Optimization of integration time and distance cut in the CUPID array

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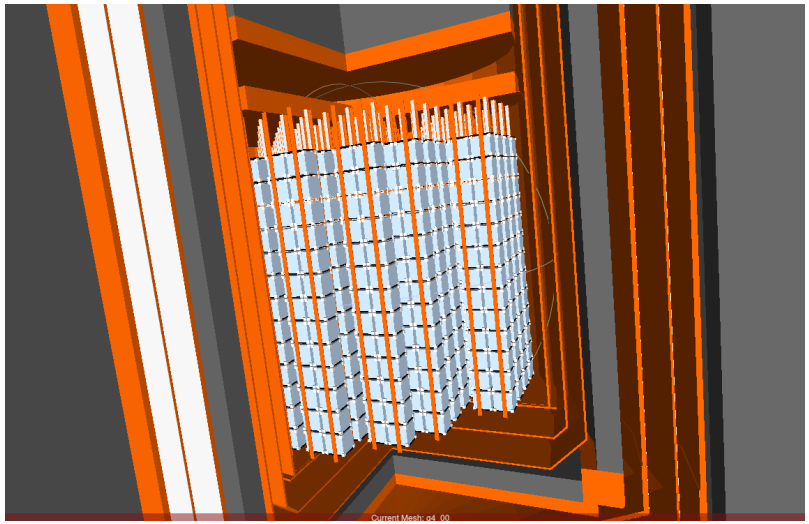
DNP October 2021

Mini-Symposium: Neutrinos and Nuclei XII: Double Beta Decay Analysis Techniques

CUPID experiment

- Proposed $0\nu\beta\beta$ search using bolometric array of 1596 Li_2MoO_4 crystals, deployed in the CUORE[1] cryostat.
- Aims to eliminate dominant background of alpha particles present in CUORE.
- **Are new backgrounds introduced with a using a new element for the bolometers?**

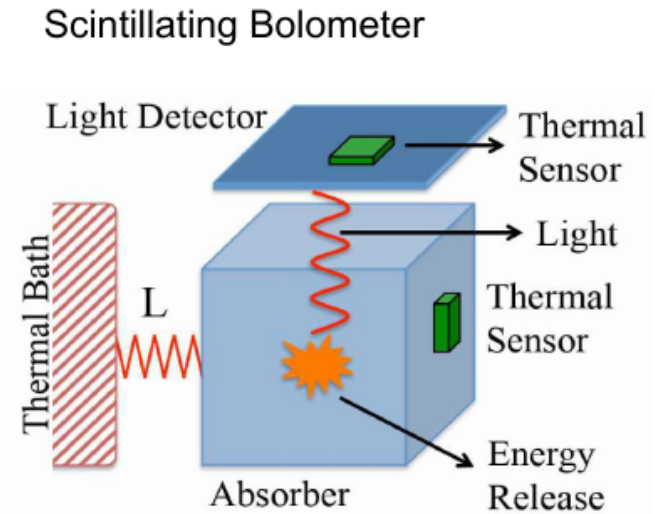


Rendering of proposed CUPID array of Li_2MoO_4 crystals

[1] Clarke and Braginski 2004.

Lithium molybdate

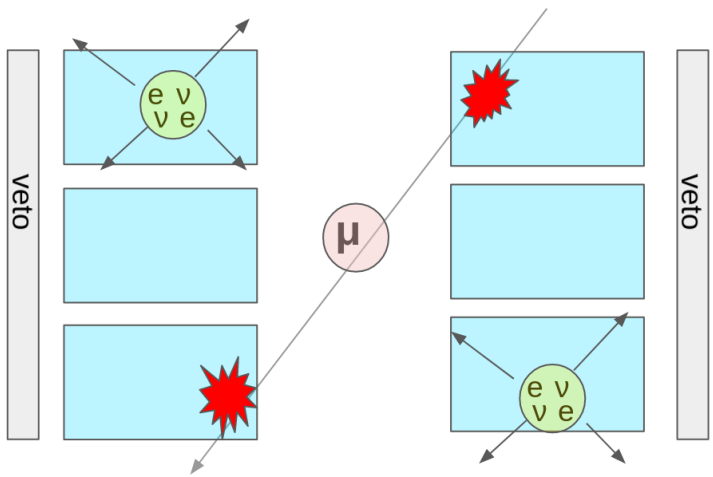
- Li_2MoO_4 crystals allow for discrimination of α backgrounds from $\beta\beta$ events (Q=3034keV) via thermal + scintillation signals.
- relatively high isotopic abundance of ^{100}Mo (10%)
- enrichment above 95% already demonstrated in CUPID-Mo



$2\nu\beta\beta$ events and muons

- The rate of $2\nu\beta\beta$ events is not negligible in CUPID array[2]
- Minimizing the distance cut helps avoid mis-labelling random $2\nu\beta\beta$ coincidences as multiplicity 2.
- Assuming a simple muon veto geometry, increasing the distance cut rejects more muon events.

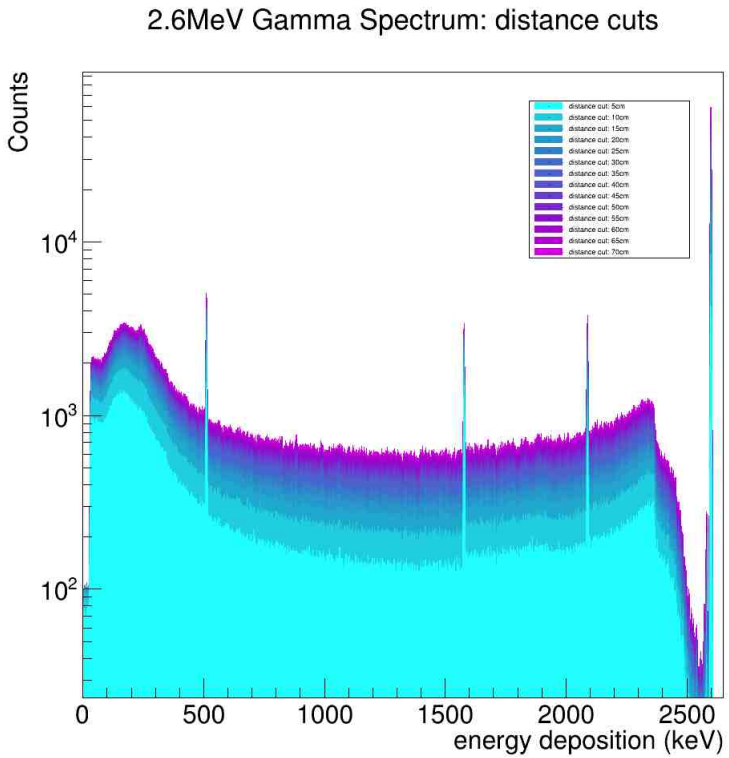
$$T_{1/2} = 7.1 * 10^{18} yr$$
$$\rightarrow \text{rate} \sim 3mHz$$



[2] **chernyak**.

Distance cut in the CUPID array

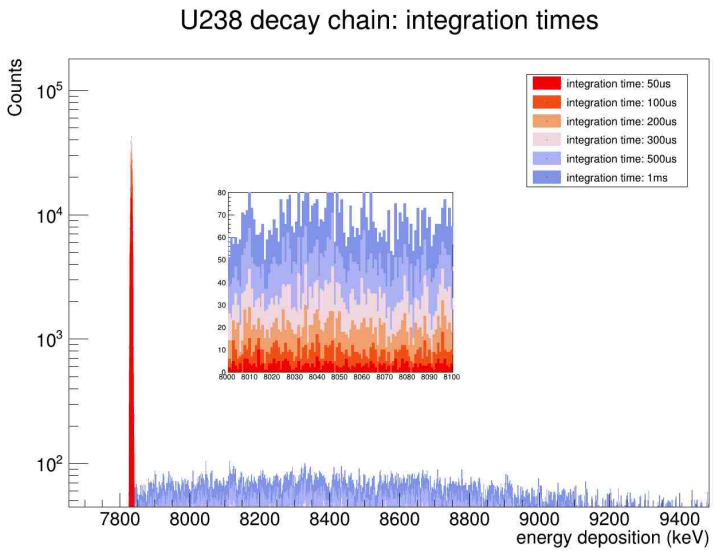
- monte-carlo simulation of 1 million 2.6MeV gamma rays in the crystal volume.
- With this energy, we expect multiple scattering events in the crystals (cite scattering length)
- multiplicity 2 $>$ events are discarded



Integration time in the CUPID array

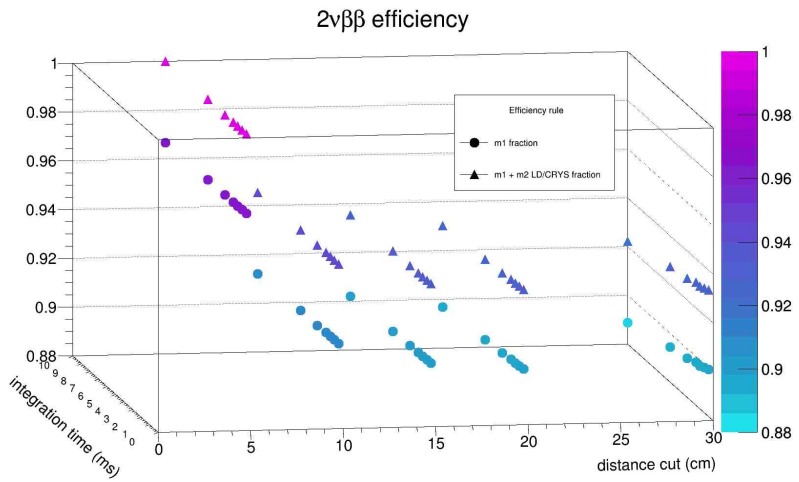
$$^{238}U \xrightarrow{\alpha} {}^{234}Th \rightarrow \ldots$$
$$^{214}Bi \xrightarrow{\beta} {}^{214}Po \xrightarrow{\alpha} {}^{210}Pb\ldots$$

- 100000 uranium-238 events (full chain)
- $T_{1/2}$ ^{214}Po $\sim 160\mu$s
- $T_{1/2}$ ^{214}Bi $\sim$ 20 minutes



$2\nu\beta\beta$ efficiency simulation

- sensitivity studies expect on the order of 90
- larger distance cut causes more random coincidences and more variation with integration time
- Explain LD+CRYS data points
- bremsstrahlung, escape, random coincidences



muon background

- muon flux LNGS
- planned muon veto , 90
- muon track + showers induced by the muon. muon background suppression vs efficiency

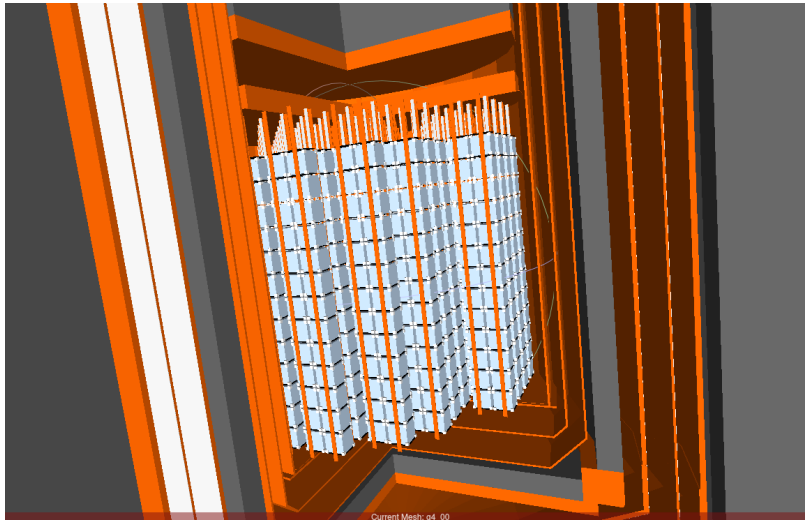


Figure: