LA-UR-18-29911
Approved for public release; distribution is unlimited.

Title: Updating the experimental 239Pu(n,f) cross-section uncertainties in the Neutron Data Standards database

Author(s): Neudecker, Denise

Intended for: Nuclear Data Week-CSEWG, 2018-11-05/2018-11-07 (Upton, New York, United States)
Web

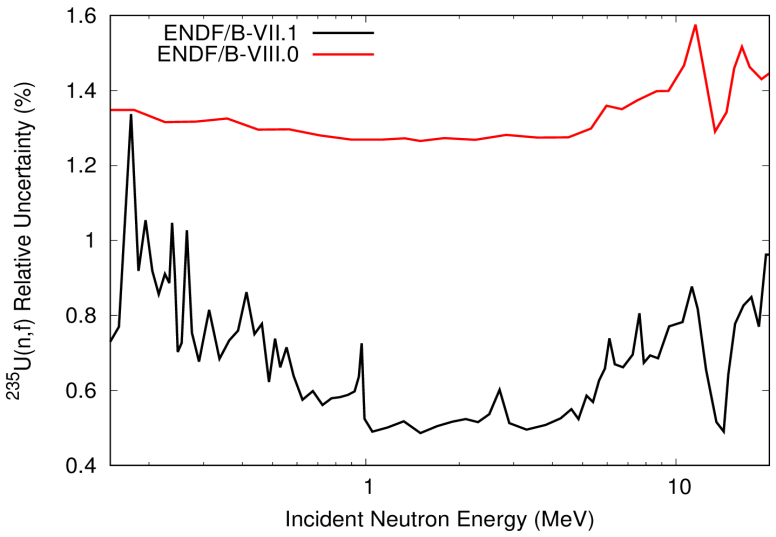
Issued: 2018-10-18 (Draft)

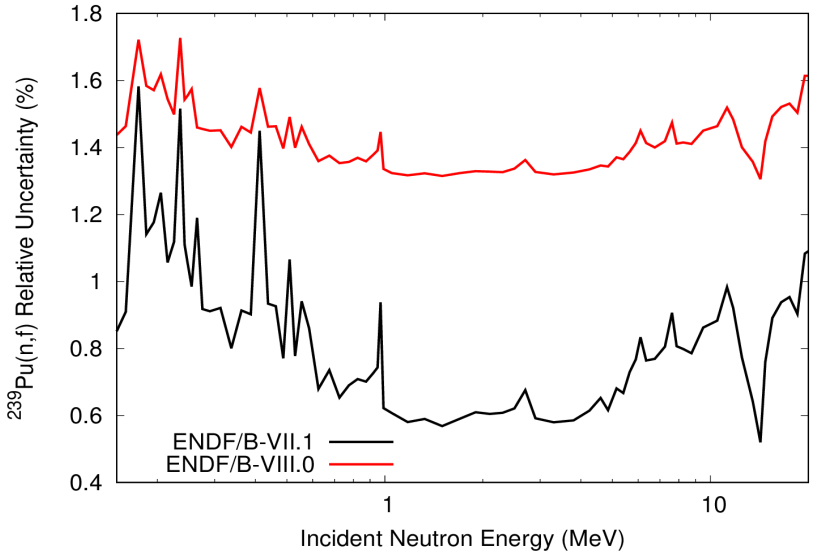
Updating the experimental ^{239}Pu(n,f) cross-section uncertainties in the Neutron Data Standards database

D. Neudecker, CSEWG 11/6/2018

Thanks to: R. Capte, V. Pronyaev, D.L. Smith, F. Tovesson, M.C. White, B. Hejnal, D. Vaughan, the TPC collaboration (N. Bowden, S. Sangiorgio, K. Schmitt, L. Snyder, N. Walsh, W. Younes)

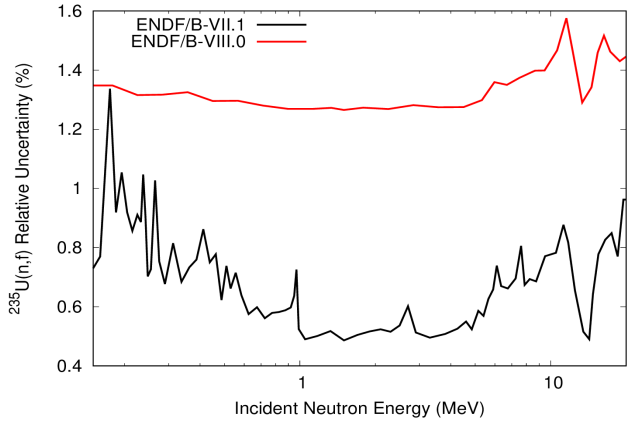
The standards project increased the unc. of some observables significantly from VII.1 to VIII.0.

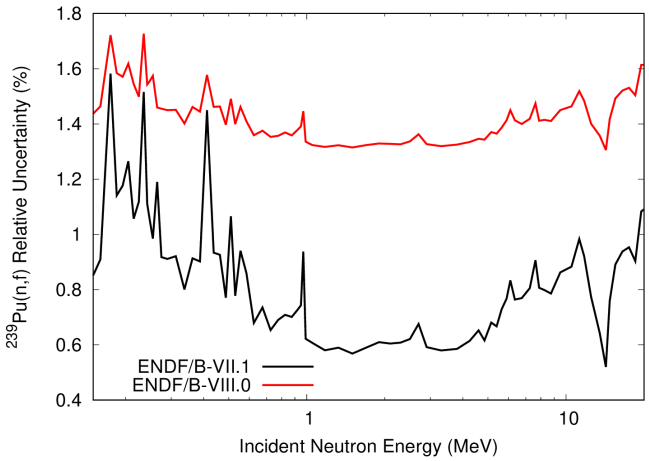




$\bar{\nu}_{tot}$	^{252}Cf	^{233}U	^{235}U	^{239}Pu	^{241}Pu
VIII.0 (b)	3.7637	2.487	2.425	2.878	2.940
(%)	**0.42**	**0.44**	**0.45**	**0.45**	**0.44**
VII.1 (b)	3.7692	2.4968	2.4355	2.8836	2.9479
(%)	0.12	0.14	0.09	0.16	0.18

These increased uncertainties impact some application calculation uncertainties significantly.





Library	HMF001 k_{eff} unc. due to ^{235}U(n,f) unc.	PMF001 k_{eff} unc. due to ^{239}Pu(n,f) unc.
ENDF/B-VII.1	269	331
ENDF/B-VIII.0	**788**	**903**

See M.B. Chadwick et al., NDS 148, 189 (2018).

Eval. unc. were increased to account for missing unc. in the experimental standards database.

The original evaluated uncertainties evaluated by the standards committee were considered to be unrealistically small because:

- Unrecognized unc. across many data sets due to using the same method.
- Missing cross-correlations between experimental unc.
- Missing uncertainty sources for single experimental data sets.

Additional unc. were added a-posteriori to the standards evaluation using the spread of the experimental data (analysis of unknown systematic uncertainties) → ***NOT APPLIED to the exp. unc. in database which would change the mean values!***

Eval. unc. were increased to account for missing unc. in the experimental standards database.

The original evaluated uncertainties evaluated by the standards committee were considered to be unrealistically small because:

- Unrecognized unc. across many data sets due to using the same method.

- **Missing cross-correlations between experimental unc**
- **Missing uncertainty sources for single experimental data sets.**

We investigate those!

A template of unc. expected in an (n,f) exp. is used to look for missing unc. sources.

Unc. Source	Typical range	Correlations	Cor(Exp_1,Exp_2)
Sample Mass	> 1%	Full	Possible (same sample)
Counting Statistics	Sample-dependent	Diagonal	0
Attenuation	0.02-2%	Gaussian	Likely
Detector Efficiency	0-0.3%, 1-2%	Full < 10 MeV	Likely, 0.5-1.0
FF Angular Distrib.	~0.1%	Gaussian	Likely, 0.75-1.0
Background	0.2 - >10%	Gaussian	Possible
Energy Unc.	1%, 1-2 ns	Arises from conv.	Technique-dependent
Neutron Flux	0%, >1%	Full-0.5	Technique-dependent
Multiple Scattering	0.2-1%	Gaussian	0.5-0.75
Impurit. in Sample	Sample-dependent	1.0-0.9	0.5-0.75
Dead Time	>0.1%	Full	0

The template was used to update the standards with missing uncertainties.

The template uncertainties were compared to the uncertainty sources given for individual measurements in the standards database to:

- Pinpoint uncertainties that are missing (e.g., no sample mass unc. for absolute measurements ...)
- Detect unrealistically low uncertainties (e.g., sample mass uncertainty below 0.7%.)
- Pinpoint missing correlations between uncertainties of different measurements.

About 2/3rds of the ^{239}Pu(n,f) data in the standards database were re-estimated.

Data Type	Absolute	Shape	Clean Ratio Absolute	Clean Ratio Shape	Indirect Ratio Absolute	Clean Ratio Shape
Number of Data Sets in GMA	16	3	17 (16 relative to ^{235}U(n,f), 1 relative to ^{238}U(n,f))	6 (4 relative to ^{235}U(n,f), 2 relative to ^{238}U(n,f))	0	19 (17 relative to ^{10}B(n,α), 2 relative to ^{6}Li(n,α))
Number of Re-estimated Data Sets	16	3	11	2	0	10

Underestimate uncertainties are typical cases rather than exceptions.

GMA #	GMA unc.	Reestimated unc.
611	1.0	**1.7**
644	2.0	**2.2**
615	2.1	**2.4**
1038	2.3-7.7	2.3-7.7
640	2.4-3.1	**3.3-4.3**
620	2.8-6.6	**3.0-6.7**
622	2.8-7.0	**3.0-7.3**
619	2.9	**4.7**
621	2.9-3.2	**3.6-11.0**
623	3.2-4.1	**3.5-4.3**
612	3.8-4.7	**4.0-5.8**
672	4.9-5.4	**5.4-5.5**
616	5.4	5.1

GMA #	GMA unc.	Reestimated Unc.
617	5.8	5.8
628	5.9	**6.4**
657	9.3	9.3
521	2.3-4.8	**3.4-5.6**
589	2.9-3.9	**3.7-14.0**
671	4.3-25.8	**5.5-26.0**
8002	0.7-3.8	**2.2-4.9**
602	0.8-6.8	**1.5-6.9**
654+653	1.0-6.9	**1.8-75.5**
685	1.1	**2.0**
1014	1.3-1.6	**1.7-2.6**
536	0.7-6.5	**1.0-7.3**
1029	1.0-2.5	**2.5-3.5**

From May 2018, more did not fit on the slide ...

Yes, original standards evaluated uncertainties are underestimate.

The original evaluated uncertainties evaluated by the standards committee were considered to be unrealistically small because:

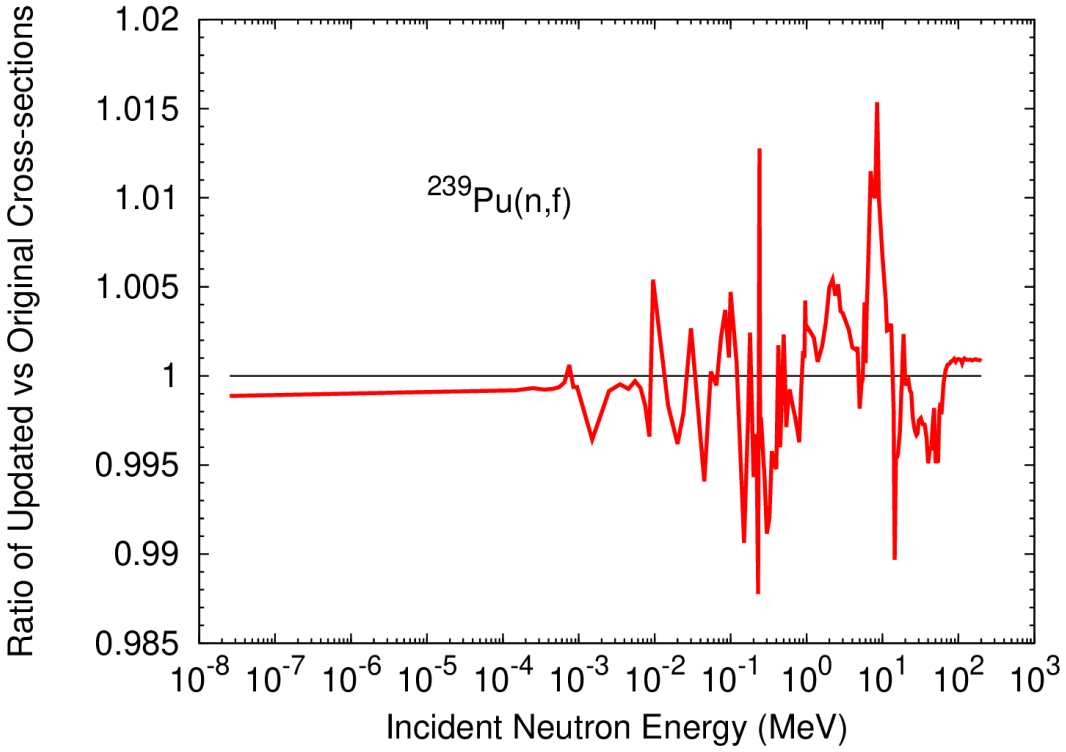
- Unrecognized unc. across many data sets due to using the same method.
- **Missing cross-correlations between experimental unc.**
- **Missing uncertainty sources for single experimental data sets.**

There are indeed uncertainties missing for single experimental data sets and cross-correlations in the standards database.

WIP: About 1/3rds of the ^{239}Pu(n,f) data in the standards database were updated.

Data Type	Absolute	Shape	Clean Ratio Absolute	Clean Ratio Shape	Indirect Ratio Absolute	Clean Ratio Shape
# Data Sets in GMA	16	3	17 (16 relative to ^{235}U(n,f), 1 relative to ^{238}U(n,f))	6 (4 relative to ^{235}U(n,f), 2 relative to ^{238}U(n,f))	0	19 (17 relative to ^{10}B(n,α), 2 relative to ^{6}Li(n,α))
# Re-estimated Data Sets	16	3	11	2	0	10
# Updates in GMA	11	0	11	0	0	0

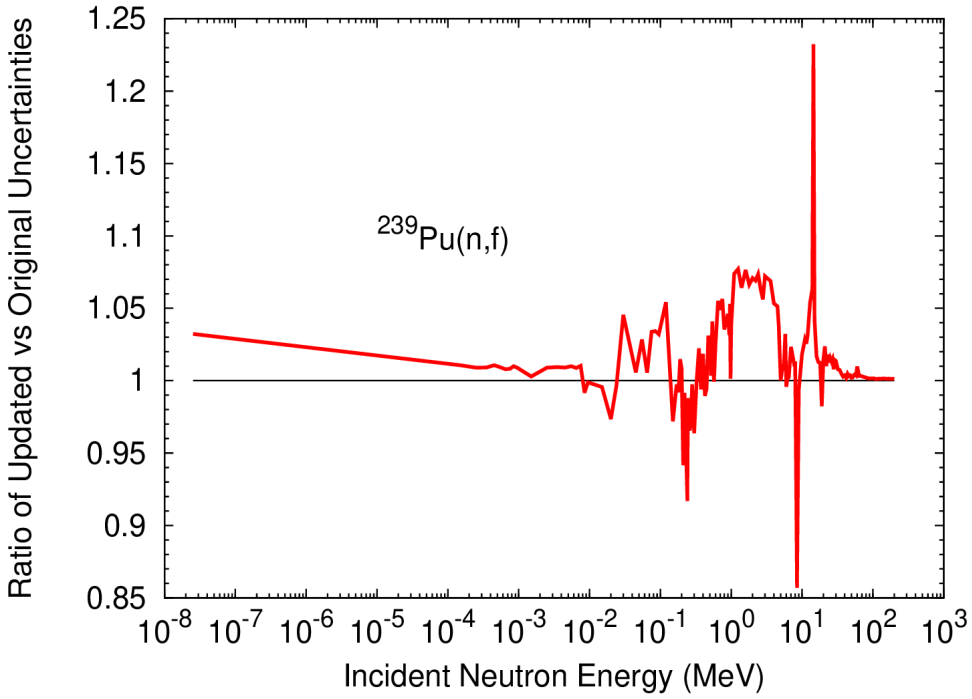
Updating the unc. of ^{239}Pu(n,f) data sets in the standards database changes eval. mean values.



This result is a work in progress and WILL CHANGE with every data set updated.

Updates of other standard observable experiments can also impact the ^{239}Pu(n,f).

Updating the unc. of ^{239}Pu(n,f) data sets in the standards database changes eval. uncertainties.



This result is a work in progress and WILL CHANGE with every data set updated.

Updates of other standard observable experiments can also impact the ^{239}Pu(n,f) unc.

Summary

- Standards eval. unc. of some observables were increased by USU due to missing uncertainty sources of single exp., missing unc. across many measurements and missing correlations.
- Here, **unc. of ^{239}Pu(n,f) exp. data in the standards database were re-estimated. → there are uncertainties and correlations missing in the standards database**.
- **Updating the uncertainties in the standard database changes evaluated mean values and uncertainties!!! (work in progress)**
- The uncertainties of other experiments in the standards database should be investigated.

Thank you for your attention!