Neutrinoless Double Beta Decay and the CUORE experiment

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neutrinos in the Standard Model

- standard model leptons e, μ, τ each have associated neutrinos ν_e, ν_μ, ν_τ.

- Neutrinos only exist as left handed particles, so via the Higgs Mechanism and the Yuakawa interaction term, the Standard model predicts they are **massless**.

U(1) gauge invariance

$$\begin{pmatrix} \nu_\alpha \\ \ell_\alpha \end{pmatrix} \rightarrow e^{i\theta_\alpha} \begin{pmatrix} \nu_\alpha \\ \ell_\alpha \end{pmatrix}$$

$\Longrightarrow$ **lepton flavor conservation**

$\Longrightarrow$ $\nu_\alpha \nleftrightarrow \nu_\beta$

neutrino mixing

A given flavor eigenstate is a linear combination of mass eigenstates (PMNS-matrix)

$$|\nu_\alpha\rangle = \sum_{i=1}^{3} U_{\alpha i} |\nu_i\rangle$$

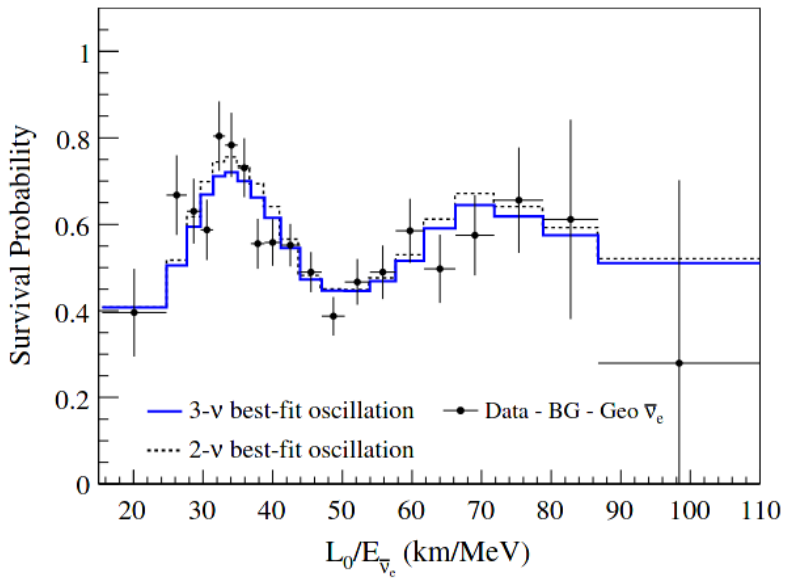
parameters: angles $\theta_{12}, \theta_{13}, \theta_{23}$ CP-violating phases $\delta_{CP}, \alpha_1, \alpha_2$, and neutrino masses m_1, m_2, m_3

$$U = \begin{pmatrix} c_{12}c_{13} & s_{12}c_{13} & s_{13}e^{-i\delta_{CP}} \\ -s_{12}c_{23} - c_{12}s_{23}s_{13}e^{i\delta_{CP}} & c_{12}c_{23} - s_{12}s_{23}s_{13}e^{i\delta_{CP}} & s_{23}c_{13} \\ s_{12}s_{23} - c_{12}c_{23}s_{13}e^{i\delta_{CP}} & -c_{12}s_{23} - s_{12}c_{23}s_{13}e^{i\delta_{CP}} & c_{23}c_{13} \end{pmatrix} \times \begin{pmatrix} e^{i\alpha_1/2} & 0 & 0 \\ 0 & e^{i\alpha_2/2} & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

neutrino oscillations

neutrinoless double beta decay has characteristic decay - can resolve in gaseous TPC the tracks. the only irreducible background is 2vbb.

- Proposed $0\nu\beta\beta$ search using bolometric array of 1596 Li_2MoO_4 crystals, to be deployed in the CU

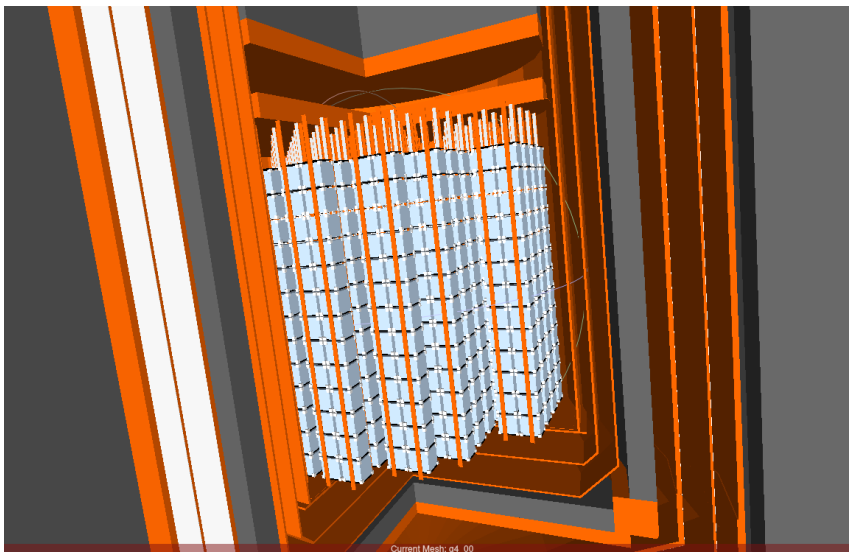


Survival probability

neutrino less double beta decay

neutrinoless double beta decay has characteristic decay - can resolve in gaseous TPC the tracks. the only irreducible background is 2vbb.

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



Rendering of proposed CUPID array of Li_2MoO_4 crystals

detection techniques

- semiconductors
- bolometers
- time-projection chambers
- organic scintillators