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Title: From Majorana to LEGEND - live from the Davis

Author(s): Massarczyk, Ralph
Meijer, Samuel Joseph

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From MAJORANA To LEGEND

Ralph & Sam
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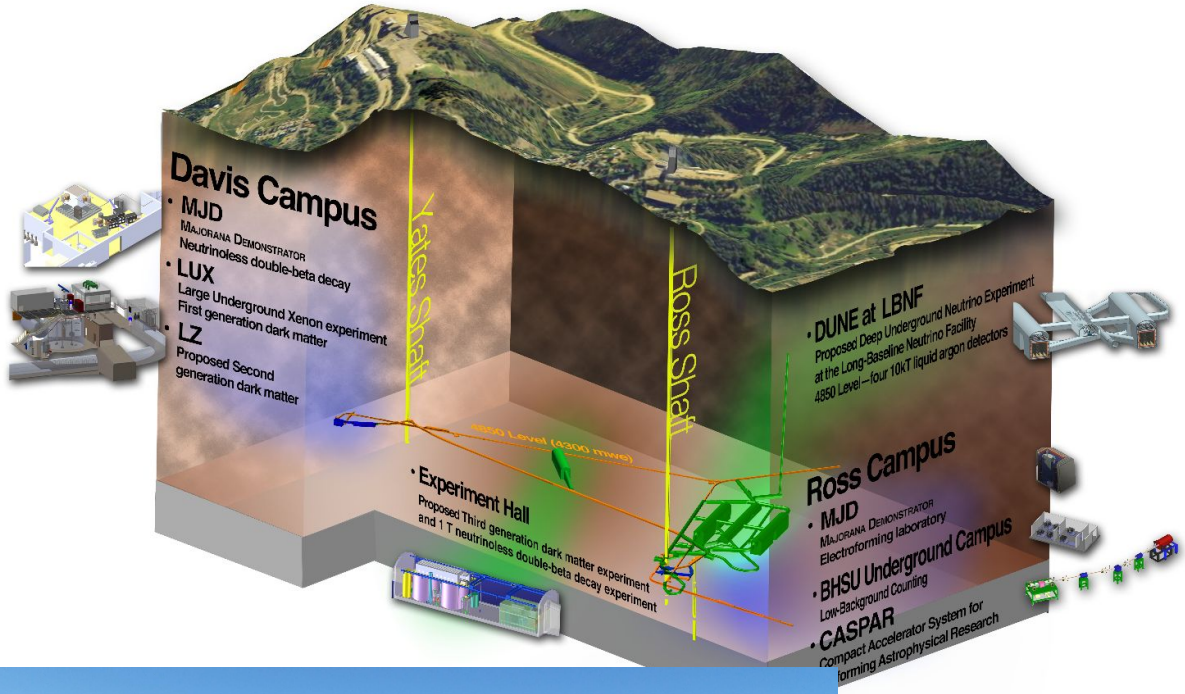
From the Davis Campus



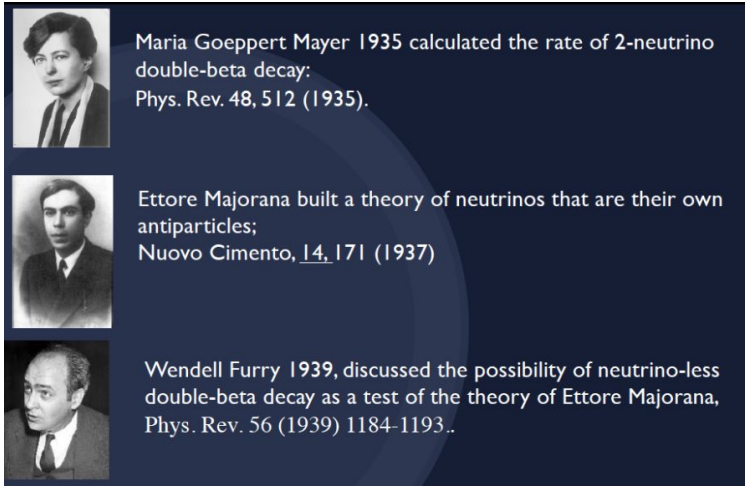
A short physics summary on double beta-decays

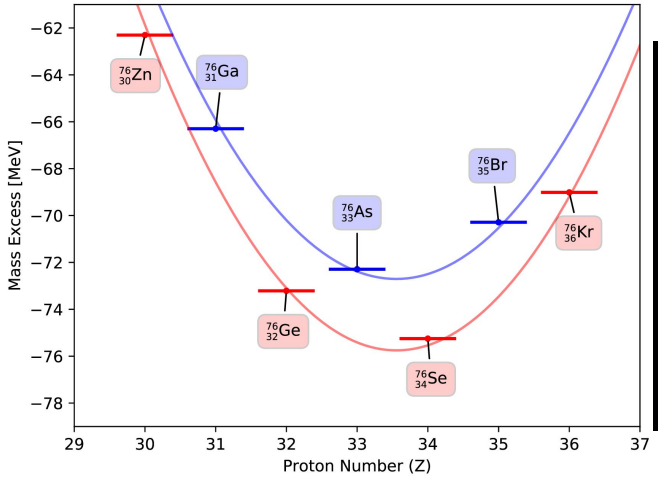
- 2^{nd} order weak process
- Observable when single β-decay not possible
- With and without neutrino emission
- **0νββ requires the neutrino to be its own antiparticle**

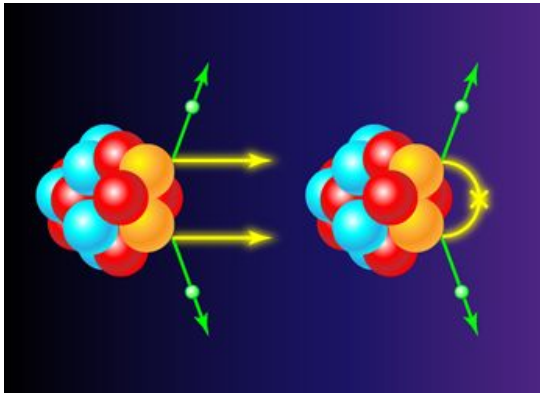
❖ **Physics beyond the standard model needed**

❖ **Non-zero mass neutrinos**

❖ **A path into Leptogenesis**



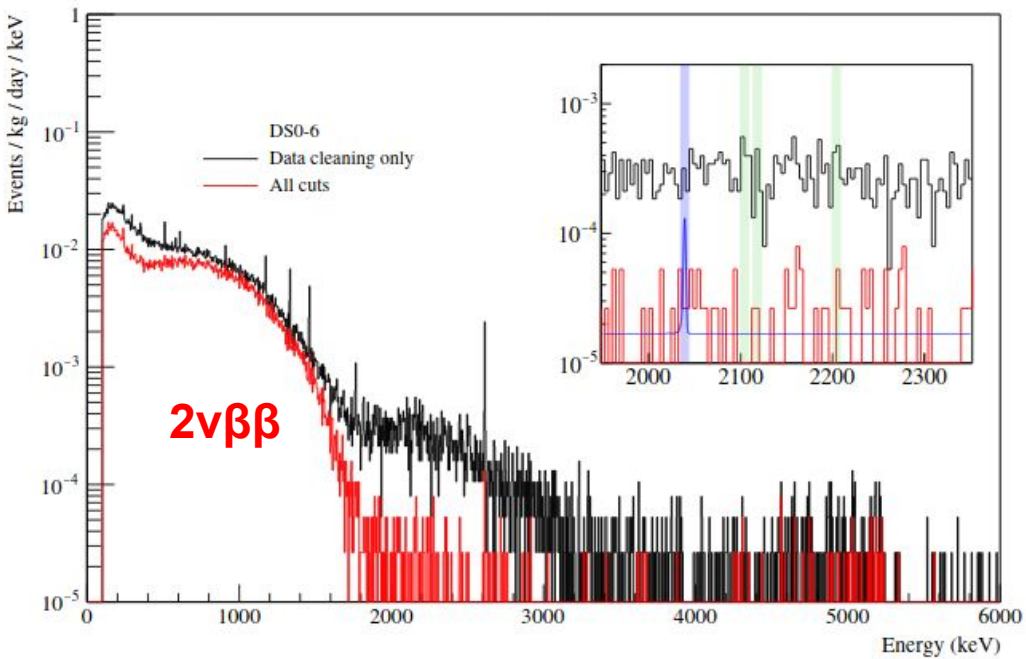




From an experimentalist point of view

- Extremely rare process
  - $T_{1/2} > 10^{26}$ years (0νββ)
  - Rate for this limit : ~1 cts/(ton yr) @ 2 MeV
- Search for signal at the Q-value
- Use germanium detectors enriched in ^{76}Ge (~88%)
- Key points for a successful experiment are:
  - Energy resolution
  - Background reduction
  - Exposure (Mass * Time)
  - Efficiency

0νββ (limit)



Phys. Rev. Lett. 120, 132502
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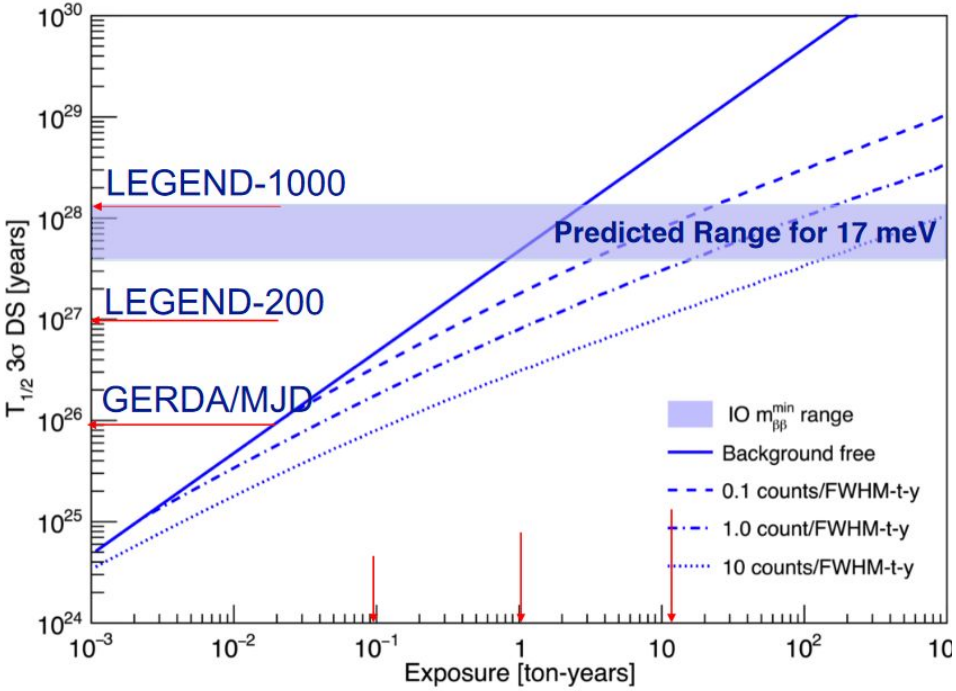
From MAJORANA to LEGEND

LEGEND Large Enriched Germanium Experiment for Neutrinoless ββ Decay

- Current generation experiments in using germanium achieved the world leading results in **resolution and background**
- Best Limit set with modest exposures
- Next generation combines the best of GERDA and MAJORANA
- LEGEND-200 starts data taking this year
- LEGEND-1000 competes in DOE portfolio review this summer



$$\left[T_{1/2}^{0\nu}\left(0^+ \rightarrow 0^+\right)\right]^{-1} = G^{0\nu}(E_0, Z)\left|M^{0\nu}\right|^2 \langle m_{\nu_e}\rangle^2$$

LANL's role

- Leadership roles in MAJORANA and LEGEND
  - Spokesperson, Executive committee chairs (MJD)
  - Task leads for lab infrastructure, calibration, detector work, data cleaning, and high-energy physics

- Past LANL investments (LDRD) have driven:
  - Development of the point-contact germanium detector supplies from different vendors
  - Develop a 2nd isotope vendor to reduce risk and price
  - Crucial contributions in nuclear matrix elements and particle theory

- Our plan forward
  - Lead the Post MAJORANA Physics effort:
    Measure the decay of ^{180m}Ta
  - Play a crucial role in the heart of LEGEND:
    Drive the R&D efforts in the development
    Of large scale Point Contact detectors

From our pre-Covid planning retreat