Watching the Watchers: Monitoring the nEXO's Muon Veto System

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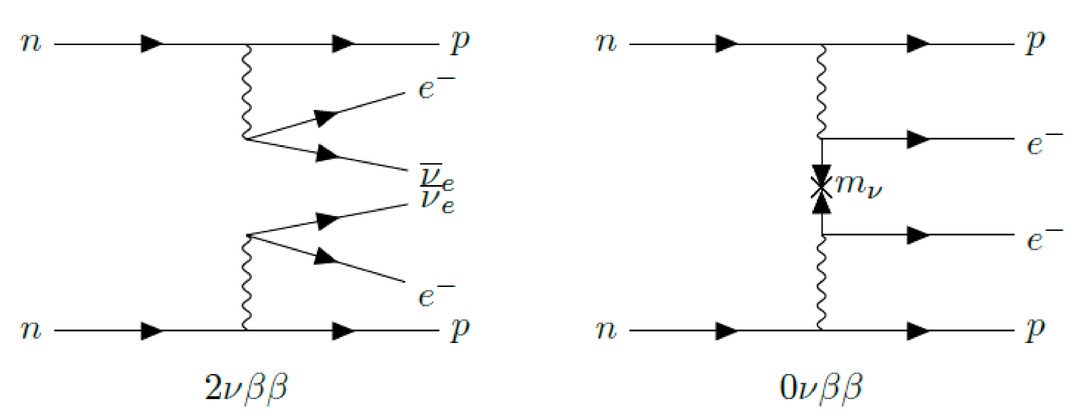
We are developing a system to monitor both the performance of the photomultiplier tubes and the quality of water in the water Cherenkov muon veto of the nEXO experiment.

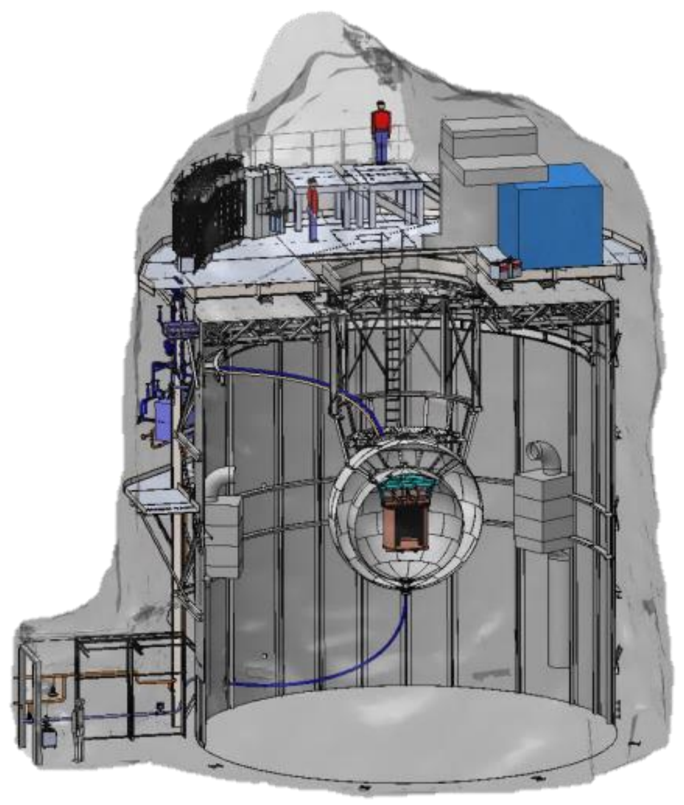
A Search for Neutrinoless Double Beta Decay

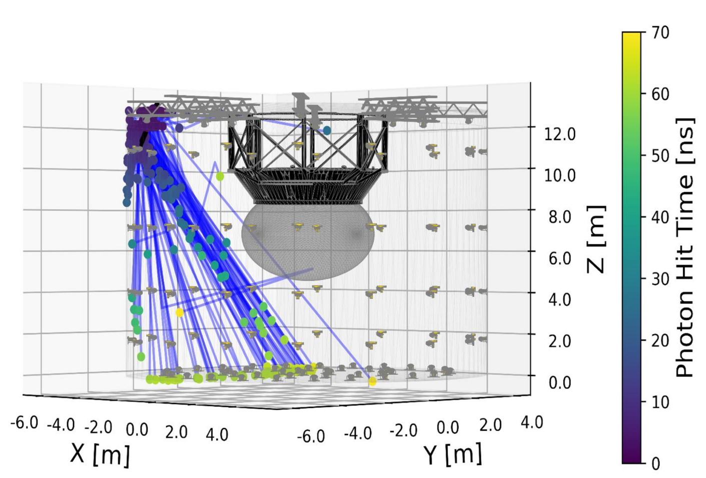
Large-volume, low-background noble-liquid-based detectors have become a leading technology in neutrino and dark matter physics. One such detector, nEXO, uses a 5-tonne liquid xenon time projection chamber (TPC), enriched in the isotope ^{136}Xe, which is placed at the center of a water tank. nEXO is designed to search for neutrinoless double beta ($0\nu\beta\beta$) decay with a projected half-life sensitivity that is greater than 10^{28} years.



Muon Tagging for Background Rejection

A requirement for low-background experiments is minimizing environmental radiation, including those caused by cosmic muons. As muons pass through the water, they generate neutrons, some of which may capture on ^{136}Xe, producing ^{137}Xe; a β-emitter that mimics the signal of interest. To mitigate this background, muons are tagged via their Cherenkov light in the water.

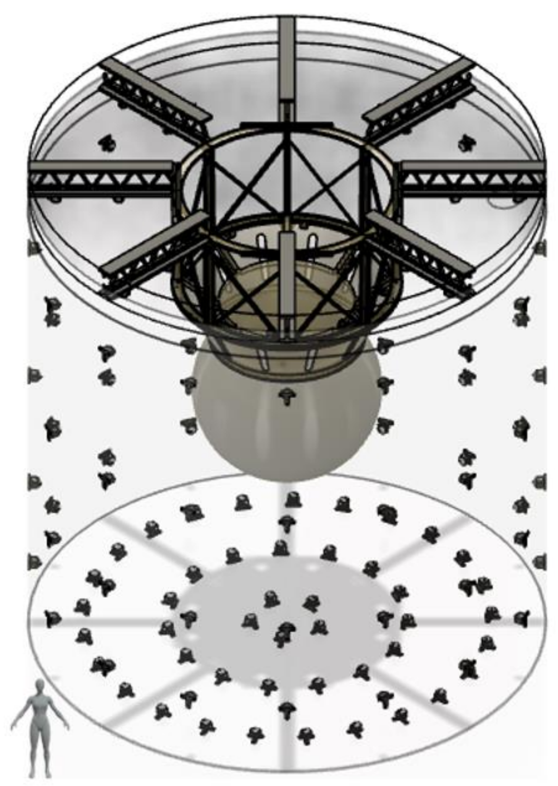




$$n + {}^{136}Xe \rightarrow {}^{137}Xe^*$$
$$^{137}Xe^* \rightarrow {}^{137}Xe + \gamma$$
$$^{137}Xe \rightarrow {}^{137}Cs + \bar{e} + \bar{\nu}_e$$

nEXO's Muon Veto System

For nEXO, a 12.3-meter diameter, 12.8-meter high water tank containing 1.5 kilotonnes of ultra-pure water is designed to serve as the experiment's outer detector. The tank is equipped with 125 photomultiplier tubes (PMTs) to detect the Cherenkov light.

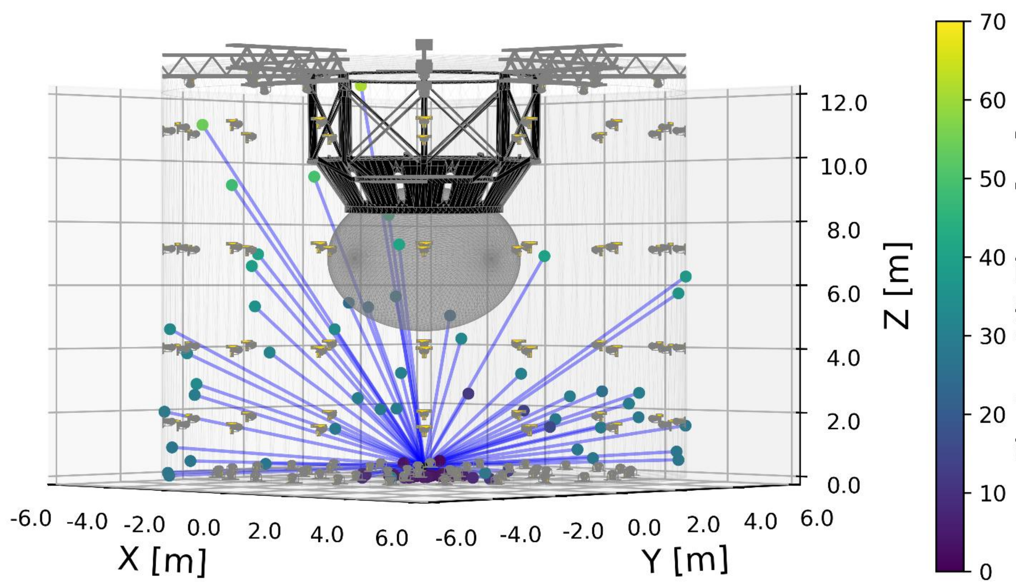


Explore More

- nEXO: neutrinoless double beta decay search beyond 10^{28} year half-life sensitivity, G. Adhikari et al. (nEXO Collaboration), Journal of Physics G: Nuclear and Particle Physics, 49(1):015104, 2021.
- nEXO pre-conceptual design report, S. Al Kharusi et al. (nEXO Collaboration), arXiv preprint arXiv:1805.11142, 2018.
- Fast Optical Monte Carlo Simulation With Surface-Based Geometries Using Chroma, Stanley Reid Seibert and Anthony Latorre, Semantic Scholar, 2011.

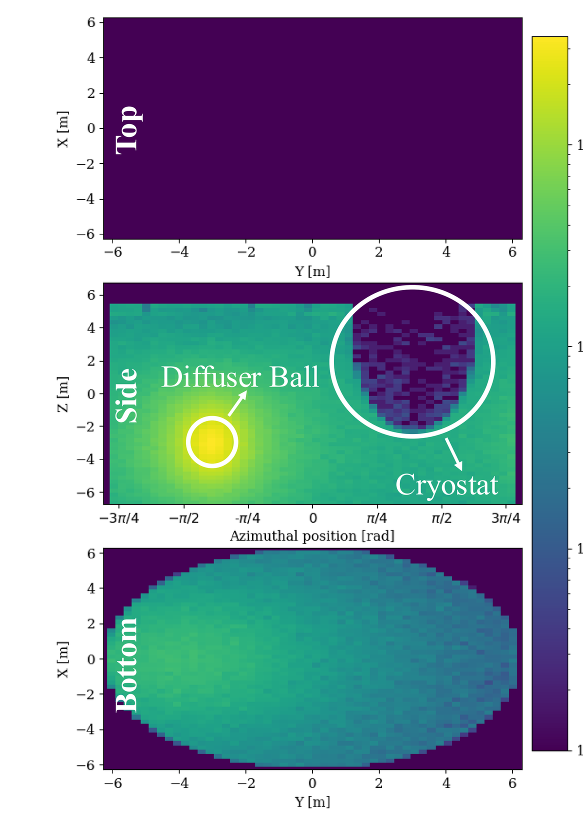
1 Conceptual

Laser light is transmitted through optical fibers to the diffuser balls in the water tank.



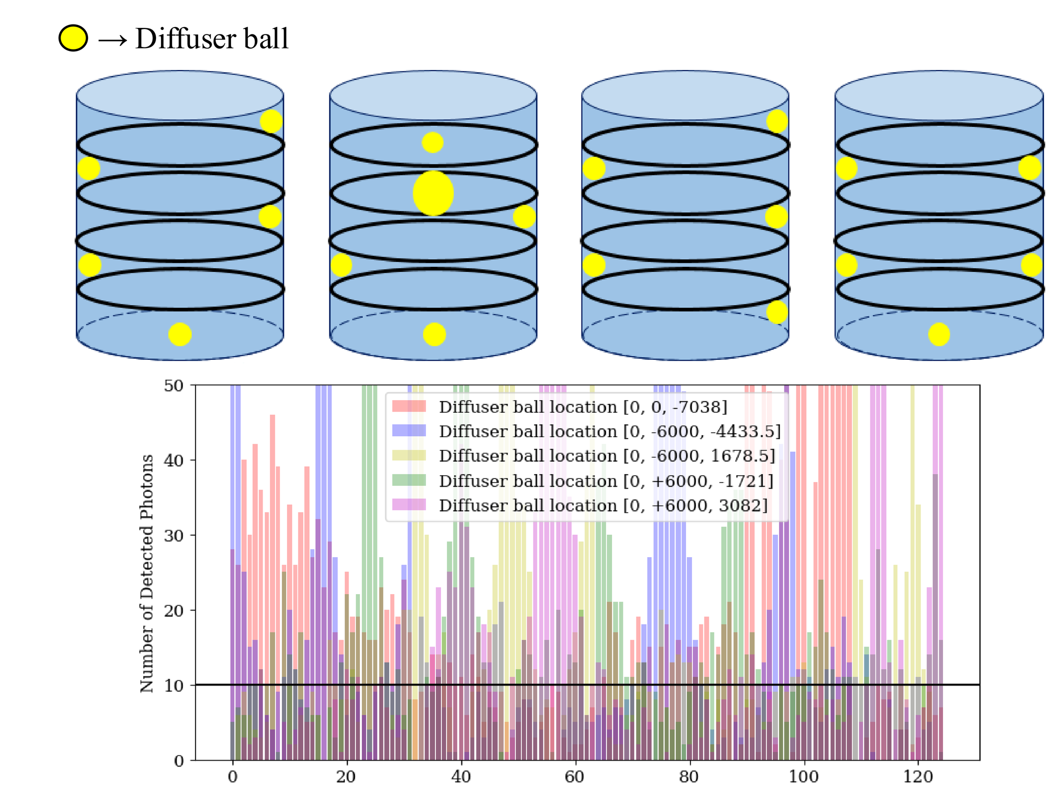
2 Validation

Chroma simulations used to validate the conceptual design.



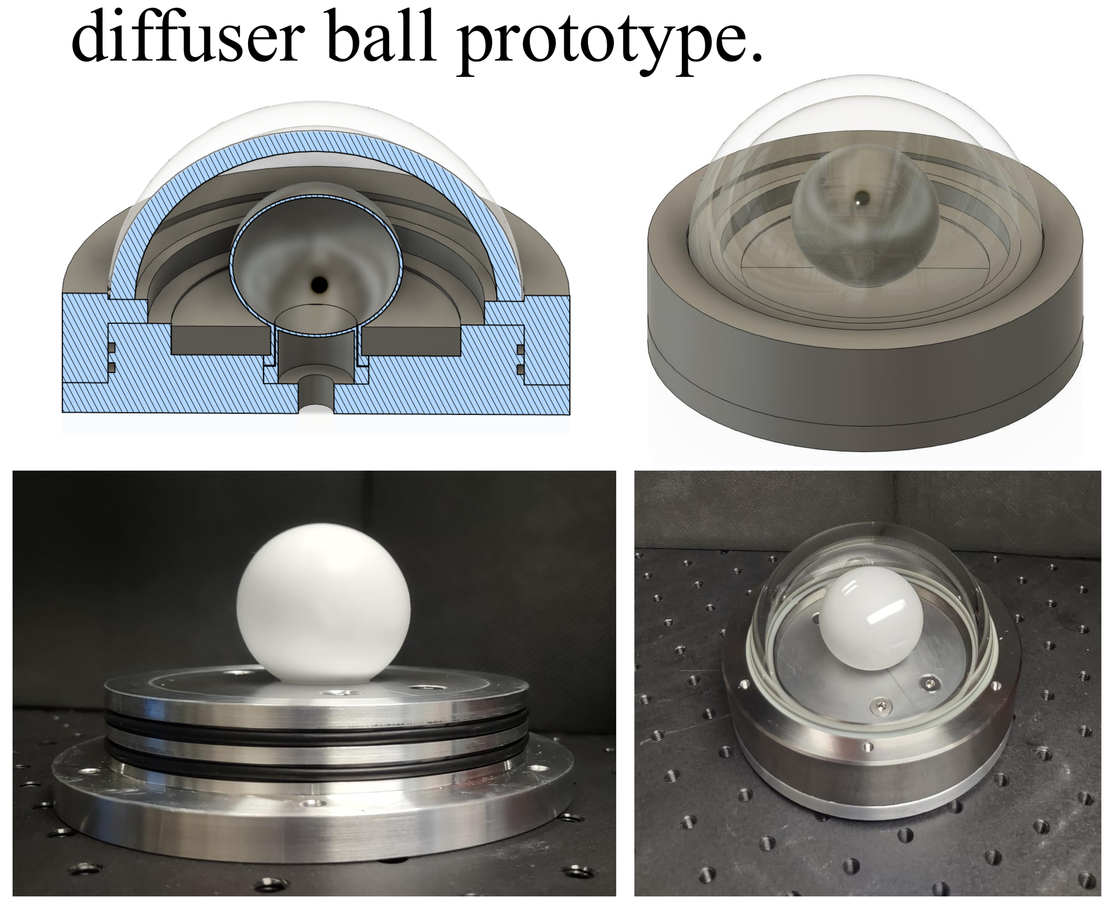
3 Optimization

Determining optimal number and placement of diffuser balls.



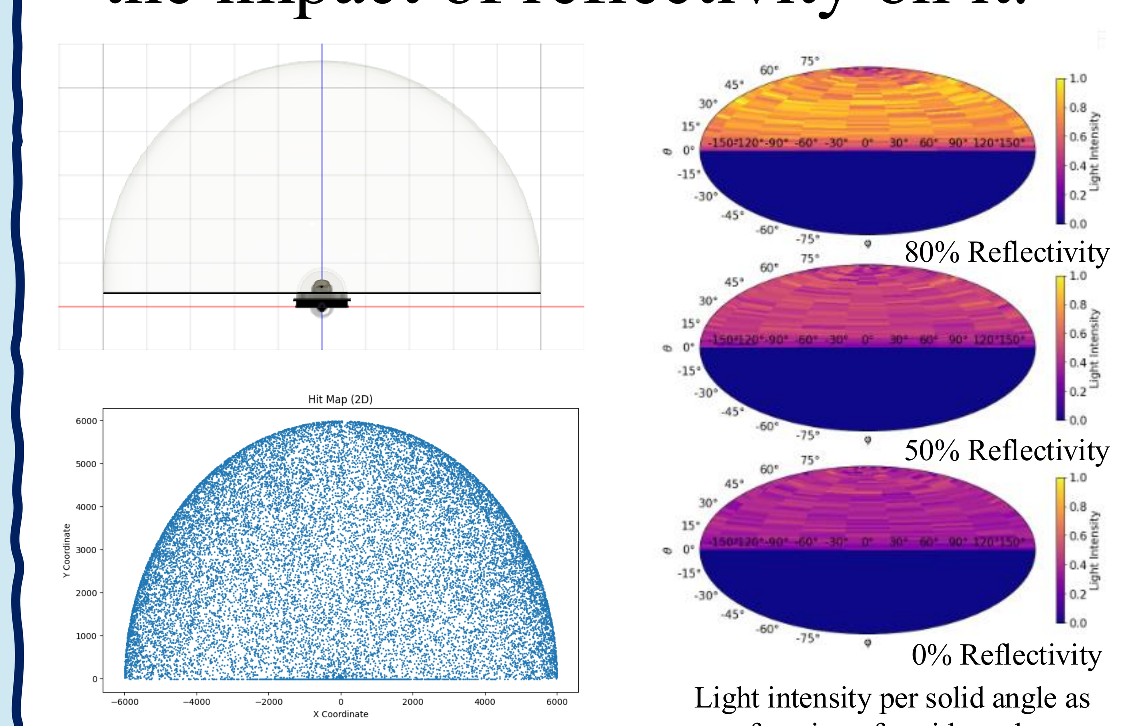
4 Design

Design and construction of the diffuser ball prototype.



5 Testing - Simulations

Testing the emission profile of the diffuser ball and evaluating the impact of reflectivity on it.



6 Testing - Hardware

Evaluating the isotropy of the diffuser ball's emission profile under real-world conditions