TM on Nuclear Data Retrieval, Dissemination, and Data Portals
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IAEA
International Atomic Energy Agency
Atoms for Peace and Development

Developments of IAEA Nuclear DataExplorer:

Experimental and Evaluated Nuclear Data Libraries Visualization and Retrieval System

Shin Okumura

Nuclear Data Section, International Atomic Energy Agency

nds.contact-point@iaea.org

Message in 2023

Modern AI/ML tools, including the development and use of Natural Language Processing (NLP) could shorten the time needed for an EXFOR compilation to be completed by automatically processing tables, graphs, and relevant in-text context. The incorporation of these tools, however, will require new skills not currently present in the EXFOR network. **Outdated formats and compilation rules have also substantially hindered the progress of such modern mechanisms.** This has motivated the creation of NEA SG-50, which is working to provide a modern interface to EXFOR as well as a framework for providing corrections, both simple error fixes and more complex ones discovered by evaluators in the course of their work.

2023 Second Report of the Nuclear Data Charge Subcommittee of the Nuclear Science Advisory Committee
https://science.osti.gov/-/media/np/nsac/pdf/docs/2023/NSAC-ND_Report_2_031923.pdf

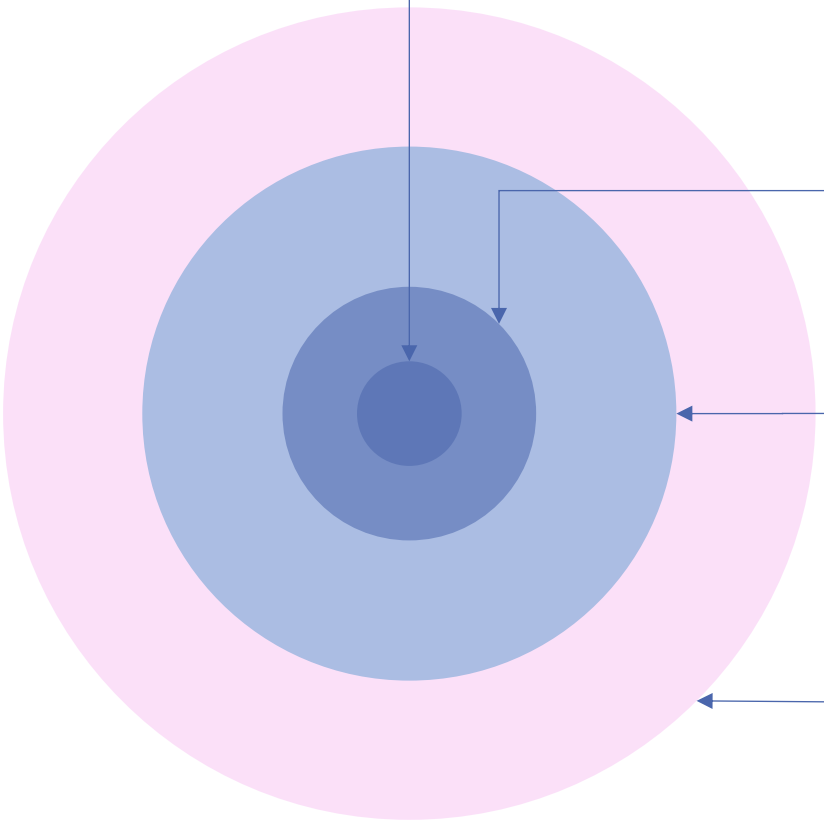
Nearly 20 years since WPEC SG30

- While WPEC SG30, “Quality Improvement of the EXFOR Database”, which was established in 2007 and closed in June 2010, EXFOR has significantly improved in quality.

> In spite of this compilation effort, **the retrieval of experimental data from EXFOR runs the danger of becoming one of the main delaying factors in contemporary nuclear data evaluation**. In the past, experimental data have been added to EXFOR by various compilers who, although the EXFOR format was unified in 1969, have used different (and often allowed) procedures and entries to store the data. The result is a database that contains the numerical data of almost the entire history of nuclear reaction measurements. The main question now is whether and how the user has access to all these data. For the study of a few detailed reactions, web interfaces are helpful tools to retrieve a few data sets, and one may find all available data by trying various different search options. However, **nuclear data evaluation is becoming more automated and quality-assured, so that a genuine step forward in the production of data libraries requires that *all* nuclear data that exist in EXFOR can be retrieved in an unambiguous manner, and without unnecessary delay, and this is lacking at the moment**.
>
> A. Koning, Quality Improvement of the EXFOR Database WPEC SG30 Final Report

Who are the users?

Researchers and students in fields of



Nuclear data evaluations

Want to access all available experimental, evaluated, theoretical, curated data for their evaluations

Experimental/theoretical nuclear physics

Want to access the experimental, theoretical, or evaluated data for their research

Nuclear engineering

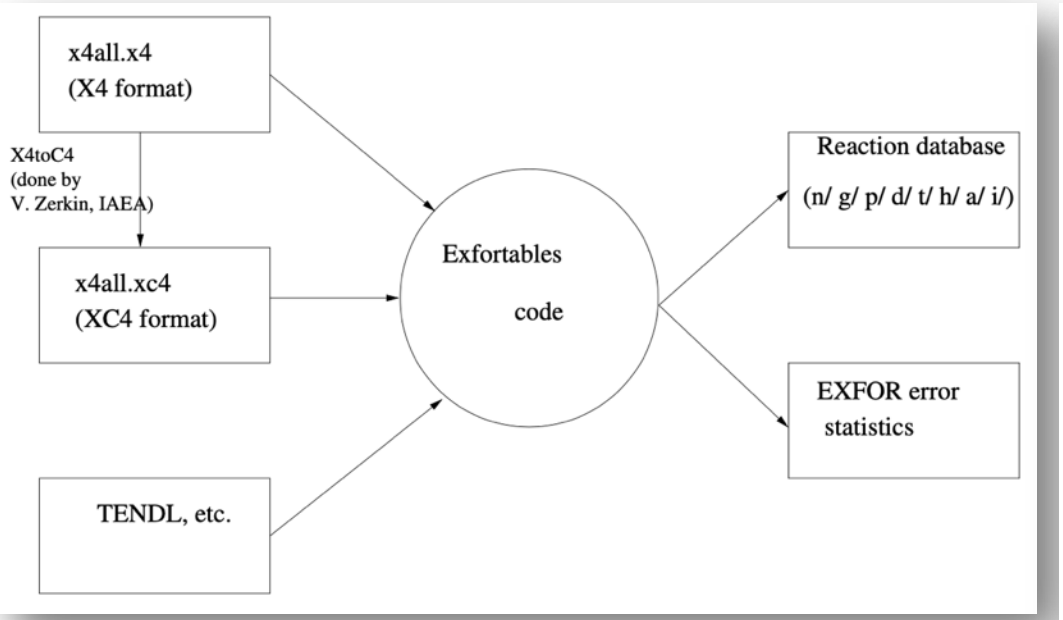
Use nuclear data natually included in the software codes, for example transport simulation (reactor simulation), shielding calculation, burn-up calculation.

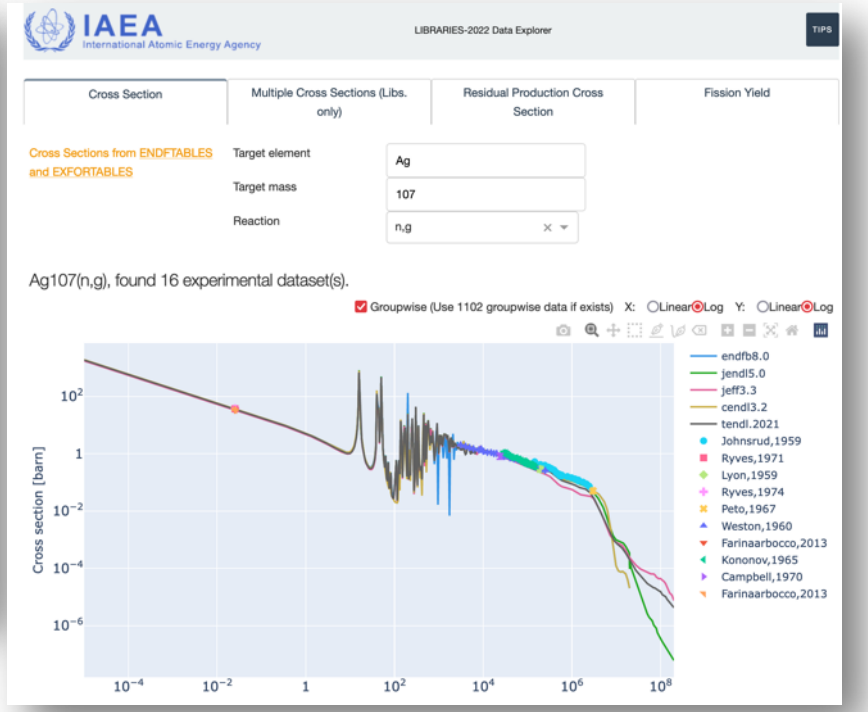
Nuclear science and applications

Need to see the gamma emission lines for gamma-ray spectroscopy, decay half-life, medical isotope production cross sections..etc

EXFORTABLES and LIBRARIES-2021/22 Data Explorer

- **LIBRARIES-2022** = EXFORTABLES + ENDFTABLES
  - **EXFORTABLES** is a directory-structured database from C4 format
  - **ENDFTABLES** is a pre-processed and directory-structured database
- **LIBRARIES-2022 Data Explorer**, easy nuclear data online plotter, was developed in 2021 as a data viewer for LIBRARIES-2021





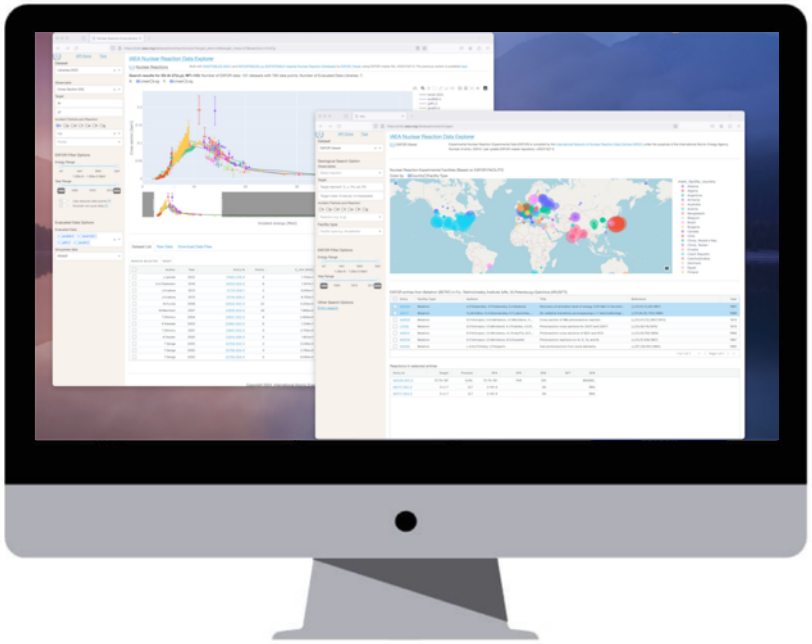
/n/Ag107/exfor/xs/102/n-Ag107-MT102-Farinaarbocco-23266106.2013.txt

* A. Koning, iaea-nds-0235, EXFORTABLES-1.0: An experimental nuclear reaction database based on EXFOR https://nds.iaea.org/talys/
** Accessible at https://nds.iaea.org/dataexplorer/

IAEA Nuclear Reaction Dataexplorer

https://nds.iaea.org/dataexplorer

Python 3 based, Open sourced project



Reaction based data plotter

- Input target and reaction to get evaluated and experimental datasets
  - Cross section
  - Thermal neutron cross section
  - Residual production cross section
  - Fission yield

New!

EXFOR entry viewer

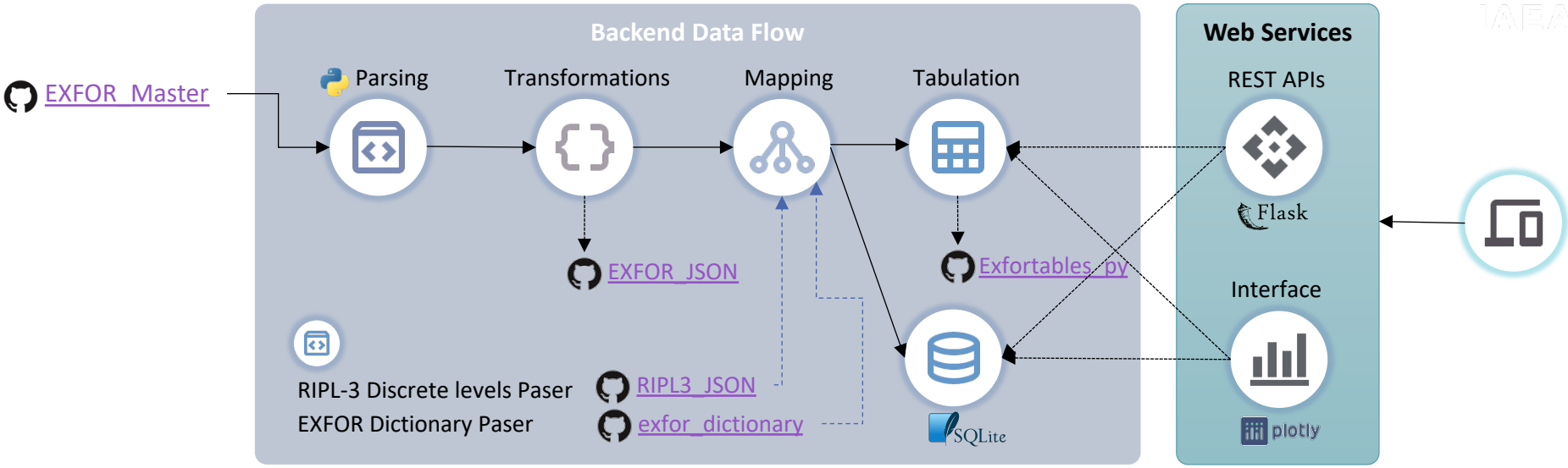
- Easy access without understanding of EXFOR format
  - Search by reactions
  - Entry viewer
  - Geographical analysis

New!

Web APIs

- Easy computational access
  - Reaction, EXFOR entry and definition of EXFOR keywords, RIPL-3 levels

IAEA Nuclear Reaction Dataexplorer Data Flow



- EXFOR Parser*
  - Inspired by x4i by David Brown (NNDC, BNL)
  - Python program to convert all ASCII files in EXFOR_Master in EXFOR format into JSON and to produce tabulated (x, y, dx, dy) database
  - Python3.x (https://github.com/IAEA-NDS/exforparser)
- IAEA Nuclear Reaction Dataexplorer has been renewed in March 2024
  - EXFOR datasets: Created by EXFOR Parser (available in text and SQL)
  - Web interfaces: Reaction based data plotter and EXFOR entry viewer developed in Dash/Plotly framework
  - APIs: Easy computational access developed in Flask

* S. Okumura, G. Schnabel and A. Koning, *EPJ Web Conf.*, 292, 12003 (2024)

Issues in these years

- EXFOR data dissemination
  - 'Trans' files had been password protected for a year
  - The EXFOR master repository used in Dataexplorer had only updated once a year due to the change in NRDC's data dissemination policy since last NRDC meeting in 2023 (solved in early 2024).
    - Many efforts done by OECD/NEA Databank, 'Trans' were back online
    - EXFOR Master file update policy has been fixed
- EXFOR JSON Schema
  - At least 5 versions of EXFOR in JSON format
    - 3 from IAEA NDS, 1 from BNL generated by x4i, and 1 from SG50
  - Need to agree with the JSON Schema for the inter-exchange
    - SG50's one is more extensive, a simplified one is required
- A Good Data Model
  - Accommodate evaluated and experimental data
    - GNDS is a good example
    - EXFOR accommodates excessive observables, but cross sections hold 51%

https://github.com/IAEA-NDS/exfor_master

- Clone/download all EXFOR files anytime

  `git clone https://github.com/IAEA-NDS/exfor_master.git`

- Easy access to change logs of entry using Git command

  `git log -p exforall/224/22449.x4`

```
commit 0dda483cd04058da0c0dbcd4b72a7b07a42c7f56 (tag: Backup-2006-06-16)
Author: shinkoo <s.okumura@iaea.org>
Date:   Sun Oct 2 00:07:10 2022 +0200

    2006-06-16

diff --git a/exforall/224/22449.x4 b/exforall/224/22449.x4
index fbc87f440..a0f5895b7 100644
--- a/exforall/224/22449.x4
+++ b/exforall/224/22449.x4
@@ -1,5 +1,5 @@
 ENTRY            22449   20000202   20010329
-SUBENT        22449001   20000202   20010329
+SUBENT        22449001   20000202   20010329   20050926       0000
 BIB                 15         38
 TITLE        .The Stellar (N,GAMMA) Cross Section of the Stable
              Iridium Isotopes
@@ -46,7 +46,7 @@ KEV        NO-DIM     NO-DIM     NO-DIM
         30.       15.7       3.67       12.2
 ENDCOMMON            3
 ENDSUBENT           45
-SUBENT        22449002   20000202   20010329
```

name of branch (=db update)

number of commits in main branch

```
{
  "entry": "22449",
  "last_updated": "2006-07-20",
  "number_of_revisions": "3",
  "histories": [
    {
      "x4_code": "(20000202C)",
      "free_txt": [
        "  Compiled by S.M."
      ]
    },
    {
      "x4_code": "(20000202U)",
      "free_txt": [
        "  Last checking has been done."
      ]
    }
  ],
```

https://github.com/IAEA-NDS/exfor_json

- Separate information by pointer
- Separate EXFOR Keyword from free text

```
FACILITY   (REAC,2UK HAR) Harwell pile at Atomic Energy Research
            Establishment.
```

```
"facilities": {
  "0": [
    {
      "x4_code": "(REAC,2UK HAR)",
      "free_txt": [
        " Harwell pile at Atomic Energy Research",
        " Establishment."
      ],
      "facility_type": "(REAC)",
      "institute": "(2UK HAR)"
    }
  ]
}
```

- Organize folded DATA block

```
EN          EN-RSL      DATA        ERR-T       ERR-S       ERR-1
ERR-2       ERR-3       ERR-4       ERR-5       ERR-6       ERR-9
ERR-10
MEV         MEV         MB          PER-CENT    PER-CENT    PER-CENT
PER-CENT    PER-CENT    PER-CENT    PER-CENT    PER-CENT    PER-CENT
PER-CENT
    1.00E-6     4.2E-9      6.38E+5         4.17        0.19        0.48
       3.81                     0.42        0.02        0.06        0.00
       0.27
    1.26E-6     5.4E-9      5.37E+5         2.62        0.26        2.03
       0.05                     0.43        0.03        0.10        0.00
       0.32
```

```
"data": {
  "heads": [
    "EN",
    "EN-RSL",
    "DATA",
    "ERR-T",
    "ERR-S",
    "ERR-1",
    "ERR-2",
    "ERR-3",
    "ERR-4",
    "ERR-5",
    "ERR-6",
    "ERR-9",
    "ERR-10"
  ],
  "units": [
    "MEV",
    "MEV",
    "MB",
    "PER-CENT",
    "PER-CENT",
    "PER-CENT",
    "PER-CENT",
    "PER-CENT",
    "PER-CENT",
    "PER-CENT",
    "PER-CENT",
    "PER-CENT",
    "PER-CENT"
  ],
```

```
"data": [
  [
    1e-06,
    1.26e-06,
    1.58e-06,
    2e-06,
    2.51e-06,
    3.16e-06,
    3.98e-06,
    5.01e-06,
    6.31e-06,
    7.94e-06,
    1e-05,
    1.26e-05,
    1.58e-05,
    2e-05,
    2.51e-05,
    3.16e-05,
    3.98e-05,
    5.01e-05,
```

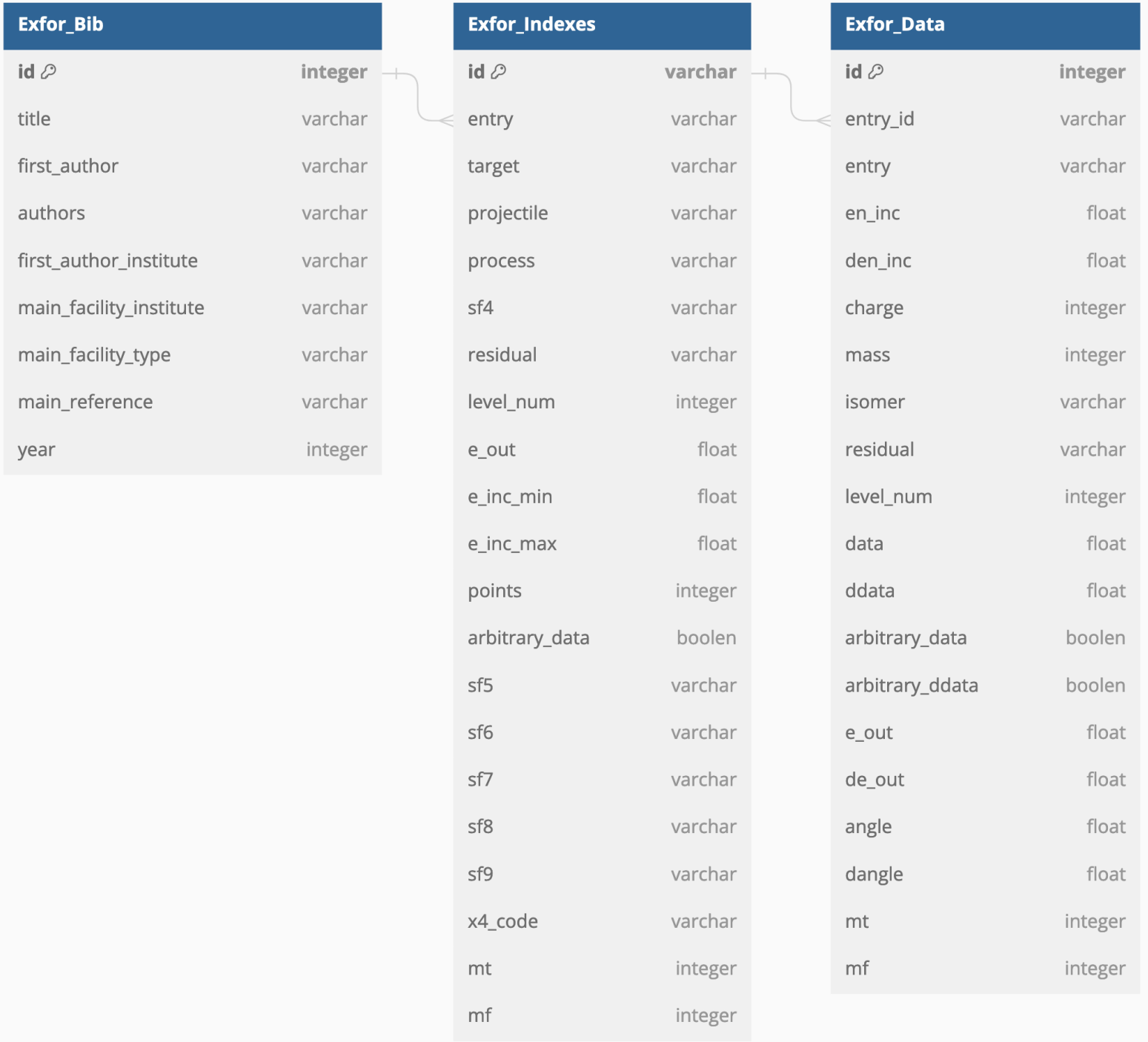
https://github.com/IAEA-NDS/exfor_json/blob/main/json/238/23804.json

https://github.com/IAEA-NDS/exfortables_py

- Directory structured nuclear physics-baseddatabase via EXFOR parser
  - Inspired by EXFORTABLES by Arjan Koning (NDS, IAEA)
  - Without C4 or C5
  - Best effort to get smallest ”dataset” of physical observable and tabulate them
  - Data in ASCII text files and SQL database

```
# entry-subent-pointer  : 20788-008-0
# EXFOR reaction        : ['26-FE-56', ['N,INL'], '26-FE-56,PAR,SIG']
# incident energy       : 2.02e+00 MeV - 4.50e+00 MeV
# target                : Fe-56
# product               : Fe-56
# level energy          : 8.45e-01 MeV
# MF-MT number          : 3 - ['51']
# first author          : E.Almen-Ramstrom
# institute             : (2SWDAE ): Studsvik Energiteknik AB
# reference             : (R,AE-503,197504)
# year                  : 1975
# facility              : (VDG): Van de Graaff
# git                   : https://github.com/IAEA-NDS/exfor_master/blob/main/exforall/207/20788.x4
# nds                   : https://nds.iaea.org/EXFOR/20788
#
#       E_in(MeV)       dE_in(MeV)            XS(B)          dXS(B)
      2.02000E+00      0.00000E+00      8.40000E-01      1.26000E-01
      2.27000E+00      0.00000E+00      8.85000E-01      1.33000E-01
      2.50000E+00      0.00000E+00      8.62000E-01      1.29000E-01
      2.77000E+00      0.00000E+00      7.53000E-01      1.13000E-01
      3.01000E+00      0.00000E+00      8.22000E-01      1.23000E-01
      3.29000E+00      0.00000E+00      6.12000E-01      9.20000E-02
      3.52000E+00      0.00000E+00      5.54000E-01      8.30000E-02
      3.78000E+00      0.00000E+00      4.82000E-01      7.20000E-02
      4.02000E+00      0.00000E+00      4.43000E-01      6.60000E-02
      4.26000E+00      0.00000E+00      3.52000E-01      5.30000E-02
      4.50000E+00      0.00000E+00      3.16000E-01      4.70000E-02
```

/n/Fe-56/n-inl-L1/xs/Fe-56_n-inl-L1_Fe56_Almen-Ramstrom-20788-008-0-1975.txt


Exfor_Bib
id integer
title varchar
first_author varchar
authors varchar
first_author_institute varchar
main_facility_institute varchar
main_facility_type varchar
main_reference varchar
year integer
Exfor_Indexes
id varchar
entry varchar
target varchar
projectile varchar
process varchar
sf4 varchar
residual varchar
level_num integer
e_out float
e_inc_min float
e_inc_max float
points integer
arbitrary_data boolen
sf5 varchar
sf6 varchar
sf7 varchar
sf8 varchar
sf9 varchar
x4_code varchar
mt integer
mf integer
Exfor_Data
id integer
entry_id varchar
entry varchar
en_inc float
den_inc float
charge integer
mass integer
isomer varchar
residual varchar
level_num integer
data float
ddata float
arbitrary_data boolen
arbitrary_ddata boolen
e_out float
de_out float
angle float
dangle float
mt integer
mf integer

https://github.com/IAEA-NDS/exfor_dictionary

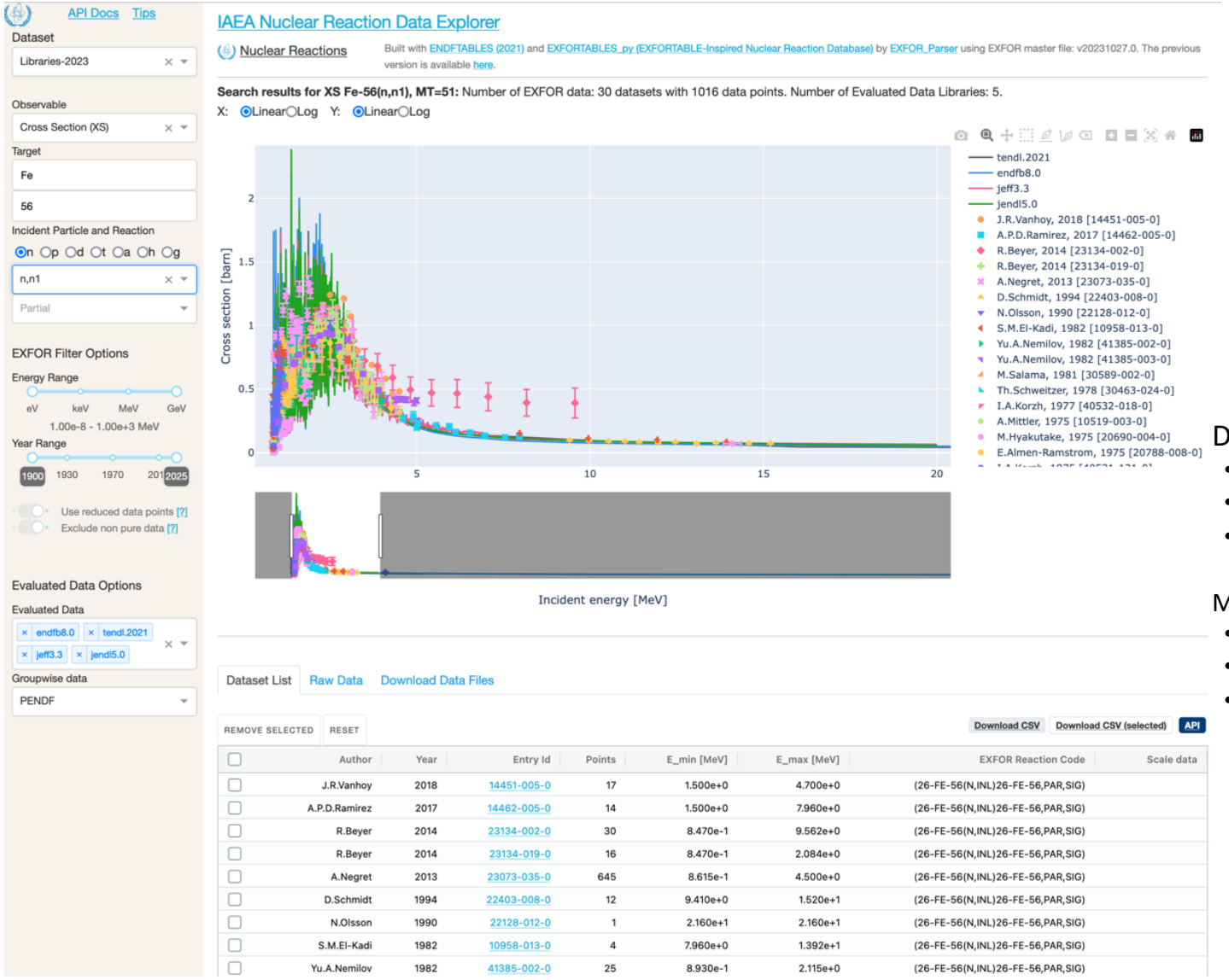
- EXFOR dictionary in JSON
- Convert abbreviations
  - e.g. ”abs.” →"Absolute”, but does "f." mean **f**ragment, **f**actor, **f**ission, **f**or or **f**inal?
- EXFOR keywords are in JSON key
- Easy to lookup programmatically from JSON friendly computer languages


```
"21": {
  "diction_name": "Methods",
  "codes": {
    "ACTIV": {
      "description": "Activation",
      "active": true
    },
    "AMS": {
      "description": "Accelerator mass spectrometry",
      "active": true
    },
    "ASEP": {
      "description": "Off-line mass separation of a product",
      "active": true
    },
    "ASPEC": {
      "description": "Alpha spectrometry",
      "active": true
    },
    "ASSOP": {
      "description": "Associated particle",
      "active": true
    },
    "BCINT": {
      "description": "Beam current integrated",
      "active": true
    },
    "BGCT": {
      "description": "Beta-gamma coincidence technique",
      "active": true
```

```
"25": {
  "EV": {
    "description": "electron-Volts",
    "additional_code": "E",
    "unit_conversion_factor": "1.E+0",
    "active": true
  },
  "GEV": {
    "description": "GeV",
    "additional_code": "E",
    "unit_conversion_factor": "1.E+9",
    "active": true
  },
  "KEV": {
    "description": "keV",
    "additional_code": "E",
    "unit_conversion_factor": "1.E+3",
    "active": true
  },
  "MEV": {
    "description": "MeV",
    "additional_code": "E",
    "unit_conversion_factor": "1.E+6",
    "active": true
  },
```

Reaction based data retrieval ^{56}Fe(n,n'_1)

https://nds.iaea.org/dataexplorer



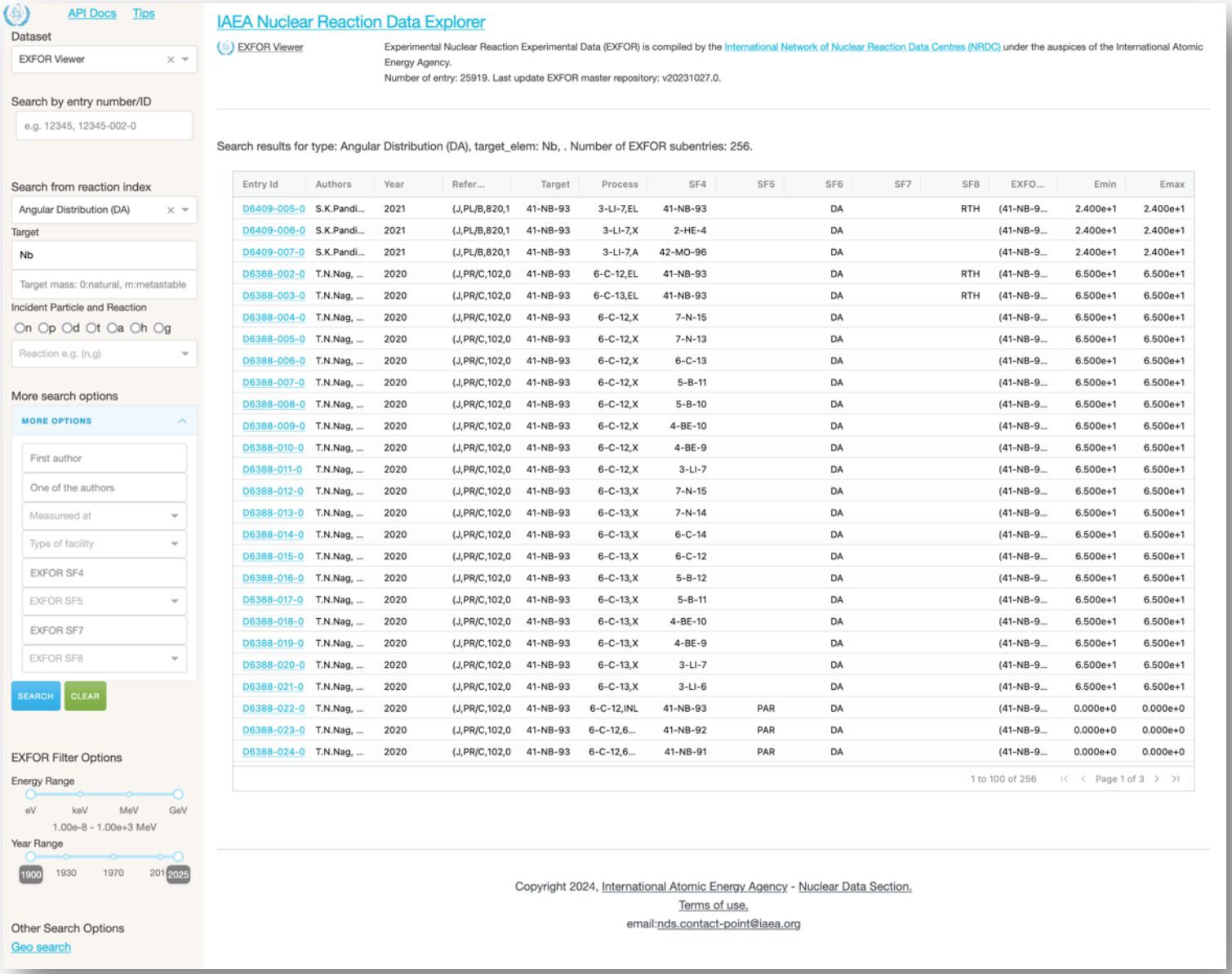
Scan me!

Data plots for
- Cross Section (XS)
- Residual Production XS
- Fission Yield (FY)

More will be included…
- **Angular Distribution (DA)**
- **Energy Distribution (DE)**
- **Fission Observables**
  - **PFNS, PFGS, nu_bar**

EXFOR Entry Search

https://nds.iaea.org/dataexplorer/exfor/search?type=DA&target_elem=Nb



API Docs Tips

Dataset

EXFOR Viewer

Search by entry number/ID

e.g. 12345, 12345-002-0

Search from reaction index

Angular Distribution (DA)

Target

Nb

Target mass: 0:natural, m:metastable

Incident Particle and Reaction

On Op Od Ot Oa Oh Og

Reaction e.g. (n,g)

More search options

MORE OPTIONS

First author

One of the authors

Measureed at

Type of facility

EXFOR SF4

EXFOR SF5

EXFOR SF7

EXFOR SF8

SEARCH CLEAR

EXFOR Filter Options

Energy Range

eV keV MeV GeV

1.00e-8 - 1.00e+3 MeV

Year Range

1900 1930 1970 2025

Other Search Options

Geo search

IAEA Nuclear Reaction Data Explorer

EXFOR Viewer

Experimental Nuclear Reaction Experimental Data (EXFOR) is compiled by the International Network of Nuclear Reaction Data Centres (NRDC) under the auspices of the International Atomic Energy Agency.

Number of entry: 25919. Last update EXFOR master repository: v20231027.0.

Search results for type: Angular Distribution (DA), target_elem: Nb, . Number of EXFOR subentries: 256.

Entry Id	Authors	Year	Refer...	Target	Process	SF4	SF5	SF6	SF7	SF8	EXFO...	Emin	Emax
D6409-005-0	S.K.Pandi...	2021	(J,PL/B,820,1	41-NB-93	3-LI-7,EL	41-NB-93		DA		RTH	(41-NB-9...	2.400e+1	2.400e+1
D6409-006-0	S.K.Pandi...	2021	(J,PL/B,820,1	41-NB-93	3-LI-7,X	2-HE-4		DA			(41-NB-9...	2.400e+1	2.400e+1
D6409-007-0	S.K.Pandi...	2021	(J,PL/B,820,1	41-NB-93	3-LI-7,A	42-MO-96		DA			(41-NB-9...	2.400e+1	2.400e+1
D6388-002-0	T.N.Nag, ...	2020	(J,PR/C,102,0	41-NB-93	6-C-12,EL	41-NB-93		DA		RTH	(41-NB-9...	6.500e+1	6.500e+1
D6388-003-0	T.N.Nag, ...	2020	(J,PR/C,102,0	41-NB-93	6-C-13,EL	41-NB-93		DA		RTH	(41-NB-9...	6.500e+1	6.500e+1
D6388-004-0	T.N.Nag, ...	2020	(J,PR/C,102,0	41-NB-93	6-C-12,X	7-N-15		DA			(41-NB-9...	6.500e+1	6.500e+1
D6388-005-0	T.N.Nag, ...	2020	(J,PR/C,102,0	41-NB-93	6-C-12,X	7-N-13		DA			(41-NB-9...	6.500e+1	6.500e+1
D6388-006-0	T.N.Nag, ...	2020	(J,PR/C,102,0	41-NB-93	6-C-12,X	6-C-13		DA			(41-NB-9...	6.500e+1	6.500e+1
D6388-007-0	T.N.Nag, ...	2020	(J,PR/C,102,0	41-NB-93	6-C-12,X	5-B-11		DA			(41-NB-9...	6.500e+1	6.500e+1
D6388-008-0	T.N.Nag, ...	2020	(J,PR/C,102,0	41-NB-93	6-C-12,X	5-B-10		DA			(41-NB-9...	6.500e+1	6.500e+1
D6388-009-0	T.N.Nag, ...	2020	(J,PR/C,102,0	41-NB-93	6-C-12,X	4-BE-10		DA			(41-NB-9...	6.500e+1	6.500e+1
D6388-010-0	T.N.Nag, ...	2020	(J,PR/C,102,0	41-NB-93	6-C-12,X	4-BE-9		DA			(41-NB-9...	6.500e+1	6.500e+1
D6388-011-0	T.N.Nag, ...	2020	(J,PR/C,102,0	41-NB-93	6-C-12,X	3-LI-7		DA			(41-NB-9...	6.500e+1	6.500e+1
D6388-012-0	T.N.Nag, ...	2020	(J,PR/C,102,0	41-NB-93	6-C-13,X	7-N-15		DA			(41-NB-9...	6.500e+1	6.500e+1
D6388-013-0	T.N.Nag, ...	2020	(J,PR/C,102,0	41-NB-93	6-C-13,X	7-N-14		DA			(41-NB-9...	6.500e+1	6.500e+1
D6388-014-0	T.N.Nag, ...	2020	(J,PR/C,102,0	41-NB-93	6-C-13,X	6-C-14		DA			(41-NB-9...	6.500e+1	6.500e+1
D6388-015-0	T.N.Nag, ...	2020	(J,PR/C,102,0	41-NB-93	6-C-13,X	6-C-12		DA			(41-NB-9...	6.500e+1	6.500e+1
D6388-016-0	T.N.Nag, ...	2020	(J,PR/C,102,0	41-NB-93	6-C-13,X	5-B-12		DA			(41-NB-9...	6.500e+1	6.500e+1
D6388-017-0	T.N.Nag, ...	2020	(J,PR/C,102,0	41-NB-93	6-C-13,X	5-B-11		DA			(41-NB-9...	6.500e+1	6.500e+1
D6388-018-0	T.N.Nag, ...	2020	(J,PR/C,102,0	41-NB-93	6-C-13,X	4-BE-10		DA			(41-NB-9...	6.500e+1	6.500e+1
D6388-019-0	T.N.Nag, ...	2020	(J,PR/C,102,0	41-NB-93	6-C-13,X	4-BE-9		DA			(41-NB-9...	6.500e+1	6.500e+1
D6388-020-0	T.N.Nag, ...	2020	(J,PR/C,102,0	41-NB-93	6-C-13,X	3-LI-7		DA			(41-NB-9...	6.500e+1	6.500e+1
D6388-021-0	T.N.Nag, ...	2020	(J,PR/C,102,0	41-NB-93	6-C-13,X	3-LI-6		DA			(41-NB-9...	6.500e+1	6.500e+1
D6388-022-0	T.N.Nag, ...	2020	(J,PR/C,102,0	41-NB-93	6-C-12,INL	41-NB-93	PAR	DA			(41-NB-9...	0.000e+0	0.000e+0
D6388-023-0	T.N.Nag, ...	2020	(J,PR/C,102,0	41-NB-93	6-C-12,6...	41-NB-92	PAR	DA			(41-NB-9...	0.000e+0	0.000e+0
D6388-024-0	T.N.Nag, ...	2020	(J,PR/C,102,0	41-NB-93	6-C-12,6...	41-NB-91	PAR	DA			(41-NB-9...	0.000e+0	0.000e+0

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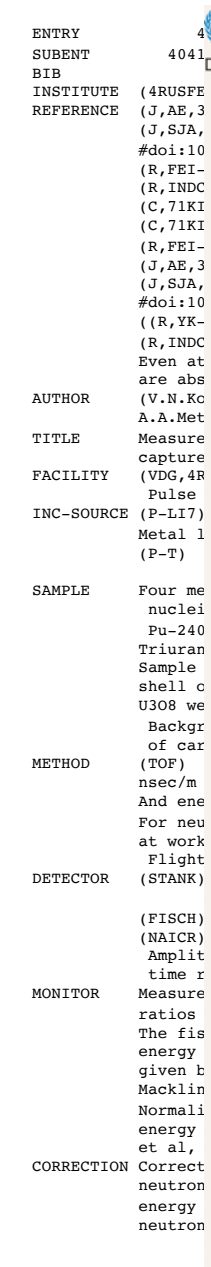
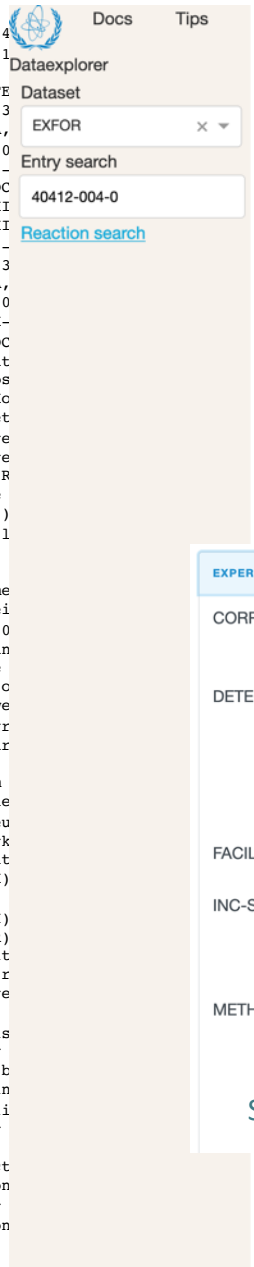
email:nds.contact-point@iaea.org

New UX for the EXFOR Entry Viewer





IAEA Nuclear Data Explorer

Experimental Nuclear Reaction Data (EXFOR) is compiled by the International Network of Nuclear Reaction Data Centres (NRDC) under the auspices of the International Atomic Energy Agency.

Number of entry: 2448, Number of dataset: 123456

Entry number: 40412: Last updated on 2020-05-15 (Rev. 7) Compilation history EXFOR Git JSON

Title:	Measurement of alpha and the 235U and 239Pu fission and capture cross sections for 10-80 keV neutrons
Autors:	V.N.Kononov, E.D.Poletaev, B.D.Yurlov, Yu.S.Prokopets, A.A.Metlev, Yu.Ya.Stavisskiy,
Institute:	(4RUSFEI)
References:	(J,AE,38,82,1975), (J,SJA,38,105,1975), (R,FEI-274,1971), (R,INDC(CCP)-21,1972), (C,71KIEV,1,293,1971), (C,71KIEV,1,301,1971), (R,FEI-290,1972), (J,AE,32,85,1972), ((R,YK-15,12,1974)=(R,INDC(CCP)-57,12,1974)), ((R,YK-15,12,1974)=(R,INDC(CCP)-57,12,1974)),
Reactions:	40412-004-0: (92-U-235(N,G)92-U-236,,SIG,,AV)

← Simplified bibliographic in

← Reactions in ENTF

←Measurement i

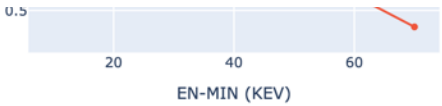
EXPERIMENTAL CONDITIONS

CORRECTION		Correction for isotopic impurities,correction for neutron multiplication in the samples, correction for energy dependence nu-bar, correction for multiple neutron scattering and resonance self-shielding.
DETECTOR	(STANK)	Large (400. l) liquid scintillation detector loaded with cadmium
	(FISCH)	Fast ionization chamber with Cf-252.
	(NAICR)	NaI(Tl) Crystal of 150x80 mm size detector. Amplitude resolution about 13 % at E-gamma=478 keV, time resolution 8ns at E-gamma 420.-540. keV.
FACILITY	(VDG,4RUSFEI)	FEI pulsed Van-de-Graaff accelerator. Pulse duration 22ns, frequency 300.kHz.
INC-SOURCE	(P-LI7)	Proton-Lithium-7 Metal lithium targets were used
	(P-T)	Proton-tritium, standard tritium-titanium targets were used
METHOD	(TOF)	Time-of-flight method with resolution 18 nsec/m for neutron energy range from 10 keV to 80 keV And energy resolution from 10 keV to 30 keV For neutron energy range from 100 keV to 1 MeV at working on monoenergetic neutrons. Flight path 1.18 m.

↓Tooltip from dictionary

Scintillator tank

Separate code and free text→



Example: https://nds.iaea.org/dataexplorer/exfor/entry/40412

Web API Endpoints

- An architectural style for an application program interface (API) that uses HTTP requests to access and use data - Addressability, Stateless, Uniform Interface

  - **Reactions**: datasets with data tables used in the dataexplorer

    GET http://nds.iaea.org/dataexplorer/api/reactions

  - **EXFOR entry**: entry, subentry, bib, data, experimental condition, reactions

    GET http://nds.iaea.org/dataexplorer/api/exfor/entry/

  - **EXFOR dictionary**: facilities, institutes, methods, detectors

    GET http://nds.iaea.org/dataexplorer/api/exfor/dict/

  - **RIPL-3 discrete level**: levels, level records

    GET http://nds.iaea.org/dataexplorer/api/ripl3/levels/

Reactions API

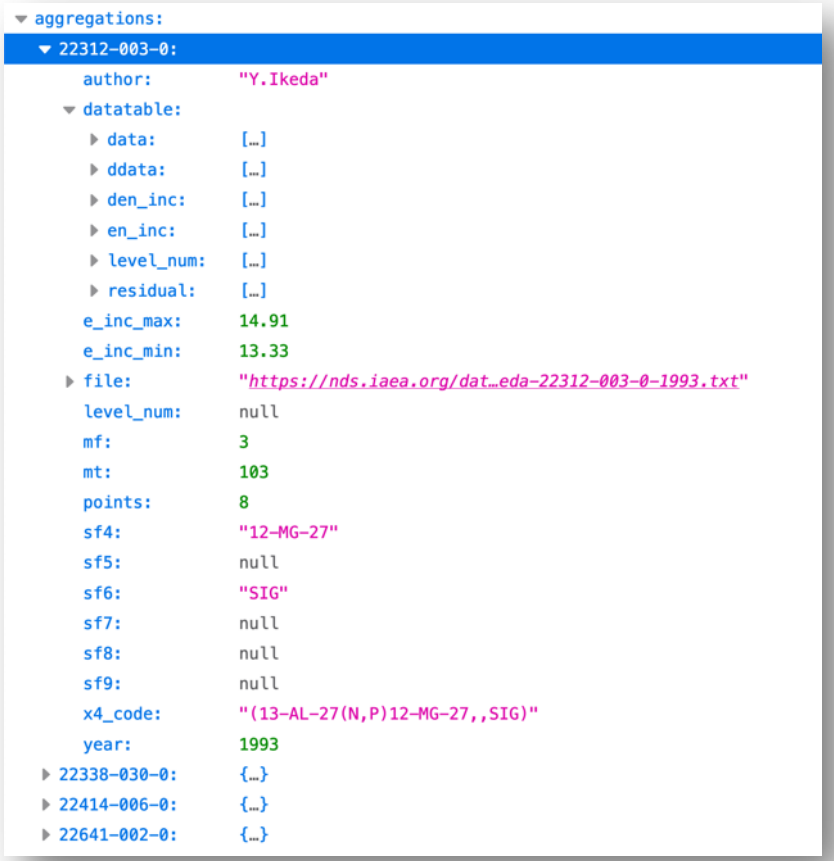
GET /dataexplorer/api/reactions/{type}

https://nds.iaea.org/dataexplorer/api/reactions/**xs**?target_elem=Al&target_mass=27&reaction=n%2Cp&table=True&page=1

Name	Data Type	Required	Description
type	string		**xs**: Cross section **residual**: Residula production cross sections **thermal**: Thermal neutron cross sections **fy**: fission yields

- General search parameters

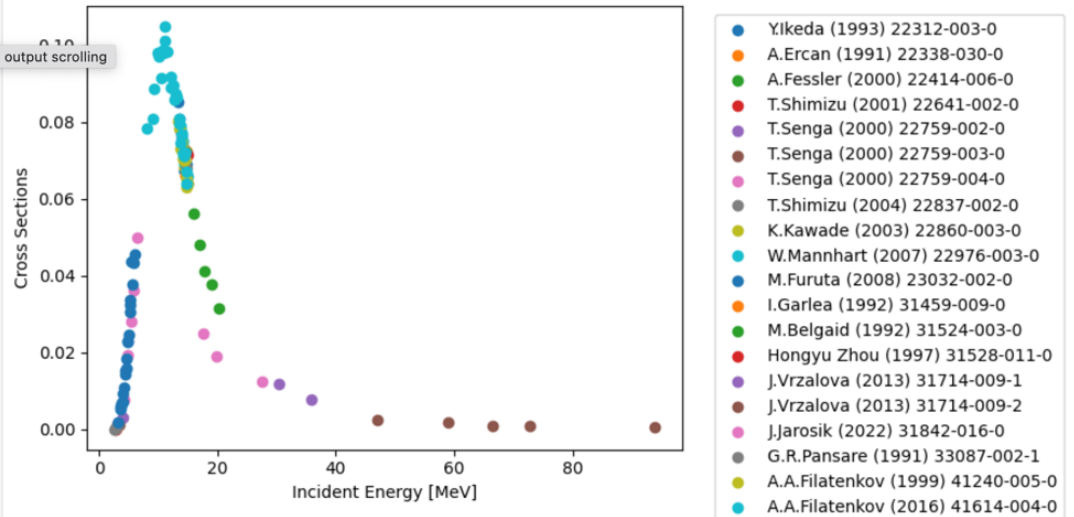
Name	Data Type	Required	Description
target_elem	string		e.g. Al
target_mass	number		e.g. 27
reaction	string		e.g. n,g
rp_elem	string	optional	Element name of the residual product
rp_mass	number	optional	Mass number of the residual product
fy_type	string	optional	Cumulative, Independent, Primary for FPY
table	boolen	optional	Default: False, True to include data table in the return
page	number		Default: 1, page number of pageing. 100 datasets in one page are returned.



Simple Use Case of Reactions API

```python
import json
import pandas as pd
import requests
import matplotlib.pyplot as plt

# access to the reaction data via HTTPS
headers = {
    "Authorization": "Bearer xxxxxxxxxxx",
    "User-Agent": "Get all samples",
    "Content-Type": "application/json",
}
response = requests.get("https://nds.iaea.org/dataexplorer/api/reactions/xs?target_elem=Al&target_mass=27&reaction
                        headers=headers)

# get response in JSON format
entries = response.json().get("aggregations")

# loop over the entries and make the plot and store the data into pa
df = pd.DataFrame()
for entry in entries.keys():
    entry_df = pd.DataFrame.from_dict(entries[entry]["datatable"])
    author = entries[entry]["author"]
    year = entries[entry]["year"]
    plt.scatter(entry_df["en_inc"], entry_df["data"], label= f"{auth
    df = pd.concat([df, entry_df])

plt.ylabel('Cross Sections')
plt.xlabel('Incident Energy [MeV]')
plt.legend(bbox_to_anchor=(1.04, 1), loc="upper left")
plt.show()
print(df)
```

output scrolling



	data	ddata	den_inc	en_inc	level_num	residual
0	0.0641	0.0022	None	14.91	None	Mg-27
1	0.0688	0.0031	None	14.65	None	Mg-27
2	0.0675	0.0063	None	14.42	None	Mg-27
3	0.0721	0.0038	None	14.22	None	Mg-27
4	0.0760	0.003	None	13.98	None	Mg-27
..	...	...	...	...	...	...
3	0.0718	0.001501	None	14.04	None	Mg-27
4	0.0710	0.001377	None	14.26	None	Mg-27
5	0.0720	0.001368	None	14.44	None	Mg-27
6	0.0671	0.001389	None	14.63	None	Mg-27
7	0.0640	0.001242	None	14.81	None	Mg-27

[113 rows x 6 columns]

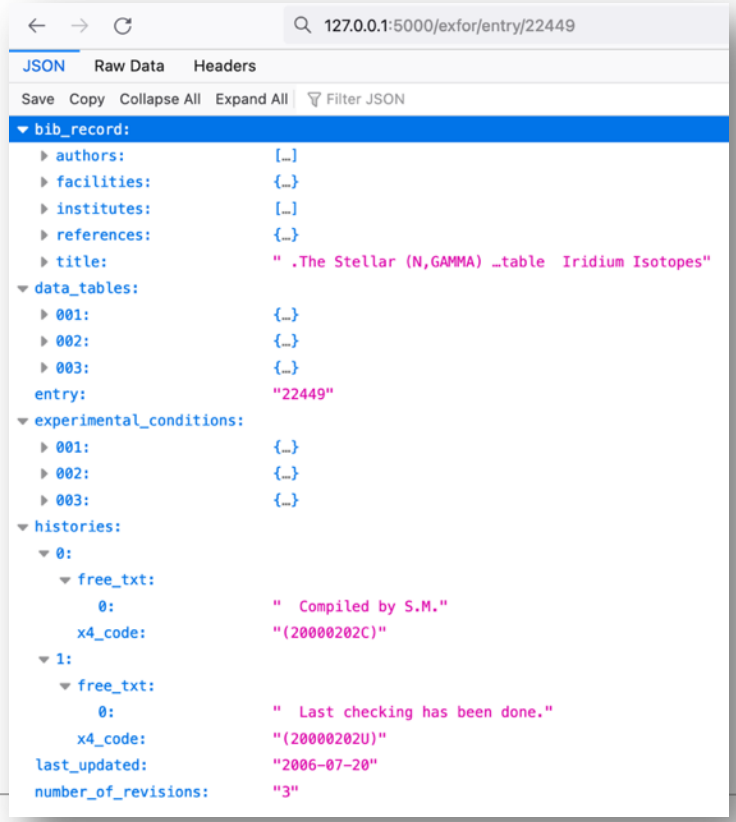
EXFOR Entry API

GET /dataexplorer/api/exfor/entry/{entry_id}/{subent_id}

Name	Data Type	Required	Description
entry_id	string		EXFOR entry number
subent_id	string	optional	Subentry number

GET /dataexplorer/api/exfor/entry/{entry_id}/{section}

Name	Data Type	Required	Description
section	string	optional	bib: return bibliographic data data: return datatable experiment: return experimental conditions histories: return entry history



EXFOR Dictionary API

GET /dataexplorer/api/exfor/dict/{field}/{name}

Name	Data Type	Required	Description
field	string		institute: used in INSTITUTE field facility: used in FACILITY field method: used in METHOD field detector: used in DETECTOR field
name	string	optional	

http://nds.iaea.org/dataexplorer/api/exfor/**dict/institute/1CANALA**

```
active:        true
description:   "University of Alberta, Edmonton, Alberta"
```

https://nds.iaea.org/dataexplorer/api/exfor/**dict/facility/accel**

```
active:        true
description:   "Accelerator"
```

http://nds.iaea.org/dataexplorer/api/exfor/**dict/method/activ**

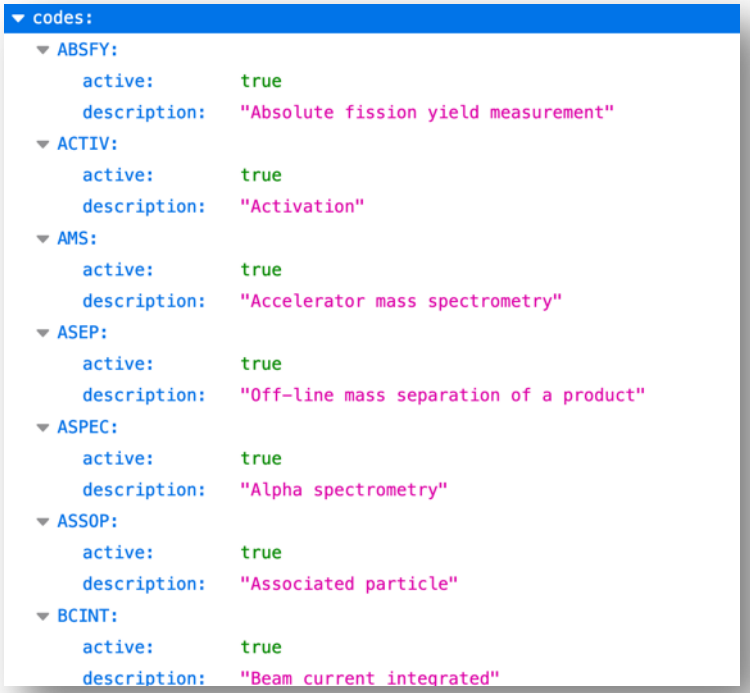
```
active:        true
description:   "Activation"
```

http://nds.iaea.org/dataexplorer/api/exfor/**dict/detector/hpge**

JSON

```
active:        true
description:   "Hyperpure Germanium detector"
```

https://nds.iaea.org/dataexplorer/api/exfor/**dict/method**

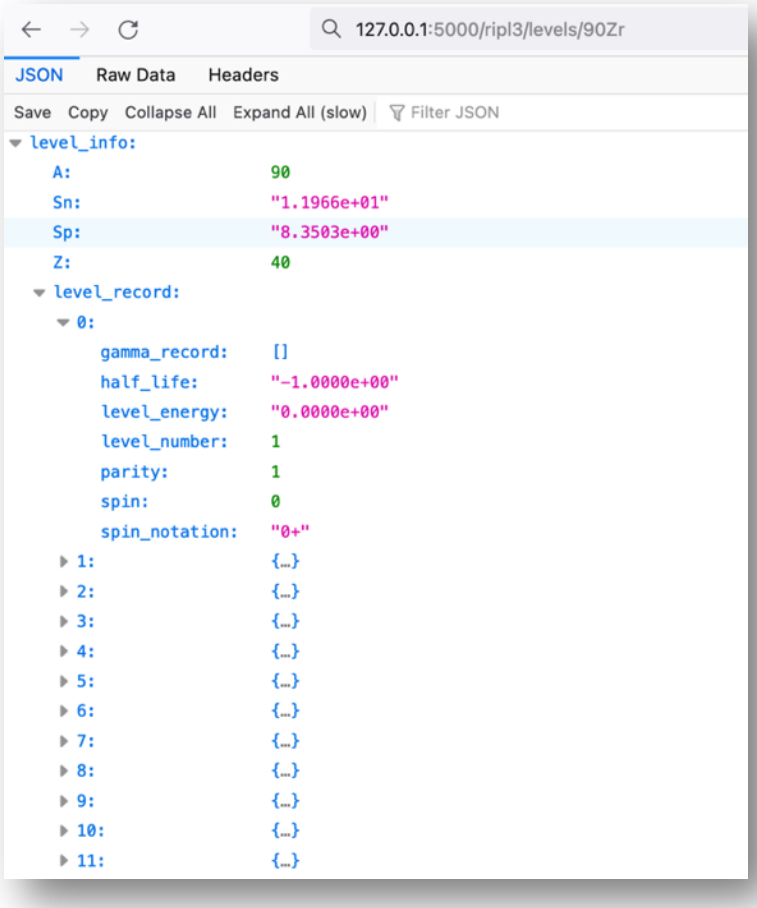


RIPL-3 discrete level API

GET /dataexplorer/api/exfor/ripl3/{field}/{nuclide}

Name	Data Type	Required	Description
field	string		levels: discrete level information
nuclide	string		Name of nuclide with '235U' format

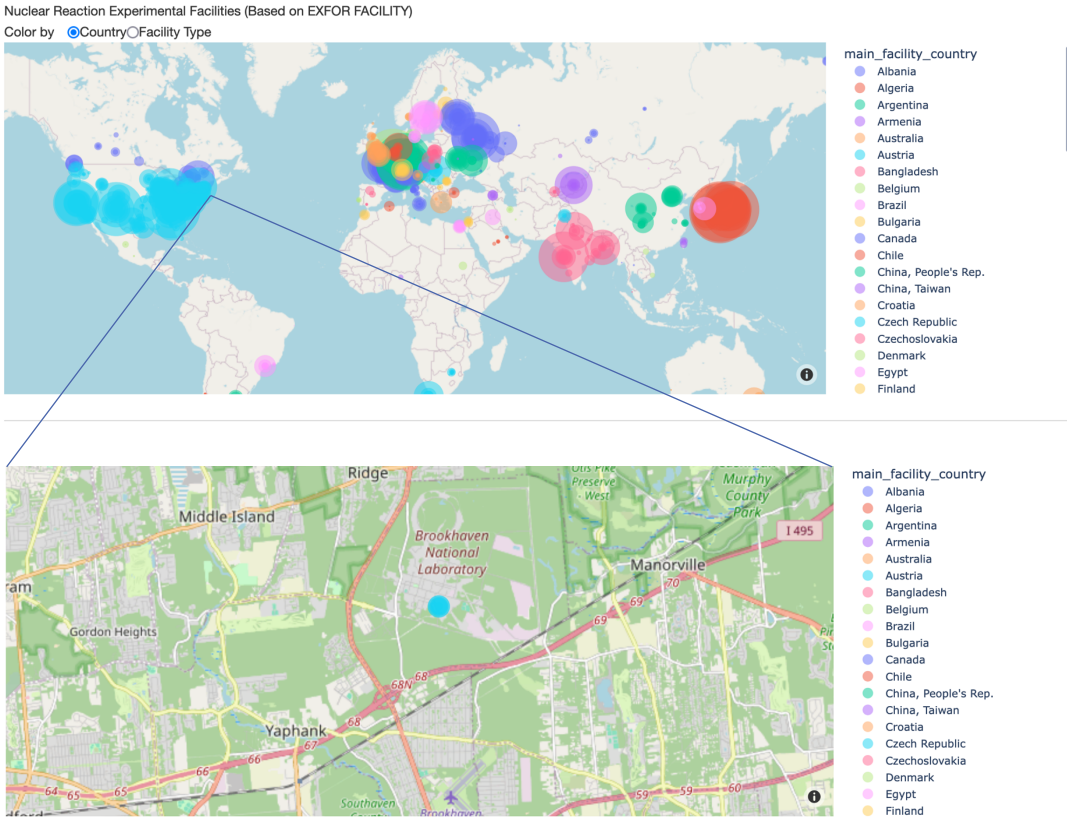
http://nds.iaea.org/dataexplorer/api/**ripl3/levels/90Zr**



Inter-Agency-operablities?

- **Bubble Chart**
  - Displays the number of nuclear reaction measurements in EXFOR based on the first author's institute.
- **GPS Coordinates (latitude and longitude)**
  - Retrieved from the Google Maps API using the institute's name.
- **Facility Location**
  - The exact location of the facility within certain institutes is unavailable. Are there any interconnectable API in the Agency?

Geographical distribution of nuclear reaction measurements in https://nds.iaea.org/dataexplorer/exfor/geo



EXFOR entries from Slow chopper (CHOPS) in Brookhaven National Laboratory, Upton, NY (1USABNL)

Entry	Facility Type	Authors	Title	Reference	Year
11719	Slow chopper	J.A.Moore, H.Palevsky, R.E.Chrien	Neutron Capture in Iron	(J,PR,132,801,1963)	1963
12324	Slow chopper	H.R.Muether, H.Palevsky	Private Communication	(W,MUETHER,1955)	1955
11714	Slow chopper	H.Palevsky, D.J.Hughes	Magnetic Inelastic Scattering of Slow Ne...	(J,PR,92,202(2),1953)	1953
14781	Slow chopper	H.Palevsky, D.J.Hughes, R.R.Smith	Cross Section of Fe for Cold Neutrons	(J,PR,87,221(U3),1952)	1952

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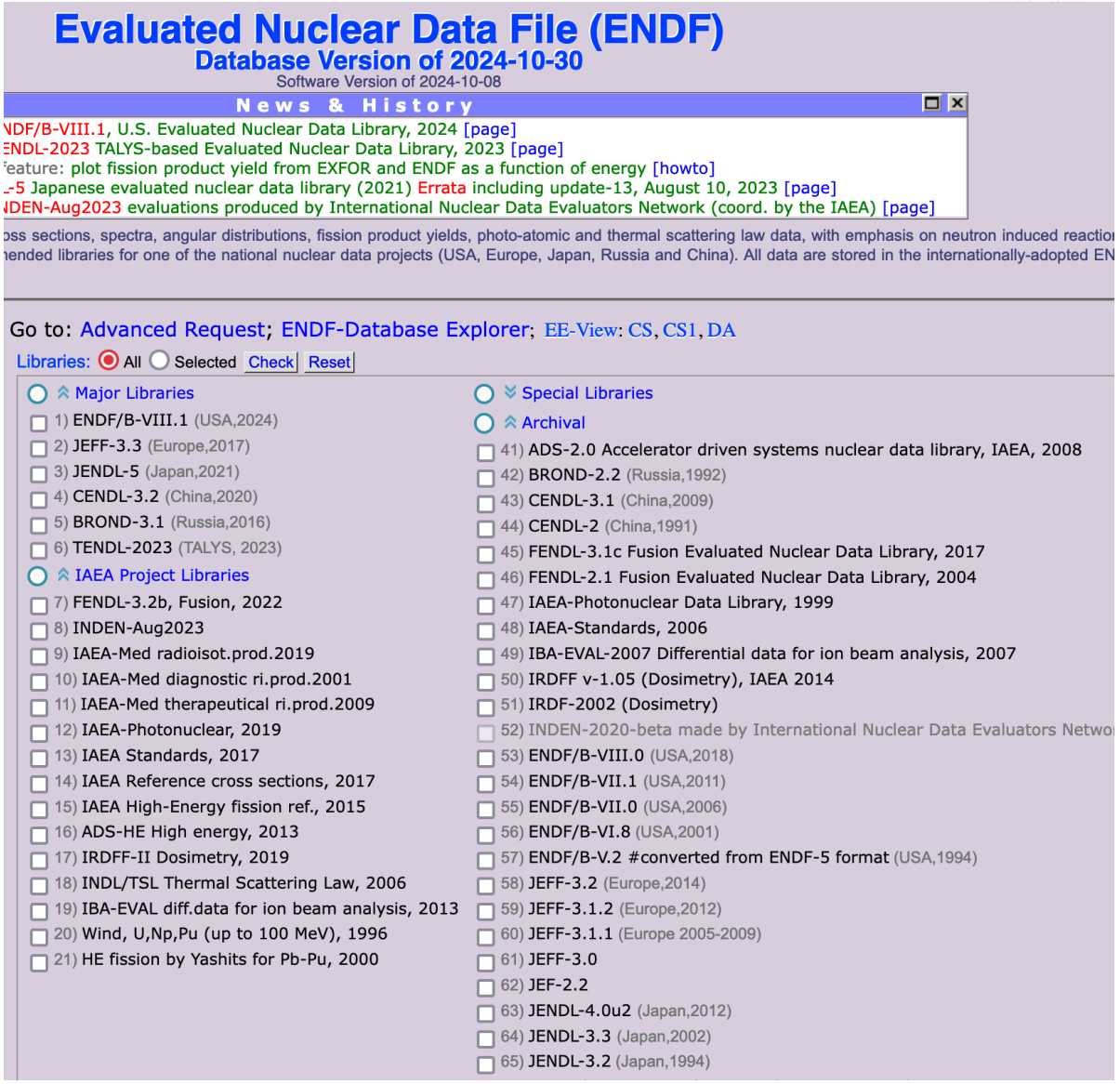
ENDF Interface

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



ENDF-Archive

https://www-nds.iaea.org/public/download-endf/?C=M;O=D

Forthcoming: ENDF-6 Viewer

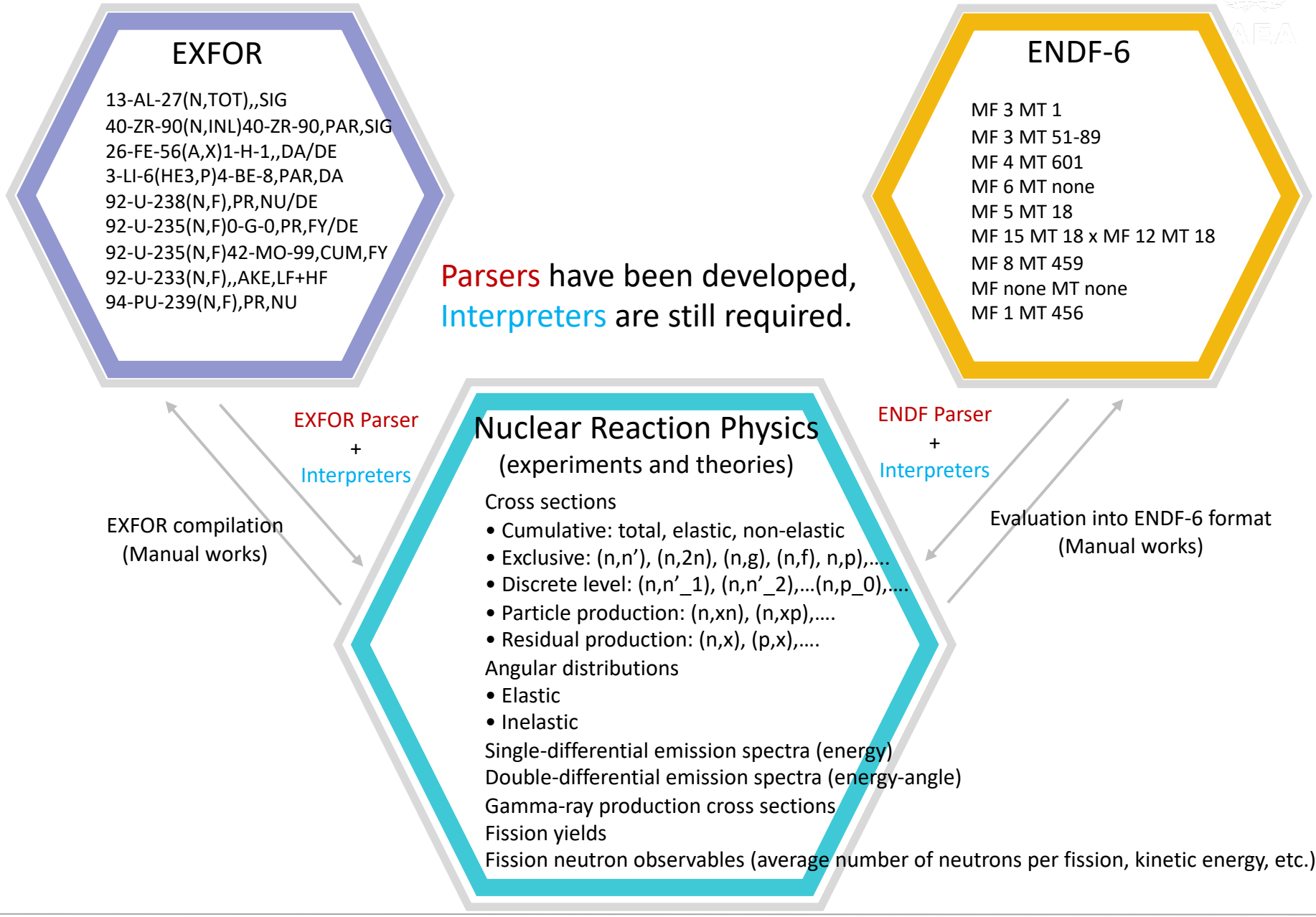
ENDF-6 content viewer powered by DeCE[1], C++ program to manipulate ENDF-6 formatted file.

- showheaders (print parameters in header MF1 MT 451)
- extract (print section in ENDF-6 format)
- table (print section in tabulated table format)
- reconstruct (cross section from resonance parameters)

- Allow users access to the historical ENDF-6 format libraries stored in IAEA-NDS.

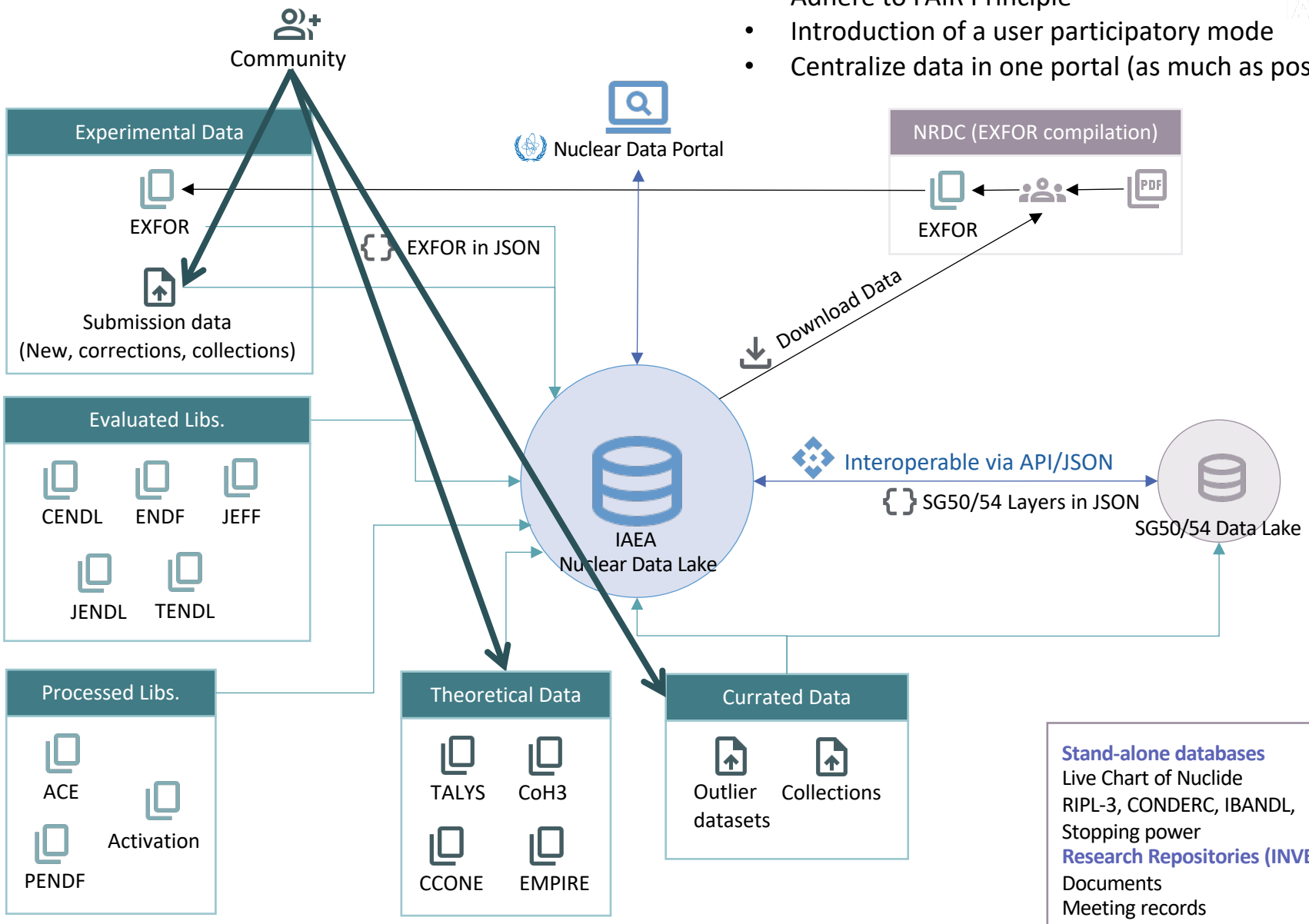
[1] Developped by T. Kawano (LANL), *J. Nucl. Sci. Technol.*, 56, 1029-1035 (2019)
https://github.com/toshihikokawano/DeCE

Nuclear reaction data in different forms



Goal: Centralize nuclear reaction data into “Nuclear Data Portal”

- Adhere to FAIR Principle
- Introduction of a user participatory mode
- Centralize data in one portal (as much as possible)



Stand-alone databases
Live Chart of Nuclide
RIPL-3, CONDERC, IBANDL,
Stopping power
Research Repositories (INVENIO)
Documents
Meeting records

Summary

- IAEA Nuclear Reaction Dataexplorer
  - Datasets has been renewed - with a new EXFOR parser and APIs
  - Ready to inter-connect to other systems
  - Will become a prototype of *Nuclear Data Portal*

- Our goal: *Nuclear Data Portal*
  - Centralize experimental, evaluated, and theoretical nuclear data
  - Promote data collection and submission by users
    - IAEA Nucleus account would be required (under discussion)
  - AI/DL supported journal scanning (find EXFORable publications) and EXFOR compilation based on AI/DL should be exploited

Nuclear Data Portal

Thank you!

IAEA
International Atomic Energy Agency
Atoms for Peace and Development