PAUL SCHERRER INSTITUT

PSI

Daniel Trutmann :: Development Engineer :: Paul Scherrer Institut

Development of a New Sub-4K ARPES Endstation at PSI

27.6.2018

MEDSI
MECHANICAL ENGINEERING DESIGN OF SYNCHROTRON RADIATION EQUIPMENT AND INSTRUMENTATION

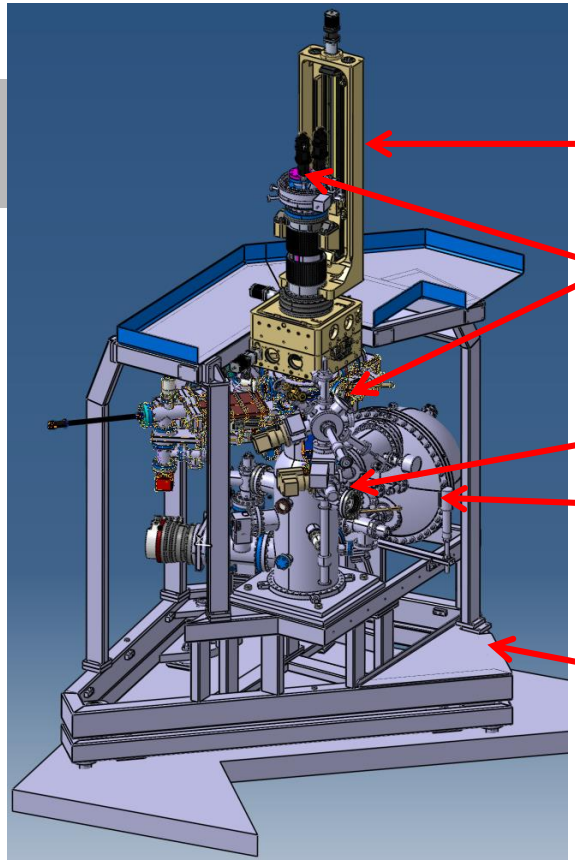
PARIS 2018

New ARPES Endstation

- Angle-resolved photoemission spectroscopy (ARPES)
- Lower temperature enables the study of new materials
- New endstation of the Surface/Interface Spectroscopy (SIS) beamline
- “High-throughput workhorse”
  - Easy manipulation, sample access, alignment
- Planned to begin operation in spring 2019

Current Endstation	New Endstation
Sample temperature 14K	<4K
6 Axis mechanic w/o thermal drift	←
Good access to sample	←
1E-11 mbar	<1E-11 mbar
Custom sample plates	Omicron compatible plates

New ARPES Endstation



Cryostat

XYZ-Stage

Preparation Chamber (PC)

Manipulator

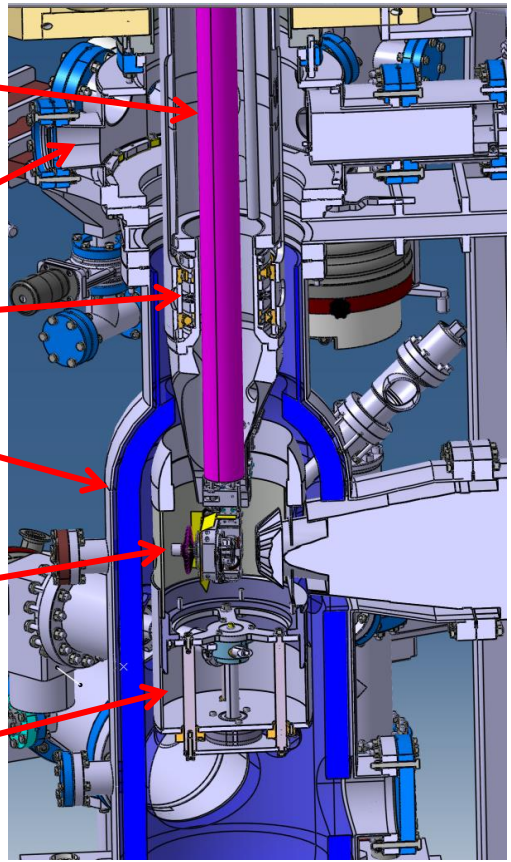
Analyser Chamber (AC)

Analyser

Manipulator Head

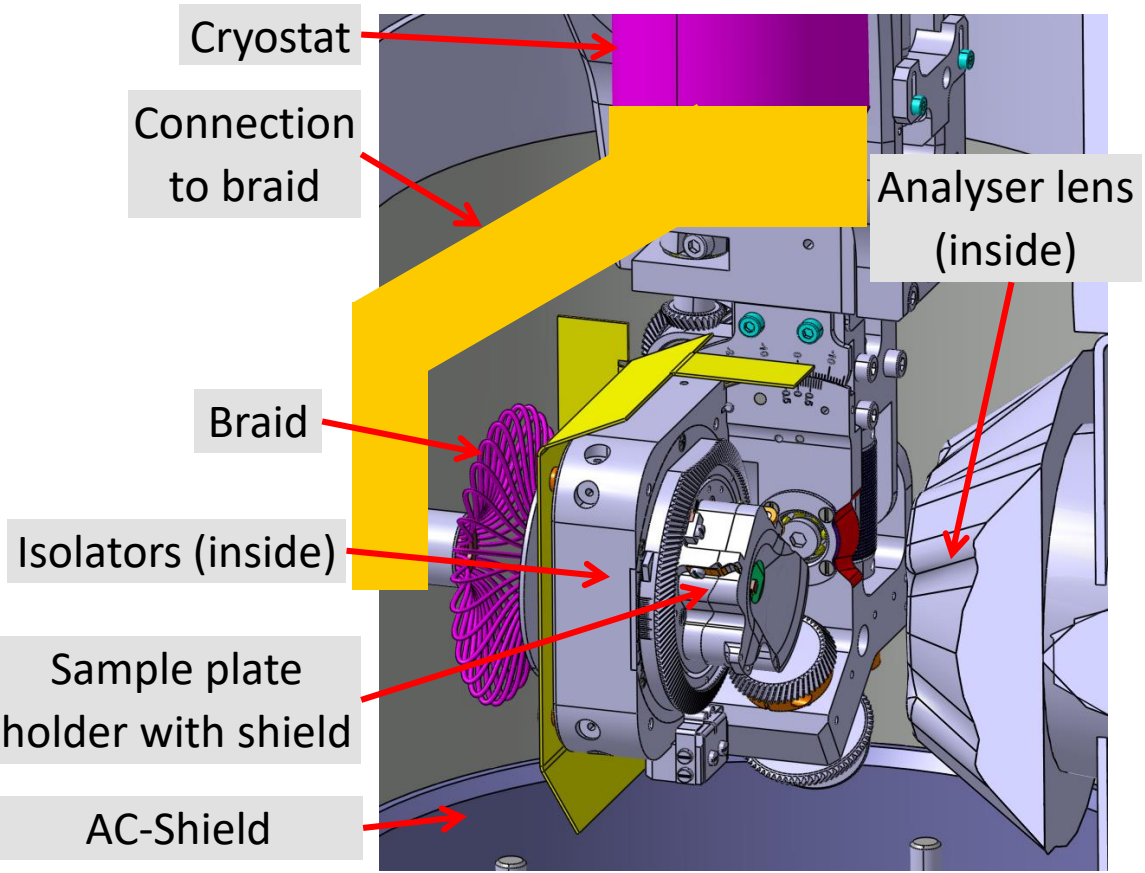
User platform

AC-Shield

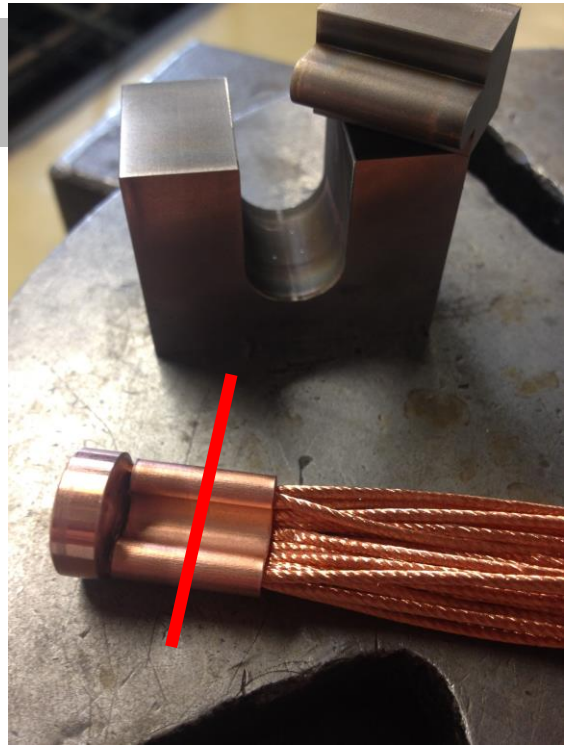


Head

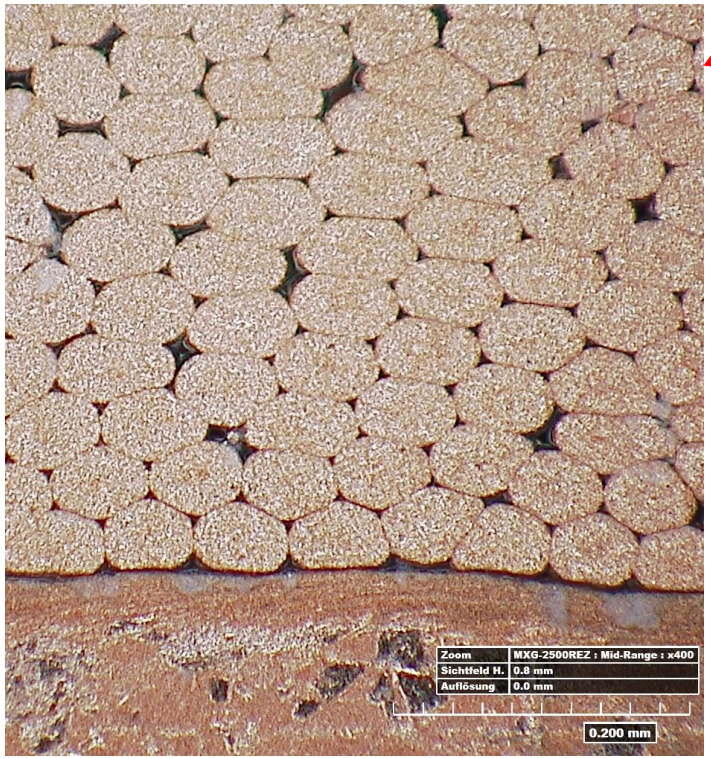
- Analyser lens is the main source of heat input (5mW)
- Conductive heat input is much lower
- Critical is the connection cryostat - sample plate
  - Connection to braid
  - Braid
  - Sample plate holder

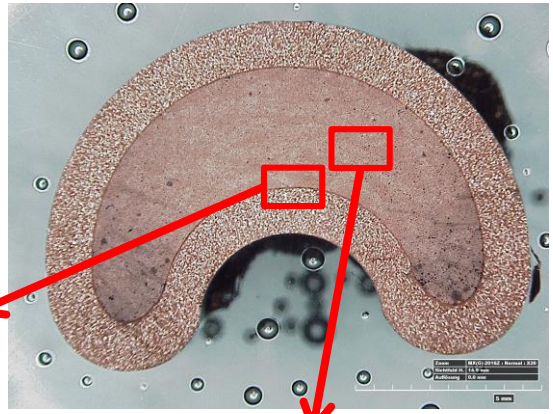


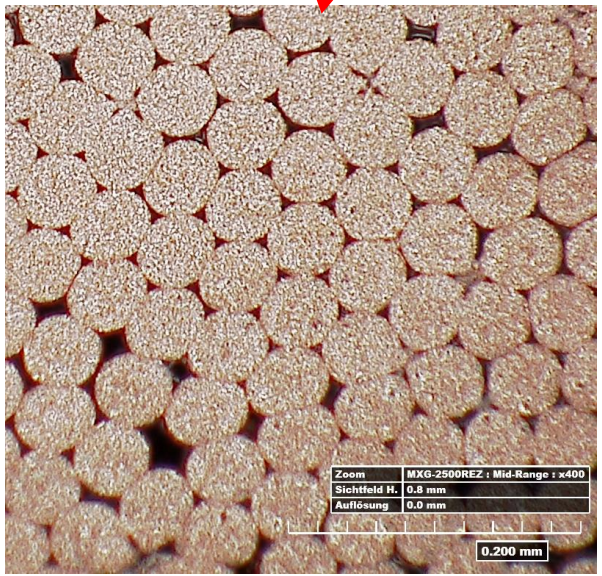
Braid: early iteration



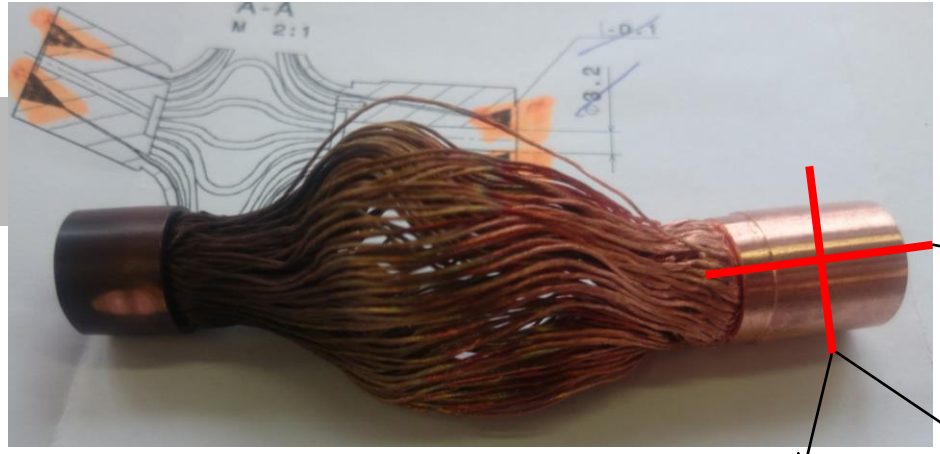
Single wire: D=0.05mm

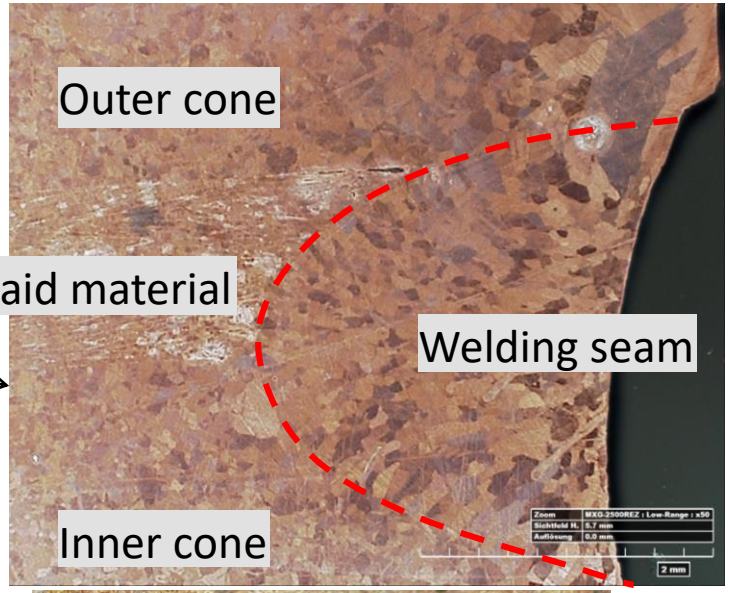


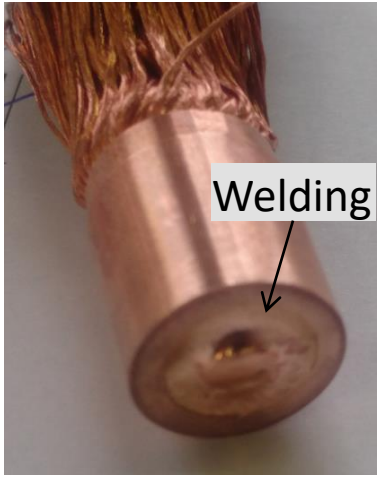


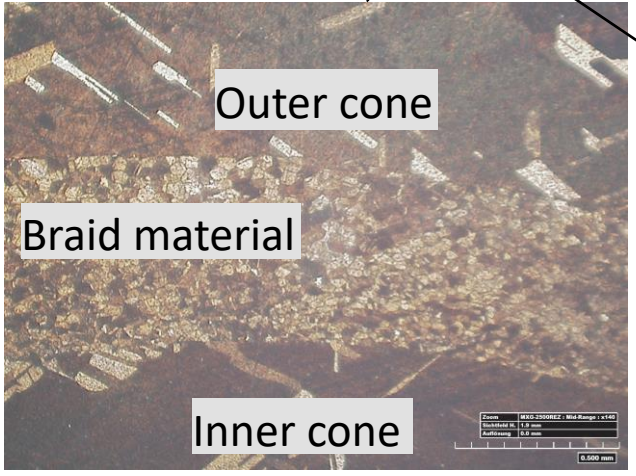


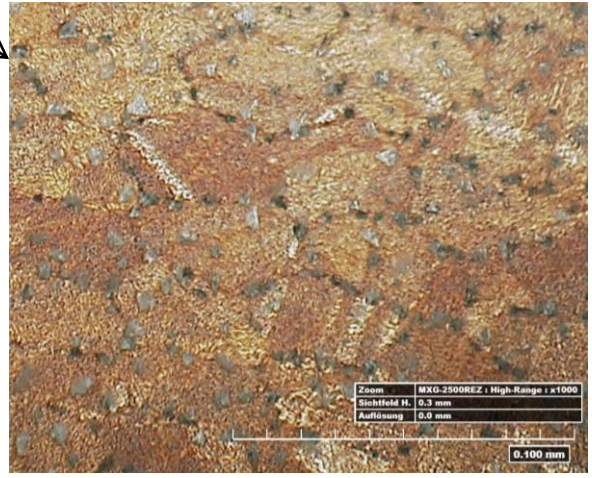
Braid: later iteration











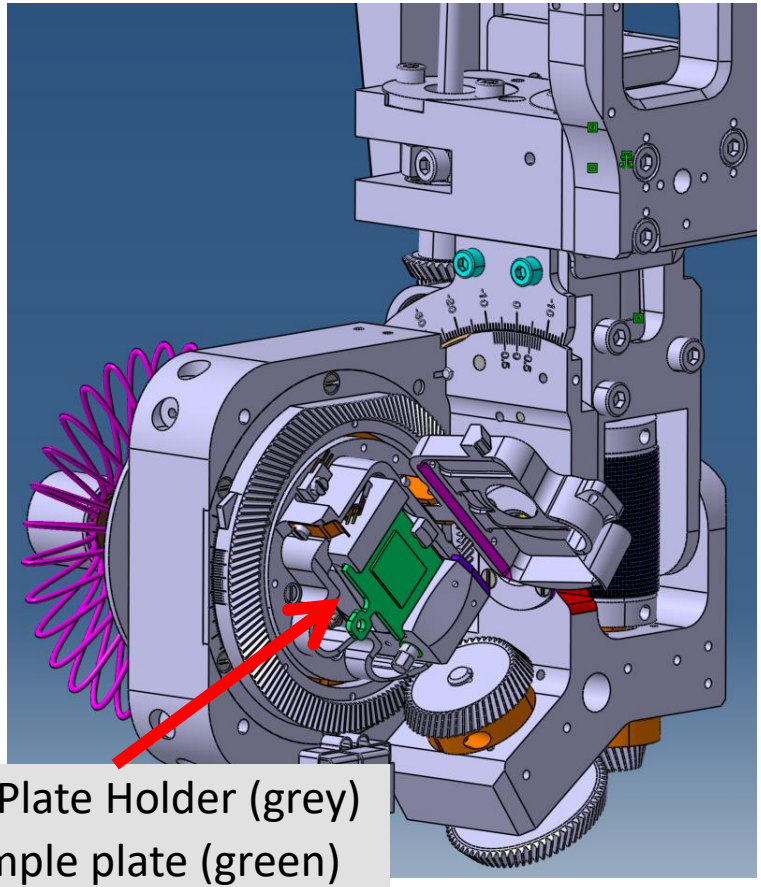
Sample Plate Holder

Design goals:

- Hold the sample plate
- Provide good cooling
- Operated with wobblestick

But:

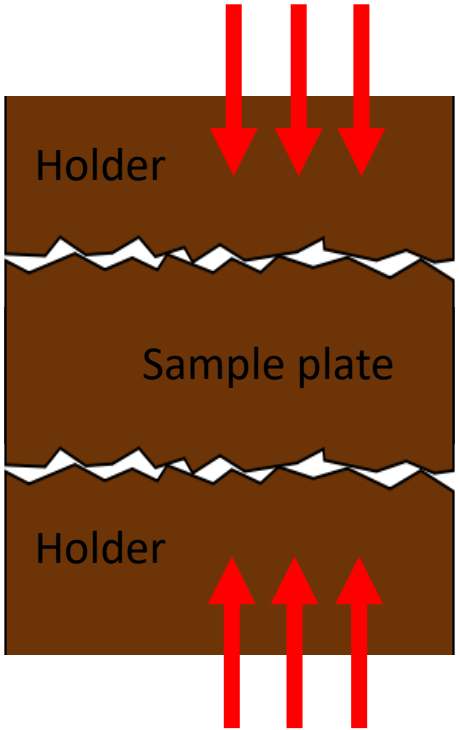
- Good thermal contact comes only with large pressing forces
- Wobblestick-Torque is limited (0.4Nm)

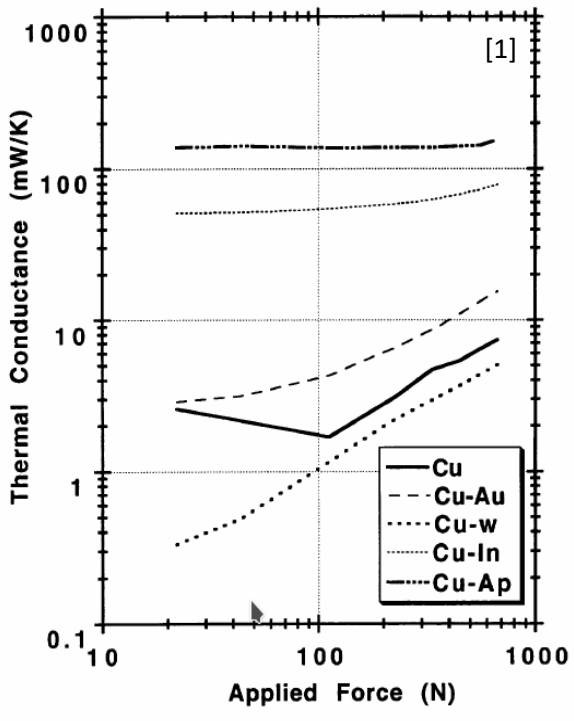


Sample Plate Holder (grey) with sample plate (green) and opened cover

Sample Plate Holder

- Contact interfaces are not perfect because surfaces are not actual flat
- Contacts have a «conductance»/«resistance»
- Material, surface quality, temperature specific
- Force dependent
- But not on the area or pressure (force/area)

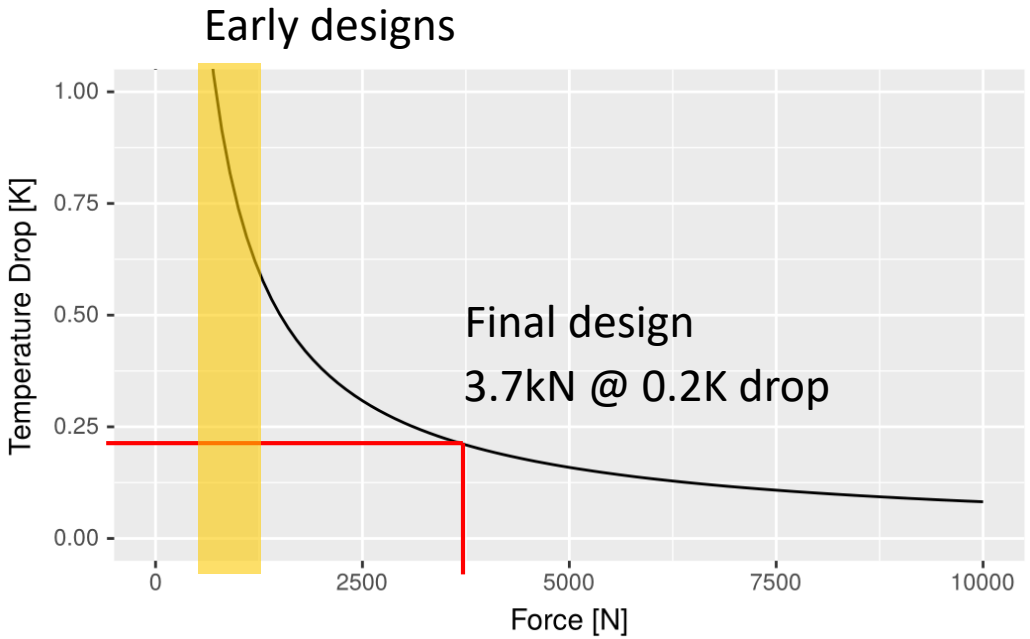




[1] L. J. Salerno and P. Kittel, "Thermal Contact Conductance“, NASA Technical Memorandum, vol. 110429, 1997

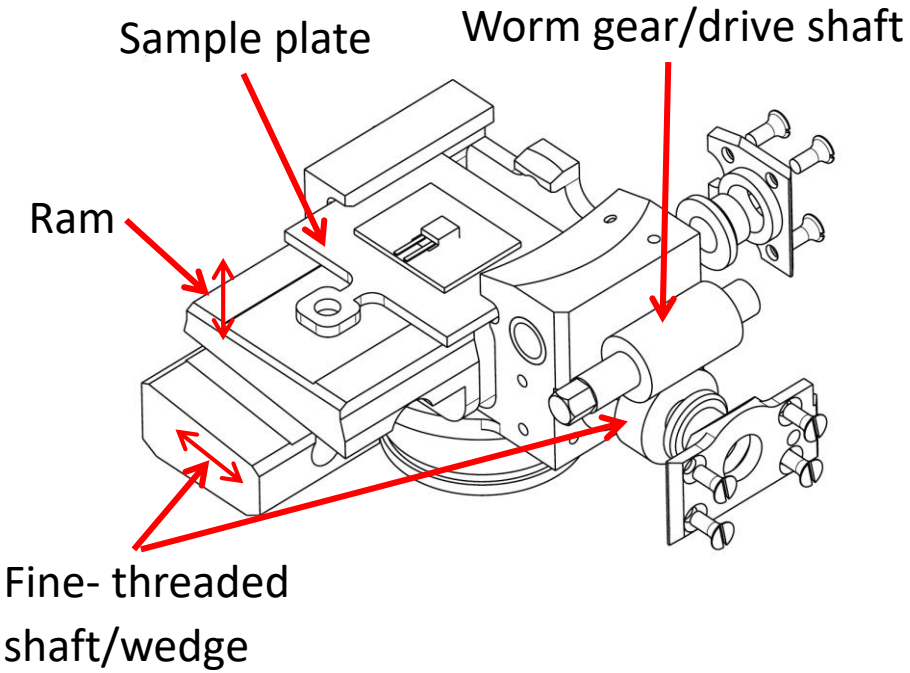
Sample Plate Holder

- Temperature gap across an interface
- Based on experiments [1] but scaled, extrapolated and interpreted to our needs
- Not generally applicable

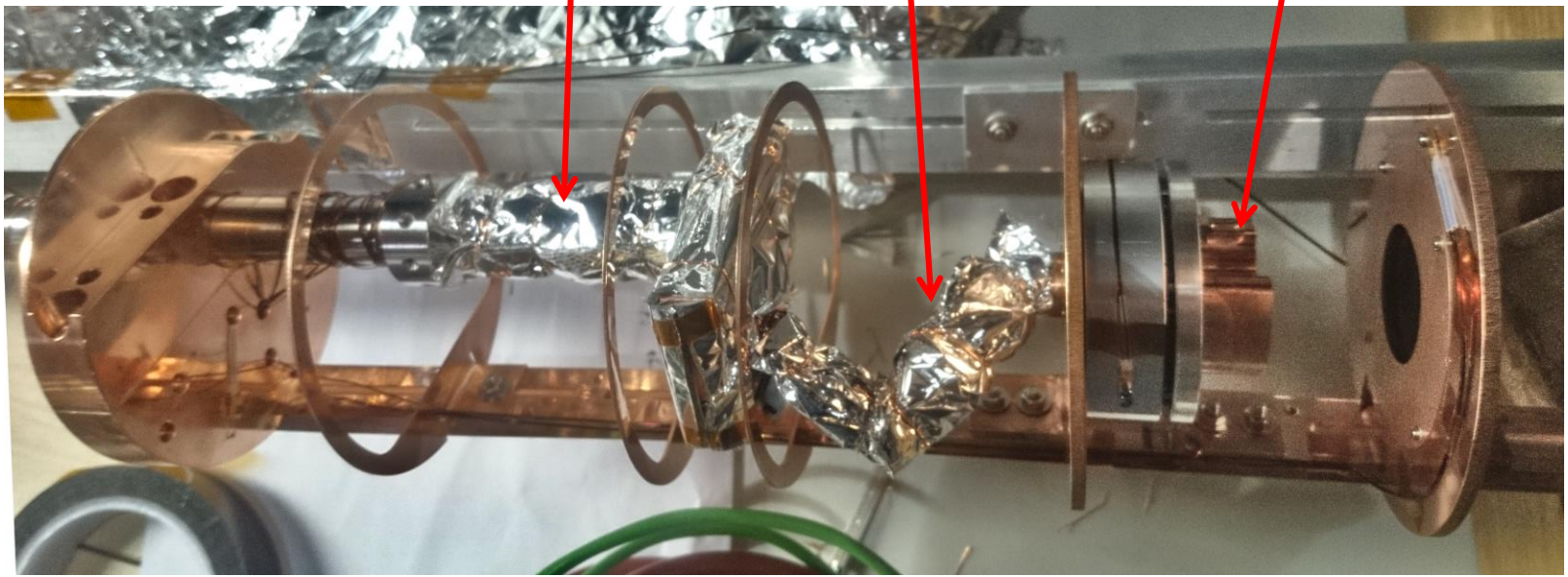


Sample Plate Holder

- Clamping force ~3.7kN with 0.1Nm torque
- Temperature drop 0.2K

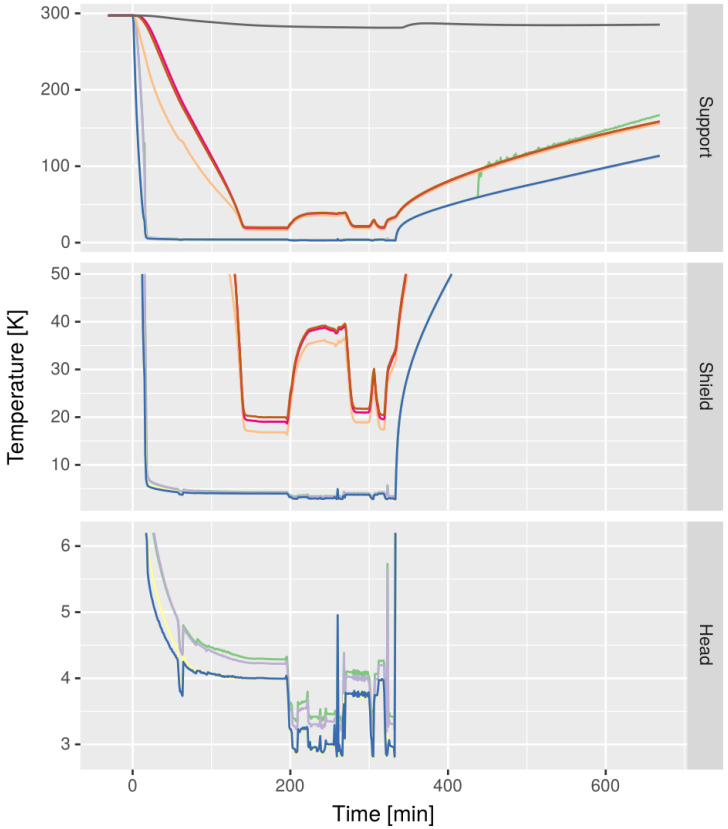


Test Setup



Things are wrapped in super insulating foil to mimic gold plating.

Test Results



Minute	Cryostat Flow	Cryostat Temp.	Event
0	0 → 100%	-	Cooling started
+18	100%	NA	Sample plate @ 10K
…	…	…	…
0*	Adjusting	NA	Sample plate @ 4.3K
+7*	Optimal	2.7K	Sample plate @ 3.4K

Diode
- D1 Sample Plate
- D2 Plate Holder
- D3 Shield Flange
- D4 Clamping Block
- D5 Clamping Block
- D6 Front Shield
- D7 Holder Shield
- D8 Bearing Dummy

Conclusion

- Lowest stable sample plate temperature: 3.4K
- Braid design in OK
- Sample holder design in OK
- Helium consumption is about the same

From/To	Temperature loss
Cryostat → sample plate	0.7K
Across the braid	0.4K
Holder → Plate	0.1K (0.2K predicted)

My thanks go to

- N. C. Plumb
- S. Maag
- L. Nue
- A. Pfister
- A. Schwarb
- K. Zehnder
- M. Shi
- and the workshop