Generation-3 Dark Matter: LXe

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History of Direct Detection Dark Matter at LBL

UCSB-LBL Ge detectors in Oroville in the 1980s: low background assay, HPGe detectors, shielding & veto

CDMS: low background assay, detector developments

DAMIC: CCDs

LUX: lead-lab, laboratory-infrastructure, OPS

LZ: lead-lab, project and experimental leadership, engineering, low background assay, OPS, calibration, HV delivery, simulations, analysis routines, …

R&D Efforts: HeRALD, CrystaliZe, HydroX, TESSERACT, instrumentation efforts

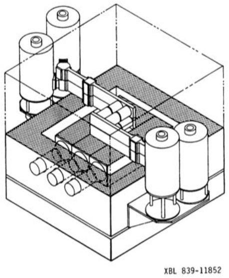
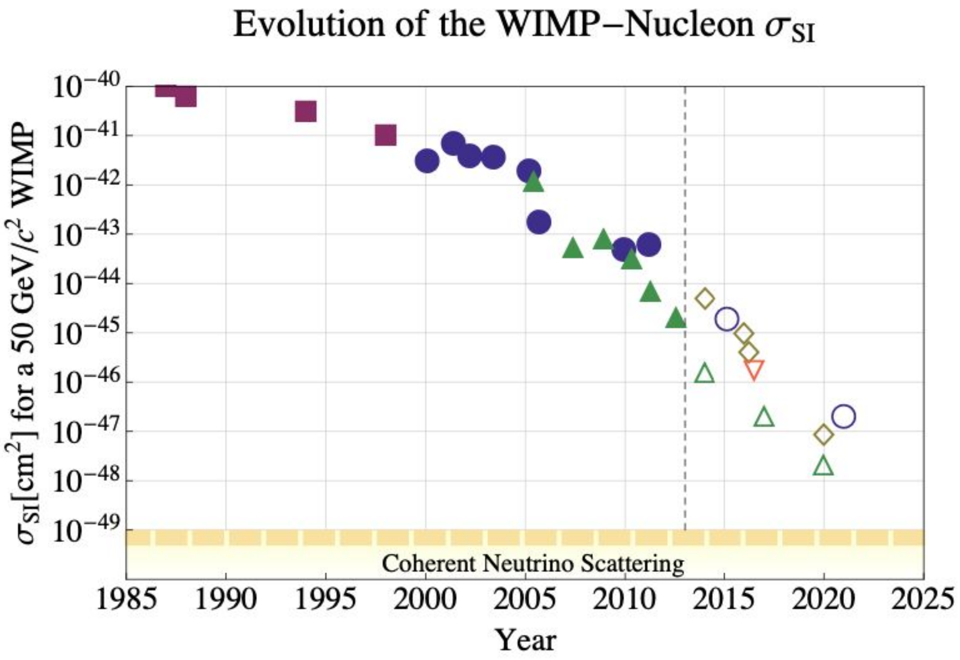


Fig. 2 Exploded view of the lower layers of detectors.

Future of Direct Detection of Dark Matter

Impressive progress in pursuing WIMPS over the past ~35 years.



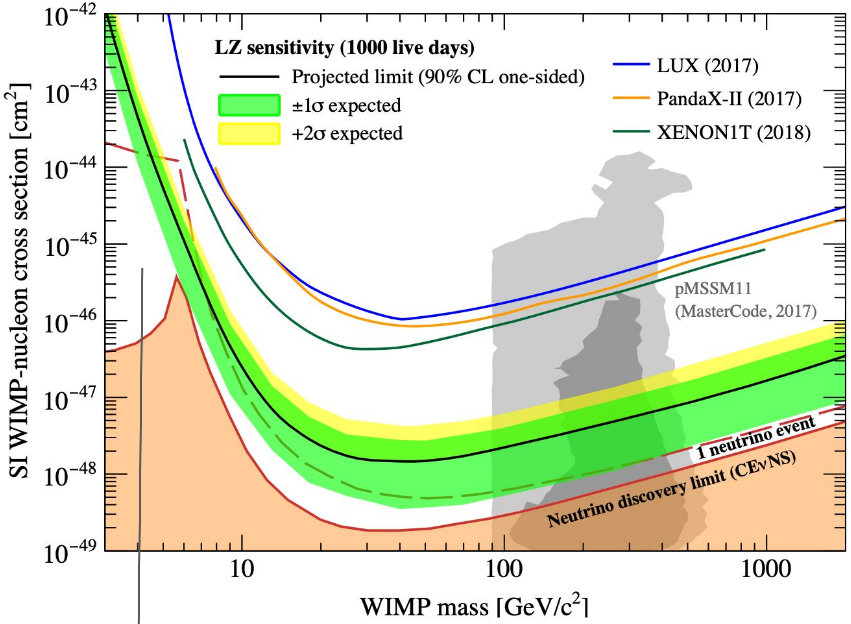
Liquid Nobles leading the way for ~ few to 100s GeV WIMPs

- Scalable to large masses
- Background control advancing rapidly
- Good Energy and Position Resolution
- Detector microphysics well-known
- Larger detectors offer greater physics reach

Details in forthcoming white-paper

https://arxiv.org/pdf/1310.8327.pdf

Current status of G-2 Experiments



XenonNT - ‘taking physics data’ (4T fiducial)

LZ - ‘final commissioning stages’ (5.6T fiducial)

Panda4T - Published first results (3.7T fiducial)

SuperCDMS@SNOLAB - recently rebase-lined, several years of construction and I&I remaining

ADMX: covered mass range 2.66 to 3.3 microeV down to DFSZ limit, continues scanning, R&D higher freq

SNOWMASS 2013

Recommendation to host a *domestic* Generation-3 Dark Matter Experiment

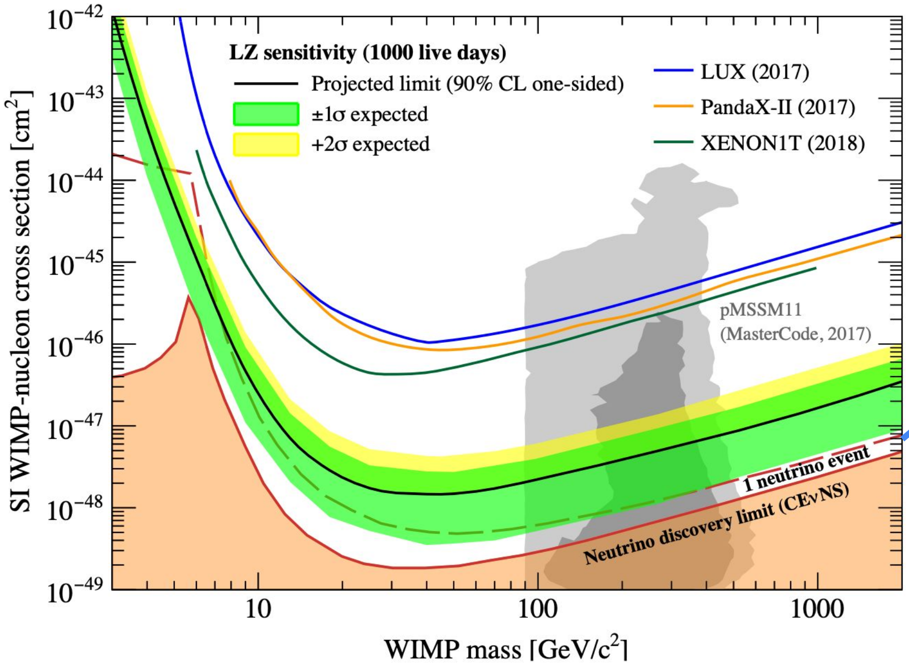
Informed by Generation-2 experiments

Generation-3 not well defined, but discussion at that time was continued pursuit of GeV-scale WIMPs.

Community will have to assess in the upcoming SNOWMASS process where the greatest opportunity for discovery lies.

We will present some of the physics opportunities of a large-scale LXe TPC, scaling and informed from LZ, XenonNT, Panda4T, and R&D in many areas

Physics Opportunities of a Xenon Observatory



- Dark Matter
  - WIMP
  - EFT interpretations
  - Low Mass Sensitivity
  - Other DM models
- Neutrinoless Double-Beta Decay
- Astronomical Neutrinos
  - Solar
  - Atmospheric
  - Supernovae

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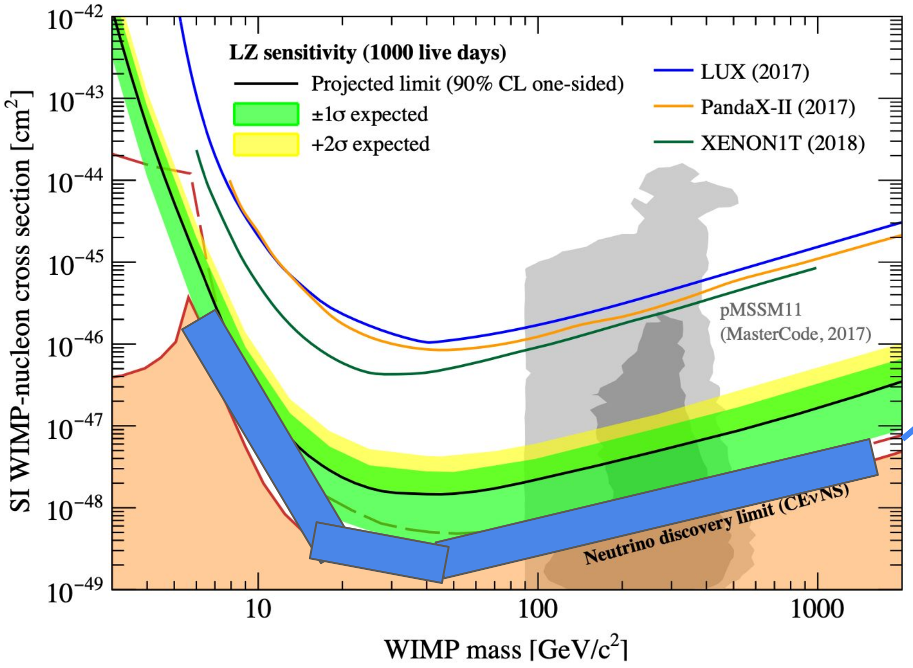

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Neutrinoless Double-Beta Decay

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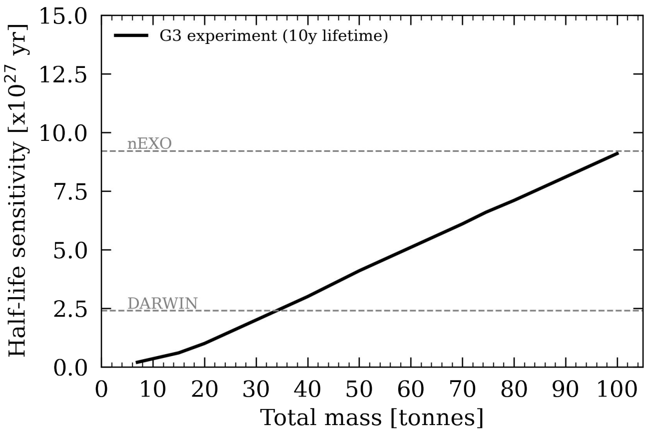
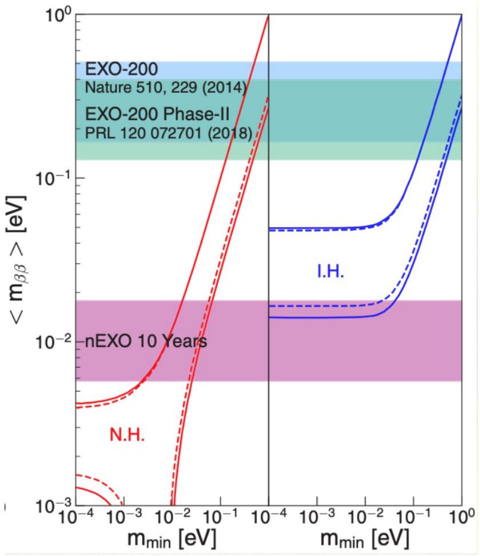
Neutrinoless Double-Beta Decay

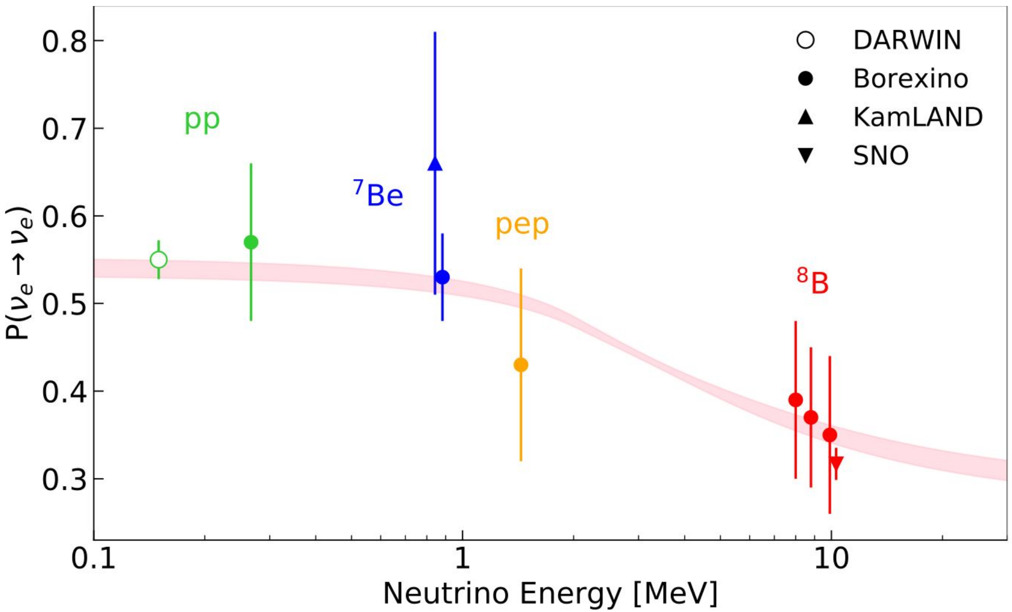
^{136}Xe ~ 9% abundance

- No isotopic separation required
- Reach across Inverted Hierarchy
- Additional isotopes offer signals
- Sensitivity vs. exposure by Ibles
- 100 T would have sensitivity ~ nEXO
- Additional challenges to operation from ev to MeV detector energy range





Solar Neutrinos



Measurement of pp neutrinos below 420 keV

Refine MSW osc.

From 2006.03411 (Darwin)

LZ-Darwin Efforts and Collaboration

Recently LZ has engaged the Darwin Collaboration to form new, combined effort (LBL and SLAC have seats, election completed of “LZ” membership

Interest in exploring larger Fiducial Mass O(100 T)

Notional - 3.5m diameter 3.5m tall right cylinder of LXe (~ 4.5 x 6m cryostat)

Add 3m water shield and PMT array (10.5m diameter x 12m tall) water tank and Outer Veto

Possible sites:

Boulby 2800 mwe: 16 to 20 m custom cavities discussed, Cosmic Ray veto needed, low Rn, potash mine

Gran Sasso 3100 mwe: 20w x 18m tall x 100m long ∴ 20 to 40T discussed by Darwin, Cosmic Ray veto required and a challenge

SURF 4200 mwe (see next)

Jinping 6700 mwe (14 x 14 x 130 m halls) (included for completeness)

DUNE cavities

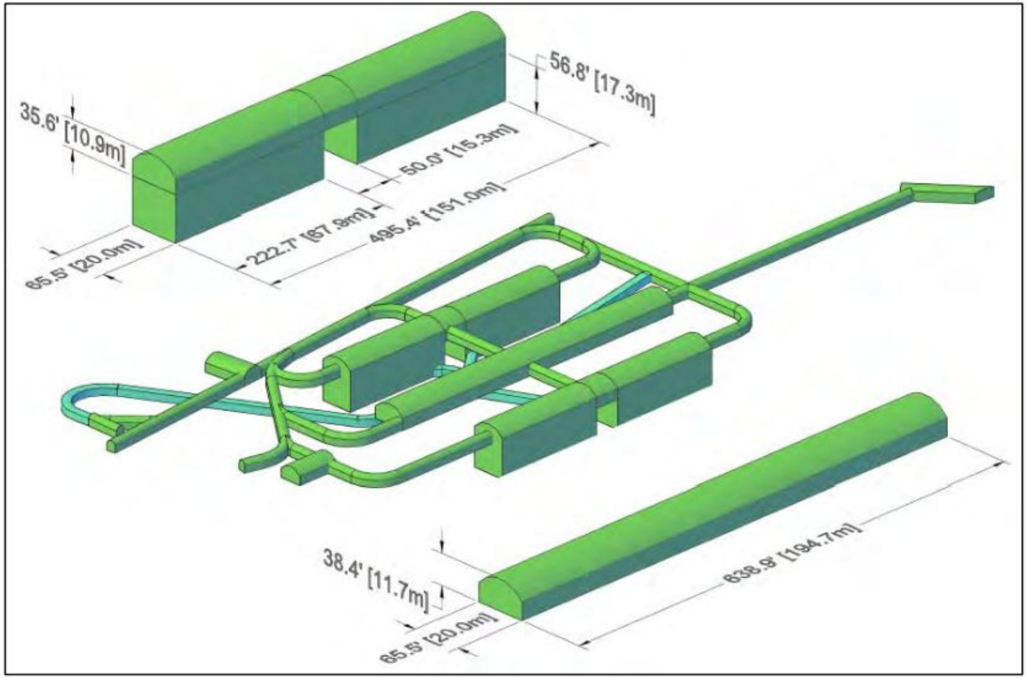
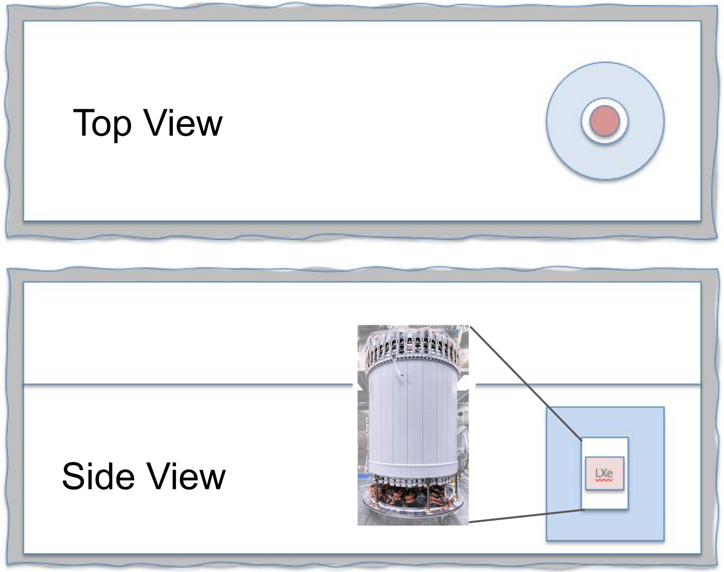


Figure 3r12: Dimensions of the main LBNF cavern excavations (final dimensions will be slightly smaller). (Sanford Lab)

20m wide 67m long (17+11)m tall



Other considerations

Waste heat

Access

U/G construction

  Cleanrooms

  Radon-reduced air

The neighbours

Emergency power

ODH

Electronics space

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Cost of Xenon and world production capacity

In general, G3-LXe is a smaller consumer of resources than the proposed 20kt DUNE modules. Co-existing with LBNE will require careful coordination. Obtaining permission will require substantial discussion with DOE, DUNE, STFC, CERN, … will likely be the larger hurdle.

LZ-Darwin SNOWMASS efforts

Developing a white-paper

Formed international proto-collaboration formed from LZ, Darwin, XenonNT membership

R&D efforts underway in the UK and Europe, starting in the US