

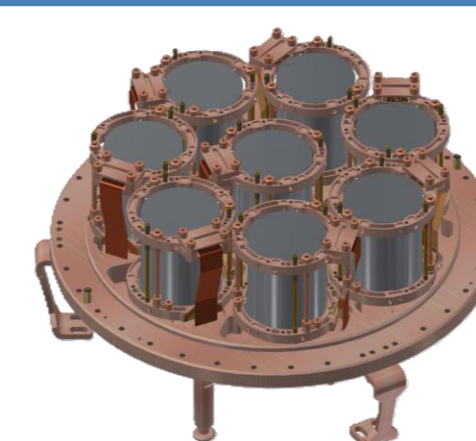
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on behalf of the
COSINUS collaboration
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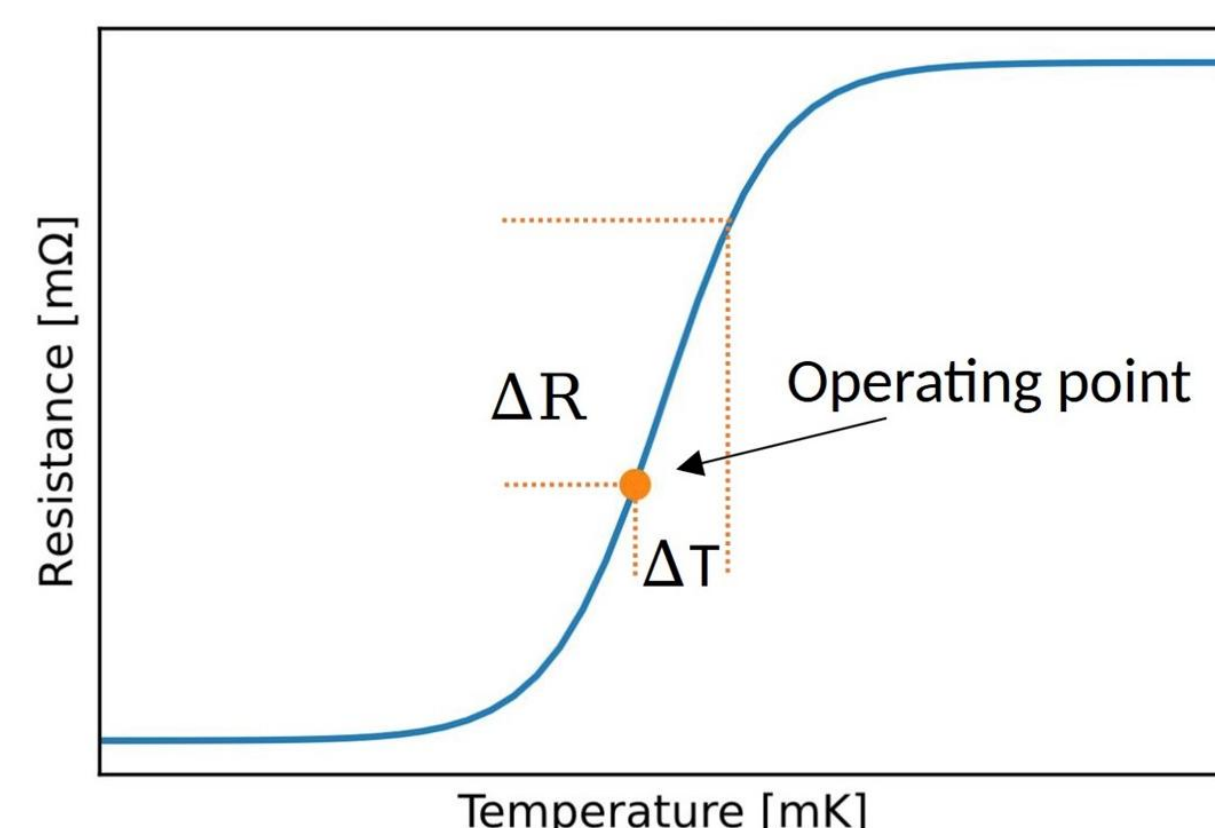
Run 1 Overview

- Anticipated start date: within 2026
- Location: Laboratori Nazionali del Gran Sasso (LNGS)
- Projected detector resolution ≤ 1 keV
- 8 sodium iodide (NaI) modules $\rightarrow$ 100 kg d exposure after one year

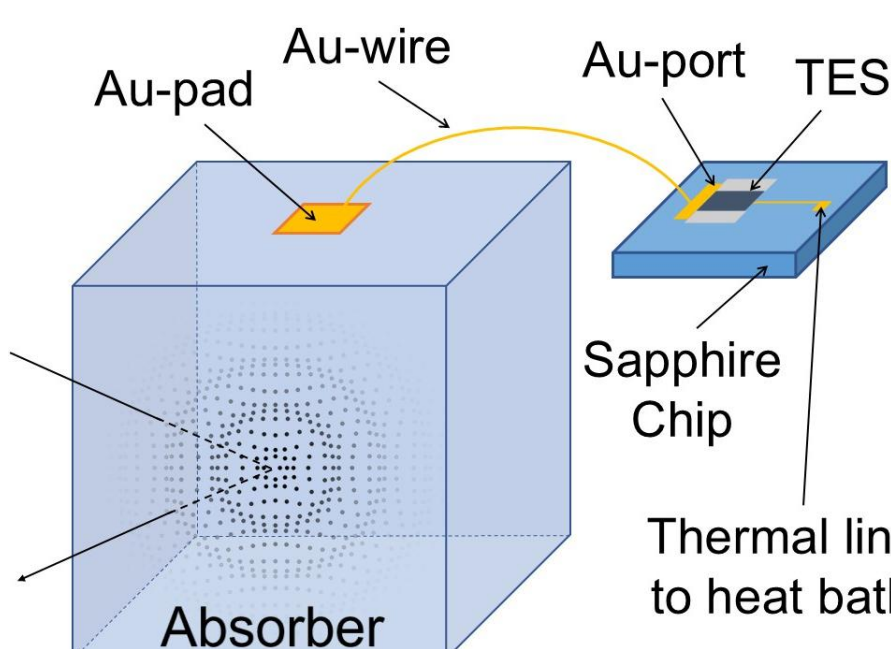


Transition Edge Sensor (TES)

- Tungsten (W) film in transition between normal and superconducting state
- Small increase in temperature (μ K) $\rightarrow$ measurable change in resistance ($\leq$ m Ω)
- Temperature increase after energy deposition (ΔE): $\Delta T \approx \Delta E/C$

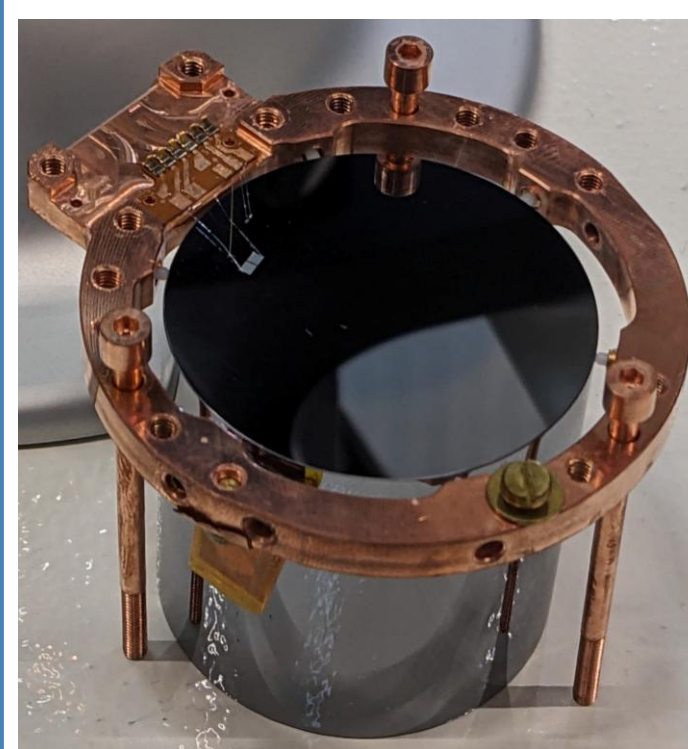
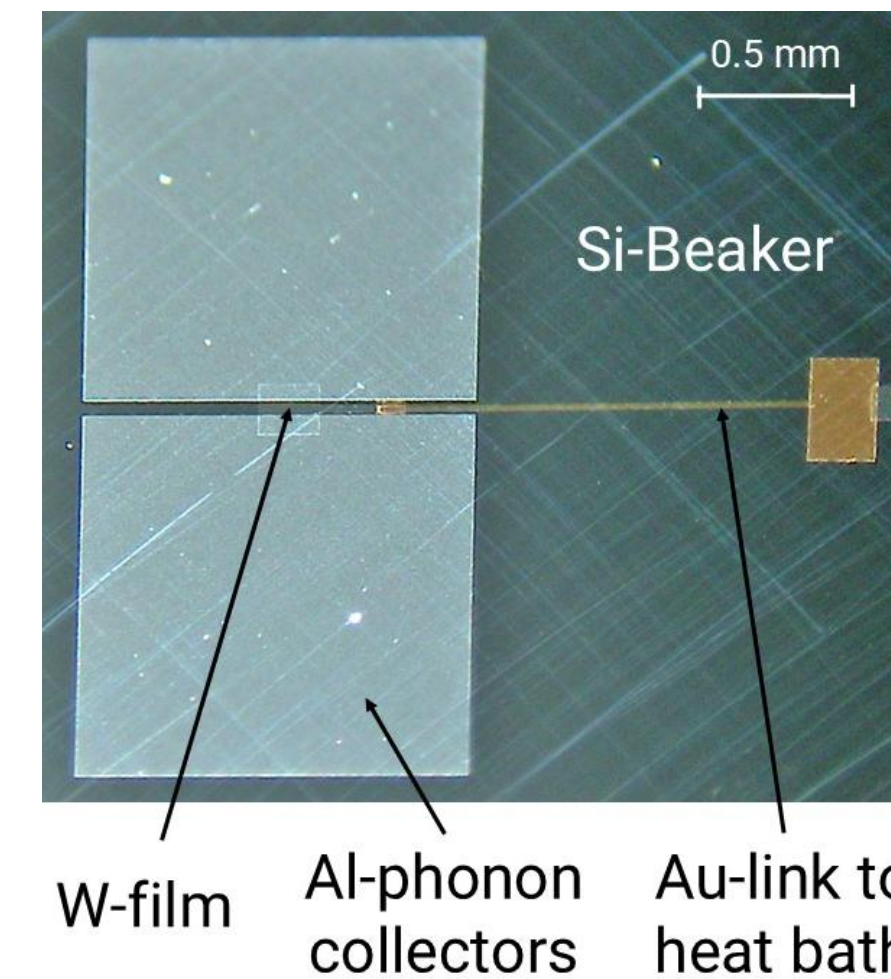


- Fabrication not possible on NaI $\rightarrow$ remoTES design [1]
- Separation of TES and absorber: event in NaI $\rightarrow$ phonon interaction with free electrons in gold (Au) pad $\rightarrow$ electronic signal transmission to TES on chip
- Run 1 TESs fabricated in collaboration with CRESST MPP group [2]



Scintillation Light Detector

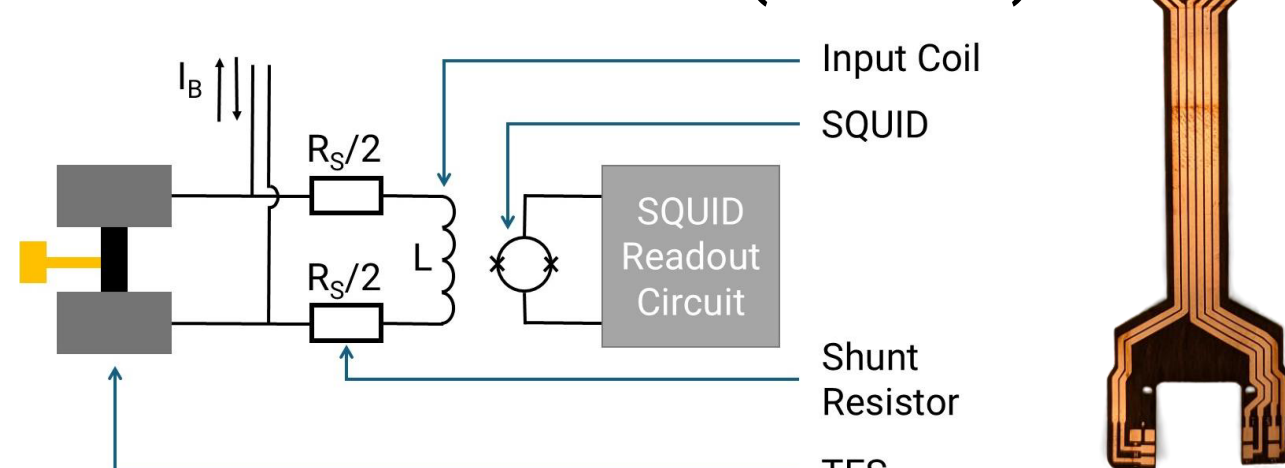
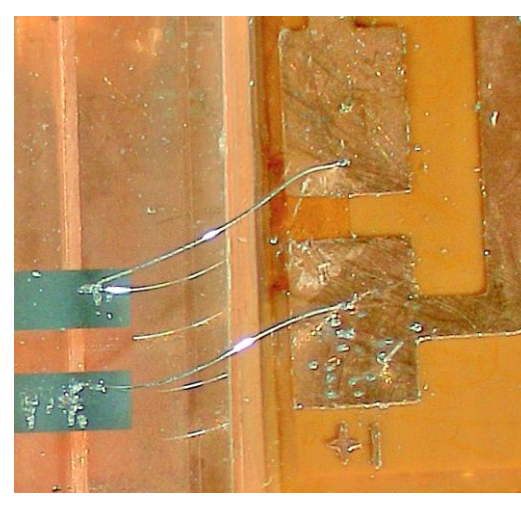
- Particle interaction in NaI $\rightarrow$ scintillation light
- Light absorbed with beaker (and additional lid) both made of optically polished silicon
- Signal detection with TES
- Latest underground test: baseline resolution of ~ 4 eV
- Additional function: rejection of α -particles



- Dimensions:
 - Diameter: 40 mm
 - Height: 40 mm
 - Wall thickness: 1 mm
- Weight: ~ 15 g
- Held in copper structure with six POM tips

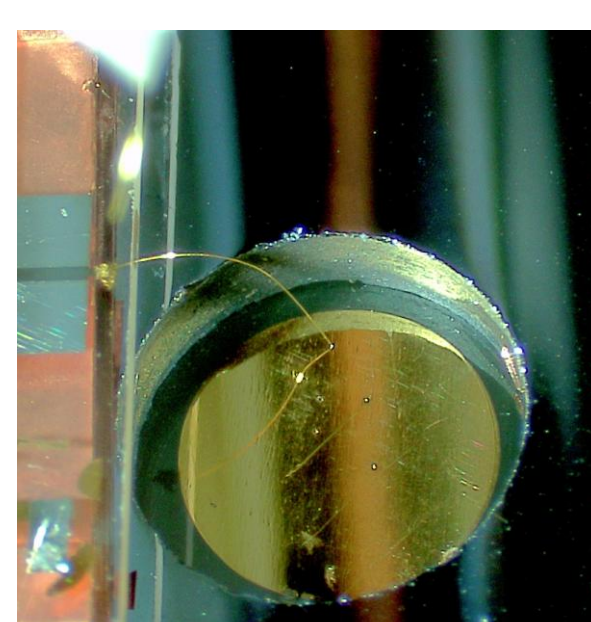
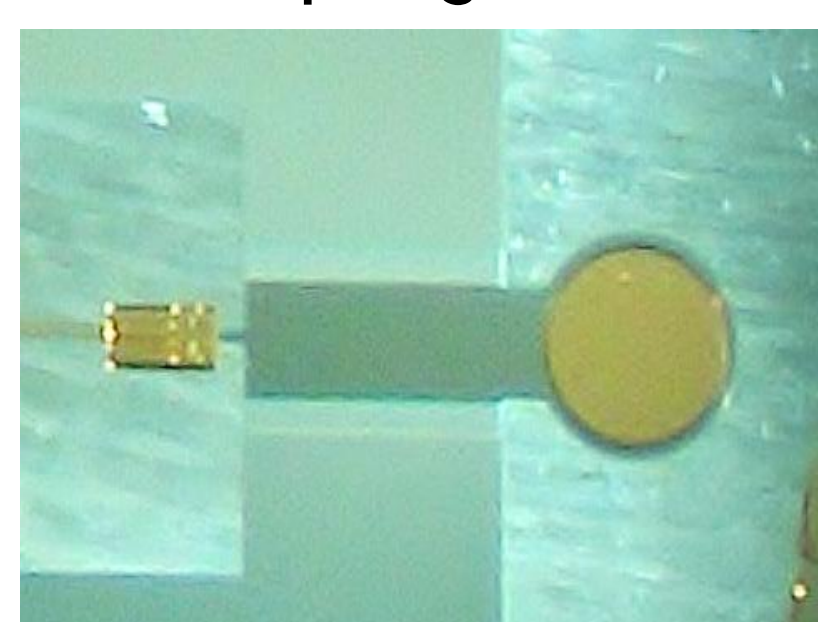
Cabling and Readout

- TES is connected via aluminum bond wires (33 μ m) to copper-Kapton-copper printed circuit board
- Read-out via superconducting interference device (SQUID)

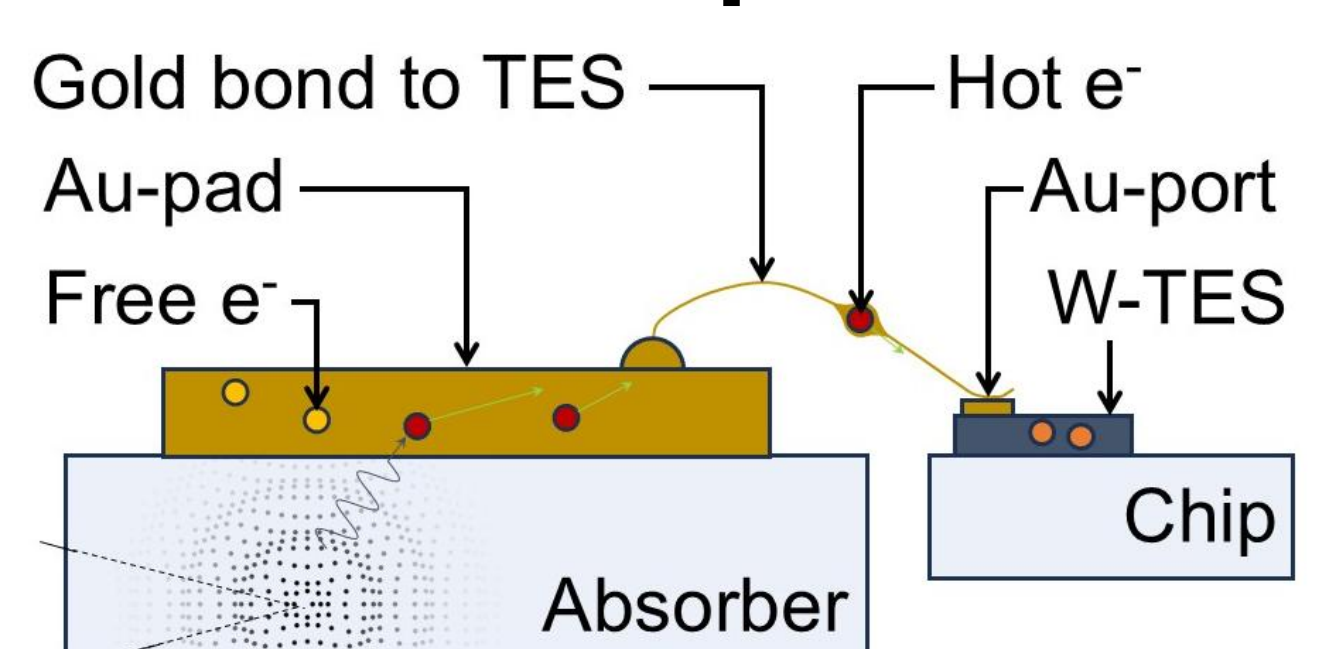


Gold Link

- Connection of NaI with TES via Au-pad on NaI, Au-wire bond (25 μ m) and Au-port on TES
- Weak coupling to heat bath for TES relaxation



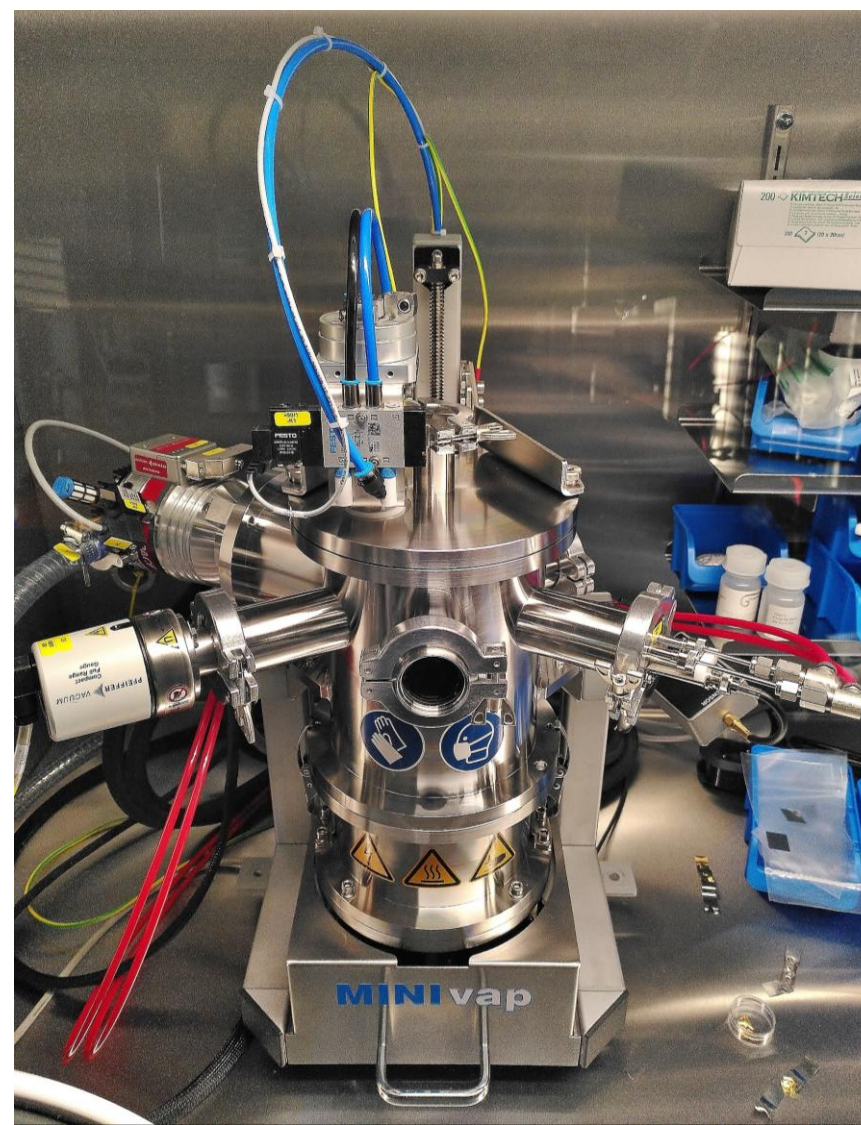
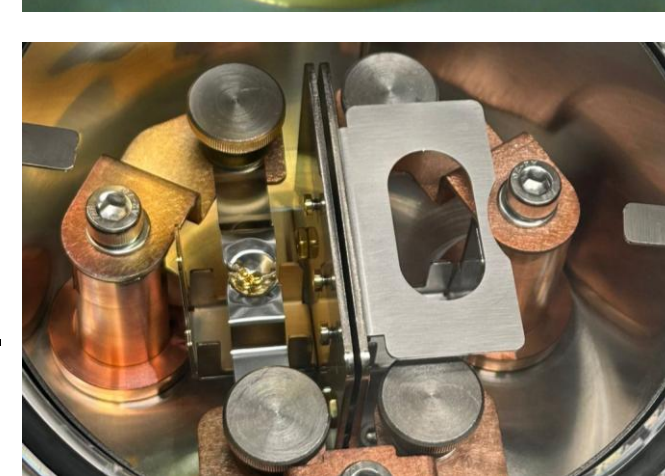
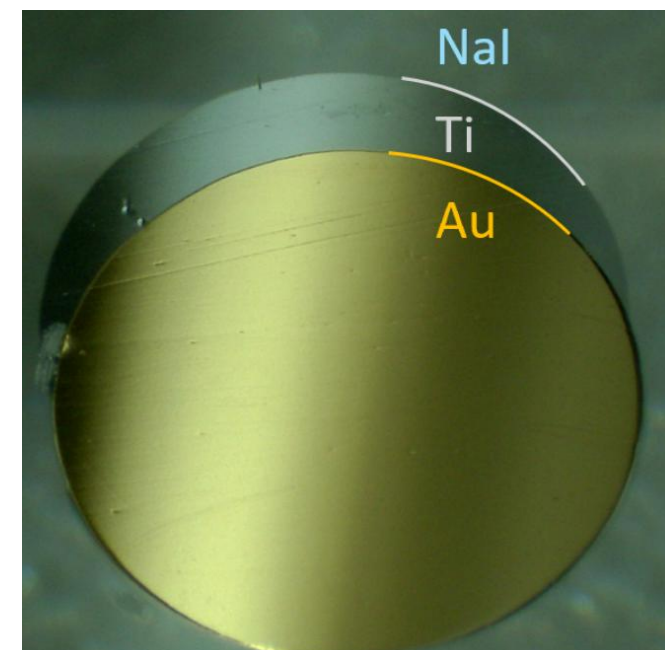
Phonon Absorption Pad on NaI



- remoTES: for signal transmission metallic film on absorber required
- Classic design: Au-pad cut out of thin Au foil with biopsy punch and glued to crystal
- New approach: Evaporation of Au-pad

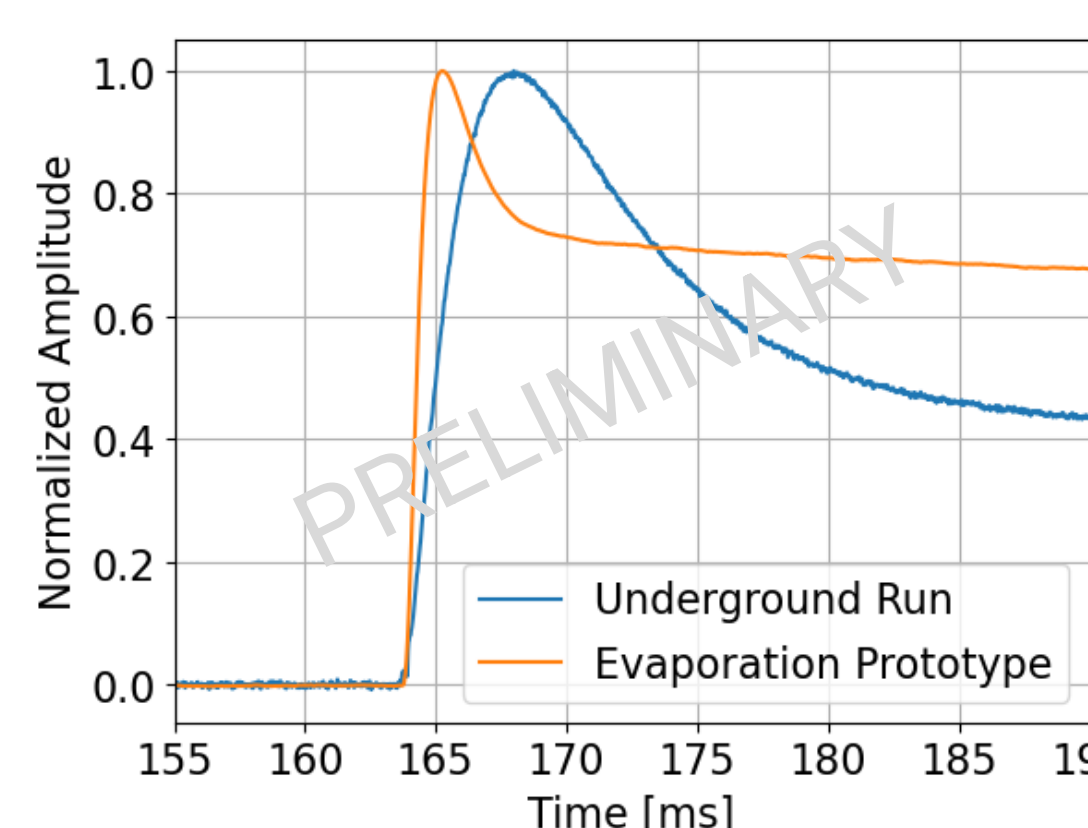
Evaporation:

- Thermal evaporation of high-purity Au-thin films
- For better adhesion: ~ 10 nm titanium (Ti) layer primarily evaporated
- Advantages:
 - Reproducible process
 - Thinner film thicknesses possible $\rightarrow$ reduces heat capacity
- First tests 2024 at TUM ECS group [1]
- Spring 2026: our own COSINUS evaporation machine in glovebox delivered



Prototype Test

- Prototype tested above ground achieved a baseline resolution of 150 eV [4] $\rightarrow$ better than best performing NaI detector with glued Au-pad so far (tested underground) [5]
- Signal shape shows a faster rise time for the evaporation prototype
- New prototype for LNGS underground test under preparation right now

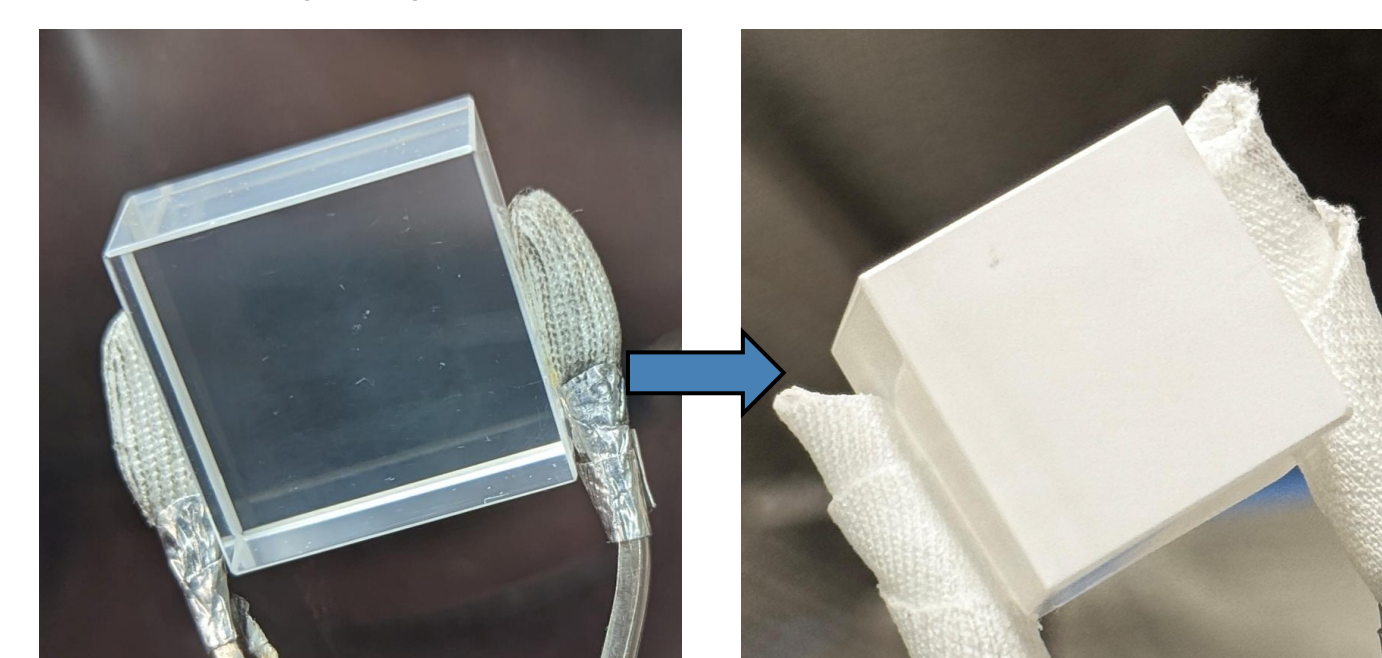


NaI Crystals

- Produced by SICCAS out of ultra-pure astrograde NaI powder from Merck
- Size: (2.1 x 2.1 x 2.1) cm 3 $\rightarrow$ ~ 34 g
- Contamination [5]:

^{40}K	^{208}Th	^{238}U
6 - 22 ppb	< 1 ppb	< 1 ppb
- Fixation of crystal on lid with vacuum grease

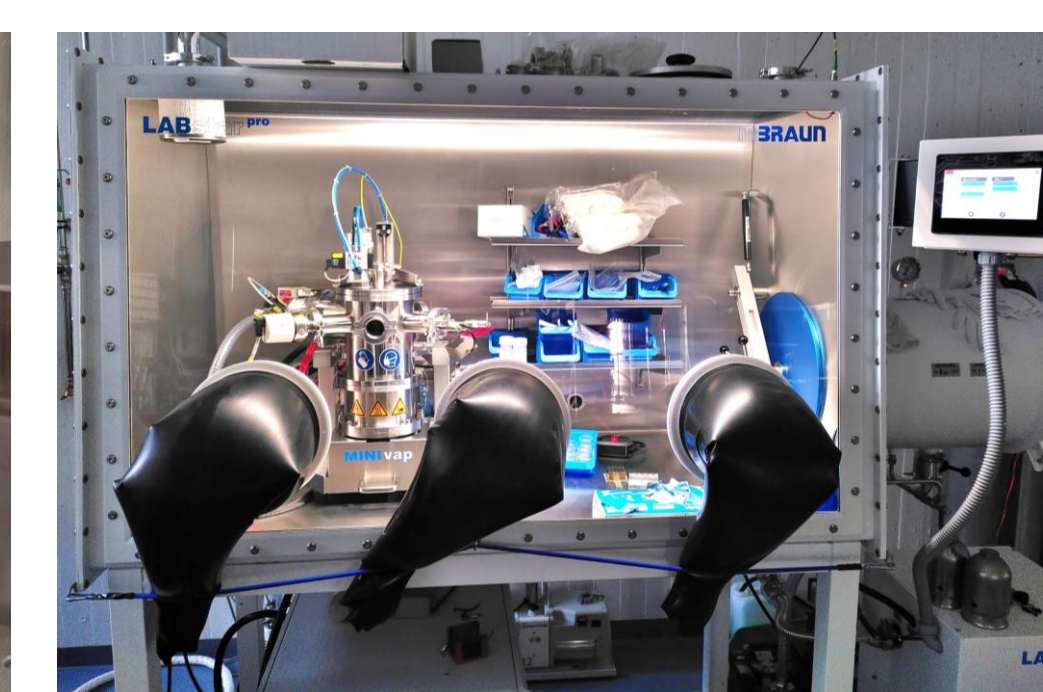
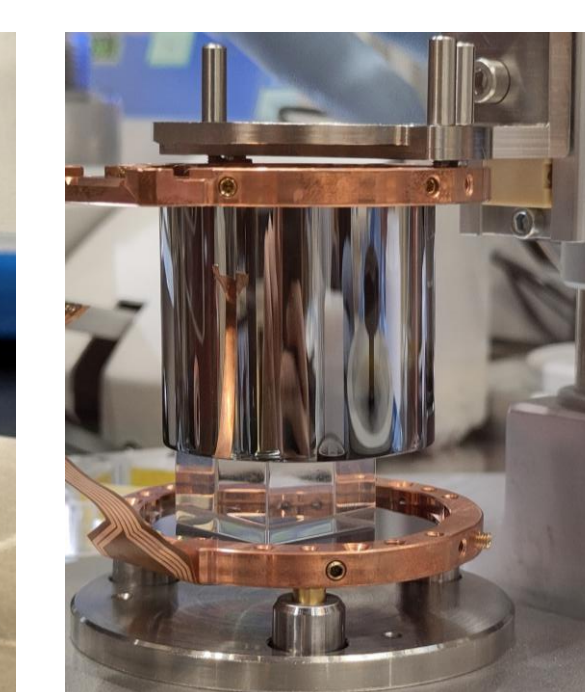
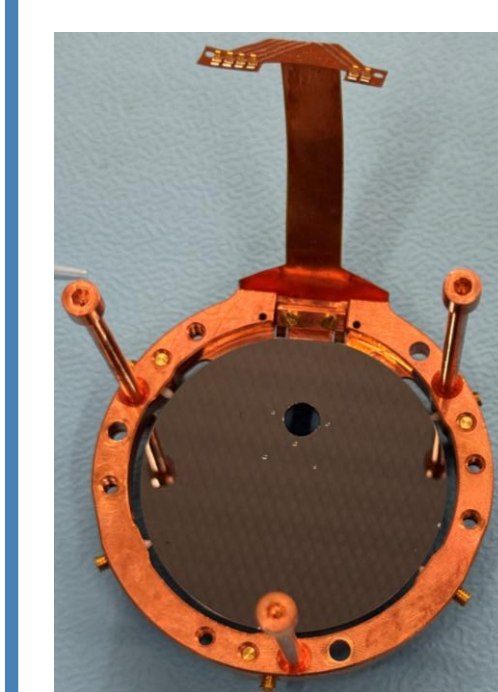
- Surfaces optically polished
- Highly hygroscopic :



Degradation of NaI

Assembly

- TES and remoTES fabrication
 - Mounting Si beaker and lid into copper rings
 - Mounting remoTES and cabling
 - Bonding of TES and remoTES
 - Gold pad evaporation on NaI
 - Fixation of NaI crystal on Si lid
 - Turning around Si lid and bonding of gold link
 - Mounting the beaker on top of NaI copper box
 - Packing the module into an airtight
- Due to the hygroscopic nature of NaI, steps 5 - 9 must be performed in a moisture-controlled glovebox.



[1] First measurements of remoTES cryogenic calorimeters: Easy-to-fabricate particle detectors for a wide choice of target materials, Nucl. Instrum. Methods: A, 1045, 167532, January 2023
 [2] <https://cresst-experiment.org/>
 [3] In cooperation with TUM Energy Conversion and Storage (ECS) group of Prof. Bandarenka
 [4] Development of Cryogenic Single-Photon Detectors to Study the Light Output of Sodium Iodide Crystals for Rare Event Searches, M.Sc. Thesis, L. Ziegele, TUM, 2025
 [5] Deep-underground dark matter search with a COSINUS detector prototype, Phys. Rev. D 110, 043010 – Published August 2024



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16th International Workshop on the Identification of Dark Matter 2026