Sensitivity and Discovery Potential of the nEXO Experiment to $0\nu\beta\beta$

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0νββ and nEXO

Discovery of neutrinoless double beta decay (0νββ) would demonstrate additional physics beyond the Standard model:

- Neutrinos are their own anti-particles
- Lepton number conservation is violated

nEXO is the next generation of EXO-200 searching for 0νββ at the tonne scale and features:

- Single Phase Time Projection Chamber
- Filled with $5000\ \mathrm{kg}$ of liquid xenon
- Enriched to $90\,\%$ in $^{136}\mathrm{Xe}$
- Monolithic design with single drift volume with $1.3\ \mathrm{m}$ drift length
- Energy resolution of $\sigma/Q_{\beta\beta} \leq 1\,\%$
- $\sim 6000\ \mathrm{mwe}$ overburden (SNOLAB)
- Active water Cherenkov veto

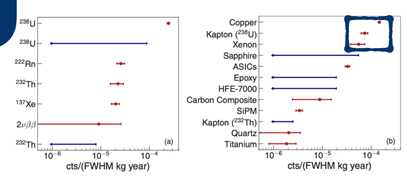
Radioactive Backgrounds

nEXO continued with its comprehensive plan of radioassay characterization and material selection.

Recent improvements include:

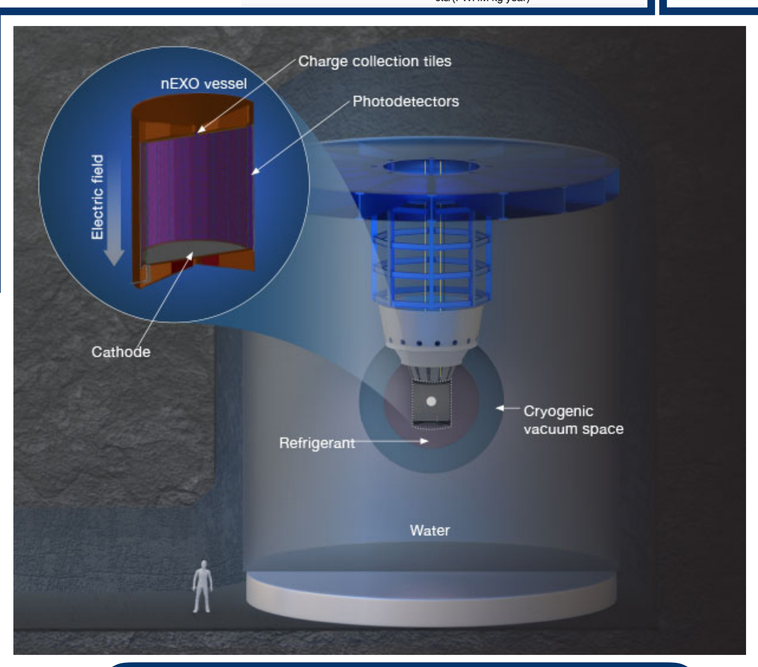
- Investigating in-house electro-formed copper for TPC vessel, cathode and field shaping rings to further reduce backgrounds
- Incorporate veto efficiency against $^{137}\mathrm{Xe}$
- Refined radio-assay measurements ($\sim 90\,\%$ reduction in readout cable activities)

Expect substantial reduction of three largest backgrounds



New backgrounds studied and quantified:

- $^{42}\mathrm{Ar}$ in the xenon
- $^{26}\mathrm{Al}$ in sapphire rods (and reflective coatings)
- Detailed tagging efficiency of $\mathrm{Bi/Po}$ from $^{222}\mathrm{Rn}$ dissolved in LXe
- Non-cosmogenic $^{137}\mathrm{Xe}$



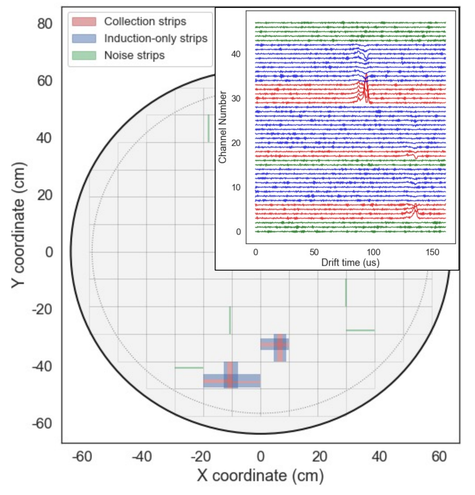
Detailed Light and Charge Simulation

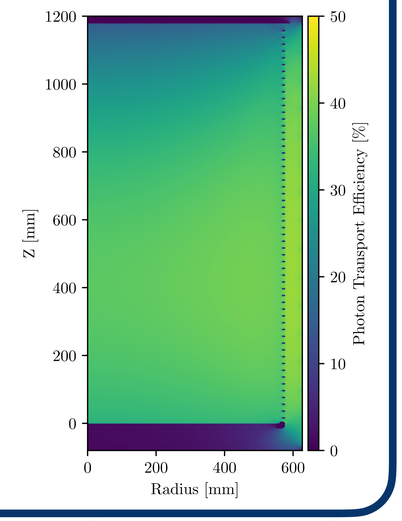
Ionization Charge

- Charge readout is modeled end-to-end
- Complete charge propagation through TPC with inclusion of diffusion & electron lifetime effects
- Induction and noise signals generated to mimic real data
- Electronics noise is added to current waveforms based on simulated frequency spectrum of the ASIC
- The current noise is scaled to have an equivalent RMS noise of 100 electrons

Scintillation Light

- Crucial to optimize total light collection efficiency $\epsilon = \mathrm{PTE} \cdot \mathrm{PDE}$
- Improved understanding of light propagation in nEXO with help from GPU-based Chroma software
- Incorporated measured optical parameters of SiPMs
- Estimated average light collection efficiency of $\epsilon = 6.2\% - 9.5\,\%$ at $80\,\%$ reflective FSRs and cathode

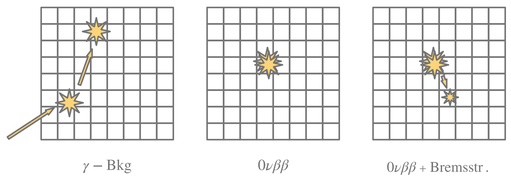


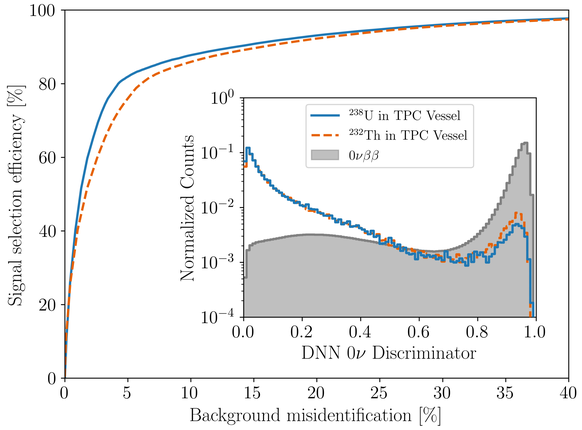


Event Topology via DNN

Based on the success in EXO-200 a discriminator based on a Deep Neural Network (DNN) was developed for better signal and background classification.

- Trained on waveform-level simulations, as we would with real data
- The DNN discriminator is trained with uniform energy and spatial distribution, and thus disentangled from the other two fit dimensions
- It provides a continuous variable to improve discrimination instead of binary single-site classification based on event multiplicity
- Equivalent bkg discrimination with improved signal efficiency (recovering 0νββ events accompanied by Bremsstrahlung)
- Expect $\sim 80\,\%$ signal efficiency at $\sim 5\,\%$ background misidentification





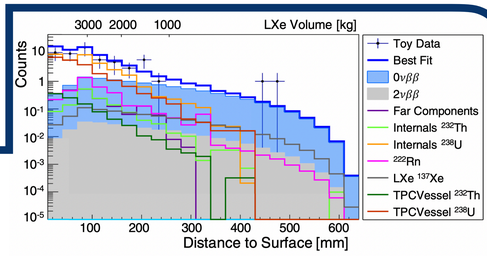
Maximum Likelihood Analysis

nEXO follows the successful implementation of a multi-dimensional maximum likelihood analysis by EXO-200 using 3 fit dimensions:

- Event energy
- Standoff-distance (distance to nearest detector surface)
- DNN discriminator

This multi-parameter analysis is really key to nEXO's success making use of the

- good energy resolution in our detector
- the self-shielding power of liquid xenon against external gamma radiation and
- the topological discrimination possible in a TPC



While the outer parts of the detector measures the background really well, the inner most region of the detector will be dominated by 0νββ signals.

Projected Median Sensitivity to 0νββ after 10 years at 90% CL:

$$T^{0\nu}_{1/2} > 10^{28}\ \mathrm{yr}$$

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