

Status of the LZ Project

Hugh Lippincott

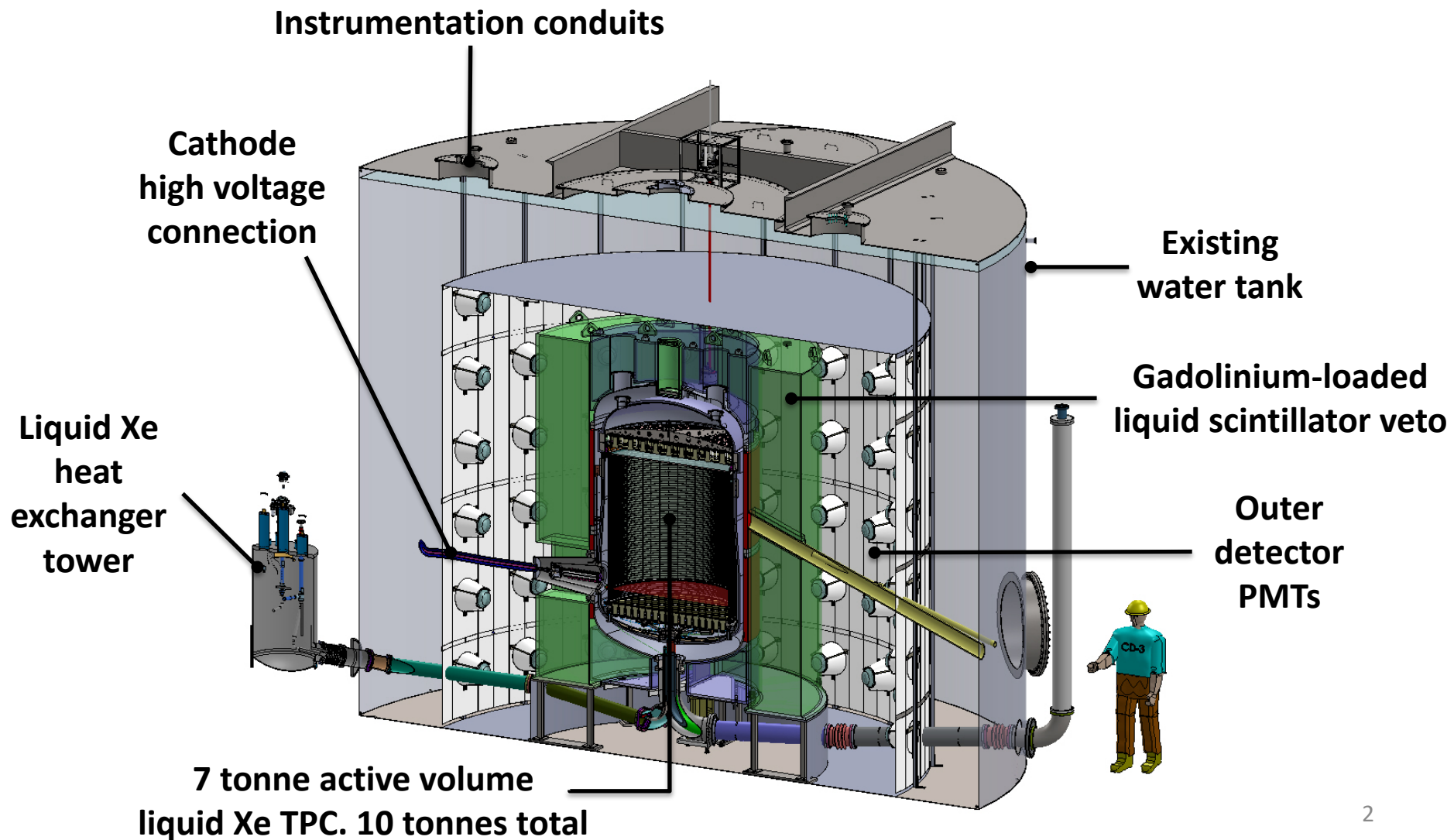
Fermilab

February 23, 2018

UCLA Dark Matter 2018



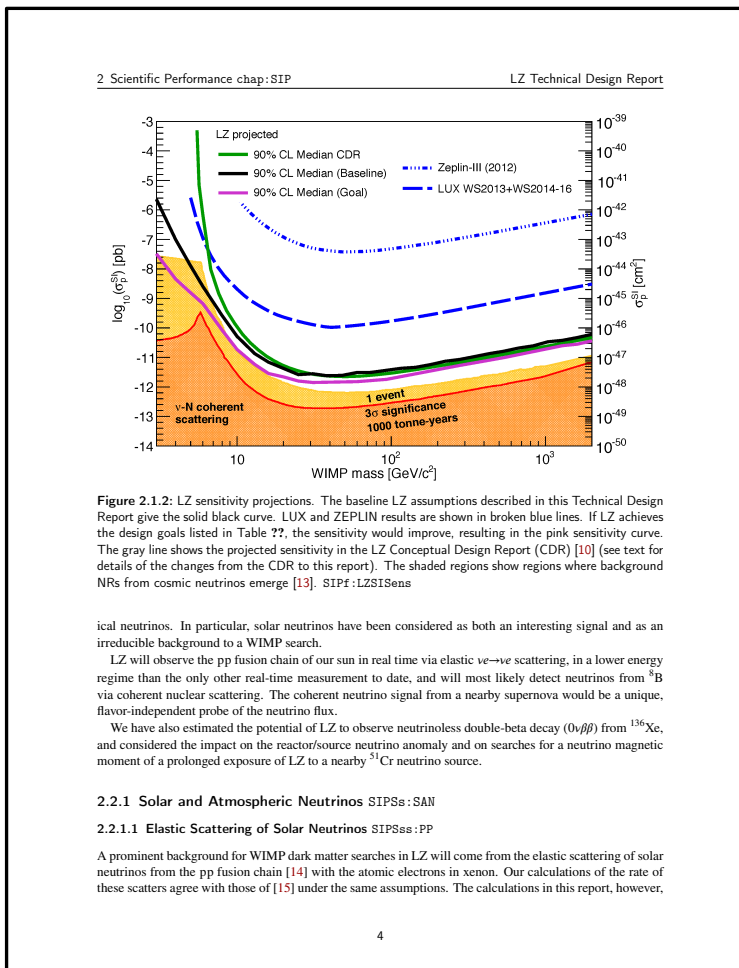
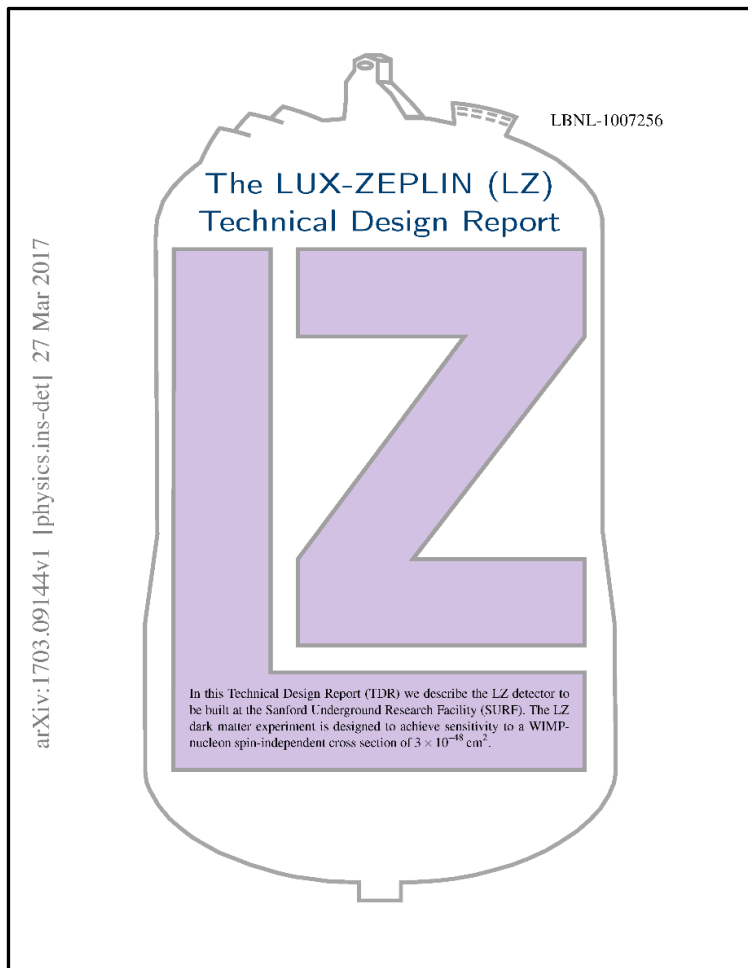
LZ Detector Overview





LZ Technical Design Report

arXiv:1703.09144, March 27, 2017



LZ: 256 authors, 36 institutions (25 US), 396 pages.



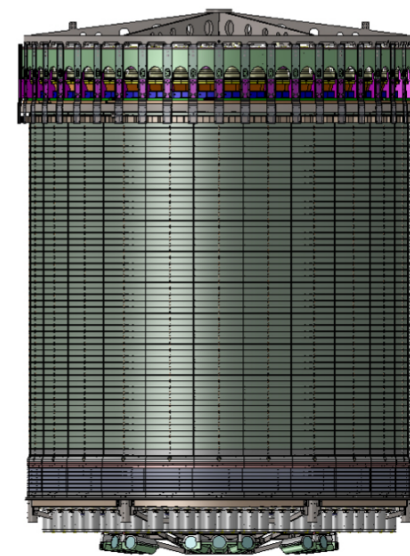
Schedule

- CD1 Review – March 2015
- CD2 Review – April 2016
- CD3 Review – February 2017 - construction can start in earnest
- Cryostat fabrication just completed
- PMT array assembly begins in March
- Xenon handling installation and commissioning starts Fall 2018
- TPC installation Spring-Summer 2019
- Cooldown starts Winter 2019
- First physics data – Spring 2020



Design notes

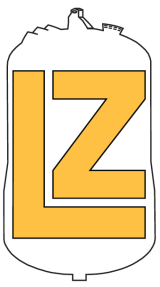
- Lots of mass – 7 tonnes in TPC, 5.6 tonnes fiducial
 - 494 3" PMTs in TPC
 - 58 drift field sections covered by PTFE segments
- 50 kV cathode HV
 - Significant R&D and prototyping at SLAC
- 2-component veto system
 - LXe skin – 93 1" PMTs, 38 2" PMTs
 - Outer detector – 120 8" PMTs (see S. Shaw, next)
- Gas circulation/purification system
 - 500 slpm, turns over inner volume every ~2.5 days
- Calibrations
 - Extensive internal and external sources, including DD generator and photoneutron sources





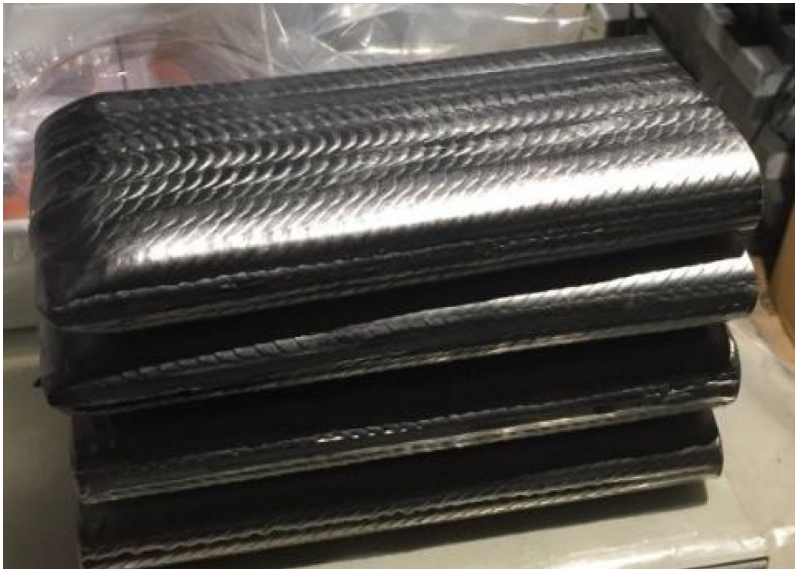
Radiopurity

- Nothing goes into the detector without being screened
 - ~2000 planned assays, roughly 50% complete
 - 13 HPGe detectors, Neutron Activation Analysis, GDMS, two ICPMS setups, four radon emanation chambers, two XIA alpha counters, etc.
 - Extensive searches for low radioactivity components
 - Titanium for cryostat and other internal structures
 - “Identification of Radiopure Titanium for the LZ Dark Matter Experiment and Future Rare Event Searches”, arXiv:1702.02646, Astroparticle Physics 96 (2017) 1–10
 - All PMT materials screened before fabrication by Hamamatsu, finished PMTs assays 95% complete
 - All PMT base components and completed bases (100%)
 - PTFE source material (in fabrication now)
 - Bolts, nuts, peek fasteners, cable ties, cables, instrumentation, etc., etc., etc.
 - Internal detector components contribute less than 10 total events before discrimination! (See J. Dobson on sensitivity)



Radiopurity

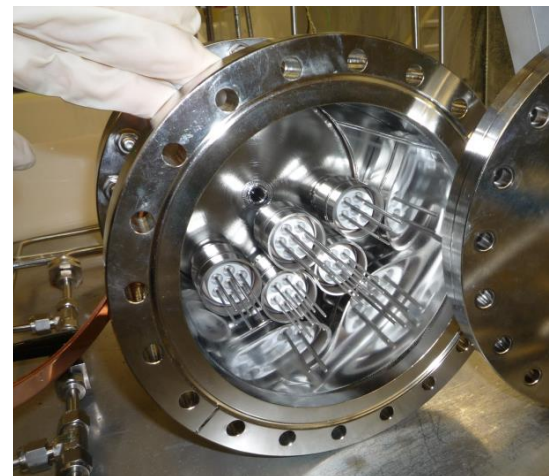
- Backed up by extensive quality control
 - E.g. Cryostat fabrication – weld coupons made early on were hotter than stock Ti
 - Fabrication stopped, massive screening investigation launched
 - Wrong welding tips were being used - color code on one provided by a supplier was missing, and trace Th was being introduced into the welds
 - Caught in time, fabrication restarted

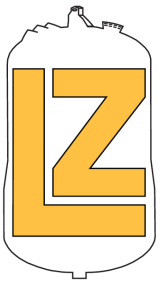




Radon and Dust

- Radon (naked Pb beta decay) is biggest expected background (see J. Dobson)
- Extensive radon assay campaign underway
 - Cables, getter, heat exchanger
 - Some credit taken for cold components
- Radon mitigation system for portion of warm plumbing
- Dust another large component
 - 500 ng/cm² of dust allowed
- All parts fabricated in well-understood clean rooms with witness plates and travelers to ensure quality control
- Commercial vendor cleaning most TPC parts



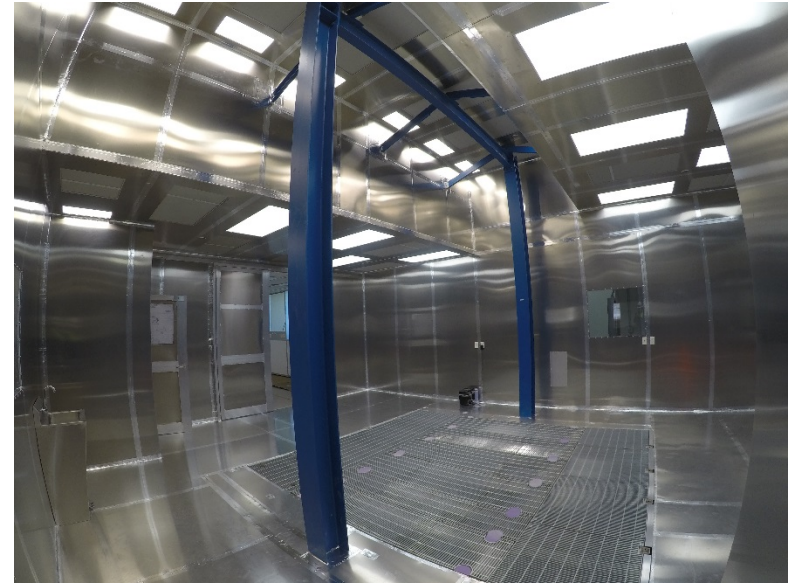


LZ Project

- Ready for the picture round

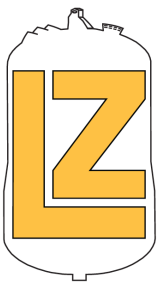


On Site Facilities



- Low radon, class 100-1000 cleanroom ready at SURF for first parts
- Radon reduction system installed
- Underground improvements started, to finish by May

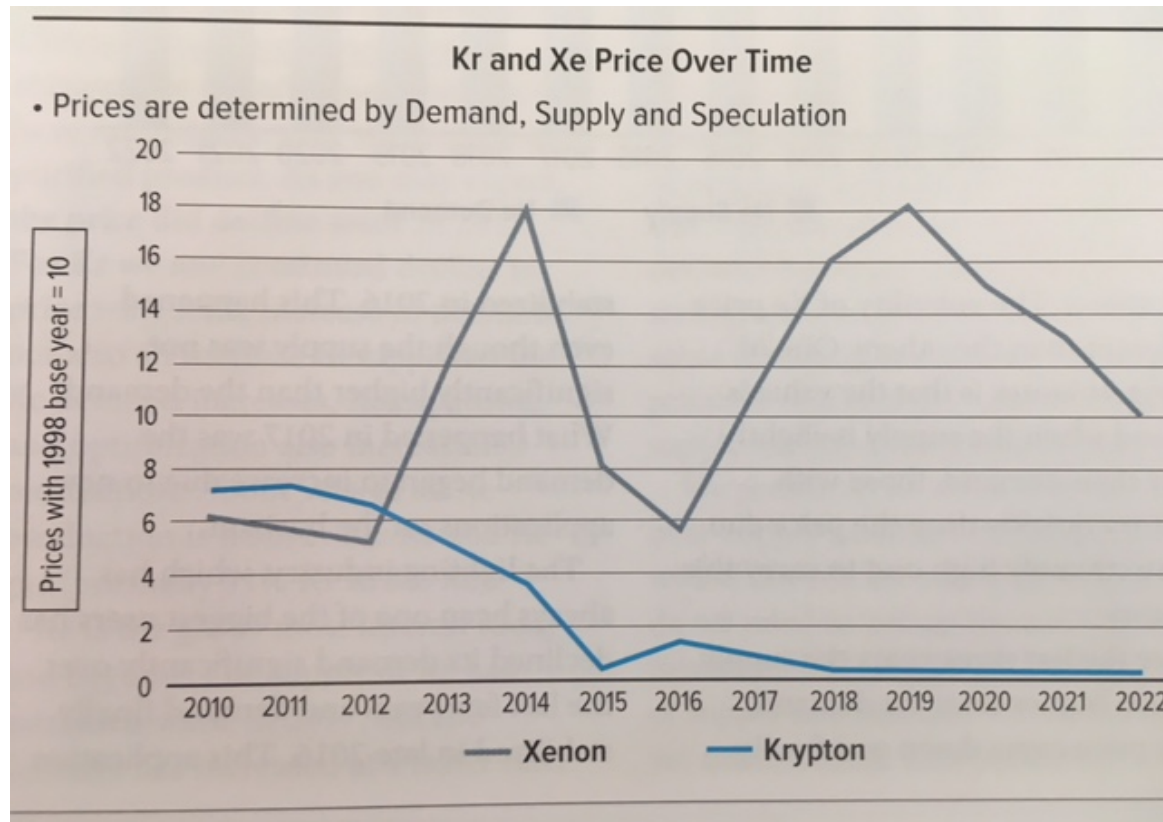




Xenon

- 10.7 tonnes xenon under contract (most in 2016)
- 6.5 tonnes in hand, with final delivery middle of 2019

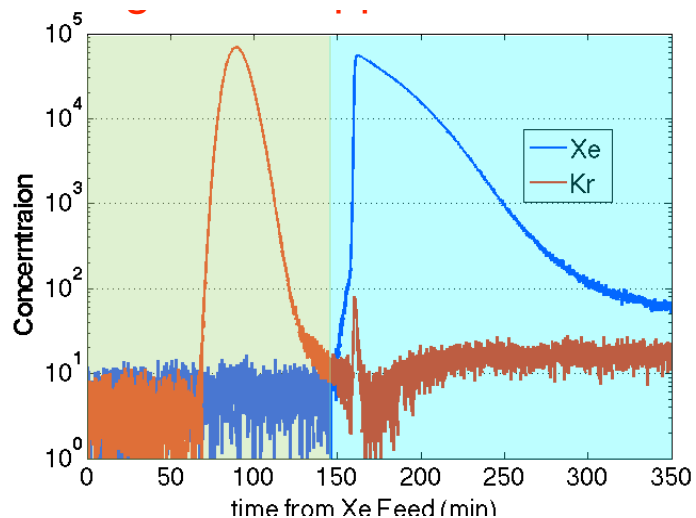
Approximately \$/gas liter



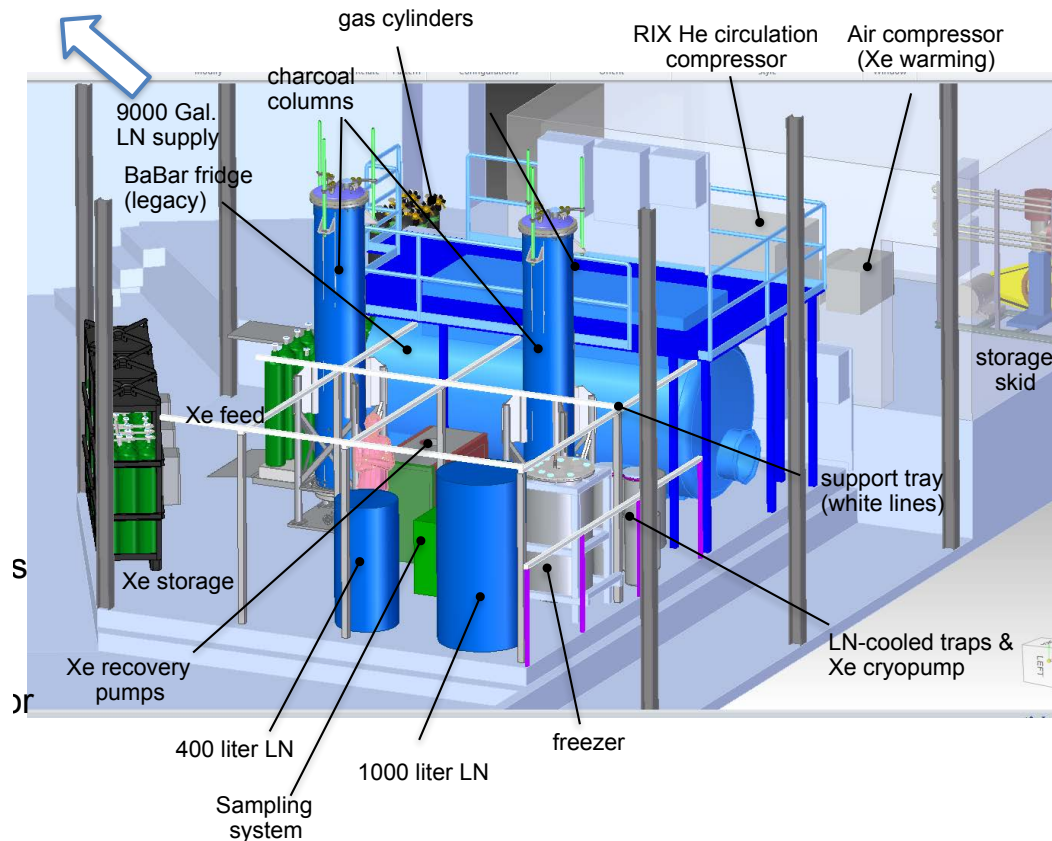


Xenon and Krypton

- Chromatography to separate krypton (and ^{85}Kr) from xenon
- Demonstration of 0.075 ppt in R&D at SLAC
- Production system designed to remove to 0.015 ppt (subdominant by $>10x$ to radon)



- On track for production second half of 2019





Xenon Circulation

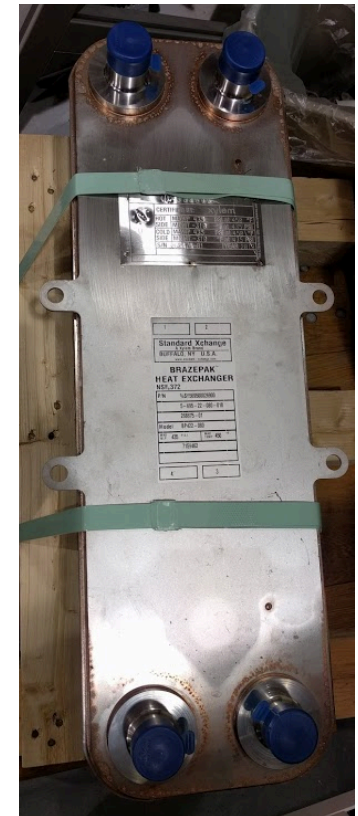
- Full circulation test planned underground starting end of 2018
- Commission all parts of circulation system with a dummy cryostat



Circulation Compressors under construction (2 of 4)



Xenon storage pack (1 of 12)



Heat exchanger



Cryostat

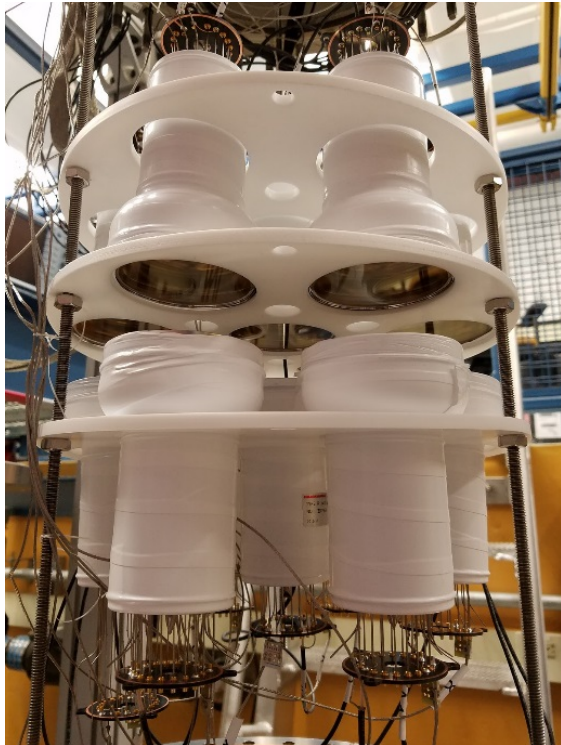
- Fabrication complete at Loterios in Italy - about to ship to US



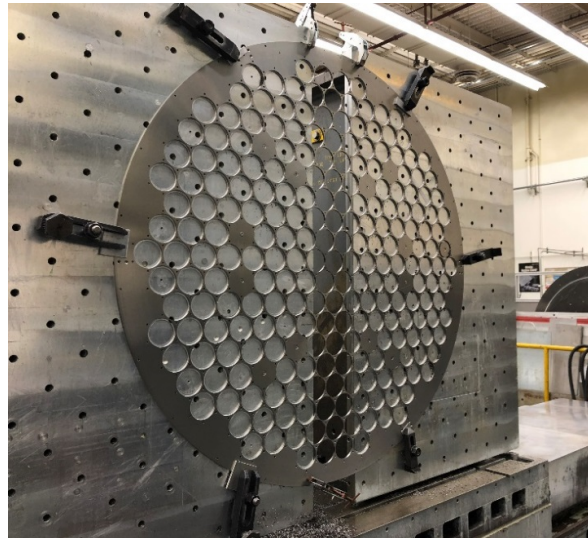


PMTs

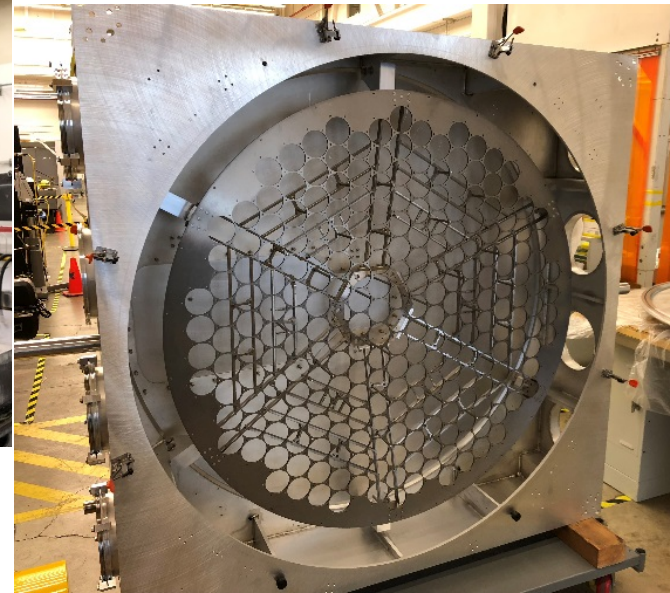
- 3" PMT delivery complete except for small number of replacements (96% yield)
- Main array assembly construction launching at Brown in March, practice assembly now underway



All PMTs cold tested at Brown



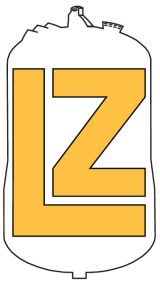
Titanium array plate machining



PALACE shipping frame



Base burn in at Imperial



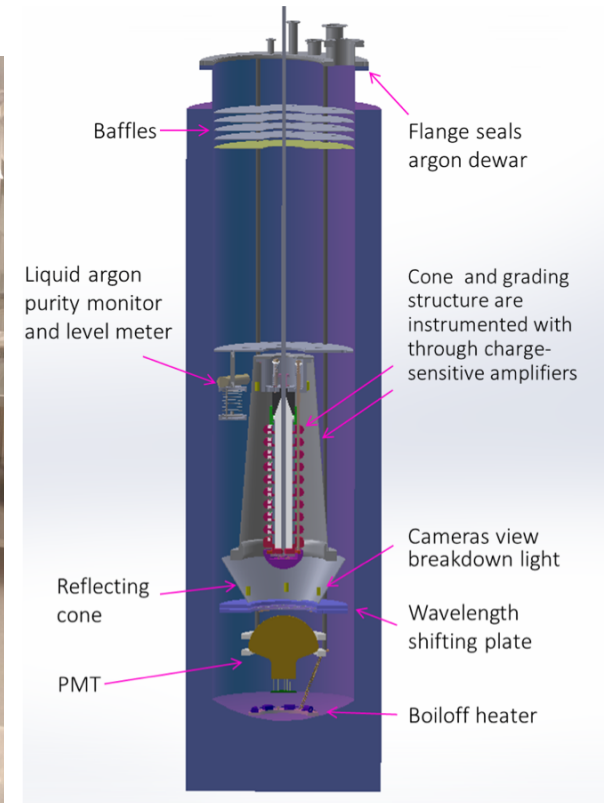
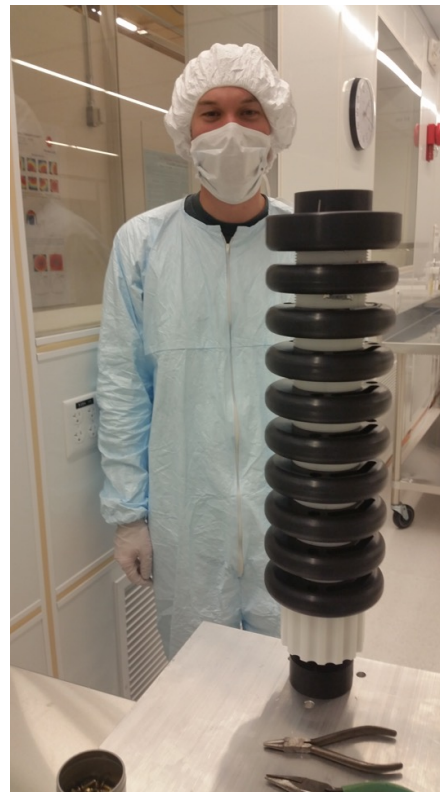
HV Delivery

- Main cable tested to 120 kV
- Full cathode testing happening now in LAr



Liquid argon testing at LBNL

Test Structure Under Assembly

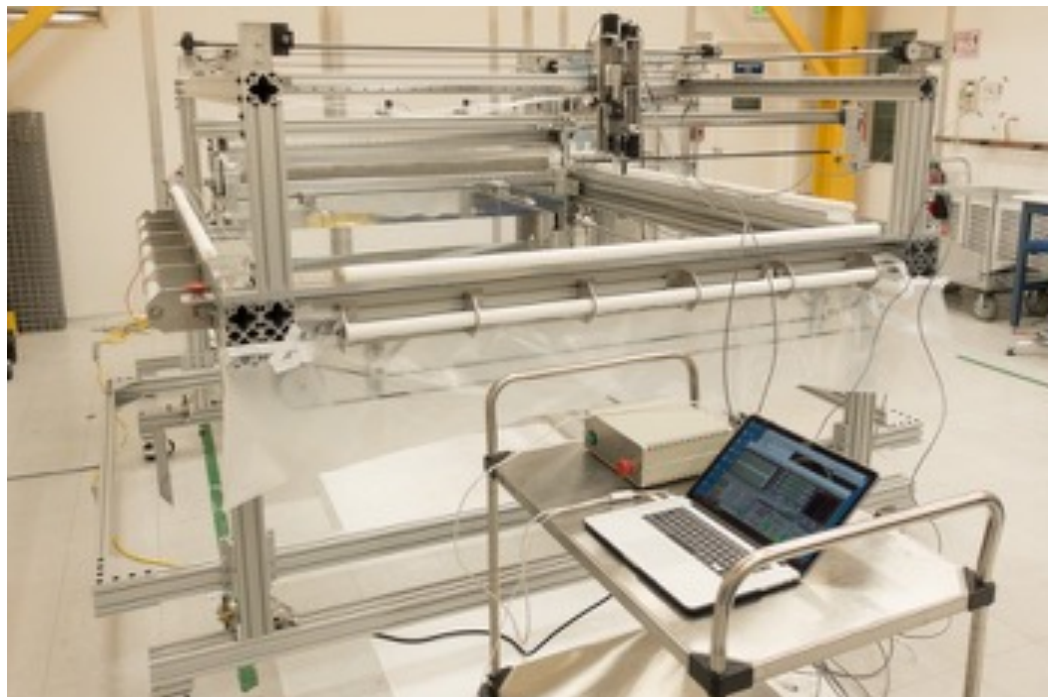




HV Grids and Rings

- TPC field rings being machined
- Prototype grid rings for bottom and cathode complete, to be tested in SLAC system test
- Machining of production grid rings underway

Titanium TPC field ring

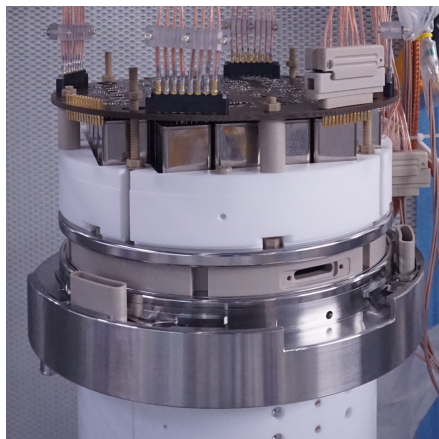
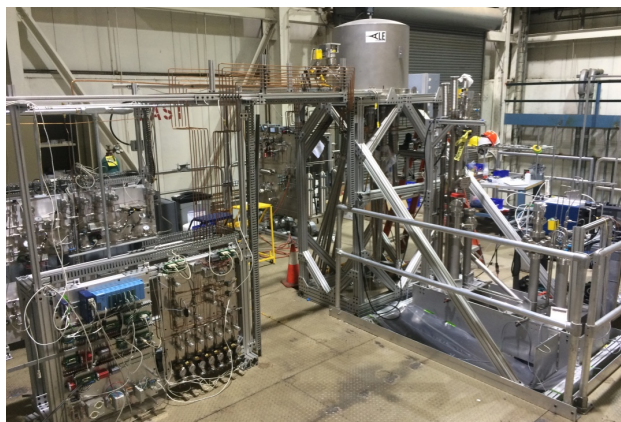


Grid weaving loom at SLAC: [Loom in action](#)



System Test and R&D

- PTFE reflectivity measurements, wire emission, HV design verification, purification, circulation, full scale grid QA, etc, etc, completed or in full swing

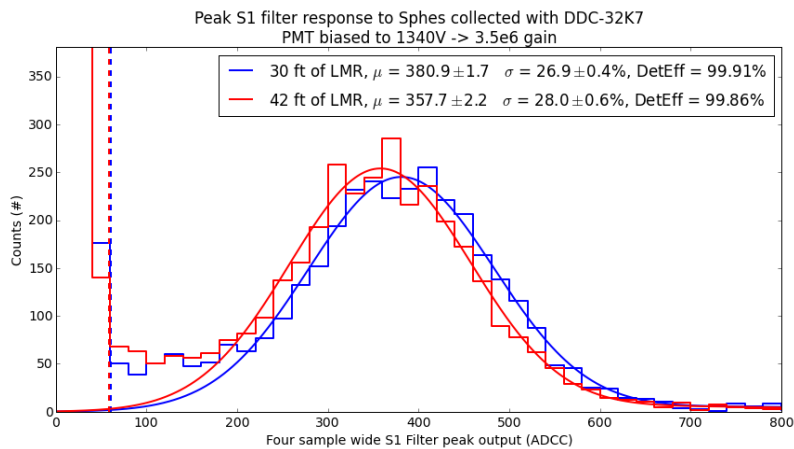




DAQ and Electronics

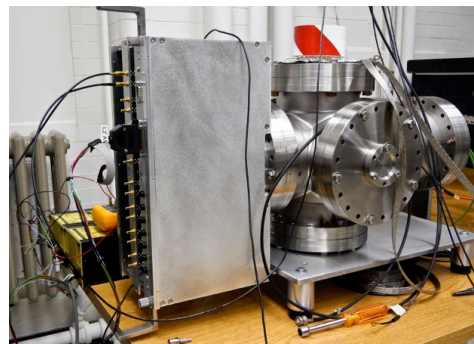


Pre-production prototype

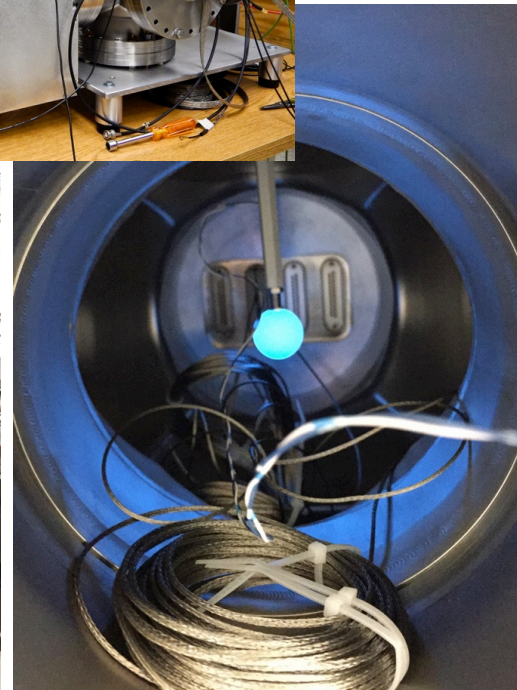
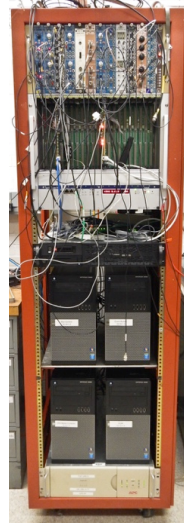


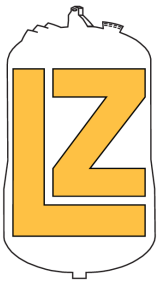
Excellent results obtained with prototype 1.

Complete electronics chain test



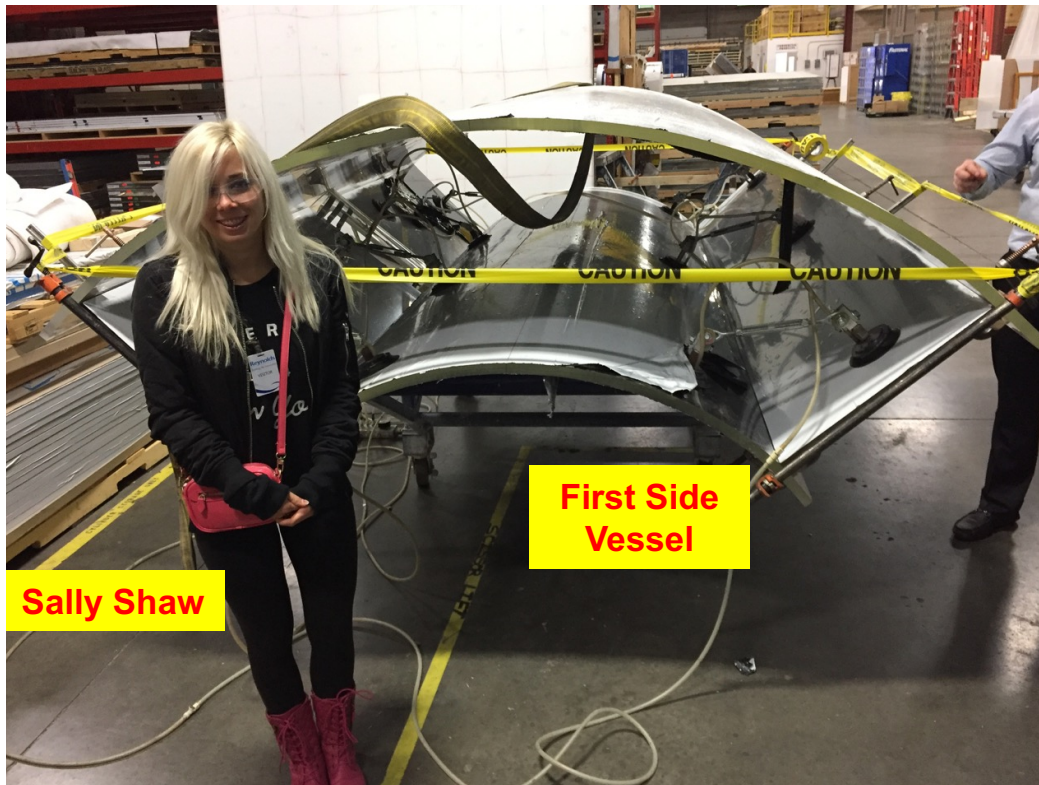
Chain Test Images





Outer Detector

- Final bonding of side tanks this month
- Liquid scintillator production at BNL this summer





Software

- Complete simulation and reconstruction package from events to waveforms to analysis
- Exercised in mock data challenges
 - Second MDC starts in April
- Sensitivity estimates are mature (J. Dobson)
- Will be ready for first data



Summary

- On schedule and on budget
- Good technical progress on all fronts, no showstoppers
- First physics data planned in April 2020

SURF collaboration meeting, July 2017

