

LLNL Testing of ENDF/B-VIII.1 β 1 Covariances

Mini-CSEWG – April 25-27, 2022
Covariance Session

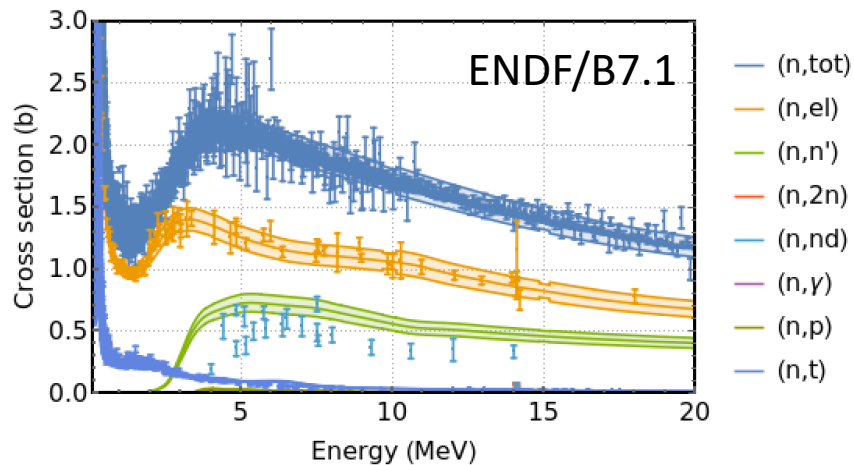
Robert Casperson
Lawrence Livermore National Laboratory



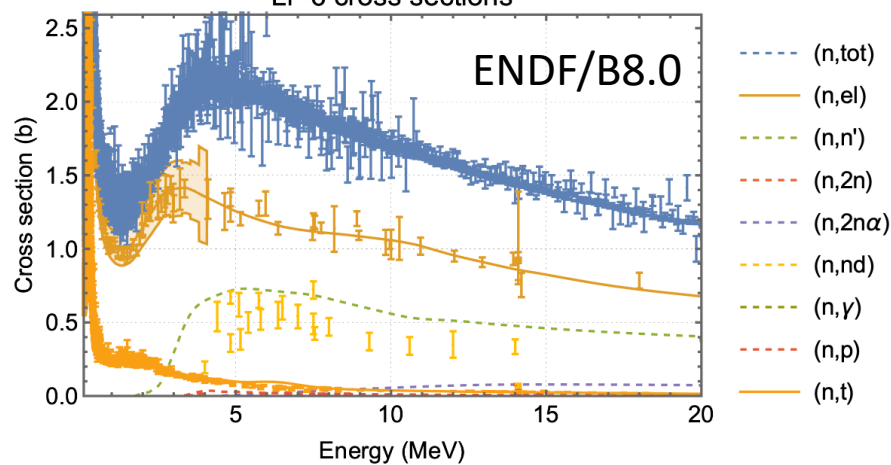
Covariance Testing

- Looked at isotopes that were flagged for *any* changes in the covariance section.
 - ${}^6\text{Li}$, ${}^9\text{Be}$, ${}^{10}\text{B}$, ${}^{16}\text{O}$, ${}^{19}\text{F}$, ${}^{50,52,53,54}\text{Cr}$, ${}^{54,56}\text{Fe}$, ${}^{103}\text{Rh}$, ${}^{140,142}\text{Ce}$, ${}^{156,158,160,161,162,163,164}\text{Dy}$, ${}^{168}\text{Er}$, ${}^{181}\text{Ta}$, ${}^{234,235,236,238}\text{U}$, ${}^{239}\text{Pu}$
- ENDF files processed with NJOY-2016 using Caleb's python interface.
- Extracted means and uncertainties visually compared to EXFOR data where available.
- For cross section plots: dashed means no covariance, solid means covariance
- For uncertainty plots: dashed means ENDF/B8.0, solid means ENDF/B8.1β1

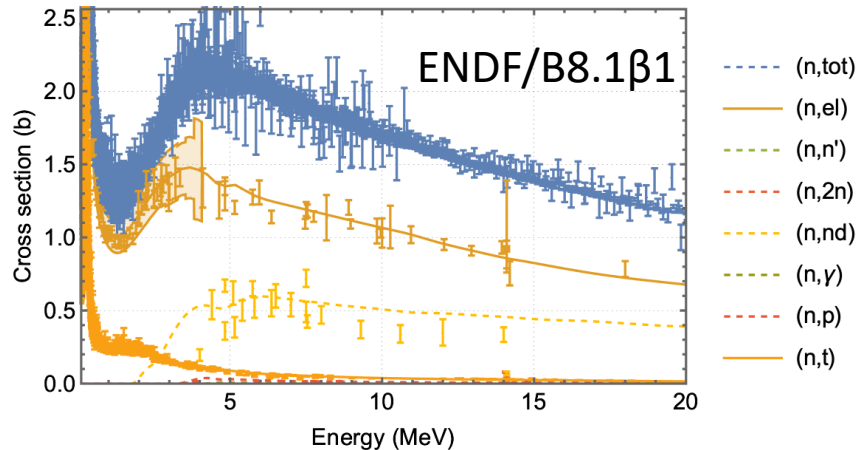
Li-6 cross sections



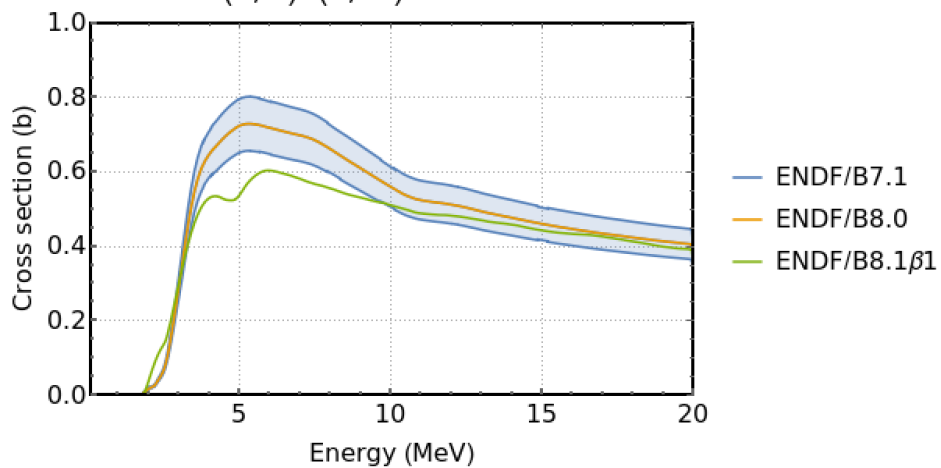
Li-6 cross sections



Li-6 cross sections



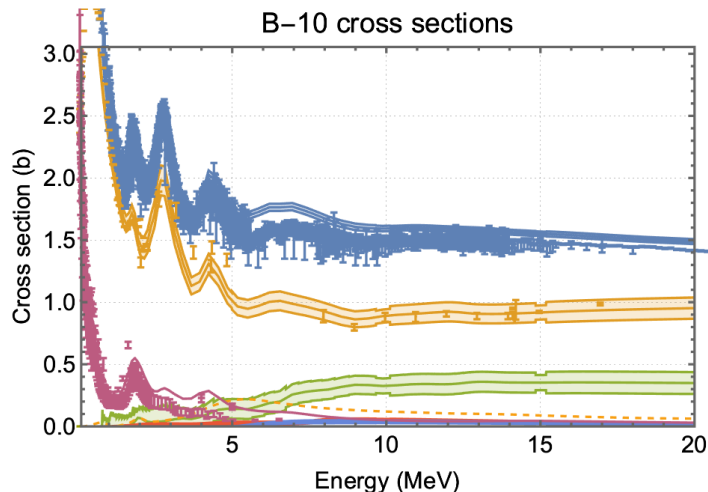
Li-6(n,n')+(n,nd) cross sections



Other light isotopes

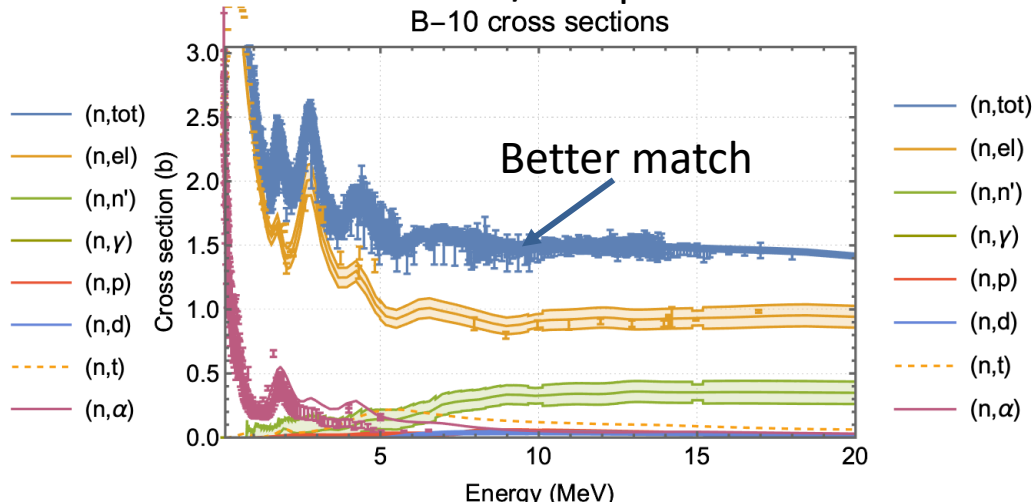
ENDF/B8.0

B-10 cross sections

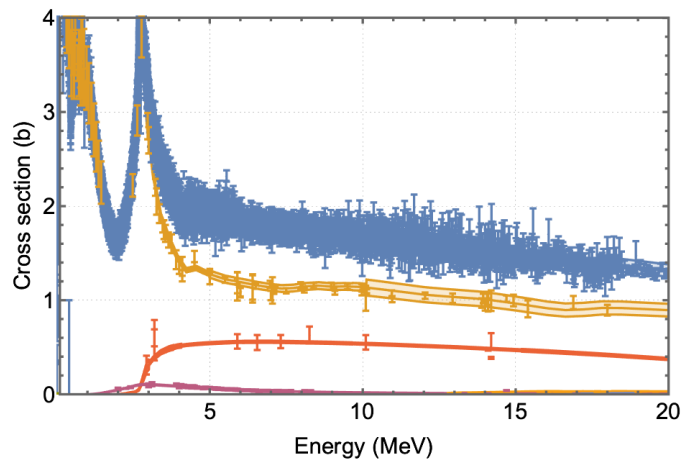


ENDF/B8.1β1

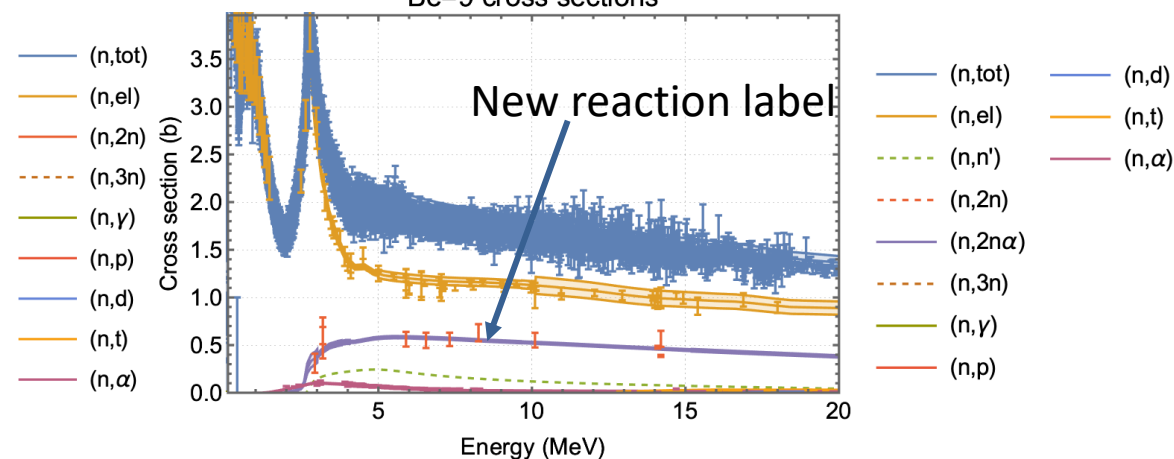
B-10 cross sections



Be-9 cross sections

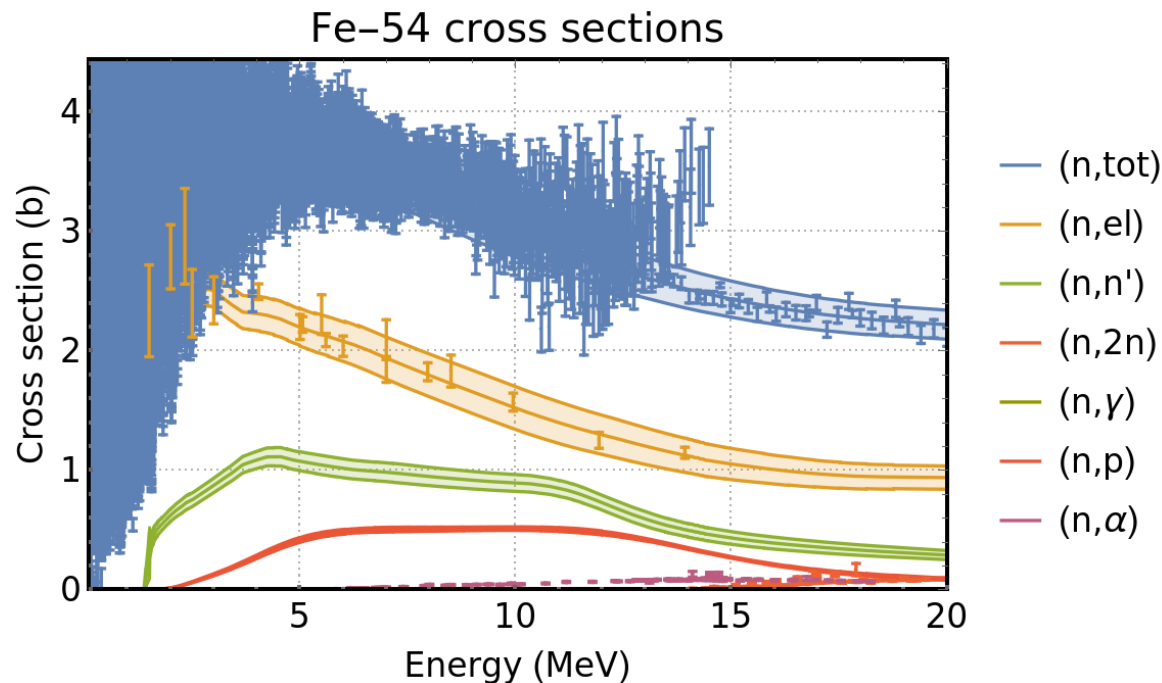


Be-9 cross sections



Chromium and iron

- $^{50,52,53,54}\text{Cr}$ and ^{56}Fe do not appear to have cross section covariances.
 - All but ^{54}Cr had cross section covariances in ENDF/B8.0.
- ^{54}Fe has covariances while ENDF/B8.0 did not.

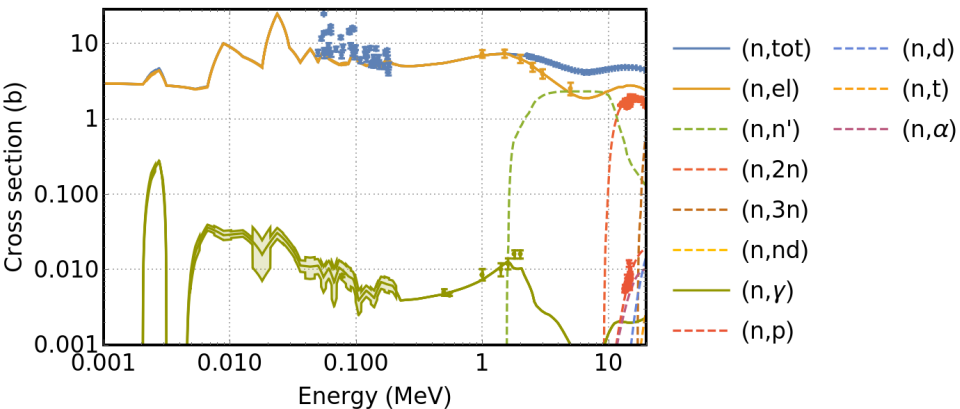


Covariances at lower energy only

- $^{140,142}\text{Ce}$ and $^{156,158,160,161,162,163,164}\text{Dy}$ only have covariances at lower energy, and would not be suitable for UQ.
- If LLNL needed UQ for these isotopes we would likely use Low-Fi instead, as those cover the full energy range for these isotopes.

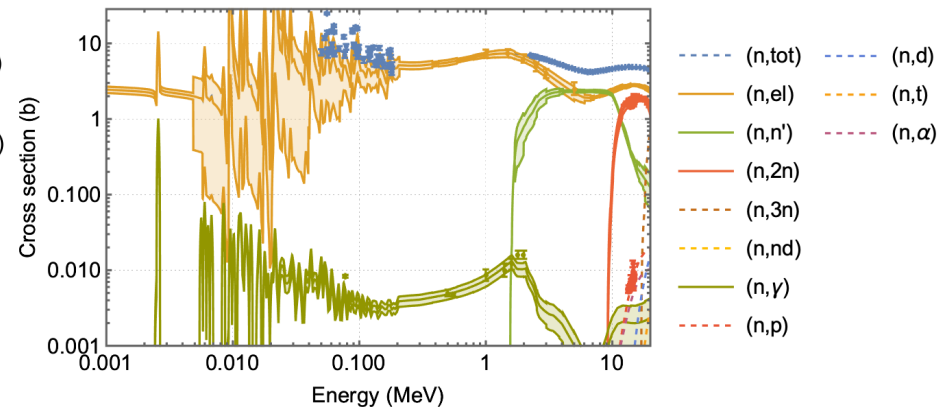
ENDF/B8.1 β 1

Ce-140 cross sections



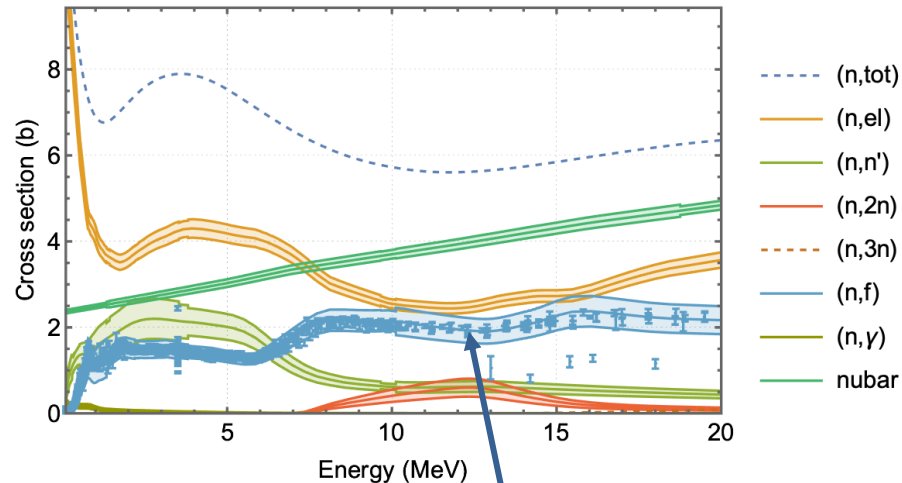
Low-Fi

Ce-140 cross sections

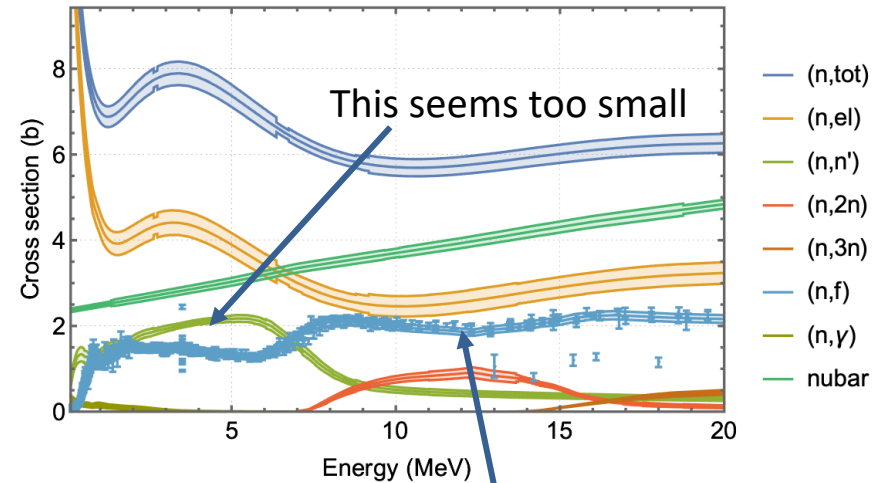


^{234}U and ^{236}U fission cross section

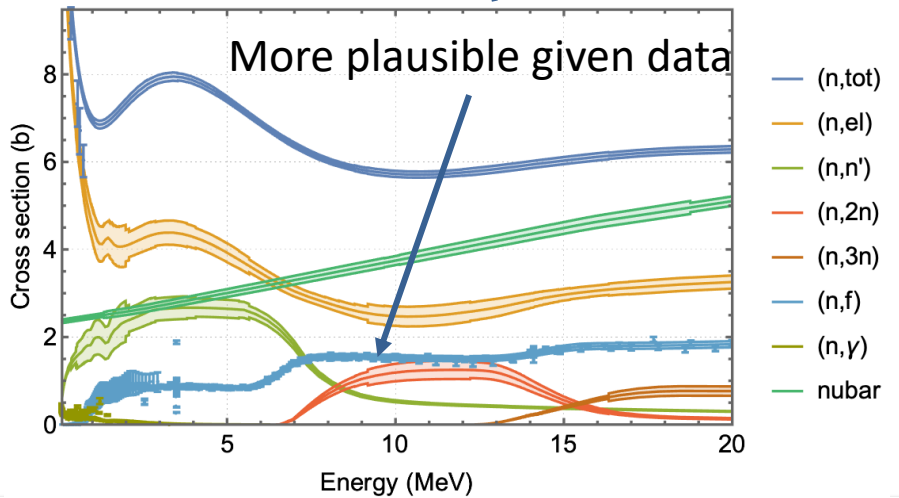
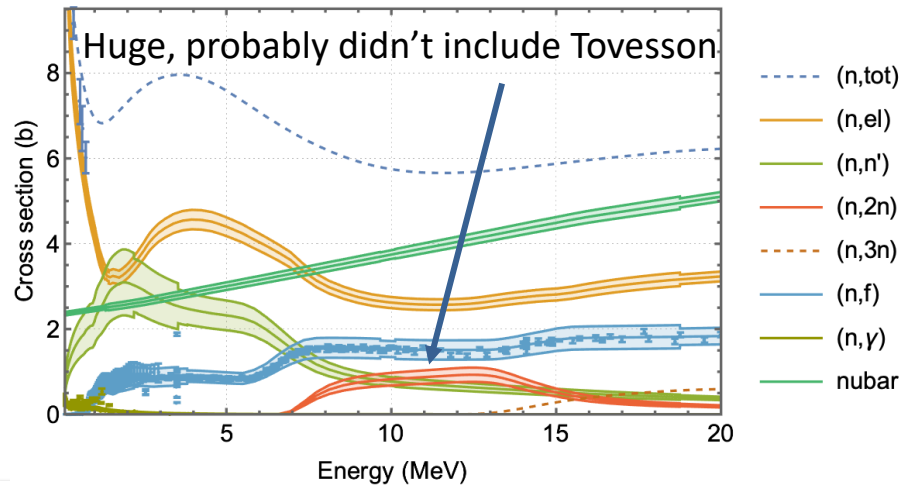
ENDF/B8.0
U-234 cross sections



ENDF/B8.1 β 1
U-234 cross sections

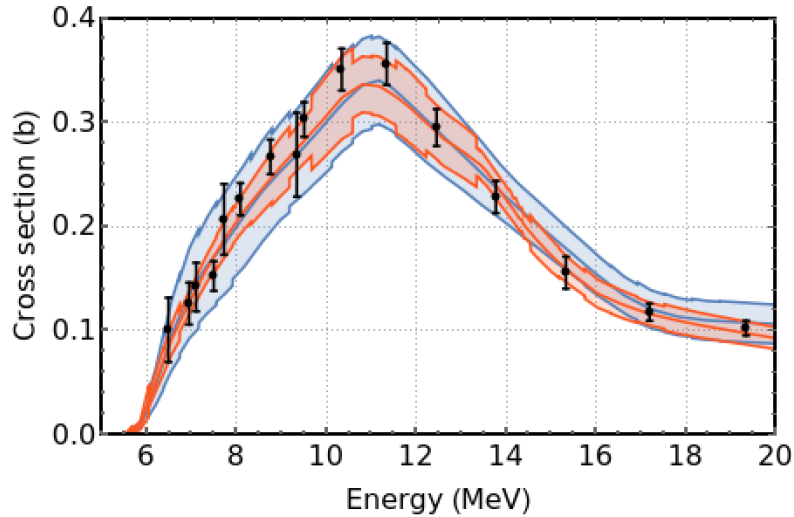


U-236 cross sections

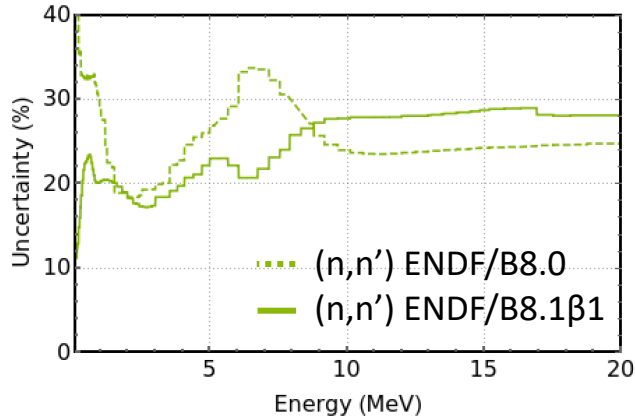


^{239}Pu

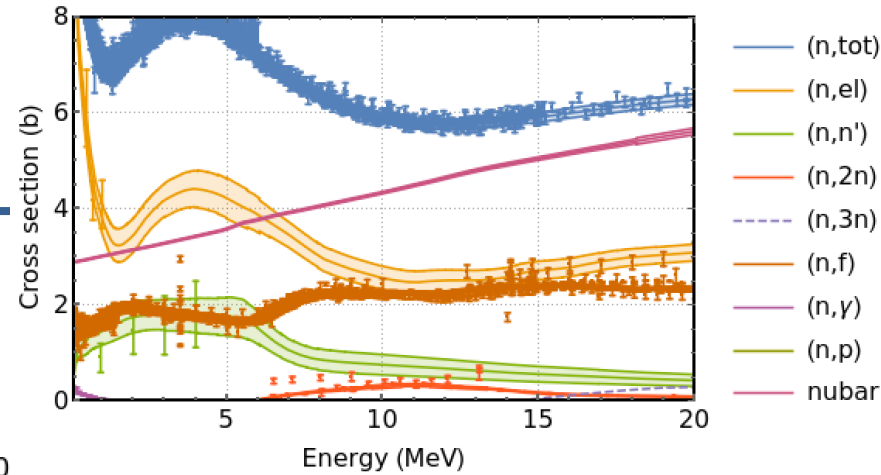
Pu-239(n,2n) cross section



Pu-239 cross section uncertainties



Pu-239 cross sections

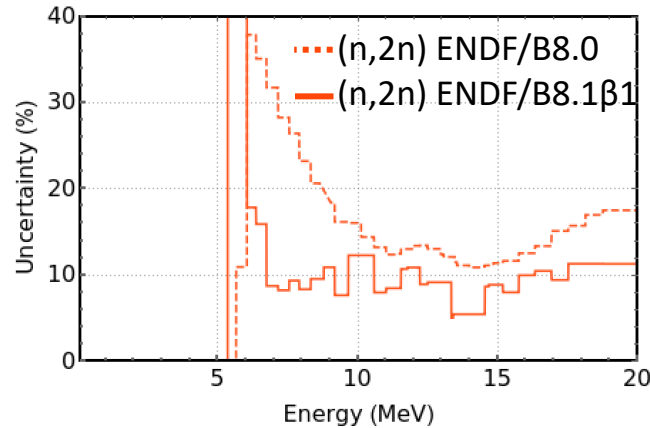


- ENDF/B8.0
- ENDF/B8.1β1
- EXFOR

Had trouble processing PFNS

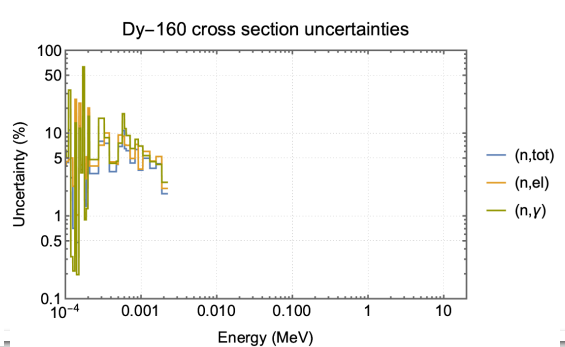
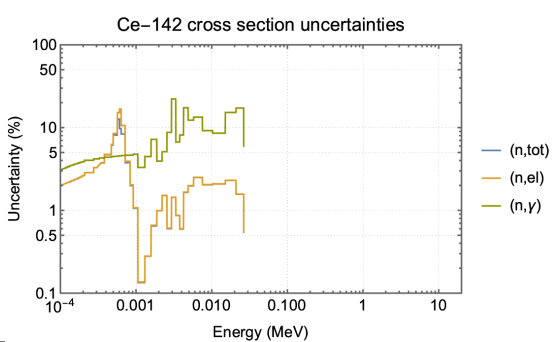
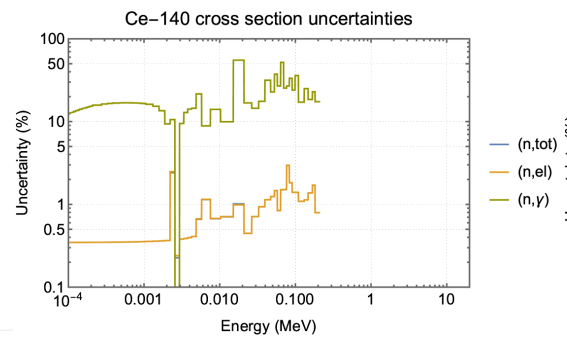
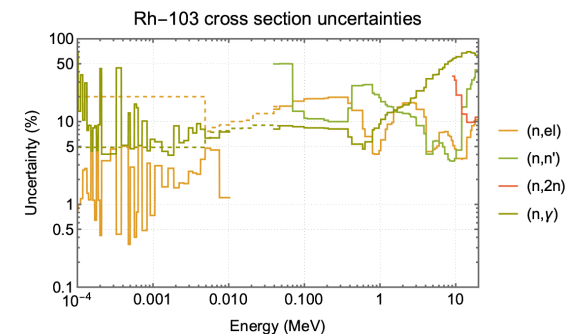
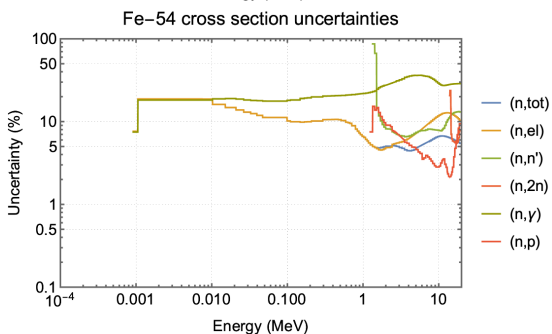
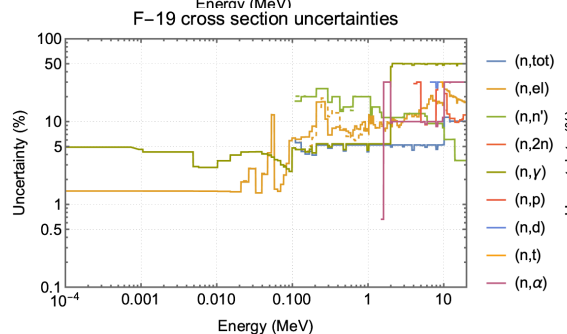
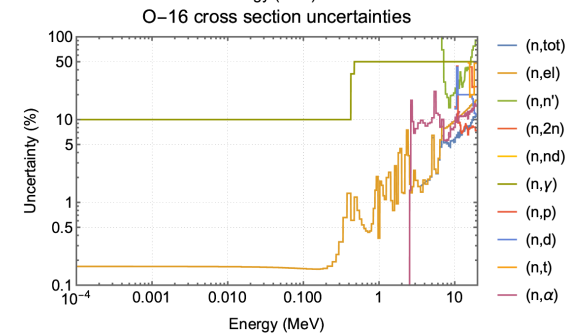
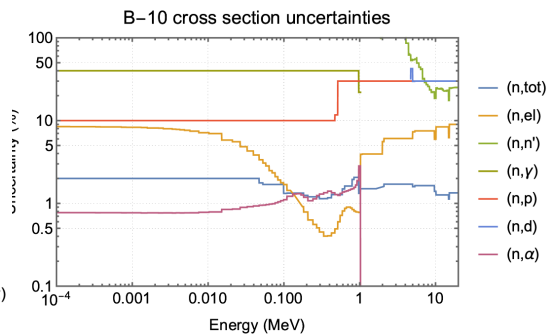
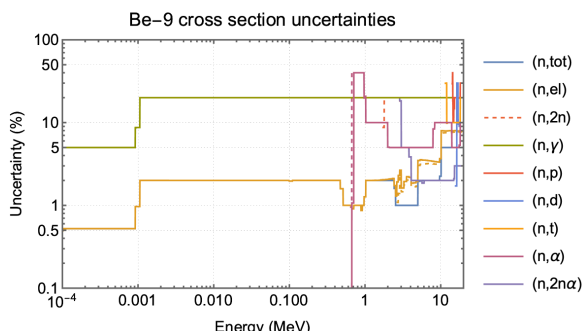
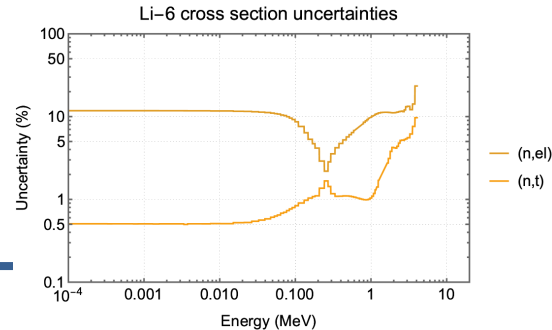
Much smaller (n,2n) uncertainty is troubling.
Limited data, much of which required modeling corrections.

Pu-239 cross section uncertainties



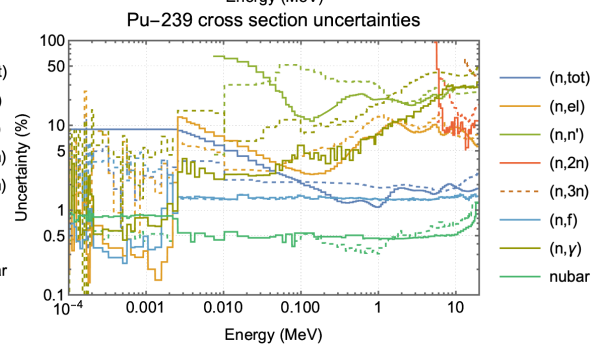
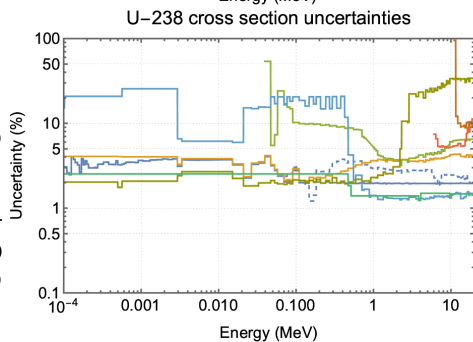
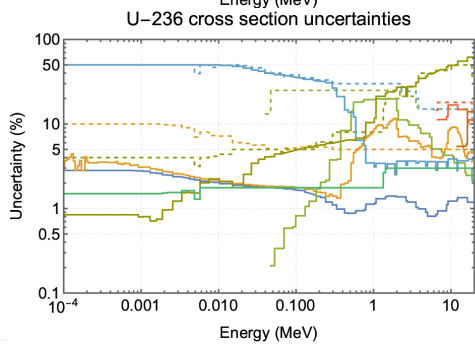
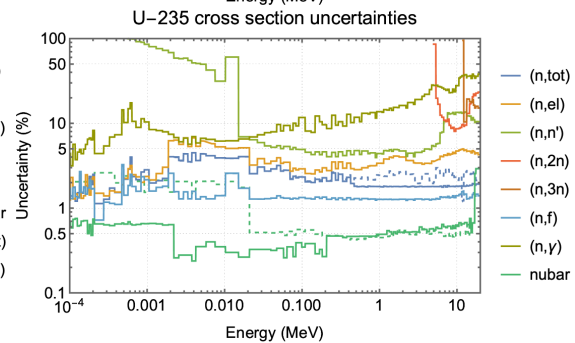
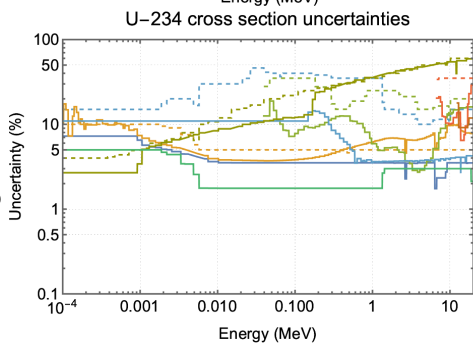
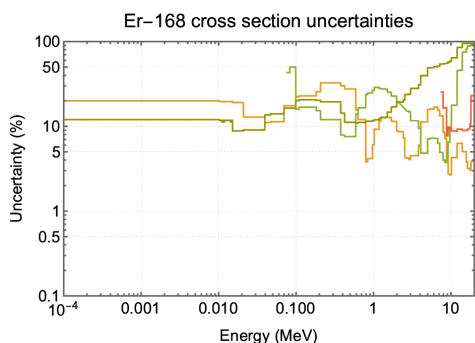
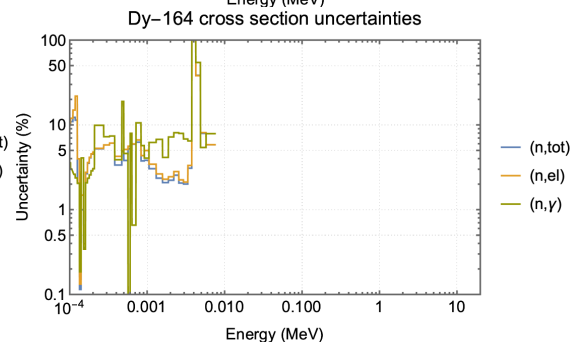
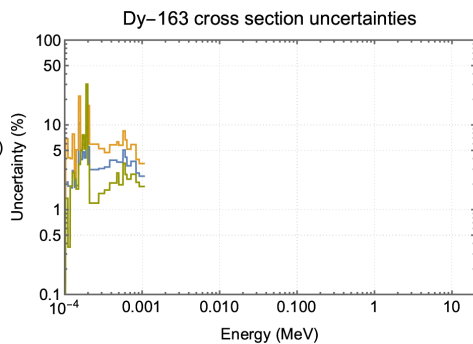
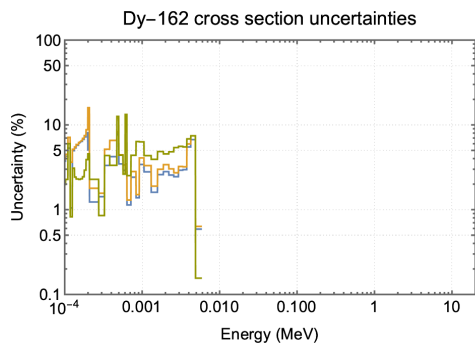
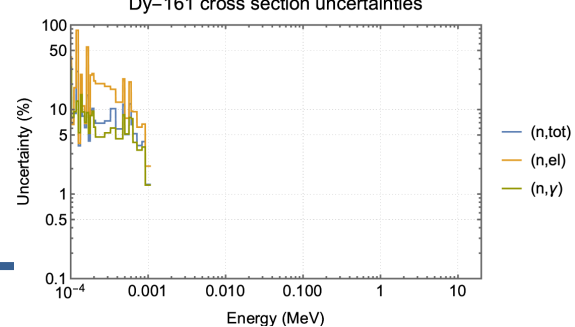
Uncertainty Plots 1

---- ENDF/B8.0
— ENDF/B8.1 β 1



Uncertainty Plots 2

---- ENDF/B8.0
— ENDF/B8.1 β 1



Summary table

Isotope	Processed	Notes
003_Li_006	Yes	Extremely limited, similar to ENDF/B8.0, we use ENDF/B7.1
004_Be_009	Yes	Improved (n,tot)
005_B_010	Yes	Relabeled (n,2n)
008_O_016	Yes	Similar
009_F_019	Yes	Slight change in (n,el)
024_Cr_050	No	Missing
024_Cr_052	No	Missing
024_Cr_053	No	Missing
024_Cr_054	No	Processing issue
026_Fe_054	Yes	New
026_Fe_056	No	Missing
045_Rh_103	Yes	Change in scattering
058_Ce_140	Yes	Low energy only
058_Ce_142	Yes	Low energy only
066_Dy_156	Yes	Low energy only
066_Dy_158	Yes	Low energy only
066_Dy_160	Yes	Low energy only
066_Dy_161	Yes	Low energy only
066_Dy_162	Yes	Low energy only
066_Dy_163	Yes	Low energy only
066_Dy_164	Yes	Low energy only
068_Er_168	Yes	Low energy only
073-Ta_181	No	Error in Gridd, mt1=0
092_U_234	Yes	Better fission uncertainty, small scattering uncertainty
092_U_235	Yes	No PFNS in beta1, small scattering uncertainty
092_U_236	Yes	Better fission uncertainty
092_U_238	Yes	Small scattering uncertainty, better fission uncertainty
094_Pu_239	No	New PFNS format, small (n,2n) uncertainty

Outlook

- Nuclear data covariances are an important part of applied uncertainty quantification, and complete sets of covariances are needed.
 - When incomplete, we use older evaluations (e.g. for Li-6) or Low-Fi.
- I worry about the choices that are leading to small actinide (n,n') uncertainties, and now $^{239}\text{Pu}(n,2n)$ uncertainty.
- There are some improvements in ENDF/B8.1 β 1, e.g. $^9\text{Be}(n,\text{tot})$, $^{234}\text{U}(n,\text{f})$, $^{236}\text{U}(n,\text{f})$, but there are also many disappeared and incomplete covariances.



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