



# Modernizing Experimental Nuclear Data Access: The IAEA Nuclear Reaction Data Explorer

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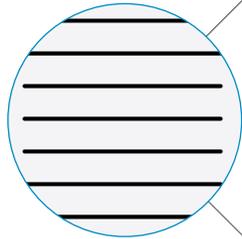
Shin Okumura

1. **Nuclear Data Section**, Division of Physical and Chemical Sciences, Department of Nuclear Sciences and Applications, International Atomic Energy Agency



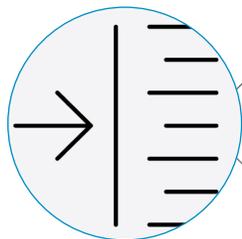
# Background and Challenges

- Current nuclear data formats such as EXFOR, ENDF-6, XUNDL, and ENSDF inherited constraints from the Fortran era (Punch card legacy): making them difficult and often painful to first understand the format prior to use.



## **Challenges in data management and accessibility**

due to ASCII text-based fixed-width formats, which complicate programmatic searching, version control, data retrieval, compatibility with plotting or visualization tools, and utilization of large-scale data to AI/ML application.



## **High entry barriers for newcomers**

caused by the steep learning curve and the need for additional preprocessing or database support.

# IAEA Nuclear Reaction Dataexplorer

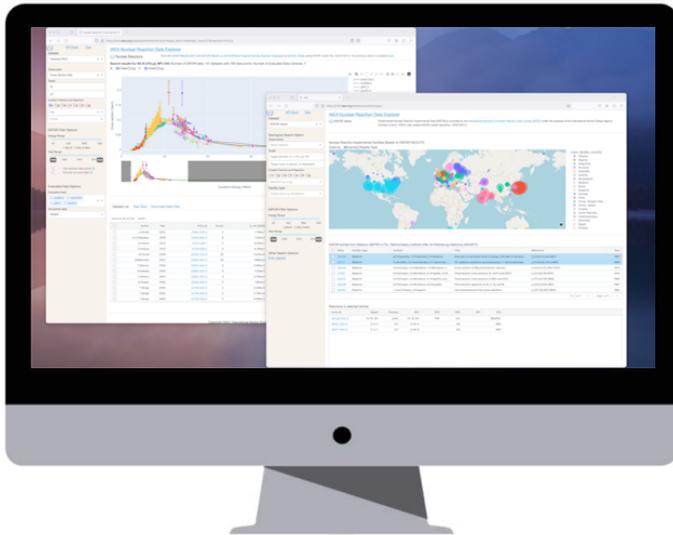
- As only *experts* know how to work with ENDF-6 and EXFOR formatted data, it is necessary to decouple the presentation layer (UI) from the underlying data formats and access mechanisms for entry users.
- Solution:



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



Python 3 based, Open source 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

## EXFOR entry viewer

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

## Web APIs

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

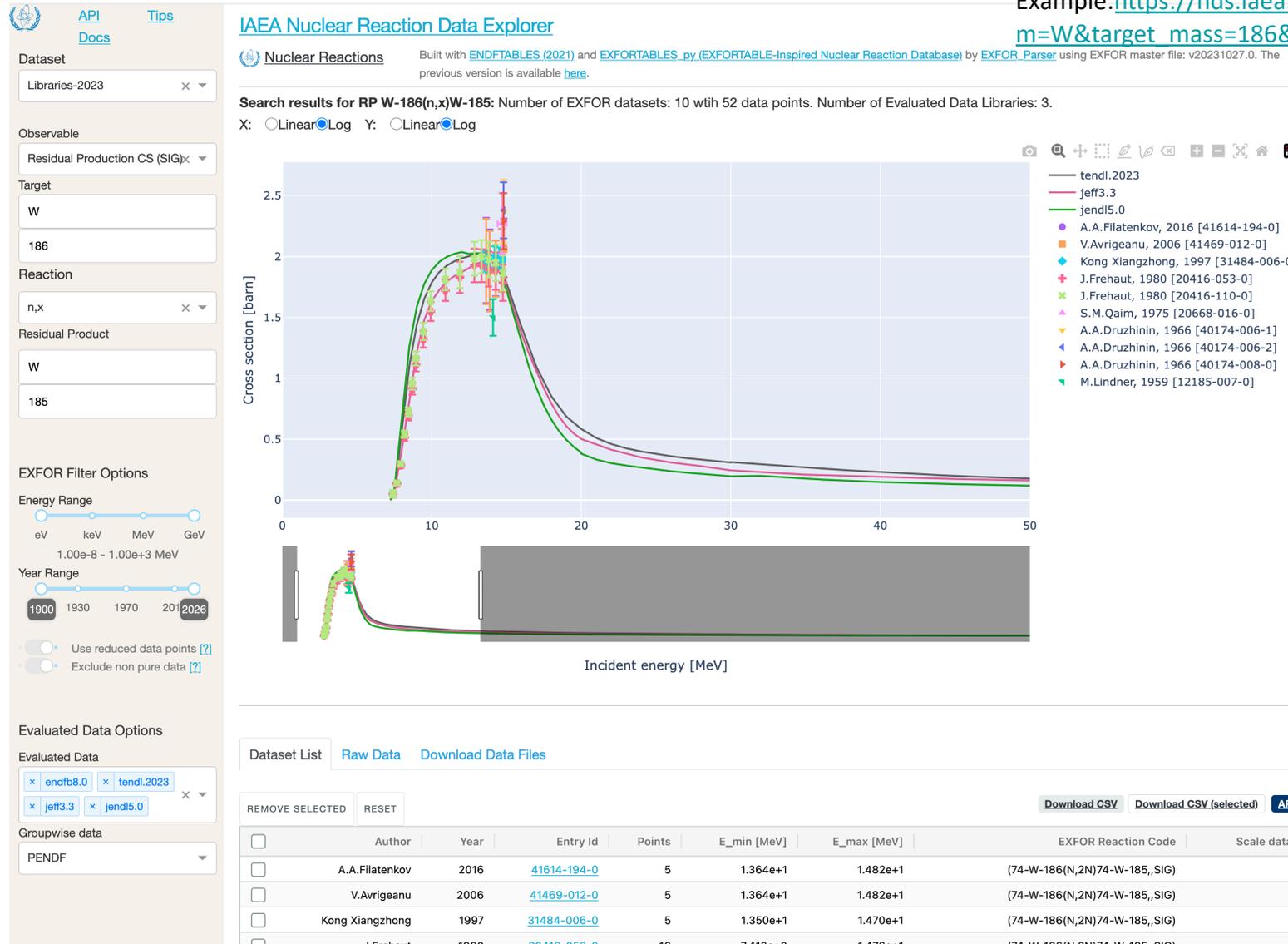
# Fe56(n,p) Cross Section Plot

Example: [https://nds.iaea.org/dataexplorer/reactions/xs?target\\_elem=Fe&target\\_mass=56&reaction=n%2Cp](https://nds.iaea.org/dataexplorer/reactions/xs?target_elem=Fe&target_mass=56&reaction=n%2Cp)



# $^{186}\text{W}(n,x)^{185}\text{W}$ Residual Production Cross Section Plot

Example: [https://nds.iaea.org/dataexplorer/reactions/residual?&target\\_element=W&target\\_mass=186&inc\\_pt=N&rp\\_elem=W&rp\\_mass=185](https://nds.iaea.org/dataexplorer/reactions/residual?&target_element=W&target_mass=186&inc_pt=N&rp_elem=W&rp_mass=185)



# The EXFOR Entry Viewer

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

ENTRY 40412 20200318 20200515 20200514  
 SUBENT 40412001 20200318 20200515 20200514  
 BIB 13 76  
 INSTITUTE (4RUSFEI)  
 REFERENCE (J,AE,38,82,1975) Issue 2.  
 (J,SJA,38,105,1975) Engl.translation of AE,38,  
 #doi:10.1007/BF01208866  
 (R,FEI-274,1971)  
 (R,INDC(CCP)-21,1972) Engl.translation of R,FE  
 (C,71KIEV,1,293,1971) Graphs of Alpha val  
 (C,71KIEV,1,301,1971) Exp.method.  
 (R,FEI-290,1972) Facility details.  
 (J,AE,32,85,1972) Issue 1. Graphs of Alpha val  
 (J,SJA,32,95,1972) Engl.translation of AE,32,8  
 #doi:10.1007/BF01261042  
 ((R,YK-15,12,1974)=  
 (R,INDC(CCP)-57,12,1974))  
 Even at NDS web-site in this INDC(CCP)-57 pdf  
 are absent.  
 AUTHOR (V.N.Kononov, E.D.Poletaev,B.D.Yurlov, Yu.S.Pr  
 A.A.Metlev, Yu.Ya.Stavisskiy)  
 TITLE Measurement of alpha and the 235U and 239Pu fi  
 capture cross sections for 10-80 keV neutrons  
 FACILITY (VDG,4RUSFEI) FEI pulsed Van-de-Graaff accele  
 Pulse duration 22ns, frequency 300.kHz.  
 INC-SOURCE (P-LI7) Proton-Lithium-7  
 Metal lithium targets were used  
 (P-T) Proton-tritium, standard tritium-ti  
 targets were used  
 SAMPLE Four metal Pu-239 discs of 40 mm diameter, 2.9  
 nuclei/b thickness. Total weight 14.5 g.  
 Pu-240 content in the sample - 0.2%.  
 Triuranium octoxide U3O8 (90.3 percents of U-2  
 Sample of 4.1E-3 U-235-nuclei/b thickness in a  
 shell of 40 mm Diameter and 0.5mm wall thickne  
 U3O8 weight - 24.4g.  
 Background measurements equivalent scattering  
 of carbon and lead were used  
 METHOD (TOF) Time-of-flight method with resolutio  
 nsec/m for neutron energy range from 10 keV to  
 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.  
 DETECTOR (STANK) Large (400. l) liquid scintillation de  
 loaded with cadmium  
 (FISCH) Fast ionization chamber with Cf-252.  
 (NAICR) NaI(Tl) Crystal of 150x80 mm size det  
 Amplitude resolution about 13 % at E-gamma=47  
 time resolution 8ns at E-gamma 420.-540. keV.  
 MONITOR Measurement of the capture-to-fission cross-se  
 ratios (ALFA) was absolute  
 The fission cross-sections have been measured  
 energy dependence of B-10(n,alpha-gamma) react  
 given by Sowerby M.G. et al, 70HELKINKI,1,161  
 Macklin P.L. et al, Phys.Rev., 165, 1147, 1968  
 Normalization of fission cross-section was mad  
 energy region 30-40 keV to evaluated data by S  
 et al, Ann. Of Sci. and Eng., V1, No.718,1974.  
 CORRECTION Correction for isotopic impurities,correction  
 neutron multiplication in the samples, correct  
 energy dependence nu-bar, correction for multi  
 neutron scattering and resonance self-shieldin

IAEA Nuclear Data Explorer

Docs Tips

Dataexplorer

Dataset

EXFOR

Entry search

40412-004-0

Reaction search

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 info

← Reactions in ENTRY

← Measurement info

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.

EN-MIN (KEV)

↓ Tooltip from the EXFOR dictionary

Scintillator tank

Separate code and free text →

# EXFOR Entry Search

Example: [https://nds.iaea.org/dataexplorer/exfor/search?type=DA&target\\_elem=Nb&target\\_mass=93](https://nds.iaea.org/dataexplorer/exfor/search?type=DA&target_elem=Nb&target_mass=93)

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  
Measured at  
Type of facility  
EXFOR SF4  
EXFOR SF5  
EXFOR SF7  
EXFOR SF8

**SEARCH** **CLEAR**

EXFOR Filter Options  
Energy Range  
1.00e-8 - 1.00e+3 MeV  
Year Range  
1900 - 2025

Other Search Options  
[Geo search](#)

## IAEA Nuclear Reaction Data Explorer

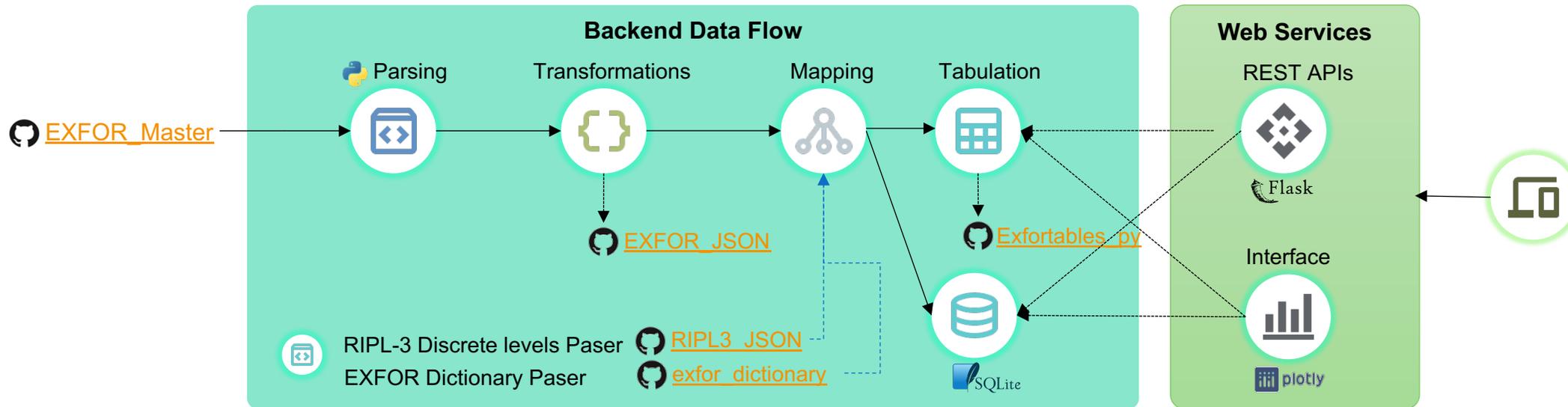
EXFOR Viewer  
Experimental Nuclear Reaction Experimental Data (EXFOR) is compiled by the [International Network of Nuclear Reaction Data Centres \(NRDC\)](#) under the auspices of the International Atomic Energy Agency.  
Number of entry: 25919. Last update EXFOR master repository: v20231027.0.

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 |

1 to 100 of 256 < > Page 1 of 3 > >

# 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 are produced by EXFOR Parser (available in text and SQL)
  - Web interfaces
  - APIs: Easy computational access developed in Flask
  - ENDF-6 libraries is from ENDFTABLES\*\*

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

\*\* A. Koning, <https://nds.iaea.org/talys/>

# Available Web API Endpoints

- Users can access the following endpoints via HTTP requests:

- **Reactions:** Datasets containing data tables used in the Data Explorer.

GET

<https://nds.iaea.org/dataexplorer/api/reactions/>

- **EXFOR Entry:** Entries, subentries, bibliography, data, experimental conditions, and reactions.

GET

<https://nds.iaea.org/dataexplorer/api/exfor/entry/>

- **EXFOR Dictionary:** Provide information on facilities, institutes, methods, and detectors defined in the EXFOR dictionary.

GET

<http://nds.iaea.org/dataexplorer/api/exfor/dict/>

- **RIPL-3 Discrete Level:** Includes levels and level records.

GET

<http://nds.iaea.org/dataexplorer/api/ripl3/levels/>

You can find API links everywhere!

Download CSV

Download CSV (selected)

API

| MeV] | Data      | dData     |
|------|-----------|-----------|
| 0e+0 | 9.7470e+1 | 6.4000e-1 |

# Reactions API

GET

</dataexplorer/api/reactions/{type}>

| Name | Data Type | Required | Description  |
|------|-----------|----------|--|
| type | string    |          | <b>xs</b> : Cross section<br><b>residual</b> : Residual production cross sections<br><b>thermal</b> : Thermal neutron cross sections<br><b>fy</b> : 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       | boolean   | optional | Default: False, True to include data table in the return                  |
| page        | number    |          | Default: 1, page number of paging. 100 datasets in one page are returned. |

Example: [https://nds.iaea.org/dataexplorer/api/reactions/xs?target\\_elem=Al&target\\_mass=27&reaction=n%2Cp&table=True&page=1](https://nds.iaea.org/dataexplorer/api/reactions/xs?target_elem=Al&target_mass=27&reaction=n%2Cp&table=True&page=1)

```
aggregations:
  22312-003-0:
    author: "Y.Ikeda"
    datatable:
      data: [...]
      ddata: [...]
      den_inc: [...]
      en_inc: [...]
      level_num: [...]
      residual: [...]
    e_inc_max: 14.91
    e_inc_min: 13.33
    file: "https://nds.iaea.org/dataexplorer/api/reactions/xs?target_elem=Al&target_mass=27&reaction=n%2Cp&table=True&page=1"
    level_num: null
    mf: 3
    mt: 103
    points: 8
    sf4: "12-MG-27"
    sf5: null
    sf6: "SIG"
    sf7: null
    sf8: null
    sf9: null
    x4_code: "(13-AL-27(N,P)12-MG-27,,SIG)"
    year: 1993
  22338-030-0: {...}
  22414-006-0: {...}
  22641-002-0: {...}
```

# Simple Use Case of Reactions API

```

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

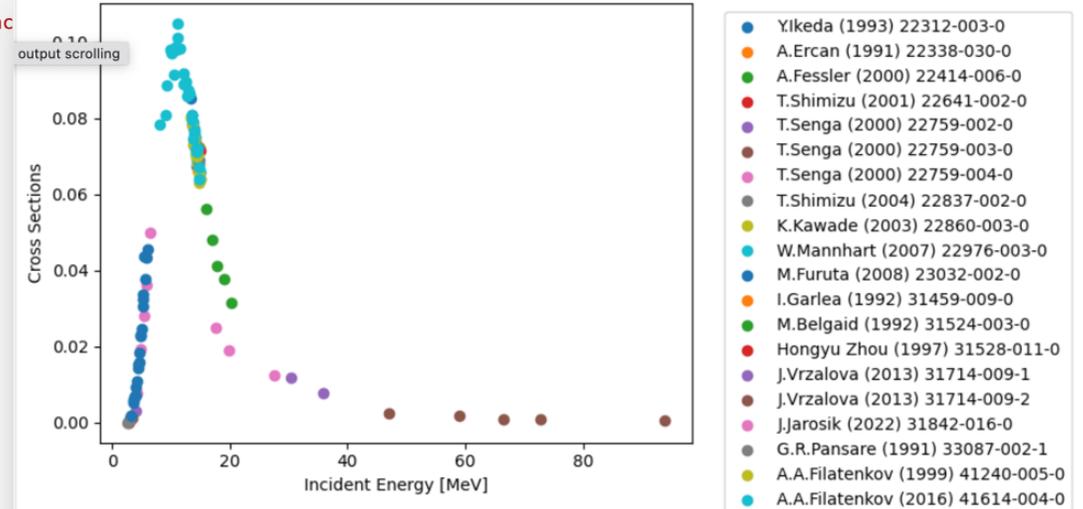
# access to the reaction data via HTTPS
headers = {
    "Authorization": "Bearer xxxxxxxxxxxx",
    "User-Agent": "Get all samples",
    "Content-Type": "application/json",
}
response = requests.get("https://nds.iaea.org/dataexplorer/api/reactions/xs?target_elem=Al&target_mass=27&reac
              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

```



|    | 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]

- Ylkeda (1993) 22312-003-0
- A.Ercan (1991) 22338-030-0
- A.Fessler (2000) 22414-006-0
- T.Shimizu (2001) 22641-002-0
- T.Senga (2000) 22759-002-0
- T.Senga (2000) 22759-003-0
- T.Senga (2000) 22759-004-0
- T.Shimizu (2004) 22837-002-0
- K.Kawade (2003) 22860-003-0
- W.Mannhart (2007) 22976-003-0
- M.Furuta (2008) 23032-002-0
- I.Garlea (1992) 31459-009-0
- M.Belgaid (1992) 31524-003-0
- Hongyu Zhou (1997) 31528-011-0
- J.Vrzalova (2013) 31714-009-1
- J.Vrzalova (2013) 31714-009-2
- J.Jarosik (2022) 31842-016-0
- G.R.Pansare (1991) 33087-002-1
- A.A.Filatenkov (1999) 41240-005-0
- A.A.Filatenkov (2016) 41614-004-0

# EXFOR Entry API

Example: <https://nds.iaea.org/dataexplorer/api/exfor/entry/31558>

GET [/dataexplorer/api/exfor/entry/{entry\\_id}/{subent\\_id}](/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}](/dataexplorer/api/exfor/entry/{entry_id}/{section})

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

```
127.0.0.1:5000/exfor/entry/22449
JSON Raw Data Headers
Save Copy Collapse All Expand All Filter JSON
▼ bib_record:
  ▶ authors: [-]
  ▶ facilities: [-]
  ▶ institutes: [-]
  ▶ references: [-]
  ▶ title: ".The Stellar (N,GAMMA) ...table Iridium Isotopes"
▼ data_tables:
  ▶ 001: [-]
  ▶ 002: [-]
  ▶ 003: [-]
entry: "22449"
▼ experimental_conditions:
  ▶ 001: [-]
  ▶ 002: [-]
  ▶ 003: [-]
▼ histories:
  ▼ 0:
    ▼ free_txt:
      0: " Compiled by S.M."
      x4_code: "(20000202C)"
  ▼ 1:
    ▼ free_txt:
      0: " Last checking has been done."
      x4_code: "(20000202U)"
last_updated: "2006-07-20"
number_of_revisions: "3"
```

# EXFOR Dictionary API

GET

</dataexplorer/api/exfor/dict/{field}/{name}>

| Name  | Data Type | Required | Description  |
|-------|-----------|----------|--|
| field | string    |          | institute: used in INSTITUTE field<br>facility: used in FACILITY field<br>method: used in METHOD field<br>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>

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

Example: <https://nds.iaea.org/dataexplorer/api/exfor/dict/method>

```
codes:
  ABSFY:
    active: true
    description: "Absolute fission yield measurement"
  ACTIV:
    active: true
    description: "Activation"
  AMS:
    active: true
    description: "Accelerator mass spectrometry"
  ASEP:
    active: true
    description: "Off-line mass separation of a product"
  ASPEC:
    active: true
    description: "Alpha spectrometry"
  ASSOP:
    active: true
    description: "Associated particle"
  BCINT:
    active: true
    description: "Beam current integrated"
```

# 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 |

Example: <http://nds.iaea.org/dataexplorer/api/ripl3/levels/90Zr>

```
level_info:
  A: 90
  Sn: "1.1966e+01"
  Sp: "8.3503e+00"
  Z: 40
level_record:
  0:
    gamma_record: []
    half_life: "-1.0000e+00"
    level_energy: "0.0000e+00"
    level_number: 1
    parity: 1
    spin: 0
    spin_notation: "0+"
  1: {...}
  2: {...}
  3: {...}
  4: {...}
  5: {...}
  6: {...}
  7: {...}
  8: {...}
  9: {...}
  10: {...}
  11: {...}
```

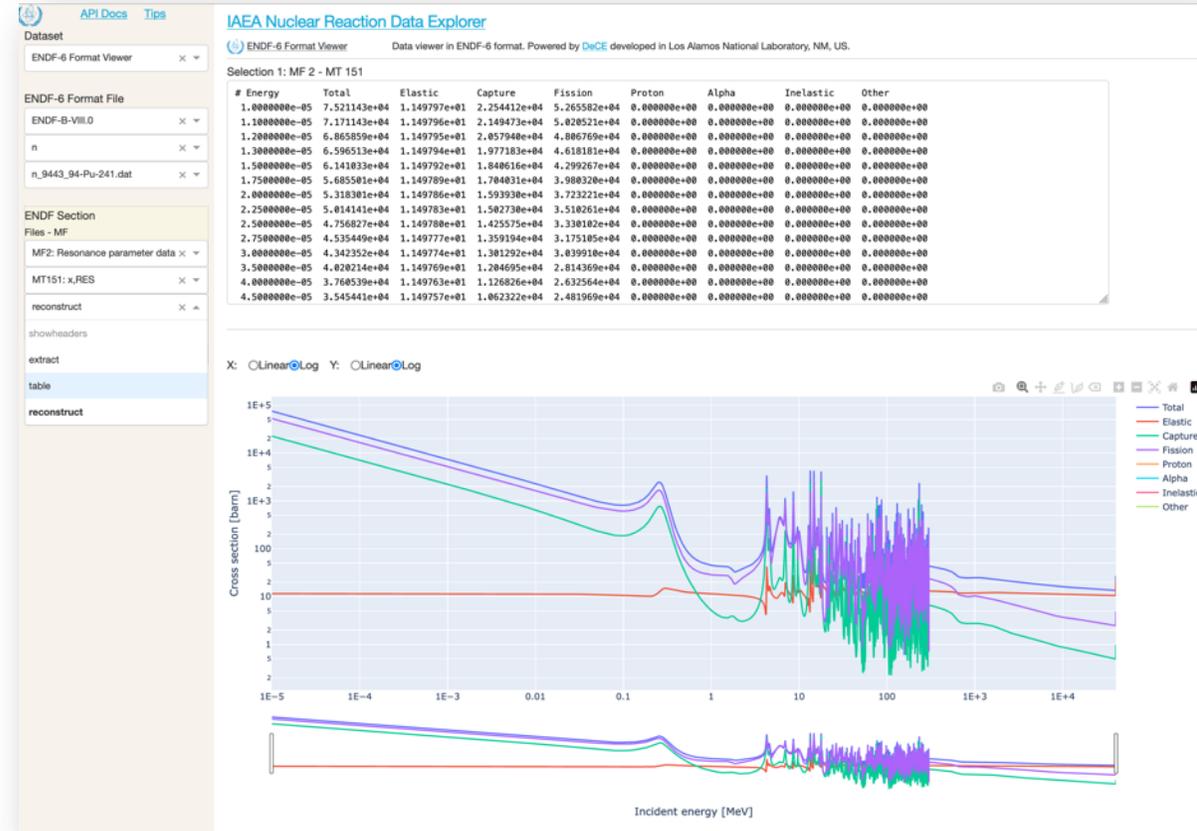
# Useful Resources around EXFOR

| Area  | Name                           | Purpose  | GitHub Repository   |
|-------|--------------------------------|--|---|
| EXFOR | EXFOR Master Files             | Preservations of all historical changes on EXFOR entries, Created: September 2022          | <a href="https://github.com/IAEA-NDS/exfor_master">https://github.com/IAEA-NDS/exfor_master</a>             |
|       | EXFOR in JSON                  | All EXFOR entries converted into JSON, Created: October 2022                               | <a href="https://github.com/IAEA-NDS/exfor_json">https://github.com/IAEA-NDS/exfor_json</a>                 |
|       | EXFOR Dictionary in JSON       | EXFOR dictionary converted into JSON, Created: October 2022                                | <a href="https://github.com/IAEA-NDS/exfor_dictionary">https://github.com/IAEA-NDS/exfor_dictionary</a>     |
|       | EXFOR Parser                   | Program to Parse EXFOR and convert into JSON and create tabulated table, Created: May 2022 | <a href="https://github.com/IAEA-NDS/exforparser">https://github.com/IAEA-NDS/exforparser</a>               |
|       | EXFORTABLES_py                 | EXFOR data in tabulated format similar to EXFORTABLES, Created: April 2023                 | <a href="https://github.com/shinokumura/exfortables_py">https://github.com/shinokumura/exfortables_py</a>   |
|       | RIPL-3 Discrete Levels in JSON | All discrete levels converted into JSON, Created: November 2022                            | <a href="https://github.com/shinokumura/ripl3_json">https://github.com/shinokumura/ripl3_json</a>           |
|       | Thermal Cross Section          | Extracted thermal cross section from EXFOR, Created: January 2021                          | <a href="https://github.com/shinokumura/thermaldata">https://github.com/shinokumura/thermaldata</a>         |
|       | Resonance Parameters           | Resonance spacing (D0, D1), resonance integrals (RI), MACS, Created: March 2025            | <a href="https://github.com/shinokumura/resonance_data">https://github.com/shinokumura/resonance_data</a>   |
|       | More DOIs for EXFOR            | DOIs for REFERENCE, REL-REF and MONIT-REF for EXFOR entries, Created: Feb 2025             | <a href="https://github.com/shinokumura/exfor_entry_doi">https://github.com/shinokumura/exfor_entry_doi</a> |

# Forthcoming: ENDF-6 Viewer

- ENDF-6 content viewer powered by DeCE<sup>[1]</sup>, 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] Developed by T. Kawano (LANL), <https://github.com/toshihikokawano/DeCE>



# Ongoing and Upcoming Work

- Improve documentation across all repositories in the ecosystem to support long-term maintenance.
- Integrate latest ENDF-6 library data (will be provided by Alejandra Martinez, IAEA-NDS).
- Include additional physical observables from EXFOR, such as angular distributions and emission spectra.
- Unify the data model for EXFOR and ENDF-6 to ensure easy access and usability for end users.
- Expansion of features such as the renormalization of data by a new monitor reaction.
- New version should be online before summer (hopefully....)

# Conclusion

- The IAEA Nuclear Reaction Data Explorer has been under development since 2021 and was renewed in March 2024 with the following updates:
  - Integration of EXFOR data using the EXFOR parser
  - Implementation of a new EXFOR entry interface
  - Update of ENDF-6 data from ENDFTABLES
  - Implementation of APIs for programmatic access
- Any comments and requests from FENDL community are appreciated.
  - Feedback: [nds.contact-point@iaea.org](mailto:nds.contact-point@iaea.org) or [s.okumura@iaea.org](mailto:s.okumura@iaea.org)



IAEA

*Thank you for your  
attention!*

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Feedback: [nds.contact-point@iaea.org](mailto:nds.contact-point@iaea.org)

[s.okumura@iaea.org](mailto:s.okumura@iaea.org)