High Temperature Superconductor Lead Assemblies for XRISM

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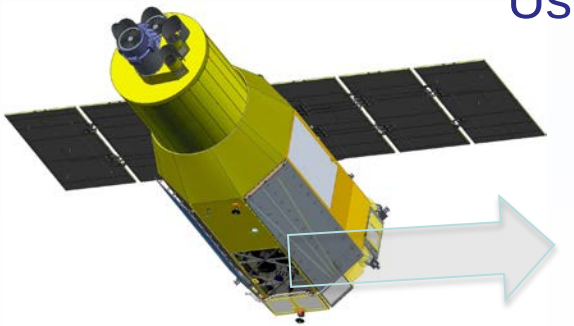
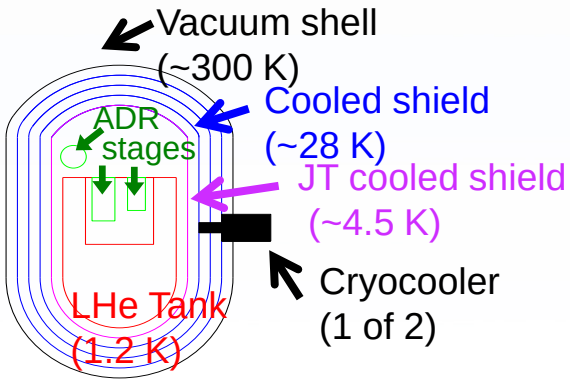
Background: RESOLVE

RESOLVE: soft x-ray spectrometer on XRISM (X-Ray Imaging and Spectroscopy Mission)

Rebuild of SXS instrument on Astro-H — no changes except where necessary

Uses a microcalorimeter array operating at 50 mK





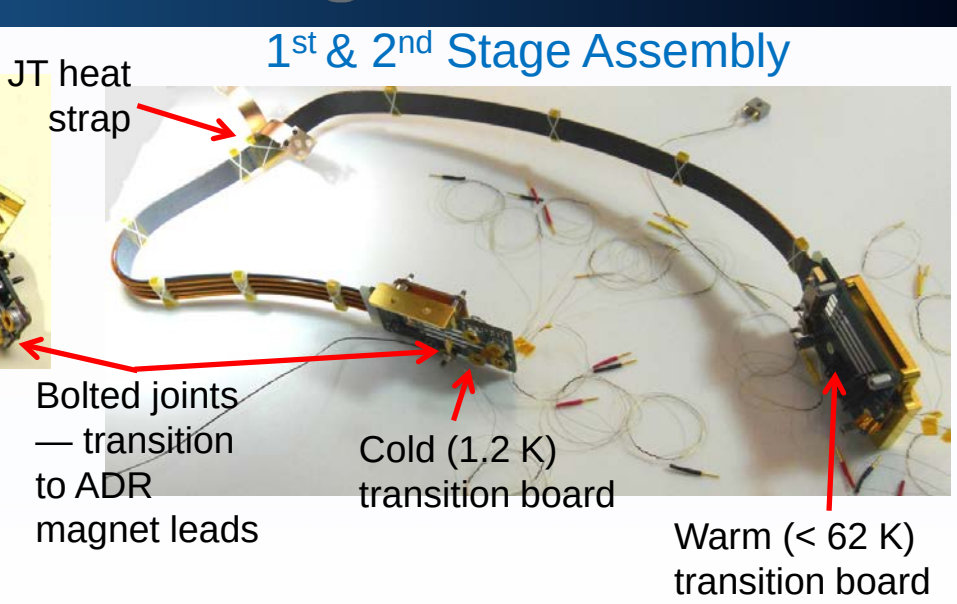
RESOLVE Thermal System:

- (2x) 2 stage Stirling coolers
- JT cooler (4.5 K)
- 40 l LHe tank (1.2 K)
- 3 stage ADR (50 mK)

Background: HTS Lead Assemblies

- High Temperature Superconductor Lead Assemblies necessary to carry high current to 3 ADR magnets
- Driving requirements:
  - 2 Amp maximum on each of 3 circuits @ up to 62 K warm end
  - < 12 μWatt total conducted heat leak to 1.3 K
  - < 10 μΩ per circuit total resistance at cold end (bolted and solder joints)

HTS Lead Assemblies — Configuration



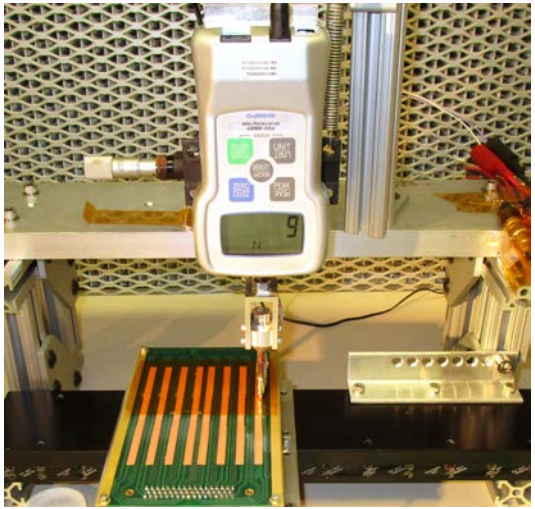
- Status
  - Engineering Model complete
  - Flight Model 1 fabricated and fully verified
  - Flight Model 2 fabricated; pre-vibe testing complete

Solder Joints: Material Changes

- HTS tape
  - SXS: AuAg alloy coated tape; slit to 1 mm after production (open sides)
  - RESOLVE:
    - Slit to 1 mm, then sputter coated with AuAg (all sides)
    - Individual sections cut and plated over solder region with > 20 µm Cu
    - Section I_c's measured to 20 Amperes:
      - 37 of 48 long (590 mm), 21 of 24 short (335 mm) sections ≥ 20 A;
      - All I_c's ≥ 16 A
- Solder
  - In3%Ag (SXS) ➔ In48%Sn (RESOLVE)
    - Lower T_{melt} (144 C ➔ 118 C)

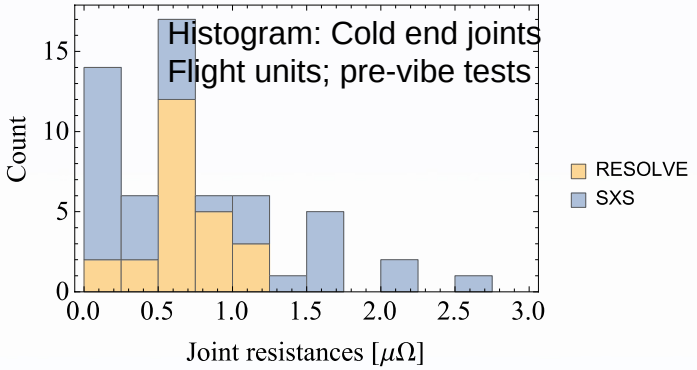
Solder Joints: Process Changes

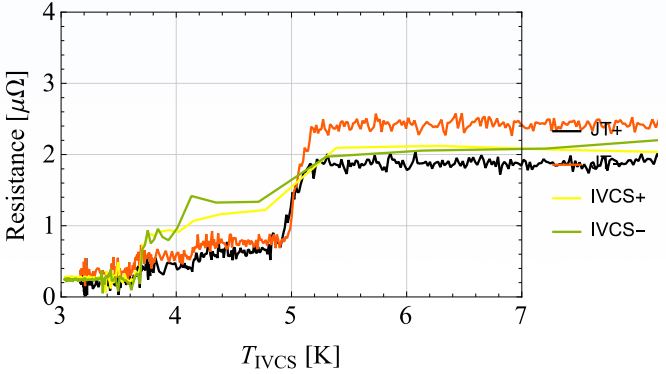
- Solder rig
  - Precise control over pressure, temperature, & time
  - Changes for flight boards:
    - Custom soldering tips match joint length
    - Wires & bobbins act act as cooling fins ➔ added secondary heaters to cancel effect



Solder Joints: Results

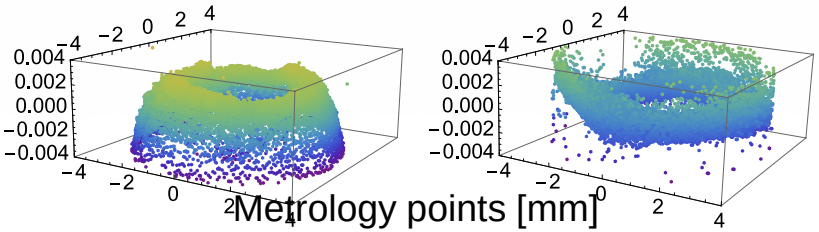
- Improved Consistency:
  - Compared all pre-vibe qualification tests: I-V measurement to 5 Amps, cold end at 4.5 K
  - Cold end solder joint resistances much more uniform
  - No values > 1.1 μΩ
  - Similar results for warm end (62 K)
- Very low resistance at low T
  - Bridge (low current) measurements show transitions at ~5.0, ~3.7 K
  - Below 3.7 K, R < 0.4 μΩ

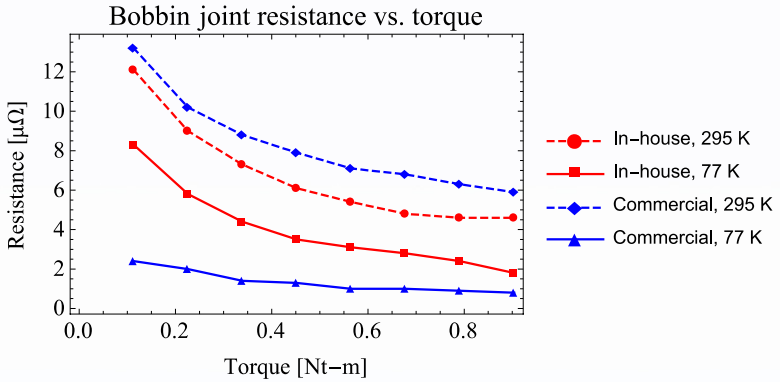




Bolted Joints: Changes and Results

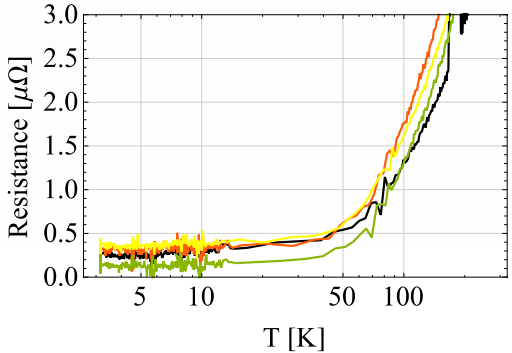
Bobbins:	In-house	Commercial
Cu material:	99.999%	CU101
Au Plating	Ni flash, Thick Au	No Ni flash, Standard thickness
Fabrication	EDM, polished	Lathe
Metrology:	rounded	Flat,+ ridge





Result:

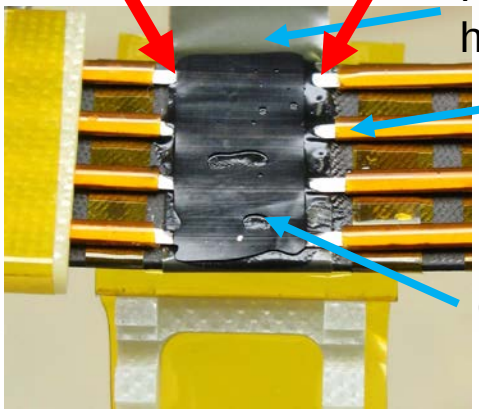
Bolted joint resistance now typically < 0.5 μΩ at low T



1st & 2nd Stage Thermal Intercept: Changes

HTS tapes in 1st&2nd Stage unit must be well heat sunk to JT shield

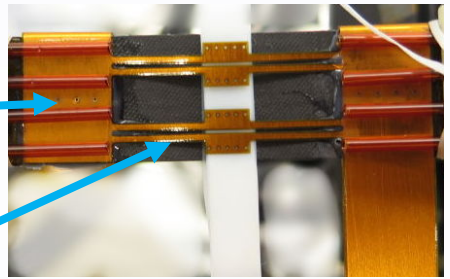
Concern over stress concentration at JT thermal intercept

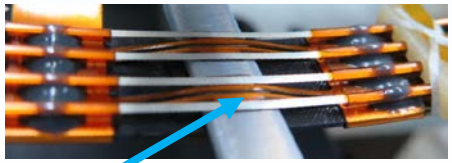


New strap design:

Multilayer Pyralux strap

Compliant bridge for each HTS tape

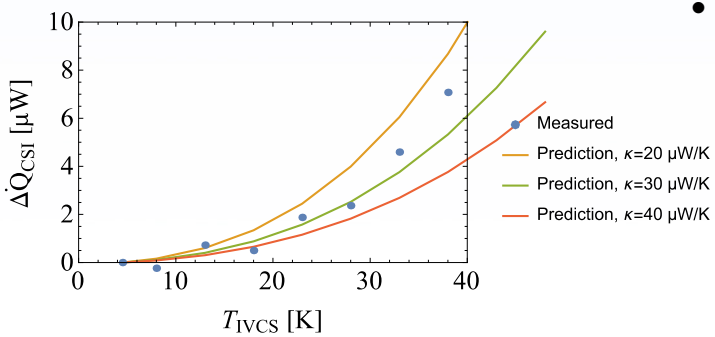


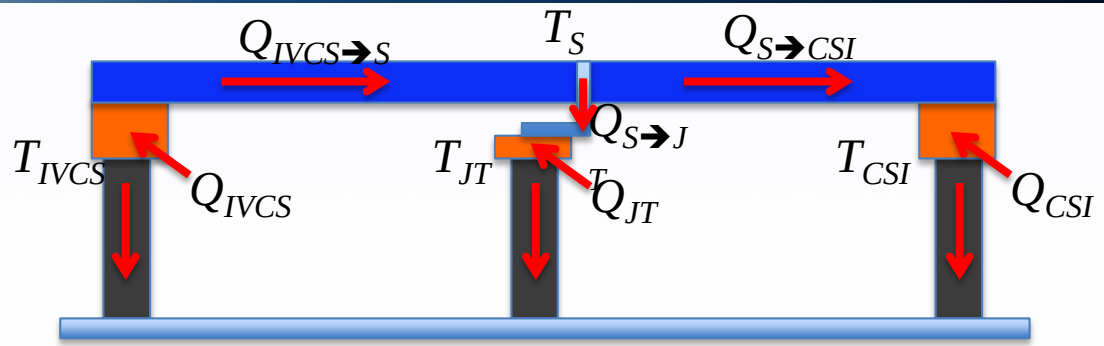


Each HTS tape bonded to small flag on bridge

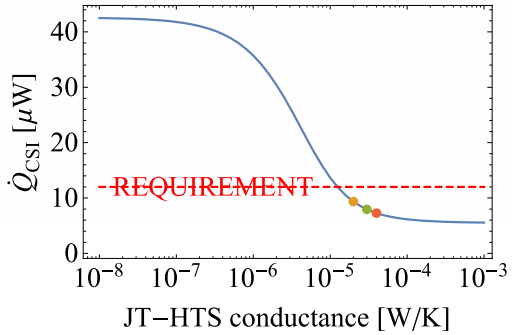
1st & 2nd Stage Thermal Intercept: Results

- Measurement:
  - Control T_{IVCS}, $T_{JT} = T_{CSI}$
  - Measure ΔQ_{CSI} vs T_{IVCS}
- If strap conductance, $\kappa \rightarrow \infty$
  - $T_s = T_{JT} = T_{CSI}$ ➔ $\Delta Q_{CSI} = Q_{s \rightarrow CSI} = 0$
- With imperfect strap:





- 1-D Conduction-only model
- For flight condition (T_{IVCS} = 28 K, T_{JT} = 4.5 K, T_{CSI} = 1.3 K), heat leak to CSI:



Conclusions

- HTS Lead Assemblies for RESOLVE instrument — largely rebuild, except
- Solder joints:
  - New tape and solder
  - Tighter solder process control
  - Result: much more consistent solder joint resistances
- Bolted joints:
  - Initial testing lead to change to commercial bobbins
  - Pre-assembly screening
  - Result: much more consistent and lower bolted joint resistances
- JT heat intercept:
  - New design eliminates concern over stress concentration
  - Improved thermal test apparatus allows determination of 1st & 2nd Stage parasitic conductance

- Overall, RESOLVE HTS lead assemblies meet their requirements with significantly better margin than the Hitomi/SXS units