GRE@T–PIONEER

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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

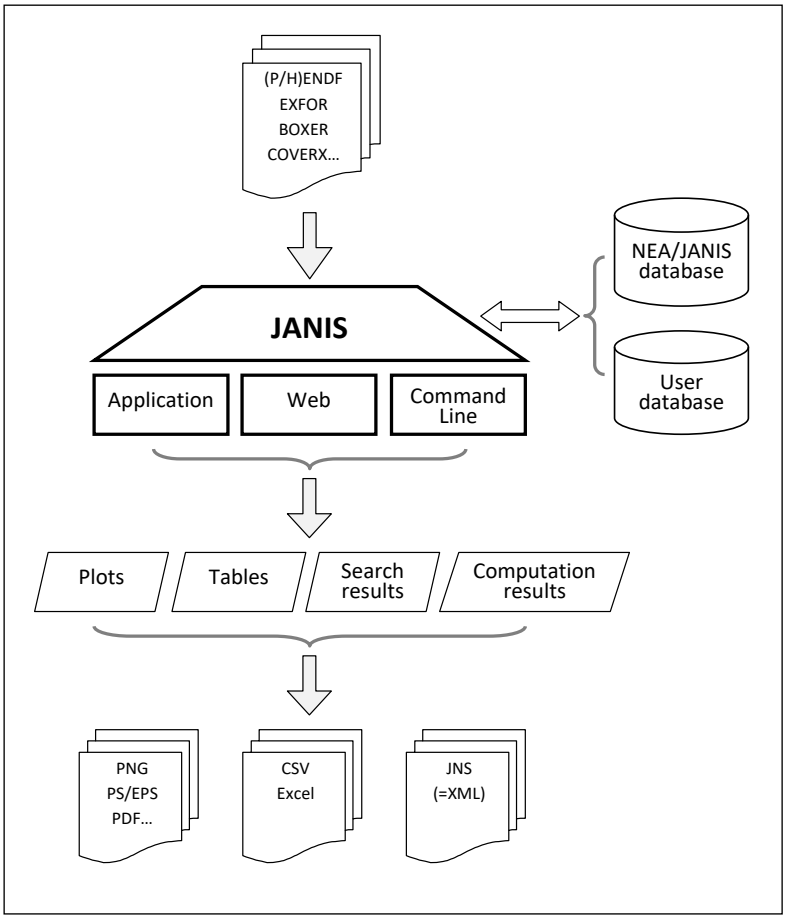
4.1 JANIS software

JANIS (JAva-based Nuclear Data Information System) software[1] 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.

Figure 1. Database, capabilities and input/output information flow in JANIS

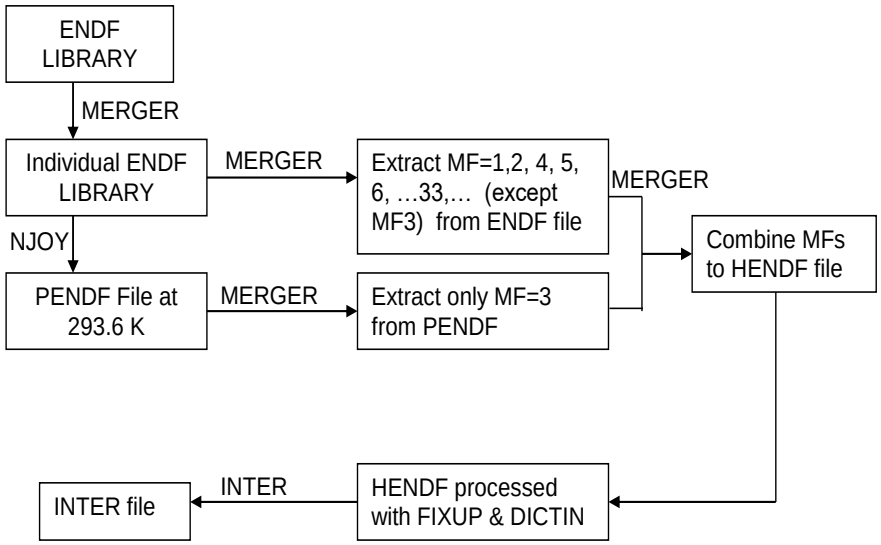


[1] https://www.oecd-nea.org/janis

An example[2] 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 packages[3], 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.

Figure 2. Flowchart of processing JANIS database from ENDF tapes



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] https://github.com/IAEA-NDS/ENDF-utility-codes

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.

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

Nuclear Properties	*NUBASE-1997/2003/2012/2016/2020*
Radioactive data	*ENDF/B-VI.8/VII.0/VII.1/VIII.0* *JEF-2.2, JEFF-3.1/3.1.1/3.3* *GEFY-3.2/3.3/4.2/5.2/6.1/6.2* *JENDL-4.0* *JENDL-DDF-2015, JENDL-FPD2000/2011, JENDL/FPY-2011* *TENDL-2010*
Incident neutron data	*EXFOR* *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-1.0/1.0640g, 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, JENDL-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 gamma data	*EXFOR* *ENDF/B-VII.0/VII.1/VIII.0* *IAEA/PD-2019* *JENDL-PD-2004/201672016.1* *TENDL2009/10/…/17/19*
Incident proton data	*EXFOR* *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 deuteron & triton data	*EXFOR* *ENDF/B-VI.8/ VII.0/VII.1, VIII.0* *JENDL-DEU-2020* *TENDL2009/10/…/17/19*
Incident he3 data	*EXFOR* *ENDF/B-VII.0/VII.1/VIII.0* *TENDL2009/10/…/17/19*
Incident alpha data	*EXFOR* *ENDF/B-VIII.0* *JENDL-AN-2005* *TENDL2009/10/…/17/19*
Incident heavy particles, electron data, antiprotons, kaons(-,+) and pions(-,+)	*EXFOR*

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

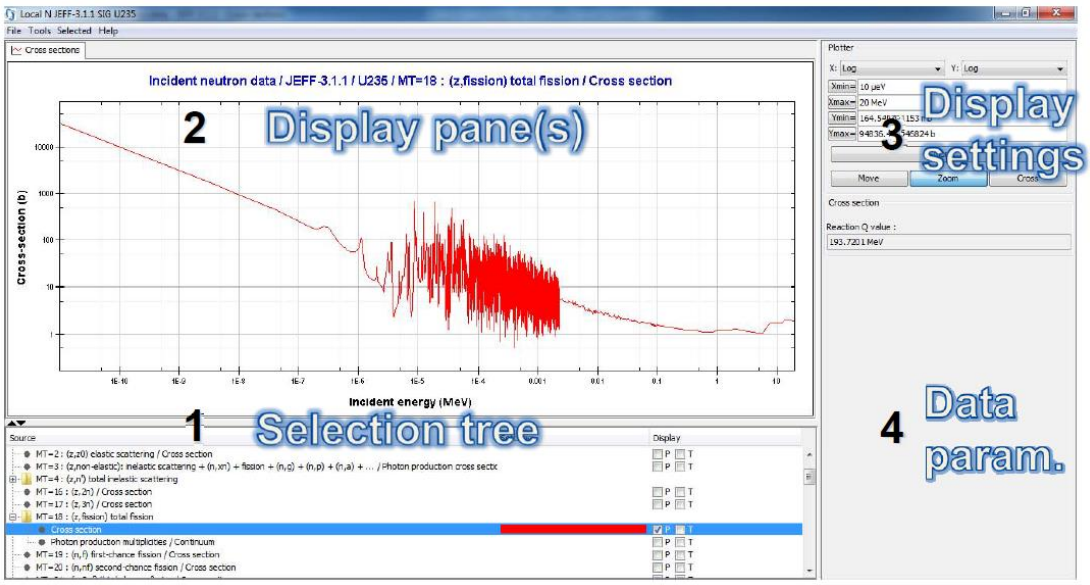


Figure 3 shows main JANIS window:

- 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 ϕ(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:

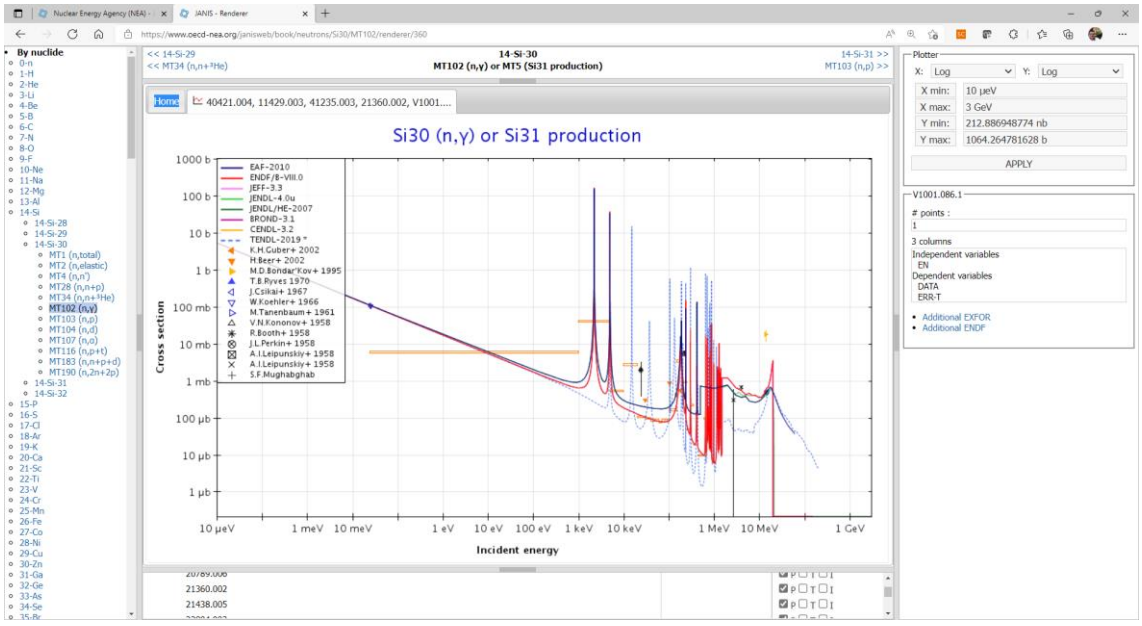
- Use the “Database > Load” function to open a personal database
- Set “.h2.db” file” to select the downloaded h2.db file
- Set “root folder” to the folder where h2.db is located

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

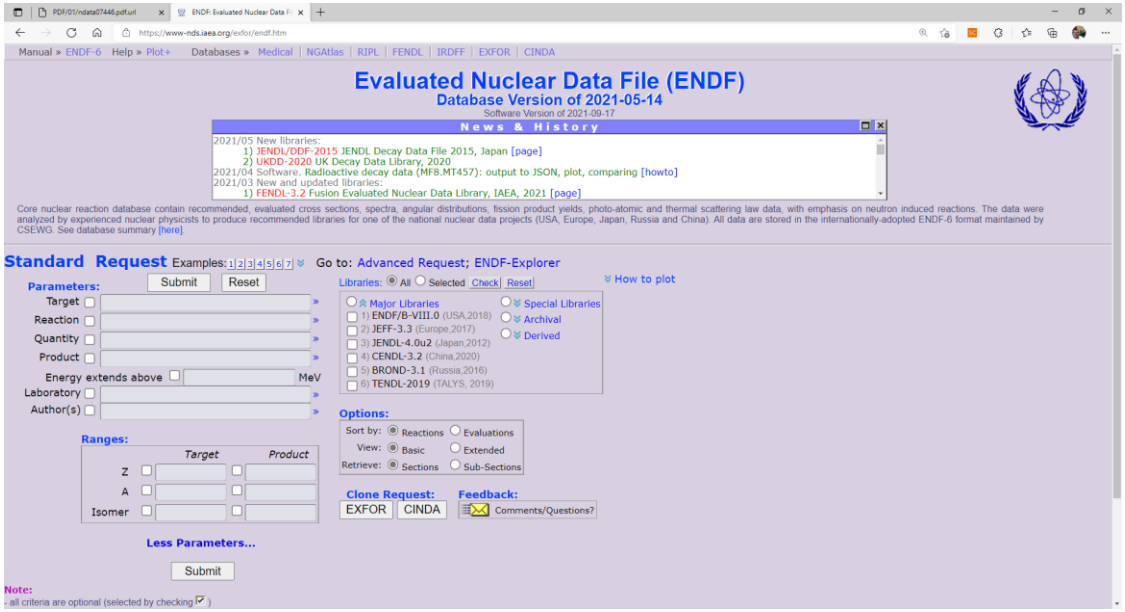
4.2.a The EXFOR-CINDA-ENDF retrieval system

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

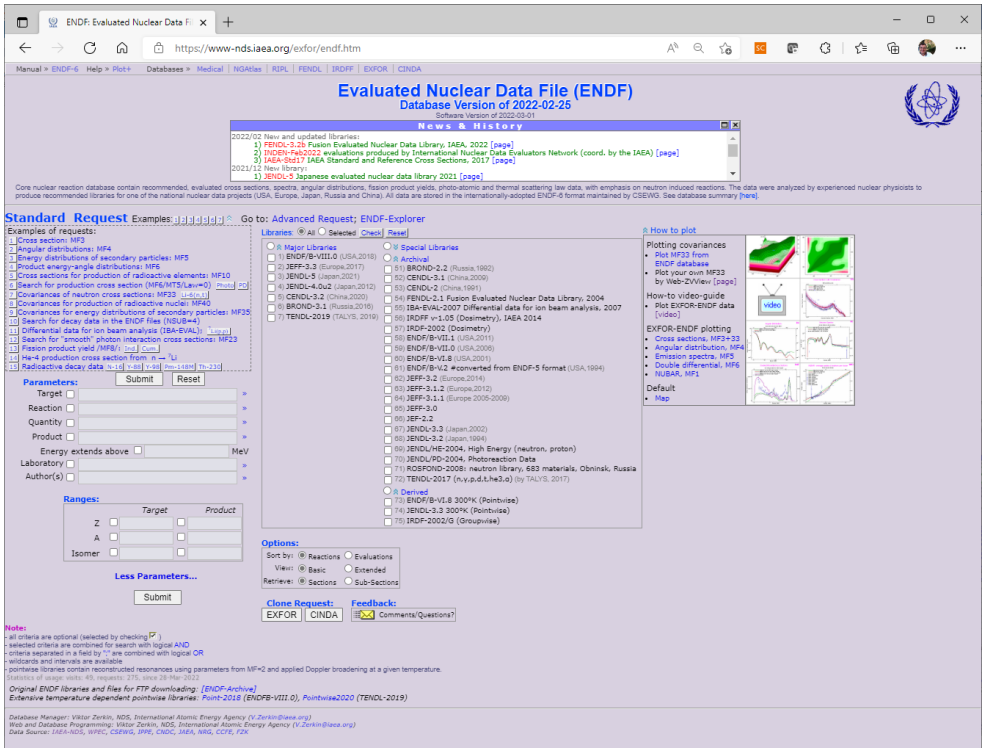


[4] https://www-nds.iaea.org/exfor/endf.htm

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

The ENDF visualizer[5] 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 Databases[7] distributed by IAEA/NDS for the simulation of nuclear reactions. Basically, this tool is able to accomplish the following:

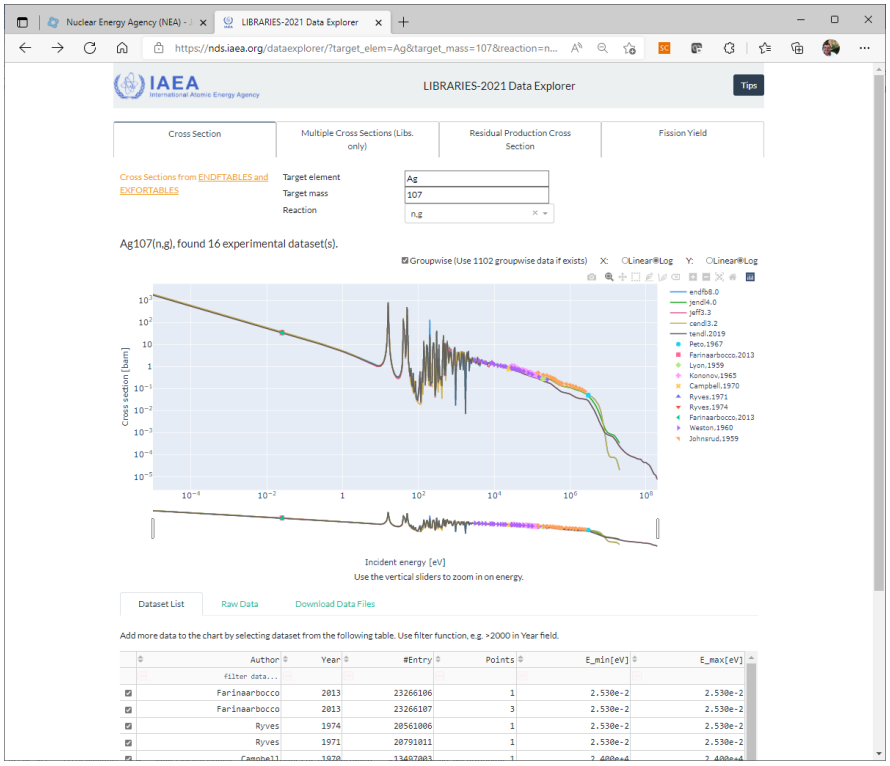
- Use the EXFORtables code to mine data from EXFOR/C5 format
- Use the ENDFtables code to mine data from ENDF
- Put the results into a large database (LIBRARIES-2021)
- Feed the database into a plotting tool to plot the results

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

[6] https://nds.iaea.org/dataexplorer

[7] https://www-nds.iaea.org/talys/

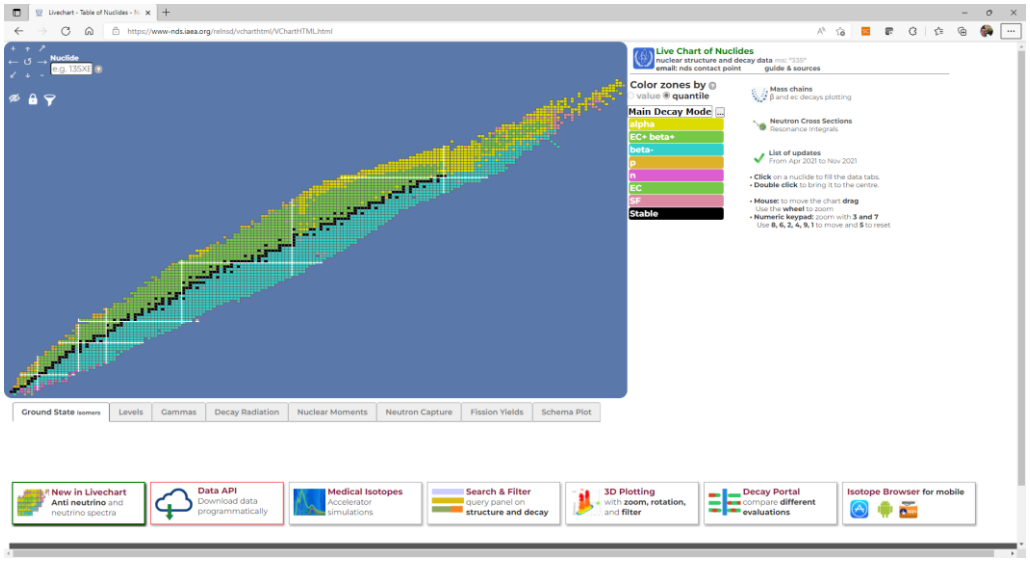
Figure 7. The IAEA/NDS "Libraries-2021 Data Explorer"



4.2.d Live Chart of Nuclides

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

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

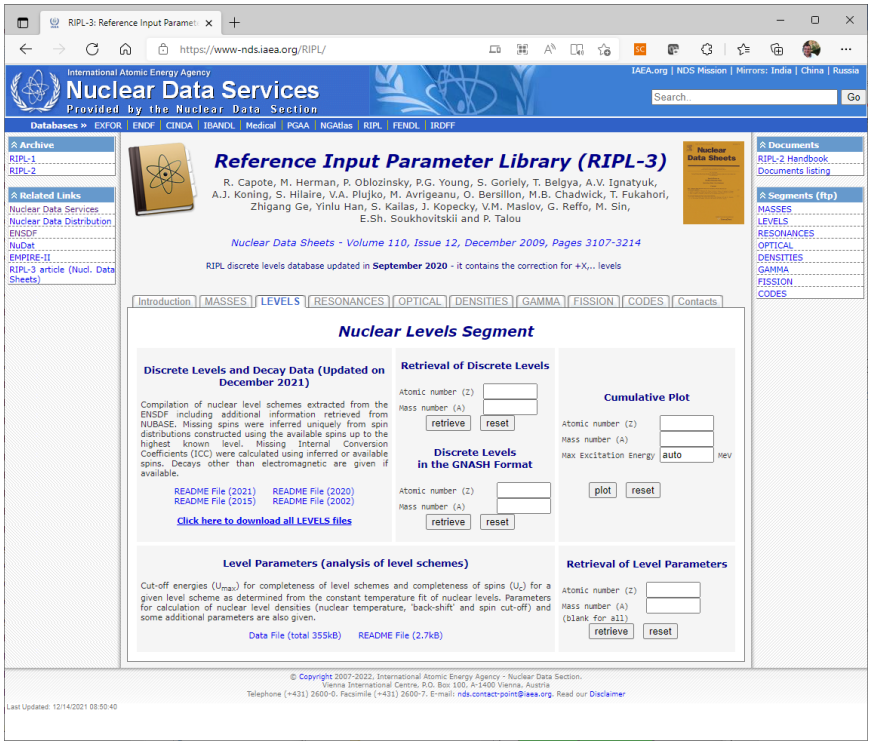


[8] https://www-nds.iaea.org/relnsd/vcharthtml/VChartHTML.html

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 ENDF[10] (see **Figure 10**) and SIGMA[11] (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.

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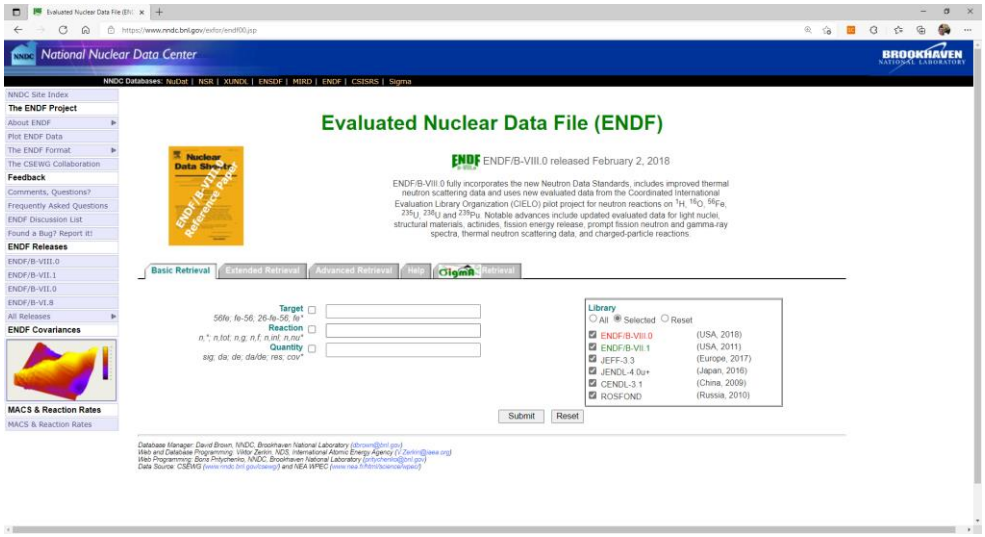
[9] https://www-nds.iaea.org/RIPL/

[1010] https://www.nndc.bnl.gov/exfor/endf00.jsp

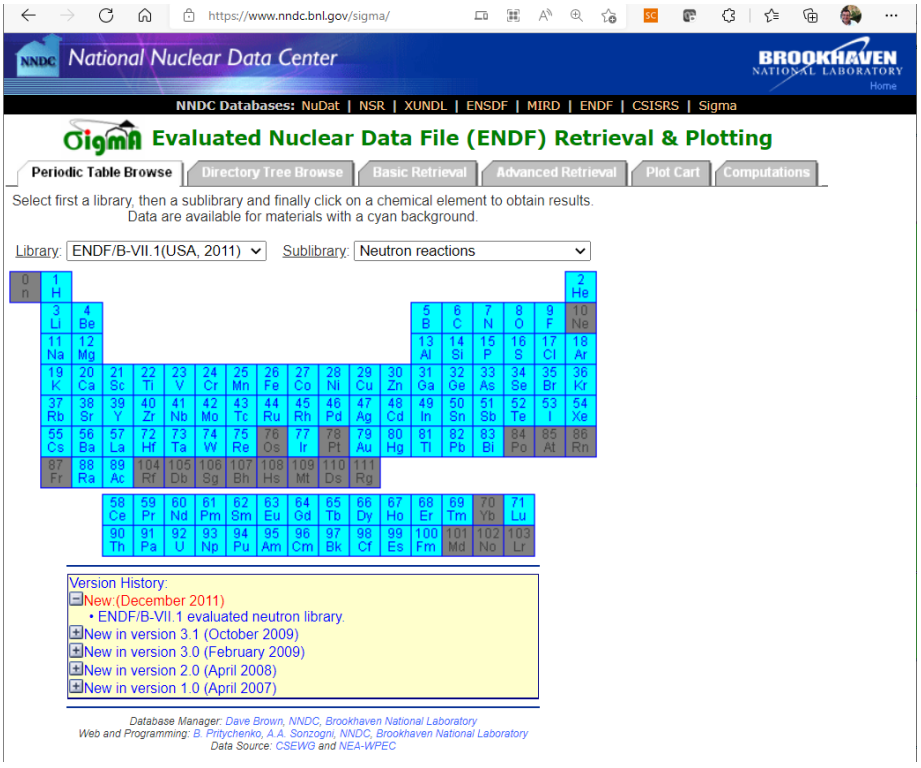
[11] https://www.nndc.bnl.gov/sigma/

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.

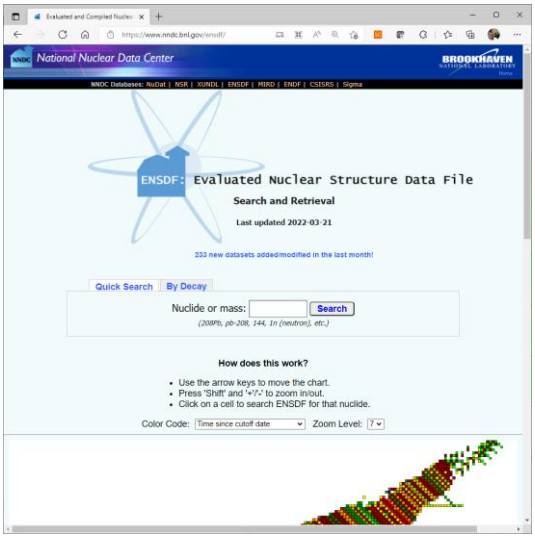
Figure 11. The SIGMA/NNDC retrieval system's website



4.3.b The ENSDF search and retrieval system

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

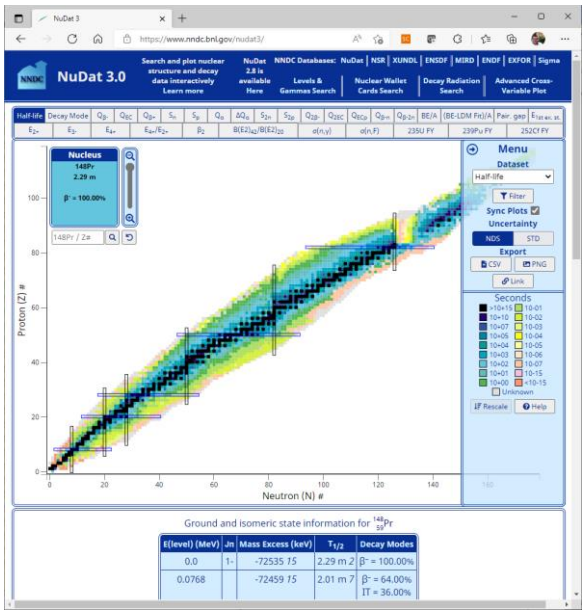
Figure 12. The NNDC retrieval ENSDF system



4.3.c The NuDat3.0

The NuDat3.0[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 tools[14] for drawing nuclear data graphs:

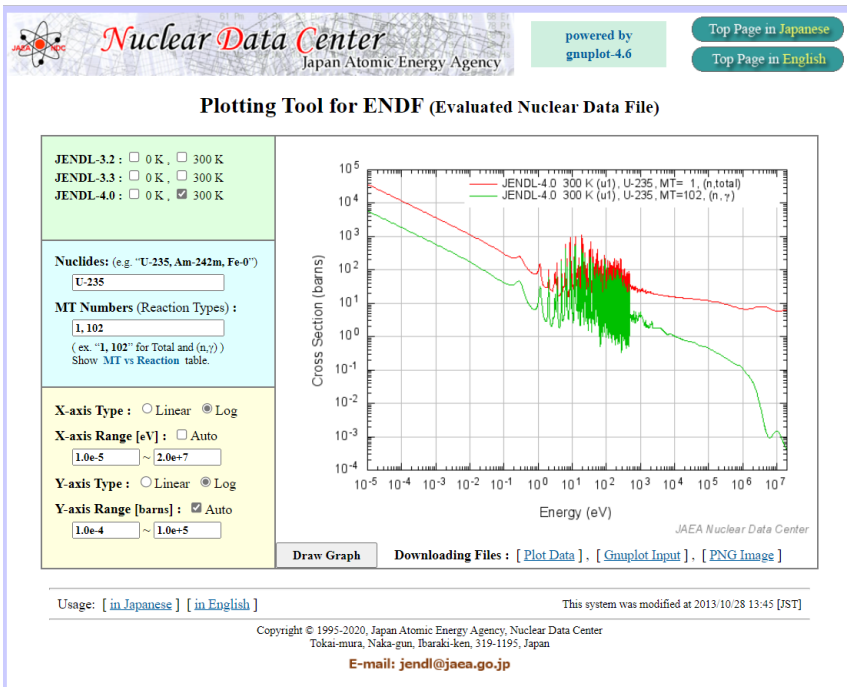
- Plotting Tool for ENDF (Evaluated Nuclear Data File) (see **Figure 14)**
  Generating a cross section graph of JENDL-3.2, -3.3 and -4.0.

- 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

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

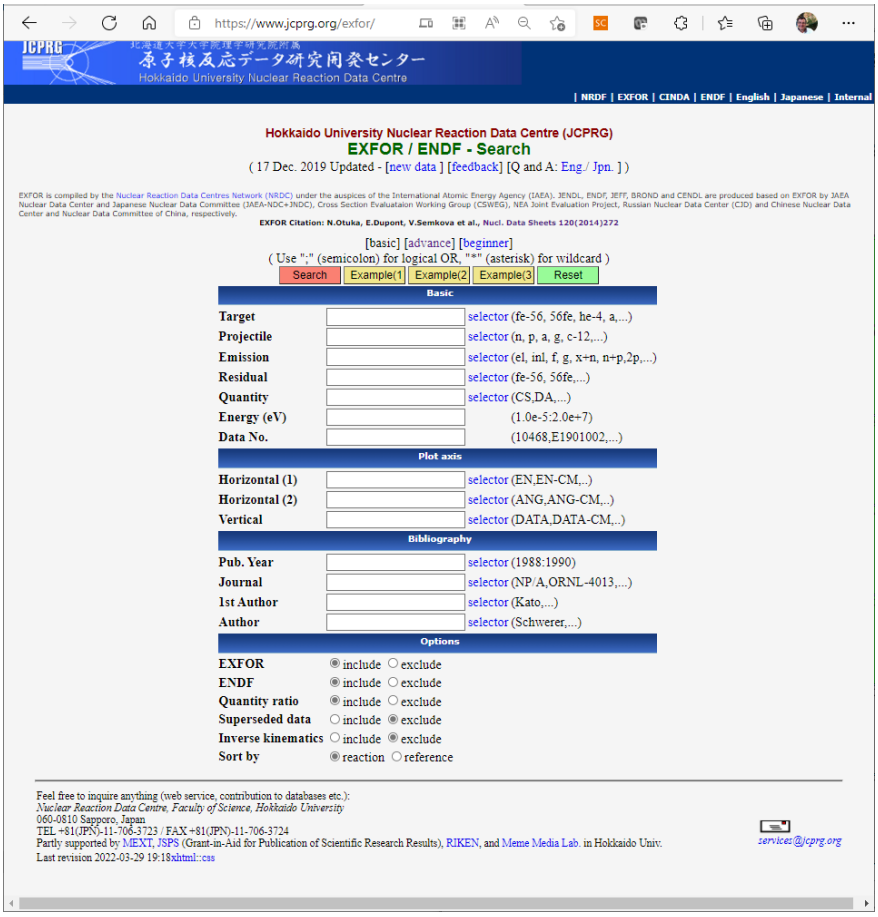


[14] https://wwwndc.jaea.go.jp/tools/index.html

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 tool[15] (see **Figure 15**).

Figure 15. The JCPRG retrieval system's website



[15] https://www.jcprg.org/exfor/

4.5 Exercises

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

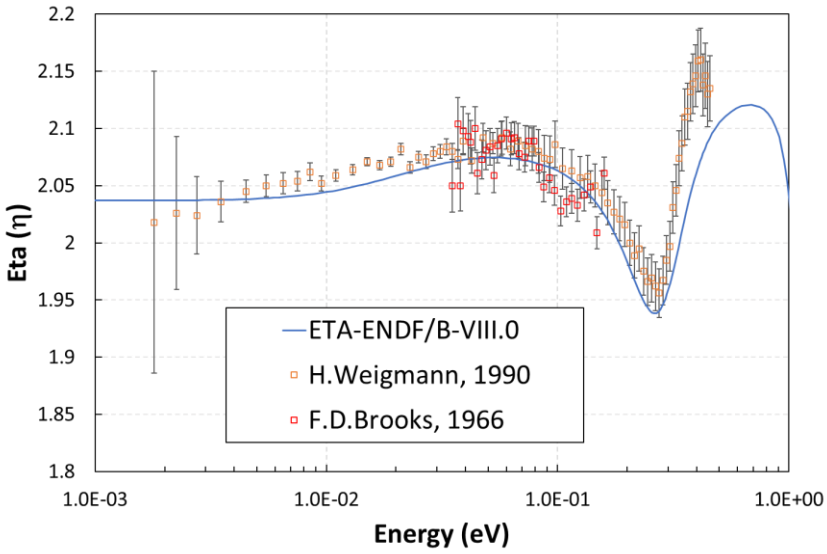
Exercise 1:

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."



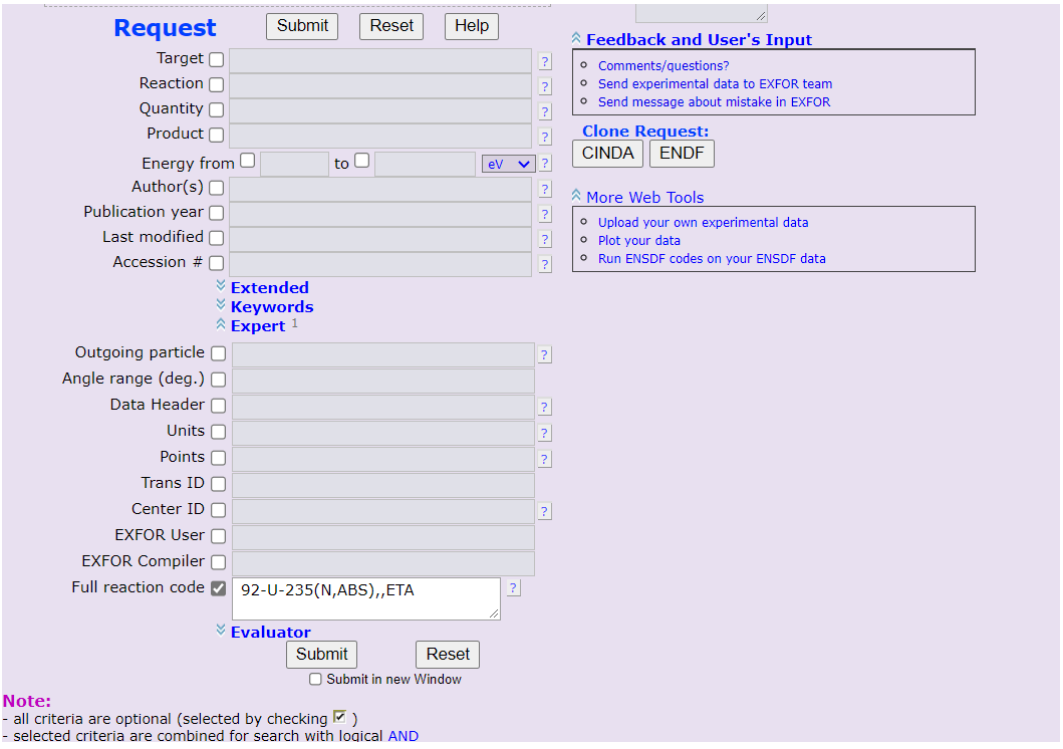
Procedure:

- "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 :
  - n_9222_92-U-233.dat.pendf
  - n_9228_92-U-235.dat.pendf
  - n_9437_92-Pu-239.dat.pendf
  - 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

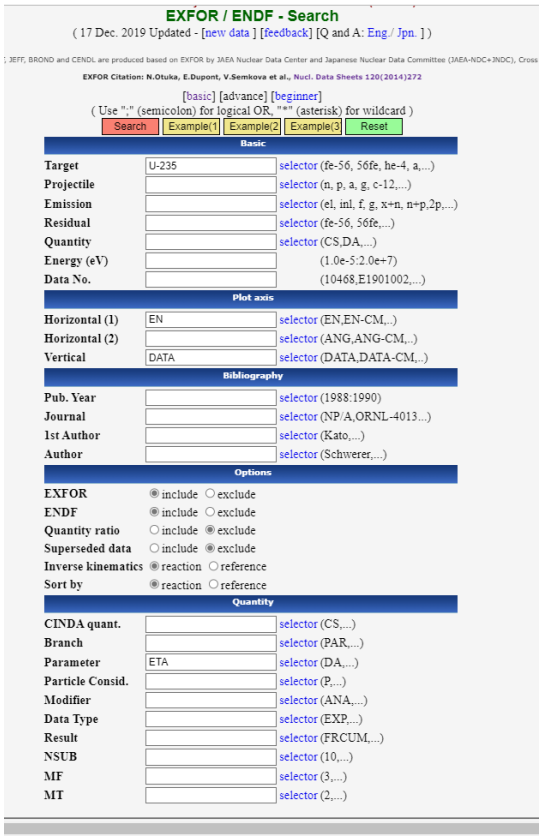
“run.bat”

```
@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
   sigma1.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/



Searching EXFOR ETA values (select: **advance user**) using https://www.jcprg.org/exfor/



EXFOR / ENDF - Search

(17 Dec. 2019 Updated - [new data] [feedback] [Q and A: Eng./ Jpn.])

; JEFF, BROND and CENDL are produced based on EXFOR by JAEA Nuclear Data Center and Japanese Nuclear Data Committee (JAEA-NDC+JNDC), Cross

EXFOR Citation: N.Otuka, E.Dupont, V.Semkova et al., Nucl. Data Sheets 120(2014)272

[basic] [advance] [beginner]

(Use ";" (semicolon) for logical OR, "*" (asterisk) for wildcard)

Search | Example(1 | Example(2 | Example(3 | Reset

Basic

Target	U-235	selector (fe-56, 56fe, he-4, a,...)
Projectile		selector (n, p, a, g, c-12,...)
Emission		selector (el, inl, f, g, x+n, n+p,2p,...)
Residual		selector (fe-56, 56fe,...)
Quantity		selector (CS,DA,...)
Energy (eV)		(1.0e-5:2.0e+7)
Data No.		(10468,E1901002,...)

Plot axis

Horizontal (1)	EN	selector (EN,EN-CM,..)
Horizontal (2)		selector (ANG,ANG-CM,..)
Vertical	DATA	selector (DATA,DATA-CM,..)

Bibliography

Pub. Year		selector (1988:1990)
Journal		selector (NP/A,ORNL-4013...)
1st Author		selector (Kato,...)
Author		selector (Schwerer,...)

Options

EXFOR	◉ include	○ exclude
ENDF	◉ include	○ exclude
Quantity ratio	○ include	◉ exclude
Superseded data	○ include	◉ exclude
Inverse kinematics	◉ reaction	○ reference
Sort by	◉ reaction	○ reference

Quantity

CINDA quant.		selector (CS,...)
Branch		selector (PAR,...)
Parameter	ETA	selector (DA,...)
Particle Consid.		selector (P,...)
Modifier		selector (ANA,...)
Data Type		selector (EXP,...)
Result		selector (FRCUM,...)
NSUB		selector (10,...)
MF		selector (3,...)
MT		selector (2,...)

Hokkaido University Nuclear Reaction Data Centre (JCPRG)

EXFOR / ENDF - Results

(EXFOR: 25 hits, ENDF: 0 hits)

Plot | Reset

Plot	Author	Year	Inc. energy (eV)		Work	Type	Reference	Library	Data ID
	92-U-235(N,NON),,ETA (Neutron yield (Eta))								
	F.D.Brooks et al.	1966	1.7e-01	2.0e+02	Expt	Rept	AERE-M-1670,1966	EXFOR	20938.029
	F.D.Brooks et al.	1966	1.1e+01	2.0e+02	Expt	Rept	AERE-M-1670,1966	EXFOR	20938.024
	A.A.Van'Kov et al.	1965	2.4e+07	2.4e+07	Expt	Jour	SJA,19,903,1965	EXFOR	40808.007
	N.N.Flerov et al.	1958	1.4e+07	1.4e+07	Expt	Jour	SJA,5,1593,1958	EXFOR	40806.002
	V.N.Andreev	1958	2.4e+04	8.8e+05	Expt	Jour	SJA,4,247,1958	EXFOR	40385.004
	P.E.Spivak et al.	1957	3.0e+04	9.0e+05	Expt	Jour	JNE,4,79,1957	EXFOR	40350.003 2
	P.E.Spivak et al.	1957	3.0e+04	9.0e+05	Expt	Jour	JNE,4,79,1957	EXFOR	40350.003 1
	92-U-235(N,NON),,ETA,,SPA (Neutron yield (Eta)- spectrum average)								
	P.E.Spivak et al.	1957	1.5e-01	1.3e+02	Expt	Jour	JNE,4,79,1957	EXFOR	40350.018
	92-U-235(N,ABS),,ETA (Neutron yield (Eta))								
	H.Weigmann et al.	1990	1.5e+00	1.5e+02	Expt	Conf	90MARSEI,3,(PI),33,1990	EXFOR	22194.003
	H.Weigmann et al.	1990	1.8e+00	4.6e+02	Expt	Conf	90MARSEI,3,(PI),33,1990	EXFOR	22194.002
	J.R.Smith et al.	1984	2.5e-02	6.0e-02	Expt	Rept	EPRI-NP-3436,(2),1984	EXFOR	13805.003
	J.R.Smith et al.	1982	2.5e-02	2.5e-02	Expt	Priv	SMITH,1982	EXFOR	12318.004
	J.R.Smith et al.	1970	1.6e-01	1.6e-01	Expt	Prog	IN-1407,39,1970	EXFOR	13018.003
	J.R.Smith et al.	1968	2.5e-02	6.0e-02	Expt	Conf	68WASH,1,589,1968	EXFOR	12554.004
	F.D.Brooks et al.	1966	3.5e-02	1.6e-01	Expt	Rept	AERE-M-1670,1966	EXFOR	20938.028
	F.D.Brooks et al.	1966	1.8e-01	8.7e-01	Expt	Rept	AERE-M-1670,1966	EXFOR	20938.027
	F.D.Brooks et al.	1966	9.2e-01	3.9e+00	Expt	Rept	AERE-M-1670,1966	EXFOR	20938.026
	F.D.Brooks et al.	1966	1.8e+00	1.1e+01	Expt	Rept	AERE-M-1670,1966	EXFOR	20938.025
	K.G.Ignat'Ev et al.	1964	3.0e-02	1.2e+00	Expt	Jour	SJA,16,121,1964	EXFOR	40156.002
	R.L.Macklin et al.	1960	2.5e-02	2.5e-02	Expt	Jour	NSE,8,210,1960	EXFOR	12349.003
	H.M.Skarsgard et al.	1958	6.0e-03	5.0e-02	Expt	Jour	JNE,6,212,1958	EXFOR	21202.002
	J.R.Smith et al.	1957	1.0e-01	9.3e+00	Expt	Prog	IDO-16373,37,1957	EXFOR	12411.002
	H.Palevsky et al.	1956	1.0e-02	1.7e-01	Expt	Jour	JNE,3,177,1956	EXFOR	12322.003
	92-U-235(N,ABS),,ETA,,REL (Neutron yield (Eta)- relative data)								
	B.R.Leonard et al.	1955	2.5e-02	4.5e-01	Expt	Rept	HW-38202,41,1955	EXFOR	12393.002
	92-U-235(N,ABS),,ETA,,MXW (Neutron yield (Eta)- Maxwellian average)								
	C.O.Muehlhause et al.	1959	2.5e-02	2.5e-02	Expt	Jour	NSE,5,225,1959	EXFOR	12361.003

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 (http://www.oecd-nea.org/janis) 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

[1] N. Soppera, M. Bossant, O. Cabellos, E. Dupont C. J. Díez, "JANIS: NEA JAva-based Nuclear Data Information System," *EPJ Web of Conferences*, Vols. 146, 07006, pp. 1-3, https://www.epj-conferences.org/articles/epjconf/pdf/2017/15/epjconf-nd2016_07006.pdf, 2017.

[2] D.E. Cullen, "PREPRO 2021: ENDF/B Pre-processing Codes," *IAEA-NDS-0238*, pp. 1-38, https://www-nds.iaea.org/publications/iaea-nds/IAEA-NDS-0238.pdf, 2021.

[3] V. Zerkin, A. Trkov, "Development of IAEA nuclear reaction databases and services," *International Conference on Nuclear Data for Science and Technology*, pp. 1-4, doi: 10.1051/ndata:07446, 2007.

[4] B.Pritychenko, A.Sonzogni, "Sigma: Web Retrieval Interface for Nuclear Reaction Data," *Nuclear Data Sheets*, vol. 109, no. 12, pp. 2822-2827, https://doi.org/10.1016/j.nds.2008.11.017, 2008.