Xenoscope: a full-scale vertical demonstrator for the DARWIN observatory

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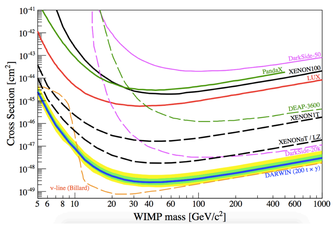
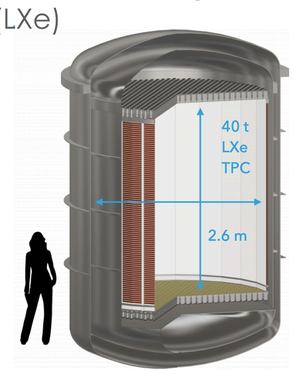
The future DARWIN observatory



- Proposed next generation **dark matter detector**
- Search for WIMPs with unprecedented sensitivity above 5 GeV/c^2 [1]
- Two-phase TPC: 2.6 m Ø, 2.6 m height
- **50 t** of liquid xenon (LXe)



Multi-tonne scale LXe TPCs require R&D test platforms

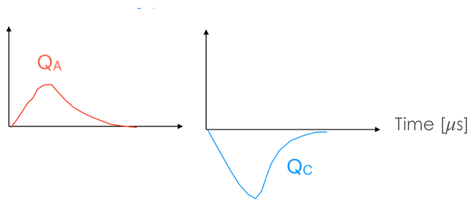
- **Full scale vertical demonstrator at UZH [2]**
- Full scale horizontal demonstrator at Uni Freiburg

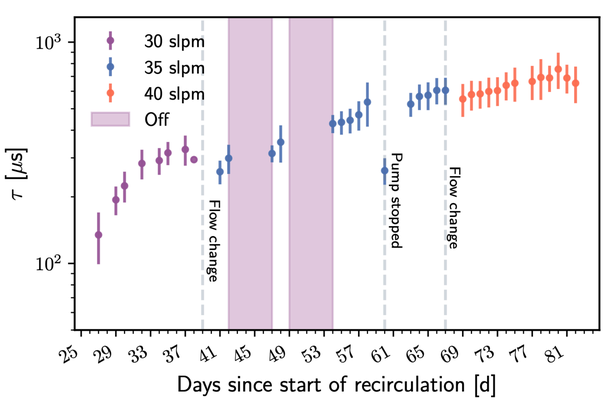
Goal: Test full-size detector subsystems under real conditions in LXe

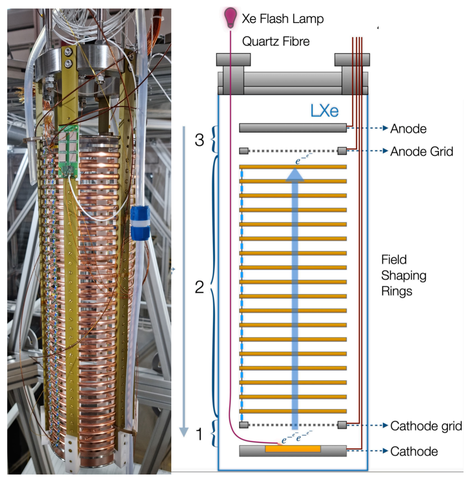
Phase 1: Purity Monitor

Goal: Investigate the LXe purity as a function of the recirculation speed

- Drift length: 53 cm
- In-house made thin film Au photocathode
- Pulsed xenon flash lamp (Hamamatsu L7685)
- Charge readout on top (Q_A) and bottom (Q_C)







- Waveforms acquired by oscilloscope and ADC
- Charges are obtained from integrals of the current pulses
- Ratio of signals proportional to the e-lifetime τ_e

$$\frac{Q_A}{Q_C} = e^{-t_d/\tau_e} \qquad \tau_e > (660 \pm 50)\ \mu s$$

PM was successfully operated under stable conditions for more than 70 days

The Xenoscope R&D platform

Proof of principle: **electron drift** over **2.6 m** LXe. To achieve this goal, the system requires:

- Excellent Xe purification system
- Efficient High-Voltage system
- Electric field uniformity

Main R&D projects:

- Custom-made HV distribution
- Electron cloud diffusion
- Light attenuation measurements
- Test of various light sensors

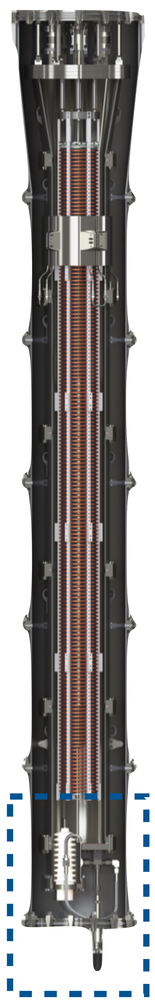
Measurement campaign in 2 stages

Phase 1: 53 cm Purity Monitor — Spring 2022

Phase 2: 2.6 m Dual-phase TPC — 2023

Towards the 2.6 m TPC

For the following phase the PM will be converted to a two-phase xenon TPC
Three major upgrades will be implemented:



1. **SiPM array:** The proportional scintillation light will be observed by 192 6×6 mm^2 SiPMs arranged in tiles of 16 units

2. **Liquid gas interface and level control:** One long and three short capacitive level meters will enable real-time monitoring of the liquid level in the TPC as well as a precise measurement and setting of the liquid-gas interface height

3. **HV system:**

- **Generation of the nominal voltage (~ 50 kV)**
- **Safe transmission from the power supply to the cathode**
- **Stable operation at the max. allowed voltage (100 kV) and under cryogenic temperature and pressure conditions**

Cup & spring mechanism — Custom-made connection to the cathode

Vacuum-to-LXe feedthrough — Commercial ceramic FT welded on a DN125CF flange

Air-to vacuum feedthrough — Heinzinger HV cable cryofitted to a custom DN40CF flange

Stay tuned for upcoming results!

References:

[1] DARWIN collaboration, J. Aalbers et al., DARWIN: towards the ultimate dark matter detector, JCAP 11 (2016) 017.

[2] L. Baudis et al., Design and construction of Xenoscope – a full-scale vertical demonstrator for the DARWIN observatory, JINST 16 (2021) P08052.

[3] DARWIN Collaboration., Aalbers, J., Agostini, F. *et al.* Solar neutrino detection sensitivity in DARWIN via electron scattering. *Eur. Phys. J. C* 80, 1133 (2020). https://doi.org/10.1140/epjc/s10052-020-08602-7

[4] Agostini, F., Maouloud, S.E.M.A., Althueser, L. *et al.* Sensitivity of the DARWIN observatory to the neutrinoless double beta decay of ^{136}Xe. *Eur. Phys. J. C* 80, 808 (2020). https://doi.org/10.1140/epjc/s10052-020-8196-z