



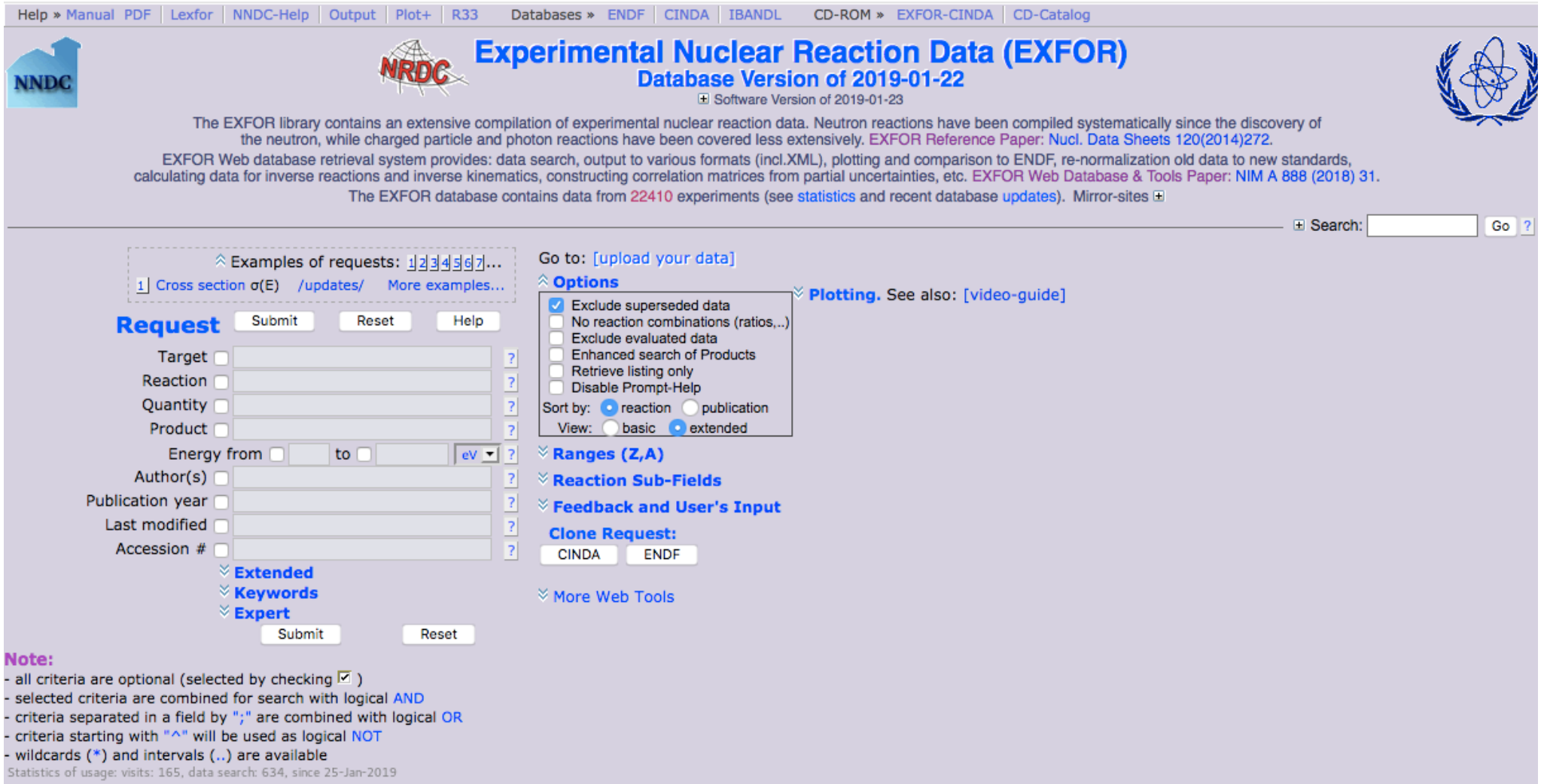
IAEA

EXFOR fortified to better serve

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<https://www-nds.iaea.org/exfor/>



The screenshot shows the EXFOR web database interface. At the top, there is a navigation menu with links like 'Help', 'Manual', 'PDF', 'Lefxor', 'NNDC-Help', 'Output', 'Plot+', 'R33', 'Databases', 'ENDF', 'CINDA', 'IBANDL', 'CD-ROM', 'EXFOR-CINDA', and 'CD-Catalog'. The main header features the NNDC logo, the NRDC logo, and the title 'Experimental Nuclear Reaction Data (EXFOR) Database Version of 2019-01-22'. Below the header, there is a paragraph describing the EXFOR library and its retrieval system. A search bar is located on the right side of the header. The main content area is divided into several sections: 'Request' with input fields for Target, Reaction, Quantity, Product, Energy from/to, Author(s), Publication year, Last modified, and Accession #; 'Options' with checkboxes for 'Exclude superseded data', 'No reaction combinations (ratios,...)', 'Exclude evaluated data', 'Enhanced search of Products', 'Retrieve listing only', and 'Disable Prompt-Help'; 'Ranges (Z,A)', 'Reaction Sub-Fields', 'Feedback and User's Input', 'Clone Request' (with CINDA and ENDF buttons), and 'More Web Tools'. A 'Note' section at the bottom left provides instructions on how to use the search criteria. The footer contains statistics of usage: visits: 165, data search: 634, since 25-Jan-2019.

Help » Manual PDF Lefxor NNDC-Help Output Plot+ R33 Databases » ENDF CINDA IBANDL CD-ROM » EXFOR-CINDA CD-Catalog

Experimental Nuclear Reaction Data (EXFOR)
Database Version of 2019-01-22
Software Version of 2019-01-23

The EXFOR library contains an extensive compilation of experimental nuclear reaction data. Neutron reactions have been compiled systematically since the discovery of the neutron, while charged particle and photon reactions have been covered less extensively. [EXFOR Reference Paper: Nucl. Data Sheets 120\(2014\)272.](#)

EXFOR Web database retrieval system provides: data search, output to various formats (incl.XML), plotting and comparison to ENDF, re-normalization old data to new standards, calculating data for inverse reactions and inverse kinematics, constructing correlation matrices from partial uncertainties, etc. [EXFOR Web Database & Tools Paper: NIM A 888 \(2018\) 31.](#)

The EXFOR database contains data from **22410** experiments (see [statistics](#) and recent database [updates](#)). [Mirror-sites](#)

Search: Go ?

Examples of requests: [1](#) [2](#) [3](#) [4](#) [5](#) [6](#) [7](#)...

1) [Cross section \$\sigma\(E\)\$](#) /updates/ [More examples...](#)

Request Submit Reset Help

Target ?

Reaction ?

Quantity ?

Product ?

Energy from to eV ?

Author(s) ?

Publication year ?

Last modified ?

Accession # ?

Extended
 Keywords
 Expert

Submit Reset

Go to: [\[upload your data\]](#)

Options

Exclude superseded data
 No reaction combinations (ratios,...)
 Exclude evaluated data
 Enhanced search of Products
 Retrieve listing only
 Disable Prompt-Help

Sort by: reaction publication
View: basic extended

Plotting. See also: [\[video-guide\]](#)

Ranges (Z,A)
Reaction Sub-Fields
Feedback and User's Input
Clone Request:
CINDA ENDF
More Web Tools

Note:

- all criteria are optional (selected by checking)
- selected criteria are combined for search with logical AND
- criteria separated in a field by ";" are combined with logical OR
- criteria starting with "^" will be used as logical NOT
- wildcards (*) and intervals (..) are available

Statistics of usage: visits: 165, data search: 634, since 25-Jan-2019

15 years of age !

EXFOR metrics: 42 quantities ! what was really measured?

ALF	α -value ($\sigma_{\text{capt}}/\sigma_{\text{fis}}$)	FY	Fission product yield
AMP	Length or amplitude	INT	Cross section integral over incident energy
CHG	Fragment charge	KE	Kinetic energy
CS	Cross section	KER	Kerma factor
CSN	Differential with respect to number of particles	MLT	Multiplicity
CSP	Partial cross section	NQ	Nuclear quantity
CST	Temperature dependent cross section	NU	Fission neutron multiplicity $\bar{\nu}$
D3A	Triple differential $d\Omega_1/d\Omega_2/dE'$	NUD	Delayed fission neutron multiplicity $\bar{\nu}_d$
D3E	Triple differential $d\Omega/dE'_1/dE'_2$	NUF	Fragment neutrons
D4A	Quadruple diff. $d\Omega_1/d\Omega_2/dE'_1/dE'_2$	POL	Polarization
DA	Differential $d/d\Omega$	POD	Differential polarization
DAA	Double differential $d\Omega_1/d\Omega_2$	PY	Product yield (other than fission)
DAE	Double differential $d\Omega/dE'$	RI	Resonance integral
DAP	Partial differential $d/d\Omega$	RP	Resonance parameter
DAT	Temperature-dependent Legendre coefficient	RR	Reaction rate
DE	Differential d/dE'	SIF	Self indication
DEP	Energy spectrum for specific group	SPC	Gamma spectrum
DP	Diff. by linear momentum of outgoing part.	TSL	Thermal scattering
DT	Diff. by 4-momentum transfer squared	TT	Thick target yield
ETA	η -value $\bar{\nu}\sigma_{\text{fis}}/(\sigma_{\text{capt}} + \sigma_{\text{fis}})$	TTD	Differential thick target yield, $d/d\Omega$
EVL	Evaluation	TTP	Partial thick target yield


















Special codes in incident energy field

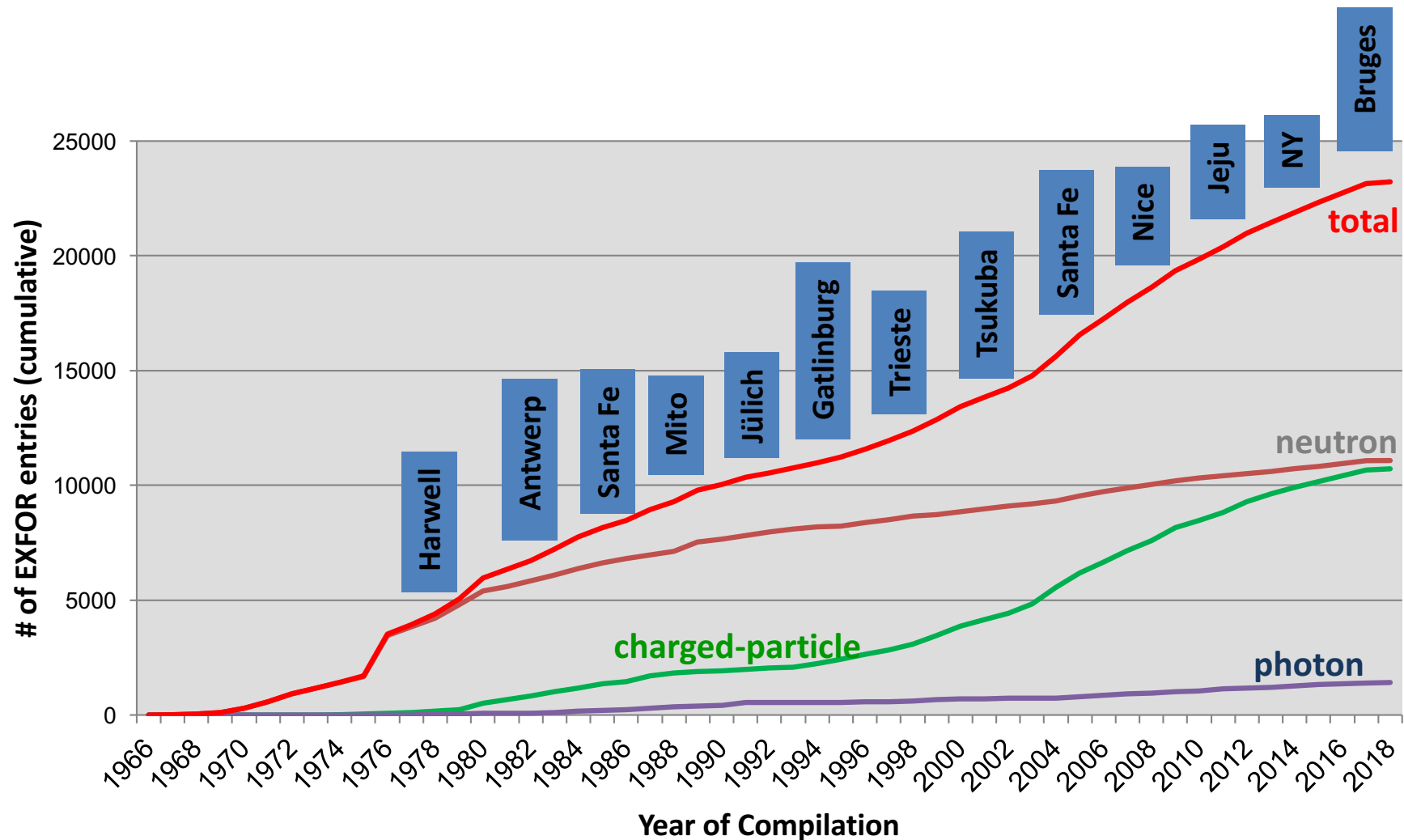
Fast	Fast reactor spectrum average	Maxw	Maxwellian spectrum average
Fiss	Fission spectrum average	Spont	Spontaneous (for fission)

Special codes in outgoing particle field

abs	Absorption	fus	Fusion	sct	Scattering	tot	Total
el	Elastic	inel	Inelastic	tcx	Total charge changing		
fis	Fission	non	Nonelastic	ths	Thermal scattering	3	

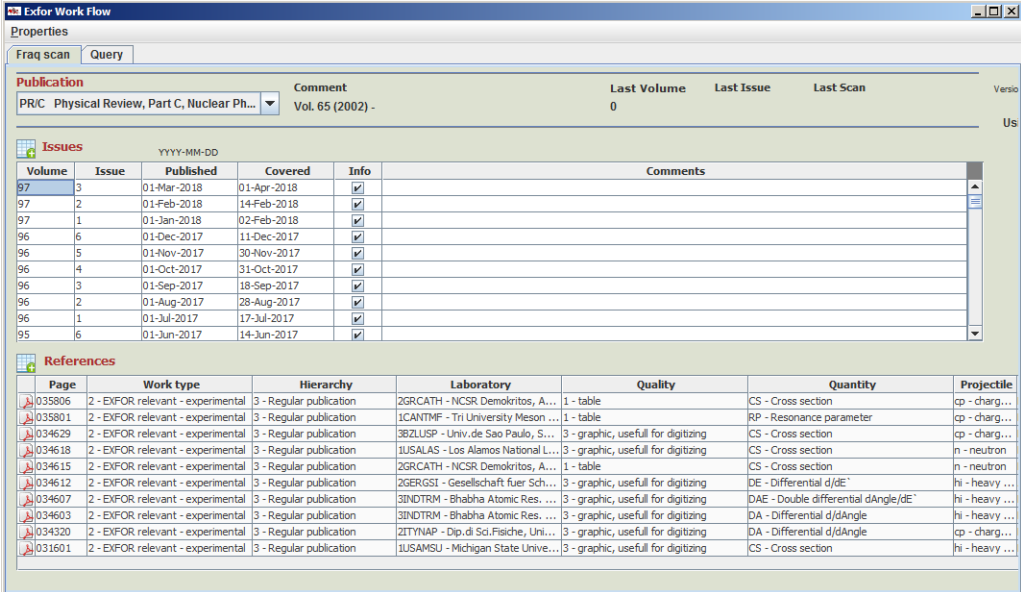
EXFOR Quantity

#	Code	Quantity	Counts	Percent
1	CS	Cross section data	11495	 51.2
2	DAP	Partial differential data with respect to angle	4338	 19.3
3	DA	Differential data with respect to angle	4333	 19.3
4	RP	Resonance parameters	1996	 8.9
5	CSP	Partial cross section data	1923	 8.58
6	FY	Fission product yields	1119	 4.99
7	POL	Polarization data	1114	 4.97
8	DAE	Differential data with respect to angle and energy	1094	 4.88
9	MFQ	Fission neutron quantities	529	 2.36
10	SP	Gamma spectra	464	 2.07
11	RI	Resonance integrals	458	 2.04
12	DE	Differential data with respect to energy	383	 1.7
13	TT	Thick target yields	342	 1.52
14	E	Kinetic energies	338	 1.5
15	L	Scattering amplitudes	222	 0.99
16	INT	Cross section integral over incident energy	193	 0.86
17	PY	Product yields	176	 0.78
18	NQ	Nuclear quantities	112	0.49
19	MLT	Outgoing particle multiplicities	109	0.48
20	RR	Reaction rates	105	0.46
21	TTD	Differential thick target yields	51	0.22
22	CST	Temperature dependent cross section data	40	0.17
23	DEP	Partial differential data with respect to energy	12	0.053
24	SQ	Special quantities	8	0.035
25	COR	Secondary particle correlations	3	0.013
26	TTP	Partial thick target yields	3	0.013



As of today more than **22,400 experimental works** have been compiled in EXFOR, corresponding to ten's of billions in investment the World over

- NDS regularly scans **40 journals**
- NDS also regularly receives reports of journal scanned by NNDC, CNPD (Sarov) and JAEA



The screenshot shows the 'Exfor Work Flow' application window. It has a 'Properties' section at the top with a 'Frag scan' and 'Query' tab. Below that is a 'Publication' section with a dropdown menu for 'PRIC Physical Review, Part C, Nuclear Ph...' and a 'Comment' field containing 'Vol. 65 (2002)'. To the right of the publication section are fields for 'Last Volume' (0), 'Last Issue', and 'Last Scan'. Below the publication section is an 'Issues' table with columns for 'Volume', 'Issue', 'Published', 'Covered', 'Info', and 'Comments'. The 'Issues' table contains 12 rows of data. Below the 'Issues' table is a 'References' table with columns for 'Page', 'Work type', 'Hierarchy', 'Laboratory', 'Quality', 'Quantity', and 'Projectile'. The 'References' table contains 10 rows of data.

Volume	Issue	Published	Covered	Info	Comments
97	3	01-Mar-2018	01-Apr-2018	<input checked="" type="checkbox"/>	
97	2	01-Feb-2018	14-Feb-2018	<input checked="" type="checkbox"/>	
97	1	01-Jan-2018	02-Feb-2018	<input checked="" type="checkbox"/>	
96	6	01-Dec-2017	11-Dec-2017	<input checked="" type="checkbox"/>	
96	5	01-Nov-2017	30-Nov-2017	<input checked="" type="checkbox"/>	
96	4	01-Oct-2017	31-Oct-2017	<input checked="" type="checkbox"/>	
96	3	01-Sep-2017	18-Sep-2017	<input checked="" type="checkbox"/>	
96	2	01-Aug-2017	28-Aug-2017	<input checked="" type="checkbox"/>	
96	1	01-Jul-2017	17-Jul-2017	<input checked="" type="checkbox"/>	
95	6	01-Jun-2017	14-Jun-2017	<input checked="" type="checkbox"/>	

Page	Work type	Hierarchy	Laboratory	Quality	Quantity	Projectile
035806	2 - EXFOR relevant - experimental	3 - Regular publication	2GRCATH - NCSR Demokritos, A...	1 - table	CS - Cross section	cp - charg...
035801	2 - EXFOR relevant - experimental	3 - Regular publication	1CANTMF - Tri University Meson ...	1 - table	RP - Resonance parameter	cp - charg...
034629	2 - EXFOR relevant - experimental	3 - Regular publication	3BZLUSP - Univ.de Sao Paulo, S...	3 - graphic, usefull for digitizing	CS - Cross section	cp - charg...
034618	2 - EXFOR relevant - experimental	3 - Regular publication	1USALAS - Los Alamos National L...	3 - graphic, usefull for digitizing	CS - Cross section	n - neutron
034615	2 - EXFOR relevant - experimental	3 - Regular publication	2GRCATH - NCSR Demokritos, A...	1 - table	CS - Cross section	n - neutron
034612	2 - EXFOR relevant - experimental	3 - Regular publication	2GERGSI - Gesellschaft fuer Sch...	3 - graphic, usefull for digitizing	DE - Differential d/dE	hi - heavy ...
034607	2 - EXFOR relevant - experimental	3 - Regular publication	3INDTRM - Bhabha Atomic Res. ...	3 - graphic, usefull for digitizing	DAE - Double differential dAngle/dE	hi - heavy ...
034603	2 - EXFOR relevant - experimental	3 - Regular publication	3INDTRM - Bhabha Atomic Res. ...	3 - graphic, usefull for digitizing	DA - Differential d/dAngle	hi - heavy ...
034320	2 - EXFOR relevant - experimental	3 - Regular publication	2ITYNAP - Dip. di Sci.Fisiche, Uni...	3 - graphic, usefull for digitizing	DA - Differential d/dAngle	cp - charg...
031601	2 - EXFOR relevant - experimental	3 - Regular publication	1USAMSU - Michigan State Unive...	3 - graphic, usefull for digitizing	CS - Cross section	hi - heavy ...

Internal database for article registration

- Recent comparison between EXFOR and NSR (Nuclear Science References) databases shows that at least 3% of proton, 20% of alpha induced data are still not in EXFOR

LETTER

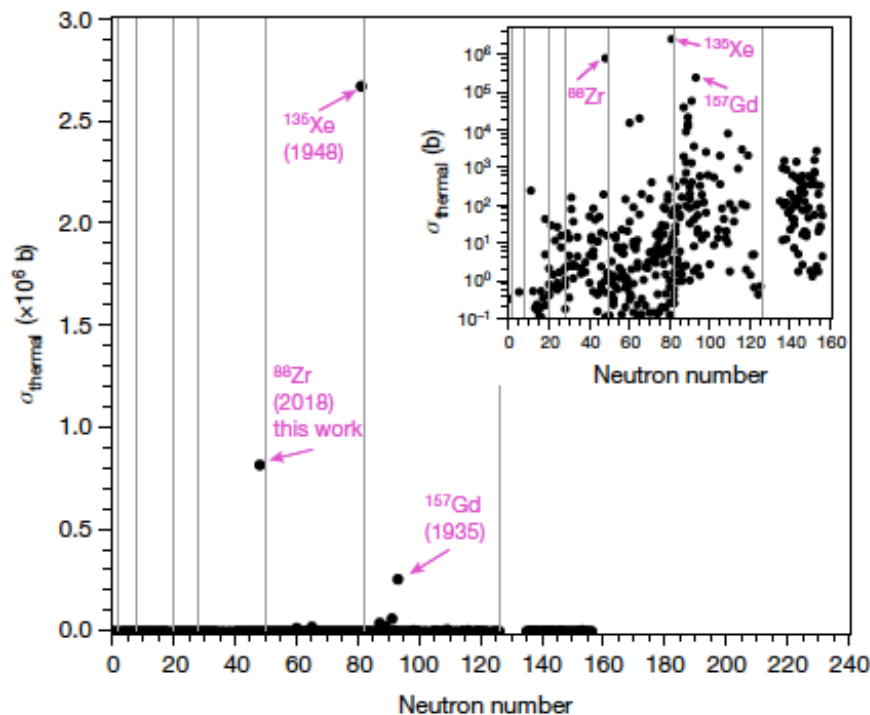
2019 from Nature (already 17 entries)

<https://doi.org/10.1038/s41586-018-0838-z>

Zr88 83.4 d E 0.68	Zr89 4.16 m E 2.833	Zr90 51.45 E 89.904704	Zr91 11.22 E 90.905646	Zr92 17.15 E 91.905041	Zr93 1.5E6 a E 0.091	Zr94 17.38 E 93.906315	Zr95 64.02 d E 1.124	Zr96 2.80 E 96.908273
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The surprisingly large neutron capture cross-section of ^{88}Zr

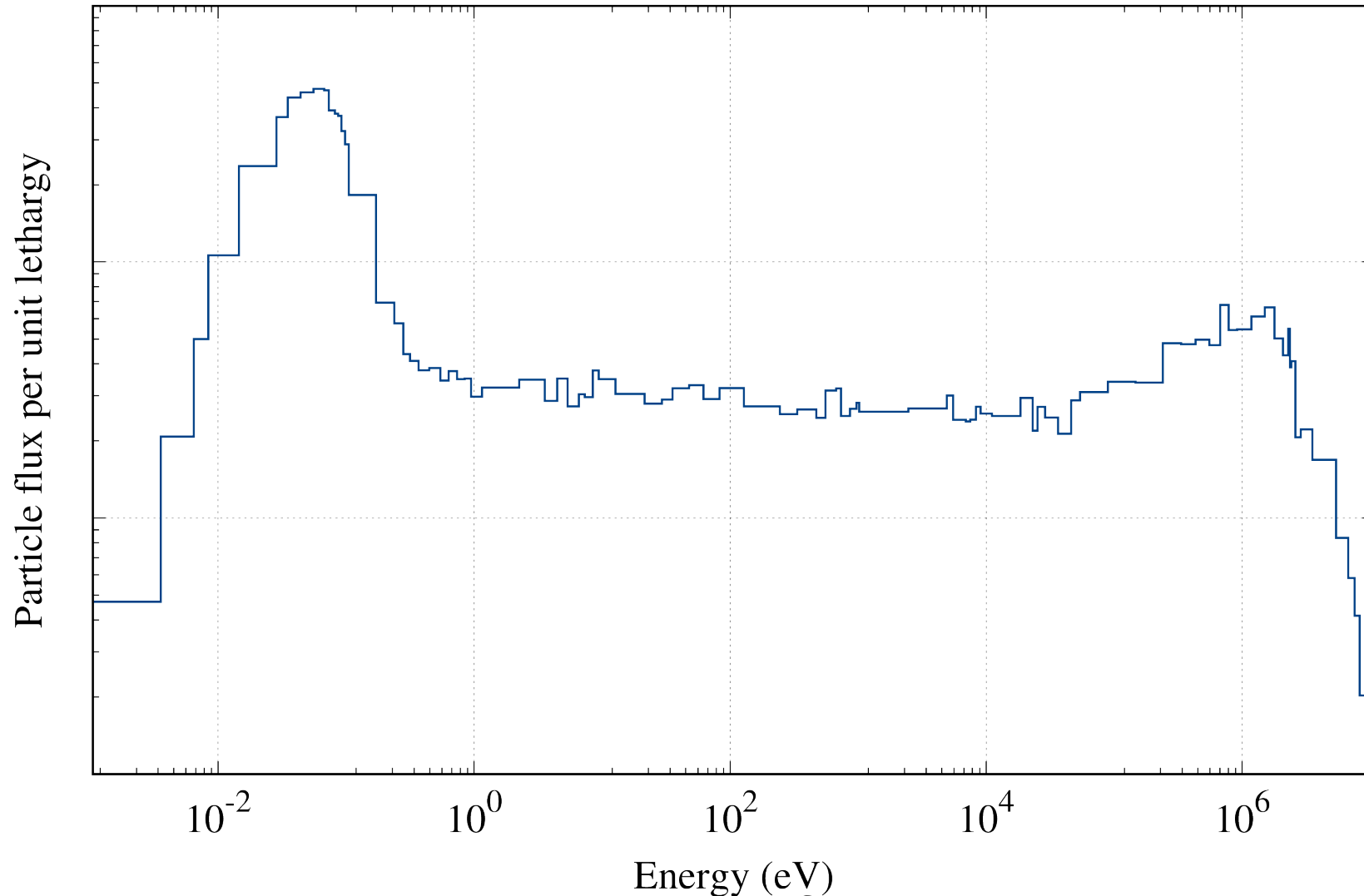
Jennifer A. Shusterman^{1,2,3*}, Nicholas D. Scielzo¹, Keenan J. Thomas¹, Eric B. Norman⁴, Suzanne E. Lapi⁵, C. Shaun Loveless⁵, Nickie J. Peters⁶, J. David Robertson⁶, Dawn A. Shaughnessy¹ & Anton P. Tonchev¹



- ^{88}Zr $T_{1/2} = 83.4$ d
- $\sigma_{\text{th}} = 861,000 \pm 69,000$ barns
- Fortunately not produced in the Zircalloy of the World's PWRs

- $7.3 \times 10^{13} \text{ n cm}^{-2} \text{ s}^{-1}$ average thermal

MURR-G1 (112 grps)



- More complete experimental information stored

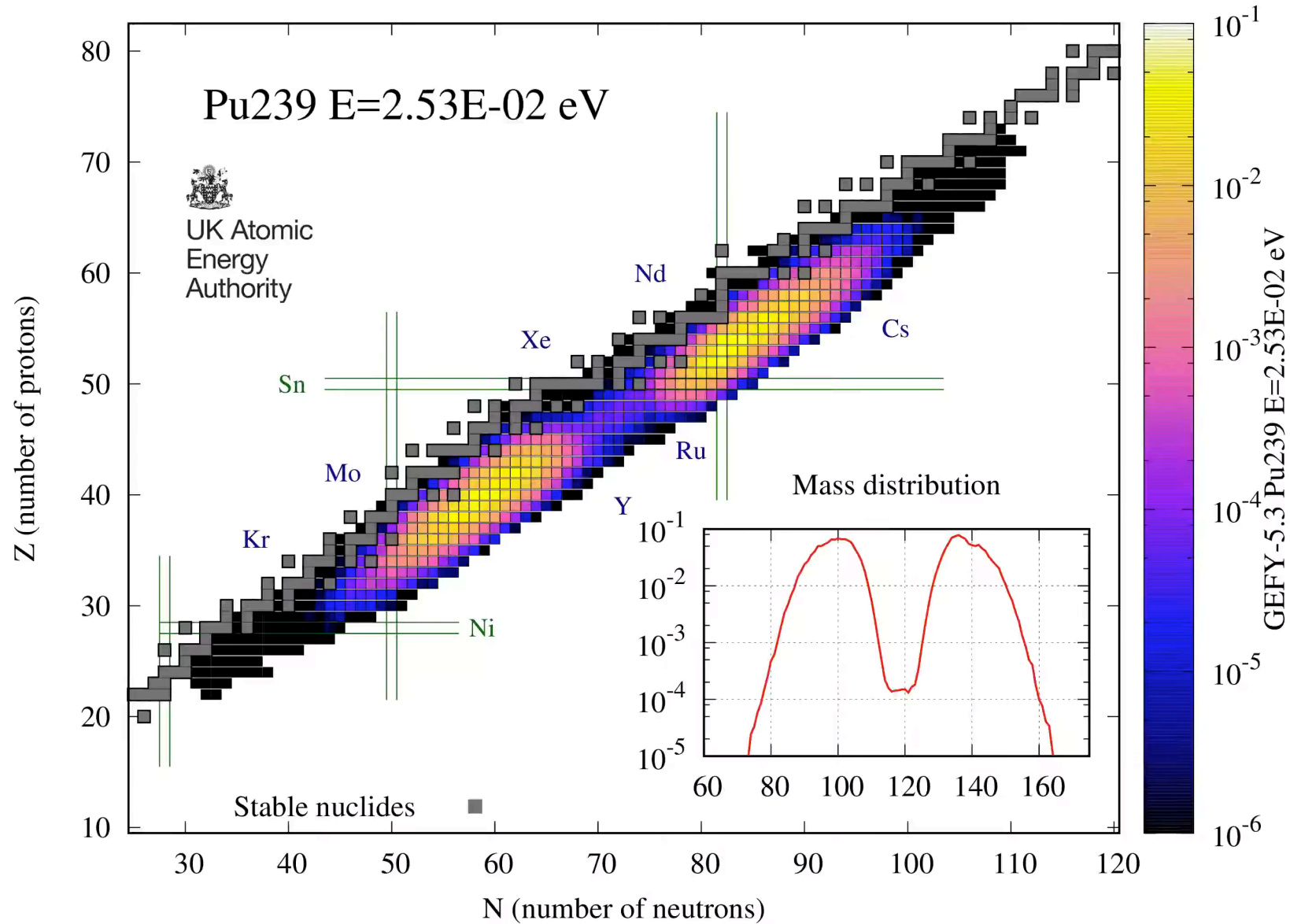
- Reference list (Bibliographic) in Robert William Mills' Ph.D. thesis and England-Rider's evaluation.

Number of Bibliographic in Robert William Mills' Ph.D. thesis

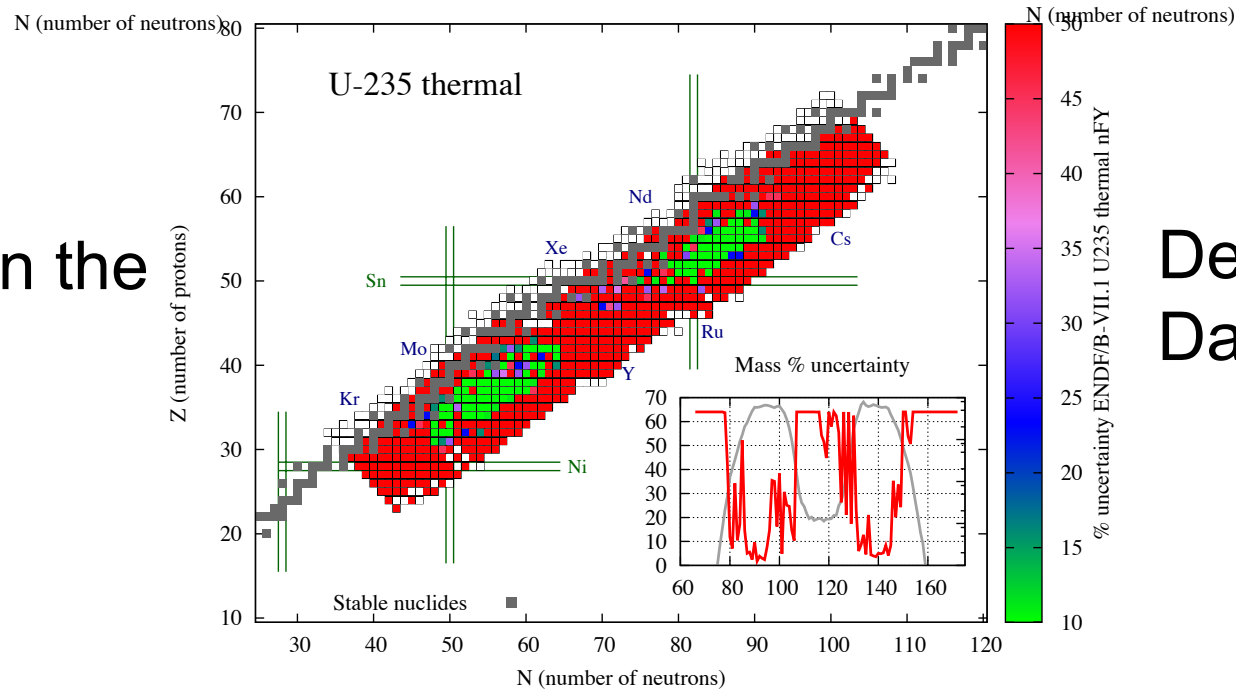
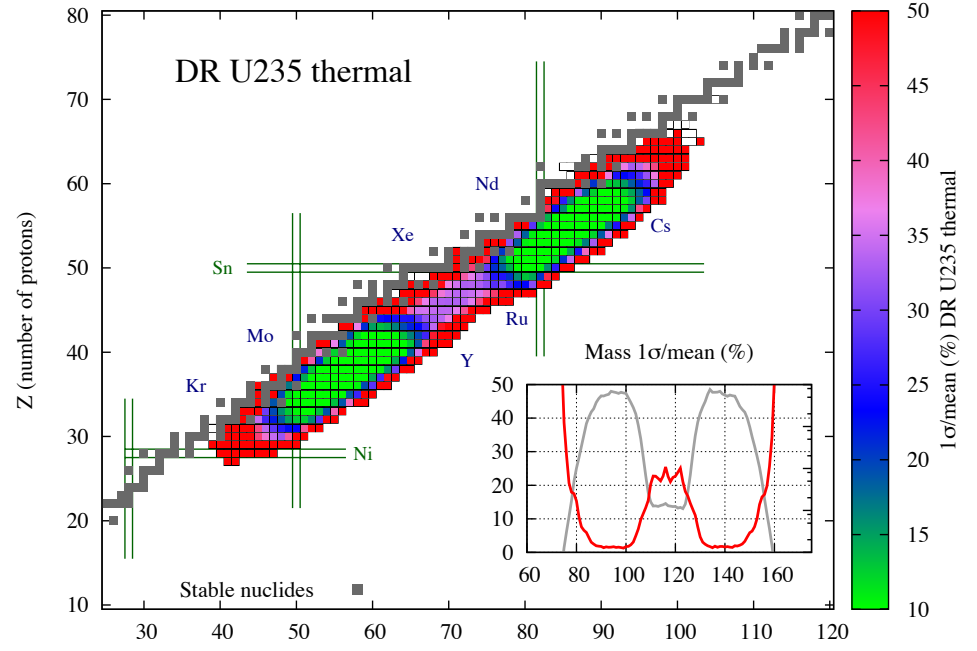
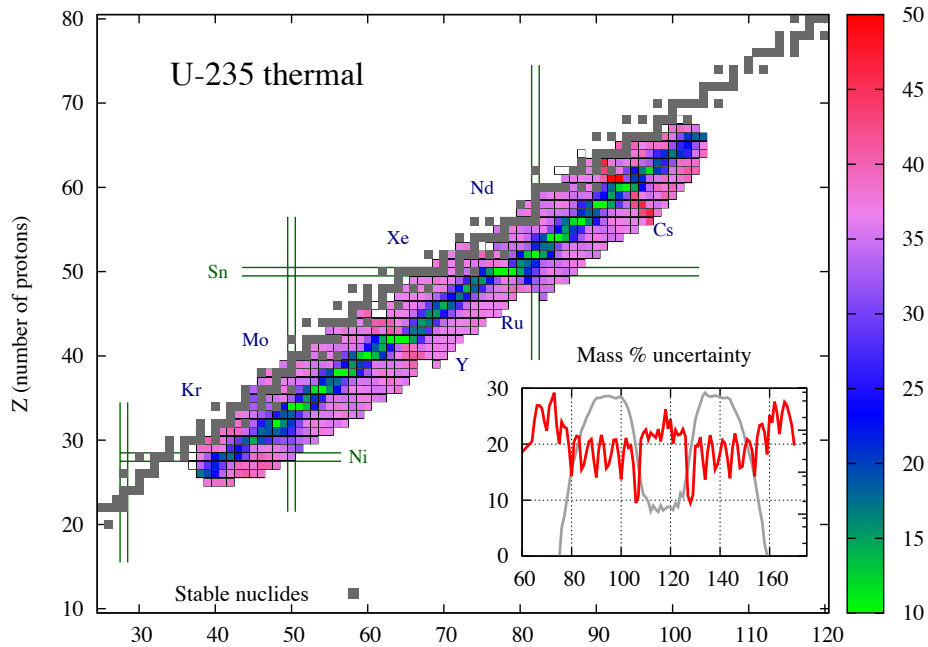
	Mills' list	In EXFOR
Data 1	498	361
2	16	8
3	69	30
4	56	19

- Most of the missing data is from old issues of two journals (written in Russian and German), some conference proceedings, and master or others Ph.D. thesis.
- Compilations need to be done while a CRP on FPY is running
 1. Completeness check and statistical analysis by NDS
 2. Assemblage of missing entries by NDS
 3. Compilation by NRDC
- Fission cross-sections are well known, but what about the others fission observables?

An evaluation, GEFY Pu239, 59 steps



U235 FY's uncertainty @ 0.0253 eV

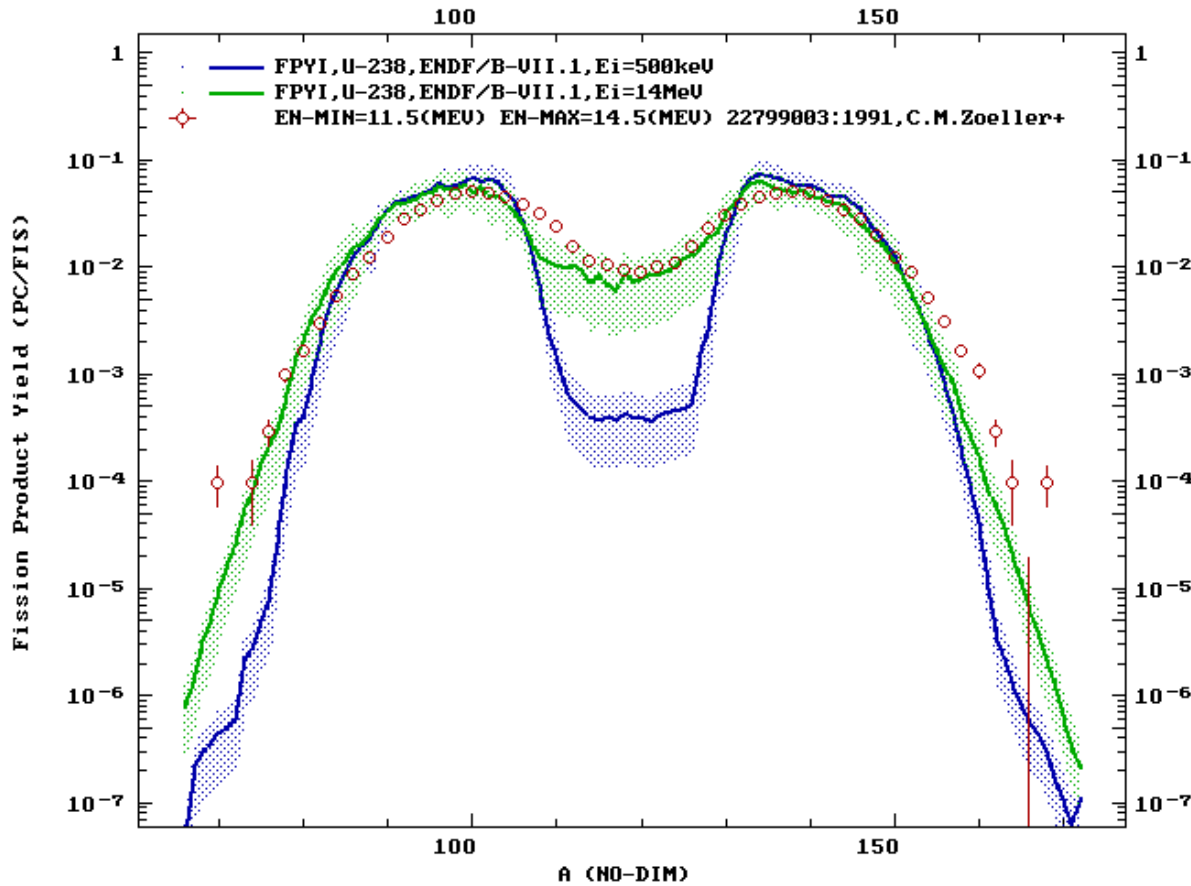


Depend on the method?

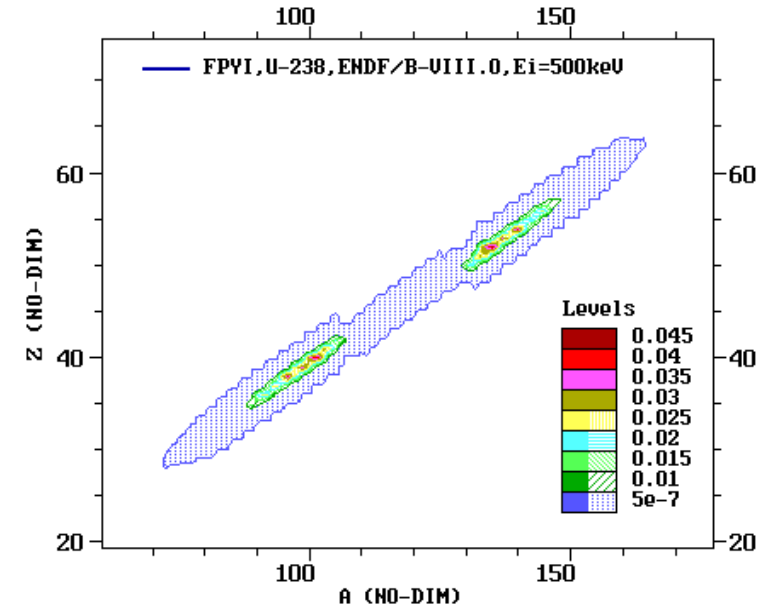
Depend on the Data ?

FPY Plotting ENDF vs. EXFOR data -under development-

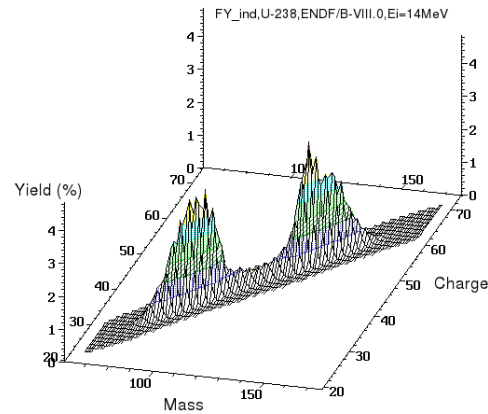
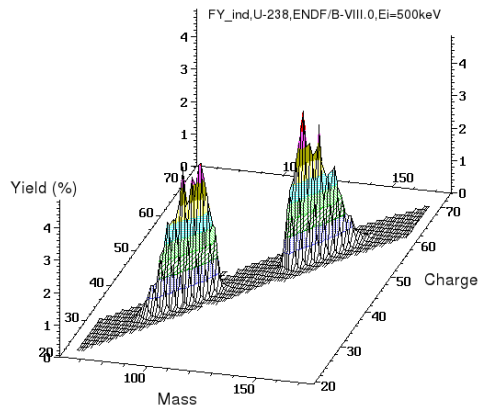
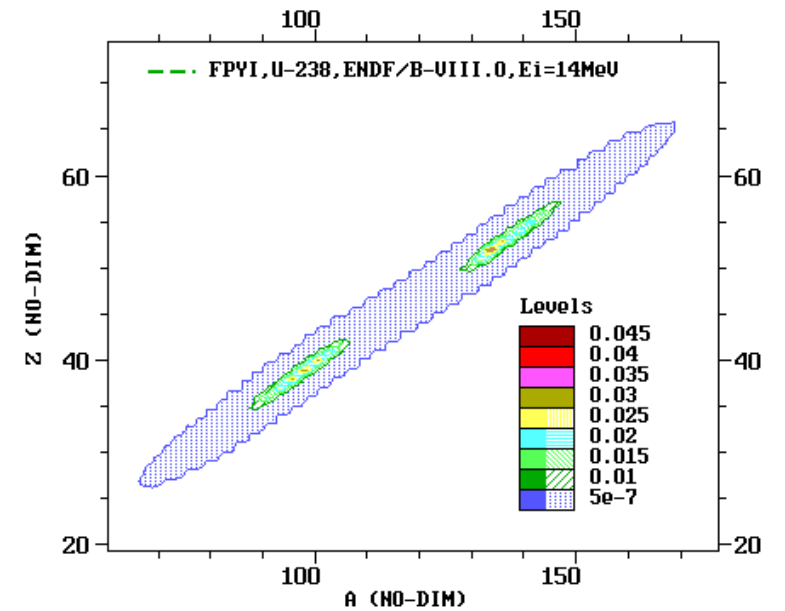
Fission Product Yield



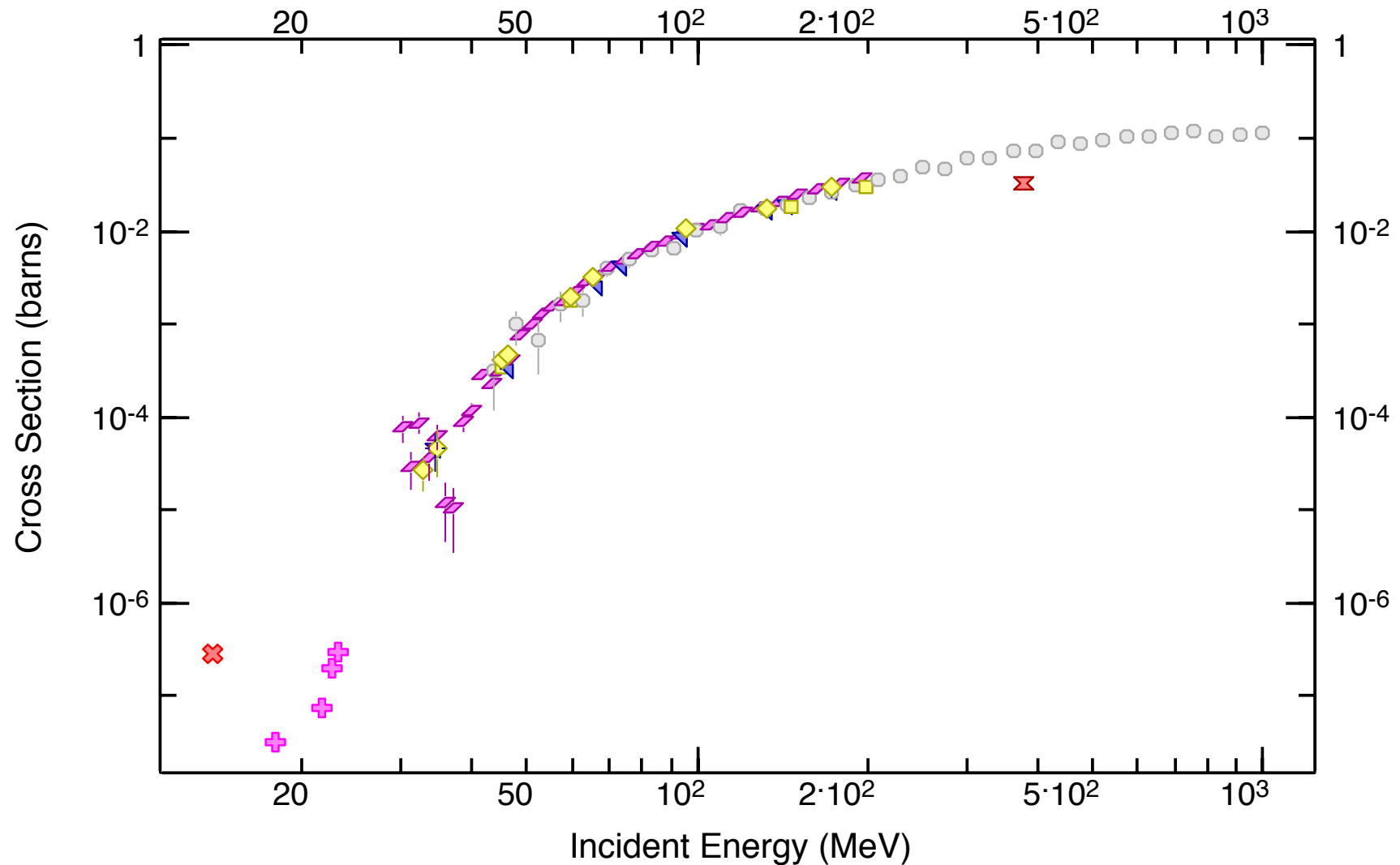
Fission Product Yield



Fission Product Yield



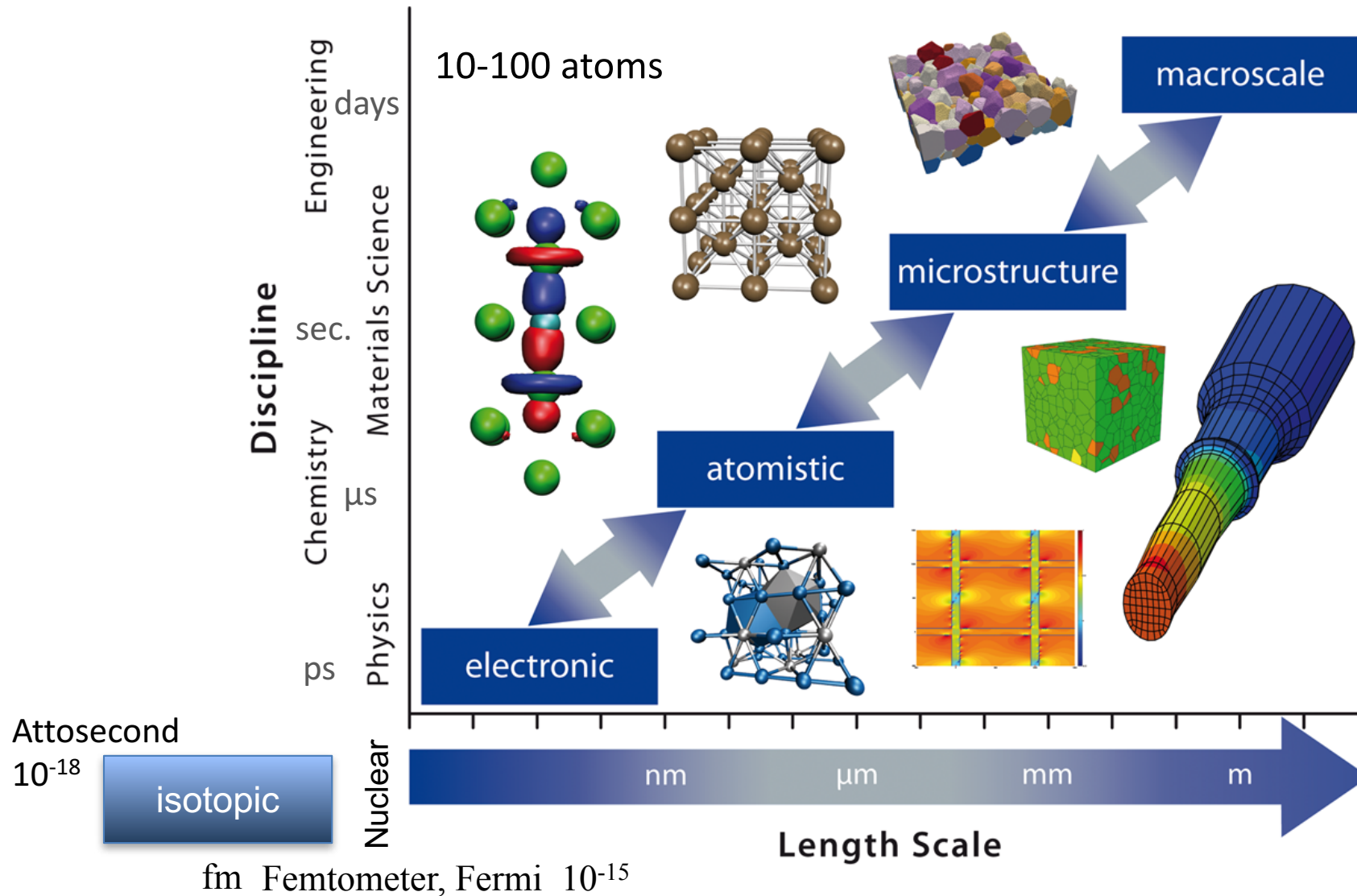
- An entry of the lesser world... of evaluation



EXFOR serves different scientific communities, the World over and those are traditionally involved in:

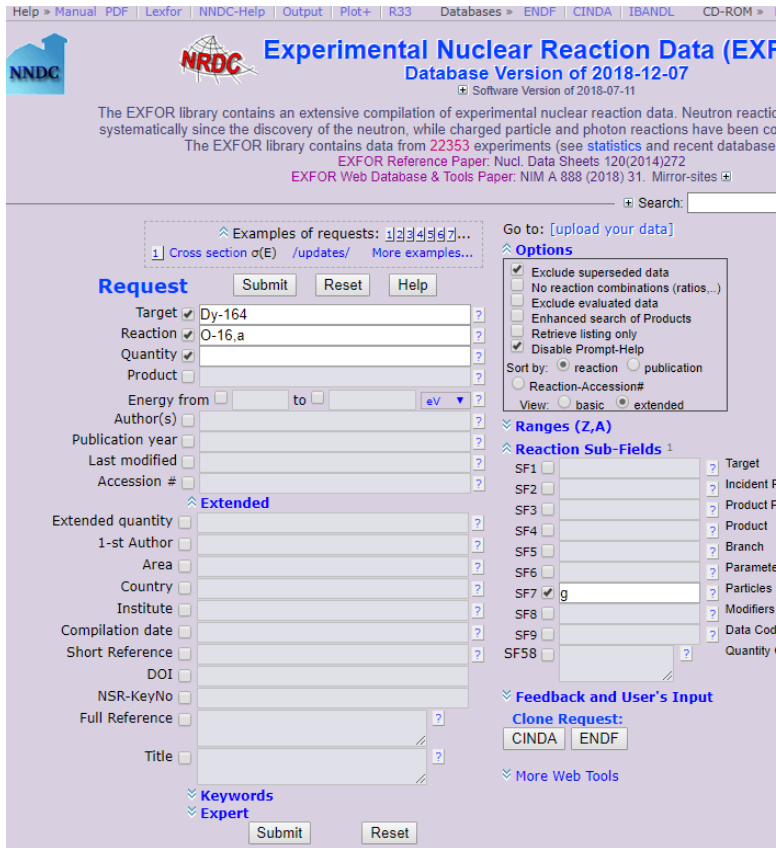
- Physics models
 - Allows to pin down the physics at play
- Nuclear data evaluation
 - Allows to shape/shift the different data forms
- Verification and Validation of codes
 - Allows to constrain the simulation results

Multi-scales modelling: material sciences



Traditionally different disciplines focus on different length scales. Multiscale modelling of materials across the length scales requires overcoming the borders between the disciplines for a seamless integration of the models on different length scales into one coherent multi-scale modelling framework (After D. Pettifor, 1991).

- Increases charged particle entries
- Completes/corrects/clean up the neutron entries
- Fills up the fission yields, other observables entries
- Search/prototype for new ways to:
 - Better exploit the data, all of them: elemental and isotopic
 - Deploys, pushes some of its metrics further
 - Develops analytics
 - Serves a broader community
 - Sub-package EXFOR, with dedicated wrapping
 - ...



Experimental Nuclear Reaction Data (EXFOR) Database Version of 2018-12-07

Software Version of 2018-07-11

The EXFOR library contains an extensive compilation of experimental nuclear reaction data. Neutron reactions systematically since the discovery of the neutron, while charged particle and photon reactions have been compiled since the 1950s. The EXFOR library contains data from 22353 experiments (see statistics and recent database update).

EXFOR Reference Paper: Nucl. Data Sheets 120(2014)272
EXFOR Web Database & Tools Paper: NIM A 888 (2018) 31. Mirror-sites

Search:

Go to: [\[upload your data\]](#)

Options

- Exclude superseded data
- No reaction combinations (ratios,...)
- Exclude evaluated data
- Enhanced search of Products
- Retrieve listing only
- Disable Prompt-Help

Sort by: reaction publication
View: basic extended

Ranges (Z,A)

Reaction Sub-Fields

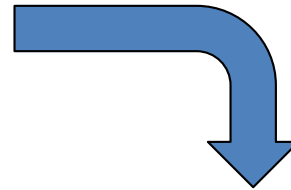
SF1 SF2 SF3 SF4 SF5 SF6 SF7 g SF8 SF9 SF58

Feedback and User's Input

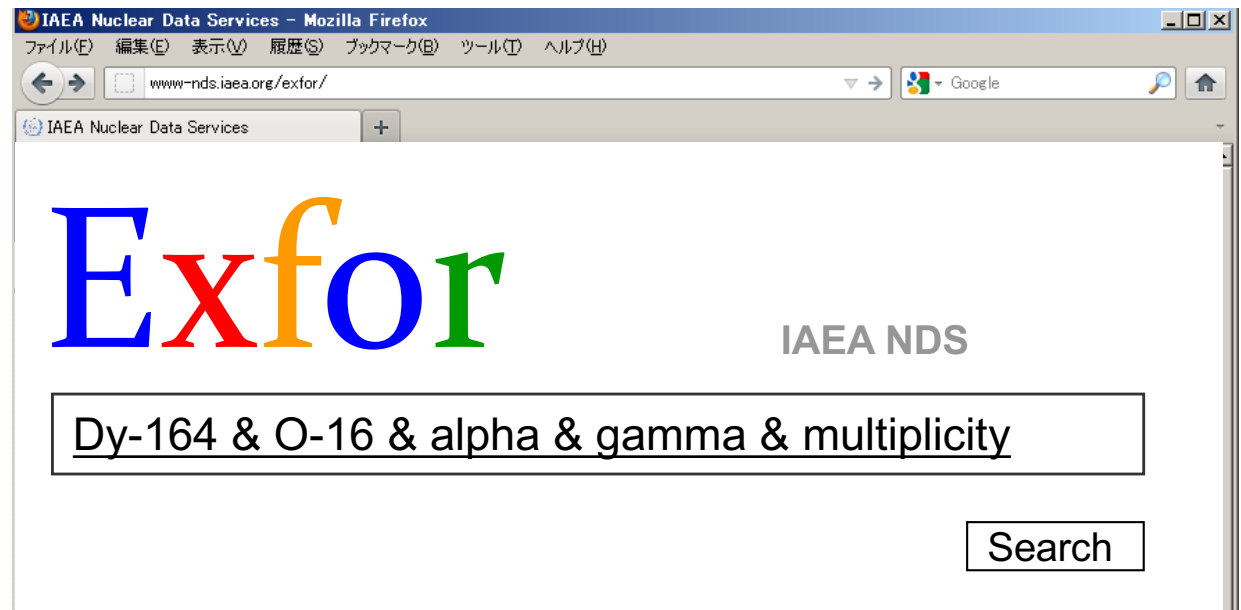
Clone Request:

Many input forms
(Relational database oriented design)

Why not providing multiple interfaces,
not just the one?



Single form (with a clever interpreter)



IAEA Nuclear Data Services – Mozilla Firefox

www-nds.iaea.org/exfor/

IAEA Nuclear Data Services

Exfor

IAEA NDS



Experimental Nuclear Reaction Data (EXFOR)

Database Version of 2019-01-22

Software Version of 2019-01-30



The EXFOR library contains an extensive compilation of experimental nuclear reaction data. Neutron reactions have been compiled systematically since the discovery of the neutron, while charged particle and photon reactions have been covered less extensively. [EXFOR Reference Paper: Nucl. Data Sheets 120\(2014\)272](#).

EXFOR Web database retrieval system provides: data search, output to various formats (incl.XML), plotting and comparison to ENDF, re-normalization old data to new standards, calculating data for inverse reactions and inverse kinematics, constructing correlation matrices from partial uncertainties, etc. [EXFOR Web Database & Tools Paper: NIM A 888 \(2018\) 31](#).

The EXFOR database contains data from **22410** experiments (see [statistics](#) and recent database [updates](#)). Mirror-sites [+](#)

Search:

Sort by: Year Author Entry

View: extended Page: Entries

Text search help is [\[here\]](#).
[\[Hide\]](#) options. [\[Reset\]](#) form.



<https://www-nds.iaea.org/exfor/servlet/X4sSearch5>

Request #379

Access-Level=2 /pdf/

Text search

Found EXFOR Entries: 1 List: [\[full\]](#) [\[compact\]](#)

Page: 1.

1) 2009, Y.K.Gupta+, Jour: Physical Review, Part C, Nuclear Physics, Vol.80, p.054611 (2009). ENTRY #C1772: [\[E\]](#) [\[R\]](#) [\[x4+\]](#)

REACTION: (66-DY-164(8-O-16,X)2-HE-4,,DA/DE,,MSC)

REACTION: (66-DY-164(8-O-16,X)2-HE-4,,DA/DE,,MSC)

DETECTOR: (TELES,SIBAR,SIBAR)The **alpha** particles emitted in

detector: (BGO) **Gamma**-ray multiplicity setup consisting of 14

detector: (BGO) Gamma-ray **multiplicity** setup consisting of 14

Subent:21 Pnt:393 Ene=77-86MeV An=125-153° Target:Dy-164;Ta-181 Reaction:(c-12,x);(o-16,x)

1) [\[pdf\]](#)+ Jour: Physical Review, Part C, Nuclear Physics, Vol.80, p.054611 (2009) DOI: [10.1103/PhysRevC.80.054611](https://doi.org/10.1103/PhysRevC.80.054611) NSR: 2009GU30 [\[pdf\]](#)

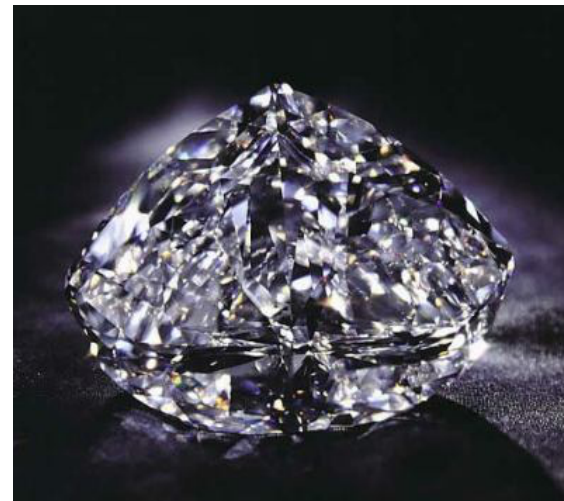
Nuclear level-density parameters of nuclei in the $Z \approx 70$ and $A \approx 180$ mid-shell regions

Y.K.Gupta, D.C.Biswas, B.John, B.K.Nayak, A.Saxena, R.K.Choudhury

Select Entries on the Page: [\[all\]](#) [\[none\]](#)

Go to EXFOR [\[Request\]](#) with selected Entries (0):

Moving from raw to shaped diamond



Blue Zoe