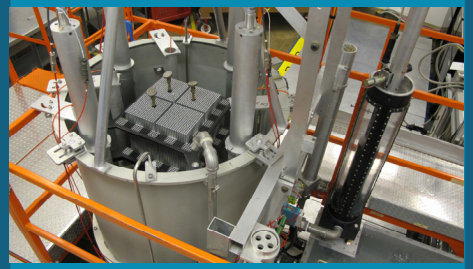
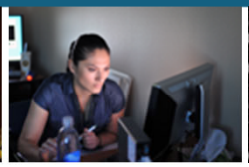
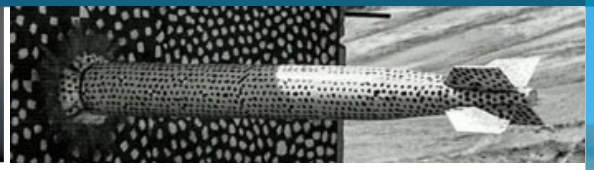
This work was supported by the DOE Nuclear Criticality Safety Program, funded and managed by the National Nuclear Security Administration for the Department of Energy.

Sandia National Laboratories

NCSP Integral Experiments at Sandia in FY21







Gary A. Harms and David E. Ames

NCSP Technical Program Review
February 15-17, 2022

U.S. DEPARTMENT OF ENERGY | NNSA

Sandia National Laboratories is a multimission laboratory managed and operated by National Technology & 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.

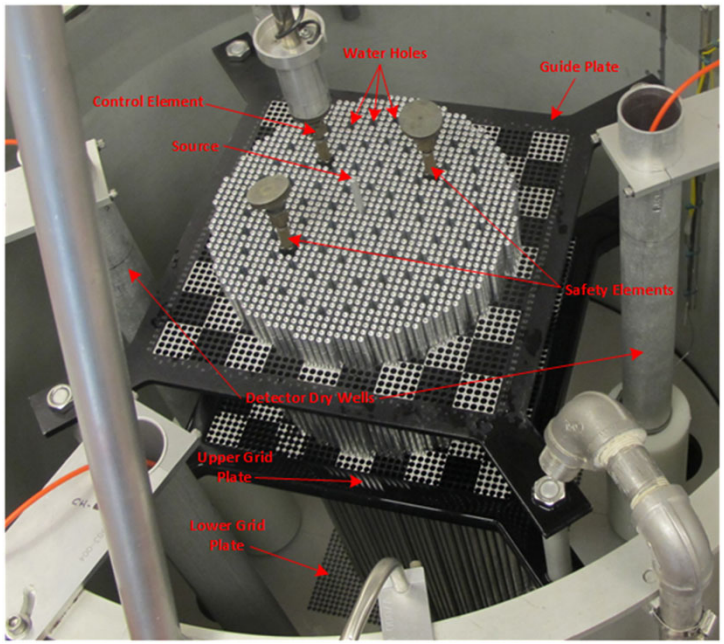
SAND2022-1652 PE

Integral Experiment Requests at Sandia

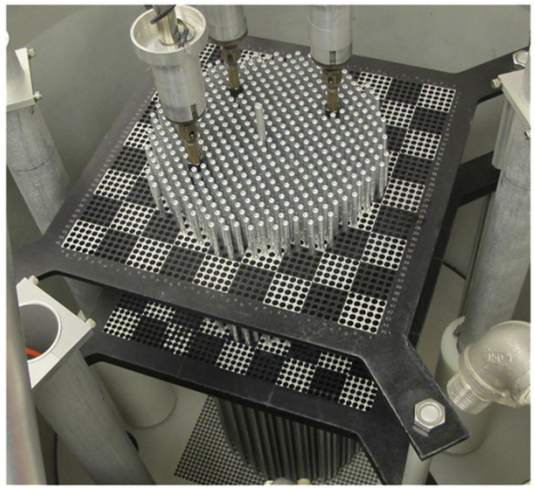
IER	Description	Started FY21	Ended FY21
230	Characterize the Thermal Capabilities of the 7uPCX	CED-3b	CED-4b (Complete)
304	Temperature Dependent Critical Benchmarks	CED-2	CED-2 (Complete)
305	Critical Experiments with UO_2 Rods and Molybdenum Foils	CED-2	CED-3a
306	Critical Experiments with UO_2 Rods and Rhodium Foils	CED-1	CED-2
441	Epithermal HEX Lattices with SNL 7uPCX Fuel for Testing Nuclear Data	CED-3a	CED-3a
452	Inversion Point of the Isothermal Reactivity Coefficient	CED-1	CED-1
523	Critical Experiments with ACRR UO_2-BeO Fuel	Feasibility	Feasibility

IER-230 - Characterize the Thermal Capabilities of the 7uPCX (1)

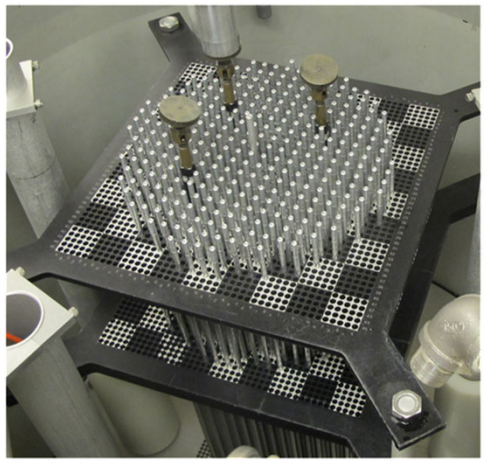
IER-230 is a Sandia experiment intended to explore the behavior of our 7uPCX experiment as a function of fuel-to-water ratio



LCT-102 Case 6
0.800 cm pitch



LCT-102 Case 12
1.132 cm pitch



LCT-102 Case 20
1.600 cm pitch

IER-230 - Characterize the Thermal Capabilities of the 7uPCX (2)

IER-230 is a Sandia experiment intended to explore the behavior of our 7uPCX experiment as a function of fuel-to-water ratio

David Ames is the experimenter

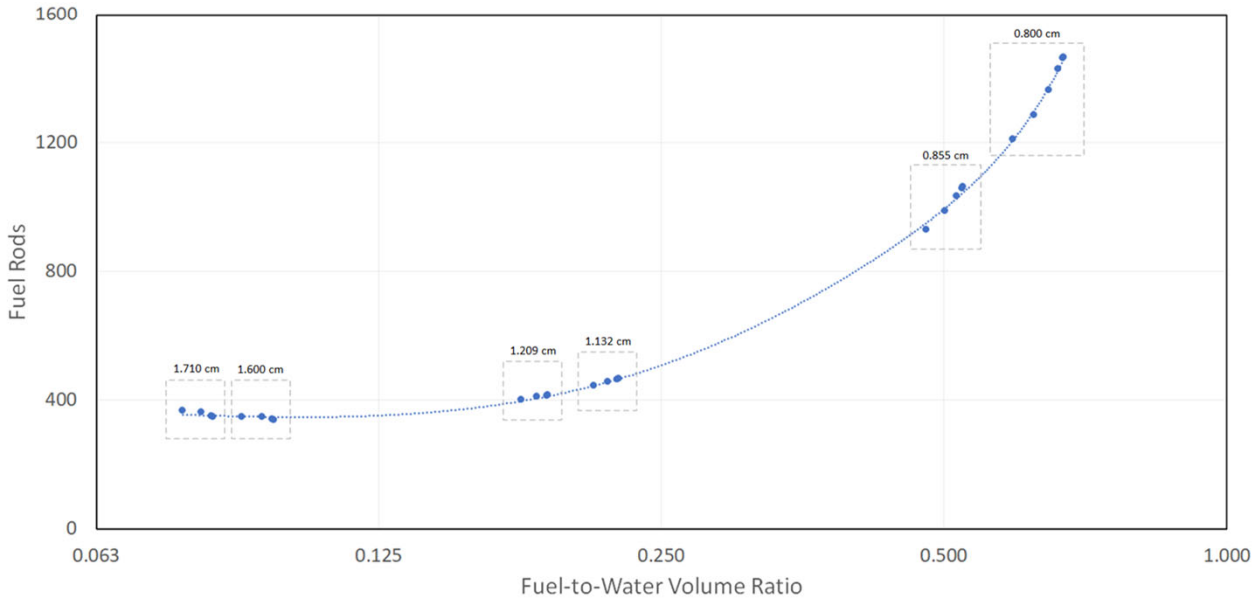
The critical experiments were completed in FY20

The experiment was taken from CED-3b (Execution) to CED-4a (Evaluation) through CED-4b (Publication) in FY21

The experiment appeared as

LEU-COMP-THERM-102

in the 2021 edition of the benchmark book



IER-304 – Temperature dependent critical benchmarks

IER-304 is an ORNL experiment intended to explore the behavior of the Sandia criticals as a function of temperature

Initially proposed by Thomas Miller, the current ORNL PI is Justin Clarity

Justin shepherded the experiment through CED-2 Final Design in FY21

There are many core design options available using either 7uPCX or BUCCX fuel

To perform critical experiments at temperatures significantly different from room temperature, the proposed modifications to the critical assembly are:

- **Add insulation to the water tanks including covers**
- **Add a new heating system to maintain elevated temperatures**
- **Add a new cooling system to maintain temperatures below room temperature**
- **Replace the dump tank with a larger water storage tank**
- **Install improved temperature instrumentation**
- **Add a dehumidification system**

The experiment is now in CED-3a Facility Planning/Cost Estimation

IER-305 – Critical Experiments with UO_2 Rods and Molybdenum foils (1)

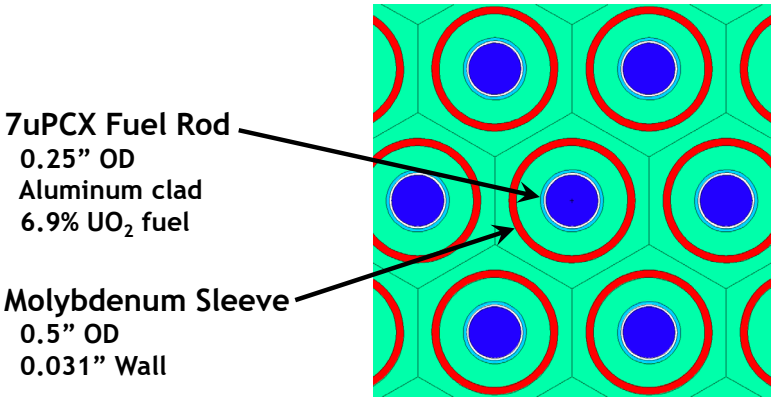
IER-305 is an IRSN experiment intended to benchmark the effect of molybdenum on critical systems.

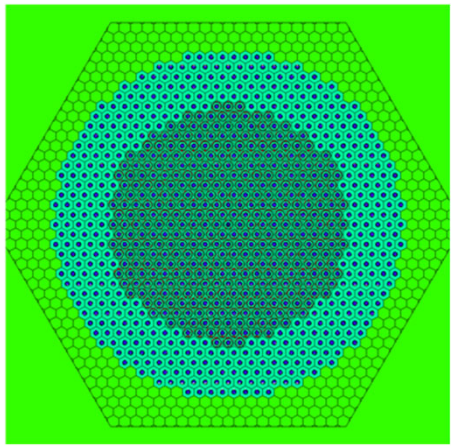
Nicolas Leclaire at IRSN has led the experiment through CED-2 Final Design.

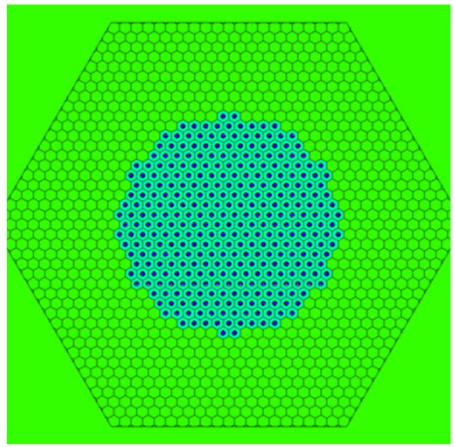
The experiment will use the 7uPCX fuel in a new triangular grid plate set with a 1.55 cm triangular pitch

The experiment has a central region of 7uPCX fuel rods in molybdenum sleeves surrounded by a driver region of 7uPCX fuel rods

A baseline configuration with only 7uPCX fuel rods will be used for comparison







IER-305 – Critical Experiments with UO_2 Rods and Molybdenum foils (2)

The experiment is now in CED-3a Facility Planning/Cost Estimation.

IRSN has purchased a set of 400 0.5” diameter molybdenum tubes that will be used as sleeves on 7uPCX fuel rods.

The fuel rods will be put in a new set of grid plates with a 1.55 cm triangular pitch.

The new core hardware is being designed at Sandia.

We expect to perform the critical experiments in FY22.

IER-305 – Critical Experiments with UO_2 Rods and Molybdenum foils (3)

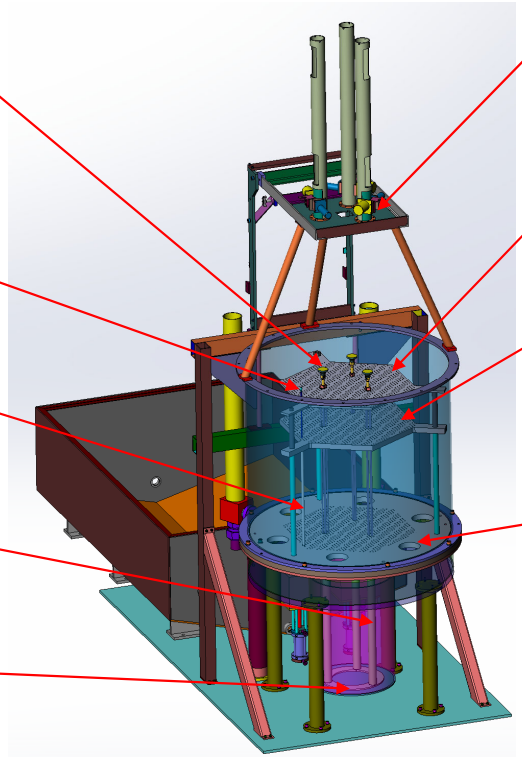
J69335
REACTIVITY AND CONTROL
ROD BUNDLE ASSEMBLY
(J69336, J69337, J69338)

7uPCX FUEL ROD
ASSEMBLY

MOLY SLEEVE
ASSEMBLY (J78480)

HYDRO TUBE
(J69329, J69330)

LOWER GUIDE RING,
HYDRO TUBE, 1.55
PITCH
(J69328)



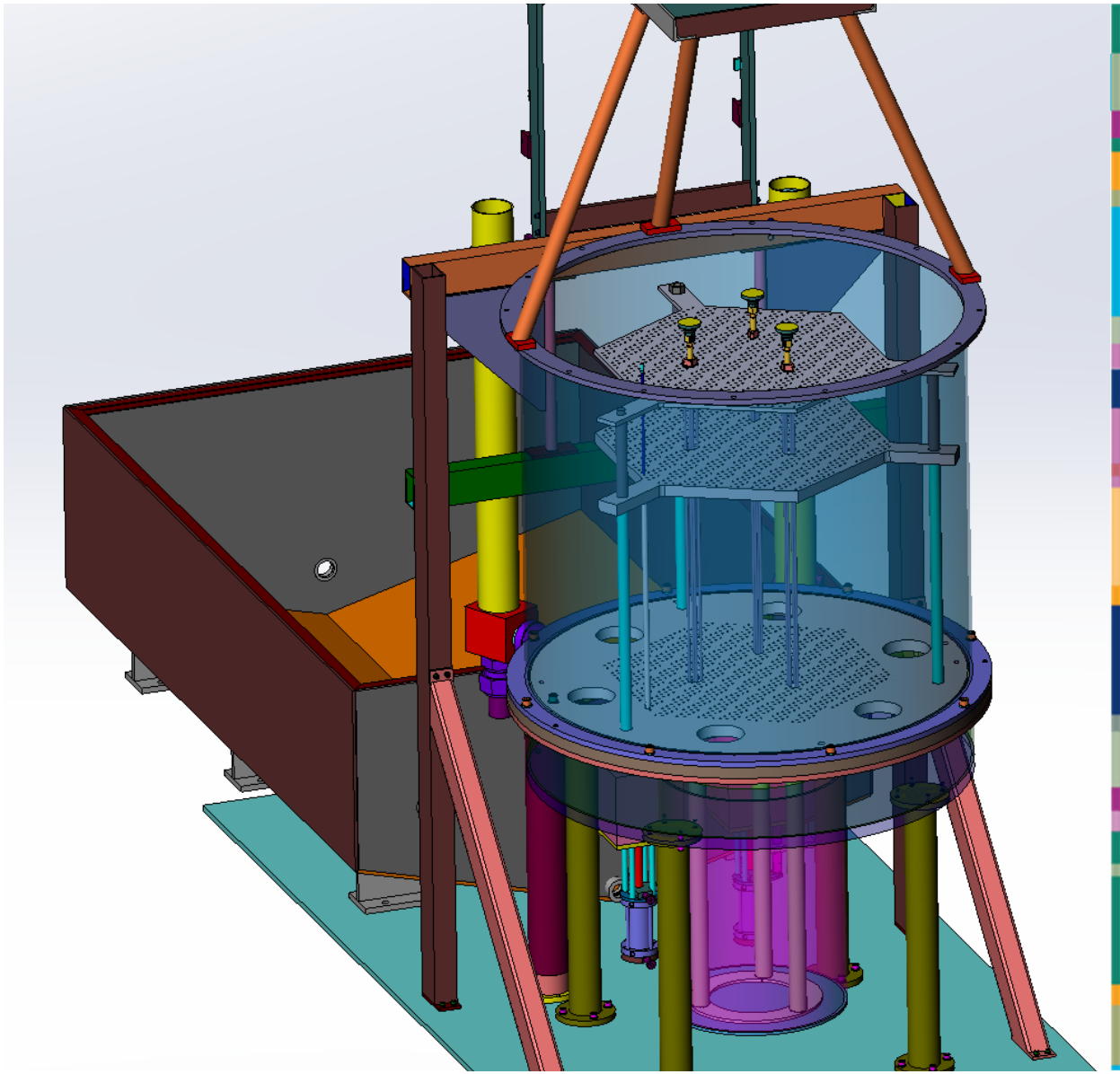
DRIVE MOUNTING
PLATE, 1.55 PITCH
(J69334)
BUC_Drive_Mtn2-8

UPPER GRID PLATE
GUIDE, 1.55 PITCH
(J69333)

UPPER GRID PLATE,
1.55 PITCH (J69332)

LOWER GRID PLATE,
1.55 PITCH (J69331)

IER-305 – Critical Experiments with UO_2 Rods and Molybdenum foils (3)



IER-306 – Critical Experiments with UO_2 Rods and Rhodium Foils

IER-306 is an IRSN experiment intended to benchmark the effect of rhodium on critical systems.

Nicolas Leclaire at IRSN is leading the experiment through CED-2 Final Design.

IRSN has completed the CED-2 summary report which is being reviewed by the CEdT.

The report examined three design approaches:

- **Rhodium in foils between fuel pellets in the fuel rods as was done in LCT079**
- **Rhodium in solution with fuel rods in the solution tank**
- **Rhodium incorporated in resin blocks with fuel rods through the blocks**

The design with rhodium in a solution tank appears to be the most tractable.

The design requires 1385 g of rhodium at a current cost of about $1.3 M.

IRSN will monitor the cost of rhodium.

IER-441 – Epithermal HEX Lattices with SNL 7uPCX Fuel for Testing Nuclear Data

IER-441 is an ORNL experiment intended to harden the neutron spectrum in the assembly

The experiment was originally proposed by Mike Westfall at ORNL

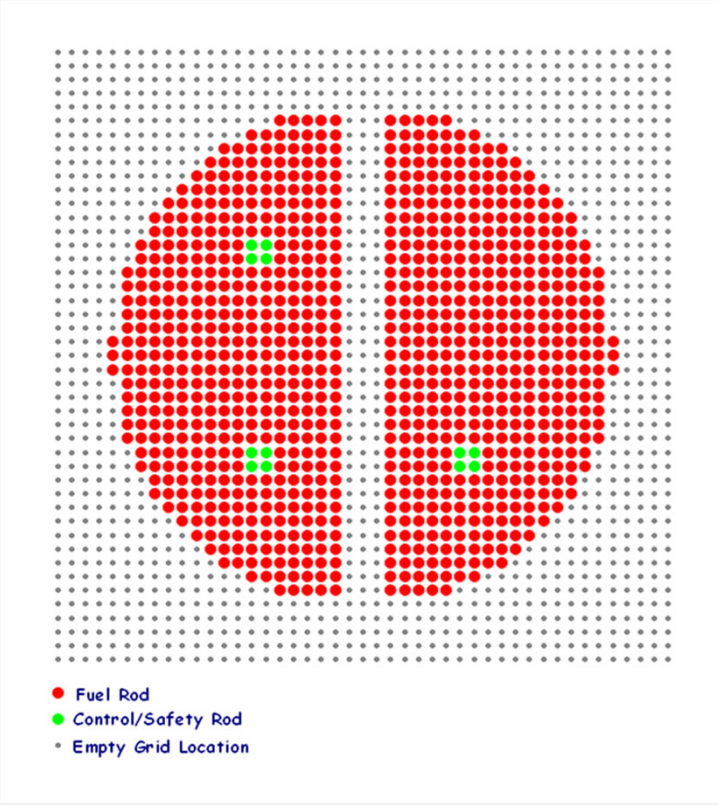
The current PI at ORNL is Justin Clarity

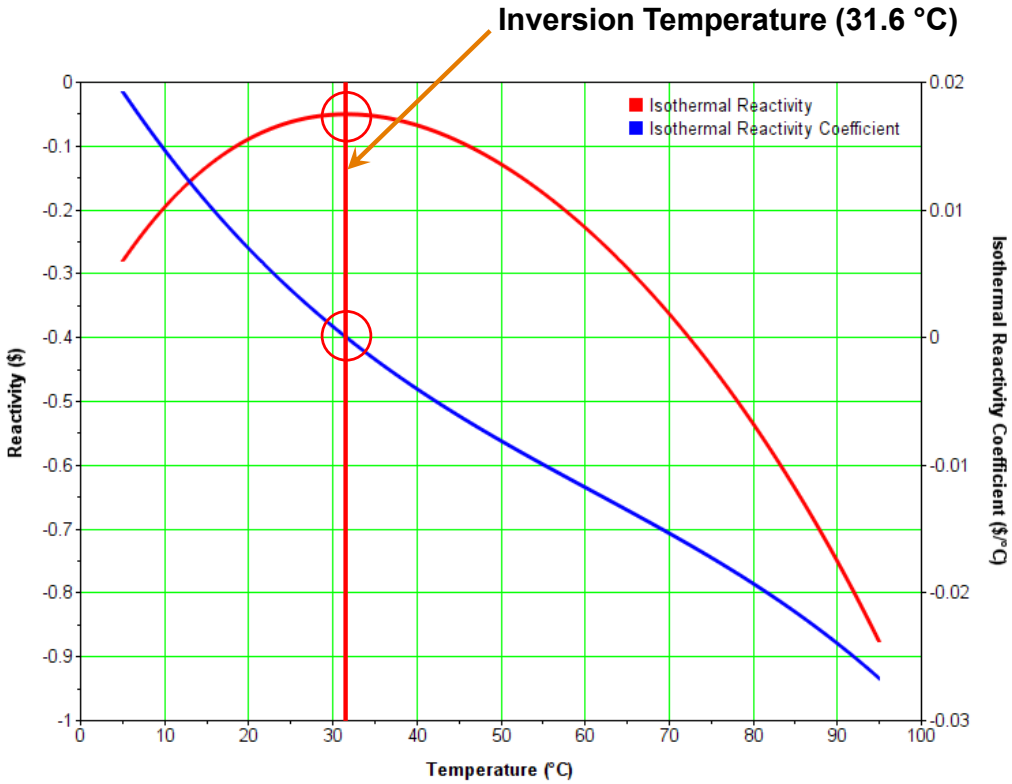
Justin has led the design of the experiment through CED-2 Final Design

The experiment requires significant modifications to the core hardware

The experiment is now in CED-3a Facility Planning/Cost Estimation

IER-452 – Inversion Point of the Isothermal Reactivity Coefficient (1)





Subcritical Multiplication

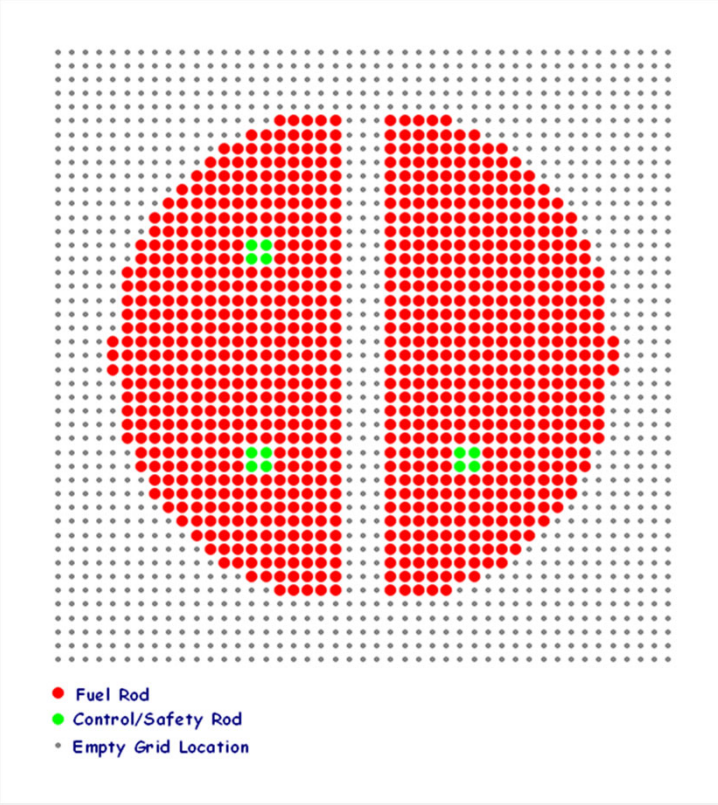
$$M = \frac{1}{1 - k_{eff}}$$

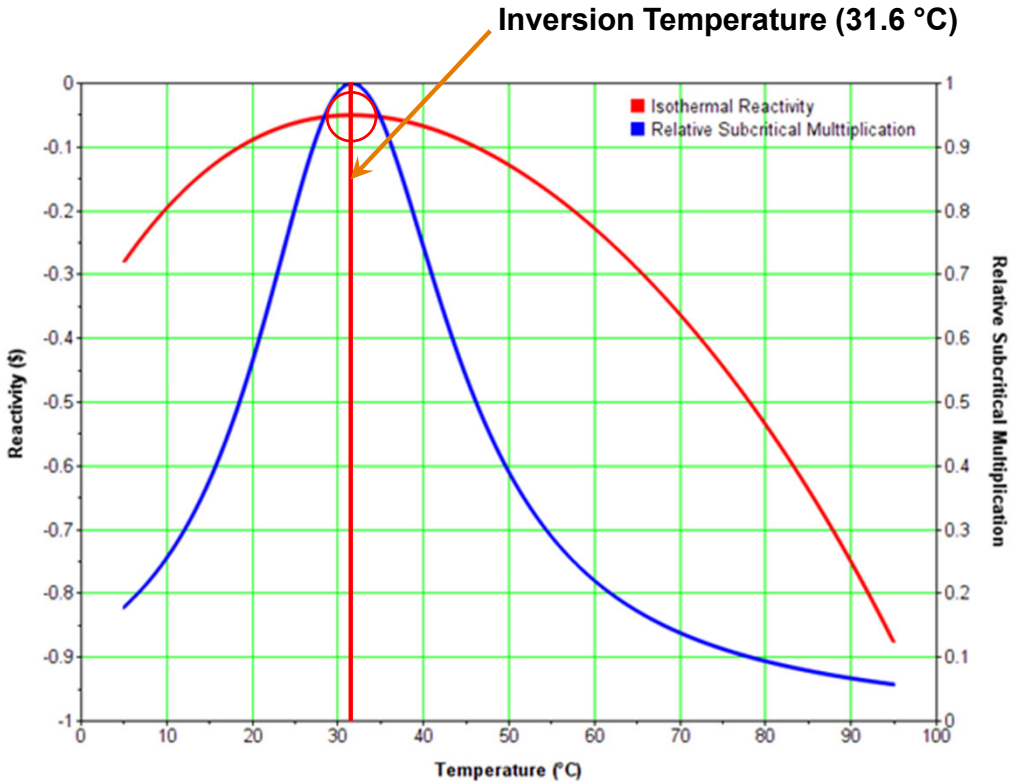
$$\rho = \frac{k_{eff} - 1}{k_{eff}}$$

$$M = \frac{\rho - 1}{\rho}$$

The count rate in detectors near the critical assembly follows the subcritical multiplication

IER-452 – Inversion Point of the Isothermal Reactivity Coefficient (2)





Subcritical Multiplication $M = \frac{1}{1 - k_{eff}}$ $\rho = \frac{k_{eff} - 1}{k_{eff}}$ $M = \frac{\rho - 1}{\rho}$

The count rate in detectors near the critical assembly follows the subcritical multiplication

IER-452 – Inversion Point of the Isothermal Reactivity Coefficient (3)

IER-452 is a Sandia experiment intended to explore the behavior of the temperature coefficient in the Sandia Critical Experiments.

This experiment is related to but different from the IER-304 experiment.

The two experiments need the same modifications to the critical assembly to control and measure the temperature in the assembly:

- **Insulation of the water tanks including covers**
- **A heating system to maintain elevated temperatures**
- **A cooling system to maintain temperatures below room temperature**
- **A larger water storage (dump) tank**
- **Improved temperature instrumentation**
- **A dehumidification system**

This experiment will be discussed at NCSD 2022.

IER-523 – Beryllium Oxide Critical Assembly

The Annular Core Research Reactor (ACRR) is our primary tool to test the neutron/gamma-ray hardness of Sandia (and other lab) components.

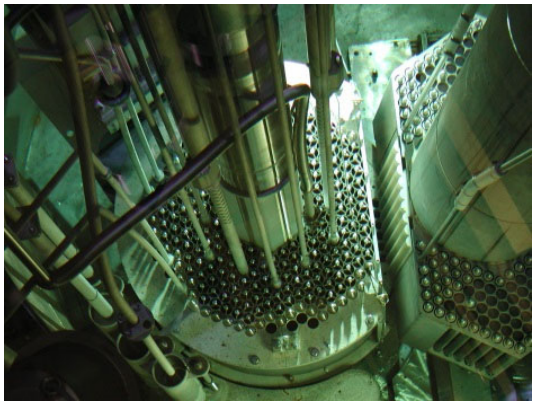
IER-523 is a Sandia experiment intended to explore the behavior of the ACRR UO_2-BeO fuel in a critical experiment.

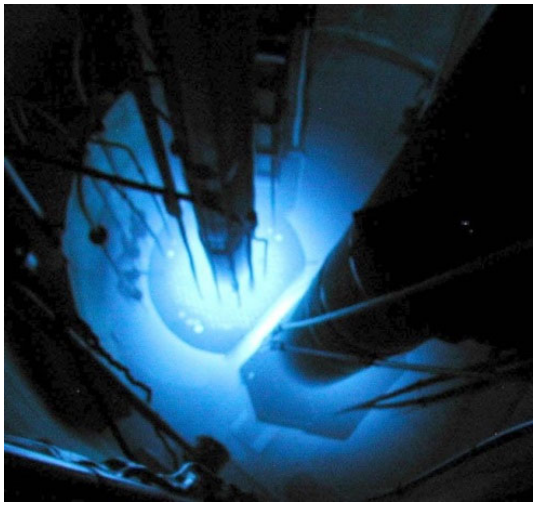
The critical experiment will benefit the criticality safety community – 35% enriched UO_2, UO_2-BeO fuel.

The critical experiment will benefit the Sandia Nuclear Deterrence program – ACRR characterization, ACRR fuel health program, safety basis code validation.

A feasibility study was initiated in FY21. The feasibility study found that Sandia has sufficient UO_2-BeO fuel to perform a meaningful critical experiment.

David will take it from here…





Critical Experiments at Sandia

This work was supported by the DOE Nuclear Criticality Safety Program, funded and managed by the National Nuclear Security Administration for the Department of Energy.