SAND2019-3160PE

Overview of NCSP Integral Experiments at Sandia

Nuclear Criticality Safety Program Technical Program Review

PANTEX

March 27, 2019

Presented by
Gary A. Harms
Sandia National Laboratories

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Sandia Integral Experiment Requests

IER	Title	Sponsor	CED
206	Re-establish the 4.3% Enriched Critical Experiment Capability at Sandia	SNL	4b
209	7uPCX 0.855 cm Pitch, Variable Depth Pure Water Moderator	SNL	3b
230	Characterize the Thermal Capabilities of the 7uPCX	SNL	3a
304	Temperature Dependent Critical Benchmarks	ORNL	2
305	Critical Experiments with UO2 Rods and Molybdenum Foils	IRSN	2
306	Critical Experiments with UO2 Rods and Rhodium Foils	IRSN	1
441	Epithermal HEX Lattices with SNL 7uPCX Fuel for Testing Nuclear Data	ORNL	2
451	Titanium Cross Sections in a Thermal Application (BUCCX Hardware)	SRNL	4a
452	Inversion Point of the Isothermal Reactivity Coefficient	SNL	1

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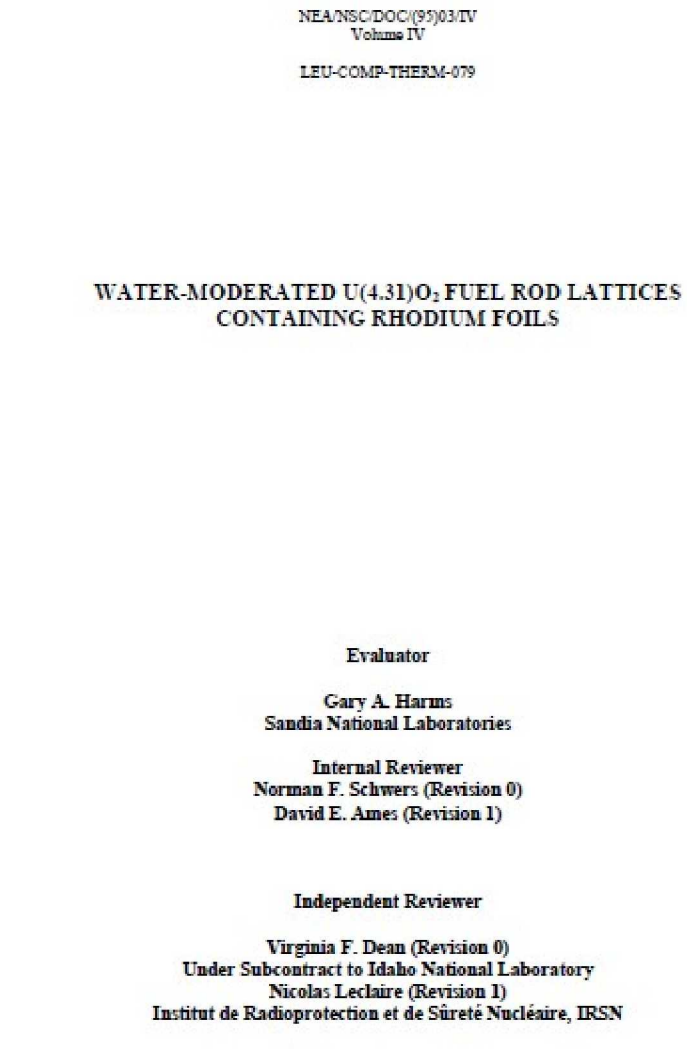
IER-206



NEA/NSC/DOC/(95)03/IV
Volume IV

LEU-COMP-THERM-079

WATER-MODERATED U(4.31)O_2 FUEL ROD LATTICES
CONTAINING RHODIUM FOILS

Evaluator

Gary A. Harms
Sandia National Laboratories

Internal Reviewer
Norman F. Schwers (Revision 0)
David E. Ames (Revision 1)

Independent Reviewer

Virginia F. Dean (Revision 0)
Under Subcontract to Idaho National Laboratory
Nicolas Leclaire (Revision 1)
Institut de Radioprotection et de Sûreté Nucléaire, IRSN

- **A revision of the LCT079 evaluation was completed**
- **The revised version appeared in the December 2018 version of the International Handbook of Evaluated Criticality Benchmark Experiments**

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IER-451

NEA/NSC/DOC/(95)03/IV
Volume IV

LEU-COMP-THERM-099

TITANIUM AND/OR ALUMINUM SLEEVE EXPERIMENTS IN FULLY-REFLECTED WATER-MODERATED U(4.31)O_2 FUEL ROD LATTICES WITH 2.8 CM PITCH

Evaluator

David E. Ames
Sandia National Laboratories

Internal Reviewer

Gary A. Harms
Sandia National Laboratories

Independent Reviewer

Nicolas Leclaire
Institut de Radioprotection et de Sûreté Nucléaire, IRSN

- David Ames is the Experimenter and Evaluator for this experiment
- His presentation preceded this one

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Sandia Integral Experiment Requests

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IER-209 – 7uPCX 0.855 cm Pitch, Variable Depth Pure Water Moderator

- This is similar to the experiments completed in IER-208 that resulted in the benchmark evaluation LEU-COMP-THERM-096 (2015)
- The difference is in the fuel rod pitch (0.855 vs 0.800 cm)
- The 0.855 cm pitch array is more reactive than the 0.800 cm pitch array (~1060 rods fully reflected vs ~1450)

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Water Level Control

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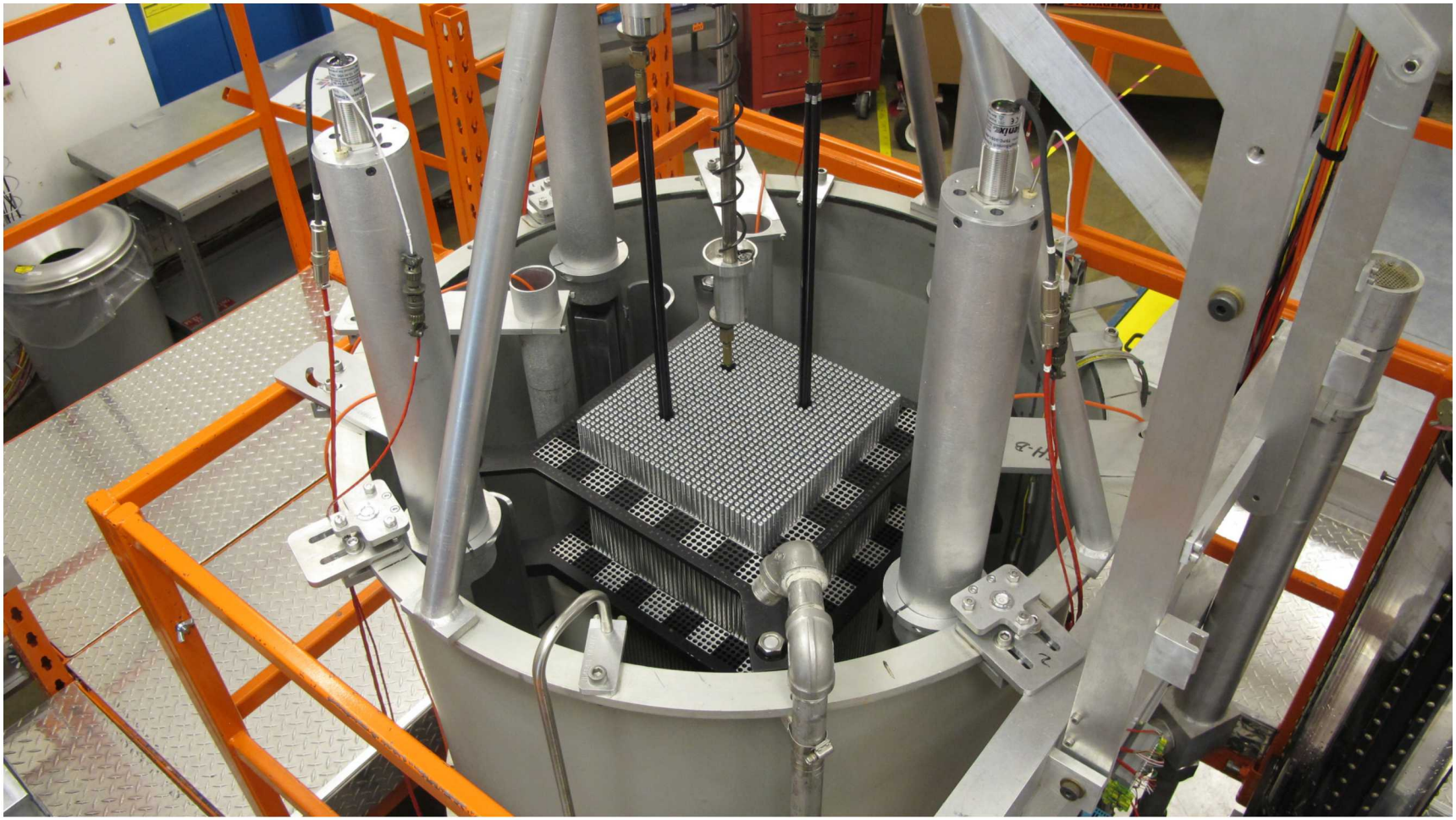
Water Level Measurement



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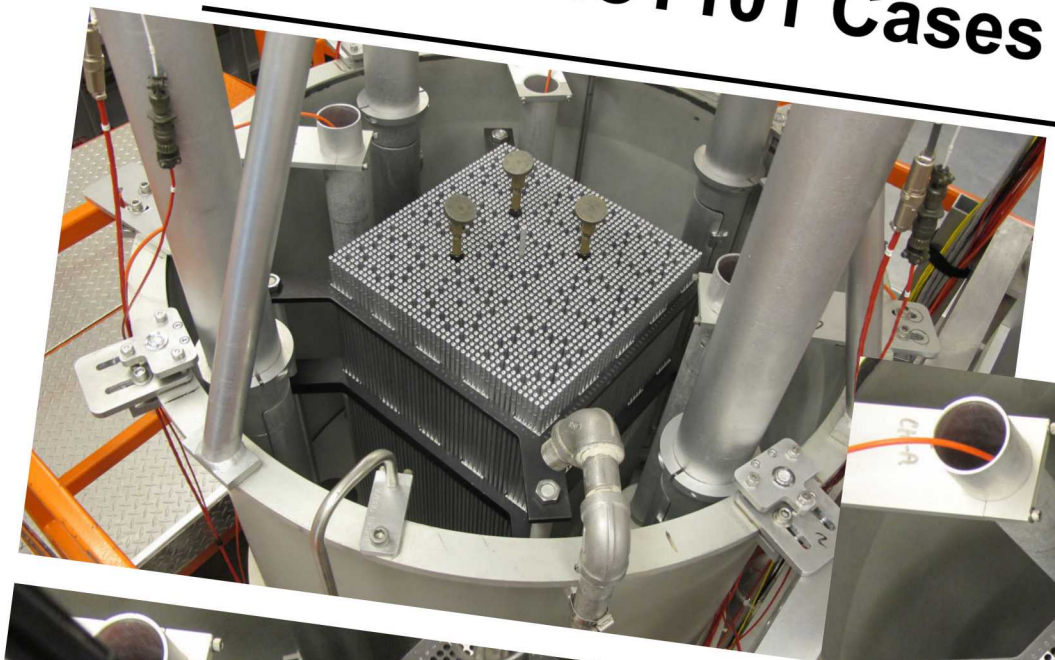
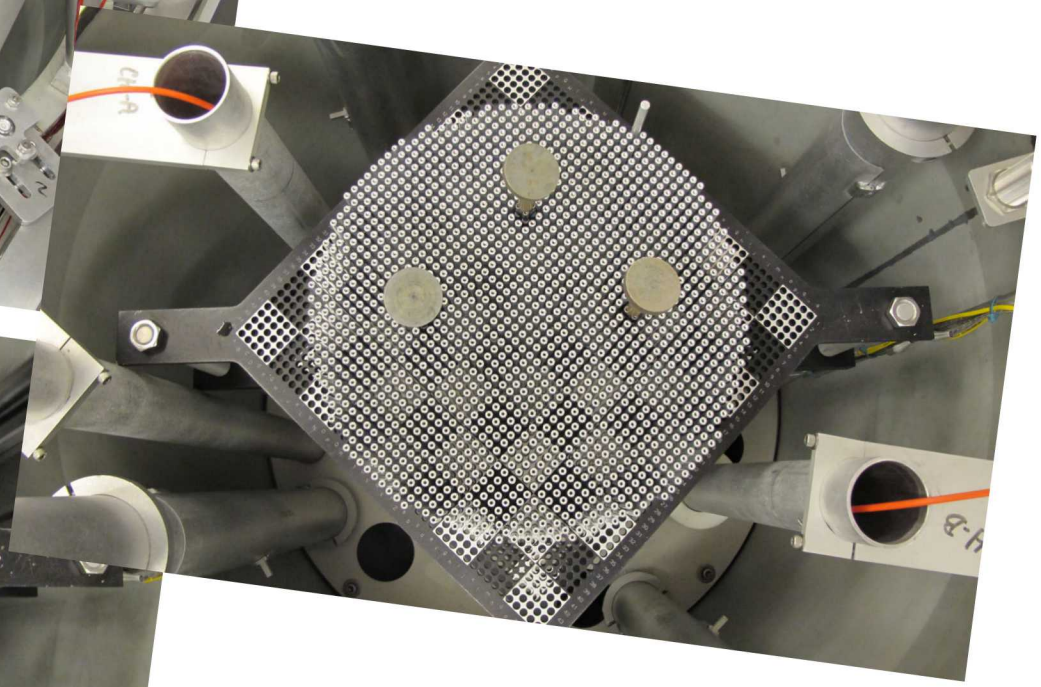
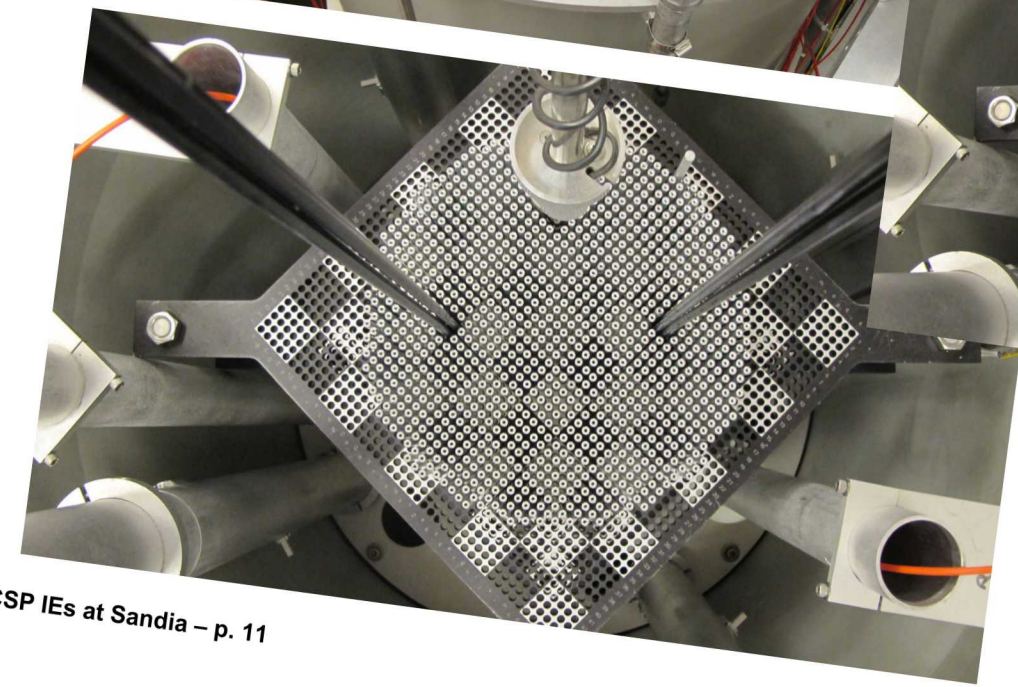
LCT101 Cases 2, 4, and 7







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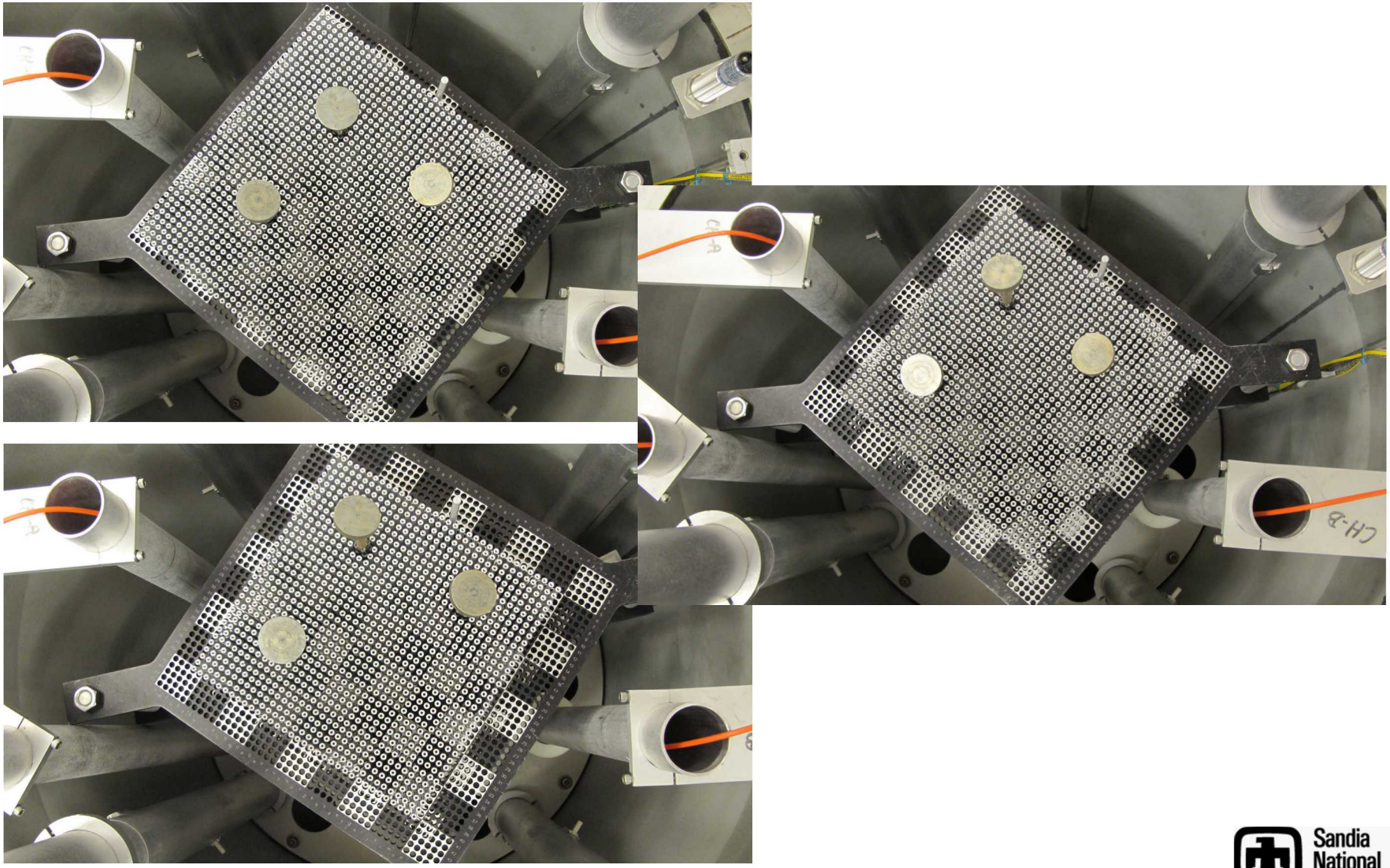
LCT101 Cases 9, 10, and 11



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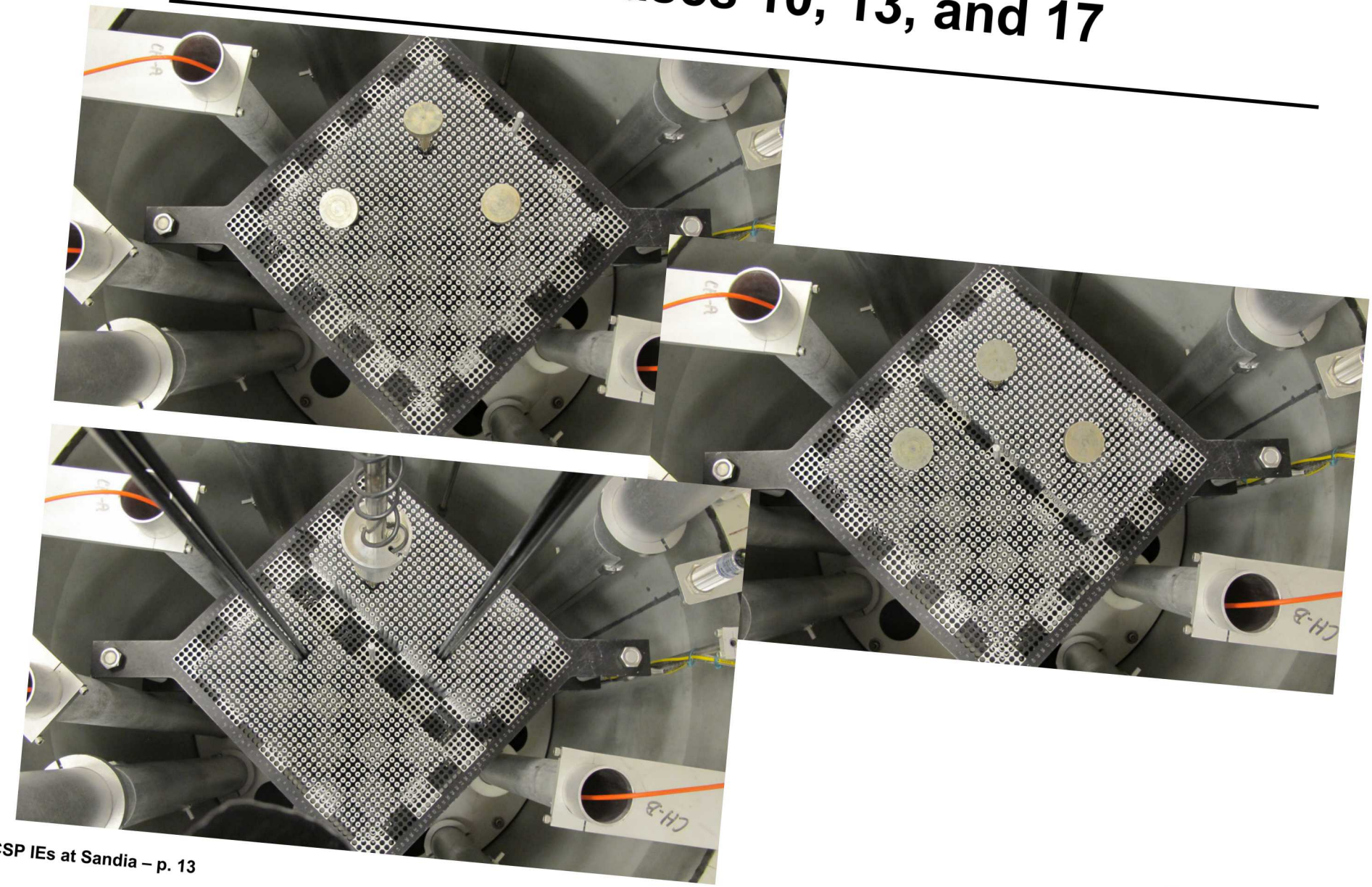
LCT101 Cases 10, 13, and 17



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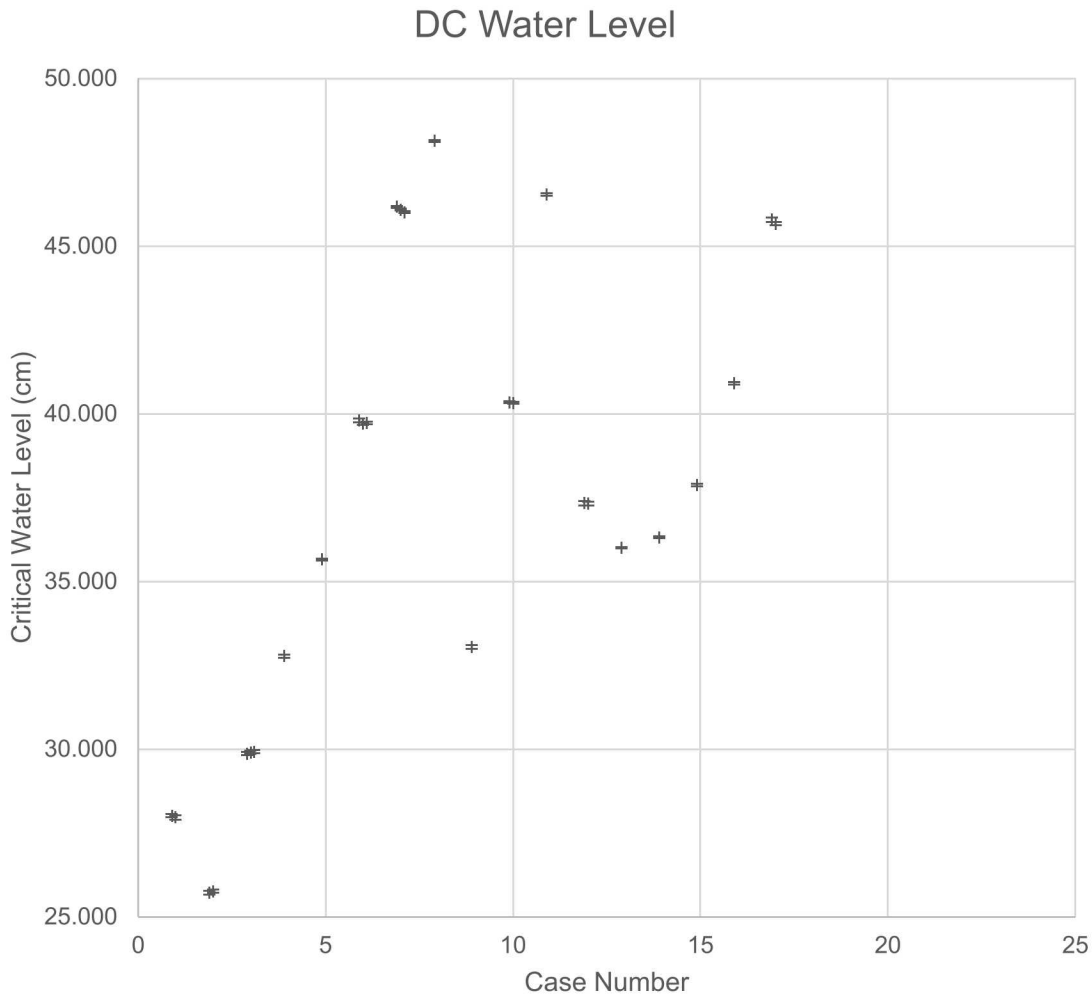
LCT101 Experiment Results on 3/14/19



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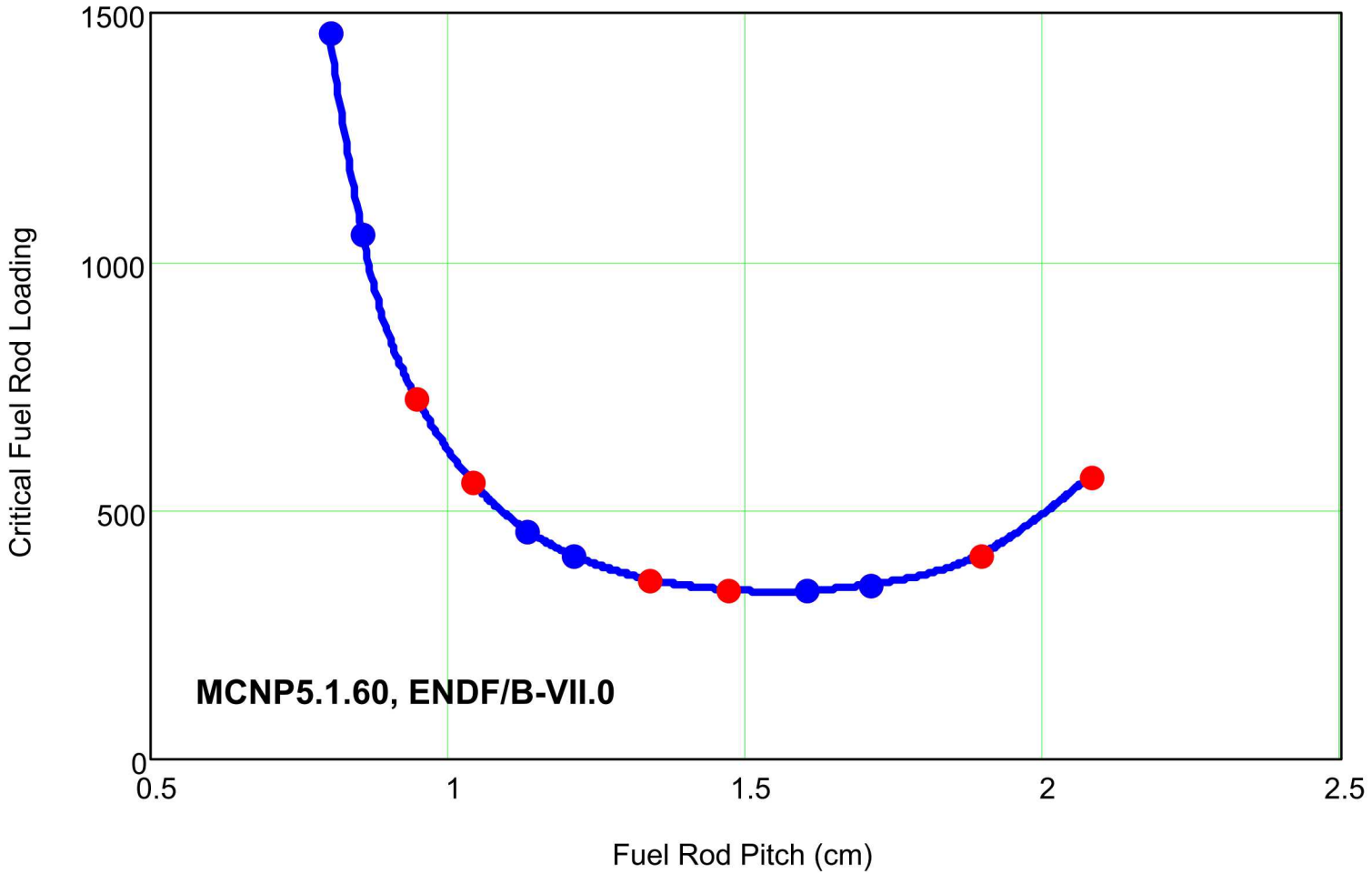
Number of Fuel Rods at DC vs Pitch



The blue points are for existing grid plates (0.800 and 0.855 cm pitch).
The red points are for new grid plates (0.947 and 1.039 cm pitch)

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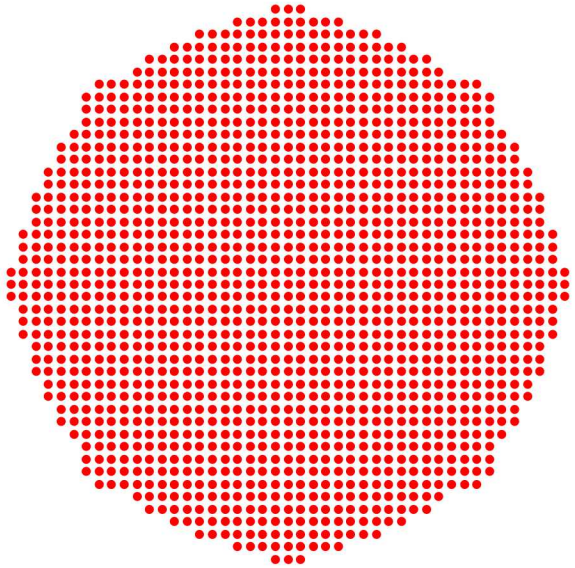
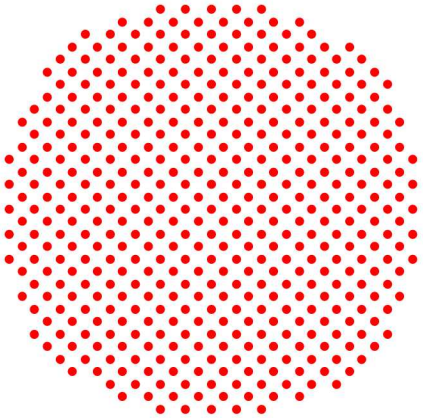
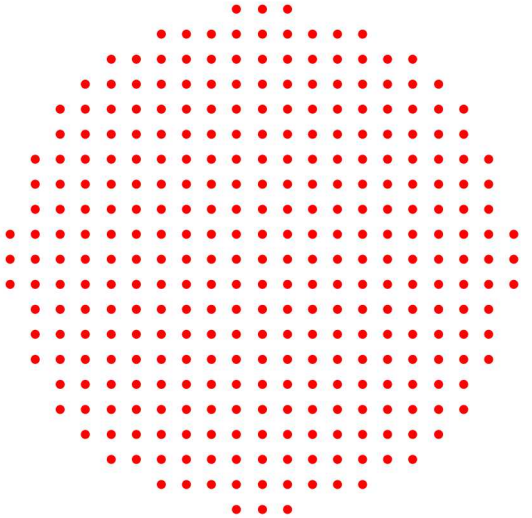
IER-230 – Characterize the Thermal Capabilities of the 7uPCX



0.800 cm Pitch
1461 Rods at DC



1.132 cm Pitch
454 Rods at DC



1.600 cm Pitch
328 Rods at DC

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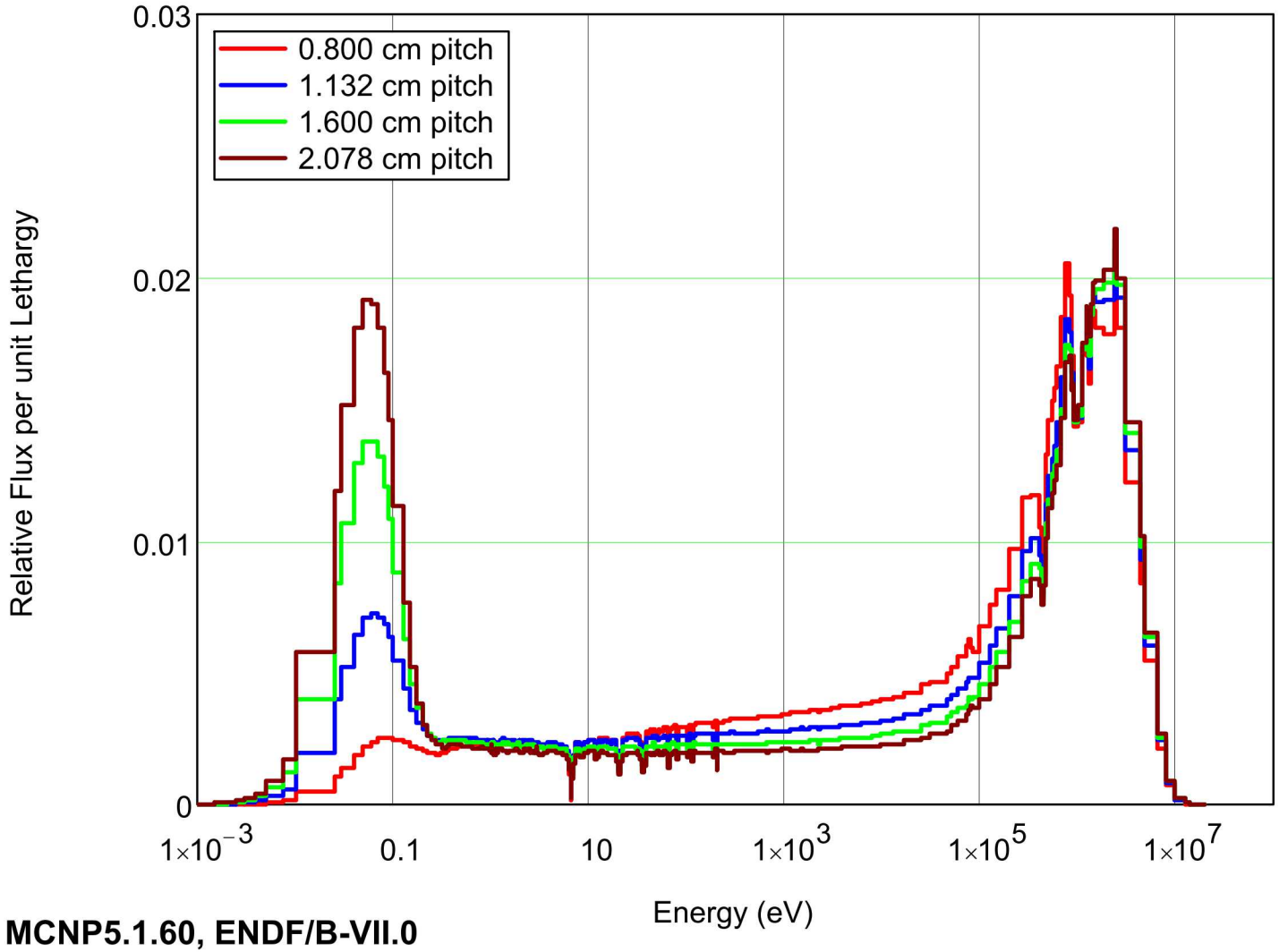
The Neutron Spectrum vs Pitch



MCNP5.1.60, ENDF/B-VII.0

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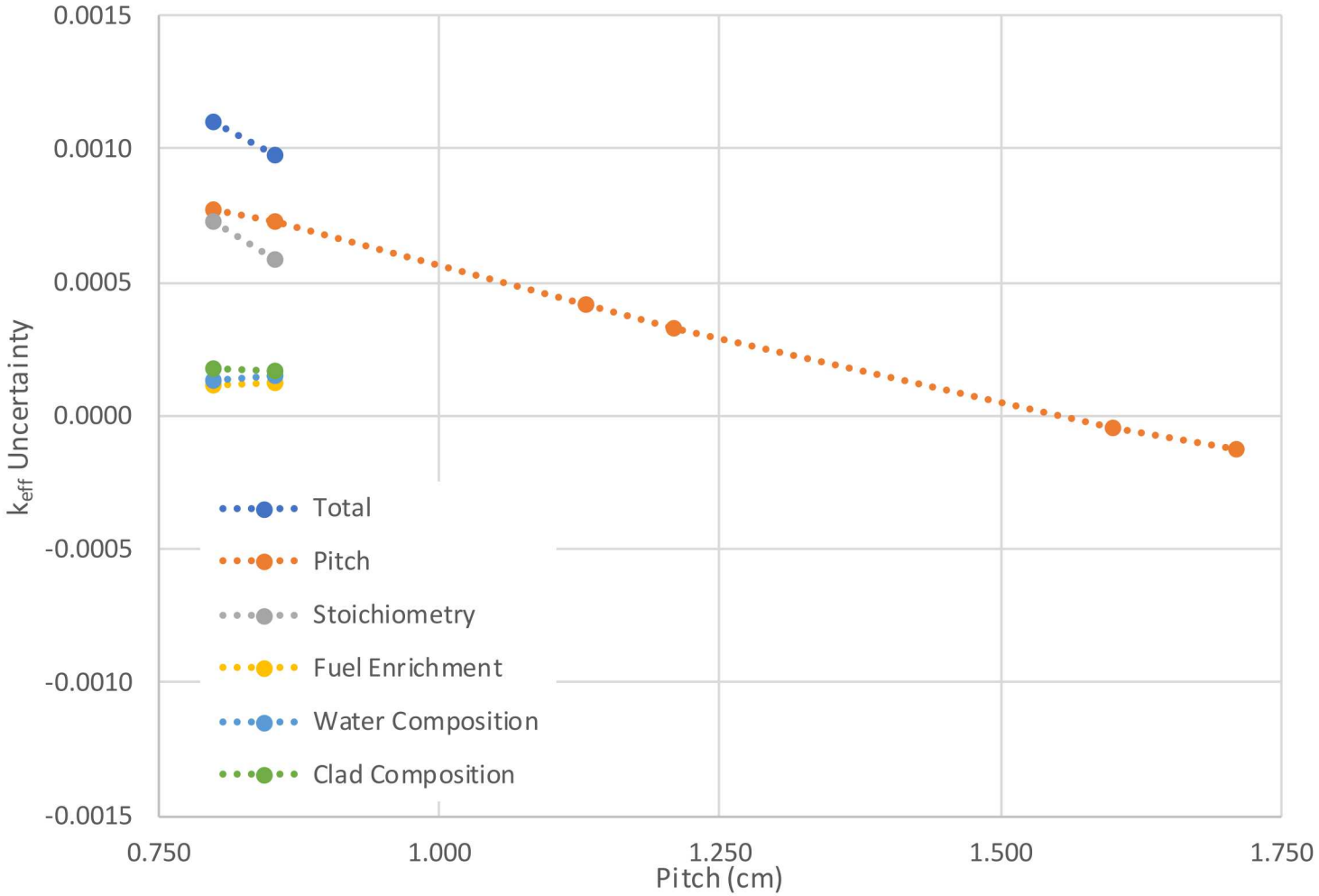
LCT080 (0.800 cm) and LCT078 (0.855 cm) Uncertainties



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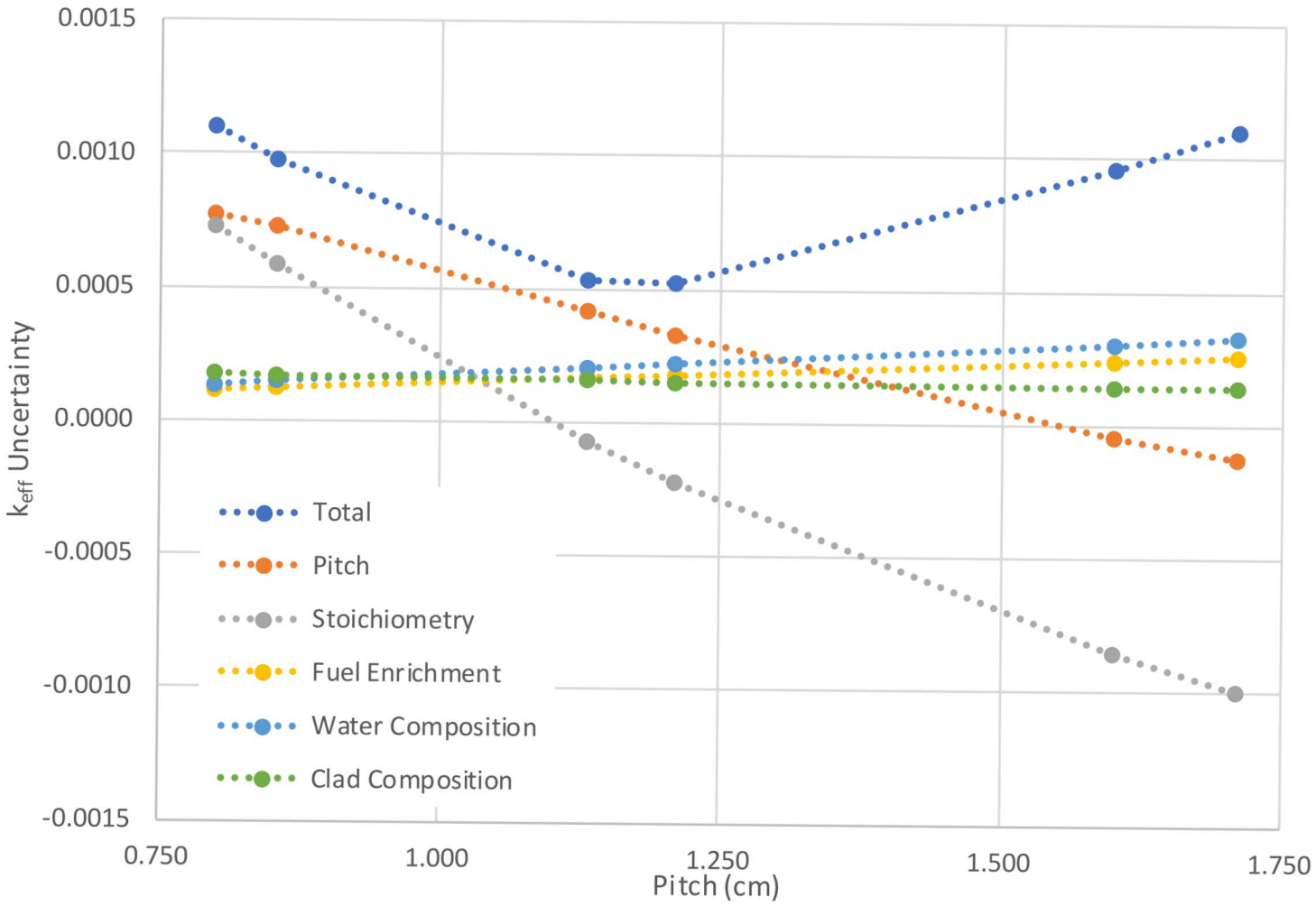
IER-230 Uncertainties



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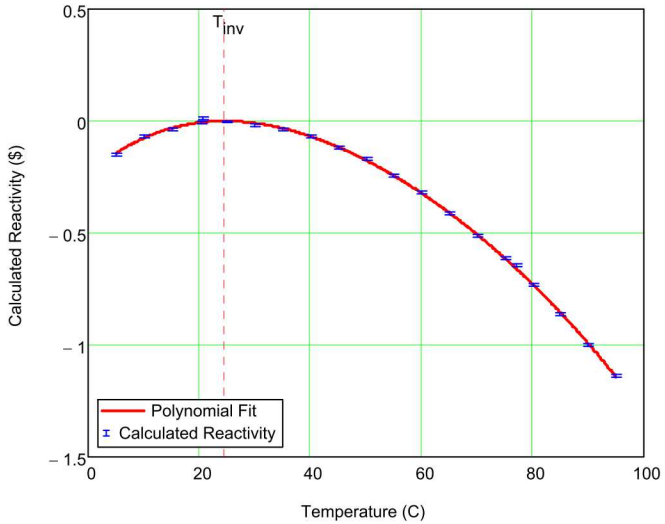
IER-452 – Inversion Point of the Isothermal Reactivity Coefficient



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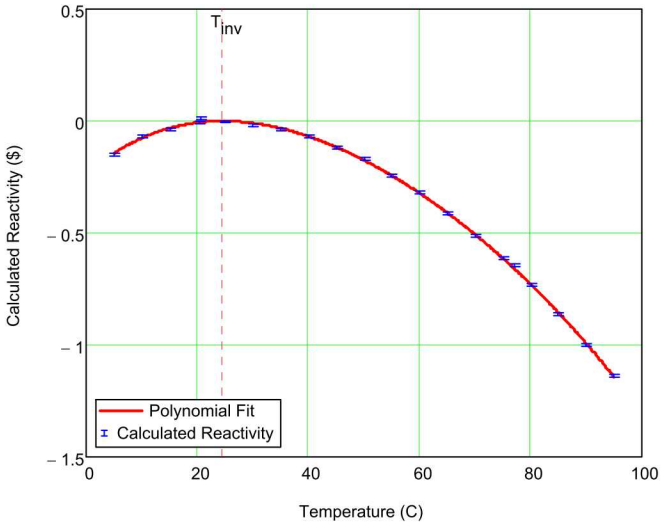
IER-452 – Inversion Point of the Isothermal Reactivity Coefficient



International Reactor Physics Experiment Evaluation Project: International Handbook of Evaluated Reactor Physics Benchmark Experiments

IPEN(MB01)-LWR-RESR-017
THE INVERSION POINT OF THE ISOTHERMAL REACTIVITY COEFFICIENT OF THE IPEN/MB-01 REACTOR
Adimir dos Santos et al.

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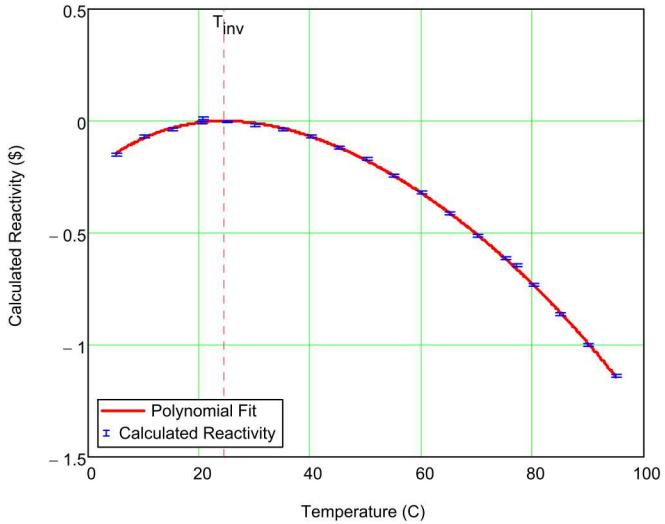
IER-452 – Inversion Point of the Isothermal Reactivity Coefficient



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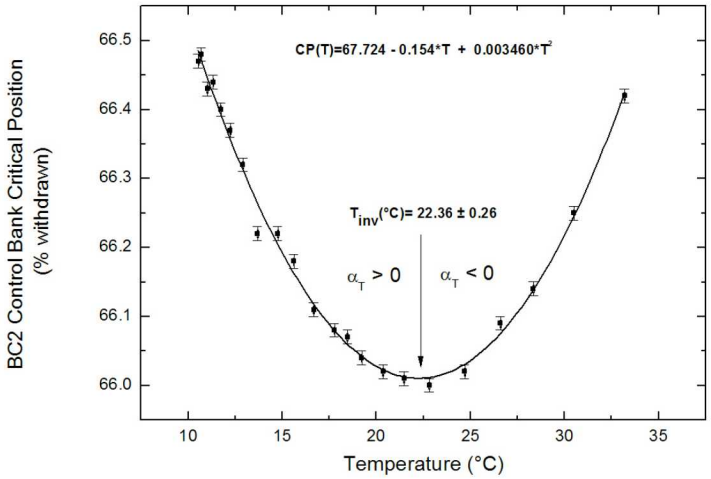

Adimir and his colleagues measured three systems with T_{inv} between 14.99 and 22.36 C

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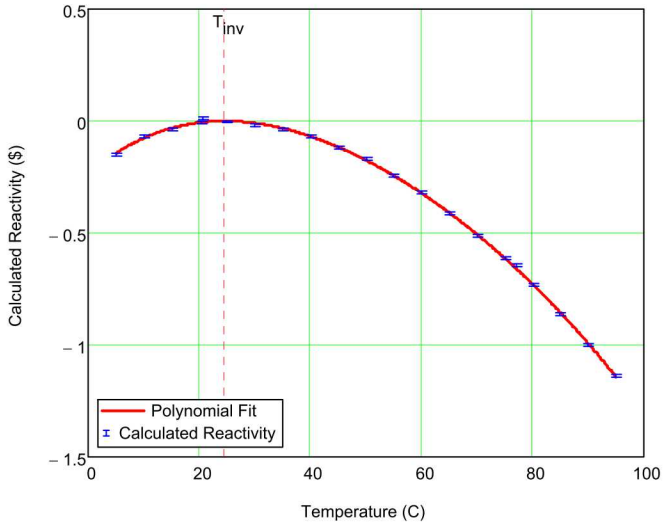
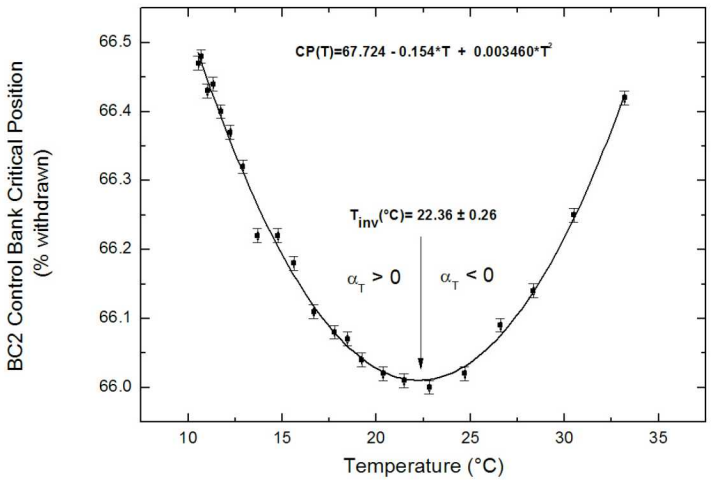
IER-452 – Inversion Point of the Isothermal Reactivity Coefficient





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What IS NOT required:
Knowledge (measurement/calculation/guess) of the kinetics parameters of the system

Adimir and his colleagues measured three systems with T_{inv} between 14.99 and 22.36 C

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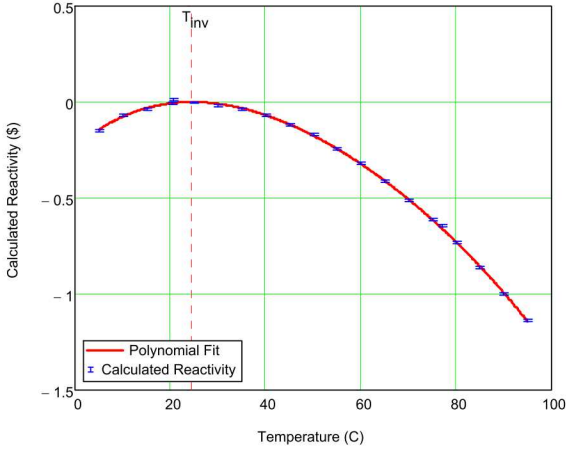
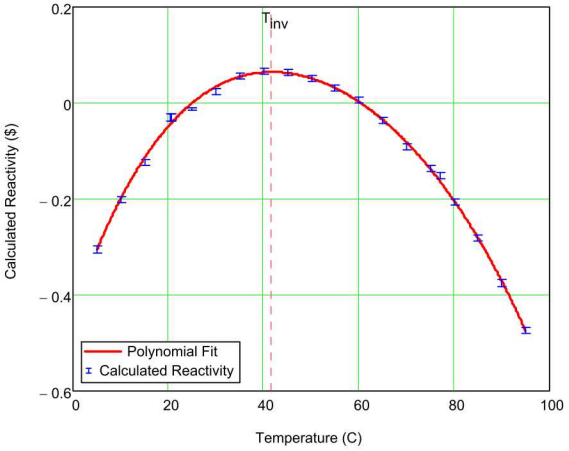
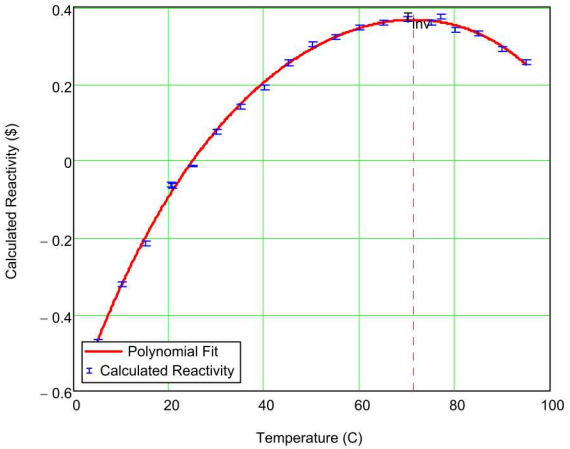
IER-452 – What can we do?



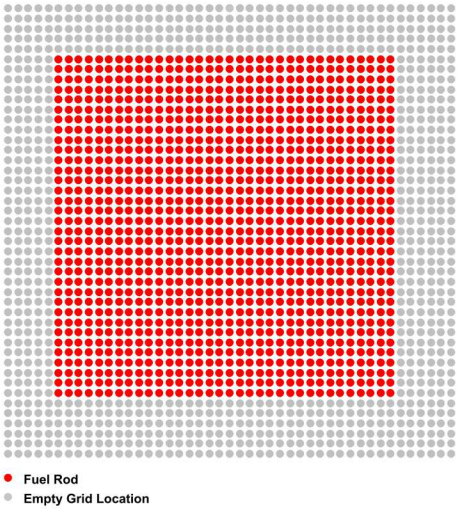
T_{inv} ~ 25ºC

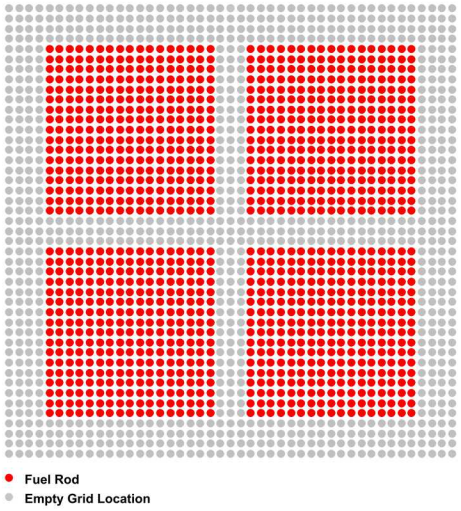


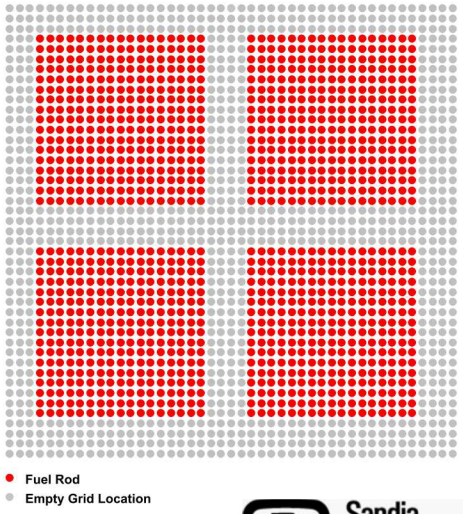
T_{inv} ~ 42ºC



T_{inv} ~ 71ºC







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New features needed for IER-452

- Temperature control of the assembly
  - Heater/chiller with significant capacity
  - Bigger heat sink (dump tank)
  - Insulation of tanks
  - Homogenization of core moderator/reflector
  - Ability to make detailed temperature measurements across core
- Fine control of the assembly reactivity
  - Low-worth but agile shim rod
  - High-resolution measurement of shim position
  - Automatic shim rod controller?
- Linear count-rate system
- Removable source

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IER-304 and IER-441 are ORNL experiments

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452	Inversion Point of the Isothermal Reactivity Coefficient	SNL	1

- **Justin Clarity at ORNL is leading the design of these experiments**

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IER-305 and IER-306 are IRSN experiments

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452	Inversion Point of the Isothermal Reactivity Coefficient	SNL	1

- **Nicolas Leclaire at IRSN is leading the design of these experiments**
  - **IER-305 is projected to complete final design in June**
  - **IER-306 is projected to complete conceptual design in April**

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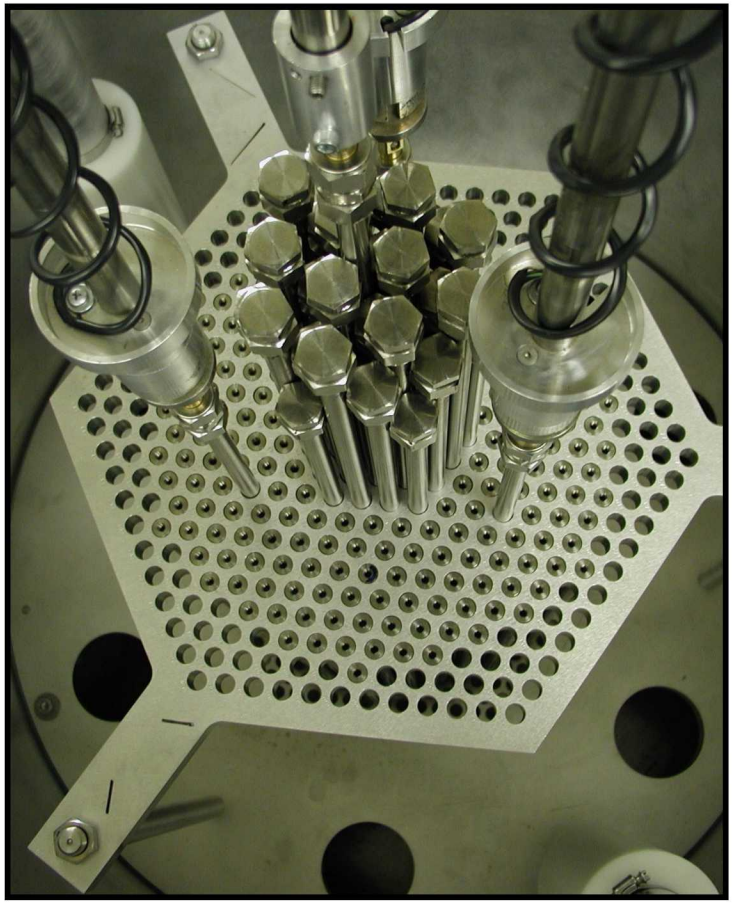
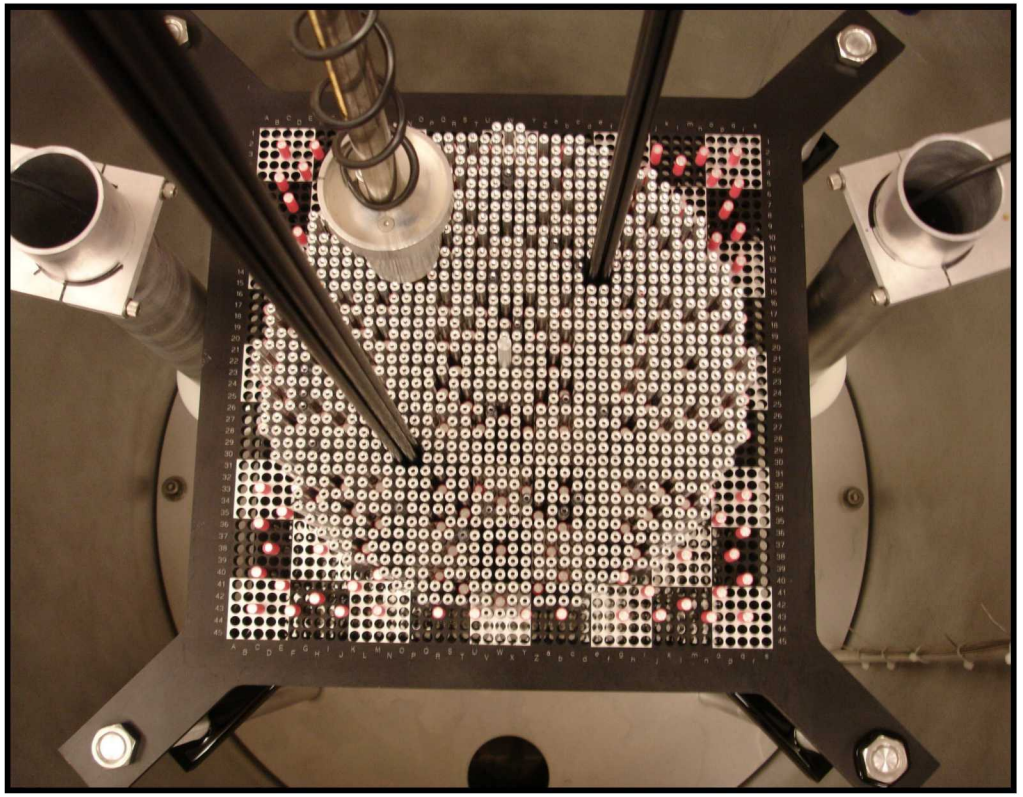
Critical Experiments at Sandia

IER-206 – Re-establish the 4.3% Enriched Critical Experiment Capability at Sandia





The cores (fuel, grid plates, etc.) are different. The balance of the assembly hardware is the same.

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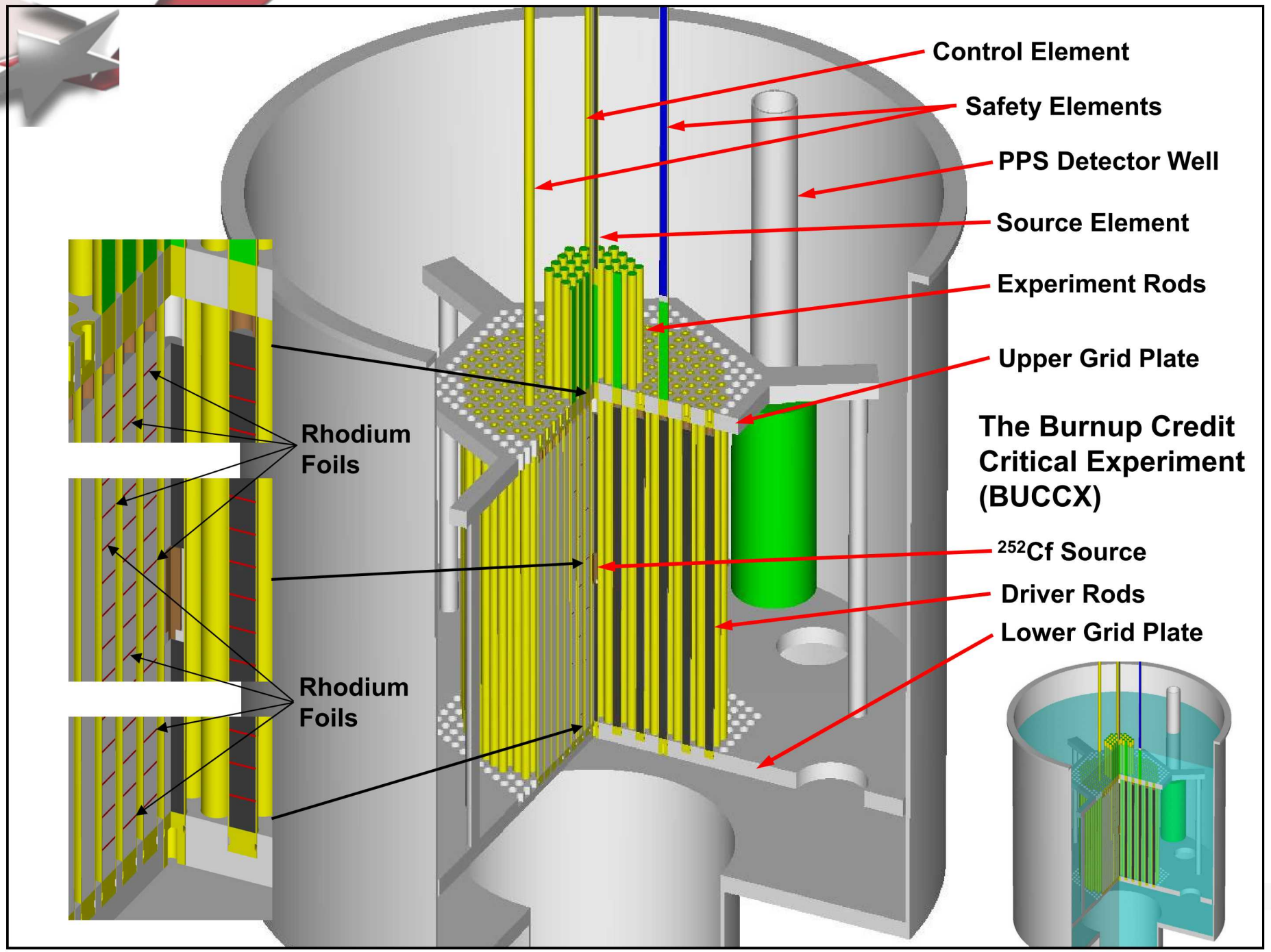
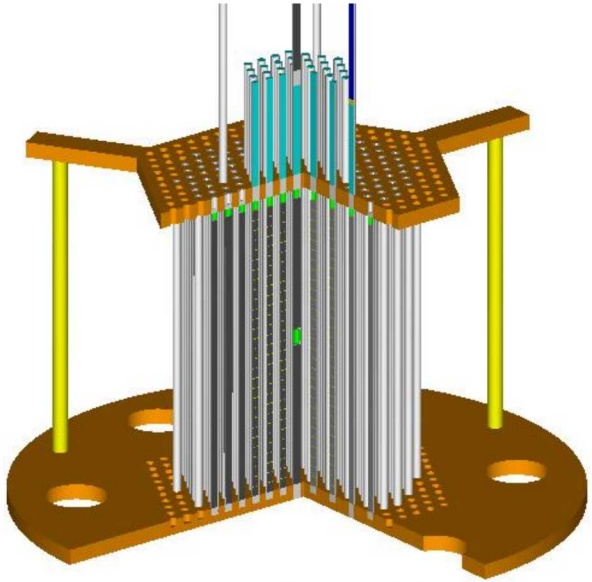
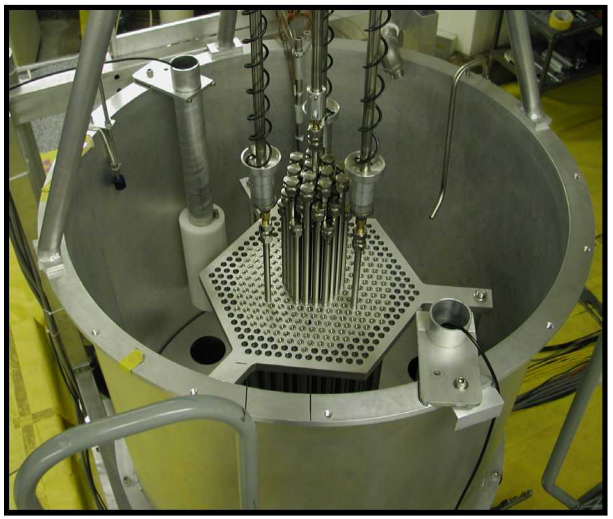

Control Element
Safety Elements
PPS Detector Well
Source Element
Experiment Rods
Upper Grid Plate
The Burnup Credit Critical Experiment (BUCCX)
252Cf Source
Driver Rods
Lower Grid Plate
Rhodium Foils
Rhodium Foils

IER-206 – Re-establish the 4.3% Enriched Critical Experiment Capability at Sandia





- In 2002, we built a critical assembly in which we could insert fission product materials to measure reactivity effects
- We completed a set of experiments with rhodium between the fuel pellets in "experiment" elements
- The experiment is documented as LEU-COMP-THERM-079
- In 2017, we completed approach-to-critical experiments on all the original configurations
- Improvements for new experiments:
  - We precisely measured the diameter of each fuel/experiment element (decrease in the uncertainty)
  - We performed the experiments with the original source away from the assembly
- At the conclusion of the experiments we rolled into the IER-451 Titanium Sleeve experiments

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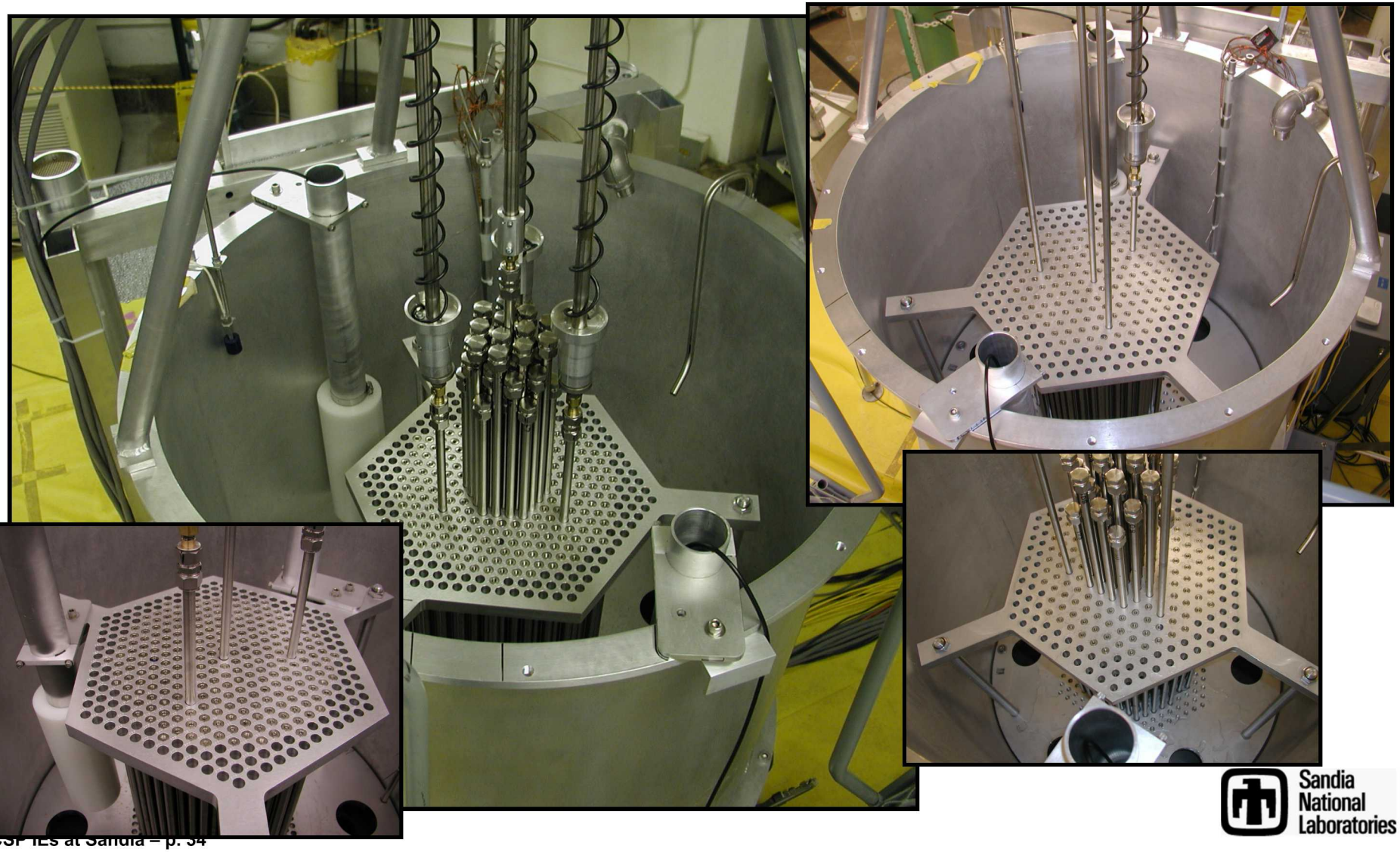
The BUCCX core shown at the end of approach-to-critical experiments



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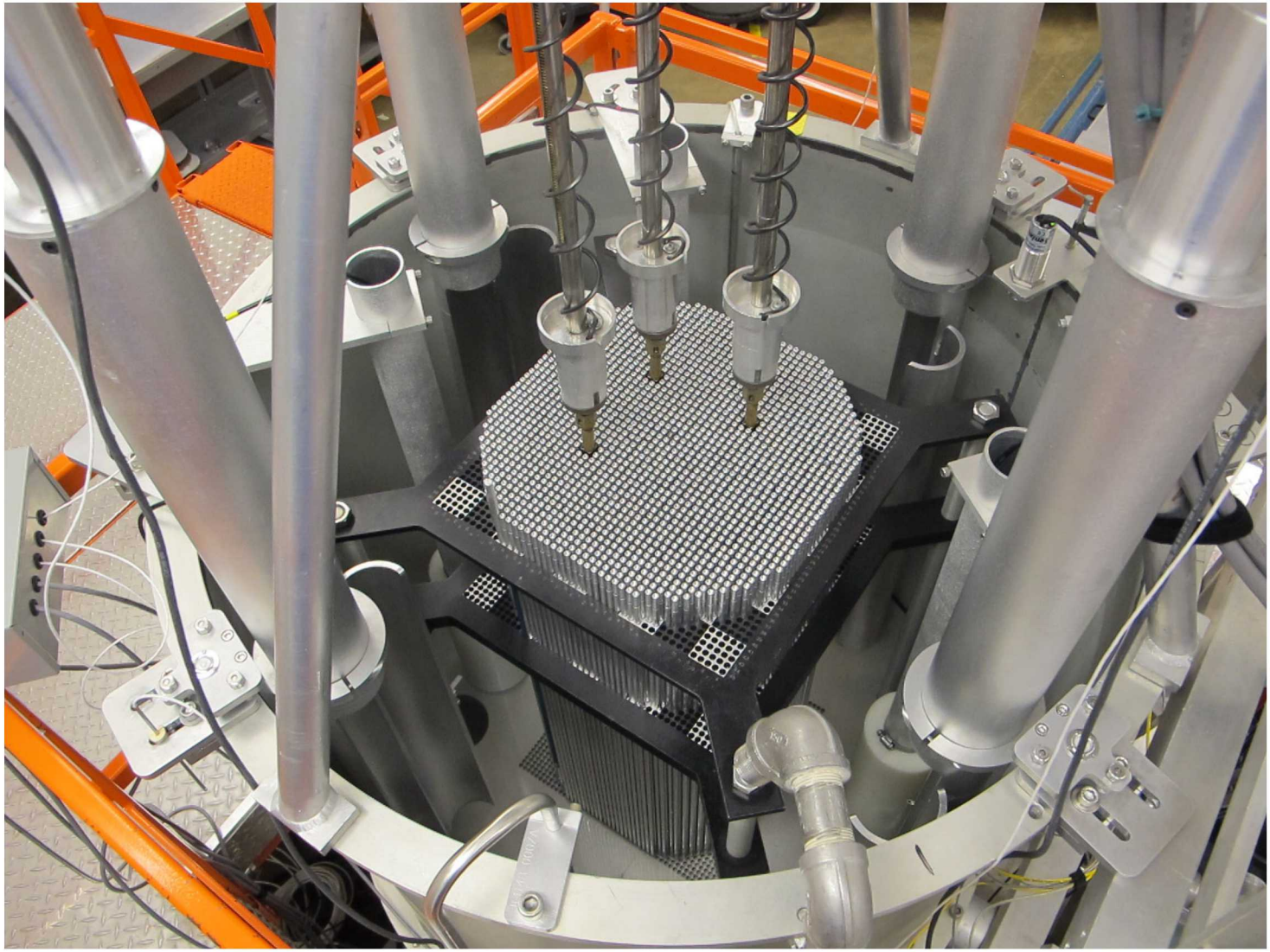
IER-208 Configuration



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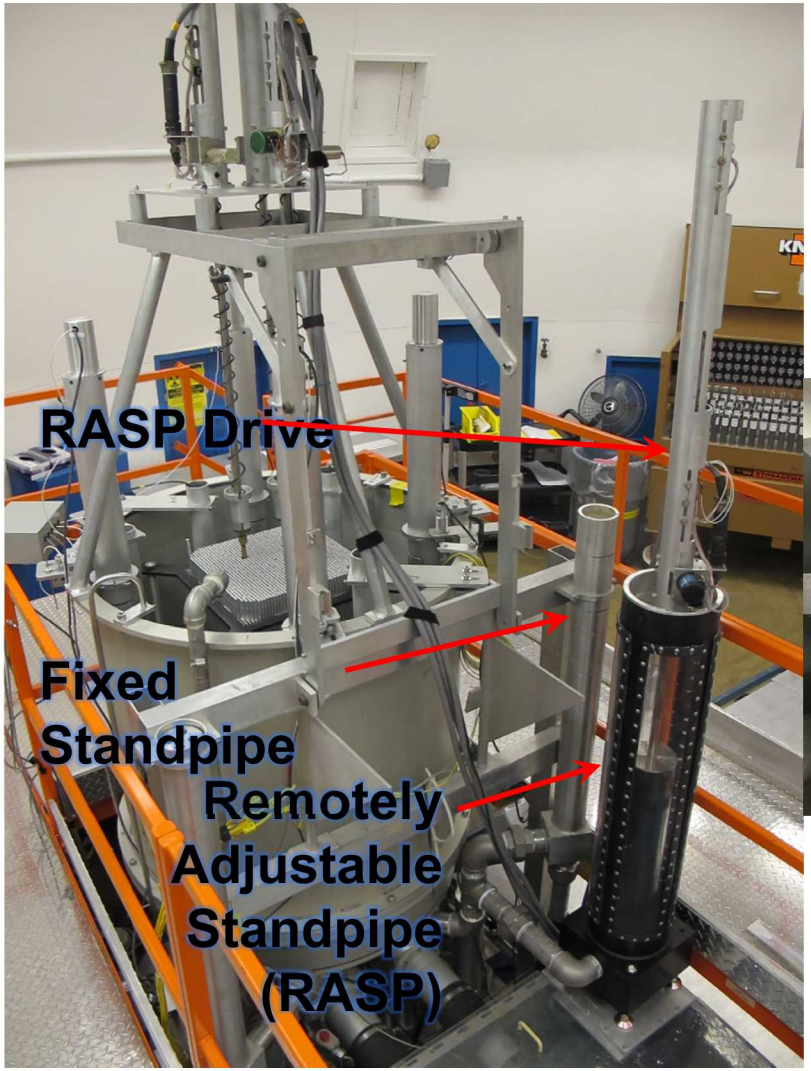
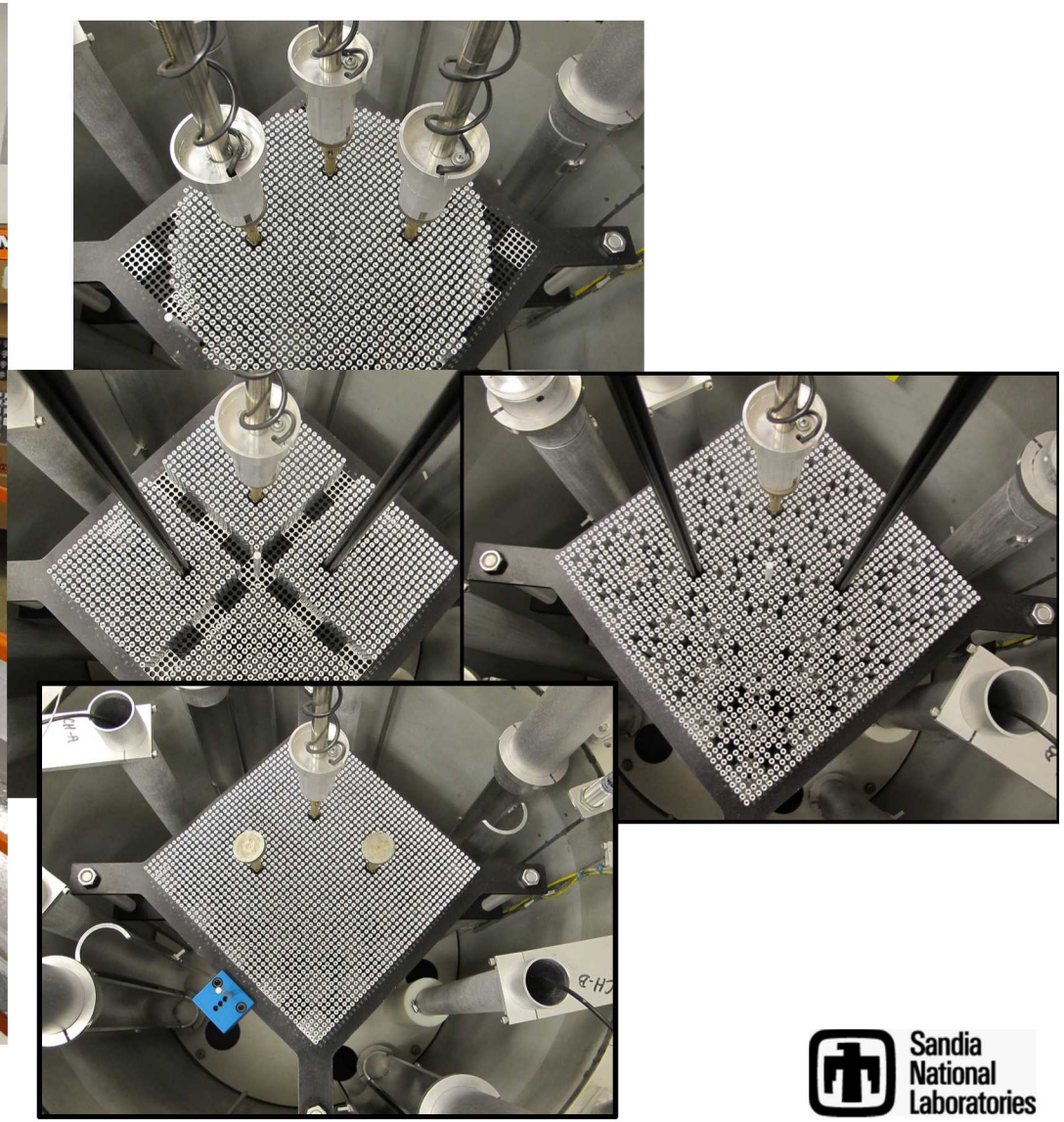
IER-208 Experiments





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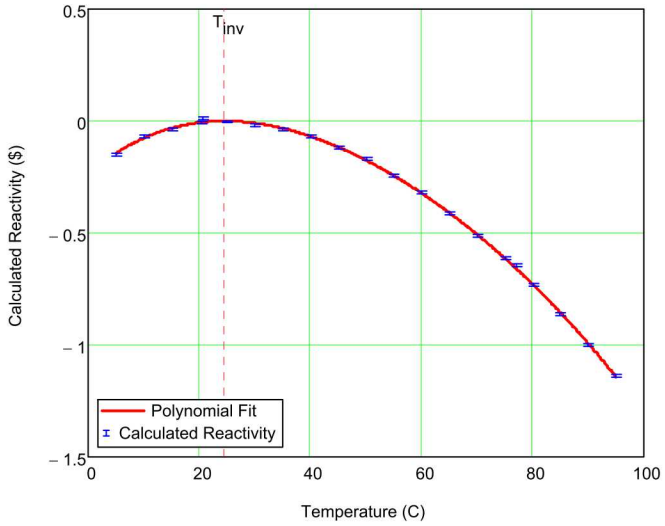
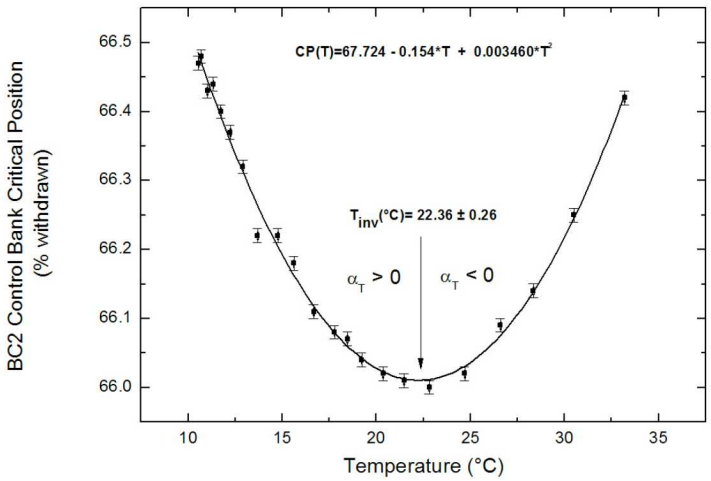
IER-452 – Inversion Point of the Isothermal Reactivity Coefficient





International Reactor Physics Experiment Evaluation Project: International Handbook of Evaluated Reactor Physics Benchmark Experiments

IPEN(MB01)-LWR-RESR-017
THE INVERSION POINT OF THE ISOTHERMAL REACTIVITY COEFFICIENT OF THE IPEN/MB-01 REACTOR
Adimir dos Santos et al.

What IS required:

1. Control element with high-precision position indication (worth need not be calibrated)
2. Ability to measure power changes
3. Accurate knowledge of the temperature in the core (uniformity – space and time – is important)

What IS NOT required:

Knowledge (measurement/calculation/guess) of the kinetics parameters of the system

Adimir and his colleagues measured three systems with T_{inv} between 14.99 and 22.36 C

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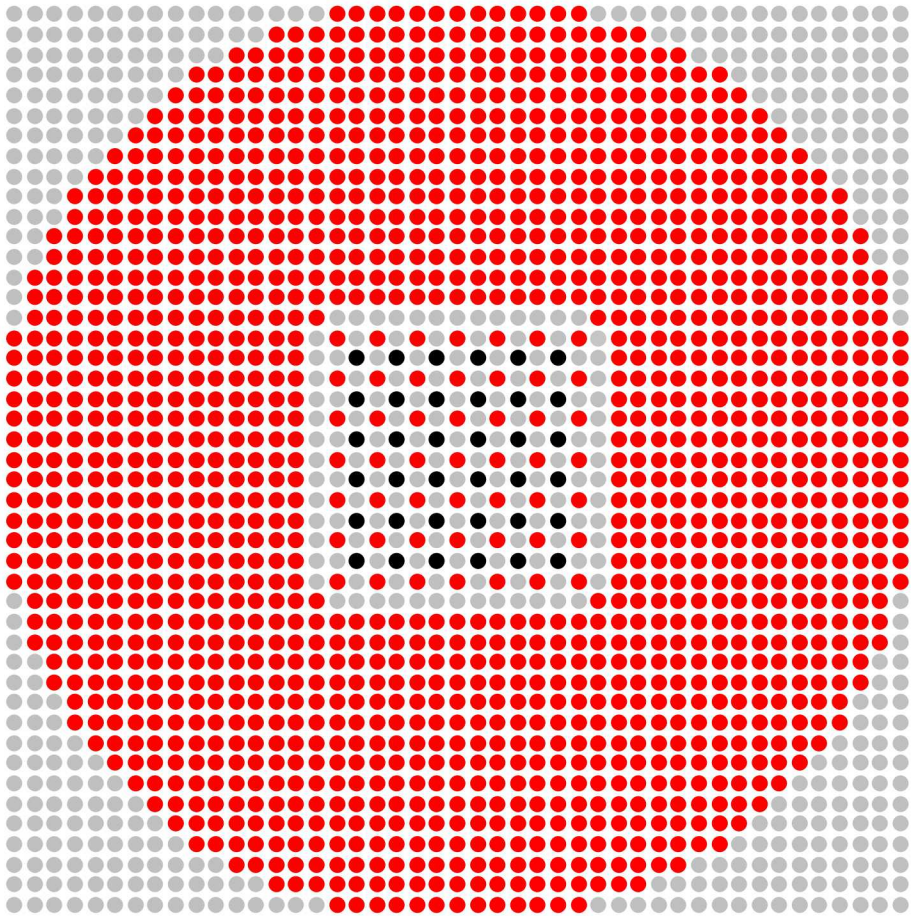
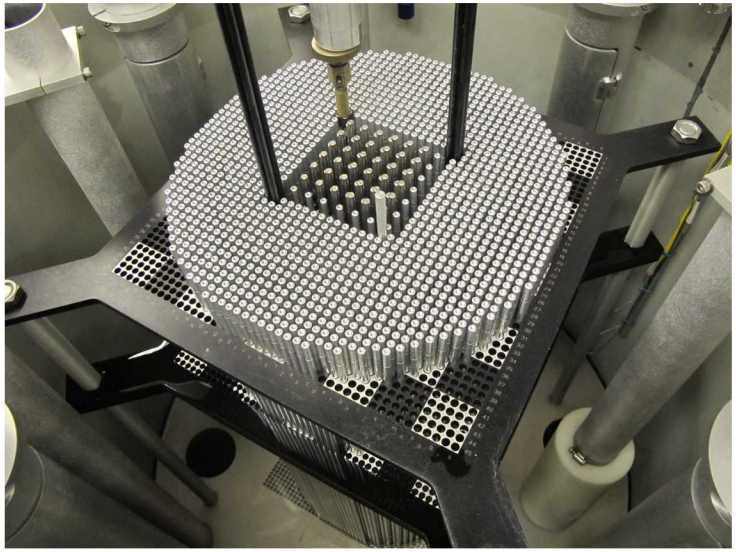
IER-285
LEU-COMP-THERM-097 Case 24



- Fuel Rod
- Empty Grid Location
- Titanium Experiment Rod

We stole the IER-230 concept from ourselves and used it in some of the IER-285 experiments



Fuel	1485
Expt.	36 Ti
Empty	136
Total	1657

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