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Course Handbook

Nuclear Data for Energy and non-Energy Applications

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Handbook on Nuclear Data

Great-Pioneer EU Project

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CHAPTER 4

Nuclear Data Visualization Tools

Abstract

Nuclear data visualization tools are developed in different nuclear data centers and international organizations. These tools are freely available via web. The printed and downloaded plots can be used for teaching and research purposes with appropriate acknowledgement of these organizations.

These tools are user-friendly interfaces working in most of the current platforms and operating systems. Manuals and examples how to use are also provided in their official websites.

Key Words

ND software visualization tools, JANIS, IAEA, NNDC

4.1 JANIS software

JANIS (JAva-based Nuclear Data Information System) software¹ is developed by the OECD Nuclear Energy Agency (NEA) Data Bank to facilitate the visualization and manipulation of nuclear data, giving access to evaluated nuclear data libraries, such as ENDF/B, JEFF, JENDL, TENDL etc., and also to experimental nuclear data (EXFOR) and bibliographical references (CINDA).

JANIS is available as a standalone Java program, downloadable and distributed on DVD and also a web application available on the NEA website. [1]

Neutron evaluated libraries (e.g. JEFF-3.3) are processed for being uploaded in JANIS Database (see **Figure 1**) by merging ENDF-6 (original files) and PENDF (reconstructed-pointwise ENDF) files to produce HENDF (Hybrid ENDF) files, an acronym used at NEA, which includes reconstructed cross section from MF3, in consistency with MF33 covariance data when necessary, plus all the other MF data included in the original ENDF-6 format file.





¹ <u>https://www.oecd-nea.org/janis</u>

An example² of the procedure to generate HENDF files can be seen in **Figure 2**. The processing code system used is essentially NJOY code together with routines from the PREPRO [2] and ENDF Checking & Utility packages³, specifically INTER code. The NJOY modules used in this processing are: MODER, RECONR, BROADR, HEATR, GASPR, ERRORR and COVR.

For HENDF files, PENDF data are generated with general tolerance criteria for the reconstruction, thinning and broadening (e.g. 0.5%) and at any temperature, by default the room temperature is defined at 293.6K. The processed data contain kinematic kerma factors, total damage energy production and gas production cross section whenever such data are contained in the ENDF library. Processing covariance data into ERRORR and BOXER formats is carried out at different group structure (e.g. SCALE-238 groups). Therefore, at the end of the processing three files are generated: one HENDF, one BOXER (if evaluated file provides covariance data) and one INTER (containing cross section integral data). These three files are then uploaded into JANIS database.





The content of all JANIS databases is summarized in Table 1.

Recently, JANIS command line's features have been implanted in JANIS software. The basic syntax of the command line is: "*java -jar janis.jar <options>*". The command line arguments use the JANIS identifiers. The "-list" argument gives the identifiers that can be used. The general rule is to take the paths written with '~' from either JANIS Web tree of from JNS

² HENDF contains raw ENDF data and processed data. In this example NJOY code is used to create the PENDF data for reaction cross-sections (BROADR), KERMA and damage (HEATR) and gas production (GASPR) energy cross-sections. The PENDF file created with NJOY keeps only the PENDF data in the file MF3, the raw ENDF data MF2, MF4 and following MFs are not kept in the PENDF. The HENDF is created merging PENDF with ENDF data.

³ <u>https://github.com/IAEA-NDS/ENDF-utility-codes</u>

XML files and replace '~' with blank(s) to get the command line syntax (e.g. NEA N ENDF/B-VII.1 SIG U235 MT2 xs). An example of command line to retrieve cross-section data in a table format: "*java -jar janis.jar -table NEA N JEFF-3.1.1 SIG U235 MT2*")

The "-render" option was recently implemented to handle the conversion of JNS file into PNG graphics. JANIS-4.0 permits to save and restore the content of a renderer in an XML file (with extension "JNS", by default). It is available through the menu "File > Save…" and "File > Open…". The XML file includes all the information needed to re-open the renderer in the state it was saved. So, all data selected, including calculation results, and all customizations done on plots will be completely restored.

1		
Nuclear Properties	NUBASE-1997/2003/2012/2016/2020	
Radioactive	ENDF/B-VI.8/VII.0/VII.1/VIII.0	JEF-2.2, JEFF-3.1/3.1.1/3.3
data	GEFY-3.2/3.3/4.2/5.2/6.1/6.2	JENDL-4.0
	JENDL-DDF-2015, JENDL-FPD2000/2	2011, JENDL/FPY-2011
	TENDL-2010	
Incident	EXFOR	
neutron data	CENDL-2.1/3.1/3.2	BROND-2.2, BROND-3.1
	EAF-2007/.2010	
	ENDF/B-VI.8/VI.8-HE/VII.0/VII.1/VIII.	0
	FENDL-2.1/2.1MG, FENDL-3.1b	GEFY-3.2/3.3/4.2/5.2/5.3/6.1/6.2
	IRDF-2002/2002MG, IRDFF-1.0/1.064	0g, IRDFF-1.05
	IRDF-II	
	JEF-2.2, JEFF-3.0/3.0A/3.1/3.1.1/3.1.2/	/3.2/3.3
	JENDL3.3/4.0, JENDL-AC-2008, JENL	DL-FPY-2011, JENDL-HE-2007
	RUSFOND-2010	TENDL2009/10/ /17/19
	TSL-ENDF/B-VI.8/, TSL ENDF/B-VII.0), TSL-JEFF3.0/3.1
Incident	EXFOR	
gamma data	ENDF/B-VII.0/VII.1/VIII.0	IAEA/PD-2019
	JENDL-PD-2004/201672016.1	TENDL2009/10//17/19
Incident	EXFOR	
proton data	ENDF/B-VI.8/VI.8-HE/VII.0/VII.1/VIII.	0
	JEFF-3.1	
	JENDL-4.0/HE, JENDL-AD-2007	JENDL-HE-2007
	PADF-2007	TENDL2009/10//17/19
Incident	EXFOR	
deuteron &	ENDF/B-VI.8/VII.0/VII.1, VIII.0	JENDL-DEU-2020
triton data	TENDL2009/10//17/19	
Incident	EXFOR	
he3 data	ENDF/B-VII.0/VII.1/VIII.0	TENDL2009/10//17/19
Incident	EXFOR	
alpha data	ENDF/B-VIII.0	
	JENDL-AN-2005	TENDL2009/10//17/19
Incident	EXFOR	
heavy particles,		
electron data,		
antiprotons,		
<i>kaons(-,+)</i>		
and pions(-,+)		

Table 1. Nuclear data libraries available in the NEA/JANIS database

4.1.a JANIS Basics

JANIS is JAva-based Nuclear Data Information Software designed to facilitate the visualization and manipulation of nuclear data. JANIS is a graphical interface to access:

- Bibliographical nuclear reaction data (CINDA)
- Experimental nuclear reaction data (EXFOR)
- Evaluated nuclear reaction and decay data (e.g. JEFF, ENDF/B)
- Basic properties of nuclei (NUBASE)

JANIS provides ways for:

- exploring nuclear data libraries and databases
- visualization and comparison of data
- arithmetic operations (normalization, ratio, linear combination)
- some processing (weighted average)

JANIS allows to export plots and numerical values in several formats:

- PNG for images
- WMF/EMF, PS, PDF for vectorial images
- CSV, copy & paste to Excel for numerical values

Figure 3. The JANIS – Plot (renderer) window



Figure 3 shows main JANIS window:

- Selection tree: To select the data you want to display
- Display pane(s): To display textual information, tabulated values, plots, decay paths
- Display settings: To adjust the settings of the plot or table
- Data parameters: To display additional information on the selected data and select variable values for distributions, yields...
- Other panels available in JANIS: Text panels, decay paths, 2D- color maps (e.g. covariance data)

JANIS is able to save JANIS session (JNS file) into XML format. This feature is very useful to automatize procedures and to easily share JANIS information among users.

JANIS allows automated plots generation through scripting via the command line execution. An example of plot generation: "*java -jar janis.jar -o FILE.png -render FILE.jns png 1024* 768".

JANIS has implemented different import options: EXFOR, CINDA, ENDF, PENDF, GENDF, ERRORR, BOXER, COVERX, INTER and NUBASE

Additionally, JANIS allows search capabilities of nuclear data based on general ENDF reactions, resonances, decay line, experimental data (EXFOR) and bibliographical references (CINDA).

JANIS is very useful for comparing data, manually comparing evaluated data against experimental data, or using the "Compare with Evaluated data" tool.

JANIS has implemented capabilities to perform simple arithmetic computations (with operators: +, -, * and /) and weighting cross sections calculated using the following equation:

$$\sigma^g = \frac{\int_{E_g}^{E_{g+1}} \sigma(E) \cdot \phi(E) \, dE}{\int_{E_g}^{E_{g+1}} \phi(E) \, dE}$$

where $\phi(E)$ is the spectrum. The "Weighting" dialog box enables the definition of the weighting flux spectrum, and the energy group structure.

4.1.b Creating a personal database using the import WIZARD tool

An important feature for users is the possibility to create own databases for JANIS. This can be carried out with the "Database > Import Wizard" tool.

The steps to create this database are

- 1. New folder shall be created with three sub-folders, one per type of file (i.e. hendf, boxer and inter). Then, the files generated shall be copied to their corresponding sub-folders (advice: delete those empty files)
- 2. Open JANIS, and at the toolbar click on "database -> import wizard"
- 3. Add HENDF files. For that use either "Add directory" or "add files" options. Then, click on "next"
- 4. "Automatic detection" should work fine. Click on "next"
- 5. Choose a library name (e.g. JEFF-3.3) with less than 20 characters. Click on "next"
- 6. Select "a new base "when importing HENDF, that means for the first import. For BOXER and INTER files, "an existing base" shall be selected, and then, selecting the created database for HENDF files
- 7. Choose "path to the folder" where the database will be created. Click on "next"
- 8. The "base root" shall point to the folder created with the three sub-folders (one for each kind of file type). Click on "next"
- 9. Type a "database" name (e.g. GPIONER) for showing later in JANIS. Click on "next"

- 10. A summary of the task to do, plus input parameters, is presented before importing data from files. Click on "Finish"
- 11. Once imported HENDF files, for BOXER and INTER files repeat these instructions until step (5), where to change to "existing base" option
- 12. Errors might arise if empty files are read, so remove them from the importing list
- 13. Check that once the BOXER files have been imported into the database, a "Others" tag does not appear in the "Nuclide / Compound tree". If this tag exists, then, there is an issue in regard to cross-correlation covariance data, likely to be missing data for one of the two isotopes present in the cross-correlation matrix
- 14. At the end of this process, a "db.h2.db" le is created, plus the importing logs. This database can be distributed and share between other JANIS users.

Then, to download a JANIS Database (db.h2.db) into JANIS, the users have to:

- Use the "Database > Load" function to open a personal database
- Set ".h2.db" file" to select the downloaded h2.db file
- Set "root folder" to the folder where h2.db is located

4.1.c JANIS Books

The JANIS Books are compilations of cross-section curves of different evaluated and experimental data, for nuclear reactions induced by neutrons, photons and light-charged particles.

JANIS Books are available in online up-to-date interactive versions (see **Figure 4**), PDF and JNS formats. The Handbooks contains plots with one page per isotope and reaction, allowing a quick visual comparison of many data.



Figure 4. The JANIS – online Handbook

4.2 IAEA software visualization tools

4.2.a The EXFOR-CINDA-ENDF retrieval system

The IAEA nuclear data services offer access to improved and extended nuclear reaction databases.⁴ The IAEA nuclear reaction retrieval systems [3] include the following features:

- plotting capabilities: angular distributions, double-differential distributions, energy spectra and cross sections, with errors of evaluated data
- inter-database links: CINDA, EXFOR, ENDF and user's data
- different output formats
- flexible ENDF database explorer: the system offers "direct" types of request with any combination of search parameters.

The EXFOR-CINDA-ENDF retrieval system is designed for the "expert" users with having well-defined tasks involving data search, downloading and presentation (see Figure 5). The system offers "direct" types of requests with any combination of search parameters. The advantage of this method is that users, who know exactly what they need, can access the data quickly and without any limits; disadvantage is that users have no a priori information about the existence of the data they require nor a knowledge of the full contents of the Database.



Figure 5. The IAEA/NDS retrieval system's website

⁴ <u>https://www-nds.iaea.org/exfor/endf.htm</u>

4.2.b The Evaluated Nuclear Data File (ENDF) visualizer

The ENDF visualizer⁵ developed by IAEA/NDS allows visualization of evaluated data, allowing addition of EXFOR data in the same plot (see Figure 6). The IAEA/NDS web tools include a set of "Examples of requests" to introduce users in the tool. An "standard" request and "advanced" request preference may give more options in the searching tool.



Figure 6. The IAEA/NDS "ENDF" tools

4.2.c The "Libraries-2021 Data Explorer"

In August 2021, the IAEA/NDS launched the "Libraries-2021 Data Explorer"⁶ (Figure 7). This is a tool for quick and easy comparison of EXFOR data and the major nuclear data libraries. This tool uses the TALYS-Related Databases⁷ distributed by IAEA/NDS for the simulation of nuclear reactions. Basically, this tool is able to accomplish the following:

- Use the EXFORtables code to mine data from EXFOR/C5 format
- Use the ENDFtables code to mine data from ENDF
- Put the results into a large database (LIBRARIES-2021)
- Feed the database into a plotting tool to plot the results

⁵ https://www-nds.iaea.org/exfor/endf.htm

⁶ <u>https://nds.iaea.org/dataexplorer</u>

⁷ <u>https://www-nds.iaea.org/talys/</u>



Figure 7. The IAEA/NDS "Libraries-2021 Data Explorer"

4.2.d Live Chart of Nuclides

The Live Chart of Nuclides⁸ is an interactive tool useful for nuclear structure and decay data (see **Figure 8**).



Figure 8. The IAEA/NDS "LiveChart of Nuclides"

⁸ https://www-nds.iaea.org/relnsd/vcharthtml/VChartHTML.html

4.2.e Reference Input Parameter Library (RIPL-3)

The Reference Input Parameter Library $(RIPL-3)^9$ is for searching, retrieval and plot of nuclear data (see Figure 9).



Figure 9. The RIPL searching and retrieval tool

4.3 NNDC software visualization tools

4.3.a The ENDF search and retrieval system

The ENDF¹⁰ (see Figure 10) and SIGMA¹¹ (see Figure 11) interfaces were designed to plot ENDF data.

The "Extended Retrieval" and "Advanced Retrieval" are designed for advanced user with knowledge of ENDF format.

⁹ https://www-nds.iaea.org/RIPL/

¹⁰¹⁰ <u>https://www.nndc.bnl.gov/exfor/endf00.jsp</u>

¹¹ <u>https://www.nndc.bnl.gov/sigma/</u>

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National Nuclea	Data Center				BRO	KHAV	E
NNDC	Databases: NuDat NSR XUNDL ENSDF MIRD ENDF CSISRS Sigma						
IDC Site Index				 			
e ENDF Project							
out ENDF	Evaluated Nuclear Data File (ENDF)						
t ENDF Data							
ENDF Format	The Area and Ar						
CSEWG Collaboration	Data Show to ENDF/B-VIII.0 released February 2, 2018						
edback	ENDE/B-VIII 0 fully incorporates the new Neutron Data Standards, includes improved thermal						
nments, Questions?	neutron scattering data and uses new evaluated data from the Coordinated International						
quently Asked Questions	Evaluation Library Organization (CiELO) pilot project for neutron reactions on ¹ H, ¹⁰ O, ¹⁰ Pie,						
DF Discussion List	 Section 2 and Section 2 and Sec						
nd a Bug? Report it!	spectra, thermal neutron scattering data, and charged-particle reactions						
DF Releases							
F/B-VIII.0	Basic Retrieval Estended Betrieval Advanced Betrieval Help						
SF/B-VII.1			_				
DF/B-VII.0							
DF/B-VI.8	Target						
Koloases P	56/6, fe-56, 25.4e-56, fe* OAII ® Selected. O Reset						
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	ally, us, us, us, us, us, us, us, us, us, us						
	CENTLA1 (China, 2009)						
	ROSFOND (Russia, 2010)						
CS & Reaction Rates							
CS & Reaction Rates	-submit Reset						
	Lunabase namager. Lavora amenin, muuci, anoomaren natiofal (Jaborato) (Constitution) (Jaborato) (Ja						
	web - Programming: Boro - Physicenesis, NVLVL, proceedings / address (address) (physicenesis)(physice) Data Source - CSENE (www.mol.chi.gov/secase) and NEA IMEE (new mol.shiftmane/secase) (physice)						

Figure 10. The ENDF/NNDC retrieval system's website

SIGMA [4] (see Figure 11) is a web application which provides user-friendly access in processing and plotting of the evaluated and experimental nuclear reaction data stored in the ENDF-6 and EXFOR formats. The main interface includes browsing using a periodic table and a directory tree, basic and advanced search capabilities, interactive plots of cross sections, angular distributions and spectra, comparisons between evaluated and experimental data, and computations between different cross section sets. Interactive energy-angle, neutron cross section uncertainty plots and visualization of covariance matrices are under development.





4.3.b The ENSDF search and retrieval system

The Evaluated Nuclear Structure Data File (ENSDF) search and retrieval system¹² allows a quick search of nuclides in the ENSDF database (see Figure 12).



Figure 12. The NNDC retrieval ENSDF system

4.3.c The NuDat3.0

The NuDat 3.0^{13} is a search-plot tool for nuclear structure and decay data (see **Figure 13**).

Figure 13. The NuDat3.0 retrieval system's website



¹² https://www.nndc.bnl.gov/ensdf/

¹³ https://www.nndc.bnl.gov/nudat3/

4.4 Japanese Software

4.4.a JAEA

The Japan Atomic Energy Agency (JAEA) has developed tools¹⁴ for drawing nuclear data graphs:

- Plotting Tool for ENDF (Evaluated Nuclear Data File) (see Figure 14) Generating a cross section graph of JENDL-3.2, -3.3 and -4.0.
- Graph of Fission Product Yields Generating some types of fission yield graphs of JENDL-4.0.
- View of Average Resonance Cross Section (VARCS) Average cross sections broadened at 293.6 K by using LINEAR, RECENT and SIGMA1 codes based on JENDL-4.0
- Search for Resolved Resonances Retrieved information on resolved resonances on JENDL-4.0

Top Page in Japanese Nuclear Data Center powered by gnuplot-4.6 lapan Atomic Energy Agency Plotting Tool for ENDF (Evaluated Nuclear Data File) JENDL-3.2 : 0 K , 300 K 105 JENDL-3.3 : □ 0 K , □ 300 K JENDL-4.0 : □ 0 K , ☑ 300 K JENDL-4.0 300 K (u1), U-235, MT= 1, (n,total JENDL-4.0 300 K (u1), U-235, MT=102, (n,γ) 104 103 Nuclides: (e.g. "U-235, Am-242m, Fe-0") Cross Section (barns) 10² U-235 10¹ MT Numbers (Reaction Types) : 1,102 10⁰ 1, 102
 (ex. "1, 102" for Total and (n,γ)) Show MT vs Reaction table. 10-1 10-2 X-axis Type : O Linear
 Log X-axis Range [eV] : Auto 10-3 1.0e-5 ~ 2.0e+7 10-4 Y-axis Type: O Linear
 Log $10^{-5} \ 10^{-4} \ 10^{-3} \ 10^{-2} \ 10^{-1} \ 10^{0} \ 10^{1} \ 10^{2}$ 10³ 10⁴ 105 106 107 Y-axis Range [barns] : 🗹 Auto Energy (eV) ~ 1.0e+5 1.0e-4 JAEA Nuclear Data Cente Draw Graph Downloading Files : [Plot Data], [Gnuplot Input], [PNG Image] Usage: [in Japanese] [in English] This system was modified at 2013/10/28 13:45 [JST] Copyright © 1995-2020, Japan Atomic Energy Agency, Nuclear Data Center Tokai-mura, Naka-gun, Ibaraki-ken, 319-1195, Japan E-mail: jendl@jaea.go.jp

Figure 14. Scree-shot of the JAEA's Plotting Tool for ENDF

¹⁴ <u>https://wwwndc.jaea.go.jp/tools/index.html</u>

4.4.b The Hokkaido University Nuclear Reaction Data Centre (JCPRG)

The Hokkaido University Nuclear Reaction Data Centre (JCPRG) has developed an EXFOR searching and visualizer web tool¹⁵ (see Figure 15).

← → C බ ⊡ https://www.jcp	org.org/exfor/		3	A»	Q	τ _ρ	SC	(F)	G	Σ_≡	Ĥ		
JCPRC 北海道大学大学院理学研究院附属		-							-		_		
ネ子核及応テータが Hollaida University Nuclear B	「究 同 癸 センタ Inaction Data Contr	9-											
Howaldo oniversity Ruclear A	eaction Data Centr	U					NRDF	EXFOR	CINDA	ENDF E	nglish	Japanese	Internal
Hokka	aido University Nu	iclear F	Reacti	on Dat	a Cen	itre (J	CPRG						
(17 Dec.	2019 Updated - [ne	w data] [feed	lback] [Q and	A: Er	ıg./ Jpn	-1)					
EXFOR is compiled by the Nuclear Reaction Data Centres Network (NRDC) a	under the auspices of the Int	ternational	Atomic	Energy Age	incy (IAI	EA), JENI	DL. ENDE.	JEFF, BRONG	and CENE	L are produ	ed based	on EXFOR b	ABA
Nuclear Data Center and Japanese Nuclear Data Committee (JAEA-NDC+3N Center and Nuclear Data Committee of China, respectively.	DC), Cross Section Evaluata	ion Workin	ng Group	(CSWEG),	NEA Joi	nt Evalua	tion Proje	ct, Russian I	Nuclear Dat	a Center (CI	D) and Ch	inese Nuclea	ir Data
EXPORCI	[basic]	Fadvan	cel [b	eginner	ata she	iets 120	(2014)23	2					
(Use	";" (semicolon) for	logical	OR, "	*" (aste	risk) f	or wil	dcard)						
S	Example(1	Exam	nple(2	Examp	ole(3	Res	et						
Target			- AC	elector	(fe-56	56fe	he-4						
Projectile			_	elector	(n. p.	a. g. c	-12)	a,)					
Emission			-	elector	(el, in	l, f, g,	x+n, n-	+p,2p,)					
Residual			5	elector	(fe-56	, 56fe	,)						
Quantity			s	elector	(CS,D)A,)							
Energy (eV)			_		(1.0e-	5:2.0e	+7)						
Data No.		Plot	axis		(1040	8,E19	01002,.)					
Horizontal (1)				elector	(EN F	N-CA	()						
Horizontal (2)				elector	(ANG	,ANG	-CM,)					
Vertical			5	elector	(DAT.	A,DA	TA-CM	,)					
		Bibliog	graphy										
Pub. Year			5	elector	(1988	:1990))						
Journal				elector	(NP/A	I,ORN	L-4013	3,)					
1st Author Author				elector	(Kato, (Schu	,) :erer	`						
Author	L	Opti	ions	ciccior	(Senti		.,						
EXFOR	⊜include ○	exclude											
ENDF	● include ○	exclude											
Quantity ratio	● include ○	exclude	2										
Inverse kinem	atics O include ()	exclude											
Sort by	● reaction ○	referen	ice										
Feed fine to inquire anything (web service, contribution to dat Muclear Beaction Data Conver, Faculty of Science, Hokkado 060,0810 Support, Japan TEL, +81(JPN)-11-706-3723 (FAX -81(JPN)-11-706-3724 Party supported by MEXT, JAPS (Grant-n-Aid for Publicatic Last revision 2022-03-29 19:18xhtml:css	abases etc.); University on of Scientific Research	1 Results)), RIKE	N, and M	eme M	edia La	b. in Hok	kaido Uni	v.		servi	n ces@jcprg	org
4													•

Figure 15. The JCPRG retrieval system's website

¹⁵ <u>https://www.jcprg.org/exfor/</u>

4.5 Exercises

4.5.a Comparing experimental "eta" data with evaluated data

Exercise 1:

Extract eta values with EXFOR tool and plot/calculate the "eta" evaluated data.

Use PREPRO or JANIS for calculations.

The **eta** value is the number of neutrons emitted per neutron absorbed. This related parameter of fissile nuclei for thermal neutron energies plays an important effect on the temperature coefficient of reactivity in thermal reactor.

Figure 16. Eta (η) for 235U for thermal neutron energy. EXFOR data retrieved using searching tool for the reaction code: "92-U-235(N,ABS),,ETA."



Procedure:

- "run.bat" procedure will automatically process eta values for U233, U235, Pu239 and Pu241
- Evaluated files are in .\Lib\ folder
- Processing at 300K is carried out with PREPRO codes :
 - LINEAR, RECENT SIGMA1, FIXUP, DICTIN
- Point-wise files are :
 - o n_9222_92-U-233.dat.pendf
 - o n_9228_92-U-235.dat.pendf
 - o n_9437_92-Pu-239.dat.pendf
 - o n_9443_92-Pu-241.dat.pendf
- Eta value is saved in MT255
- Visualization/extract point-wise "eta" that can be carried out with JANIS code
- Visualization/extract EXFOR data
- Create a plot with "eta" point-wise and EXFOR data

"run.bat" @echo off FOR %%G IN (n 9222 92-U-233.dat n_9228_92-U-235.dat n_9437_94-Pu-239.dat n_9443_94-Pu-241.dat) DO (copy .\Lib\%%G ENDFB.OUT copy .\Input\LINEAR.INP . copy .\Input\RECENT.INP . copy .\Input\SIGMA1.INP . copy .\Input\FIXUP.INP_%%G FIXUP.INP copy . $\Input\DICTIN.INP$. copy .\Input\MT.DAT linear.exe recent.exe sigmal.exe fixup.exe dictin.exe move DICTIN.OUT %%G.pendf del LINEAR.INP LINEAR.OUT LINEAR.LST del RECENT.INP RECENT.OUT RECENT.LST del SIGMA1.INP SIGMA1.OUT SIGMA1.LST del FIXUP.INP FIXUP.OUT FIXUP.LST del DICTIN.INP DICTIN.LST del MT.DAT del ENDFB.OUT

Searching EXFOR ETA values using https://www-nds.iaea.org/exfor/ Submit Reset Request Help Feedback and User's Input Target 🗌 Comments/questions?
 Send experimental data to EXFOR team
 Send message about mistake in EXFOR Reaction Quantity 🗌 Clone Request: Product 🗌 CINDA ENDF Energy from to 🗆 eV 💙 ? Author(s) A More Web Tools Publication year Upload your own experimental data
 Plot your data
 Run ENSDF codes on your ENSDF data Last modified Accession # Extended Keywords
 A Expert ¹ Outgoing particle Angle range (deg.) Data Header 🖂 Units 🗌 Points 🗌 Trans ID 🗌 Center ID 🗌 EXFOR User EXFOR Compiler Full reaction code 🗹 92-U-235(N,ABS),,ETA [⊗] Evaluator Reset Submit Submit in new Window Note all criteria are optional (selected by checking
 selected criteria are combined for search with logical AND

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	EXFOR / ENDF	- Search					
(17 Dec. 2019	Updated - [new data] [fe	edback] [Q and A: Eng./ Jpn.])					
and CENDL are produced	based on EXFOR by JAEA Nuclear Di	ata Center and Japanese Nuclear Data Committee (JAEA-NDC+3NDC	XC), Cross				
EXFOR Citation:	N.Otuka, E.Dupont, V.Semkova e	t al., Nucl. Data Sheets 120(2014)272					
	[basic] [advance]	[beginner]					
(Use ";" (s	emicolon) for logical OR	"*" (asterisk) for wildcard)					
Search	Example(1 Example)	Z Example(3 Reset					
	Dasic						
larget	U-235	selector (fe-50, 50fe, he-4, a,)					
Projectile		selector (n, p, a, g, c-12,)					
mission		selector (el, inl, f, g, x+n, n+p,2p,)					
Residual		selector (fe-56, 56fe,)					
Quantity		selector (CS,DA,)					
nergy (eV)		(1.0e-5:2.0e+7)					
Data No.		(10468,E1901002,)		Ho	kkaldo University Nuclear Reaction	on Data Centre (JCPRG)
	Piot axis				(EXFOR: 25 hits FND	Results F: 0 hits)	
Iorizontal (1)	EN	selector (EN,EN-CM,)			(1.54) 014: 2.5 11(5, 1.14)		
forizontal (2)		selector (ANG,ANG-CM,)			Plot Res	set	
Vertical	DATA	selector (DATA,DATA-CM,)	Plot	Author	Year Inc. energy (eV) Work Type	Reference	Library Data ID
	Bibliograp	hy		92-U-235(N,NON),,E	TA (Neutron yield (Eta))		
ub. Year		selector (1988:1990)		F.D.Brooks et al.	1966 1.7e-01 2.0e+02 Expt Rept	AERE-M-1670,1966	EXFOR 20938.029
ournal		selector (NP/A,ORNL-4013)		F.D.Brooks et al.	1966 1.1e+01 2.0e+02 Expt Rept 1965 2.4e+07 2.4e+07 Expt Jour	AEKE-M-10/0,1900	EXFOR 20938.024 EXFOR 40808.007
st Author		selector (Kato,)		N.N.Flerov et al.	1958 1.4e+07 1.4e+07 Expt Jour	SJA,5,1593,1958	EXFOR 40806.002
luthor		selector (Schwerer,)		V.N.Andreev	1958 2.4e+04 8.8e+05 Expt Jour	SJA,4,247,1958	EXFOR 40385.004
	Options			P.E.Spivak et al.	1957 3.0e+04 9.0e+05 Expt Jour	JNE,4,79,1957	EXFOR 40350.003
XFOR	● include ○ exclude			P.E.Spivak et al.	1957 3.0e+04 9.0e+05 Expt Jour	JNE,4,79,1957	EXFOR 40350.003
ENDF	● include ○ exclude			P.E. Spivak et al.	1957 1.5e-01 1.3e+02 Expt Jour	JNE.4.79.1957	EXFOR 40350.018
Quantity ratio	⊖include ®exclude			92-U-235(N,ABS),,E	TA (Neutron yield (Eta))		
uperseded data	\bigcirc include \circledast exclude			H.Weigmann et al.	1990 1.5e+00 1.5e+02 Expt Conf	90MARSEI,3,(PI),33,199	0 EXFOR 22194.003
nverse kinematics	\circledast reaction \bigcirc reference			H.Weigmann et al.	1990 1.8e+00 4.6e+02 Expt Conf	90MARSEI,3,(PI),33,199	0 EXFOR 22194.002
Sort by	$^{\textcircled{o}}$ reaction \bigcirc reference			J.R.Smith et al.	1982 2.5e-02 2.5e-02 Expt Rept	SMITH,1982	EXFOR 12318.004
	Quantity			J.R.Smith et al.	1970 1.6e-01 1.6e-01 Expt Prog	IN-1407,39,1970	EXFOR 13018.003
		selector (CS,)		J.R.Smith et al.	1968 2.5e-02 6.0e-02 Expt Conf	68WASH,1,589,1968	EXFOR 12554.004
CINDA quant.		selector (PAR,)		F.D.Brooks et al.	1900 5.5e-02 1.0e-01 Expt Rept	AERE-M-10/0,1966	EXFOR 20938.028
CINDA quant. Branch				F.D.Brooks et al.	1966 9.2e-01 3.9e+00 Expt Rept	AERE-M-1670,1966	EXFOR 20938.026
CINDA quant. Branch Parameter	ETA	selector (DA,)				AERE-M-1670,1966	EXFOR 20938.025
CINDA quant. Branch Parameter Particle Consid.	ETA	selector (DA,) selector (P,)		F.D.Brooks et al.	1966 1.8e+00 1.1e+01 Expt Rept	SJA,16,121,1964	
INDA quant. ranch arameter article Consid. Iodifier	ETA	selector (DA,) selector (P,) selector (ANA,)		F.D.Brooks et al. K.G.Ignat'Ev et al.	1966 1.8e+00 1.1e+01 Expt Rept 1964 3.0e-02 1.2e+00 Expt Jour		EXFOR 40156.002
CINDA quant. Branch Parameter Particle Consid. Modifier Data Type	ETA	selector (DA,) selector (P,) selector (ANA,) selector (EXP,)		F.D.Brooks et al. K.G.Ignat'Ev et al. R.L.Macklin et al.	1966 1.8e+00 1.1e+01 Expt Rept 1964 3.0e-02 1.2e+00 Expt Jour 1960 2.5e-02 2.5e-02 Expt Jour 1980 6.0e 3.0e 0.2 Expt Jour	NSE,8,210,1960	EXFOR 40156.002 EXFOR 12349.003
CINDA quant. Granch 'arameter 'article Consid. Iodifier Data Type Gesult	ETA	selector (DA,) selector (P,) selector (ANA,) selector (EXP,) selector (FRCUM,)		F.D.Brooks et al. K.G.Ignat'Ev et al. R.L.Macklin et al. H.M.Skarsgard et al. J.R.Smith et al.	1966 1.8e+00 1.1e+01 Expt Rept 1964 3.0e-02 1.2e+00 Expt Jour 1960 2.5e-02 2.5e-02 Expt Jour 1958 6.0e-03 5.0e-02 Expt Jour 1957 1.0e-01 9.3e+00 Expt Prog	NSE,8,210,1960 JNE,6,212,1958 IDO-16373,37,1957	EXFOR 40156.002 EXFOR 12349.003 EXFOR 21202.002 EXFOR 12411.002
CINDA quant. Branch Parameter Particle Consid. Jodifier Data Type Result SSUB	ETA	selector (DA,) selector (P,) selector (ANA,) selector (FXCUM,) selector (FXCUM,) selector (10,)		F.D.Brooks et al. K.G.Ignat'Ev et al. R.L.Macklin et al. H.M.Skarsgard et al. J.R.Smith et al. H.Palevsky et al.	1966 1.8e+00 1.1e+01 Expt Rept 1964 3.0e-02 1.2e+00 Expt Jour 1960 2.5e-02 2.5e+02 Expt Jour 1958 6.0e-03 5.0e-02 Expt Jour 1957 1.0e-01 9.3e+00 Expt Pour 1957 1.0e-01 1.7e-01 Expt Pour	NSE,8,210,1960 JNE,6,212,1958 IDO-16373,37,1957 JNE,3,177,1956	EXFOR 40156.002 EXFOR 12349.003 EXFOR 21202.002 EXFOR 12411.002 EXFOR 12322.003
EINDA quant. iranch arameter article Consid. fodifier lata Type cesult ISUB IF	ETA	selector (DA,) selector (DAA,) selector (ANA,) selector (EXP,) selector (FRCUM,) selector (I0,)		F.D.Brooks et al. K.G.Ignat'Ev et al. R.L.Macklin et al. H.M.Skarsgard et al. J.R.Smith et al. H.Palevsky et al. 92-U-235(N,ABS),,E	1966 1.8e+00 1.1e+01 Expt Rept 1964 3.0e-02 1.2e+00 Expt Jour 1960 2.5e-02 2.5e-02 Expt Jour 1958 6.0e-03 5.0e-02 Expt Jour 1957 1.0e-01 9.3e+00 Expt Prog 1956 1.0e-02 1.7e-01 Expt Jour TAL, REL (Neutron yield (Eta)- relation) relation Period	NSE,8,210,1960 JNE,6,212,1958 IDO-16373,37,1957 JNE,3,177,1956 ive data)	EXFOR 40156.002 EXFOR 12349.003 EXFOR 21202.002 EXFOR 12411.002 EXFOR 12322.003
EINDA quant. iranch arameter article Consid. Iodifier ata Type esult SUB F T		selector (DA,) selector (DA,) selector (ANA,) selector (EXP,) selector (EXCUM,) selector (10,) selector (10,) selector (2,)		F.D. Brooks et al. K.G. Ignat'Ev et al. R.L. Macklin et al. H.M. Skarsgard et al. J.R. Smith et al. H.Palevsky et al. 92-U-235(N,ABS),,E B.R. Leonard et al.	1966 1.8e+00 1.1e+01 Expt Rept 1964 3.8e+00 1.2e+00 Expt Jour 1960 2.5e+02 2.5e+02 Expt Jour 1958 6.0e-03 5.0e+02 Expt Jour 1957 1.0e+01 3.5e+00 Expt Jour 1957 1.0e+01 3.5e+00 Expt Jour 1958 1.0e+02 1.7e+01 Expt Jour	NSE,8,210,1960 JNE,6,212,1958 IDO-16373,37,1957 JNE,3,177,1956 ive data) HW-38202,41,1955	EXFOR 40156.002 EXFOR 12349.003 EXFOR 21202.002 EXFOR 12411.002 EXFOR 12322.003 EXFOR 12393.002
CINDA quant. Branch Parameter Particle Consid. Modifier Jata Type Result NSUB MF	ETA	selector (DA,) selector (DA,) selector (ANA,) selector (EXCU,) selector (FRCU,) selector (G,) selector (G,) selector (2,)		FD Brooks et al. K.G.Ignat'Ev et al. R.L.Macklin et al. H.M.Skarsgard et al. J.R.Smith et al. H.Palevsky et al. 92-U-235(N,ABS),,F B.R.Leonard et al. 92-U-235(N,ABS),F	1966 1.8e+00 1.1e+01 Expt Rept 1964 3.0e-02 1.2e+00 Expt Jour 1959 3.0e-02 1.2e+00 Expt Jour 1958 6.0e-03 5.0e-02 Expt Jour 1959 1.0e-01 9.2e+00 Expt Jour 1959 1.0e-01 J.7e+01 Expt Jour TA_REL (Neutron yield (Eta)-relati 1955 2.5e-02 4.5e-01 Expt Rept TA_MXW (Neutron yield Rept	NSE,8,210,1960 JNE,6,212,1958 IDO-16373,37,1957 JNE,3,177,1956 ive data) HW-38202,41,1955 xwellian average)	EXFOR 40156.00 EXFOR 12349.00 EXFOR 1202.00 EXFOR 12411.00 EXFOR 12322.00 EXFOR 12393.00

4.5.b Searching, processing and visualization nuclear data

Exercise 2:

Processing and visualization of nuclear data: Al27 -JEFF-3.3

2.1 Search and download: evaluated data file at https://www-nds.iaea.org

2.2Search and download: EXFOR "ENTRY-10377"

- 2.3 Create a HENDF file using NJOY and PREPRO codes (merge resonances with pointwise)
 - Temperature: 293.6K

2.4 Create an INTER file (cross-sections and integral data)

2.5 Create the BOXER file (covariance library in BOXER format) in 7-energy groups

2.6 Create the GENDF file (multigroup library) in 238-energy groups

2.7 Create a JANIS database using the import WIZARD tool with the files: HENDF, INTER and BOXER (see steps at 4.1.b)

Procedure:

- "run.bat" procedure will automatically process the evaluated files into the right format
- Use JANIS tool (<u>http://www.oecd-nea.org/janis</u>) to visualize the content of processed files
- Plot PENDF (HENDF) and EXFOR data in the same plot
- Show INTER data in a Table
- Plot BOXER
- Plot GENDF and PENDF (HENDF) data in the same plot
- Create a JANIS database

4.6 References

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