DISCOVERY POSSIBILITY OF NEW PHYSICS BEYOND THE $2\nu\beta\beta$

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INTRODUCTION

Experiments for neutrinoless double beta decay ($0\nu\beta\beta$) are also sensitive to bSM processes effecting $2\nu\beta\beta$ spectrum shape. Nowadays, the data collected with these experiments allowed to set stringent limits on these processes. Nevertheless, the unavoidable background induced by the standard $2\nu\beta\beta$ represents an intrinsic limit in the search for these processes and its fluctuations could easily mimic the new physics signal. We performed a systematic study to determine whether a discovery is possible in future.

NEW PHYSICS BEYOND THE $2\nu\beta\beta$

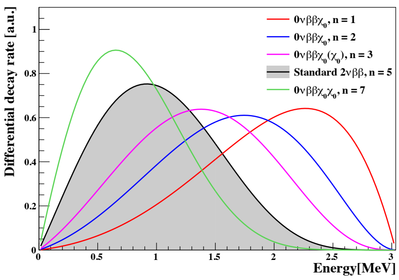
The majorons are massless bosons that can be resulting from a spontaneous violation of the B-L symmetry. In some bSM extensions, $0\nu\beta\beta$ can be mediated by the emission of one or two majorons:

$$(A, Z) \rightarrow (A, Z+2) + 2e^- + \chi_0 \quad \text{or} \quad +2\chi_0$$

The experimental signature of the Majoron emitting decays is a continuum spectrum similar to the SM-$2\nu\beta\beta$. The spectral shape is determined by the differential decay rate:

$$\frac{dG}{dT} \sim (Q_{\beta\beta} - T)^n$$

where n is the spectral index



STATISTICAL METHOD

Model data as a sum of SM-$2\nu\beta\beta$, background and bSM process.

H_0: Only SM-$2\nu\beta\beta$ and flat background (B only)

H_1: Add bSM contribution (S+B)

$$\mu_i = f_{2\nu\beta\beta}(E)\cdot N_{2\nu\beta\beta} + f_{bkg}(E)\cdot N_{bkg} + f_{bSM}\cdot N_{bSM}$$

Binned Likelihood fit: $\mathscr{L} = \prod_{bins} \mathrm{Pois}(n_i; \mu_i)$

Evidence: $P(D\,|\,H_i) = \int_\Omega \mathscr{L}(\vec{\theta}\,|\,H_i)\pi(\vec{\theta})d\vec{\theta}$

Posterior probability: $P(H_0) = \dfrac{P(D\,|\,H_0)}{P(D\,|\,H_0) + P(D\,|\,H_1)}$

1) **Frequentist analysis**

- Generate TOY-MC with zero signal and compute $P(H_0)$, interpret it as test statistic
- Select the cut such that a false discovery is claimed in 0.14% of the toys

2) **Bayesian analysis**

- Claim discovery when $P(H_0)$ is lower than 0.14% corresponding to 3 sigma evidence

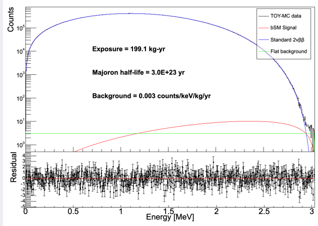
Once the cut is set, generate TOY-MC assuming positive signal and compute the discovery probability as:

$$P = \frac{N_{toys}(P(H_0) < \mathrm{cut})}{N_{toys}^{tot}}$$

PRELIMINARY RESULTS

Preliminary study performed using the spectral shape of ^{100}Mo.

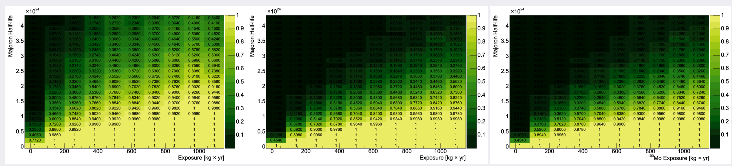
$2\nu\beta\beta$ half - life ~7.1×10^{18} yr



METHODS COMPARED

Scan in exposure and Majoron half-life considering only SM-$2\nu\beta\beta$ as background source. The Bayesian analysis consider both non informative priors (NIP) and gaussian priors (GP) over the Majoron events with mean at zero and width set considering the actual experimental limits

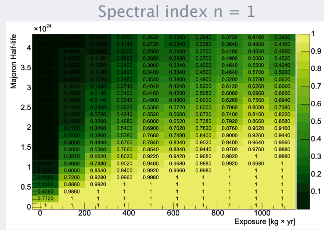
Frequentist | Bayesian (NIP) | Bayesian (GP)



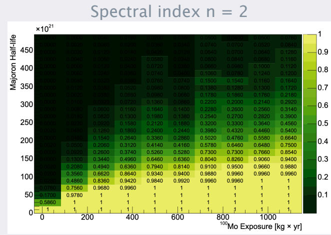
DISCOVERY PROBABILITY FOR MAJORON DECAYS

Only SM-$2\nu\beta\beta$ as background contribution

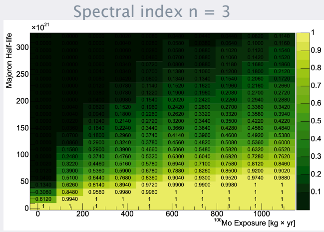
Spectral index n = 1



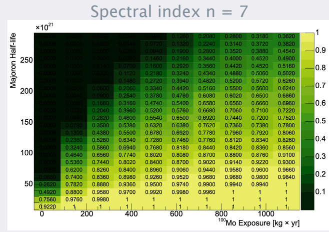
Spectral index n = 2



Spectral index n = 3

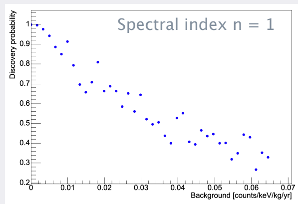


Spectral index n = 7



SYSTEMATICS AND BACKGROUND

1) **Flat Background:** The effect decreases the discovery probability for n = 1, it does not have a strong effect on the others.

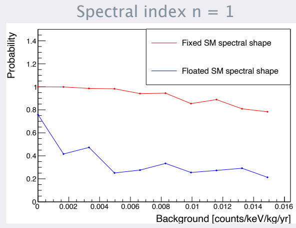


2) **$2\nu\beta\beta$ spectral shape:** Fit the $2\nu\beta\beta$ spectrum using the improved model where

$$\frac{dG}{dT} \sim \frac{dG_0}{dT} + \xi_{3,1}\frac{dG_2}{dT}$$

and $\xi_{3,1}$ can be fixed in the fit or a free parameter. A strong effect on the discovery probability has been observed for all the majoron decays.

Spectral index n = 1



NEXT STEPS

- Extend to ^{76}Ge, ^{136}Xe, and other isotopes
- Analyze different bSM processes (Lorenz violation, Sterile neutrinos)
- Consider other possible systematics

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