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Simulated Optimization of HFE Volume around the nEXO TPC[1]

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nEXO is a leading contender in the next generation of neutrinoless double beta decay ($0\nu\beta\beta$) detectors. Given the extreme rarity of $0\nu\beta\beta$, with a half-life measured to be no less than 10^{25} years by EXO-200, and both spatial and energy resolution limits of the large nEXO time projection chamber (TPC), controlling backgrounds near the $0\nu\beta\beta$ Q-value is critical. Conveniently, the hydrofluoroether (HFE) fluid which insulates the TPC vessel has excellent radiopurity, thus shielding the active xenon volume from outside gamma rays without adding significant contaminations. Still, HFE is expensive and adds complexity to the detector's engineering. This study uses GEANT4 simulations to estimate background effects in the active xenon from a varying HFE thickness, in an effort to simultaneously minimize backgrounds and HFE volume. We have determined that a minimum HFE thickness of slightly more than 0.75 m will reduce counts from external sources in a $\sim$52 keV energy range about the $0\nu\beta\beta$ Q-value to less than 1 per year, while additional HFE will have diminishing impacts. This finding informs required HFE quantities, cryostat design specifications, and permissible radiopurity levels of experiment components outside the HFE barrier.

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[2]While research was performed with the nEXO project, it does not represent any offical findings or published results by the nEXO Collaboration.

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