



# Pre-Irradiated THOR Assembly

March 2024

*Changing the World's Energy Future*

Klint Stephens Anderson



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# **Pre-Irradiated THOR Assembly**

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**<http://www.inl.gov>**

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# Pre-Irradiated THOR Assembly

Klint Anderson

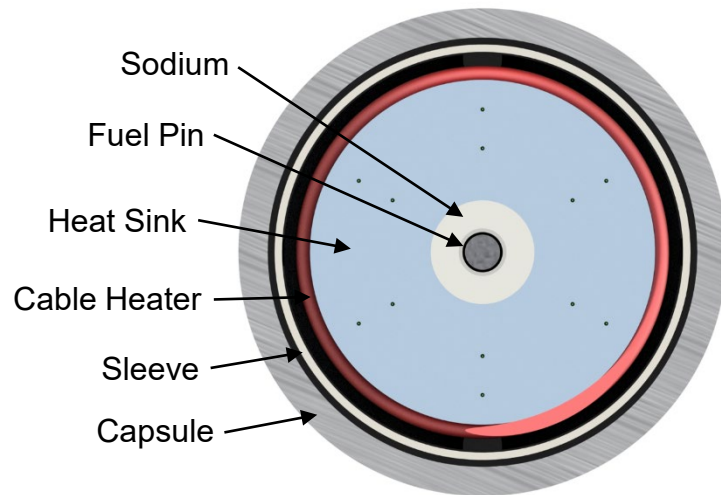
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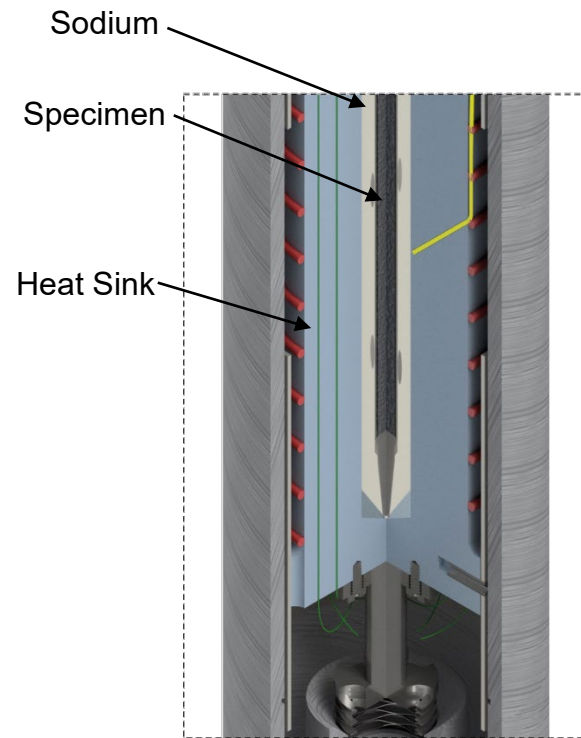
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# THOR Design

- Large capsule which houses a single pin sodium bonded to heat sink
- Compact static sodium environment
- Extended capsule and heat sink design allows testing of pins up to 40" long (MOXTOP)



THOR Capsule  
Cross Section



THOR-M

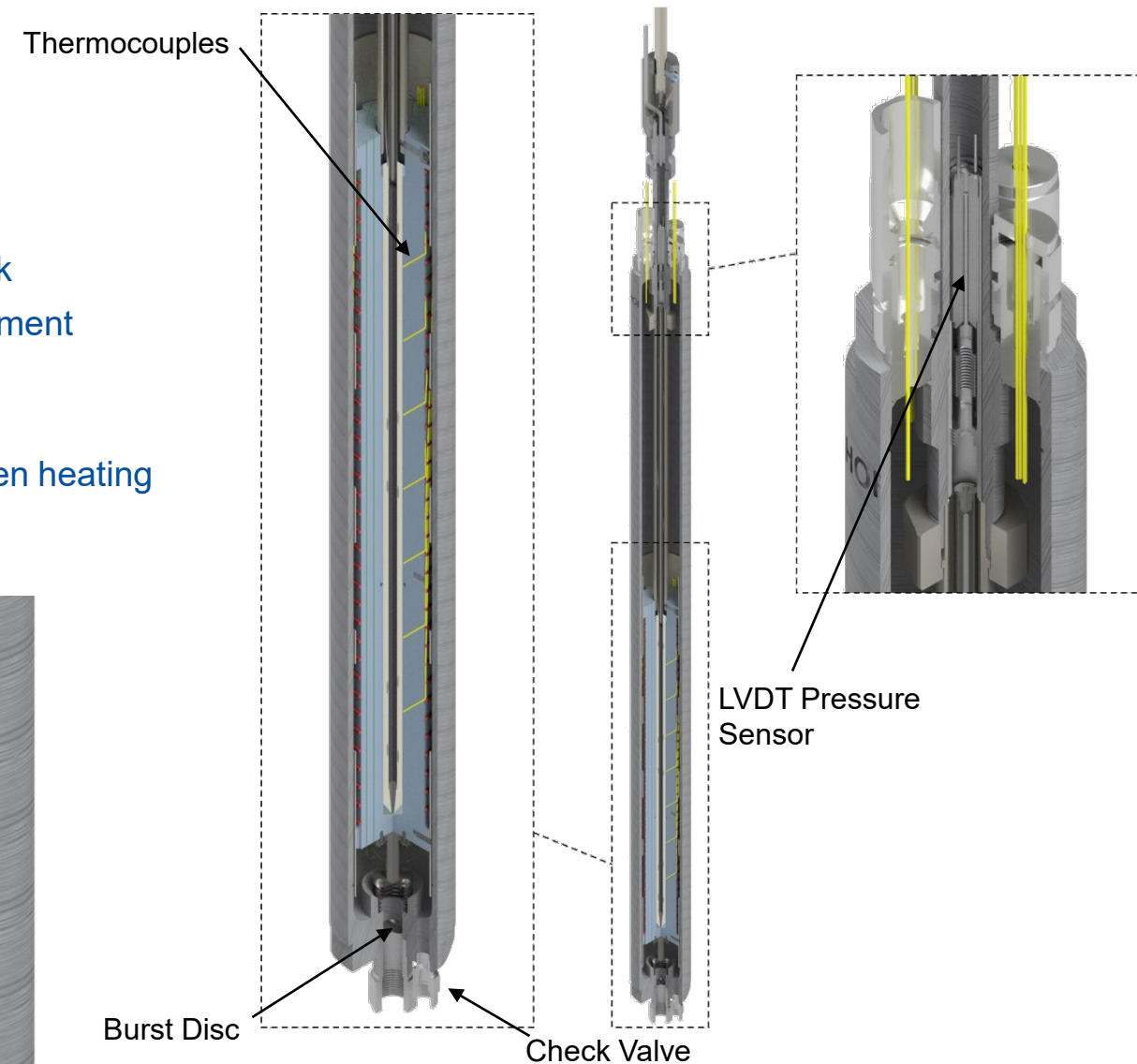
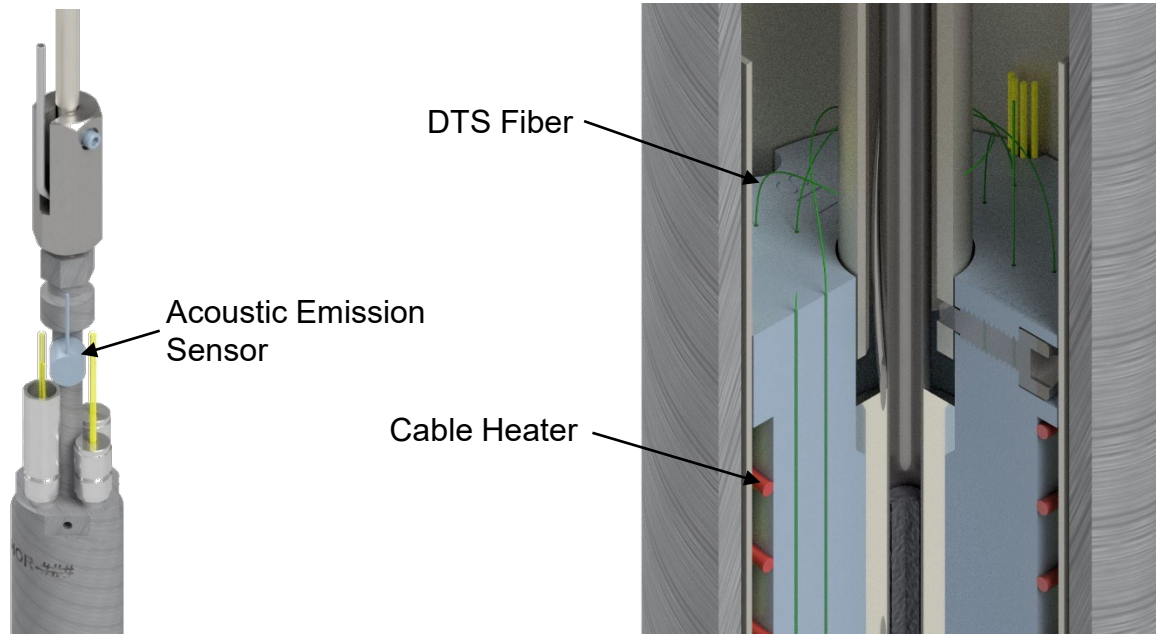


THOR-MOXTOP

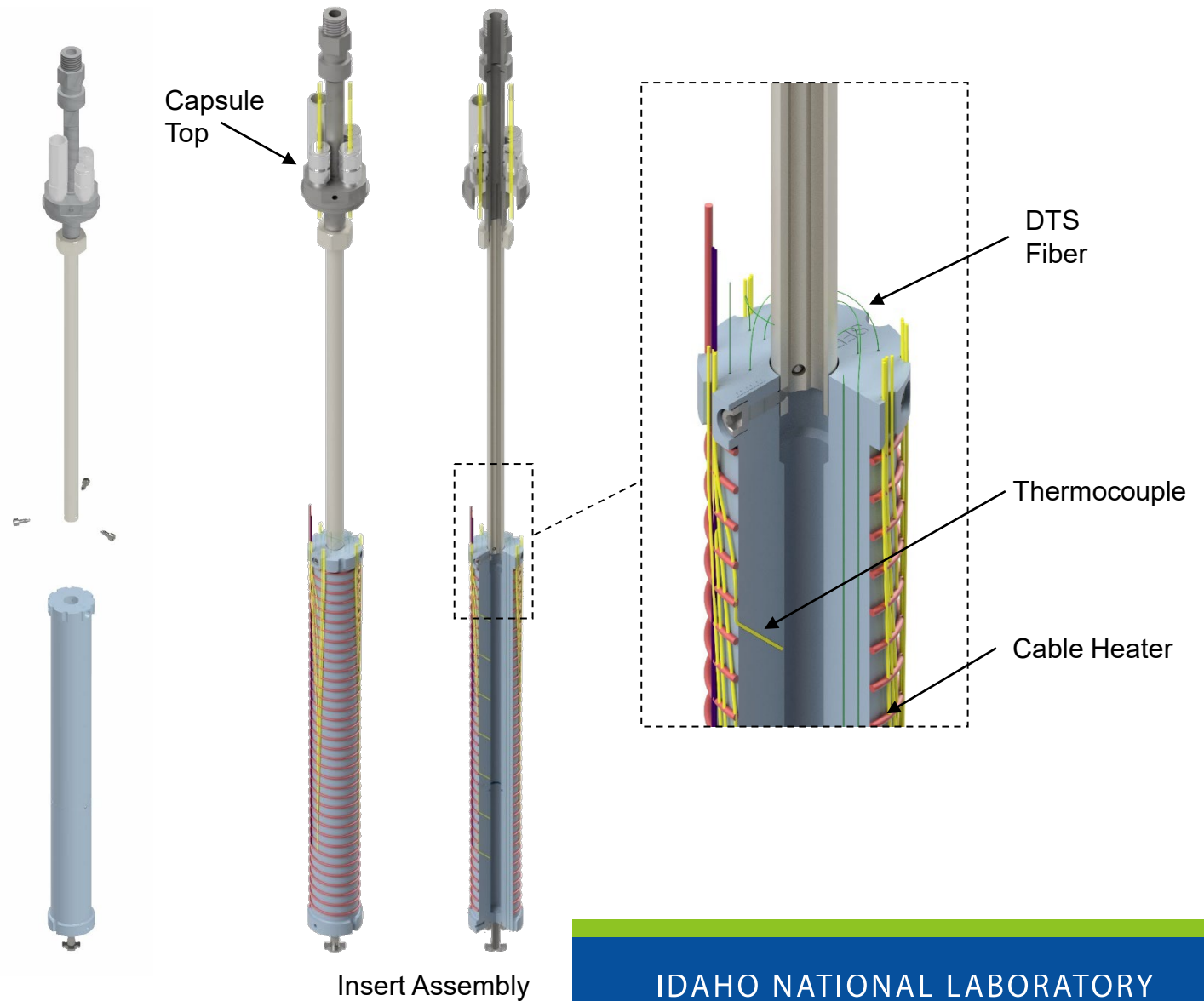
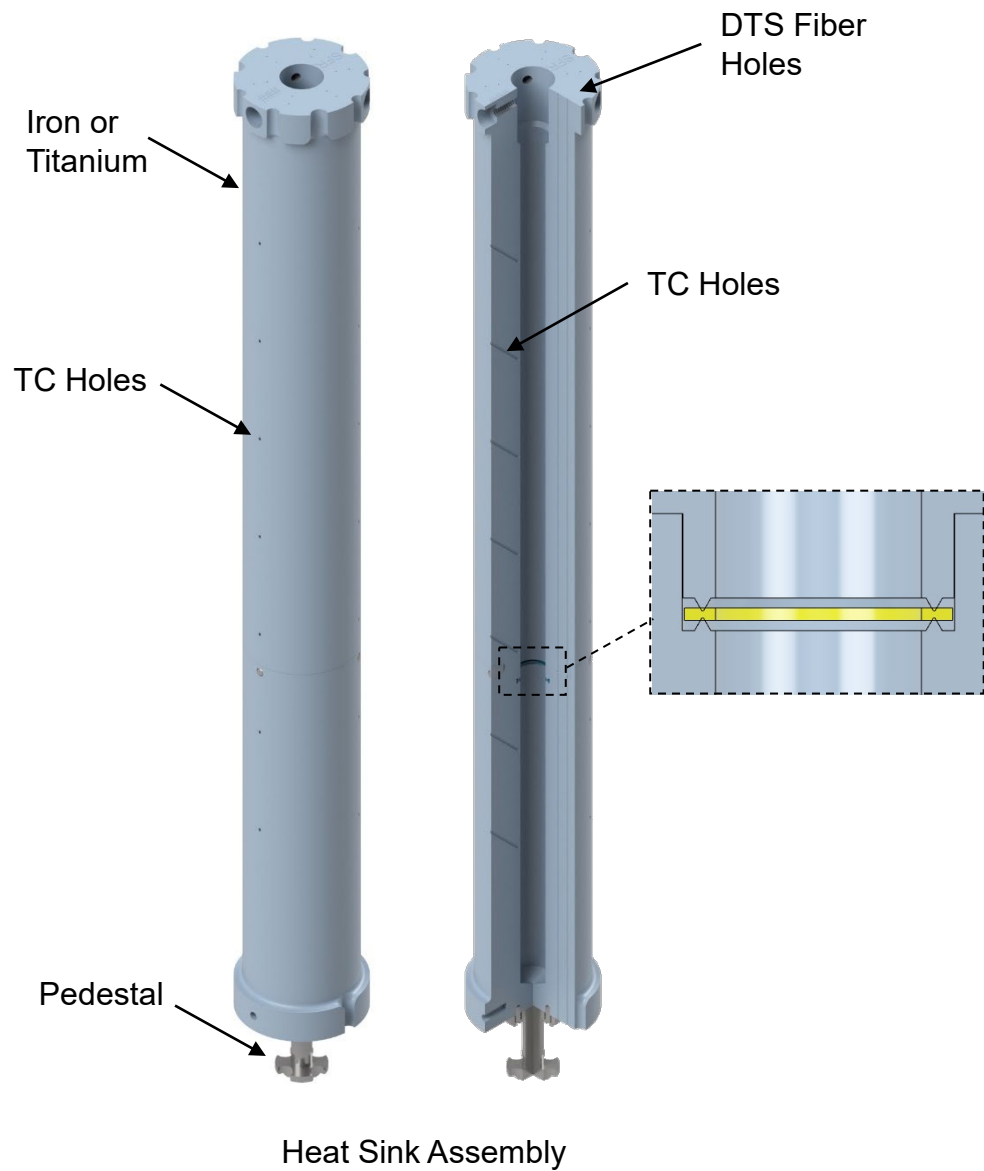
# THOR Design

- **Extensive instrumentation**

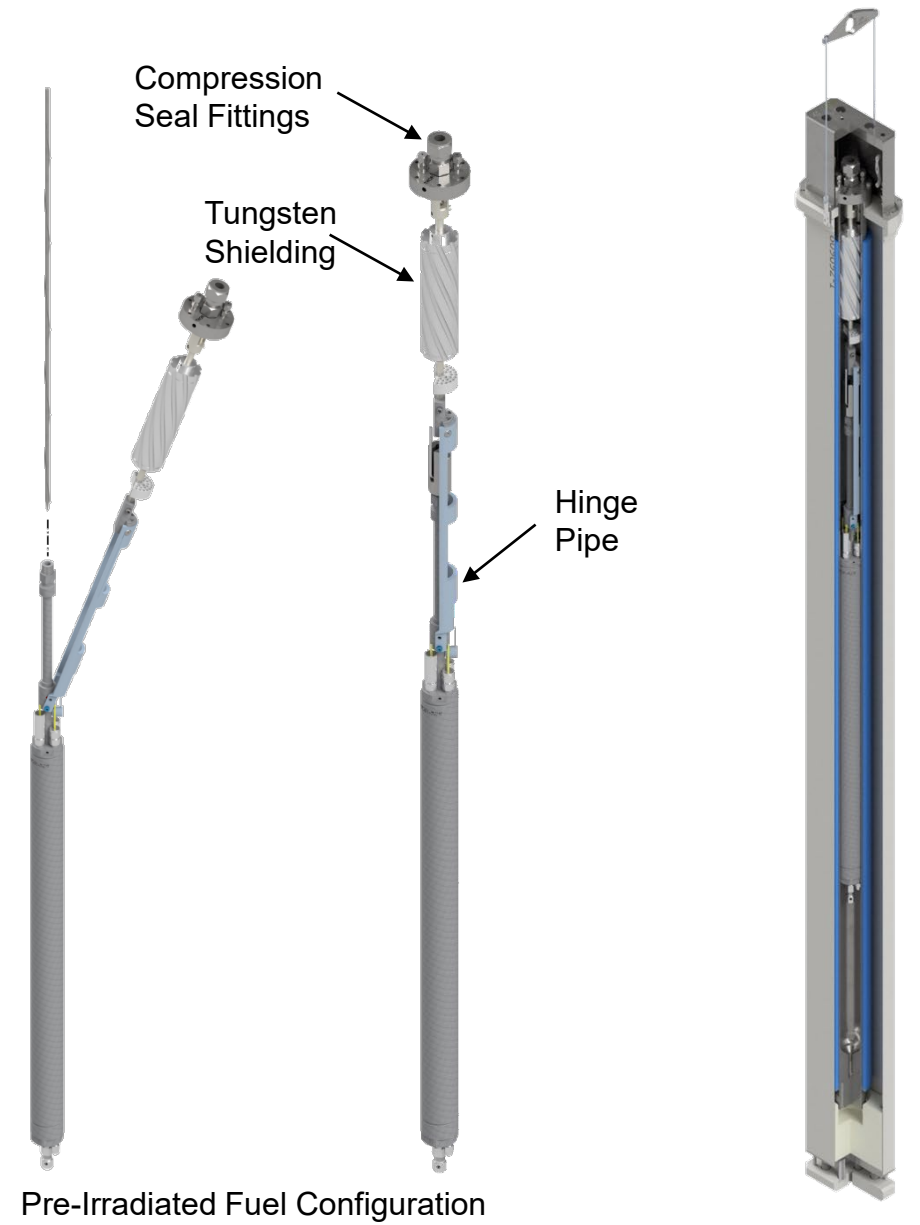
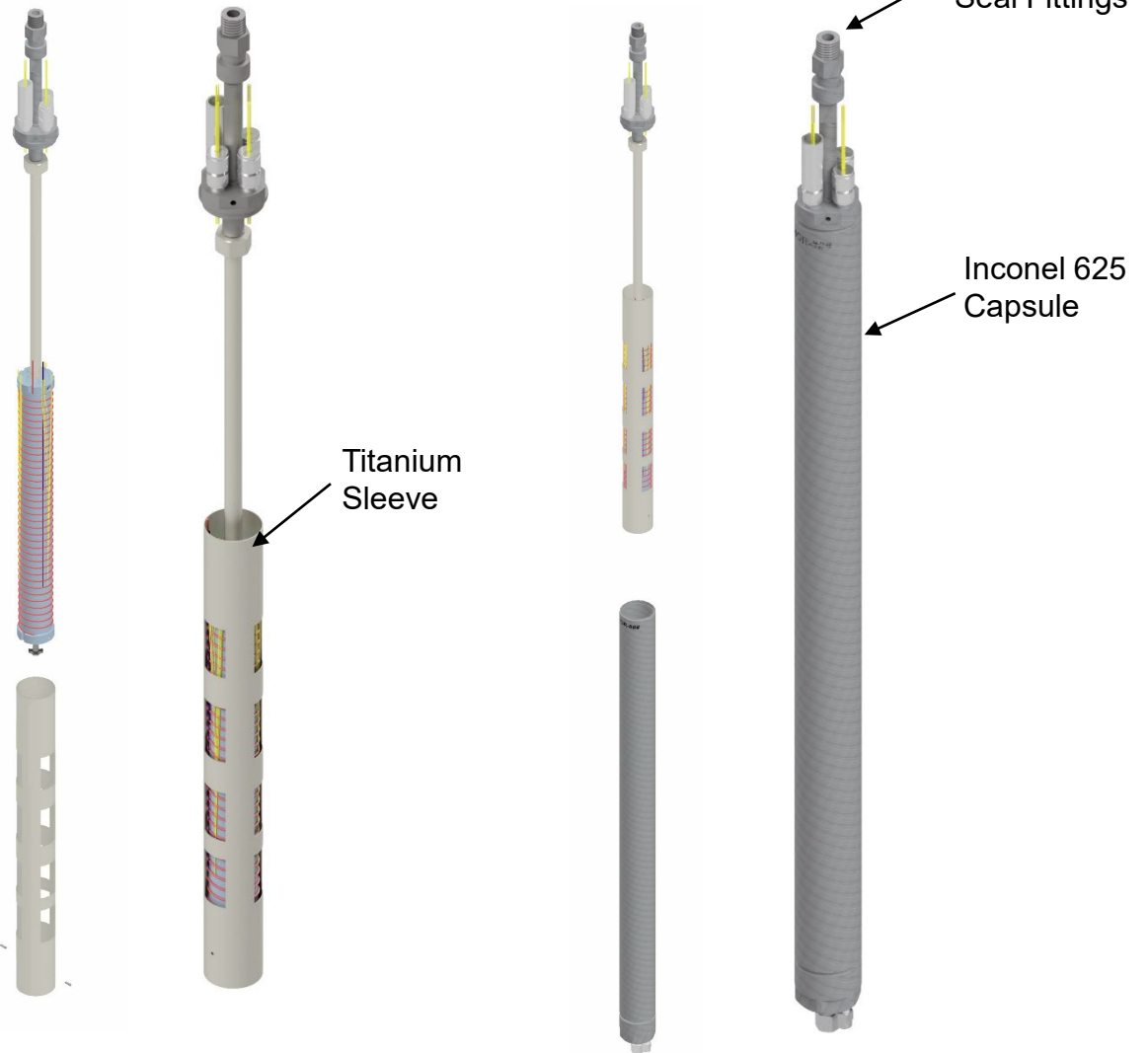
- 21 thermocouples placed around the fuel at different axial stacks
- Distributed Temperature Sensing Fiber runs through the heat sink
- LVDT Pressure Sensor or Elongation LVDT depending on experiment objectives
- Acoustic Emission Sensor for cladding rupture detection
- Cable heater wrapped around heat sink for pre-transient specimen heating
- 2 heater protection thermocouples



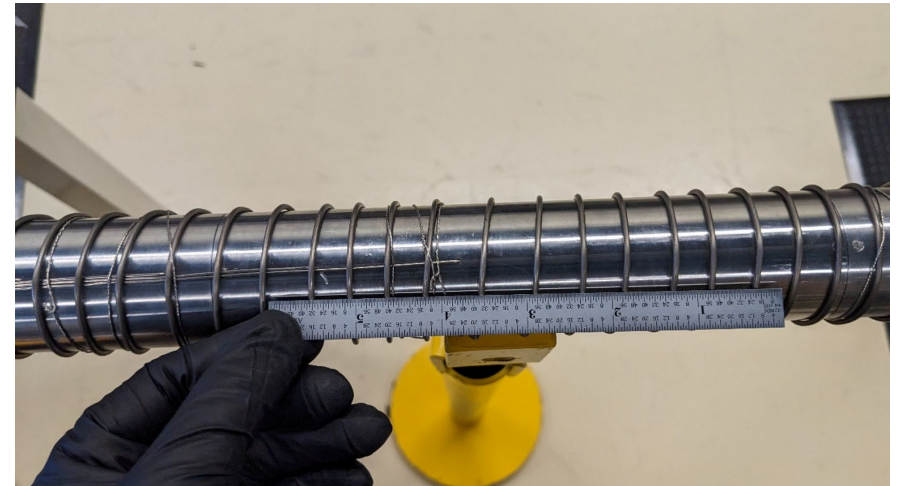
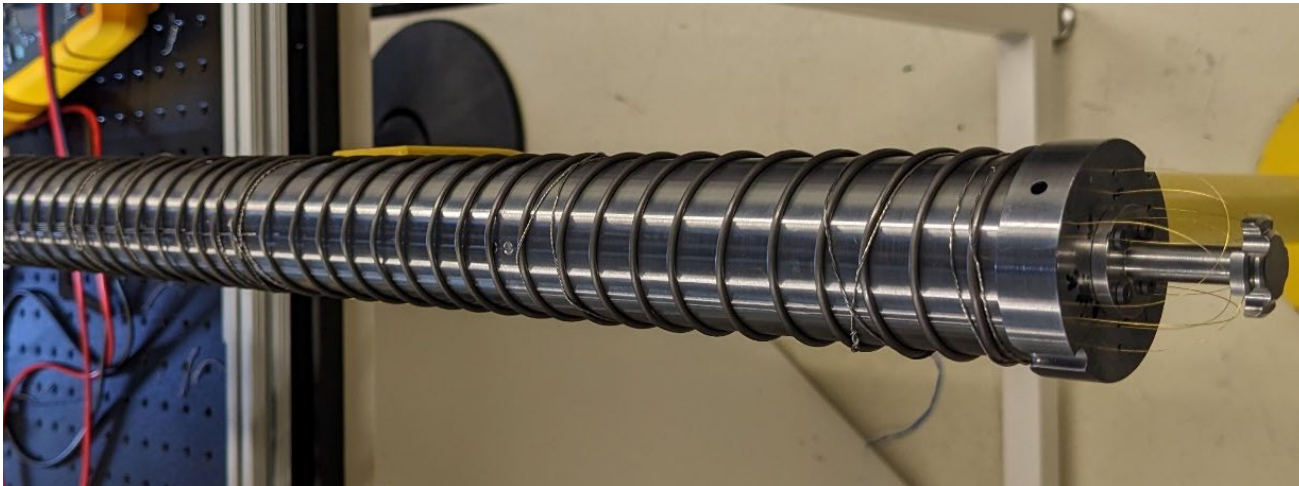
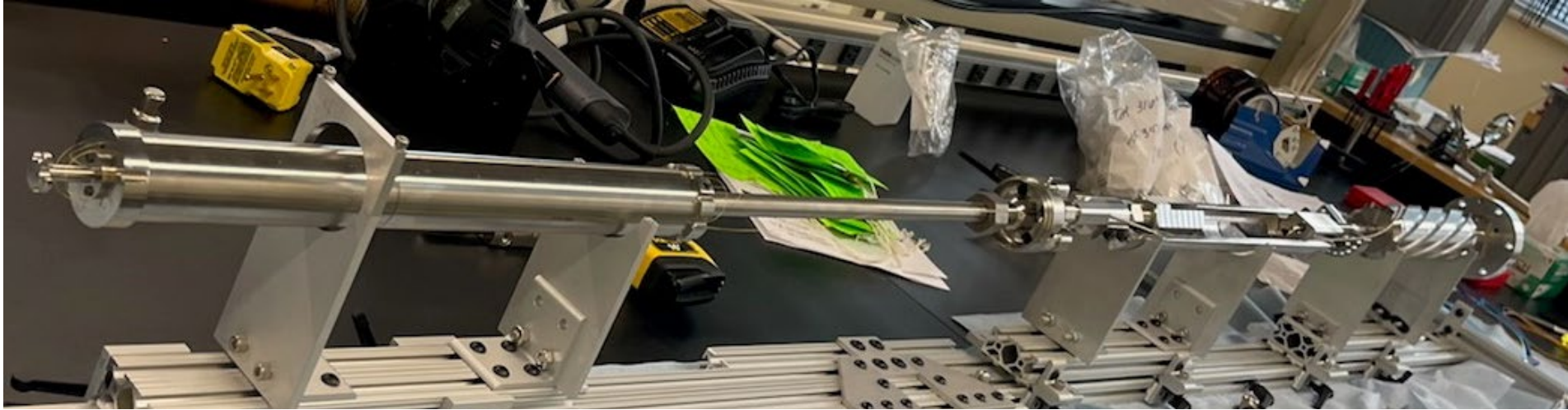
# THOR Design



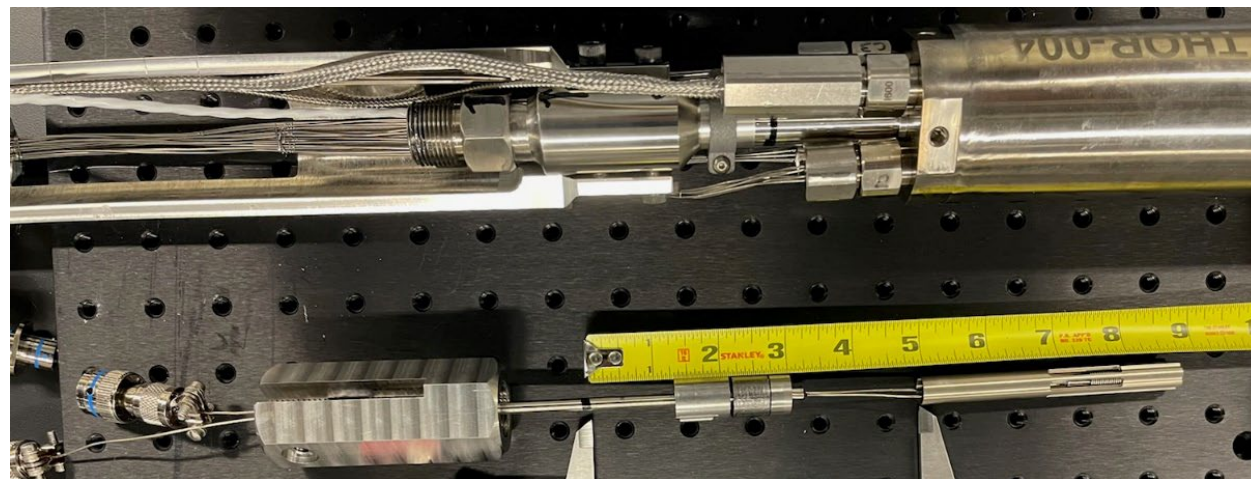
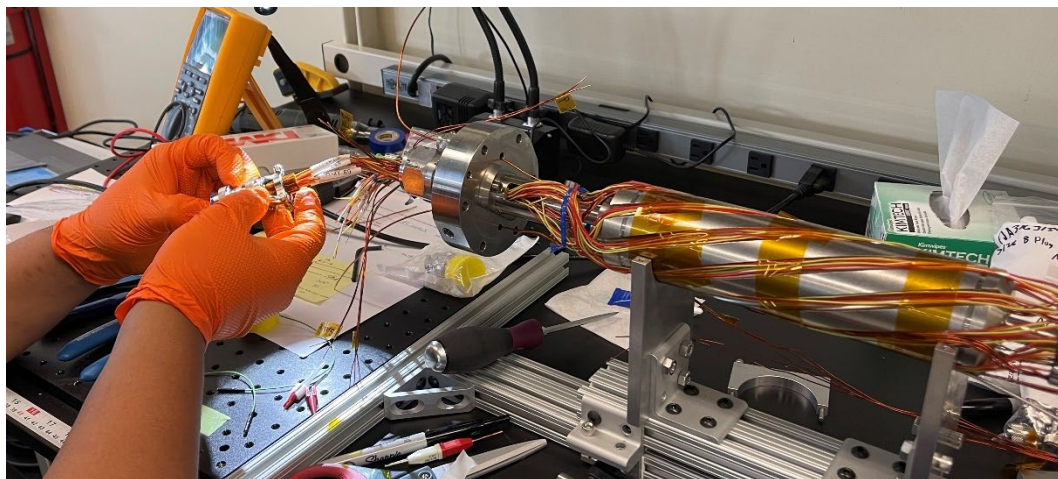
# THOR Design



# Module Assembly



# Module Instrumentation Assembly

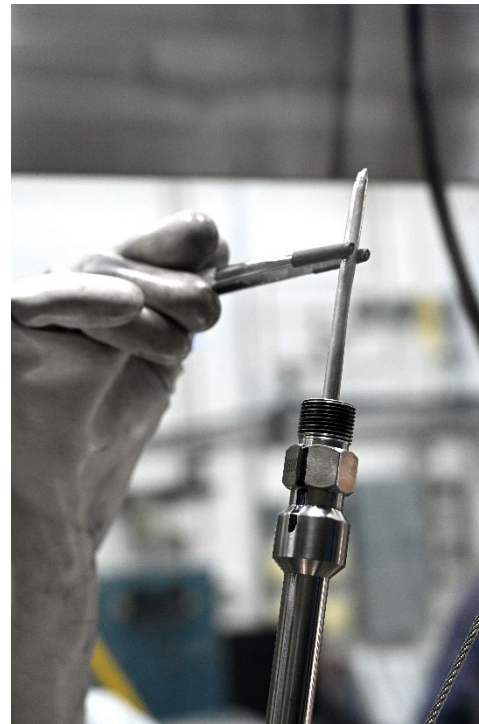


# Sodium Loading

- After hardware assembly is complete, the capsule is shipped to HFEF for handling hardware installation
- The capsule is then loaded into the Pyro-chemistry Glovebox (PCG) in the Fuels and Applied Science Building (FASB) and transferred into a stand via a rigging system
- Solid sodium is rolled into  $\sim\frac{1}{4}$ " diameter cylinders and loaded into the capsule, melted, allowed to solidify, and checked with a height gauge to verify loading



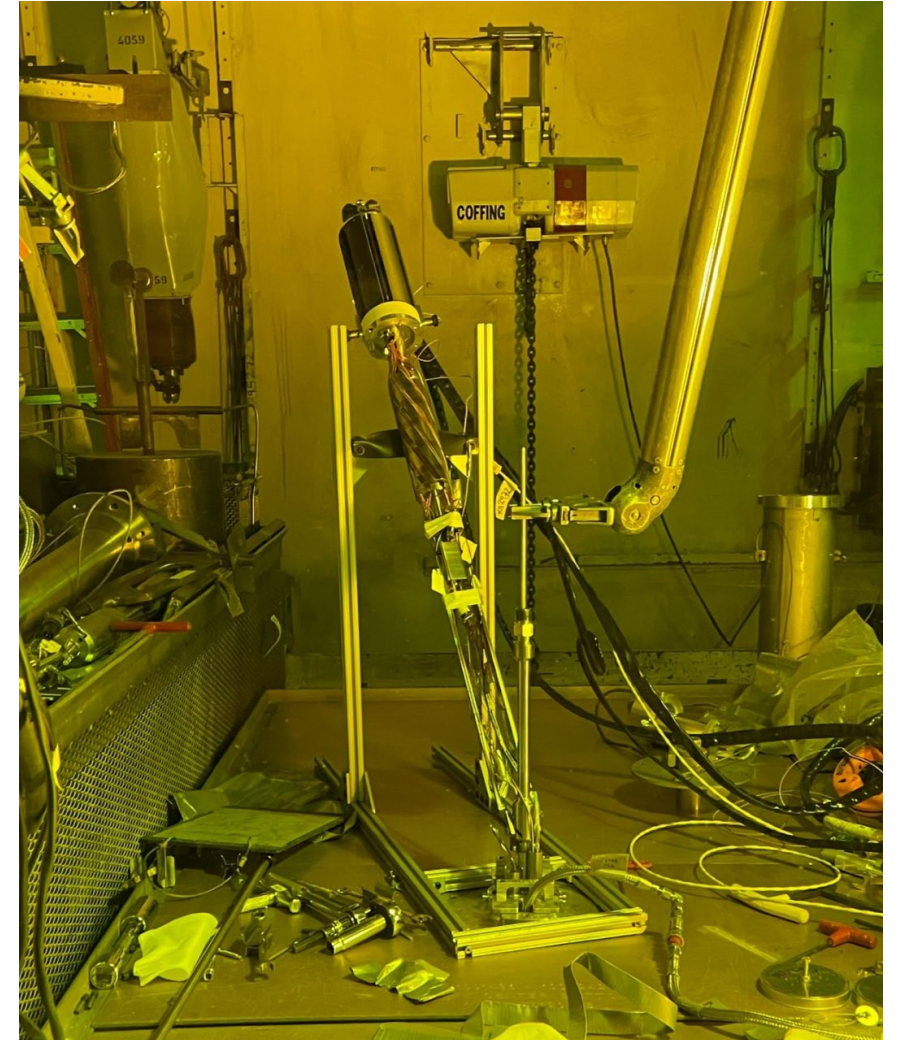
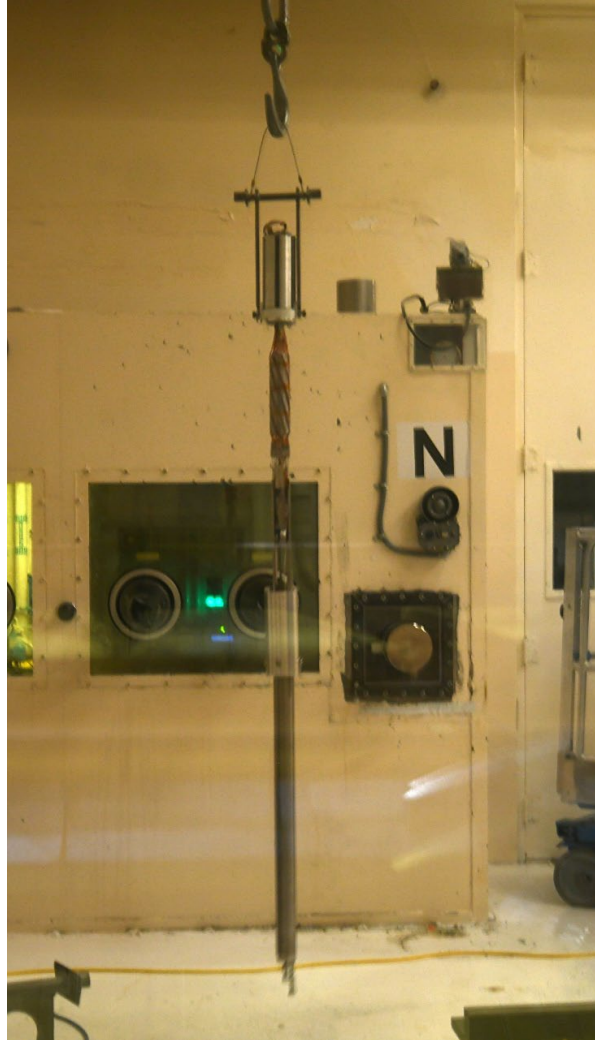
Loading Sodium into Capsule Heat Sink



THOR-MOXTOP 1 Capsule resting in PCG

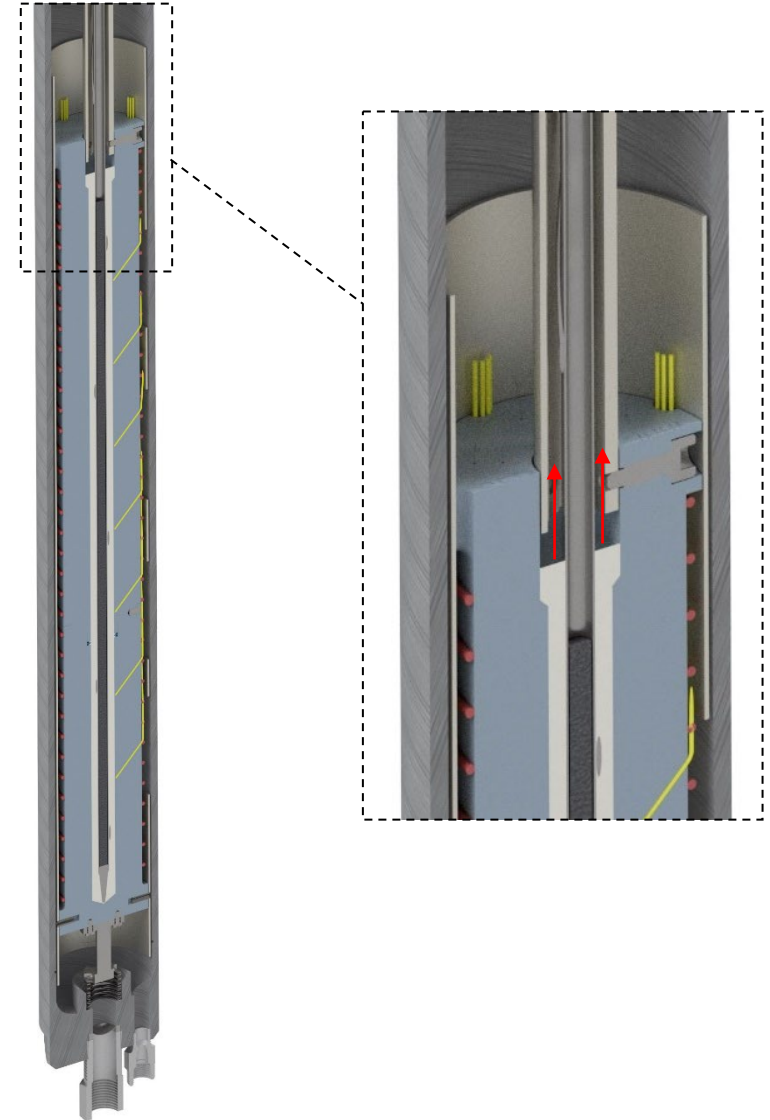
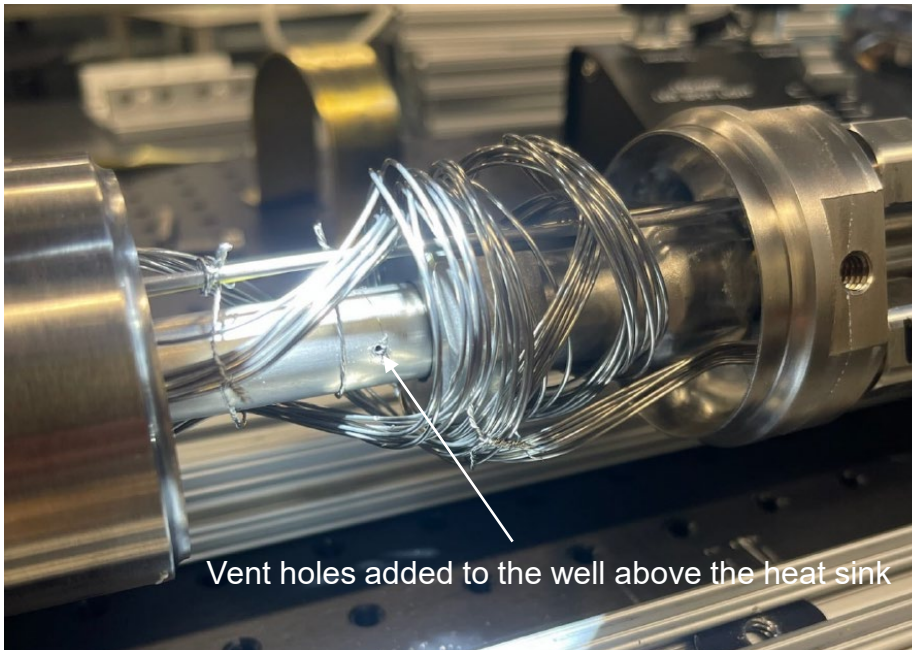
# Pre-Irradiated Fuel Pin Loading

- Following sodium loading at FASB, the experiment is transferred into the decon cell of HFEF
- An argon line is connected to the check valve on the bottom of the capsule for an argon purge through the capsule
- The top portion of the experiment module is hinged out of the way and the pre-irradiated pin is loaded into the capsule
- Sodium wetting is accomplished by powering the cable heater
- The capsule is sealed, pressurized, leak check, and transferred into the experiment primary containment



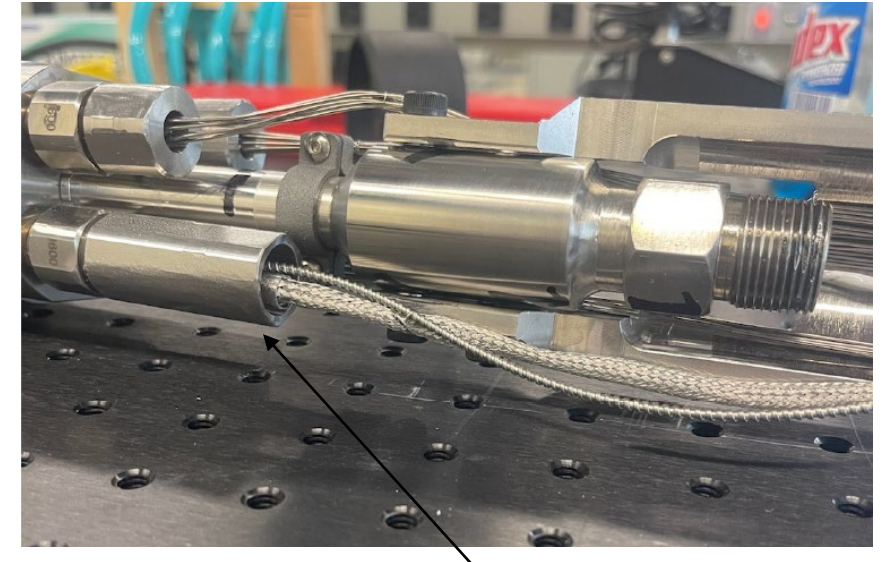
# Sodium Level

- Thermal expansion of sodium during wetting/bonding on the THOR-M experiment caused the sodium level to rise and block the argon purge flow path, which caused the pin to be pushed out after loading
- This was addressed on THOR-MOXTOP by adding vent holes to the well above the heat sink to provide an argon flow path above the sodium level in the heat sink
- The sodium wetting/bonding temperature was decreased, and the wetting time increased for THOR-MOXTOP to ensure no sodium spilled over the heat sink top
- The counterbore diameter at the top of the heat sink will be increased on future experiments to allow for thermal expansion of the sodium in the heat sink

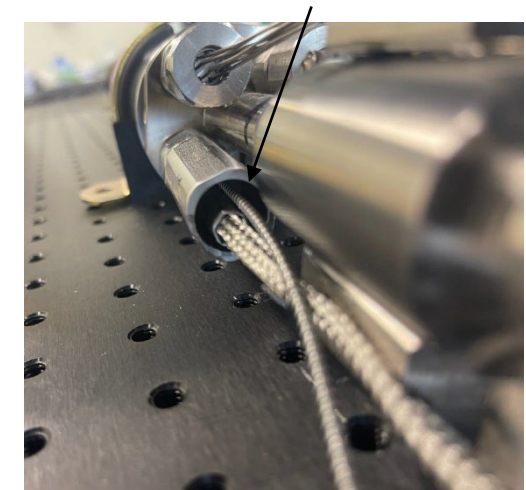


# Cable Heater

- Cable heater problems in THOR-M and THOR-MOXTOP-1
  - The failure mechanisms appear to differ between the two cable heaters
  - THOR-M failed open (with a loss of continuity), indicating failure in the mineral insulated cable
  - THOR-MOXTOP-1 failed with one leg grounding out initially and the other leg grounding out a few days later
- Pre-heating with thermocouples tested and deployed in THOR-MOXTOP-1



Cable Heater Transition Location

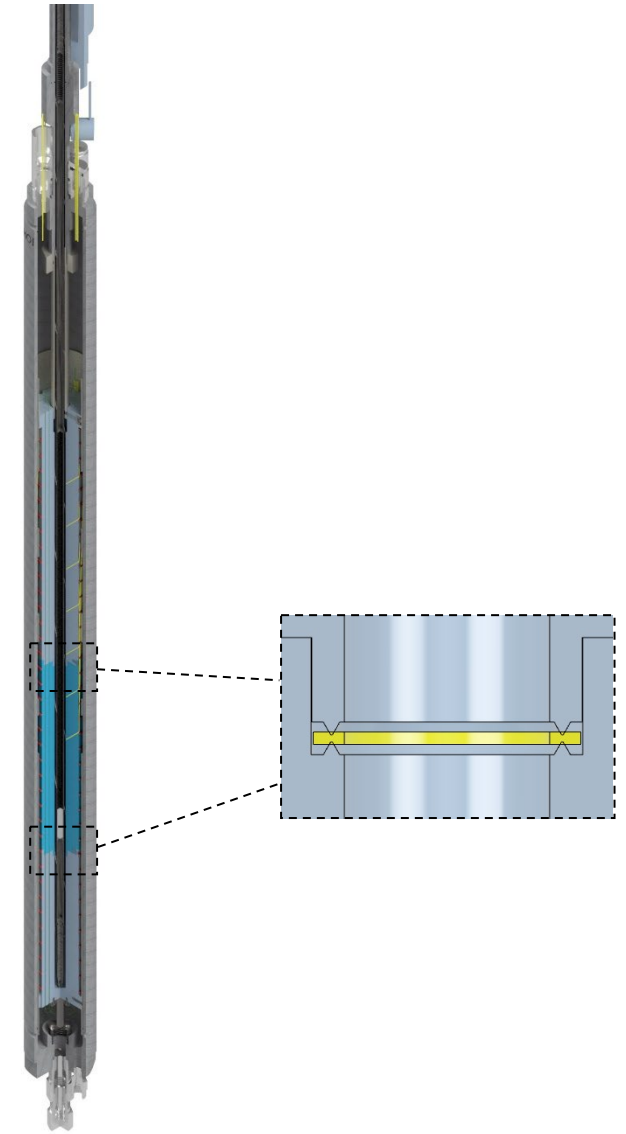


# Sodium Relocation

- The two-piece heat sink design allowed small holes to be fabricated with an EDM hole popper along the length of each heat sink segment for the DTS fiber
- A metallic knife edge crush gasket is installed between the mating faces of the heat sink
- Sodium was found to be leaking from these joints in the THOR-MOXTOP capsules



Crush gasket testing with iron heat sink



# Summary

- The assembly and loading of the first pre-irradiated THOR capsules went remarkably well given the complexity of the system and assembly process
- Encountered challenges were resolved during assembly or are easily resolved with relatively minor design updates
- The knowledge and expertise gained from the initial pre-irradiated assemblies will reduce challenges in future assemblies





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