Search for the neutrinoless double beta decay of ^{136}Xe with the XENON1T experiment

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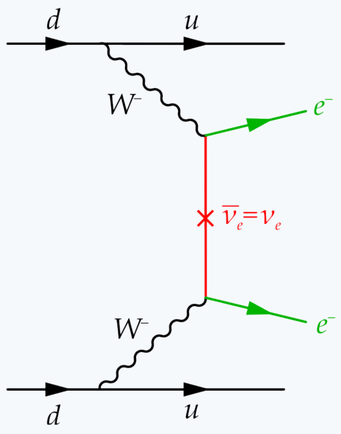
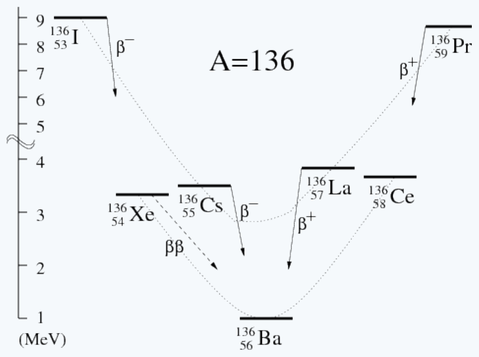
Motivation: Search for $0\nu\beta\beta$ of ^{136}Xe

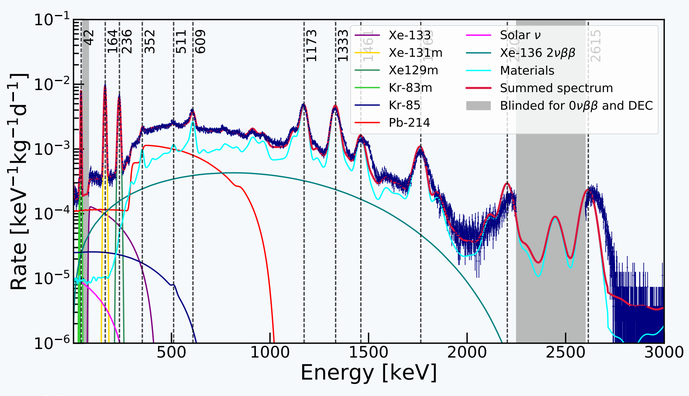
- Double beta decay in XENON1T: $\mathbf{^{136}Xe \rightarrow {}^{136}Ba + 2e^- + 2\bar{\nu}_e}$ with Q-value at $\mathbf{(2457.83 \pm 0.37)\ keV}$ [1]
- Measured isotopic abundance of ^{136}Xe: **8.49%**
- Target volume of 2.2 tonnes of xenon in the TPC $\Longrightarrow$ **187 kg** of ^{136}Xe

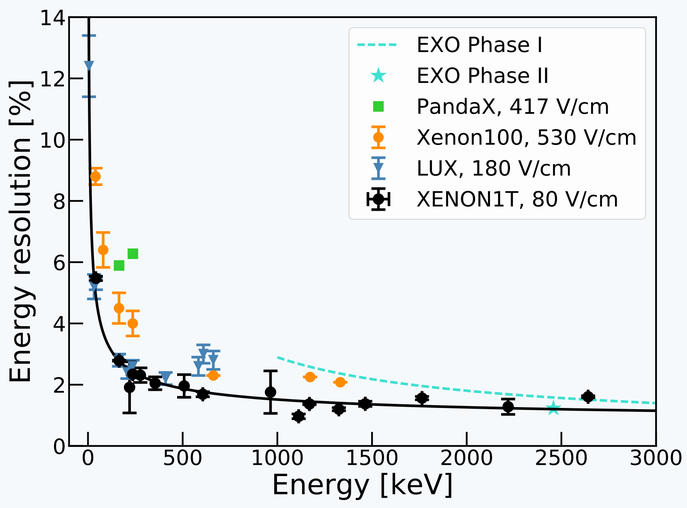




Background & Resolution

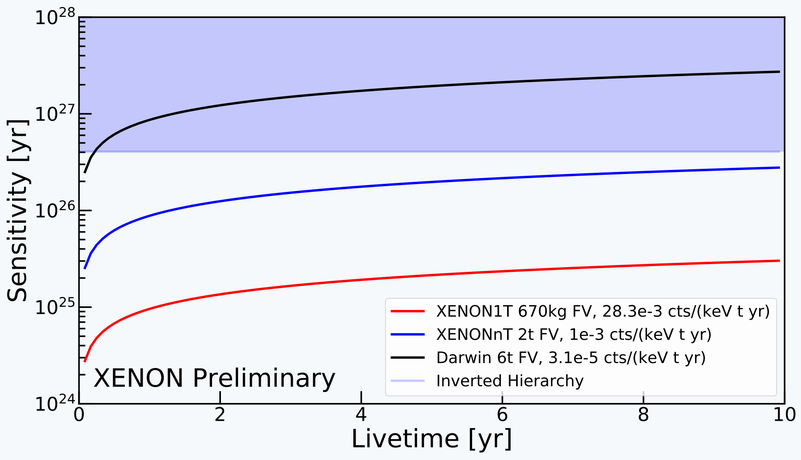
- Experimental sensitivity: $S^{0\nu} \propto \epsilon \frac{a}{A}\sqrt{\frac{M \cdot t}{\Delta E \cdot b}} \Longrightarrow$ low background and high energy resolution needed[2]
- **Energy resolution** at the Q-value: **1.2%**, comparable with dedicated $0\nu\beta\beta$ xenon experiments
- Blinded data between 2.3 and 2.6 MeV





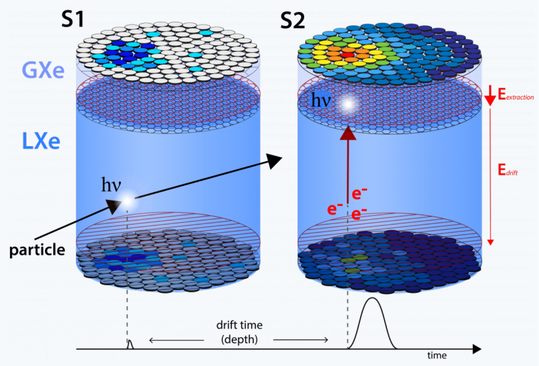
$0\nu\beta\beta$ Expected Sensitivity

- Preliminary study on sensitivity for XENON1T in 670 kg fiducial volume
- Expected sensitivity for XENONnT: 2 tonnes fiducial volume and one order of magnitude improvement in background
- Expected sensitivity for Darwin: 6 tonnes fiducial volume $\Longrightarrow$ two order of magnitude improvement in sensitivity compared to XENON1T



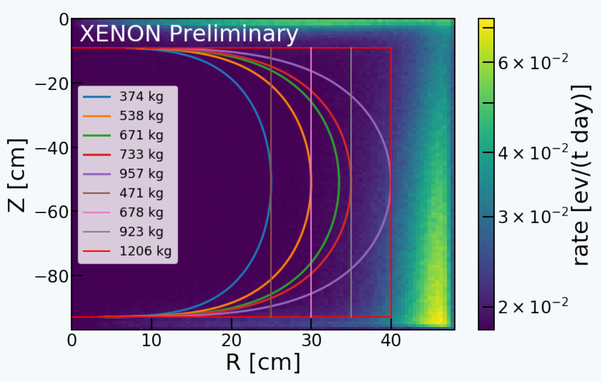
The XENON1T Experiment

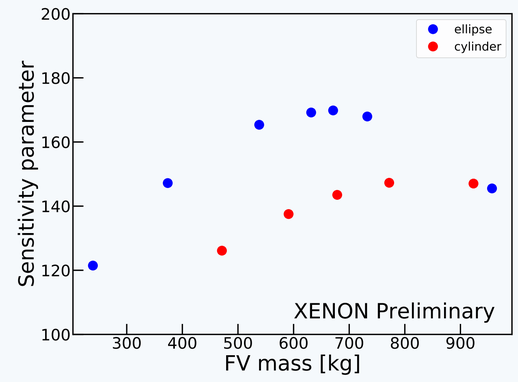
- Located at Laboratori Nazionali del Gran Sasso shielded by 3600 m.w.e
- Dual-phase xenon time projection chamber with PMT arrays top and bottom $\Longrightarrow$ main purpose WIMP dark matter candidate search[3]
- Prompt scintillation (S1) and electro-luminescence from extracted electrons (S2) detected for each interaction
- 3D position reconstruction: X-Y from PMT patterns and Z from drift time between S1 and S2
- Electronic and nuclear recoil discrimination based on S2/S1 ratio



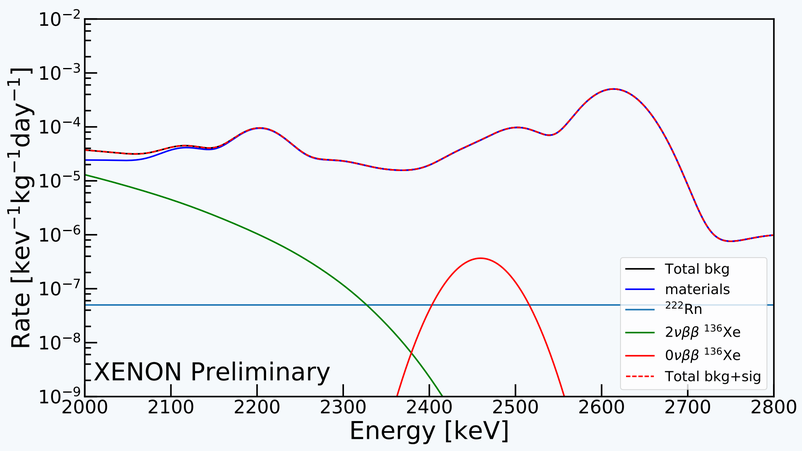
High Energy

- Fiducial volume in superellipsoid optimized to achieve best sensitivity
- Background contribution in the region [2.3,2.6] MeV from **$2\nu\beta\beta$ ^{136}Xe, ^{222}Rn and materials**
- Estimated background rate of 28 cts/(keV t yr) in inner fiducial volume of 670 kg: **under study** for improvement at high energy





- Experiment optimized for low energy dark matter search $\Longrightarrow$ ongoing studies to improve high energy region
- Considering a $0\nu\beta\beta$ signal from ^{136}Xe with half-life of $5.6{\cdot}10^{25}$ yr (the current KamLAND-Zen sensitivity[4]), the signal is still more than an order of magnitude below the background



References

[1] M. Redshaw, E. Wingfield, J. McDaniel, and E. G. Myers, "Mass and double-beta-decay q value of ^{136}Xe," *Phys. Rev. Lett.* **98** (Feb, 2007) 053003. https://link.aps.org/doi/10.1103/PhysRevLett.98.053003.

[2] **XENON** Collaboration, E. Aprile *et al.*, "Physics reach of the XENON1T dark matter experiment," *JCAP* **1604** no. 04, (2016) 027, arXiv:1512.07501 [physics.ins-det].

[3] **XENON** Collaboration, E. Aprile *et al.*, "The XENON1T Dark Matter Experiment," *Eur. Phys. J.* **C77** no. 12, (2017) 881, arXiv:1708.07051 [astro-ph.IM].

[4] **KamLAND-Zen** Collaboration, A. Gando *et al.*, "Search for Majorana Neutrinos near the Inverted Mass Hierarchy Region with KamLAND-Zen," *Phys. Rev. Lett.* **117** no. 8, (2016) 082503, arXiv:1605.02889 [hep-ex]. [Addendum: Phys. Rev. Lett.117,no.10,109903(2016)].