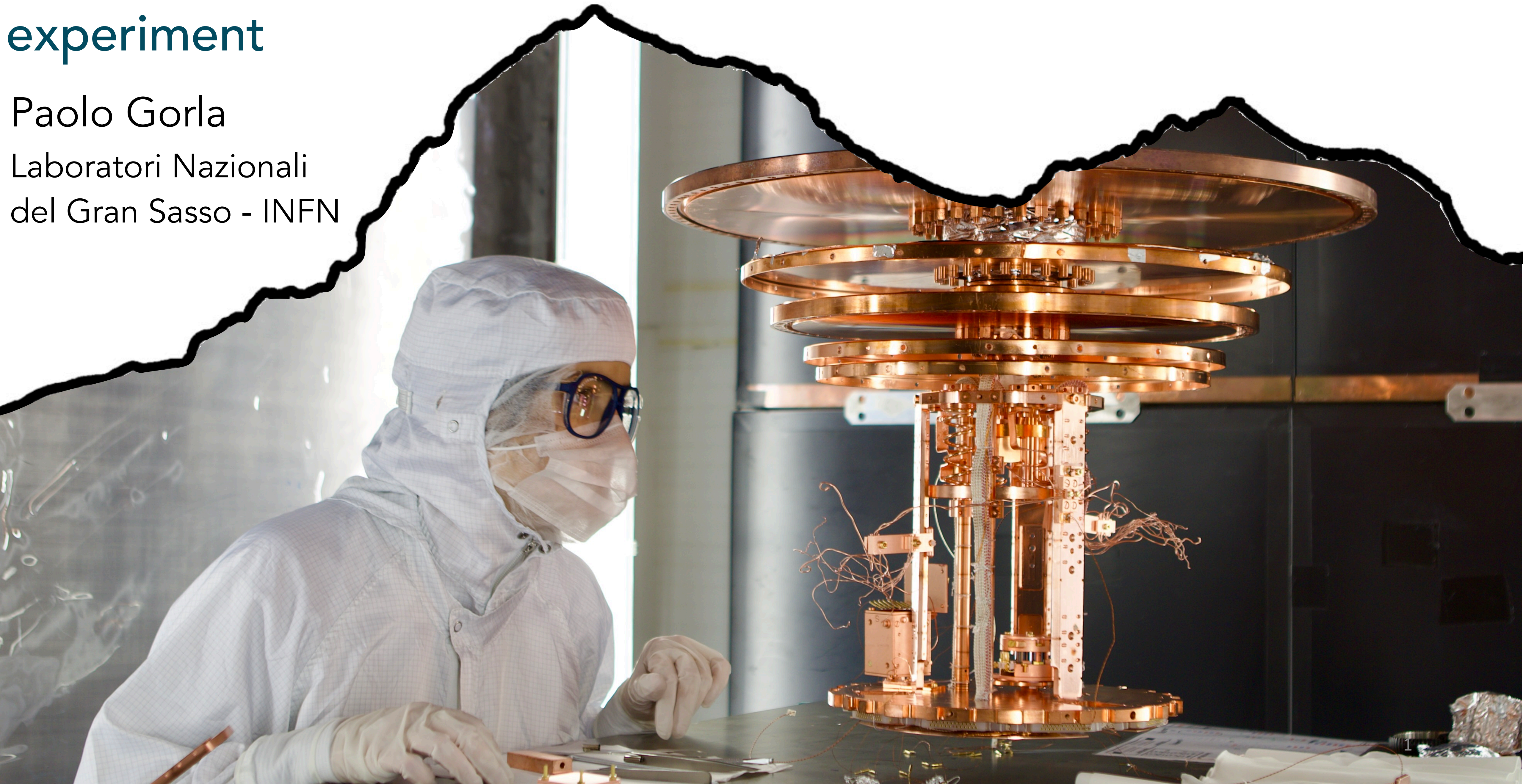


Direct Dark Matter search with the CRESST-III experiment

Paolo Gorla

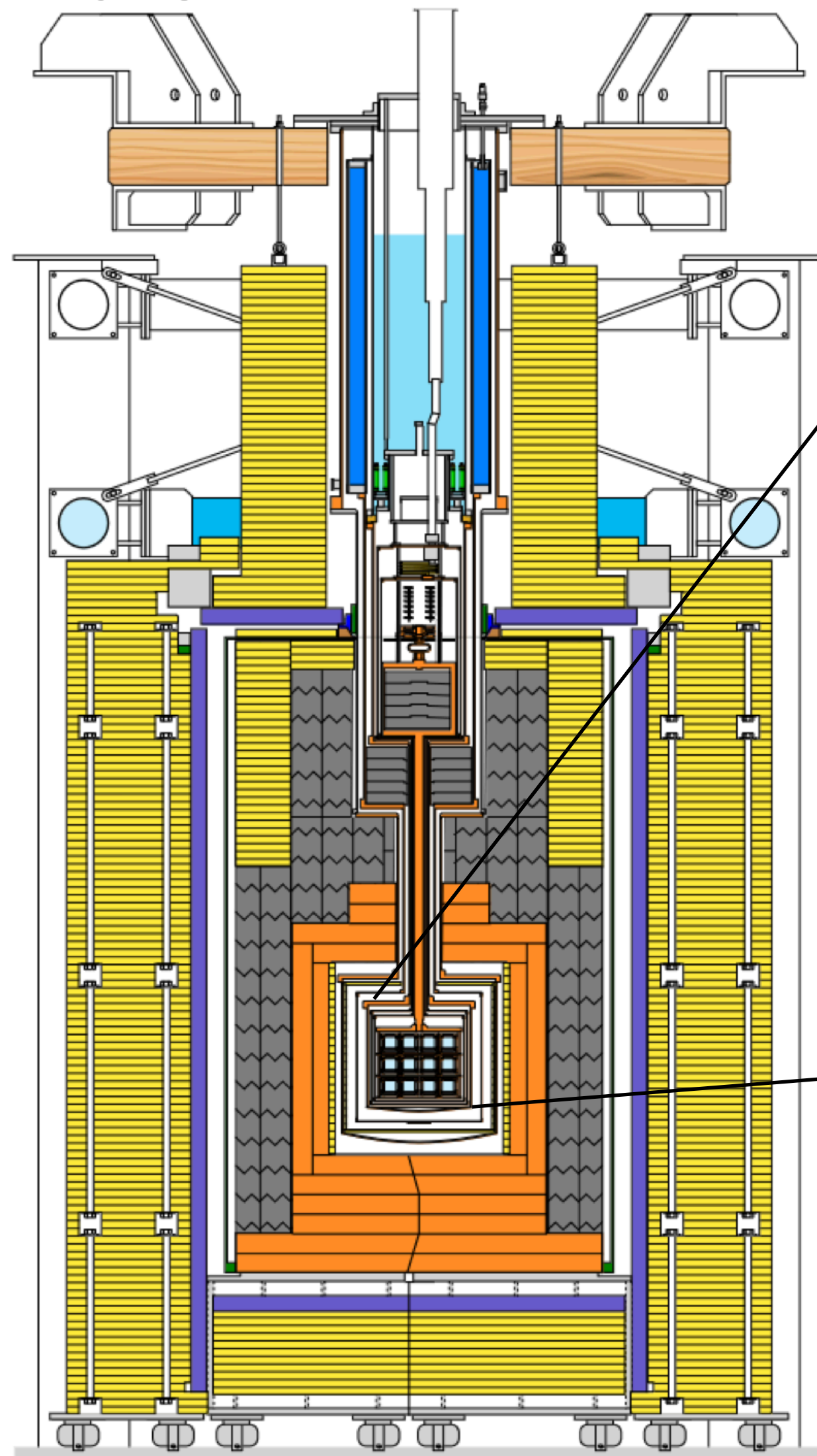
Laboratori Nazionali
del Gran Sasso - INFN



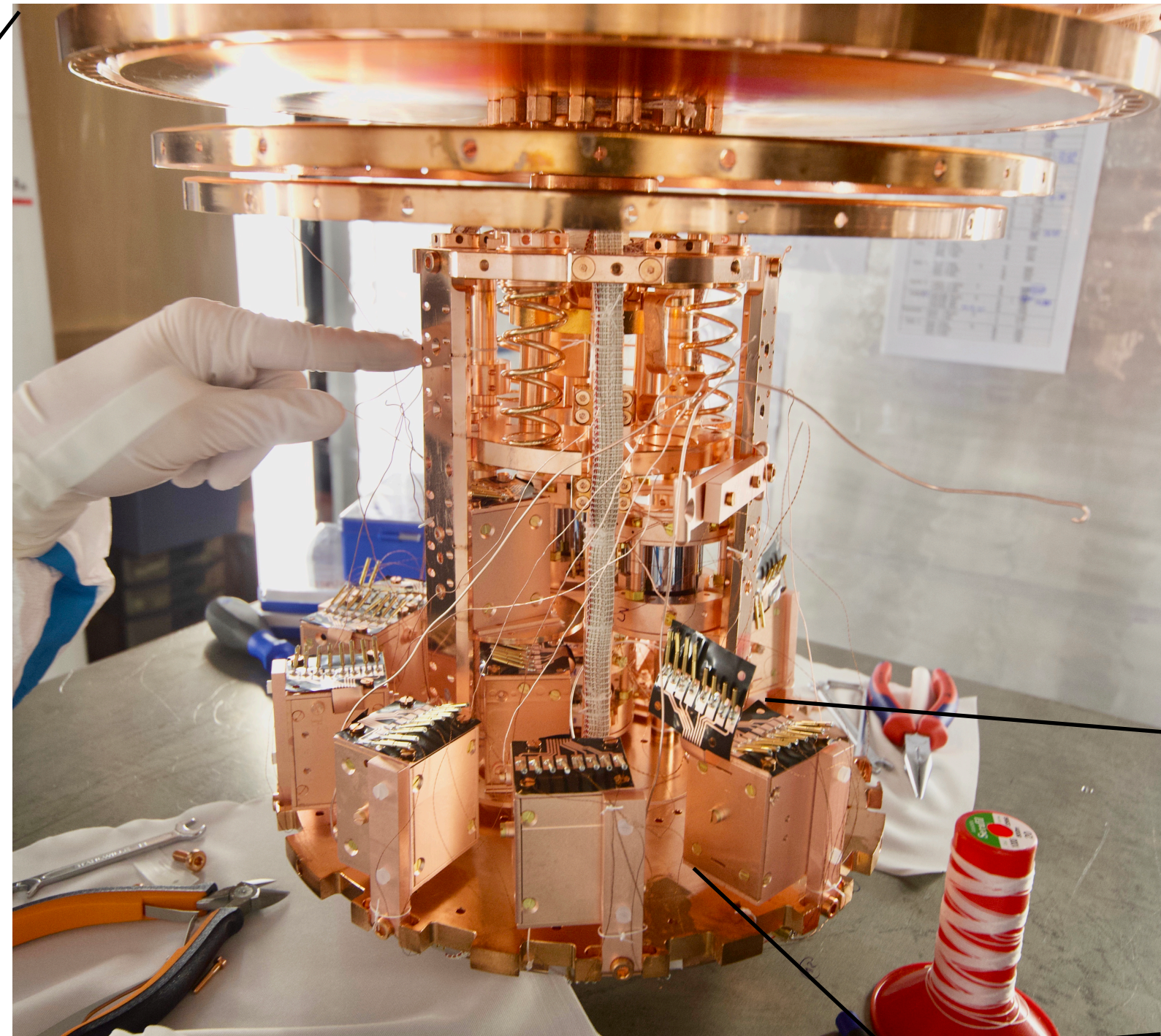
The CRESST experiment



Cryogenic Rare Event Search with Superconducting Thermometers



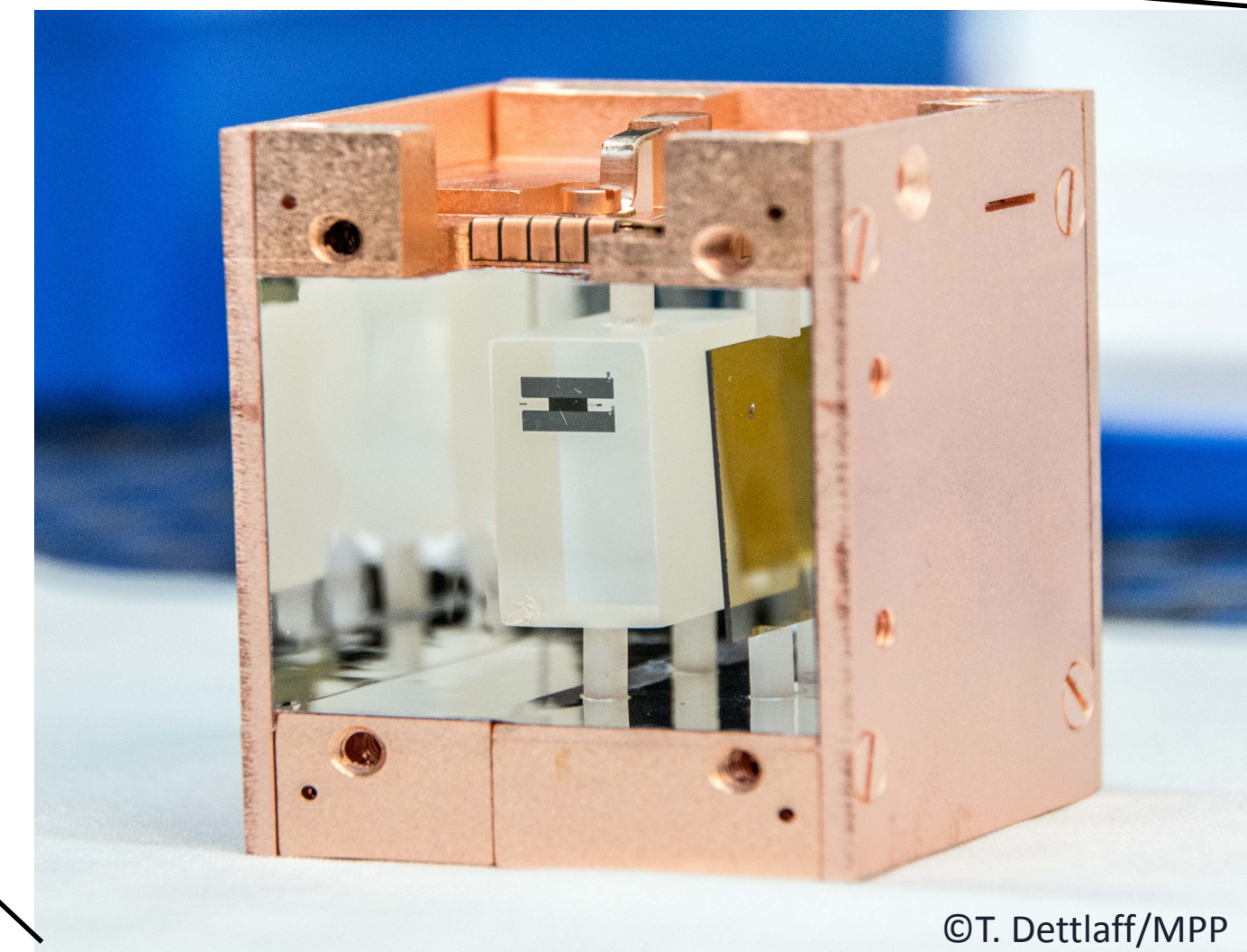
Dilution Refrigerator



Scintillating (CaWO_4) crystals as target

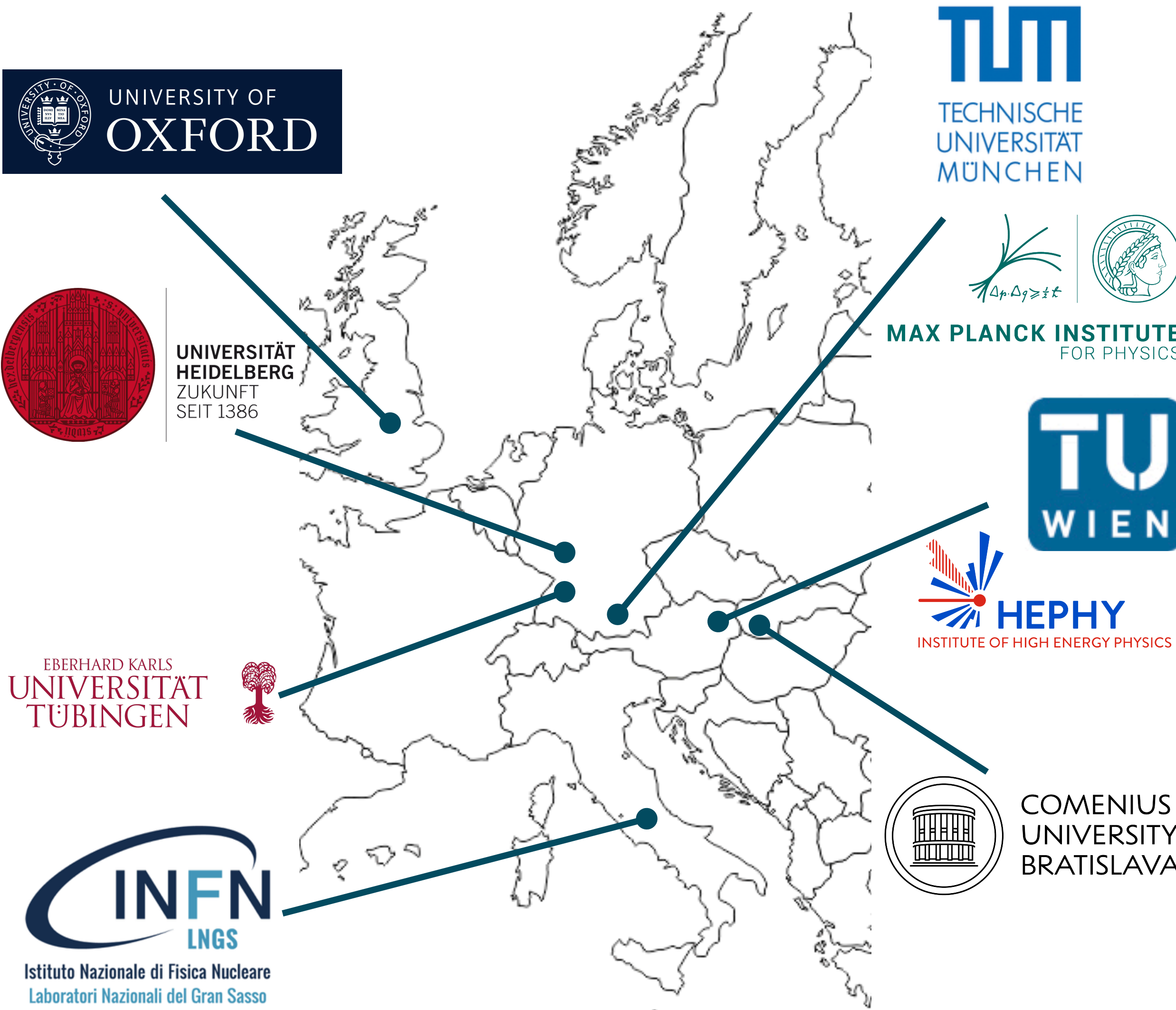
Separate cryogenic light detector

CRESST goal: direct detection of dark matter particles via their scattering off target nuclei in cryogenic detectors, operated at ~ 15 mK



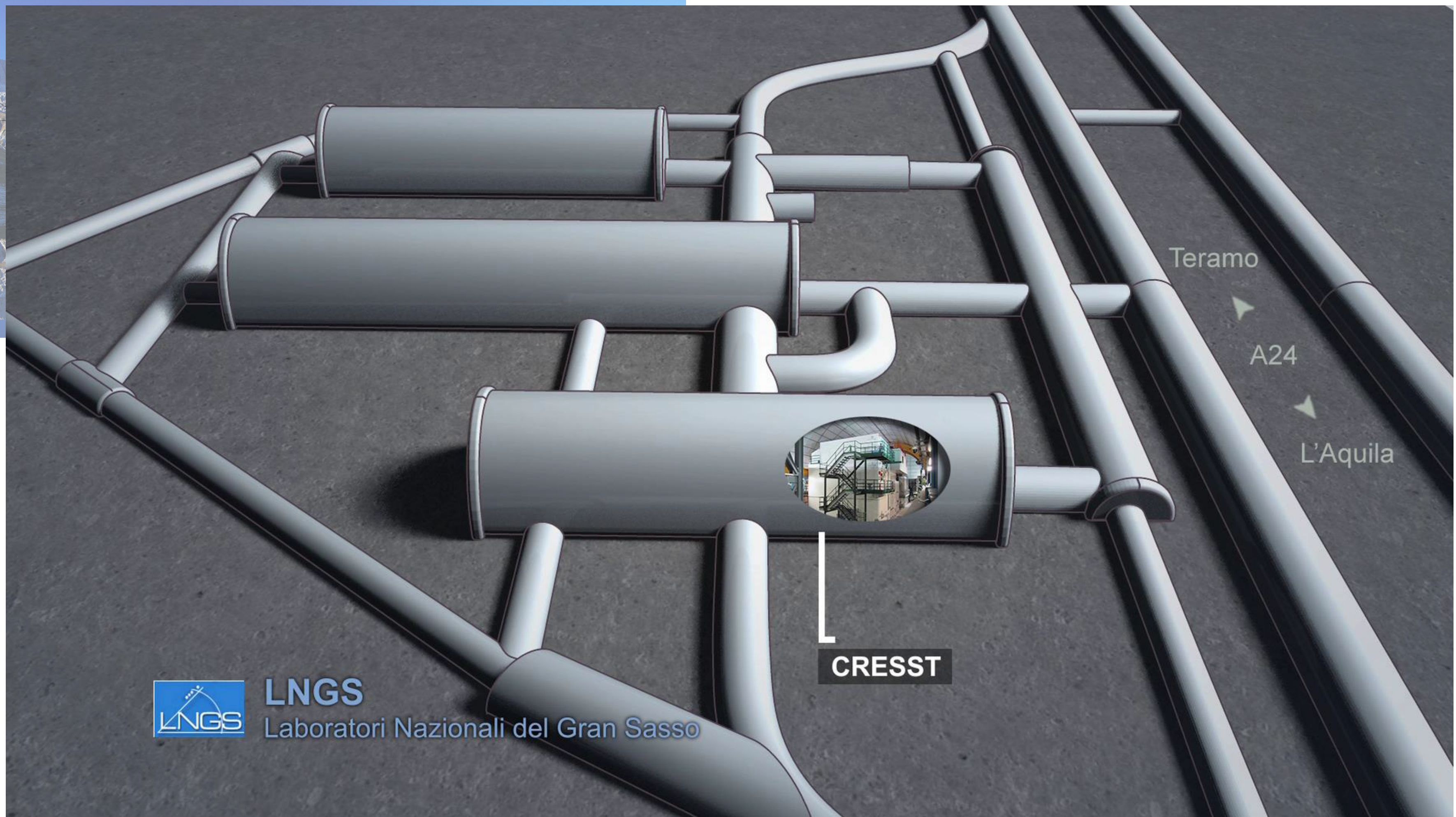
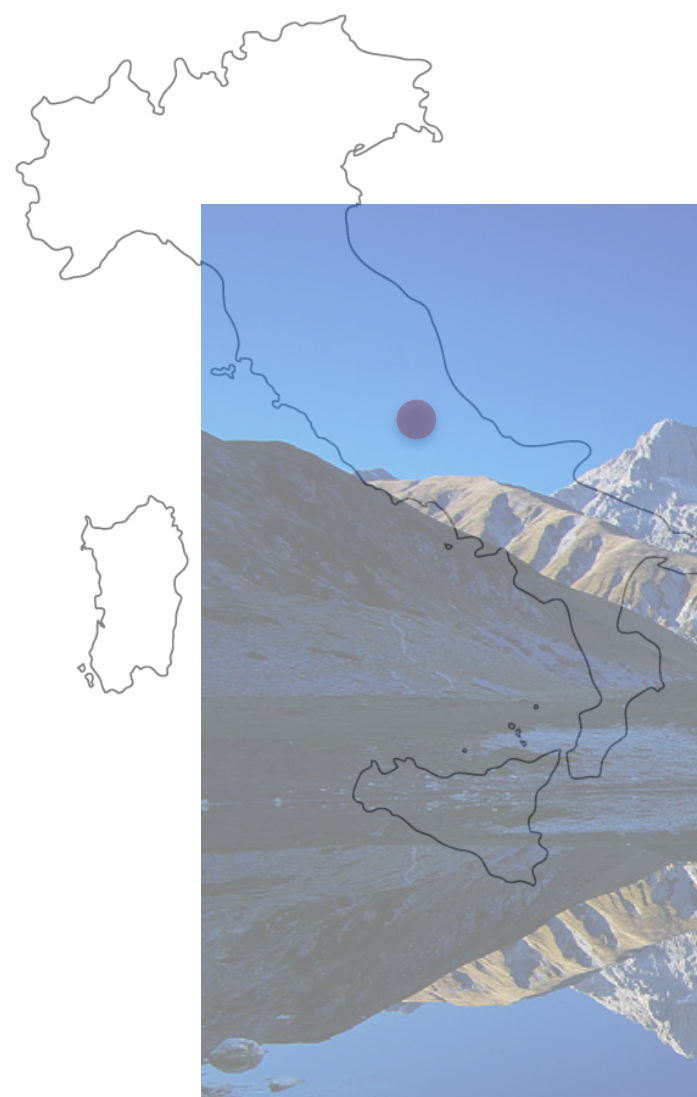
©T. Dettlaff/MPP

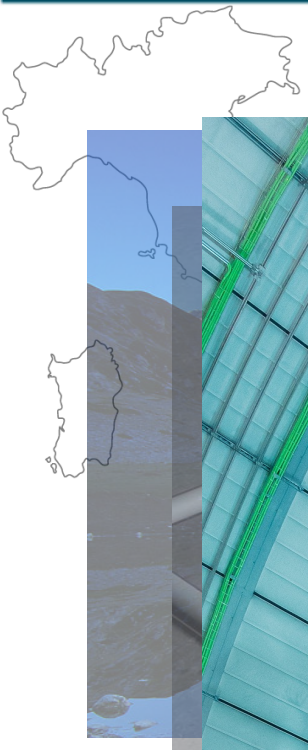
The CRESST collaboration







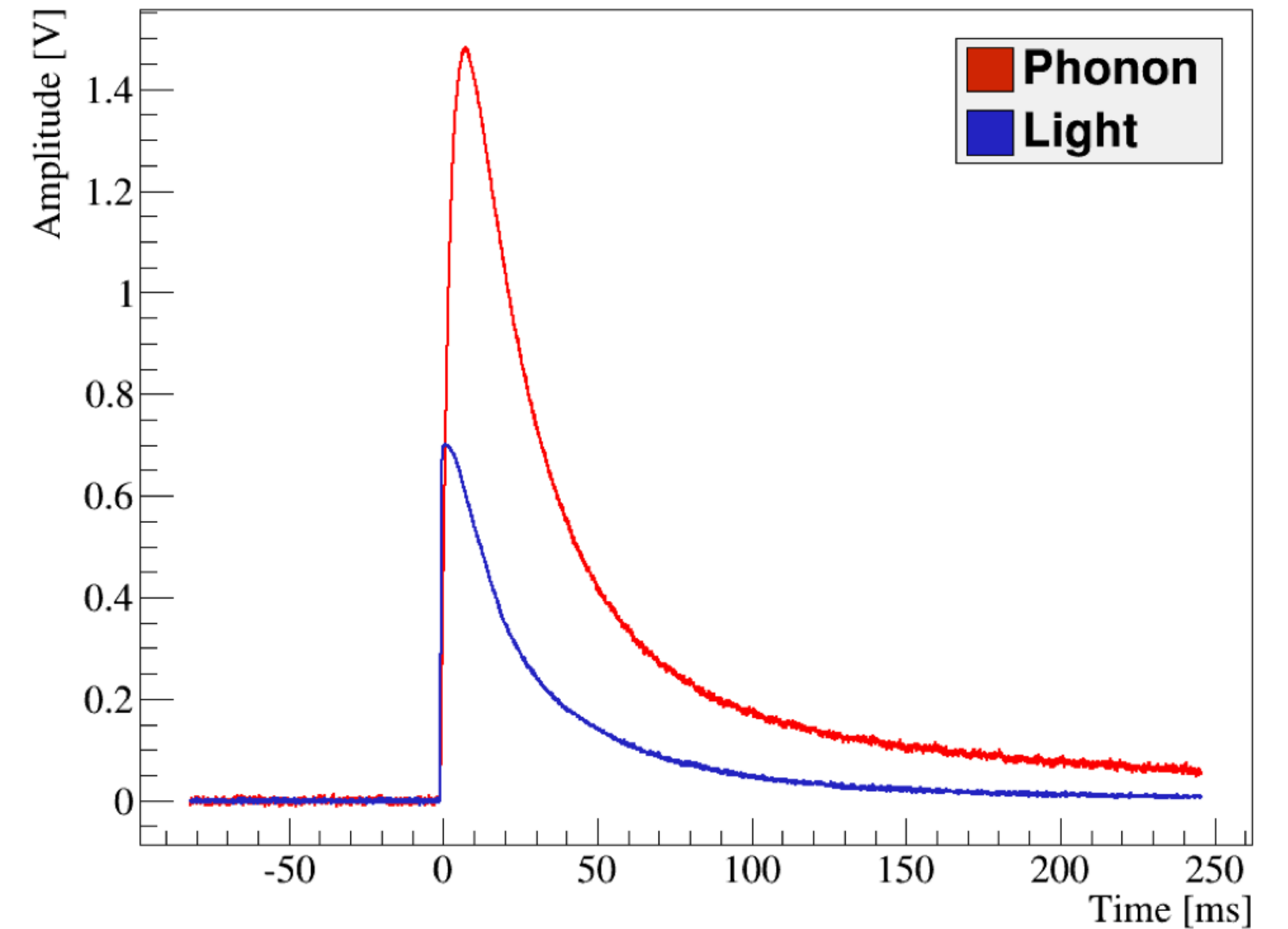
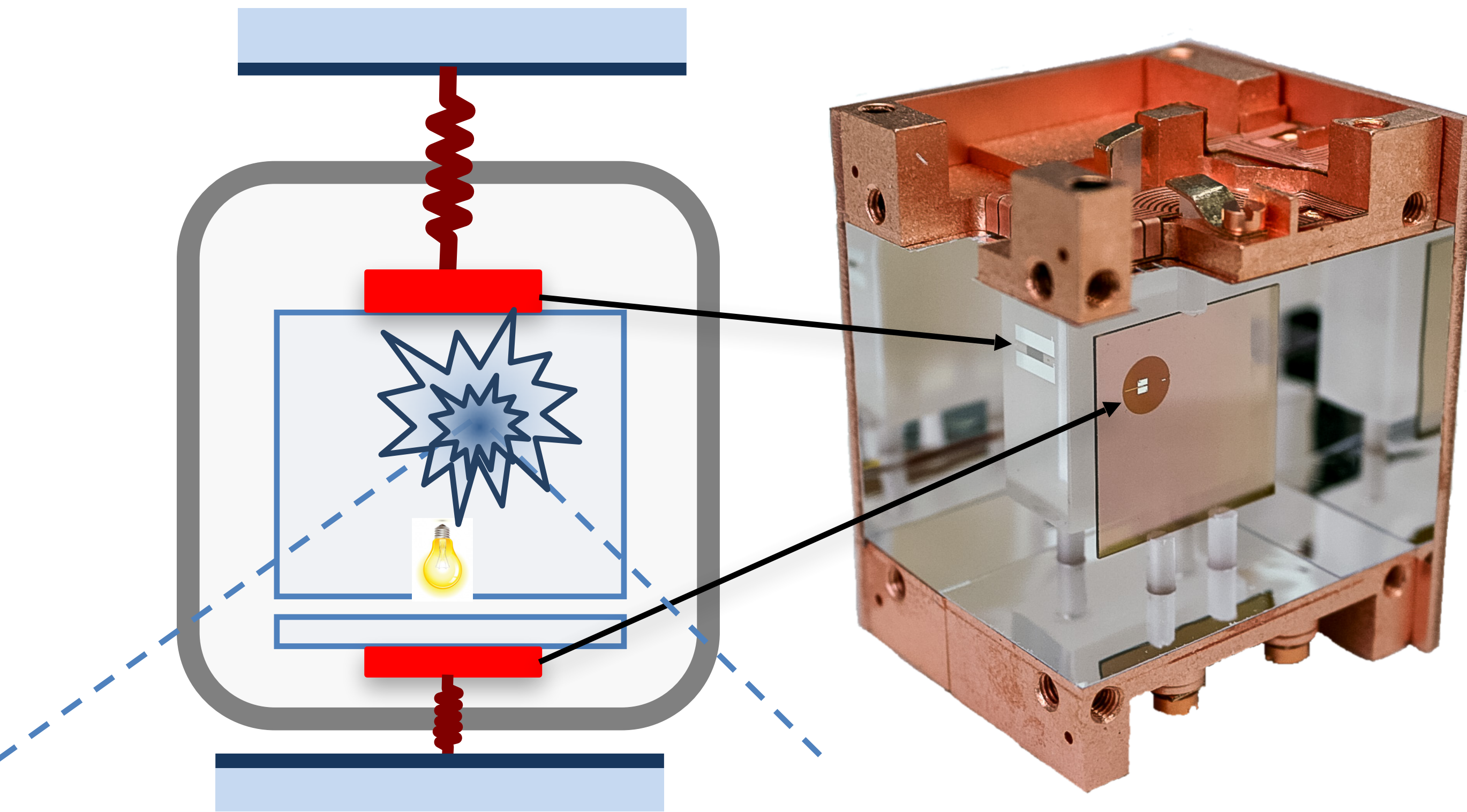




CRESST
Hall A

- ~3600 m.w.e. deep
- μ s: $\sim 3 \times 10^{-8}/(\text{s cm}^2)$
- γ s: $\sim 0.73/(\text{s cm}^2)$
- neutrons: $4 \times 10^{-6} \text{ n}/(\text{s cm}^2)$

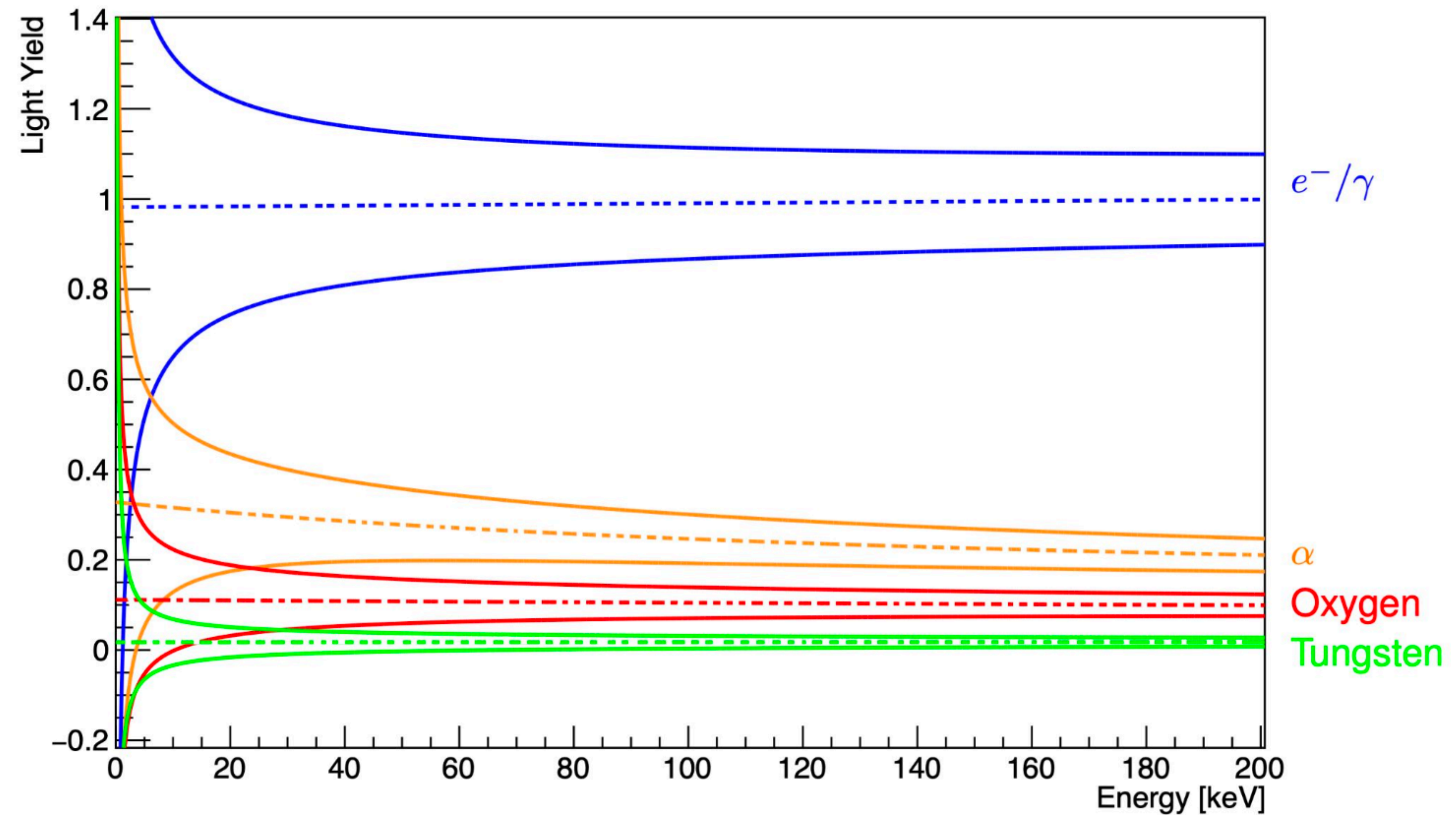


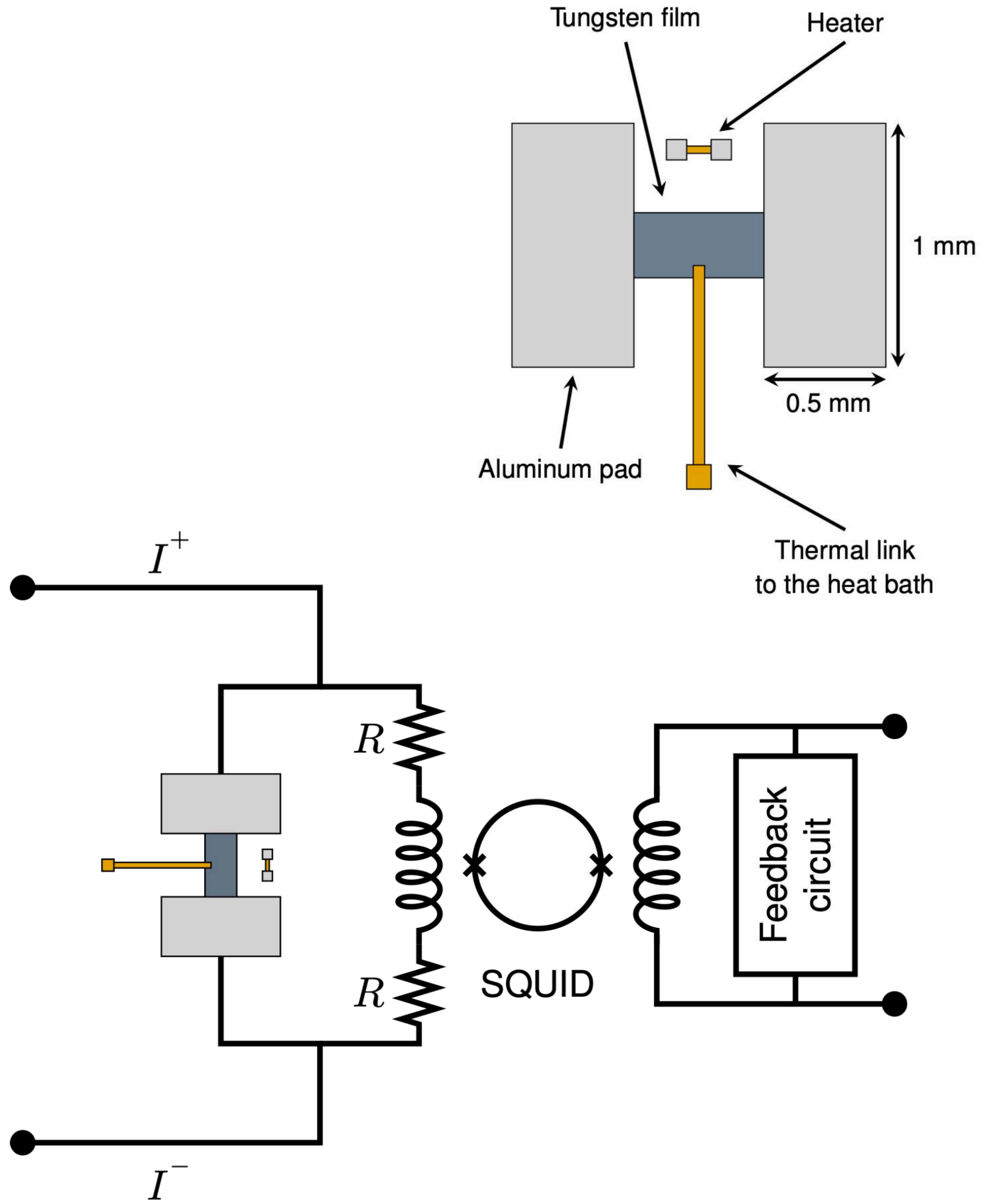
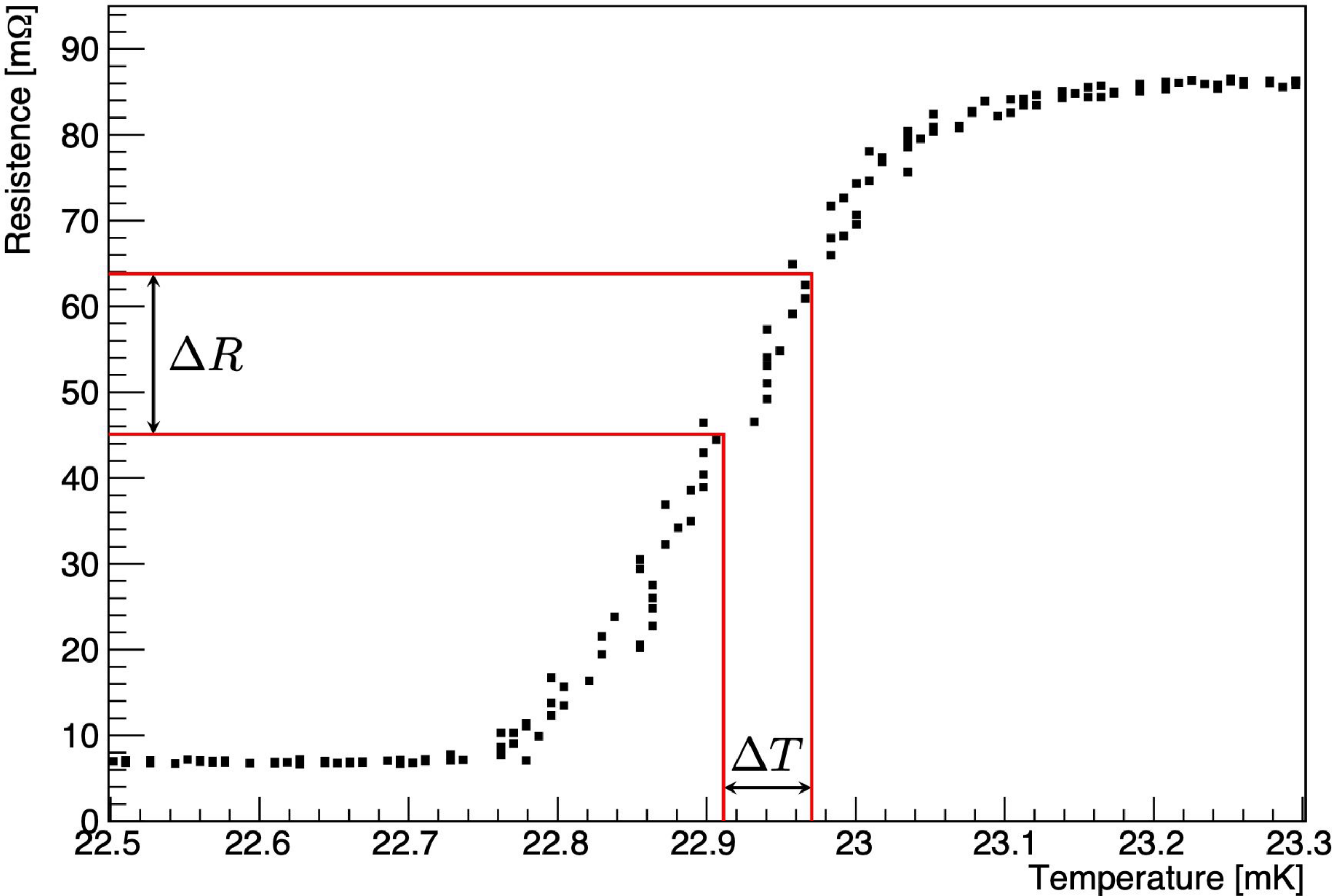


CRESST standard detectors are composed of a scintillating crystal as the main absorber, paired with a Silicon-on-Sapphire wafer as light detector.

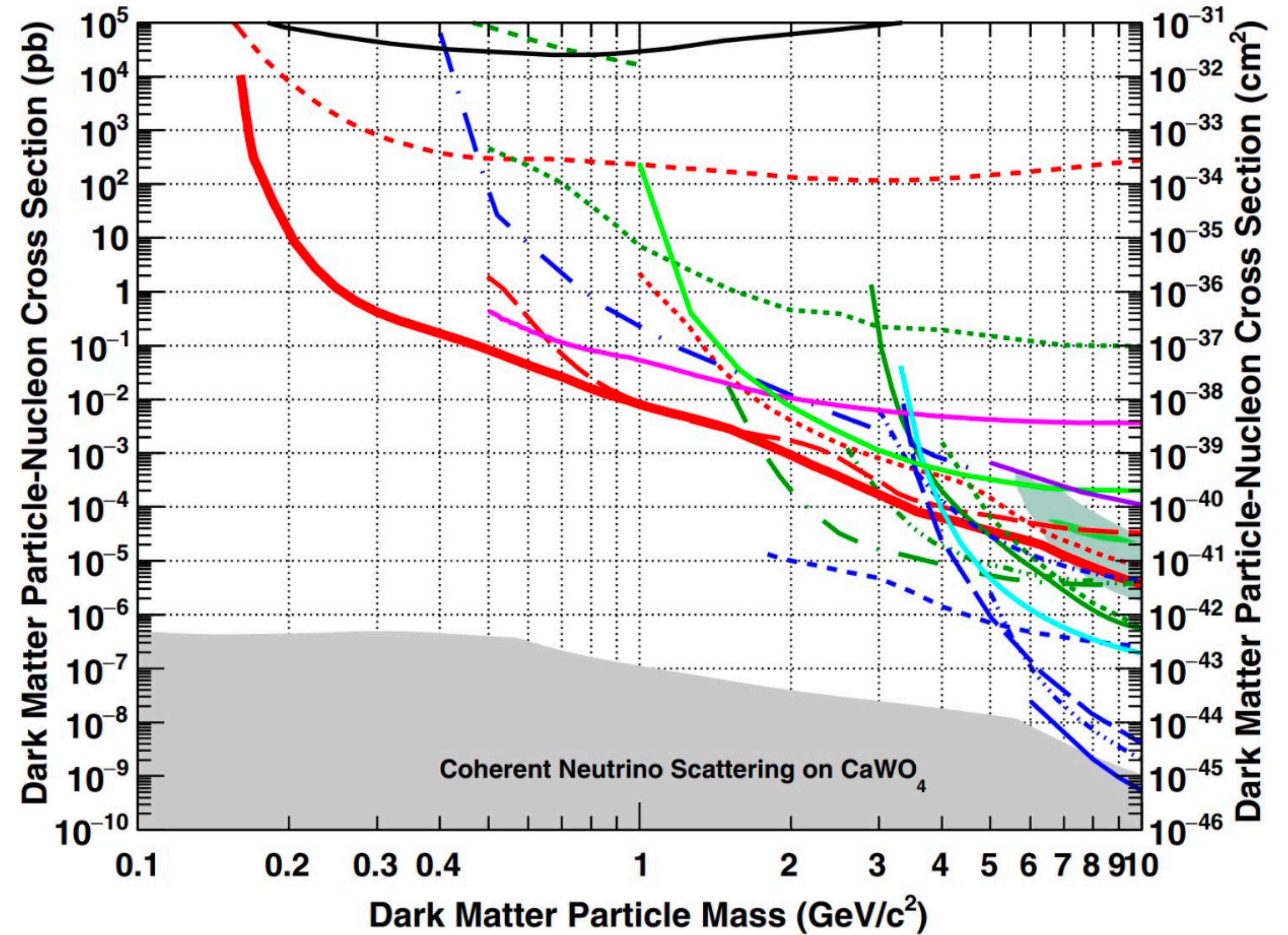
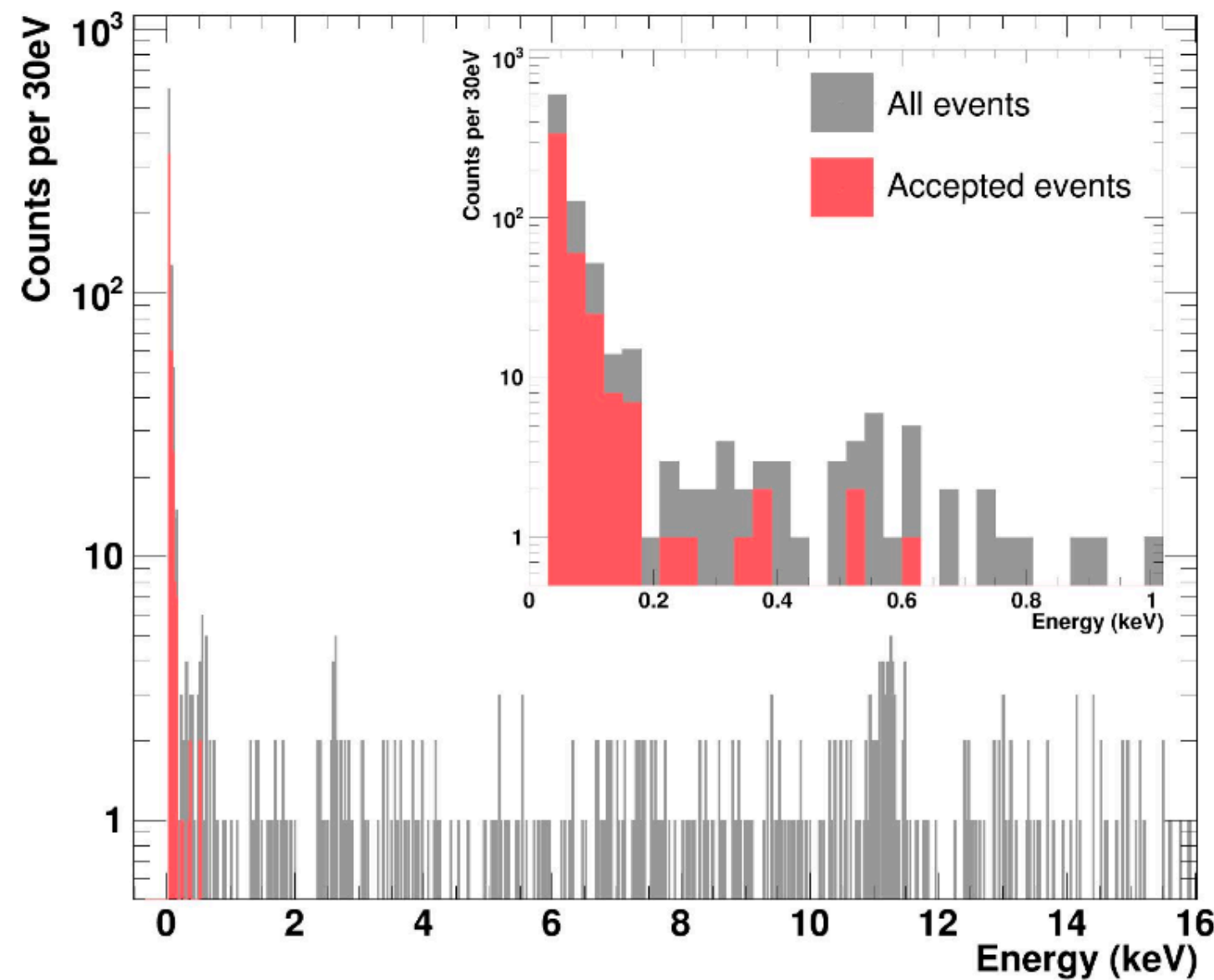
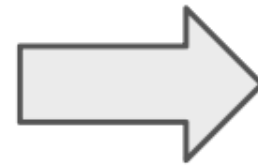
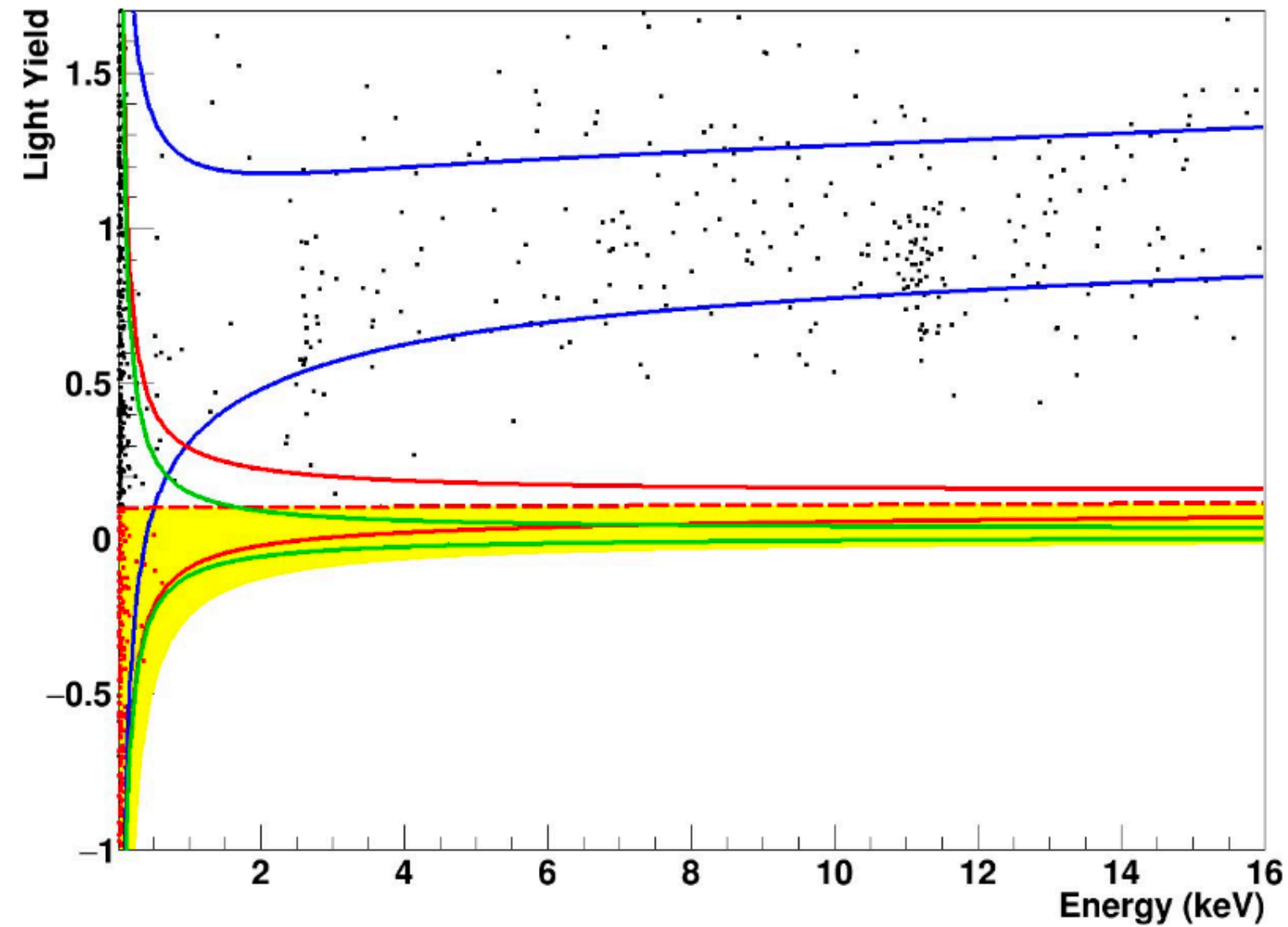
The double readout of light and phonon signals allows for separating potential signal events (nuclear recoils) and the dominant radioactive background (electron recoils) and defining different bands.

$$LY = \frac{\text{Light signal}}{\text{Phonon signal}}$$

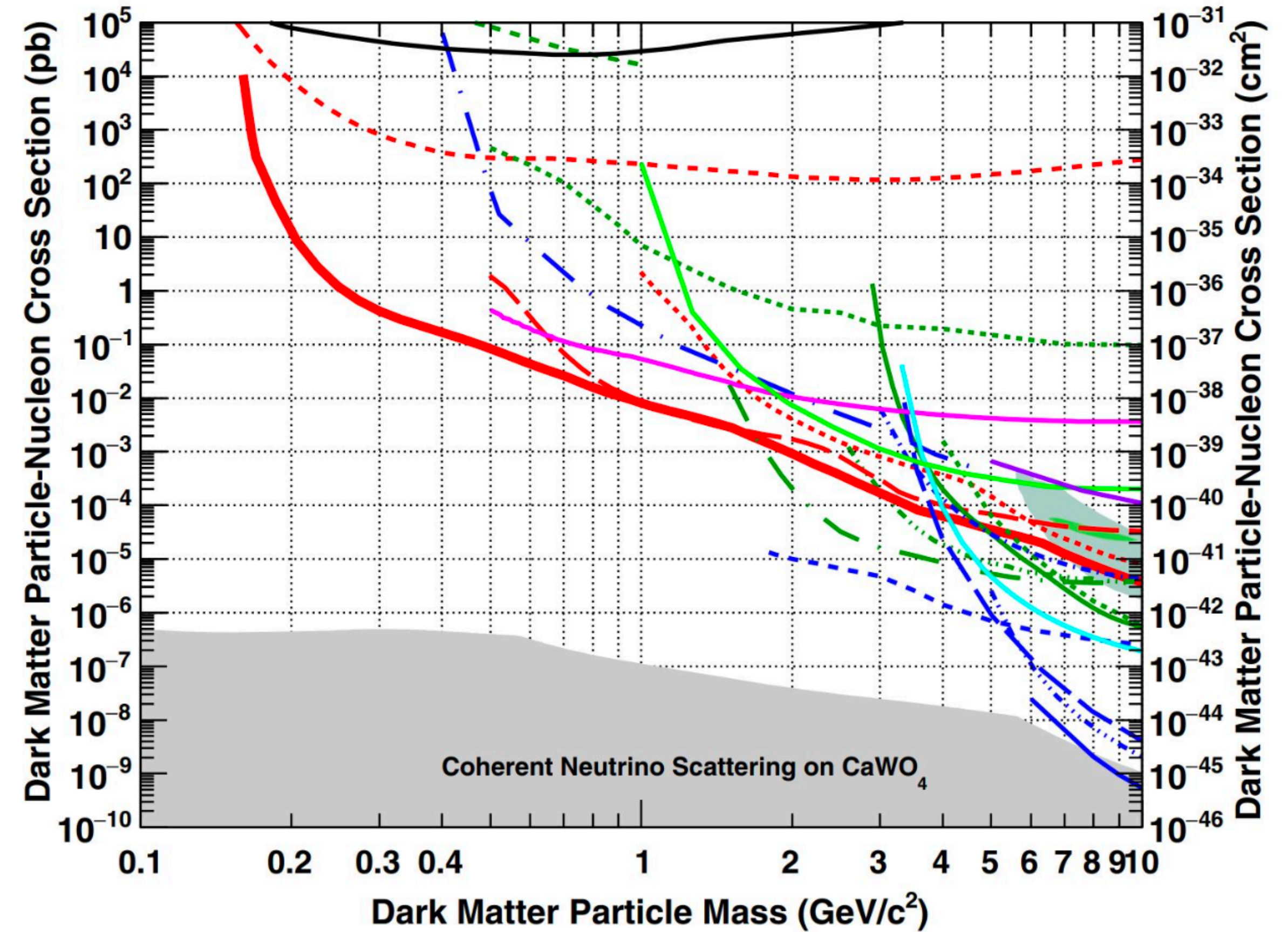
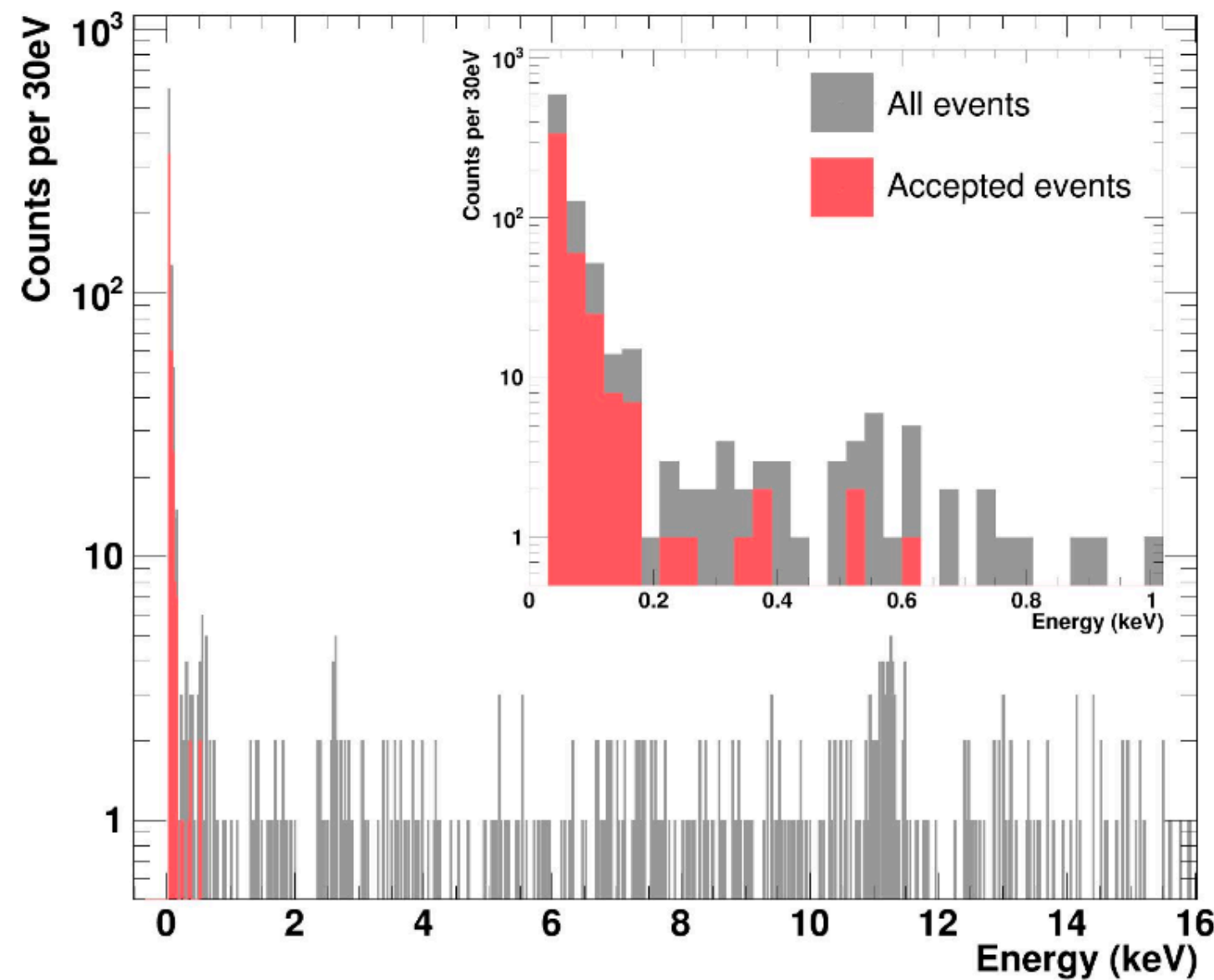
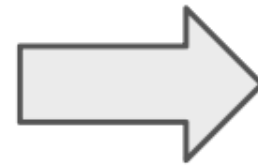
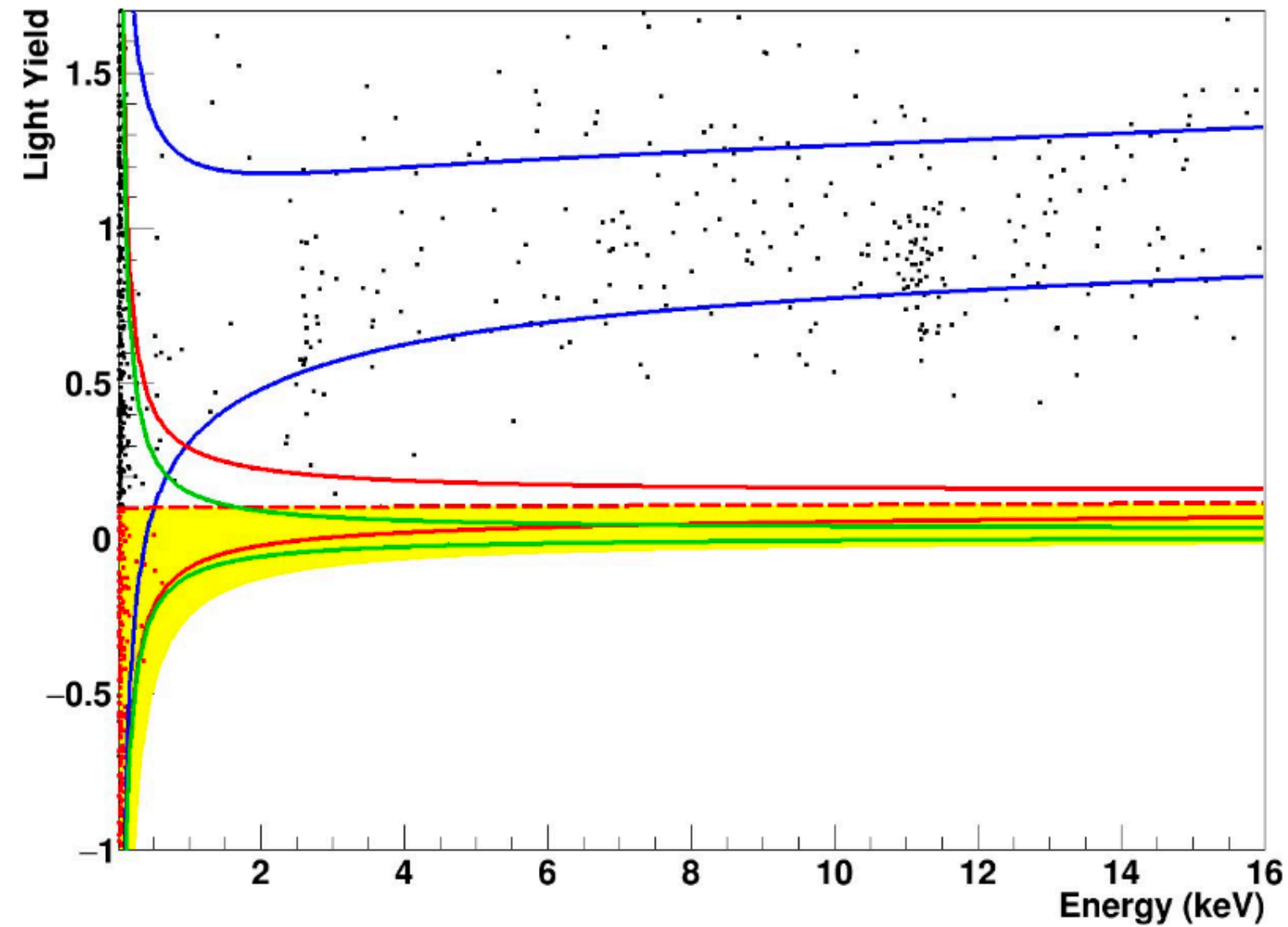




$E \sim \text{keV} \Rightarrow T \sim \mu\text{K} \Rightarrow R \sim \text{m}\Omega$



[Phys. Rev. D 100, 102002](#)



[Phys. Rev. D 100, 102002](#)

Breakthrough result + First observation of the unexpected rise of events below 200 eV, Low Energy Excess (LEE), limiting Dark Matter sensitivity

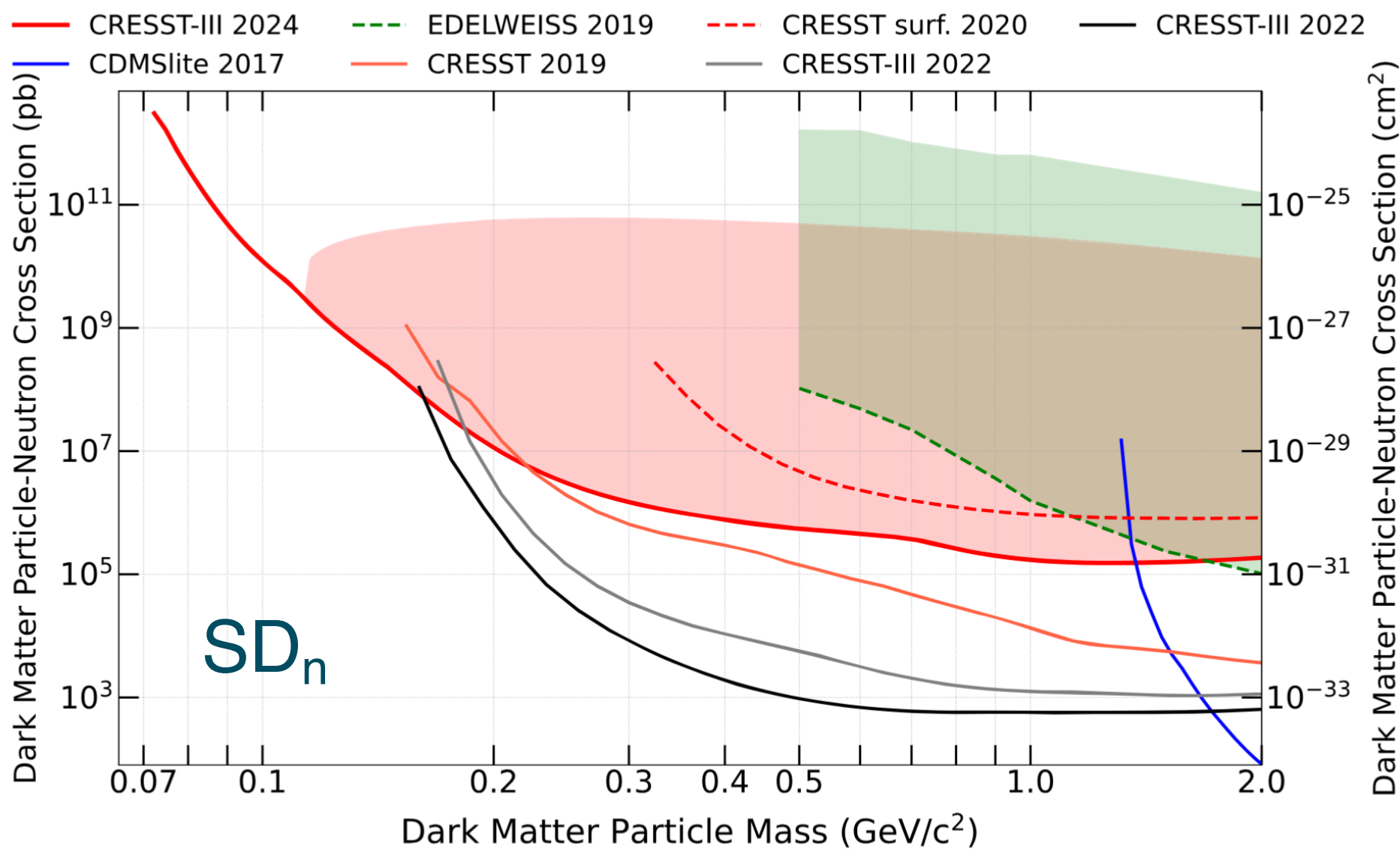
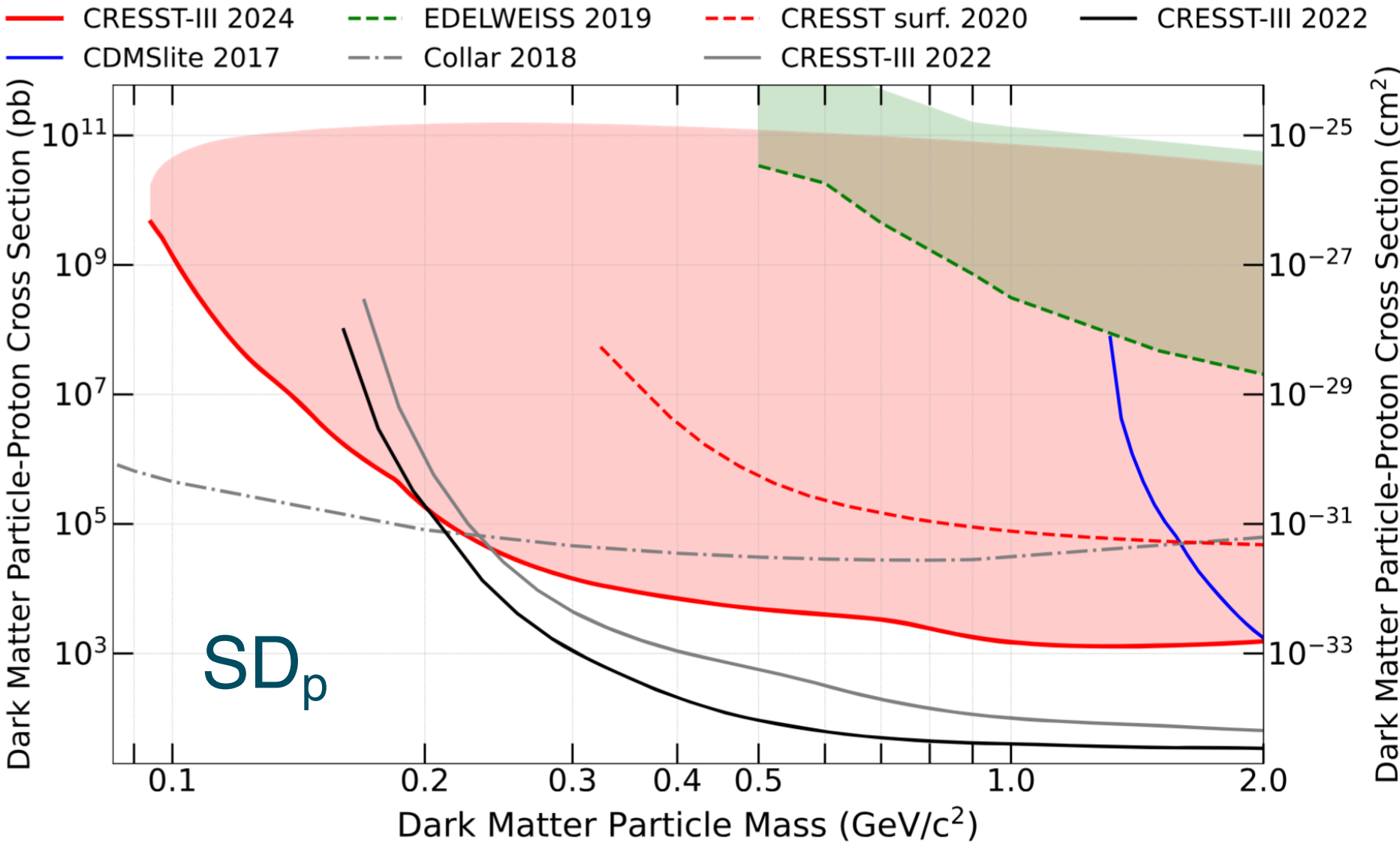
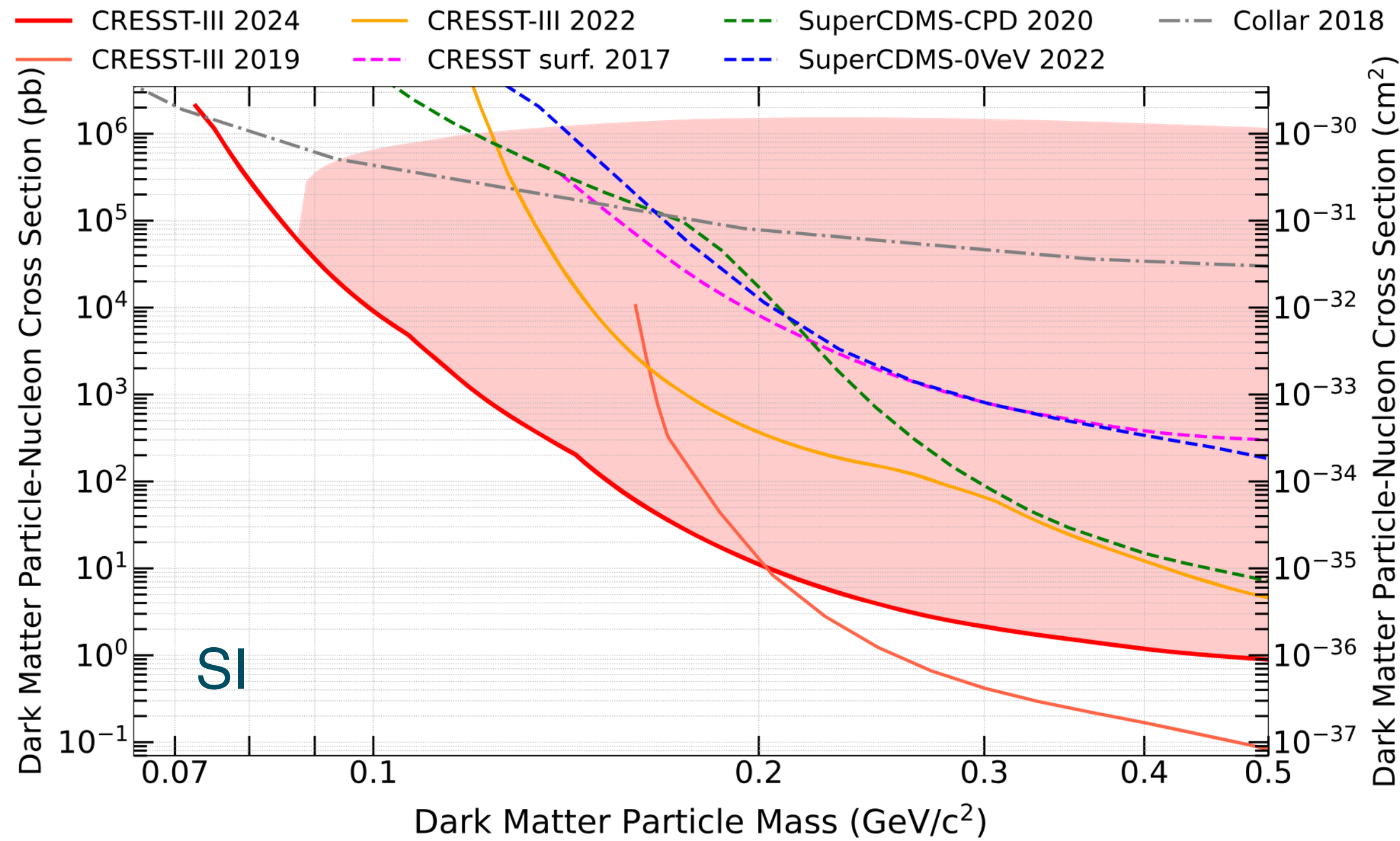
The logo for CRESST, featuring the word "CRESST" in a bold, dark blue, sans-serif font. A stylized orange and red curved line, resembling a comet or a swoosh, passes behind the letters, starting from the bottom left and curving upwards towards the top right.

Spin independent limit with Detector A - **projections with reduced LEE**, Low Energy

Low-threshold Dark Matter results

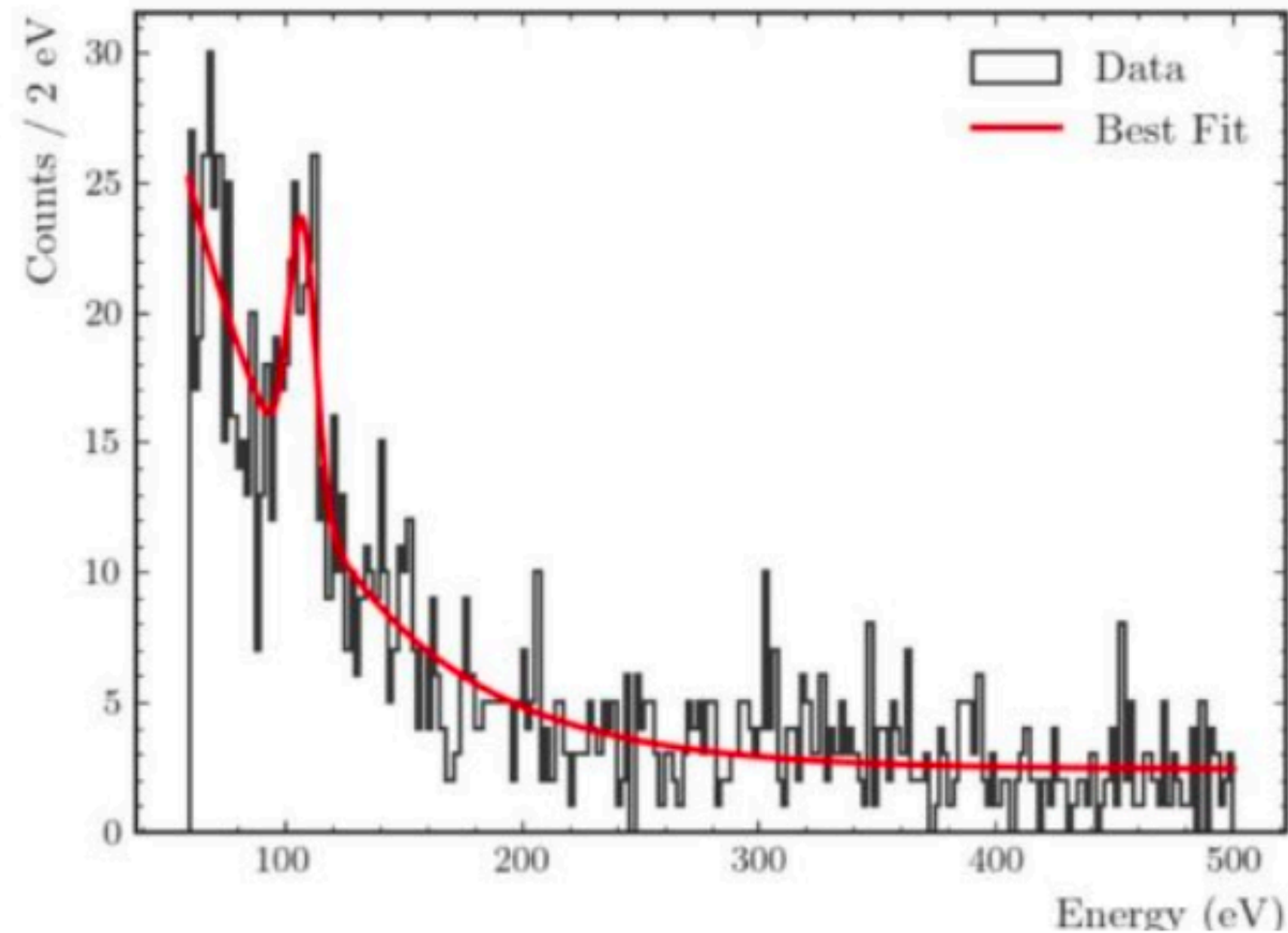
Light detector analyzed for dark matter limit:

Material: Al_2O_3
Mass: 0.6 g
Exposure: 138 g · days
Resolution: 1 eV
Threshold: 6.7 eV_{nr}



10.1103/PhysRevD.110.083038

[Phys. Rev. D 108, 022005](#)

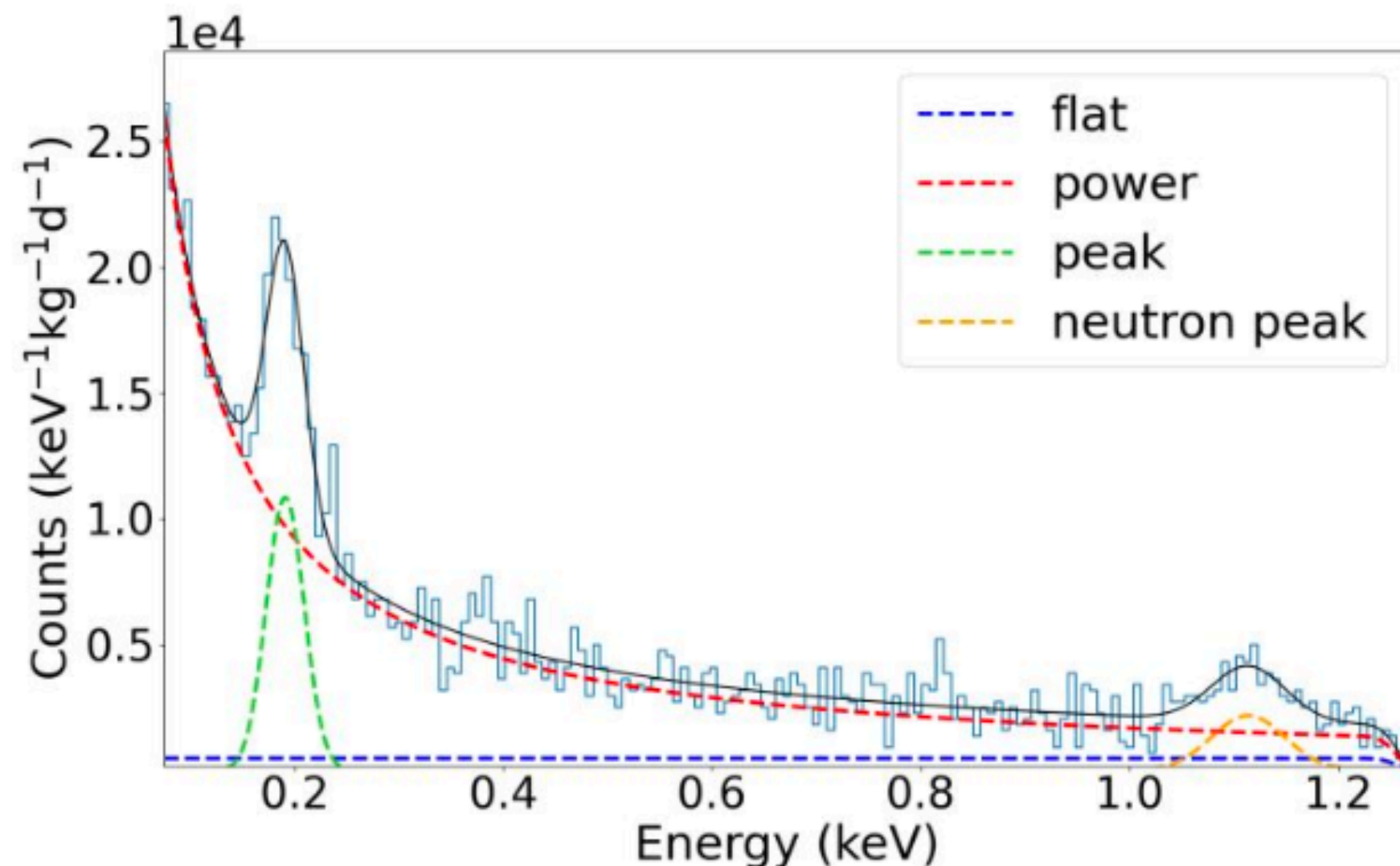


New technique for low nuclear recoil energy calibration for CaWO_4 and Al_2O_3 crystals through (n, γ) reactions



De-excitation gamma of 6.1 MeV and W nuclear recoil of 112eV

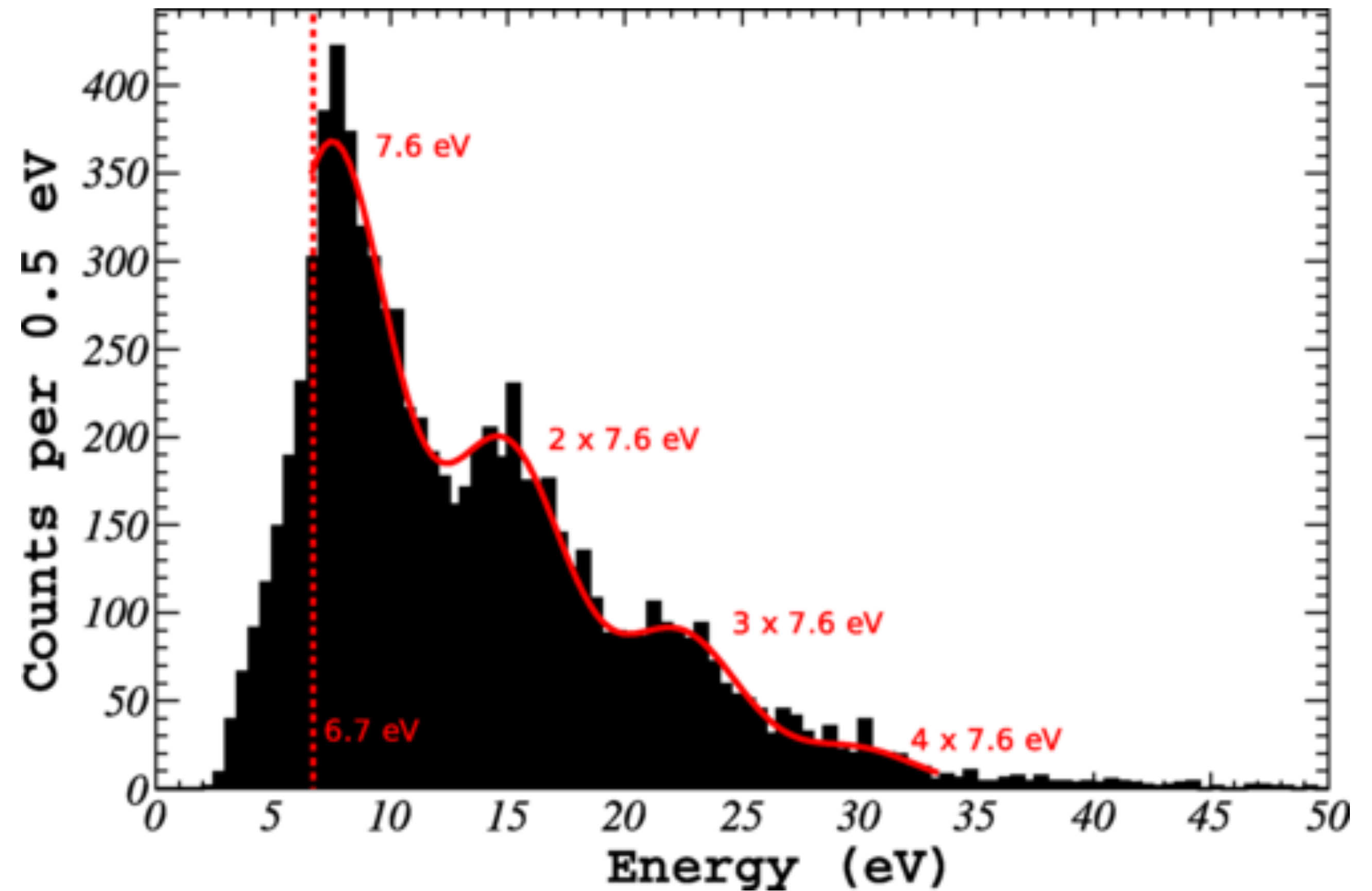
[arxiv.org:2506.09059](#)



De-excitation gamma of 7.7 MeV and Al nuclear recoil of 1144eV

First measurement of single photon in CRESST from sapphire de-excitation

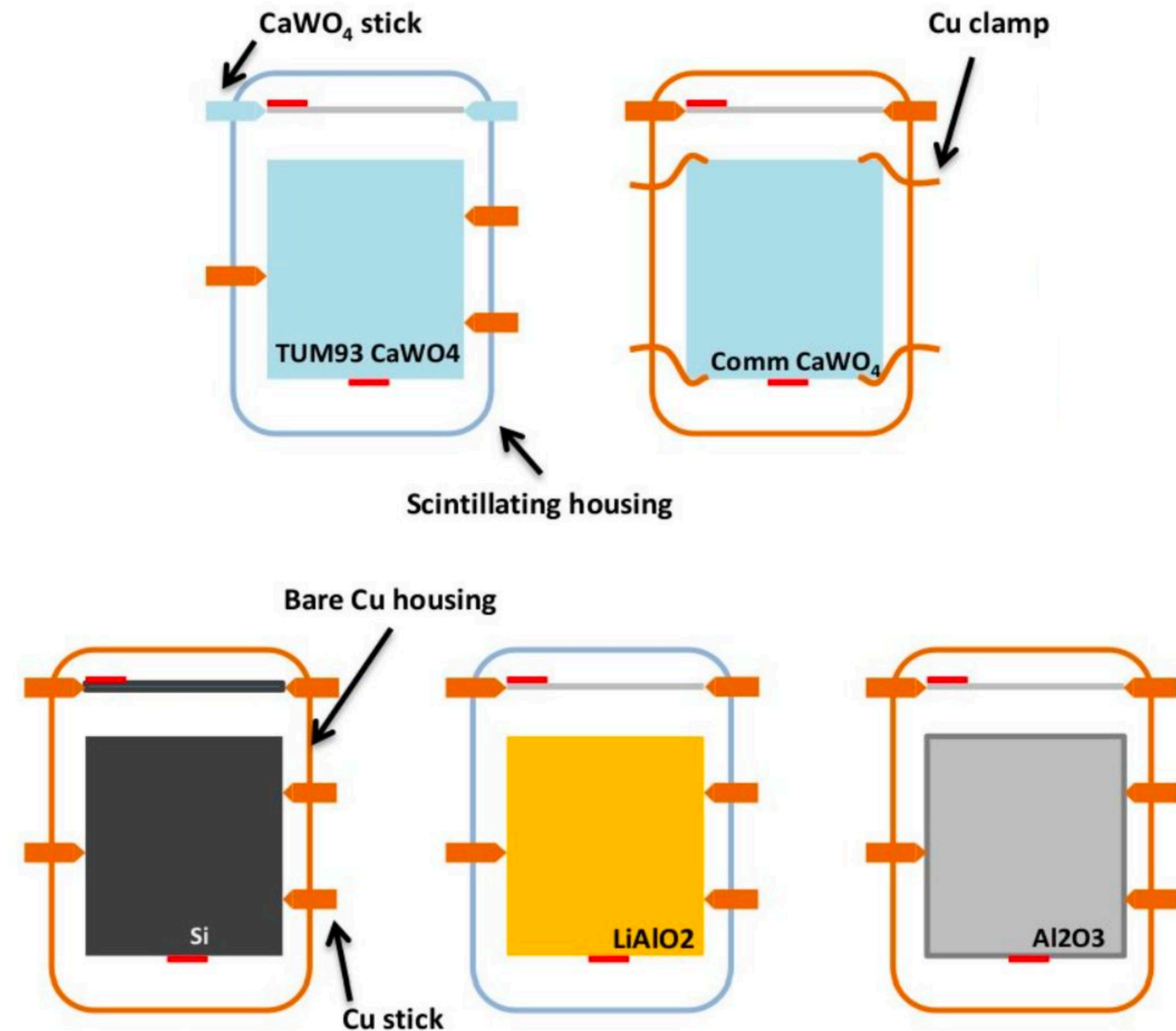
Confirm validity of our calibration method done with ^{55}Fe source (5.9 and 6.5 keV) is valid down to threshold



Phys. Rev. D 110, 083038

Physics campaign to pinpoint the LEE

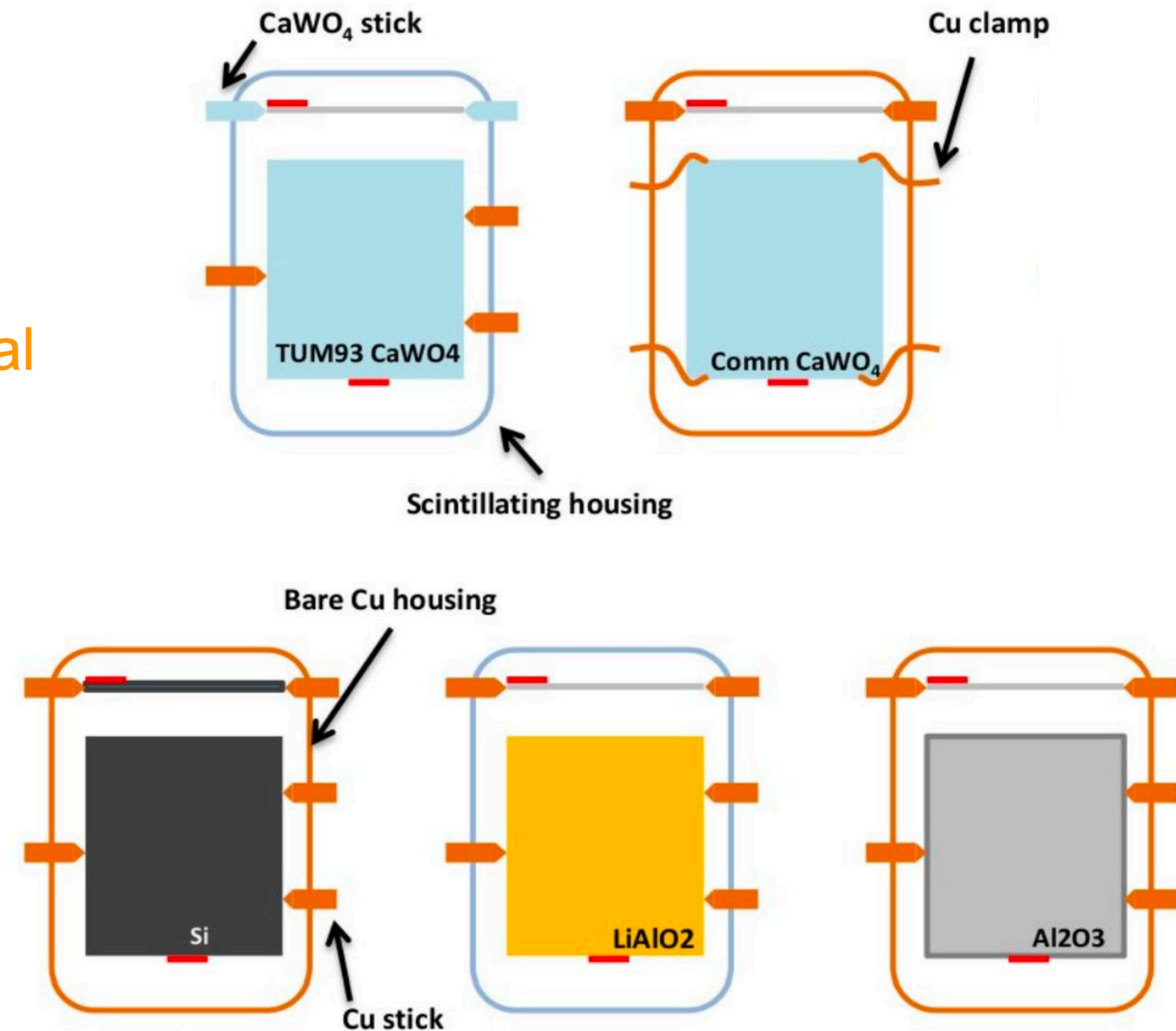
Target material?
Stress induced by holder?
Crystal growth parameters?
Scintillating material?
Geometry?

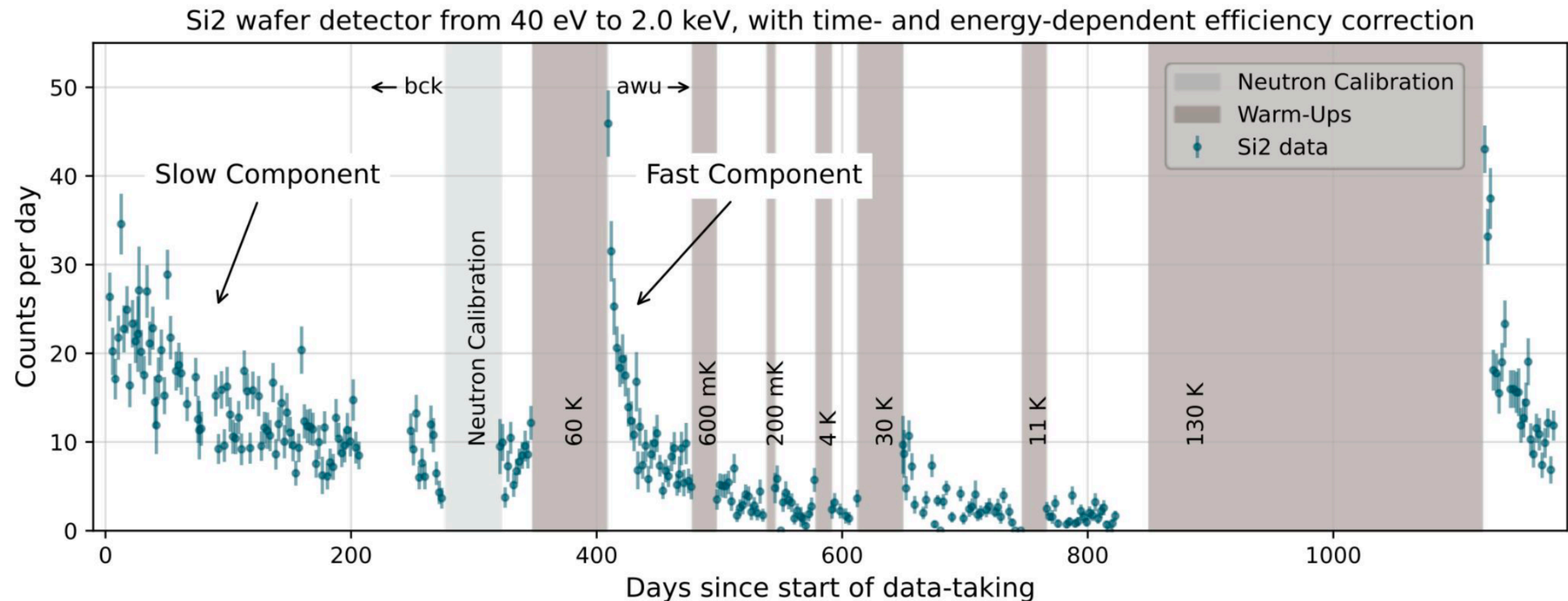


Physics campaign to pinpoint the LEE

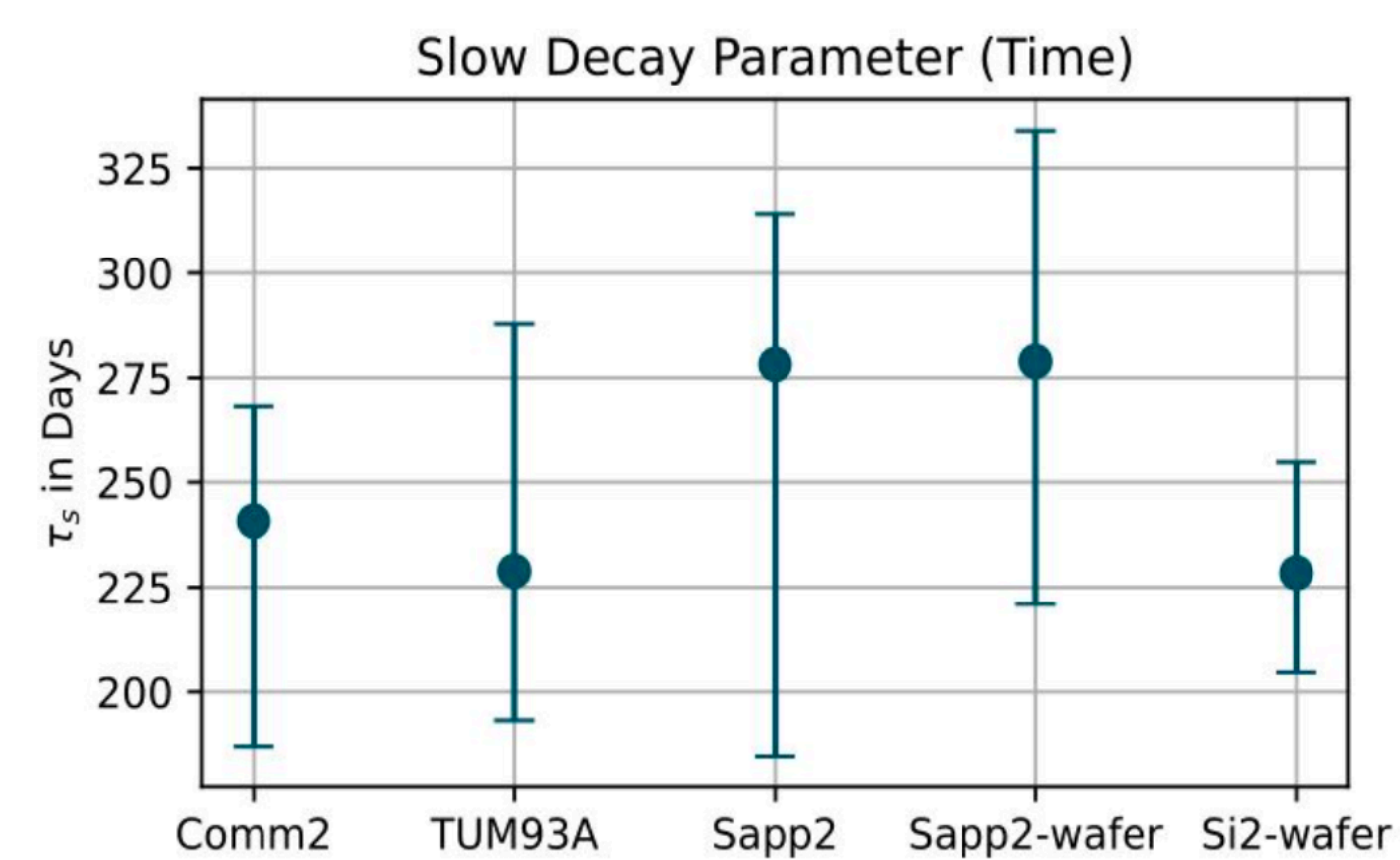
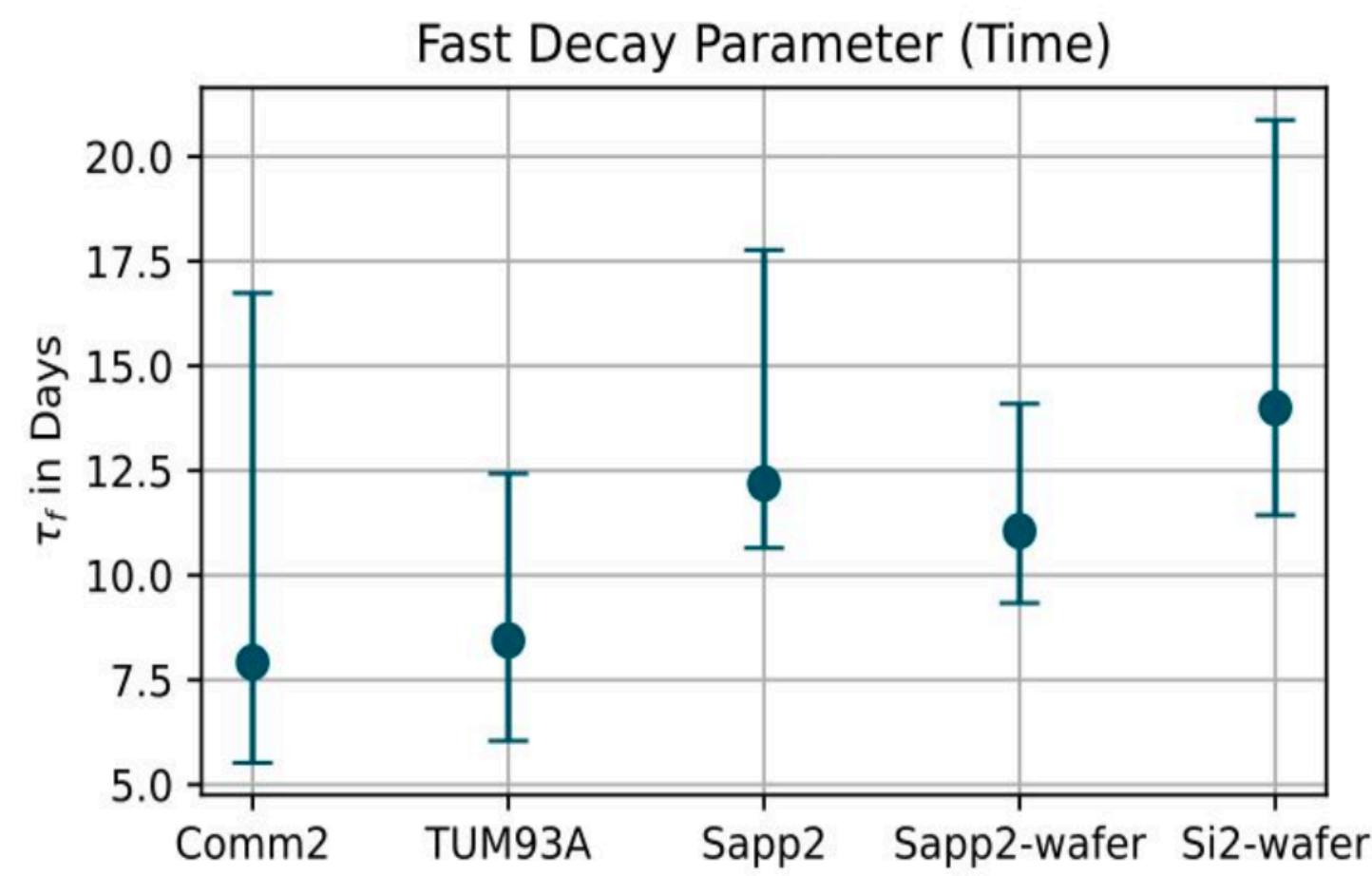
Target material? Different materials
Stress induced by holder? Different holder
Crystal growth parameters? Tested on slow grown crystal
Scintillating material? Removed scintillating material
Geometry? LEE studies also on wafer

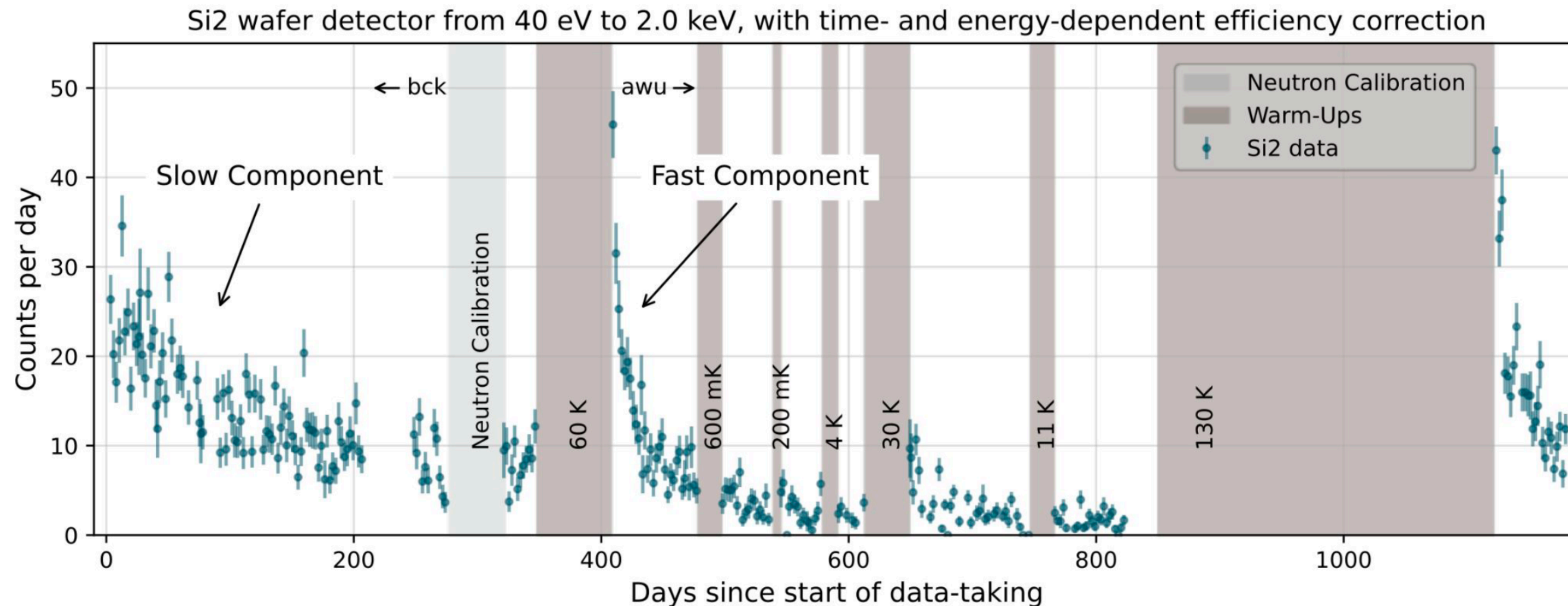
None of the modification had a significant impact on the LEE





- Rate monitoring over time:
- Rate decays exponentially in time
 - Reset of the rate after warm-up cycles
 - Two decay constants
 - Fast decay ~ 10 days
 - Slow decay ~ 250 days

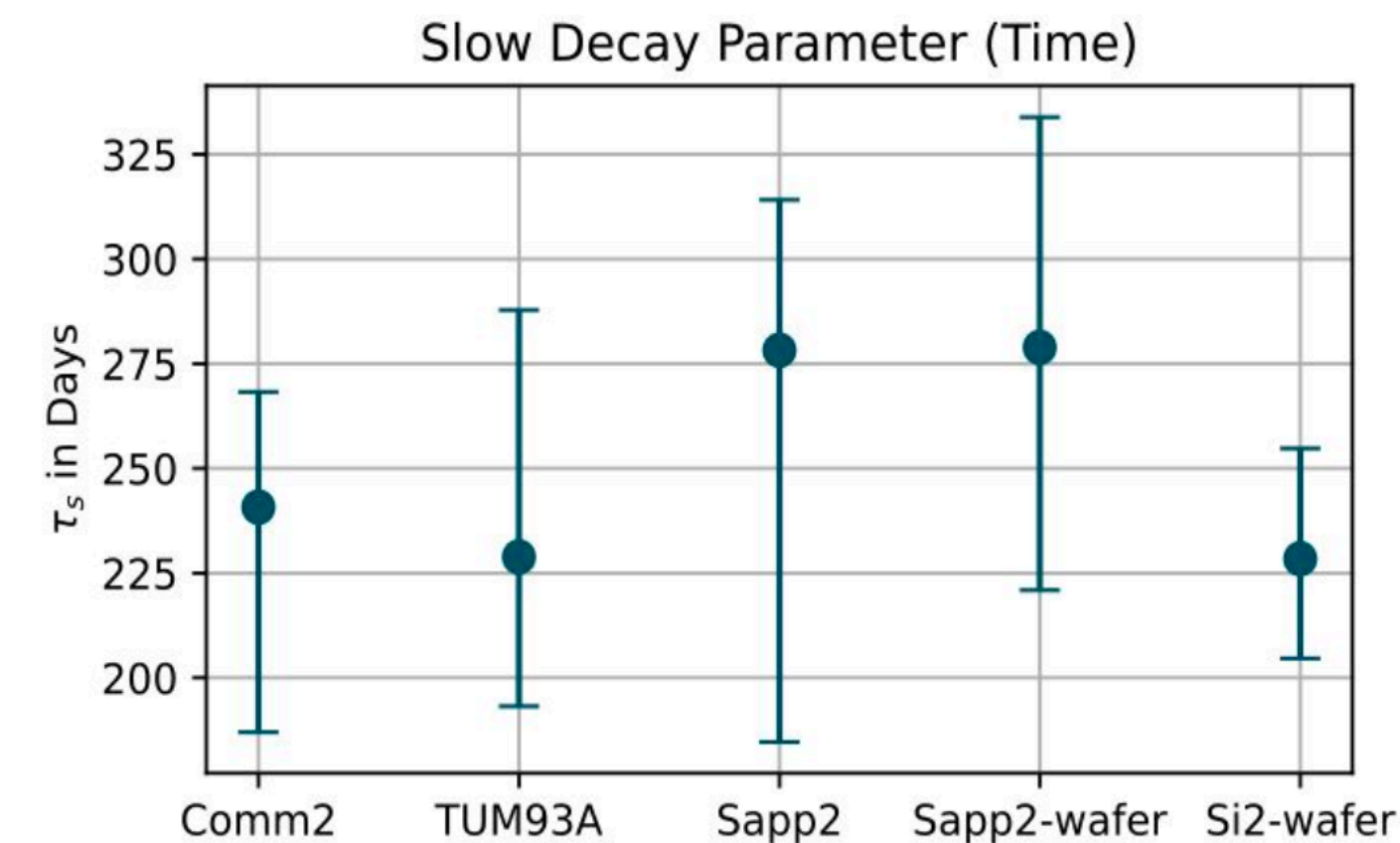
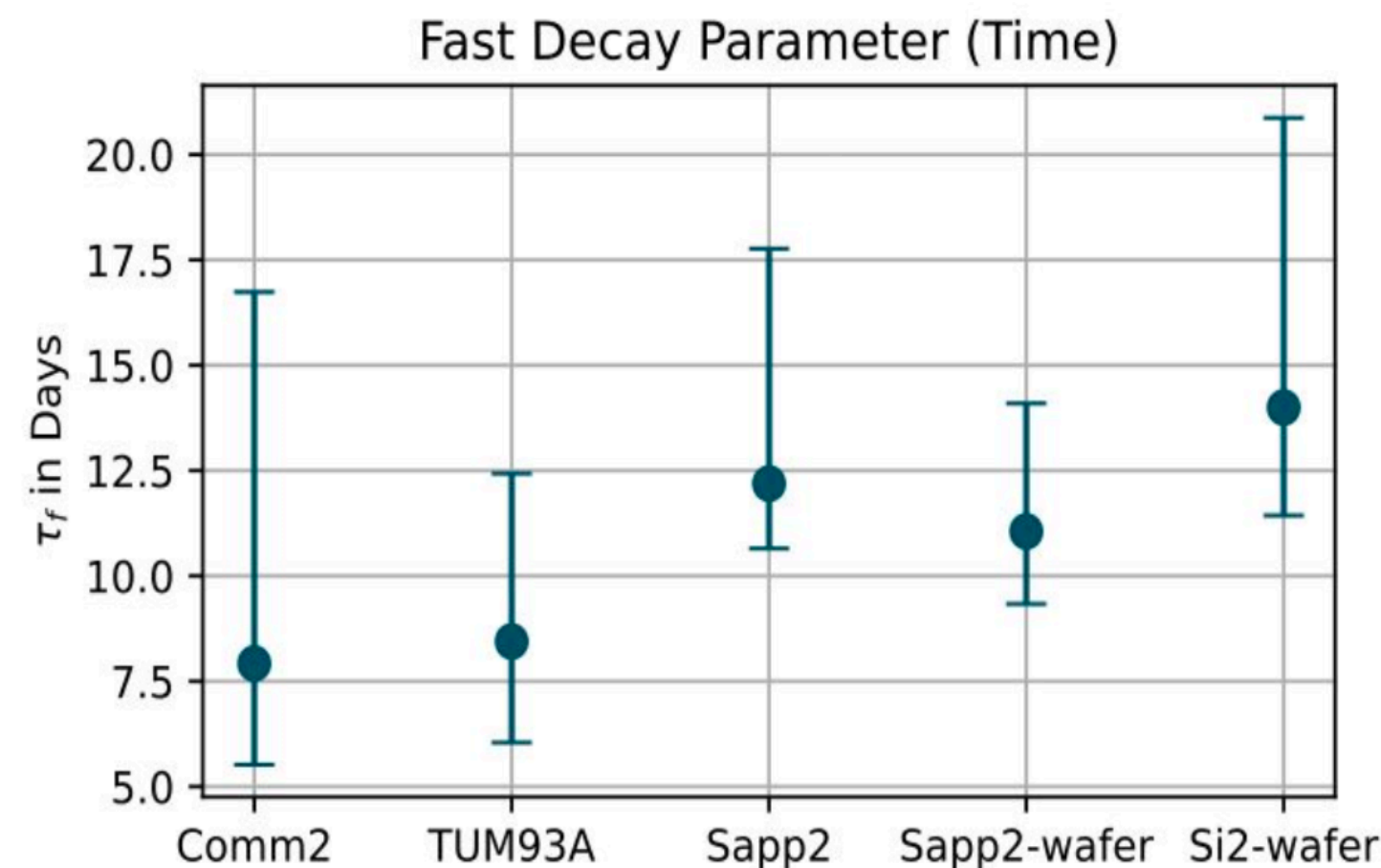




Not caused by radioactivity

Rate monitoring over time:

- Rate decays exponentially in time
- Reset of the rate after warm-up cycles
- Two decay constants
 - Fast decay ~ 10 days
 - Slow decay ~ 250 days



Double TES approach

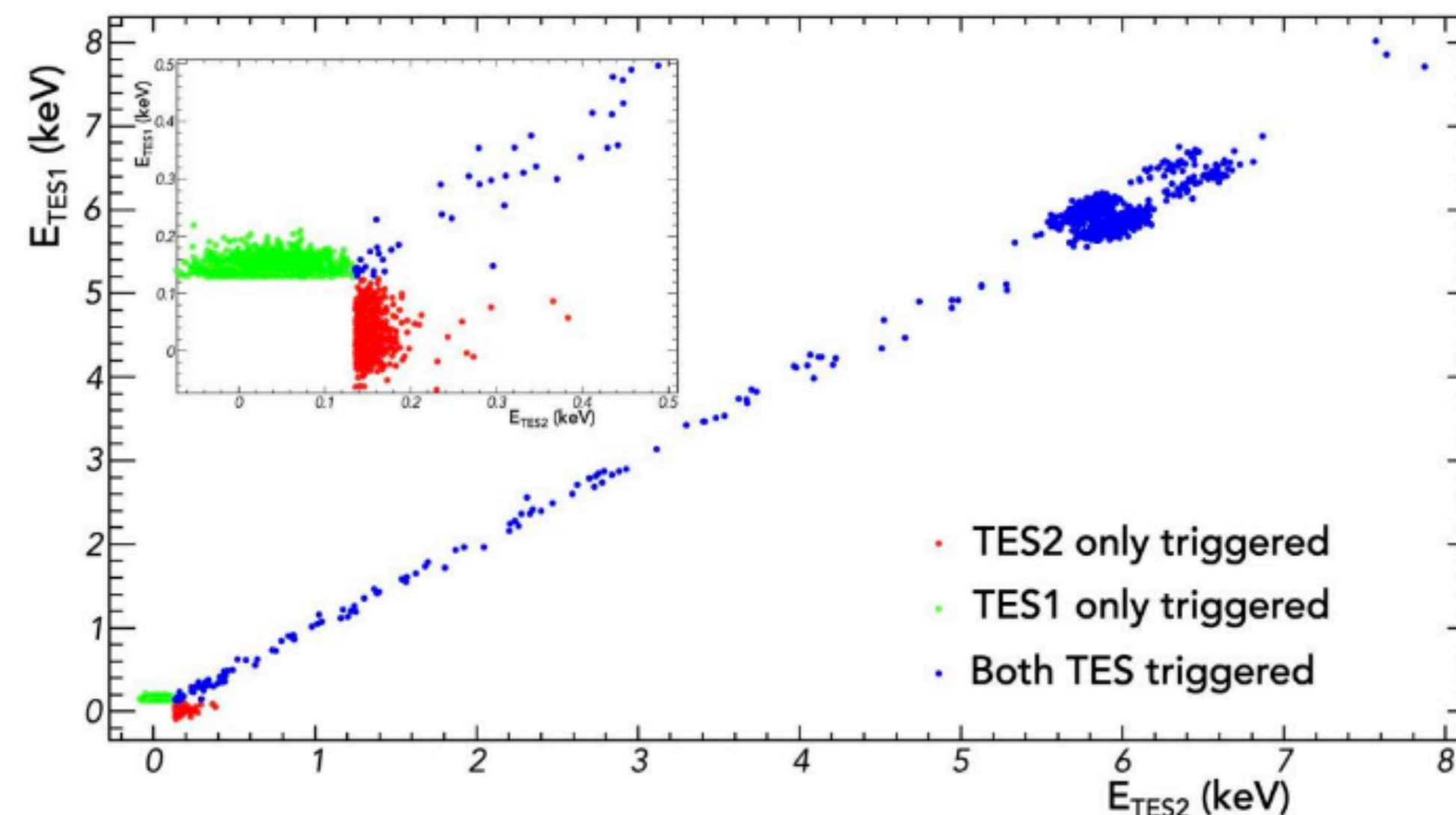
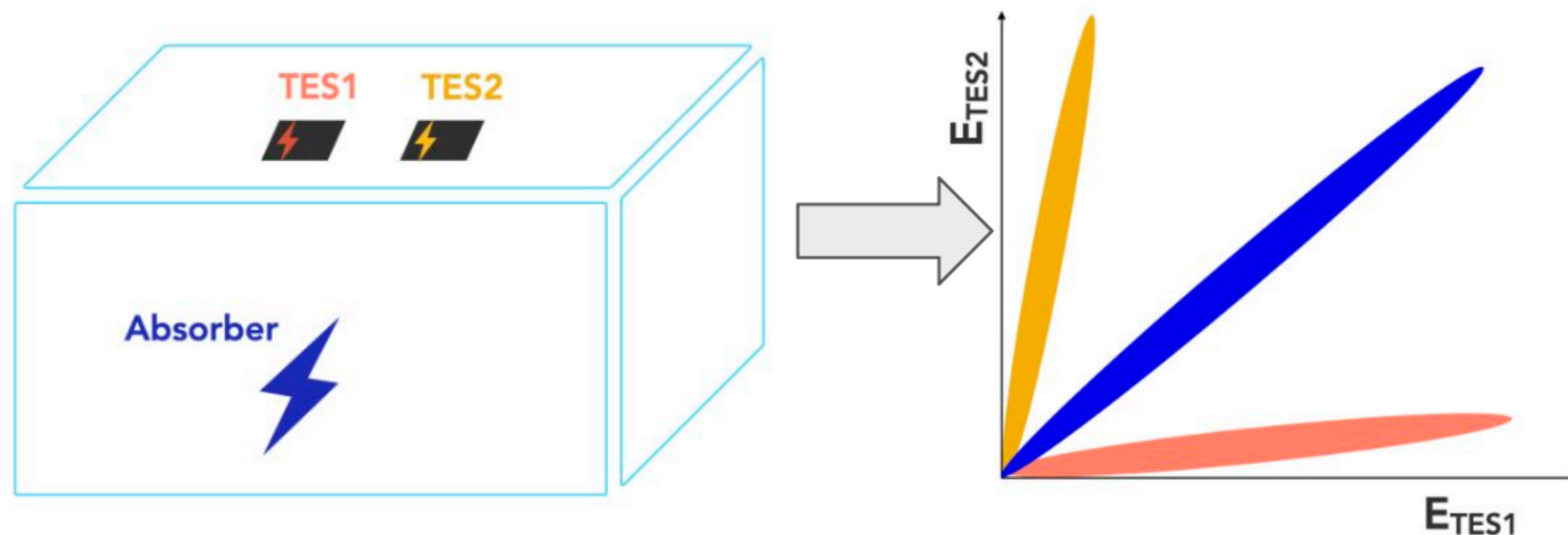
Probe the LEE origin

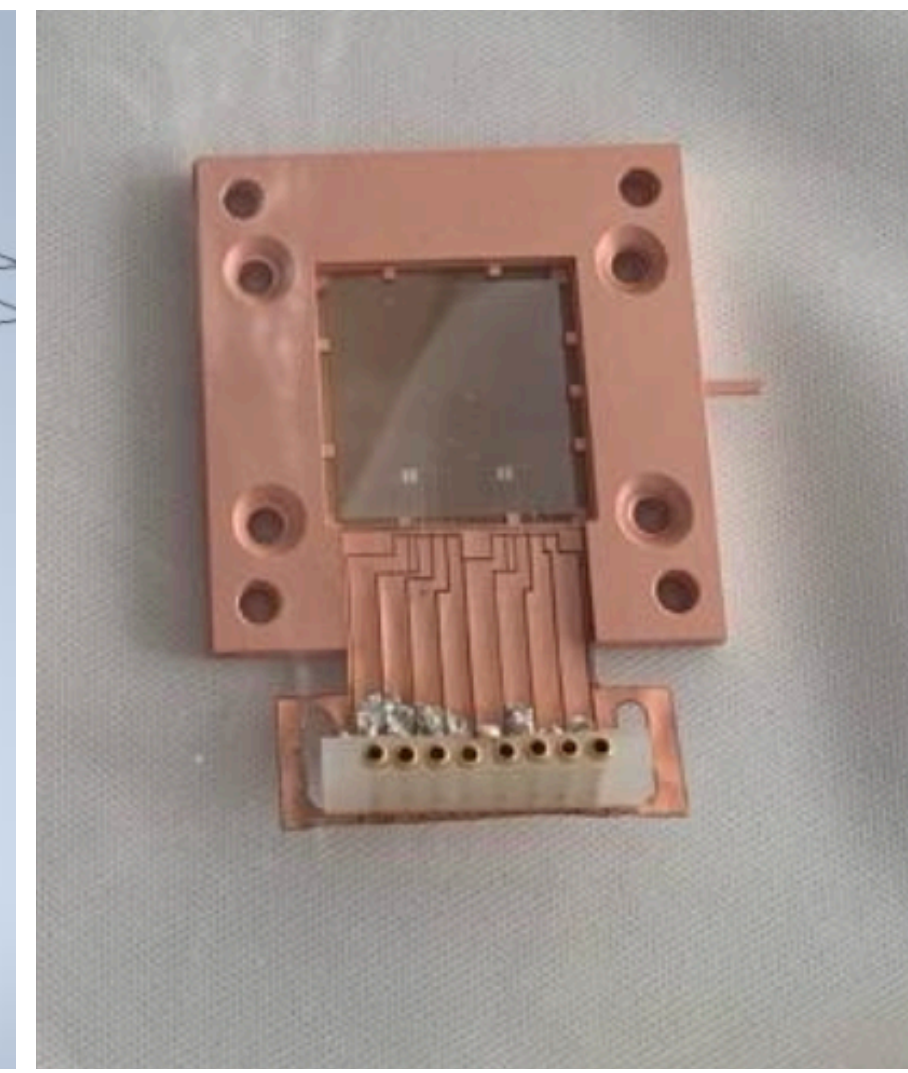
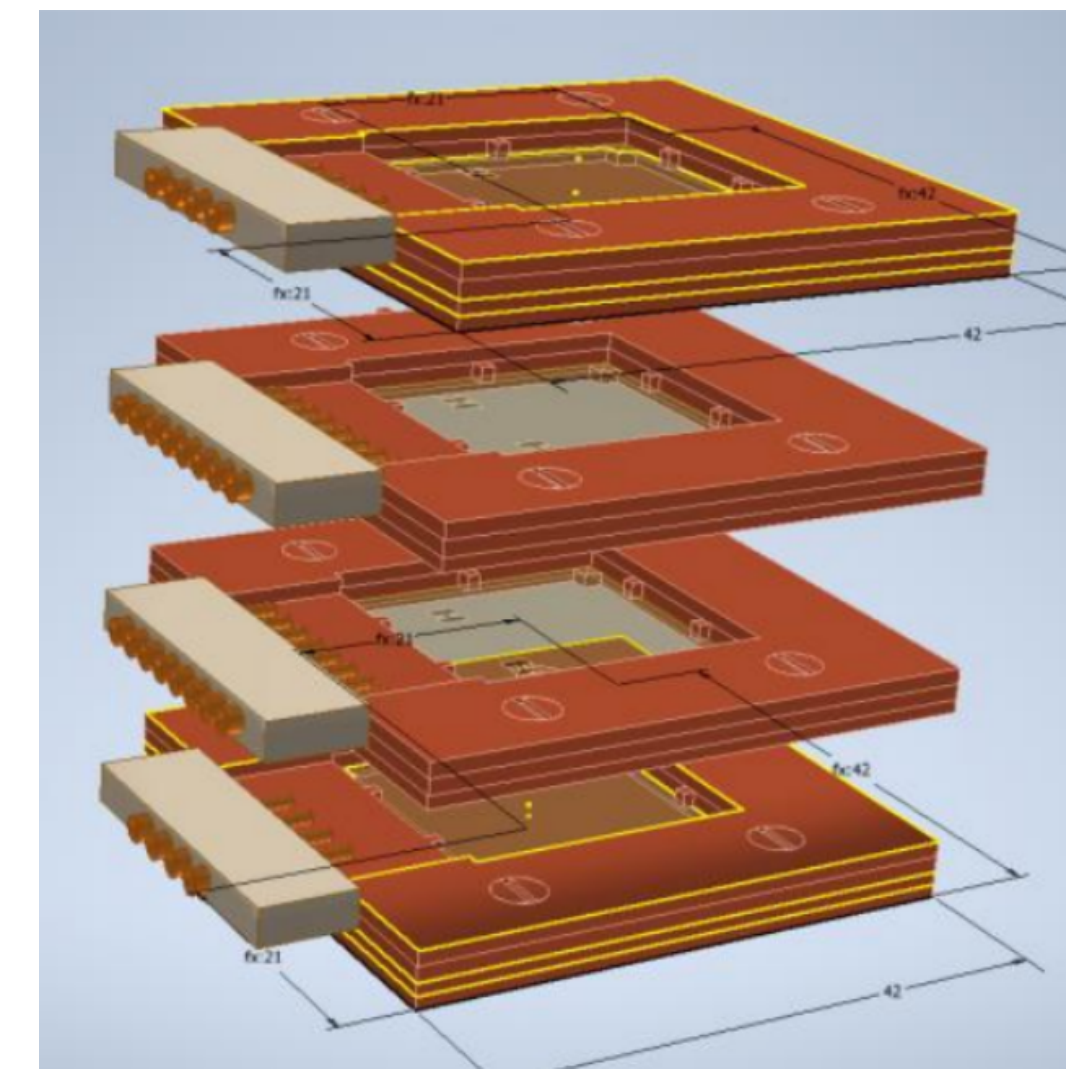
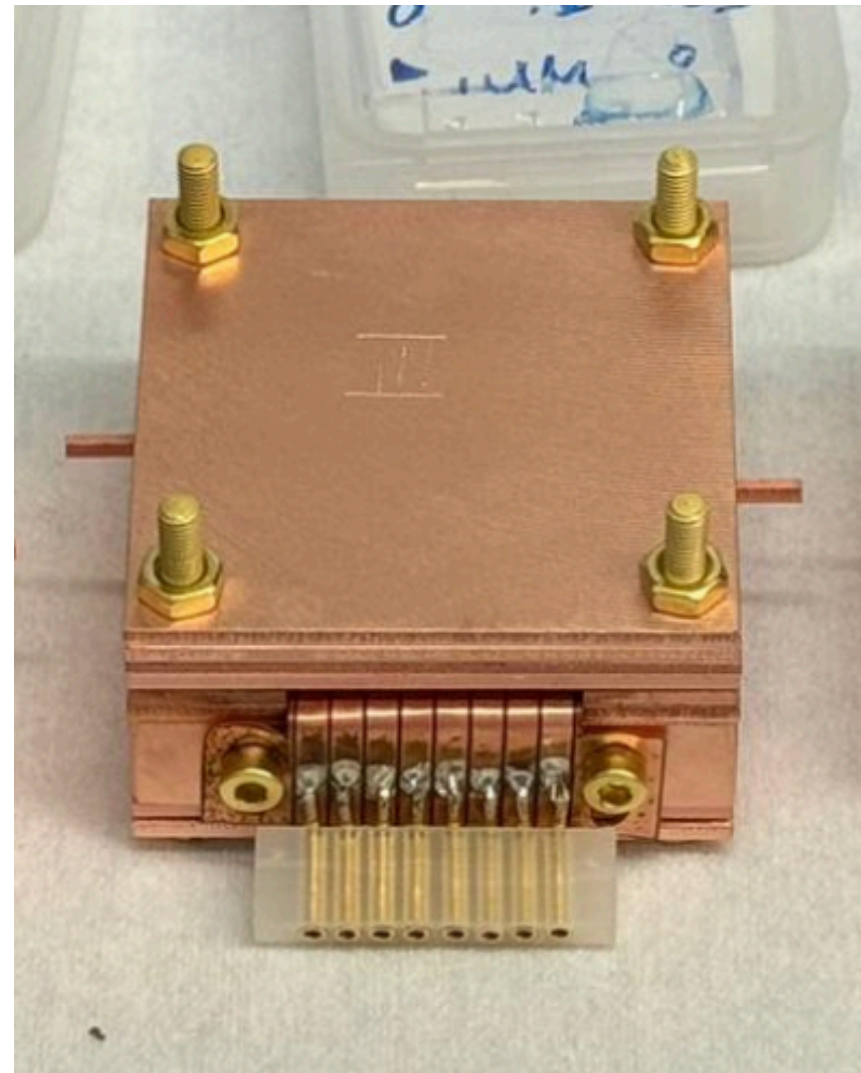
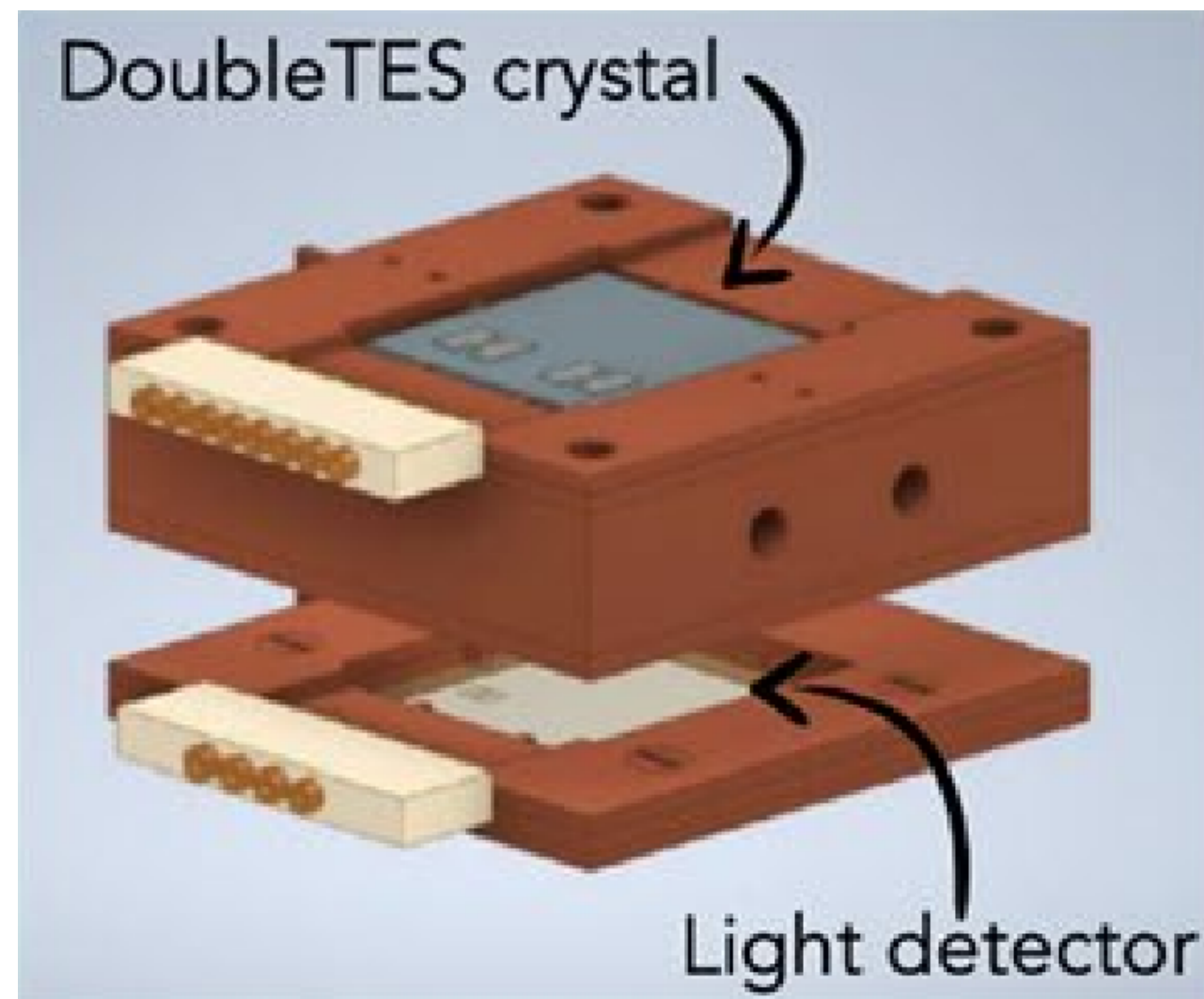
from inside TES or from interface between TES and the crystal

Idea

- Events from the absorber are shared between the 2 TES
- Events close to single TES are seen only by one TES

First results from above ground measurement





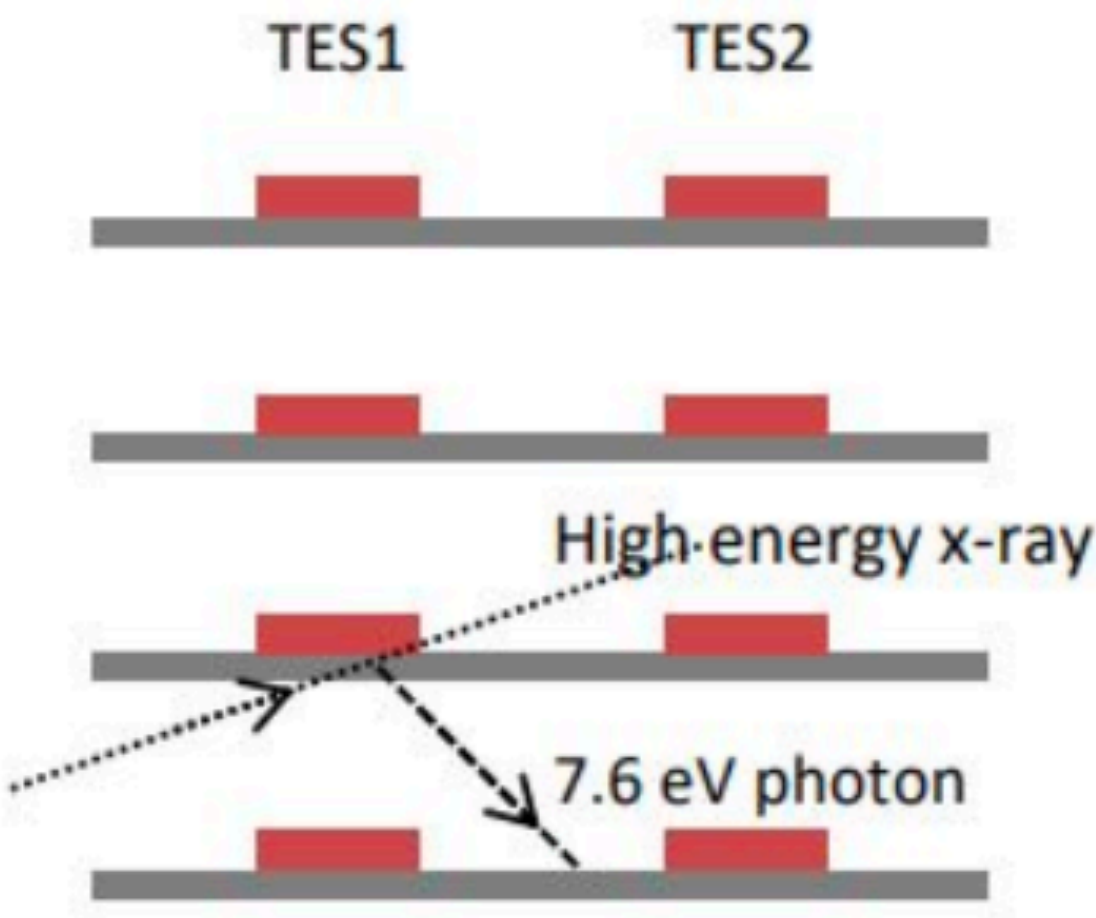
5x Double TES

- CaWO_4 crystal $20 \times 20 \times 10 \text{ mm}^3$
- Operated with two TESs
- Gravity-assisted holder
- Sapphire light detector

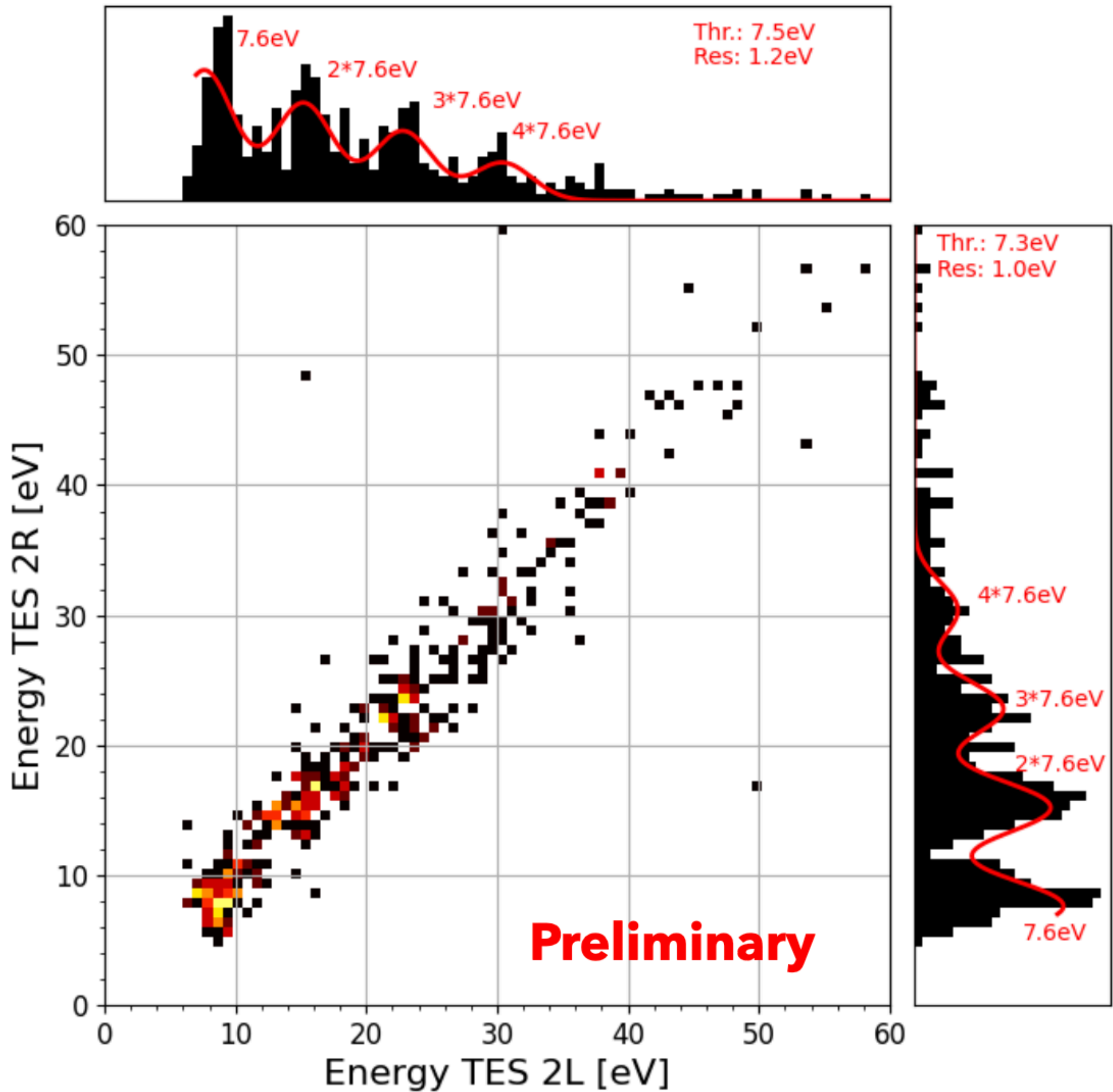
Stack

- 4x Silicon-On-Sapphire wafers $20 \times 20 \times 0.4 \text{ mm}^3$
- Operated with two TESs
- Gravity-assisted holder

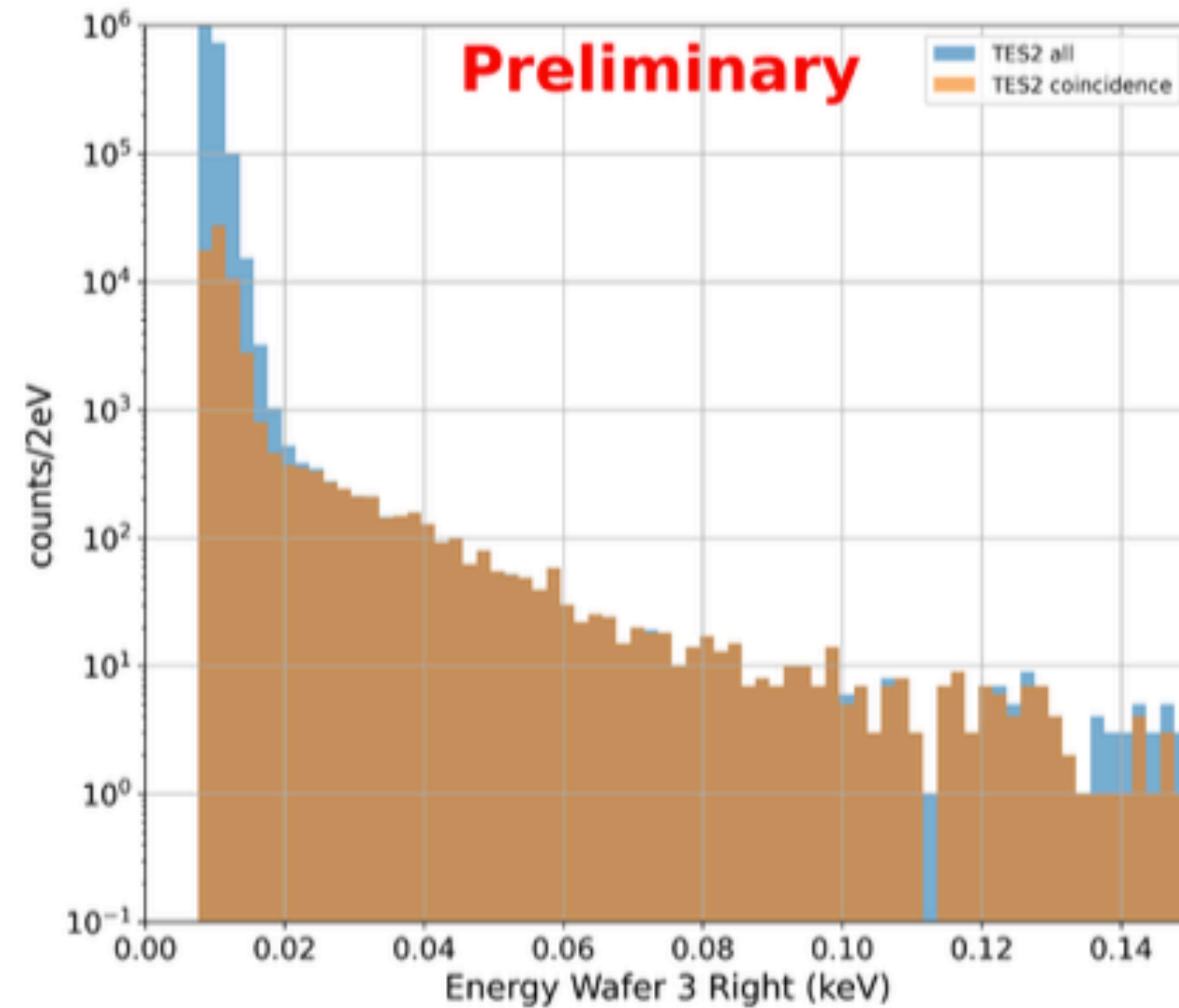
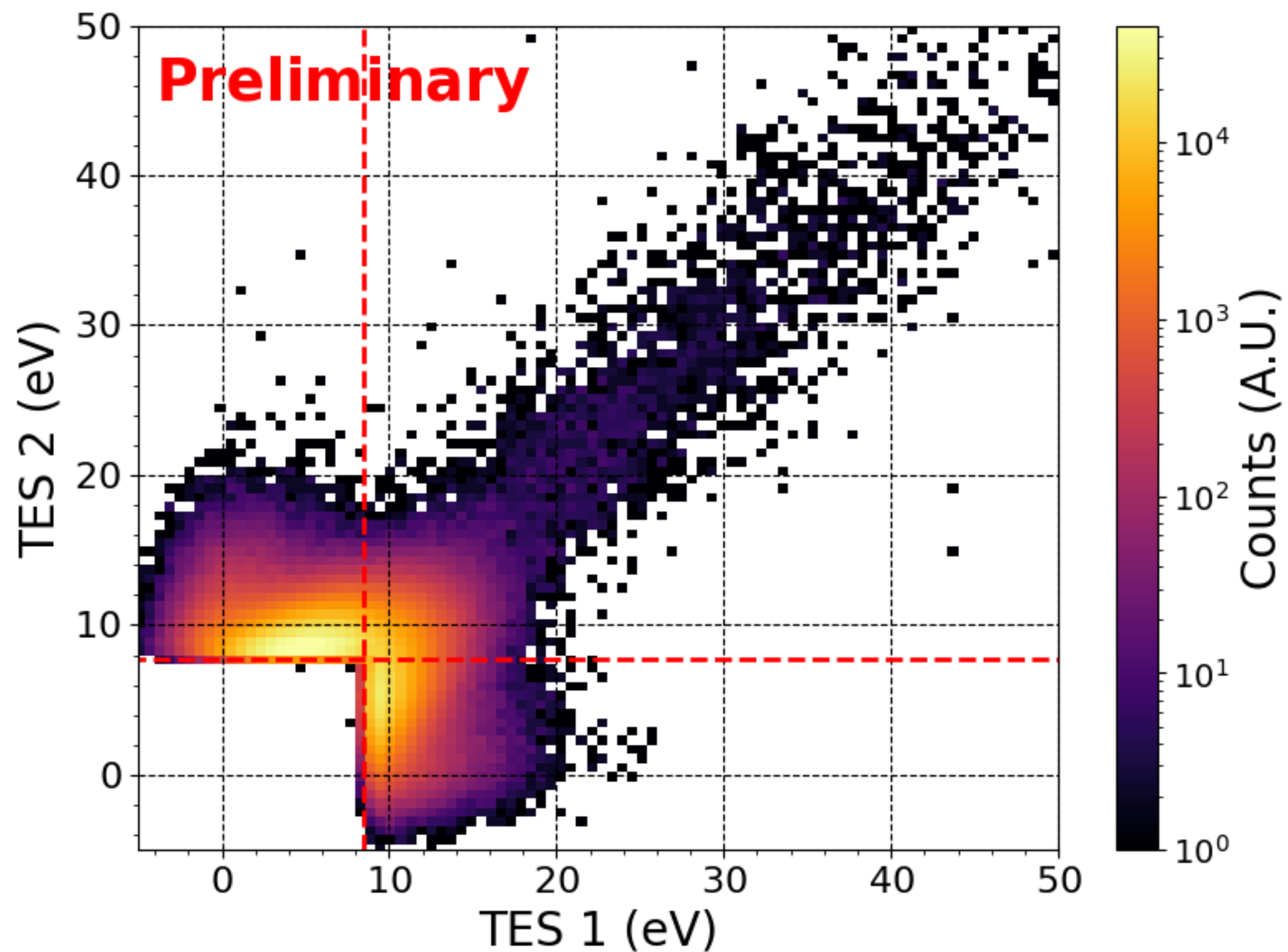
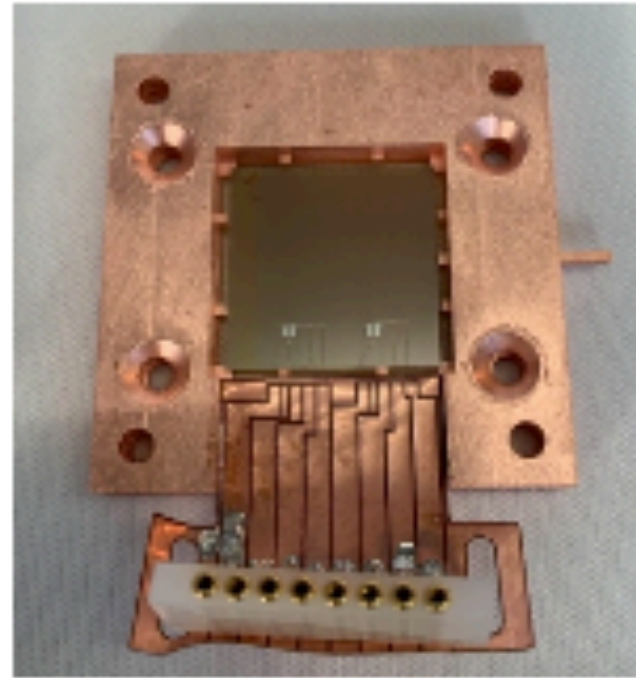
- 8 TESs fully working
- Calibrated with an ^{55}Fe source
- Low-energy thresholds optimized to light dark matter
- Baseline resolution: ~ 1 eV
- Analysis threshold: ~ 7.5 eV
- Single photon detection



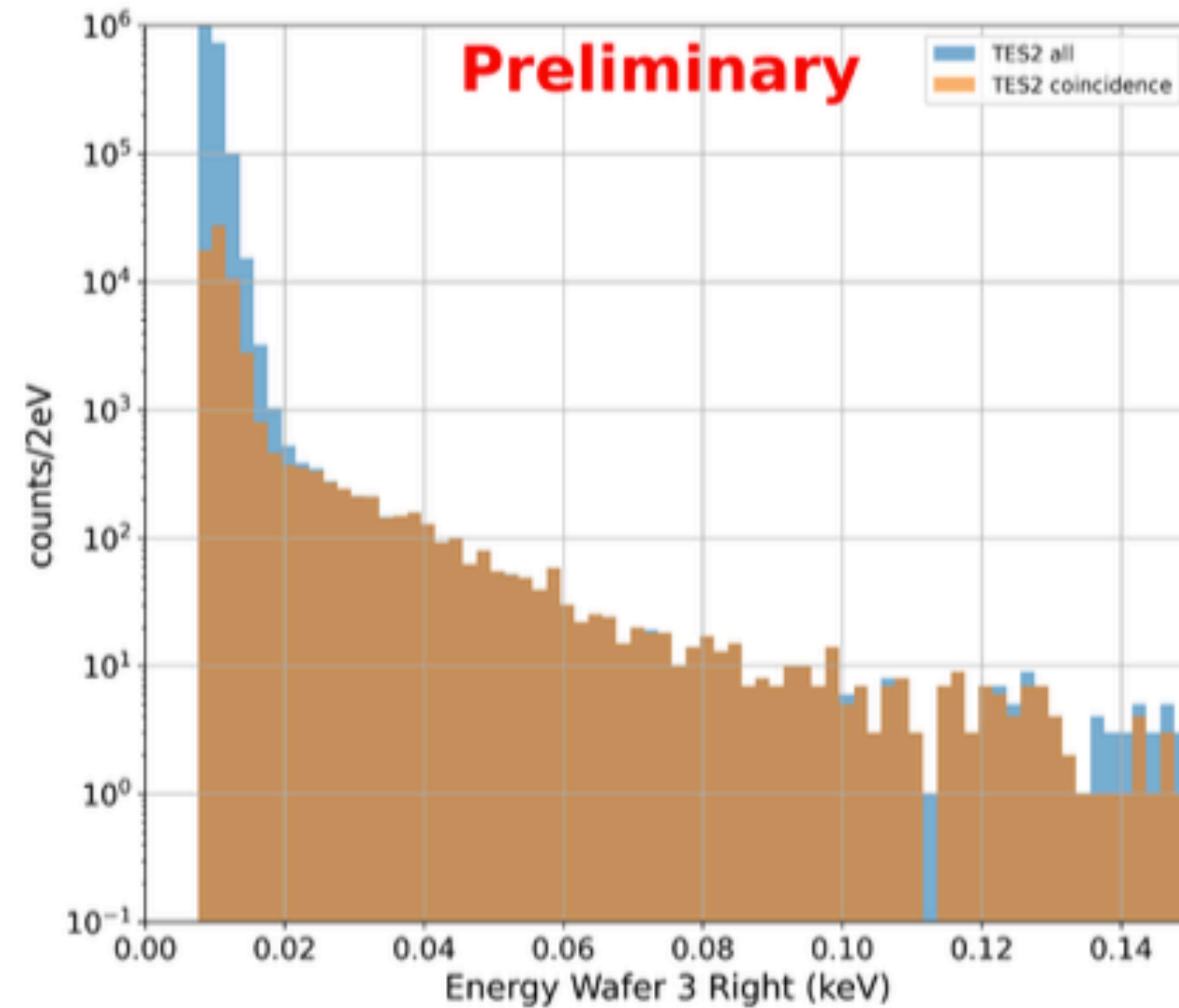
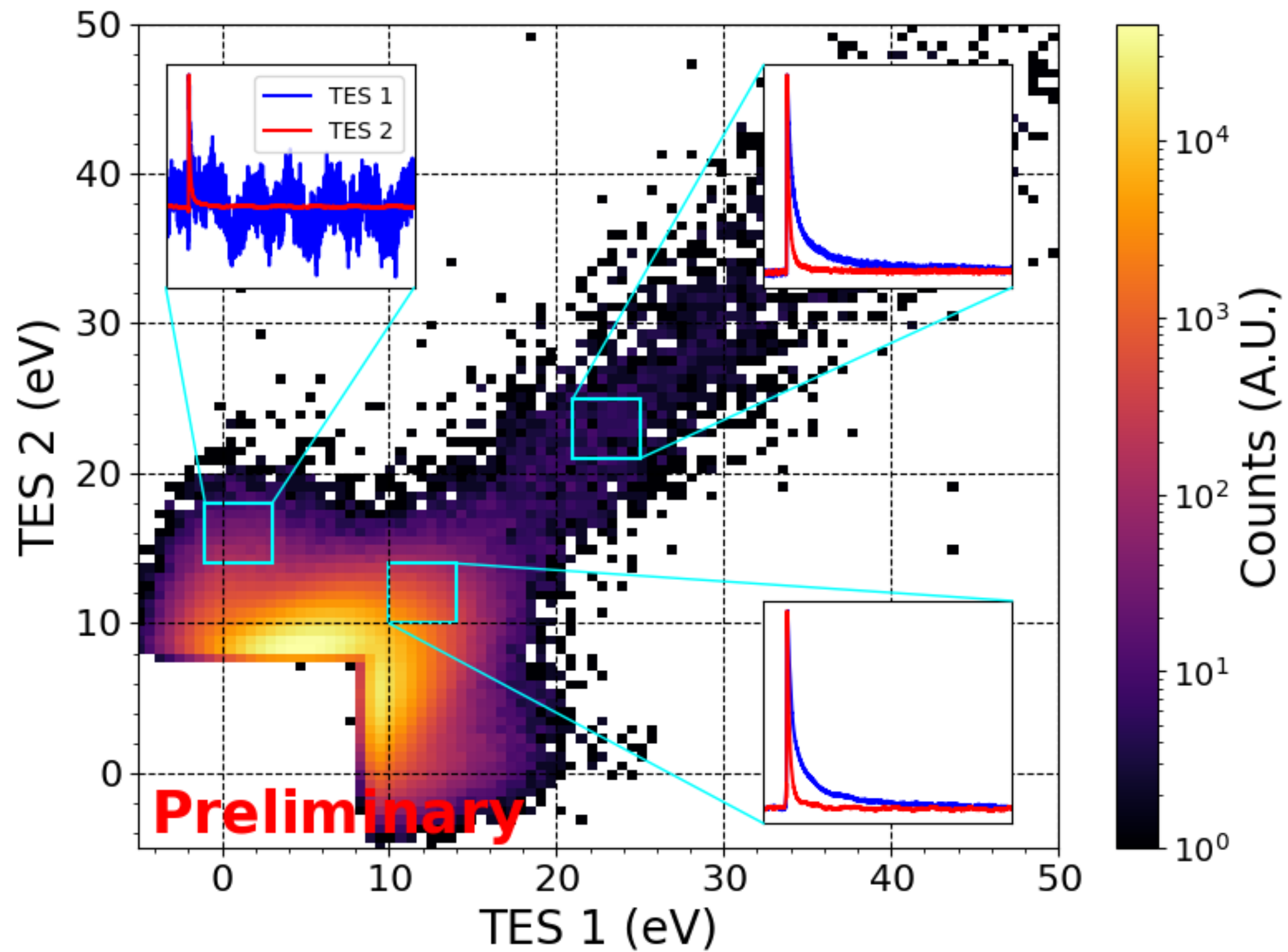
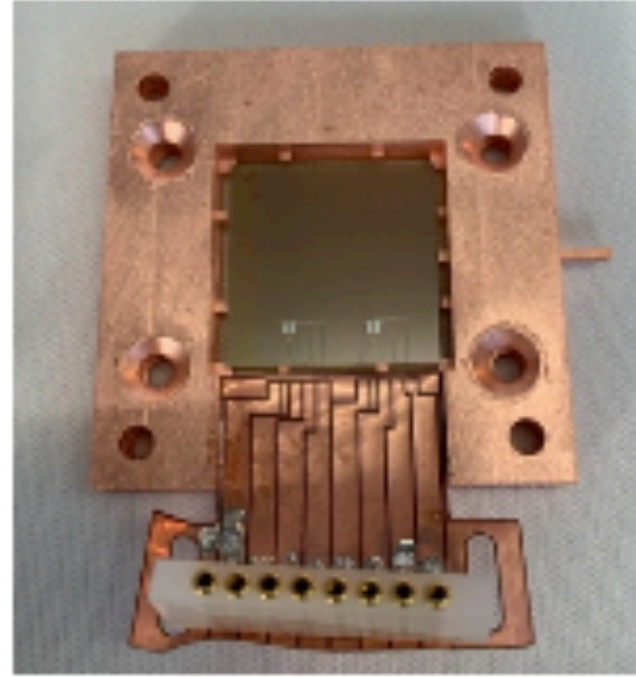
#	Baseline resolution TES1	Baseline resolution TES2
1	1.4 eV	1.1 eV
2	1.2 eV	1.0 eV
3	1.7 eV	1.5 eV
4	1.4 eV	3.9 eV



- Wafer doubleTES detectors reach thresholds below 10 eV
- The shared band cut reduces the LEE

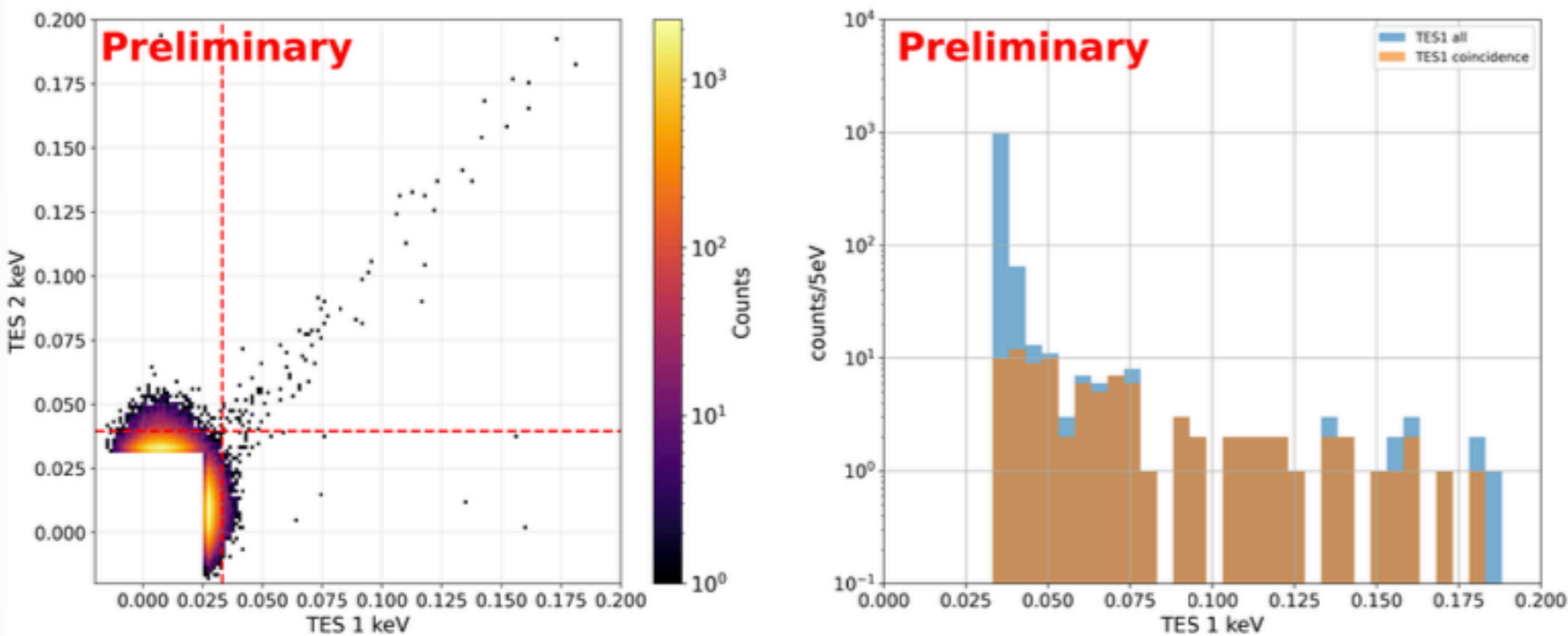
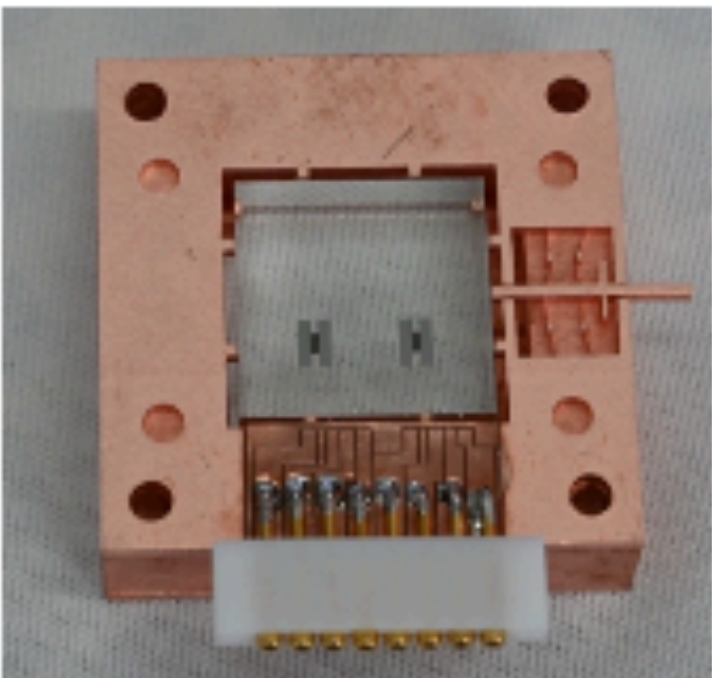


- Wafer doubleTES detectors reach thresholds below 10 eV
- The shared band cut reduces the LEE



DoubleTES 2

- $CaWO_4$ doubleTES modules reach thresholds of ~ 35 eV
- Calibration done with external ^{57}Co source
- The shared band cut strongly reduces the LEE

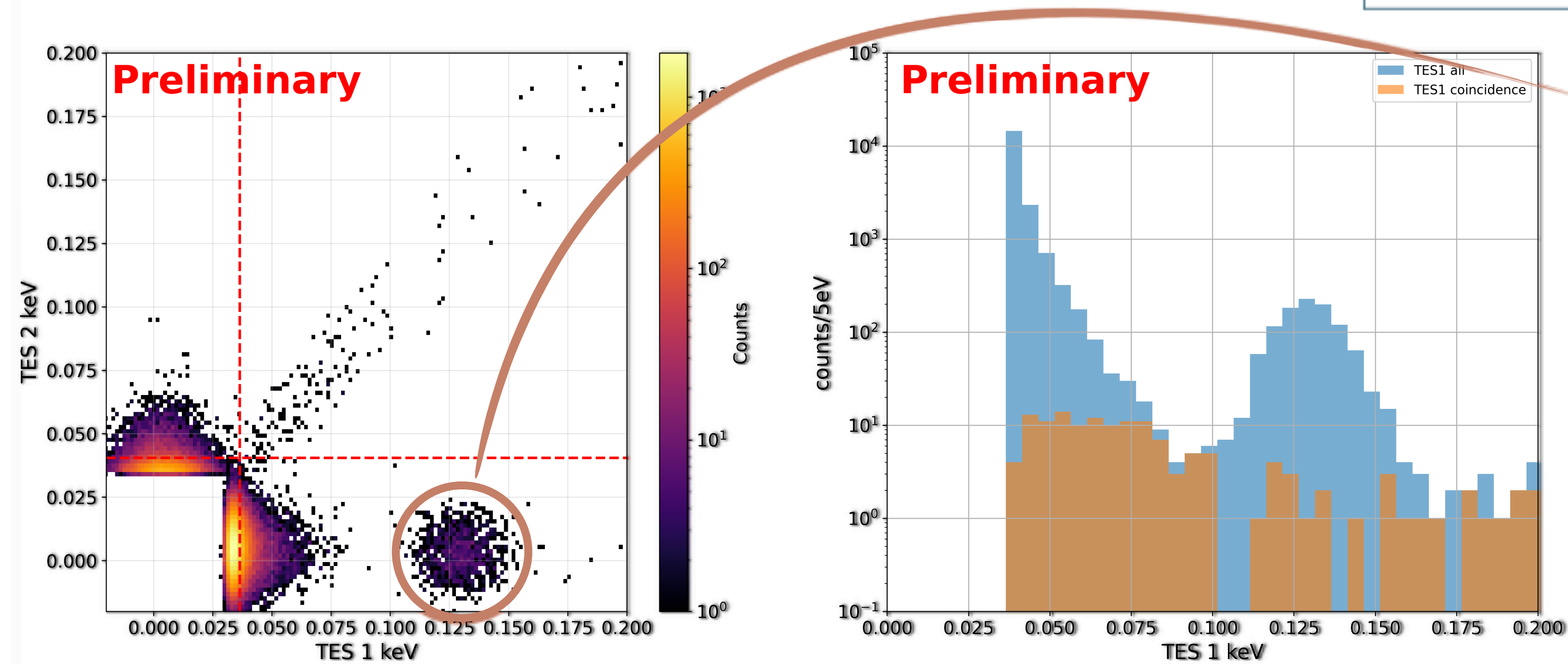
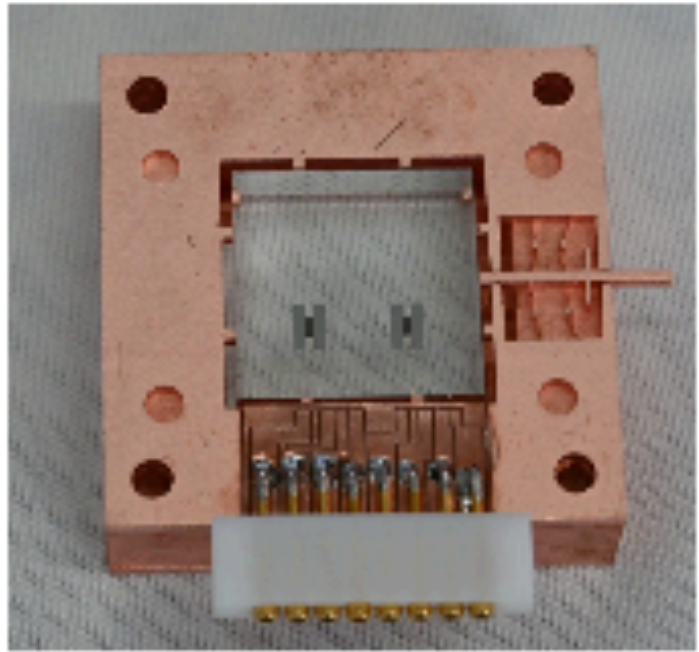


#	Baseline resolution TES1	Baseline resolution TES2
doubleTES 2	6.6 eV	7.9 eV

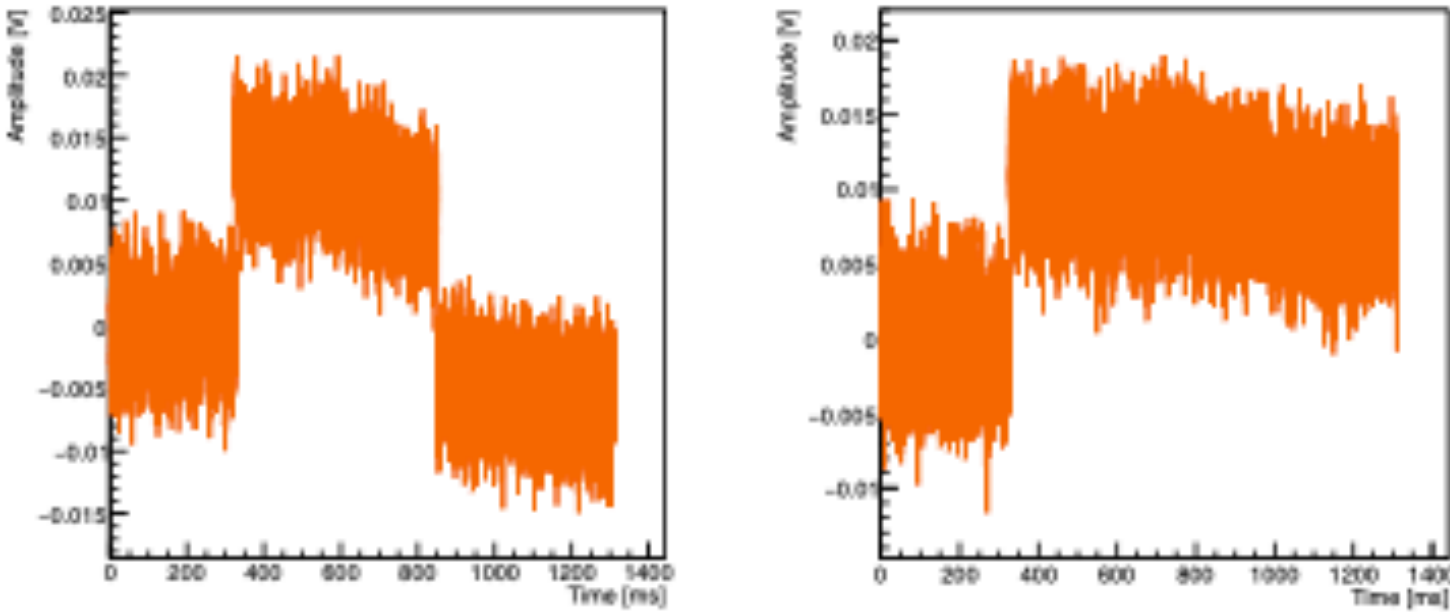
DoubleTES 5

- $CaWO_4$ doubleTES modules reach thresholds of ~ 35 eV
- Calibration done with external ^{57}Co source
- The shared band cut strongly reduces the LEE

#	Baseline resolution TES1	Baseline resolution TES2
doubleTES 5	8.1 eV	7.3 eV



DoubleTES is also very effective in removing electronics artefacts



Conclusion

- CRESST energy thresholds $O(30-10\text{eV})$ allow for deep exploration of **light DM** mass region, extending sensitivity in the $\sim 100\text{ MeV}$ range for the DM mass
- CRESST's capability of using **different target crystals** allows investigation of both SI (Si , CaWO_4) and SD (LiAlO_2 , Al_2O_3) interactions
- Recoils induced by **radiative capture of thermal neutrons (n,γ)** allow **low-energy calibration** of CaWO_4 and Al_2O_3 detectors with nuclear recoils
- **Double TES** preliminary results show, for the first time, a relevant **reduction of LEE events**. Analyses are ongoing to understand the behavior of the different populations.
- **Stay tuned for upcoming DM results!**

