Evaluation of the CUPID First Tower Prototype performance

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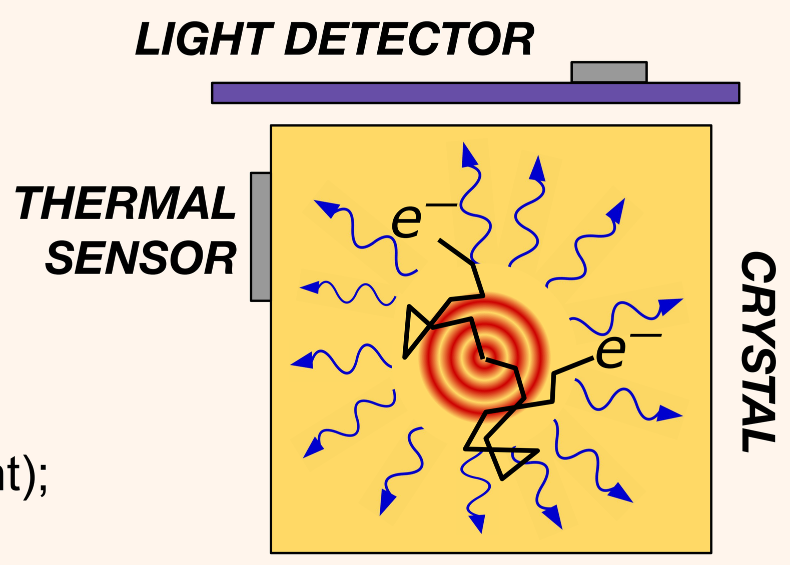
The CUPID experiment

$0\nu\beta\beta$ decay: LNV process → neutrino nature (Majorana);
→ neutrino mass scale.

CUPID:

- Search for $0\nu\beta\beta$ decay in ^{100}Mo ($Q_{\beta\beta}$ = 3034 keV);
- 1596 Li_2MoO_4 crystals → ~ 240 kg ^{100}Mo (95% enrichment);
- Ge light detectors (LD) with NTL amplification;
- 99% α vs β/γ discrimination through heat/light read-out;
- Crystals energy resolution: 5 keV FWHM;
- LD pile-up time resolution: < 0.17 ms;
- Light Yield for β/γ: 0.3 keV/MeV.

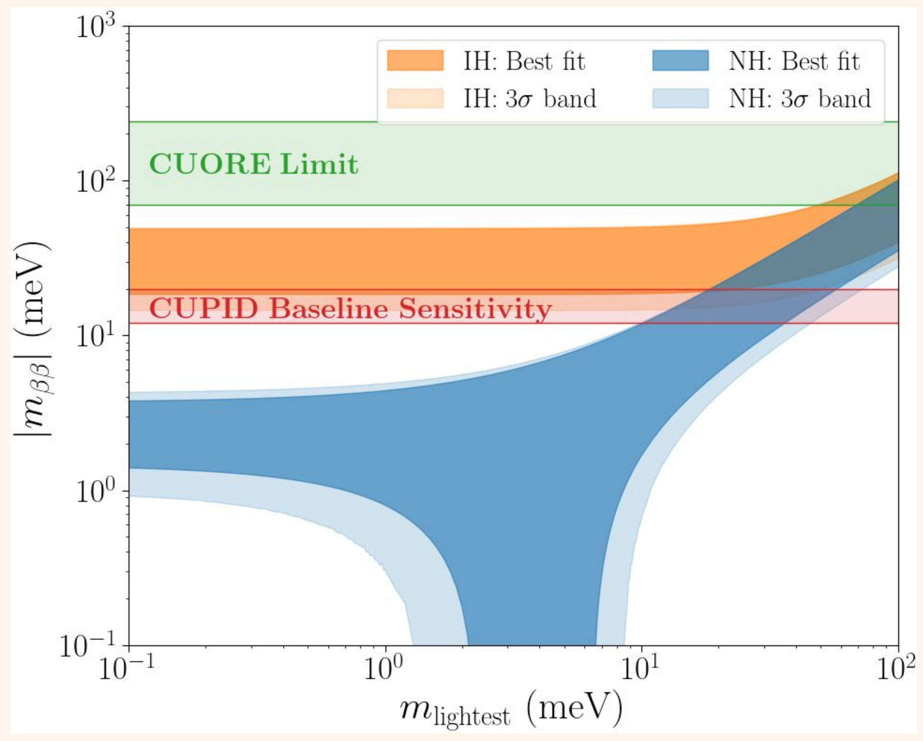


Background index in ROI:
*1 x 10^{-4} counts / (keV*kg*yr)*

$0\nu\beta\beta$ decay sensitivity:
$T_{1/2}^{0\nu} > 10^{27}$ yr (10 yr) → $m_{\beta\beta}$ ~ 12-20 meV

Sensitivity

! See also: **"The CUPID $0\nu\beta\beta$ experiment", ID: 376**



BDPT: design and goals

First CUPID full-tower (two columns):

- 28 LMO crystals;
- 30 LD.

Read-out through NTD thermistors

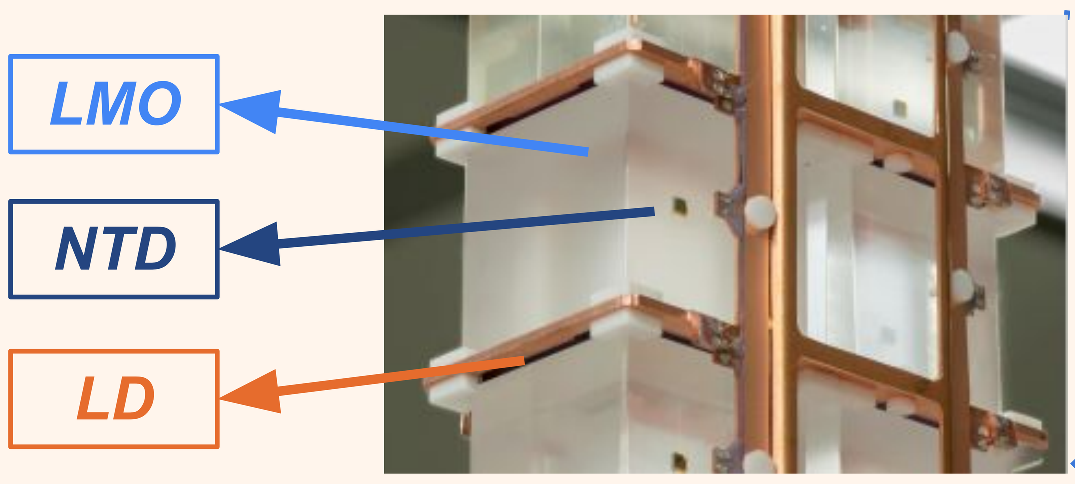
New frame design:

- Easier and faster assembly;
- Reduced machining;
- Minimized passive materials close to the detectors.

- *Mechanical properties*
- *Thermal properties*
- *Detector performance*

+

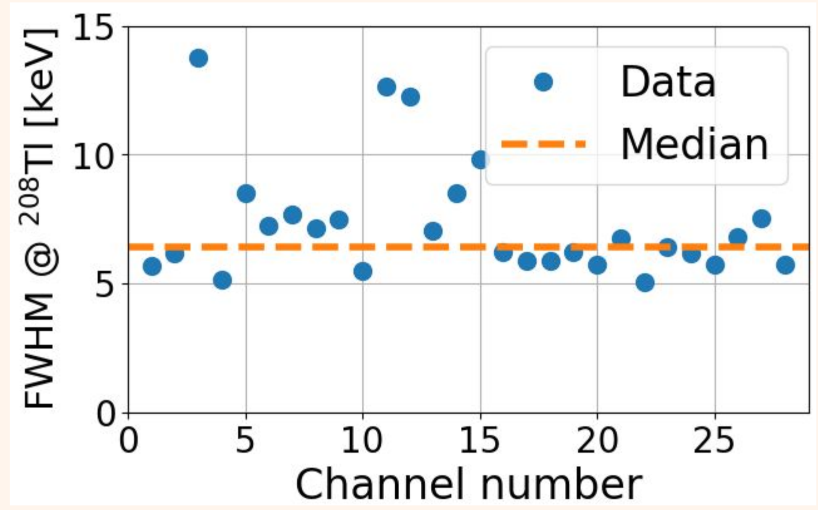
- *LMO contaminations, growing techniques* and *thermistor glues*
- *LD anti-reflecting coatings*
- Characterization of the new CUPID DAQ



Detector performance

LMO performance:

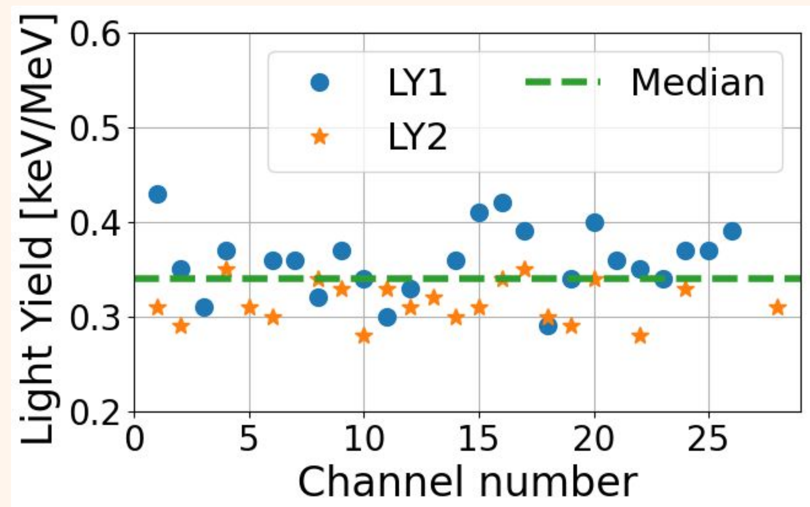
- *Median FWHM$_{baseline}$* = 3.1 keV
- *Median FWHM$_{2615\ keV}$* = 6.2 keV



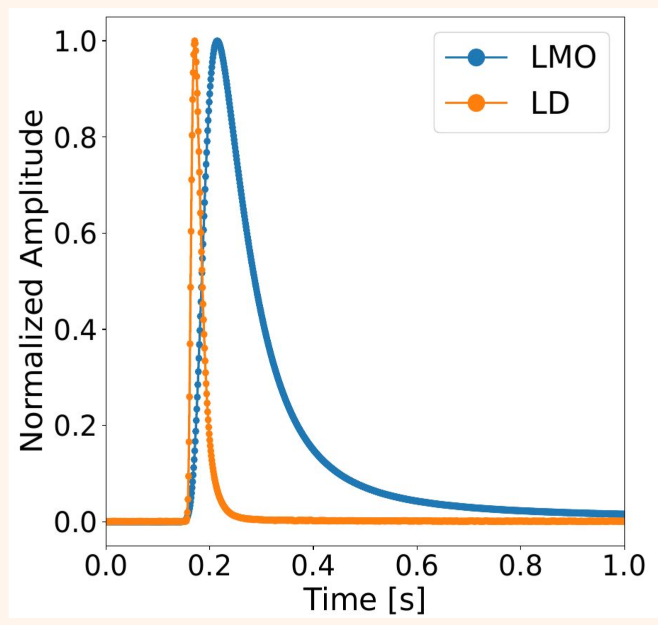
LD performance:

- *Median Light Yield = 0.34 keV/MeV*
- *Median Discrimination Power*

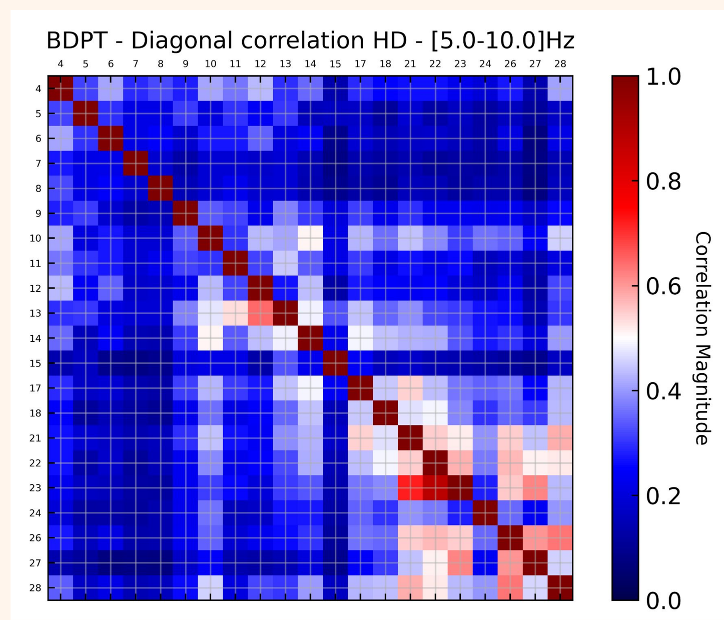
$$DP = \frac{|LY_{\beta,\gamma} - LY_{\alpha}|}{\sqrt{\sigma^2_{\beta,\gamma} + \sigma^2_{\alpha}}} = 3.21$$



Further studies:



Light signal → $2\nu\beta\beta$ pile-up rejection.



No major noise correlations between crystals introduced by the new tower structure.

Cool-down and thermal stability

Performed **two cooldowns @ LNGS** (Hall-A):

Run 1 → July-August 2022 *Run 2* → September-October 2022

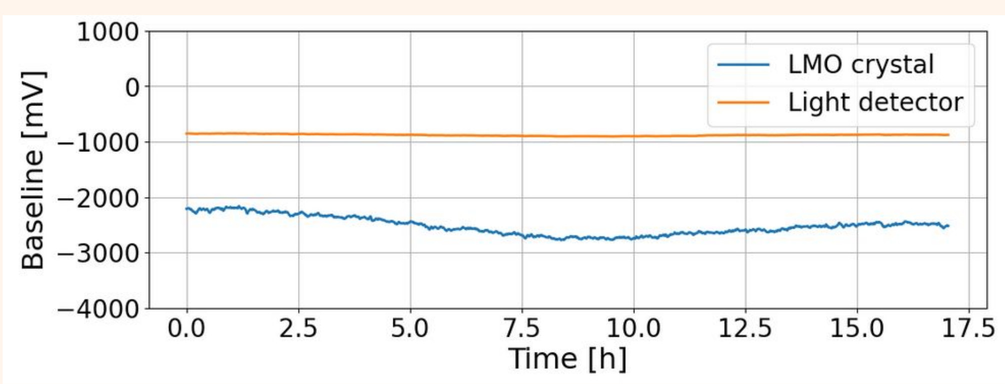
The detectors successfully reached T_{base} ~ 10 mK uniformly in few hours

✔ Uniform LMO base resistances (temperatures) along the tower.

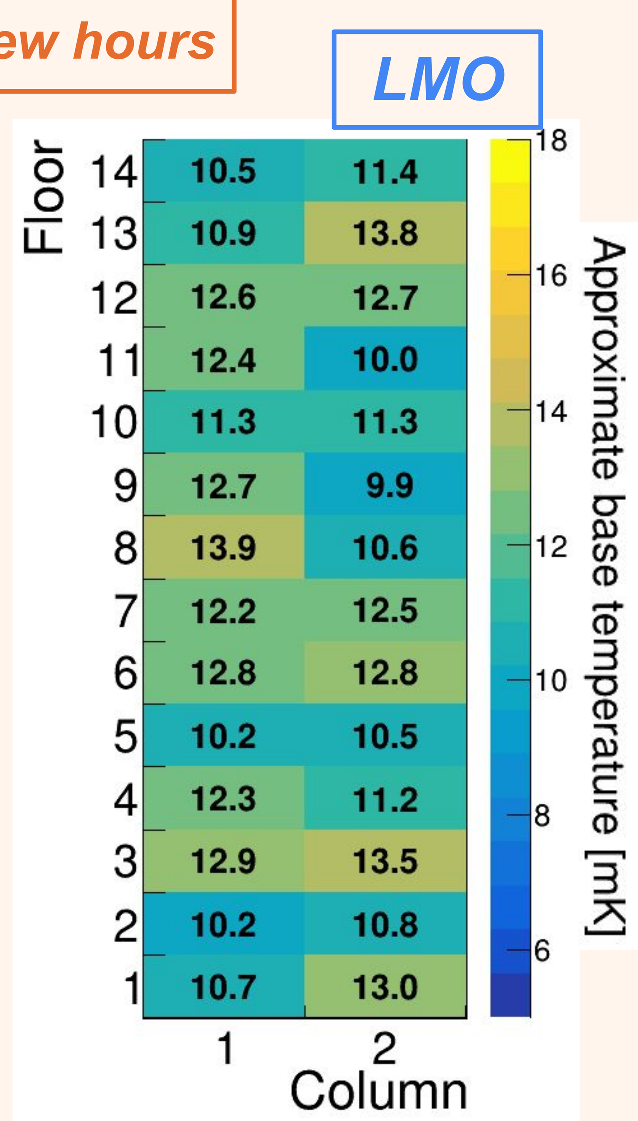
$$R(T) = R_0 \exp\sqrt{\frac{T_0}{T}}$$

✔ Baseline stable over time.

✔ LD working resistances tuned by injecting constant power.



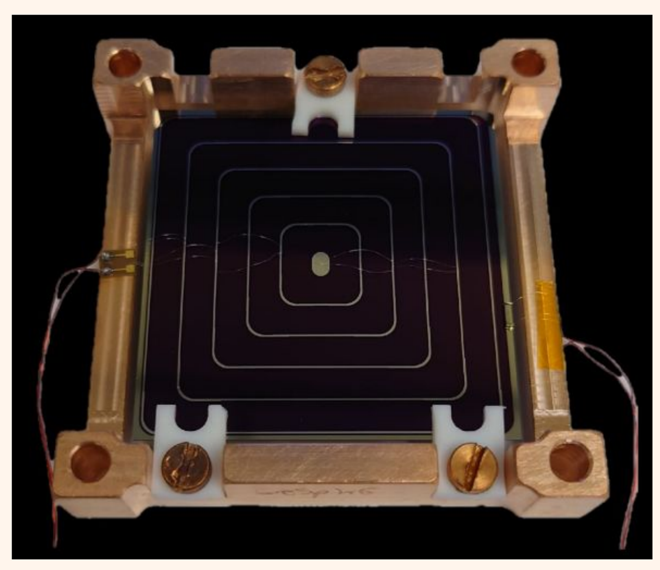
We also apply active temperature stabilization and offline baseline stabilization



Conclusions & Future

BDPT results

- First full-scale CUPID tower;
- Validated thermal properties tower structure;
- Tested performance of LMO and LD with NTD read-out.



Next steps

New CUPID baseline design for **LD with Neganov-Trofimov-Luke amplification** to enhance S/N to improve pile-up rejection through PSD.

Ongoing design of a new tower, **Vertical Slice Test Tower (VSTT):**

- new CUPID tower under design;
- LMO with NTD read-out;
- LD with Neganov-Luke amplification.

! See also: **"Development of NTL light detectors for the CUPID 0v2β experiment", ID: 474**

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