Hyper-Kamiokande detectors

Alessandro Di Nola – PhD student

Photodetectors

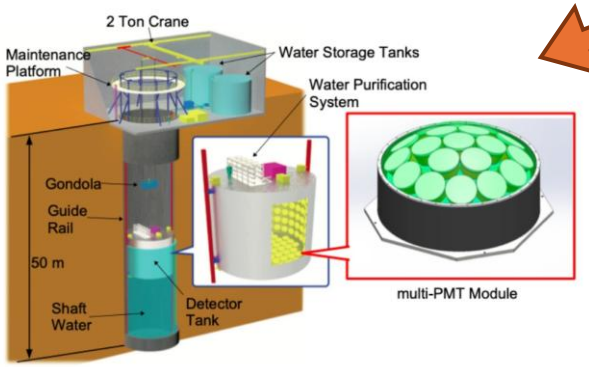
Hyper-Kamiokande will be instrumented with **20,000** 20’’ photomultipliers

The PMT used are the newly developed Hamamatsu R12860

PMT improvements compared to the previous ones used in SK:

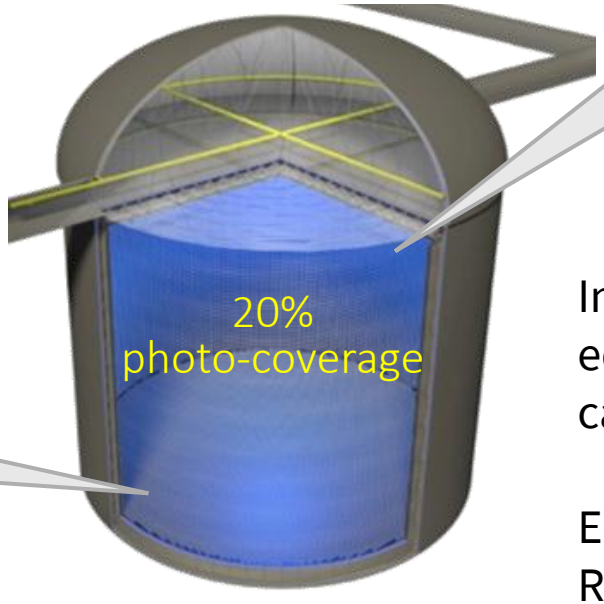
- higher pressure resistance
- double detection efficiency
- half time&charge resolutions

mPMTs will be the only photodetectors in IWCD



3" R14374 PMT

mPMT module

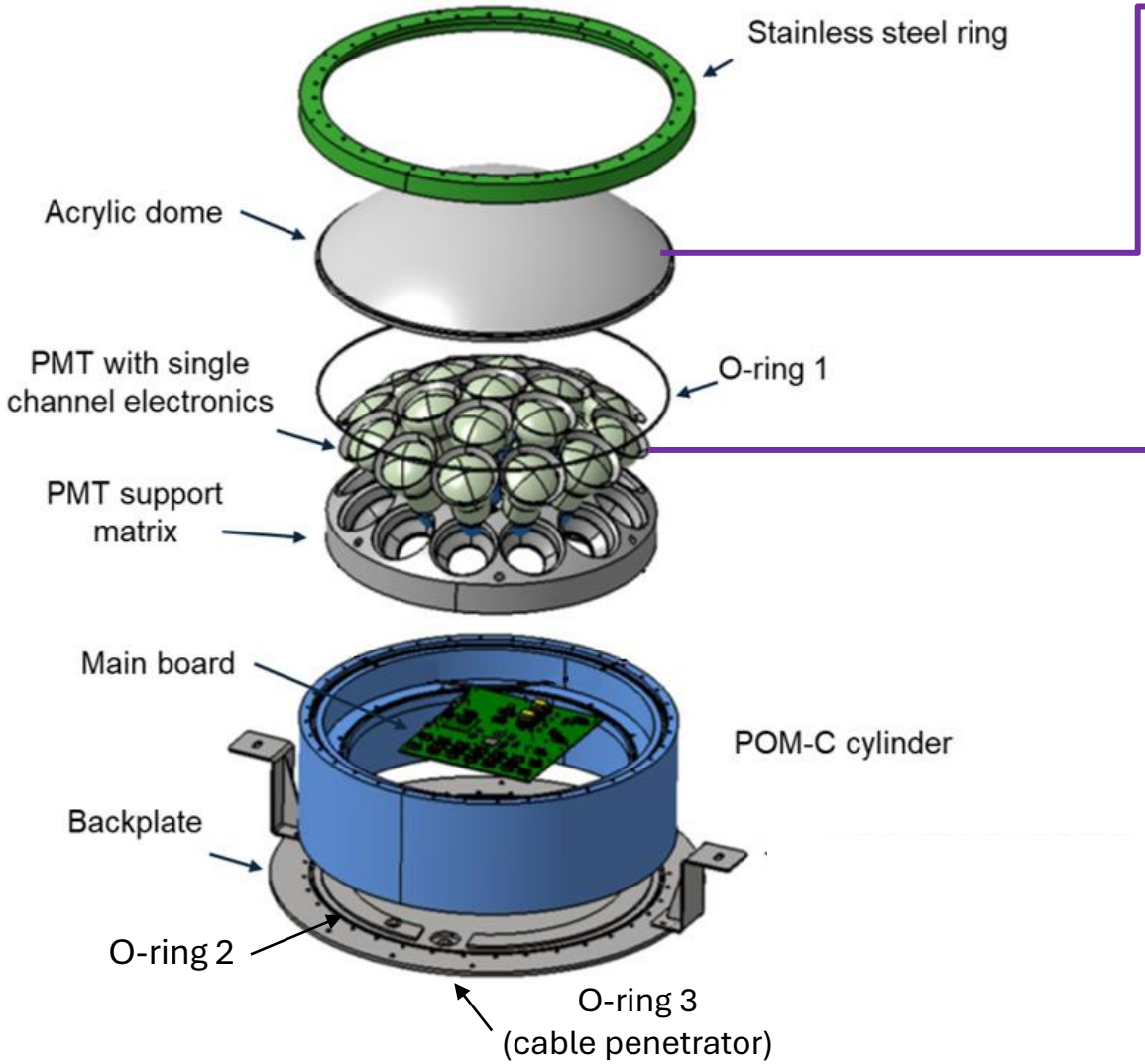


20" R12860-HQE B&L PMT

In addition to the 20’’ PMTs, Hyper-K will be equipped with **808 multi-PMT optical modules** called mPMTs

Eeach mPMT is equipped with 19 Hamamatsu R14374 PMTs

Il multi-PMT



Acrylic dome

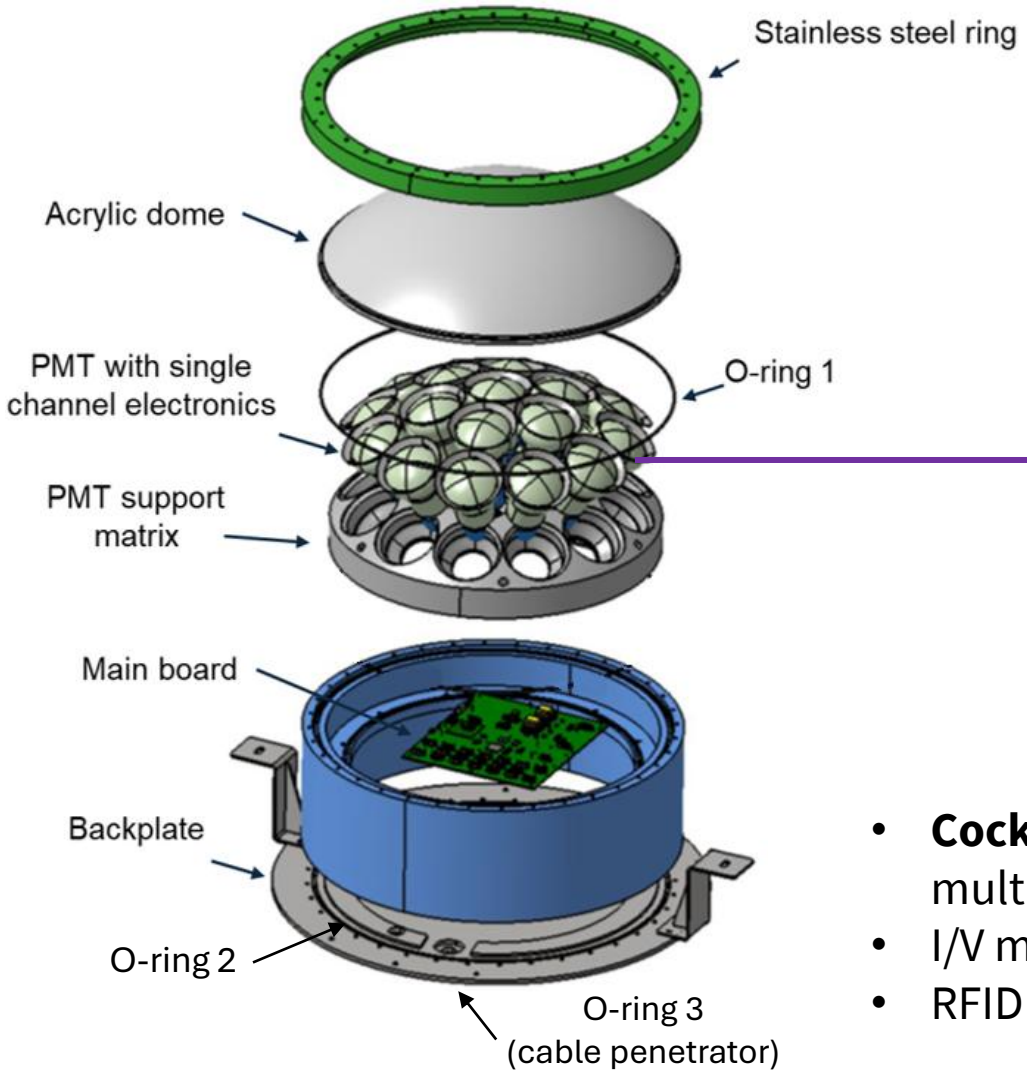
- 13mm thickness
- **Refraction index** similar to ultra-pure water
- Low radioactivity
- Ease of manufacture and low cost

Optical gel

Transparent silicone rubber gel for optical coupling:

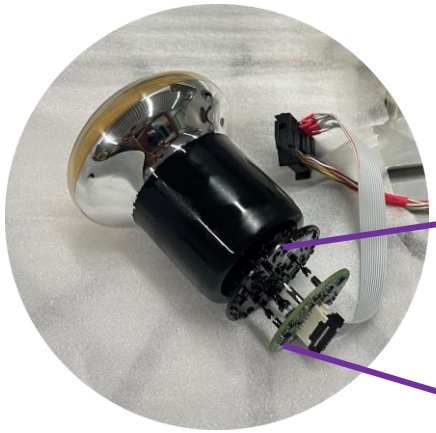
- High optical transparency
- **Refraction index** close to acrylic and water
- Stiffness and elasticity to mechanical stresses
- Containment of deformation of acrylic
- **Long-term stability** (20 years of operation)

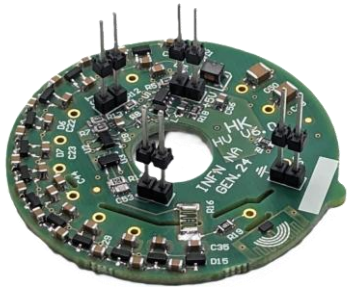
Il multi-PMT



3” PMT

19 Hamamatsu R14374 with a **DCB coating**





HV Board

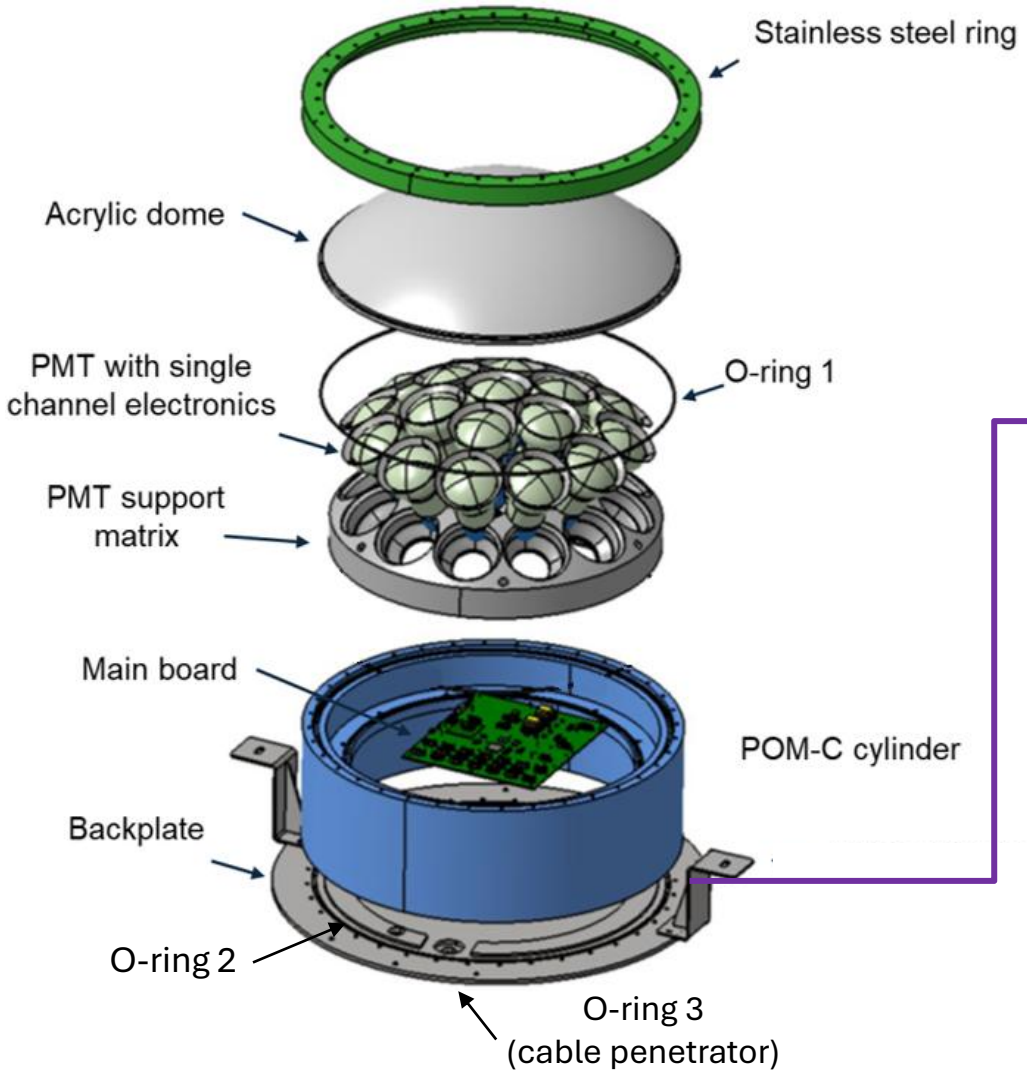
- **Cockroft-Walton** with 11 multiplication steps up to 1500 V
- I/V measuring circuit
- RFID chip for identification

Front-End Board

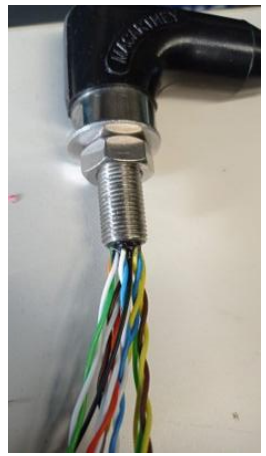
- **Time measurement circuit**, using a discriminator (FWHM of 100 ps)
- **Charge measurement circuit**, using a sample-and-hold (S/H) ADC
- Acquisition up to **1 MHz** (entire detector)

Il multi-PMT

Backplate, Mainboard and cable

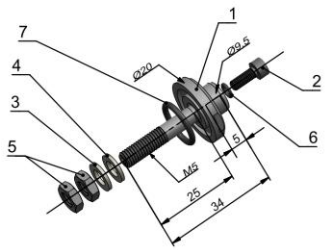


Penetrator



Connectors sealed with an **epoxy resin**

Pressure valve



Submarine industrial cable:

- **Polyurethane** jacket
- Comunication with the outside via ethernet
- Power supply via **POE** (Power-over-Ethernet)

Il multi-PMT

Dark Rate reduction

3’’ PMTs have low darkrate → better reconstruction for Low Energy Events

Extension of dynamic range

Each channel can detect up to 80 photoelectrons

Improved angular acceptance

With 19 PMTs the detector covers a bigger angle

Intrinsic directional sensitivity

Reconstruction of the directions from which photons come from the study of charge distribution

Failure rate reduction

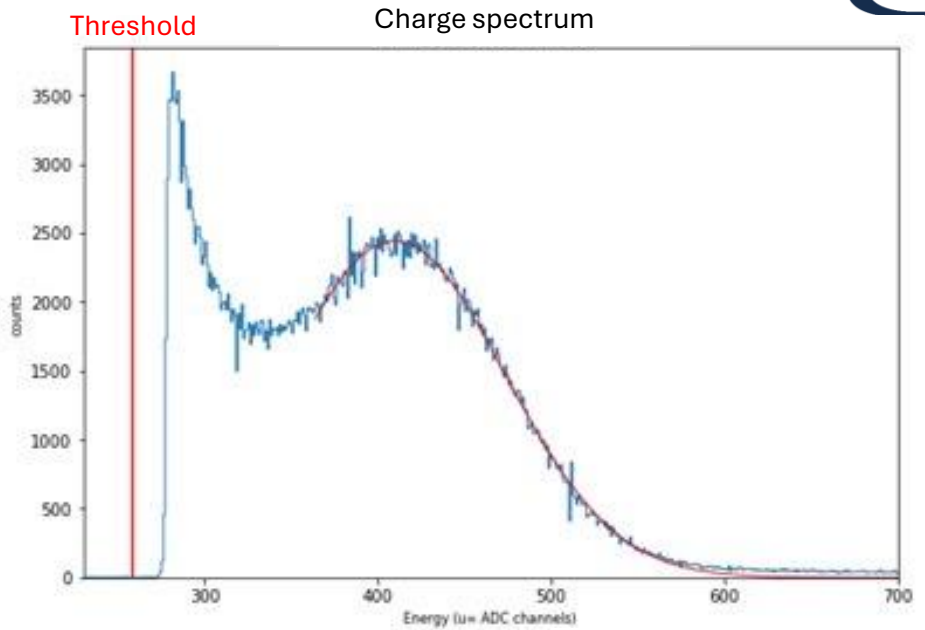
A singla channel failure does not compromises the entire detector

Local coincidences

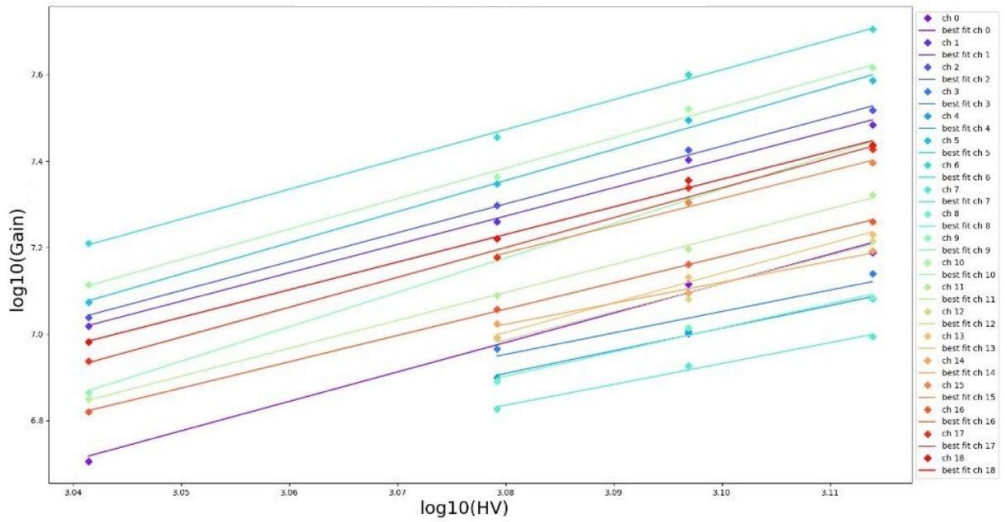
Dark counts and dark rate can be reduced studying local coincidences

mPMT characterization

- **Single photon spectra and S/N ratio**
- **Gain equalization**
- Peak-to-valley ratio measurement
- Coincidences

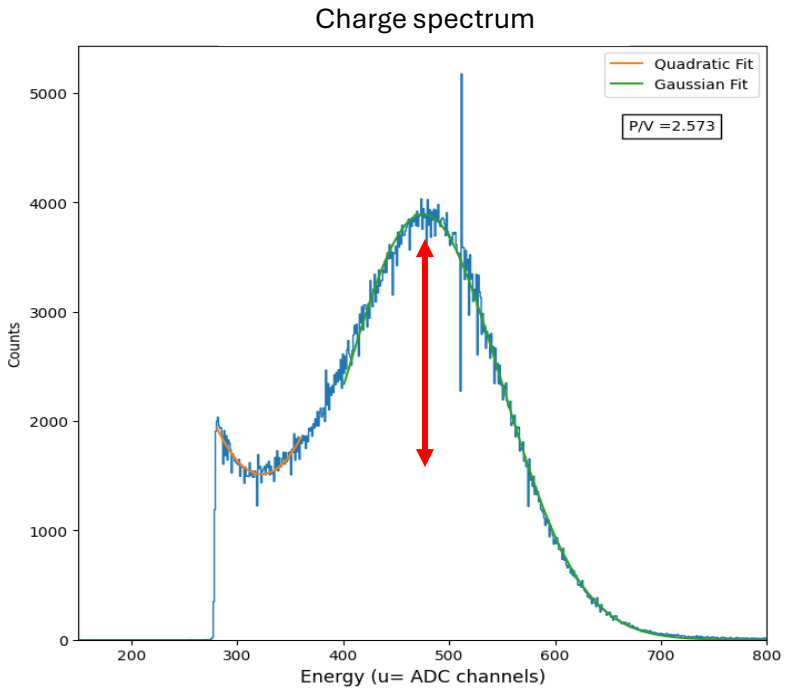


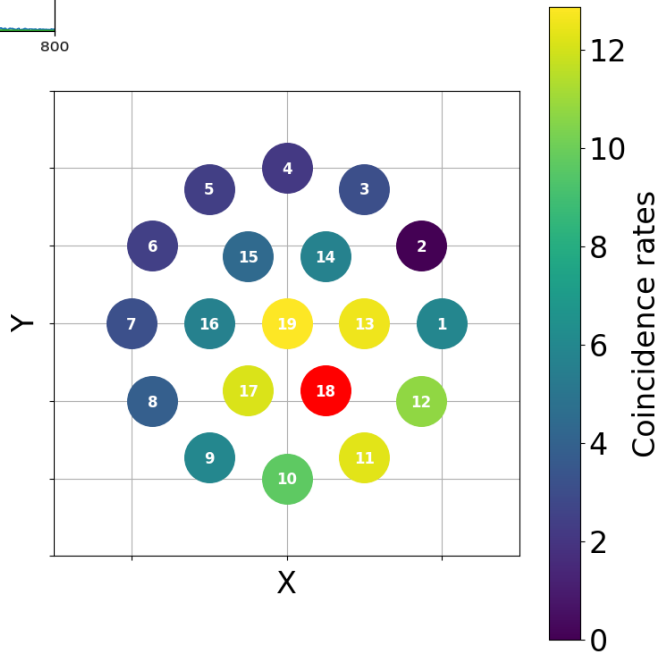
PMT gain



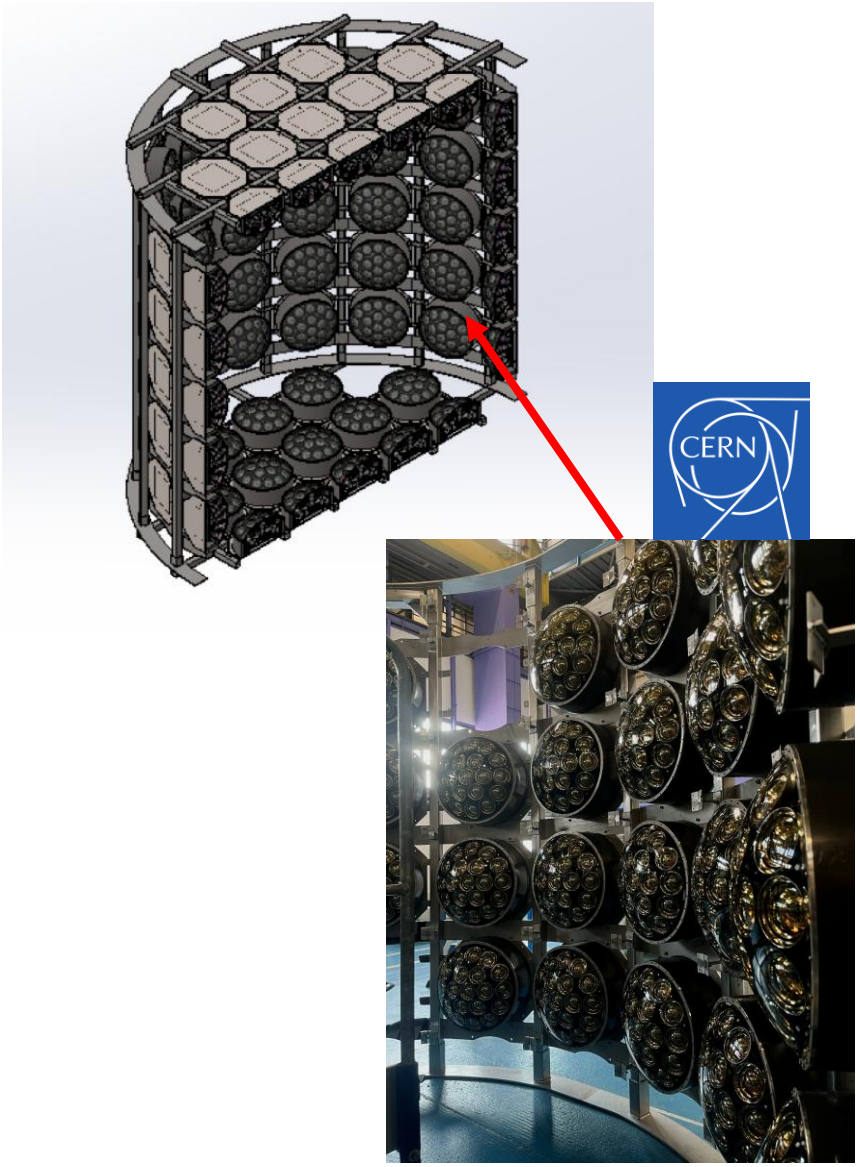
mPMT characterization

- Single photon spectra and S/N ratio
- Gain equalization
- **Peak-to-valley ratio measurement**
- **Coincidences**





Water Cherenkov Test Experiment



The WCTE will act as a **technology demonstrator** for water Cherenkov detector technologies developed for Hyper-Kamiokande and IWCD

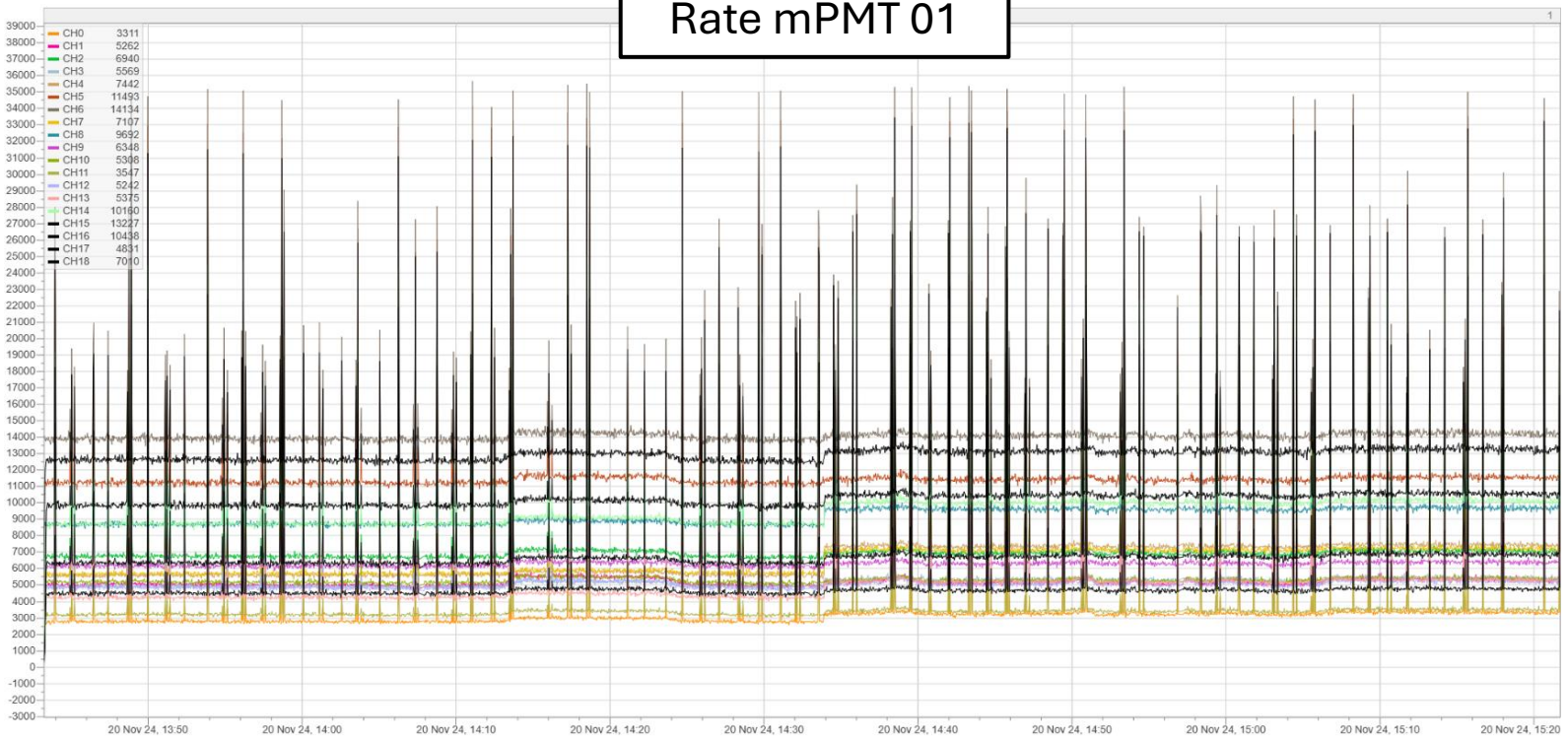
- 4 m height 4 m diameter
- Beamline T9 (e±, μ±, π±, p), with a momenta between tra 140 MeV/c e 1200 MeV/c.
- 128 mPMT (**4 FD** + 124 IWCD)
- Start data-taking October 2024, now halted. Waiting for the first results in **first half 2025**

FD mPMT in WCTE

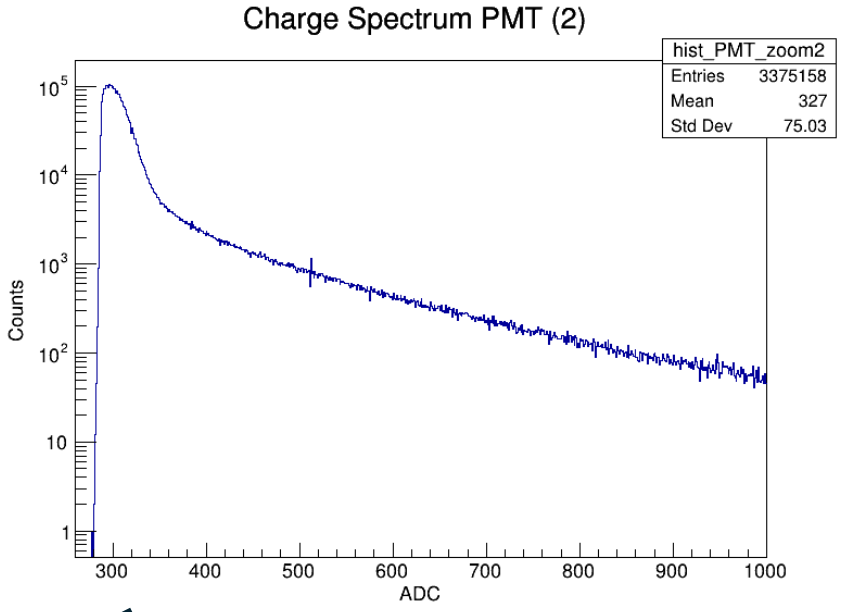
Real time monitoring of ratemeters

- Substantial light leaks in the tanks and also possibly a bad LED generating light in the tank gave high rate for weeks
- After all the mPMT worked fine until beam shutdown

Rate mPMT 01



Trend of beam spill clearly visible



Data are under conversion. ToolDAQ format requires custom libraries for analysis, but today we will start looking to the full data

Thanks for your attention