IER-547: Low-Temperature TEX

The Completion of Surrogate Testing for Low-Temperature TEX and a Look Towards the Future

Eric Aboud, Jesse Norris, Catherine Percher, Nick Killingsworth, Paul Yap-Chiongco, Jacob Glesmann

Lawrence Livermore National Laboratory

Venkata Ravindra, Steve Graham, Alfie O'Neill, Deborah Hill

National Nuclear Laboratory, United Kingdom

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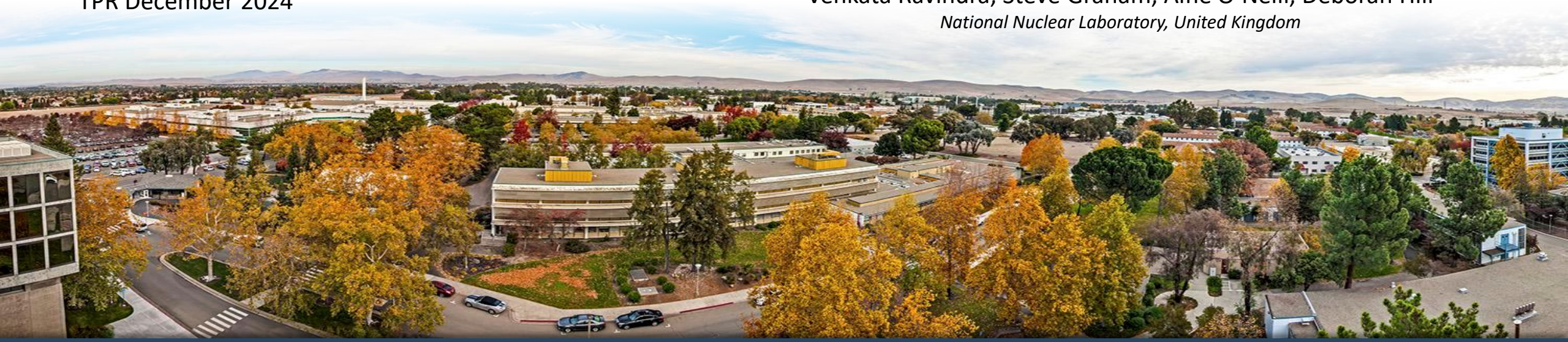
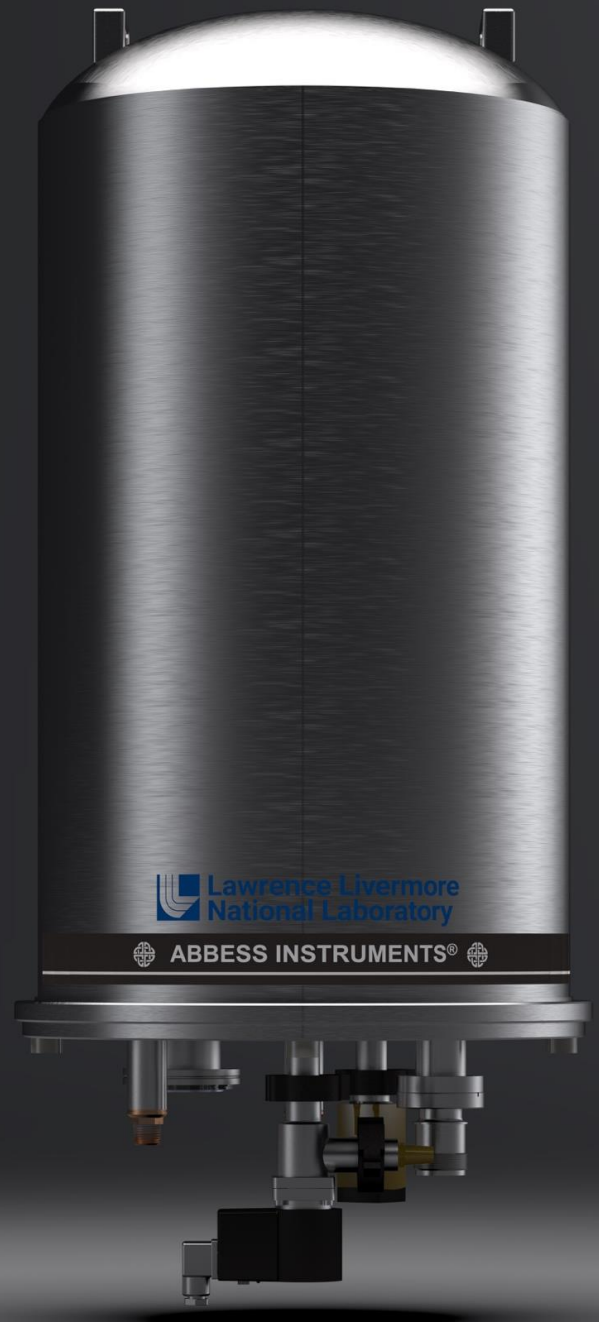
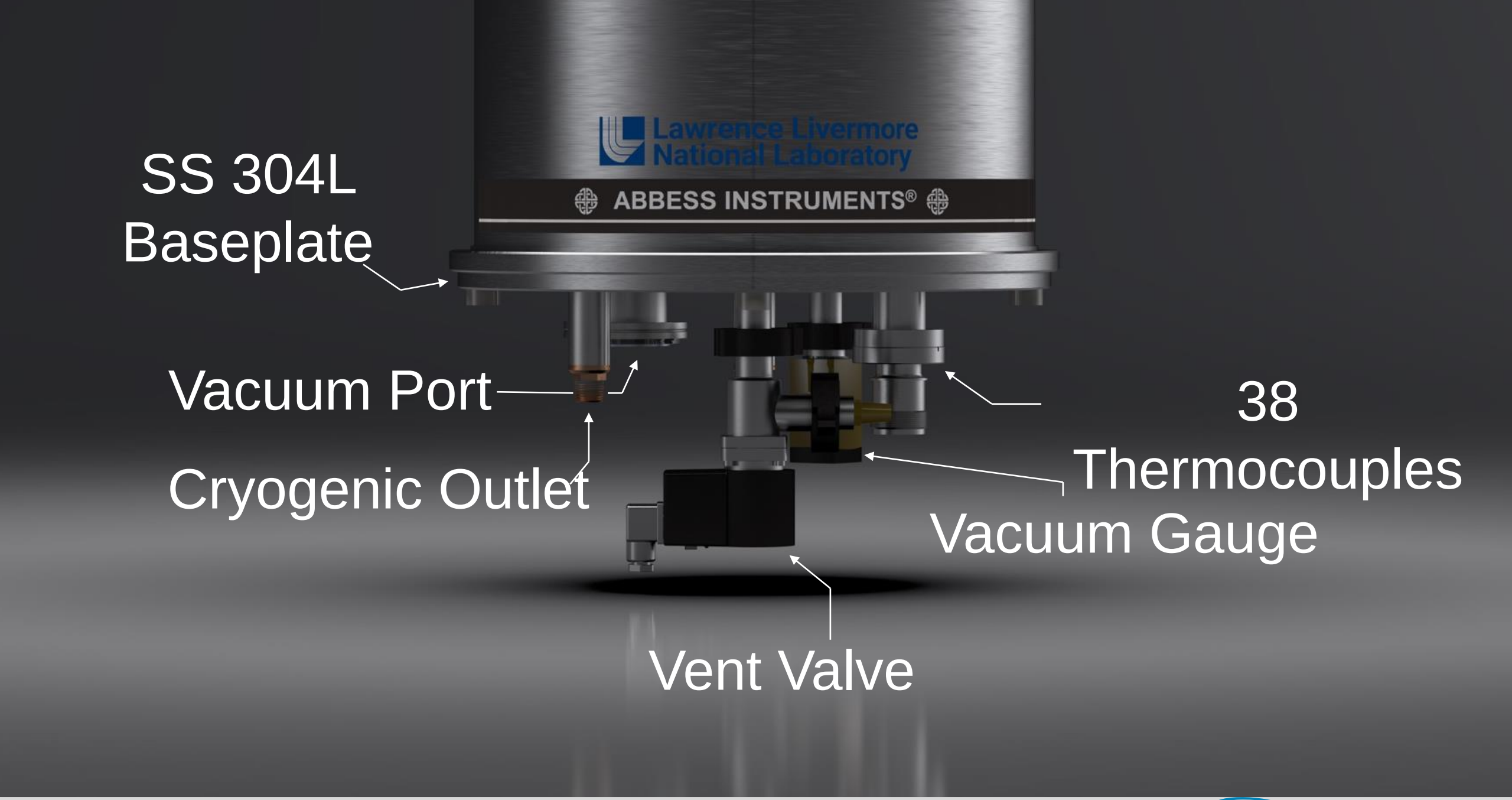


Low-Temperature **TEX**



SS 304L Vacuum Jacket

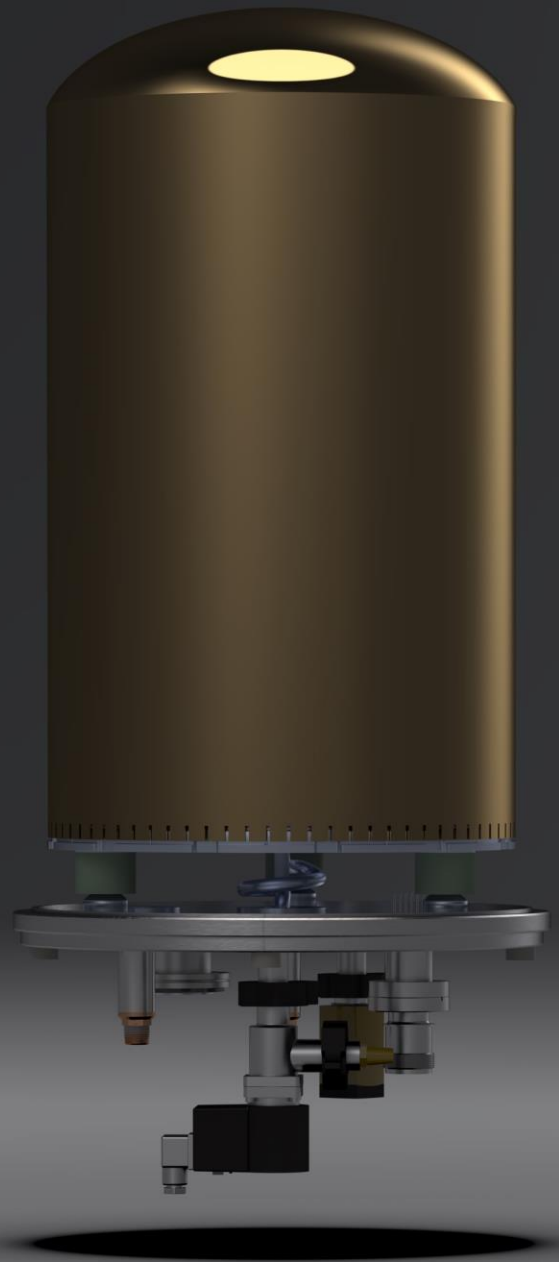
- Vacuum down to 10^{-6} Torr
- Temperatures down to -50°C
- Interior usable height of 21¾”
- Interior usable diameter of 15”
- Designed to use existing HEU ‘Jemima’ Plates
- Maximally thermally insulated


SS 304L
Baseplate
Vacuum Port
Cryogenic Outlet
38
Thermocouples
Vacuum Gauge
Vent Valve
Lawrence Livermore
National Laboratory
ABBESS INSTRUMENTS®

Vacuum Jacket

- 1/8” Stainless Steel
- Houses stack

- Au and Ni Flashed
- Primary Thermal Insulation



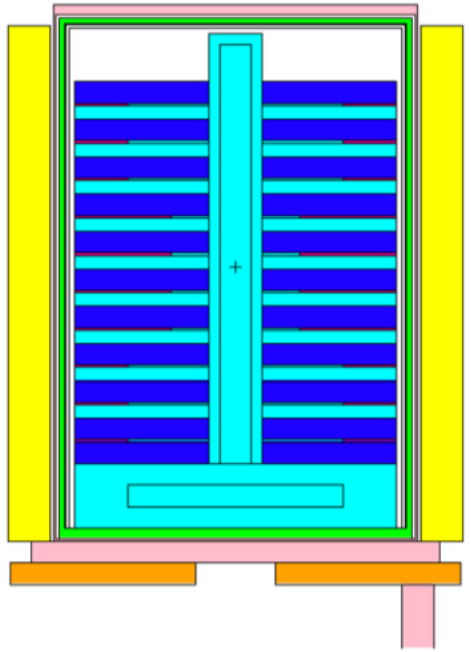
Copper Shield

- HEU ‘Jemima’ Plates
- Replication of Case 2
- Performed with Al Plates

Stack

Experimental Configurations

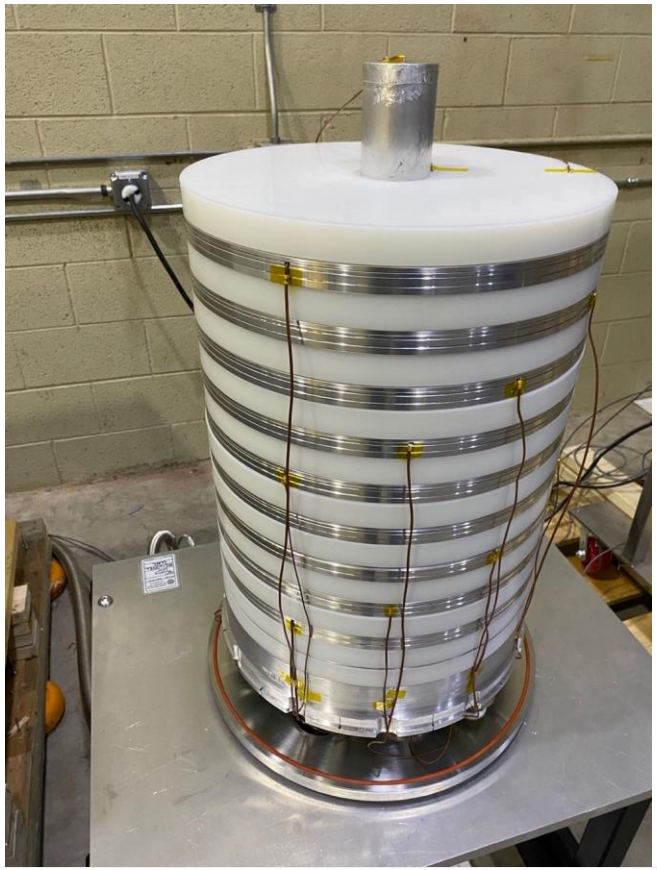
- 6 proposed configurations from thermal to fast
  - One configuration requires the non-spindle heatsink while the other five utilize the spindle heatsink

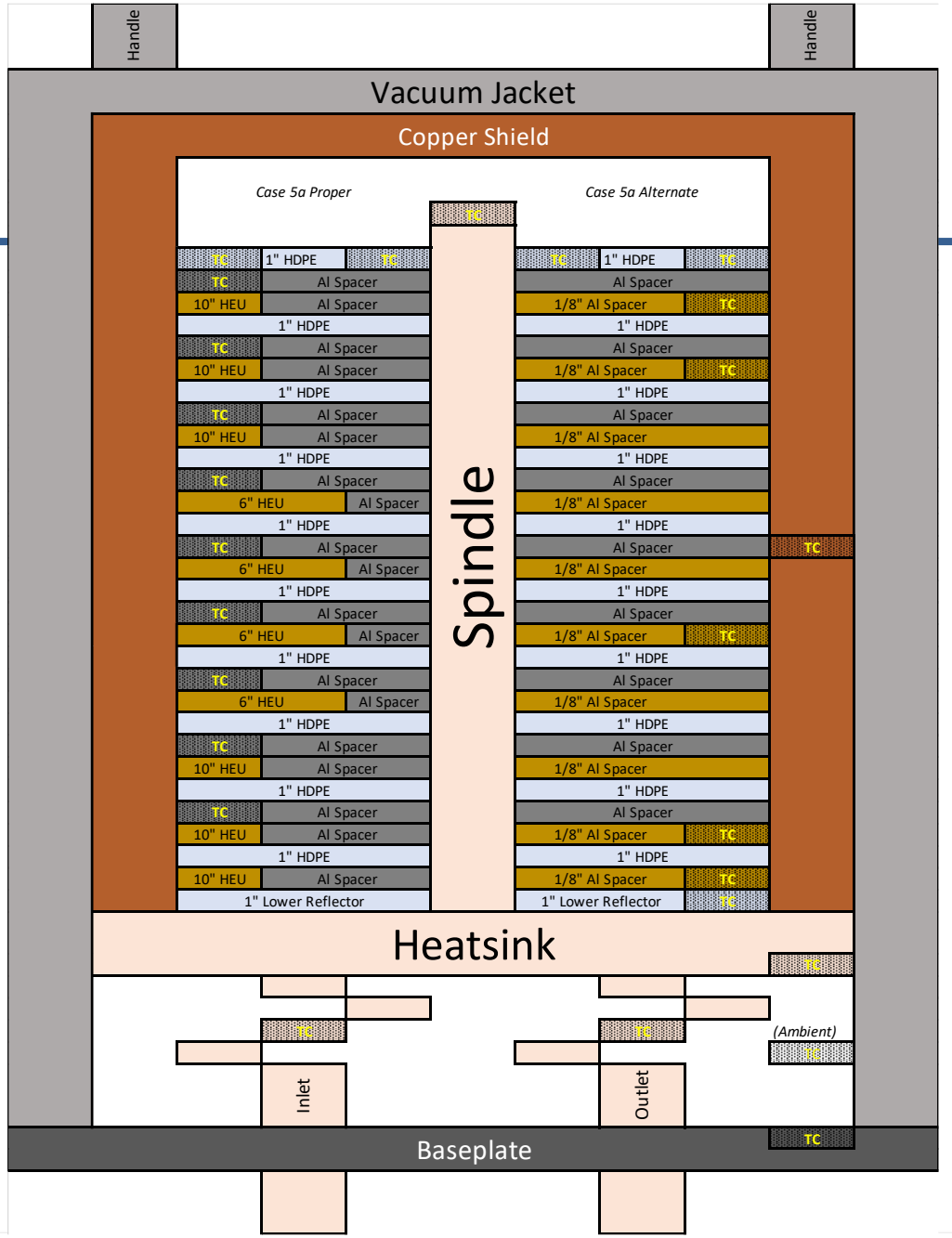


Case Number	HEU Mass (g)	Moderator Thickness	Fission Fractions		
			Thermal (<0.625 eV)	Intermediate	Fast (>100 keV)
1	134,488	-	15%	21%	64%
2	93,074	1/8	21%	48%	31%
3	68,650	1/4	30%	48%	22%
4	50,610	1/2	47%	38%	15%
5a/b	43,421 / 45,290	1	60%	28%	12%

Thermal Performance Measurements

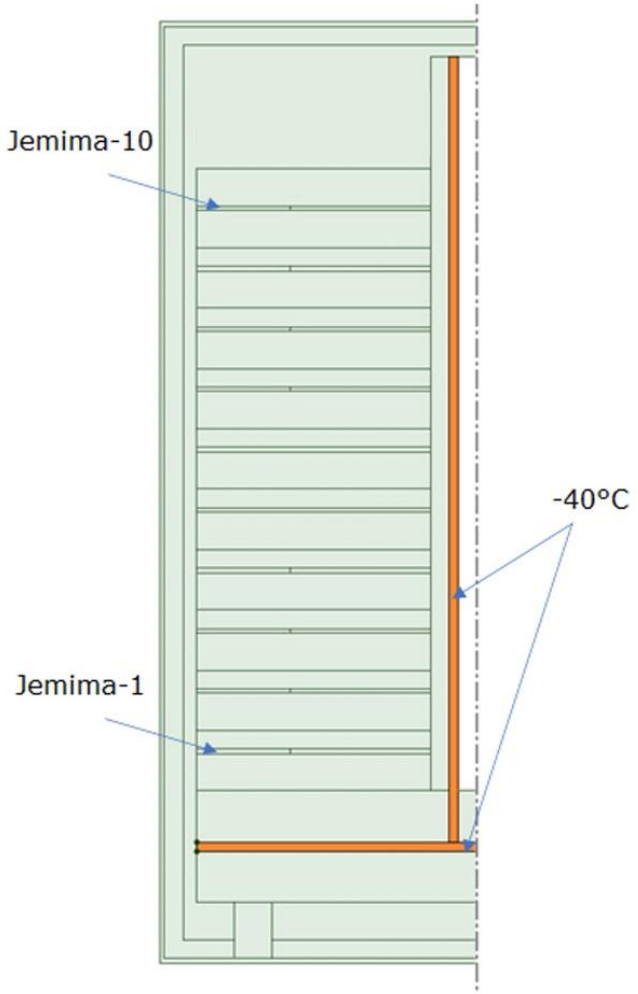
- In order to read the temperatures in the chamber we have 38 thermocouples
- Diagnostic TC's are placed strategically to monitor the temp of the system

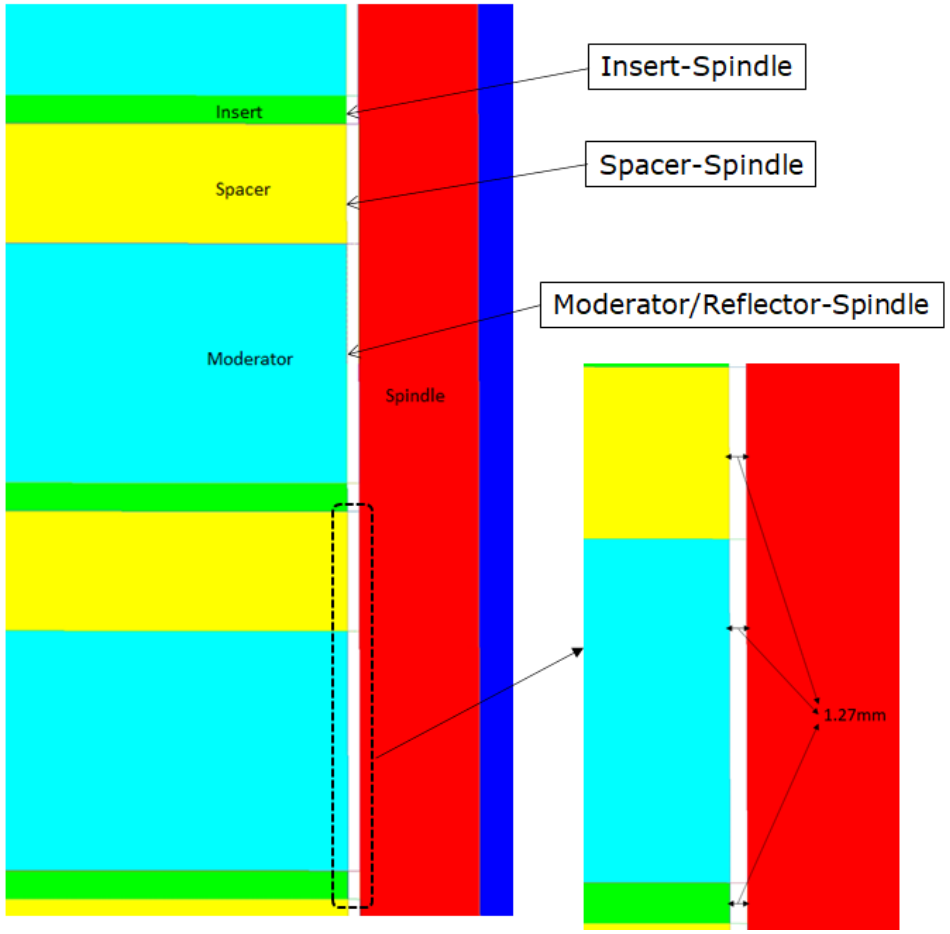




Thermal Modeling

Case 5

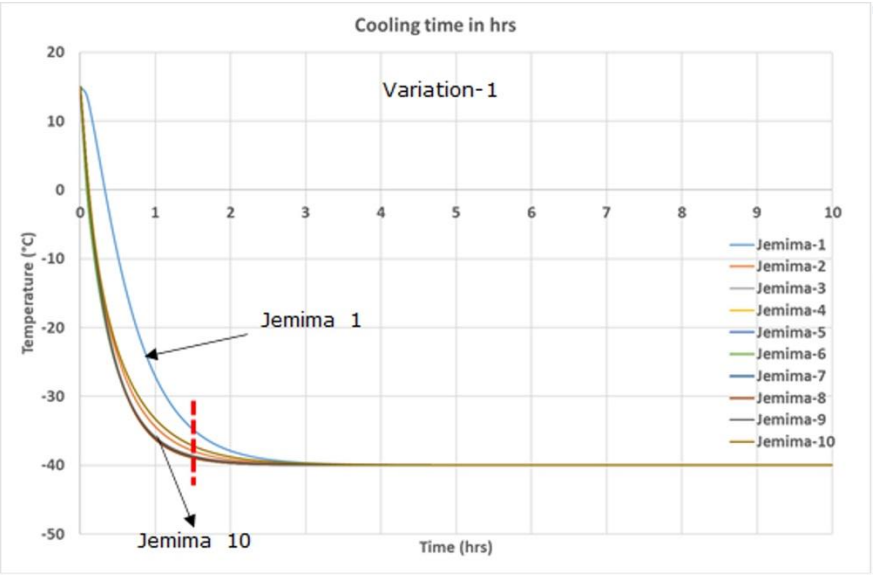


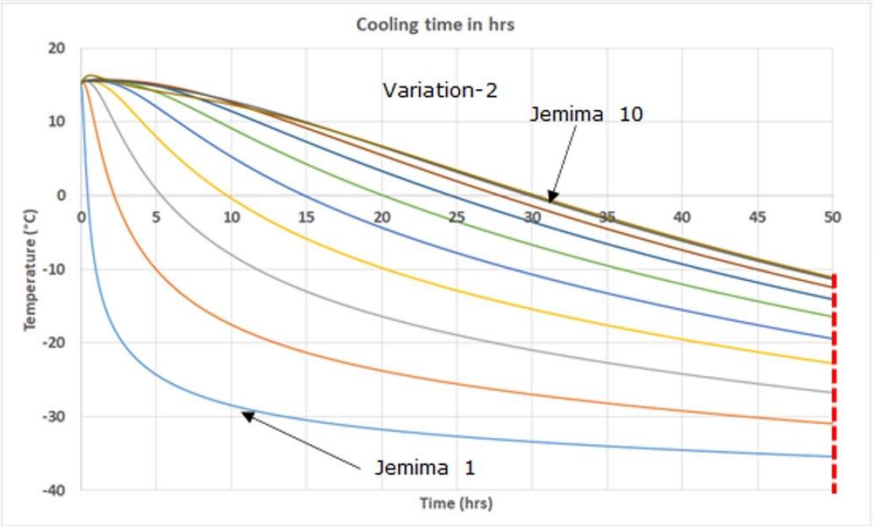


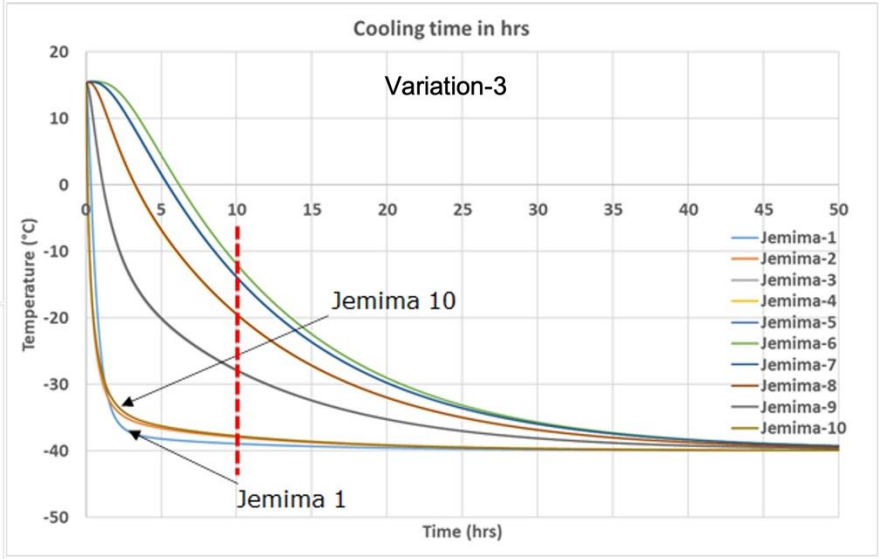
- Case 5 is the most thermal configuration
- Uses the spindle heatsink
- Three variations were modeled:
  1. Perfect coupling between the spacer plates and the spindle
  2. No contact between the spacer plates and the spindle
  3. Mixed coupling between the spacer plates and the spindle

Thermal Modeling

Case 5



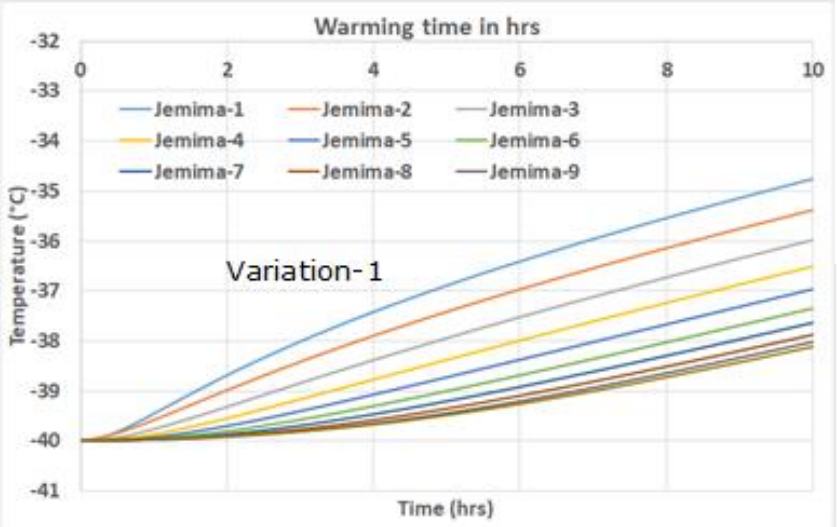


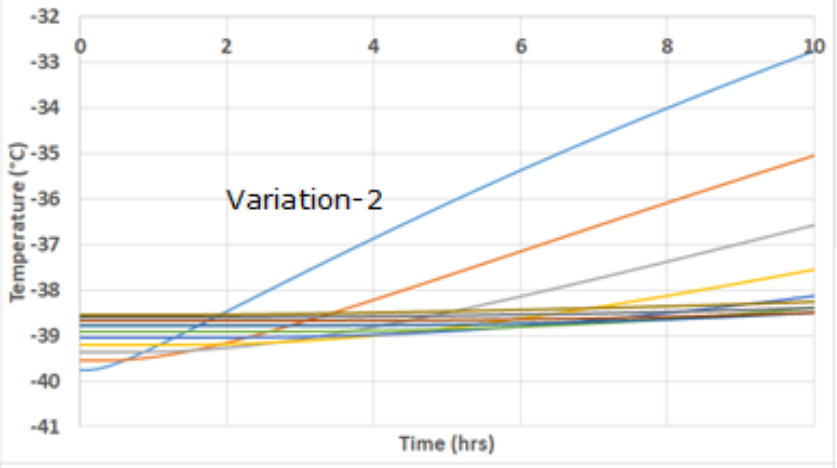


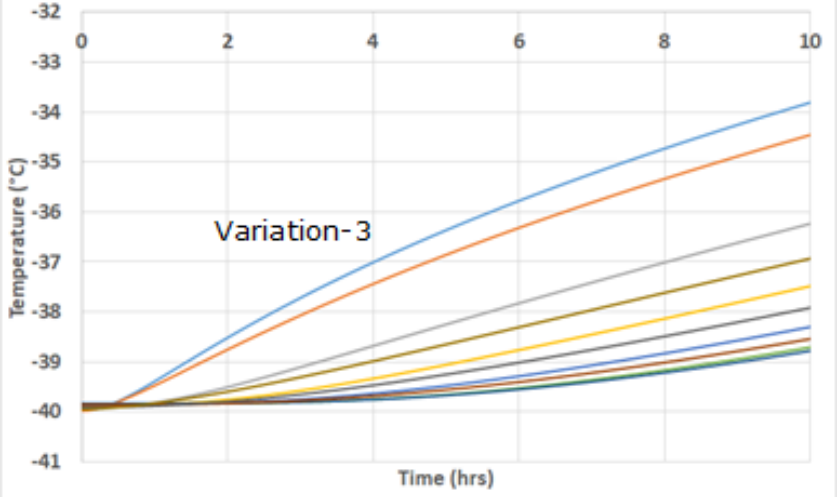
- With perfect coupling we would expect cooling in ~2 hours
  - Of course we don't see this
- With no coupling we wouldn't expect cooling in less than two days
- With mixed coupling we would expect cooling in around 40 hours

Thermal Modeling

Case 5





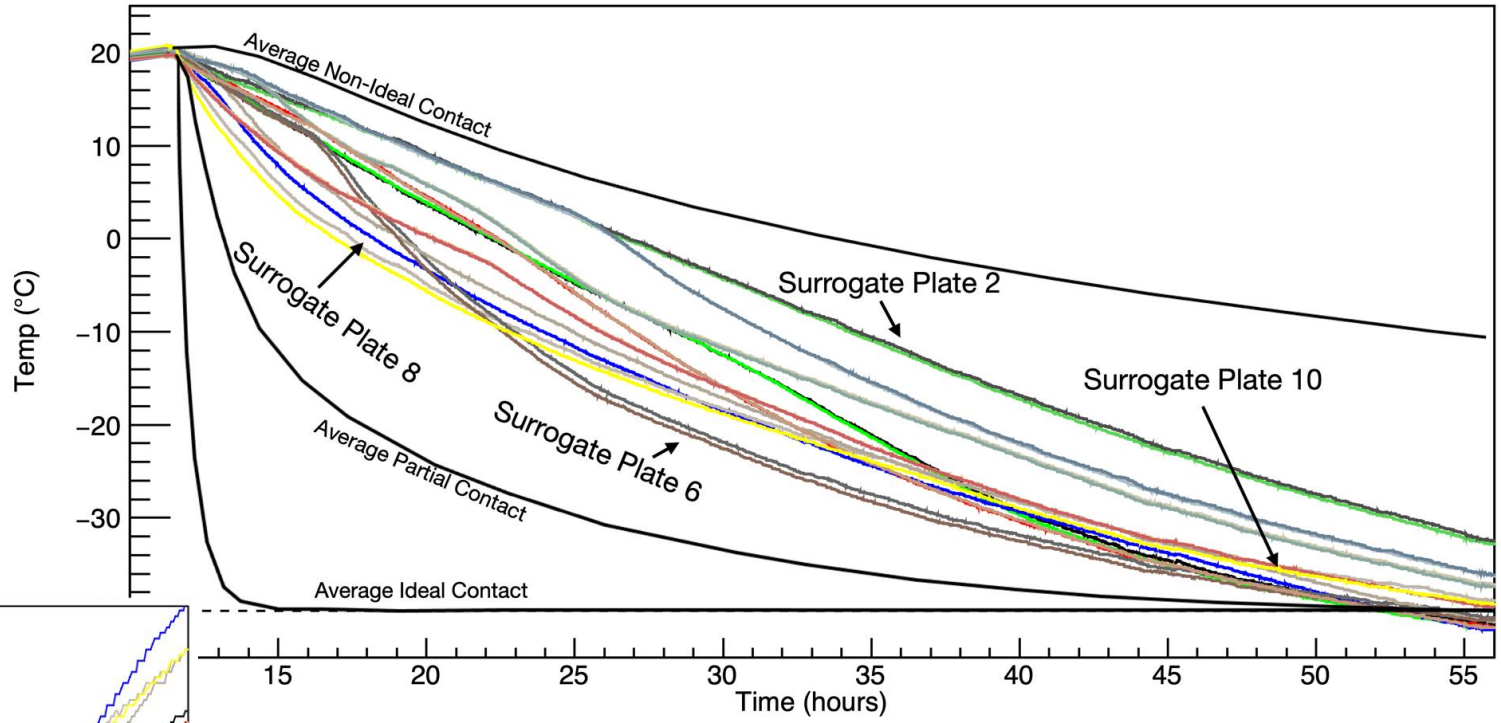


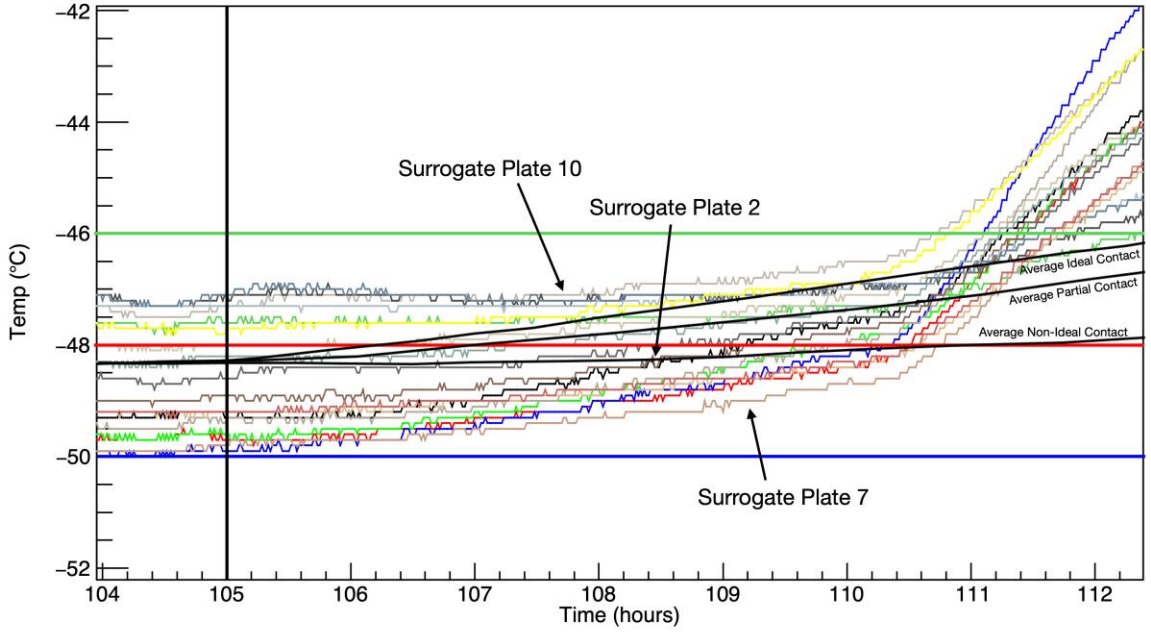
- Regardless of the coupling we would anticipate a working time between 2 and 8 hours
- Some layers would warm much quicker than other layers

Thermal Performance

Case 5a Base Configuration

- Cooling to -40°C +/- 2.5°C within about 48 hours
- Working time >6 hours





Thermal Considerations

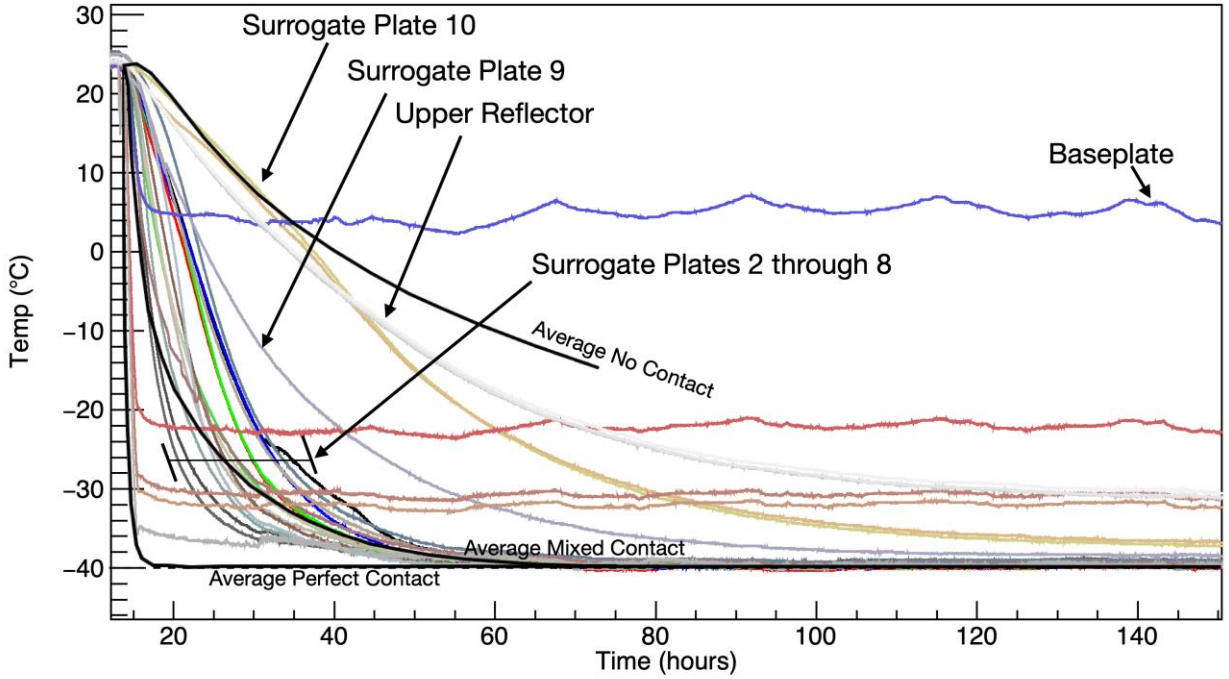
Case 5 Fabricated Gaskets

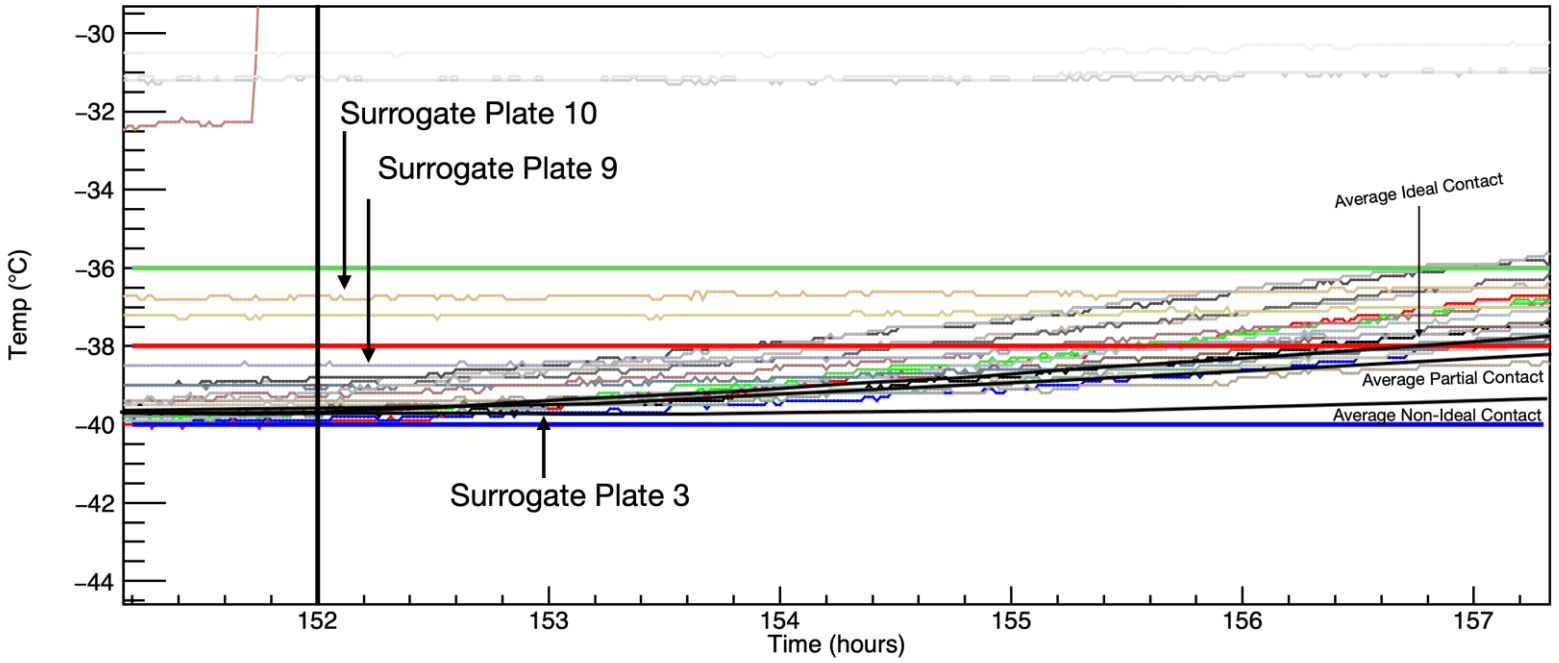
- To improve the thermal contact between the stack and the spindle, aluminum wire gaskets were press formed
- Press-formed gaskets replace hand pressing aluminum wire into the gaps
- Press-formed gaskets are repeatable and provide better thermal contact than the hand pressed alternative

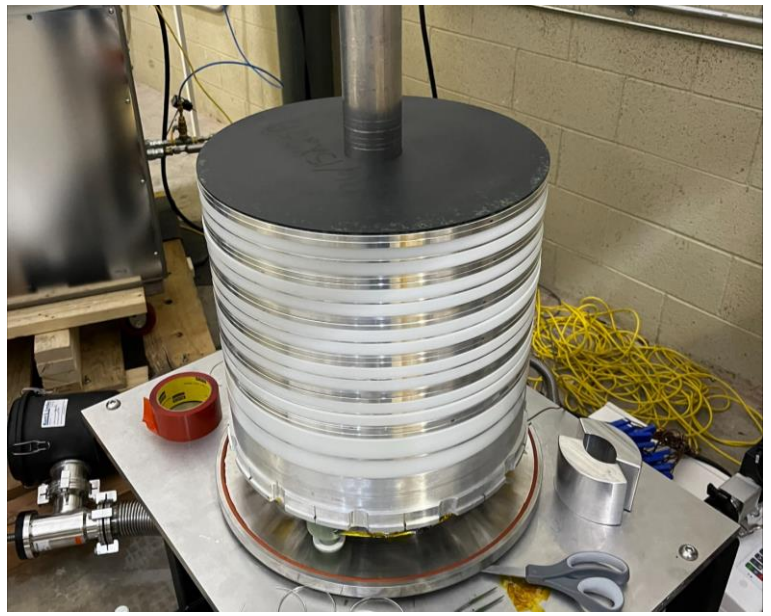
Thermal Performance

Case 5a Fabricated Gasket Configuration

- Cooling to -40°C +/- 2.5°C within about 48 hours
- Working time ~6 hours*
- Natural Uranium Plate in Layer 7





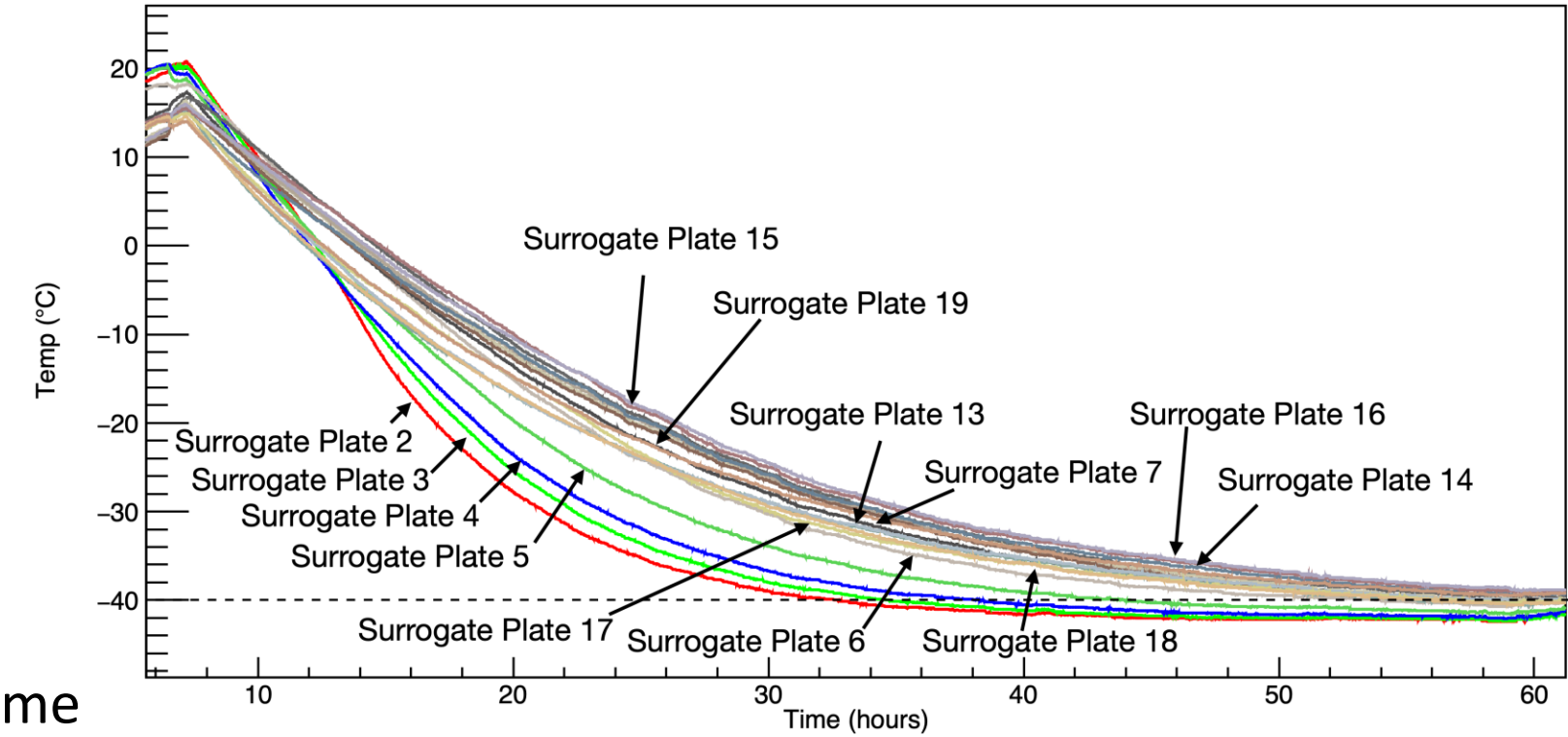


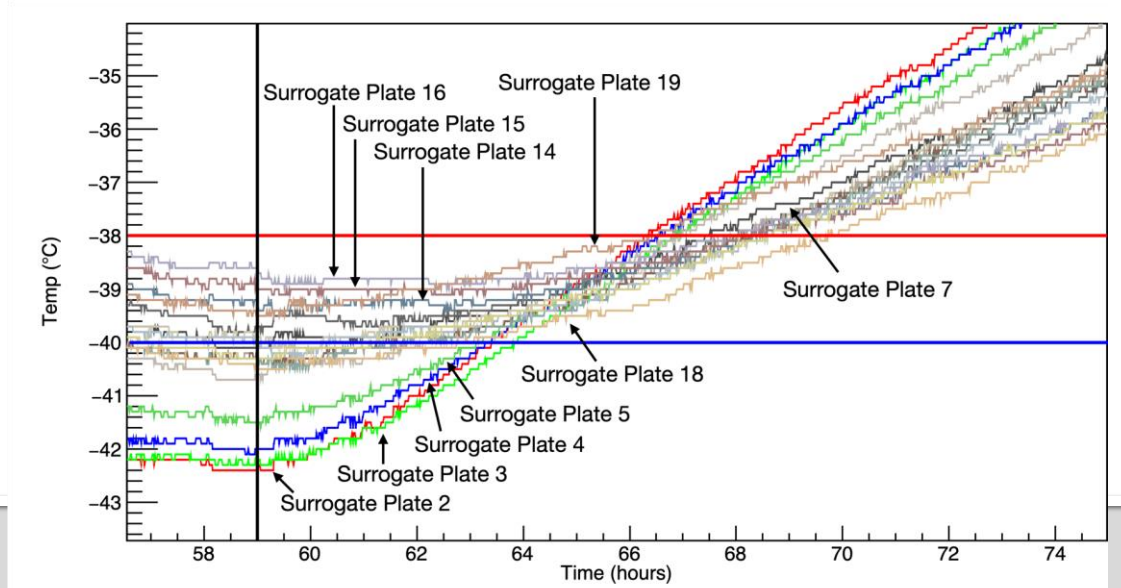
*Testing was terminated early due to a facility power outage. Facility had to active A/C and room temperature were >80F

Thermal Performance

Case 2

- Cooling to -40°C +/- 2.5°C within about 48 hours
- Working time ~8 hours
- Inclusion of Mylar below heatsink increased working time





Performance of Uranium

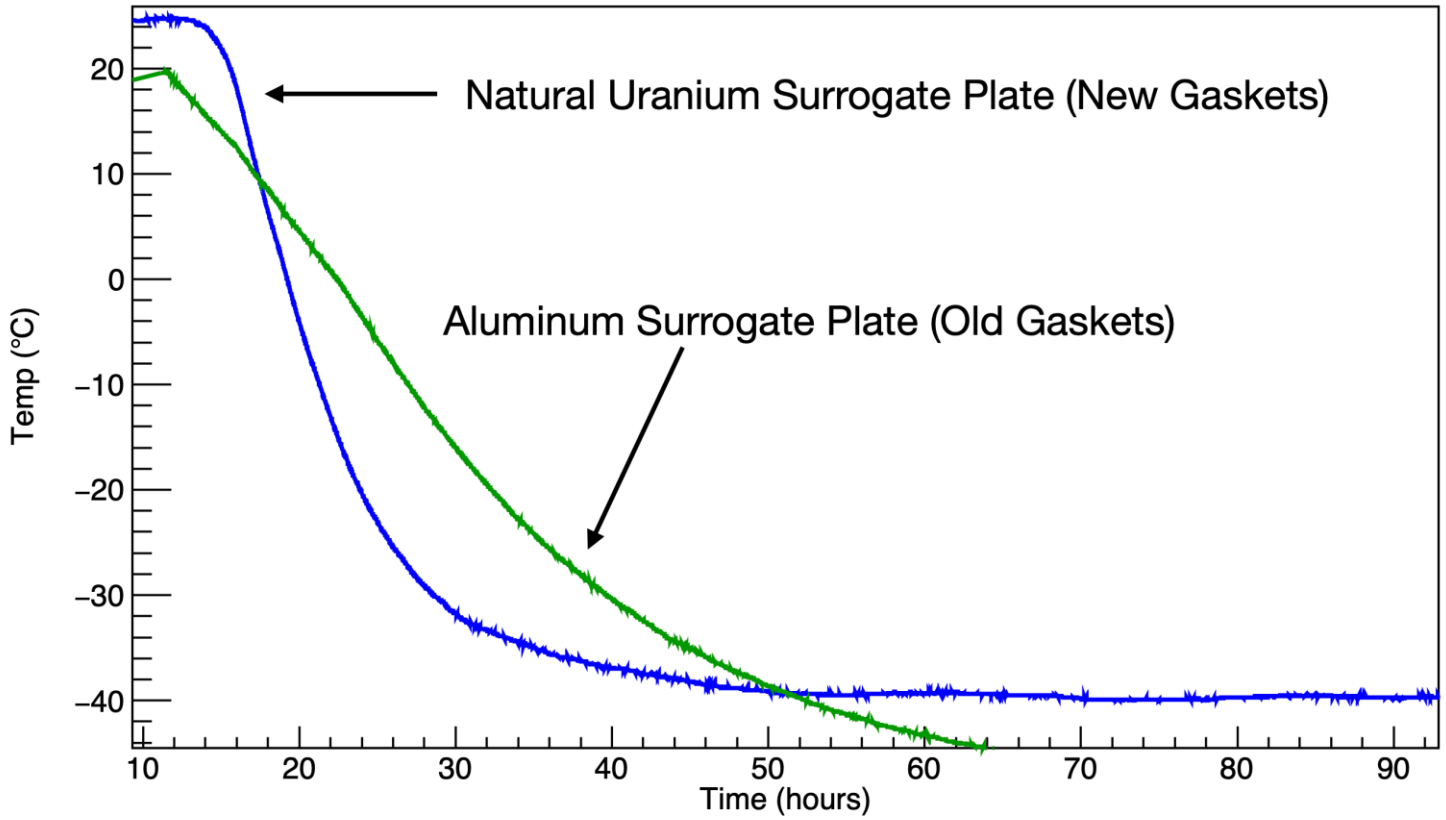
Natural Uranium of the Jemima Dimensions

- Two tests with natural uranium were performed to test the reliability of the material and well as characterize it
- We used a 15” Big Ten nat U plate
- We tested to ensure that oxidation did not accelerate
- Fracturing or warping did not occur
- No ‘sweat’ or condensation formed on the plate during the entirety of testing

Performance of Uranium

Natural Uranium vs Aluminum Surrogate Plates

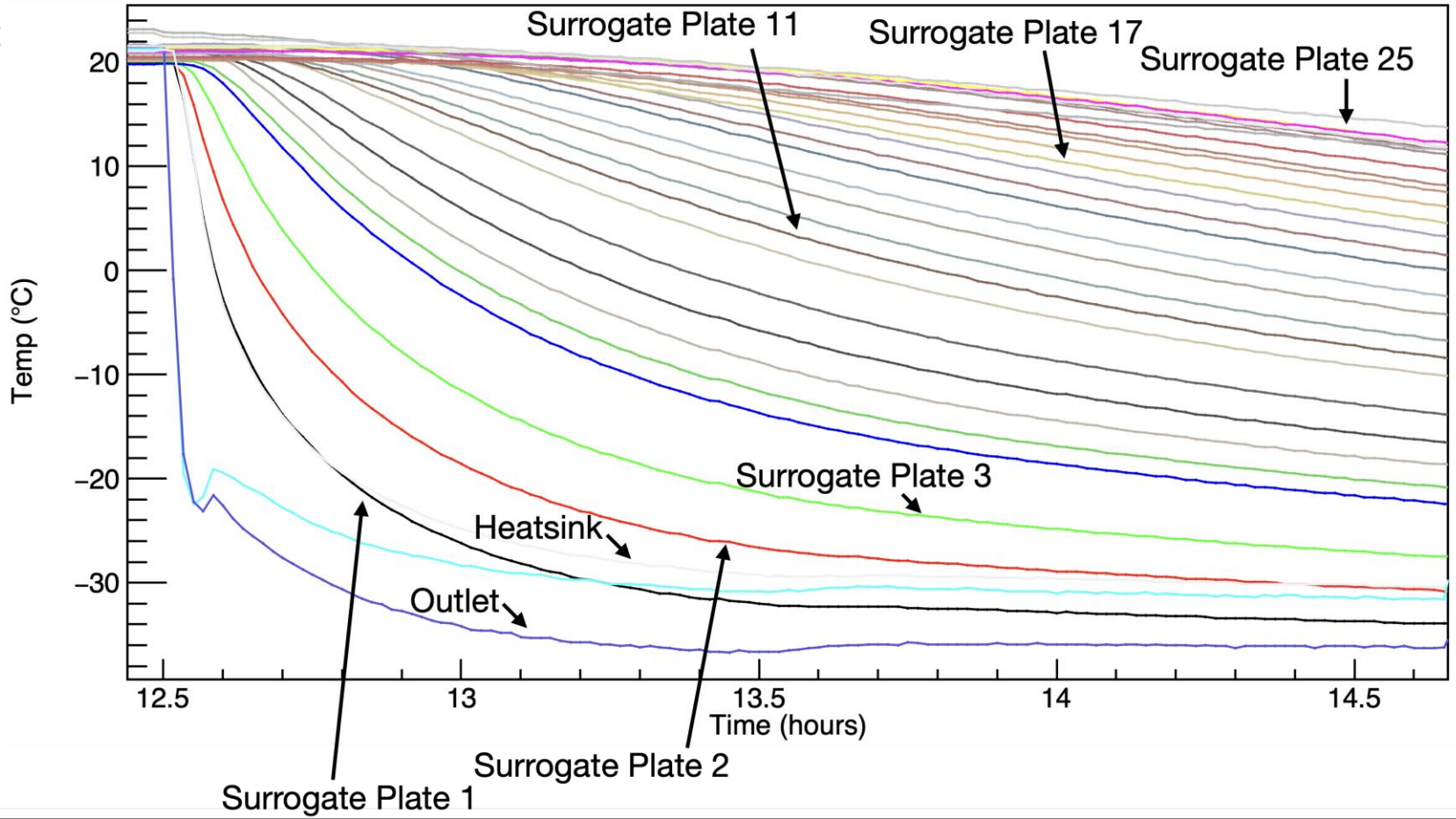
- Case 5a was testing four different times
  - Three with only aluminum surrogate plates
  - Once with a natural uranium plate in the 7th layer
- A direct comparison of Layer 7 is shown
  - Differences:
    - Press-formed vs hand pressed gaskets
    - 1” moderator was split into two ½” moderator plates



Loss of Vacuum

What happens if there is no vacuum?

- Case 1 was testing without vacuum
  - Test was **without** Nat U plate



Loss of Vacuum

What happens if there is no vacuum?

- After a few hours, half of the stack was cooled down
  - The chamber and copper shield were removed to observe the stack
- Immediately after exposure to the room, minor condensation formed on the heatsink

Loss of Vacuum

What happens if there is no vacuum?

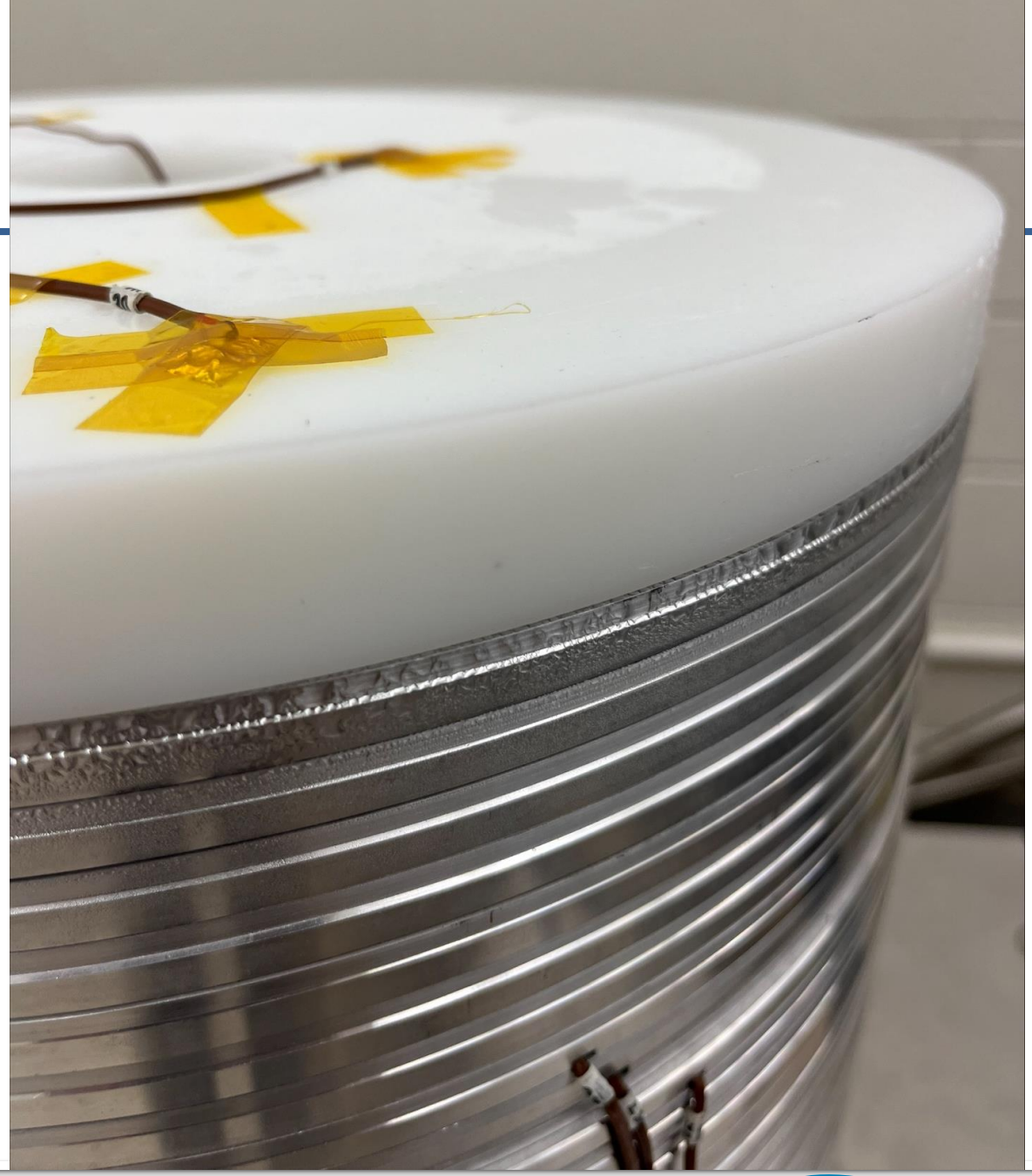
- After about 3 minutes more condensation (frost) formed on the heatsink

Loss of Vacuum

What happens if there is no vacuum?

- The stack was allowed to return to room temp and condensation formed at the top

- Takeaways:
  - Without access to room air, air circulation, and therefore moisture, is limited
  - Cooling and warming occurs faster since there is air between the plates, which acts as a conductor
  - While condensation does form, no other potential risks to the system were found from this test



Conclusions

- Surrogate testing for Low-Temperature TEX has been complete
  - All open questions have been resolved
- There is no apparent danger to the fuel plates during these experiments
- Thermal performance with the spindle aligns closely with the thermal models
- Cooling and working times are as anticipated

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