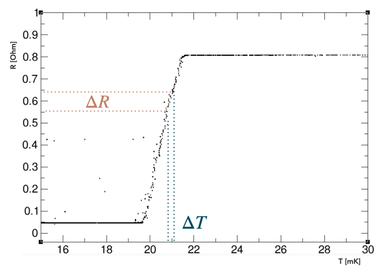
DoubleTES detectors to investigate the CRESST low energy background: results from above-ground prototypes

CRESST

- **Direct detection** of dark matter particles through their scattering off target nuclei
- Cryogenic calorimeters consisting of an absorber crystal equipped with a tungsten Transition Edge Sensor (**W-TES**)
- Tungsten film stabilised in its superconducting transition (~15 mK)
- Temperature signal ($\Delta T = \Delta E/C$) readout through a resistance change

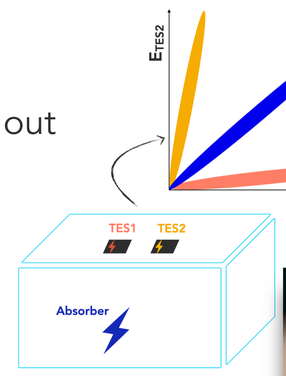


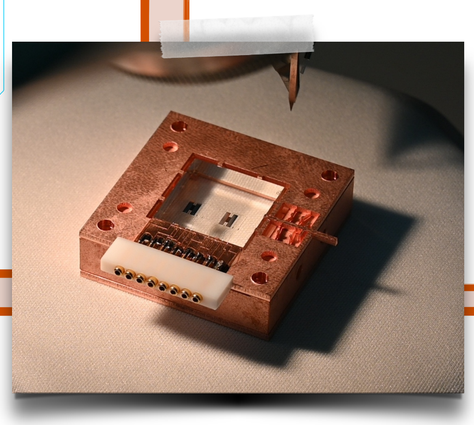
The Low Energy Excess (LEE)

- Background of **unknown origin** hindering low mass dark matter and neutrino searches
- Rise of event rate close to detectors' thresholds
- **Decaying over time** with two time constants: a slow one (~200 days) and a fast one (~15 days)
- Can be reactivated with thermal cycles
- **Particle-like events**, occurring with a positive trigger only

The doubleTES

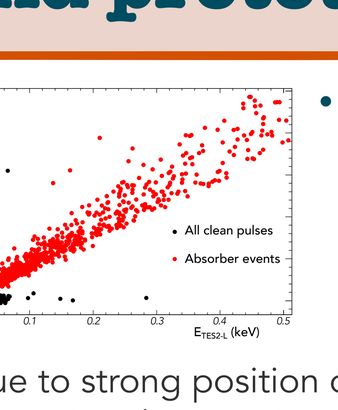
- A single crystal equipped with **two identical TESs**, independently read out
- Insulated heater for independent stabilisation
- **Gravity-assisted** holding scheme
  → reduce stress-induced events
- Distinguish bulk events from events originating in proximity of one TES
  → study TES-crystal **interfaces** as LEE origin



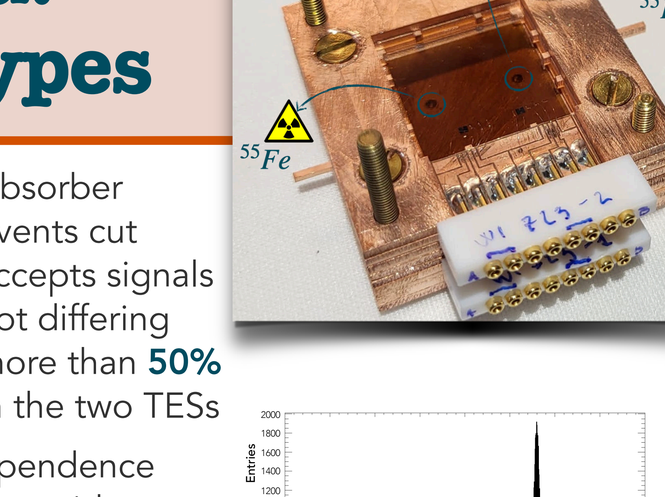


$CaWO_4$ doubleTES

- (20x20x10) mm^3 absorber crystal
- Proof of principle measurement:
  - Two TESs can be simultaneously optimised

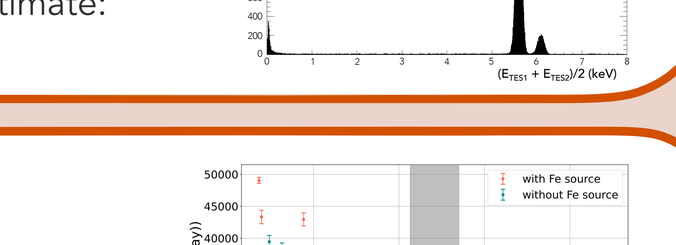


  - Events happening in the bulk of the crystal and those happening in close proximity to one of the two TES can be distinguished



	TES1	TES2
Energy Threshold	137 eV	148 eV
σ_{BL}	(27.1±0.3) eV	(29.6±0.3) eV
σ_{Fe}	(117±3) eV	(118±2) eV

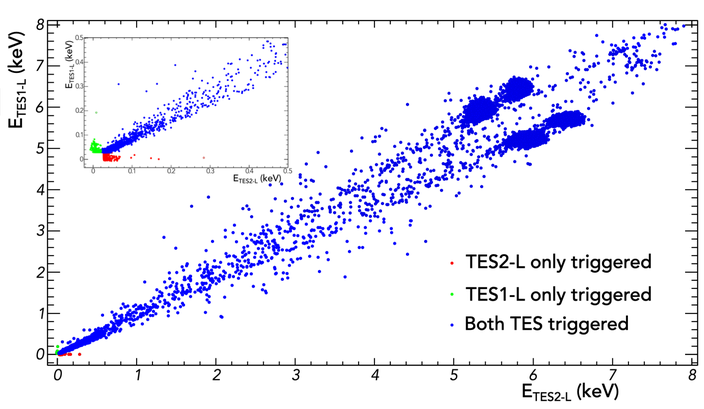
- Defined an **"absorber events" cut** based on the ratio of the two TESs signals
- Bulk events generate similar signals in the two sensors
- Absorber events cut accepts signals not differing more than **35%** among the two TESs (specifically designed for every measurement)



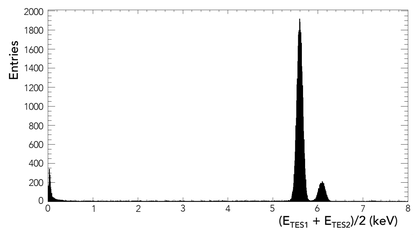
Silicon-On-Sapphire (SOS) doubleTES

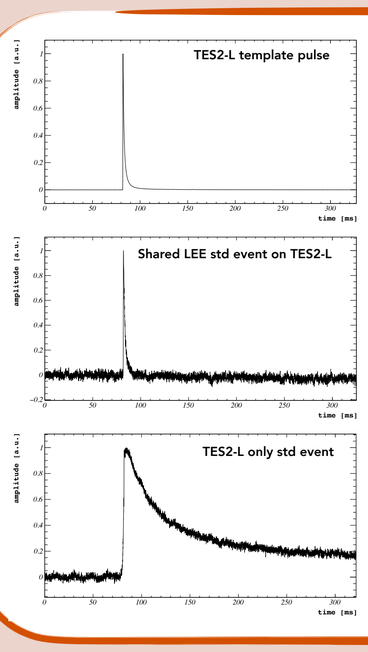
- (20x20x0.4) mm^3 absorber crystal

	TES1-L	TES2-L
Energy Threshold	27 eV	20.5 eV
σ_{BL}	(5.4±0.1) eV	(4.1±0.1) eV
σ_{Fe}	(149.0±3.8) eV	(121.6±2.3) eV



- Absorber events cut accepts signals not differing more than **50%** in the two TESs
- Due to strong position dependence averaging the two signals provides a better energy resolution estimate: σ_{Fe} = (90.0±1.1) eV



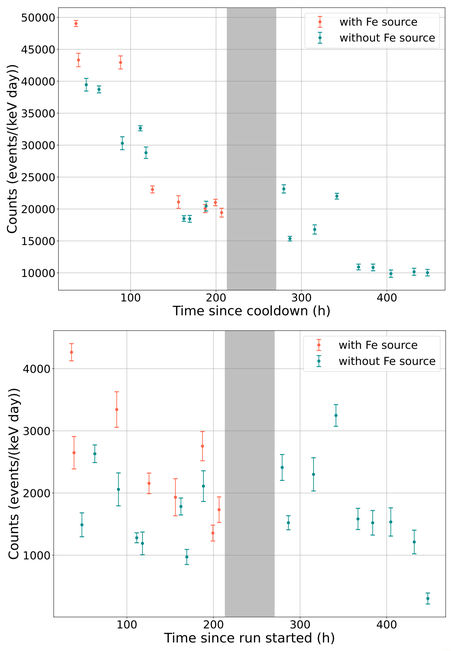


Pulse shapes

- All populations of events consist of **genuine pulses**
- **Differences** in pulse shapes for single TES and absorber events
- Discrimination only possible with doubleTES information **at low energies**

Time dependence

- Second measurement with SOS doubleTES: removed ^{55}Fe calibration sources and built a lead shield around the setup
- Calibration sources and external radiation do not significantly impact the LEE rate
- Rate of absorber events LEE observed to **decay** over time with a time constant of approximately 10 days — compatible with CRESST fast decay
  → same origin **?**
- Not possible to confirm a clear time decay of the single TES component of LEE, further studies needed



Conclusions and Outlook

- Above-ground tests proved the doubleTES' unprecedented ability to discriminate events with **different origins**
- Confirmed observation of **multiple LEE components**
- Only one LEE component generates single TES events
- Absorber LEE component decays
- Major contribution from external radiation to LEE ruled out
- Various doubleTES modules installed in the CRESST LNGS facility
- **Underground measurement in progress**

Stay tuned!

Francesca Pucci francesca.pucci@mpp.mpg.de behalf of the CRESST Collaboration

MAX PLANCK INSTITUTE FOR PHYSICS · INFN LNGS Istituto Nazionale di Fisica Nucleare Laboratori Nazionali del Gran Sasso · COMENIUS UNIVERSITY BRATISLAVA · HEPHY INSTITUTE OF HIGH ENERGY PHYSICS · TU WIEN TECHNISCHE UNIVERSITÄT WIEN · UNIVERSITY OF OXFORD