



Exceptional service in the national interest

Sandia Critical Experiments Program

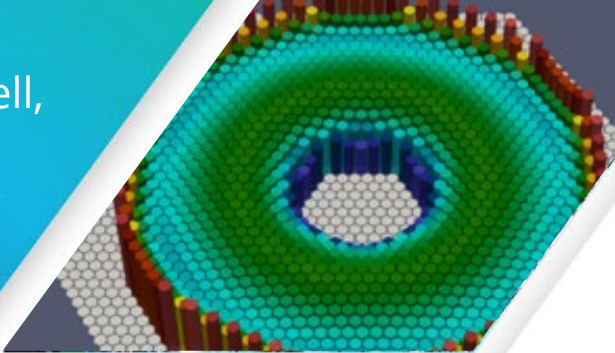
David Ames

Gary Harms, Elijah Lutz, Beth Hanson, Rafe Campbell,
Jason Soares, Patrick Ward, Mike Csernak

Sandia National Laboratories

2024 TRTR

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Sandia National Laboratories



Sandia Critical Experiments Program



Sandia National Laboratories



SRPF/CX



Technical Area V (TA-V)



Core Tank with 7uPCX fuel

DOE Nuclear Criticality Safety Program (NCSP)

- Integral Experiments
 - Design, perform, and document benchmark quality experiments
 - Support safe and efficient fissionable material operations
 - International Criticality Safety Benchmark Evaluation Project (ICSBEP)
- Training and Education
 - Hands-On Training Courses

SANDIA CRITICAL EXPERIMENTS PROGRAM



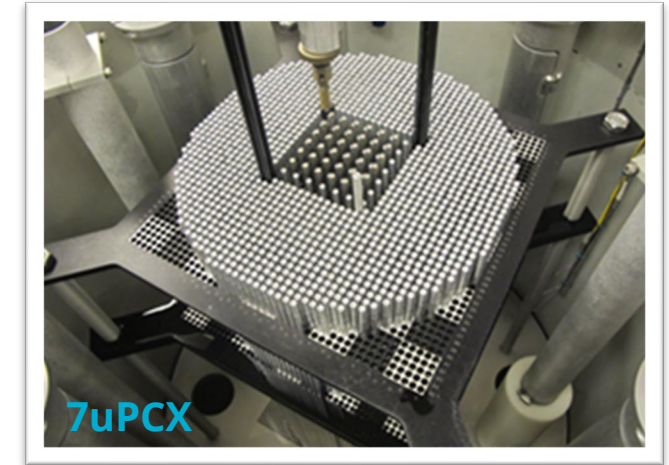
Sandia Pulsed Reactor Facility (SPRF)



CX Assembly Tank and Dump Tank

The Seven Percent Critical Experiment (7uPCX)

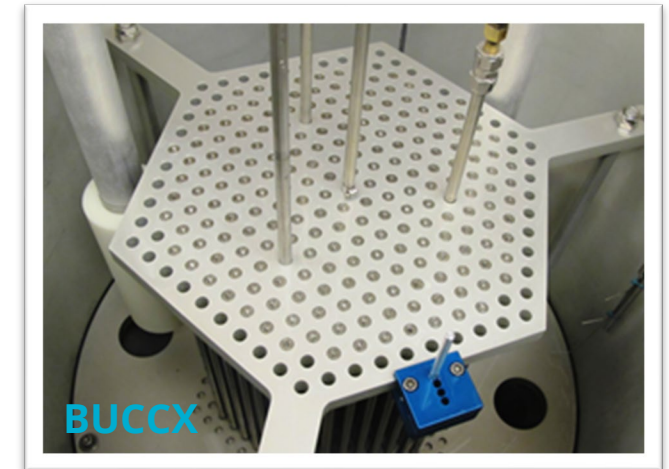
- UO_2 fuel (6.9% ^{235}U)
- Four sets of grid plates
 - 45x45 Square pitch array (0.8 cm)
 - 45x45 Square pitch array (0.855 cm)
 - Triangular pitch array (1.55 cm)
 - Triangular pitch array (1.02 cm)
- Fuel rod diameter 0.635 cm
- Fuel length 48.9 cm
- Seven Experimental Series in the ICSBEP Handbook
 - LCT-078, 080, 096, 097, 101, 102, 111



7uPCX

The Burnup Credit Critical Experiment (BUCCX)

- UO_2 fuel (4.3 % ^{235}U)
- Two sets of grid plates
 - Triangular pitch array (2.0 cm)
 - Triangular pitch array (2.8 cm)
- Fuel locations 397 and 271
- Fuel rod diameter 1.38 cm
- Fuel length 49.2 cm
- Two Experimental Series in the ICSBEP Handbook
 - LCT-079, 099

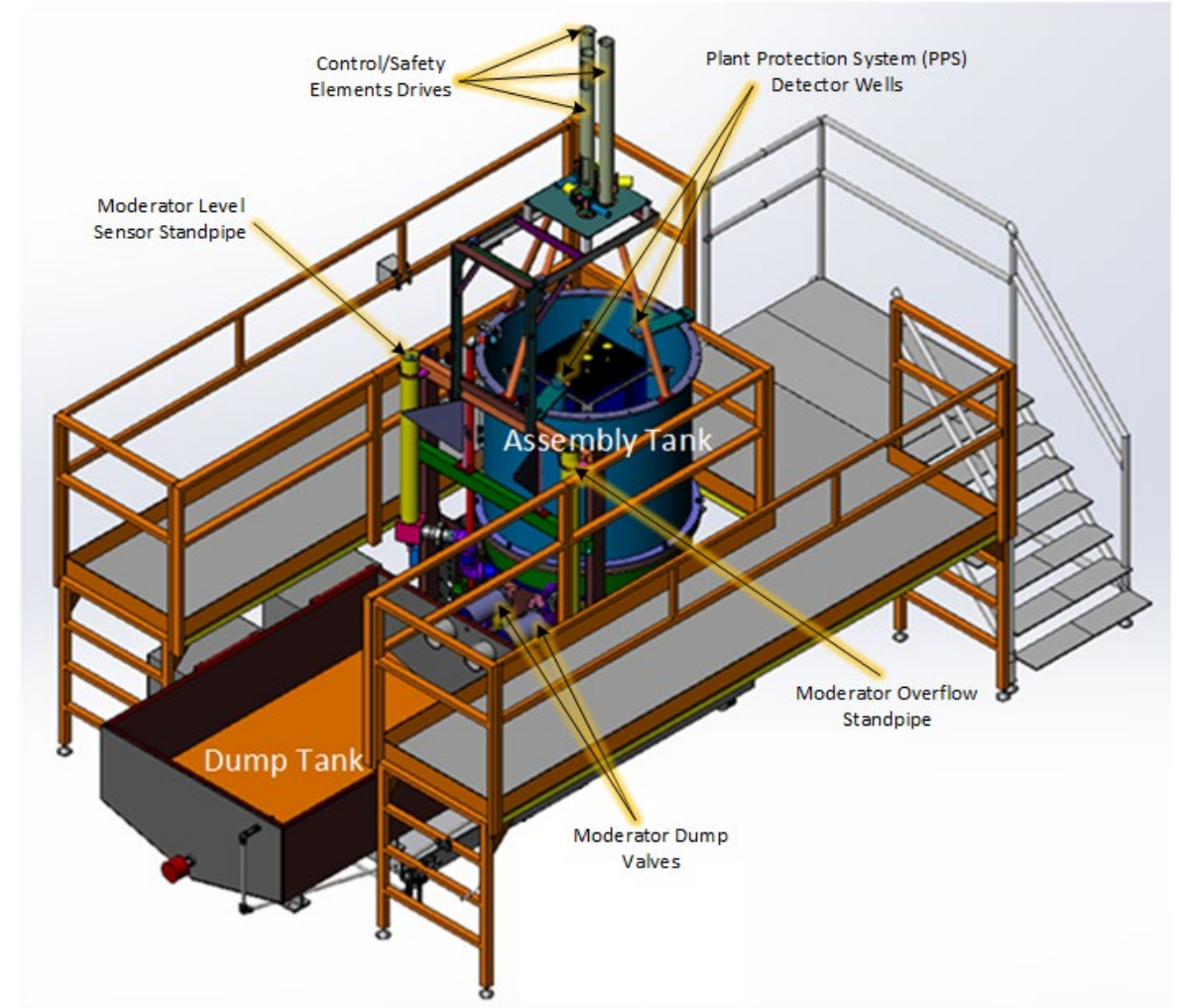


BUCCX

CRITICAL ASSEMBLY DESIGN

Notable Design Features

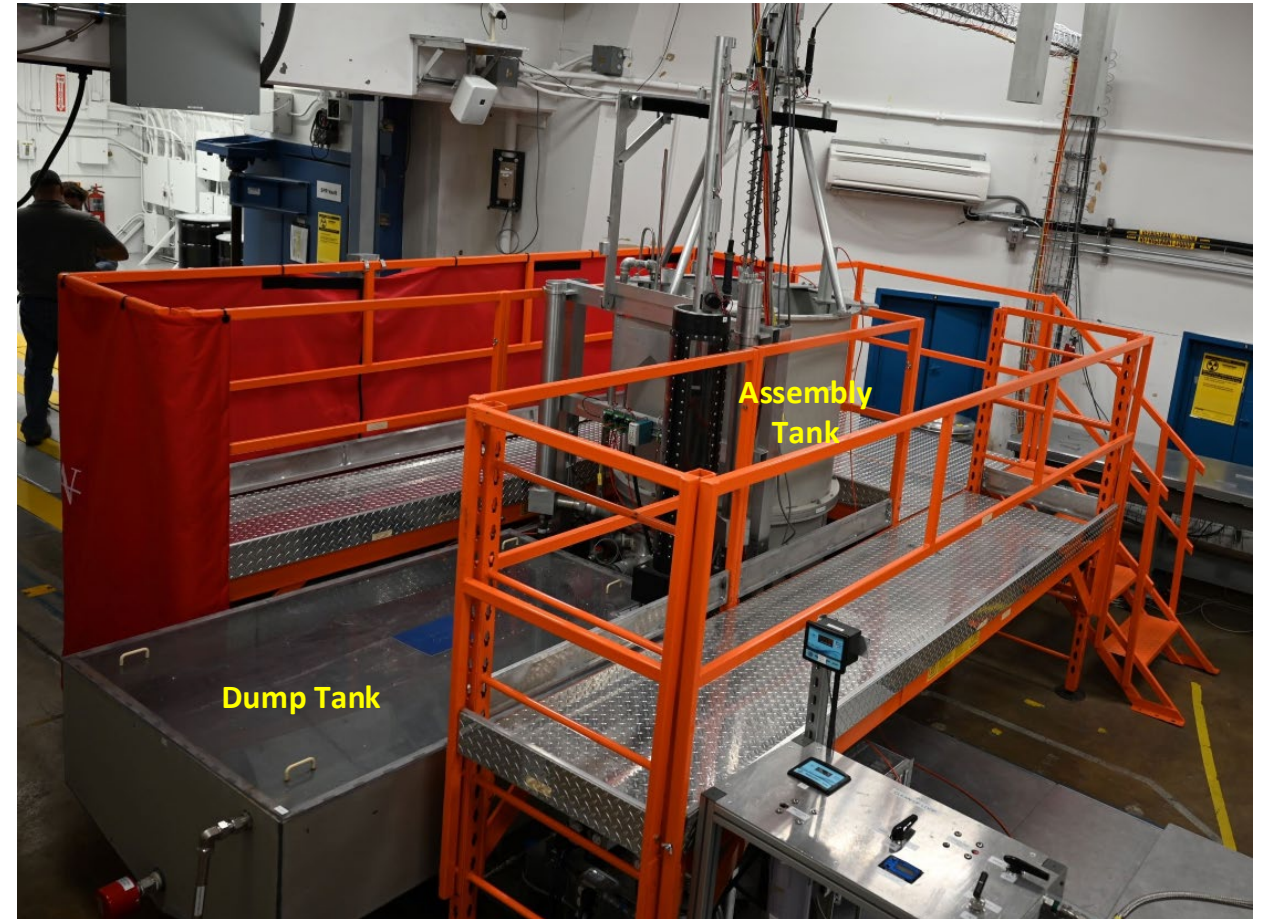
- Assembly tank
 - Fuel rods and grid plates
 - Elevated for gravity release of moderator to the dump tank
 - Provides full water-reflection and water level control
- Dump tank
 - Moderator resides in dump tank until operations
 - Heater maintains temperature
- Moderator Overflow Standpipe
 - Maintain water level in assembly tank
 - Water continually circulated between dump tank and assembly tank
- Control and Safety Elements
 - B₄C absorber section followed by fueled section
- Plant Protection System
 - Two fission chambers



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Burnup Credit Critical Experiment (BUCCX)



Started in the 1999 (NERI Project) by Gary Harms → first experiment in 2002



The Burnup Credit Critical Experiment (BUCCX)

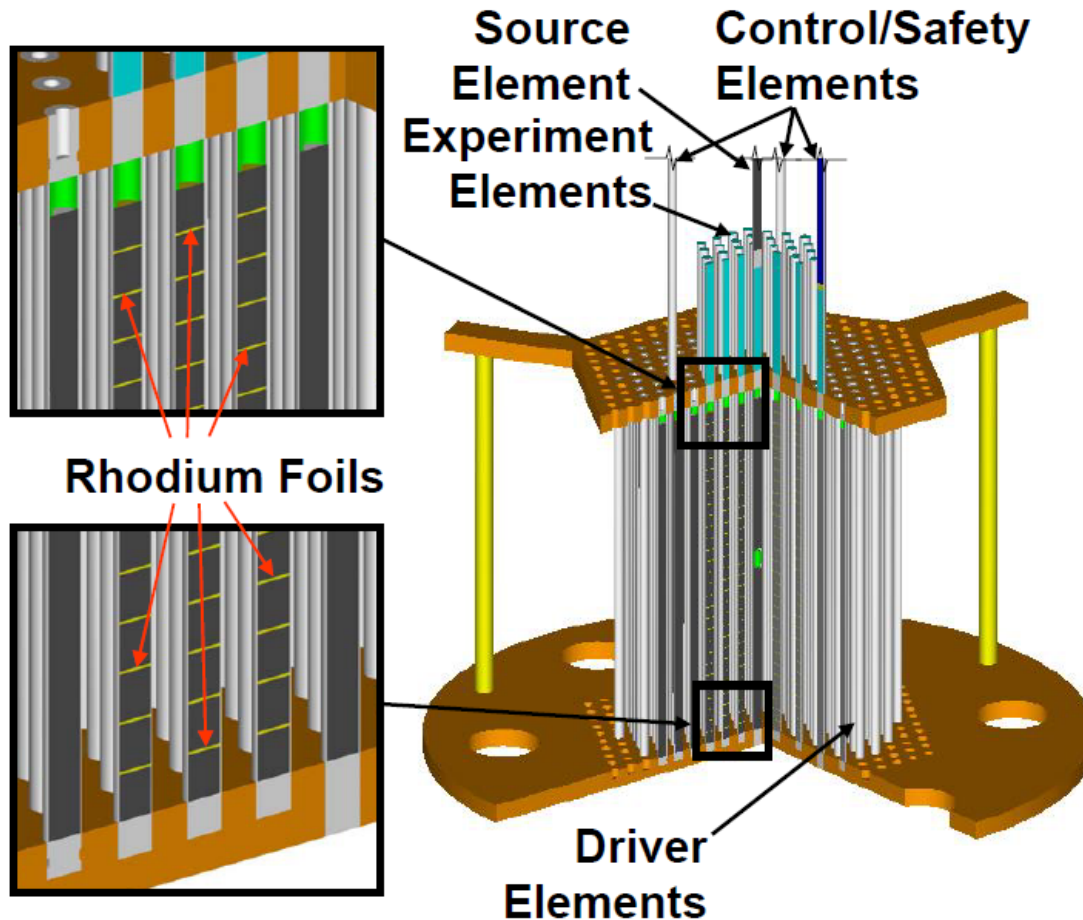
- UO₂ fuel (4.3 % ²³⁵U)
- Two sets of grid plates
 - Triangular pitch array (2.0 cm)
 - Triangular pitch array (2.8 cm)
- 350 fuel rods and 150 experiment rods
- Fuel rod diameter 1.38 cm
- Fuel length 49.2 cm
- Two Experimental Series in the ICSBEP Handbook
 - LCT-079, 099

NEW REACTOR — Sandia researcher Gary Harms conducts experiments with a new Sandia-built reactor that are paving the way toward possible changes in regulations on transport and storage of nuclear waste. (Photo by Randy Montoya)

Burnup Credit Critical Experiment (BUCCX)



The BUCCX core was designed to be easy to model

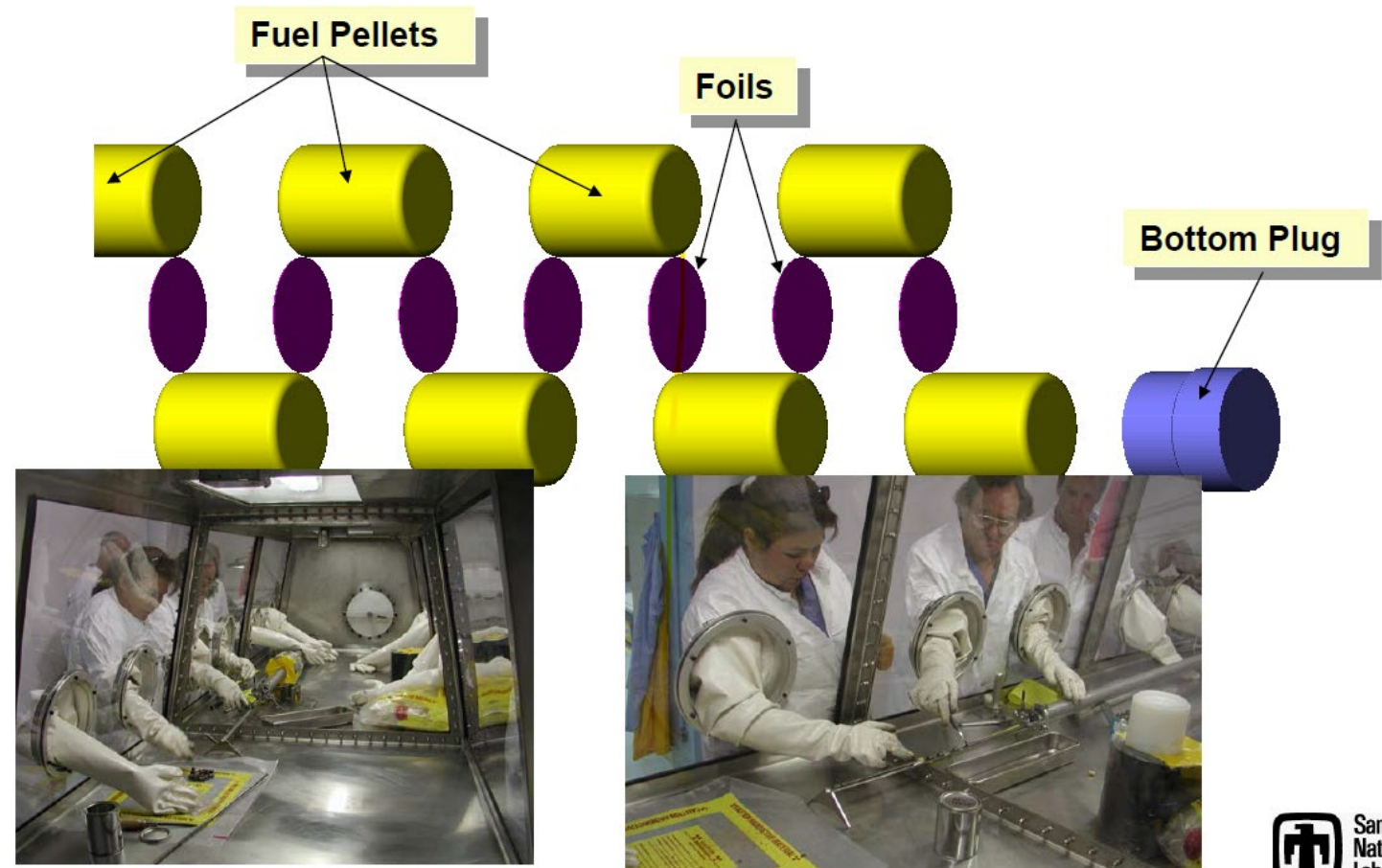
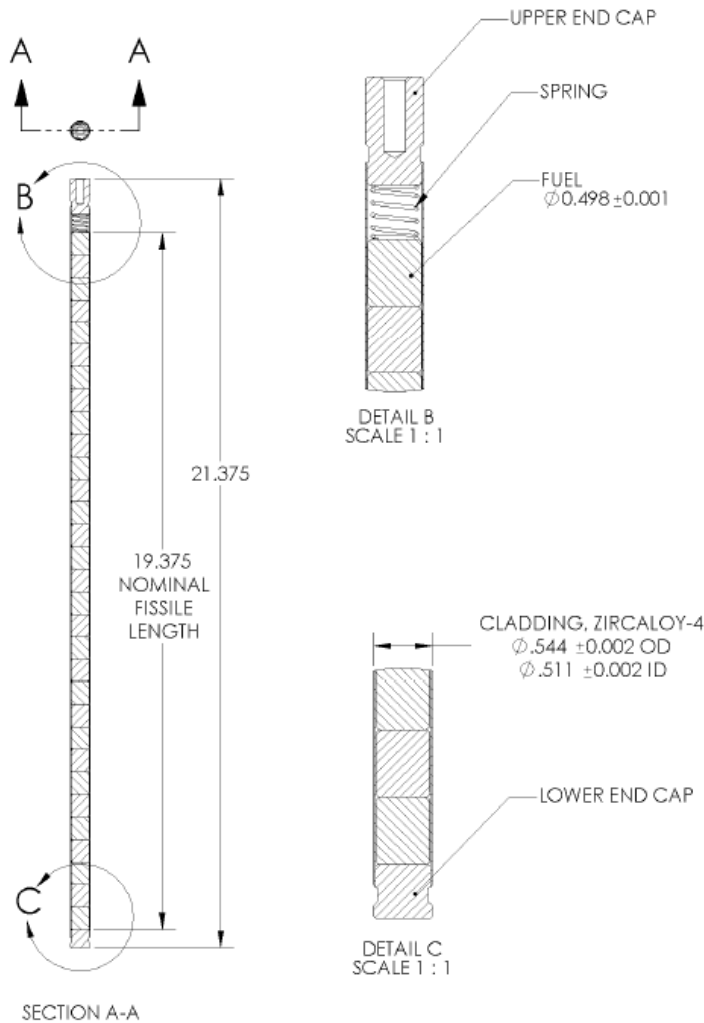


- The assembly is a triangular-pitched array of Zircaloy-4 clad U(4.31%)O₂ fuel (driver) elements
- The assembly has 3 control/safety elements
 - the B₄C absorber is decoupled from the assembly by a polyethylene spacer
 - the absorber is followed by a fuel rod
- Test materials are placed between the fuel pellets in “experiment elements”
- The source is in the central fuel element
- The grid plates are aluminum
 - the grid plates “line up” with the plugs at the top and bottom of the fuel rods
- The pitch of the array is modified by replacing the grid plates

Burnup Credit Critical Experiment (BUCCX)



Built special experiment fuel rods that allowed access to the fuel pellets



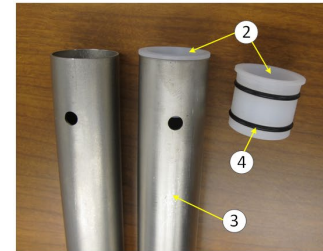
Burnup Credit Critical Experiment (BUCCX)



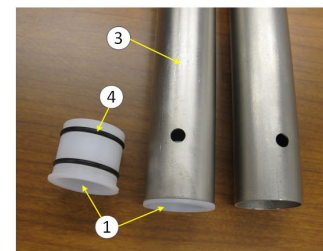
Two experiment series in the ICSBEP handbook

LEU-COMP-THERM-079

- Ten critical experiments performed in 2002
 - Measure the effect of rhodium on critical systems

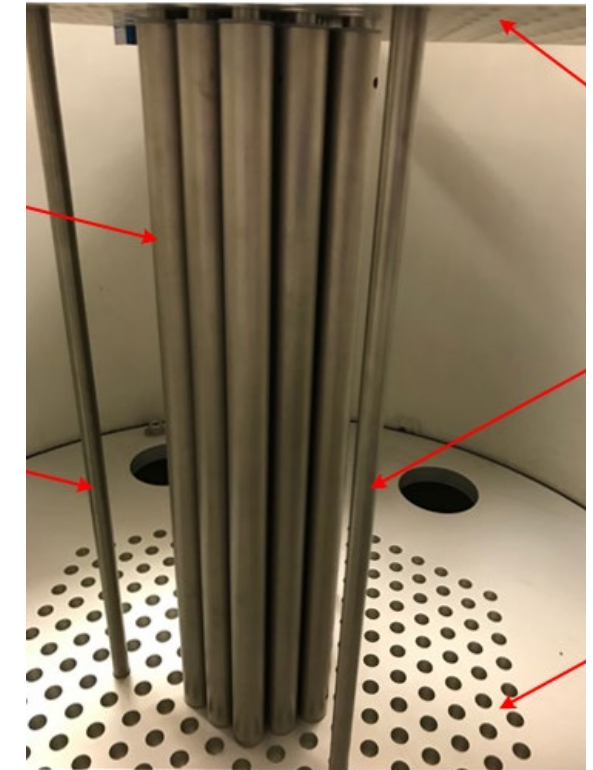
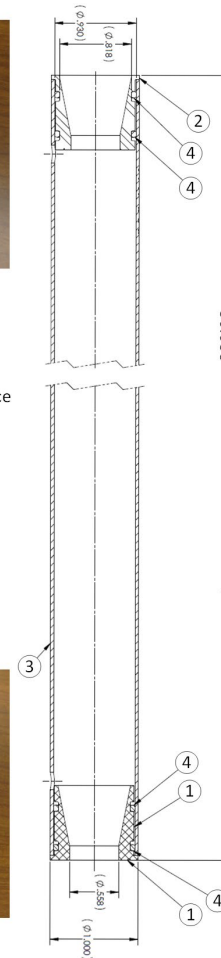


- ① = Bottom Polyethylene Centering Piece
- ② = Top Polyethylene Centering Piece
- ③ = Experiment Sleeve
- ④ = O-ring



LEU-COMP-THERM-099

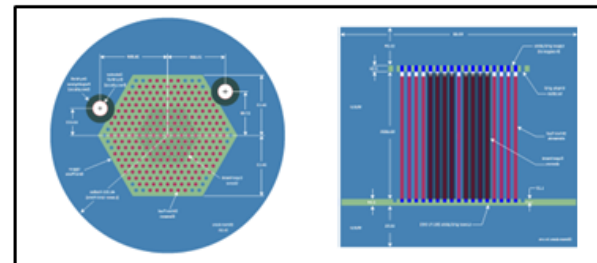
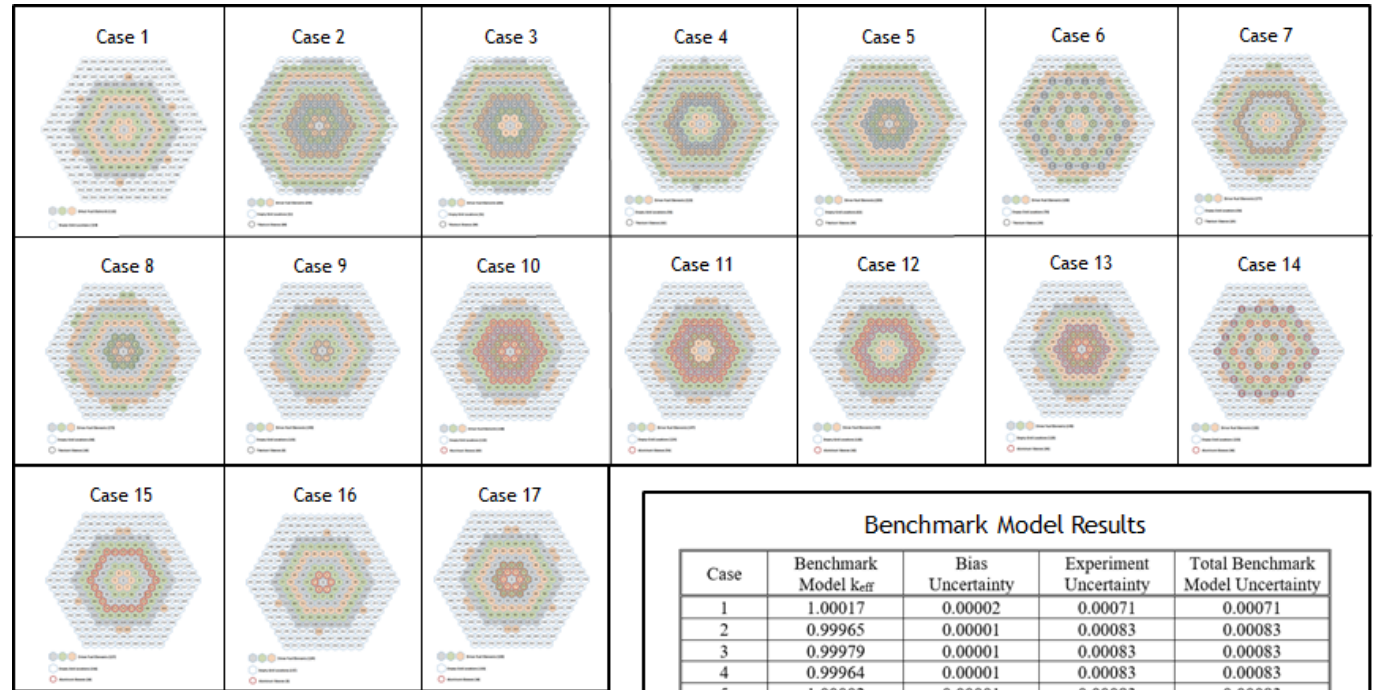
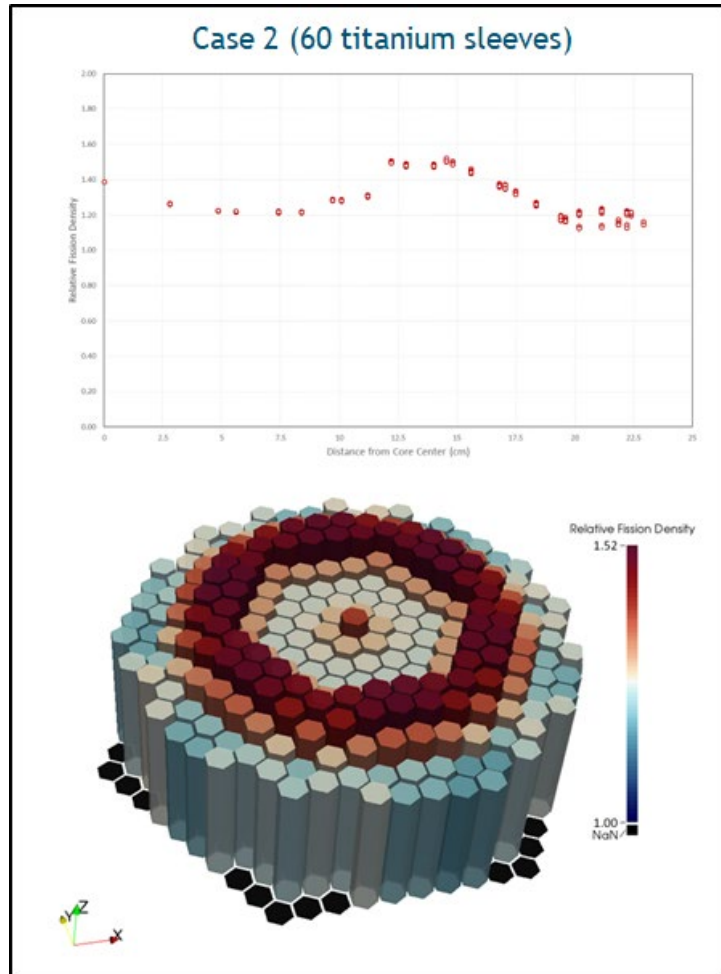
- Seventeen critical experiments performed in 2017-2018
 - Measure the effect of titanium on critical systems



Burnup Credit Critical Experiment (BUCCX)



Two experiment series in the ICSBEP handbook



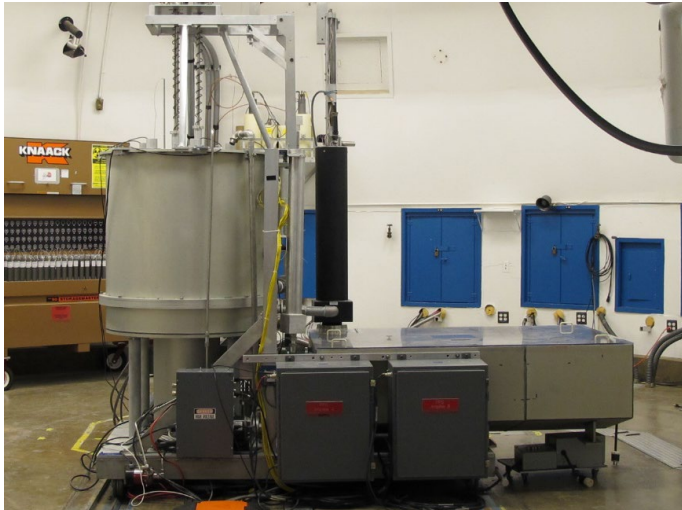
Benchmark Model Results

Case	Benchmark Model k_{eff}	Bias Uncertainty	Experiment Uncertainty	Total Benchmark Model Uncertainty
1	1.00017	0.00002	0.00071	0.00071
2	0.99965	0.00001	0.00083	0.00083
3	0.99979	0.00001	0.00083	0.00083
4	0.99964	0.00001	0.00083	0.00083
5	1.00002	0.00001	0.00083	0.00083
6	1.00054	0.00002	0.00083	0.00083
7	0.99991	0.00001	0.00083	0.00083
8	1.00055	0.00001	0.00083	0.00083
9	0.99955	0.00002	0.00083	0.00083
10	0.99909	0.00002	0.00071	0.00071
11	1.00054	0.00002	0.00071	0.00071
12	1.00051	0.00002	0.00071	0.00071
13	1.00006	0.00002	0.00071	0.00071
14	1.00000	0.00002	0.00071	0.00071
15	0.99952	0.00001	0.00071	0.00071
16	1.00037	0.00002	0.00071	0.00071
17	1.00005	0.00002	0.00071	0.00071

Seven Percent Critical Experiment (7uPCX)



Project began in 2001 (NERI Project) → first experiment in 2009



Seven Percent Critical Experiment (7uPCX)



Project began in 2001 (NERI Project) → first experiment in 2009



The Seven Percent Critical Experiment (7uPCX)

- UO_2 fuel (6.9% ^{235}U)
- Four sets of grid plates
 - 45x45 Square pitch array (0.8 cm)
 - 45x45 Square pitch array (0.855 cm)
 - Triangular pitch array (1.55 cm)
 - Triangular pitch array (1.02 cm) with central test region
- Fuel rod diameter 0.635 cm
- Fuel length 48.9 cm
- Seven Experimental Series in the ICSBEP Handbook
 - LCT-078, 080, 096, 097, 101, 102, 111

Seven Percent Critical Experiment (7uPCX)



Seven experiment series in the ICSBEP handbook

LEU-COMP-THERM-080

- Eleven critical experiments performed in 2009-2012
 - Measure the effect of water hole patterns on critical array size with 0.80 cm square pitch

LEU-COMP-THERM-078

- Fifteen critical experiments performed in 2011-2012
 - Measure the effect of water hole and aluminum replacement rod patterns on critical array size with 0.80 cm square pitch

LEU-COMP-THERM-096

- Nineteen critical experiments performed in 2014-2015
 - Explore partially reflected arrays with 0.80 cm square pitch

LEU-COMP-THERM-097

- Twenty-four critical experiments performed in 2015-2016
 - Measure the effect of titanium and aluminum rod replacements on critical array size with 0.855 cm square pitch

LEU-COMP-THERM-101

- Twenty-two critical experiments performed in 2019
 - Investigate partially reflected arrays with 0.855 cm square pitch

LEU-COMP-THERM-102

- Twenty-seven critical experiments performed in 2020
 - Measure the effect of decreasing the fuel-to-water ratio on critical arrays with square pitch

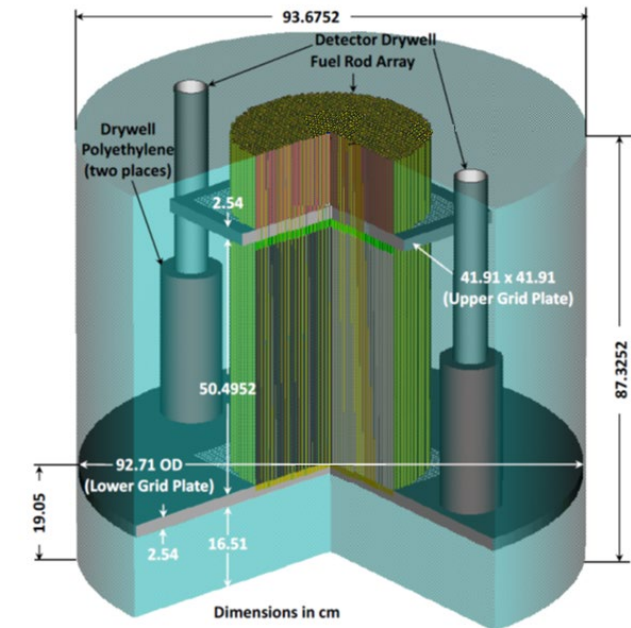
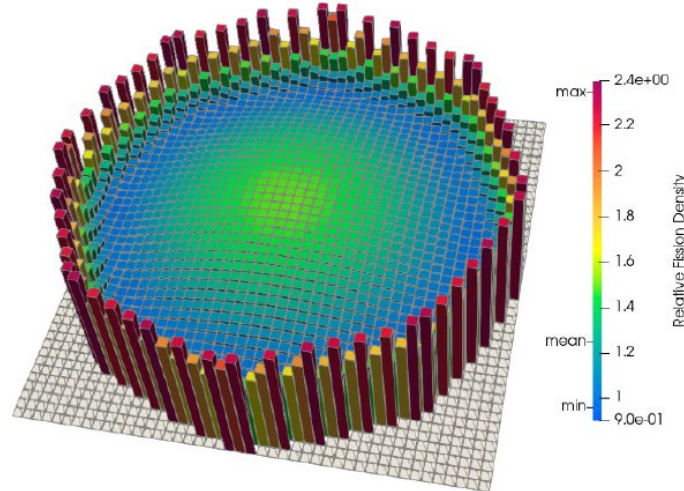
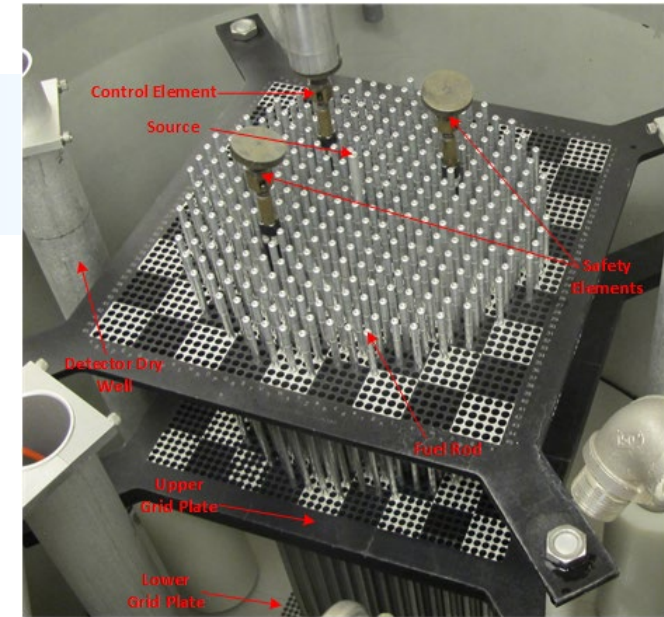
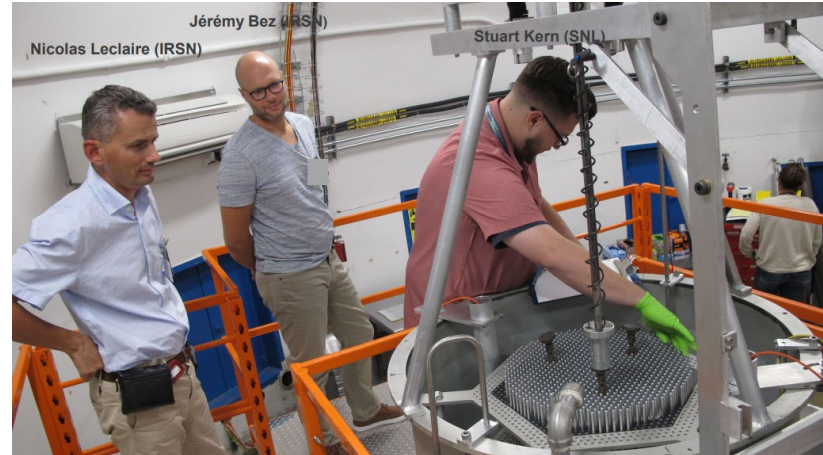
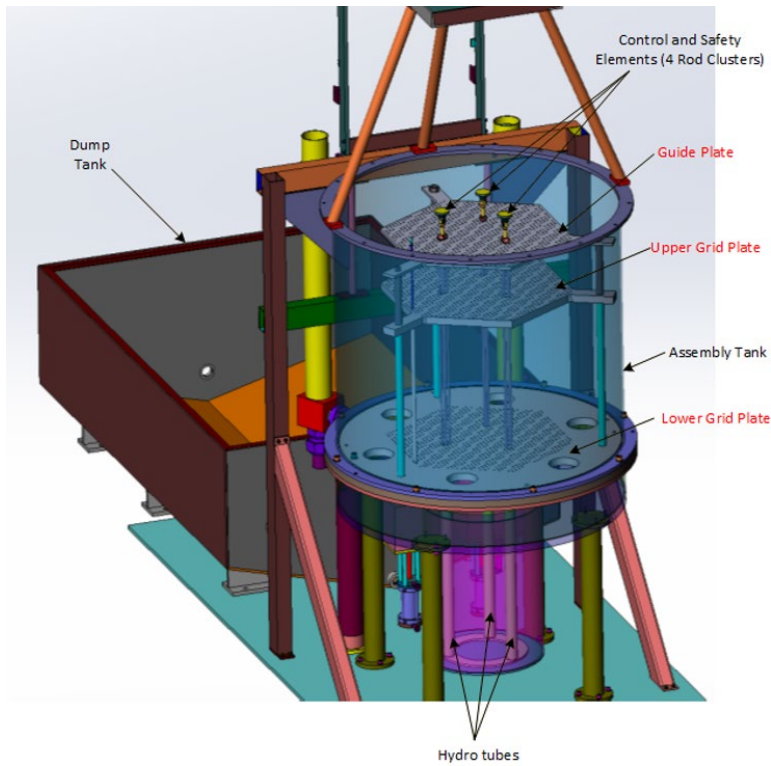
LEU-COMP-THERM-111

- Eleven critical experiments performed in 2023
 - Measure the effect of molybdenum on critical array size with 1.55 cm triangular pitch

Seven Percent Critical Experiment (7uPCX)



Seven experiment series in the ICSBEP handbook



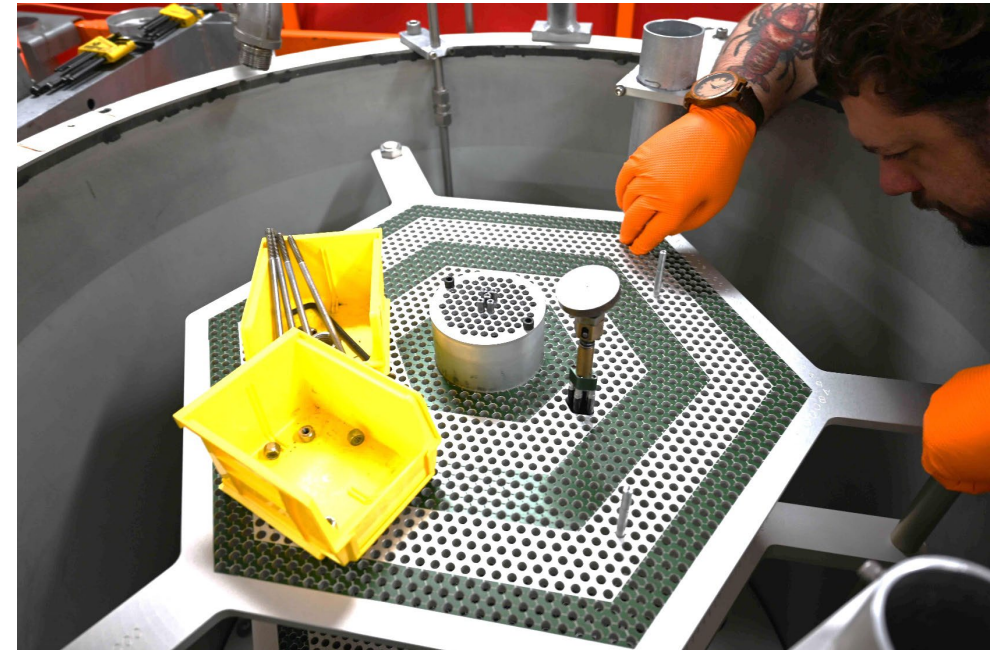
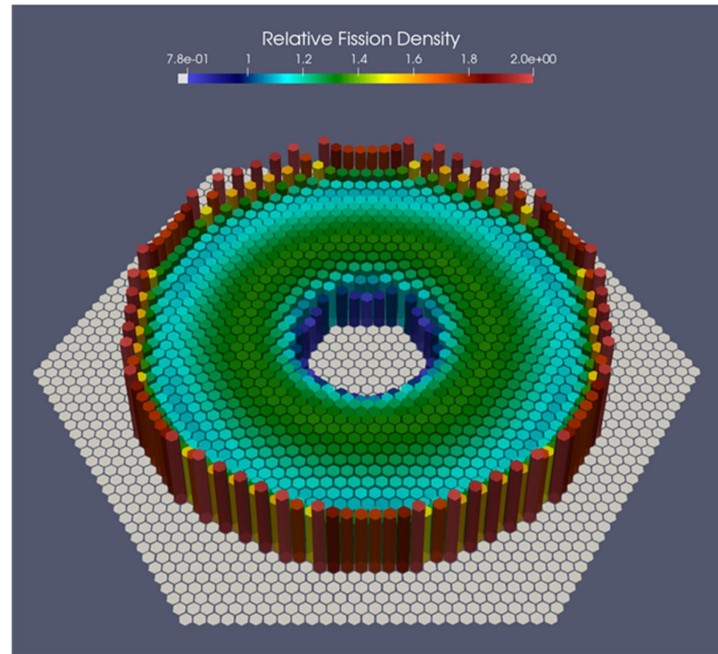
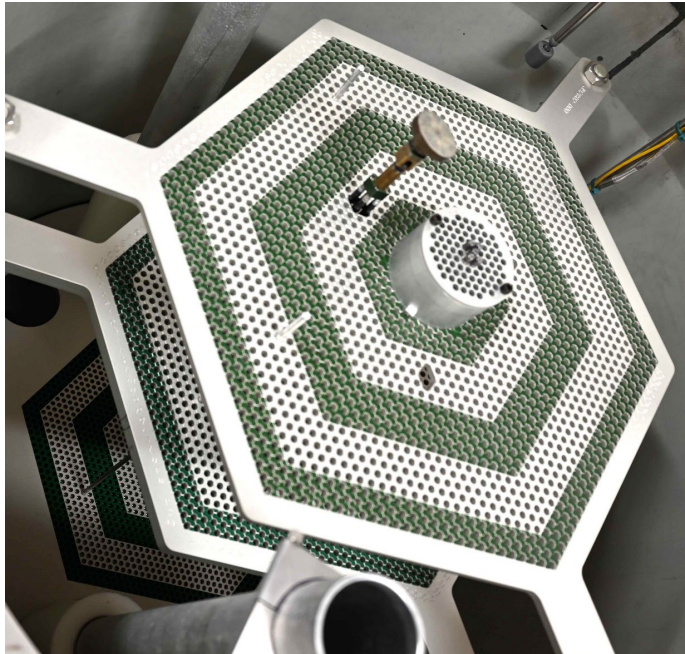
Seven Percent Critical Experiment (7uPCX)



Current and future experiments

Epithermal Experiments

- Central Test Region
 - Measure the effect of tantalum on critical array size



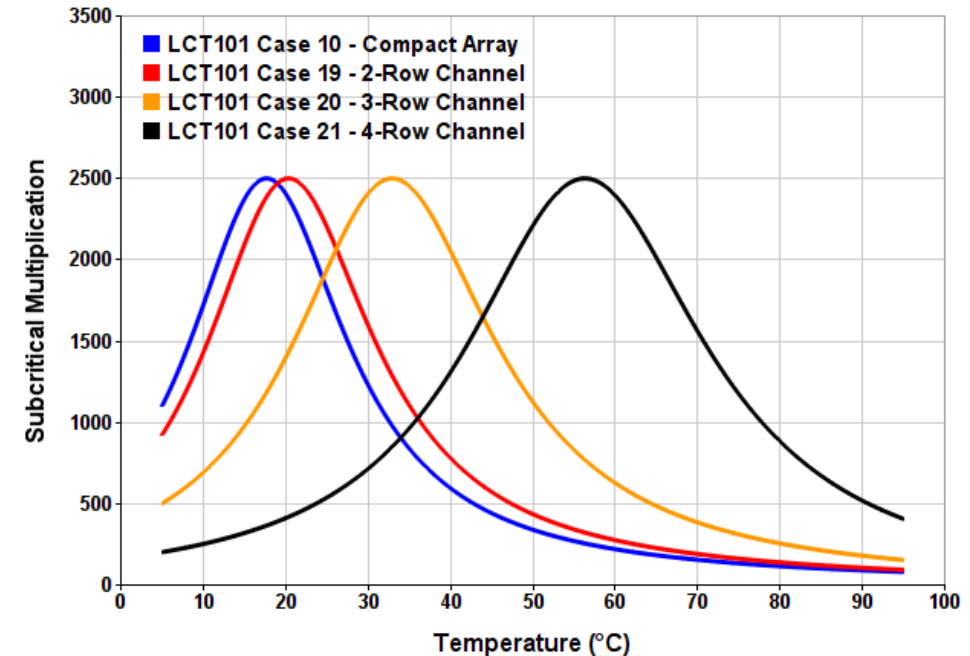
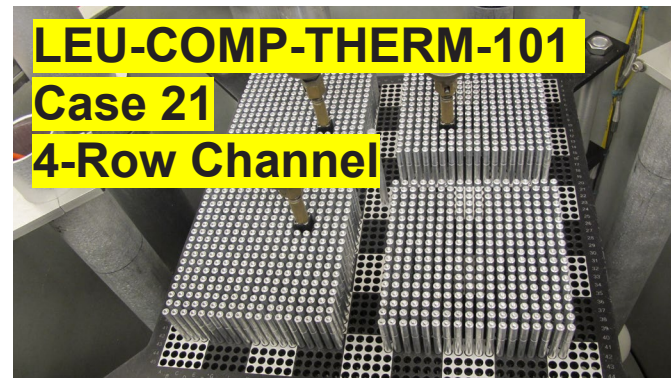
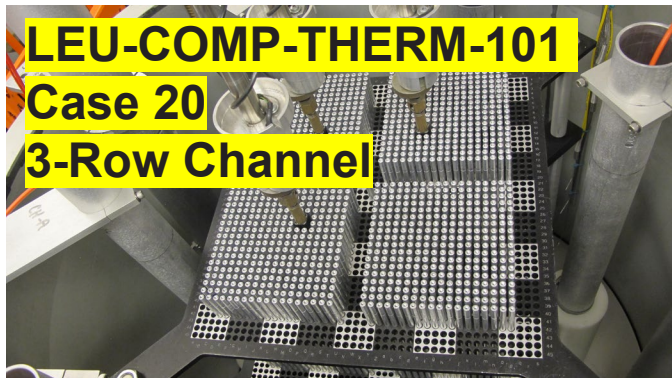
Seven Percent Critical Experiment (7uPCX)



Current and future experiments

Temperature Experiments

- Measure inversion point of the isothermal reactivity coefficient

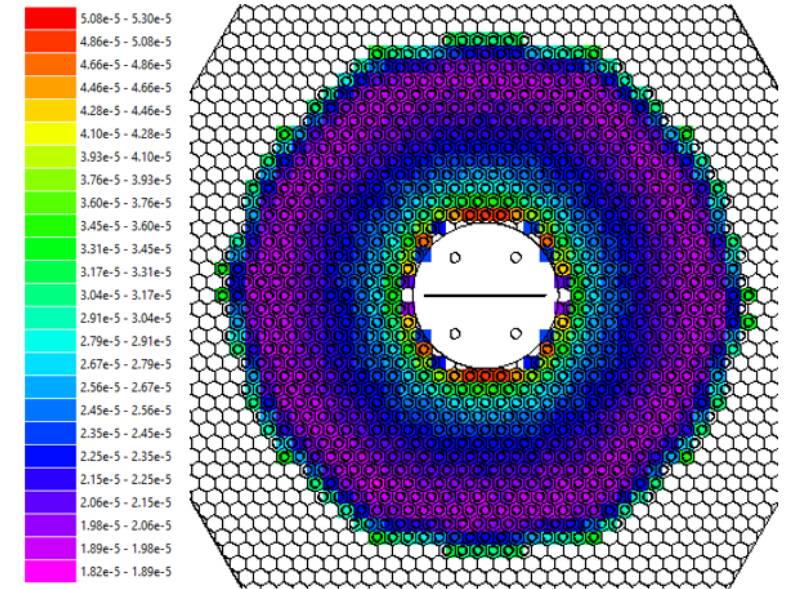
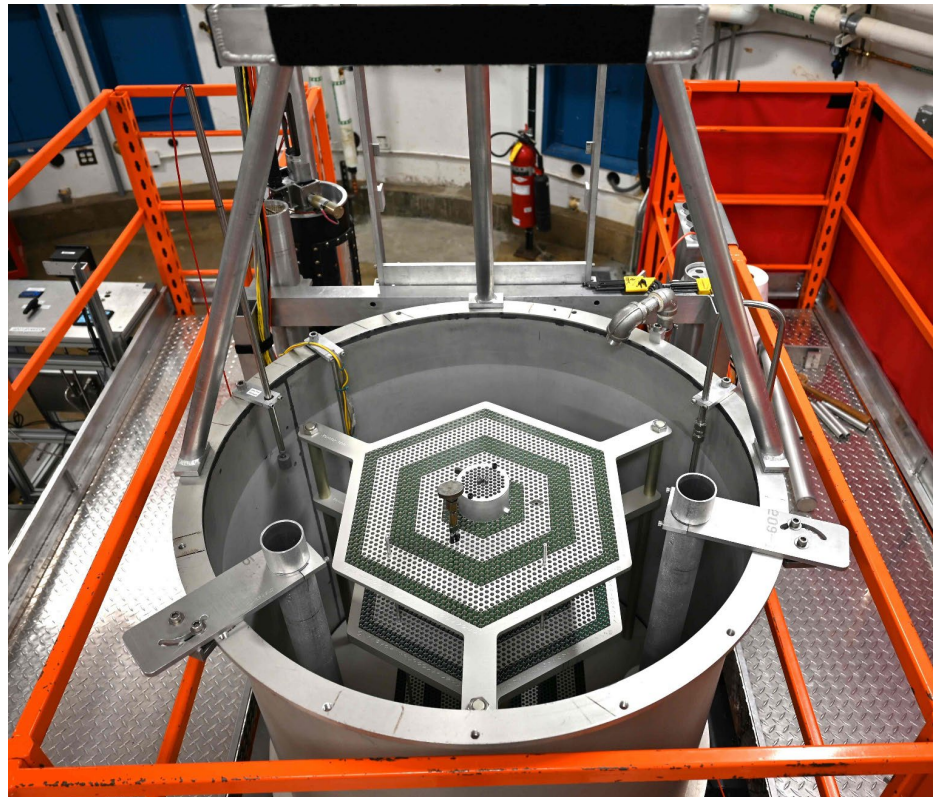
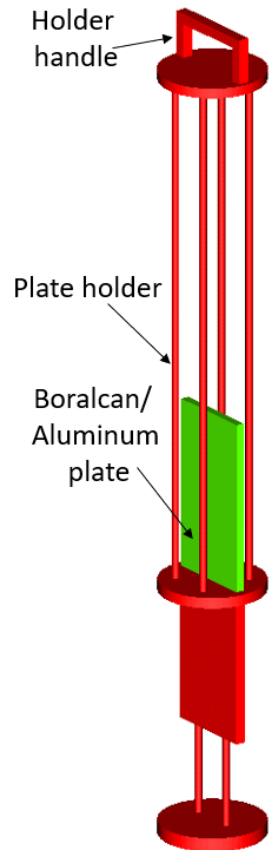


Seven Percent Critical Experiment (7uPCX)



Current and future experiments

Absorber plate (Boraclan) Experiments

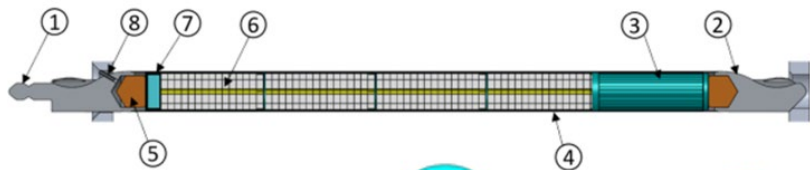


Seven Percent Critical Experiment (7uPCX)

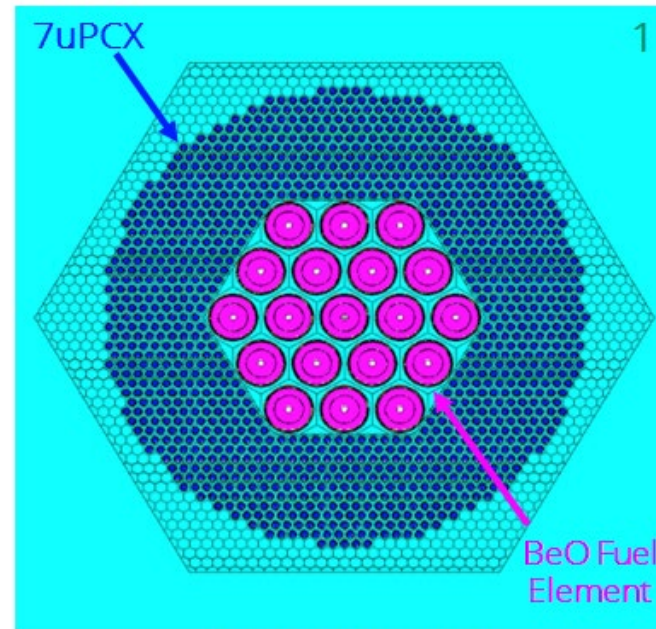
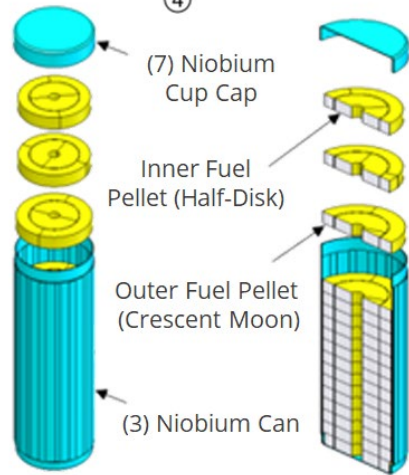


Current and future experiments

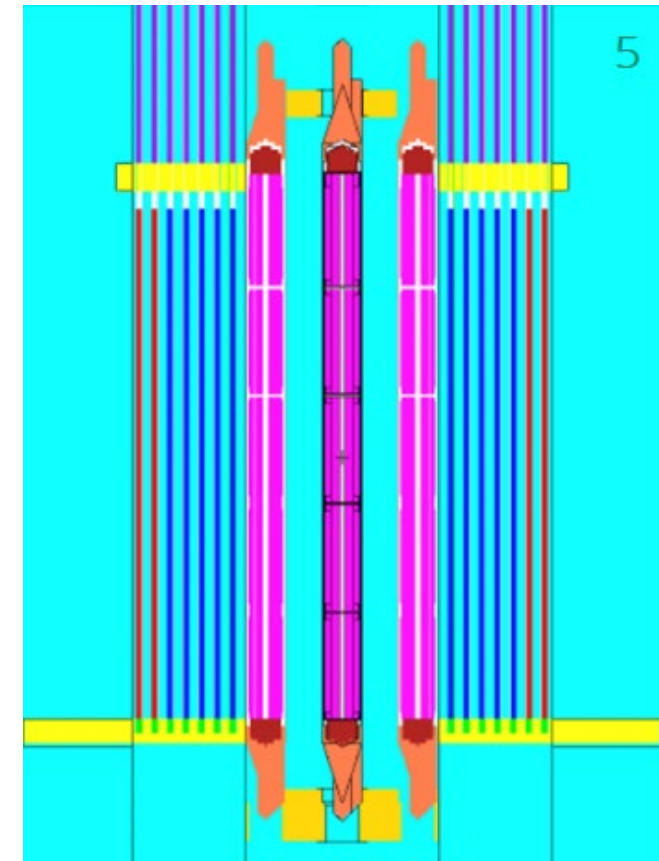
UO₂-BeO (ACRR fuel rod) Experiments



1	Top Fitting
2	Bottom Fitting
3	Fuel Cup
4	Stainless-Steel Cladding
5	BeO Reflector
6	UO ₂ -BeO Fuel Assembly
7	Fuel Cap
8	Fill Tube



Top Cross Section View

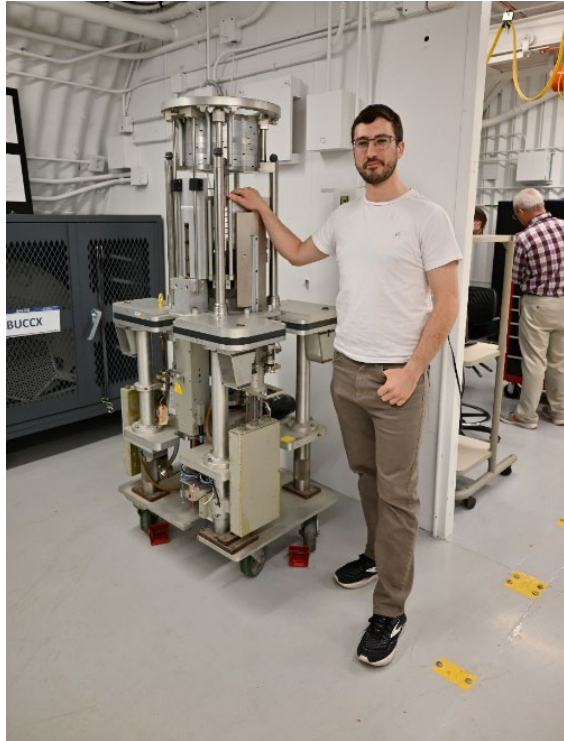


Side Cross Section View

Sandia NCS Hands-On Training Course

14 years of NCS courses (over 600 students)

This course is designed to meet the ANSI/ANS-8.26, "Criticality Safety Engineer Training and Qualification Program," requirement for hands-on experimental training.





QUESTIONS