Xenoscope, a full-scale vertical demonstrator for the XLZD observatory

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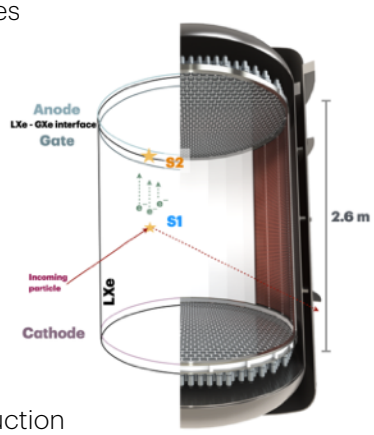
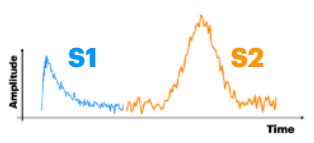
Dark matter detection with dual-phase LXe TPCs

- XLZD [1] is a proposed multipurpose observatory focused on dark matter search
- Technology used: liquid xenon (LXe) dual-phase time projection chamber (TPC)
- Prompt scintillation light (**S1**) in LXe
- Secondary light (**S2**) in gas xenon (GXe) from ionization charges
- 3D position reconstruction
  - x,y from **S2** top photosensor pattern
  - z from **S1**-**S2** time delay



- Energy reconstruction

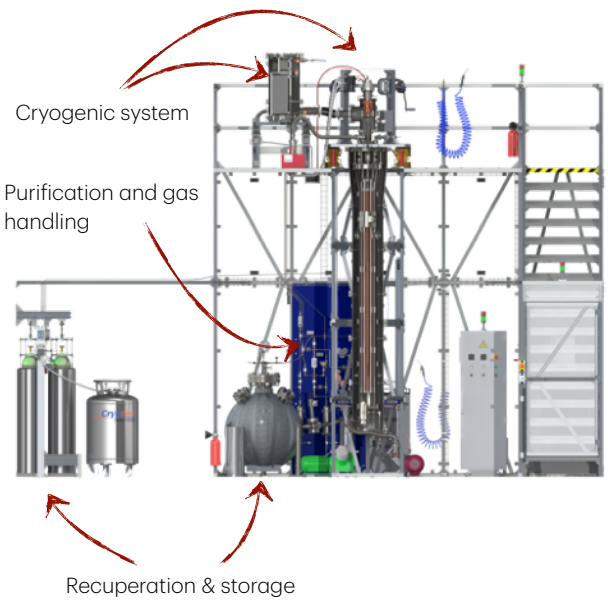
$$E \propto \left(\frac{S1}{g1} + \frac{S2}{g2}\right)$$



- Interaction classification via **S1**/**S2** signal ratio

The Xenoscope R&D platform [2]

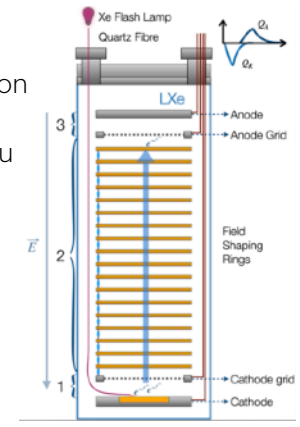
- Goal: electron drift over 2.6 m
- Light attenuation measurements in LXe
- Electron cloud diffusion properties
- R&D test platform for xenon purification, high-voltage delivery, photosensors



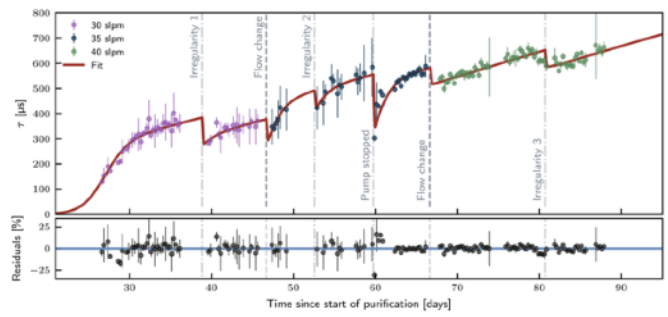
Xenoscope phase 1: LXe purity monitor [3]

- Drift length: 53 cm
- Signal from pulsed xenon flash-lamp onto an in-house made thin film Au photocathode
- Charge readout on top (Q_A) and bottom (Q_C)

$$\frac{Q_A}{Q_C} = e^{-t_d/\tau}$$

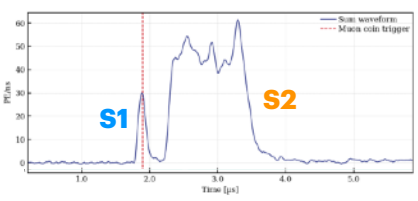


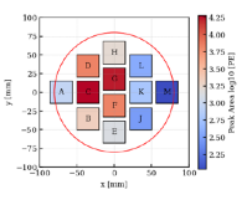
- Achieved e⁻ lifetime τ = 600 µs
- e⁻ cloud transport properties at different fields
  - Drift velocity of e⁻
  - Longitudinal diffusion



Xenoscope phase 2: dual-phase TPC [4]

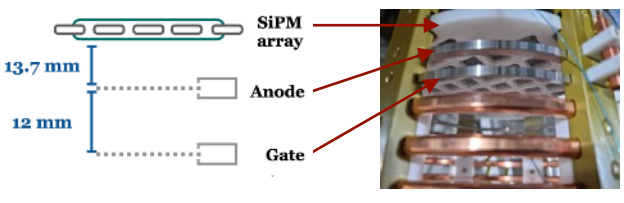
- Drift length: 2.6 m
- Signals from
  - ☑ Cosmic muons
  - ☐ Xenon flash-lamp onto photocathode
  - ☐ External calibration sources
- Prompt and proportional scintillation light readout with SiPM array located at the top in the GXe
- First run completed with all new subsystems successfully commissioned and first muon-induced S1-S2 events observed

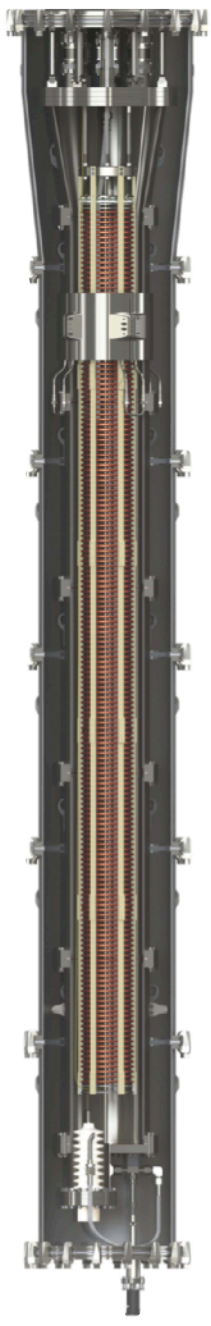




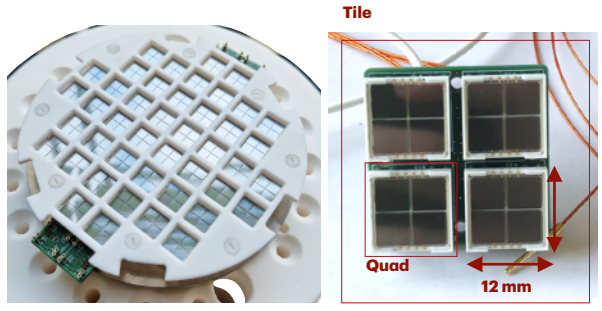
Field cage

- 173 copper rings, 15 cm internal diameter, arranged in 5 modules
- Connected via two parallel chains of 1 GΩ resistors
- 6 torlon supporting pillars with PTFE connectors





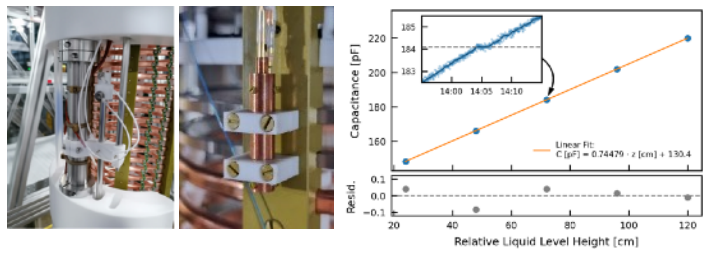
SiPM array [5]



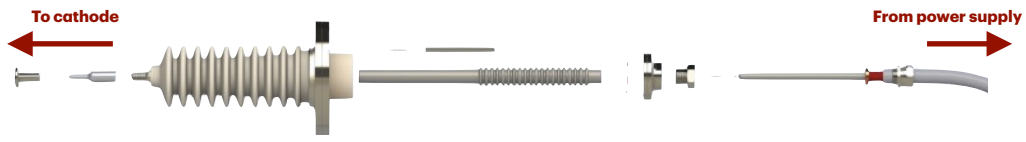
- Plate: Ø 160 mm, TPC active area: Ø 150 mm
- 192 VUV4 SiPMs (Hamamatsu) arranged in 12 tiles
- Per-tile summed readout with a x20 pre-amplified circuit

Liquid level monitoring and control

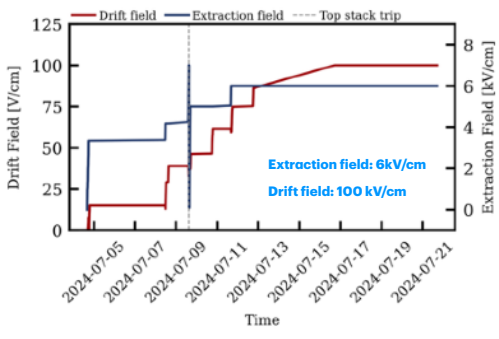
- Two-segment long level meter for real time monitoring during LXe filling
- Three short level meters for precise liquid level information at the LXe-GXe interface
- A weir for level setting between gate and anode



Cathode high-voltage delivery



- Three parts:
  - Air-to-vacuum feedthrough
  - Vacuum-to-LXe feedthrough
  - Cup and spring mechanism to deliver voltage to stainless steel cathode plate
- Designed to operate up to 50 kV



References

[1] XLZD Collaboration • J. Aalbers et al. 2024 arXiv:2410.17137

[2] L. Baudis, Y. Biondi, M. Galloway, F. Girard, A. Manfredini et al. *JINST* 16 (2021) P08052

[3] L. Baudis, Y. Biondi, A. Bismark, A.P. Cimental Chávez, J.J. Cuenca-García et al. *Eur. Phys. J. C* 83 (2023) 8, 717

[4] M. Adrover, M. Babicz, L. Baudis, Y. Biondi, A. Bismark et al. 2024 arXiv:2411.08022

[5] R. Peres on behalf of the Xenoscope team *JINST* 18 (2023) C03027