Beyond Ton Scale 0νββ and Future Xe Experiments

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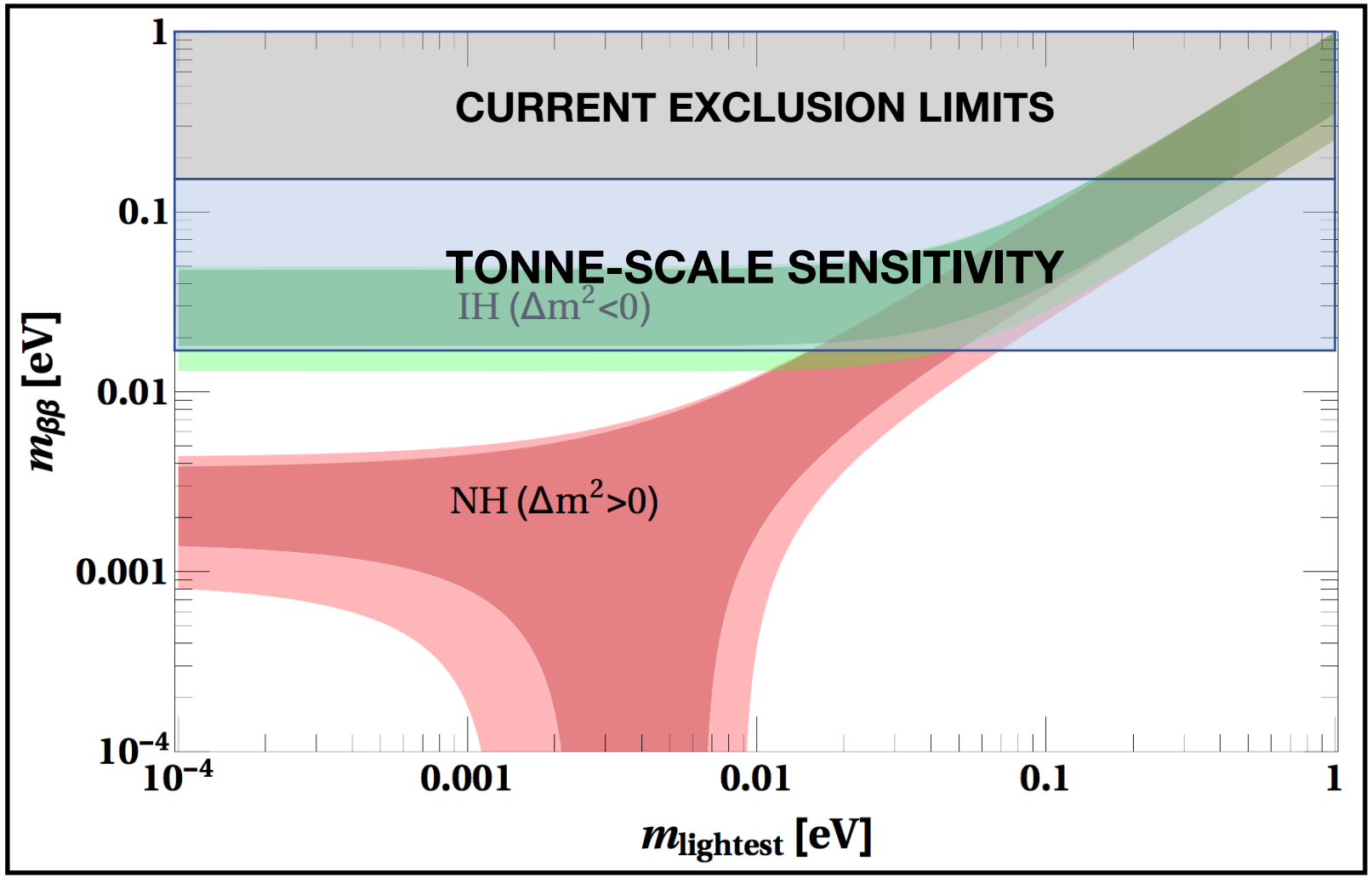
Snowmass Community Summer Study Workshop

Pacific Northwest
NATIONAL LABORATORY

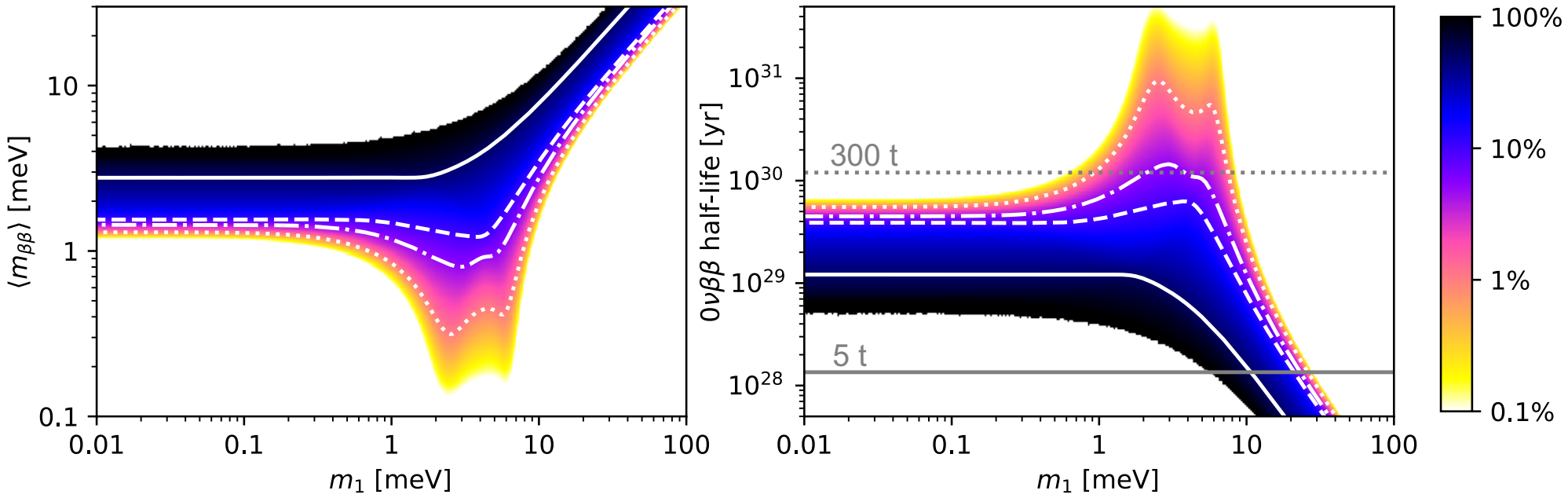
Tonne-scale neutrinoless double beta decay experiments will reach sensitivities of ~ 10^{28} yrs, covering the entire inverted hierarchy and a lot of the normal hierarchy parameter space



WHAT'S NEXT?

To cover ~ 90%* of the remaining parameter space at any given neutrino mass, one needs to reach a <mββ> sensitivity of ~ 1 meV

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



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

$$= 2.3 \text{ decays/(kt yr FWHM)} \left(\frac{10^{30} \text{ yr}}{T_{1/2}}\right)$$

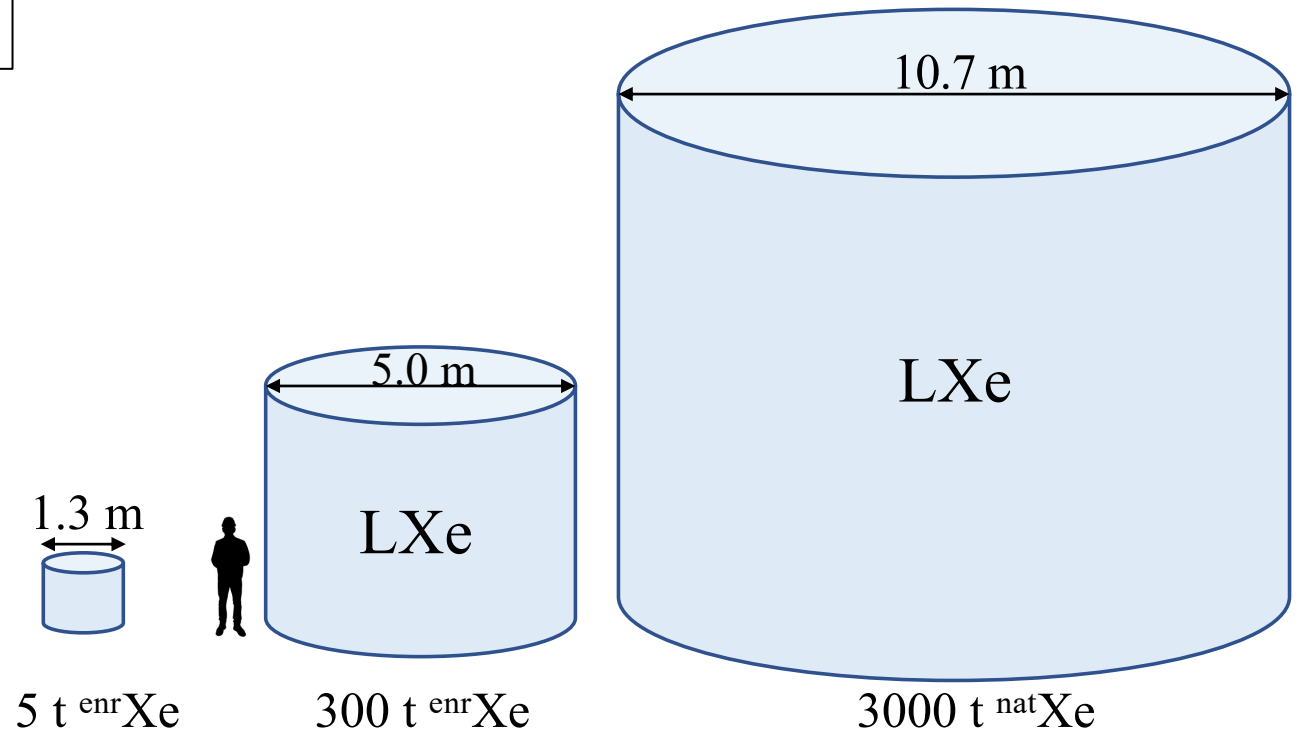
You need a ~100-1000 tonnes of ^{136}Xe to probe this parameter space

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

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



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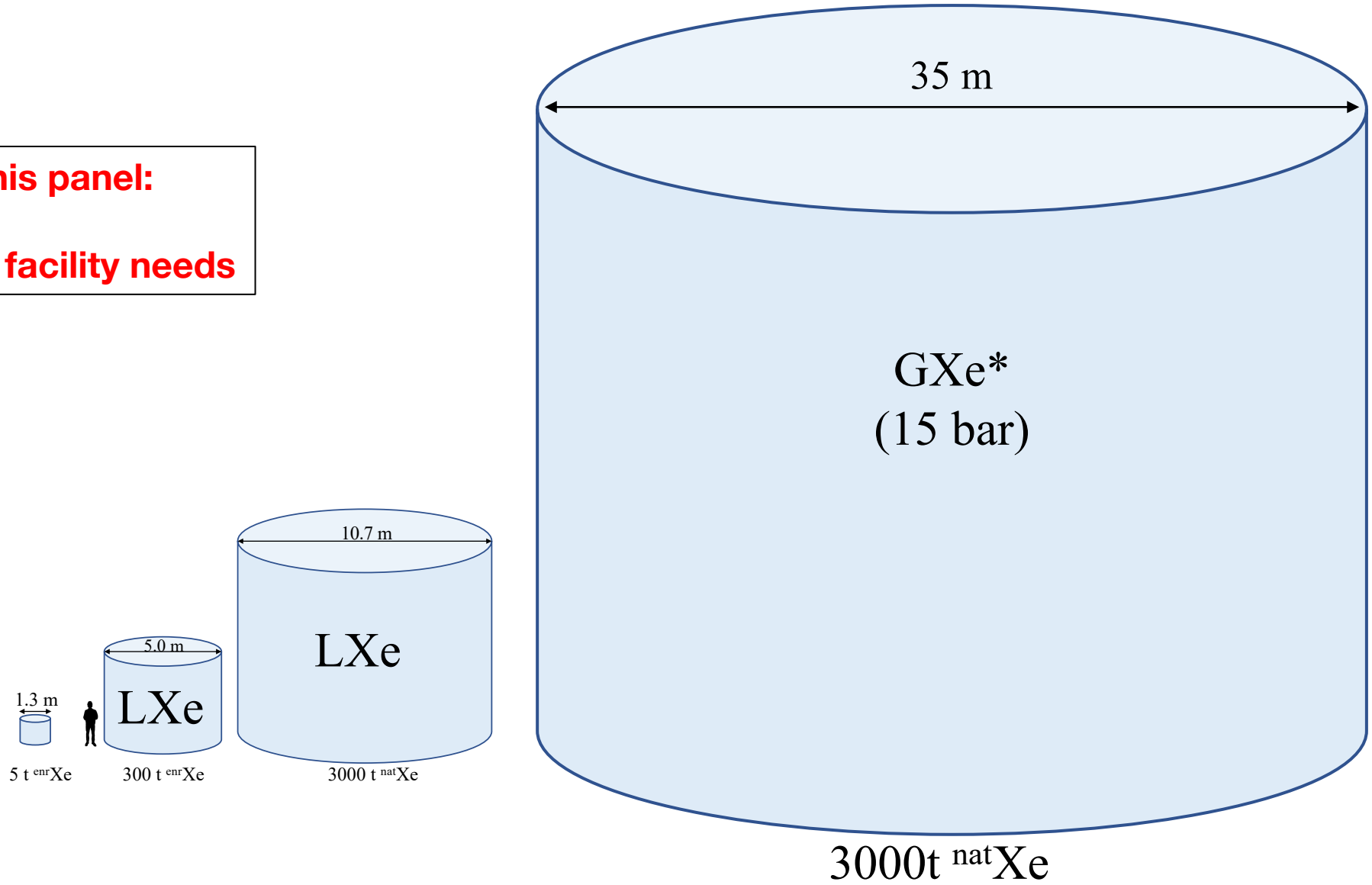


*multiple smaller modules with the same total mass might provide a more optimal design

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

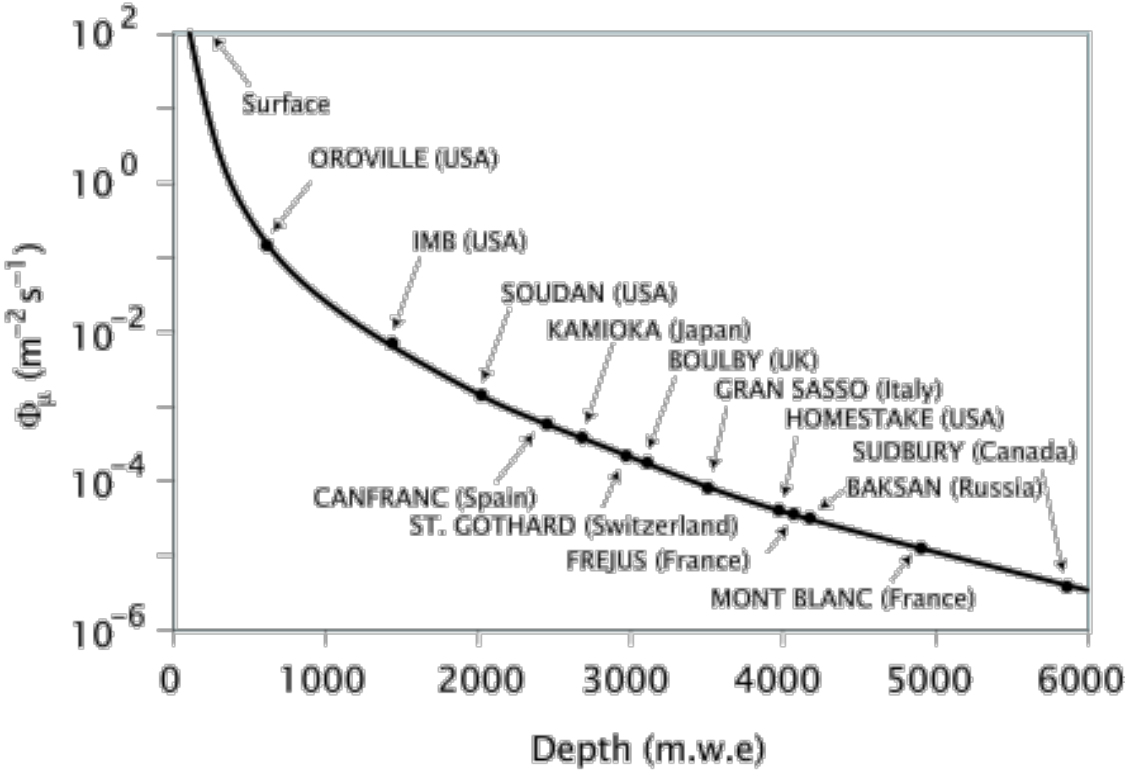
- Cryogenics
  - Cooling
  - Safety
- Shielding from neutrons

GXe

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

General Underground Facility Needs

More to an underground facility than just the muon flux!



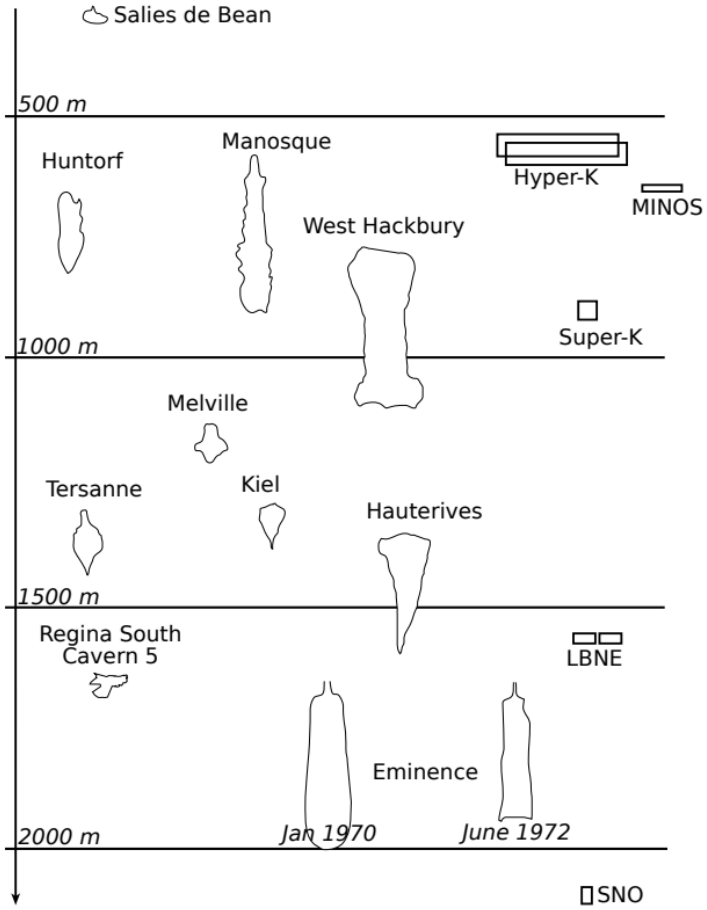
Lab Level:
Available experimental space
Maximum dimensions of equipment for access
Cleanroom area / class
Machining and welding capabilities
Assembly space
Electroforming facilities
Available storage space
Seismic safety requirements
(would be great to have a unified reference website for all labs)

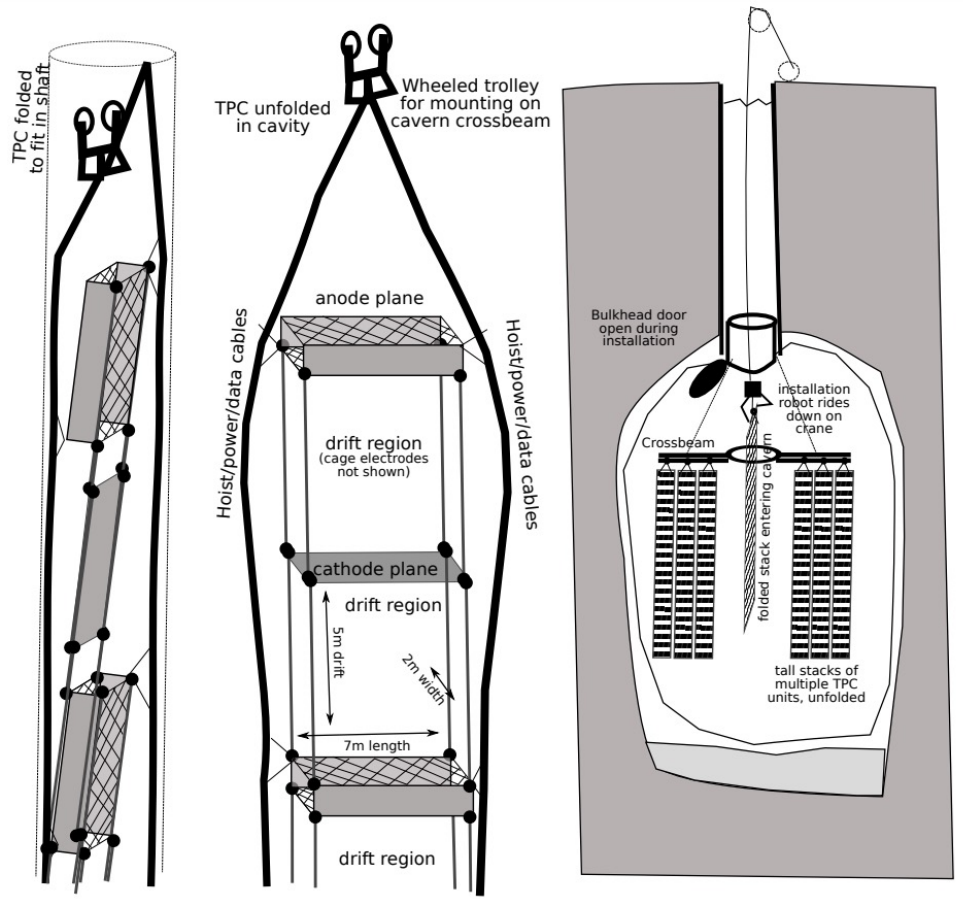
Location/Cavern specific:
Radon levels in air
Neutron flux and spectrum
Gamma ray flux and spectrum
Dust radioactivity and plateout rate in cleanrooms
(would be great to have a set of standardized measurements)

THANK YOU

Underground physics without underground labs: large detectors in solution-mined salt caverns

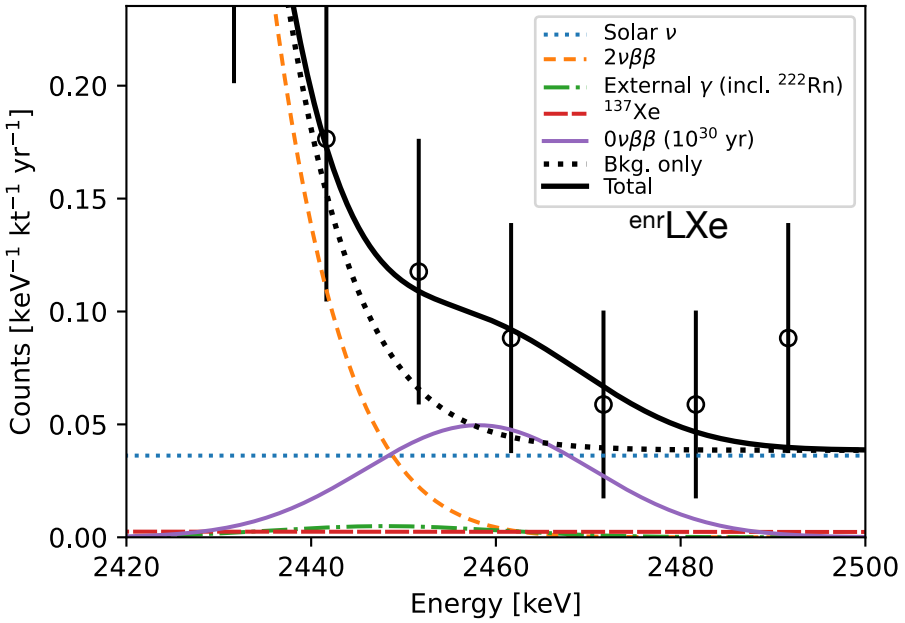
Benjamin Monreal, arXiv:1410.0076



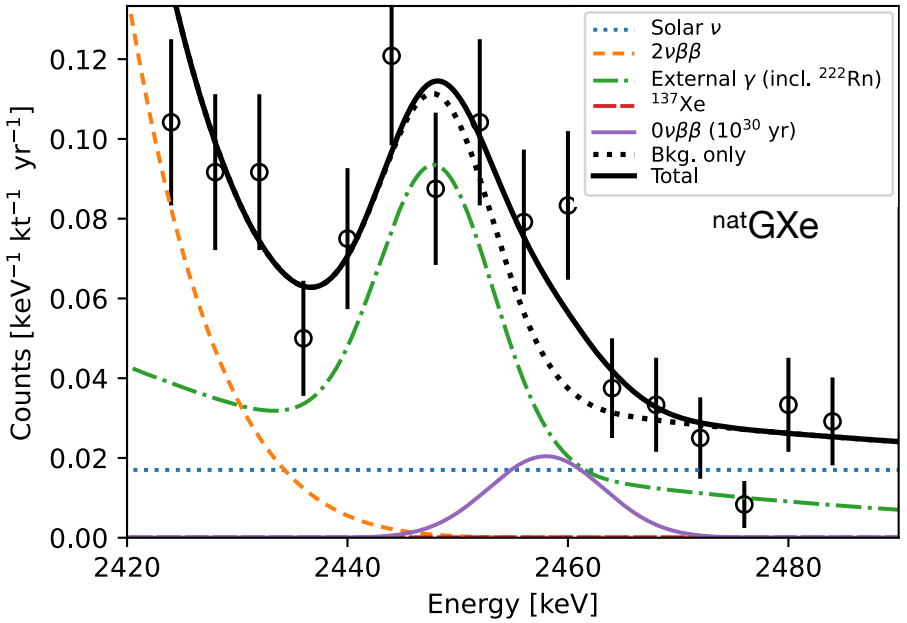


Underground Facility Needs

- 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)



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