Status of the International Criticality Safety Benchmark Evaluation Project

Presented at the 2026 Cross Section Evaluation Working Group
Validation Session
Brookhaven National Laboratory

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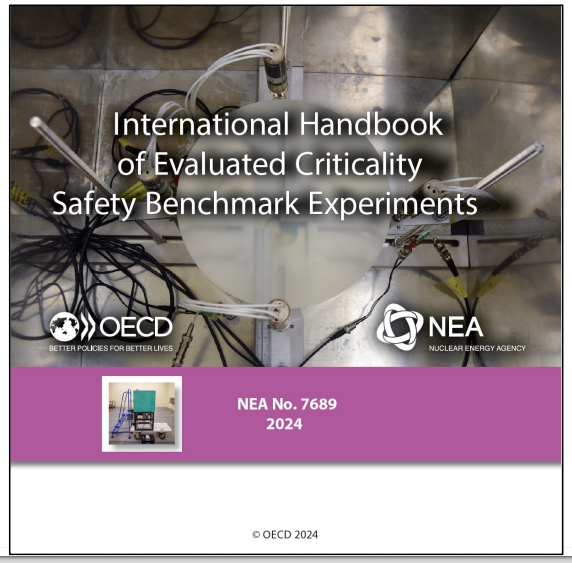
Lawrence Livermore National Laboratory

International Criticality Safety Benchmark Evaluation Project (ICSBEP)

- Official activity of the Organization for Economic Cooperation and Development's (OECD) Nuclear Energy Agency since 1995 under the Working Party for Nuclear Criticality Safety (WPNCS)
- Main Goal: Provide standardized benchmarks for **criticality safety validation**
- Updated handbook with new evaluations released regularly- 2024 edition released Dec 2025

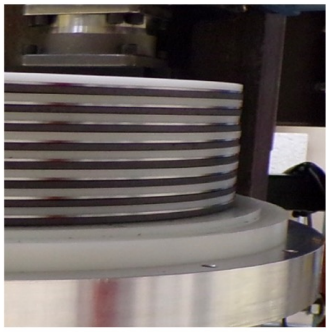
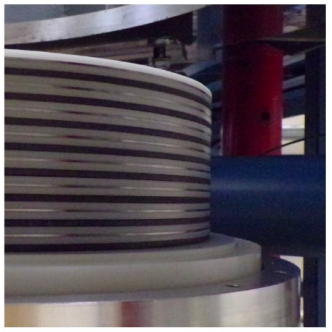
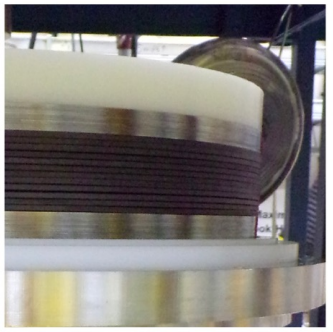


ICSBEP Type	Description	Configurations
PU	Plutonium	805
HEU	Highly Enriched Uranium	1455
IEU	Intermediate Enriched Uranium	278
LEU	Low Enriched Uranium	1827
U233	Uranium 233	244
MIX	Mixed Material Systems	536
SPEC	Other Actinides	20
ALARM	Shielding and Criticality Accident Alarm Placement	51
FUND	Fundamental Physics Measurements	246
	Handbook Total	5462

New Content for 2024 ICSBEP Handbook

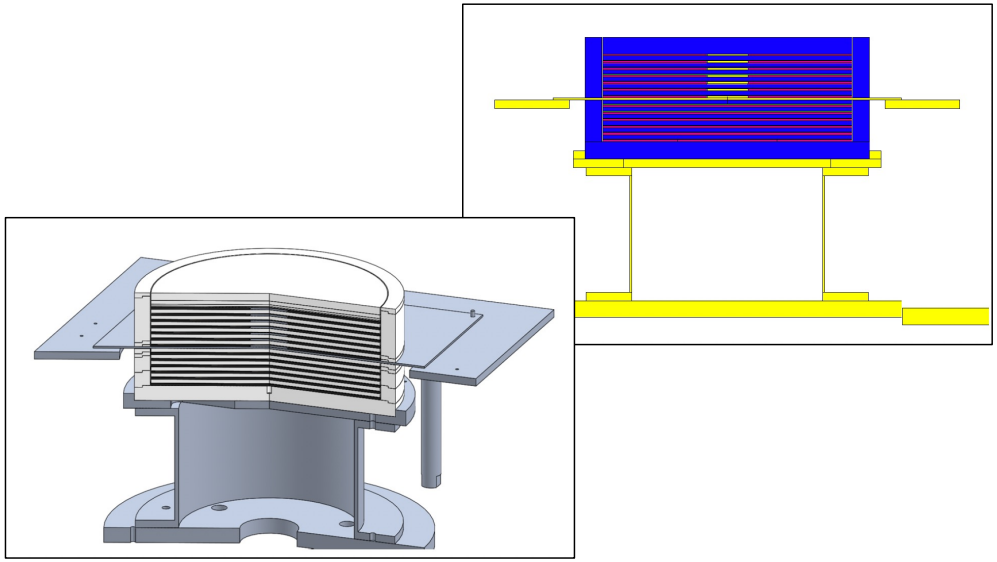
- 2 new evaluations with 7 critical configurations and 8 fundamental physics configurations
  - Volume II: Two new fast HEU, three intermediate HEU, one mixed spectra HEU, and one thermal HEU (all metal)
  - Volume IX: Eight new pulsed neutron die-away fundamental physics cases, four with polyethylene and four with Lucite
- One major revision to HEU-MET-FAST-028 (Flattop with HEU Core)
  - **Important to update your benchmark suite for major revisions!**

New Evaluation 1: HEU-MET-INTER-013

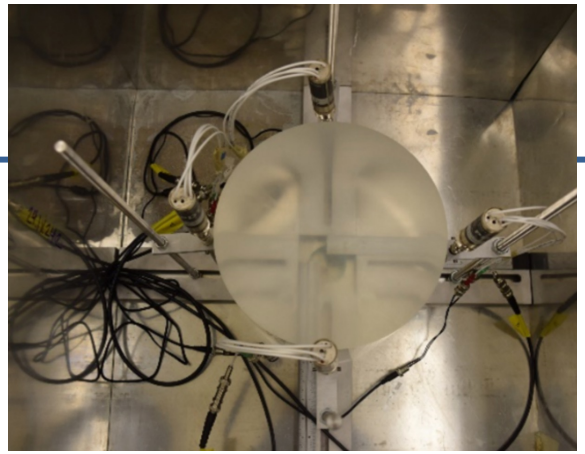




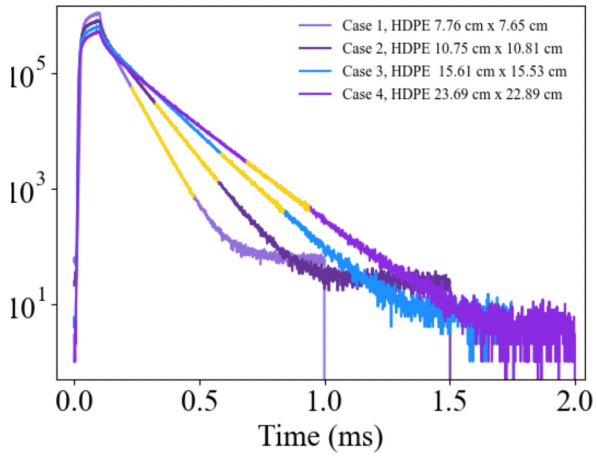
TEX-Hf Assemblies: Highly Enriched Uranium Plates with Hafnium Using Polyethylene Moderator and Polyethylene Reflector

- Comet Assembly with HEU Jemima Plates at National Criticality Experiments Research Center (NCERC), USA
- Varied polyethylene moderator thickness to adjust neutron spectra
- Included **hafnium** in different configurations (**interstitially and as a reflector**)
- 7 Cases, **1 thermal, 3 intermediate, 1 mixed, 2 fast**



New Evaluation 2: FUND-LLNL-DT-PE-PNDA-001

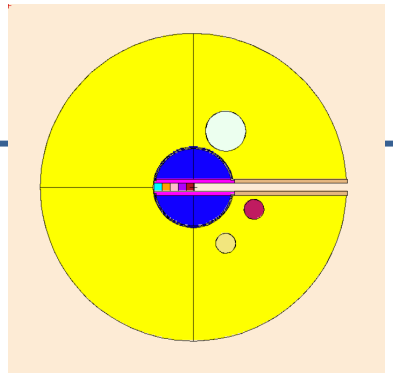


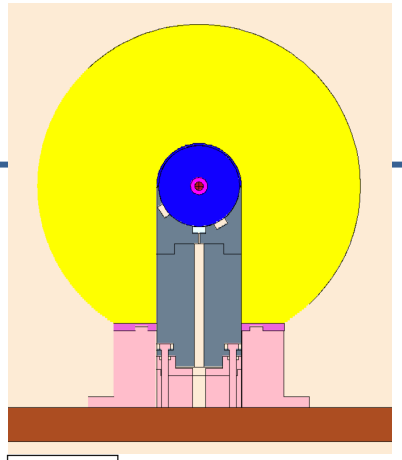


Pulsed-Neutron Die-Away Response of Polyethylene and Polymethyl Methacrylate Targets to a D-T Neutron Generator Pulse

- LLNL, USA
- Four different target sizes of **PE and PMMA (Lucite)**
- Benchmark quantity is characteristic exponential decay eigenvalue, α
- Useful to **test thermal scattering law data**
  - Smaller targets- more sensitive to scattering
  - Larger targets- more sensitive to absorption

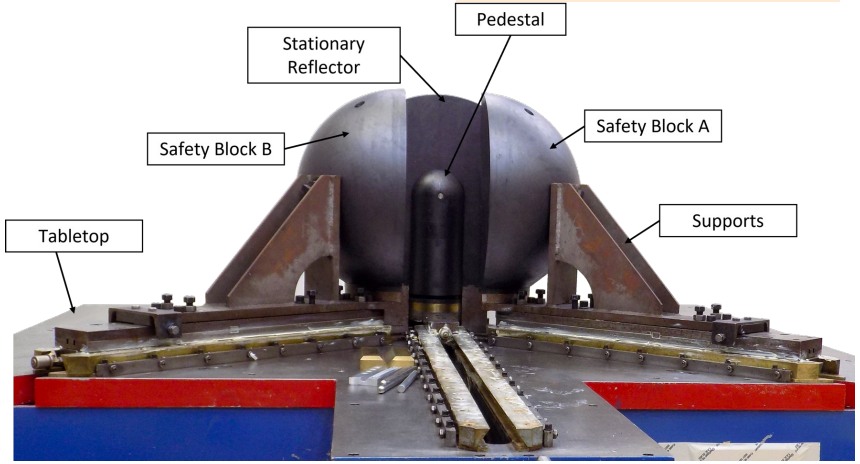
Revised Evaluation: HEU-MET-FAST-028





Uranium-235 Sphere Reflected by Normal Uranium Using Flattop

- Flattop Assembly with HEU Core at NCERC, USA
- **Major revision based on new dimensional and critical measurements**
- High fidelity models, one detailed and one simplified
  - Results with ENDF/B-VIII.0 agree within 1 sigma of HMF-028, Rev 2



2025 ICSBEP Meeting

- Jozef Stefan Institute hosted the annual Technical Review Group (TRG) meeting in Ljubljana, Slovenia in April 2025
  — 61 in-person attendees, 20 virtual
- Ten benchmarks presented, eight received conditional approval for 2025 Handbook
- Seven ultimately finalized for the 2025 Handbook, plus one additional from 2024 meeting

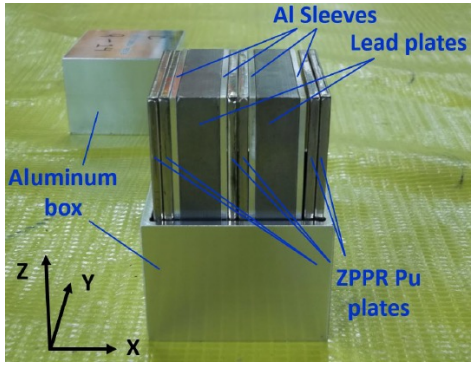
New Content for the 2025 Edition of the ICSBEP Handbook

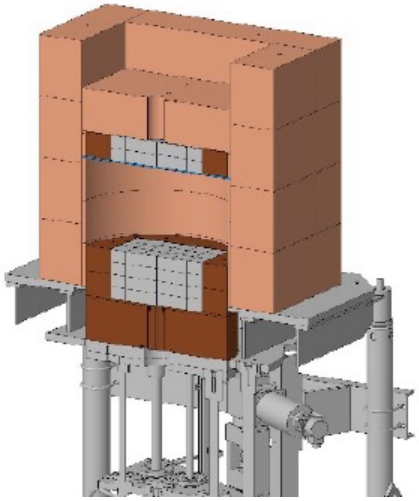
- 8 new evaluations with 19 critical configurations, 4 fundamental physics configurations, and 2 alarm/shielding configurations
  - Volume I (PU): Two new fast Pu evaluations
  - Volume II (HEU): One new fast HEU, one intermediate HEU, and one thermal HEU evaluations
  - Volume IV (LEU): One new thermal LEU evaluation
  - Volume VII (ALARM): Two new ^{252}Cf source shielding evaluations
  - Volume IX (FUND): One new pulsed neutron die-away evaluation
- Final files provided to NEA, expect publication soon!

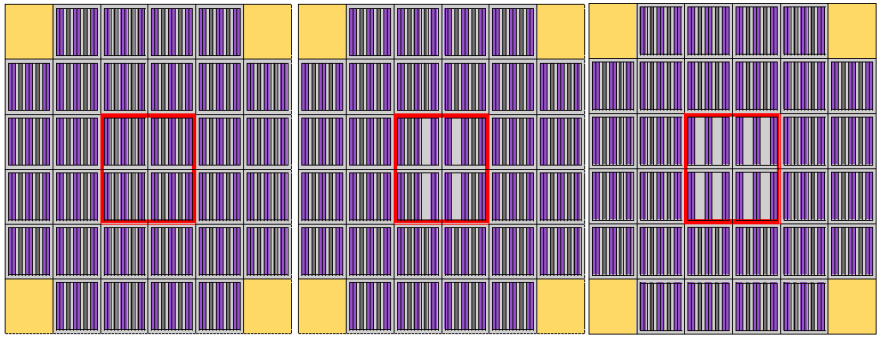
New Evaluation 1 and 2: PU-MET-FAST-047 and PU-MET-FAST-050

The Jupiter Experiments: Plutonium Metal Plates Separated by Lead and Reflected by Copper

- Comet Assembly Machine at NCERC, USA
- Collaboration between LANL and the Japan Atomic Energy Agency (JAEA) for **fast reactor lead void reactivity studies**
- Plutonium Zero Power Physics Reactor (ZPPR) plates mixed with lead plates and ZEUS copper reflector
- 3 cases in PU-MET-FAST-047 with increasing central lead void
- 2 cases in PU-MET-FAST-050 with higher ^{240}Pu content ZPPR plates



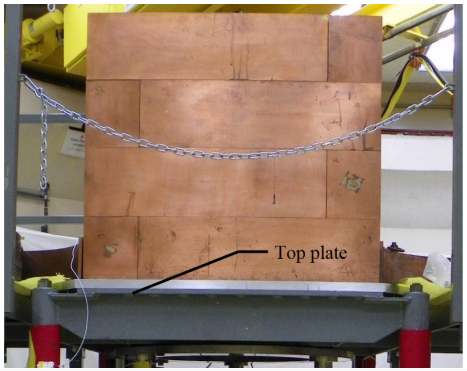


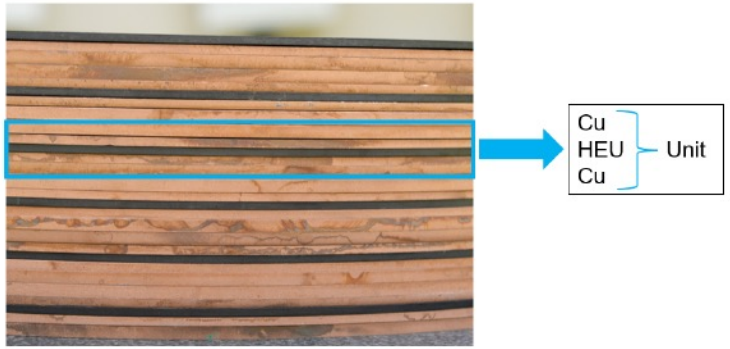


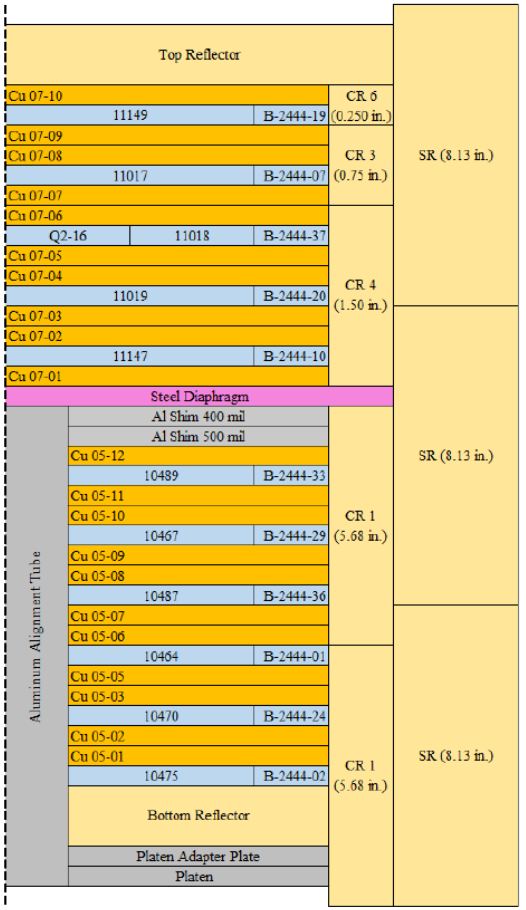
New Evaluation 3: HEU-MET-FAST-106

CERBERUS: A Zeus Configuration with HEU and Copper Reflected by Copper

- Comet Assembly Machine at NCERC, USA
- Zeus Copper Reflector and HEU Jemima Plates
- 3 cases with increasing thicknesses of **interstitial copper plates**
- In combination with other Zeus experiments, goal is to provide a holistic test of copper nuclear data



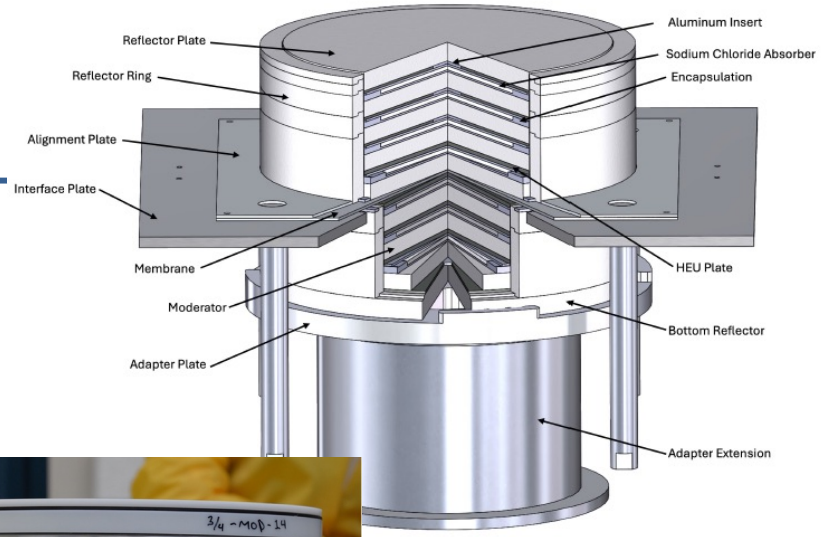


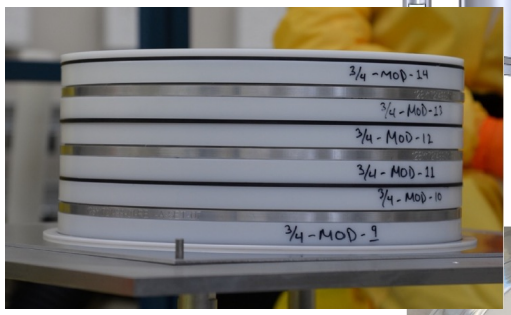


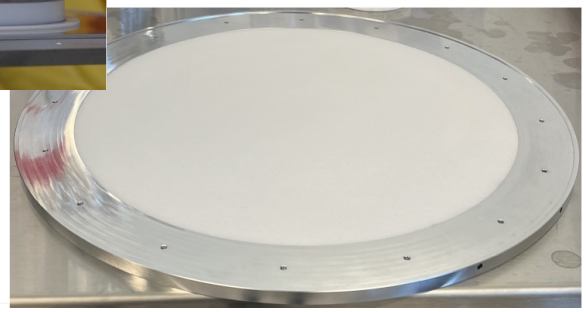
New Evaluation 4: HEU-MET-THERM-038

TEX-Chlorine Assemblies: Highly Enriched Uranium Plates with Sodium Chloride Absorbers Using Polyethylene Moderator and Polyethylene Reflector

- Comet Assembly with HEU Jemima Plates at NCERC/NNSS
- Varied polyethylene moderator thickness to adjust neutron spectra
- Included vibro-packed **sodium chloride** absorber plates between layers
- 3 Cases, **2 thermal and 1 intermediate**
- Provide test of chlorine absorption for criticality safety validation cases for electrorefining and molten salt fuel fabrication



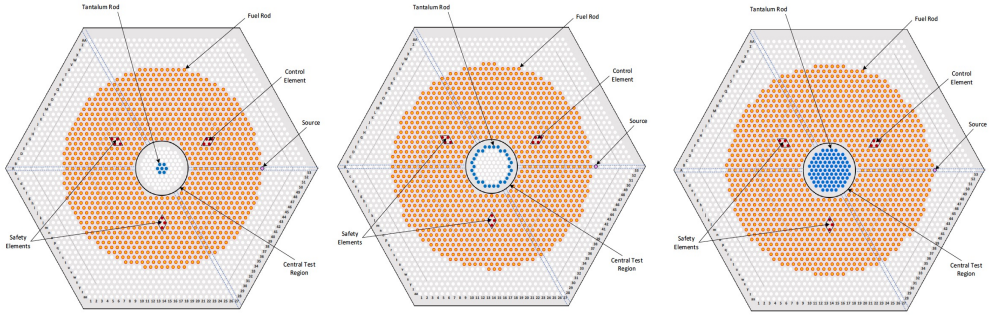




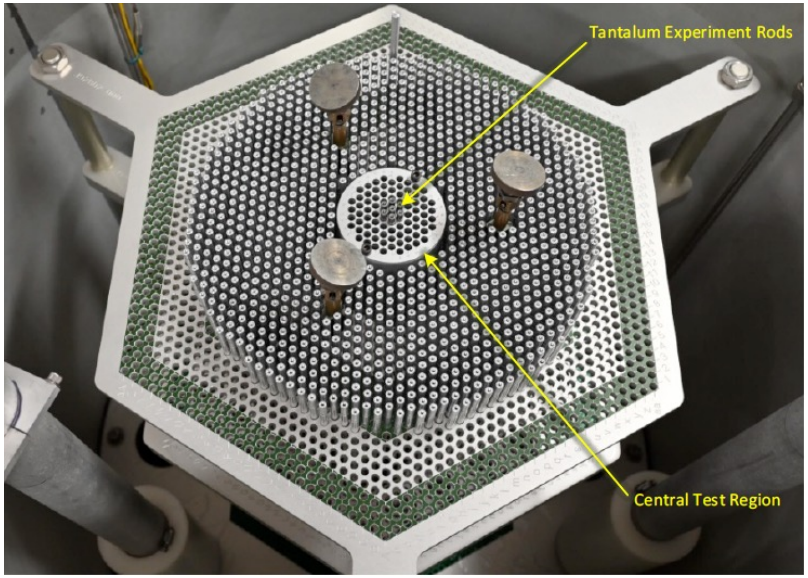
New Evaluation 5: LEU-COMP-THERM-112

Tantalum Experiments in Fully-Reflected Water-Moderated Triangular-Pitched $U(6.90)O_2$ Fuel Rod Lattices (1.02 cm Pitch)

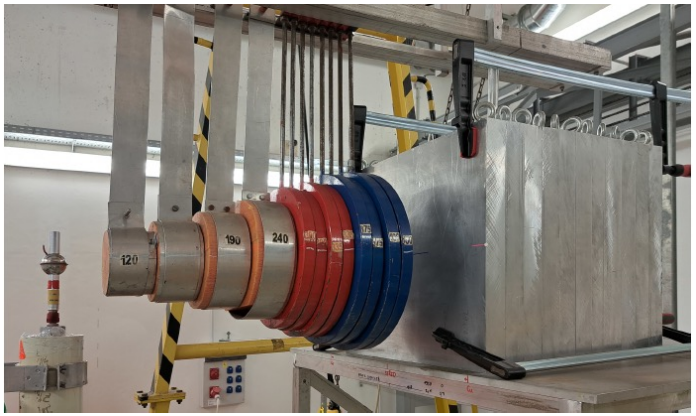
- Sandia Critical Experiments Facility (SCXF) with 7uP fuel
- Purpose of the experiment was to measure the effects of **Ta in epithermal systems**
- Fuel arranged around a central test region lined with Cd to absorb thermal neutrons and provide harder spectrum to the Ta rods
- 8 cases with varying configurations of Ta rods within the test region

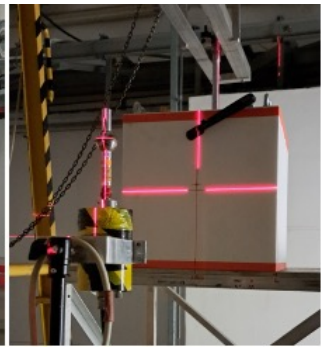


Case 2 Case 5 Case 8



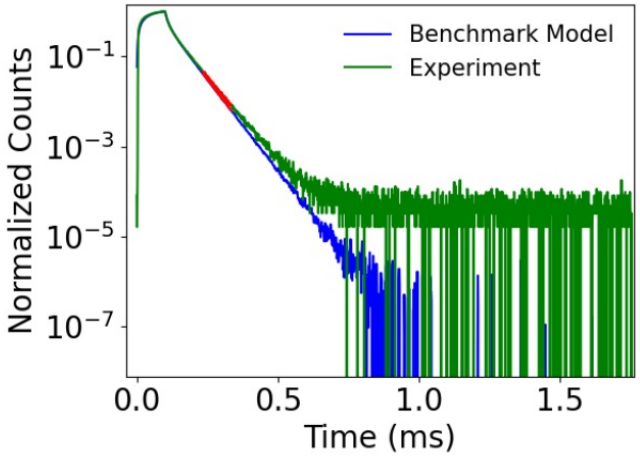
New Evaluation 6 and 7: ALARM-CF-PTFE-SHIELD-001 and ALARM-CF-AL-SHIELD-001

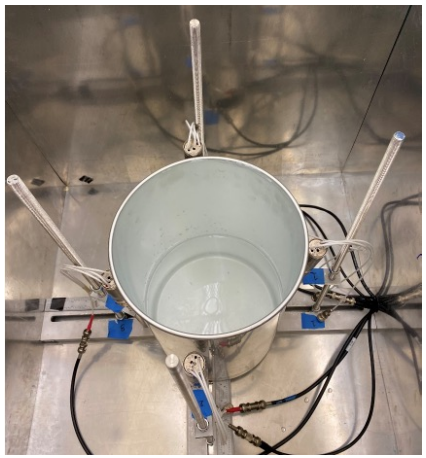


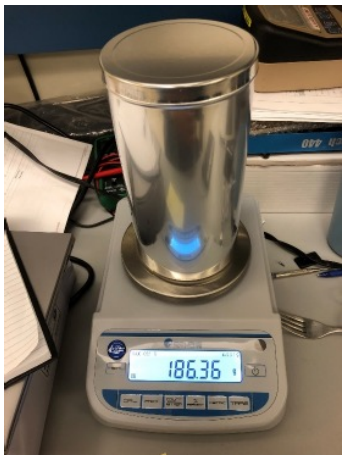


Fast Neutron Leakage and Spatial Distribution of Activation Foils from a Polytetrafluoroethylene (PTFE) [or Aluminum] Block with a ^{252}Cf Source in the Center

- Performed at Research Center Řež (RCR), Czechia
- Measured proton recoil method to obtain neutron leakage spectrum
- Activation foils placed within and outside the block
- Useful to test the validity of neutron cross section data, very sensitive to **scattering**
  - **^{19}F scattering (PTFE)**
  - **Aluminum scattering**







New Evaluation 8: FUND-LLNL-DT-H2O-PNDA-001

Pulsed-Neutron Die-Away Response of H_2O Targets to a D-T Neutron Generator Pulse

- LLNL, USA
- Four different target sizes of **water**
- Benchmark quantity is characteristic exponential decay eigenvalue, α
- Useful to **test thermal scattering law data**
  - Smaller targets- more sensitive to scattering
  - Larger targets- more sensitive to absorption

Next ICSBEP TRG Meeting

- OECD/NEA Headquarters, Boulogne Billancourt, France
- April 13-16, 2026 (M-Th)
- International Reactor Physics Evaluation Project (IRPhEP) will meet April 17

Benchmarks Currently Expected at Next Meeting

1. Autorité de Sûreté Nucléaire et de Radioprotection (France) – *Apparatus B Salt Water Configurations*
2. Centrum Výzkumu Řež (Czechia) – *Fast Neutron Leakage and Activation from a C_2Cl_4 Sphere with a ^{252}Cf Source*
3. Idaho National Laboratory (USA) – *PROTEUS Critical Configurations with TRISO Fuel*
4. Instituto de Peruano d Energia Nuclear (Peru) – *IPEN/RP10 Research Reactor Evaluation with U_3Si_2-Al, 19.75% enriched in U-235 Plate Type Fuel*
5. Instituto de Pesquisas Energéticas e Nucleares (Brazil) – *IPEN/MB-01 New Core Evaluation with U_3Si_2-Al, 19.75% enriched in U-235 Plate Type Fuel*
6. Lawrence Livermore National Laboratory (USA) – *Pulsed-Neutron Die-Away Experiments with Oil Targets (FUND)*
7. Lawrence Livermore National Laboratory (USA) – *High Multiplication Subcritical Benchmark at Sandia National Laboratory LEU SPR/CX Facility* (FUND)
8. Lawrence Livermore National Laboratory (USA) – *Unreflected and Polyethylene-Reflected U(97.7%)F_6 Cylinder Benchmark*
9. Los Alamos National Laboratory (USA) – HEU-MET-FAST-086: *Godiva IV Benchmark Revision*
10. Los Alamos National Laboratory (USA) – *Prompt Fission Uranium Neutron Spectrum (PFUNS) Critical Experiments*
11. Los Alamos National Laboratory (USA) – *MUSIC: Bare Highly-Enriched Uranium Shells Subcritical Measurements (FUND)*
12. Los Alamos National Laboratory (USA) – *Deimos: HALEU as Tri-structural isotropic (TRISO) Kernels Reflected by Graphite and Beryllium*
13. Rensselaer Polytechnic Institute (USA) – *Temperature Dependent Configurations of the Walthousen Reactor Critical Facility*
14. Sandia National Laboratory (USA) – *Neutron Absorber (Boralcan) Experiments with Water Moderated U(6.90%)O_2 Fuel Lattices*
15. University of New Mexico (USA) – *AGN Reactor Critical Benchmark*

Conclusions

- The ICSBEP is a very active project that continues to produce high quality integral benchmark data for code and data validation
- Many new experiments are being designed to fill validation gaps and target novel materials or neutron spectra
- Many of the new benchmarks are being evaluated soon after the experiment was conducted, with active participation from knowledgeable experimenters
- The ICSBEP standards have changed over time and some of the older, historical benchmarks would likely not be accepted by the TRG today due to missing experimental information or unanalyzed uncertainties
- Next Meeting: April 13-16, 2026 at OECD/NEA headquarters (Boulogne-Billancourt, France)

NEA NUCLEAR ENERGY AGENCY

Acknowledgments

- The International Criticality Safety Benchmark Evaluation Project (ICSBEP) is a Collaborative Effort
  - Numerous Scientists, engineers, administrative support, and program sponsors
  - 28 different countries have participated in evaluating and reviewing benchmark data for 30 years
  - Without these dedicated individuals, the international benchmark projects would not exist
- Immediate Past Chair, John Bess
  - Guided the ICSBEP for almost ten years, contribution cannot be overstated
- New Co-Vice Chairs, Mathieu Dupont (Oak Ridge National Laboratory, USA) and Luke Yaraskavitch (Canadian National Laboratories, Canada)

Backup Slides

This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under contract DE-AC52-07NA27344. Lawrence Livermore National Security, LLC