MIRI Cooler Subsystem Test Facility Overview

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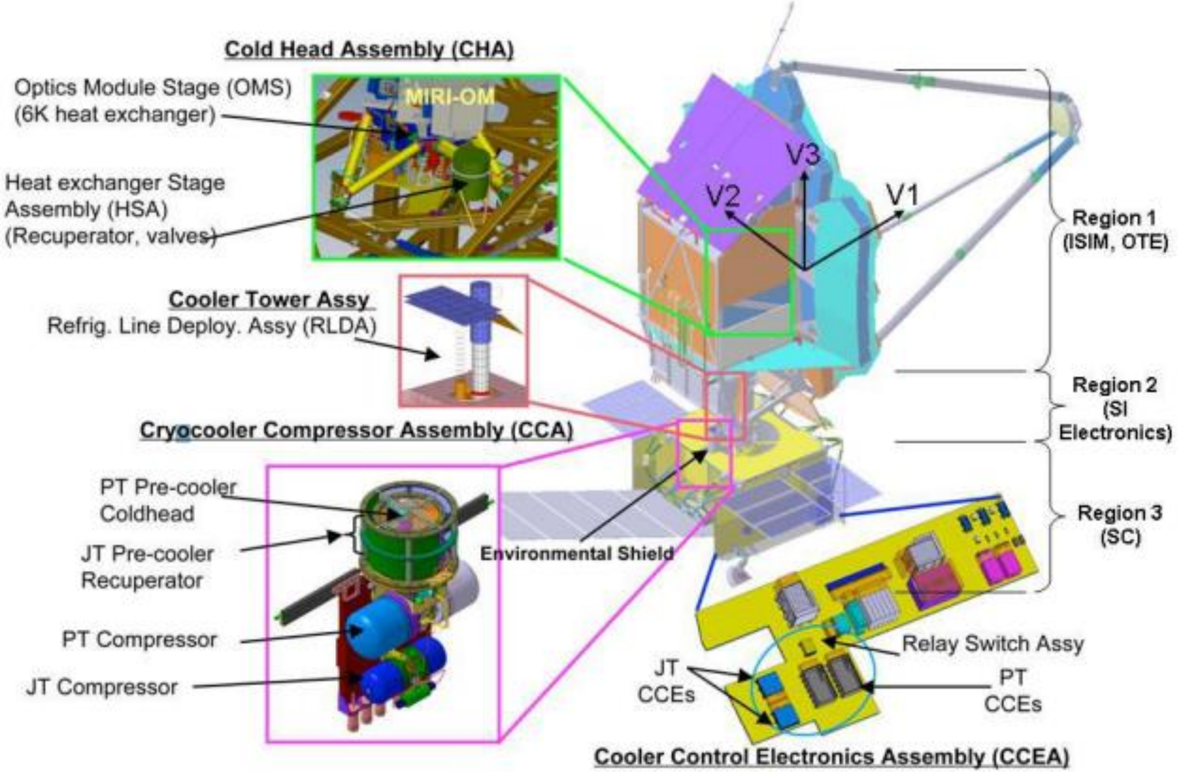
MIRI Cooler System Overview

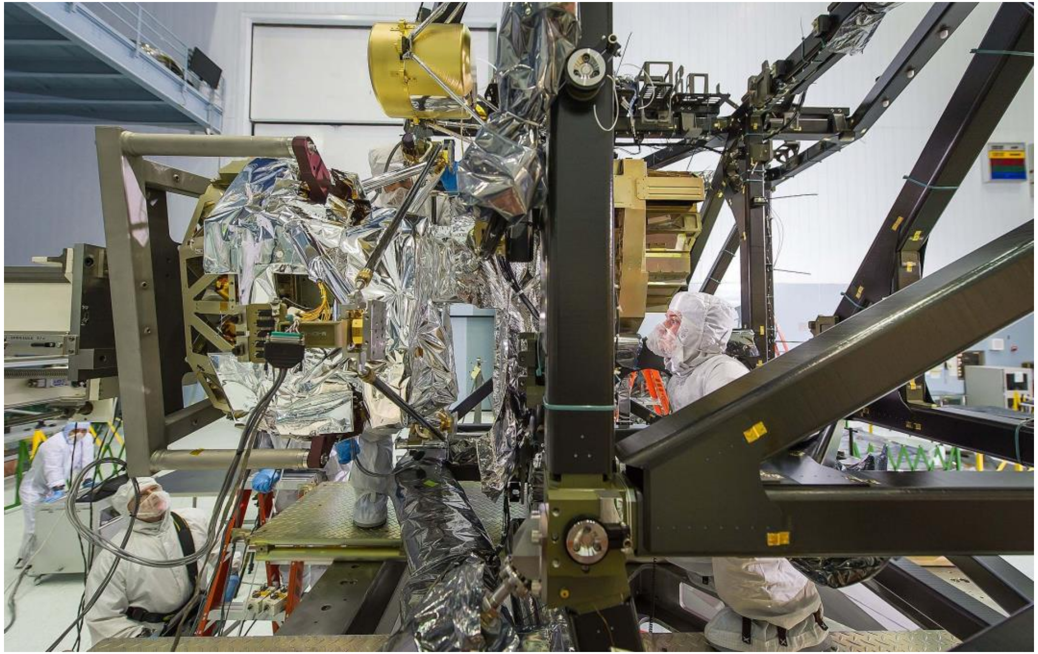
- Provides 5.9K to 6.2K interface temperature for the Mid InfraRed Instrument (MIRI) on the James Webb Space Telescope (JWST)
- Cooler components (shown at right) integrated into spacecraft at different phases
  - Testing at JPL is the only functional cryogenic test of the full cooler system.



http://ircamera.as.arizona.edu/MIRI/miricooler.pdf

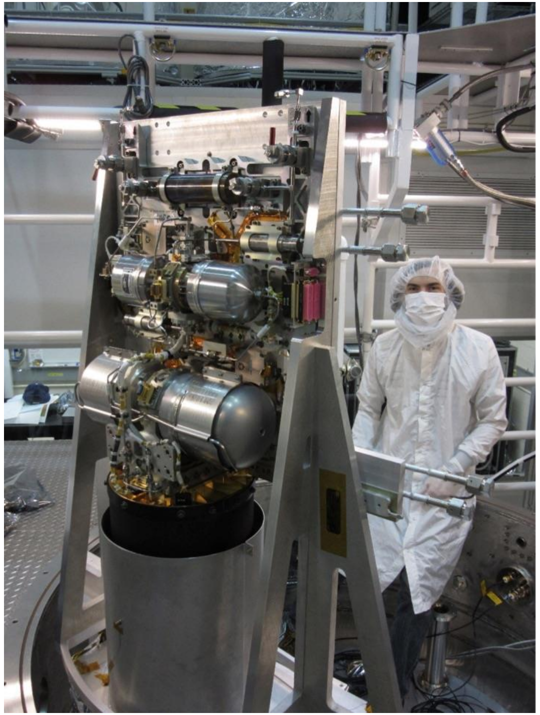
MIRI Cooler System Overview

HSA and MIRI OM on ISIM



https://en.wikipedia.org/wiki/MIRI_(Mid-Infrared_Instrument)

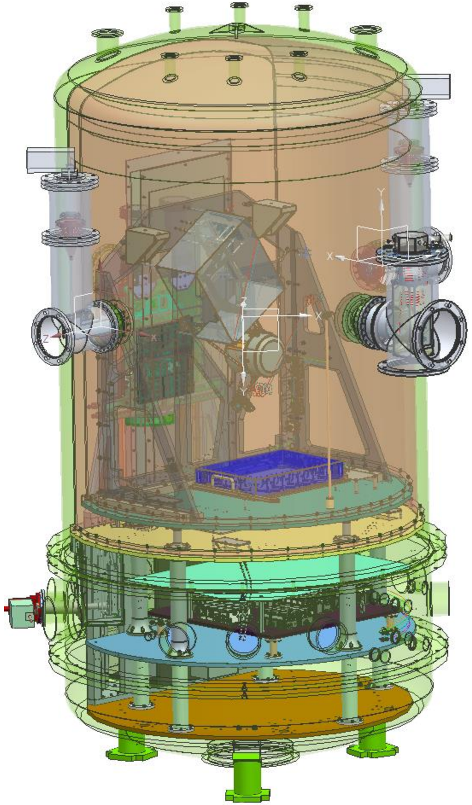
CCA in MIRI Test Chamber

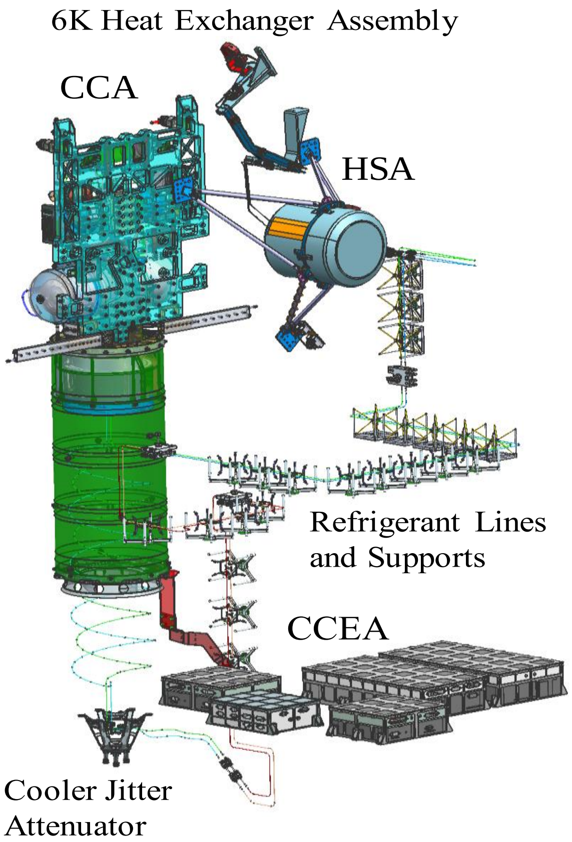


https://jwst.nasa.gov/cryocooler.html

Hardware under test

- Flight/Flight Spare Cooler Compressor Assembly (CCA)
  - Acceptance testing completed in chamber
- Flight/Flight Spare Cooler Control Electronics Assembly (CCEA)
  - TVAC and functional tests completed in chamber
- Flight Spare Heat Exchanger Stage Assembly (HSA)
- Flight Spare 6K Heat Exchanger Assembly (6K HX)
- Cooler Jitter Attenuator (CJA)
  - EM for thermal representation
- Refrigerant Line and Supports (RL/RLS)
  - GSE Stand-ins, gold plated and matched to flight length and volume
- Characterization testing currently ongoing with this complete cooler system and a flight-like instrument stand-in

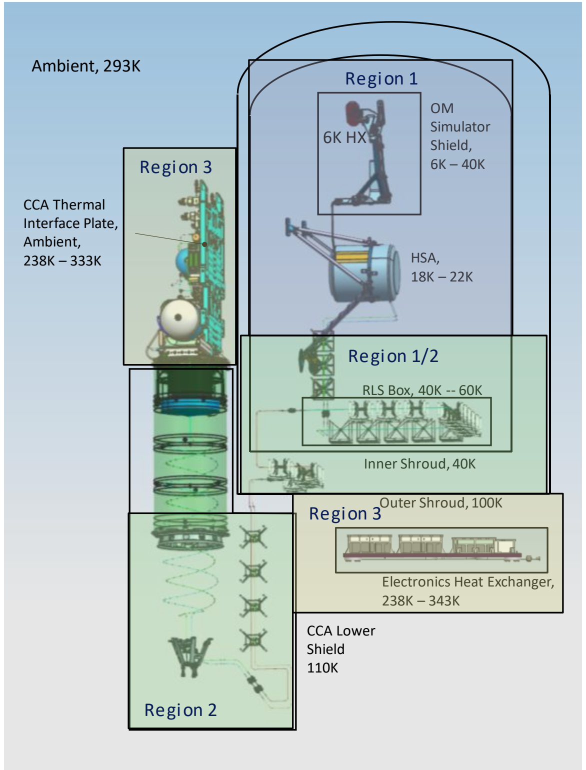




Thermal Regions

Thermal System

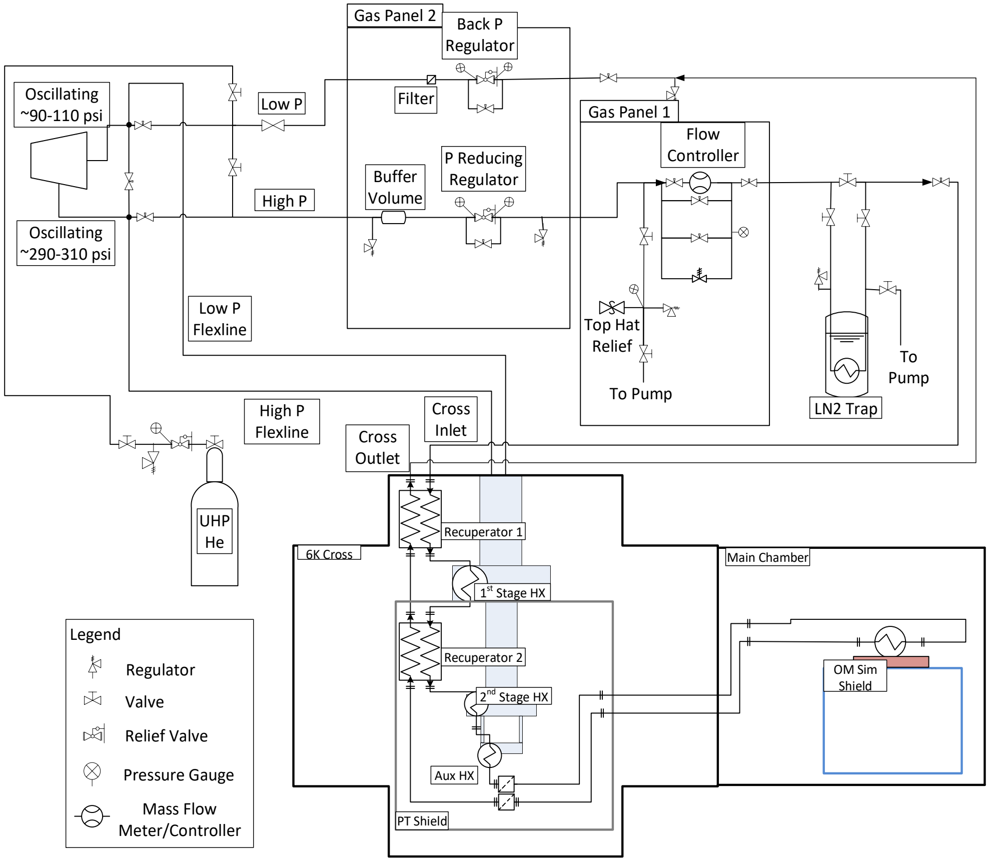
- In flight, the spacecraft is lumped into 3 thermal regions (with temperature gradients between)
- To accurately represent the transitions between those zones and interfaces at the spacecraft bus, the chamber has 7 thermal zones:
  - Zone 1: Ambient
    - Vacuum chamber and CCA Scaffold.
  - Zone 2: Outer Shroud and CCA Shield
    - 100K
    - Cooled by two single stage Gifford-McMahon cryocoolers (GM1 and GM2) via gravity fed N2 heat pipes, and the CCA shield cooled by the 1st stage of a two stage cryocooler (GM3) via a thermal strap
  - Zone 3: Inner Shroud
    - 40K
    - Cooled by the 2nd stage of cryocooler GM3 via a thermal strap.
- Zone 4: OM (Optical Module) Simulator Shield
  - 6-40K
  - Cooled by a recirculating helium loop from a GSE PT cooler
- Zone 5: RLS (Refrigerant Line Support) box
  - 40-80K
  - heater controlled region surrounding a subset of the GSE refrigerant lines and line supports.
- Zone 6: CCEA Chiller Plate
  - Recirculating chiller cooled/heated plate on which the flight electronics are mounted
- Zone 7: CCA Chiller Plate
  - Recirculating chiller cooled/heated plate on which the flight CCA is mounted. This zone is controlled by two separate chillers, one for each compressor, to provide consistent temperature across the CCA thermal interface



OM Simulator Shield

Thermal System

- For acceptance testing there was not a representative thermal stand-in for instrument (schedule driven)
  - Loads on 6K heat exchanger and HSA had to be simulated with electric heaters
- For an accurate measurements, parasitic loads were minimized with OM Simulator shield cooled with a Modified Cryomech PT 407 cooler
- Custom manifold from Cryomech allows flow to be bled off and circulated through JPL built recuperators and heat exchangers to provide remote cooling

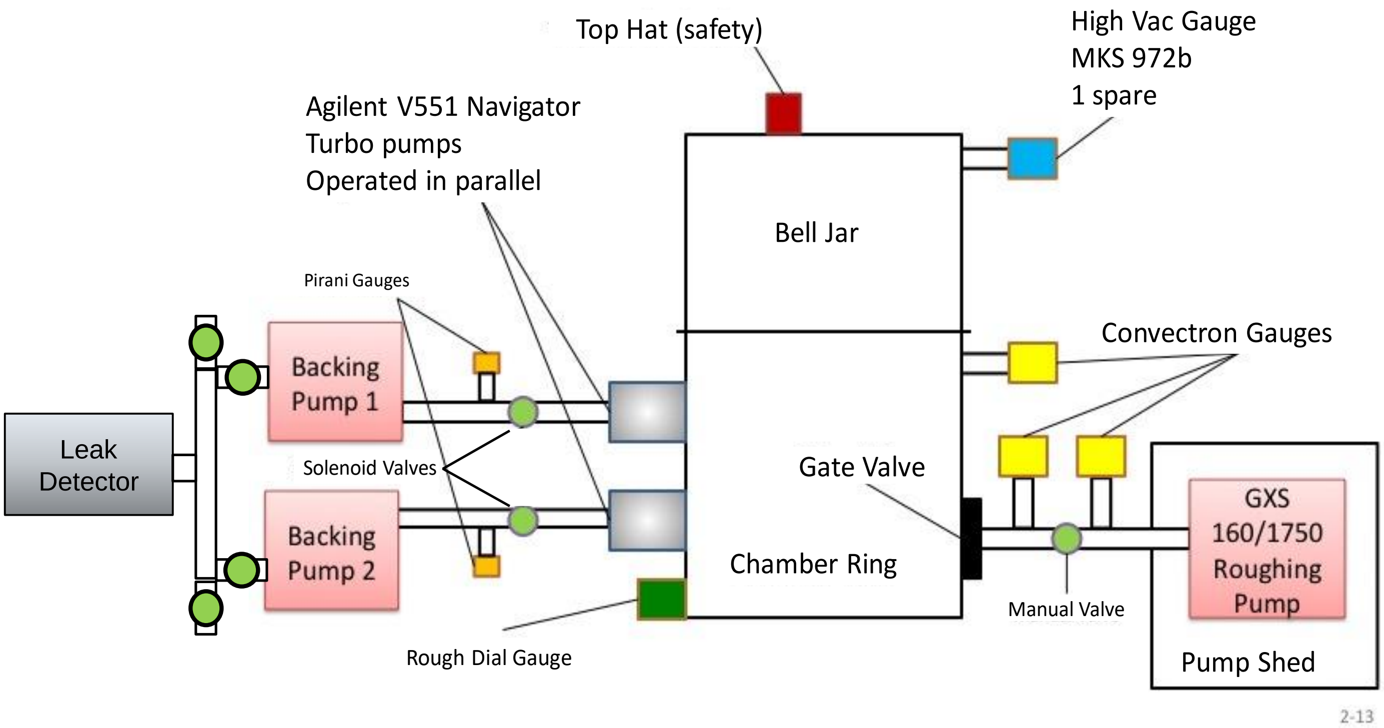


Flight Pneumatic System

- JT loop must be set with a closed charge of clean helium using an external fill cart
- There is a need for the capability for a contingency fill pressure adjustment
  - Cannot significantly increase system volume as it affects performance so external isolation not possible.
  - Accomplished with Pneumatic valves directly at inlet and outlet of CCA
  - Actuation volume leak rates unacceptably high
  - “Valve Cans” create a hermetic volume around valves and vent external to chamber

Vacuum System

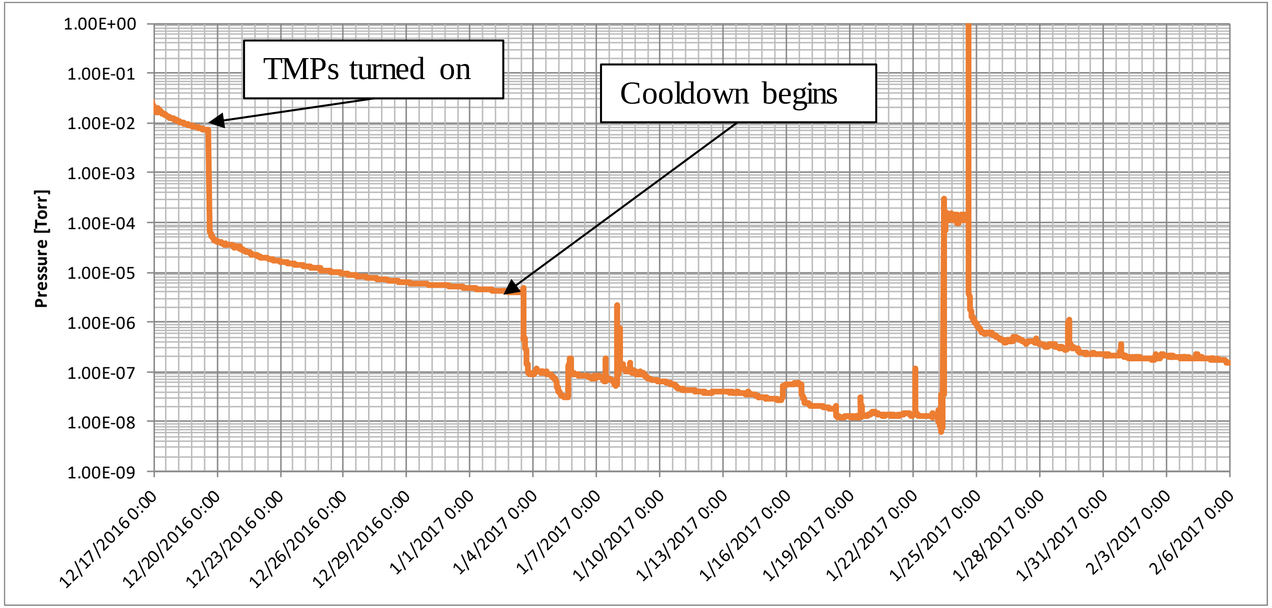
- Large Edwards GXS roughing pump for initial pull down
- Dual TMPs for redundancy
- Leak detector can back one or both backing pumps



Pumpdown

Results

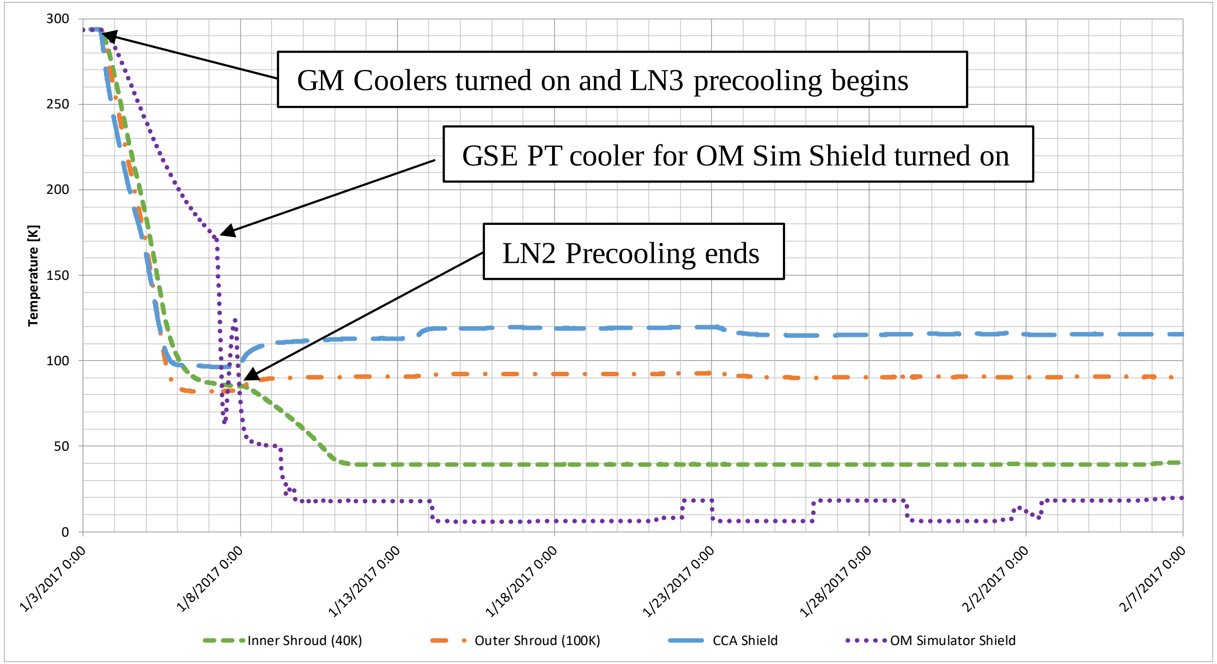
- Warm pump down times vary depending on schedule requirements
  - Cooling can be activated at ~1E-5 torr, longer pump times equate to better thermal performance
- Initial rough pump for ~3 days
- TMP pump for ~11 days
- Leak rate measured is in line with expected leak rate of the cooler
  - Measurements of chamber only leak rate on order of 1E-8 to 1E-9 (10^2-10^3 lower than cooler requirement)



Cooldown

Results

- Cooldown achieved in ~7 days (40K region final temperature to land)
- Temperatures held stable throughout test



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