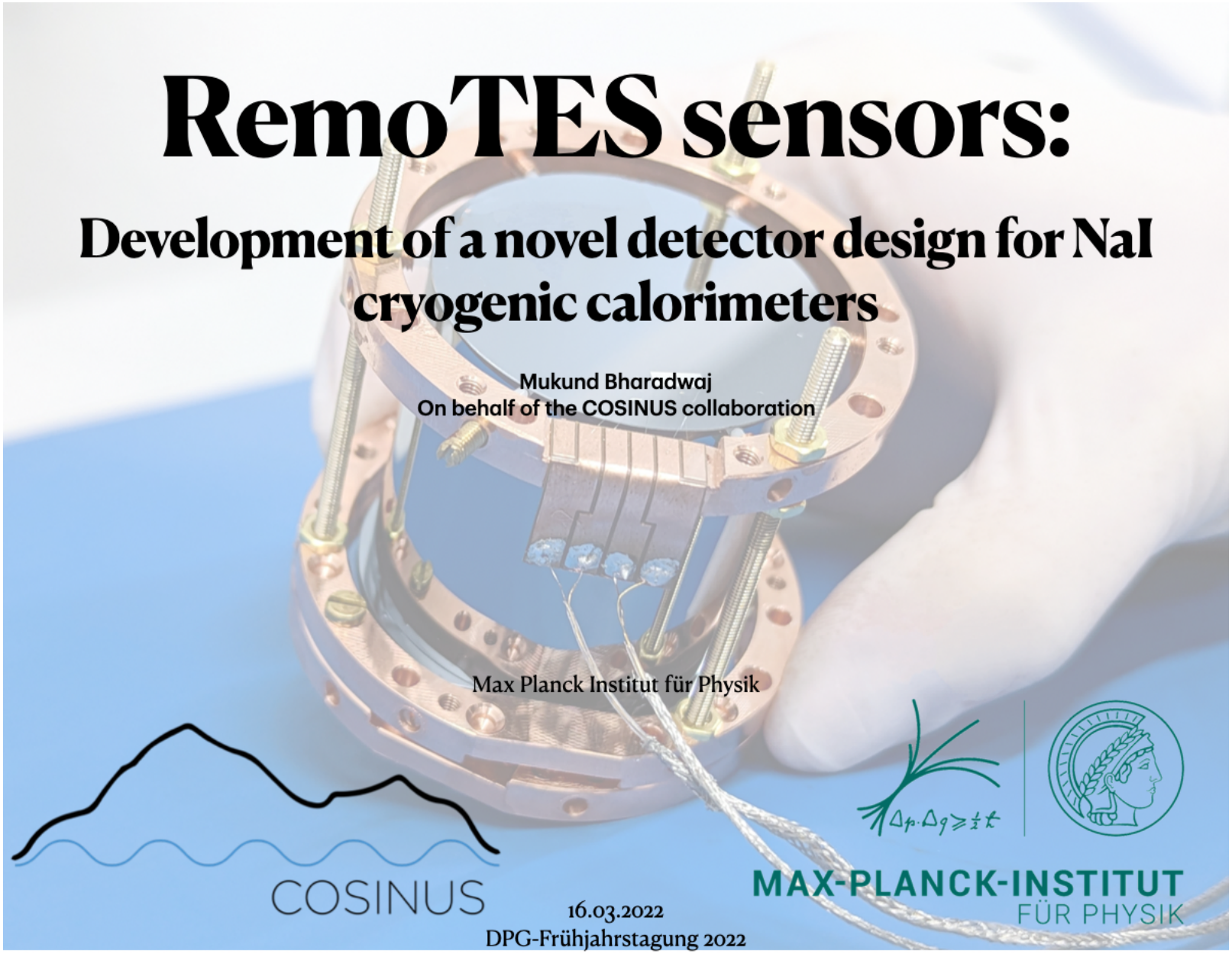
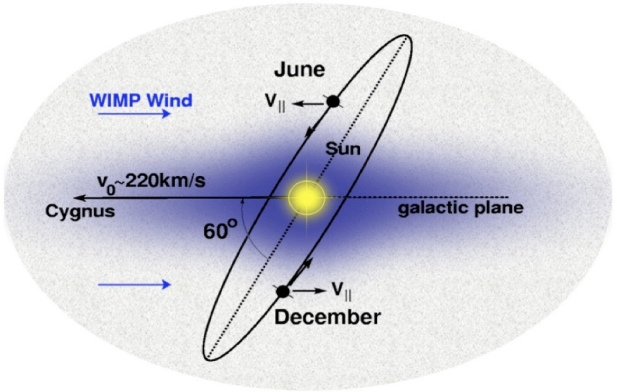

RemoTES sensors:
Development of a novel detector design for NaI cryogenic calorimeters
Mukund Bharadwaj
On behalf of the COSINUS collaboration
Max Planck Institut für Physik
COSINUS
16.03.2022
DPG-Frühjahrstagung 2022
MAX-PLANCK-INSTITUT
FÜR PHYSIK

Overview

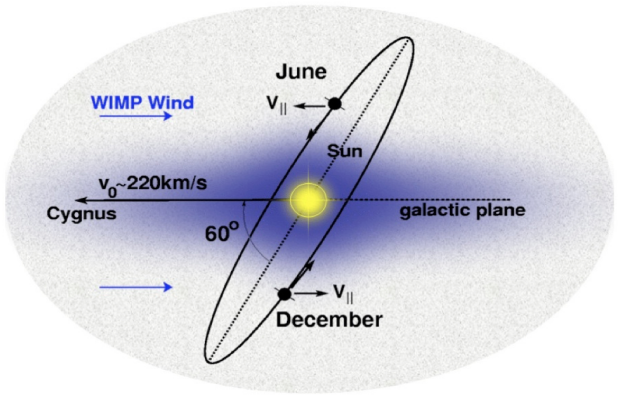
Background

Background

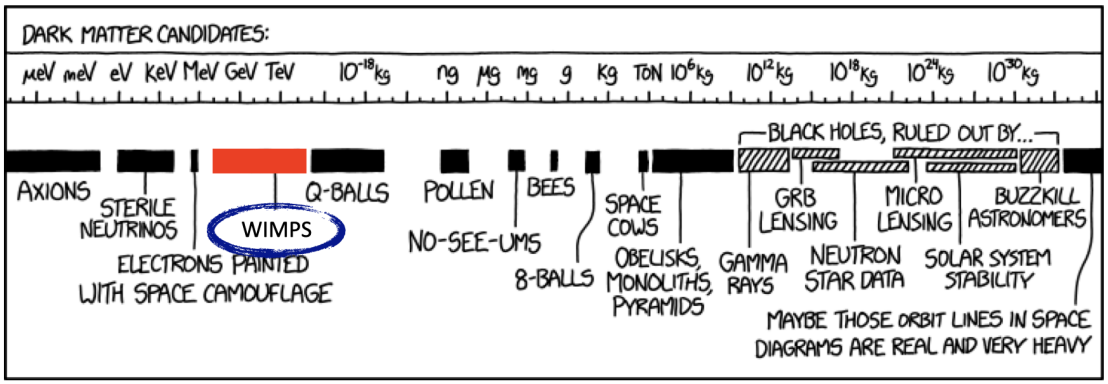


Direct Dark Matter Detection

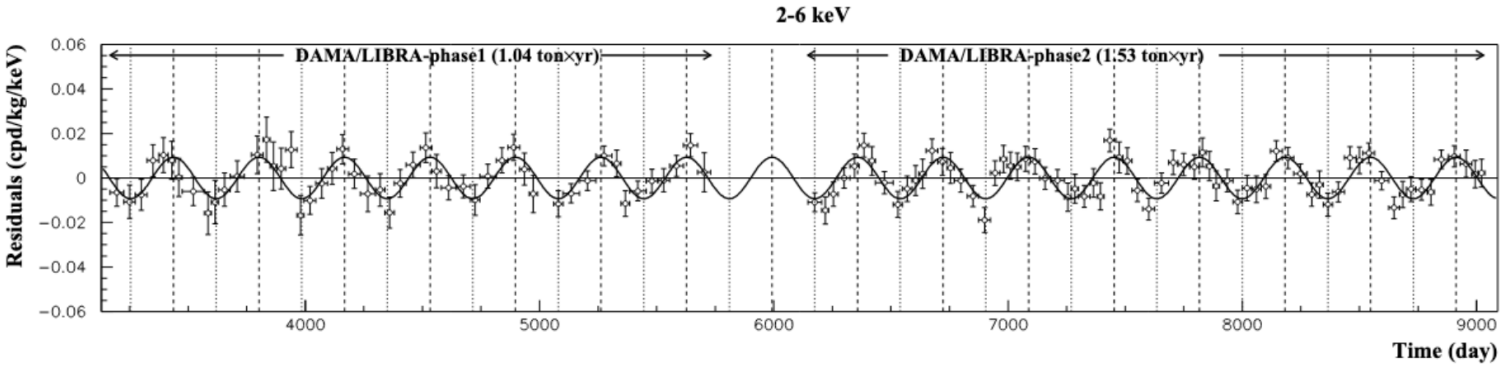
Background



Direct Dark Matter Detection



The curious case of DAMA-LIBRA



https://arxiv.org/pdf/2110.04734.pdf

13.7σ confidence level!

Design and setup

Design aspects

Experimental overview

- Cryogenic experiment.
- Target detector material: NaI
- 2 readout channels:
  - **Phonons** : Energy measurement
  - **Light** : Particle identification

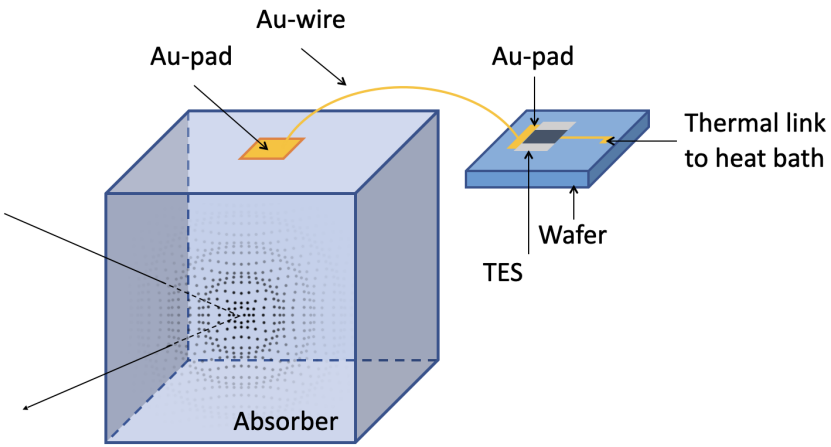


Figure 1: *remoTES* readout scheme.

Baseline design

Drawbacks

- TES on carrier crystal coupled to NaI with an interface.
- Phonon propagation from NaI to TES severely degraded.
- Contributing factor includes acoustic mis-match between the carrier crystal and NaI.

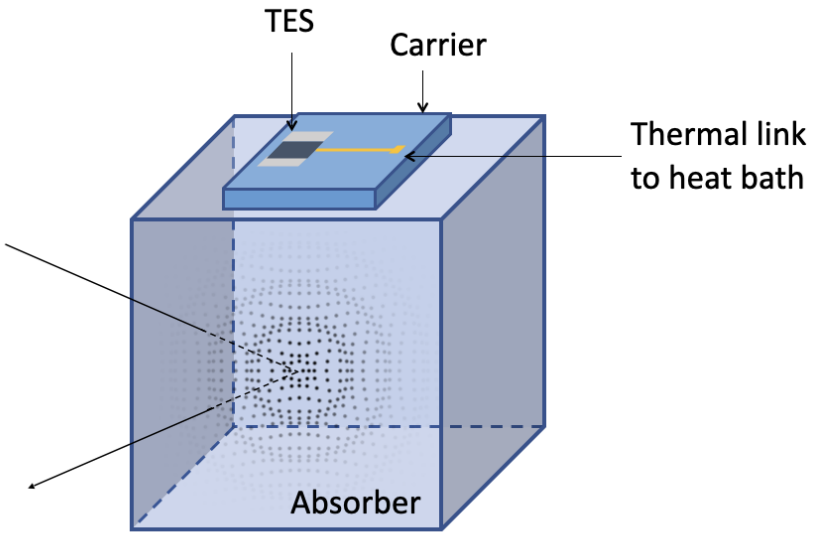


Figure 2: Schematic of the baseline design.

remoTES conceptualization

Possible solution

- TES on carrier coupled to absorber with a Au pad on the NaI surface via an Au wire.
- Proposed by M. Pyle et al, Optimized designs for very low temperature massive calorimeters, arXiv:1503.01200 (2015).
- Goal: Reduce the Energy threshold of the detectors as much as possible.

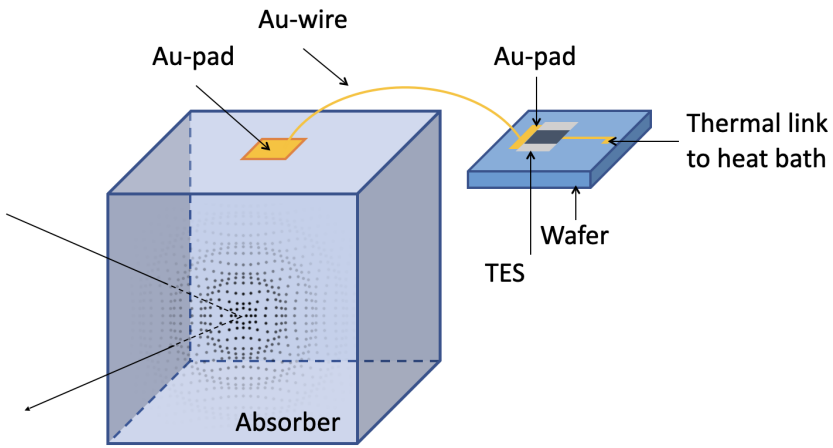


Figure 3: Schematic of *remoTES* readout scheme.

First prototypes

First measurements

Prototype - 1: Si absorber (m=2.23g)

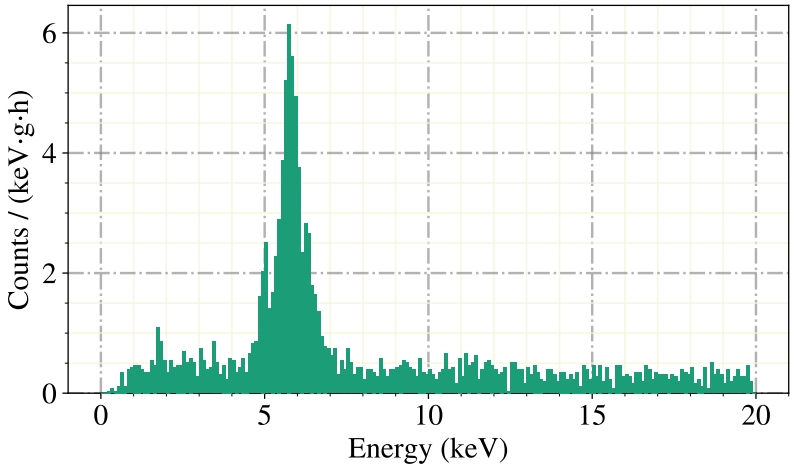


Figure 4: Energy spectra of Si *remoTES* with a ^{55}Fe calibration source

Prototype - 2: TeO_2 absorber (m=2.27g)

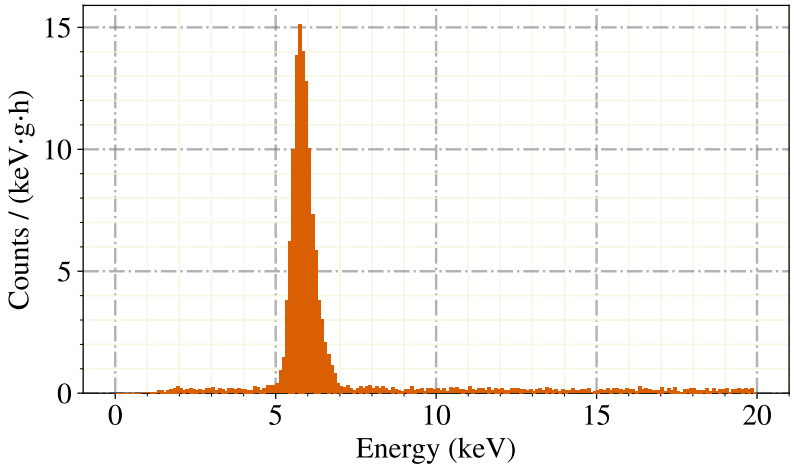


Figure 5: Energy spectra of TeO_2 *remoTES* with a ^{55}Fe calibration source

First measurements

Prototype - 1: Si absorber (m=2.23g)

Key takeaways

- *remo*TES coupling design successfully implemented!
- Baseline resolution of 87.8eV achieved.

Prototype - 2: TeO_2 absorber (m=2.27g)

Key takeaways

- *remo*TES coupling design successfully verified!
- Baseline resolution of 193.5eV achieved.

First measurements

★ Paper on arxiv: *https://arxiv.org/abs/2111.00349* and under publication currently.

★ *remo*TES detectors successfully verified as valid candidate for cryogenic rare event searches.

Next Step: Use a NaI absorber!

NaI *remoTES* design - v1

Points to note

- NaI is hygroscopic.
- Au link b/w absorber and TES must be short.
- Effectively route bias and heater lines.

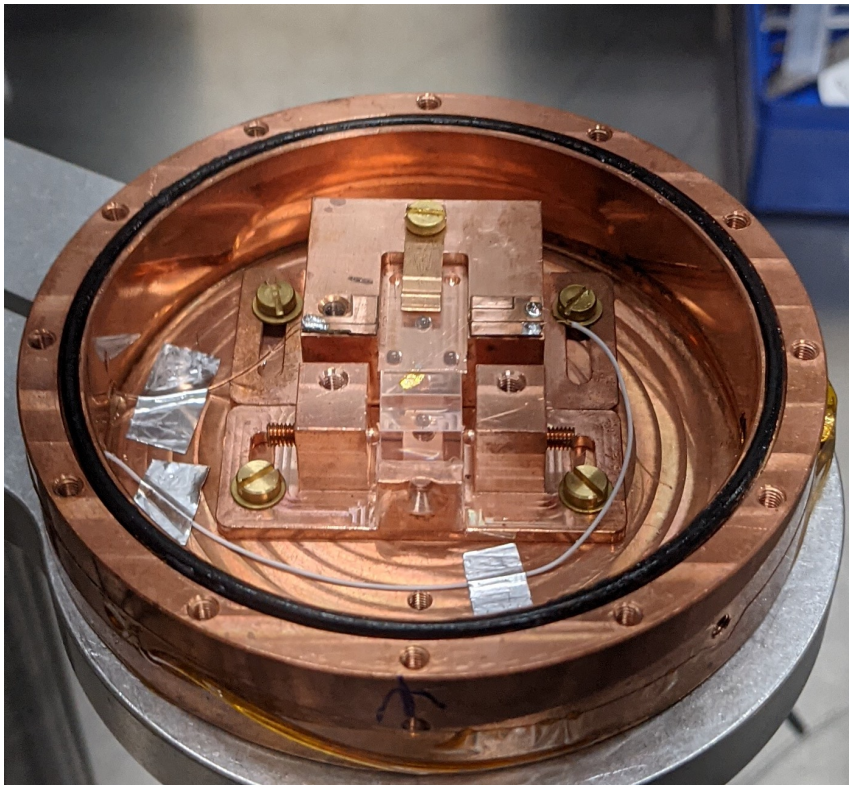


Figure 6: Holder design v1 for NaI *remoTES* detector.

NaI *remoTES* design - v1

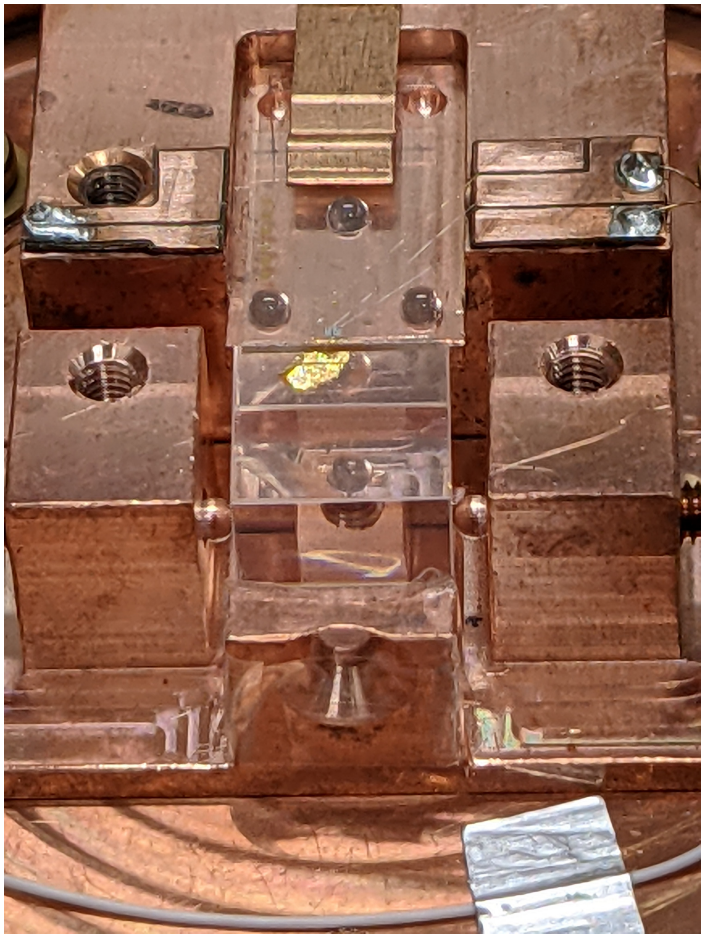


Figure 7: close-up of NaI *remoTES* holder.

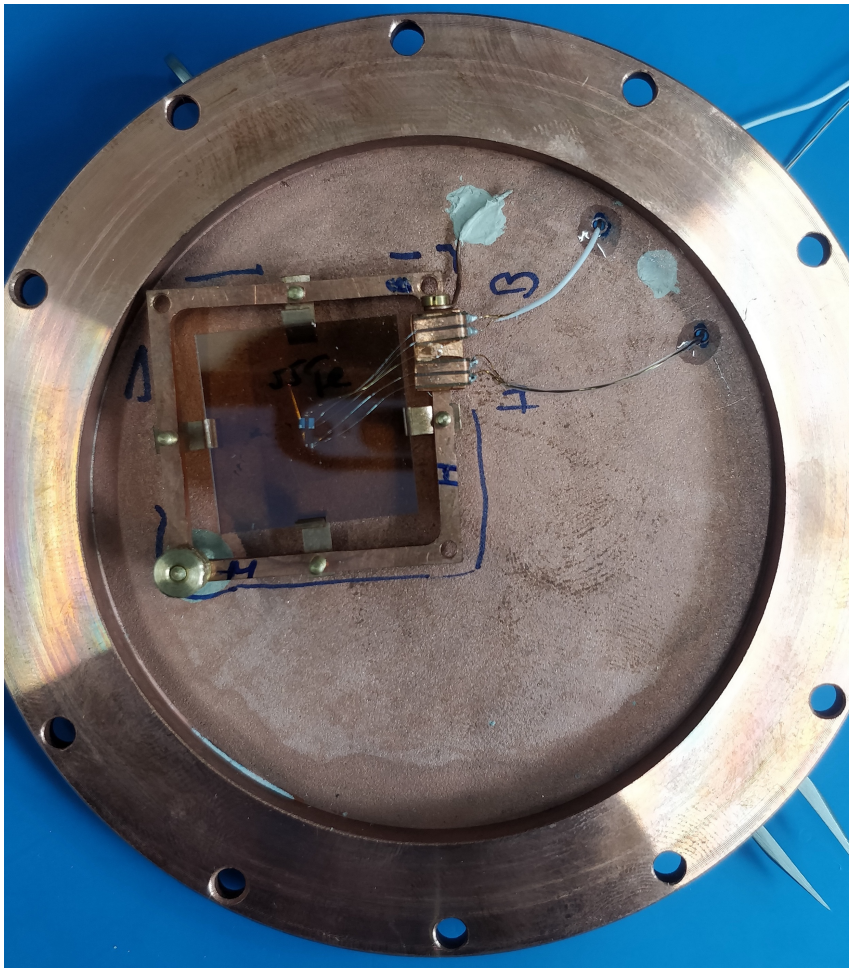
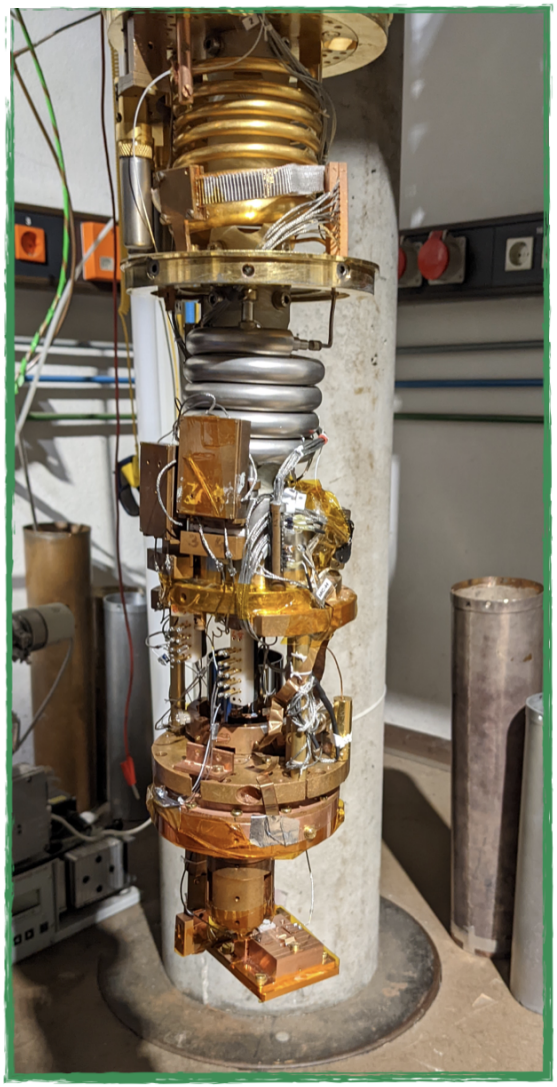
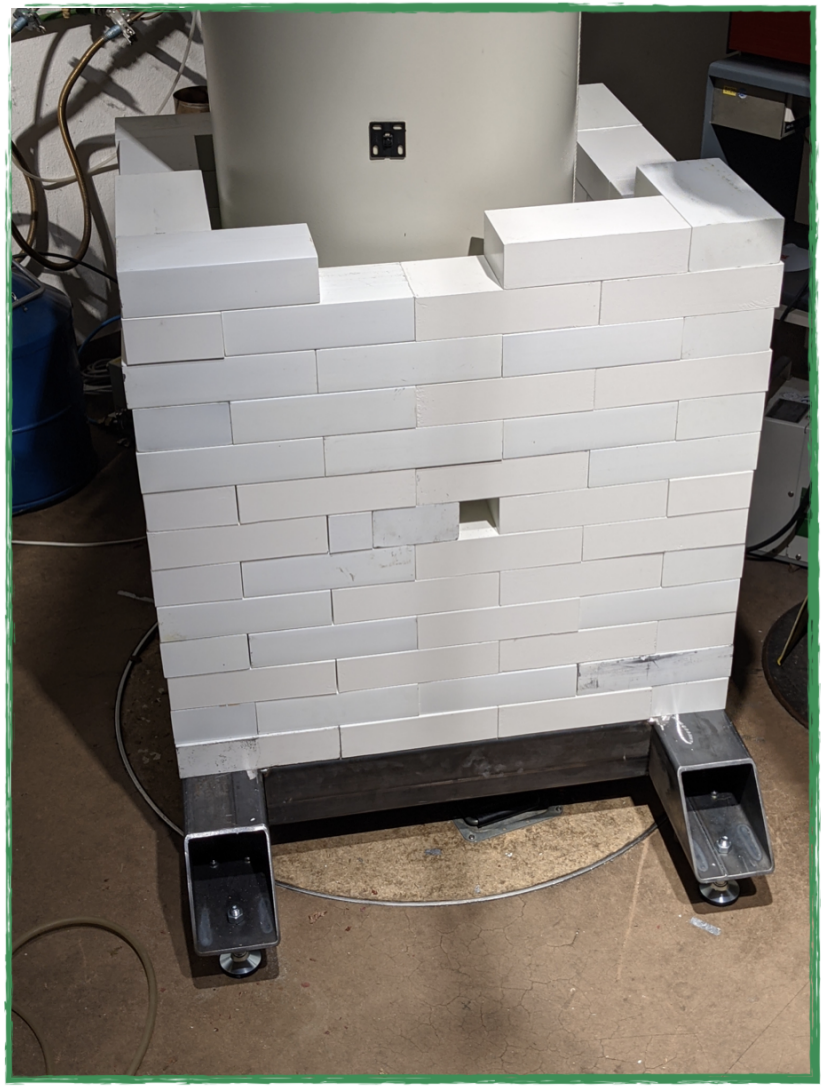


Figure 8: OFHC Cu Lid with the Si light detector.

NaI *remoTES* design - v1

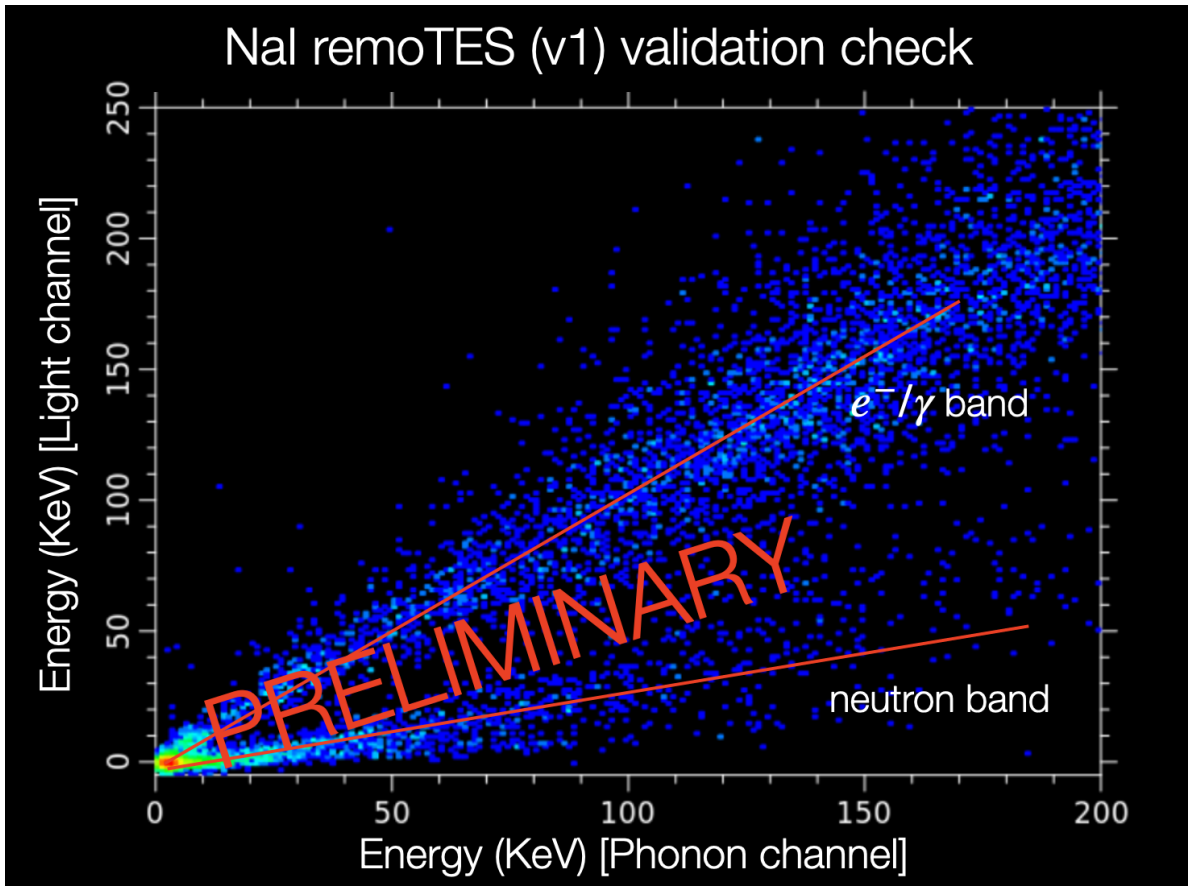




Conclusion and Future Outlook

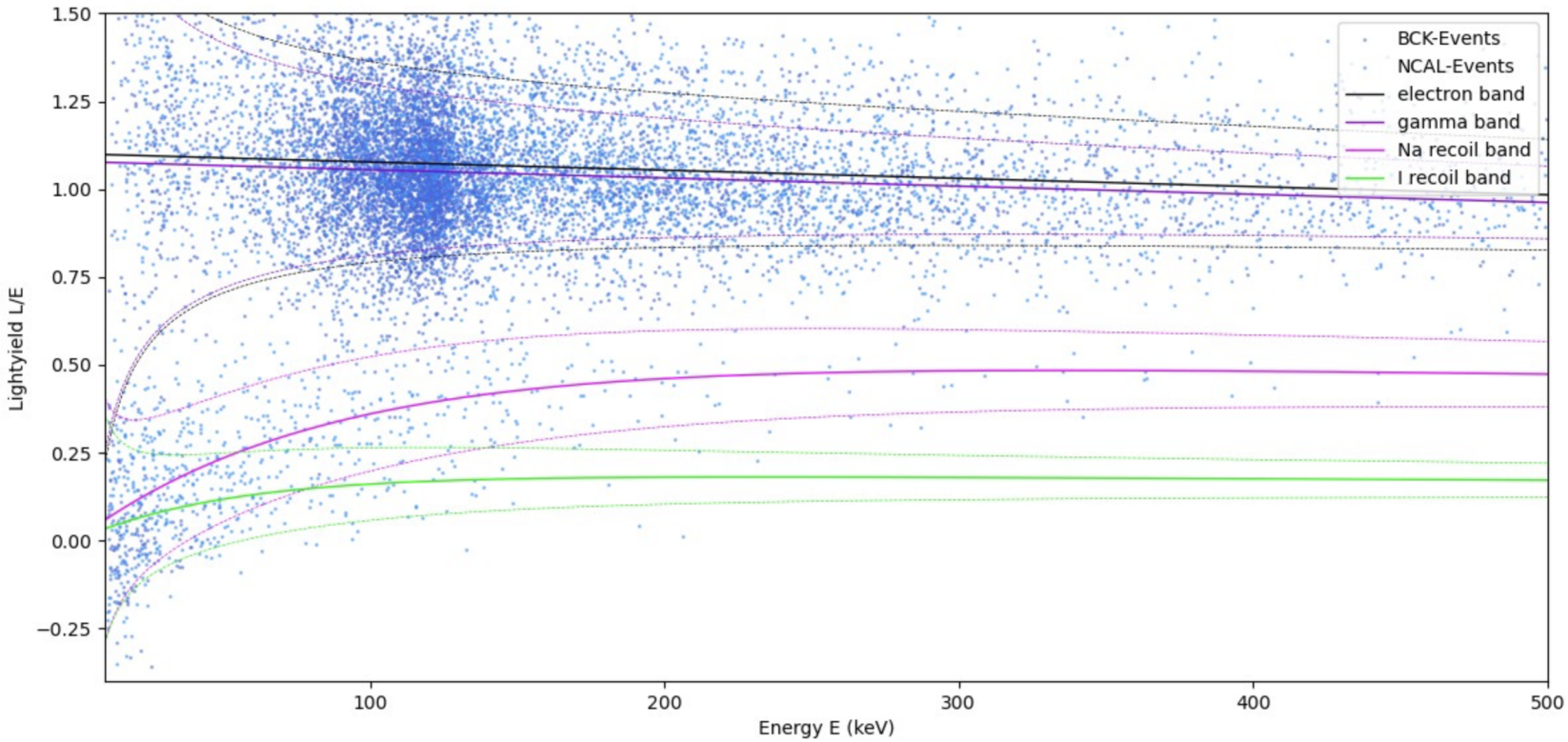
Conclusion

- First experimental tests using NaI as a non-standard absorber material using the *remo*TES design was carried out.
- Promising first results obtained with a detector resolution of $2KeV$.



Conclusion

- 2 distinct event classes observed, confirming particle discrimination.
- Preliminary bandfit using the light yield plot used to extract energy dependent quenching factor of NaI crystal at mK temperatures.



Future Work

- As a follow up, the resolution of the NaI remoTES plans to be further reduced to achieve even lower thresholds.
- New detector holder design incorporating a much larger light detector with a 4π veto has been developed and is currently under testing.
- Dimensions of *Au* pad on the NaI absorber needs to be further optimized.

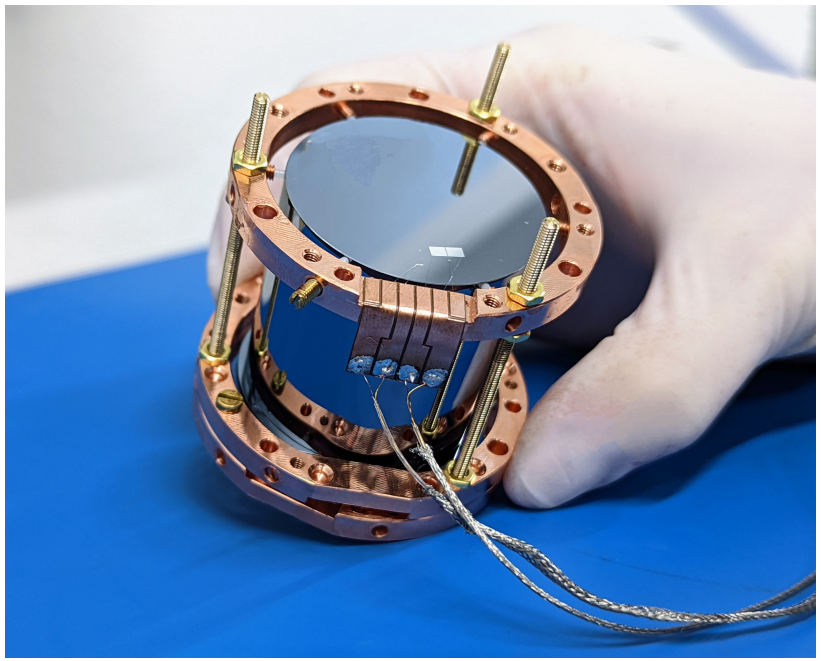


Figure 9: NaI *remo*TES - v2 (Si lid+beaker design)

Acknowledgements