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Annular Core Research Reactor

Year in Review of Operational Challenges

SAND #TBD

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Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company,
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Abstract

Sandia National Laboratories (SNL) Annular Core Research Reactor (ACRR) Operations staff has faced several new challenges in the past year while maintaining the facility in an operational state. With potential budget cuts in the weapons complex and a reduced staff size, they successfully conducted a variety of experiments for customers from universities, and national and international labs. These accomplishments were achieved in spite of a ***non-routine maintenance outage*** and a recovery from a ***high-power scram***. These challenges will be discussed in further detail herein.

The ACRR allows scientists and researchers to perform experiments and test components under extreme radiation exposure. The research reactor is used to perform in-pile experiments for radiation effects, reactor development, and safety requirements. These experiments are conducted by operating the reactor in steady state (4.0 MW licensed power) or by "pulsing" the reactor, which allows for extremely high power levels (60,000 MW licensed pulse limit) to be achieved for short periods of time.

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Annular Core Research Reactor

- 264 reactor operations since last TRTR
- ~2/3 were pulse operations
  - Pulses: 43,000 MW peak power (scram at 45,000 MW), 280-310 MJ, 7-7.5 msec pulse width (Limiting Control Setting: 500 MJ, 60,000 MW)
- Steady State: Limited by license to 4.0 MW (25 kW in the peak fuel element), but Plant Protection System trips still set at 2.7 MW.

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Several Transient Rod Withdrawal submode operations for Global Nuclear Energy Partnership (GNEP) power profile development (October 07-June08).

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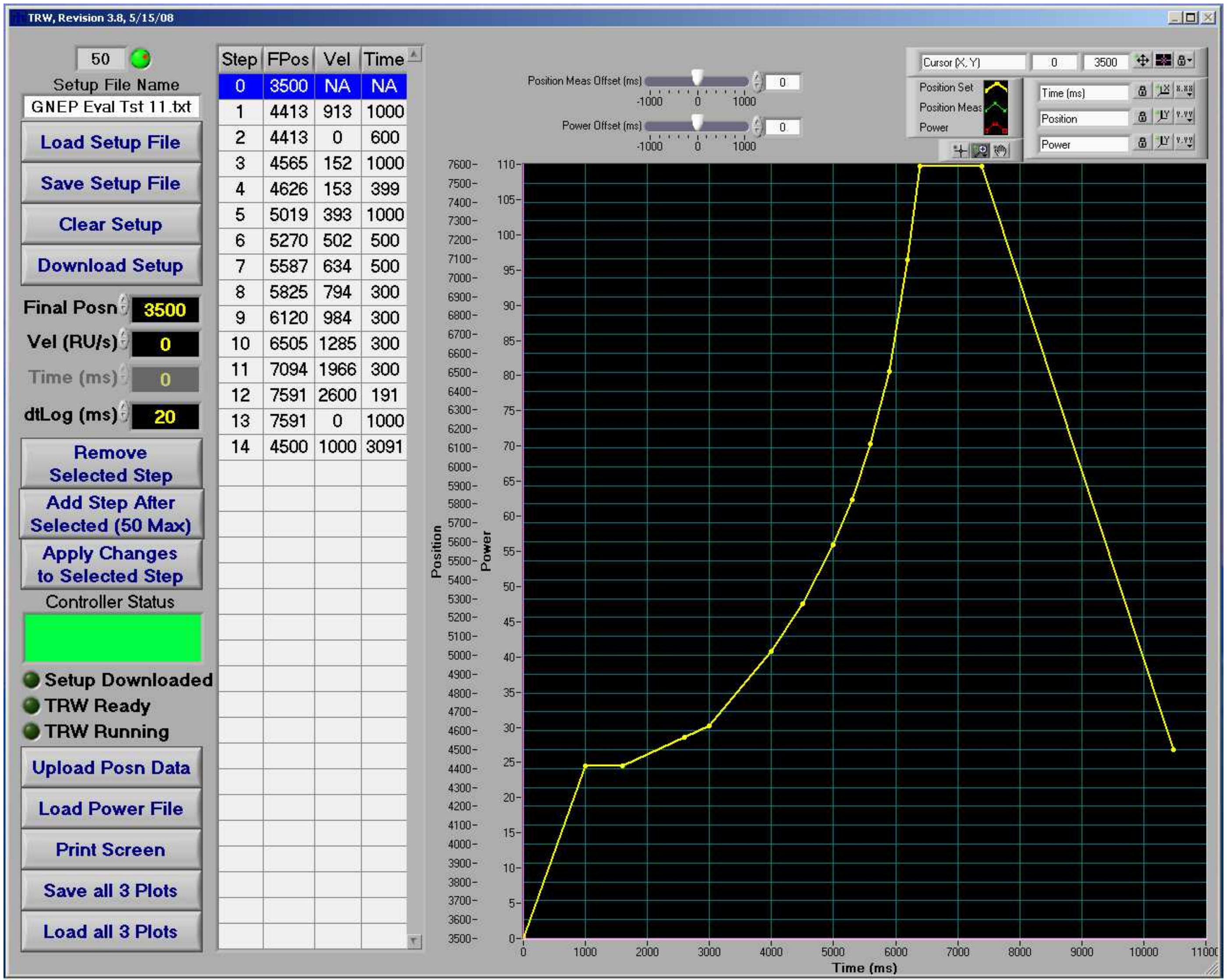
TRW Rod Drive Profile for (GNEP)



Step	FPos	Vel	Time
0	3500	NA	NA
1	4413	913	1000
2	4413	0	600
3	4565	152	1000
4	4626	153	399
5	5019	393	1000
6	5270	502	500
7	5587	634	500
8	5825	794	300
9	6120	984	300
10	6505	1285	300
11	7094	1966	300
12	7591	2600	191
13	7591	0	1000
14	4500	1000	3091

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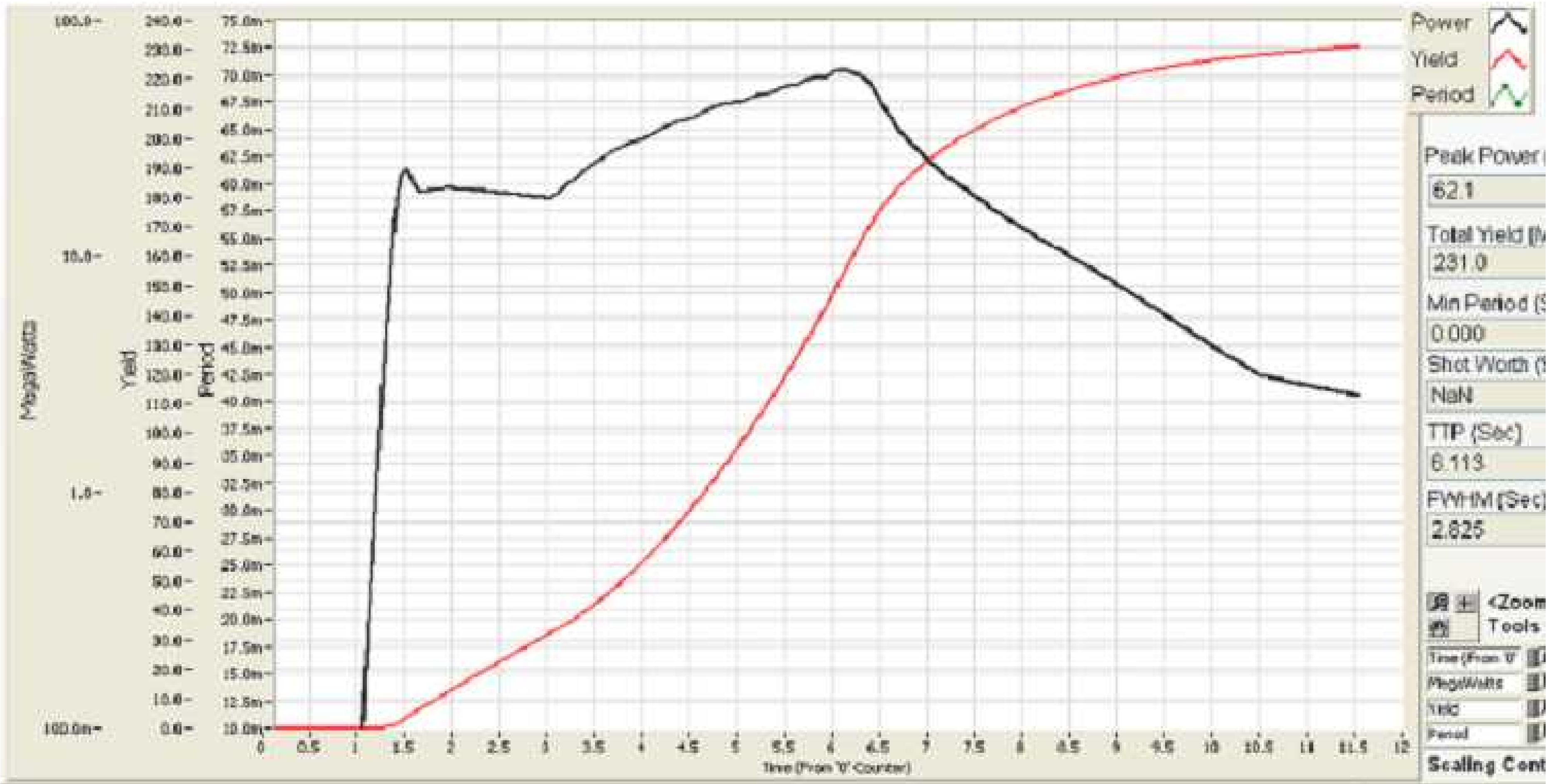
TRW Power and Energy Profile for GNEP



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Mechanical Failure of Transient Rods – Nov. 2007

•Increasing Transient Rod Bank Worth (1) over time prior to break:

6/28/07: $3.29
9/11/07: $3.33
11/20/08: $3.48

•Maintenance last performed:

- •TR A February 2007.
- •TR B October 2005.
- •TR C June 2007.

Note (1): TR Bank worth with Pb-B4C filter in Central Cavity. This filter has a negative reactivity contribution of about $6.

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Mechanical Failure of Transient Rods – Nov. 2007

•TR A broke on pulse operation of 11/31/07. No indication that break effected pulse (dosimetry, energy, power, fire times all normal).

•TR A break determined during low power delayed critical measurement on 12/07/07.

•TR A was removed from ACRR Pool for repairs.

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TR A

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TR A

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TR A

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TRs B&C Removed for Examination as a Precaution

TR C: 3 steel pins from retainer

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TR C

Held together by snug fit.

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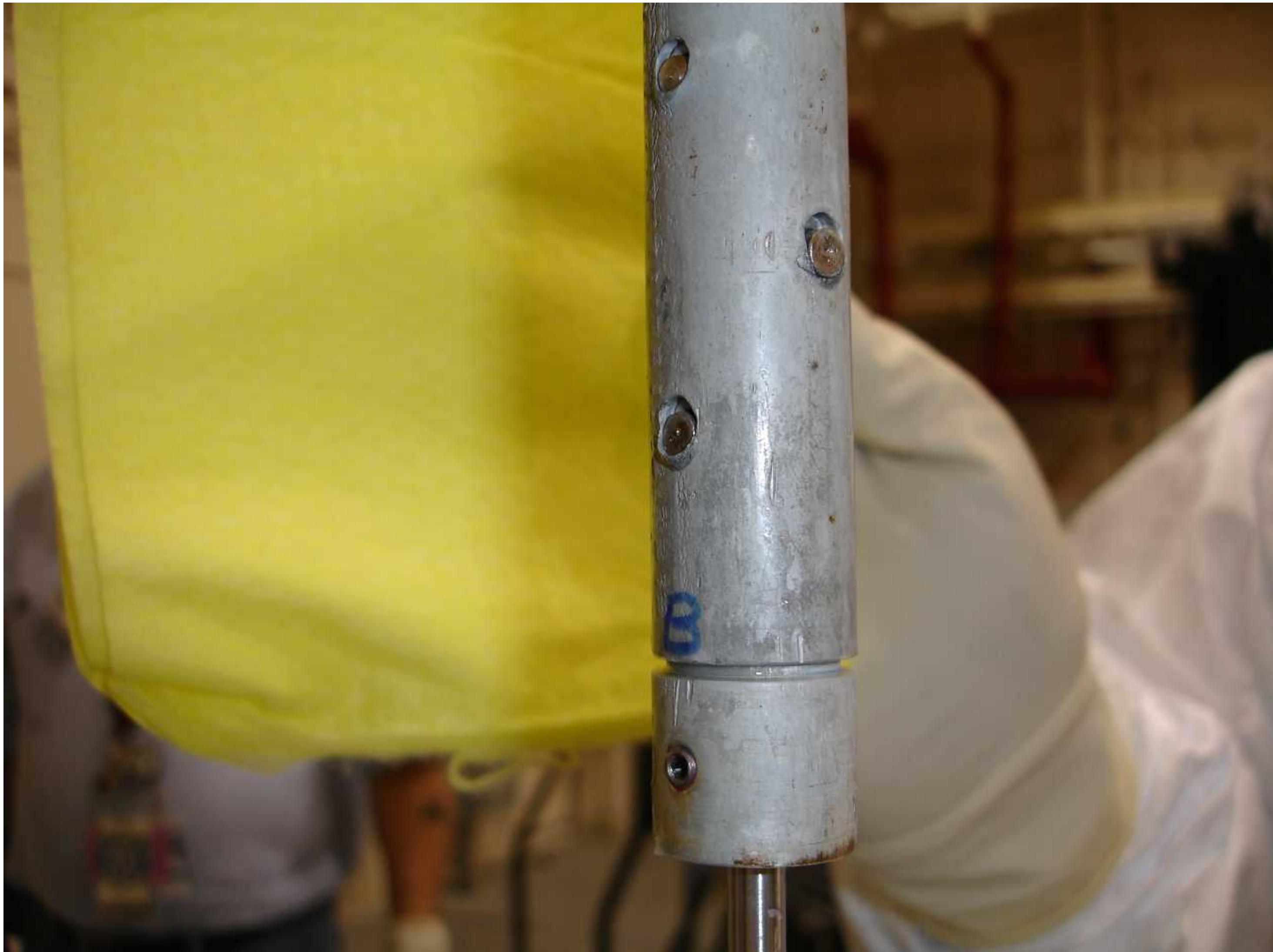
TR B: Signs of plastic deformation since 1977



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Mechanical Failure of Transient Rods – November 2007

- Cause of retainer failures was due to improper pin maintenance practice.
- 4 new upper aluminum connecting rods (UACR) ordered from General Atomics (GA).
- Roy Ray (GA) and Paul Helmick (Sandia) were instrumental in procurement of parts and inspection.
- All rods UACR's replaced on TR A, B & C on Jan 31, 08
- Returned to normal operations after 2 months of downtime on Feb 2, 2008.

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Mechanical Failure of Transient Rods – November 2007

New UACR
from GA

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High Power Scram – Feb 15, 2008

Sequence of events:

- Opened facility – performed overhead crane checks.
- Removed experiment from previous day operations from ACRR Central Cavity.
- Performed Pre-operational checks (1 hr).
- ACRR startup in preparation for 300 MJ pulse. Delayed critical measurement at 0.05% indicated that TR bank worth just over $3.5. Reactor Supervisor directs Reactor Operator to shutdown so that TR pedestals can be adjusted.
- ACRR startup for pulse operations. Successful pulse for customer: 276 MJ, 42 GW.

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High Power Scram – Feb 15, 2008

Sequence of events:

- Lunch break for operations staff.
- Removed experiment from central cavity.
- Cooled ACRR pool to 10 °C.
- Brief with staff for max power steady state operation.
- Commenced startup of ACRR for 2.4 MW operation @ 3:15 PM. (Last time achieved: Summer 2004)
- Control rod drive anomaly while ramping to 100% -RO switches rod drive shim speed to "fast" to compensate for fuel temperature feedback. Seconds later, the RO determines automatic rod leveling is driving rods inward. RO allows auto leveling to correct condition.

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High Power Scram – Feb 15, 2008

Sequence of events:

- With RX power decreasing through 25% and anomaly corrected, RS/RO team resume ramp to 100% power.
- RO shims Control Rods (CRs) out to raise power & verifies on DAC4 (Wide Range Monitor) then shifts focus to DAC1 (Rod Control Monitor) to confirm all 6 CRs moving.
- RO returns focus to DAC4 to see Rx power increasing through 90% and releases shim switch.
- Rx power scram occurs as indicated on the Plant Protection System. (Not a TSR violation.)
- Normal shutdown indication observed. Rx operations secured, Line Management and DOE informed.

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ACRR Control Room Layout

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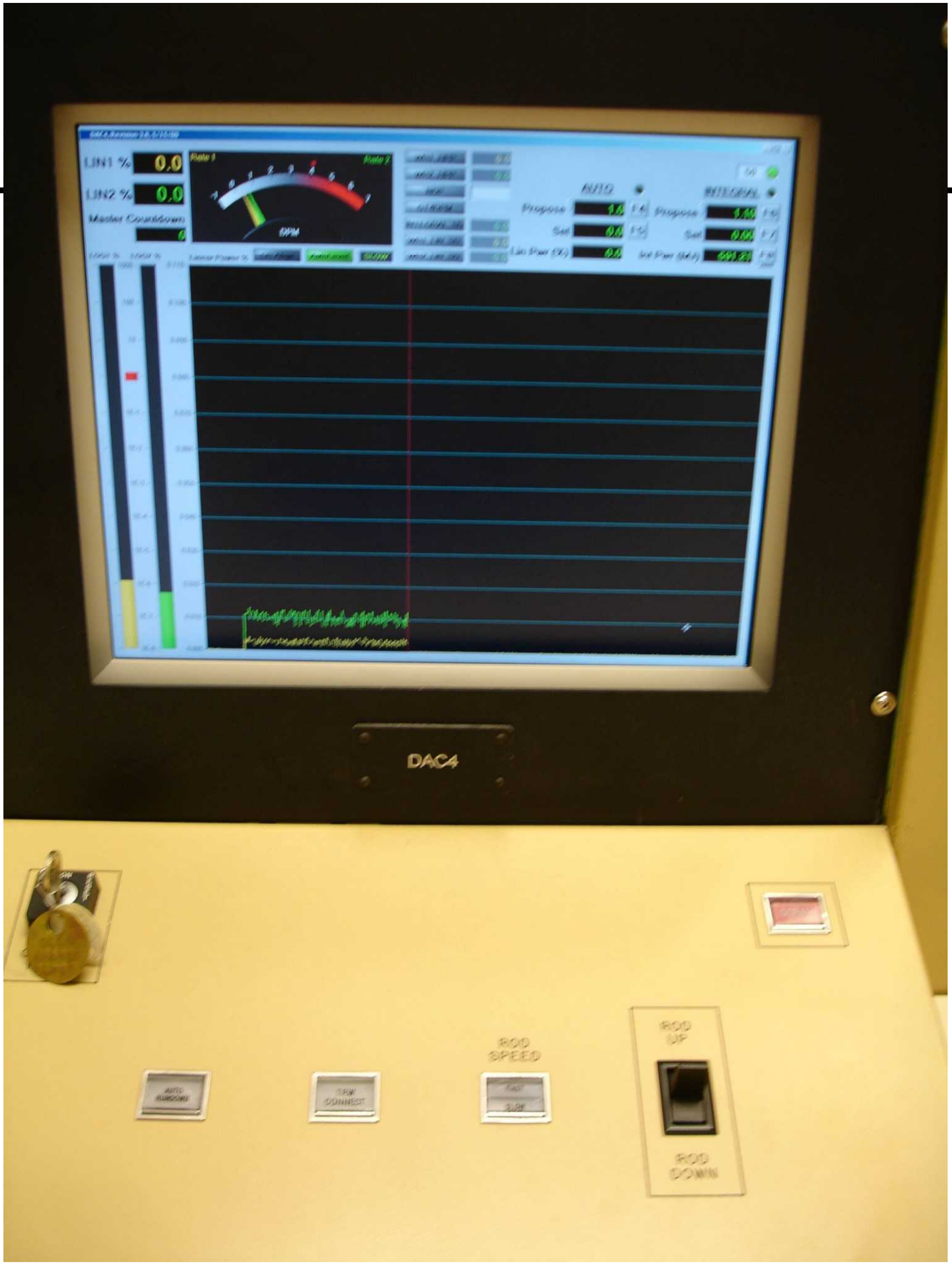
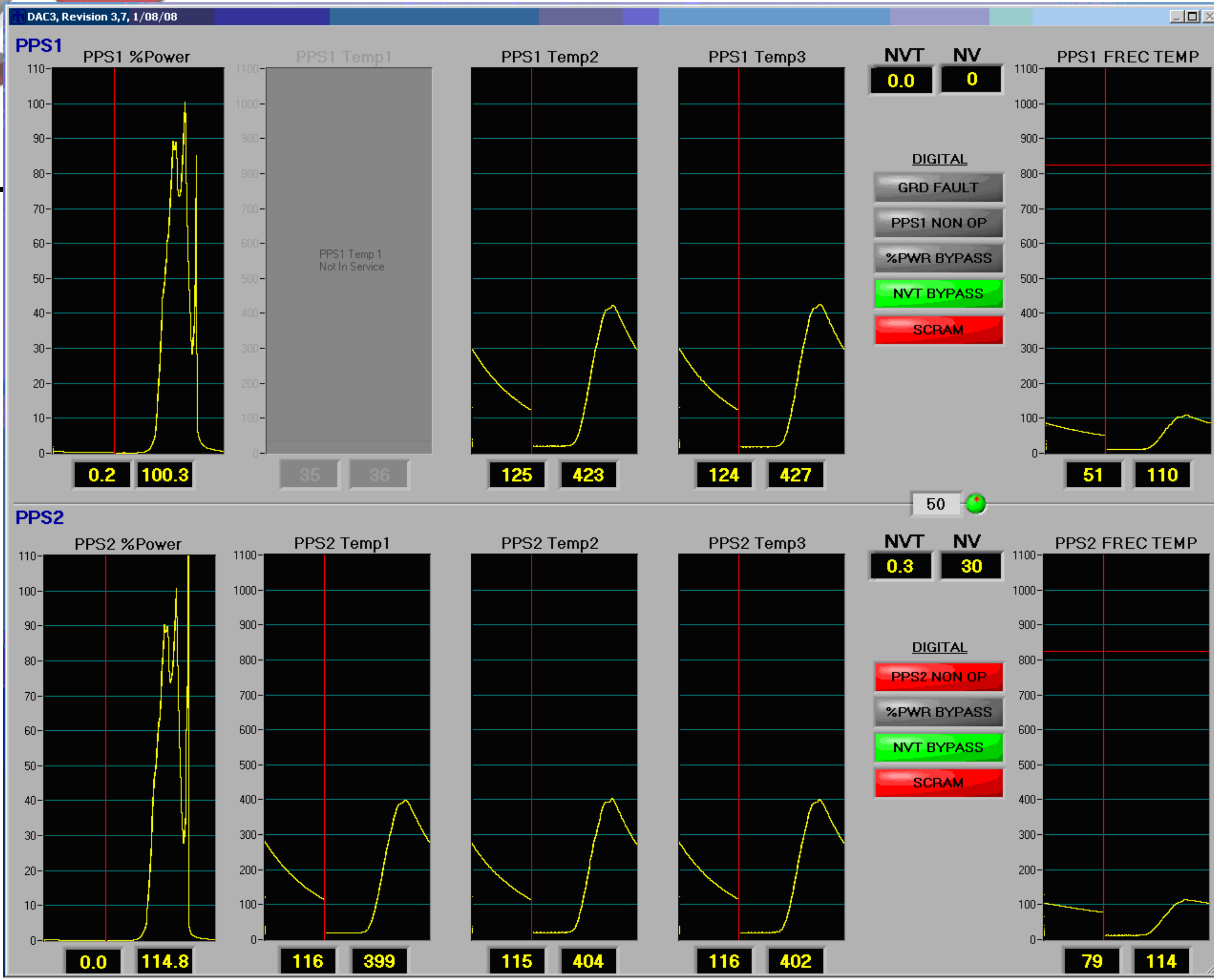
View from RO Chair

RO Primary Focus





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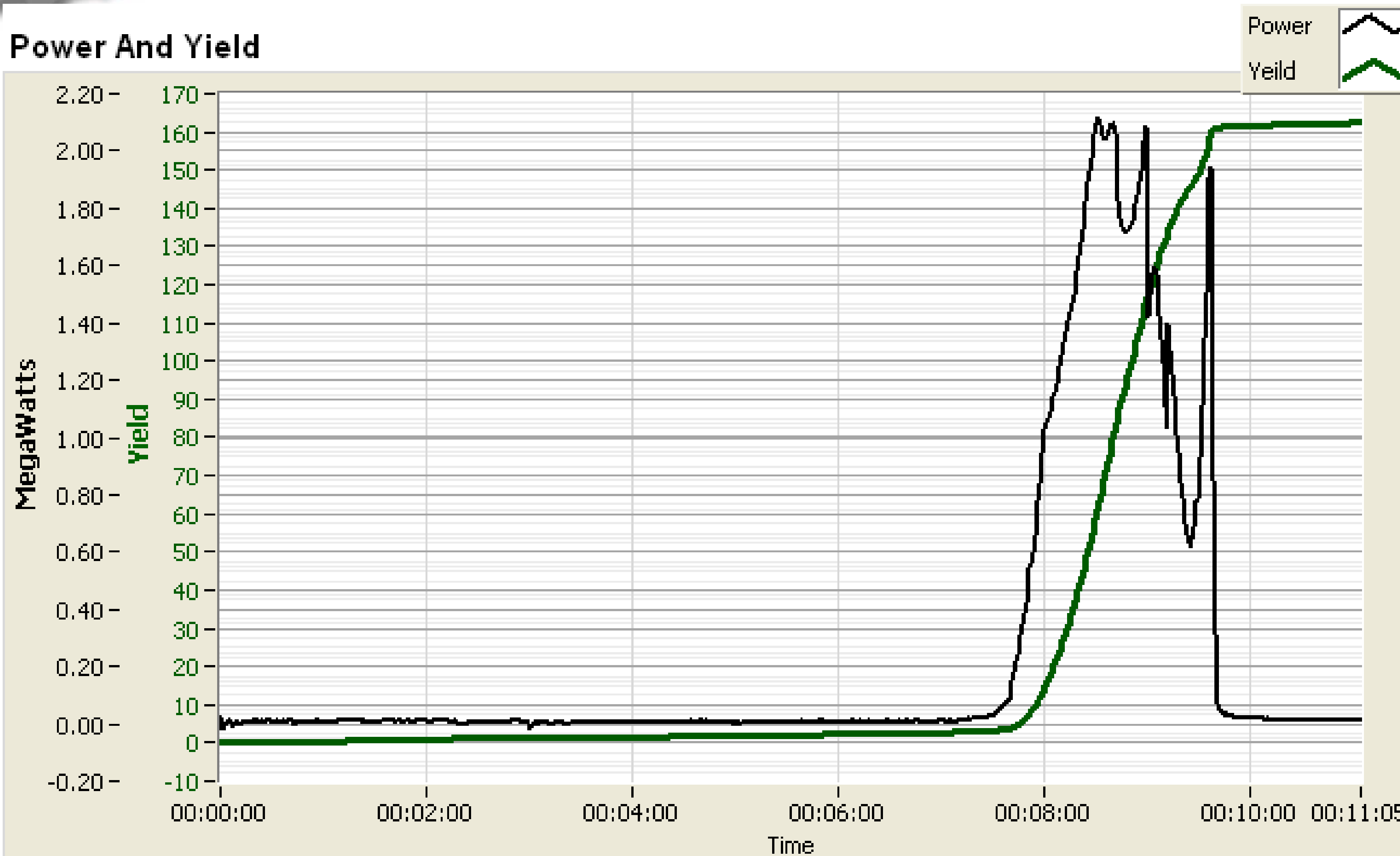
Data from Pulse Diagnostics



Contributing Causes to Scram

- Most steady state operations for experimenters do not occur in the fuel temperature feedback regime. RO proficiency requirements did not previously specify any particular power requirements.
- "Leftover" rod leveling program initiates only after rod levels vary between rods by 200 rod units (RU)(2 cm) – about 60 cents worth of reactivity.
- No audible or visual indications on DAC4 that rod leveling is actuated.
- Critical rod height for the Control Rod bank much different from initial delayed critical measurement.

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Changes made to facility after scram:

- **Audible and visual (on DAC4) indications if Auto leveling initiates.**
- **Operator proficiency for steady state must occur at or above 80% Rx power (experience fuel temperature feedback).**
- **RO can turn Auto leveling feature "off" – indication on DAC4.**
- **Rod speed indication (fast/slow) added to DAC4.**

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<u>**Changes made to facility after scram (continued):**</u>

- **Notes added to pulse and steady state operating procedures addressing effects of fuel temperature feedback and use of AUTO RUNDOWN if needed.**
- **Auto leveling occurs at 50 RU (0.5 cm) vs. 200 RU – smaller reactivity shifts.**

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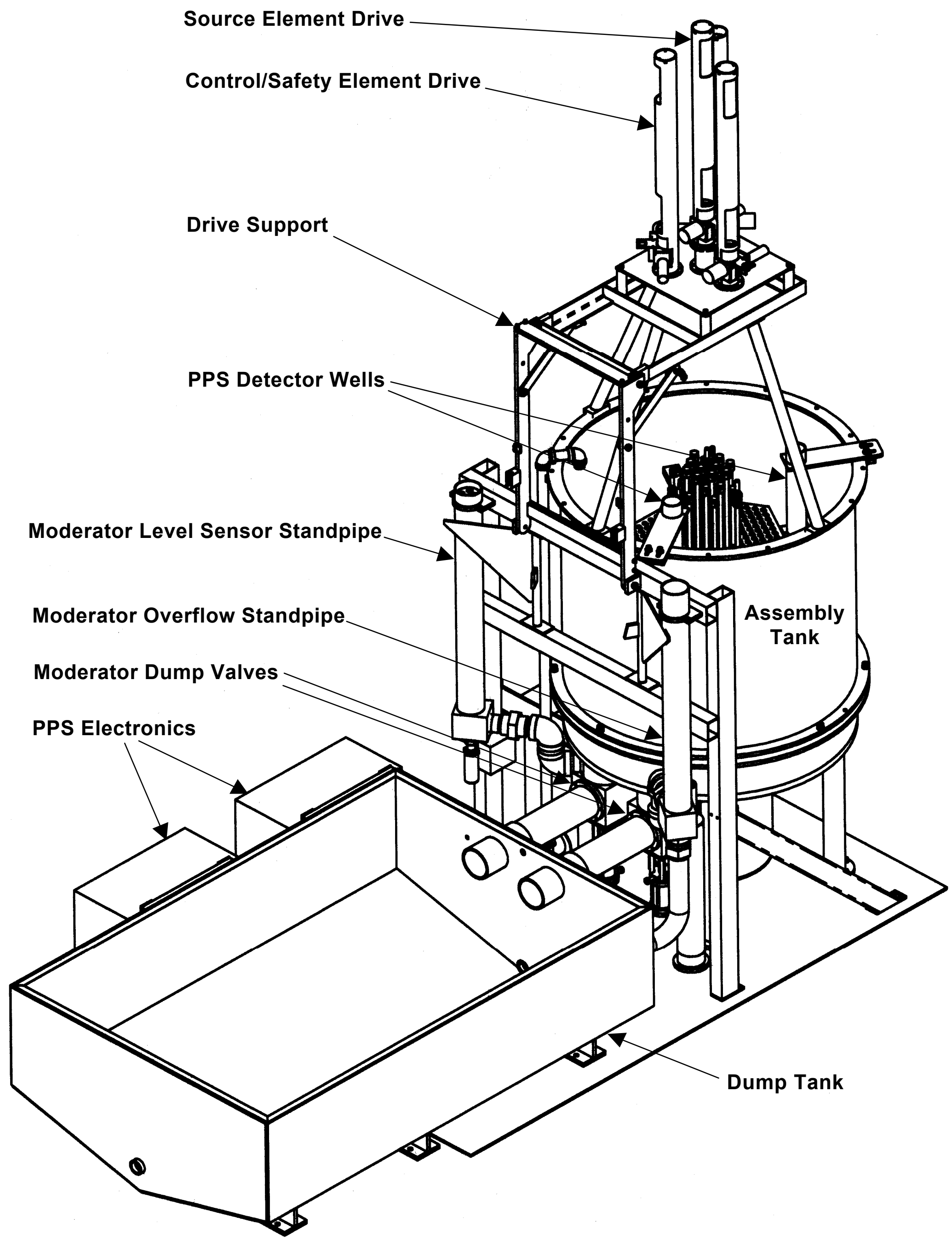
Operational impact:

- **DOE did not permit Rx operations for 13 days. Then, steady state power limited to low power runs <20% (no fast speed rod motion).**
- **Allowed to return to pulse operations (no fast speed rod motion).**
- **Later, DOE has allowed return to 100% steady state operations with a restriction that all rod motion by the RO above 0.05% power be in slow speed unless required for programmatic needs.**

Sandia Pulse Reactor Facility Critical Experiment (CX)



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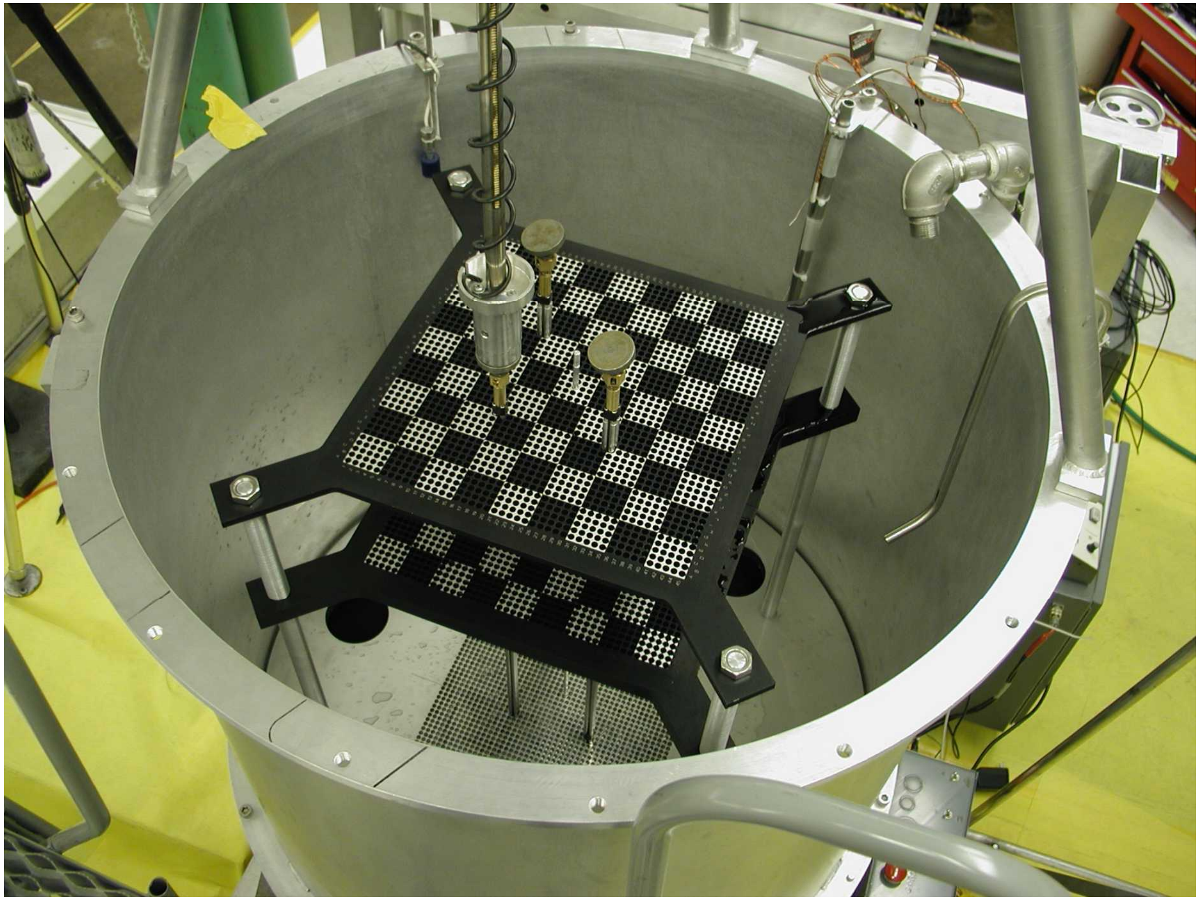
Sandia Pulse Reactor Facility Critical Experiment (CX)



Sandia Pulse Reactor Facility Critical Experiment (CX)

Purpose of CX:

- Present the broad safety case for the Seven Percent Critical Experiment (7uPCX)
- Nuclear Energy Research Initiative (NERI) project 01-124, "Reactor Physics and Criticality Benchmark Evaluations for Advanced Nuclear Fuel"
- Provide training for LANL critical assembly operators

Primary objective:

- Project is to provide benchmark data for validating commercial reactor physics methods for fuel enrichments greater than 5 weight percent 235U in geometries that can be modeled.

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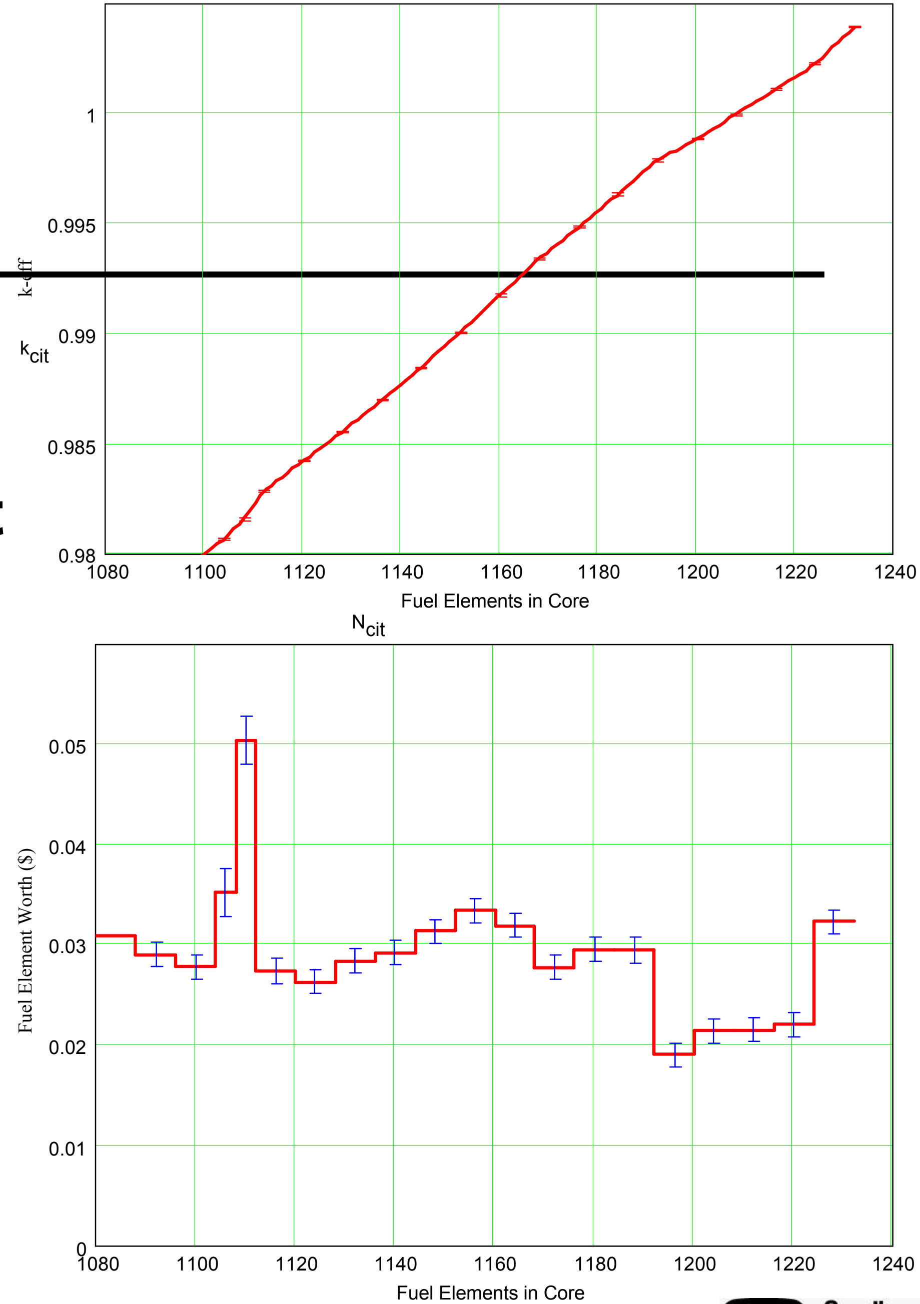
Sandia Pulse Reactor Facility Critical Experiment (CX)

- 7uPCX will use UO2 fuel pellets removed from fuel elements fabricated in the mid-1960s that have been stored at Pennsylvania State University since 1969. The fuel pellets have been fabricated into new aluminum tubes for use in the experiment.
- Fuel cladding: 3003 aluminum, element height: 74 cm, enrichment: 6.9%.

Multiplication factor (top) and incremental fuel element worth (bottom) as a function of fuel array size for 0.800 cm pitch critical assembly with no poison in the moderator.



CX Dump Valve Operation for Scram

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Nuclear Diversity among Sandia National Labs Reactor Operators

RO	Navy RX	Comm. RX	Univ. RX	DOE RX	BS	MS	PE
A	X		X	X	X	X	X
B	X		X	X	X	X	X
C				X			
D	X			X			
E	X	X		X			
F	X			X			
G	X	X		X			
H			X	X	X	X	
I	X			X	X	X	
J	X			X	X		

Nuclear Diversity

- Brings breadth and depth to an operational organization.
- Will be a needed element in the nuclear renaissance.
- Sometimes the only thing we will have in common among our nations different reactor facilities is the atom, not how we split!

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Result:
Determined staff always striving for Operational Excellence!!!

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Questions?