Brookhaven National Laboratory

U.S. DEPARTMENT of ENERGY

Nuclear Data

Chris Morse

6/25/2026

@BrookhavenLab

This material is based upon work supported by the U.S. Department of Energy, Office of Science, Office of Nuclear Physics under Contract No. DE-AC02-98CH10886

EBSS 2026

BNL-9403630

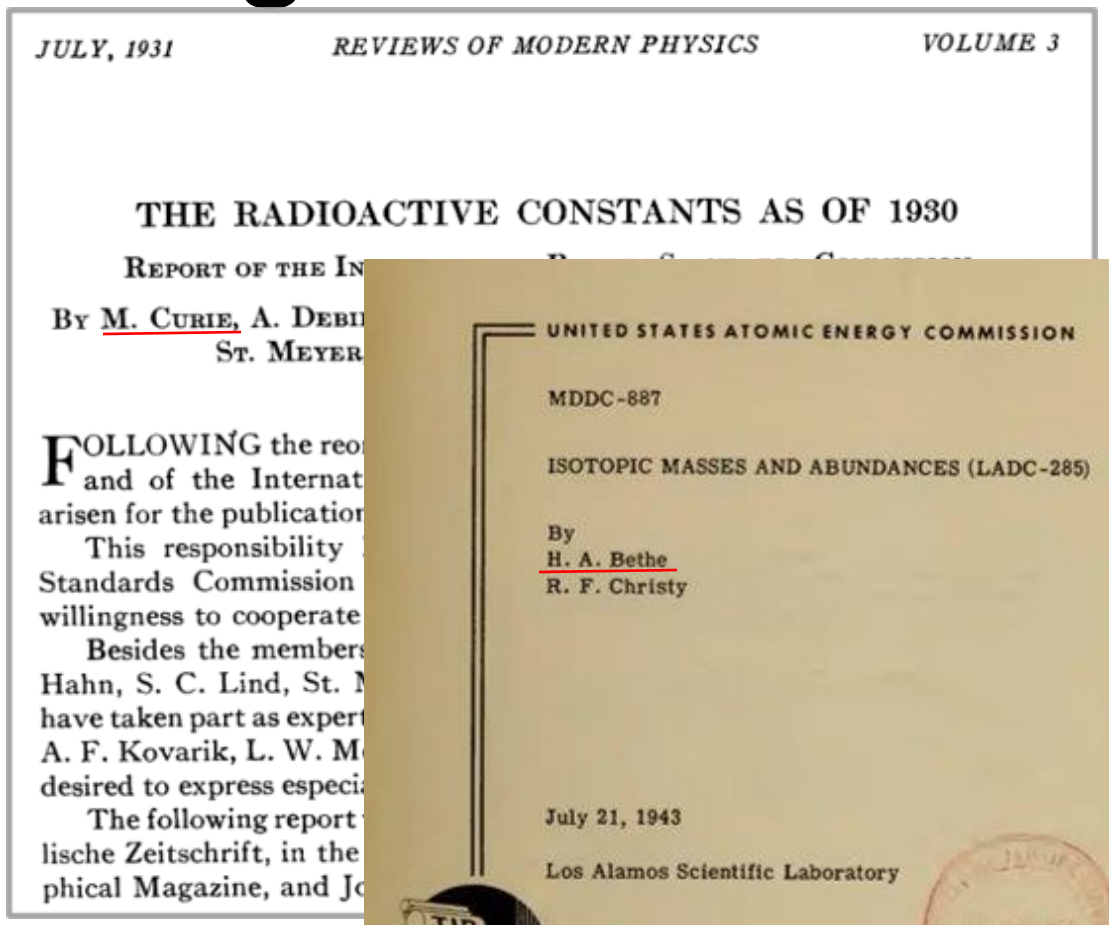
Outline

- Who and what is "the data program?"
- NNDC web services
- ENSDF API introduction

Many of the following slides are c/o David Brown, Elizabeth Ricard, and Alejandro Sonzogni

Origins of the Data Program

The need for up-to-date information on the atomic nucleus has been recognized since the earliest days of nuclear science.



JULY, 1931 REVIEWS OF MODERN PHYSICS VOLUME 3

THE RADIOACTIVE CONSTANTS AS OF 1930

REPORT OF THE IN

BY M. CURIE, A. DEBI
ST. MEYER

FOLLOWING the reo
and of the Internat
arisen for the publicatio
This responsibility
Standards Commission
willingness to cooperate
Besides the member
Hahn, S. C. Lind, St. M
have taken part as expert
A. F. Kovarik, L. W. M
desired to express especi
The following report
lische Zeitschrift, in the
phical Magazine, and Jo

UNITED STATES ATOMIC ENERGY COMMISSION

MDDC-887

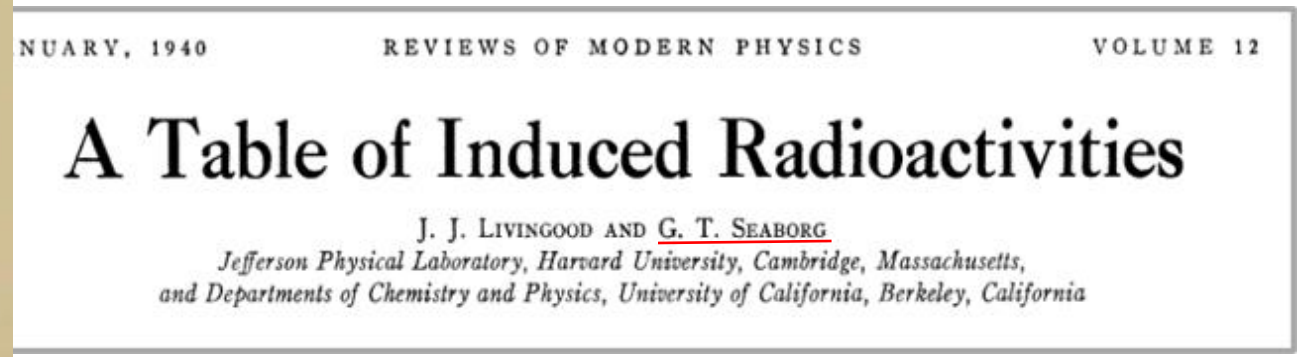
ISOTOPIC MASSES AND ABUNDANCES (LADC-285)

By
H. A. Bethe
R. F. Christy

July 21, 1943

Los Alamos Scientific Laboratory

Technical Information Division, ORE, Oak Ridge, Tennessee

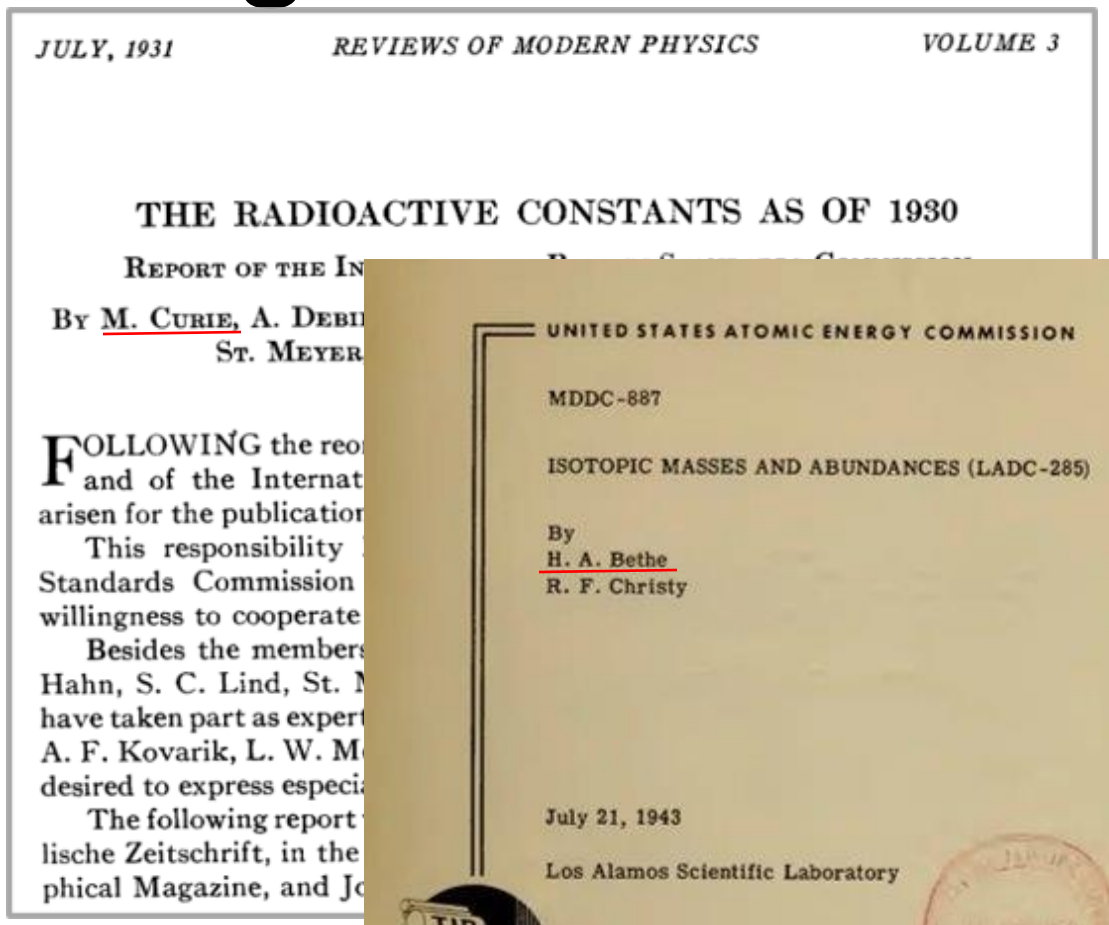


NUARY, 1940 REVIEWS OF MODERN PHYSICS VOLUME 12

A Table of Induced Radioactivities

J. J. LIVINGOOD AND G. T. SEABORG
Jefferson Physical Laboratory, Harvard University, Cambridge, Massachusetts, and Departments of Chemistry and Physics, University of California, Berkeley, California

Origins of the Data Program



JULY, 1931 REVIEWS OF MODERN PHYSICS VOLUME 3

THE RADIOACTIVE CONSTANTS AS OF 1930

REPORT OF THE IN

BY M. CURIE, A. DEBI
ST. MEYER

FOLLOWING the reo
and of the Internat
arisen for the publicatio
This responsibility
Standards Commission
willingness to cooperate
Besides the member
Hahn, S. C. Lind, St. M
have taken part as expert
A. F. Kovarik, L. W. M
desired to express especi
The following report
lische Zeitschrift, in the
phical Magazine, and Jo

UNITED STATES ATOMIC ENERGY COMMISSION

MDDC-887

ISOTOPIC MASSES AND ABUNDANCES (LADC-285)

By
H. A. Bethe
R. F. Christy

July 21, 1943

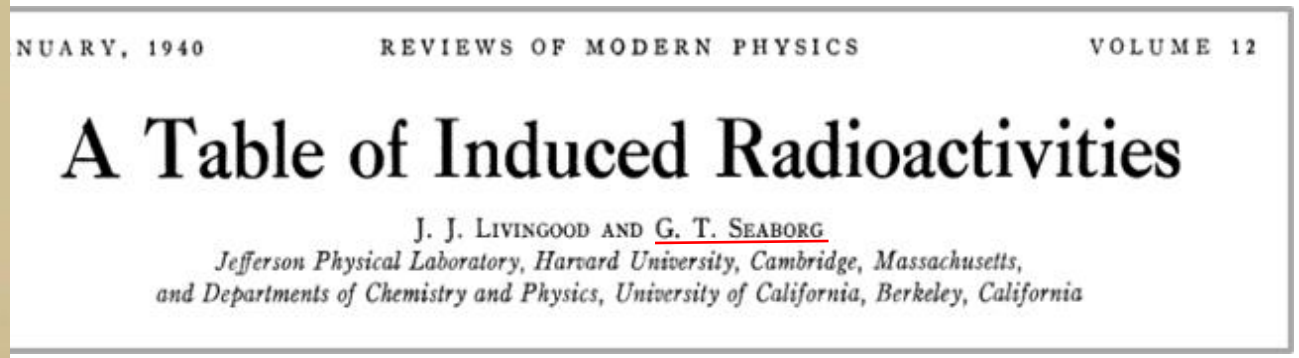
Los Alamos Scientific Laboratory

Technical Information Division, ORE, Oak Ridge, Tennessee

The need for up-to-date information on the atomic nucleus has been recognized since the earliest days of nuclear science.

In 1977, several programs coalesced to form the National Nuclear Data Center

See CSEWG 35th Anniversary Retrospective (BNL-52675) for a history of early US nuclear data efforts: https://doi.org/10.2172/15020989



NUARY, 1940 REVIEWS OF MODERN PHYSICS VOLUME 12

A Table of Induced Radioactivities

J. J. LIVINGOOD AND G. T. SEABORG
Jefferson Physical Laboratory, Harvard University, Cambridge, Massachusetts, and Departments of Chemistry and Physics, University of California, Berkeley, California

The Data Program today

The US Nuclear Data Program (USNDP)

- Formal program under the US Department of Energy, Office of Science – Nuclear Physics program
- NNDC is lead unit
- USNDP creates ENSDF, NSR, and is area #1 lead for EXFOR

The Data Program today

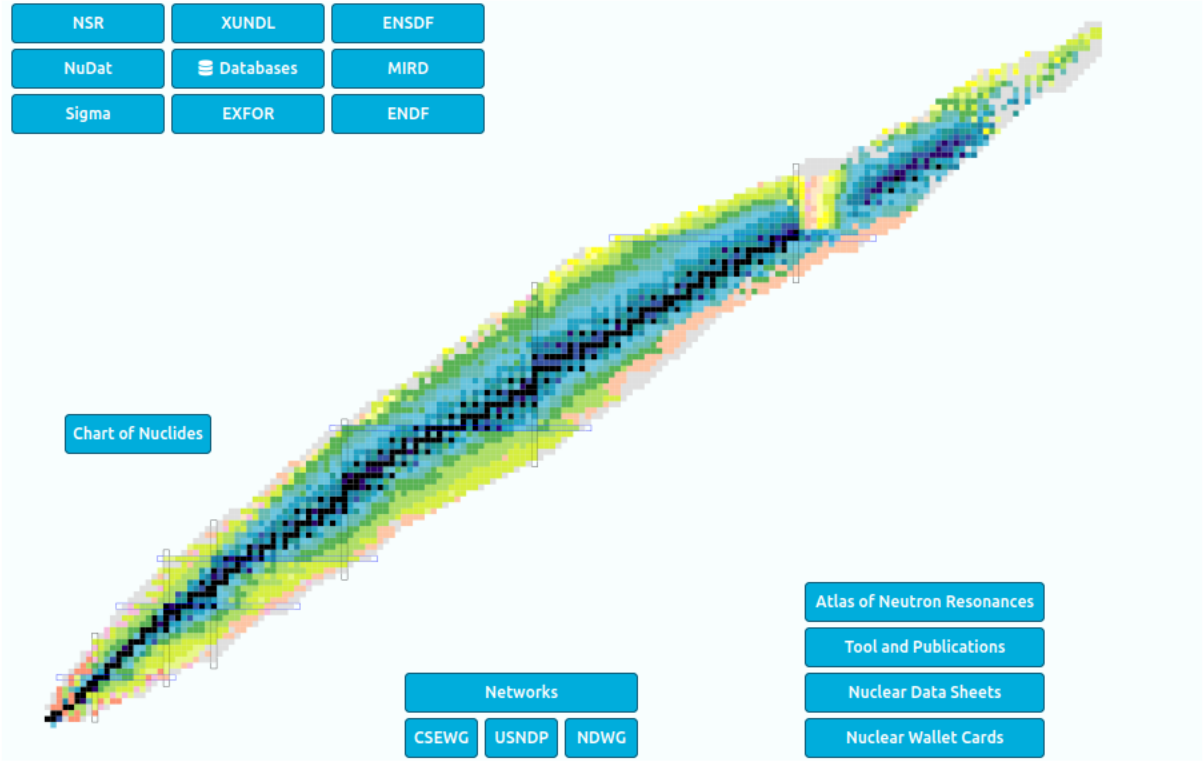
The US Nuclear Data Program (USNDP)

- Formal program under the US Department of Energy, Office of Science – Nuclear Physics program
- NNDC is lead unit
- USNDP creates ENSDF, NSR, and is area #1 lead for EXFOR

The US nuclear data programs

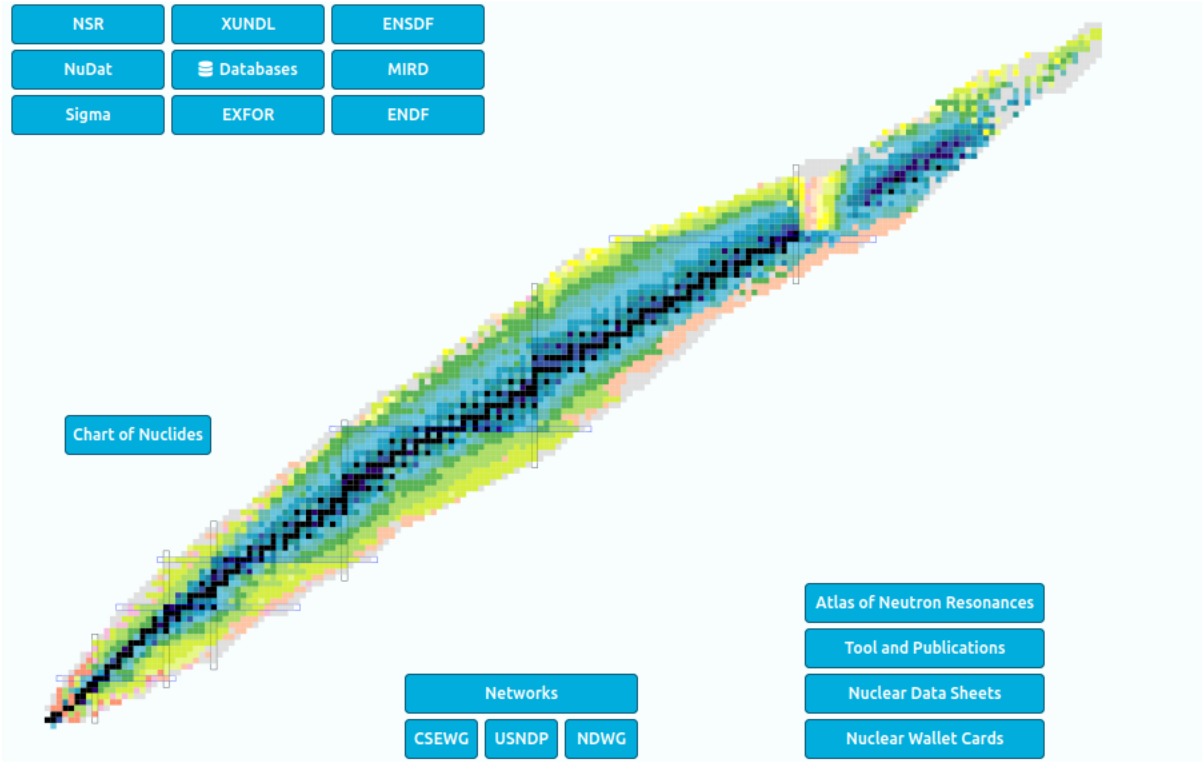
- The USNDP
- But also
  - The Nuclear Criticality Safety Program has ND interests
  - DOE Nuclear Energy Program
  - DOE Fusion Energy Program
  - Defense Nuclear Nonproliferation R&D Program
  - Defense Programs
  - NASA
  - …

Part II: NNDC web services



National Nuclear Data Center
Building 490
Brookhaven National Laboratory
Upton, NY 11973-5000
(631) 344-5590
nndc@bnl.gov

Contact Us



The most important function on this website!

National Nuclear Data Center
Building
Brookhaven National Laboratory
Upton, NY 11973-5000
(631) 344-5590
nndc@bnl.gov

Contact Us

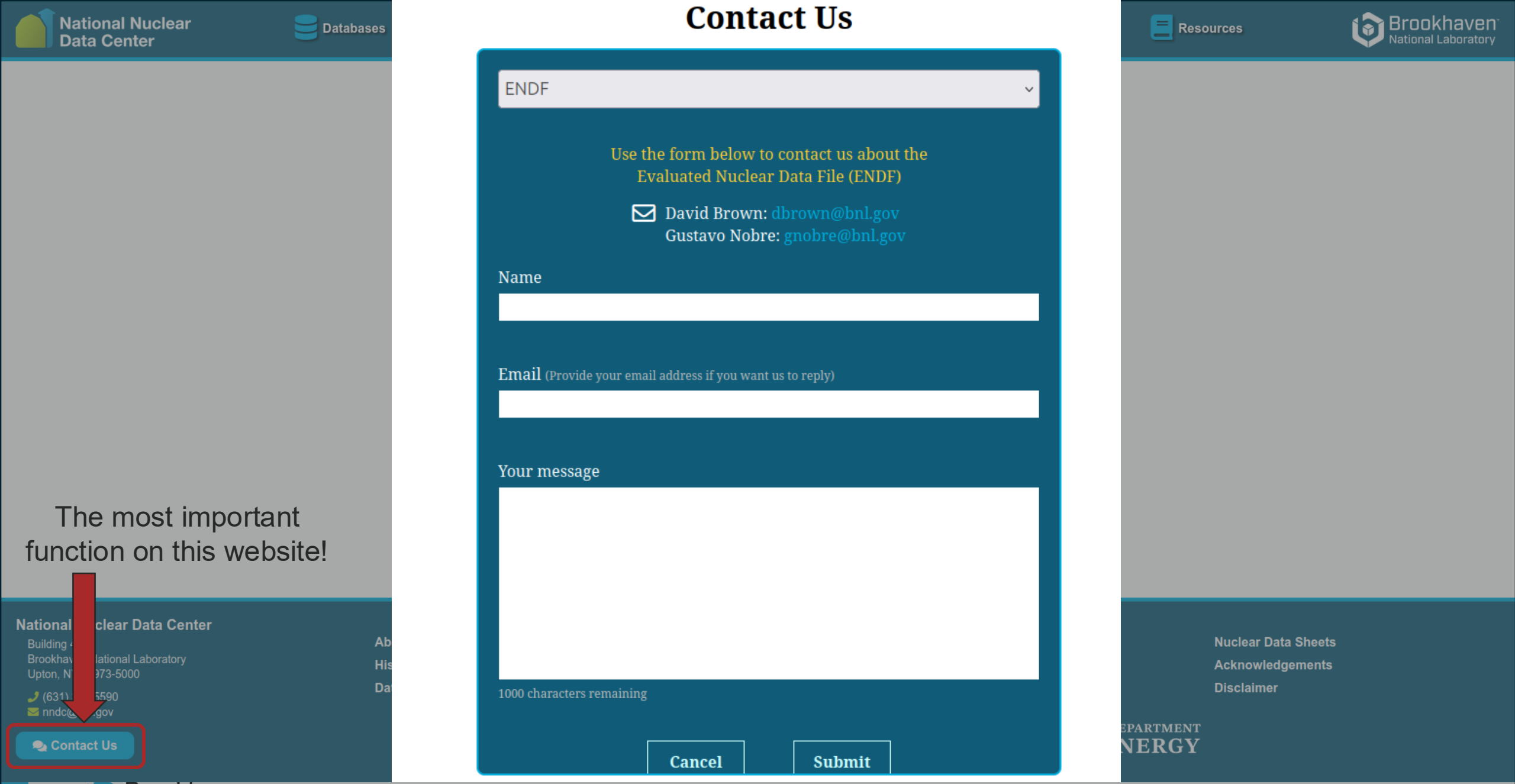
About
History
Databases

Networks
Tools & Codes
PuRe Data Resource

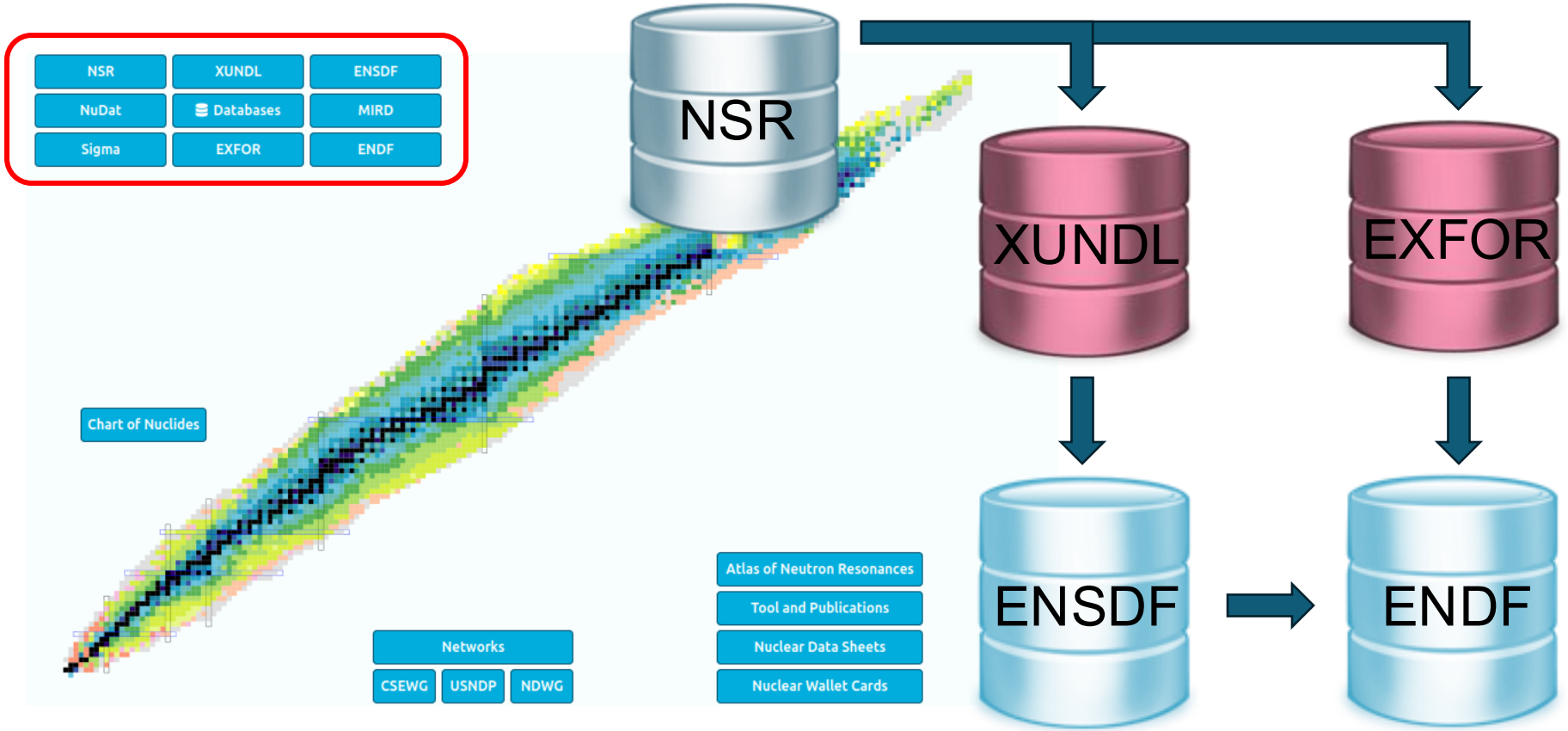
Nuclear Data Sheets
Acknowledgements
Disclaimer

Brookhaven National Laboratory

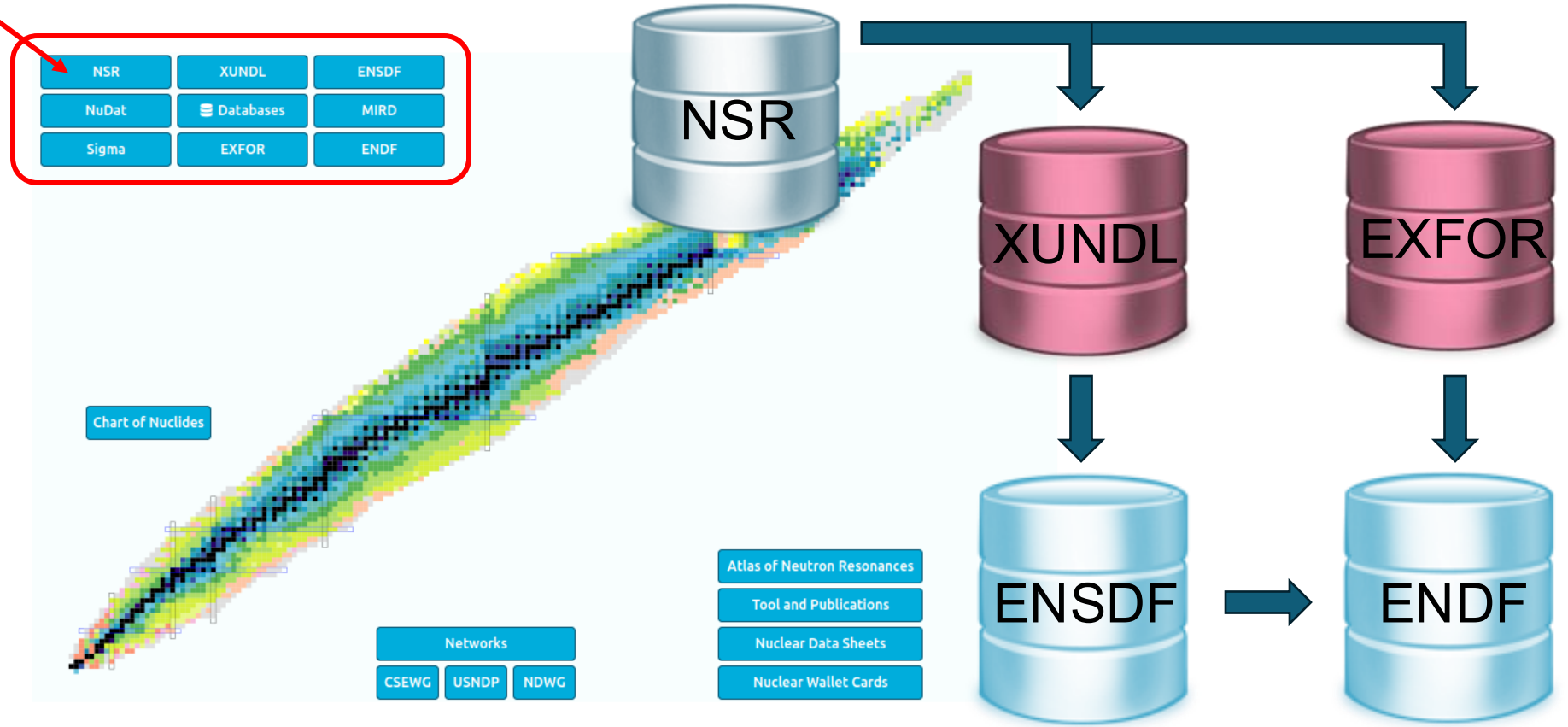
U.S. DEPARTMENT of ENERGY


National Nuclear Data Center
Databases
Resources
Brookhaven National Laboratory
Contact Us
ENDF
Use the form below to contact us about the Evaluated Nuclear Data File (ENDF)
David Brown: dbrown@bnl.gov
Gustavo Nobre: gnobre@bnl.gov
Name
Email (Provide your email address if you want us to reply)
Your message
1000 characters remaining
Cancel
Submit
The most important function on this website!
Contact Us
Nuclear Data Sheets
Acknowledgements
Disclaimer

- Bibligraphic
  - NSR
- Reactions:
  - EXFOR
  - ENDF
- Structure
  - XUNDL
  - ENSDF
- Interactive
  - NuDat

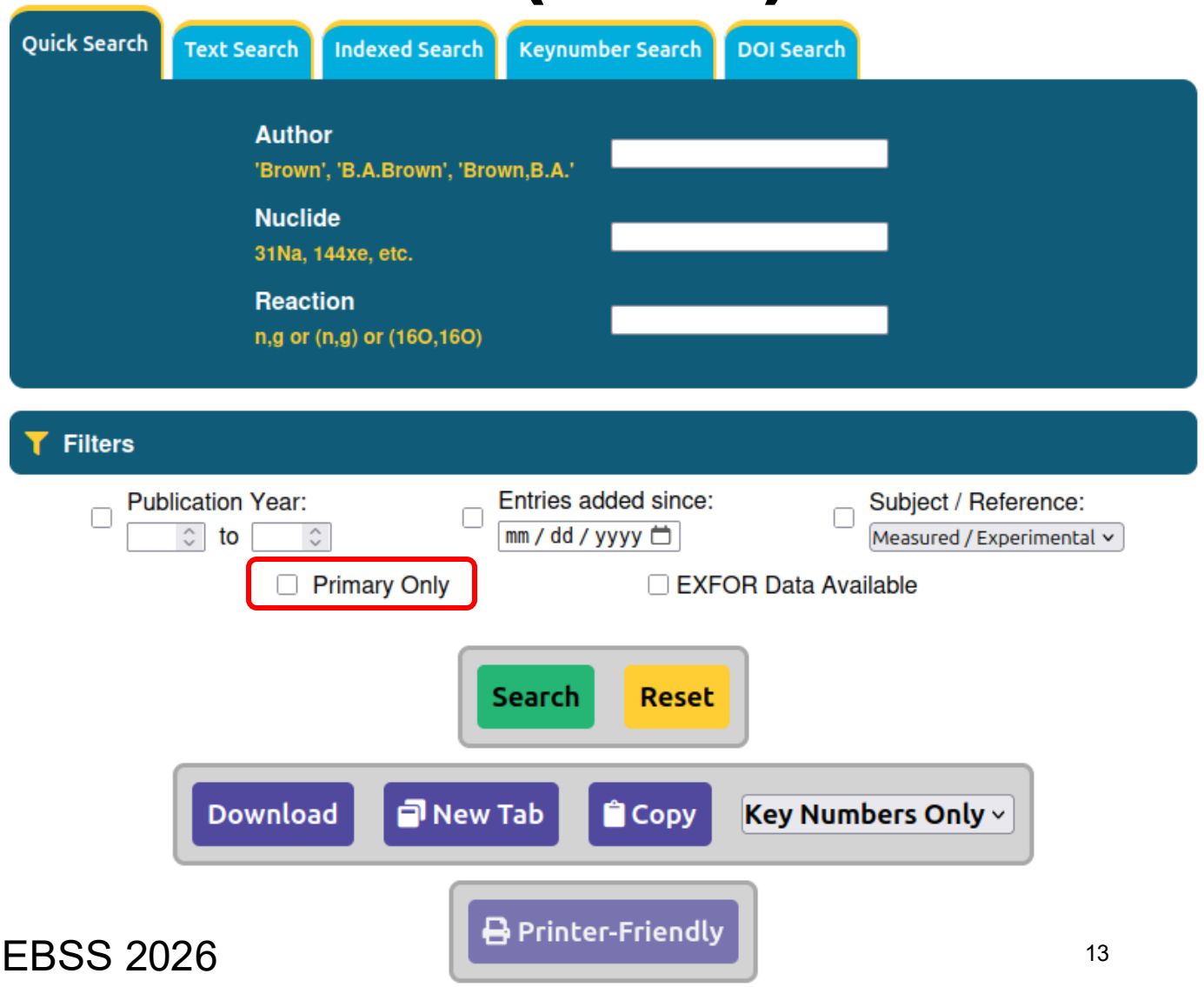


- Bibligraphic
  - **NSR**
- Reactions:
  - EXFOR
  - ENDF
- Structure
  - XUNDL
  - ENSDF
- Interactive
  - NuDat



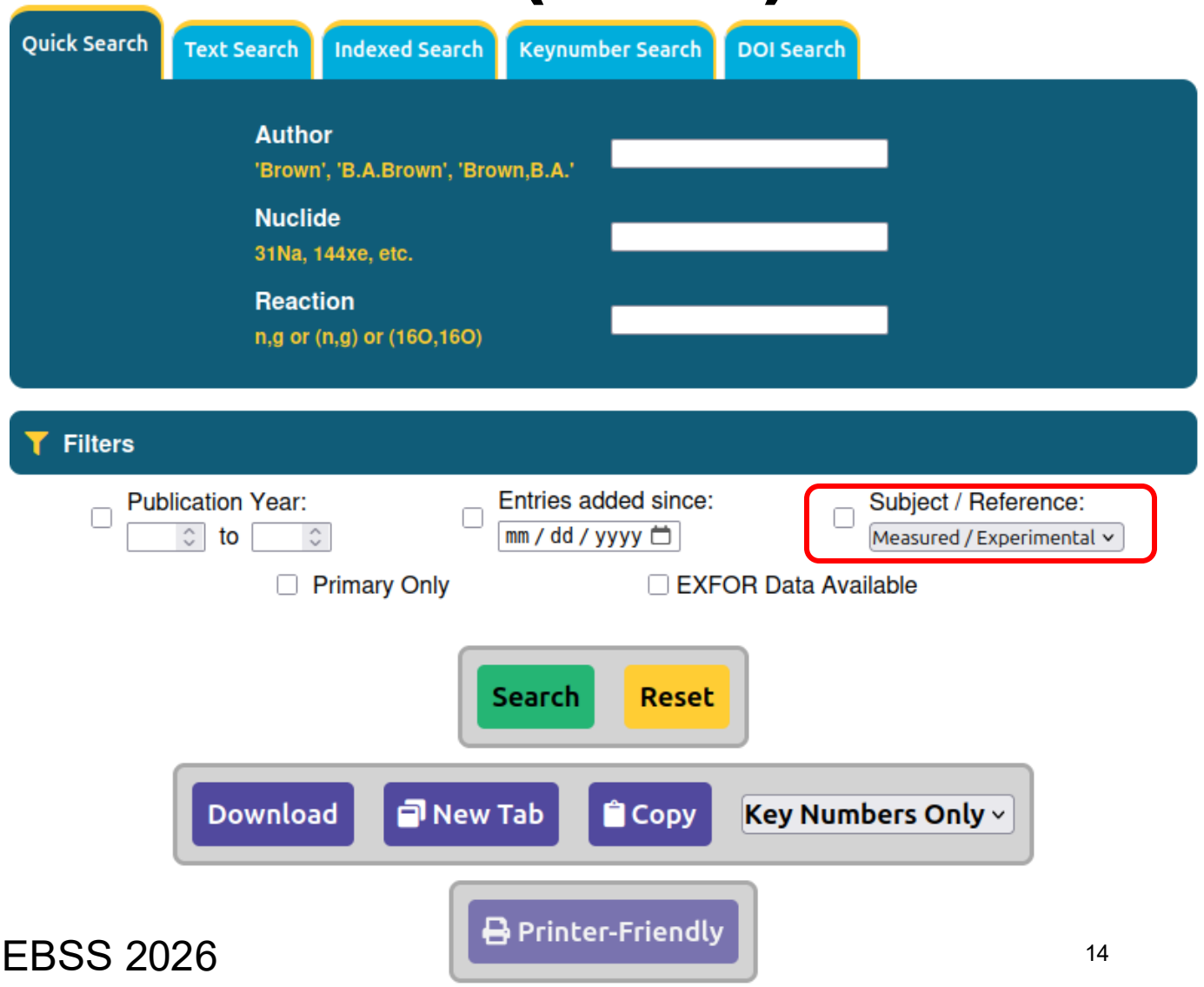
Nuclear Science References (NSR)

- Entry point to the nuclear-data pipeline
- ~250k bibliographic entries in database
- The "key number" is the primary key for the database
- Two kinds of reference:
  - Primary: 1967Al21
  - Secondary: 1988RuZZ



Nuclear Science References (NSR)

- Entry point to the nuclear-data pipeline
- ~250k bibliographic entries in database
- The "key number" is the primary key for the database
- Two kinds of reference:
  - Primary: 1967Al21
  - Secondary: 1988RuZZ
- Filters are extremely helpful
  - Err on the side of being too broad

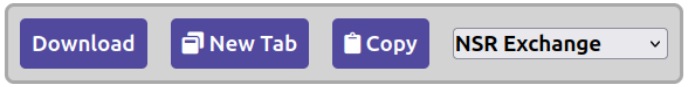


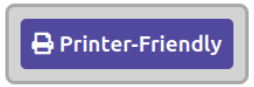
Nuclear Science References (NSR)

- Entry point to the nuclear-data pipeline
- ~250k bibliographic entries in database
- The "key number" is the primary key for the database
- Two kinds of reference:
  - Primary: 1967Al21
  - Secondary: 1988RuZZ
- Filters are extremely helpful
  - Err on the side of being too broad
- More granular search terms can be found by using "Indexed Search"

Nuclear Science References (NSR)

- Entry point to the nuclear-data pipeline
- ~250k bibliographic entries in database
- The "key number" is the primary key for the database
- Two kinds of reference:
  - Primary: 1967Al21
  - Secondary: 1988RuZZ
- Filters are extremely helpful
  - Err on the side of being too broad
- More granular search terms can be found by using "Indexed Search"
- "Keywords" are a structured summary of the referenced work





- **search-type**: 'quick'
- **subject-type**: 'measured'
- **nuclide**: '100Sn'
- **page**: '1'
- **size**: '100'

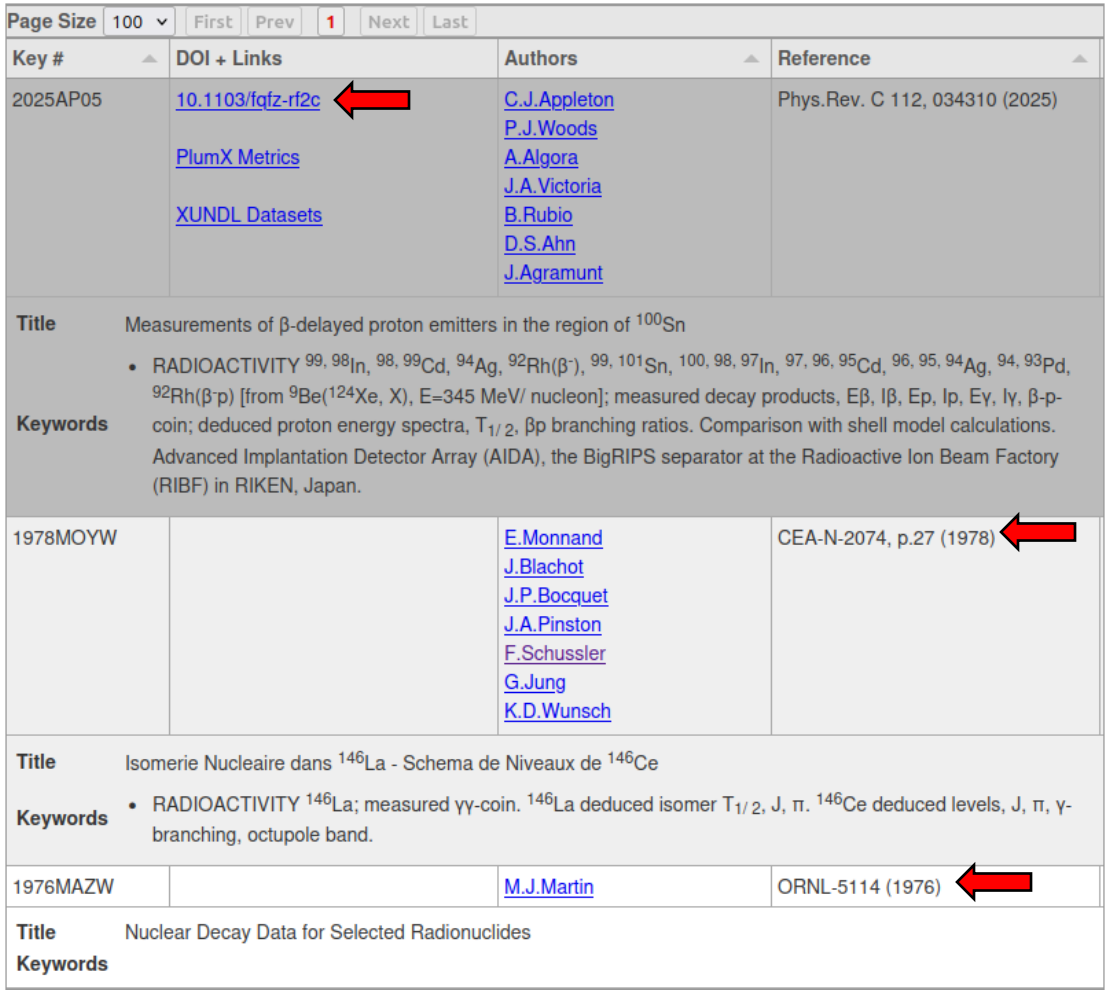
39 results found!

Page Size 100 | First | Prev | 1 | Next | Last

Key #	DOI + Links	Authors	Reference
2025AP05	10.1103/fqfz-rf2c PlumX Metrics XUNDL Datasets	C.J.Appleton P.J.Woods A.Algora J.A.Victoria B.Rubio D.S.Ahn J.Agramunt	Phys.Rev. C 112, 034310 (2025)
Title	Measurements of β-delayed proton emitters in the region of ^{100}Sn		
Keywords	• RADIOACTIVITY ^{99,98}In, ^{98,99}Cd, ^{94}Ag, ^{92}Rh(β$^-$), ^{99,101}Sn, ^{100,98,97}In, ^{97,96,95}Cd, ^{96,95,94}Ag, ^{94,93}Pd, ^{92}Rh(β$^-$p) [from ^{9}Be(^{124}Xe, X), E=345 MeV/ nucleon]; measured decay products, Eβ, Iβ, Ep, Ip, Eγ, Iγ, β-p-coin; deduced proton energy spectra, $T_{1/2}$, βp branching ratios. Comparison with shell model calculations. Advanced Implantation Detector Array (AIDA), the BigRIPS separator at the Radioactive Ion Beam Factory (RIBF) in RIKEN, Japan.		
2019XI06	10.1103/PhysRevC.100.034315 PlumX Metrics XUNDL Datasets	Y.Xiao S.Go R.Grzywacz R.Orlandi A.N.Andreyev M.Asai M.A.Bentley	Phys.Rev. C 100, 034315 (2019)

Nuclear Science References (NSR)

- Ideally, the DOI will be present, but not all references are journal articles
- Sometimes you will find citations to laboratory annual reports or similar documents.

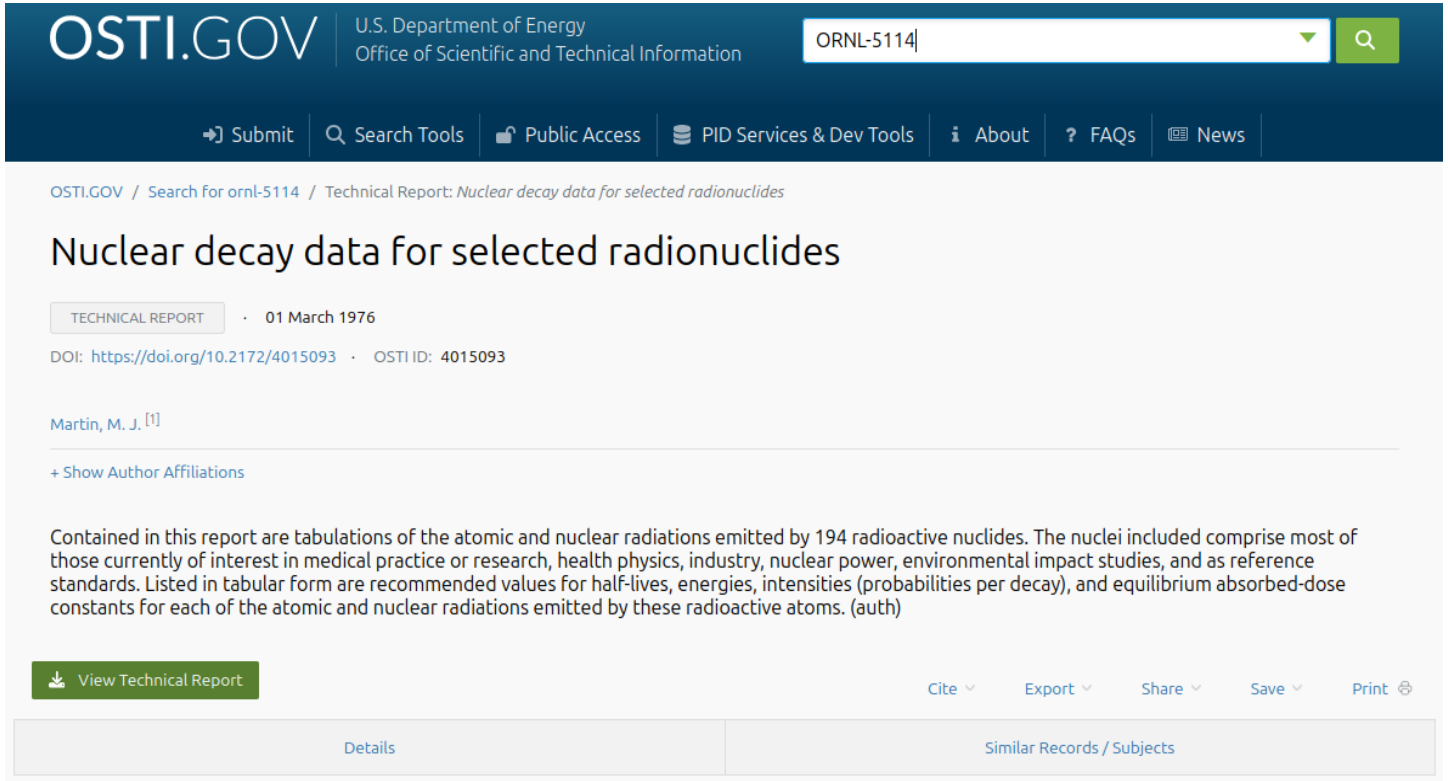


Page Size 100 First Prev 1 Next Last

Key #	DOI + Links	Authors	Reference
2025AP05	10.1103/fqfz-rf2c PlumX Metrics XUNDL Datasets	C.J.Appleton P.J.Woods A.Algora J.A.Victoria B.Rubio D.S.Ahn J.Agramunt	Phys.Rev. C 112, 034310 (2025)
Title	Measurements of β-delayed proton emitters in the region of ^{100}Sn		
Keywords	• RADIOACTIVITY ^{99,98}In, ^{98,99}Cd, ^{94}Ag, ^{92}Rh(β$^-$), ^{99,101}Sn, ^{100,98,97}In, ^{97,96,95}Cd, ^{96,95,94}Ag, ^{94,93}Pd, ^{92}Rh(β$^-$p) [from ^{9}Be(^{124}Xe, X), E=345 MeV/ nucleon]; measured decay products, Eβ, Iβ, Ep, Ip, Eγ, Iγ, β-p-coin; deduced proton energy spectra, $T_{1/2}$, βp branching ratios. Comparison with shell model calculations. Advanced Implantation Detector Array (AIDA), the BigRIPS separator at the Radioactive Ion Beam Factory (RIBF) in RIKEN, Japan.		
1978MOYW		E.Monnand J.Blachot J.P.Bocquet J.A.Pinston F.Schussler G.Jung K.D.Wunsch	CEA-N-2074, p.27 (1978)
Title	Isomerie Nucleaire dans ^{146}La - Schema de Niveaux de ^{146}Ce		
Keywords	• RADIOACTIVITY ^{146}La; measured γγ-coin. ^{146}La deduced isomer $T_{1/2}$, J, π. ^{146}Ce deduced levels, J, π, γ-branching, octupole band.		
1976MAZW		M.J.Martin	ORNL-5114 (1976)
Title	Nuclear Decay Data for Selected Radionuclides		
Keywords			

Nuclear Science References (NSR)

- Ideally, the DOI will be present, but not all references are journal articles
- Sometimes you will find citations to laboratory annual reports or similar documents.
- There are a couple of places to look:
  - OSTI is actively digitizing legacy documents and making them available to the public



Nuclear Science References (NSR)

- Ideally, the DOI will be present, but not all references are journal articles
- Sometimes you will find citations to laboratory annual reports or similar documents.
- There are a couple of places to look:
  - OSTI is actively digitizing legacy documents and making them available to the public
  - For documents from international organizations, the IAEA INIS system is a good place to look

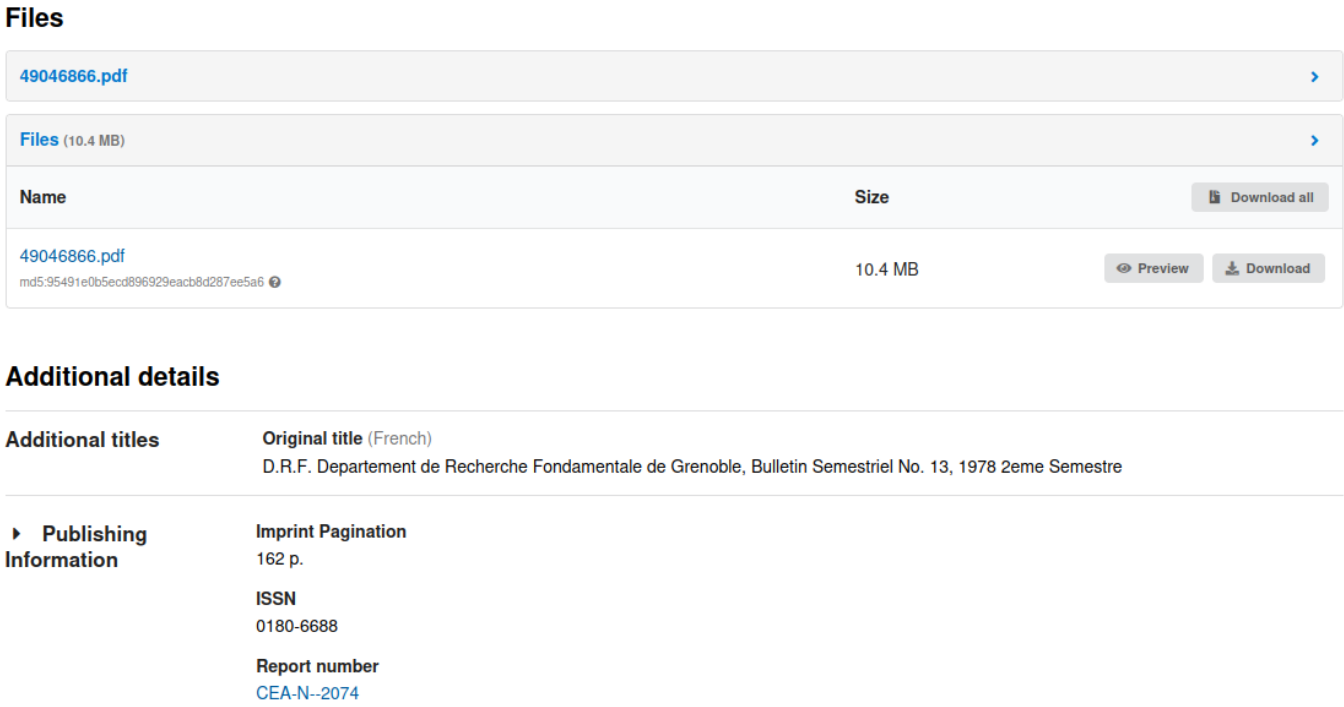
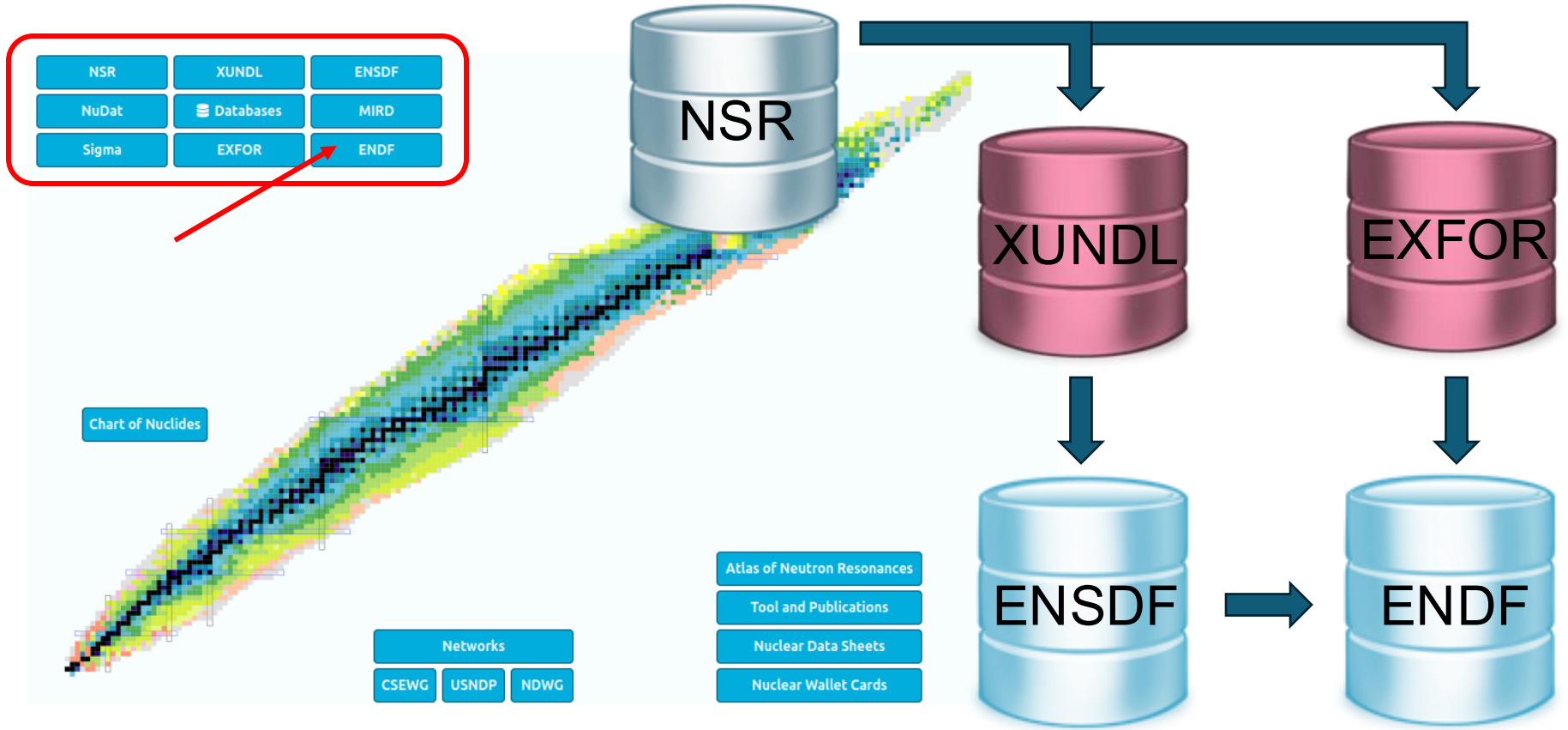


Image screen-captured from https://inis.iaea.org June 5, 2026

- Bibligraphic
  - NSR
- Reactions:
  - EXFOR
  - **ENDF**
- Structure
  - XUNDL
  - ENSDF
- Interactive
  - NuDat



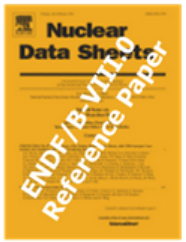
Evaluated Nuclear Data File

Evaluated Nuclear Data File (ENDF)

Try the updated ENDF landing page — ENDF Library

ENDF/B VIII.1 — ENDF/B-VIII.1 released August 30, 2024 — Download Here

I highly recommend the new landing page!



ENDF/B-VIII.0 fully incorporates the new Neutron Data Standards, includes improved thermal neutron scattering data and uses new evaluated data from the Coordinated International Evaluation Library Organization (CIELO) pilot project for neutron reactions on ^{1}H, ^{16}O, ^{56}Fe, ^{235}U, ^{238}U and ^{239}Pu.

Notable advances include updated evaluated data for light nuclei, structural materials, actinides, fission energy release, prompt fission neutron and gamma-ray spectra, thermal neutron scattering data, and charged-particle reactions.

These search functions take you to the IAEA EXFOR site

Basic Retrieval | Extended Retrieval | Advanced Retrieval | Help | SigmA Retrieval

Target — *56fe; fe-56; 26-fe-56; fe**

Reaction — *n,*; n,tot; n,g; n,f; n,inl; n,nu**

Quantity — *sig; da; de; da/de; res; cov**

Library: All / Selected / Reset

- ENDF/B-VIII.0 (USA, 2018)
- ENDF/B-VII.1 (USA, 2011)
- JEFF-3.3 (Europe, 2017)
- JENDL-5 (Japan, 2021)
- CENDL-3.2 (China, 2020)
- ROSFOND (Russia, 2010)

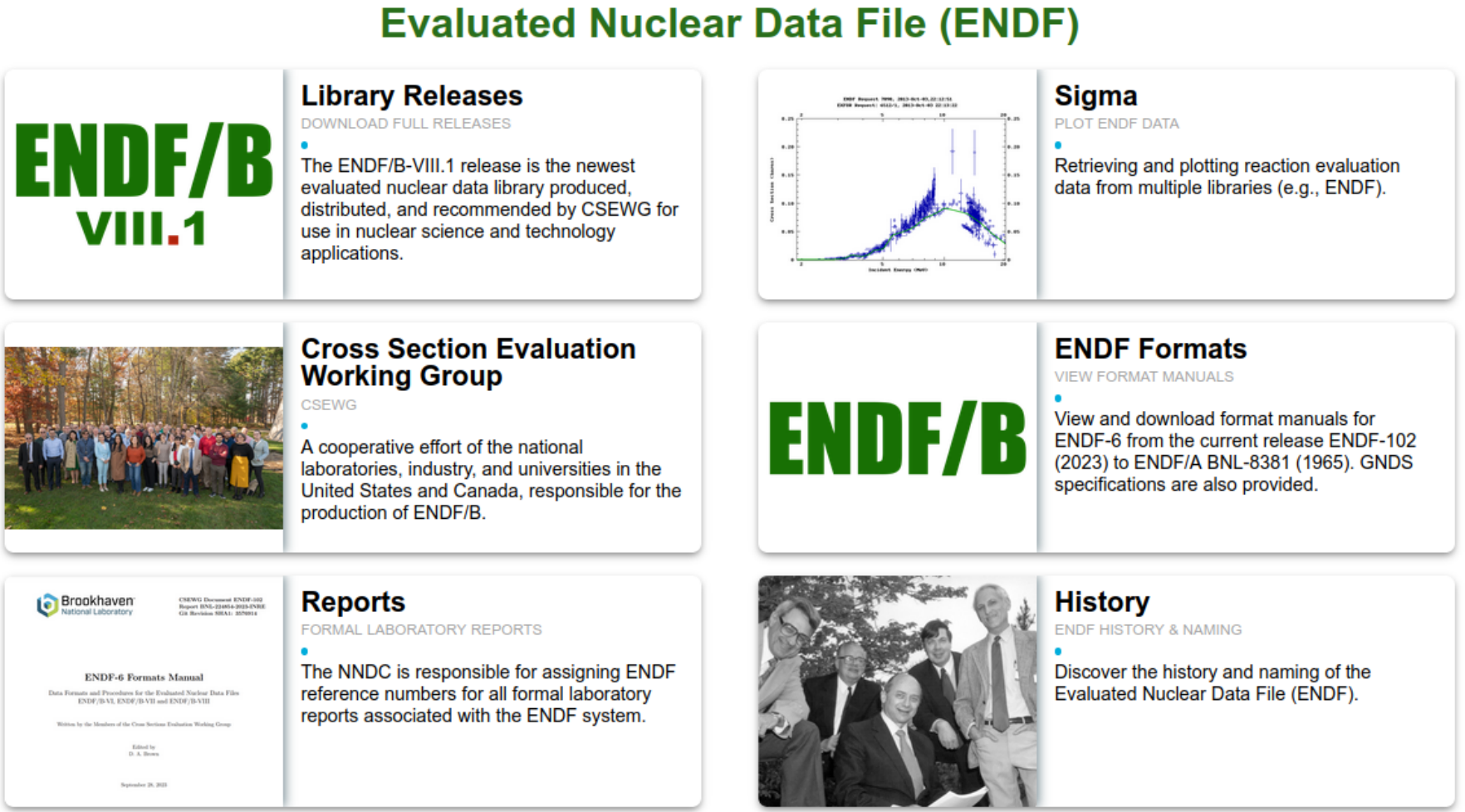
Submit | Reset

Sponsored by the Office of Nuclear Physics - Office of Science - U.S. Department of Energy

Acknowledgments - About Us - Comments/Questions - Disclaimer

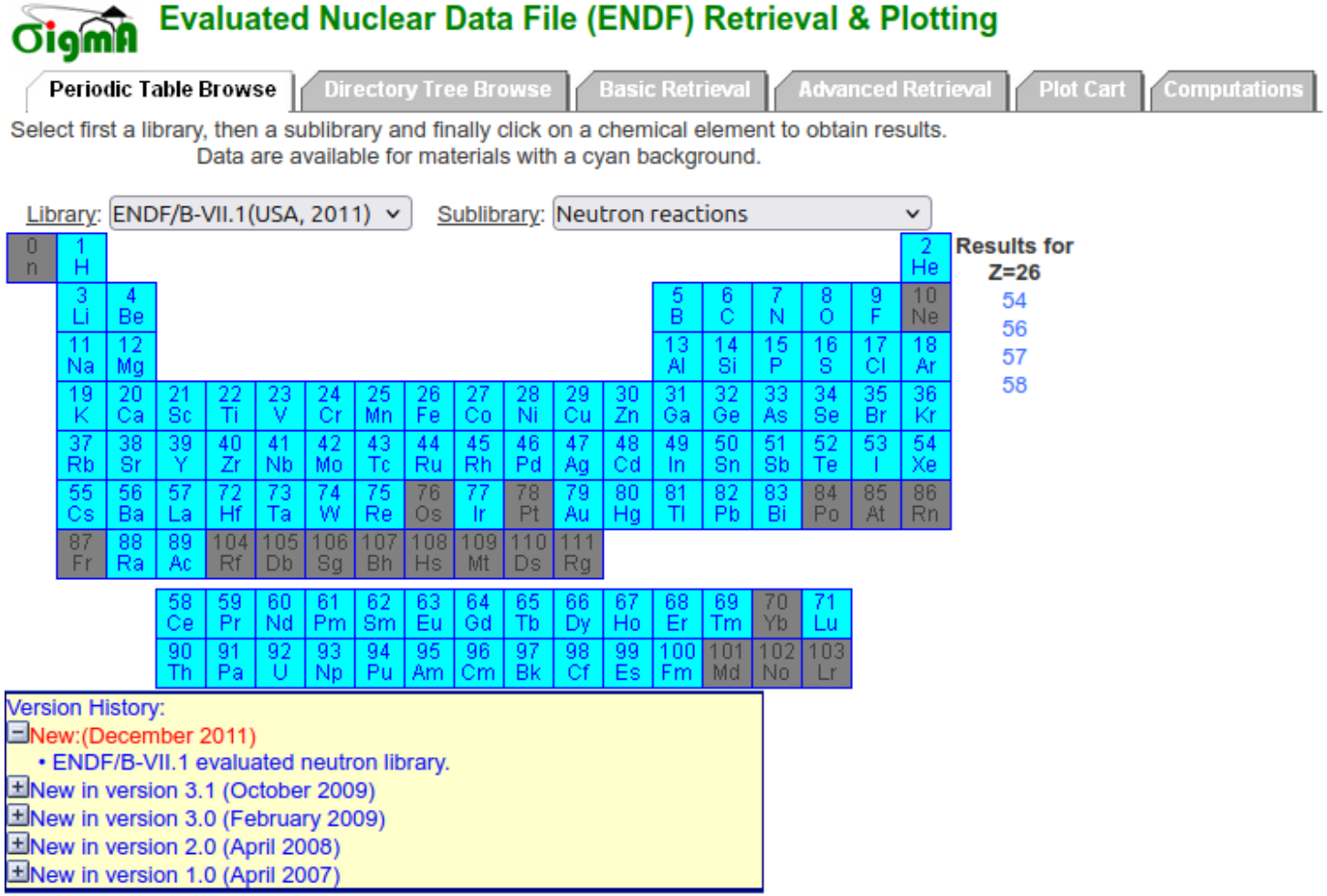
Evaluated Nuclear Data File

- Library Releases page has all the sublibraries and tells you when they were last updated
- Sigma is a front-end for looking at cross-section data



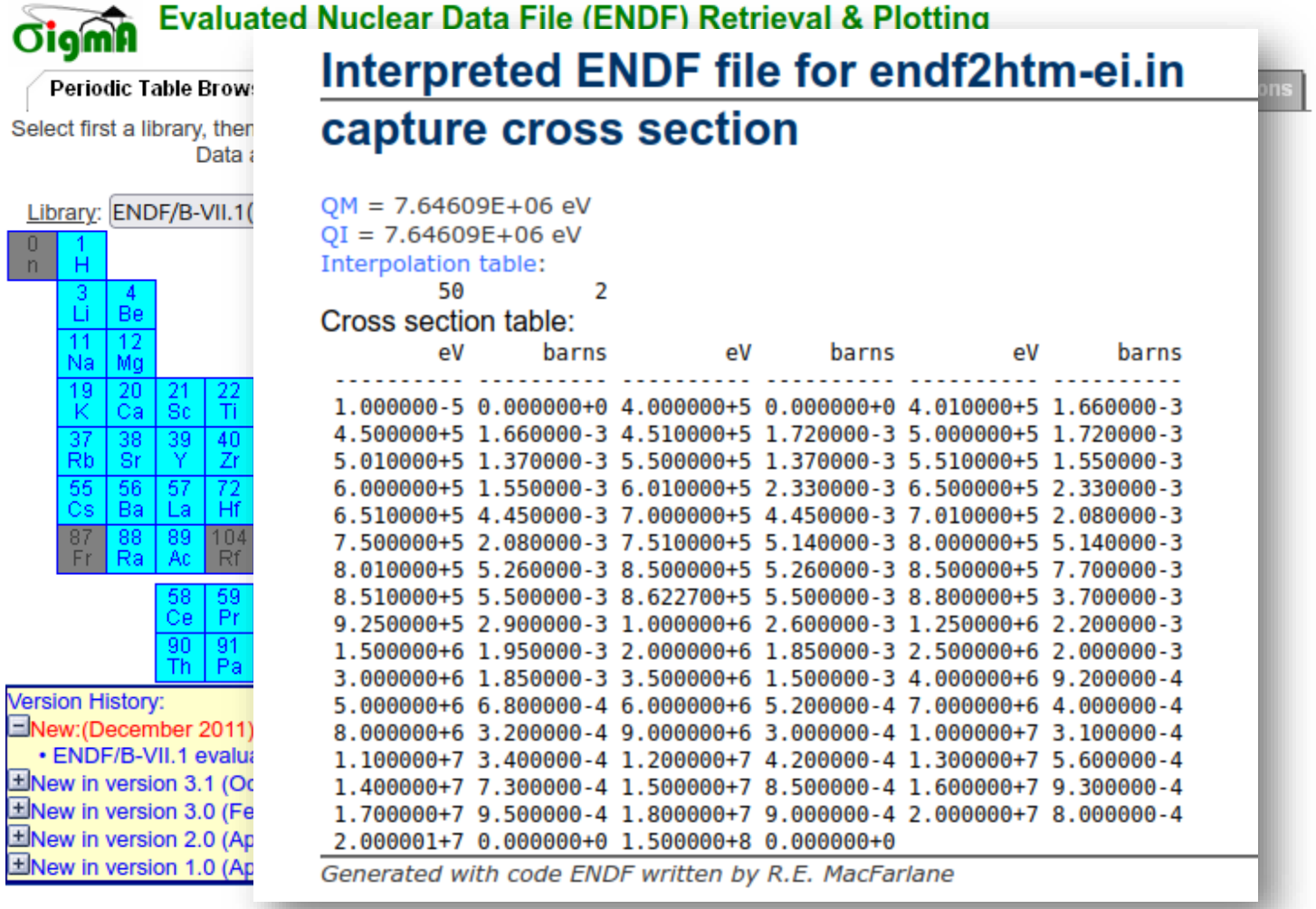
Evaluated Nuclear Data File

- Sigma gives you many choices!
  - Main library (ENDF, JEFF,…)
  - Sublibrary: neutrons, charged particles, decay...
  - Click on an element to select data on a specific isotope



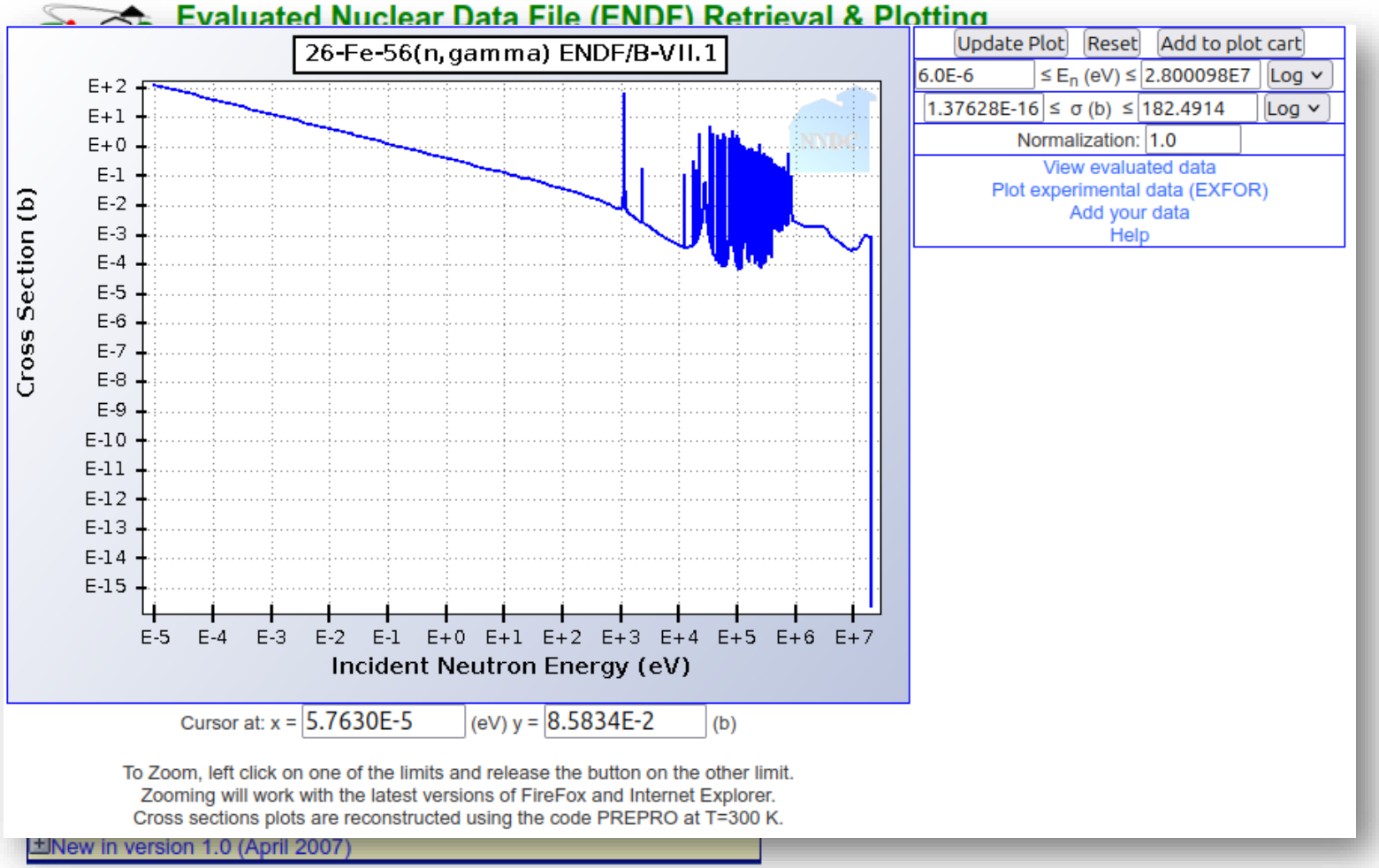
Evaluated Nuclear Data File

- Sigma gives you many choices!
  - Main library (ENDF, JEFF,…)
  - Sublibrary: neutrons, charged particles, decay...
  - Click on an element to select data on a specific isotope
- Data are available in tabular form...
  - This is neutron-capture data just to serve as an example

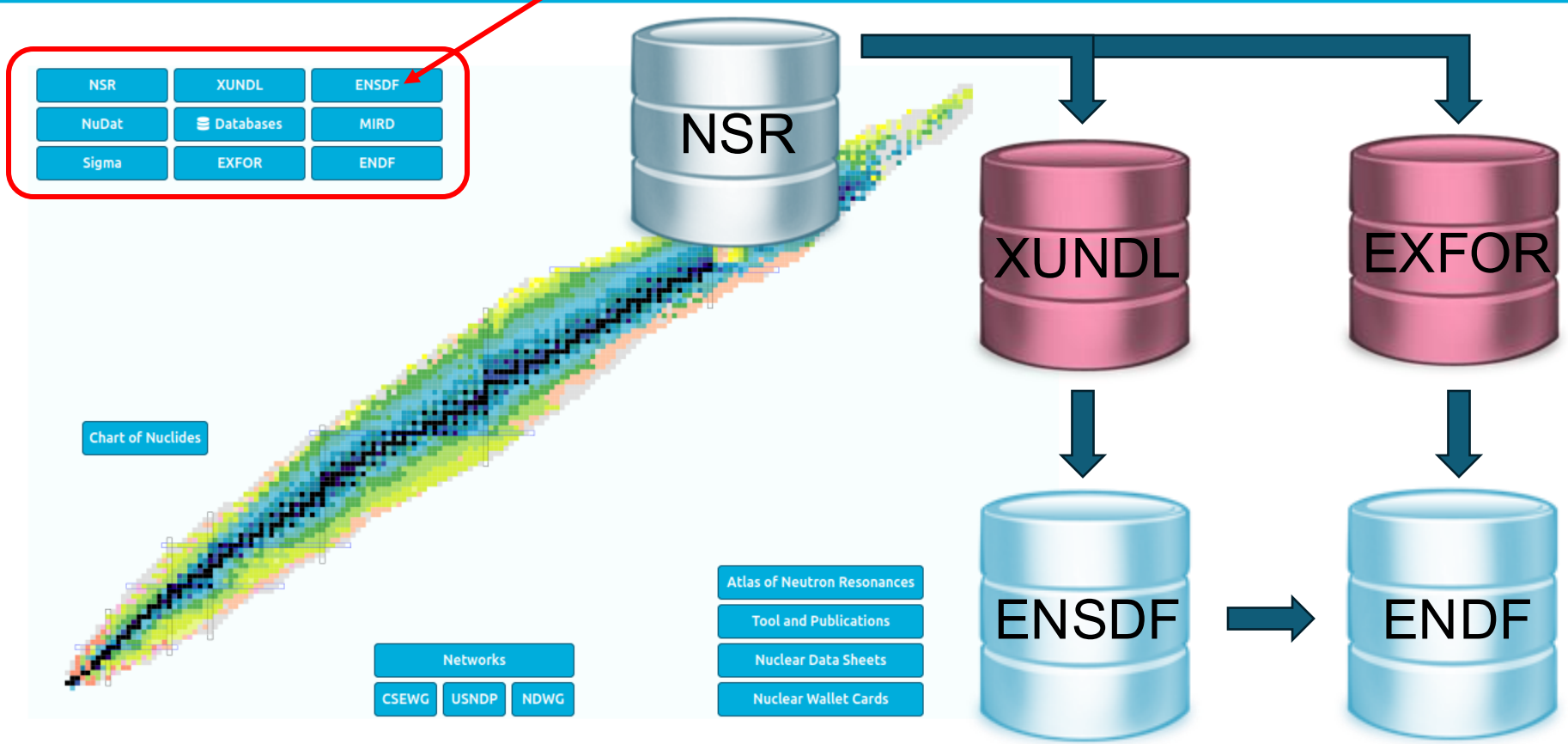


Evaluated Nuclear Data File

- Sigma gives you many choices!
  - Main library (ENDF, JEFF,…)
  - Sublibrary: neutrons, charged particles, decay...
  - Click on an element to select data on a specific isotope
- Data are available in tabular form...
  - This is neutron-capture data just to serve as an example
- ...and graphical form
- There is an API to access ENDF data available at https://www.nndc.bnl.gov/endf-api/

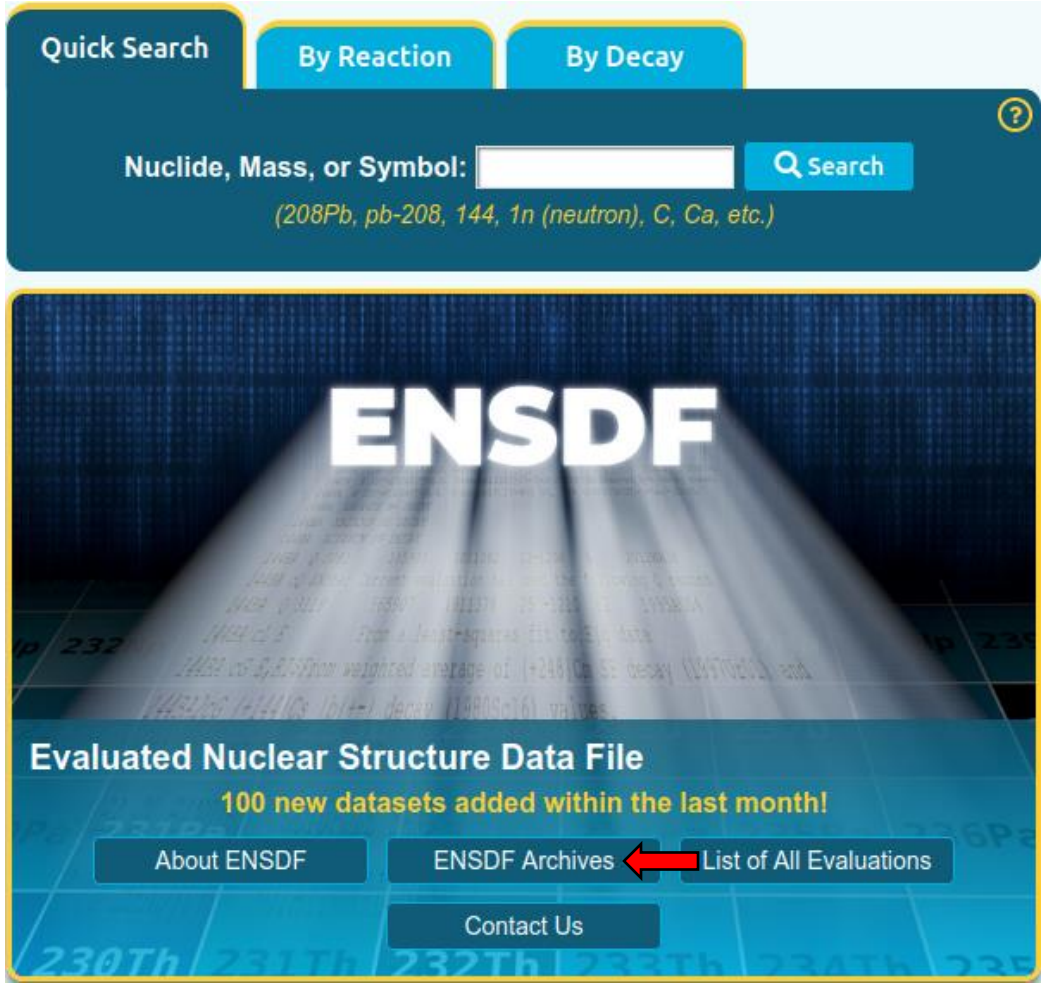


- Bibligraphic
  - NSR
- Reactions:
  - EXFOR
  - ENDF
- Structure
  - XUNDL
  - **ENSDF**
- Interactive
  - NuDat



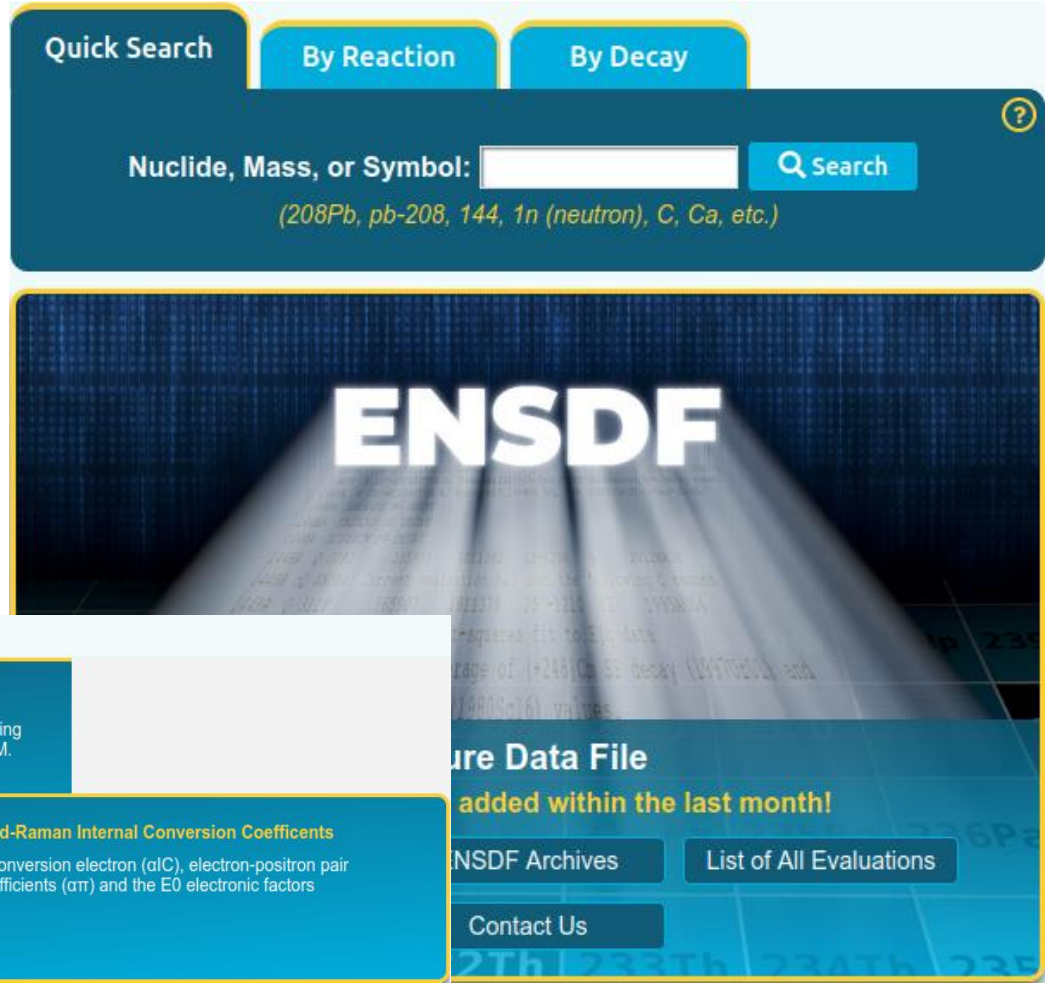
Evaluated Nuclear Structure Data File

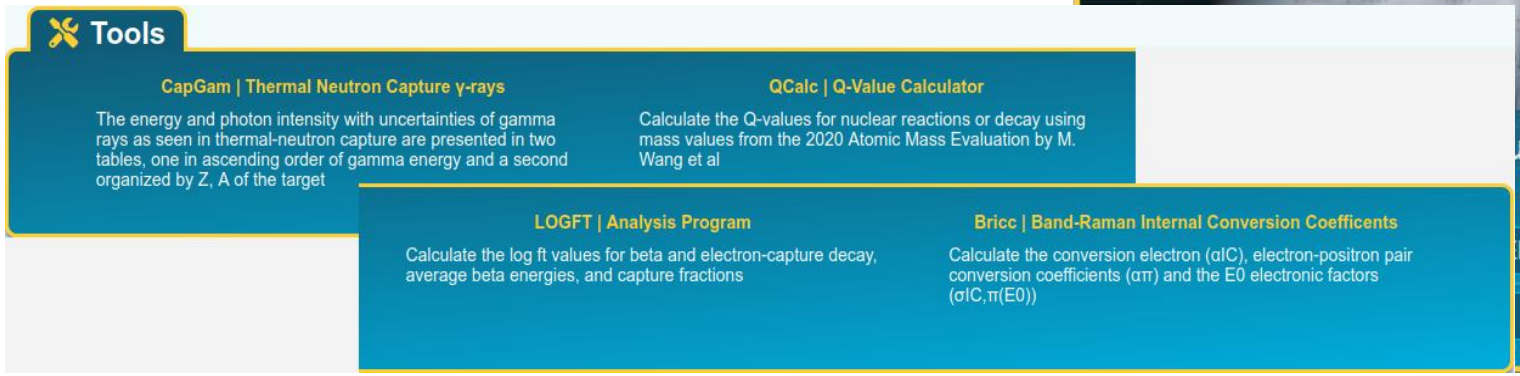
- Your go-to source for evaluated nuclear-structure data.
- Snapshots are archived monthly



Evaluated Nuclear Structure Data File

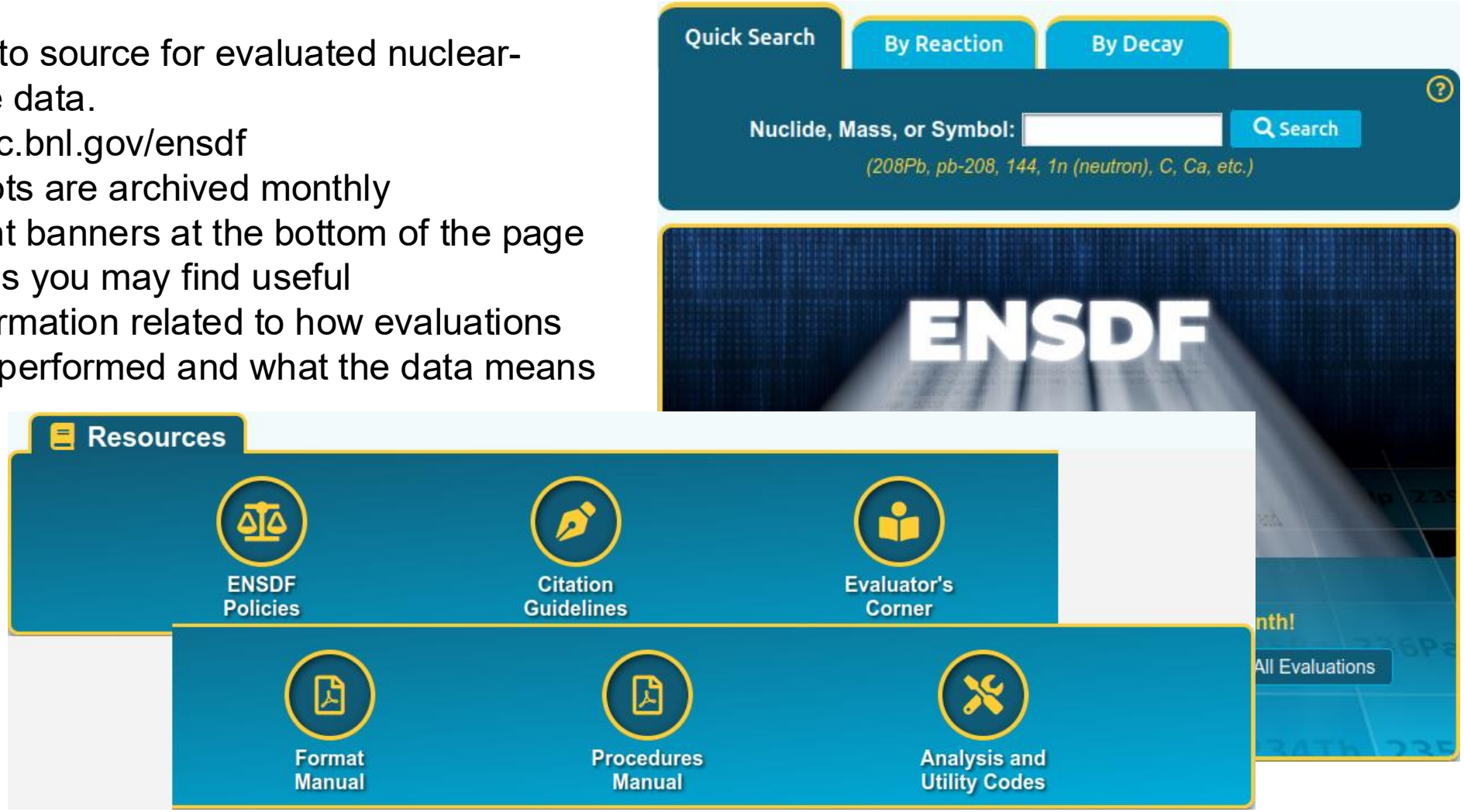
- Your go-to source for evaluated nuclear-structure data.
  - nndc.bnl.gov/ensdf
- Snapshots are archived monthly
- Important banners at the bottom of the page
  - Tools you may find useful





Evaluated Nuclear Structure Data File

- Your go-to source for evaluated nuclear-structure data.
  - nndc.bnl.gov/ensdf
- Snapshots are archived monthly
- Important banners at the bottom of the page
  - Tools you may find useful
  - Information related to how evaluations are performed and what the data means



Evaluated Nuclear St

- Your go-to source for evaluated nuclear-structure data.
  - nndc.bnl.gov/ensdf
- Snapshots are archived monthly
- Important banners at the bottom of the page
  - Tools you may find useful
  - Information related to how evaluations are performed and what the data means

How to cite data from ENSDF

If data are used from 10 or fewer nuclides and the evaluation has been published in Nuclear Data Sheets, it is recommended that the citation is to the publication of the mass chain evaluation. This information can be found at the top of the ENSDF file.

Example:

Adopted Levels, Gammas

Type	Author	History Citation	Literature Cutoff Date
Full Evaluation	M. J. Martin	NDS 114, 1497 (2013)	31-Aug-2013

Citation should read: M.J. Martin, Nucl. Data Sheets 114, 1497 (2013).

If data are used from more than 10 nuclides or if the evaluation was published solely in the ENSDF database, it is recommended to cite the ENSDF database itself. An example of the latter case is:

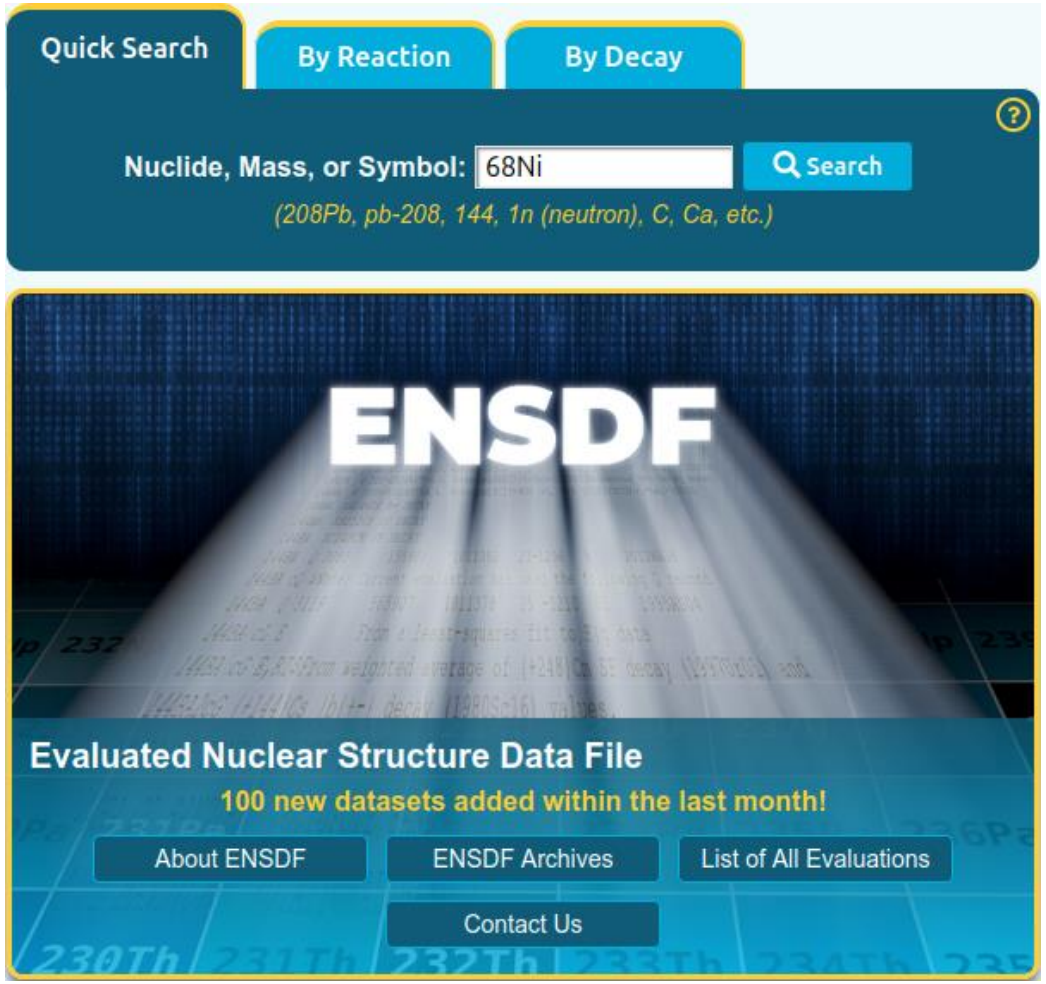
Adopted Levels, Gammas

Type	Author	History Citation	Literature Cutoff Date
Full Evaluation	Balraj Singh	ENSDF	28-Feb-2018

Citation should read: "From ENSDF database as of Month day, Year. Version available at http://www.nndc.bnl.gov/ensarchivals/"
The date should correspond to the date on which the ENSDF database was consulted.

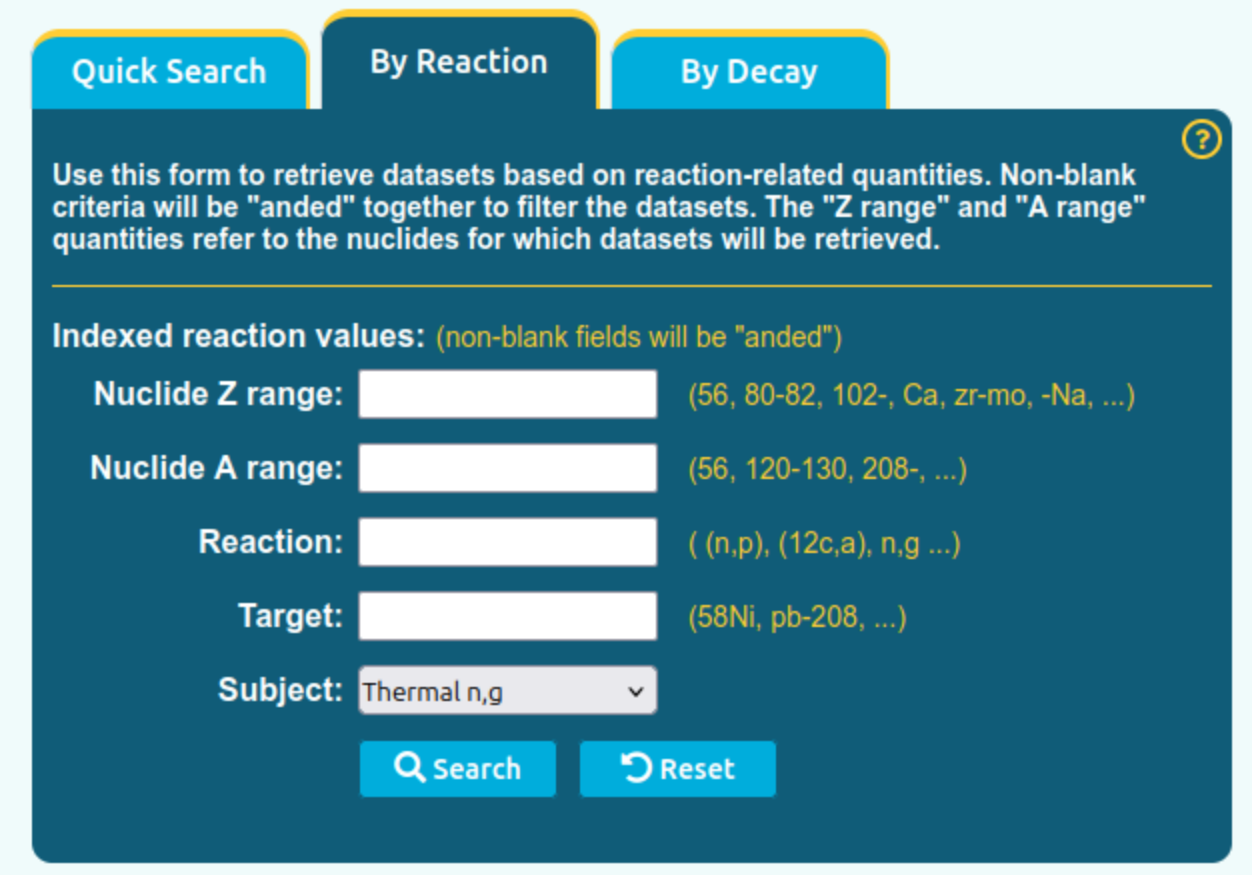
Evaluated Nuclear Structure Data File

- Examples of ENSDF datasets
  - Adopted Levels, Gammas
  - Beta decay
  - Transfer reactions
  - Not an exhaustive list!



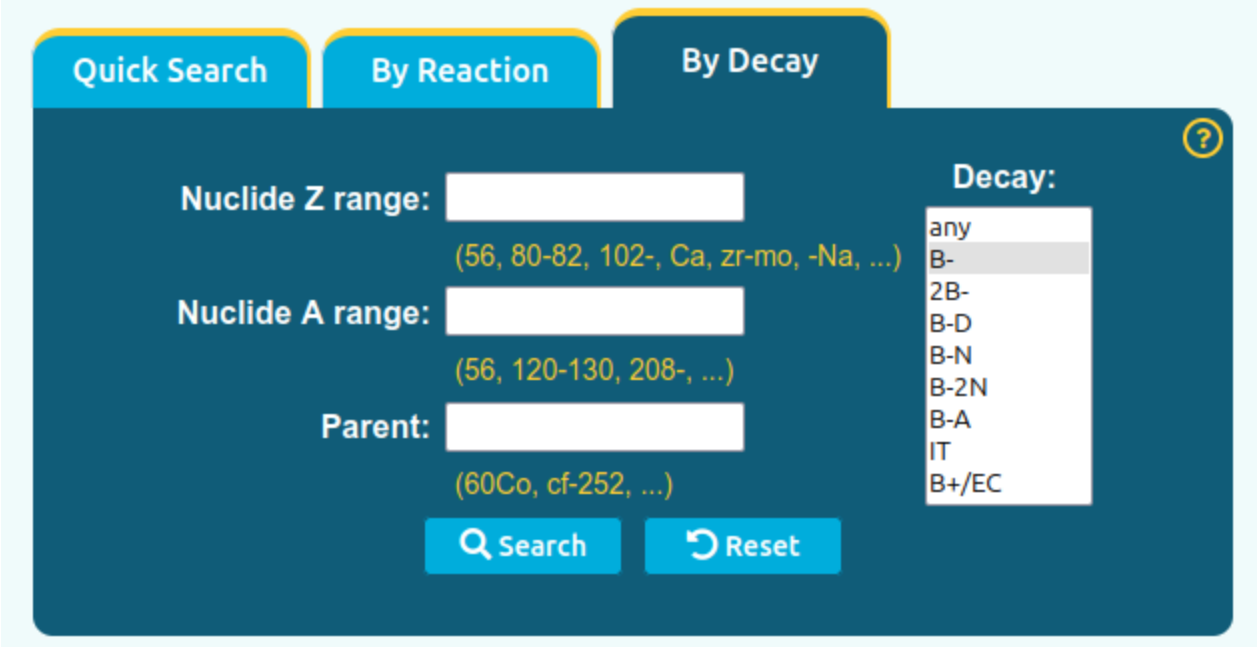
Evaluated Nuclear Structure Data File

- Examples of ENSDF datasets
  - Adopted Levels, Gammas
  - Beta decay
  - Transfer reactions
  - Not an exhaustive list!
- If you don't care about decay datasets, you can search by reaction



Evaluated Nuclear Structure Data File

- Examples of ENSDF datasets
  - Adopted Levels, Gammas
  - Beta decay
  - Transfer reactions
  - Not an exhaustive list!
- If you don't care about decay datasets, you can search by reaction
- Conversely, you can also search exclusively for decay datasets



Evaluated Nuclear Structure Data File

Nuclide, Mass, or Symbol: Search

Datasets for ^{68}Ni

There are 18 corresponding XUNDL (unevaluated) sets

Matching datasets in ENSDF

Retrieve selected ENSDF datasets:
PDF Version ENSDF text format

Dataset	Last Revised	References
Select All		
ADOPTED LEVELS, GAMMAS	2012-06	All references
68CO B- DECAY (0.20 S)	2012-06	All references
68CO B- DECAY (1.6 S)	2012-06	All references
68NI IT DECAY (0.86 MS)	2012-06	All references
COULOMB EXCITATION	2012-06	All references
70ZN(14C,16O)	2012-06	All references
70ZN(14C,16OG)	2012-06	All references
130TE(64NI,XG),208PB(64NI,XG)	2012-06	All references
198PT(70ZN,XG)	2012-06	All references
NI(86KR,XG),58NI(70ZN,XG)	2012-06	All references

Retrieve selected ENSDF datasets:
PDF Version ENSDF text format

Scroll down...

Evaluated Nuclear Structure Data File

- If you are specifically interested in recent publications on the structure of a specific nuclide, XUNDL is a useful alternative to NSR.
- Important note: XUNDL is younger than ENSDF, and full coverage of new publications wasn't achieved until the 2000s

Here are the XUNDL datasets which came in after the cutoff date of the last ENSDF evaluation.

Nuclide	Dataset	Last Revised	References
	Select All		
^{68}Ni	238U(70ZN,XG):XUNDL-6	2012-10	All references
	238U(64NI,XG):DELAYED:XUNDL-7	2013-03	All references
	238U(64NI,XG):PROMPT:XUNDL-8	2013-03	All references
	208PB(70ZN,XG):XUNDL-9	2013-10	All references
	68CO B- DECAY:1.6 S:XUNDL-10	2014-02	All references
	4HE(68NI,4HE'):ISGMR:XUNDL-11	2015-08	All references
	68CO B- DECAY:1.6 S:XUNDL-12	2015-03	All references
	68NI IT DECAY:T1/2:XUNDL-13	2015-03	All references
	68CO B- DECAY:1.6 S:XUNDL-14	2018-09	All references
	U(P,X):IS,RADIUS:XUNDL-15	2020-06	All references
	COULOMB EXCITATION:XUNDL-16	2021-11	All references
	3H(66NI,PG):XUNDL-17	2022-12	All references
	68CO B- DECAY (1.6 S):XUNDL-18	2024-02	All references

Retrieve selected XUNDL datasets:
PDF Version ENSDF text format

Adopted Levels, Gammas

Adopted Levels, Gammas

Publication

Type	Author	History Citation	Literature Cutoff Date
Full Evaluation	E. A. Mccutchan	NDS 113,1735 (2012)	1-Mar-2012

Q(β^-)=2103 *4*; S(n)=7792 *5*; S(p)=15431 *7*; Q(α)=−10919 *6* 2012Wa38
Note: Current evaluation has used the following Q record 2103 4 *7792* 4 *15431* 7 −10919 *6* 2011AuZZ.
S(2n)=13600 *3*; S(2p)=27974 *5*; Q(β^-n) = −4216 *3* (2011AuZZ).
α: Additional information 1.

^{68}Ni Levels

In addition to the levels given here, peaks are reported in ^{70}Zn(^{14}C,^{16}O) at 2700 *40*, with L=0,2, at 3280 *50* with L=2,4, and at 3450 *50* and 4120 *50*. The ^{70}Zn(^{14}C,^{16}O) level at 2200 *30*, with L=2 appears to correspond to the 2034 level but the large energy difference makes it difficult to give unique associations for any of the other peaks.

Cross Reference (XREF) Flags

A	^{68}Co β^- decay (0.20 s)	F	^{70}Zn(^{14}C,^{16}Oγ)
B	^{68}Co β^- decay (1.6 s)	G	^{130}Te(^{64}Ni,Xγ),^{208}Pb(^{64}Ni,Xγ)
C	^{68}Ni IT decay (0.86 ms)	H	^{198}Pt(^{70}Zn,Xγ)
D	Coulomb excitation	I	Ni(^{86}Kr,Xγ),^{58}Ni(^{70}Zn,Xγ)
E	^{70}Zn(^{14}C,^{16}O)		

Main data for energy levels

Links to datasets with supporting information

E(level)†	J$^\pi$	T$_{1/2}$	XREF	Comments
0.0‡	0$^+$	29 s *2*	ABCDEFGHI	%β^-=100 T$_{1/2}$: from 1998Fr15. The authors also give this value in 2001Fr21. Other: 19 s *+3−6* (1988ScZH,1988KoZT).
1770 *30*	0$^+$	270 ns *5*	EF I	T$_{1/2}$: from γ(t) in ^{58}Ni(^{70}Zn,Xγ). Others: 211 ns *50* from I(ce)(t) and I(e$^+$,e$^-$)(t) in (^{14}C,^{16}Oγ), and 340 ns *30* from γ(t) in (^{86}Kr,Xγ). J$^\pi$: L=0 in (^{14}C,^{16}O); E0 transition to 0$^+$ g.s.

Adopted Levels, Gammas

Adopted Levels, Gammas (continued)

$\gamma(^{68}Ni)$

E_i(level)	J_i^π	E_γ[†]	I_γ[†‡]	E_f	J_f^π	Mult.	α	$I_{(\gamma+ce)}$[‡]	Comments
1770	0^+	1770		0.0	0^+	E0		100	E_γ: from (^{14}C,$^{16}O\gamma$). Mult.: from conversion electrons and pair production in (^{14}C,$^{16}O\gamma$).
2034.08	2^+	2033.2 *2*	100	0.0	0^+	[E2]	0.000383 *6*		α(K)=4.96×10^{-5} *7*; α(L)=4.81×10^{-6} *7*; α(M)=6.77×10^{-7} *10*; α(N+..)=0.000328 *5* B(E2)(W.u.)=3.2 *7*
2511.9	(0^+)	477.8 *2*	100 *5*	2034.08	2^+	[E2]	0.00191 *3*		α(K)=0.001717 *25*; α(L)=0.0001711 *24*; α(M)=2.40×10^{-5} *4*; α(N+..)=1.005×10^{-6} *1*
		2511.9[&]		0.0	0^+	(E0)		≤138	The source of the observed 511γ's in ^{68}Co β decay (1.6 s) may be from (e^+,e^-) from the 2512 state to the 0^+ g.s.; however, no 1511γ-511γ coincidences were observed.

Conversion coefficient from BrIcc, T. Kibedi, NIM A 589, 202 (2008)

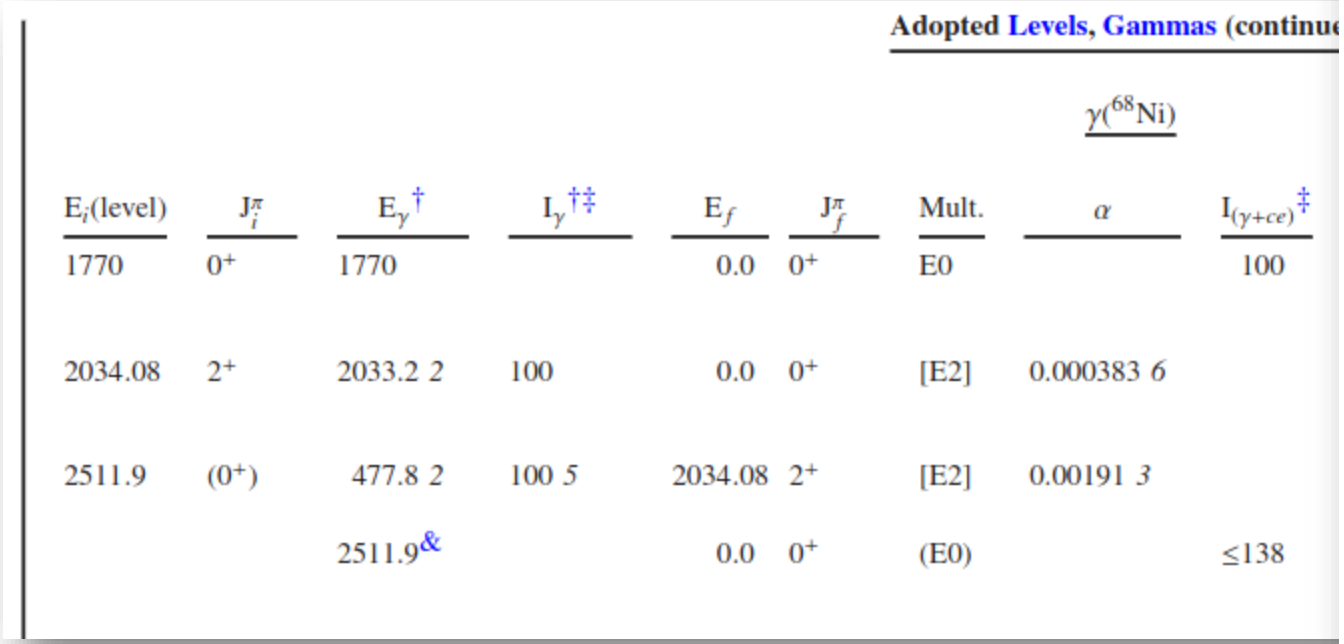
Multipolarity
- [E2]: Inferrred by evaluator
- (E2): Tentative assignment
- E2: Definite assignment

Cross Reference (XREF) Flags

A	^{68}Co β^- decay (0.20 s)	F	^{70}Zn(^{14}C,^{16}Oγ)
B	^{68}Co β^- decay (1.6 s)	G	^{130}Te(^{64}Ni,Xγ),^{208}Pb(^{64}Ni,Xγ)
C	^{68}Ni IT decay (0.86 ms)	H	^{198}Pt(^{70}Zn,Xγ)
D	Coulomb excitation	I	Ni(^{86}Kr,Xγ),^{58}Ni(^{70}Zn,Xγ)
E	^{70}Zn(^{14}C,^{16}O)		

E(level)[†]	J^π	$T_{1/2}$	XREF	Comments
0.0[‡]	0^+	29 s *2*	ABCDEFGHI	%β^-=100 $T_{1/2}$: from 1998Fr15. The authors also give this value in 2001Fr21. Other: 19 s *+3–6* (1988ScZH,1988KoZT).
1770 *30*	0^+	270 ns *5*	EF I	$T_{1/2}$: from γ(t) in ^{58}Ni(^{70}Zn,Xγ). Others: 211 ns *50* from I(ce)(t) and I(e^+,e^-)(t) in (^{14}C,^{16}Oγ), and 340 ns *30* from γ(t) in (^{86}Kr,Xγ). J^π: L=0 in (^{14}C,^{16}O); E0 transition to 0^+ g.s.

Adopted Levels, Gammas



Adopted Levels, Gammas (continue

$\gamma(^{68}Ni)$

E_i(level)	J_i^π	E_γ[†]	I_γ[†‡]	E_f	J_f^π	Mult.	α	$I_{(\gamma+ce)}$[‡]
1770	0^+	1770		0.0	0^+	E0		100
2034.08	2^+	2033.2 *2*	100	0.0	0^+	[E2]	0.000383 *6*	
2511.9	(0^+)	477.8 *2*	100 *5*	2034.08	2^+	[E2]	0.00191 *3*	
		2511.9[&]		0.0	0^+	(E0)		≤138

Cross Reference (XREF) Flags

A	^{68}Co β^- decay (0.20 s)	F	^{70}Zn(^{14}C,^{16}Oγ
B	^{68}Co β^- decay (1.6 s)	G	^{130}Te(^{64}Ni,Xγ
C	^{68}Ni IT decay (0.86 ms)	H	^{198}Pt(^{70}Zn,Xγ
D	Coulomb excitation	I	Ni(^{86}Kr,Xγ),^{58}
E	^{70}Zn(^{14}C,^{16}O)		

E(level)[†]	J^π	$T_{1/2}$	XREF	
0.0[‡]	0^+	29 s *2*	ABCDEFGHI	%β^-=100 $T_{1/2}$: from 1998Fr15. The autho 19 s *+3−6* (1988ScZH,1988K
1770 *30*	0^+	270 ns *5*	EF I	$T_{1/2}$: from γ(t) in ^{58}Ni(^{70}Zn,Xγ I(e$^+$,e$^-$)(t) in (^{14}C,^{16}Oγ), and J^π: L=0 in (^{14}C,^{16}O); E0 transi

The 80-column format is... dense. It is a relic of the halcyon days of FORTRAN and should be replaced by JSON "Soon™"

```
68NI    ADOPTED LEVELS, GAMMAS                                  12NDS    201206
68NI  H TYP=ERR$AUT=E.A. McCutchan$DAT=11-Jul-2012$COM=changed DE for 1770 lev$
68NI  H TYP=FUL$AUT=E.A. McCutchan$CIT=NDS 113, 1735 (2012)$CUT=1-Mar-2012$
68NI  Q 2103      4 7792    5 15431   7 -10919  6     2012WA38
68NI cQ $Note: Current evaluation has used the following Q record
68NI2cQ 2103      4  {I7792}   4  {I15431}  7  -10919  {I6}    2011AuZZ
68NI cQ $S(2n)=13600 {I3}; S(2p)=27974 {I5}; Q(|b{+-}n) = -4216 {I3}
68NI2cQ (2011AuZZ)
68NI cL E$From least-squares fit to E|g's by evaluator; |DE=1 keV assumed
68NI2cL when not given.
68NI CL BAND(A)$|ng{+2}{-9/2}|np{+-2}{-1/2} configuration.
68NI2cL From comparison to the level spacings in {+70}Ni, the 6+ and 8+
68NI3cL states have a very pure |ng{+2}{-9/2}|np{+-2}{-1/2} configuration
68NI4cL while the 4+ contains a significant admixture of other components,
68NI5cL likely the (|ng{+2}{-9/2}|nf{+-2}{-5/2}){-4+} configuration.
68NI cL J(a)$Low-lying J=1 states are not expected from the available neutron
68NI2cL fp orbitals. A strong |g to the g.s. indicates J|p=2+ for the 2744
68NI3cL state. Lack of a similar transition from the 2512 state and the
68NI4cL possible E0 transition to the g.s. supports a J|p=0+ assignment.
68NI cL $In addition to the levels given here, peaks are reported in
68NI2cL {+70}Zn({+14}C,{+16}O) at 2700 {I40}, with L=0,2, at 3280 {I50} with
68NI3cL L=2,4, and at 3450 {I50} and 4120 {I50}. The {+70}Zn({+14}C,{+16}O)
68NI4cL level at 2200 {I30}, with L=2 appears to correspond to the 2034 level
68NI5cL but the large energy difference makes it difficult to give unique
68NI6cL associations for any of the other peaks.
68NI cG E,RI$From {+68}Co |b- decay (1.6 s), except as noted.
68NI cG RI,TI$Relative photon or I(|g+ce) branching ratio from each level.
68NI cG E(a),RI(b)$From {+68}Co |b- decay (0.20 s).
68NI cG E(c),RI(d)$From {+198}Pt({+70}Zn,X|g)
68NI D  CC$ FROM BrIcc v2.2b (20-Jan-2009) 2008Ki07, "Frozen Orbitals" appr.
68NI  XA68CO B- DECAY (0.20 S)
68NI  XB68CO B- DECAY (1.6 S)
68NI  XC68NI IT DECAY (0.86 MS)
68NI  XDCOULOMB EXCITATION
68NI  XE70ZN(14C,16O)
68NI  XF70ZN(14C,16OG)
68NI  XG130TE(64NI,XG),208PB(64NI,XG)
68NI  XH198PT(70ZN,XG)
68NI  XINI(86KR,XG),58NI(70ZN,XG)
68NI  L 0.0          0+               29 S      2                        A
68NIX L XREF=ABCDEFGHI
68NI2 L %B-=100
68NI cL T$from 1998Fr15. The authors also give this value in 2001Fr21. Other:
68NI2cL 19 s {I+3-6} (1988ScZH,1988KoZT).
68NI  L 1770      30 0+                270 NS    5
68NIX L XREF=EFI
68NI cL T$from |g(t) in {+58}Ni({+70}Zn,X|g). Others: 211 ns {I50} from
68NI2cL I(ce)(t) and I(e{++},e{+-})(t) in ({+14}C,{+16}O|g), and 340 ns {I30}
68NI3cL from |g(t) in ({+86}Kr,X|g).
68NI cL J$L=0 in ({+14}C,{+16}O); E0 transition to 0+ g.s.
68NI  G 1770                    E0                                  100
68NI cG E$from ({+14}C,{+16}O|g)
68NI cG M$from conversion electrons and pair production in ({+14}C,{+16}O|g)
```

Beta decay

^{68}Co β^- decay (0.20 s) 2000Mu10

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	E. A. Mccutchan	NDS 113, 1735 (2012)	1-Mar-2012

Parent: ^{68}Co: E=0.0; $J^\pi=(7^-)$; $T_{1/2}$=0.20 s *2*; Q(β^-)=1.155×10^4 *13*; %β^- decay=100.0

NB: ^{68}Co decay into ^{68}Ni

^{68}Ni Levels

E(level)†	Jπ‡	$T_{1/2}$‡	Comments
0.0	0^+	29 s *2*	%β^-=100.
2033.23 *20*	2^+	0.31 ps *5*	
2848.2 *3*	5^-	0.86 ms *5*	%IT=100
3120.1 *3*			
3443.6 *3*	$(6^-,7^-)$#		
3557.1 *3*	(6^-)#		
3934.5 *6*	(7)		

Jπ *must* be from Adopted Levels!

† From a least squares fit to Eγ's by evaluator.

‡ From the Adopted Levels.

Suggested configuration $\nu f_{5/2}^{-1} \nu g_{9/2}^{+1}$. Assuming a simple δ interaction the 3444 state is most likely 7^- and the 3557 state is most likely 6^- (2000Mu10).

Intensities/log *ft* values inform Jπ assignments

β^- radiations

E(decay)	E(level)	Iβ−†#	Log *ft*	Comments
(7.62×10^3 *13*)	3934.5	1.5 *2*	5.95 *9*	av Eβ=3527 *64*
(7.99×10^3 *13*)	3557.1	28 *2*	4.78 *7*	av Eβ=3711 *64*
(8.11×10^3 *13*)	3443.6	62 *5*	4.46 *7*	av Eβ=3766 *64*
(8.43×10^3‡ *13*)	3120.1	5 *3*	5.6 *3*	av Eβ=3924 *64*
(8.70×10^3‡ *13*)	2848.2	<10	>5.4	av Eβ=4057 *64*

Transfer reactions

Orbital angular momentum

^{208}Pb(d,p),(pol d,p) 1974Ko20,1973Vi06,1978Ba13

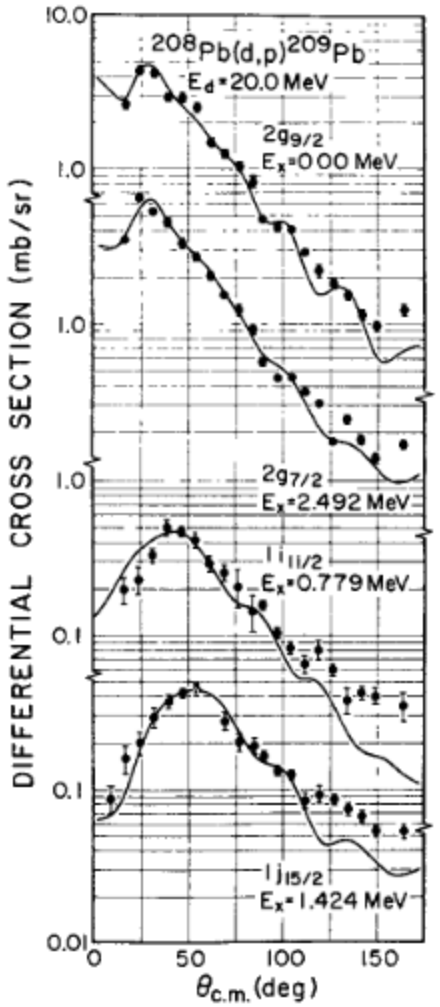
History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	J. Chen # and F. G. Kondev	NDS 126, 373 (2015)	30-Sep-2013

^{209}Pb Levels

E(level)†	Jπ‡	L#	C²S@	Comments
0.0	9/2+	4	0.83	C²S: for configuration=$\nu(2g_{9/2})^{+1}$.
779 5	11/2+	6	0.86	C²S: for configuration=$\nu(1i_{11/2})^{+1}$.
1424 5	15/2−	7	0.58	C²S: for configuration=$\nu(1j_{15/2})^{+1}$.
1565 5	5/2+	2	0.98	C²S: for configuration=$\nu(3d_{5/2})^{+1}$.
2033 5	1/2+	0	0.98	C²S: for configuration=$\nu(4s_{1/2})^{+1}$.
2152 5		1		C²S: 0.0067 if configuration=$\nu(3p_{1/2})^{-1}$, 0.0036 if $\nu(4p_{1/2})^{+1}$.
2319 5		1		E(level): 2310 keV 5 (1969Je01).

Spectroscopic factor: derived from ratio of experimental and (typically) DWBA cross sections



Adapted from Nucl. Phys A 231, 266 (1974)

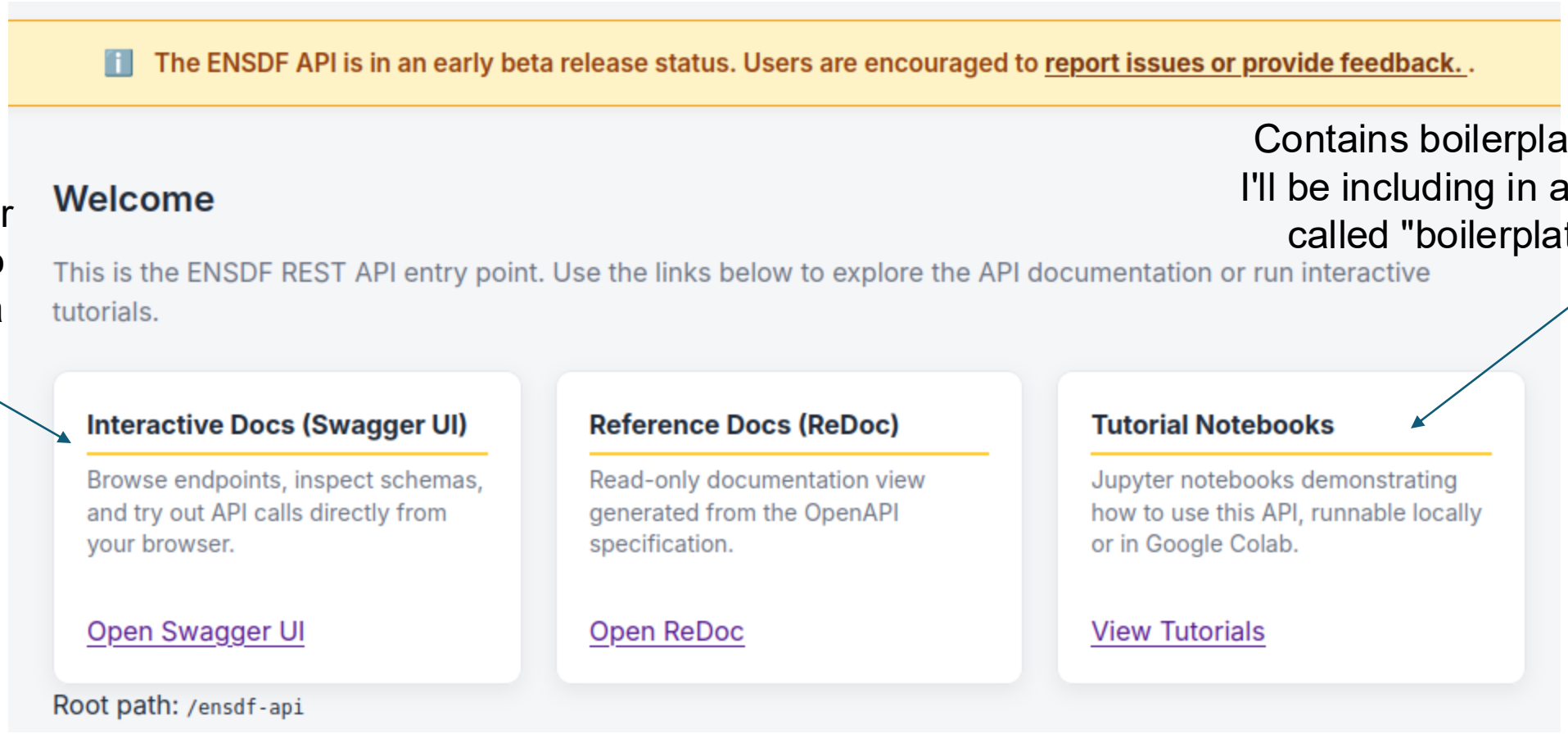
Part III: ENSDF API

ENSDF API

https://www.nndc.bnl.gov/ensdf-api/

Look here for endpoints to access data

Contains boilerplate code I'll be including in a module called "boilerplate.py"



ENSDF API

- The API is organized around a collection of "endpoints"
- /nuclides
- /datasets
- /levels
- /gammas
- ...

Each endpoint accepts filters to select specific results, e.g.

- /nuclides
  - a,z,n,symbol,...
- /datasets
  - dataset-type,...
- /levels
  - energy-min/max, halflife-min/max,...

ENSDF API

- How to use it? You could type directly into your address bar...
- You will get a JSON object back
  - Meta: details about the HTTP request/response
  - Results: the actual thing you want to inspect

ENSDF API

- Better: use your programming language of choice
- These slides use python with the "requests" package to handle HTTP matters
- The "get()" method is just a convenient helper method to construct requests.
  - Find it in any of the Jupyter notebooks at the API site

```
>>> import boilerplate as bp
>>> bp.get("/nuclides",params={"z":56,"a":144})
GET https://www.nndc.bnl.gov/ensdf-api/nuclides?z=56&a=144
Status: 200
{'meta': {'total': 1, 'limit': 50, 'offset': 0, 'next': None,
 'previous': None}, 'results': [{'id': 3182, 'name': '144BA',
 'z': 56, 'n': 88, 'a': 144, 'elementSymbol': 'BA', 'elementN
ame': 'Barium'}], 'datasetSummary': None}
>>>
```

NB: The code on these slides isn't the point. The *brevity* of the code is the point!

ENSDF API

- A more interesting example: print info on an isotopic chain
- Use the "/levels" endpoint
- General approach:
  - Filter
  - Fetch
  - Process

```
import boilerplate as bp

def print_info(level):
    dataset = bp.get(f"/datasets/{level['datasetId']}",verbose=False)
    print('Nucleus: ',f"{dataset['a']}{dataset['elementSymbol']}")
    print('  Ex:', bp.quantity_label(level.get('energy')))
    print('  Jpi:', level.get('spinParityStr'))
    print('  T1/2:',bp.quantity_label(level.get("halflife")))

filters={
    "z":56,
    "document-type":"adopted",
    "level-index-max": 0
}

baria = bp.get("/levels",params=filters)["results"]
for barium in baria:
    print_info(barium)
```

ENSDF API

- A more interesting example: print info on an isotopic chain
- Use the "/levels" endpoint
- General approach:
  - Filter
  - Fetch
  - Process

```
import boilerplate as bp

def print_info(level):
    dataset = bp.get(f"/datasets/{level['dataset'
    print('Nucleus: ',f"{dataset['a']}{dataset['e
    print('  Ex:', bp.quantity_label(level.get('e
    print('  Jpi:', level.get('spinParityStr'))
    print('  T1/2:',bp.quantity_label(level.get('

filters={
    "z":56,
    "document-type":"adopted",
    "level-index-max": 0
}

baria = bp.get("/levels",params=filters)["results
for barium in baria:
    print_info(barium)
```

```
Nucleus:  150Ba
  Ex: 0.0 keV
  Jpi: 0+
  T1/2: 0.259 s
Nucleus:  151Ba
  Ex: 0.0 keV
  Jpi: None
  T1/2: 0.167 s
Nucleus:  152Ba
  Ex: 0.0 keV
  Jpi: 0+
  T1/2: 0.139 s
Nucleus:  153Ba
  Ex: 0.0 keV
  Jpi: None
  T1/2: 0.116 s
Nucleus:  154Ba
  Ex: 0.0 keV
  Jpi: 0+
  T1/2: 53.0 ms
```

ENSDF API

- A real-life example: plot ground-state half-lives across the chart
- /levels/export endpoint is useful when you want global systematics (avoids limits on normal /levels endpoint)

```
import requests
import json

def get_all(endpoint,params):
    url = "https://www.nndc.bnl.gov/ensdf-api/"
    url += endpoint+"/export"
    with requests.get(url,params=params,stream=True) as r:
        r.raise_for_status()
        return [json.loads(line) for line in r.iter_lines()]
```

Note: this is a very quick demonstration method. Find more robust examples in the Jupyter notebooks on the API site

ENSDF API

- A real-life example: plot ground-state half-lives across the chart
- /levels endpoint is useful when you want global systematics
- Again:
  - Filter
  - Fetch
  - Process

```
params = {
    'document-type': 'adopted',
    'level-index-max':0,
    'has-halflife':True
}
ground_states = get_all("levels",params)

Z = [state["datasetSummary"]["z"] for state in ground_states]
N = [state["datasetSummary"]["n"] for state in ground_states]
T = [state["halflifeSeconds"] for state in ground_states]

figure,axis = make_2dhist(N,"N",Z,"Z",T,"$T_{1/2}$ (s)")
figure.show()
```

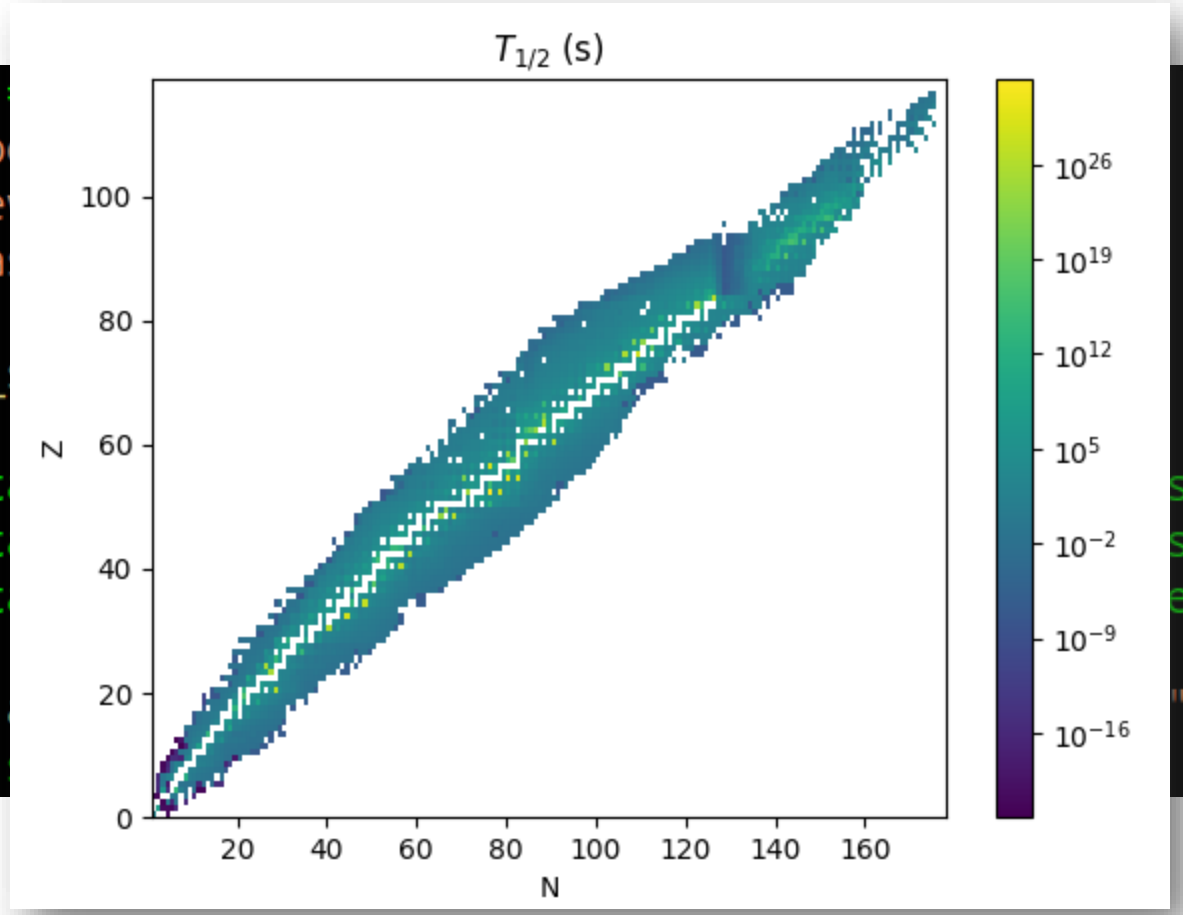
ENSDF API

- A real-life example: plot ground-state half-lives across the chart
- /levels endpoint is useful when you want global systematics
- Again:
  - Filter
  - Fetch
  - Process

```
params =
    'do
    'le
    'ha
}
ground_

Z = [st
N = [st
T = [st

figure,
figure.
```



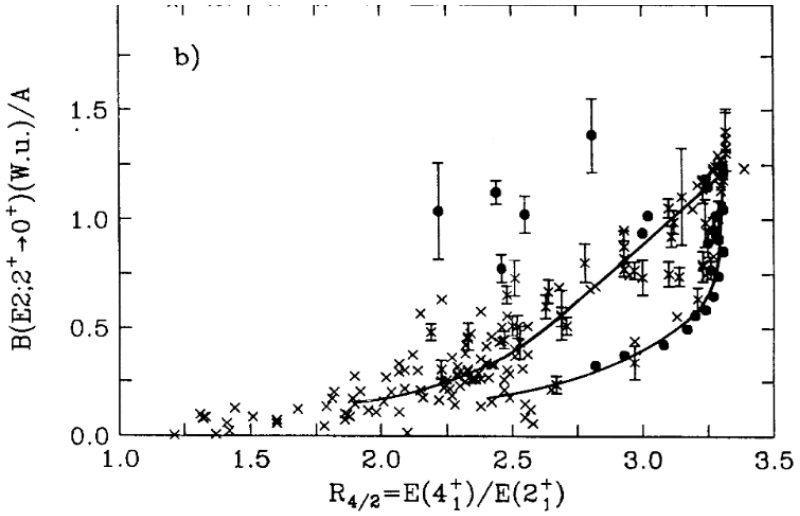

```
states]
states]
es]

")
```

ENSDF API

- Final thoughts:
- The API is in very early beta – we want your feedback!
  - That also means endpoints, responses, and filters may evolve
- c.f. many tutorials at https://www.nndc.bnl.gov/ensdf-api/tutorials

A challenge: reproduce Fig. 4 from Casten and Zamfir, PRL 70, 402 (1993)



Fin!

Questions?