



# Status of the LZ dark matter experiment

**Brais López Paredes, Imperial College London**  
**On behalf of the LZ collaboration**

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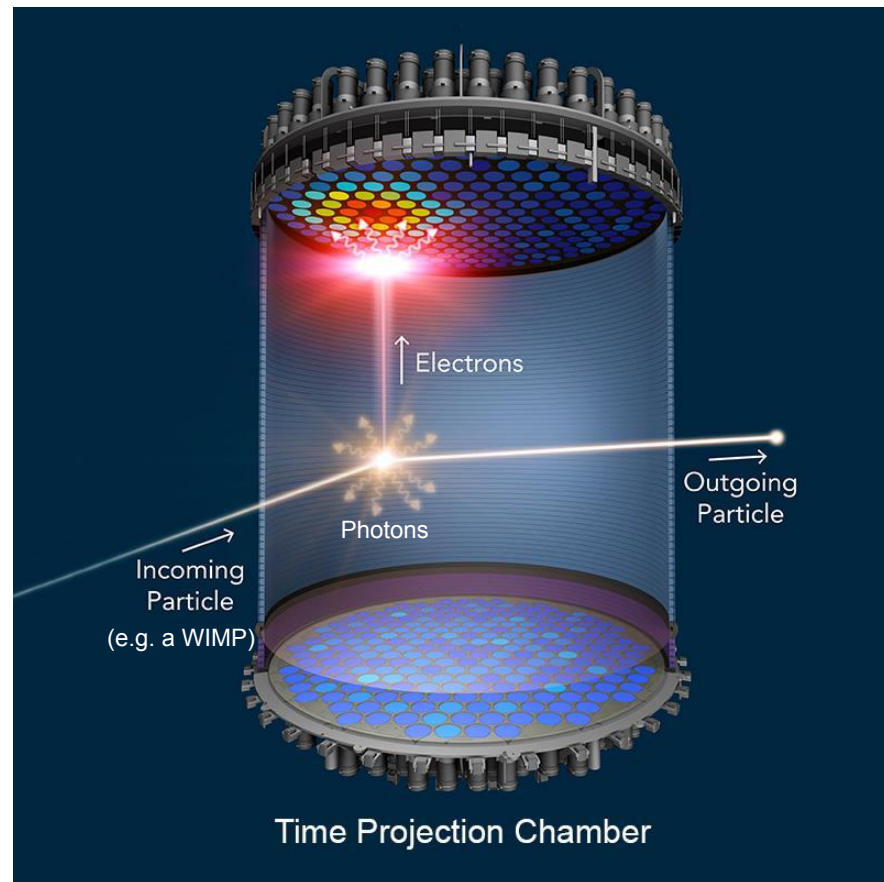
IOP Joint APP & HEPP conference 2019

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# The LZ core

- Liquid/Gas Xenon TPC (LXe-TPC)
- Looking for very low-E WIMP recoils
- Particle scattering on Xe produces prompt scintillation (S1) and electrons.
- Electrons swept up into gas phase produce electroluminescence (S2).
- Full 3D reconstruction from light pattern (XY) and S1-S2 time delay (Z) enables fiducialisation.
- S2/S1 ratio for ER-NR discrimination.

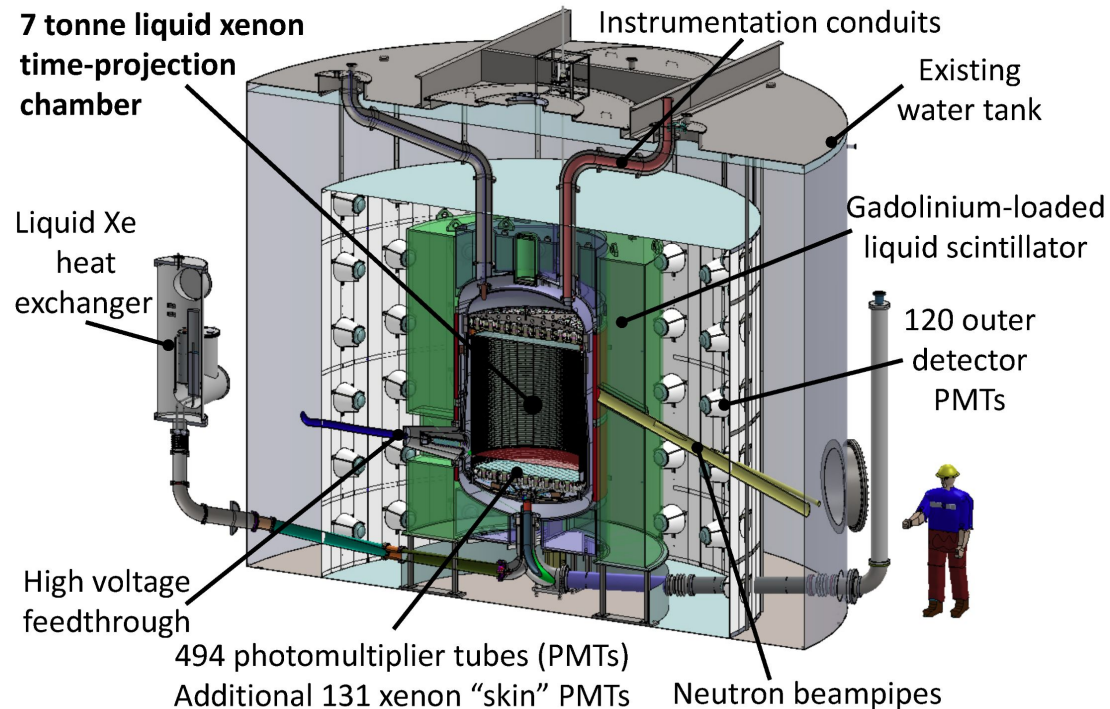




# The LZ detector

- **LXe-TPC:**
  - 7 tonnes active Xe
  - 5.6 tonnes fiducial volume
- **Two veto systems**
  - LXe skin
  - Outer detector (20 tonnes Gd-LS)
- **Internal and external calibrations (ER and NR)**
- **Location:**  
**Sanford Underground Research Facility (SURF)**  
**in Lead, South Dakota**

## The LZ Detector

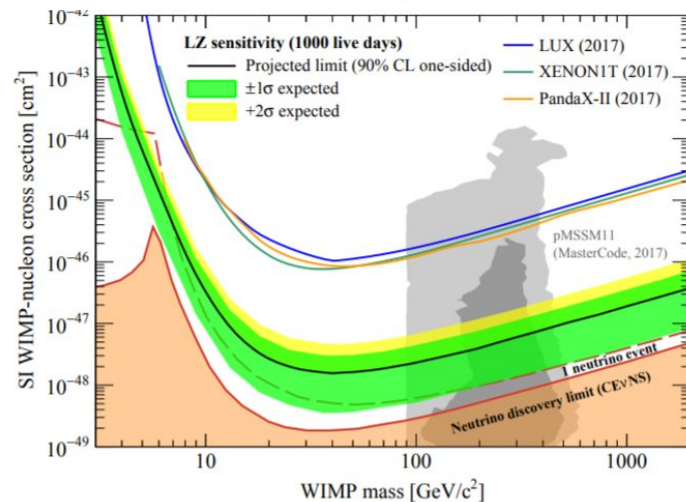
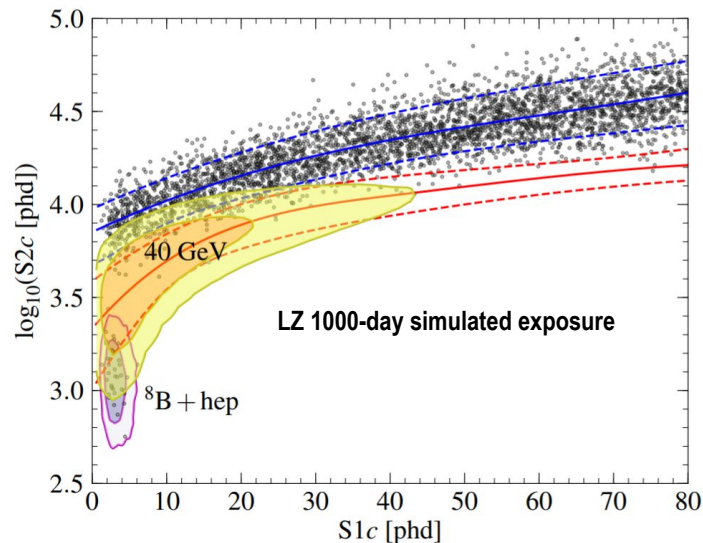




# Physics at LZ

- **WIMPs: Weakly Interacting Massive Particles**
  - SI, SD and more generic EFT operator searches
  - $O(10^0)$  to  $O(10^4)$   $\text{GeV}/c^2$
- **Complementary to LHC**
- **Neutrinoless double beta decay**
  - $^{136}\text{Xe}$  8.9% natural concentration
- **Solar and supernova neutrinos**
  - ~10 tonne scale detector
  - Solar  $^8\text{B}$  neutrino via  $\text{CE}\nu\text{NS}$

All made possible by an extensive cleanliness programme, backgrounds control and calibrations!



# WIMP backgrounds

1000 days, 5.6 tonnes (ER: 1.5–6.5 keV, NR: 6–30 keV)

Source	ER counts	NR counts
Detector components	9	0.07
Surface contaminants, dust	40	0.39
Xenon contaminants	819	0
Laboratory and cosmogenics	5	0.06
$2\nu\beta\beta$ , Solar $pp+{}^7\text{B}+{}^{13}\text{N}$ , DSN and atmospheric neutrinos	322	0.51
<b>Total</b>	<b>1195</b>	<b>1.03</b>
99.5% ER discrimination, 50% NR acceptance	<b>5.97</b>	<b>0.52</b>

Radio-assays (HPGe, ICP-MS, NAA)

→ >1000 detector material assays!

Rn emanation screening

Surface cleanliness programme

+ Detector assembled in Rn-reduced cleanroom

Online Rn removal system

Charcoal chromatography ( ${}^{85}\text{Kr}$ ,  ${}^{39}\text{Ar}$ )

Expect ~6 counts ER+NR in 1000 days, 5.6 tonnes FV after all analysis cuts



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# Status of construction





# Cryostat

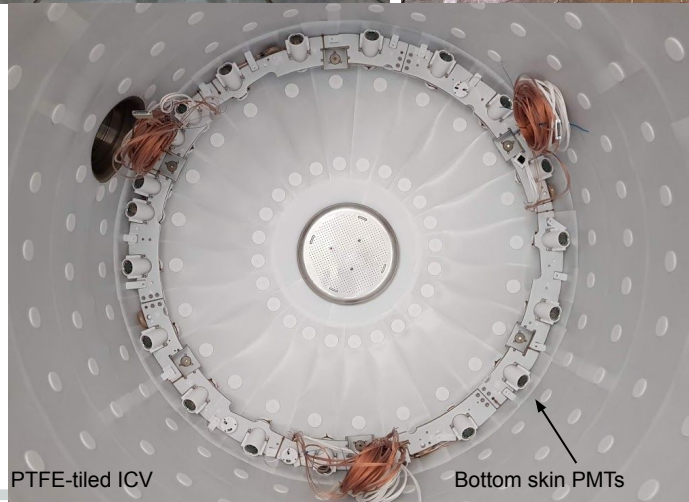
- Outer cryostat vessel (OCV) transported and assembled underground in LZ water tank
- Laser metrology and leak checking completed
- Inner cryostat vessel (ICV) completely tiled with PTFE, at surface lab.
- Bottom skin PMTs in place



OCV and ICV at factory



OCV in water tank



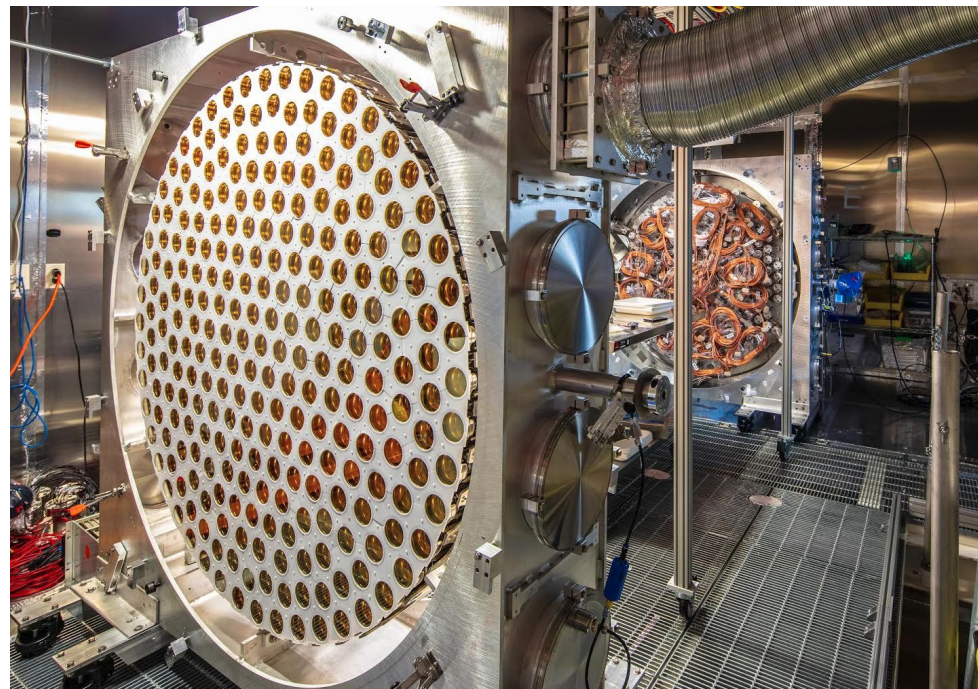
PTFE-tiled ICV

Bottom skin PMTs



# Photomultiplier arrays

- PMT arrays delivered to SURF
- Ongoing:
  - PMT cabling
  - Array dressing with PTFE
  - Additional components: calibration LEDs, thermometers, sensors, fluid tubes

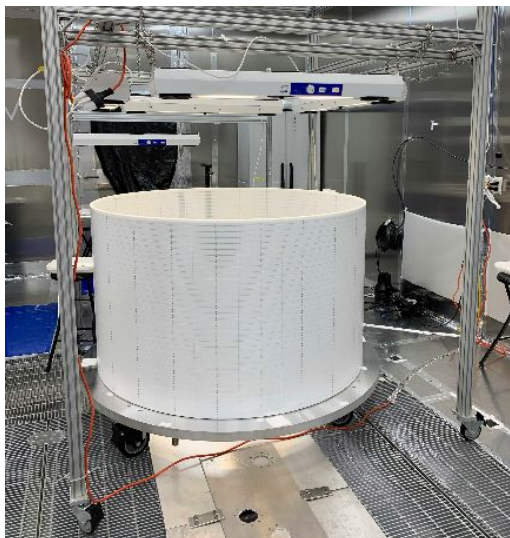






# TPC stacking

- **Forward Field Region (FFR) assembled.**
- **Interlocking PTFE and titanium rings - voltage ladder**

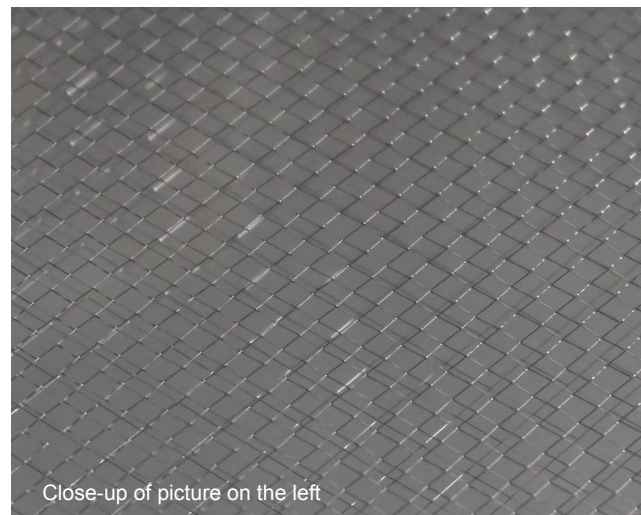
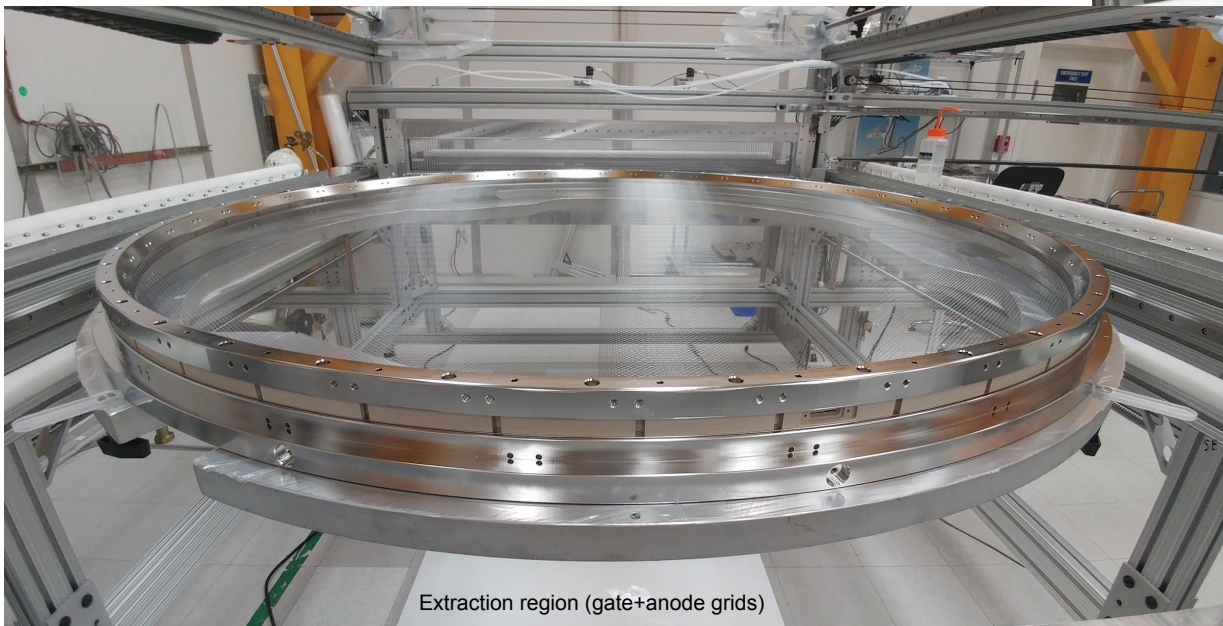


- **Reverse Field Region (RFR) and Extraction Region assembled soon**



# Grid manufacture

- Semi-automated robot for wire weaving
- $\sim 100\mu\text{m}$  wires epoxied to ring
- Manufacture of all grids finalised
- Full scale grid testing

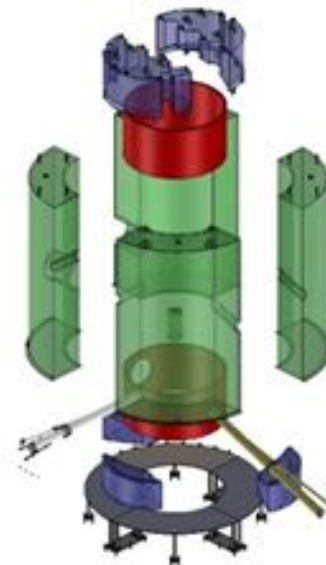






# Outer Detector

- 4 large side acrylic tanks in water tank
- Smaller tanks delivered soon
- Major progress in Gd-loaded scintillator production





# Timeline

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- **CD-1/3a Review – March 2015 (conceptual design, UK project kick-off)**
  - **Conceptual Design Report – September 2015 (arXiv:1509.02910)**
- **CD-2/3b Review – April 2016 (project baseline)**
- **CD-3 Review – February 2017 (start of construction)**
  - **Technical Design Report – March 2017 (arXiv:1703.09144)**
- **Cryostat delivered to SURF – May 2018**
- **TPC assembly - Ongoing**
- **TPC underground installation – Summer 2019**
- **Cooldown – Winter 2019-2020**
- **Physics-ready – Spring 2020**

# The LZ collaboration

**38 institutions, ~250 scientists, engineers, technicians**



- 1) IBS-CUP (Korea)
- 2) LIP Coimbra (Portugal)
- 3) MEPHl (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) Washington University in St. Louis (US)
- 38) Yale University (US)





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**Thank you**



# LZ calibration sources

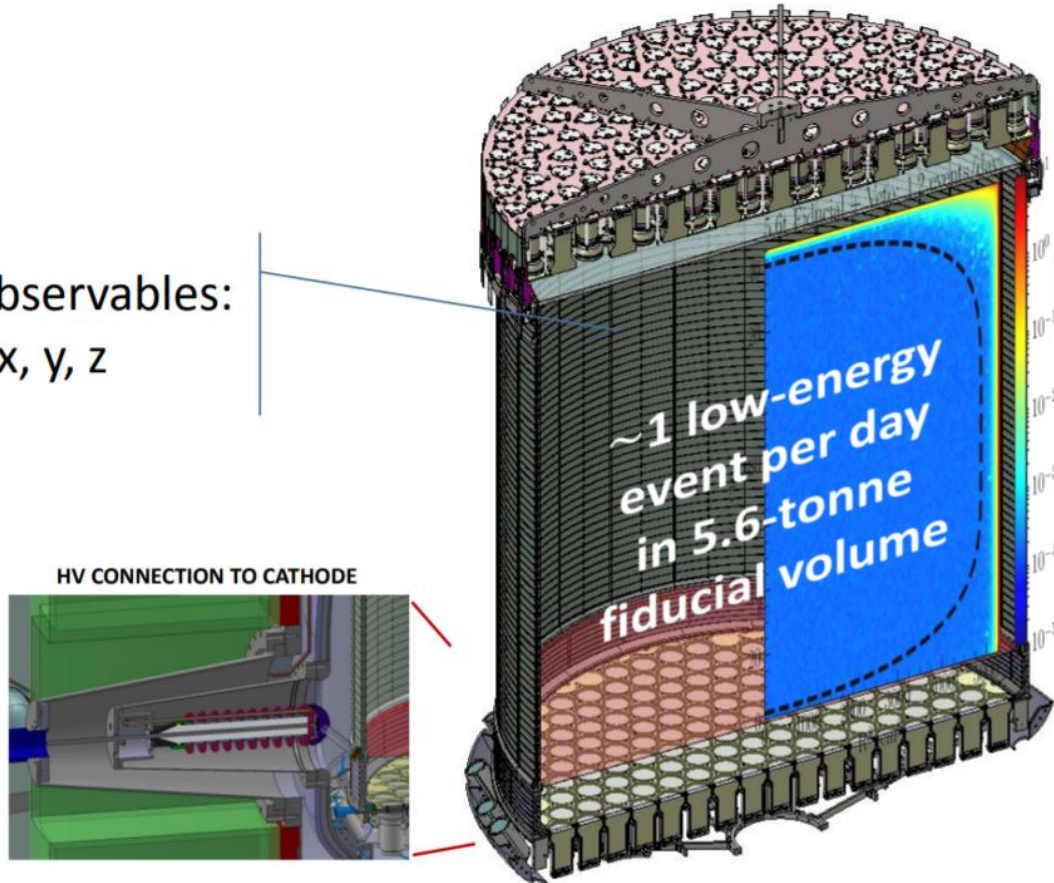
Table 7.0.1: Baseline calibration sources for LZ.

Isotope	What	Purpose	Deployment	Custom?
Tritium	beta, $Q = 18.6$ keV	ER band	Internal	N
$^{83m}\text{Kr}$	beta/gamma, 32.1 keV and 9.4 keV	TPC $(x,y,z)$	Internal	Y
$^{131m}\text{Xe}$	164 keV $\gamma$	TPC $(x,y,z)$ , Xe skin	Internal	Y
$^{220}\text{Rn}$	various $\alpha$ 's	xenon skin	Internal	N
AmLi	$(\alpha,n)$	NR band	CSD	Y
$^{252}\text{Cf}$	spontaneous fission	NR efficiency	CSD	N
$^{57}\text{Co}$	122 keV $\gamma$	Xe skin threshold	CSD	N
$^{228}\text{Th}$	2.615 MeV $\gamma$ , various others	OD energy scale	CSD	N
$^{22}\text{Na}$	back-to-back 511 keV $\gamma$ 's	TPC and OD sync	CSD	N
$^{88}\text{Y}$ Be	152 keV neutron	low-energy NR response	External	N
$^{205}\text{Bi}$ Be	88.5 keV neutron	low-energy NR response	External	Y
$^{206}\text{Bi}$ Be	47 keV neutron	low-energy NR response	External	Y
DD	2,450 keV neutron	NR light and charge yields	External	N
DD	272 keV neutron	NR light and charge yields	External	Y

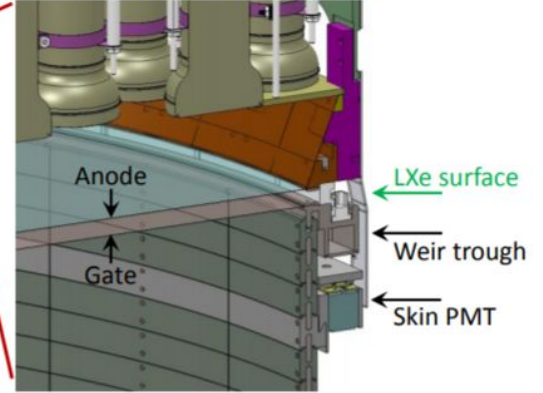


# Self-shielding LXe-TPC

Main observables:  
S1, S2, x, y, z



GAS PHASE AND ELECTROLUMINESCENCE REGION

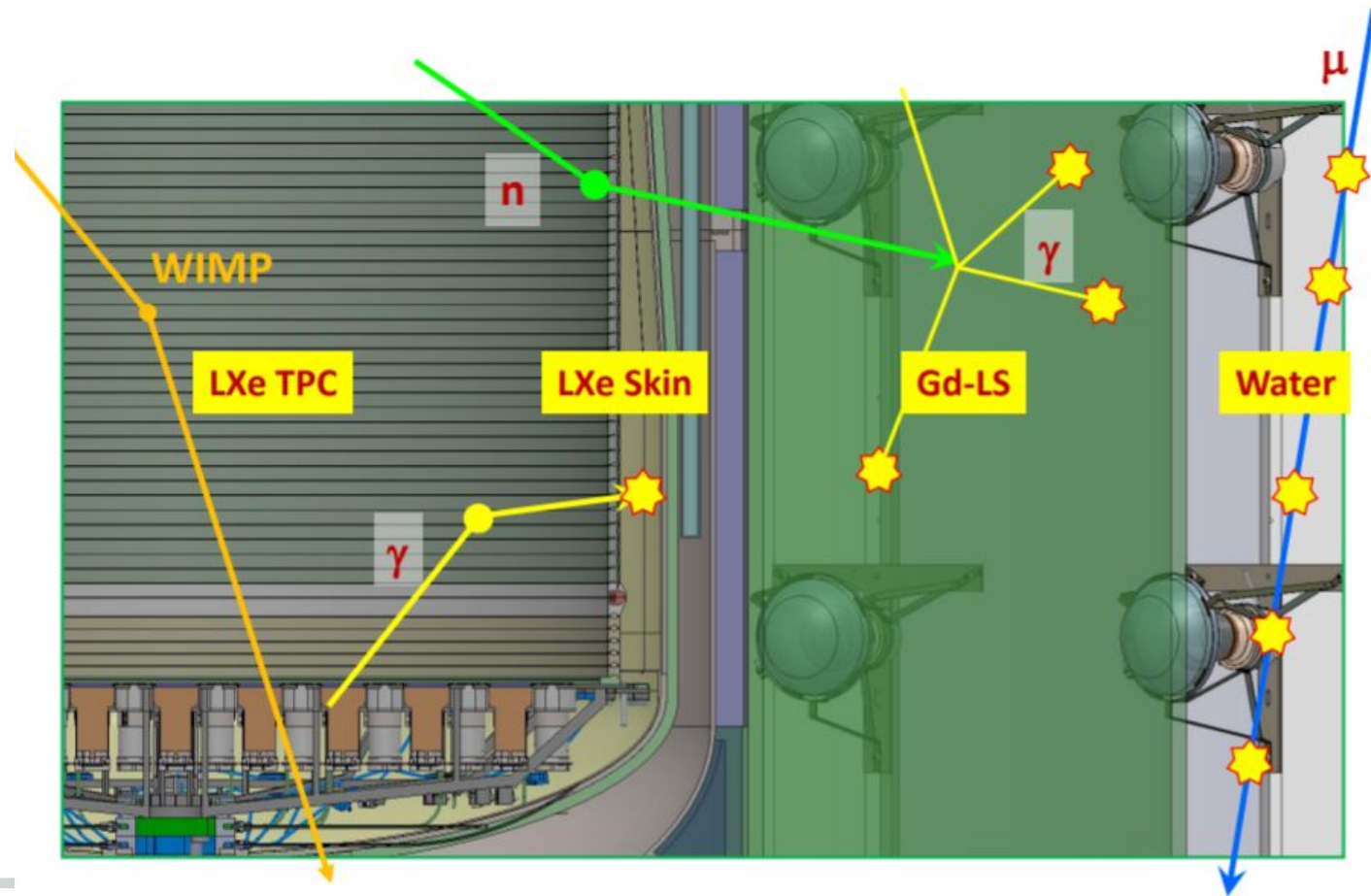


**Active mass: 7 tonnes**

**Fiducial mass: 5.6 tonnes**



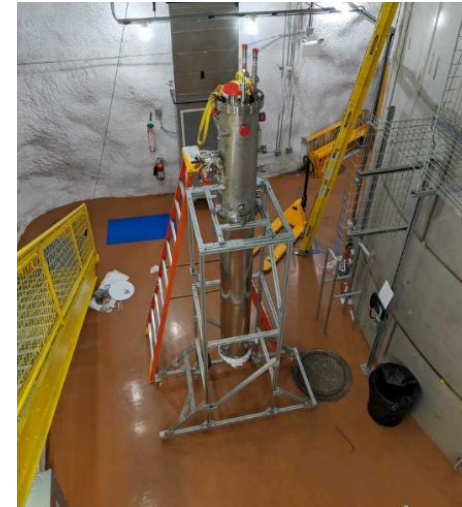
# Veto strategy





# Cryogenic and xenon systems

- Xenon liquefaction tower recently delivered and installed underground
- Test cryostat assembled
- First Xe pack in u/g storage
- Now piping together all systems for circulation testing
- Nearly all xenon in hand
- Kr removal to start in the summer



## DAQ and electronics

- Electronics chain test confirmed 99.8% SPE efficiency
- Final amplifier boards produced by end of month