Godiva 4 CAAS Shielding Benchmark Pre CED-3A Overview

Riley Cumberland

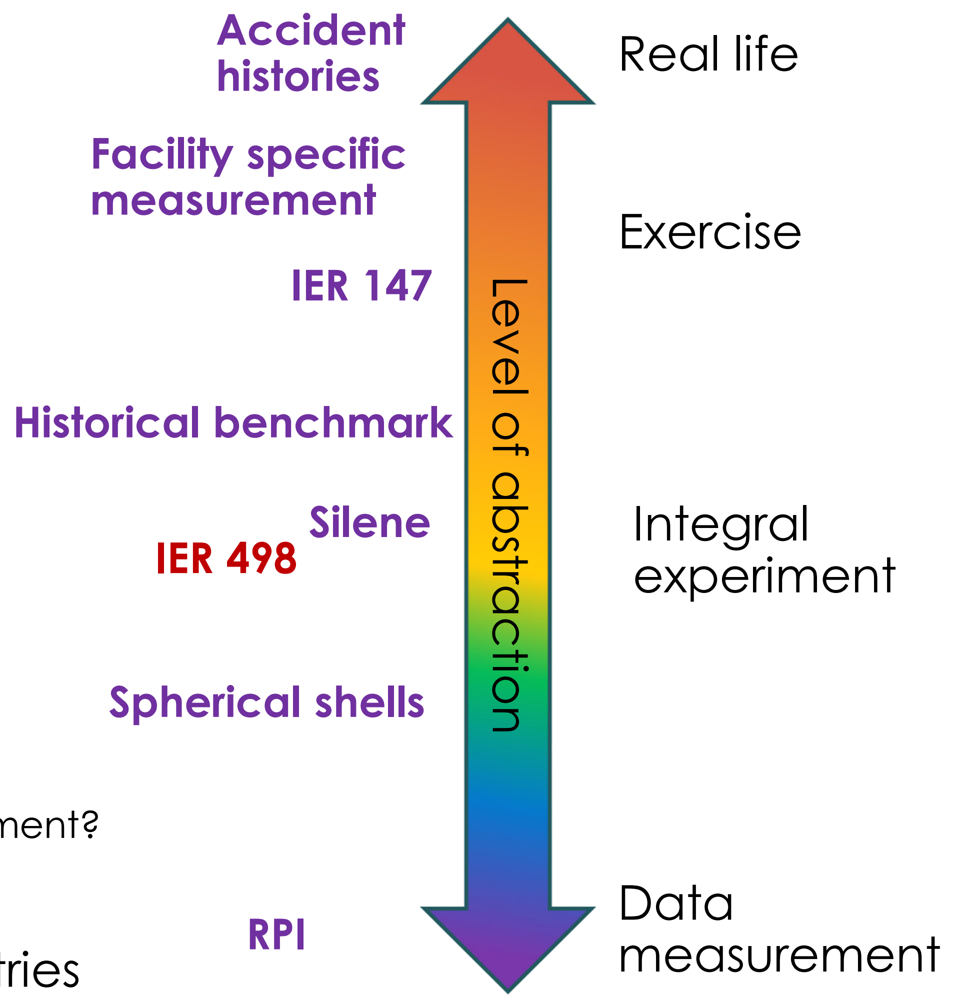
This presentation briefly outlines the CAAS benchmark project using Godiva 4 as a source (IER 498) and discusses the implications of the Godiva 4 Reproducibility work (IER 557)

Overview

- The character of an integral experiment
- Why Godiva 4?
- The IER 498 benchmark quantity
- Activities facilitated by IER 498
- Proposed CED-2 test matrix
- What happened during the IER 498's gap year?

The character of an integral experiment

- Similar enough to applications of nuclear simulation codes
  - Applicable materials (fuel, reflector, moderator, absorber, structural, and shield)
  - Applicable neutron and gamma spectrum
  - Applicable metrics (dose, reaction rate, flux, etc.)
  - Similar source spectrum
- Tractability
  - Easily manageable and/or justifiable uncertainties
  - Easy to simulate benchmark geometry
- “Good” data
  - Uncertainty < 20% for a shielding benchmark
- Informs nuclear data needs
  - e.g., “How bad is the (n,γ) data?”
- Provides tacit knowledge
  - How much variation is due to detector uncertainty vs the room environment?
  - When does geometry matter?
- A level of validation to CAAS simulation codes and geometries



Why Godiva 4?

- Inherently has similarity to a criticality accident
  - Can we inform on other uncertainties besides nuclear data?
  - When is nuclear data the dominant uncertainty?
- Real super prompt critical fast spectrum burst with limited room return
- Source is strong enough to use foils as detectors

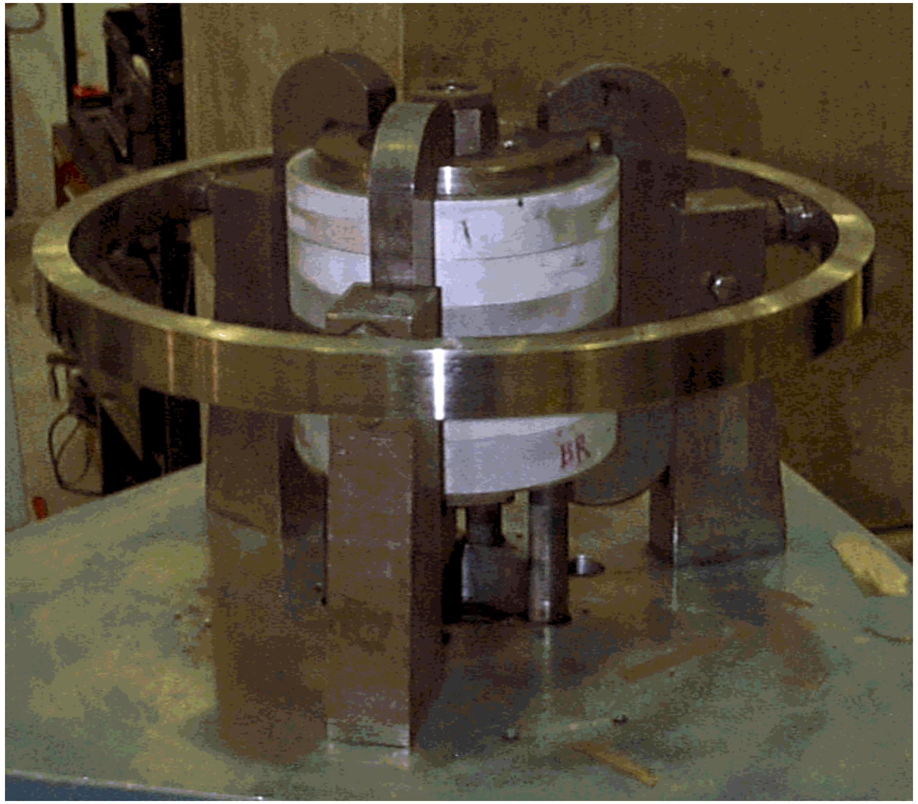


Photo from R. D. Mosteller, "Godiva-IV Delayed-Critical Experiments and Description of an Associated Prompt-Burst Experiment," Los Alamos National Laboratory, NEA/NSC/DOC/(95)03/II, HEU-MET-FAST- 086, 2014.

The IER 498 benchmark quantity is a comparison

The test relies on a comparison of shield sample vs no-shield sample to reduce uncertainty

Shielded measurement with uncertainty

VS

Baseline measurement with uncertainty

⇨ Effect of shielding

Benchmark Quantity $$Q = \frac{x_{i,shielded}}{x_{i,baseline}}$$

$Q_{Trial1} \cong Q_{Trial2}$ ⇨ Confidence in the measurements

$Q \cong Q_{simulated}$ ⇨ Confidence in the simulation of shielding sample

$x \cong Q_{simulated}$ ⇨ Confidence in full simulation (very lucky)

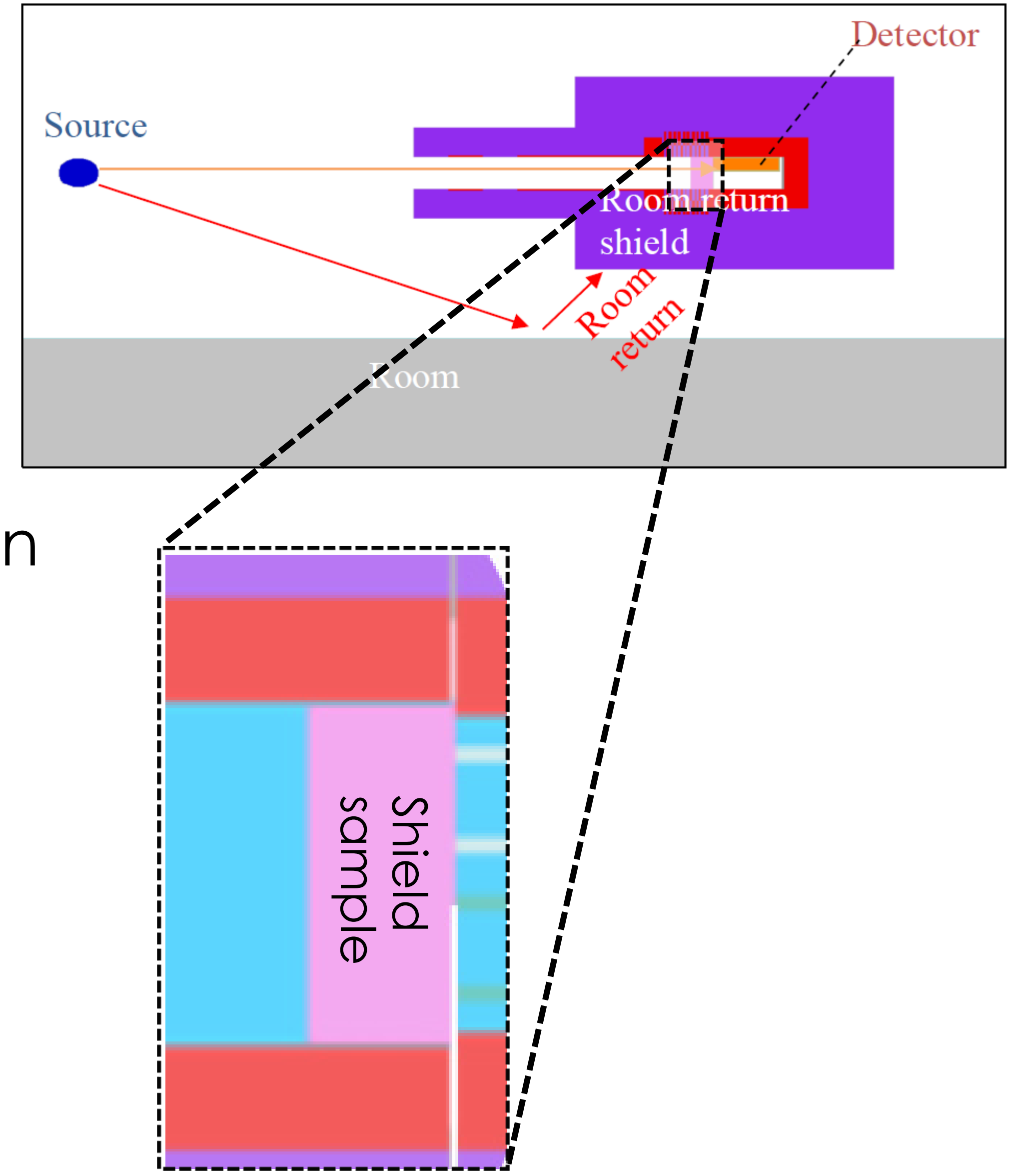
Ensuring that the difference in burst size is known is fundamentally necessary for burst tests

*Fantasy Art Bogeyman in Deep by David S. Soriano.

IER 498 enables several activities

- A suite of shielding tests
  - Highlight (n,γ) reaction
  - Highlight material mixtures (resonance overlaps)
- A customized environment for detectors under test
- Diagnostic measurements of room reflection at specific locations and perhaps from specific materials
- Sufficient agreement using electronic detectors could enable further use, potentially streamlining experiments

The room return shield blocks room return, and provides a known environment



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Proposed CED-2 test matrix ranges from low power to burst

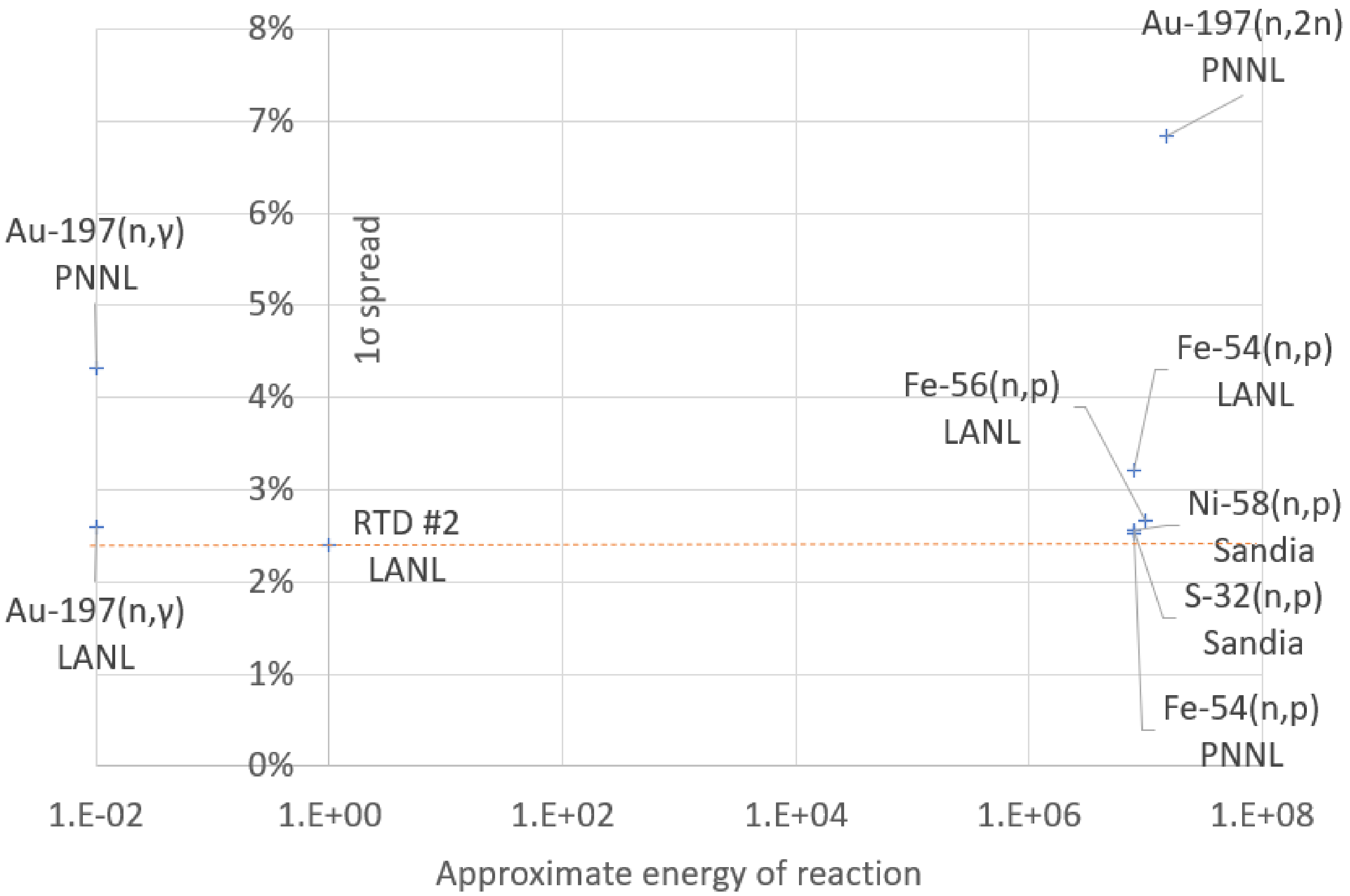
- The burst operations can provide more foil information
- The steady-state operation provides contrasting data, with fewer passive detectors
- The steady-state operation with electronic detectors can provide a second cross-comparison
  - Could enable streamlined experiments
- Materials are selected to minimize nuclear data and material data used

Table 17. Test matrix.

Shielding Sample	Number of Detectors: Steady state operation electronic detectors	Steady state operation passive detectors	Burst operation passive detectors
Blank	2+	2	2
Pb 10cm	1	1	2
Pb 5cm	1	1	2
PE 10cm	1	1	2
PE 5cm	1	1	2
SiO_2 10cm	1	1	2
SiO_2 5cm	1	1	2
total	8+	8	14

IER 557 has aided IER 498

- Onsite experience with foil counting
- Sandia and PNNL provided excellent instrumentation expertise
- Demonstrated the reproducibility for ΔT=70C
  - We can claim a 1σ uncertainty of 3%
  - All we needed was 7%



Summary

- Integral experiments increase the level of realism from that of data measurements.
- Godiva 4 is capable of intensities to activate foils
- IER 498 uses a relative measurement to provide an intermediate level of realism.
  - Reproducibility and room return management are key components
  - The test matrix put forward in CED-2 enables numerous cross comparisons
- IER 498 facilitates various additional works using a room return shield to isolate the source
- IER 557 demonstrated burst reproducibility sufficient for IER 498