

Optimization of integration time and distance cut in the CUPID array

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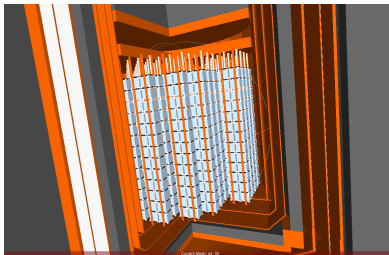
Virginia Tech

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

CUPID experiment

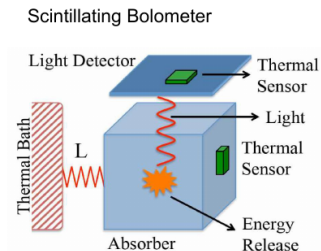
- Proposed $0\nu\beta\beta$ search using bolometric array of 1596 Li_2MoO_4 crystals, deployed in the CUORE cryostat.
- Aims to eliminate dominant background of alpha particles present in CUORE.
- **Are new backgrounds introduced with using a new element for the bolometers?**



Rendering of proposed CUPID array of Li_2MoO_4 crystals

Lithium molybdate

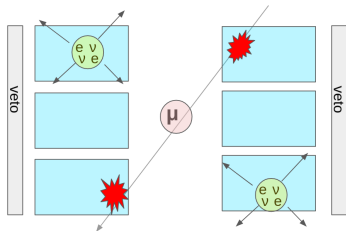
- Li_2MoO_4 crystals allow for discrimination of α backgrounds from $\beta\beta$ events ($Q=3034\text{keV}$) via thermal + scintillation signals.
- relatively high isotopic abundance of ^{100}Mo (10%)
- enrichment above 95% already demonstrated in CUPID-Mo



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

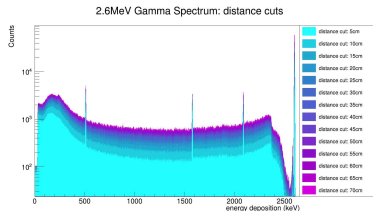
- The rate of $2\nu\beta\beta$ events is not negligible in CUPID array
- Minimizing the distance cut helps avoid mis-labelling random $2\nu\beta\beta$ coincidences as multiplicity 2.
- Assuming a simple muon veto geometry, increasing the distance cut rejects more muon events.

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

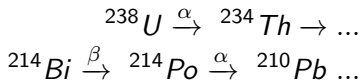


Distance cut in the CUPID array

- 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.
- $2 >$ multiplicity events are discarded

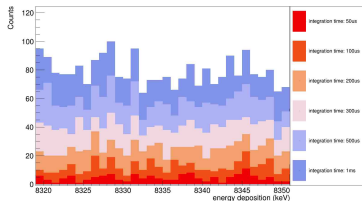
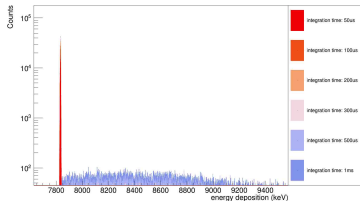


Integration time in the CUPID array



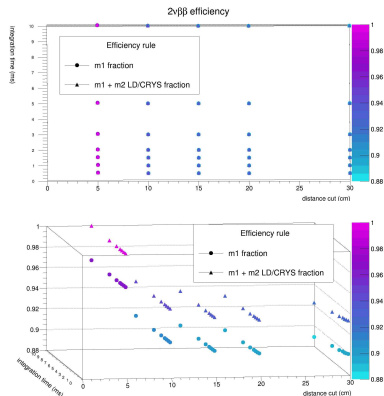
- 100,000 uranium-238 events (full chain)
- $T_{1/2} {}^{214}\text{Po} \sim 160\mu\text{s}$
- $T_{1/2} {}^{214}\text{Bi} \sim 20 \text{ minutes}$

U238 decay chain: integration times



$2\nu\beta\beta$ efficiency simulation

- 40 million events generated in crystal volume.
- sensitivity studies expect on the order of 90% efficiency for $2\nu\beta\beta$ efficiency
- larger distance cut causes more random coincidences and more variation with integration time
- bremsstrahlung, escape, random coincidences are primary contributors



future work and the muon background

- incorporate scintillating muon veto geometry into monte-carlo simulations
- muon flux at LNGS is $3 \cdot 10^{-8} \text{ muons} / (s \cdot cm^2)$
- muon suppression versus distance cut optimization.

