IER 297: TEX-HEU Baselines Benchmark
IER 532: TEX-Hf Update

2023 NCSP Technical Program Review

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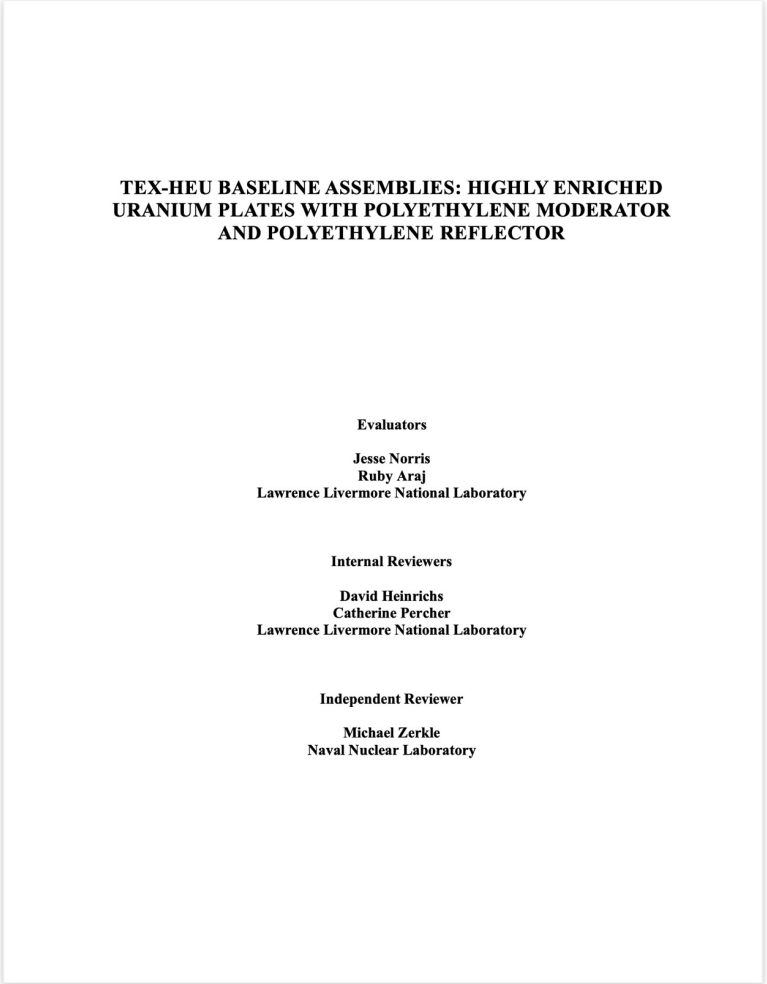
Overview

TEX-HEU

1. Uncertainties and Simplification Biases
2. Benchmark Model k_{eff} and C/E

TEX-Hf

1. TEX-Hf Design
2. Experimental Measurements



TEX-HEU BASELINE ASSEMBLIES: HIGHLY ENRICHED URANIUM PLATES WITH POLYETHYLENE MODERATOR AND POLYETHYLENE REFLECTOR

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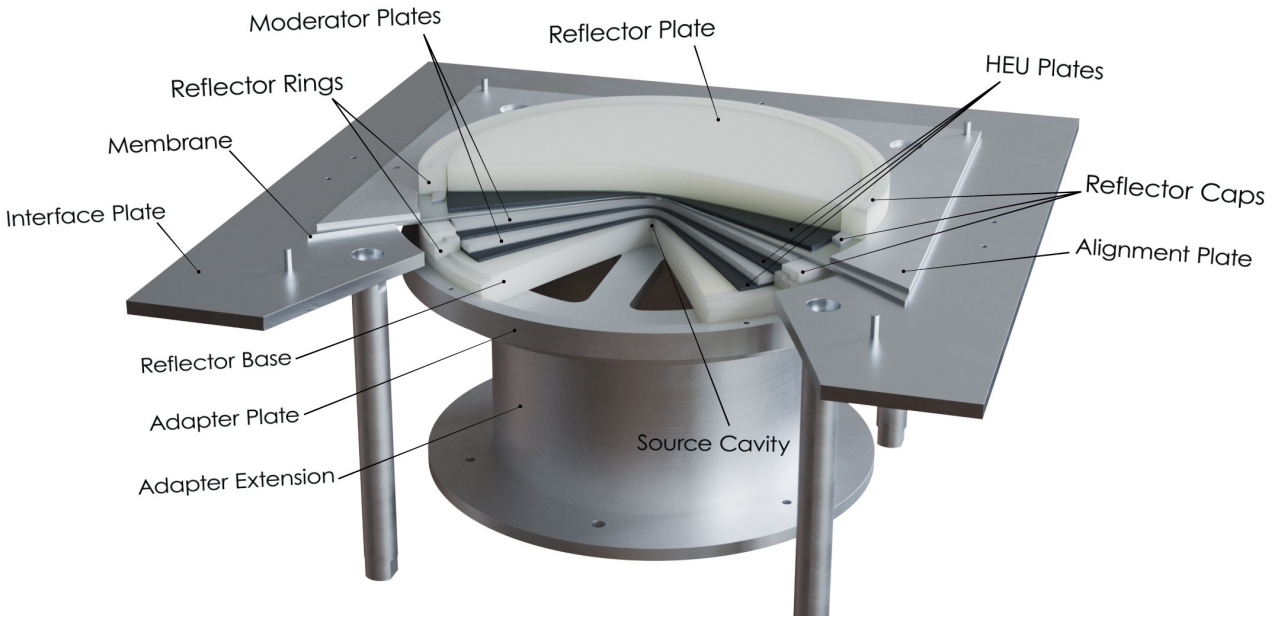
TEX-HEU Design

- Highly enriched (93+) uranium (HEU) fuel with polyethylene moderator and reflector
- Multiple thicknesses of the polyethylene moderator plates to vary the neutron energy spectrum from thermal to fast



Simplification and Bias Results

$$\text{Bias}_i = k - k_i'$$

Unbiased model k and biased model k_i' due to a simplification in component i

- Model simplifications include:
  - HEU and polyethylene impurity removal
  - Comet and experiment room removal
  - Temperature correction to 20°C

Simplification Bias Component	Standard Uncertainty in k_{eff} (pcm)				
	Case 1	Case 2	Case 3	Case 4	Case 5
HEU Impurities	-10	-3	-3	+7	0
Polyethylene Impurities	-3	-15	0	-12	-5
Comet & Room Removal	+214	+229	+204	+203	+159
Temperature Correction*	-74	-89	-92	-84	+222
Average Core Stacks (Simplified Model)	+21	-18	-11	-10	+67

*Preliminary pending review

Experimental and Benchmark Model k_{eff}

- The final benchmark model k_{eff} is based on the inferred experimental k_{eff} and the calculated model simplification biases

Case	Experimental $k_{eff} \pm 1\sigma$	Bias in $k_{eff} \pm 1\sigma$	Benchmark Model k_{eff}
1	1.00026 ± 0.00001	0.00127 ± 0.00013	0.99899 ± 0.00133
2	1.00038 ± 0.00002	0.00122 ± 0.00013	0.99916 ± 0.00128
3	1.00067 ± 0.00003	0.00115 ± 0.00013	0.99952 ± 0.00130
4	1.00112 ± 0.00004	0.00114 ± 0.00013	0.99998 ± 0.00150
5	1.00094 ± 0.00004	0.00376 ± 0.00013	0.99718 ± 0.00122

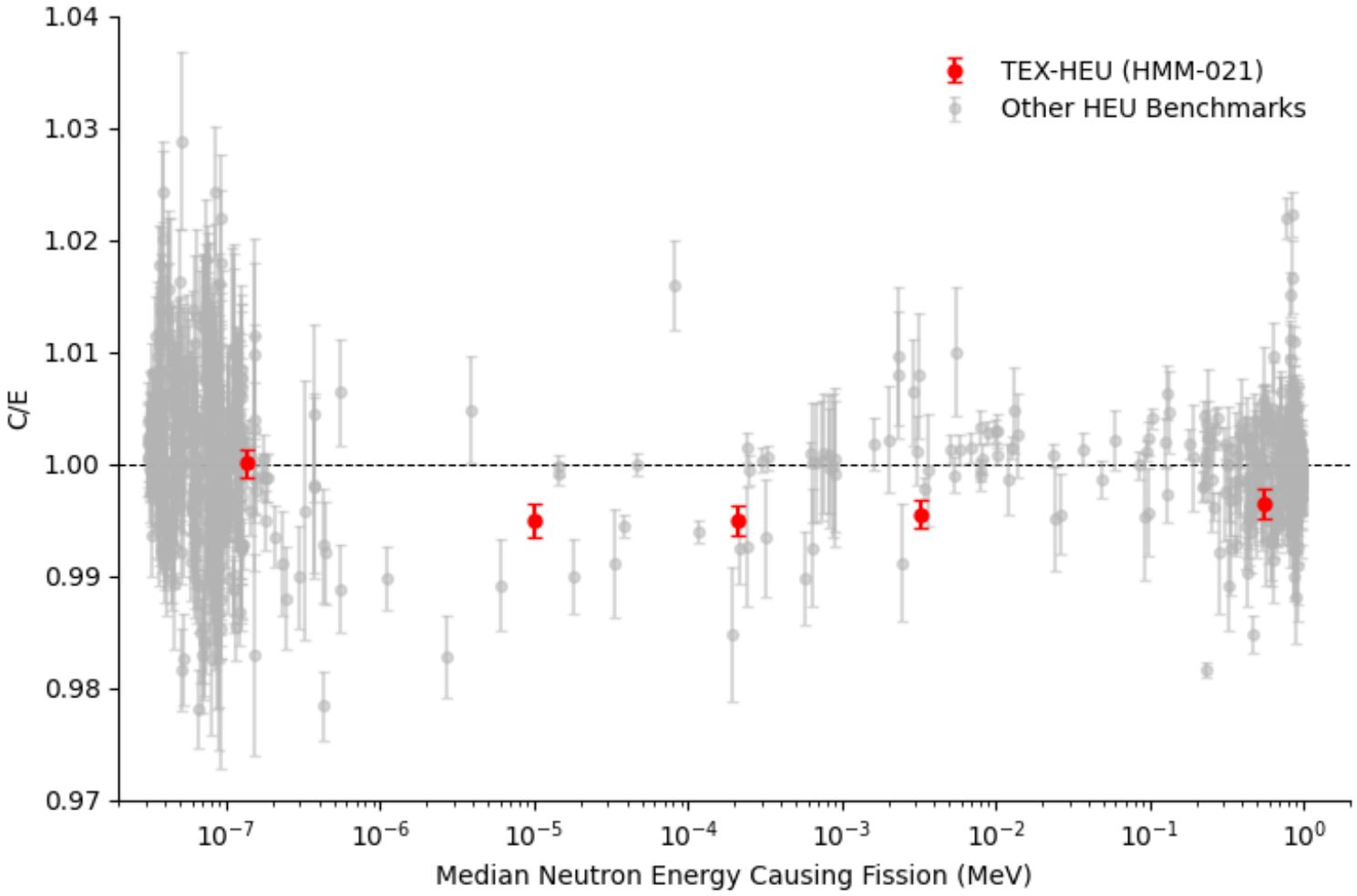
Results of Sample Calculations (C/E)

MCNP® 6.2.0 with Continuous Energy ENDF/B-VIII.0

- Calculated k_{eff} is slightly, but consistently, under-predicting the experimentally inferred k_{eff}

Case	Detailed Model	Simplified Model
1	0.99645 ± 0.00133	0.99645 ± 0.00133
2	0.99551 ± 0.00128	0.99552 ± 0.00128
3	0.99490 ± 0.00130	0.99490 ± 0.00130
4	0.99493 ± 0.00150	0.99494 ± 0.00150
5	1.00006 ± 0.00122	1.00006 ± 0.00122

Comparison to HEU Benchmarks in ICSBEP

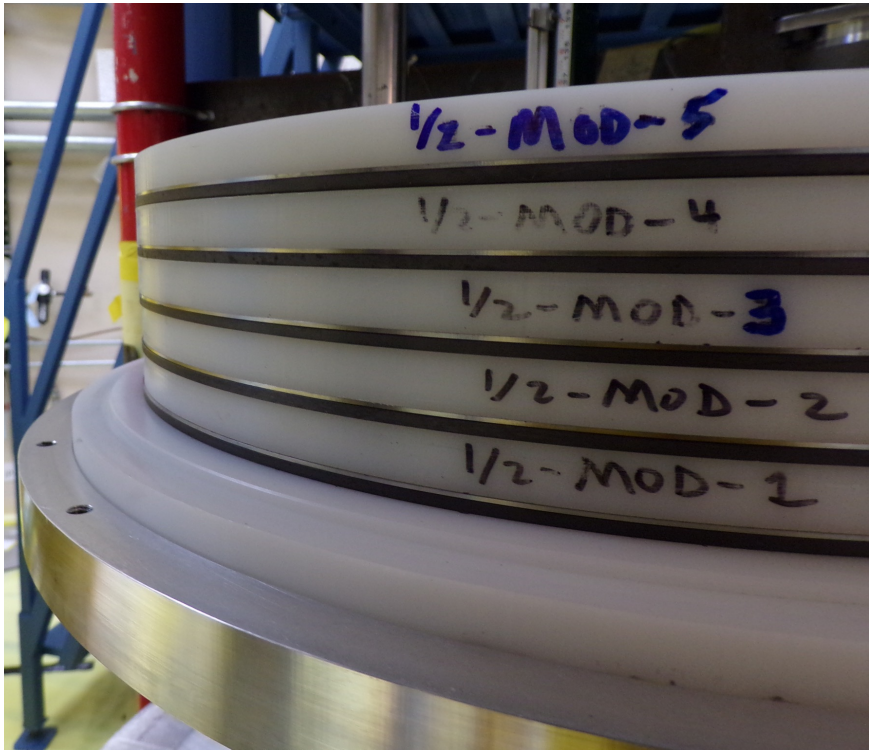


TEX-HEU Conclusions

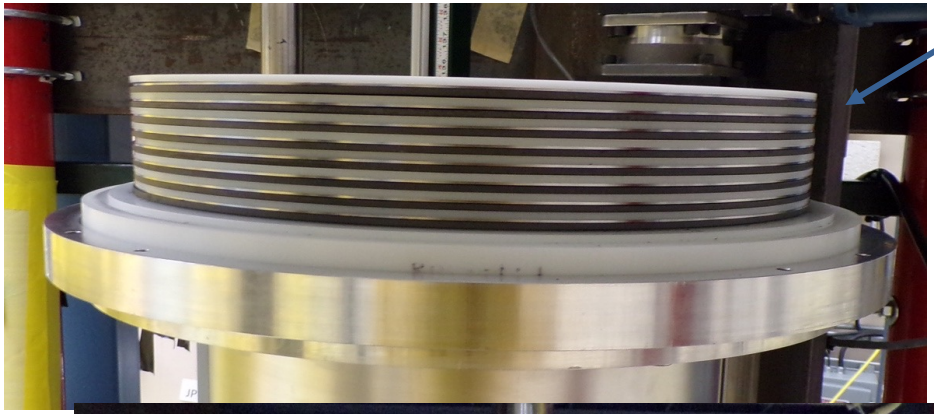
- The intermediate and fast configuration models (Cases 1-4) consistently underpredict the experiments while the thermal configuration model (Case 5) is in good agreement
- The TEX-HEU Benchmark Evaluation (HMM-021) was accepted pending review and approval by a Subgroup of the ICSBEP TRG in 2021
  - TRG comments received in Q3 of FY22
  - All reviewer comments have now been address and the evaluation has been provided to a majority of the reviewers seeking their approval earlier this month
- The TEX-HEU Benchmark Evaluation will provide a baseline that can be compared against for all future experiments using the TEX-HEU design, including TEX-Hf

TEX-Hf Overview

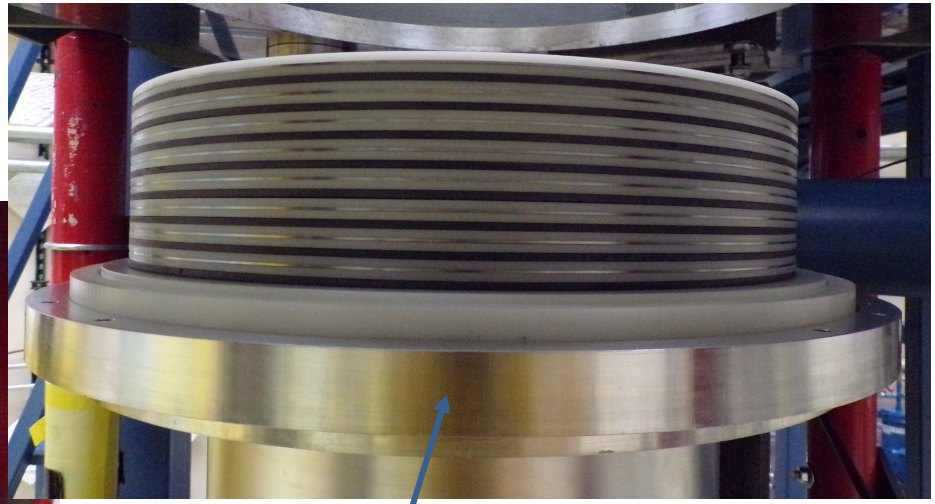
- TEX-Hf is the first variation on TEX-HEU and incorporates Hafnium as a diluent material
- The goal of the TEX-Hf configurations is maximize the sensitivity in k_{eff} to the hafnium isotope cross sections
- The TEX-Hf configurations are neutronically similar to the TEX-HEU configurations and extend the design using new stacking variations



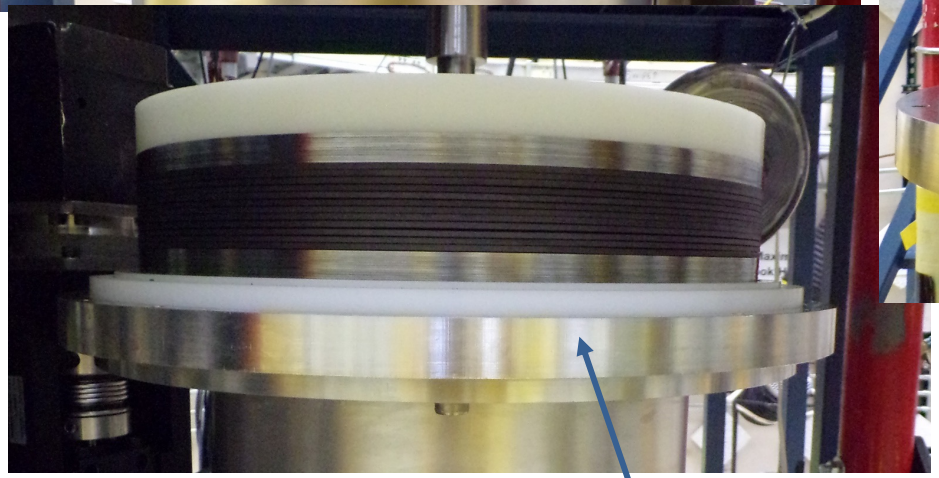
TEX-Hf Stacking Variations



Standard
Hafnium between HEU and HDPE



Sandwich
Hafnium between HDPE



Bunched
Hafnium as a reflector

TEX-Hf Measurements

- A total of seven experimental configurations were measured with four reproducibility measurements

Configuration	Benchmark Measurement		Reproducibility Measurement	
	Period (s)	Excess (¢)	Period (s)	Excess (¢)
0” Std.	59.2 ± 0.6	14.1 ± 0.1	71.9 ± 0.2	12.2 ± 0.0
1/8” Std.	64.8 ± 0.4	13.2 ± 0.1	-	-
1/4” Std.	25.4 ± 0.1	24.2 ± 0.5	25.2 ± 0.1	24.3 ± 0.3
1/2” Std.	122.9 ± 0.5	8.1 ± 0.1	-	-
1-1/2” Std.	84.5 ± 0.5	10.9 ± 0.0	74.9 ± 0.4	11.8 ± 0.2
1/4” Sand.	50.7 ± 0.2	15.7 ± 0.0	50.7 ± 0.2	15.7 ± 0.0
0” Bunch.	73.8 ± 0.0	12.0 ± 0.0	-	-

TEX-Hf Conclusions & Future Work

- The experiment campaign for TEX-Hf spanned seven weeks in August, September, and October of 2022
- Lessons learned from the TEX-HEU experiment campaign and benchmark evaluation were incorporated into TEX-Hf
- The Experiment Execution Report (CED-3b) is near completion with delivery planned for Q2 of FY23
- The Benchmark Evaluation (CED-4a) is planned for submission to ICSBEP in 2024

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