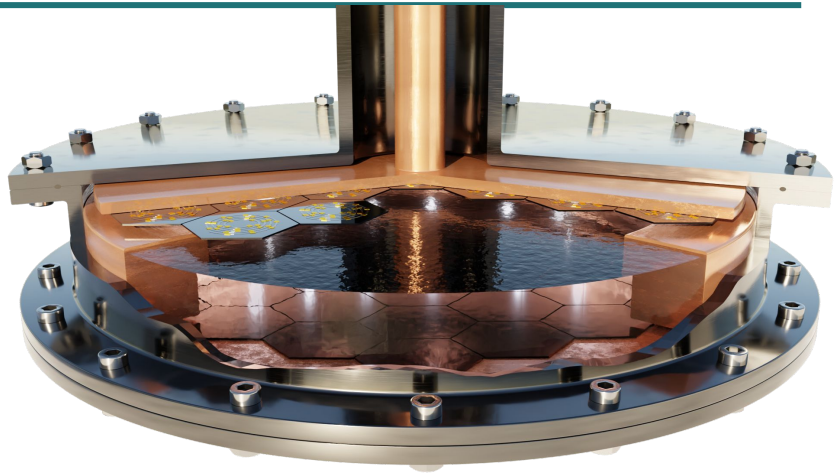
Towards DELight

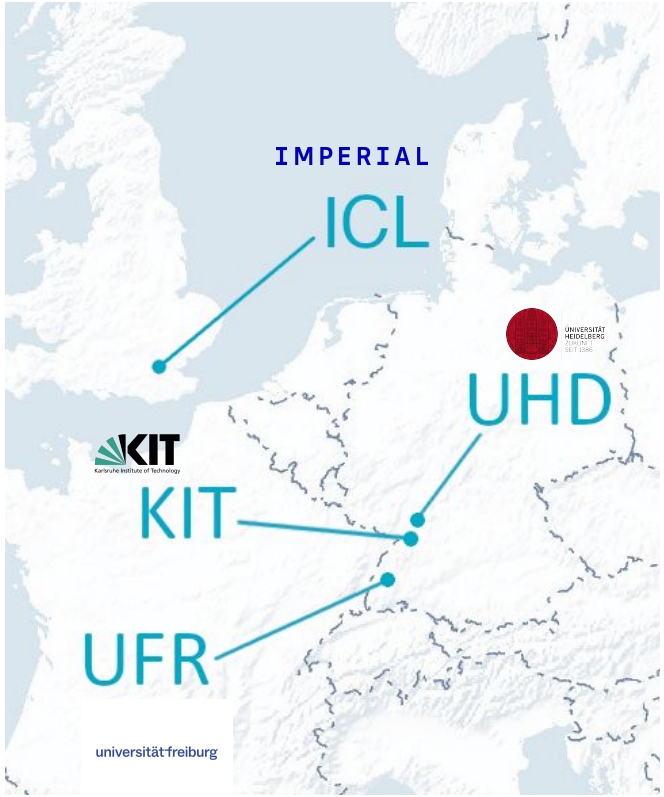
First Results from a Prototype R&D Cell



IDM Zaragoza
03.06.2026

Anna Bertolini
Heidelberg University
on behalf of the DELight Collaboration

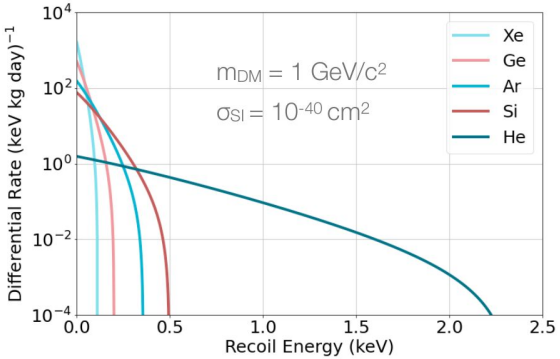
The Collaboration

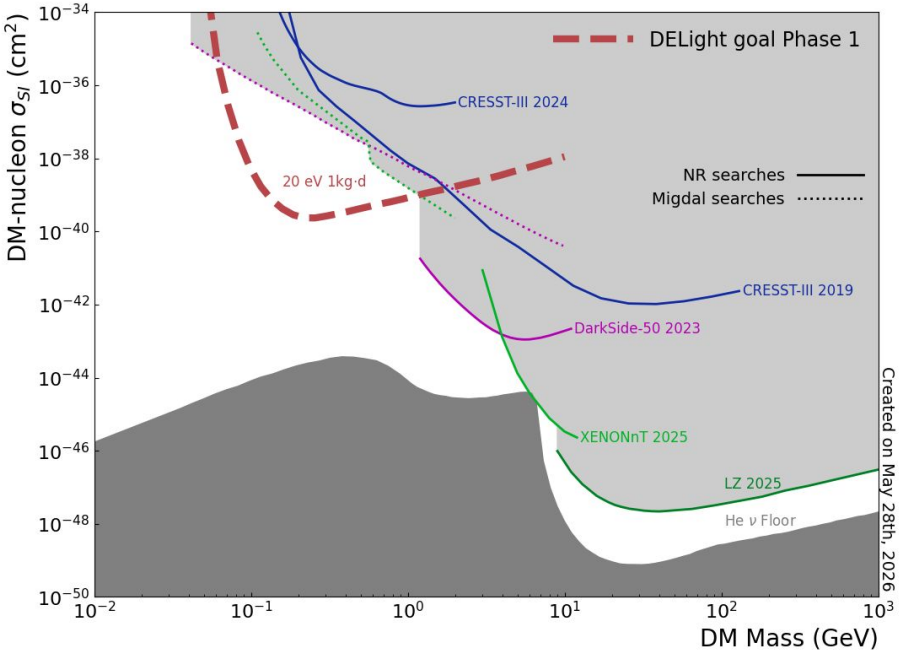


- >20 scientists
- Four institutions
- Designing future **Direct search Experiment for LIGHT dark matter**

Goal of the DELight Experiment

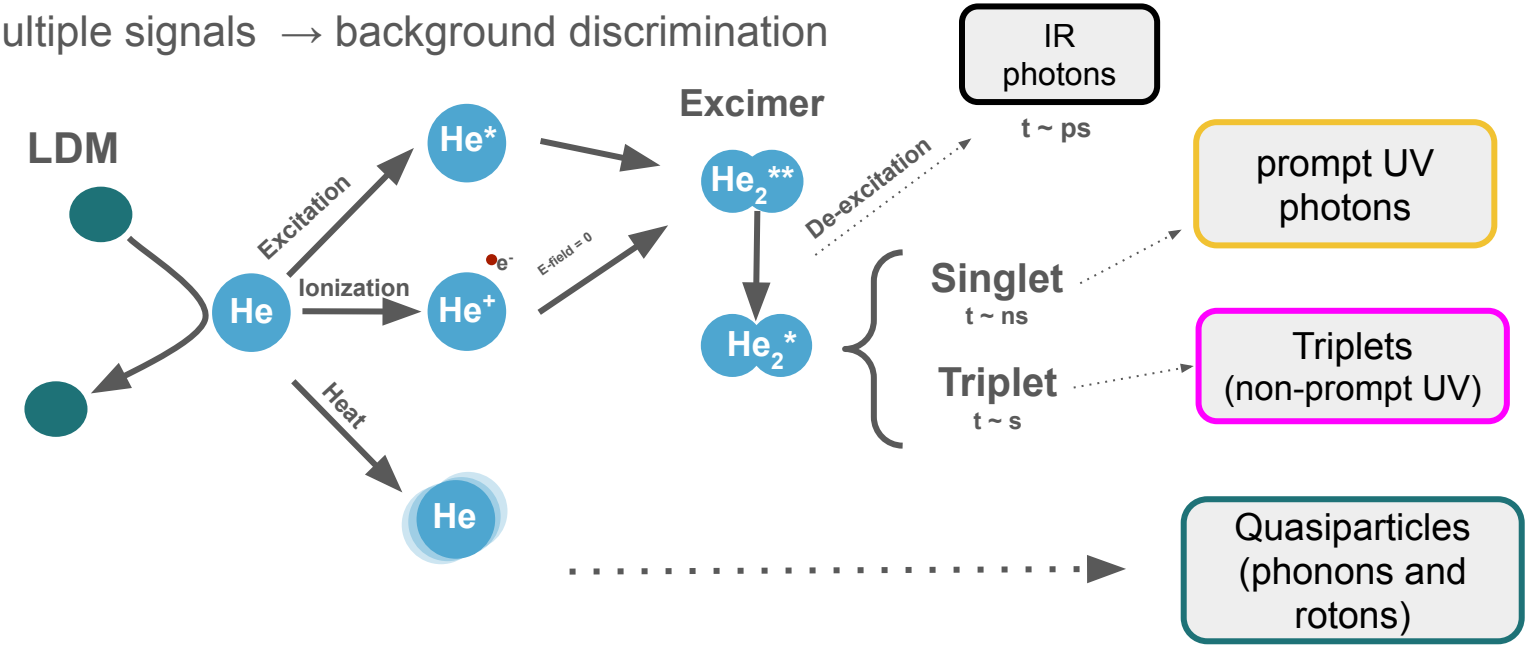
- Goal: probe **Light Dark Matter**
  → DM-nucleon interaction
- Use superfluid ^{4}He as target material
- Light nuclei → ideal for LDM search
- Measurement of phonons
- No stress-related Low-Energy-Excess in LHe



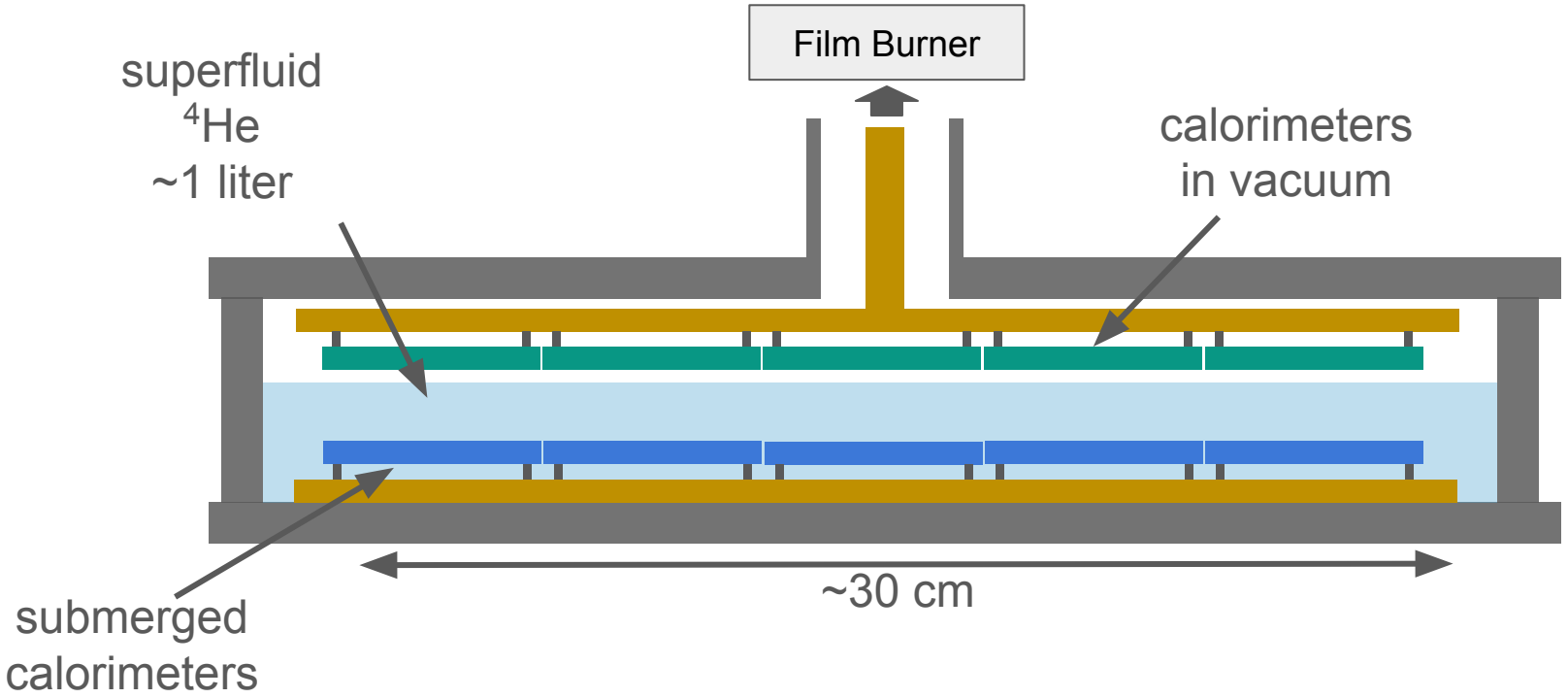


Superfluid ^{4}He as Target Material

- No intrinsic long-lived backgrounds
- Contaminants freeze-out
- Multiple signals → background discrimination



DELight Detector Design



- **In liquid** → measurement of UV
- **In vacuum** → measurement of UV + quasiparticles

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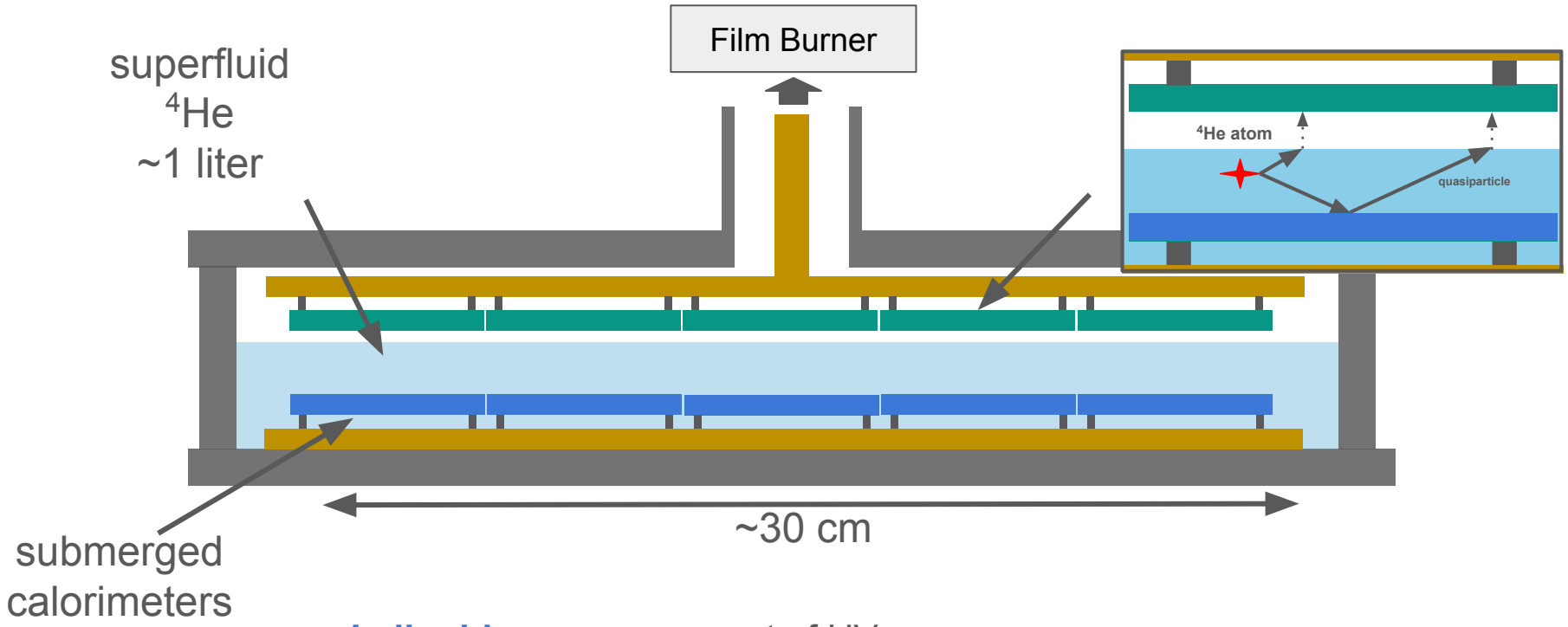

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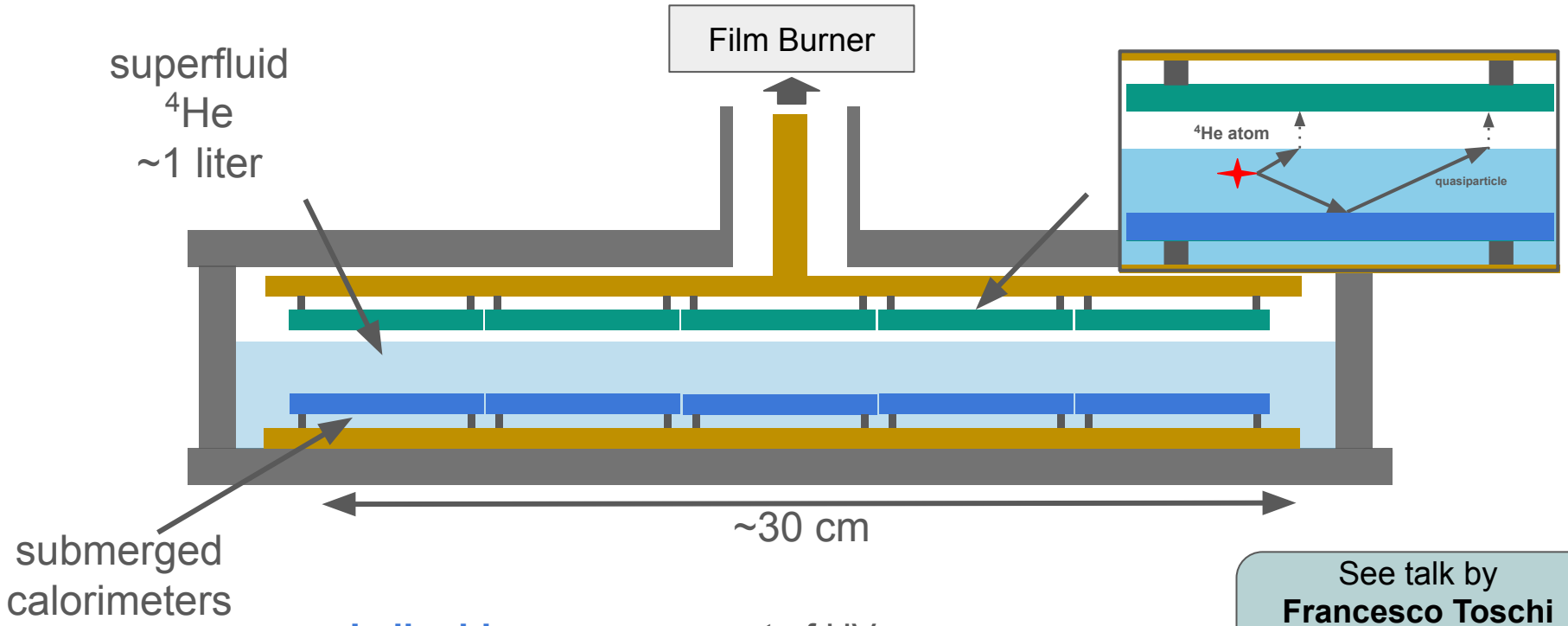
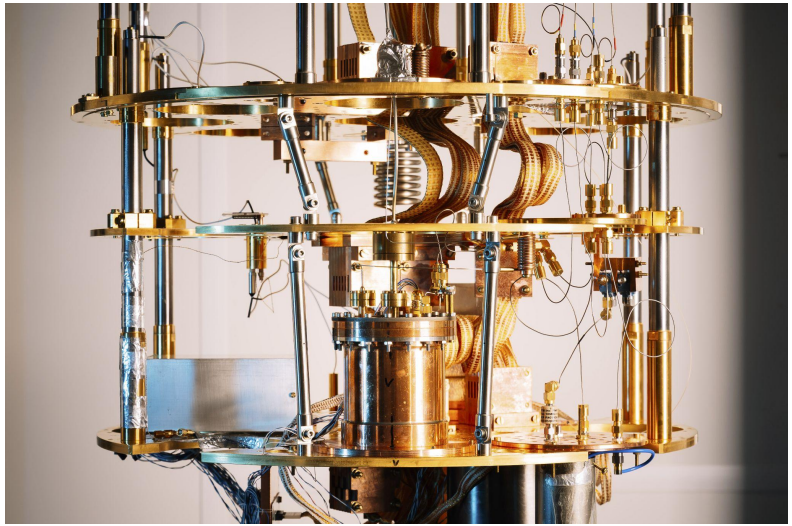


- **In liquid** → measurement of UV
- **In vacuum** → measurement of UV + quasiparticles

See talk by
Francesco Toschi
and poster by
Lena Hauswald

Towards DELight: the R&D Cell

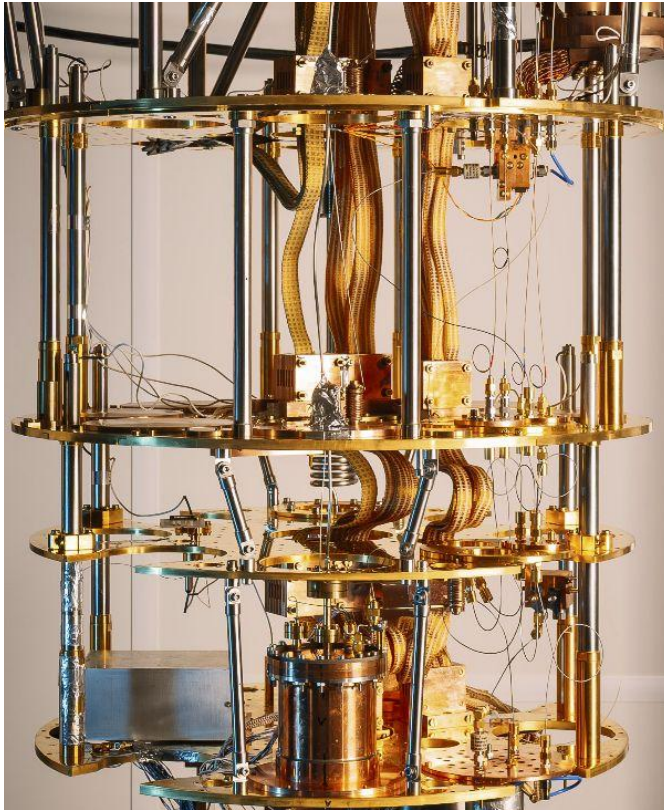
- R&D Cell at Heidelberg University
- Goals for this project
  - Superfluid leak tight cell
  - Filling system for the cell
  - Measurement of particle interactions in superfluid helium
  - …



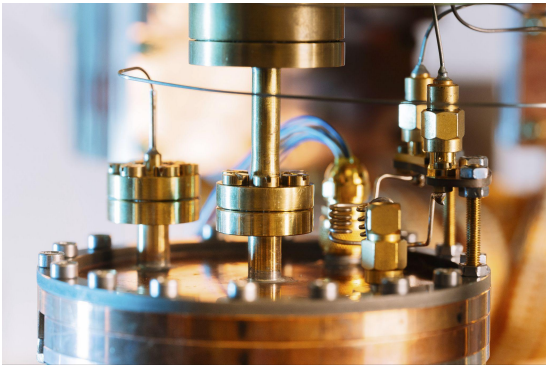
Signal expectation

- measurement of UV photons generated by muon interactions in helium
- possible measurement of quasiparticles in high energy events

Filling System



- $^{3}He/^{4}He$ dry dilution refrigerator
- Small capillary line for ^{4}He filling
  → thermally coupled at every stage
- Indium sealings
- Burst disk and an exhaust line
  → for the case of overpressure



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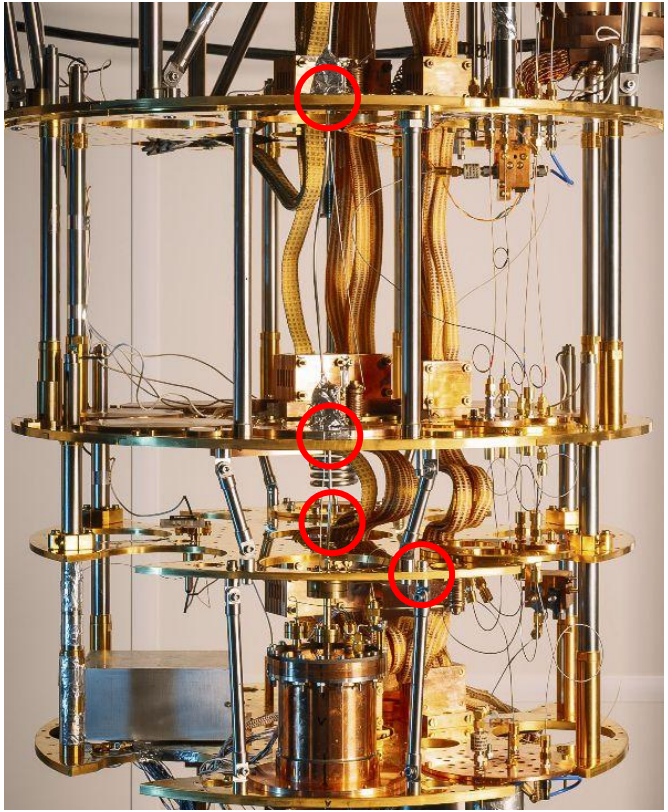

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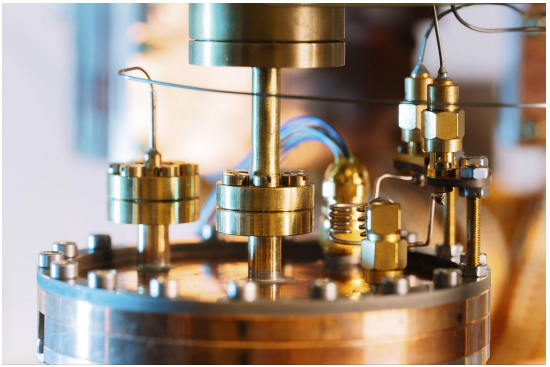
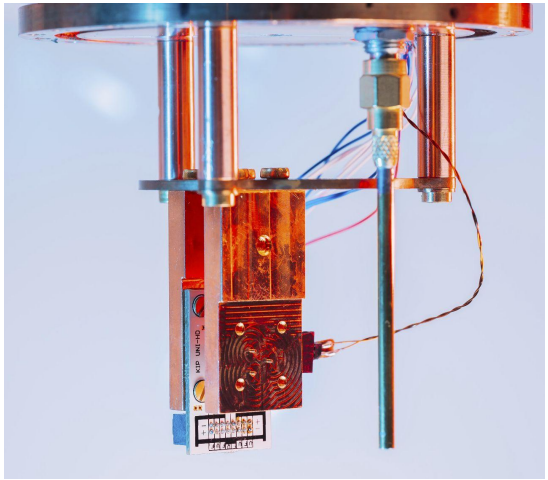
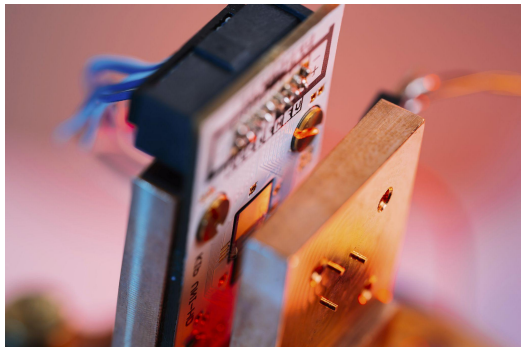
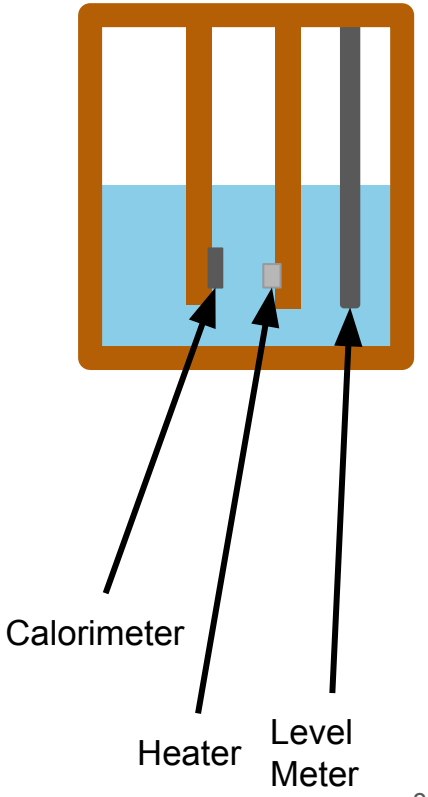


Inside the R&D Cell

- Calorimeter submerged in liquid helium
- Helium level measured via a capacitive level meter
- A resistive heater faces the sensor
  → generates quasiparticles in helium

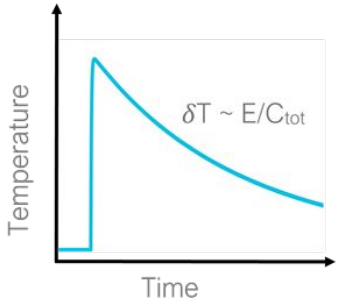


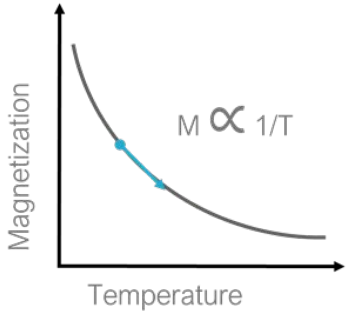


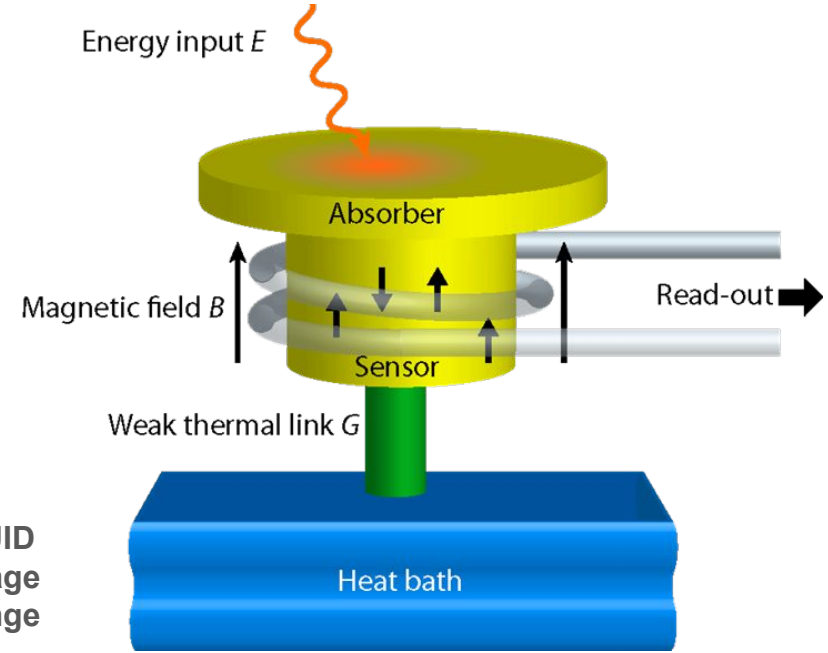


MMC-Based Calorimeter

Silicon absorber + MMC





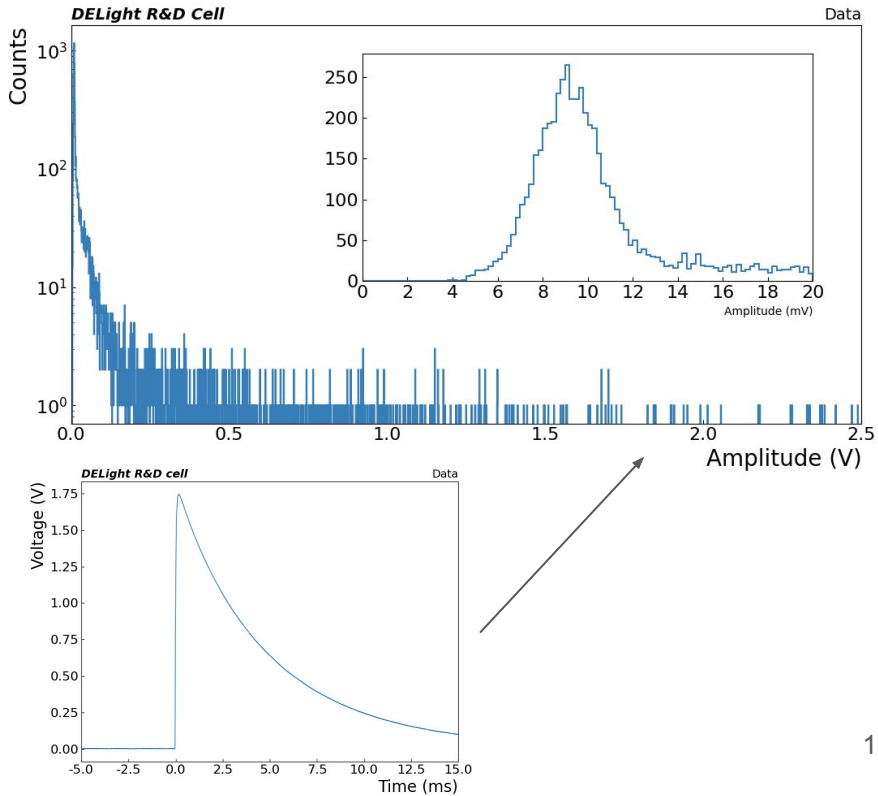


Energy deposition ➡ **Temperature Variation** ➡ **Magnetization Variation** ➡ **SQUID voltage change**

First Measurement

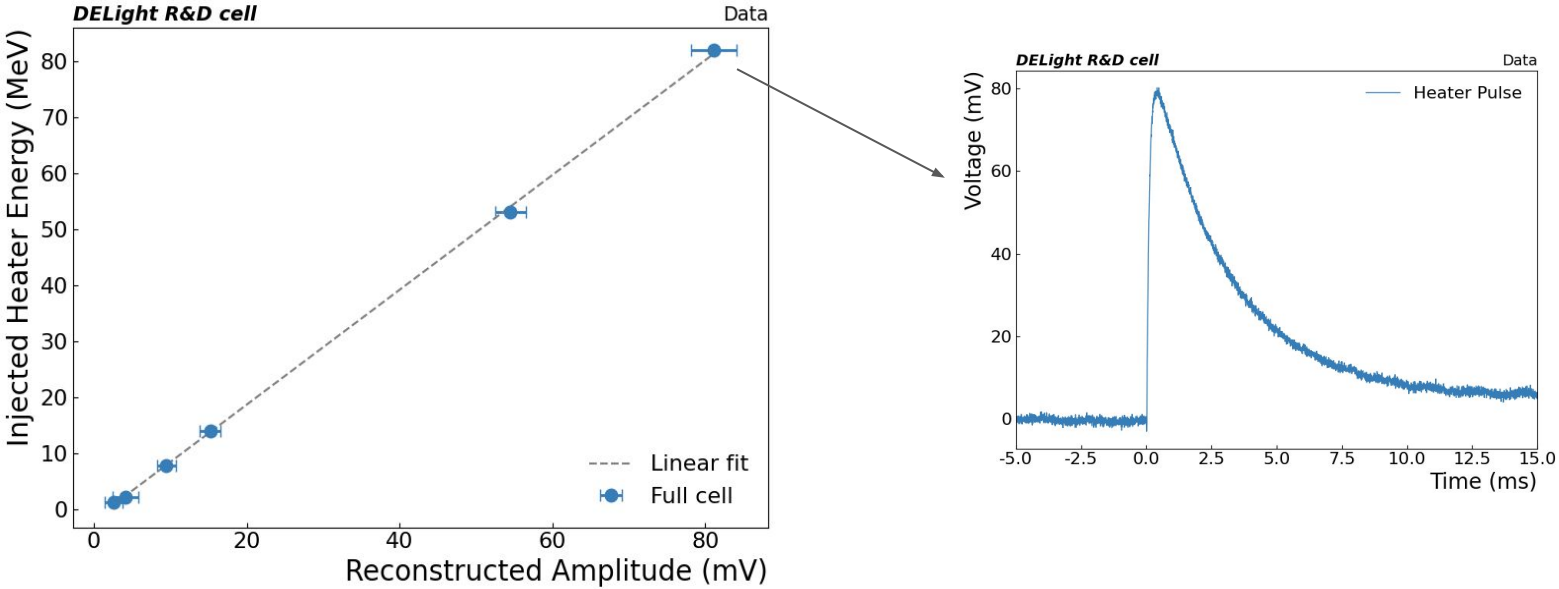
- Measurement **@15 mK** for ~40 hours
- No calibration source present
- **Muons** energy deposit $\mathcal{O}$(100keV)
- Detection of energy fraction deposited as **UV photons**
  → Collection efficiency reduced by copper boards

Reconstruction of background particle spectrum



High Energy Quasiparticles Signal

- Inject artificial pulses → monitor coincident response
- Observed a signal → response linear to injected energy
- Indication of high energy quasiparticles detection



Next Steps

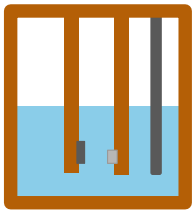
- Perform simulations for particle spectrum comparison
- Go towards DELight by testing other components e.g.
  - new calorimeters
  - film burner
- Develop a DAQ
- …

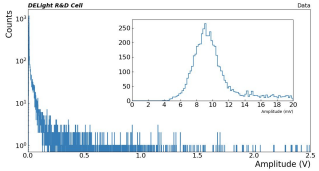
Components of film burner

Summary

Leak tight cell filled with helium @15mK

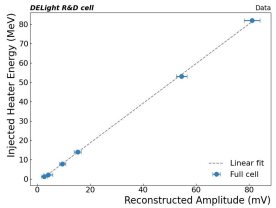
Operated submerged MMC-based calorimeter

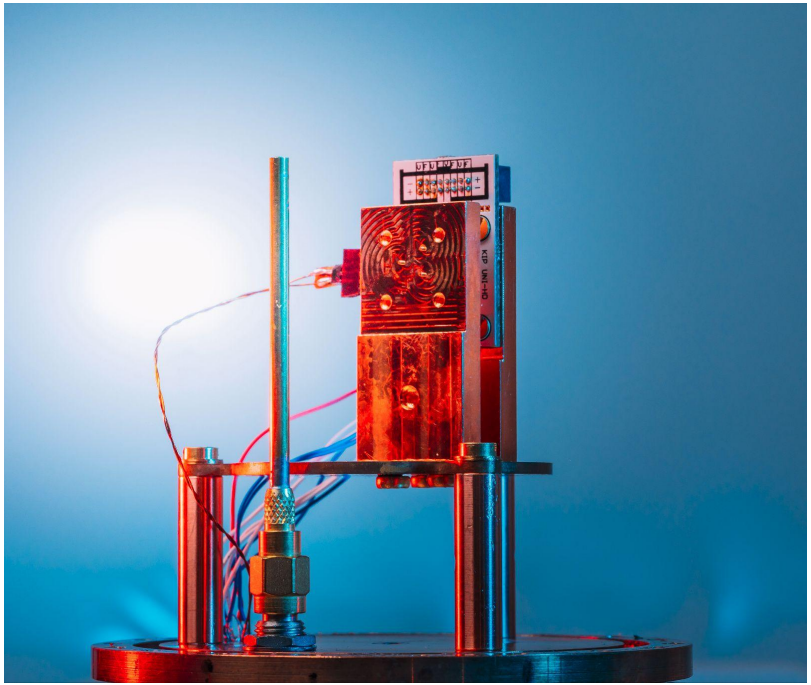




Measured UV signal generated in helium

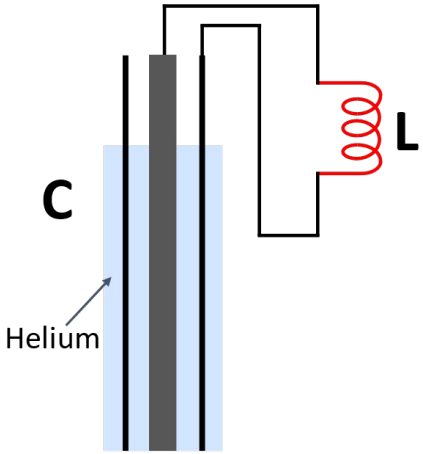
Indication of high-energy quasiparticle signals

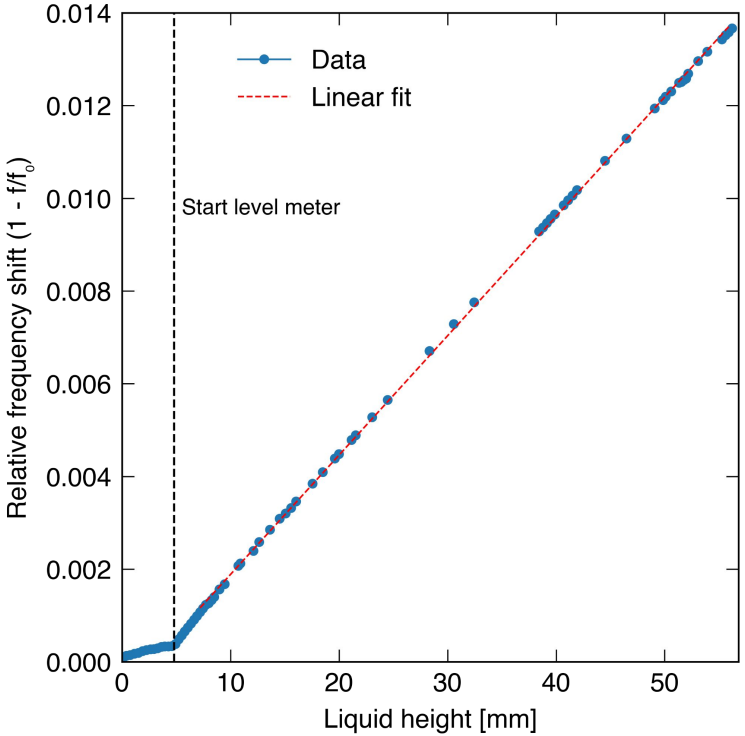




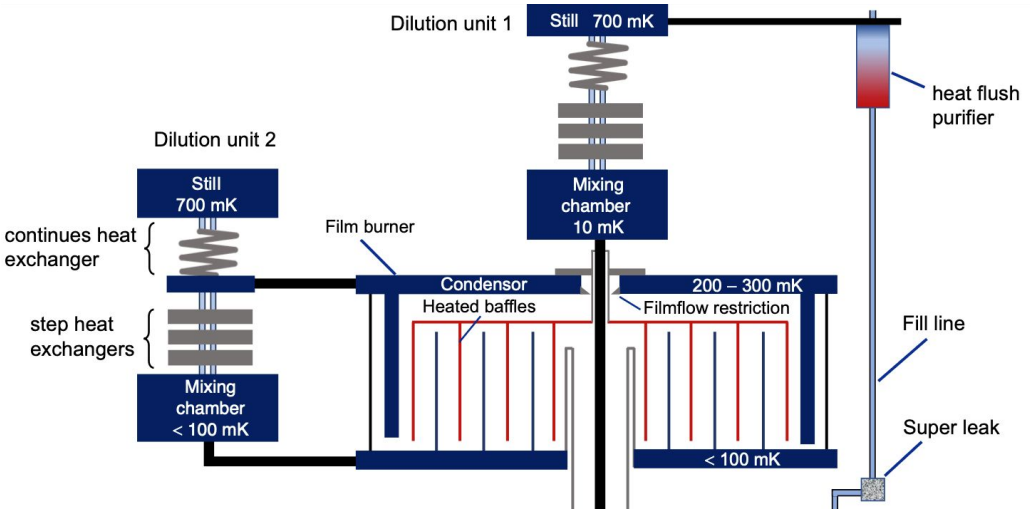
Backup

The Level Meter





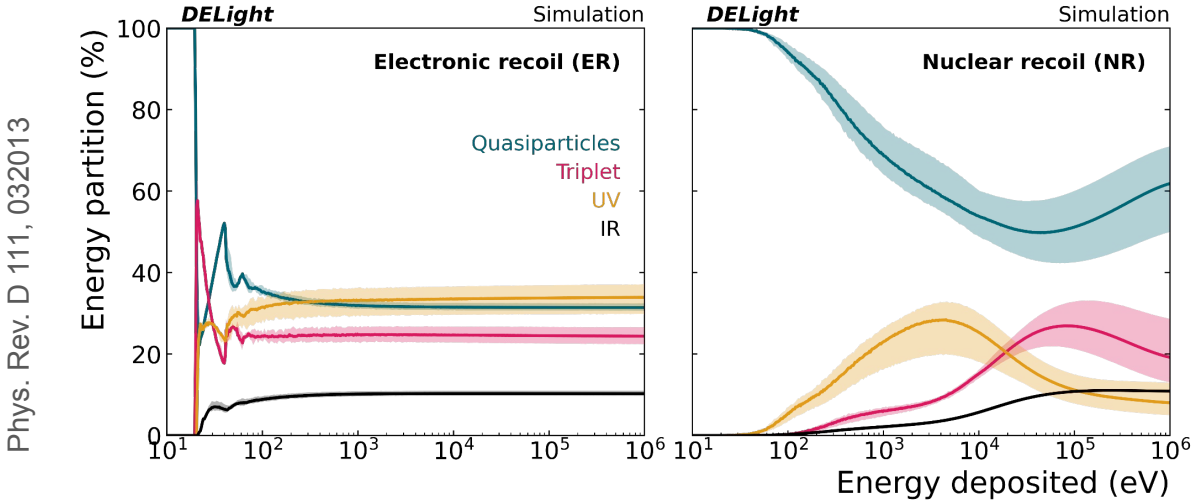
Film Burner



- Additional structure close to the helium cell
- Needed against superfluid helium moving up to upper calorimeters
- Already tested by HERON collaboration

Signal Partitioning in Superfluid ^{4}He

- Different Signal partition for electron and nuclear recoils
  → **potential ER/NR discrimination**



Phys. Rev. D 111, 032013

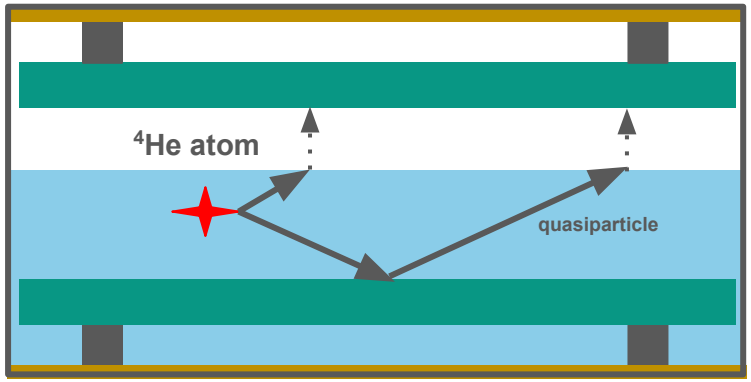
IR photons

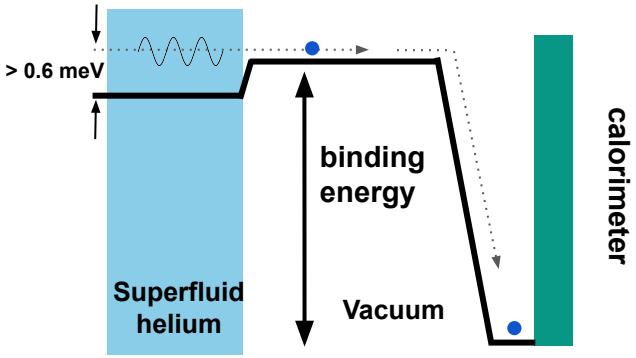
prompt UV photons

Triplets (non-prompt UV)

Quasiparticles (phonons and rotons)

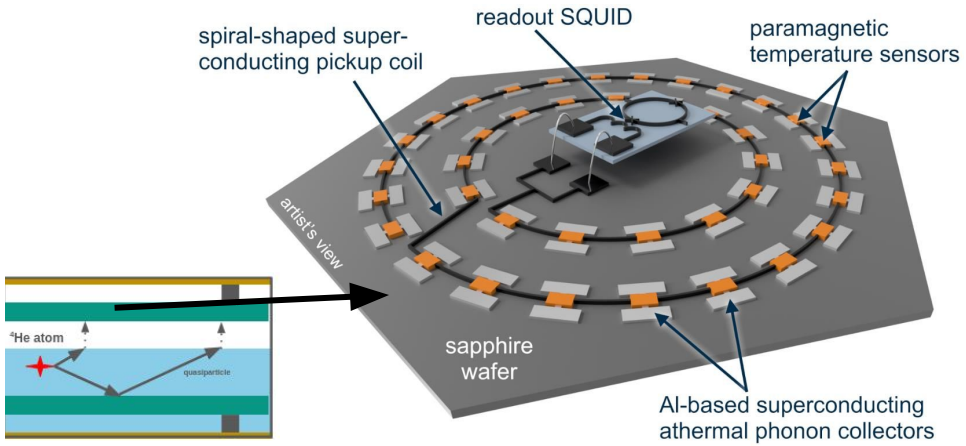
Quantum Evaporation





- Released He atoms condense on the sensor in vacuum
- Adsorption energy onto sapphire wafer ~20x binding energy → effective **signal amplification**
- Sensor in vacuum must be free from He film → Film burner

Calorimeters: LAMCALs



- Large Area cryogenic Micro-CALorimeter
- Sapphire-wafer as absorber
- Expected baseline resolution ~1eV

MMC

Temperature variation measured as a change in magnetization