IER 518: High Multiplication Subcritical Benchmark Experiments at SNL

2023 NCSP Technical Program Review

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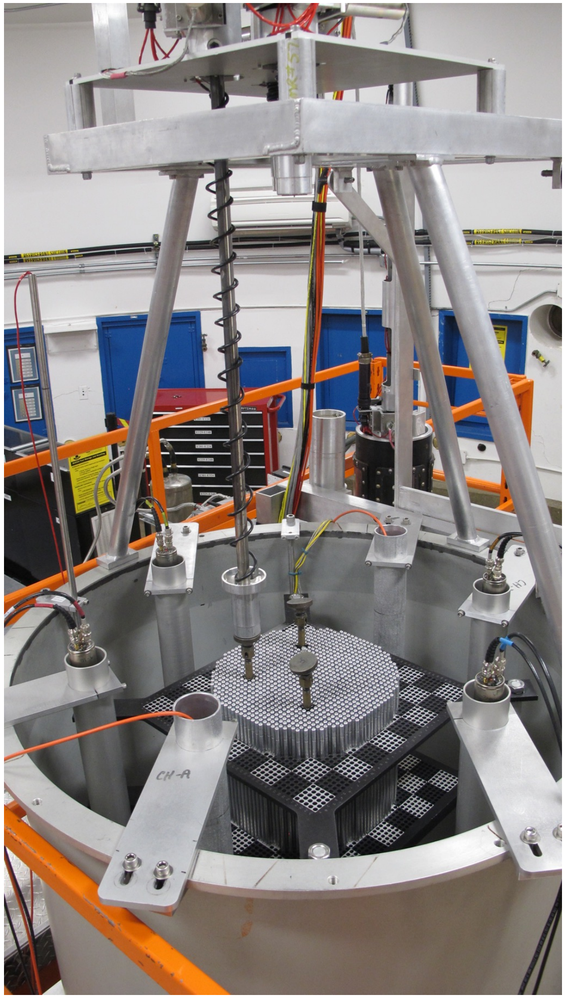
LLNL-PRES-845407

Overview

- Goals & Planning
- Experiment Setup
- Configuration Selection
- Experimental Configurations & Measurements
- Conclusion & Future Work



Goals

- Measure time-tagged list-mode data for configurations exceeding 20-100 multiplication
  - Overlap and extend existing subcritical multiplication measurements
  - Provide intercomparison between LLNL, LANL, and IRSN detector systems
- Create fundamental physics benchmarks for ICSBEP with greater than 20 multiplication
  - Currently none exist with greater than about 20 multiplication
- Leverage existing critical experiment and detector system benchmarks to limit required modeling and uncertainty analysis
  - Minimize cost required to produce benchmark

Planning

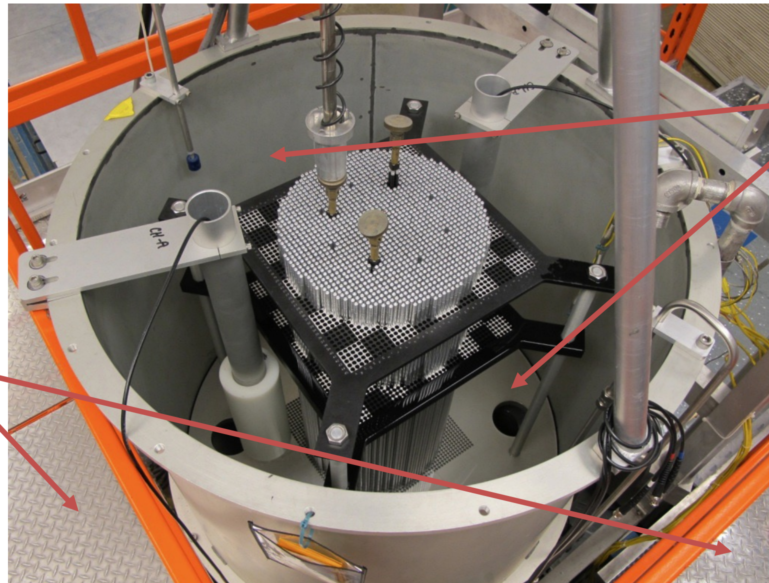
- The planning and execution of the measurements involved a collaboration between four laboratories

Laboratory	Participants
LLNL	Jesse Norris, Samuel Varghese, Daniel Siefman, William Zywiec, Catherine Percher, David Heinrichs
LANL	Nicholas Whitman, Jesson Hutchinson, Geordie McKenzie, Jessie Walker, Joetta Goda
SNL	Gary Harms, David Ames, Rafe Campbell, Beth Hanson
IRSN	Wilfried Monange, Jea, Baptiste Clavel, Aurelie Bardelay

Planning

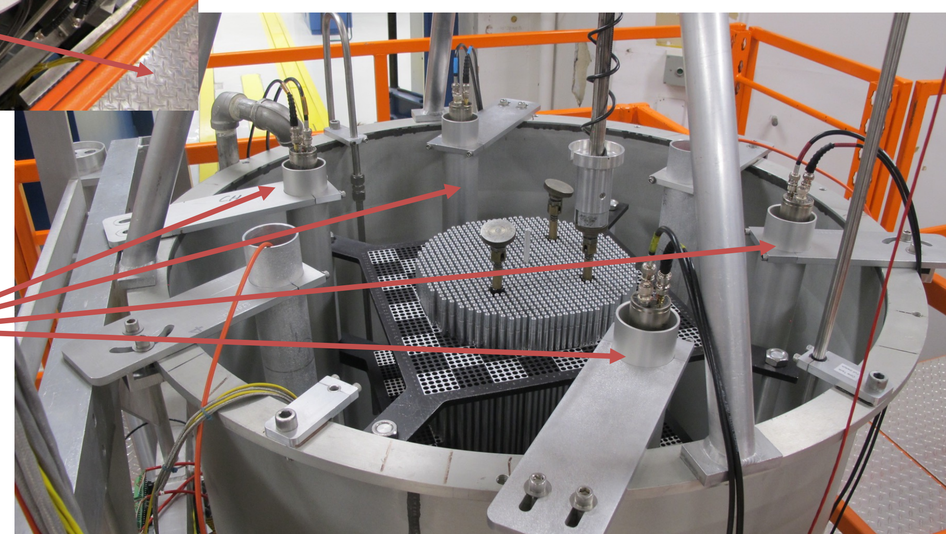
- Each of LLNL, LANL, and IRSN provided their own detector systems and expertise while SNL provided the experiment facility and operations
- SNL developed and implemented new operational capabilities to support the measurements
  - Network cabling for detector systems in the reactor room
  - Approval for sourceless operation
  - Modifications to allow for detector efficiency measurements without fuel present

Experiment Setup



Location for dry wells inside the tank

Floor around tank



Detectors within dry wells inside the tank

Configuration Selection

LEU-COMP-THERM-078

- 15 benchmark configurations
- Case 2 (like Case 1)
  - 1052-1056 fuel rods
  - Estimated delayed critical at 1057.2 rods
  - 1056 rods estimated to be k_{eff}=0.99975 (M=4000)
  - Fuel rods worth 18-21 pcm
- Case 15
  - 864-872 fuel rods

LEU-COMP-THERM-080

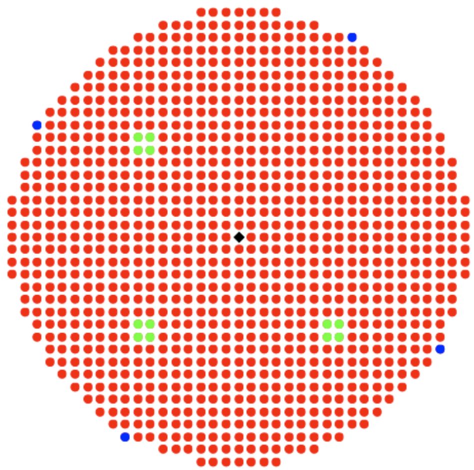
- 11 benchmark configurations
- Case 2 (like Case 1)
  - 1436-1444 fuel rods
  - Estimated delayed critical at 1457.4 rods
  - 1444 rods estimated to be k_{eff}=0.99804 (M=510)
  - Fuel rods worth 14-22 pcm
- Case 11
  - 1128-1136 fuel rods

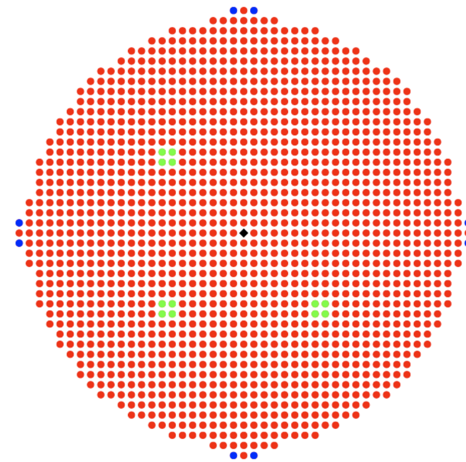
Configuration Selection

- Fuel Rod
- Incremental Fuel Rod
- Control/Safety Rod
- Source

LCT-078

- Case 2
  - 1056 rods

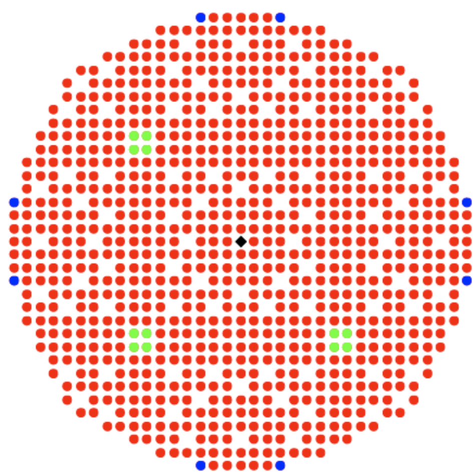


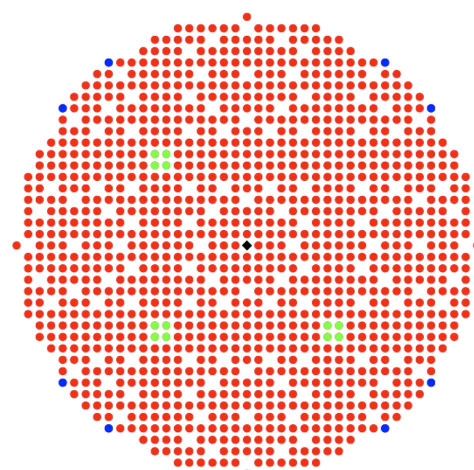


LCT-080

- Case 2
  - 1444 rods

- Case 15
  - 872 rods





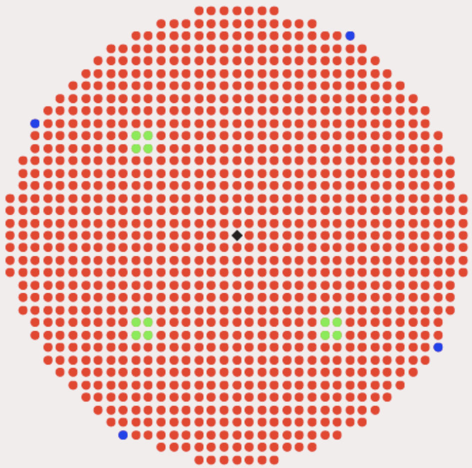
- Case 11
  - 1136 rods

Configuration Selection

- Fuel Rod
- Incremental Fuel Rod
- Control/Safety Rod
- Source

LCT-078

- Case 2
  - 1056 rods



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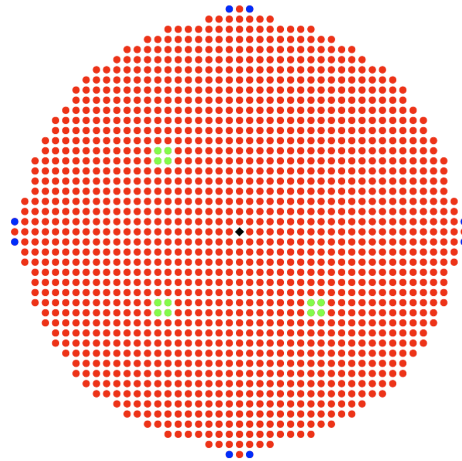

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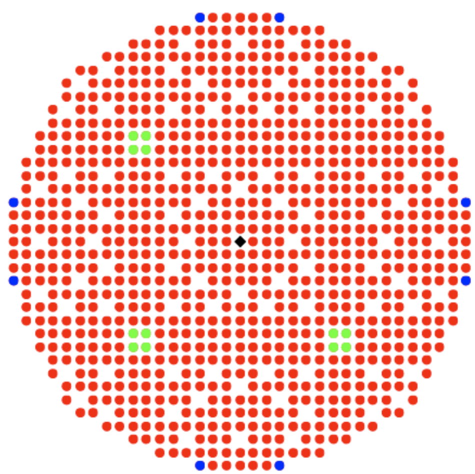
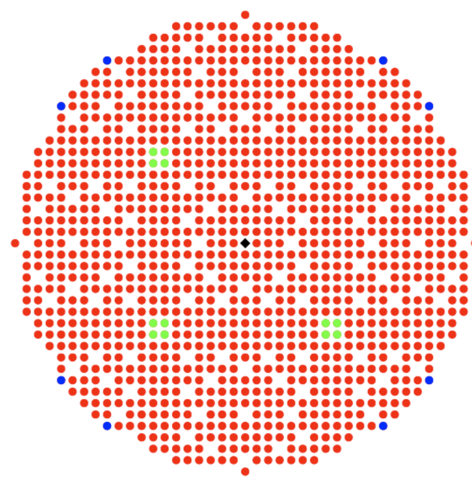


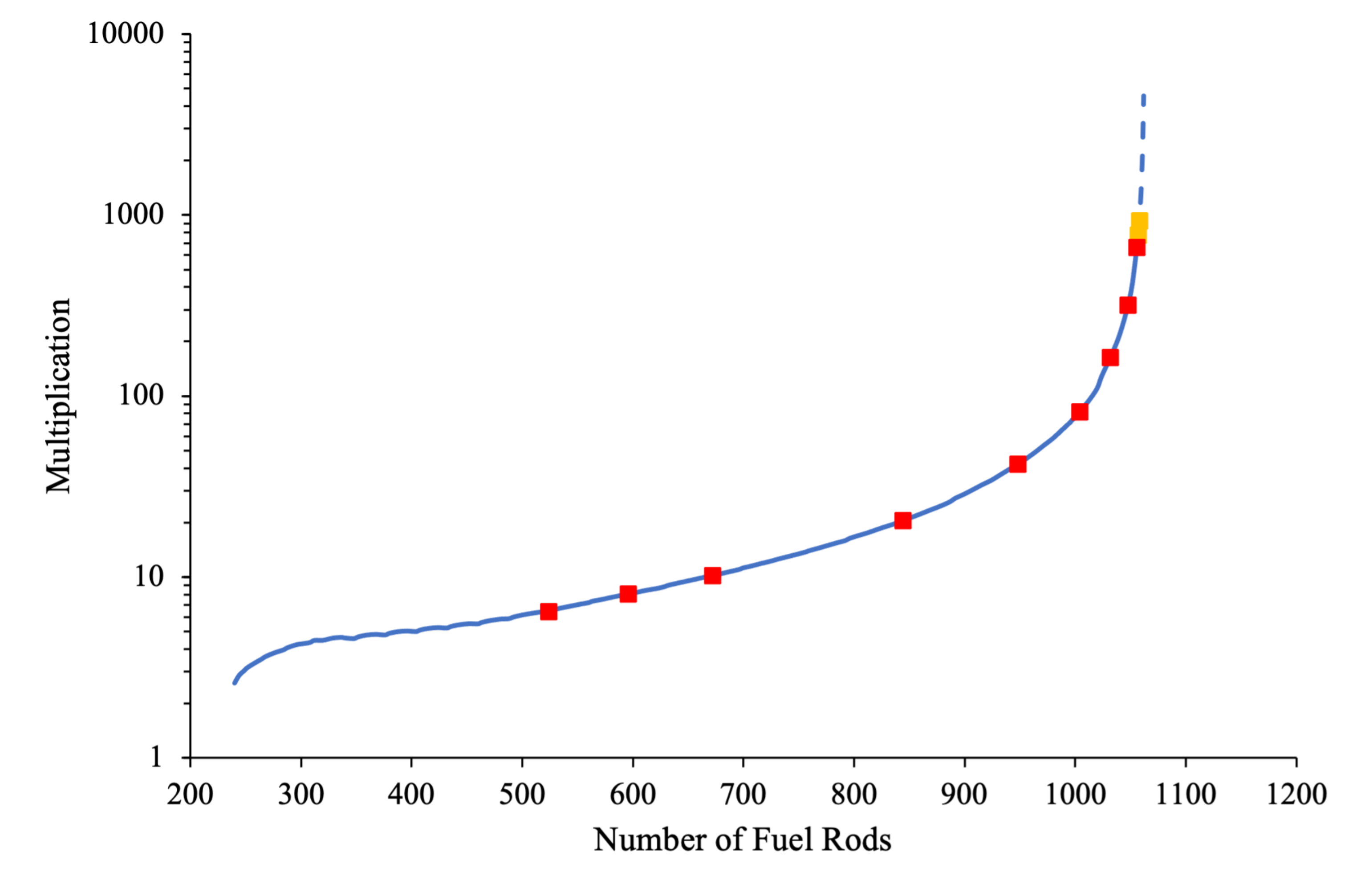


- Case 11
  - 1136 rods

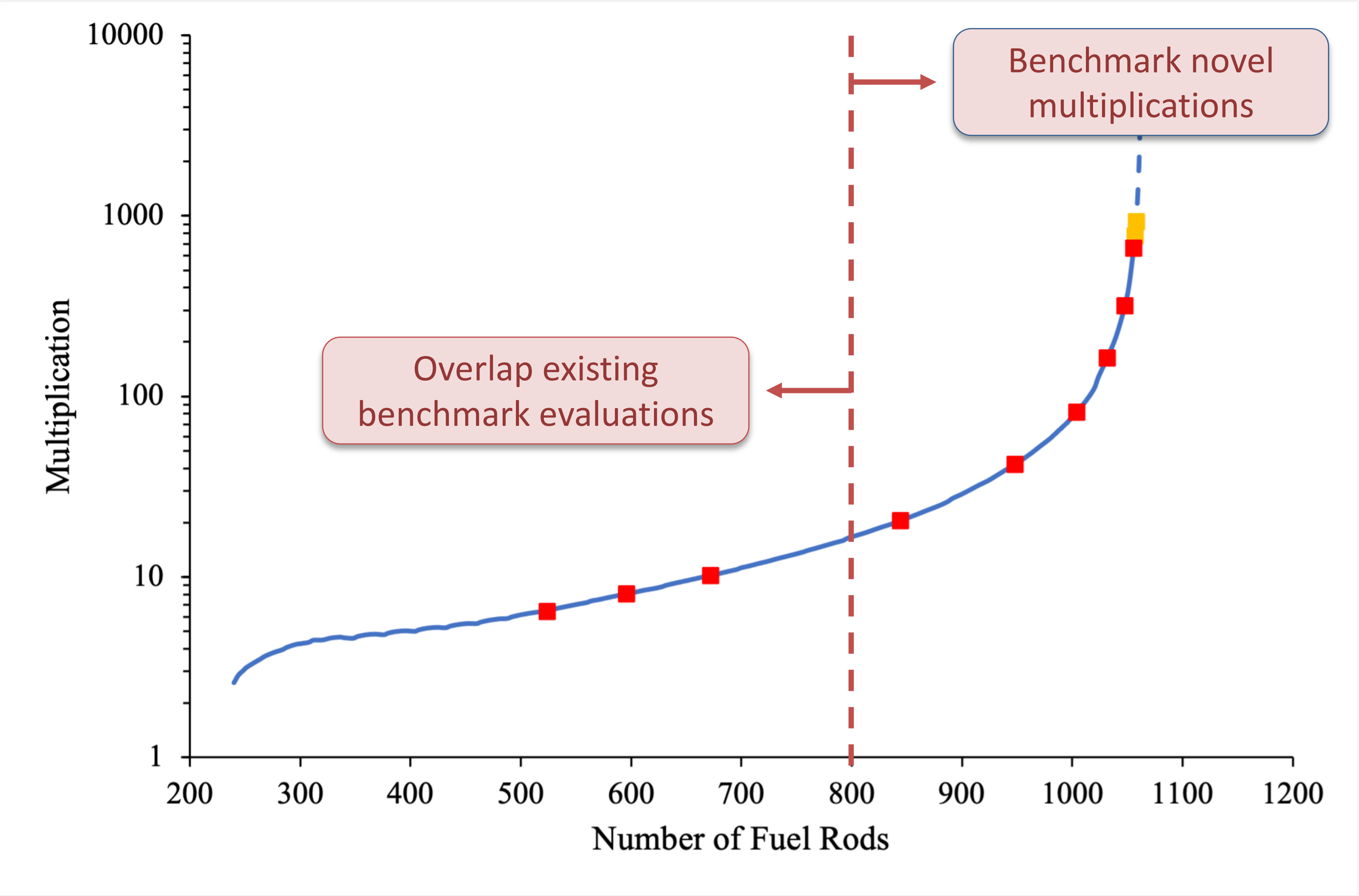
Experimental Configurations

Configuration	Number of Fuel Rods	Estimated k_{eff}	Multiplication
1	524	0.84469	6.4
2	596	0.87595	8.1
3	672	0.90138	10.1
4	844	0.95116	20.5
5	948	0.97610	41.8
6	1004	0.98776	81.7
7	1032	0.99388	163.4
8	1048	0.99684	316.5
9	1056	0.99849	662.3
10	1058	0.99892	925.9

Experimental Configurations



Experimental Configurations



Experimental Measurements

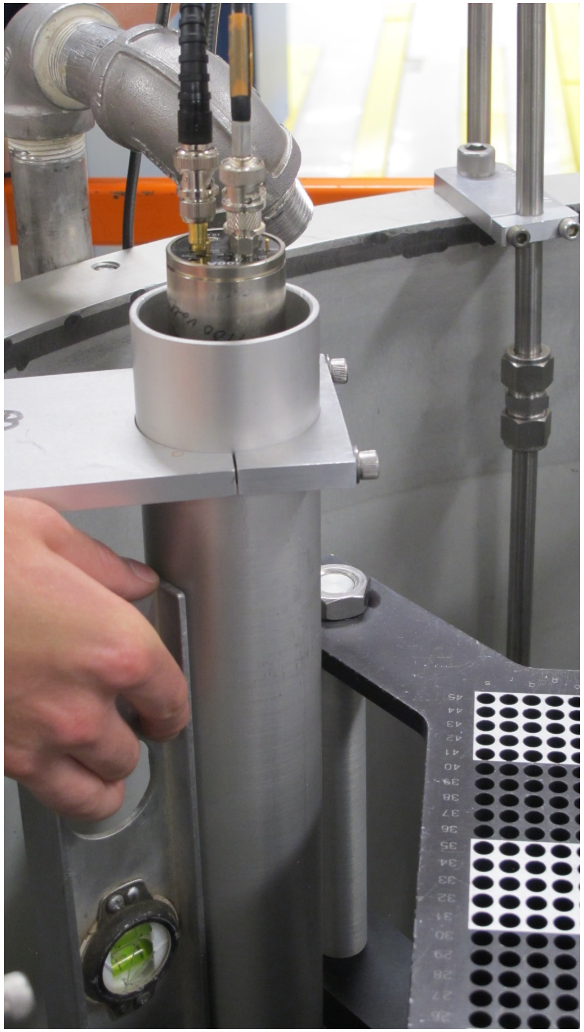
- Separate measurements for each detector system using the same configurations
  - Allow intercomparison while preventing the need to model other systems

- Experimental measurements:
  1. Background measurement
  2. Detector efficiency measurements for each detector system using a well-characterized neutron source, no fuel present
  3. 5-10 experimental configurations, ranging from a multiplication of 5 to 1000+

- Additionally, physical measurements of the system were performed including detector location and water temperature

Experimental Measurements

- IRSN performed measurements in June, LLNL is July, and LANL in October
- LLNL Measurements
  - Performed 33 total measurements
  - Six experimental configurations (5-10) with 1 hour counts each
  - Efficiency measurement with 2 hour count
  - Background measurement with 4 hour count



Conclusion & Future Work

- Successful collaboration between LLNL, LANL, SNL, and IRSN
  - Improved capabilities at SNL's SCX for future measurements of this nature
- Subcritical multiplication measurements exceeding those already in the ICSBEP performed with multiple detector systems to provide an intercomparison
- The Experiment Plan (CED-3a) was completed in Q4 of FY22
- The Experiment Execution Report (CED-3b) is currently in progress and planned for completion in Q2 of FY23
- The Benchmark Evaluation (CED-4) for the LLNL measurements is being performed by Daniel Siefman (LLNL)

Acknowledgements

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- Thanks to the Sandia National Laboratory SCX operators for their support of the experiment
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