Beyond Ton Scale $0\nu\beta\beta$
and Future Xe Experiments

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Tonne-scale neutrinoless double beta decay experiments will reach sensitivities of $\sim 10^{28}$ yrs, covering the entire inverted hierarchy and a lot of the normal hierarchy parameter space.

**WHAT’S NEXT?**
To cover \( \sim 90\% \) of the remaining parameter space at any given neutrino mass, one needs to reach a \(<m\beta\beta>\) sensitivity of \( \sim 1\) meV.

For \(^{136}\text{Xe}\), that corresponds\(^*\) to a half-life of roughly \(10^{30}\) yrs.

\[
R = 0.3 \text{ decays/yr} \left( \frac{m_{136}}{100 \text{ t}} \right) \left( \frac{10^{30} \text{ yr}}{T_{1/2}} \right) = 2.3 \text{ decays/(kt yr FWHM)} \left( \frac{10^{30} \text{ yr}}{T_{1/2}} \right)
\]

* Assuming flat priors on Majorana phases
** Assuming median NME

You need a \(~100\)-1000 tonnes of \(^{136}\text{Xe}\) to probe this parameter space.
Kiloton-scale xenon detectors for neutrinoless double beta decay and other new physics searches
Physical Review D 104, 112007 (2021)
Explore motivation for extending Xe time-projection chambers to the kton scale, possible avenues for Xe acquisition that avoid existing supply chains, discuss possible detector concepts for liquid and gaseous xenon detectors.

Relevant to this panel:
Underground facility needs
Kiloton-scale xenon detectors for neutrinoless double beta decay and other new physics searches
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Relevant to this panel:
Underground facility needs

*multiple smaller modules with the same total mass might provide a more optimal design
Underground Facility Needs

- Space underground for detector + associated vessels and vetos/shields
- Entry access for large components
- Space for assembly of detectors (large clean room areas, cranes, vertical clearance)
- Welding and fabrication facilities (e.g. electroforming facility)
- Clean rooms (dust free, radon reduced air)
- Xenon recovery and storage

LXe Requirements

- Cryogenics
  - Cooling
  - Safety
- Shielding from neutrons

GXe

- Large pressure vessel(s)
  - Safety
- Low radioactive backgrounds
General Underground Facility Needs

More to an underground facility than just the muon flux!

**Lab Level:**
- Available experimental space
- Maximum dimensions of equipment for access
- Cleanroom area / class
- Machining and welding capabilities
- Assembly space
- Electroforming facilities
- Available storage space
- Seismic safety requirements

(would be great to have a unified reference website for all labs)

**Location/Cavern specific:**
- Radon levels in air
- Neutron flux and spectrum
- Gamma ray flux and spectrum
- Dust radioactivity and plateout rate in cleanrooms

(would be great to have a set of standardized measurements)
THANK YOU
Underground physics without underground labs: large detectors in solution-mined salt caverns
Benjamin Monreal, arXiv:1410.0076
Underground Facility Needs

- Space underground for detector + associated vessels and vetos/shields
- Access for large vessels
- Xenon recovery and storage
- Clean rooms (dust free, radon reduced air)
- Electroforming copper capability

LXe Requirements
- Cryogenics
- 137Xe (neutron capture)

GXe
- Large pressure vessel(s)
- Low radioactive backgrounds