NRIC National Reactor Innovation Center

INL/EXP-24-77227

Advanced Test Reactor (ATR)

Capabilities in Support of Advanced Reactor Development

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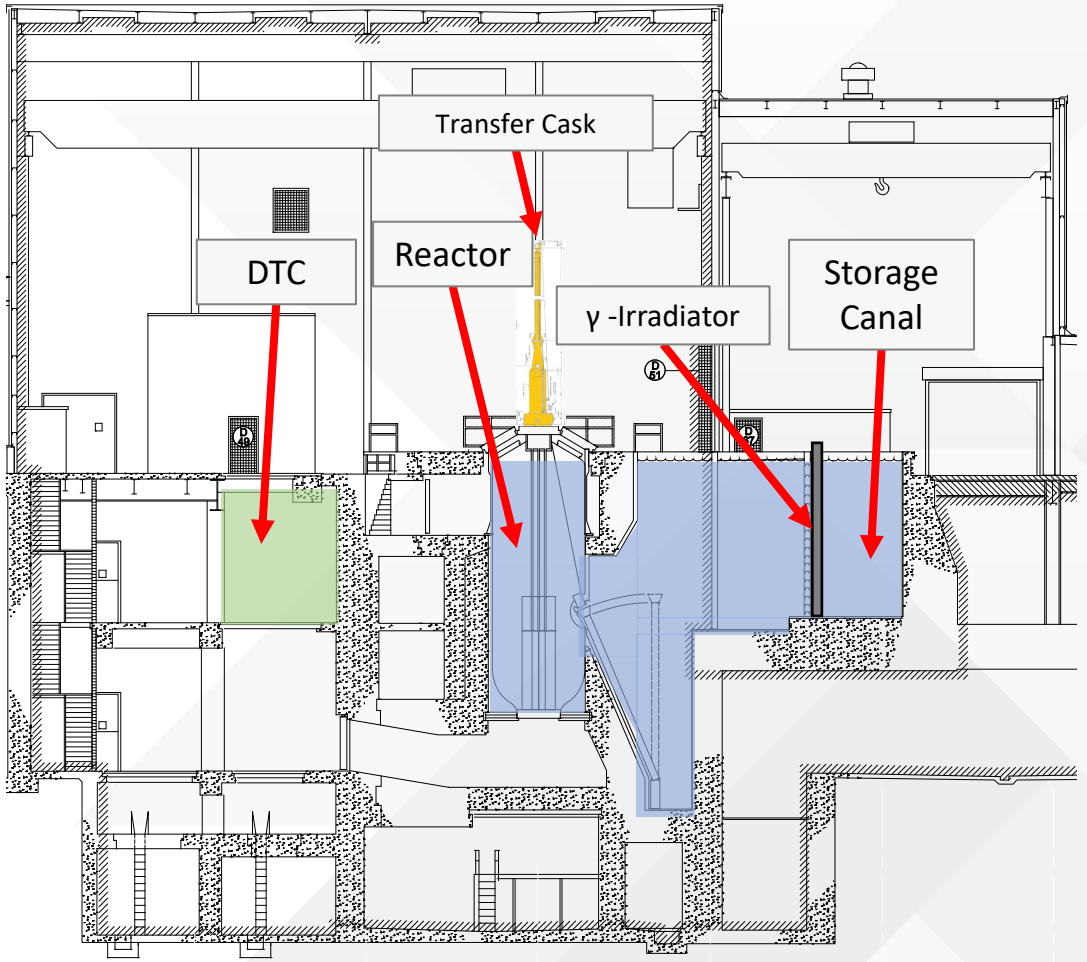
Overview

1. ATR Description
2. Experiment Overview
3. Thermal and Fast Spectrum Testing
4. Advanced Material Testing

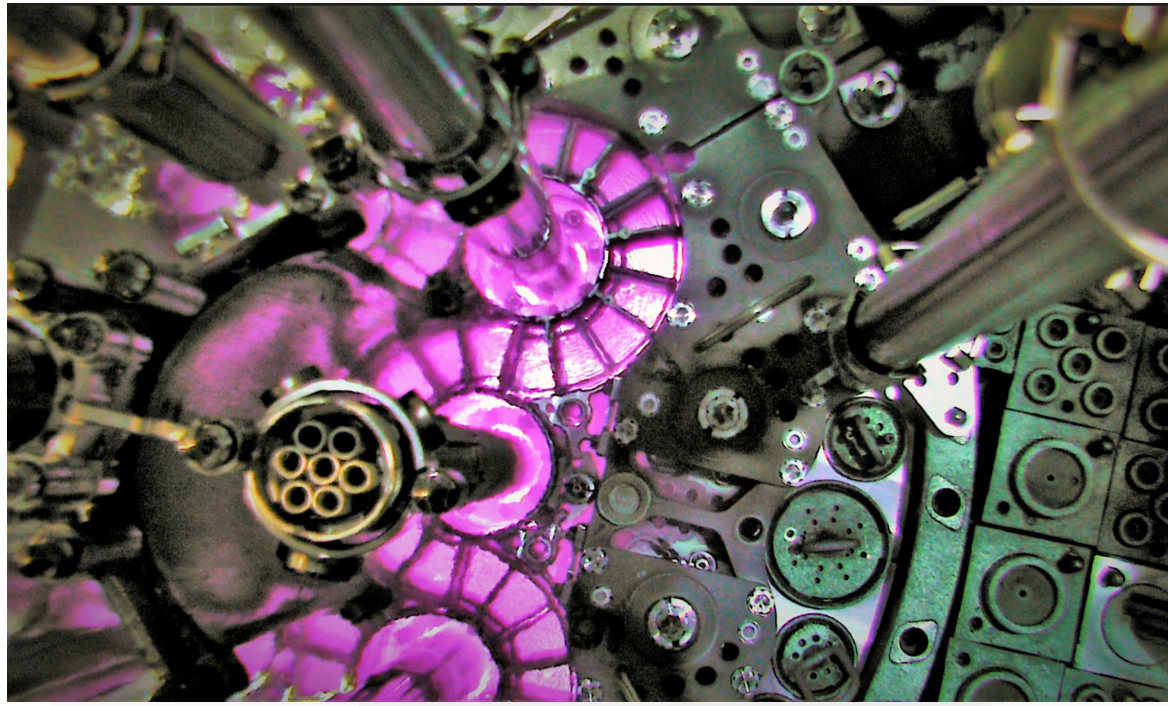
ATR Description (Facility)

- Reactor
  - 250MW$_t$
  - Light Water
- Storage Canal
  - Storage
  - Wet sizing
- Gamma Irradiator
  - Driver Fuel Source
  - $\leq 5 \times 10^6 R/hr$ exposure
- Dry Transfer Cubicle (DTC)
  - Sizing facility
  - Air atmosphere



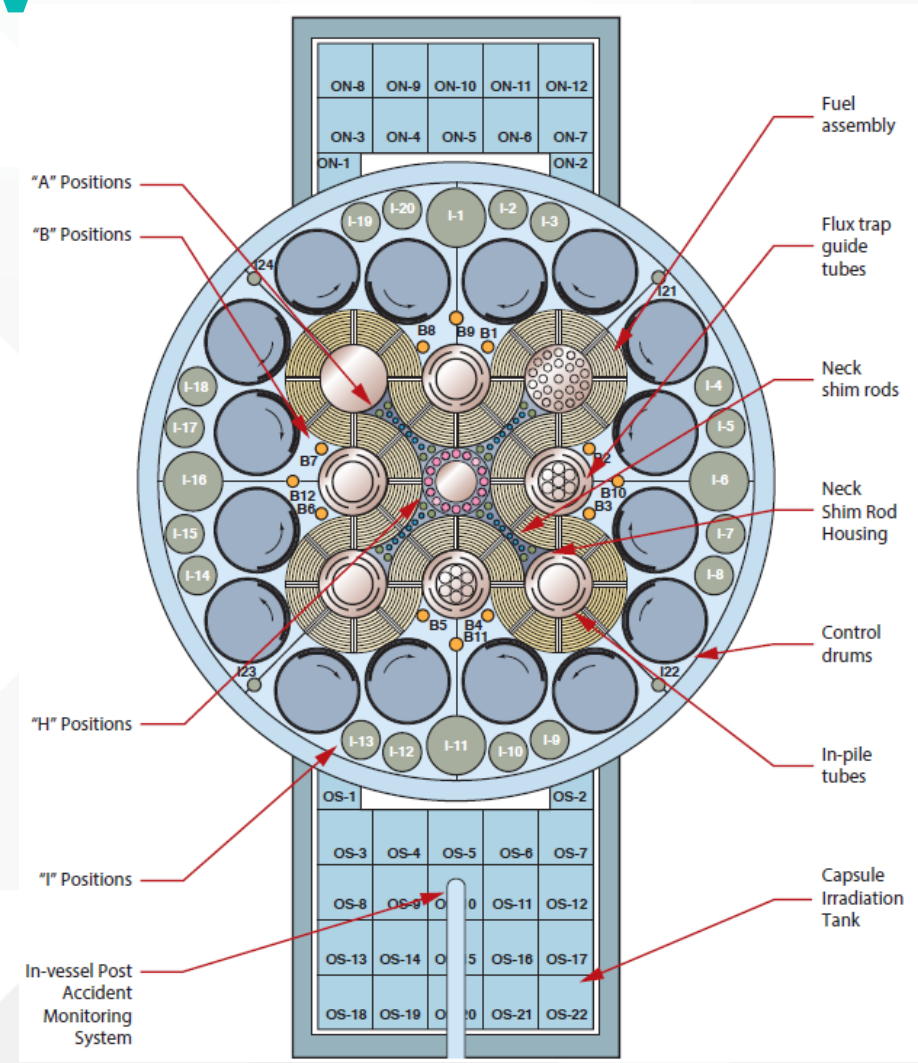
ATR Description (Reactor)

- General Parameters
  - Low Temperature and Pressure
  - Light Water
  - Aluminum Clad Driver Fuel
- Clover Shape Design
  - Reactor “Tilt” Capability
  - Nine Flux Traps
- Two types of operational cycles
  - Standard (~110 MW, 60 day)
  - PALM (~170 MW, ~7 day)



Experiment Overview

- Variety of Experiment Positions
  - Flux Traps
  - Inboard Positions
  - Outboard Positions
- Variety of Experiment Types
  - γ-Irradiation
  - Simple Capsule
  - Instrumented Capsule
  - Gas Loop
  - Pressurized Water Loop (PWL)



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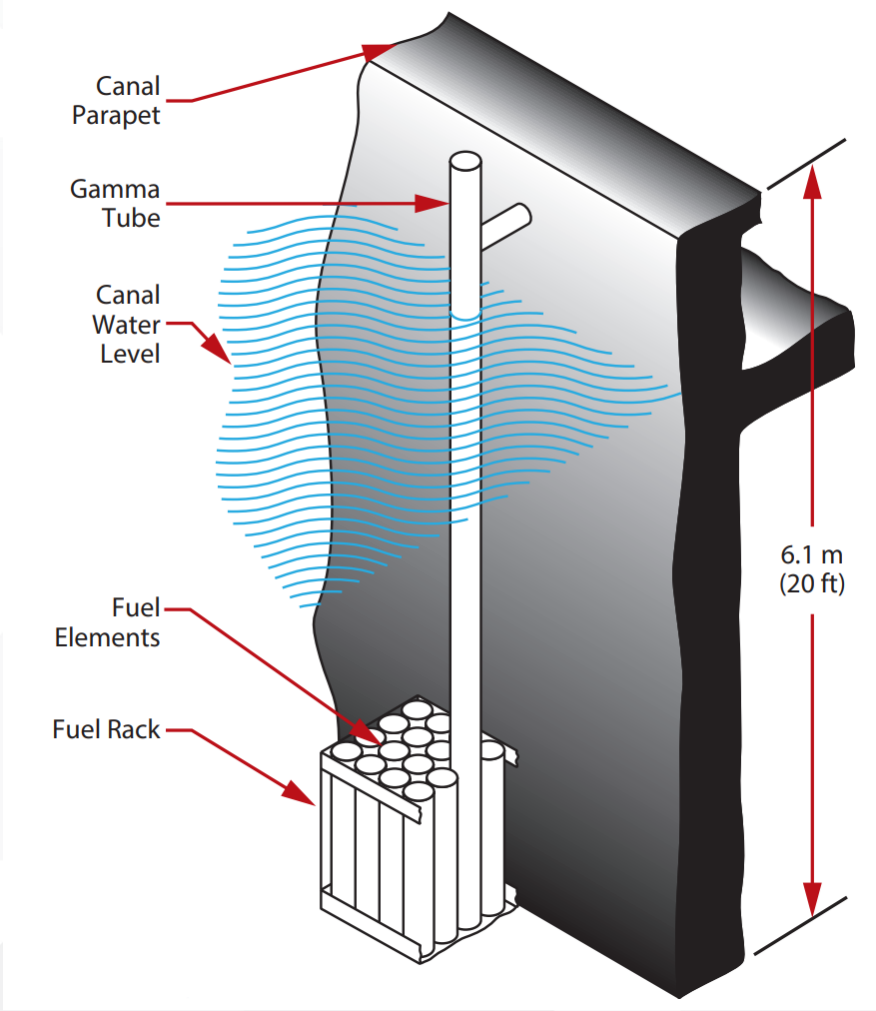
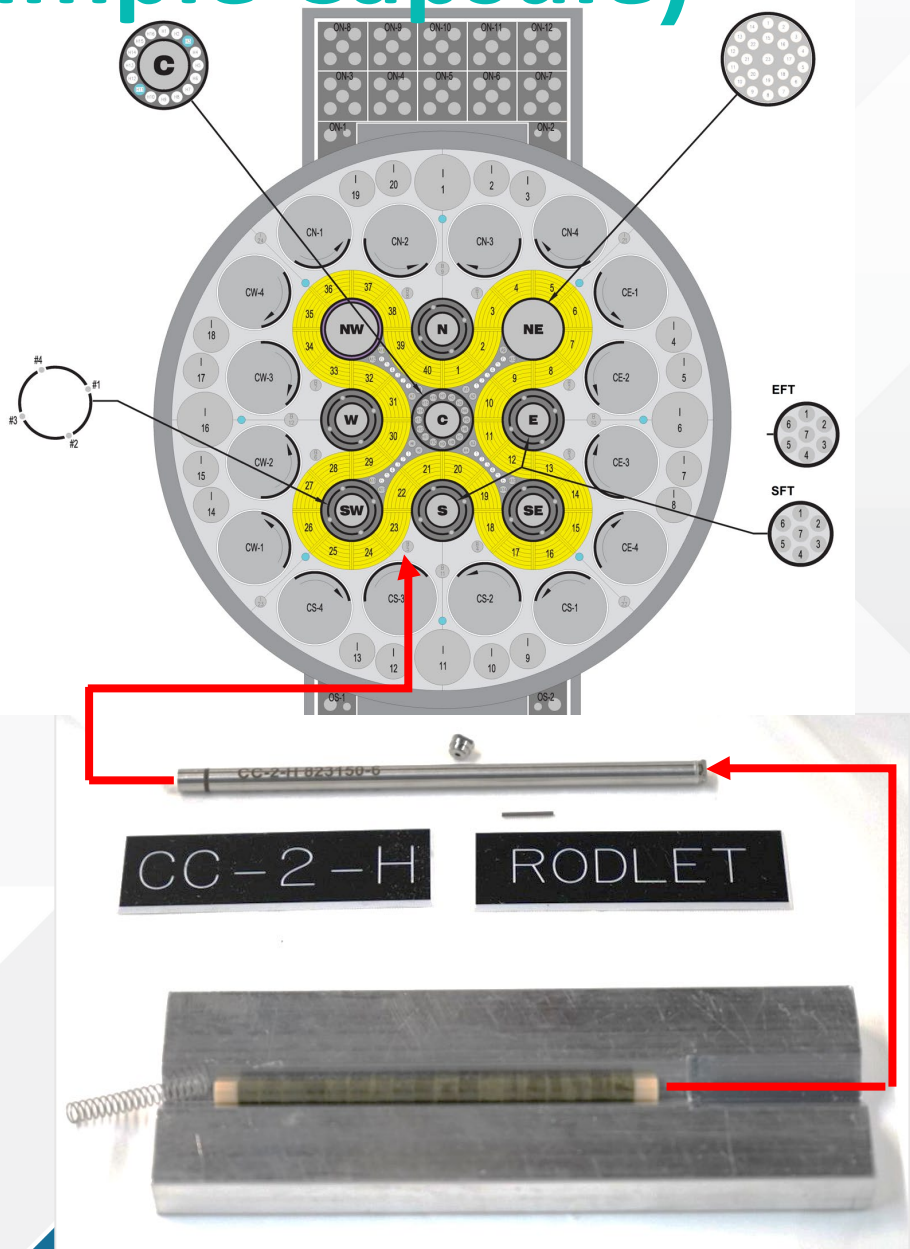
Experiment Overview (γ-Irradiation)

- Dry Tube Gamma Irradiation
  - Testing of fuel, materials, and instrumentation
  - Leeway on materials and design
- High exposure rates
  - $\leq 5 \times 10^6 R/hr$ $(4.4\ Gy/hr)$
  - Driver Fuel Source Term
  - 5% decrease/day in exposure rate
- Benefits:
  - Cost effective
  - Minimal Restrictions



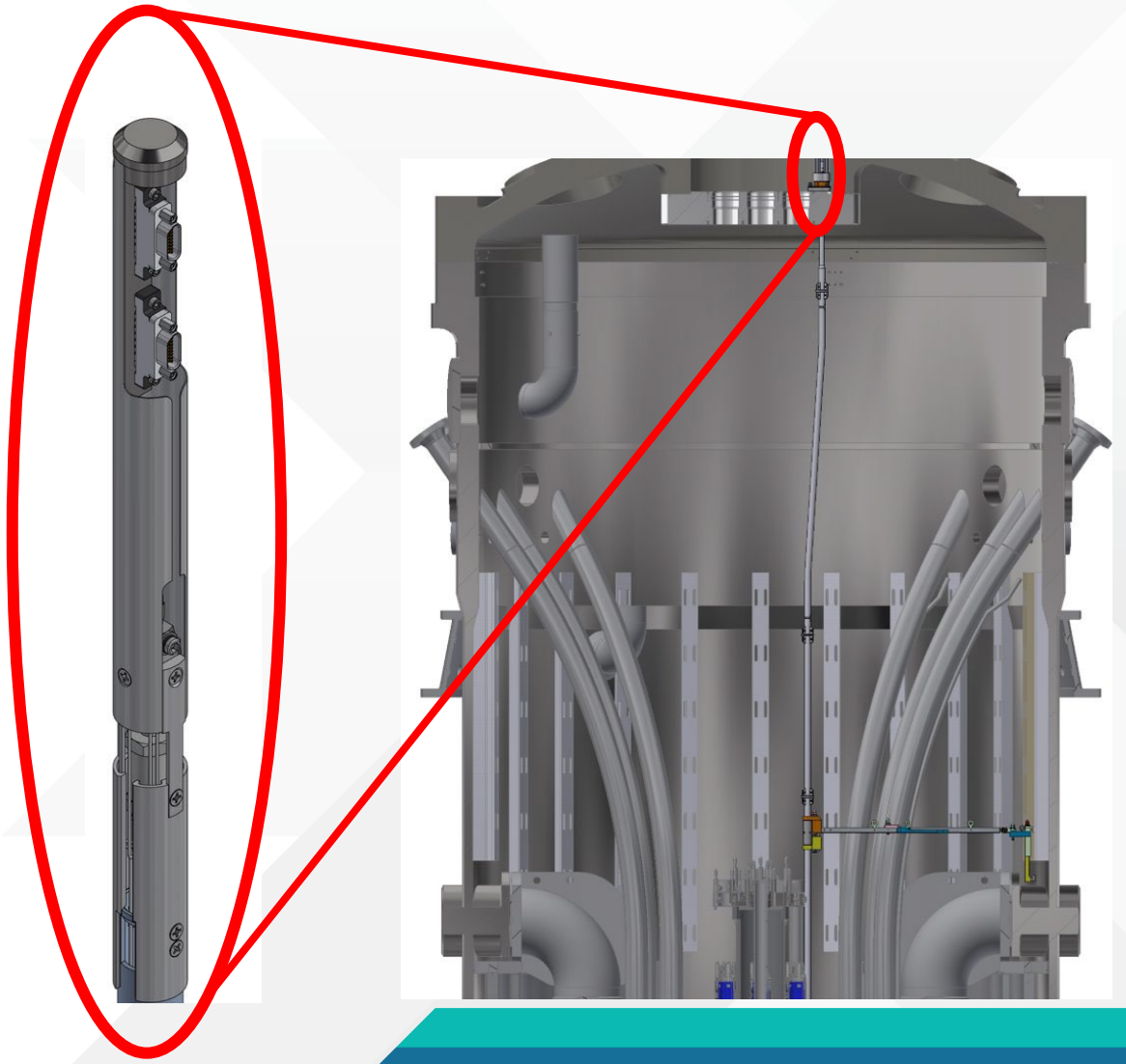
Experiment Overview (Simple Capsule)

- Simple capsule containment
  - Fuel and material testing
  - Temperature determined by fill gas mix
  - Melt/fluence wires for PIE
- Neutron irradiation
  - High flux
  - Standard or PALM cycles
  - Flux trap, inboard, or outboard positions
- Cost effective



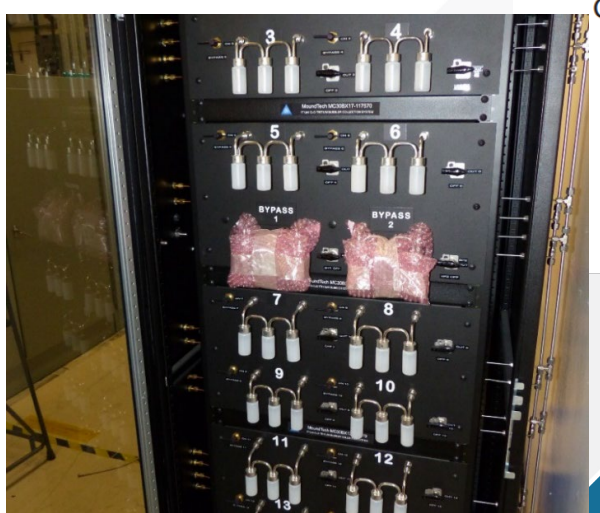
Experiment Overview (Instrumented Capsule)

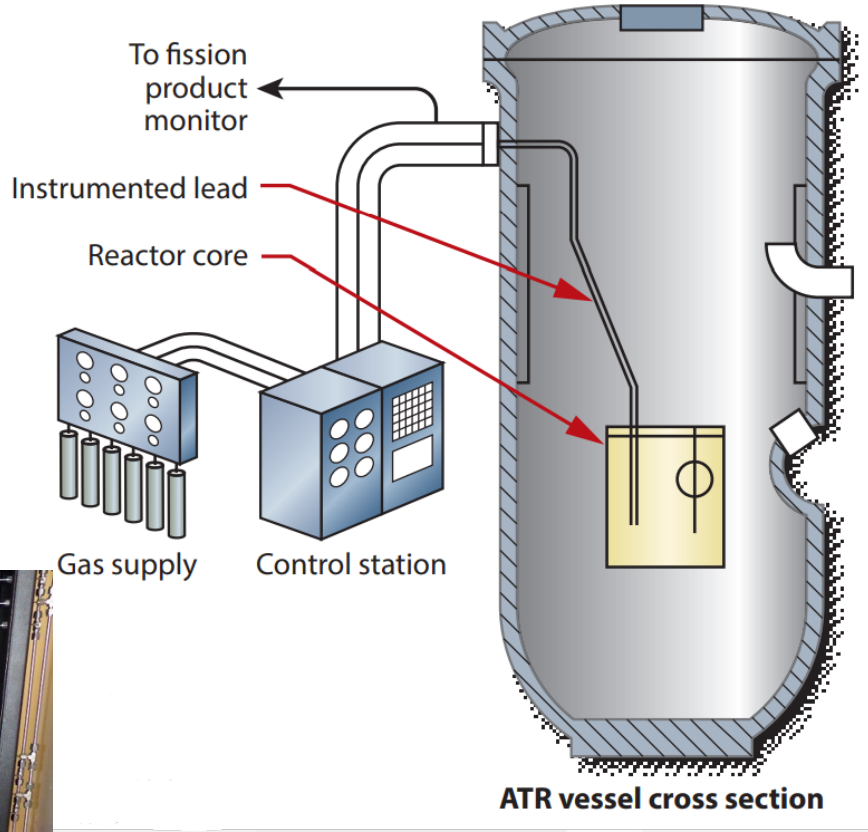
- Simple capsule containment
  - Fuel and material testing
  - Temperature controlled with predetermined gas mixture
- Instrument Leads
  - In-situ measurements of material properties
  - Temperature, conductivity



Experiment Overview (Gas Loop)

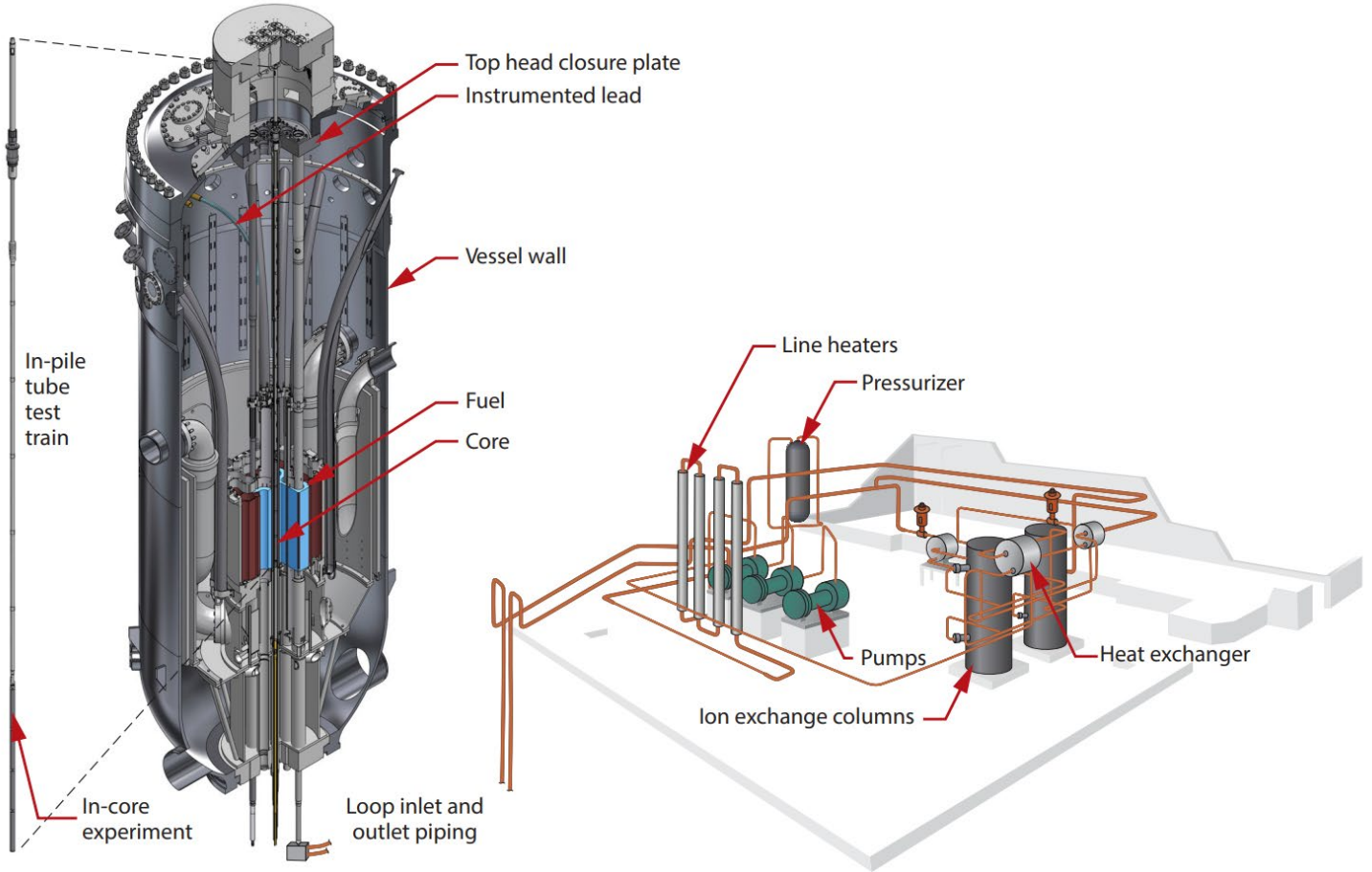
- Active Monitoring
  - Real-time specimen data
- Active Control
  - Ability to vary gas mixture
  - Real-time temperature Control
- Measurement flexibility
  - Speciation
  - Migration





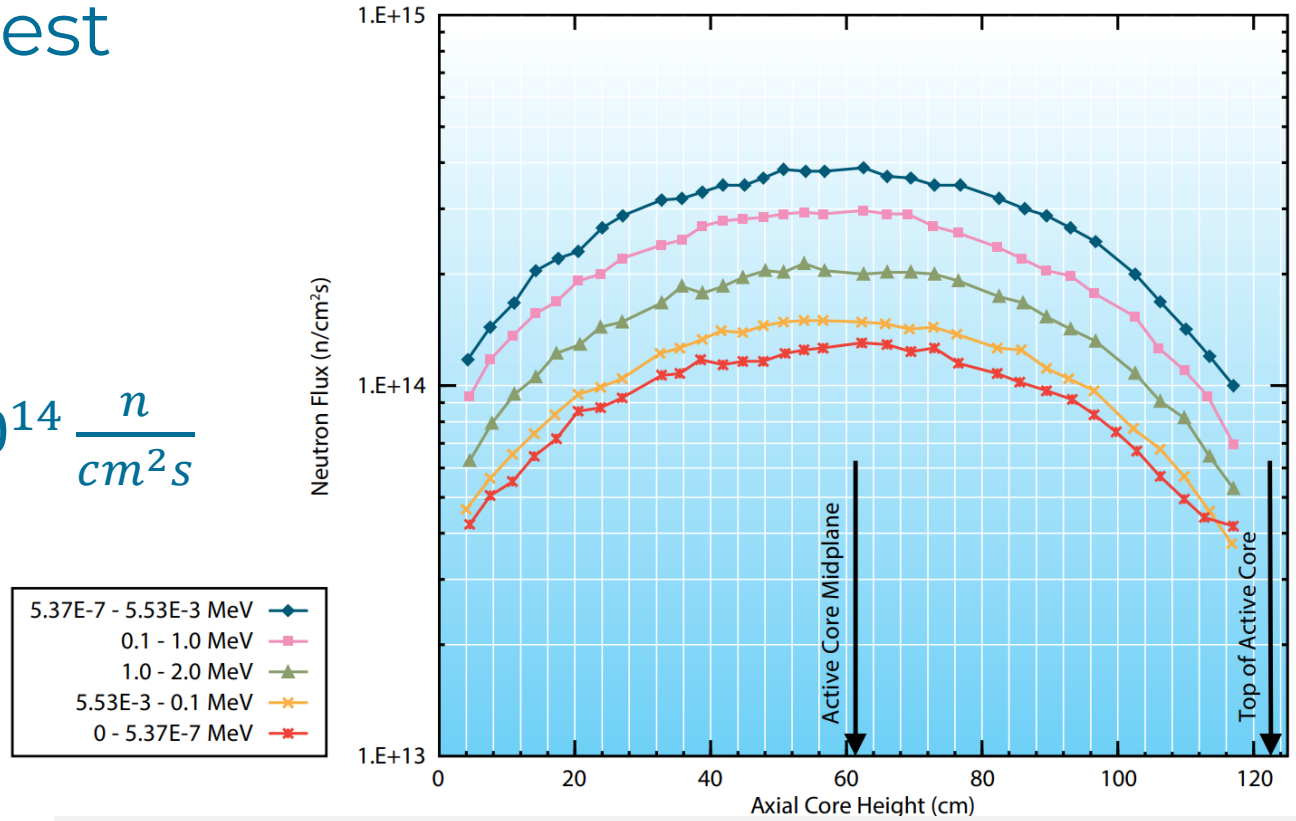
Experiment Overview (PWL)

- All advantages of a gas loop
- Pressurized water environment



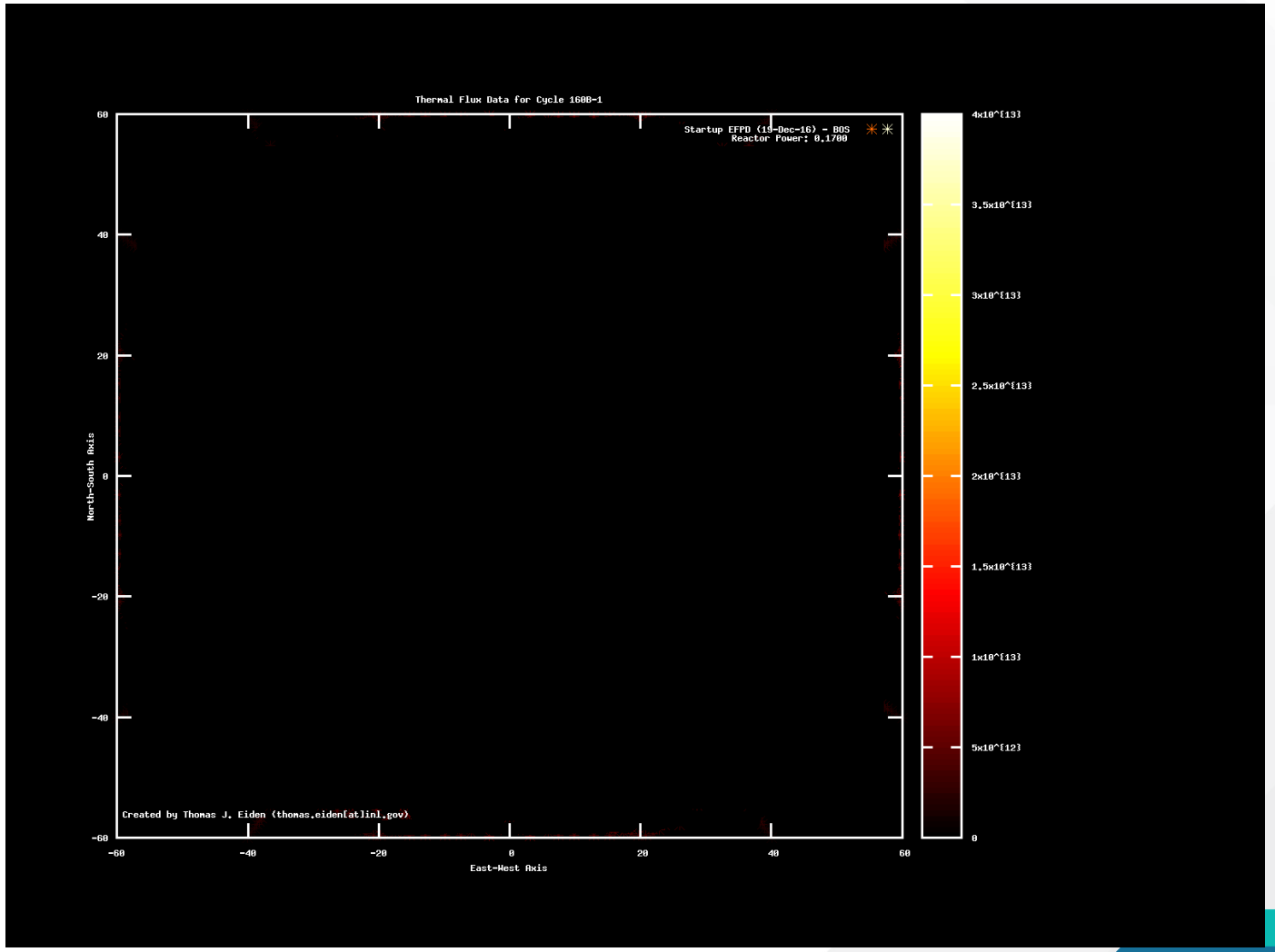
Thermal and Fast Spectrum Testing

- ATR is primarily a thermal test reactor
- Thermal flux range
  - Position dependent
  - Between 1×10^{13} and 4.4×10^{14} $\frac{n}{cm^2 s}$



Unperturbed five-energy group neutron flux intensity profiles over the active core length of the ATR center flux trap for total reactor power of 125 MW.

Thermal and Fast Spectrum Testing



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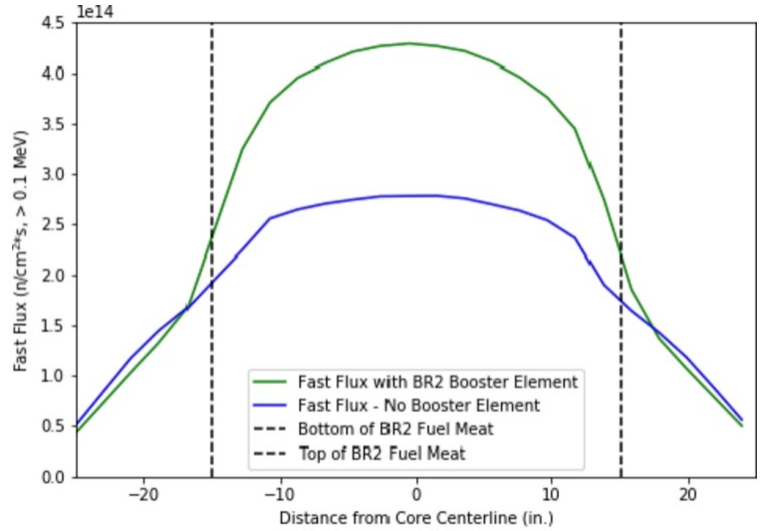
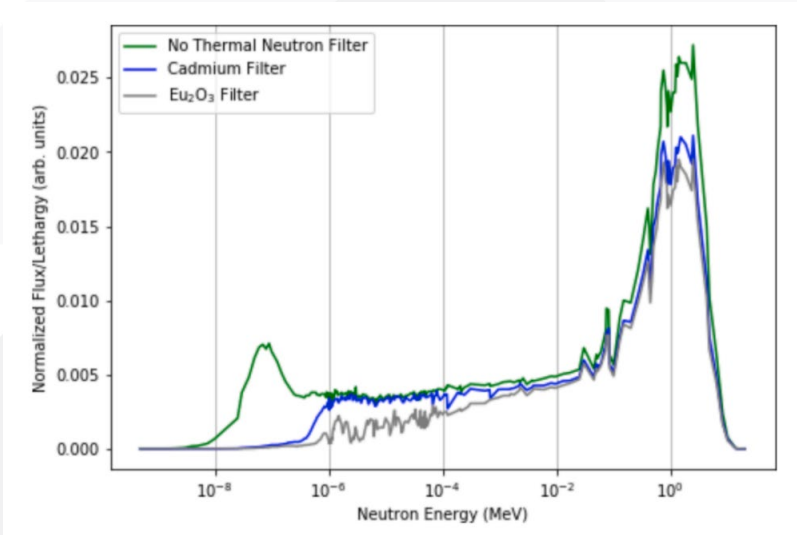
Thermal and Fast Spectrum Testing

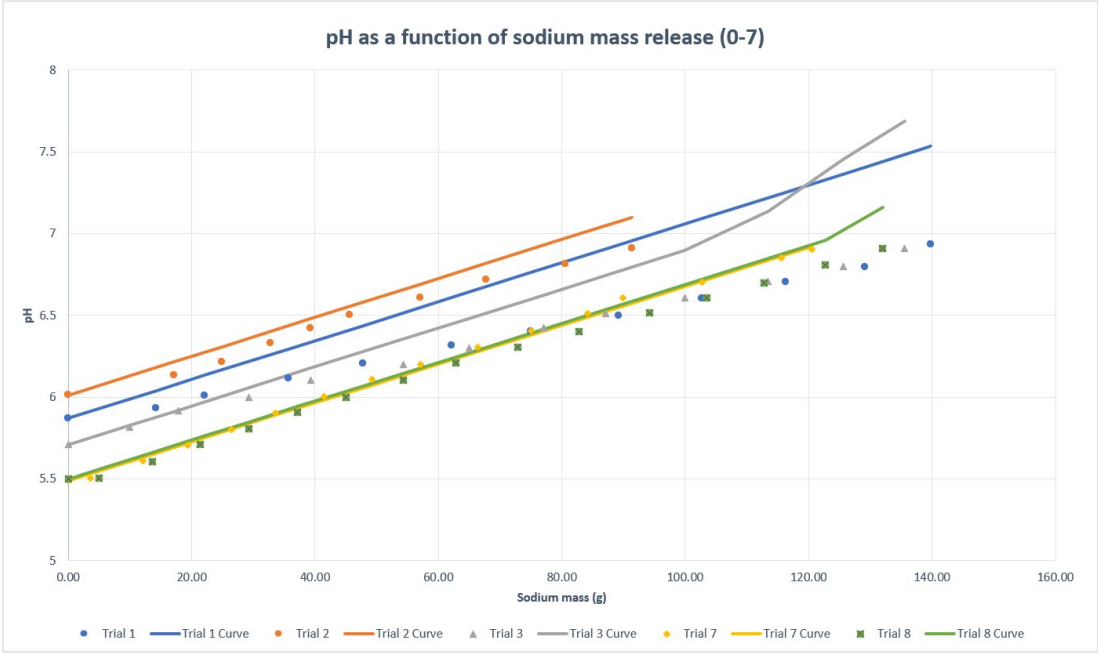
- Fast Reactor Environments may be simulated
- Cadmium neutron filters are used to reduce thermal flux
- Booster fuel elements have also been proposed to increase fast flux (Curnutt 2022)





Advanced Material Testing

- Standard fuel and materials testing
- Advanced fuel and materials testing capability
  - Sodium bonded fuels
  - Molten salt fuel (NaCL-UCl_3 and UF_4-NaF-KF)
  - Metallic eutectic mixtures



Data from an experiment safety evaluation for sodium bonded experiments.

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References

1. J. Campbell, “ATR User Guide,” INL/EXT-21-64328-Rev000, September 2021.
2. C. Downey, et. al., “Design of a First-of-A-Kind Instrumented Advanced Test Reactor Irradiation Capsule Experiment for in Situ Thermal Conductivity Measurements of Metallic Fuel,” https://dx.doi.org/10.2139/ssrn.4764661
3. B. Curnutt, et. al., “A neutronics investigation simulating fast reactor environments in the thermal-spectrum advanced test reactor,” Nucl. Eng. Des., Vo. 387, February 2022.
4. D. Sluder, et. al., “Safety Considerations for Advanced Material Irradiation at the Advanced Test Reactor,” INL/CON-24-76144-Rev000, June 2024.

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