Istituto Nazionale di Fisica Nucleare

SAPIENZA
UNIVERSITÀ DI ROMA


XIX International Workshop on Neutrino Telescopes

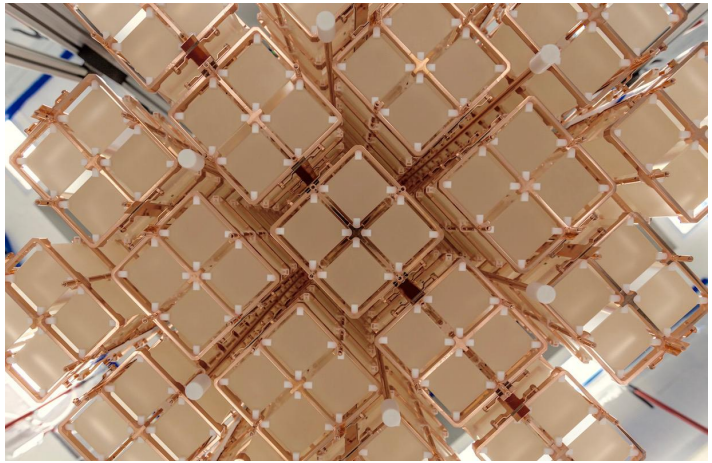
Scintillating Li_2MoO_4 Bolometers for neutrinoless double beta decay search

XIX International Workshop on Neutrino Telescopes

Alberto Ressa, Sapienza - University of Rome
on behalf of CUPID collaboration

CUORE and CUPID

See G. Fantini's Talk
https://agenda.infn.it/export/event/24250.ics



arXiv:2011.09295 **[physics.ins-det]**

CUORE:

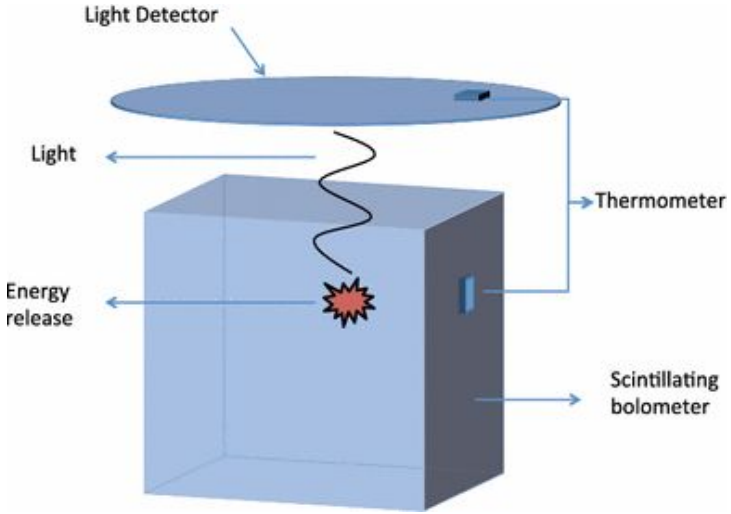
Searching for ^{130}Te **0νββ** decay with TeO_2 bolometers at 10 mK

- First **ton-scale** bolometric experiment
- Reached **1 ton × year exposure**
- **~0.2% energy resolution** at ^{130}Te Q-value ($Q_{\beta\beta} \simeq 2527$ keV)
- ^{130}Te 0νββ: limit on $\mathbf{t_{1/2} > 10^{25}\ y}$

➔ Background level dominated by α particles from surface contamination: 10^{-2} counts/(keV kg y) → 50 counts/y in the ROI

See A. Giuliani's Talk
https://agenda.infn.it/export/event/24250.ics

CUORE and CUPID



CUPID:

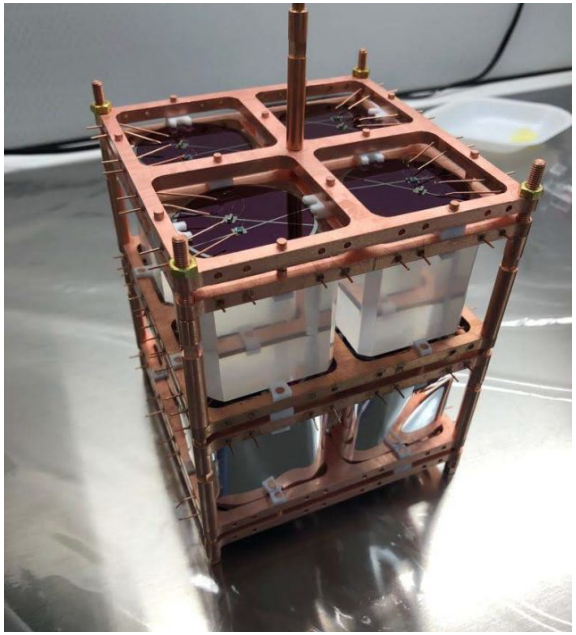
Next generation experiment searching for ^{100}Mo 0νββ with **Scintillating Bolometers** using CUORE infrastructure:

- **Reject α particles** background with scintillation light detection
- **^{100}Mo isotope**: higher $Q_{\beta\beta}$ (3034 keV) to reduce natural radioactivity background in the ROI

➔ **"Background-free" condition**
➔ **10^{27} y** sensitivity on the ^{100}Mo 0νββ half-life

CUPID R&D Activities

R&D tests ongoing at LNGS to define the final CUPID design.



- 8 enriched Li_2MoO_4 cubic crystals (LMO)
- 12 Light Detectors (LD) on top and bottom faces
- 4 crystals are covered with Reflecting Foil (RF)
- Heater: inject fixed energy purely thermal pulses

Light detected with small bolometers

➢ Ge disk coated with SiO and equipped with thermistors

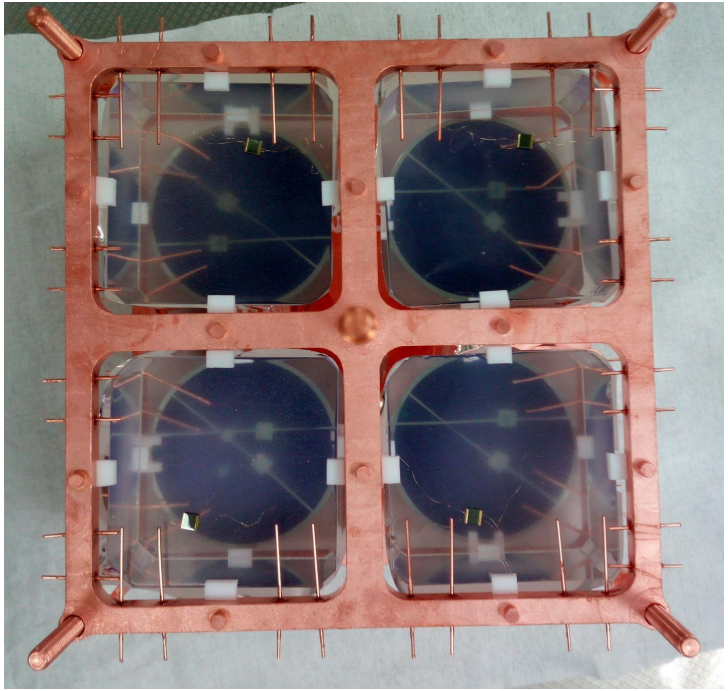
CUPID R&D Activities

Targets:

1. Test **Energy Resolution**
   → cubic Li_2MoO_4 studied for the first time

2. Analyse **Light Detectors Performances** and Noise Level

3. Study the **Particle Identification** capabilities and Light Collection
   → with/without RF to study the final CUPID configuration

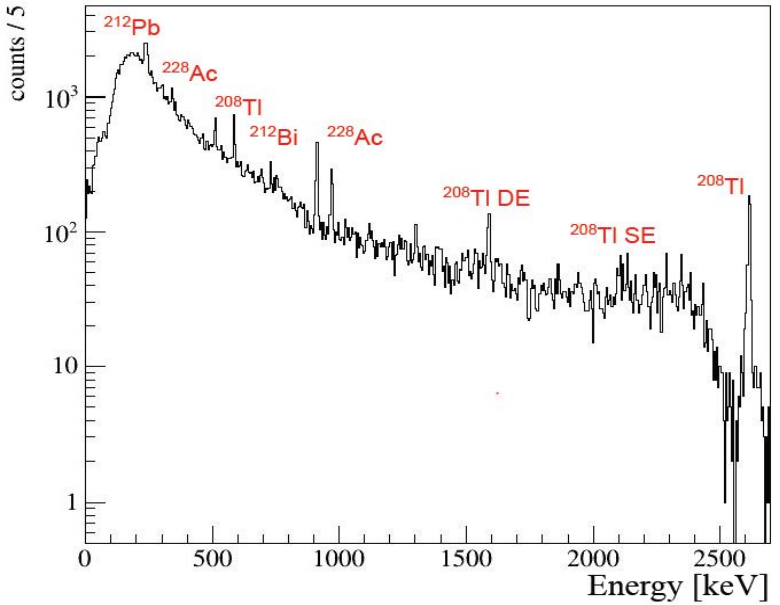


Energy Resolution

Energy spectrum: peaks from ^{232}Th source
FWHM (**ΔE**) vs Energy fitted using (p_0+p_1E)

Extrapolate **ΔE** at the ^{100}Mo Q-value (3034 keV)

➪ **(6.7 ± 0.6) keV**
➪ **0.22%**



Despite not optimal cryogenics conditions, the result **approaches the CUPID goal** of 5 keV FWHM

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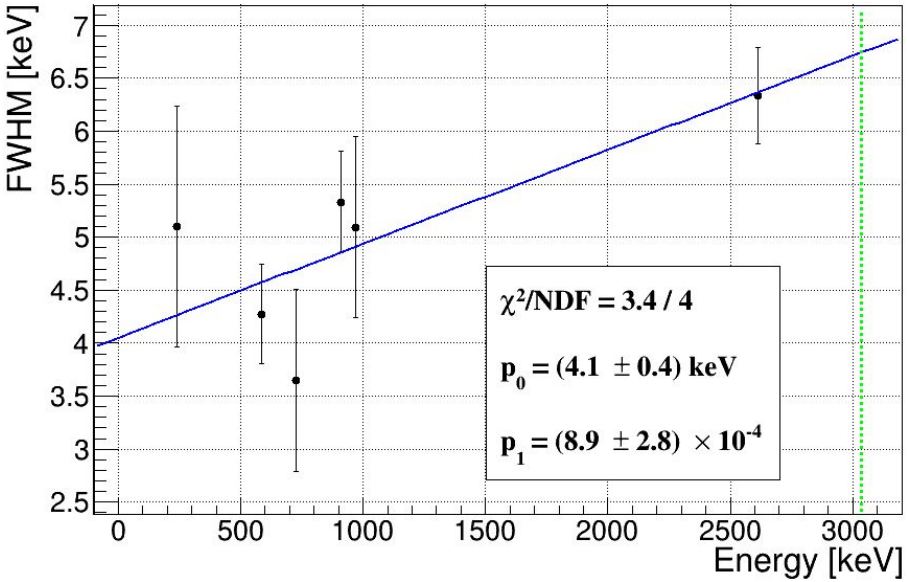
arXiv:2011.13656v1 **[physics.ins-det]**



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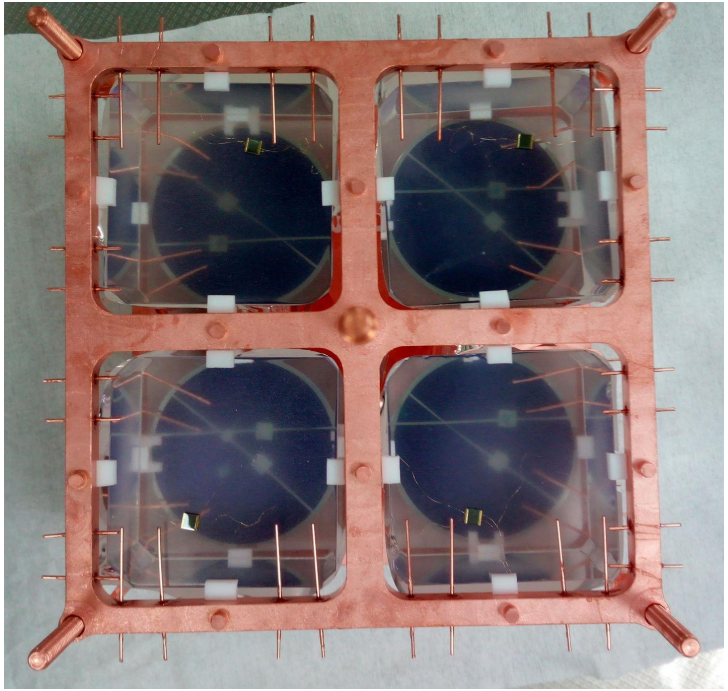
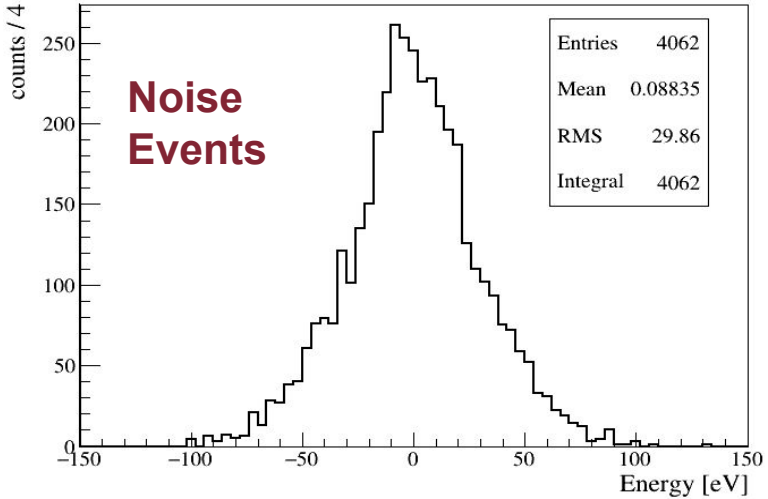


Light Detectors Performances

Light Detectors calibrated with X-rays hitting directly the Ge disk from ^{55}Fe sources



Noise RMS results in the range **25-40 eV** for each LD

Reproducible result which satisfy the request for CUPID

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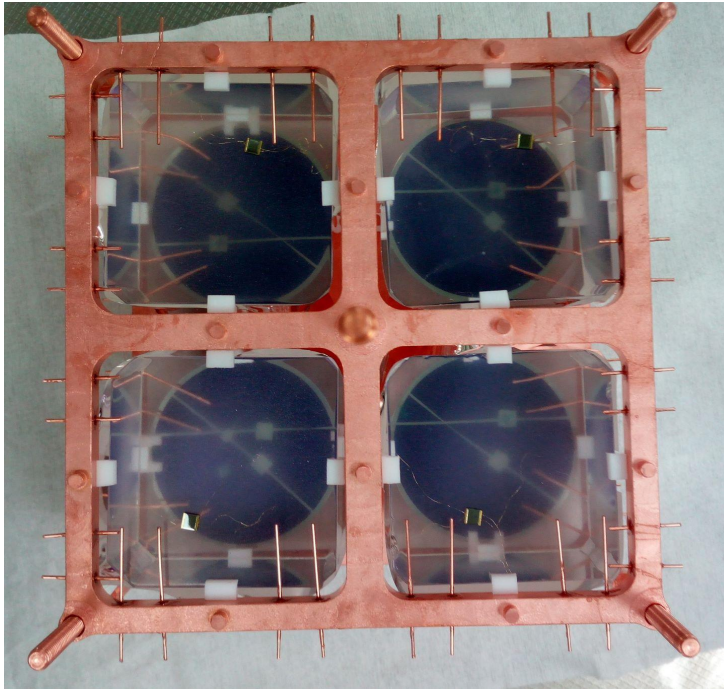
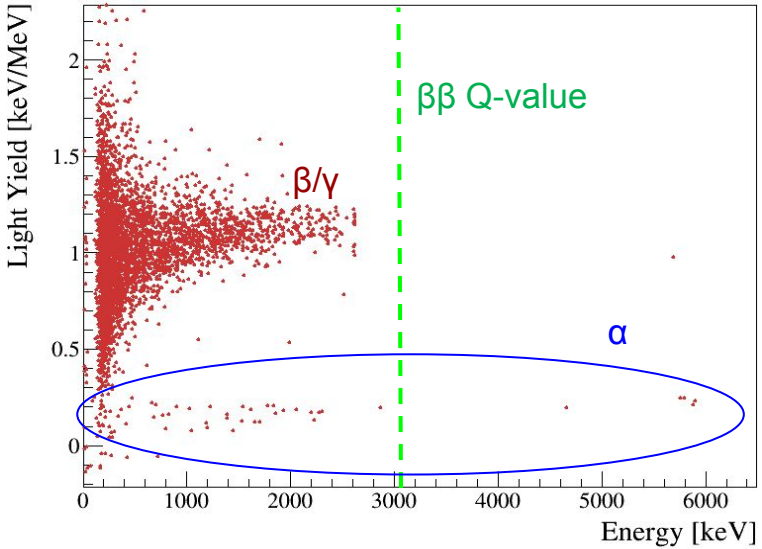


Particle Identification

Light Yield at a fixed Energy on heat channel is quenched for α particles
Heat and **Light** simultaneous read-out allows Particle Identification



Reject α from surfaces contamination:
it is the dominant background at the
ββ Q-value in CUORE

Discrimination Power:

$$DP \equiv \frac{\left|LY_{\beta/\gamma} - LY_{\alpha}\right|}{\sqrt{\sigma^2_{\beta/\gamma} + \sigma^2_{\alpha}}}$$

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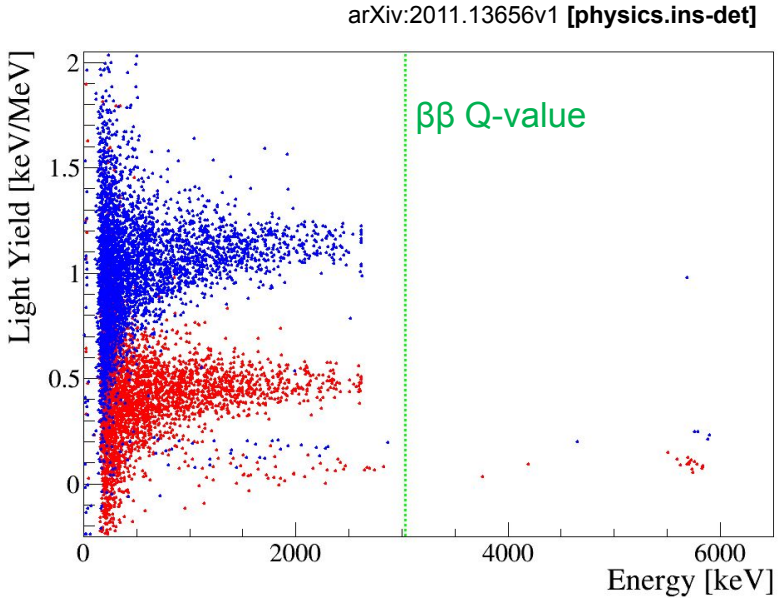


Study of the **Light Yield** with/without Reflecting Foil (RF) using 2 LD:

Blue: crystals with RF ➔ (1.10±0.05) keV/MeV

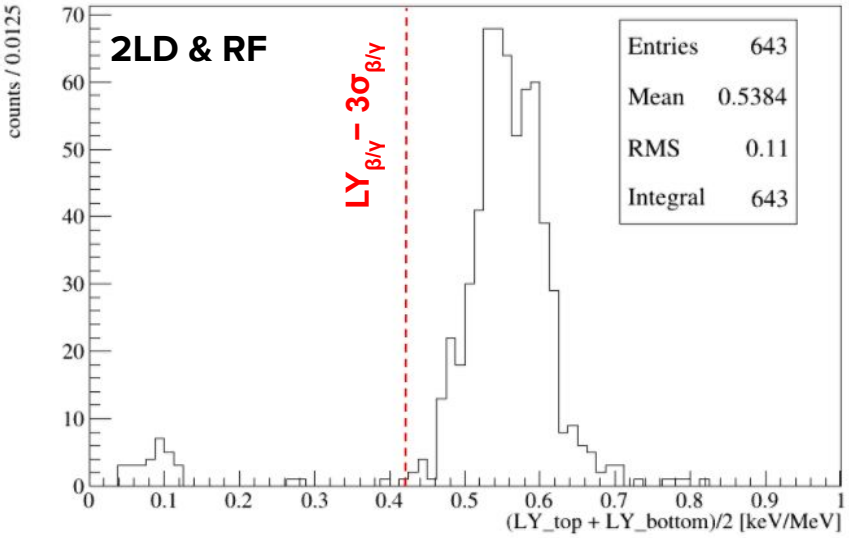
Red: bare crystals ➔ (0.50±0.05) keV/MeV

→ the RF increases the light collection by a factor > 2

Particle Identification

Study of α particles events discrimination with **different configurations**:
Signal acceptance: 99.7% → cut at $LY_{\beta/\gamma} - 3\sigma_{\beta/\gamma}$

- ✓ Complete Rejection (**DP > 8**) using 2 LDs & crystal with RF
- ✓ Good Results with
  - 1 LD & RF (**DP > 7**)
  - no RF but 2 LDs (**DP > 4**)
- ✗ Inefficient with 1 LD and no RF (**DP < 4**)



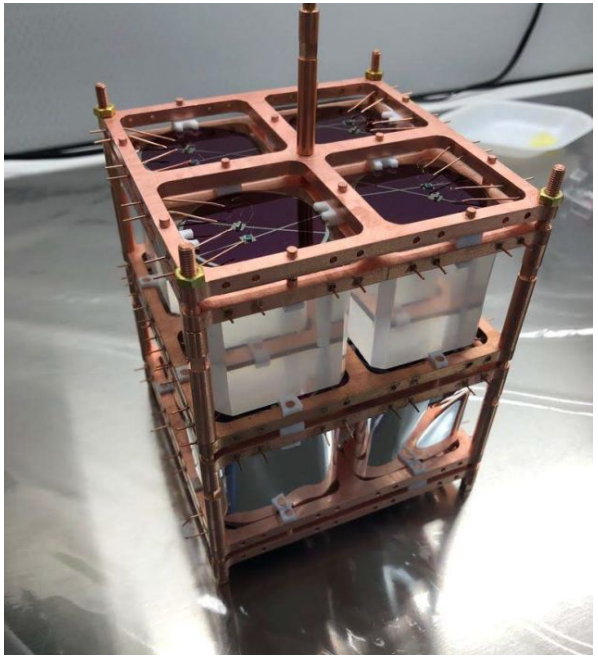
Summary

Targets:

1. **Energy Resolution** of Li_2MoO_4 cubic crystals:
   ⇨ **(6.7 ± 0.6) keV FWHM:** Close to CUPID goal

2. **Light Detectors Performances** and Noise Level:
   ⇨ **25-40 eV RMS:** reproducible results

3. **Particle Identification** and Light Collection:
   ⇨ RF increases LY by a factor **> 2**
   ⇨ **Complete α rejection** with different light collection configurations



Future Prospects

New R&D run is ongoing at LNGS Hall C:

- Foreseen better experimental conditions. **Noise and cryogenics can be improved**. Operating the detector at 10 mK, instead of 20 mK, the energy resolution is expected to improve.

- Light collection will be improved using **square, instead of circular, Light Detectors** which will be also placed closer to the crystals

THANKS FOR YOUR ATTENTION!