Alternative Searches for Physics Beyond the Standard Model in LEGEND-200

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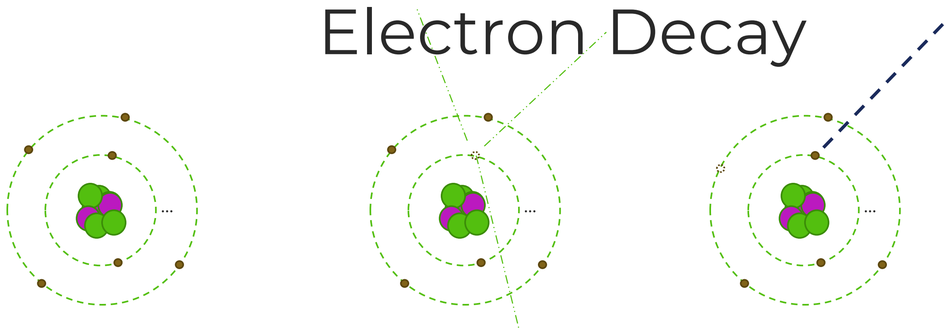
LEGEND Large Enriched Germanium Experiment for Neutrinoless ββ Decay

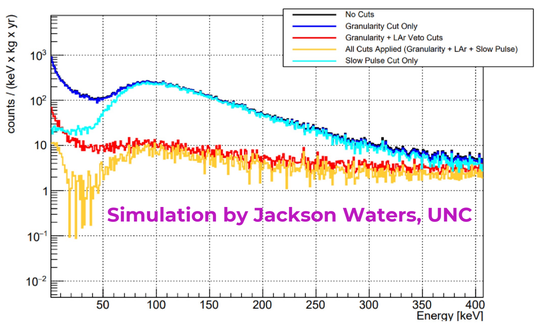
Peak Searches:
Electron Decay

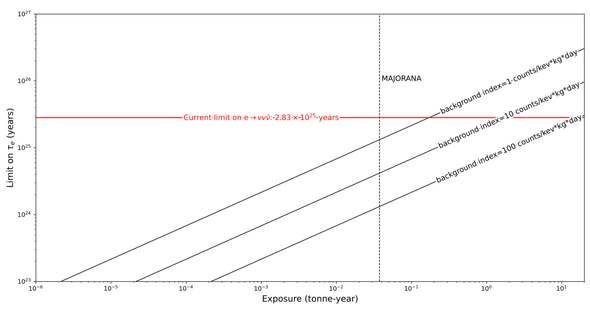


Channel	Current Limit	Experiment
$e^- \to \nu\underline{\nu}\nu$	2.83 E25 yr	MJD
$e^- \to \nu\gamma$	6.6 E28 yr	Borexino

The MAJORANA Collaboration Nat. Phys. (2024);
A Vishneva et al 2017 J. Phys.: Conf. Ser. 888 012193

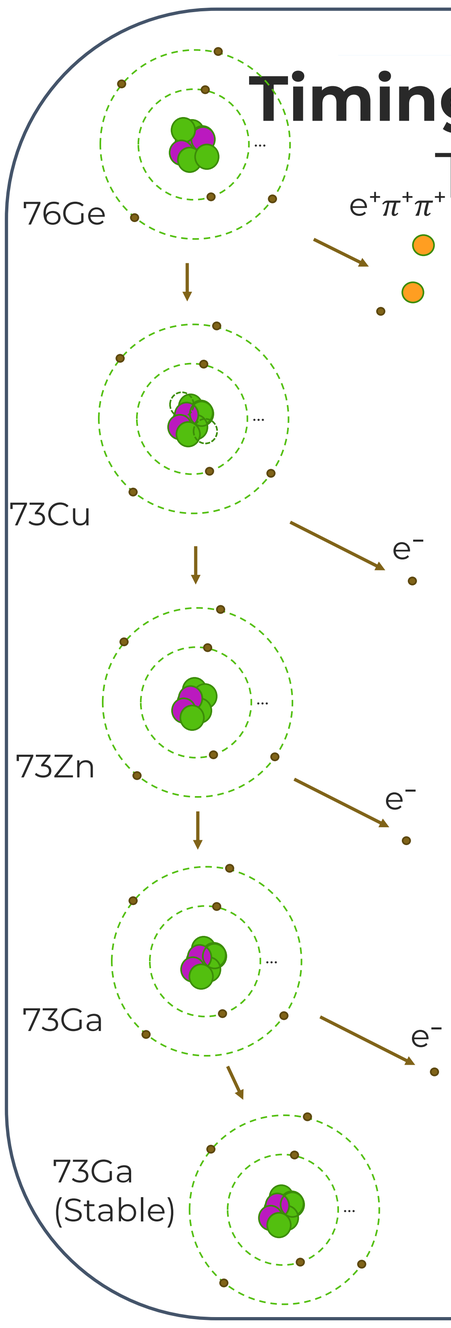
Motivation:
We can test assumed fundamental symmetries in L200 by looking for low energy peaks consistent with new physics.





Current thresholds in L200 are set around ~50 keV, but with lower thresholds (~5 keV) the detector is well positioned to expand limits on fundamental physics with moderate exposure.

Timing Coincidence Studies:
Tri Nucleon Decay



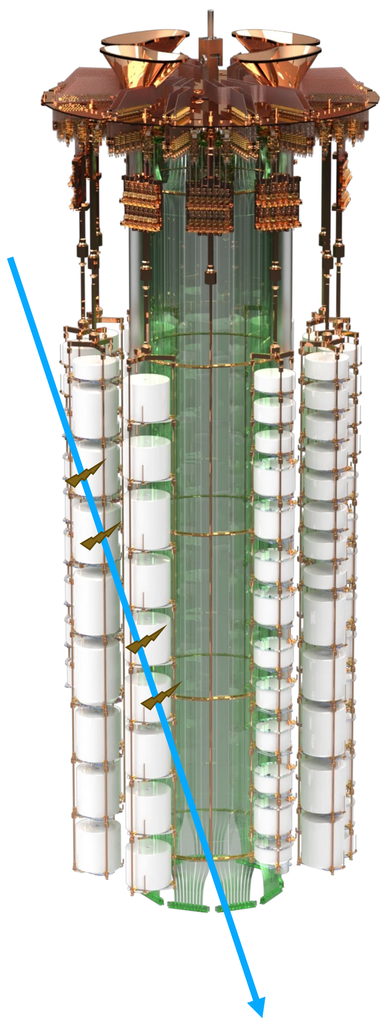
Motivation:
Baryon number violation is expected in many extensions of the Standard Model. We can look for tri-nucleon decay using timing coincidences in L200.

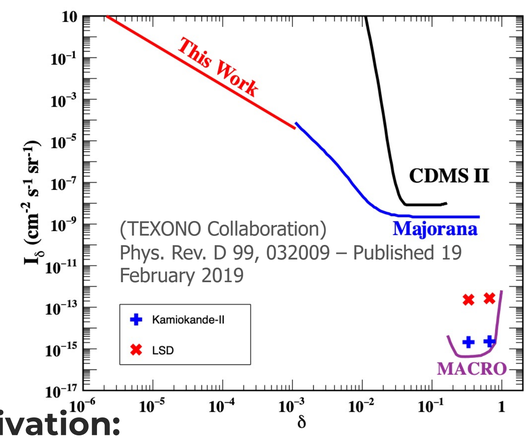
Channel	Limits
^{76}Ge (ppp)→^{73}Cu X	47.0E24 yr
^{76}Ge(ppn) →^{73}Zn X	48.7E24 yr
^{76}Ge(pn) →^{74}Ga X	47.6E24 yr
^{70}Ge(nnn) →^{67}Ge X	1.9E24 yr

S. I. Alvis *et al.* (Majorana Collaboration) Phys. Rev. D 99, 072004 – Published 12 April 2019

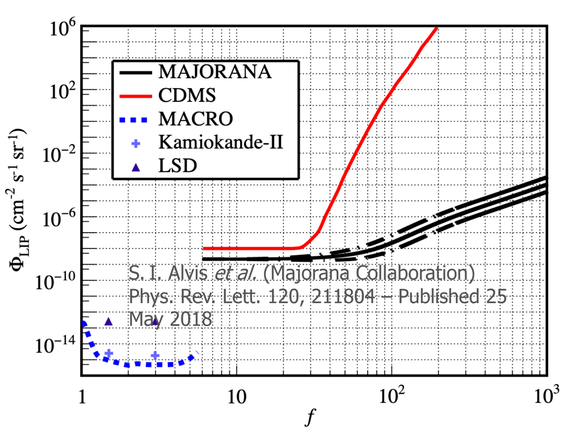
- In the MAJOROANA DEMONSTRATOR an analysis window in each detector was set on the order of minutes where the chance of accidental coincidences would be low.
- In L200 this timescale can be widened to order of hours, allowing for searches involving decays with longer lifetimes.

Multiplicity Searches:
Fractionally Charged Particles





Motivation:
In the SM we do not know of free fractionally charged particles. Using L200 we can search for ambient fluxes of lightly ionizing particles by looking for "tracks" go through several detectors.



Spectral Distortion:
2νββ

Motivation:
We are entering an era of precision physics with two neutrino double beta decay. This opens the possibility of exploring a variety of new physics models beyond the Standard Model in L200, but requires more precise predictions to identify real spectral distortions.

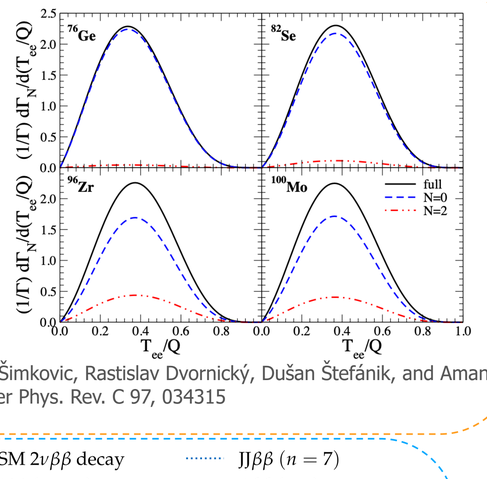
Many have begun to improve 2vBB predictions, but there is still much to do...

- Typical 2vBB predictions make the following simplification in calculating matrix elements, where epsilon depends on the lepton kinematics.

$$M_{GT}^{K,L} = m_e \sum_n M_n \frac{E_n - (E_i + E_f)/2}{[E_n - (E_i + E_f)/2]^2 - \varepsilon_{K,L}^2}$$

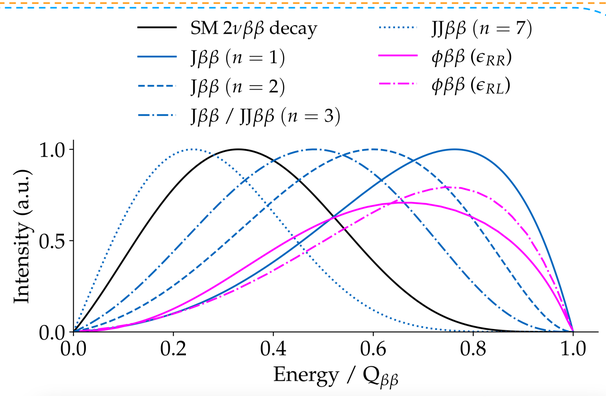
$$M_{GT}^{K,L} \simeq M_{GT}^{2\nu} = m_e \sum_n \frac{M_n}{E_n - (E_i + E_f)/2}$$

- Simkovic *et al* have performed a correction by expanding in powers of the ratio ε and the energy splitting. The 0th order is the standard approximation.



Fedor Šimkovic, Rastislav Dvornický, Dušan Štefánik, and Amand Faessler Phys. Rev. C 97, 034315

Armed with better predictions we can consider models BSM which will distort the 2vBB spectrum. Larger exposures and a strong handle on systematic uncertainties are necessary to look for subtle distortions...



Elisabetta Bossio and Matteo Agostini 2024 J. Phys. G: Nucl. Part. Phys. 51 023001

Collaboration Institutes:

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