OAK RIDGE National Laboratory

Updated Gadolinium Validation in SCALE 6.3.0 using ENDF/B-VIII.0 Data

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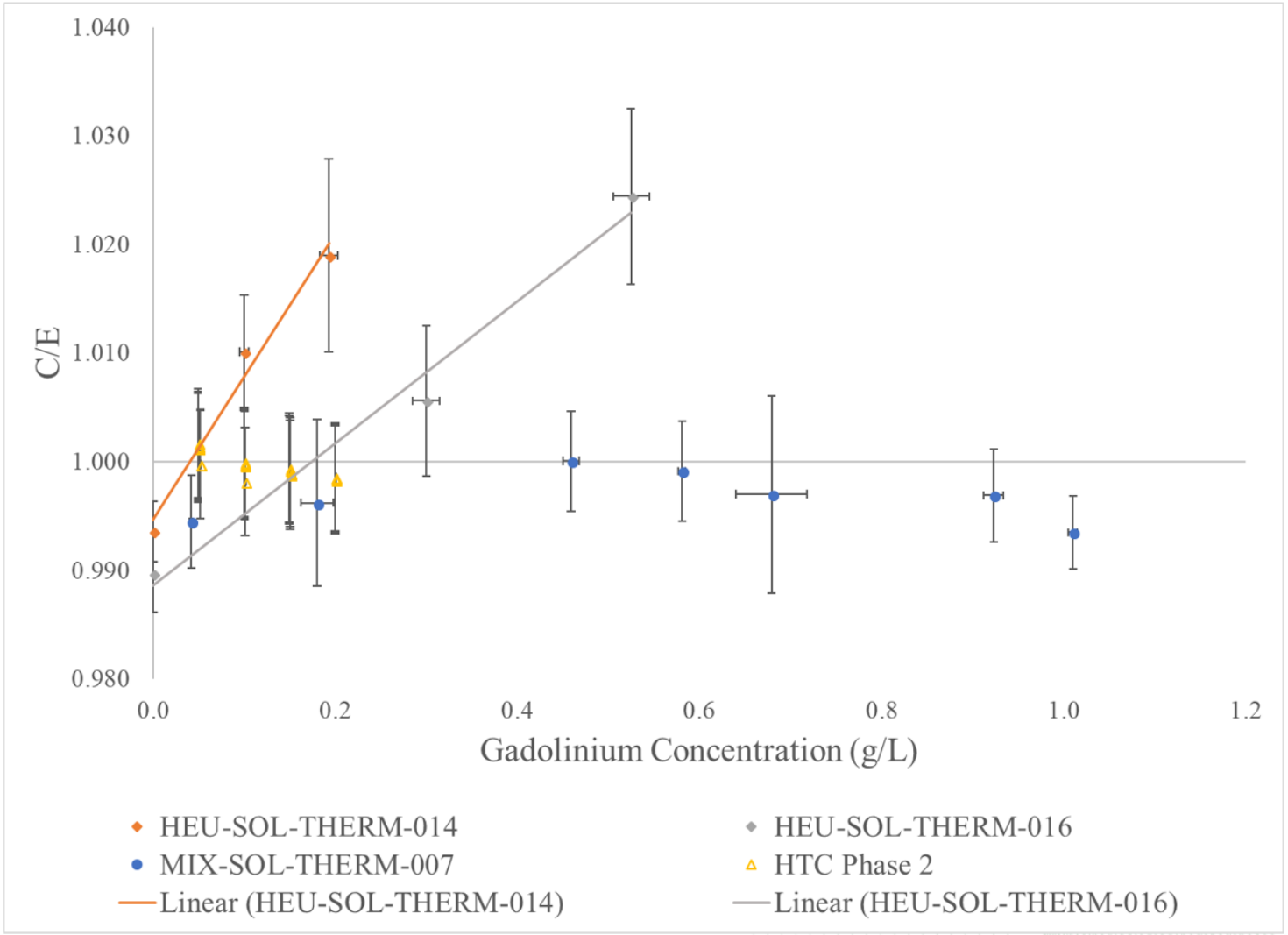
Outline

- Where we were in 2018
- Overview of new models
- Results
- Conclusions

ANS Summer meeting in 2018[1]

All results now

- SCALE 6.2.2 with CE KENO and ENDF/B-VII.1
- Uncertainties in Gd concentration also shown
- No clear bias in MST-007 results
- Maybe a slight negative bias in HTC results?



[1]W.J. Marshall, "The Case for and Against a Gadolinium Bias in SCALE: Opening Arguments," *Trans. Am. Nucl. Soc.* **118**, 554-557 (2018).

Overview of new models

- All new models have been checked, but not yet added to the VALID library
- Models originally created as part of masters thesis or summer internships
  - Alex Shaw MS at Georgia Tech
  - Karl Florida and Brant Purcell internships from US Naval Academy
- All models rerun in SCALE 6.3.0 using CE ENDF/B-VIII.0 library

Overview of models (continued)

Soluble gadolinium

- IPPE HEU Solutions
  - **HST-014** and **HST-016** (from VALID)
  - **HST-015, -017, -018, -019** (from Shaw MS)
  - **HST-025** (from midshipmen)
- CEA Valduc MIX solution
  - **MST-006** (from midshipmen)
- PNL MIX solution
  - **MST-007** (from VALID)
- PNL Pu solution
  - **PST-034** (from Shaw MS)

Solid gadolinium (metal or oxide)

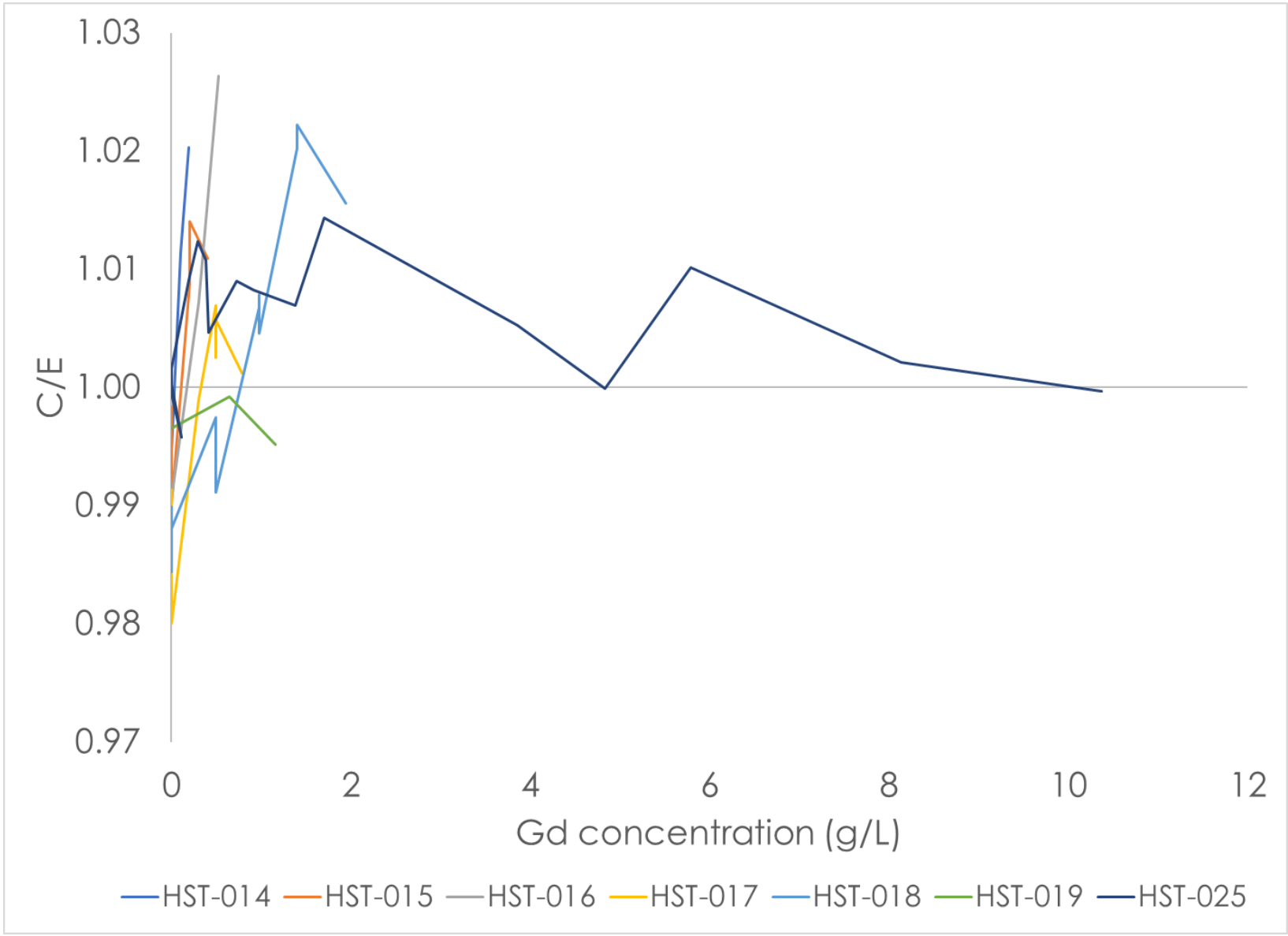
- LANL poly/HEU foil experiments
  - **HMT-010, -016,** and **-044** (from midshipmen)
- KFKI VVER Experiments Part 2
  - **LCT-036 Cases 27-45** (from midshipmen)
  - No Gd_2O_3 in Cases 27, 31, 32, or 33
- IPEN/MB-01 reactor with heavy SS-304 reflector
  - **LCT-043** (from midshipmen)

Results: IPPE models

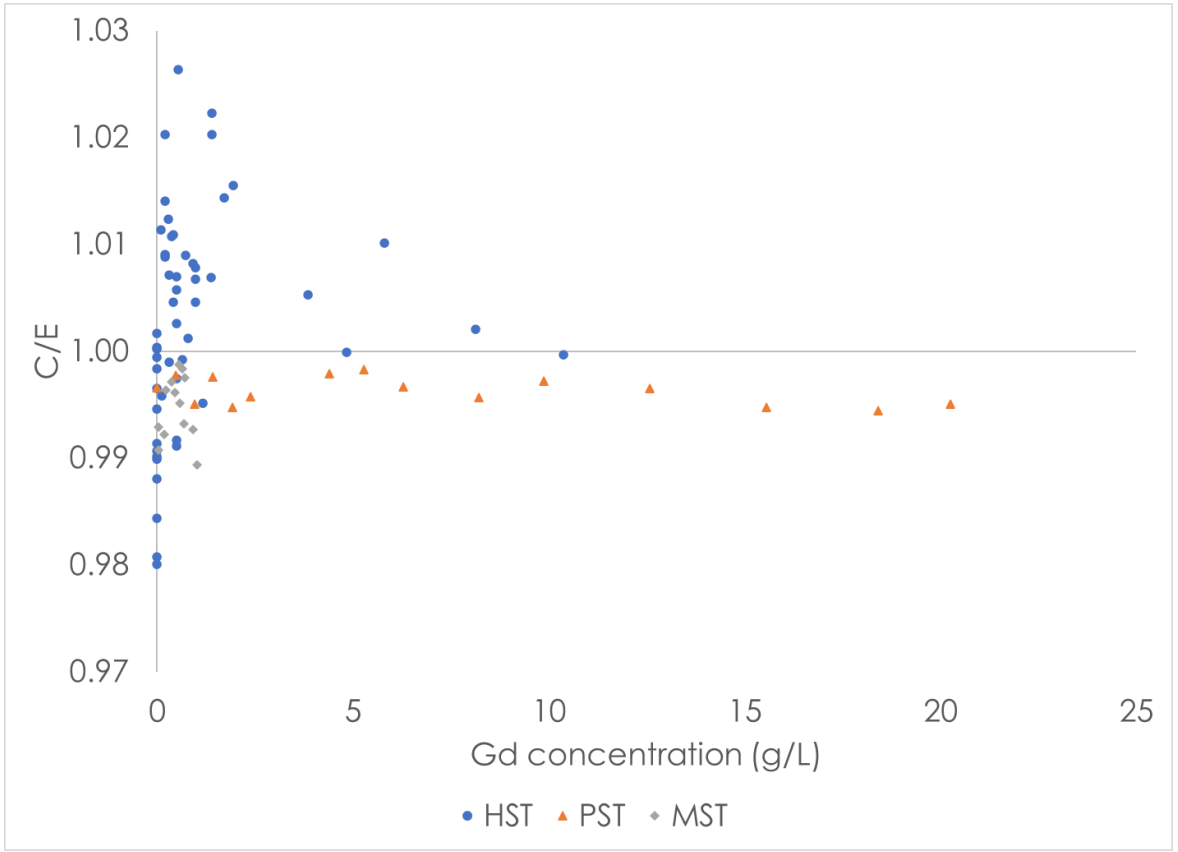
- Questions about these evaluations have existed for some time, given the results from several different codes and data libraries
- ORNL VALID library only contained HST-014 and HST-016
- Examination of other related models prudent to understand performance of all the related evaluations
- 52 total configurations: 20 within 1 σ, 14 between 1 & 2 σ, 10 between 2 & 3 σ, 6 between 3 & 4 σ, and 2 greater than 4 σ
  - 6 existing configurations in VALID, 46 additional configurations here

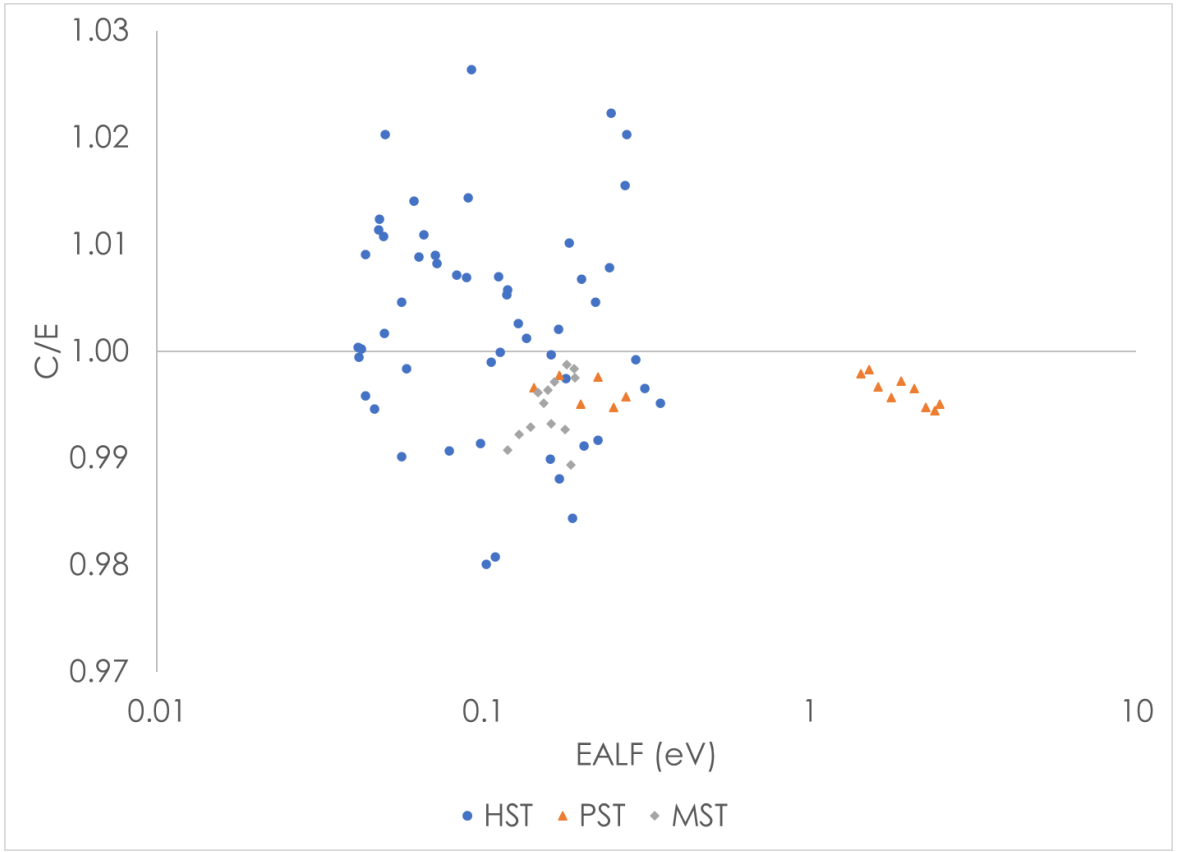
Results: IPPE models

- Generally large variability
- C/E does not always increase with Gd concentration
- Largely confirmation that the evaluations are unreliable



Results: All solutions





No clear trends in data, much larger variability in HST results

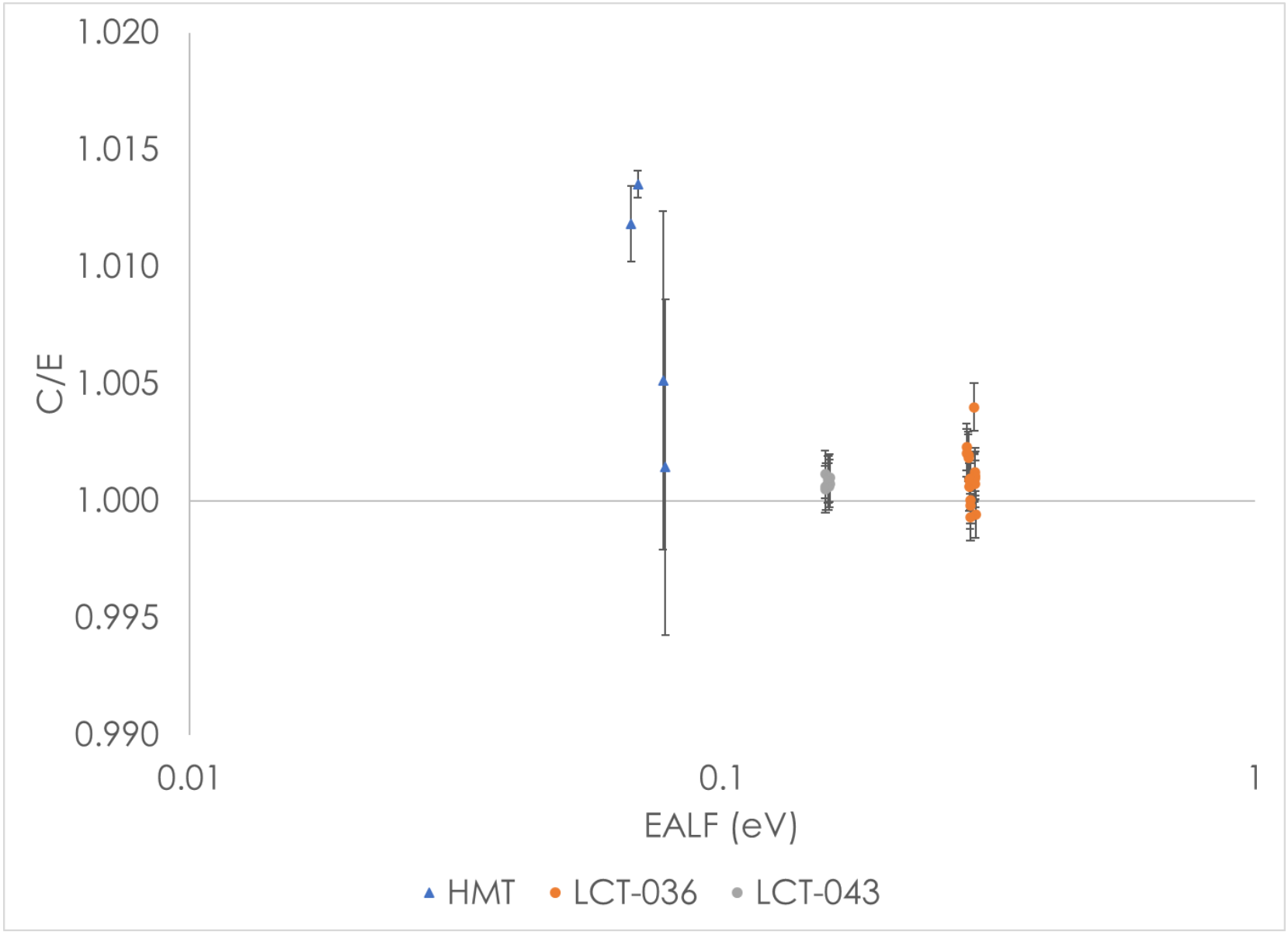
Results: HEU/poly with Gd foils or plates

- HMT-010 has two cases: Case 1 with 14 15-mil foils and Case 2 with 13 7.5-mil foils
  - Both high by less than 1 σ
- HMT-016 has one case with Ni-Cr-Mo-Gd alloy plates
  - High by 7.3 σ
- HMT-034 has one case with Ni-Cr-Mo-Gd alloy plates
  - High by 24 σ
- No trend as a function of EALF

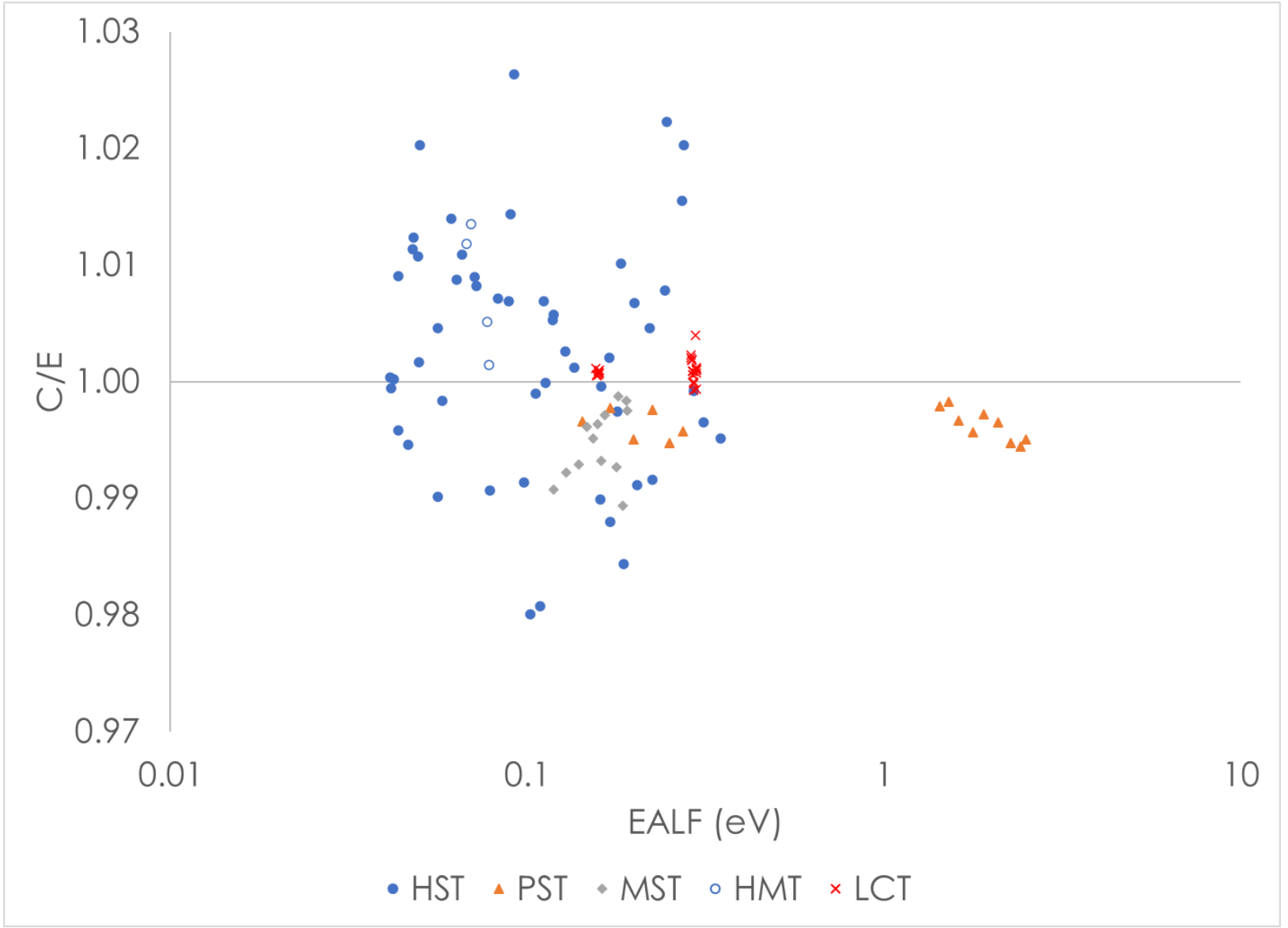
Results: LCT with gadolinia rods

- LCT-036: VVER experiments, part 2
  - Included 4 cases with no Gd rods, 5 cases each 1, 30, or 31 rods
  - Lattice pitch 1.27 cm, enrichment 3.56 wt% ^{235}U
- LCT-043: IPEN/MB-01 reactor with heavy SS-304 reflector
  - Included all 9 cases, 4 or 6 gadolinia rods
  - Lattice pitch 1.5 cm, enrichment 4.35 wt% ^{235}U
- No trend as function of Gd mass or EALF

Results: Solid gadolinium cases



Results: All benchmarks



Conclusions

- Significant expansion of validation set containing gadolinium
  - 13 cases previously in VALID plus 99 new cases
- Completion of IPPE HST experiments confirm no clear trend as a function of concentration or spectrum
  - Significant variability and many mispredictions
- Solid absorber cases also show no clear trends
  - LANL HMT experiments have significant discrepancies in Gd alloy cases
- Almost half of the total gadolinium-bearing cases from the ICSBEP Handbook are considered here: more work to do

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Questions?