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Inauguration of the LOCA Blowdown Capsule for TREAT

November 2023

Klint Stephens Anderson

Changing the World's Energy Future

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Advanced Fuels Campaign

Inauguration of the LOCA Blowdown Capsule for TREAT

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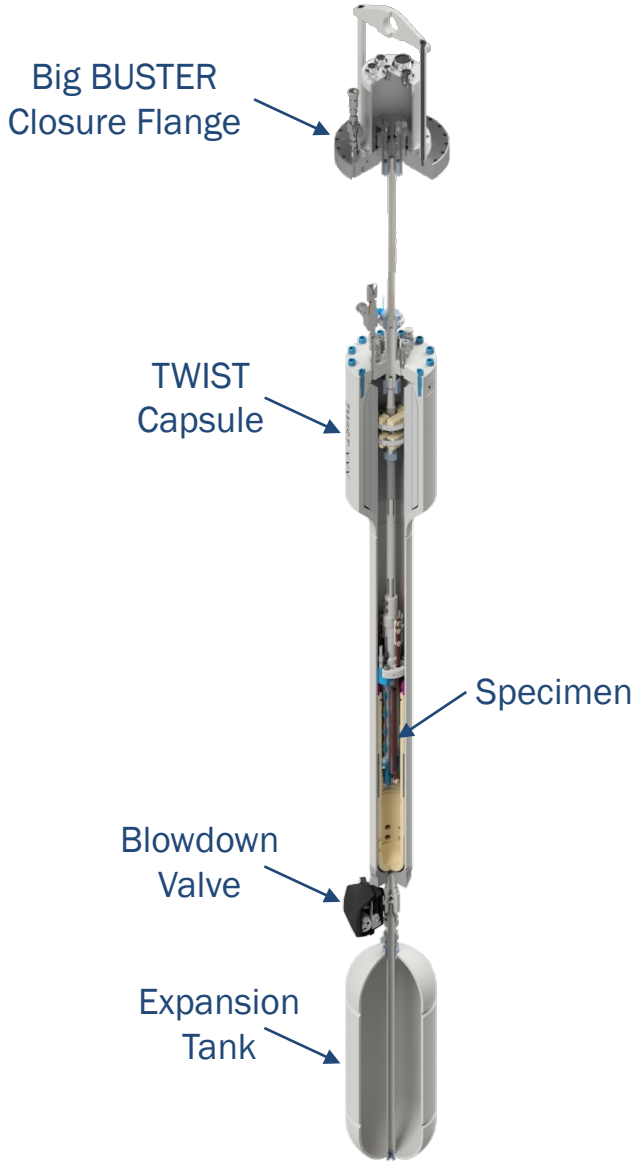
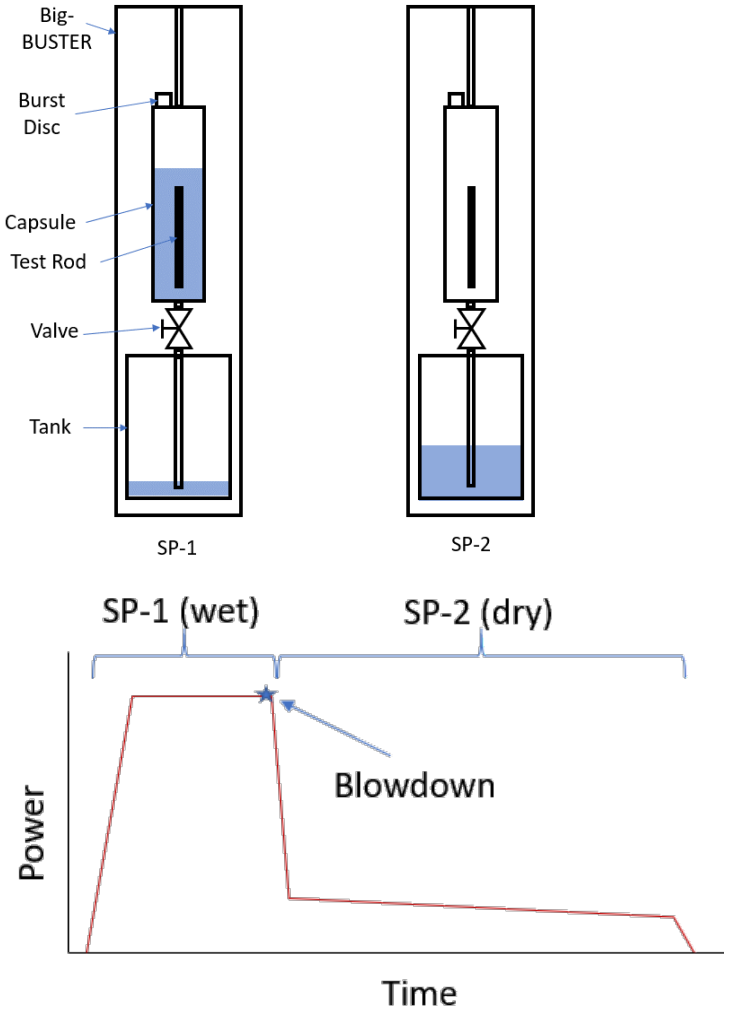
U.S. DEPARTMENT OF ENERGY | Office of NUCLEAR ENERGY

Transient Water Irradiation System for TREAT (TWIST)

- Simulates LWR Loss of Coolant Accidents (LOCA)
- State Point 1 (SP-1)
  - Water in capsule at 20° C and ~ 500 psi
  - ~30 second transient segment ~40MW reactor power
  - Nucleate boiling to achieve LWR fuel temperature state
- State Point 2 (SP-2)
  - Valve opens, water drains in ~2-3 seconds
  - ~100 second transient segment ~5 MW reactor power
  - LOCA "prototypic" specimen temperature rise





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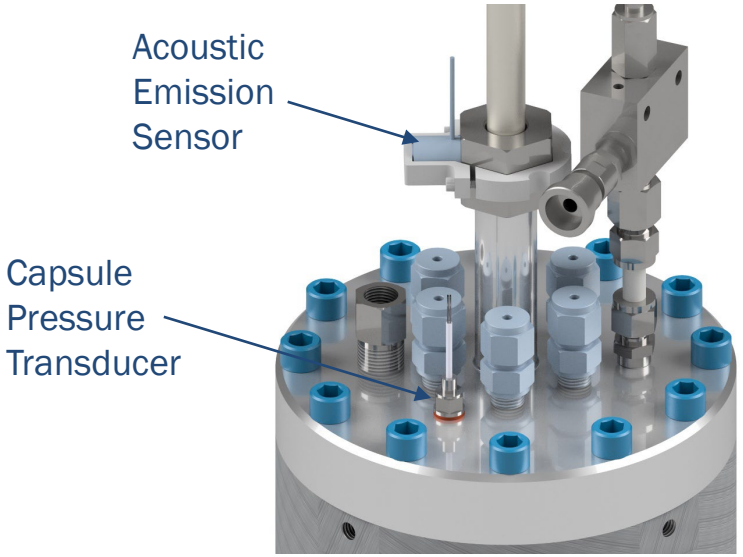
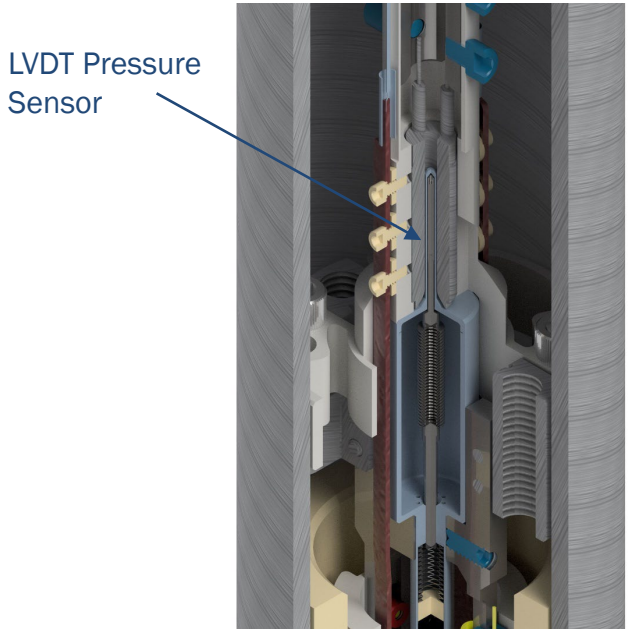
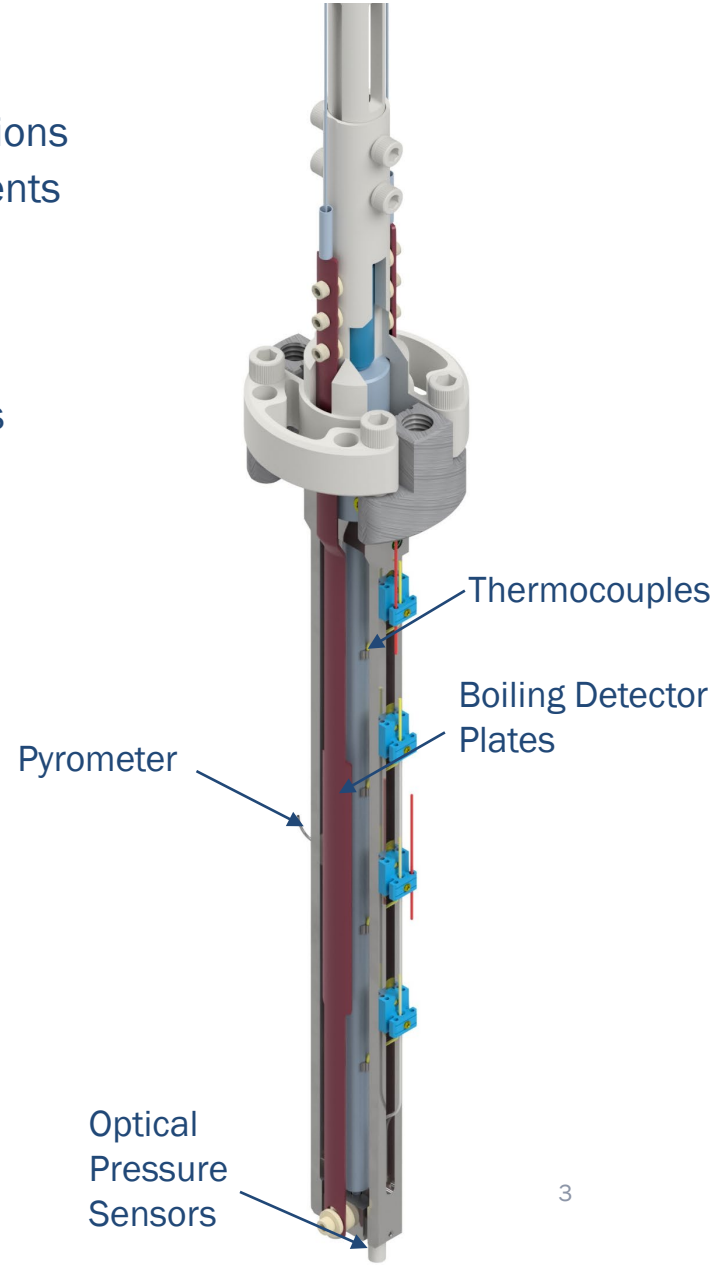
Instrumentation

- Instrumentation Package Includes
  - 6-10 thermocouples measure cladding and water temperature at various axial elevations
  - Thermocouple for centerline fuel temperature or LVDT for rodlet pressure measurements
  - Pressure Transducer for capsule pressure
  - Optical Pyrometer for cladding temperature
  - Fiber Optic Pressure Sensors located inside the capsule
  - Electroimpedence Sensors (Boiling Detector Plates) to measure phase change events
  - Acoustic Emission Sensor for cladding rupture detection

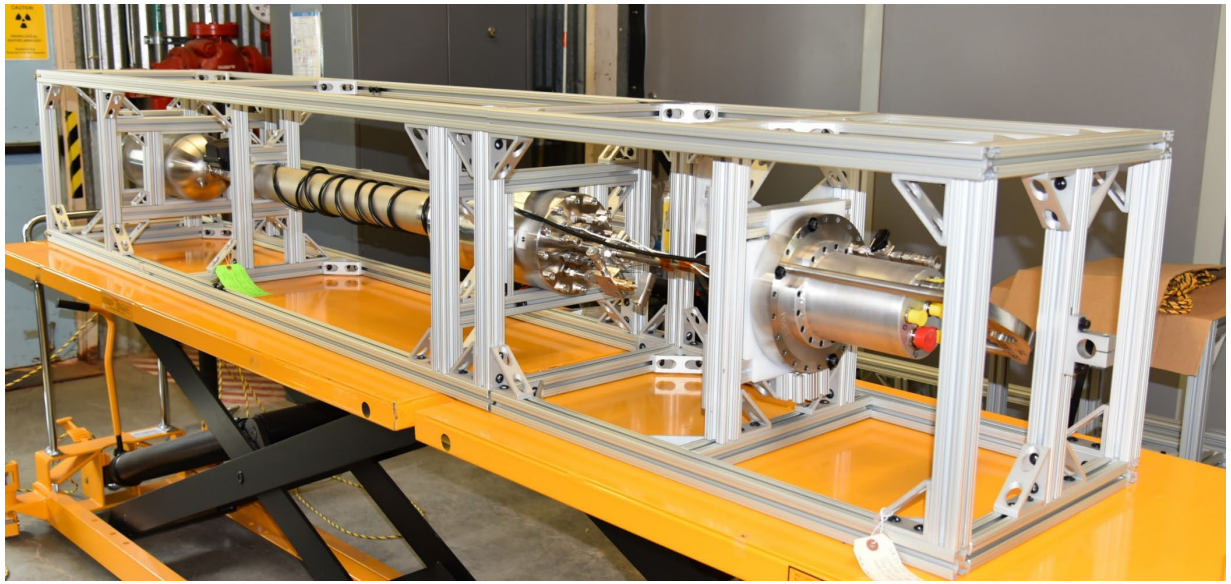


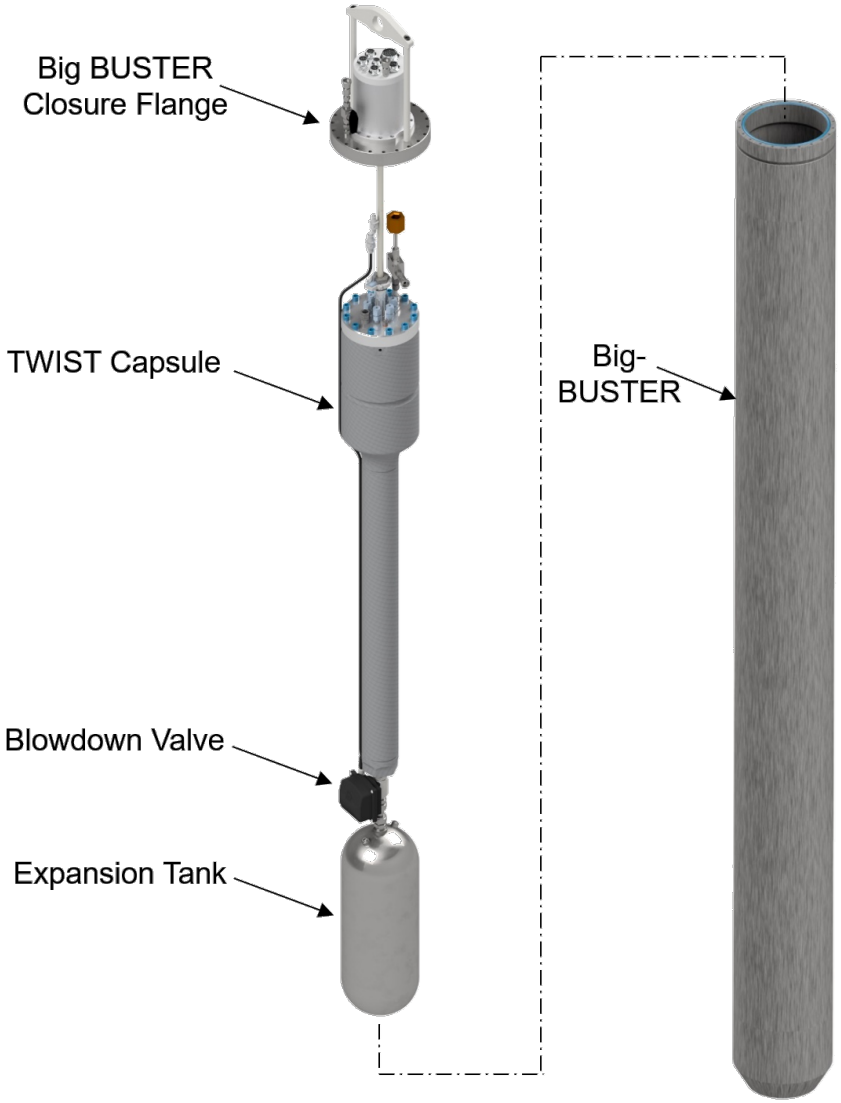




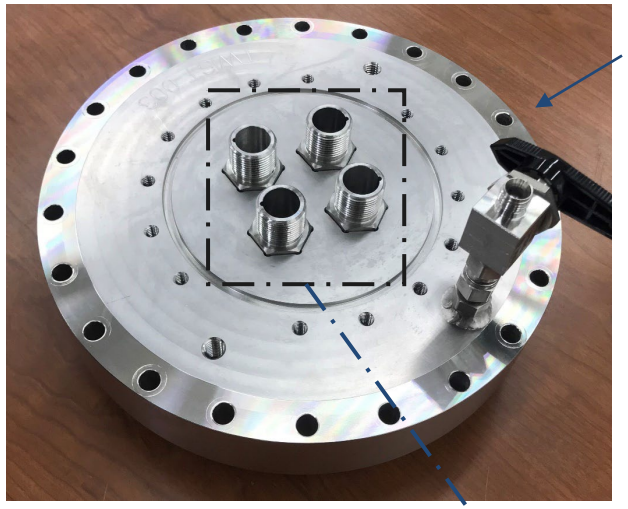
FY23 Scope

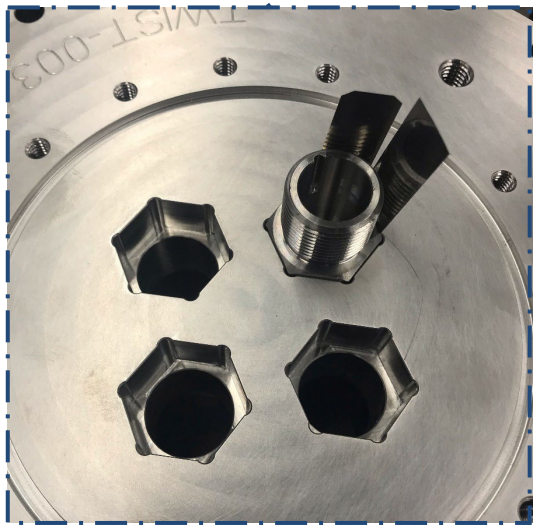
- Inauguration of the LOCA blowdown capsule for TREAT
  - Complete the fabrication, assembly, and irradiation of the first experiment utilizing the TWIST capsule
  - The size of the TWIST capsule requires coordination between multiple INL facilities all working in parallel
  - The inauguration of the TWIST capsule restores LOCA safety testing capability to the U.S.





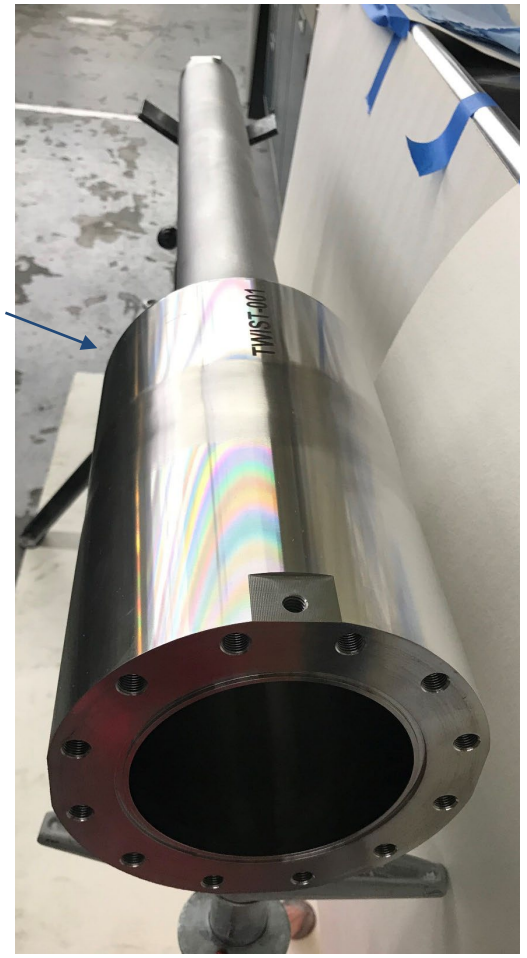
Component Fabrication





Big BUSTER
Closure Flange

TWIST
Capsule

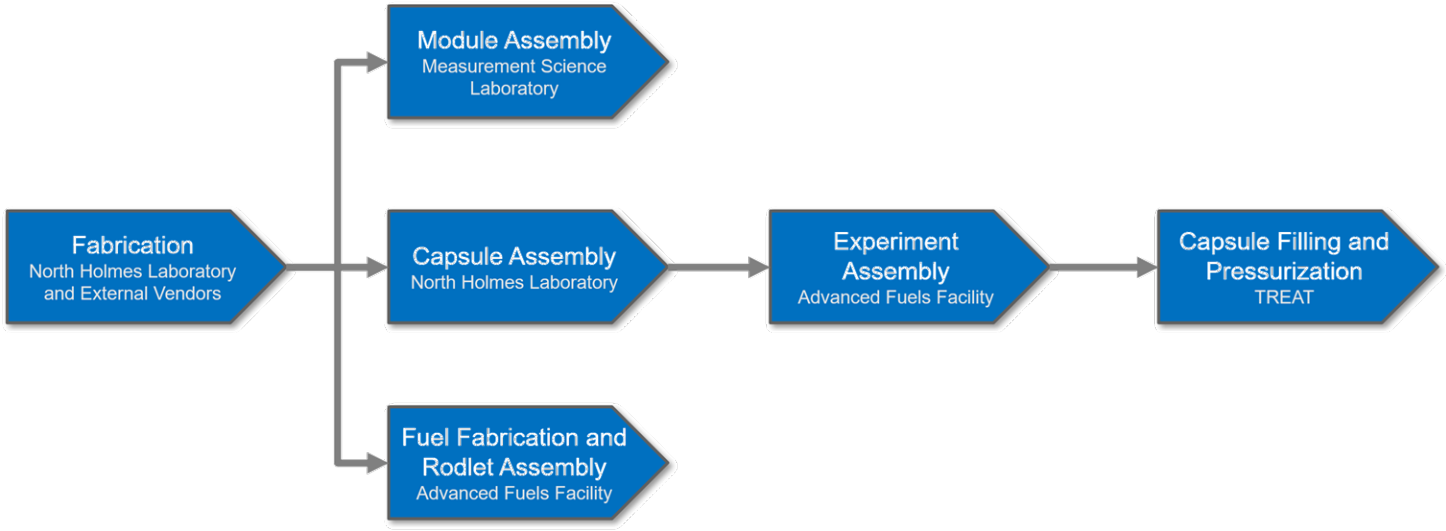


Capsule Filler Pieces

Specimen Holder Support

Examination and Testing

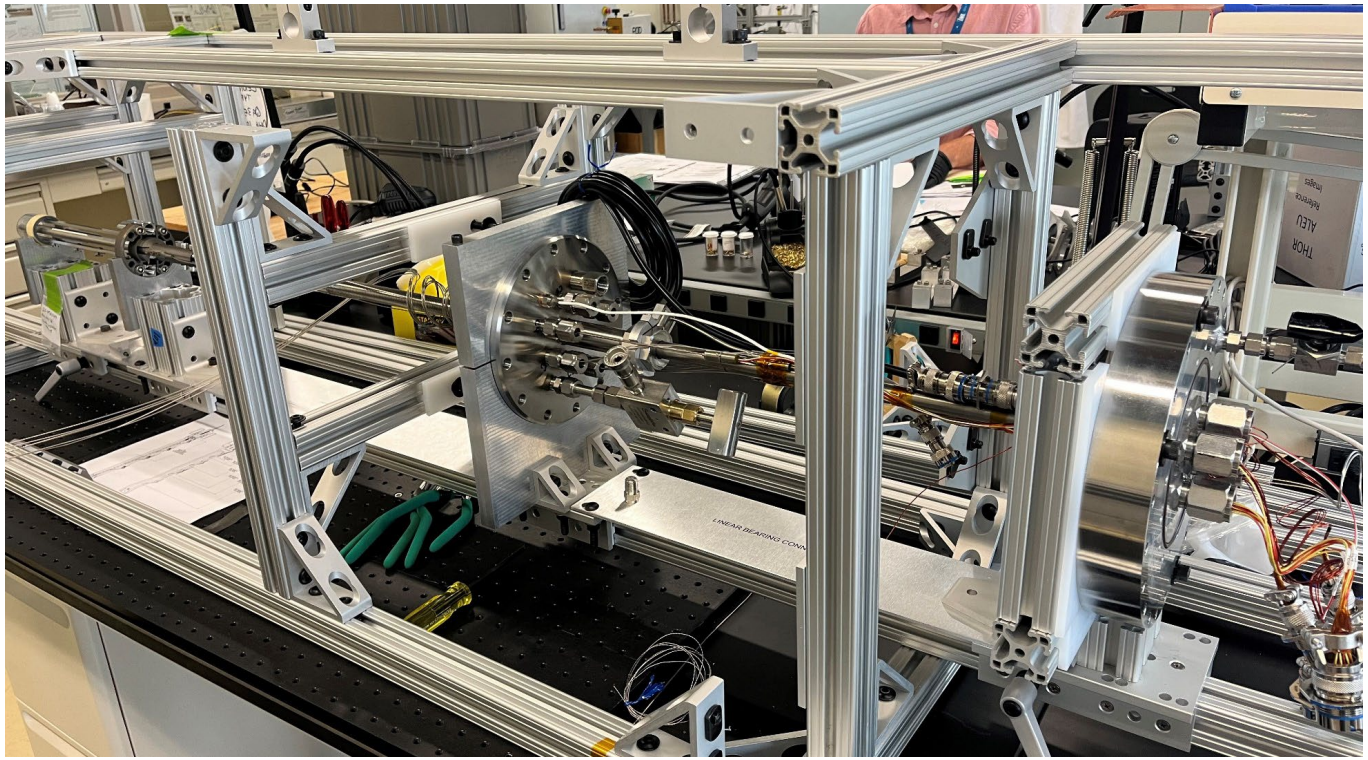
- Components were fabricated at internal INL machine shops and by external vendors
- Following fabrication, components were inspected, examined, and pressure tested at INL North Holmes Lab (NHL) prior to assembly



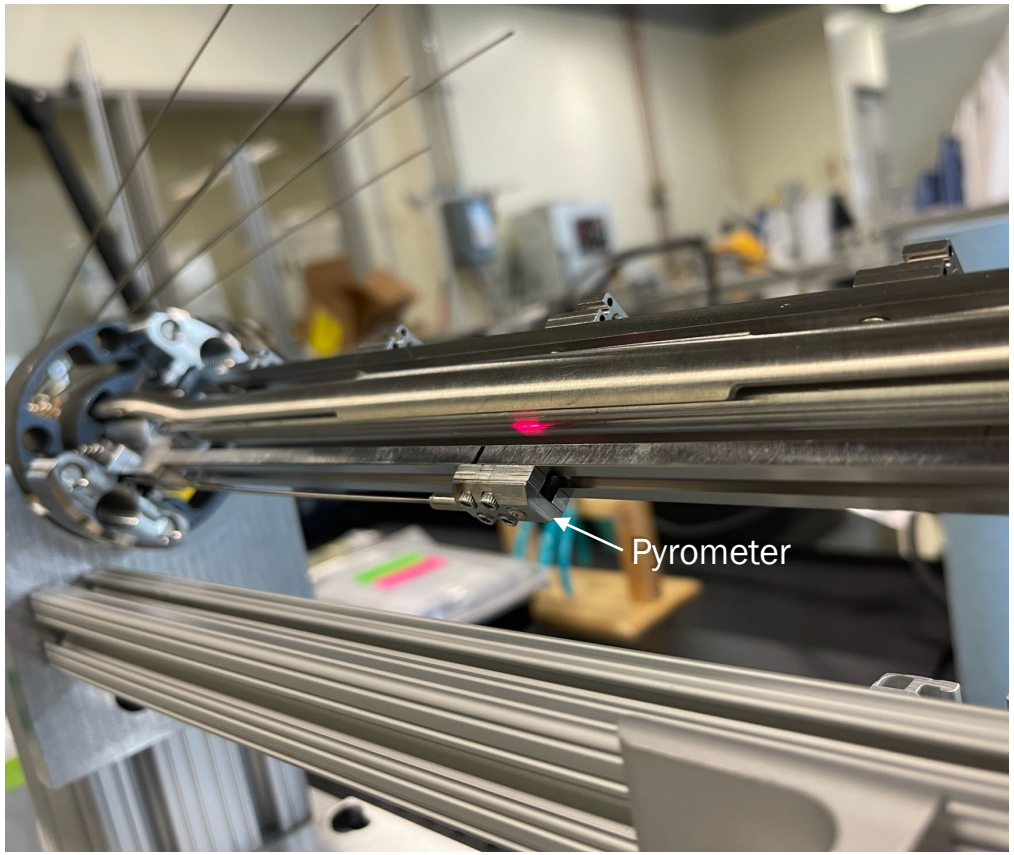
Capsule and expansion tank assembly

Module Assembly

- Specimen holder module and instrumentation assembled, tested, and calibrated at the INL Measurement Science Laboratory (MSL)

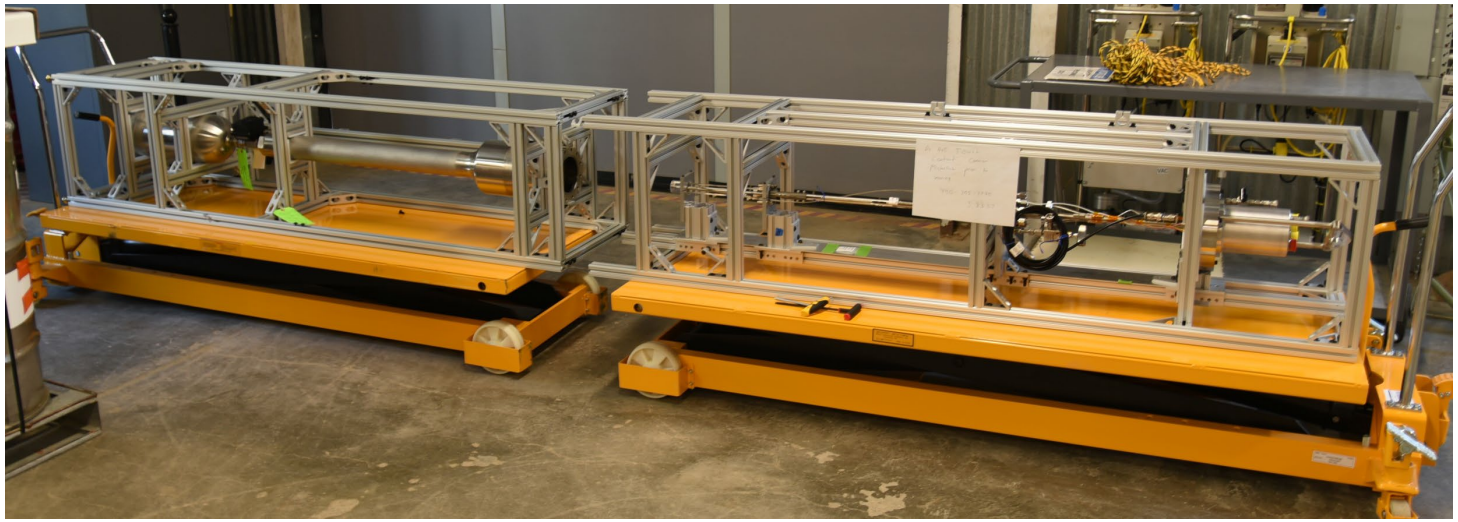


Instrumented Module Assembly



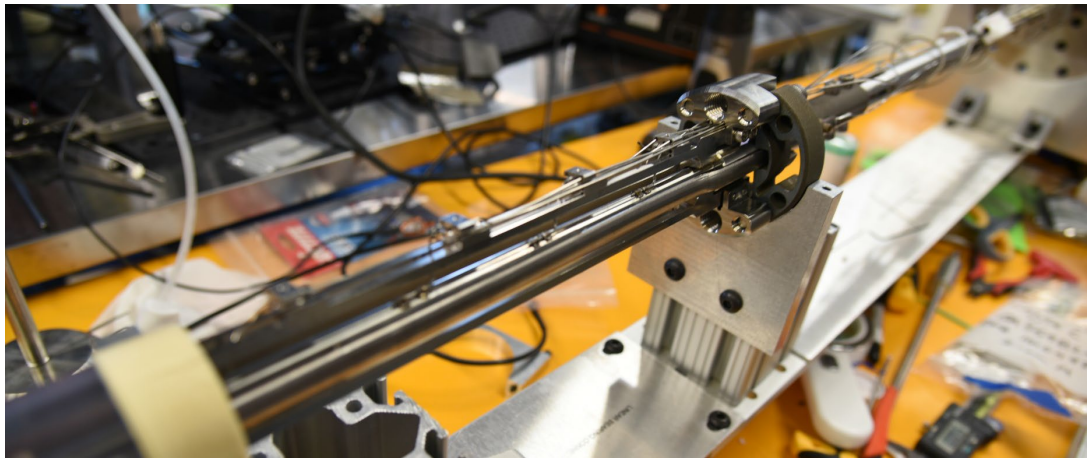
Final Assembly

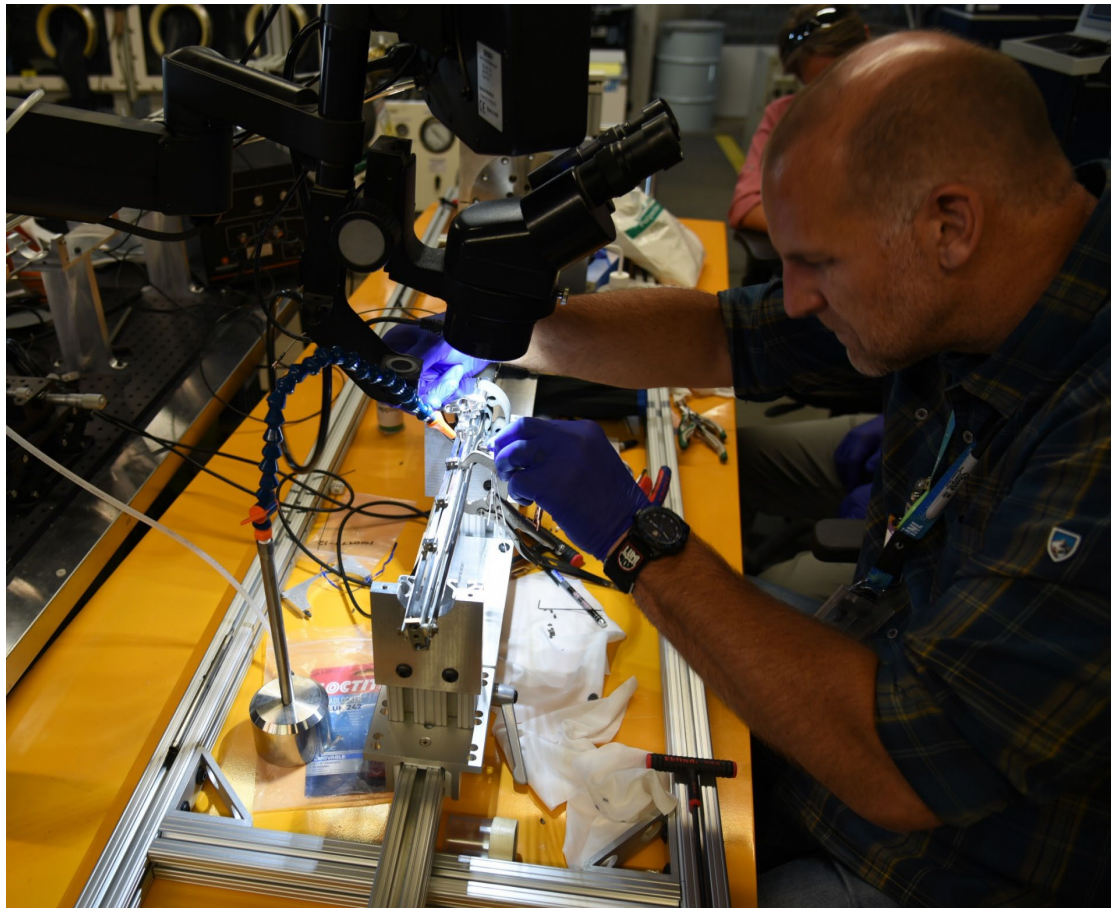
- The module and capsule assembly were delivered to the INL Advanced Fuels Facility (AFF) for final assembly
- Aluminum frame served as an assembly fixture, shipping crate, and upending stand



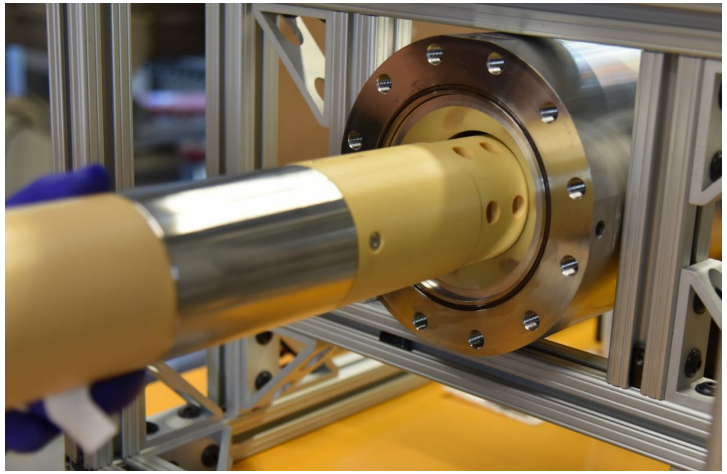
Fuel Rodlet Assembly

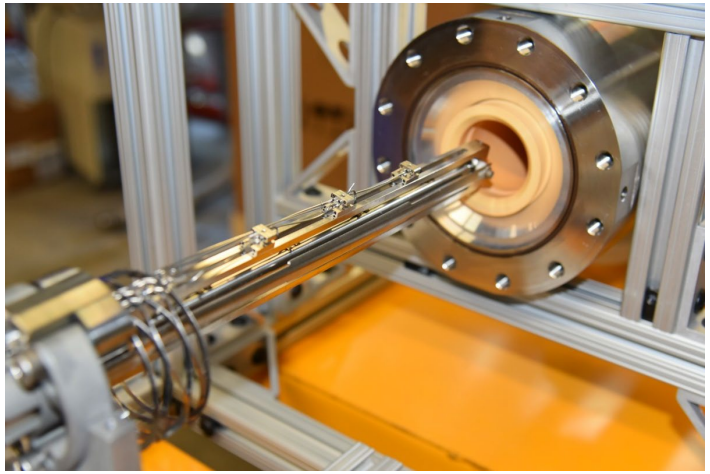
- At AFF the rodlet was assembled, loaded into the module, and thermocouples were secured to the cladding using zircaloy weld clips

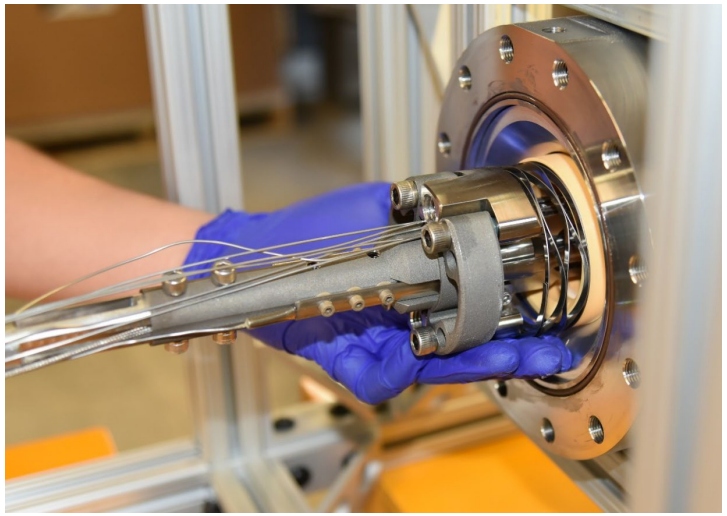


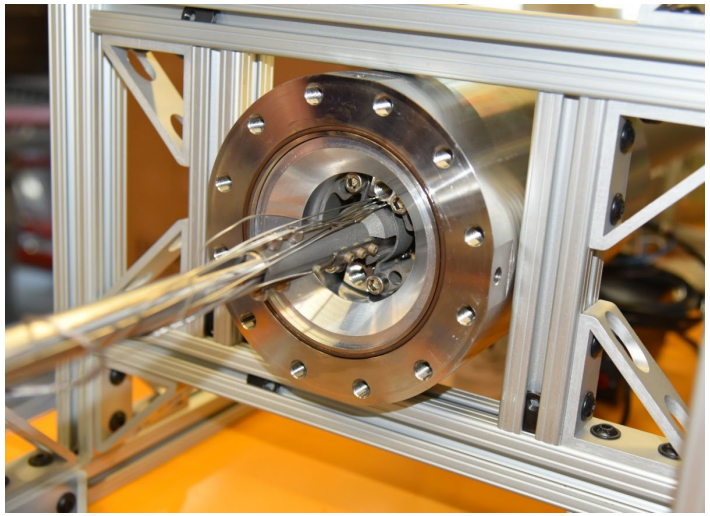


Final Assembly









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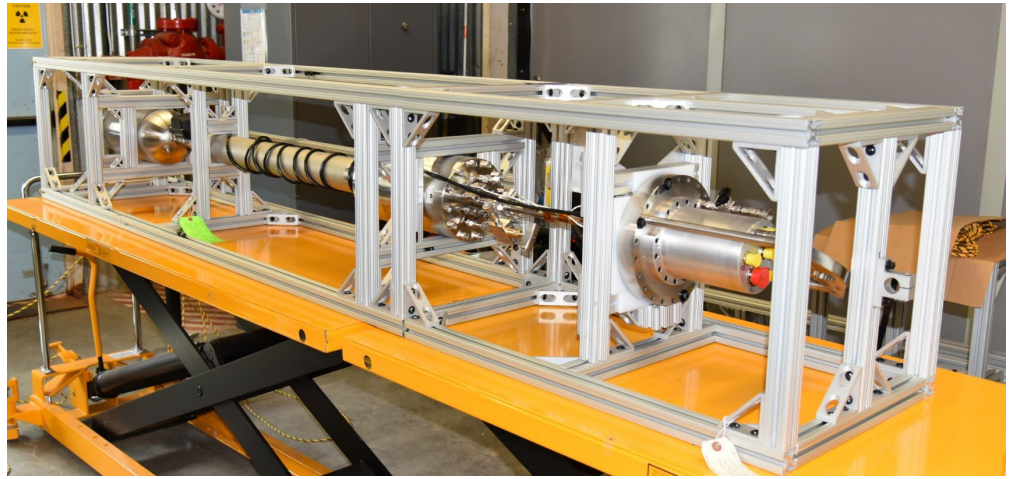
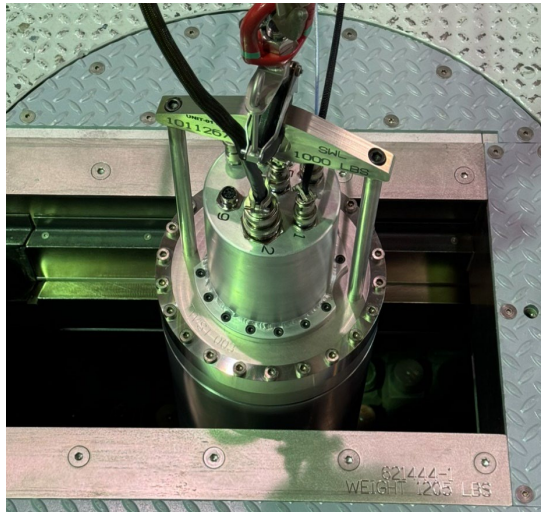
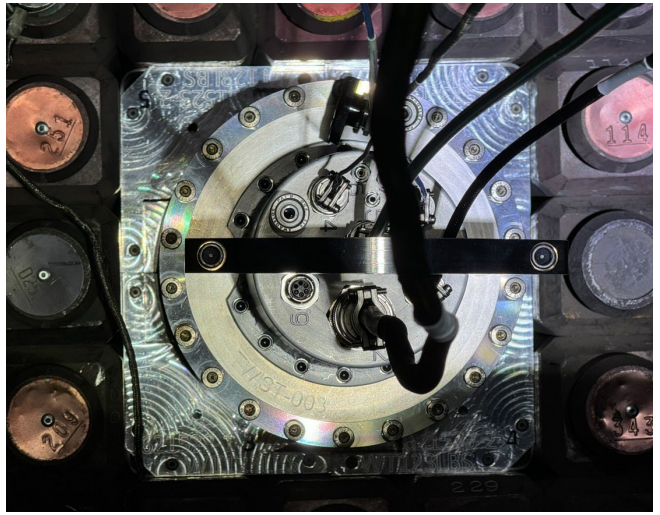
- The TWIST experiment assembly was completed at TREAT
  - The capsule was filled with water and pressurized to 500 psi after an argon purge
  - Capsule leak check and installation in Big-BUSTER
  - Big-BUSTER leak check



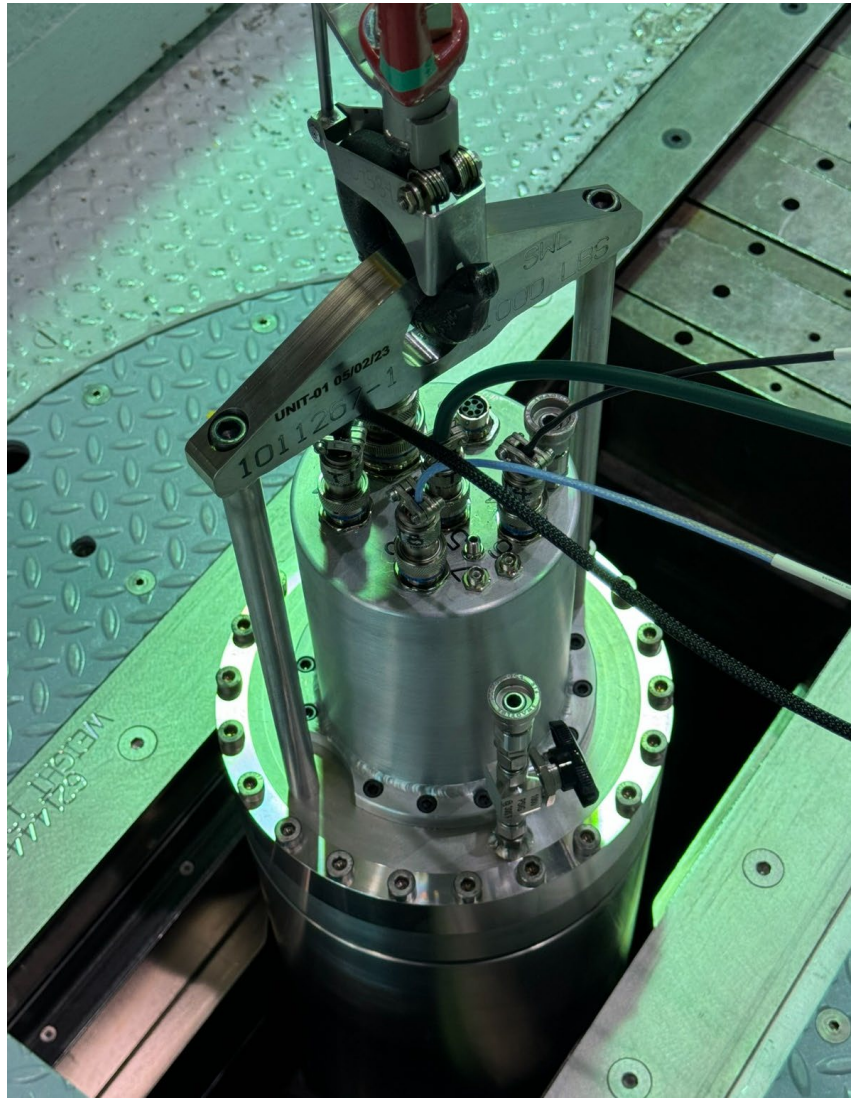
TWIST Device Commissioning Accomplishment

- Completed the fabrication, assembly, and first commissioning test of the TWIST device
- The newly commissioned capsule restores LOCA safety testing capability to the U.S. and allows continued research on fuel fragmentation relocation and dispersal (FFRD)
- The TWIST capsule addresses industry needs to support ongoing efforts to extend the allowable fuel burnup limits in Light Water Reactors (LWR) and helps eliminate capability gaps resulting from the closure of the Halden Boiling Water reactor





TWIST in TREAT Core Reconfigured for Big-BUSTER



TWIST Installation into TREAT Core

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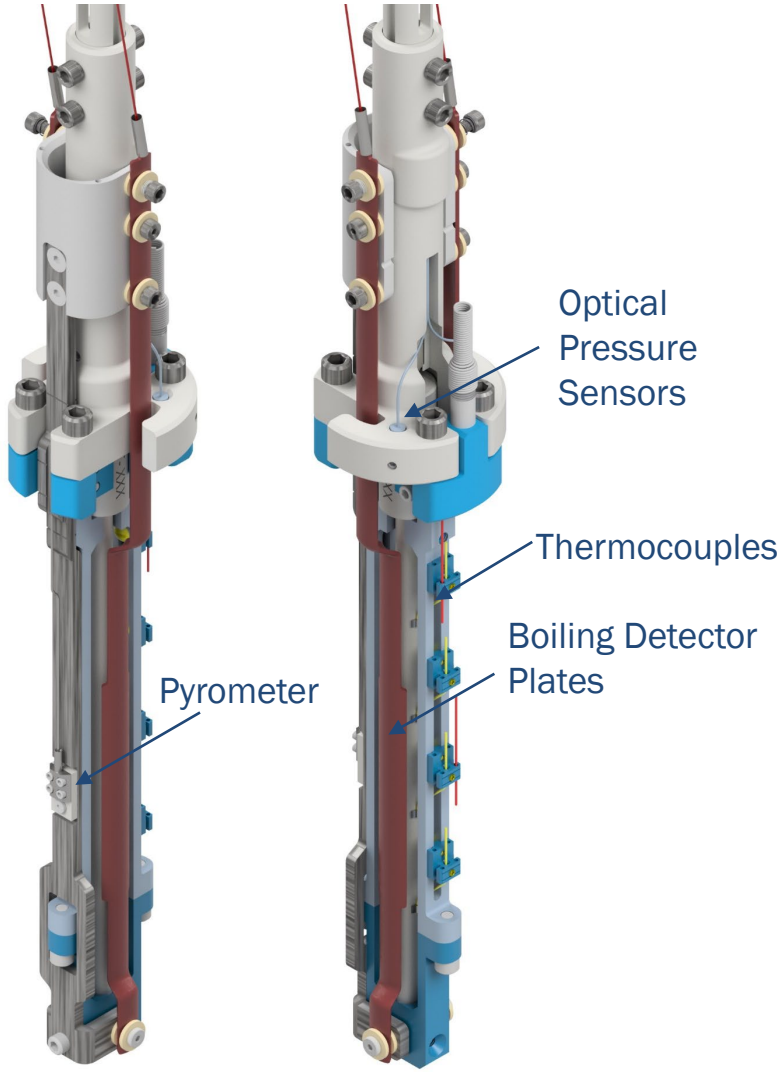
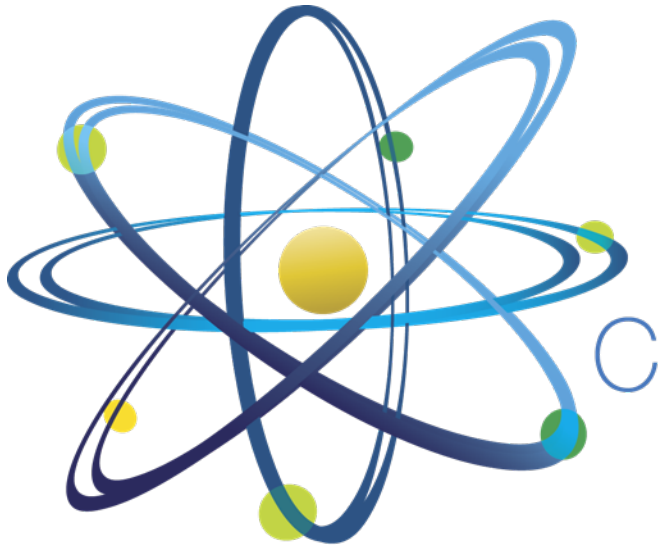
Next steps

- Additional tests making up the TWIST commissioning series will be completed this fiscal year
- Design modifications of internal components for assembly in HFEF with High-Burnup (HBu) fuel is currently being finalized
- TWIST will serve as the LWR testbed for TREAT experiments with pre-irradiated fuel and is planned to be used for both LOCA and reactivity-initiated accident (RIA) experiments starting in late calendar year 2024



TWIST HBu Design

Questions?



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