



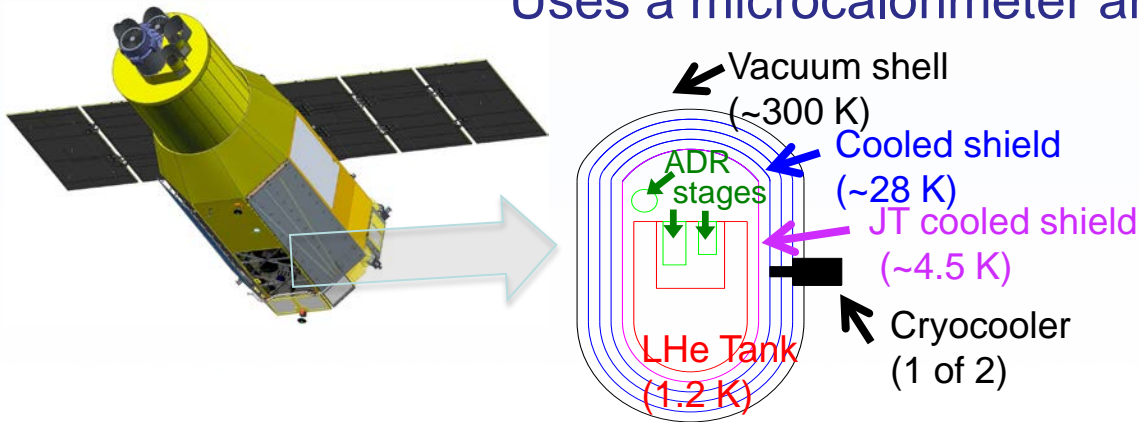
High Temperature Superconductor Lead Assemblies for XRISM

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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
 - $< 12 \mu\text{Watt}$ total conducted heat leak to 1.3 K
 - $< 10 \mu\Omega$ per circuit total resistance at cold end (bolted and solder joints)

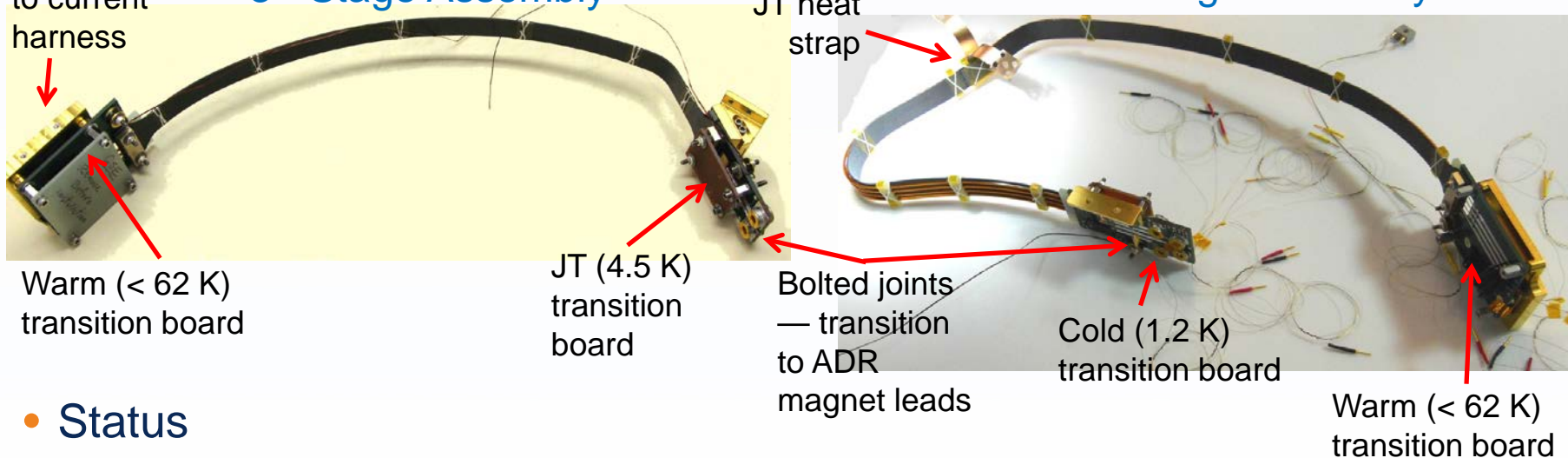
HTS Lead Assemblies — Configuration

Connector
to current
harness

3rd Stage Assembly

JT heat
strap

1st & 2nd Stage Assembly



- **Status**

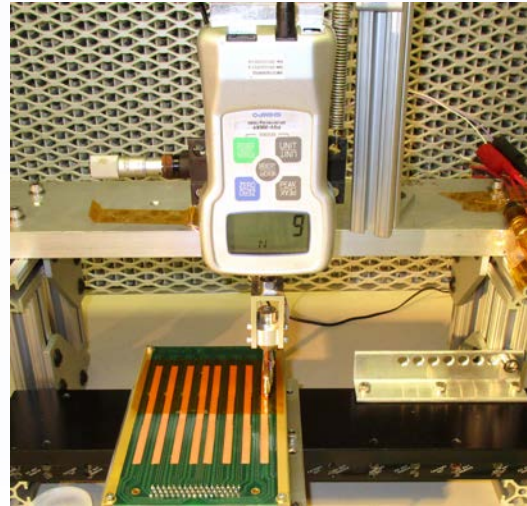
- Engineering Model complete
- Flight Model 1 fabricated and fully verified
- Flight Model 2 fabricated; pre-vibe testing complete

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 $> 20 \mu\text{m}$ 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) \rightarrow In48%Sn (RESOLVE)
 - Lower T_{melt} (144 C \rightarrow 118 C)

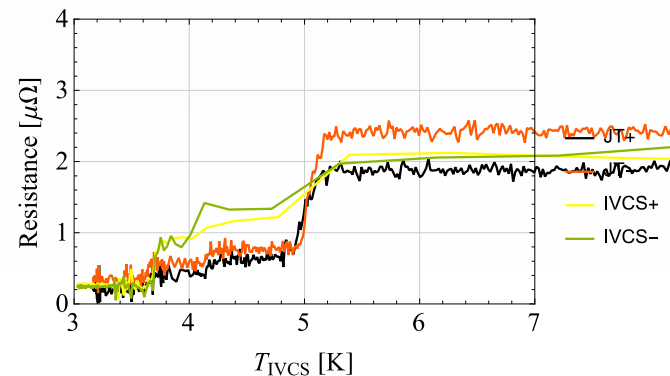
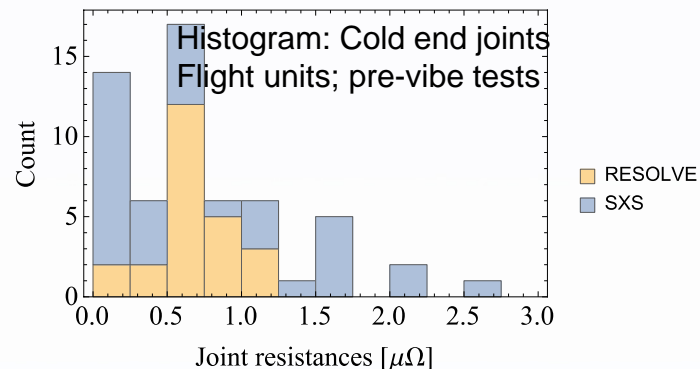
Solder Joints: Process Changes

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



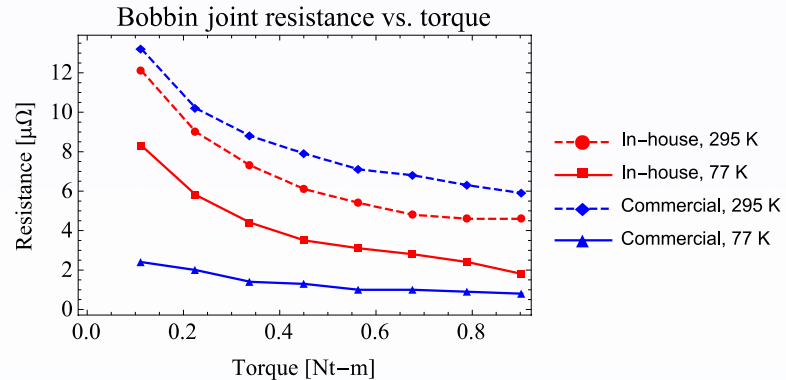
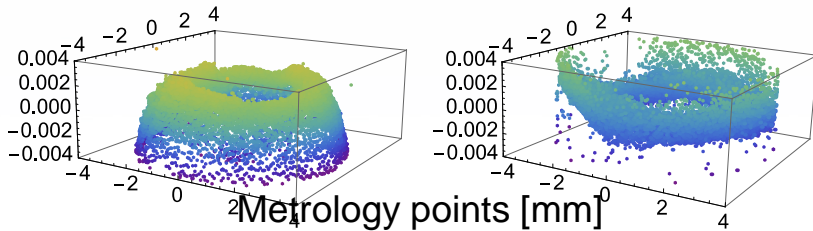
Solder Joints: Results

- 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 $> 1.1 \mu\Omega$
 - 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, $R < 0.4 \mu\Omega$

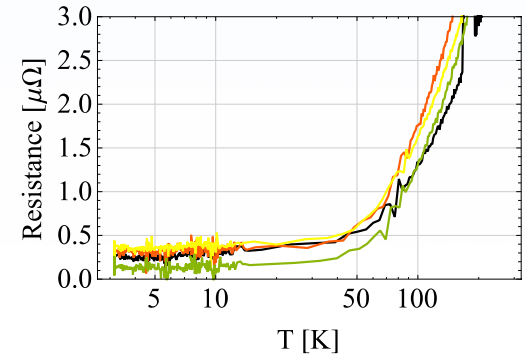


Bolted Joints: Changes and Results

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



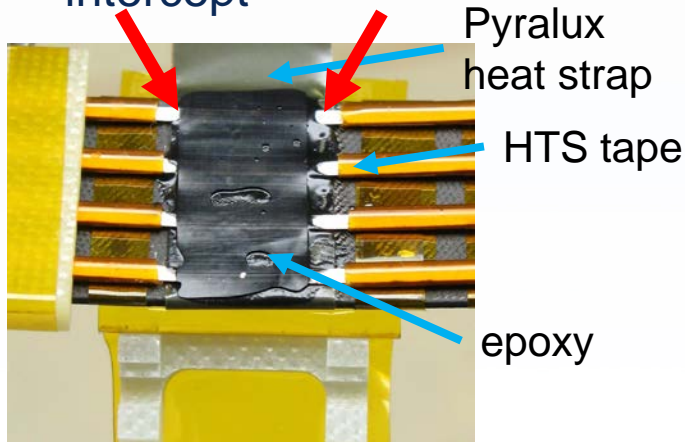
Result:
Bolted joint resistance
now typically $< 0.5 \mu\Omega$
at low T



1st & 2nd Stage Thermal Intercept: Changes

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

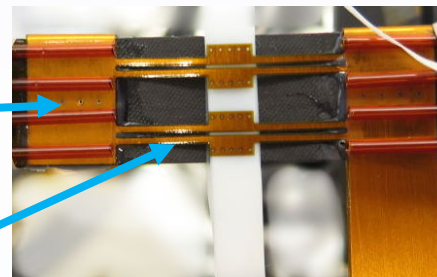
Concern over stress concentration at JT thermal intercept



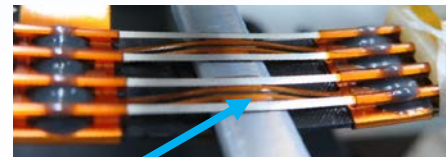
New strap design:

Multilayer Pyralux strap

Compliant bridge for each HTS tape



Each HTS tape bonded to small flag on bridge



1st & 2nd Stage Thermal Intercept: Results

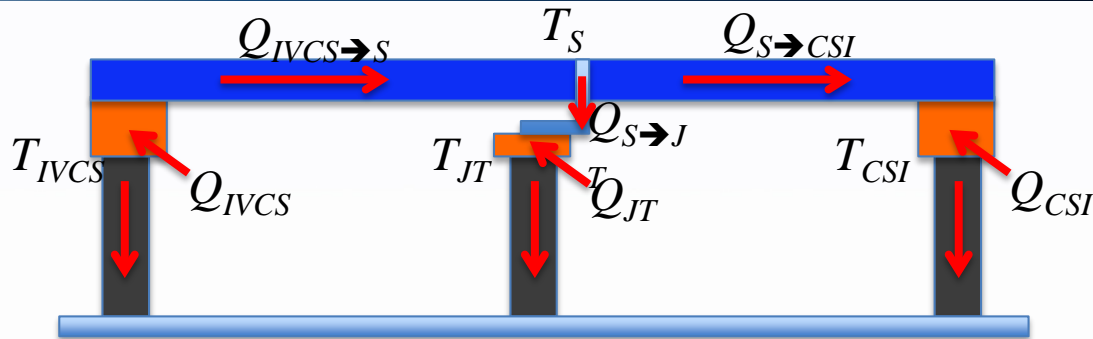
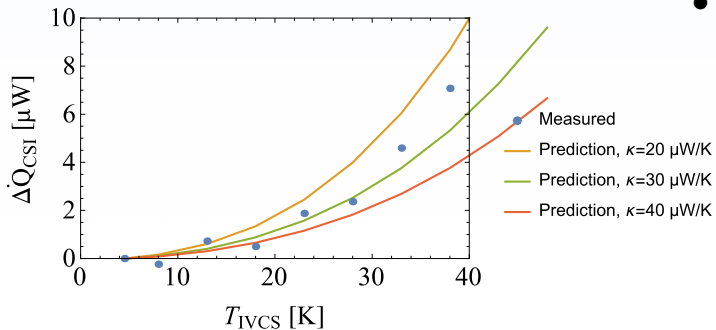
- Measurement:

- Control T_{IVCS} , $T_{JT} = T_{CSI}$
- Measure ΔQ_{CSI} vs T_{IVCS}

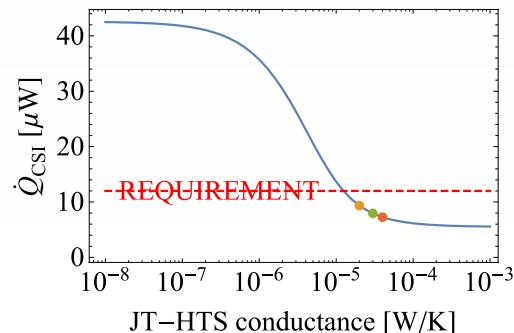
- If strap conductance, $\kappa \rightarrow \infty$

- $T_s = T_{JT} = T_{CSI} \rightarrow$
 $\Delta Q_{CSI} = Q_{s \rightarrow CSI} = 0$

- With imperfect strap:



- 1-D Conduction-only model
- For flight condition
 $(T_{IVCS} = 28 \text{ K}, T_{JT} = 4.5 \text{ K},$
 $T_{CSI} = 1.3 \text{ K}),$ 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