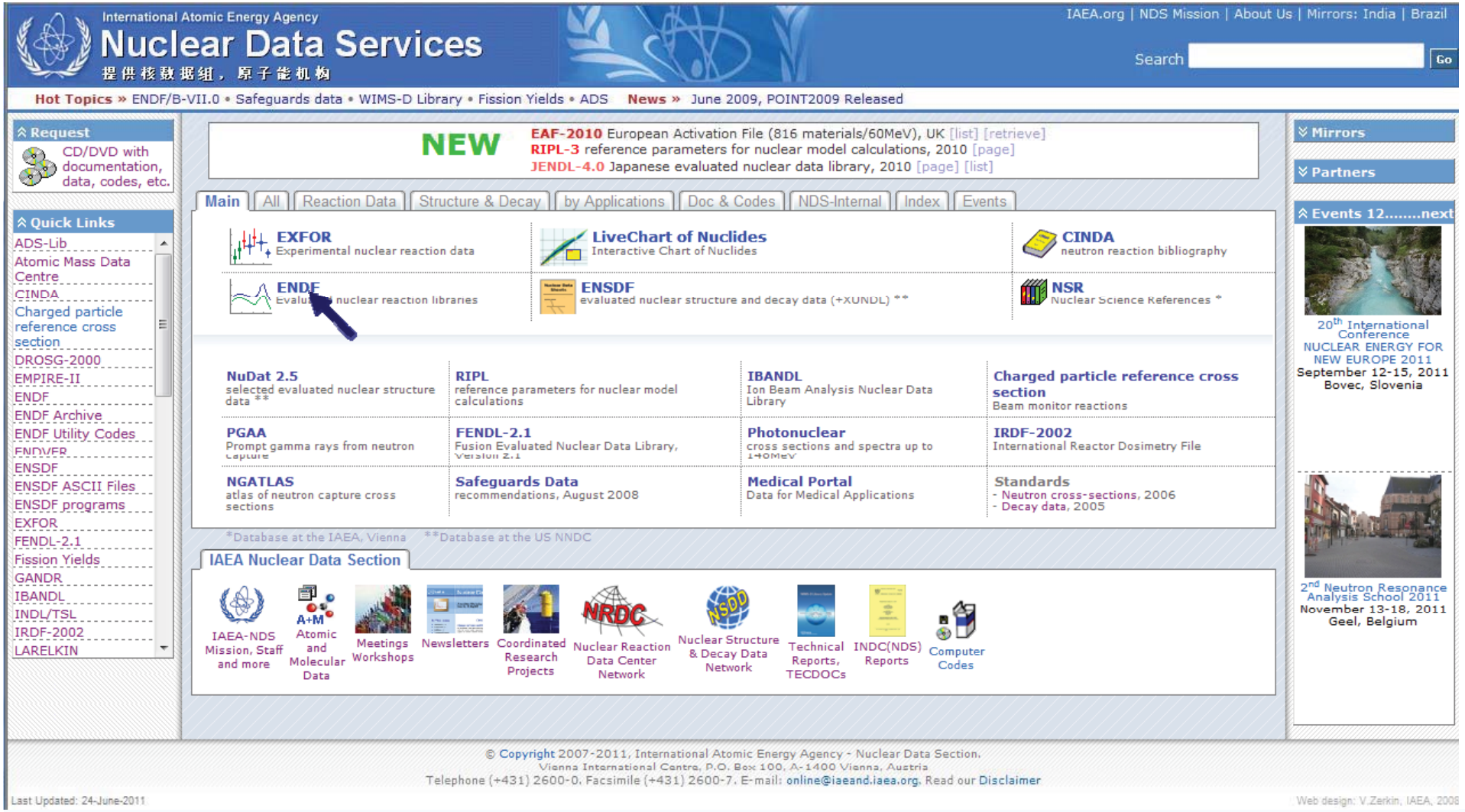
Q. Where to get Nuclear Data?

A. The Internet

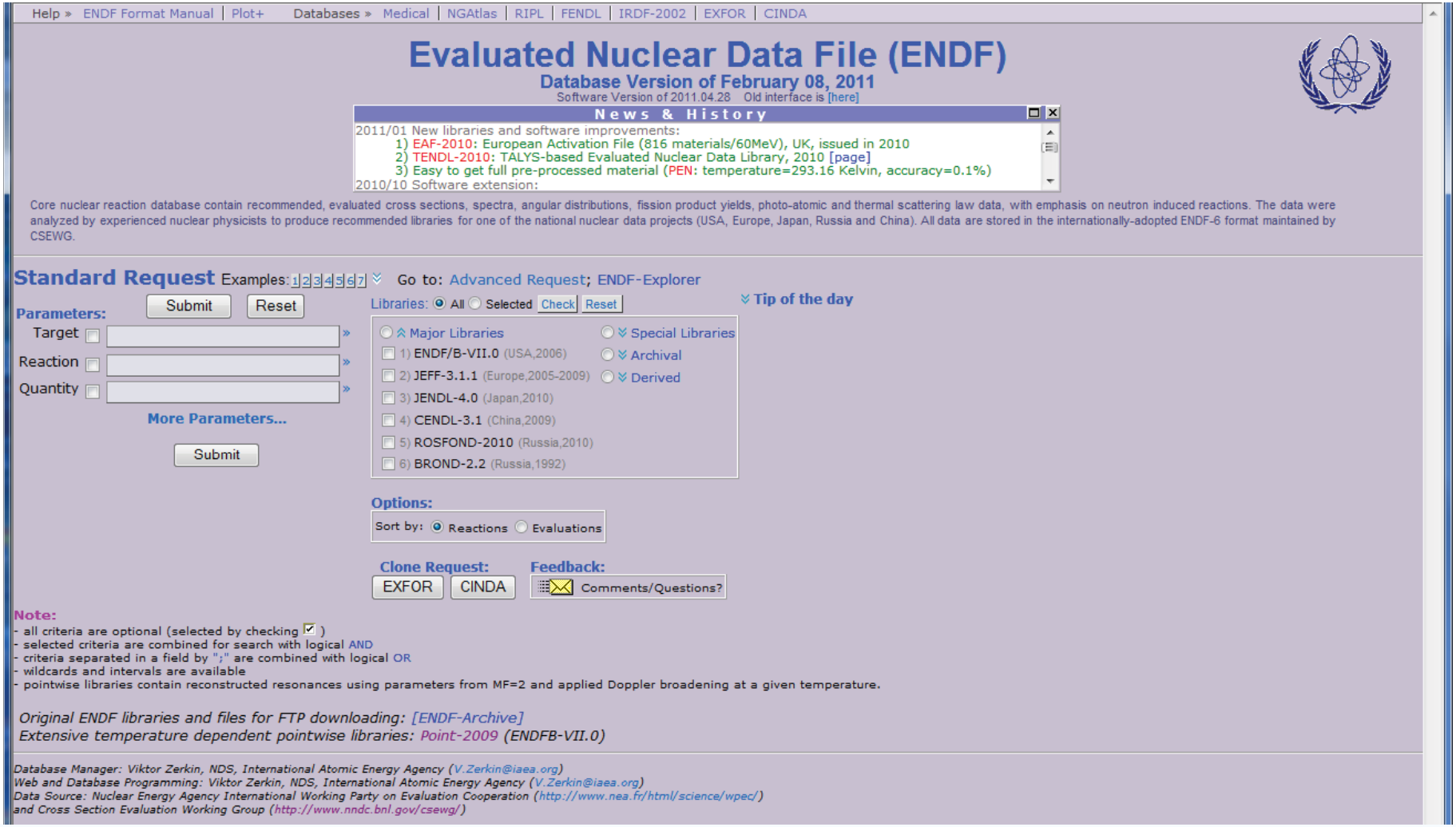
Example:

what is the capture cross section of ^{91}Zr at E_n = 30 keV ?

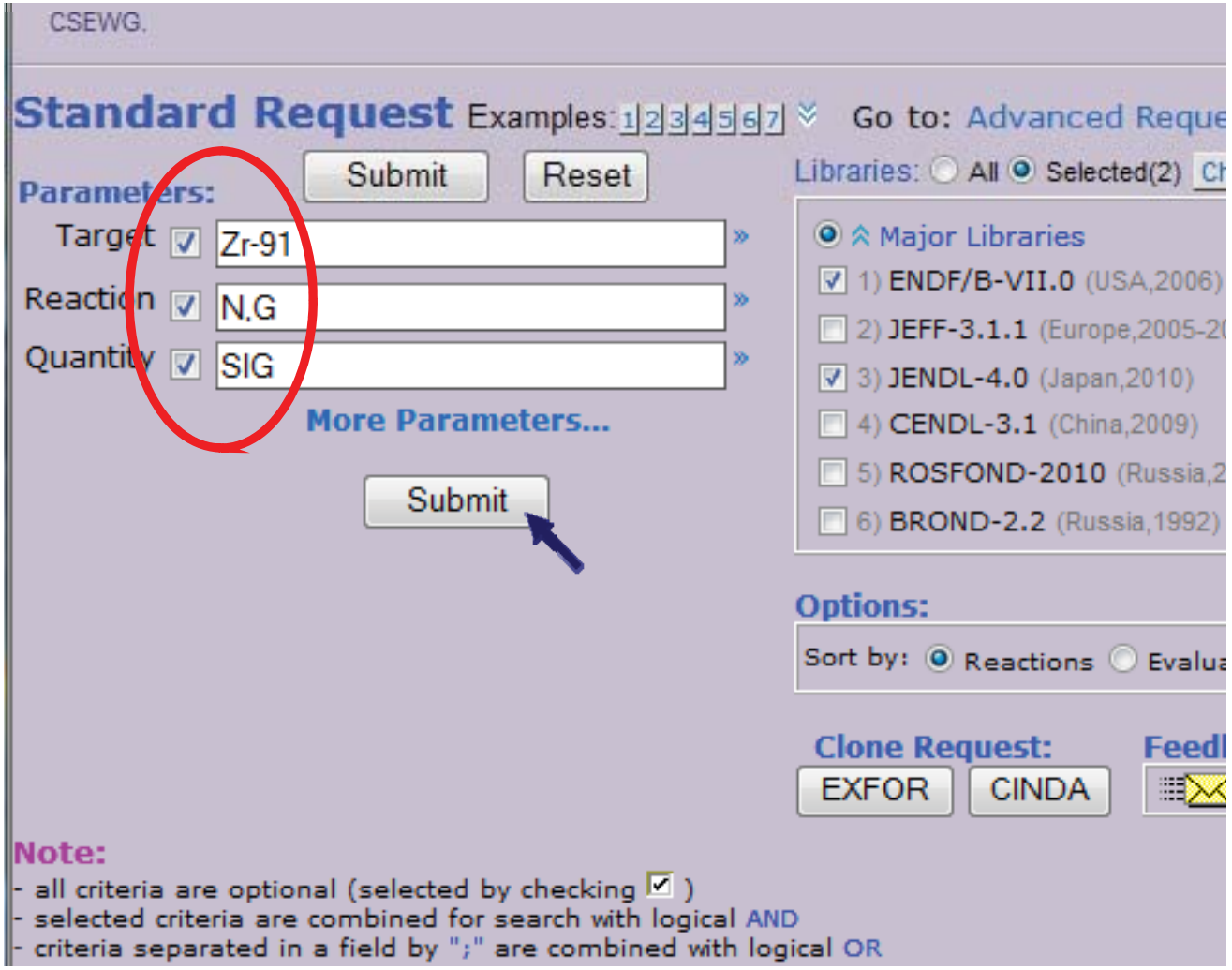
Nuclear Data Online



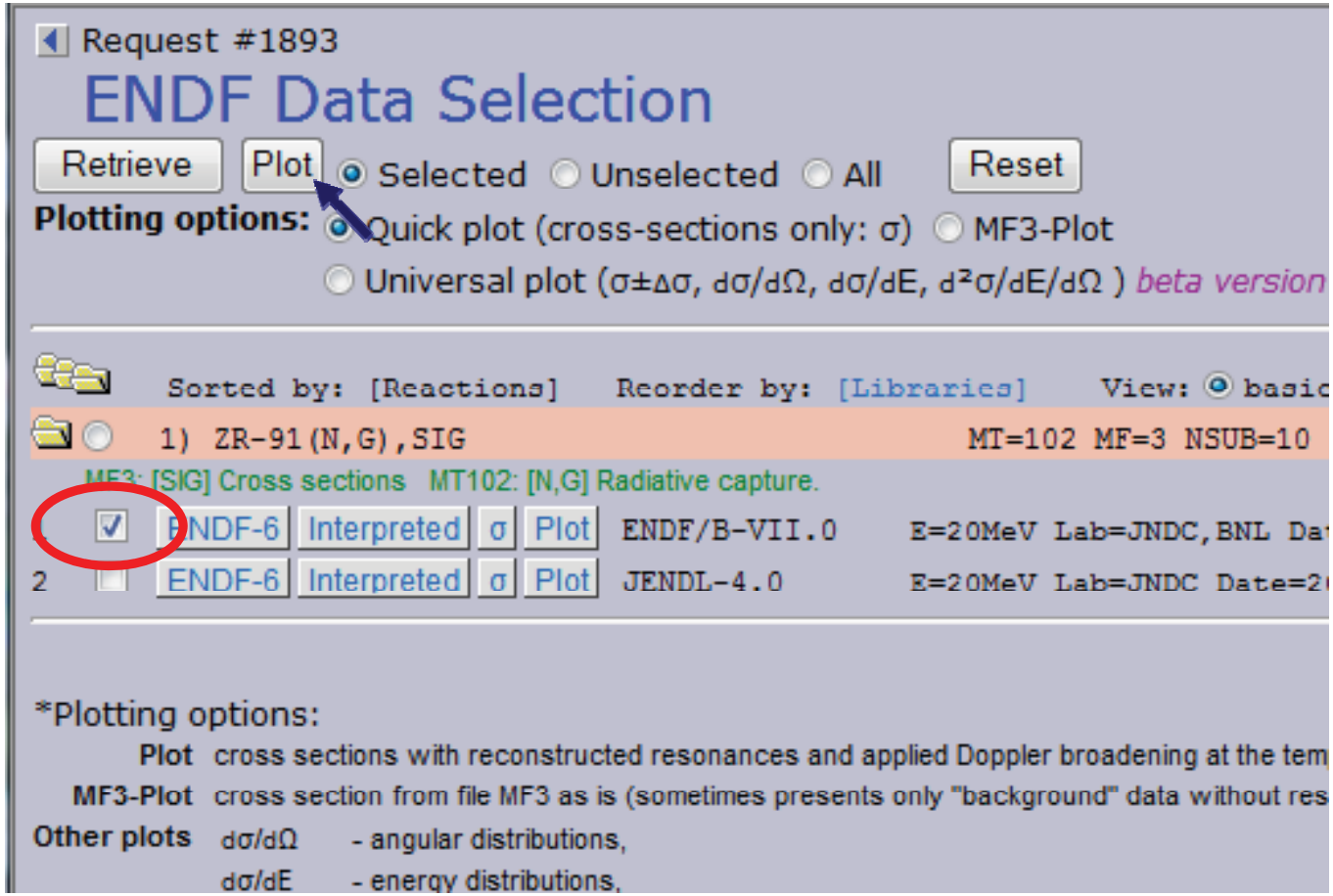
Nuclear Data Online



Nuclear Data Online



Nuclear Data Online



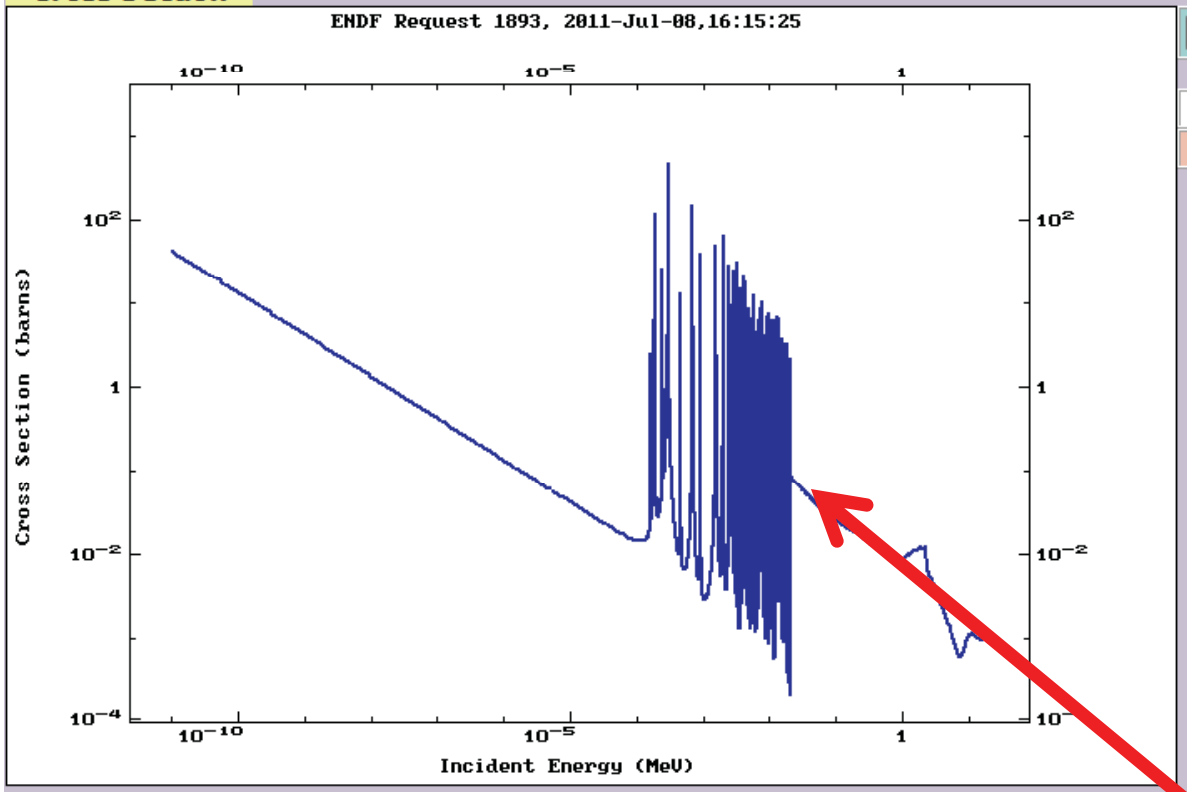
Nuclear Data Online

ENDF Request #1893 (1175)

Output Data

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

Cross Section



Log: XY X Y Lin: XY X Y Auto-range: XY X Y Page: >> << Zoom: <> >< Grid: VH 0 V H Pts: Txt Box PL

Reset Repaint Legend Authors Info+ PostScript Manual options:[+]

Data for plotting: ZVD (536Kb), send to ZVView; download ZVView; upload and plot your ZVD file

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]

See: plotted data (556Kb)

0.025	0.072177
0.0257054	0.070513
0.02625	0.0692284
0.0269907	0.0676302
0.0275	0.0665312
0.028276	0.0649943
0.02875	0.0640554
0.03	0.0617753
0.03125	0.059672
0.0321318	0.0582977
0.0396461	0.0489016

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

Nuclear Data Online

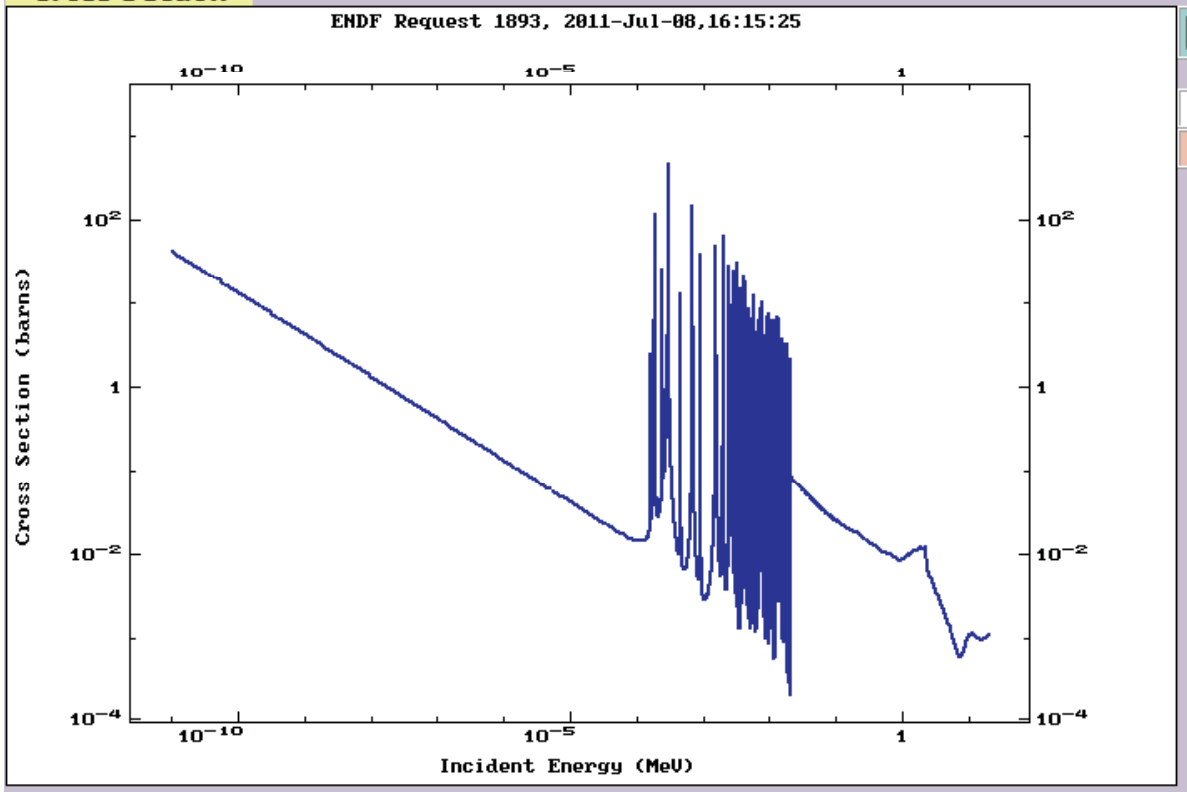
ENDF Request #1893 (1175)

Output Data

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

Easy to add experimental data

Cross Section



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]

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

Reset Repaint Legend Authors Info+ PostScript Manual options:[+]

Data for plotting: ZVD (536Kb), send to ZVView; download ZVView; upload and plot your ZVD file

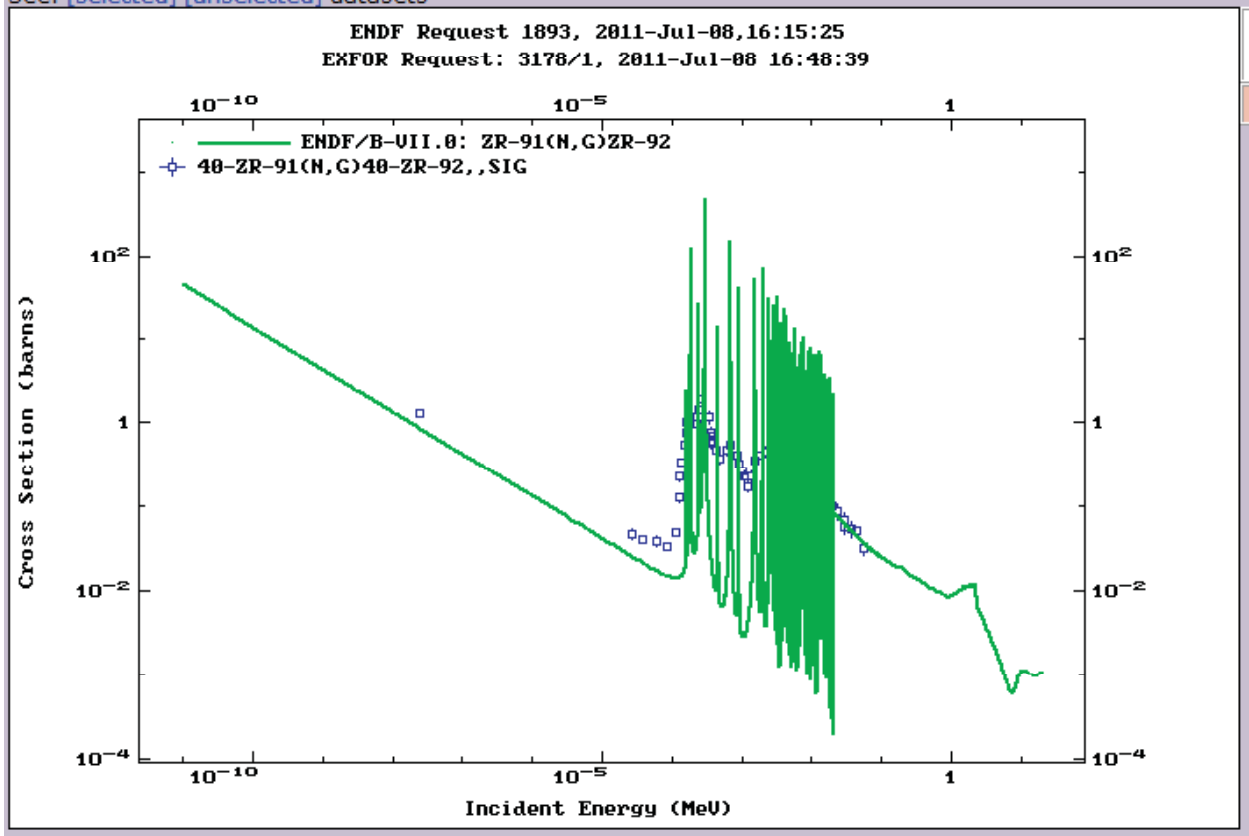
Nuclear Data Online

EXFOR Request #3178/1174 (folowing ENDF Request #1893)

Output Data

Format	Data (Size)
EXFOR	Text (16Kb) ZIP (4Kb) Generate: X4± X4s C5
Bibliography	html (5Kb) BibTeX (2Kb)

See: [selected] [unselected] datasets



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 (561Kb)

Log: XY X Y Lin: XY X Y Auto-range: XY X Y Page: >> << Zoom: <> >< Grid: VH 0 V H Pts: Txt Box PL

Reset Repaint Legend Authors Info+ PostScript Manual options:[+]

Data for plotting: ZVD (542Kb), send to ZVView; download ZVView; upload and plot your ZVD file

EXFOR

- Database of experimental data, from 1935, initially neutron-induced but now enlarged
- Not necessary to read original papers and extract data
- Covers ~19,000 experiments
- Computer readable format
- Includes ~11,500,000 data points

Compilation

PHYSICAL REVIEW C VOLUME 37, NUMBER 2 FEBRUARY 1988

Neutron capture cross section of ^{197}Au: A standard for stellar nucleosynthesis

W. Ratynski* and F. Käppeler
Kernforschungszentrum Karlsruhe, Institut für Kernphysik, D-7500 Karlsruhe, Federal Republic of Germany
(Received 19 October 1987)

We have measured the neutron capture cross section of gold using the ^{7}Li(p,n)^{7}Be reaction for neutron production. This reaction not only provides the integrated neutron flux via the ^{7}Be activity of the target, but also allows for the simulation of a Maxwellian neutron energy spectrum at $kT = 25$ keV. As this spectrum is emitted in a forward cone of 120° opening angle, the cross section can be measured in good geometry and independent of any other standard. Systematic uncertainties were studied experimentally in a series of activations. The final stellar cross section at $kT = 25$ keV was found to be 648±10 mb, and extrapolation to the common *s*-process temperature $kT = 30$ keV yields 582±9 mb. This result is used for renormalization of a number of cross sections which had been measured relative to gold.

I. INTRODUCTION

The importance of the neutron capture cross section of gold as a standard in the keV region initiated a number of measurements. In the energy range of astrophysical interest around 30 keV neutron energy, differential data obtained with time-of-flight (TOF) techniques as well as data obtained with the activation technique are available. Conversion of these results to stellar cross sections is achieved by folding with the Maxwellian neutron energy distribution

$$\Phi \sim E_n \exp(-E_n/kT) . \quad (1)$$

For nucleosynthesis by slow neutron captures (*s* process) the common thermal energy is $kT = 30$ keV, corresponding to temperatures of 3.5×10^8 K, as they are typical for helium burning in red giant stars. According to the definition

$$\frac{\langle \sigma v \rangle}{v_T} = \frac{2}{\sqrt{\pi}} \frac{\int_0^\infty \sigma(E_n) E_n \exp(-E_n/kT) dE_n}{\int_0^\infty E_n \exp(-E_n/kT) dE_n} , \quad (2)$$

the stellar capture cross section can easily be derived from differential data, $\sigma(E_n)$. Here, E_n is the total kinetic energy in the center-of-mass system. The factor $2/\sqrt{\pi}$ comes from the normalization of the Maxwellian flux formula, using the mean thermal velocity $v_T = (2kT/m)^{1/2}$ (m being the reduced mass) instead of the average velocity. Table I collects all recent gold cross sections, while data prior to 1971 are represented by the evaluation of Allen, Gibbons, and Macklin.[1] The respective experimental cross sections for 30±3 keV are listed in column 4. Maxwellian averages were calculated if the differential data covered a sufficiently large energy range. Otherwise, the 30 keV value was simply multiplied by the factor $2/(1.05\sqrt{\pi})$; this approximation was derived from the data of Macklin[2] and accounts for the fact that the cross section falls slightly steeper than $E_n^{-0.5}$.

Inspection of Table I shows a confusing situation: Most Maxwellian averages[3–6] group around 640±20 mb, except the values of Macklin[2] and of Yamamuro *et al.*,[7] which are at 590±20 mb, but with both groups being characterized by similar uncertainties. In view of this discrepancy and because of their relevance for the present study, the measurements of Macklin[2] and of Zhu *et al.*[6] will be discussed in more detail.

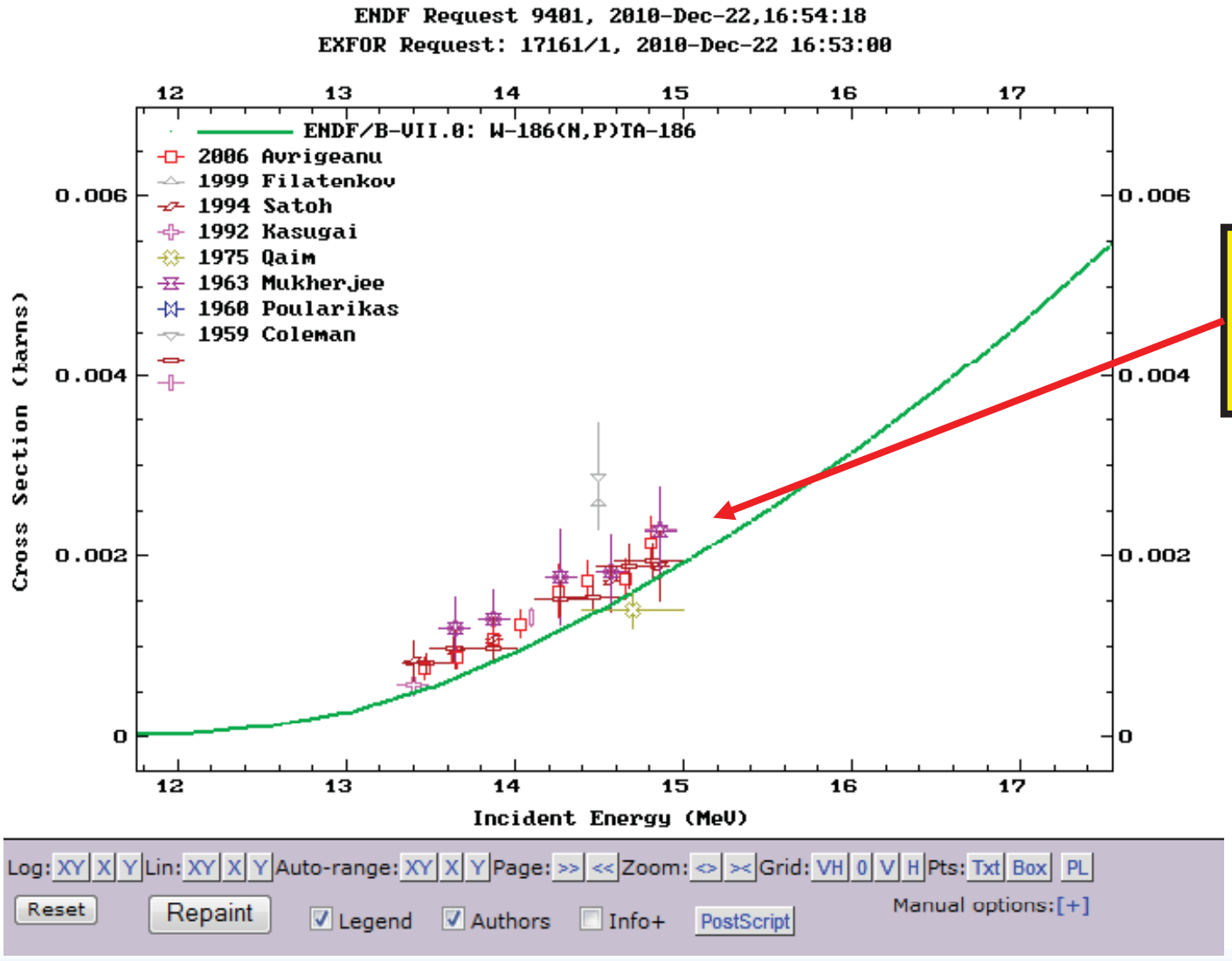
The data given by Macklin[2] were obtained in a measurement of Macklin, Halperin, and Winters,[8] but were later revised at energies below ~100 keV due to an error in data processing. These cross sections were measured relative to the ^{6}Li(n,α) cross section between 3 and 550

```
ENTRY          22099      910716              20050926       0000
SUBENT      22099001      910716              20050926       0000
BIB               18          96
REFERENCE   (J,PR/C,37,(2),595,8802)
TITLE       -NEUTRON CAPTURE CROSS SECTION OF AU-197 - A STANDARD
             FOR STELLAR NUCLEOSYNTHESIS.
AUTHOR      (W.RATYNSKI,F.KAEPPELER)
INSTITUTE   (2GERKFK)
FACILITY    (VDG,2GERKFK) A VAN DE GRAAFF ACCELERATOR DELIVERED A
             BEAM OF 1912 KEV PROTONS. THE ACCELERATOR WAS OPERATED
             IN A DC MODE DURING IRRADIATIONS AND IN PULSED MODE
             WHEN OBTAINING THE NEUTRON ENERGY SPECTRUM WITH TIME-
             OF-FLIGHT. THE BEAM CURRENT HAD A DENSITY OF LESS THAN
             1 MICROAMP/MM2.
CRITIQUE    .ALTHOUGH THE TERM 'MAXWELLIAN SPECTRUM' IS USED
             THROUGHOUT THE PAPER THIS IS UNDERSTOOD IN A STELLAR
             CONTEXT, THE ACTUAL AVERAGE CROSS SECTION (<SIGMA>KT)
             BEING DEFINED AS THE AVERAGED REACTION RATE (CROSS
             SECTION MULTIPLIED BY VELOCITY) DIVIDED BY THE MEAN
             THERMAL VELOCITY (VT) WITHIN THE STELLAR PLASMA OF
             THERMAL ENERGY KT :
                <SIGMA>KT  = <SIGMA X VELOCITY>/ VT
             USING THE ACCEPTED MAXWELL VELOCITY DISTRIBUTION
             FORMULA THE TERM VT CAN EASILY BE SHOWN TO BE
             (2KT/M)**0.5, M BEING THE REDUCED MASS. THIS IS EQUI-
             VALENT TO FOLDING THE CROSS SECTION WITH AN ENERGY
             SPECTRUM PROPORTIONAL TO A MAXWELLIAN DISTRIBUTION
             TIMES VELOCITY (E(N) X EXP(-E(N)/KT)) WITH A NORMAL-
             ISATION FACTOR OF 2/(PI)**0.5, INSTEAD OF A TRUE
             MAXWELLIAN (E(N)**0.5 X EXP(-E(N)/KT)). IT IS THIS
             FORMER SPECTRUM THAT IS REPRODUCED EXPERIMENTALLY
             USING THE P-LI7 SOURCE, AND THE RESULTING AVERAGE
             CROSS SECTION WITHOUT THE 2/(PI)**0.5 FACTOR APPEARS
             IN THE DATA TABLE.
```

IAEA role

- Coordinate the network of data centres throughout the world doing compilation
- Maintain Master EXFOR file
- Do compilation
- Maintain format and documentation
- Develop tools to search and visualise

Visualisation

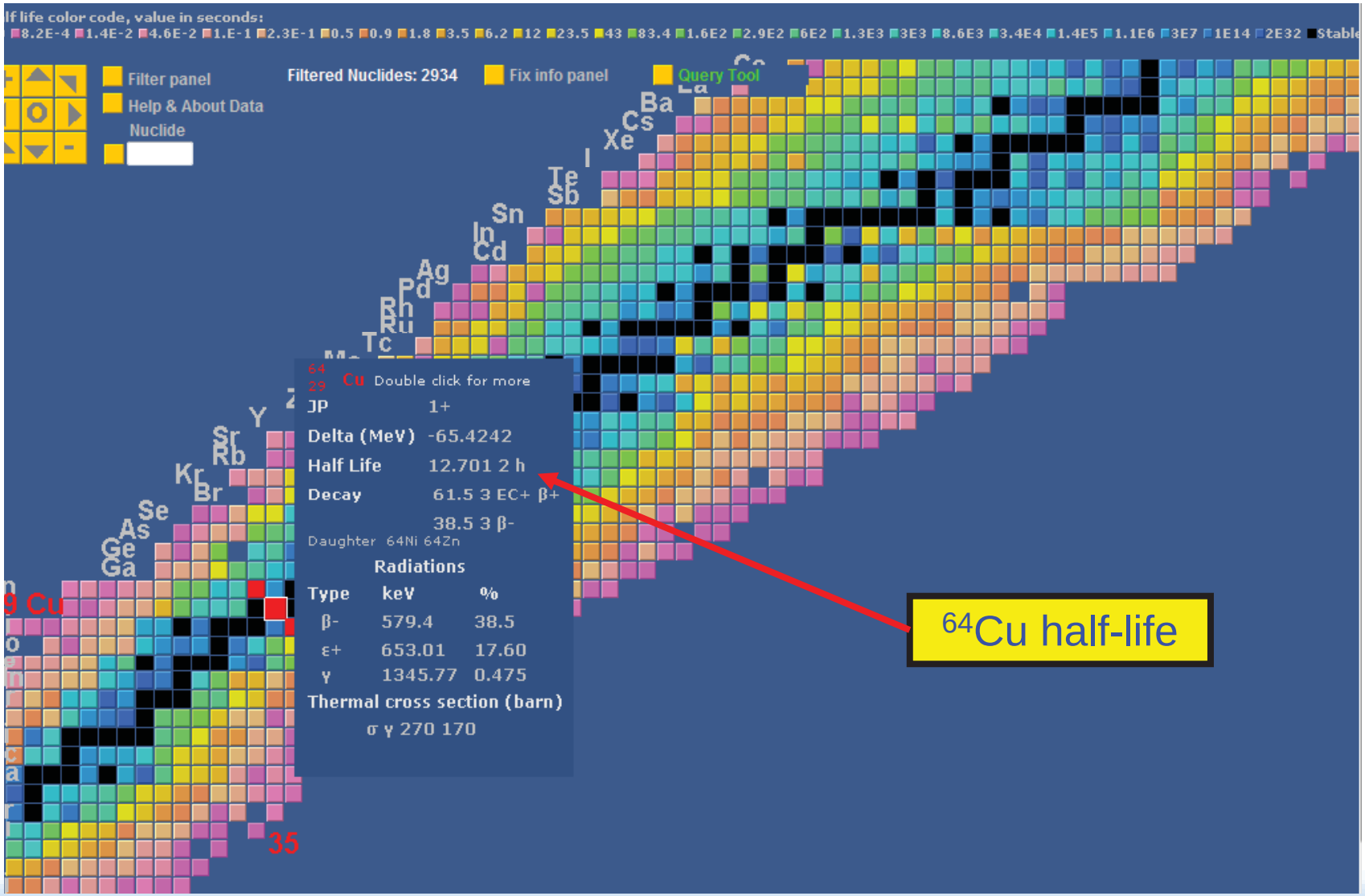


EXFOR data compared to evaluated data

ENSDF

- Database of evaluated data for properties of nuclides (structure and decay)
- Results published in printed form
- Interactive computer programme valuable
- IAEA has developed LiveChart

Data for nuclides - LiveChart



RIPL

- Model codes (theoretical calculations) require many input parameters
- Previously very time consuming to collect
- Not sure if data up to date and consistent
- Now use RIPL (Reference Input Parameter Library)
- Produced by IAEA over 15 years
- Universal

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

Next update of the RIPL-3 scheduled for January 2011.

Introduction | MASSES | LEVELS | RESONANCES | OPTICAL | DENSITIES | GAMMA | FISSION | CODES | Contacts

Nuclear Levels Segment

Enter nuclide and retrieve

Discrete Levels and Decay Data

Compilation of nuclear level schemes extracted from the ENSDF (CD-ROM in the Table of Isotopes - version 1998). Missing spins were inferred uniquely from spin distributions constructed using the available spins up to the highest known level. Missing Internal Conversion Coefficients (ICC) were calculated using inferred or available spins. Decays other than electromagnetic are given if available.

Retrieval of Discrete Levels

Atomic number (Z)

Mass number (A)

retrieve reset

Discrete Levels in the GNASH Format

Atomic number (Z)

Cumulative Plot

Atomic number (Z)

Mass number (A)

Max Excitation Energy auto MeV

plot reset

Bibliographic

- Information on all relevant papers can be found in databases such as CINDA and NSR
- CINDA – nuclear reactions
- NSR – originally covered nuclear structure but now enlarged
- Enter requests interactively

Computer Index of Nuclear Reaction Data (CINDA)

Database Version of December 07, 2010
Software Version of 2010.03.23

CINDA contains bibliographic references to measurements, calculations, reviews, and evaluations of neutron cross-sections and other microscopic neutron data; it also includes index references to computer libraries of numerical neutron data available from four regional neutron data centers.
Since 2005, database is extended by photonuclear and charged particle reaction data.

Standard Request (example);

Submit Reset

Target	☑	Al-27
Reaction	☑	n,tot
Product	☐	Na-24
Quantity	☑	CS
Old Quantity	☐	NG
Energy from	☐	0 to ☐ 20e6 eV
Work type	☐	E
1-st Author	☐	Norman
Laboratory	☐	1USAANL; 2GERKFK; 4CCPFEI
Publication year	☐	1970-2002
Last modified	☐	1970/01/01-2001/12/31
Area	☐	1; 3
Country	☐	CAN; GER
Short Reference	☐	J,NIM; 4,EXFOR
Full Reference	☐	J,NIM,86,83; R,INDC-156
Comment	☐	Ohkubo.*; Shen+*; Malik+*

Submit Reset

Options

Sort: ◉ by Reactions ○ by References
☐ Show full CINDA-blocks
☐ Include lines imported from NSR [Test]

Ranges

		Target	Product
Z	☐	13-15	☐ 13
A	☐	0;27-29	☐ 28

Clone Request:
EXFOR ENDF

Feedback:
Comments/Remarks?

Enter target and reaction type

Request #119015
CINDA Data Search Results: Reactions: 1; Lines: 527; Full Blocks:212

Data Selection

Submit Reset

Data for Output: ○ Selected ○ Unselected ◉ All

Output Formats: ☑ CINDA ☑ Bibliography ☐ EXFOR ☐ Show full CINDA-blocks

	n	Lab	iLn	Energy range,eV		Work	Type	Reference	Date	[Author] Comment	Display	[NSR-Key]
○	1)	13-AL-27(N,TOT),CS		OldQuantity=[TOT]								
☐	1	1USADKE	1	1.0+05	8.0+07	Theo	Jour	J,PR/C,70,064604	2004	Nagadi+Cc Disp Olmp Spin-Spin Vol Int	L B .	2004NA40
☐	2	2JPNOSA	1	1.40+07		Expt	Conf	C,2004SANTA,1,769	2004	Murata+	L B .	
☐	3		2	1.40+07		Expt	Data	4,EXFOR22743.002	200707	.1pt	L .	X4
☐	4	2GERTHS	1	7.0-04	1.0+00	Eval	Jour	J,NSTS,2,124	200208	Bernnat+.AT 100 AND 293K.FIG CFD EXP	L B .	
☐	5		2	7.0-04	1.0+00	Eval	Conf	C,2001TSUKUB,1,124	200110	Bernnat+.SAME AS NSTS, 2, 124	L . .	
☐	6	2SPNSPN	1	1.0+05	2.5+08	Theo	Jour	J,PR/C,65,(3),4616	200203	Molina+ DISP OMP	L B .	
☐	7	1USAORL	1	1.0+02	6.0+05	Expt	Conf	C,2001TSUKUB,,346	200110	Guber+ ORELA. GRPH TRNSM.	L B .	
☐	8		2	1.0+02	+05	Expt	Abst	A,BAP,4[illegible],1	199911	Guber+ PPR ID01. ORELA. NDG.	L . .	
☐	9		3	+05		Expt	Abst	A,BAP,4[illegible],1534	199810	Guber+ PPR B3-7. NDG.	L . .	
☐	10		4	1.0+02	4.0+02	Expt	Data	0,EXFOR00000.	200405	.DATA REQUESTED.	L . .	

List of titles, clicking will open PDF of paper

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

National Nuclear Data Center

IAEA NDS Main Databases: ENDF | EXFOR | CINDA | LiveChart | NuDat | NSR | XUNDL | ENSDF | MIRD

Nuclear Science References (NSR)

Database version of December 21, 2010

The NSR database is a bibliography of nuclear physics articles, indexed according to content and spanning nearly 100 years of research. Over 80 journals are checked on a regular basis for articles to be included. For more information, see the help page. The NSR database schema and web applications have undergone some recent changes. This is a revised version of the NSR Web Interface.

Quick Search | Text Search | Indexed Search | Keynumber Search | Combine View | Recent References

Author (Brown or B.A.Brown): Forrest

Nuclide (31Na or ca-38):

Reaction (n,g or (n,g) or 16O,16O):

Publication Year: from 1980 to 2011

Reference Type: All | Experiment | Theory

Output Format: HTML | BibTex | Text

Search | Reset

Enter Author to find list of papers

Database Manager: Boris Pritychenko, NNDC, Brookhaven National Laboratory
Web Programming: Boris Pritychenko, NNDC, Brookhaven National Laboratory
Data Source: NNDC, Brookhaven National Laboratory,
NDS, International Atomic Energy Agency,
NDG, McMaster University

Nuclear Data Development

The main tools to produce Nuclear Data Libraries for users are:

- **Coordinated Research Projects**
- **Data Development Projects**
- **Staff work**
- **Individual Contracts**

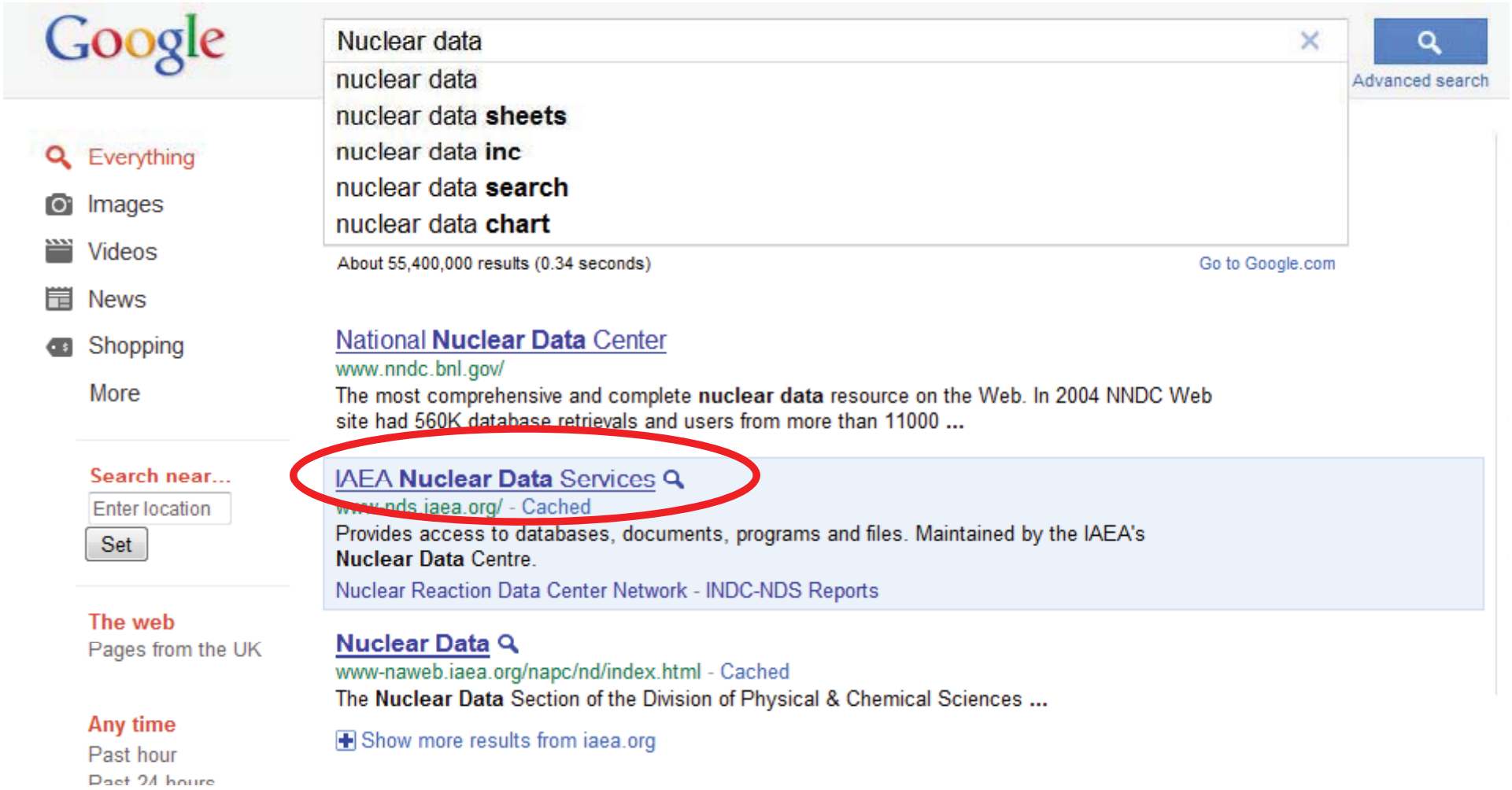
Examples of CRPs

- Minor actinide neutron reaction data (MANREAD)
- Nuclear data libraries for advanced systems: fusion devices (FENDL-3)
- Prompt fission neutron spectra for actinides
- Nuclear data for Particle Induced Gamma Ray Emission (PIGE) analysis

IAEA Nuclear Data Section

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

How to reach our Web-page?



Conclusions

- Nuclear Data underpins much of Technology
- The IAEA NDS provides data for users from Member States
- Discussion of concepts of cross section and radioactive decays
- How to get nuclear data
- Examples of important databases:
  - EXFOR
  - ENSDF
  - RIPL
- CRPs tool for data development

Thank you!