Validation Testing at LANL with Several Nuclear Data Libraries

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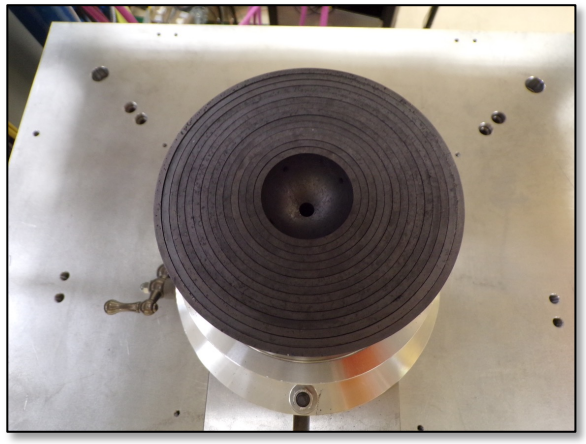
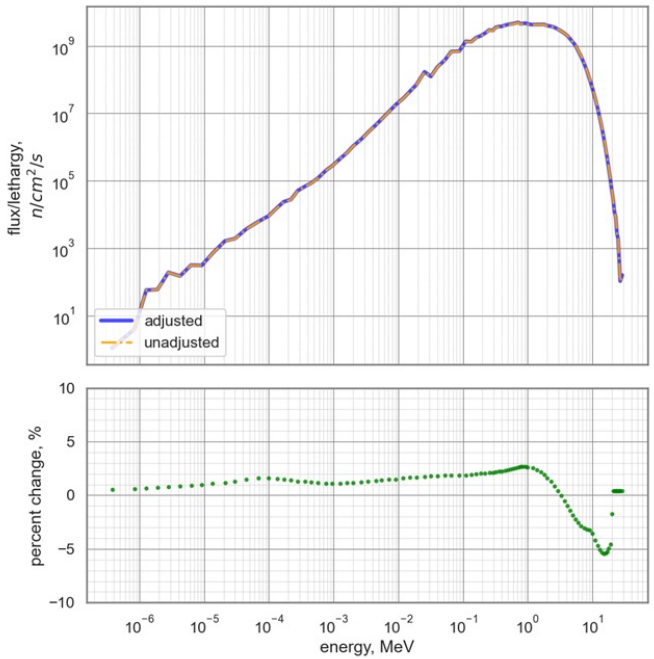
Recent Experiments! → HEU

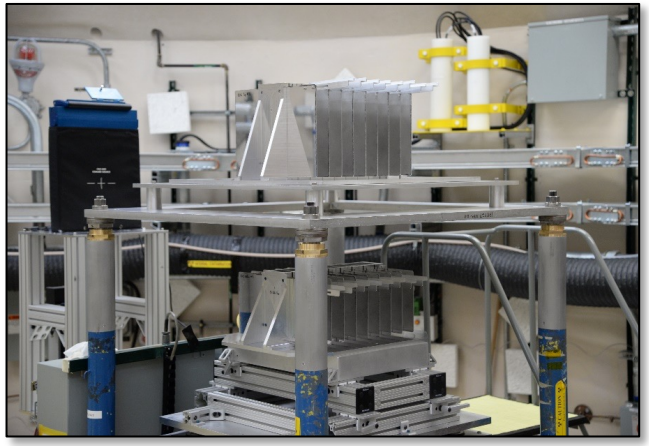
- MUSiC (HEU-MET-FAST-104)
  - Measurement of Uranium Subcritical and Critical
  - NCERC Experiment: Dec 2020 – Mar 2021
  - 2 critical configurations (accepted), 7 subcritical configurations (submission to ICSBEP in progress)
- PFUNS
  - Prompt Fission Uranium Neutron Spectrum
  - NCERC Experiment: Feb 2024 – Mar 2024
  - Four configurations (submission to ICSBEP in progress)
  - Designed to help constrain PFNS at high energies using many foils with threshold energies
- Both MUSiC and PFUNS used Rocky Flats HEU hemi-shells – bare sphere configuration very similar to Lady Godiva (HEU-MET-FAST-001)
- No recent effort to update HMF-1 benchmark… MUSiC and PFUNS should be used for ^{235}U validation efforts

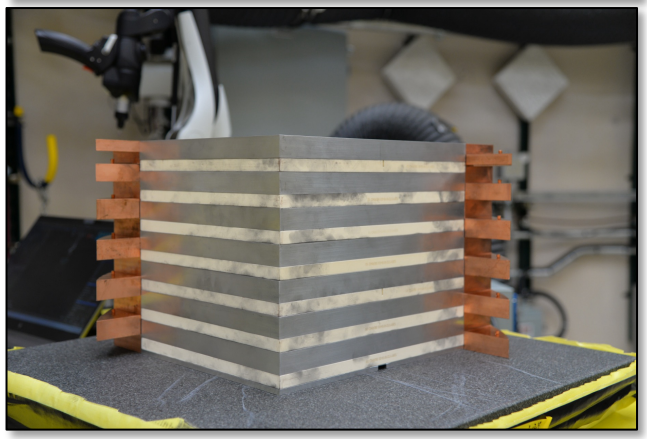




Recent Experiments! → Pu

- EUCLID
  - Experiments Underpinned by Computational Learning for Improvements in nuclear Data
  - NCERC Experiment: Dec 2022 – Jan 2023
  - Designed to reduce ^{239}Pu compensating errors
  - Cube and slab configurations have very different scattering properties and critical masses
  - Utilized critical (reactivity), reaction rate ratios, reactivity coefficients, Rossi-α, neutron leakage spectra, and subcritical experiments
- PARADIGM
  - PARallel Approach of Differential and InteGral Measurements
  - NCERC Experiment: Mar 2025 – Apr 2025
  - Designed to reduce ^{239}Pu intermediate-energy region (1 keV – 600 keV) uncertainties
  - Included LANSCE differential experiment – Other CSEWG talks on PARADIGM will contain more information

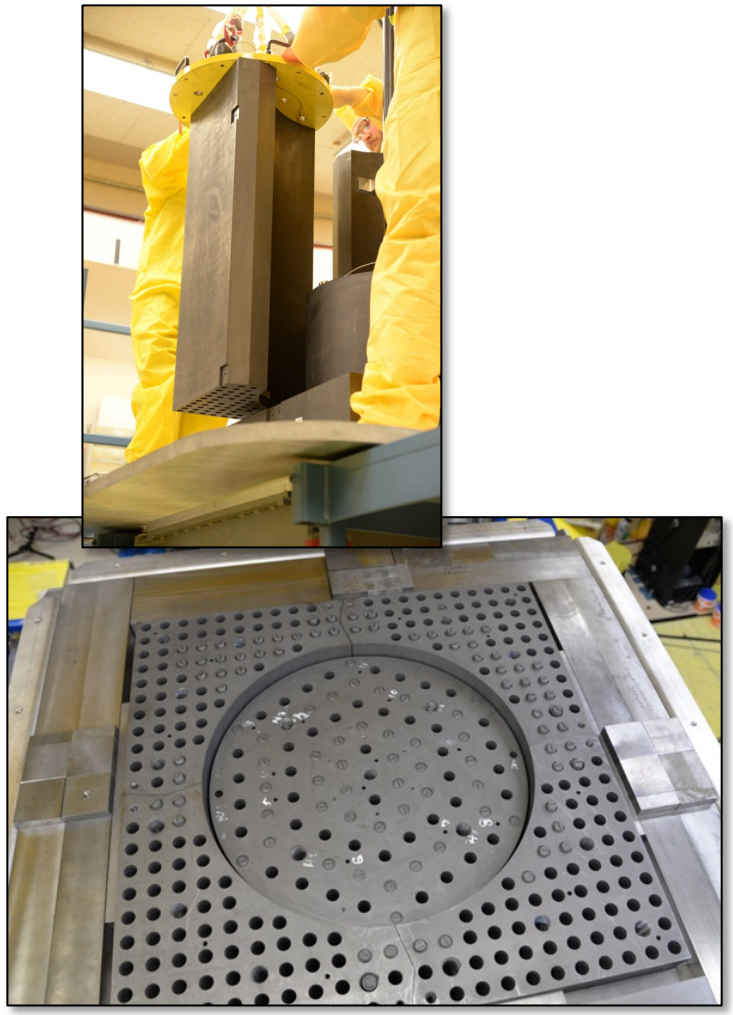




Recent Experiments! → TRISO

TRISO: TRi-structural ISOtropic

- Deimos/THETA
  - Deimos (Mar's Moon) is an experimental program designed to be an advanced reactor testbed
  - Deimos consisted of HALEU TRISO fuel embedded in a graphite moderator with a beryllium radial reflector (2024)
  - THETA (TRISO-form HALEU-fueled Experiment for Transport Applications) is the first use of the testbed in coordination with Kairos Power LLC including new configurations with polyethylene, borated polyethylene, and steel
  - Deimos and THETA are both planned to be included in the ICSBEP (planned 2026, 2027)

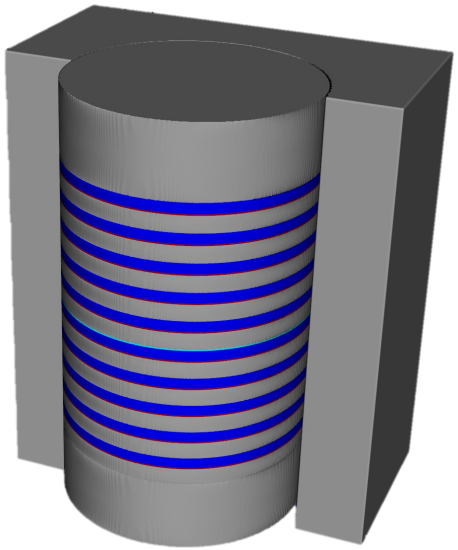


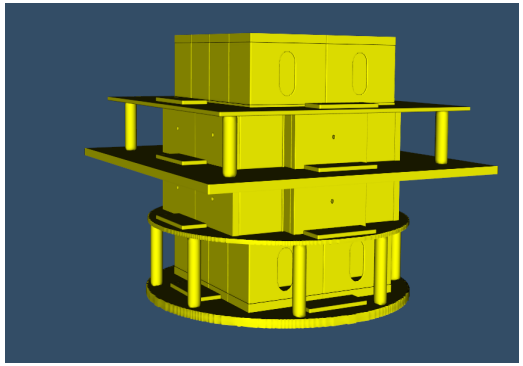
COMET

Future Experiments* (Next 5 Years)

*Not a full list

- Flattop-Pu
- Thales (Fast Pu with Ta)
- MOBY DICK (Mo with HEU)
- ZTA (Zirconium Test Assembly – Full spectra HEU + Zr)
- TEX (Li, Low Temperature, MOX)
- Hanford (Steel and Pu absorption)
- CERBERUS II (Intermediate Cu)
- Many experiments using the Deimos platform
- Other DOE/NRC Collaboration for Criticality Safety Support for Commercial-Scale HALEU Fuel Cycles and Transportation (DNCSH) experiments

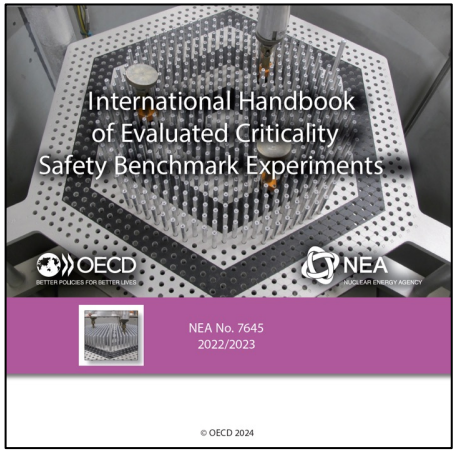




Back to Validation Testing... Computational Setup

- ENDF/B-VIII.0 and ENDF/B-VIII.1 processed ACE files found on LANL Nuclear Data Team Website (https://nucleardata.lanl.gov/)
- JEFF-4.0 processed ACE files downloaded from NEA Data Bank GitLab Platform (https://databank.io.oecd-nea.org/data/jeff/40/#neutron-induced-cross-sections-evaluations)
- IAEA ^{239}Pu file from Roberto Capote processed into ACE file using NJOY2016 (https://github.com/njoy/NJOY2016) – "IAEA-Pu9 library" consists of ENDF/B-VIII.1 files and IAEA ^{239}Pu file
- Benchmark names are taken from the International Criticality Safety Benchmark Evaluation Project (ICSBEP) Handbook designations
- Monte Carlo N-Particle® (MCNP) version 6.3.0 was used for all calculations

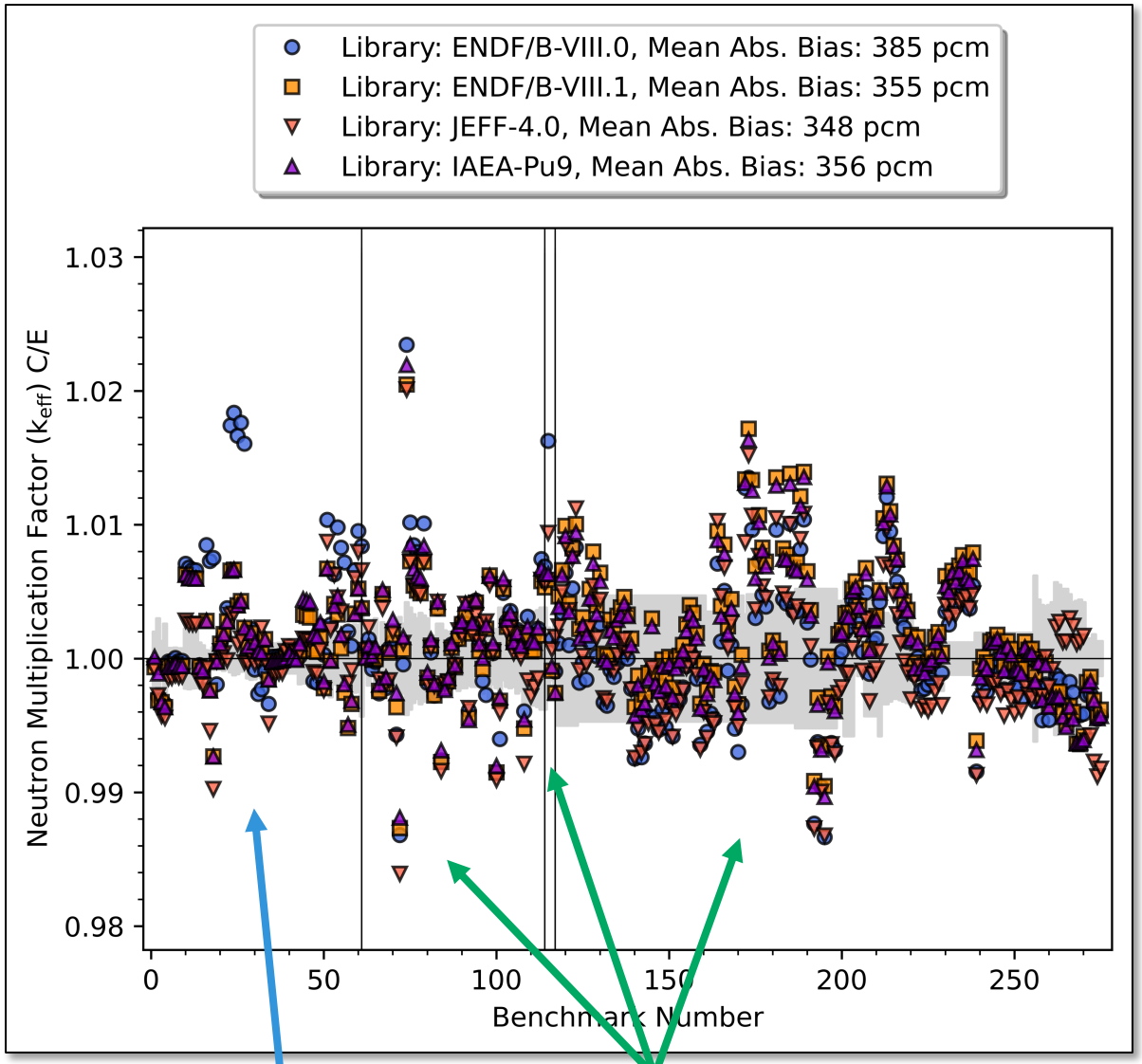
MCNP®
MONTE CARLO N-PARTICLE



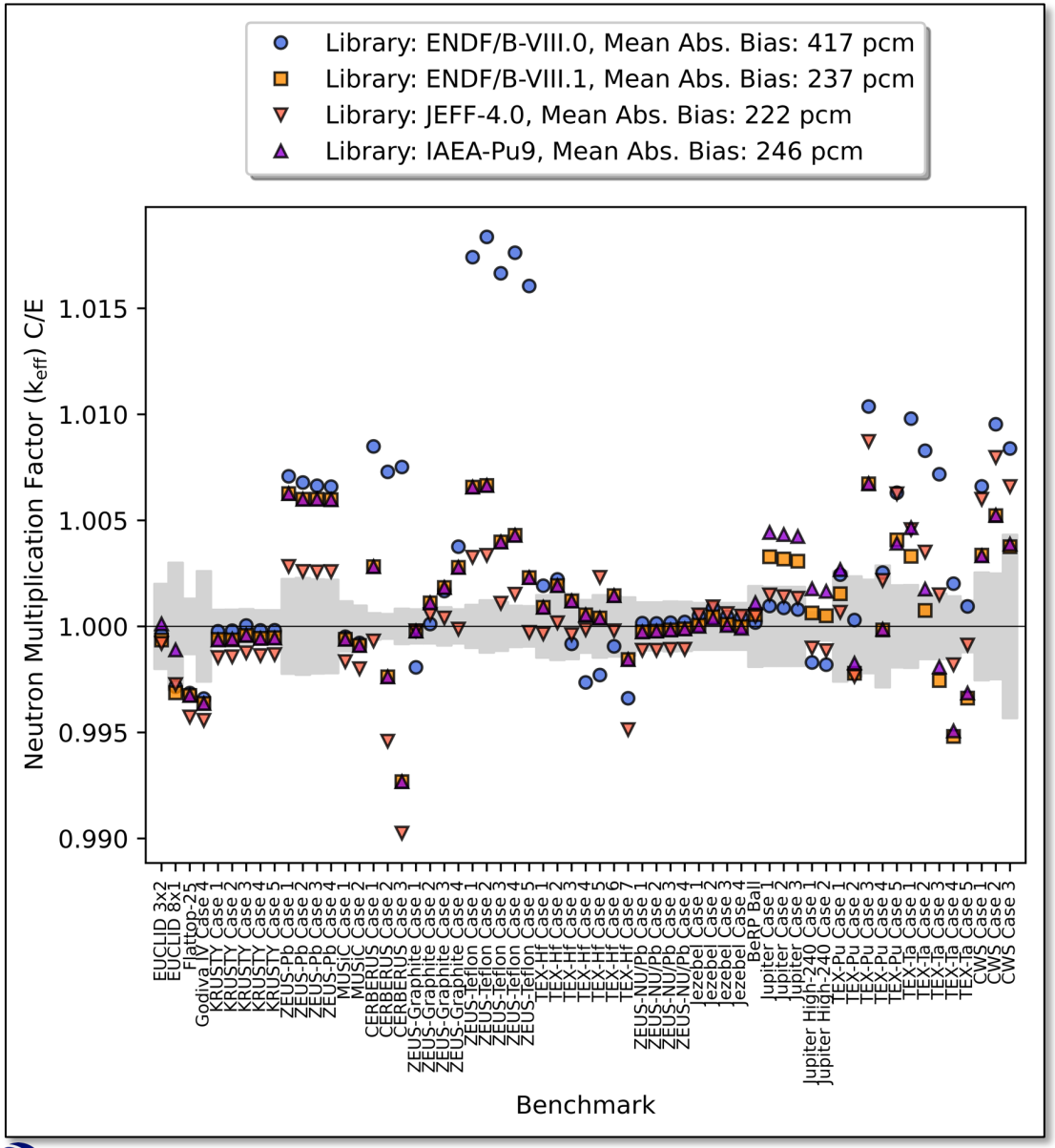
Organisation for Economic Co-operation and Development (OECD)/Nuclear Energy Agency (NEA), "International Handbook of Evaluated Criticality Safety Benchmark Experiments," NEA/NSC/DOC(95)03 (2023)

Modern/Pu Benchmark Validation

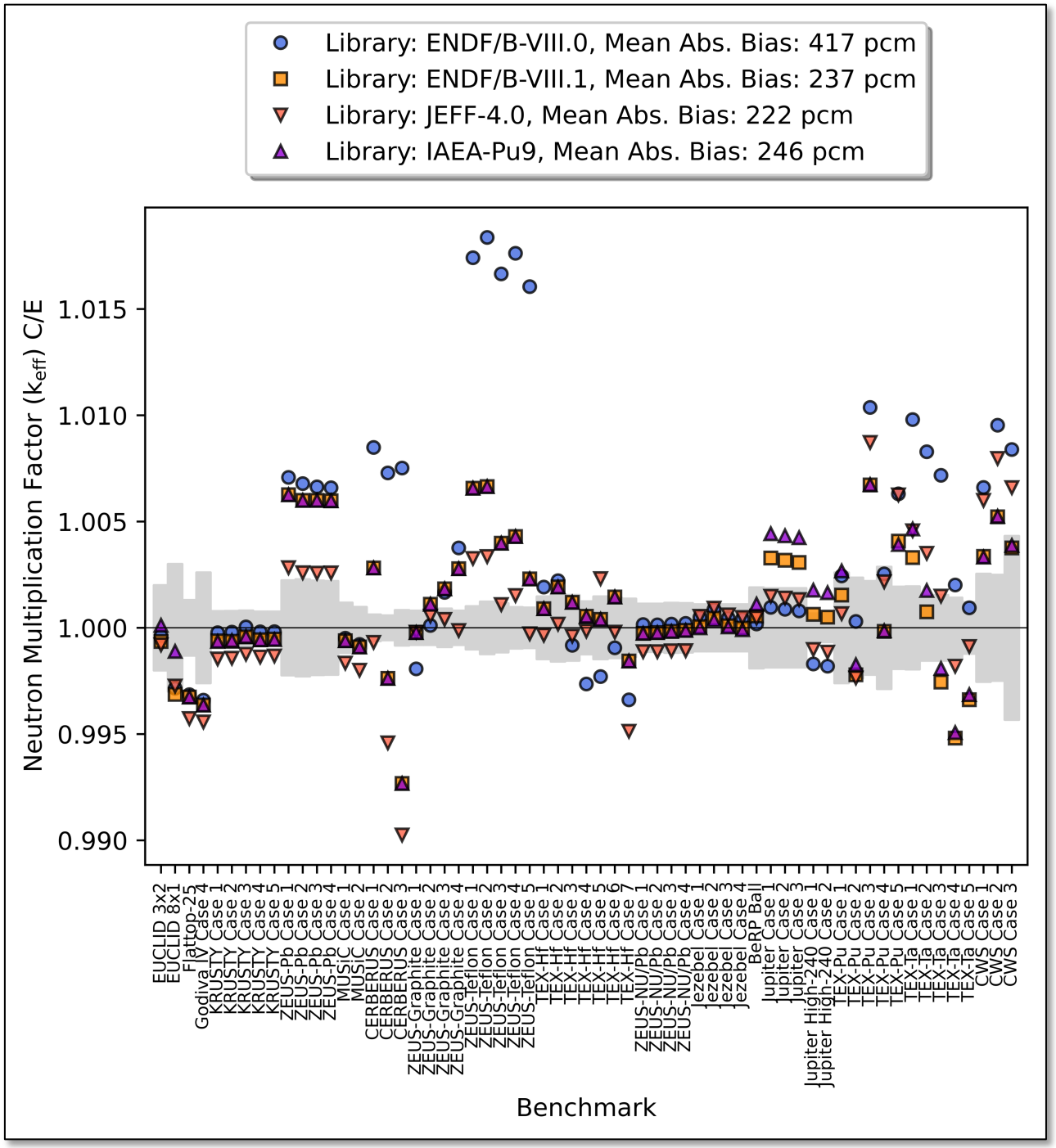
$$\text{Mean Absolute Bias} = \frac{\sum_i^N |C_i - E_i|}{N}$$



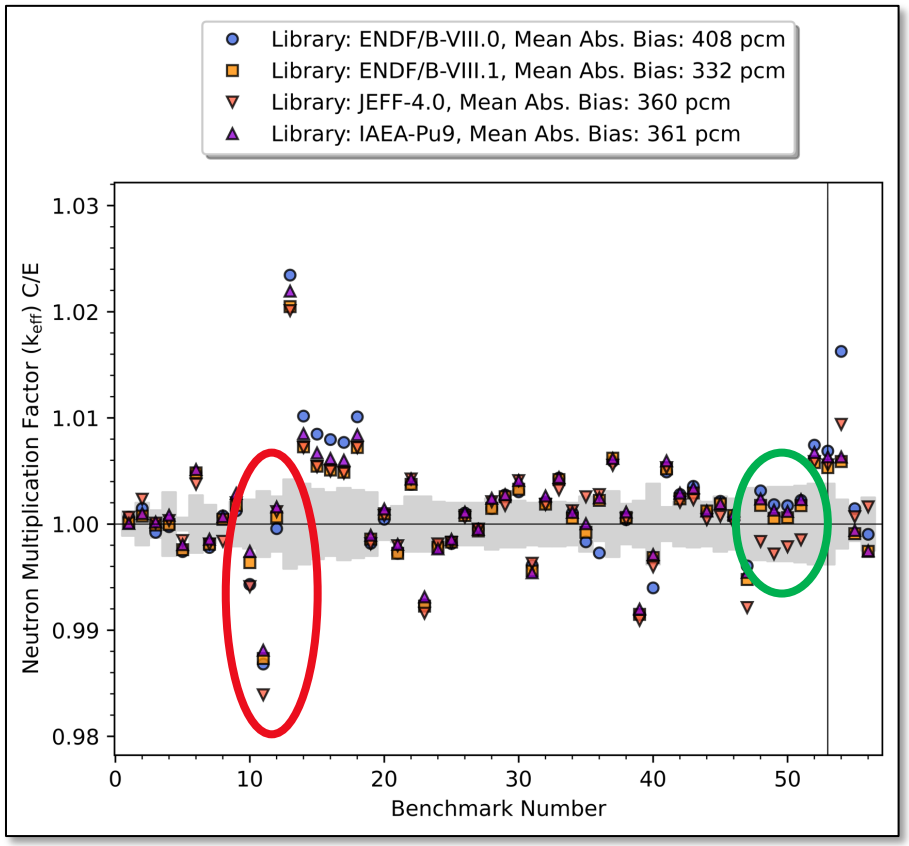
Modern Benchmark Suite

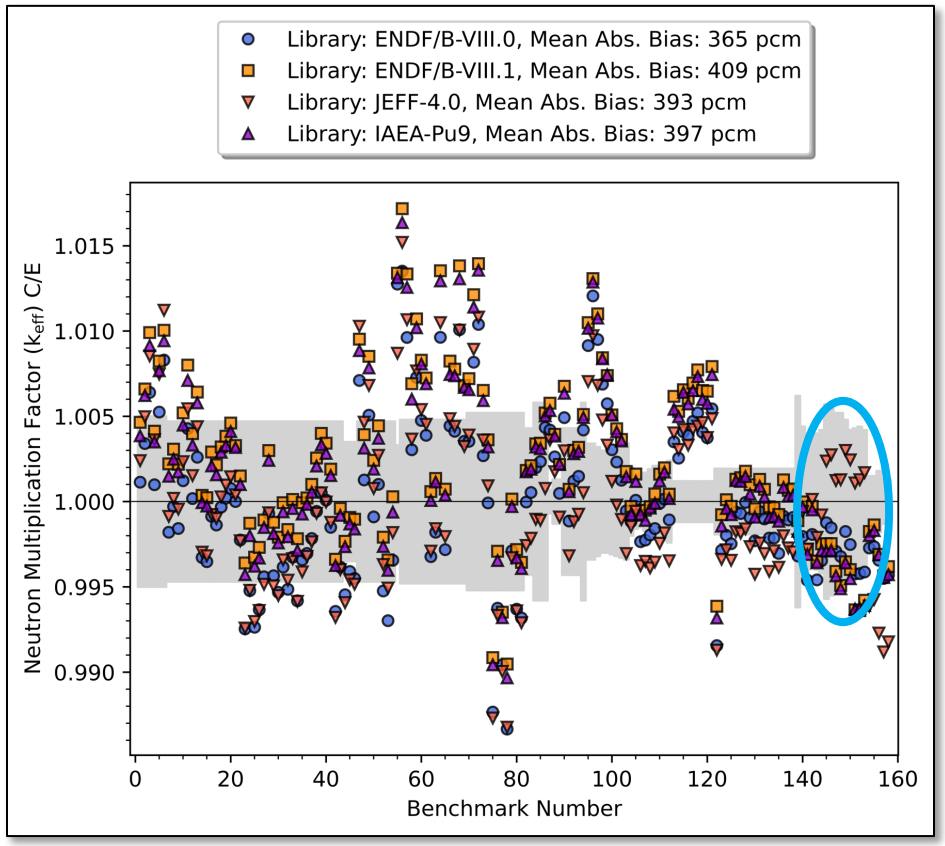


- Reminder that "IAEA-Pu9" = ENDF/B-VIII.1 + IAEA ^{239}Pu File
- IAEA ^{239}Pu has new updates for scattering that show better prediction capability for large leakage systems, such as EUCLID 8x1 configuration
- Are these changes good for systems with large reflectors (Jupiter/Jupiter High-240)? → Assemblies without large reflectors (e.g., TEX-Pu) are not affected in the same way as assemblies with large reflectors
- Significant differences between ENDF/B-VIII.1 and JEFF-4.0 for benchmarks with Pb, Cu, Teflon $(C_2F_4)_n$, Cl
- New Cl-35/37 work part of upcoming ENDF/B release, which will improve things
- Future work:
  - TSL file impact analysis
  - ENDF/B-VIII.2/IX.0 Cl-35/37 comparison with JEFF-4.0


Library: ENDF/B-VIII.0, Mean Abs. Bias: 417 pcm
Library: ENDF/B-VIII.1, Mean Abs. Bias: 237 pcm
Library: JEFF-4.0, Mean Abs. Bias: 222 pcm
Library: IAEA-Pu9, Mean Abs. Bias: 246 pcm
Neutron Multiplication Factor (k_{eff}) C/E
1.015
1.010
1.005
1.000
0.995
0.990
EUCLID 3x2
EUCLID 8x1
Flattop-25
Godiva IV Case 4
KRUSTY Case 1
KRUSTY Case 2
KRUSTY Case 3
KRUSTY Case 4
KRUSTY Case 5
ZEUS-Pb Case 1
ZEUS-Pb Case 2
ZEUS-Pb Case 3
ZEUS-Pb Case 4
MUSiC Case 1
MUSiC Case 2
CERBERUS Case 1
CERBERUS Case 2
CERBERUS Case 3
ZEUS-Graphite Case 1
ZEUS-Graphite Case 2
ZEUS-Graphite Case 3
ZEUS-Graphite Case 4
ZEUS-Teflon Case 1
ZEUS-Teflon Case 2
ZEUS-Teflon Case 3
ZEUS-Teflon Case 4
ZEUS-Teflon Case 5
TEX-Hf Case 1
TEX-Hf Case 2
TEX-Hf Case 3
TEX-Hf Case 4
TEX-Hf Case 5
TEX-Hf Case 6
TEX-Hf Case 7
ZEUS-NU/Pb Case 1
ZEUS-NU/Pb Case 2
ZEUS-NU/Pb Case 3
ZEUS-NU/Pb Case 4
Jezebel Case 1
Jezebel Case 2
Jezebel Case 3
Jezebel Case 4
BeRP Ball
Jupiter Case 1
Jupiter Case 2
Jupiter Case 3
Jupiter High-240 Case 1
Jupiter High-240 Case 2
TEX-Pu Case 1
TEX-Pu Case 2
TEX-Pu Case 3
TEX-Pu Case 4
TEX-Pu Case 5
TEX-Ta Case 1
TEX-Ta Case 2
TEX-Ta Case 3
TEX-Ta Case 4
TEX-Ta Case 5
CWS Case 1
CWS Case 2
CWS Case 3
Benchmark

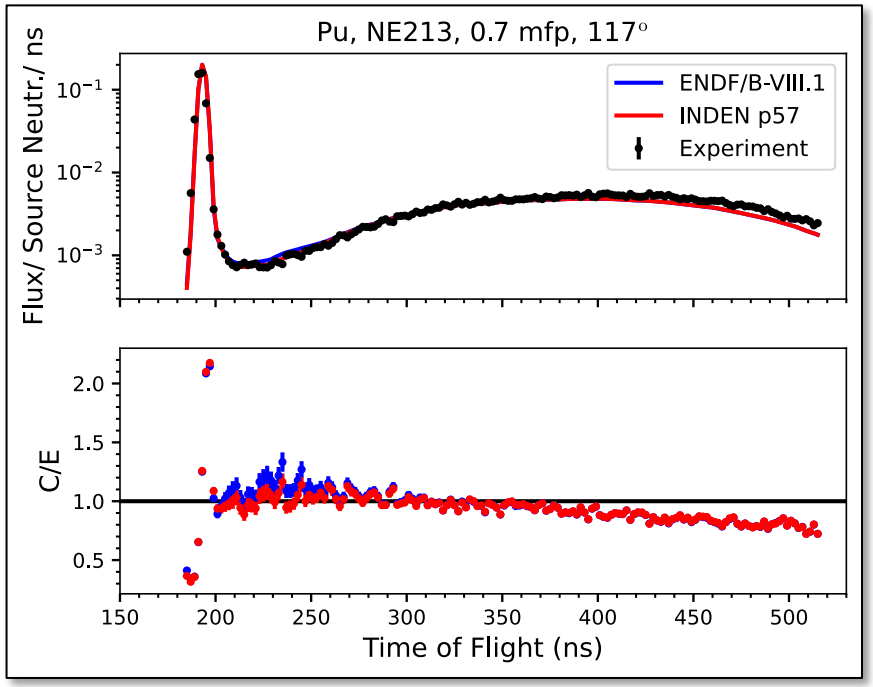
PMF/PMI/PST Benchmark Suites

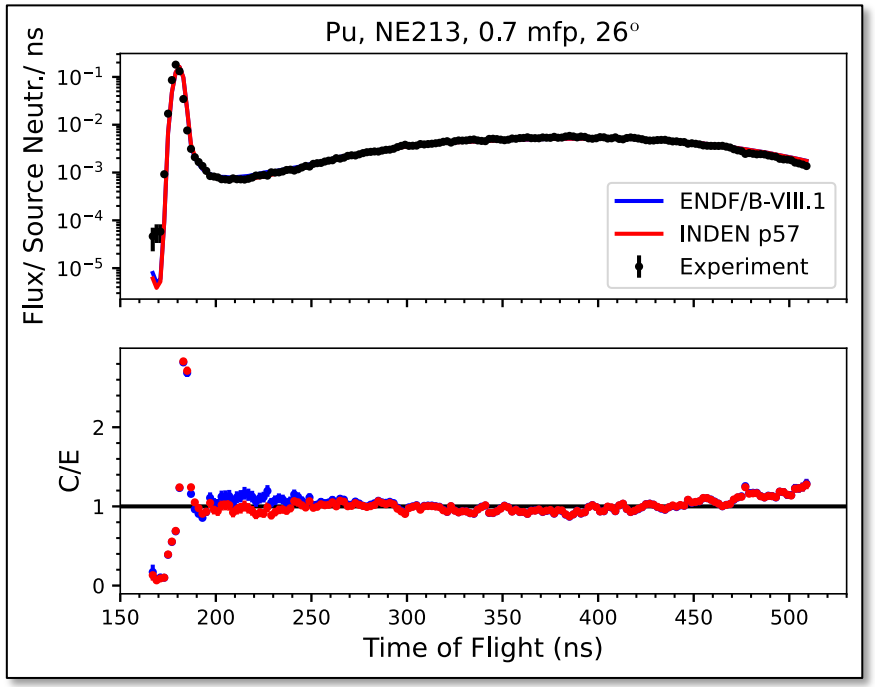




- Cylindrical assembly of Pu metal (97.6 at. % ^{239}Pu) reflected by copper, nickel, and iron
- Los Alamos Molten Plutonium Reactor (LAMPRE), LCX-I experiments included Ni and/or Fe reflector, Pu Pu/Ta or Pu/Ta/Al core
- Pu Nitrate solution with Gd in water-reflected cylinder

LLNL Pulsed Spheres Results





- Improvements in the inelastic valley
- Work done on continuum (MT=91) and angular distributions from the location of improvements – MT=51,52 would be closer to the peak

Acknowledgments

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Questions?

Contact the Los Alamos National Laboratory
Nuclear Data Team by email at nucldata@lanl.gov