

The background of the slide is a deep purple and blue image showing the cosmic web, with intricate filaments and clusters of light representing galaxy distributions in the universe.

# LZ: A Second Generation Experiment for the Direct Detection of Dark Matter

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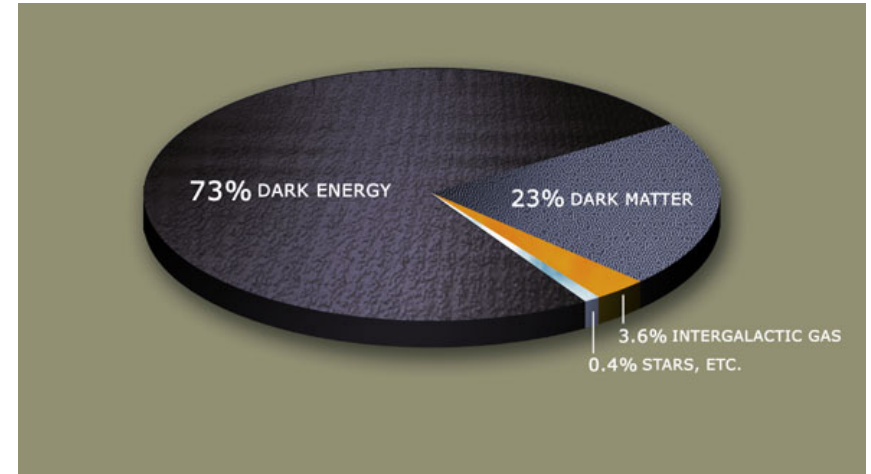
ICPPA  
Moscow  
October 3, 2017



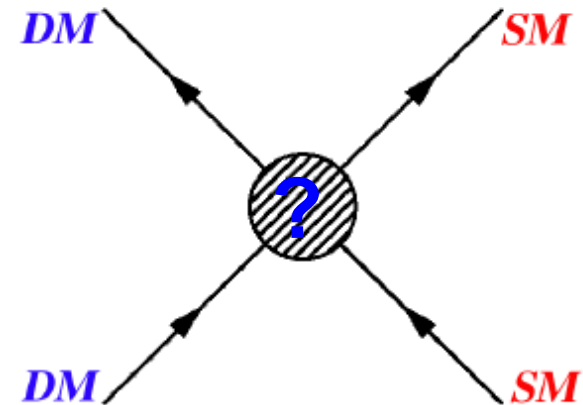
# The Dark Matter Problem

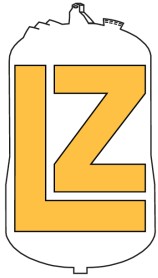
A good problem to have. There is a **known** effect looking for an answer ... as opposed to **proposed** models looking for an experimental effect.

A real challenge/opportunity for experimentalists to study this known energy density.



- **Postulate 1:** DM is a particle.
- **Postulate 2:** DM and SM particles interact with some force that is very weak but much stronger than gravity.





# Direct Detection of DM

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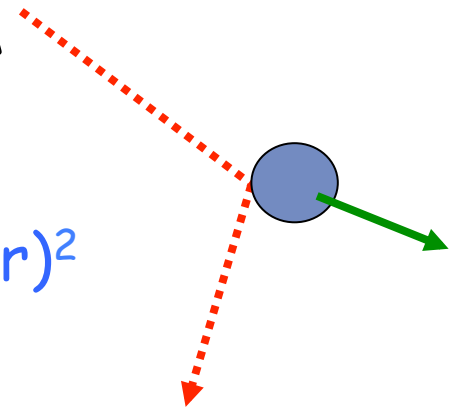
Basic goal: search for nuclear recoil from DM elastic scattering.

Simple dynamics. Cross section  $\propto (\text{form factor})^2$

Spin-independent: Nucleon form factor gives rise to  $A^2$  enhancement due to coherence. The dependence on  $q^2$  is also contained in the form-factors.

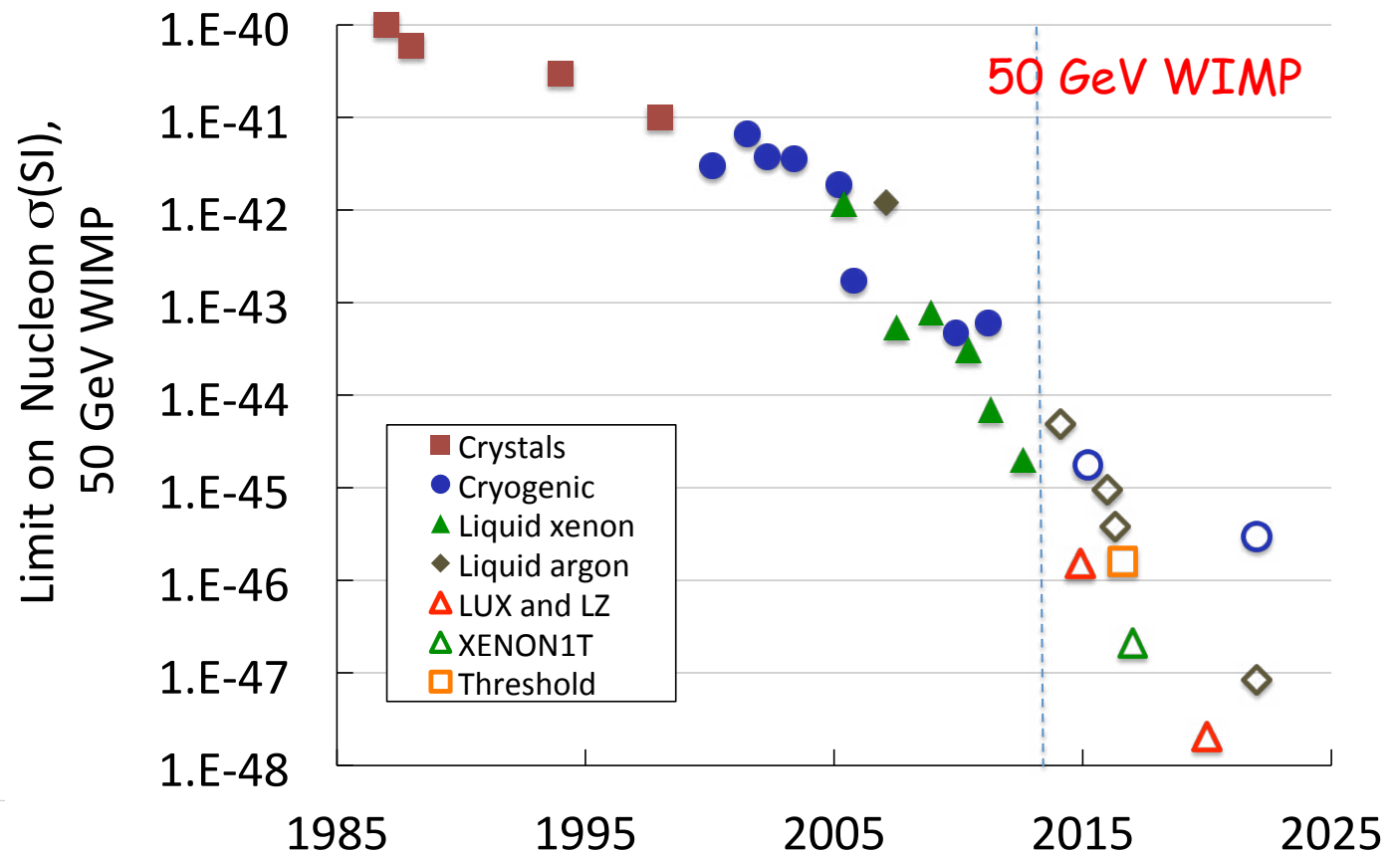
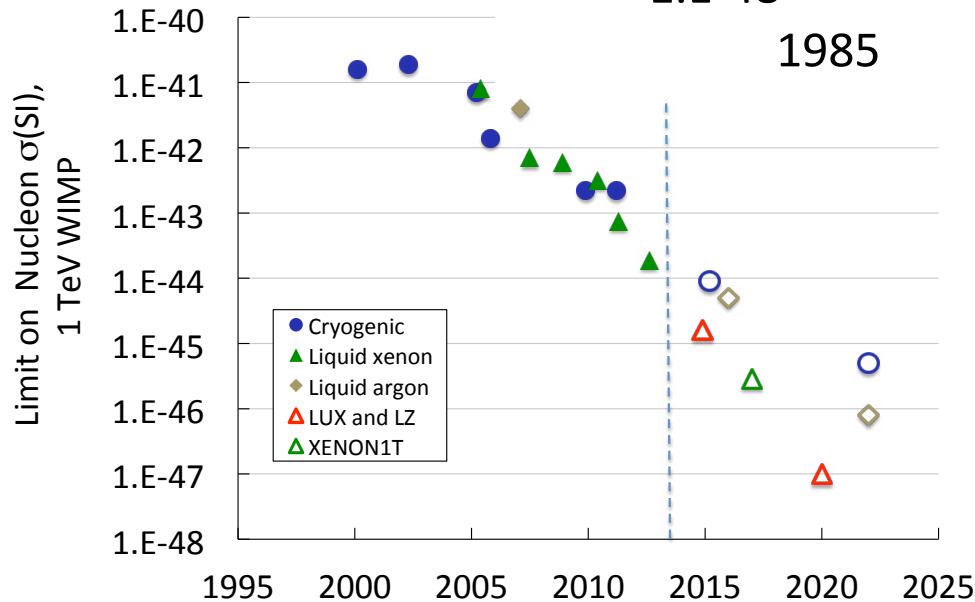
WIMPs are the leading candidates for GeV-scale mass.

Spin-dependent: Form factor depends on nuclear spin. No coherence enhancement.



# A compact history of WIMP Searches

1 TeV WIMP

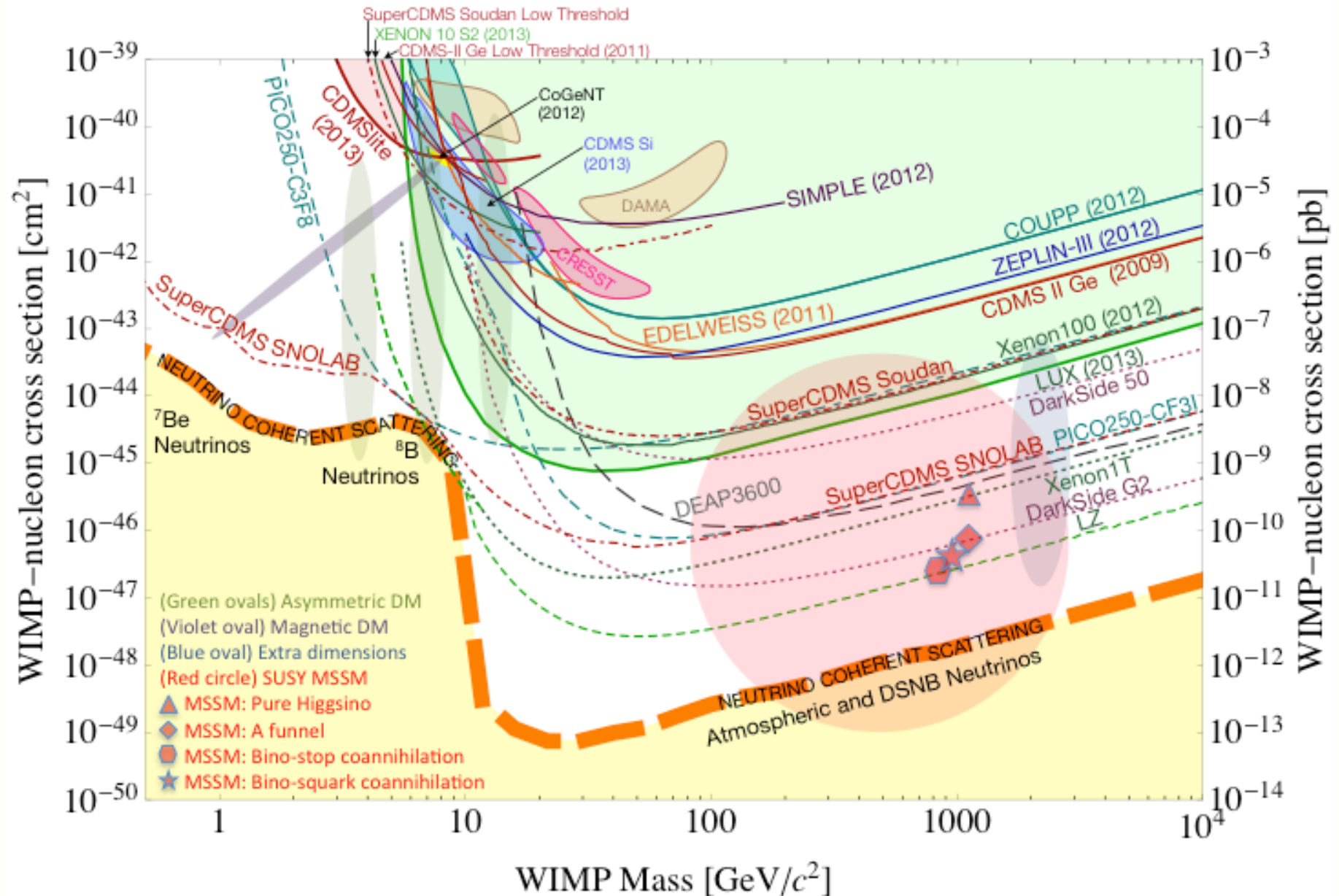


LZ is poised to possibly provide an end-point to this saga ... hopefully by discovering WIMPs or, by ruling out most of the theoretical and experimentally accessible landscape.

Plots compiled by Mike Witherell, UCSB



# A Compilation of Limits and Reaches





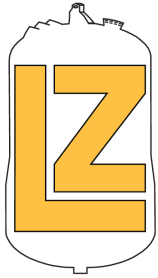
# LZ Collaboration

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38 institutions from US, UK, Portugal, Russia and South Korea.  
Still growing. At present >250 members.







# Two-phase TPC Technique

Excellent introduction yesterday  
by Alex Bolozdynya

- 5.6 ton total fiducial mass nominally
- Turn-on in 2020, with 1,000 live-days of running.
- 6 keVnr threshold with >99.5% discrimination
- Spin-independent WIMP search sensitivity goal of  $\leq 2.3 \times 10^{-48} \text{ cm}^2$  interaction cross-section for a WIMP mass of 40 GeV

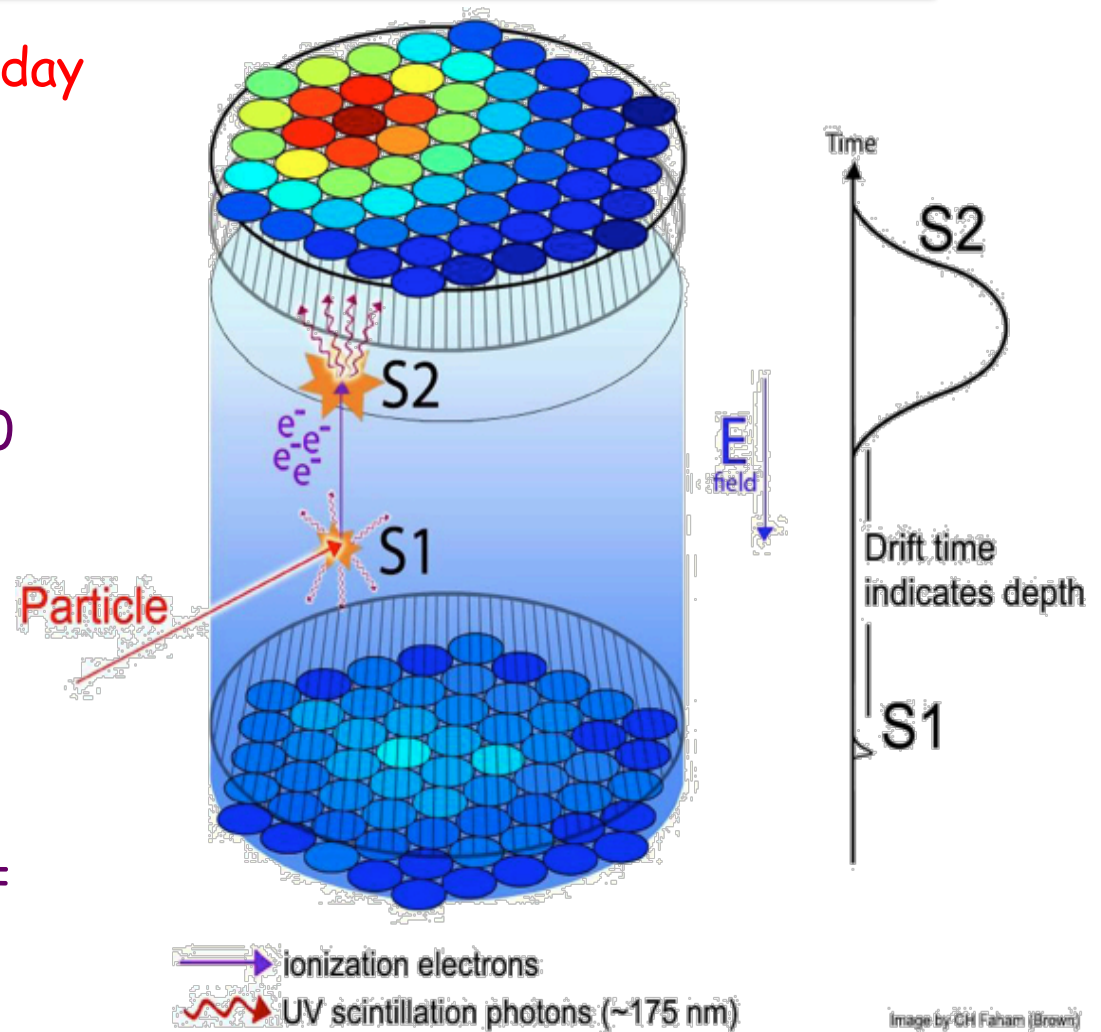


Image by GH Faham (Brown)



# Scale Up ~50x in Fiducial Mass

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LZ

Total mass - 10 T

Active Mass - 7 T

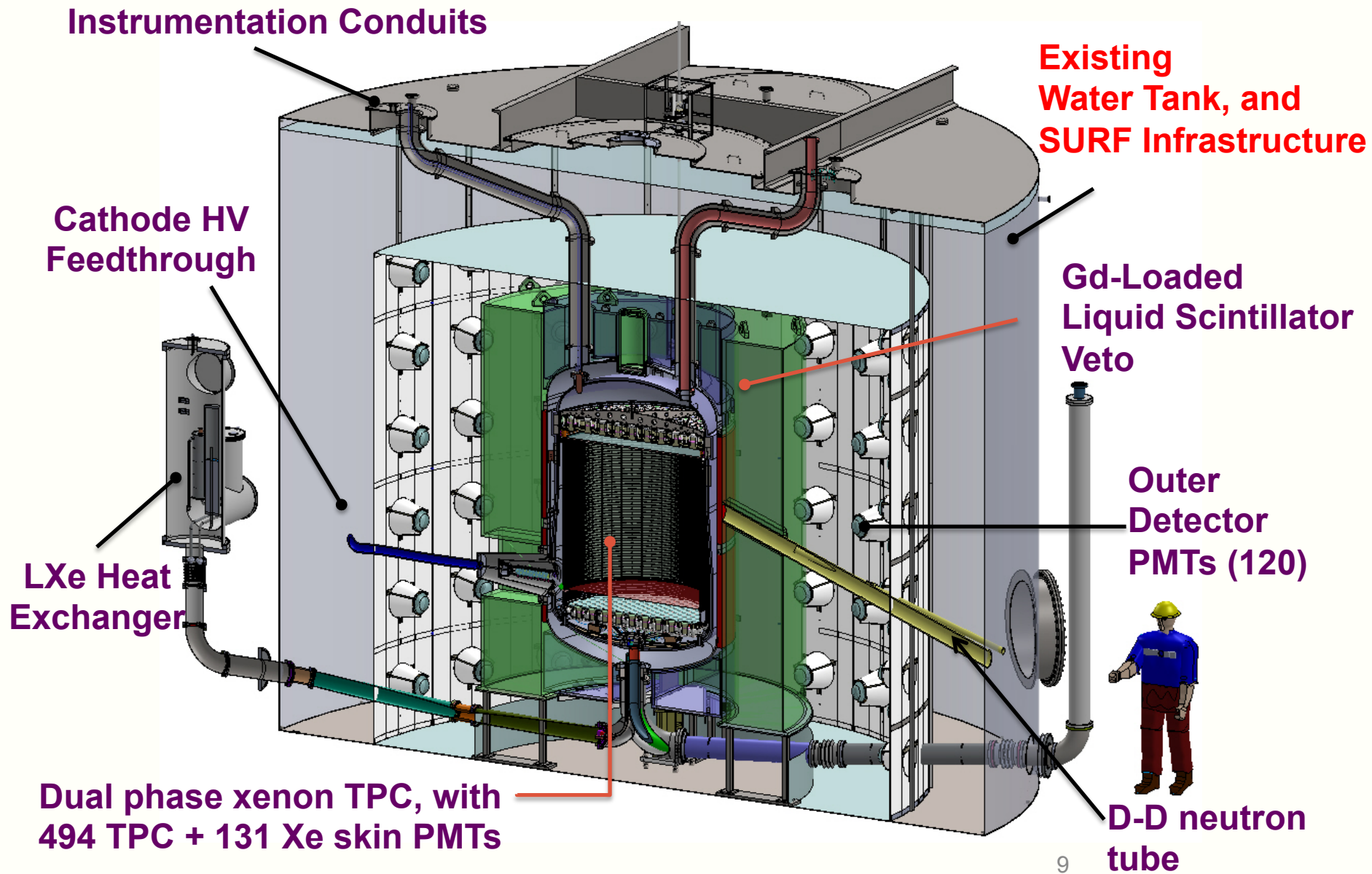
Fiducial Mass - 5.6 T



LUX



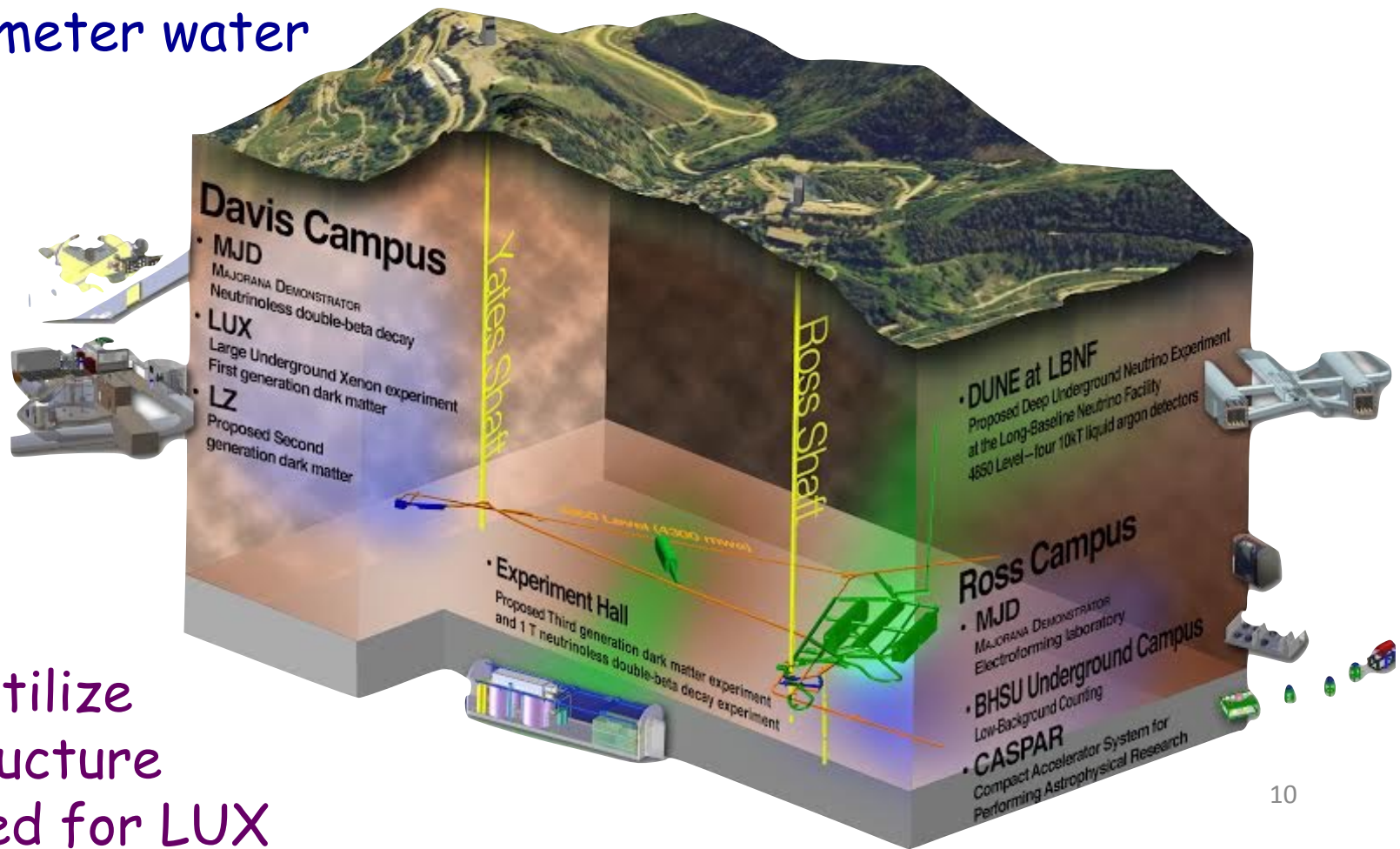
# Doubly Shielded TPC



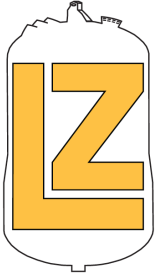


# Sanford Underground Research Facility

LUX was operated ~1.5 km underground in the Davis cavern.  
~ $10^{-7}$  reduction in muon flux.  
~6m diameter water shield.

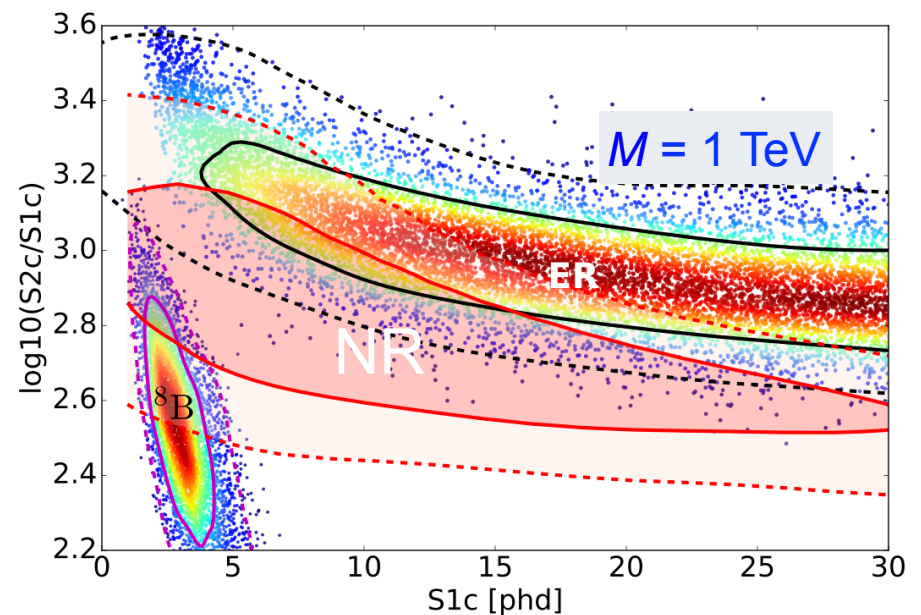
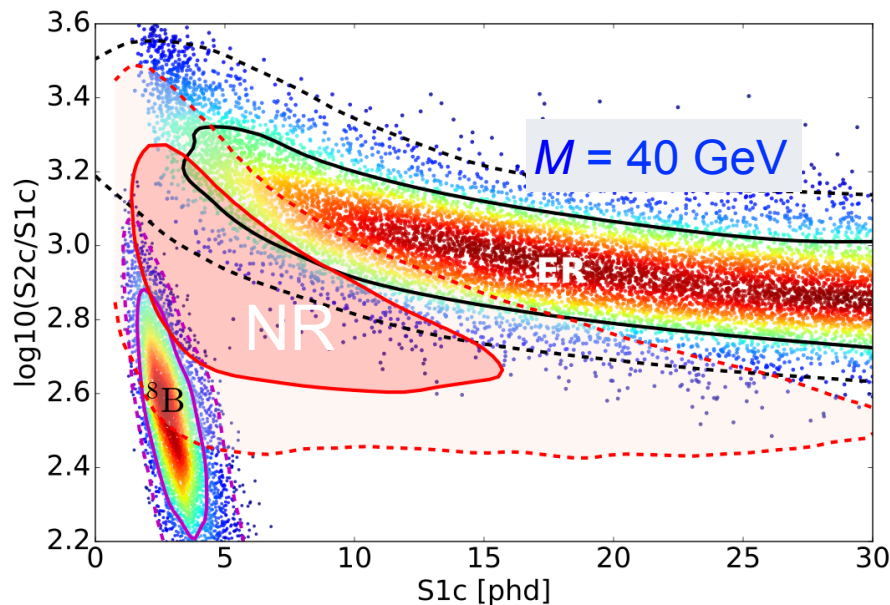


LZ will utilize infrastructure developed for LUX



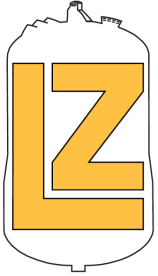
# Expected WIMP Footprints

- WIMPs detected via nuclear recoils (NR). Majority of BG is from electronic recoils (ER).
- Shape of observed spectrum gives info on WIMP mass.
- Low mass sensitivity affected by NR from  $^8\text{B}$  solar neutrinos ( $7 \pm 3$  events in 1000d).

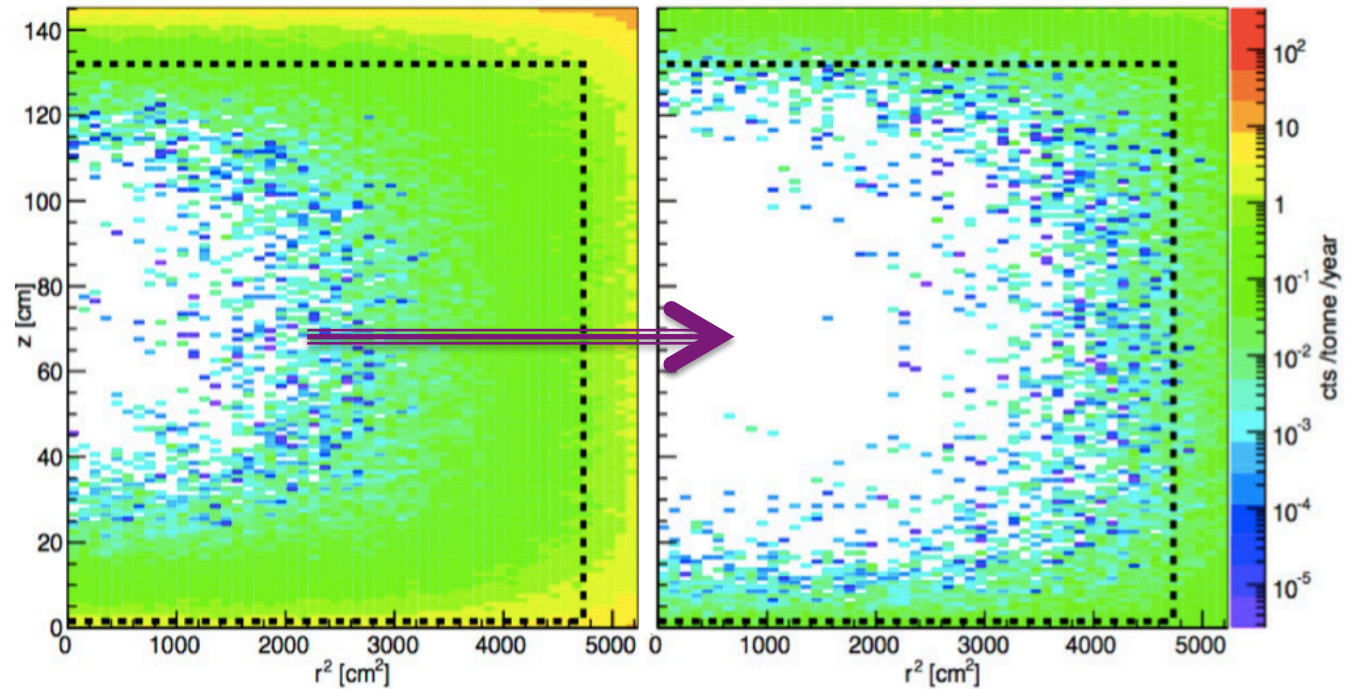
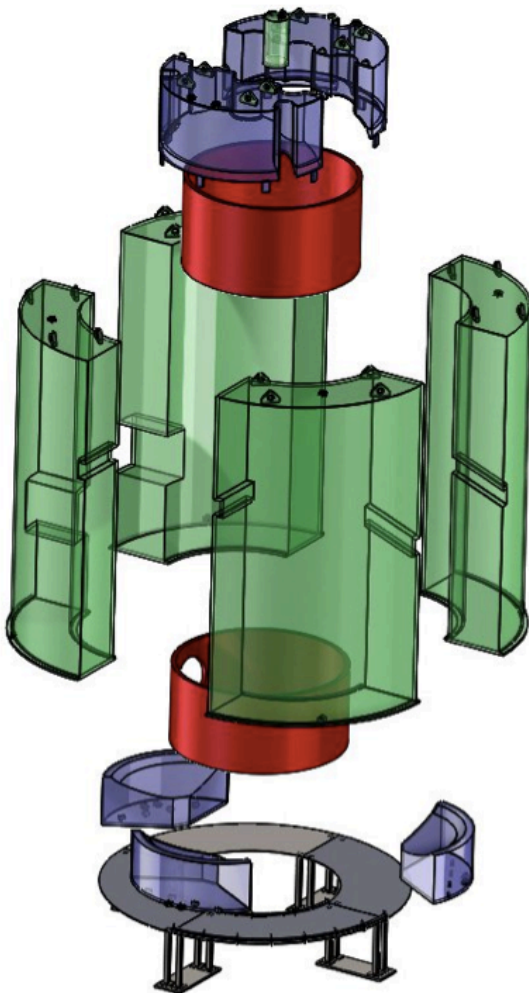


ER and CNS spectra have been highly exaggerated to show shapes.





# Background Rejection



Three layers of defense against BG

1. instrumented xenon "skin" layer
2. 61-cm thick Gd-loaded scintillator
3. water shield, an active muon veto





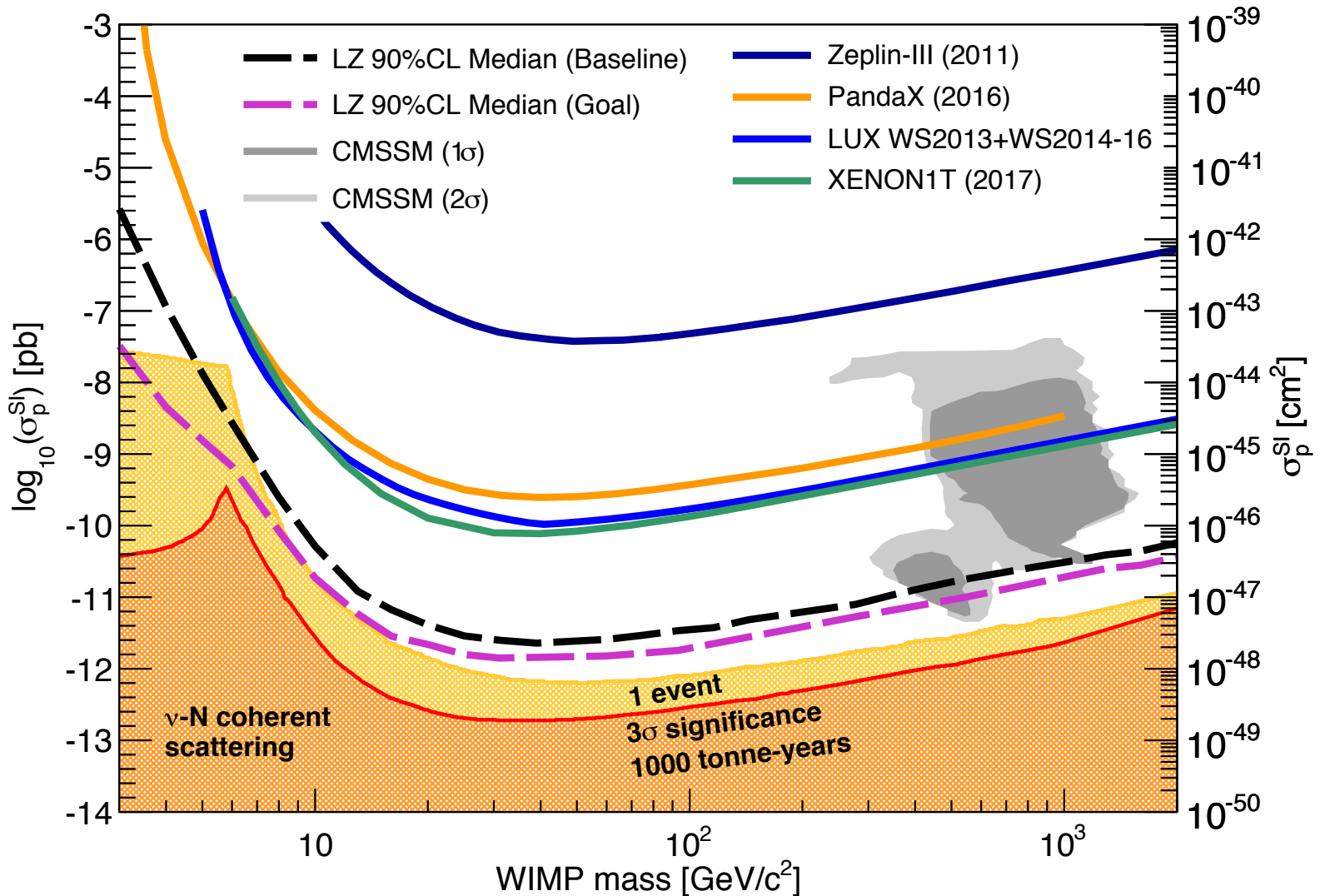
# Sources of Background

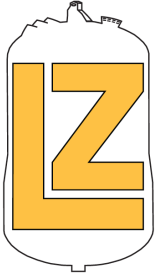
Item	ER cts	NR cts
Detector Components	6.2	0.07
Dispersed radionuclides (Rn, Kr, Ar)	911	-
Laboratory and cosmogenic	4.3	0.06
Fixed surface contamination	0.19	0.37
$^{136}\text{Xe } 2\nu\beta\beta$	67	-
Neutrinos ( $\nu$ -e, $\nu$ -A)	255	0.72
Total	1244	1.22
Total (with 99.5% ER discrimination, 50% NR efficiency)	6.22	0.61
Total ER+NR background events	6.83	

Estimates for 5.6M kg-days and energy ranges: 1.5-6.5 keV<sub>ee</sub>/6-30 keV<sub>nr</sub>



# Sensitivity Projection





# Summary

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- ★ LZ has been fully approved by funding agencies and is in the process of construction.
- ★ There are no major technical risks at this point.
- ★ Expected completion by early 2020.
- ★ Data taking in late 2020.
- ★ Stay tuned.