IAEA
International Atomic Energy Agency
Atoms for Peace and Development

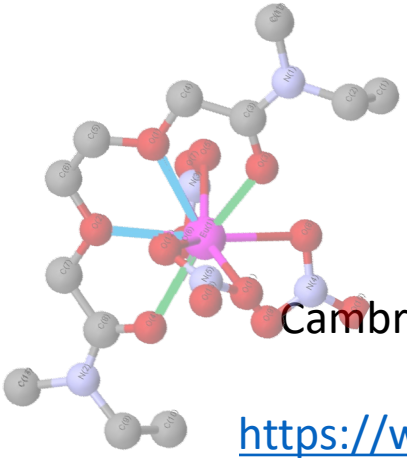
15th January 2024
CM on Information Exchange on Developments and Operations of Nuclear Data Dissemination Services

IAEA Nuclear Data Reaction Dataexplorer (nds.iaea.org/dataexplorer) Developments

Shin Okumura / IAEA-NDS

Experimental databases in various fields

A lot of scientific experimental databases in the world.

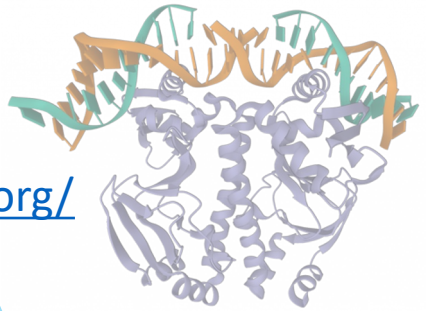


CCDC

Cambridge Crystallographic Data Centre
https://www.ccdc.cam.ac.uk/

RCSB PDB PROTEIN DATA BANK

Protein Data Bank
https://www.rcsb.org/



HEPData

High-Energy Physics data
https://www.hepdata.net/

HTEM

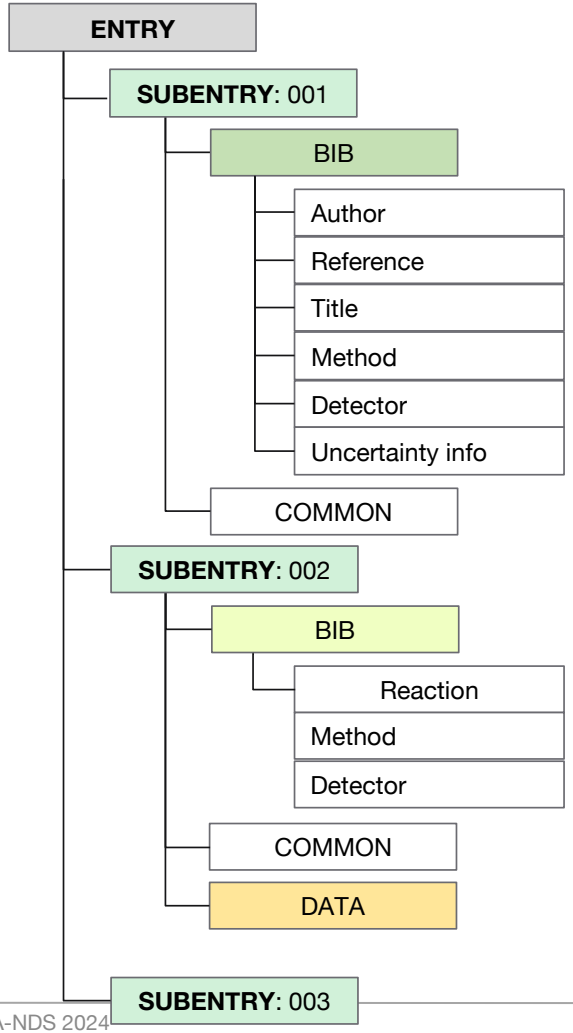
High Throughput Experimental Materials Database
https://htem.nrel.gov/

IAEA International Atomic Energy Agency

Experimental Nuclear Reaction Database (EXFOR)
https://nds.iaea.org/exfor/

EXFOR jargons

- Despite the availability of both metadata and the numerical data in EXFOR master files, programmatically searching for and retrieving relevant data is often cumbersome
- 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,r
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                        cintillator, 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 hardenin
            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.
```

What is (1USADAV)??

What is (CYCLO)??

What is (TELES)??

What is "SIG"??

What is the minimum dataset of nuclear reaction?

- 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

Folded DATA block, metadata with parenthesis

```
SUBENT        30328002   20191015   20191211   20191204       3191
BIB                5         13
REACTION  1(56-BA-134(N,G),,WID/STR)
          2(56-BA-134(N,G),,ARE)
          3(56-BA-134(N,EL),,WID)
          4(56-BA-134(N,EL),,WID/RED)
          5(56-BA-134(N,G),,WID)
ASSUMED    (ASSUM,56-BA-134(N,EL),,WID)
ERR-ANALYS2(ERR-S) Statistical errors
          3(DATA-ERR) No information on the source of uncertainty
STATUS     (TABLE) Table 2 of Nucl.Phys.A256(1976)173
           (OUTDT) Correction factor 0.9833 not taken into account
HISTORY    (19821210U) DG. ISO-QUANT to REACTION conversion
           (19830712A) DG. MOMENTUM L added.
           (20191015A) On. STATUS=OUTDT added.
ENDBIB            13
NOCOMMON           0          0
DATA              10         58
EN-RES     ASSUM      DATA      1DATA      2ERR-S     2DATA      3
DATA-ERR   3DATA      4DATA     5MOMENTUM L
KEV        NO-DIM     EV         B*EV       PER-CENT   EV
EV         EV         MILLI-EV   NO-DIM
 3.1450E+00            4.8000E-02 6.3400E+01 1.0000E+00 8.0000E-02

 3.2370E+00            5.8000E-02 7.5000E+01 1.0000E+00 1.1400E-01

 3.2620E+00            4.5000E-02 5.6800E+01 1.0000E+00 7.1000E-02

 3.4270E+00            9.7000E-02 1.1710E+02 1.0000E+00 1.0000E+00
 5.0000E-01 1.7000E-02 1.0700E+02 0.0000E+00
 3.6920E+00            2.9000E-02 3.3100E+01 3.0000E+00 3.9000E-02

 3.8650E+00            7.3000E-02 7.8400E+01 2.0000E+00 1.8000E-01

 3.9110E+00            9.0000E-02 9.5500E+01 3.0000E+00 8.0000E+00
 2.0000E+00 1.3200E-01 9.1000E+01 0.0000E+00
 3.9460E+00            4.2000E-02 4.4400E+01 3.0000E+00 6.5000E-02
```

```
FLAG       (1.).The presented values of the yields
been
            obtained from experimental data via sim
            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)
```

Format is the big barrier for newcomers

- Understanding formats (ENDF, ENSDF, and EXFOR) is the first barrier for a newcomer in this field .

> 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

Being a specialist ≠ Format understandings

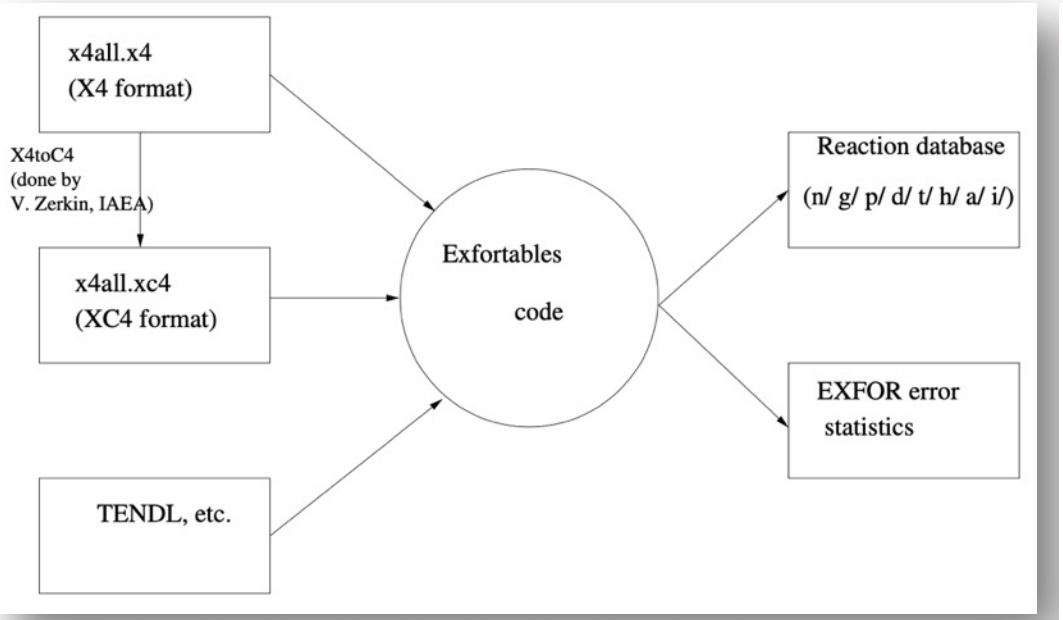
Extended use cases of EXFOR data

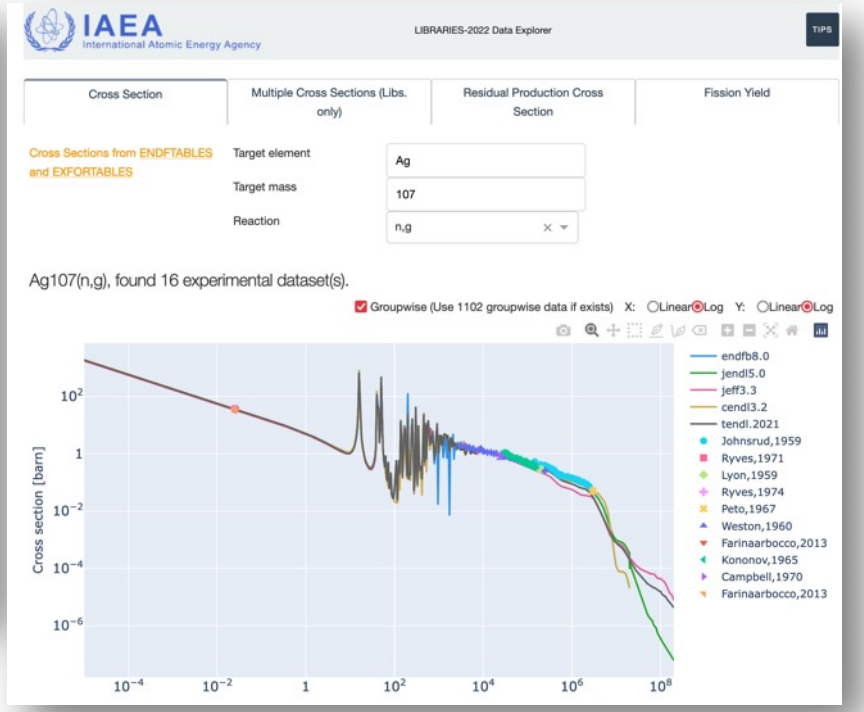
Name	Author	Purpose	Language	Data source	Source code/data
ENEL (EXFOR Nuclear Extraction Library)	Ahmed A. Selman	Package for MATLAB	?	C4	https://www.mathworks.com/matlabcentral/fileexchange/110930-enel-exfor-nuclear-extraction-library
EXFORTABLES	Arjan Koning	Developing TENDL using experimental data 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

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/

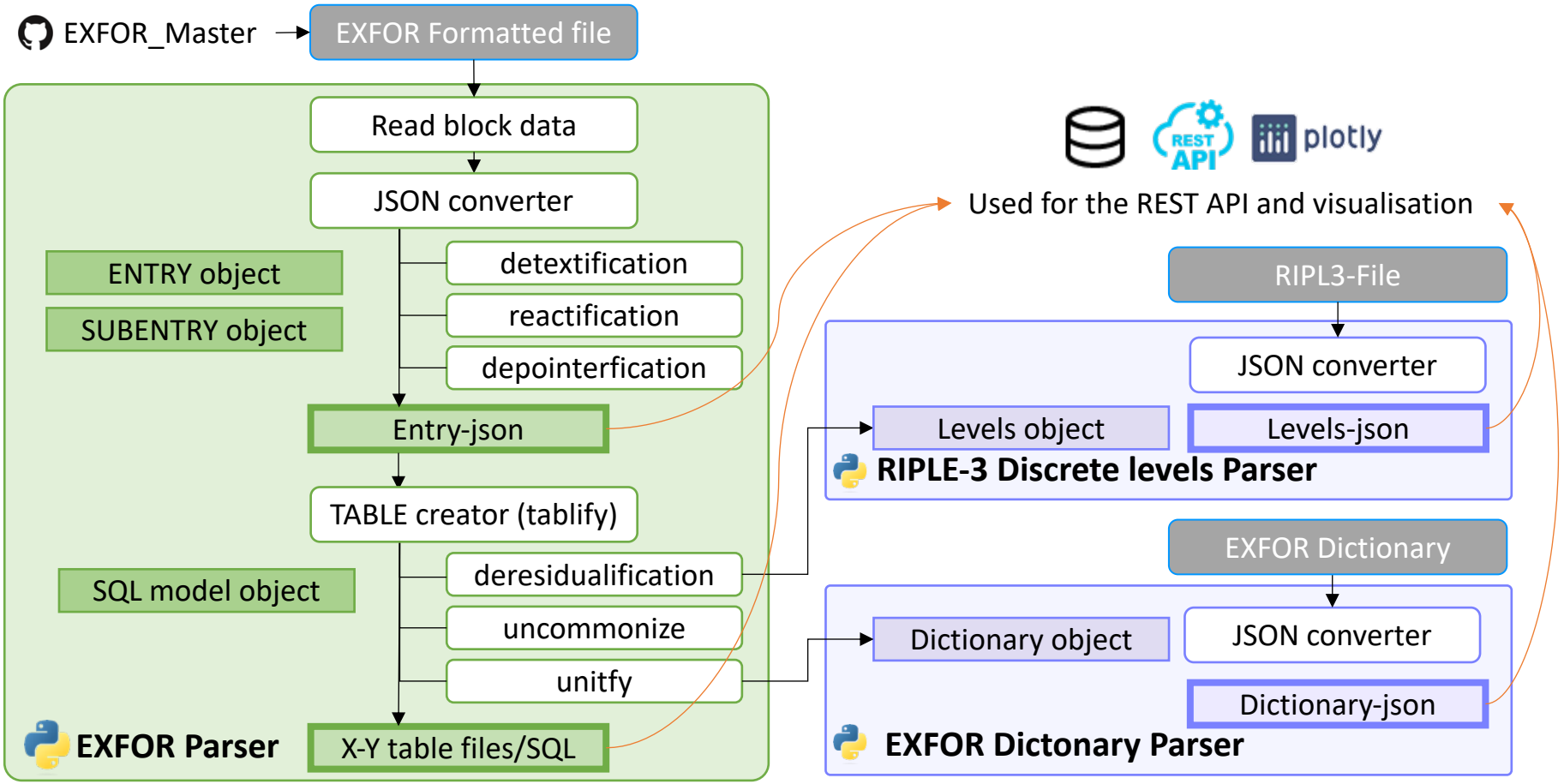
EXFOR Parser

- 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
  - Detextification: Codes and free texts separation
  - Reactification: Reaction codes conversion to the human understandable nuclear reaction
  - Depointerfication: Records are separated into the minimum physical observables
  - Deresidualification: Residual products extraction from the data table and listing in the database to be searchable
  - Uncommonize: Common data unification into the data table
  - Unitfy: Unify units

After all conversions, one can produce tabulated (x, y, dx, dy) format tables.

- Cross sections – X: Incident energy, Y: Cross section
- Angular distribution – X: Angle, Y: Angular distribution
- Fission Yield – X: mass/charge/incident energy, Y: yield



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/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/IAEA-NDS/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
```

Decay Chain in JSON

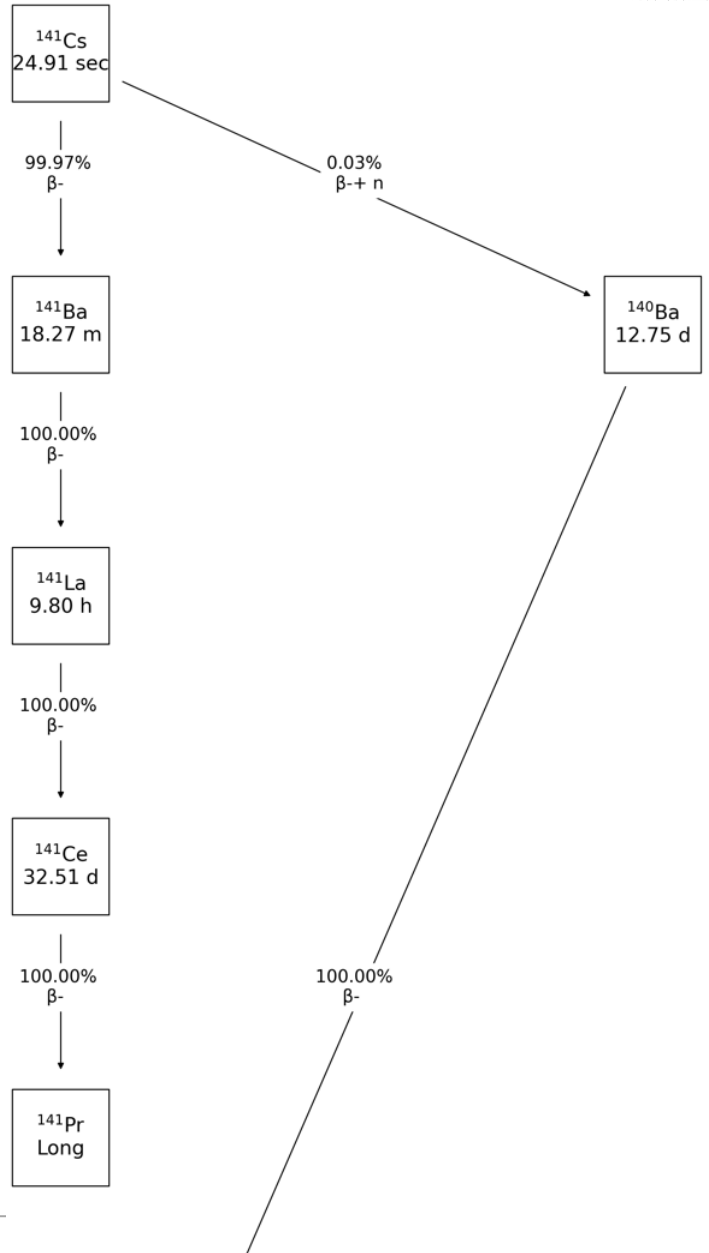
Decay data


```
"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)



IAEA
International Atomic Energy Agency
Atoms for Peace and Development

New Nuclear Reaction Dataexplorer UX and { REST API }

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)

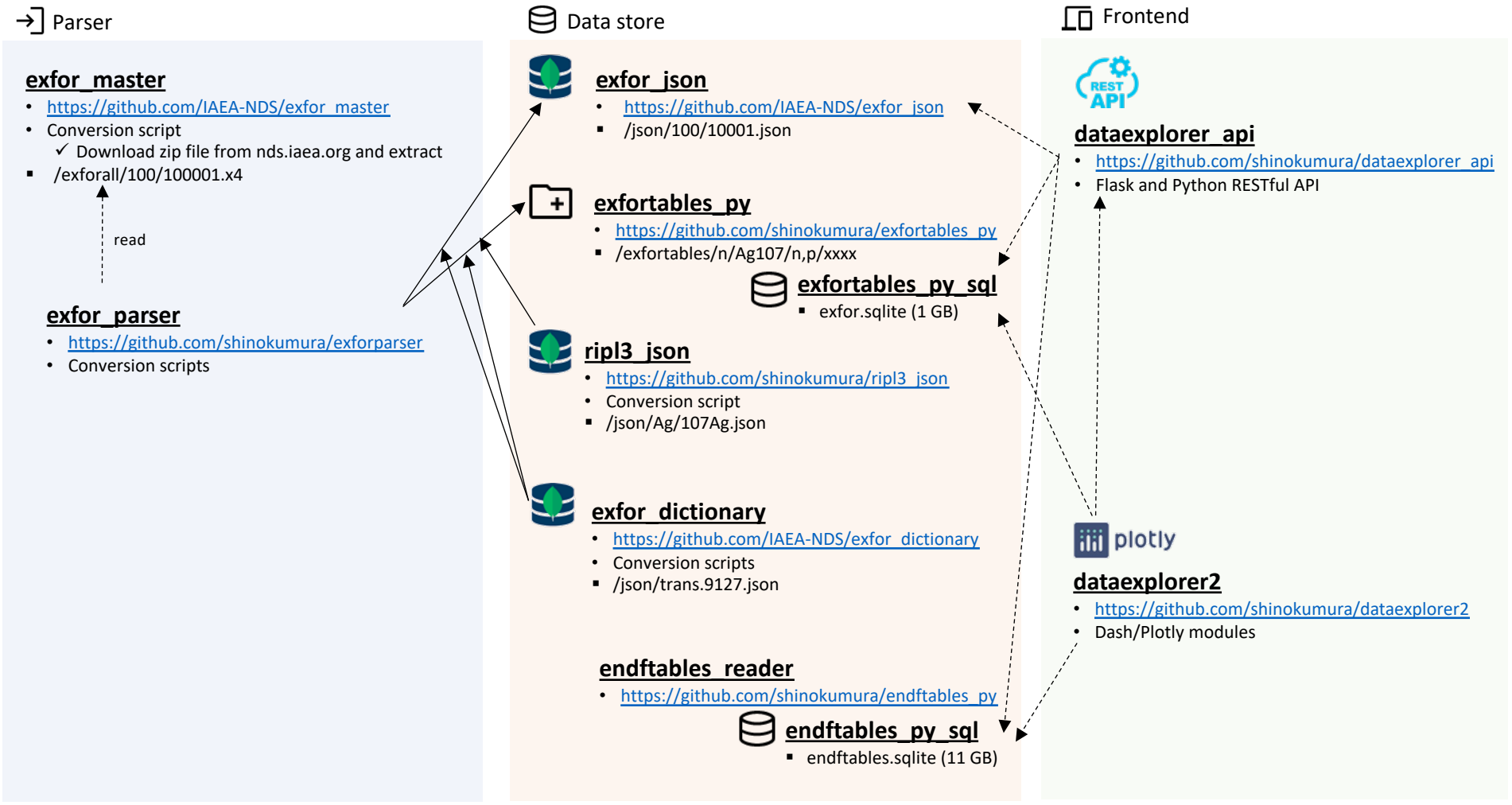
- https://github.com/IAEA-NDS/**exfortables_py**
  - Tabulated data files of datasets from EXFOR entry to the tabulated data like EXFORTABLES*produced by the EXFOR Parser

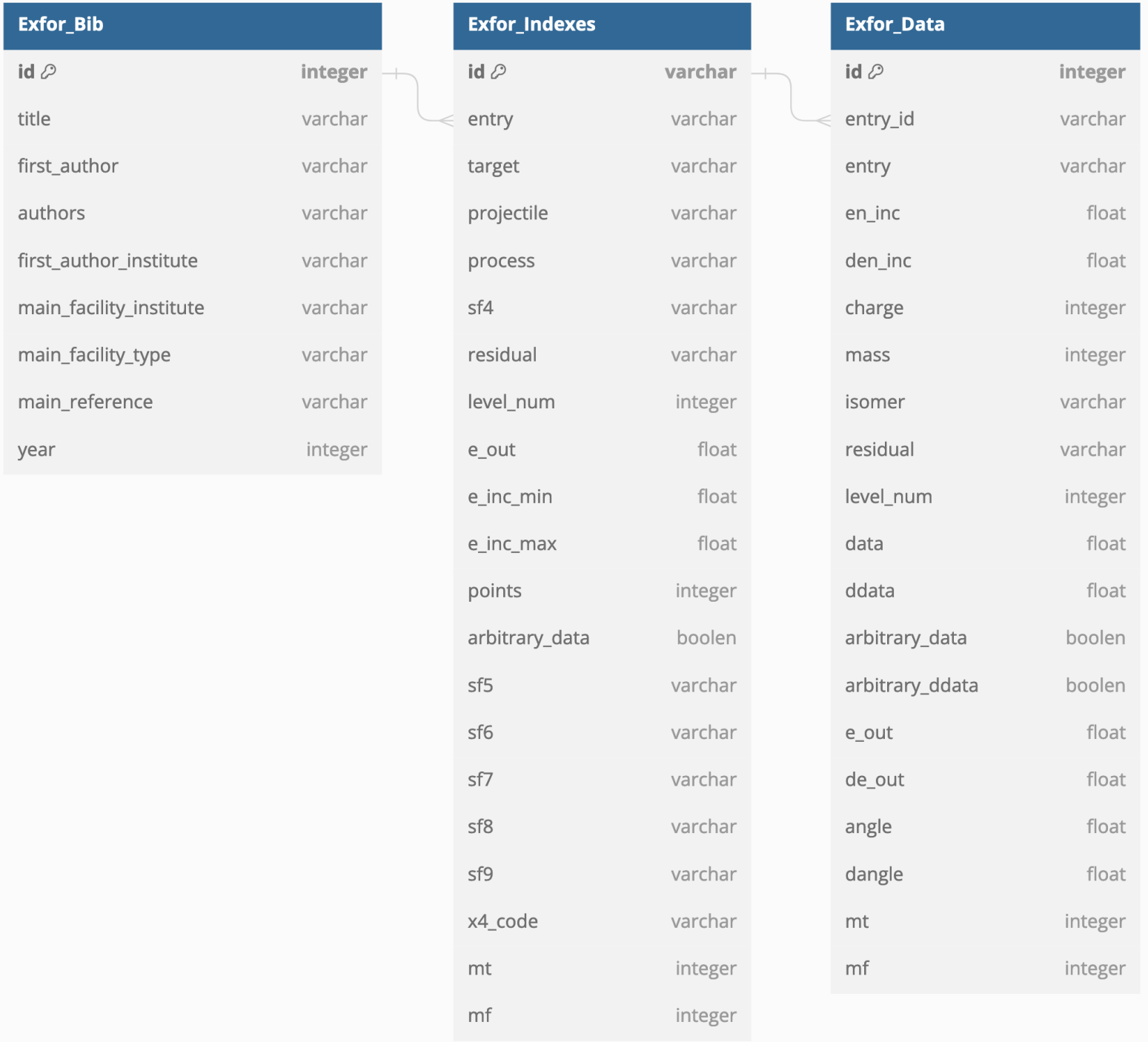
* A. Koning, iaea-nds-0235, EXFORTABLES-1.0: An experimental nuclear reaction database based on EXFOR

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

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




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

Technical changes from the previous version

- Dataset, which are loaded to the plotter, are changed from the **C5 + EXFORTABLE** to **EXFOR_master + EXFOR_Parser**

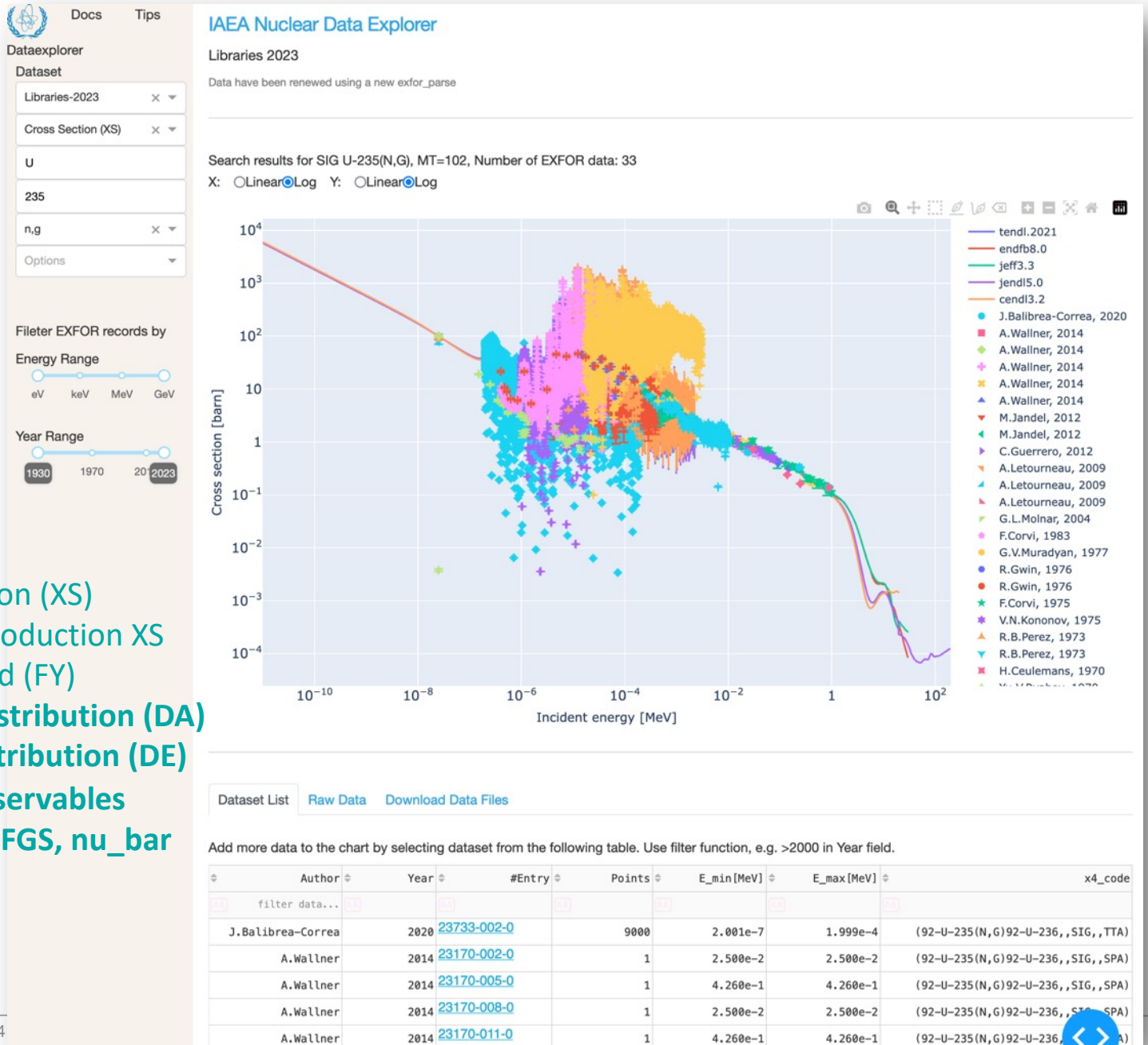
- Data table was switched from dash_datatable to AG Grid
  - AG Grid: https://www.ag-grid.com/

- Datasets are stored in SQLite

- noSQL is not yet in use but JSON files are loaded to the interfaces

- Future?
  - Integrate with INVENIO?

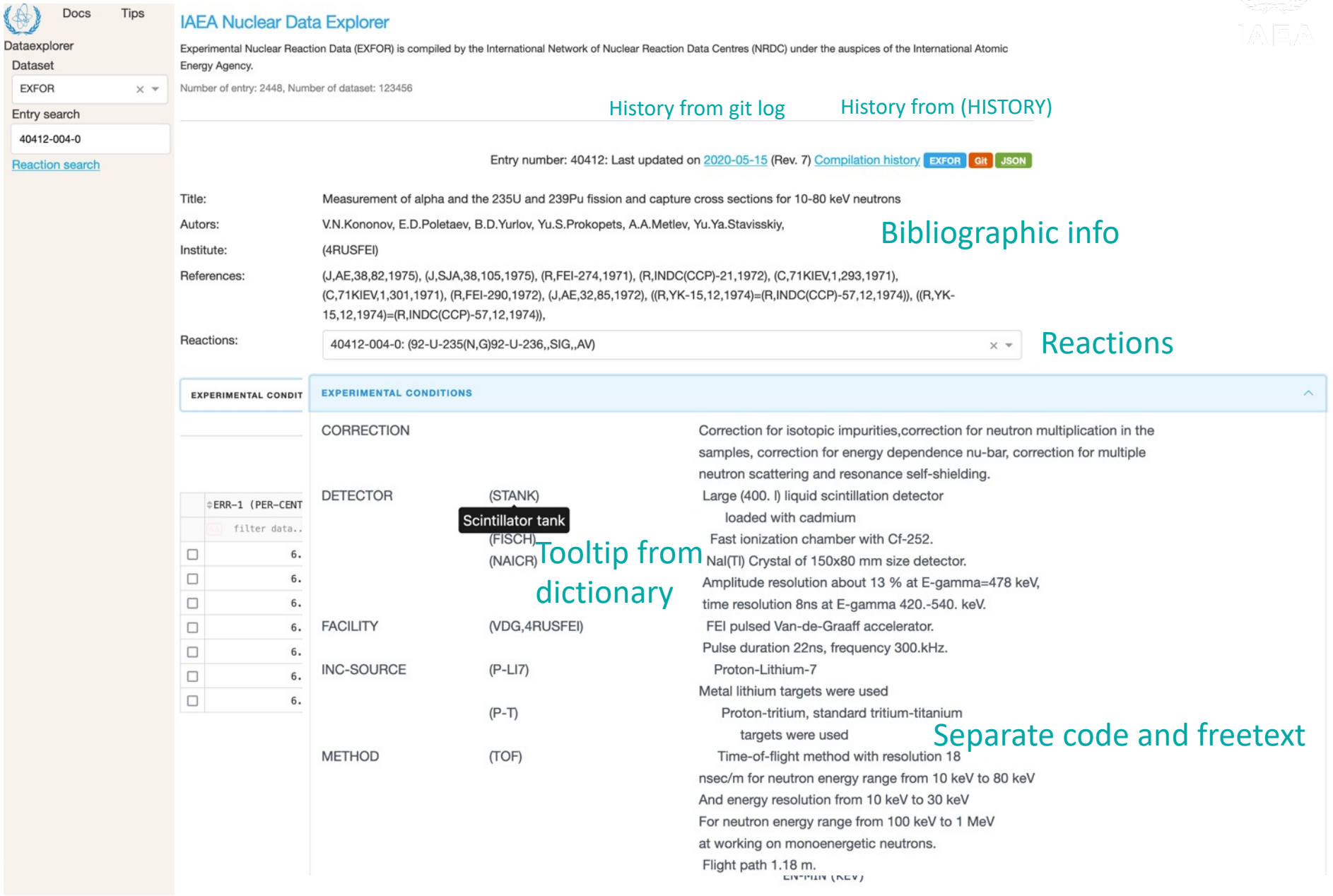
Renewed interface of https://nds.iaea.org/dataexplorer/



Data plots for

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

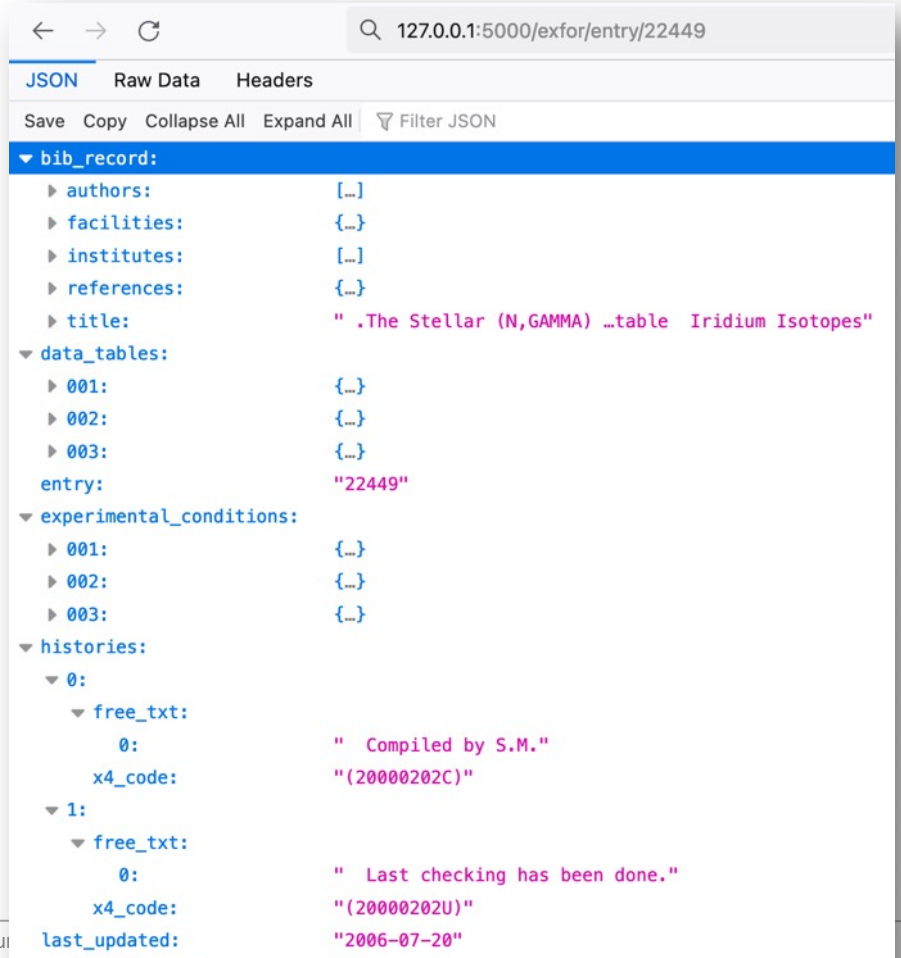
New UX for EXFOR entry viewer based on API



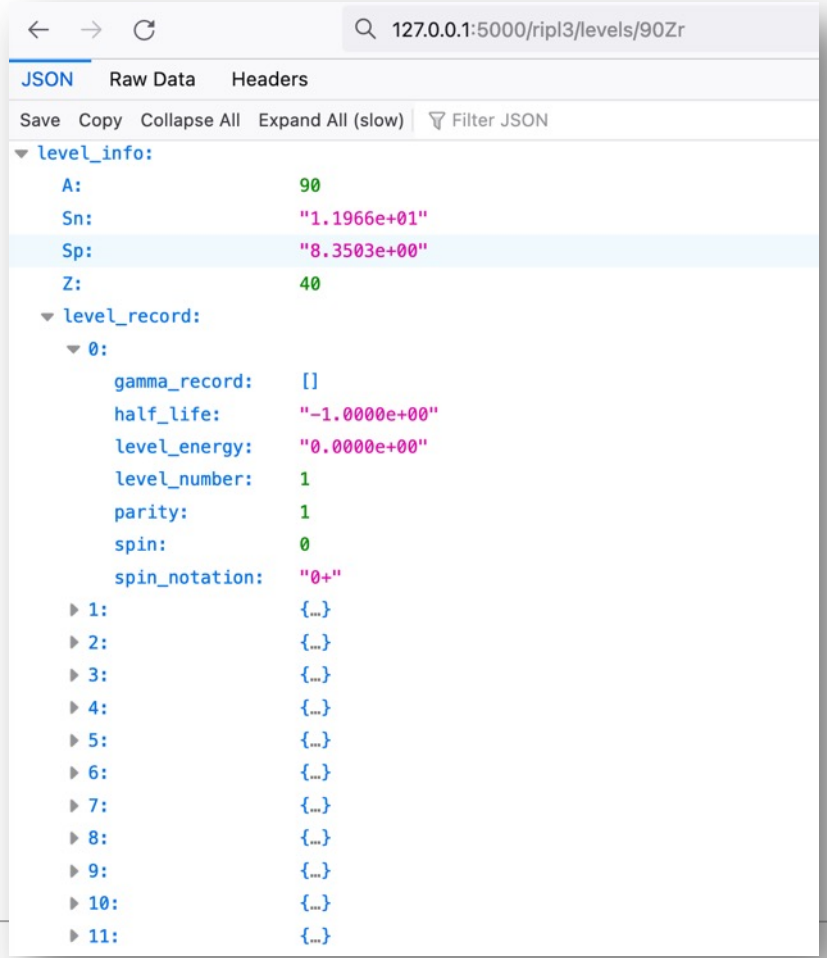
RESTful API

- 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

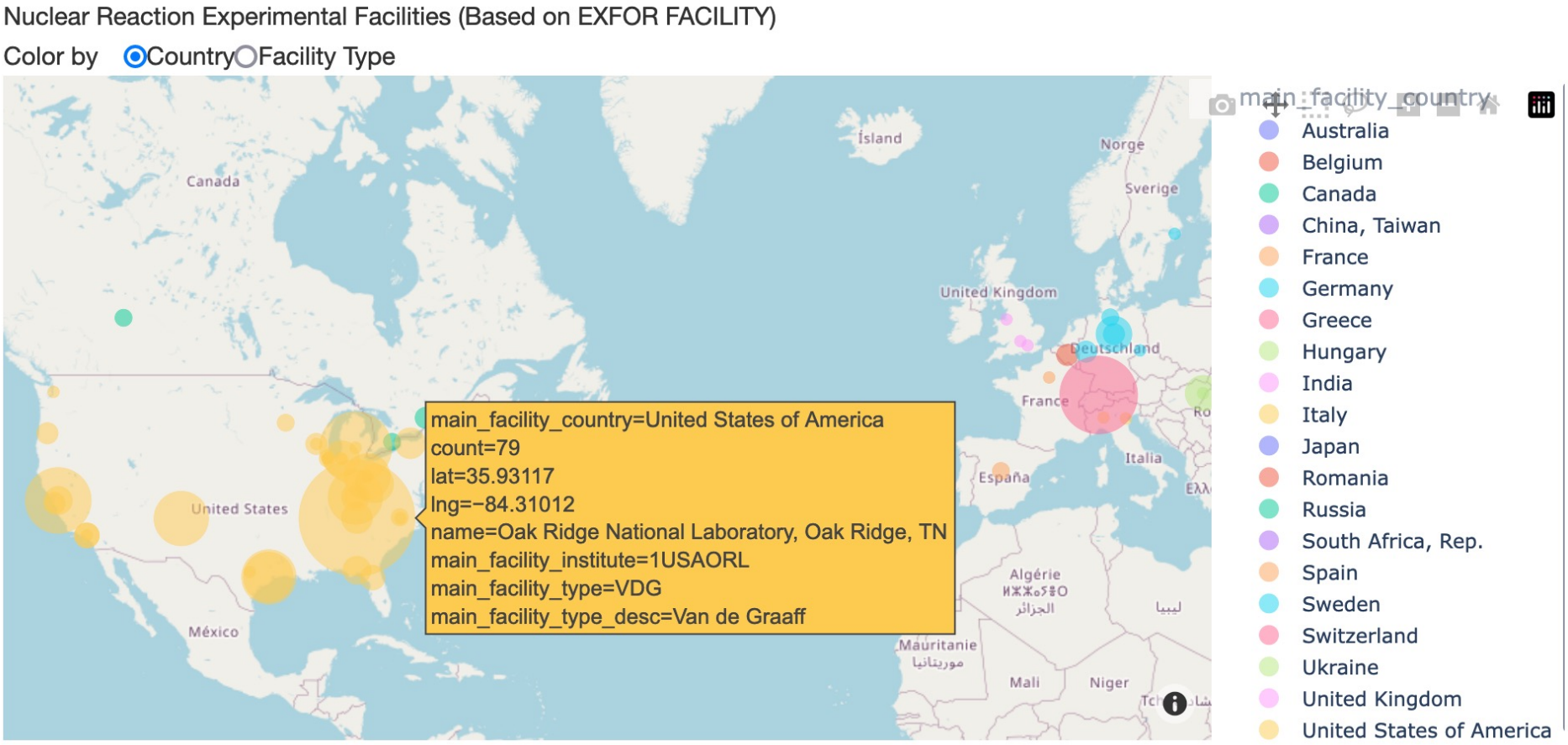
http://nds.iaea.org/dataexplorer/api/exfor/entry/22449



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



New reaction dataexplorer – EXFOR Bib analysis



Summary

- Developments are 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

Thank you!

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