

Status of the LZ Experiment



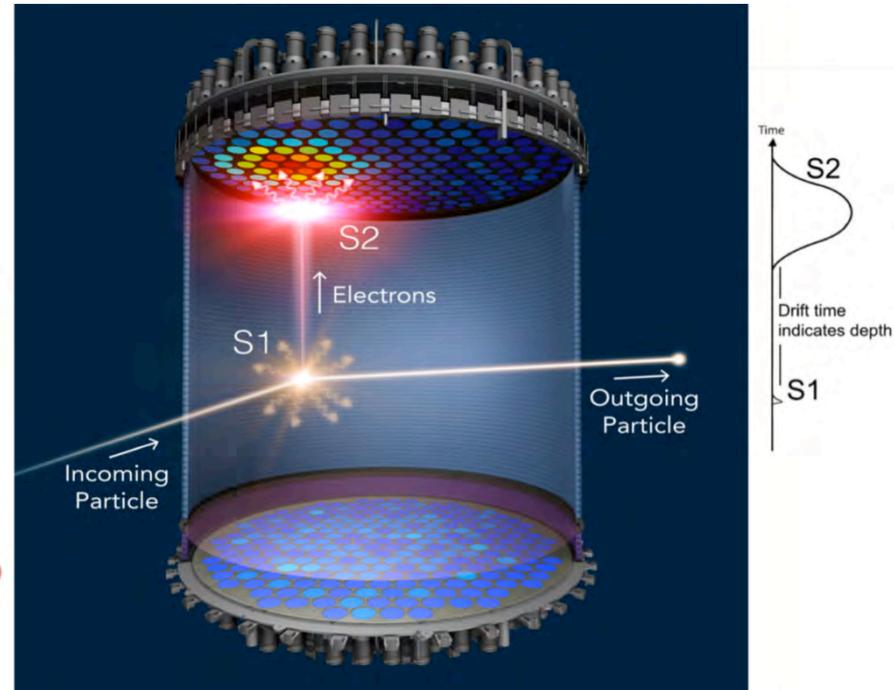
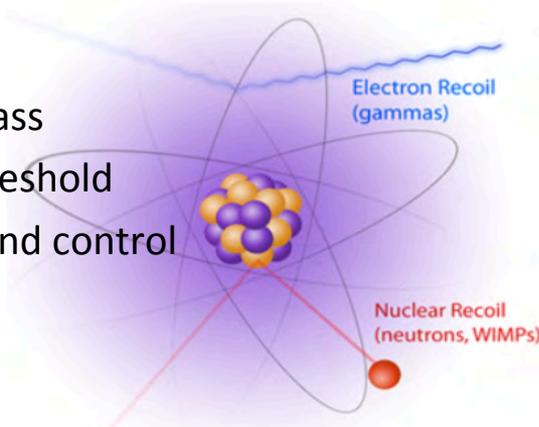
Nicholas Chott – SD School of Mines & Technology
On behalf of the LZ collaboration

American Physical Society – April Meeting 2019
April 13 - 16, 2019 – Denver, CO



WIMP search with 10 tonnes of LXe

- LUX-ZEPLIN (LZ) experiment is currently under construction at the 4850' level of the Sanford Underground Research Facility (SURF) in Lead, South Dakota.
- Dual-phase xenon Time Projection Chamber (TPC) provides:
 - Energy and (3-D) position
 - Electron/nuclear recoil discrimination (200:1)
- Direct search for anomalous low-energy nuclear recoils
- Requirements:
 - Large target mass
 - Low energy threshold
 - Strict background control



LZ detector overview

Xenon TPC

7t active LXe (5.6t fiducial)
Field cage
Top/bottom PMT array
Cathode/gate/anode grids

Xenon Skin Region

Instrumented Xe skin detector
Top/bottom skin PMT array

Titanium Cryostat

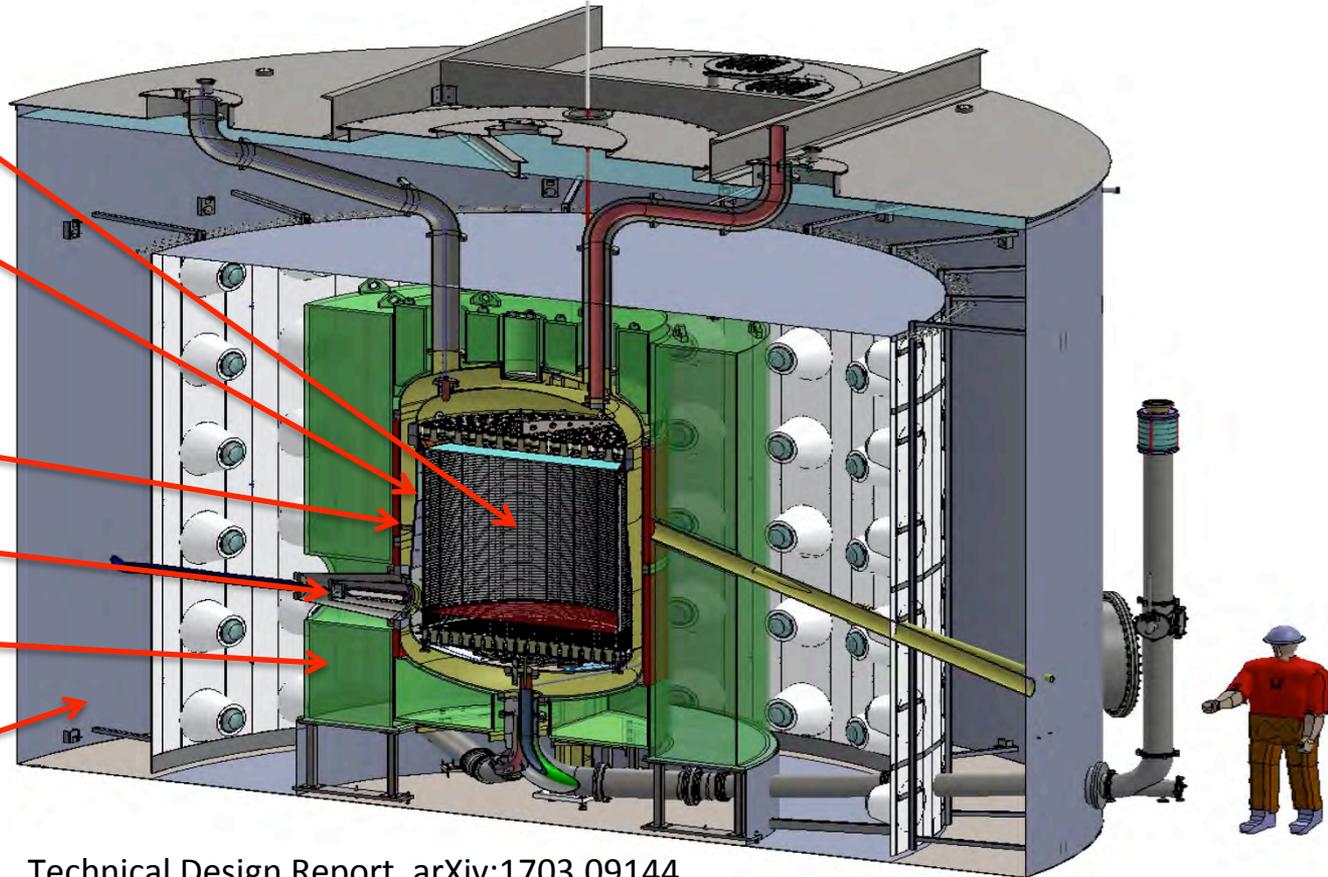
HV connection
50 kV cathode

Outer Detector (OD)

17t Gd-loaded liquid scintillator
PMT array in water tank

Water Shield

High purity water

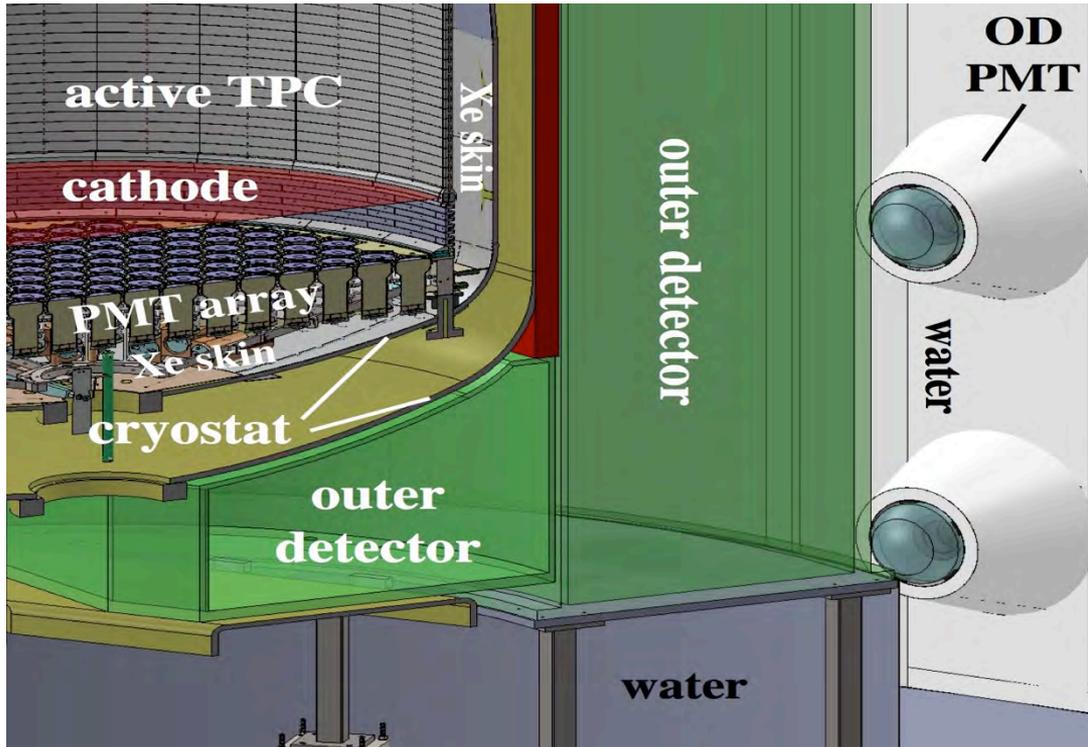


Technical Design Report, arXiv:1703.09144.

N. Chott - APS April 2019

Two veto systems: Xe skin + Outer Detector

Capable of tagging gammas and neutrons with high eff.



Instrumented Xe skin:

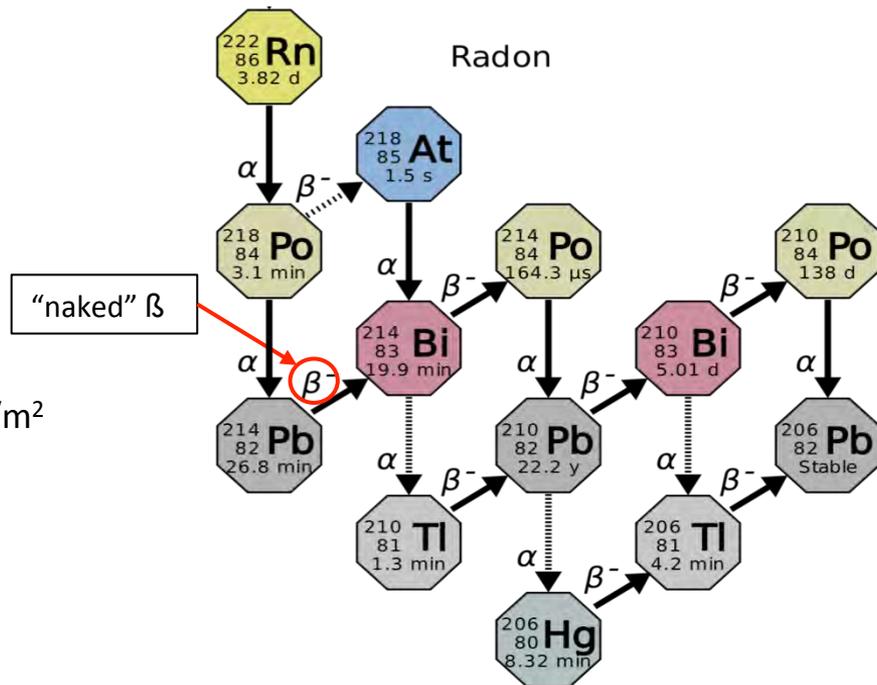
- Primary role: detection of scattered gamma rays
- Optically segregated from TPC
- Top: 93, 1" PMTs
- Bottom: 38, 2" PMTs

Outer detector:

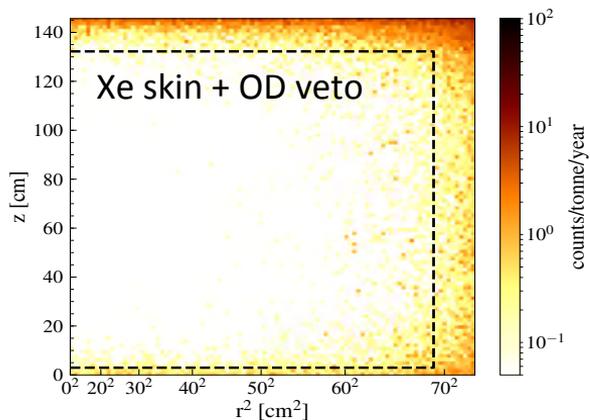
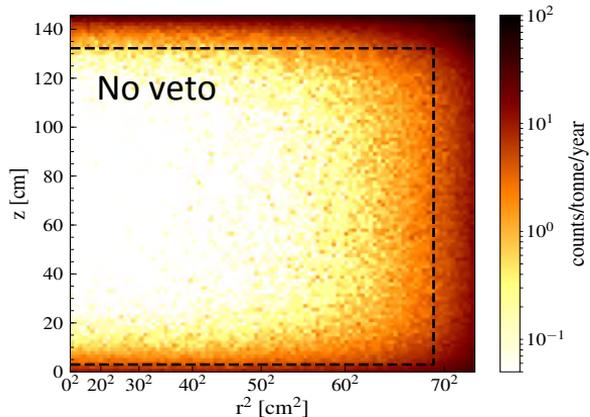
- Primary role: tag neutrons after a NR event within the TPC
- Neutrons thermalize and capture
- 120, 8" PMTs in water tank
- ~200 keV threshold

Background sources and mitigation

- **Detector materials**
 - Radio-assay campaign
 - gamma-screening, ICPMS, NAA
- **Rn emanation**
 - Four Rn emanation screening sites
 - Two portable Rn assay panels
 - Target Rn activity: 2 $\mu\text{Bq/kg}$
- **Rn daughters and dust on surfaces**
 - TPC assembly in Rn-reduced cleanroom
 - Dust < 500 ng/cm^3 on all LXe wetted surfaces
 - Rn-daughter plate-out on TPC walls < 0.5 mBq/m^2
- **Xenon contaminants** – ^{85}Kr , ^{39}Ar
 - Charcoal chromatography @ SLAC
 - Final $^{\text{nat}}\text{Kr/Xe}$ 0.015 ppt
- **Cosmogenics and externals**
 - 4300 m.w.e. underground at SURF in Lead, SD
 - Instrumented Xe skin region
 - Gd-Liquid scintillator outer detector
 - High purity water shield



WIMP background summary



1000 live days x 5.6 tonnes fiducial mass;
 $1.5 - 6.5 \text{ keV}_{ee}$ ($6 - 30 \text{ keV}_{nr}$)

NR background equivalent fiducial mass:

- No veto: 3.2 tonnes
- Xe skin + Outer Detector (OD) veto: 5.6 tonnes

Background source	ER (cts)	NR (cts)
Detector Components	9	0.07
Laboratory and Cosmogenics	5	0.06
Surface Contamination and Dust	40	0.39
Xenon Contaminants – Rn, Kr, Ar	819	0
Physics – DBD, neutrinos	322	0.51
Total	1195	1.03
99.5% ER discrimination, 50% NR eff.	5.97	0.51

Mostly neutrons

Radon dominates ER bkg.

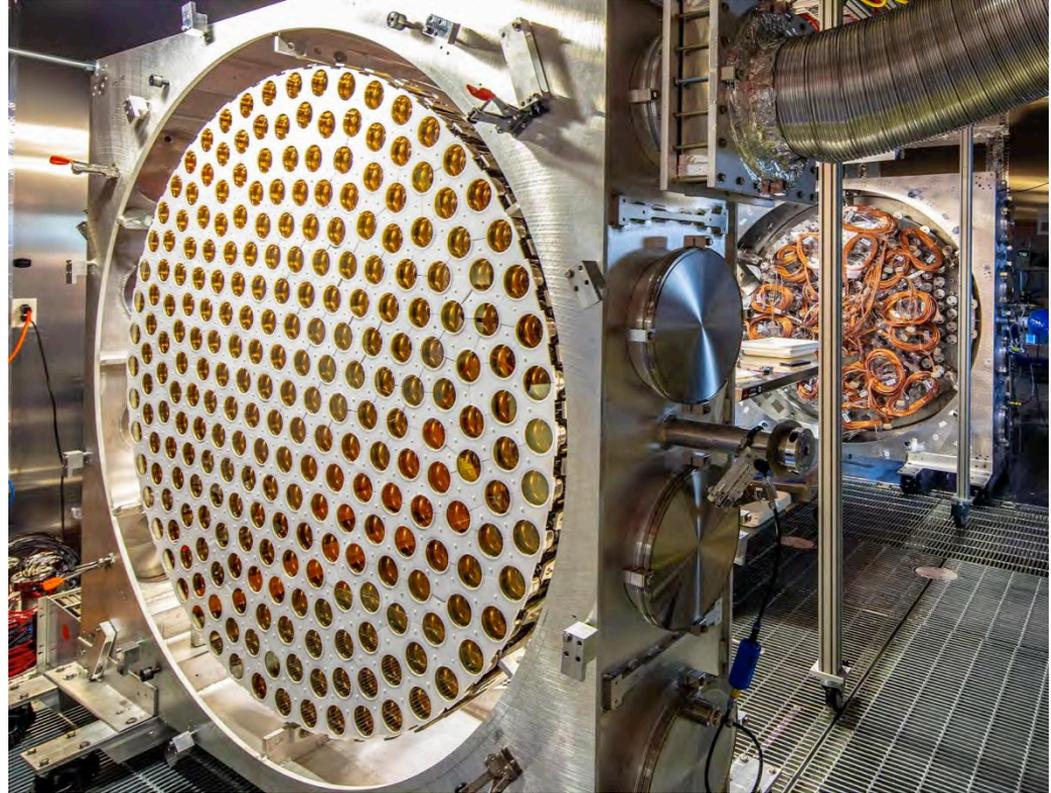
Titanium cryostat

- Intensive R&D program identified low activity titanium material (arXiv:1702.02646)
- Fabricated by Loterios in Italy
- Delivered to SURF May 2018
- Outer cryostat vessel (OCV):
 - Acceptance testing complete
 - Moved underground
- Inner cryostat vessel (ICV):
 - PTFE skin tiling of inner walls complete
 - Bottom skin PMT array complete
2" (LUX) PMTs



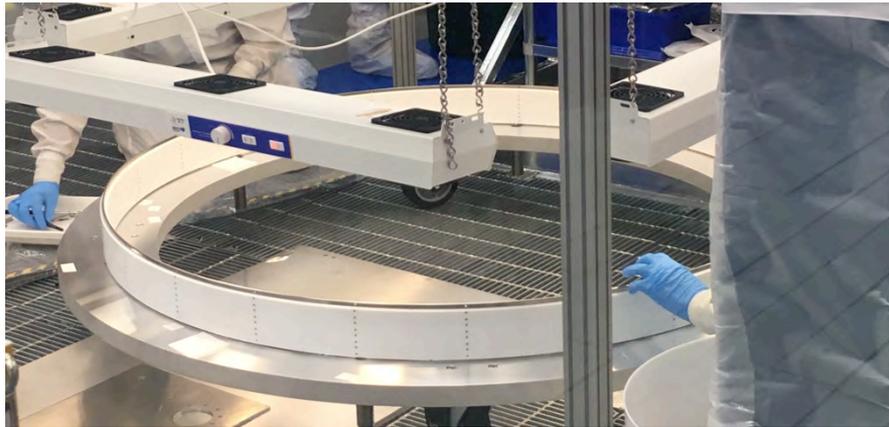
TPC – PMTs

- Both PMT arrays complete
 - Top array: 252 x 3" PMTs
 - Bottom array: 241 x 3" PMTs
- Arrays assembled in PALACE (PMT Array Lifting And Commissioning Enclosure)
 - PMT dark electrical testing
 - Shipping enclosure
 - Dust control with HEPA filter
 - Low radon air



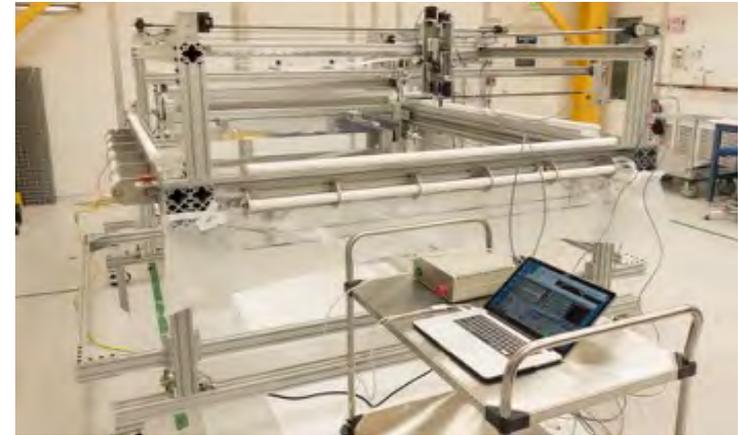
TPC – Field cage

- 57 titanium field shaping rings encased within PTFE
- Field cage assembly completed December 2018



TPC – Grids

- (Semi-)automated loom for weaving SS wire grids
- Two full size prototype grids (1.5 m diameter) complete
- Fabrication of final LZ grids underway



Video of the weaving process:

<https://www.youtube.com/watch?v=yNycDcMQkss>

Outer Detector

- Acrylic vessels:
 - Side tanks (4) underground inside water tank
 - Top/bottom tank fabrication almost finished
- All outer detector PMTs in-hand:
 - Testing at IBS (Korea) complete
 - Mock PMT ladder installed inside water tank
- Gd-Liquid Scintillator production:
 - Equipment being installed at BNL



Xe acquisition and Kr removal

- 7 tonnes of Xe in-hand
Fixed price contract for remainder
- Chromatography to separate Kr (^{85}Kr) from Xe
 - R&D at SLAC: demonstrated 0.06 ppt (g/g)
 - Production system: designed for 0.015 ppt (g/g)

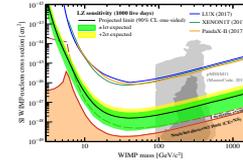


2 charcoal chromatography columns at SLAC

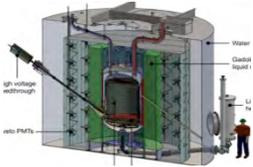
Kr removal at SLAC to start by July 2019 and finish by end of 2019.

Timeline

WIMP sensitivity paper,
Feb 2018



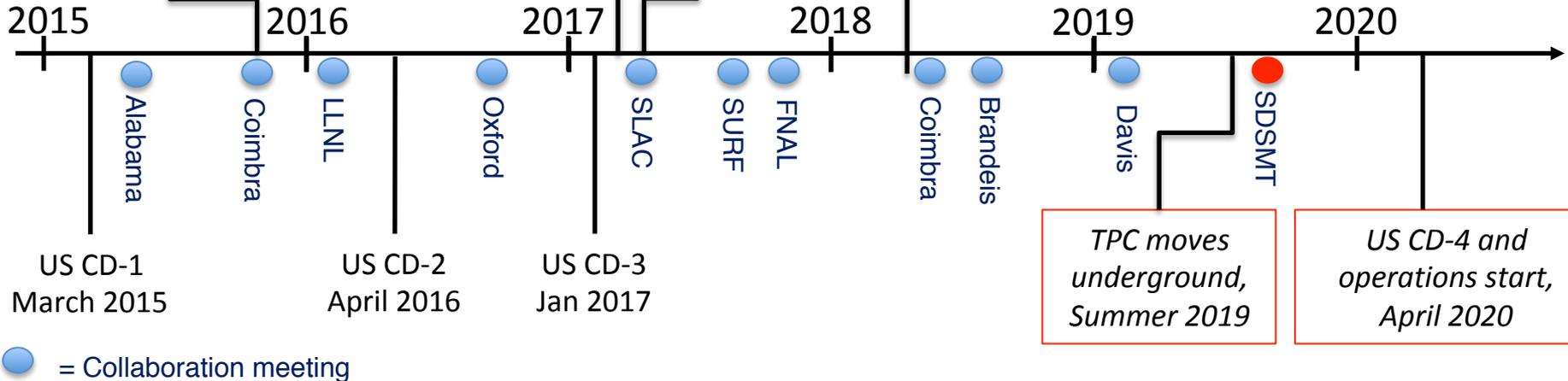
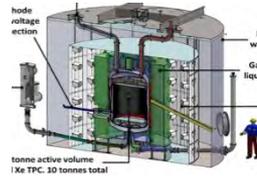
CDR,
Sept 2015



Titanium paper,
Feb 2017



TDR,
March 2017



● = Collaboration meeting

LZ Collaboration

37 institutions; 250 scientists, engineers and technicians



- 1) IBS-CUP (Korea)
- 2) LIP Coimbra (Portugal)
- 3) MEPhI (Russia)
- 4) Imperial College London (UK)
- 5) Royal Holloway University of London (UK)
- 6) STFC Rutherford Appleton Lab (UK)
- 7) University College London (UK)
- 8) University of Bristol (UK)
- 9) University of Edinburgh (UK)
- 10) University of Liverpool (UK)
- 11) University of Oxford (UK)
- 12) University of Sheffield (UK)

- 13) Black Hill State University (US)
- 14) Brandeis University (US)
- 15) Brookhaven National Lab (US)
- 16) Brown University (US)
- 17) Fermi National Accelerator Lab (US)
- 18) Lawrence Berkeley National Lab (US)
- 19) Lawrence Livermore National Lab (US)
- 20) Northwestern University (US)
- 21) Pennsylvania State University (US)
- 22) SLAC National Accelerator Lab (US)
- 23) South Dakota School of Mines and Technology (US)
- 24) South Dakota Science and Technology Authority (US)

- 25) Texas A&M University (US)
- 26) University at Albany (US)
- 27) University of Alabama (US)
- 28) University of California, Berkeley (US)
- 29) University of California, Davis (US)
- 30) University of California, Santa Barbara (US)
- 31) University of Maryland (US)
- 32) University of Massachusetts (US)
- 33) University of Michigan (US)
- 34) University of Rochester (US)
- 35) University of South Dakota (US)
- 36) University of Wisconsin – Madison (US)
- 37) Yale University (US)