0υββ searches at a theoretical DUNE 4th module

G. Reesman – University of Missouri at Kansas City (SULI Intern), J. Zennamo – Fermilab, F. Psihas - Fermilab

Introduction & Background

Background	Origin
Thorium 232 (^{232}Th)	Cryostat Steel
Uranium 238 (^{238}U)	Cryostat Steel
Cobalt 60 (^{60}Co)	Cryostat Steel
Boron 8 (^{8}B) Solar Neutrinos	Sun
Argon 39 (^{39}Ar)	LAr Background
Argon 41 (^{41}Ar)	Spallation
Phosphorus 32 (^{32}P)	Spallation
Chlorine 39 (^{39}Cl)	Spallation
2υββ	Xenon 136 (^{136}Xe) Double Beta Decay
0υββ (signal)	Xenon 136 (^{136}Xe) Double Beta Decay

The goal of this project was to examine DUNE's potential for observing 0υββ with the doping of the detector medium (LAr) with 2% ^{136}Xe. The backgrounds around the 0υββ signal that were examined are given in the table.

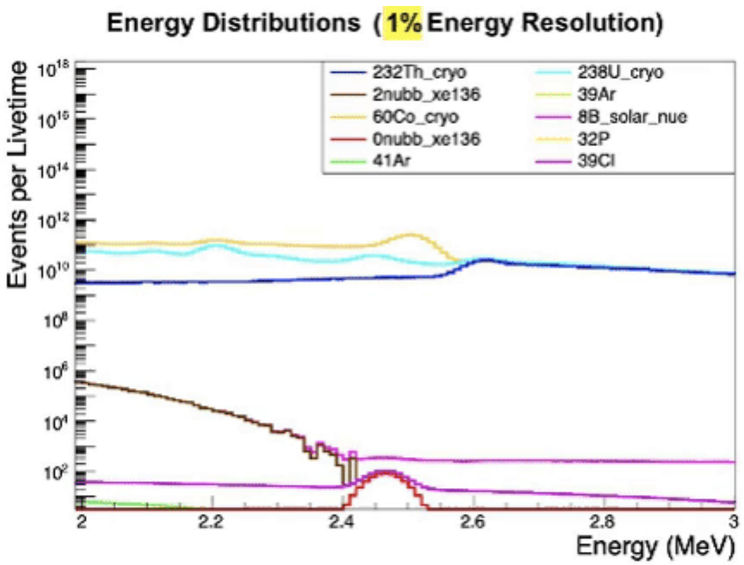
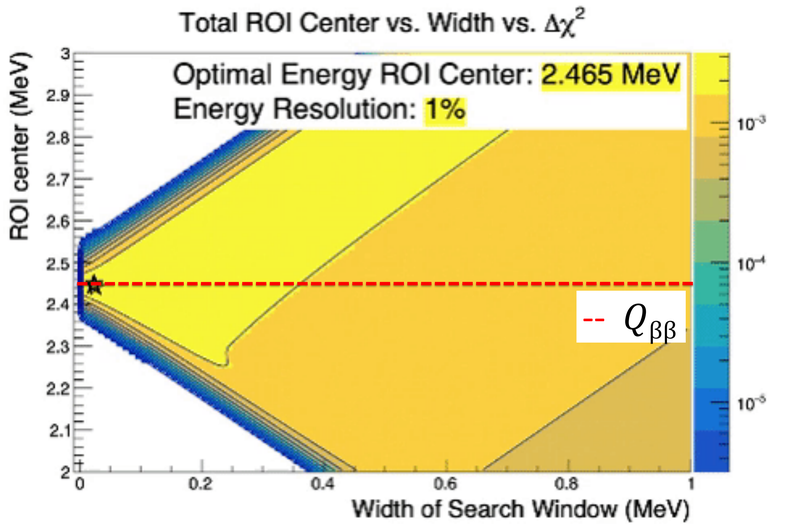


Figure 1: The gif shows energy spectra including all simulated sources different smeared energy resolution (no background mitigation).



Energy Resolution

Detector energy resolution contributes to difficulties in differentiating the signal from the background. In order to account for imperfect energy resolution, energy is smeared at a range of resolutions assuming Gaussian fluctuations.

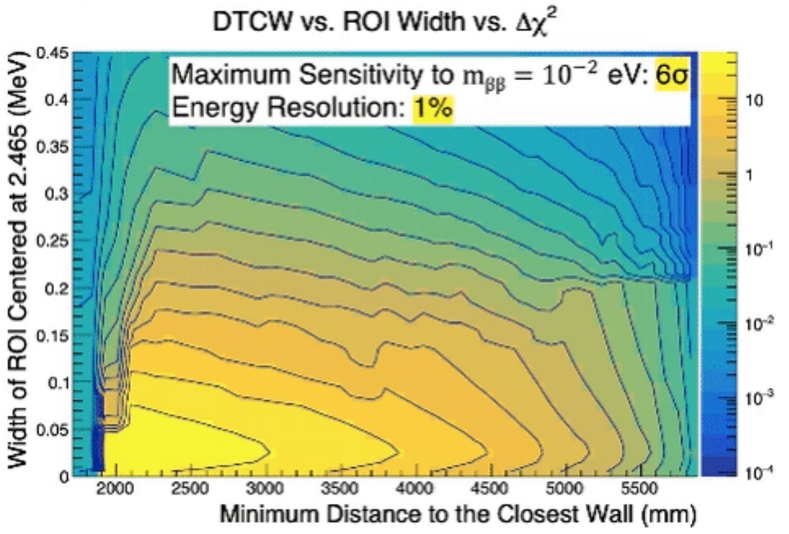


Figure 3: The width of the search window is plotted against the minimum distance to the closest wall. The color axis is the sensitivity to $m_{\beta\beta} = 10^{-2}$ eV.

Figure 2 (left): The The width of the search window is plotted against the center of the energy ROI. The color axis is the sensitivity.

Signal Selection

An energy region of interest (ROI) and optimal minimum distance to the closest wall were used to optimize a signal event selection and fiducial volume. Because the ROI center and radius that produce the highest sensitivities are dependent on smeared energy resolution, these metrics were optimized for signal selection at multiple energy resolutions.

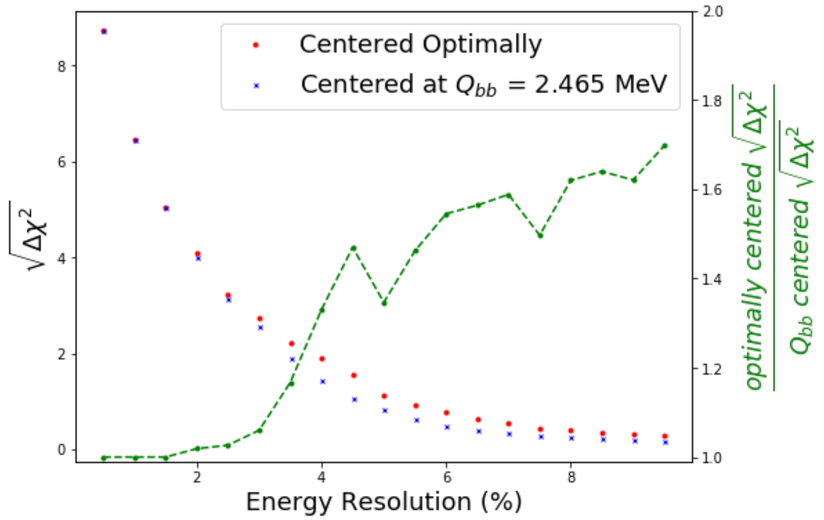


Figure 4: Energy resolution is plotted against the ratio between sensitivity when optimally centered and when centered at $Q_{\beta\beta}$.

Conclusions

Assuming a test mass of $m_{\beta\beta} = 10^{-2}$ eV, the maximum discovery significance attained was 6σ at 1% energy resolution. This study shows centering the ROI using the methods found in this project resulted in up to 1.7 times greater discovery significance than when centered at $Q_{\beta\beta}$.