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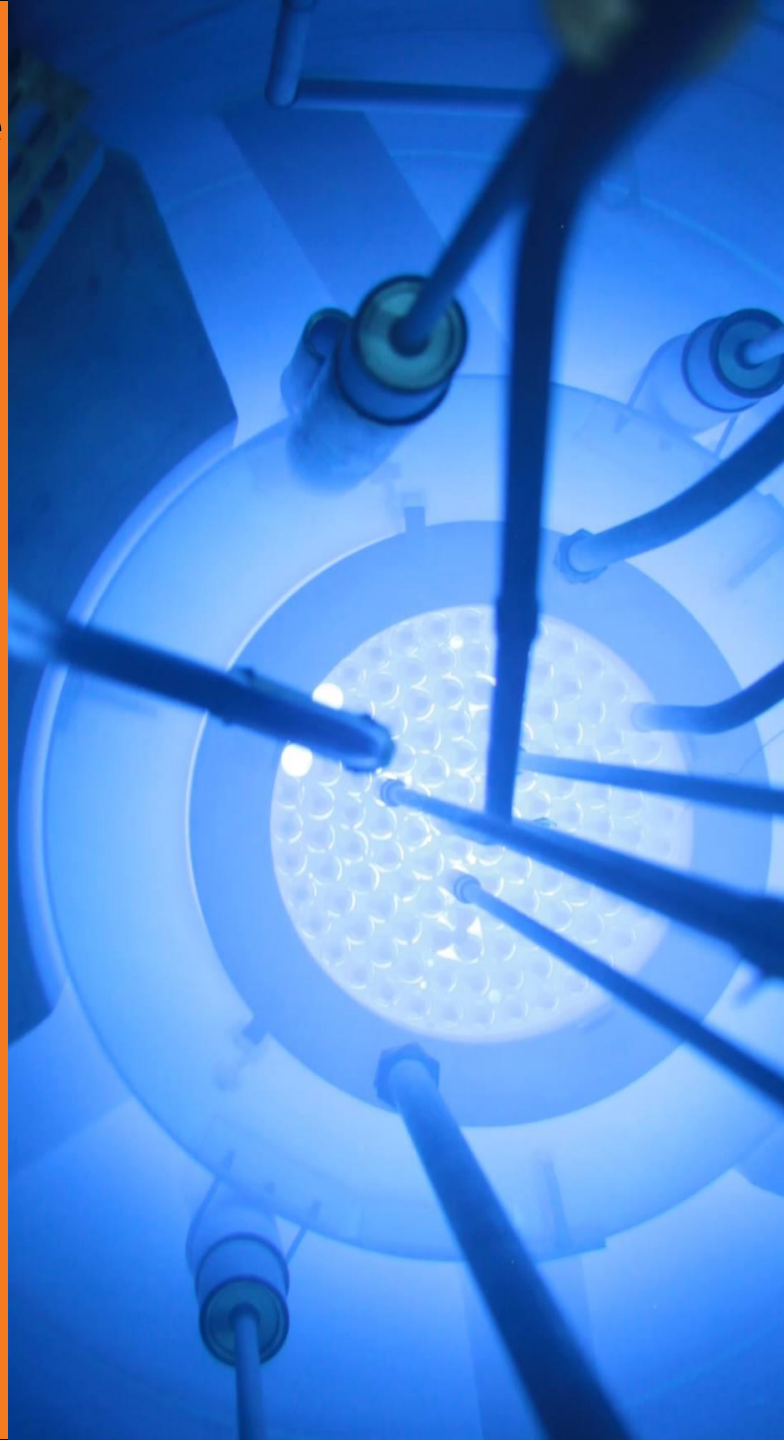
**School of Nuclear Science and Engineering**

# Installation of a Second CLICIT Irradiation Facility at the Oregon State TRIGA® Reactor

Robert Schickler

Dr. Steve Reese

18th IGORR Conference



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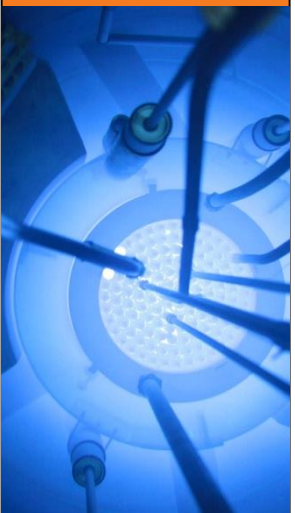

# Background

The Oregon State TRIGA® Reactor (OSTR) is a 1 $MW_{th}$ research reactor that provides irradiation services for researchers throughout the world.

The most requested irradiation service at the OSTR involves Argon/Argon geochronology.

These samples are irradiated in a cadmium-lined in-core irradiation tube (CLICIT).

OSTR also produces antimony sources in an unlined in-core-irradiation tube for use in beryllium mining.

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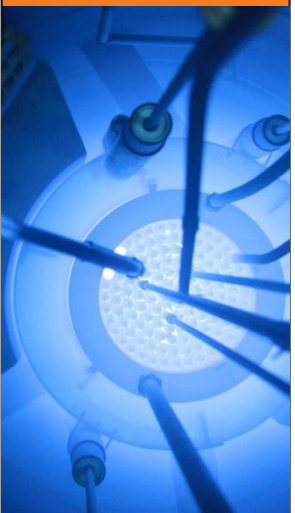
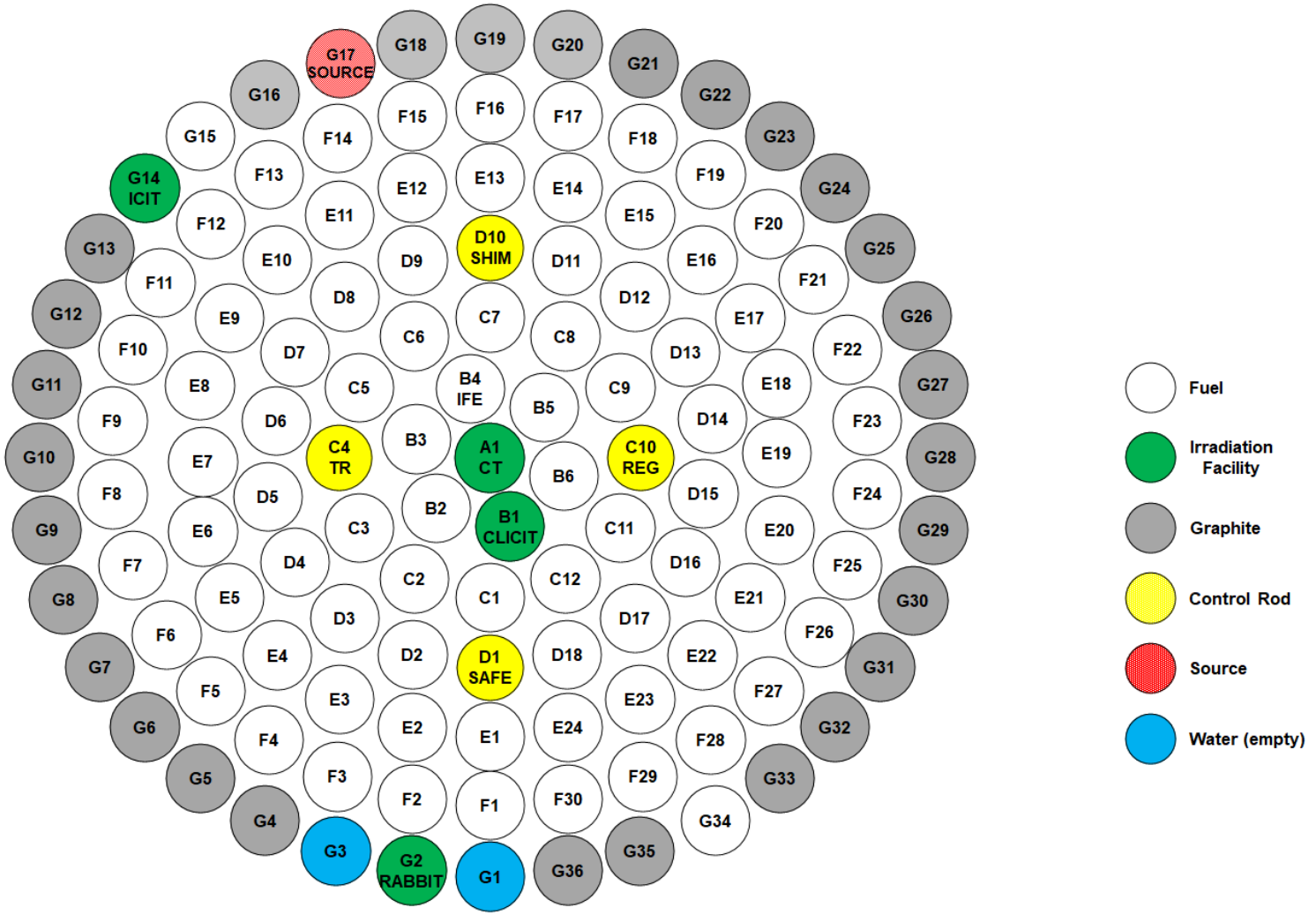


# Original LEU Core Configuration



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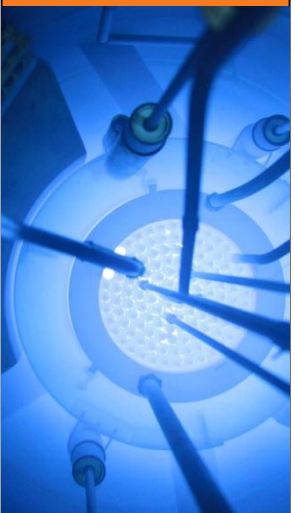
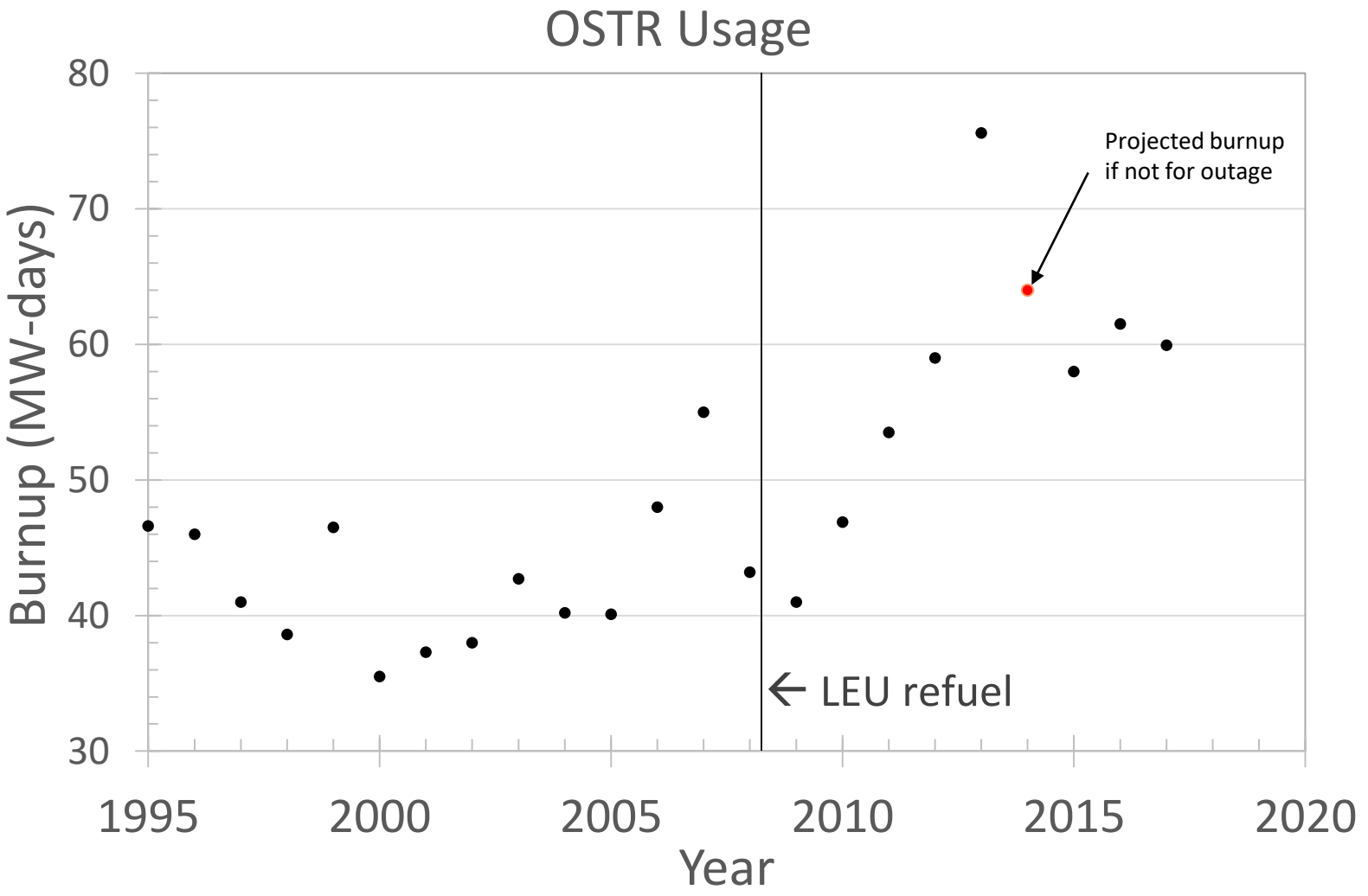


# Motivation

The reactor has seen an increase in usage in recent years



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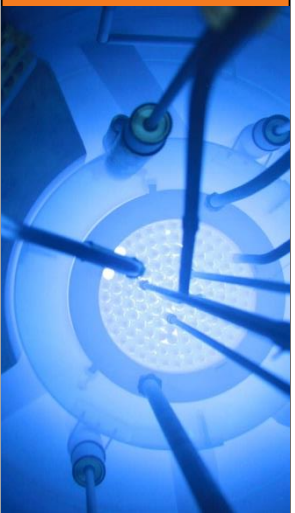

# Background

The increase in usage has led to exceptional backlogs.

- It is not unusual to have hundreds of hours of backlog
- The OSTR operates about 35 hours per week on average (Monday thru Friday, 0800-1700)
- Sometimes extended hours are performed to catch up on the backlog

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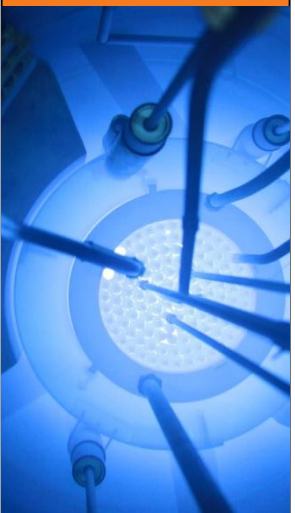
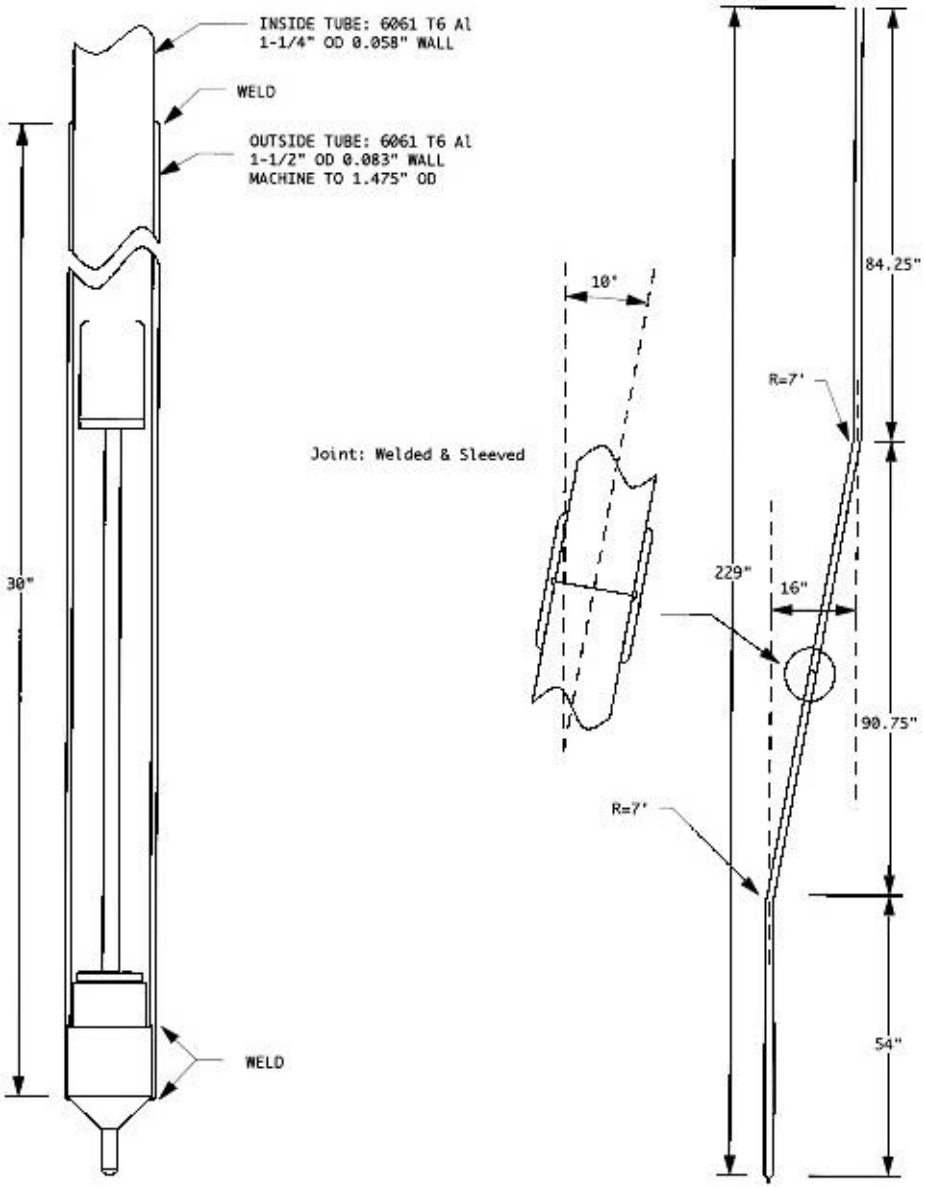


# Objective

Model a second CLICIT facility that will allow for multiple simultaneous Ar/Ar irradiations



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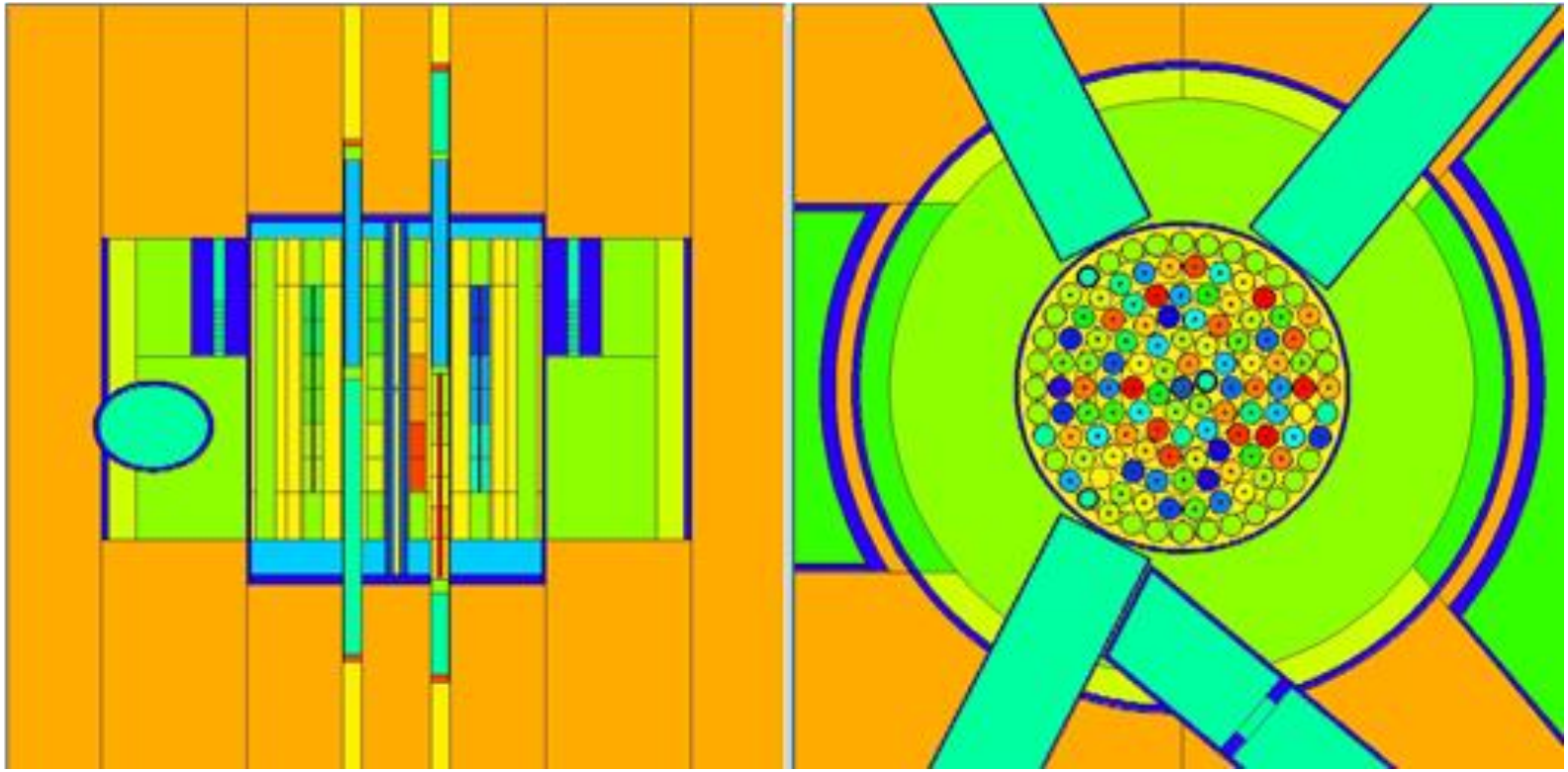
# Finding a Location for 2nd CLICIT

OSTR utilizes a highly-resolved MCNP model for various neutronic analyses



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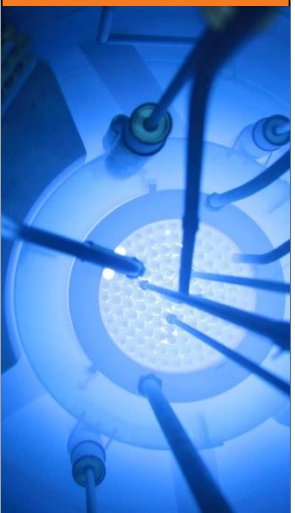
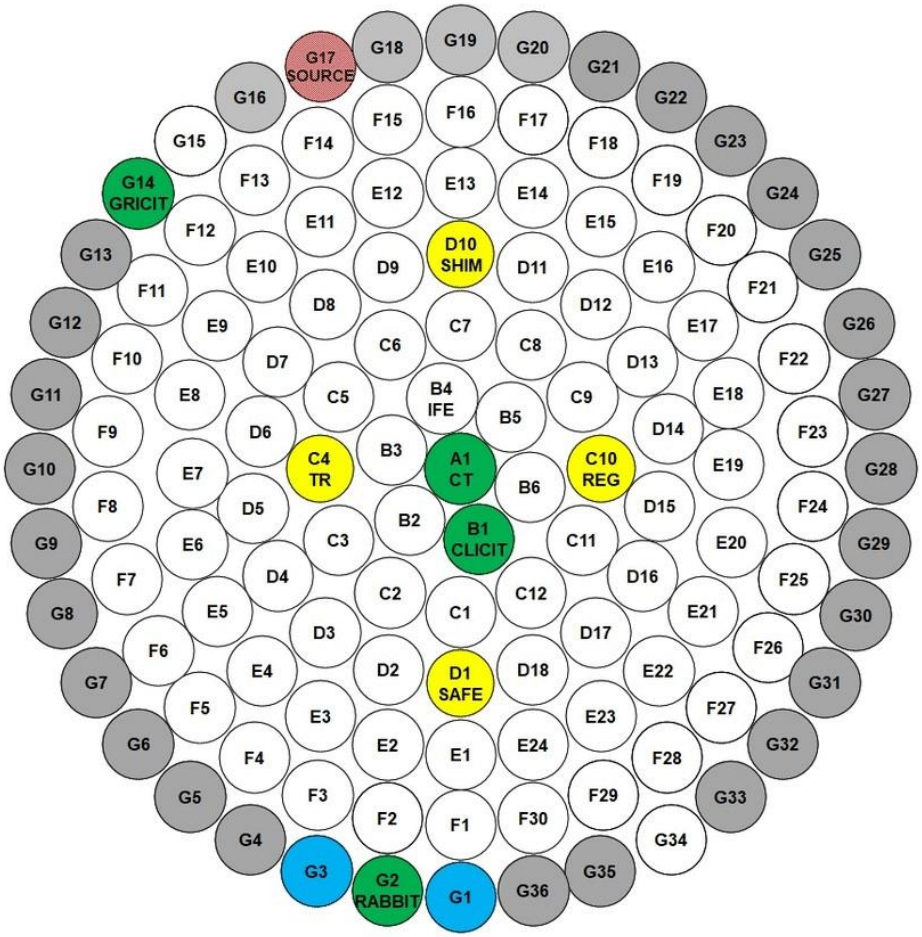


# Finding a Location for 2nd CLICIT

Four locations in the NW section of core were modeled



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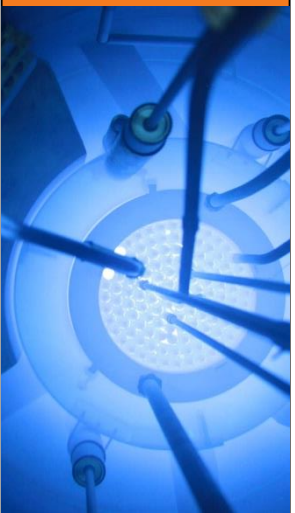

# Finding a Location for 2nd CLICIT

The base configuration was modeled with actual 1 MW critical core configuration and subsequent models were compared to this to determine reactivity effect of 2nd CLICIT

| 2nd CLICIT Location | k-effective | Reactivity | Reactivity Difference |
|---|---|---|---|
| None (Original Config) | 0.99853 | -$0.20 | - |
| D12 | 0.98776 | -$1.65 | -$1.45 |
| E16 | 0.99061 | -$1.26 | -$1.06 |
| F20 | 0.99315 | -$0.92 | -$0.72 |
| G24 | 0.99705 | -$0.39 | -$0.19 |

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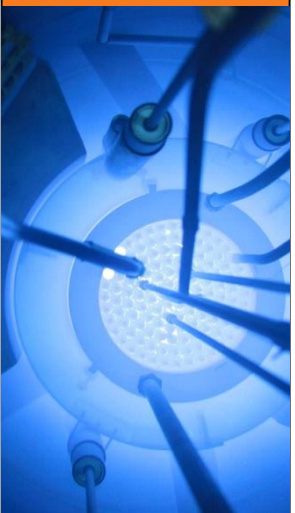

# Finding a Location for 2nd CLICIT

Flux tallies were used to determine epithermal (0.5 eV to 100 keV) and fast (100 keV to 20 MeV) neutron spectra.

Ratio of flux in B1 CLICIT vs. 2nd CLICIT:

| Spectrum | D12 | E16 | F20 | G24 |
|---|---|---|---|---|
| Epithermal | 1.25 | 1.54 | 2.19 | 3.07 |
| Fast | 1.24 | 1.53 | 2.28 | 3.51 |

These ratios are essentially an irradiation time multiplier.

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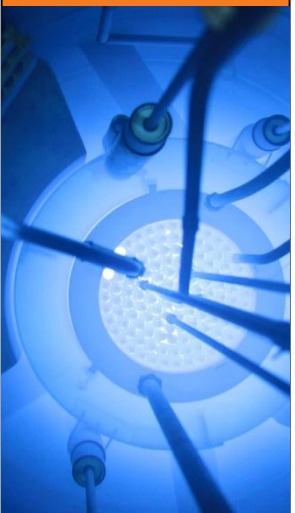
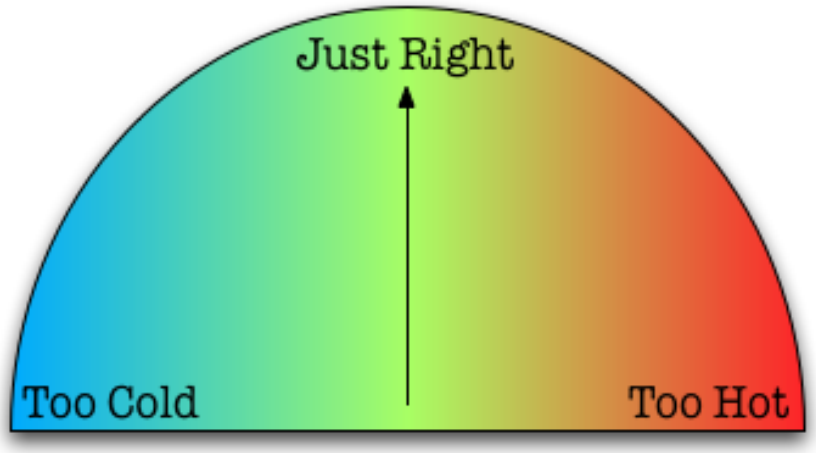


# Finding a Location for 2nd CLICIT

The OSTR staff decided that the location of the 2nd CLICIT would be in F20, due to its balance of reactivity worth and flux.

D12 and E16 had desirable flux levels, but they exhibited significant negative reactivity effects. G24 had negligible reactivity effect, but would take too long to irradiate.




Porridge Temperature Monitor

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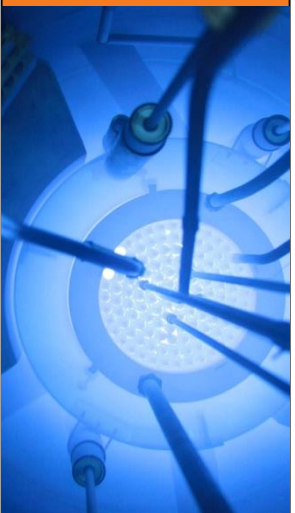

# Core Optimization

Various changes were modeled to optimize the OSTR core

- 2 fresh fuel elements were added to the core to try to counteract the negative reactivity of the 2nd CLICIT
- Fuel was shuffled to increase flux in beam port facilities, as well as shift the spectrum in the Rabbit facility
- G14 ICIT was moved in one ring to boost flux in order to reduce antimony irradiation time

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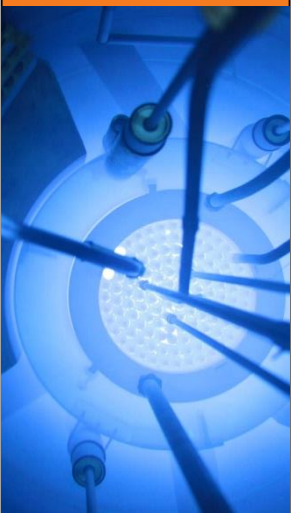
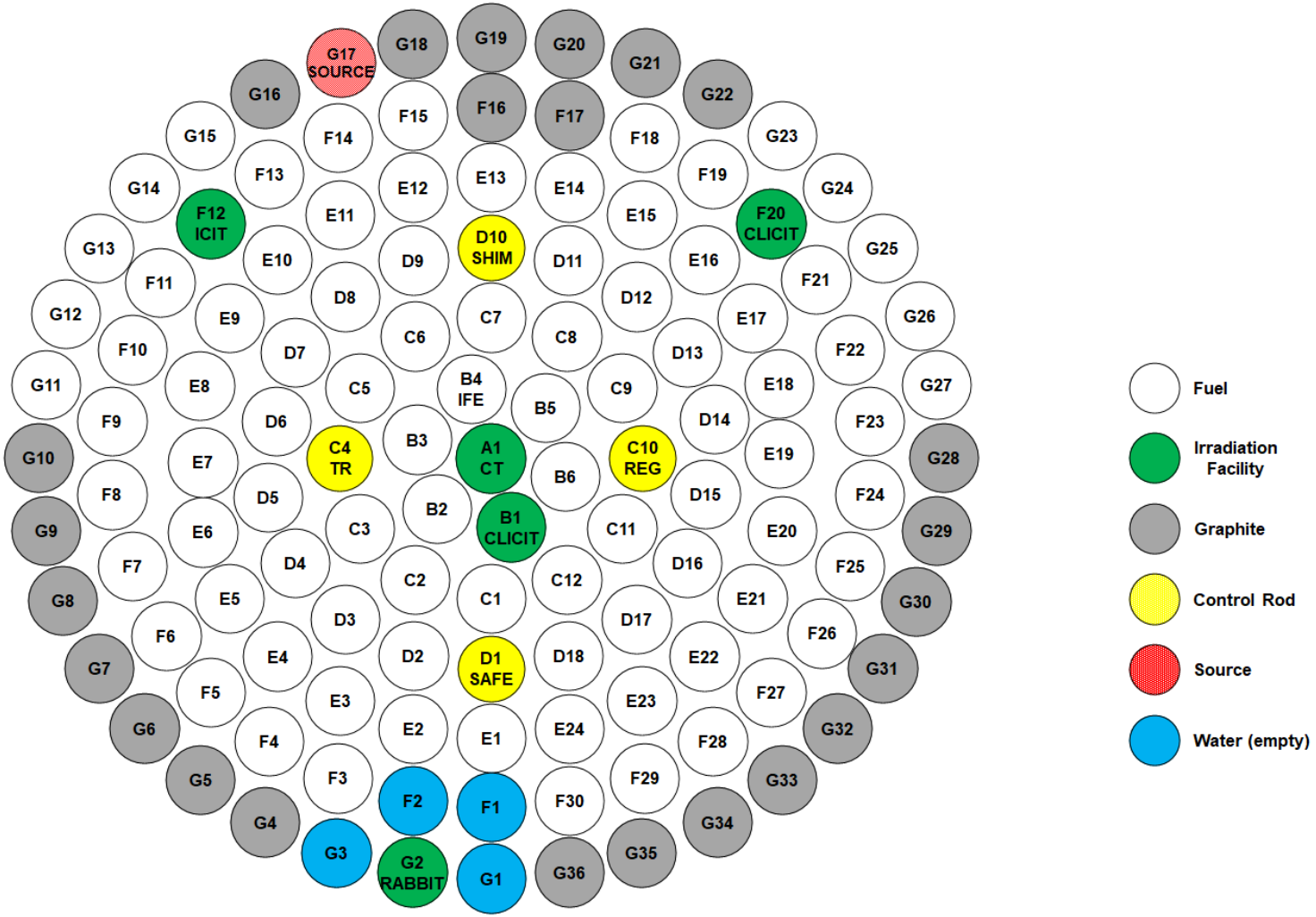


# New Core Configuration



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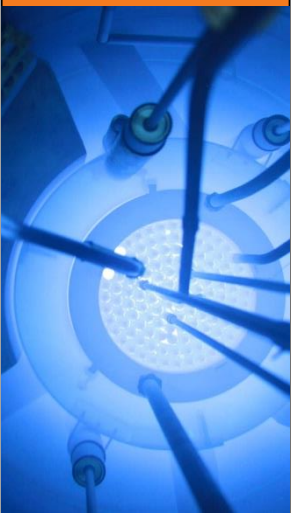

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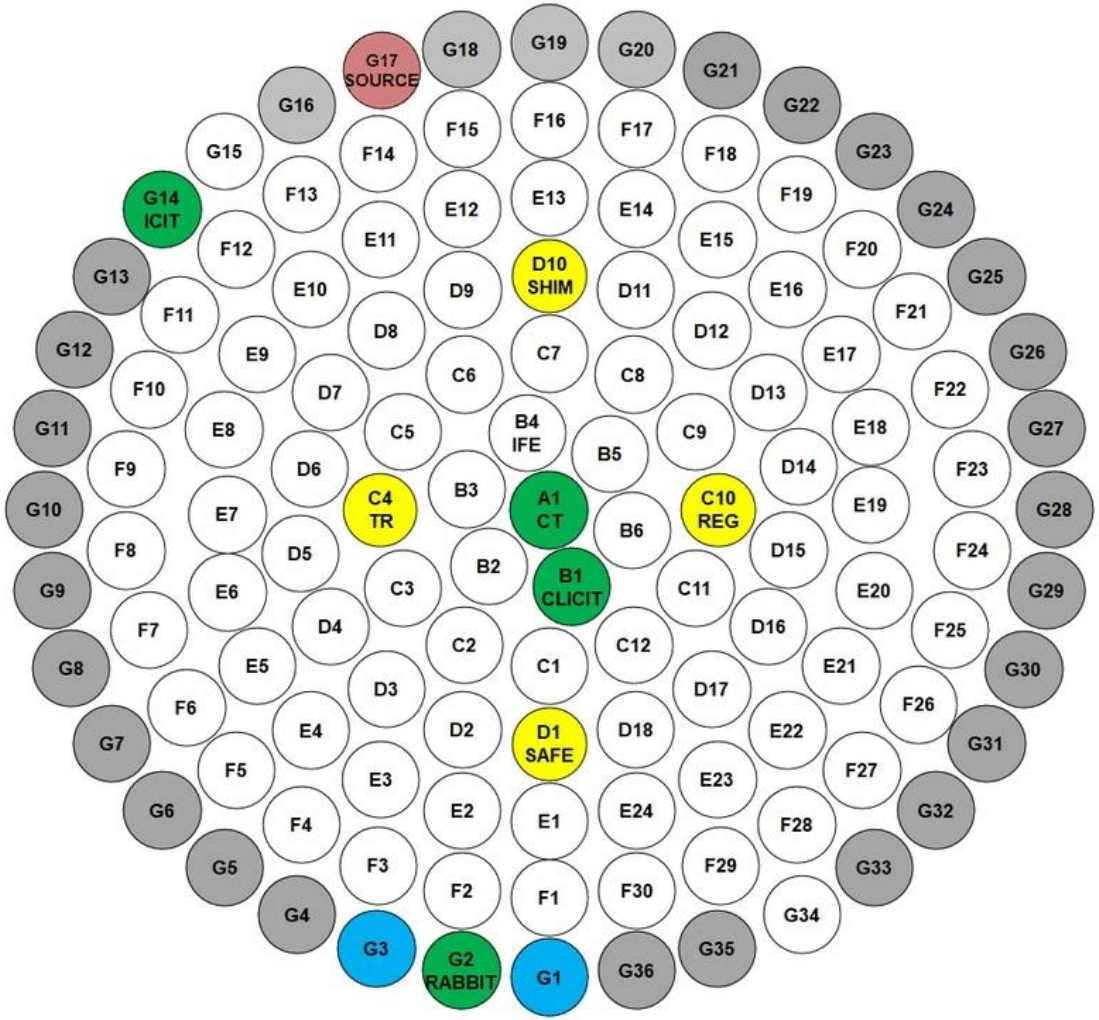

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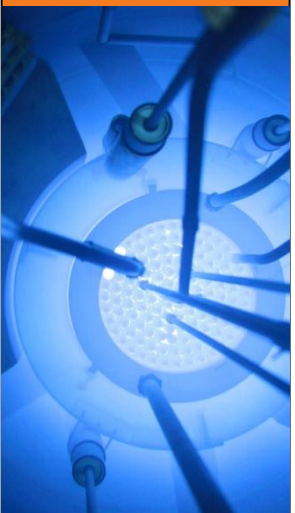

# MCNP Criticality Prediction

MCNP was used to predict the critical rod heights of the new core configuration. The prediction was calculated by withdrawing control rods until achieving $0.27 negative reactivity, which incorporated bias from a previous study.

This prediction compared quite favorably to the actual critical rod heights:

| | k-eff | ρ | Error | Critical Rod Heights at 1 MW (% withdrawn) | | | |
|---|---|---|---|---|---|---|---|
| | | | | Trans | Safe | Shim | Reg |
| **MCNP Prediction** | 0.99799 | -$0.27 | $0.02 | 69 | 69 | 69 | 69 |
| **Experimental** | 1.00000 | $0.00 | - | 68 | 68 | 68 | 68.8 |

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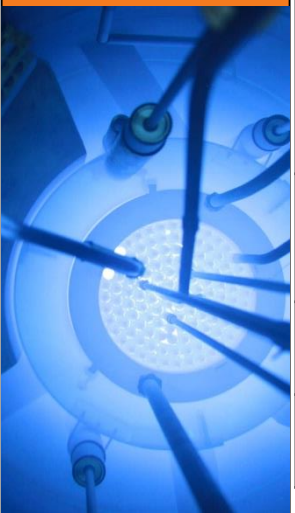

# MCNP Rod Worth Prediction

MCNP was used to predict the rod worths by performing a k-eff calculation with all-rods-in then subsequent runs with all rods but one in.

This prediction compared quite favorably to the actual critical rod heights, which were determined from control rod calibrations that utilize the “rod pull/period” method.

| | Control Rod Worths | | | | |
|---|---|---|---|---|---|
| | Transient | Safety | Shim | Regulating | Total Rod Worth |
| **MCNP Prediction** | $2.91 | $2.04 | $2.66 | $3.10 | $10.71 |
| **MCNP Error** | ± $0.10 | ± $0.07 | ± $0.07 | ± $0.08 | ± $0.16 |
| **Experimental** | $2.74 | $2.00 | $2.58 | $3.17 | $10.49 |

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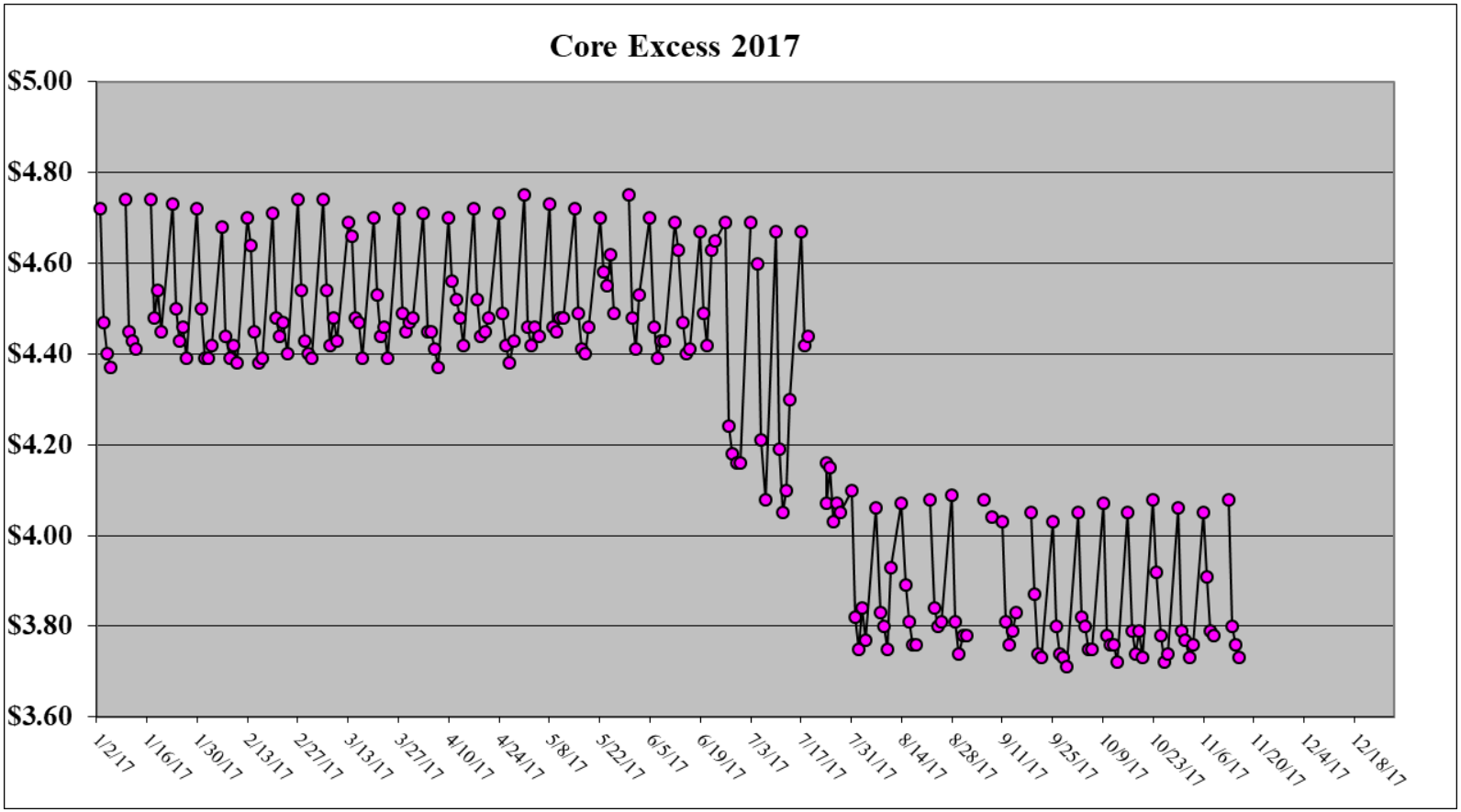
# MCNP Core Excess Prediction

MCNP was used to predict the excess reactivity of the core by performing a k-eff calculation with all rods withdrawn. Core excess was predicted to be \$4.14 ± \$0.10. Actual core excess on the morning of 31 July 17 was \$4.10.



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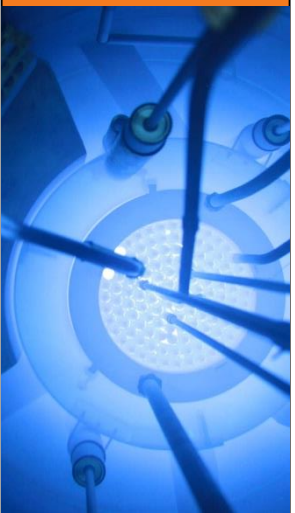

# Conclusion

MCNP is an incredibly useful tool for predicting criticality changes of new core configurations.

MCNP successfully predicted the change in excess reactivity, rod worth and critical rod heights.

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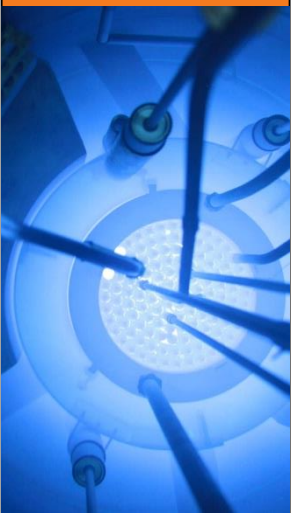

# Future Work

Characterizing new CLICIT

- Aluminum-gold flux wires were irradiated and analyzed in August 2017 and initial results appear to match with the flux ratios predicted by MCNP
- We are working with experimenters to determine the "J-value" for the new CLICIT
- We expect to begin heavily utilizing the 2$^{nd}$ CLICIT in 2018

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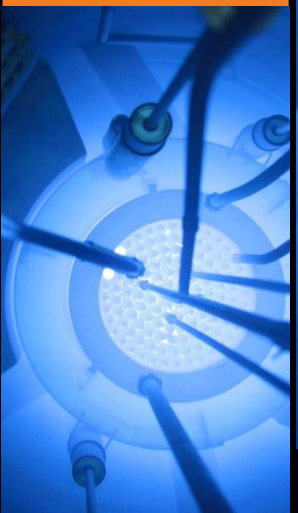

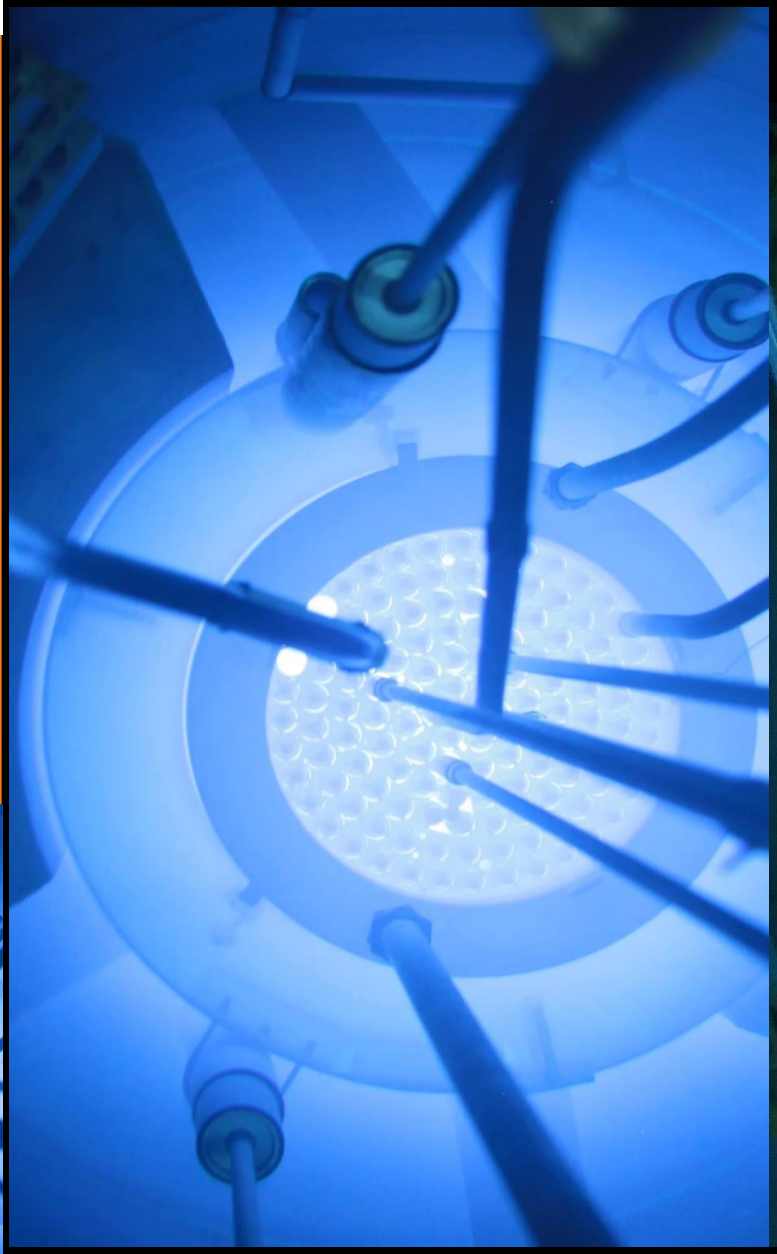

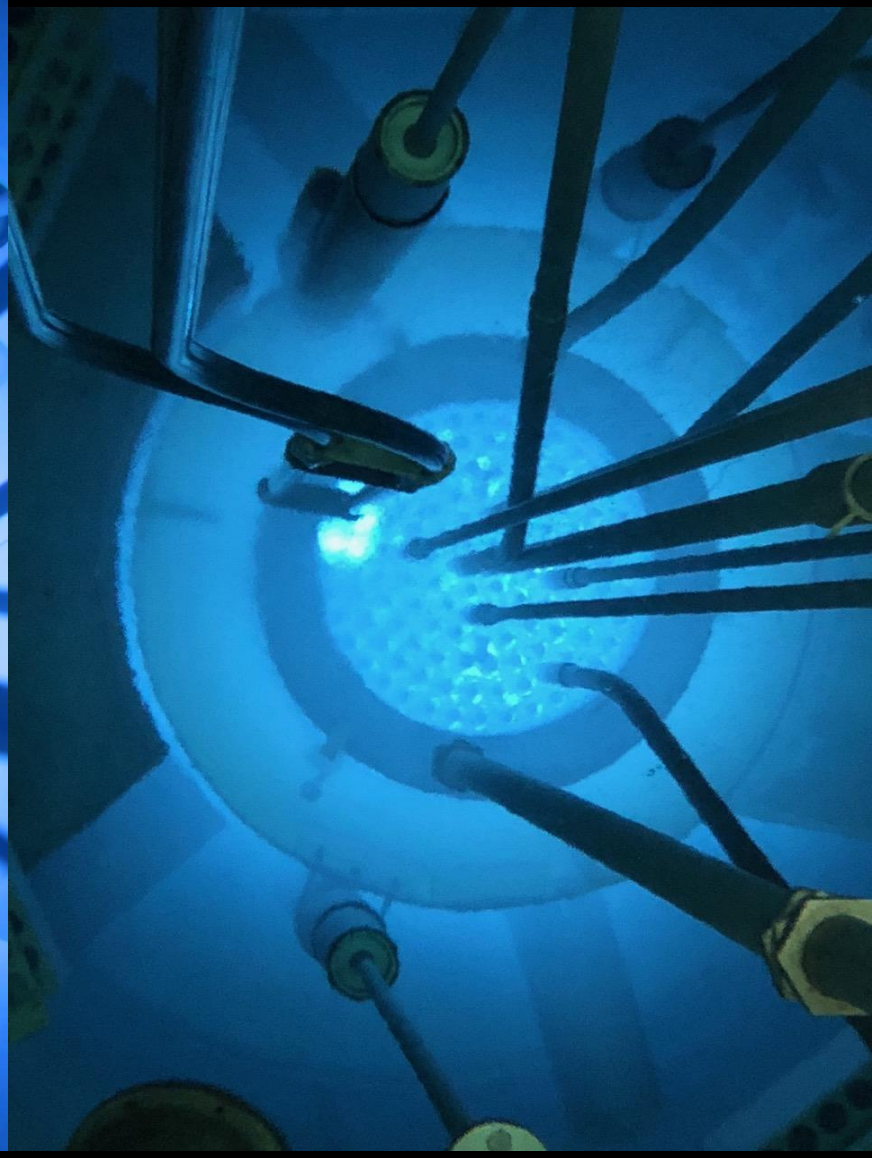

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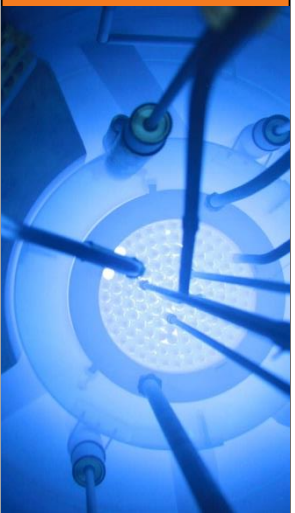

# Questions?