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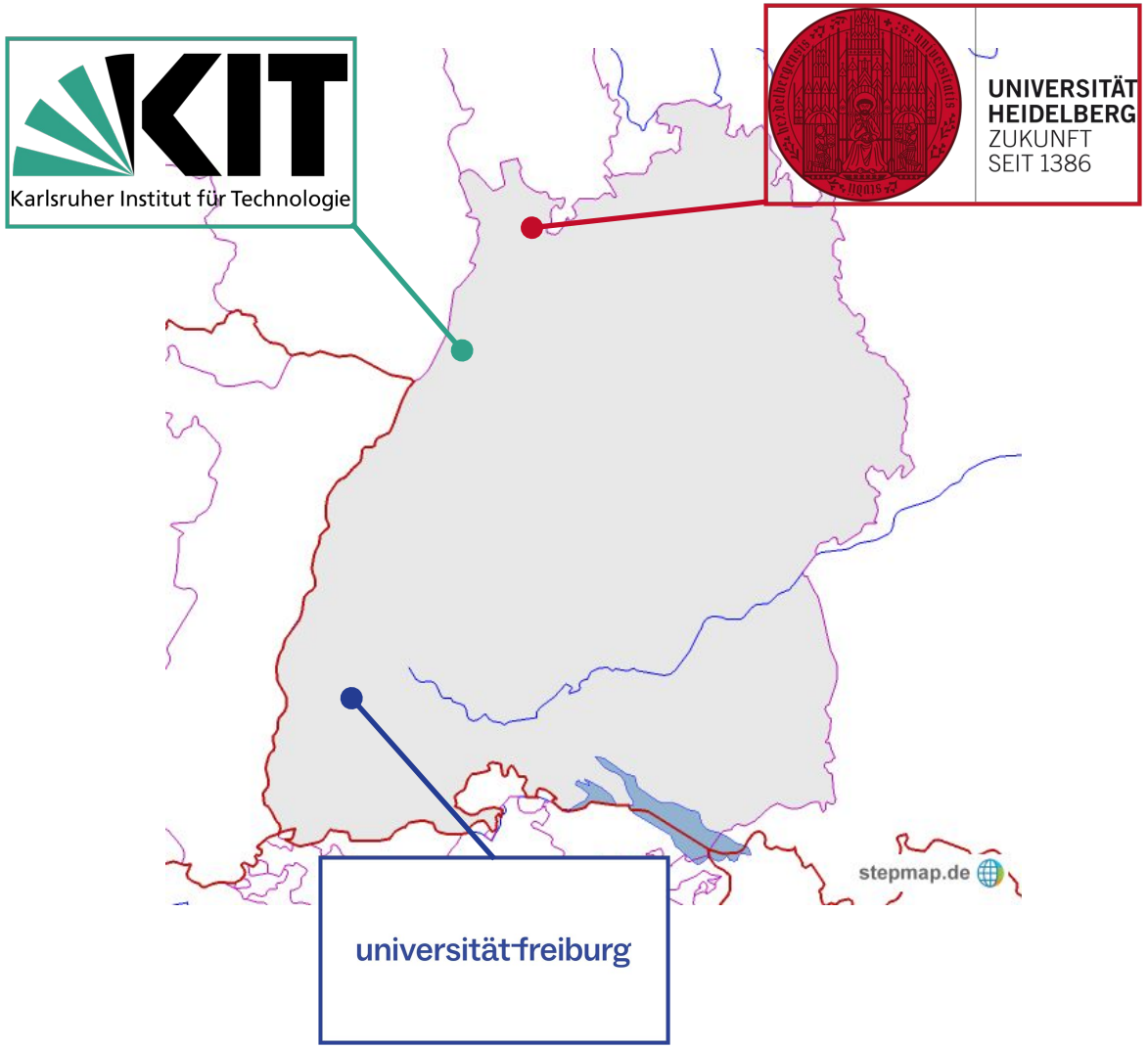
Towards Dark Matter Detection with Superfluid Helium: First Results from the DELight Demonstrator

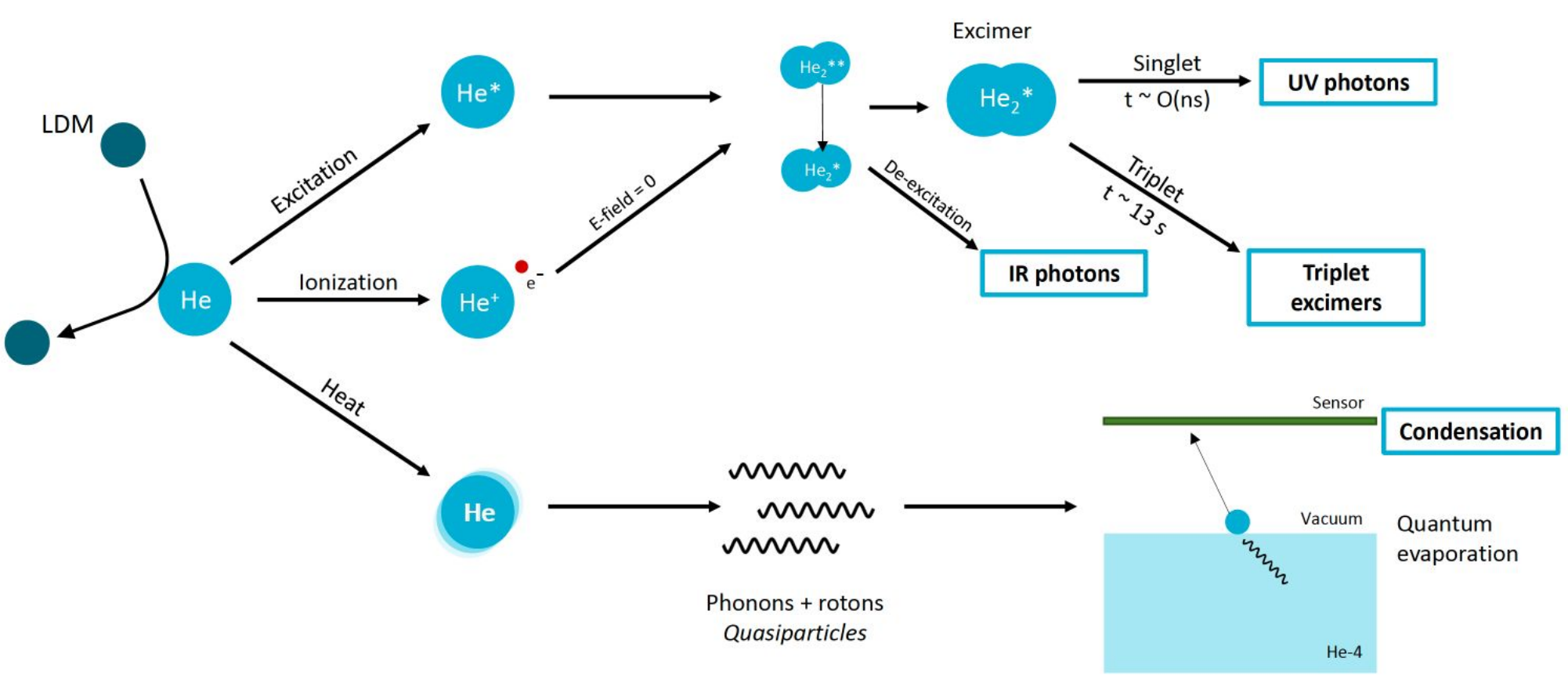
Axel Brunold on behalf of the DELight Collaboration
DPG Göttingen 2025

The DELight Collaboration



An upcoming superfluid helium-4 based light dark matter search

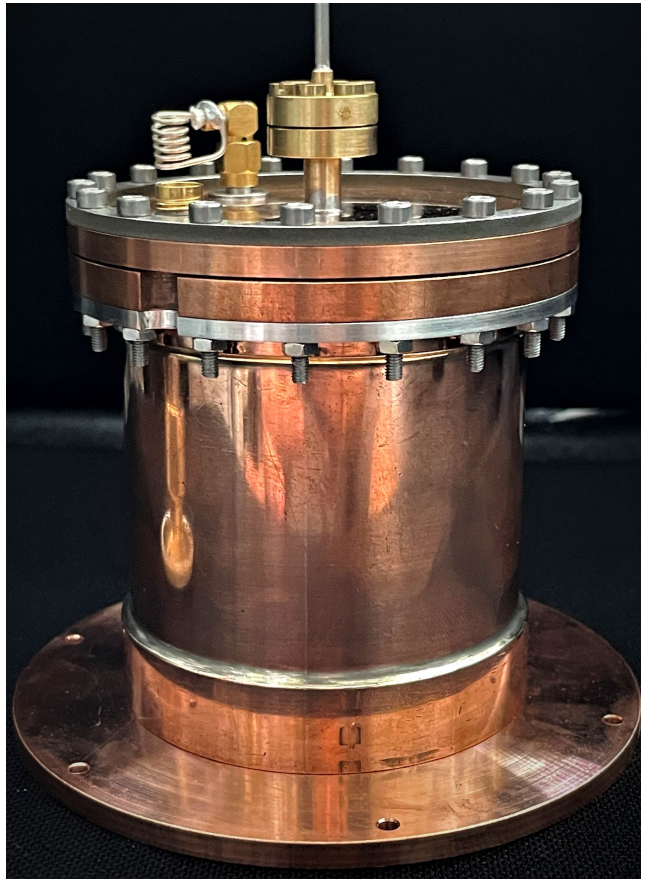
Signals in Superfluid He-4



Can one detect quasiparticles with MMC submerged in superfluid liquid ?

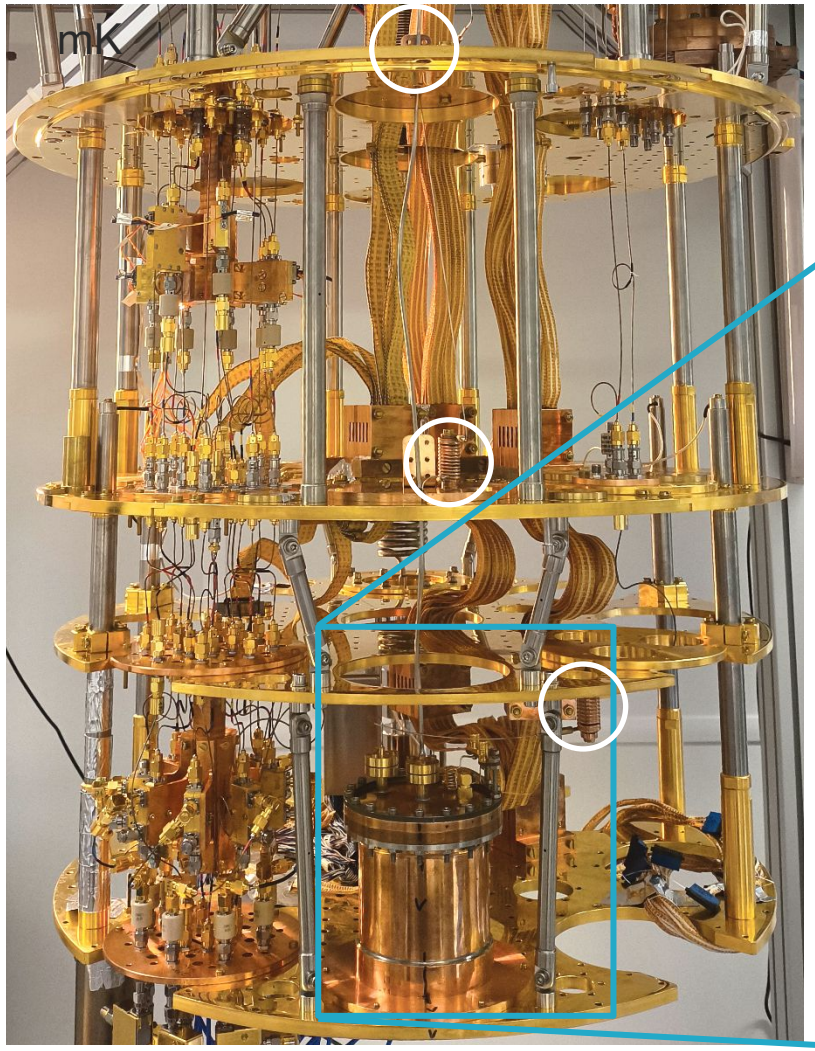
The DELight Demonstrator

- Test of filling system
- Development and test of purification system
- Determine the reflectivity of quasiparticles on different surfaces
- Observation of UV-photons from singlet and triplet excimers
- Test of prototype LAMCALs
- Efficiency of quasiparticle detection
- Test of calibration system

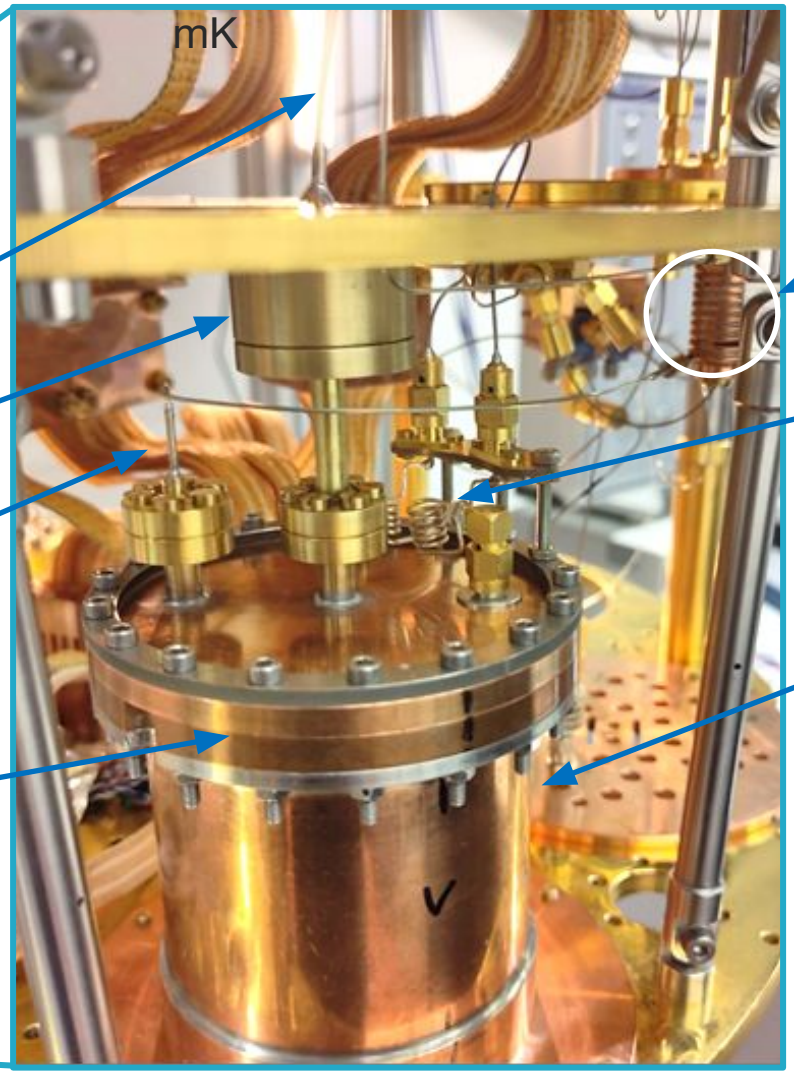


The DELight Demonstrator

^{3}He/^{4}He dilution refrigerator, T~10 mK



Filled with helium, T~15 mK



Exhaust line

Burst disc

Filling line

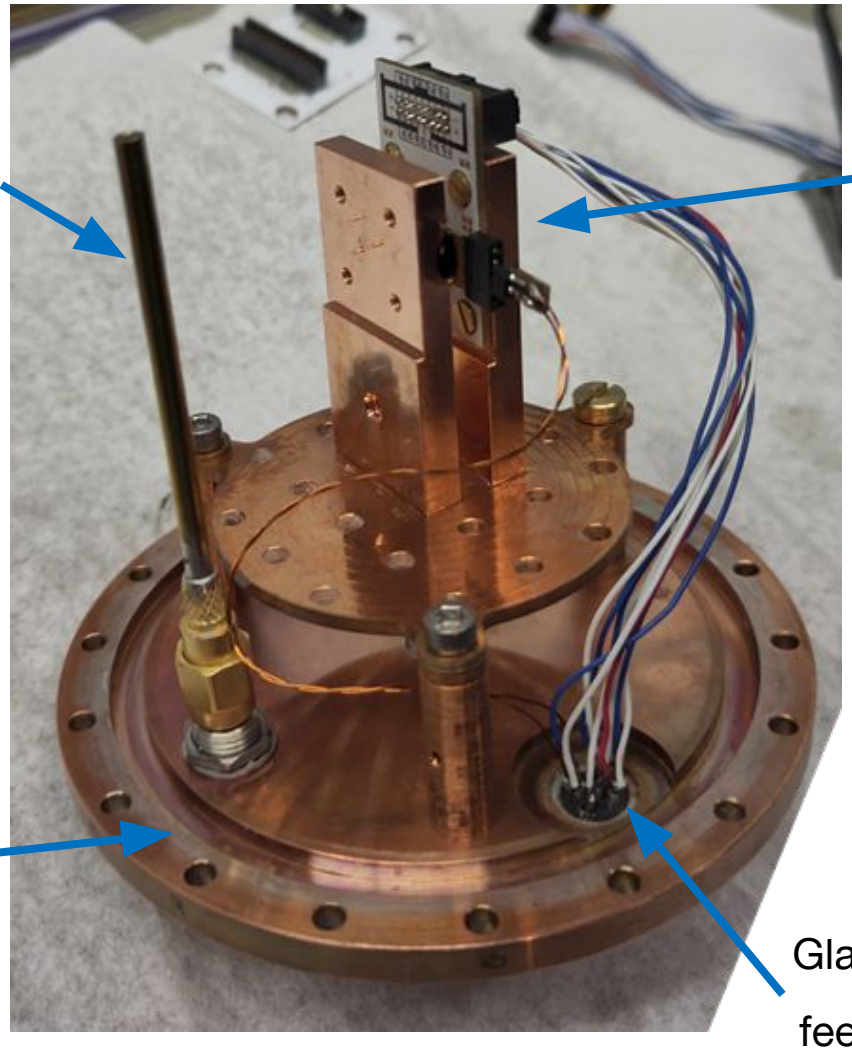
Indium sealed

Thermal coupling

Level meter coil

Copper cell, 300ml

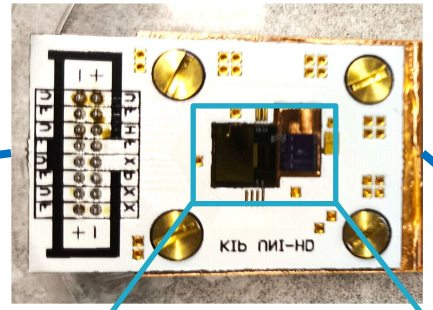
Inside the Demonstrator Cell

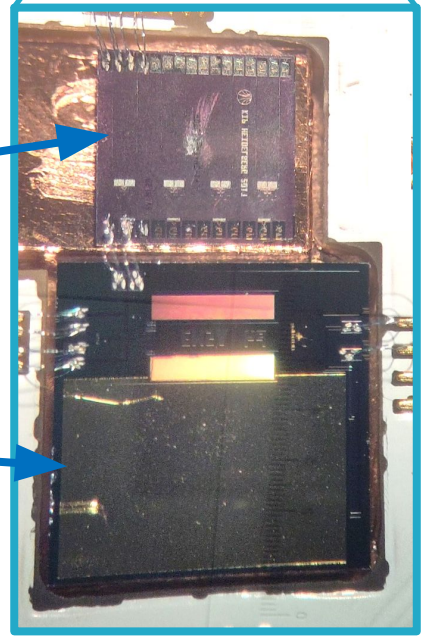


Capacitive level meter

Indium sealed lid

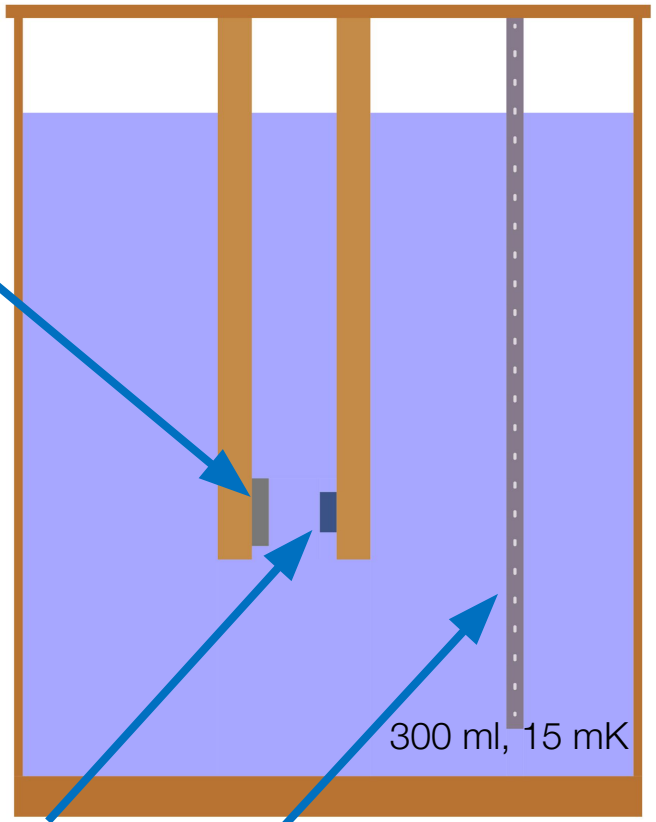
Glass sealed feedthrough





SQUID

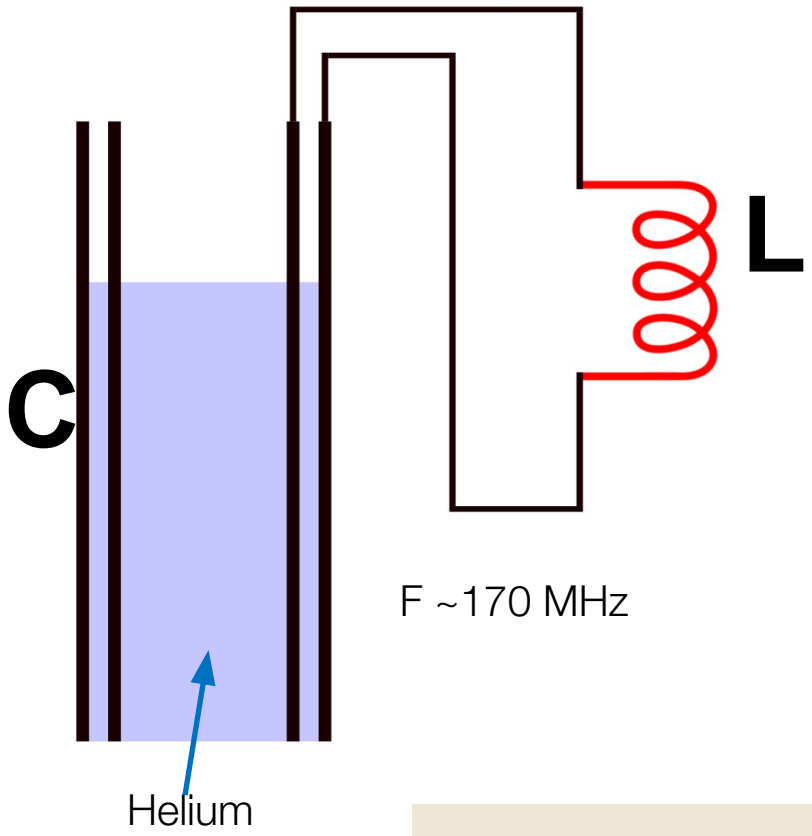
MMC

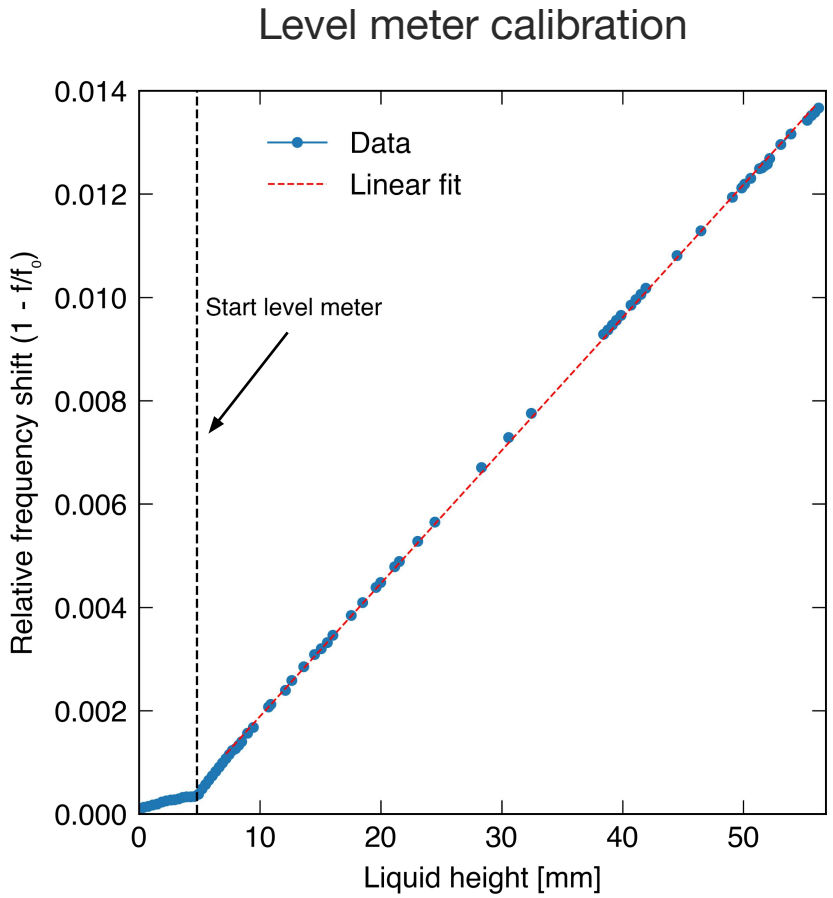


Heater (56 Ω)

Capacitive level meter

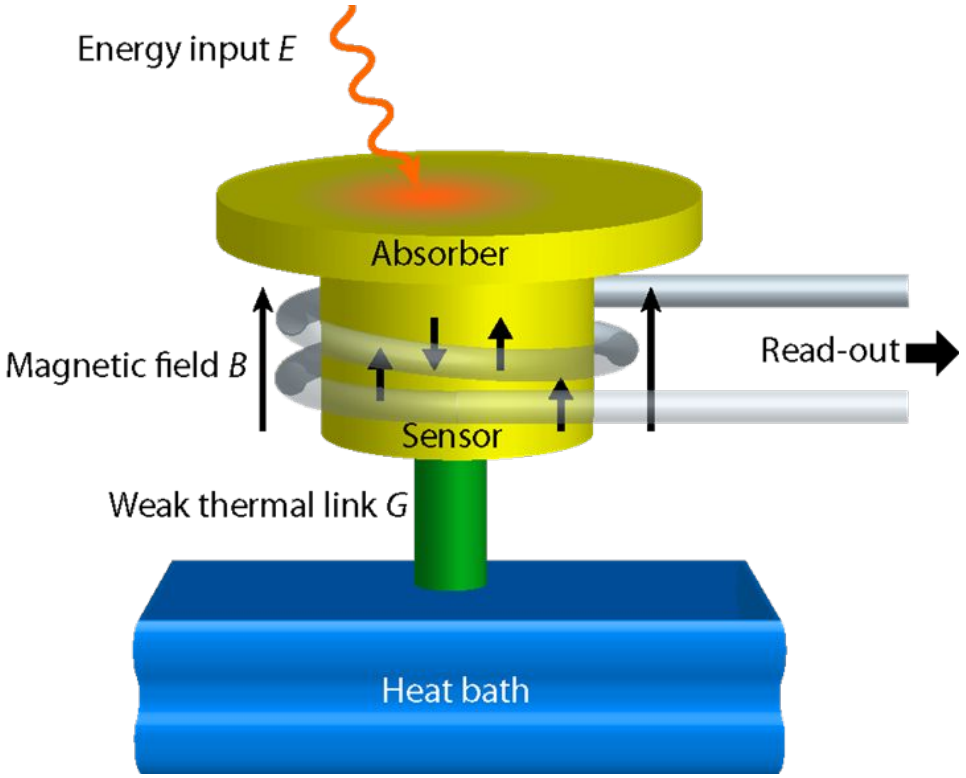
Capacitive Level Meter

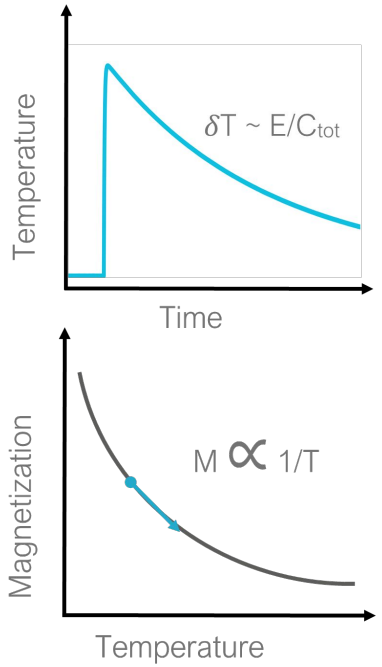


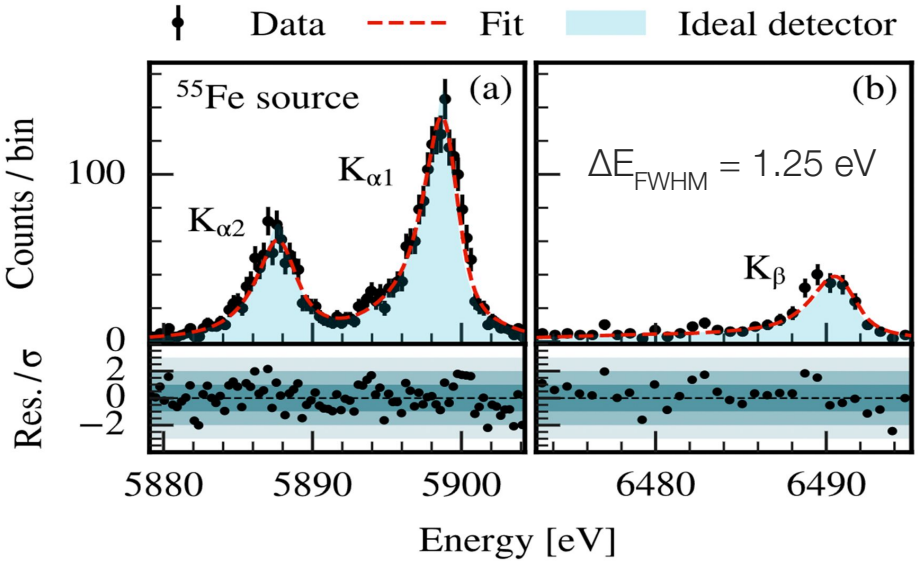


Liquid level rise ⇨ Capacitance rise ⇨ Resonance frequency decrease

Magnetic Microcalorimeters (MMC)



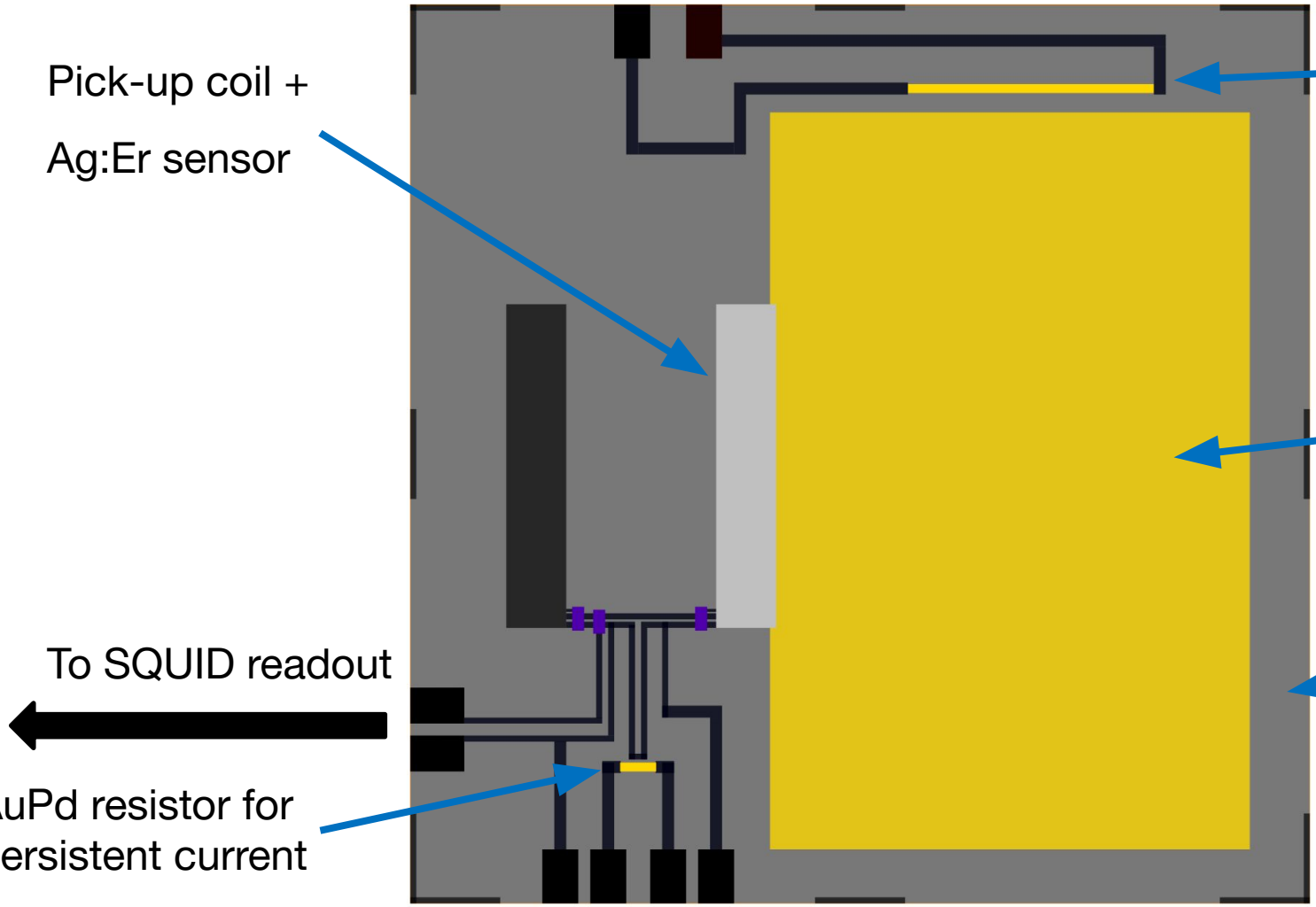




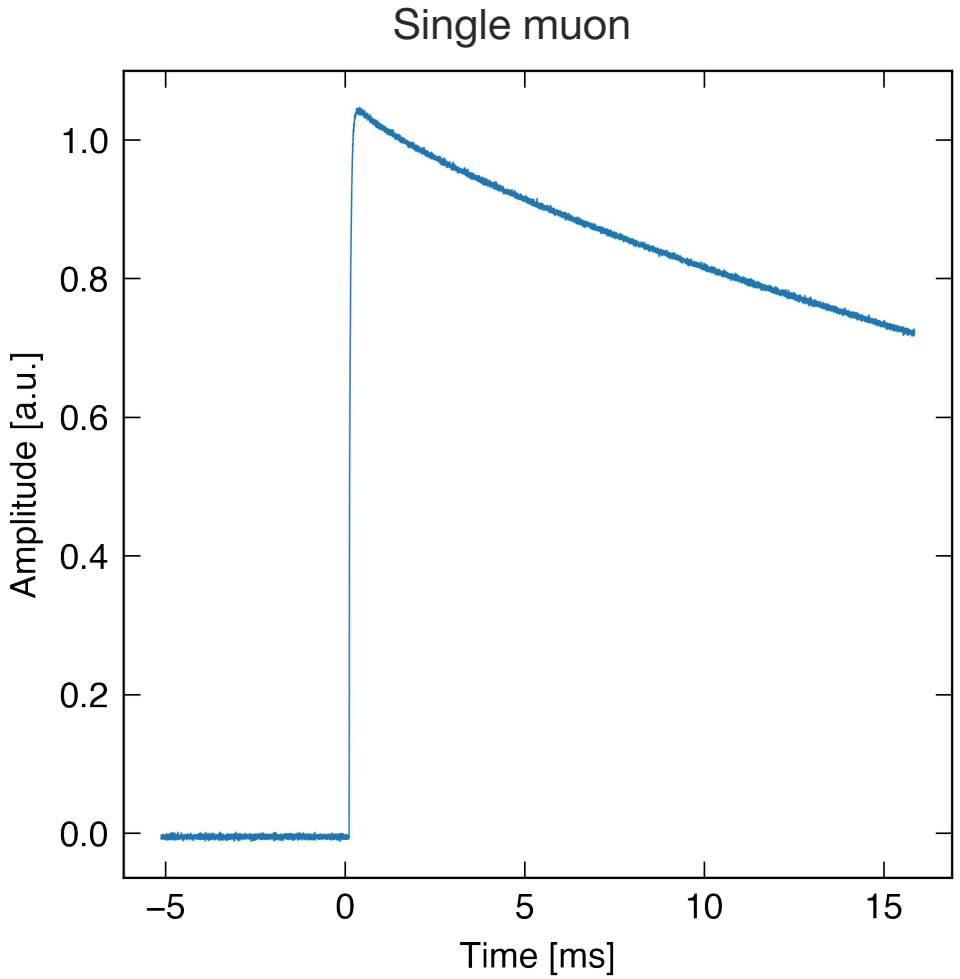
Appl. Phys. Lett. 124, 032601 (2024)

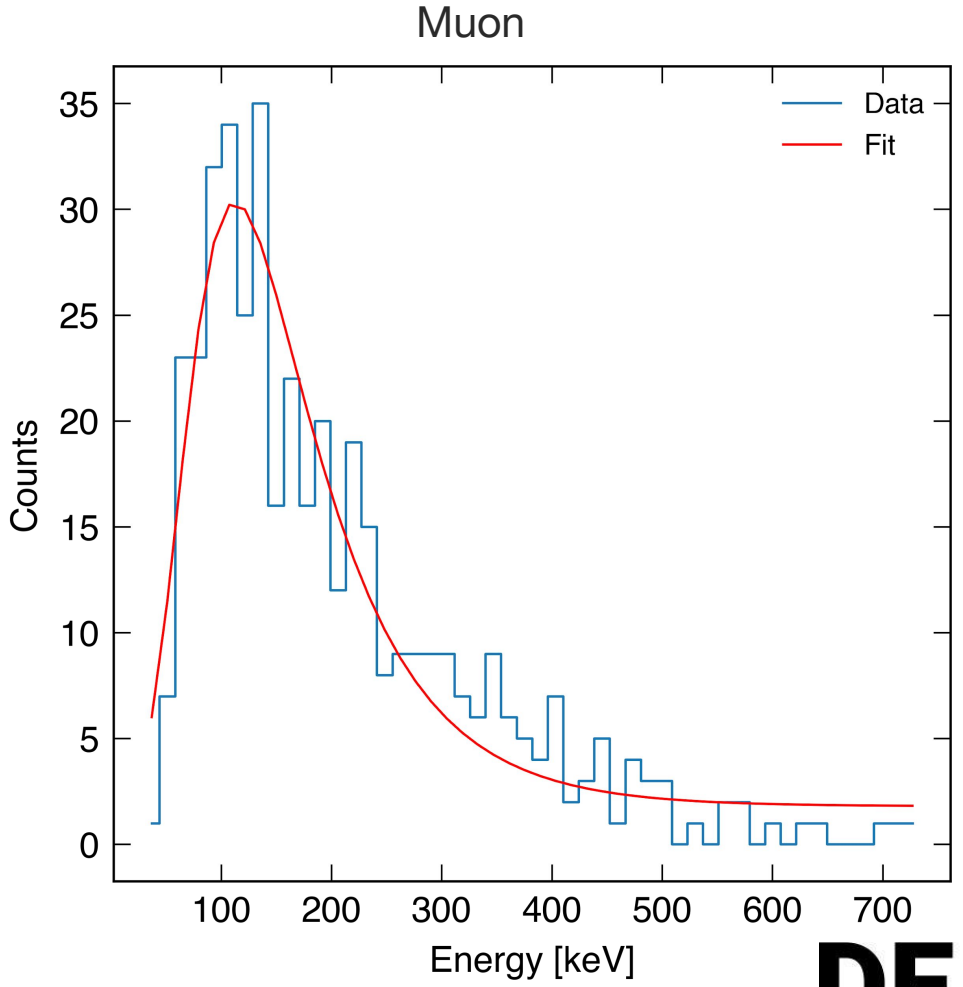
Energy input ⇨ Temperature rise ⇨ Magnetization + flux change ⇨ SQUID voltage change

Currently used MMC



First Data w/o Helium





The MMC is operational !

Magnetization

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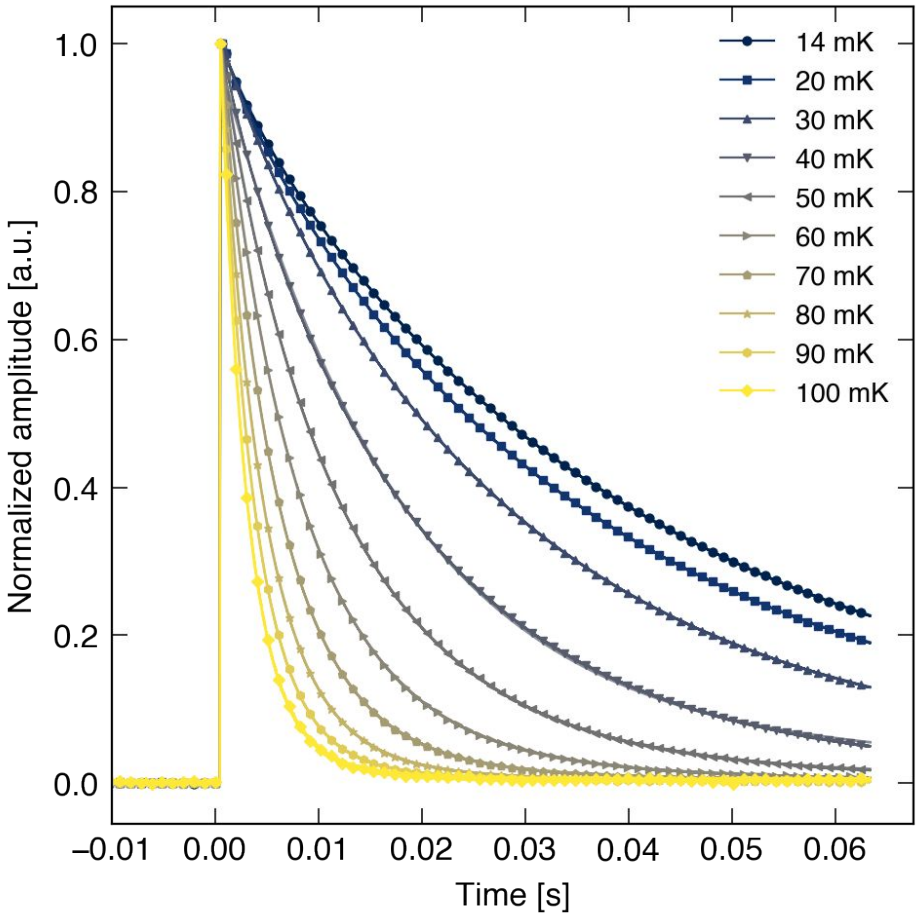
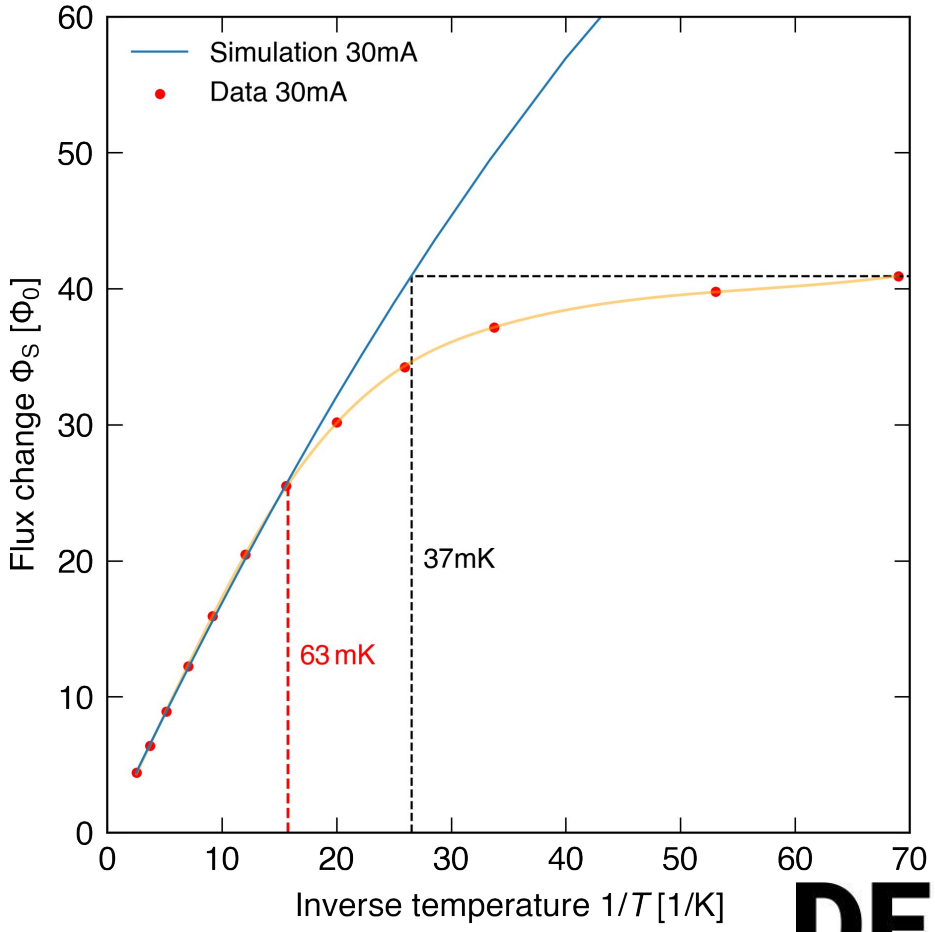
Muon pulses at different temperatures

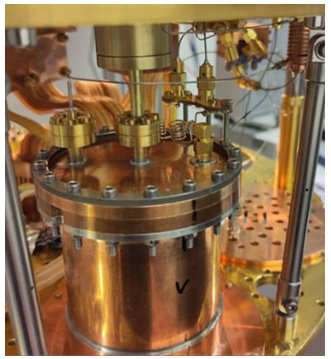


Magnetization

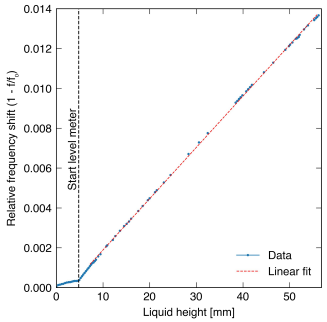


DELight

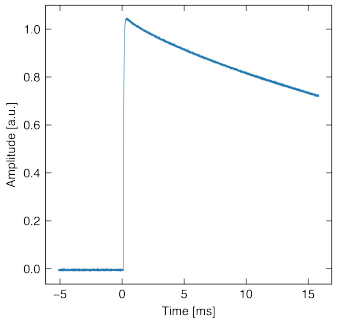
Conclusion and Outlook



- Cell was established
- Cooled down to 15mK



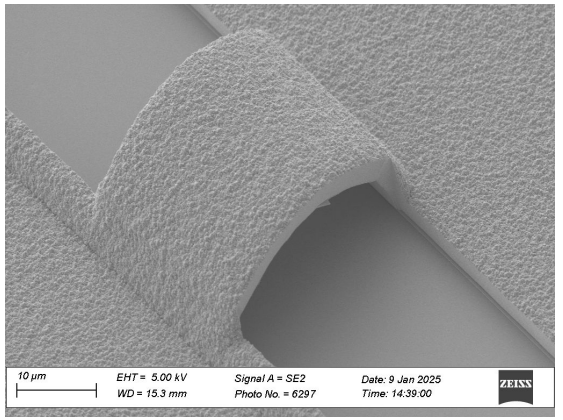
- Filling works
- Level meter calibrated



- Muons detected
- Detector characterized

Next

- Measurements in cell with helium
- New MMC and heater design



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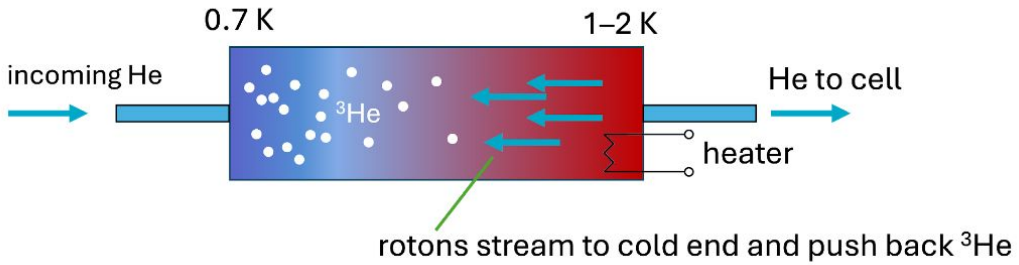
Thank You

DElight

Fill and Purifying System

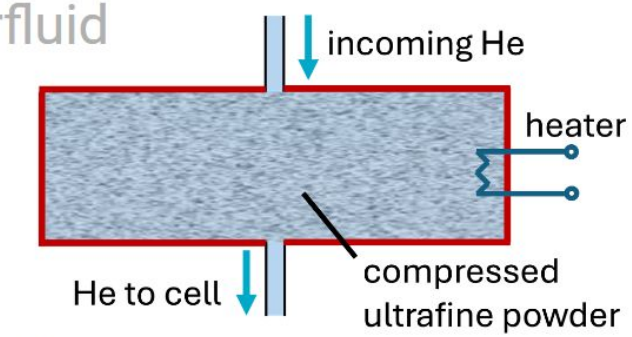
^{3}He concentration needs to be reduced from natural abundance, to enhance quasiparticle mean free pass → heat flush purifier [2]



- concentration of ^{3}He in prototype cell will be determined after purification

Superleak Valve as Fill Stop

utilizing the unique superfluid to normal transition



- precision fill stop
- switched at 2.17 K
- coupled to 200 mK stage
- In normal state (> 2.17) no helium can flow
- in superfluid (open) state ^{3}He is still blocked