OAK RIDGE National Laboratory

Recent Testing of ENDF/B-VIII.0 at ORNL

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CSEWG Validation Committee
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Outline

1. Overview of comparison of ENDF/B-VII.1 and ENDF/B-VIII.0
2. Summary of results from VALID
3. Detailed comparisons
   - LCT recap
   - MCT/MST/PST individually and combined
4. A few words about graphite
5. Summary

Overview of comparisons of ENDF/B-VII.1 and ENDF/B-VIII.0

- Use VALID suite to test >600 cases with ENDF/B-VII.1 and ENDF/B-VIII.0 in KENO V.a/KENO-VI
  - SCALE 6.3 beta releases have both libraries
  - Compare k_{eff} C/E values
- Limited number of cases tested with TSUNAMI
  - Compare sensitivities primarily through c_k and E calculations
  - No further details in this presentation
    - All c_k values 0.98 or higher
    - All E values 0.99 or higher

KENO V.a results summary

Category	ENDF/B-VIII.0		ENDF/B-VII.1		Difference		
	Avg. C/E	Avg. C/E unc.	Avg. C/E	Avg. C/E unc.	(E8.0 – E7.1)	Unc.	Δ/Unc.
HMF	1.00179	0.00039	1.00198	0.00039	-0.00019	0.00055	0.3
HST	0.99824	0.00074	0.99774	0.00072	0.00050	0.00103	0.5
IMF	1.00061	0.00082	1.00289	0.00083	-0.00228	0.00117	2.0
LCT	0.99921	0.00018	0.99960	0.00018	-0.00039	0.00025	1.5
LST	0.99845	0.00083	0.99823	0.00083	0.00022	0.00117	0.2
MCF	0.99797	0.00157	0.99890	0.00157	-0.00093	0.00222	0.4
MCT	0.99811	0.00087	0.99916	0.00087	-0.00105	0.00123	0.9
MST	0.99354	0.00157	0.99839	0.00158	-0.00485	0.00223	2.2
PMF	0.99942	0.00062	0.99952	0.00062	-0.00010	0.00088	0.1
PST	0.99772	0.00055	1.00301	0.00056	-0.00529	0.00078	6.7
UCT	0.99818	0.00140	1.00080	0.00141	-0.00262	0.00199	1.3
UMF	0.99860	0.00051	0.99845	0.00051	0.00015	0.00072	0.2
USI	0.97945	0.00123	0.98275	0.00124	-0.00330	0.00175	1.9
USM	0.97546	0.00214	0.97901	0.00215	-0.00355	0.00303	1.2
UST	0.99750	0.00052	1.00016	0.00052	-0.00266	0.00074	3.6

KENO-VI results summary

Category	ENDF/B-VIII.0		ENDF/B-VII.1		Difference		
	Avg. C/E	Avg. C/E unc.	Avg. C/E	Avg. C/E unc.	(E8.0 – E7.1)	Unc.	Δ/Unc.
HMF	0.99814	0.00044	0.99872	0.00044	-0.00058	0.00062	0.9
IMF	1.00407	0.00274	1.00589	0.00275	-0.00183	0.00388	0.5
MCT	0.99362	0.00078	0.99417	0.00078	-0.00055	0.00110	0.5

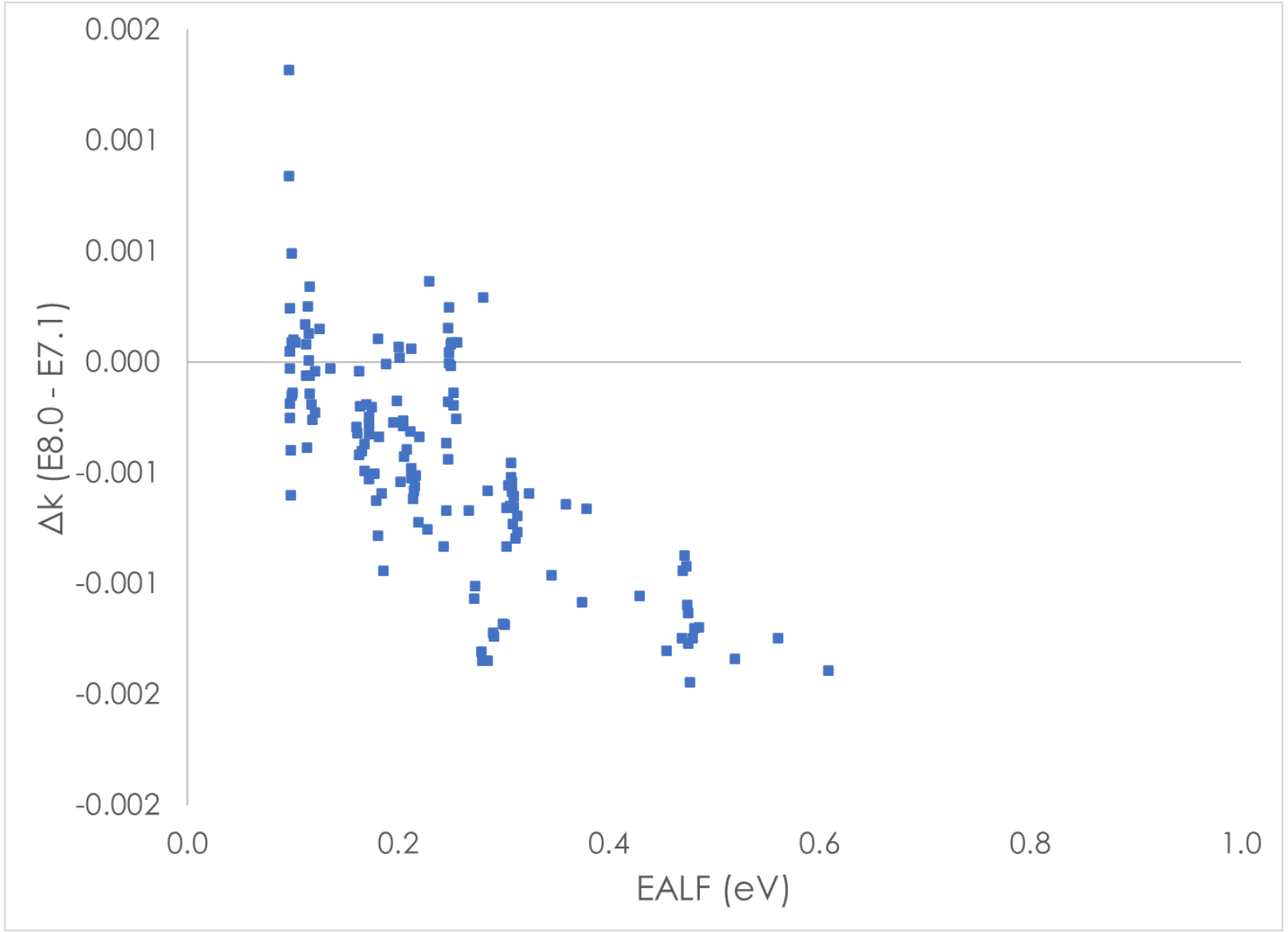
Pooled results summary

Category	ENDF/B-VIII.0		ENDF/B-VII.1		Difference		
	Avg. C/E	Avg. C/E unc.	Avg. C/E	Avg. C/E unc.	(E8.0 – E7.1)	Unc.	Δ/Unc.
HMF	0.99982	0.00030	1.00022	0.00030	-0.00040	0.00042	1.0
IMF	1.00114	0.00081	1.00335	0.00082	-0.00222	0.00115	1.9
MCT	0.99555	0.00058	0.99631	0.00058	-0.00076	0.00082	0.9

- HMF: 23 KENO V.a and 27 KENO-VI (50 total cases)
- IMF: 11 KENO V.a and 2 KENO-VI (13 total cases)
- MCT: 21 KENO V.a and 28 KENO-VI (49 total cases)
- Such pooling not recommended for code validation

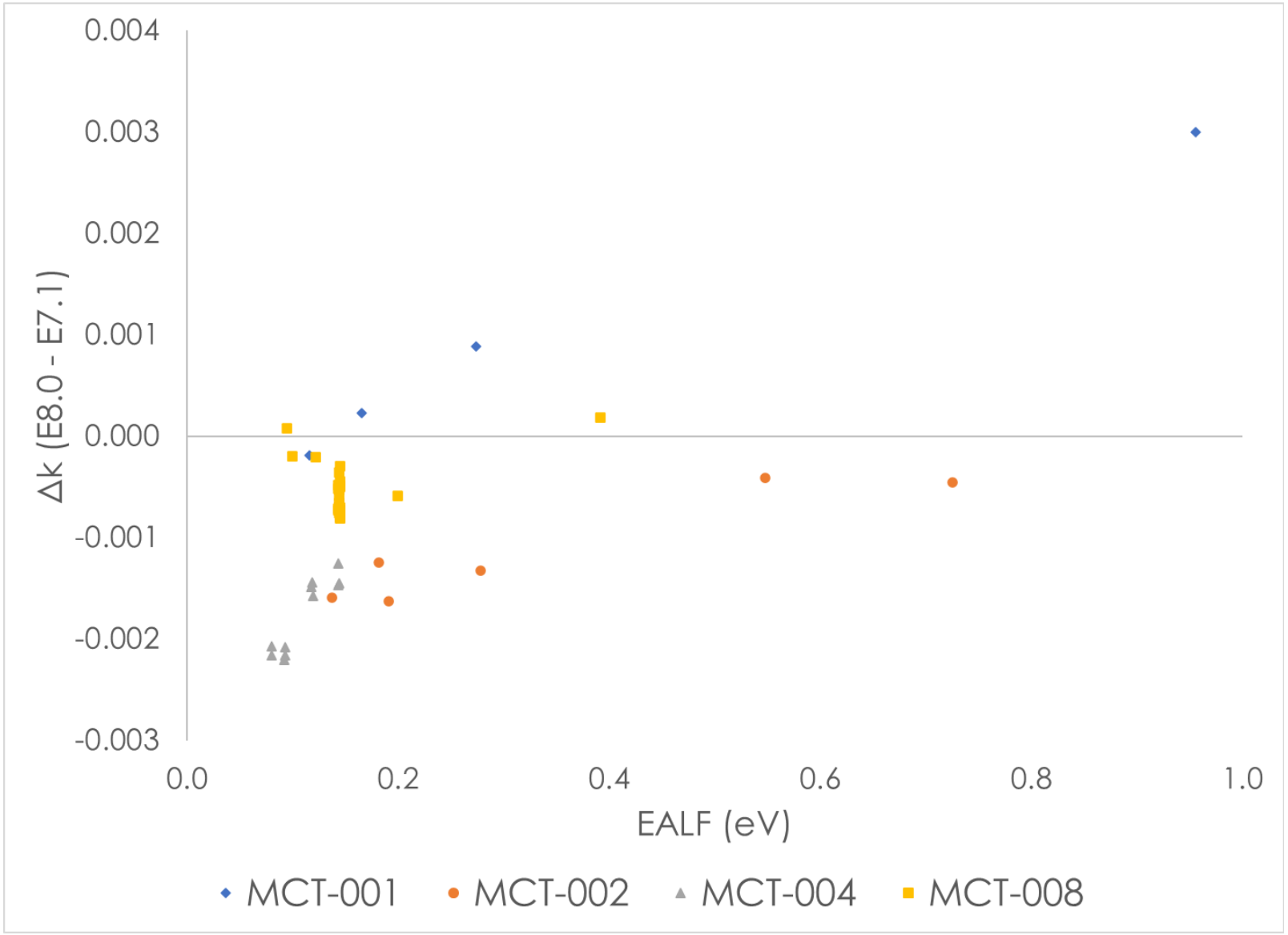
Changes for LCT experiments – recap from last year

- Bias attributed to ^{16}O
- Lower calculated k_{eff} values represent increased magnitude bias for ENDF/B-VIII.0



Changes for MCT experiments

- Slightly positive trend
  - Opposite of LCTs
- Lower calculated k_{eff} values represent increased magnitude bias for ENDF/B-VIII.0



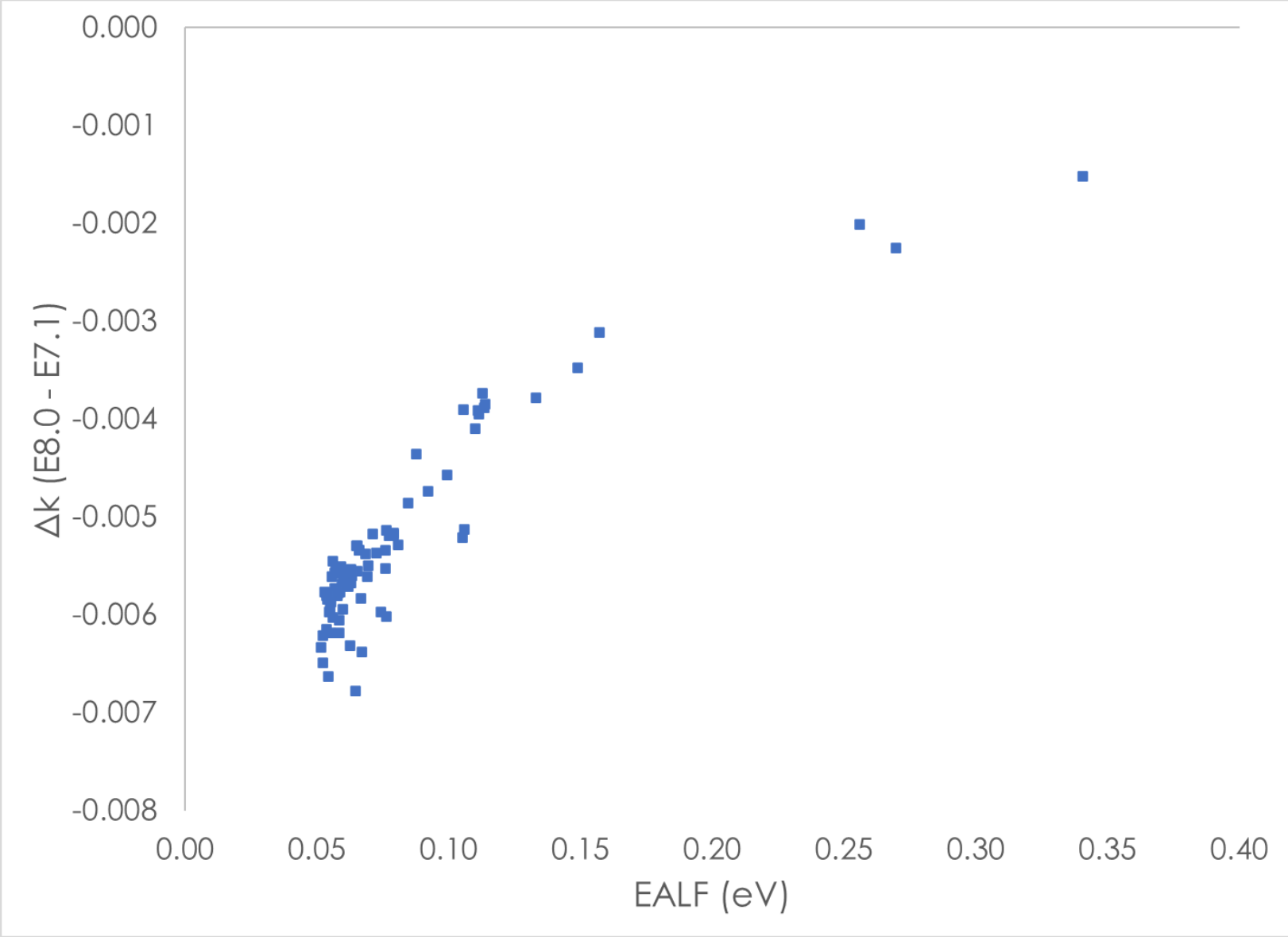
Changes for MST experiments

- MCT delta was unexpected
- What trend do MST experiments show?
- Lower calculated k_{eff} values represent increased magnitude bias for ENDF/B-VIII.0
- Only 10 cases, but significantly lower average C/E:
  - ENDF/B-VII.1: 0.99839 ± 0.00158
  - ENDF/B-VIII.0: 0.99354 ± 0.00157
- Consistent with PST results
  - Natural or depleted uranium in all cases

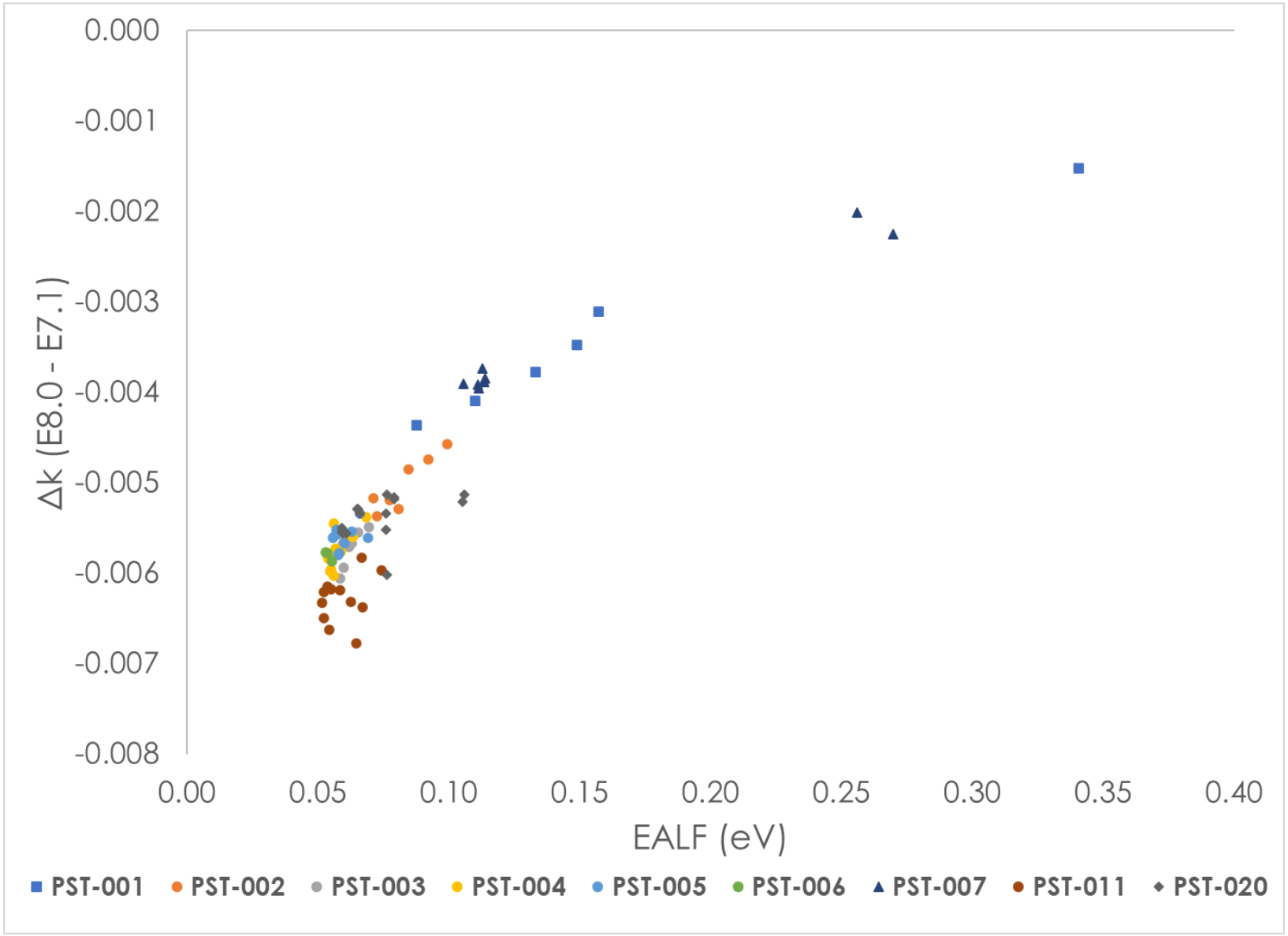
Changes for PST experiments

- Decreasing overprediction for PST experiments is one of the top-line features of ENDF/B-VIII.0
- Average C/E dropped from 1.00301 ± 0.00056 to 0.99772 ± 0.00055
- Change not uniform – as shown on next slide
- Generally consistent trend across multiple evaluations

Changes for PST experiments (continued)

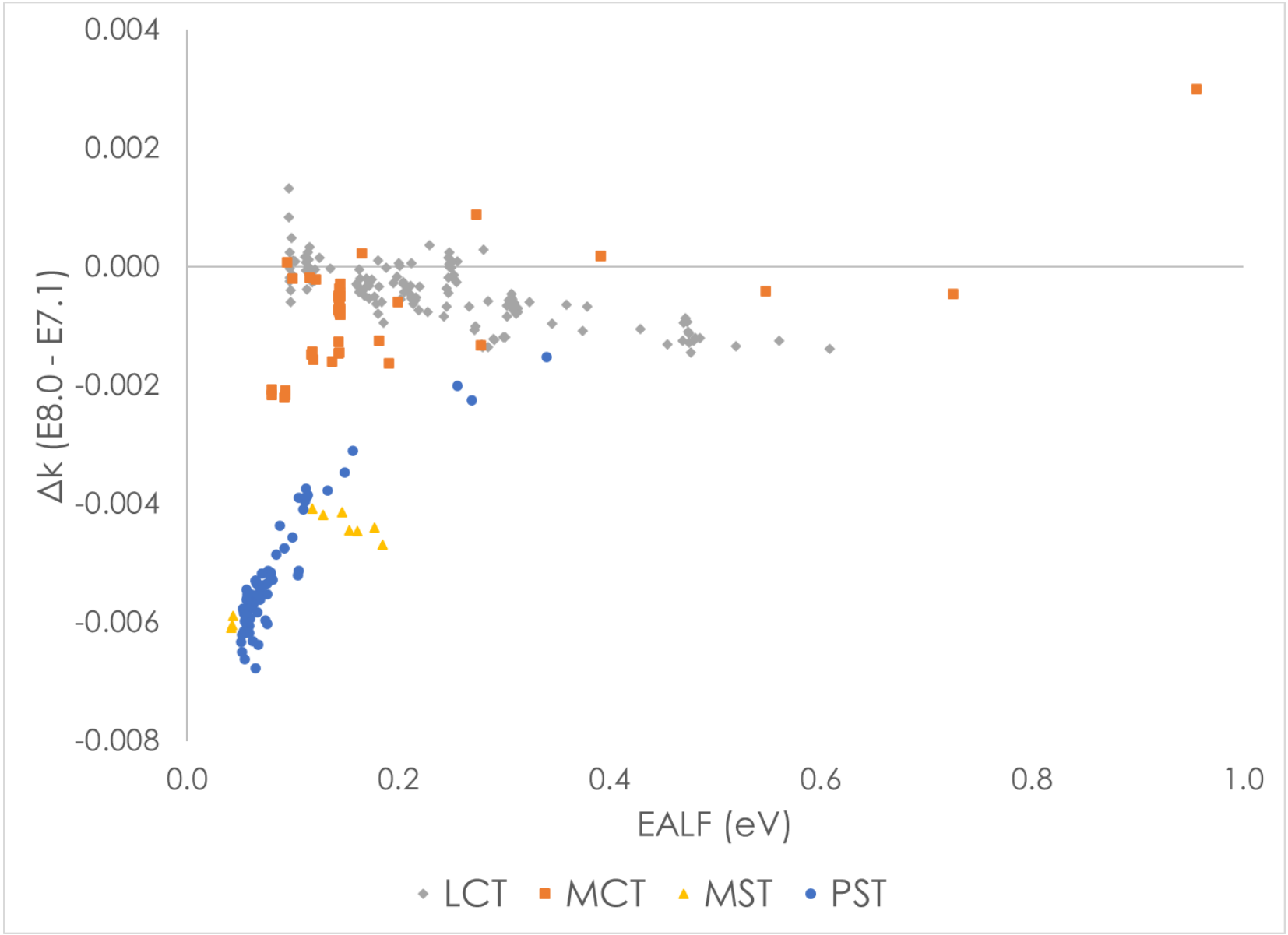


Changes for PST experiments (continued)



Crossing the streams…

- MCT results driven by Pu
- Predictions of oxide-fueled array experiments closer to measurements than solutions for highly thermalized systems



A few words about graphite

- Graphite performance investigated across ENDF/B-VII.0, ENDF/B-VII.1, and ENDF/B-VIII.0 for MSR and HTGR models
  - Results published previously at ANS Winter Meeting 2019 and *Annals of Nuclear Energy* June 2020
  - Models at room temperature
    - Elevated temperature HTTR models may be examined in the future
- Brief summary of the results presented here to make sure the Validation Committee is aware of the work

Eigenvalue comparison – graphite moderated systems

	Δρ (pcm) ENDF/B-VII.0 vs. ENDF/B-VII.1	Δρ (pcm) ENDF/B-VIII.0 vs. ENDF/B-VII.1
Graphite moderated MSR cell – fresh	259(10)	-68(22)
Graphite moderated MSR cell – depleted	483(22)	-93(24)
HTTR (Full core model)	913(16)	-312(19)
HTR-10 (Full core model)	1090(14)	-311(13)

Carbon capture update, e.g. at 0.0253 eV:

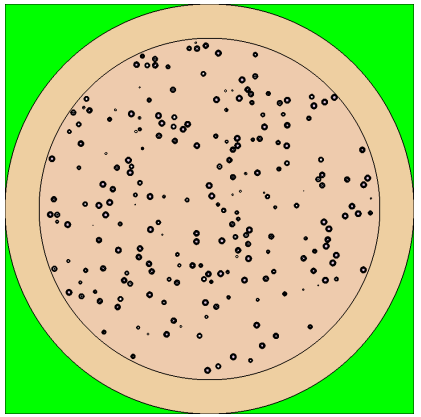
- ENDF/B-VII.0: 3.368 mb
- ENDF/B-VII.1: 3.861 mb

Differences caused by?

HTR-10 pebble model: ENDF/B-VII.1 vs. ENDF/B-VIII.0

Replace individual nuclides in ENDF/B-VII.1 calculation by ENDF/B-VIII.0 data:

Basis: ENDF 7.1	**Δρ to all ENDF 7.1 (pcm)**
But: graphite from ENDF 8.0	**−3(14)**
But: ^{235}U from ENDF 8.0	**−251(13)**
But: ^{238}U from ENDF 8.0	**85(13)**
All ENDF 8.0	**−157(13)**



HTR-10 fuel pebble

- Differences between ENDF/B-VII.0 and VII.1: carbon capture
- Differences between ENDF/B-VII.1 and VIII.0: ^{235}U and ^{238}U

ENDF/B-VIII.0: graphite with different porosities

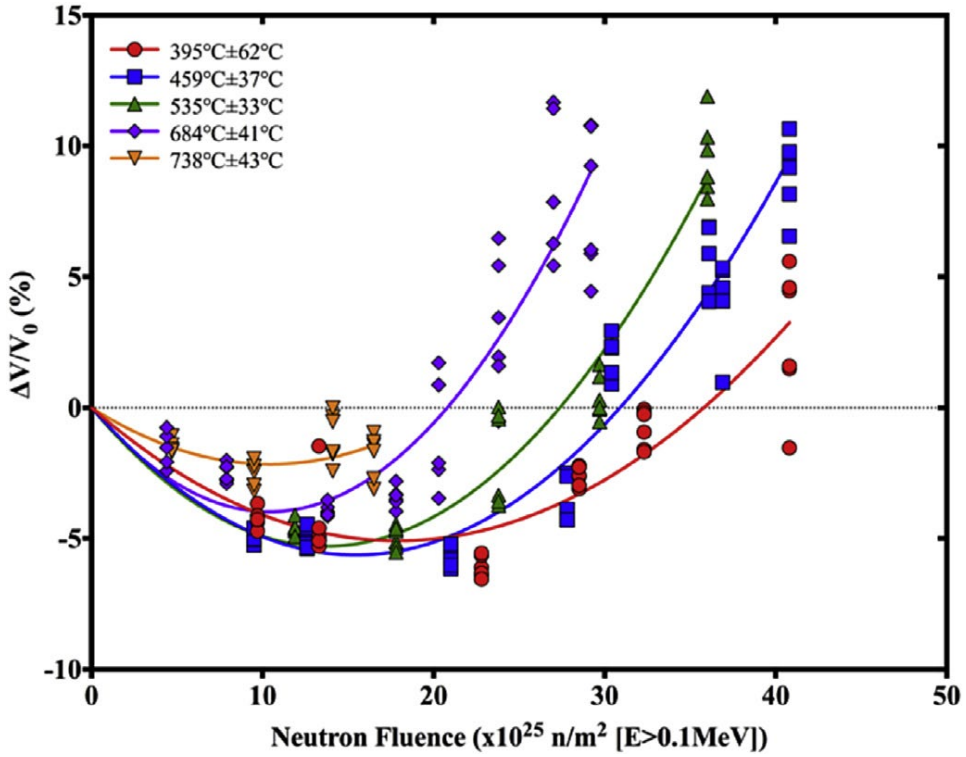
ENDF/B-VIII.0 provides different graphite data:

1. perfect crystal
2. 10% porosity
3. 30% porosity

HTR-10: ENDF/B-VIII.0 data

Applied graphite data	Δρ (pcm)
All graphite	(ref)
10% porosity in reflector (but not in pebbles)	**1(49)**
30% porosity in reflector (but not in pebbles)	**−165(55)**
All 10% porosity	**342(28)**
All 30% porosity	**665(26)**

Do we always know our porosity? In each area?



Specimen volume change versus neutron fluence for specimens irradiated at different temperatures (courtesy of A. A. Campbell)

Anne A. Campbell, et al., "Property Changes of G347A Graphite Due to Neutron Irradiation," *Carbon* 109, pp. 860–873, 2016.

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Summary

- ORNL has recently completed a comparison of ENDF/B-VIII.0 and ENDF/B-VII.1 using the VALID library
  - ORNL/TM report in review, to be published soon
- Work is also being performed for advanced reactor applications
- Other efforts on-going
  - Covariance data evaluations discussed in covariance committee
  - Expanding VALID for greater applicability to advanced reactors
    - Intermediate enrichment
    - Graphite and lead
  - Also trying to investigate more intermediate spectrum cases

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Questions?

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