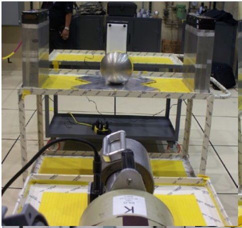

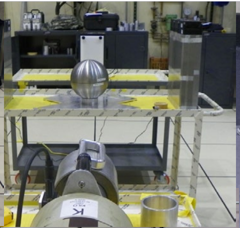

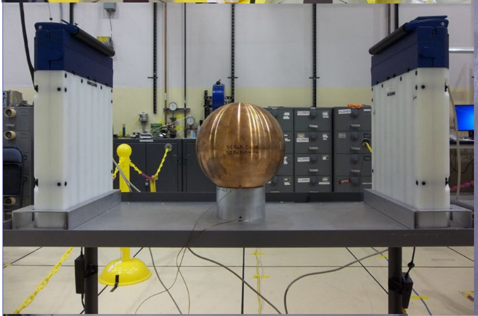

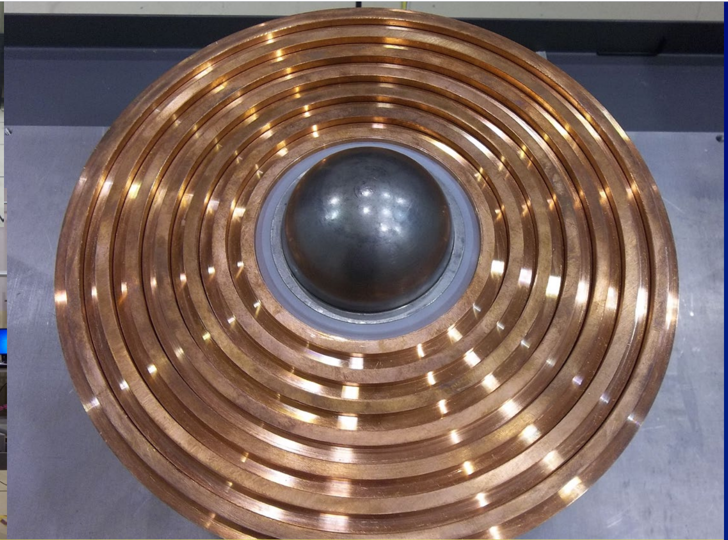

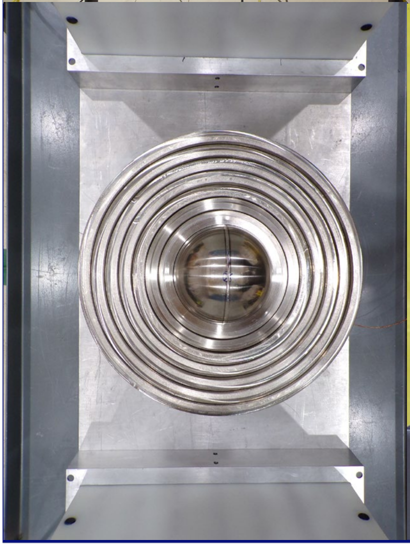

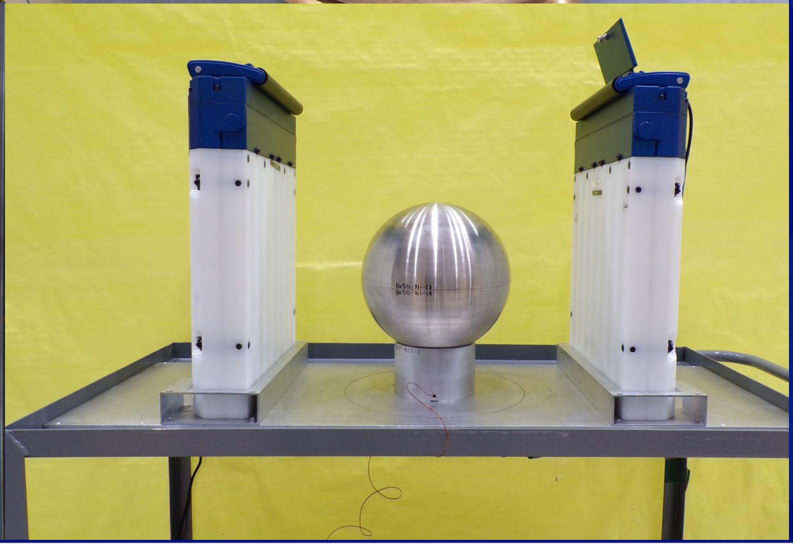

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IER 567: MUSiC Subcritical NoMAD Leakage Multiplication Benchmark Results

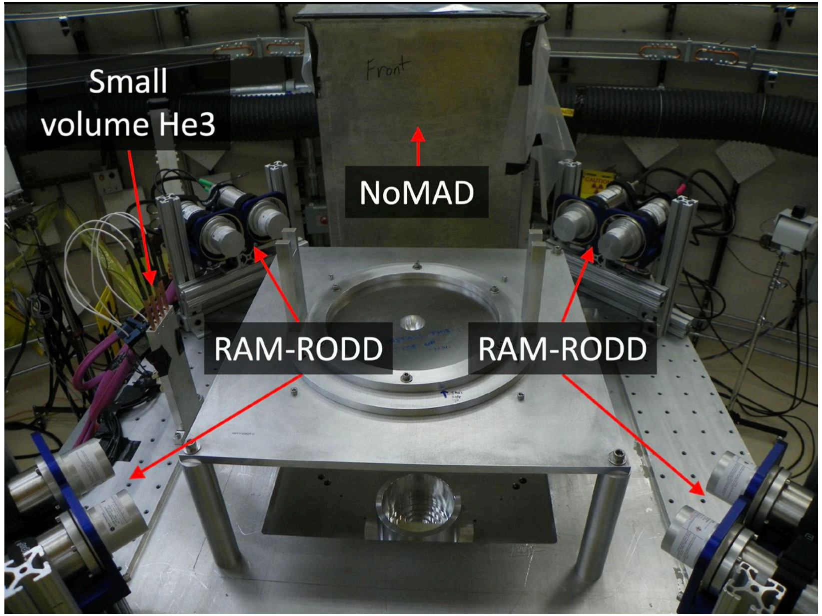
Alex McSpaden, Rob Weldon, George McKenzie

December 4th, 2024

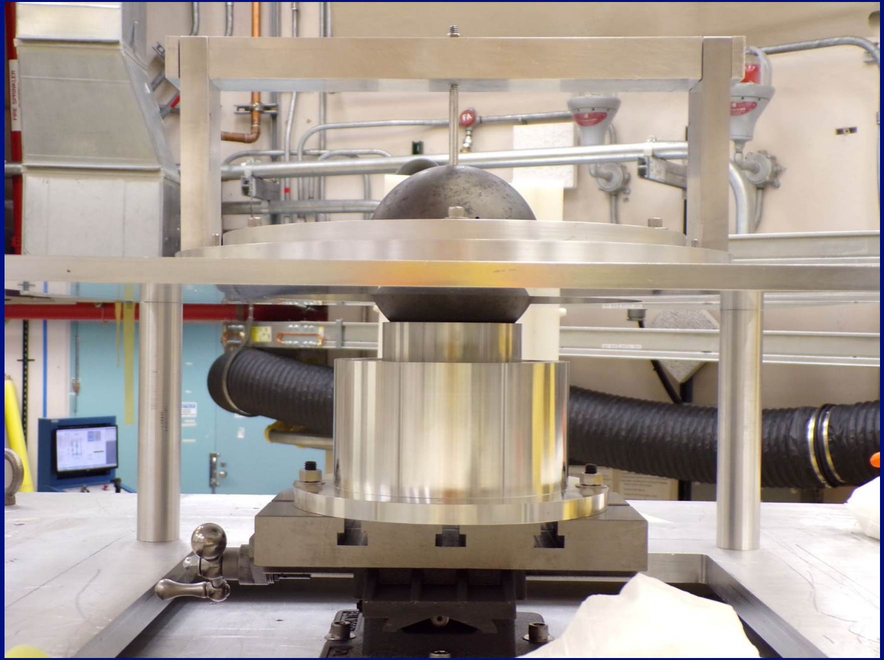
LA-UR-24-32603

MUSIC Overview

- Multiple configurations of highly-enriched uranium (HEU) hemishells measured using many detectors, and able to be analyzed with a variety of methods
  - Deeply subcritical to delayed supercritical
- Executed at NCERC from Dec 2020 to March 2021
  - Utilized the Planet vertical lift machine
- Collaboration with IRSN and University of Michigan



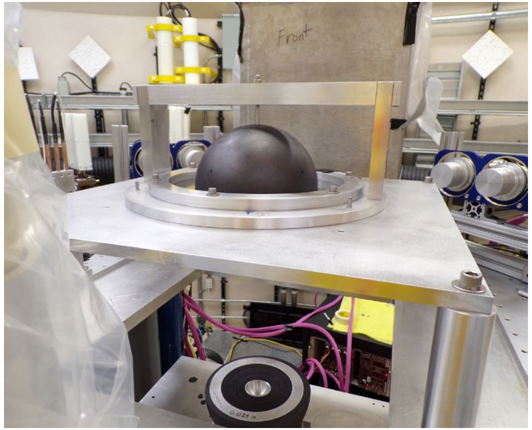
Configurations

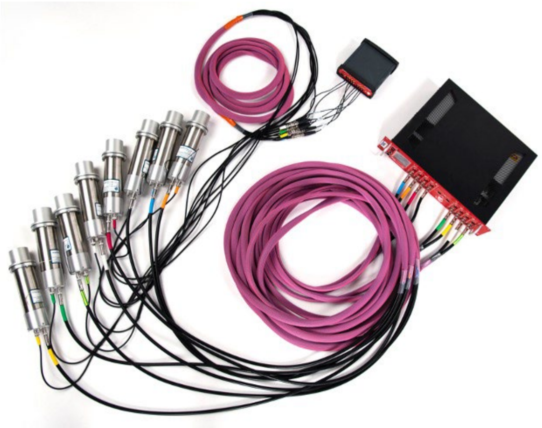


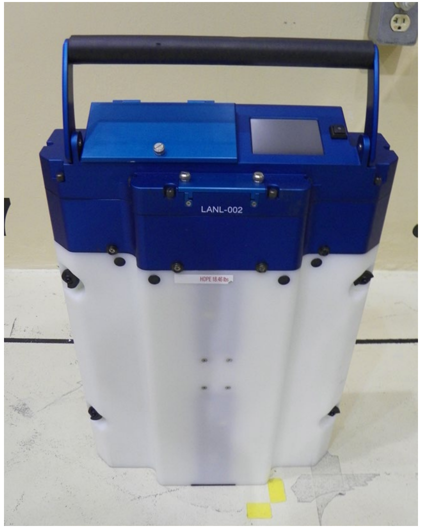
- Main difference is HEU mass:
  - C1 – 13.042 kg
  - C8 – 60.607 kg
- Measured with no source, ^{252}Cf, and neutron generator

Configuration	Rocky Flats Shells	Super-/Subcritical	Date
1	3-24	Subcritical	22-23 February, 2021
2	3-30	Subcritical	23-24 February, 2021
3	3-34	Subcritical	25 February, 2021
4	3-38	Subcritical	8 March, 2021
5	3-40	Subcritical	9 March, 2021
6	3-42	Subcritical	9 March, 2021
7	3-44	Subcritical	9/23 March, 2021
8	3-46	Supercritical	24-25 March, 2021
9	3,5-46	Supercritical	15 December, 2020 25 March, 2021
10	9-46	Subcritical	29 March, 2021

Avenues of Work







Critical Benchmark

Approved as HEU-MET-FAST-104, also NSE journal article[1]

Organic Scintillator

Focus of Rob Weldon and Arel D'Agostino's talk

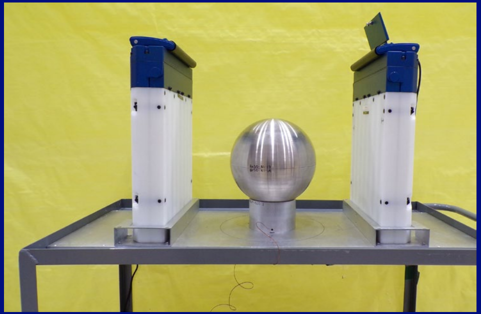
NoMAD

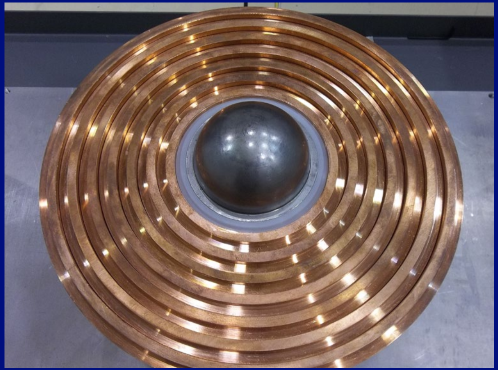
Focus of this talk (Feynman) and Kris Ogren's research (active interrogation)

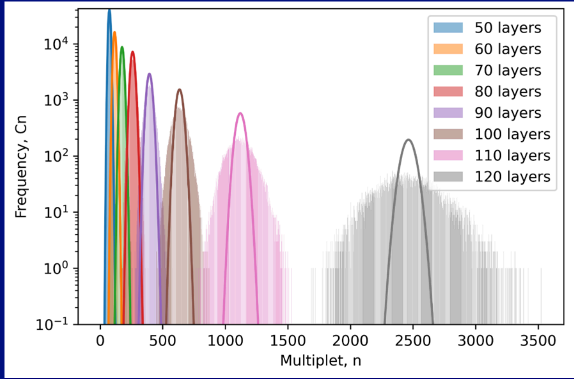
[1]A. McSpaden, et al, "The MUSIC Critical Benchmark and Nuclear Data," *Nuclear Science and Engineering*, 2024

LANL's Growing Set of Subcritical Multiplication Benchmarks

- Complement k_{eff} benchmarks by having different nuclear data sensitivities
  - SCRαP benchmark suggested changes to not only ^{239}Pu $\bar{\nu}$, but also the P_ν distribution
  - Perhaps an HEU benchmark could do the same for ^{235}U?
- Allow for further validation of correlated physics models CGMF and FREYA
- Allow for configurations where criticality is not possible
- Gives nuclear data evaluators another response to target
- *Allows multiple ways to get useful data from the same experiment*

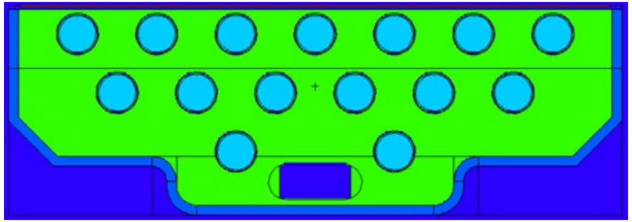






NoMAD

- 15 ^{3}He tubes in a high-density polyethylene matrix
- Records data in list-mode
  - Recorded counts have time to nearest 100 ns
    - Slowing down time in detector of ~40μs
- Used for many subcritical measurements (e.g. SCRαP, EUCLID, NeSO)



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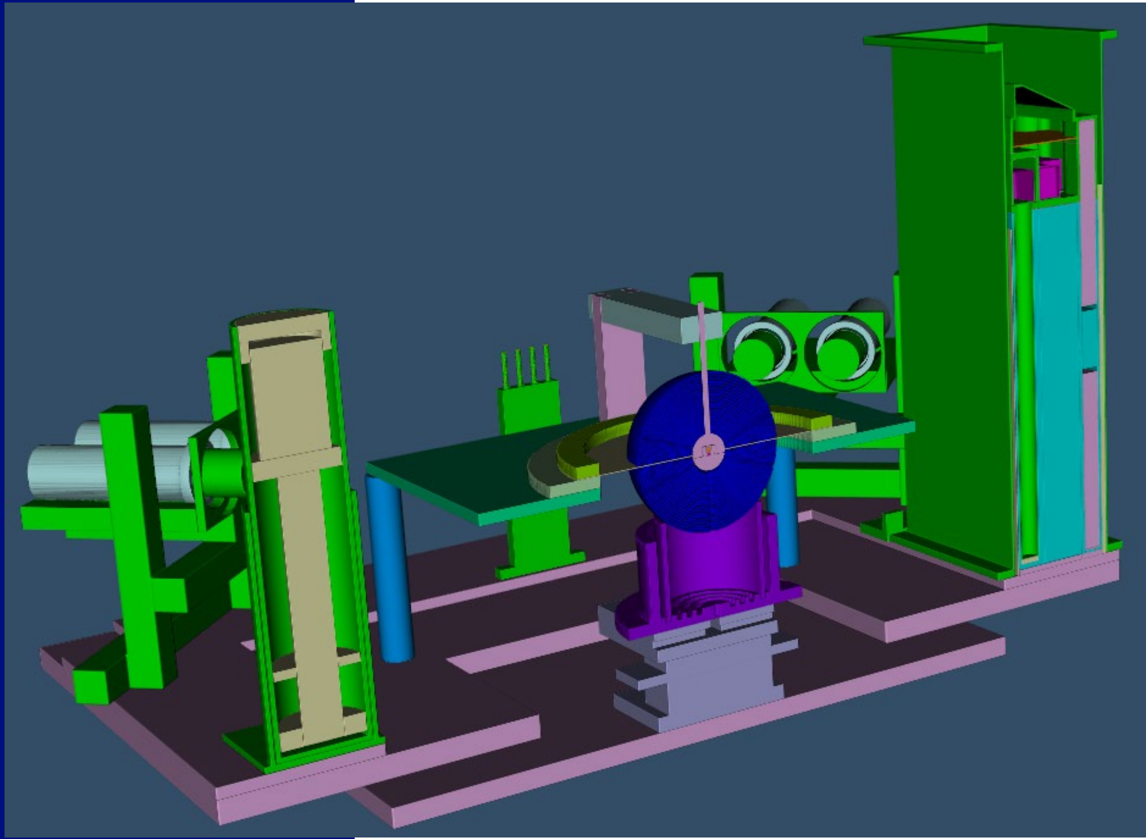
Measured Results – ICNC 2023

Table 52: NoMAD Results for a Subset of Configurations With an External ^{252}Cf Source.

Configuration	Measurement Time (min)	R_1	R_2	M_L
1	180	25234.23 ± 2.33	2137.82 ± 13.42	2.08 ± 0.01
2	180	35632.31 ± 2.94	5655.13 ± 21.18	2.82 ± 0.01
3	120	50193.32 ± 3.30	14370.4 ± 30.63	3.76 ± 0.02
4	120	78196.99 ± 6.93	48362.99 ± 95.65	5.49 ± 0.03
5	120	106738.7 ± 9.51	111628.3 ± 181.3	7.12 ± 0.04
6	120	165027.8 ± 13.1	358939.0 ± 413.7	10.2 ± 0.05
7	120	394938.8 ± 42.90	3176330 ± 3777	19.6 ± 0.10
10	120	376851.9 ± 43.12	3222145 ± 3904	20.2 ± 0.10

Current Models

- Very detailed
  - Includes all detectors and support components
  - Looking into which components can be removed or simplified for the final detailed model



Conclusions/Future Work

- Have made significant progress on the benchmark evaluation
  - Section 1 ready for independent review
  - Section 3 is in progress
  - On track for submission to Spring 2026 ICSBEP TRG

Acknowledgments

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