Towards a modern and comprehensive database of experimental fission yields, starting with ^{238}U

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U.S. DEPARTMENT OF ENERGY

BROOKHAVEN SCIENCE ASSOCIATES

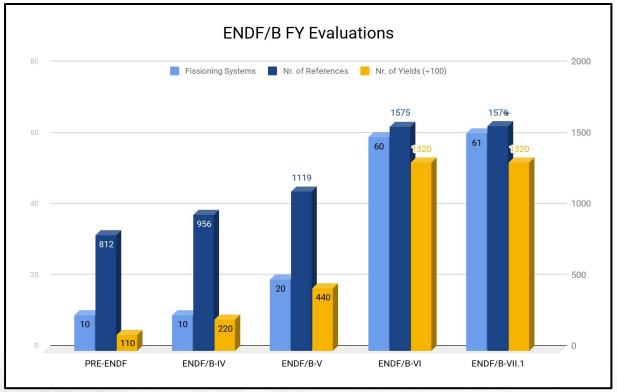
Outline

- Motivation
- U238F: the prototype for a new database of FYs:
  -  Bibliographic Compilation
  -  JSON: a *working format* for FYs
  -  Update of Nuclear Data
- Compilation of Isomeric Yield Ratios

Status of current evaluations of FPYs

ENDF/B-VIII inherited FPYs from ENDF/B-VII.1

- Most FYs largely based on the Eng&Rid evaluation of 1993 (that extended the 1983 evaluation from 34 to 60 fission reactions).
- Revision and update of FYs for ^{239}Pu+n (new evaluation at 2 MeV)



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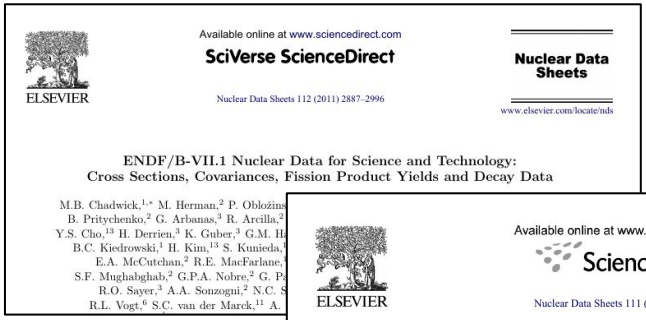

ELSEVIER

Available online at www.sciencedirect.com

SciVerse ScienceDirect

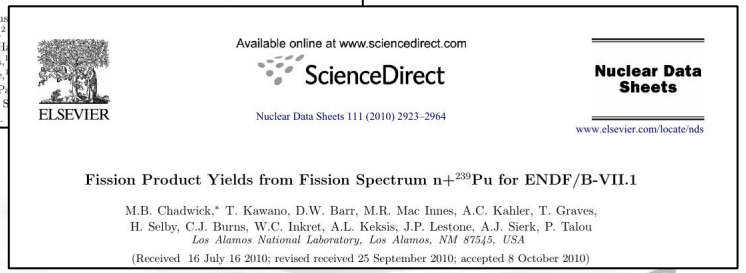
Nuclear Data Sheets

Nuclear Data Sheets 112 (2011) 2887–2996

www.elsevier.com/locate/nds

ENDF/B-VII.1 Nuclear Data for Science and Technology: Cross Sections, Covariances, Fission Product Yields and Decay Data

M.B. Chadwick,[1,*] M. Herman,[2] P. Obložin
B. Pritychenko,[2] G. Arbanas,[3] R. Arcilla,[2]
Y.S. Cho,[13] H. Derrien,[3] K. Guber,[3] G.M. H
B.C. Kiedrowski,[1] H. Kim,[13] S. Kunieda,[
E.A. McCutchan,[2] R.E. MacFarlane,[
S.F. Mughabghab,[2] G.P.A. Nobre,[2] G. P
R.O. Sayer,[3] A.A. Sonzogni,[2] N.C. S
R.L. Vogt,[6] S.C. van der Marck,[11] A.


ELSEVIER

Available online at www.sciencedirect.com

ScienceDirect

Nuclear Data Sheets

Nuclear Data Sheets 111 (2010) 2923–2964

www.elsevier.com/locate/nds

Fission Product Yields from Fission Spectrum n+^{239}Pu for ENDF/B-VII.1

M.B. Chadwick,* T. Kawano, D.W. Barr, M.R. Mac Innes, A.C. Kahler, T. Graves, H. Selby, C.J. Burns, W.C. Inkret, A.L. Keksis, J.P. Lestone, A.J. Sierk, P. Talou

Los Alamos National Laboratory, Los Alamos, NM 87545, USA

(Received 16 July 16 2010; revised received 25 September 2010; accepted 8 October 2010)

^{238}U in FPYs evaluations

- Evaluation of FY of ^{238}U at fission energy in ENDF/B is largely based on measurements of CFY performed 40+ years ago: [Maeck *et al.* (1975)]
- Independent Fission Yields are a small fraction of datapoints
- Gaps in data are filled using models, often "tuned" on U-235 data.

EFFECTS ON REACTOR ANTINEUTRINO SPECTRA

U-238 Fission Yields have been identified as a possible source of the disagreement between experiments and predictions of reactor antineutrino spectra. The effect of the latest Independent Fission Yields measurements on reactor antineutrino spectra have been investigated.

^{238}U Fission Yields Compilation

*Update/improvement of FY starting from a system that is of **immediate interest for applications***
&
*does **not** have **an overwhelming amount of data***

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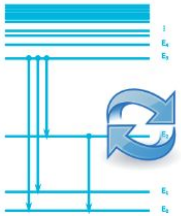

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FY-JSON: A NEW WORKING FORMAT FOR FISSION YIELDS

A new working format was developed, based on the JSON format, in order to easily store, access and correct Fission Yields data. An EXFOR-to-JSON conversion tool (by V.Zerkin) is available online on the IAEA website.

Retrieval of FY experimental references

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NSR - BibNr	NSR link	Exp I/O	X4 data (entrynr)			pdf I/O	Details	En / E*	Not (from
2019RA07	https:/\	1	n/a		0	1	1-n transfer reaction (CN: 238U)	7.4MeV Eex	
2019RA23	https:/\	1	n/a		0	1	1-n transfer reaction (CN: 239U)	near barrier fission	
2019FO04	https://	1	https://www.r	https://www.nnd	14522	1		fast	
2017PE08	https:/\	1	n/a		0	1		CoulEx	SOFIA/A
2017WI09	https:/\	1	https://www.ni	https://www.nndc	23403	1	anomaly (see 2019FO04)		
2017NA17	https:/\	1	https://www.ni	https://www.nndc	33106	1	charge distributions		
2017HI10	https:/\	1	n/a		0	1	inv-kin | multinucleon transfer reaction | FFMD	E* > 10-20 MeV	
2017UL01	https:/\	1	n/a		0	1	inv-kin | NO FY data		
2016GO02	https://	1	n/a		0	1	FY mass distro | new data? Also see: LLNL	0.5-14.8 MeV	dual-fis
2016DU22	https:/\	1	https://www.ni	https://www.nndc	14463	1	mass landscape / Fragment Y	1-30MeV	
2015NA13	https://	1	https://www.r	https://www.nnd	33093	1	FP offline: Y, peak/valley ratio	E=6.35, 8.53, 12.52 MeV	
2015BH09	https://	1	https://www.r	https://www.nnd	14423	1	92Sr 97Zr 99Mo 132Te 133I 140Ba 143Ce 14	8.9 MeV	TUNL
2015VO11	https:/\	1	https://www.ni	https://www.nndc	0	1	inv-kin		
2014TO09	https:/\	1	https://www.ni	https://www.nndc	14402	1	XS / Yields?	<200 MeV	
2014HA25	https:/\	1	https://www.ni	https://www.nndc	23280	1	XS / Yields?	0.2-5 MeV	
2014GO06	https:/\	1	https://www.ni	https://www.nndc	41598	1	FF yields		
2014BH11	https:/\	1	n/a		0	1	FPY ratio	E=4.6, 9.0, 14.5 MeV	
2013NA18	https://	1	https://www.r	https://www.nnd	33052	1	FY mass distro	E=3.72, 5.42, 7.75, 10.09 MeV	
2013KH11	https:/\	1	https://www.ni	https://www.nndc	41483	1	FFY's	E=5, 6.5 MeV	
2013GR14	https:/\	1	https://www.ni	https://www.nndc	14377	1	deduced atomic X-ray yields per fission	0.7-400MeV	
2012FI07	https:/\	1	https://www.ni	https://www.nndc	14441	1	FPs mass distro	0.00001 - 10 MeV	
2012RUZZ	https:/\	1	n/a		0	1			
2011RY09	https://e of 2011RY04?				0				
2010SE15	https://	1	n/a		0	1	99Mo/95Zr/137Cs/140Ba/141,143Ce/147Nd	E=0.4-1.9 MeV	LANL
2010AD13	https:/\	1	https://www.ni	https://www.nndc	41529	1	inv-kin --> the X4 file doesn't contain all info?		

- 200+ references containing ^{238}U(n,f) data
- Reduced to 166 references of interest for ^{238}U(n_{FAST},f)
- The large majority have a corresponding EXFOR entry, but some did not (too recent / being worked on / …)
- Table used as the starting point of compilation effort

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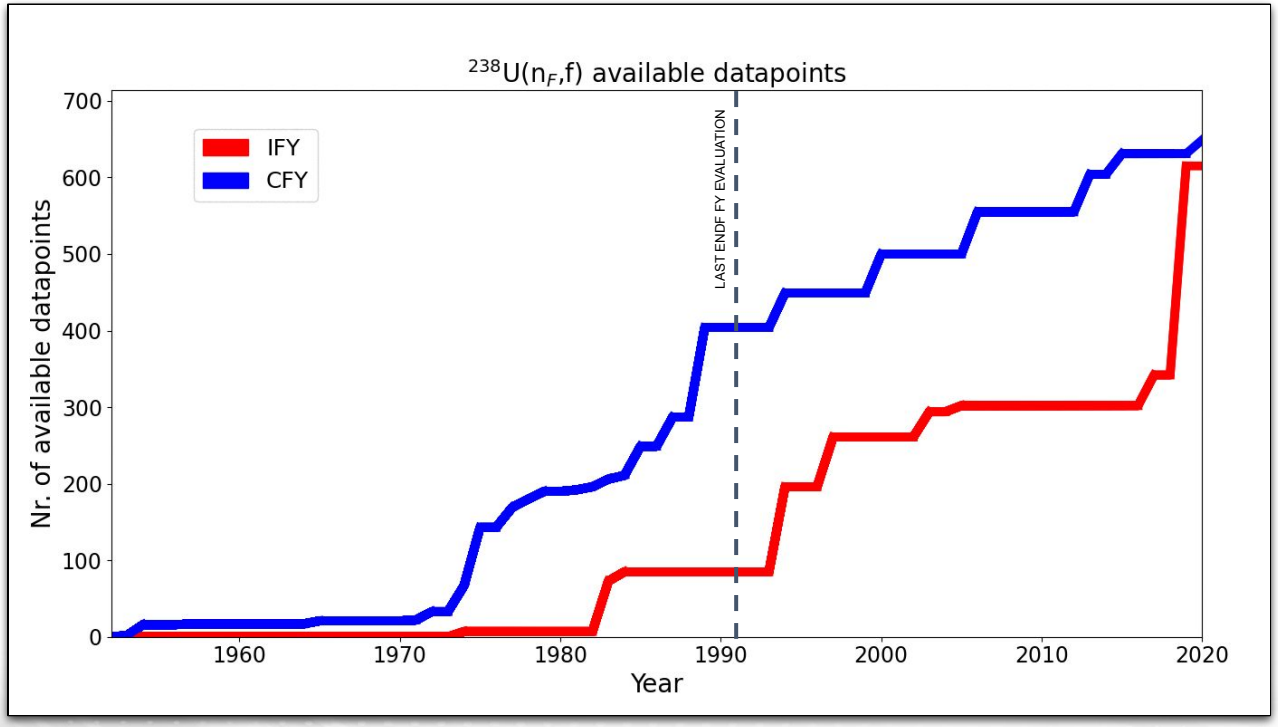

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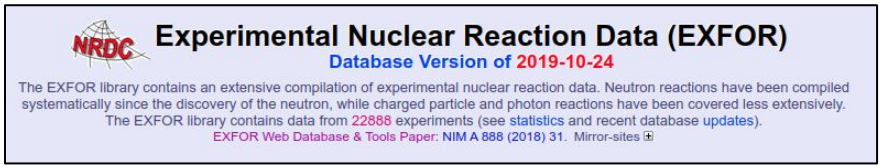
A new working format for FY data

FY-JSON: A NEW WORKING FORMAT FOR FISSION YIELDS

A new working format was developed, based on the JSON format, in order to easily store, access and correct Fission Yields data. An EXFOR-to-JSON conversion tool (by V.Zerkin) is available online on the IAEA website.

- Adapting the format of experimental files to the needs of FY compilation (simpler, lighter, more intuitive)
- Make it easier to access, plot, verify and update experimental values currently stored in the EXFOR format
- Modernizing the format to make it more human- and DB-friendly



V. Zerkin, G. Fabricante

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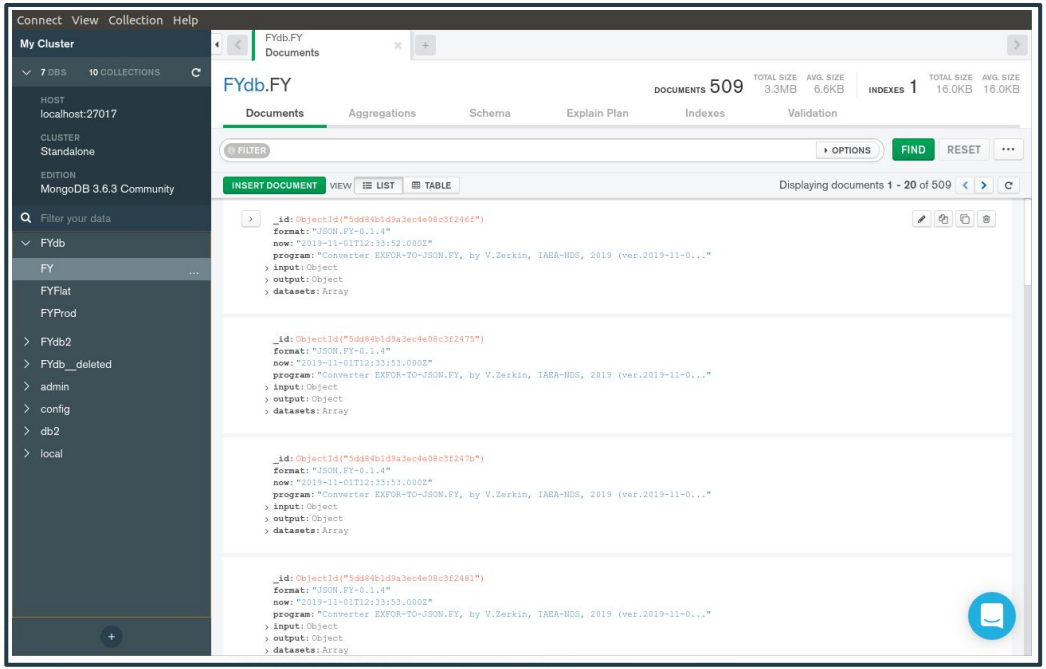
json files imported in a mongoDB structure

It is easy to create queries to **filter data** and to produce custom output formats (e.g. a "flatter" json output, or simple .csv for plotting)



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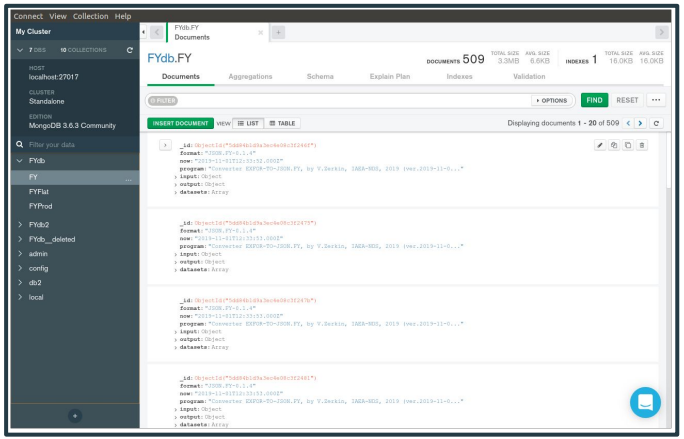

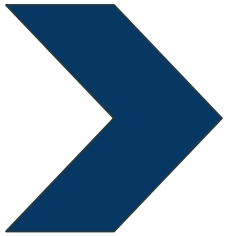

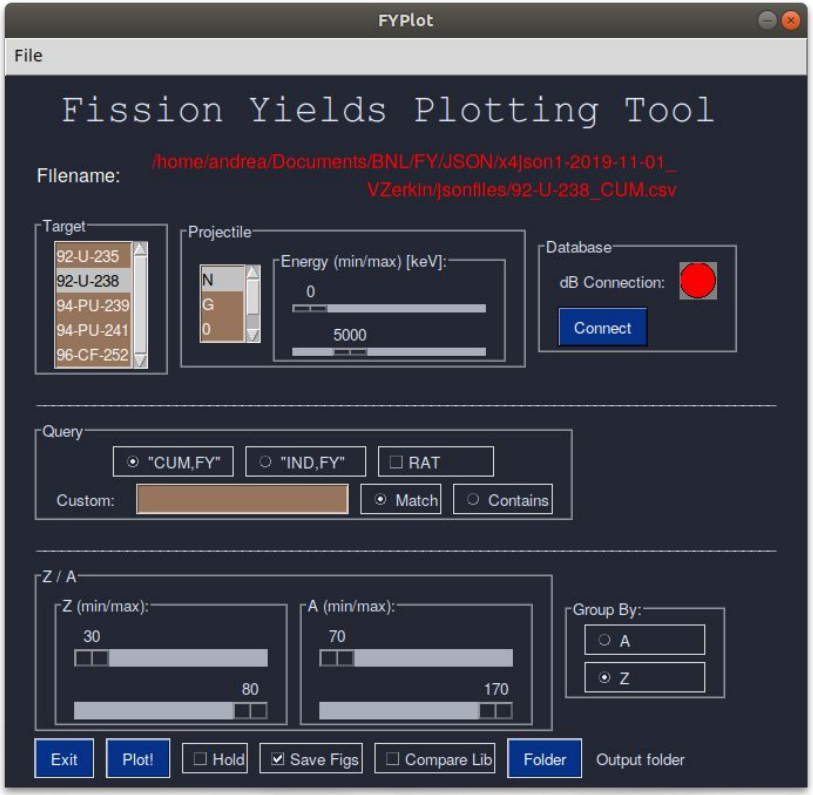

once data are stored in the database, any software can be used to query / extract / plot the data.

We developed a simple GUI to extract and plots selected FYs.

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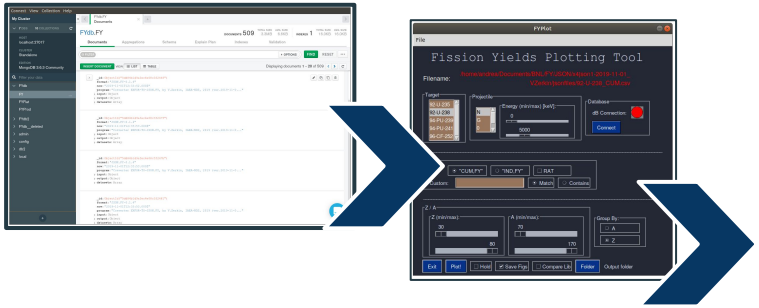
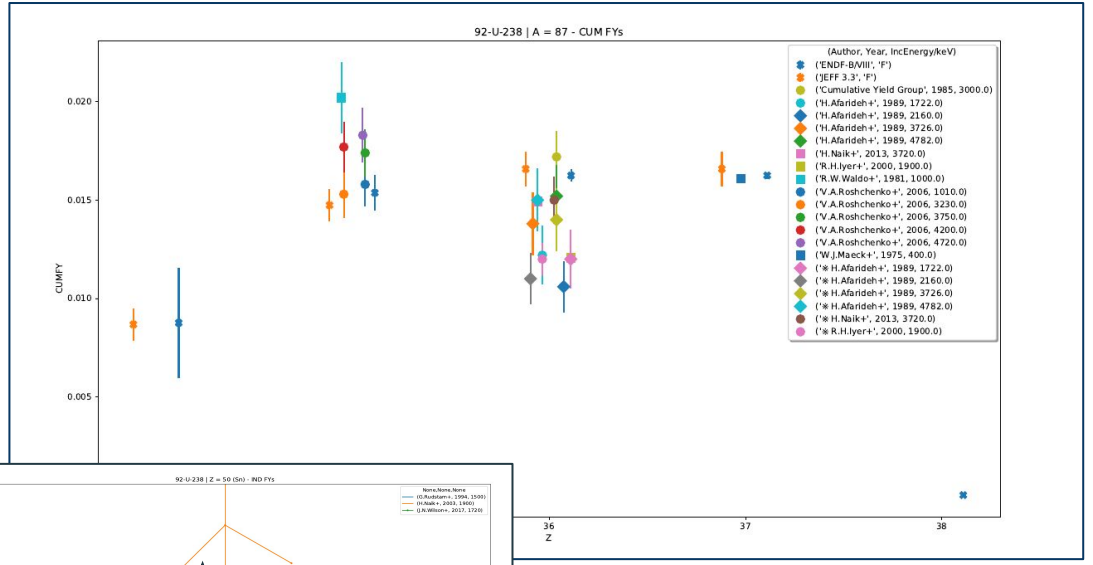
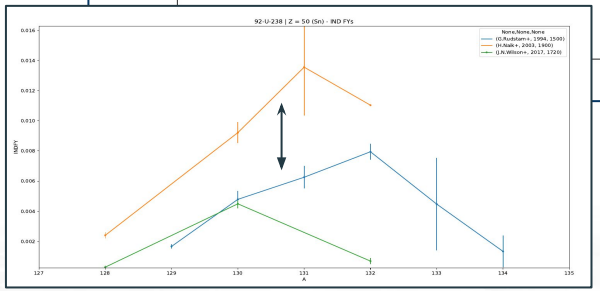






The plots make it easy to identify inconsistency in the data:

- conversion mistakes (e.g., % vs abs uncertainties; normalization to 1/100%; relative vs abs. FYs)
- EXFOR database issues (e.g., multiple entries containing the same data → #33011 and #33046 - corrected by Naohiko Otsuka).

FY correction & update

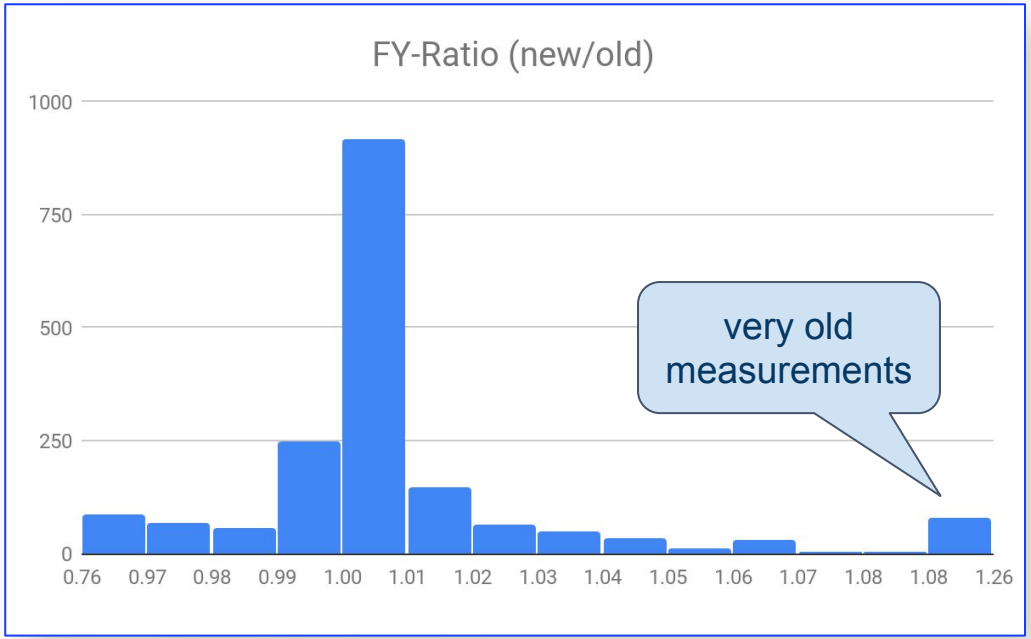
UPDATED NUCLEAR DATA

All those experimental data in which Fission Yields were measured using nuclear data (e.g., decay schemes, cross sections, etc.) have been updated to reflect the latest knowledge of these quantities. In total, 1850 data points have been updated.

A number of experimental campaigns used nuclear data to determine FYs (most often γ-ray intensities).

If the values used in the experiments were reported/referenced in the original paper it is possible to check their currency and update them if necessary.

This update process was possible for 38 EXFOR entries and 1850 decay data points.



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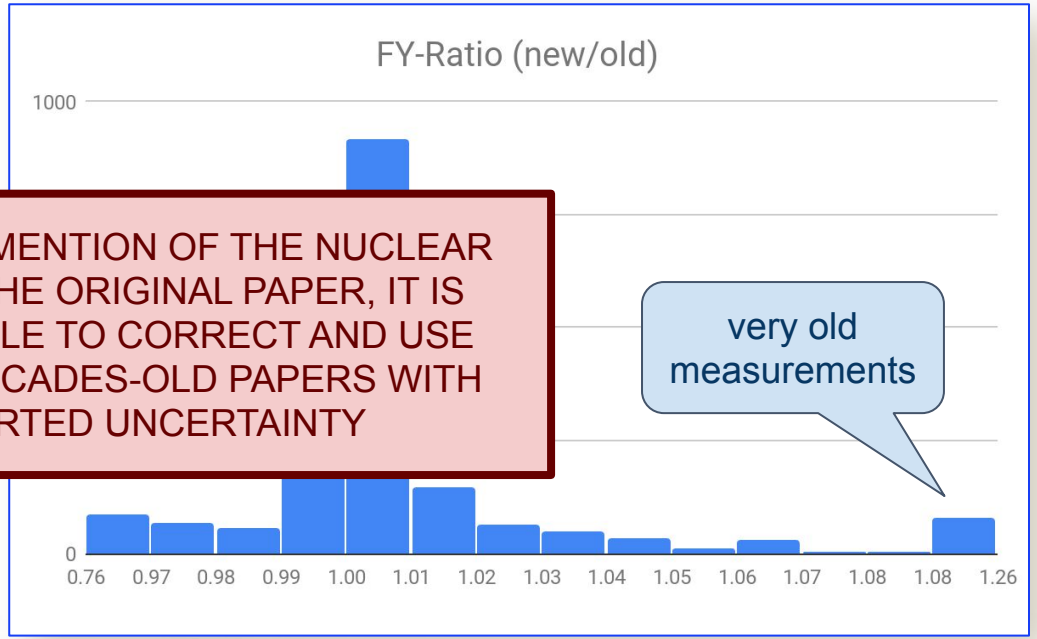
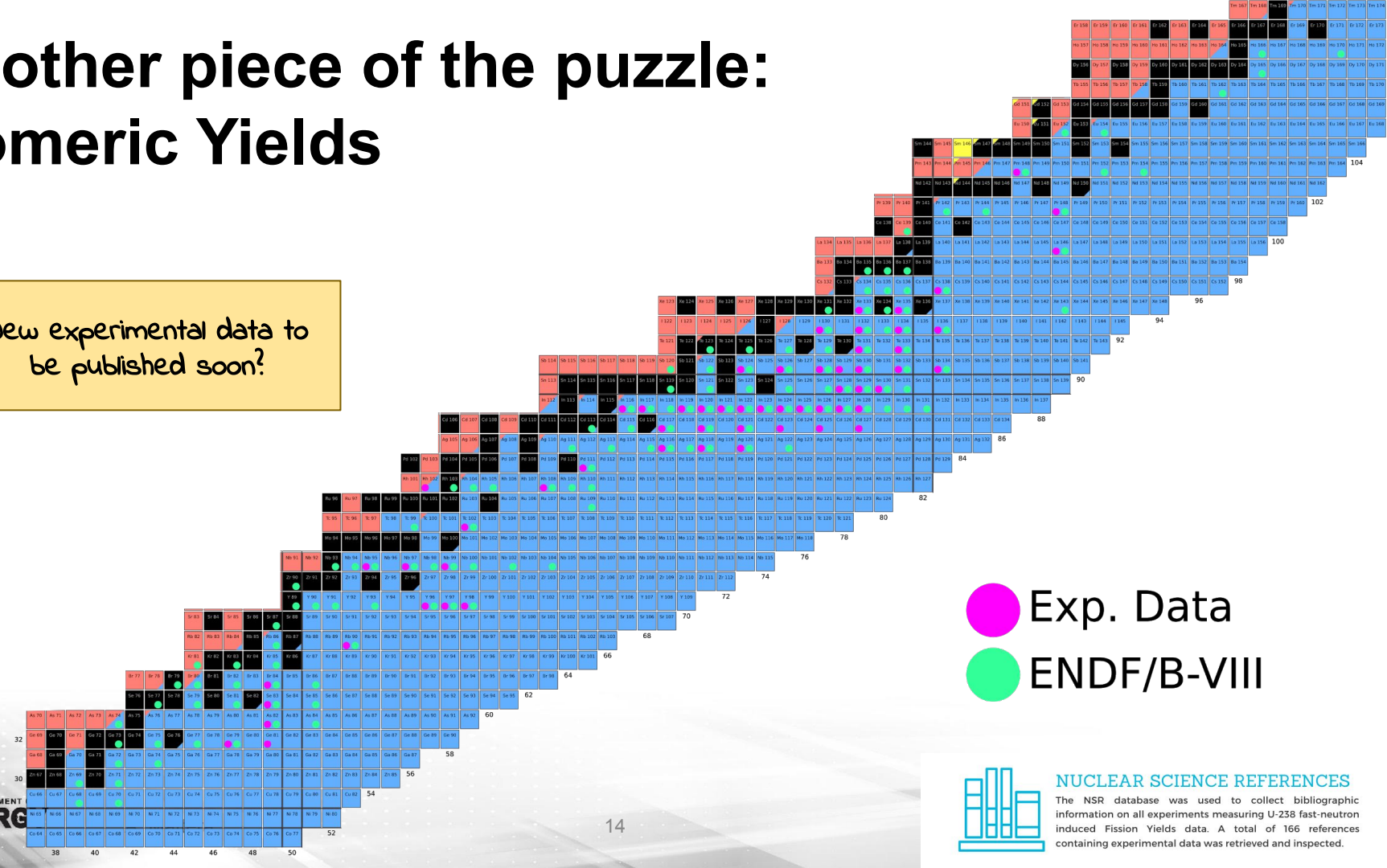
WITH NO EXPLICIT MENTION OF THE NUCLEAR DATA VALUES IN THE ORIGINAL PAPER, IT IS ALMOST IMPOSSIBLE TO CORRECT AND USE RESULTS FROM DECADES-OLD PAPERS WITH THEIR REPORTED UNCERTAINTY



Another piece of the puzzle: Isomeric Yields

New experimental data to be published soon?



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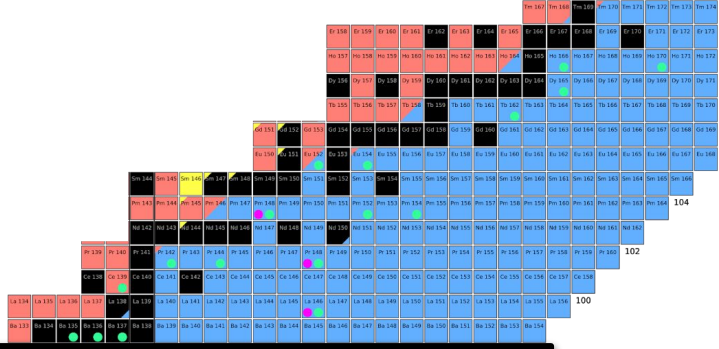
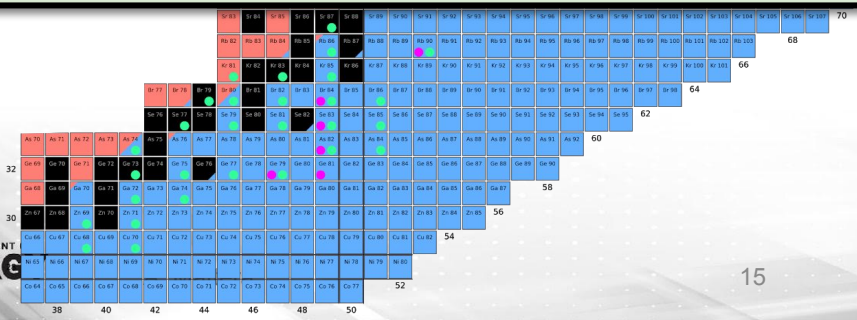


486 data points. Majority from (n,f) and SF.
Some points from (γ,f), (p,f), ...

Exp.

ENDF/B-VIII



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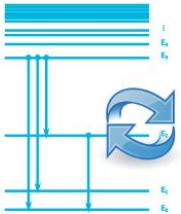

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UNDERSTANDING ENDF/B UNCERTAINTIES

Comparing the uncertainties of Cumulative Fission Yields in the evaluation by England & Rider with the available experimental data hints to a possible underestimation of chain yield uncertainties. The averaging and merging procedures are being revised.

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Thank you!

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