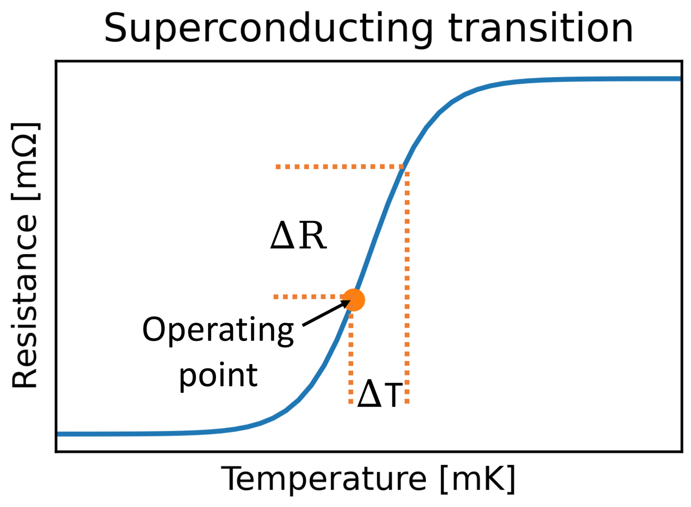
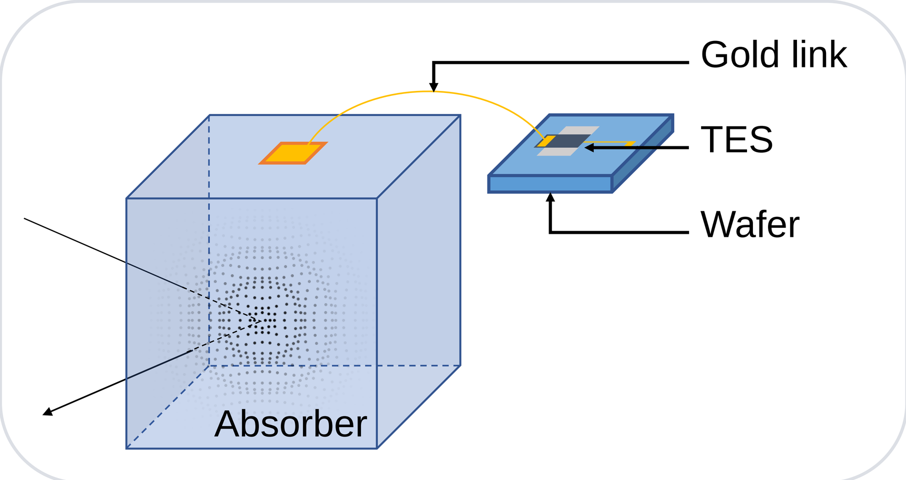
# NaI-remoTES: Cryogenic detectors with delicate absorbers

## remoTES – remote transition edge sensors

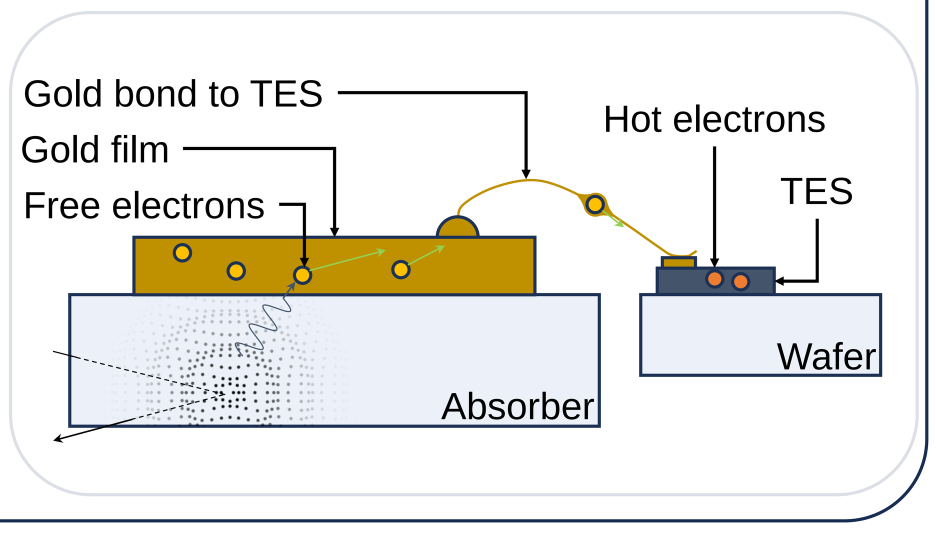
A transition edge sensor (TES) is a superconducting thin film operated at the critical temperature of its superconducting transition. In this region, temperature fluctuations on the order of μK lead to changes in resistance on the order of mΩ. Typically the TES is deposited directly on the target material to collect most of the phonons generated by an atomic recoil.




In the remoTES design the TES is not deposited directly on the absorber, but located on a separate wafer disk. A gold link consisting of a gold film and a gold bond wire connects the TES with the absorber. The benefits of this design are a wider choice of absorber materials, higher reproducibility and higher purity standards

In an atomic recoil phonons are created in the absorber's crystal lattice. The phonons propagate and enter the gold film where they interact with free electrons via electron-phonon-coupling. Through the gold bond and its thermal heat conductivity the TES is heated up and generates a measurable signal.





## Moritz Kellermann

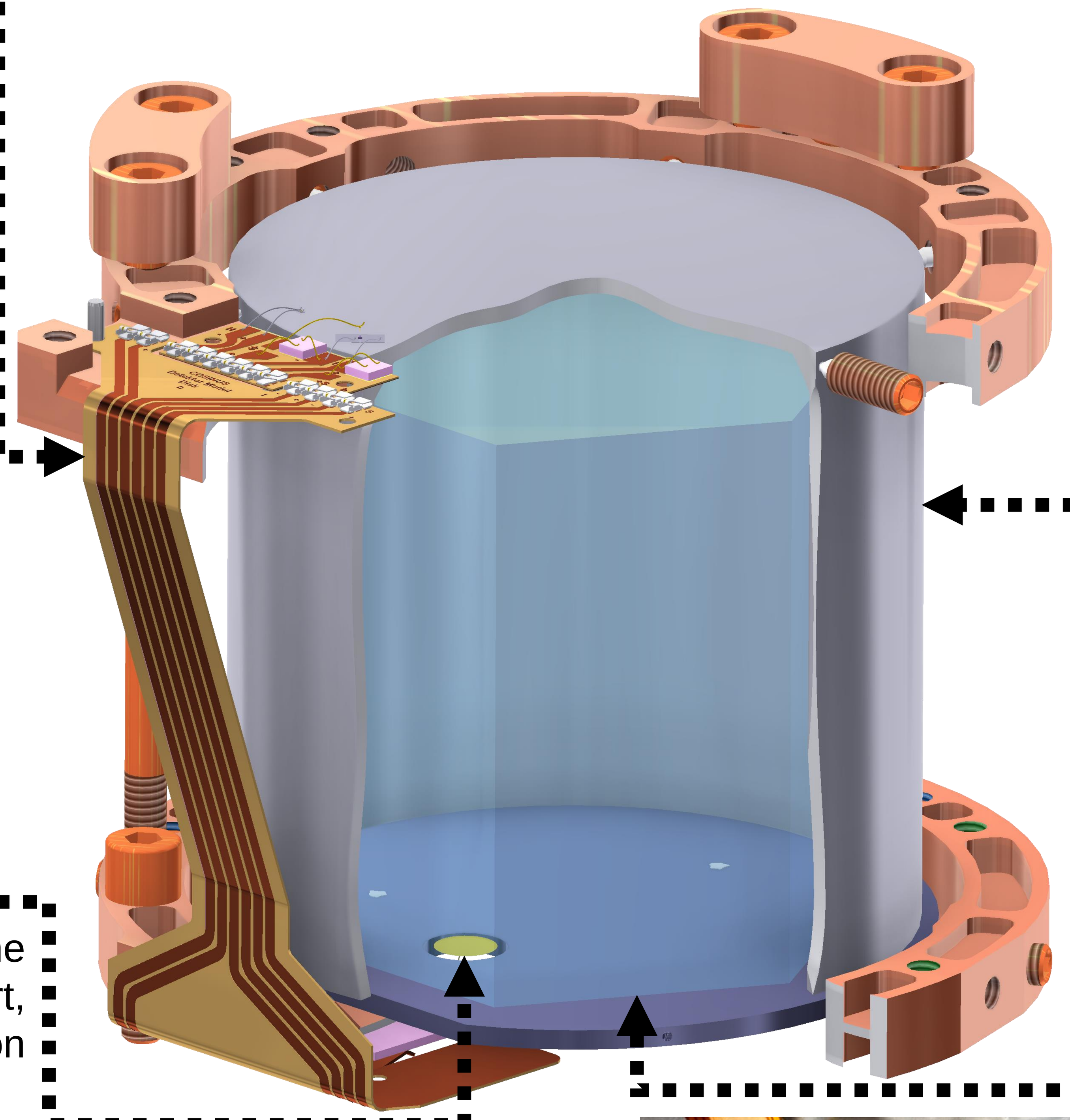
On behalf of the COSINUS collaboration


## The COSINUS experiment

- **Who?:** 38 scientists, 7 institutions, 5 countries
- **What?:** model-independent cross-check of the DAMA/LIBRA dark matter claim
- **How?:** Operation of sodium iodide (NaI) as cryogenic calorimeters at mK-temperatures allows for dual channel readout of phonon and light signal and, thus, particle discrimination on event-by-event basis
- **Where?:** Low background facility located in hall B of Laboratori Nazionali del Gran Sasso (LNGS)
- **When?:** Data taking starts early 2025, first results are expected late 2025

## Readout

The TES is contacted with superconducting bond wires and read out in a parallel circuit with shunt resistors $R_S$ and Superconducting Quantum Interference Device (SQUID). In the present design the connections are done with copper traces on a copper-polymide base and spring connectors.

## Light channel

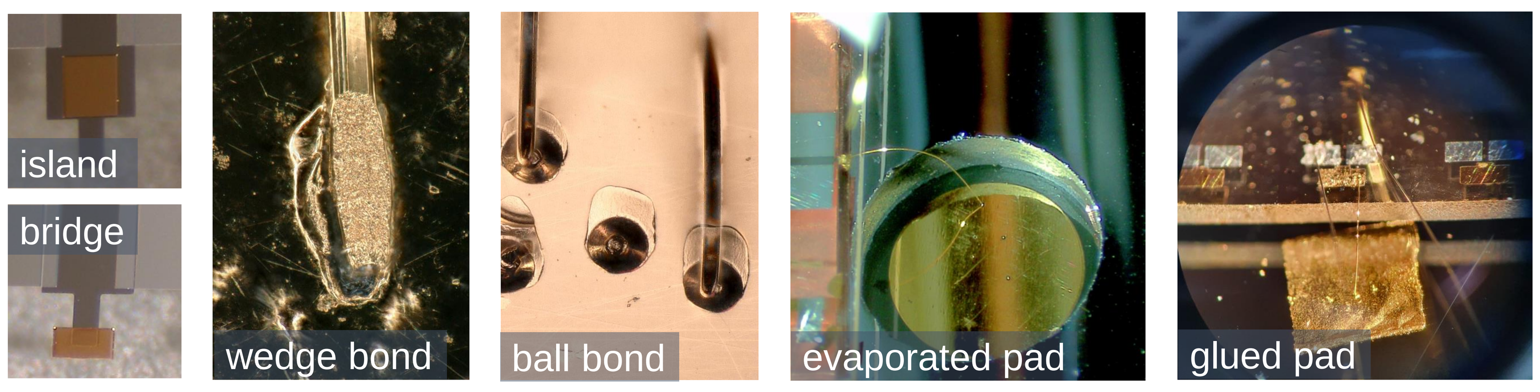
A beaker shaped silicon light detector collects any scintillation light generated in the absorber material. It is equipped with a TES and features excellent energy resolution and light collection efficiency. On the bottom a silicon disk covers the detector for a complete 4π-coverage to reject α-particles from the outside.

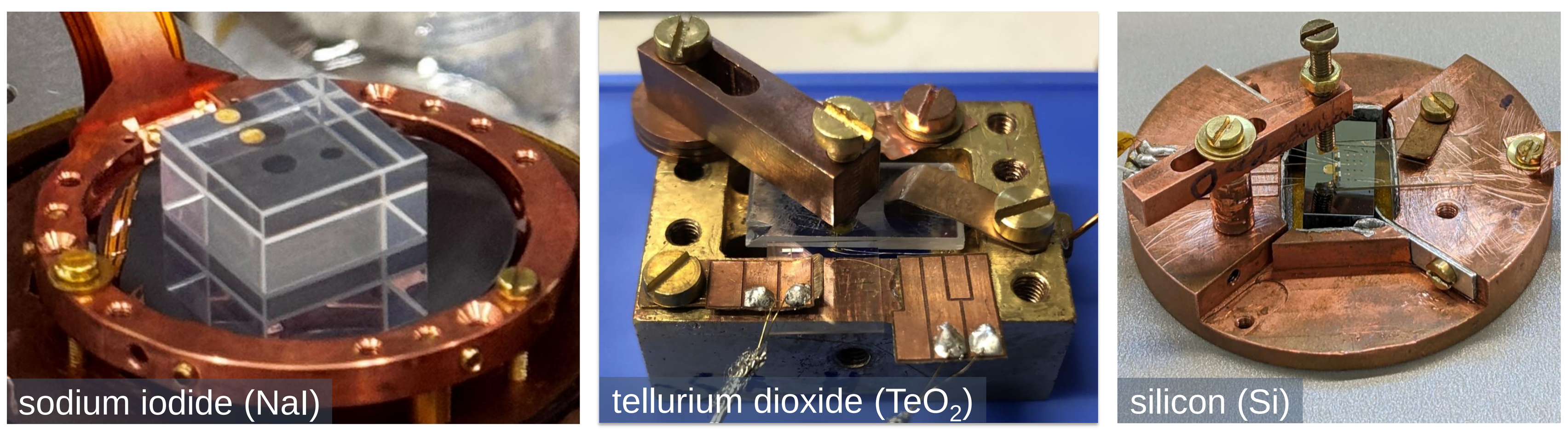
## Gold link

The gold link is a metallic connection between the TES and the absorber and consists of a TES-port, bond-wire and gold pad. During optimization studies different designs were employed.

## Absorbers

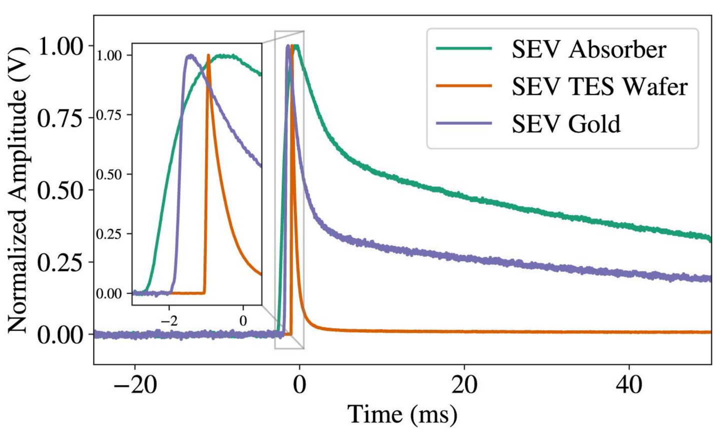
The absorber serves as target material of the detector. Since the only fabrication step the absorber is exposed to is the deposition of gold, the choice of materials contains a vast range of delicate and hygroscopic materials.




## MILESTONES

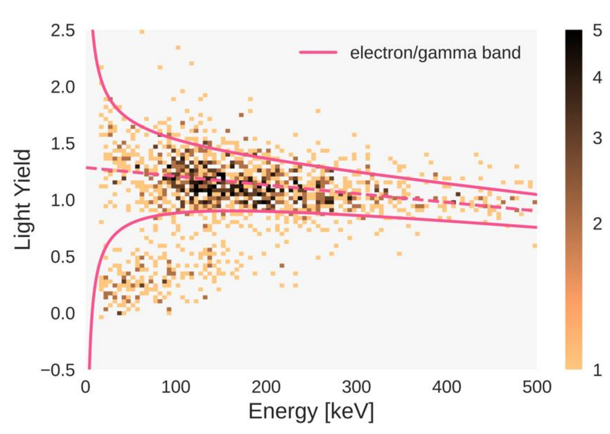
### First proof of concept




- Successful pulse shape discrimination between event localities

Nucl. Instrum. Methods: A, 1045, 167532 (2023)

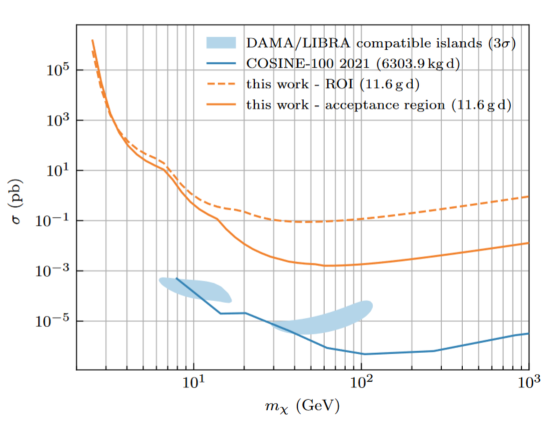
### First operation of NaI




- Successful event-by-event particle discrimination in sodium iodide

Phys. Rev. D 109, 082003 (2024)

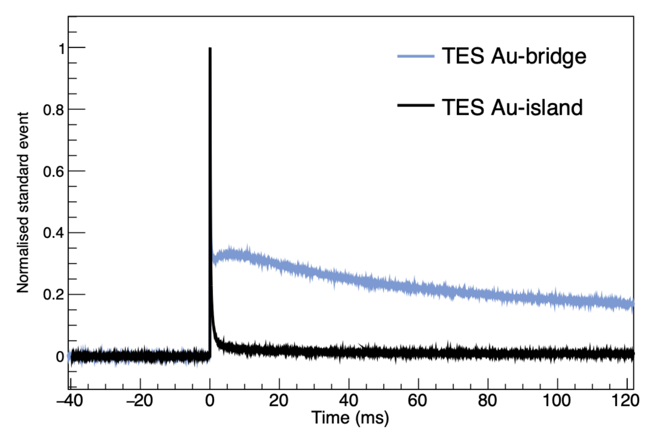
### First underground data




- Benchmark test with a sodium iodide prototype detector

arxiv:2307.11139 (2023)
(accepted for PRD)

### Design optimization




- Optimization of bond type and TES-port design

(submitted to Journal of Low Temperature Physics)

### First evaporated Au on NaI

Data taking right now !


COLLABORATION

GSI · Helsinki Institute of Physics · INFN LNGS Istituto Nazionale di Fisica Nucleare Laboratori Nazionali del Gran Sasso · Max-Planck-Institut für Physik (Werner-Heisenberg-Institut) · TU Wien · HEPHY Institute of High Energy Physics · SICCAS Since 1928

15th International Workshop on the Identification of Dark Matter 2024



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Contact: mkellerm@mpp.mpg.de

cosinus.it