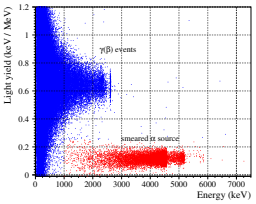
SEARCHING FOR NEW PHYSICS IN 2νββ DECAY WITH CUPID

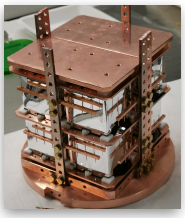
EMANUELA CELI ON BEHALF OF CUPID COLLABORATION

The development of cryogenic calorimeters to search for neutrinoless double-beta decay (0νDBD) has given in the last years increasingly promising results. To achieve a nearly background-free condition, scintillating crystals for 0νDBD have been developed. Thanks to the light-assisted particle discrimination, this technology demonstrated the complete rejection of the dominant alpha background. In addition, the possibility of achieving ton-scale exposures, maintaining an excellent energy resolution, lays the foundations for the CUPID project. CUPID is a next-generation experiment aiming to exploit ^{100}Mo enriched scintillating Li_2MoO_4 crystals, operating as cryogenic calorimeters, to investigate the entire inverted hierarchy region for neutrino masses. Thanks to the high $Q_{\beta\beta}$ of ^{100}Mo and the α-discrimination, the CUPID goal is to achieve a background level in the region of interest of 10^{-4} counts/(keV kg yr). Although the 0νDBD is the main objective of CUPID, other processes are open to experimental investigation, particularly those inducing a distortion of the 2νDBD spectral shape. Given the relatively fast half-life of ^{100}Mo 2νDBD, we expect to reach unprecedented sensitivities in the search for distortions induced by physics beyond the Standard Model.

THE CUPID PROJECT

- Re-use of CUORE cryogenic infrastructure at LNGS;
- Li_2MoO_4 scintillating crystals;
- Enrichment > 95%;
- 45×45×45 mm³ crystals;
- ~1500 crystals for 250 kg of ^{100}Mo;
- Goal FWHM: 5 keV at $Q_{\beta\beta}$;
- Target background index ~10^{-4} counts/(keV kg yr)
- Li_2MoO_4 Light Assisted particle ID;





BACKGROUND PROJECTION

Simulations performed with a Geant4 based software taking into account the detector preliminary geometry.

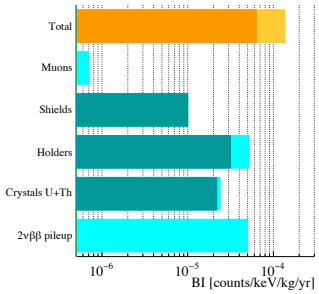
- ^{232}Th, ^{238}U and crystals internal contaminations taken from CUPID-Mo background studies (^{40}K, ^{90}Sr, ^{87}Rb);
- ^{232}Th and ^{238}U in near copper taken from CUORE-0 background model;
- ^{232}Th and ^{238}U in Cryostat taken from CUORE background studies;
- Activity of cosmogenic activated isotopes simulated with ACTIVIA;

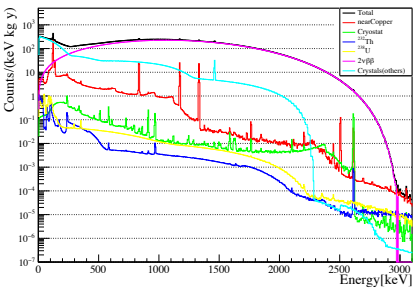
EVENTS SELECTION

Rejection of α events
Light-assisted particle ID

→ Single crystal interactions
2 electrons mostly contained in a single crystal

→ Delayed coincidences
remove background from ^{232}Th and ^{238}U chains in the ROI



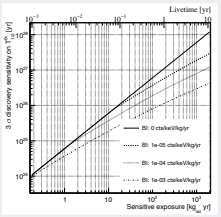


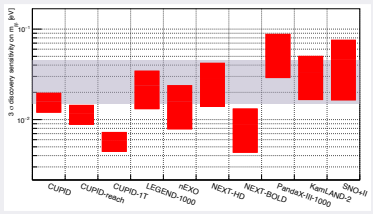
REFERENCES

[1] CUPID pre-CDR, 7 2019.
[2] Eur. Phys. J. C 81, no.2, 104 (2021).
[3] JINST 16, no.02, P02037 (2021).
[4] Phys. Rev. C 104, 015501 (2021).

0νDBD SENSITIVITY

0νββ sensitivity to fully cover the inverted ordering region, corresponding to a discovery sensitivity greater than 10^{27} yr;





2νDBD SENSITIVITY STUDIES

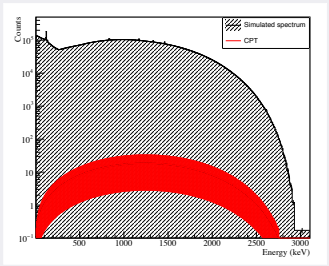
1. The CUPID predicted experimental spectrum is simulated with 1 yr equivalent statistic;
2. With a Bayesian analysis toolkit, the spectrum was fitted including bSM hypotheses changing spectral index *n*;
3. The analysis is repeated in two cases:
   a. ^{90}Sr is included but not fitted (underestimation)
   b. ^{90}Sr is fitted but not included (overestimation)

CPT violation

Lorentz-violating term $a_{of}^{(3)}$ implies $n = 4$.

$a_{of}^{(3)}$ upper limit (90% C.I.)

1.60×10^{-14} GeV	Exclusion sensitivity
1.52×10^{-14} GeV	Exclusion sensitivity with ^{90}Sr overestimated
5.70×10^{-13} GeV	Exclusion sensitivity with ^{90}Sr underestimated
3.5×10^{-7} GeV	Actual experimental limit (NEMO-3)



Majoron Emission

Half-life depends on the Majoron-neutrino coupling constant: $1/T_{1/2} = \left|\langle g_{ee}\rangle\right|^m G\,|M|^2$.

Half-lives at 90%C.I. (yr)

n	normal case	^{90}Sr overestimated	^{90}Sr underestimated
1	7.9×10^{23}	7.3×10^{23}	2.0×10^{24}
3	5.0×10^{22}	5.0×10^{22}	2.5×10^{21}
7	7.3×10^{21}	7.3×10^{21}	2.8×10^{23}

n	mode	g_{ee} exclusion sensitivity
1	χ^0	(6.1 - 8.4) $\times 10^{-6}$
3	χ^0	(0.8 - 1.5)
3	$\chi^0\chi^0$	(4.6 - 6.7) $\times 10^{-3}$
7	$\chi^0\chi^0$	(5.0 - 8.3) $\times 10^{-1}$

For spectral indices n=1,7 bSM spectra do not correlate with ^{90}Sr.

CUPID

GRAN SASSO SCIENCE INSTITUTE

INFN Istituto Nazionale di Fisica Nucleare

TAUP 2021 VALENCIA
XVII INTERNATIONAL CONFERENCE
ON TOPICS IN ASTROPARTICLE AND UNDERGROUND PHYSICS
26 August - 3 September 2021 Online conference