National Aeronautics and Space Administration

Measuring the Heat Load on the Flight Astro-H Soft Xray Spectrometer Dewar

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ASTRO-H/SXS

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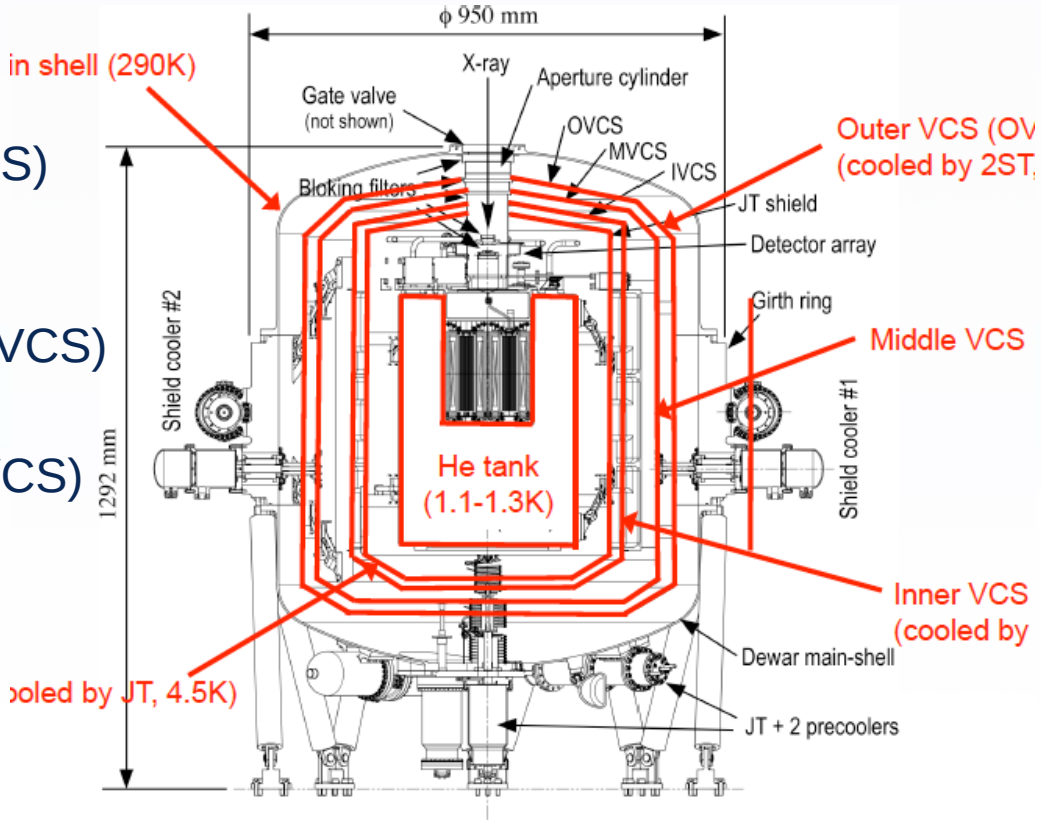
Introduction

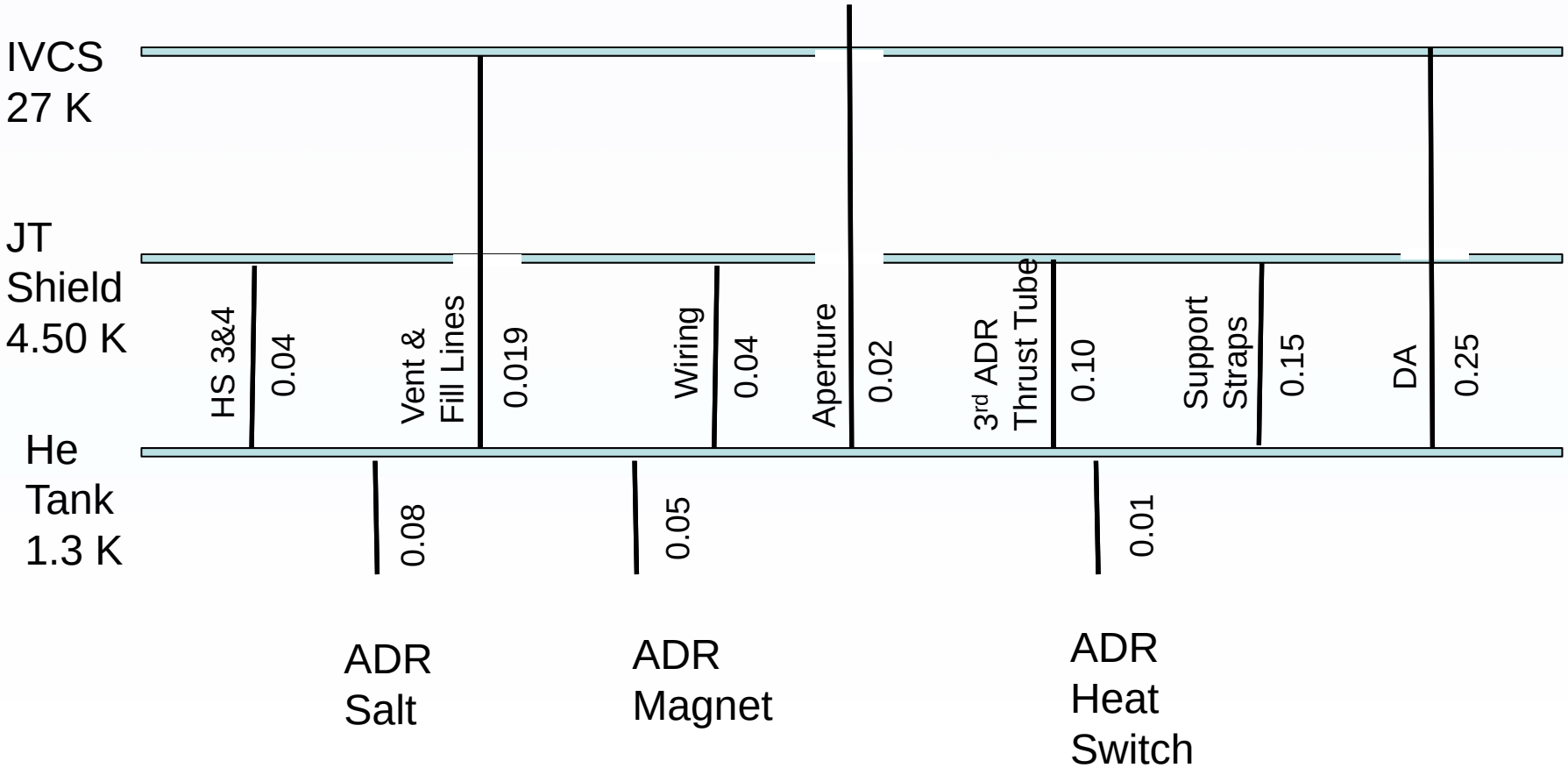
- The Astro-H SXS Dewar will is expected to have a usable lifetime in orbit of greater than 3 years
  - LHe lifetime is also expected to be > 3 Years
- Lifetime can be met only if heat load to helium tank is < 0.93 mW
  - This is a lower heat load than any previous mission using LHe
  - Assumes an initial fill level of 30 liters (76%)
    - Actual demonstrated fill is >36 L (>91%)
- We measured heat loads to the helium tank with LHe, and compared with thermal model predictions
- The instrument can also operate cryogen free using a 3rd ADR stage to cool the cryogen tank, lifting the heat to the 4.5 K JT cooler – see paper by Shirron in this workshop
- This paper describes tests on FM dewar to measure the heat load to the helium tank only (not cooler heat loads) and the heat load without helium as measured on the EM dewar

Brief Dewar Description

- Helium tank is suspended from and shielded by several layers of cryocooled/vapor cooled shields
  - Joule Thomson (JT) Shield
    - Cooled by JT cooler to ~ 4.5 K
  - Inner Vapor Cooled Shield (IVCS)
    - Cooled by 2nd stage of Stirling Coolers to ~27 K
  - Middle Vapor Cooled Shield (MVCS)
    - Cooled by vapor only to 100 K
  - Outer Vapor Cooled Shield (OVCS)
    - Cooled by 1st stage of Stirling Coolers to ~150 K



Heat Flow Schematic - Nominal



Test Objectives

- Determine the steady state heat loads to the helium tank from the CSI and other sources
  - Set cryocoolers to nominal operating temperature/input power
- Measure transient heat load from 2 stage ADR recycle
  - Then apply conservative expected duty cycle to this heat load to obtain avg. heat load

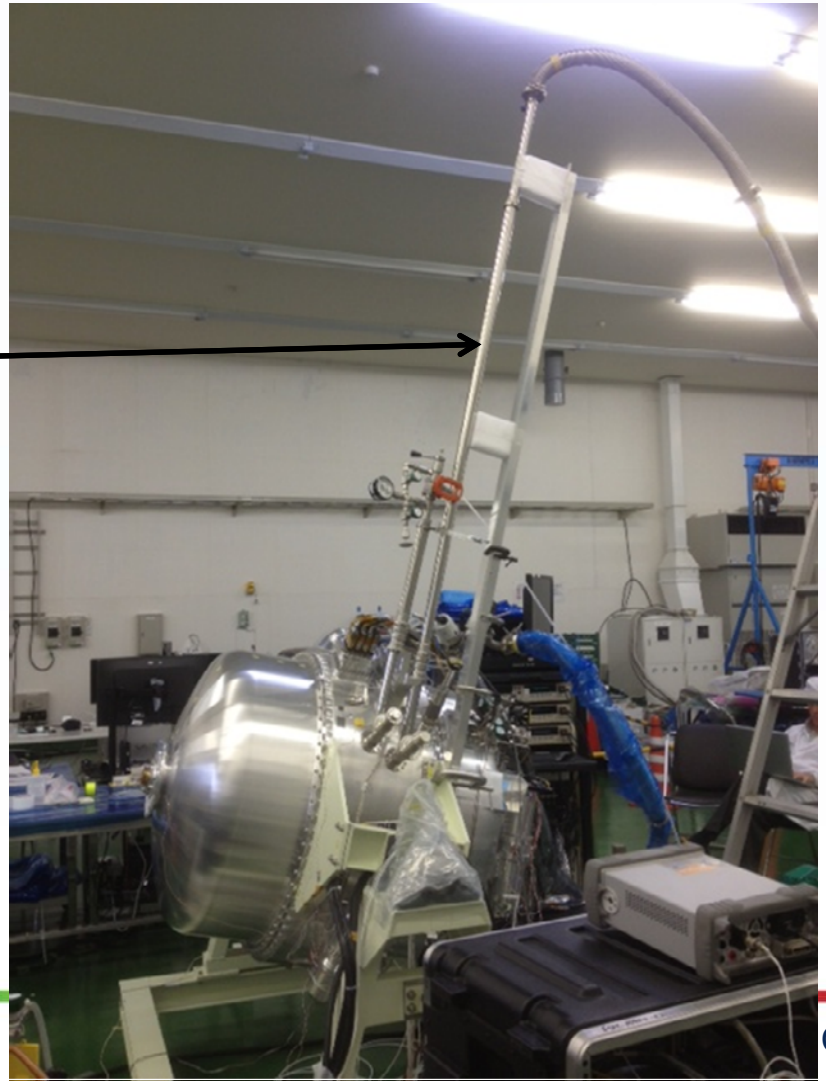
Measurements with Volume Flow Meter

- Measure GHe flow rate out of dewar to determine steady state heat load
  - LHe temperature must be held very constant
  - At 1.3 K ~1 mK/hr = ~500 μW!
  - Must be integrated over a long time (~ 5-10 hours) to obtain high accuracy (< 5%)
- Fill and porous plug (PP) bypass valves must be closed
  - Film flow out each valve equivalent to 1000 μW!
- Tip dewar to wet porous plug to ensure proper test of film flow suppression

Porous Plug Test Set-Up [actually EM Dewar]

75˚ Dewar Rotation compared to
50˚ Rotation for FM

Vent Mast
(Sail is not deployed!)



Method

- Mass gauge to determine fill level
- Tilt dewar to wet porous plug
- Use 3rd ADR stage to help cool helium tank to shorten pump down time by factor of 2 to 3
- Measure flow rate and helium temperature drift rate
- Calculate heat load
- Throttle vent valve to lower temperature drop across porous plug
- Measure flow rate vs. temperature drop
- Measure transient temperature rise when performing ADR recycle and use know liquid helium volume to calculate heat rejected to helium tank by ADR

Calculated/Estimated Heat Loads [Revise]

Item	Heat Load (mW)	Error	M/C/E
DA heat from IVCS	0.25	±0.03	M
Parasitic heat through HS 3&4 and S3 supports	0.14	±0.02	M
Aperture	0.02	±0.02	E
HTS and other wiring	0.02	±0.002	C
Support straps	0.15	±0.02	C
Fill and Vent lines	0.019	±0.003	C
ADR	0.14	±0.01	C
Total	**0.75**	±0.05	
Measured	**0.635**	±0.03	
ADR (avg. based on 24 hr cycle)	**0.105**	±0.003	

Summary

- Heat leak from flow rate and temperature drift is very close to the modelled value (0.74 mW vs. 0.75 mW modelled), well within the error bars (combined ±0.056 mW)
- Measured heat load numbers correspond to an on-orbit lifetime of > 4.7 years
- Will repeat this test after spacecraft environmental testing if time permits