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Updates to the GMA database and ^{252}Cf evaluations for the next release of the IAEA Neutron Data Standards

D. Neudecker

Thanks to: G. Belier, D. Brown, R. Capote, S. Croft, A.D. Carlson, C. Fritsch, M. Devlin, M.J. Grosskopf, R.C. Haight, K.J. Kelly, T. Massey, G. Noguere, B. Pritychenko, G. Schnabel, J. Silano, L. Snyder, J. Taieb, P. Talou, A. Trkov, S. Vander Wiel, N. Walton, M. White

Neutron Data Standards Meeting 2026 Jan 26-30, 26

LA-UR-26-20484

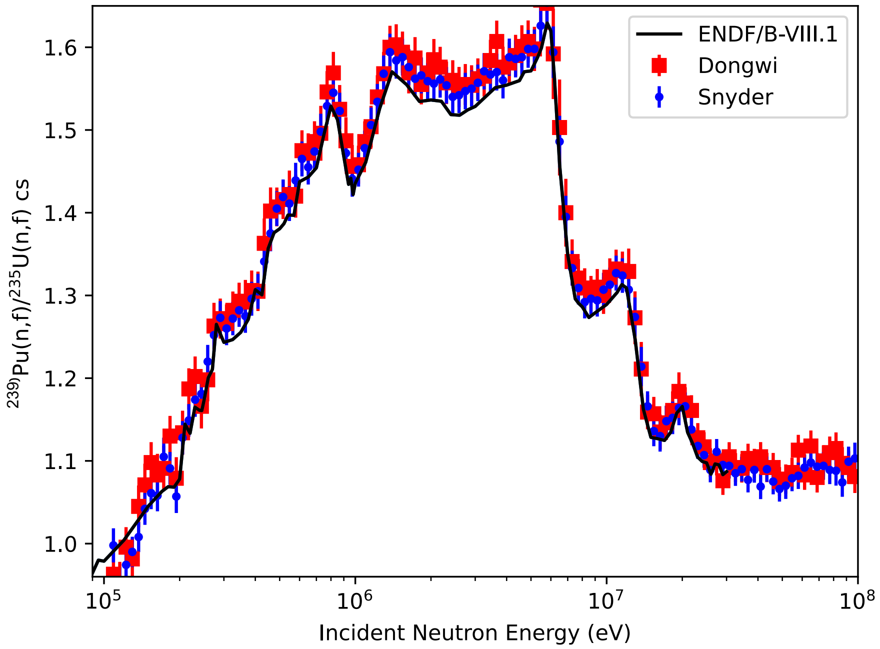
Discussion item:

- Inclusion of 6 new data sets into the GMA database.
- Summary of progress of working group on $^{252}Cf(sf)$ nu-bar.
- New $^{252}Cf(sf)$ PFNS evaluation.

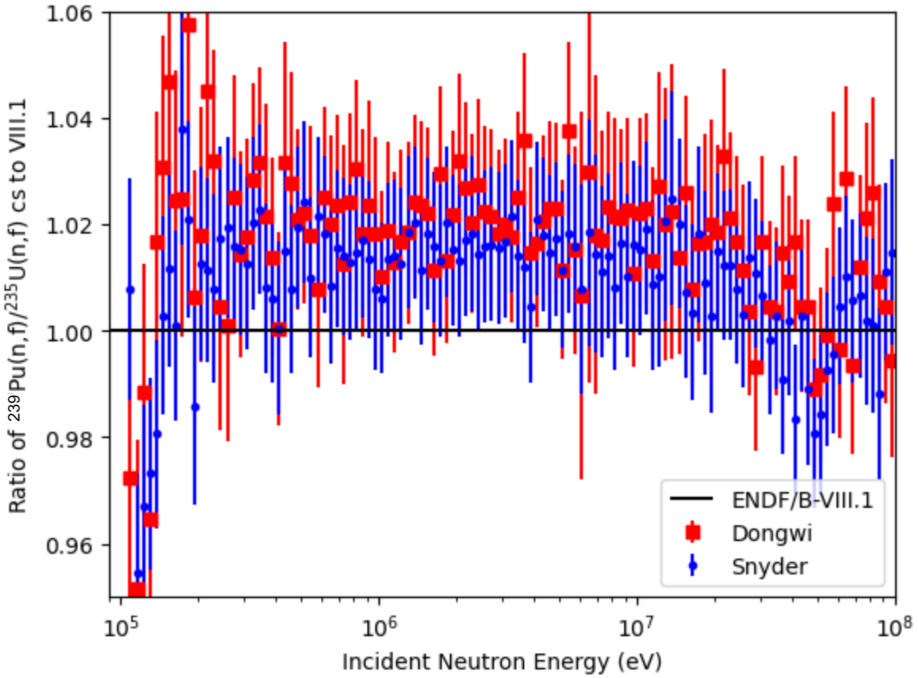
Inclusion of 6 new data sets into the GMA database:

- fissionTPC Snyder $^{239}Pu(n,f)/^{235}U(n,f)$.
- fissionTPC Dongwi $^{239}Pu(n,f)/^{235}U(n,f)$.
- Silano (connected to fissionTPC) $^{239}Pu(n,f)/^{235}U(n,f)$.
- Silano (connected to fissionTPC) $^{238}U(n,f)/^{235}U(n,f)$.
- n_TOF $^{239}Pu(n,f)$ shape.
- n_TOF (Amaducci) $^{10}B(n,a)/^{6}Li(n,a)$ shape.

fissionTPC ^{239}Pu(n,f)/^{235}U(n,f) by Snyder and Dongwi are systematically high and offset with respect to each other.

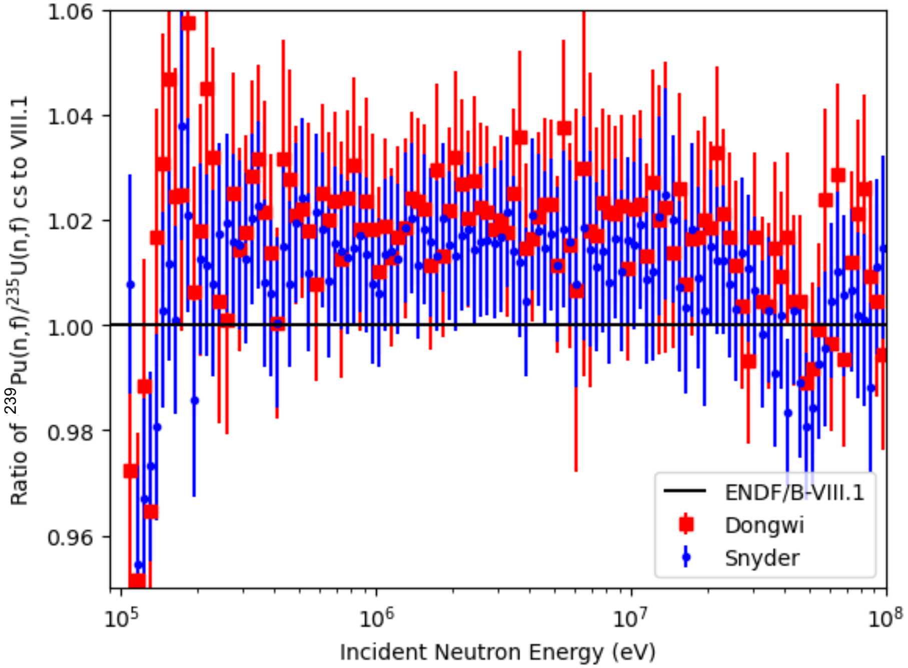


Snyder, NDS 178, 1 (2021).



Dongwi, NDS 202, 30 (2025).

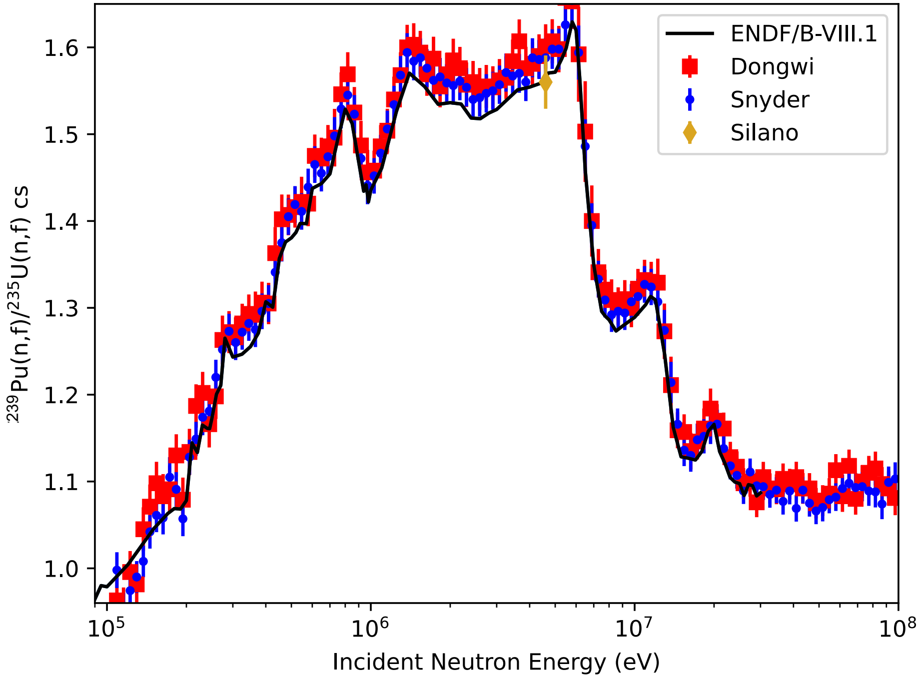
There are open questions on background and space-charge correction that lead to 1.1% additional uncertainties.

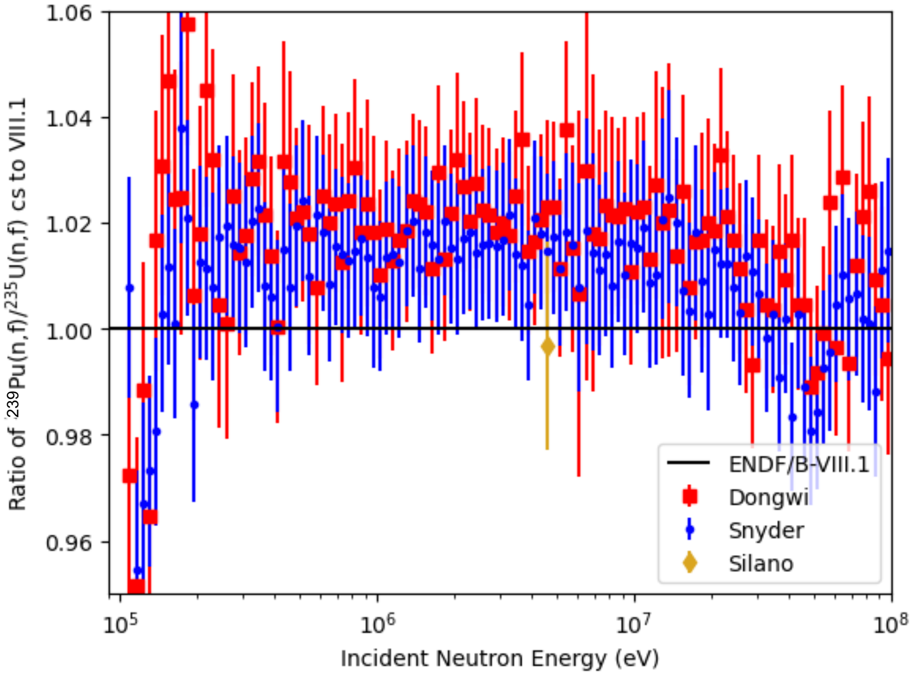


Background: Could be a thermal background that cannot be easily simulated (unknown how much water was in concrete). **Added 0.75% systematic unc**. which is a mid-sized estimate of the effect.

Space-charge correction: Artificial enlargement of ^{239}Pu sample due to α emission → changes beam overlap; related exp. at LANL and LLNL (different bias settings) differs by **0.85%, which we use as additional unc.** This effect is differently treated for Snyder data, but ^{239}Pu samples and backgrounds differ also.

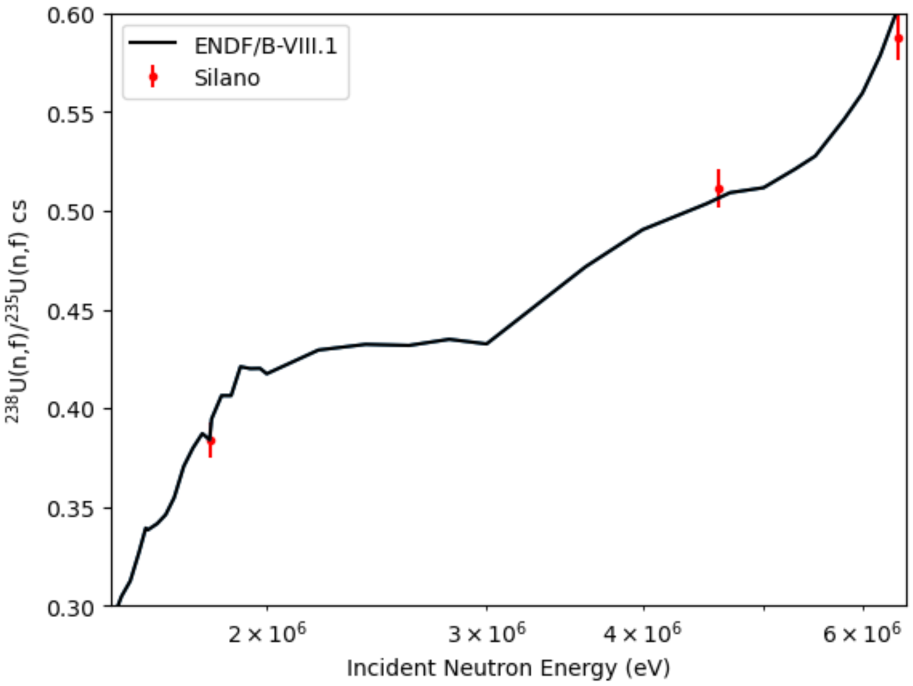
Also, Silano $^{239}Pu(n,f)/^{235}U(n,f)$ data point, connected to fissionTPC collaboration, does not show systematic effect.





Silano, LLNL-TR-2011630 (2025); Bhatia, NIMA 757, 7 (2014); Silano, NIMA 1063, 169234 (2024).

Data provided in private communication for $^{239}Pu(n,f)/^{235}U(n,f)$ and $^{238}U(n,f)/^{235}U(n,f)$ cs with stat. and syst. unc.

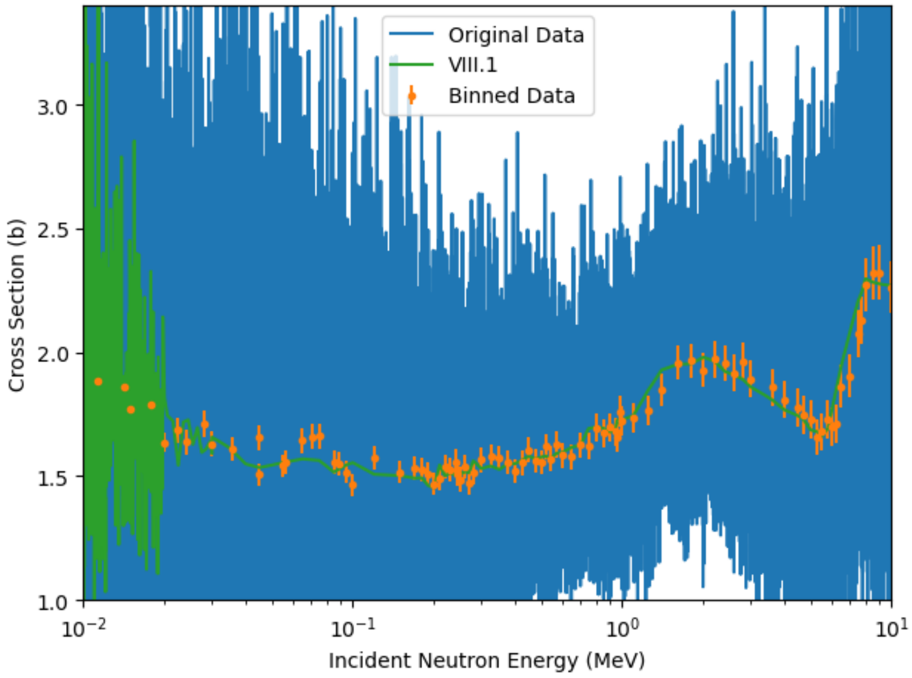


Silano data were measured with a more traditional fission chamber.

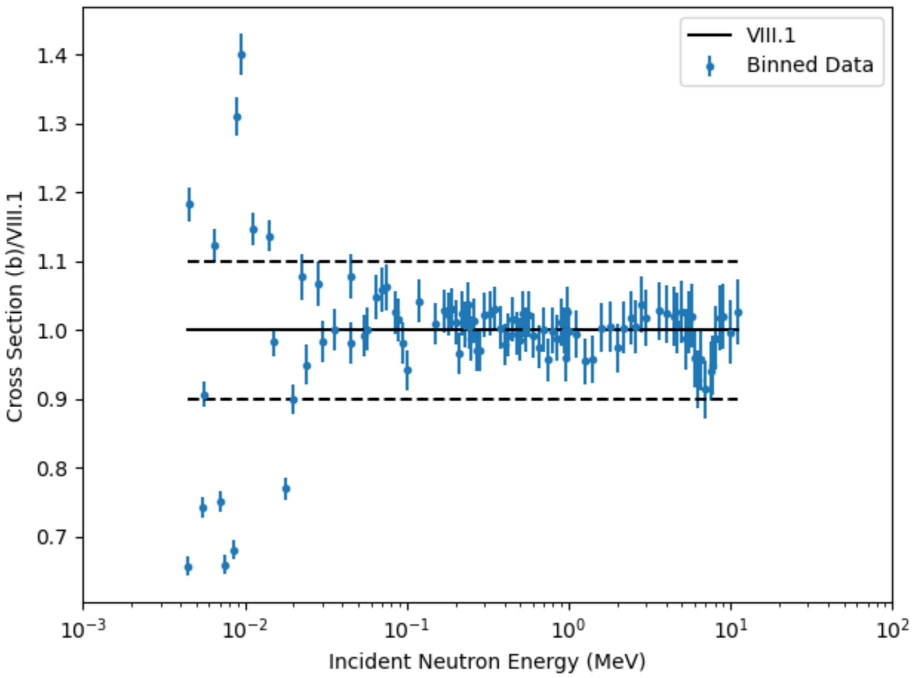
<u>Open questions</u>:

- Multiple scattering only roughly simulated → added 0.2%.
- Detector efficiency quantification did not account for angular distribution effects and sample roughness → added 0.4%.

n_TOF ^{239}Pu(n,f) shape data (priv. comm.) cover for 1st time broad E range; re-binning needed due to too high resolution.

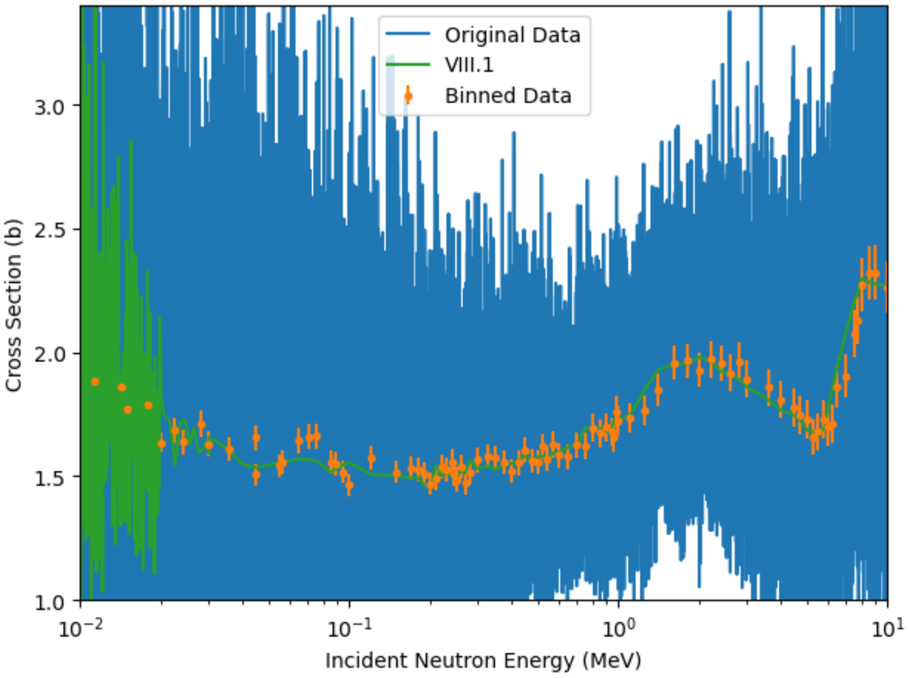


Sanchez-Caballero, PLB, submitted (2025).



Re-binning worked until 0.0045 MeV compared to re-binning shown by exp.

After private communication with n_TOF authors, some uncertainties were added.

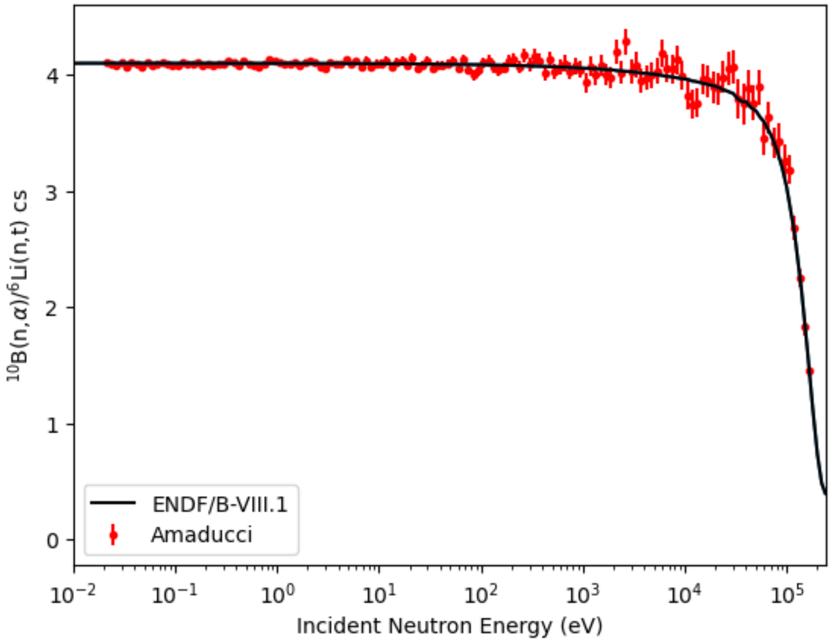


Sanchez-Caballero, PLB, submitted (2025).

<u>Added uncertainties:</u>

- No multiple scattering and attenuation in surrounding described, added 0.2% unc.
- Angular distribution unc. 0-2% added per priv. comm. with authors.
- Small impurity unc. of 0.01% added (sample purity 99.9%).
- Energy unc. is only given for 2 points, interpolation between was assumed.

n_TOF (Amaducci) ^{10}B(n,a)/^{6}Li(n,a) shape data were included. They agree well with ENDF/B-VIII.1 data.



In EXFOR are several data sets with different binning. I chose 23453010.

In EXFOR are only statistical uncertainties. I added based on the publication variational uncertainties (eff cut) for B-10, Li-6, attenuation, forward angle, background unc.

Amaducci, EPJ A 55, 120 (2019)

Summary of progress of working group on ^{252}Cf(sf) nu-bar

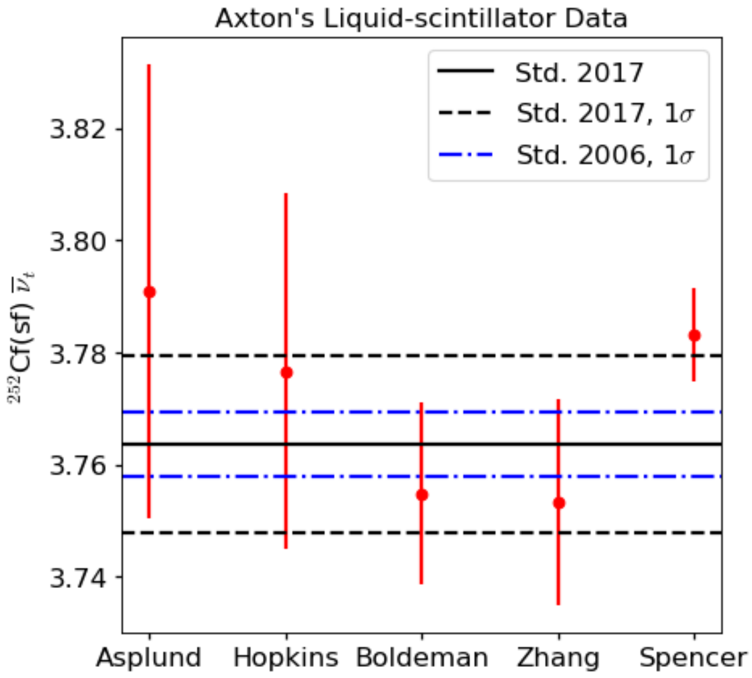
Working group on ^{252}Cf(sf) nu-bar uncertainty met from April to July. More open questions than expected.

Participants: G. Belier, R. Capote, A. Carlson, S. Croft, D. Neudecker, G. Schnabel, J. Taieb, M. White

Meetings: five from April–July.

Data reviewed: all liquid scintillator data

- Asplund (high unc.),
- Boldeman (good exp.),
- Hopkins (high unc.),
- Spencer (lowest-uncertainty measurement with many question marks),
- Zhang (good exp.)



Open questions would benefit from more experiments and theory studies before reducing evaluated uncertainties.

Possible source of correlated uncertainties discussed:

- Delayed neutron correction: only applies to liquid-scintillator measurements, very few measurements support the actual values but low overall uncertainty contribution.
- Late prompt gamma correction: the data used for simulations of this effect is not well-known, the uncertainty on the data could lead to it being a major uncertainty source, but more experiment and theory studies are needed. CEA is planning a measurement.
- PFNS: We are right now changing the PFNS, and more studies are needed to understand the effect of a realistic PFNS on all nu-bar measurements rather than assuming a Maxwellian.

New ^{252}Cf(sf) PFNS evaluation:

- Experimental input to evaluation.
- Evaluation technique.
- Evaluated results and SACS.

We rejected replaced 2 data sets used by Mannhart with final versions, rejected one and added 9 data set.

Mannhart standard evaluation

Author & year	EXFOR-number
Dyachenko 1989	41158.003.
Boettger 1990	Not in EXFOR.
Poenitz 1983	14278.002
Blinov 1973	40418.007
Boldemann (Li) 1986	30775.003
Boldemann (Plastic)	30775.002
Maerten 1984	Not in EXFOR.

Input for new standard

Author + Year	New Experiments
Lajtai 1990	Kornilov 2017
Boettger 1990	3xBoytsov 1983 (low energy)
Poenitz 1983	Chalupka 1990
Blinov 1973	4xBlinov 1980 (low energy extension)
X	
Boldemann (Plastic)	
X	Maerten, 60° 1990

Evaluation described and input provided in D. Neudecker et al., Vol. 11 EPJ-N (2025).

We use as evaluation technique generalized least squares and a non-informative prior.

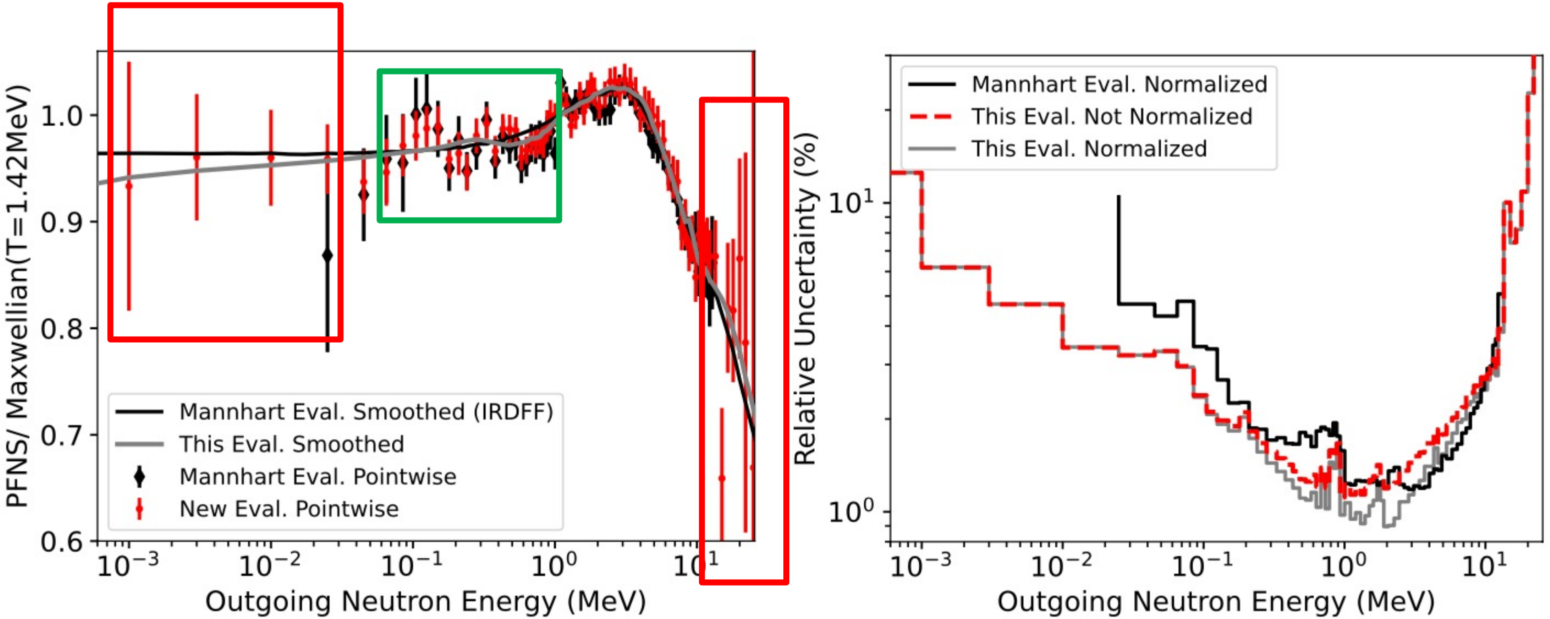
Input:

- Experimental UQ was undertaken in detail using ARIADNE.
- Non-informative prior with 100% uncertainty and diagonal covariance matrix used.

Methodology:

- Evaluation technique: generalized least squares.
- All experimental data were treated as shape.
- Data were extrapolated to lowest and highest energies with Maxwellian.
- Data were smoothed with Savitzky-Golay.
- Evaluated data & covariances normalized that integral of PFNS gives unity & rows/columns of covariances sum to 0.

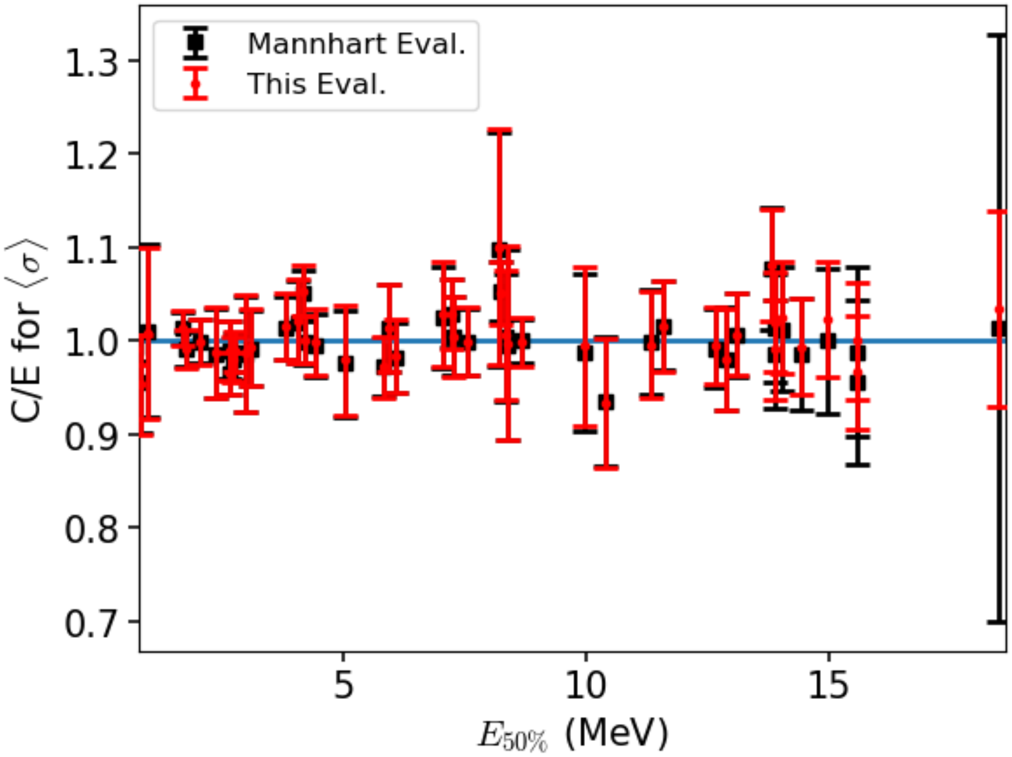
The AIACHNE project produced a new, fully reproducible ^{252}Cf(sf) PFNS evaluation covering a larger energy range.



Previous Standard (Mannhart, 1985) not reproducible because input data lost.
New one has lower evaluated unc. except for 3-8 MeV due to including new exp. data.

D. Neudecker et al., Vol. 11 EPJ-N (2025).

Good performance of spectrum-averaged cross section was maintained by new evaluation.



- Summary:
- o Provided 6 data sets GMA database.
- o New working group on ^{252}Cf(sf) nu-bar.
- o New ^{252}Cf(sf) PFNS evaluation provided.

Discussion:

- o Are there any concerns about the changes made to uncertainties made for 6 new GMA data sets?
- o Should we wait for new exp. before changing ^{252}Cf(sf) nu-bar unc. or continue?
- o Is there any feedback on ^{252}Cf(sf) PFNS from IRDFF community?

Thank you for listening!

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Back-up

Abstract

The Neutron Data Standards are planned to be released in spring 2026. At LANL, we contributed via a new ^{252}Cf(sf) PFNS evaluation that was recently published in Ref. [1] and is planned to be released as part of the new Standards. We also contributed GMA input decks for several data sets spanning ^{239}Pu(n,f), ^{235}U(n,f), ^{10}B(n,a) and ^{6}Li(n,t) cross sections and ratios thereof. Finally, several meetings were held on the credibility of ^{252}Cf(sf) nu-bar uncertainties of experimental data entering the evaluation. A summary of all this work will be provided.

[1] D. Neudecker et al., EPJ Nuclear Sciences & Technologies 11 (2025).