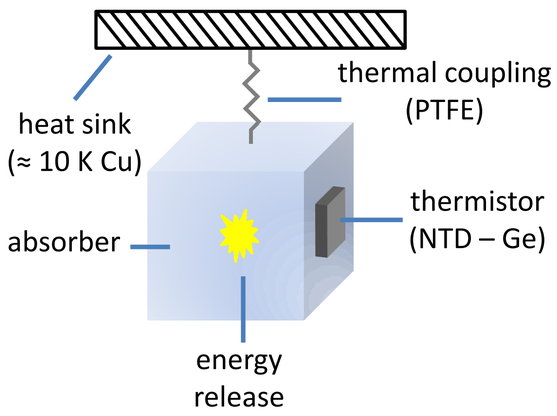
A software algorithm to lower the energy threshold of a bolometric light detector

Gabriele Piperno - Sapienza, Università di Roma & INFN Roma

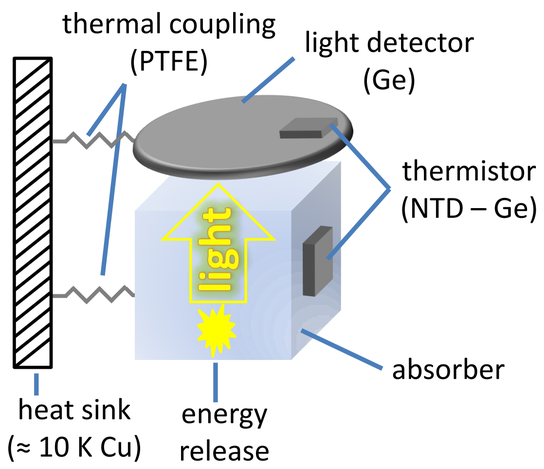
Bolometric experiment, as CUORE and LUCIFER, are of primary importance for rare processes search, in particular for neutrinoless double beta decay (0νDBD) and dark matter interactions.
Detectors with high energy resolution, low background and low energy threshold are needed:

- energy resolution is an intrinsic characteristic of the selected material (some keV per MeV of deposited energy),
- background can be reduced by means of light detectors that allow a discrimination between signal (β) and background (α),
- here is presented an algorithm to lower the energy threshold of light detector by a factor of 3, which allowed to measure light emitted by Čerenkov process in a TeO_2:Sm bolometer.

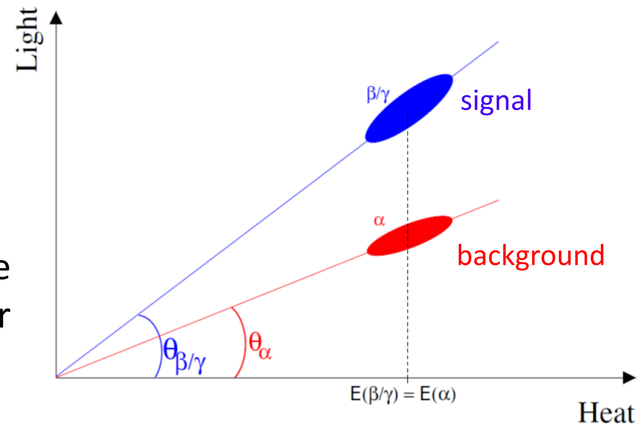
Bolometric technique



1) particle energy converted into phonons
2) temperature variation in the absorber (≈ 0.1 mK/MeV)
3) A biased NTD thermistor measures this heating

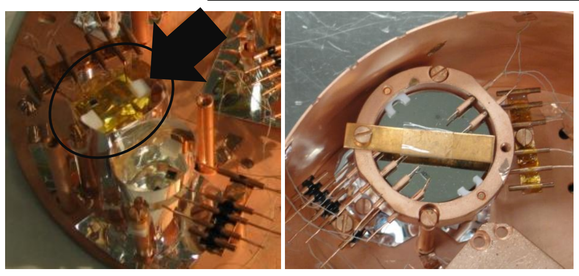


It is possible to reject background detecting the light (scintillation or Čerenkov) produced during the interaction: for the same energy release in the absorber, β/γ and α's produce different amount of light.



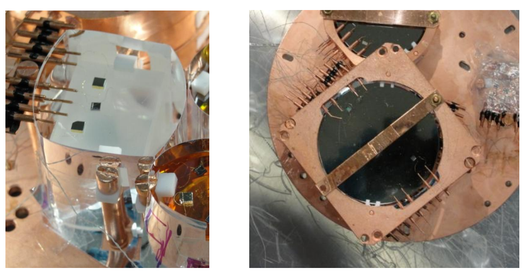
Due to experimental setup the light detector (LD) is a bolometer too.

Test detectors @ LNGS



$ZnMoO_4$

- Scintillating bolometer
- Dimensions: 28.5 x 18.4 x 13.2 mm
- Mass: 29.9 g
- LD: 1 mm Ge + 60 nm SiO_2



TeO_2:Sm

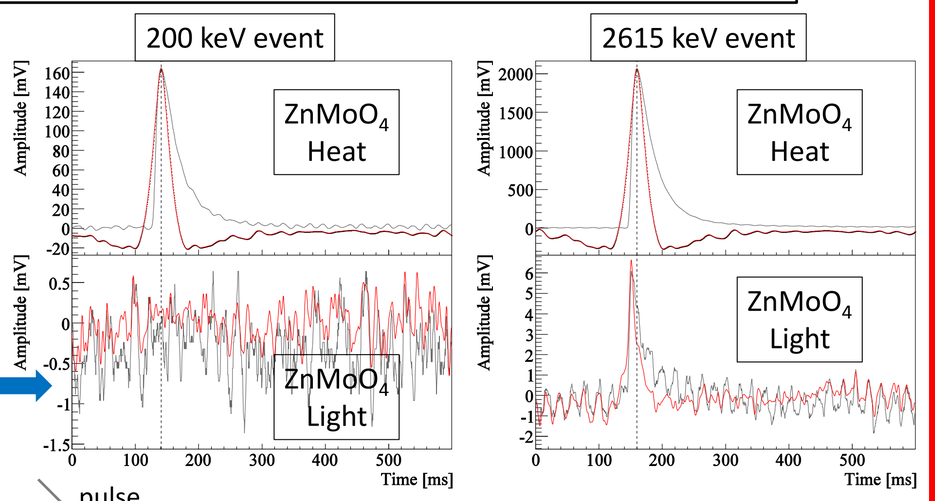
- Non scintillating bolometer
- Dimensions: 30.0 x 24.0 x 28.0 mm
- Mass: 116.65 g
- LD: 1 mm Ge + 60 nm SiO_2

Maximum search algorithm

Event = Pulse

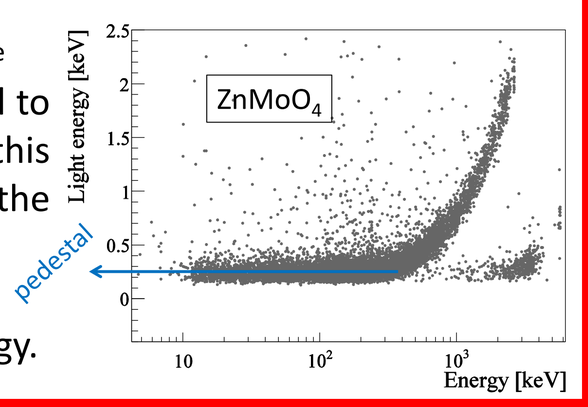
Pulse ∝ Energy

For low energy releases in light detectors, noise oscillations may hide the pulse



Coupling light channel to heat channel to obtain the light – heat scatter plot, this algorithm takes the maximum in the acquired window as pulse height.

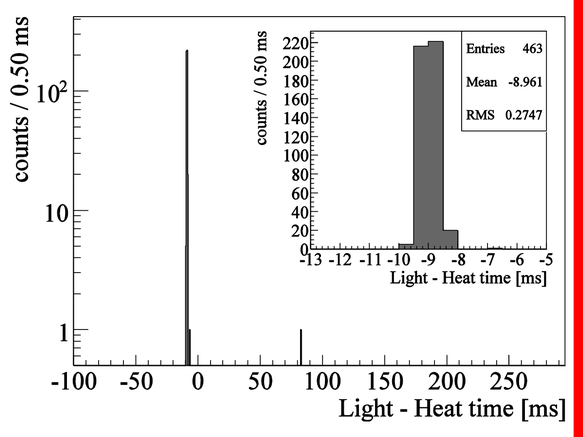
Appearance of a pedestal at low energy.



New algorithm

To eliminate the pedestal it is possible to use a new algorithm:

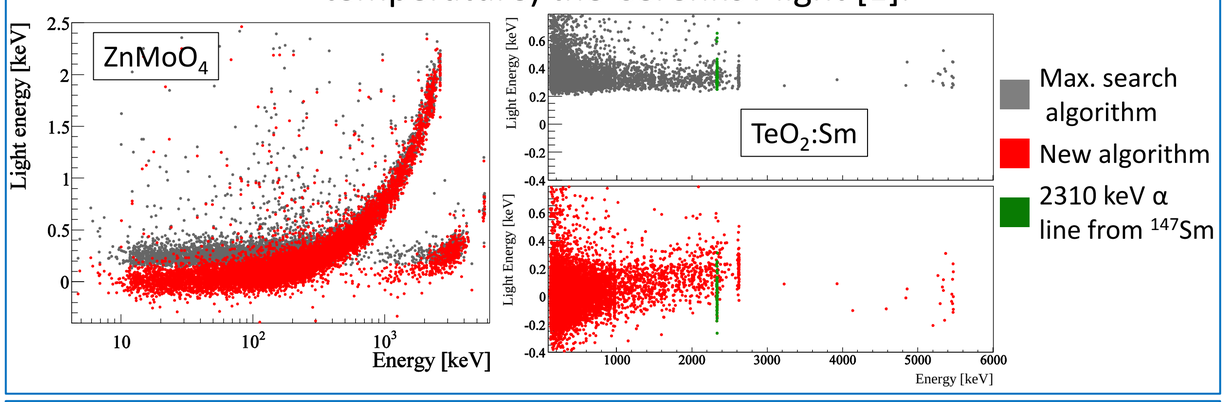
1) select events with much energy released in both heat and light channels (pulses are well defined)
2) apply maximum search algorithm
3) event by event evaluate the time delay between the two channels and make the distribution
4) select the mode of the distribution as the time delay of the two channels (*jitter*)



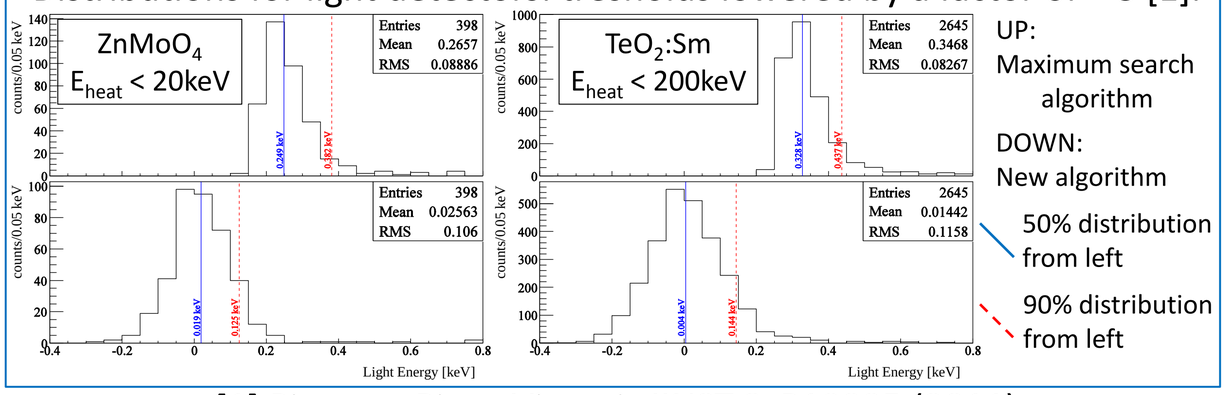
Now light pulse height is evaluated as the amplitude in the acquired window at the time:

$$t_{light} = t_{heat\ max} + jitter$$

Pedestal disappear and for TeO_2:Sm crystal seen (first time at criogenic temperature) the Čerenkov light [1].



Distributions for light detectors: tresholds lowered by a factor of ≈ 3 [1].



[1] Piperno, Pirro, Vignati, *JINST* 6, P10005 (2011)