Neutrinoless Double Beta Decay: Investigating Effective Field Theories with NuDoBe

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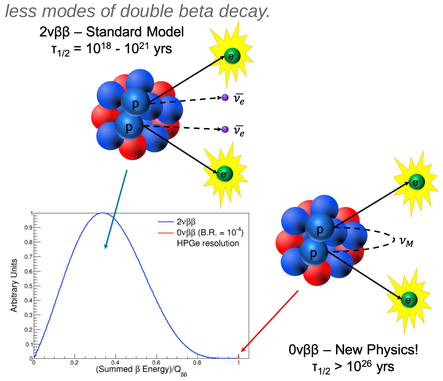
Introduction

0νββ: A **hypothetical** nuclear decay process where two neutrons in a nucleus simultaneously decay into two protons, emitting two electrons (β particles) without any accompanying antineutrinos.
NEXT: The Neutrino Experiment with a Xe-136 Time Projection Chamber is a significant endeavor probing LNV & neutrino mass by studying double beta (ββ) decay. It utilises high-pressure xenon gas TPCs, such as NEXT-White, to detect charged particles generating scintillation light, allowing precise measurement of event topology and energy.

Spectrum of energy emitted into electrons in the two-neutrino and neutrino-less modes of double beta decay.



Methods

A Python Tool:

NuDoBe utilises advanced computational techniques to calculate 0νββ rates, considering LNV operators up to dimension 9, incorporates renormalization-group running and matches to low-energy EFT, accounting for various sets of NMEs & hadronic low-energy constants.

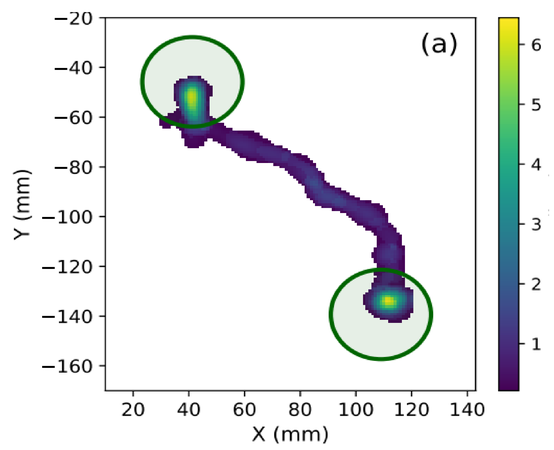
We see beta particles in the detector.

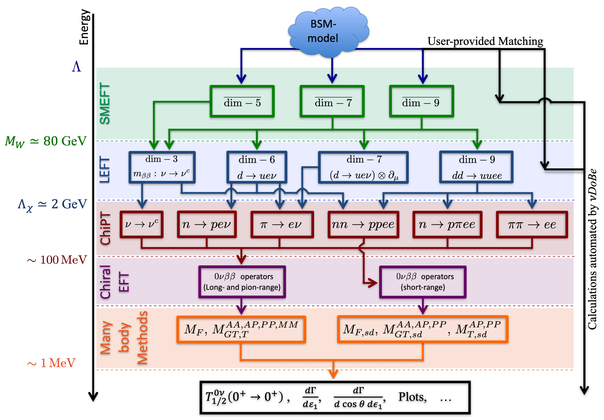
Data Analysis

NuDoBe implements different models such as:

- The Light-Neutrino-Exchange Mechanism
- Putting limits on Higher Dimensional Mechanisms
- The Minimal Left-Right Symmetric Model
- A Leptoquark Mechanism

NEXT Experiment



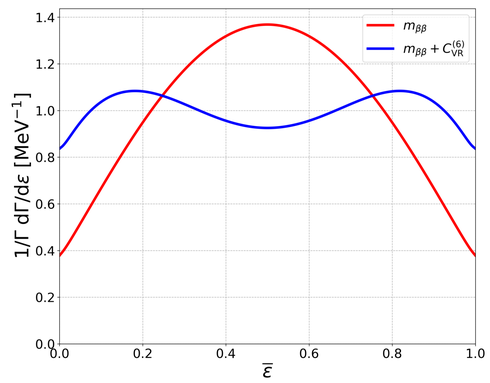


Discussion

NMEs are important in determining 0νββ decay rates. NuDoBe allows flexibility with three NME sets for exploring different methods includes two approximation schemes for Phase-Space Factors (PSFs) and enables LEC adjustments.

Results & Conclusion

Single electron energy spectrum

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[7]: model.plot_spec(linewidth = 4, normalize_x = True, savefig = True,
                     file = "spec.png")
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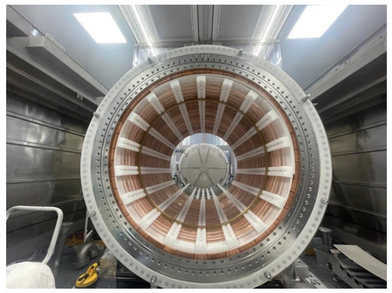
$$^{136}\mathrm{Xe} \rightarrow {}^{136}\mathrm{Ba}^{2+} + 2e^-$$

NEXT-100



Future Work

- Further updates to enhance NuDoBe's capabilities, including the incorporation of effects from light sterile neutrinos and refinement of phase-space factor (PSF) calculations.
- Facilitate NEXT to expand neutrino exploration, reconstruction of particle topology
- Calculate automatically & interpret the 0νββ decay rates using Wilson coefficients in the SMEFT framework, extraction of constraints on parameters like mββ and WC, tools for analysing e^−spectra, angular correlations
- Easily graphed the computation of differential decay rates using up-to-date data.
- Generation of plots for half-lives or distributions based on neutrino masses or LNV Wilson coefficients.
- Contribute to BSM → New Physics!

References

1. Oliver Scholer, Jordy de Vries, Lukáš Gráf https://arxiv.org/abs/2108.09364v2
2. Ben Jones https://arxiv.org/abs/2108.09364

Acknowledgements

1. The Neutrinos and Rare Event Searches group (nuRES), UTA
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