Magnetic field penetration experiment for flat samples

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Why do we want to measure the field penetration?

- The maximum accelerating gradient can be increased through the use of superconducting-insulating-superconducting (SIS) structures by delaying the field of first flux penetration, H_{vp}.
- Field must be applied from one side of the sample, with the field measured on both sides of the sample to determine H_{vp}.

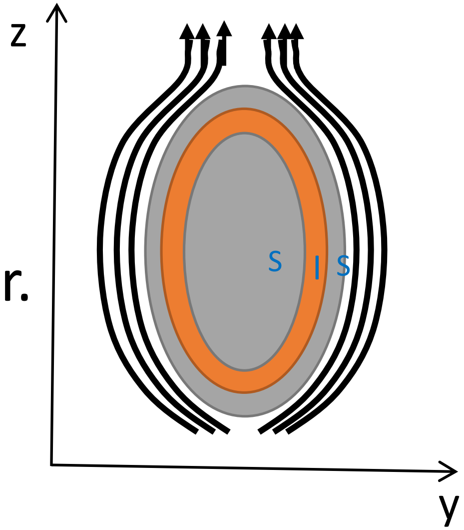
Multilayer and SIS structures

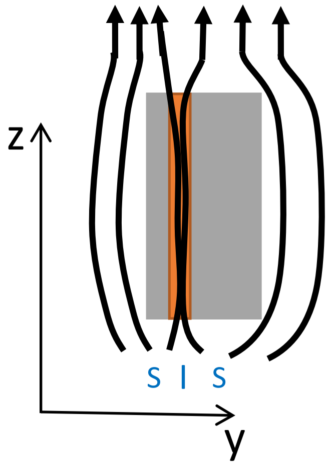
- By delaying the vortex penetration of type II superconductors further than the thermodynamic critical field (H_c) of Nb, it makes it possible to take advantage of type II superconductors with a higher H_c in RF applications.
- The screening due to the interface field is reduced by N, the number of superconducting layers.

$$B_i = B_o e^{(-\frac{Nd}{\lambda})}$$

- For 3 layers of Nb_3Sn with a thickness d = 50 nm, which has a London penetration depth of 65 nm, $B_i = 0.1B_o$.

Magnetometry complications

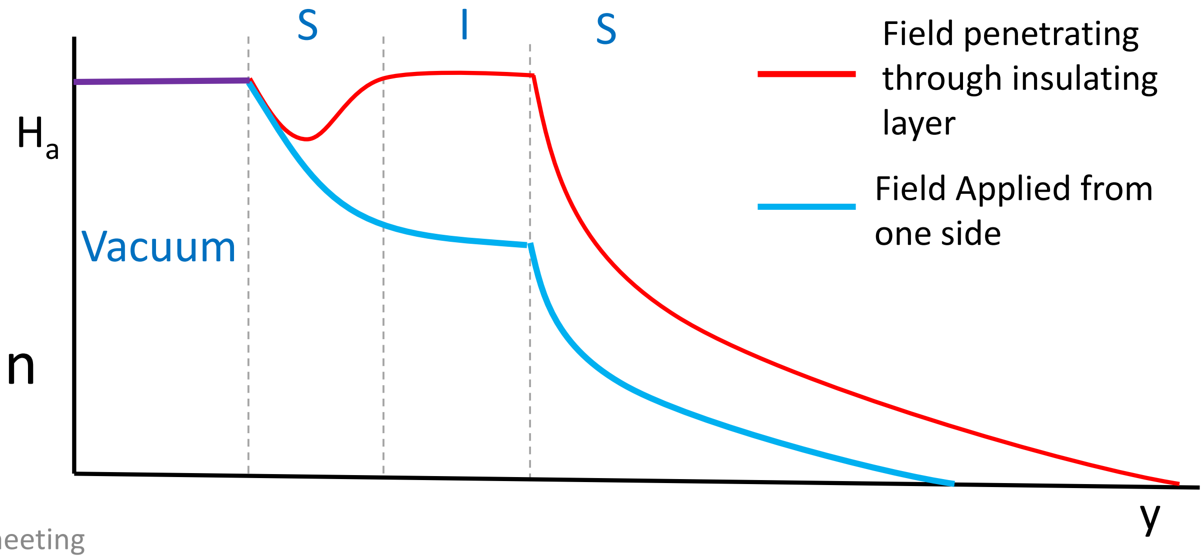




- SQUID measurements apply a parallel field over an entire small sample. Therefore the applied field can enter a multilayer sample through the insulating layer.
- If SIS multilayers are being tested, the magnetic field screening cannot be observed due to the field being applied over the entire sample.

$$H_{c1} = \frac{2\Phi_0}{\pi d^2}\ln\left(\frac{d}{\tilde{\xi}}\right)$$

Enhancement of rf breakdown field of superconductors by multilayer coating – A. Gurevich



- Only small samples can be tested in comparison to the magnetic field, which can cause edge effects and cause the flux to penetrate the sample earlier.

Previous work – Tubular samples

- A facility was commissioned at Daresbury laboratory, in which small superconducting magnetic coil was placed in the middle of a long sample tube.

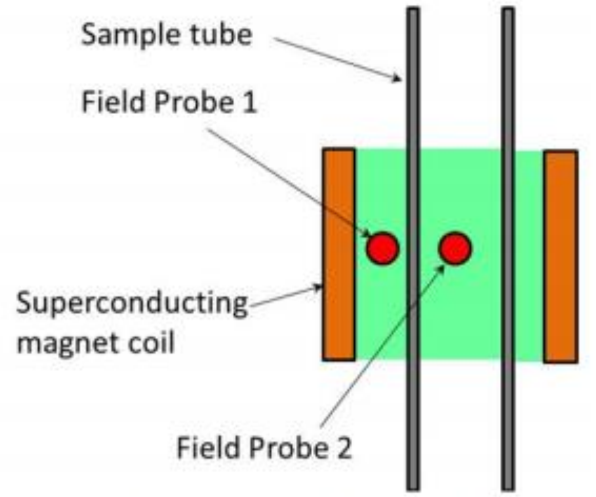


Figure 1: A schematic layout of magnetic measurements with tubular superconducting samples.

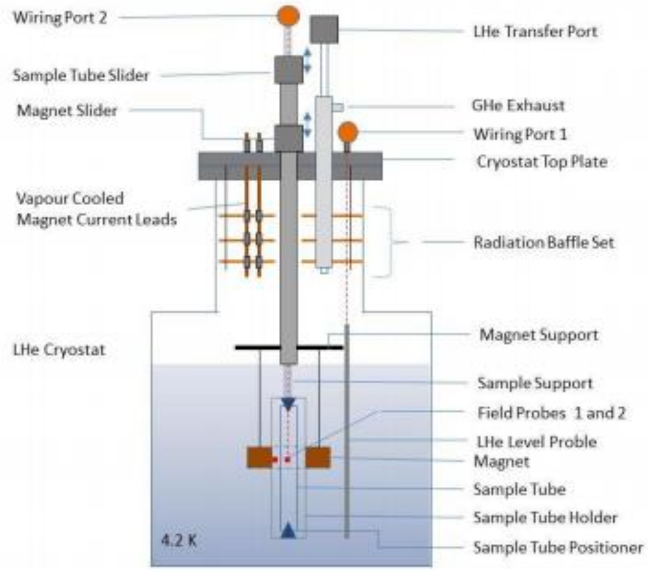


Figure 2: A detailed layout of the magnetic penetration facility.

- Hall effect sensors either side of sample tube in the central plane of the magnet.
- Sample and superconducting magnet were submerged in liquid He.

"*A Facility for Magnetic Field Penetration Measurements on Multilayer S-I-S Structures – O.Malyshev et al - Proceedings of SRF 2015*"

Tubular samples continued

- Tubular samples do not resemble an SRF cavity (intended application of the superconductors) in terms of physical and chemical deposition.

- $H_{pinnning}$ = 145 mT
- H_{vp} = 264 mT

"A Facility for Magnetic Field Penetration Measurements on Multilayer S-I-S Strucures – O.Malyshev et al – Proceedings of SRF 2015"

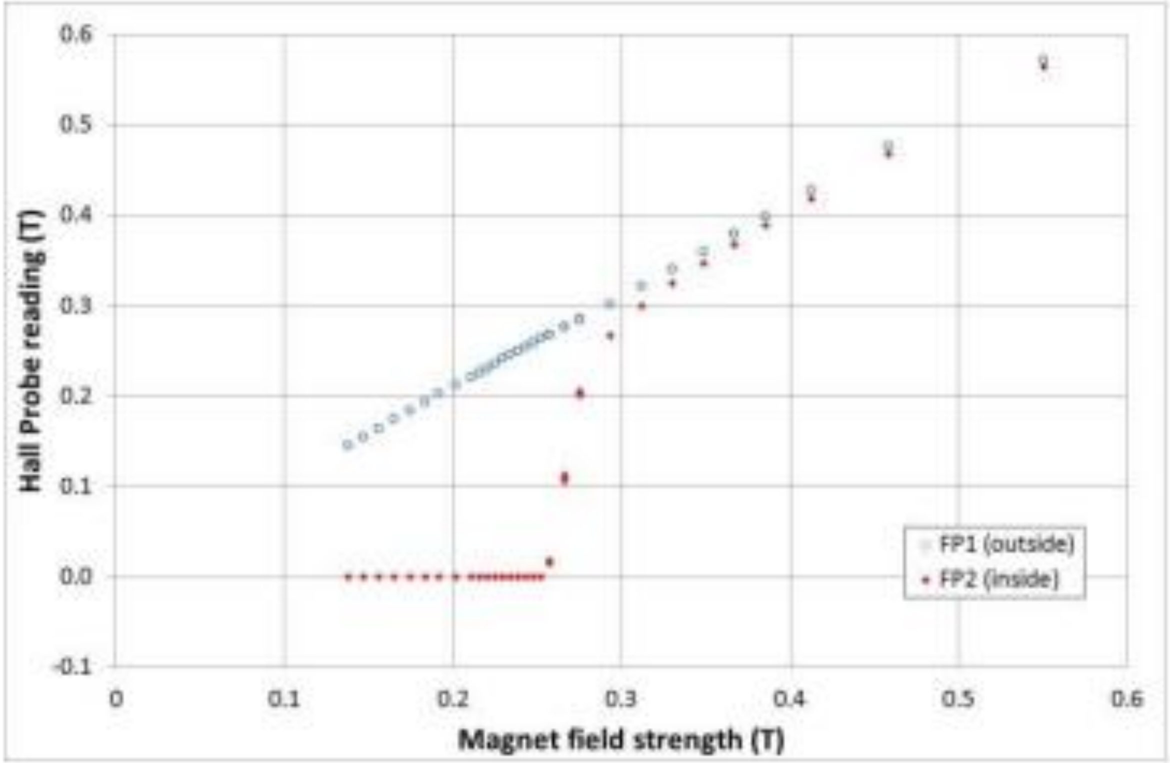
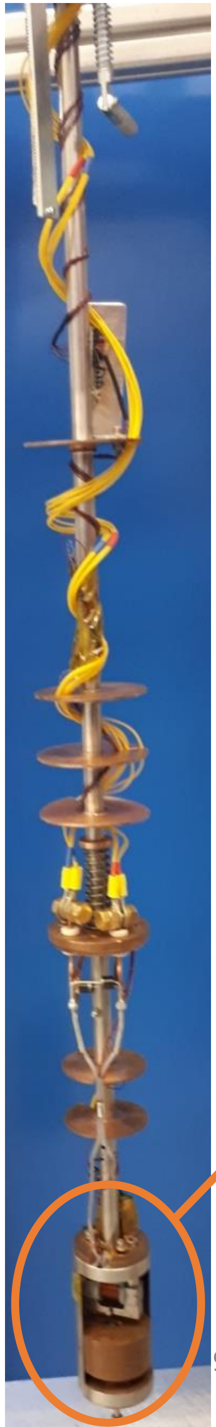
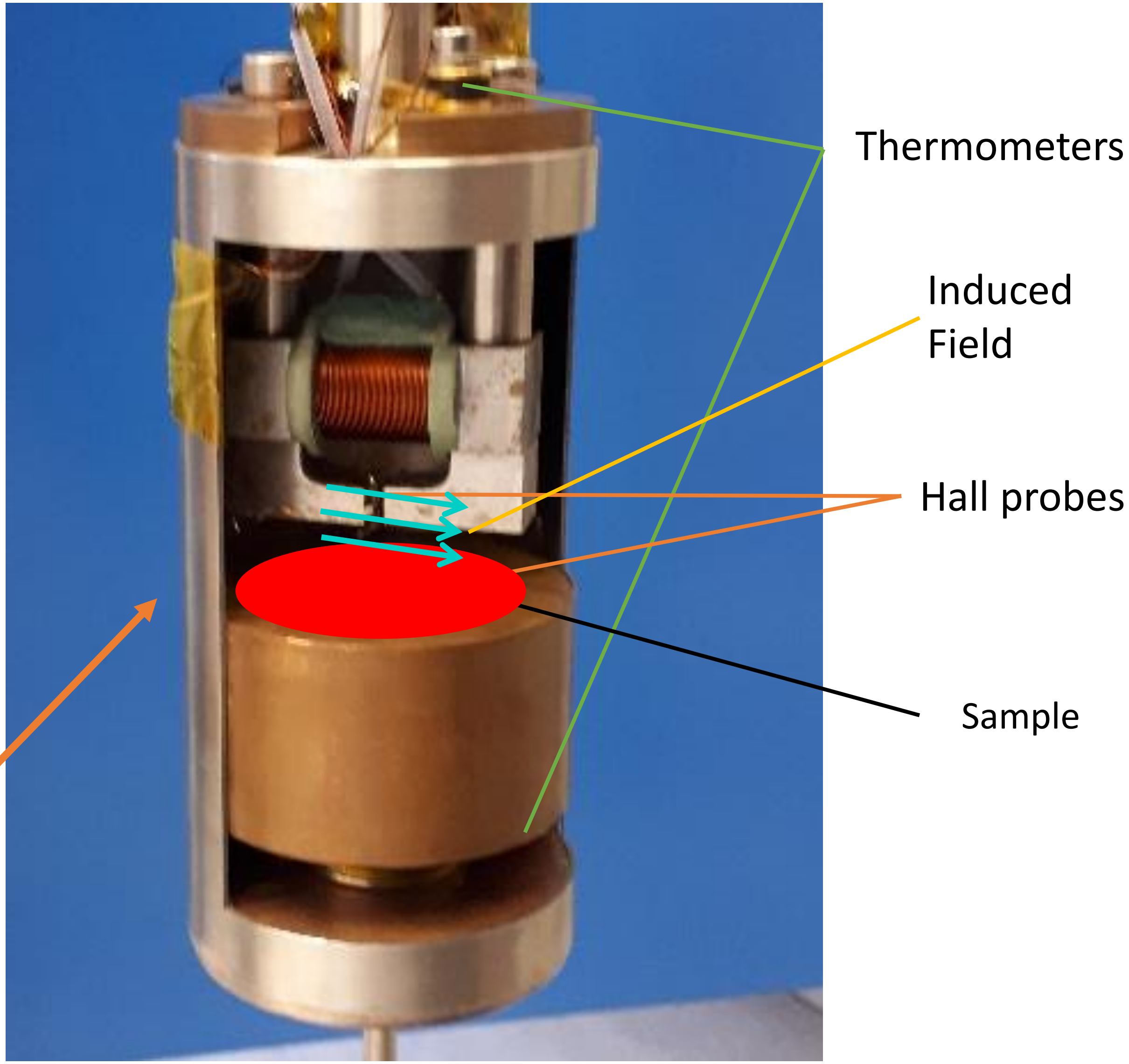


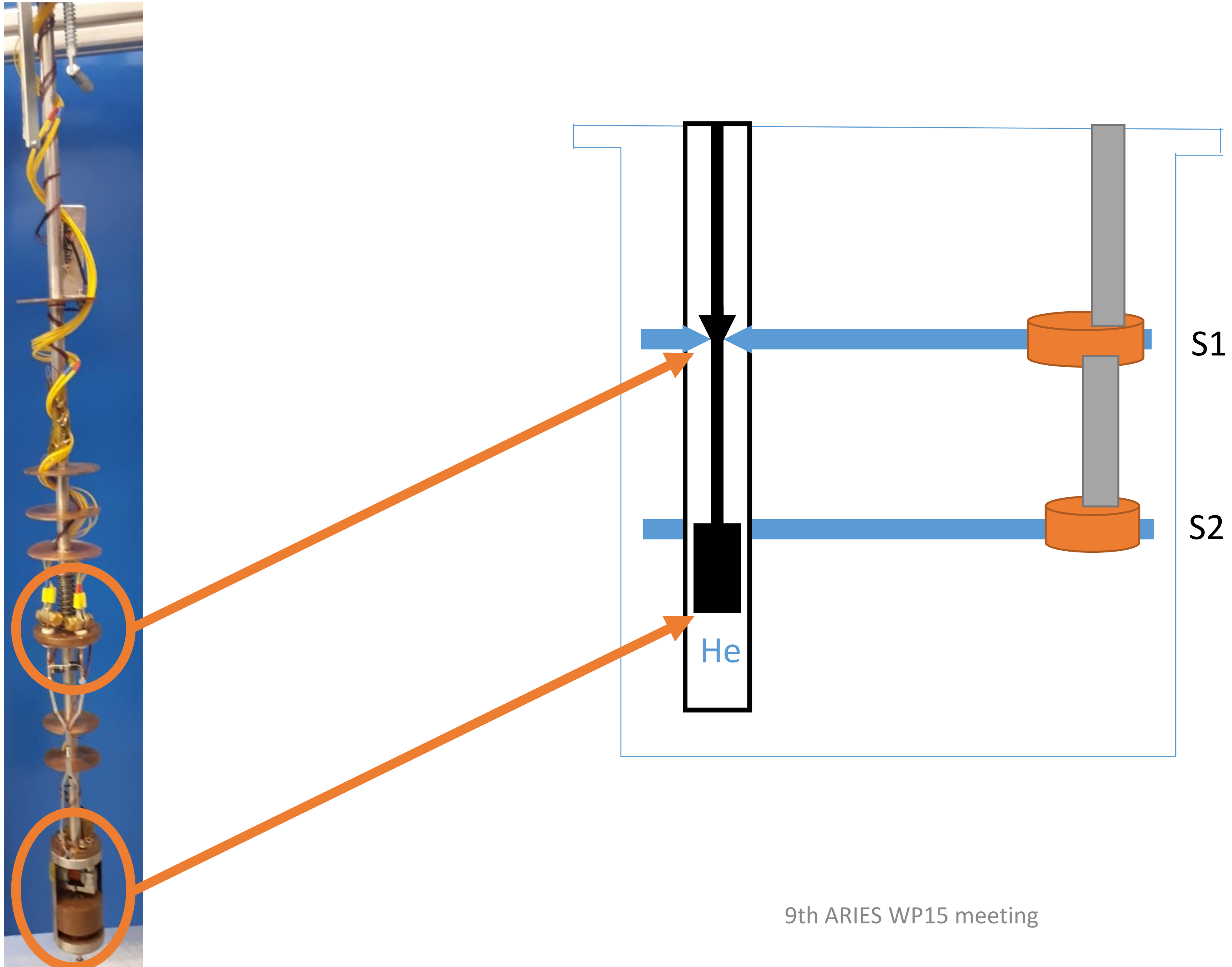
Figure 4: Field penetration measurements with Sample 1 (bulk Nb tube).

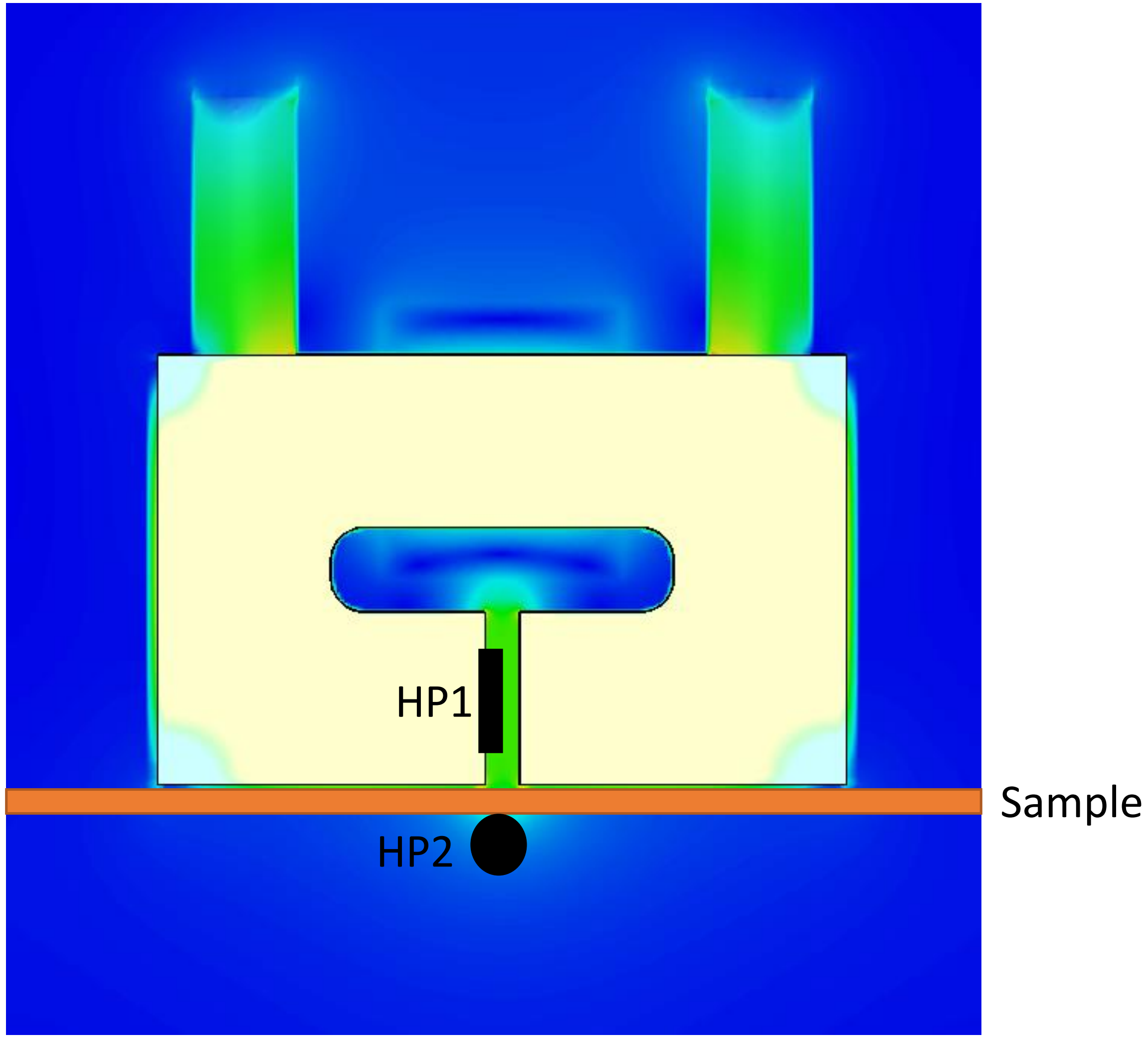
Sample Cage

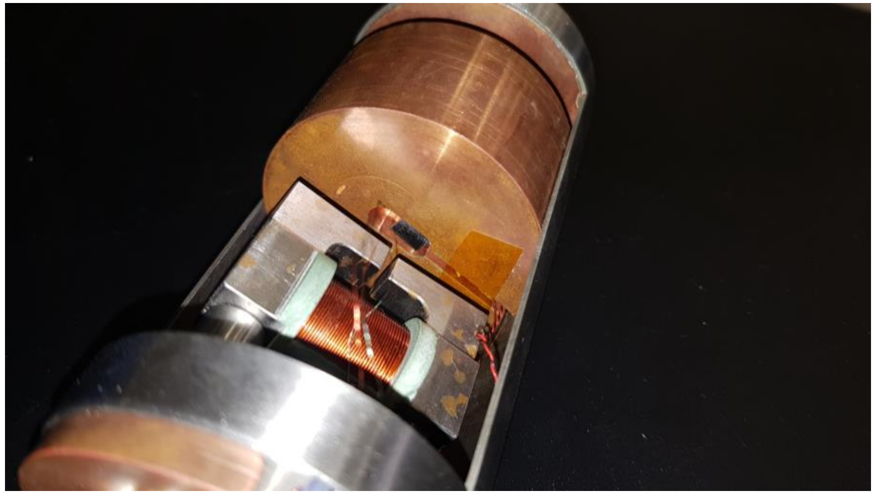
- Low temperature superconducting wire is joined to high temperature superconducting wire as close to the sample cage as possible to ensure the wire should be superconducting.
- Magnetic field applied to the sample is directed to be parallel to the sample by the use of a ferrite yoke.
- Spring loaded to ensure the sample is in contact with the yoke.

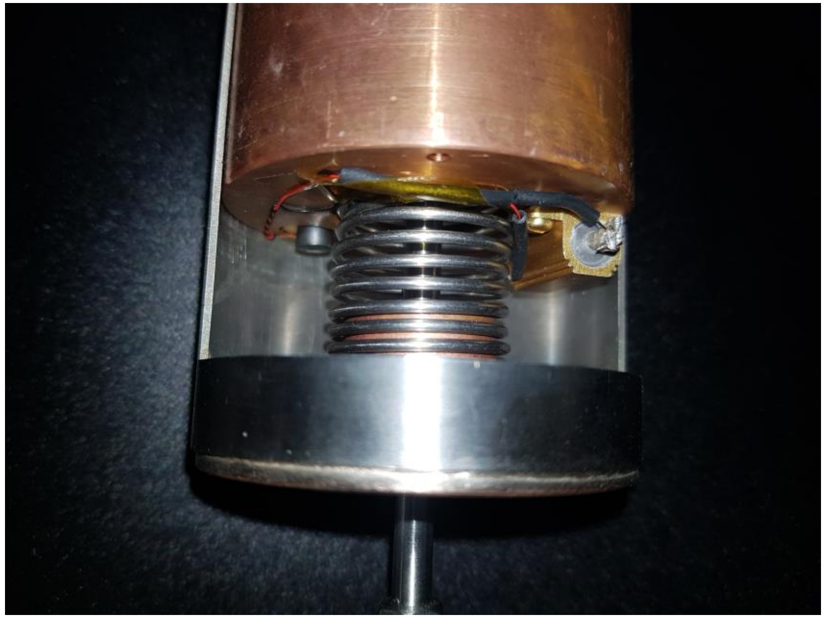




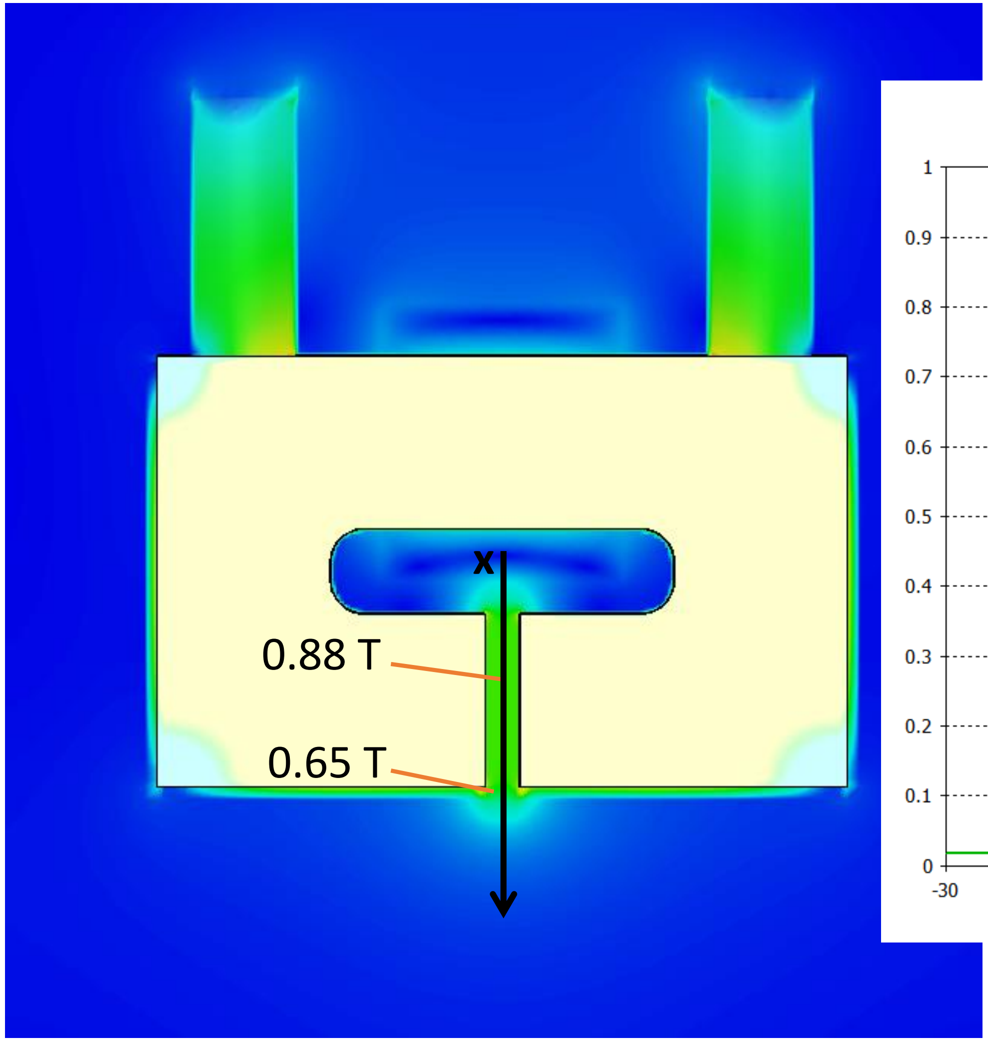

S1
S2
He

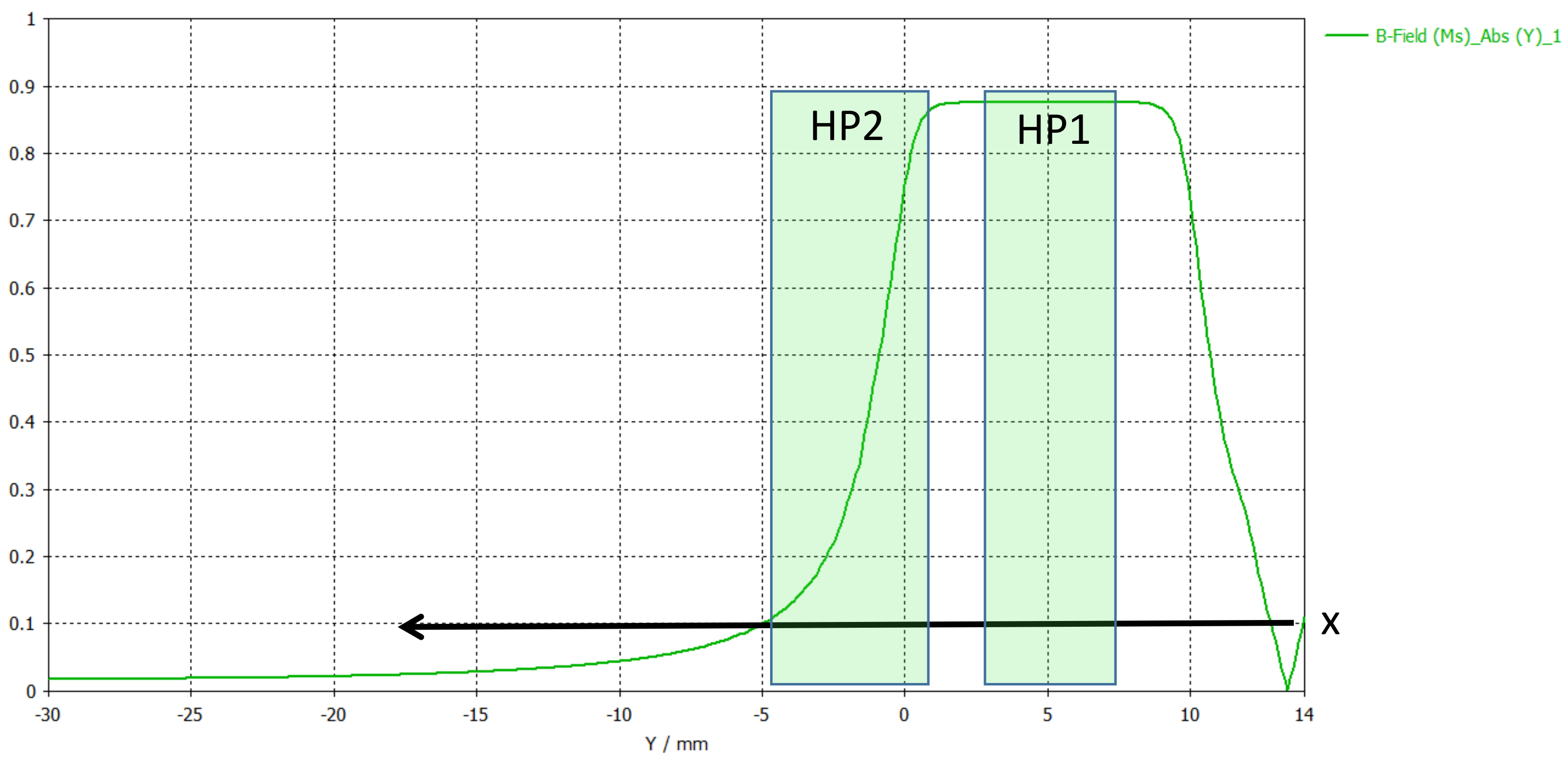

HP1
Sample
HP2



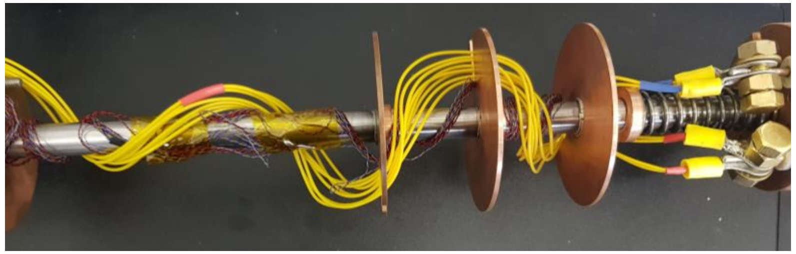


Magnet simulations – 20 A

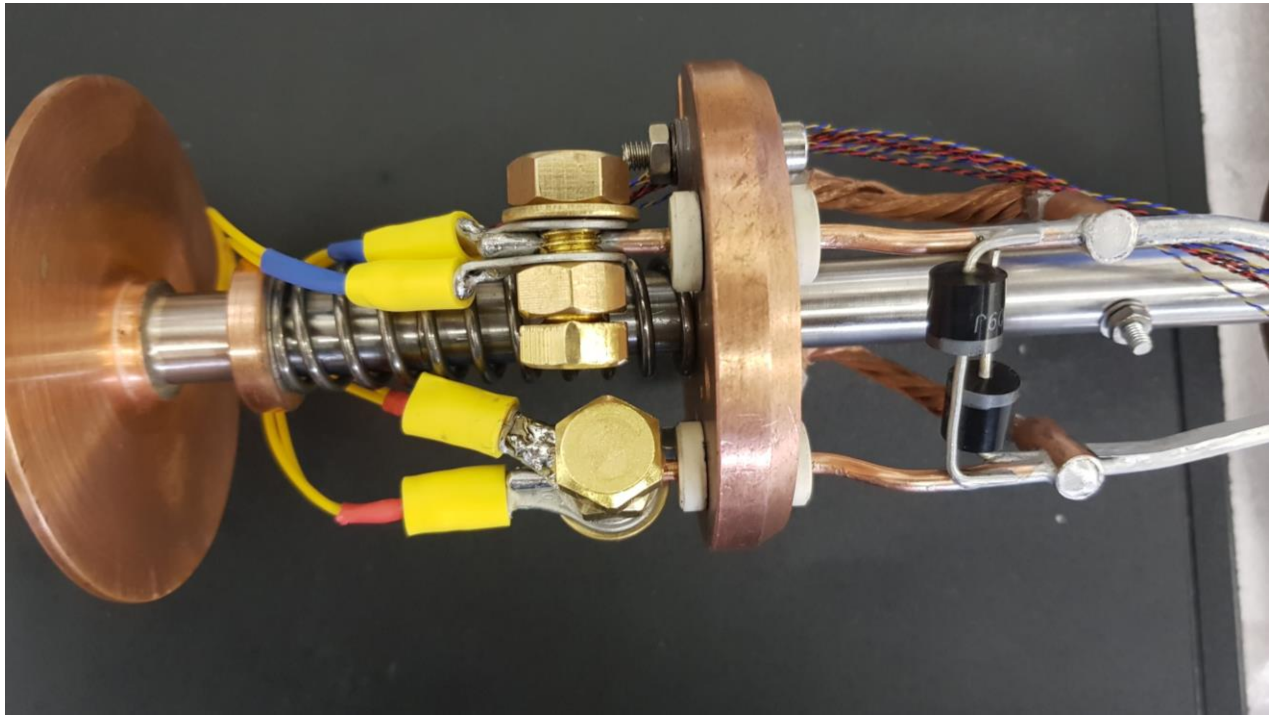




First stage baffle

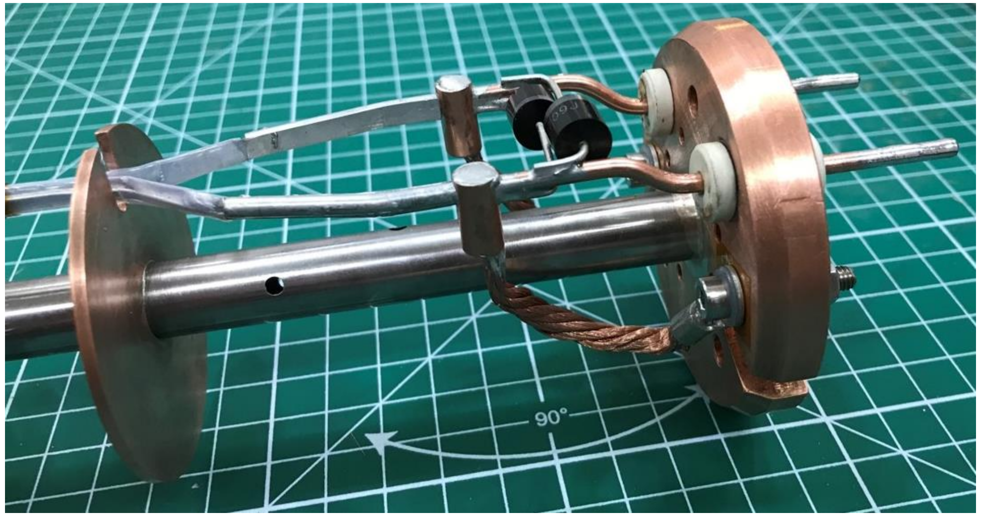


- Spring loaded to allow compression onto the first stage for thermalisation.
- Thermometer stuck with GE cryogenic varnish to determine temperature.
- Copper rods to allow connection between wires and superconducting joins



High current wiring - TBC

- High temperature superconducting ribbon was attached to the Cu rod by team at Rutherford Appleton Laboratory.
- Superconducting wire used to reduce the heat load on the second stage.
- Diodes to trip circuit in case resistance builds up due to the wire not in a superconducting state.



First Run and Next Steps

- All electronics are working – Hall probes, Thermometers and Heater.
- VTI cooled to 7.5 K
- Coil is operational up to 2 A corresponding to 51.8 mT before heating ensues.
  - To be addressed next week

- Temperature needs to be lowered in the cryostat.
- Connected to LabView for ease of measurements.
- Commissioning facility with:
  - Nb disc RRR 400, 1 mm thick, 50 mm diameter
  - Nb foil to see effect of thickness
- Sample specs:
  - 50 mm diameter (max)

Acknowledgements

- Tobias Junginger
- Graeme Burt
- Oleg Malyshev
- Reza Valizadeh
- Ninad Pattalwar
- James Conlon
- Lewis Gurran
- Ben Green
- Josef Boehm

Thanks for listening – Any Questions?