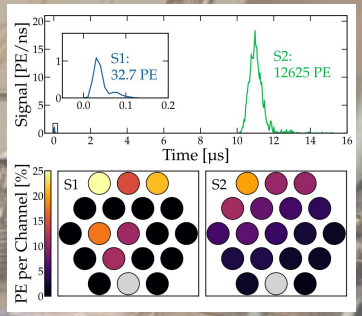
PANCAKE
Freiburgs large-scale LXe test platform

Sebastian Lindemann on behalf of the
Pancake team
(with a particular thanks to Julia Mueller
and Jaron Grigat)

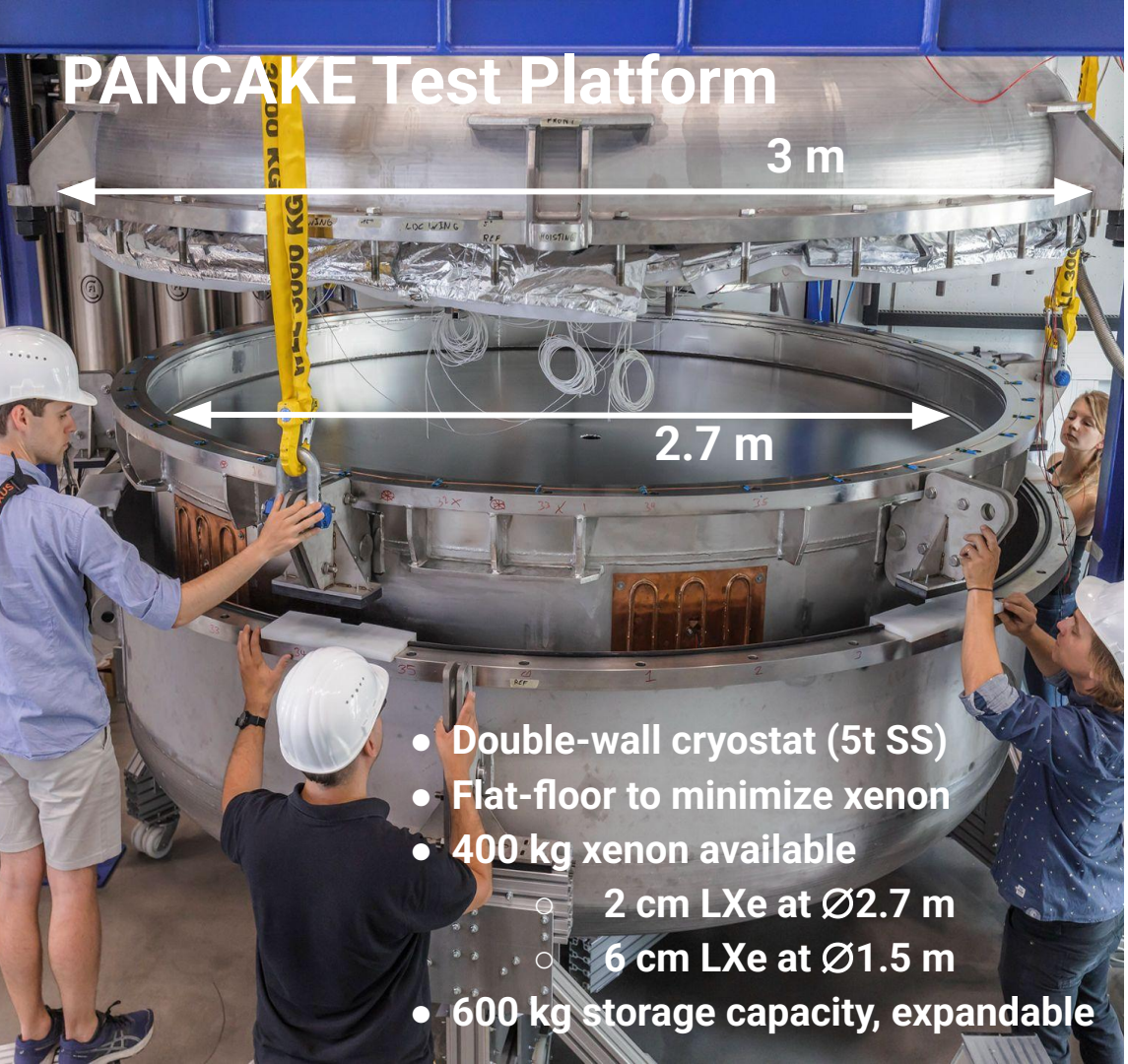
universität freiburg



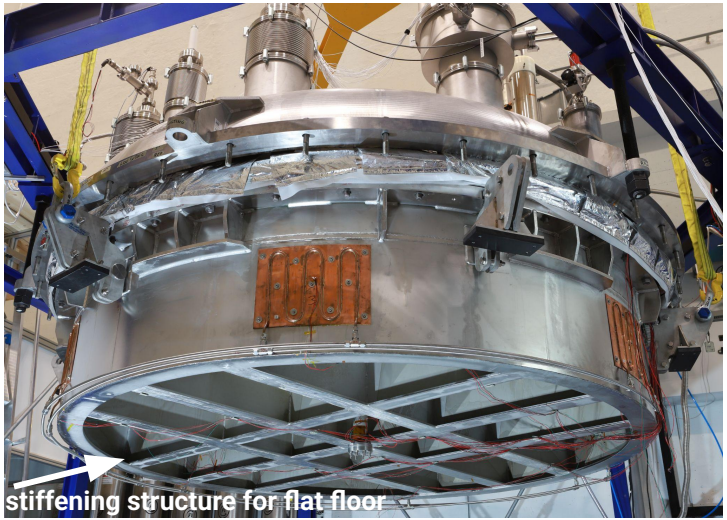
arXiv: 2312.14785, *JINST* 19 P05018

sebastian.lindemann@physik.uni-freiburg.de | July 1, 2025 | XLZD meeting @ LNGS

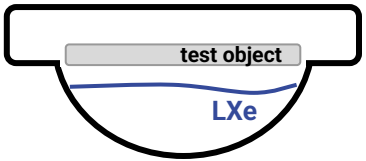
PANCAKE Test Platform



- Double-wall cryostat (5t SS)
- Flat-floor to minimize xenon
- 400 kg xenon available
  - 2 cm LXe at ∅2.7 m
  - 6 cm LXe at ∅1.5 m
- 600 kg storage capacity, expandable



pressure vessel



PANCAKE flat floor design

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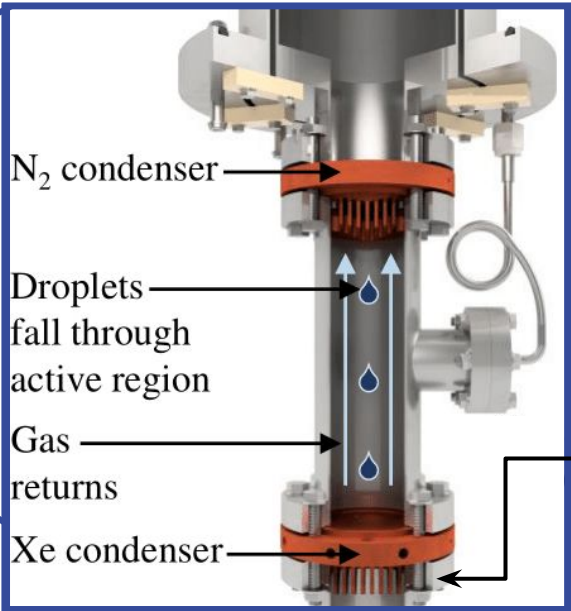
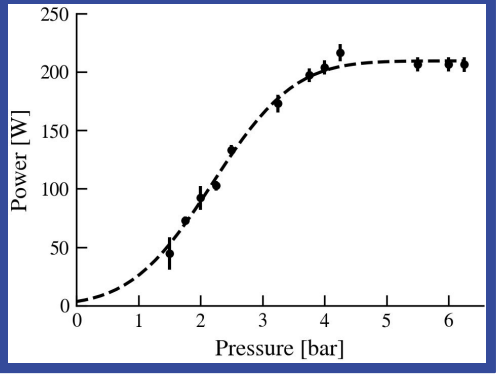
Liquid Nitrogen Cooling



Active cooling and liquefaction: **thermosyphon**

- **Three regions: LN2 reservoir, GN2 active region, condensation side**
- **up to ~200W adjustable cooling**



Pre-cooling system of the inner cryostat, remember 3t stainless steel

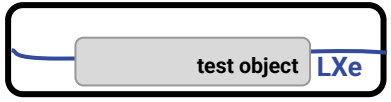
- **Six copper plates with pipes**
- **Cooling power of several kWp**

MLI + vacuum insulation:
Heat load @ -100°C < 100W

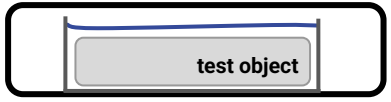
Open-topped vessel “bathtub”

- ∅1.5 m open-topped vessel
- increase liquid level
- submerge test objects in LXe

PANCAKE flat floor design



bathtub concept



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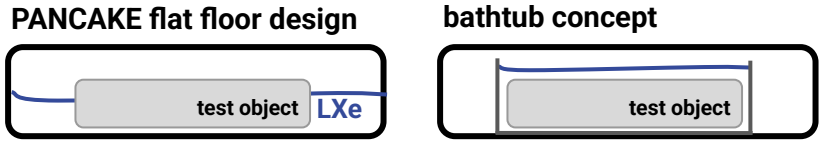
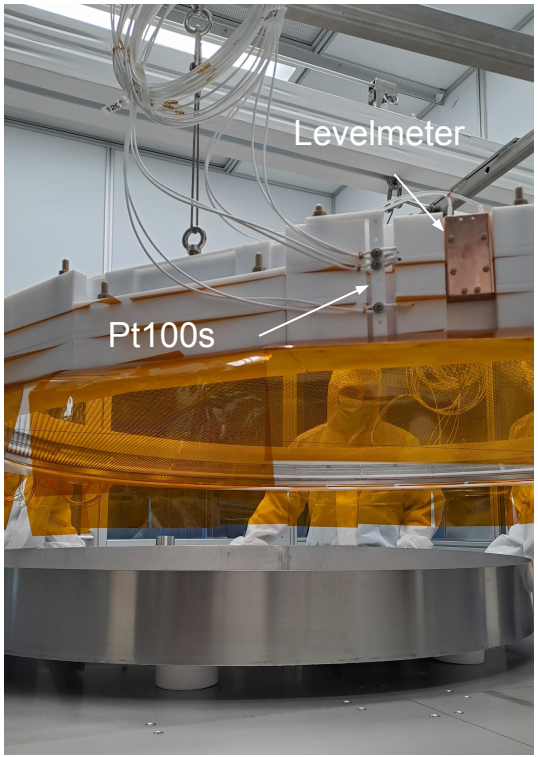
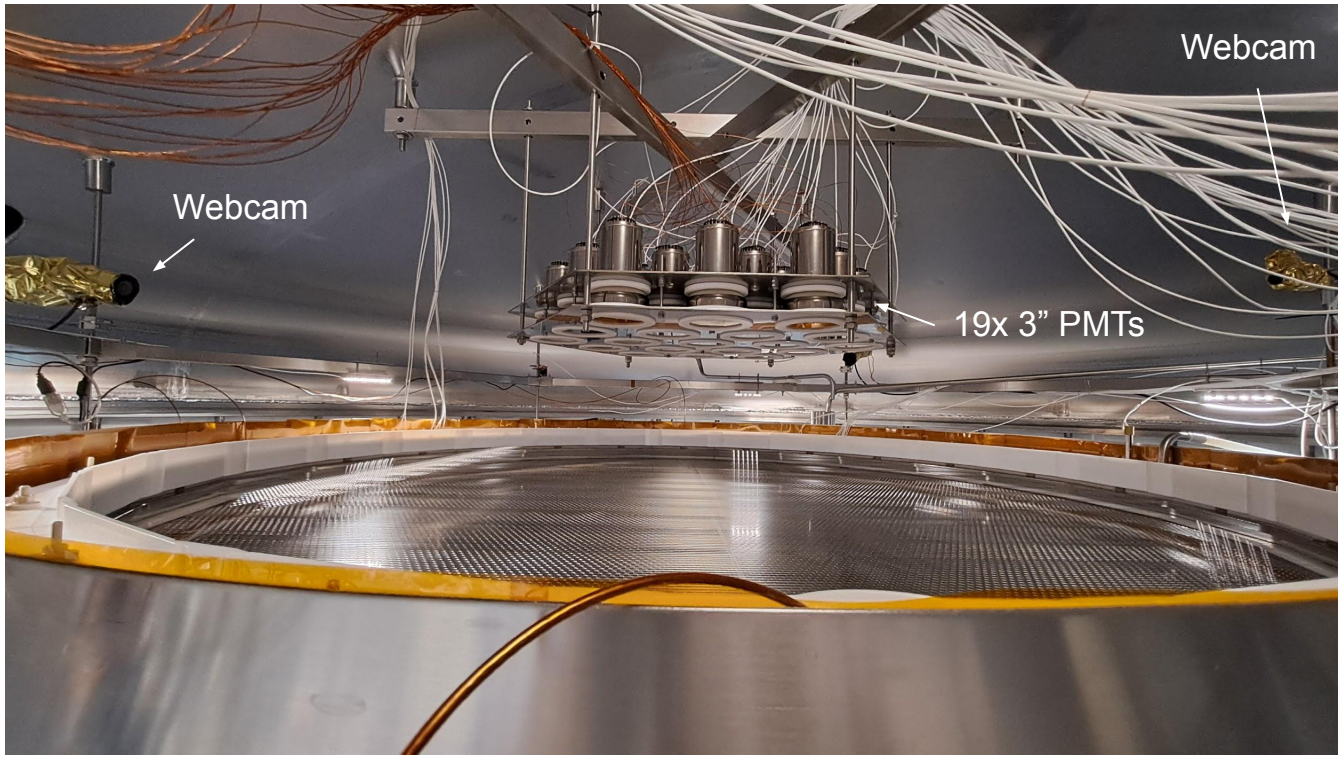


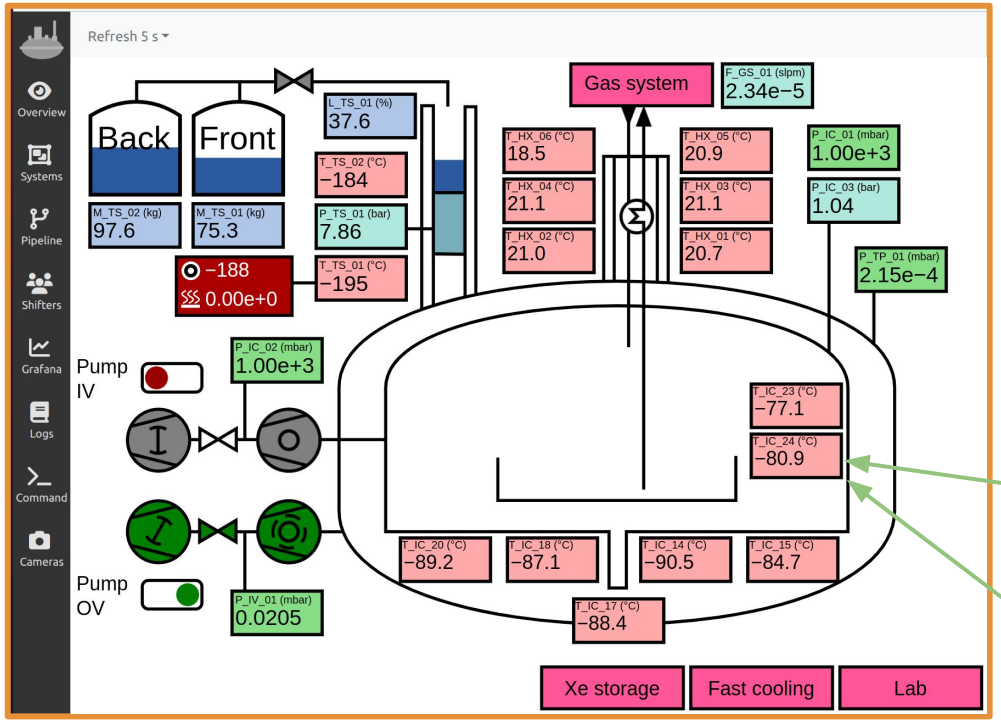
We tested and validated this concept during our commissioning run. Then, we successfully employed it during our shallow TPC run with three ∅1.5 m electrodes in operation.

Instrumentation

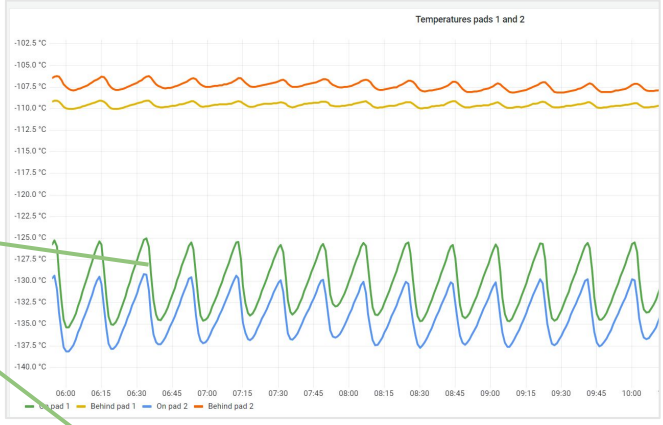


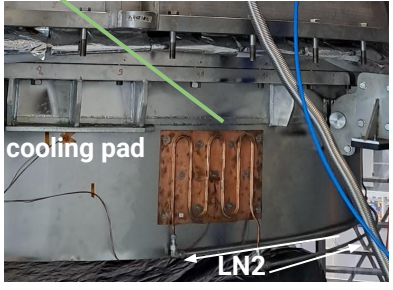


Slow Control System Doberman



- constructed in Python
- Revolution Pis based on Raspberry Pis
- $\mathcal{O}(200)$ sensors used so far
- web-based interface (monitor & control)





https://github.com/AG-Schumann/Doberman

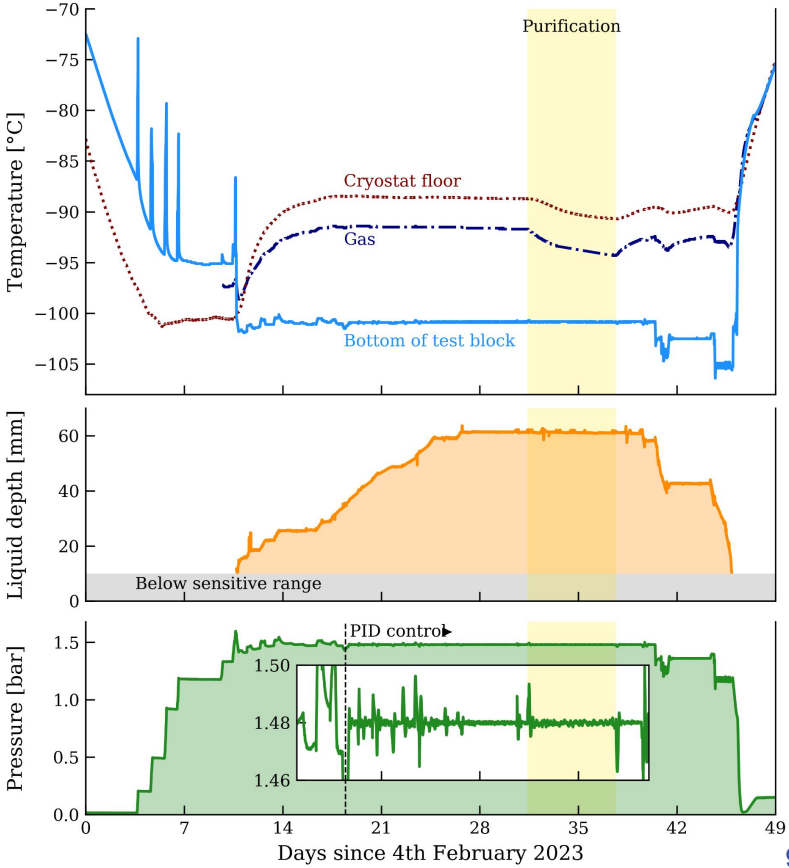
arXiv: 1607.08189

PANCAKE OPERATIONAL

two successful xenon runs!

PANCAKE Commissioning Run

- First at 50 kg, then at 300 kg over ~3 months
- Validated bathtub principle @ -100°C
- Commissioning of all sub-systems
- Great pressure stability due to PID-control loop



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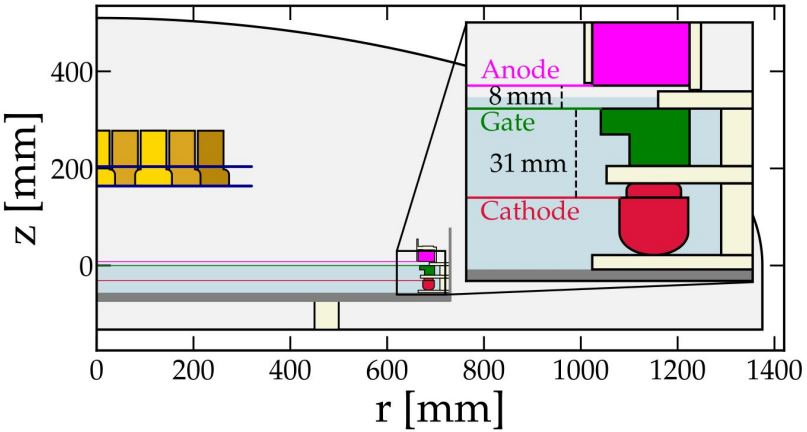
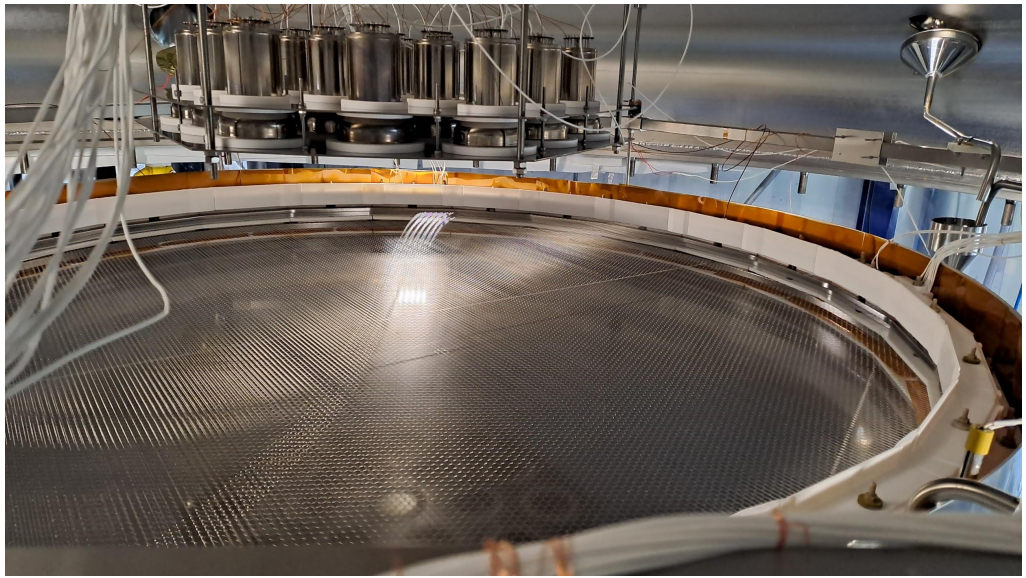
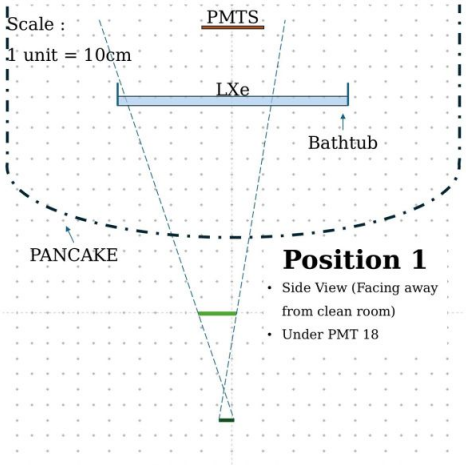
First Operation of a shallow TPC

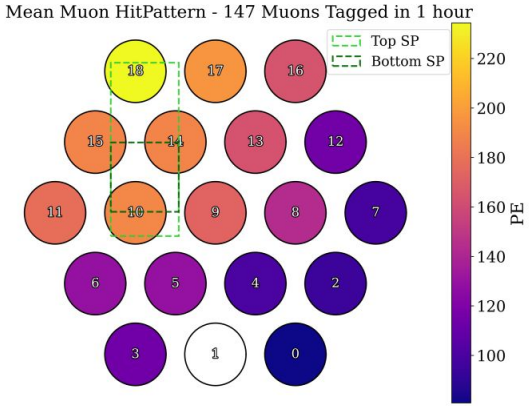
- More than 4 months of operation
- 350 kg of xenon filled
- Three ∅1.5 m electrodes enabled dual-phase TPC operation
- First time PMT data from PANCAKE

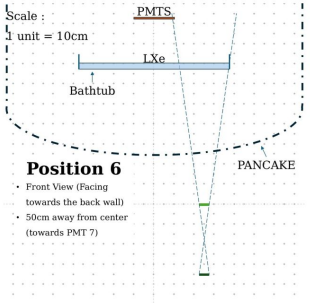


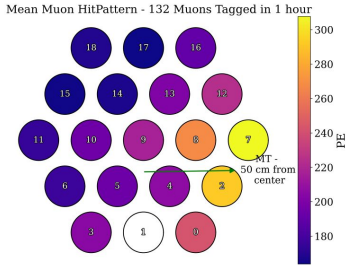


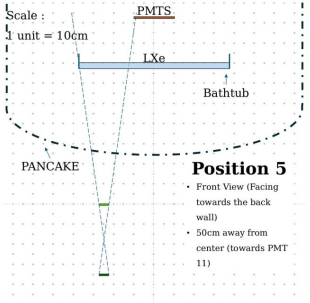
Muon tagged events in S1-only configuration

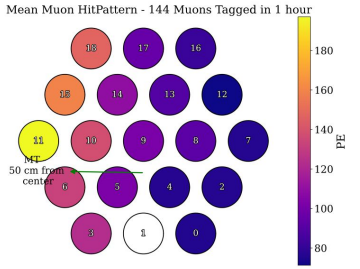




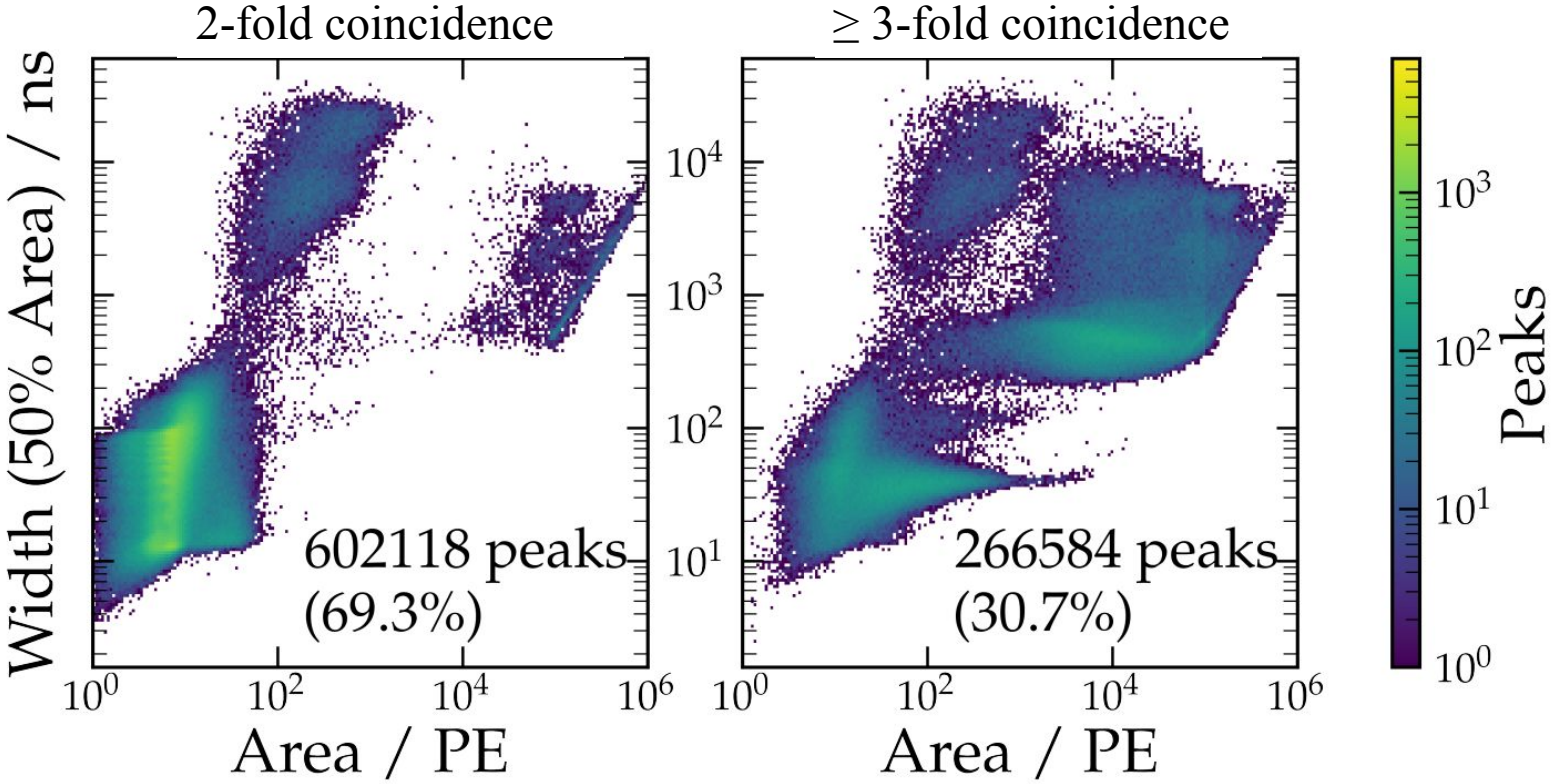








Shallow TPC – high rates observed



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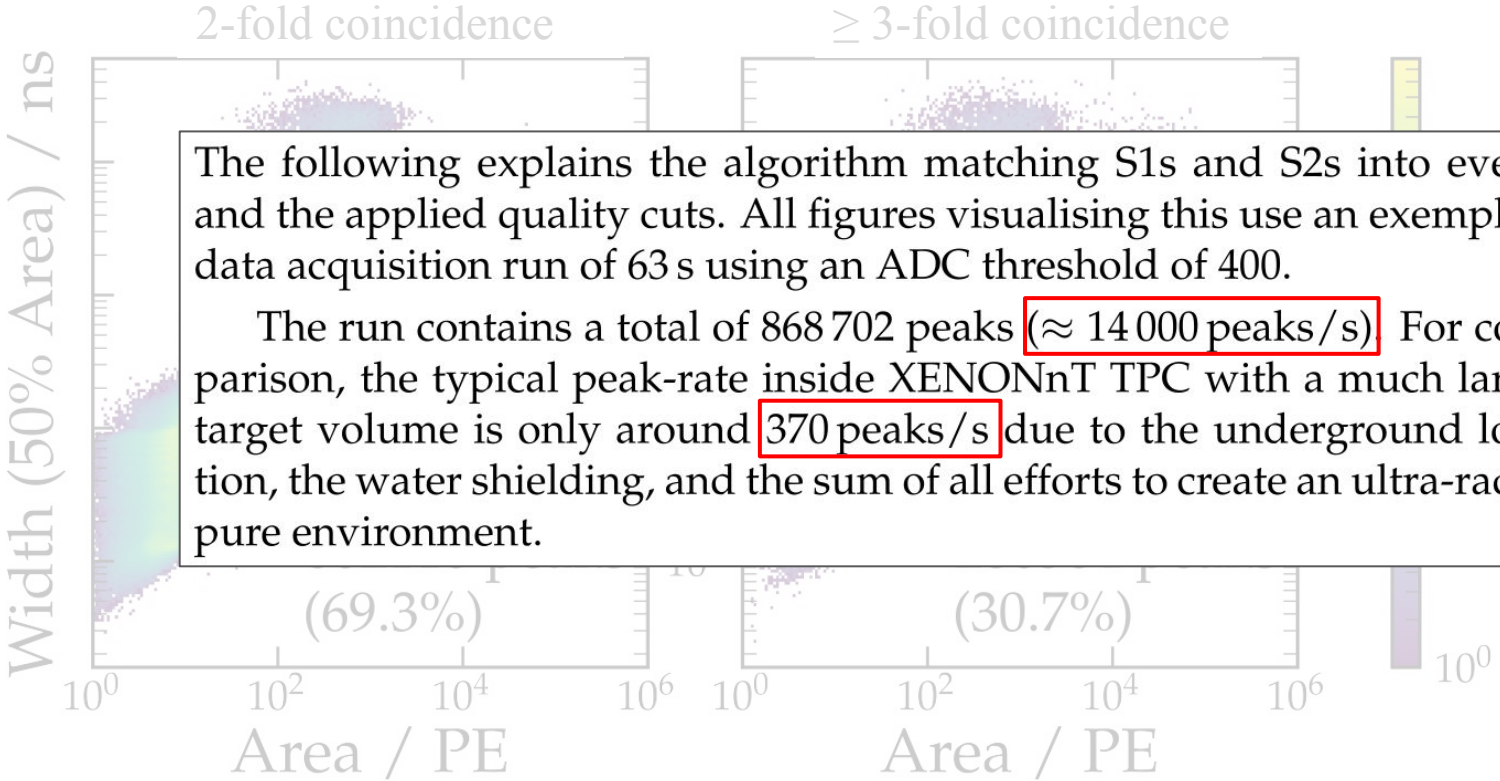
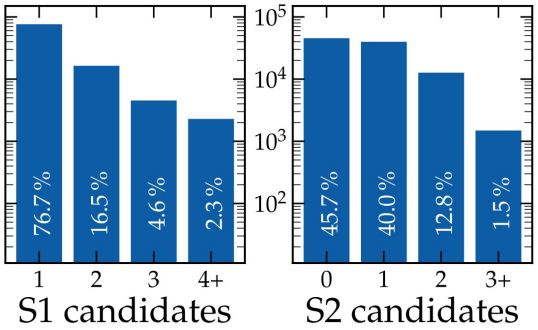
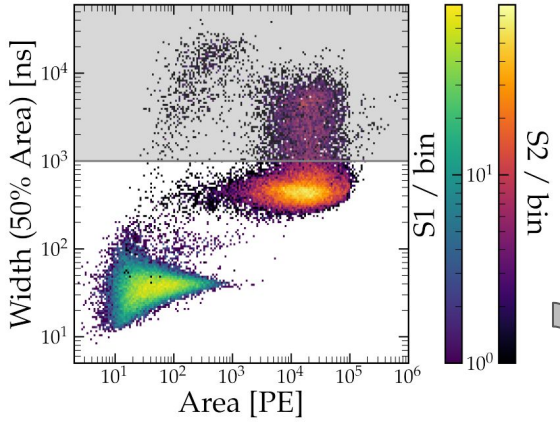


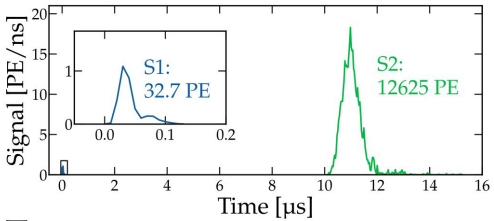
The following explains the algorithm matching S1s and S2s into events and the applied quality cuts. All figures visualising this use an exemplary data acquisition run of 63 s using an ADC threshold of 400.

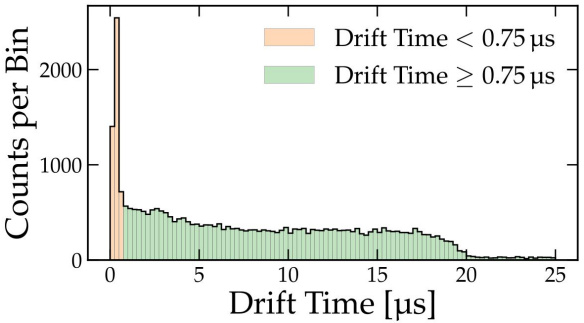
The run contains a total of 868 702 peaks (≈ 14 000 peaks/s). For comparison, the typical peak-rate inside XENONnT TPC with a much larger target volume is only around 370 peaks/s due to the underground location, the water shielding, and the sum of all efforts to create an ultra-radiopure environment.

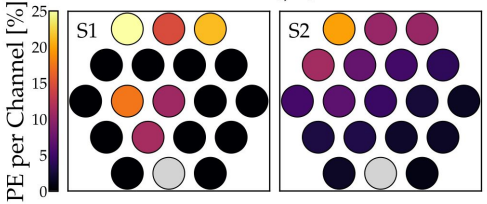
Shallow TPC – Event matching



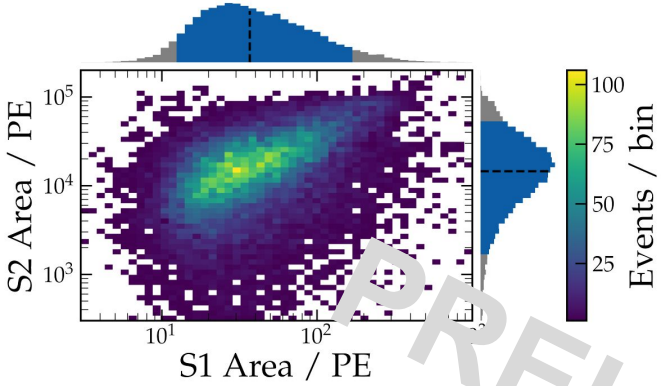


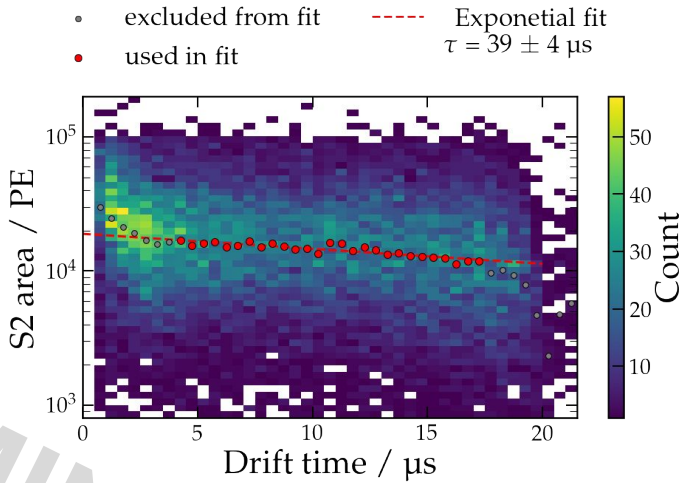


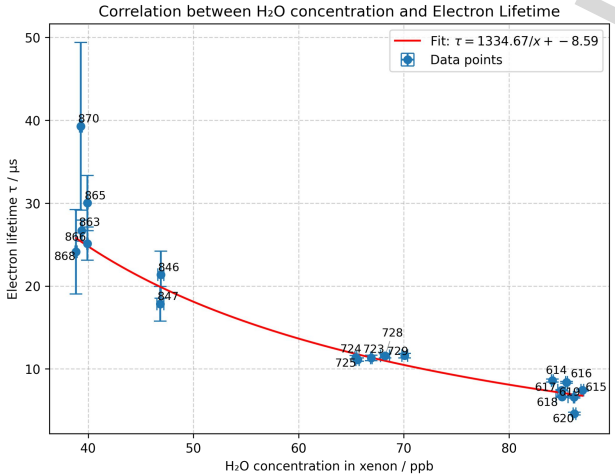


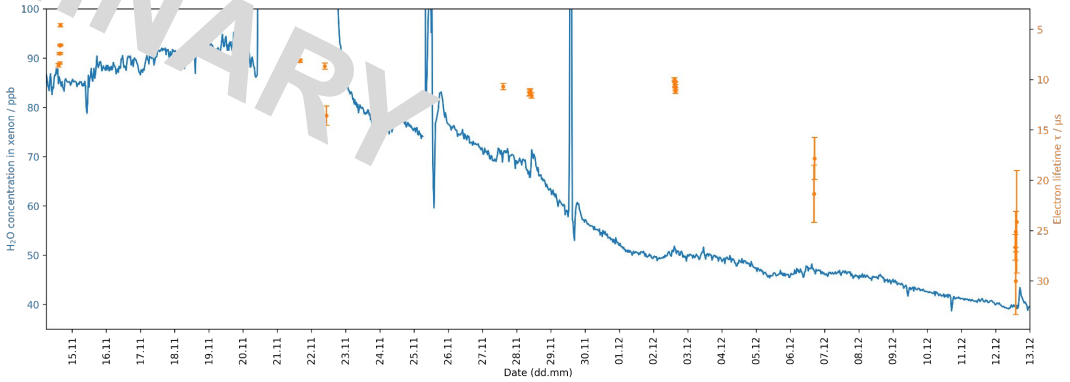


Shallow TPC – Electron lifetime and Purity

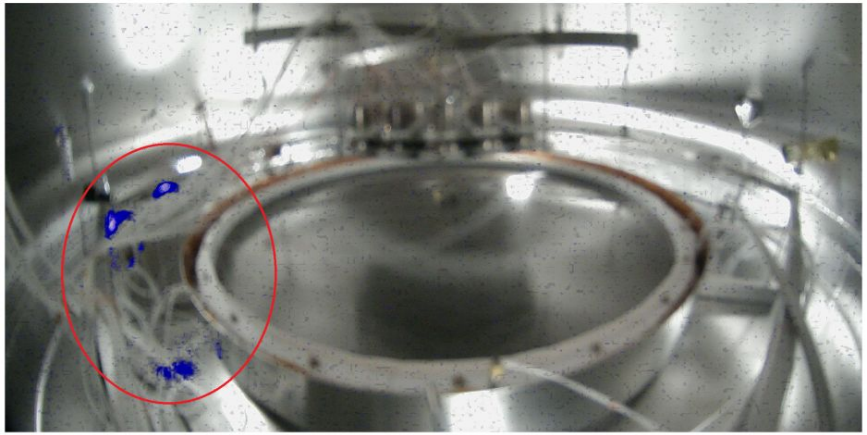




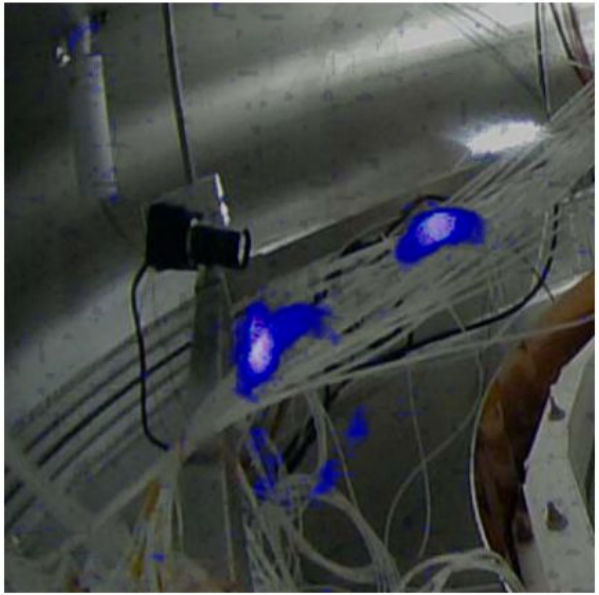




Valuable visual feedback provided by webcams



- Cathode HV limited to ~10 kV
- Webcam images of sparks overlaid on illuminated counterparts
- Kapton cable not well routed



PANCAKE in Freiburg

- **400kg Xenon inventory (expandable!)**
- **Cryogenics:**
  - Thermosyphon ~200W
  - Pre-cooling (initial cooling) several kW
- **Gas purification:**
  - KNF pump ~20 slpm
  - MonoTorr S4-MT15-R
- **High voltage:**
  - Heinzinger PNC-60000-3ump (± 60kV)
  - Feedthrough: MDC HV40-1S-C40 (≤40kV)
- **Cleanroom and extended clean areas with FFUs**
- **Cameras, PMTs, T- and level-sensors**
- **$\mathcal{O}$(200) sensors → robust slow control Doberman**

Two successful xenon runs!

Xenon Gas Handling & Storage

- xenon gaseous purification:
  - **SAES MonoTorr hot-getter**
  - **cycling by KNF diaphragm pump ⟶ 20slpm**
  - **heat exchanger**
- recuperation and storage:
  - **six aluminum bottles freezable with LN2**
  - **six steel bottle for gas only**
  - **recuperation time ~7days**