

Chlorine Benchmark Comparison Study

ENDF/B-VIII.0, ENDF/B-VIII.1, and ENDF/B-VIII.2beta

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Introduction to Chlorine Benchmarks

- There currently exists five benchmark evaluations that utilize chlorine absorbers:
 - TEX-Chlorine (HEU-MET-THERM-038)
 - Chlorine Worth Study (PU-MET-THERM-005)
 - LEU-COMP-THERM-045
 - LEU-COMP-THERM-106
 - HEU-SOL-THERM-044

ENDF/B-VIII.0 → ENDF/B-VIII.1 → ENDF/B-VIII.2beta
New Chlorine Evaluation

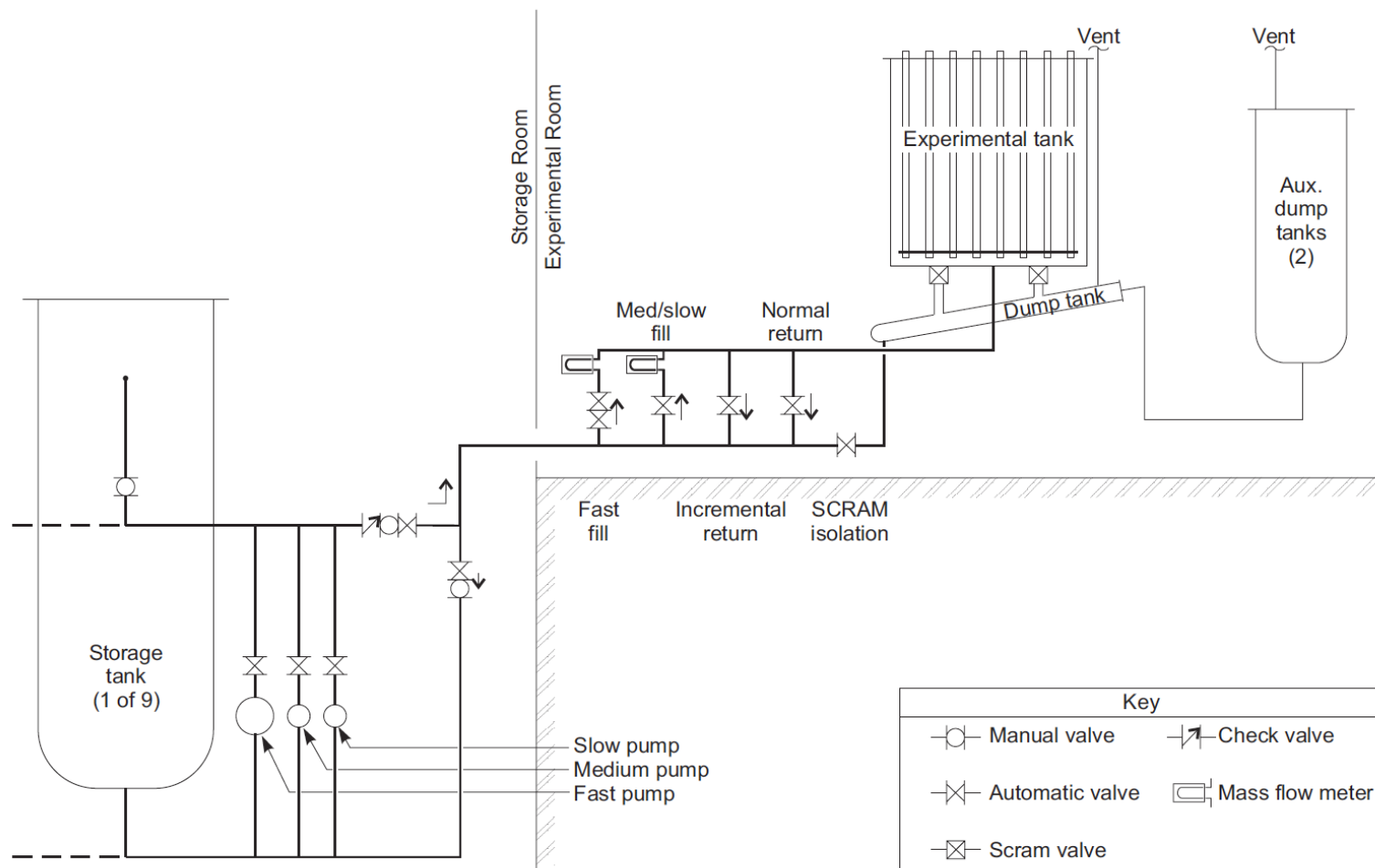
Changes to the Nuclear Data

- Changes to isotopes and channels of importance to these benchmarks:
 - **Cl-35/37:** Significant changes including addition of LANL evaluation
 - Still uses ENDF/B-VIII.0 resonance region
 - C-12: Small cross section changes
 - Fe-54: Cross section changes in the resonance region / (n,elastic) dip change
 - U-234: Updated resonance parameters
 - Changes to elastic, capture, and fission cross sections
 - U-238: Prompt fission neutron spectrum adjustments

*Phase 1 branch as of October 16, 2025

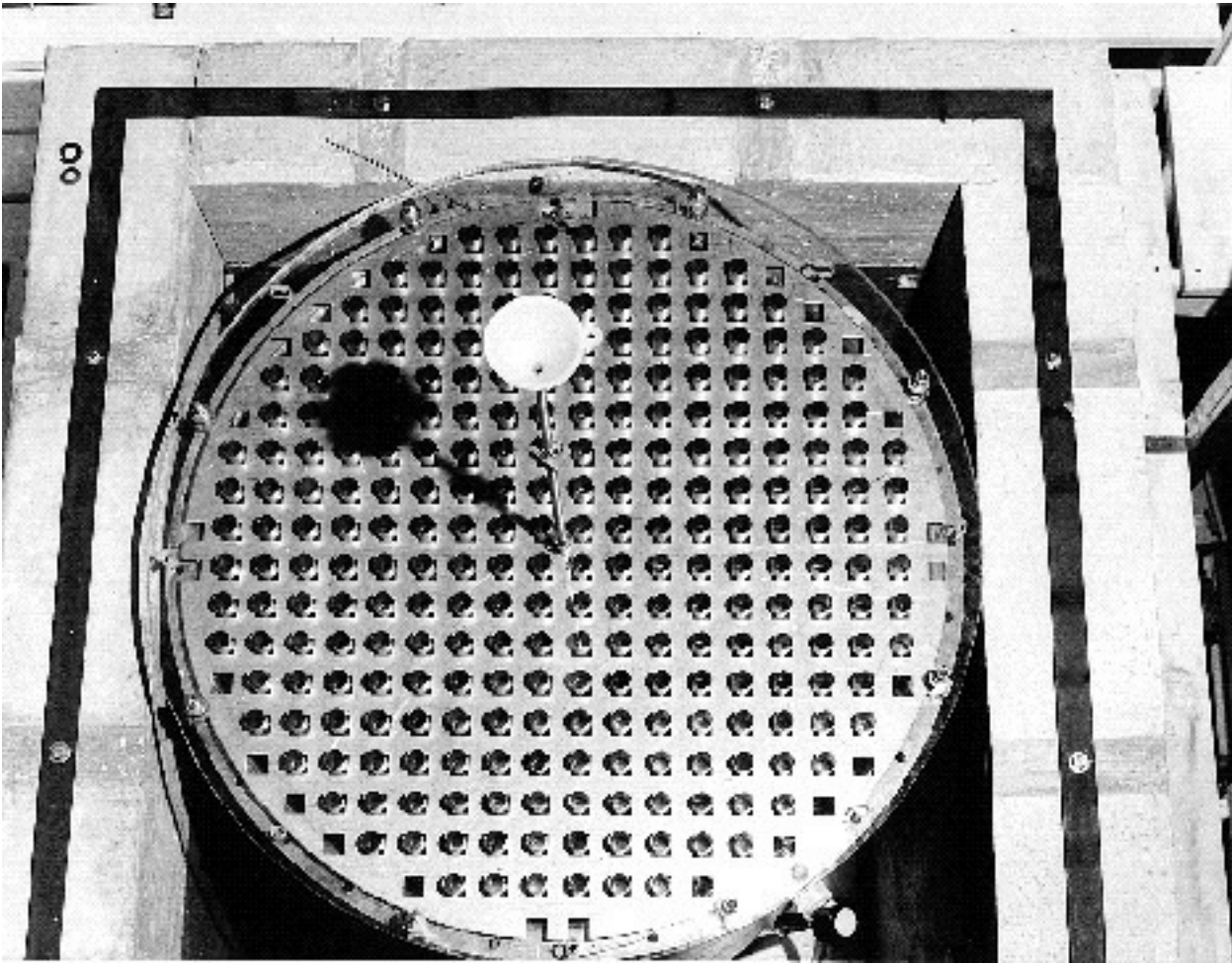
HEU-SOL-THERM-044

- This is a uranyl nitrate solution experiment with absorber rods
 - 31 experiments were found to be acceptable
 - 2 included PVC absorbers
 - 29 included no chlorine
- Experiments performed at the Rocky Flats Critical Mass Lab in 1983 and 1984



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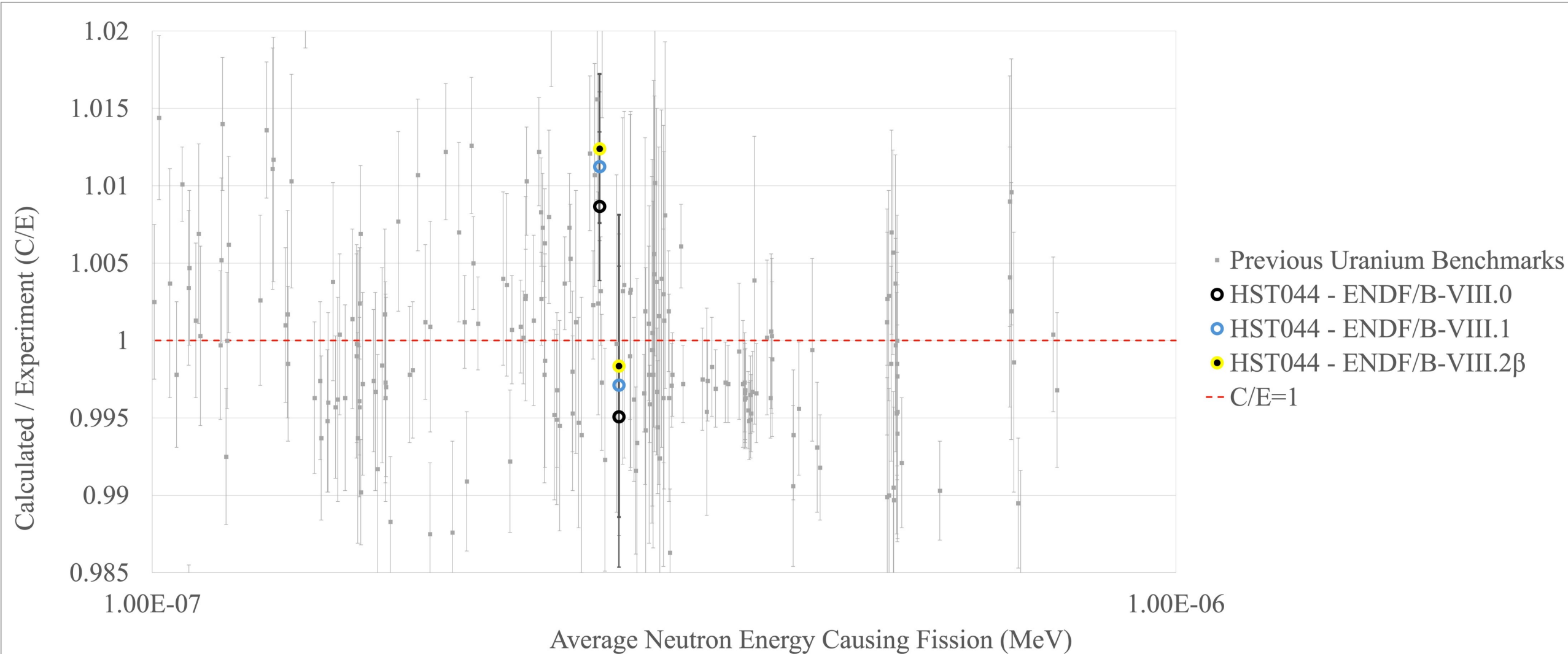
HEU-SOL-THERM-044



- Both of the configurations are dominated in the thermal regime
- Reactivity was controlled via solution height
- Rods are non-fissile absorber rods encapsulated in stainless steel

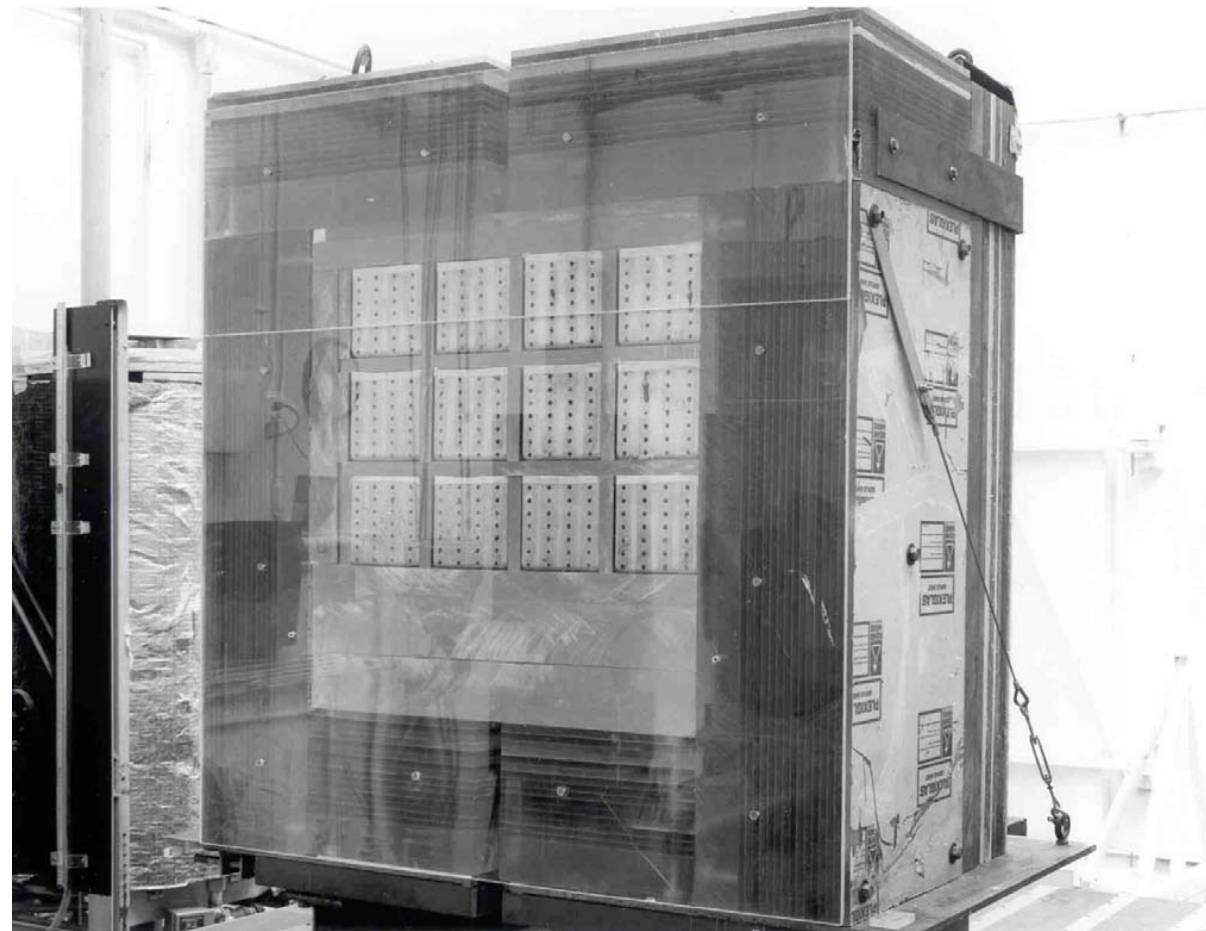
Case	Thermal (<0.625 eV)	Intermediate (0.625 eV - 100 keV)	Fast (>100 keV)
2	77.55%	20.37%	2.08%
3	77.90%	20.17%	1.93%

HEU-SOL-THERM-044

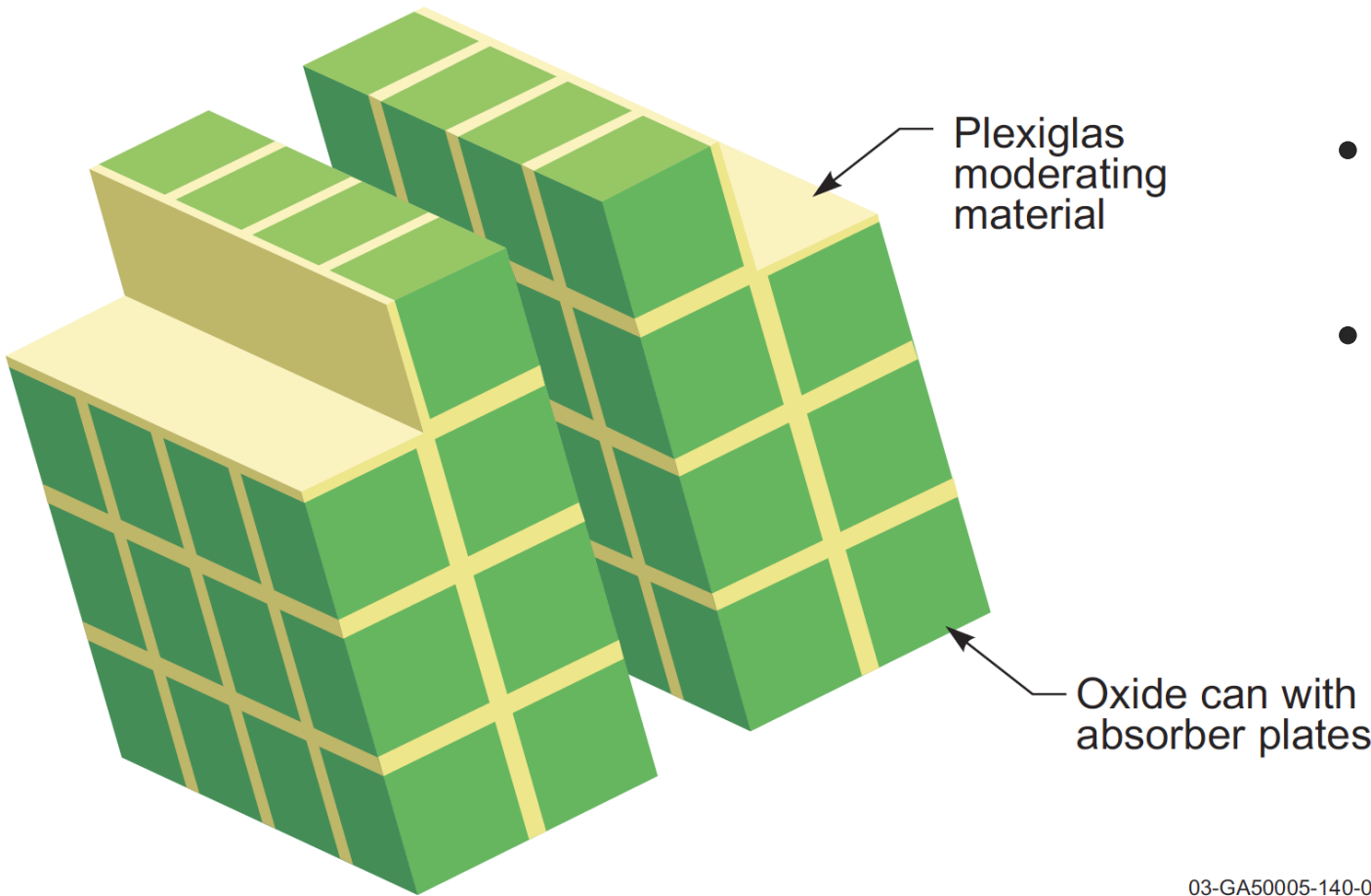


LEU-COMP-THERM-045

- U_3O_8 Powder experiments using a Horizontal Split Table at the Rocky Flats Critical Experiment Facility in 1978
 - Used either Plexiglas or Concrete reflectors
 - Interstitial Plexiglas in all configurations
 - 21 acceptable configurations
 - 3 used PVC absorbers
 - 1 used a Plexiglas reflector
 - 2 used a concrete reflector



LEU-COMP-THERM-045



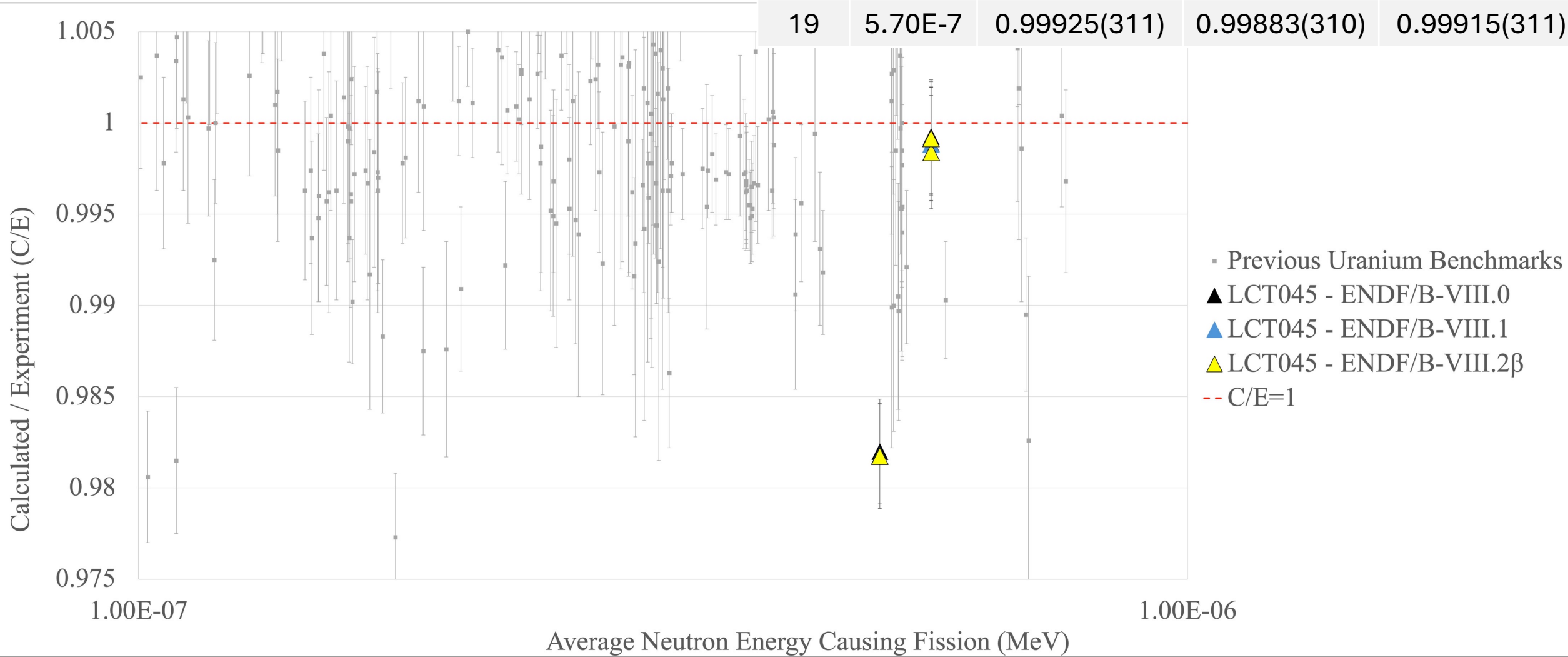
- All three configurations were almost entirely thermal
- Interstitial moderator thicknesses were all the same
- Reactivity was controlled by separation distance

Case	Thermal (<0.625 eV)	Intermediate (0.625 eV - 100 keV)	Fast (>100 keV)
6	78.10%	13.80%	8.10%
18	76.83%	14.96%	8.21%
19	76.80%	15.00%	8.20%

03-GA50005-140-0:

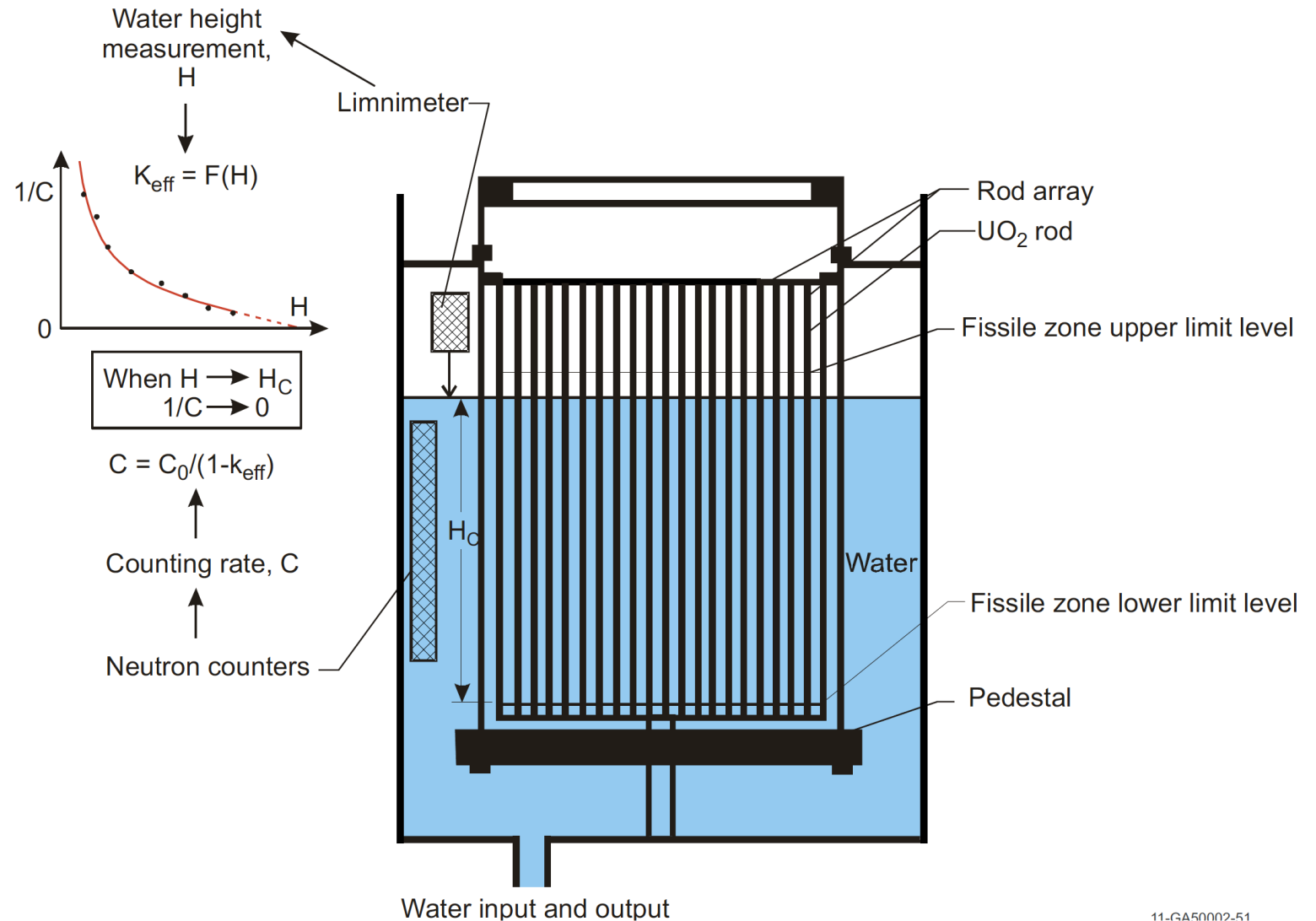
LEU-COMP-THERM-045

Case	EALF (MeV)	ENDF/B-VIII.0 C/E	ENDF/B-VIII.1 C/E	ENDF/B-VIII.2b C/E
6	5.09E-7	0.98200(287)	0.98176(287)	0.98174(286)
18	5.70E-7	0.99886(311)	0.99841(310)	0.99840(311)
19	5.70E-7	0.99925(311)	0.99883(310)	0.99915(311)



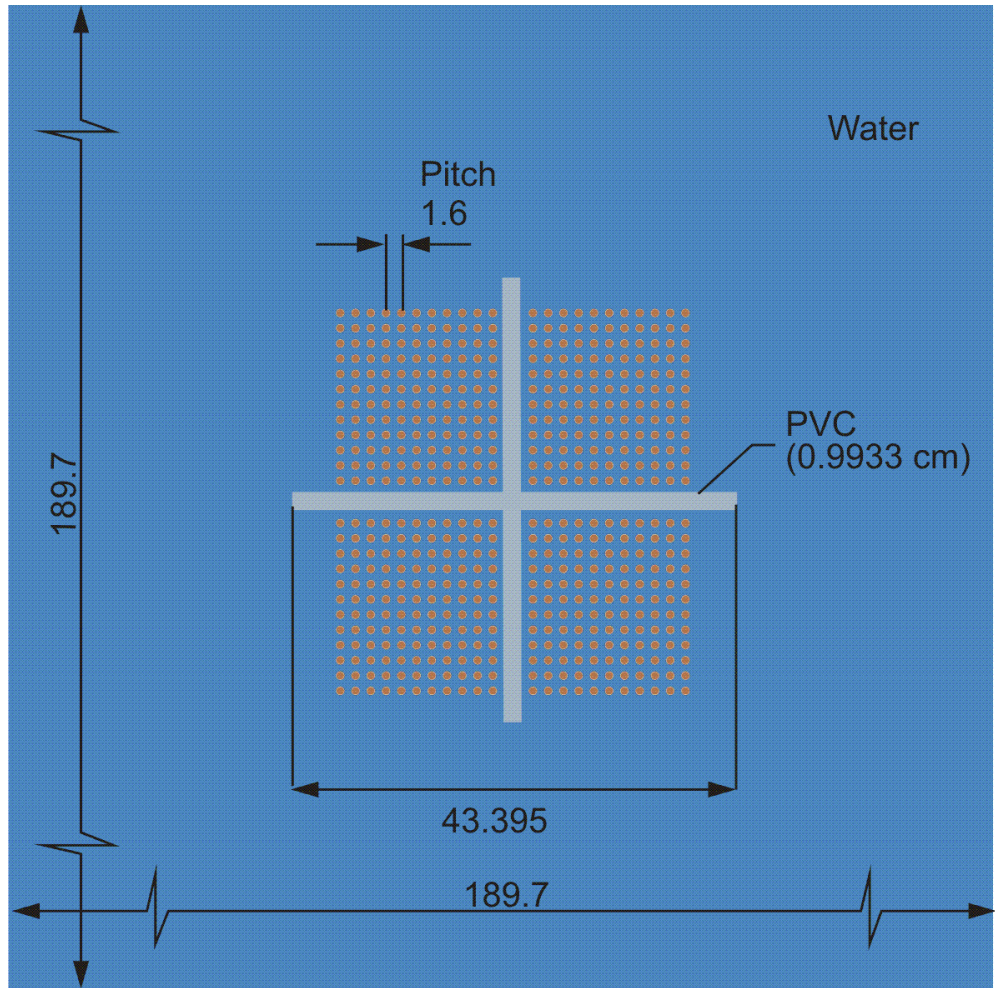
LEU-COMP-THERM-106

- UO_2 fuel rod experiment performed at the Matériaux Interaction Reflexion Toutes Epaisseurs (MIRTE2.2) at IRSN before December 2013
 - 6 cases were evaluated
 - 2 cases included chlorine
 - 1 PVC absorber case
 - 1 NaCl absorber case

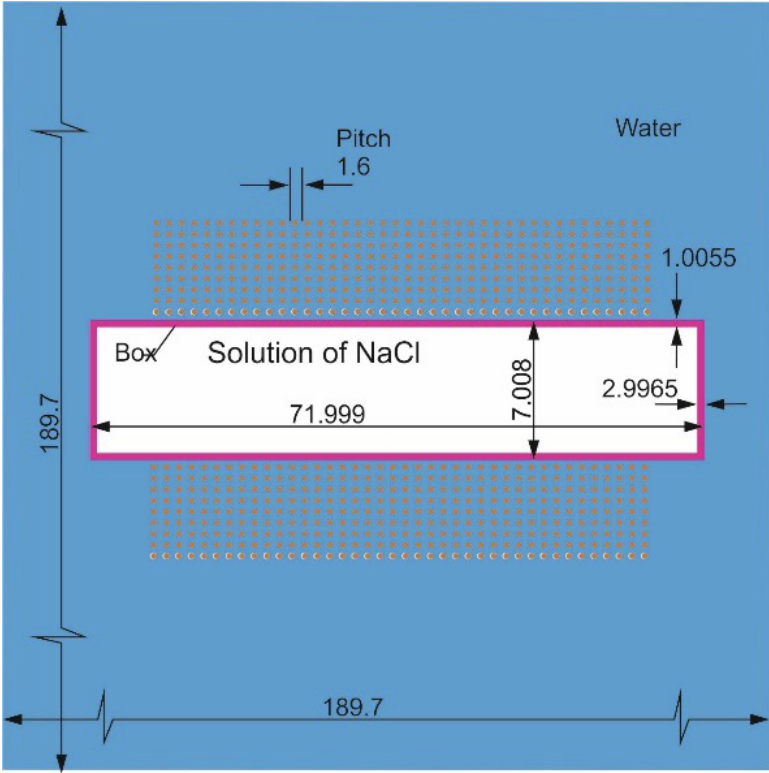


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LEU-COMP-THERM-106



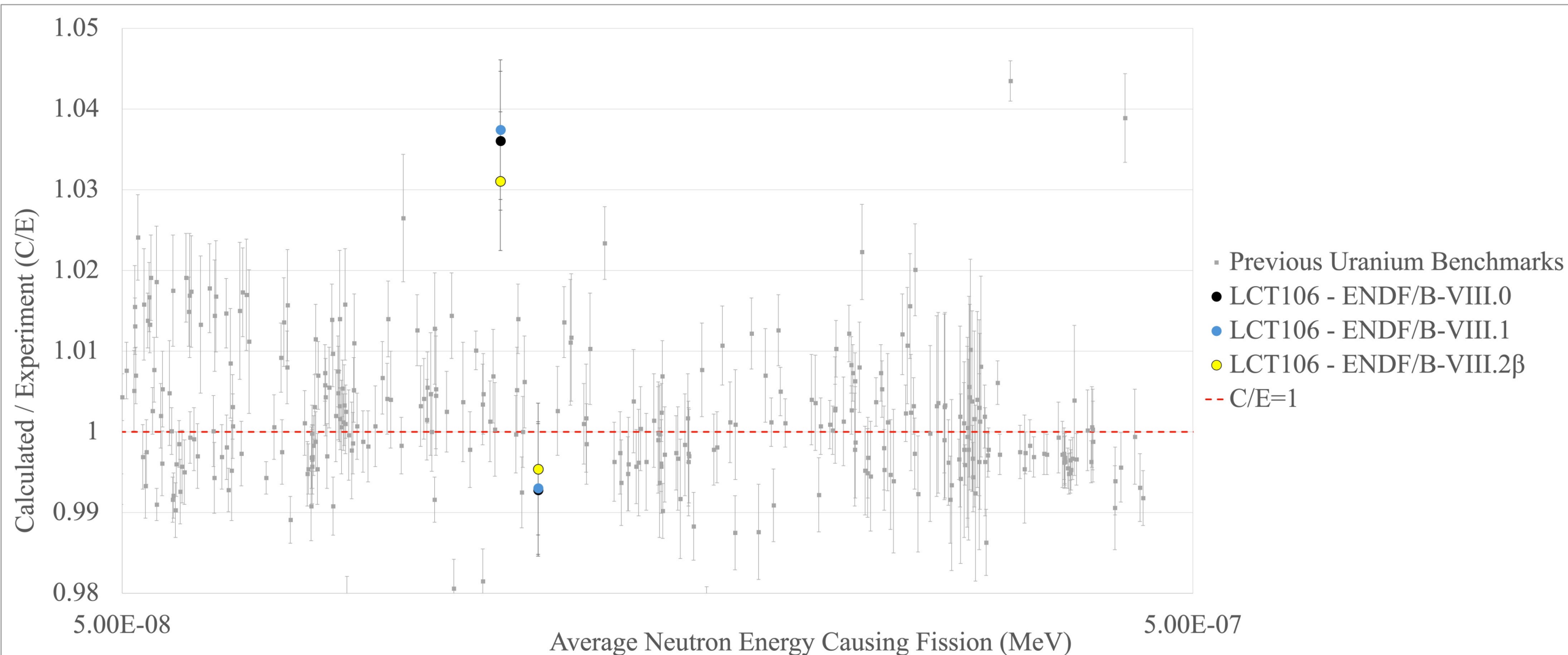
Dimensions in cm
11-GA50002-107-29



Dimensions in cm
11-GA50002-107-23

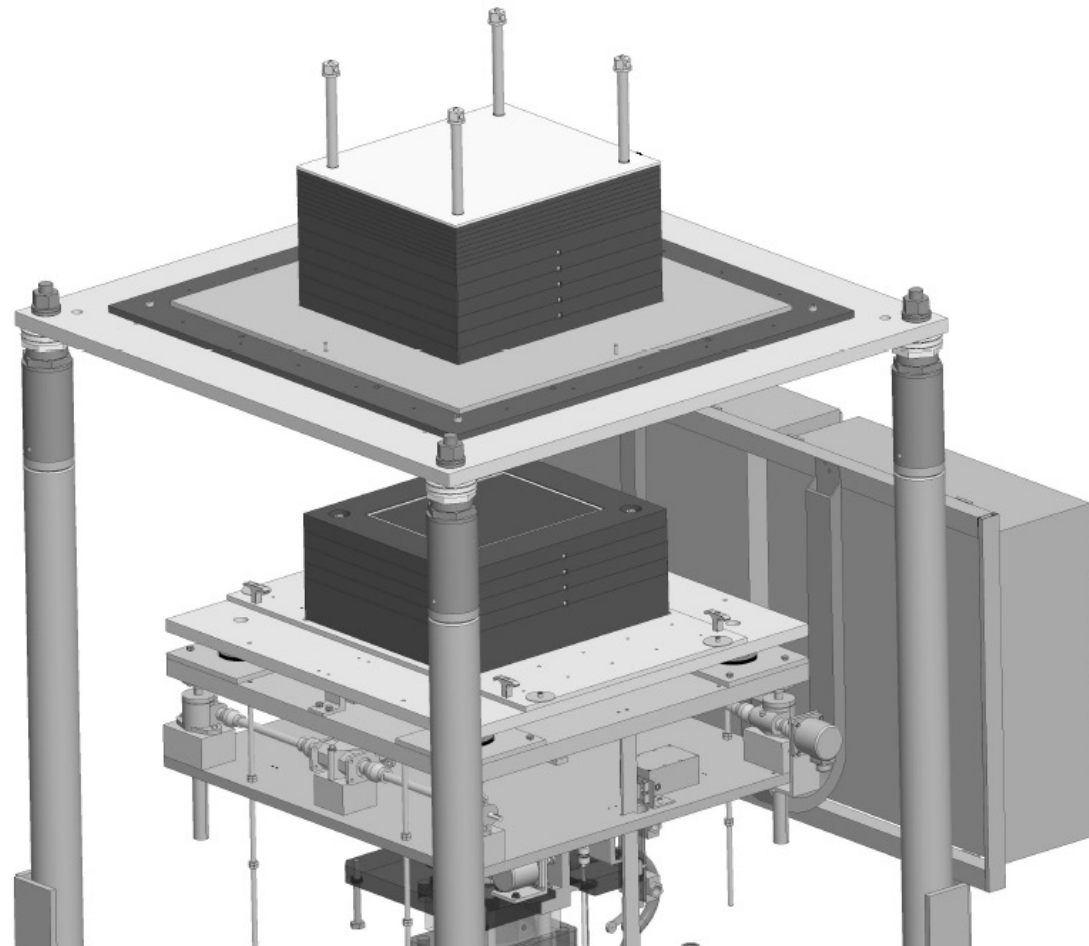
Case	Thermal (<0.625 eV)	Intermediate (0.625 eV - 100 keV)	Fast (>100 keV)
1	89.27%	7.05%	3.67%
2	89.96%	6.59%	3.45%

LEU-COMP-THERM-106

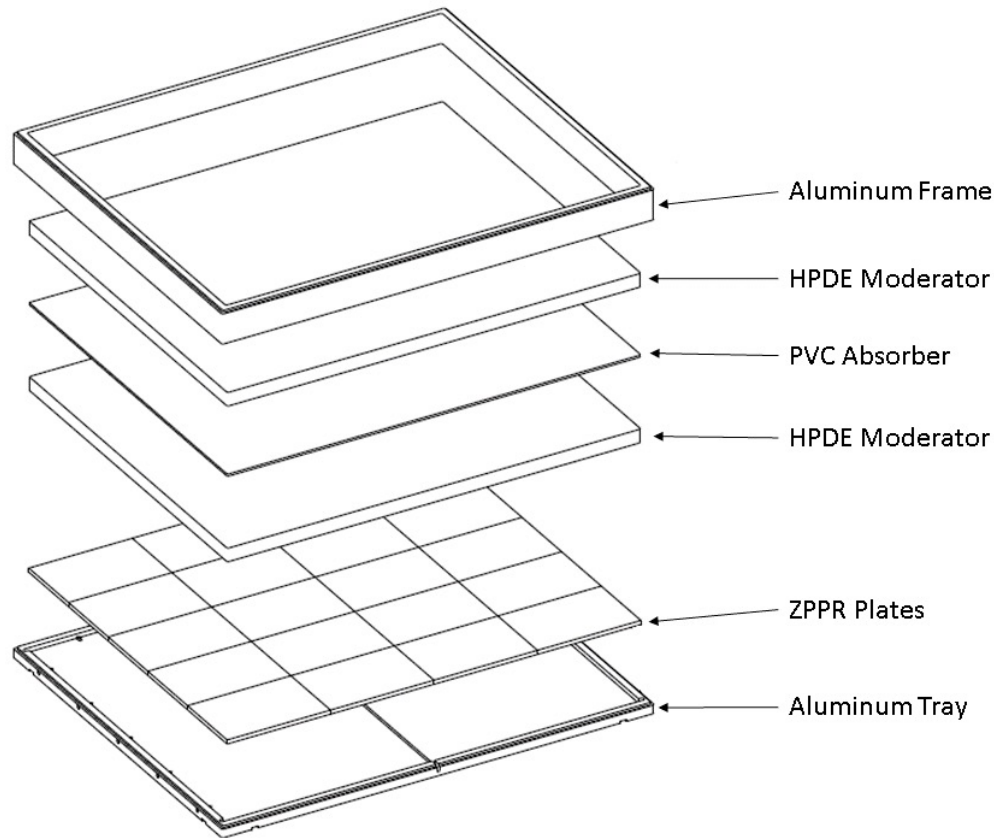


PU-MET-THERM-005 (Chlorine Worth Study)

- Uses the Pu ZPPR PANN plates
- Experiments performed at NCERC (NNSS) in November to December 2021
 - PVC and CPVC absorber material
 - HDPE reflection and moderation
- 3 configurations evaluated
 - All three contained chlorine
 - 2 include PVC
 - 1 included CPVC



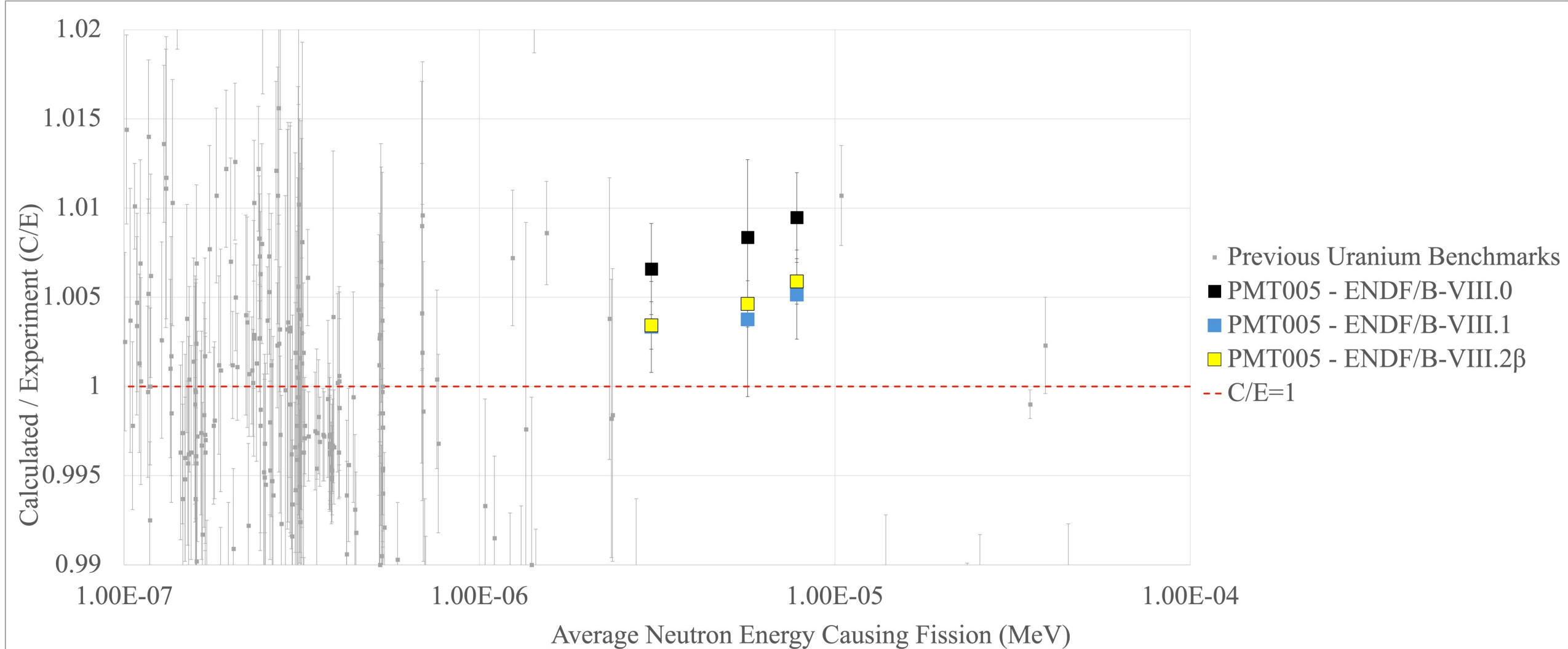
PU-MET-THERM-005 (Chlorine Worth Study)



- All three configurations were predominantly thermal
- CPVC and PVC primarily differ by chlorine content

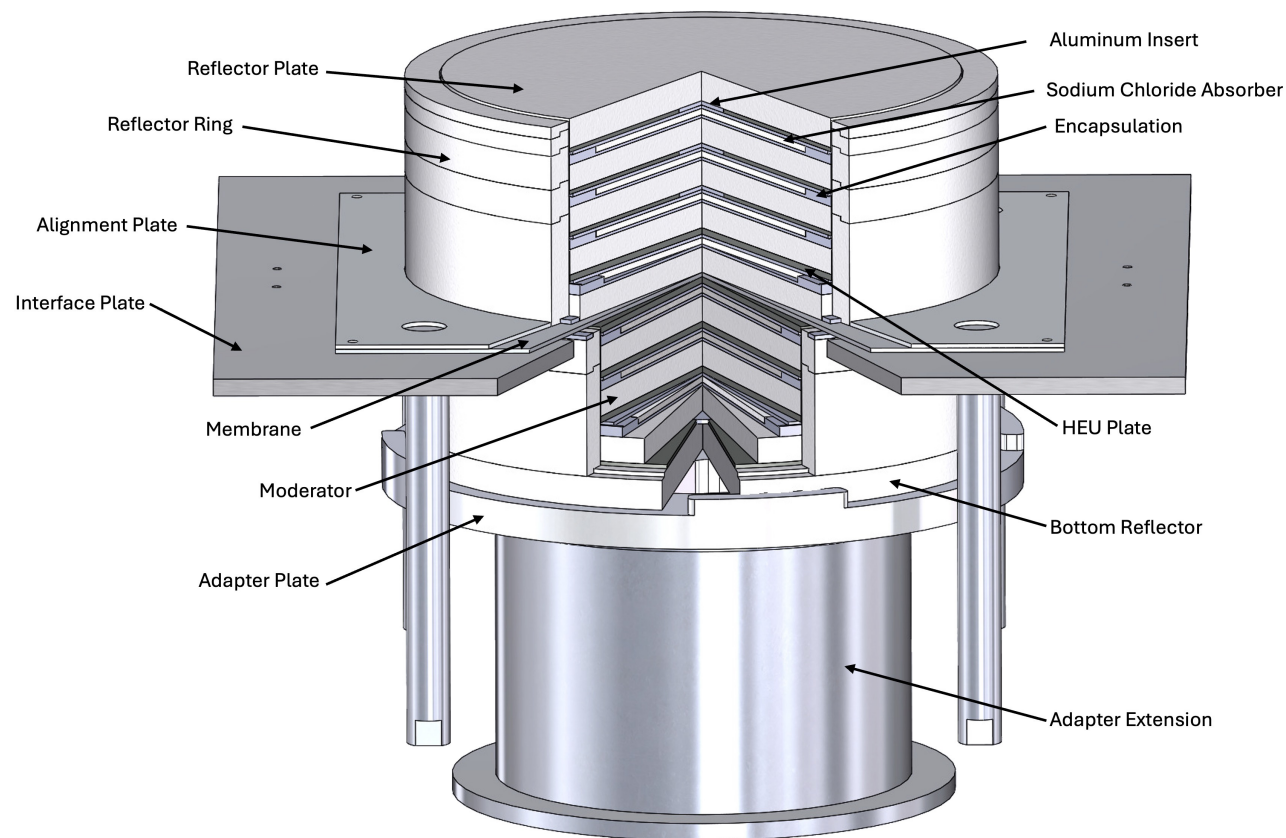
Case	Thermal (<0.625 eV)	Intermediate (0.625 eV - 100 keV)	Fast (>100 keV)
1	62.95%	23.54%	13.51%
2	54.12%	29.50%	16.38%
3	57.02%	27.58%	15.40%

PU-MET-THERM-005 (Chlorine Worth Study)

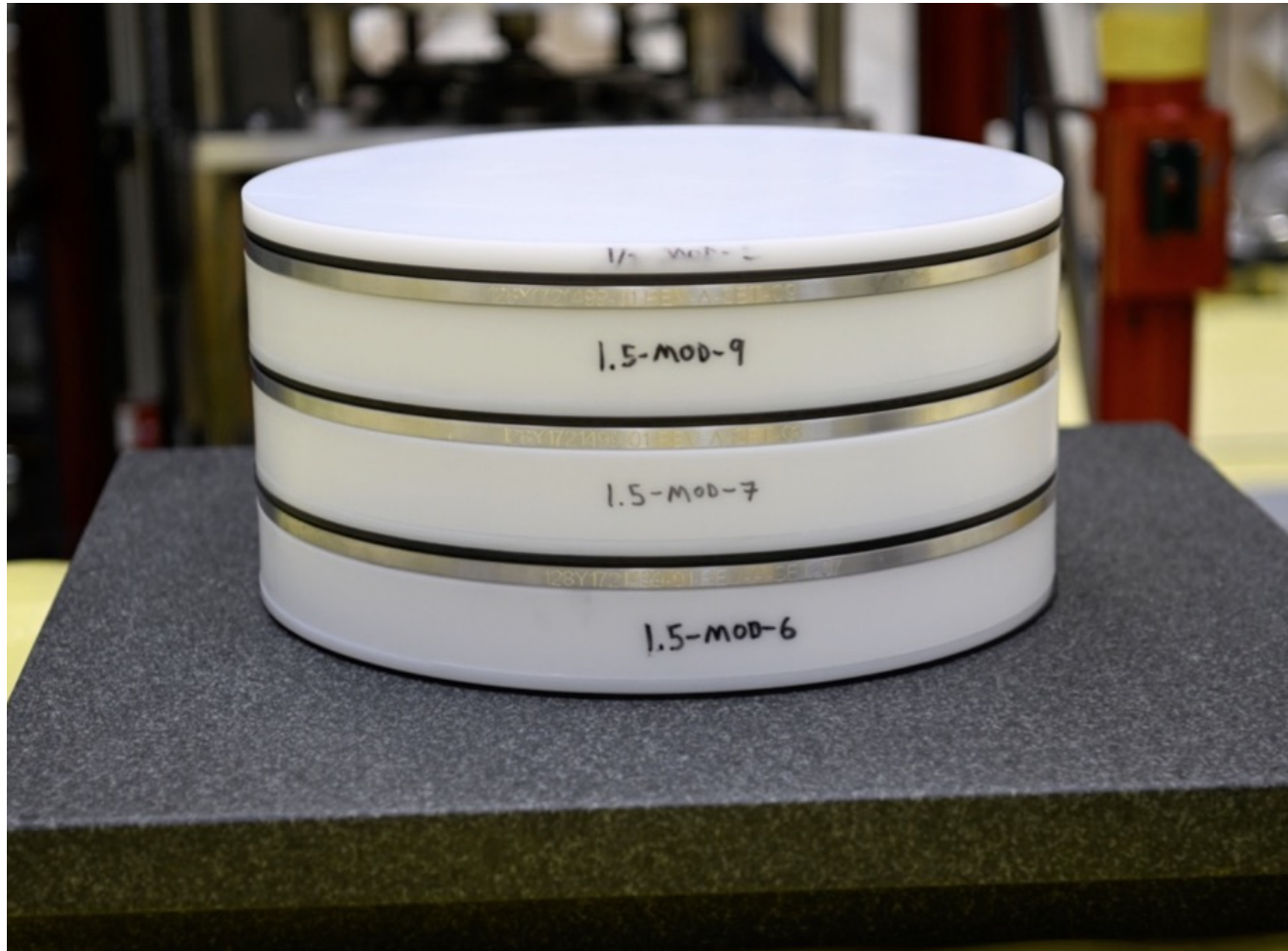


HEU-MET-THERM-038 (TEX-Chlorine)

- Used the HEU ‘Jemima’ Plates
- Experiments performed at NCERC (NNSS) in July to August 2024
 - NaCl absorber material
 - HDPE reflection and moderation
- 3 configurations evaluated
 - All three contained NaCl absorbers



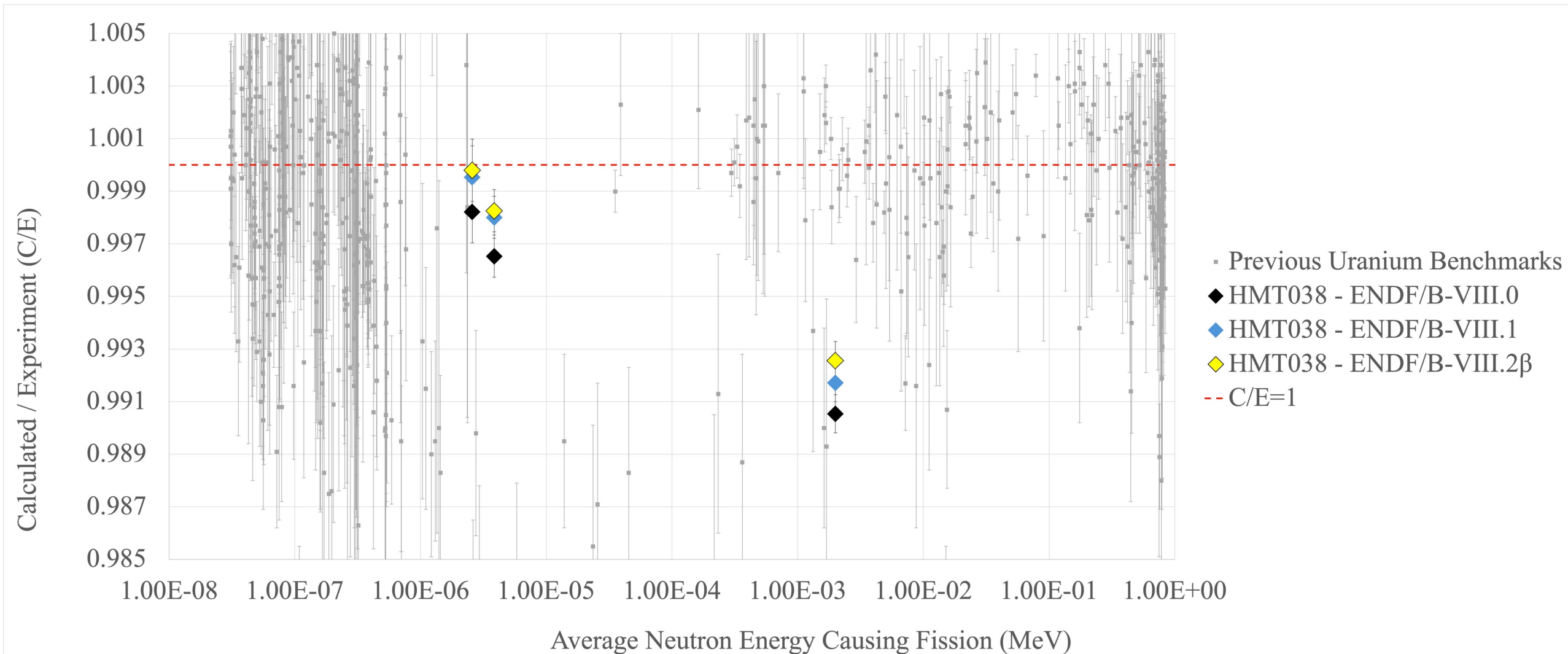
HEU-MET-THERM-038 (TEX-Chlorine)



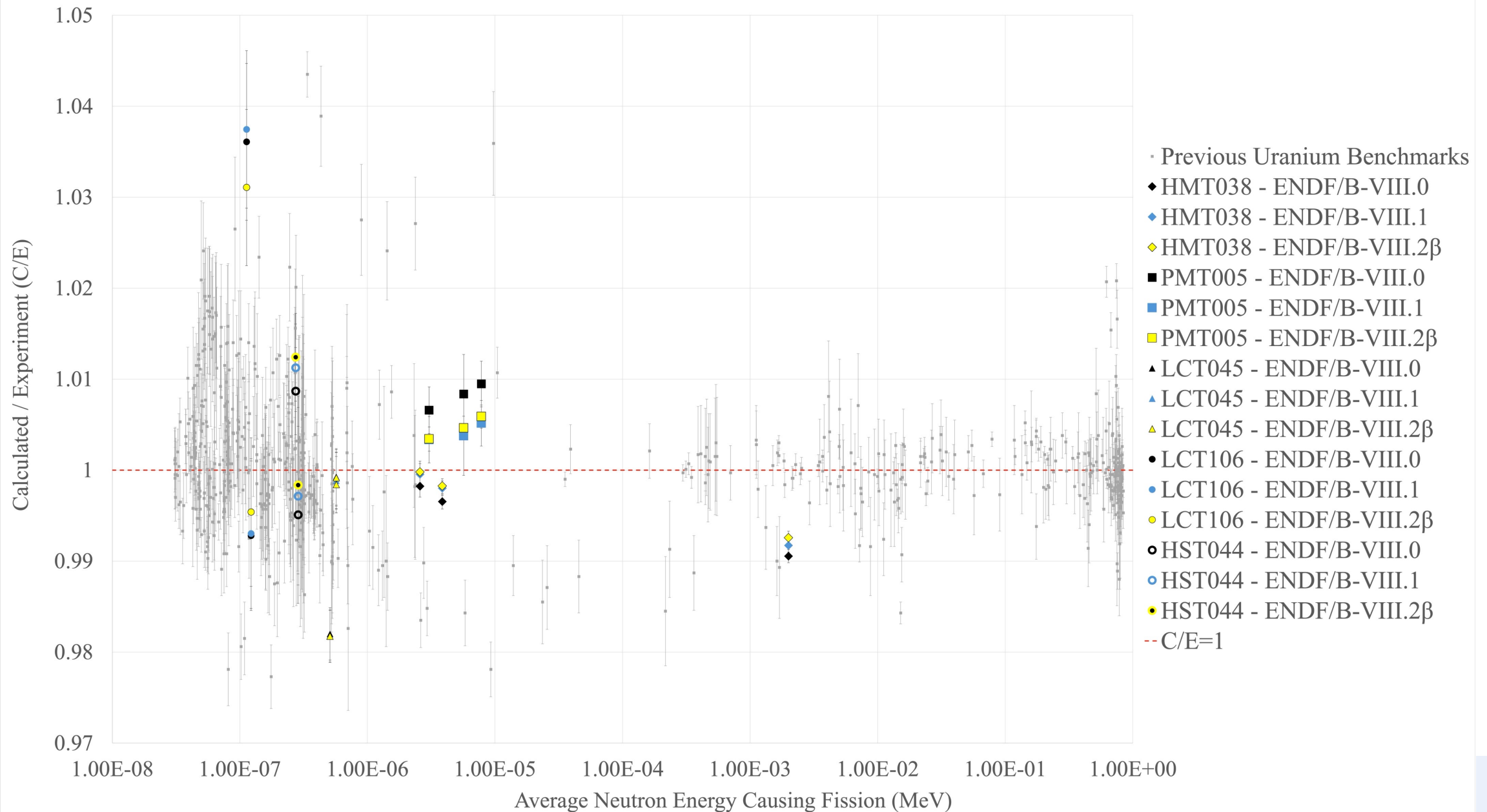
- Two configurations were predominantly thermal
- One configuration reached into the fast neutron energy region

Case	Thermal (<0.625 eV)	Intermediate (0.625 eV - 100 keV)	Fast (>100 keV)
1	58.07%	30.15%	11.78%
2	62.99%	25.51%	11.50%
3	13.64%	51.10%	35.26%

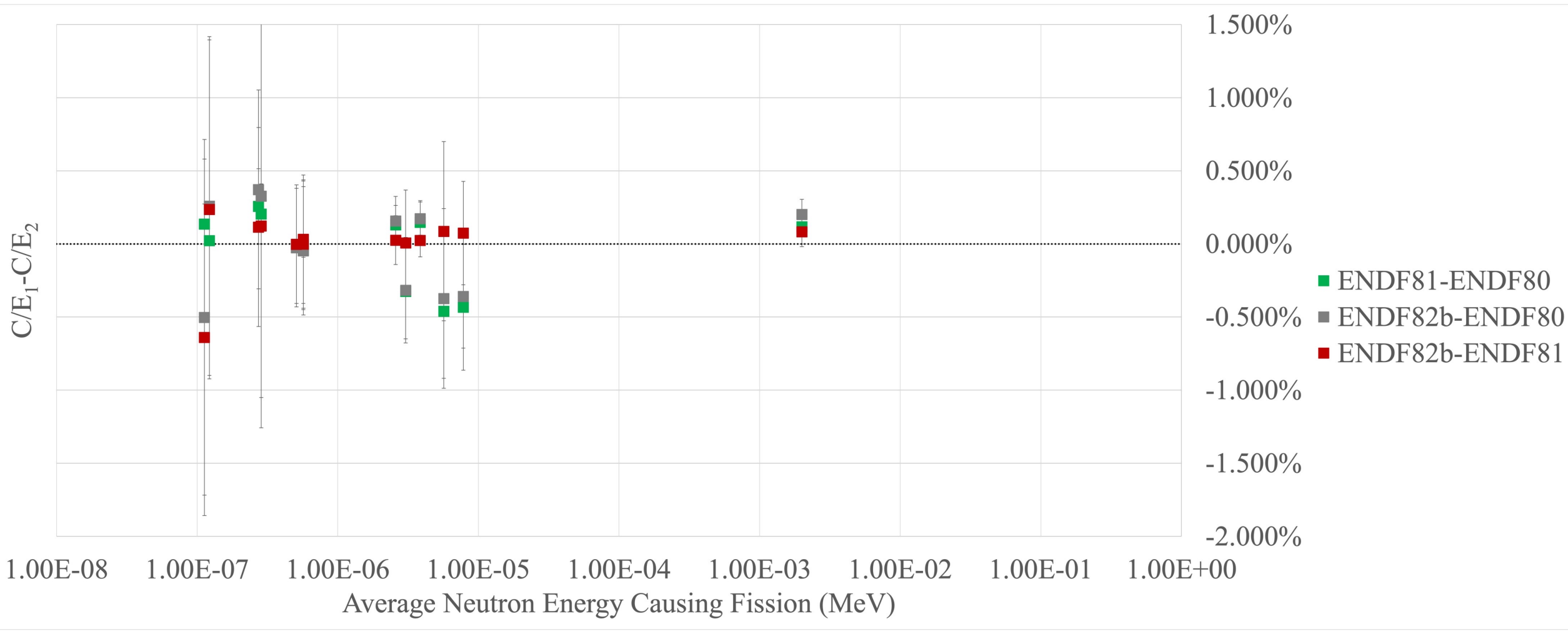
HEU-MET-THERM-038 (TEX-Chlorine)



Comparing Them All

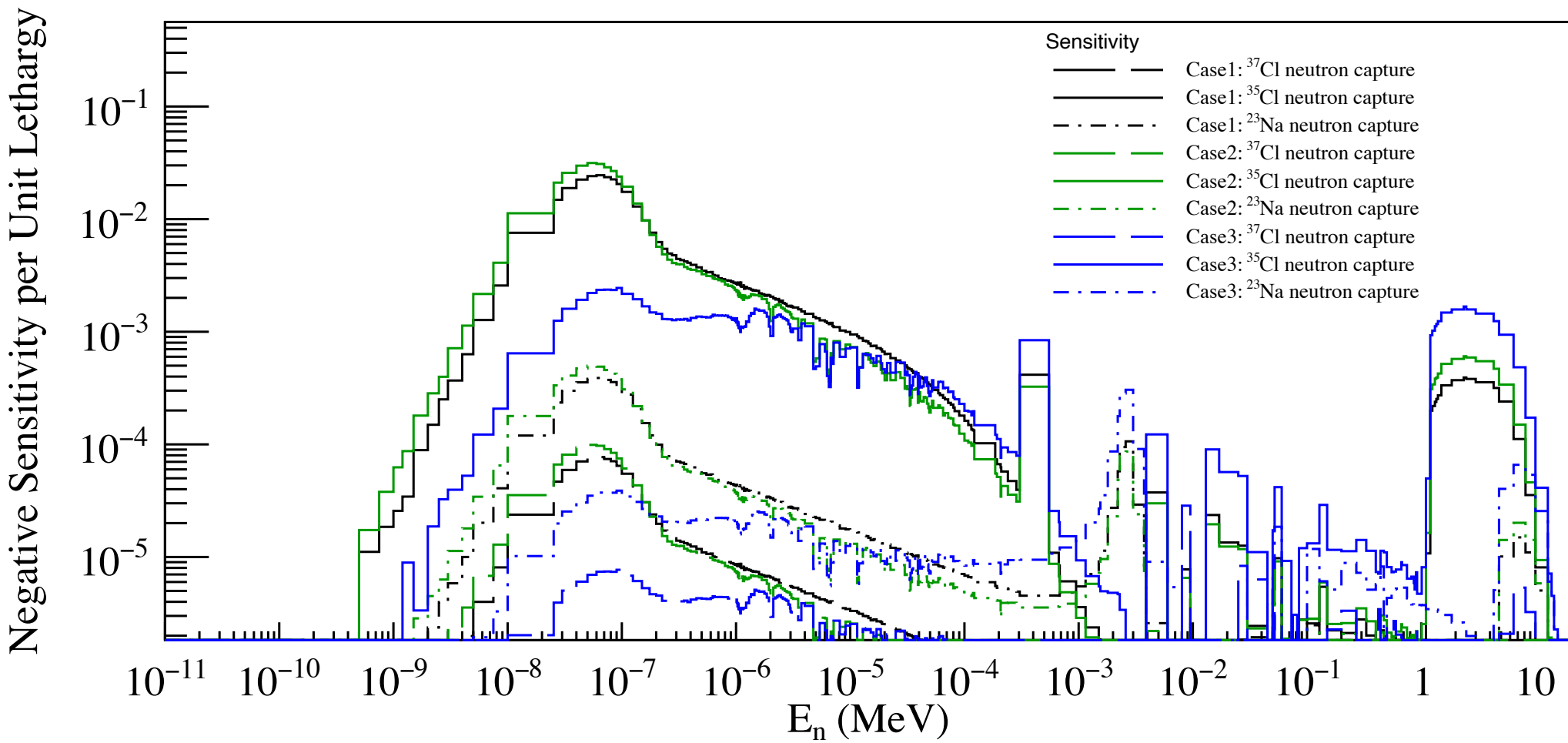


Comparing Them All – Changes between the libraries



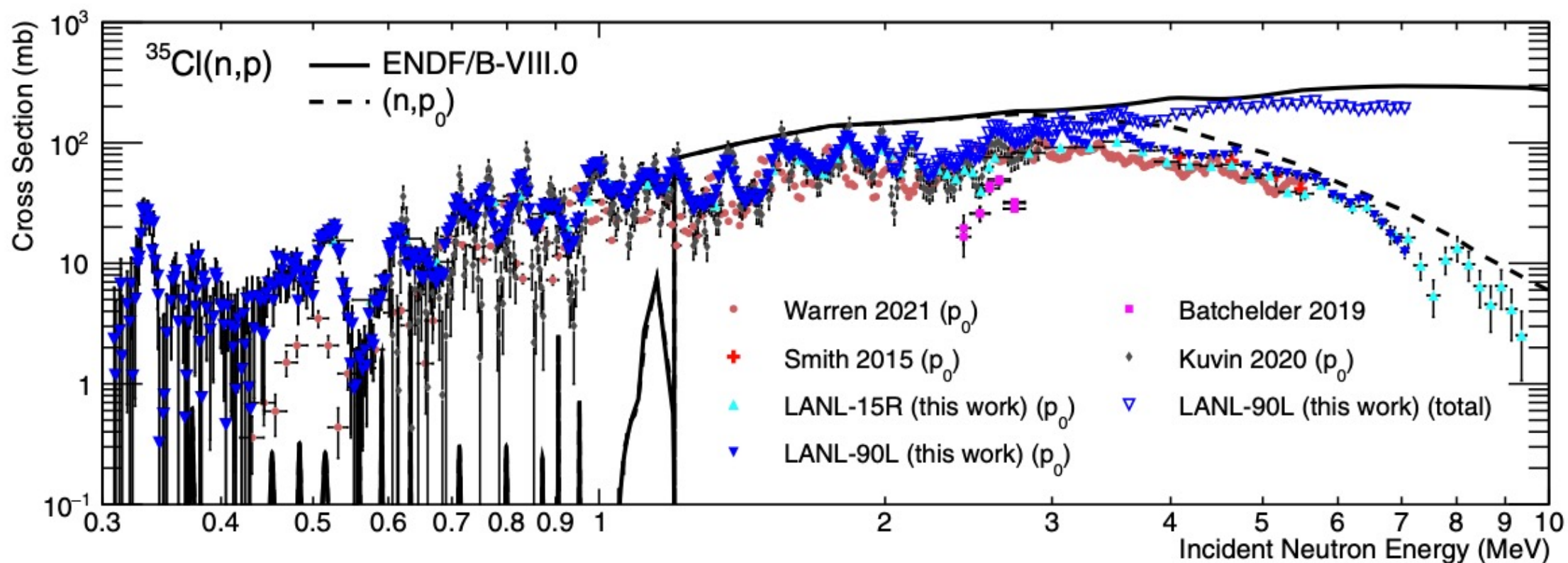
HEU-MET-THERM-038 (TEX-Chlorine)

- Isotopic contributions (^{23}Na , ^{35}Cl , and ^{37}Cl)



HEU-MET-THERM-038 (TEX-Chlorine)

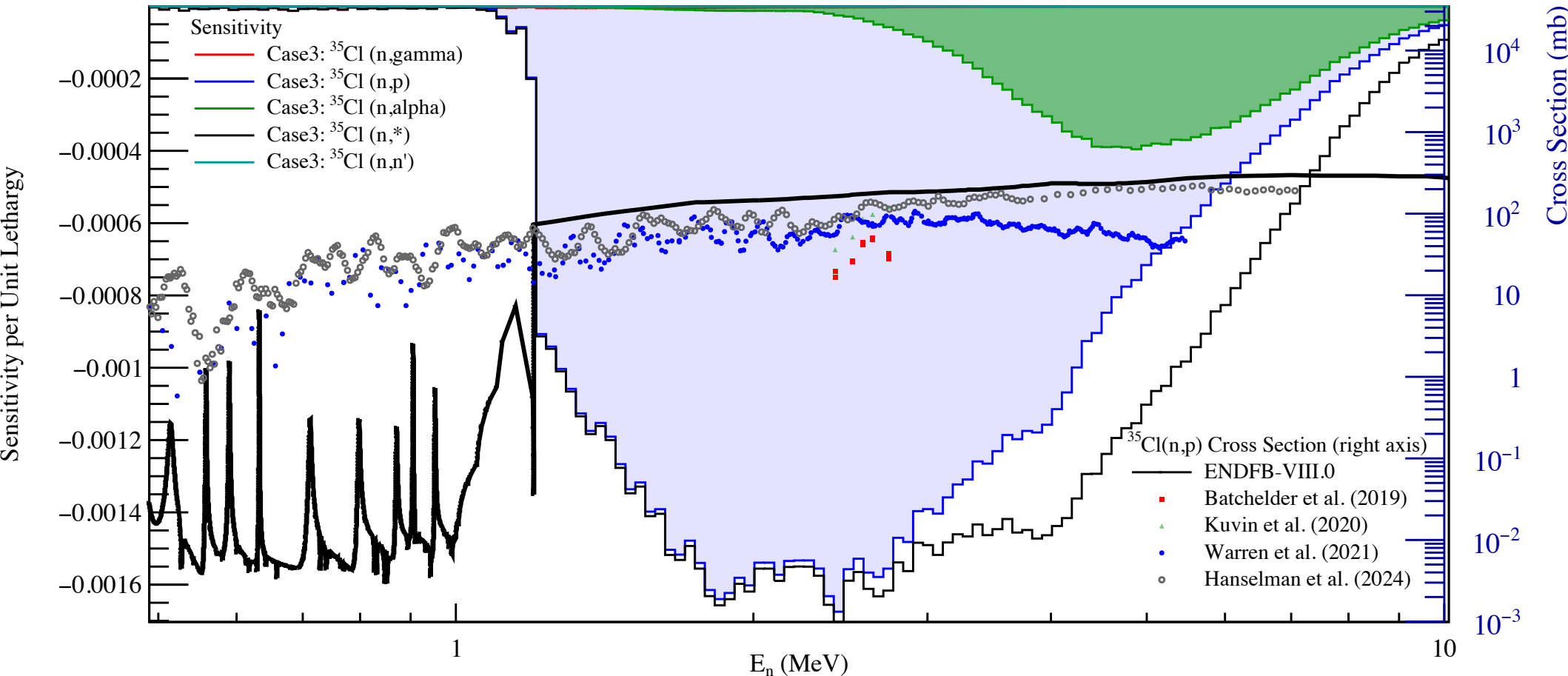
- $^{35}\text{Cl}(n,p)$ Cross Section – The uncertain channel



*From: K. Hanselman *et al.*, Improved modeling of neutron-induced reactions on chlorine isotopes aided through new (n,p) and (n,α) measurements at LANSCE, Phys Rev C 110, 024609 (2024)

HEU-MET-THERM-038 (TEX-Chlorine)

- $^{35}\text{Cl}(n,p)$ Cross Section Sensitivity for fastest configuration



Summary

- Five benchmark evaluations with 13 benchmark configurations *currently* exist within the ICSBEP
- All but one configuration are predominantly thermal with one in the intermediate to fast regime
- Changes from ENDF8 to 8.1
 - In general, results trend towards C/E=1
- Changes from ENDF8.1 to 8.2beta
 - Generally, enhancements to reactivity going from 8.1 to 8.2beta

More Benchmark Experiments are Coming!

Questions?