Fission Yields Effect on the Calculation of Antineutrino Spectra

A.A. Sonzogni, E.A. McCutchan, T.D. Johnson

National Nuclear Data Center

BROOKHAVEN NATIONAL LABORATORY

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ENDF/B-VII.1 yields were released in 1992,

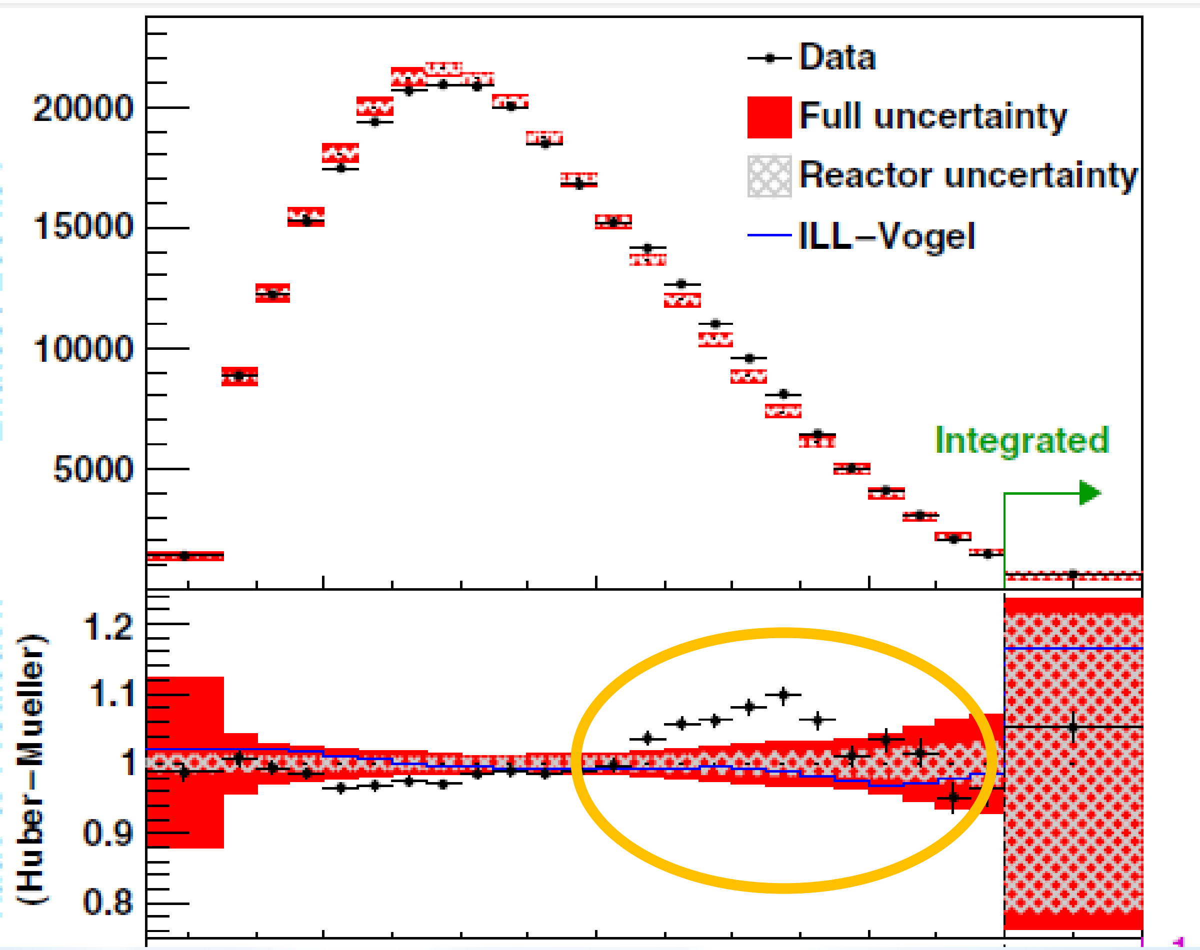
- A few yields seem anomalous.
- Isomeric ratios could be updated
- Yields are not fully compatible with modern decay data.

We explored correcting the independent fission yields, and then obtain cumulative yields with the decay sub-library, to finally perform some calculations.

For more details see A.A. Sonzogni et al, PRL 116, 132502 (2016).

Main motivation

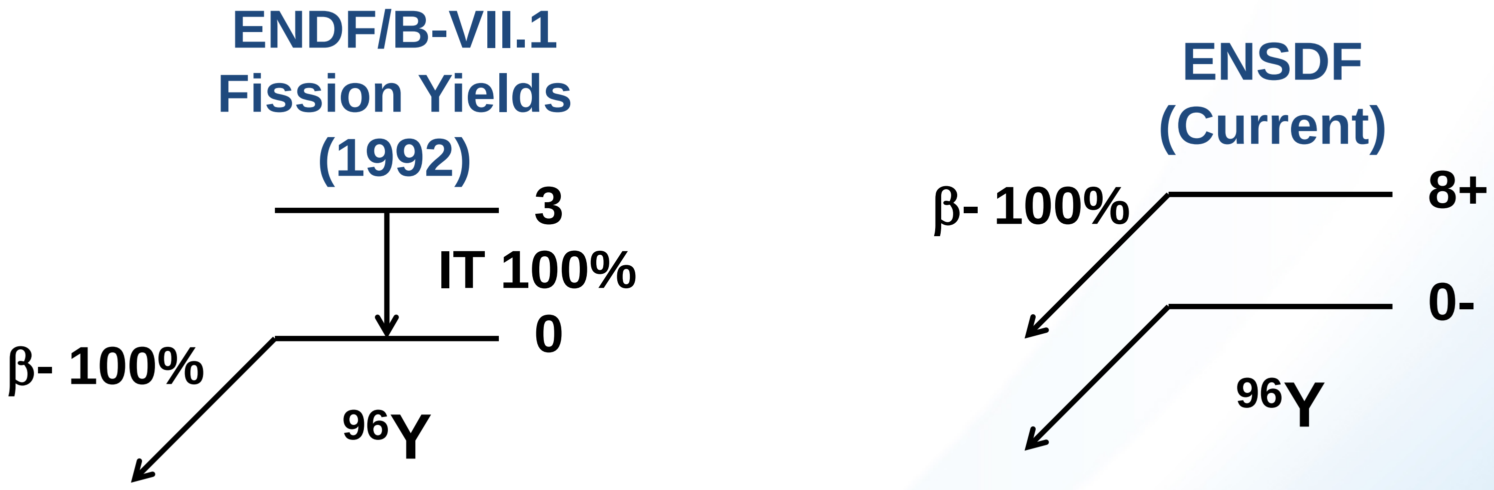
The recently published Daya Bay antineutrino spectrum shows an excess at 5.5 MeV.



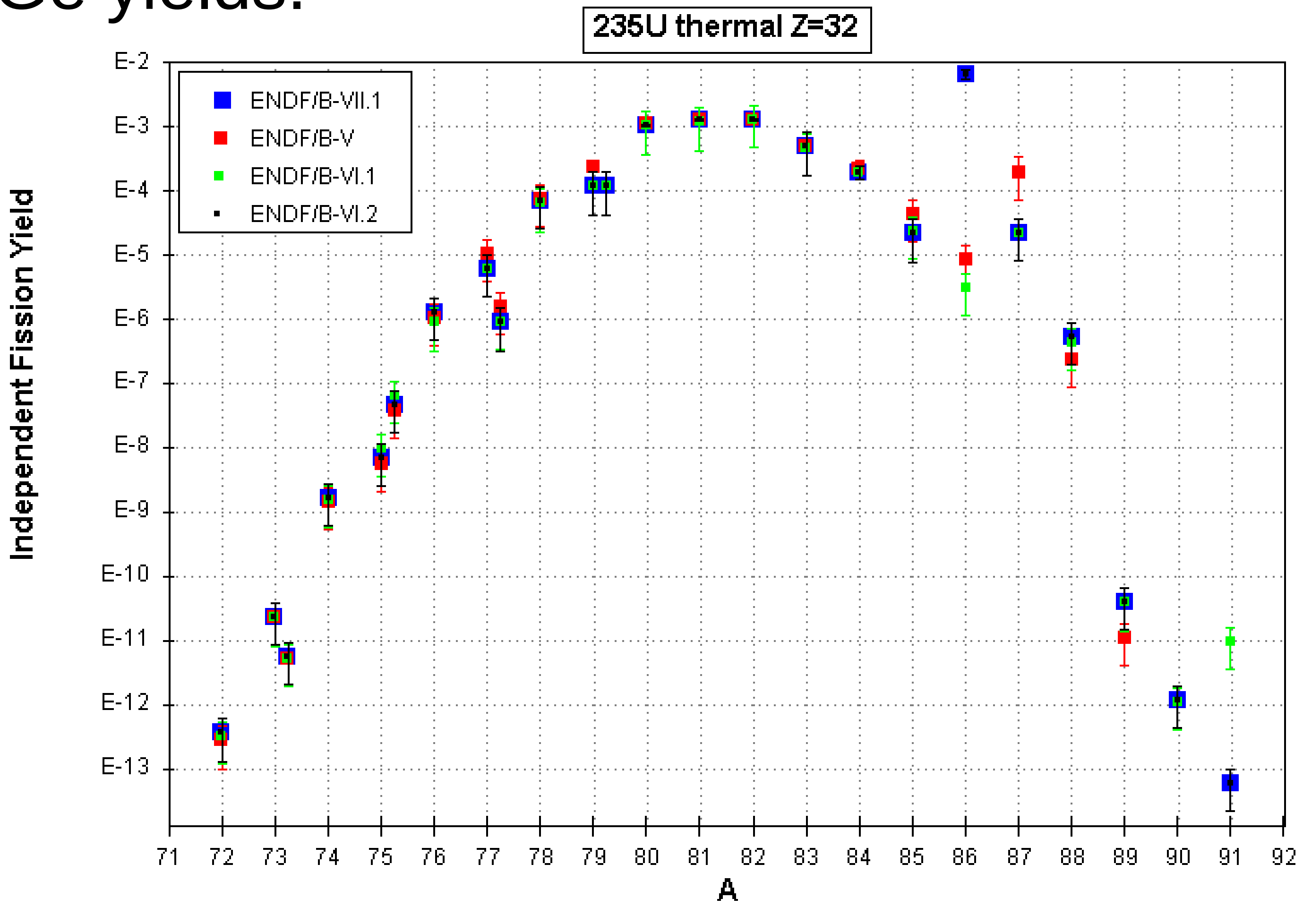
F.P. An et al, PRL 116, 061801 (2016)

Sterile neutrinos or problems in the model.

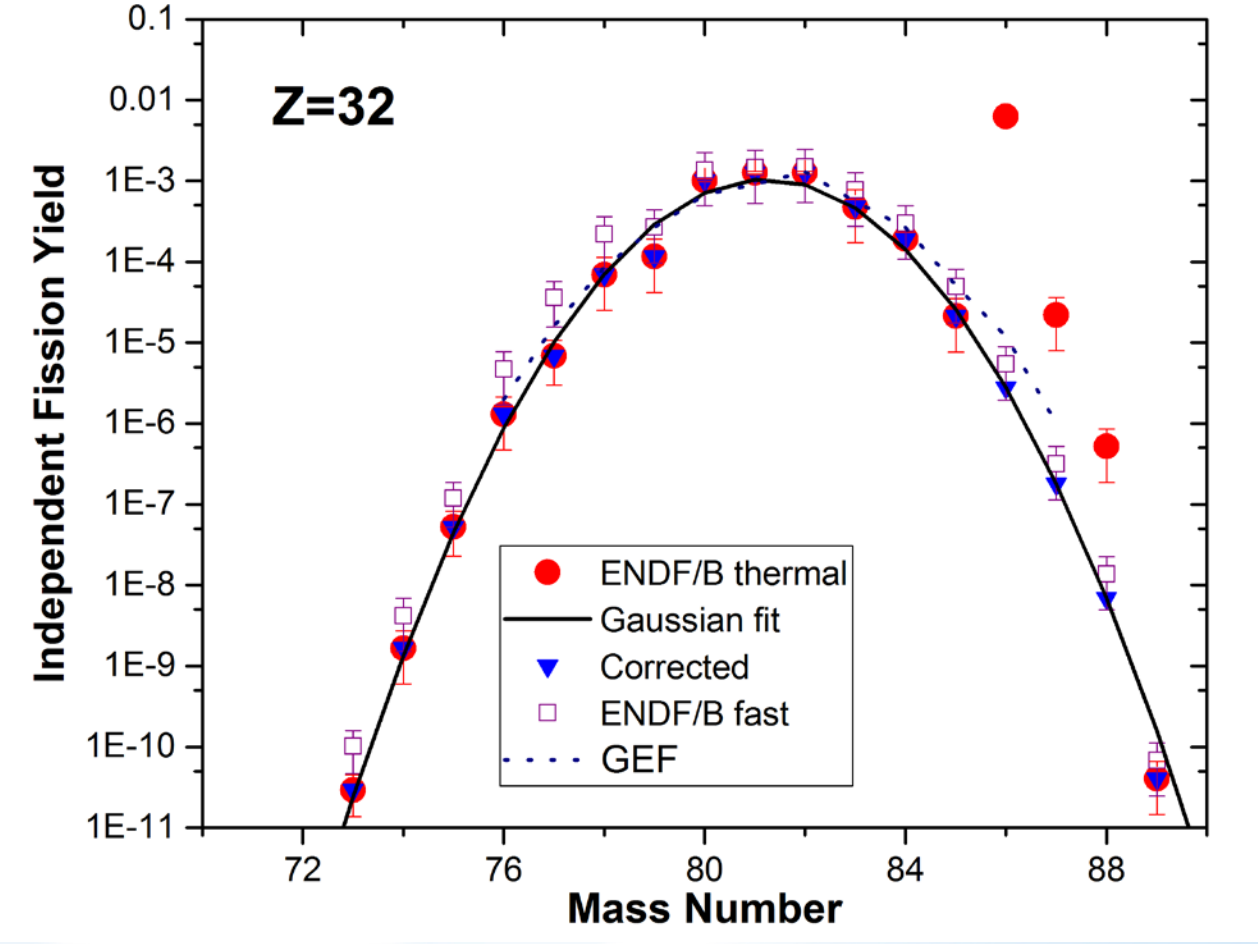
96Y, example of compatibility issues with modern decay data



We looked in the historical releases of ENDF/B yields, trying to understand the anomalous ^{86,87,88}Ge yields.



We concluded that the $^{86,87,88}Ge$ yields are anomalous, and corrected them using a weighted Gaussian fit.



We used isomeric ratios measured by Bail et al for ^{239}Pu PRC **84**, 034605 (2011)

TABLE V. Sum of the ground-state and the first isomeric-state yields ($S = Y^{GS} + Y^m$) and ratio between the isomeric yield and the sum [$R = Y^m/(Y^{GS} + Y^m)$]. Results obtained in this work (Loh.) are compared with those from JEFF-3.1.1 [5].

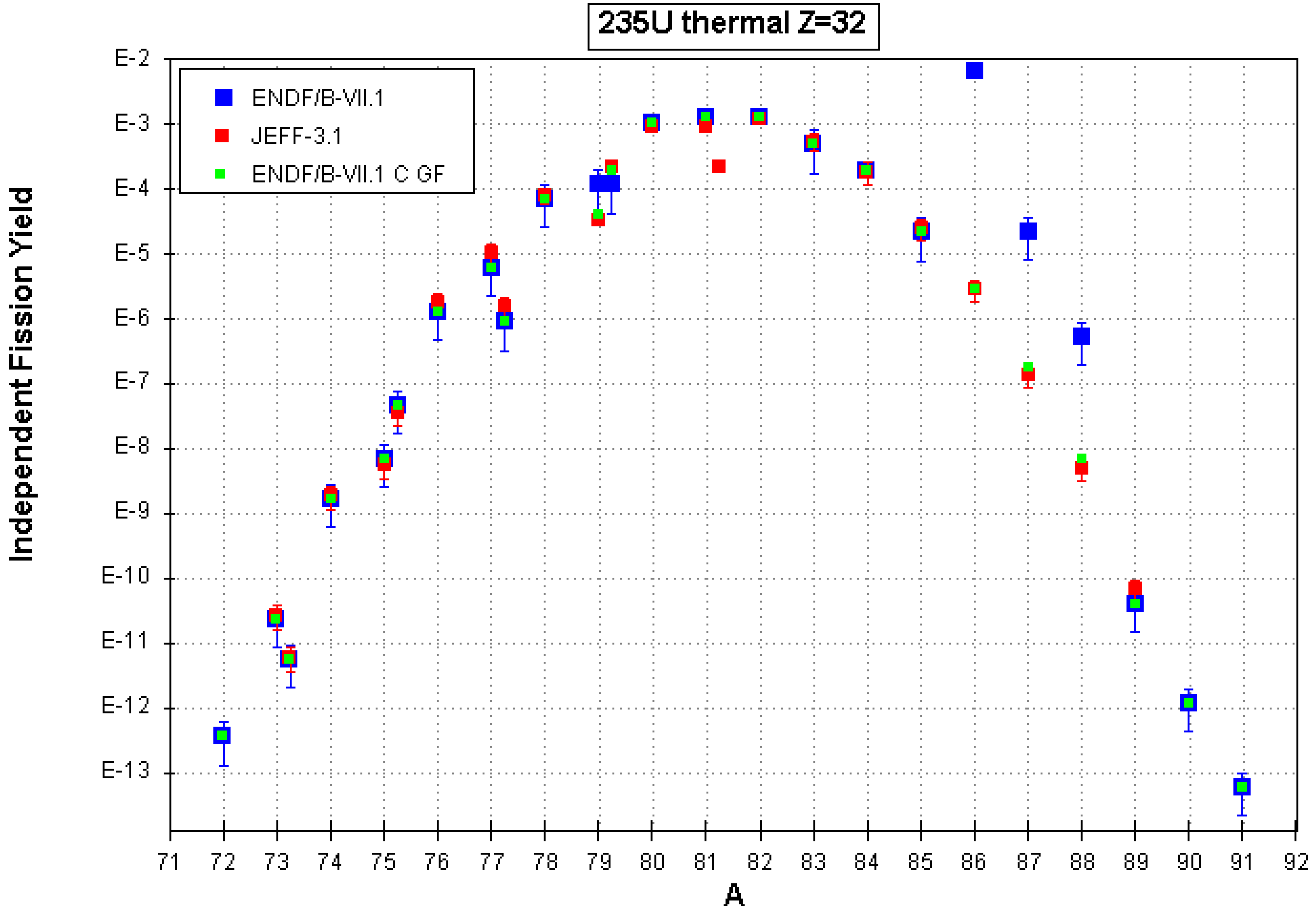
Mass	Nuclide	$S_{Loh.}$ (%)	$S_{JEFF-3.1.1}$ (%)	$R_{Loh.}$ (%)	$R_{JEFF-3.1.1}$ (%)
98	$_{39}$Y	2.433 ± 0.280	2.310 ± 0.512	19.6 ± 3.3	80.8 ± 25.3
99	$_{41}$Nb	0.710 ± 0.108	0.850 ± 0.280	20.0 ± 4.2	18.8 ± 8.7
133	$_{52}$Te	4.779 ± 0.468	4.646 ± 0.534	60.6 ± 8.4	70.7 ± 11.5
134	$_{53}$I	2.612 ± 0.614	2.248 ± 0.545	42.7 ± 11.3	42.4 ± 14.6
136	$_{53}$I	3.290 ± 0.375	3.358 ± 0.591	75.5 ± 11.7	70.1 ± 17.4
138	$_{55}$Cs	1.420 ± 0.383	1.033 ± 0.348	60.3 ± 17.7	58.7 ± 28.0
146	$_{57}$La	1.035 ± 0.101	1.258 ± 0.213	71.7 ± 9.9	64.3 ± 15.4

We surveyed ENSDF to derive the average spin population in even-even nuclides following the fission of ^{252}CF, obtaining:

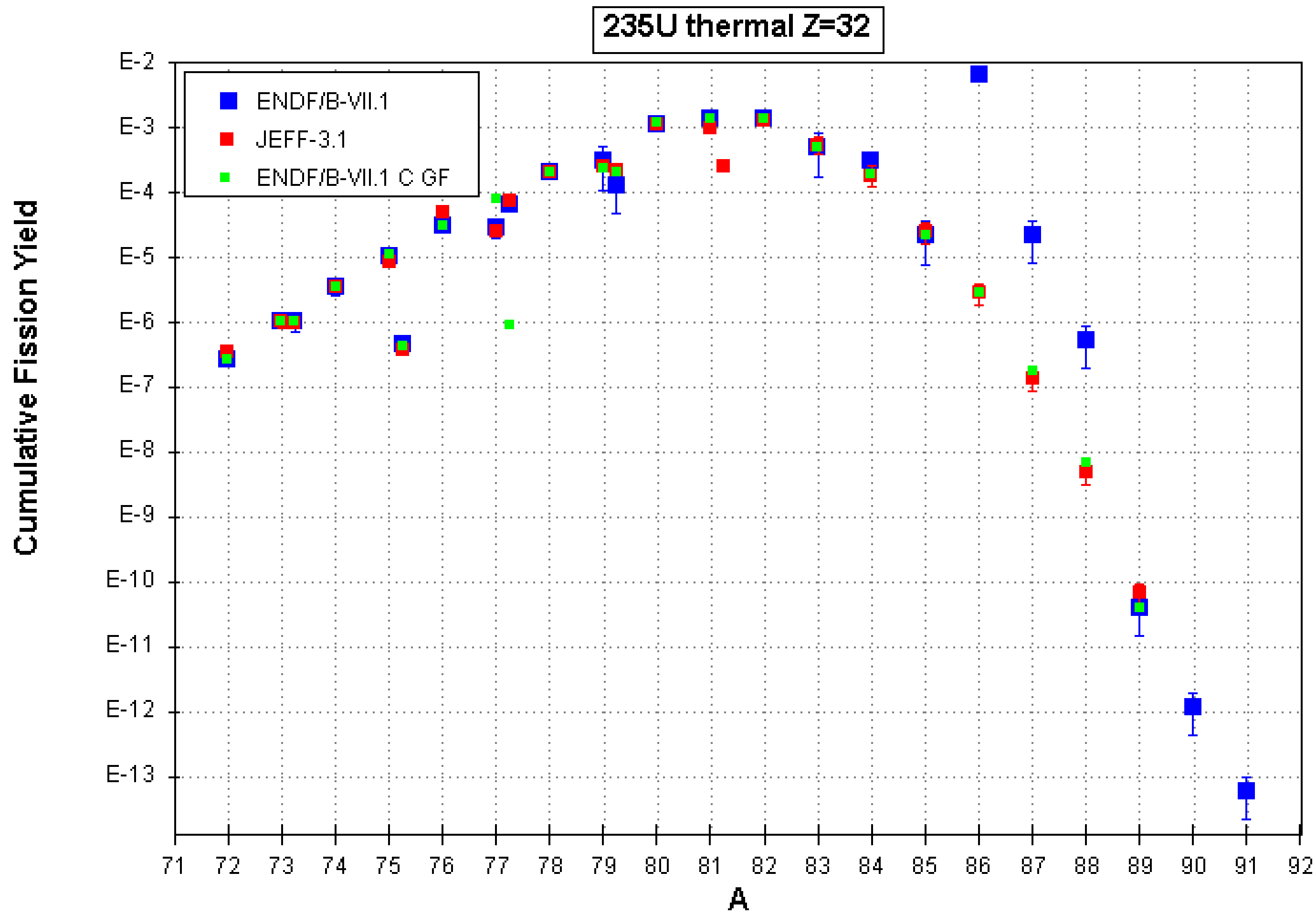
2+: 100%
4+: 66%
6+: 41%
8+: 18%
10+: 8%

When the spins of the ground state and isomer where known, but there was no experimental isomeric ratio, this distribution was used to obtain an estimate of the isomeric ratio.

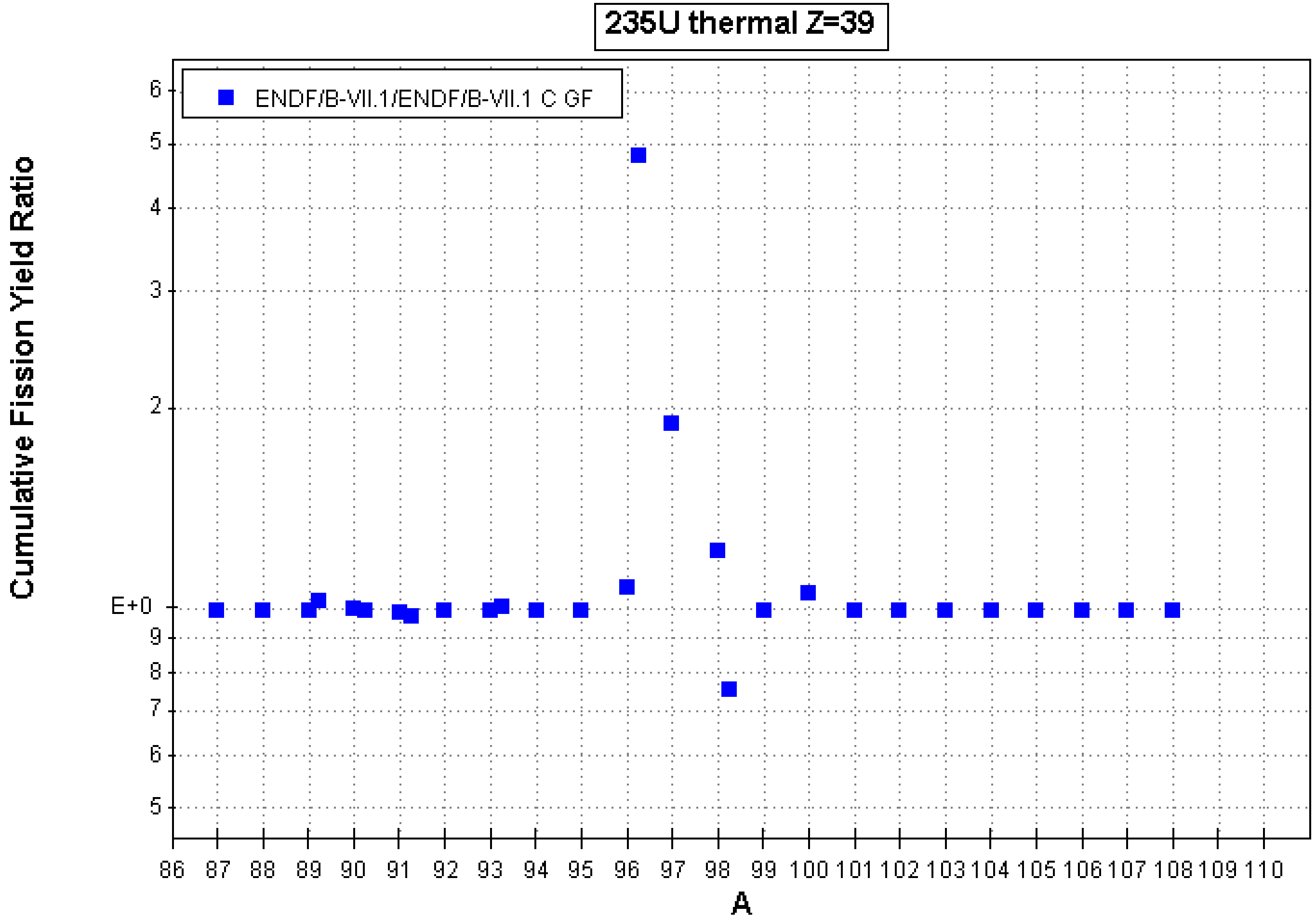
Ge independent yields after the corrections



Ge cumulative yields after the corrections



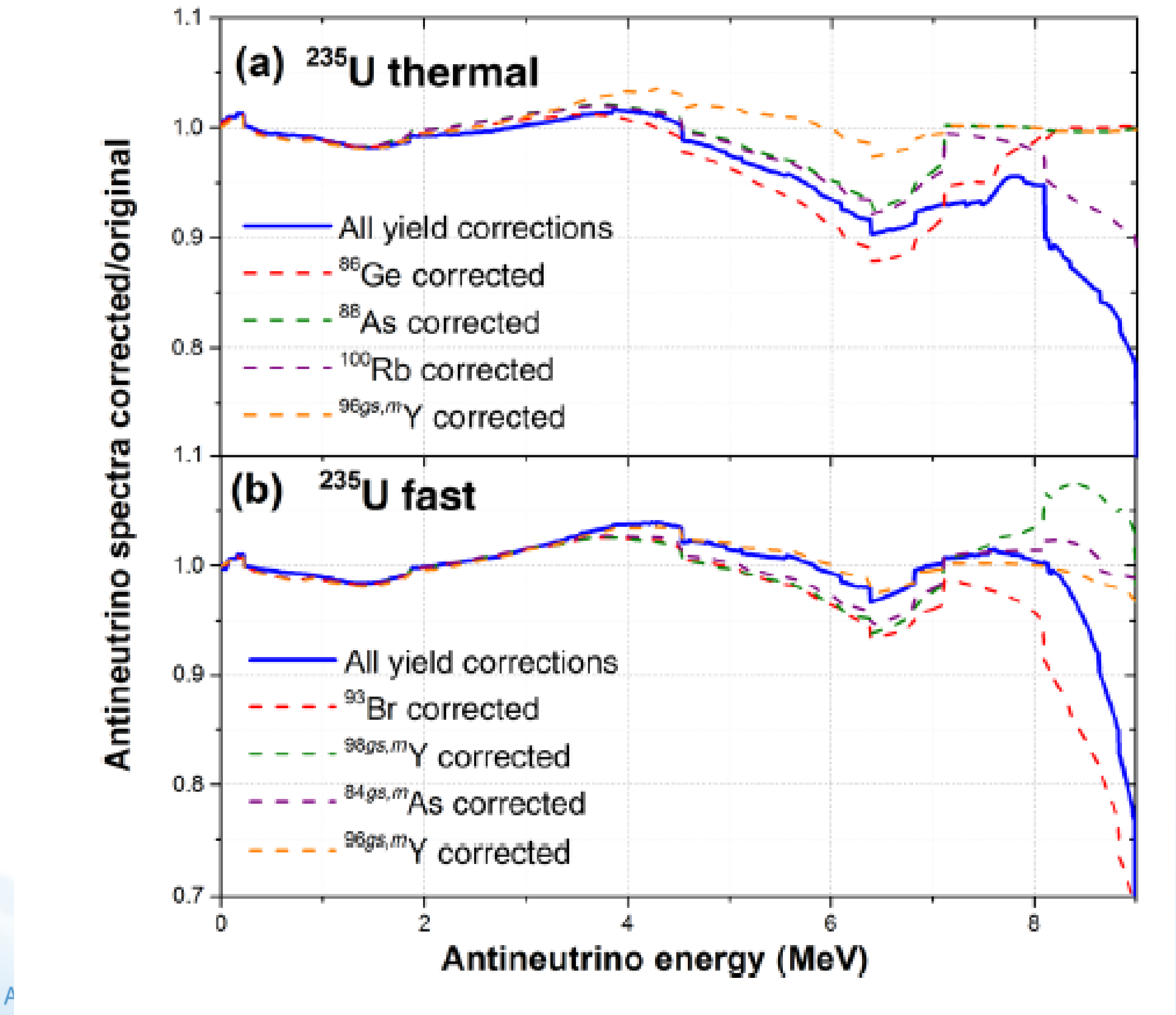
Yttrium original / corrected cumulative yields, reflecting changes in the isomeric ratio and the decay data



We checked that the corrected cumulative fission yields for some long-lived nuclides are in agreement with those measured by L. A. Metz et al. J. Radioanal. Nucl. Chem. 296, 763 (2013).

With the corrected yields we obtain a delayed nu-bar of 1.559E-2, while the original yields give a 2.021E-2 value. The recommended value is 1.585E-2. This has been known for a while, see the Go Chiba talk in ND2013.

Effects on the antineutrino spectrum when all corrections are applied, as well when only one nucleus is corrected.



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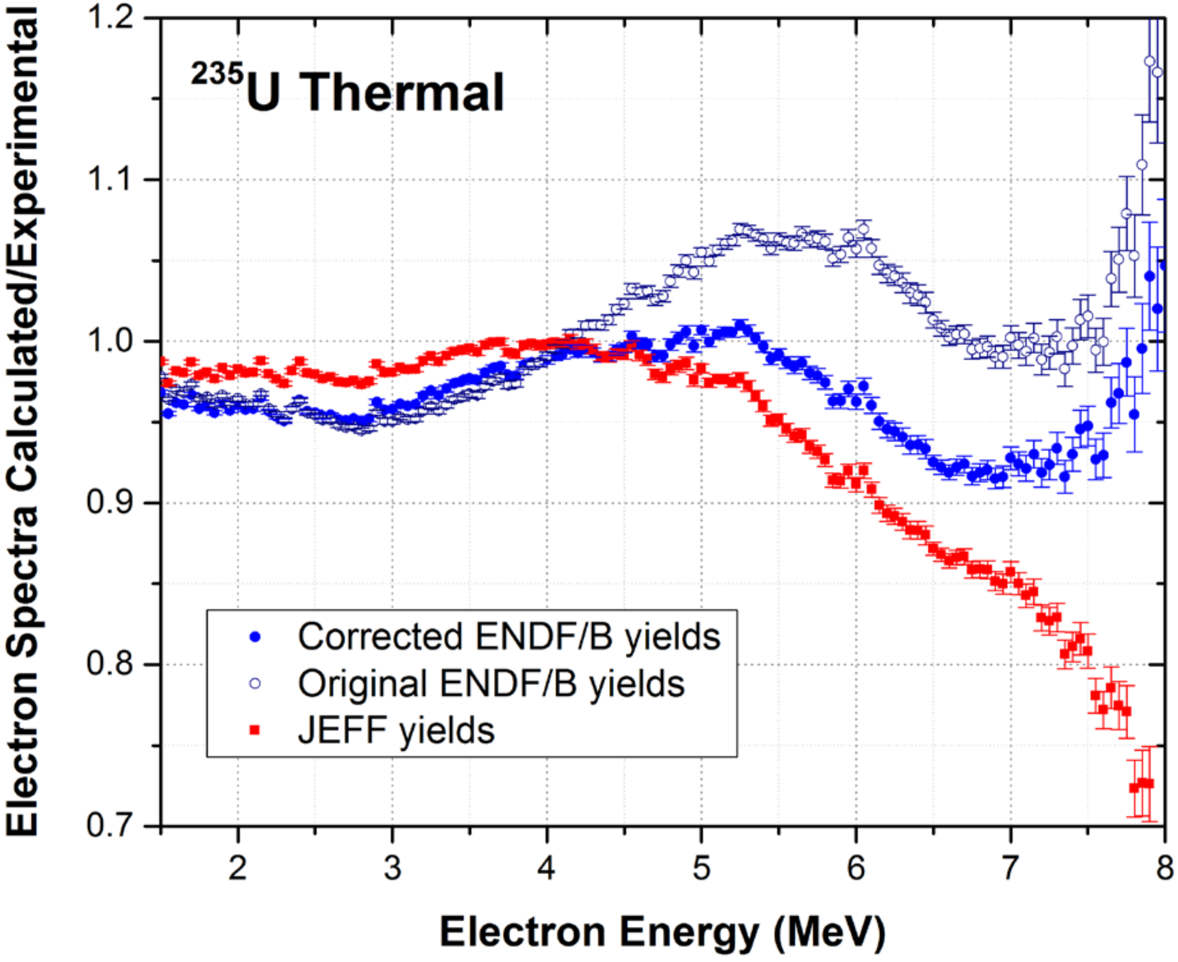
Thermal ^{235}U spectrum



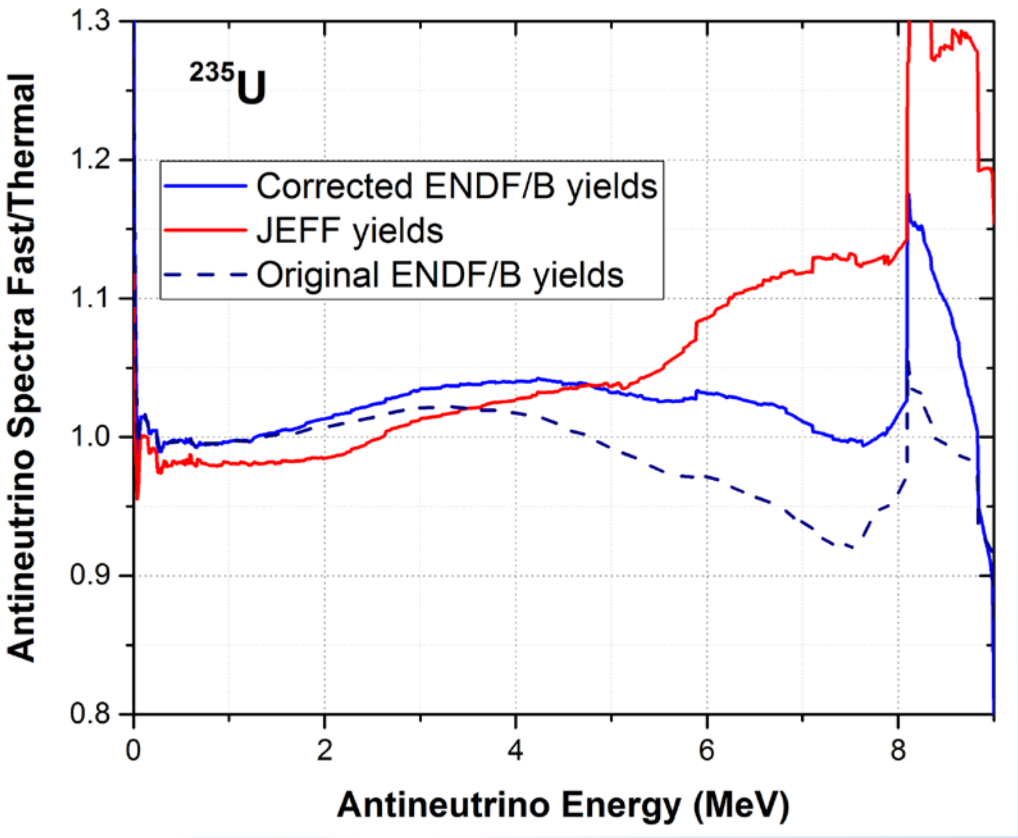
Corrected yields:

- No electron excess.
- Better agreement with JEFF.

Fast to Thermal comparison

- When using corrected fission yields, the antineutrino spectrum for fast neutrons is harder than the spectrum for thermal neutrons.

- In agreement with JEFF yields and as expected.



Conclusions

There is currently plenty of interest on the reactor antineutrino spectrum. What we have learned from our research is:

- There have been new measurements of fission yields since 1992, and more are expected to come soon.
- There have been many measurements on the fission products decay properties since 1992.
- Funding is needed to ensure that these data are included the fission yields sub-library.