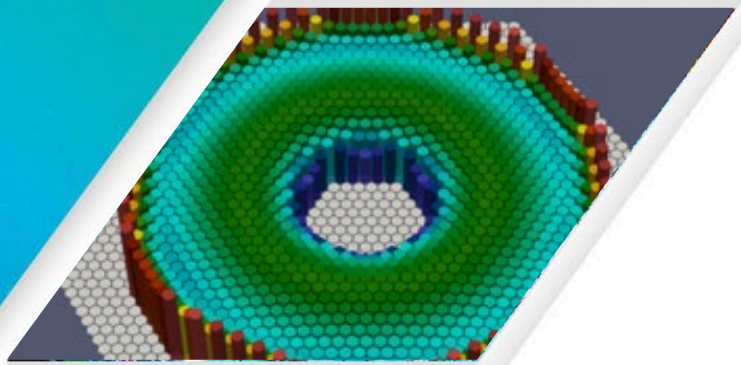
Sandia National Laboratories

Exceptional service in the national interest

Sandia Critical Experiments (SCX) & Annular Core Research Reactor (ACRR)



David Ames

Sandia National Laboratories

WANDA 2026

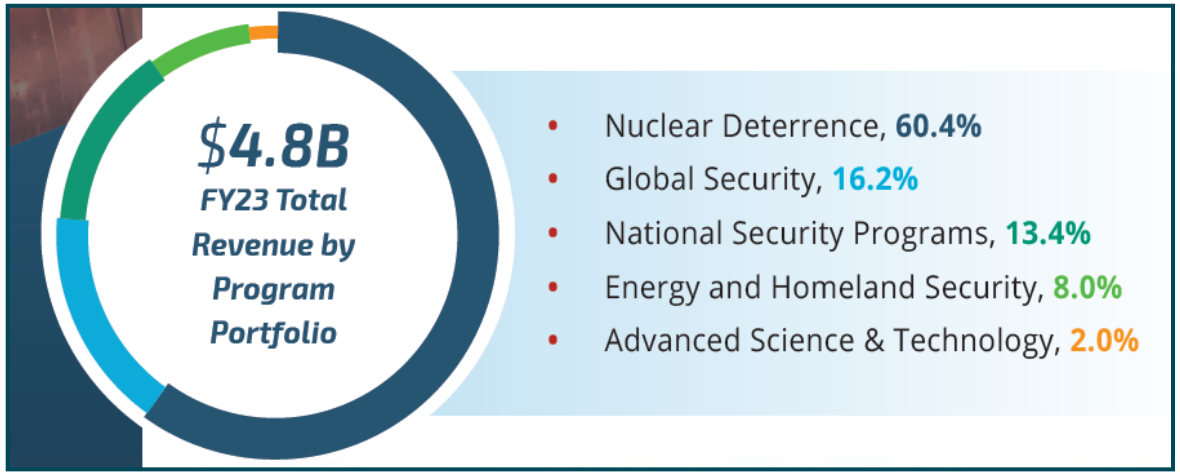
February 12, 2026

Sandia National Laboratories is a multimission laboratory managed and operated by National Technology and Engineering Solutions of Sandia LLC, a wholly owned subsidiary of Honeywell International Inc. for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.

SAND2026-17050PE

Sandia National Laboratories

Exceptional Service in the National Interest



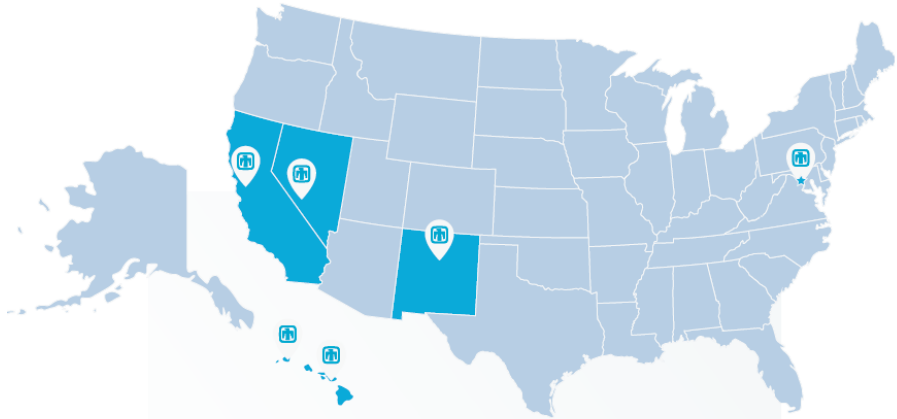
- Nuclear Deterrence, **60.4%**
- Global Security, **16.2%**
- National Security Programs, **13.4%**
- Energy and Homeland Security, **8.0%**
- Advanced Science & Technology, **2.0%**

- Electrical Engineering, **17%**
- Mechanical Engineering, **18%**
- Other Engineering Fields, **27%**
- Computing, **18%**
- Cybersecurity, **8%**
- Physics, **3%**
- Chemistry, **1%**
- Math and Other Science, **4%**

Note: The figures do not add up to 100 percent, due to rounding.

Sandia Sites

Sandia operates in Albuquerque, N.M.; Livermore, Calif.; Tonopah Test Range, Nev.; and Kauai Test Facility, and Maui, Hawaii; and has leased space at other locations, including a Washington, D.C., office.

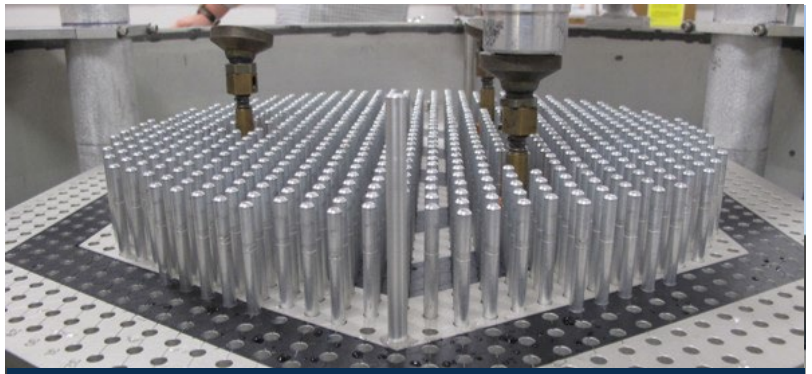


- **Albuquerque** — 707 buildings and 13,724 acres
- **California** — 78 buildings and 410 acres
- **Tonopah** — 81 buildings and 3,520 acres
- **Kauai and Maui** — 46 buildings and 133 acres
- **Leased facilities, all locations** — 17 buildings and 2,713 acres

Sandia National Laboratories – Technical Area V

Annular Core Research Reactor (ACRR) and Sandia Critical Experiments (SCX)

Sandia National Laboratories - ABQ



SCX – 7uPCX Fuel

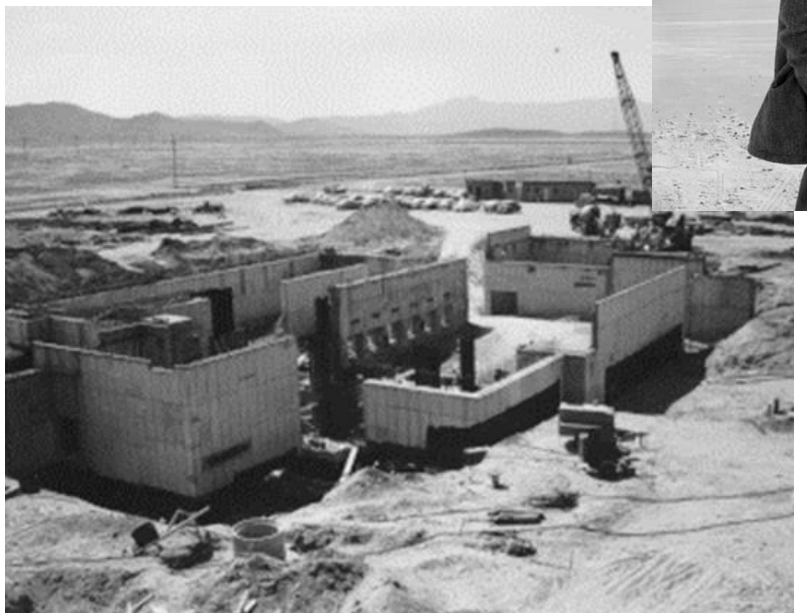
Tech Area V (TA-V)

ACRR - Pulse Operation

Sandia Technical Area V

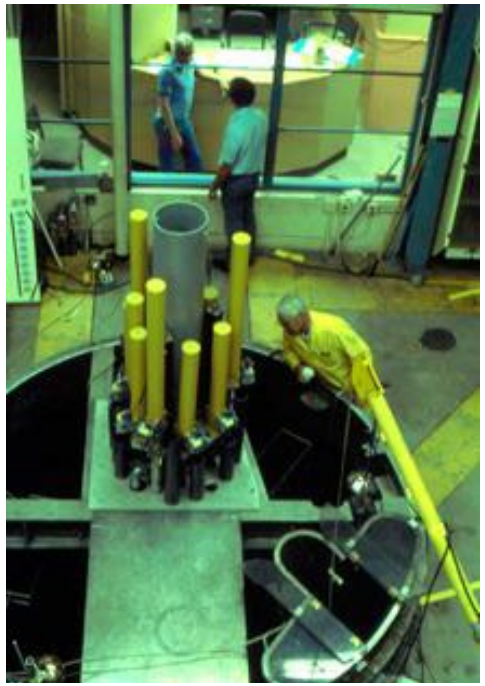
Technical Area V History

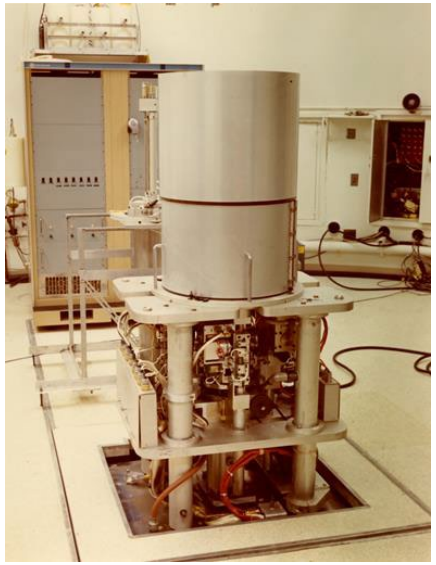
- TA-V was constructed in 1959 as part of the Nuclear Airplane Project
  - Sandia Pulse Reactor (SPR-I) – 1961
  - Sandia Nuclear Assembly Reactor Experiment (SNARE) – 1962
  - Sandia Engineering Reactor (SER) – 1963
  - Annular Core Pulse Reactor (ACPR) 1967 (Predecessor of ACRR)

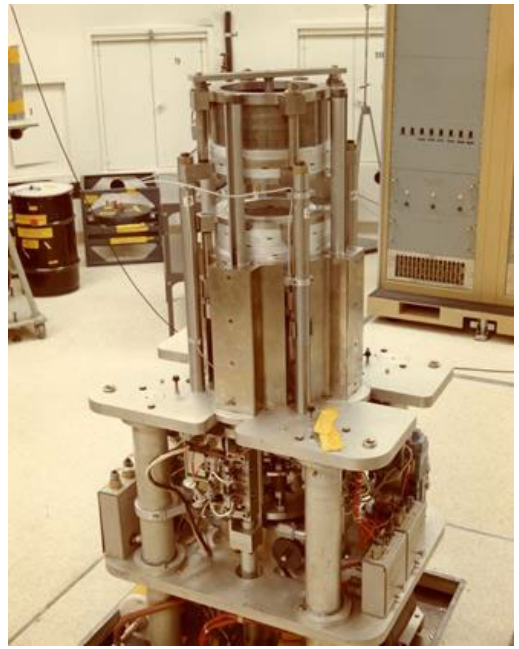


Technical Area V History

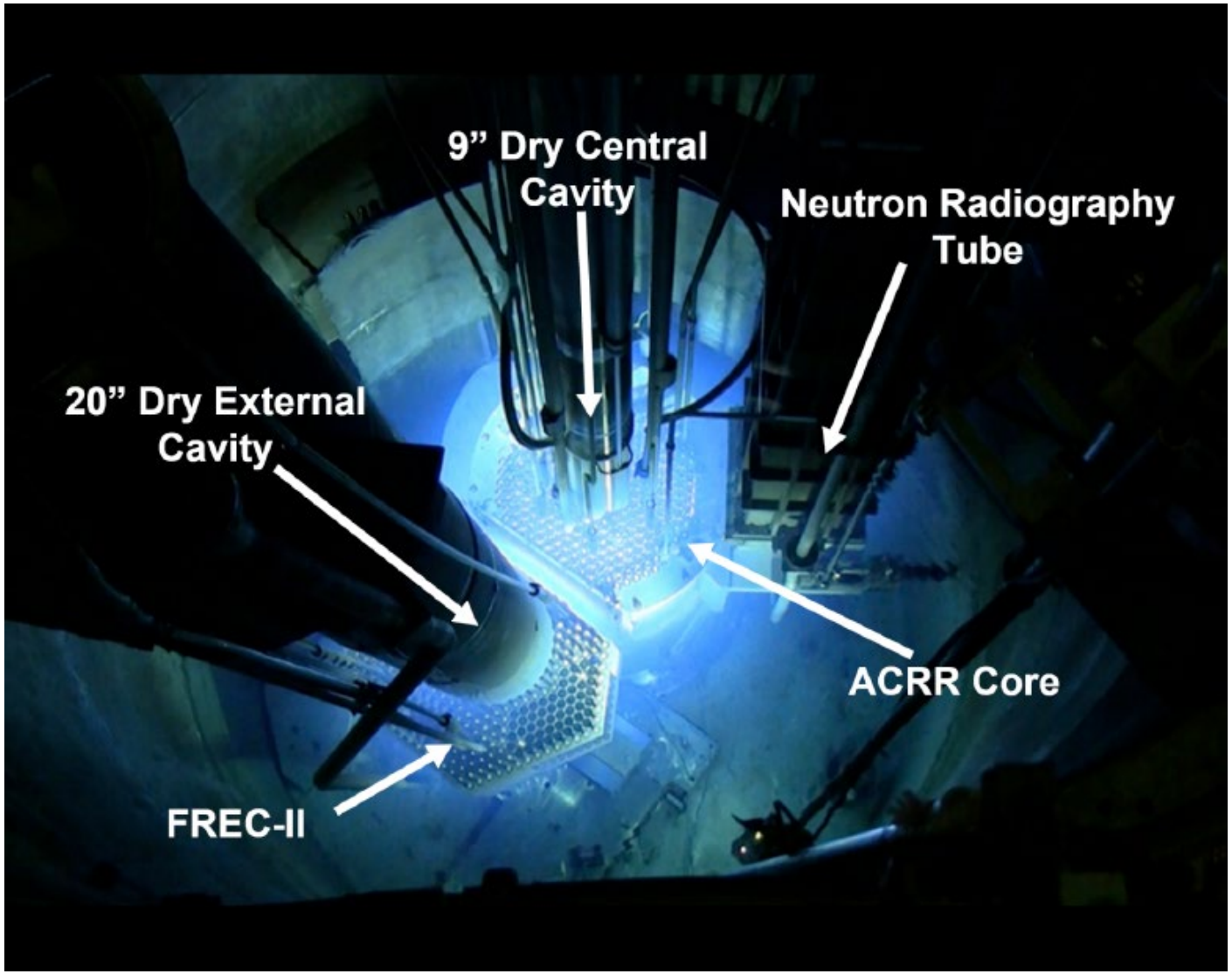
- TA-V continued to build on its nuclear reactor success
  - Sandia Pulse Reactor (SPR-III) – 1976 to 2008
  - Annular Core Research Reactor (ACRR) – 1978 to present
  - Critical Experiment-Space Nuclear Thermal Power (SPRF/CX) – 1989 to 1994
  - ACRR-Fueled Ringed External Cavity (FREC-II) – 1988 to present
  - Critical Experiments-DOE NCSP (SPRF/CX) – 2004 to present







Annular Core Research Reactor (ACRR)



236 UO_2-BeO Fueled Elements
- 1.5" (3.8 cm) dia. x 20.5" (52cm)
- 35% enriched

Operating Power Level
- 2.4 MW_{th} Steady-State Mode
- 300 MJ Pulse Mode (6ms FWHM)

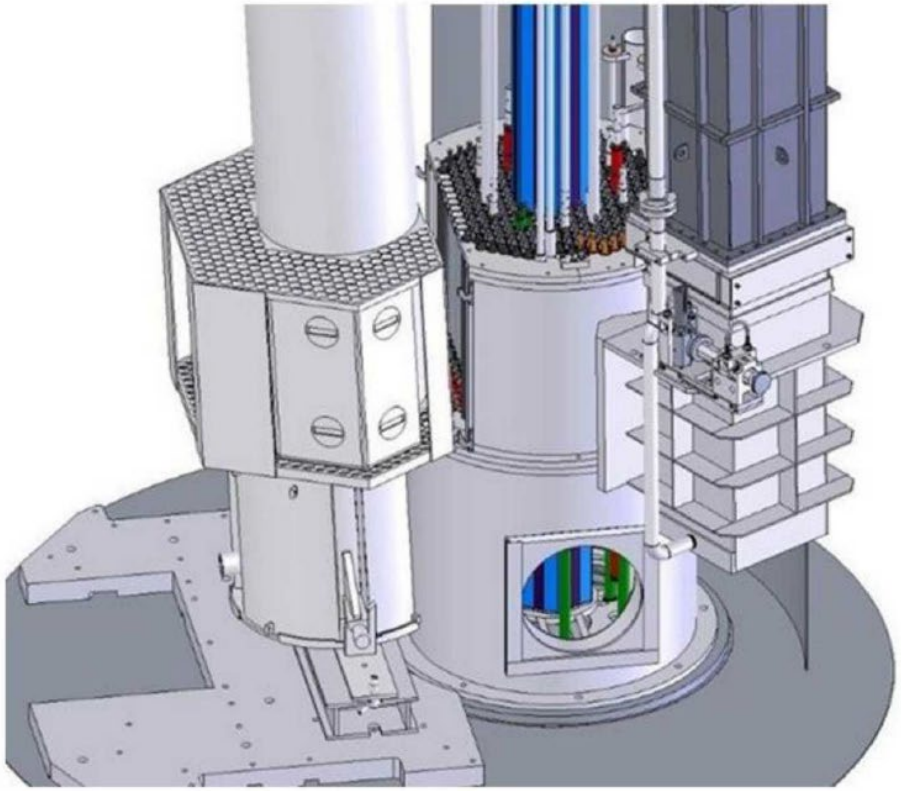
Dry Central Cavity 9" (23 cm) Diameter
- Neutron Flux 4 x 10^{13} n/cm^2 at 2 MW
- Neutron Fluence 4 x 10^{15} n/cm^2 at 300 MJ

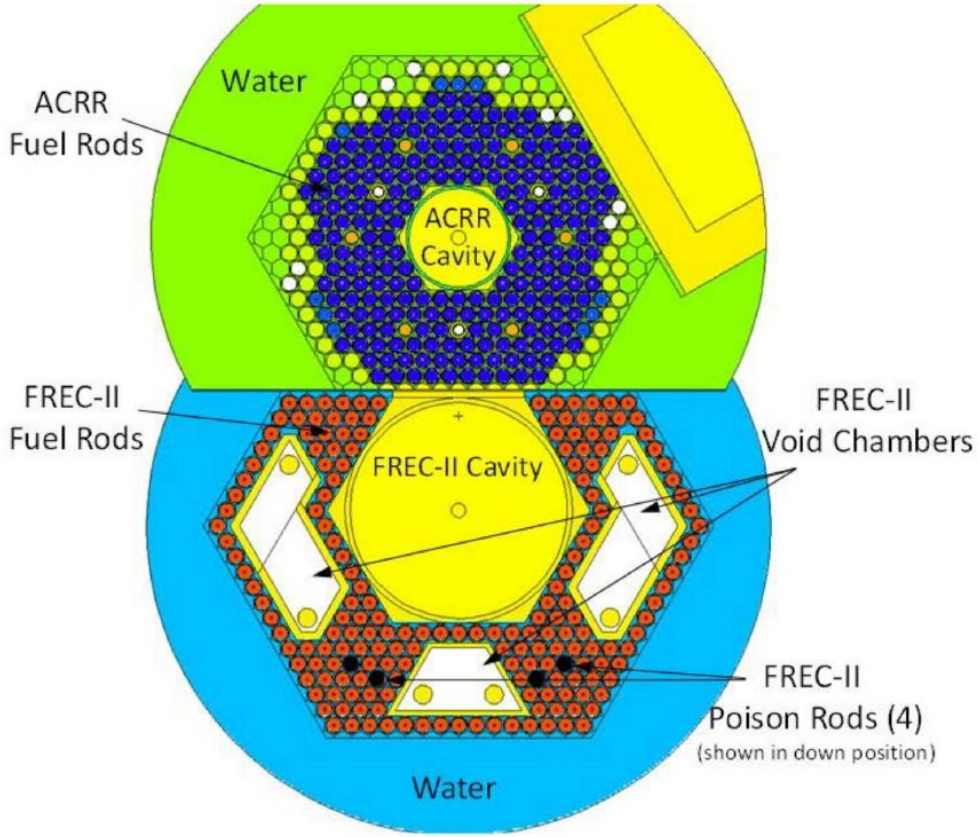
Epithermal/Fast Spectrum
- Flux in cavity can be tailored for desired energy spectrum using buckets

Open-Pool Type Reactor
- Core cooled by natural convection

FREC-II (Previous ACPR Fuel)
- TRIGA type (UZrH)
- Dry cavity 20" (51 cm) diameter

Annular Core Research Reactor (ACRR)





Annular Core Research Reactor (ACRR)

Unique Attributes

- Large dry central cavity
- Epithermal neutron flux
- Large pulsing capability
- Fueled-ring external cavity with larger dry cavity

Fuel is similar in size and shape to TRIGA fuel

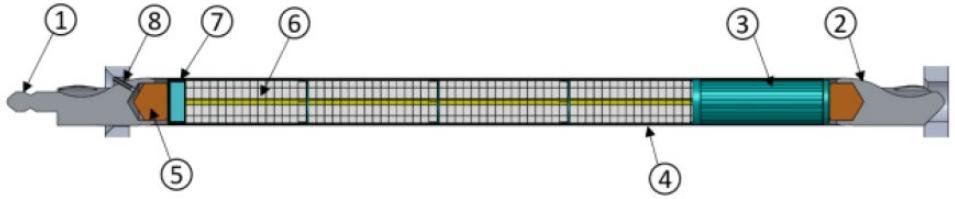
- UO_2-BeO
- Larger heat capacity allowing for larger pulsing capabilities compare to TRIGA-like pulsed reactors

Cavity Spectrum Modifying Capabilities

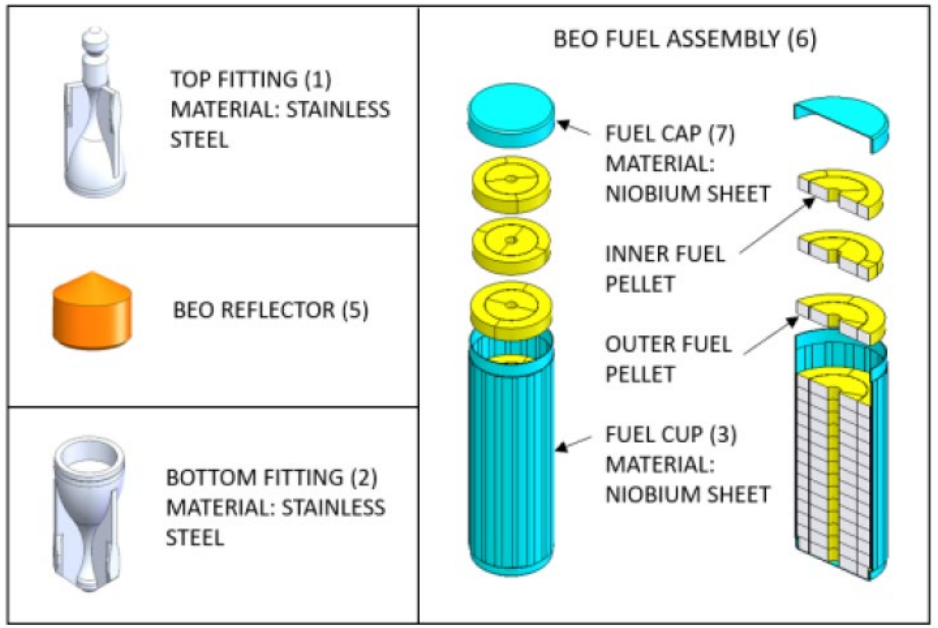
- "Buckets" with materials to achieved desired results

Experiment Campaigns

- Support Sandia's Primary Mission (ND)
- Radiation damage in materials testing, nuclear fuels testing, medical isotope production, space nuclear propulsion testing, in-situ imaging



FILL TUBE	8
FUEL CAP	7
BEO FUEL ASSEMBLY	6
BEO REFLECTOR	5
CLADDING	4
FUEL CUP	3
BOTTOM FITTING, FUEL ELEMENT	2
TOP FITTING, FUEL ELEMENT	1



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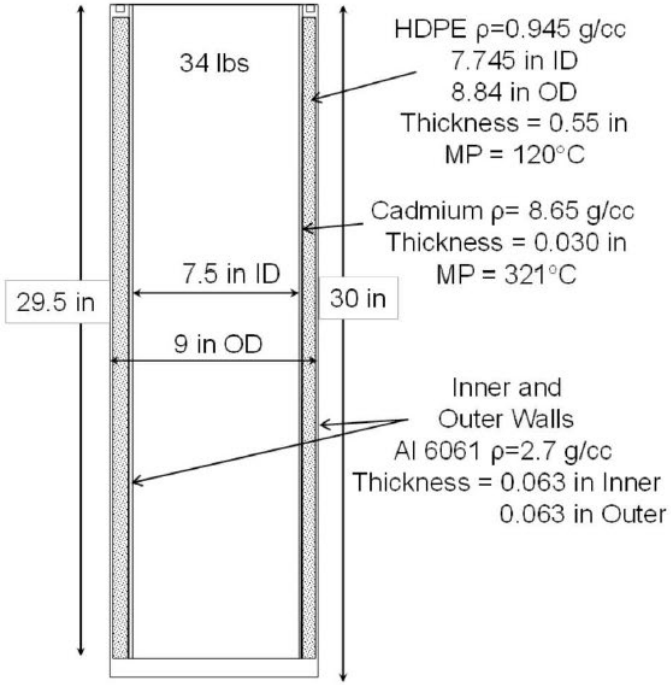


The Cd-Poly Spectrum Modifying Bucket

ACRR – Spectrum Modification Capability

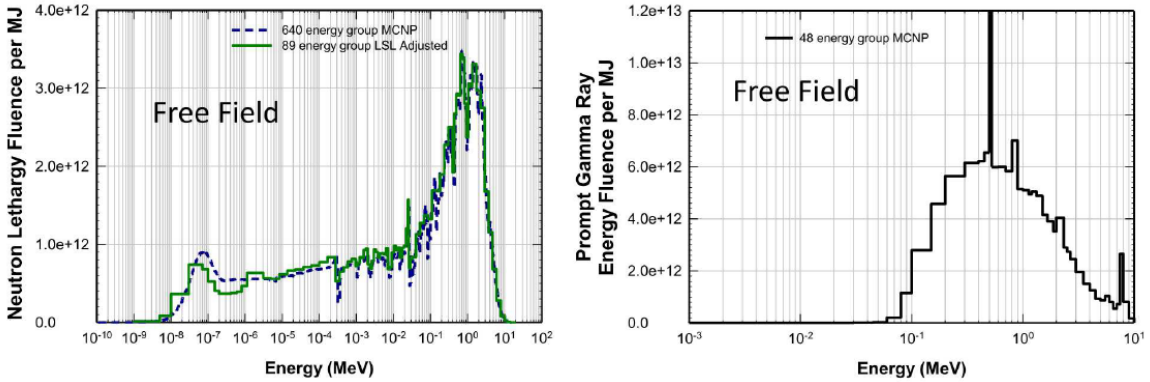


Figure 10. Neutron and Prompt Gamma-Ray Energy Spectra for the Central Cavity Free-Field Environment.

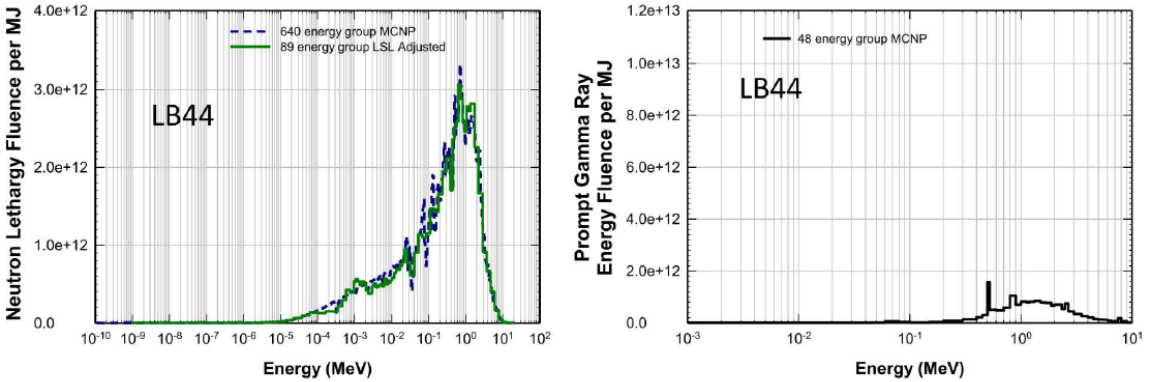


Figure 12. Neutron and Prompt Gamma-Ray Energy Spectra for the Lead-Boron (LB44) Bucket Environment.

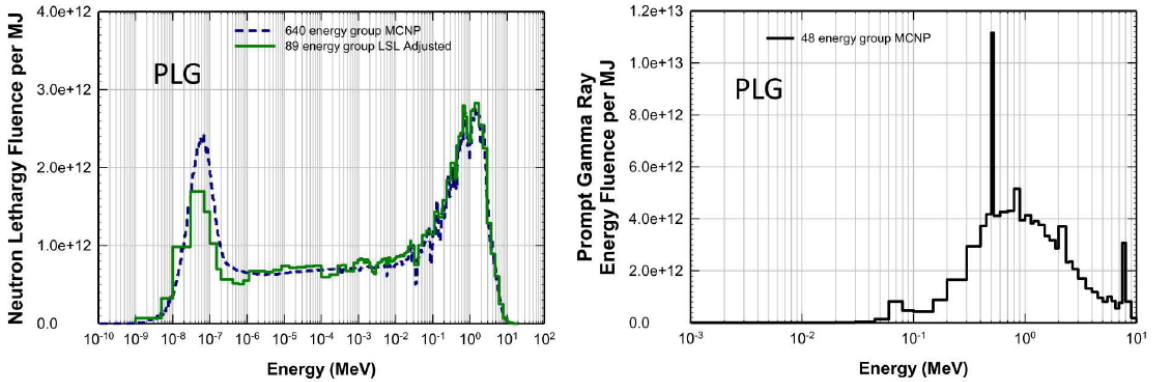


Figure 11. Neutron and Prompt Gamma-Ray Energy Spectra for the Polyethylene-Lead-Graphite (PLG) Bucket Environment.

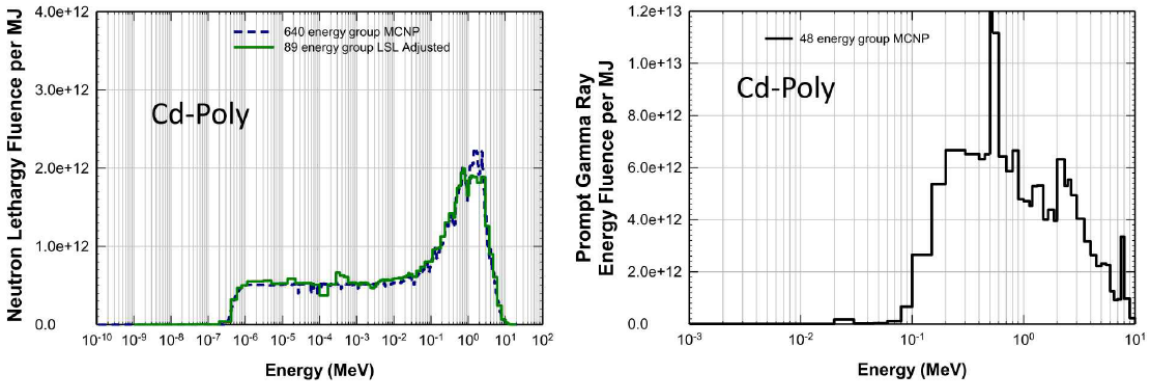


Figure 13. Neutron and Prompt Gamma-Ray Energy Spectra for the Cadmium-Polyethylene (Cd-Poly) Bucket Environment.

The CREST Project – Continuing the Mission of ACRR

CREST is *Combined Radiation Environments for Survivability Testing*

The focus of CREST is a new research reactor facility with coupled accelerator located at Sandia National Laboratories

- Will replace the existing annular core research reactor (ACRR) facility at Sandia's Tech Area V
- The new facility will be purpose built and designed according to modern codes and standards
- Will preserve current capabilities of ACRR:
  - → Dry central cavity in reactor in which experimental packages may be loaded
  - → External subcritical assembly with larger dry central cavity to test larger experiments
  - → Neutron radiography

CREST at TA-V

Sandia National Laboratories

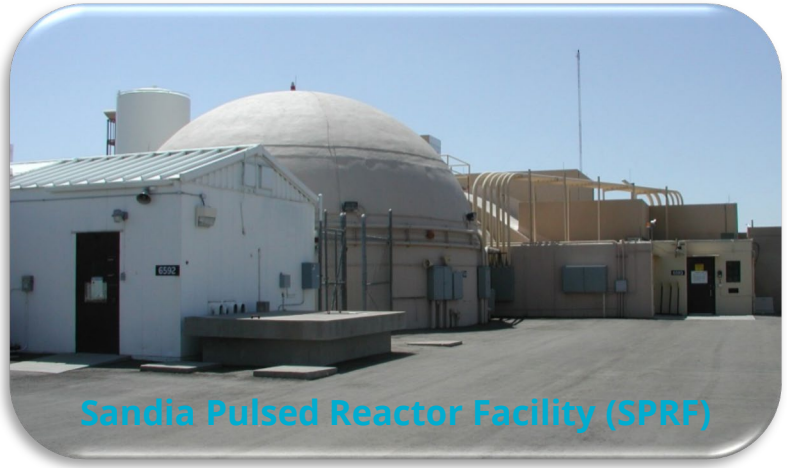
CREST Nuclear Facility

Temporary Modular Office Complex (MOC)

Offices & Light Labs (OLL) Building

Central Utilities Building/Central Alarm Station (CUB/CAS)

SPRF/CX - Sandia Critical Experiments (SCX) Program


Sandia Pulsed Reactor Facility (SPRF)

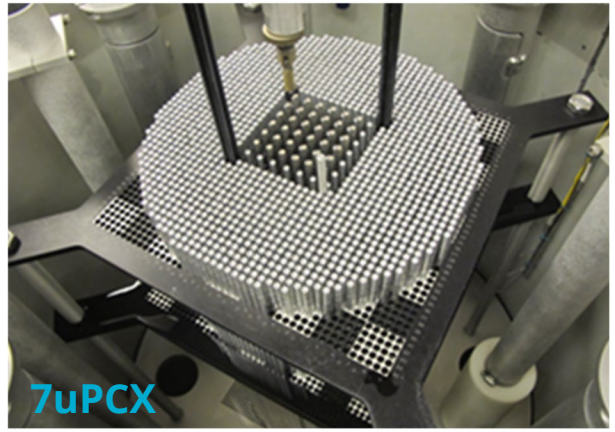
CX Assembly Tank and Dump Tank

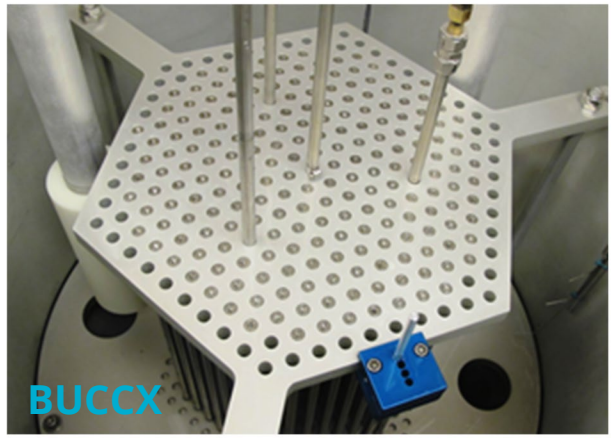
The Seven Percent Critical Experiment (7uPCX)

- 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) with central test region
- Fuel rod diameter 0.635 cm
- Fuel length 48.9 cm
- Eight Experimental Series in the ICSBEP Handbook
  - LCT-078, 080, 096, 097, 101, 102, 111

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

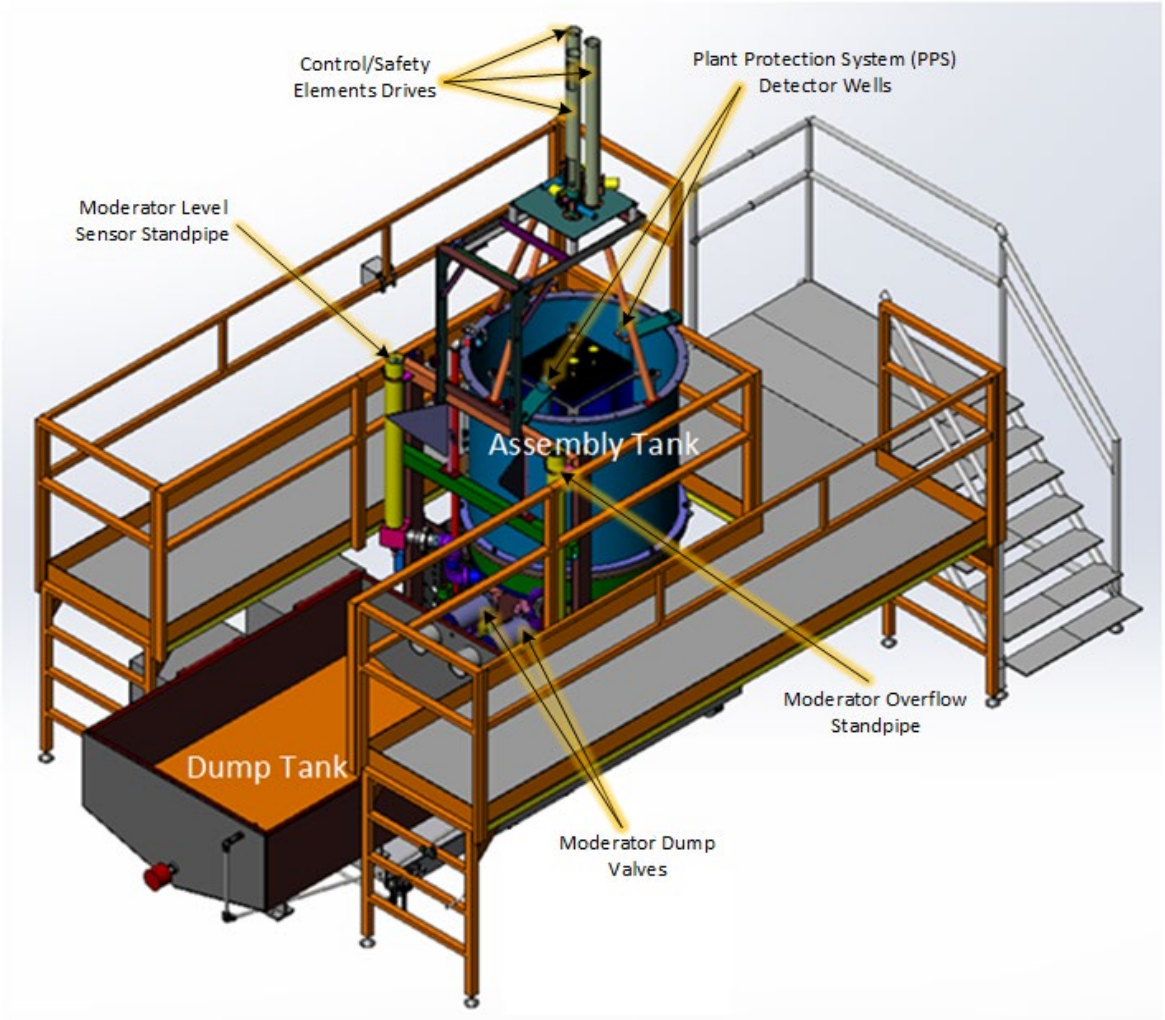

7uPCX


BUCCX

SCX 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
  - B_4C absorber section followed by fueled section
- Plant Protection System
  - Two fission chambers



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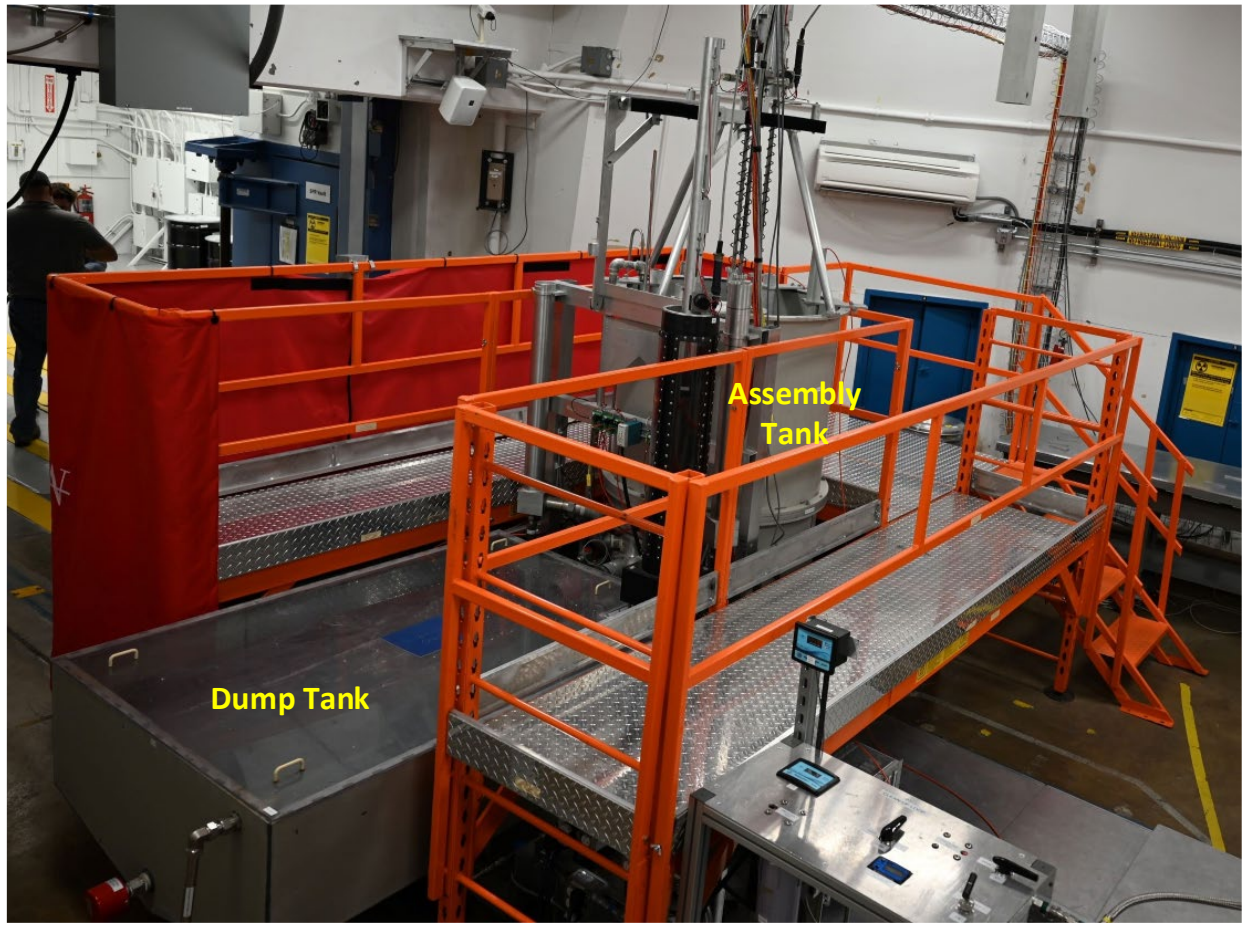
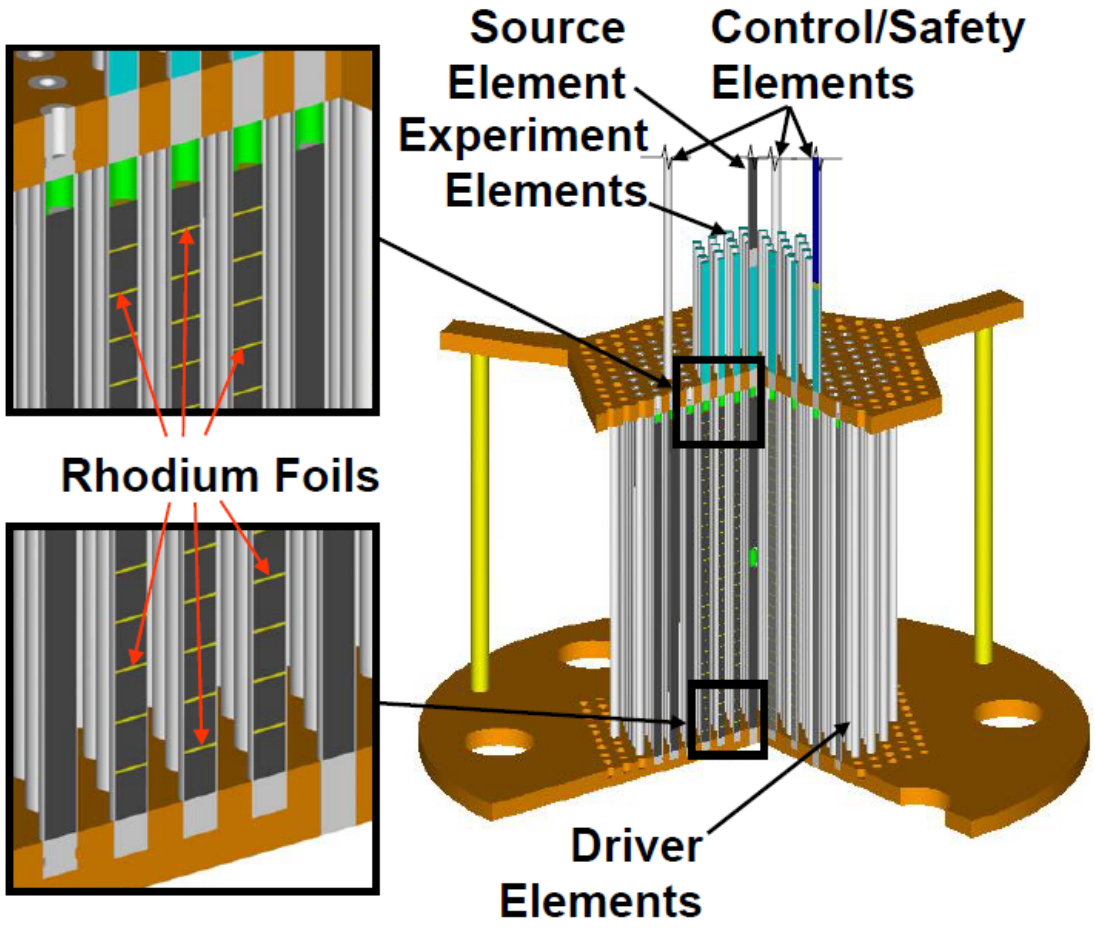


Burnup Credit Critical Experiment (BUCCX)

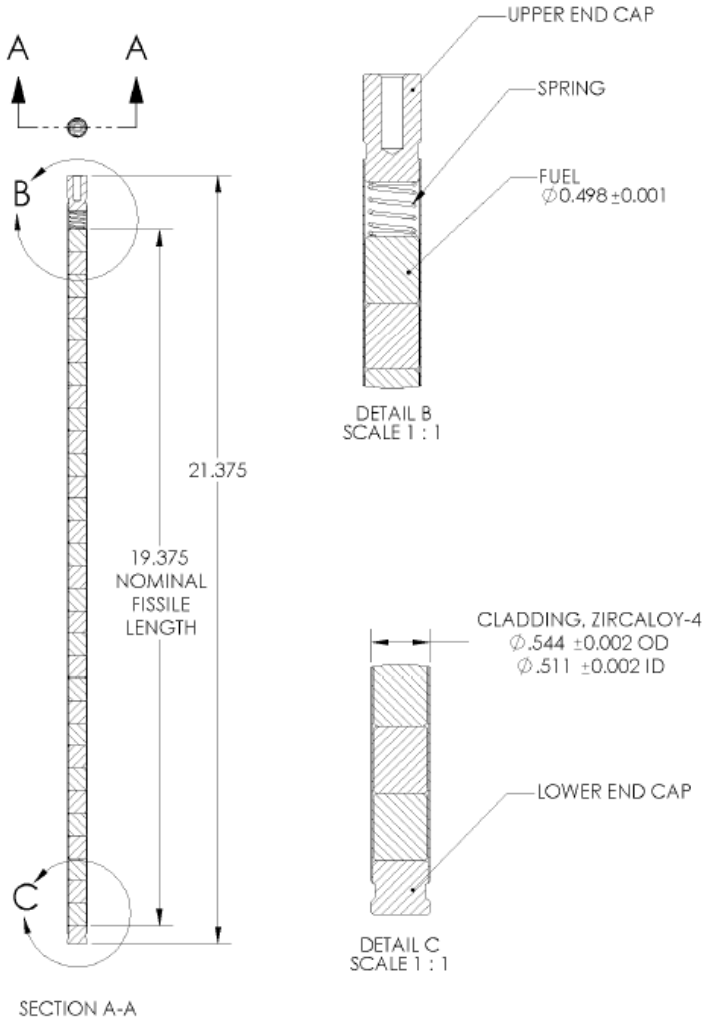
The BUCCX core was designed to be easy to model

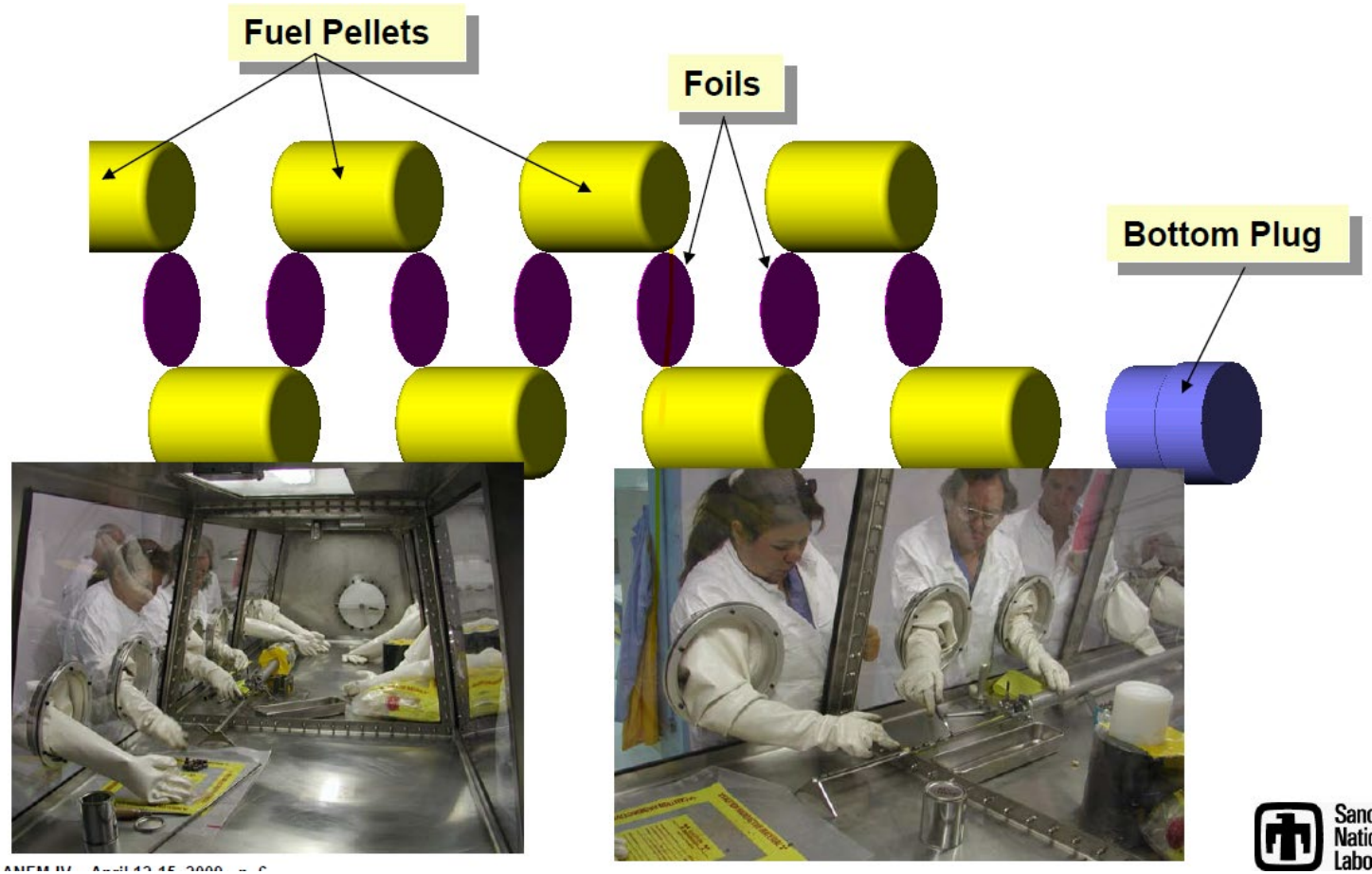


- The assembly is a triangular-pitched array of Zircaloy-4 clad U(4.31%)O_2 fuel (driver) elements
- The assembly has 3 control/safety elements
  - the B_4C absorber is decoupled from the assembly by a polyethylene spacer
  - the absorber is followed by a fuel rod
- Test materials are placed between 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





Sandia National Laboratories

Burnup Credit Critical Experiment (BUCCX)

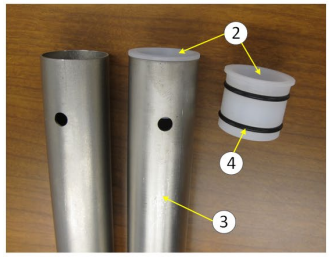
Two experiment series in the ICSBEP handbook

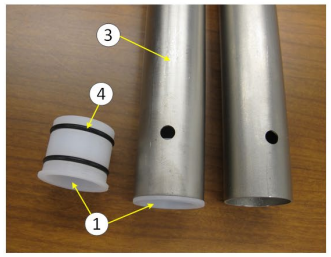
LEU-COMP-THERM-079

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

LEU-COMP-THERM-099

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



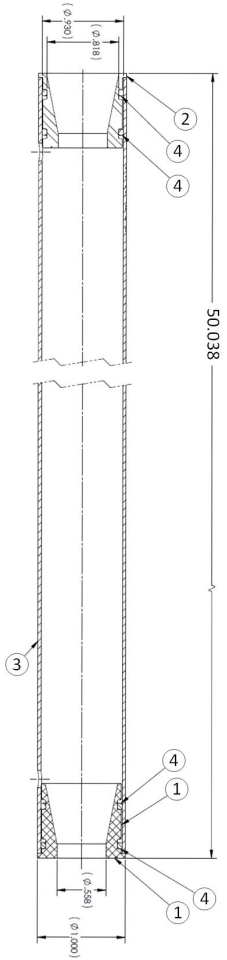


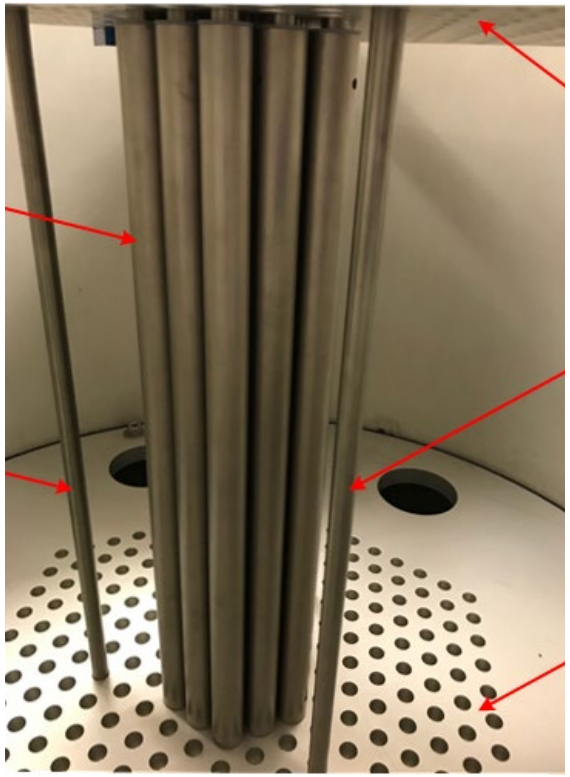
1 = Bottom Polyethylene Centering Piece

2 = Top Polyethylene Centering Piece

3 = Experiment Sleeve

4 = O-ring





Seven Percent Critical Experiment (7uPCX)

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

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
- Eight Critical Benchmarks in the ICSBEP Handbook
  - LCT-078, 080, 096, 097, 101, 102, 111, 112

Seven Percent Critical Experiment (7uPCX)

Eight Critical Benchmark Evaluations 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

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

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

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

LEU-COMP-THERM-111

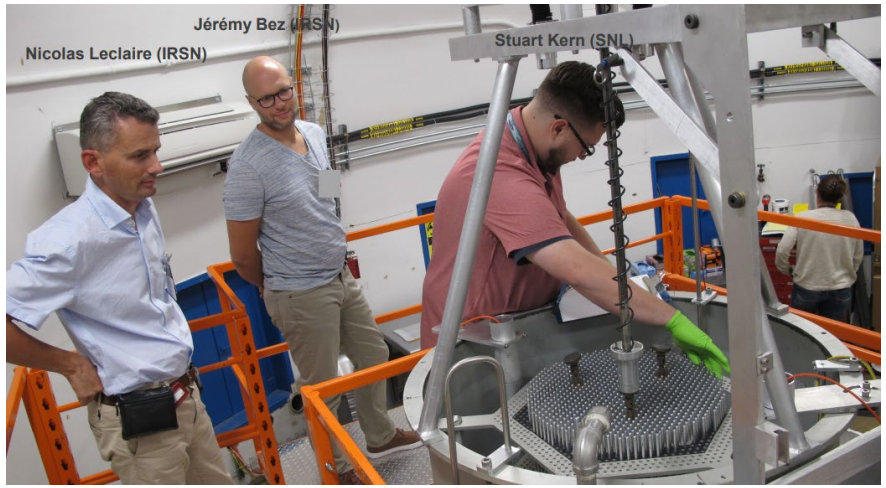
- Five critical experiments performed in 2023
  - Measure the effects of molybdenum in critical systems

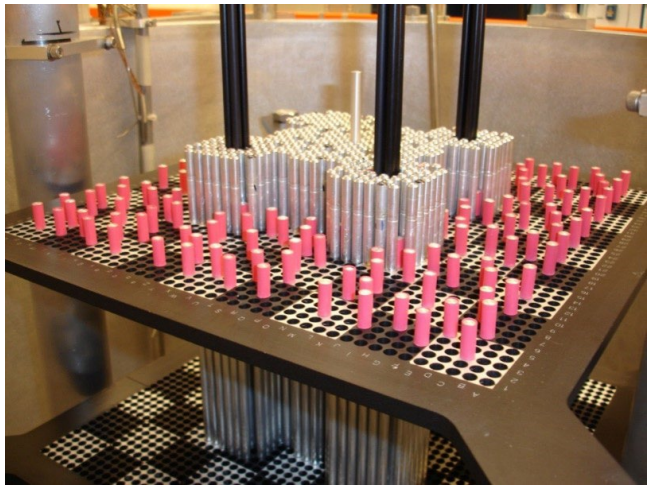
LEU-COMP-THERM-112

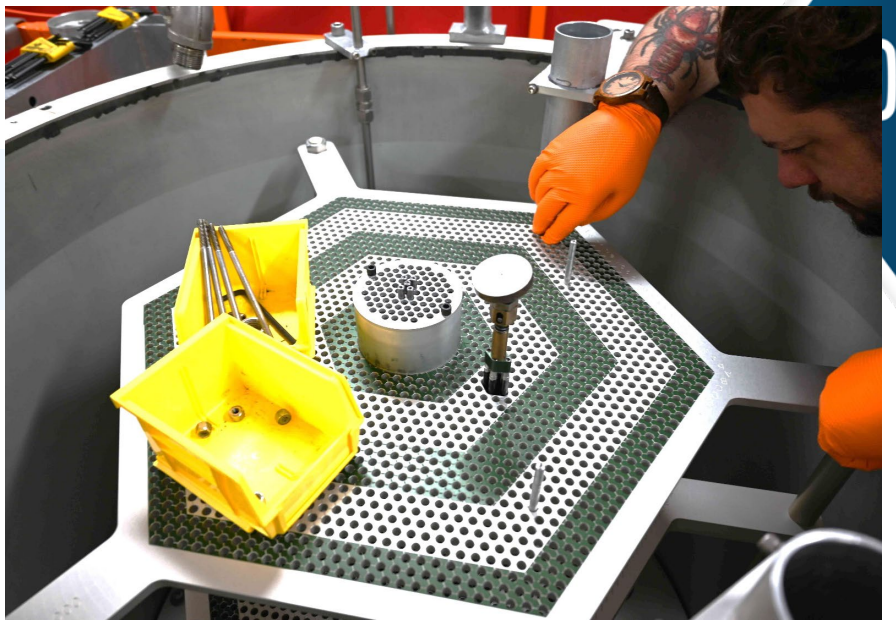
- Eight critical experiments performed in 2024
  - Measure the effects of tantalum in critical systems

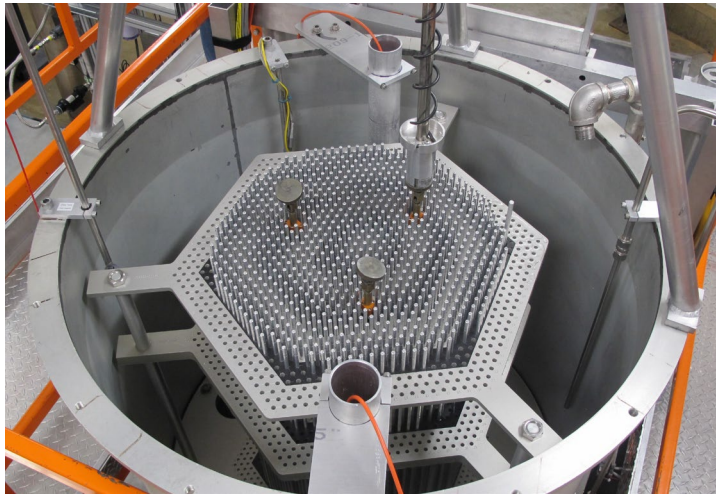
Seven Percent Critical Experiment (7uPCX)

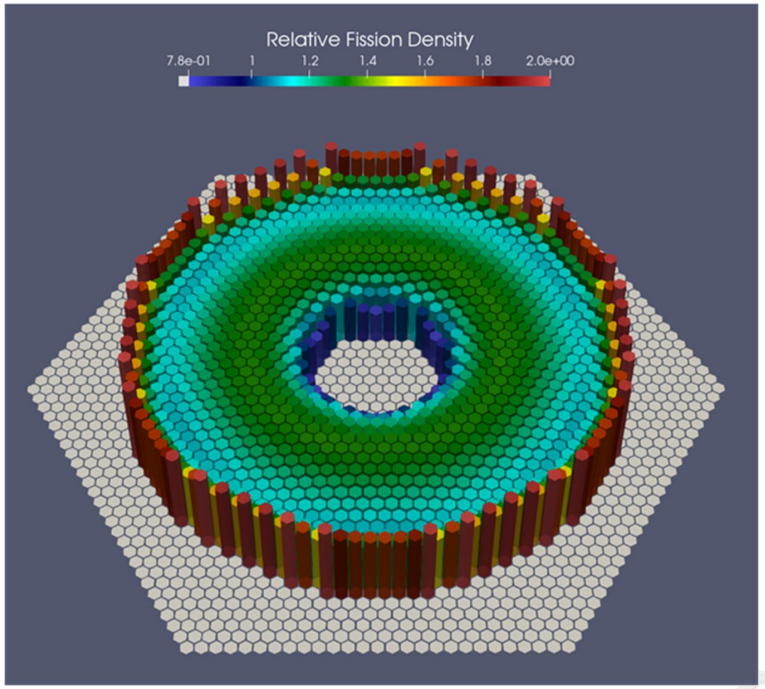
Eight Benchmarks in the ICSBEP Handbook







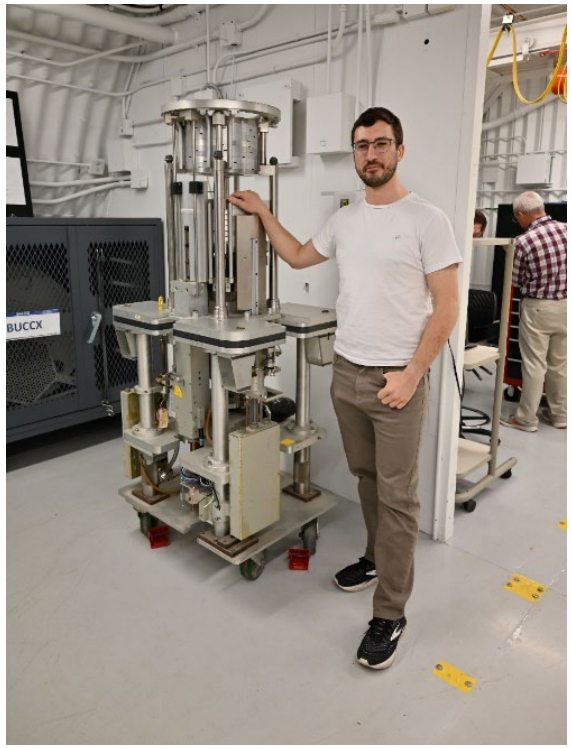


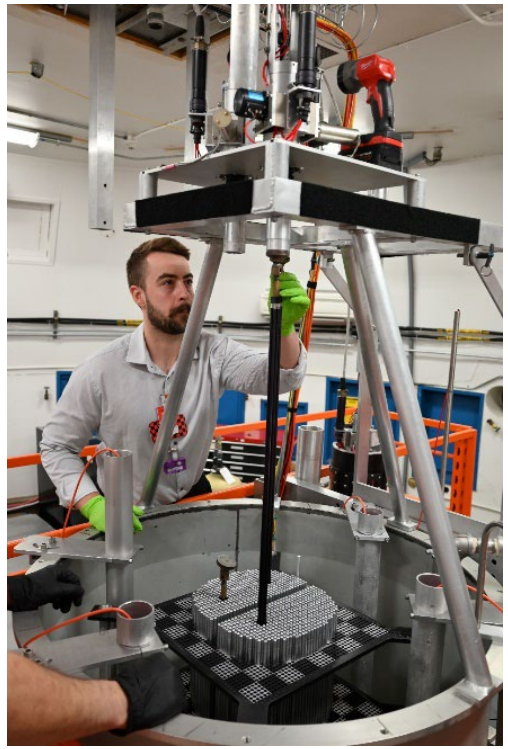


Sandia NCS Hands-On Training Course

NCSP Hands-On Courses (~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.





SCX – Facility Upgrades and Future Plans

Digital Indications and Plant Protection System Upgrades
- Integrated new Plant Protection System drawers and modernized control panel faces

Fabricated backup Control/Safety Elements
- Developed laser wielding technique

Procurement of HALEU fuel (DNSCH)
- Fuel rod fabrication

Redesign of SCX Lower Grid Plate Interface
- Significantly simplifies full core change outs

Temperature Experiments
- Targeting large temperature range (10°C to 80°C)

SCX Classroom Upgrades

QUESTIONS