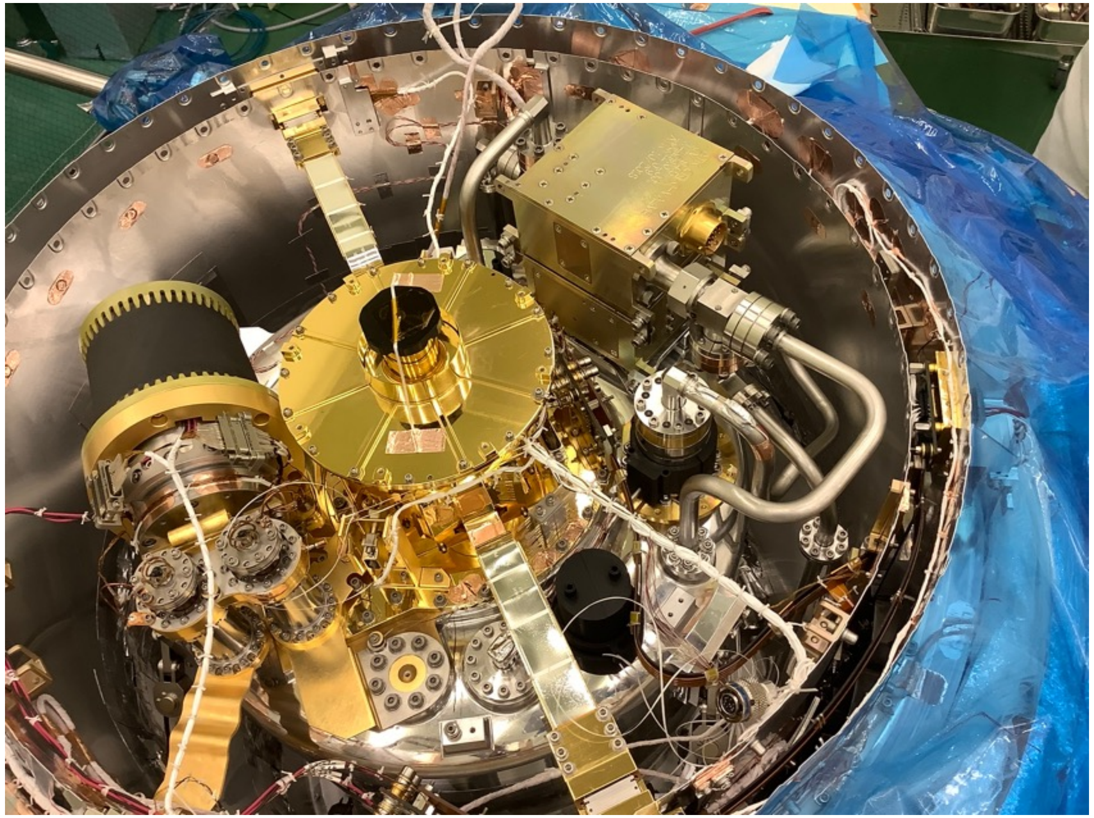

Finding and Fixing a Small Low Temperature Leak – A Case Study on XRISM/Resolve

Mike DiPirro for the

NASA/JAXA/SHI XRISM/Resolve Team

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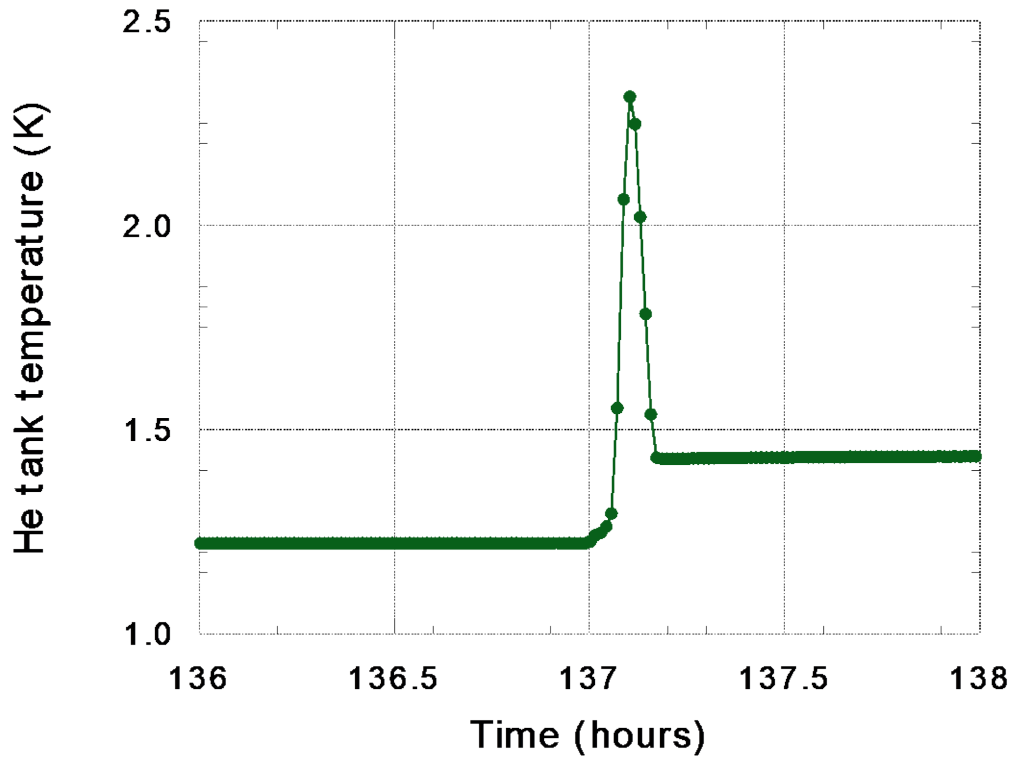
Introduction – The Problem

- "Puff" occurs when an adsorbing surface (He tank and JT shield) saturates, causing cascade release of GHe, which is then re-adsorbed onto a charcoal getter
- Requirement, Leak <4.8e-11 Pa m^3/s
    - No puff for required life of helium (3 years) x 2 margin
- Two prior cool down tests with no leak seen



Where Could the Leak Be?

- Tests during TC-2 warm up isolated the leak to the helium tank and attachments – it was not in the fill or vent line or cryocoolers

27 components or interfaces where the leak could be

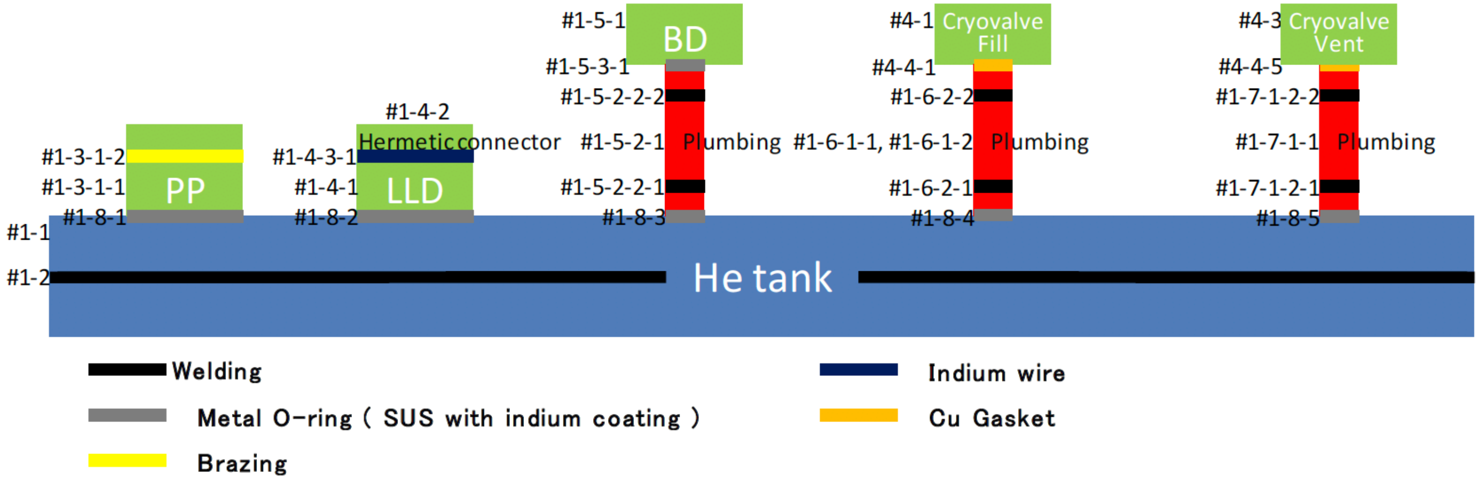
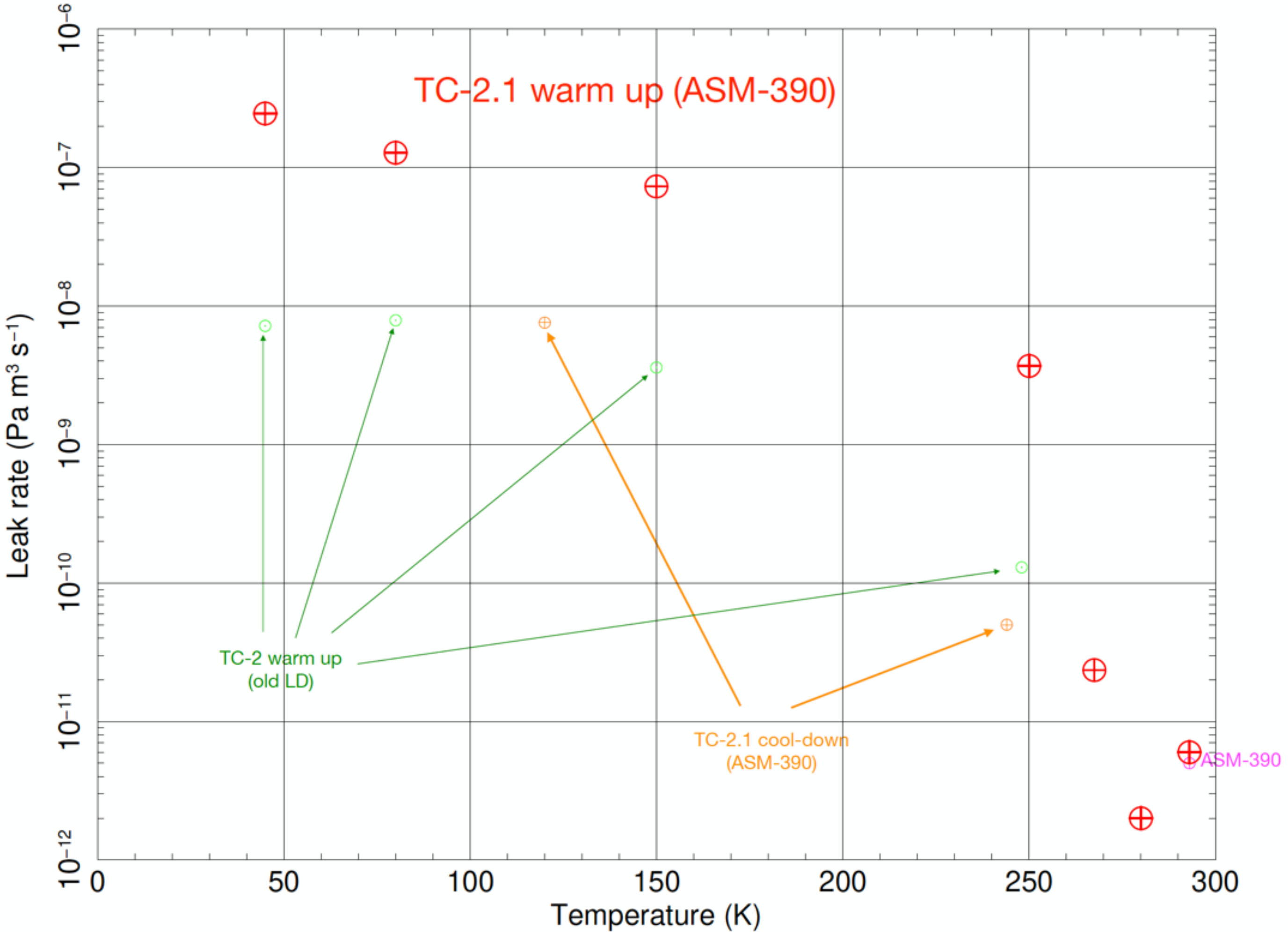


図 1-1 リーク候補箇所の模式図

Figure 1-1 Schematic diagram of possible leak locations

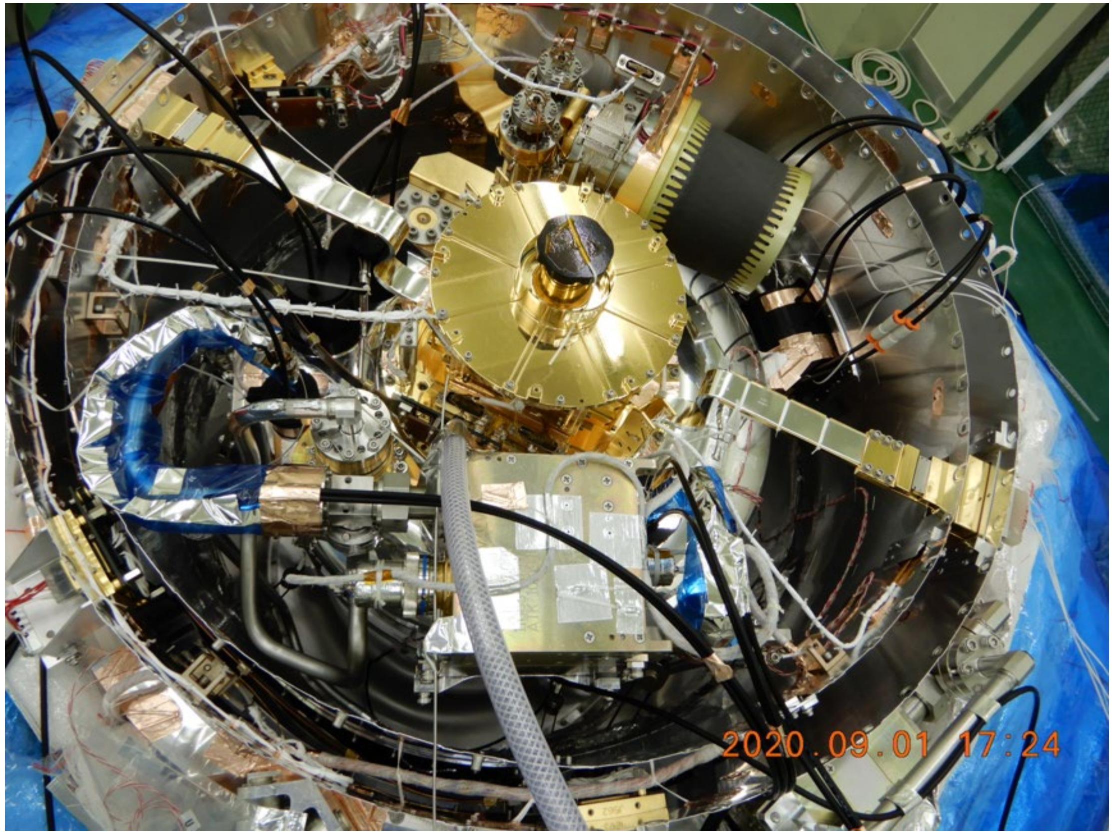
What does the leak look like vs. temperature?

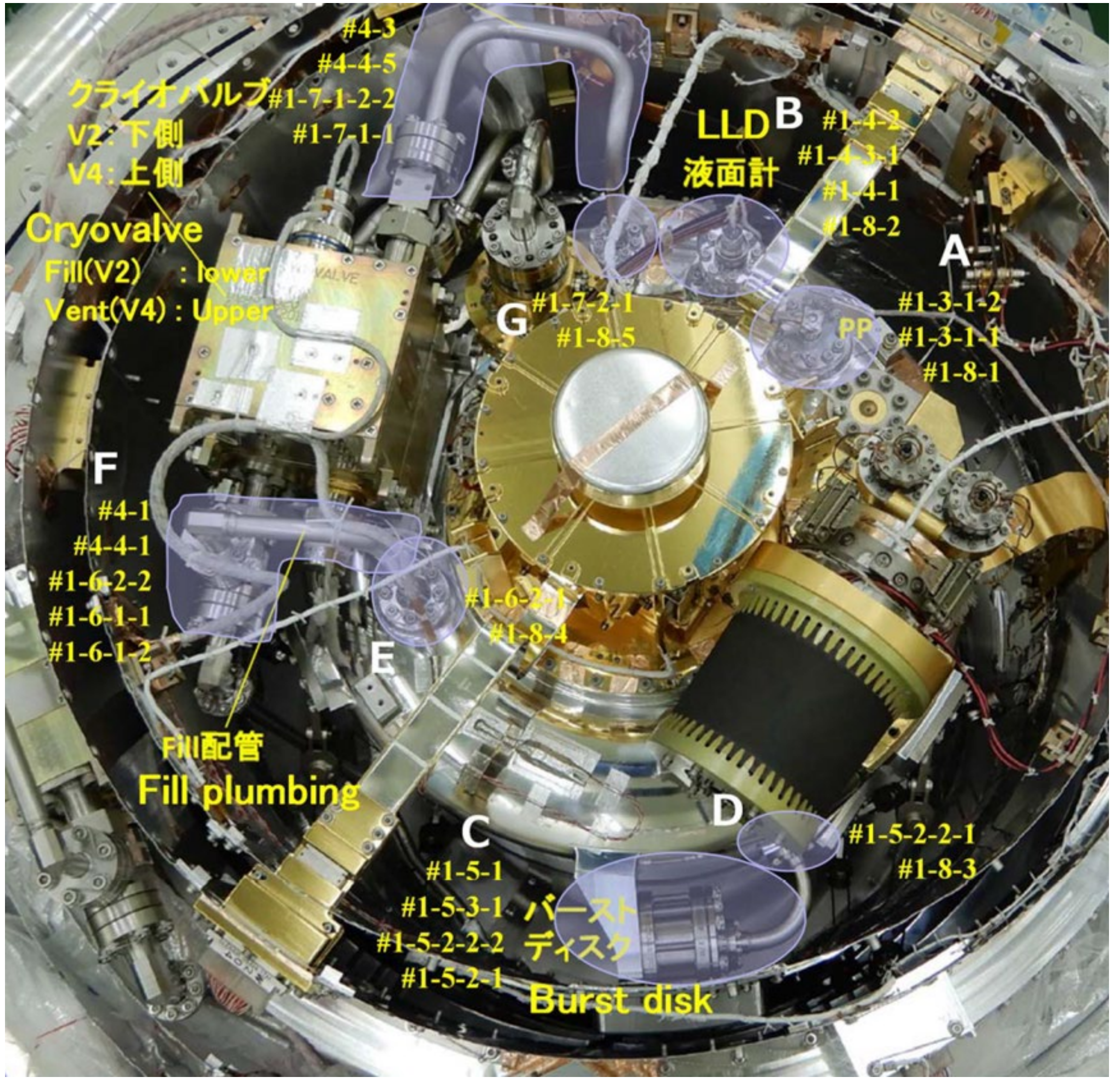


Leak Types

- Laminar varies as gas density and inversely with viscosity
  - T^-1.67
- Molecular varies with gas density
  - T^-1
- Permeation varies exponentially with the inverse temperature
  - only one component identified with a non-metal seal – electrical feedthrough into the tank
- Constant hole size does not fit the data
  - Points to increasing hole size at low T caused by strain or differential contraction

What does the actual Tank Top Look Like?



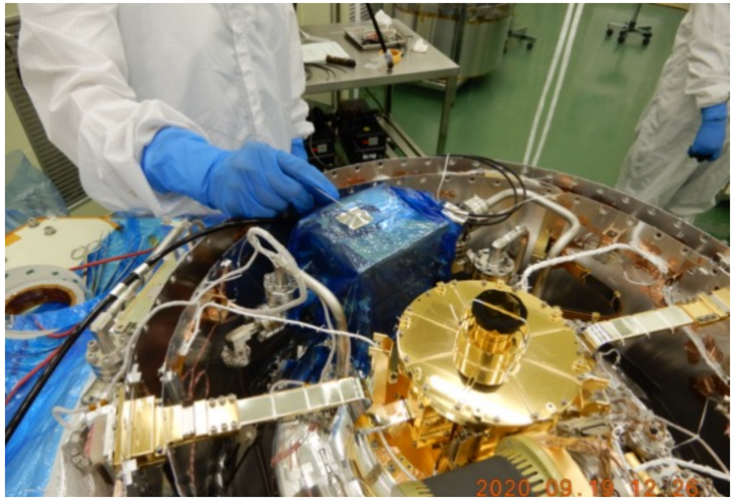


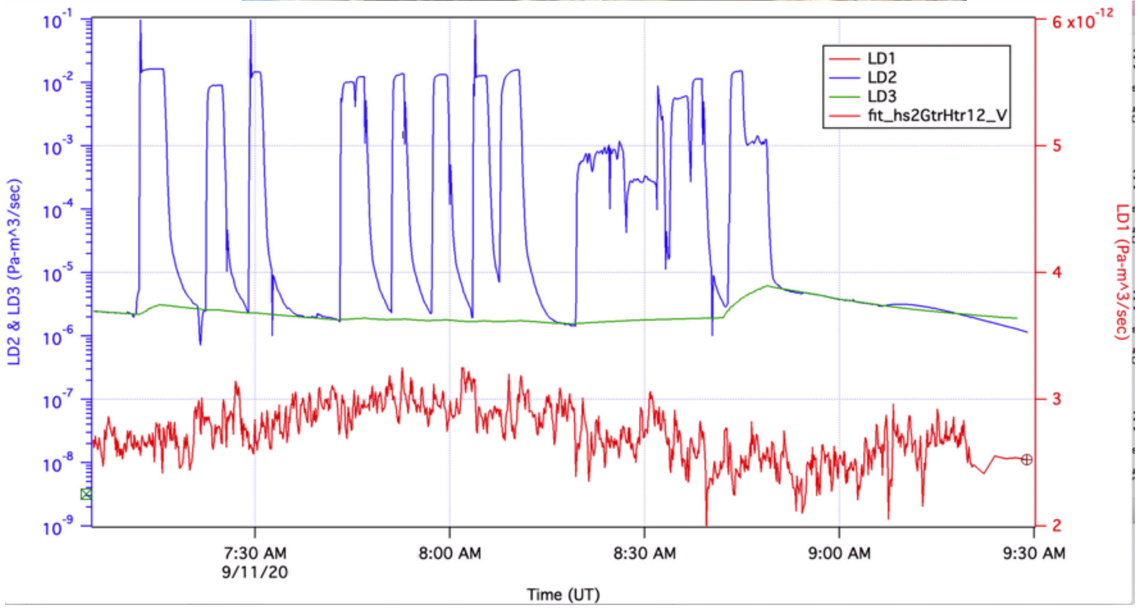
Context – This is a very sensitive, assembled instrument

- Potential leak spots are very close to sensitive wiring
- Hard to get to for leak checking or disassembly
- Detectors are pressure, moisture, and shock sensitive
  - Even local cooling is not possible to find a leak
- Filters are very sensitive to pressure and small particulates

Check of Individual Components

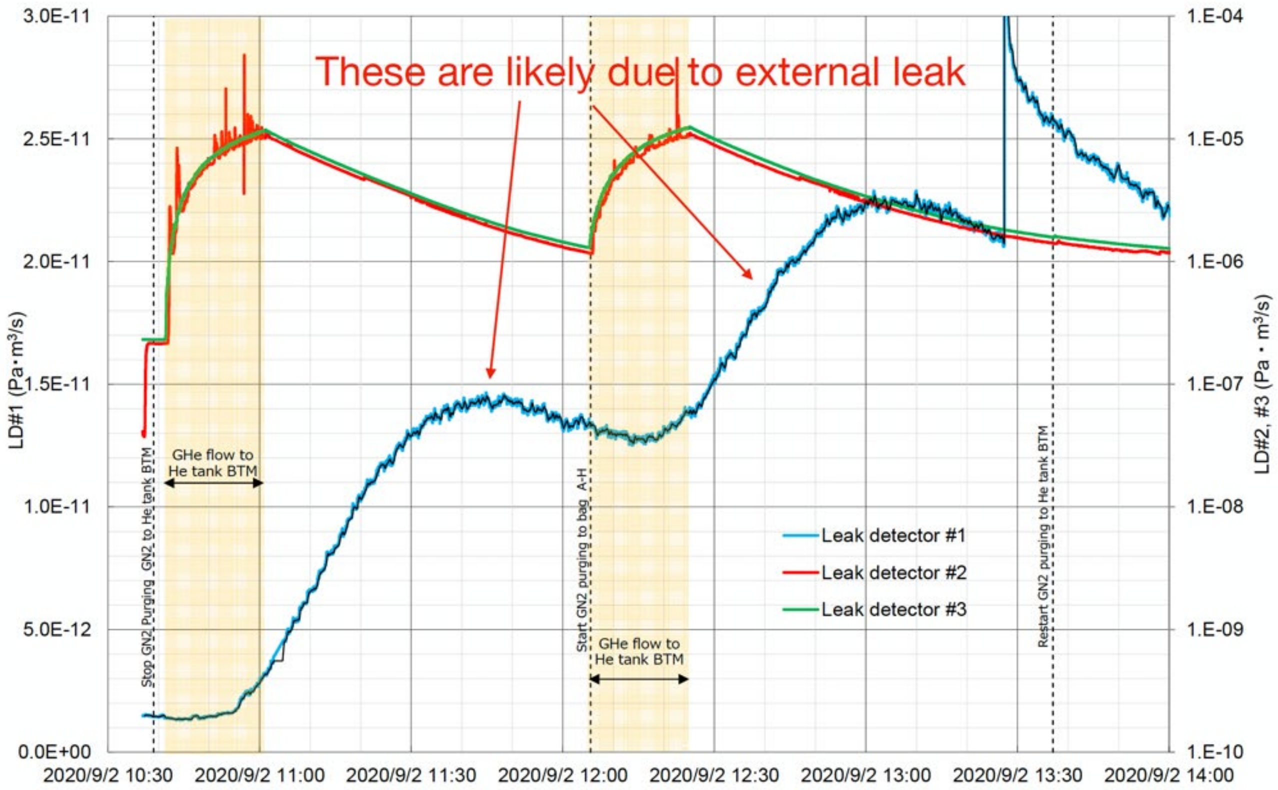
- Sensitive Leak Check
- Bagging Components and room T leak check
- He concentration measurement
- Outside He interference
- Removing individual components and testing to low temperature
- Remainder of dewar with blanks was cooled to superfluid helium
- Small room T leak in vent valve and no low T leaks found

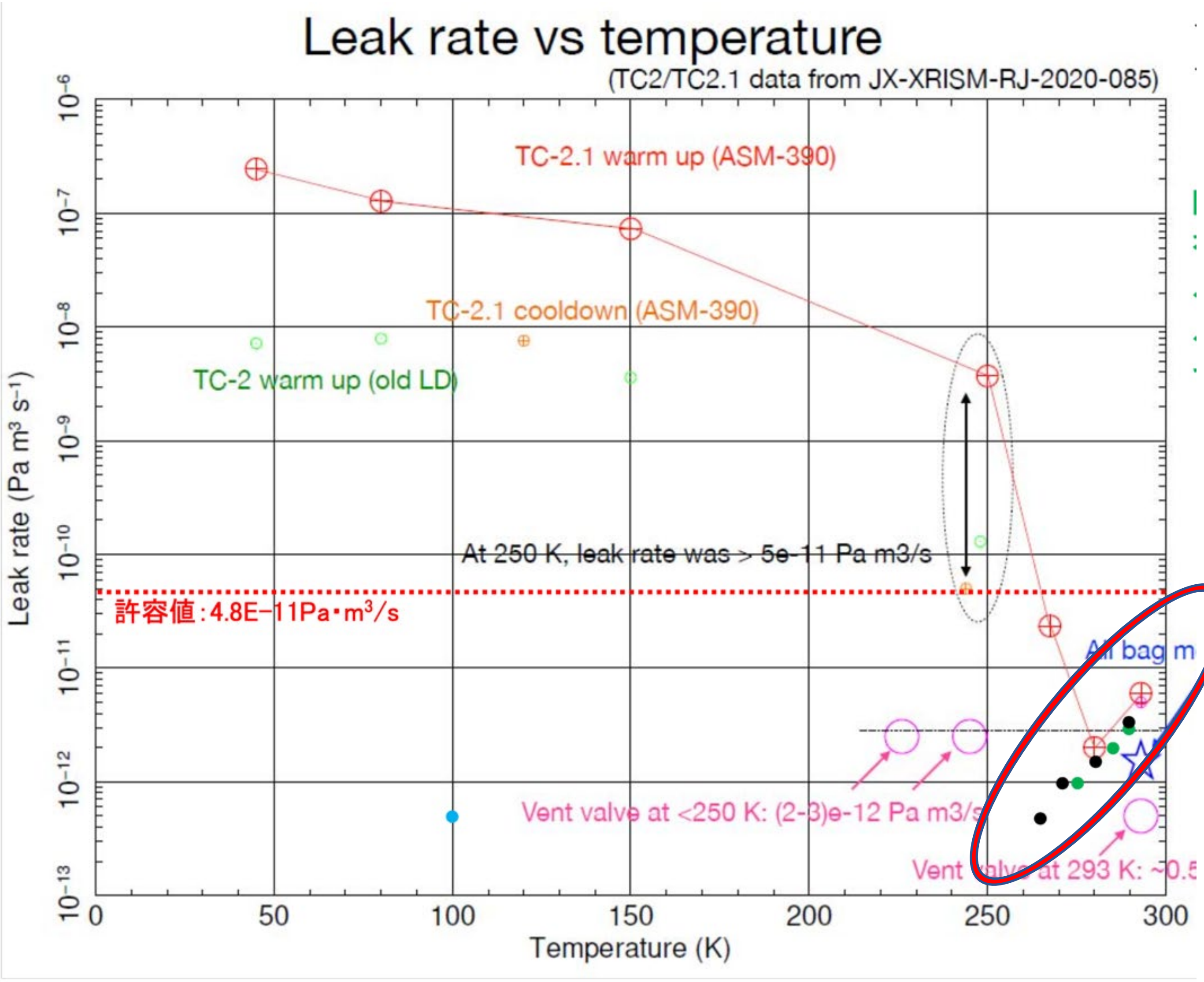




Helium Background

- Put a GN2 purged tent around LD1
- Used 2 additional Leak Detectors as sniffers
  - LD2 shows background near bags
  - LD3 shows background in room
- Effects are definitely seen with a time delay
- See Mark Kimball's presentation

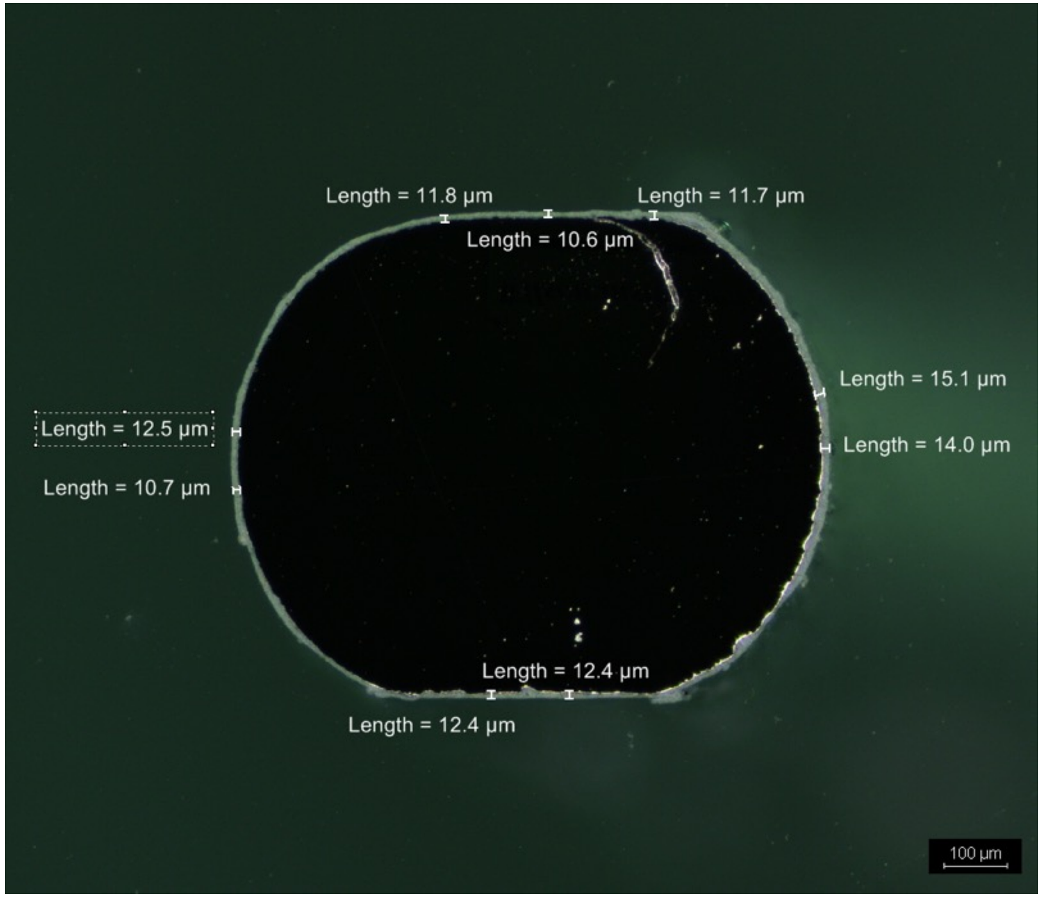




Black dots are component Tests of Vent Valve

The Room Temperature Leak

- The room T leak was a separate leak (actually permeation from an unexpected source)
  - See Mark Kimball's presentation
  - Permeation through a thin Teflon coating on a metal seal is the culprit

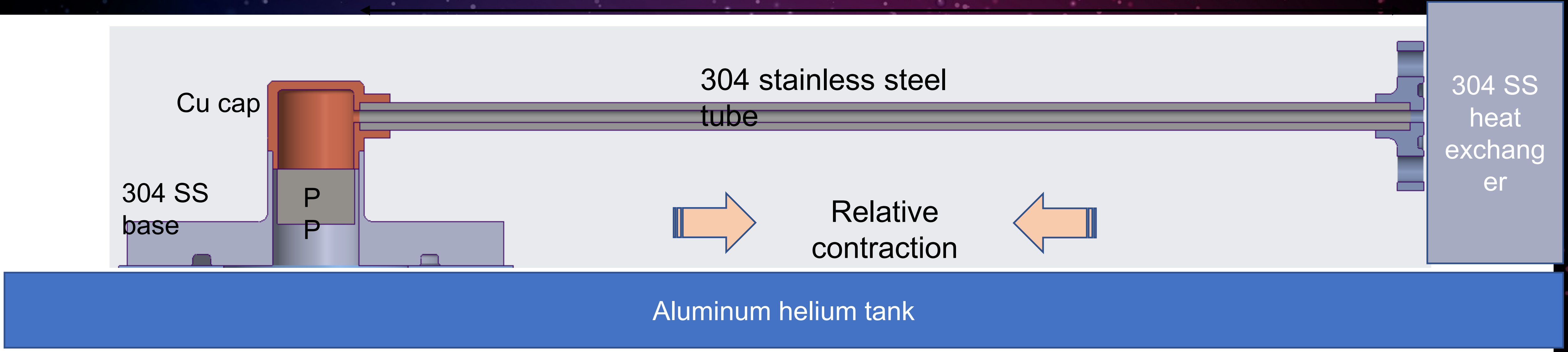


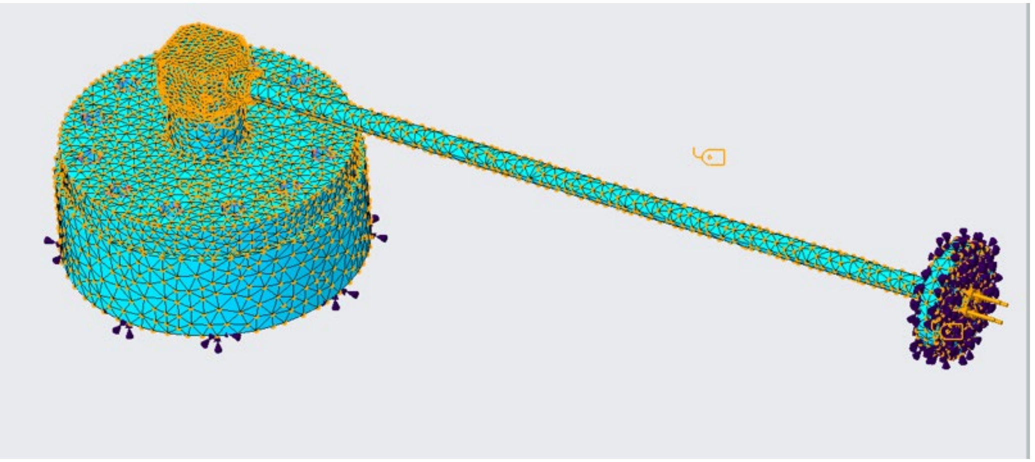
Bottom Line – There were two leaks

- The cold leak was not visible at room T
  - The leak decreased from ~5e-7 to <5e-13 Pa•m^3/s (limit of sensitivity)
- Some of the valves had a very small permeation rate
  - Vent valve and bypass valve and one of two spares had small room T leaks (<1e-11 Pa•m^3/s)
- All removed components were leak tight at superfluid temperature, including the valves
- The leak was assumed to be in one of the removed interfaces

Leak Investigation and Repair – Path Forward

- Porous plug capillary geometry was redesigned
  - Eliminates differential contraction stresses
  - [show schematic next page]
- More attention was paid to interface joints
  - Mini-conflat torques, bolt interference, cleanliness of surfaces, smoothness of surfaces
- During the post repair cooldown of complete system (TC-1A) more attention was paid to leak checking at each step in the process including intermediate cool down temperatures
- Neither TC-1A nor TC-2A showed any sign of a leak and accumulated leak check showed that the requirements were met.





Finite element model

$$\Delta CTE_{AL6061\ TO\ SS304} = 0.00118\ mm/mm_L$$

$$Relative\ Thermal\ Contraction = (0.00118)L_{TUBE}$$

$$Relative\ Thermal\ Contraction = (0.00118)(119.93\ mm)$$

$$\boldsymbol{Relative\ Thermal\ Contraction = 0.14\ mm\ (0.00557\ in)}$$

Summary/Lessons Learned

- A daunting task was overcome with teamwork and time
  - Experienced and capable team
  - Covid-19 slowed us down
- Remote participation was essential
  - Remote tools and regular communication is key
  - However, it does not substitute for on-site support at critical times
- Logistical support cut the waiting time
  - Dedicated personnel for this
  - Being able to buy and send stuff to the site was critical to keeping the schedule manageable