

Development and performance of the PandaX veto system



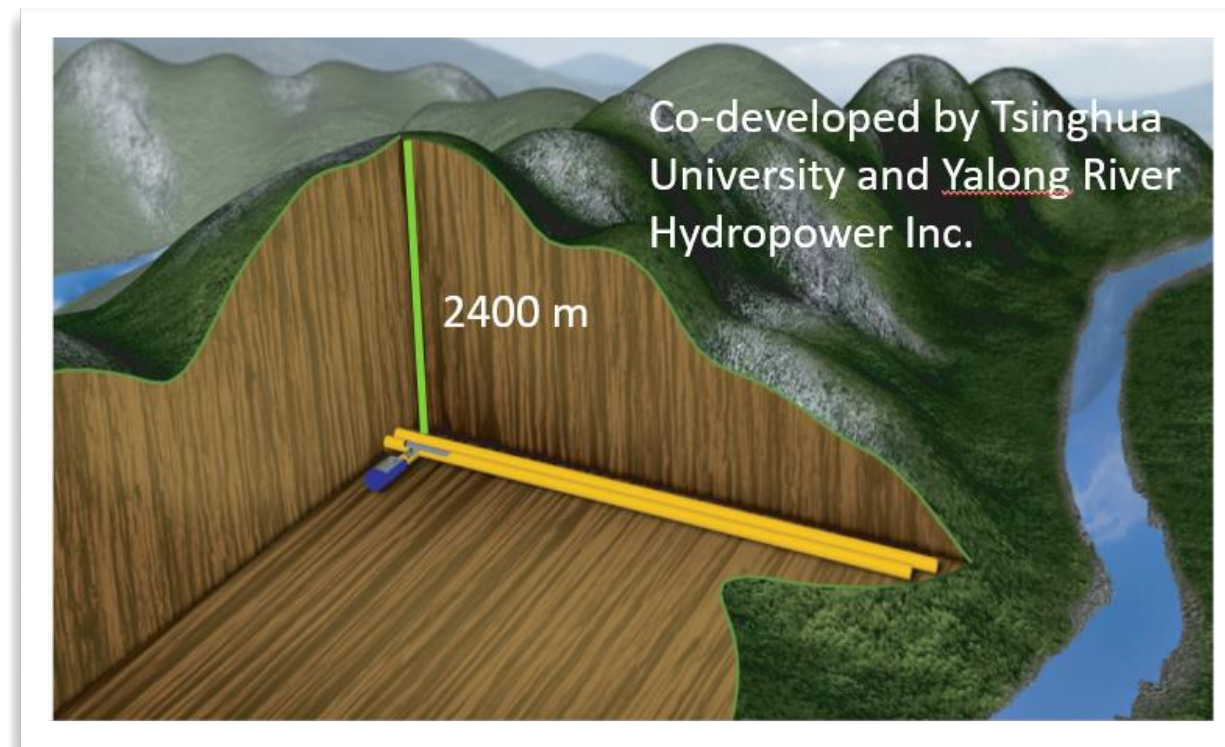
Yuehuan Wei for PandaX Collaboration

Sun Yat-sen University

2026/06/04



PandaX experiment at CJPL

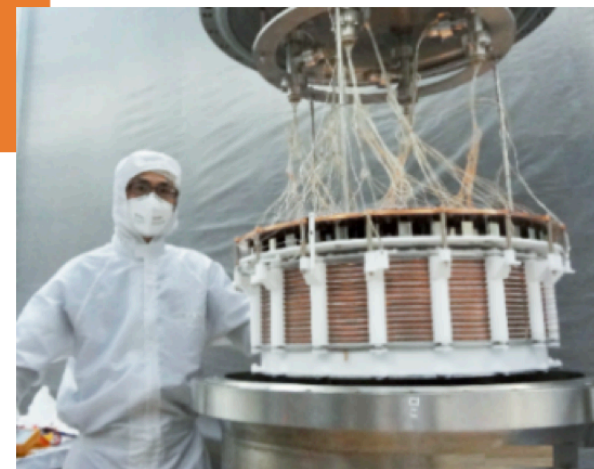


PandaX initiated



2009

PandaX-I
120 kg



2010-2014

PandaX-II
580 kg



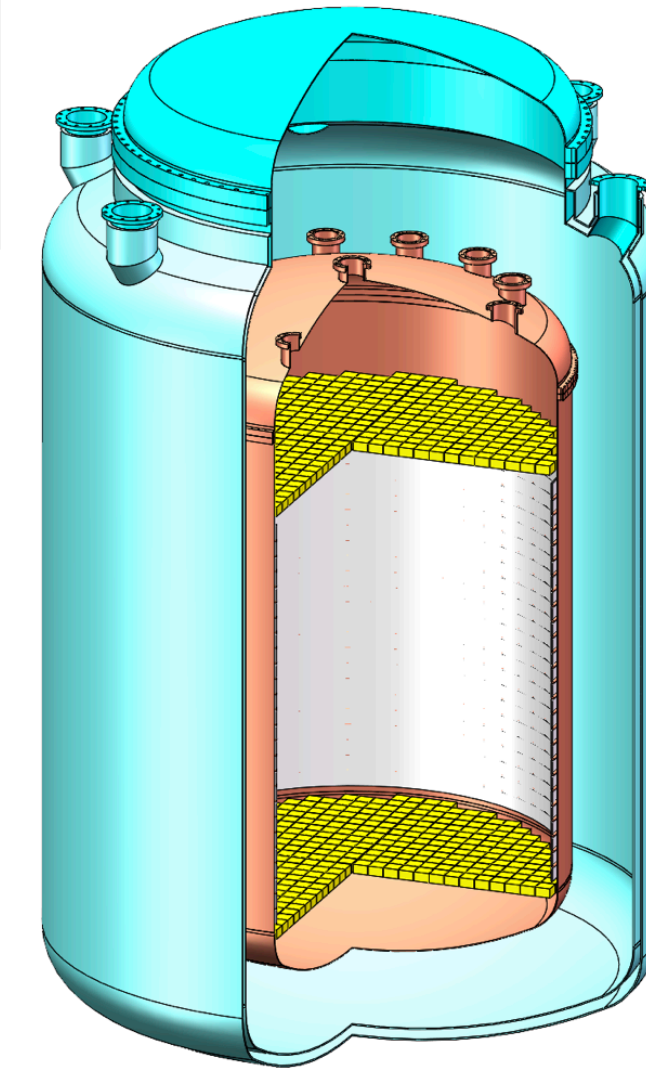
2015-2019

PandaX-4T
3.7 tonne



2020-2026

PandaX-xT
20 tonne -> 47 tonne



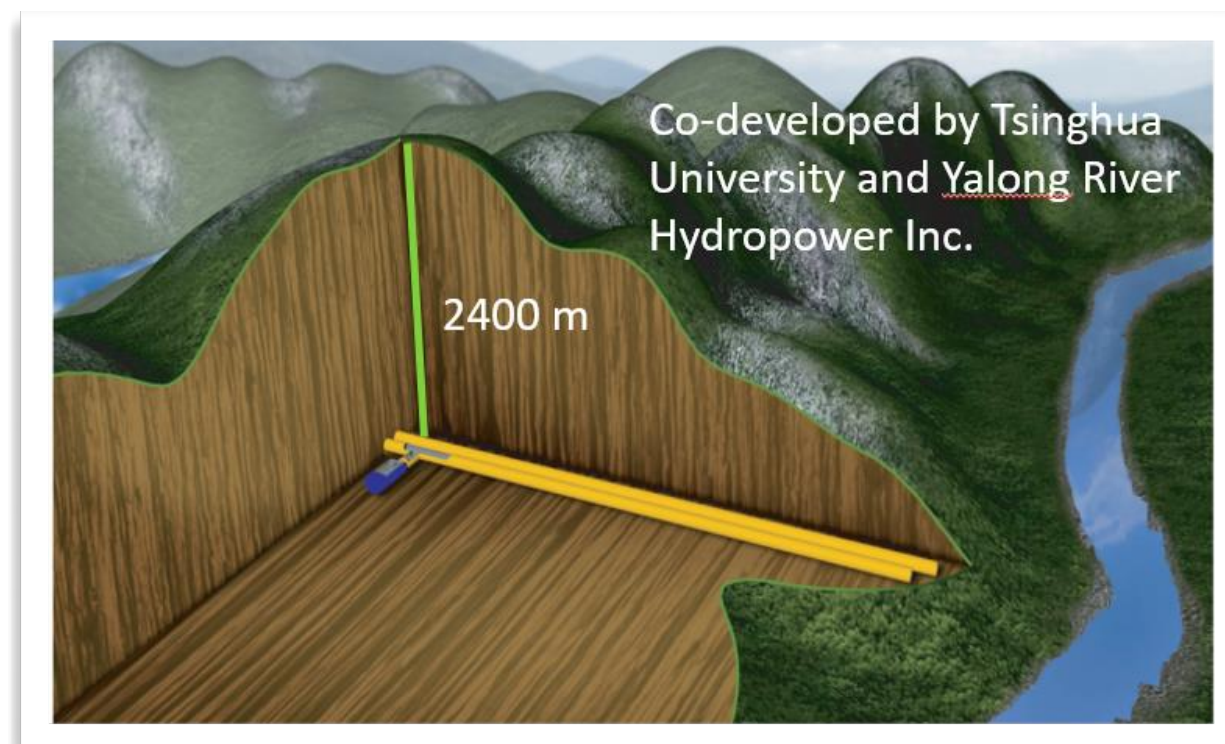
2027-

Ref Talk 1: Latest results of the PandaX-4T experiment, [Xiaopeng Zhou](#), Tues, 2 Jun 2026

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Ref Talk 2: [PandaX-20T](#): the next generation xenon detector for dark matter and neutrino searches, [Xiang Xiao](#), Tues, 2 Jun 2026

PandaX experiment at CJPL

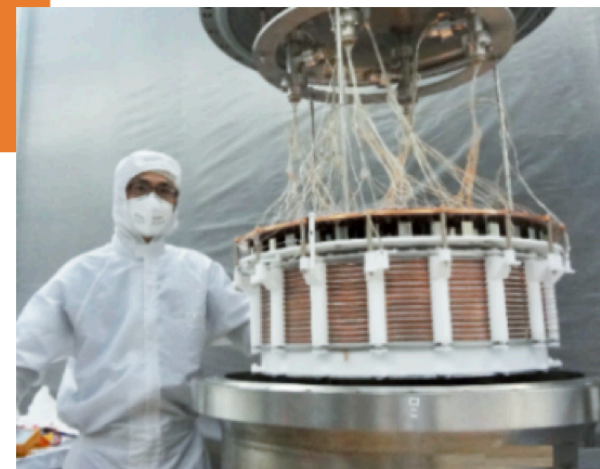


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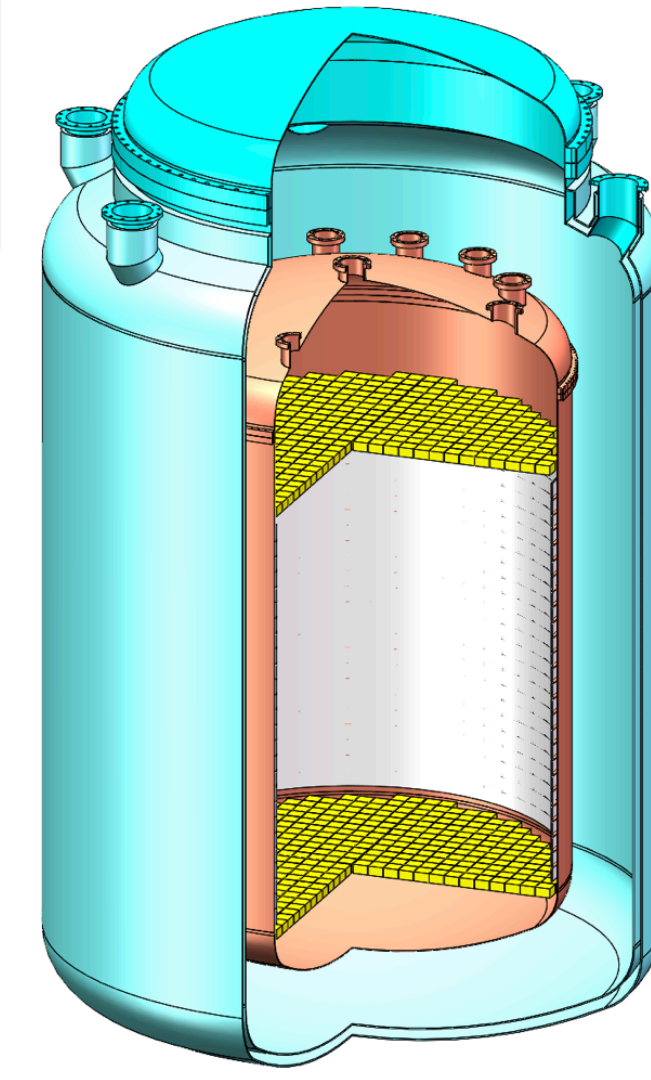
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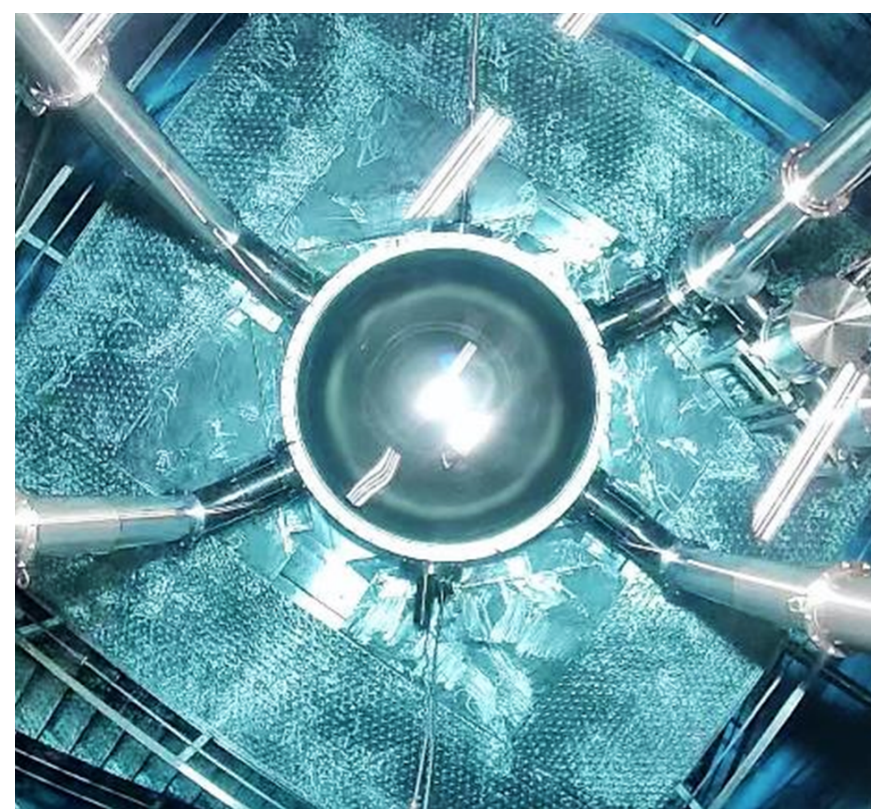
Ref Talk 2: [PandaX-20T](#): the next generation xenon detector for dark matter and neutrino searches, [Xiang Xiao](#), 2 Jun 2026

Veto system of PandaX experiment

- **PandaX-4T: Water Cherenkov detector**
- **PandaX-20T: Liquid scintillator (construction)**
- **PandaX-xT: Cold liquid scintillator (R&D)**

PandaX-4T: Water Cherenkov detector

Run0、Run1



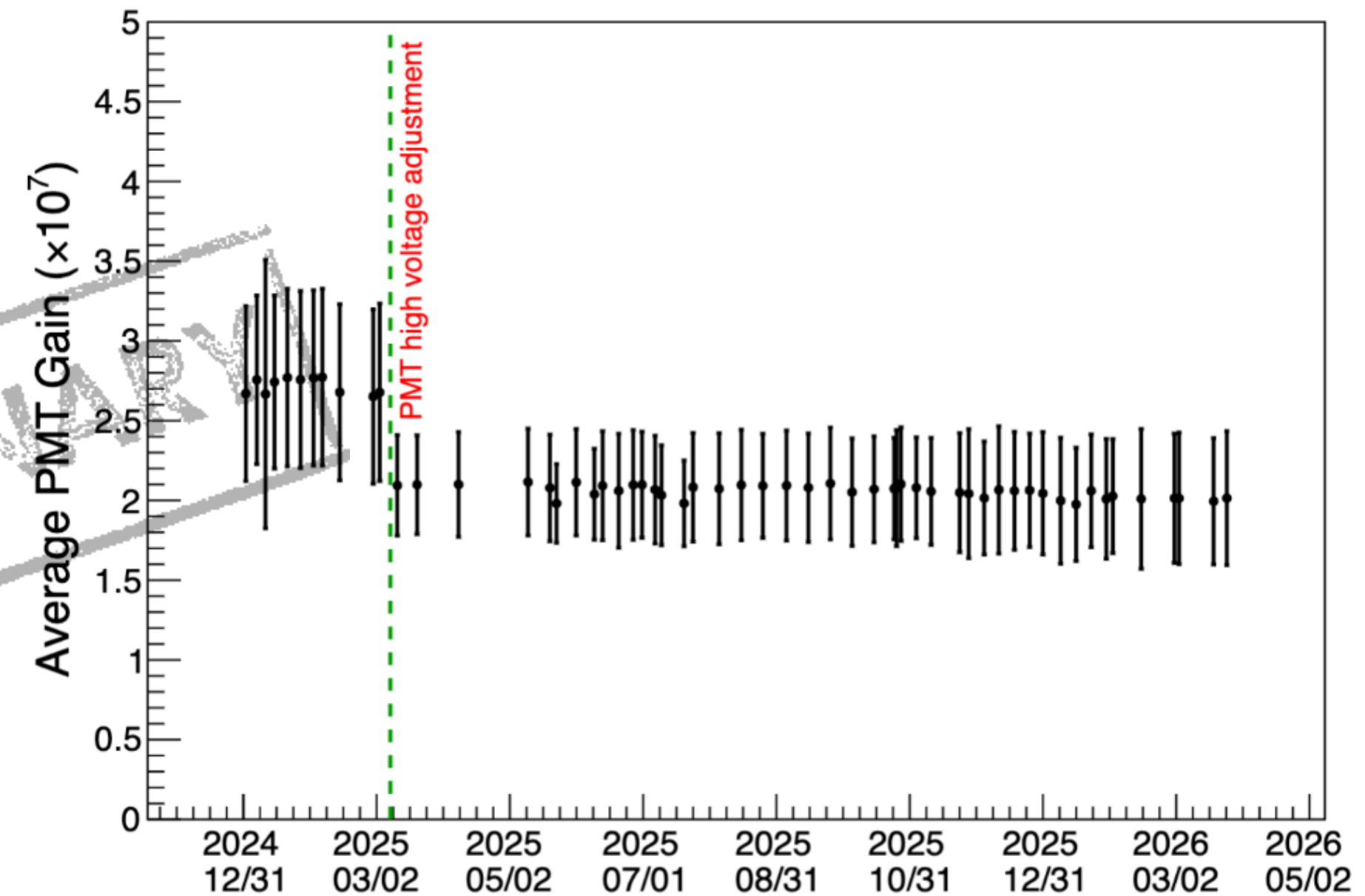
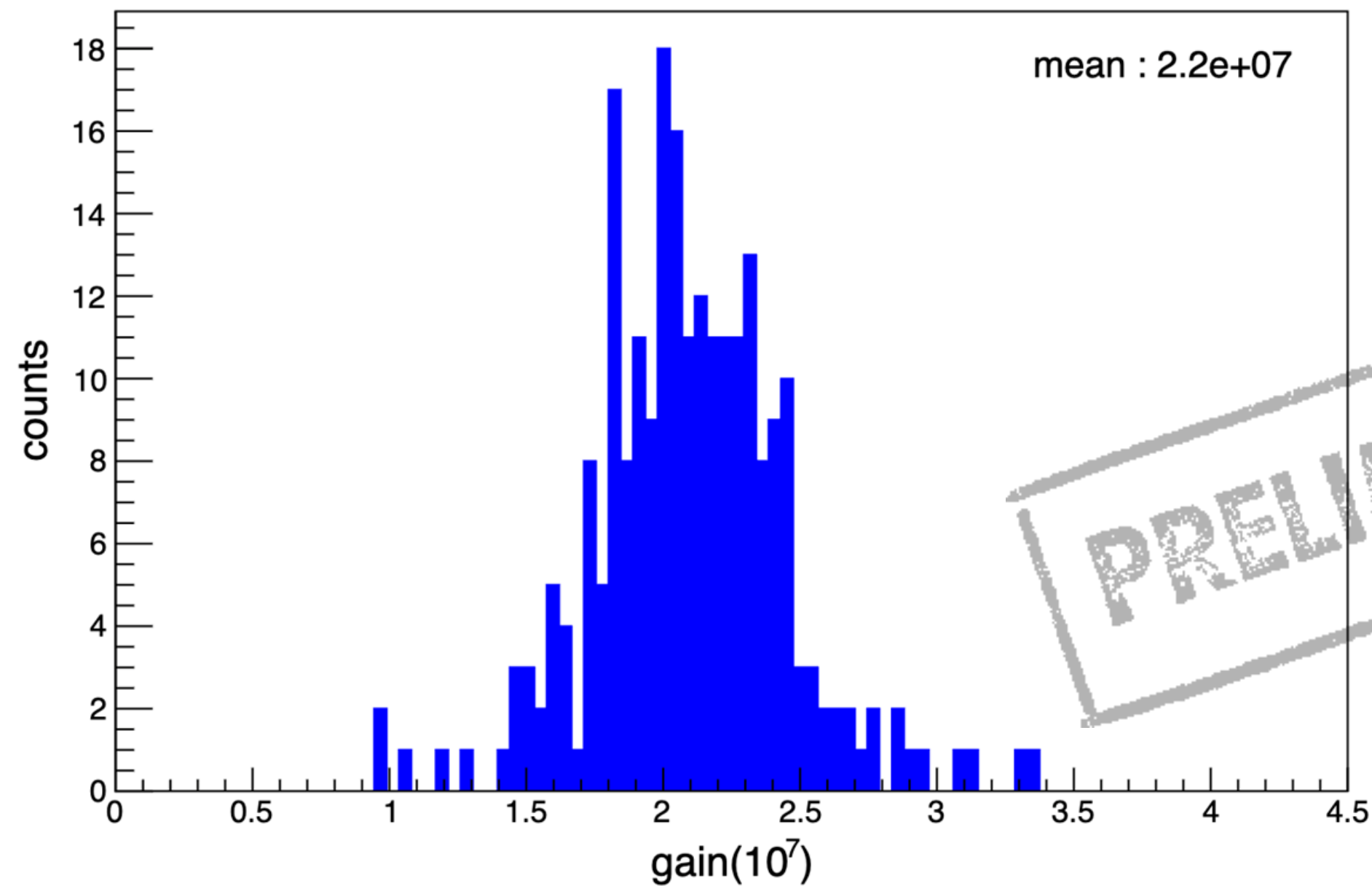
Run2

- two layers of 8-inch MCP PMTs in 900 m³ of water shielding
- inner layer: 165 PMTs; outer layer: 105 PMTs, side and bottom
- data taking: from July 2024 to April 2026



PandaX-4T: Water Cherenkov detector

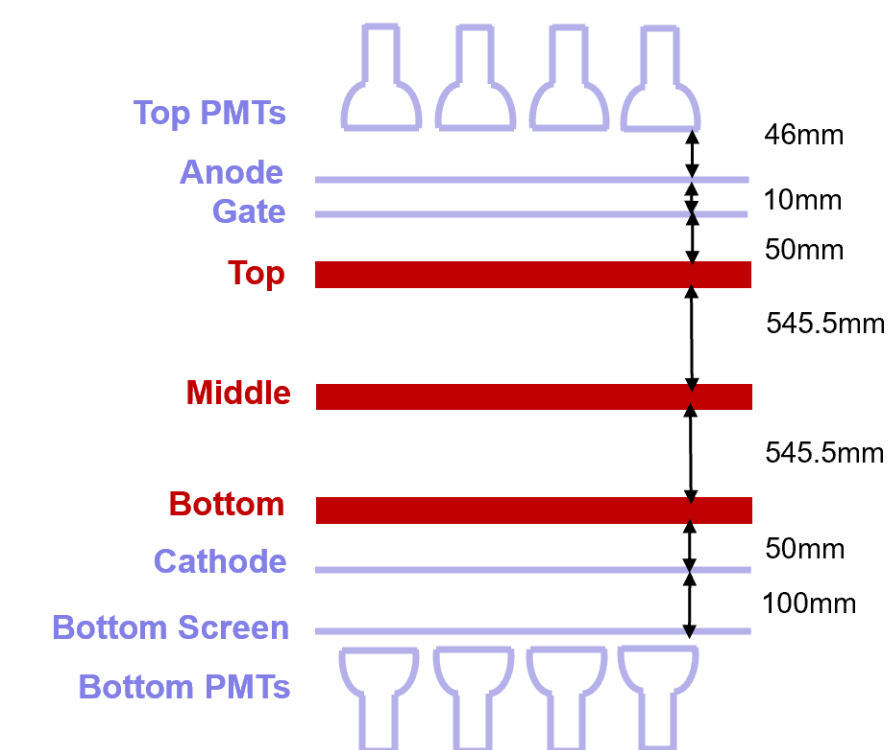
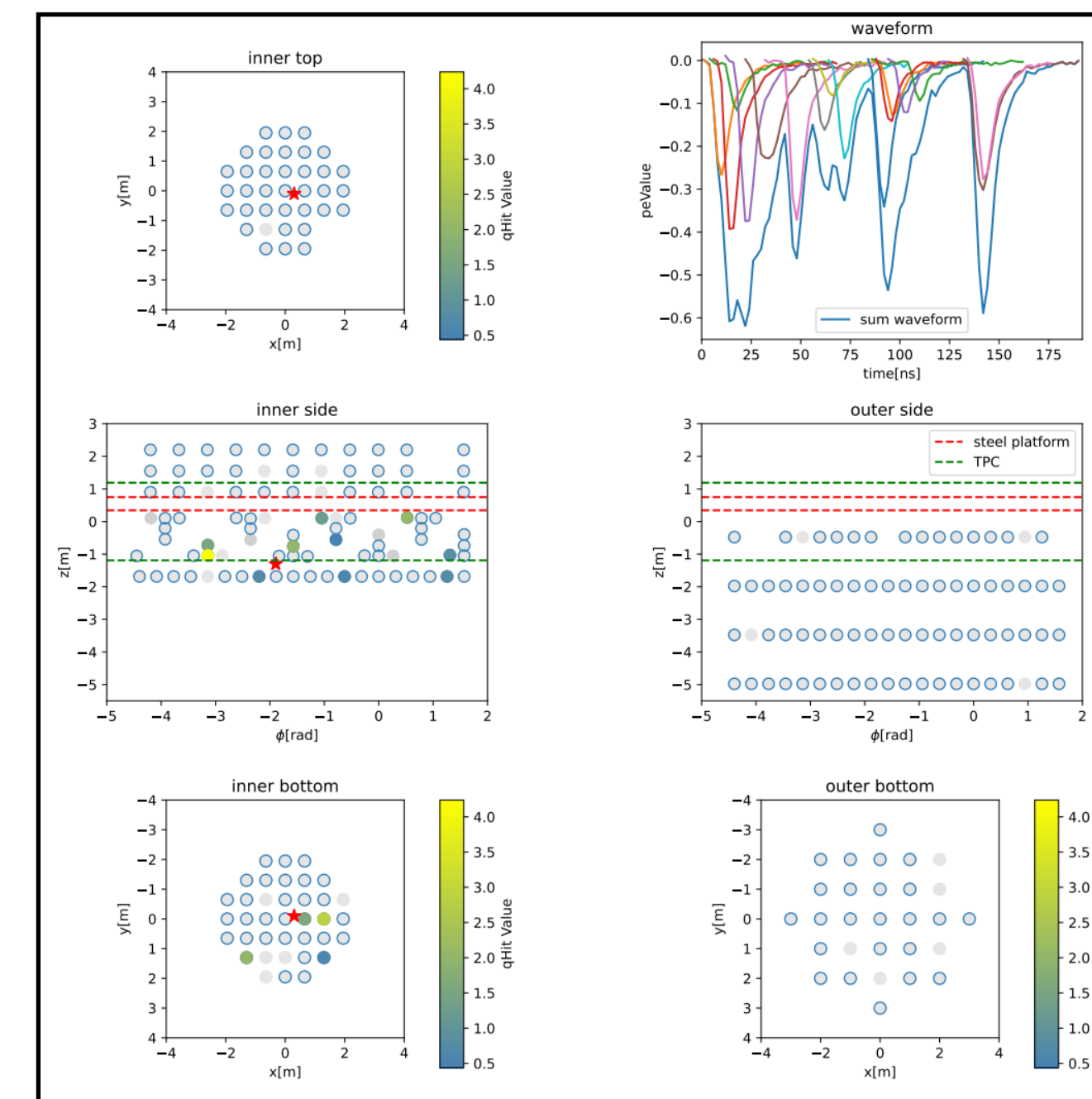
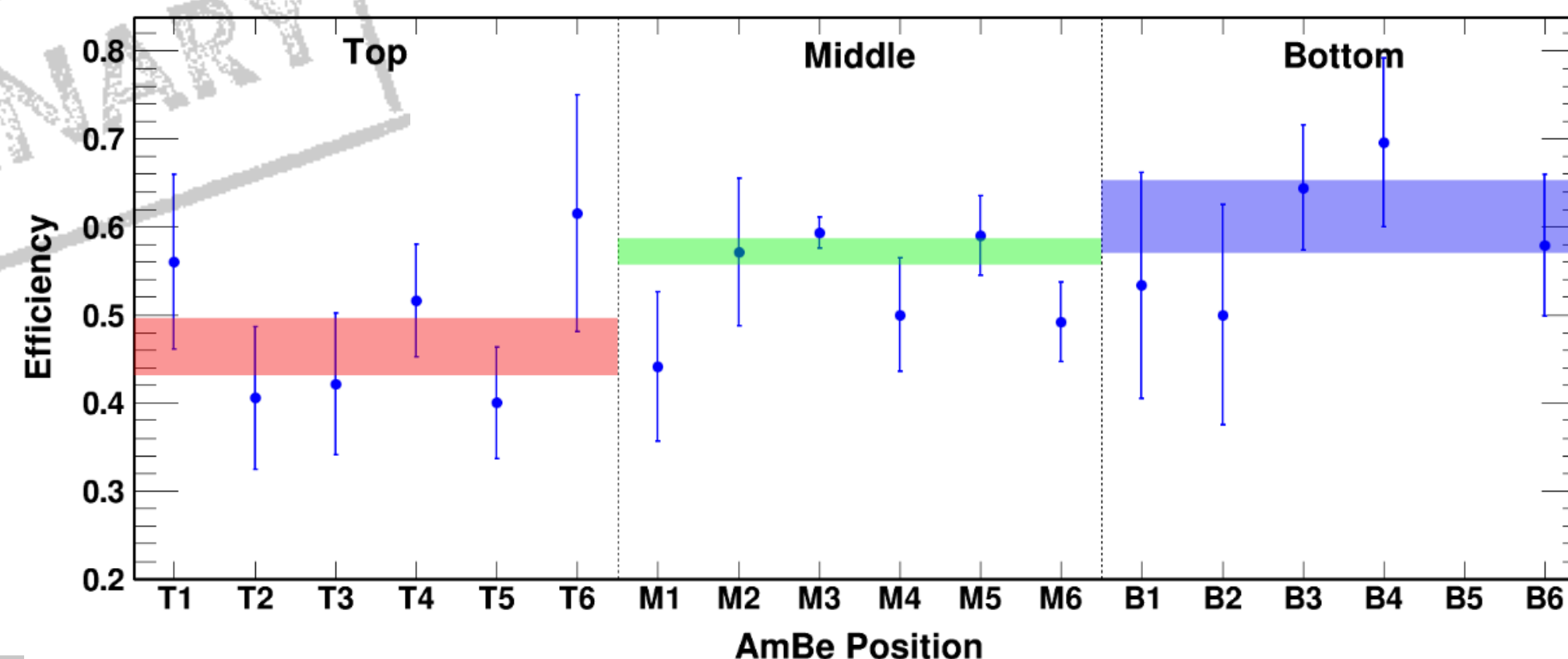
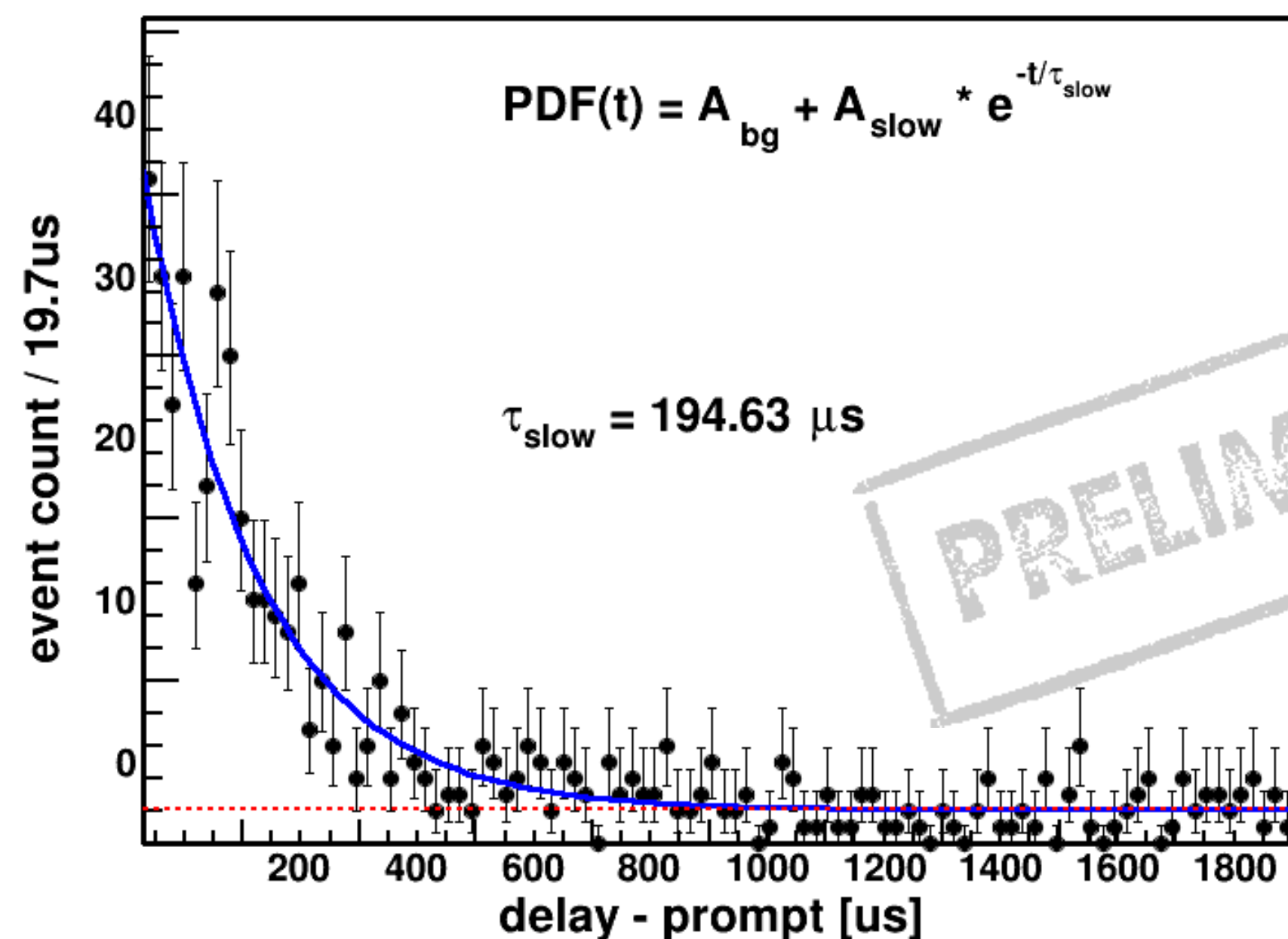
- 14-bit, 500 MHz, 8-channel waveform digitizer
- mainly operating in self-trigger mode
- average PMT dark current rate: 1-1.5 kHz
- average PMT gain: 2.2×10^7



PandaX-4T: Water Cherenkov detector

Neutron Veto Efficiency using AmBe calibration data

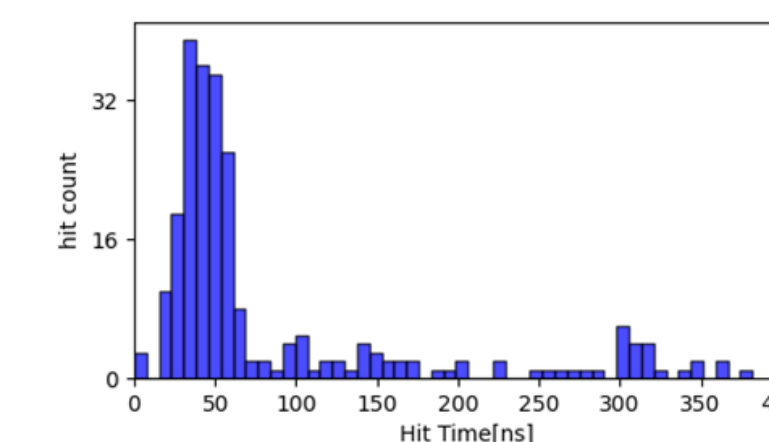
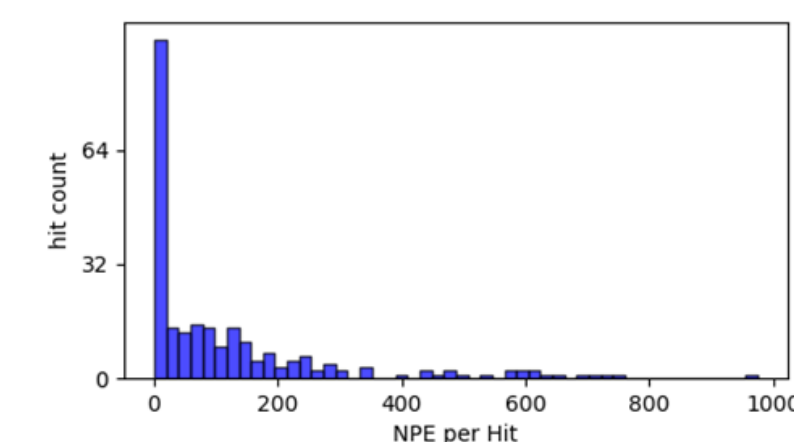
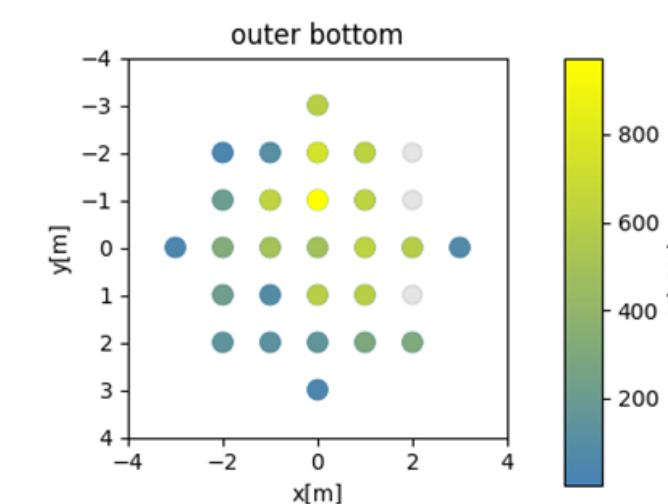
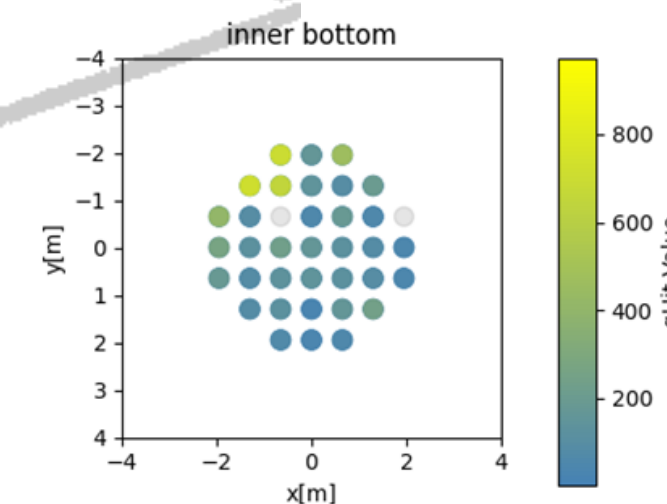
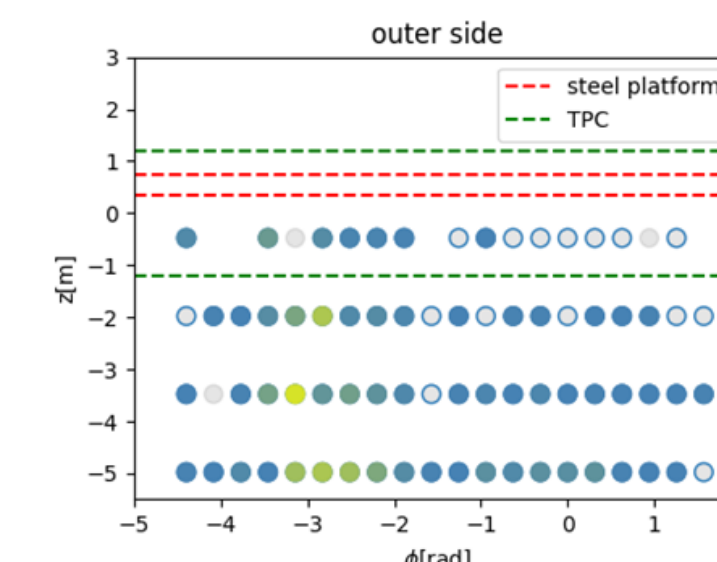
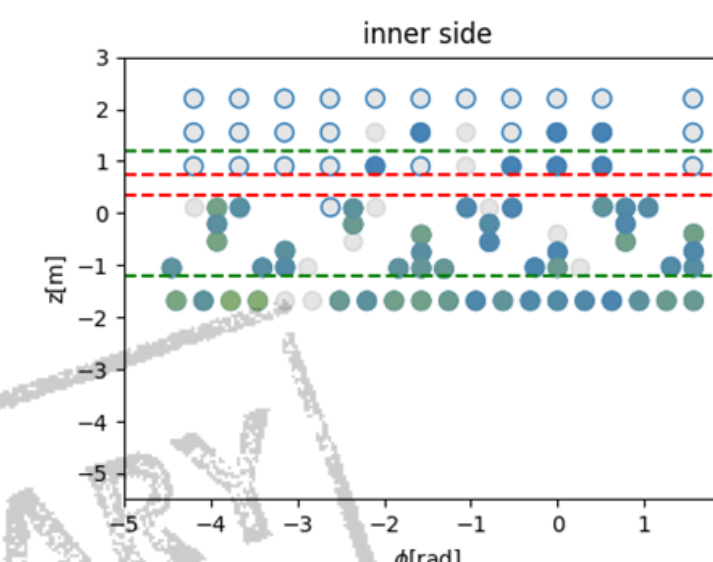
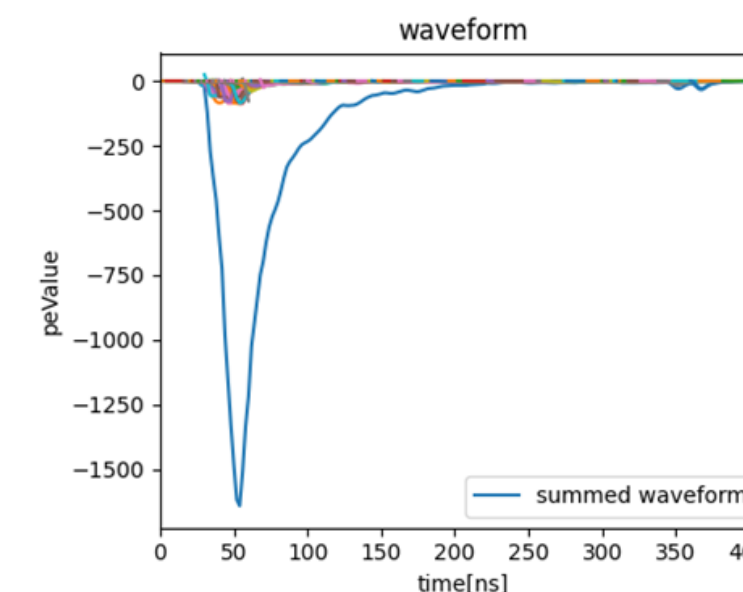
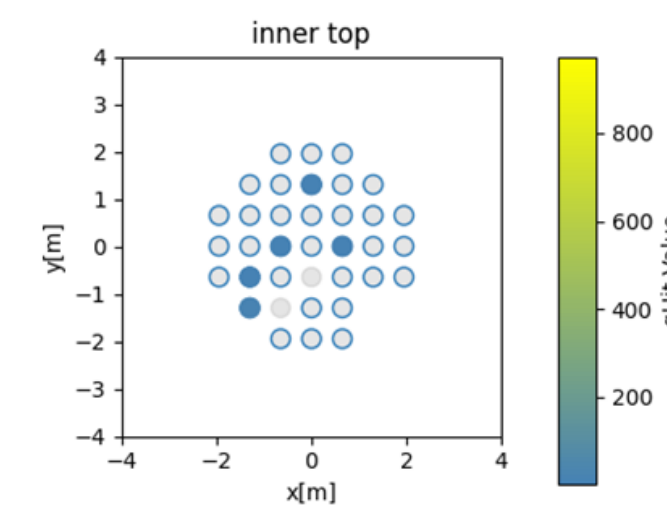
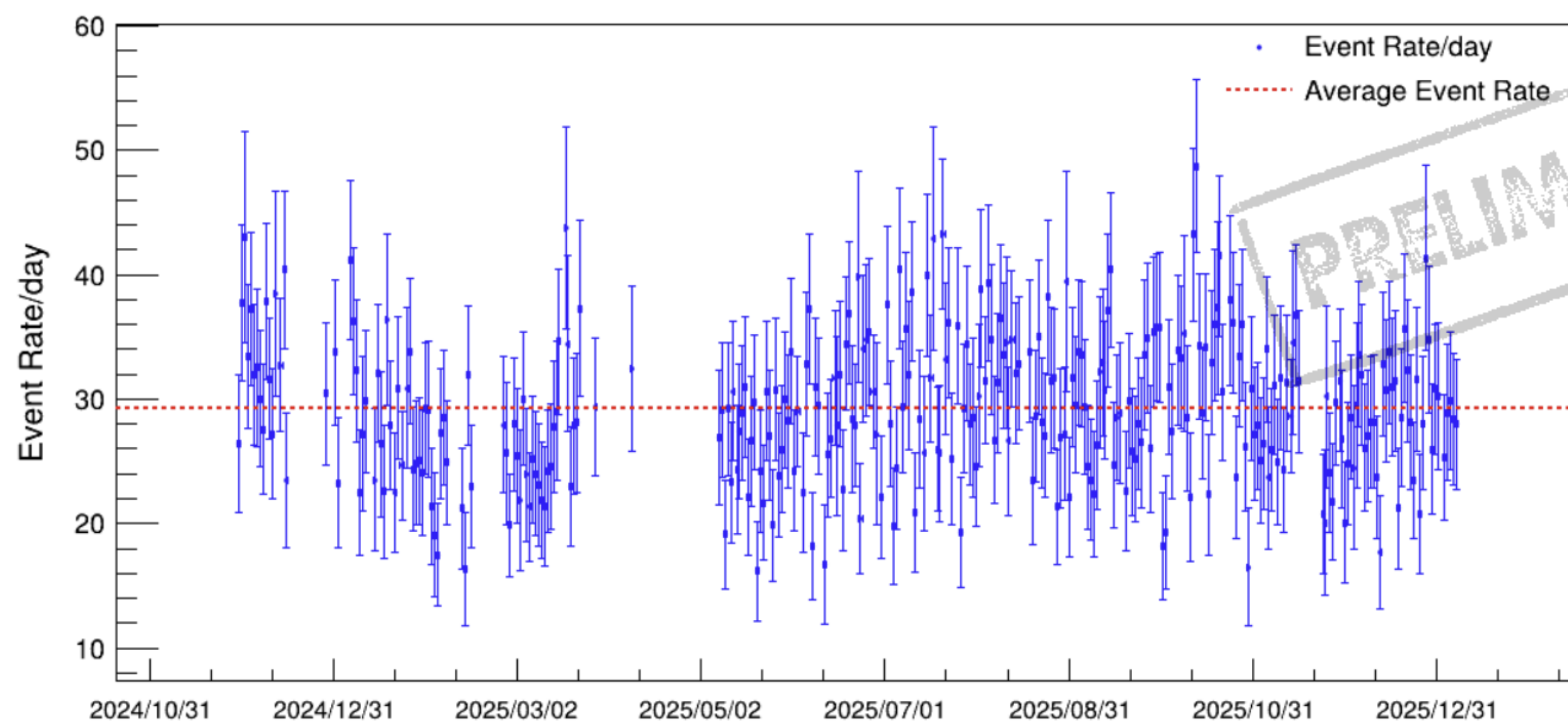
- AmBe source: use 4.4 MeV gamma to tag nuclear recoil in TPC
- 2.2 MeV neutron capture on hydrogen
- neutron veto efficiency: 53.9% (500 μ s), 57.4% (800 μ s) (*preliminary*)



PandaX-4T: Water Cherenkov detector

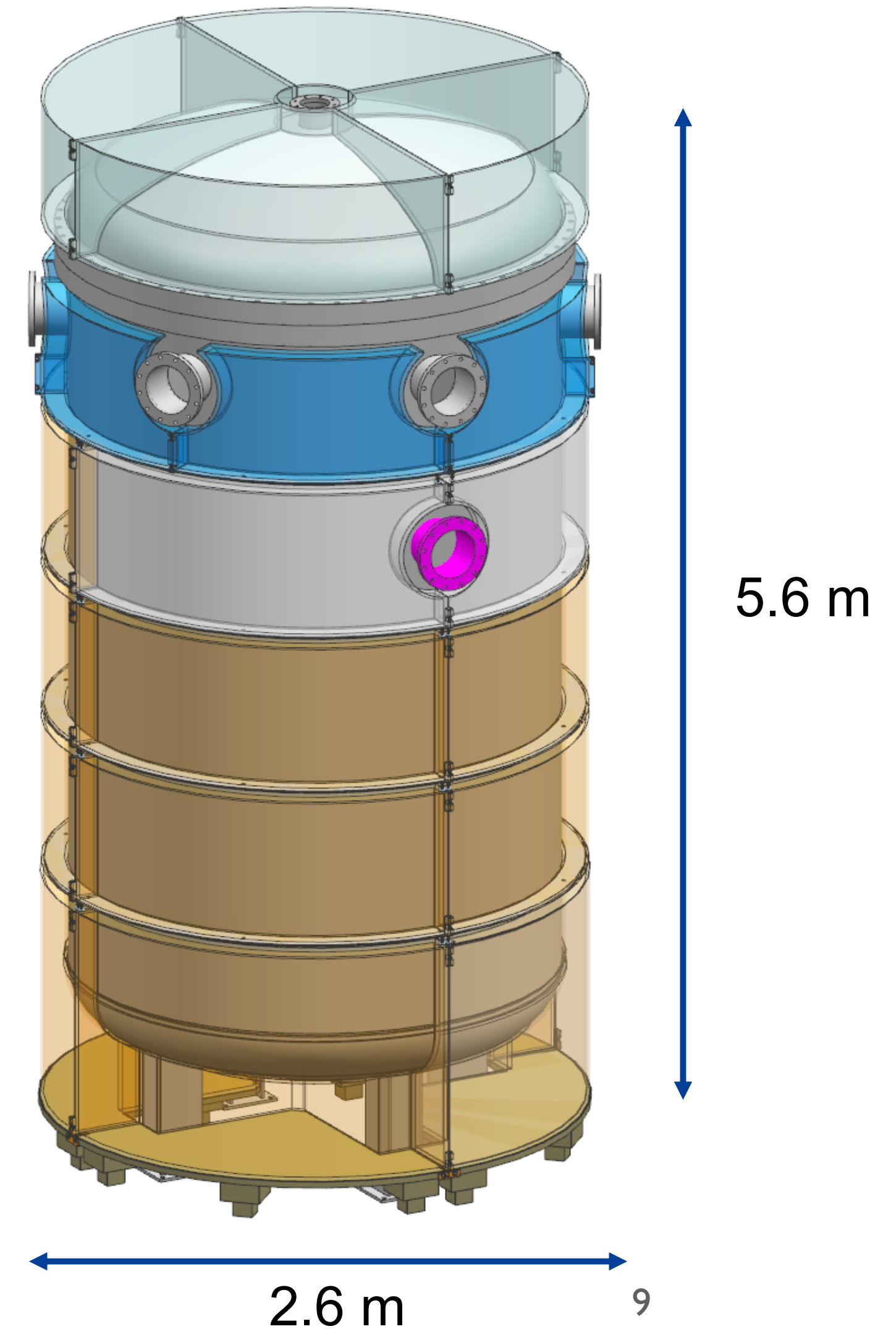
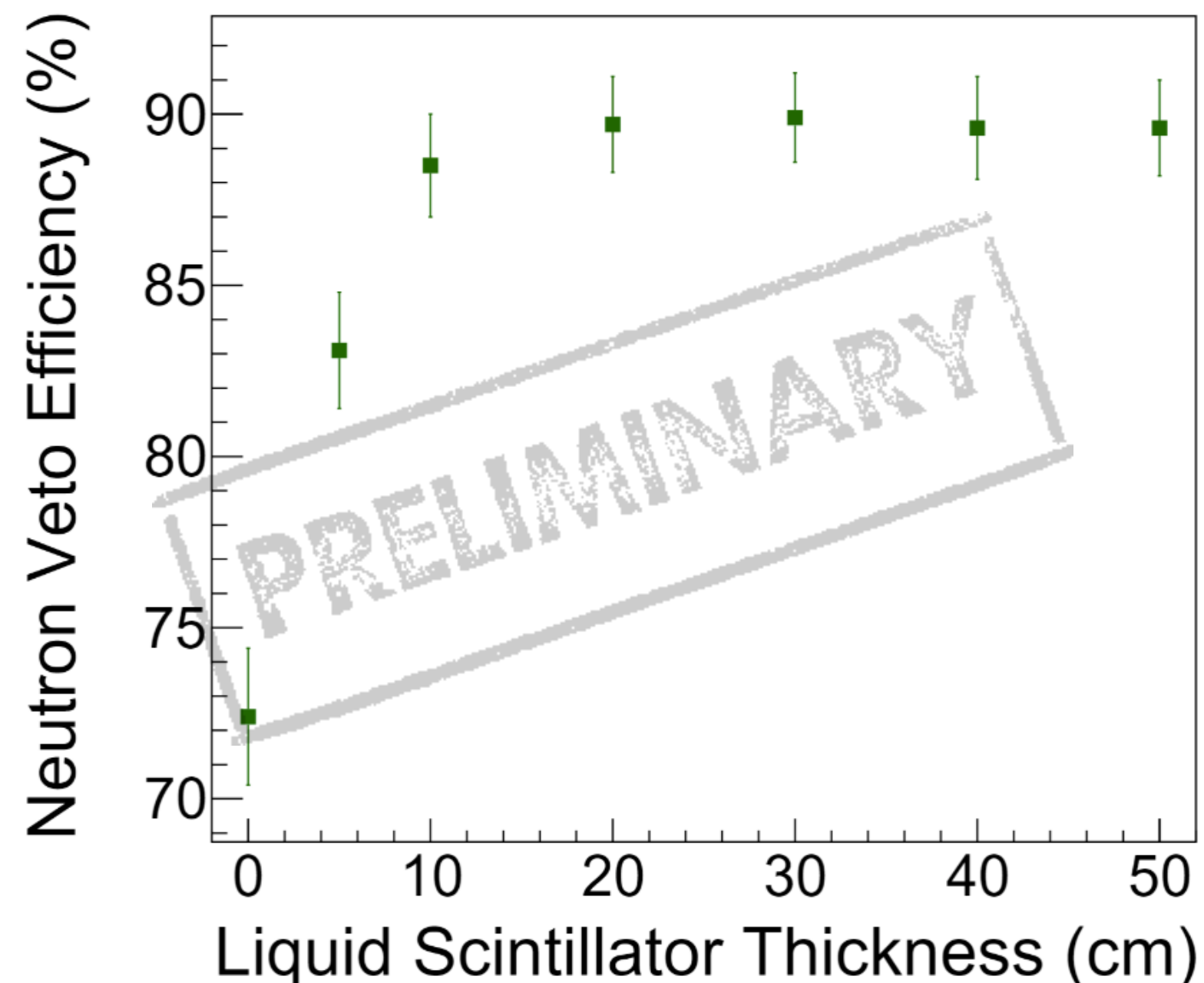
Muon Veto Detector

- Selection: ≥ 12 fired outer layer PMTs
- ~ 30 muons per day, the largest muon detector at CJPL
- 83.2 ± 2.7 (stat) / m^2 / year (preliminary)



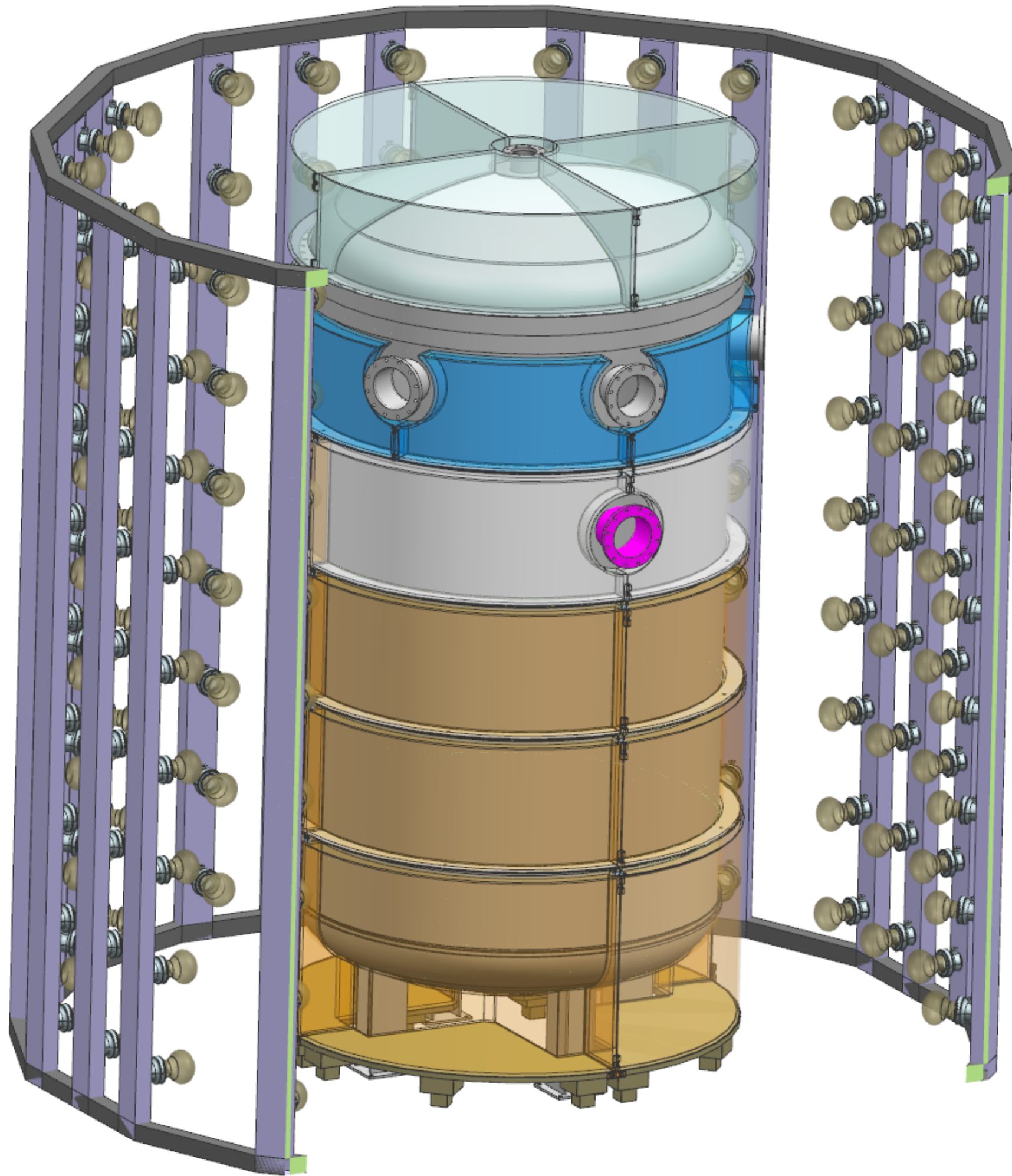
PandaX-20T: Liquid scintillator

- 10 cm thickness JUNO liquid scintillator (LAB + PPO + bisMSB) in acrylic containers
- optical simulation: close to $\sim 90\%$ neutron veto efficiency, about $\sim 20\%$ gamma veto efficiency



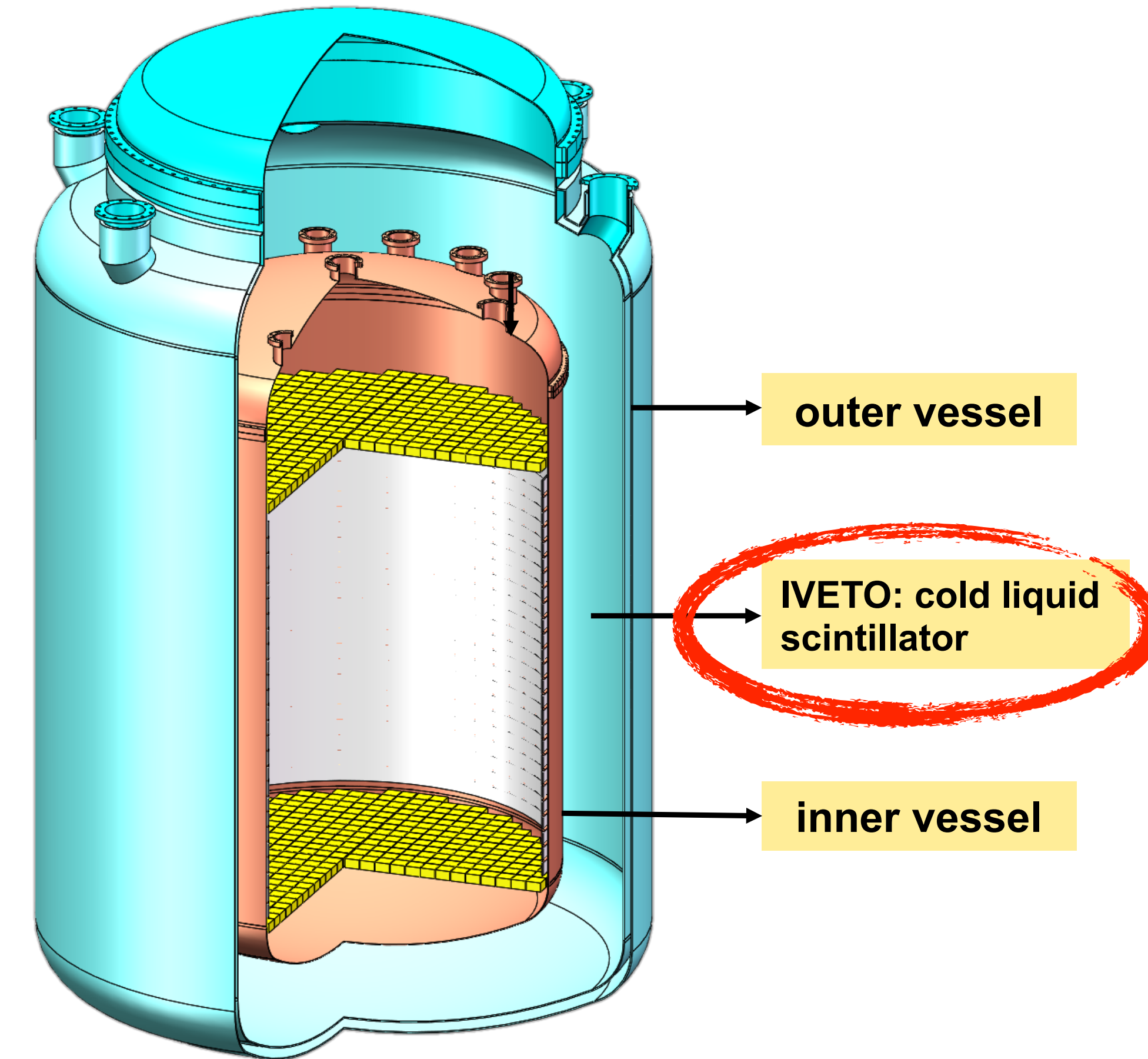
PandaX-20T: Liquid scintillator

- 270 existing PMTs, possibly purchasing another 50 PMTs
- Plan: mid-2027 for installation



PandaX-xT: Cold liquid scintillator

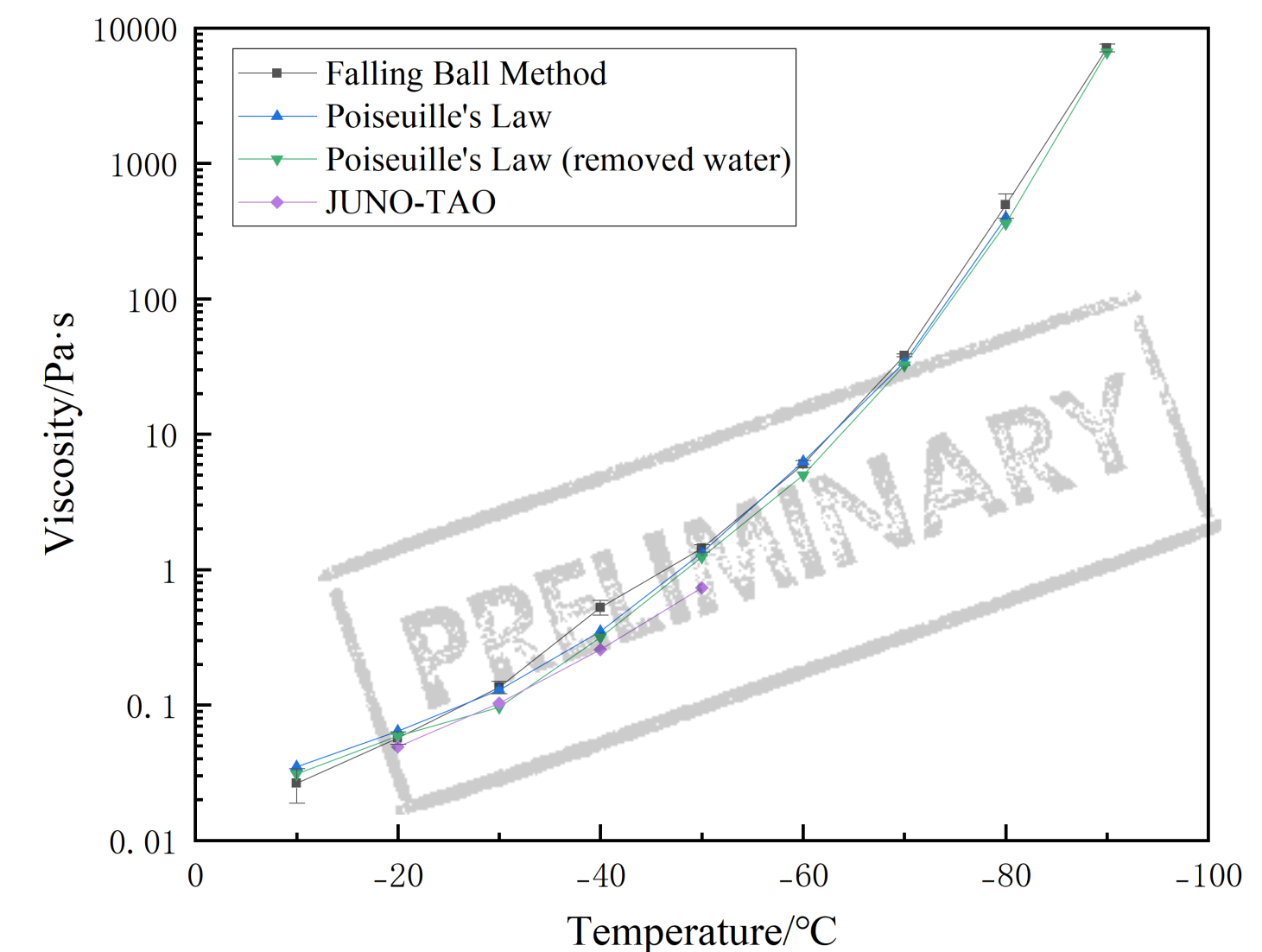
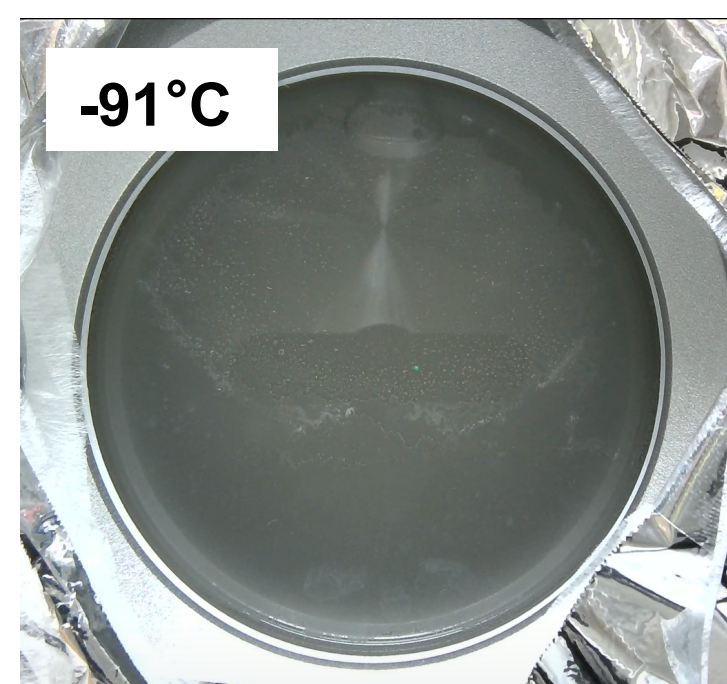
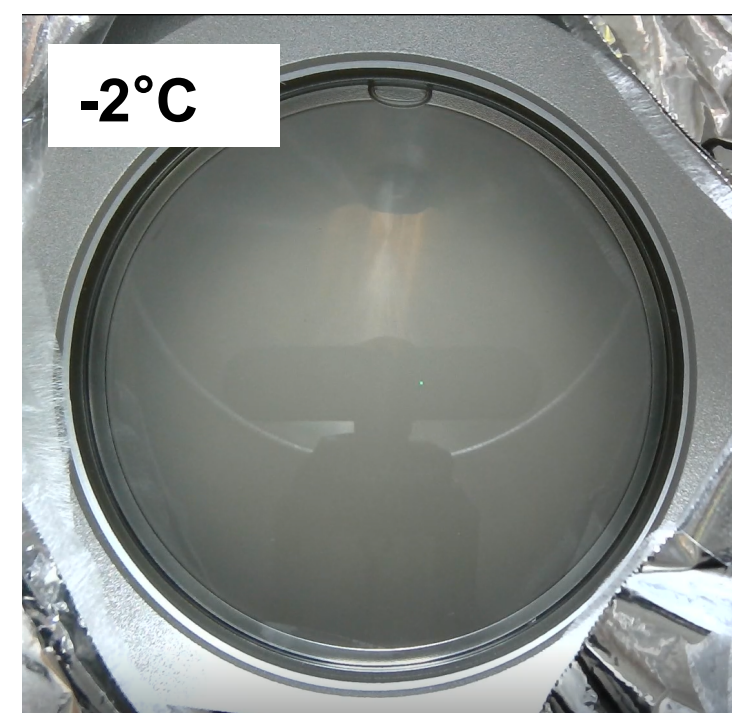
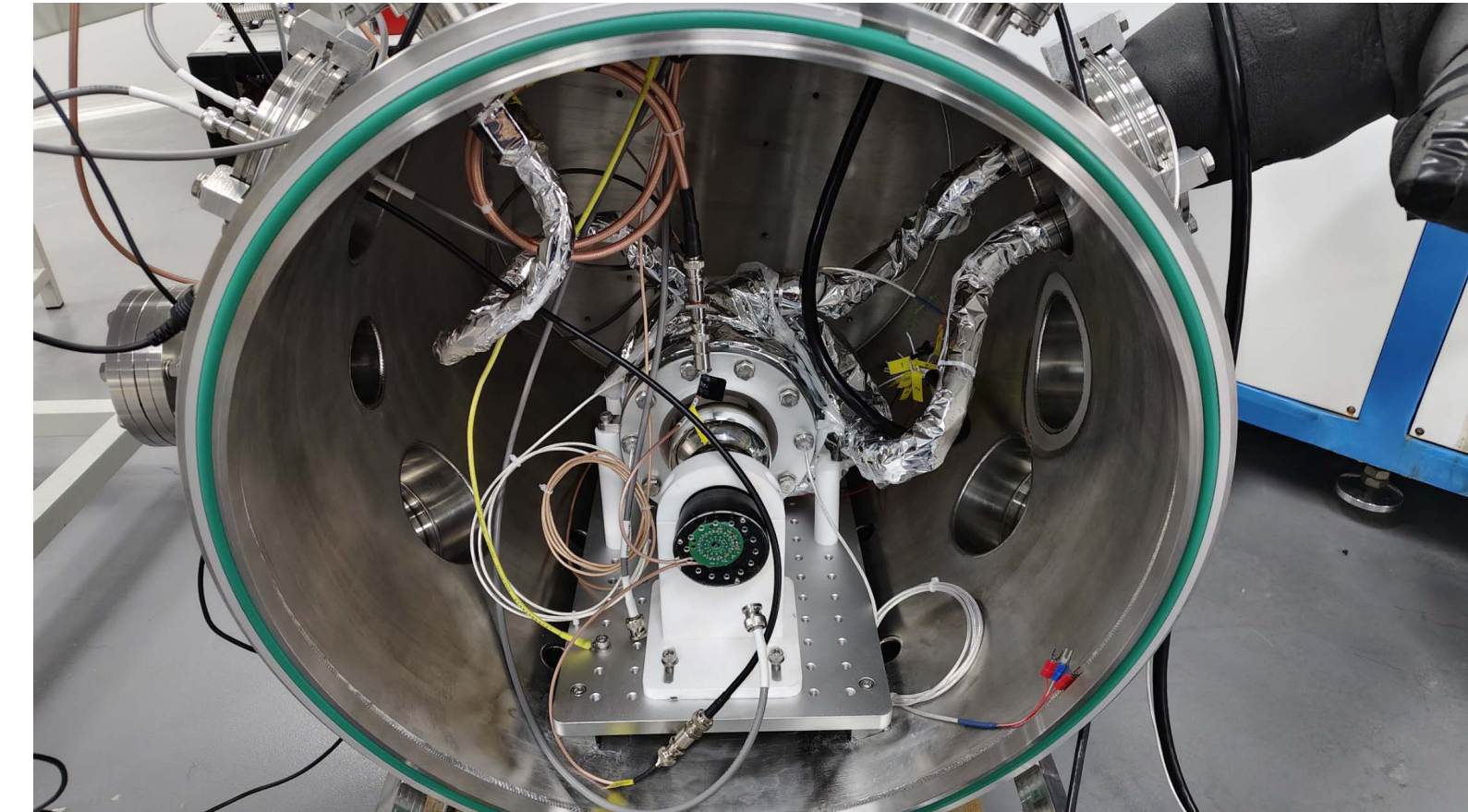
- PandaX-xT: reduce background as much as possible
- Advantages of cold liquid scintillator
 1. pressure balance, reduce LXe container wall thickness
 2. close to LXe, high veto efficiency
 3. shielding the radioactivity from the cryostat container
- Topics of R&D
 - How to do filling: viscosity
 - optical properties: transparency, light yield, light detection method



PandaX-xT: Cold liquid scintillator

I-Liter prototype

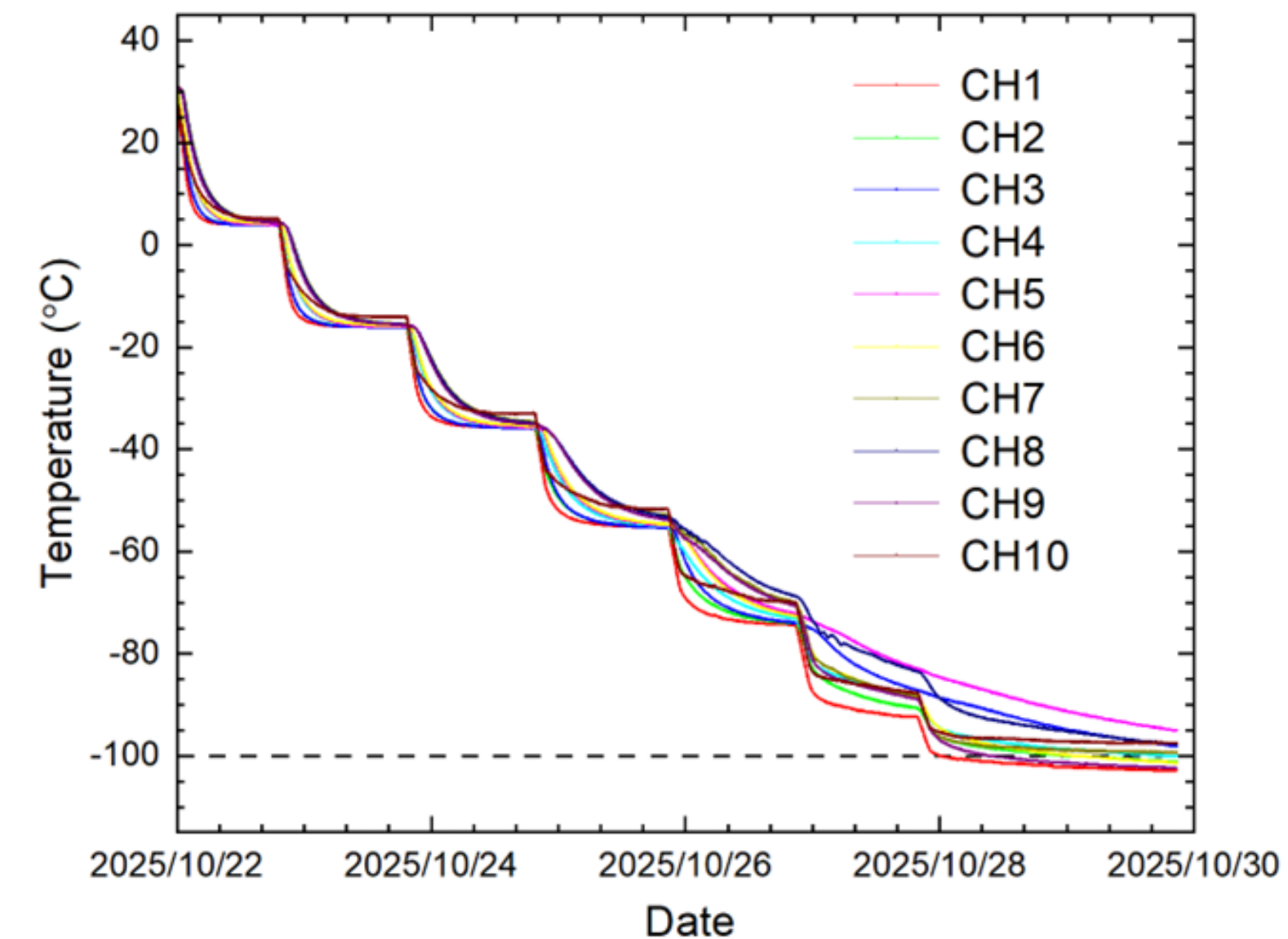
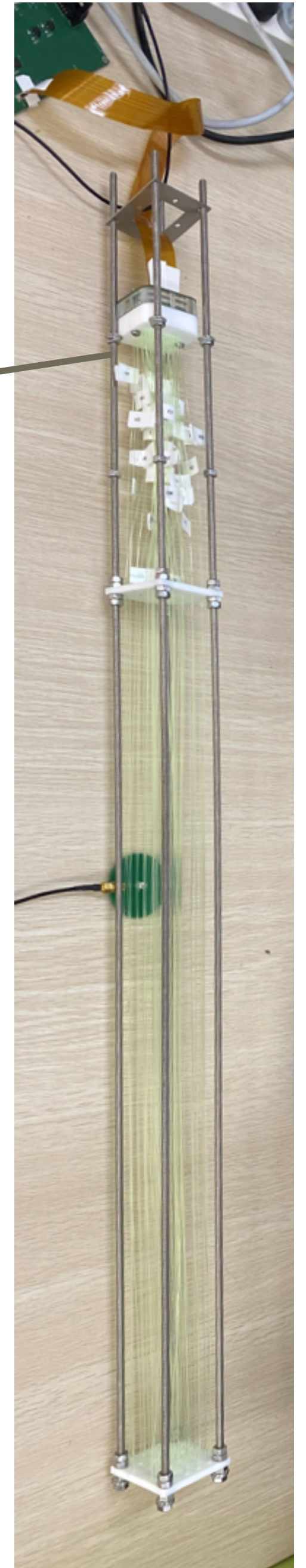
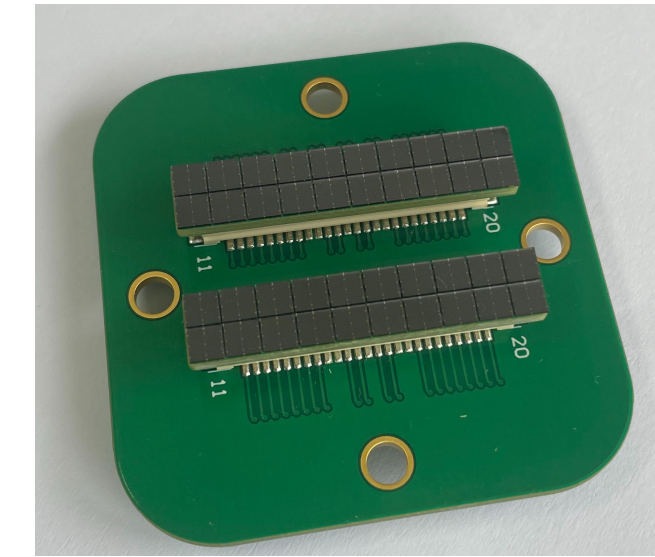
- Due to the water content in LS, transparency decreases as the temperature drops.
- At -91°C , transparency drops to about 20% of that in room temperature (430 nm LED)
- Viscosity measurement consistent with JUNO-TAO results for Temperature $> -50^{\circ}\text{C}$



PandaX-xT: Cold liquid scintillator

1-m³ prototype

- Reduced liquid scintillator transparency improves light collection of fibers (LiquidO concept - Commun Phys 4, 273 (2021))
- building a 1 m³ prototype, test fiber + SiPM readout



Veto system of PandaX experiment

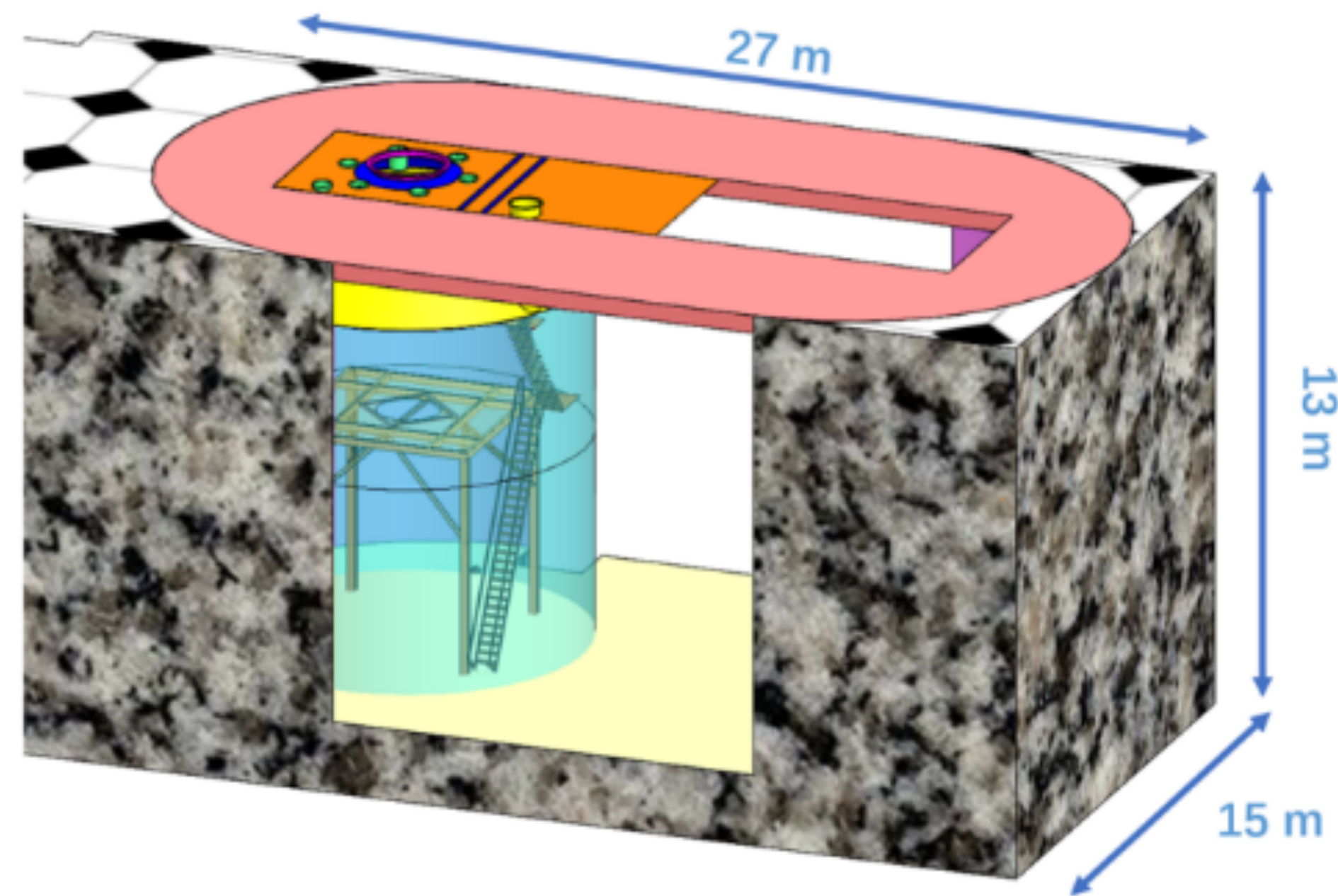
- **PandaX-4T: Water Ch**
- **PandaX-20T: Liquid sc (ction)**
- **PandaX-xT: Cold liquid (o)**



Veto system of PandaX experiment

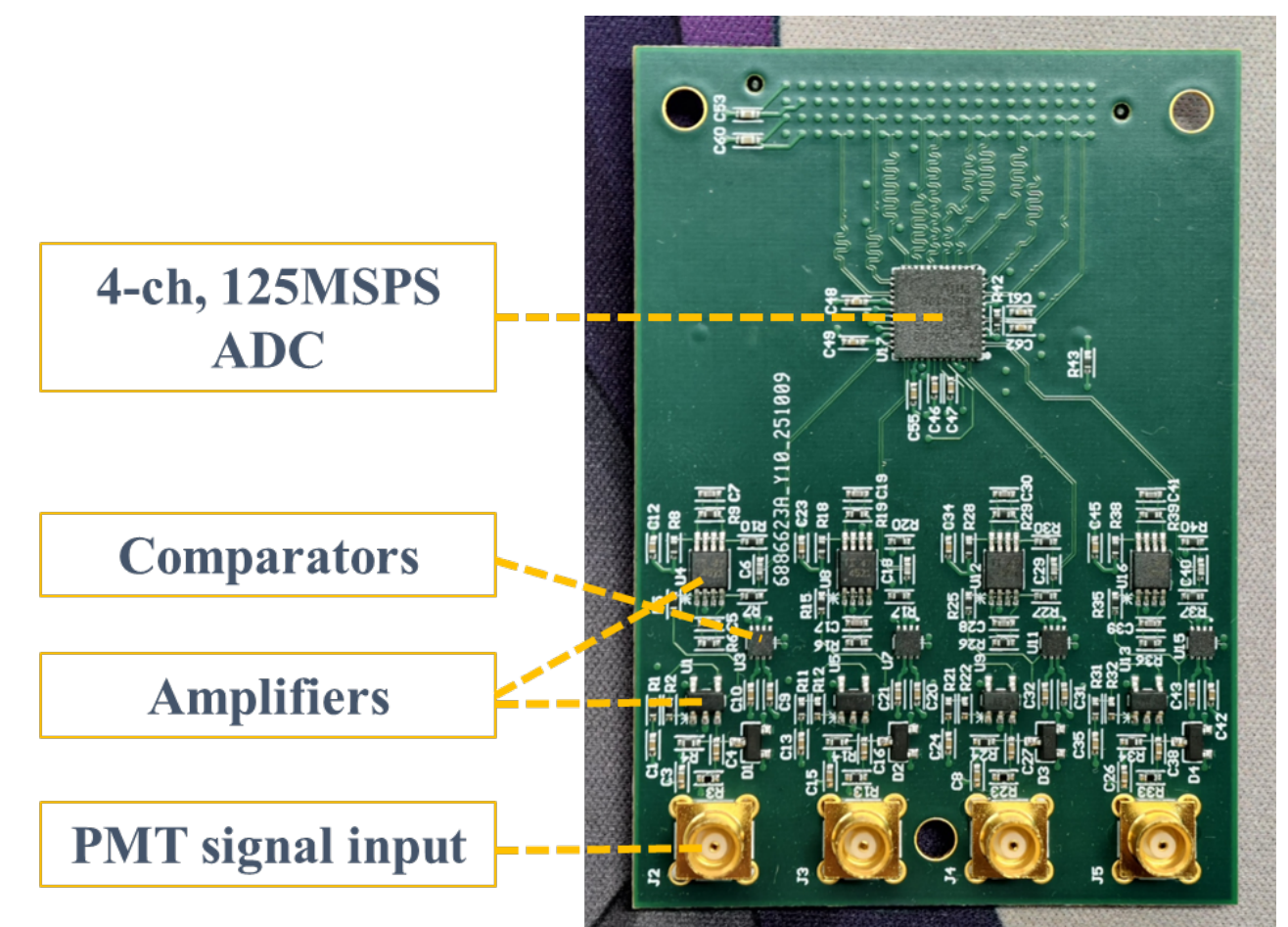
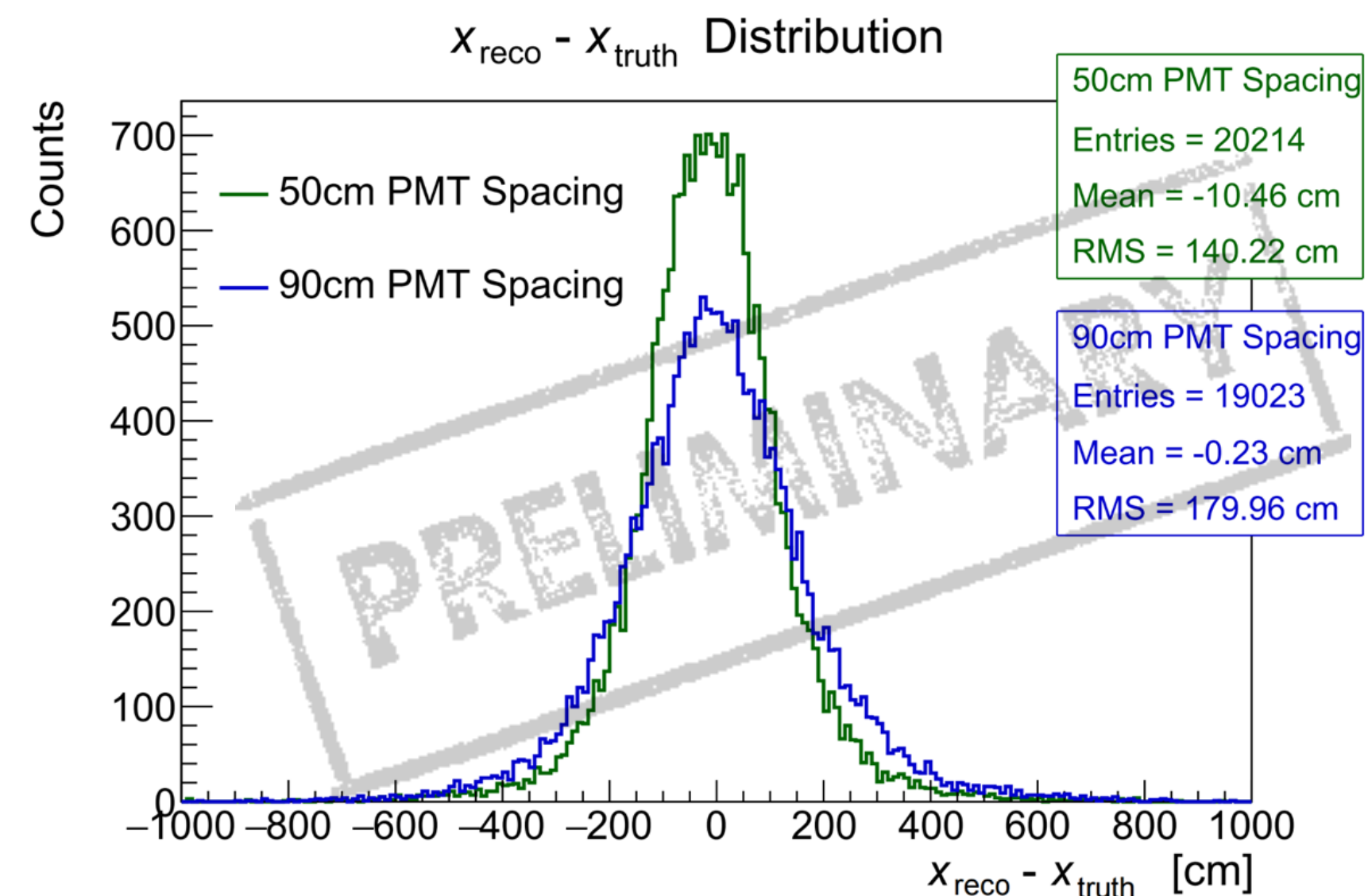
Outside of the 900 m³ water tank ...

- ~4500 m³ water pit, mount 3-inch PMT arrays on the side wall
- measure muons, atmospheric neutrino flux in-situ at CJPL



Veto system of PandaX experiment

- ~4000 3-inch PMTs (HZC XP82B2FNB) donated by Prof. Jenny Thomas from UCL.
- GNN reconstruction algorithm based on GENIE & WCSim simulation is under development to optimize the PMT layout.
- Readout electronics under development: under water, above water, time synchronizition, etc.



Summary

1. PandaX-4T Water Cherenkov veto detector

- A neutron tagging efficiency of 53.9% (500 μ s) can be achieved using AmBe calibration data. More detailed studies on the veto efficiency of background neutrons are underway.

2. PandaX-20T: Liquid scintillator

- The simulation demonstrates high efficiency for both neutrons ($\sim 90\%$) and gamma ($\sim 20\%$). The fabrication and installation workflow is being verified.

3. PandaX-xT: Cold liquid scintillator

- R&D on transparency, light yield, and viscosity, fiber Layout, etc are ongoing using prototype detectors.

4. 4.5kton water Cherenkov detector

- The reconstruction algorithms are being developed, and the PMT layout is being optimized based on the reconstruction results. Electronics system is under development.

Thanks

