

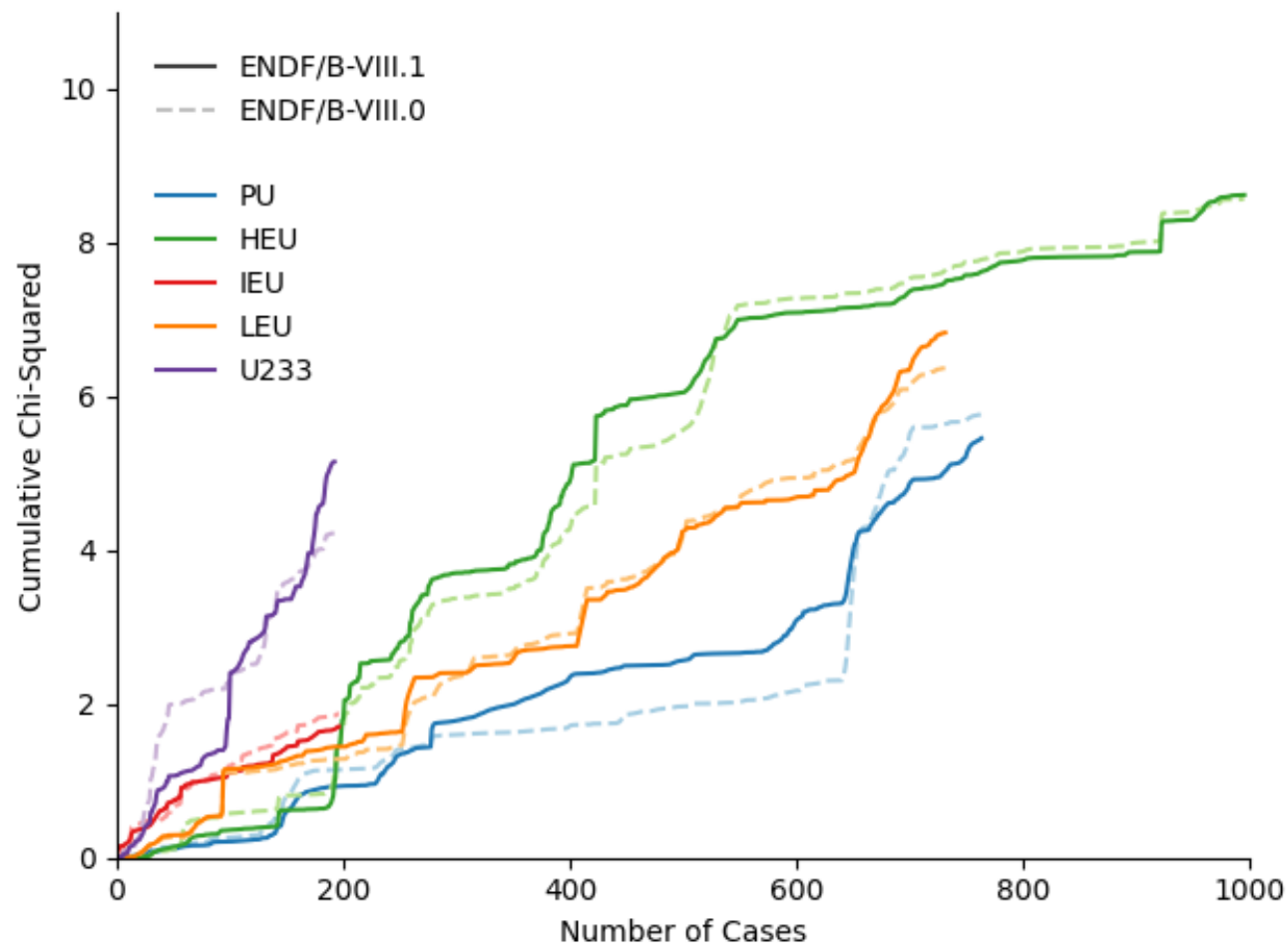
LLNL Testing of ENDF/B-VIII.1 with the COG Validation Suite

Cross Section Evaluation Working Group (CSEWG)
Brookhaven National Laboratory, Jan. 6-9, 2025

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Overview

- COG Validation Suite
- Results
 - Mosteller Suite
 - The Full Suite
 - U-233
 - Pu Solutions
- Conclusions & Future Work



COG Validation Suite

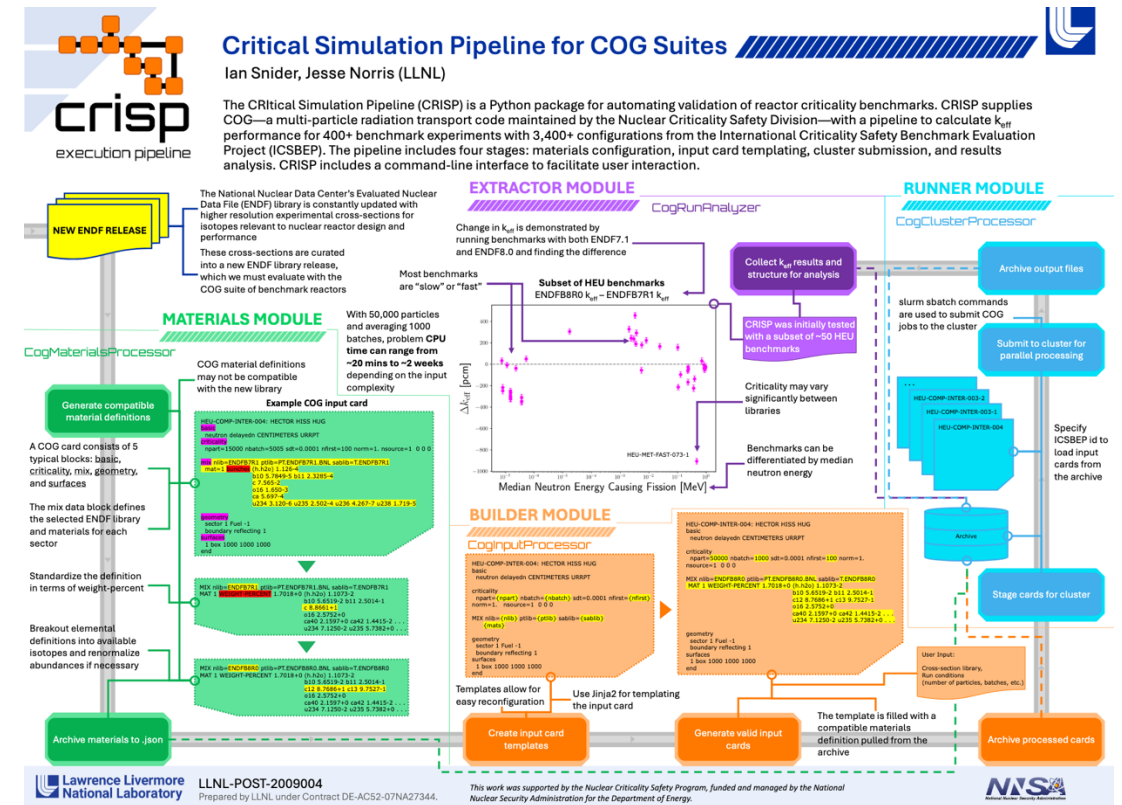
- Benchmarks from the ICSBEP
 - Neutron cross sections processed by PREPRO with probability tables from NJOY's release of ENDF/B-VIII.1
- Previous comparisons with ENDF/B-VII.1, ENDF/B-VIII.0, and JEFF-3.3
- Recent work to extend comparison to new ENDF/B-VIII.1 and include additional benchmark cases

Category	# Cases
PU	781
HEU	1056
IEU	207
LEU	815
U-233	193
MIXED	358
SMF	10
Total	3420

Heinrichs, D., S. Kim, and S. McKinley. "Expanded COG criticality validation suite for inter-laboratory benchmark data comparison." ND2022, Livermore, CA (2022). <https://www.osti.gov/biblio/1890074>

Extending the COG Validation Suite

- Generalized the suite's input files and implemented a software pipeline for running the 3400+ benchmarks
- Input file parameterization now includes:
 - Swapping between libraries
 - Processing of material definitions to convert between elemental and isotopic specifications
 - Toggling of TSL and URR treatments



Implemented by Ian Snider, see the poster for more details:
<https://doi.org/10.2172/3005985>

Methodology

- Calculations were performed using COG 11.3 with ENDF/B-VIII.0 and ENDF/B-VIII.1 to a statistical uncertainty of 10-20 pcm

- The chi-squared value used in this comparison is defined as:

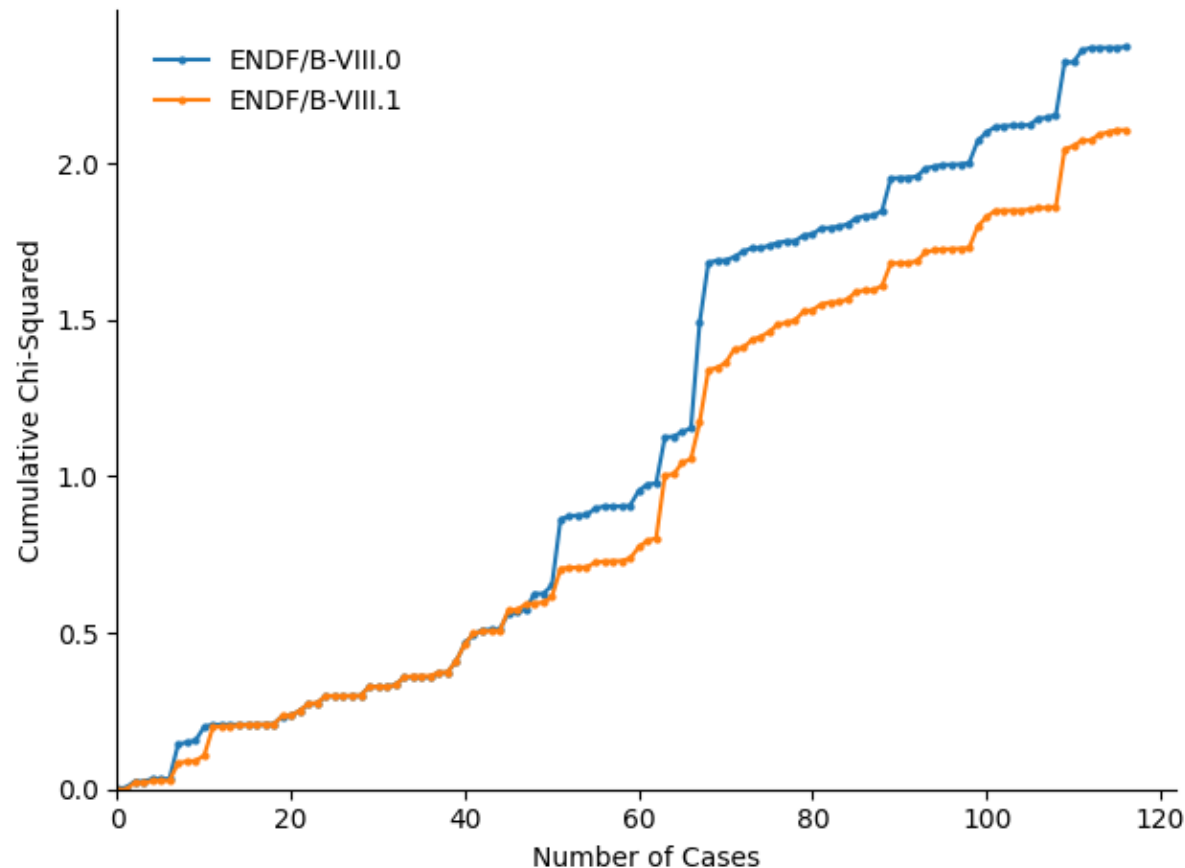
$$\chi^2 = \frac{1}{N} \sum_{i=1}^N \frac{(k_{calc,i} - k_{bench,i})^2}{\sigma_{bench}^2}$$

- The root mean square error (RMSE) also used in this comparison is defined as:

$$RMSE = \sqrt{\frac{\sum_{i=1}^N (k_{calc,i} - k_{bench,i})^2}{N}}$$

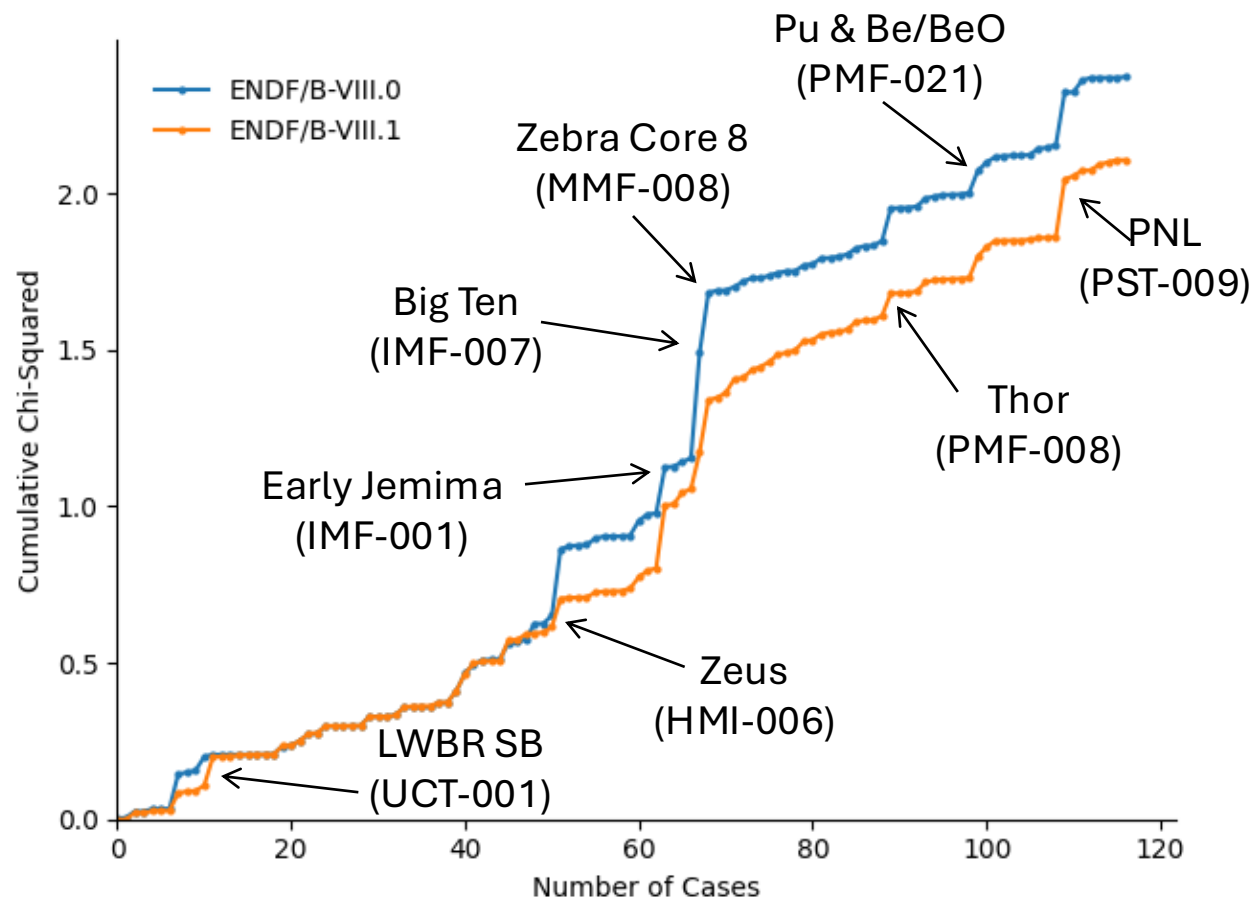
Mosteller Suite

- Agreement with results from the ENDF/B-VIII.1 paper
- Consistent improvement in the χ^2 from ENDF/B-VIII.0 to ENDF/B-VIII.1, specifically:
 - Zeus (HMI-006)
 - Big Ten (IMF-007)
- Regressions in:
 - LWBR SB Core (UCT-001, Case 6)
 - Early Jemima (IMF-001)



Mosteller Suite

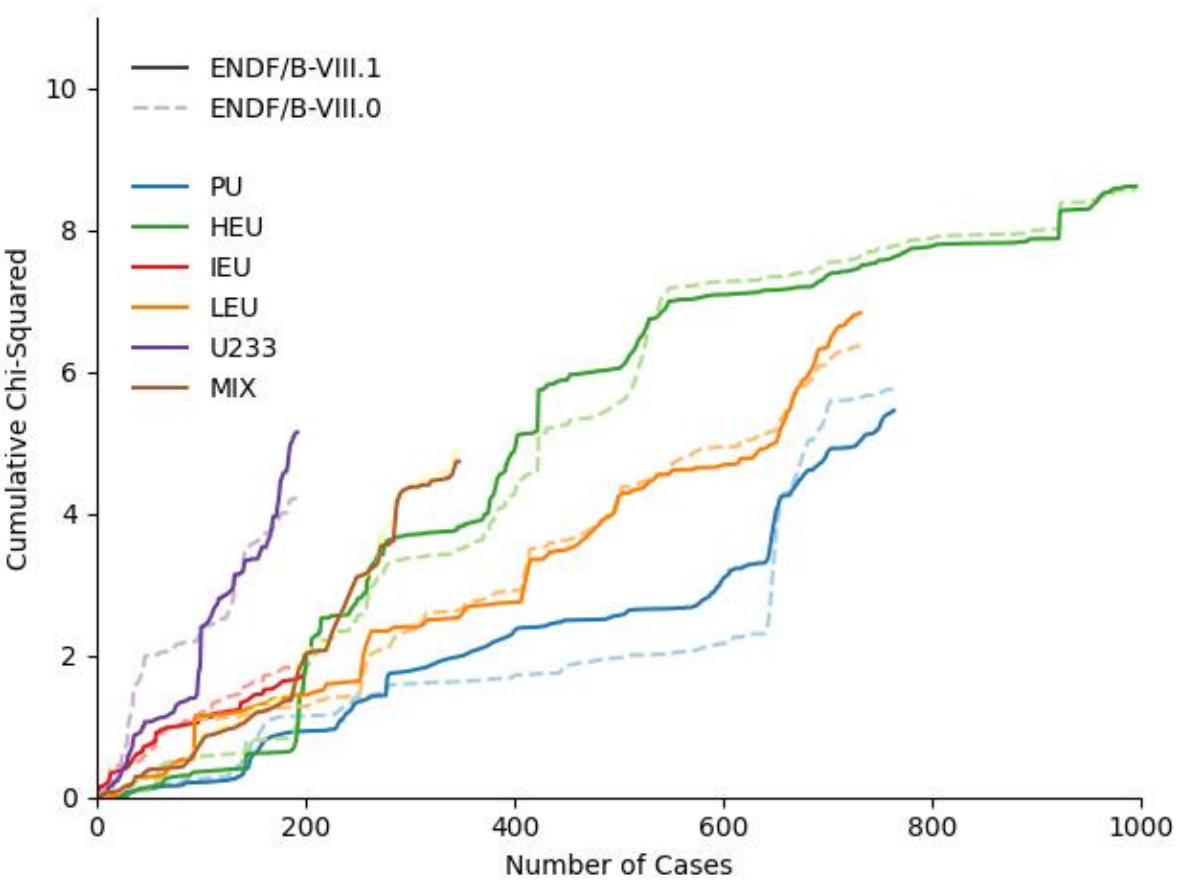
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The Full Suite

- Overall performance of ENDF/B-VIII.1 is improvement from ENDF/B-VIII.0

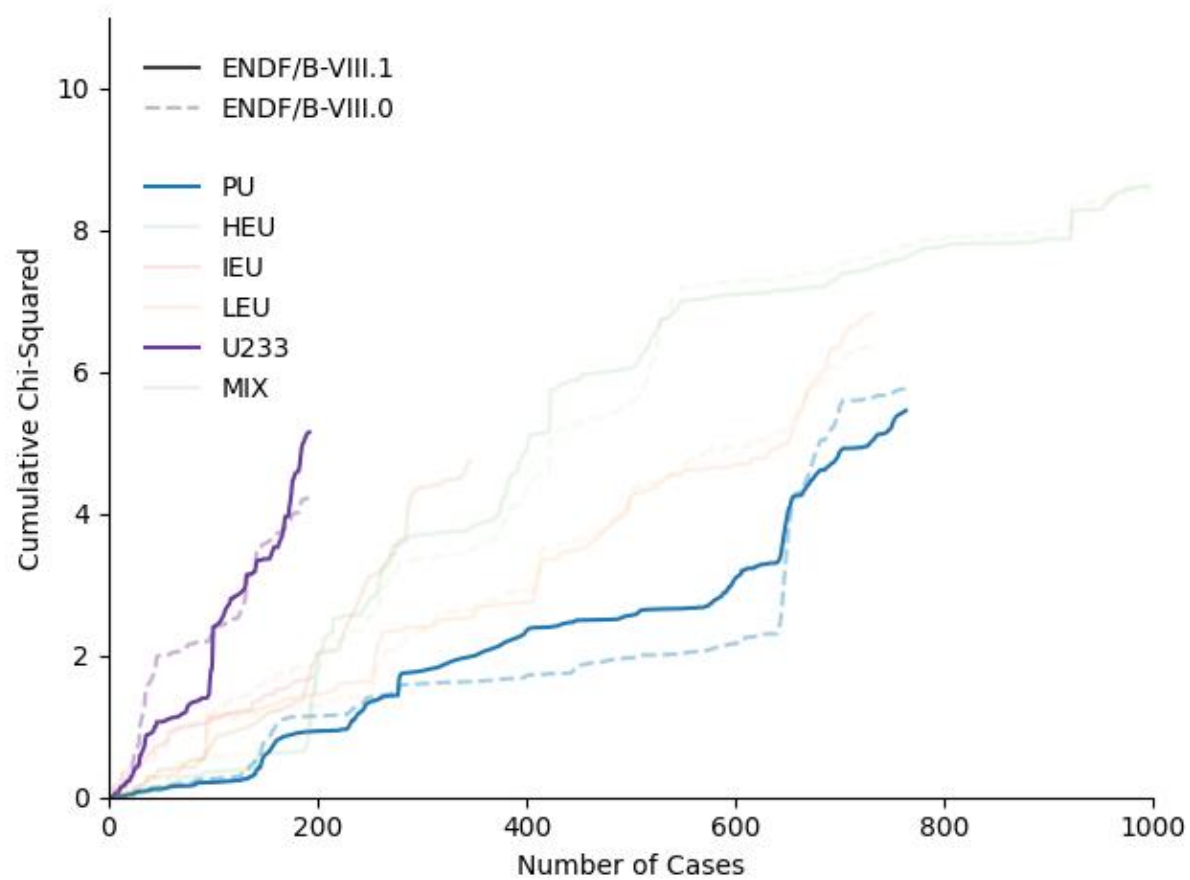
Fissile	RMSE (*lower is better)	
	ENDF/B-VIII.0	ENDF/B-VIII.1
PU	0.00745	0.00779
HEU	0.00694	0.00683
IEU	0.00535	0.00485
LEU	0.00550	0.00517
U233	0.01142	0.01056
MIX	0.00988	0.00988



The Full Suite

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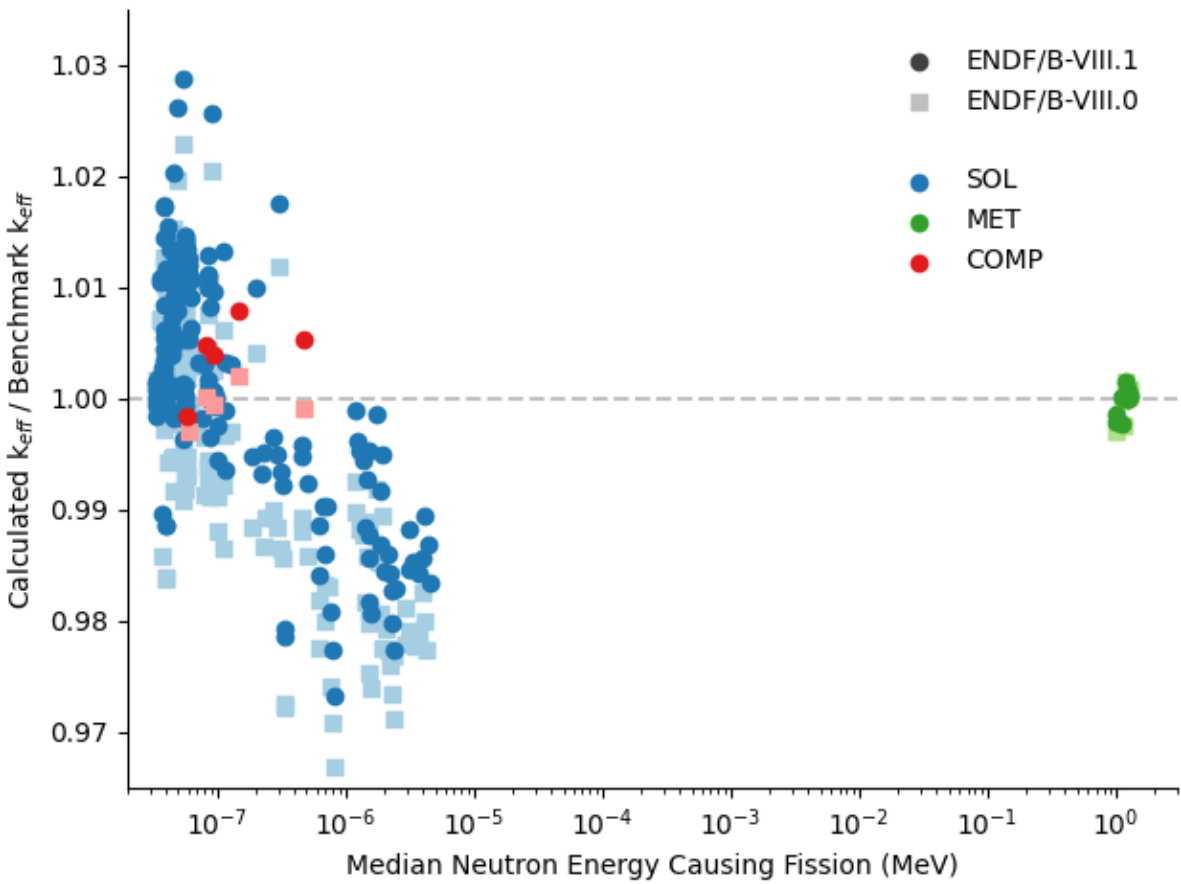
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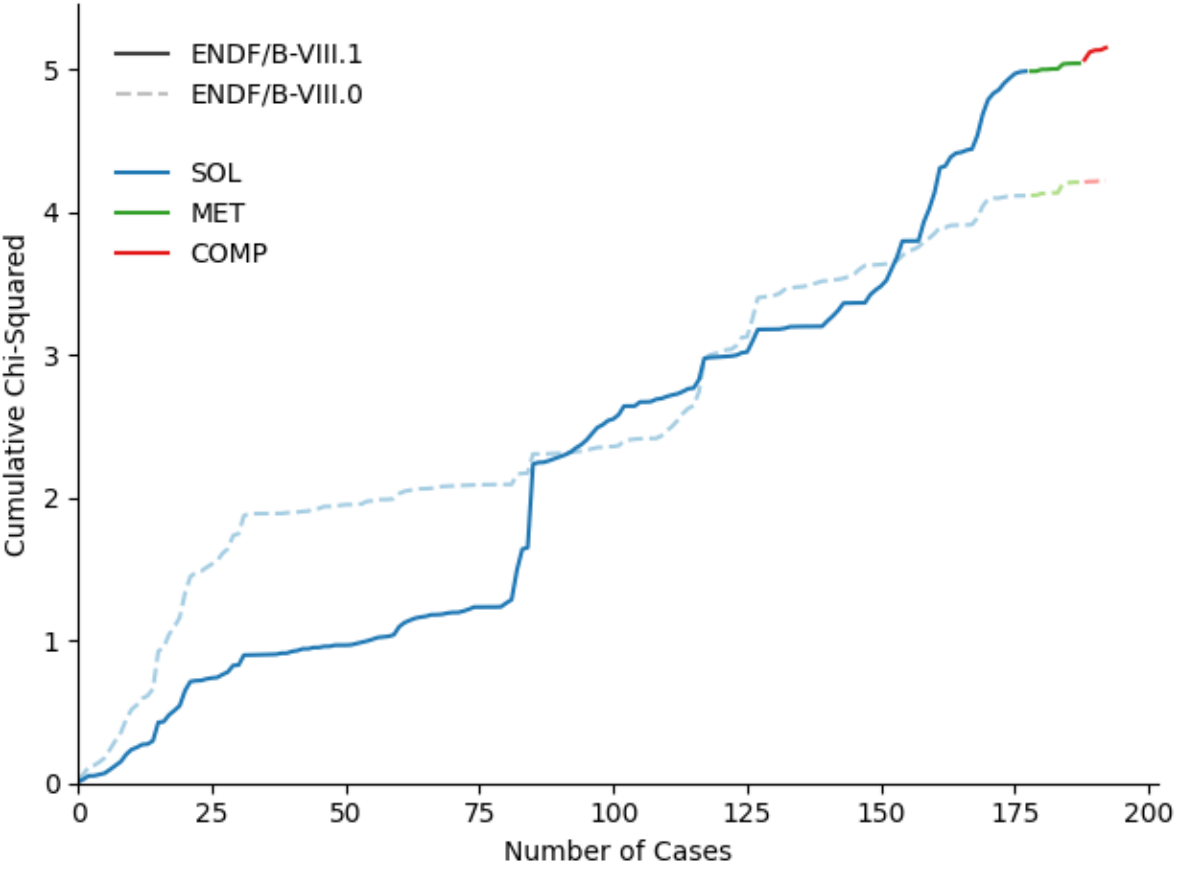
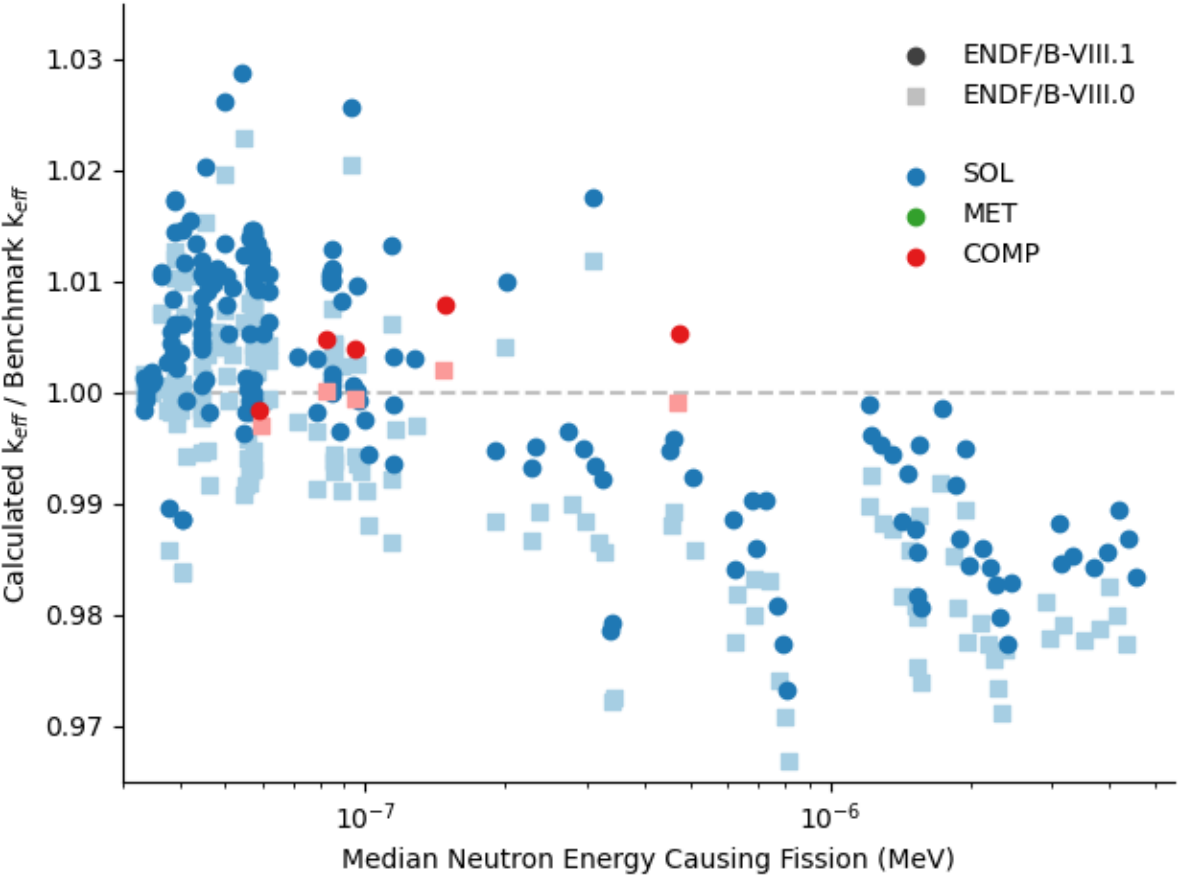
U-233 Benchmarks

- Changes in ENDF/B-VIII.1 results in an increase in k_{eff} compared to ENDF/B-VIII.0, especially in the thermal region
- Significant increase in the LWBR SB Core (UCT-001)

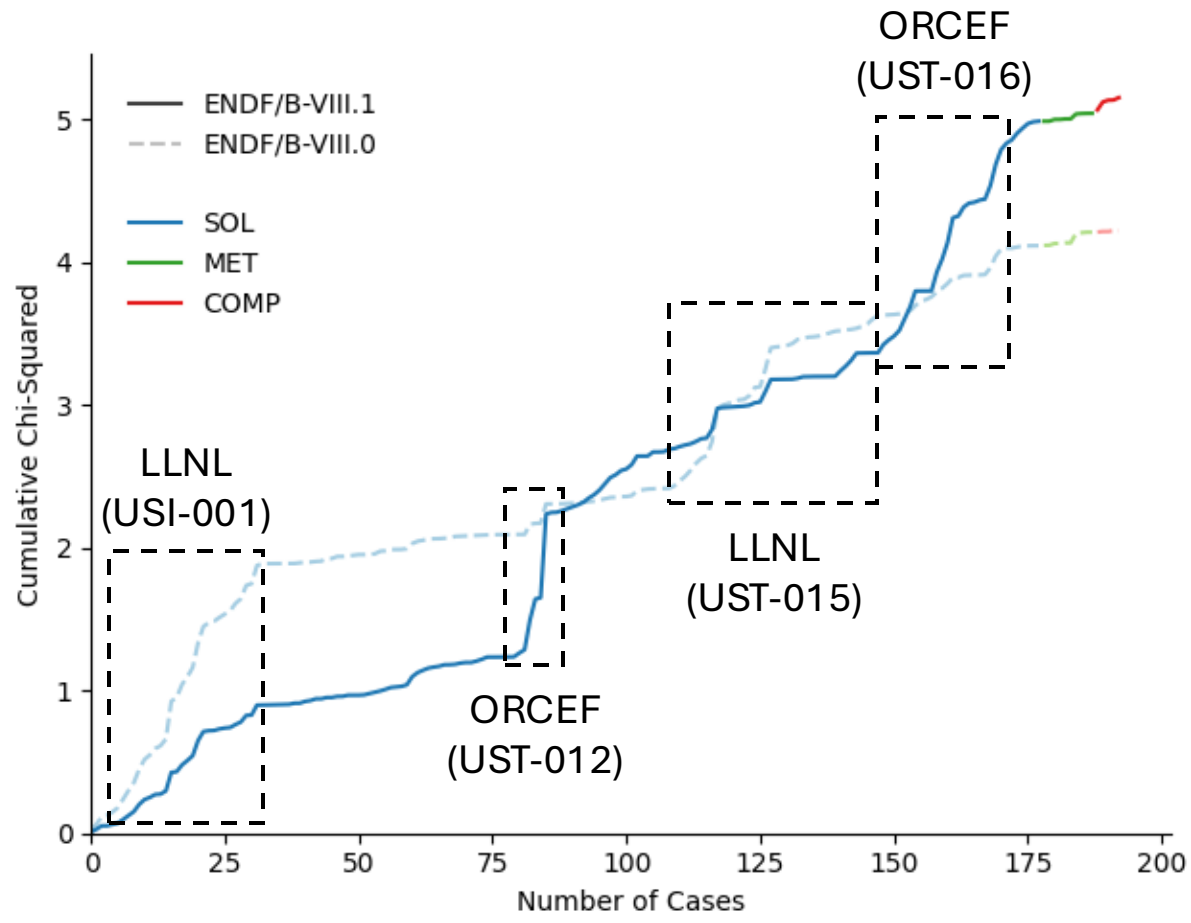
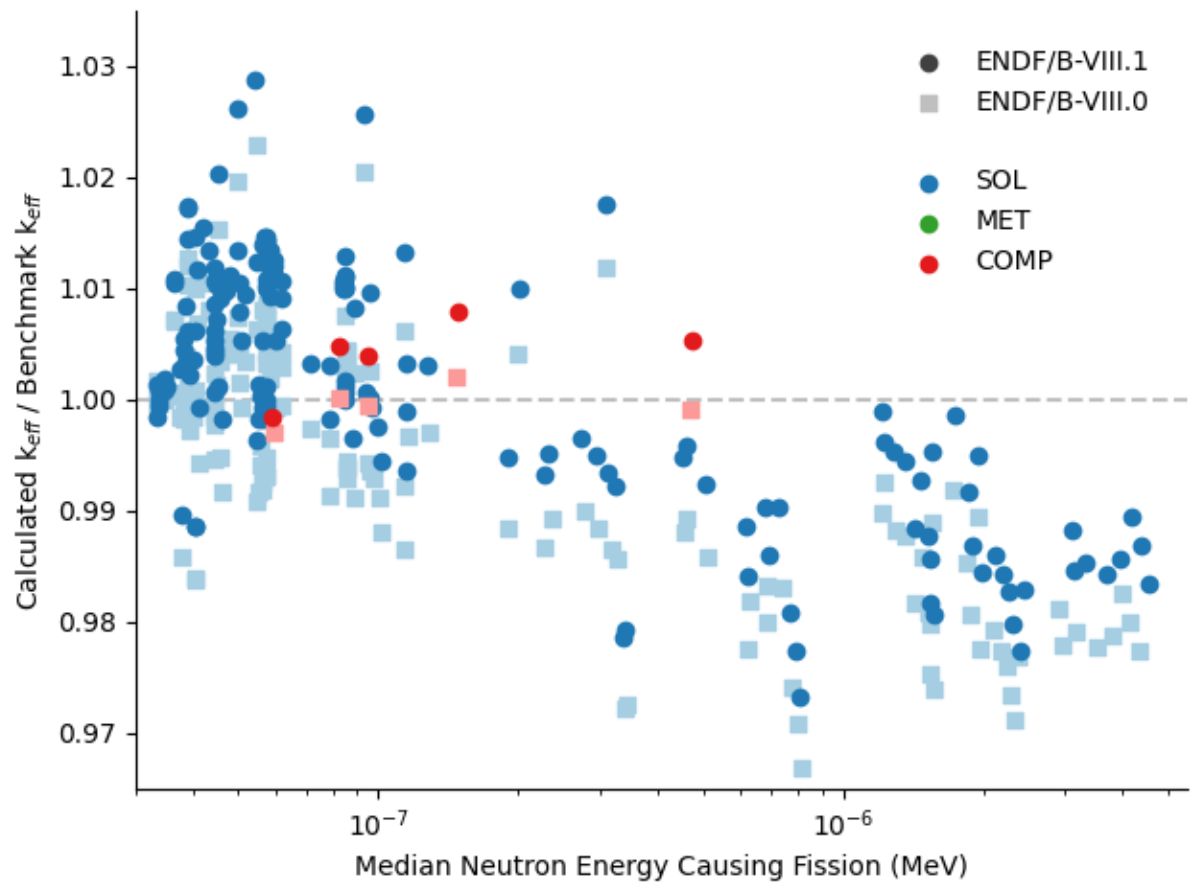
Library	RMSE	Average k_{eff}
ENDF/B-VIII.0	0.0114	0.99633
ENDF/B-VIII.1	0.0106	1.00189



U-233 Benchmarks



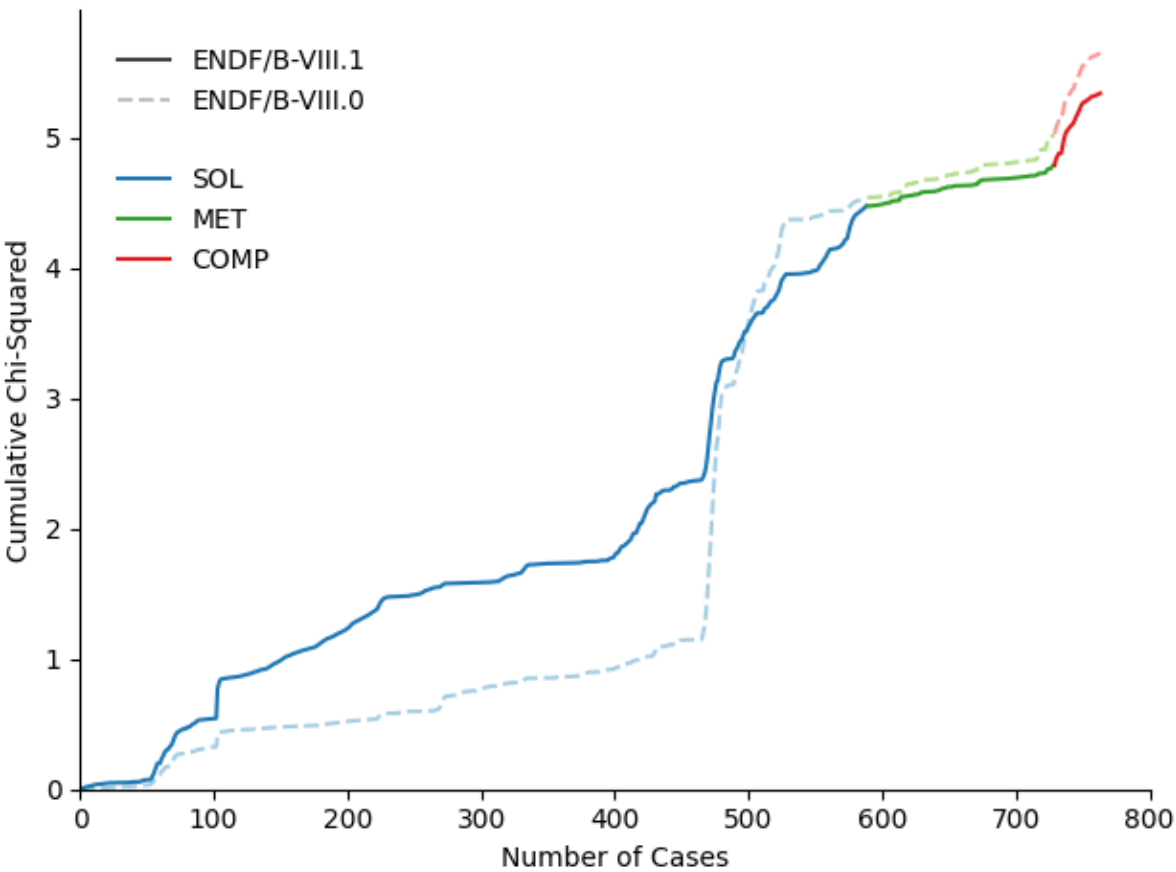
U-233 Benchmarks



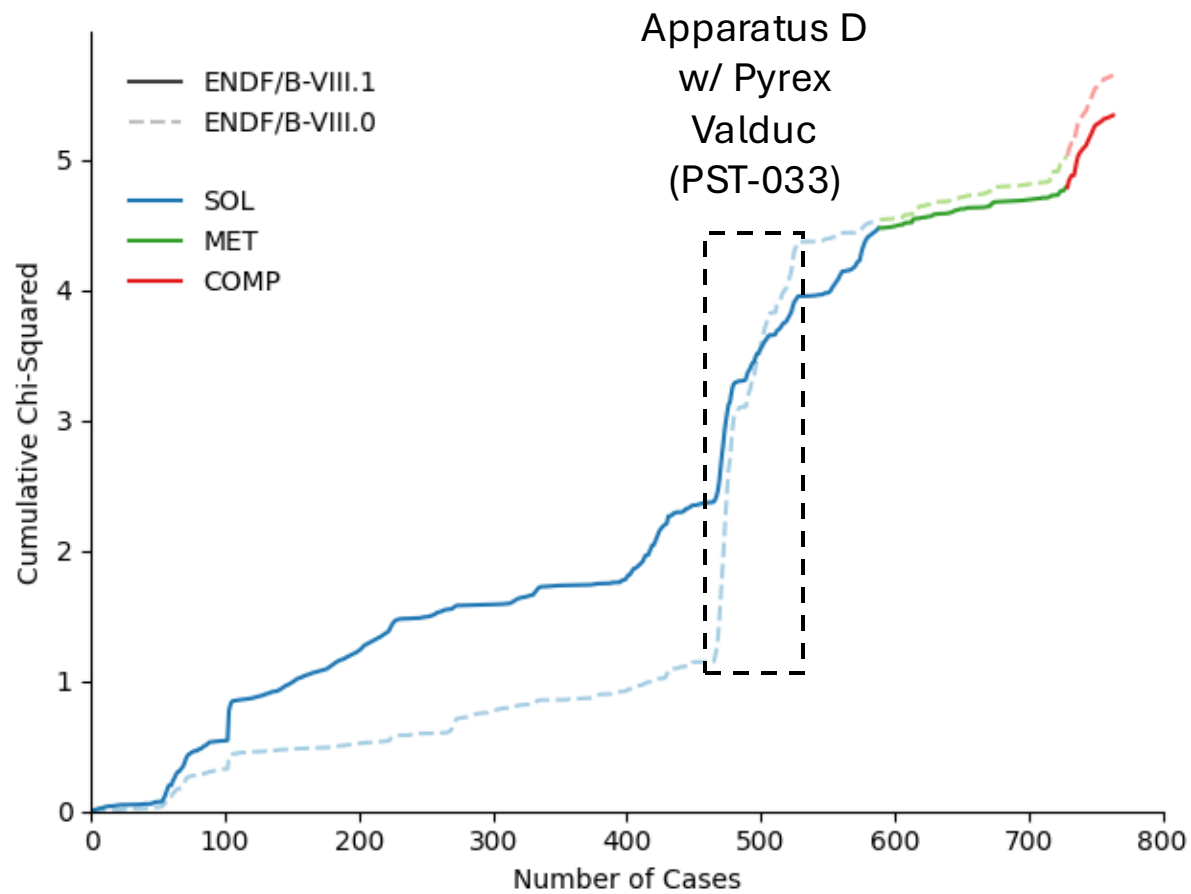
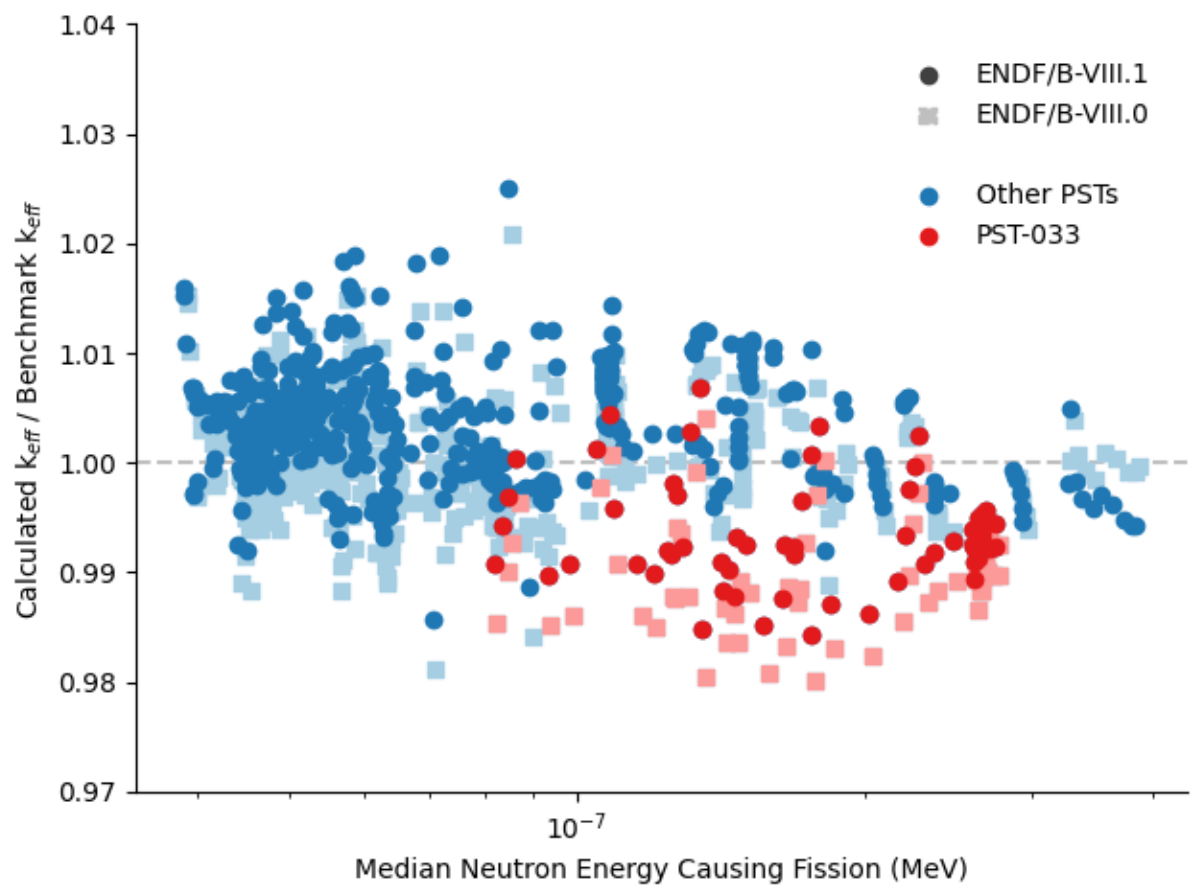
Plutonium Solution Benchmarks

- Similar overall performance between ENDF8.1 and ENDF8.0
 - Notably ENDF8.0 is mostly impacted by PST-033 (63 cases)
- Trends in χ^2 for ENDF8.1 match the previous ENDF7.1

Library	RMSE	Average k_{eff}
ENDF/B-VIII.0	0.0058	0.99922
ENDF/B-VIII.1	0.0069	1.00271



Plutonium Solution Benchmarks



Conclusion

- The COG Validation Suite includes 3420 ICSBEP benchmark cases useful for nuclear data validation
 - COG ingests a variety of nuclear data formats allowing it to test multiple nuclear data processing codes
 - Recent work has streamlined the execution of these many cases
- Overall, ENDF/B-VIII.1 performance is an improvement from ENDF/B-VIII.0 in both χ^2 and RMSE metrics
 - Average calculated k_{eff} for U-233 benchmark has increased by 550 pcm
 - Apparent regression in C/E results for UCT-001, only non-solution thermal cases
 - Plutonium solution benchmark performance follows similar trends to previous ENDF/B-VII.1

Future Work

- Continue to develop the execution pipeline for the suite
- Future improvements to the suite include:
 - Testing of additional nuclear data libraries (e.g., JEFF-4.0) and nuclear data processing codes
 - Additional responses including neutron flux, TSL and URR sensitivity
 - Work underway to implement nuclear data sensitivity in COG
- Explore making the data and results available to the community in an interactive form

Acknowledgements

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