From ENSDF to NuDat: Disseminating Digestible Data Using Modern Web-based Technologies to Search, Filter, and Visualize Nuclear Data

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Brookhaven National Laboratory
U.S. DEPARTMENT OF ENERGY
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Evaluated Nuclear Structure Data File

ENSDF contains recommended nuclear structure and decay data for all the known nuclides

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Includes:

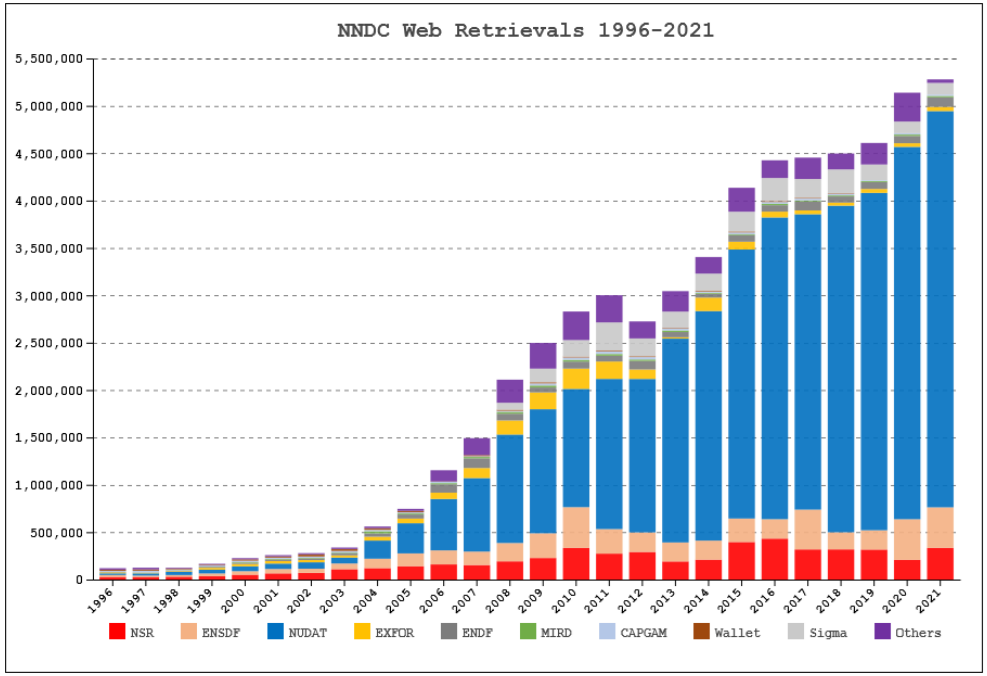
- Nuclear level properties
- Gamma ray information
- Nuclear radiation and decay data

Evaluated Nuclear Structure Data File

ENSDF contains recommended nuclear structure and decay data for all the known nuclides

Highly referenced database

Over 4 million annual retrievals through the NNDC web apps and rising



Current ENSDF Format

Archaic 80-column ASCII format

Limitations:

- Sharing data with non-experts
- Not human readable
- Challenging to parse
- > 100-page manual
- Impractical to apply machine learning
- No room to add new data
- Non-standardized comments

ENSDF Modernization

JavaScript Object Notation (JSON)

Benefits:

- Web-friendly format to share
- Human readable
- Simple to parse
- Machine learning friendly
- Extensible
- Self-contained data objects


```
1  {
2      "header": {
3          "schemaVersion": "1.0",
4          "documentType": "nuclide",
5          "z": 42,
6          "n": 46,
7          "a": 88,
8          "elementName": "Molybdenum",
9          "elementSymbol": "Mo",
10         "history": [{
11             "evaluationType": "full",
12             "cutoffDate": "2013-11-01",
13             "authors": [{
14                 "name": "E.A. McCutchan and A.A. Sonzogni"
15             }],
16             "publication": "NDS 115, 135 (2014)"
17         }]
18     },
19     "isObserved": true,
20     "isStable": false,
21     "isPublic": true,
22     "qValues": [{
23         "type": "oneBetaMinus",
24         "energy": {
25             "value": -1.101E+4,
26             "isRelative": false,
27             "uncertainty": {
28                 "uncertaintyType": "symmetric",
29                 "evaluatorInferred": false,
30                 "uncertaintyValue": 150
31             }
32         },
33         "unit": "keV",
34         "isFromSystematics": false,
```


CouchDB
relax

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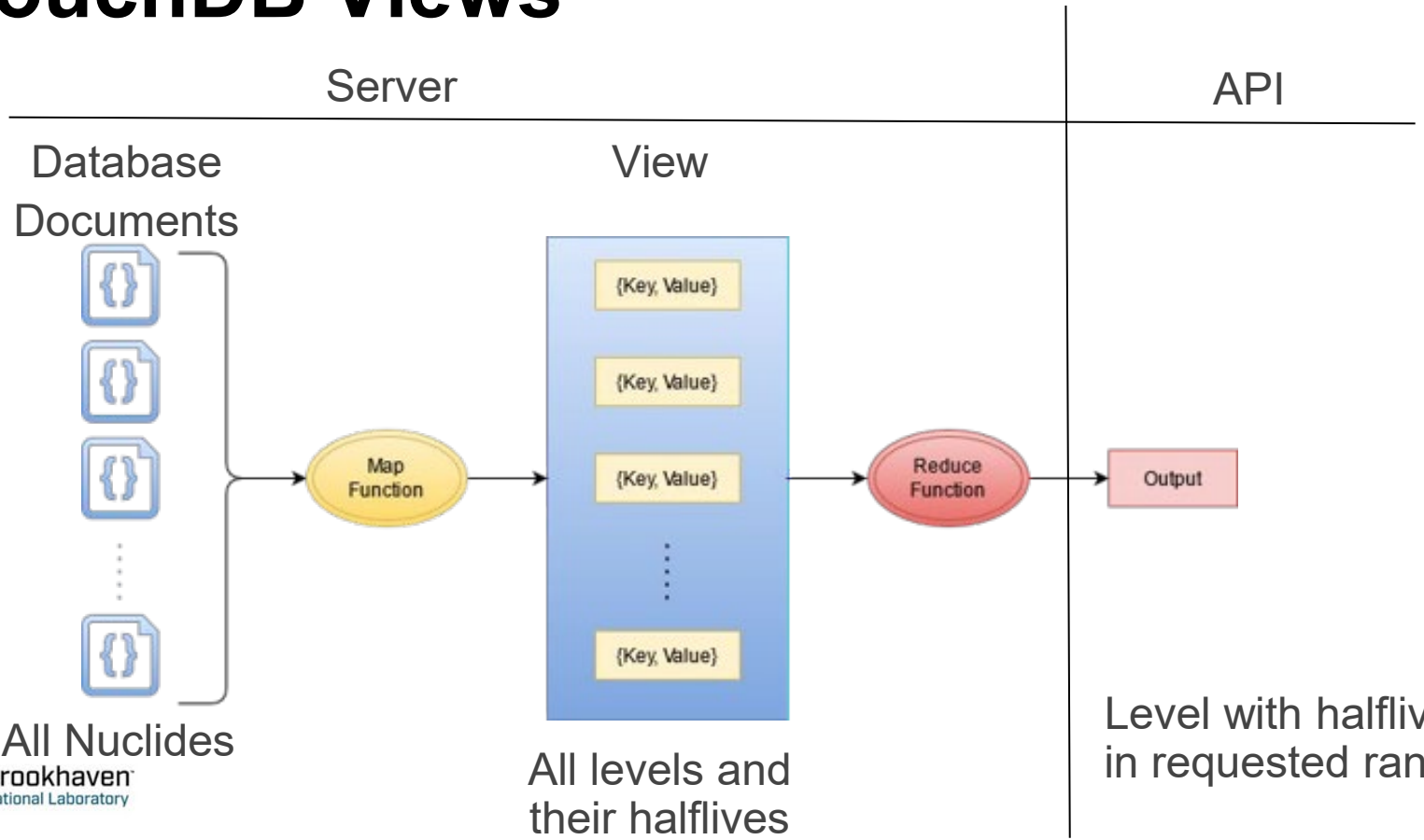
CouchDB Views



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Migrating 80-column to JSON

```
88MO    ADOPTED LEVELS, GAMMAS                                    14NDS    201401
88MO  H TYP=FUL$AUT=E.A. McCutchan and A.A. Sonzogni$CIT=NDS 115, 135 (2014)$
88MO2 H CUT=1-Nov-2013$
88MO  Q -1.101E+4 15 13873  5  6102   8  -3691   7    2012WA38
88MO cQ $S(2n)=24719 {i5}; S(2p)=9296 {i5} (2012Wa38)
88MO cG E$From {+58}Ni({+36}Ar,|a2p|g)
88MO cG RI$Relative branching ratios from {+58}Ni({+36}Ar,|a2p|g), except
88MO2cG where noted.
88MO cG RI(X)$For SD bands, values are relative intensities within each band,
88MO2cG normalized to |?1 for the strongest transition in the band.
88MO cG M$From |g|g(|q)(DCO), |g|g(lin pol) in {+58}Ni({+36}Ar,|a2p|g)
88MO2cG (2007An21), except where noted.
88MO cG E(d)$Doublet transition
88MO cG M(a)$Stretched Q from R(DCO) in {+58}Ni({+36}Ar,|a2p|g), E2 from
88MO2cG assumed band structure (1992We02).
88MO cG M(g)$Stretched Q from R(DCO) {+58}Ni({+36}Ar,|a2p|g), M2 excluded by
88MO2cG comparison to RUL.
88MO cG M(b)$From R(DCO) measurements in {+58}Ni({+36}Ar,|a2p|g)
88MO2cG (1992We02,1994Ka20).
88MO cG M(s)$From R(DCO) in {+58}Ni({+40}Ca,2|a2p|g):SD
88MO cG MR$From |g(|q)(DCO) in {+58}Ni({+36}Ar,|a2p|g) (1994Ka20).
88MO cL E$From least-squares fit to E|g by evaluators.
88MO cL J$For levels populated in {+58}Ni({+36}Ar,|a2p|g) all E2 transitions
88MO2cL are of stretched character and spin assignments are made under the
88MO3cL assumption of increasing spin with increasing excitation energy,
88MO4cL except where noted.
88MO cL T$From Recoil distance Doppler-shift measurements in
88MO2cL {+58}Ni({+36}Ar,|a2p|g).
88MO CL BAND(F)$Yrast band.
88MO CL BAND(G)$Negative parity cascade.
88MO CL BAND(A)$SD-1 band (1999Bb13,2003La24,2004La21).
88MO2cL Q(intrinsic)=5.2 {I3} (2003La24), 6.0 {I+20-14} (1999Bb13).
88MO3cL Configuration=|p1/2[431]{+-1}5{+1}; |p=-, |a=1 (1999Bb13);
88MO4cL |n5{+2}|p5{+1} or |n5{+2}|p5{+0} (2003La24). Percent population |?1%
88MO5cL of the reaction channel
```


```
{
    "header": {
        "schemaVersion": "1.0",
        "documentType": "nuclide",
        "z": 42,
        "n": 46,
        "a": 88,
        "elementName": "Molybdenum",
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            }
        },
        "unit": "keV",
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```


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JSONSchema (https://json-schema.org/)

Schema validation:

- Defines schema and rules for a JSON document
- Can be used to validate documents prior to database changes
- Powerful conditional rules
- Automatically find errors in migration

```
{
  "name": "Mary",
  "age": 25
}
```

Document

```
{
  "properties": {
    "name": {
      "type": "string"
    },
    "age": {
      "type": "integer",
      "minimum": 0
    }
  }
}
```

Schema Definition

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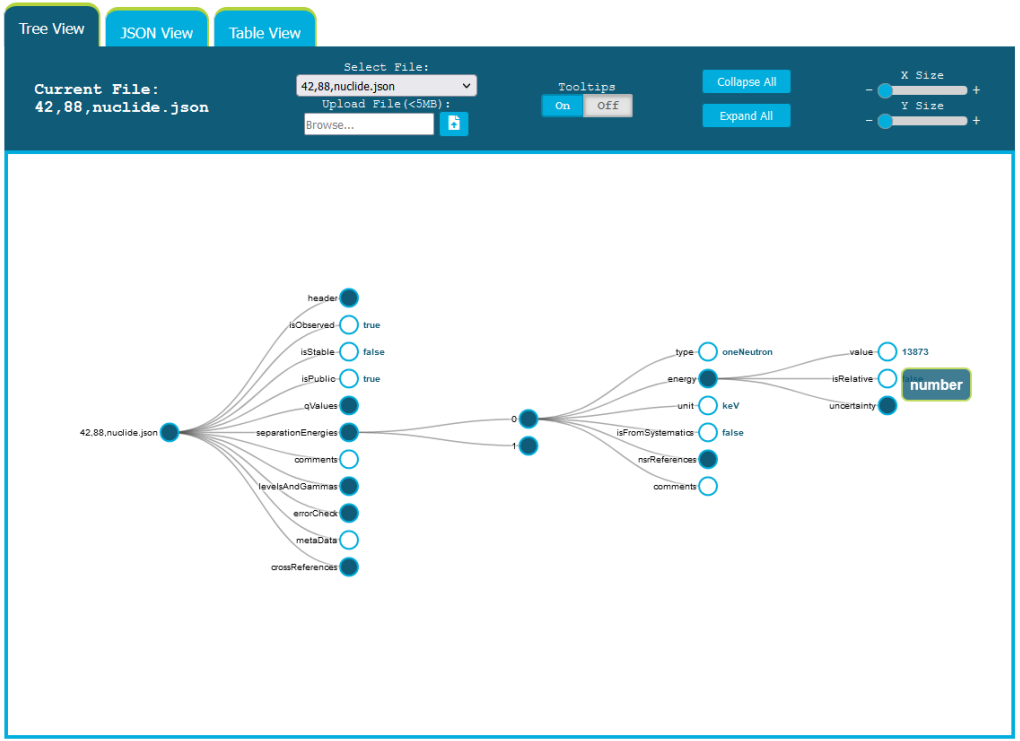
Tree Viewer (www.nndc.bnl.gov/ensdfschema)



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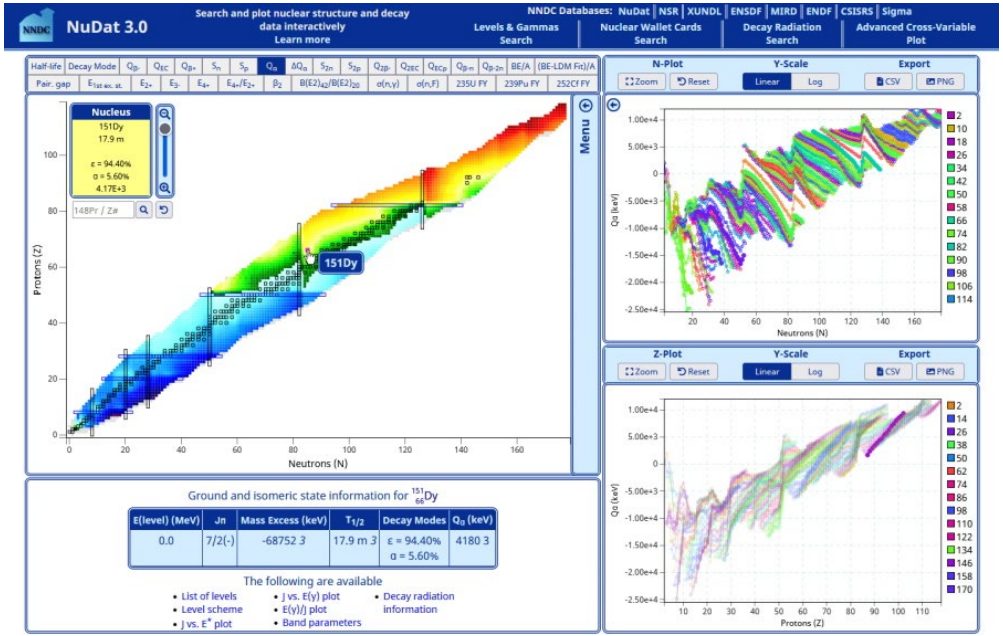
NuDat Overview

NuDat is the main application used to query and visualize nuclear data from **ENSDF**



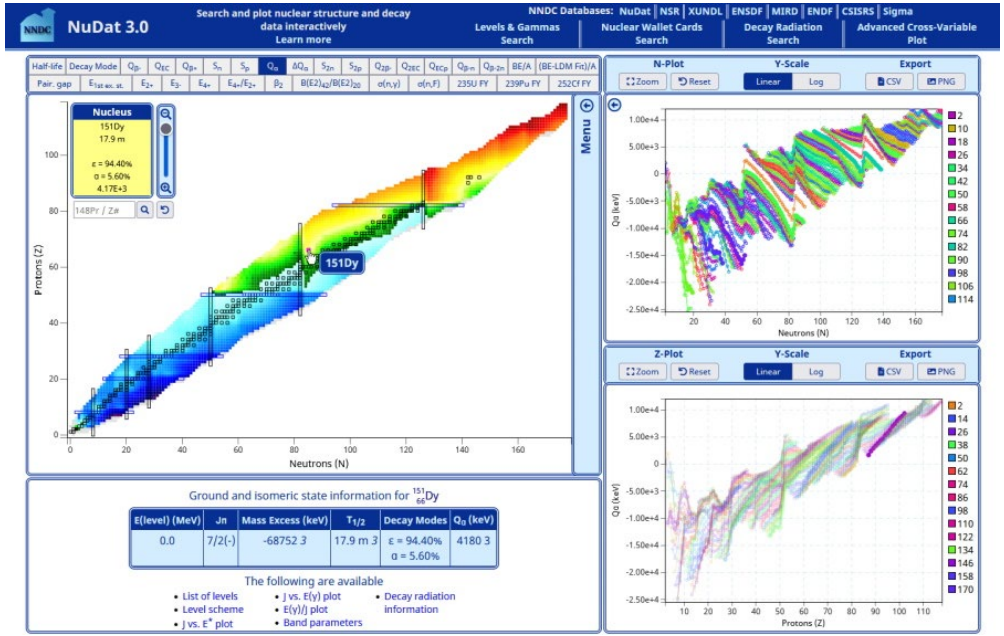
www.nndc.bnl.gov/nudat

NuDat Overview

NuDat is the main application used to query and visualize nuclear data from **ENSDF**

Search and visualize:

- Nuclear structure
- Nuclear decay
- Neutron-induced nuclear reactions



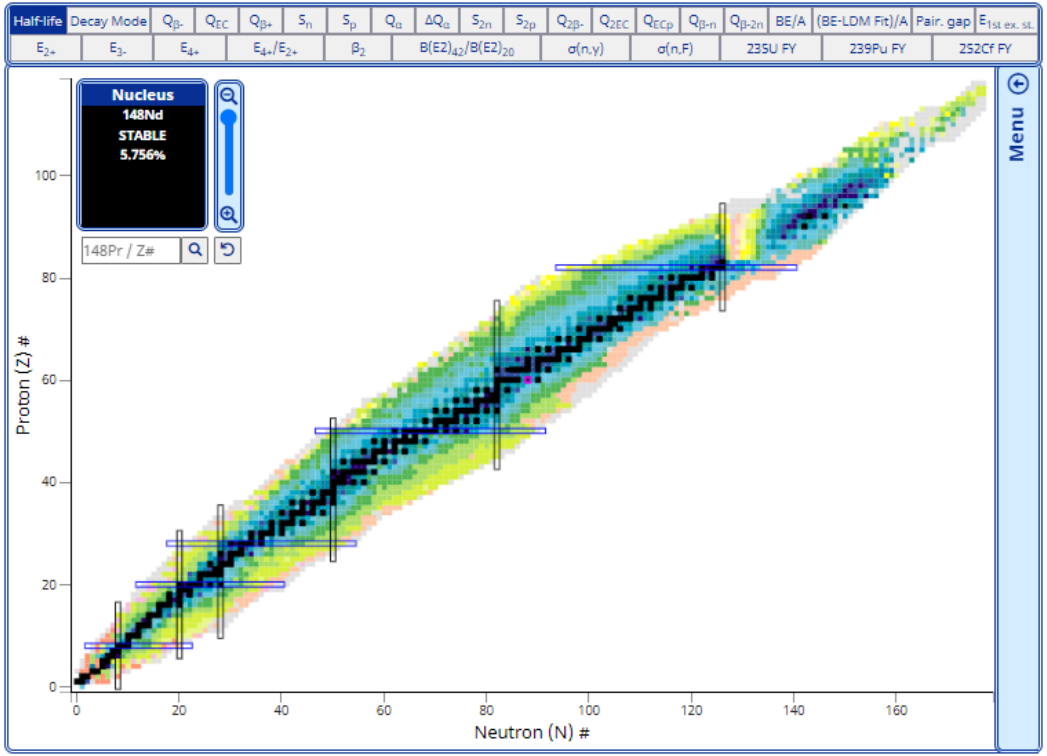
www.nndc.bnl.gov/nudat

NuDat 3.0

NuDat 3.0 supports exploring nuclear data using responsive visualizations

Fully interactive nuclide chart and 1-D plots

Smooth pan and zoom using intuitive gestures



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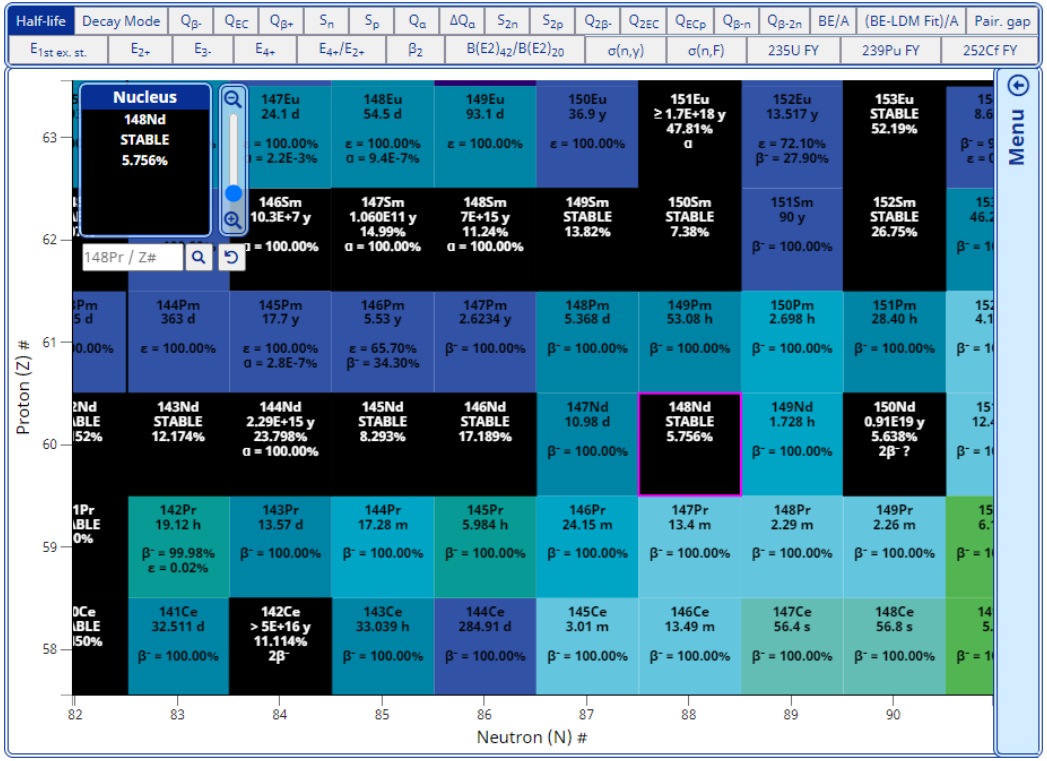
Features:

- **Interactive chart of nuclides**
- 1-D neutron and proton plots
- Data Filtering
- Export Data (CSV, PNG, Link)
- Additional Resources



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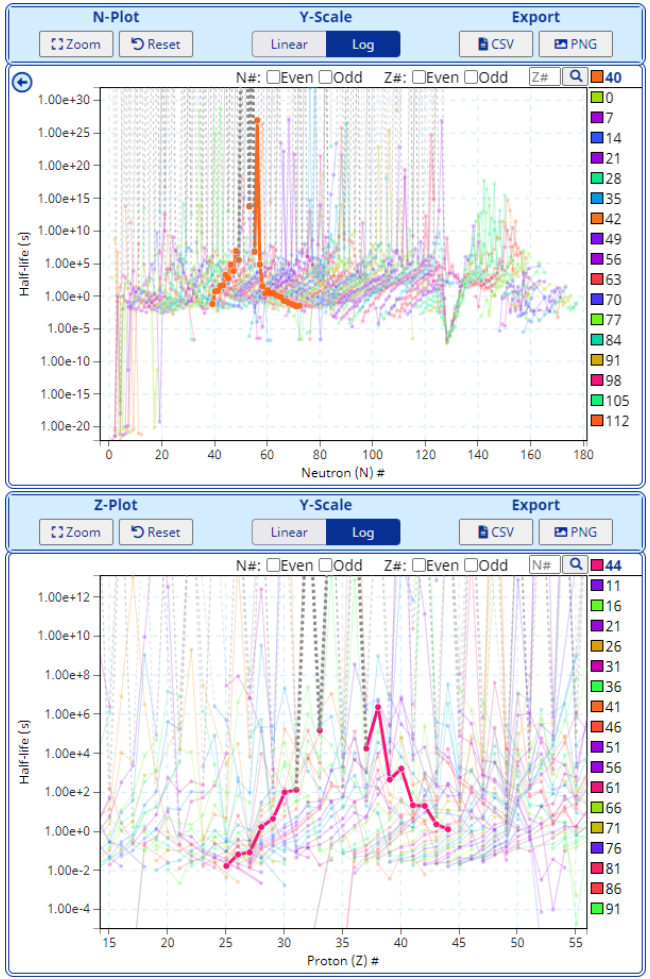

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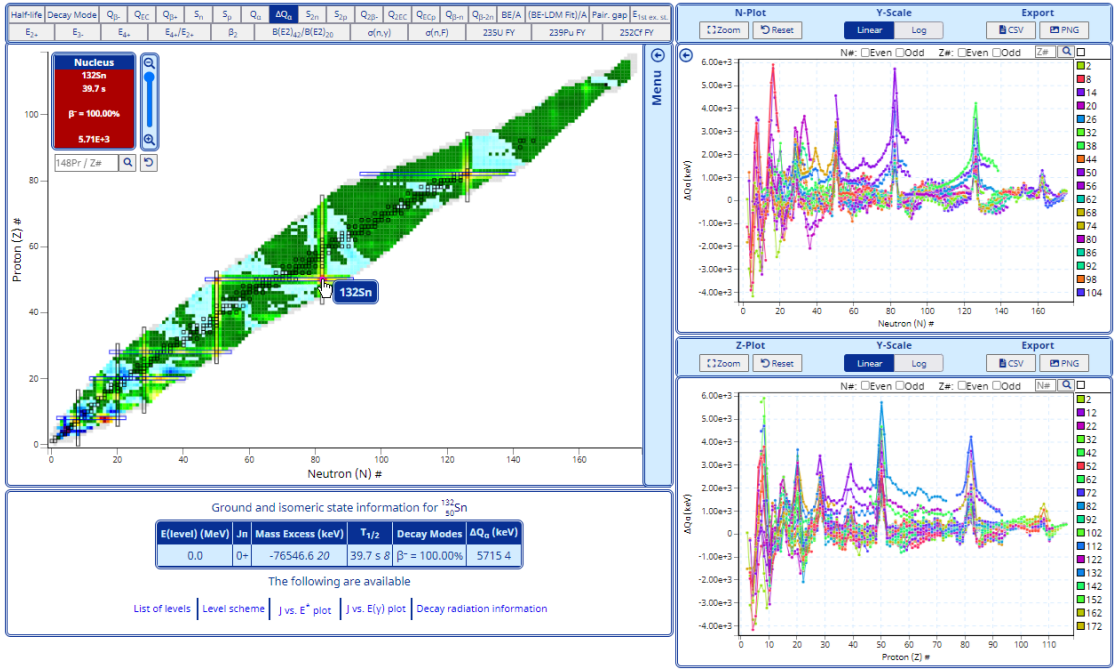
Synchronized 1-D Plots

Optionally sync plots:

1-D plots update to the current view of the chart of nuclides

Visualization of structures and patterns in the chart to extract underlying physics

$\Delta Q_\alpha = 0.5 \times (Q_\alpha(Z+2, N+2) - Q_\alpha(Z, N))$, in



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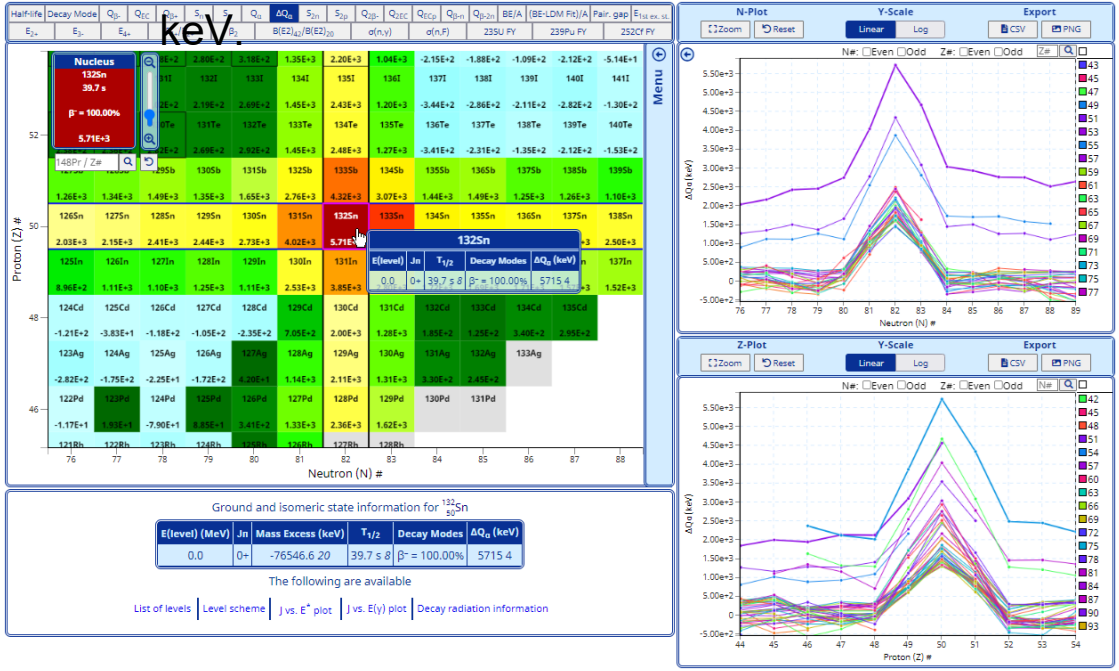
Visualize patterns in regions of chart, such as peaks

$\Delta Q_\alpha = 0.5 \times (Q_\alpha(Z+2, N+2) - Q_\alpha(Z, N))$, in keV.



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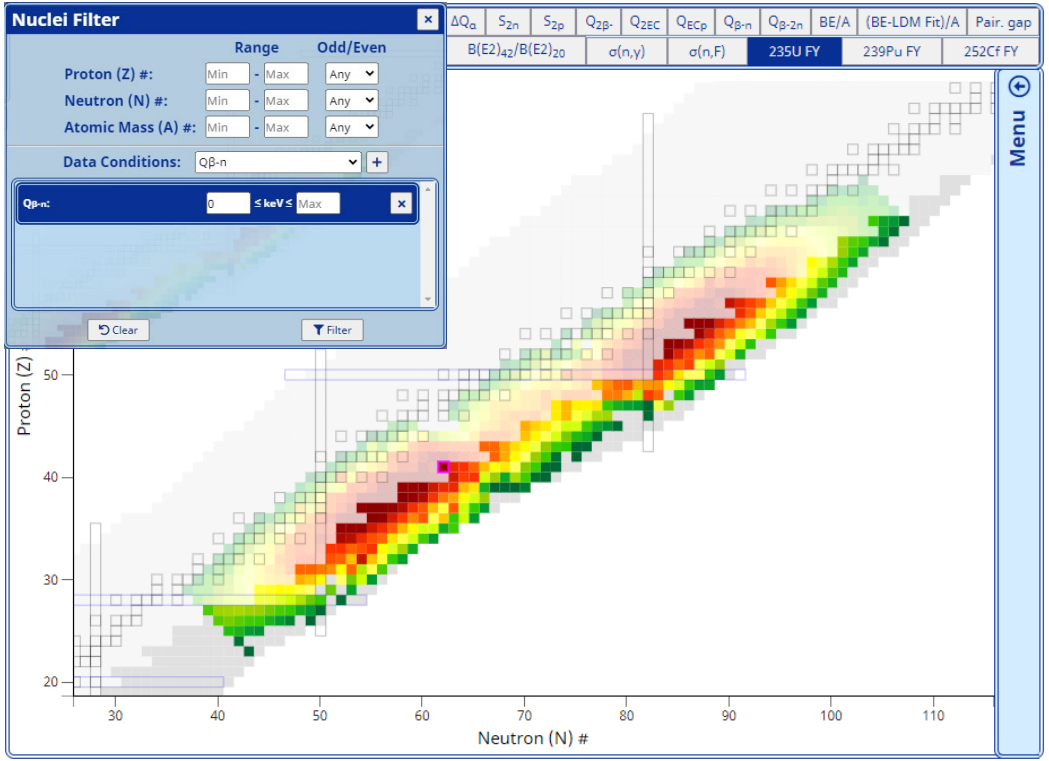

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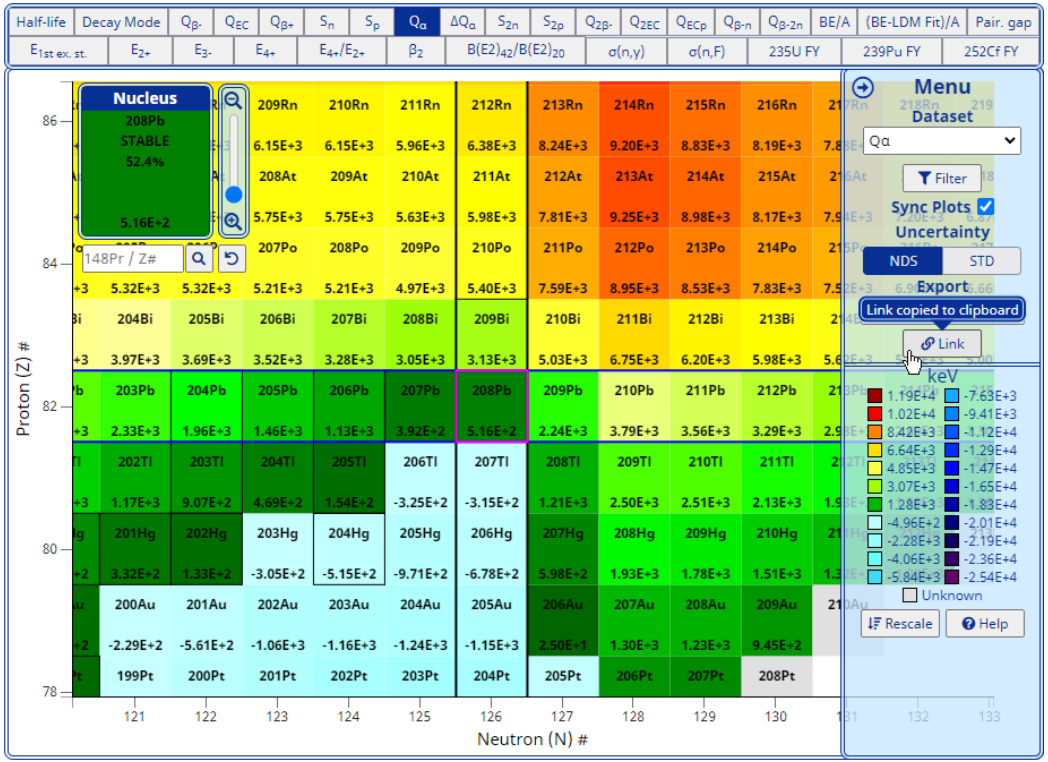

www.nndc.bnl.gov/nudat3/?x=-9.29&y=-3.88&k=13.92&z=82&n=126&mode=7

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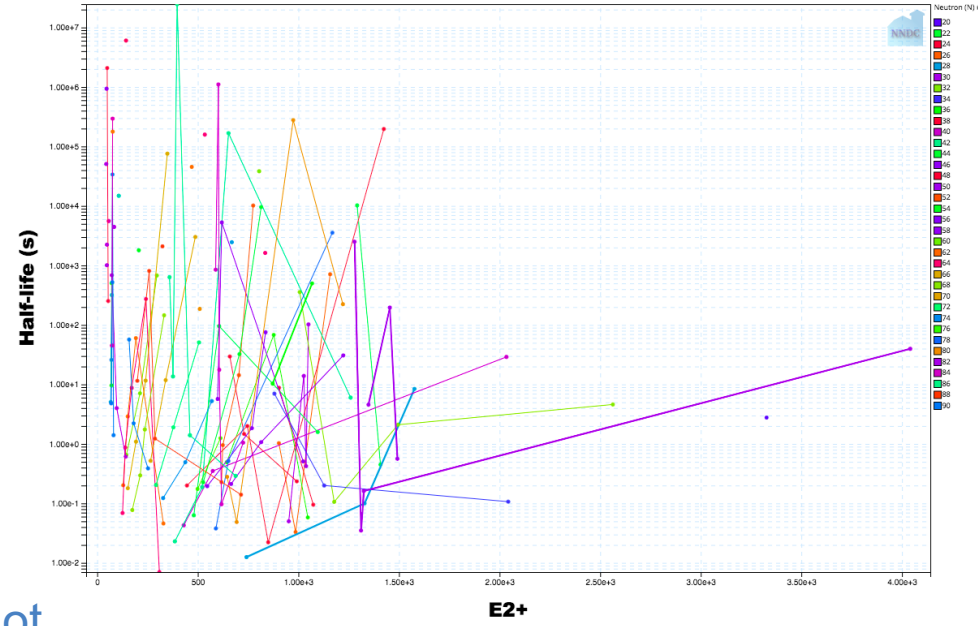
Advanced Cross-Variable Plot

Plot observable nuclear properties as functions of each other with customizable settings

Options:

- Grouping data by Z, N, or A
- Setting axis scales
- Displaying lines/uncertainty bars
- Data filtering
- Highlighting selections



www.nndc.bnl.gov/nudat3/advancedplot

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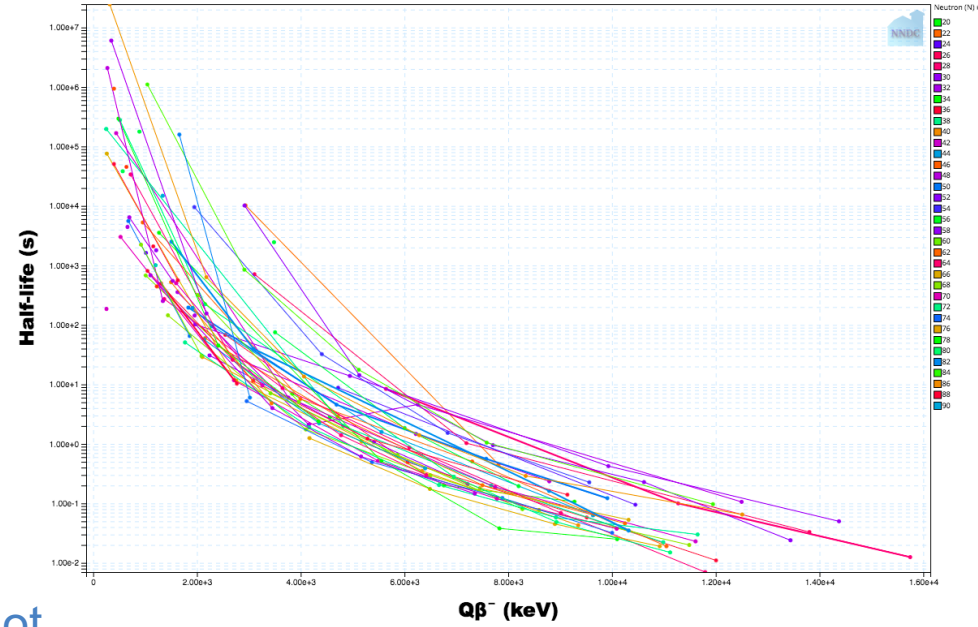

www.nndc.bnl.gov/nudat3/advancedplot

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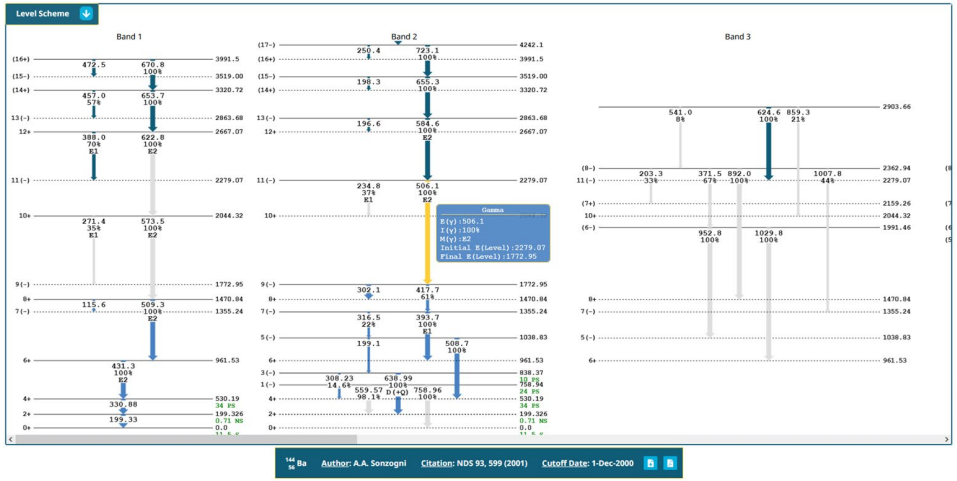
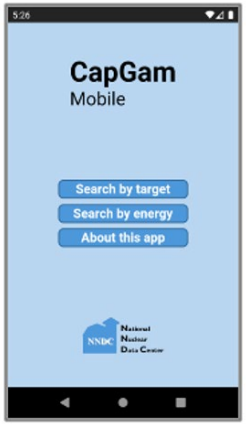
Future Work

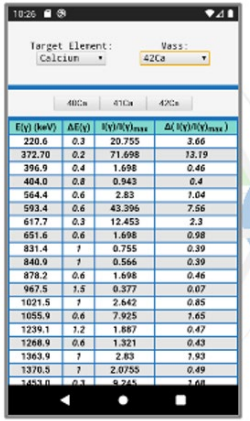
Interactive Level Schemes

Modernizing Web Applications for Nuclear Reaction Data

Wallet Cards Mobile Applications





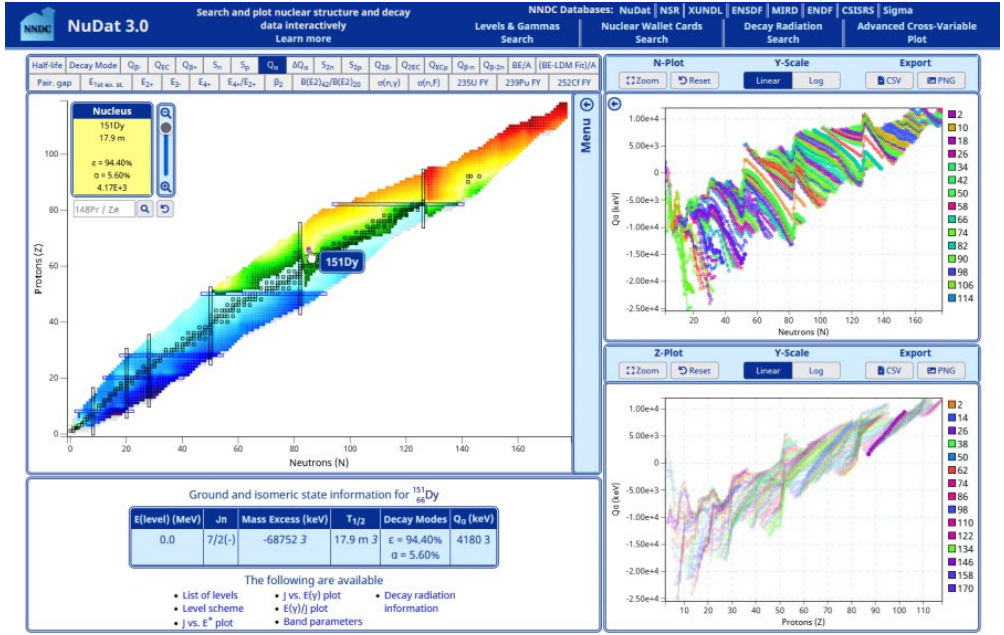


Contact Us

NuDat 3 is available here:
www.nndc.bnl.gov/nudat3/

Improvements based on community feedback

We encourage you to send us your feedback and suggestions



Donnie Mason - dmason@bnl.gov

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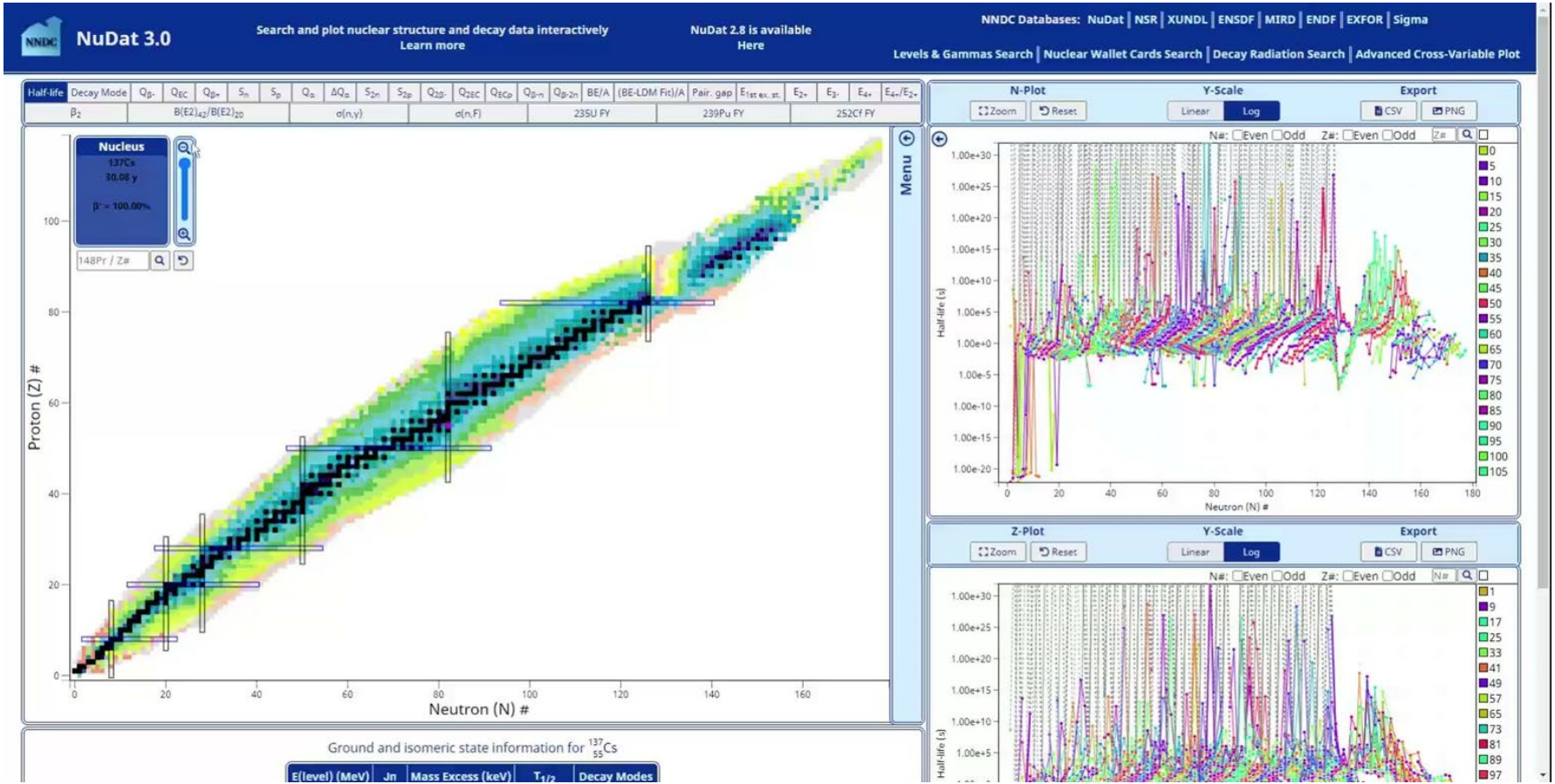
Thank you!


NuDat 3.0
Search and plot nuclear structure and decay data interactively
Learn more
NuDat 2.8 is available
Here
NNDC Databases: NuDat | NSR | XUNDL | ENSDF | MIRD | ENDF | EXFOR | Sigma
Levels & Gammas Search | Nuclear Wallet Cards Search | Decay Radiation Search | Advanced Cross-Variable Plot
Half-life | Decay Mode | Qβ- | QEC | Qβ+ | Sn | Sp | Qα | ΔQα | S2n | S2p | Q2β- | Q2EC | QECp | Qβ-n | Qβ-2n | BE/A | (BE-LDM Fit)/A | Pair. gap | E1st ex. st. | E2+ | E3- | E4+ | E4+/E2+
β2 | B(E2)42/B(E2)20 | σ(n,γ) | σ(n,F) | 235U FY | 239Pu FY | 252Cf FY
Nucleus
137Cs
30.08 y
β- = 100.00%
148Pr / Z#
Proton (Z) #
Neutron (N) #
Menu
Ground and isomeric state information for 137 55 Cs
E(level) (MeV) | Jπ | Mass Excess (keV) | T1/2 | Decay Modes
N-Plot
Y-Scale
Export
Zoom
Reset
Linear
Log
CSV
PNG
N#: Even Odd Z#: Even Odd
Half-life (s)
Neutron (N) #
Z-Plot
Y-Scale
Export
Zoom
Reset
Linear
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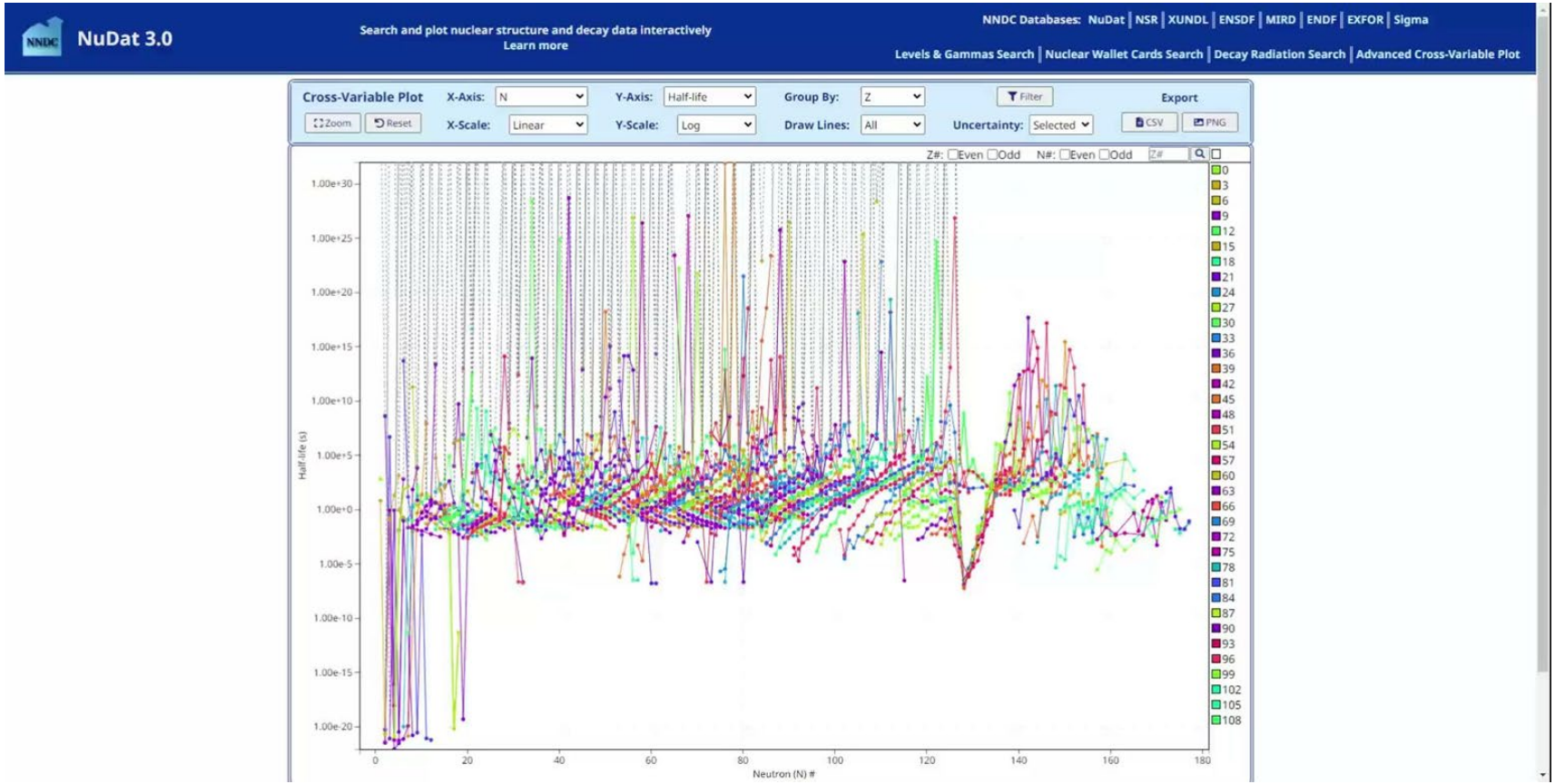
N#: Even Odd Z#: Even Odd
Half-life (s)



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