High Voltage Feedthrough for the DARWIN demonstrator

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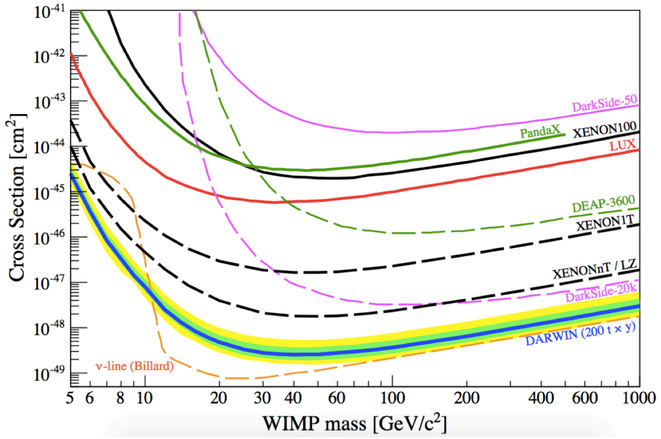
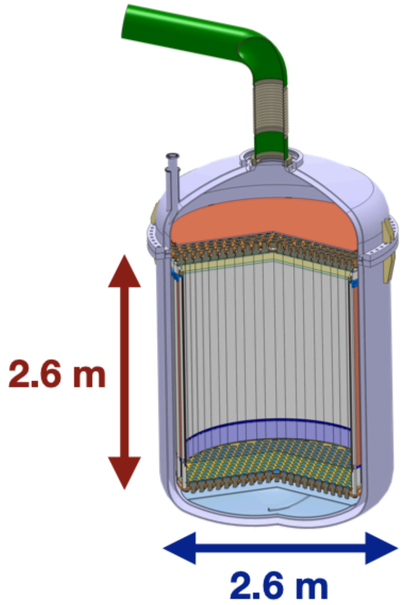
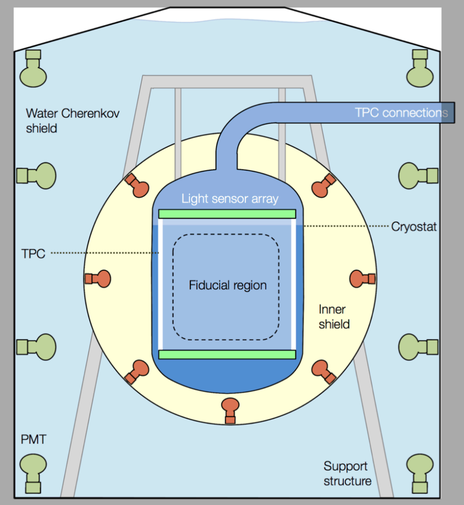
DARWIN (**DAR**k matter **WI**mp search with liquid xeno**N**)





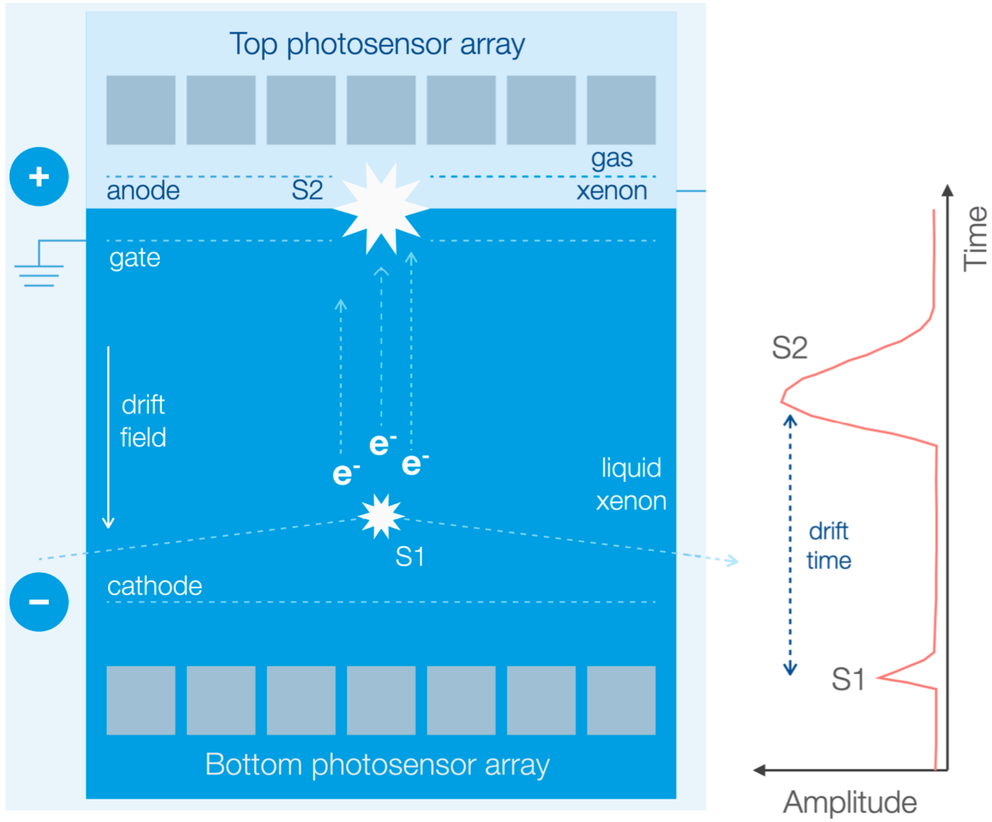
- Proposed next generation dark matter detector
- Goal: design and construct the **ultimate dark matter detector** aimed to search for WIMPs with unprecedented sensitivity above 5 GeV/c^2 [1]
- Baseline design: dual phase TPC featuring
  - 50 t (40 t active) of LXe
  - 2.6 m diameter x 2.6 m height
  - Two arrays of PMTs
  - Low background cryostat
  - Surrounded by highly reflective PTFE walls
  - Muon & neutron veto



1: arXiv:1606.07001 **[astro-ph.IM]**

DARWIN

- Dual-phase LXe TPC
- Working principle: A particle recoils with LXe atoms, this produces
  - Scintillation light and ionisation electrons
  - Photosensors detect **prompt scintillation light (S1)**
  - Ionisation electrons are drifted under the influence of an electric field along z-axis towards gas phase.
  - Extracted electrons produce electroluminescence
  - Photosensors detect the delayed **proportional scintillation light (S2)**
- Technological challenges at the 2.6 m scale must be first addressed
  - Cryostat and shield design, charge and light readout, purification and storage of noble liquids, HV systems, ultra low radioactivity materials

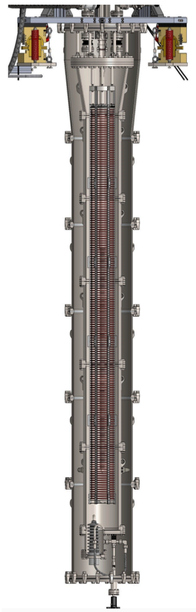


Designing and building a multi-ton scale detector requires R&D test platforms

Xenoscope (DARWIN vertical demonstrator)

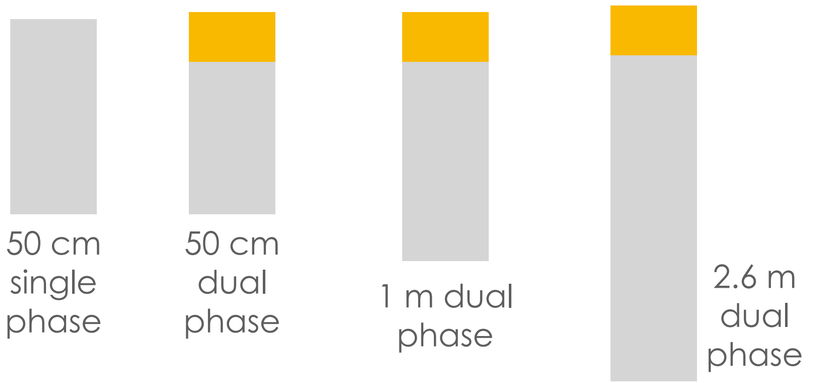
- Full-height R&D platform at UZH
- Operated in three stages:
  1. Purity monitor (PM)
  2. 1.0 m tall TPC
  3. 2.6 m tall TPC
- The main goal is to show electron drift over 2.6 m, this requires extremely **high purity** and a strong electric field (efficient **high voltage** system)
- Some R&D projects:
  - Test **HV systems** (Hardware PhD project)
  - Test xenon purification systems
  - Test SiPM array
  - ..

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



University of Zurich[UZH]

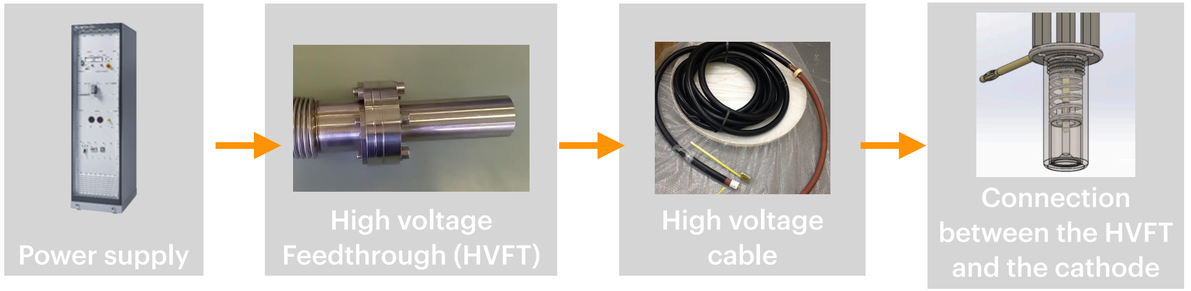
DARWIN demonstrator facility at UZH

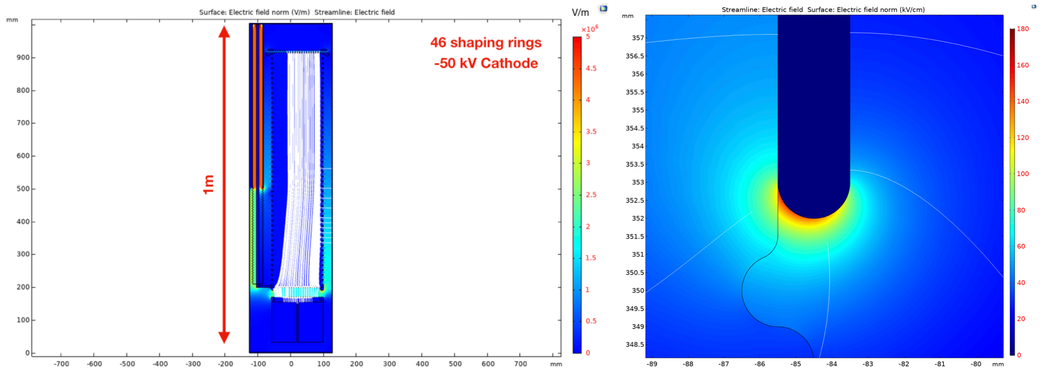


Commissioning phases

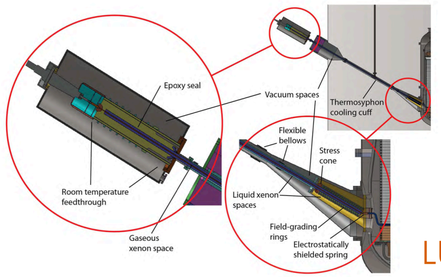
HV FT concept

- High voltage system:
  - Generation of the nominal voltage
  - Safety transmission from the power supply to the cathode
- HV must be feed though a vacuum tight flange into the cryostat
  - Hermetically-sealed
  - Optimised to avoid unwanted mechanisms affecting the detection process: EF distortion, critical field regions, etc.
- For LXe TPCs, there are several approaches:
  - LUX/LZ- from the side
  - nEXO- from the bottom
  - XENON1T/nT from the top



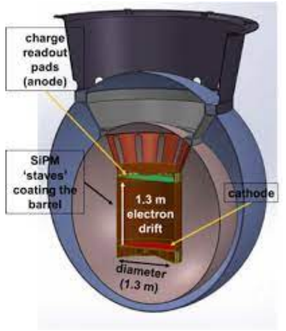


Left: EF distortion. Right: High field region at the ground termination of the FT.



LUX

XENON1T

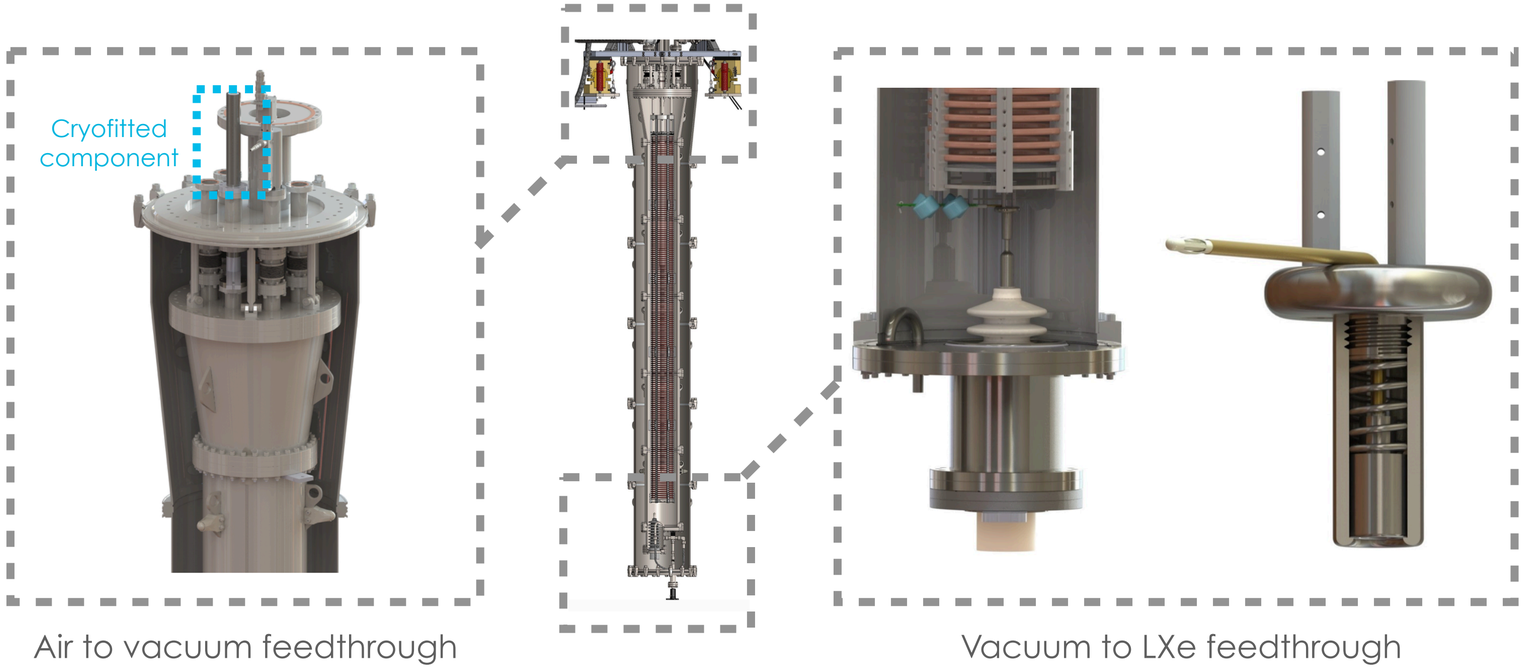


nEXO

HV status for Xenoscope

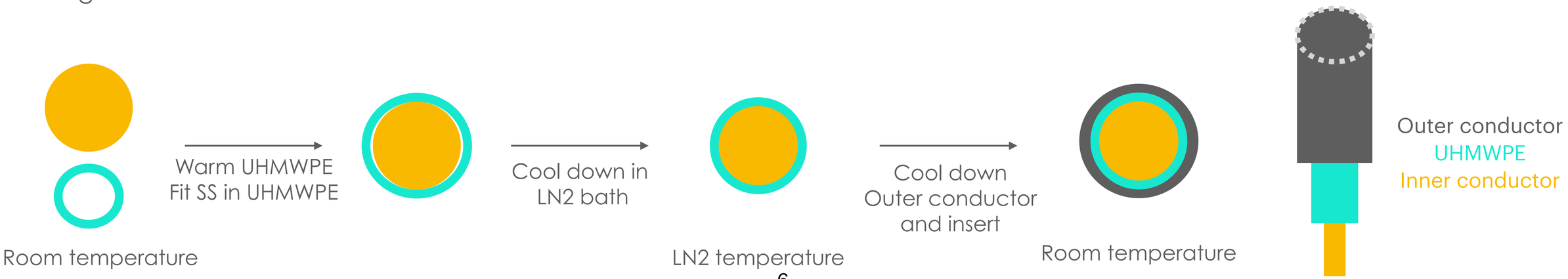
- Mechanical design consists of
  - Cryofitted Air-to-vacuum FT
  - HV cable
  - Vacuum to LXe FT: CeramTec entering the TPC via the bottom flange
  - Spring & cup system to connect to the cathode
- Cryofitting

Tight tolerance fit through contraction/ expansion under cryogenic temperature changes



Air to vacuum feedthrough

Vacuum to LXe feedthrough



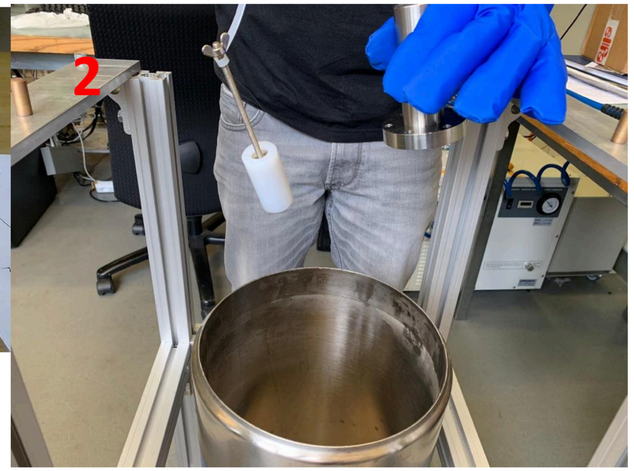
Room temperature

LN2 temperature

Room temperature

HV status for Xenoscope

- Cryofitting proof of principle tests



Cryofitting Tower at Darwin demonstrator facility

- Cryofitting tower is a vacuum insulated long thin tube, filled with LN_2 from the bottom
- Capable of fitting various sizes of HV rods

- Cryofitting air to vacuum feedthrough
- Testing air to vacuum FT
  - Check vacuum tightness
  - Plugging in HV power supply and test feedthrough
- Assembling vacuum to LXe FT

Summary and outlook

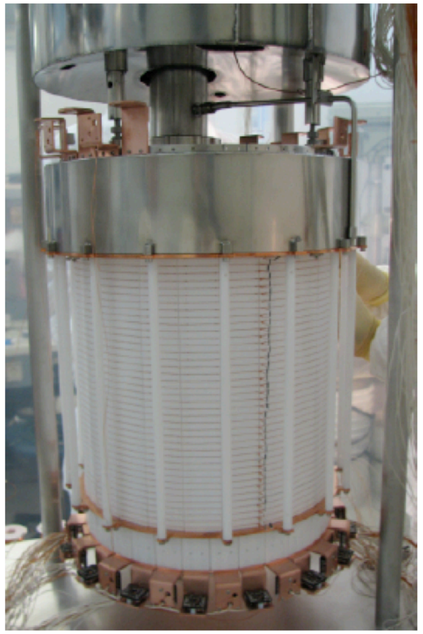
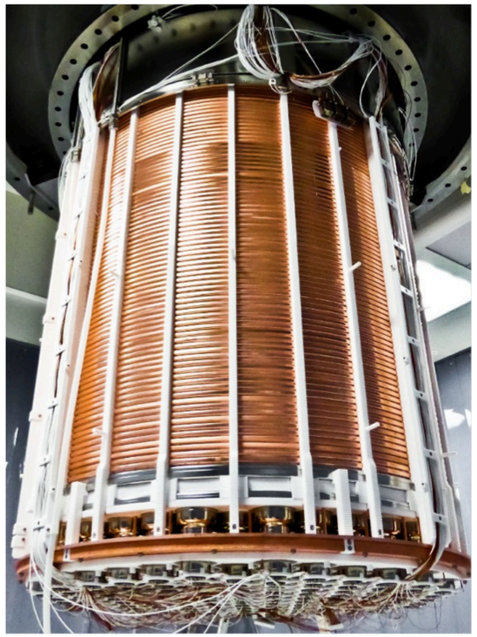
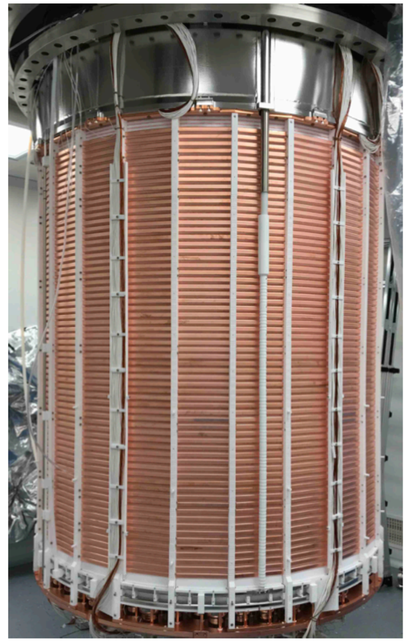
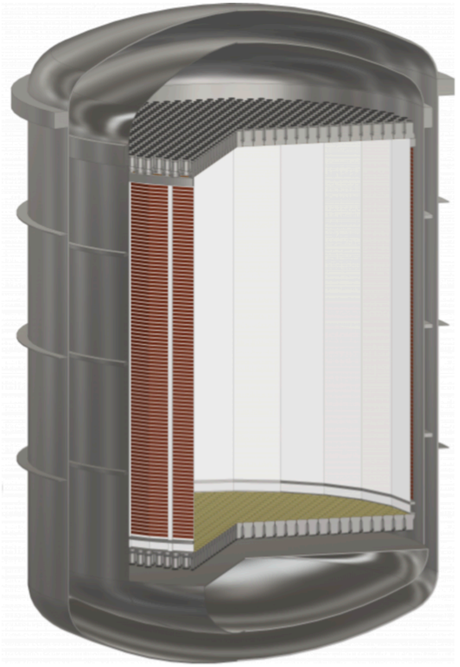
- **DARWIN** will be the next generation dark matter detector
  - Aimed to provide excellent sensitivity in dark matter search
  - Features a **dual-phase TPC** located in ultra low background conditions
- R&D full-height demonstrator ongoing
  - SiPMTs
  - Xe purification
  - HV systems
- Xenoscope is aiming to provide a proof of principle for electron drift over 2.6 m in LXe
  - Excellent purity
  - Strong electric field
- At present, cryofitting is a promising technique suitable for the high voltage feedthrough of the DARWIN demonstrator.
  - Requires to be exhaustively tested at Xenoscope
- This facility will be accessible to all DARWIN collaborators to test instruments and technologies at the DARWIN scale

Thank you for your attention

Back up

Comparison to previous DM detectors

XENON10 XENON100 XENON1T XENONnT DARWIN

2005 - 2007	2008 - 2016	2012 - 2018	2020 - 2025	2027
15 kg	161 kg	3200 kg	8400 kg	50 t
15 cm	30 cm	96 cm	150 cm	260 cm

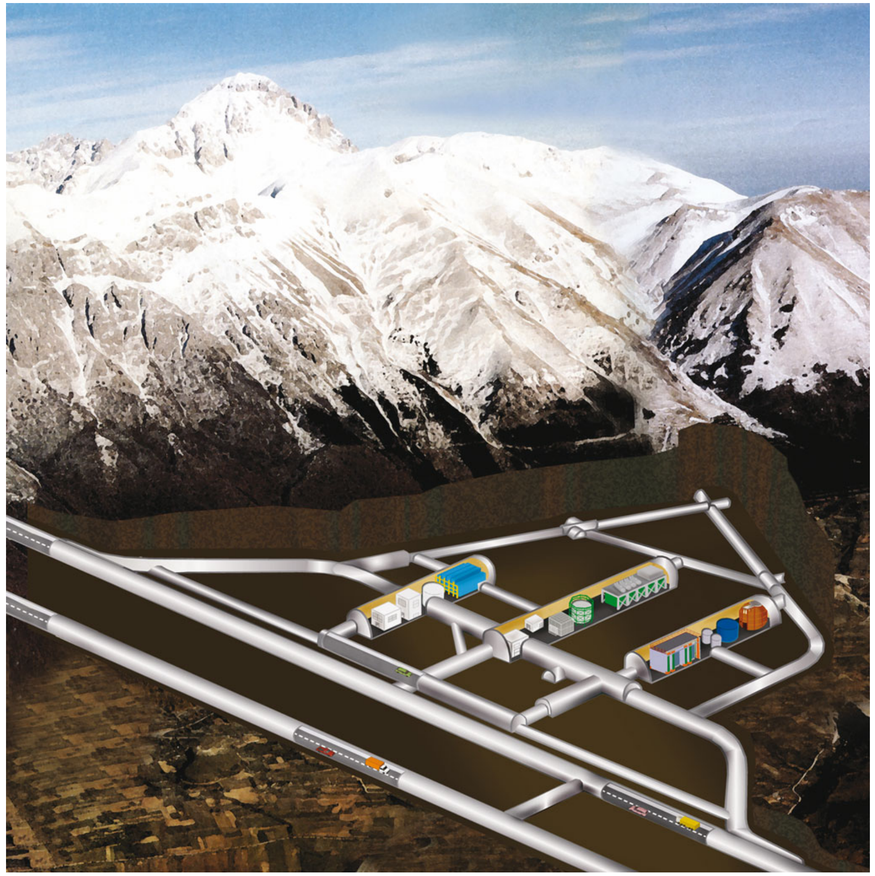
Background sources at Xenoscope

Cosmigenic

- Mainly from muons
- Typically reduced by placing the detector deep underground
- Master thesis ongoing to study double coincidence cosmic muon events

Radiogenic

- From α-, β-, and γ-decays of radioactive isotopes near/in the detector.
- Master thesis on the
- Typically reduced by carefully selecting and screening materials and purifying liquid xenon



Commissioning phases

- 50 cm single phase
- Signal comes from a photocathode
- Only charge induced in electrodes is acquired

- 50 cm dual phase
- Signal comes from a photocathode
- SiPM array at the top
- Charge and scintillation in gas phase can be acquired

- Same but 1 m dual phase

- Same but 2.6 m dual phase