Dark Matter Options for DUNE's Cavity of Opportunity

Kevin Lesko

(not polished collection of opportunities and requirements)

Future of Direct Detection of Dark Matter

Impressive progress in pursuing WIMPS over the past 35 years.

L. Baudis / Dark Universe 1 (2012) 94–108 105

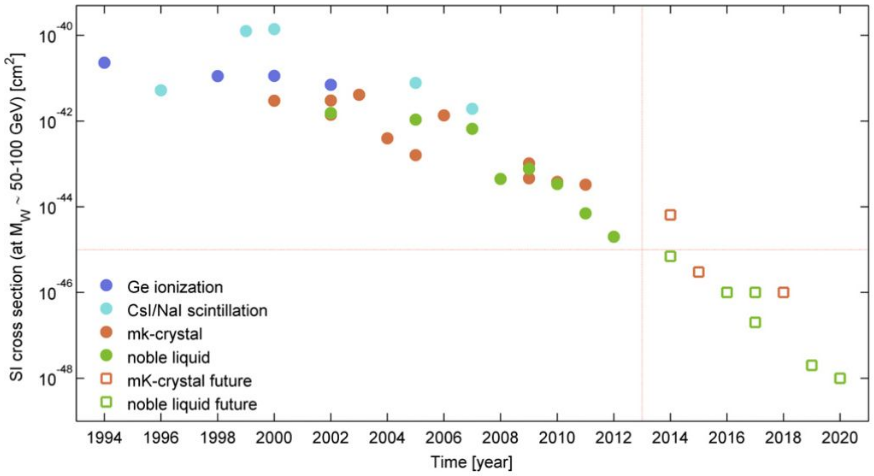


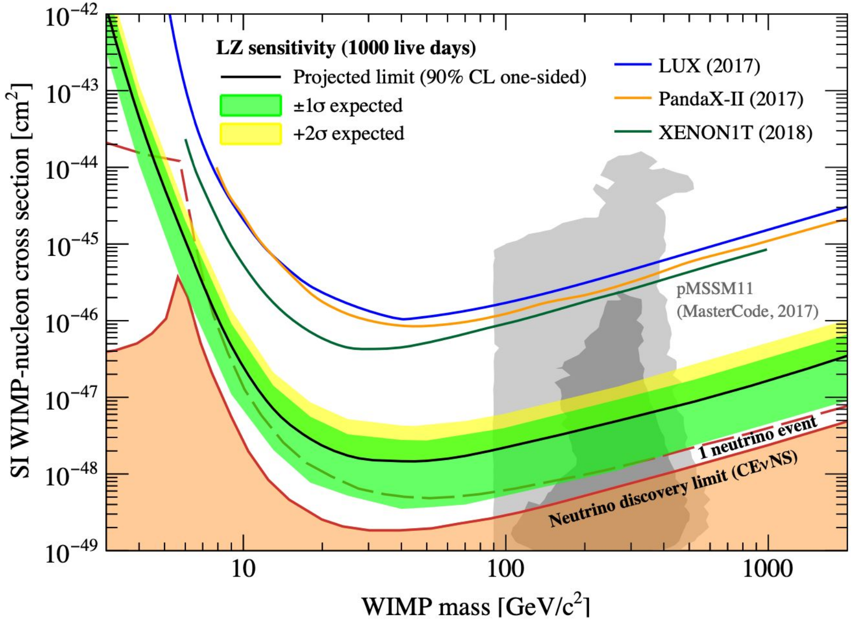
Fig. 2. Existing upper limits on spin-independent WIMP-nucleon cross sections (for WIMP masses around 50–100 GeV) from various direct detection techniques (filled circles), along with projections for the future (open squares), as a function time. Part of the data was retrieved from dmtools [85].

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

Physics of a ~ 100T Xenon Observatory



Dark Matter

- WIMP
- Low Mass Sensitivity
- Other DM models

Neutrinoless Double-Beta Decay

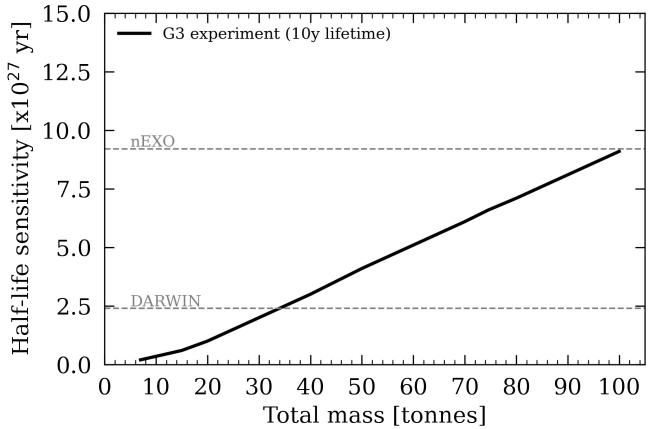
Astronomical Neutrinos

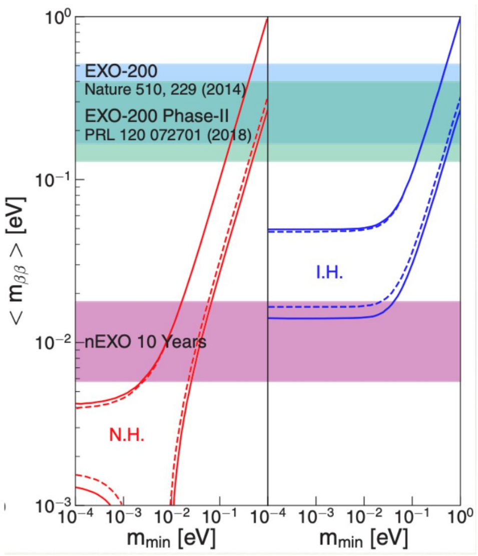
- Solar
- Atmospheric
- Supernovae

Neutrinoless Double-Beta Decay

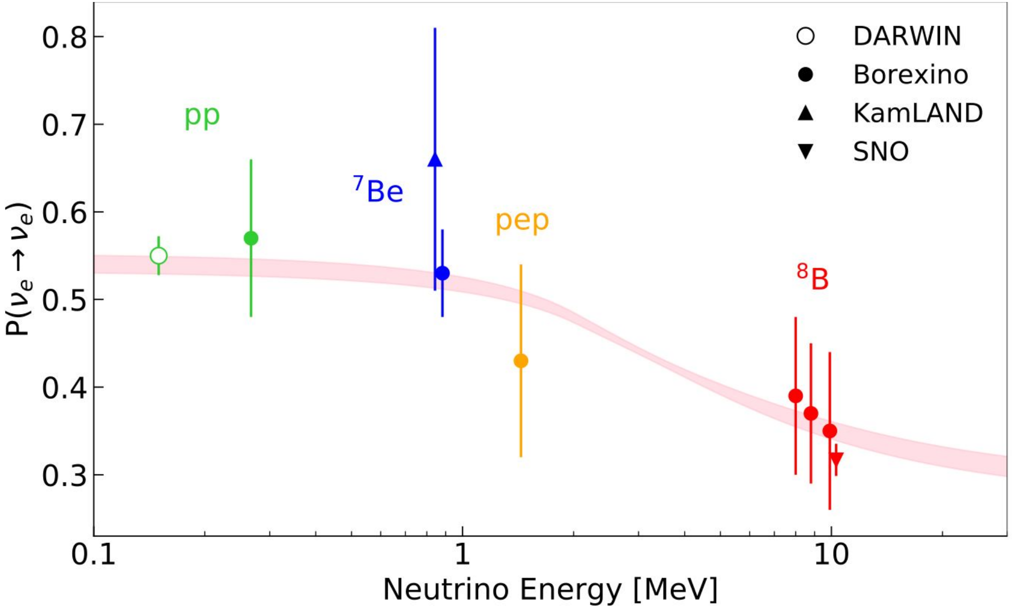
^{136}Xe ~ 9% abundance

- Reach across Inverted Hierarchy
- Additional isotopes offer signals
- 100 T ^{nat}Xe offers ~ same reach as nEXO





Solar Neutrinos



Measurement of pp neutrinos below 420 keV

From 2006.03411 (Darwin)

LZ-Darwin Efforts

Recently LZ has engaged the Darwin Collaboration to form new, combined effort

Interest in exploring larger Fiducial Mass O(100 t)

- 3.5m tall 3.5m diameter right cylinder of LXe (~ 4.5 x 6m cryostat)
- 3m water shield and PMT array (10.5m tall x 12m diameter) water tank

Possible sites

- Boulby 2800 mwe (16 to 20 m cavities discussed)
- Gran Sasso 3100 mwe (20w x 18m tall x 100m long)
- SURF 4200 mwe (see next)
- Jinping 6700 mwe (14 x 14 x 130 m halls) (for completeness)

DUNE cavities

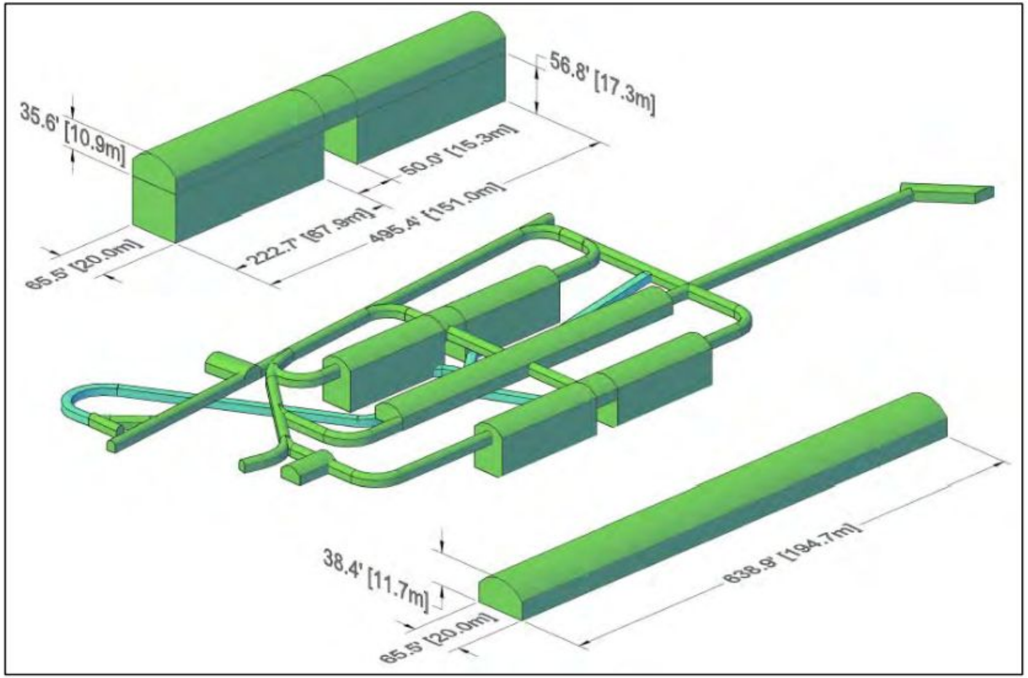
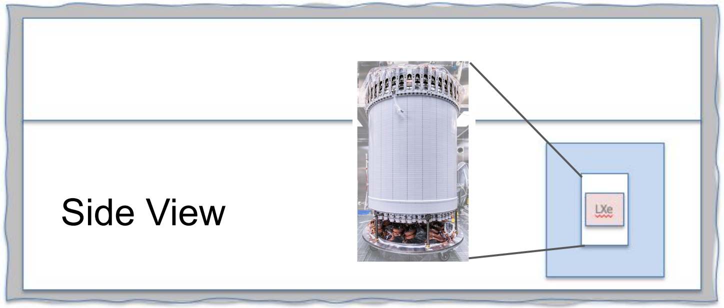


Figure 3r12: Dimensions of the main LBNE cavern excavations (final dimensions will be slightly smaller). (Sanford Lab)

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



Other considerations

Waste heat

Access

U/G construction

- Cleanrooms
- Radon-reduced air

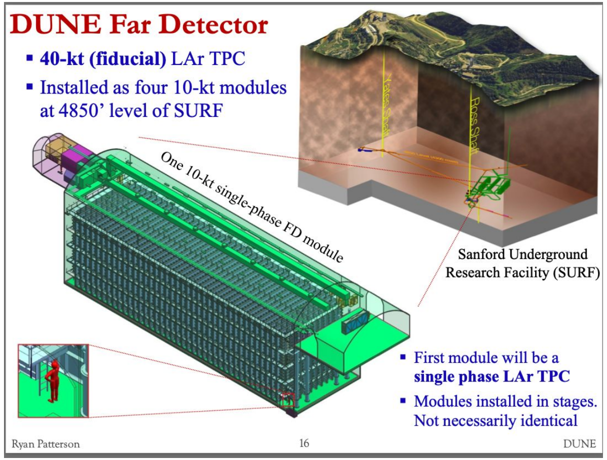
The neighbours

Emergency power

ODH

Electronics space

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.



Schedule

Excavations complete by 2024 - *Chris Mossey presentation to HEPAP Nov 2021*

Then cavity outfitting

Then experimental infrastructure

Experiment installation 2025 of modules 1 and (then?) 2

Astrophysics w/ these beginning ~2029

Beam physics beginning ~2031

LBNF community interactions

Nov 2019 limited participation workshop convened by LBNF

DM Discussion mostly focused on LAr

SNOWMASS engagement

SNOWMASS offers an opportunity to to widen the discussion to additional experiments for ‘temporary occupation’ of unused excavations

DUNE experiment → landlord model

Timelines need to be examined, and additional support/resources issues.

Underground Facilities Frontier may turnout to be *interesting* after all.