$0\nu\beta\beta$ decay searches with a G3 liquid Xe TPC experiment

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Mini Workshop: $0\nu\beta\beta$ experiments II
G3 LXe Collaborators

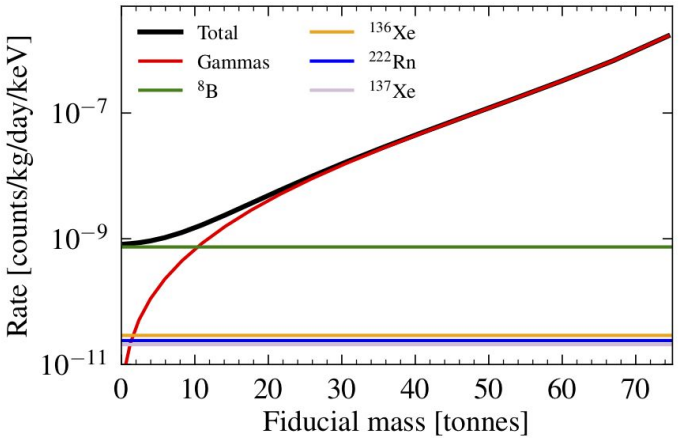
Search for $0\nu\beta\beta$ in a G3 LXe two-phase TPC

G3 experiment

- In accordance with an existing P5 recommendation (2014 P5 Report).
- 75 tonnes of non-enriched xenon (in active mass), and a TPC of 3.2 m in both diameter and height (x2.2 larger than LZ [1]).
- Two-phase system: event energy and 3D position reconstructed by using prompt (S1) and delayed (S2) scintillation signals.
- $0\nu\beta\beta$ search is possible both in ^{134}Xe and ^{136}Xe isotopes.
- Broad and deep scientific reach: sensitive to a wide variety of dark matter models, coherent neutrino scattering, supernova neutrinos, etc.
- Detector design and construction materials used are based on current LXe two-phase TPC experiments [1, 2, 3].

Background mitigation

- A considerable background reduction is possible with modest changes from current designs, by using cleaner materials throughout and alternative engineering solutions when possible, e.g.:
  - In-house developed field shaping resistors, as in [4].
  - Cleaner capacitors and copper batches for PMT cables.
  - Lowered outer detector radioactivity.



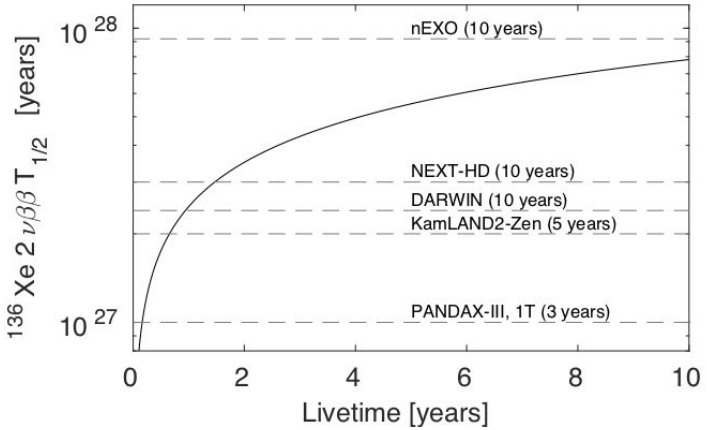
Sensitivity projection

Assumptions

- A modest and experimentally substantiated reduction of 68.4% in component radioactivity in comparison to the LZ gamma background [1].
- 0.8% energy resolution at $0\nu\beta\beta$ peak, as measured by XENON1T [2].
- Semi-analytical toy model of gamma-ray attenuation in a cylindrical detector.
    - Able to reproduce both LZ and DARWIN [5] gamma-ray background models.
- To account for the spatial dependence of the background sources, the detector volume was divided in N sections, and the corresponding half-life sensitivity was calculated as a weighted sum over each of the sections, following the figure-of-merit estimator from ref. [6].

Results

- Sens. to $0\nu\beta\beta$ of ^{136}Xe: $T_{1/2} > 8 \times 10^{27}$ years (90% C.L.), for 10 years livetime and 75 tonnes liquid xenon active mass.
- This is two orders of magnitude larger than the current best limit [7], and competitive with other planned experiments (see below).



References

[1] LZ Collaboration, Phys. Rev. C 102 no. 1, (2020) 014602.

[2] XENON Collaboration, Eur. Phys. J. C77no. 12, (2017) 890.

[3] PandaX-III Collaboration, Nucl.Instrum. Meth. A958 (2020) 162439.

[4] EXO-200 Collaboration, Journal of Instrumentation 7 no. 05, (2012).

[5] DARWIN Collaboration, arXiv:2003.13407.

[6] Avignone et al., Rev. Mod. Phys. 80 (2008) 481–516.

[7] KamLAND-Zen Collaboration, Phys. Rev. Lett. 117 (2016) 082503.