IAEA-NDS Nuclear Reaction Databases and Services

Viktor Zerkin
International Atomic Energy Agency, Nuclear Data Section

Joint ICTP-IAEA Workshop on Nuclear Structure and Decay Data: Experiment, Theory and Evaluation
Trieste, Italy, 15 October – 26 October 2018
1. Nuclear reaction databases and software system. Overview
2. Introduction to EXFOR-ENDF Web database retrieval system
3. Flexible ENDF database explorer
4. IBANDL Web system
5. EXFOR data re-normalization system
6. Inverse reactions and inverse kinematics in EXFOR and IBANDL
7. Uploading your experimental data
8. Plotting on Web with Web-ZVView
9. Not covered topics
Nuclear Reaction Database and Software Systems Overview
Our Internet Address

http://www-nds.iaea.org

Our Postal Address:
Nuclear Data Section,
International Atomic Energy Agency
Vienna International Centre,
P.O. Box 100, A-1400 Vienna,
Austria
# Nuclear Reaction Databases

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>EXFOR</strong></td>
<td>contains experimental nuclear reaction data for incident neutrons, charged particles and photons</td>
<td>13,500 Entries 97,000 Data sets 400 Mb ASCII-text</td>
<td>22,294 Entries 169,989 Data sets 752 Mb ASCII-text</td>
</tr>
<tr>
<td><strong>ENDF</strong></td>
<td>collection of evaluated data libraries containing cross sections, spectra, angular distributions, fission product yields, photo-atomic and thermal scattering law data</td>
<td>~300 Mb ASCII 5 basic libraries</td>
<td>&gt;250 Gb ASCII 58 libraries</td>
</tr>
<tr>
<td><strong>CINDA</strong></td>
<td>contains bibliographical references to experimental and evaluated nuclear reaction data, and to calculations, reviews, compilations of nuclear data.</td>
<td>266,000 Lines 40,500 publications 32,500 Blocks 37 Mb ASCII-text</td>
<td>577,219 Lines 94,100 publications 294,302 Blocks 112 Mb ASCII-text</td>
</tr>
<tr>
<td><strong>IBANDL</strong></td>
<td>Ion Beam Analysis Nuclear Data Library of experimental differential cross-sections</td>
<td>615 Datasets 1.9 Mb</td>
<td>3,690 Datasets 16 Mb ASCII-text</td>
</tr>
</tbody>
</table>
Basic principals of the IAEA-NDS nuclear databases and software systems

- Maximum of platform independency
  - operating systems: Linux, Windows, Mac
  - relational databases (MySQL, Access, SyBase, etc.)
  - programming languages: Java, SQL, Javascript, C, Fortran

- Free of charge system components
  - Linux, Apache, Tomcat, MariaDB

- Full integration of components
  - no installation (CD-ROM, Web, individual programs)
  - automatic configuration of Web-Servlets and scripts
  - encapsulated graphics
NDS CD-ROM Database Retrieval Systems

/since 2003/

- Full database on your PC
- For Windows, Linux and Mac
- Does not need installation
- Can run from CD-ROM (database server and Java JVM running from CD)
- Can work with remote databases
- Integrated EXFOR and CINDA
- Help with Dictionaries
- Advanced search (+users’ SQL)
- Interactive plotting with ZVView
- EndVer/GUI with integrated PrePro and EXFOR
- Includes non-interactive retrievals to build new user’s applications
- Used by Applications: Empire, EndVer, GANDR, expandable…
- Nowadays updated once per year
Retrieval system:
main stream of users’ interactions
Web interface

1. Intuitive
2. Suitable for beginners and ND professionals
3. Alternative interfaces
4. Non-trivial operations are described in:
   a) Documentation
   b) Examples
   c) News, software history, how-to, FAQ pages
   d) Video-Guides
Introduction to EXFOR-ENFD
Web database retrieval system
EXFOR: library, database, retrieval systems

Experimental data in exchange format

- 1970 agreed format and established exchange between USA, NEA, IAEA, USSR
- Contains data from ~22,300 experiments
- NRDC: 13 nuclear data centres compile ~500 new Entries every year
- Since 2005: global library with central maintenance in the IAEA (NDS)
- Master File (750Mb), 52 Dictionaries, 2 Manuals (400 pages)
- Distribution to users: EXFOR, X4+, C4, XML, Html, plots
- Assess via: Web, CD/DVD ROM, FTP
- Databases DBMS: MySQL, MS-Access, SyBase
- Software: C, Java (GUI-Applications, Web-Servlets), Fortran
- Connection to other databases ENDF, CINDA, NSR, IBANDL: import-export data, common plotting, links, cross-search
**ENTRY** 41323 20050902
**SUBENT** 41323001 20050902
**BIB** 7 12

**INSTITUTE** (4RUSMIF)
**REFERENCE** (J,AE,50,(5),350,198105) MAIN REFERENCE, DATA ARE GIVEN (J,SJA,50,325,1981) ENGLISH TRANSLATION
**AUTHOR** (V.E.ZHITAREV,A.M.MOTORIN,S.B.STEPANOV)
**TITLE** .INTERACTION CROSS SECTIONS OF CERTAIN METALS WITH COLD NEUTRONS
**FACILITY** (REAC)
**ERR-ANALYS** (EN-ERR) WAVE-LENGTH RESOLUTION DELTA-LAMBDA/LAMBDA TIMES 100 (IN PERCENT)

**HISTORY** (19981121C) + + COMPILED AT THE CJD + + (20050902A) . . Corrected at the CJD + + Data heading "EN" changed to "WVE-LN"

**ENDBIB** 12
**COMMON** 3 3
**EN-ERR** TEMP TEMP-ERR PER-CENT DEG-C DEG-C
3. 22. 3.
**ENDCOMMON** 3
**ENDSUBENT** 19
**SUBENT** 41323002 20050902
**BIB** 5 8
**REACTION** (13-Al27(N,TOT),,SIG)
**SAMPLE** .ALUMINIUM MONOCRYSTAL, PURITY 99.99 PC, THICKNESS 96 MM, DENSITY 2.70 GRAM/CM3 AND MACROCRISTALLINE ALUMINIUM, PURITY 99.99 PC, THICKNESS 50 MM, DENSITY 2.70 GRAM/CM3
**ERR-ANALYS** (DATA-ERR) NO INFORMATION GIVEN
**STATUS** (TABLE) DATA ARE TAKEN FROM TABLE 1 OF MAIN REF.

**HISTORY** (19981121T) + + CONVERTED FROM SUBENT 88023002

**ENDBIB** 8
**NOCOMMON** 0 0
**DATA** 3 8
**WVE-LN** DATA DATA-ERR ANGSTROM B B
1.3000E+01 1.9300E+00 1.3000E-01
1.4000E+01 2.1200E+00 9.0000E-02
1.5000E+01 2.2500E+00 8.0000E-02
1.6000E+01 2.3800E+00 7.0000E-02
1.7000E+01 2.5400E+00 6.0000E-02
1.8000E+01 2.6100E+00 6.0000E-02
1.9000E+01 2.8200E+00 8.0000E-02
2.0000E+01 3.1500E+00 6.0000E-02

**ENDDATA** 10
**ENDSUBENT** 23
**ENDENTRY** 2
Experimental Nuclear Reaction Data (EXFOR) Database Version of 2018-10-12

The EXFOR library contains an extensive compilation of experimental nuclear reaction data. Neutron reactions have been compiled systematically since the discovery of the neutron, while charged particle and photon reactions have been covered less extensively.

Examples, Help, Dynamic sections

Important:
• More examples,
• Software/History

Text search (~google)
EXFOR Request Form. Examples

Examples of requests: 1 2 3 4 5 6 7 ...

1. Cross section $\sigma(E)$ /updates/
2. Angular distributions $d\sigma/d\Omega$
3. Emission spectra $d\sigma/dE_{out}$
4. Double differential cross section $d^2\sigma/d\Omega/dE_{out}$
5. Corrections data from EXFOR Ex.1 ZK1 ZK2 AT1 RC1
6. Search by outgoing particles: [$\alpha+\gamma$] P.XG (P.XG),DA
6+. Search data for IBANDL: $^{12}$C($\alpha,\alpha'$)$^{12}$C, $\theta=167^\circ$
7. Enhanced search by product with filtering product coded as ELEM/MASS for quick plot
8. Search by wildcards in full reaction code
9. Ratios converted to cross sections (C4)
10. NUBAR: average number of neutrons per fission PR DL ^DL
11. Constructing a covariance matrix from EXFOR uncertainties
12. Extended listing of references (authors, title, DOI, NSR, Web)
13. EXFOR - CINDA sequential search N,F
14. Automatic re-normalization (output data and plots); $^{55}$Mn(n,g)
15. Find data: [digitized] from plots, [not digitized], [from table] [experimental data only] [not empty datasets] [empty]
16. Search by authors using aliases Ex.2
17. Fission spectra b Thick target neutron spectra
   c Delayed neutrons  d Kerma factor
18. Invert reaction using detailed balance $^{13}$C($\alpha,n$)$^{16}$O $\to$ $^{16}$O(n,$\alpha$)$^{13}$C: [plot]
   Ex.2: $^3$He(d,p)$^4$He $\to$ $^4$He(p,d)$^3$He $d\sigma/d\Omega$
19. Various fission quantities: a Yield (chain, primary FF, secondary FF)
   b Cumulative yield of $^{147}$Nd
d Multiplicity of prompt fission neutrons
20. Plotting cross section coded with SF8=DAM; all
EXFOR Request Form. News & History

News

2017/01 New. Web-ZView plots: affine transformations (PS/EPS) [how-to], distortion picture using 2D-calibration [how-to]
2016/11 Plotting without grouping by reaction-codes (+ calculating CS ratios between diff. datasets on the fly) [example]
2016/11 Plotting cross section coded with SFB-DAM (CS divided by atomic mass of target) [example] #Adv.plot using C5
2016/11 Recalculation of angular distributions to inverse kinematics (when converting EXFOR→R33) [example] [how-to]

[History]
2016/03 New. Upload your data for constructing covariance matrix, calculating inverse reaction cross sections, etc. [page]
2016/02 Output links to NSR and Web publication for secondary references of an Entry
2016/01 New. Display original publication of the IAEA INDC Reports (in PDF format)
2015/03 New. Inverting reaction data using detailed balance. Example: $^{13}\text{C}(α,α)^{16}\text{O} \rightarrow ^{16}\text{O}(α,α)^{13}\text{C}$ See: [how-to]
2014/12 New. Text search in extended EXFOR [instructions/examples] See: [concept], [how-to]
2014/07 New. Database of expert's corrections to EXFOR data on Web. Examples: Fe-54(n,p); Mn-55(n,2n), (n,g)
2014/02 Universal X4Plot with arbitrary selection and grouping columns (use: "Sort by: reaction" and "View: extended") [how-to]
2014/02 New version (v2) of XML output format [about]
2013/05 EXFOR Milestone: 20,000 experimental works are now in the database!
2013/01 Collection of video-guides to EXFOR-ENDF database Web retrieval system: [page]
2012/11 Searching data compiled: [digitizing] plots, [not digitized], given [in tables]
2012/10 New plotting regime: switch display of data to display of ratios on the fly [video]
2012/07 Sort by publications with extended view [example]
2012/07 Searching reactions: n,xp; p,xg, etc. [example]
2012/02 Improvements and extensions:
1) Automatic data re-normalization (optional: for plots and output data only) [video]
2) Web-ZView plotting: clipboard copy/paste
2011/12 Search in CINDA (+NSR) if data not found in EXFOR
2011/10 Web-ZView plotting: output PS and PDF files
2011/09 EXFOR to XML; interpretation EXFOR-XML to HTML using XLS [xml] [html] [example]
2011/06 Software development:
1) Interactive Web-constructing a covariance matrix from EXFOR uncertainties [doc]
2) Output to C5 computational format (C5 = C4 + statistical and systematic uncertainties)
2011/05 Improvements and extensions:
1) Search by DOI and NSR-KeyNo (Extended mode)
2) Search by Keyword MONITOR
3) Search by DatasetID (SubentPointer)
2011/01 Improvements and extensions:
1) Search for recently updated data (Extended mode: Last modified)
2) Display titles of original articles (imported from NSR) when data "Sorted by Publications"
News & History

2010/08 Improvements and extensions:
1) Display range of products when coded as ELEM/MASS [example]
2) Display range of angles and secondary-energies on the "Data Selection" page

2010/02 Improvements and extensions:
1) Production of isotopes coded as ELEM/MASS: filtering and quick [plot], sorting T4 [t4] [t4x]
2) Users’ definition of ENDF:MF/MT for conversion EXFOR data to format C4 and advanced plotting
3) Search by compiling Center-ID (expert mode)
4) Search by outgoing particle coded in SF3,4,7 (expert mode)

2009/12 Improvements and extensions:
1) Correction of experimental data in computational formats [doc]

2009/07 Improvements and extensions:
1) Extended using plotting program ZVView via Web [about]

2009/02 Improvements and extensions:
1) New output format X4+: EXFOR interpreted-interactive-tree [about] [example]

2008/12 Improvements and extensions:
1) Advanced plot: ratios, ratios converted to cross sections using [IAEA-2006 Standards] [test]
2) Dynamic request page combining Standard, Extended and Advanced requests in one page
3) Prompt-Help system [page]
4) Extensions on Selection-page and EXFOR+: search by Author, Reaction, ENTRY
5) Search by full reaction code and Trans-ID (for experts only)
6) Video guide (test): how to plot EXFOR-ENDF double differential cross-sections [page]

2008/10 Common NRDC EXFOR Web Service: [IAEA-NDS] (conclusion of NRDC-2008 meeting)

2008/06 Improvements and extensions:
1) Search by data heading, units, points (in Advanced mode only)
2) New type of request: listing of experimental works

2008/04 Search by Title (in Extended and Advanced modes only)

2008/01 Software development:
1) Handling "Large" requests [about]
2) Conversion: EXFOR -> R33/IBANDL (β-version); [about][algorithm]

2007/11 Improvements/extensions:
1) General EXFOR Statistics [example]
2) Bibliography (Html and BibTeX) is improved; use link to NSR and Web journals; [example]
3) Output in R33/IBANDL format: version-1

2007/05 Output in R33/IBANDL format: angular distributions; includes plotting; version-0

2007/03 Interactive Web plotting: zoom by mouse, actions by one click, more functions...

2007/01 Improved request page of Web interface (dark non-active criteria, move focus...)

2006/10 EXFOR+: Extended EXFOR [example][about]

2006/10 BibTeX output: Bibliography for LaTeX [example][about]

2006/08 Extended plotting: experimental vs. evaluated data [example][how-to]
1. Cross sections with errors of evaluated data CS => MF3+MF33
2. Differential cross section with respect to angle DA => MF4
3. Energy spectrum of outgoing particles DE => MF5
4. Double differential cross section DAE => MF6
5. Average number of neutrons per fission (nubar) MFQ => MF1

2005/11 Submit your data for compilation to the database [here]

2005/06 Global EXFOR Master File!

2005/03 Direct link to Web-Journals

2004/06 Clone your EXFOR request to CINDA and ENDF
### Video-guide

**How-to for EXFOR-ENDF Database Web Retrieval System**

<table>
<thead>
<tr>
<th>Date</th>
<th>Video Duration</th>
<th>Video Title</th>
<th>Video Description</th>
</tr>
</thead>
</table>
| 2013.01.28 | 6:16           | Automatic re-normalization of EXFOR data under Web retrieval system                           | by V.Zerkin  
*How to renormalize experimental nuclear data from EXFOR database using NDS Web retrieval system.*                                                       |
| 2013.01.25 | 9:56           | Display covariance data from ENDF libraries with Web-ZVView                                    | by V.Zerkin  
*How to plot and compare covariances of evaluated nuclear data using ENDF Web database retrieval system with plotting package Web-ZVView.*          |
| 2012.10.31 | 4:35           | Plot and compare nuclear data using normalization regime of Web-ZVView plotting package         | by V.Zerkin  
*How to plot and compare experimental and evaluated nuclear data using normalization regime of Web-ZVView plotting package.*                          |
| 2008.09.10 | 2:02           | Using Flexible ENDF-database Explorer                                                          | by V.Zerkin  
*How to search, retrieve and plot ENDF-EXFOR cross-sections data using Flexible ENDF Explorer.*  
See also: [help-page](https://www-nds.iaea.org/exfor/x4guide/)*                                                                             |
| 2008.08.09 | 1:45           | Plot EXFOR-ENDF double differential cross-sections                                              | by V.Zerkin  
*How to retrieve and plot comparable EXFOR-ENDF double differential cross-sections using Web-ZVView plotting package.*                          |
Types of plotting on our Web

- **Quick plot**: EXFOR-ENDF, cross sections (XS) only; XS filtered by product ELEM/MASS in EXFOR
- **Advanced (Universal) plot**: EXFOR-ENDF, MF1,3,4,5,6, using EndVer (A.Trkov); ratios, ratios converted to cross sections, XS ± ΔXS
- **Native EXFOR plot**: EXFOR only, any quantities
- **Special ENDF plotting**: MF3*MF6:Low=0 by products, MF10, relative uncertainties, XS with uncertainties (MF3+MF33)
- **R33 plot**: EXFOR-IBANDL, Web interface to IBANDL-SigmaCalc (A.Gurbich, IPPE) data
- **PlotC4** (D.E. Cullen): C4 to PS and PS to PDF
- **Z(X,Y)**: MF33, MF35, MF40; correlation matrix constructed on EXFOR uncertainties
- **MyPlot**: uploaded user’s data (input: text columns, arrays, ENDF sections: MF33, MF3+MF33)
Output from EXFOR retrieval system

- EXFOR Request Form
- Search in EXFOR Database
- EXFOR Select
- Multiple or single choice of data/formats
- Retrieve EXFOR files and convert to:
  - Bibliography
  - Info
  - BibTeX
  - Table
  - T4
  - X4+
  - X4±
  - X4
  - C4
  - R33
  - C5
  - C5M
  - XML
  - HTML

How it works

Java Servlet
- Retrieve EXFOR
- X4
- X4TOC4
- (R.Cullen, A.Trkov)
- C4
- C4TOR33
- R33
- Data from one SUBENT (many Θ)
- Download R33 as text

ENDF. Evaluated database retrieval system
- ENDF: search, plot
- Plot by Web-ZVView and other service
- ZVView output
- ENDF

External programs
- Info
- BibTeX
- Table
- T4
- X4+
- X4±
- X4
- C4
- R33
ENDF Data Selection (Plot for EXFOR Request #171)

**Plot data**

<table>
<thead>
<tr>
<th>Request #102</th>
<th>ENDF Data Selection</th>
<th>Retrieve</th>
<th>Plot</th>
</tr>
</thead>
</table>

**Plotting options:** Quick plot (cross-sections only: $\sigma$)

<table>
<thead>
<tr>
<th>Sorted by: [Reactions]</th>
<th>Reorder by: [Libraries]</th>
<th>View:</th>
<th>basic</th>
<th>extended: get MAT, PEN, GND, run Inter: resonance integrals, etc.</th>
</tr>
</thead>
</table>

1. **ENDF-6** Interpreted $\sigma$ Plot
   - ENDF/B-VIII.0 E=150MeV Lab=LANL,ORNL Date=20111222
   - M.B.Chadwick+, Derrien+

2. **ENDF-6** Interpreted $\sigma$ Plot
   - ENDF/B-VII.1 E=150MeV Lab=LANL,ORNL Date=20111222
   - M.B.Chadwick+, Derrien+

3. **ENDF-6** Interpreted $\sigma$ Plot
   - ENDF/B-VII.0 E=150MeV Lab=LANL,ORNL Date=DIST-DEC06
   - M.B.Chadwick+, Derrien+

4. **ENDF-6** Interpreted $\sigma$ Plot
   - JEFF-3.3 E=150MeV Lab=LANL Date=20171231
   - M.B.CHADEWICK & P.G.YOUNG

5. **ENDF-6** Interpreted $\sigma$ Plot
   - JEFF-3.2 E=150MeV Lab=LANL Date=090105
   - M.B.CHADEWICK & P.G.YOUNG

6. **ENDF-6** Interpreted $\sigma$ Plot
   - JEFF-3.1.2 E=150MeV Lab=LANL Date=090105
   - M.B.CHADEWICK & P.G.YOUNG

7. **ENDF-6** Interpreted $\sigma$ Plot
   - JEFF-3.1 E=150MeV Lab=LANL Date=090105
   - M.B.CHADEWICK & P.G.YOUNG

8. **ENDF-6** Interpreted $\sigma$ Plot
   - JENDL-4.0 E=20MeV Lab=TIT,JAERI Date=20090828
   - Y. HARIKA, H. KITAZAWA, T. FUKAHORI

9. **ENDF-6** Interpreted $\sigma$ Plot
   - JENDL-3.1 E=20MeV Lab=TIT,JAERI Date=20010713
   - Y. HARIKA, H. KITAZAWA, T. FUKAHORI

10. **ENDF-6** Interpreted $\sigma$ Plot
    - JENDL-3.3 E=20MeV Lab=TIT,JAERI Date=20010713 T=300
    - Y. HARIKA, H. KITAZAWA, T. FUKAHORI

11. **ENDF-6** Interpreted $\sigma$ Plot
    - ENDF/B-VI E=150MeV Lab=LANL Date=20011108
    - M.B.CHADEWICK & P.G.YOUNG

12. **ENDF-6** Interpreted $\sigma$ Plot
    - ENDF/B-VII E=150MeV Lab=LANL Date=2001926 T=300
    - M.B.CHADEWICK & P.G.YOUNG

13. **ENDF-6** Interpreted $\sigma$ Plot
    - BROND-3.1 E=150MeV Lab=LANL,ORNL Date=DIST-DEC06
    - M.B.CHADEWICK+,Derrien+

14. **ENDF-6** Interpreted $\sigma$ Plot
    - ROSFOND-2010 E=150MeV Lab=IPPE Date=DIST-DEC07
    - IGNATYUK A.V.

15. **ENDF-6** Interpreted $\sigma$ Plot
    - ROSFOND-2008 E=150MeV Lab=IPPE Date=DIST-DEC07
    - IGNATYUK A.V.

16. **ENDF-6** Interpreted $\sigma$ Plot
    - CENDL-3.1 E=20MeV Lab=CNDC,JNDC Date=DIST-DEC09
    - B.S.YU, S.CHIBA, Y.HARIMA

17. **ENDF-6** Interpreted $\sigma$ Plot
    - JEFF-3.0 E=150MeV Lab=LANL Date=DIST-APR02
    - M.B.CHADEWICK & P.G.YOUNG

18. **ENDF-6** Interpreted $\sigma$ Plot
    - JEF-2.2 Lab=ECN Date=920101
    - EC BLANKET TECHNOLOGY, TASK B2
ENDF Output Form with interactive Web ZVView plotting

Select data for plotting

Add your data to the plot

Copy/Paste
Flexible ENDF Database Explorer
Sequential search in ENDF database

Direct data search: fill in a form and submit request
Sequential data search: travel on a database tree /ENDF-Explorer/

ENDF Request Form → ENDF-Explorer
ENDF Flexible Database Explorer

Target Materials
Isotopes of 1-Hydrogen

Configuration: [Show] Video demo: [show] How-to slides: [hide]
Slide-show: 1 H 3cerr H 23

Switches: open/close tree-node
T: target R: reaction L: library Q: quantity

Summary:
Elements: 110 Nuclides: 2450
Selected:
> 0) Evaluated data
* 1) Incident-Particle: [N] Incident-Neutron Data

Nuclides: [List] [Chart-txt]
ENDF Explorer: data found
Standard ENDF Select Form

Flexible Database Explorer

ENDF Data Selection

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

1) IR-193(N,2N) IR-192, COV/SIG
   MT=16 MF=33 NSUB=10
   MF33 [COV/SIG] Covariances of neutron cross sections
   MT16 [N,2N] Production of two neutrons and a residual.
   1. ENDF-6 Interpreted MF33-Plot ENDF/B-VII.0 E=20MeV Lab=LANL, BNL Date=DIST-DEC06
   2. ENDF-6 Interpreted MF33-Plot TENDL-2008 E=20MeV Lab=NRG Date=REV1-
   3. ENDF-6 Interpreted MF33-Plot TENDL-2009 E=200MeV Lab=NRG Date=REV1-

Plotting options:
- cross sections with reconstructed resonances and applied Doppler broadening at the temperature 293K = 20°C
- angular distributions, $d\sigma/d\Omega$
- energy distributions, $d\sigma/dE$
- double differential cross sections, $d^2\sigma/dE/d\Omega$
- cross sections with uncertainties (if given)

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

Page generated: 2010/05/07 21:46:11 by E4-Servlet on www-nds.iaea.org
Request from: iaea.org (161.5.149.203)
Again ENDF Output Form with interactive ZVView plotting
Display Cross Section and Uncertainty

Cross Section Uncertainty
ENDF/B-VII.0: IR-193(N,2H)IR-192

Cross Section
ENDF/B-VII.0: IR-193(N,2H)IR-192
Correlation matrix

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
<th>16</th>
<th>17</th>
<th>18</th>
<th>19</th>
<th>20</th>
<th>21</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

X (MeV)
Y (MeV)

#LB5: Symmetric Matrix

Z(26x26): Z_{i,j} = \text{Cor}(\sigma_{X_i}, \sigma_{Y_j}) \times 1000
IR-193(n,2n)IR-192

TENDL-2008 vs. ENDF-B/VI.0
IBANDL Web system
This is the Ion Beam Analysis Nuclear Data Library developed and formerly maintained by A. Gurbich under the IAEA auspices. It contains available experimental nuclear cross-sections relevant to Ion Beam Analysis. Differential cross sections are presented both as graphs and data files. The numerical data are in the R33 format. Currently, most of the data are being extracted from EXFOR using an automatic conversion procedure available in EXFOR retrieval system (see details of the algorithm here).

Two Coordinated Research Projects (CRP) have catered to the data needs of the IBA community: the CRP on Reference Database for Ion Beam Analysis (2005-2010, see: IAEA-TECDOC-1780), and the CRP on Development of a Reference Database for Particle-Induced Gamma Ray Emission (PIGE) Spectroscopy (2011-2015, see: IAEA-TECDOC-1822) both of which resulted in new measurements and the bulk of the relevant nuclear data made available in IBANDL. The activity has been further supported by the IAEA through the Technical Meeting on Benchmarking Experiments for Ion Beam Analysis, and the nuclear data evaluation project R-matrix Codes for Charged-particle reactions in the Resolved-Resonance Region.

Members of the IBA community are invited to submit new experimental data to IBANDL. Numerical data (in R33 or any other format) including references should be sent to: nds.contact-point@iaea.org (IAEA-NDS).

The IBANDL Web interface also provides evaluated (recommended) cross sections obtained with the SigmaCalc calculator developed by A. Gurbich. Evaluated cross-section data produced by SigmaCalc up to October 2013 are available for easier access and plotting. In addition, the user is offered the option to obtain SigmaCalc files on-the-fly, through remote access to the SigmaCalc calculator. R33 files can be also downloaded from SigmaCalc and imported into IBANDL. Users are cautioned however, that the 'on-the-fly' calculations can experience significant delays due to problems related with the connection to the external Web server. The IAEA therefore accepts no responsibility for usage of this option.

New
- Total cross sections (mb) can be converted to differential cross sections (mb/sr) in cases where the angular distributions are known to be isotropic. Differential cross sections (mb/sr) can be converted to Ratio-to-Rutherford (rr) and vice versa. Press 'Convert units for plotting' button on the data table header.
- Conversion to inverse kinematics is possible. Press 'inverted' button on the data table header.
- User can upload own data files to compare with existing data. See 'Add your dataset in R33 format for plotting' on the bottom of the data table.
- Search data by first author and reference: [Summary] → [+]References → click on ».
### IBANDL Web system

**13C + p**

<table>
<thead>
<tr>
<th>No.</th>
<th>Reaction</th>
<th>Angle</th>
<th>Energy [keV]</th>
<th>Pts</th>
<th>Update</th>
<th>X4</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>13C(p,p)13C</td>
<td>160°</td>
<td>700-2500</td>
<td>451</td>
<td>2013-08-15</td>
<td></td>
<td>SigmaCalc 2.0. File created 21-6-2013</td>
</tr>
<tr>
<td>3</td>
<td>13C(p,p)13C</td>
<td>160°</td>
<td>780-2430</td>
<td>96</td>
<td>2013-05-27</td>
<td></td>
<td>N.P. Barradas et al., to be published</td>
</tr>
</tbody>
</table>

Datasets: 13  Reactions: 1  Points: 1423  References: 7

Add your dataset in R33 format for plotting

References.

Legend:

- X4: link to the dataset in EXFOR database retrieval system.
Welcome to Web-ZVVView!
Interactive plotting of IBANDL and SigmaCalc data

1) $\theta=160^\circ$ N.P. Barradas et al., to be published
2) $\theta=158.4^\circ$ E.Milne, Phys. Rev. 93 (1954) 762
3) $\theta=160^\circ$ SigmaCalc 2.0. File created 22-6-2013

---

**Type of data**
- EBS
- NRA
- PIGE
- All

**Nucleus**
- C-13

---

Reset Repaint $\square$ Legend $\square$ Authors $\square$ Info $\square$ Postscript Manual options: [+] Clipboard: [Copy]
Shift legend: $x=0$ $y=0$ $\square$ Spits: $1:1x:2y$ $\square$ Plot data or ratio: $0$

Data for plotting: ZVD (15Kb), send to ZVVView; download ZVVView; upload and plot your ZVD file
Welcome to Web-ZVView!

Interactive plotting of IBANDL and SigmaCalc data

1) θ=160° N.P. Barradas et al., to be published
2) θ=158.4° E. Míne, Phys. Rev. 93 (1954) 762
3) θ=160° SigmaCalc 2.0. File created 22-6-2013

Data for plotting: ZVD (15Kb), send to ZVView; download ZVView; upload and plot your ZVD file
EXFOR data re-normalization system

Example 14

14 Automatic re-normalization (output data and plots); $^{55}\text{Mn}(n,g)$
EXFOR data re-normalization system
(correction system)

Main ideas:
1) to re-normalize data using old monitors and new standards
2) to re-normalize data using decay data
3) to create a convenient tool for data modifications: multiply data to a factor, correct wrong units, set up uncertainties, delete part of a data set, recalculate data using isotope abundances, etc.

We DO NOT change EXFOR data - we re-normalize output from EXFOR system

Final goals:
1) to implement possibility of corrections
2) to re-normalize data from EXFOR automatically (using EXFOR information)
3) to collect experts’ corrections to a database
4) to re-normalize data using experts’ corrections database
5) to have Web system offering and implementing automatic, experts’ and user’s corrections in optional, semi-automatic and interactive modes
6) to generate and distribute renormalized data of whole EXFOR database
Example of expert’s corrections results
by K. Zolotarev, 2011

Data selected

Data corrected

Before and after corrections

30-ZN-64(N,P)29-CU-64,SIG

Cross Section (barns)

Incident Energy (MeV)
Applying automatic data re-normalization

Apply corrections

Auto corrections is possible

Users’ corrections, help, documentation
Automatic re-normalization: simple plot

Applied corrections

Check Monitors

Plot result of corrections

Check data

---

# Reaction: 25-MN-55(N,A)23-V-52,,SIG
# Monitor: 26-FE-56(N,P)25-MN-56,,SIG
# m0: (20377002,H.LISKIEN+,J,JNE/AB,19,73,196502) $ fe56np;#old monit-ref
m1: recom$fe56np; #new monitor(energy)
dy=dy/y; #to rel. uncertainties----
y=y/m0*m1; #renormalized CS
dy=(dy**2-dm0**2+dm1**2)**0.5;#replace monitor uncertainties
dy=dy*y; #to abs. uncertainties
Automatic re-normalization: data checking

Old data
Old uncertainty
New data
New uncertainty
Plot old and new monitors

Final Factor

Old data
Old uncertainty
New data
New uncertainty
Automatic data re-normalization: common plot

Re-normalized data: *
Comparing to ENDF

Compare with ENDF-B/VII.0

After re-normalization: \( \chi^2 = 0.984764 \)

Before re-normalization: \( \chi^2 = 1.50476 \)
Inverse reactions and inverse kinematics in EXFOR and IBANDL

Example 18

18 Invert reaction using detailed balance $^{13}\text{C}(\alpha,n)^{16}\text{O} \rightarrow ^{16}\text{O}(n,\alpha)^{13}\text{C}$: $\sigma$ $d\sigma/d\Omega$

Ex.2: $^3\text{He}(d,p)^4\text{He} \rightarrow ^4\text{He}(p,d)^3\text{He}$ $d\sigma/d\Omega$ [plot]
EXFOR. Recalculation of cross sections to inverse reactions using detailed balance relation

View: extended $\rightarrow$ “Invert data” $\rightarrow$ Advanced plot via C5

<table>
<thead>
<tr>
<th>Quantity</th>
<th>[CS] Cross section</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6-C-13 (A,N) 8-O-16,,SIG</td>
</tr>
<tr>
<td>2</td>
<td>6-C-13 (A,N) 8-O-16,,SIG, EXP</td>
</tr>
<tr>
<td>3</td>
<td>8-O-16 (N,A) 6-C-13,,SIG</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>n</th>
<th>Display</th>
<th>Year</th>
<th>Author-1</th>
<th>Energy range, eV</th>
<th>Points</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td></td>
<td>1989</td>
<td>S.E.Kellogg+</td>
<td>4.50e5 1.04e6 13</td>
<td>[pdf]+ J,BAP,34,1192(E10.5),198904</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>1968</td>
<td>C.N.Davids</td>
<td>4.75e5 7.00e5 10</td>
<td>[pdf]+ J,NE/110,619,196803</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td></td>
<td>1968</td>
<td>B.Leroux+</td>
<td>1.49e7 1</td>
<td>[pdf]+ J,NE/116,1(1),196,196807</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td></td>
<td>1968</td>
<td>D.Dandy+</td>
<td>7.14e6 1.20e7 11</td>
<td>+ R,AWRE-0-60/68,6810</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
<td>1963</td>
<td>M.Bormann+</td>
<td>1.48e7 1</td>
<td>[pdf]+ J,ZP,174,1,196302</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td></td>
<td>1955</td>
<td>J.Seitz+</td>
<td>1.23e7 1.95e7 7</td>
<td>[pdf]+ J,HPA,28,227,5503</td>
<td></td>
</tr>
</tbody>
</table>
In advance reactions in EXFOR

Advanced plotting: LST (1kb)

Select experimental data for plotting...

Go to σ(E) SIG
Go to plot evaluated data...

ENDF

Advanced plot via C5

Limitations

Translation Log

DATASET MF MT REFERENCE REACTION

30092002 3 107 A.S.Bivatia, ET AL. (66) 8-0-16(N,A) 6-C-13, SIG
A0613003 3 4 M.H. Brotiff, ET AL. (79) 6-0-16(N,A) 6-C-13, SIG

CONVERT INC-ENERGY: C.M. TO LAB K=1.3078132
DATA CONVERTED TO INVERSE REACTION MNFT=31:107 8-0-16(N,A) 6-C-13, SIG
E1=(E0-E-0.76463526-E-2.21588388E+0.94676268 SIG=E-0.45725 E-1.8457255

Product:8-0-16 : Level1(MeV)=6.099
Q(MeV)=2.21588388 Level1-Q=8.33838383
E0_threshold for Level1(MeV)=6.4504795
E1(E0_threshold),MeV=6.4504795

Product:6-0-13 : Level1(MeV)=0.898
Q(MeV)=-2.21588388 Level1-Q=5.30438383
E1_threshold for Level1(MeV)=5.698887

Reaction inversion is correct up to KINS.638878

C0489022 3 7 J.K. Bai, ET AL. (73) 6-C-15(A,N) 8-0-18, SIG
DATA CONVERTED TO INVERSE REACTION MNFT=31:107 8-0-16(N,A) 6-C-13, SIG
E1=(E0-E-0.76463526-E-2.21588388E+0.94676268 SIG=E-0.45725 E-1.8457255

Product:8-0-18 : Level1(MeV)=6.099
Q(MeV)=2.21588388 Level1-Q=8.33838383
E0_threshold for Level1(MeV)=6.4504795
E1(E0_threshold),MeV=6.4504795

Product:6-0-13 : Level1(MeV)=0.898
Q(MeV)=-2.21588388 Level1-Q=5.30438383
E1_threshold for Level1(MeV)=5.698887

Reaction inversion is correct up to KINS.638878

Translation Summary

ENTRY 3
SUBSERT 3
DATASETS 3
TRANSLATED DATASETS 3
TRANSLATED DATA POINTS 1316
Inverse reactions in EXFOR

Plot #1

Select data for plotting [all] [none]
- 1) O-16(N,A)C-13,SIG^ 1993 H.W.DROTELL, A0613003
- 2) O-16(N,A)C-13,SIG 1973 J.K.Bair^, C0489002
- 3) Use my data [example]

See: plotted data (117Kb)

Inverted flag (for reactions and authors)

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: [+ ] Clipboard: Copy Paste
Shift legend:x= 0 y= 0 Split: 0 1:xy; 2:y Plot data or ratio: 0 0: data; 1: ratio to dataset-1; 2: ratio to 2-nd, etc.

Data for plotting: ZVD (106Kb), send to ZView; download ZView; upload and plot your ZVD file

31th INDC Meeting, 27-30 June 2016

50
EXFOR. Recalculation of differential cross sections to inverse reactions using detailed balance relation

Example: $^{13}\text{C} (\alpha,\text{n})^{16}\text{O} \rightarrow ^{16}\text{O}(\text{n,}\alpha)^{13}\text{C}$: $d\sigma/d\Omega$

Convert EXFOR to C5 computational format
Program x4toc5 (version 2018-04-18)
V. Zerkin, IAEA, Vienna, 2010-2018
Running: 2018-04-26, 18:34:41 on nds121
-i: # inverse selected reactions
-cm2lab # convert C.M. to Lab.

Translation Log

<table>
<thead>
<tr>
<th>DATASET</th>
<th>MF</th>
<th>MT</th>
<th>REFERENCE</th>
<th>REACTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>F0464007</td>
<td>4</td>
<td>50</td>
<td>T.W. BONNER, ET.AL.</td>
<td>(56) 6-C-13(A,N)8-0-16,,DA</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>DATA CONVERTED TO INVERSE REACTION MFMT=4:107 B-0-16(N,A)6-C13</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>E1=(E0*0.76463526 + 2.2156998)/0.94067925 MeV</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>A1=(A0-&gt;A0CM)-&gt;(A1CM=A0CM)-&gt;(A1CM-&gt;A1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>SIG=SIG0<em>E0/E1</em>8.457256</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>CALC.ENE. 1:(FROM 1.958 TO 3.9469) 533:(FROM 5.166 TO</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>CALC.ANG. 1:(FROM 90. TO 82.5) 533:(FROM 5. TO 4.7)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>CALC.SIG. 1:(FROM 0.001841 TO 1.9003-3) 533:(FROM 0.03</td>
</tr>
</tbody>
</table>

Product: 8-0-16 : Level1(MeV)=6.049
Q(MeV)=2.2156088 Level1-Q=3.83333
E0_threshold for Level1 (MeV)=5.0133576
E1(E0_threshold),MeV=6.438459
Product: 6-C-13 : Level1(MeV)=3.089
Q(MeV)=2.2156098 Level1-Q=5.30461
E1_threshold for Level1 (MeV)=5.6391273
Reaction inversion is correct up to E1=5.63913(MeV)

Translation Summary

| ENTRY | 1 |
| SUBENT | 1 |
| DATASETS | 1 |
| TRANSLATED DATASETS | 1 |
| TRANSLATED DATA POINTS | 533 |
Inverse kinematics in IBANDL Web interface

Flag to transform data to invert kinematics when presenting data

IBANDL contains angular distributions $d\sigma/d\Omega(\theta,E)$ for incident charged particle reactions
Inverse kinematics in IBANDL Web interface

Welcome to Web-ZVView!
Interactive plotting of IBANDL and SigmaCalc data

1) $\theta=45^\circ$, $E_1=2.3-5.7 \text{ MeV}$  Source: Z. Siketic et al., Nucl. Instr. and Meth. B 229 (2005) 180

2) $\theta=45.4^\circ$, $E_1=2.5-9.5 \text{ MeV}$  Source: W.D. Warters+(1953), Jour. Physical Review, Vol.91, Issue.4, p.917

$^7\text{Li}(p,p'0)^7\text{Li}$ $E_1=0.4-1.4 \text{ MeV}$  $\phi=45.4^\circ$, $\theta=81.1^\circ$

Details of calculations
Inverse kinematics in IBANDL Web interface

Original (direct)
Reaction: \(^{7}\text{Li}(p,p_0)^{7}\text{Li}\) Qvalue=0 nPoint:71
M1: Incident \(p\) \(M_1=1.007825\) \(E_1=1367.0\text{keV}\)
M2: Target \(7\text{Li}\) \(M_2=7.0160046\)
M3: Scattered \(p\) \(M_3=1.007825\) \(E_3=1070.6\text{keV}\) \(\theta=81.1^\circ\) \(\sigma(\theta)=45.1053\text{mb/sr}\pm5.0\%\)
M4: Recoil \(7\text{Li}\) \(M_4=7.0160046\) \(E_4=296.4\text{keV}\) \(\varphi=45.4^\circ\)

CM.

Center of mass

Reaction: \(^{7}\text{Li}(p,p_0)^{7}\text{Li}\) Qvalue=0 nPoint:71
\(E_{cm}=1195.3\text{keV}\)
M1: Incident \(p\) \(M_1=1.007825\) \(E_1'=1045.2\text{keV}\)
M2: Target \(7\text{Li}\) \(M_2=7.0160046\) \(E_2'=150.1\text{keV}\)
M3: Scattered \(p\) \(M_3=1.007825\) \(E_3'=1045.2\text{keV}\) \(\theta'=89.3^\circ\) \(\sigma'(\theta')=43.5874\text{mb/sr}\pm5.0\%\)
M4: Recoil \(7\text{Li}\) \(M_4=7.0160046\) \(E_4'=150.1\text{keV}\) \(\varphi'=90.7^\circ\)

Inverse

Inverse-kinematics

Reaction: \(^{7}\text{Li}(p,p_0)^{7}\text{Li}\) Qvalue=0 nPoint:71
M2: Incident \(7\text{Li}\) \(M_2=7.0160046\) \(E_2''=9516.4\text{keV}\)
M1: Target \(p\) \(M_1=1.007825\)
M3: Recoil \(p\) \(M_3=1.007825\) \(E_3''=2063.3\text{keV}\) \(\varphi''=45.4^\circ\) \(\sigma''(\varphi'')=122.484\text{mb/sr}\pm5.0\%
M4: Scattered \(7\text{Li}\) \(M_4=7.0160046\) \(E_4''=7453.1\text{keV}\) \(\theta''=8.2^\circ\)

Equivalent to elastic scattering of \(p\) on \(^{7}\text{Li}\) measurements of recoil nucleus \(^{7}\text{Li}\)
Inverse kinematics in IBANDL Web interface

Original (direct)
Reaction: $^7\text{Li}(p,p_0)^7\text{Li}$ Qvalue=0 nPoint:71
M1: Incident $p$ M$_1=1.007825$ E$_1=1367.0\text{keV}$
M2: Target $^7\text{Li}$ M$_2=7.0160046$
M3: Scattered $p$ M$_3=1.007825$ E$_3=1070.6\text{keV}$ $\theta=81.1^\circ$ $\sigma(\theta)=45.1053\text{mb/sr}\pm5.0\%$
M4: Recoil $^7\text{Li}$ M$_4=7.0160046$ E$_4=296.4\text{keV}$ $\varphi=45.4^\circ$

Result: inverse-kinematics data presented in R33 format
Reaction: $^1\text{H}(^7\text{Li},p_0)^7\text{Li}$ Qvalue=0 nPoint:71
M1: Incident $^7\text{Li}$ M$_1=7.0160046$ E$_1=951.6\text{keV}$
M2: Target $^1\text{H}$ M$_2=1.007825$
M3: Ejectile $p$ M$_3=1.007825$ E$_3=2061.1\text{keV}$ $\theta=45.4^\circ$ $\sigma(\theta)=122.484\text{mb/sr}\pm5.0\%$
M4: Residual $^7\text{Li}$ M$_4=7.0160046$ E$_4=7455.3\text{keV}$ $\varphi=8.2^\circ$

| # | $E_1$, keV | $\theta^\circ$ | $\sigma(\theta)$, mb/sr | $\varphi^\circ$ | $\sigma(\varphi)$ | $E_3$ | $E_4$ | $E'_{cm}$ | $\theta'$ | $\varphi'$ | $\sigma(\theta')$ | $E'_1$ | $E'_2$ | $E'_3$ | $E'_4$ | $E''_2$ | $\varphi''$ | $\sigma(\varphi'')$ | $\theta''$ | $\sigma(\theta'')$ | $E''_3$ | $E''_4$
| 1 | 358.6 | 81.1 | 529.741 | 45.4 | 4.35366e6 | 280.851 | 77.7494 | 313.558 | 89.3 | 90.7 | 511.914 | 274.174 | 39.3842 | 274.174 | 39.3842 | 2496.4 | 45.4 | 1438.52 | 8.2 | 164261. | 541.3 | 1955.2
| 2 | 368.3 | 81.1 | 497.427 | 45.4 | 4.08809e6 | 288.447 | 79.8525 | 322.04 | 89.3 | 90.7 | 480.687 | 281.591 | 40.4495 | 281.591 | 40.4495 | 2563.9 | 45.4 | 1350.77 | 8.2 | 154241. | 555.9 | 2008
| 3 | 378.5 | 81.1 | 450.076 | 45.4 | 3.69894e6 | 296.436 | 82.064 | 330.959 | 89.3 | 90.7 | 434.93 | 289.389 | 41.5698 | 289.389 | 41.5698 | 2634.9 | 45.4 | 1222.18 | 8.2 | 139559. | 571.3 | 2063.6
| 4 | 388.2 | 81.1 | 407.779 | 45.4 | 3.35132e6 | 304.033 | 84.1671 | 339.441 | 89.3 | 90.7 | 394.056 | 296.805 | 42.6351 | 296.805 | 42.6351 | 2702.5 | 45.4 | 1107.33 | 8.2 | 126444. | 585.9 | 2116.5
| 5 | 398.4 | 81.1 | 413.26 | 45.4 | 3.39637e6 | 312.021 | 86.3786 | 348.359 | 89.3 | 90.7 | 399.353 | 304.604 | 43.7553 | 304.604 | 43.7553 | 2773.5 | 45.4 | 1122.21 | 8.2 | 128143. | 601.3 | 2172.1
| 6 | 407.1 | 81.1 | 391.875 | 45.4 | 3.22062e6 | 318.835 | 88.2649 | 355.967 | 89.3 | 90.7 | 378.687 | 311.256 | 44.7108 | 311.256 | 44.7108 | 2834 | 45.4 | 1064.14 | 8.2 | 121512. | 614.5 | 2219.6
| 7 | 417.8 | 81.1 | 382.085 | 45.4 | 3.14016e6 | 327.215 | 90.5848 | 365.323 | 89.3 | 90.7 | 369.227 | 319.437 | 45.886 | 319.437 | 45.886 | 2908.5 | 45.4 | 1037.55 | 8.2 | 118476. | 630.6 | 2277.9
| 8 | 432.2 | 81.1 | 435.468 | 45.4 | 3.57888e6 | 338.493 | 93.7069 | 377.914 | 89.3 | 90.7 | 420.813 | 330.446 | 47.4675 | 330.446 | 47.4675 | 3008.8 | 45.4 | 1182.52 | 8.2 | 135029. | 652.3 | 2356.4
| 9 | 433.7 | 81.1 | 445.21 | 45.4 | 3.65895e6 | 339.668 | 94.0321 | 379.226 | 89.3 | 90.7 | 430.227 | 331.593 | 47.6322 | 331.593 | 47.6322 | 3019.2 | 45.4 | 1182.97 | 8.2 | 138050. | 654.6 | 2364.6
| 10 | 434.2 | 81.1 | 461.032 | 45.4 | 3.78898e6 | 340.059 | 94.1405 | 379.663 | 89.3 | 90.7 | 445.517 | 331.976 | 47.6872 | 331.976 | 47.6872 | 3022.7 | 45.4 | 1251.94 | 8.2 | 142956. | 655.4 | 2367.3
| 11 | 435.1 | 81.1 | 480.354 | 45.4 | 3.94778e6 | 340.764 | 94.3357 | 380.45 | 89.3 | 90.7 | 464.189 | 332.664 | 47.786 | 332.664 | 47.786 | 3029 | 45.4 | 1304.4 | 8.2 | 148948. | 656.7 | 2372.2
| 12 | 437 | 81.1 | 493.156 | 45.4 | 4.05299e6 | 342.252 | 94.7476 | 382.111 | 89.3 | 90.7 | 476.56 | 334.116 | 47.9947 | 334.116 | 47.9947 | 3042.2 | 45.4 | 1339.17 | 8.2 | 152917. | 659.6 | 2382.6
6Li(d,p_1)⁶Li

Original (direct)

Reaction: 6Li(d,p_1)⁷Li
Q-value = 4547.4 keV

M1: Incident d
M₂: Target 6Li
M₃: Ejectile p
M₄: Residual 7Li

θ = 63.1°, E₁ = 0.4-2.9 MeV

Result: Inverse-kinematics data presented in R33 format

Version: R33
X4Number: 7014004

<table>
<thead>
<tr>
<th>Calculation</th>
<th>Original (lab.)</th>
<th>6Li(d,p_1)⁷Li</th>
<th>4 = 4547.4 keV</th>
<th>Center of mass</th>
<th>Inverse kinematics</th>
</tr>
</thead>
<tbody>
<tr>
<td>θ(E_kin)</td>
<td>E_kin (MeV)</td>
<td>θ (deg)</td>
<td>E_(cm) (MeV)</td>
<td>E'_cm (MeV)</td>
<td>E'_cm (MeV)</td>
</tr>
<tr>
<td>1</td>
<td>145</td>
<td>6.67503</td>
<td>3996.7</td>
<td>655.7</td>
<td>32.2</td>
</tr>
<tr>
<td>2</td>
<td>128</td>
<td>5.99946</td>
<td>4011.2</td>
<td>718.1</td>
<td>32.2</td>
</tr>
<tr>
<td>3</td>
<td>263</td>
<td>5.73</td>
<td>4045.4</td>
<td>764.9</td>
<td>32.2</td>
</tr>
<tr>
<td>4</td>
<td>266</td>
<td>5.32</td>
<td>4045.4</td>
<td>764.9</td>
<td>32.2</td>
</tr>
<tr>
<td>5</td>
<td>366</td>
<td>5.6</td>
<td>4092.0</td>
<td>821.3</td>
<td>32.2</td>
</tr>
<tr>
<td>6</td>
<td>369</td>
<td>5.61</td>
<td>4092.0</td>
<td>821.3</td>
<td>32.2</td>
</tr>
<tr>
<td>7</td>
<td>570</td>
<td>5.37</td>
<td>4189.6</td>
<td>927.0</td>
<td>34.5</td>
</tr>
<tr>
<td>8</td>
<td>673</td>
<td>5.17</td>
<td>4204.6</td>
<td>979.4</td>
<td>34.5</td>
</tr>
<tr>
<td>9</td>
<td>773</td>
<td>5.18</td>
<td>4290.9</td>
<td>1029.5</td>
<td>34.5</td>
</tr>
<tr>
<td>10</td>
<td>875</td>
<td>5.69</td>
<td>4342.7</td>
<td>1079.6</td>
<td>34.5</td>
</tr>
<tr>
<td>11</td>
<td>975</td>
<td>5.65</td>
<td>4394.0</td>
<td>1128.5</td>
<td>34.5</td>
</tr>
</tbody>
</table>

End Data:

6Li(d,p_1)⁶Li

Comment: Automatically converted from EXFOR
by IAEA-CHS EXFOR Web-Retrieval System (7-29/11/93)
"Absolute cross sections for deuteron-induced reactions on 6Li at energies below 1 MeV."
EXFOR: T0136004 Created: 2000-11-21 Updated: 2001-03-30
X4Reaction: 3-6Li(d,p)6Li Reaction: 2H(6Li,d)7Li

Level Energy: 478.00
Theta grouping interval: 5-7.0 deg.
Recalculation of angular distributions from EXFOR to inverse kinematics and integration with Web-IBANDL

Convert to R33 format

Note. This is β-version of X4R33 conversion software. Please report any problems to V.Zerkin@iaea.org

Plots: $d\sigma/d\Omega(E):2/2$ $d\sigma/d\Omega(\theta):16/189$ See: [doc] x4:$\sigma_{CM}(E,\theta)$ Try: $\theta_{CM}\rightarrow\text{Lab}$

1) $0^\circ:2900$ Plot R33 [IBA] [Inv] 2) $150^\circ:2900$ Plot R33 [IBA] [Inv]
Uploading your experimental data
Uploading your experimental data

https://www-nds.iaea.org/exfor/x4data.htm
Uploading your experimental data

Author: C. Sage, et al.

Reaction: 95-AM-241(N,2N)95-AM-240, SIG

Method: TOF

Uncertainties Δy: nn-7

<table>
<thead>
<tr>
<th>Var: (X)</th>
<th>{Y}</th>
<th>{ΔY}1</th>
<th>{ΔY}2</th>
<th>{ΔY}3</th>
<th>{ΔY}4</th>
<th>{ΔY}5</th>
<th>{ΔY}6</th>
<th>{ΔY}7</th>
</tr>
</thead>
<tbody>
<tr>
<td>EN</td>
<td>DATA</td>
<td>ERR-TOT</td>
<td>MONIT-ERR</td>
<td>ERR-1</td>
<td>ERR-2</td>
<td>ERR-7</td>
<td>ERR-8</td>
<td>ERR-3</td>
</tr>
<tr>
<td>MeV</td>
<td>mb</td>
<td>per-cent</td>
<td>per-cent</td>
<td>per-cent</td>
<td>per-cent</td>
<td>per-cent</td>
<td>per-cent</td>
<td>per-cent</td>
</tr>
<tr>
<td>Table</td>
<td>Table</td>
<td>Table</td>
<td>Table</td>
<td>Table</td>
<td>Table</td>
<td>Table</td>
<td>Table</td>
<td>Table</td>
</tr>
<tr>
<td>x</td>
<td>y</td>
<td>Δy</td>
<td>input your data below (copy/paste)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.34</td>
<td>96.8</td>
<td>6.5</td>
<td>1.9</td>
<td>5</td>
<td>1</td>
<td>.9</td>
<td>.3</td>
<td></td>
</tr>
<tr>
<td>9.15</td>
<td>152.9</td>
<td>5.7</td>
<td>1.9</td>
<td>4</td>
<td>1</td>
<td>.6</td>
<td>.3</td>
<td></td>
</tr>
<tr>
<td>13.33</td>
<td>241.8</td>
<td>4.6</td>
<td>1.6</td>
<td>2.5</td>
<td>1</td>
<td>.4</td>
<td>.3</td>
<td></td>
</tr>
<tr>
<td>16.1</td>
<td>152.4</td>
<td>4.6</td>
<td>2</td>
<td>2.1</td>
<td>1</td>
<td>.6</td>
<td>.3</td>
<td></td>
</tr>
<tr>
<td>17.16</td>
<td>116.1</td>
<td>4.4</td>
<td>2</td>
<td>1.5</td>
<td>1</td>
<td>.6</td>
<td>.3</td>
<td></td>
</tr>
<tr>
<td>17.9</td>
<td>105.7</td>
<td>4.4</td>
<td>2.2</td>
<td>1.3</td>
<td>.7</td>
<td>.7</td>
<td>.3</td>
<td></td>
</tr>
<tr>
<td>19.36</td>
<td>89.5</td>
<td>8.2</td>
<td>3.1</td>
<td>6.3</td>
<td>2</td>
<td>.6</td>
<td>1.3</td>
<td></td>
</tr>
<tr>
<td>19.95</td>
<td>102.1</td>
<td>5.8</td>
<td>4.1</td>
<td>1.4</td>
<td>1</td>
<td>.6</td>
<td>1.4</td>
<td></td>
</tr>
<tr>
<td>20.61</td>
<td>77.9</td>
<td>8.8</td>
<td>5.4</td>
<td>5.7</td>
<td>1.6</td>
<td>.6</td>
<td>1.4</td>
<td></td>
</tr>
</tbody>
</table>

Submit in new Window

<table>
<thead>
<tr>
<th>n</th>
<th>Display</th>
<th>Year</th>
<th>Author-1</th>
<th>Energy range,eV</th>
<th>Points</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>uploaded X4 X4+ Cov</td>
<td>2016 C.Sage+</td>
<td>8.34e6</td>
<td>2.061e7</td>
<td>9</td>
<td>+ W,SAGE,20160622</td>
</tr>
<tr>
<td>2</td>
<td>X4 X4+ X4+ T4 Cov</td>
<td>2016 A.Kalamara+</td>
<td>1.00e7</td>
<td>1.71e7</td>
<td>4</td>
<td>[pdf]+ J,PR/C,93,014610,2016</td>
</tr>
</tbody>
</table>
Plotting on Web with Web-ZVView
ZVView is a multi-platform program designed for nuclear reactions data evaluators to perform efficient interactive visual analysis of cross section data retrieved from EXFOR and ENDF libraries. Kiev-Vienna, 1993-2018

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

Platforms:
1. MS-Windows
2. Linux (X-Windows)
3. Mac OSX (X11)
4. Alpha/VMS
5. DEC Unix
6. AIX/R6000
7. Windows-3.1
8. MS-DOS

Old platforms:
4. Alpha/VMS
5. DEC Unix
6. AIX/R6000
7. Windows-3.1
8. MS-DOS

Output:
1. Screen (Windows)
2. PostScript (PS, EPS)
3. Enhanced Metafile (EMF)
4. PCX, GIF, Animated-GIF

Basic ideas:
1. Language: C
2. Self-made GUI, PS, PCX, GIF
3. Low level API’s (MS-Win, X11)
4. Max platform-independency
5. Minimalistic approach
ZVView: interactive plotting program for display and analysis of nuclear data

Features:

• All features inherited from DINAMO;
• Integrated with Empire, EndVer, EXFOR CD-ROMs.
• Works on Web: integrated with EXFOR-ENDF database retrieval systems, IBANDL, SigmaCals, LiveChart: can read data from remote archives, can be called as part of external Web service, etc.
• Reads nuclear data formats: TABLE/XREF, ENDF-MF3/MF40/MF33(Law5);
• Can read data from text files(columns): \{y\}; \{x y\}; \{x y dy\}; \{x y dy dx\}; \{x y +dy –dy +dx –dx\}; \{x\} \{y\} \{z\};
• Understands ENDF interpolation laws, can display ratios to selected curve
• Can do some least squared fitting, displays $\chi^2$ (EXFOR-ENDF)
• Can work with authors: filter data, select, legend etc.

EXFOR+ENDF

IBANDL+SigmaCalc

ENDF/MF33: Web, interactive, Log-Lin, animated

FLYCHK (A+M): Web-Web communication
Database Retrieval Systems

Input formats:
- Data by columns (X : Y : ΔY)
- Text (matrix, triangle)
- Link to Web-data (archives)
- ENDF file (or MF3/33 Sections)
- ZVD file(s)

Output formats:
- GIF, EPS, PS, PDF, SVG
- Html (Table)
- Text (columns, triangle)
- EXFOR draft (COVARIANCE)
- ENDF like (MF33 Section, LB5)
- Input for Fortran (+ reading code)

Web-ZVView

Send ZVD file to user’s PC

Several formats and non-structured data

Draft for EXFOR compilation

Data for FORTRAN users

IBANDL

FLYCHK

LiveChart

Your data

ENDF uploading

EXFOR uploading

Manual input

Input

Output

Plots + interactions /Web

2009-2014 Data for FORTRAN users

Your data

Send ZVD file to user’s PC

Several formats and non-structured data

Draft for EXFOR compilation

Data for FORTRAN users

Input formats:
- Data by columns (X : Y : ΔY)
- Text (matrix, triangle)
- Link to Web-data (archives)
- ENDF file (or MF3/33 Sections)
- ZVD file(s)
Useful features of Web-ZVView:

• copy/paste data to plots (inside Web session) between: EXFOR-ENDF-IBANDL-MyPlot/etc.
• insert text of ZVD file to the form as “my data” to compare them to data from databases
• output of plotted data in several formats (can be used for re-formatting data, e.g. free-text matrix to EXFOR and ENDF)
• “manual” options: dimensions, distortions, image corrections
• generates output: PS, EPS, PDF
• etc.
Example of interactive Web ZVView plotting

Select data for plotting

Plotting options

Add your data to the plot

Copy/Paste
Recent news in Web-ZVView plotting

Implementation: ZVView → JSON → AJAX → HTML5
Plot your data: MyPlot

http://www-nds.iaea.org/exfor/myplot.htm
Welcome to Web-ZVView!

Fe-54(n,el) \( E_i = 14.7 \text{MeV} \)

Data points:
- 1973, A.I. Tutubalin
- ENDF/B-VII.0
Input ENDF section of MF33

1) ZVD file: [example]
2) ZVD file: [example]

Examples/Help

3) Array Y(X) [example]
4) Array Y(X)
5) Array Y(X)

8) Matrix from ENDF/MF33 [example]

9) Matrix from ENDF/MF33 [example] [example] [example]
10) Matrix from ENDF/MF33: upload your local ENDF file

Set default plotting parameters: y(x): CS DA DE DAE z(x,y): COV/SIG

Common Plotting Parameters

- **Title**: Correlations of Neutron Cross Sections
- **X-axis**: Incident Energy  
  - Scale: Auto
- **Y-axis**: Incident Energy  
  - Scale: Auto
- **X-units**: 1e6, (MeV)  
  - View: 3D-0
- **Y-units**: 1e6, (MeV)  
  - Style: NJOY

Graph Parameters
- **View**: Full
- **Color**: Brown
- **Label**: 
- **MT**: all
Welcome to Web-ZVView!

Correlations of Neutron Cross Sections

Remote file: http://t2.lanl.gov/nis/data/data/ENDFB-VII.1-neutron/Gd/152 filter MT=102
Additional plot: Uncertainties
Additional plot: Cross Sections

Select data for plotting [all] [none]
☑ 1) Gd-152 MT102:gamma
☐ 2) Use my data [example]

See: plotted data (92Kb) cut:x4,T,F,e6
1. Text search in EXFOR (~Google)

2. Native EXFOR plotting

3. Calculating CS ratios between different EXFOR datasets

4. Constructing covariance matrix from EXFOR uncertainties on Web

5. Reconstruction of ENDF elemental reaction data in EXFOR-ENDF Web system

6. MyEndf system for ENDF evaluators
Thank you.