



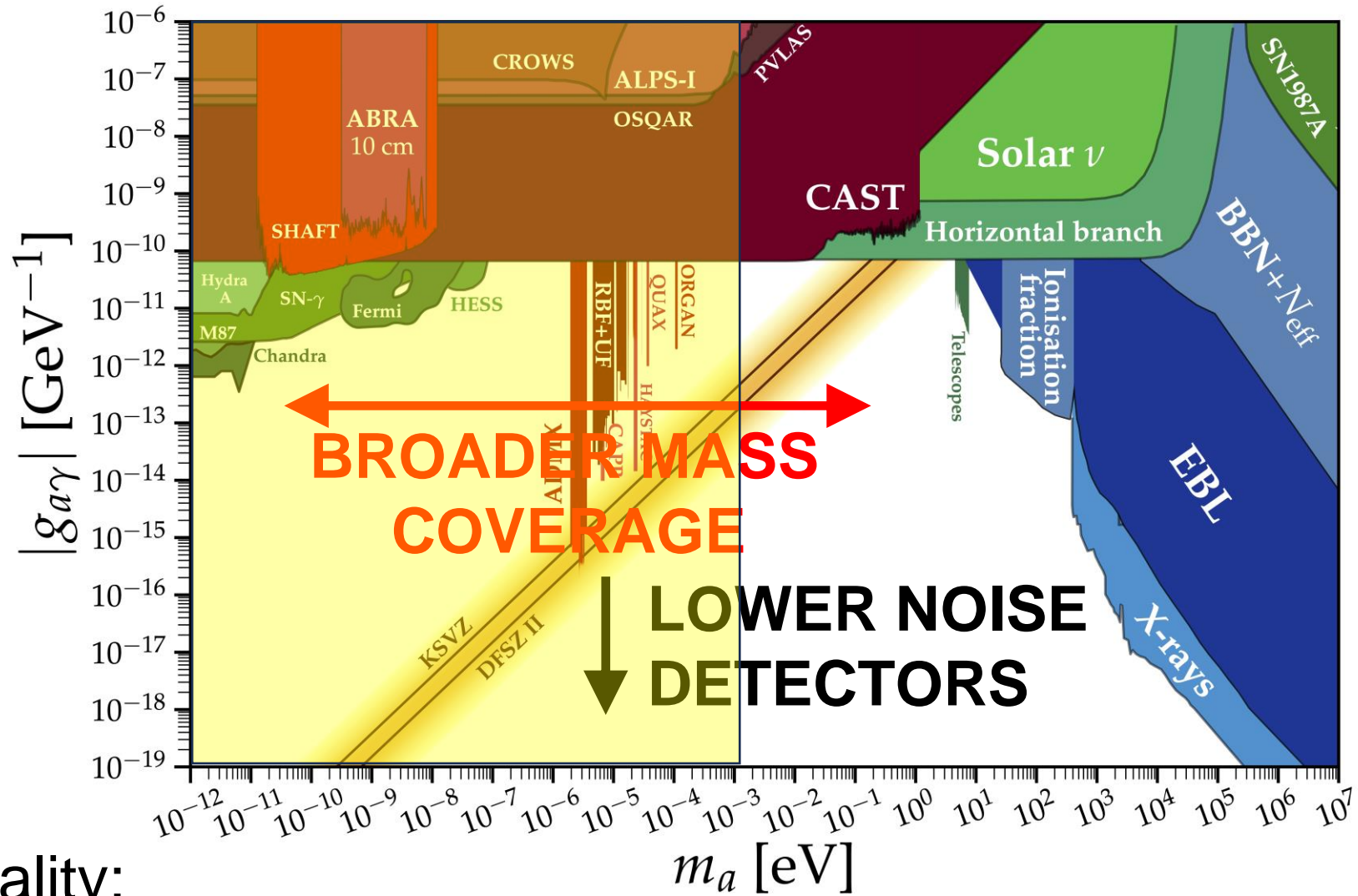
# The Quantum Sensors for the Hidden Sector Project

Ed Daw, for the QSHS collaboration  
SQMS Quantum for Science, March 2024





# Limits on QCD Axions and Alps



Experimental reality:

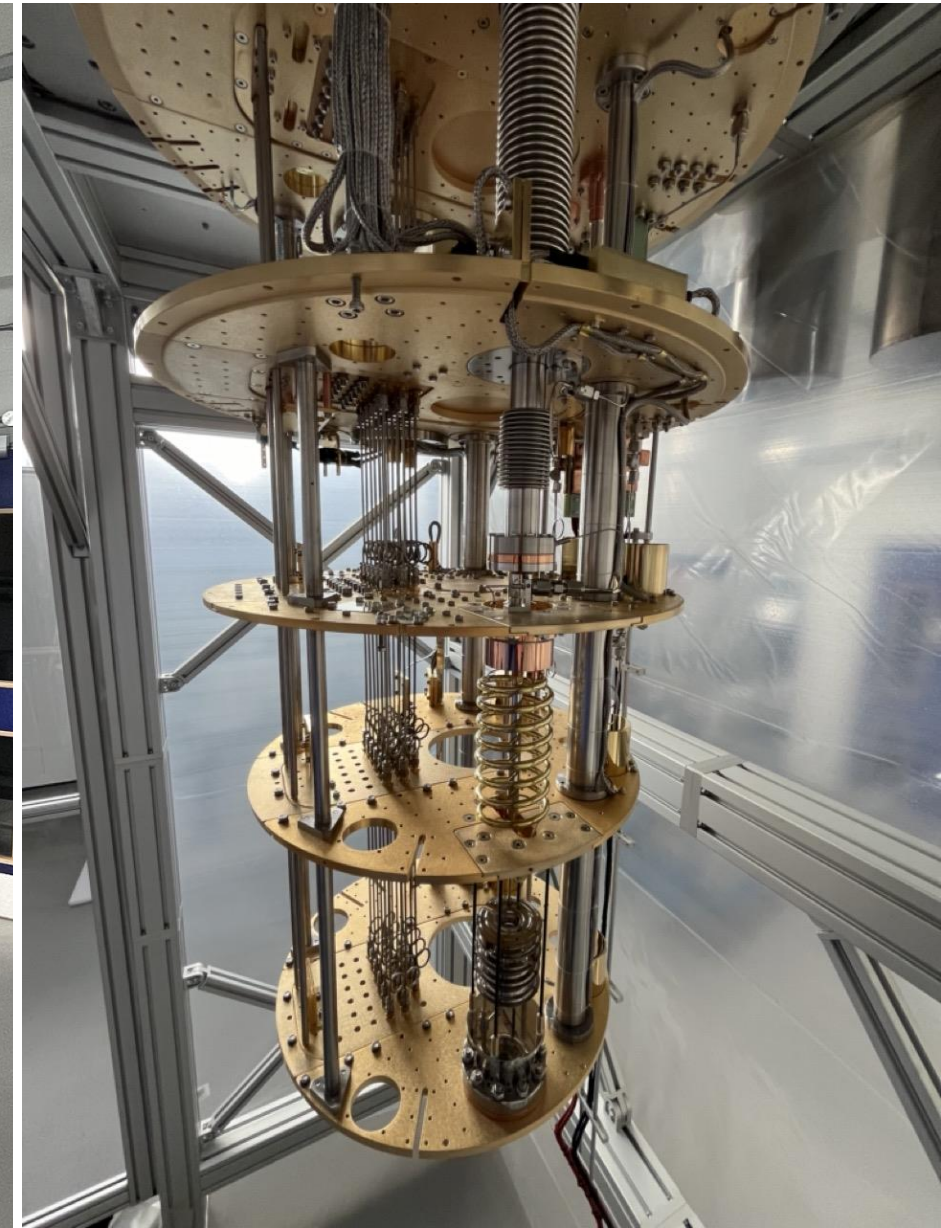
signal against a backdrop of thermal noise

$$T_{\text{Noise}} = T_{\text{Cavity}} + T_{\text{Sensor}}$$

<https://zenodo.org/records/3932430>

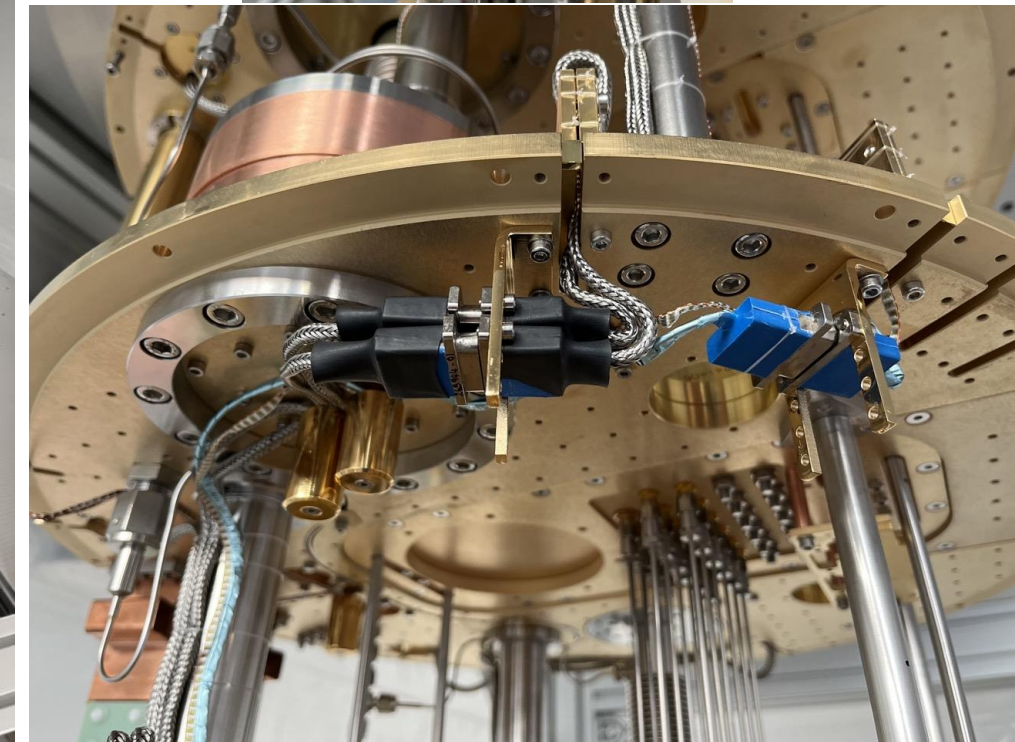
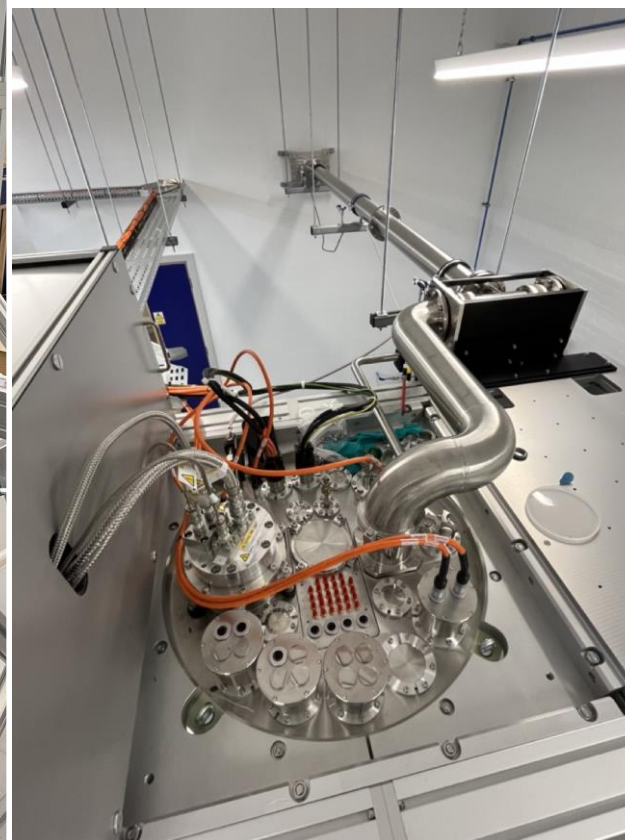
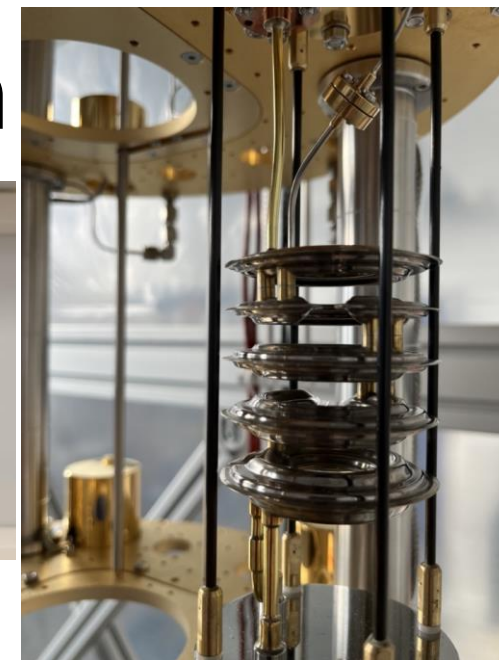
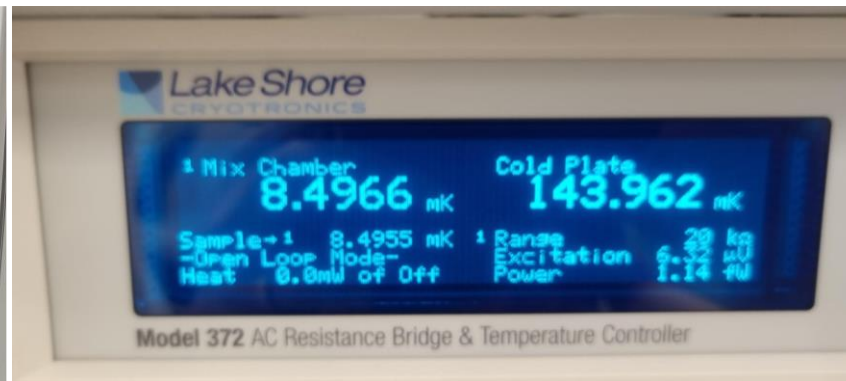


# Dilution Refrigerator Installation at Sheffield



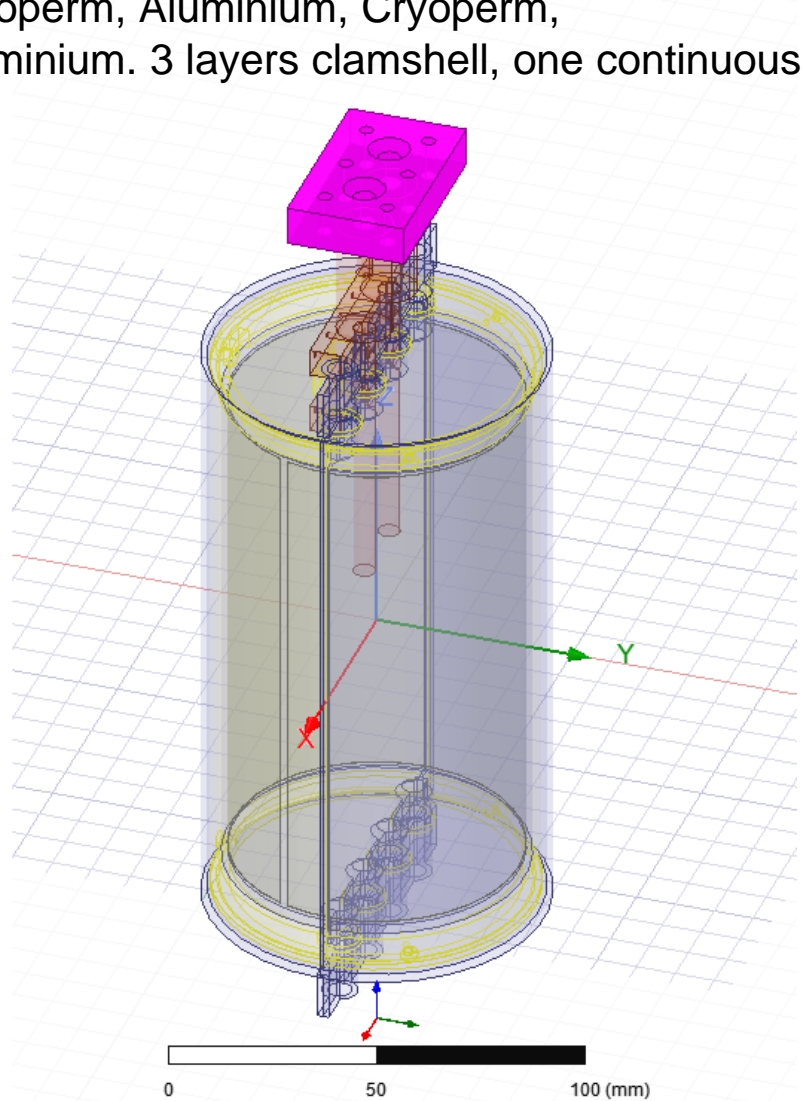
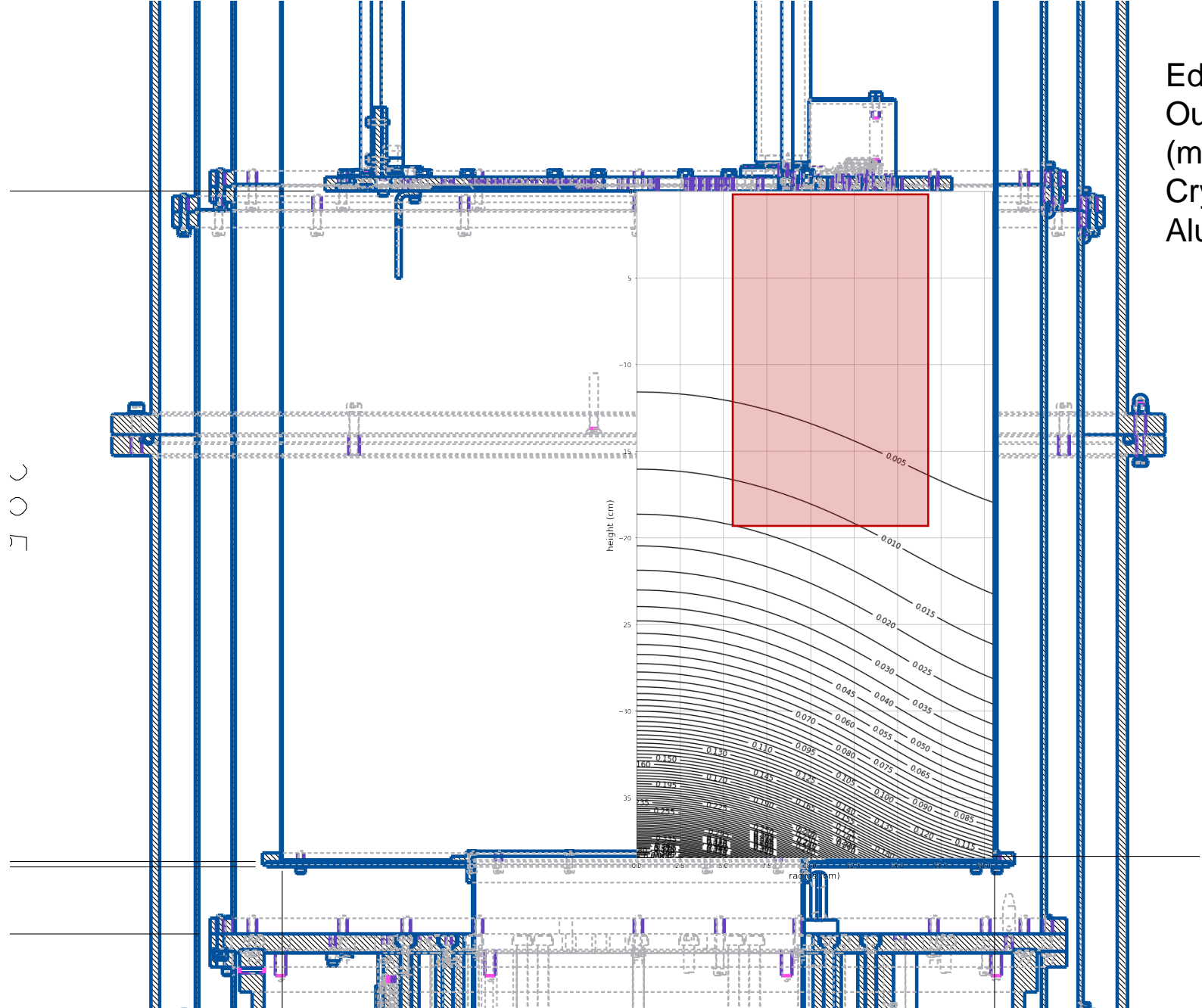


# Magnet install, first cooldown



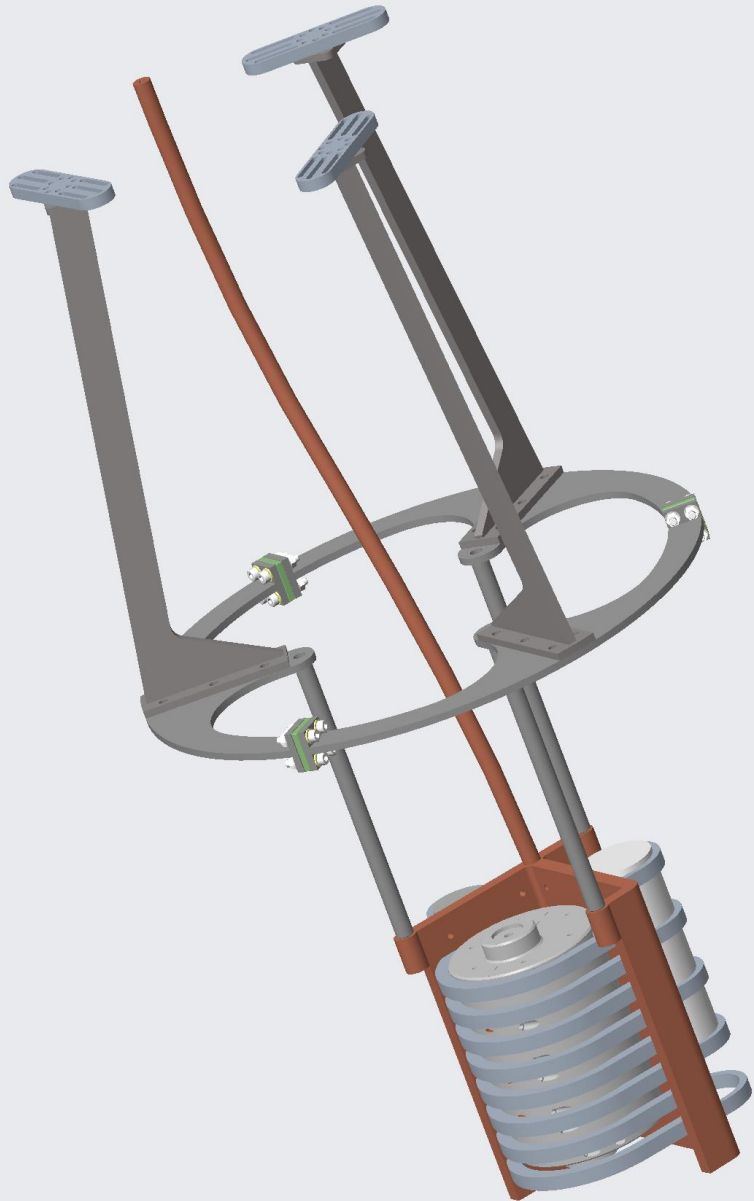
# Field shield

Ed Laird, Paul Smith  
Out for fabrication at Magnetic Shields  
([magneticshields.co.uk](http://magneticshields.co.uk)) of Nottingham.  
Cryoperm, Aluminium, Cryoperm,  
Aluminium. 3 layers clamshell, one continuous

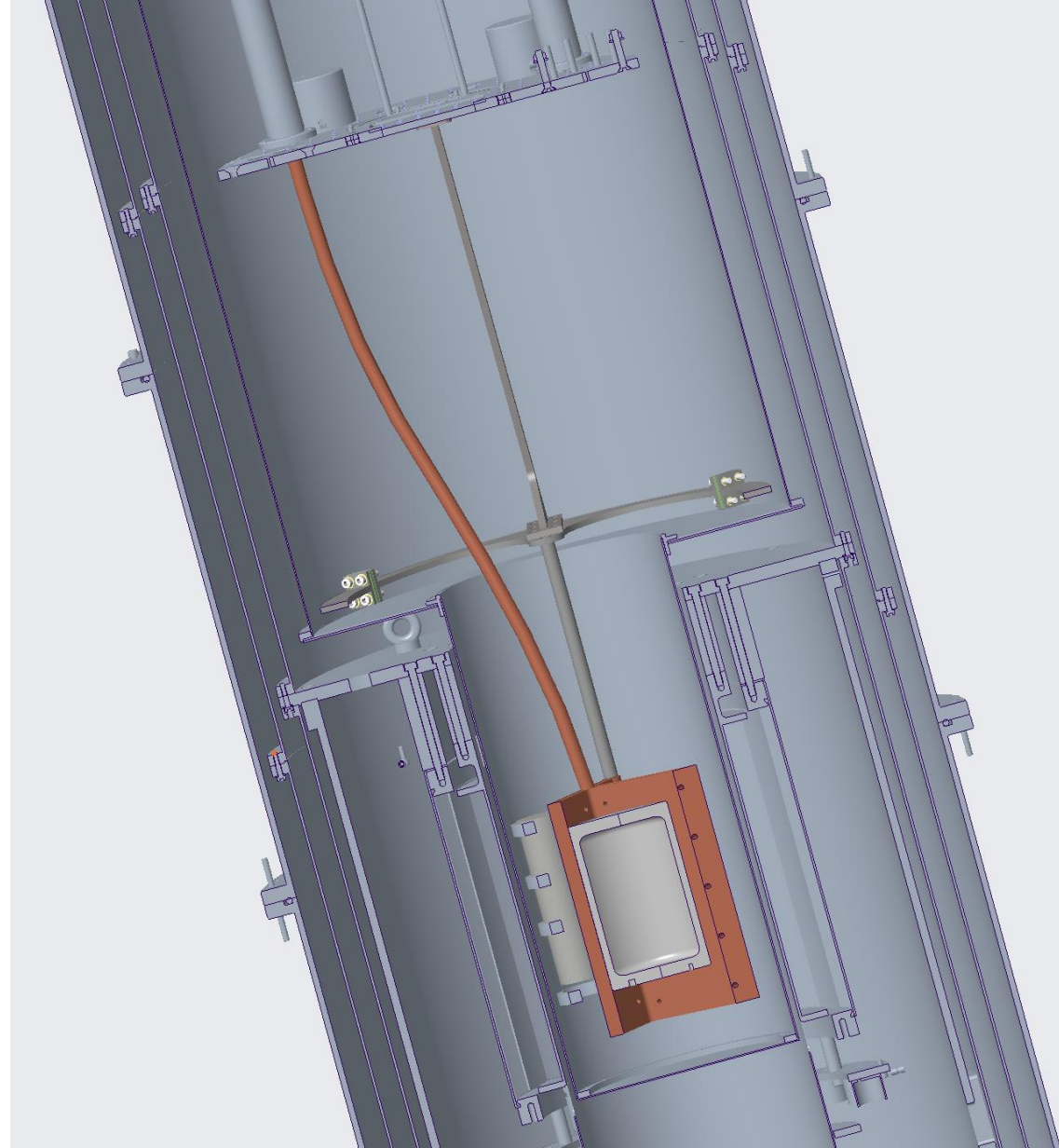


# Cavity Support Structure

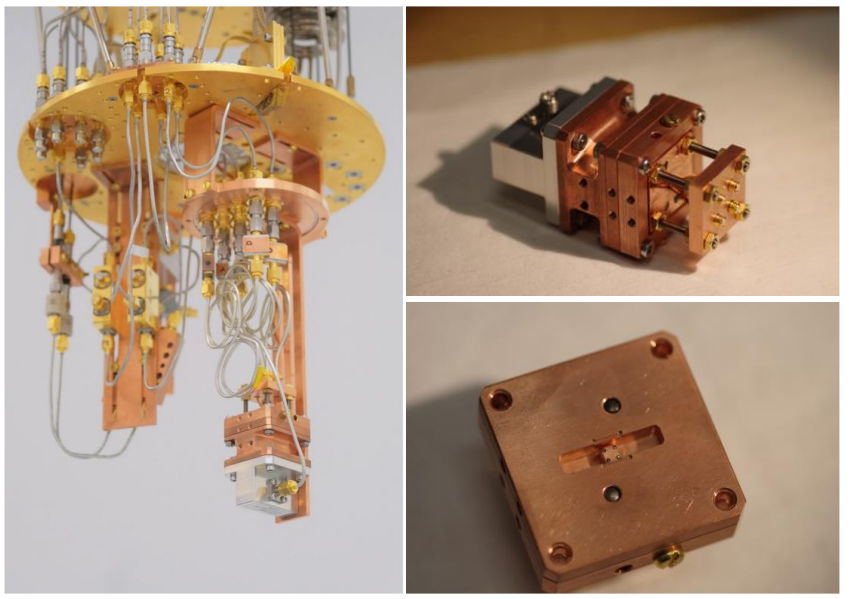
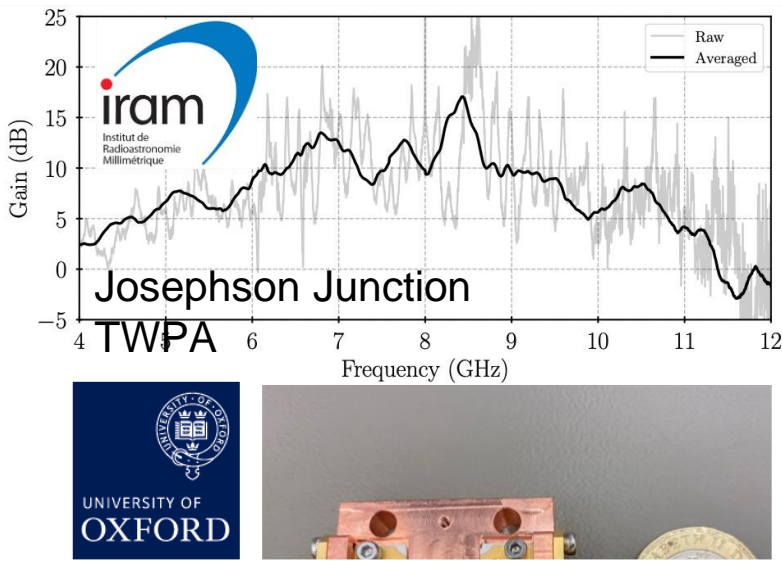
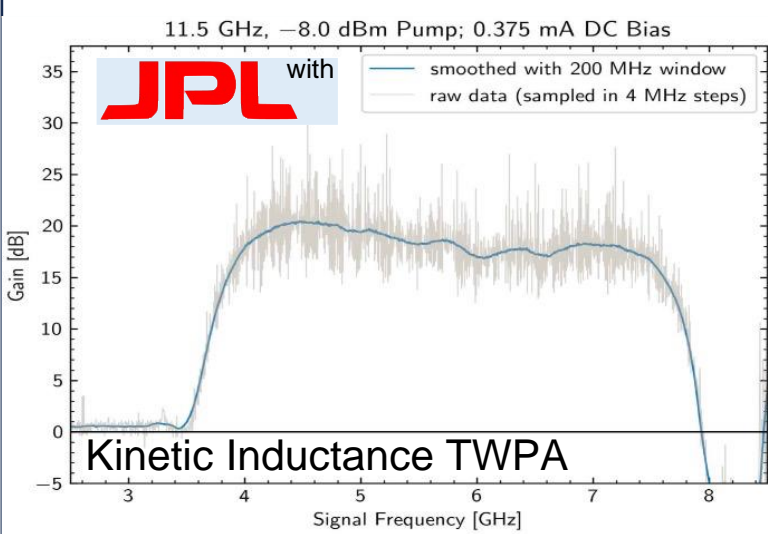
Gamble, Smith, Pashkin, Perry, Daw, Meeson



- Copper is in brown, Stainless steel is in grey.
- Supports four cavities, one tuneable, three with fixed frequency.
- Out for fabrication at M&J Engineering, Sheffield. Copper support is a single piece, wire sawed.



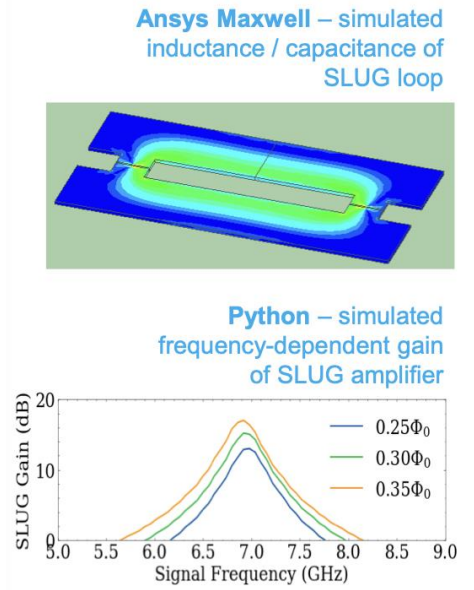
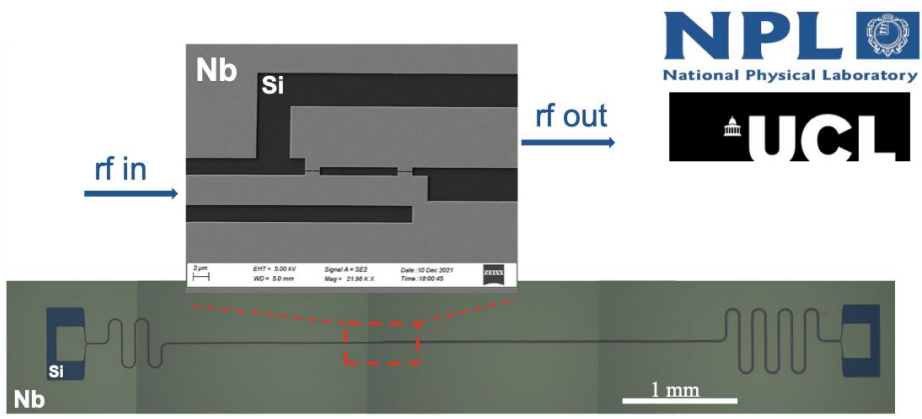
# Quantum Instrumentation



**Boon Kok-Tan's group** has produced packaged TWPAs with substantial gains in 4-10GHz band. Testing on Sheffield test stand this summer.

**Leek group** packaging qubit arrays in waveguides.

**First SLUG loaded SQUID devices** fabricated by the NPL/UCL group, Nov/Dec 2021. Currently under test.



- Withington group, developing microwave homodyne receiver.
- Lancaster group developing TWPAs, testing superconducting resonators

# Summary

- Dilution fridge and magnet installed at Sheffield.
- Base temperature of 8.5mK achieved.
- Support structure and shield for superconducting electronics are being fabricated.
- Cavity and tuning rod have been delivered. Similar cavity used as ADMX's sidecar receiver.
- Receiver electronics from first post-quantum HFET amplifier to digitizer have arrived, await commissioning in the fridge.
- Summer research season, plan to test Boon Kok Tan's TWPA, make noise temperature measurement on HFET amp.
- Resonant feedback work ongoing – recent progress with FPGA electronics in collaboration with Bartram (Stanford).