LLNL IPD Tasks: ICSBEP and Pulsed Spheres Benchmark

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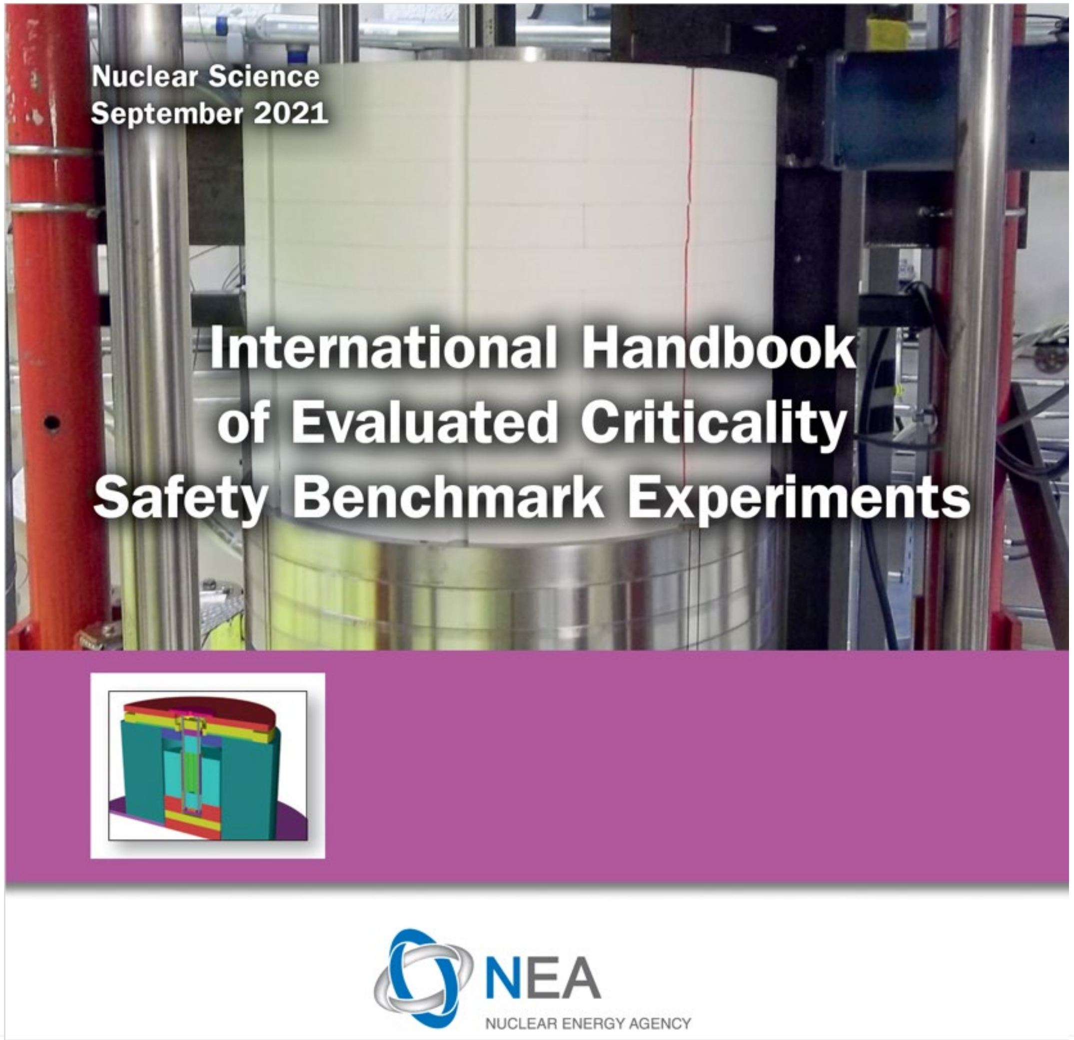
LLNL Task: International Criticality Safety Benchmark Evaluation Project

- ICSBEP Benchmarks are the main way integral experiments are promulgated to criticality safety practitioners and nuclear data evaluators

- As of May 2022, C. Percher is ICSBEP chair, chair duties mostly funded by LLNL overhead (0.3 FTE)

- NCSP IPD Task funds:
  - Independent reviews for NCSP-supported benchmarks- PU-MET-THERM-005 (Chlorine Worth Study) and ORNL Health Physics Research Reactor CAAS Benchmark
  - Technical Review Group (TRG) review of NCSP-supported benchmarks- each reviewed by 1-2 experienced staff members in advance of ICSBEP meeting (in addition to C. Percher review as chair)
  - Send 2 reviewers to ICSBEP meeting
  - Funds participation on technical subgroups after meeting, if needed
  - Used LLNL Technical Information Department (TID) to fund publication support of the handbook and evaluations (approximately 0.1 FTE)

Handbook Status

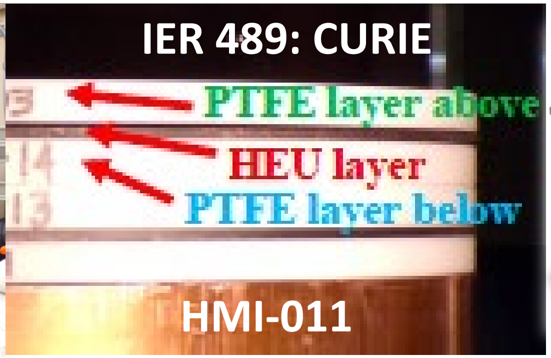


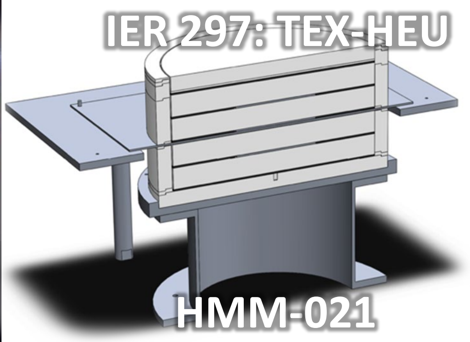
- 2021 edition of the ICSBEP Handbook published 18 Nov 2022
  - 5 new evaluations with 47 critical configurations
- 2022 edition was delayed due to chair/editor transitions
- 2022 benchmarks will be combined with the 2023 benchmarks in one 2023 release
- 2023 Handbook files provided to NEA in January 2024

Upcoming Content for the 2023 Edition of the ICSBEP Handbook

- 13 new evaluations with 41 critical configurations, 1 fundamental physics configuration, and 4 alarm/shielding configurations

- 5 of the 13 are new NCSP funded experiments (IERs), with benchmark funding for one additional non-NCSP experiment





- 7 of the 13 were completed at NCERC, 1 at Sandia

Upcoming Meeting- April 16-17, 2024

- Lawrence Livermore National Laboratory, Livermore Open Valley Campus (LVOC) Building, Livermore, California, USA **with virtual option**
- Joint meeting with SINBAD (April 18) and IRPhEP (April 19)
- Tours of LLNL experimental facilities- Inherently Safe Subcritical Assembly (ISSA), Pulsed-Neutron Die-Away laboratory, and the National Ignition Facility (NIF)- on Wednesday afternoon
- PHYSOR 2024 meeting scheduled in San Francisco, CA for April 21-25

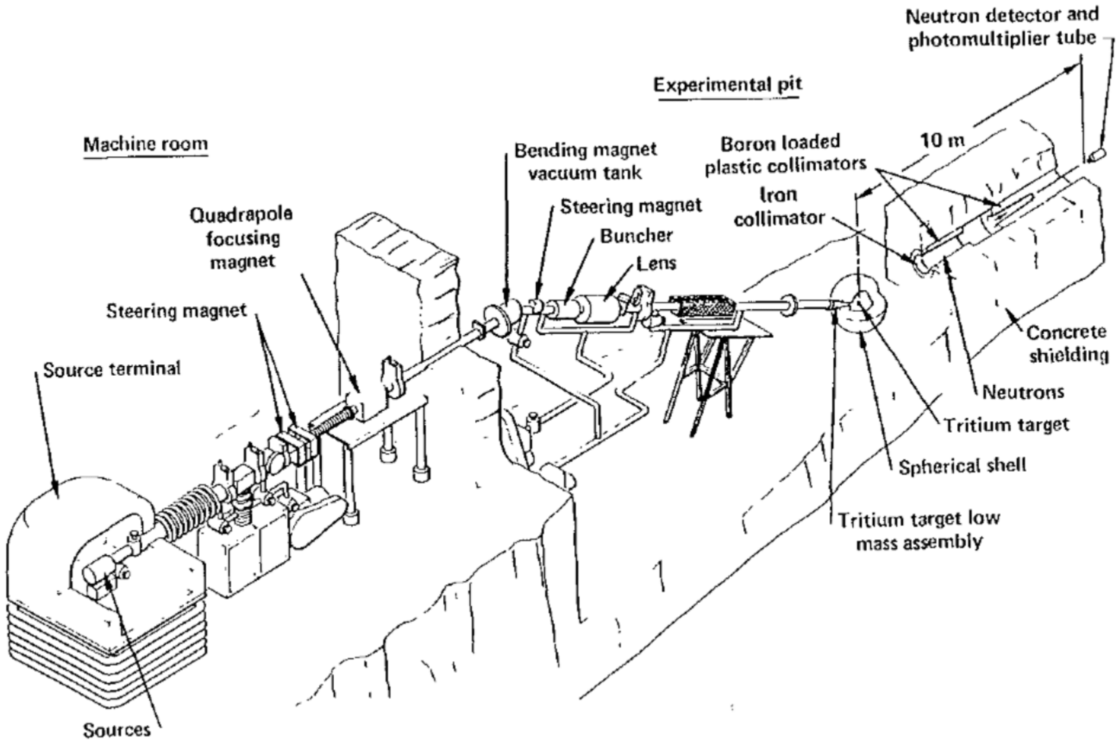
https://ncsp.llnl.gov/icsbepsinbadirphep-meetings-llnl

Benchmarks Expected at Upcoming Meeting

1. Lawrence Livermore National Laboratory (USA) – IER 501- *Pulsed-Neutron Die-Away Experiments with HDPE and PMMA Targets (Fundamental Physics Benchmark)*
2. Lawrence Livermore National Laboratory (USA) – IER 532- *TEX-HEU Critical Benchmarks with Hafnium*
3. Los Alamos National Laboratory (USA) – IER 423- *Flattop Reevaluation*
4. Los Alamos National Laboratory (USA) – *PU-MET-FAST-047: Jupiter Plutonium and Lead Void Critical Experiments*
5. University of New Mexico (USA) – *AGN Reactor Critical Benchmark*

LLNL Pulsed Sphere Program

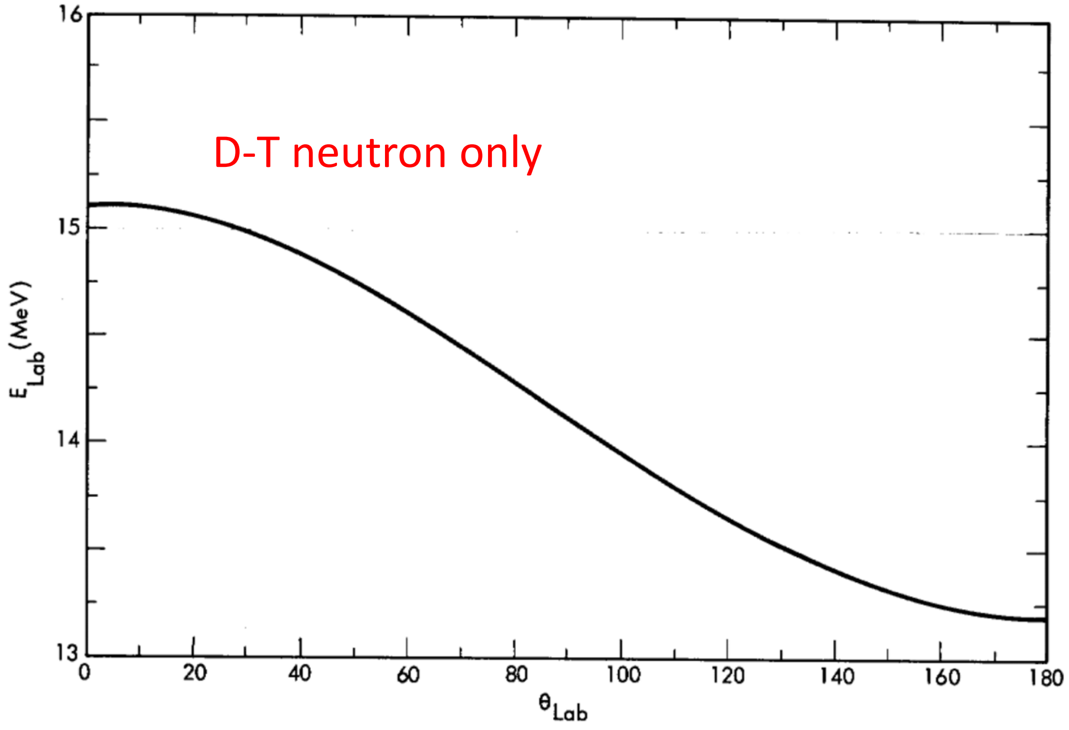
- From ~1960 to ~1985, the Lawrence Livermore National Laboratory (LLNL) Pulsed-Sphere Program conducted measurements of 14-MeV neutron leakage spectra from various spheres of different composition
- These differential-integral measurements were designed for evaluating Monte Carlo transport codes and neutron cross section data libraries

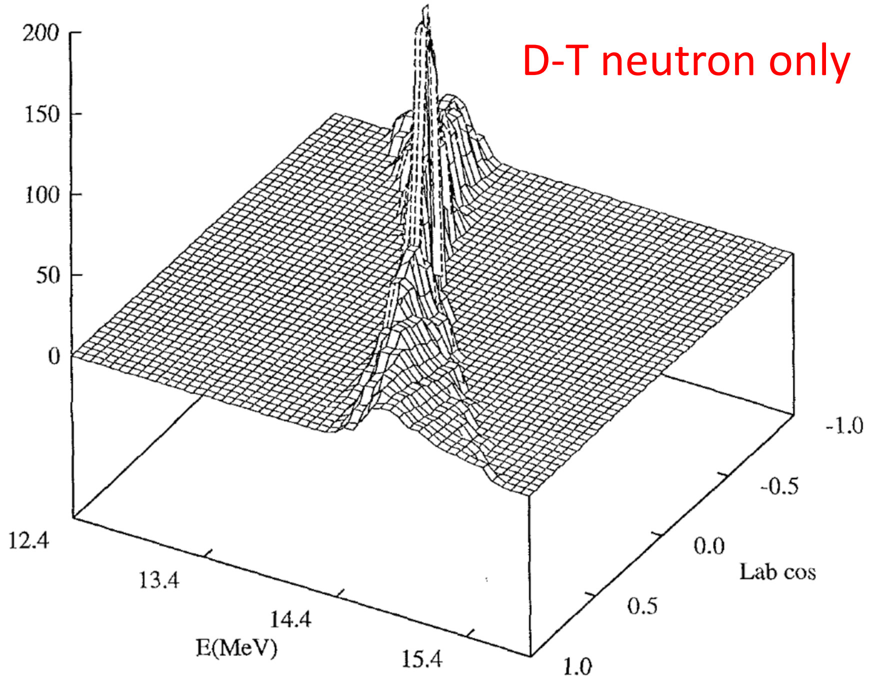


Background

- There are approximately, 145 detector measurements for 75 different spheres of 32 different materials
- LLNL Pulsed Sphere models are often used to validate 14 MeV neutron data
  - These models have not been validated or quantified for uncertainties as benchmarks
  - Simplifications (binned neutron source) and potential inaccuracies in model geometry (incident deuteron angle, collimator/detector location)
- Significant improvements in matching measured data have been made by investigating historical documents (drawings of room, equipment, etc) and higher fidelity modeling

Theoretical Neutron Source (left- 1972 and right- 1998)



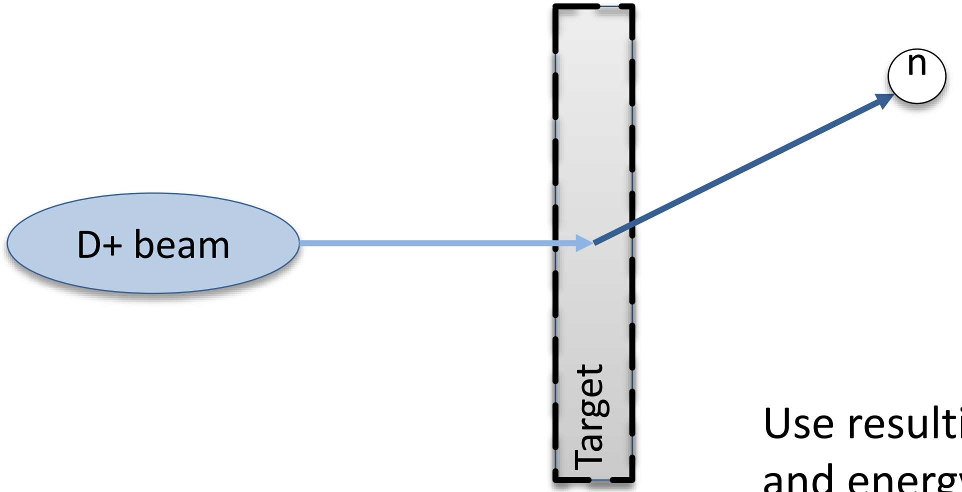


- Historically, the pulsed sphere measurements were simulated using a disk source of D-T neutrons
  - Calculate energy and angular distribution using kinematics
  - Used neutrons from 200 keV deuterons, most probable energy of deuterons within the T-Ti target

COG Deuteron Transport Allows for Much Improved Source Term

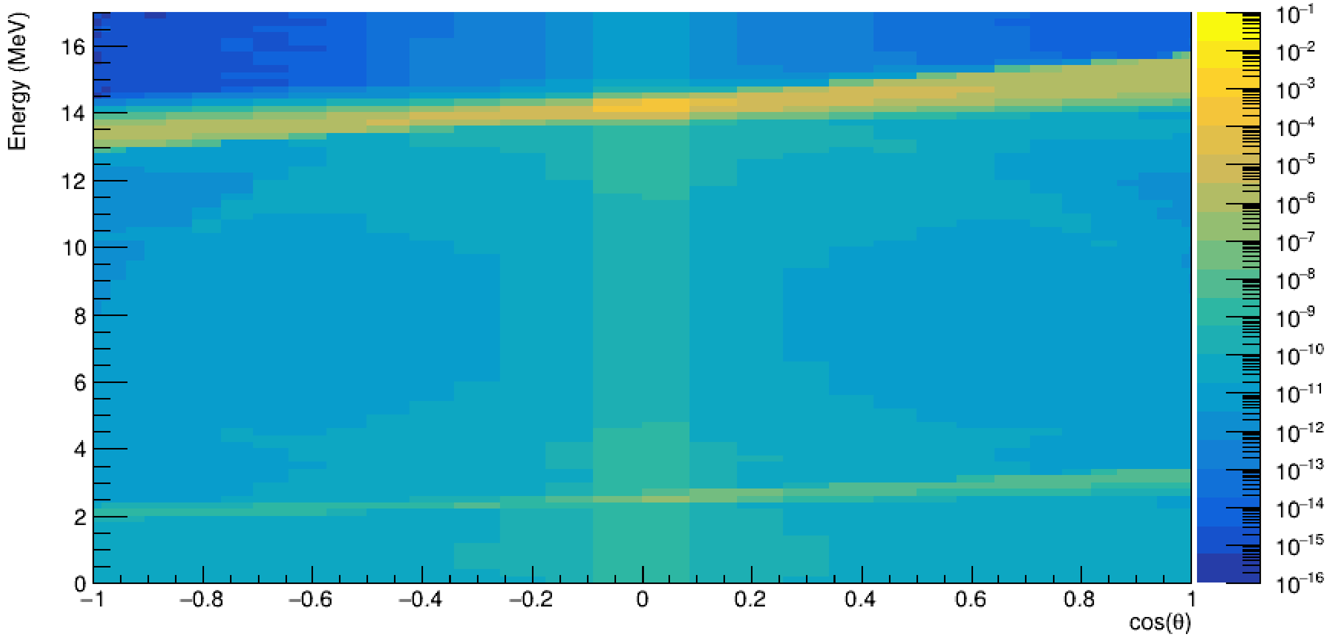
- COG is a LLNL radiation transport code
- Use COG to transport deuterons
  - Simulate D-T and D-D neutrons

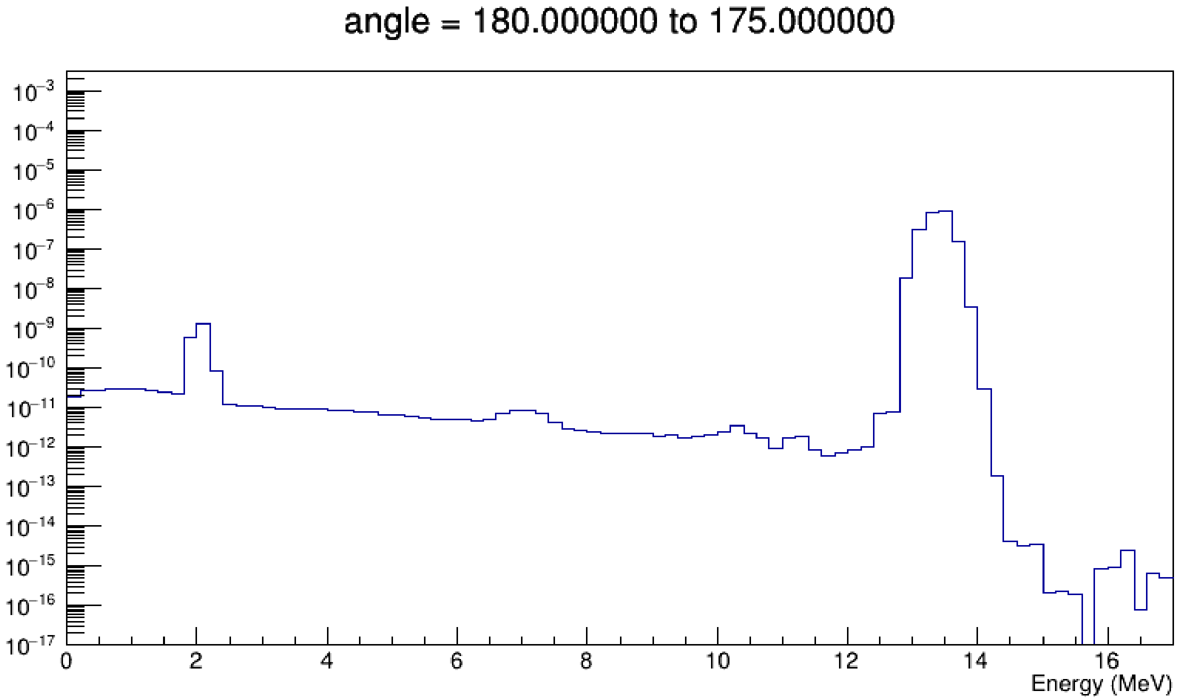
Count neutrons crossing boundary, record angle and energy



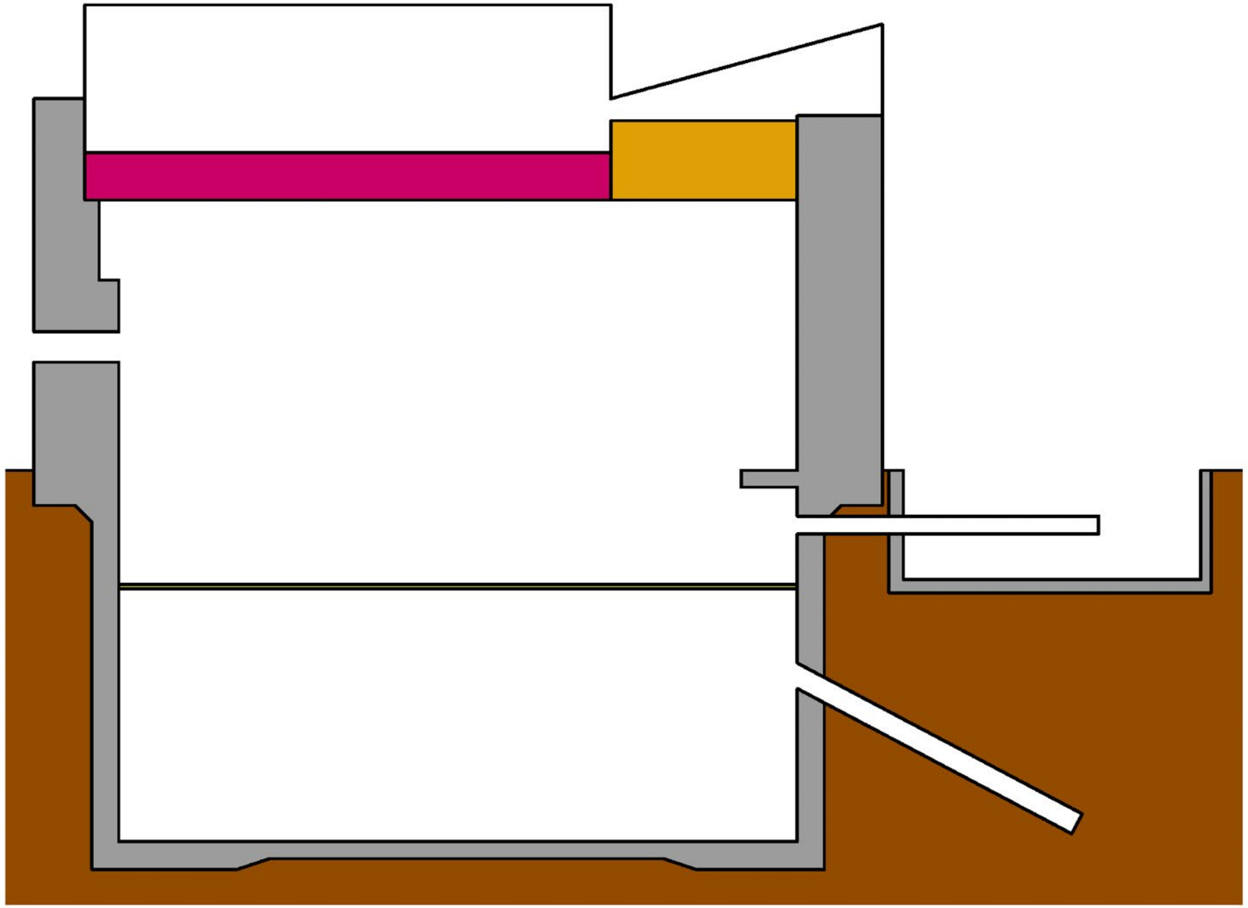
Use resulting neutron angular and energy distribution as neutron source

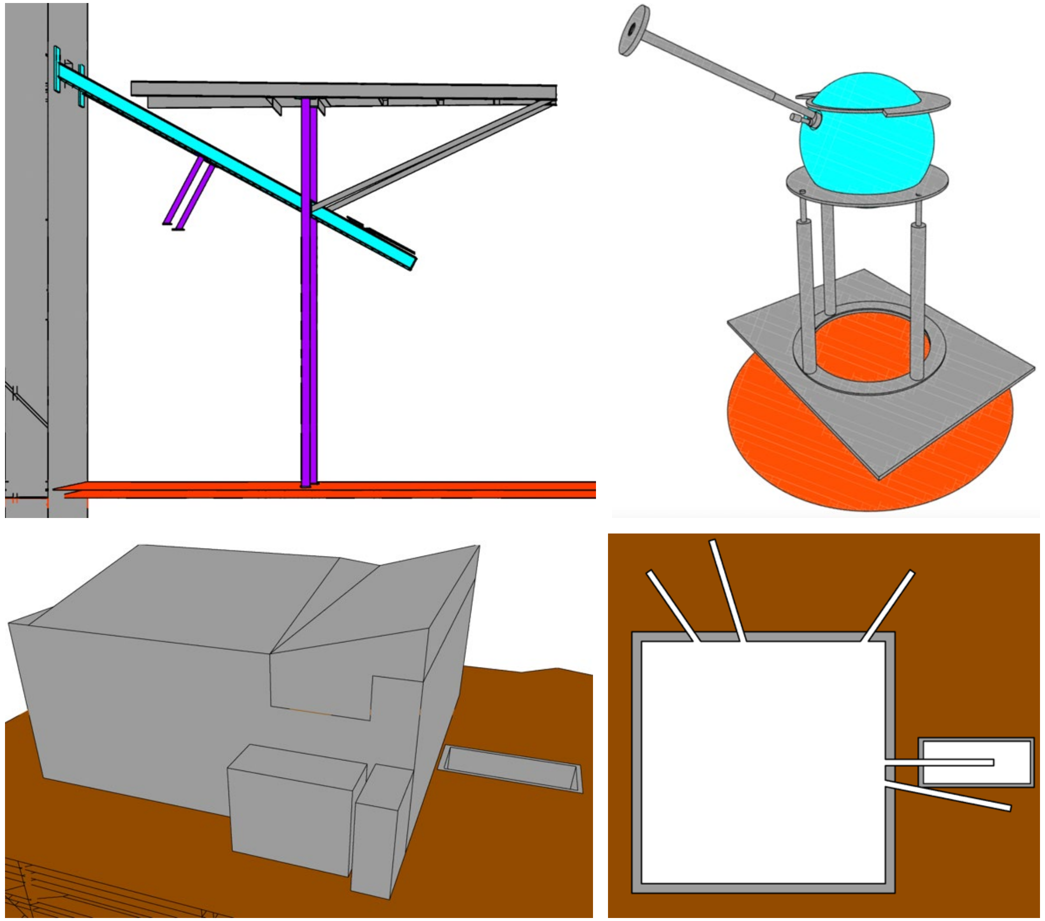
COG Generated Neutron Source



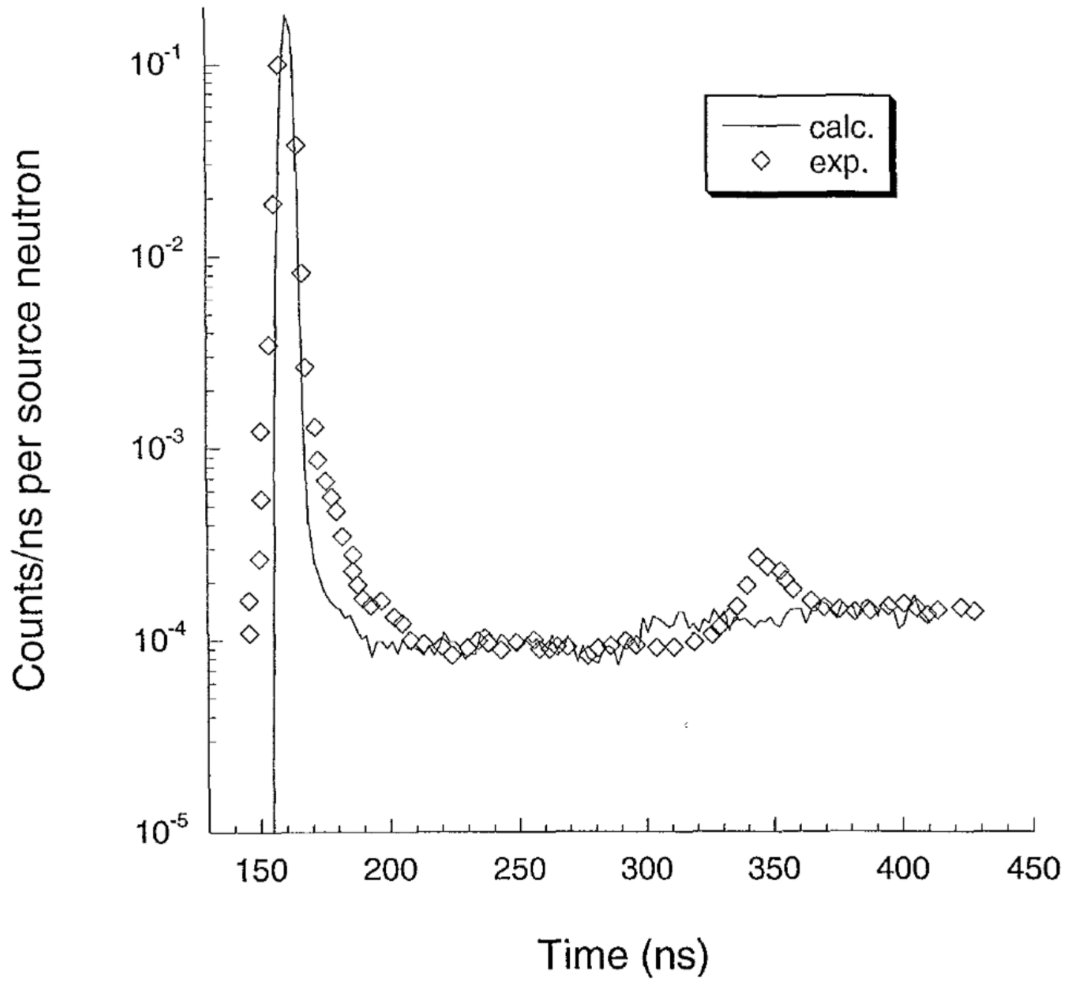


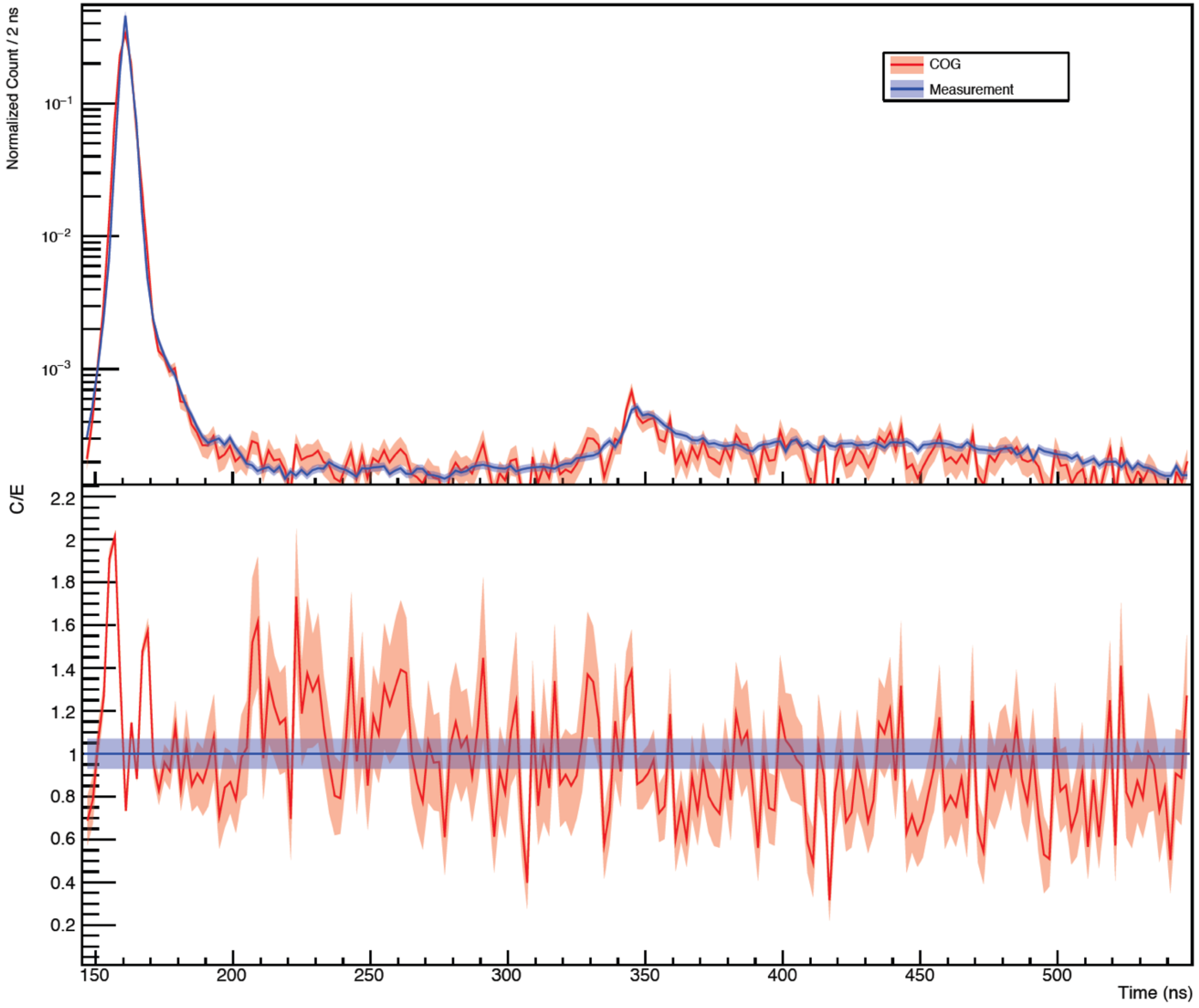
High-Fidelity Model





Blank Run Results





Conclusions

- Presented benchmark of the blank and polyethylene spheres at SINBAD in April 2023. In responding to comments about the building, we uncovered a large amount of additional detailed information about the building and experimental set up
- We incorporated this new information into an even higher fidelity model and are working on uncertainty analysis at a low level
- Scheduled to present at SINBAD meeting in April 2024