Validation of ENDF/B-VIII.1β2 Files

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Background

- ENDF-6 formatted files were processed into A Compact ENDF (ACE) files using NJOY2016.71 (https://github.com/njoy/NJOY2016)

Validation Tests:

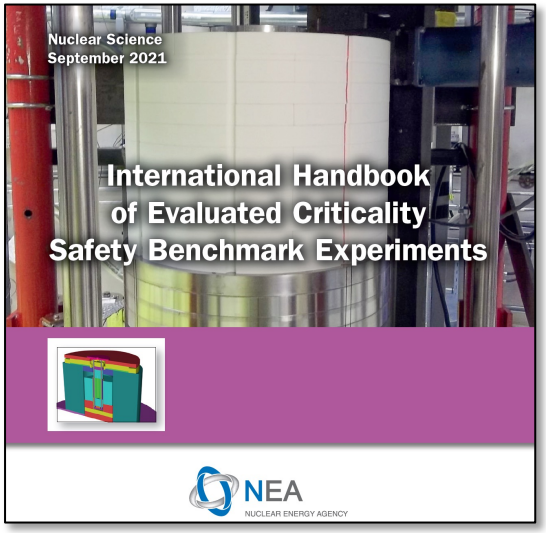
(1) Bethe Spheres
(2) LANL Legacy Benchmark Suite
(3) "Modern" Benchmark Suite
(4) HEU Benchmark Suite
(5) LEU Benchmark Suite
(6) Mixed (U+Pu) Benchmark Suite
(7) Pu Benchmark Suite
(8) ^{233}U Benchmark Suite

Validation Metrics:

Tritium Production

k_{eff}

↓



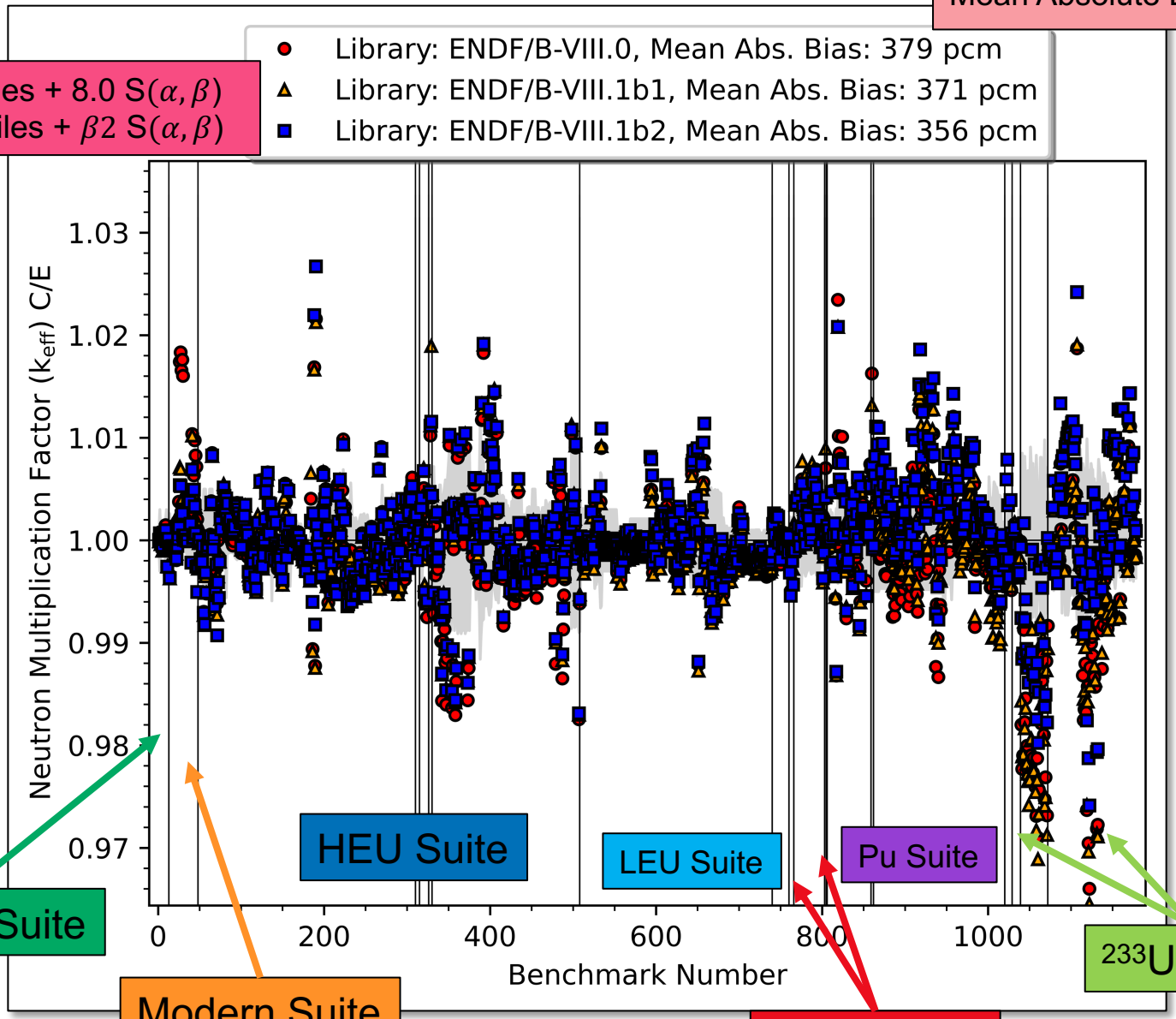
- Benchmark names from International Criticality Safety Benchmark Evaluation Project (ICSBEP) Handbook designations

OECD/NEA. International Handbook of Evaluated Criticality Safety Benchmark Experiments, NEA/NSC/DOC(95)03. Paris (France): OECD/NEA; 2021.

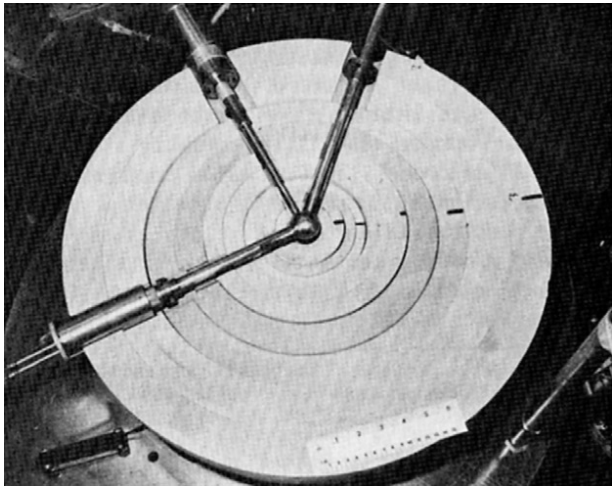
Everything, Everywhere, All at Once

Mean Absolute Bias = $\frac{\sum_i^N |C_i - E_i|}{N}$

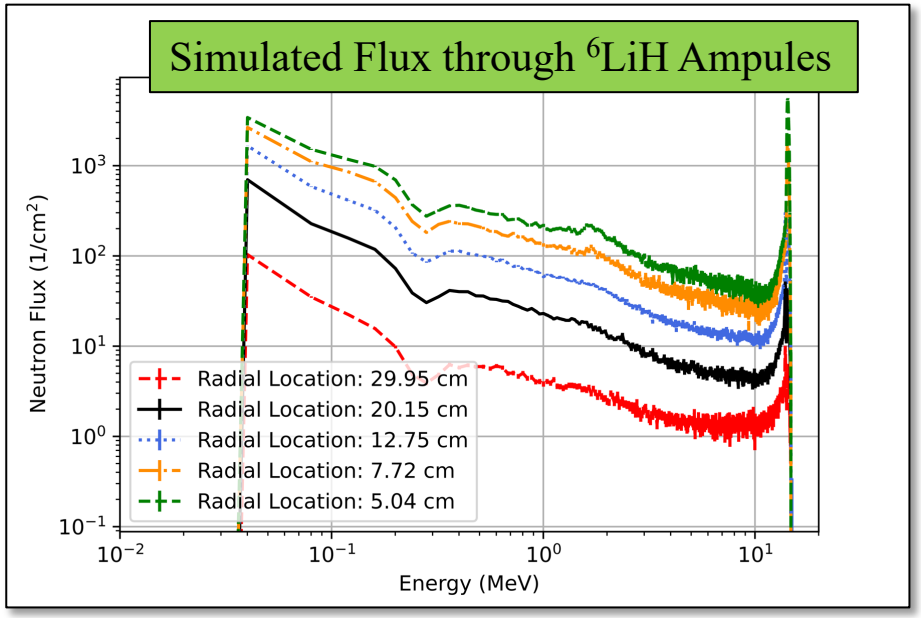
1b1→ $\beta 1$ Files + 8.0 S(α, β)
1b2 → $\beta 2$ Files + $\beta 2$ S(α, β)

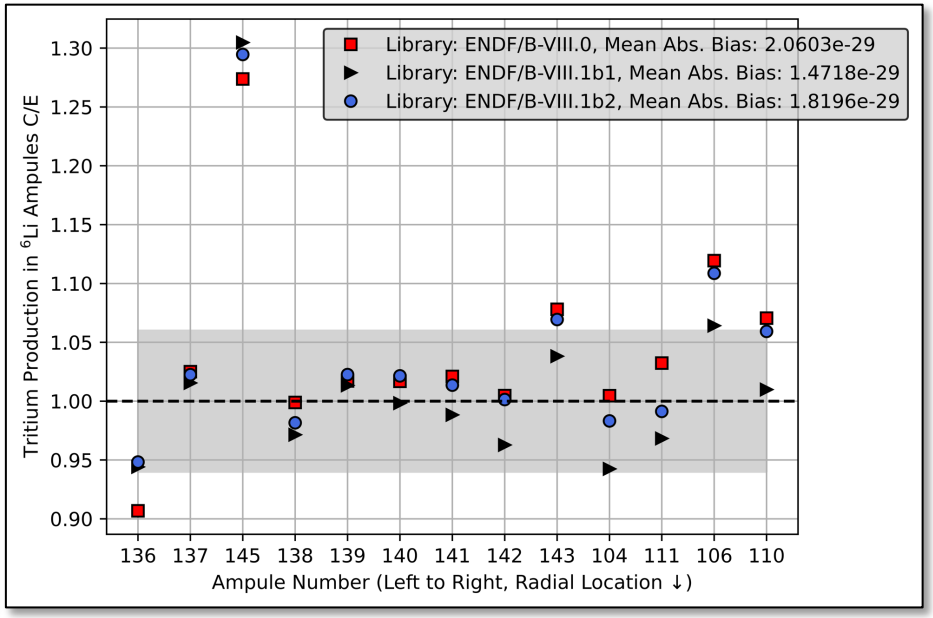


Bethe Sphere Testing



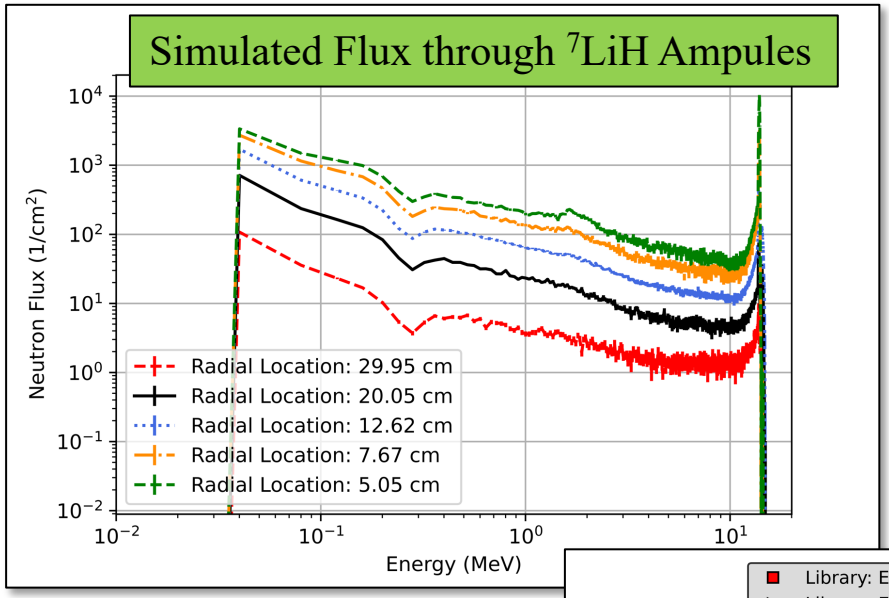
- Performed at the LANL Crockcoft-Walton accelerator in the 1970's
- 14 MeV neutron source using the d(t,n)α reaction in center of sphere of Oralloy surrounded by ^{6}LiD
- Small ampules of ^{6}LiH and ^{7}LiH located throughout spheres – tritium production measured
- New ^{6}Li evaluation → R-Matrix extension up to 8 MeV – $\beta 2$ ^{6}Li file has angular distribution fix

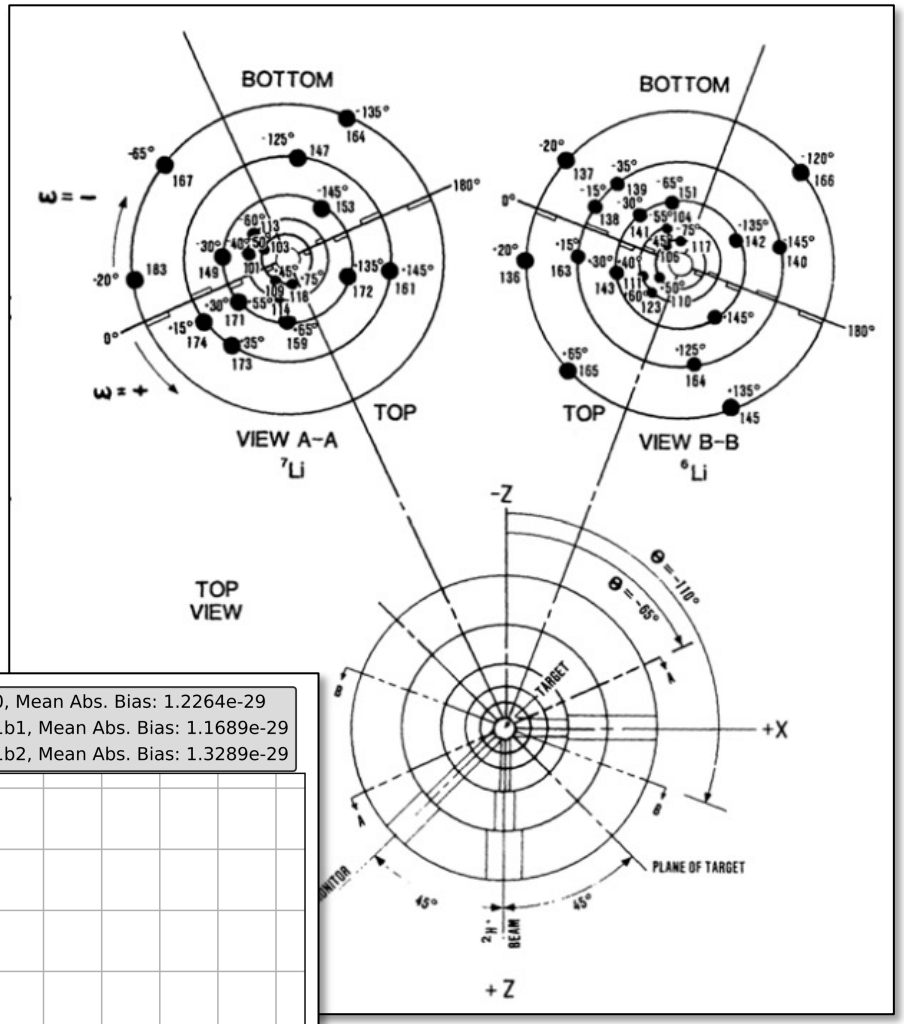


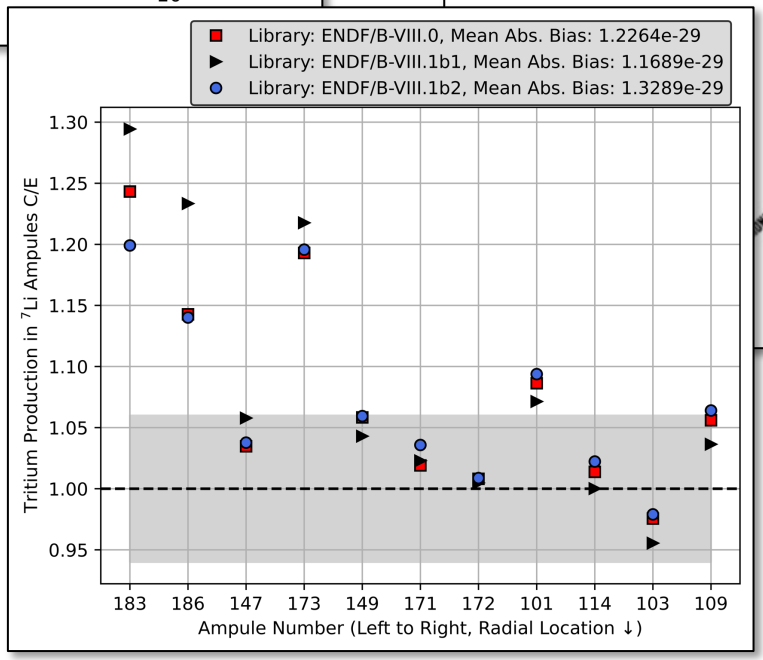


S. C. Frankle, "Tritium Production in ^{6}Li and ^{7}Li at 14-MeV in a Sphere of ^{6}LiD," LANL memorandum, X-5:SCF-04-035 (June 8, 2004).

Bethe Sphere Testing







- No change in ^{7}Li evaluation file since ENDF/B-VII
- Changes in ^{7}LiH ampule tritium production in plot are from high energy cross section changes in ^{235,238}U, ^{6}Li

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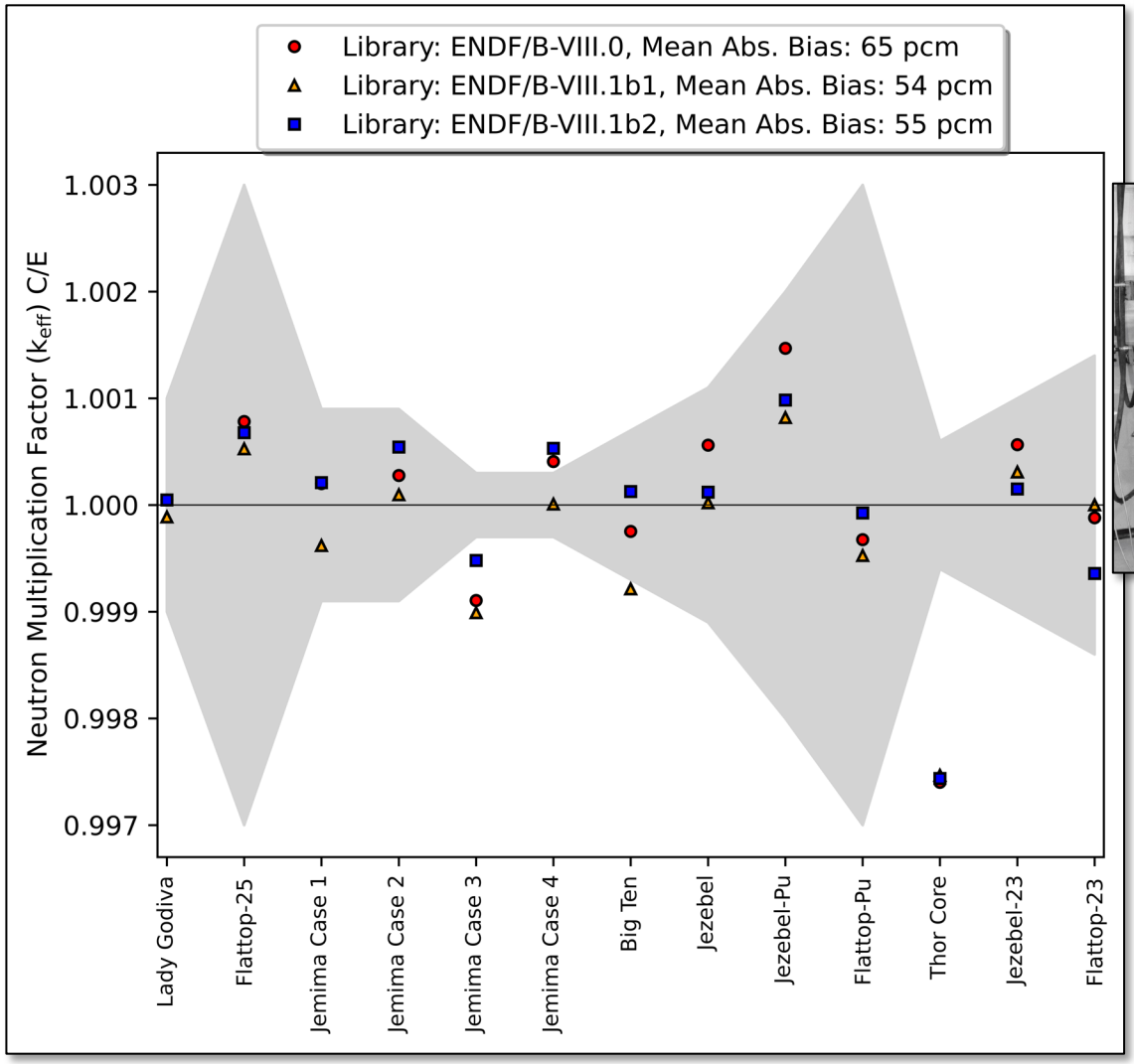
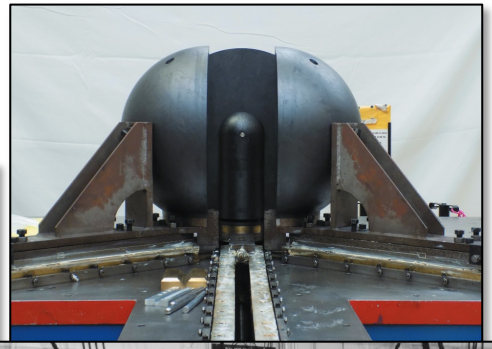
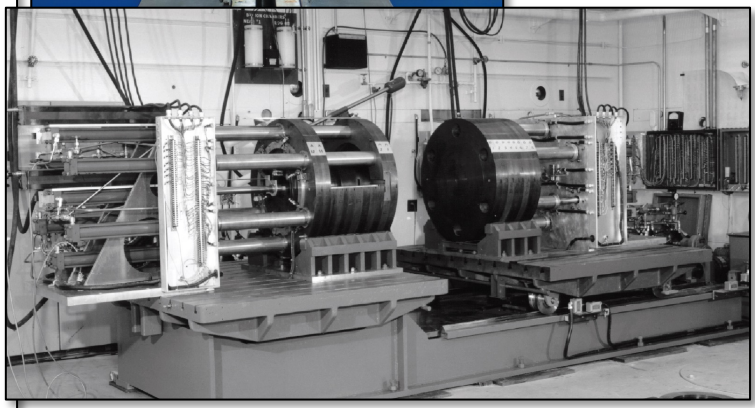
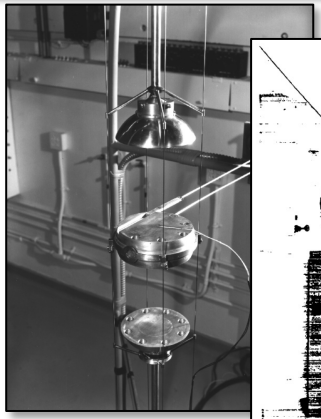
S. C. Frankle, "Tritium Production in ^{6}Li and ^{7}Li at 14-MeV in a Sphere of ^{6}LiD," LANL memorandum, X-5:SCF-04-035 (June 8, 2004).

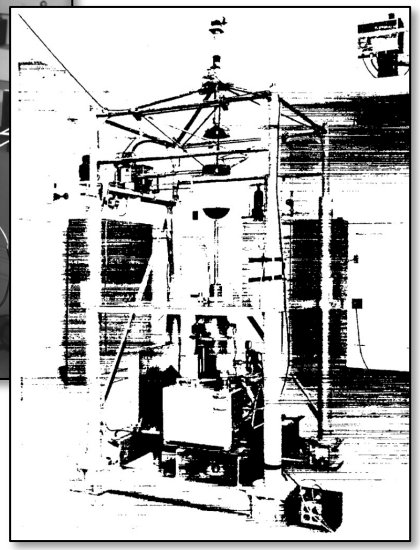
Legacy Benchmark Suite











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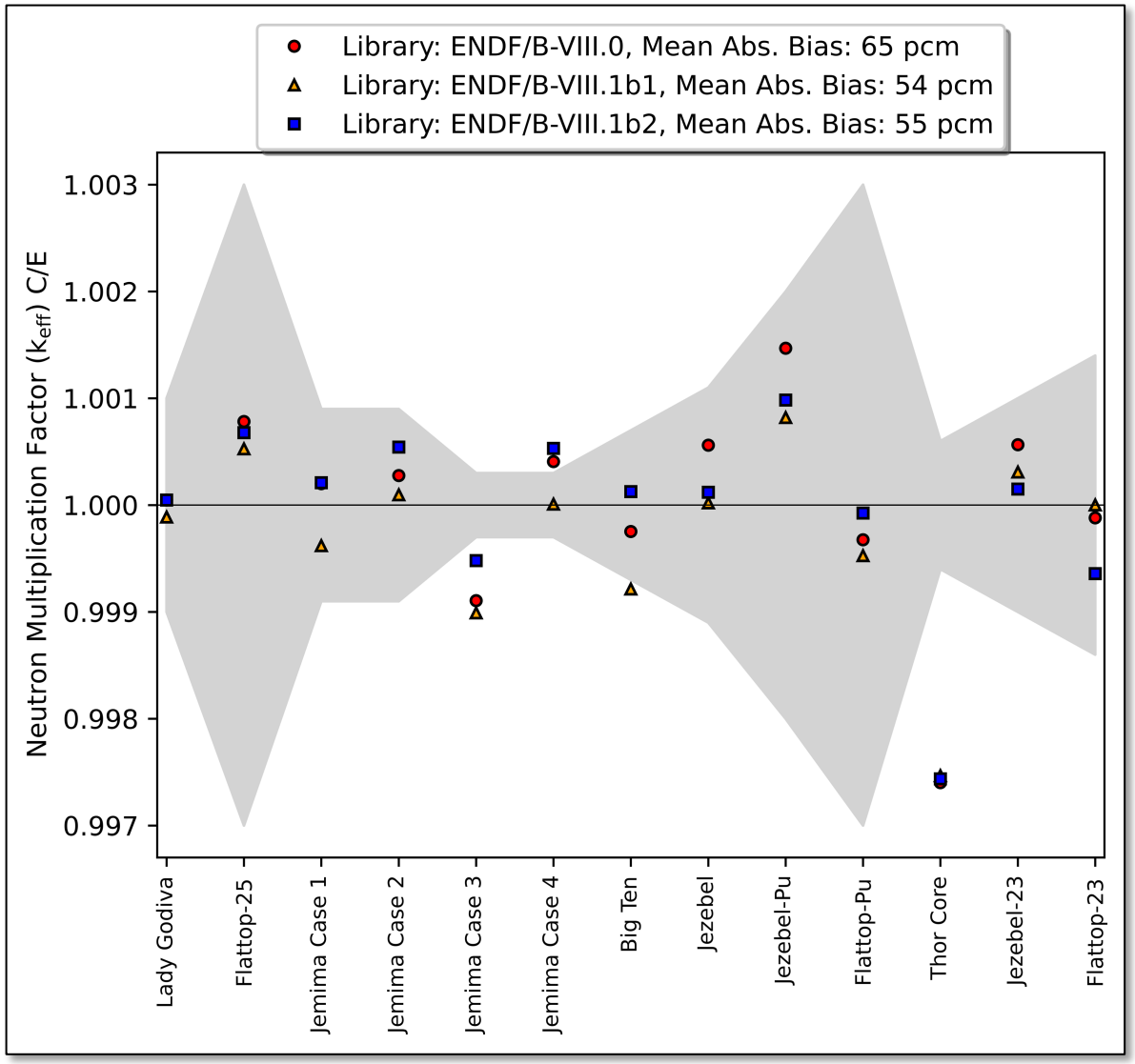
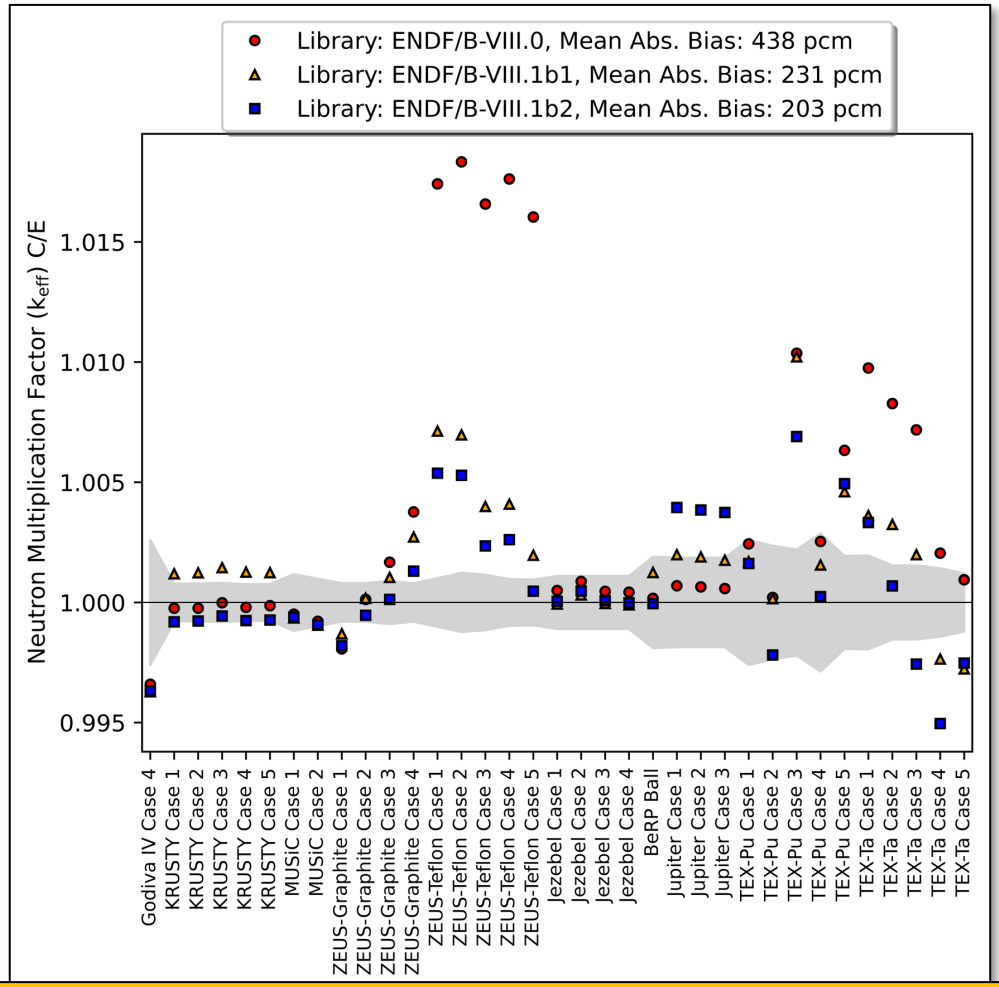
"National Criticality Experiments Research Center (NCERC): The First 10 Years of Operation," *Nuclear Science and Engineering* **195** Supplement 1 (2021)

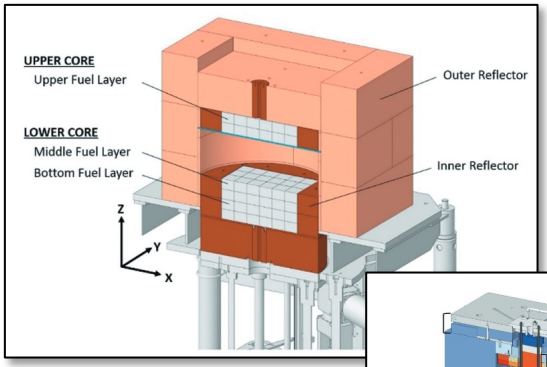
Legacy Benchmark Suite

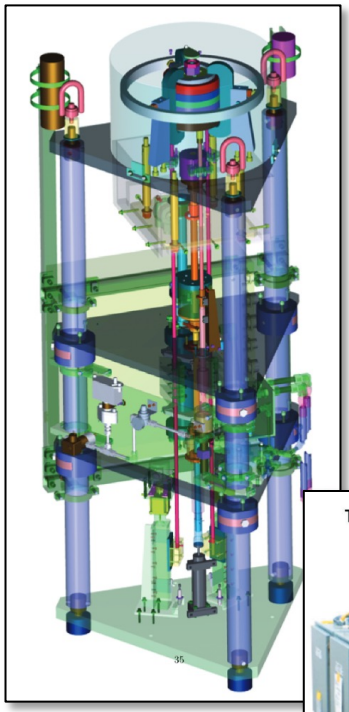


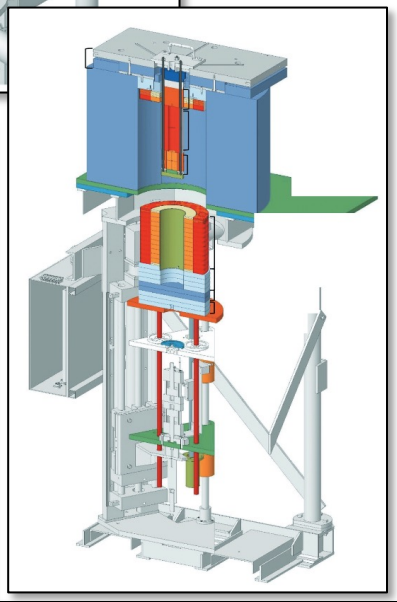
- This suite provides an overview of accuracy for fast/intermediate cross sections of ^{235,238}U, ^{239}Pu as well as ^{233}U and ^{232}Th
- Not much difference between $\beta 1$ and $\beta 2$ overall
- Good agreement between simulated and experimental criticality for HEU/Pu "bare" systems (i.e., Lady Godiva and Jezebel)
- Flattop-23 bias not necessarily bad… ^{233}U and ^{238}U changes are shown to improve prediction capability

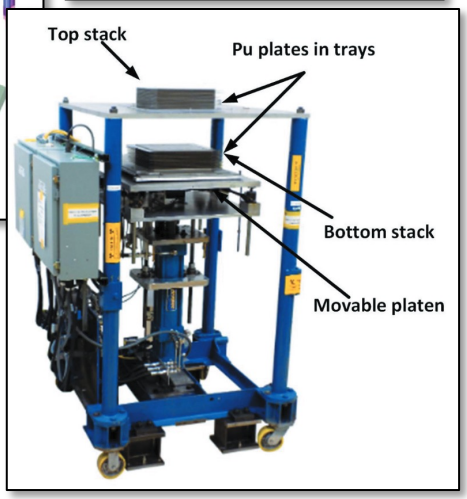
Modern Benchmark Suite







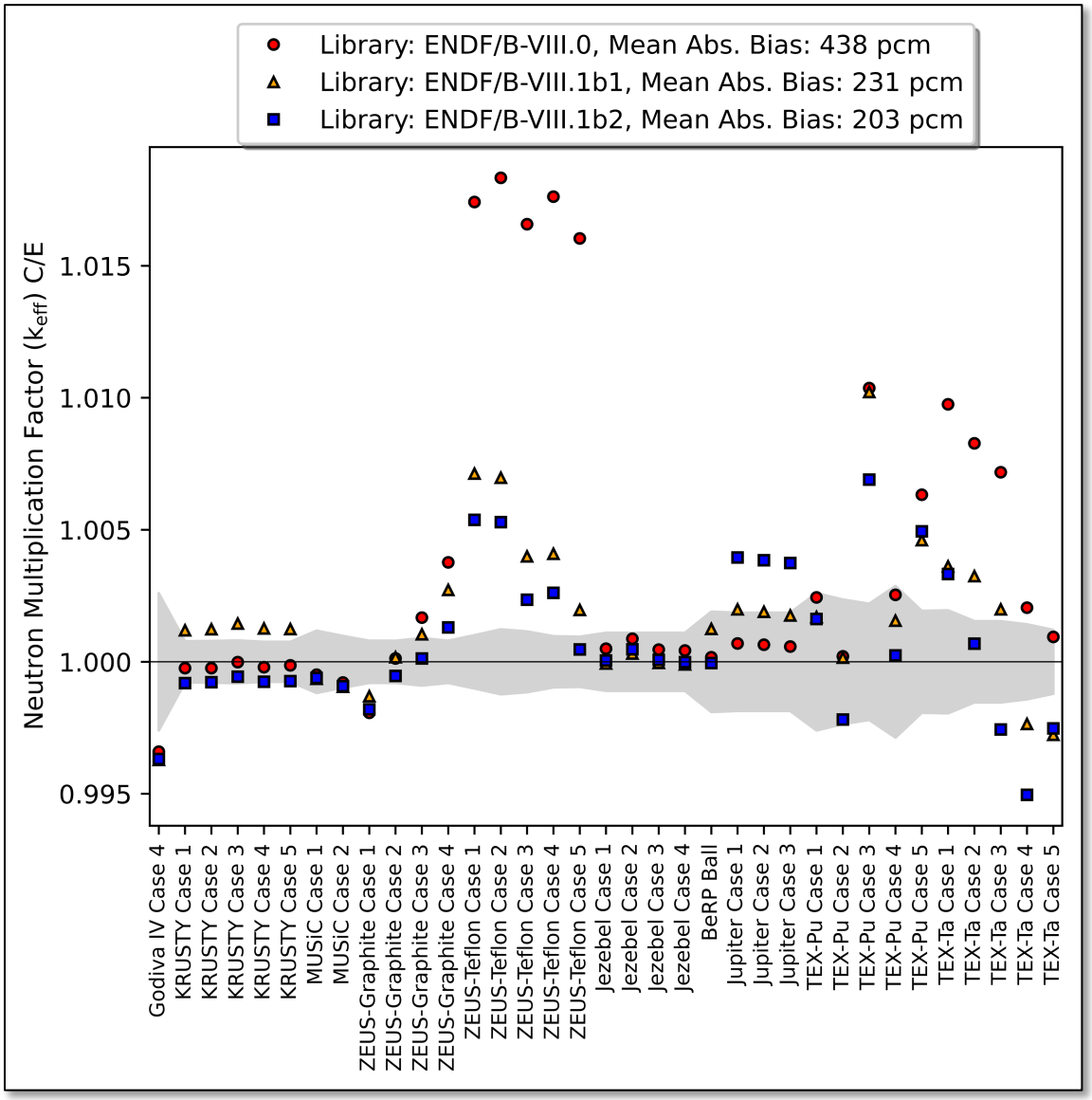




Kilowatt Reactor Using Stirling Technology (KRUSTY)
Thermal/Epithermal eXperiments (TEX)
Measurment of Uranium Subrcitical and Critical (MUSiC)
ZEUS-Teflon, Critical Unresolved Region Integral Experiment (CURIE)

"National Criticality Experiments Research Center (NCERC): The First 10 Years of Operation," *Nuclear Science and Engineering* **195** Supplement 1 (2021)

Modern Benchmark Suite



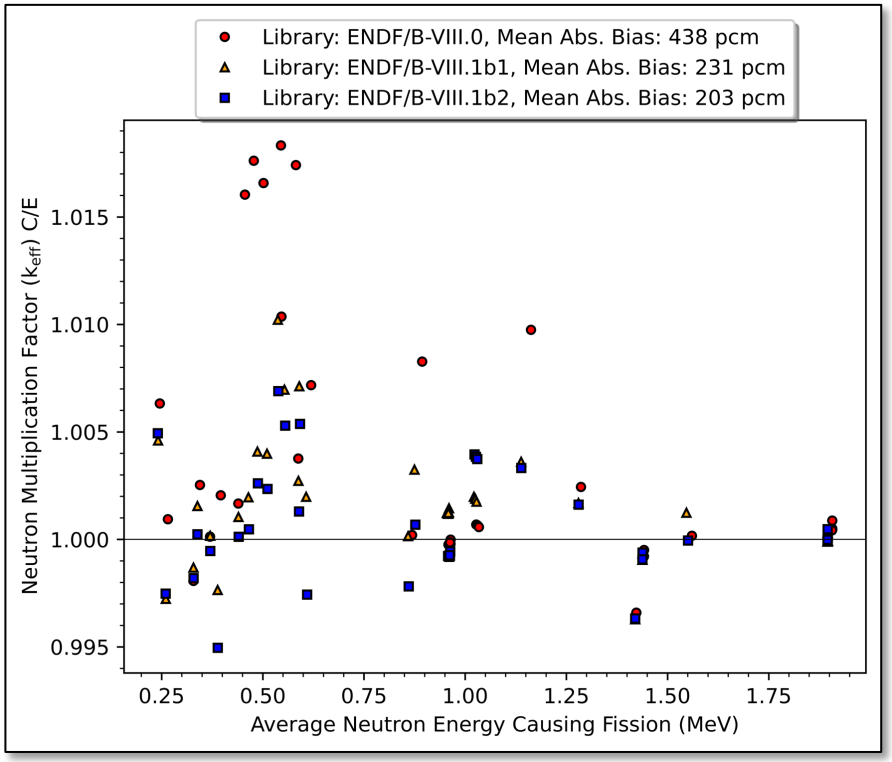
- *NEW* well-characterized Experiments
- This suite provides an overview of accuracy for modern thermal/intermediate/fast cross sections of fuel/moderator/reflector materials
- Significant reduction in bias using ENDF/B-VIII.1 b/c of multiple evaluation updates:

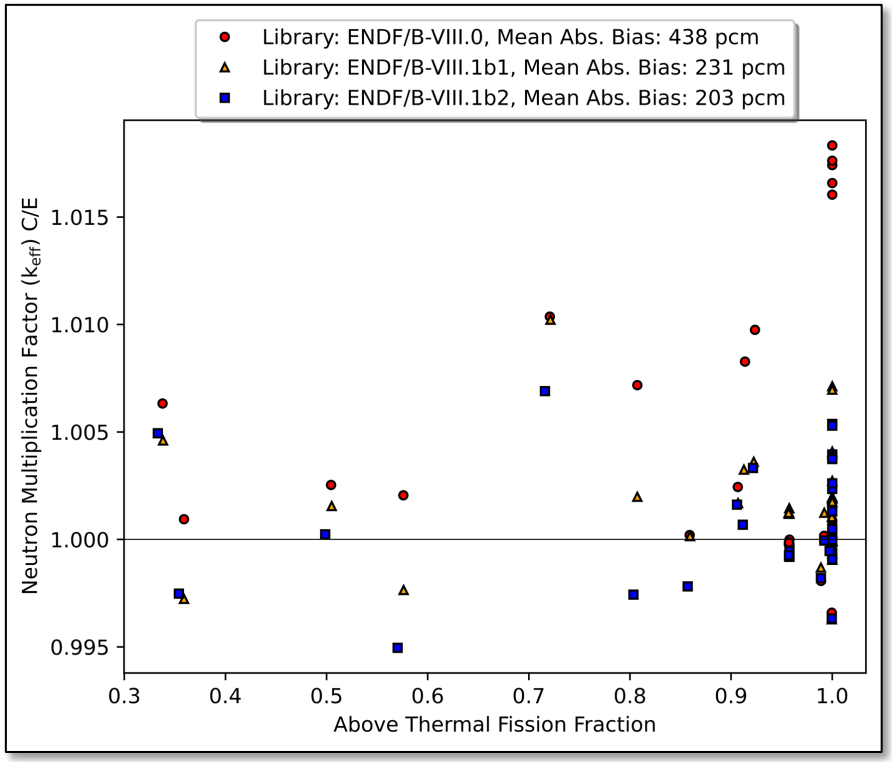
1. ^{239}Pu (Jezebel, TEX)
2. ^{181}Ta in fast energy region (TEX-Ta)
3. ^{19}F (Teflon C_2F_4) (ZEUS-Teflon, CURIE)

- Future file investigations:

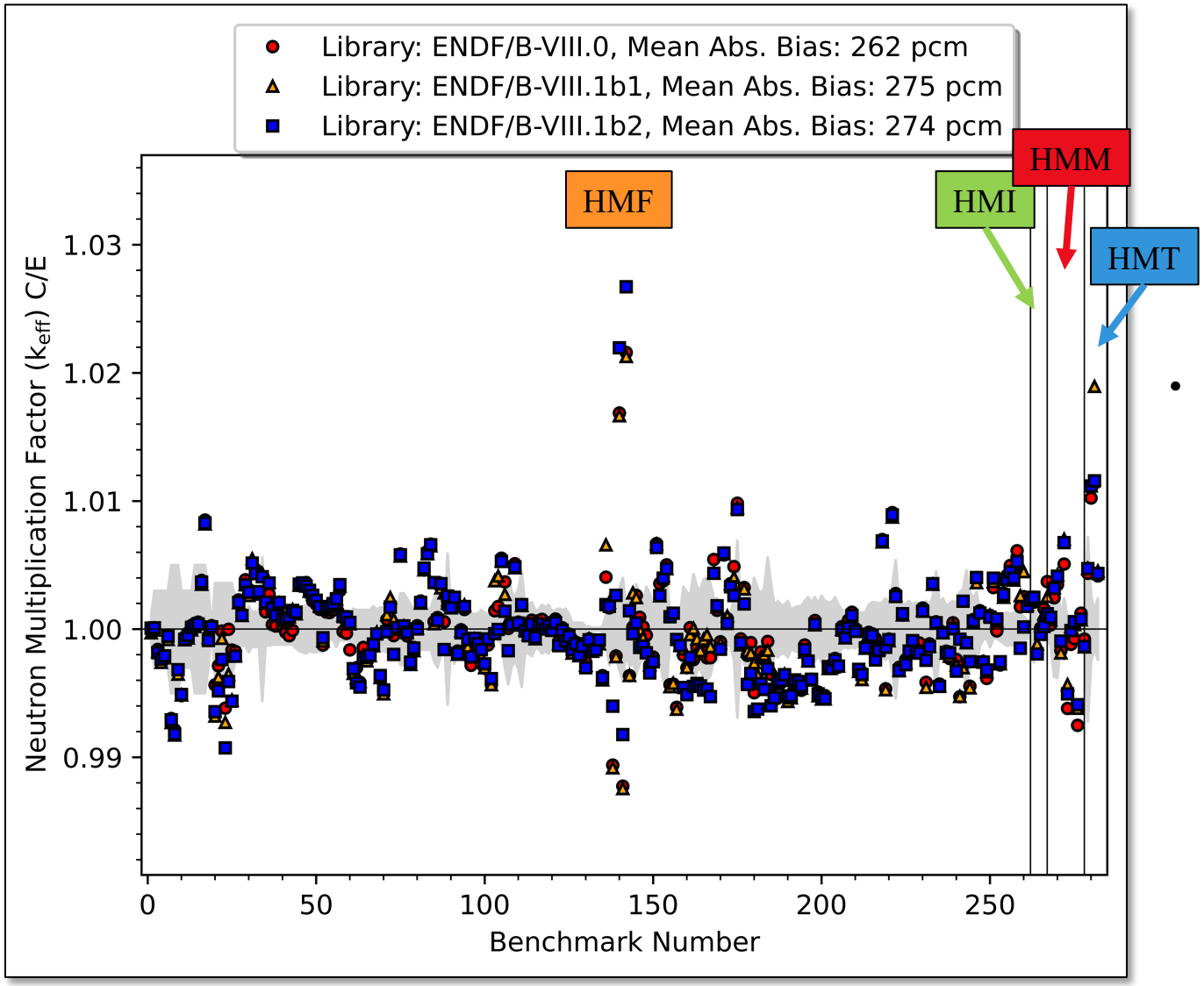
1. ^{9}Be (KRUSTY, BeRP Ball)
2. Pb (Jupiter)
3. Ta in thermal energy region/h-poly TSL File/S(α, β) (TEX-Ta)

Modern Benchmark Suite



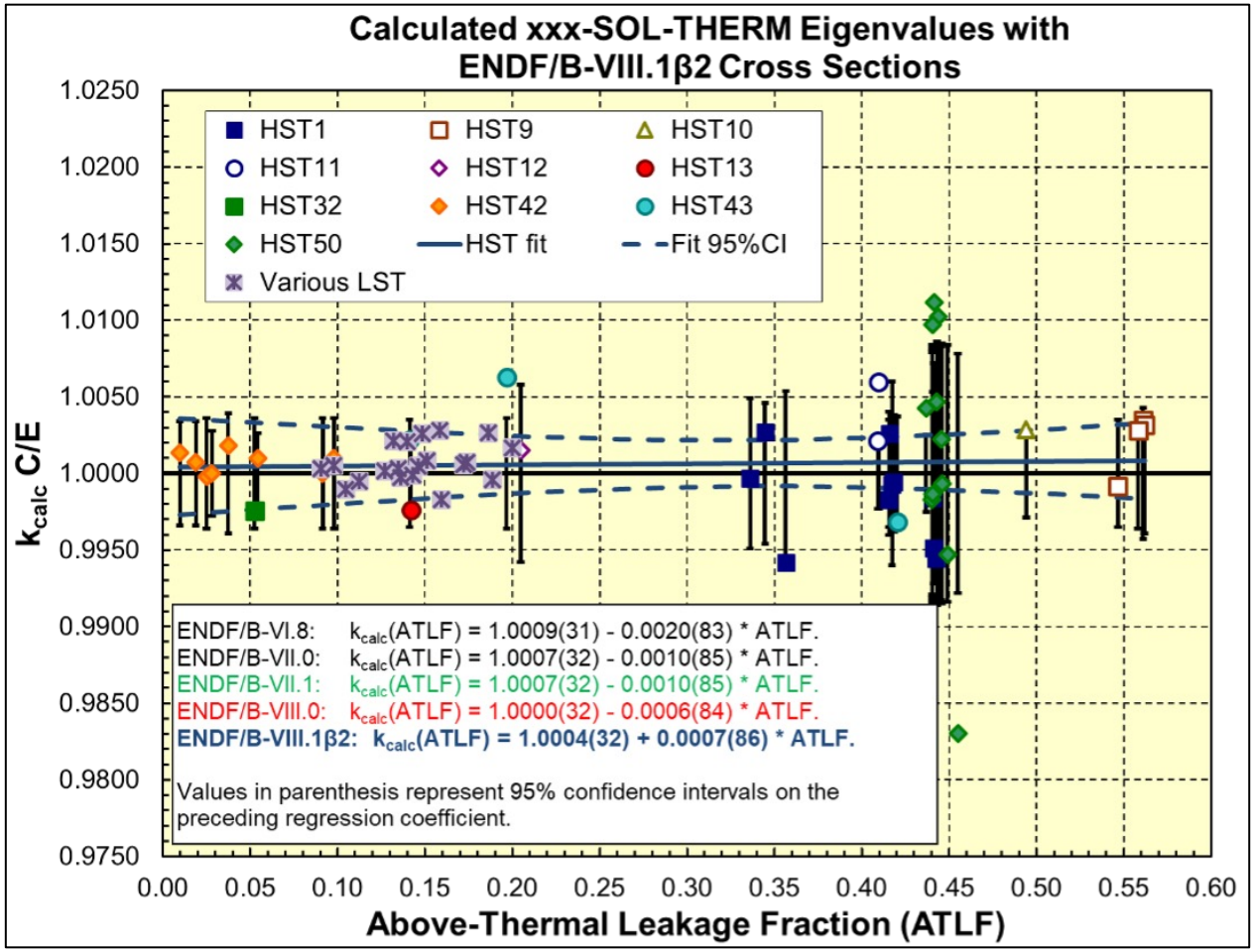


HEU Benchmark Suite



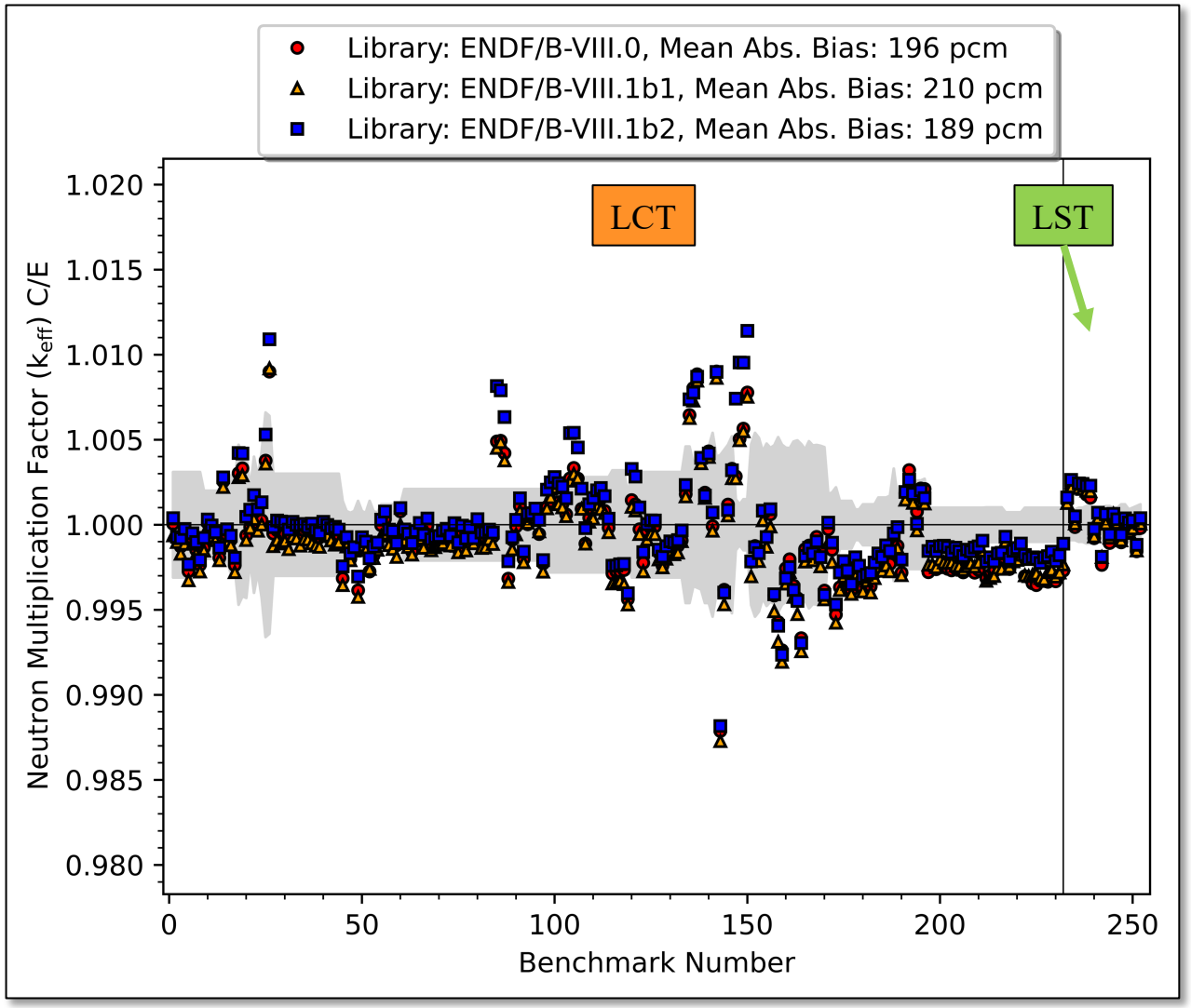
- Changes in $^{235,238}U$ don't produce significant changes in HEU metal benchmarks simulated results

HEU Benchmark Suite



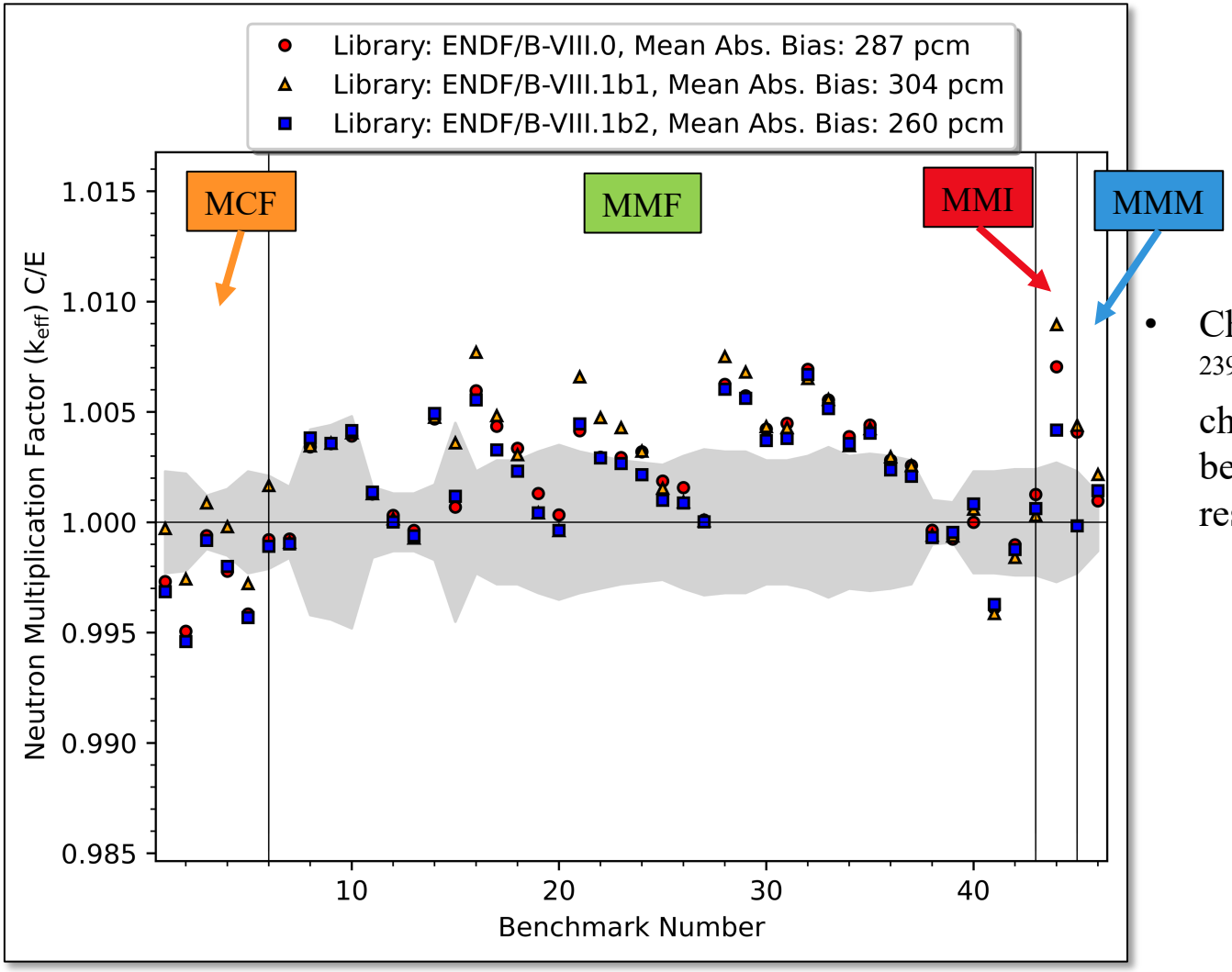
- Correlation of k_{eff} as a function of ATLF for a select suite of thermal benchmarks has provided a test of thermal ^{235}U nuclear data for decades
- LST benchmarks are <u>not</u> included in regression fit – used to support conclusion of no bias in C/E as a function of enrichment
- $\beta 2$ intercept higher than E8.0 and positive slope, but results remain consistent between E8.0 and $\beta 2$

LEU Benchmark Suite



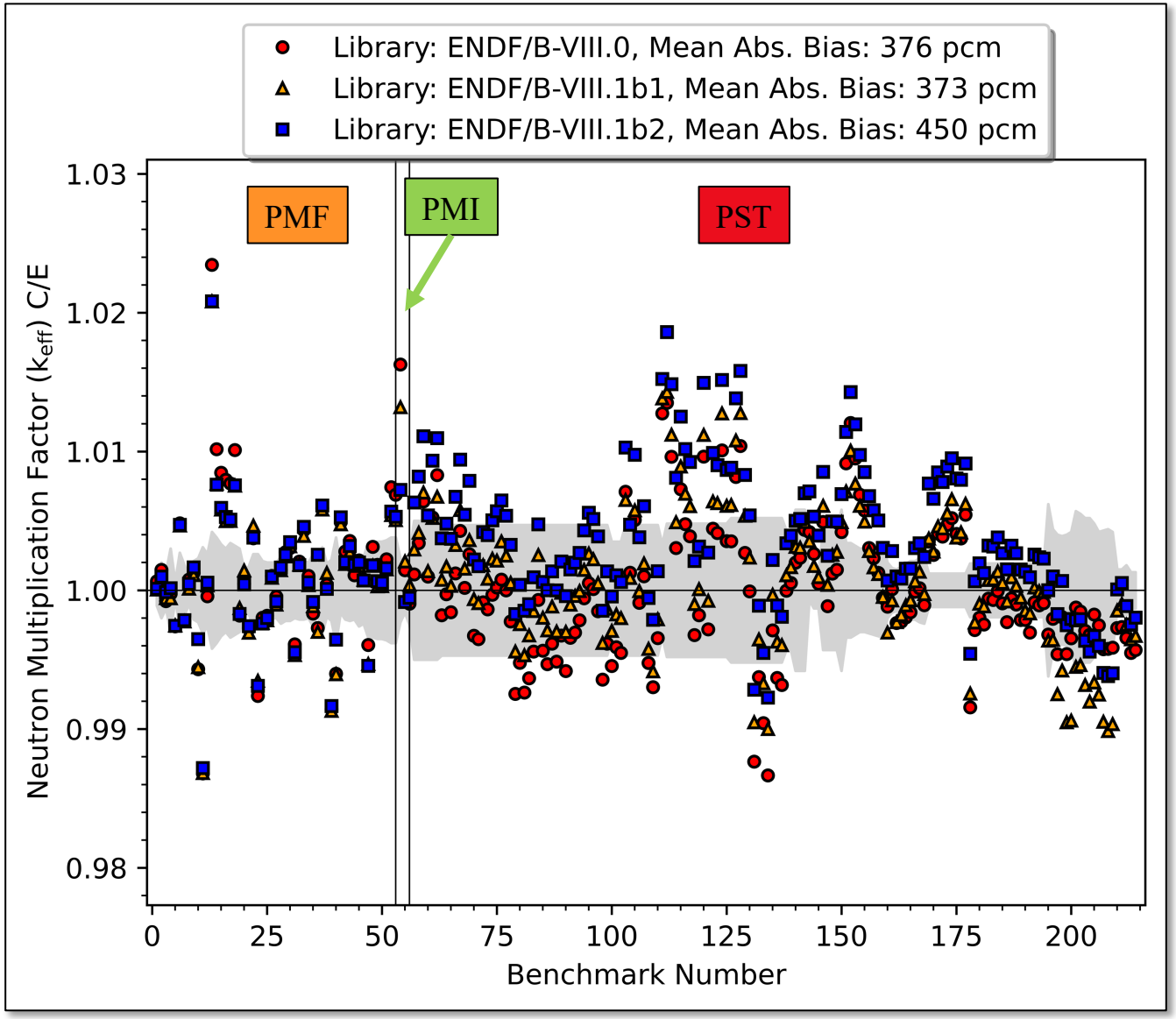
- Changes in $^{235,238}U$ don't produce significant changes in LEU benchmarks simulated results – there is a slight increase in reactivity
- Reactor lattice category ("LCT", LEU-COMP-THERM) shows excellent overall performance

Mixed (U+Pu) Benchmark Suite



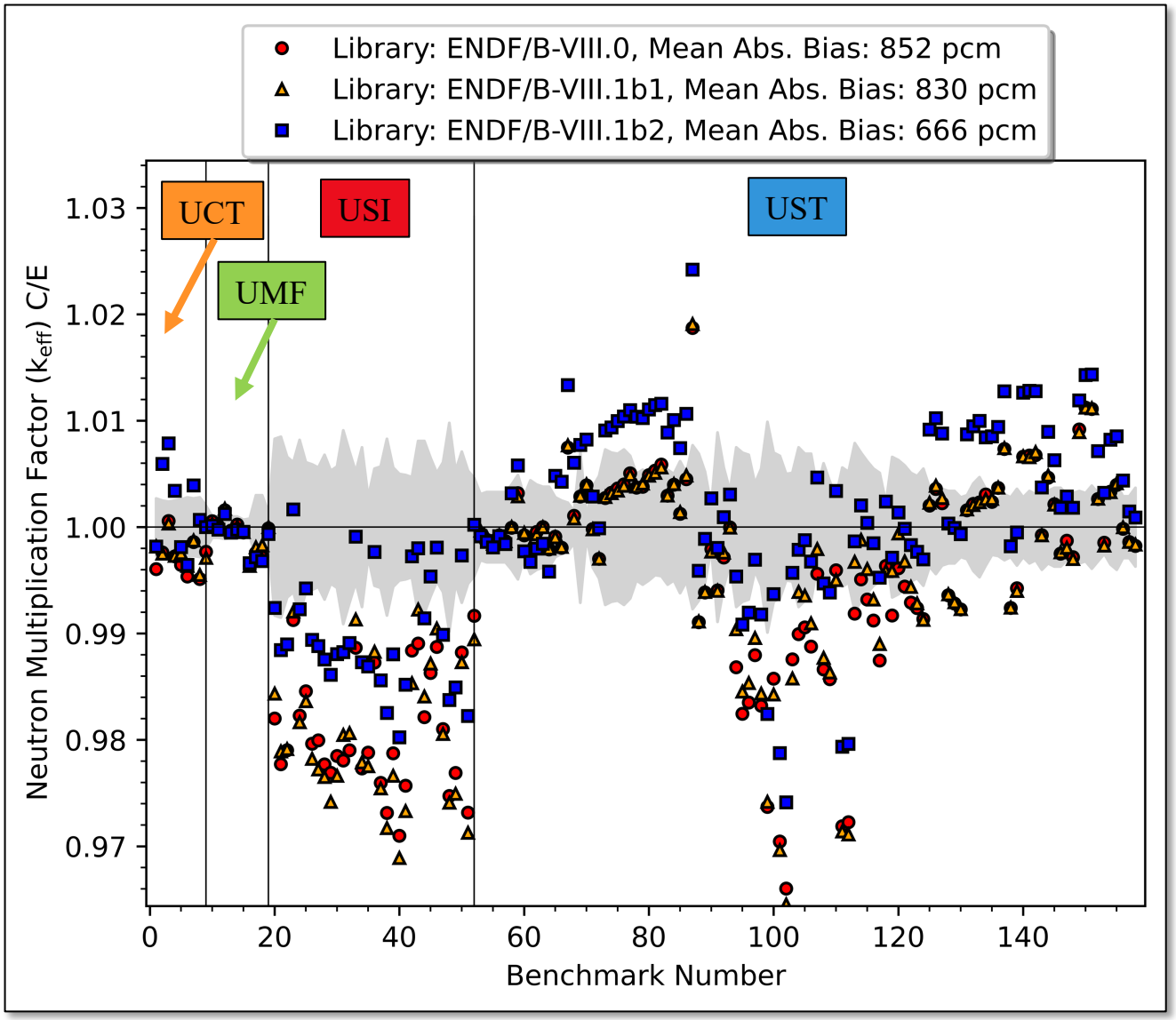
- Changes in ^{235,238}U and ^{239}Pu produce favorable changes in mixed U+Pu benchmarks simulated results

Pu Benchmark Suite



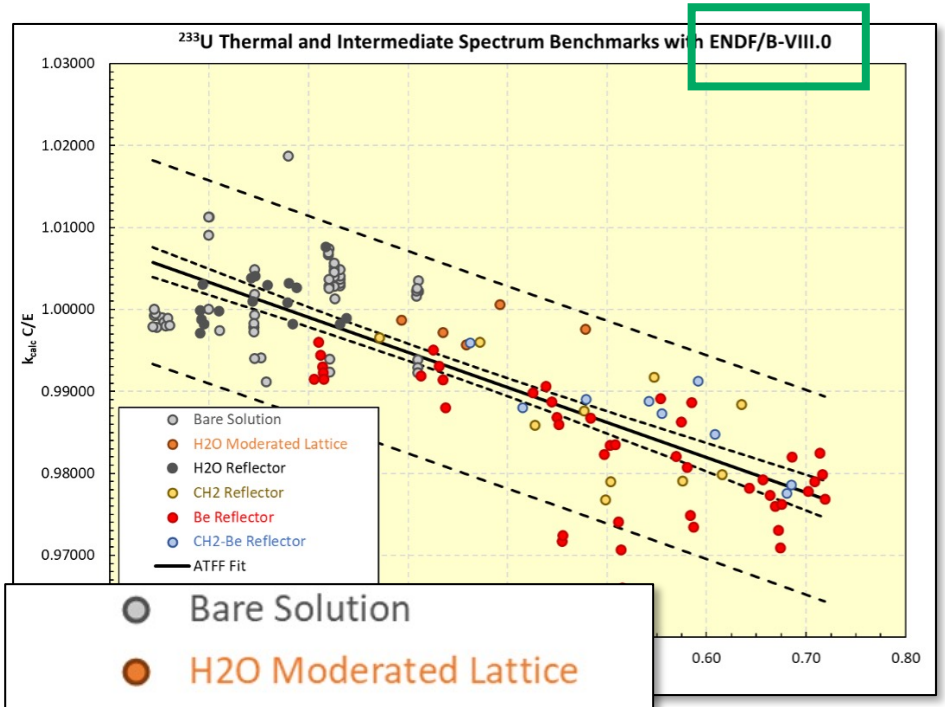
- Changes in plutonium metal intermediate/fast (PMI/F) systems are favorable due to ^{239}Pu file update
- PST benchmark simulated results are slightly concerning – E8.0 "success story" of reducing PST bias
- $\beta 2$ PST bias difference on order of hundreds of pcm
- PST benchmarks with Gd (PST-34) behave differently
- Discussion: should we compromise PST performance for better performance in depletion metrics, temperature coefficients, etc.?

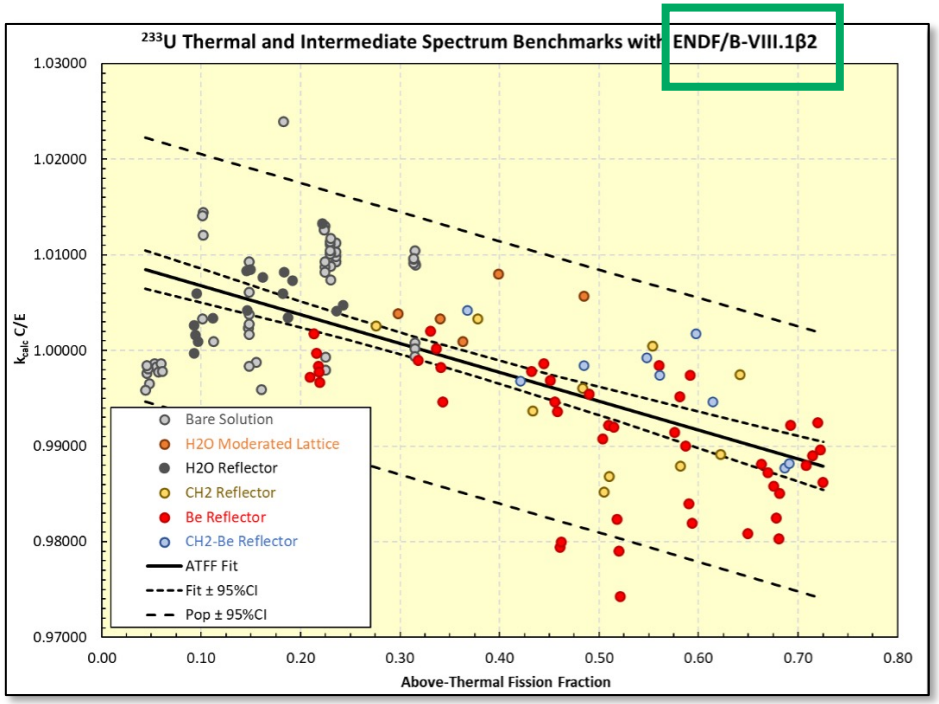
^{233}U Benchmark Suite

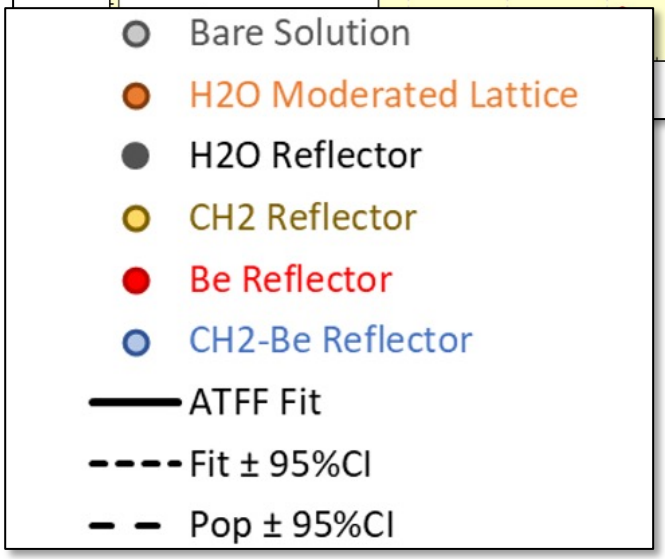


- Overall, there is a significant reduction in mean absolute bias for ^{233}U benchmarks simulated results from changes in the ^{233}U file; however, C/E values are still very far from unity…

^{233}U Benchmark Suite







- Eigenvalue calculations for thermal and intermediate energy benchmarks have exhibited a strong, negative trend with increasing energy for decades – results for $\beta 2$ follow this trend
- Higher energy: the Be and combined Be-CH_2 reflected systems are now calculated about 1000 pcm higher – good result although average results are still low
- Lower energy (i.e., ATFF from ~0.1 to 0.3): the near unity E8.0 results are now (w/ $\beta 2$) too large, with an apparent positive trend in calculated eigenvalue – LWBR lattice results are also worse than those obtained with E8.0

Acknowledgments

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Questions?

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