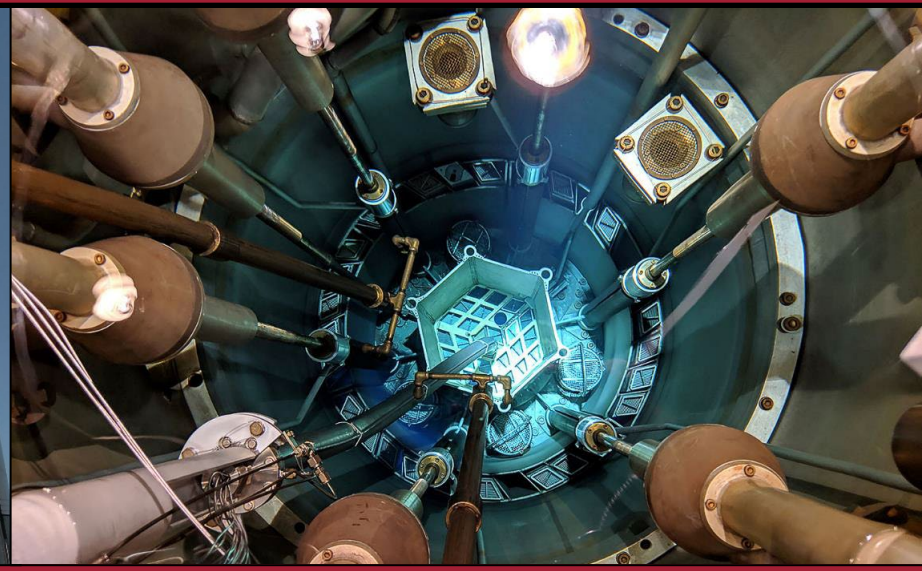
MIT NUCLEAR REACTOR LABORATORY

an MIT Interdepartmental Center



Irradiation Capabilities at the MIT Nuclear Reactor

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Managing Director for Reactor Operations

November 2, 2023 ASI FY 23 Annual Program Review Meeting

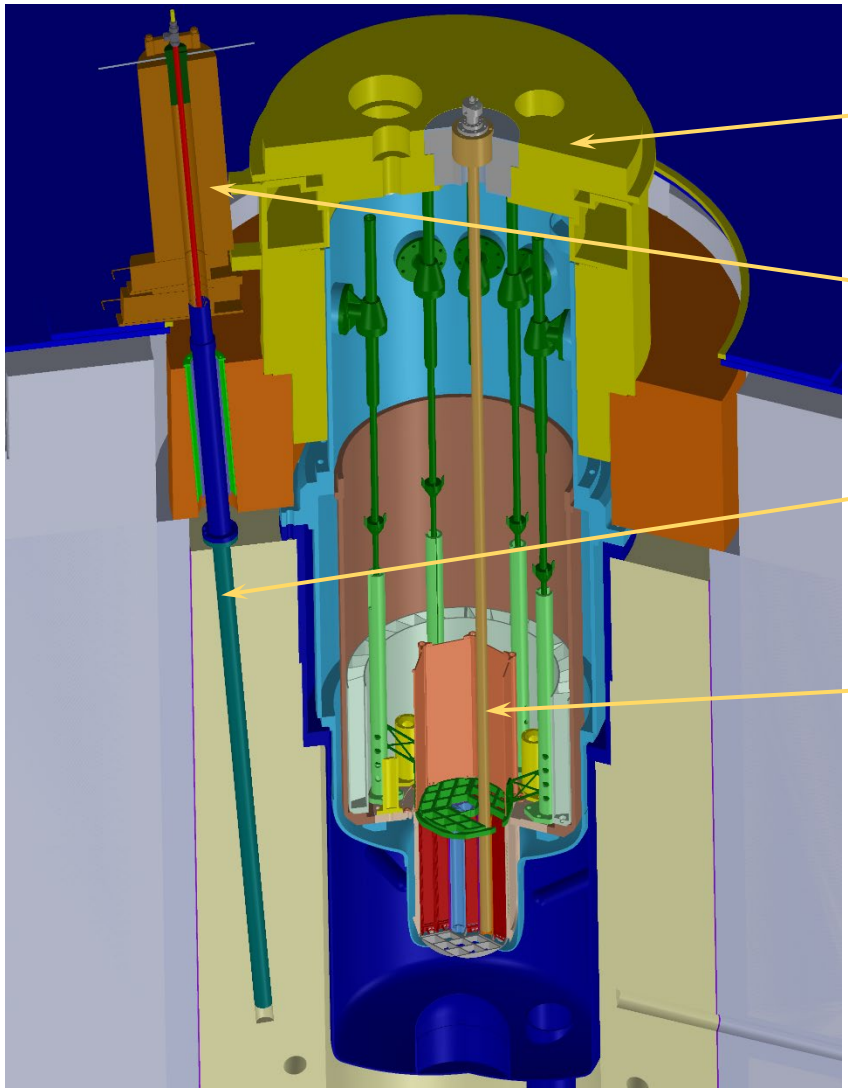
The Nuclear Reactor Laboratory

- The NRL is an interdepartmental laboratory with missions in nuclear technology applications, neutron science research, and training/education
  - Direct collaboration with academia, government, and industry
- Primary facility is the MIT Research Reactor (MITR), a 6 MWth multi-purpose research reactor owned and operated by MIT
- Advanced modeling and simulation of reactors and nuclear components, machine learning and simulator development, outreach for nuclear education for schools, universities, professional groups and the general public

Essential Parameters of the MITR

- 3 In-core irradiation positions:
  - Max facility size 5 cm OD by 60 cm long
  - Peak Flux 1.2×10^{14} n/cm^2-s E>0.1 MeV, 4×10^{13} n/cm2-s thermal
  - Peak 2×10^{14} gammas/cm^2-s, 1×10^{9} R/h
  - Wide range of environmental conditions (inert gas, water, molten salt, lead bismuth) temperatures up to 1400 °C
  - Lead out capability on all in-core positions
- Other irradiation facilities:
  - One graphite reflector position with lead out capability: 1.2×10^{13} n/cm^2-s thermal, ≈5×10^{10} n/cm^2-s E>0.1 MeV
  - One 2-inch pneumatic sample shuttle in D_2O, 5×10^{13} n/cm^2-s thermal, 3×10^{12} n/cm^2-s E>0.1 MeV
  - One pneumatic sample shuttle in graphite, 8×10^{12} n/cm^2-s thermal
  - MCube large irradiation volume under construction

In-core and 3GV irradiation positions



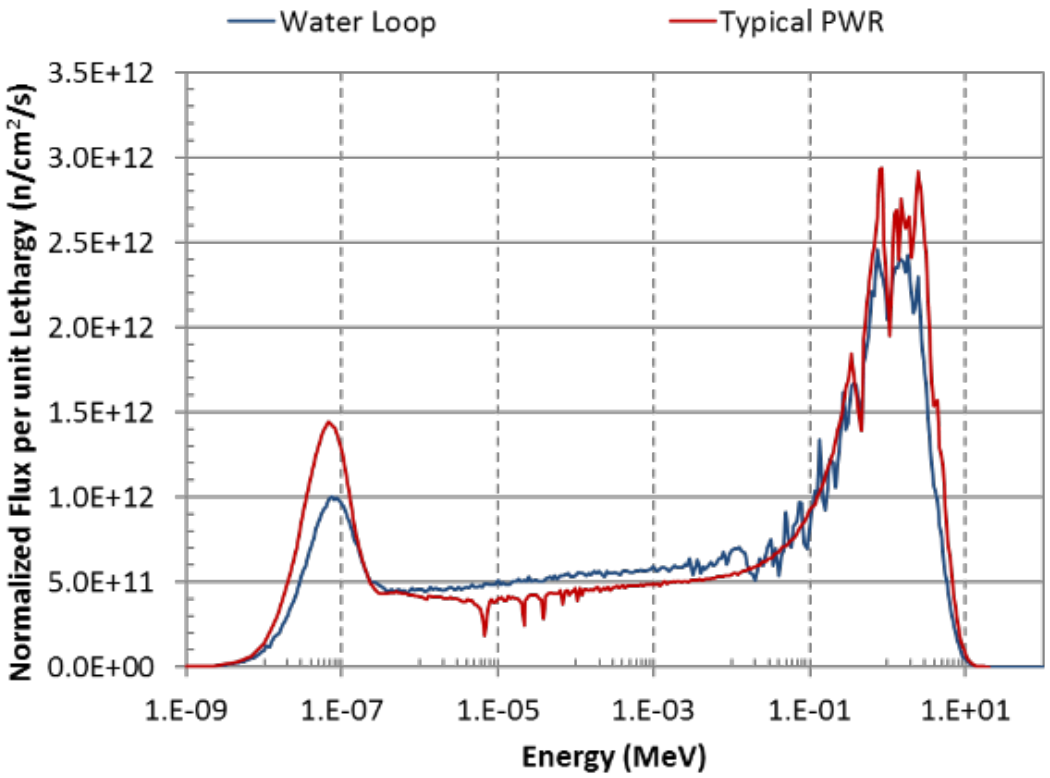
Reactor core tank lid

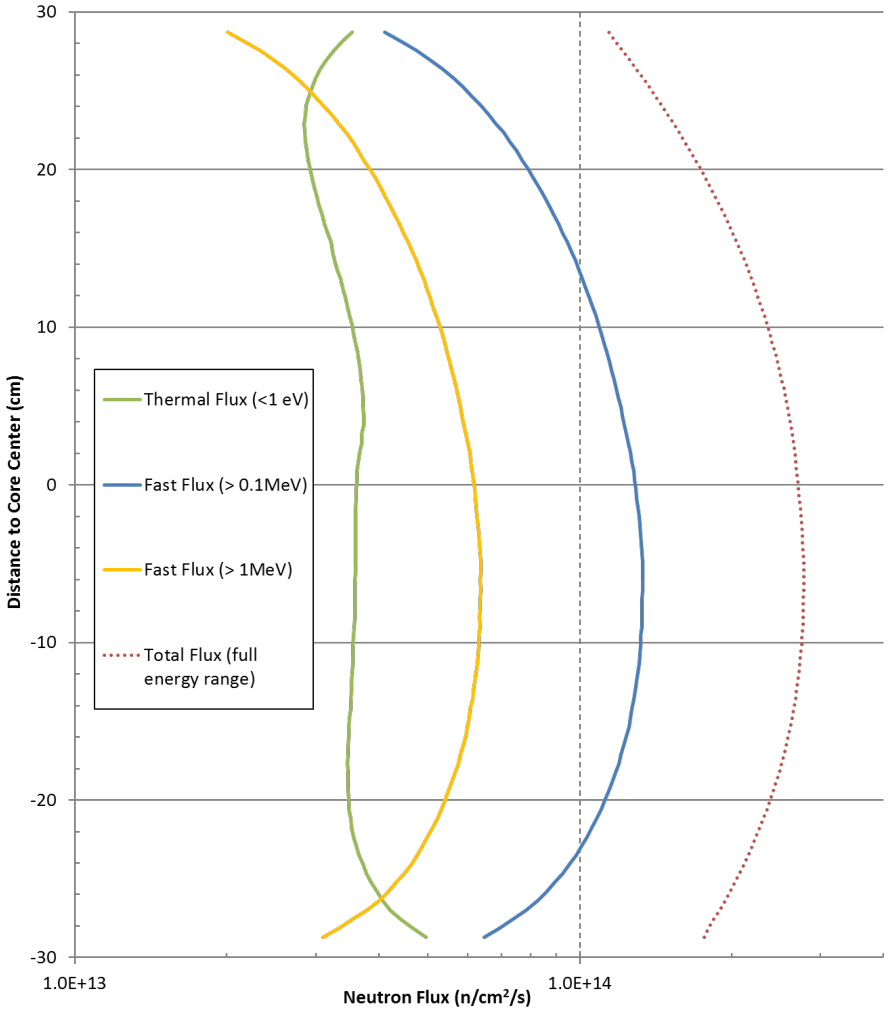
Graphite position sample transfer cask

Graphite position irradiation rig

In-core high temperature water loop

In-core Facilities Neutron Spectrum

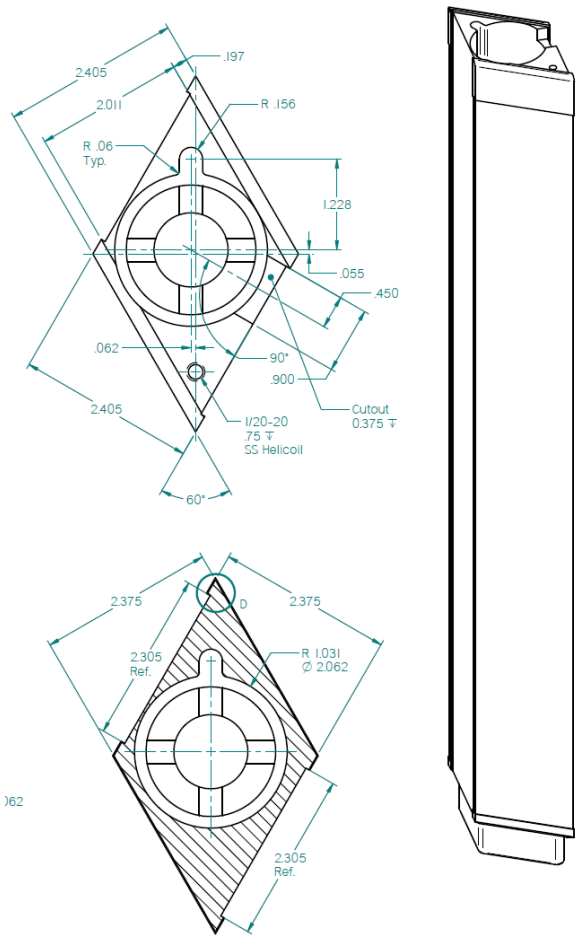


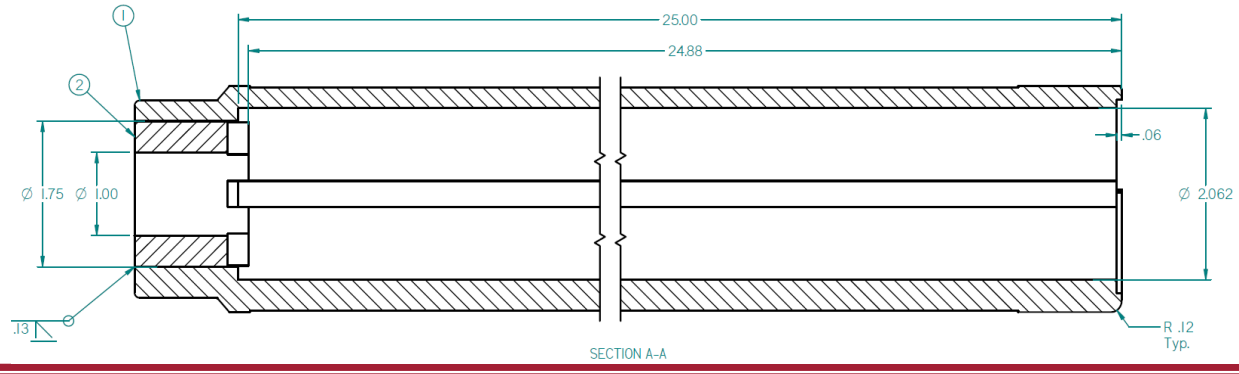


In-core facility available volume

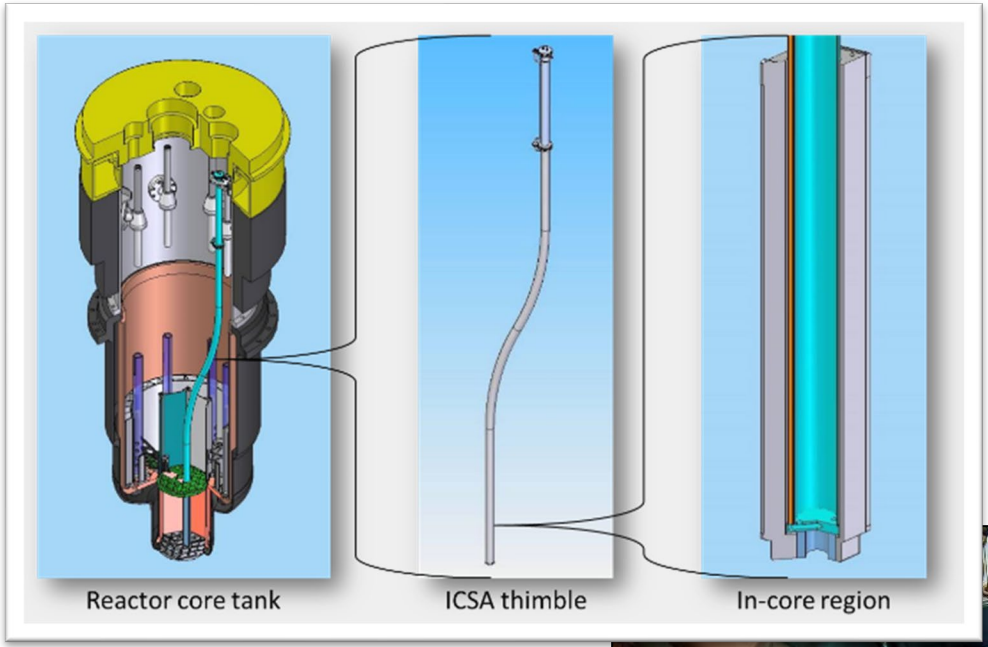
- Typically re-use standard dummy elements and fabricate new thimbles for each experiment

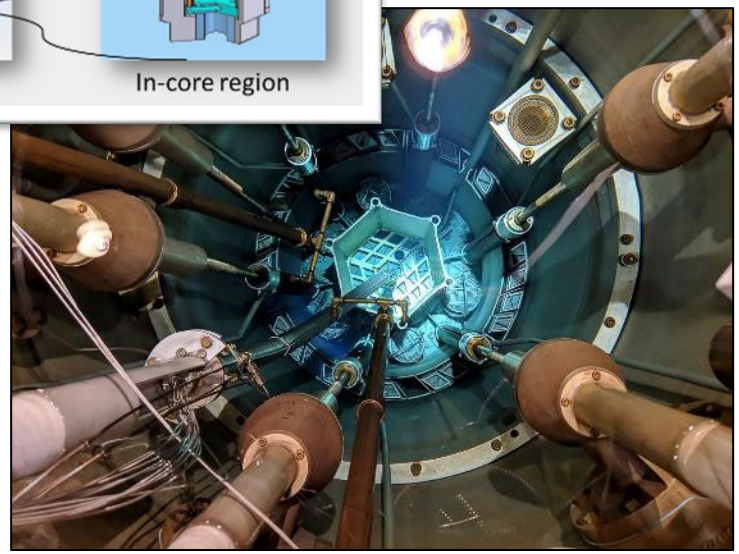
- Largest usable opening in dummy element:
  - 2.0 in (50.8 mm) diameter
  - 24 in (609 mm) height
  - Additional 11 ft (3.4 m) available above this fueled region inside core tank





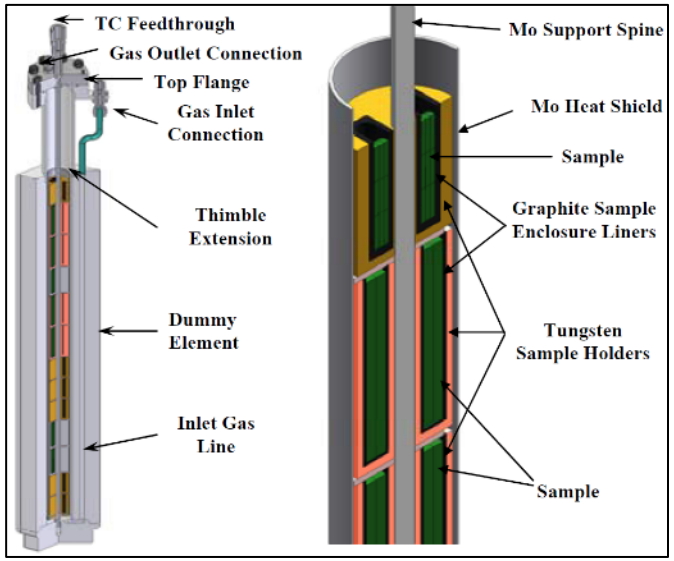
Inert gas in-core facility



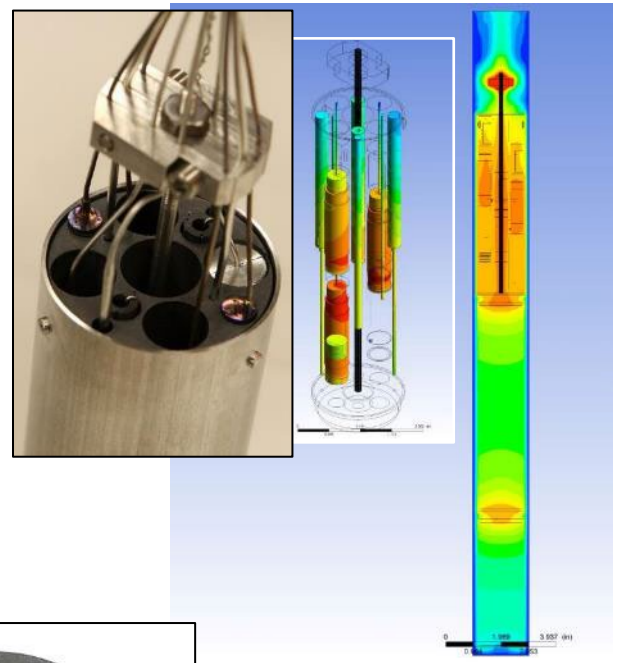


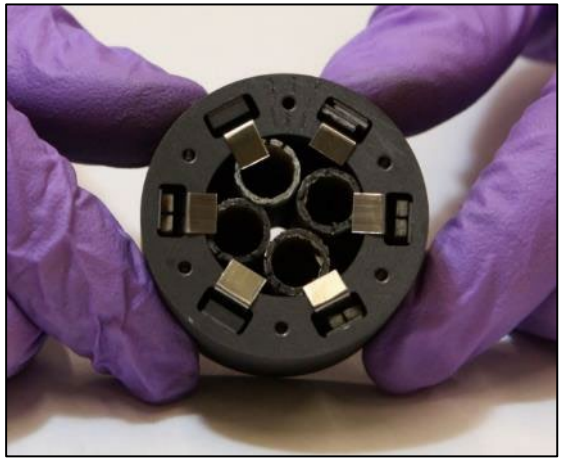
- Support for two helium/neon controlled sweep gas facilities
- Generic facility rated to 900°C, but 1400°C demonstrated with nuclear heating only
  - 450-850°C typical
  - Multi-zone electrical heating available
- Nominal operation single-zone gas control with ±2°C stability
- Typical lead-out capacity 12 x 1/16-inch lines, expandable

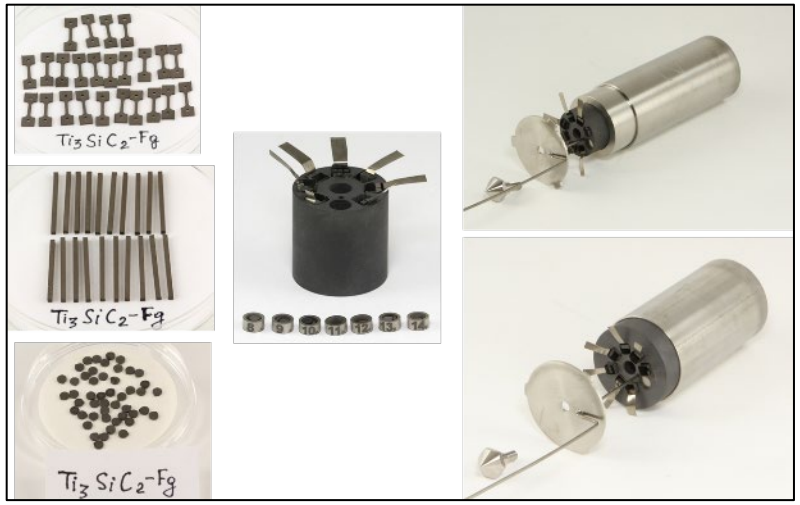
Common loading arrangements

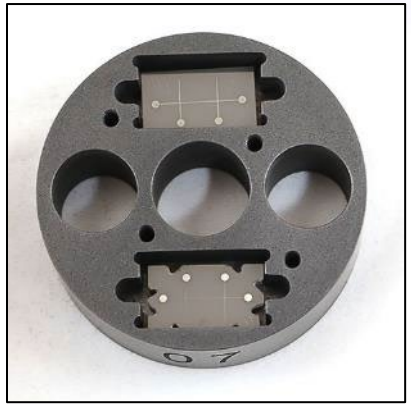


- Mixing samples and instrumentation
- High sample loading capacity
- ~2 W/g heating
- Limited reconstitution between cycles

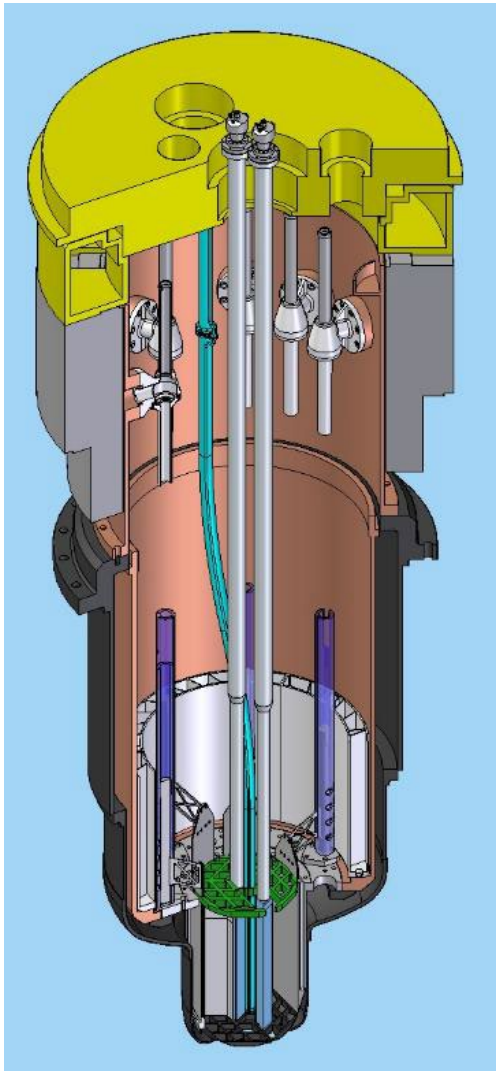








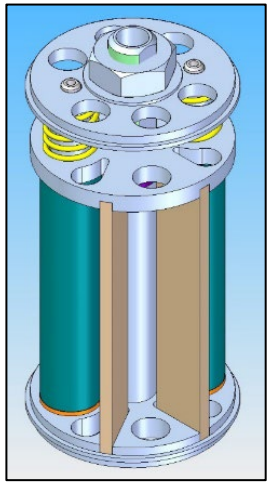
High temperature in-core water loop



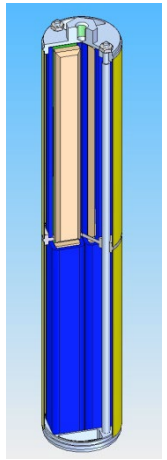
- Pressurized water loop has stepped in-vessel autoclave, with dimensions in-core:
  - 35 mm diameter
  - 495 mm height
- Additional 3.4 m available above the core region, inside core tank
- Currently adding a second water loop position
- Temperatures to 340 °C, pressure, 17 MPa, range of water chemistries

Some water loop capsule designs

Basic unsealed clad tube capsule



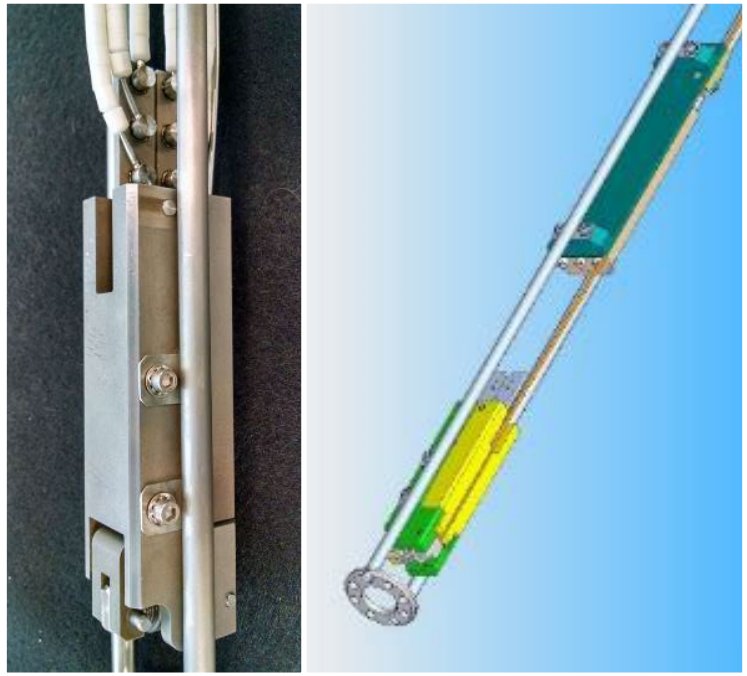
Combination sealed tube and flat plate capsule

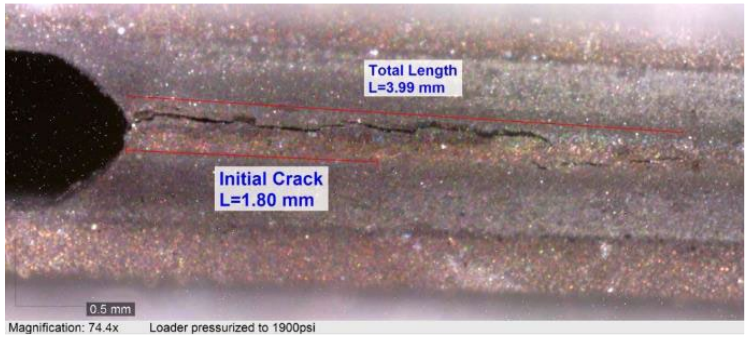


Passively loaded creep test

Water loop instrumentation

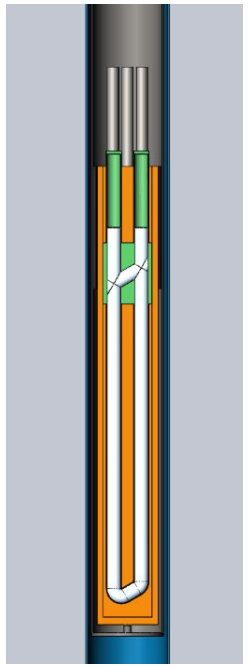
- Good access for instrumentation in core (autoclave head is above the core tank lid)
- Performed real-time fatigue crack growth and crack length measurement by adapting Halden DCPD system
  - 3000 psi driving gas, 6 electrode system
- Measured redox potential using three Halden ECP probes
- Letdown system instrumentation
  - Dissolved gas (H2, O2)
  - Conductivity/resistivity
  - pH
  - Pull samples for lab analysis

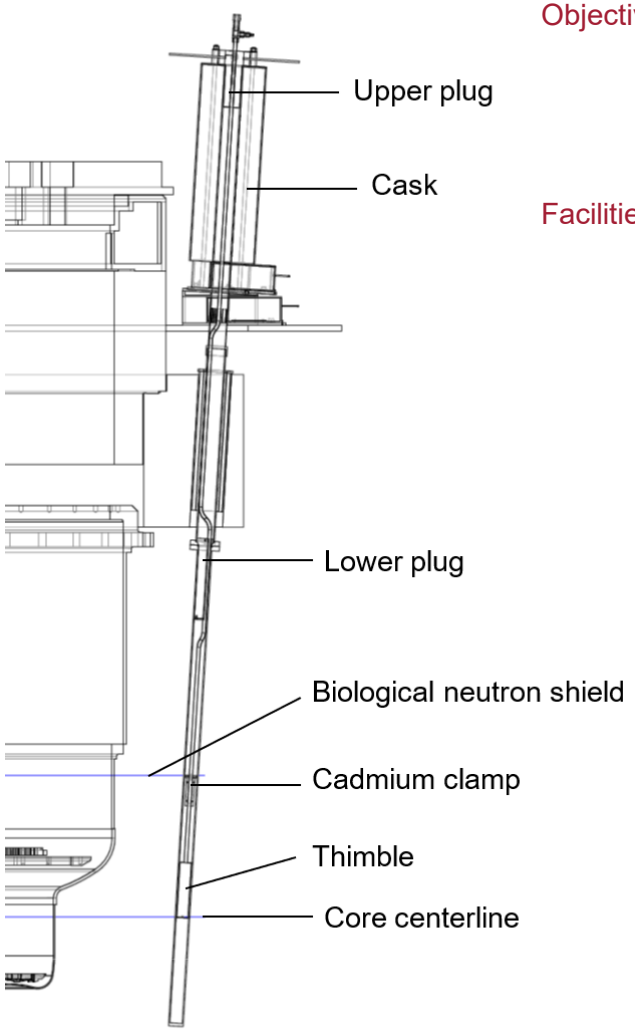




Examples of graphite reflector irradiations

- Molten salt natural convection loop
  - Initial tests with doped flinak
  - Further testing with flibe+actinides
- Irradiation in 3GV6 facility



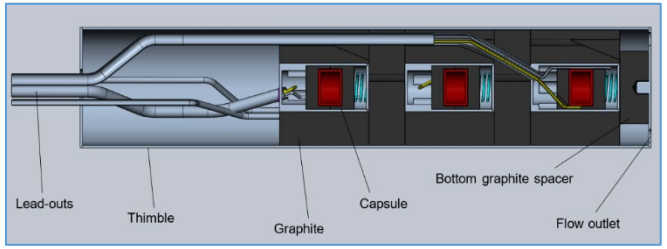


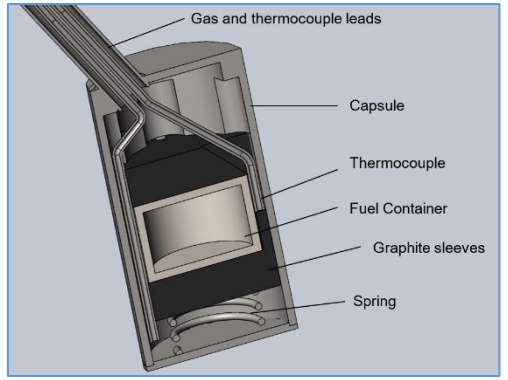
Objective: Irradiation and fission gas release measurements on ORNL-produced Advanced Manufactured fuel compacts

- UN and UCO kernels, TRISO, and TRISO compacts
- 5-50 W/cc
- He atmosphere

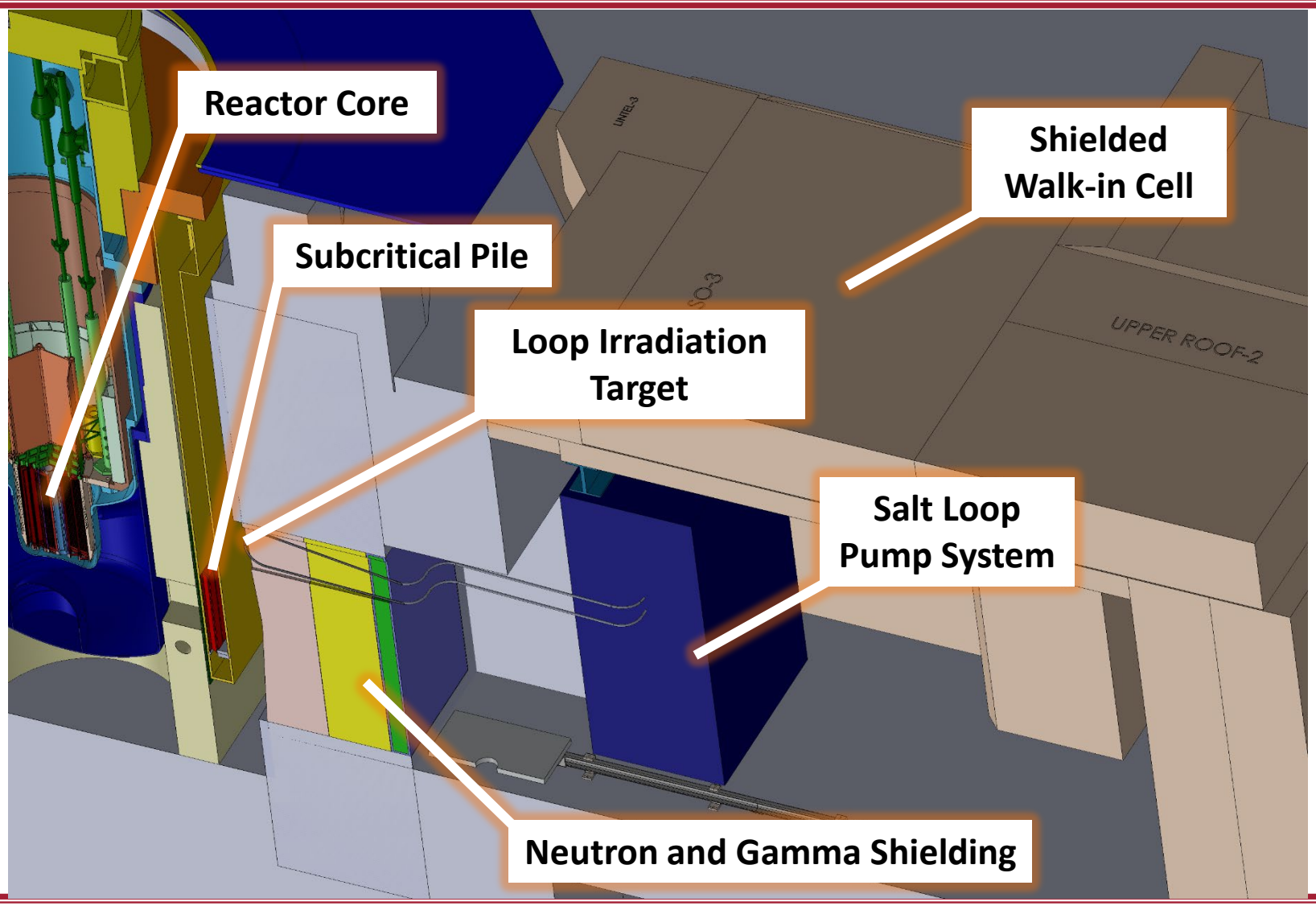
Facilities

- MITR pneumatic irradiation facility for initial evaluation
- MITR 3GV irradiation facility for instrumented tests with periodic in-situ FGR measurement
- NRL counting lab for quantitative fission gas measurements





Cutaway Reactor View Showing MCube



Questions?