Results of doubleTES detectors

Excess Workshop - Wien, 26.08.2023

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CRESST

See talk at TAUP: "Direct Dark Matter search with the CRESST-III experiment: Status and Prospects" by Margarita Kaznacheeva

nucleus EXPERIMENT

See talk at TAUP: "NUCLEUS: Detecting Coherent Elastic Reactor Neutrino Nucleus Scattering at the Chooz nuclear plant" by Thierry Lasserre

From previous talk

Summary

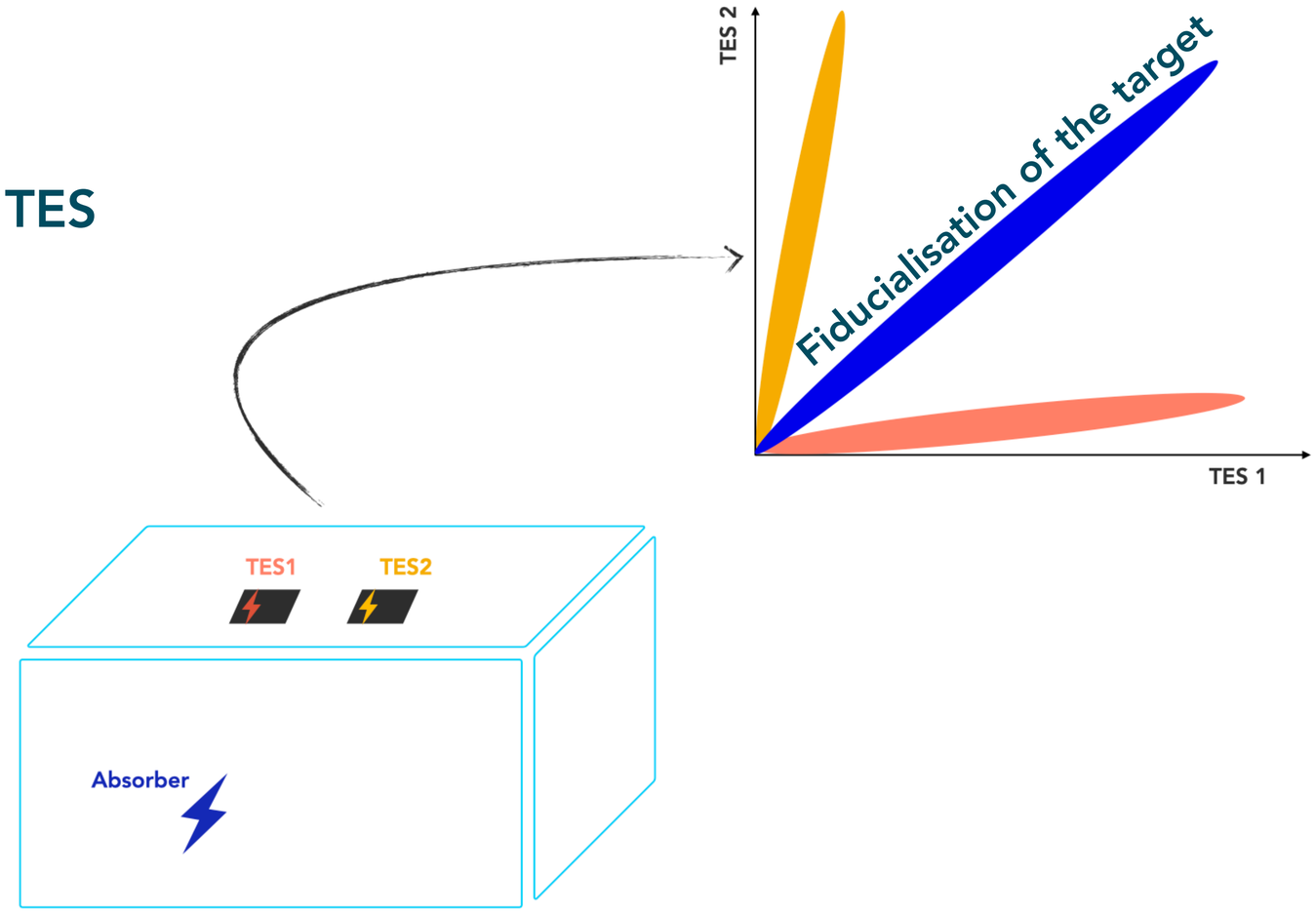
- Energy spectra can be described by single power law above $\sim$ 40 eV
- Low threshold ($\sim$ 10 eV) detectors need at least one additional component in energy
- Decay of energy spectra can be described by two exponential components
- Increase of rate after warm up seems to be function of temperature
- TEC mismatch hypothesis could be explanation for part of the LEE

  $\Rightarrow$ Test with **Double-TES** modules $\rightarrow$ **Next Talk!**

Thank you!

The DoubleTES - Motivation

- Idea: Instrument the absorber with **two TES**
  - If the signal originates in the absorber the two TES are expected to show the same response
  - If the signal originates in or close to the sensor, the two response signals are expected to be different

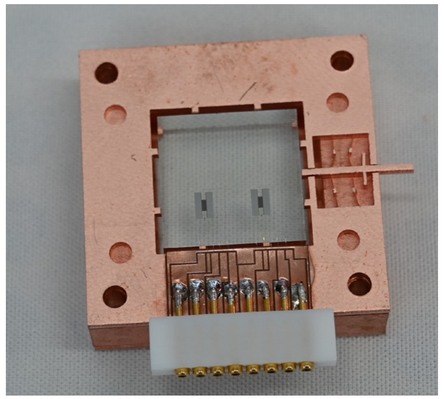


The DoubleTES - Measurements

$CaWO_4$

- Two measurements in September and November 2022
- Above ground, wet cryostat
- Two insulated heaters for independent stabilisation
- Gravity-assisted holding scheme

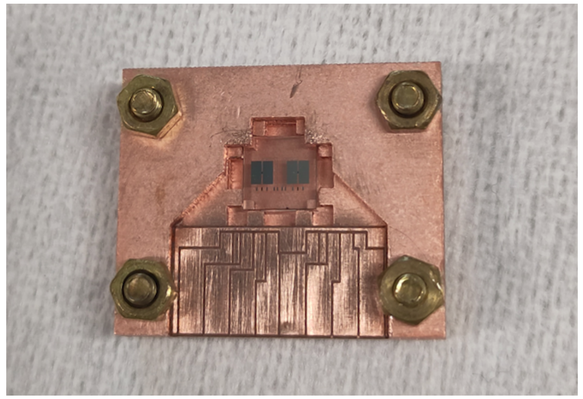
$20 \times 20 \times 10\ mm^3$



Diamond

- Measurement in April 2023
- Above ground, wet cryostat
- Two insulated heaters for independent stabilisation
- Gravity-assisted holding scheme

$7 \times 7 \times 2\ mm^3$



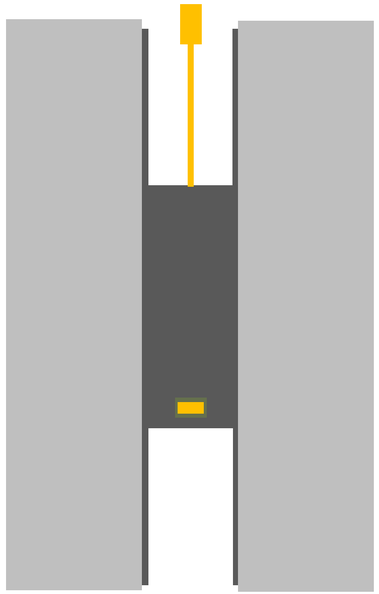
Al_2O_3

- Measurement in June 2023
- Above ground, dry cryostat
- One heater only
- Detector held with Al_2O_3 balls and brass clamps

$5 \times 5 \times 7.5\ mm^3$

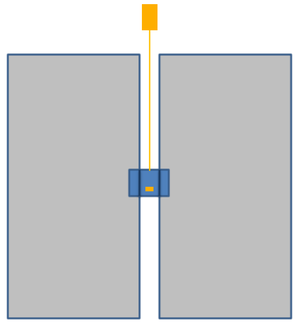
The DoubleTES - Measurements

$CaWO_4$



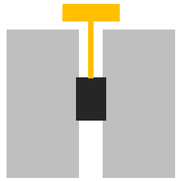
$W = 0.8 \times 1.7\ mm^2$
$Al = 0.95 \times 4\ mm^2$
$Au = 0.04 \times 1\ mm^2$

$Diamond$



$W = 0.2 \times 0.09\ mm^2$
$Al = 1 \times 2\ mm^2$
$Au = 0.01 \times 1.2\ mm^2$

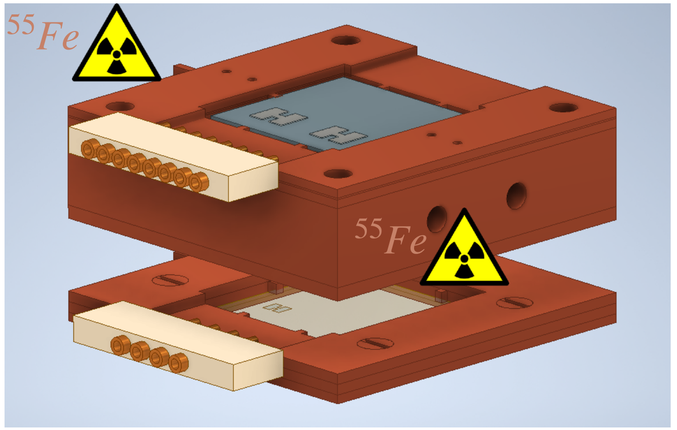
Al_2O_3

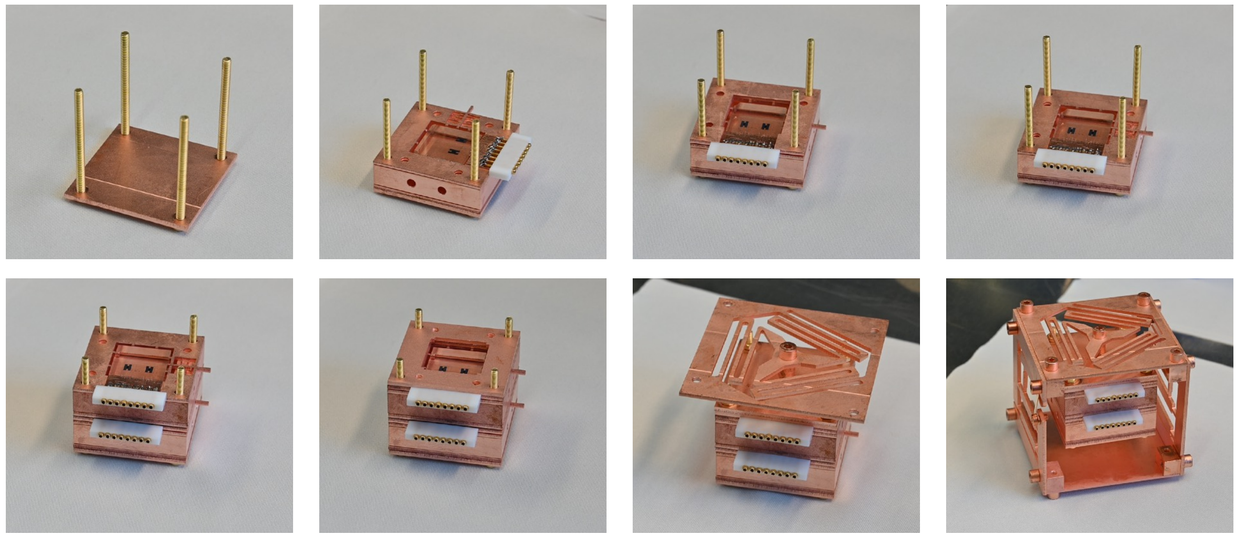


$W = 0.3 \times 0.21\ mm^2$
$Al = 0.505 \times 1.04\ mm^2$
$Au = 0.01 \times 0.4\ mm^2$

The DoubleTES - $CaWO_4$

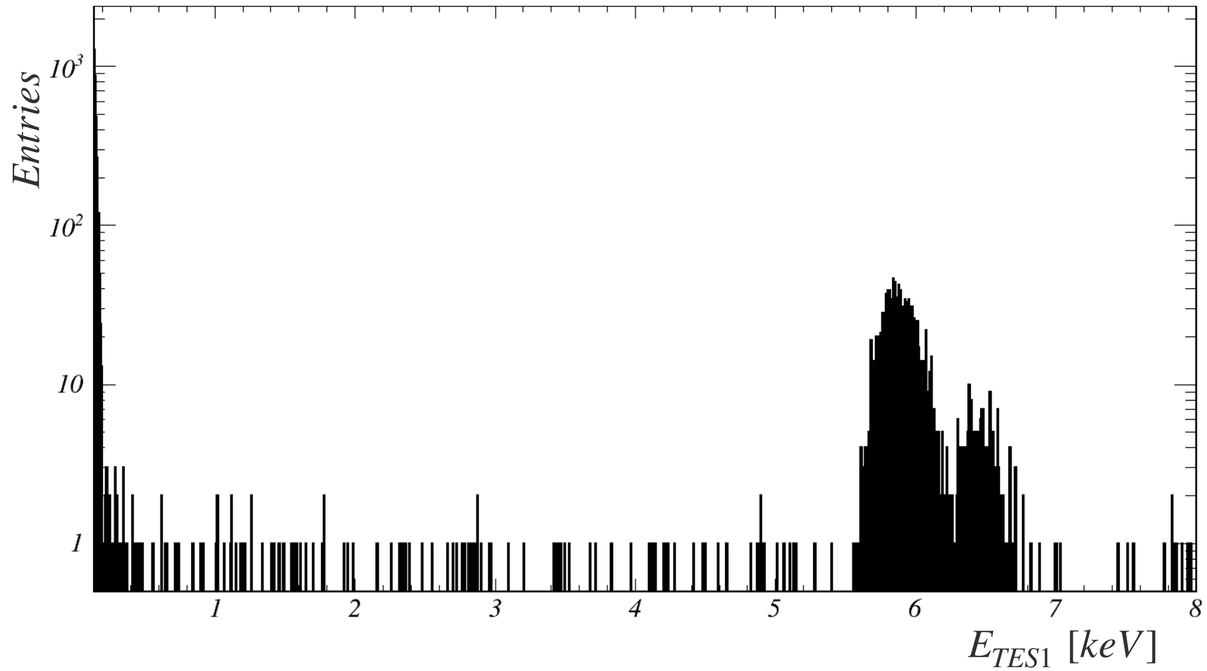
- Two TES on the same absorber crystal
- $20 \times 20 \times 10\ mm^3$ $CaWO_4$ crystal
- Insulated ($350\ nm\ SiO_2$) heater on top of each sensor for independent stabilisation
- Modular design
- Two collimated ^{55}Fe sources

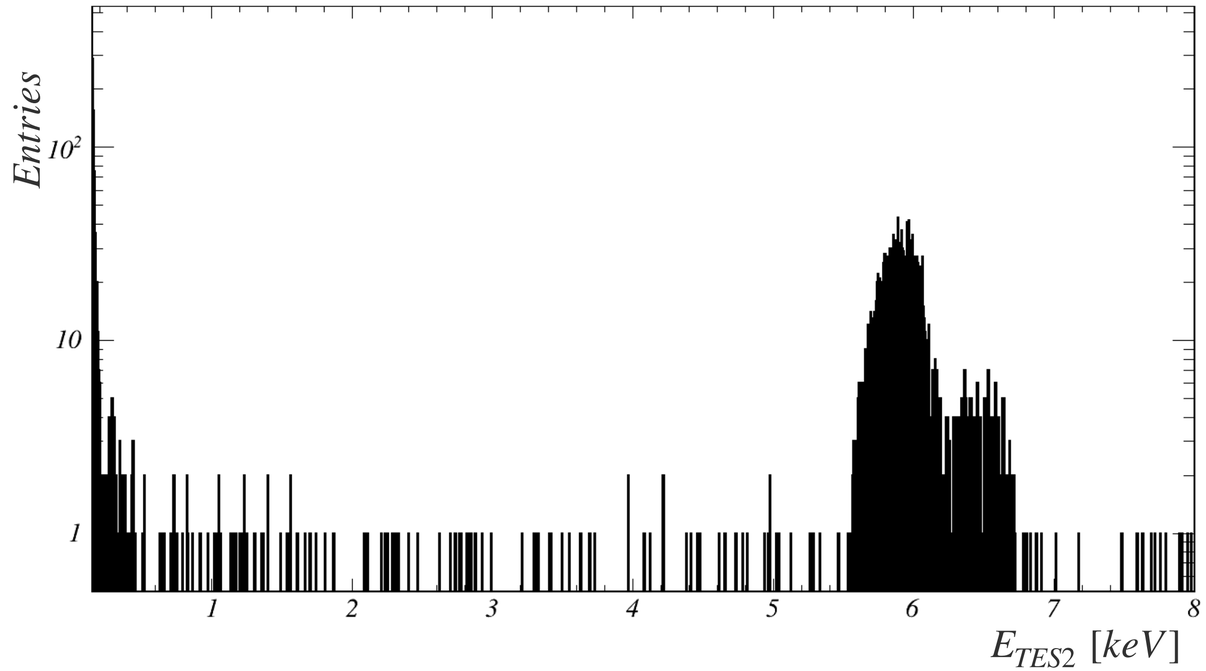




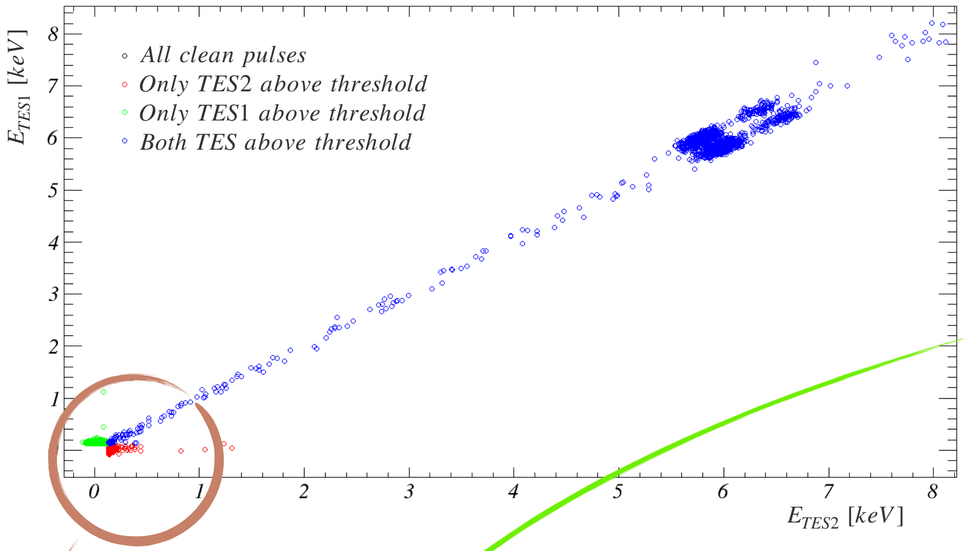
The DoubleTES - $CaWO_4$ Results

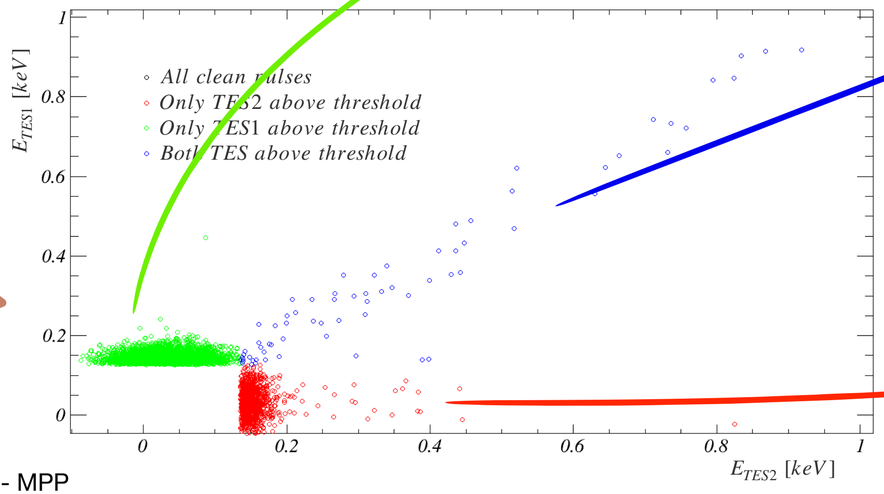
- Independent analysis of the two TES
- Basic quality cuts applied



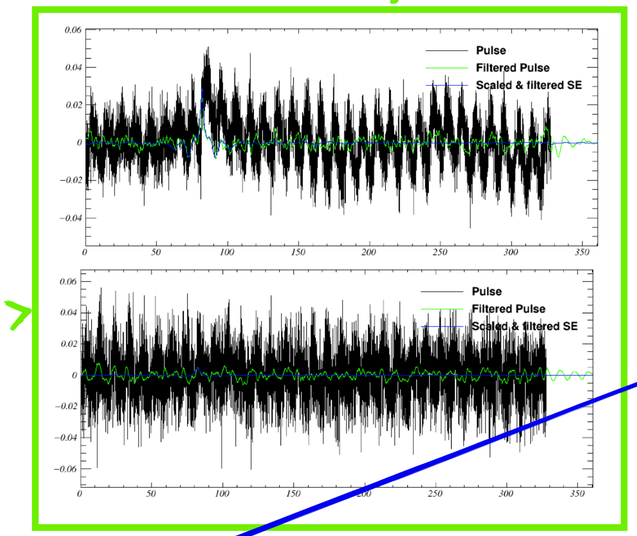


The DoubleTES - $CaWO_4$ Results

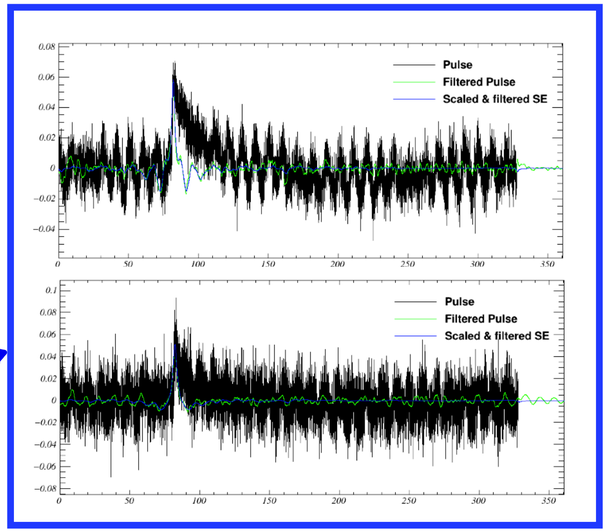




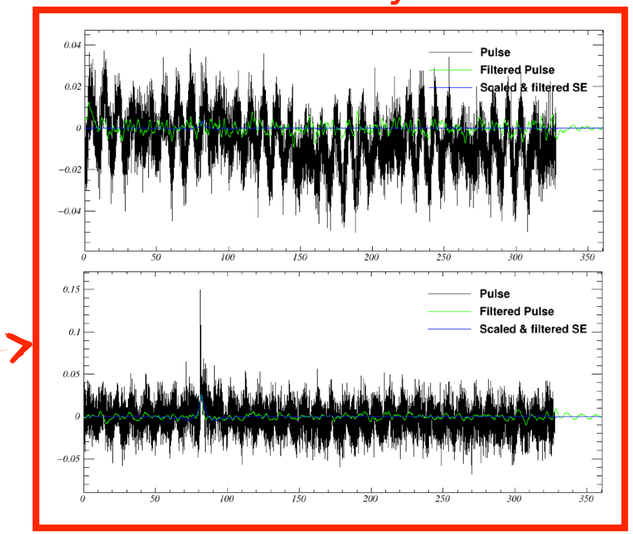
TES1 only



Absorber events

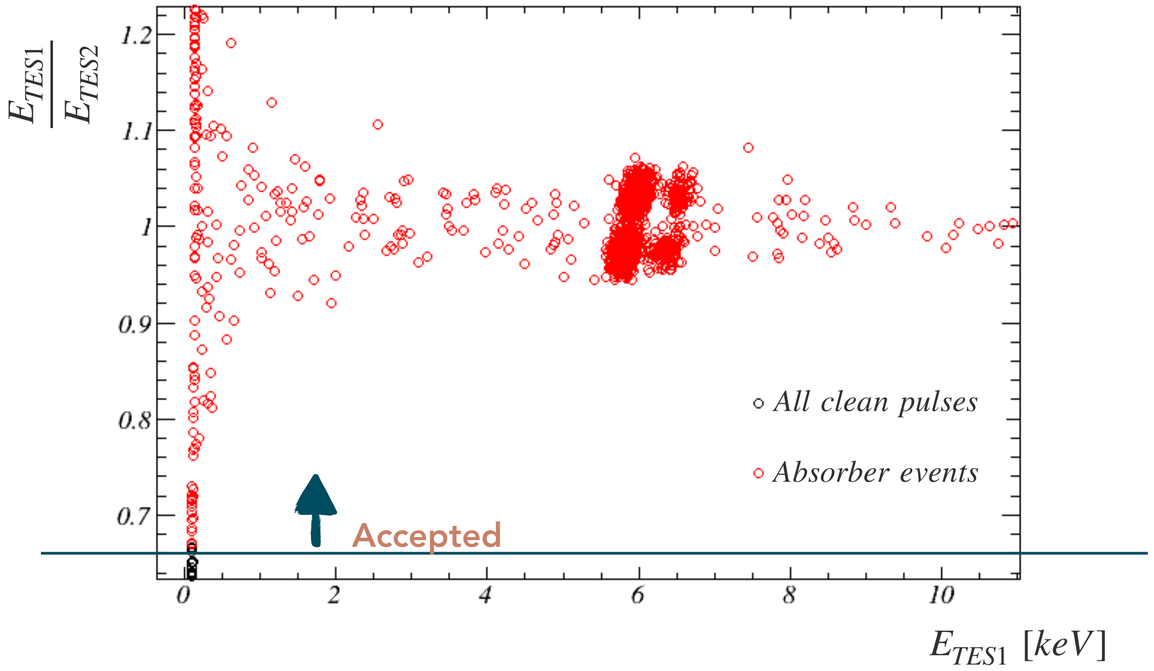


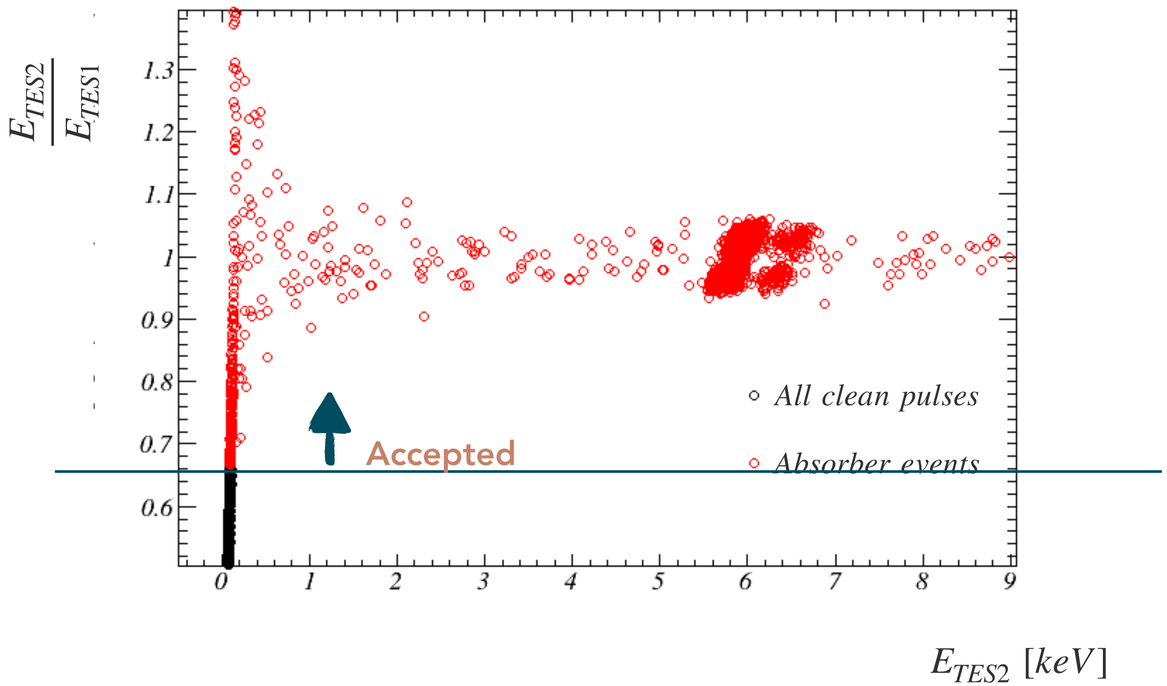
TES2 only



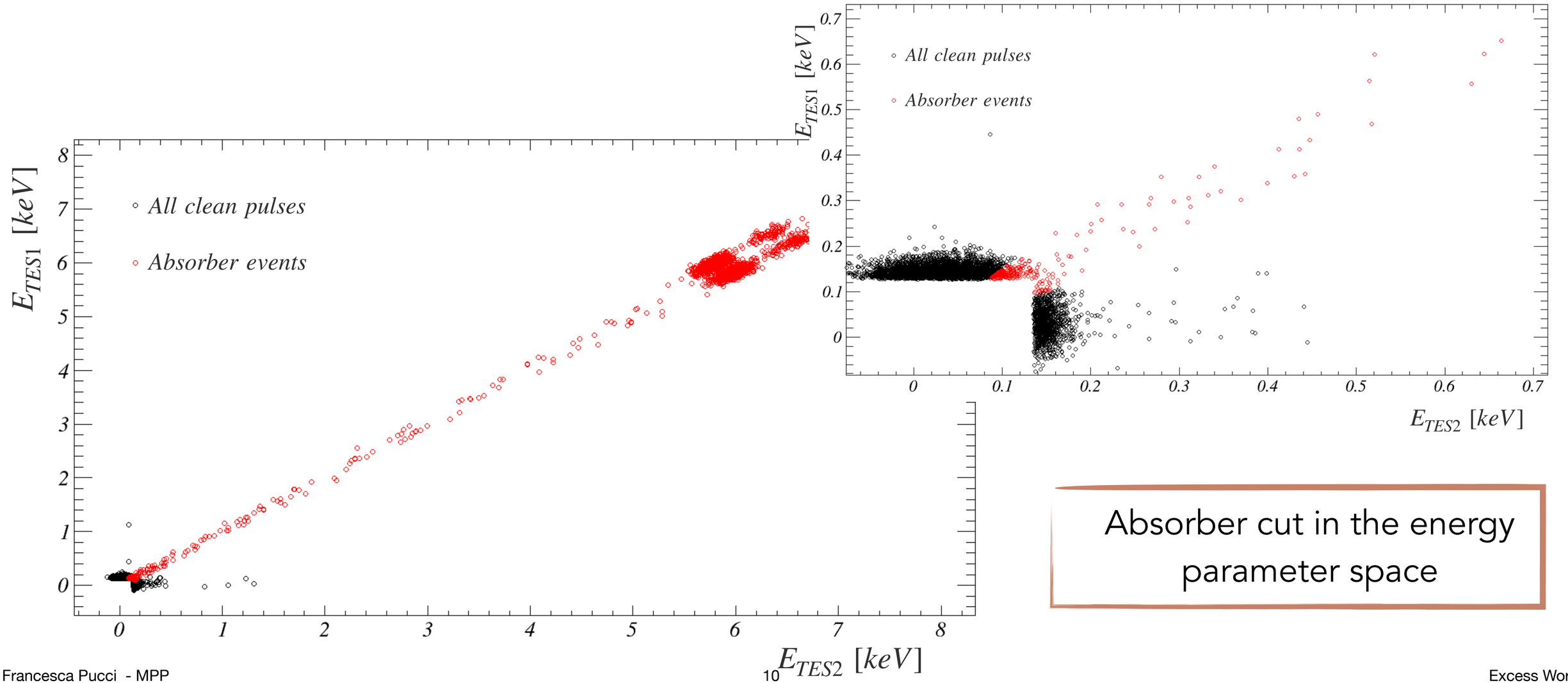
The DoubleTES - $CaWO_4$ Results

- "Absorber cut" - a first idea:
  accepts events in which the two TES have signals differing less than 35% in energy





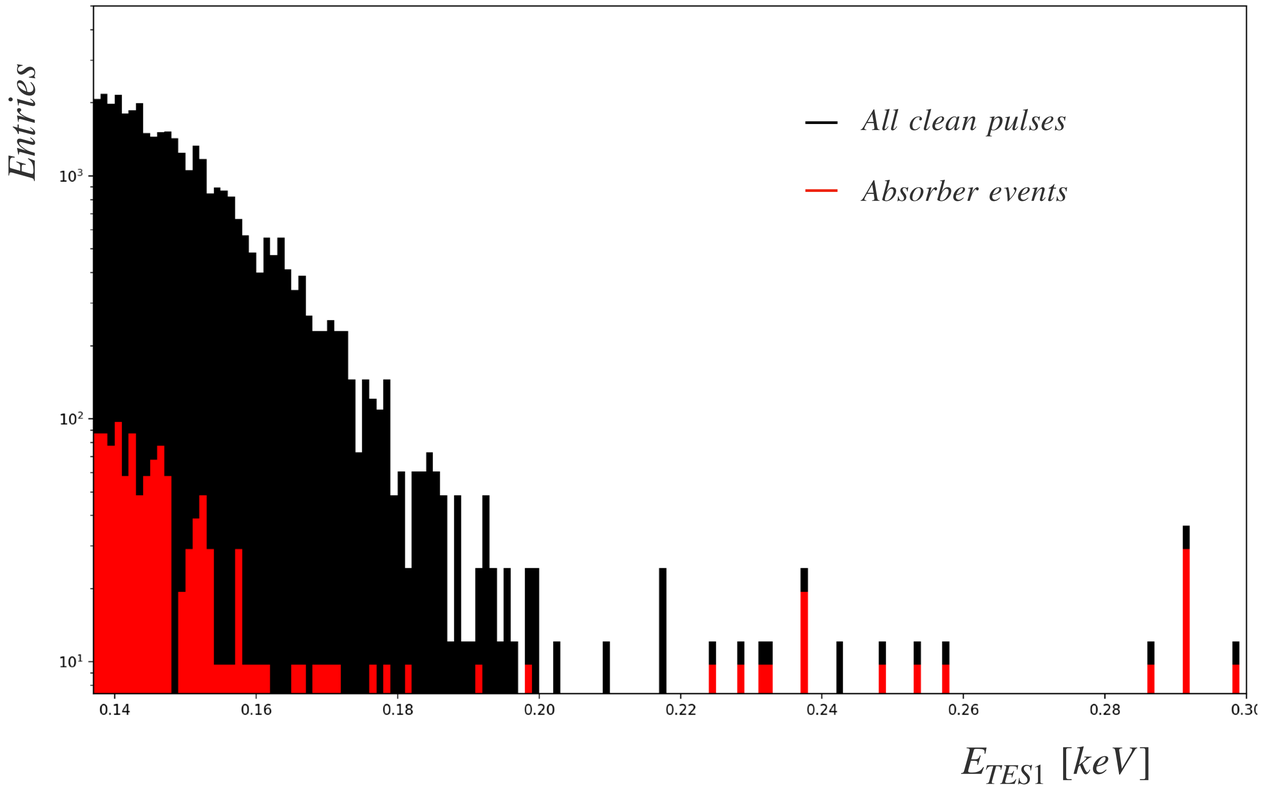
The DoubleTES - $CaWO_4$ Results

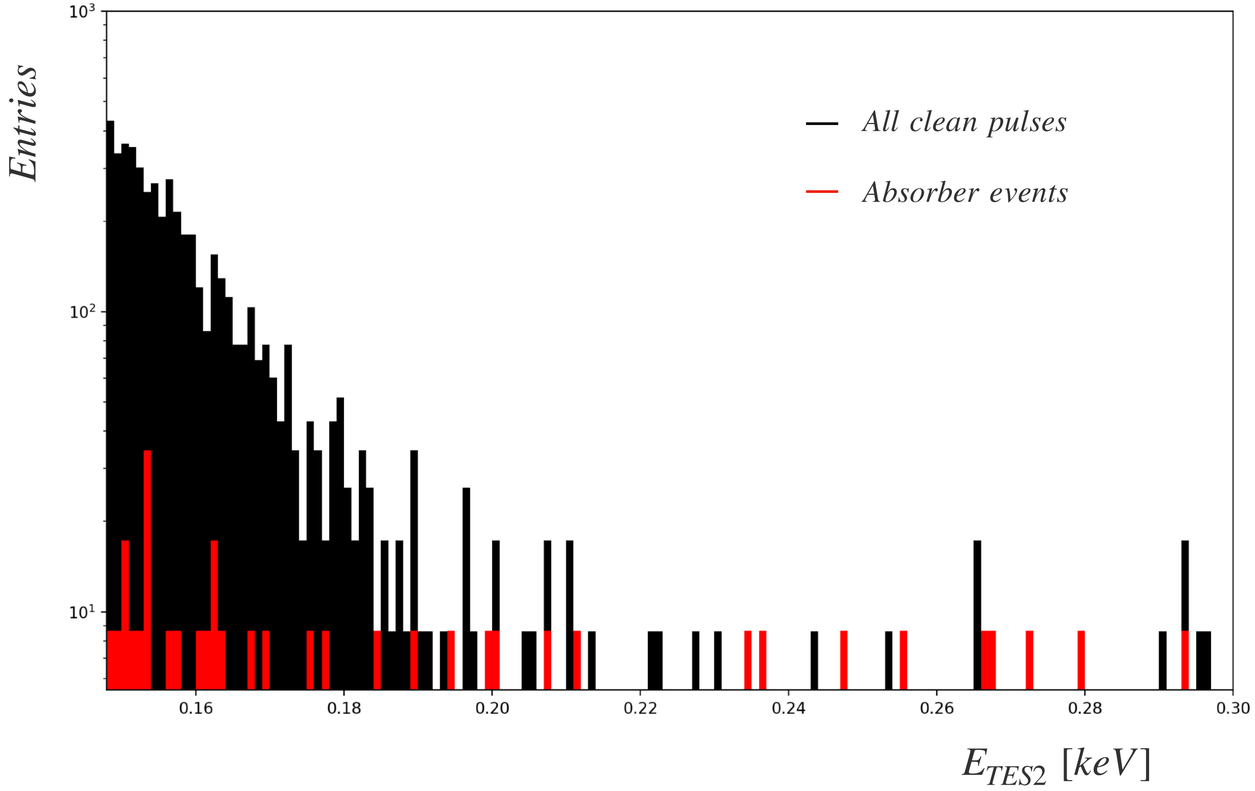


Absorber cut in the energy parameter space

The DoubleTES - $CaWO_4$ Results

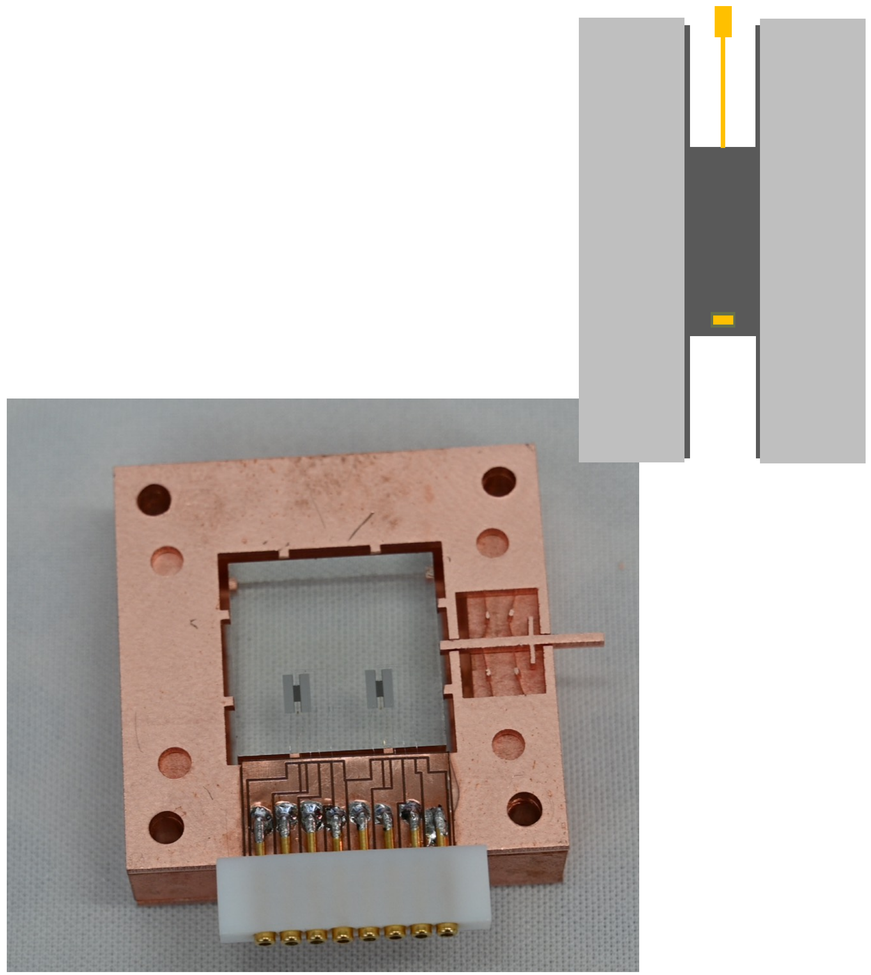
- Low energy spectra before and after the “absorber events” cut
- Spectra corrected with cut efficiency





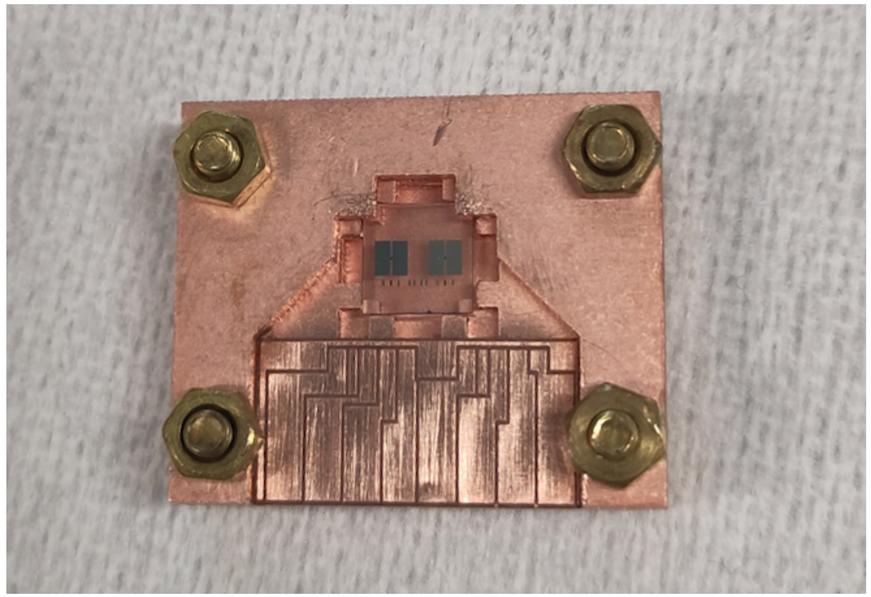
The DoubleTES - $CaWO_4$ Conclusions

- High thresholds, $5\sigma_{BL}$ of 137 eV and 148 eV
- Above ground measurement
- Reduction of events at threshold
- Very promising performance and results
- Underground measurement campaign at the test facility of CRESST at LNGS foreseen soon
- DoubleTES modules will be measured in the next CRESST-III measurement run, foreseen to start early 2024

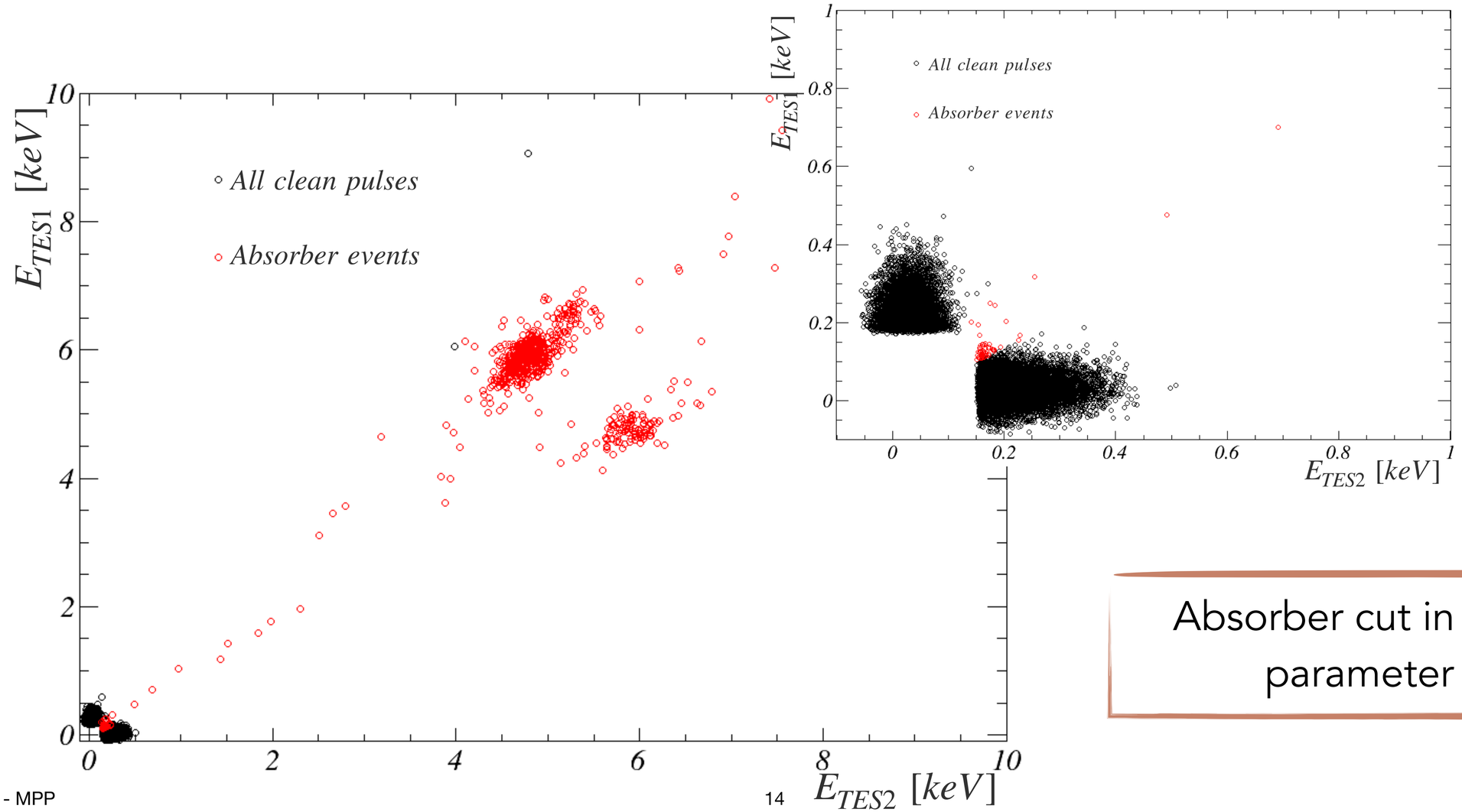


The DoubleTES - *Diamond*

- Two TES on the same absorber crystal
- $7 \times 7 \times 2\ mm^3$ diamond crystal
- Insulated ($350\ nm\ SiO_2$) heater on top of each sensor for independent stabilisation
- Gravity assisted holding scheme
- Two ^{55}Fe sources
- Sensor design with reduced W area and larger phonon collectors area

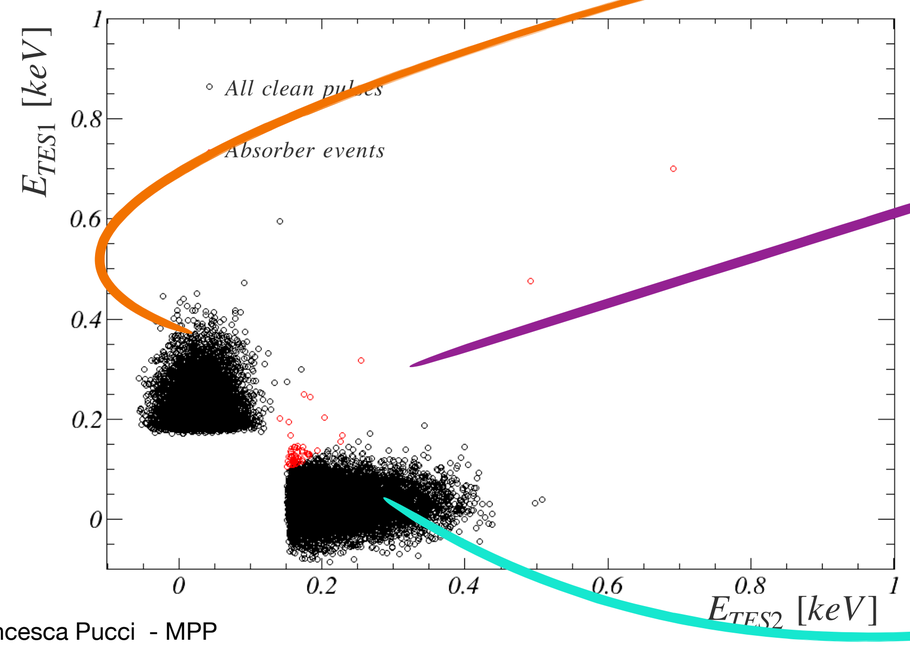


The DoubleTES - *Diamond* Results

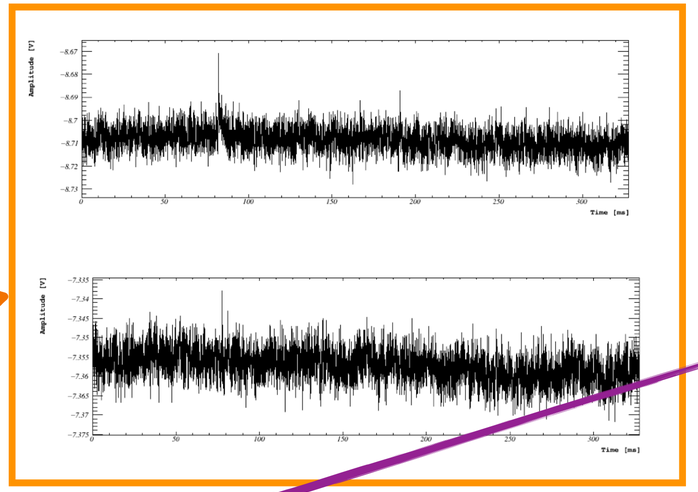


Absorber cut in the energy parameter space

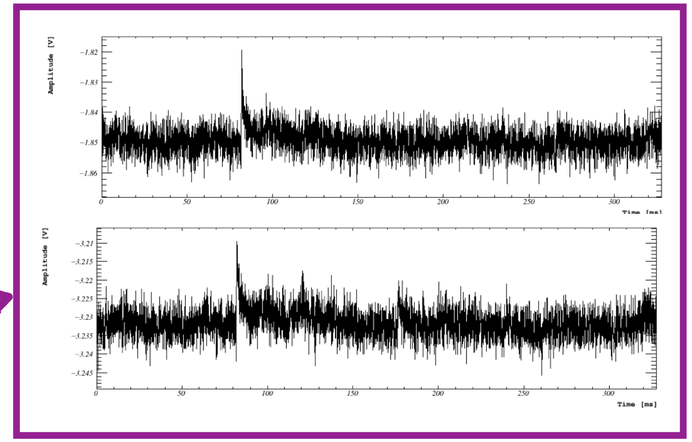
The DoubleTES - *Diamond* Results



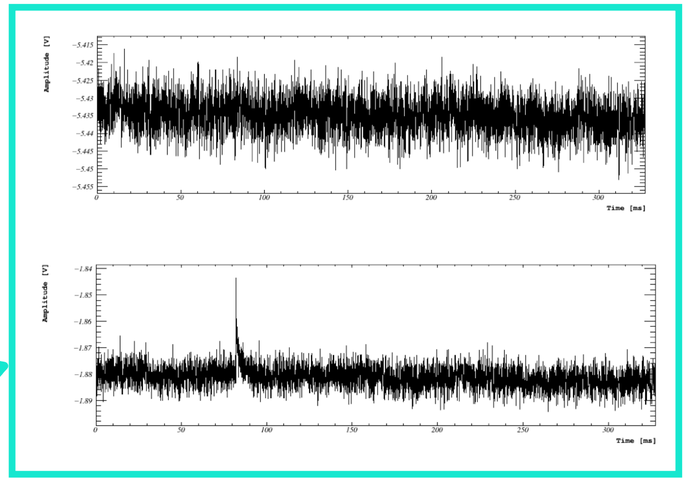
TES1 only



Absorber event

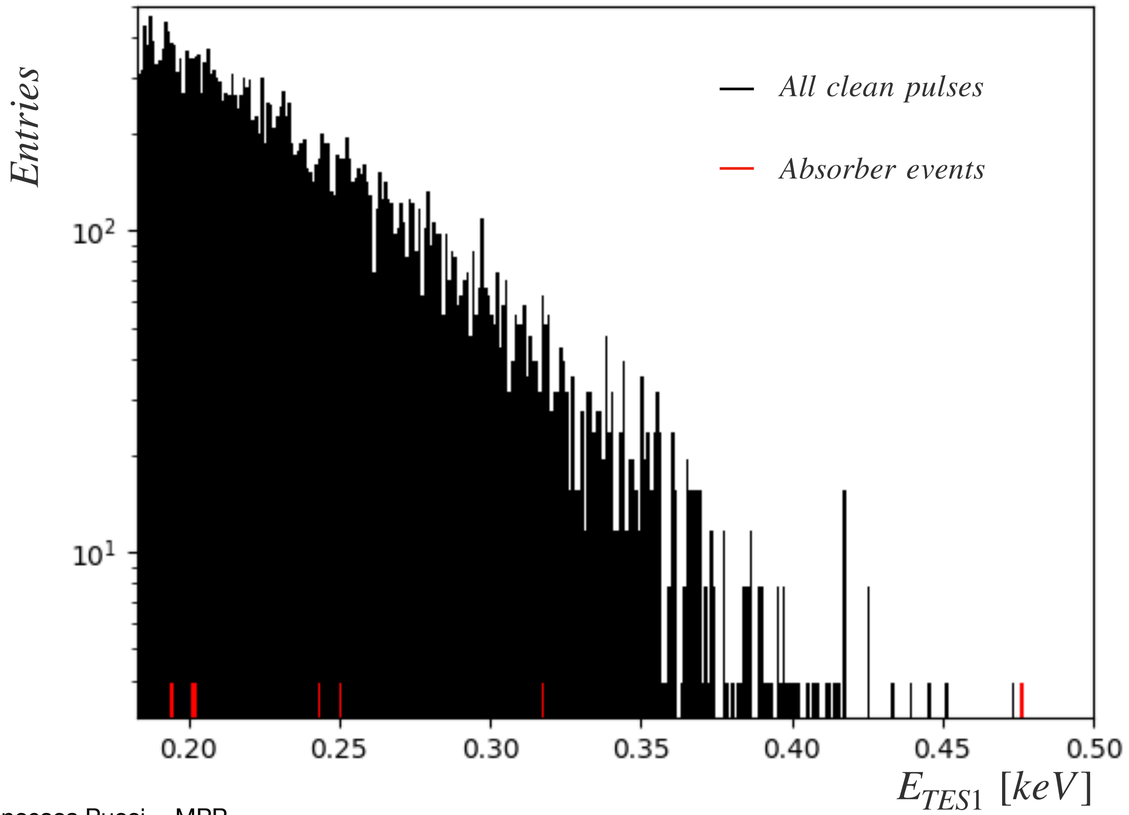


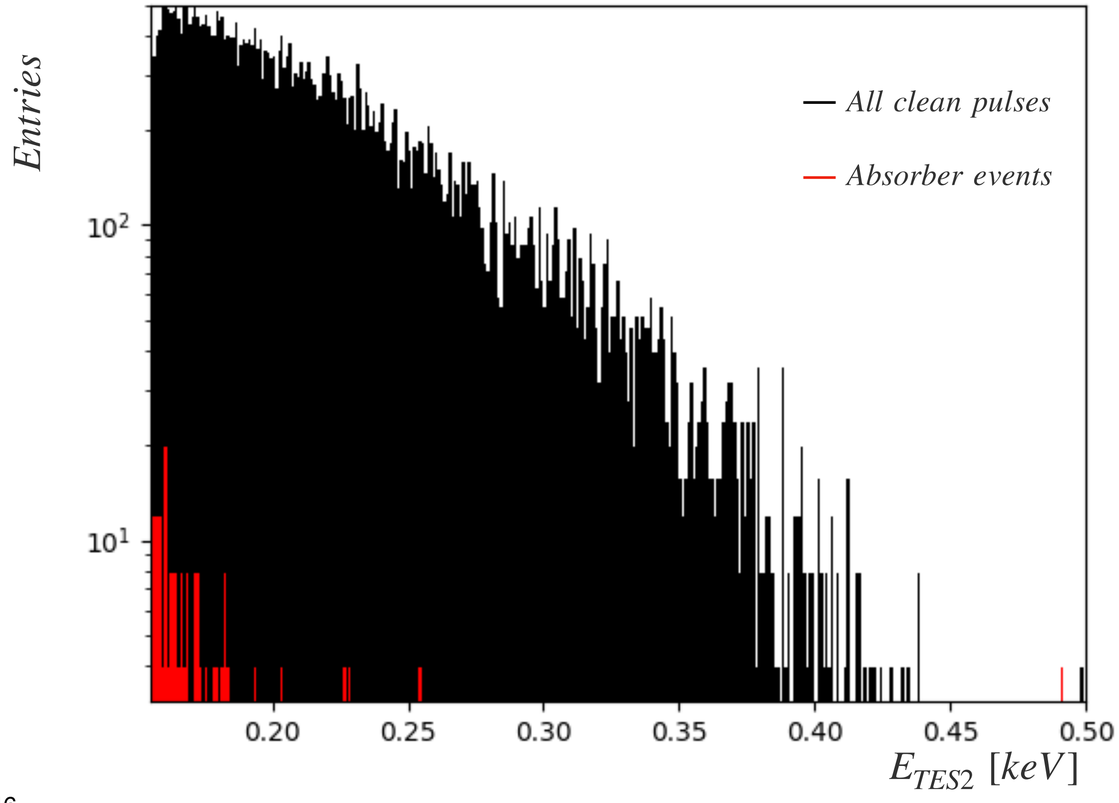
TES2 only



The DoubleTES - *Diamond* Results

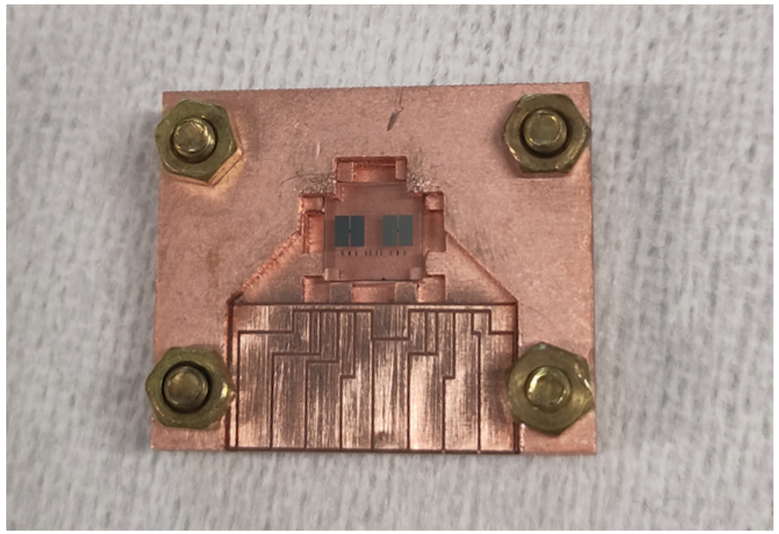
- Low energy spectra before and after the “absorber events” cut
- Spectra corrected with cut efficiency

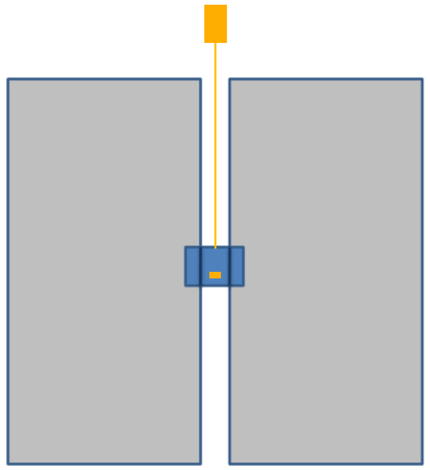




The DoubleTES - *Diamond* Conclusions

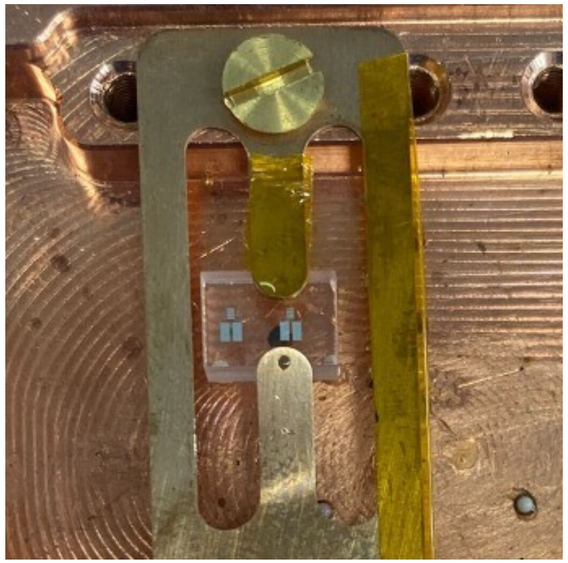
- High thresholds, $5\sigma_{BL}$ of 183 eV and 155 eV
- Above ground measurement
- Reduction of events at threshold
- Special TES design with respect to previous standard
- Single TES events extend to higher energy
- New measurement planned with different TES geometry





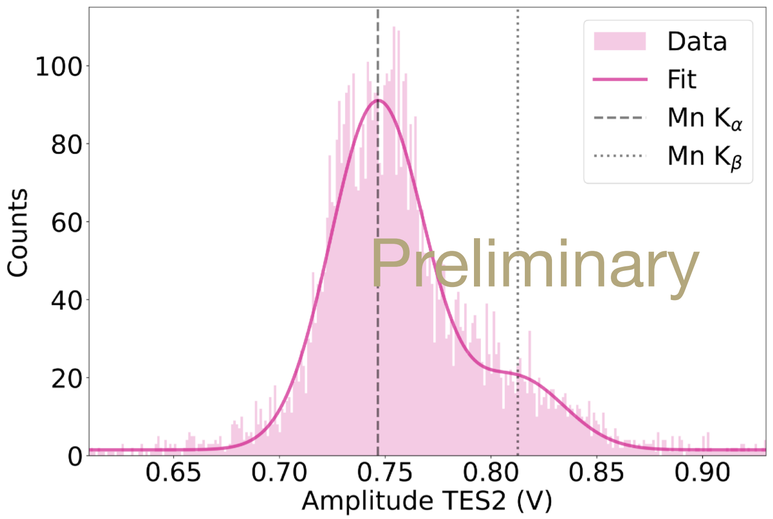
The DoubleTES - Al_2O_3

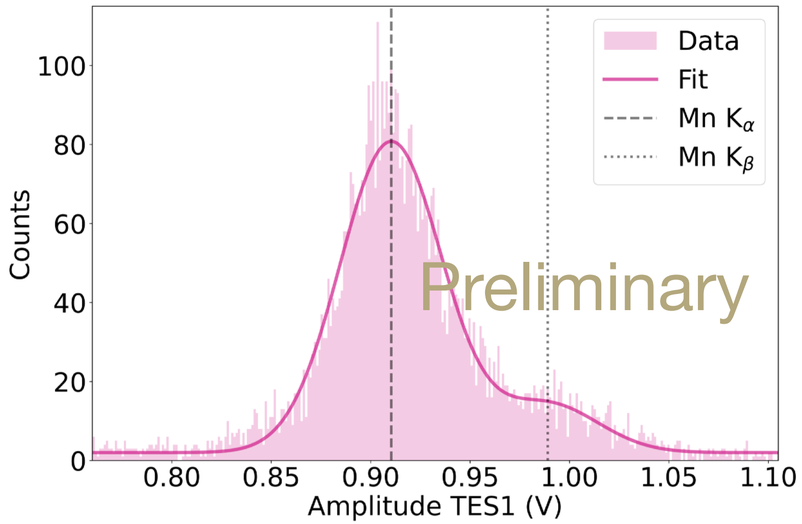
- Two TES on the same absorber crystal
- $5 \times 5 \times 7.5\ mm^3$ Al_2O_3 crystal, $m = 0.75\ g$
- One heater only
- 3 Al_2O_3 balls holding the crystal from below and 2 Al_2O_3 balls from above supported by brass clamps
- One ^{55}Fe source above the detector module

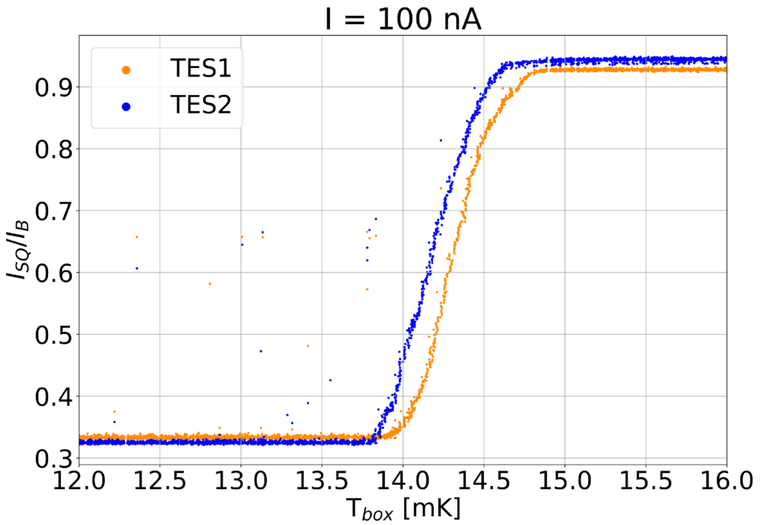


The DoubleTES - Al_2O_3 Performance

- Two TES transition curves overlap
  - ➔ possible to operate with one heater only
- Energy calibration with ^{55}Fe source
- Very low energy thresholds reachable, $5\sigma_{BL}$ of 34 eV and 31 eV

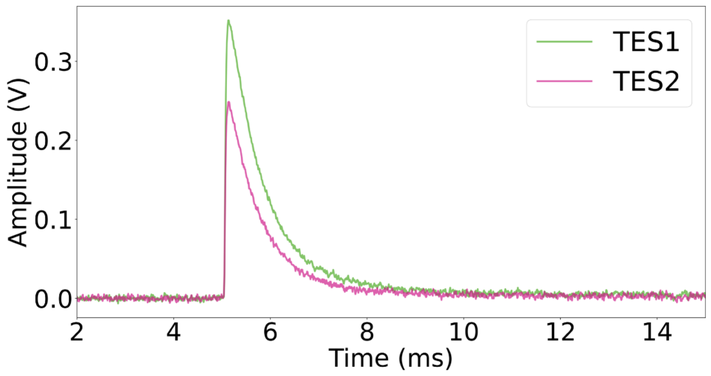


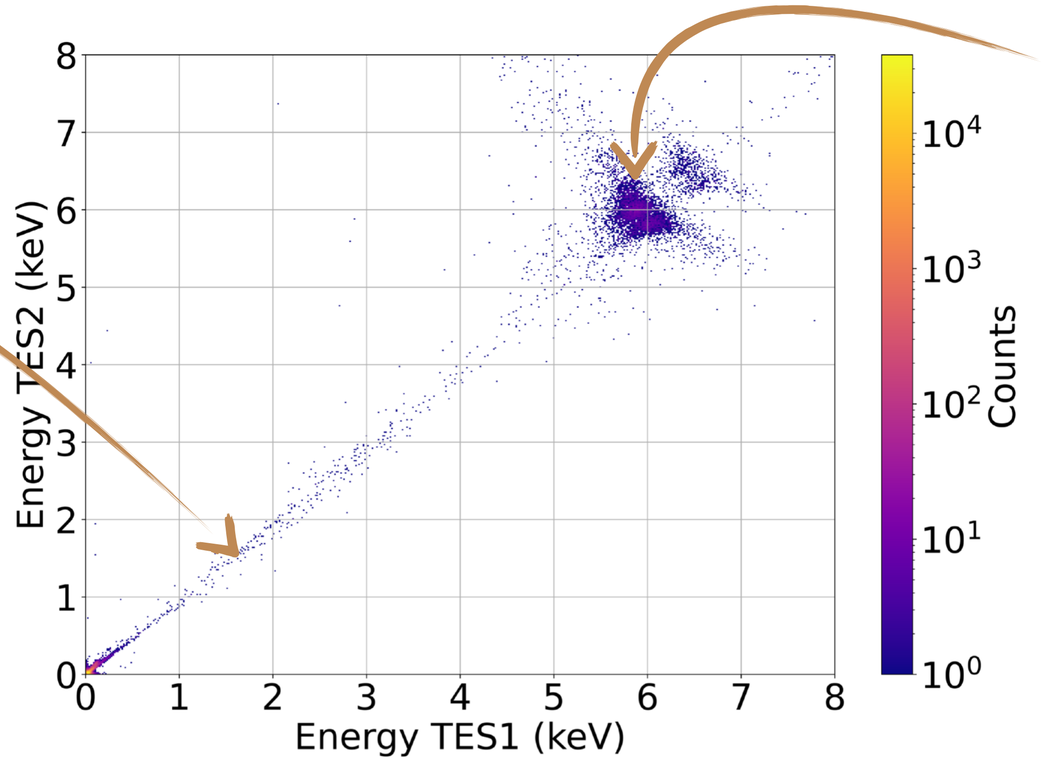




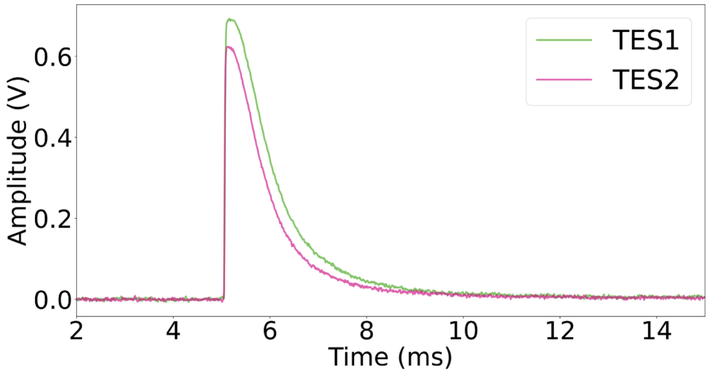
The DoubleTES - Al_2O_3 Performance

- Trigger and cut efficiency is flat at 76% above 40 eV
- Efficiency determination below 40eV is ongoing



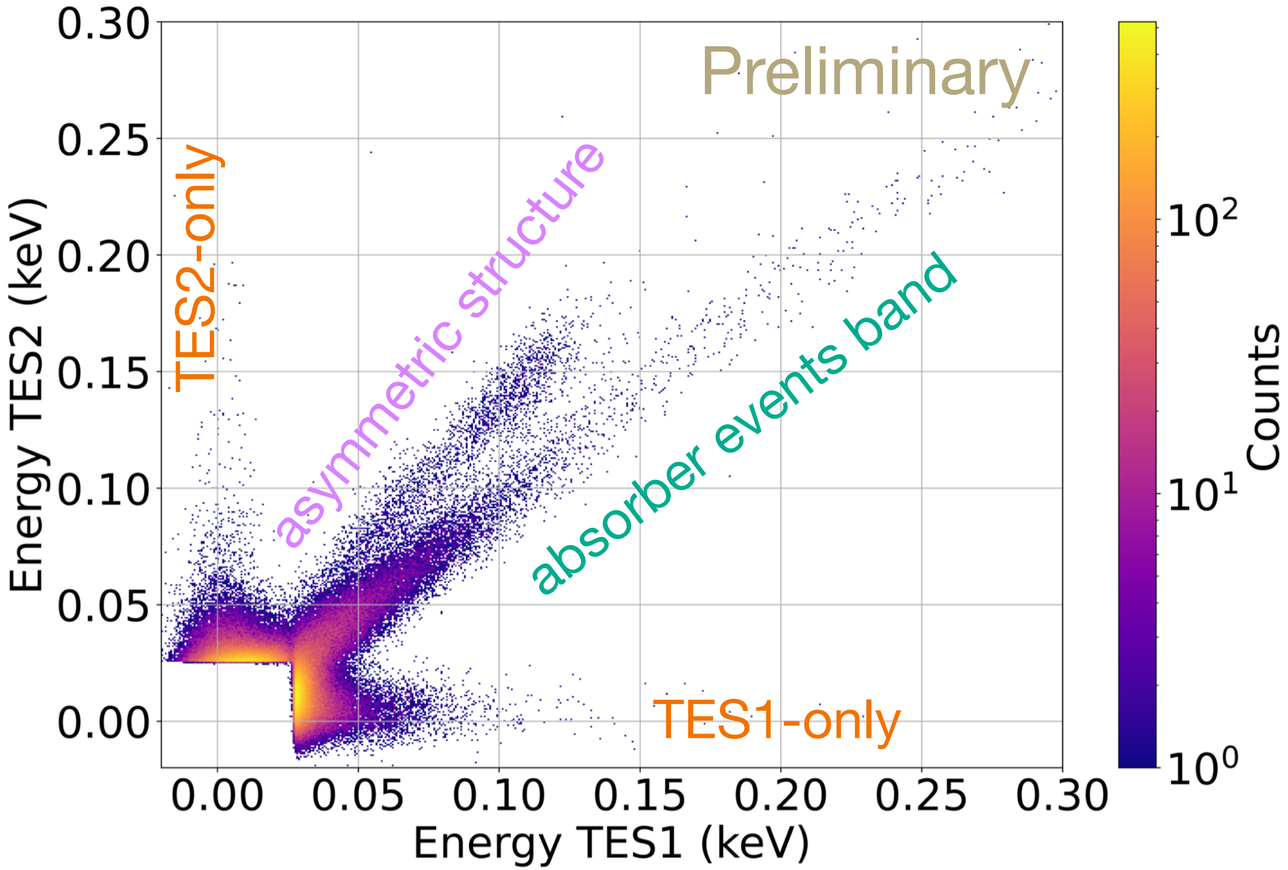


Slightly saturated iron pulses



The DoubleTES - Al_2O_3 Performance

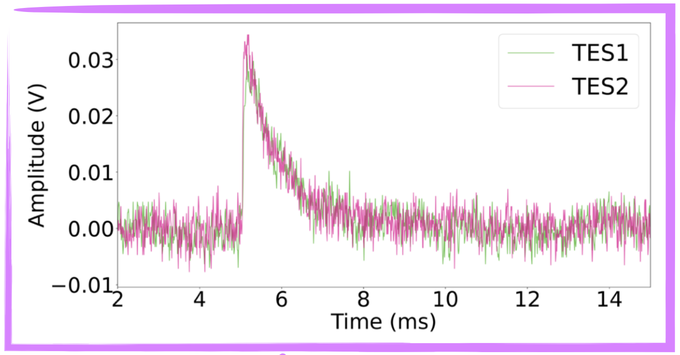
- Events after the quality and pulse shape cuts



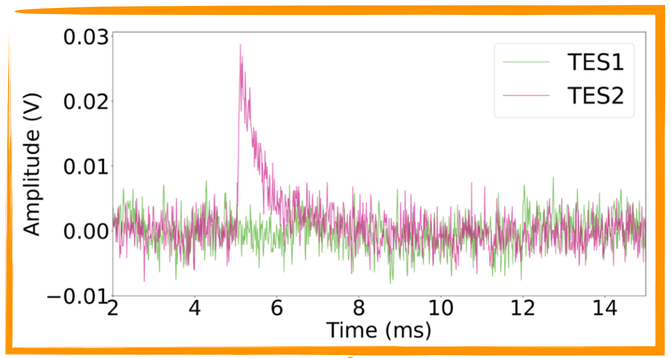
Additional structure with an asymmetric energy between the two TES not yet understood

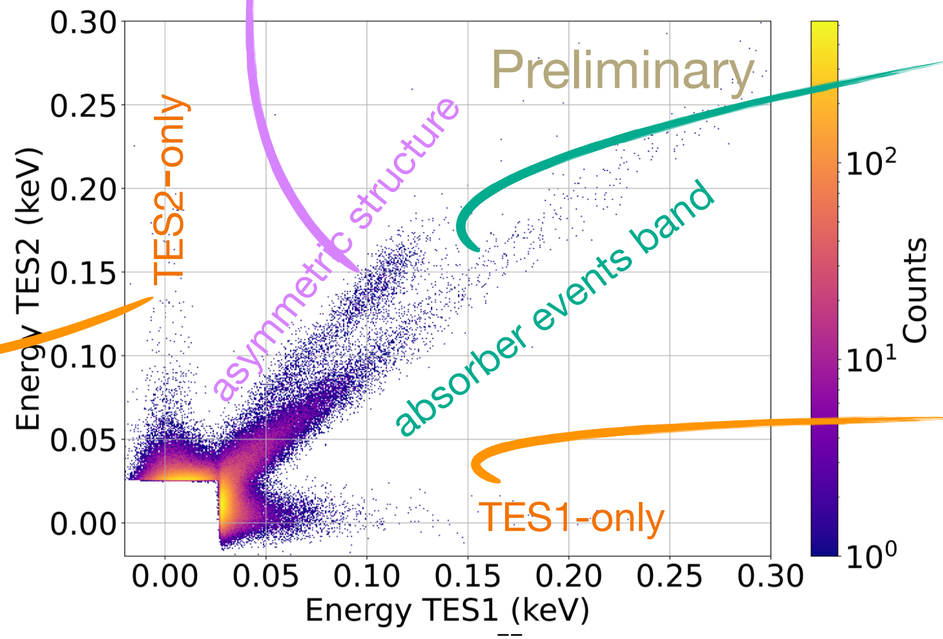
Above 50eV the majority of the events at threshold belongs to the absorber events band

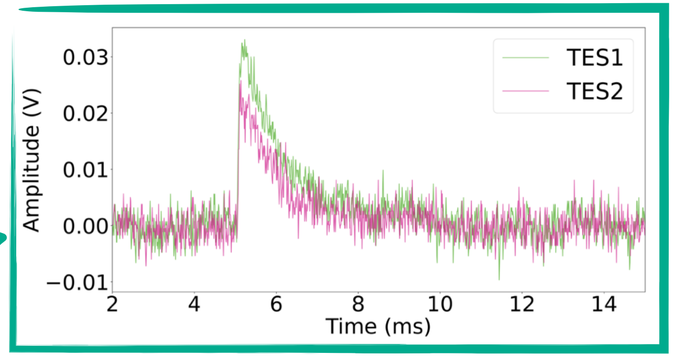
The DoubleTES - Al_2O_3 Performance

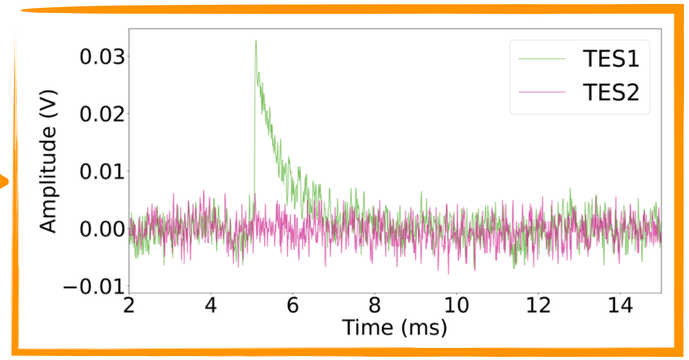


Raw pulses
(different calibration per channel!)



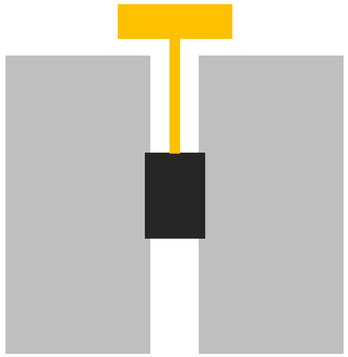


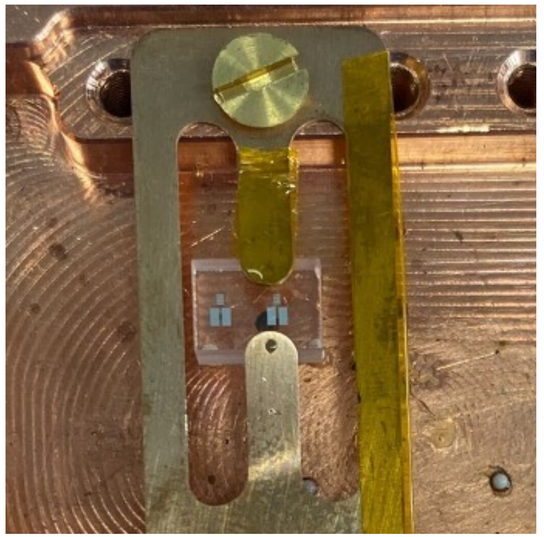




The DoubleTES - Al_2O_3 Conclusions

- There are events with an energy deposition in one TES only, with a particle-like pulse shape
- Exponentially rising energy spectra
- The spectrum at low energy has at least two components
  - Above 50 eV the absorber component seems to dominate
  - Analysis at lower energies is ongoing
- Measurement planned in a shallow underground laboratory at TUM with an instrumented holder, to understand if the absorber component is related to the holding structure





Conclusions

- The low energy excess has multiple components
- The doubleTES has been developed to study the origin of the low energy excess
- All of the tested doubleTES modules show evidence of energy deposits in single TES
  - Single TES events are observed at threshold
  - These events might not share the calibration with absorber events
    → difficult to compare between modules
- Only one measurement could explore a region below 100eV, showing a dominant absorber component of events above 50eV
- A series of measurements are planned in the near future

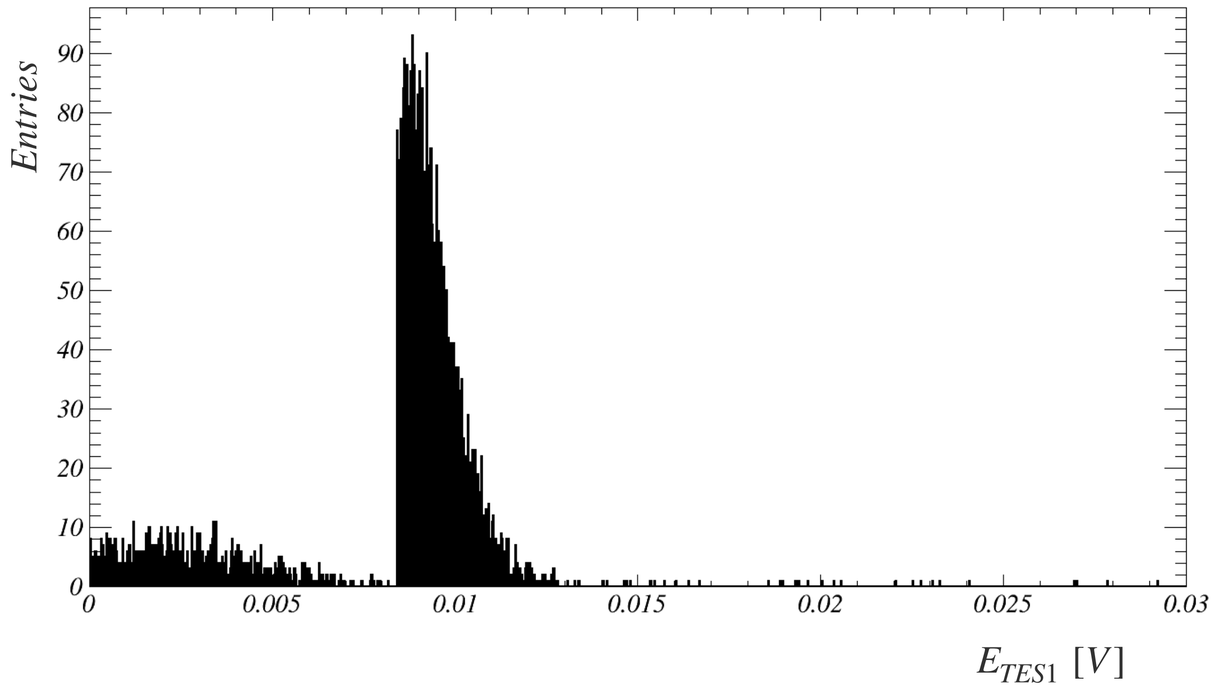
Stay tuned!

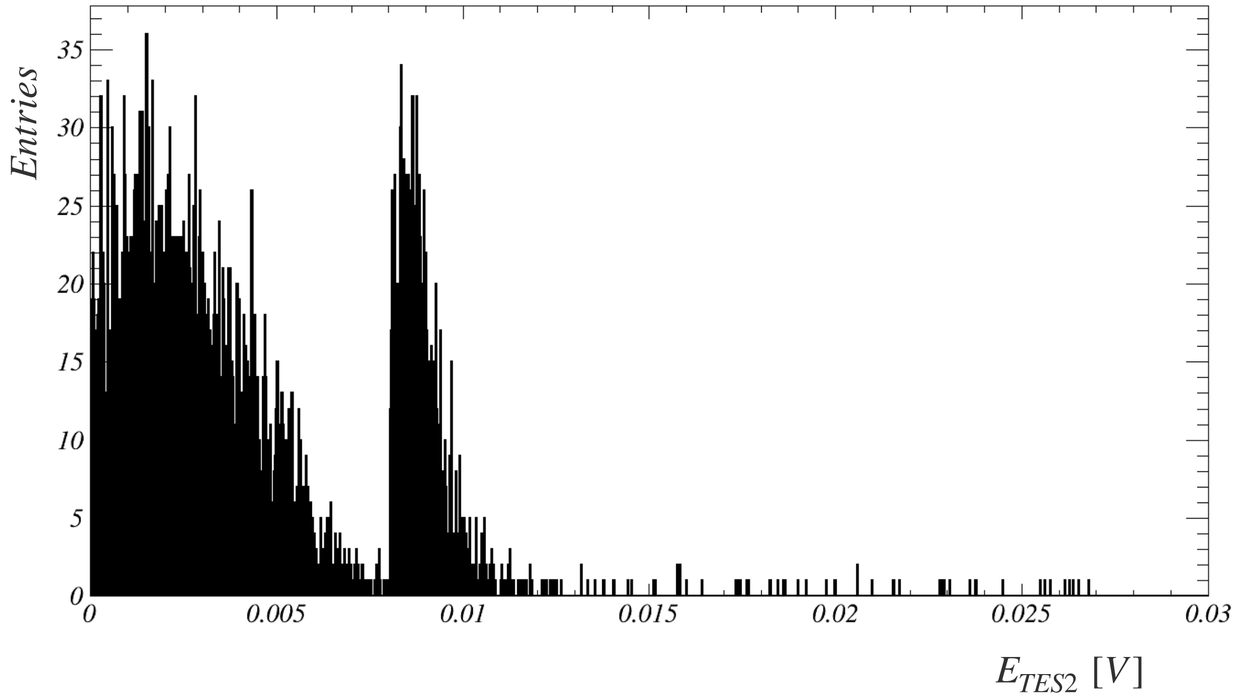
Thank you for your attention

Backup slides

The DoubleTES - $CaWO_4$ Results

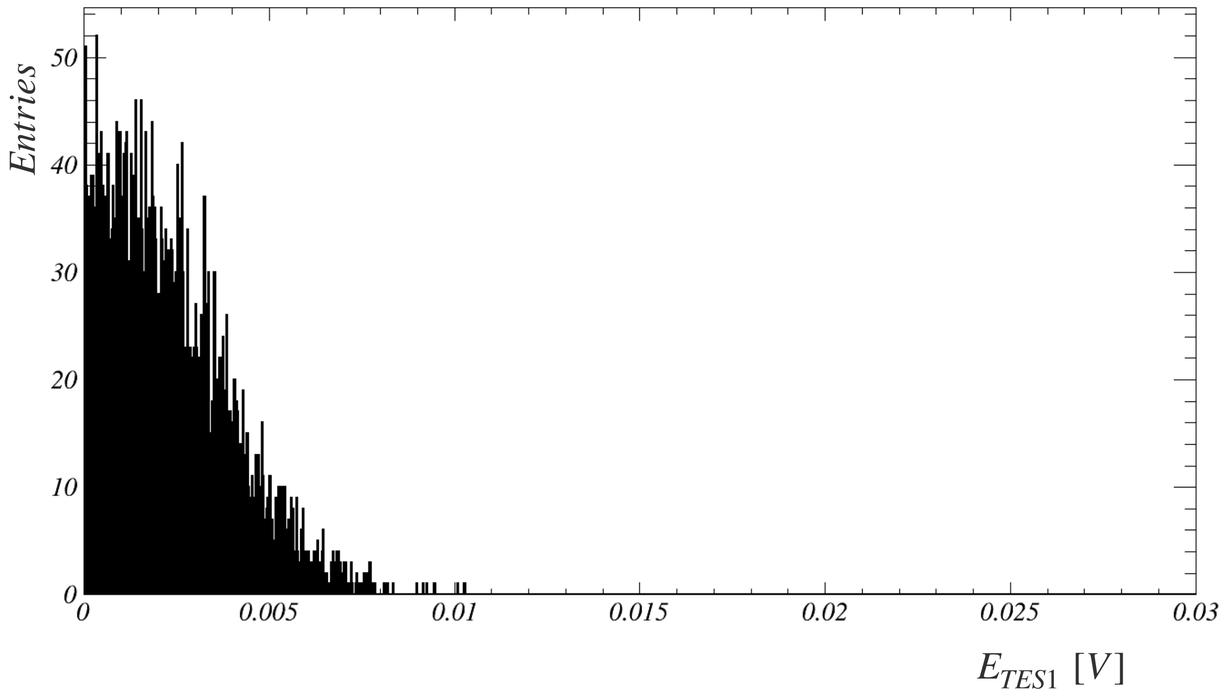
- Non calibrated spectra below threshold
- Spectra not corrected with efficiency

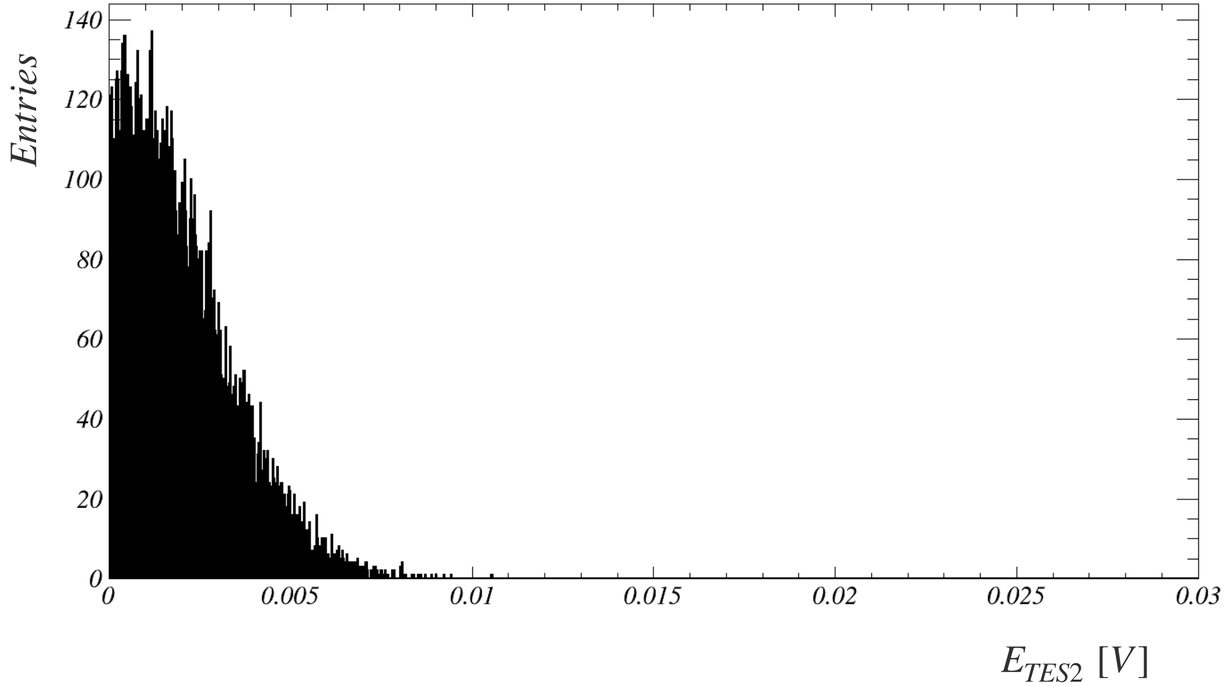




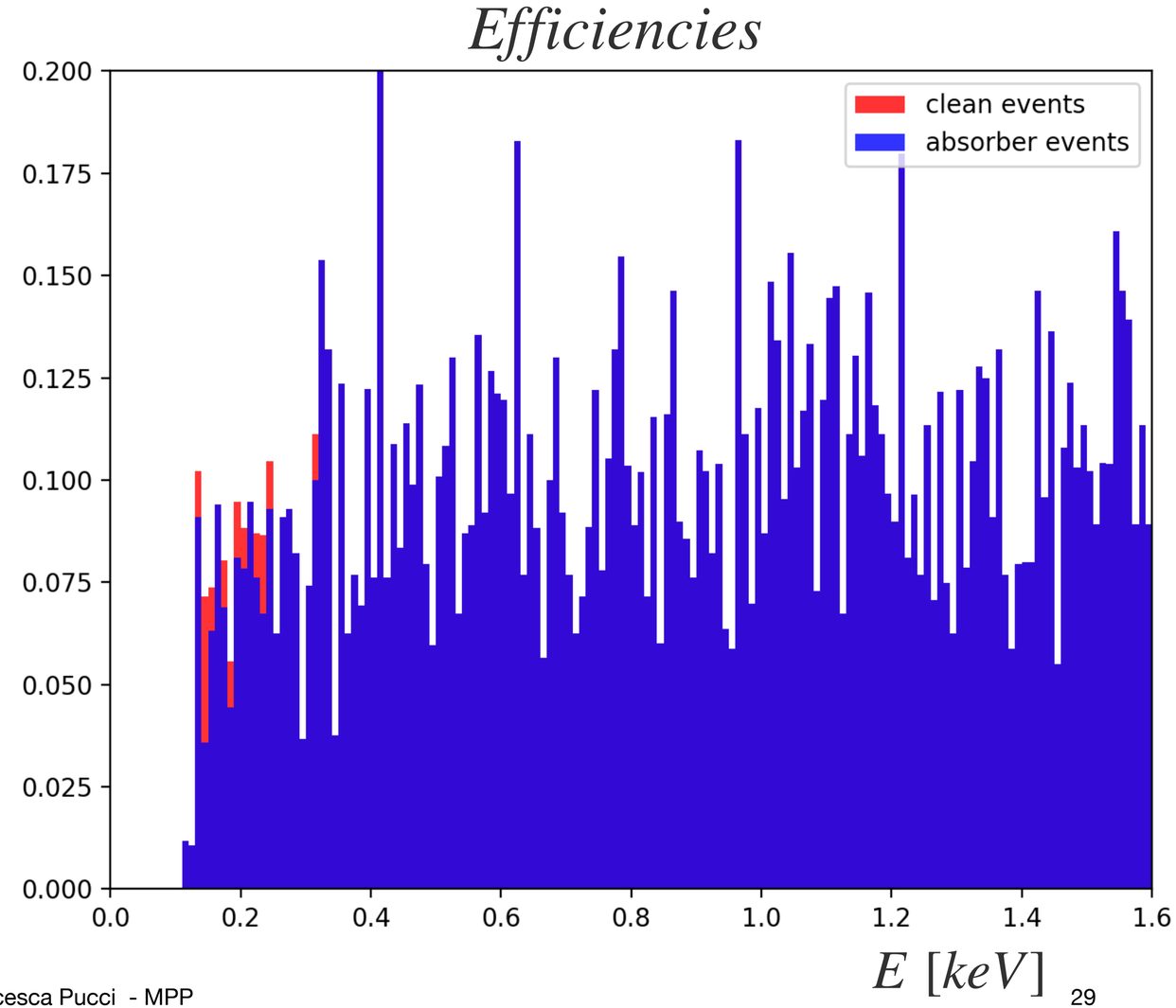
The DoubleTES - $CaWO_4$ Results

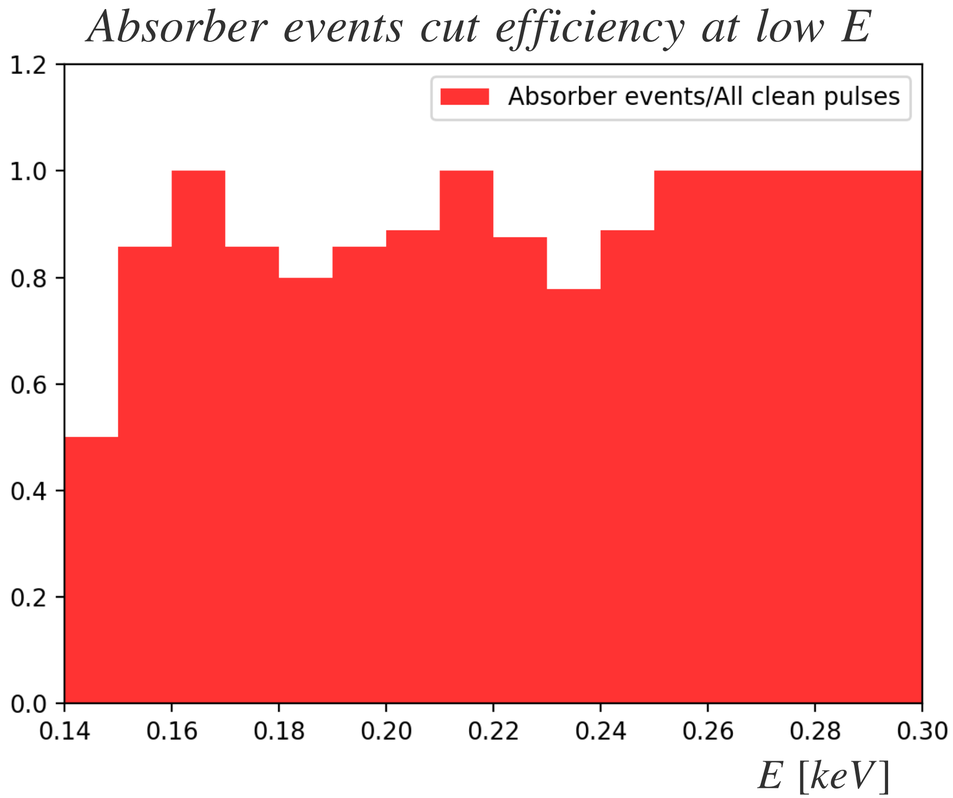
- Inverted stream analysis: non calibrated noise spectra from empty baselines





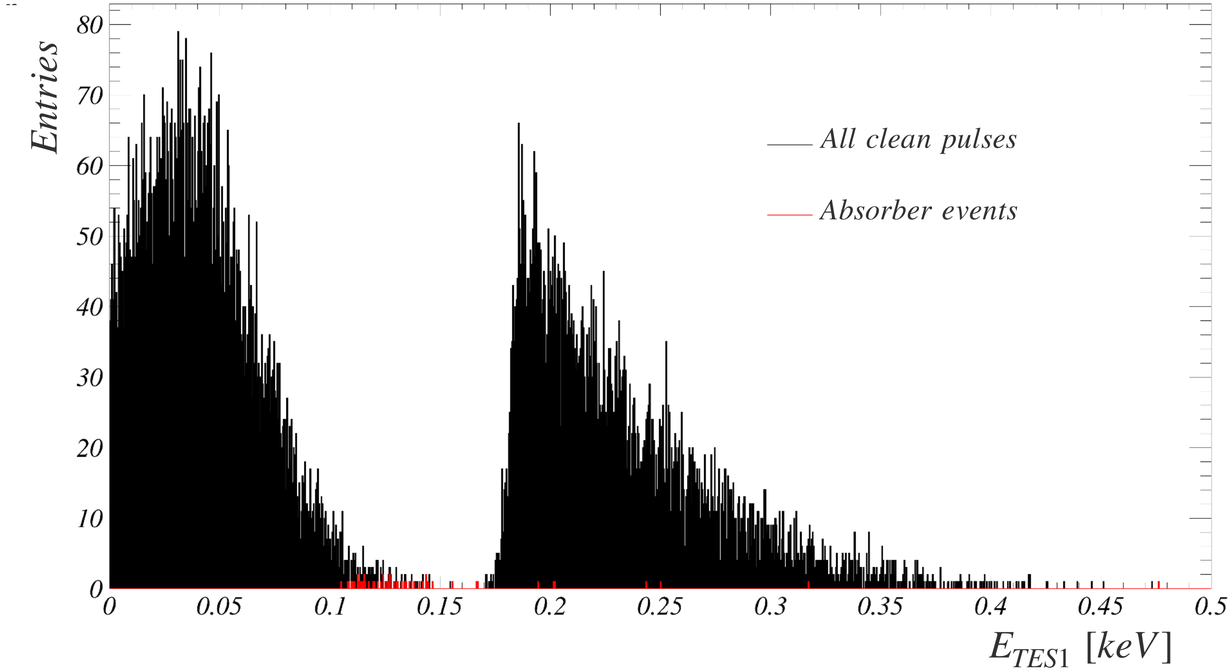
The DoubleTES - $CaWO_4$ Efficiency

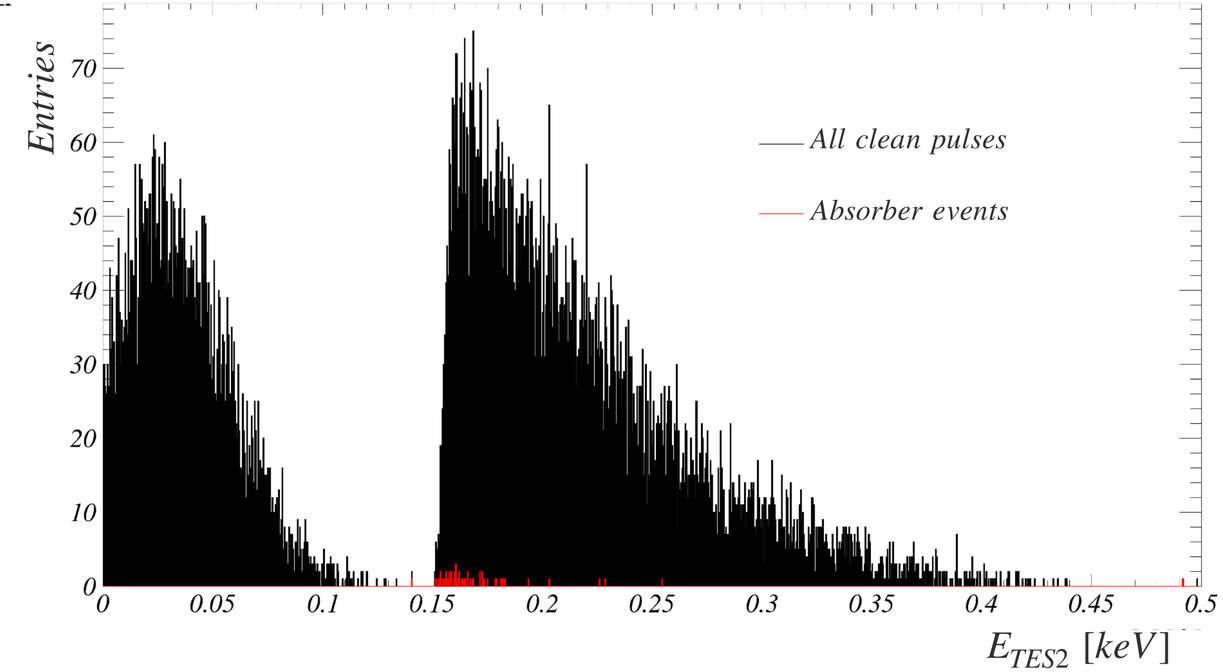




The DoubleTES - *Diamond* Results

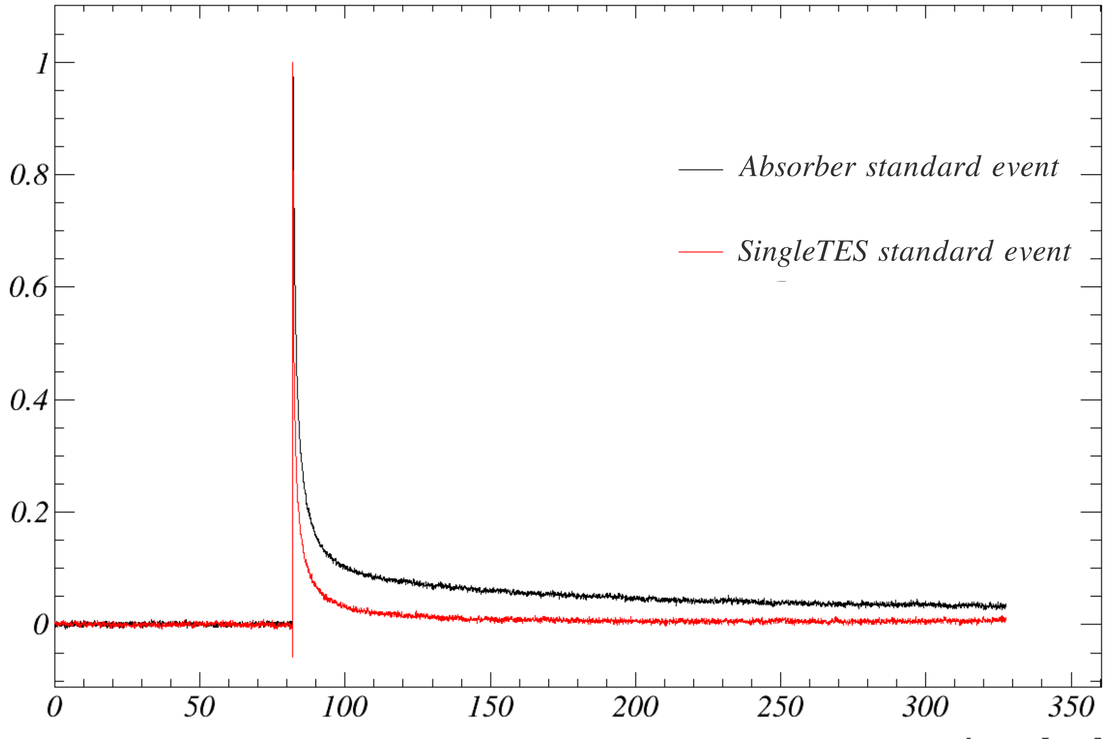
- Spectra below threshold
- Spectra not corrected with efficiency

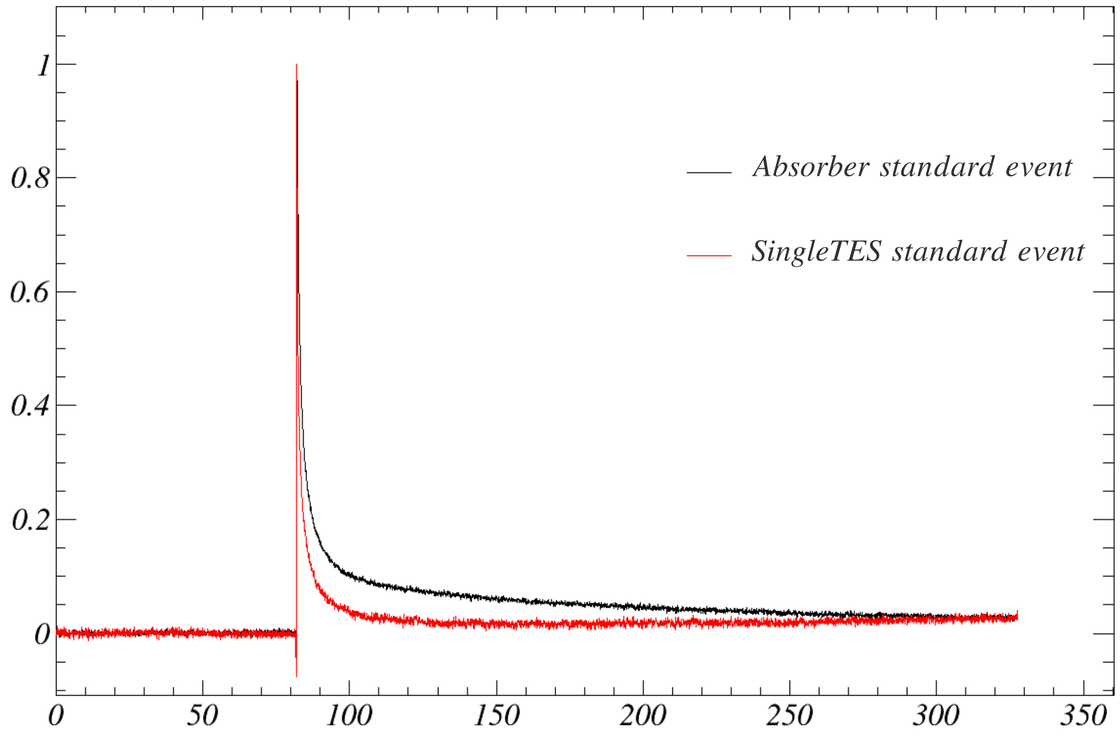




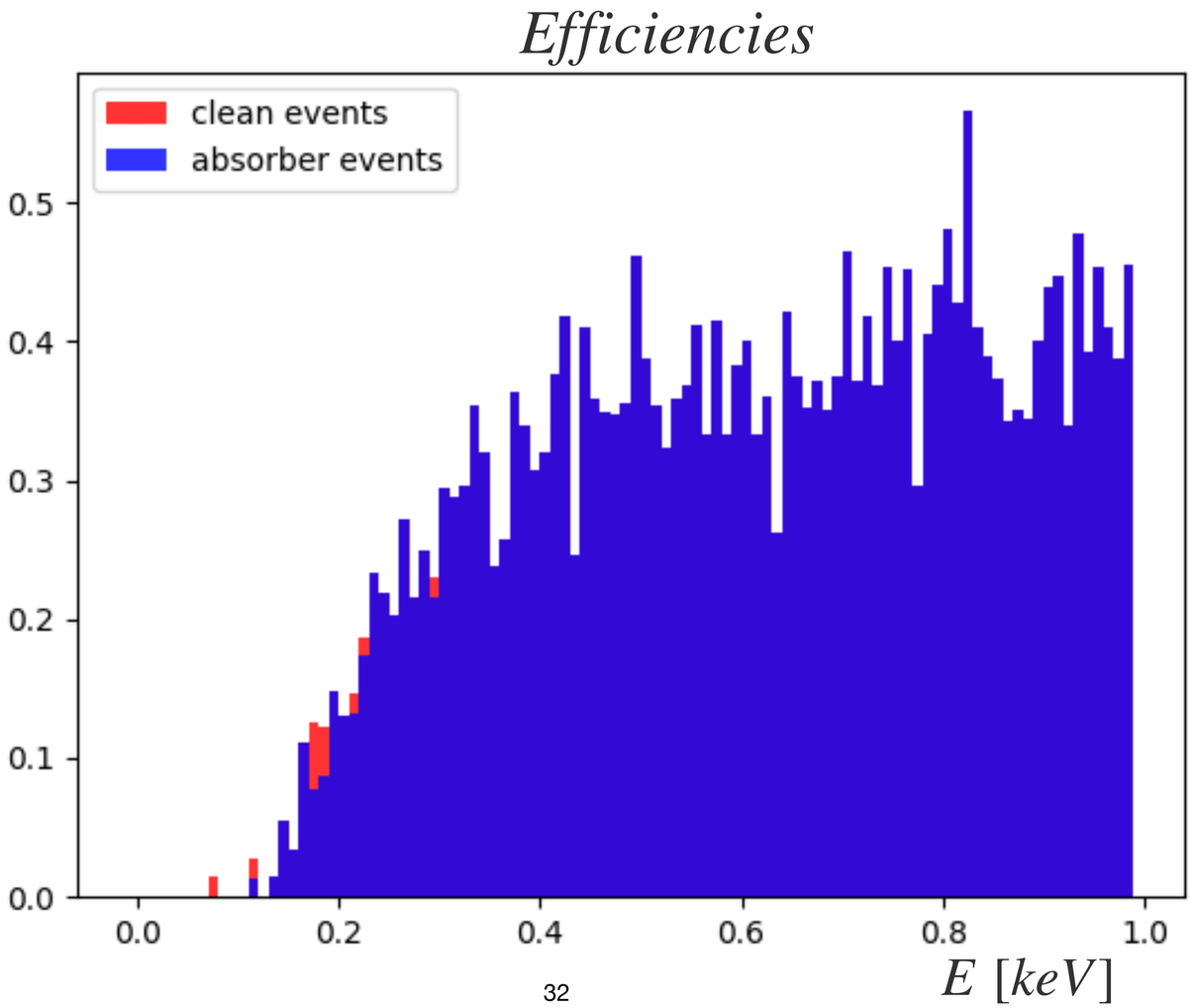
The DoubleTES - *Diamond* Results

- All the modules observe that single TES events are faster than absorber events





The DoubleTES - *Diamond* Efficiency



The DoubleTES - Results

- All the modules observe that single TES events are faster than absorber events