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The Transient Reactor Test Facility (TREAT)

January 2025

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Changing the World's Energy Future

Idaho National Laboratory

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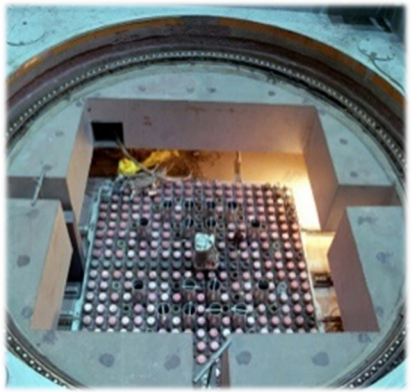
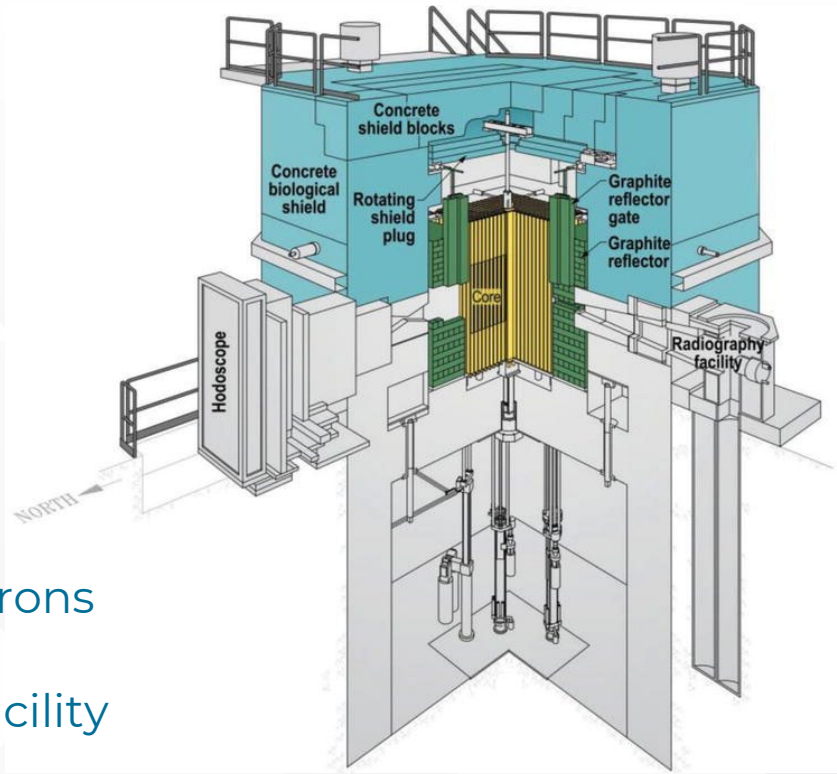
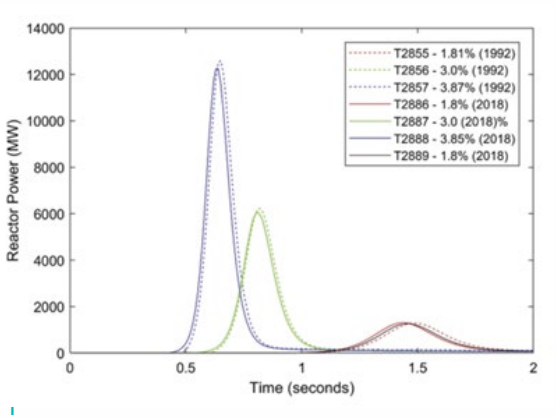
1/2/2025



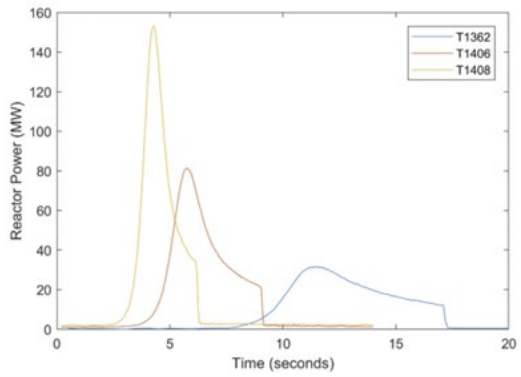
Background on TREAT

- TREAT operated from 1959-1994, later refurbished & resumed operation in 2017 to support fuel safety testing
- Zircaloy-clad graphite/fuel blocks comprise core
  - Virtually any power history possible within ~2000 MJ core transient energy capacity
  - From milliseconds to minutes: Pulses, Ramps, LOCA
- Fuel motion monitoring system "hodoscope" observes fast neutrons emitted from specimens to track fuel relocation in real time
- Reactor also can be a neutron source to adjacent radiography facility
- Experiment vehicle does everything else
  - Safety containment, specimen environment, and instrumentation

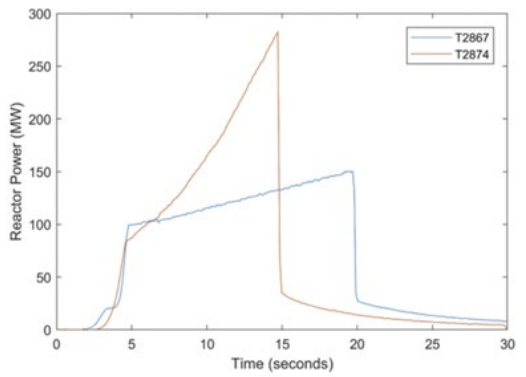




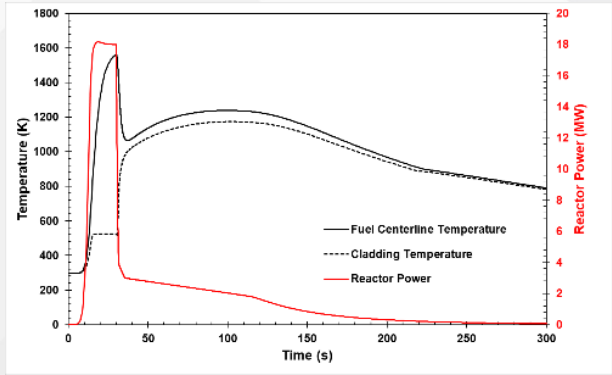
GW-Class Fast Pulses



MW-Class "Slow" Pulses



Overpower Ramps



LOCA Shaped Transient

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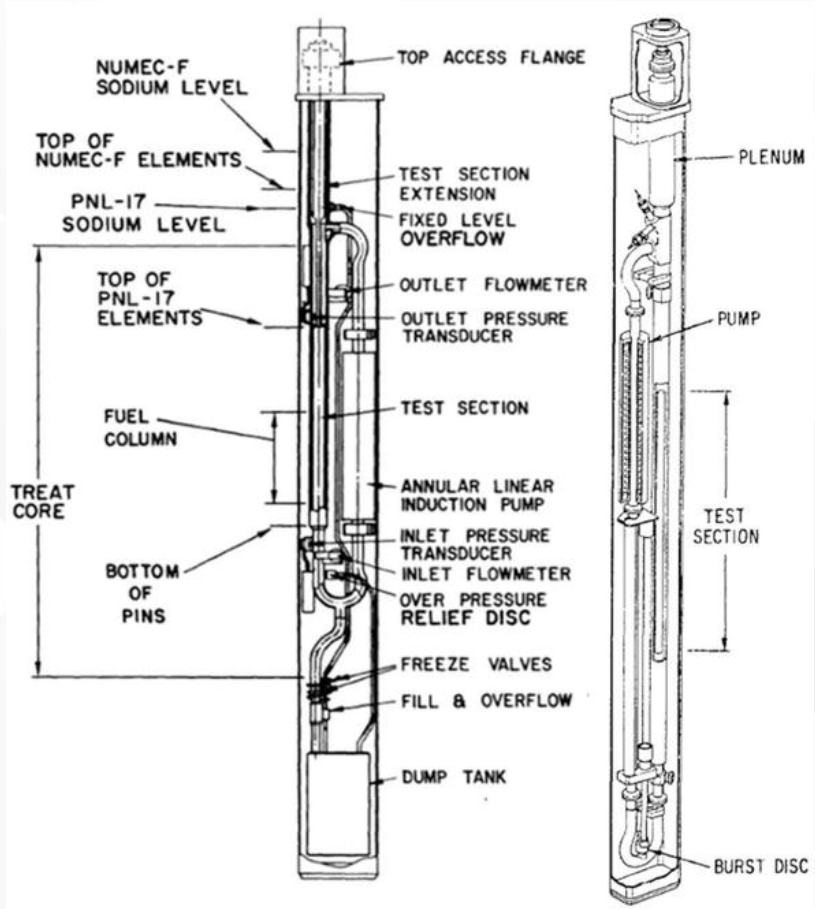
Experiment Design

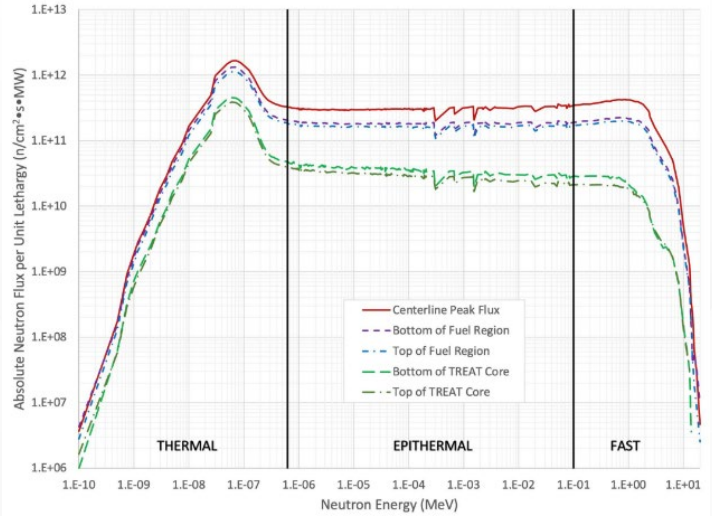
- TREAT: A concrete-shielded block of graphite with a uranium “impurity”
  - No shielded cubicles or reactor pressure vessel
  - Cooled by air blowers during 80 kW steady state runs, and to cool core down after transients
- Supports one primary experiment at a time, and pivots between missions frequently
  - LWR tests one week, SFR tests the next
- Double-contained package type experiments most successful layout
  - Pre-irradiated specimens assembled into casks at HFEF, transported in casks
  - Electrical service and instrumentation leads connections on top of experiment rig
  - Fresh fuel experiments can be usually be irradiated and examined without using hot cells

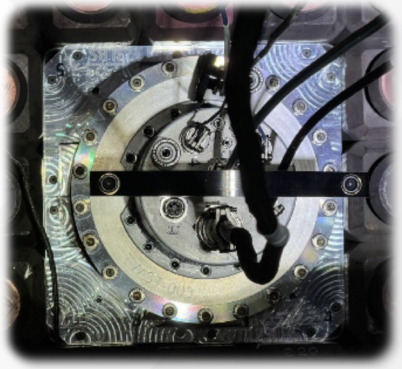


TREAT’s Historic “Loop in a box” workhorse sodium loop, the inspiration for most modern TREAT tests

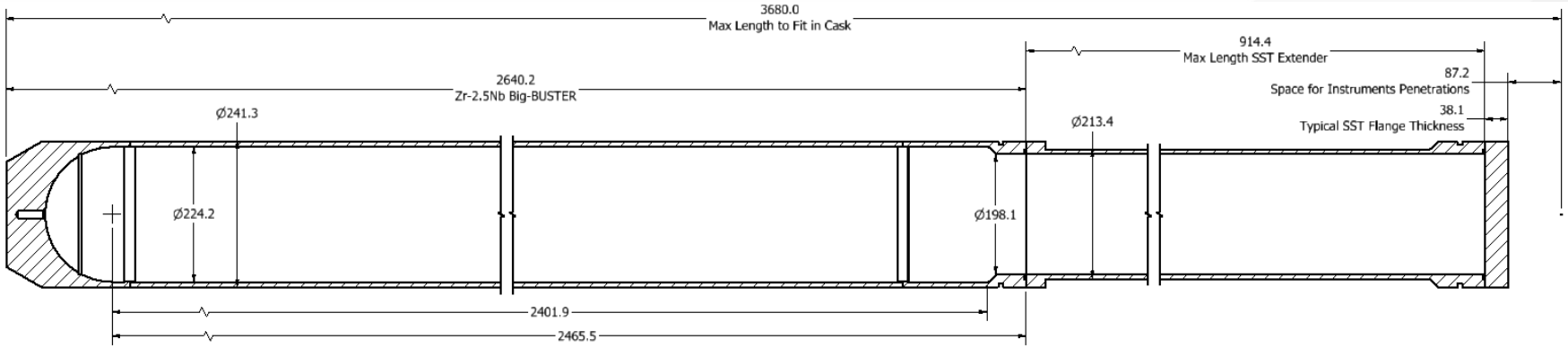
Big-BUSTER

- Enlarged version of the Broad Use Specimen Transient Experiment Rig (Big-BUSTER) developed for modern experiments
  - Reusable nuclear grade outer safety containment, commercial grade inner capsules/loops
  - Large as possible within existing transport casks (shipment between TREAT & HFEF)
  - Graphite moderators and all Zry hardware delivers more, better-thermalized flux to test
    - Max transient fluence ~2.2E16 n/cm^2 (pulse)
  - Maximizes nuclear heating capability in specimens





Big-BUSTER in TREAT core



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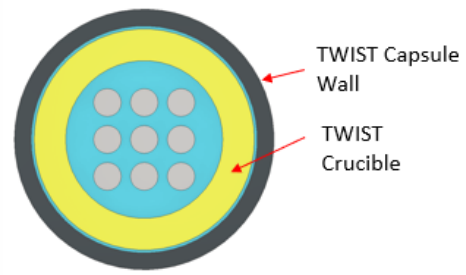
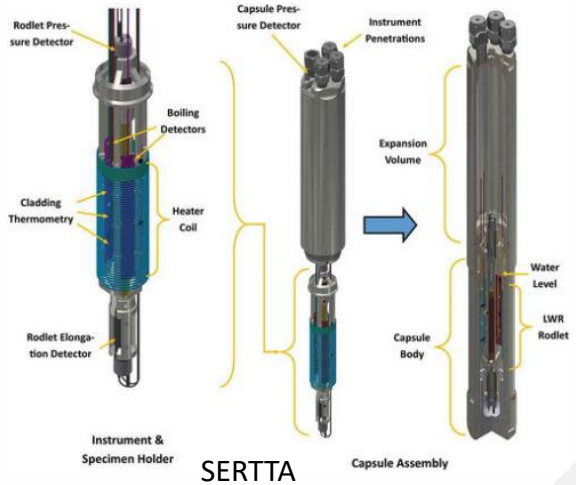
LWR Test Capabilities

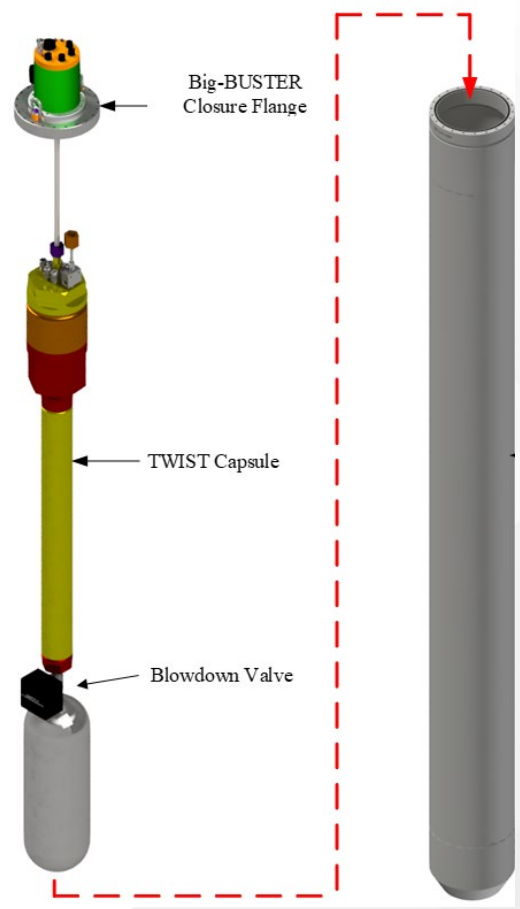
- Existing SERTTA capsule available now for low-cost irradiations
  - Capable of RIA pulses on 10 cm specimens
- Larger TWIST capsule currently undergoing in-reactor commissioning tests
  - Capable of RIA & LOCA , up to 60 cm rods or small bundles
- TWERL water loop (Development underway)
  - Full forced convection for multi-specimen assemblies
- Sensors available to measure temperature, pressure, boiling fraction, & acoustic emission



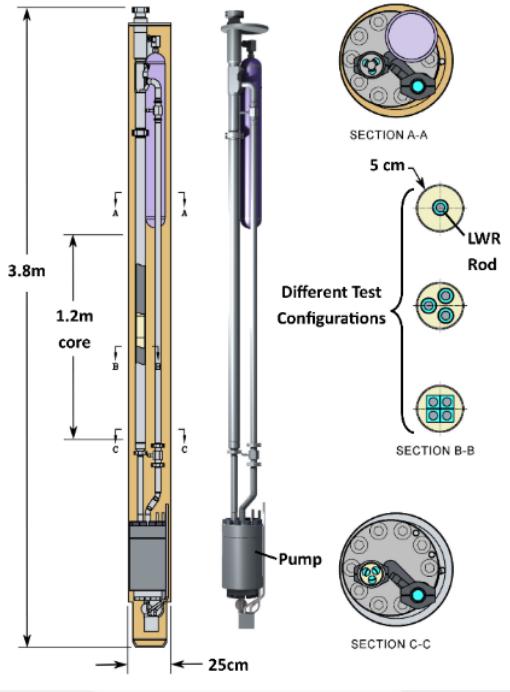
Sketch illustrating 9-rods in TWIST



SERTTA



TWIST (LOCA Config)



TWERL

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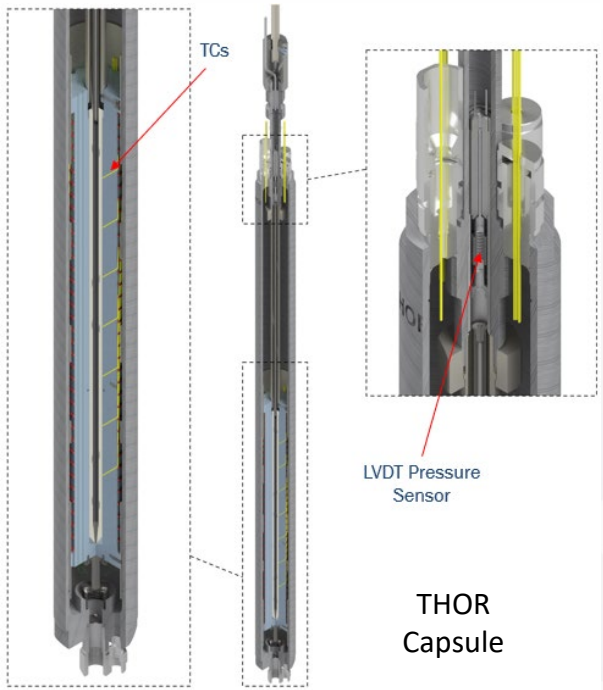
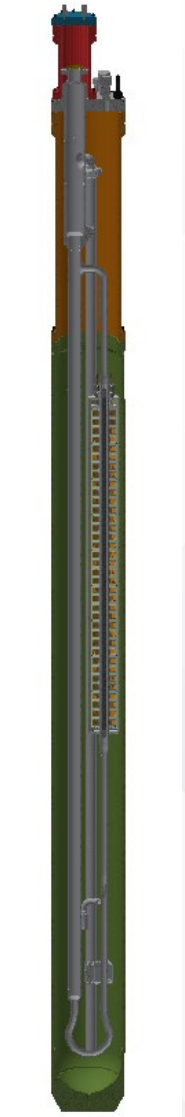
SFR Test Capabilities

- THOR heat sink sodium capsule
  - Capsule sensors: TC's, LVDT for pressure/elongation, acoustic emission sensor for cladding rupture detection
  - THOR tests have been through a few HFEF-TREAT campaigns, glitches have been worked out, a workhouse capsule for testing single-pin, EBR-II length specimens
- Sodium loop (Mk-IIIR, first deployment late 2025)
  - Forced convection loop provides prototypic thermal hydraulic conditions
  - Loop equipped with coolant temperature, pressure, and flowrate instrumentation
  - Options for 2 or 3 pins in individual flow tubes, or single 7-pin mini-bundle, length capacity for FFTF length pins

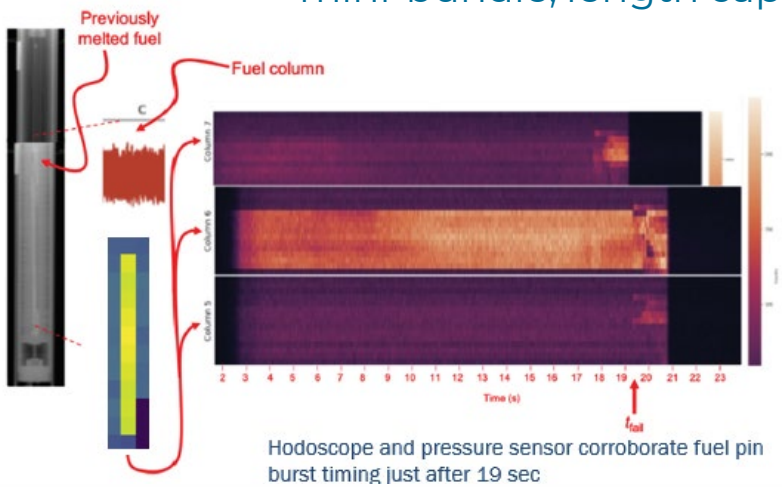


THOR Capsule

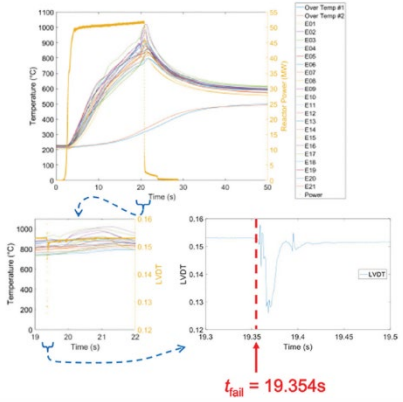


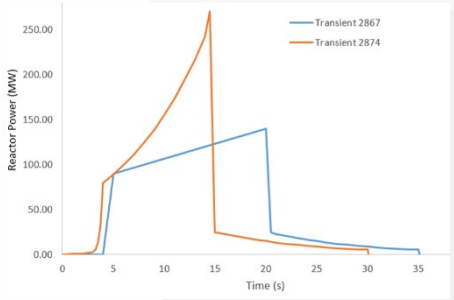
Sodium Loop

Modernized Induction Pump



Hodoscope and pressure sensor corroborate fuel pin burst timing just after 19 sec





Overpower Ramp Transients

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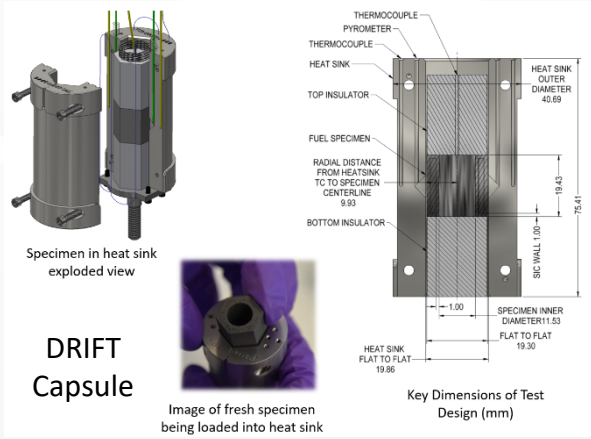
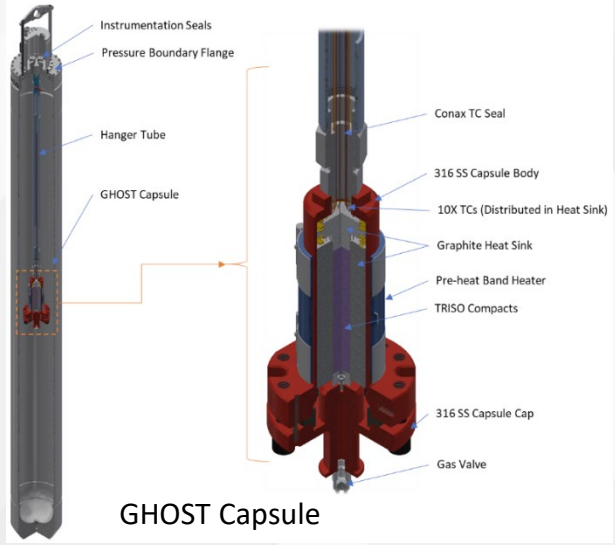
HTGR and Other Capabilities

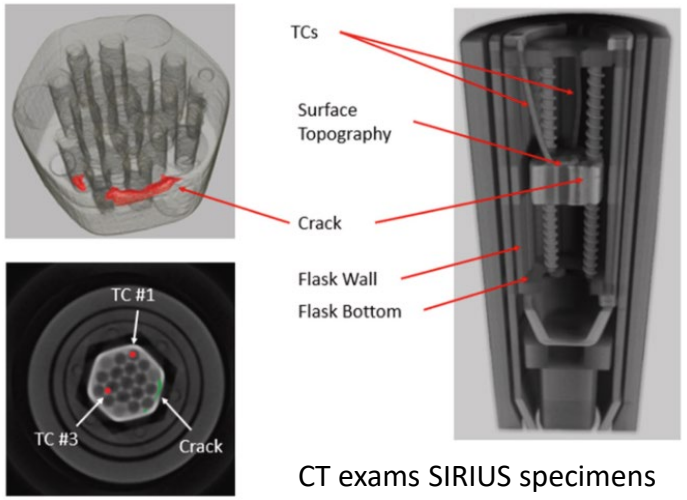
- Existing DRIFT Capsule
  - Used for AM SiC TRISO testing under TCR program
- GHOST Capsule (first test early 2025)
  - Helium environment, graphite heat sink, designed for testing TRISO compacts
  - High temperature pre-transient electrical heater
- Existing SIRIUS capsule
  - High temperature capsule with corresponding instrumentation
  - Used for space nuclear propulsion fuels testing to simulate engine startup ramp to power
  - Flowing hydrogen loop to be installed in future
- Molten salt (as coolant or fuel)
  - Loop concepts have been brainstormed, seems feasible
- Other ideas or needs
  - Let us know, there's probably a way to make it work in TREAT



DRIFT Capsule



GHOST Capsule



CT exams SIRIUS specimens

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