

LPNHE  
PARIS



# Updates on XeLab

## R&T PROJECT ON XENON DUAL PHASE TPC



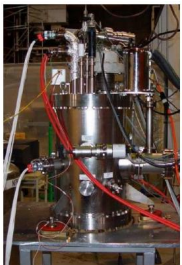
Yajing Xing, LPNHE - Sorbonne Université  
on behalf of the XeLab team

GDR DUPhy 2025 | 11-12 June | IP2I Lyon

# Xenon Time Projection Chambers

RARE EVENT SEARCHES - BIGGER, QUIETER

**XENON10**



14kg

**XENON1T**



~2t



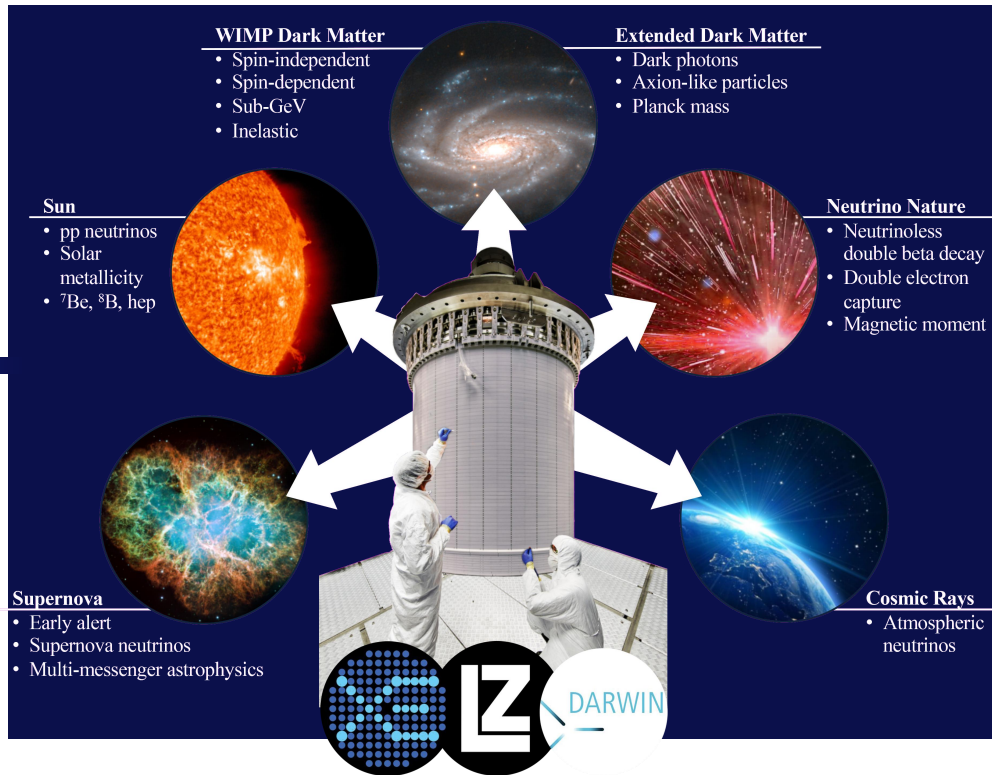
62kg

**XENON100**



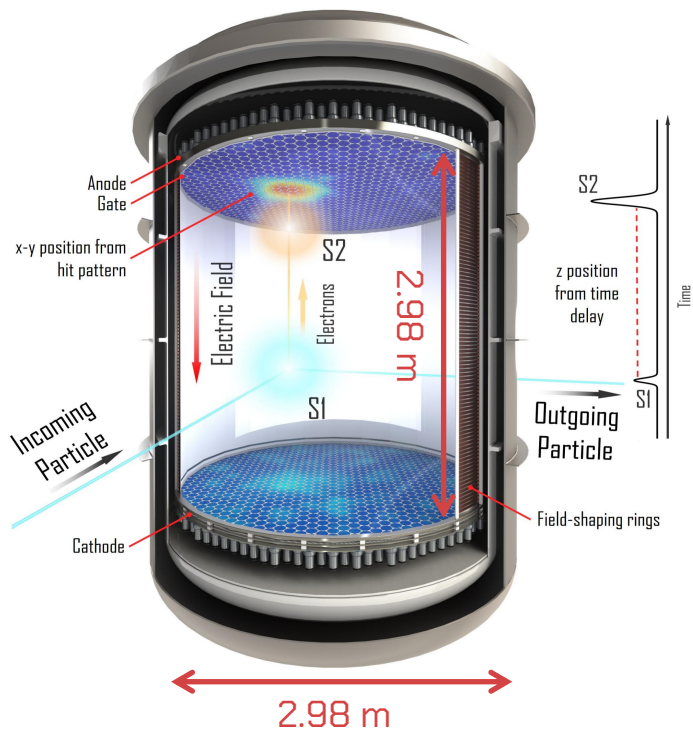
~6t

**XENONnT**



# XLZD – Upscaling challenges

SIZE MATTERS - 2X DRIFT HEIGHT & 2X DIAMETER

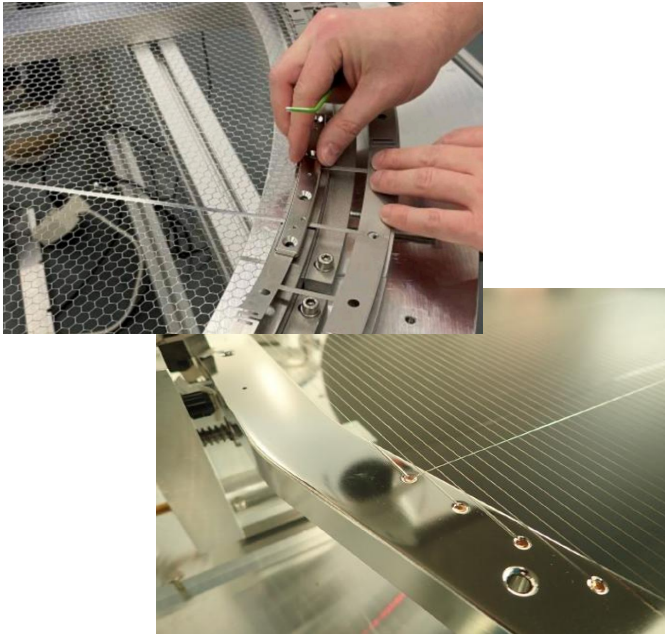


To optimise the performance

- Liquid xenon ultra-purity
- Optical transparency
- Electron extraction efficiency
- High S2 gain
- Uniformity on x,y position
- No electrical discharges [hot spots]
- Photosensor performance
- High voltage delivery
- Background mitigation
- ...

# XLZD – Upscaling challenges

SIZE MATTERS - 2X DRIFT HEIGHT & 2X DIAMETER



To optimise the performance

## Large Electrodes Development

- Optical transparency
  - Electron extraction efficiency
  - High S2 gain
  - Uniformity on x,y position
  - No electrical discharges (hot spots)
- Photosensor performance
  - High voltage delivery
  - Background mitigation
  - ...



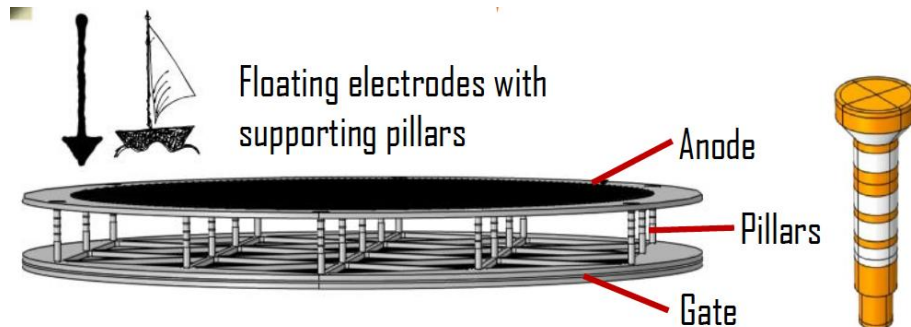
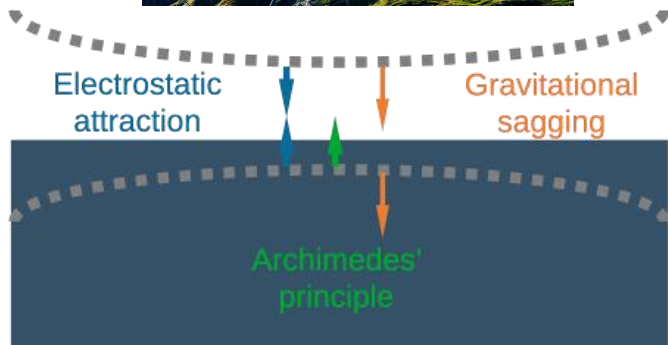
# R&T on electrodes with the XeLab Project

## SPACER-ASSISTED FLOATING ELECTRODE (SAFE)



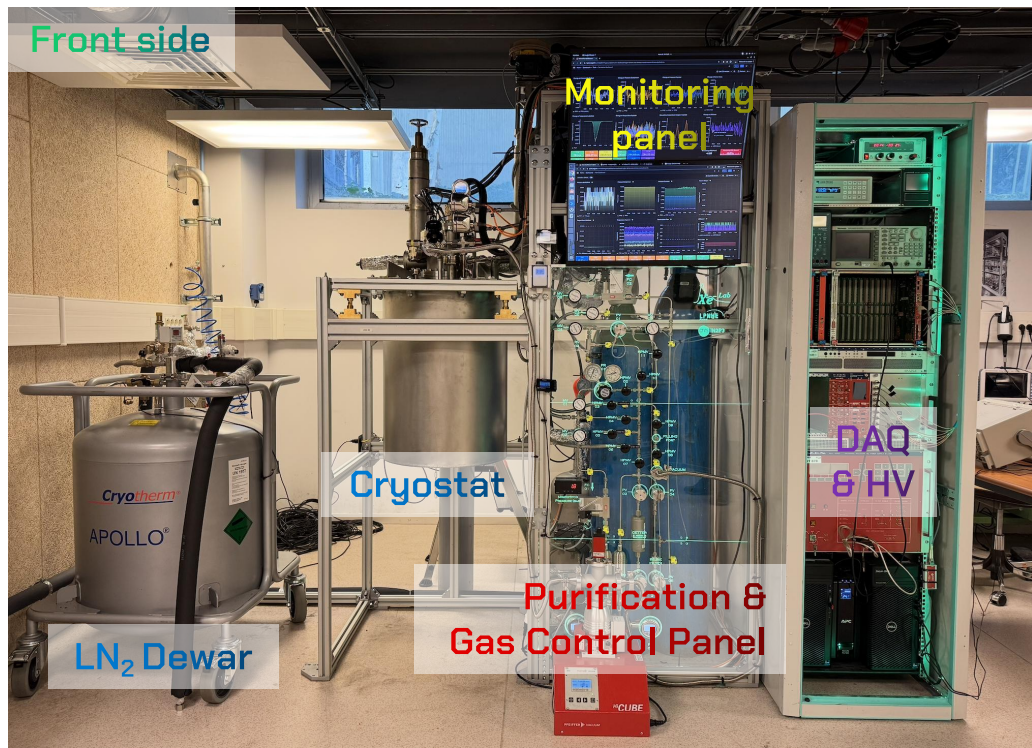
Challenge: Large electrodes with high optical transparency

Our Idea: “floating” electrodes with supporting pillars



# XeLab facility @ LPNHE

FIRST (&UNIQUE) SITE IN FRANCE WORKING WITH A XE DUAL-PHASE TPC



# Main cryogenic systems

FOR XENON OPERATION AND SAFE

## CRYOSTAT

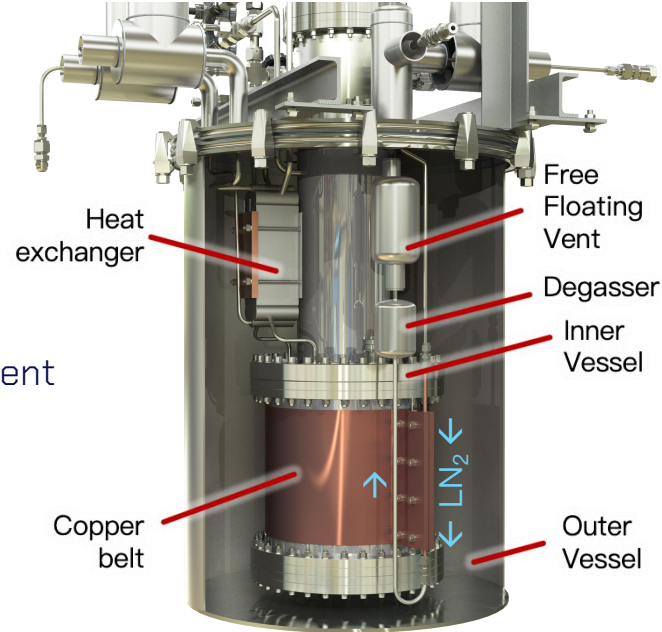
Vacuum insulated, double-walled

Main cooling mode: **copper belt**

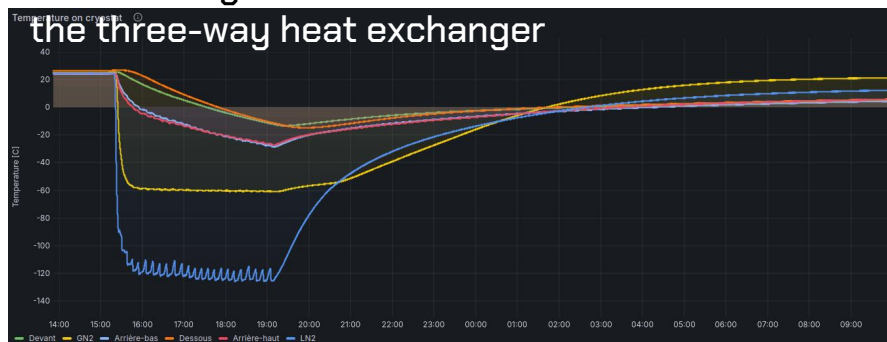
- LN2 from pressurized dewar
- Overflow prevention from free floating vent

Secondary cooling mode: **heat exchanger**

Temperature control from heating resistor



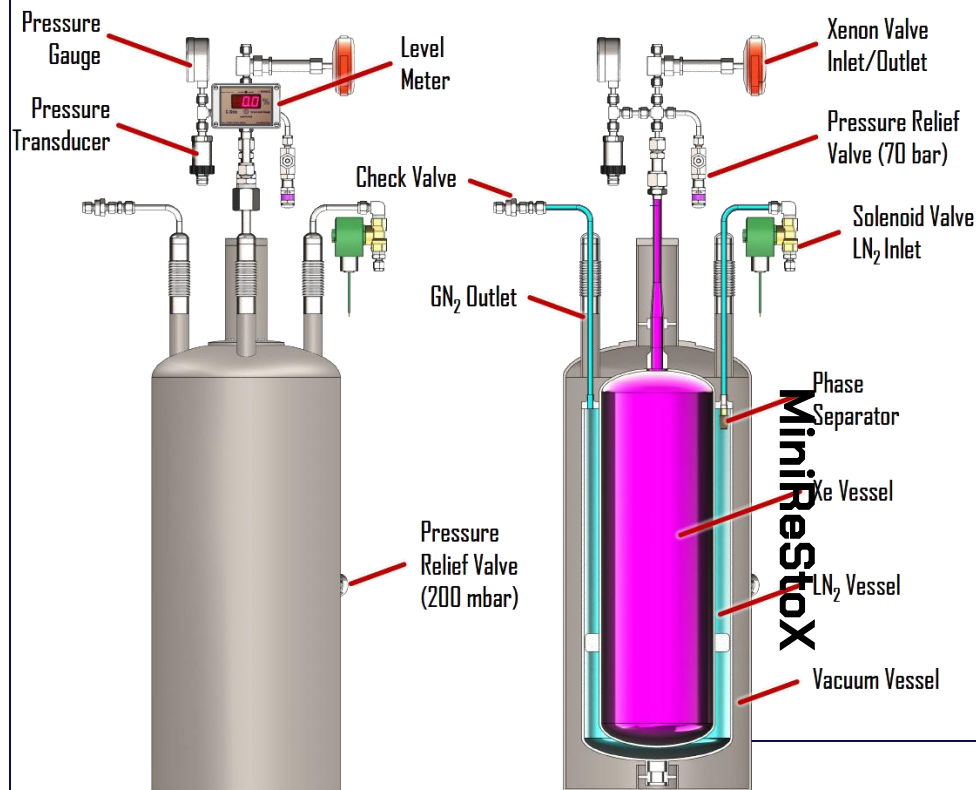
First cooling tests with  
the three-way heat exchanger





# Main cryogenic systems

FOR XENON OPERATION AND SAFE



## MiniReStoX

Xenon recovery and storage  
Three nested & vacuum-insulated vessels cooled by LN<sub>2</sub> (from 15,000 L reservoir)

Up to 70 bar Xe  
Cold during operation with instant recovery trigger

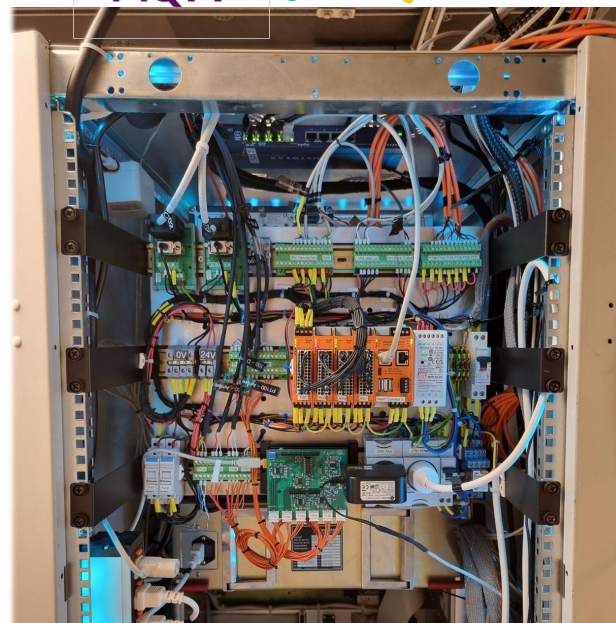
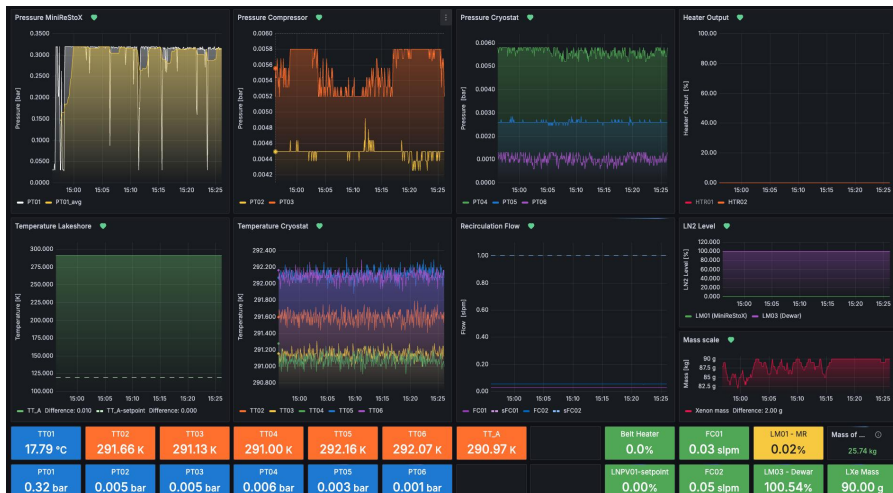




# Slow Control & Monitoring

## MULTI-INTERFACE R&D

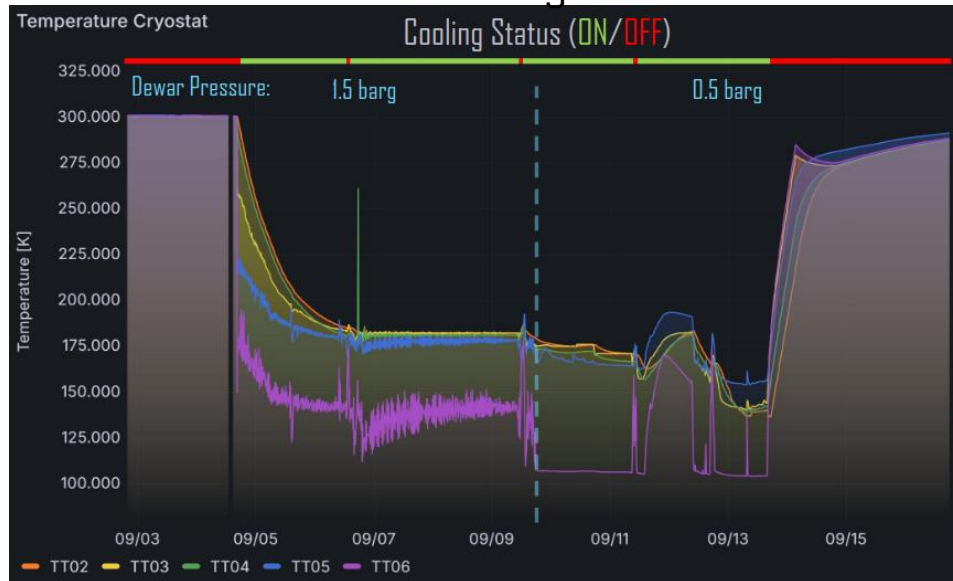
- Based on the **Revolution Pi** technology
- Home-made code (**CODESYS**)
- Home-made PT100 readout board
- **Python MQTT** broker to pull the data
- Storage in **InfluxDB** database
- Data Visualization with **Grafana**



# PRE-COMMISSIONING

## FILLING AND OPERATING WITH ARGON

Plot from our slow control system



September 2024

Run with 2 bar argon

- Duration: 9 days
- First liquefaction of argon
- Demonstration of continuous, stable operation

At 2 bar:

- TLAr = 94.29 K
- TLXe = 177.88 K

# Status Update | Milestones

## RELOCATION OF WORK CENTER FROM CRYOGENY TO TPC

### First LXe fill

Nov. - Dec. 2024

Successful completed

01



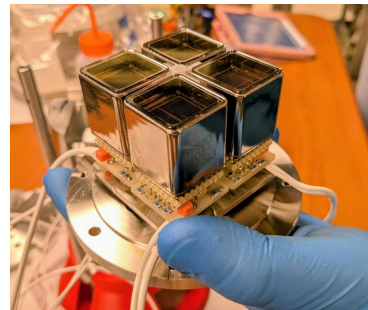
### TPC commissioning

Feb. - Apr. 2025

Checklist accomplished

03

DRD2  
IN2P3



02

### TPC delivery

27-28 Jan. 2025

Subatech Engineers

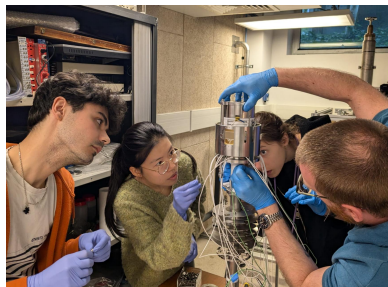


04

### PMT testing

May. - July. 2025

Two M2 Internships



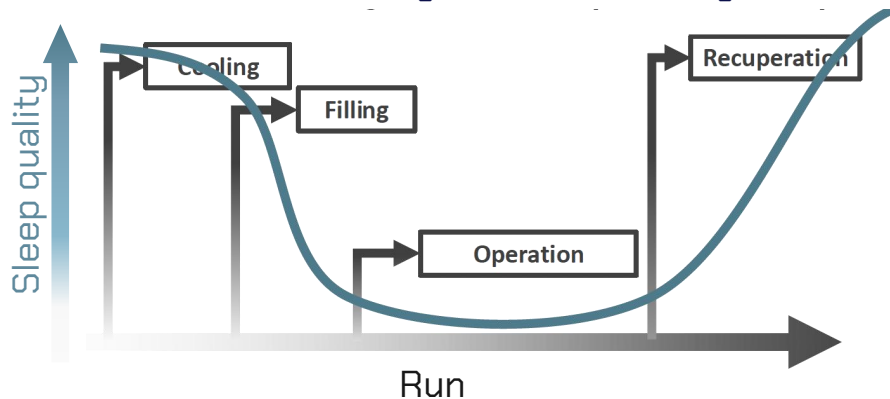
# Liquid xenon commissioning

CORRELATION WITH SLEEP QUALITY LOL...

November – December 2024

2 Runs completed with liquid Xenon

- 1<sup>st</sup> Run: 7.45 kg, run time 7 days
- 2<sup>nd</sup> Run: 10.95 kg, run time 5 days



Recuperation to the Xenon bottle



# Commissioning completed: first operations

System very predictable and responsive

Liquefy xenon ✓

Fill system with whole xenon ✓

Recuperation ✓

- cryostat → storage bottle
- cryostat → MiniReStox
- MiniReStox → storage bottle

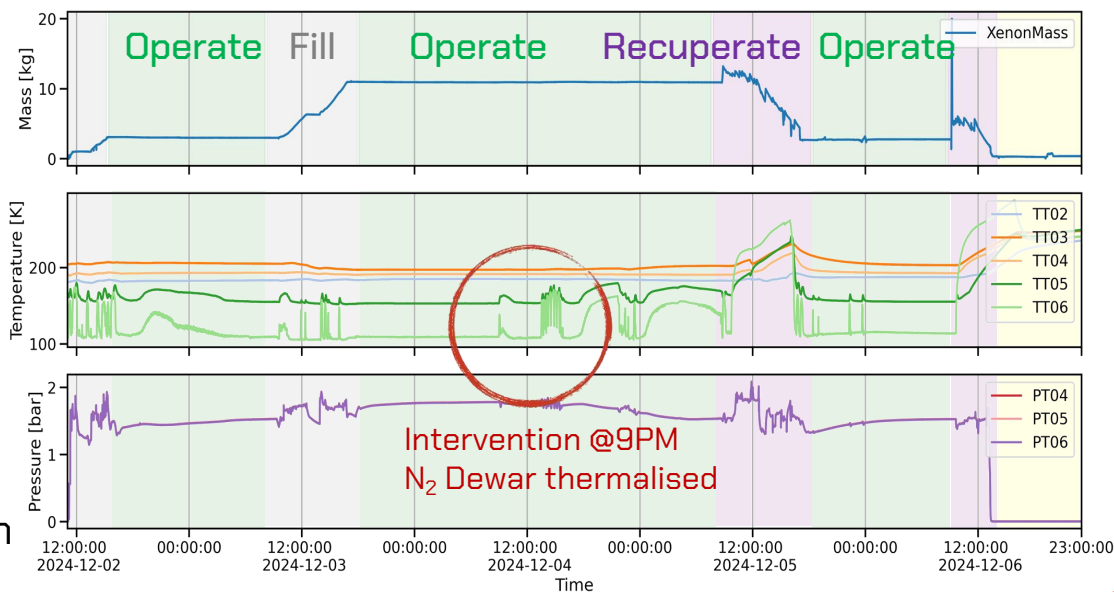
Stable operation ✓

No xenon losses ✓

Temperature stability  $\pm 5$  mK

Xe rate: fill  $\sim 2$ kg/h | recup.  $\sim 1$ kg/h

Run from Nov 29<sup>th</sup> – Dec 6<sup>th</sup>



# TPC delivery and installation

27-28 Jan. 2025

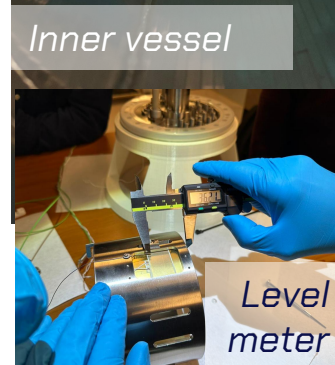
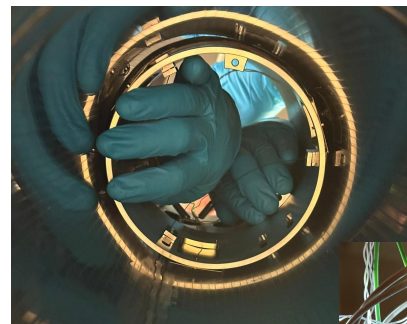
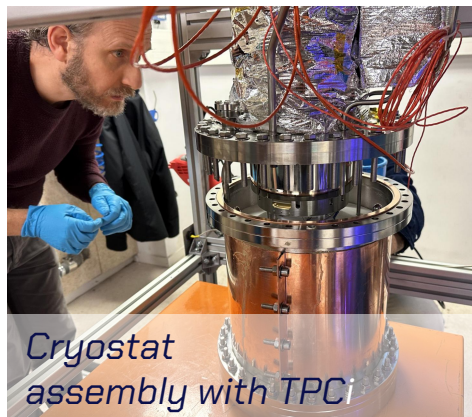


Subatech engineers

- Eric MORTEAU
- Patrick LE RAY

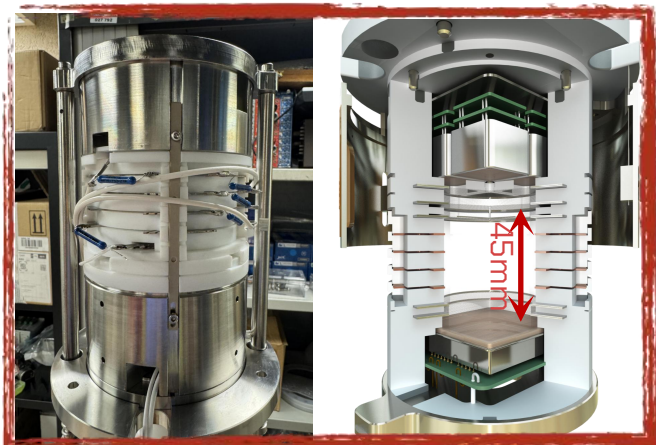
Visite LPNHE

Installation on site

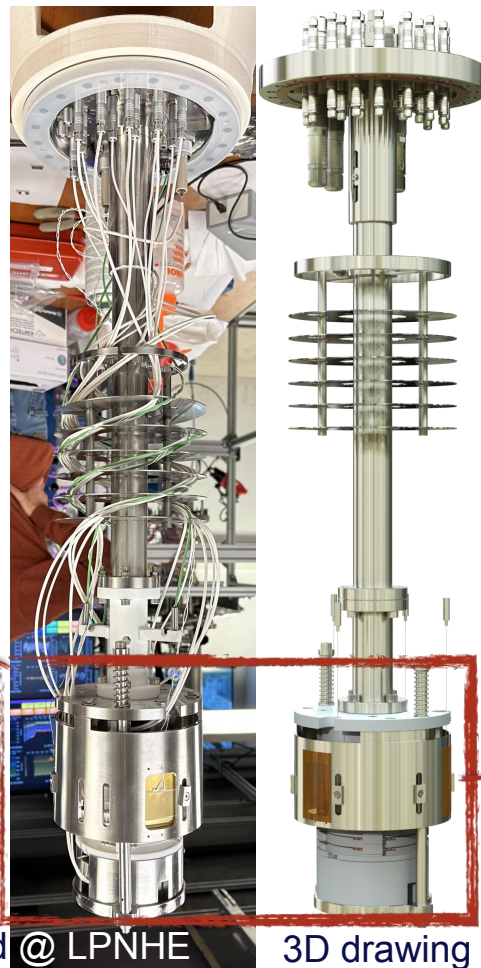




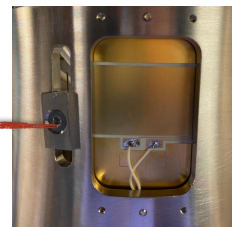
# XeLab TPC



- Designed by Subatech
- Dual-phase TPC to test new electrodes
- PTFE body (reflector)
- Stainless steel field-shaping rings
- Liquid level monitoring and control
- Hamamatsu photosensors



TPC assembled into the cryostat



Level meter



Filler

Ensembled @ LPNHE

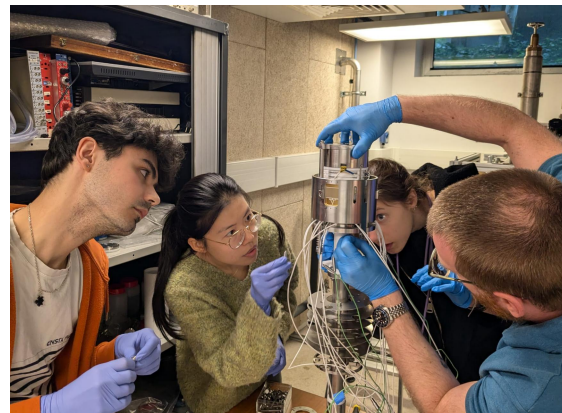
3D drawing





# TPC commissioning

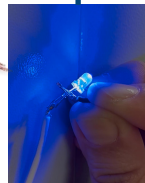
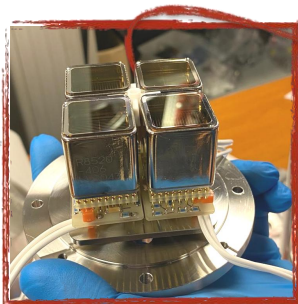
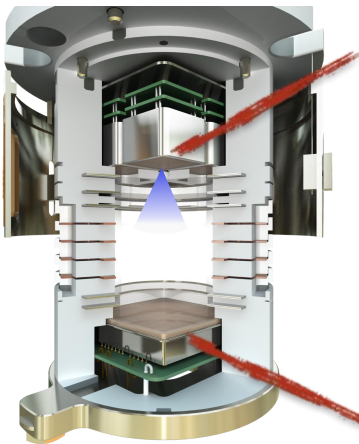
- ✓ Vacuum and Leak Testing [ $\sim 10^{-6}$  mbar]
- ✓ Cooling Down and Liquefaction (Run@April)
  - Xe level monitoring and control
- ✓ Cabling - photosensors & electrodes (FIXED)
- ✓ High Voltage ramp-up
  - ✓ Cathode HV (up 2kV)
  - ✓ Anode HV (up to 5 kV)
  - ✓ Field shaping ring checks (FIXED)
- ✓ DAQ and Trigger System
  - ✓ PMT signal readout
  - ✓ LED test @ room & LXe (FIXED - 2xTPC open)
  - ✓ Electronics & digitizers





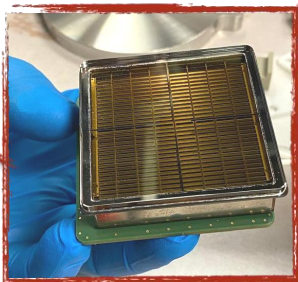
# Photosensors & DAQ

Hamamatsu



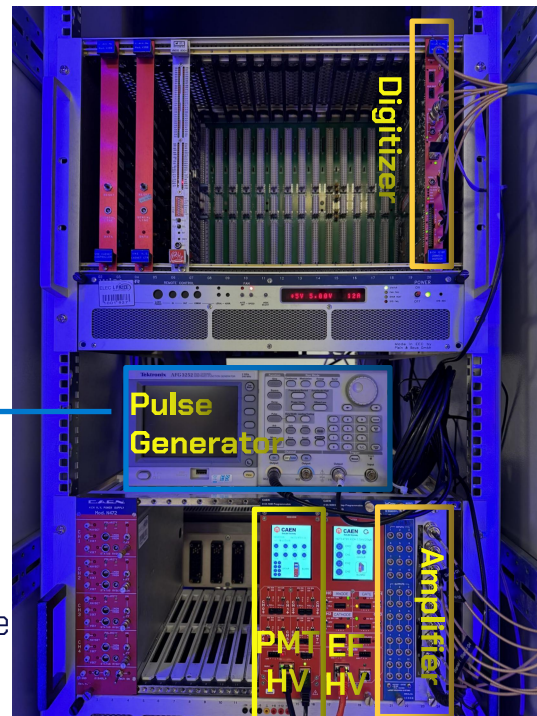
Blue  
light  
LED

R8520-406  
1" single-anode PMT  
XENON10 | XENON100



R12699-406-M4  
2" multi-anode PMT  
Low profile [fast]  
75% pho. cath. coverage  
High QE @ 175 nm: 33%

[arXiv:2506.04844](https://arxiv.org/abs/2506.04844)  
UZH and Nikhef





# Photomultiplier Testing

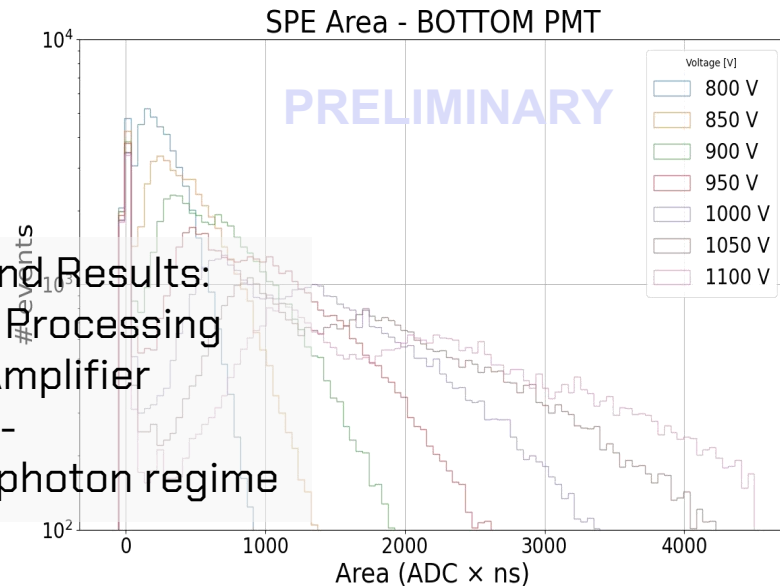
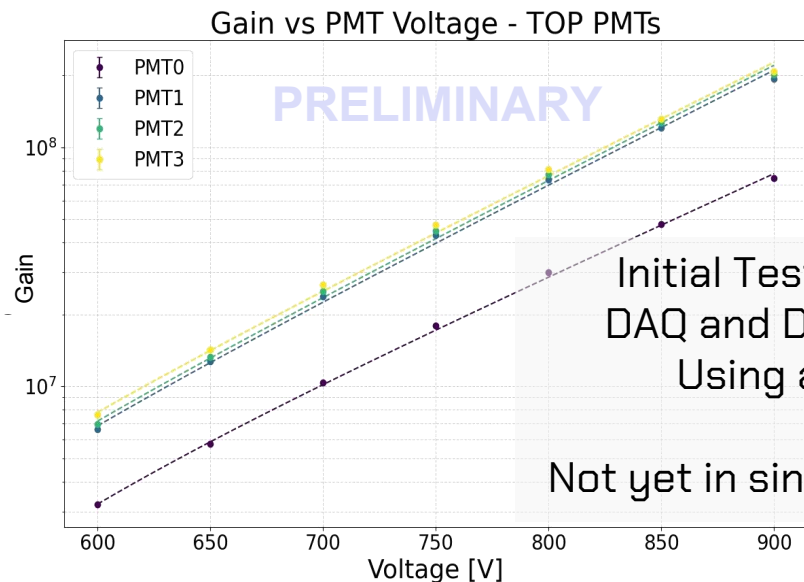
M2 INTERNSHIP STUDY

Veronica CAZZOLA (XeLab)

Christopher WINTERSTEIN (XeLab/XENONnT)

Analysis ongoing:

- Gain calibration
- Dark counts
- Afterpulses



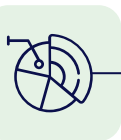
Initial Tests and Results:  
DAQ and Data Processing  
Using an Amplifier

Not yet in single photon regime

# Summary and Next

## XeLab Project

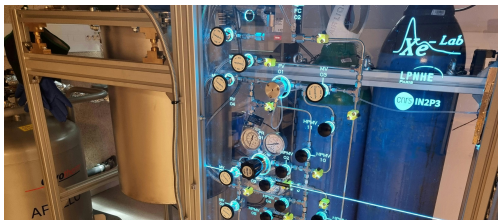
Main cryogenic work has been done  
Ready for TPC and Electrodes R&D



**DONE**

### Cryogenic facility

- LAr | pre-commissioning
- LXe | commissioning
- Runs with TPC installation



**ONGOING**

### TPC with standard electrodes

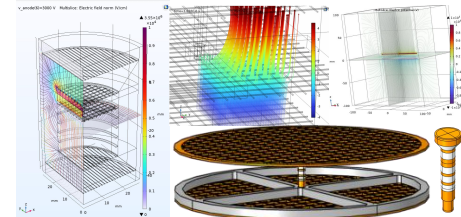
- PMT characterisation
- Extraction efficiency
- Optical transparency



**STARTING**

### Novel electrode R&D

- Simulation COMSOL
- Design optimisation
- Production & Testing





Thanks for  
your attention!  
Questions?

