University of Zurich[UZH]

Physik-Institute. Particle Astrophysics

Current status and future plans for Xenoscope

XLZD collaboration meeting, LNGS, 01.07.2025

Jose Cuenca-García, on behalf of the Xenoscope team.

Xenoscope

- XLZD large-scale demonstrator:
  - Electron drift ~2.6 m
  - Custom-made HV distribution
  - Electron cloud diffusion properties
  - Light attenuation and propagation measurements
  - R&D test platform

The Xenoscope team:

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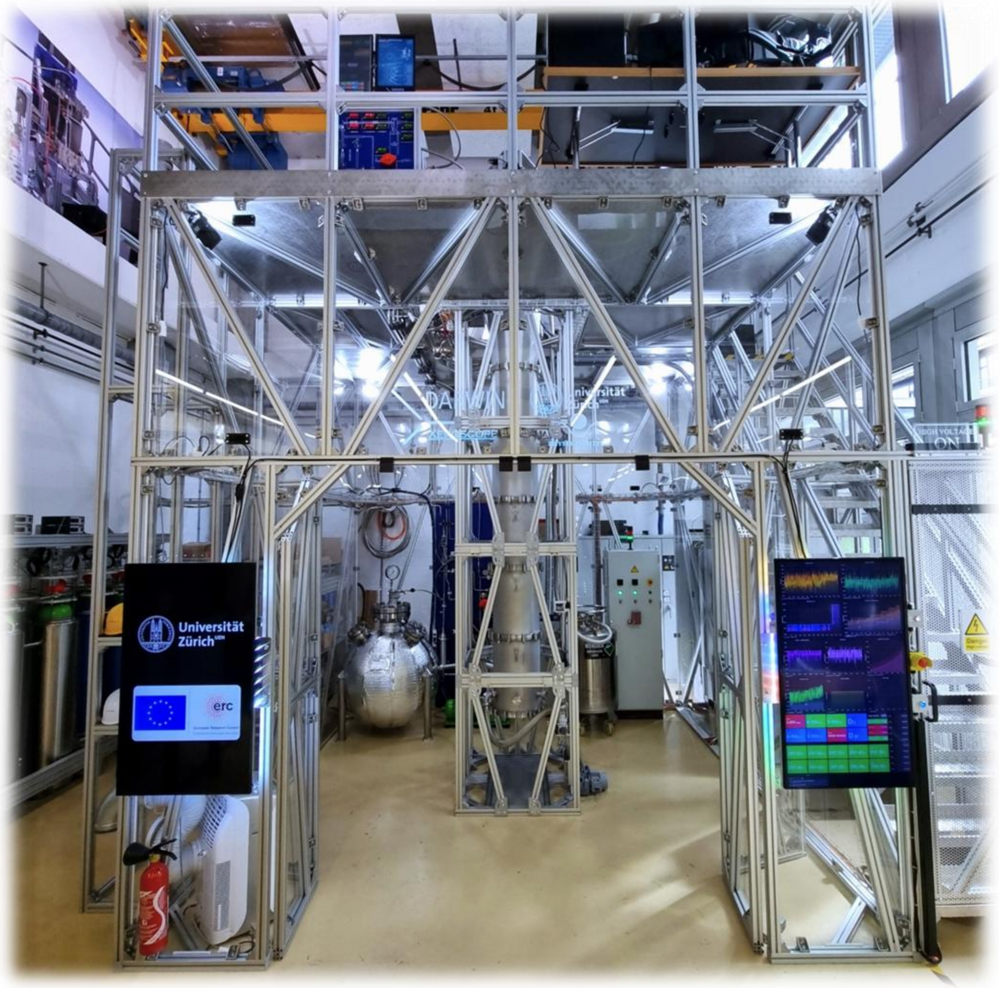
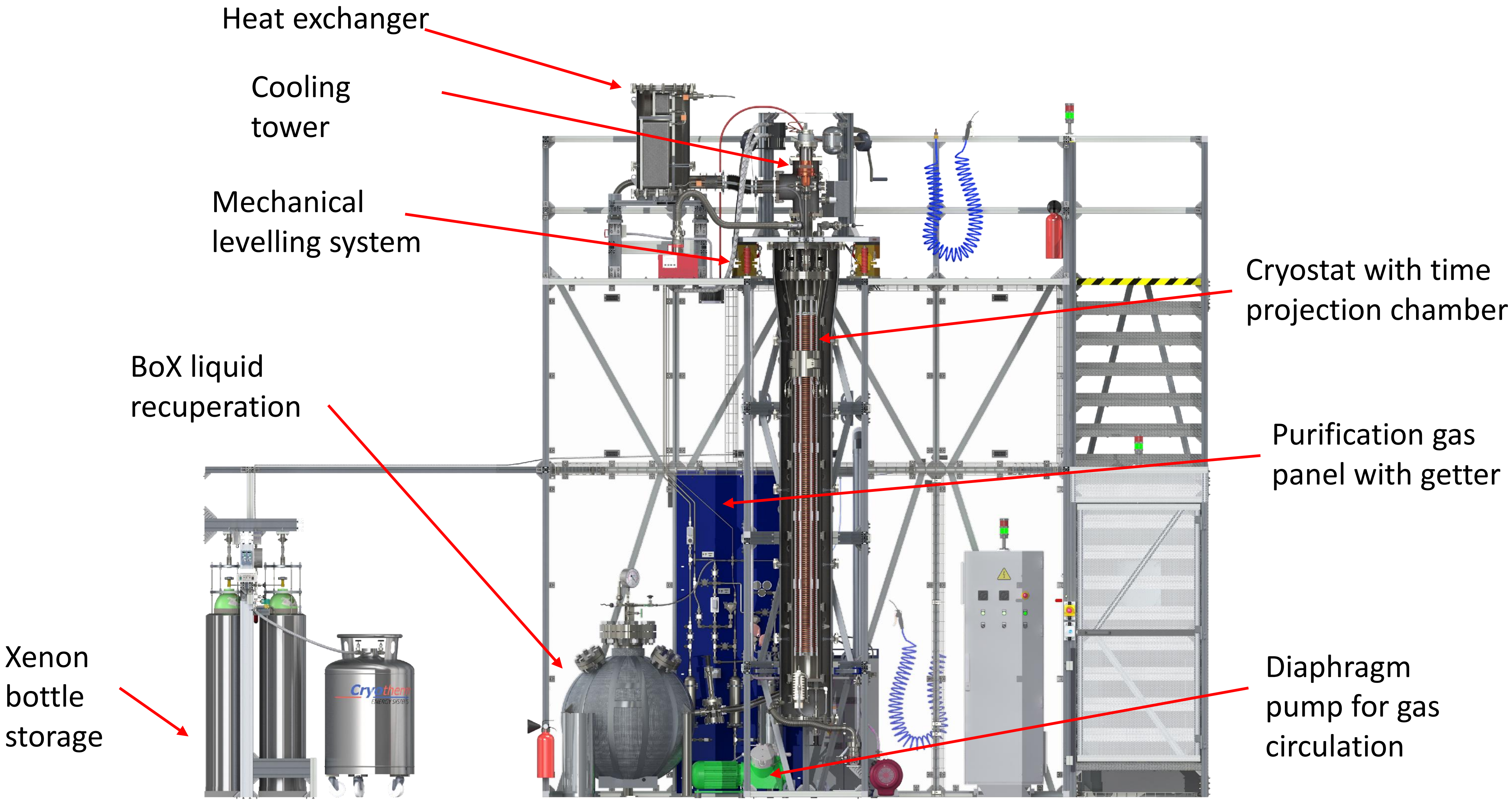
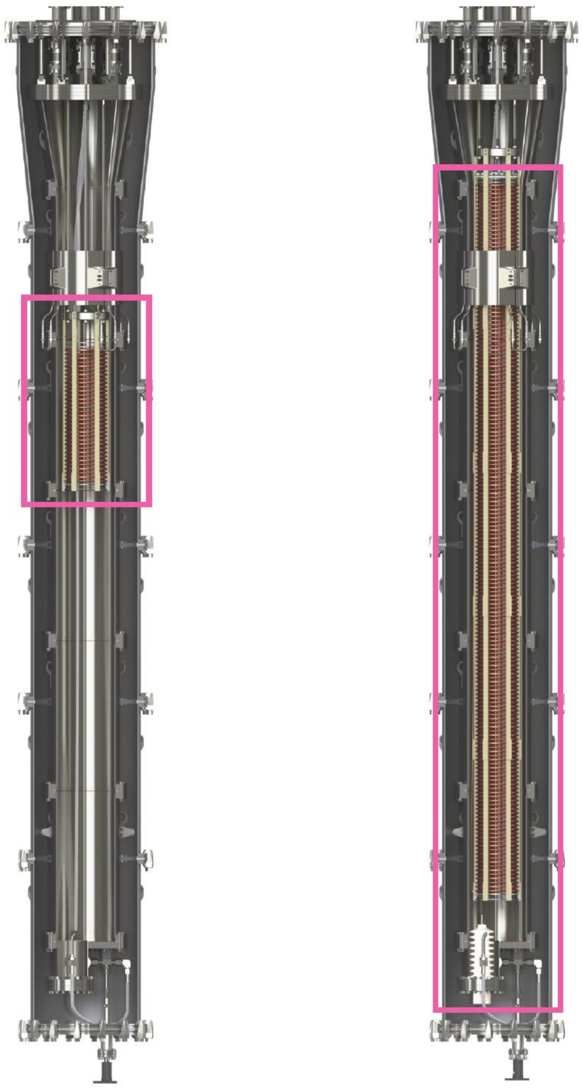


L. Baudis *et al* 2021 *JINST* **16** P08052

The facility



Current status



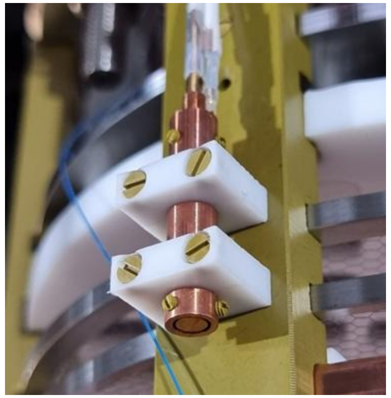
Phase 2: 2.6-m Time Projection Chamber

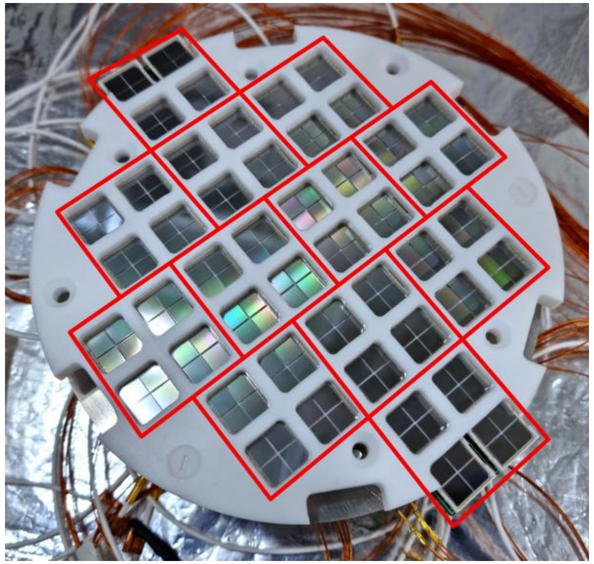
- High-voltage capable of going up to 50 kV
- SiPM array on top to detect S2 light
- Liquid level control (weir and level meters)
- Calibration sources (muons, external sources) to further improve our models

With this configuration:

- Commissioning run (April - August 2024)
- First science run (April - end of June 2025)

Commissioning run





Phase 2 upgrades:

1. SiPM array (12 channels) ✓
2. High-voltage feedthrough ✓
3. 2.6-m tall field cage ✓
4. Level control (2 long and 3 short LMs) ✓

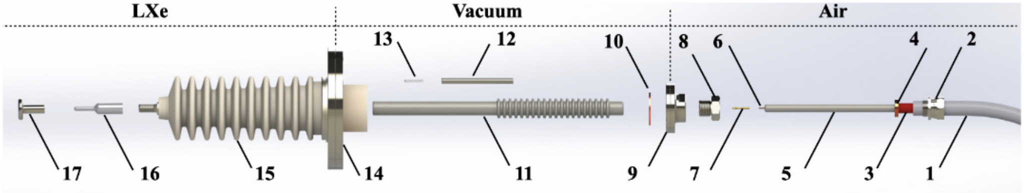
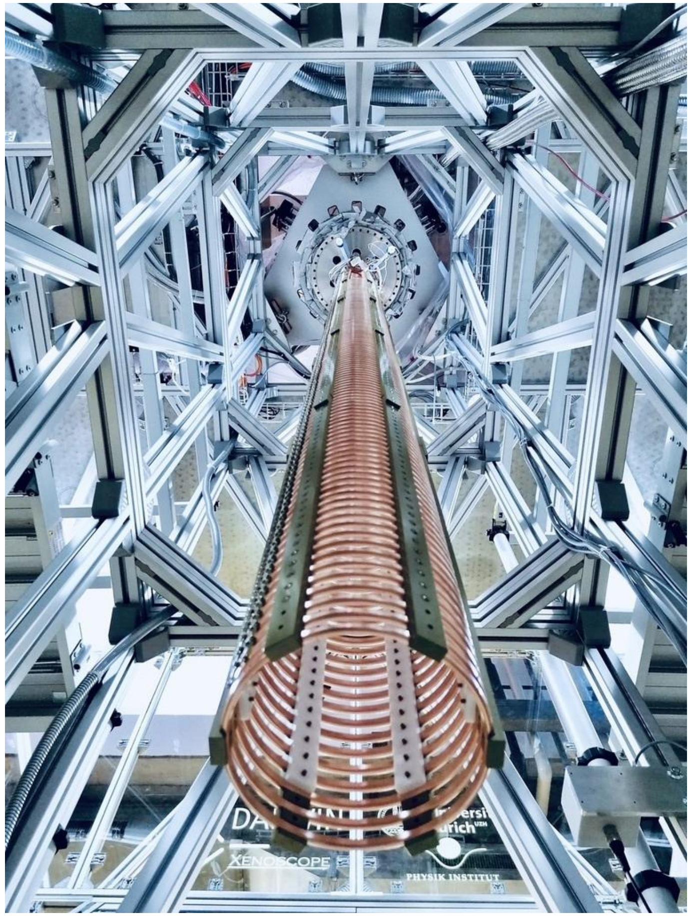
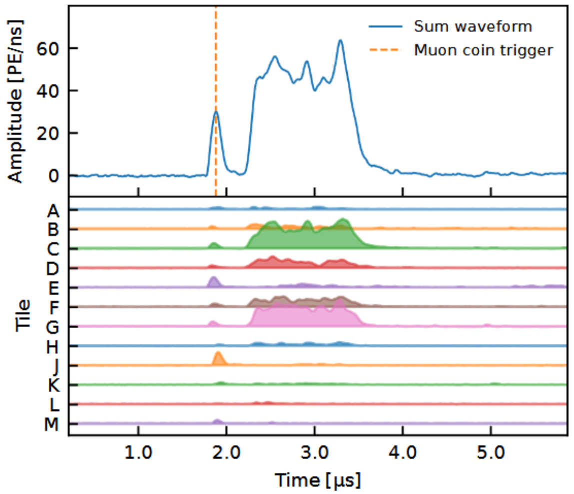


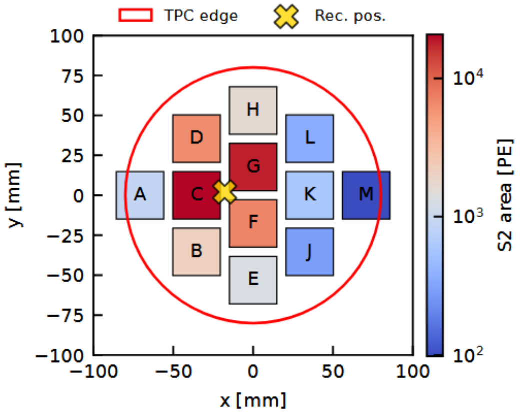
Figure 2: Exploded view of the cathode high-voltage delivery system components across the air, vacuum and LXe regions: (1) plated steel outer shield, (2) outer shield connector, (3) PVC cable outer layer, (4) copper ground shield, (5) HMWPE cable insulator, (6) copper inner conductor, (7) cable terminal, (8) grounding screw, (9) custom DN40CF flange, (10) DN40CF gasket, (11) HMWPE insulator, (12) stainless steel connector, (13) stainless steel spring, (14) DN125CF flange, (15) ceramic feedthrough, (16) round-edged high-voltage terminal, (17) cup-spring mechanism.

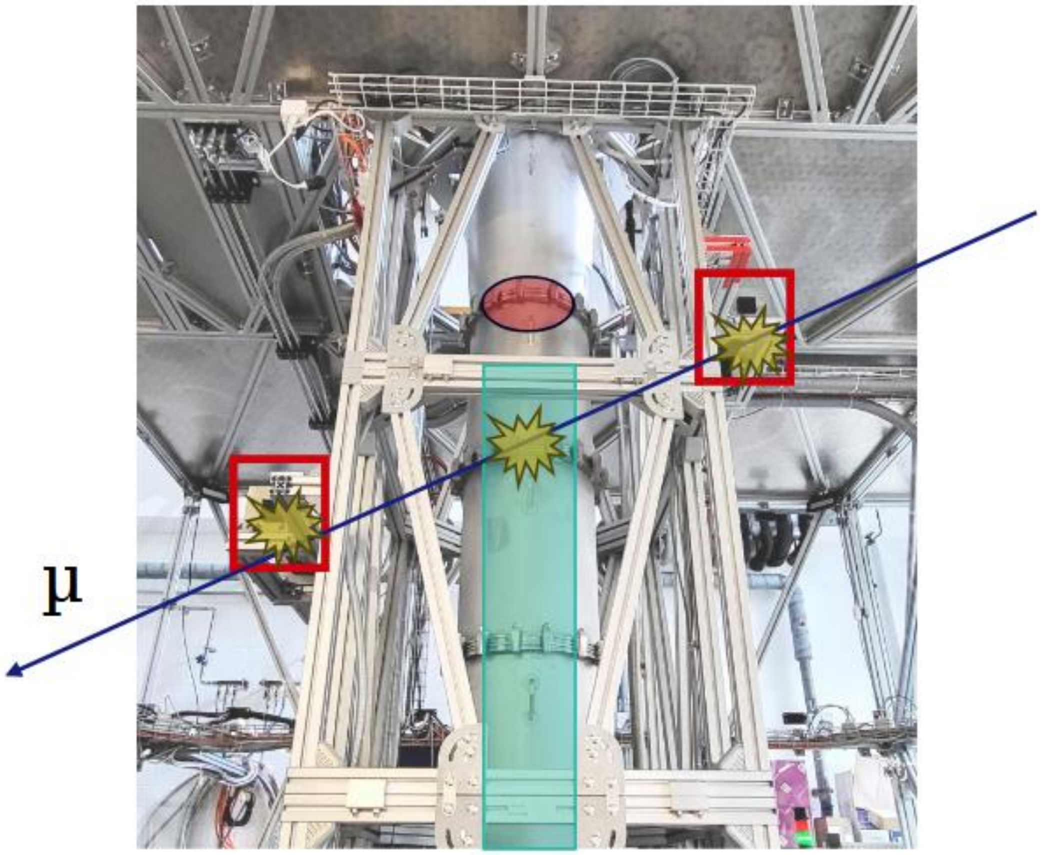


Results of the commissioning run

- From April to August 2024
- All subsystems calibrated and operative
- **No purification**
- Signals were obtained using muons (coincidence in the two panels)







M. Adrover et al 2025 JINST 20 P04013

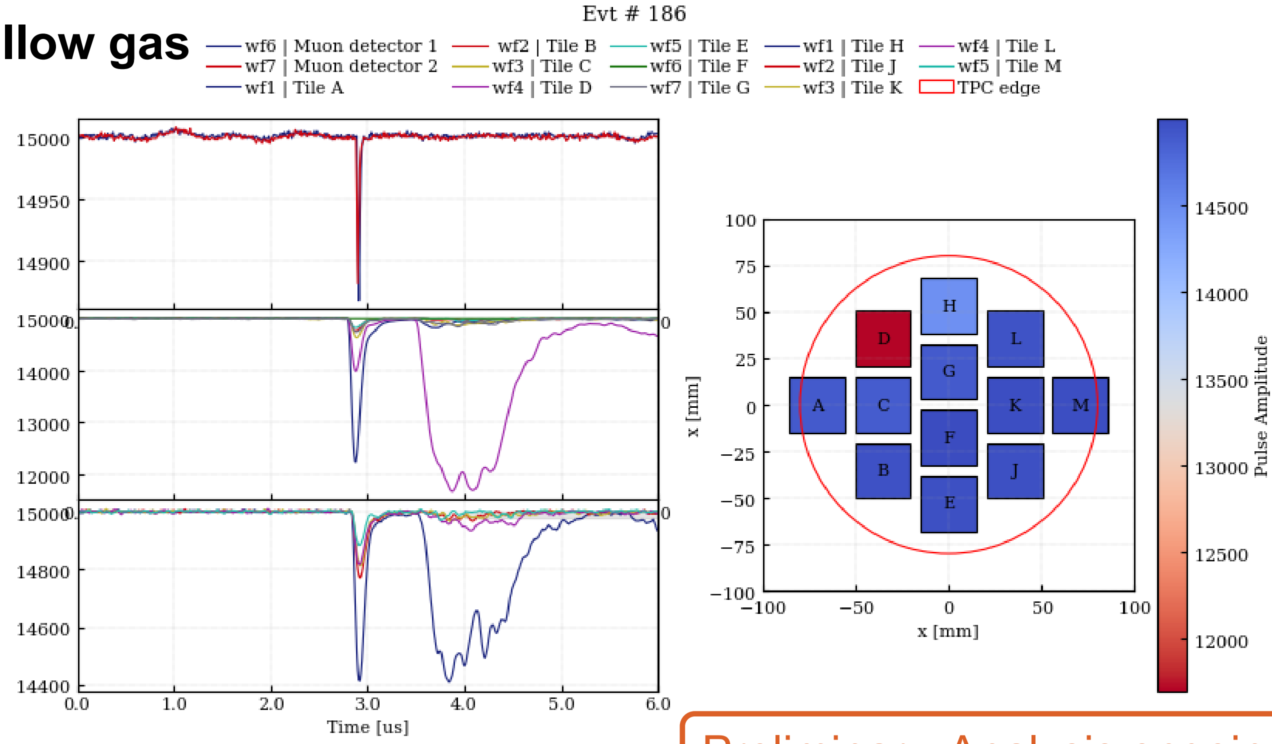
First science run (April - end of June 2025)

Further improvements in the gas system to allow gas purification:

- Particulate filter
- New connections in the xenon compressor
- **Getter ON** (PS4-MT50-R-535 by SAES)

Details:

- Run from beginning of April until end of June
- Gas circulating at 50 slpm
- Drift field of ~100 V/cm, extraction field of ~7 kV/cm
- Data from muon coincidence, xenon lamp and radioactive sources

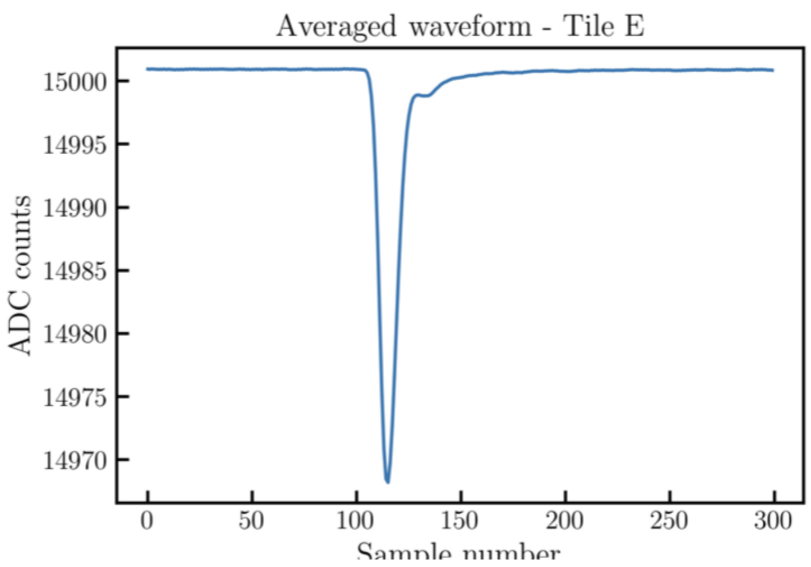


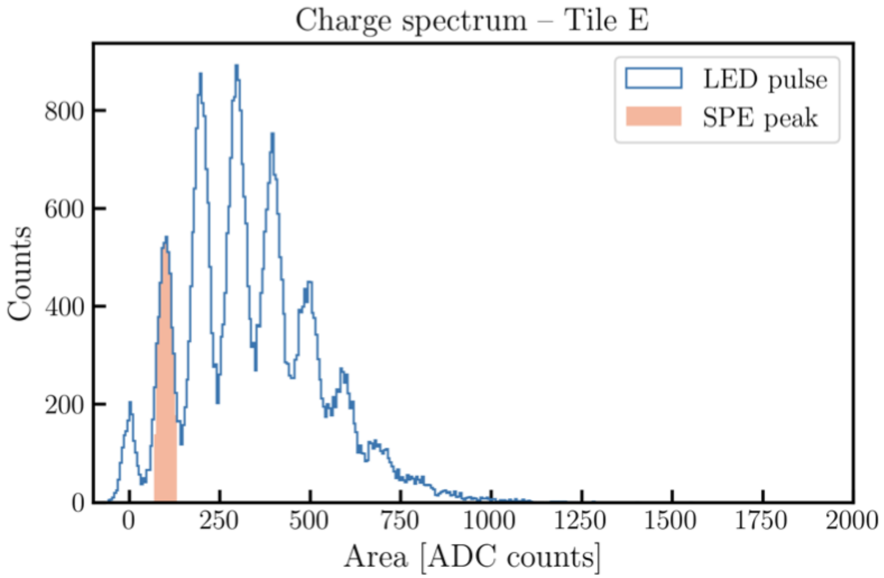
Preliminary. Analysis ongoing

Gold coated disc (fused-silica substrate)

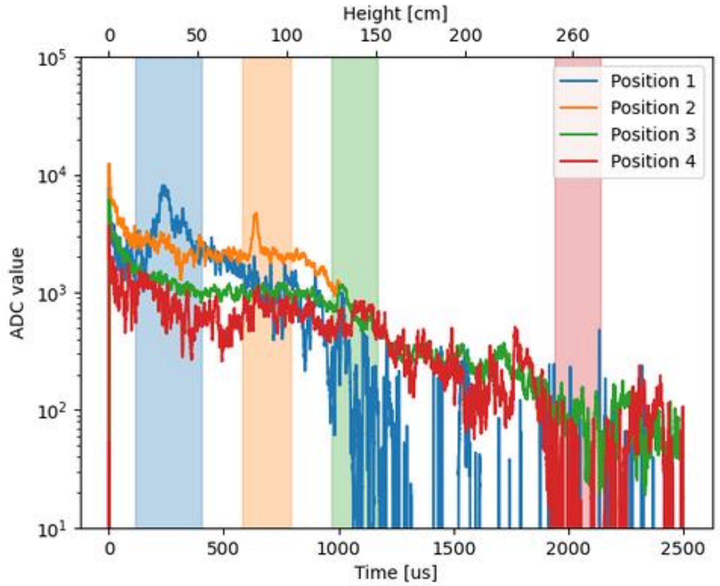
~10^6 electrons/s

Very preliminary plots





LED calibration



Muons

Analysis ongoing (Sana and Rebecca are taking care of this)

Near future plans

Further upgrades to be implemented:

- A chiller for the xenon compressor (safer gas circulation)
- Structural upgrades (planned for 2026): buffer volumes, filters, new weir, tighter HV feedthrough
- New electrodes

Optical measurements

- Array of photosensors is going to be designed and installed at the bottom part of the detector (2026)
- HALO monitor: used to monitor traces of moisture in GXe

More about optical measurements

Configuration A: xenon group velocity

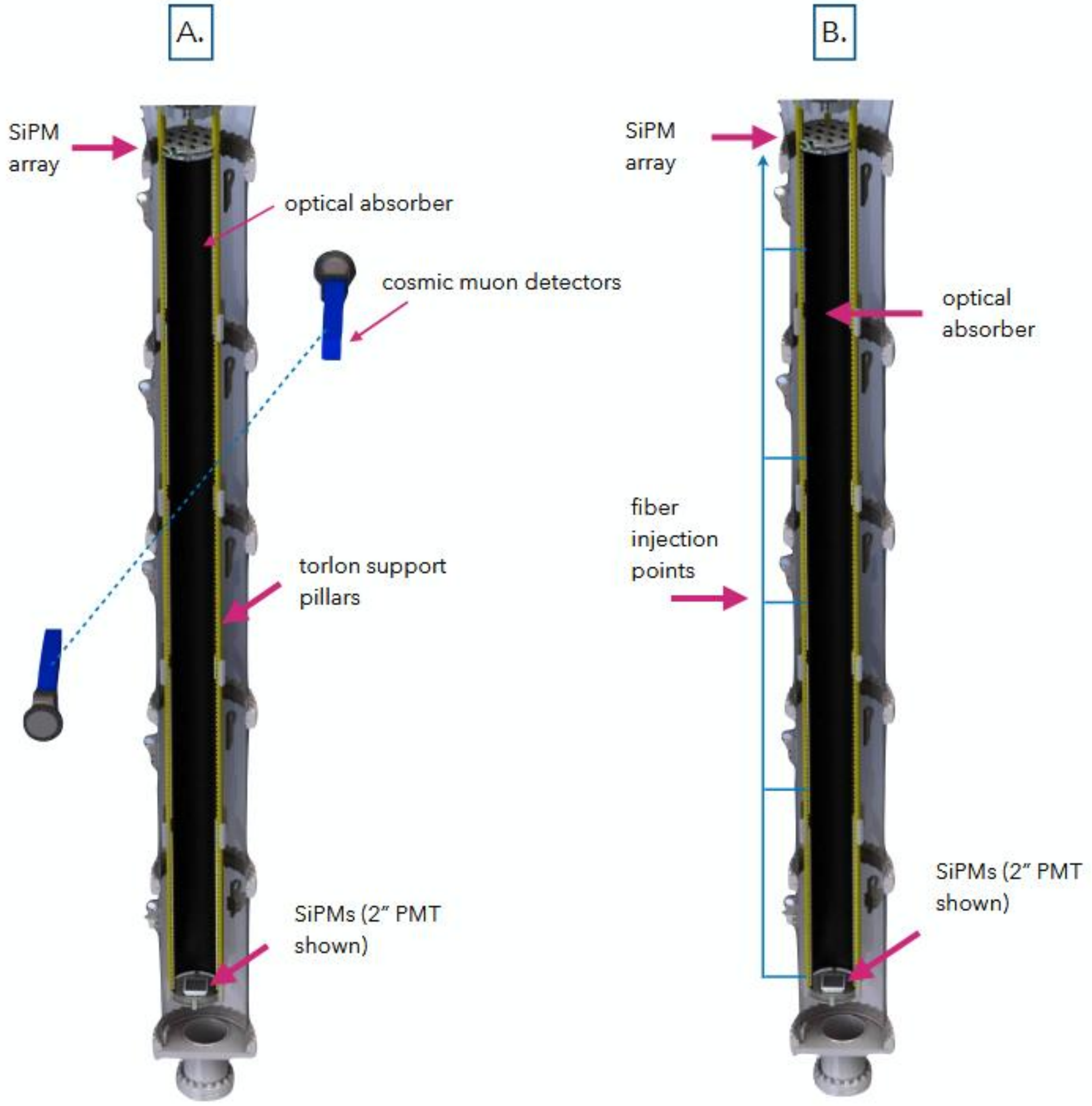
- Hodoscope using muon detectors as trigger
- Measure difference in arrival time and path lengths to photosensors at various heights
- Scintillation light group velocity (v_g) extracted from linear fit
- Refractive index (n) of LXe derived from parameterisation at 175 nm:

$$v_g = \frac{c}{n - \lambda \frac{dn}{d\lambda}}$$

- Measure Rayleigh scattering length (from n)

Configuration B: other measurements

- Measure total attenuation over 2.6 m
- Independent measurement of refractive index by varying injection point in TPC



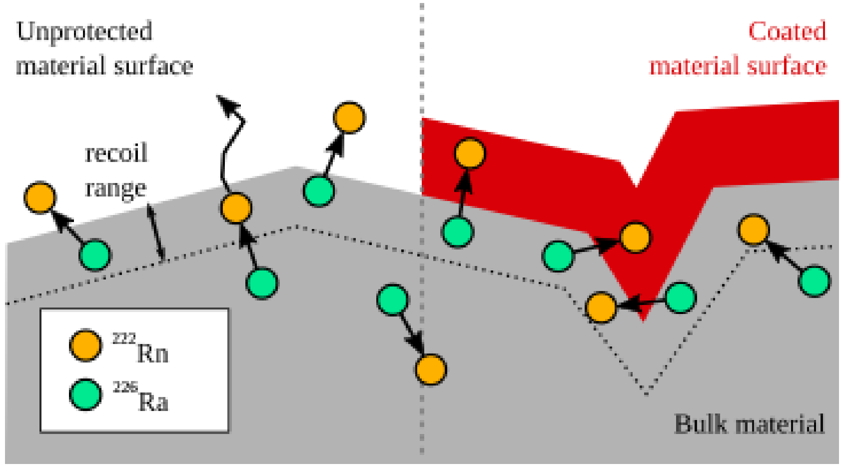
M. Babicz, et al 2020 JINST 15 P09009 (LAr)

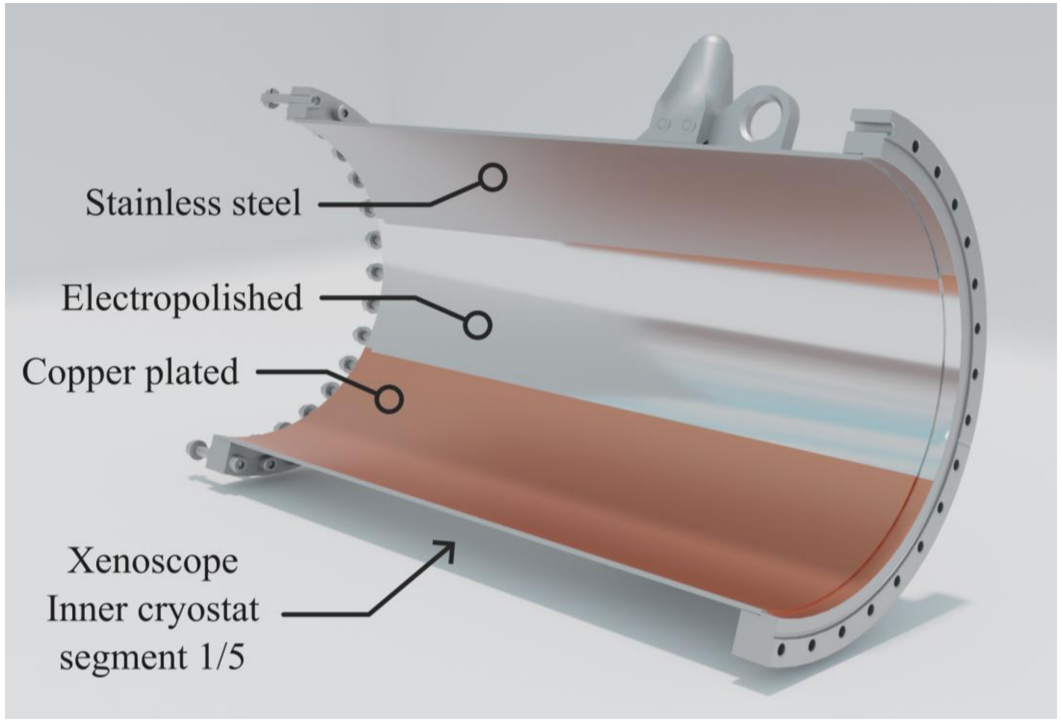
Future plans

Tests of surface coatings in Xenoscope

UZH-Max Planck Institute for nuclear physics Heidelberg (MPIK) joint effort

- Test of radon mitigating coating layers developed at MPIK Heidelberg
- Verify compatibility with cryogenic environment (UZH)
- Check if purity demands of LXe detectors are fulfilled (MPIK+UZH)
- Multi-staged test programme towards applicability of this technique in future LXe experiment. Several tests are currently carried out at MPIK
- Xenoscope offers an ideal testbed allowing for the final validation of the method.



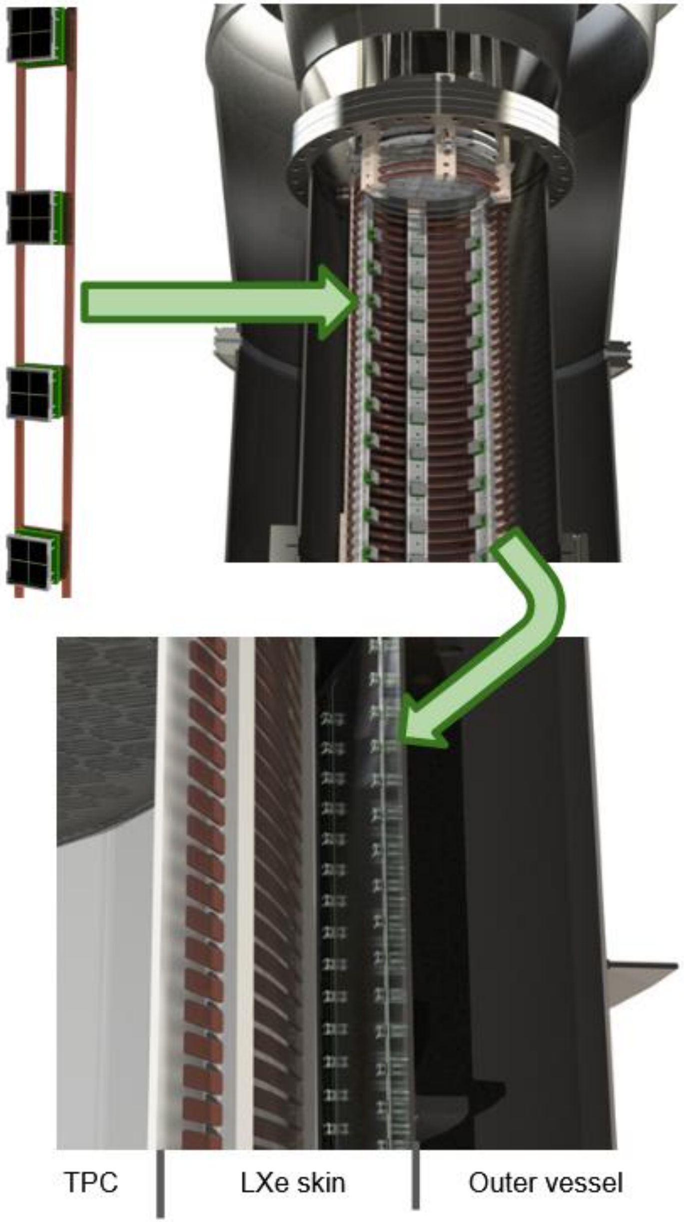


Future plans

Open platform for XLZD collaboration

UZH-Imperial joint effort

- Characterise LXe skin solutions in-situ (LXe)
- Test of SiPM alternative solution (mid 2026)
- Perform complementary light attenuation measurements
- Determine necessary/possible improvements on sensors, cold-electronics readout design, air-side electronics, and data handling

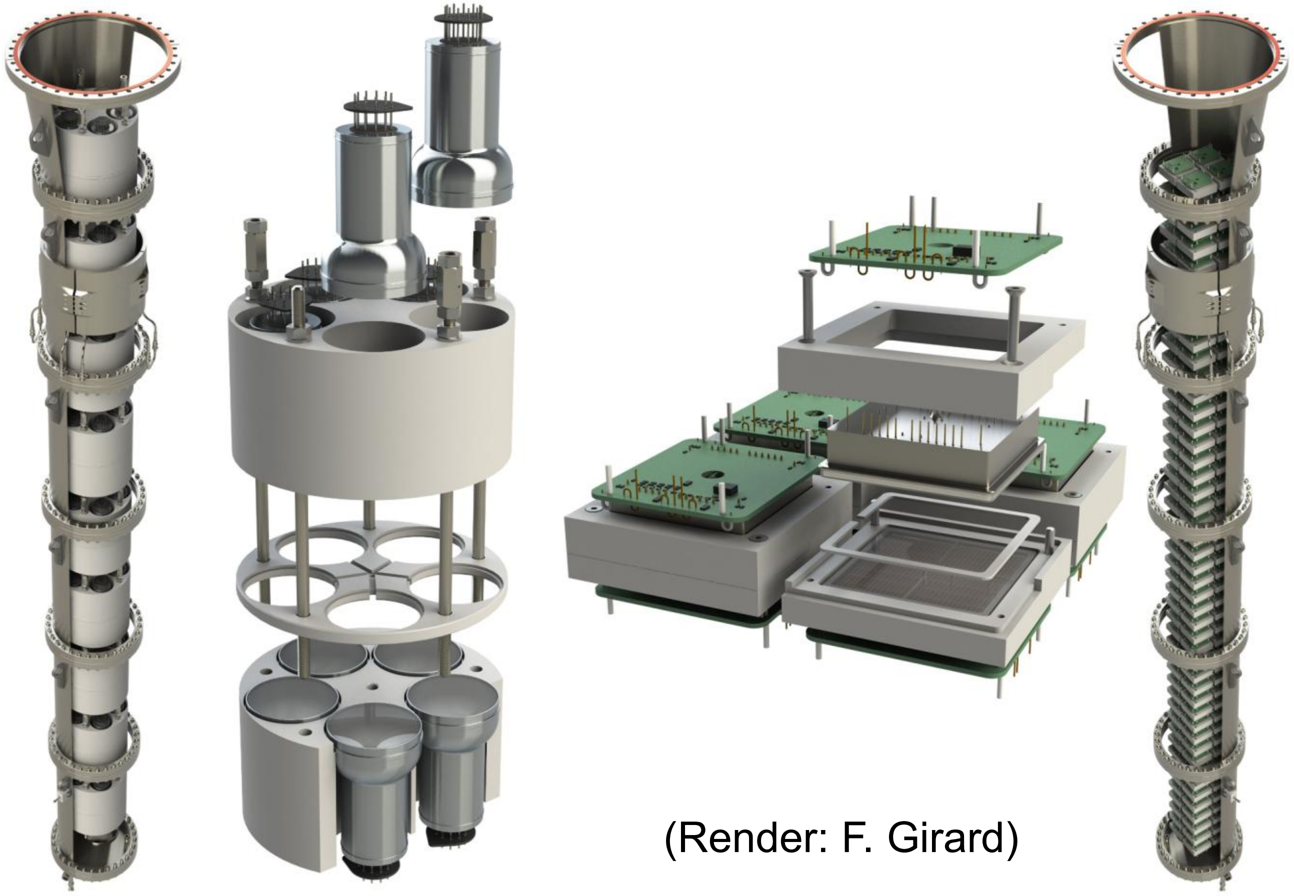


Large-scale PMT tests in Xenoscope

A large-scale detector, such as the planned for the future XLZD, requires about 2000 photosensors, ergo

a huge characterisation campaign

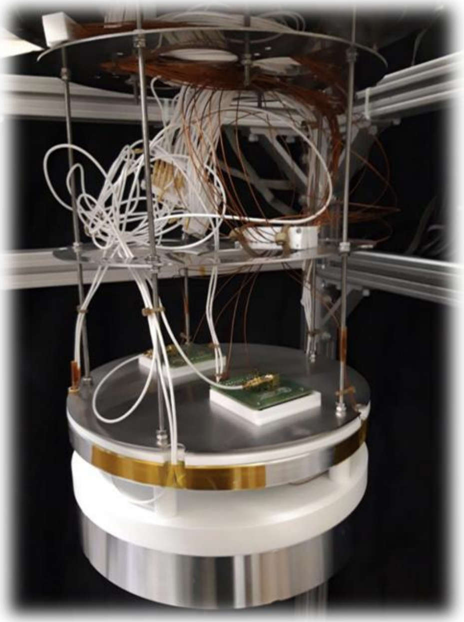
- The Xenoscope cryostat could be converted into a large-scale testing facility
- It can be used not only for testing 2” and 3” PMTs, but also to test SiPMs



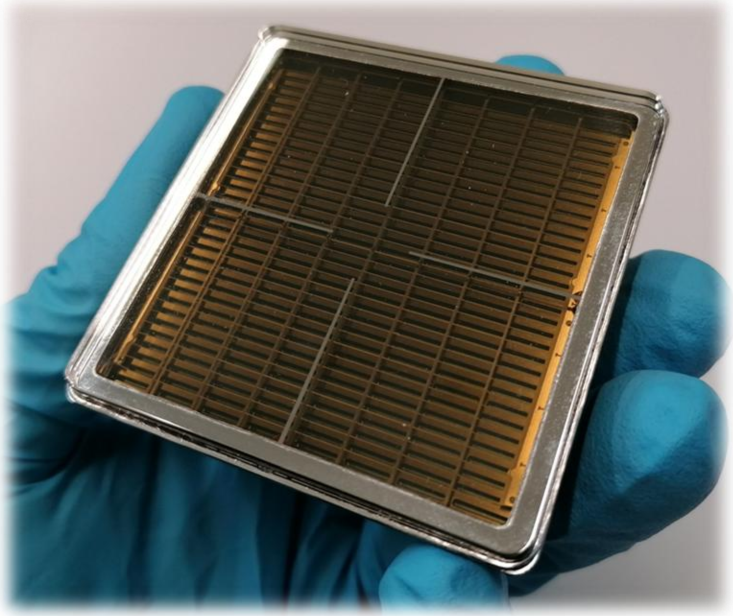
(Render: F. Girard)

Other tests in parallel to Xenoscope

- At UZH, we have a smaller setup to test and characterise photosensors in a liquid xenon environment: MarmotX



- R12699-406-M4 square 2” PMT from Hamamatsu
    1. Low profile, less buoyancy
    2. Sub-ns rise time
    3. Fast afterpulses
    4. 75% active photocathode area
    5. Up to 4 anode readout

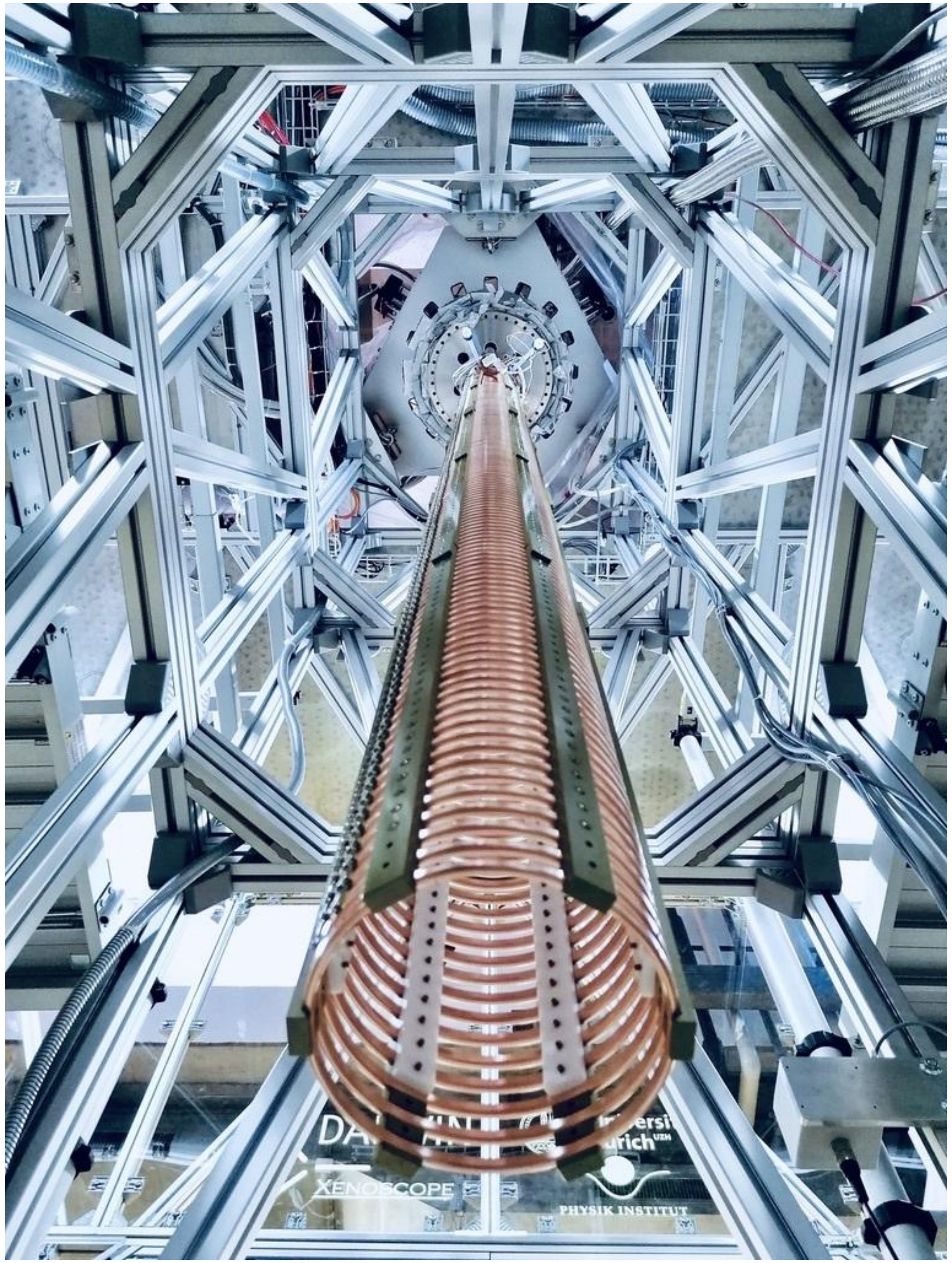


Paper in arXiv (submitted to JINST)

More detectors coming soon!

Summary

- We have built Xenoscope, a large-scale XLZD demonstrator
- Successful commissioning and (just finished) first science run with the 2.6-m tall TPC
- New upgrades are going to be implemented to make the gas circulation safer
- For the future, measurements of the optical properties of xenon, new coating techniques and studies of calibration sources are planned



The team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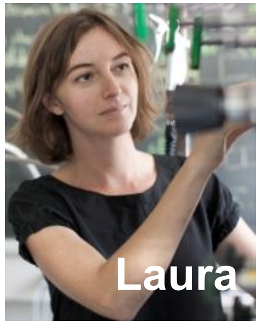
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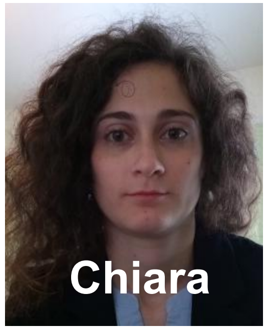
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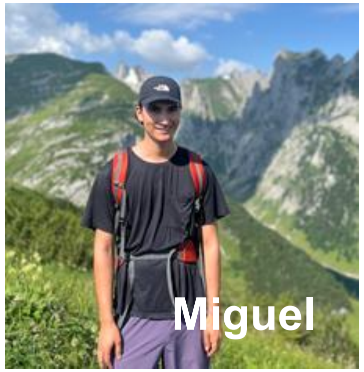
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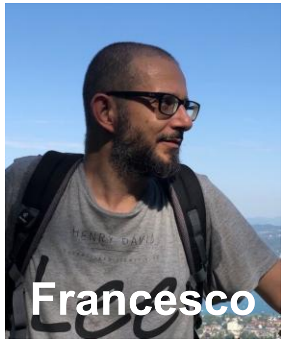
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