LA-UR-11-12069

Initial ICSBEP Criticality Calculations with ENDF/B-VII.1β4 Cross Sections

Fall CSEWG Meeting
Brookhaven National Laboratory
November, 2011

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This work was carried out under the auspices of the National Nuclear Security Administration of the U.S. Department of Energy at Los Alamos National Laboratory under Contract No. DE-AC52-06NA25396.

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Abstract

We review MCNP eigenvalue calculations from a suite of International Criticality Safety Benchmark Evaluation Project (ICSBEP) Handbook evaluations using the recently distributed ENDF/B-VII.1β4 cross section library.

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ENDF/B-VII.1 Validation Paper

ENDF/B-VII.1 Neutron Cross Section Data Testing with Critical Assembly Benchmarks and Reactor Experiments

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(Received 9 August 2011; revised received 21 September 2011; accepted 17 October 2011)

The ENDF/B-VII.1 library is the latest revision to the United States' Evaluated Nuclear Data File (ENDF). The ENDF library is currently in its seventh generation, with ENDF/B-VII.0 being

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ICSBEP Summary

- HEU, IEU, LEU systems
- Pu systems
- Mixed systems
- ^{233}U systems
  - Fast, Intermediate, Thermal energy ranges
  - Metal, Oxide, Solution fuel
  - Bare, Reflected

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E71β4 File & NJOY Summary

- 418 evaluations in the ENDF/B-VII.1β4 neutron file.
  - More files added since then – 423 files expected in the final ENDF/B-VII.1 neutron file.
- All files processed to create MCNP ACE files (with NJOY2010).
- Important β4 changes, and post β4 changes
  - ^{16}O reverted (mostly) to ENDF/B-VII.0;
  - ^{19}F reverted (mostly) to ENDF/B-VII.0;
  - ^{iso}Zr revisions;
  - ^{157}Gd thermal and resolved resonance region is closer to ENDF/B-VII.0 than in earlier beta versions.

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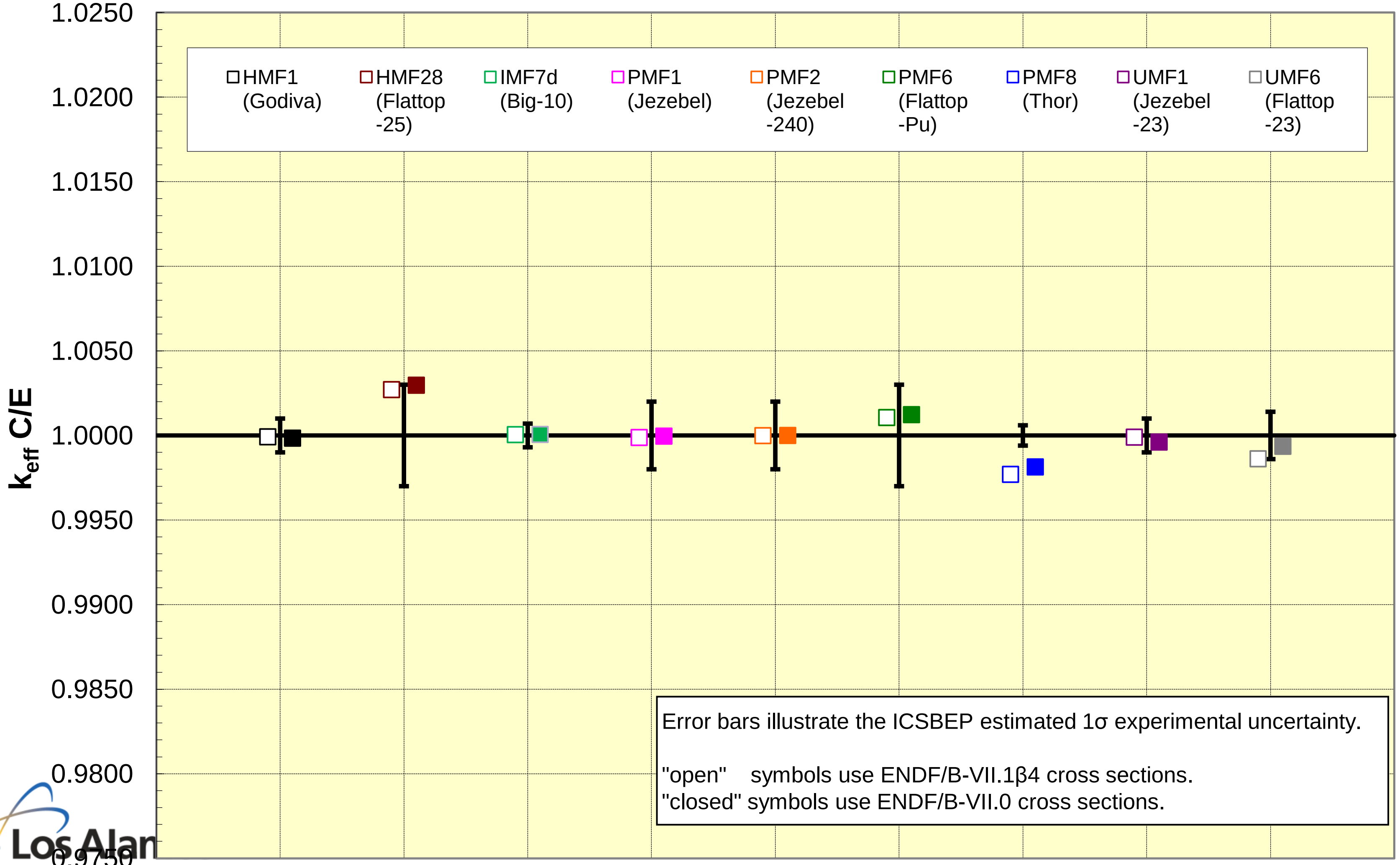
Traditional LANL Critical Assemblies



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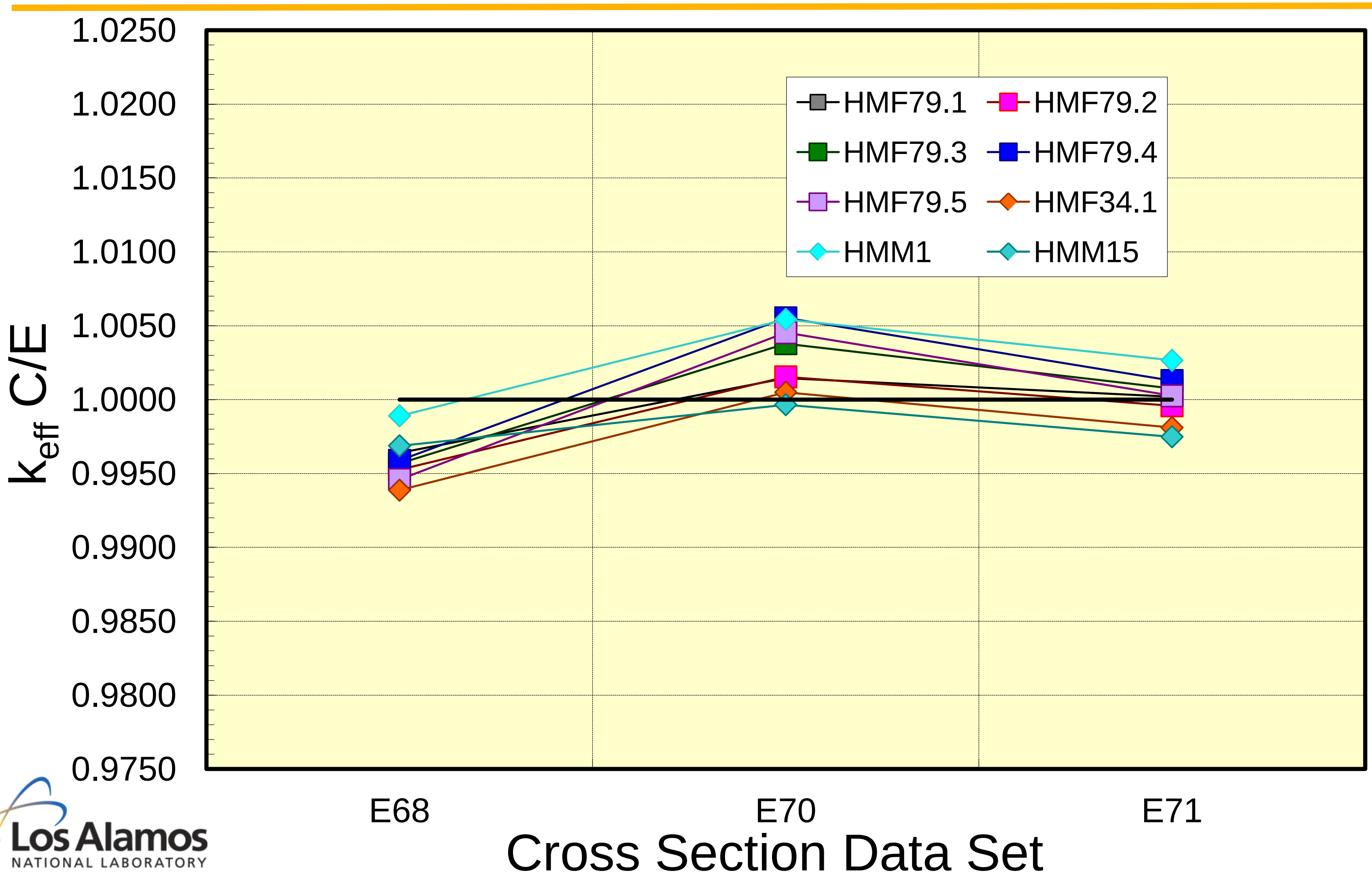
FAST Systems with Ti



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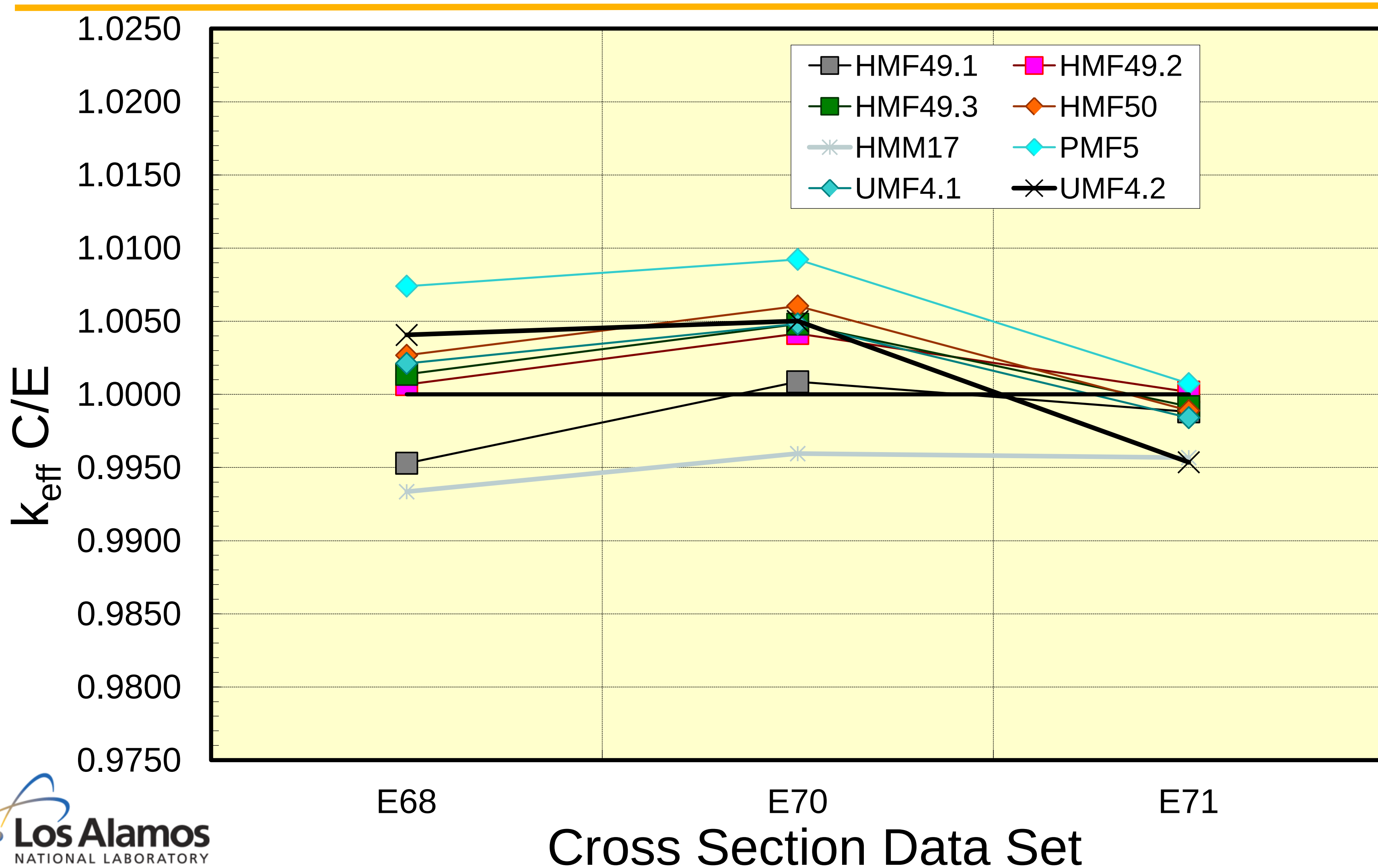
FAST Systems with W



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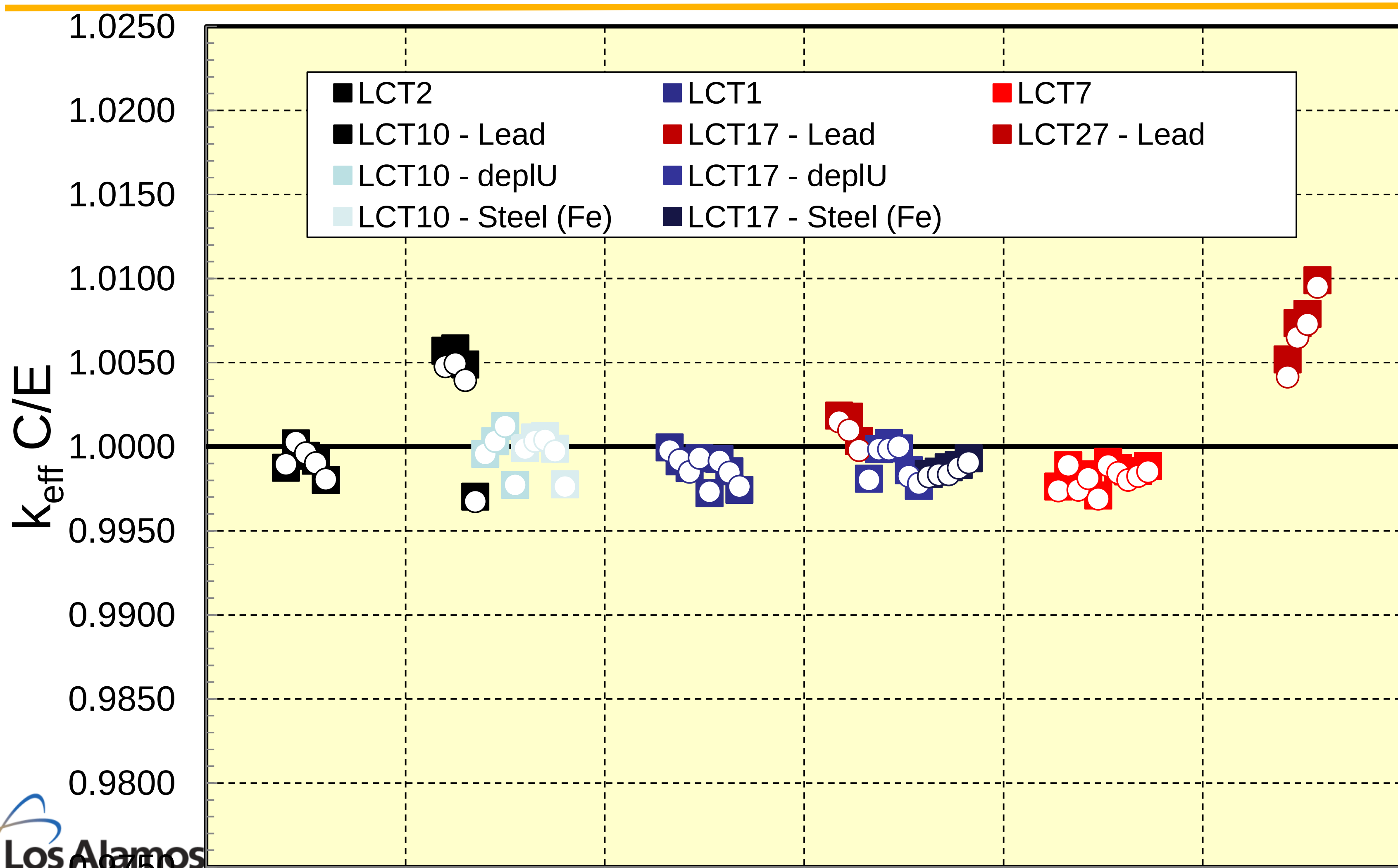
Fast Systems with Pb



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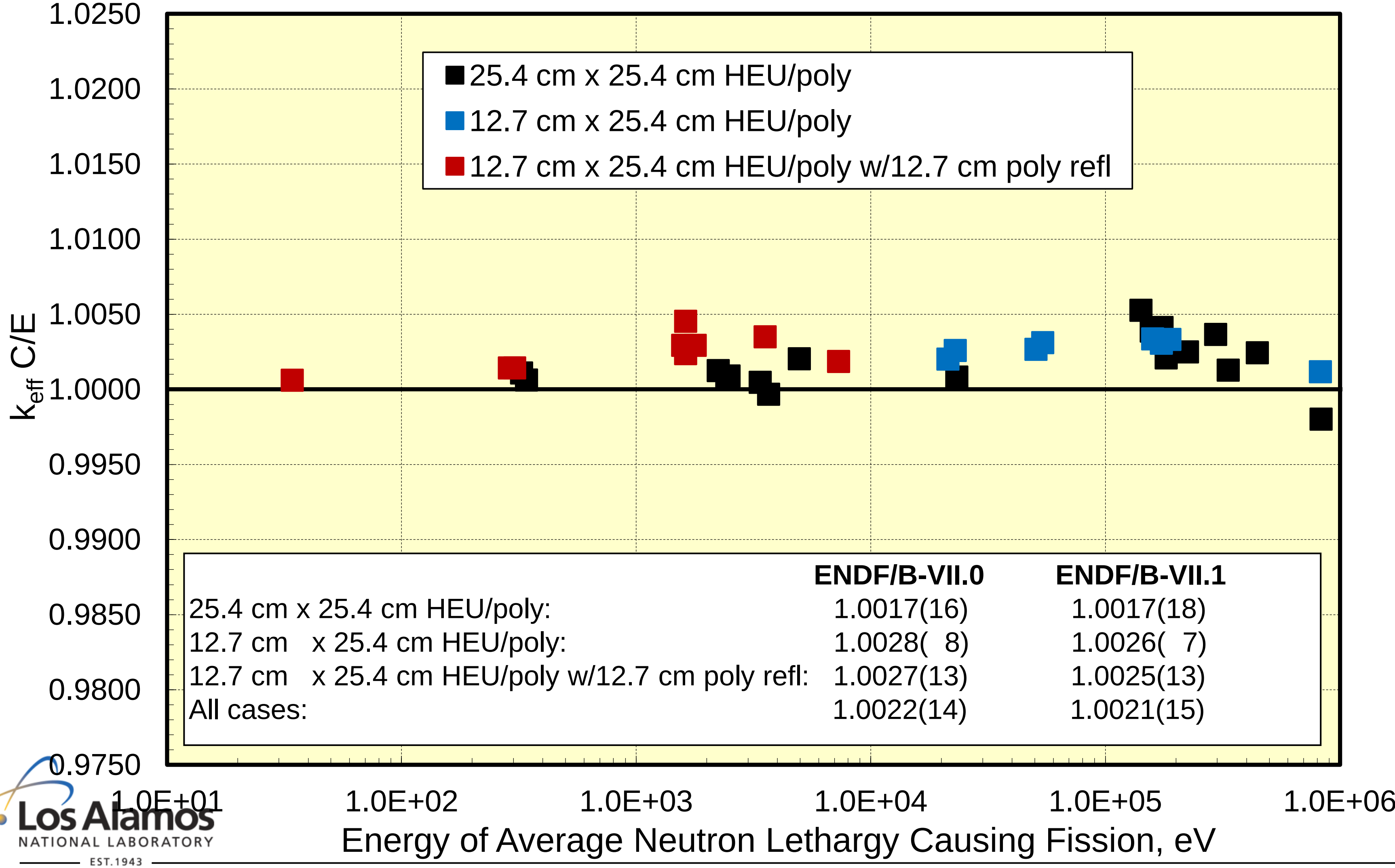
HEU … Fast to Thermal (HMF7)



	ENDF/B-VII.0	ENDF/B-VII.1
25.4 cm x 25.4 cm HEU/poly:	1.0017(16)	1.0017(18)
12.7 cm x 25.4 cm HEU/poly:	1.0028(8)	1.0026(7)
12.7 cm x 25.4 cm HEU/poly w/12.7 cm poly refl:	1.0027(13)	1.0025(13)
All cases:	1.0022(14)	1.0021(15)

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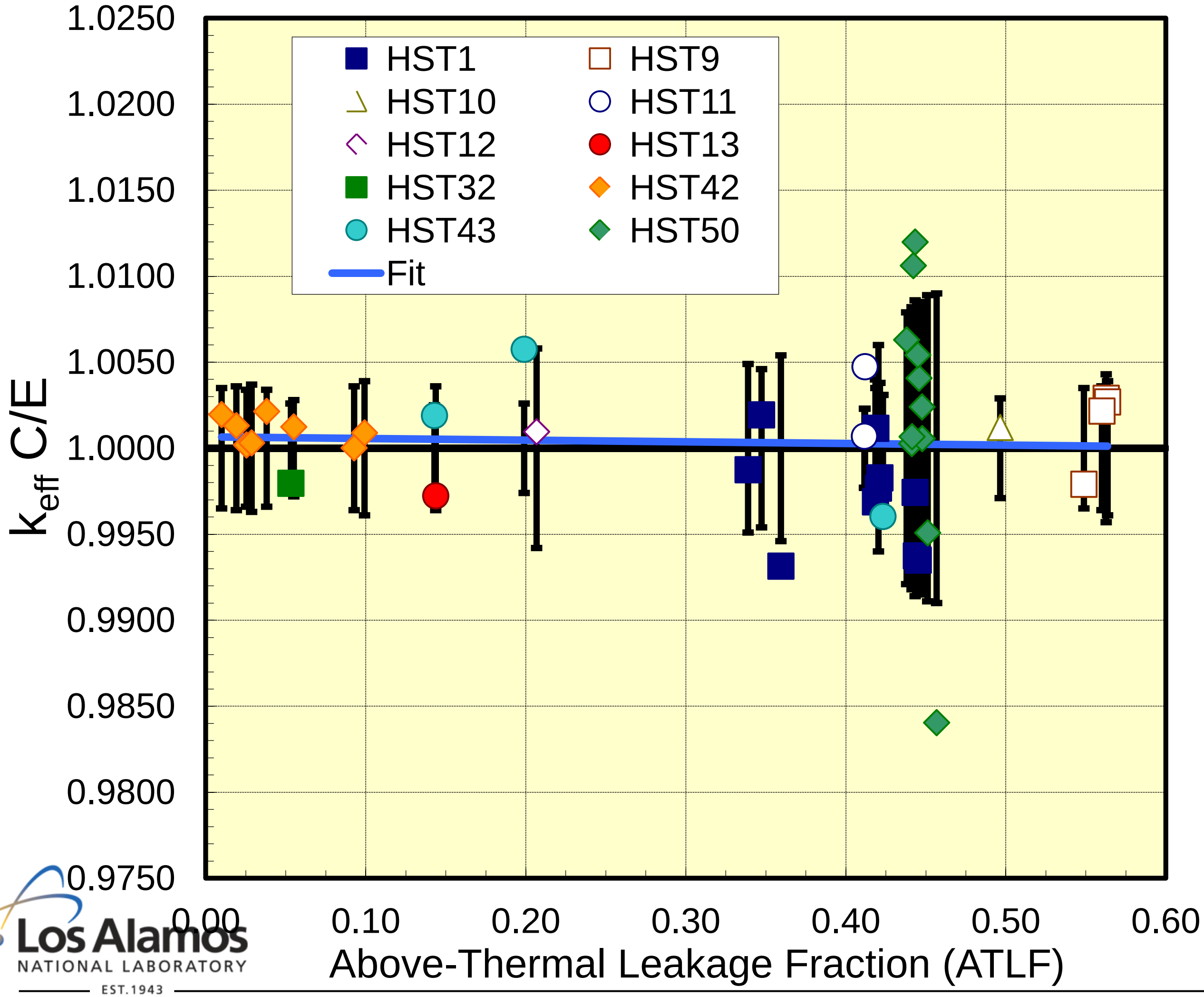
HEU Solution Systems



Impact on HST eigenvalues is minimal.

k_{calc} regression with ATLF retains near unity intercept and statistically insignificant slope.

Virtually identical regression parameters with ENDF/B-VII.0 and ENDF/B-VII.1

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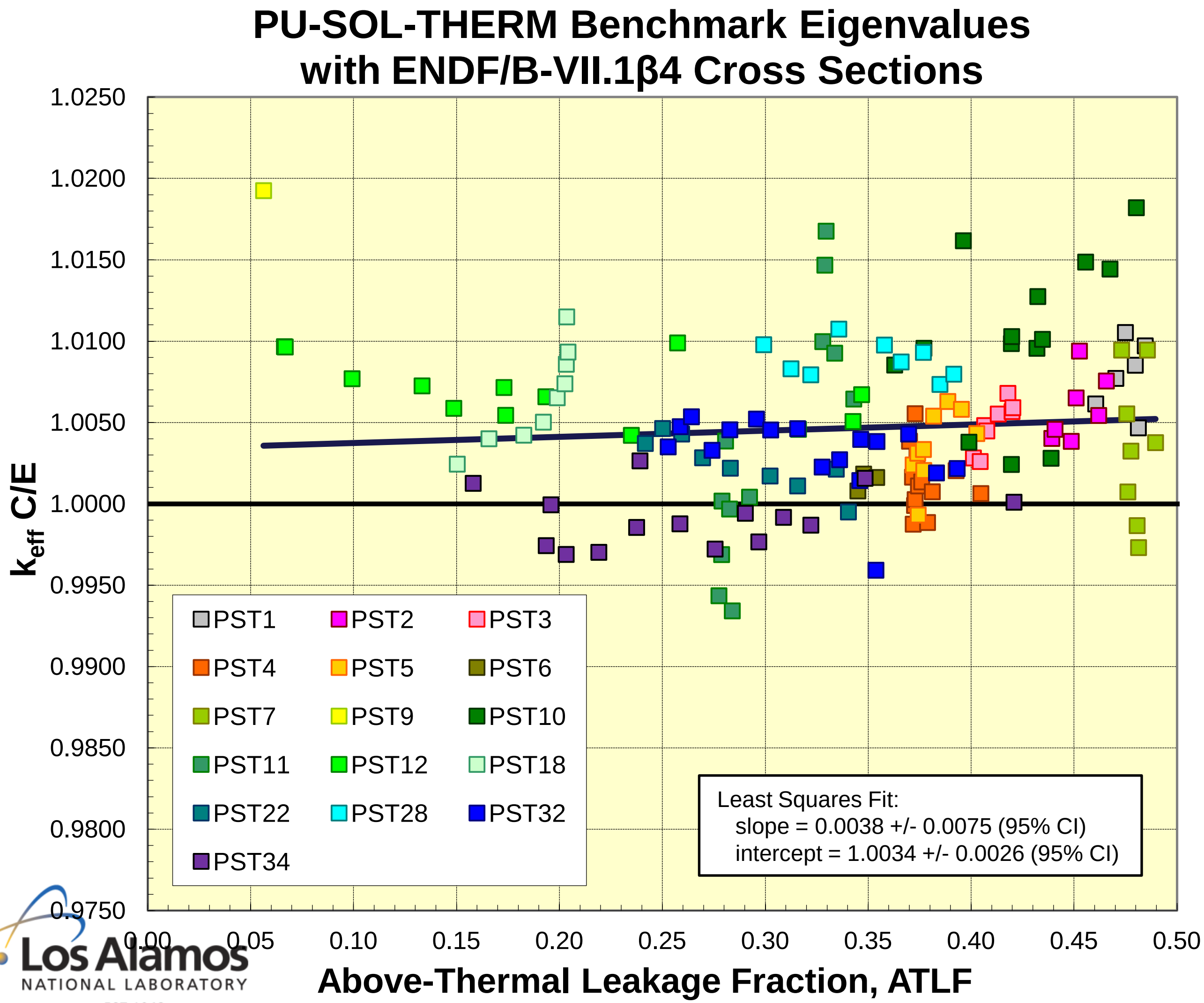
Pu Solution Systems



- PST benchmarks.
- No ATLF trend (same as HST).
- ^{239}Pu atom per-cent mostly >90%, but some at ~75% and ~40% (next figure).
- PST34 is sensitive to Gd

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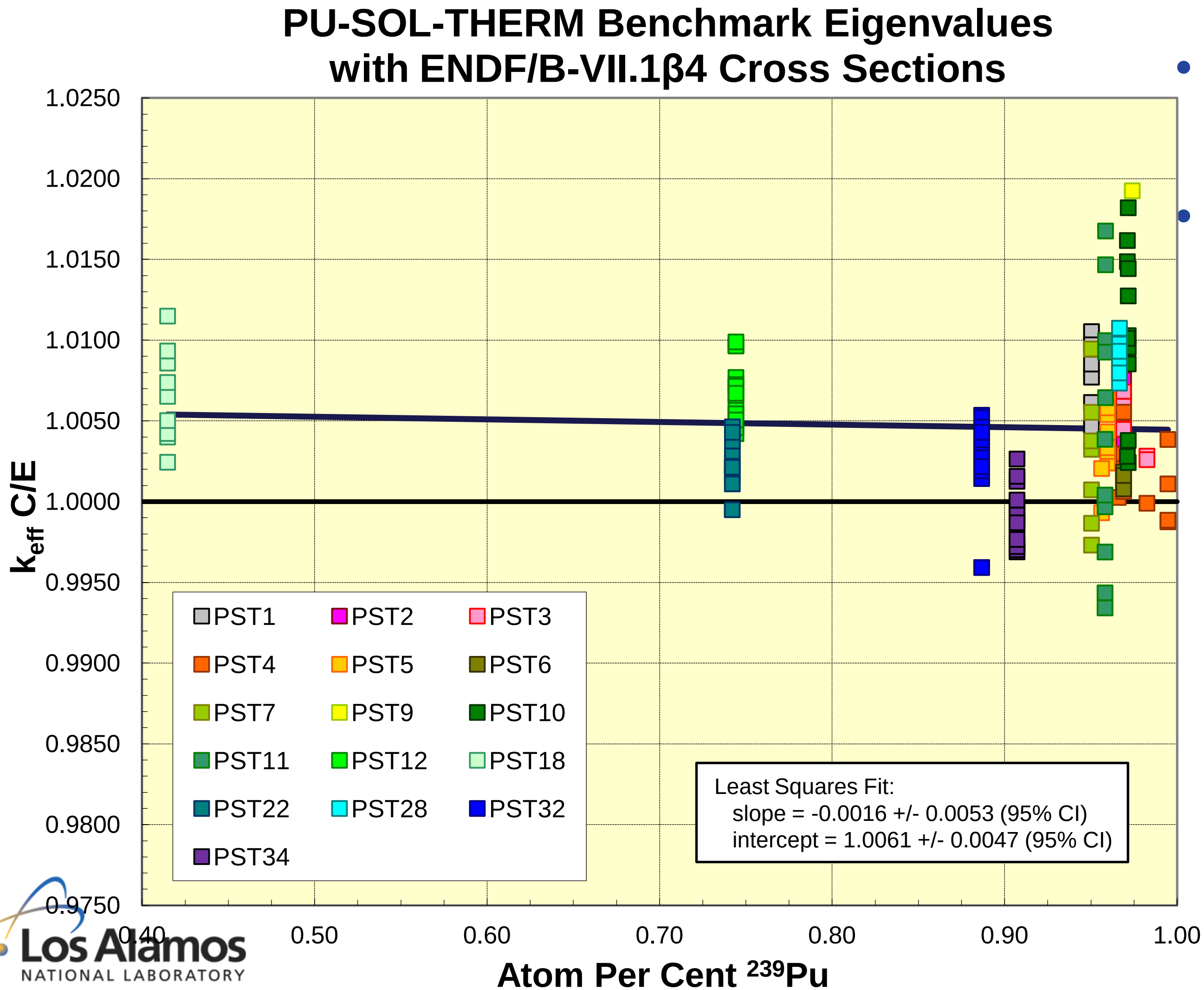
Pu Solution Systems



- PST benchmarks (con't).
- Tests for k_{calc} trend with
  - ATLF
  - ATFF
  - a/o ^{239}Pu
  - ^{239}Pu/Pu prod frac
  - Average fission E
  - Average lethargy
  - Grams pu/liter
  - ^{239}Pu/Pu capt frac
  - H capture
  - H/Pu ratio

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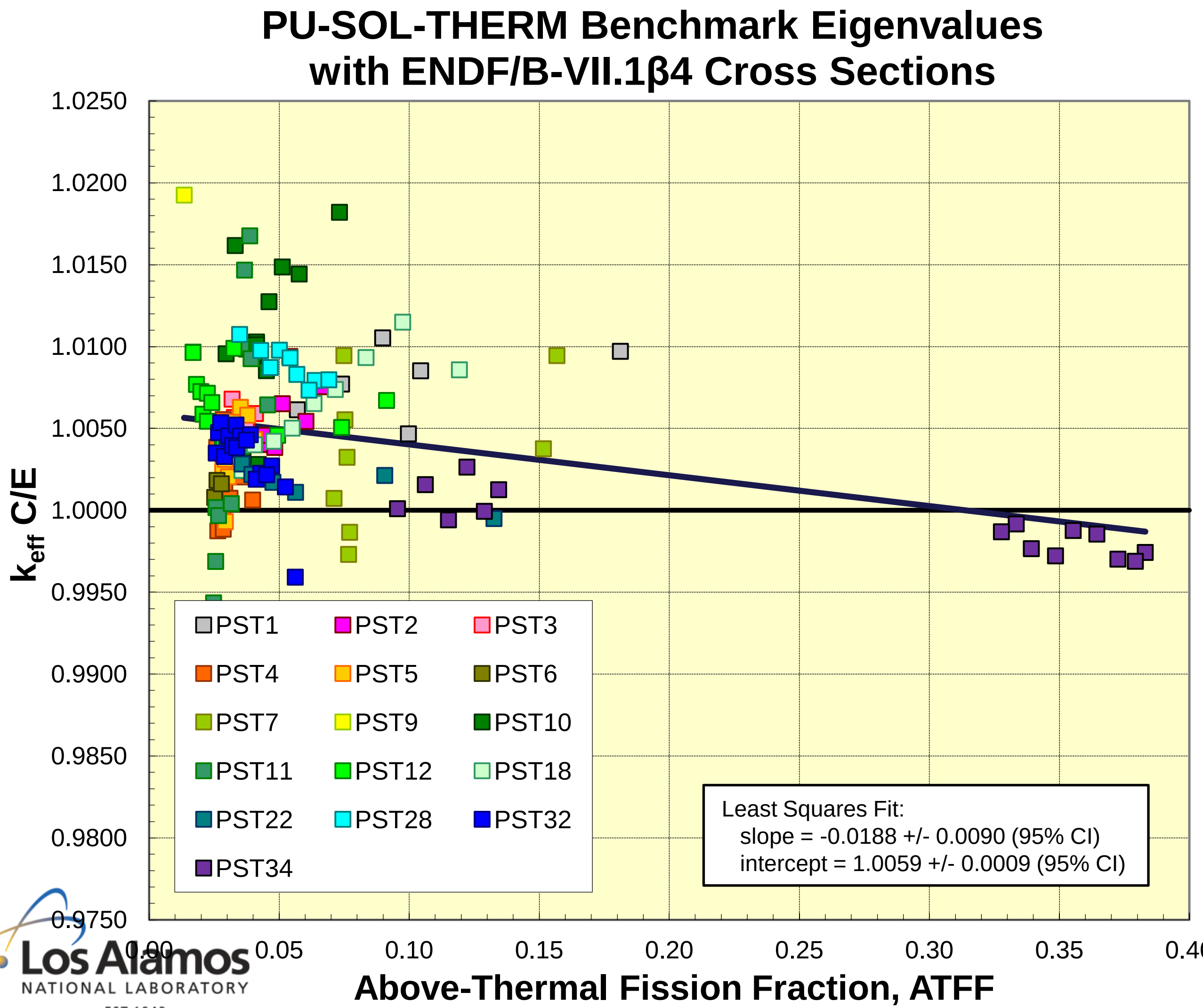
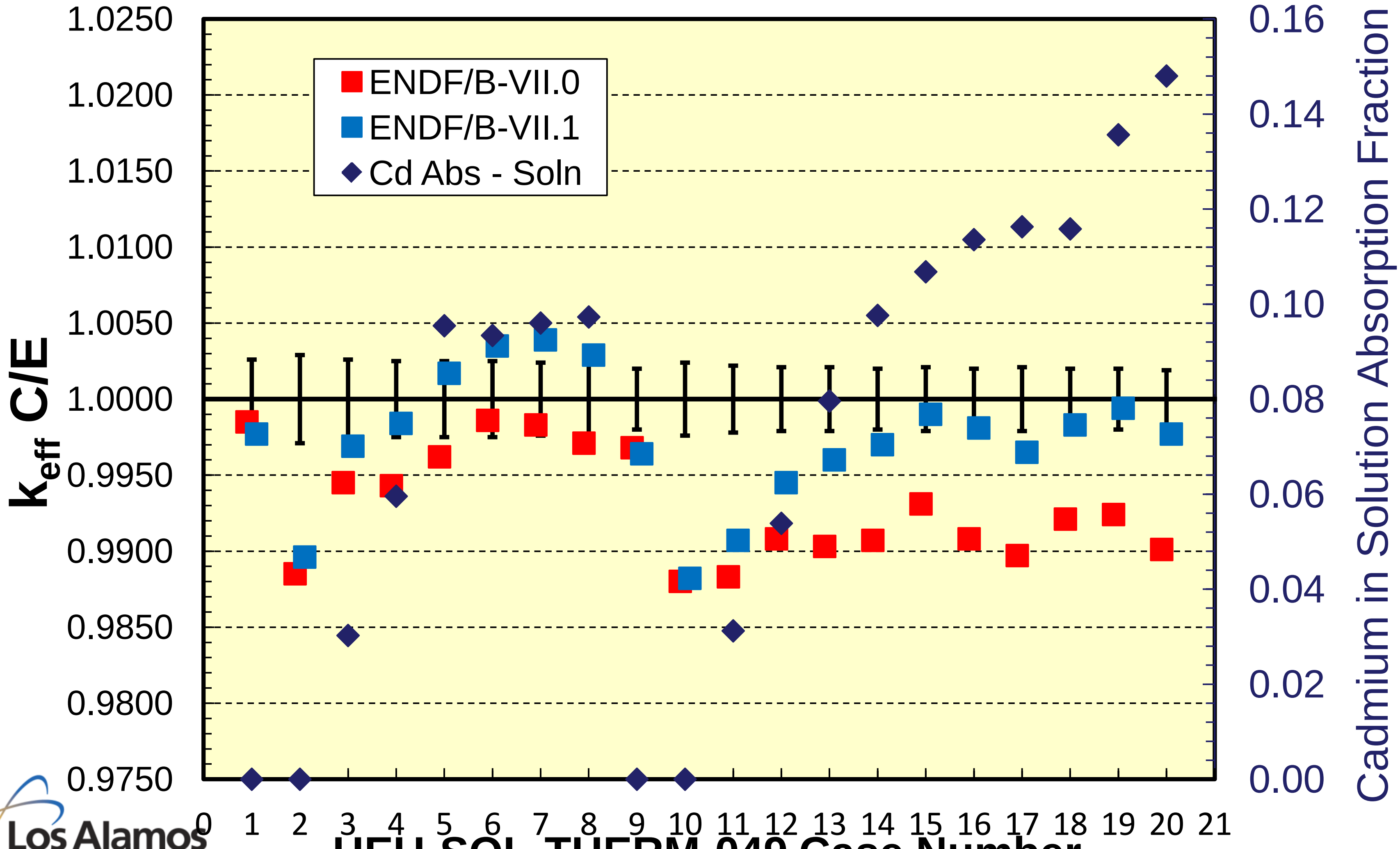
Pu Solution Systems



- k_{calc} trend with Above-Thermal Fission Fraction (ATFF)
- Driven by PST34, which has Gd, but …

HEU Solution – ^{nat}Cd poisoned



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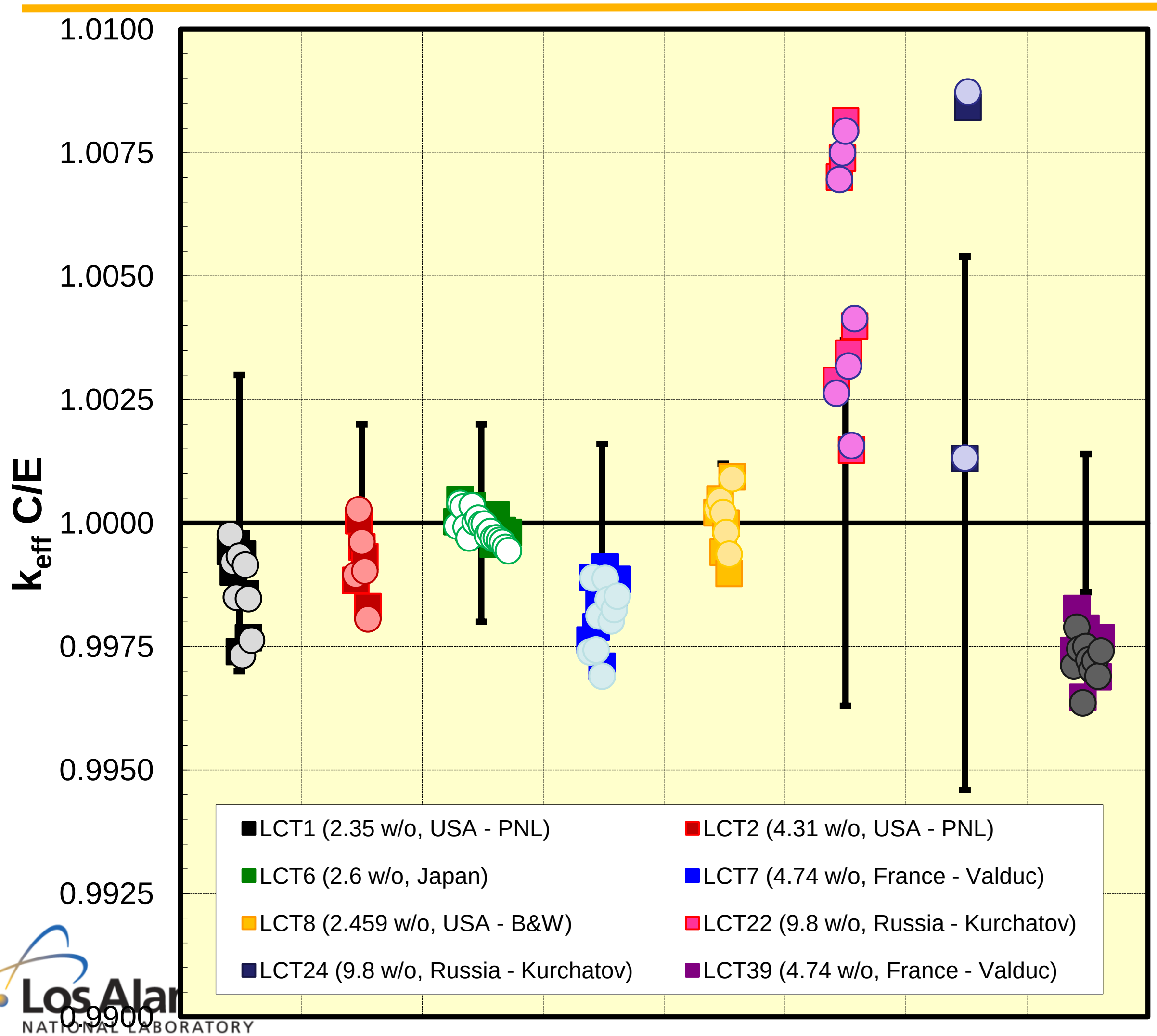
LEU Systems – Water Reflected



Minimal change in LCT k_{calc}

- Individual diffs can exceed ± 50 pcm; average diffs much smaller.

E71β4 – E70 (pcm):

- LCT1 (8): -22
- LCT2 (5): -2
- LCT6 (18): -11
- LCT7 (10): -28
- LCT8 (6): +6
- LCT22(7): -6
- LCT24(2): +16
- LCT25(4): +13
- LCT39(10): -18

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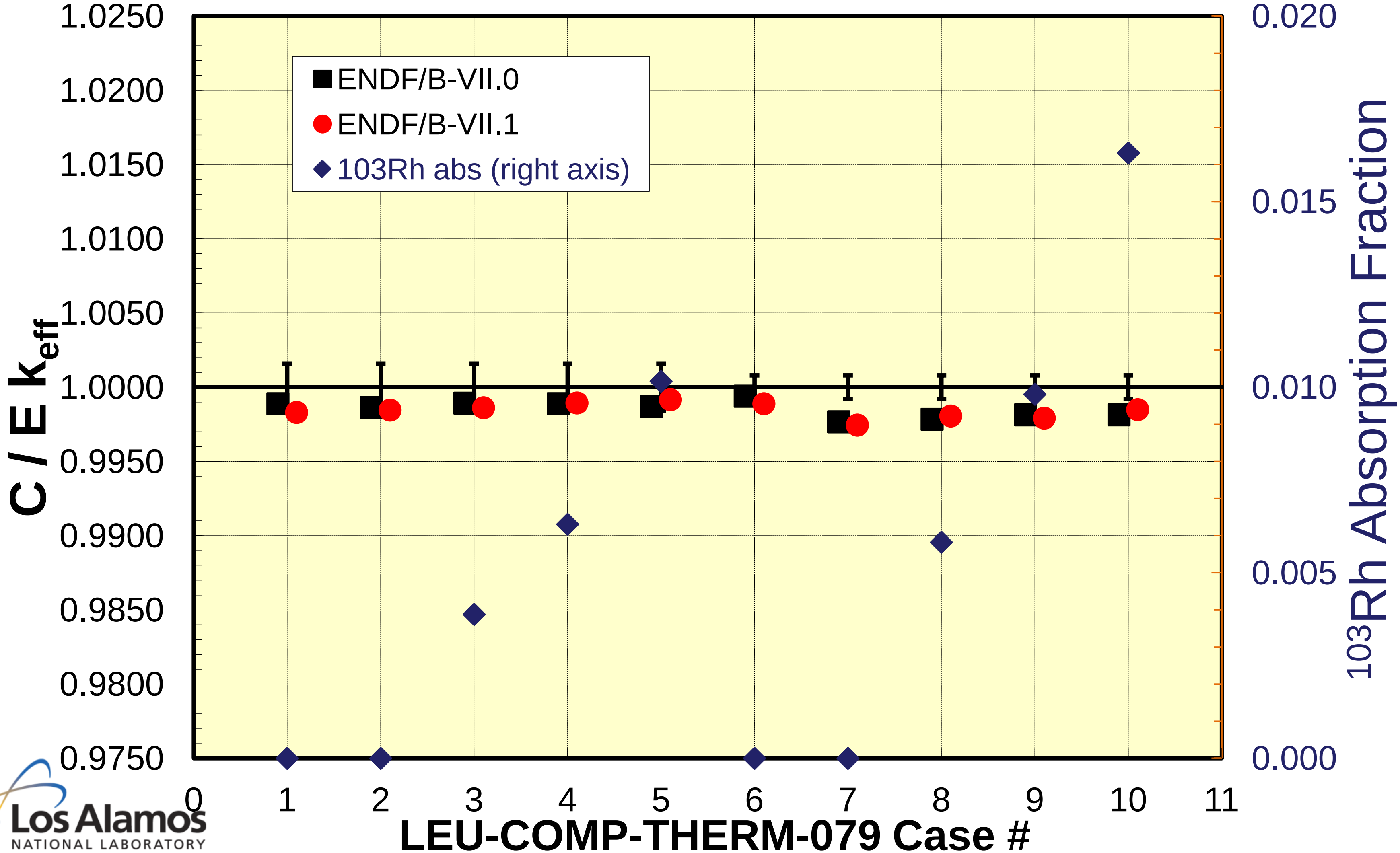
LEU Systems – ^{103}Rh poisoned



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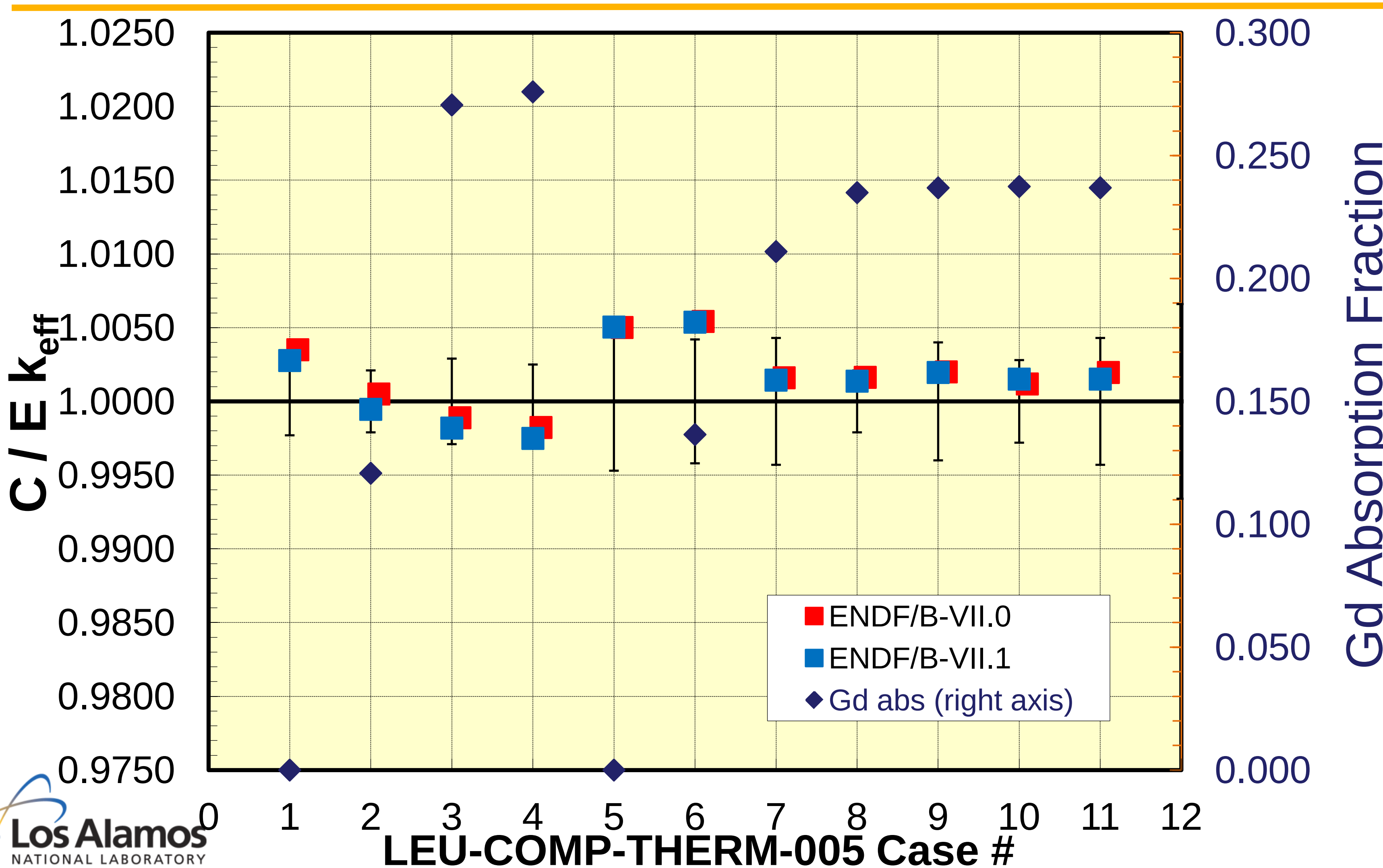
LEU Systems – ^{nat}Gd poisoned



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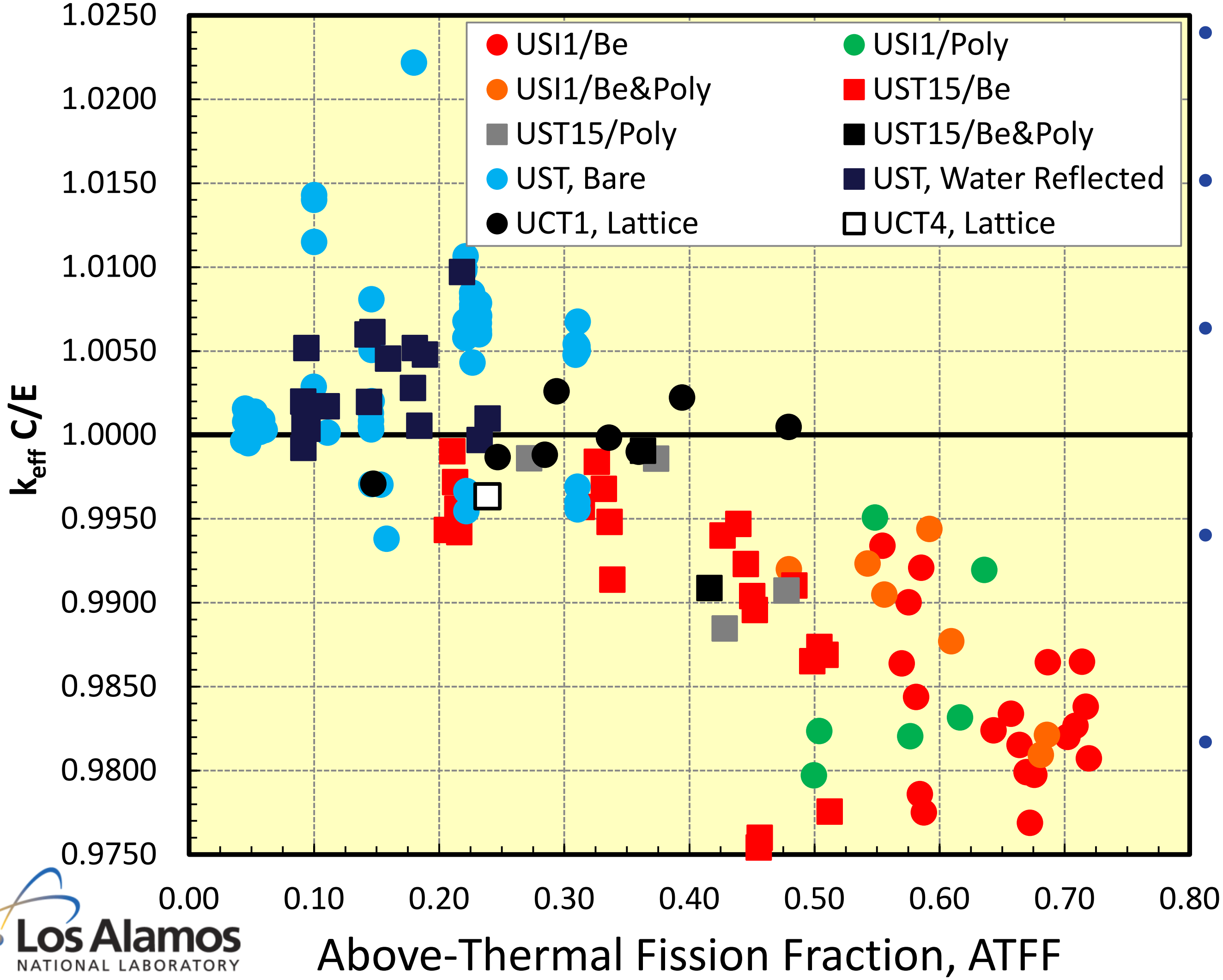
^{233}U Solution & Lattice Systems



- H_2O, CH_2 and Be reflectors
- Results in a large ATFF interval.
- Mostly small (< 20pcm) increase compared to E70.
- Lattice systems (with ^{nat}Zr) are more accurate
- Not news, but something isn't right!

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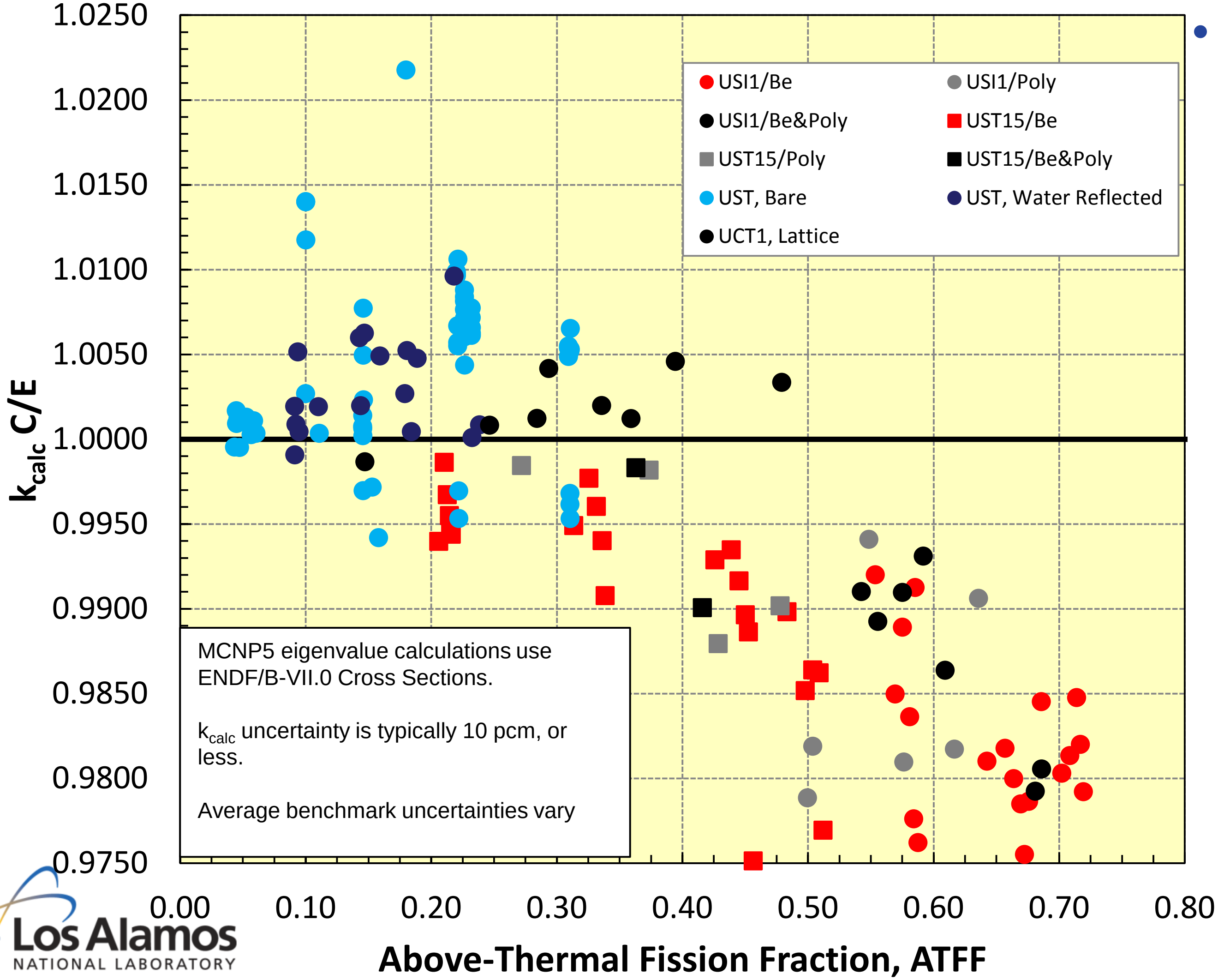
^{233}U Solution & Lattice Systems



- ENDF/B-VII.0 results.

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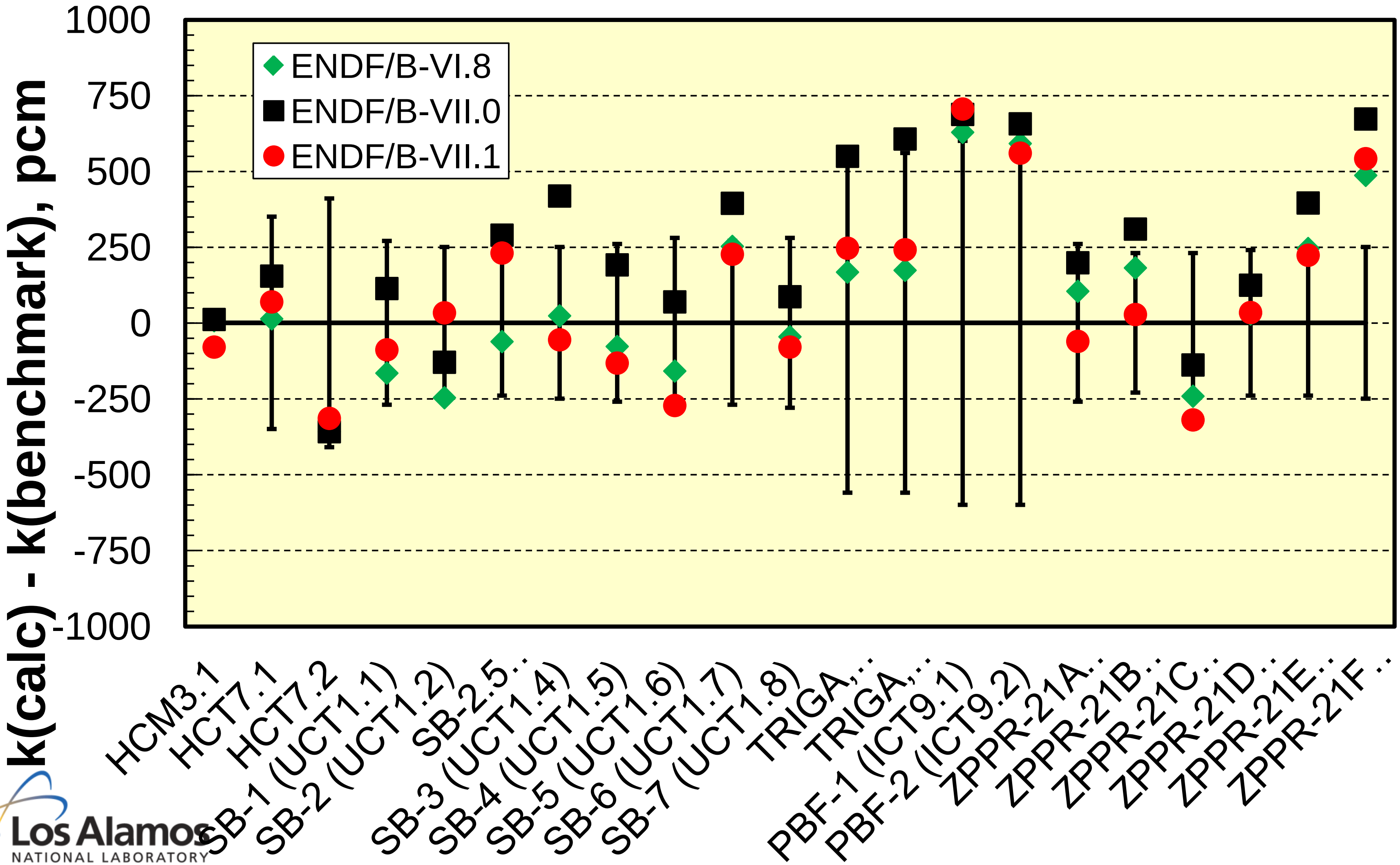
Various Benchmarks with ^{nat}Zr



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Summary & Conclusions

- Previous (ENDF/B-VII.0) calculations that were accurate remain accurate with ENDF/B-VII.1;
- Systems containing Ti, Zr, Cd, Gd, W are calculated more accurately;
- Be systems are generally calculated to within 500 pcm, but results are inconsistent;
- V and Pb systems remain biased high;
- ^{233}U solution systems continue to exhibit a trend with average fission energy;
- ^{239}Pu solution systems continue to exhibit a positive bias;
- Reaction rate benchmarks are playing an increasingly important role in cross section validation.