Cold Snout Design

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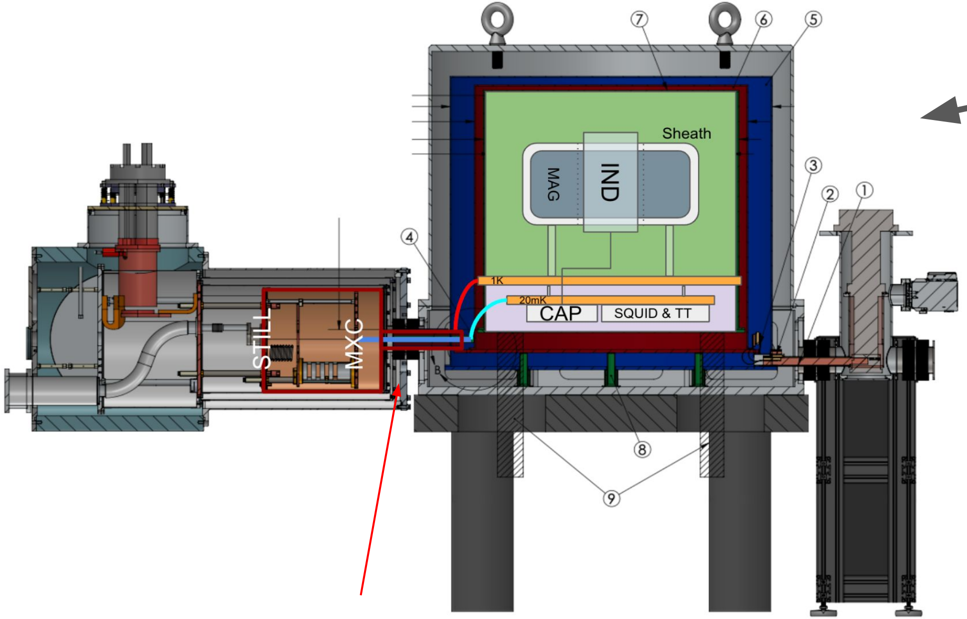
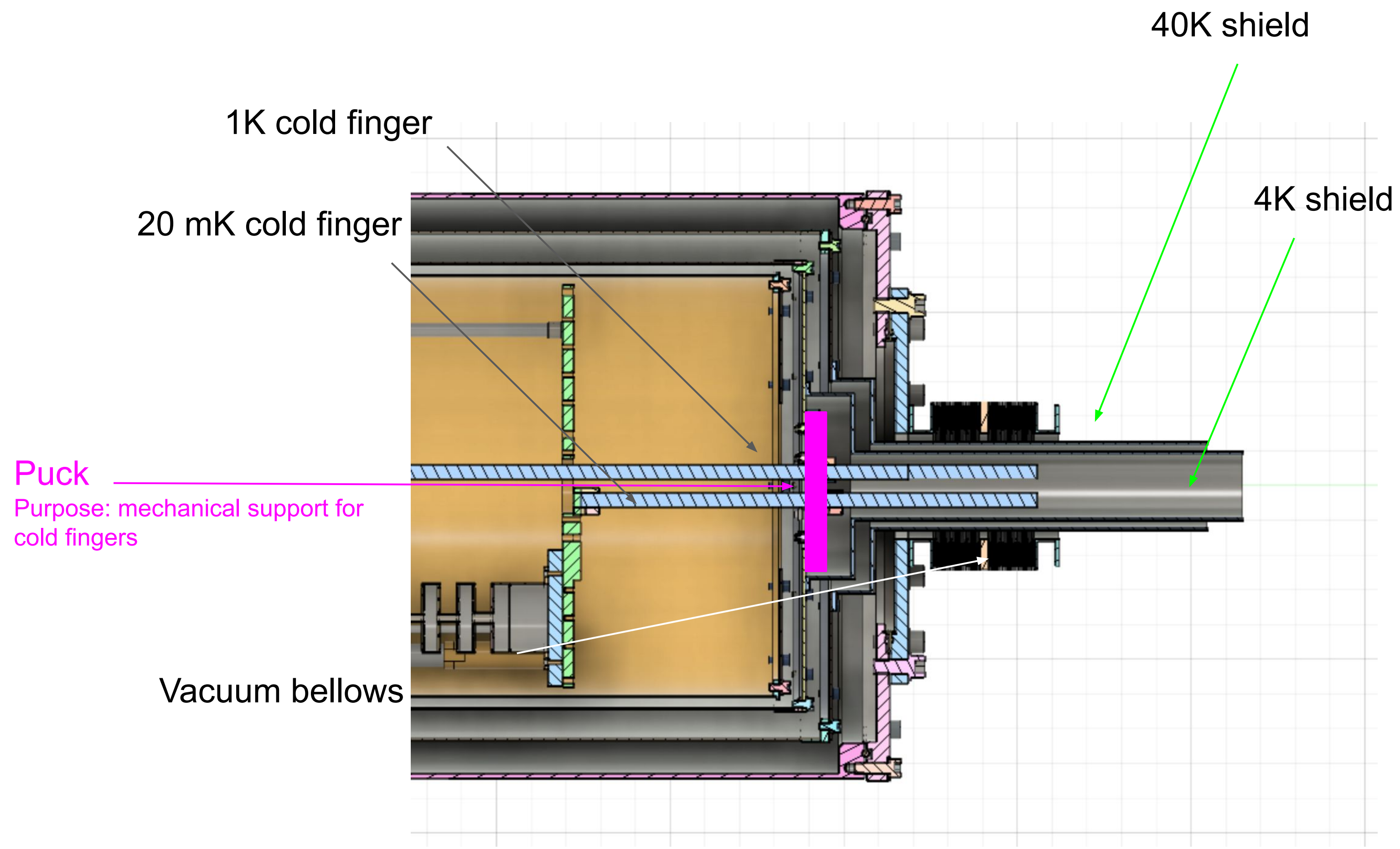
Goal: design a cold snout to cool the magnet and sheath to 1K and the receiver to 20mK using horizontal cold fingers from the DR still and MXC stages.

Snoopy
dilution refrigerator

Woodstock
4K cryostat



Cold snout


40K shield
1K cold finger
4K shield
20 mK cold finger
Puck
Purpose: mechanical support for cold fingers
Vacuum bellows

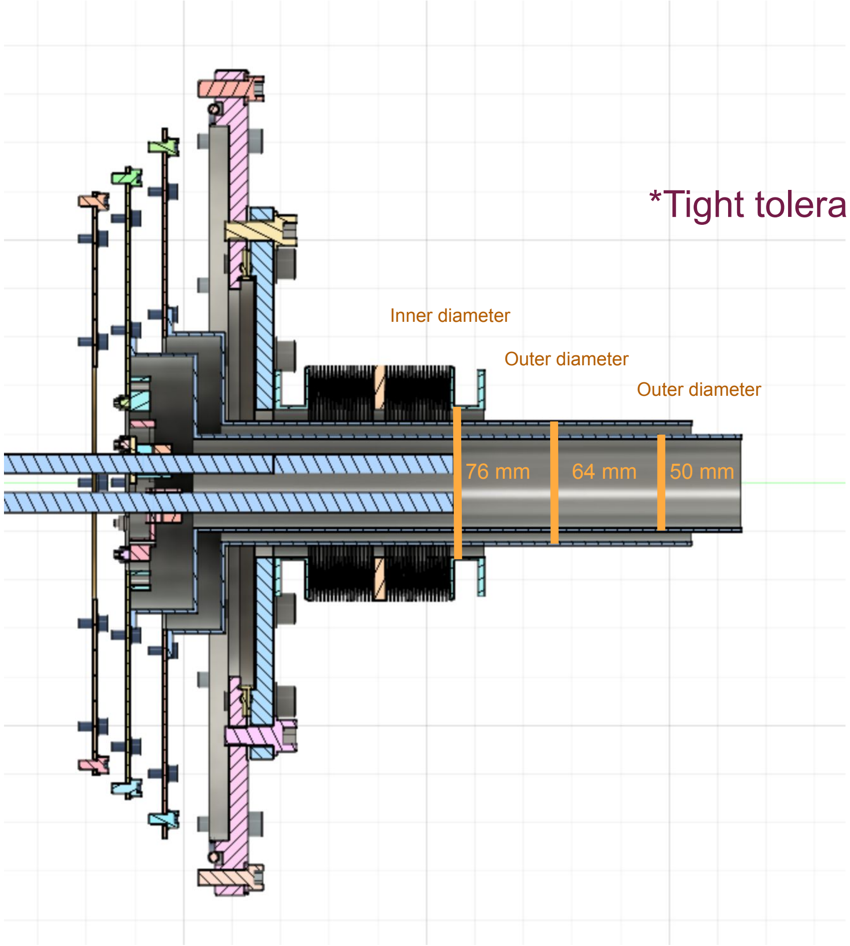
Shield dimensions

Thickness of 4K, 40K shield tubes: 2mm

Distance between 4K and 40K tubes: 2.6 mm

Distance between bellows and 40K tube: 6mm

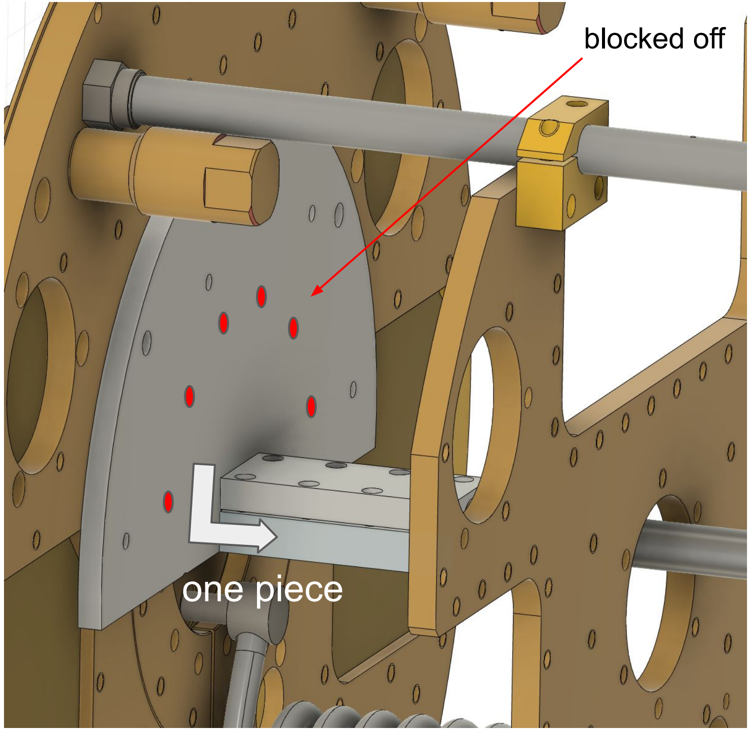
*Dimensions constrained by bellows and mating to octagonal belly of Woodstock



Tight tolerances

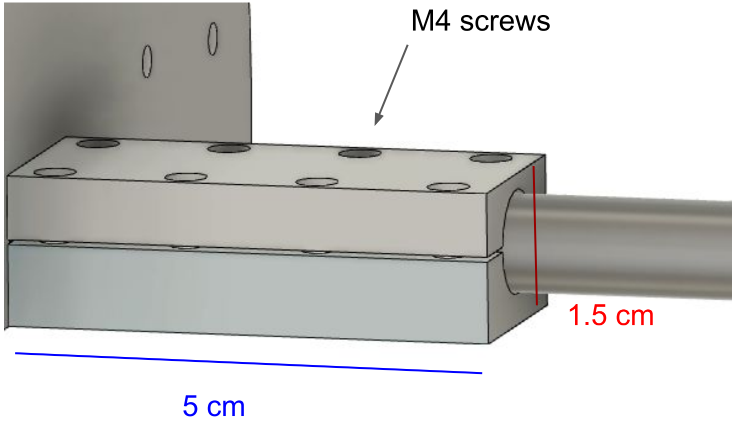
Cold Finger Attachment

*Material: ETP Copper



Concerns:

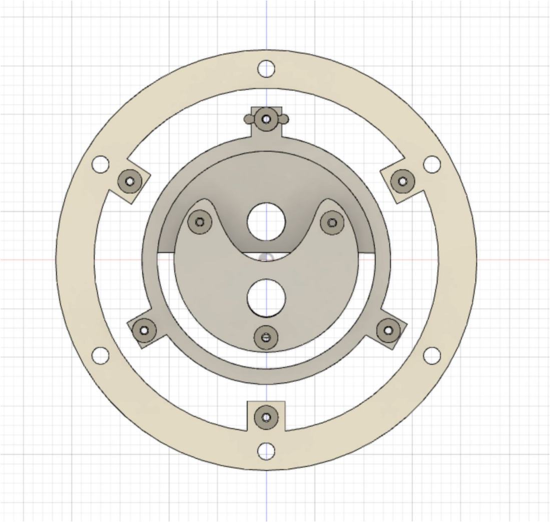
- Not enough screw holes in plate
- Machining difficulty



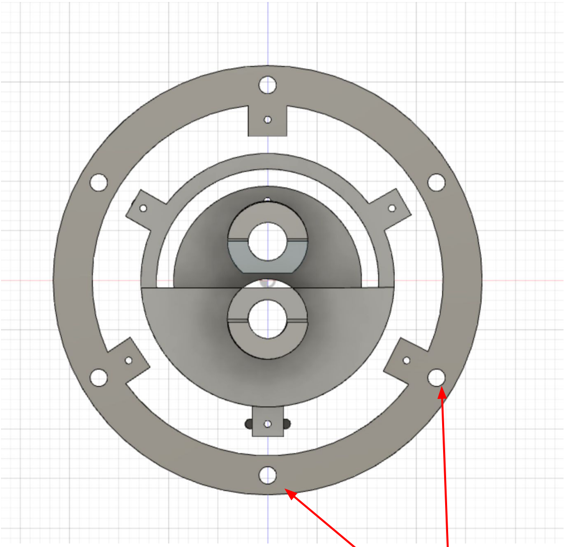
CAD design - Puck

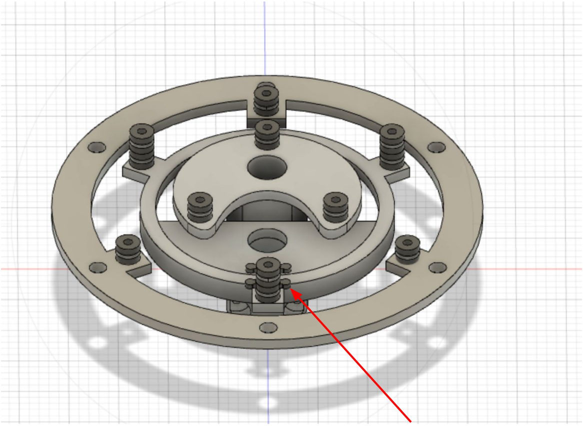
Purpose: provide mechanical support for the 1 K and 20 mK cold fingers (CF) while keeping them thermally isolated

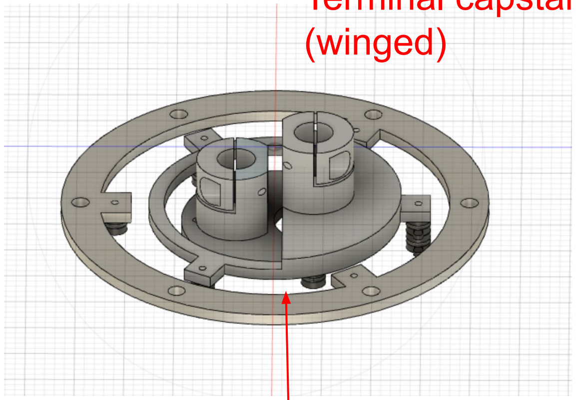
Capstan side



Clamp side







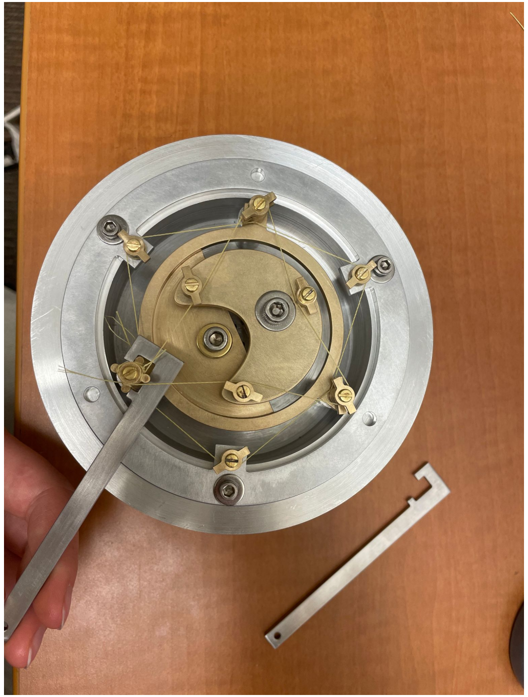
Cold finger diameter: 10 mm
Distance (edge-edge) between cold fingers: 10 mm

Puck Test Assemblies

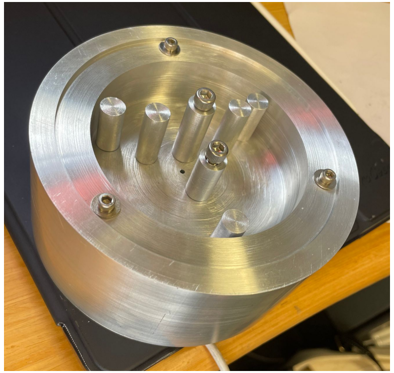
All Aluminum

Kevlar string

Brass / Aluminum Hybrid

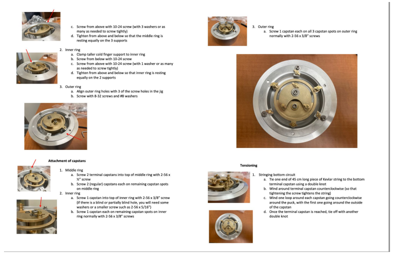


Assembly Jig



Puck assembly procedure:

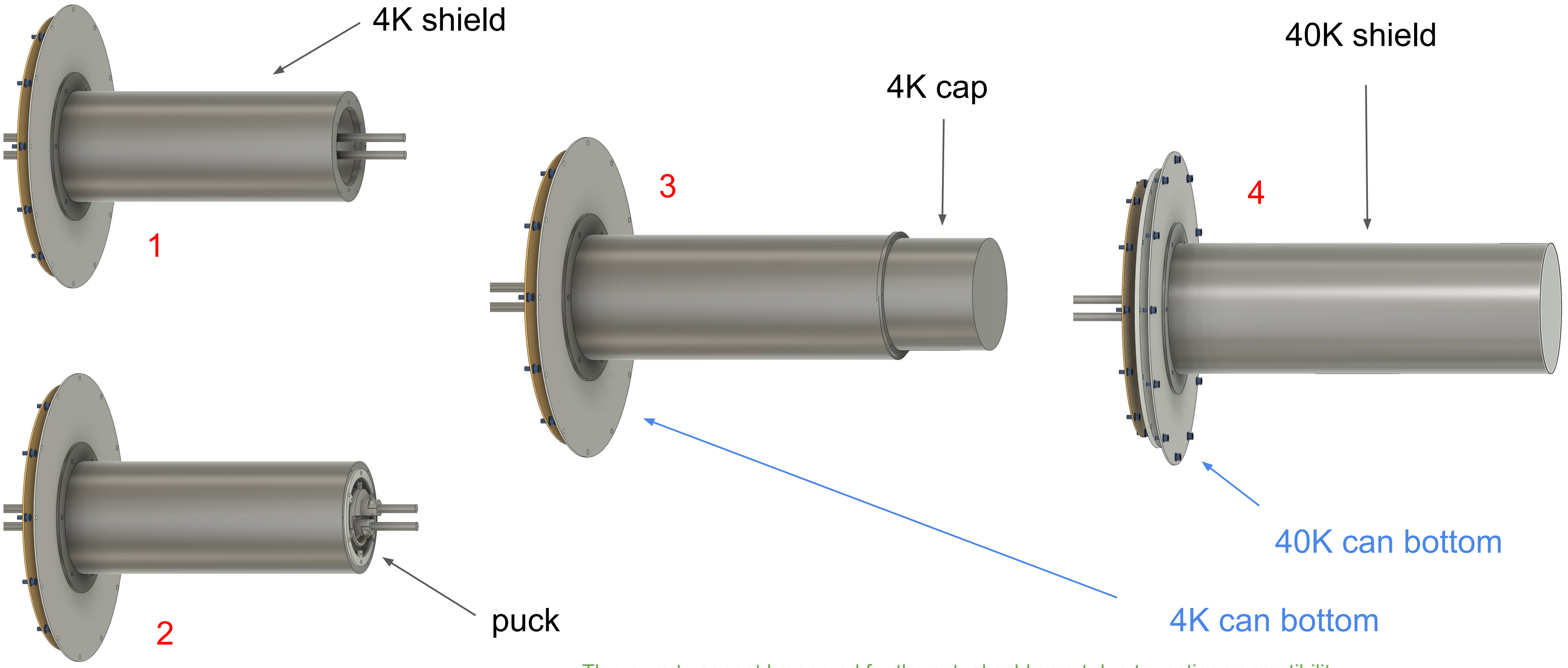
https://confluence.slac.stanford.edu/display/DMRadio/Puck



Cold Snout Testing Plan

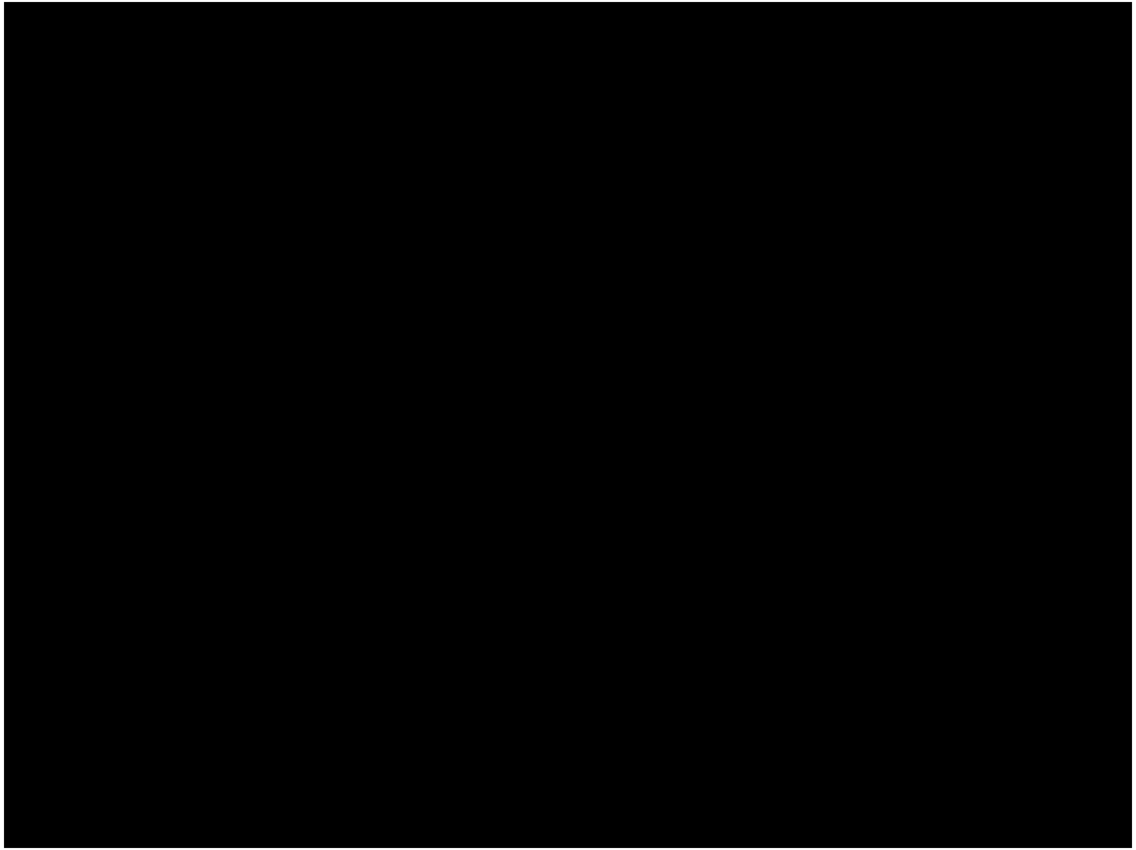
Price estimate: ~$3000

*Assembly order

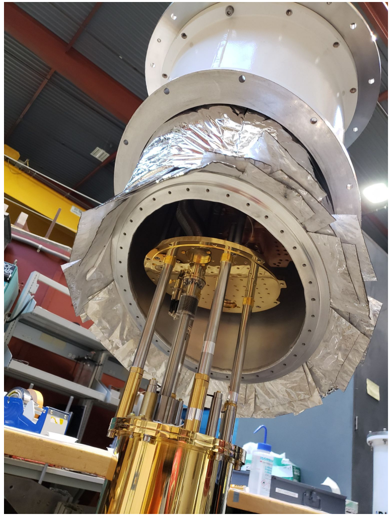


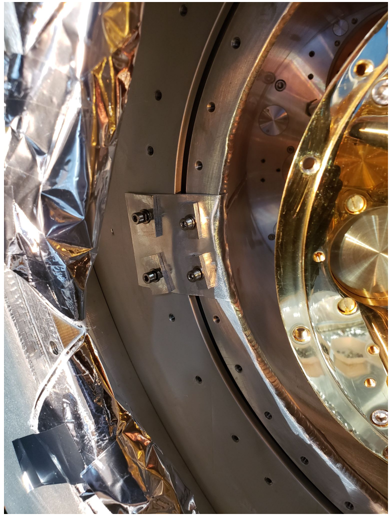
These parts cannot be reused for the actual cold snout due to mating compatibility

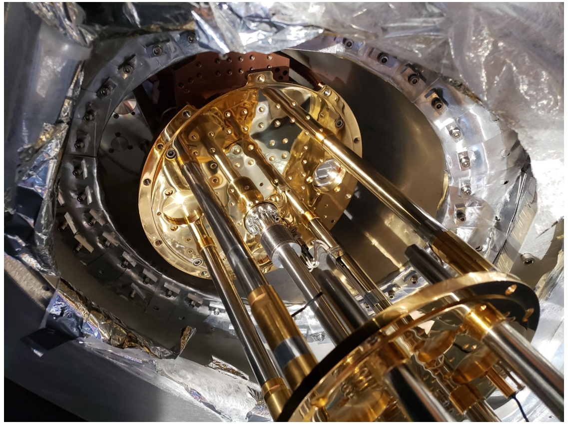
Cold Snout Testing plan

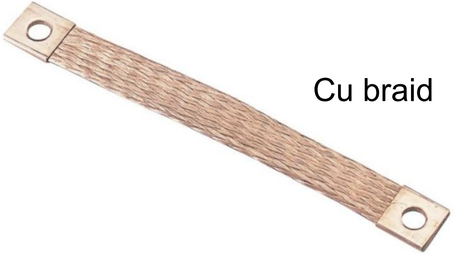


Flexible Connections to Woodstock









Cu braid

Inspiration for our design:
High purity aluminum strips used by TSAT to make flexible thermal connection at 40 K

Cold snout milestones

- Identify copper type to use for cold finger, attachments
  - By July 5th
- Test cold fingers with heater, thermometer at the end
  - By September 1st
- Design mechanically flexible thermal interface with Woodstock
  - Flexible thermal shields at 40 K, 4K (cylinders mate with flat panels)
  - Copper braids at 1 K, 20 mK
  - By July 28th

Backup

Thermal conductivity of copper: ETP > OFHC at 4 K

for COPPERS

Comments: The six curves were extrapolated to 300°K. The curve for O.F.H.C. was extrapolated to 4°K and the curve for (Pb)Cu was extrapolated to 6°K. It is estimated that the extrapolated values do not deviate more than 10% from the probable values.

$$Q = \frac{A}{L} \int_{T_o}^{T_L} \lambda \, dT; \qquad Q \frac{L}{A} = \int_{T_o}^{T_L} \lambda \, dT$$

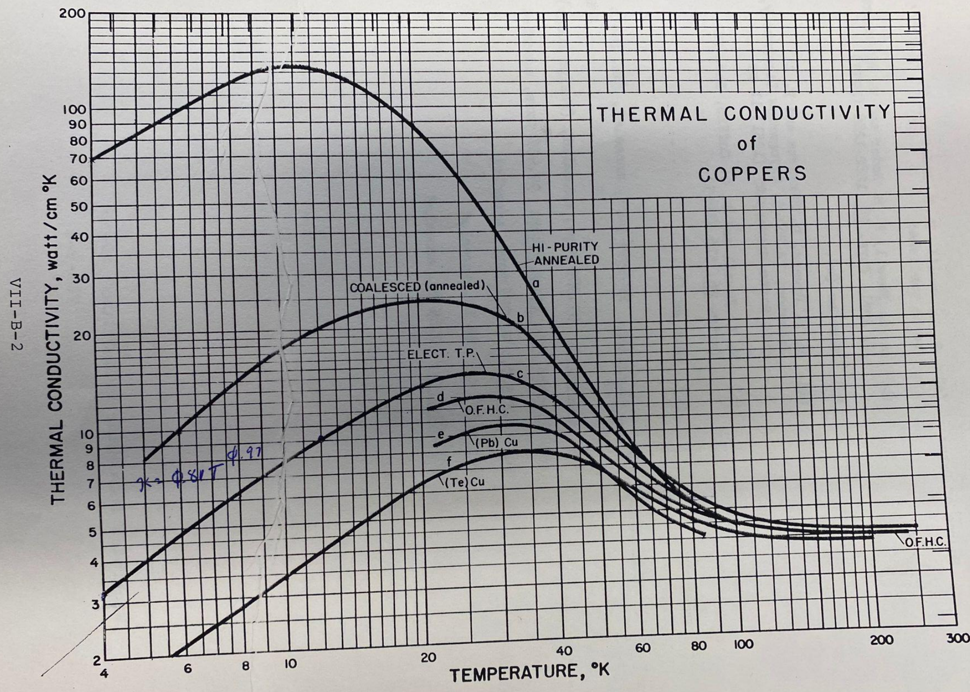
Where:

- Q = heat flow in watts
- A = cross sectional area in cm^2
- L = length in cm
- λ = thermal conductivity in watts/cm-°K
- T = temperature in °K
- T_o = initial temperature (6°K for [Pb]Cu and [Te]Cu; 4°K for all other Coppers)

Thermal Conductivity Integrals are on following page.

Temp. °K	Thermal Conductivity watts/cm-°K					
	Hi-Purity Annealed	Coalesced	Elect. T.P.	O.F.H.C.	(Pb) Cu	(Te) Cu
4	70	6.2	3.2	2.4*		
6	96	10.	4.8	3.7*	2.7*	2.2
8	120	14.	6.3	4.7*	3.6*	2.8
10	134	17.5	7.8	6.0*	4.5*	3.4
15	120	23	11	8.5*	6.3*	5.0
20	88	24	13	11 *	8 *	6.5
25	60	23	14	12	9.2	7.3
30	40	22	14	12	9.6	7.8
35	28	18.5	13	11	9.5	7.9
40	20	15	11.5	10	9	7.7
50	12	10	8.8	7.7	6.9	6.8
60	8.0	7.8	7.0	6.2	5.5	5.8
70	6.2	6.5	5.9	5.5	4.7	5.2
76	5.7	6.0	5.5	5.2	4.5	4.9
80	5.2	5.7	5.2	4.9	4.3	4.6
90	4.7	5.1	4.7	4.7	4.0*	4.3
100	4.5	4.8	4.5	4.5	3.8*	4.2
120	4.3	4.5	4.3	4.3	3.7*	4.0
140	4.2	4.3	4.2	4.2	3.6*	3.8
160	4.1	4.2	4.1	4.1	3.6*	3.8
180	4.0	4.2	4.0	4.0	3.6*	3.8
200	4.0	4.2	4.0	4.0	3.6*	3.8
250	4.0	4.2*	4.0	4.0	3.6*	3.8*
300	4.0*	4.2*	4.0*	4.0*	3.6*	3.8*

* Extrapolated Values



Final Assembly