P(ND)²-3
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Modernizing Experimental Nuclear Data Access:
The IAEA Nuclear Reaction Data Explorer (…and Beyond)

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Nuclear Data Formats

EXFOR: Experimental Nuclear Reaction Database

```
ENTRY      C      41553   20240709                                  41553000    1
SUBENT     C   41553001   20240709                                  41553001    1
BIB                10         21                                    41553001    2
TITLE       Angular distribution gamma-rays emitted during the     41553001    3
           inelastic scattering of fast neutrons from a reactor by41553001    4
           114, 116Cd                                               41553001    5
AUTHOR     (A.M.Demidov,L.I.Govor,O.K.Zhuravlev,M.M.Komkov,         41553001    6
           I.B.Shchukalov)                                          41553001    7
REFERENCE  (J,BAS,40,(6),119,1976) Engl.translation of IZV,40,157   41553001    8
           (J,IZV,40,1241,1976) Issue 6                             41553001    9
ENDSUBENT           28          0                                   4155300199999
SUBENT     C   41553002   20240709                                  41553002    1
BIB                 6         14                                    41553002    2
REACTION   ((48-CD-114(N,INL)48-CD-114,,SPC/DA,,FST)//              41553002    3
           (48-CD-114(N,INL)48-CD-114,,SPC/DA,,FST))                41553002    4
ENDBIB              14          0                                   41553002   17
DATA                 8         56                                   41553002   23
E-NM       E-NM-ERR   DATA       DATA-ERR   LVL-INI    LVL-INI-ER 41553002   24
LVL-FIN    MISC                                                     41553002   25
KEV        KEV        NO-DIM     NO-DIM     KEV        KEV        41553002   26
KEV        NO-DIM                                                   41553002   27
 367.7      0.6          0.62 E-2   0.06 E-2  1732.2   0.4        41553002   28
  1364.0     4.8   E-2                                             41553002   29
 448.3      0.8          0.35 E-2   0.09 E-2  1732.2   0.4        41553002   30
```

EXFOR example

Line numbers

ENDF-6: Evaluated Nuclear Data Library

```
 33        103         42          02725 1451  907
                               33         104         26          02725 1451  908
                               33         105         16          02725 1451  909
                               33         106          9          02725 1451  910
                               33         107         49          02725 1451  911
                               33         111          8          02725 1451  912
                               33         112         13          02725 1451  913
                               34           2         63          02725 1451  914
                                                                    2725 1  099999
                                                                    2725 0  0    0
 2.705900+4 5.842693+1          0          0          1          02725 2151    1
 2.705900+4 1.000000+0          0          0          1          02725 2151    2
 1.000000-5 1.000000+5          1          3          0          12725 2151    3
 3.500000+0 6.672000-1          0          0          2          32725 2151    4
 5.842690+1 6.672000-1          0          0        600        1002725 2151    5
-5.000000+3 3.000000+0 5.576800+2 9.215100+0 0.000000+0 0.000000+02725 2151    6
-5.000000+3 4.000000+0 1.898100+2 1.868200-1 0.000000+0 0.000000+02725 2151    7
-4.767000+2 4.000000+0 1.949000-2 2.148900+0 0.000000+0 0.000000+02725 2151    8
-2.258800+2 3.000000+0 8.910000+0 5.940000-2 0.000000+0 0.000000+02725 2151    9
 1.320000+2 4.000000+0 5.270100+0 4.700000-1 0.000000+0 0.000000+02725 2151   10
 4.323100+3 4.000000+0 1.041400+2 4.173700-1 0.000000+0 0.000000+02725 2151   11
 5.016000+3 3.000000+0 6.789600+2 1.332200+0 0.000000+0 0.000000+02725 2151   12
 6.389700+3 4.000000+0 1.681100+0 3.155600-1 0.000000+0 0.000000+02725 2151   13
 8.061900+3 3.000000+0 4.083300+1 4.078000-1 0.000000+0 0.000000+02725 2151   14
```

n+^{59}Co example

Line numbers

These formats are still actively used today, but they inherit several constraints from the Fortran era (punch-card legacy):

- incompatibility with modern data tools
- limited metadata and contextual information
- lack of human readability and semantic clarity

Challenges and Needs in Nuclear Data Usage

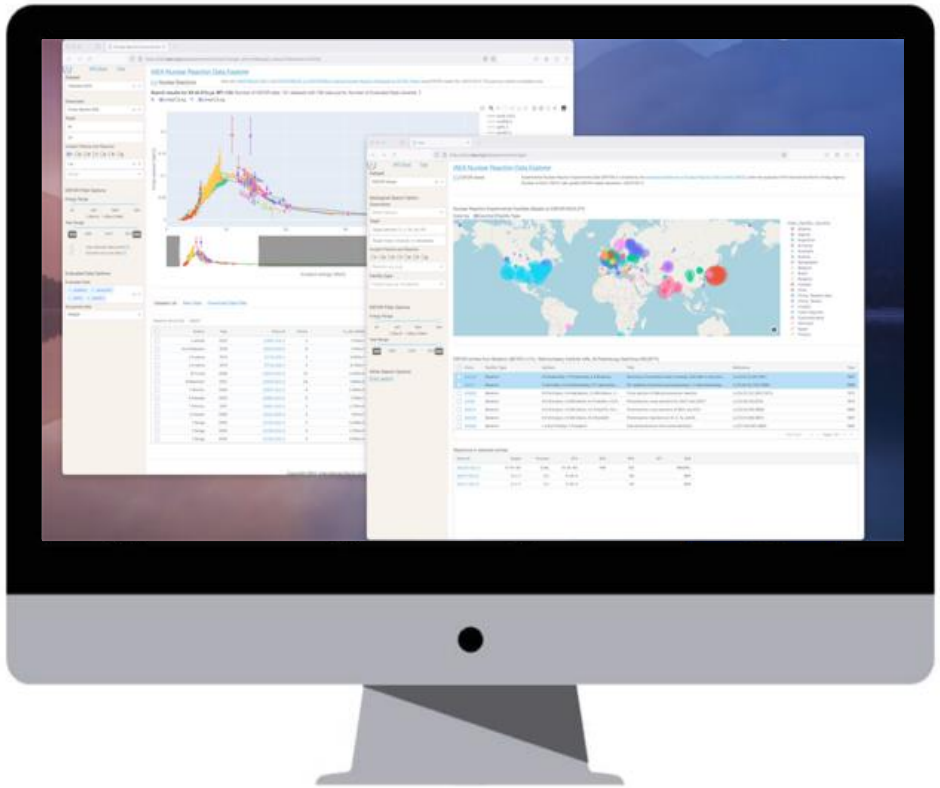
- **Traditional (Legacy) nuclear data formats**
  - Fixed-width text formats (EXFOR, ENDF-6, XUNDL, ENSDF)
  - Limited metadata and poor machine readability
  - Require format expertise and preprocessing before use
- **Impact**
  - High entry barrier for newcomers
  - Not all nuclear physicists are nuclear data format specialists
- **What researchers (not format expert) need**
  - Easy access to EXFOR and evaluated (ENDF-6) data and self-explanatory metadata
  - Compatibility with modern data science and AI/ML tools

IAEA Nuclear Reaction Data Explorer

- Developed in 2021, renewed in 2024, will be renewed in 2026 (soon)

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

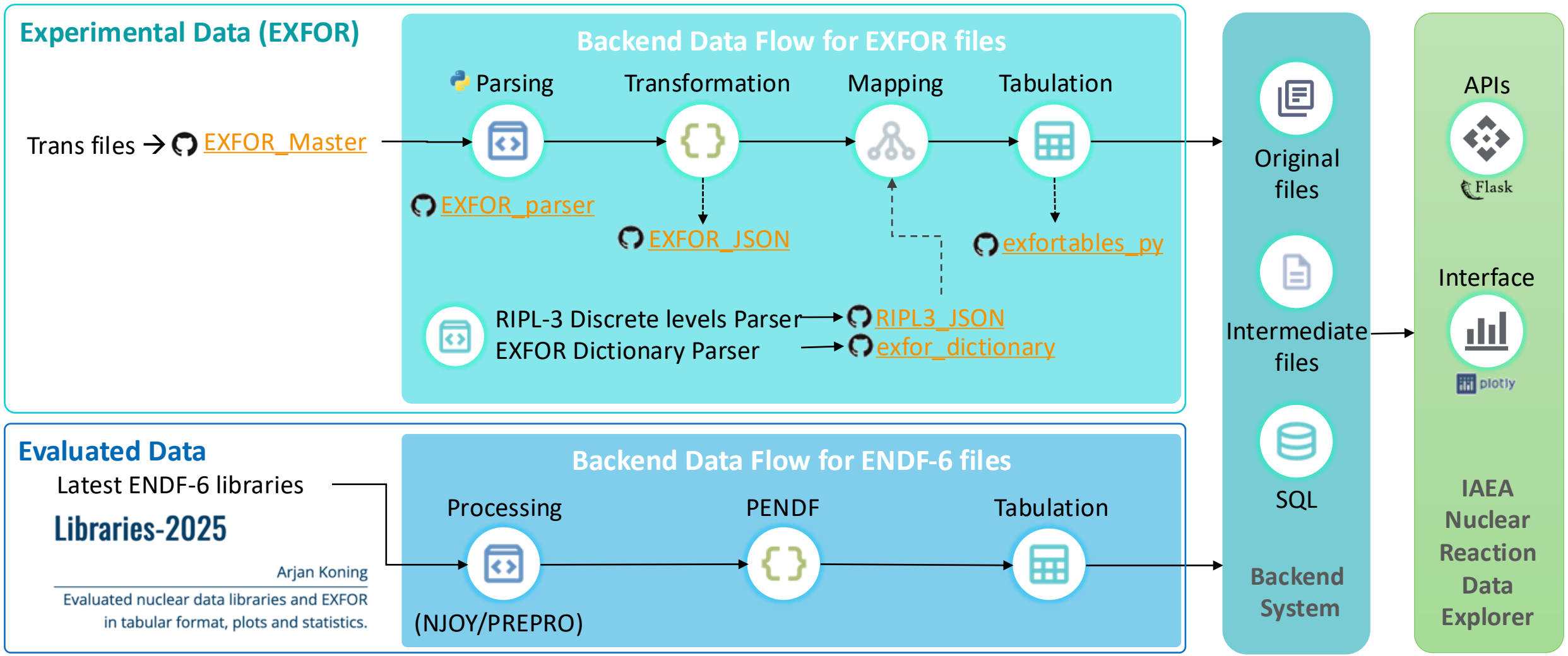
EXFOR entry viewer

- 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

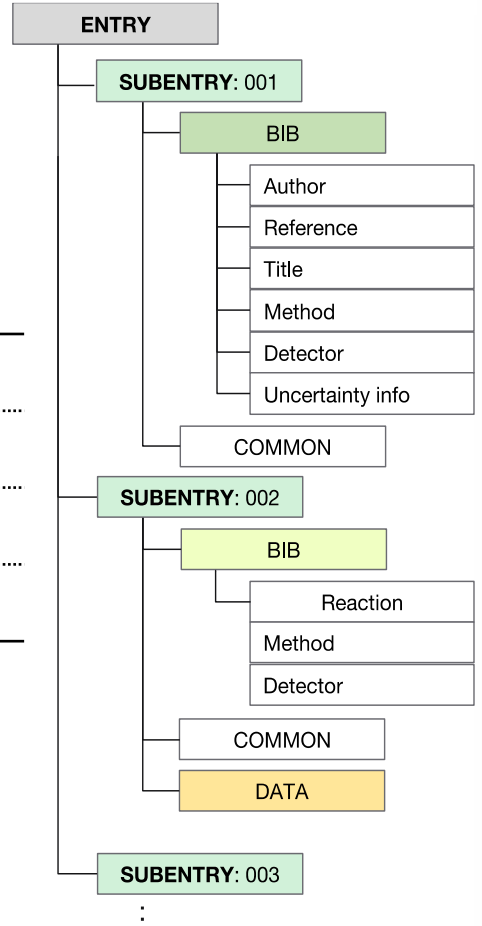
Dataflow: Experimental (EXFOR) and Evaluated (ENDF-6) Data

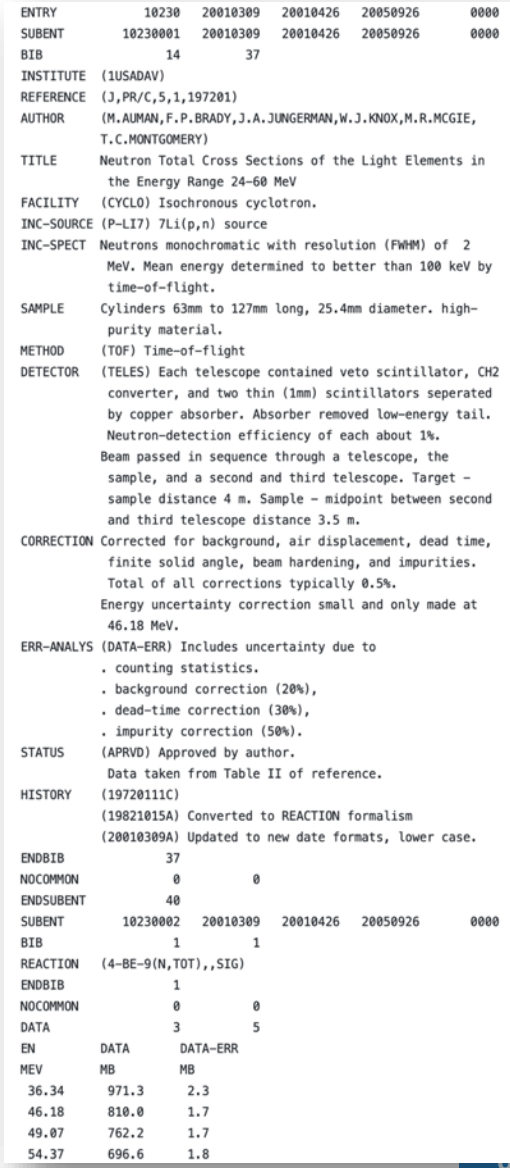


EXFOR Parsing: General Format Parsing into JSON

- **Block Parsing**
  - Pseudo-document oriented database format.
  - Based on tagged, nested blocks.

Raw Input Block	Parsed JSON Fragment
ENTRY – ENDENTRY	"entry": "D1036", "last_updated": …
SUBENT – ENDSUBENT	"subentry": "D1036001", "date": …
BIB – ENDBIB	"bib_record": { "title": "…", … }
DATA - ENDDATA	"data": { “head": […], “unit”:[], “data”*[]… }





```
ENTRY          10230   20010309   20010426   20050926       0000
SUBENT       10230001  20010309   20010426   20050926       0000
BIB              14        37
INSTITUTE  (1USADAV)
REFERENCE  (J,PR/C,5,1,197201)
AUTHOR     (M.AUMAN,F.P.BRADY,J.A.JUNGERMAN,W.J.KNOX,M.R.MCGIE,
           T.C.MONTGOMERY)
TITLE      Neutron Total Cross Sections of the Light Elements in
            the Energy Range 24-60 MeV
FACILITY   (CYCLO) Isochronous cyclotron.
INC-SOURCE (P-LI7) 7Li(p,n) source
INC-SPECT  Neutrons monochromatic with resolution (FWHM) of  2
            MeV. Mean energy determined to better than 100 keV by
            time-of-flight.
SAMPLE     Cylinders 63mm to 127mm long, 25.4mm diameter. high-
            purity material.
METHOD     (TOF) Time-of-flight
DETECTOR   (TELES) Each telescope contained veto scintillator, CH2
            converter, and two thin (1mm) scintillators seperated
            by copper absorber. Absorber removed low-energy tail.
            Neutron-detection efficiency of each about 1%.
           Beam passed in sequence through a telescope, the
            sample, and a second and third telescope. Target -
            sample distance 4 m. Sample - midpoint between second
            and third telescope distance 3.5 m.
CORRECTION Corrected for background, air displacement, dead time,
            finite solid angle, beam hardening, and impurities.
            Total of all corrections typically 0.5%.
           Energy uncertainty correction small and only made at
            46.18 MeV.
ERR-ANALYS (DATA-ERR) Includes uncertainty due to
           . counting statistics.
           . background correction (20%),
           . dead-time correction (30%),
           . impurity correction (50%).
STATUS     (APRVD) Approved by author.
            Data taken from Table II of reference.
HISTORY    (19720111C)
           (19821015A) Converted to REACTION formalism
           (20010309A) Updated to new date formats, lower case.
ENDBIB           37
NOCOMMON          0         0
ENDSUBENT        40
SUBENT       10230002  20010309   20010426   20050926       0000
BIB               1         1
REACTION   (4-BE-9(N,TOT),,SIG)
ENDBIB            1
NOCOMMON          0         0
DATA              3         5
EN         DATA       DATA-ERR
MEV        MB         MB
 36.34      971.3      2.3
 46.18      810.0      1.7
 49.07      762.2      1.7
 54.37      696.6      1.8
```

EXFOR Parsing: EXFOR Code and Free Text Separation

- **Block → Key-Value Parsing → JSON → SQL Table**
  - **Step 1: Separation of dictionary-defined codes (in parentheses) from free-text descriptions + JSON conversion**

```
FACILITY    (CYCLO,3POLIPJ) C-30 cyclotron
SAMPLE      Enriched metallic 112Sn
             (20.6 mg, 5 mm diam., 0.2 mm thick)
            (50-SN-112,ENR=0.84)
            (50-SN-114,ENR=0.13)
DETECTOR    (HPGE) 1 HPGe detector (1.8 keV resoluation at
             1332 keV) for 114m2In measurement, and 2 HPGe
             detectors (2.0 keV resolution at 1332 keV and 1.1 keV
             resolution at 122 keV)
```


```
"facilities": [
 { "x4_code": "(CYCLO,3POLIPJ)", "free_txt": ["C-30 cyclotron"],
   "facility_type": "(CYCLO)", "institute": "(3POLIPJ)"}
],
"sample": [
 { "x4_code": null, "free_txt": ["Enriched metallic 112Sn", "(20.6 mg, 5 mm diam., 0.2 mm thick)"]},
 { "x4_code": "(50-SN-112,ENR=0.84)", "free_txt": [] },
 { "x4_code": "(50-SN-114,ENR=0.13)", "free_txt": [] }
],
"detector": [
 { “x4_code”: “(HPGE)”, "free_txt": [ " 1 HPGe detector (1.8 keV resoluation at", " 1332 keV) for 114m2In” ...]}
]
```


  - **Step 2: SQL Representation**

Key	Value	Free text
SAMPLE		Enriched metallic 112Sn (20.6 mg, 5 mm diam., 0.2 mm thick)
SAMPLE	(50-SN-112,ENR=0.84)	
SAMPLE	(50-SN-114,ENR=0.13)	
METHOD	(ACTIV)	Irradiated for 5 min at 27nA or 1 hr at 3.5 nA
INC-SPECT		The proton energy beam was determined by detection of elastically scattered proton on polyethylene foil by a Si(Li) telescope.
DETECTOR	(HPGE)	1 HPGe detector (1.8 keV resoluation at 1332 keV) for 114m2In measurement, and 2 HPGe detectors (2.0 keV resolution at 1332 keV and 1.1 keV resolution at 122 keV)

EXFOR Parsing: Data Table Parsing and Unit Unification

- **Clear alignment of values with headers and units.**
- **Handles missing values (null) and multi-row** cleanly.

Original Expression

Fixed width, multiple columns (>6) with line breaks.

```
DATA                  8         19
ELEMENT    MASS       ISOMER    MASS-MIN    MASS-MAX    DATA
DATA-MIN   FLAG
NO-DIM     NO-DIM     NO-DIM    NO-DIM      NO-DIM      MB
MB         NO-DIM
 82.        203.                                        26.

 81.        202.                                         3.

 81.        201.                                        20.

 81.        200.                                        12.

 81.        199.                                        27.

 81.        198.                                        15.

 66.                             149.        153.
  0.62       1.
    :
ENDDATA
```

JSON Structured Form

Parsed each row block by column headers, units, and flattened the structure into JSON arrays.


```
{
 "data": {
  "heads": ["ELEMENT", "MASS", "ISOMER", "MASS-MIN", "MASS-MAX", "DATA", "DATA-MIN", "
  "units": ["NO-DIM", "NO-DIM", "NO-DIM", "NO-DIM", "NO-DIM", "MB", "MB", "NO-DIM"],
  "data": [
   [82.0, 81.0, 81.0, 81.0, 81.0, 81.0, 66.0, 66.0, 65.0, 56.0, 56.0, 56.0, 38.0, 38.0, 35.0, 35.0, 32.
   [203.0, 202.0, 201.0, 200.0, 199.0, 198.0, null, null, 149.0, 131.0, 129.0, 128.0, 91.0, 89.0, 82.
   [null, null, null, null, null, null, null, null, null, null, null, null, null, null, null, 1.0, null, null, null],
   [null, null, null, null, null, null, 149.0, 149.0, null, null, null, null, null, null, null, null, null, null, n
   [null, null, null, null, null, null, 153.0, 153.0, null, null, null, null, null, null, null, null, null, null, n
   [26.0, 3.0, 20.0, 12.0, 27.0, 15.0, null, null, null, 5.5, 1.9, 4.3, 0.48, 1.4, 0.22, 0.07, 0.53, 0.65, 0
   [null, null, null, null, null, null, 0.62, 1.77, 0.95, null, null, null, null, null, null, null, null, null, nu
   [null, null, null, null, null, null, 1.0, 1.0, 1.0, null, null, null, null, null, null, null, null, null, null]
  ]
 }
}
```

EXFOR Parsing: Handling Reaction Expressions

- **Re-Structuring EXFOR's Reaction Math Expressions for Better Usability**
  - **Clear Operation**
  - **JSON-Friendly**

```
{
  "type": "Ratio",
  "numerator": "...",
  "denominator": "..."
}
```

Original Expression	Structured Form
(92-U-235(N,F),,SIG)	N/A
((9-F-19(N,G)9-F-20,,RI)//(9-F-19(N,G)9-F-20,,SIG))	['Ratio', '(9-F-19(N,G)9-F-20,,RI)', '(9-F-19(N,G)9-F-20,,SIG)']
((94-PU-239(N,F),DL/GRP,NU)/(94-PU-239(N,F),DL,NU))	['Divide', '(94-PU-239(N,F),DL/GRP,NU)', '(94-PU-239(N,F),DL,NU)']
(((92-U-238(N,F)ELEM/MASS,CUM,FY)/(92-U-238(N,F)43-TC-99,CUM,FY))//((92-U-235(N,F)ELEM/MASS,CUM,FY,,MXW)/(92-U-235(N,F)43-TC-99,CUM,FY,,MXW)))	['Ratio', ['Divide', '(92-U-238(N,F)ELEM/MASS,CUM,FY)', '(92-U-238(N,F)43-TC-99,CUM,FY)'], ['Divide', '(92-U-235(N,F)ELEM/MASS,CUM,FY,,MXW)', '(92-U-235(N,F)43-TC-99,CUM,FY,,MXW)']]

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 resolutic
            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, 70HELSINKI,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
```

Docs Tips

Dataexplorer

Dataset

EXFOR

Entry search

40412-004-0

Reaction search

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

← Simplified bibliographic info

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)

← Reactions in ENTRY

EXPERIMENTAL CONDITIONS

←Measurement info

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 the EXFOR dictionary

Scintillator tank

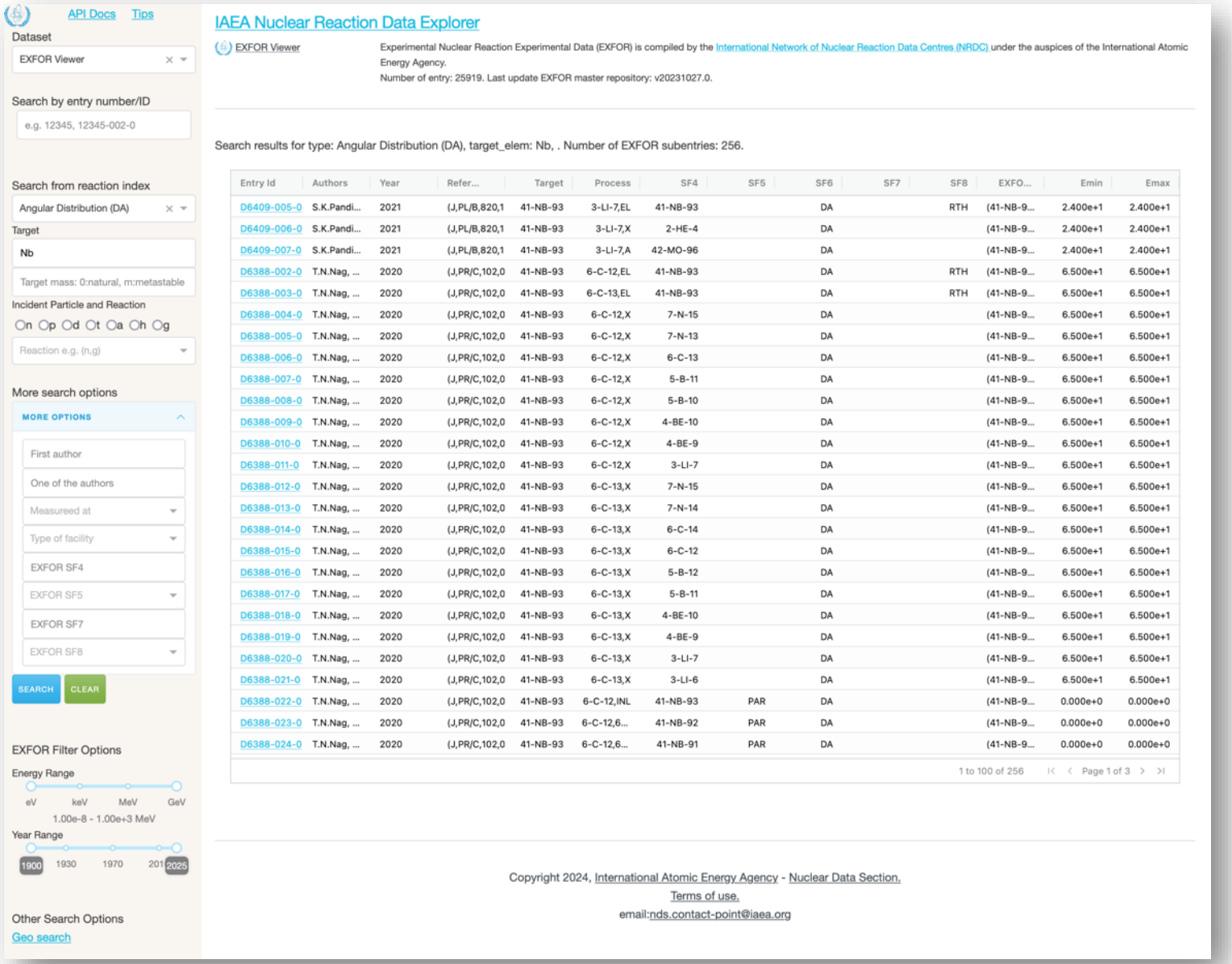
Separate code and free text→

20 40 60

EN-MIN (KEV)

Search EXFOR Entry

Example:https://nds.iaea.org/dataexplorer/exfor/search?type=DA&target_elem=Nb&target_mass=93



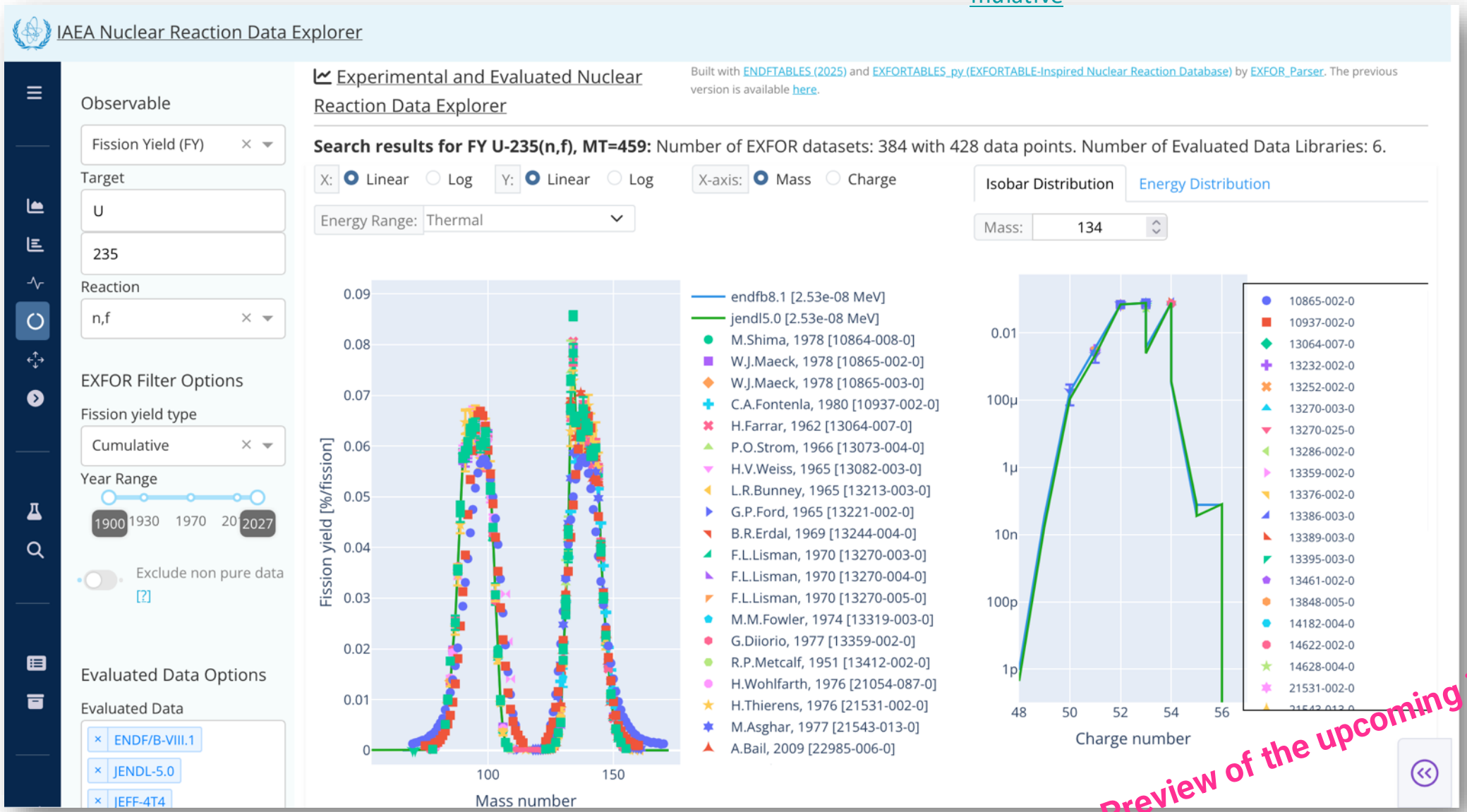
Fe56(n,g) Cross Section Plot

Example:https://nds.iaea.org/dataexplorer/reactions/xs?target_elem=Fe&target_mass=56&reaction=n%2Cg

Preview of the upcoming interface

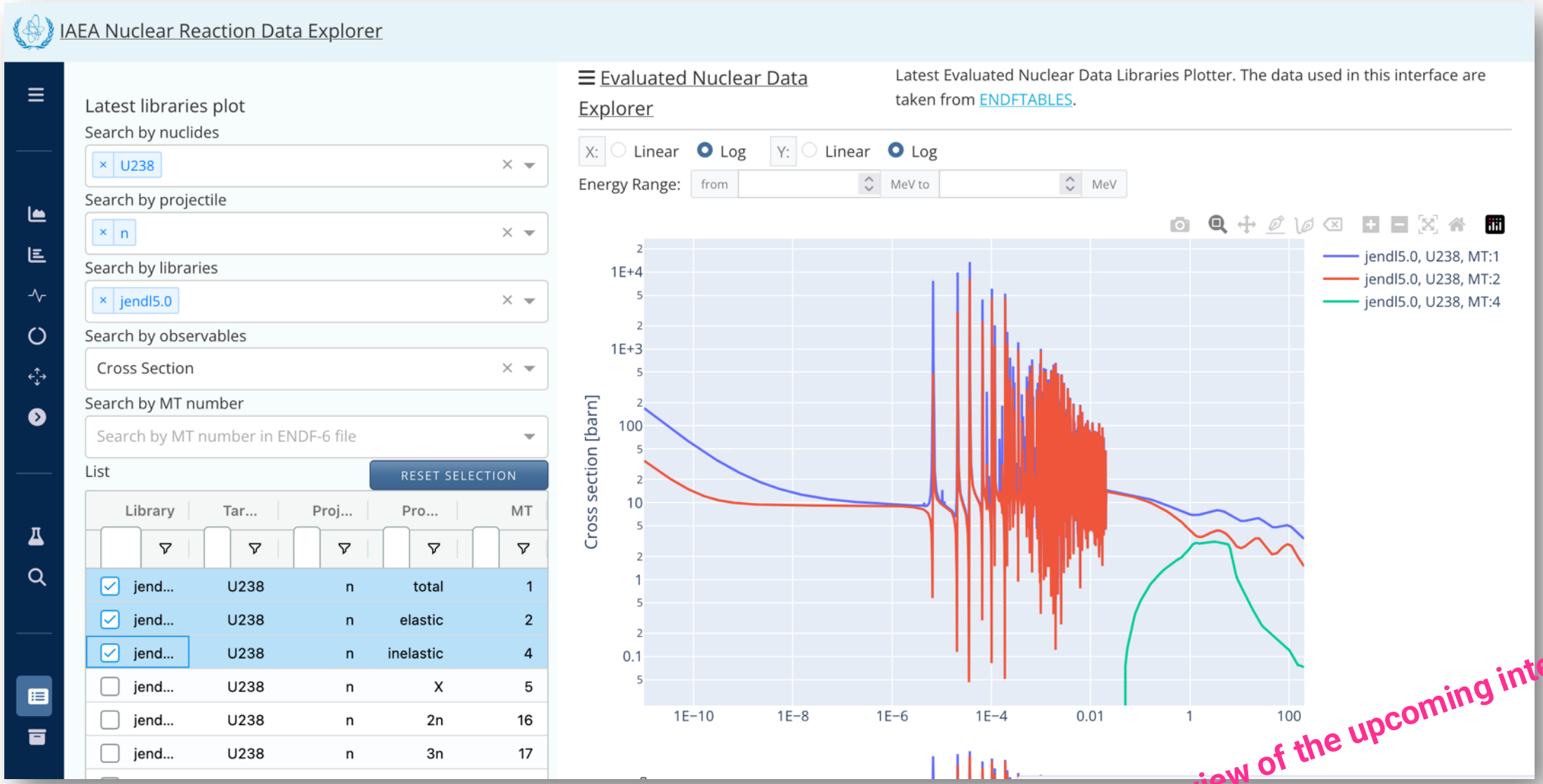
Fission Product Yield Plot

Example:https://nds.iaea.org/dataexplorer/reactions/fy?&target_elem=U&target_mass=235&reaction=n,f&fy_type=Cumulative



Preview of the upcoming interface

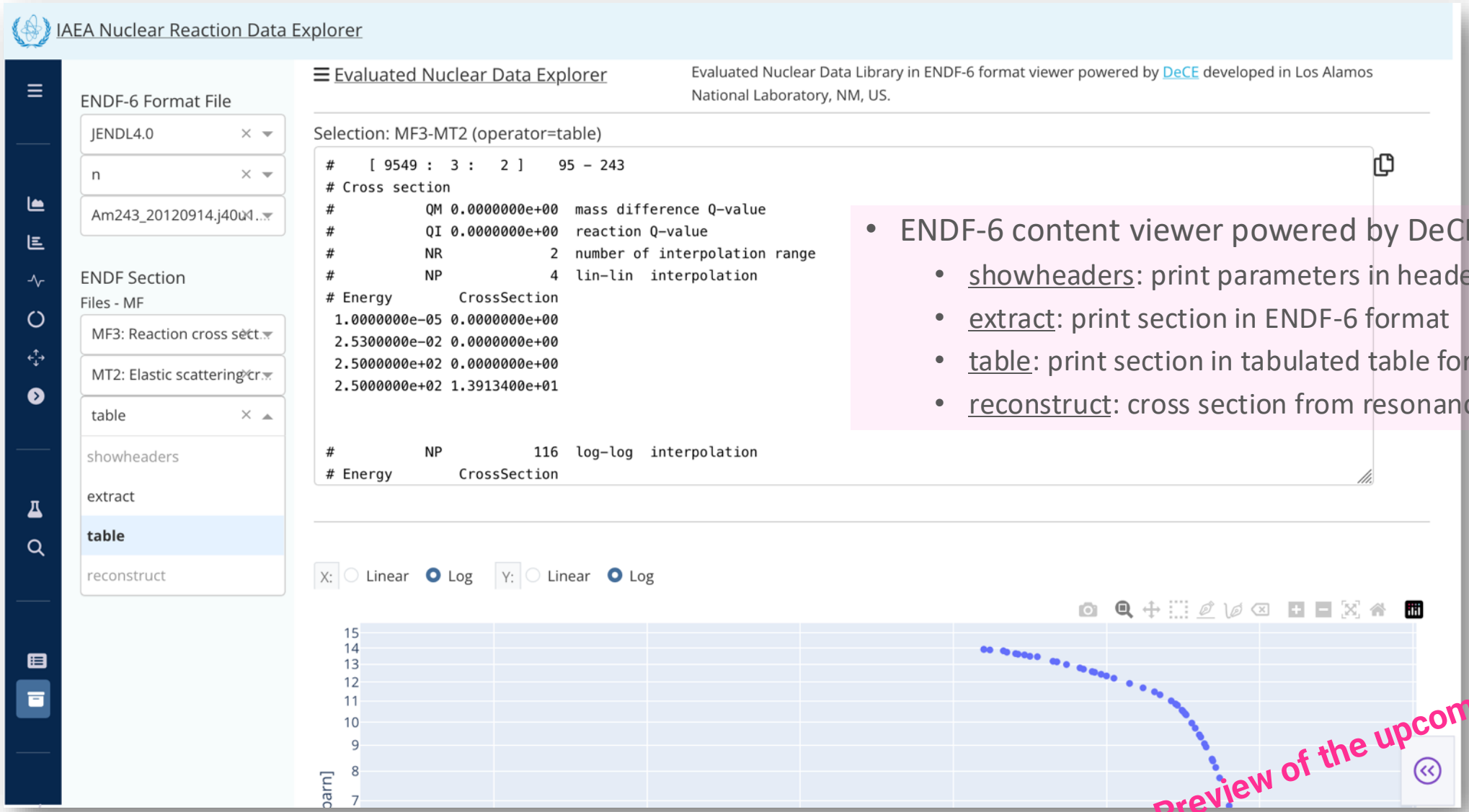
Library Comparison



Preview of the upcoming interface

[1] Developped by T. Kawano (LANL), https://github.com/toshihikokawano/DeCE

Library Archive Access (powered by DeCE)



- ENDF-6 content viewer powered by DeCE[1]
  - 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

Preview of the upcoming interface

Scenario in Next Few Years

Leading to the **IAEA Nuclear Data Portal project**

I want to share recently measured data as soon as possible with collaborators and others. I cannot wait for the EXFOR compilation.

experimentalists

Is there a place to upload data for sharing? (Ideally with a persistent identifier like a DOI.)

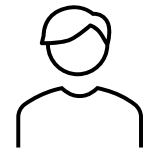
I want to preserve the datasets and methods (metadata) used to produce evaluated library data.

evaluators

theoreticians

I want to share the theoretical calculation results published in a paper so that other scientists can easily access and reuse them.

I have corrected an EXFOR entry data. The original entry contained a compilation mistake.



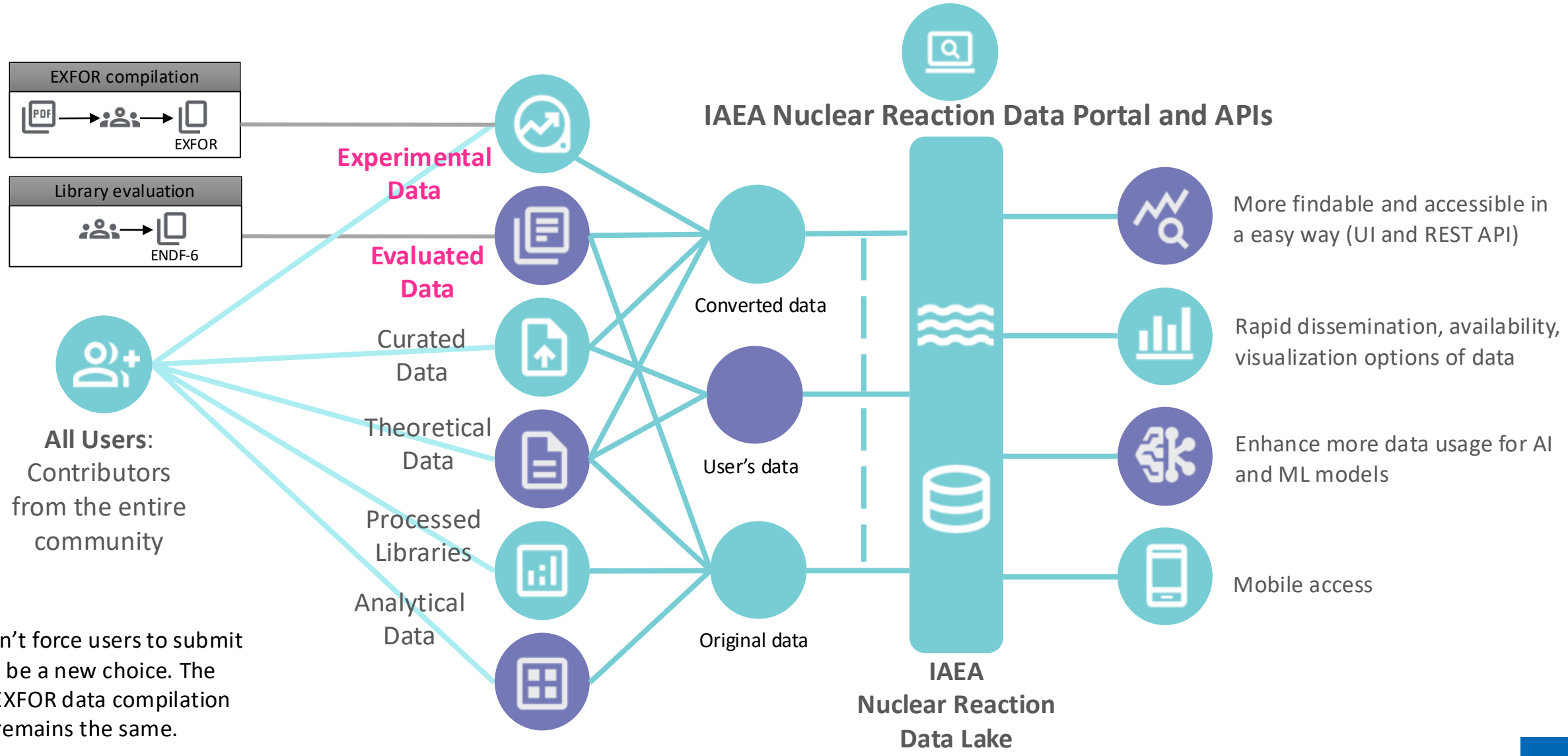
any data user

Ideas for the Next Decade – Nuclear Reaction Data Portal

Consolidating these scenario into practical implementation needs leads:

1. Format-Independent Data Access
   - Access nuclear data without requiring expertise in formats such as EXFOR or ENDF-6.
2. Rich Metadata & Contextual Relationships
   - Link between datasets, experiments, and evaluations for clear context.
3. Accelerated Data Availability
   - User submissions + automatic extraction from publications for rapid updates.
4. Community-Driven Contributions
   - Curated, corrected, theoretical, or experimental data with provenance tracking.
5. Transparent and Reproducible Evaluations (≒WPEC SG54)
   - Trace ENDF evaluations back to experimental and corrected data.
6. Future-Ready Infrastructure and Modern Data Management
   - Scalable, version-controlled, FAIR-compliant system ready for AI and new data types.

Next Step: Expand the Data Explorer into a Data Portal



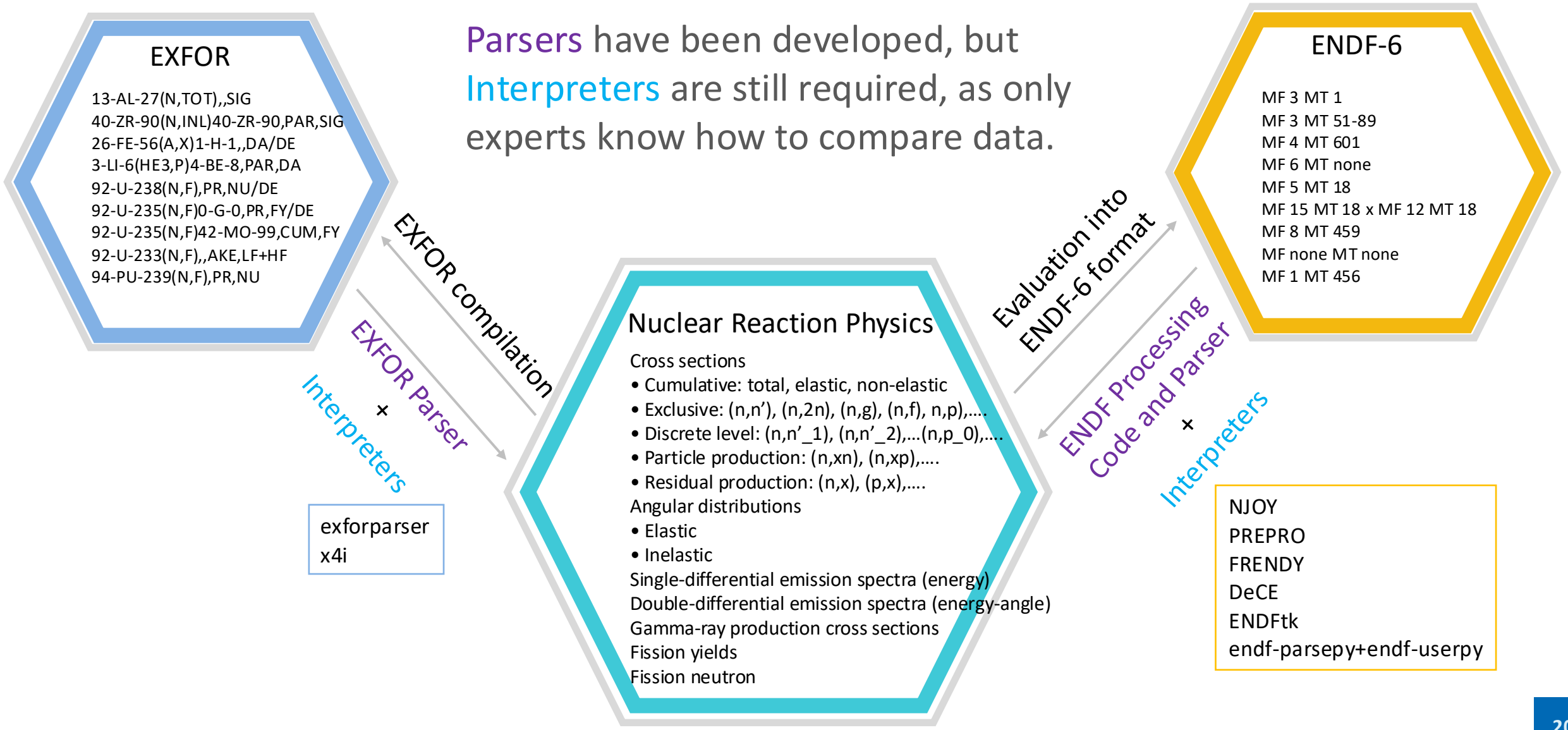
* We won't force users to submit data, it'll be a new choice. The current EXFOR data compilation process remains the same.

Data Portal Project Goals

- Goal 1: **Integrate** diverse nuclear data **into unified data models**
  - Scalable, version-controlled, AI-ready infrastructure.
  - Convert legacy nuclear data formats into machine-readable JSON and/or SQL models.
  - Support modern scientific **data management** practices.
- Goal 2: Ensure **data quality**, **provenance**, and **reproducibility**
  - Track data provenance and processing history.
  - Maintain explicit links between evaluated values and experimental / curated data.
- Goal 3: Enable **open** and **FAIR data access**
  - Align with FAIR principles (Findable, Accessible, Interoperable, Reusable).
  - Provide APIs and bulk data access for collaborating institutes.
  - Use standardized identifiers:
    - Institutes → ROR, Authors → ORCID, Publications → DOI
- Goal 4: Support **community contributions**
  - Allow submission of curated, corrected, collected, theoretical, or experimental data.
  - Support **rapid updates and dissemination** via automatic extraction and user submissions.

Challenges on Data Mapping

Parsers have been developed, but Interpreters are still required, as only experts know how to compare data.



Summary

- The IAEA Nuclear Reaction Data Explorer has been developed since 2021, was renewed in March 2024, and will be renewed in 2026 with the following updates:
  - New interface, latest datasets
  - Additional observables: Resonance Parameters, Transmission
  - New function: Library archive access using DeCE as an EDNF-6 parser
- Towards a new era of nuclear data management and utilization, developments of IAEA Nuclear Reaction Data Portal has been initiated.
  - Existing data formats and processes will remain unchanged for the official community.
  - Nuclear Reaction Data Portal will provide new options to explore and analyse data using modern mechanisms with new transparent data pipelines.
  - Timeline will be announced within 2026.
- Any comments and requests from Nuclear Data for the Next Decade community are appreciated.
  - Feedback: nds.contact-point@iaea.org or s.okumura@iaea.org

Collaborators:

Arjan Koning (IAEA)
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Alejandra Martinez (IAEA)
Toshihiko Kawano (LANL)
Julia Sprenger (OECD/NEA)

As well as many scientists who provided suggestions and feedback.

Thank you for your attention!

Feedback: nds.contact-point@iaea.org

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Useful Resources around EXFOR

Area	Name	Purpose	GitHub Repository
EXFOR	EXFOR Master Files	Preservations of all historical changes on EXFOR entries	https://github.com/IAEA-NDS/exfor_master
	EXFOR in JSON	All EXFOR entries converted into JSON	https://github.com/IAEA-NDS/exfor_json
	EXFOR Dictionary in JSON	All EXFOR entries converted into JSON	https://github.com/IAEA-NDS/exfor_dictionary
	EXFOR Parser	Program to Parse EXFOR and convert into JSON and create tabulated table	https://github.com/IAEA-NDS/exforparser
	EXFORTABLES_py	EXFOR data in tabulated format similar to EXFORTABLES	https://github.com/shinokumura/exfortables_py
	RIPL-3 Discrete Levels in JSON	All discrete levels converted into JSON	https://github.com/shinokumura/ripl3_json
	Thermal Cross Section	Extracted thermal cross section from EXFOR	https://github.com/shinokumura/thermaldata
	Resonance Parameters	Extracted resonance parameters from EXFOR	https://github.com/shinokumura/resonance_data
	More DOIs for EXFOR Entries	DOIs for REFERENCE, REL-REF and MONIT-REF in EXFOR entries	https://github.com/shinokumura/exfor_entry_doi

Reactions API

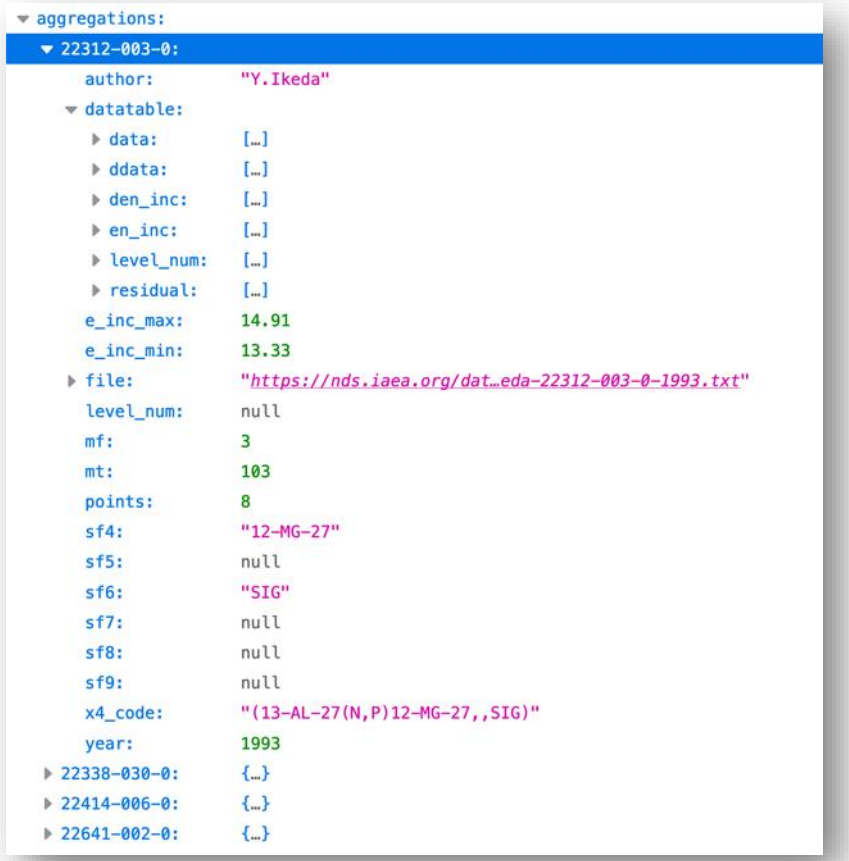
GET /dataexplorer/api/reactions/{type}

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.

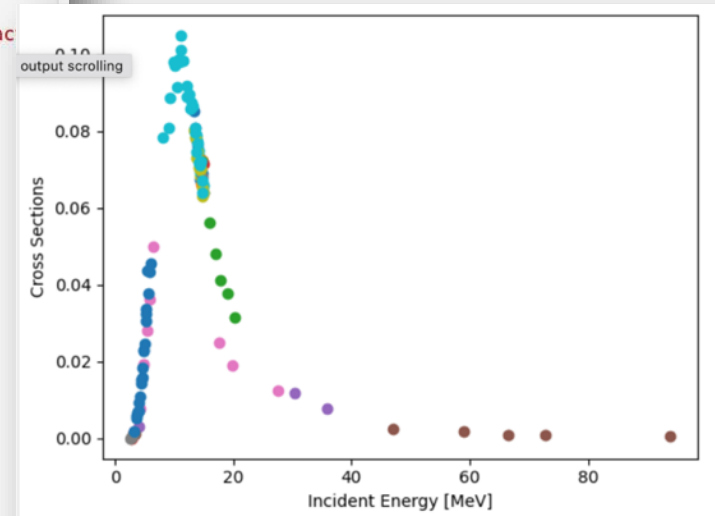
Example:https://nds.iaea.org/dataexplorer/api/reactions/**xs**?target_elem=Al&target_mass=27&reaction=n%2Cp&table=True&page=1

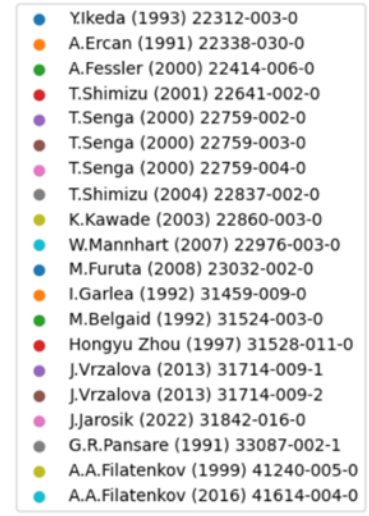


Simple Use Case of Reactions API

```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&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)
```

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

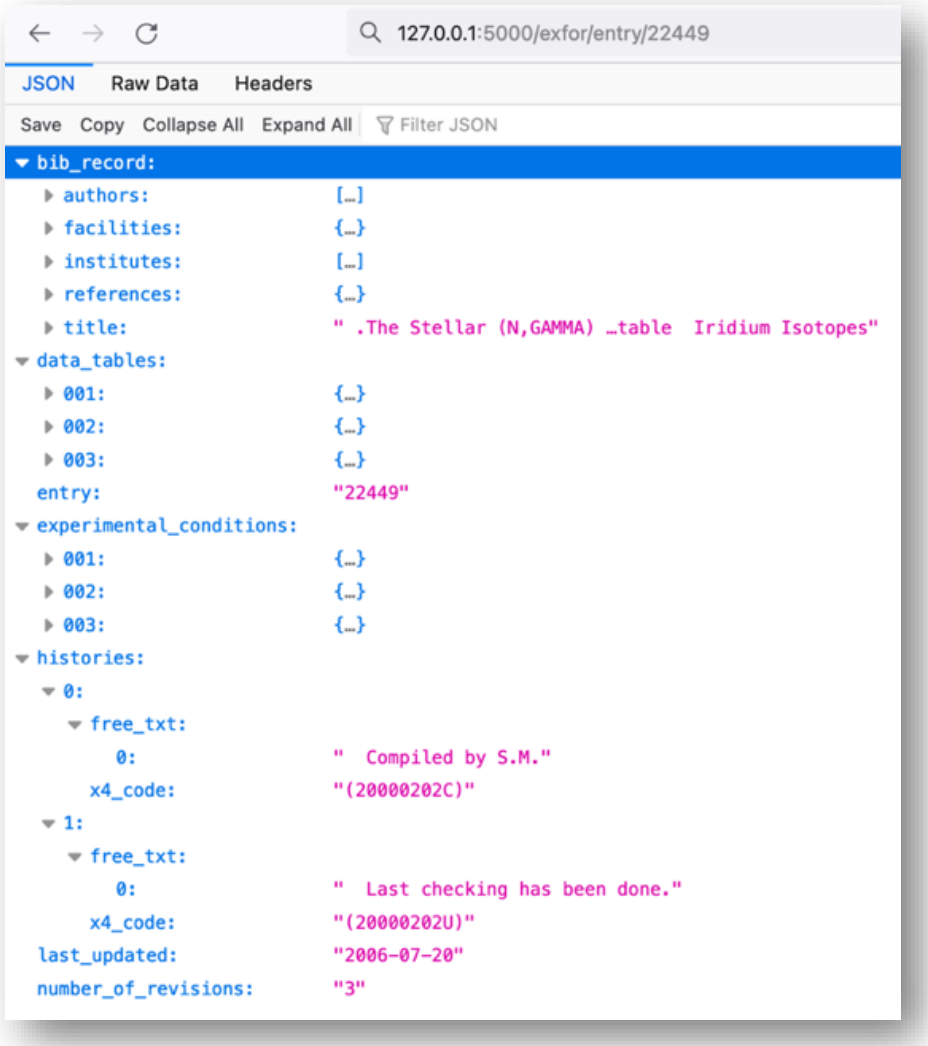
GET /dataexplorer/api/exfor/entry/{entry_id}/{subent_id}

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

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



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"
```

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**