Consultancy Meeting on GNDS/FUDGE/TAGNDS
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IAEA
International Atomic Energy Agency
Atoms for Peace and Development

Developing a Web Service for EXFOR Using RESTful API and JSON Schema

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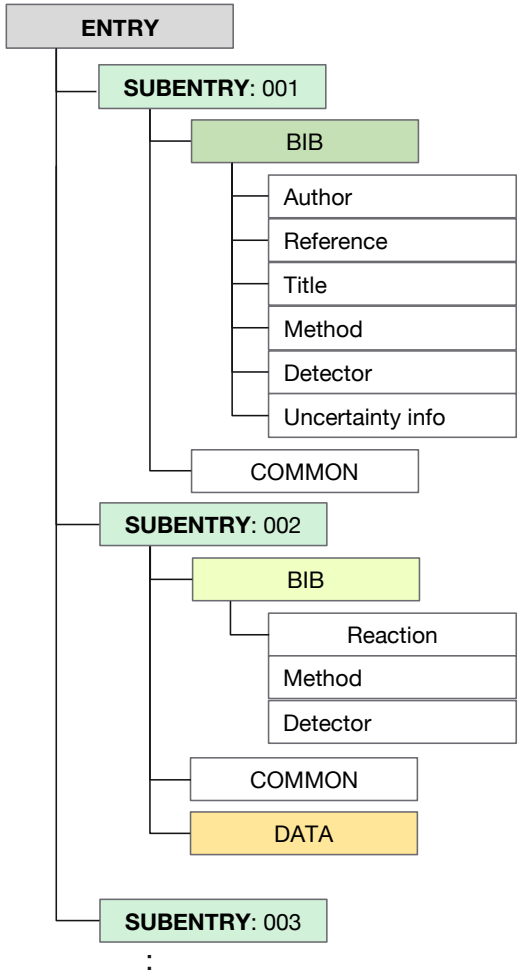
EXFOR jargons

- The EXFOR format is machine-readable, but it is difficult to use directly with plotting software such as Gnuplot
- Many jargons that the users cannot understand




```
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,
           T.C.MONTGOMERY)
TITLE      Neutron Total Cr                    the Light Elements in
            the Energy Range 24-60 MeV
FACILITY   (CYCLO) Isochronous cyclotron.
INC-SOURCE (P-LI7) 7Li(p,n
INC-SPECT  Neutrons monoch                              2
            MeV. Mean ener                 to better than 100 keV by
            time-of-flight.
SAMPLE     Cylinders 63mm to 127mm long, 25.4mm diameter                h-
            purity material.
METHOD     (TOF) Time-o
DETECTOR   (TELES) Each                                 illator, CH2
            converter, a                (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
            Total of all cor
           Energy uncertainty                                  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
```

What is (1USADAV)??

What is (CYCLO)??

What is (TELES)??

What is “SIG”??

Folded DATA block

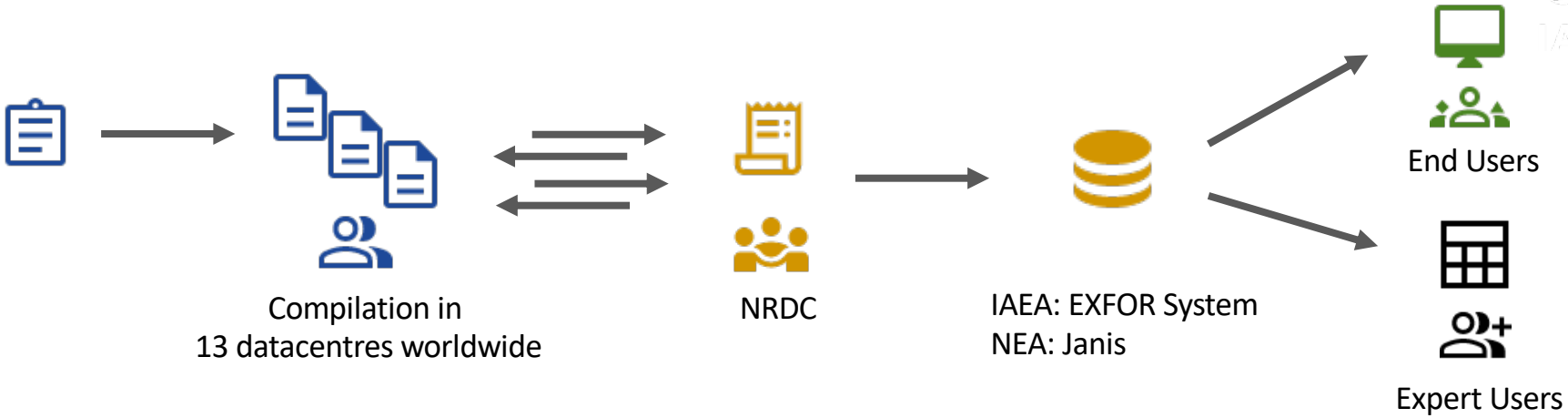
```
REACTION   (13-AL-27(P,X)4-BE-7,,SIG)
DATA                7         19
EN         EN-ERR     DATA       DATA-ERR    ERR-T      MONIT
MONIT-ERR
MEV        MEV        MB         MB          MB         MB
MB
      2606.         8.       9.18       0.29       0.78       11.4
        0.9
      1599.         4.       9.06       0.29       0.75       13.2
        1.0
      1194.         3.       8.23       0.26       0.63       14.4
        1.0
       799.         2.       6.33       0.21       0.49       15.5
        1.1
       599.         2.       4.89       0.16       0.34       16.0
        1.0
 :
       67.9        0.8      0.646      0.026      0.048       22.4
        1.4
       67.8        0.8      0.590      0.027      0.046       22.4
        1.4
       67.1        0.9      0.658      0.030      0.051       22.7
        1.4
       37.0        1.1      0.209      0.033      0.036       28.7
        2.0
       36.9        1.1      0.198      0.069      0.071       28.4
        2.0
       36.9        1.1      0.172      0.033      0.036       28.2
        2.0
       36.3        1.2      0.166      0.024      0.027       25.9
        2.0
       35.5        1.3      0.328      0.028      0.041       22.1
        2.0
ENDDATA             42
```

```
FLAG       (1.).The presented values of the yields ha
been
            obtained from experimental data via simpl
            calculations.
DECAY-DATA ((1.)84-PO-207,5.80HR,DG,2060.2,0.0132,
                                DG,1662.7,0.0032,
                                DG,1372.4,0.0122,
                                DG,1360.4,0.0057,
                                DG,1148.3,0.0572,
                                DG,992.3,0.593,
                                DG,947.9,0.0117,
                                DG,911.8,0.170,
                                DG,892.3,0.0037,
                                DG,742.6,0.282,
                                DG,687.6,0.0182,
                                DG,629.8,0.0134,
                                DG,405.8,0.097,
                                DG,369.5,0.0173,
                                DG,345.3,0.0201,
                                DG,307.6,0.0056,
                                DG,297.4,0.0095,
                                DG,249.6,0.0160)
```

What is the minimum dataset

- EXFOR (sub)entries are not compiled in the idea of “minimum” dataset
  - Pyshical observable from a reaction with target + incident particle at the particular incident energy in a particular condition
    - e.g. Neutron inelastic scattering cross section of the 0.845 MeV level in Fe-56 as a function of neutron energy
    - e.g. Prompt fission neutron spectra from the fission of Pu-239 with fast neutron
- A lot of reaction data which can not be tabulated
  - In arbitrary unit
  - Not comparable to what is in the evaluated nuclear data library

EXFOR is the product of the international collaboration



1. Compile EXFOR data from publications by 13 datacentres worldwide
2. Data check done by NRDC
3. Store (create, update, or delete entries) into the IAEA system
4. Provide interface to end users via https://nds.iaea.org/exfor/
   - X4pro package, C4 or C5 (tabulated) format data for expert users

More diverse users' requirements to manipulate data in their way
- To compare and plot with model calculation or new measured experimental data,
- To analyze data for the development of a phenomenological model,
- To use data for ML/AI applications
- ...and so on

Extended use cases

Name	Author	Purpose	Language	Data source	Source code/data
ENEL (EXFOR Nuclear Extraction Library)	Ahmed A. Selman	Package for MATLAB	?	C4	https://www.mathworks.com/matlabcentral/fileexchange/110930-enel-exfor-nuclear-extraction-library
EXFORTABLES	Arjan Koning	Developing TENDL using experimental data from EXFOR, also used in https://nds.iaea.org/dataexplorer/	Fortran	C4, C5	https://nds.iaea.org/talys/
EXFOR SQL and NucML	Pedro Jr. Vicente-Valdez	Modernizing the EXFOR Database using Google BigQuery and Python Pipeline for ML-based Nuclear Data Solutions	Python	C4	https://pedrojrv.github.io/projects.html
exfor-couchdb-docker	Georg Schnabel	EXFOR database in JSON format using CouchDB	Python	EXFOR master file	https://github.com/IAEA-NDS/exfor-couchdb-docker
x4i	David Brown	Parsing EXFOR: For the US evaluation (forked version: x4i3 by Anatoli Fedynitch)	Python	EXFOR master file	https://github.com/brown170/x4i
Visualization of nuclear data used in PHITS	Naoya Furutachi	Visualization of nuclear data with ACE format loaded in PHITS Test of a tool to convert EXFOR to PHITS “Frag data” format	Fortran	EXFOR master file	https://conference-indico.kek.jp/event/136/contributions/3032/attachments/2064/2549/P23_Furutachi.pdf
exfor-parserpy	Georg Schnabel	Parsing EXFOR: As a part of the developments of evaluation framework of SG-50/WPEC	Python	EXFOR master file	https://github.com/IAEA-NDS/exfor-parserpy
EXFOR_Parser	Shin Okumura	Parsing EXFOR: Convert EXFOR to JSON, tabulated format for the visualization	Python	EXFOR master file	https://github.com/shinokumura/exforparser

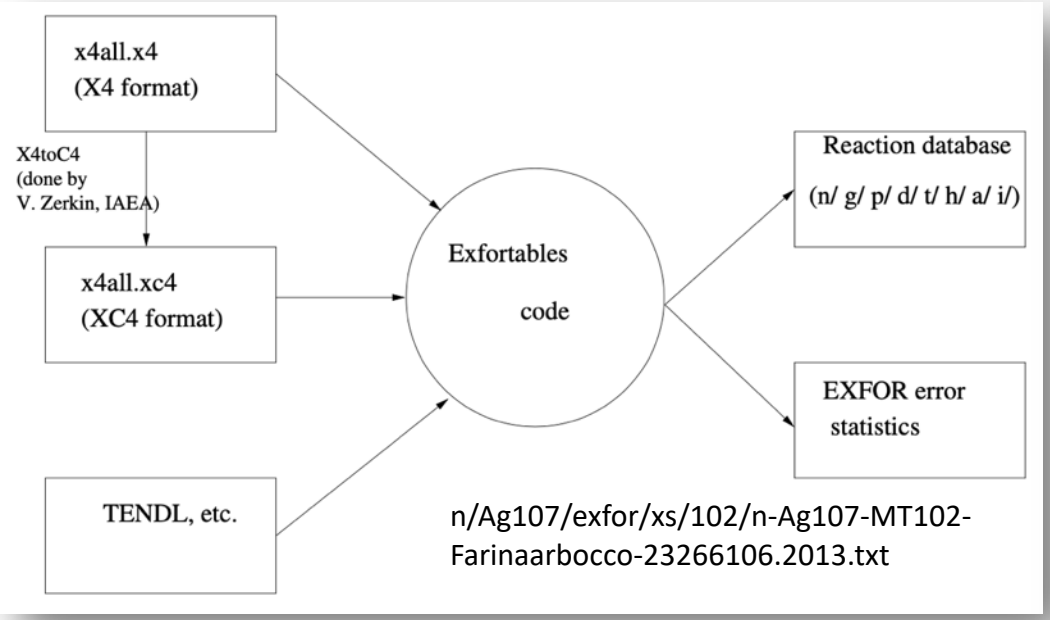
+ more local evaluation systems must exist, and data curation

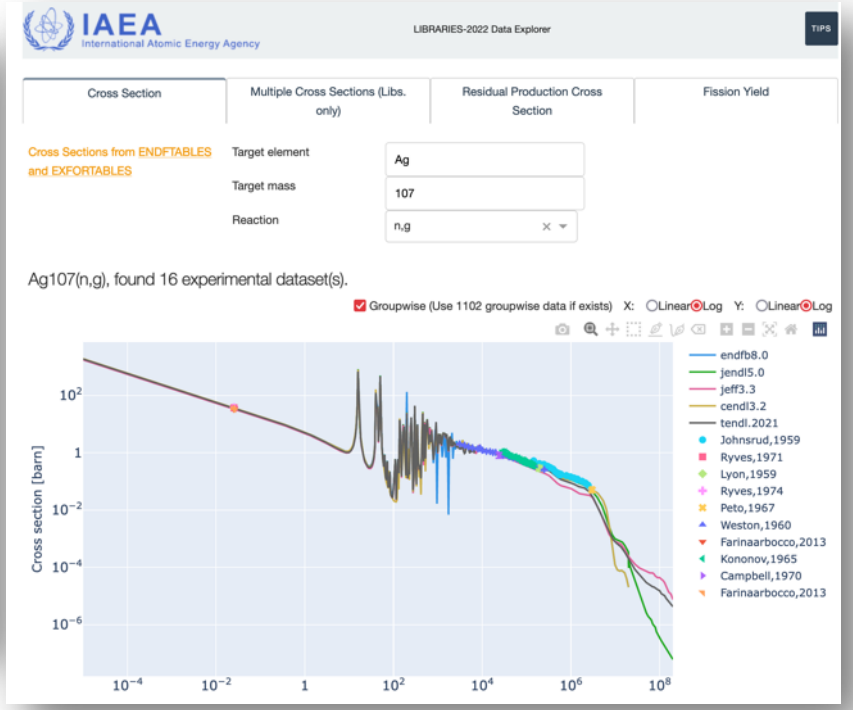
- Modern AI/ML tools, including the development and use of Natural Language Processing (NLP) could shorten the time needed for an EXFOR compilation to be completed by automatically processing tables, graphs, and relevant in-text context. The incorporation of these tools, however, will require new skills 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.

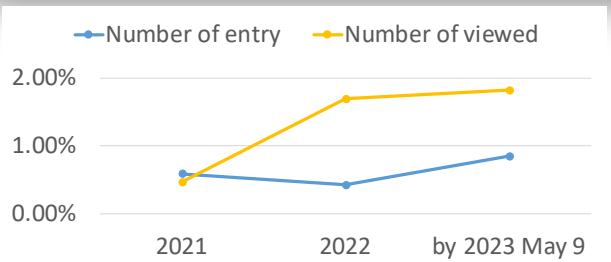
  - Second Report of the Nuclear Data Charge Subcommittee of the Nuclear Science Advisory Committee https://science.osti.gov/-/media/np/nsac/pdf/docs/2023/NSAC-ND_Report_2_031923.pdf

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







Percentage of ground total of number of access to https://nds.iaea.org/dataexplorer/

* 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/

- Increase of access, but the data is not updated frequently
  - Wait for C4/C5→EXFORTABLES production

Open science

- "Open Science, leaving no one behind" for the Sustainable Development Goals (SDGs) in "World Science Day for Peace and Development".

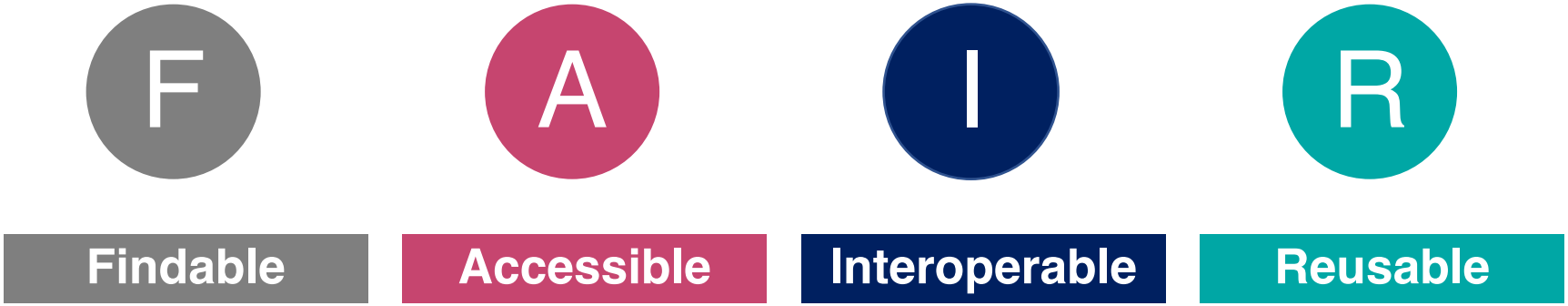
- IAEA, one of the UN Organisations, is providing access to data for peaceful use of nuclear science and technology.
  - International Nuclear Information System (INIS)
  - Experimental Nuclear Reaction Database (EXFOR) and ENDF Databases
  - ...and some other IAEA-NDS databases

- The development of data repositories should adhere to:
  - Open Science best practices and
  - Principles known as **FAIR** (Findable, Accessible, Interoperable, Reusable)

Experimental data and FAIR Principles

Research data integrity is crucial because it ensures the transparency and trustworthiness of scientific data. Therefore,

Data should be...



- easy to find for both humans and computers with machine-readable metadata
- retrievable by an identifier (e.g. DOI)
- easily work with different applications, workflows, storage, or processing
- well-described, self-explanatory

Towards FAIR for EXFOR data

Findable: Unified metadata, Query-able by SQL/ORM (e.g. SQLAlchemy)
Accessible: RESTful API, graphical frontend
Interoperable: Open-source project, transparent data pipeline, support ML/AI frameworks
Reusable: Conversion of EXFOR to JSON, helper for EXFOR jargons

Primitives of EXFOR: all remain same
- EXFOR (as a format), EXFOR dictionary
- Compilation
- Data retrieval system (https:nds.iaea.org/exfor)
- Compiled data

Data model
- parsing EXFOR
- json conversion & reversion
- validation
- automation

RESTful API, database, data store
- data management (Licence, DOI)
- data store (text, JSON, SQL, Git repository)
- multidimensional data analysis

UX Improvements
- redesgin UI, data plotter
- system integration
-

EXFOR Parser

- A new python program to convert EXFOR text into JSON.
  - Python3.x (https://github.com/shinokumura/exforparser)
  - Inspired by x4i by David Brown (NNDC, BNL)
  - Convert 25,000 entries into JSON in 30-40 min
- Features
  - EXFOR to JSON
    - Simplify JSON schema compared to previous presentation in May
    - Parse blocks (BIB, COMMON, DATA)
    - Parse identifires (TITLE, AUTHOR, REACTION, METHOD, ERR-ANALYS..etc)
    - Separate EXFOR-code and freetext
    - Separate subentries based on POINTERs
  - Outputs
    1. Pure (best effort) conversion from EXFOR to JSON
    2. Tabulated data tables
    3. Bib info., reaction index, and tabulated data in SQL db

Related repositories

- https://github.com/IAEA-NDS/**exfor_master**
  - Preservation of historical EXFOR versions
  - Recovered from more than 430 backup zip files stored in NDS since 2005
  - All updates are merged into main branch
  - Retroactive to any timestamp (commits)

- https://github.com/IAEA-NDS/**exfor_dictionary**
  - Best-effort conversion of EXFOR dictionary to JSON format

- https://github.com/IAEA-NDS/**exfor_json**
  - All entries in JSON format converted by EXFOR_parser
  - (JSON schema is not yet fixed and may will be changed)

- https://github.com/shinokumura/**exfortables_py**
  - Tabulated data files of datasets from EXFOR entry to the tabulated data like EXFORTABLES*produced by the EXFOR Parser
  - To allow user to download the data file

* A. Koning, iaea-nds-0235, EXFORTABLES-1.0: An experimental nuclear reaction database based on EXFOR

- https://github.com/shinokumura/**ripl3_json**
  - Convert RIPL3 into JSON
  - Currently, only discrete level and mass tables

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.
```

```
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
```


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

```
"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/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
  },
```

https://github.com/shinokumura/exfortables_py

- Produce-able without C4/C5
- Best effort to get smallest ”dataset” of physical observable and tabulate them

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

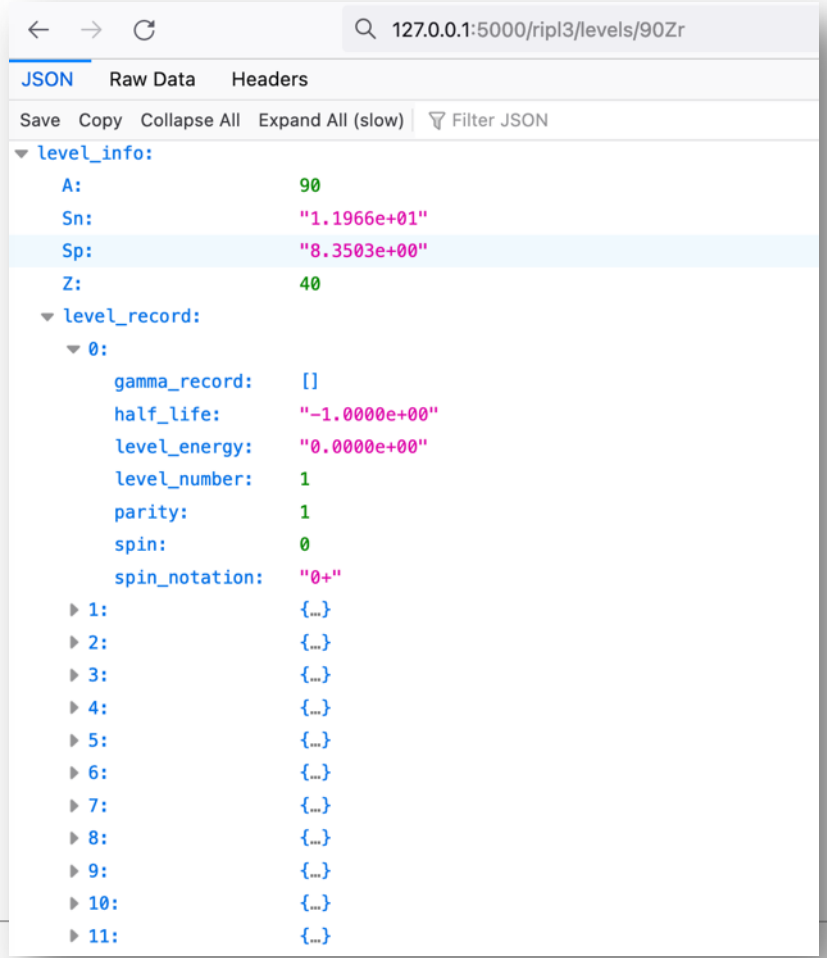
```
# entry-subent-pointer  : 20788-008-0
# EXFOR reaction        : ['26-FE-56', ['N,INL'], '26-FE-56,PAR,SIG']
# incident energy       : 2.02e+00 MeV - 4.50e+00 MeV
# target                : Fe-56
# product               : Fe-56
# level energy          : 8.45e-01 MeV
# MF-MT number          : 3 - ['51']
# 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
```

RESTful API

- An architectural style for an application program interface (API) that uses HTTP requests to access and use data - Addressability, Stateless, Uniform Interface
  - **EXFOR entry**: entry, subentry, bib, data, experimental condition, reactions
  - **EXFOR dictionary**: facilities, institutes, methods, detectors
  - **RIPL-3 descrete level**: levels, level records
- API documentation is available

http://nds.iaea.org/dataexplorer/api/exfor/entry/22449

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



Decay Chain in JSON

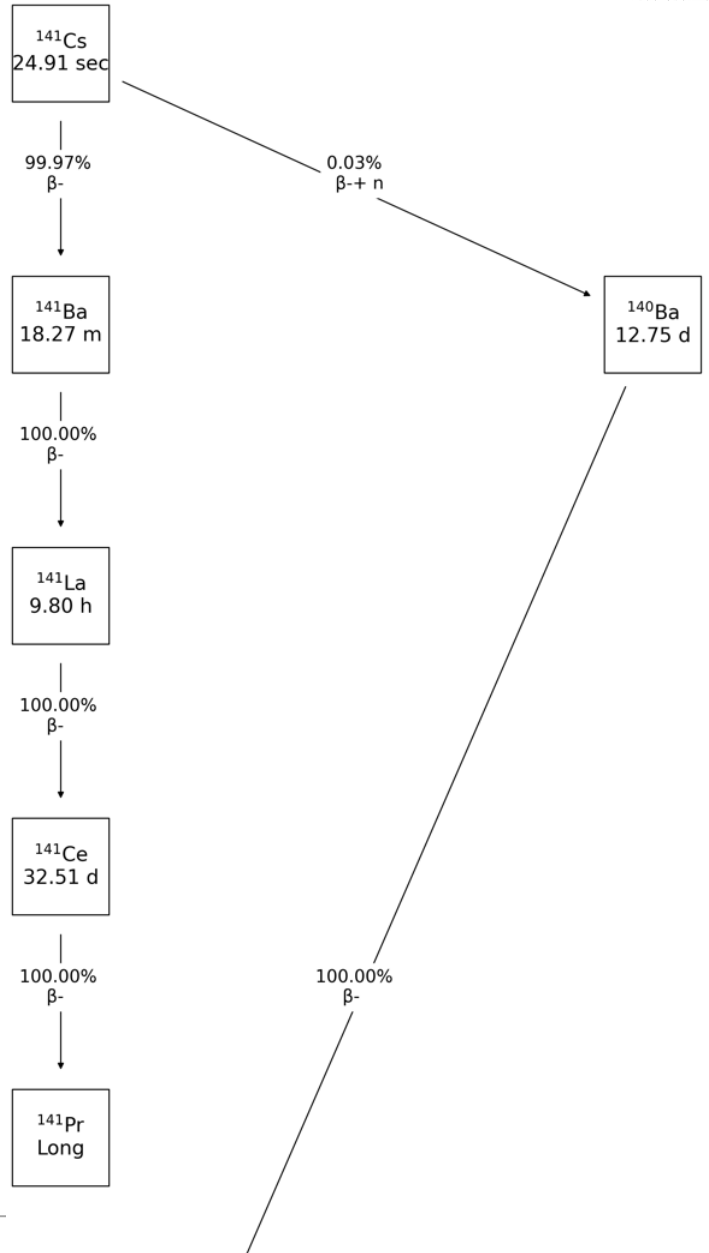
Decay data


```
"55-Cs-141-00": {
   "Z": "55",
   "ELM": "Cs",
   "MASS": "141",
   "LIS": "00",
   "HL": "2.4910000E+01",
   "LAMBDA": 0.027826,
   "En_beta": "1.5473620E+06",
   "En_gamm": "1.7248140E+06",
   "En_alpha": "7.5359650E+01",
   "DecayInfo": {
     "0": {
       "RTYP": "1.0000000E+00",
       "RFS": "0.0000000E+00",
       "Q": "5.2560000E+06",
       "BR": "9.9965800E-01",
       "DAUGHTER": "56-Ba-141-00"
     },
     "1": {
       "RTYP": "1.5000000E+00",
       "RFS": "0.0000000E+00",
       "Q": "7.2100000E+05",
       "BR": "3.4200000E-04",
       "DAUGHTER": "56-Ba-140-00"
     }
   },
   "daughters": [
     "56-Ba-141-00",
     "56-Ba-140-00"
   ]
 },
```


Decay chain (linearized)

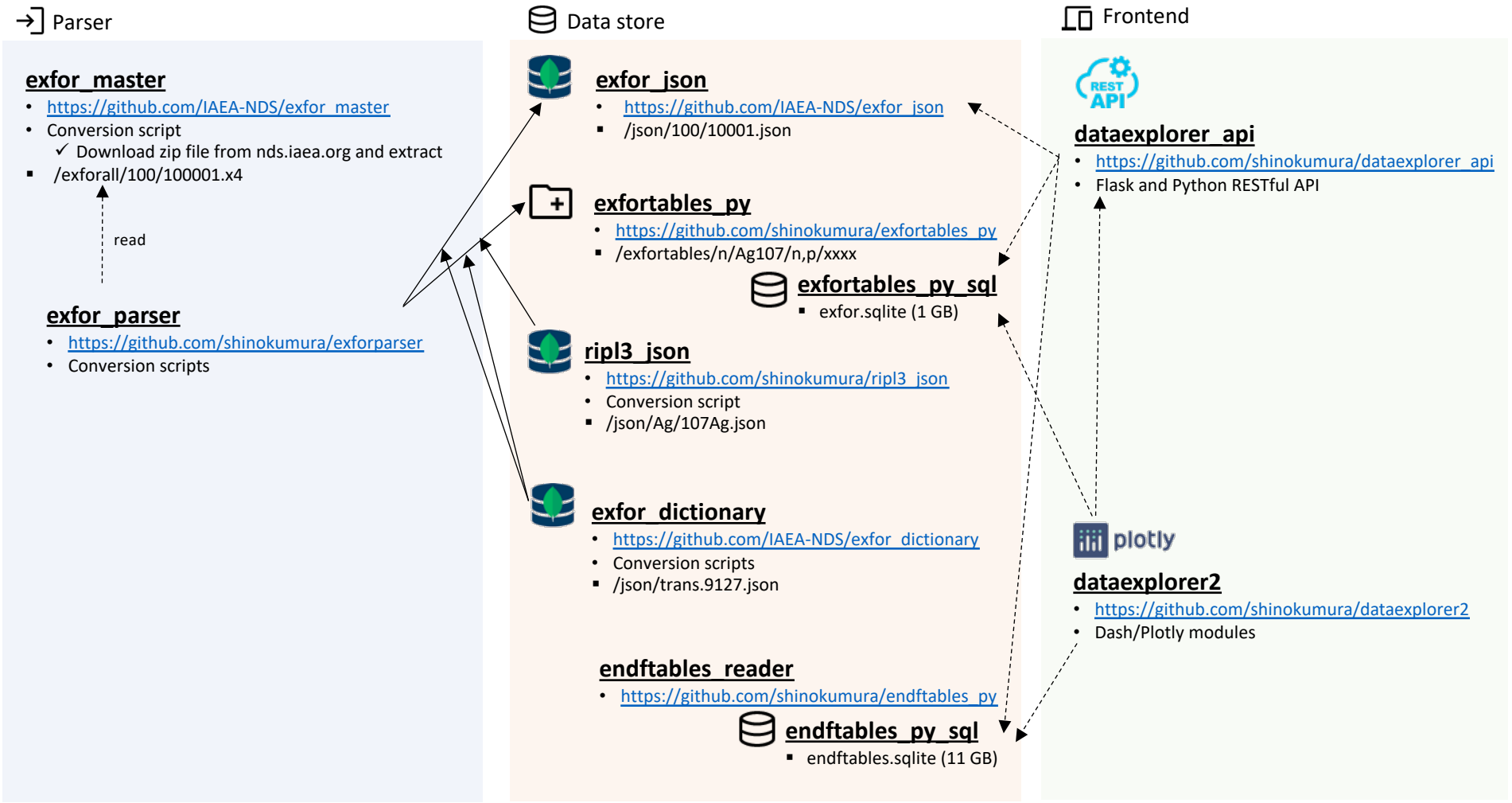

```
"55-Cs-141-00": {
   "1": {
        "chain": [
        "56-Ba-141-00",
        "57-La-141-00",
        "58-Ce-141-00",
        "59-Pr-141-00"
        ],
        "branching": [
        0.999658,
        1.0,
        1.0,
        1.0
        ],
        "rtyp": [
        1.0,
        1.0,
        1.0,
        1.0
        ],
        "lmbds": [
        0.027826,
        0.00063232,
        4.9118e-05,
        2.4676e-07,
        6.9315e-51
        ],
        "en_betas": [
        "1.5473620E+06",
        "9.6628250E+05",
        "9.8713460E+05",
        "1.9438810E+05",
        0.0
        ],
        "en_gamms": [
        "1.7248140E+06",
        "9.0968270E+05",
        "2.6780420E+04",
        "7.6901970E+04",
        0.0
        ]
        },
    "2": {
        "chain": [
        "56-Ba-140-00",
        "57-La-140-00",
        "58-Ce-140-00"
        ],
```


Decay chain (network diagram plot)

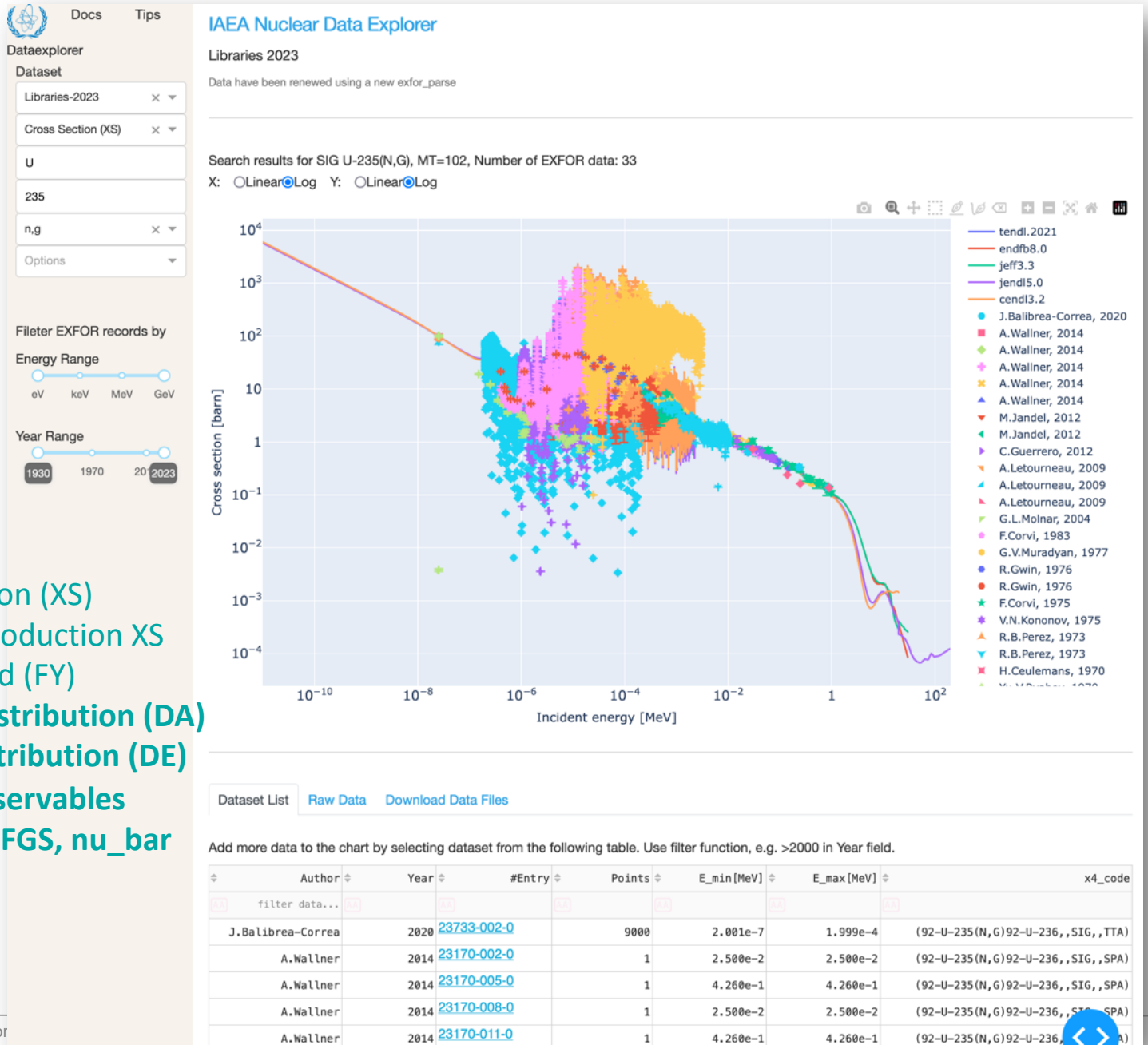


Data Explorer Pipeline

- Starting from EXFOR master files
  - Convert into JSON and data table
  - Create SQL and noSQL database
  - Access data from API and Dash/Plotly modules



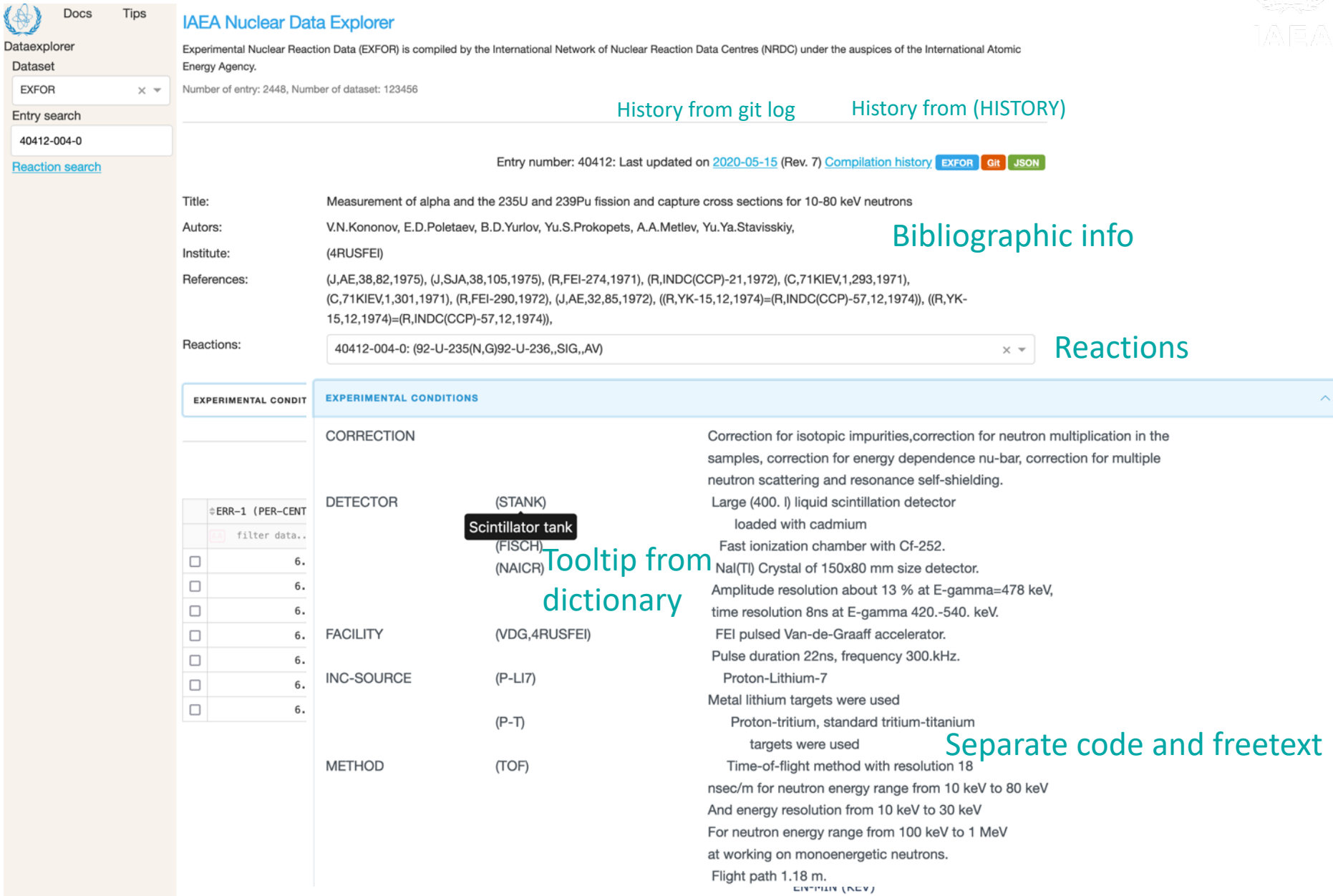
Renewed interface of https://nds.iaea.org/dataexplorer/



Data plots for

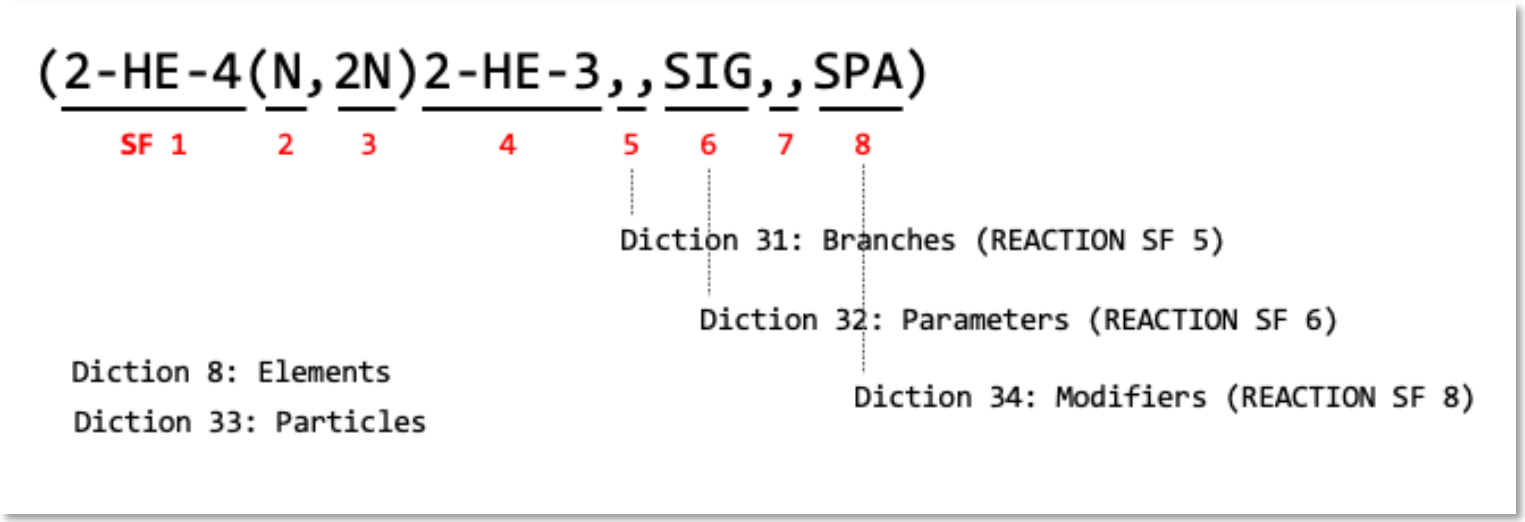
- Cross Section (XS)
- Residual Production XS
- Fission Yield (FY)
- **Angular Distribution (DA)**
- **Energy Distribution (DE)**
- **Fission Observables**
  - **PFNS, PFGS, nu_bar**

New UX for EXFOR entry viewer based on API



Index of all reactions

- Index stores “real” products as well as MASS, ELEM, or ELEM/MASS
  - If the PRODUCT (SF4) in REACTION is either of MASS, ELEM, or ELEM/MASS, one cannot know real products until reading DATA block

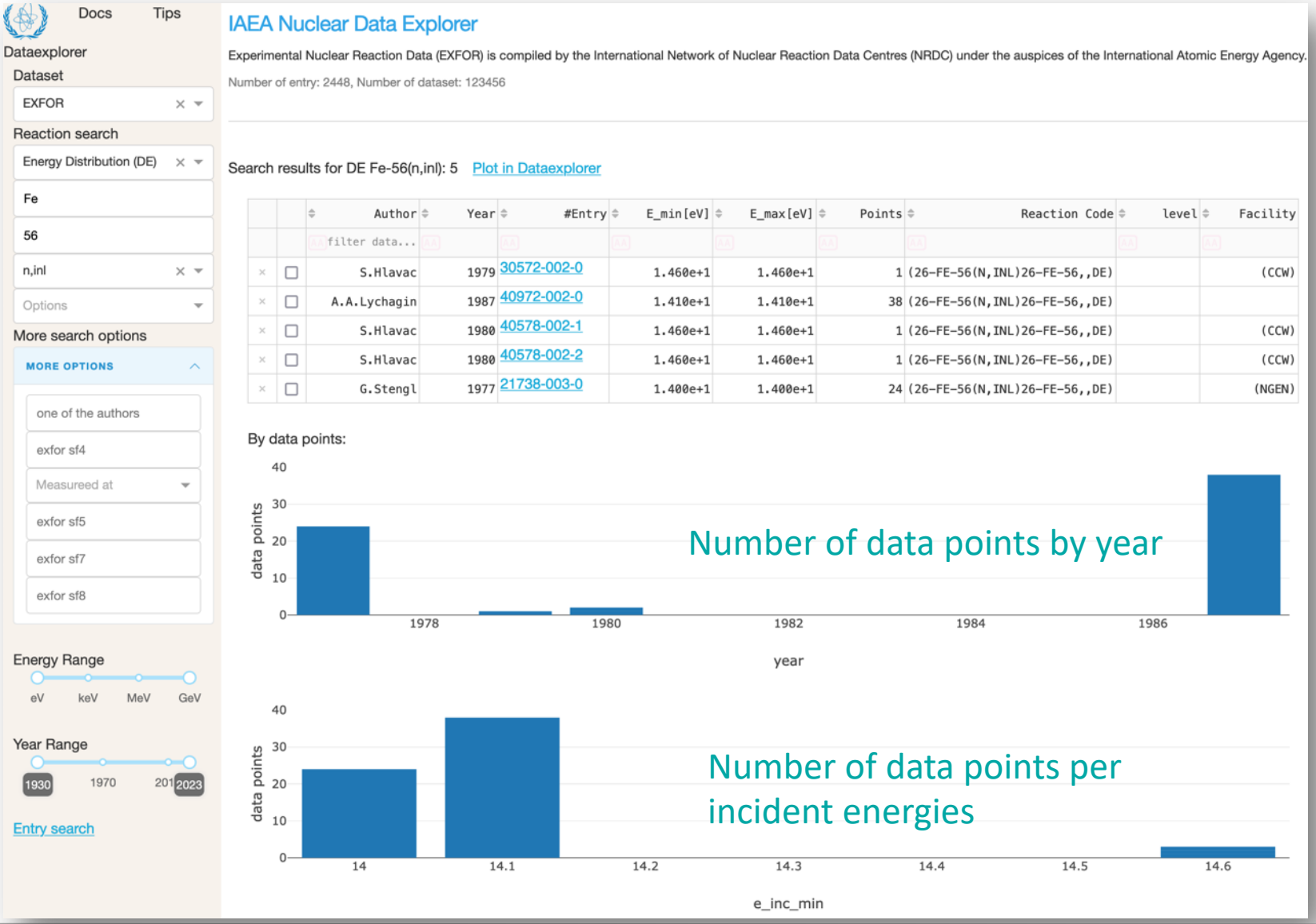


(89-AC-227(N,F)ELEM/MASS,CUM,FY,,REL/FIS)

id	year	author	min_inc_en	max_inc_en	points	target	process	sf4	residual	sf5	sf6	sf7	s
30944-002-0	1965	R.S.Iyer	1.000e+00	1.000e+00	1	89-AC-227	N,F	ELEM/MASS	35-Br-83	CUM	FY	None	REL/F
30944-002-0	1965	R.S.Iyer	1.000e+00	1.000e+00	1	89-AC-227	N,F	ELEM/MASS	38-Sr-89	CUM	FY	None	REL/F
G0074-002-0	2019	A.Chatillon	1.740e+01	1.740e+01	1	89-AC-219	G,F	ELEM	Zn	CHG	FY	None	S
G0074-002-0	2019	A.Chatillon	1.740e+01	1.740e+01	1	89-AC-219	G,F	ELEM	Ga	CHG	FY	None	S
G0074-002-0	2019	A.Chatillon	1.740e+01	1.740e+01	1	89-AC-219	G,F	ELEM	Ge	CHG	FY	None	S

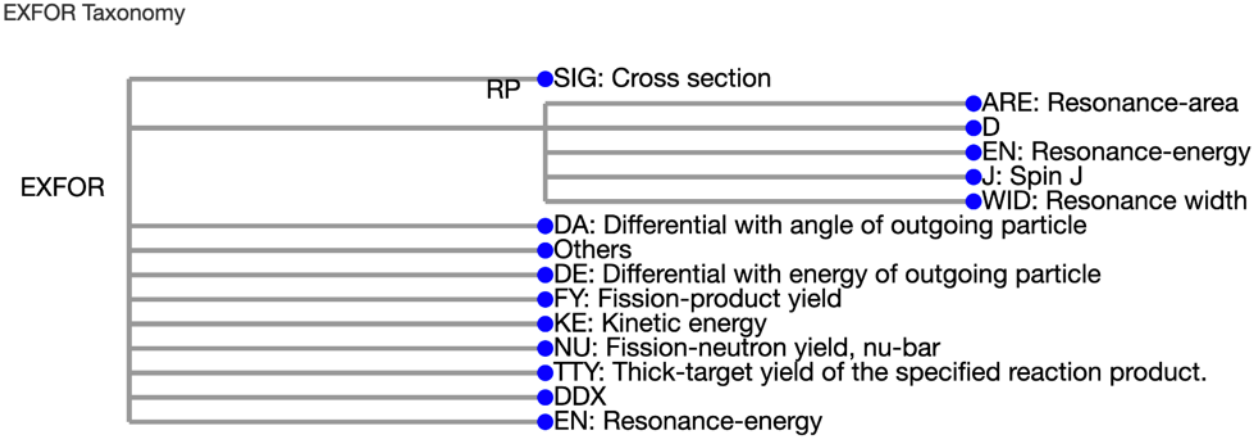
New UX to search EXFOR entry

- Search by the reaction or EXFOR subfields

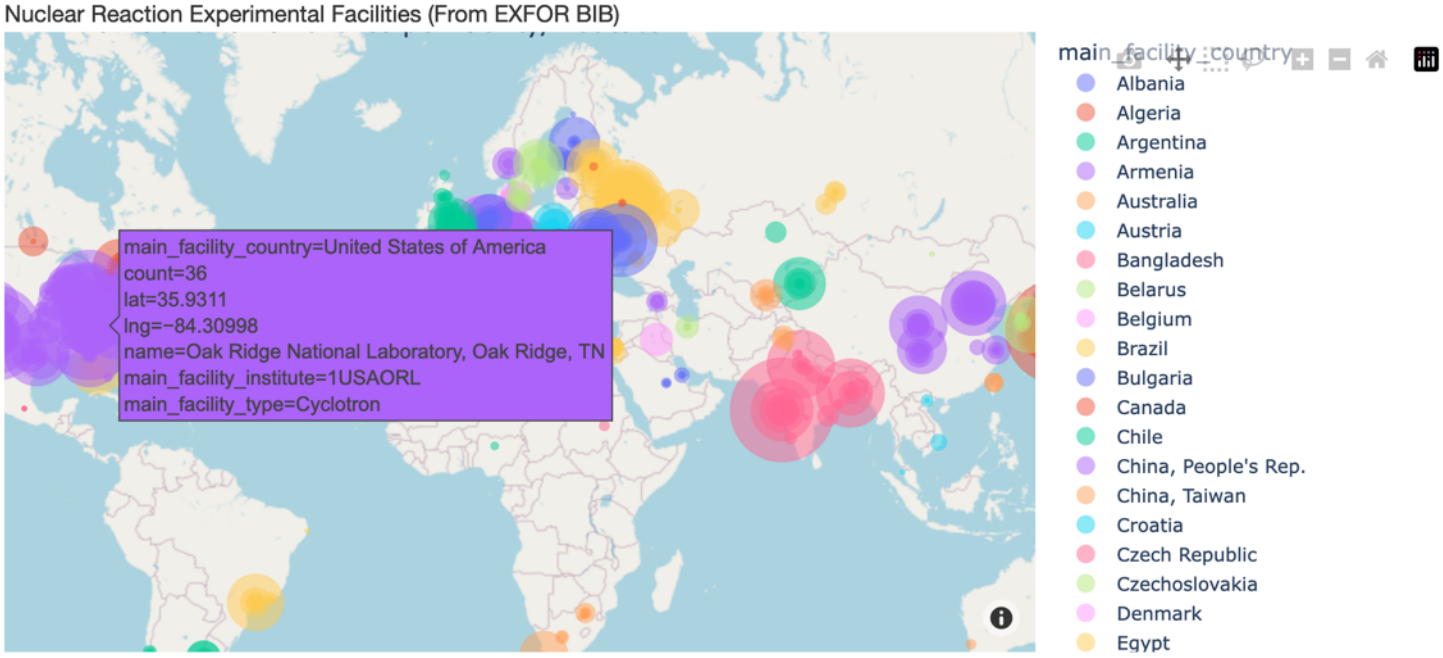


And more…

- Search by EXFOR taxonomy



- Search by geography



Summary

- We are working towards FIAR
- Open source/data on GitHub
  - Codes and data are available on GitHub/IAEA-NDS
    - EXFOR Parser: main EXFOR parsing program in Python
    - exfor_master: original EXFOR master file backup
    - exfor_json: JSON converted EXFOR files
    - exfor_dictionary: JSON converted EXFOR dictionary
    - exfortables_py: tabulated (X-Y table) reaction data

- Future work
  - Deployment, internal test, and security scan toward the production release (w/L. Marian)
  - Automatic update of data pipeline
  - Develop clear JSON schema (w/G. Schnabel)
  - Implementation of FAIR principles for EXFOR and other data stored in IAEA/NDS
    - Findable, Accessible
      - DOI assignment
      - License assignment (CC0/CC BY 4.0) is important
    - Interoperable, Reusable
      - Make use of INVENIO like research repository
- Question
  - Any feedback from GNDS point of view?

Thank you!

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