OAK RIDGE National Laboratory

ENDF/B-VIII.1β2 Validation Progress with ORNL VALID Critical Experiments

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Outline

- Summary of k_{eff} results for CE calculations with VALID
- More examination of results for:
  - LEU-COMP-THERM benchmarks
  - ^{233}U benchmarks
  - IEU and F benchmarks
  - Thermal Pu benchmarks

VALID benchmarks

- VALID suite at ORNL has been expanded in recent years to include more ICSBEP benchmarks
- More categories of experiments are covered, though some of them have very few cases
- Deuterium- and polyethylene-moderated systems have been added, expanding validation basis for moderators beyond light water

Summary of results: Highlights relative to β1

* No TSL for BeO

Category	ce_v7.1		ce_v8.0		ce_v8.1b1		ce_v8.1b2	
	Avg C/E	Unc	Avg C/E	Unc	Avg C/E	Unc	Avg C/E	Unc
HCT	1.00503	0.00231	1.00184	0.00230	1.00282	0.00231	1.00202	0.00231
HMF*	1.00090	0.00026	1.00016	0.00026	1.00026	0.00026	1.00000	0.00026
HMI	0.99921	0.00042	1.00079	0.00042	0.99956	0.00042	0.99963	0.00042
HSI	0.98602	0.00241	0.98728	0.00241	0.98966	0.00242	0.98952	0.00242
HST	0.99822	0.00072	0.99847	0.00072	0.99948	0.00072	0.99915	0.00072
IMF	1.00352	0.00082	1.00114	0.00081	1.00132	0.00081	1.00195	0.00082
IST	1.00041	0.00077	1.00120	0.00077	1.00060	0.00077	1.00044	0.00077
LCT	0.99962	0.00019	0.99912	0.00019	0.99874	0.00019	**0.99935**	**0.00019**
LMT	1.00600	0.00158	1.00155	0.00157	1.00211	0.00157	1.00162	0.00157
LST	0.99829	0.00083	0.99845	0.00083	0.99920	0.00083	0.99850	0.00083
MCF	0.99887	0.00157	0.99797	0.00157	0.99989	0.00157	0.99786	0.00157
MCT	0.99644	0.00058	0.99555	0.00058	0.99244	0.00058	**0.99611**	**0.00058**
MST	0.99837	0.00158	0.99354	0.00157	0.99177	0.00157	**0.99616**	**0.00158**
PMF	1.00003	0.00045	1.00011	0.00045	0.99978	0.00045	1.00015	0.00045
PMM	1.00040	0.00108	1.00401	0.00108	1.00387	0.00108	1.00256	0.00108
PST	1.00349	0.00051	0.99836	0.00051	0.99970	0.00051	**1.00302**	**0.00051**
UCT	1.00077	0.00141	0.99818	0.00140	1.00368	0.00141	1.00465	0.00141
UMF	0.99853	0.00051	0.99860	0.00051	0.99874	0.00051	0.99899	0.00051
USI	0.98273	0.00124	0.97945	0.00123	0.98761	0.00124	**0.98911**	**0.00124**
USM	0.97987	0.00215	0.97546	0.00214	0.98411	0.00216	**0.98527**	**0.00216**
UST	1.00083	0.00052	0.99750	0.00052	1.00281	0.00053	**1.00340**	**0.00053**

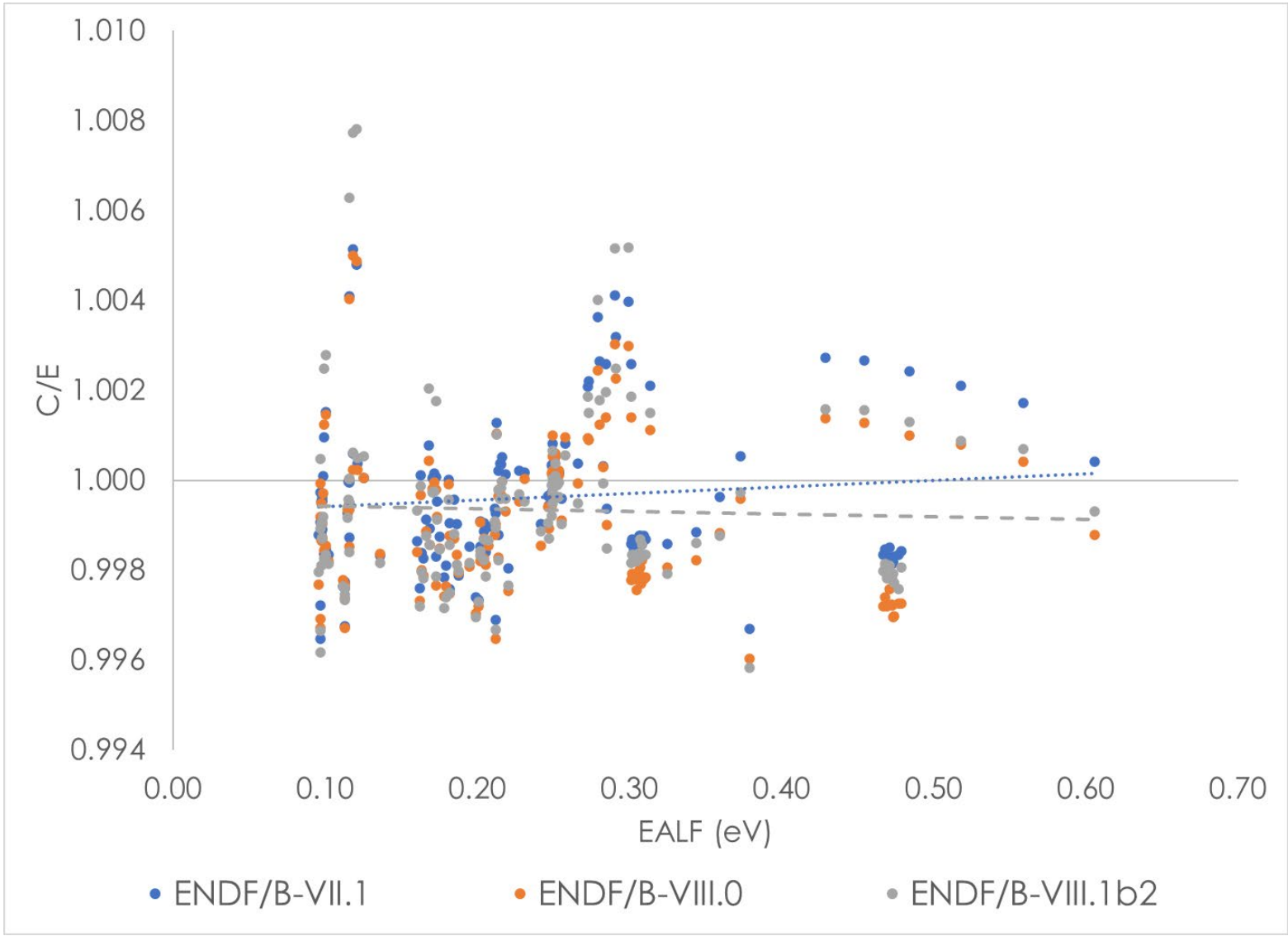
Better

Worse

Different?

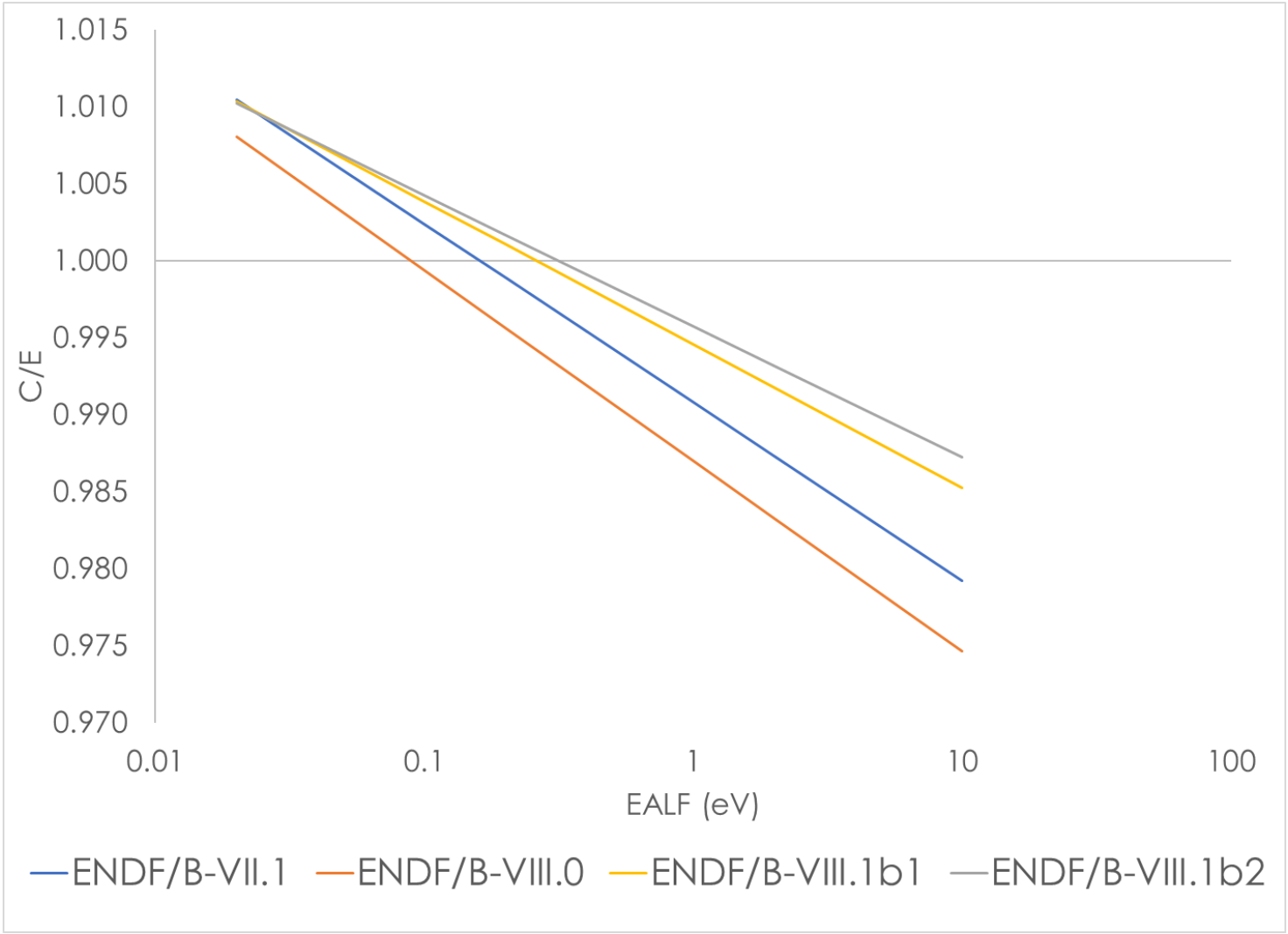
LEU-COMP-THERM results

- β2 improves on average C/E value compared to β1
- β2 average C/E better than ENDF/B-VIII.0, still not as good as ENDF/B-VII.1
- β2 EALF trend very near 0, flatter than ENDF/B-VII.1



^{233}U thermal and intermediate solutions

- C/E values generally higher for β1 & β2 relative to prior releases
- For USM and USI this is an improvement
- For UST it creates a larger over-prediction
- β2 trend is flattest yet



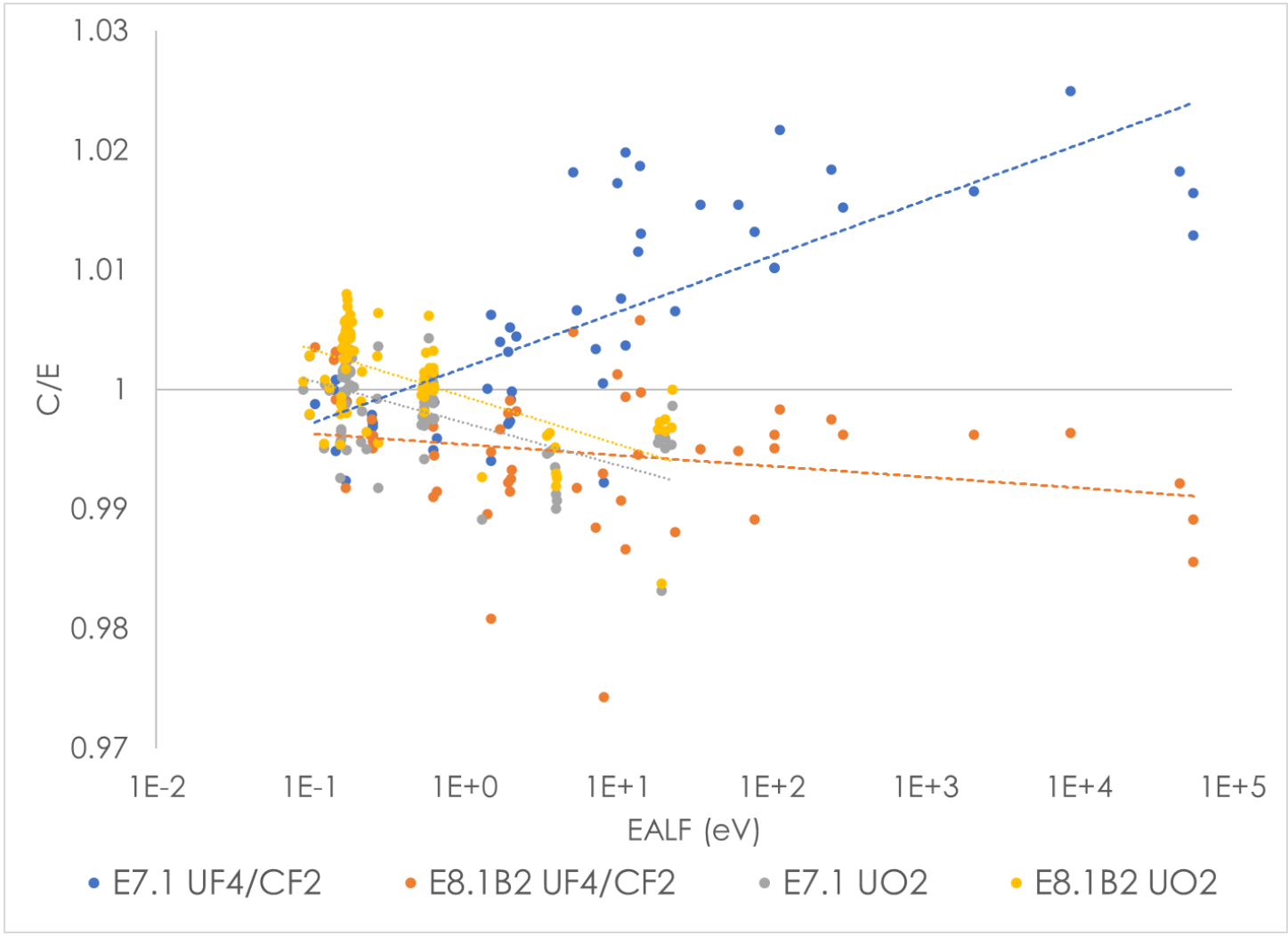
IEU benchmarks: UF_4/CF_2 and UO_2 (1/2)

- ORNL investigated performance of UF_4/CF_2 experiments from ORCEF in 2021and published results at PHYSOR 2022
  - ICSBEP evaluations: ICT-001/ICM-001, ICI-003/ICM-003/ICT-011, ICM-002/ICI-004
- Mike Zerkle indicated at ICNC that ENDF/B-VIII.1β2 improves performance for the UF_6 benchmark
- IEU benchmarks tested with ENDF/B-VIII.1β2 to look at impacts and check UF_4/CF_2 versus other UO_2 IEU experiments
  - IEU evaluations: ICT-002 (light water), ICT-015/ICI-006/ICM-004 (UO_2/wax), ICT-016 (UO_2/wax)

IEU benchmarks: UF_4/CF_2 and UO_2 (2/2)

- Significant reduction in trend for fluoride cases
- Oxide slope similar, level slightly improved
- Average bias for fluoride systems has similar magnitude but opposite sign

Form	ENDF/B-VII.1		ENDF/B-VIII.1β2	
	Avg C/E	σ	Avg C/E	σ
UF_4/CF_2	1.00586	0.00057	0.99462	0.00055
UO_2	0.99854	0.00055	1.00090	0.00055



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Pu-driven thermal benchmarks

- Mismatch between indications provided by pure Pu solutions and thermal mixed Pu/U solutions and oxide pin array systems
- ENDF/B-VIII.0 reduced reactivity of PST systems to improve benchmark predictions
  - Degraded performance for MST and MCT benchmarks
- Large change noted in thermal Pu systems in β2 compared to ENDF/B-VIII.0 and β1
- Post-β2 nubar update improves PSTs a little but slightly degrades MCT/MST systems

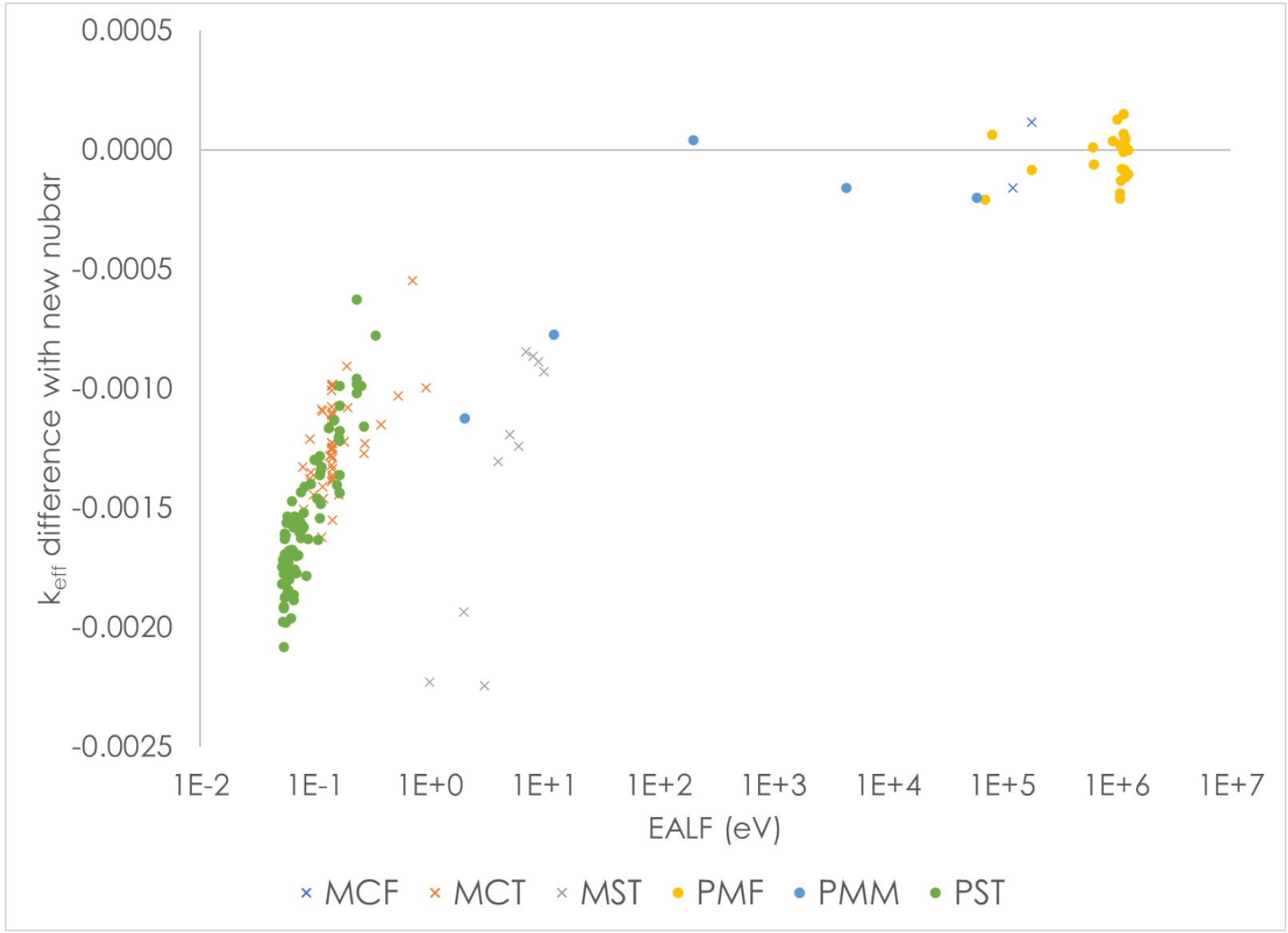
Updated nubar results (1/2)

Category	ce_v7.1		ce_v8.0		ce_v8.1b1		ce_v8.1b2		Updated nubar	
	Avg C/E	Unc	Avg C/E	Unc	Avg C/E	Unc	Avg C/E	Unc	Avg C/E	Unc
MCT	0.99644	0.00058	0.99555	0.00058	0.99244	0.00058	**0.99611**	**0.00058**	**0.99489**	**0.00058**
MST	0.99837	0.00158	0.99354	0.00157	0.99177	0.00157	**0.99616**	**0.00158**	**0.99480**	**0.00157**
PMF	1.00003	0.00045	1.00011	0.00045	0.99978	0.00045	1.00015	0.00045	1.00012	0.00045
PMM	1.00040	0.00108	1.00401	0.00108	1.00387	0.00108	1.00256	0.00108	1.00290	0.00108
PST	1.00349	0.00051	0.99836	0.00051	0.99970	0.00051	**1.00302**	**0.00051**	**1.00146**	**0.00051**

Updated nubar lowers reactivity, so **PST bias is reduced** but **MST bias is more negative**. MST bias is likely more negative as well, but the impact is not statistically significant.

Updated nubar results (2/2)

- Updated nubar does not impact intermediate or fast spectrum systems
- Reactivity change is very similar for all thermal Pu-driven systems



Conclusions

- Large differences in thermal Pu systems with β2
  - Post-β2 nubar adjustment moves partially back towards β1 and ENDF/B-VIII.0
- New fluorine evaluation dramatically reduces the energy-dependent trend in ORCEF UF_4/CF_2 experiments
  - Bias now negative, magnitude may be slightly smaller
  - Impact on fluoride salt FHRs and MSRs
- Improvement on energy-dependent trends in LCT and ^{233}U
- Bias improvement for LCTs, still not as good as ENDF/B-VII.1

Acknowledgment

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Questions?