Hyper-Kamiokande

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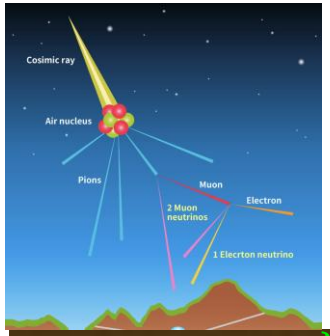
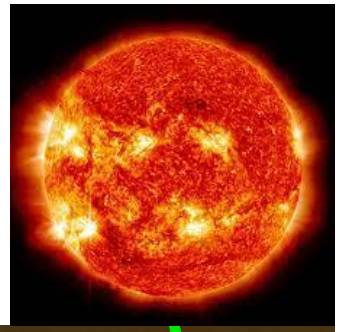
Hyper-Kamiokande Experiment – Physics Goals

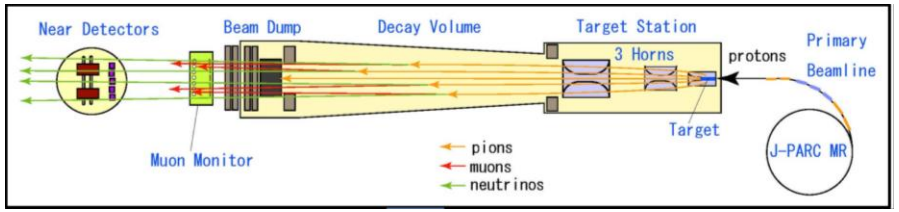
The next generation water Cherenkov experiment in Japan





Oscillation of accelerator and atmospheric ν's

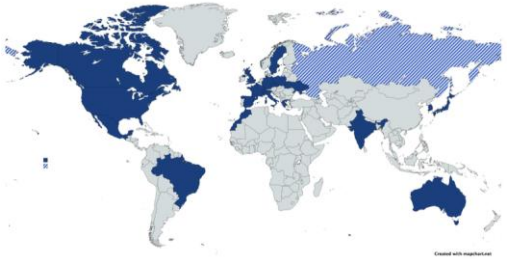
- CP violation → matter/antimatter asymmetry
- Neutrino mass ordering (MO) → ν masses, input for $0\nu\beta\beta$ and direct mass experiments
- θ_{23} octant and δ_{CP} → lepton symmetries



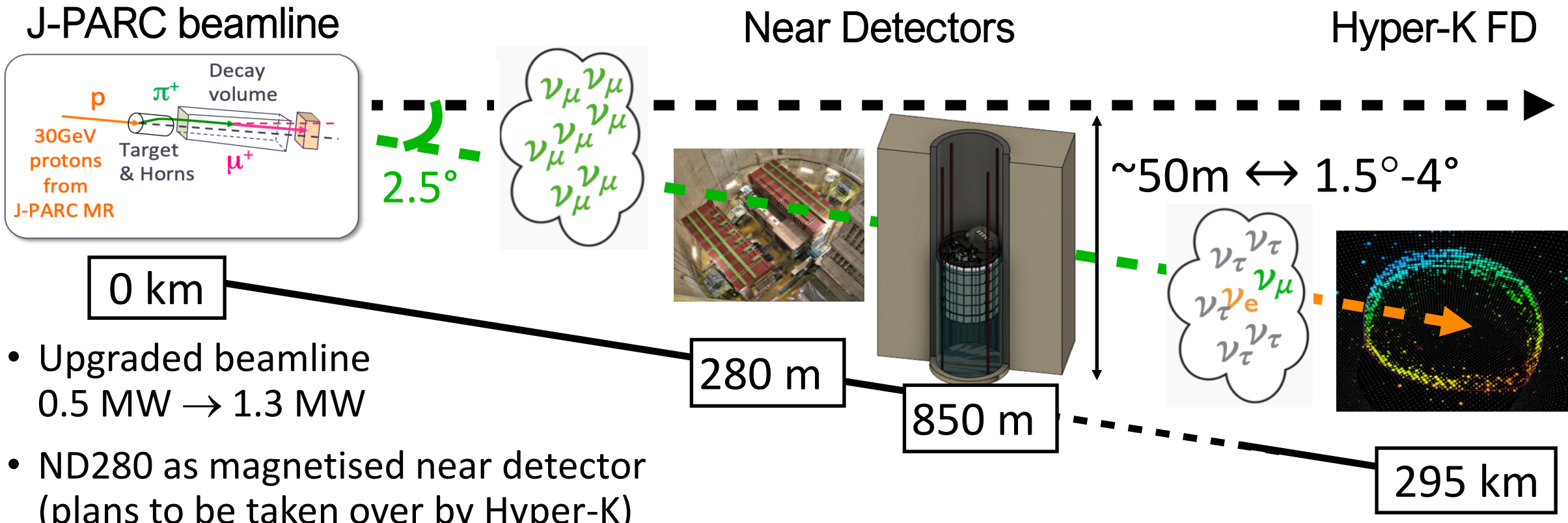
Other physics program:

- Solar ν's
- Supernova burst and diffuse background ν's
- Search for proton decay
- Indirect Dark Matter search

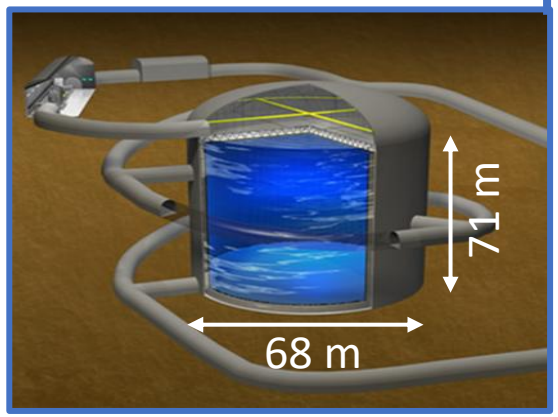
- 22 countries, 106 institutes, ~650 people (December 2024)
- Still growing (~24% Japanese and ~76% non-Japanese)



Hyper-Kamiokande Experiment



- Upgraded beamline
  0.5 MW → 1.3 MW
- ND280 as magnetised near detector
  (plans to be taken over by Hyper-K)
- A new Intermediate Water Cherenkov Detector (IWCD)
  (movable along off-axis angle, approx. kt-scale)
- Water Cherenkov far detector: 188.4 kton fiducial volume (≈8.4 x Super-K)

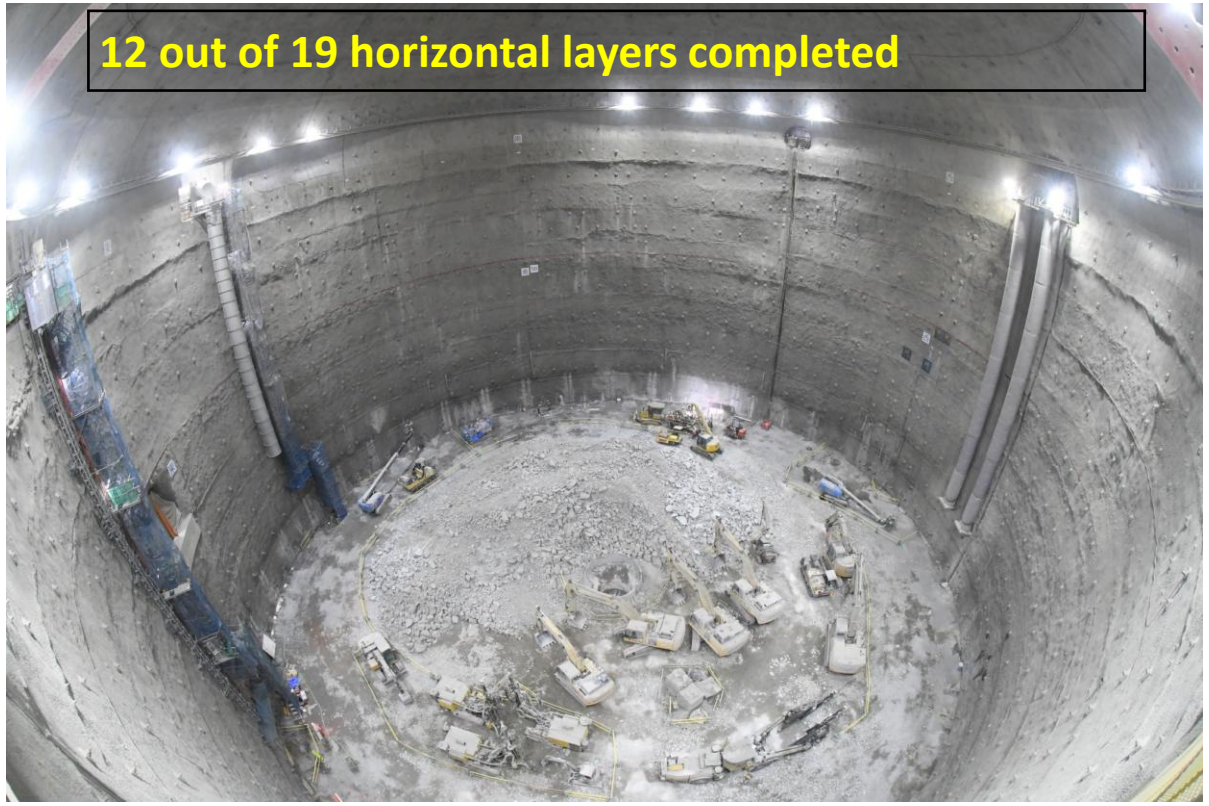


ON-GOING CONSTRUCTION (starts in 2027)

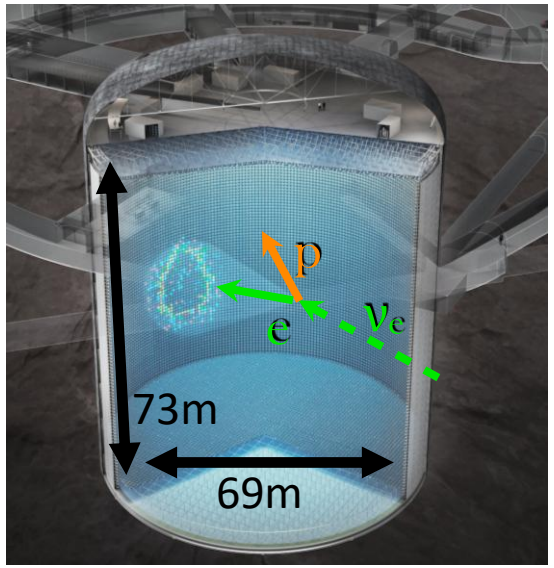
Water Cherenkov Test Experiment

- Water Cerenkov Test Experiment @ CERN
  - 50-ton scale detector (~4m×4m cylinder) to study detector calibration and response with known p, e, π, μ fluxes of 0.2-1.1 GeV/c and develop percent level calibration of water Cerenkov detector.
  - Secondary beam of particles produced by target upstream of the detector.
  - Measurements with ultra-pure and 0.2% gadolinium sulphate-doped water (to capture neutrons produced in CCQE antineutrino interaction and in secondary protons/pions interactions).
  - About 100 multi-PMTs.
- Major test bed for Hyper-Kamiokande multi-PMT systems and several calibration strategies
- Detector completed (Oct. 2024), already had first runs with beam
  - Some problems with light leaks, electronics and DAQ – to be resolved by the end of Feb. 2025

Far Detector Update

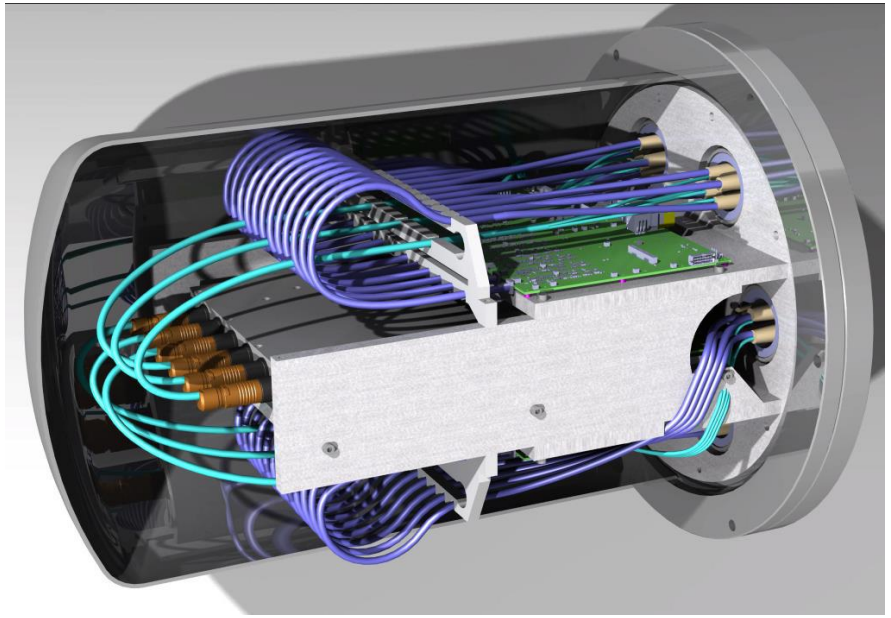


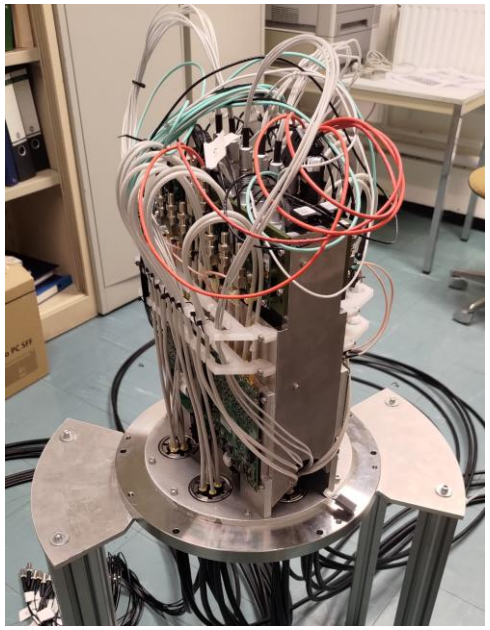
- 256 kton total mass (H = 73 m, ∅ = 69 m)
- 188.4 kton fiducial volume (~8.4 x Super-K)
- Largest ever human-made cavern

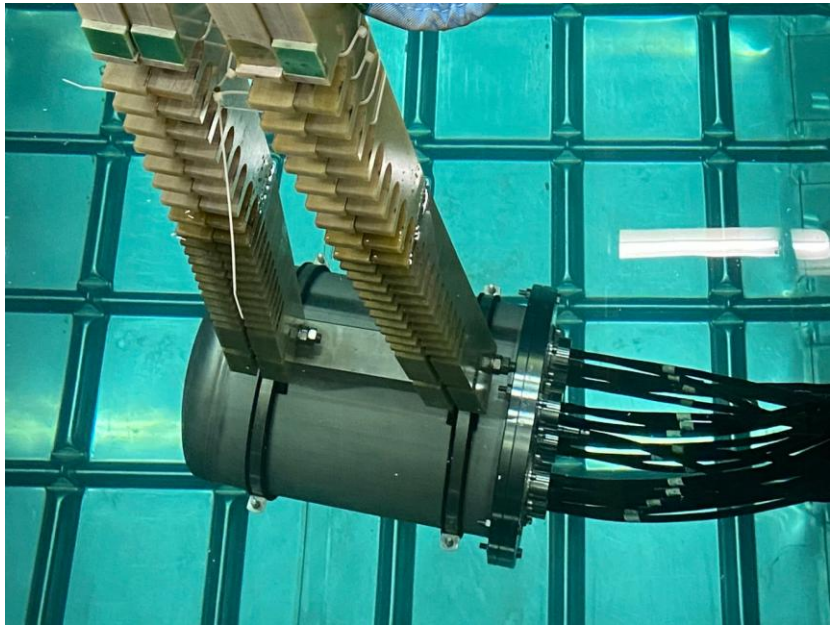


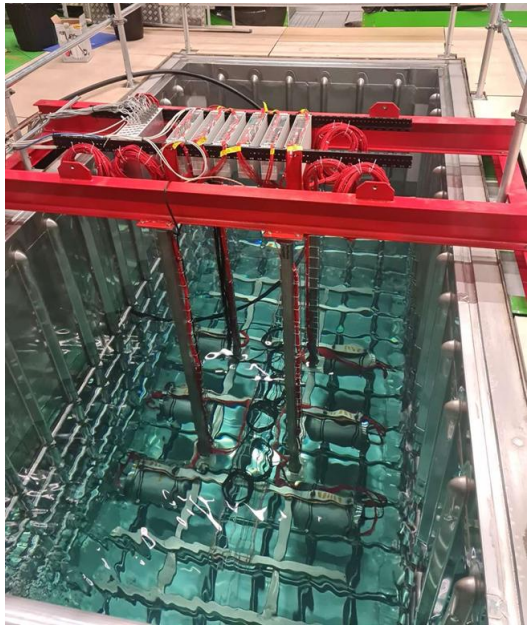
Far detector electronics

- Preparing for mass production
- On-going long-term tests
- Integration test done (ID), on-going (OD)
- Defining assembly and test protocols for mass production
- Preparing tender specifications
- Preparing assembly project at CERN (NP08 Neutrino Platform project)



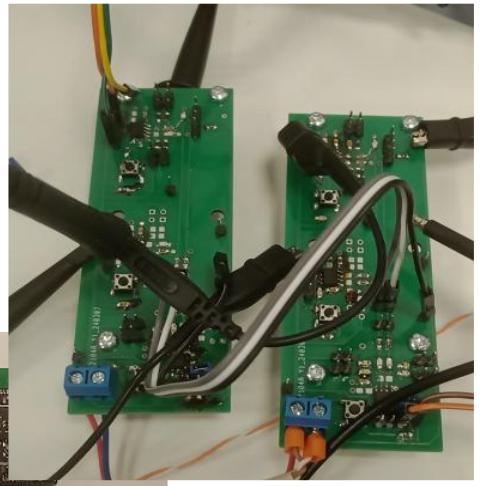


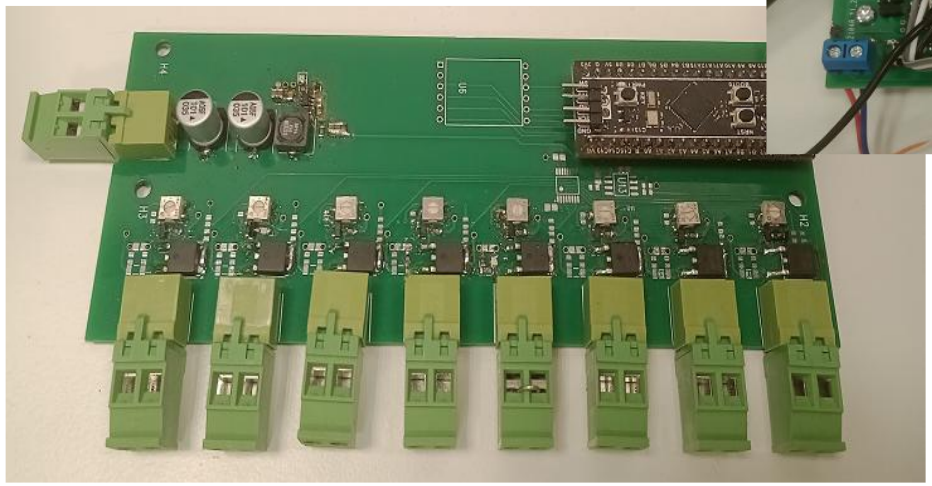




Reliability tests of electronic boards

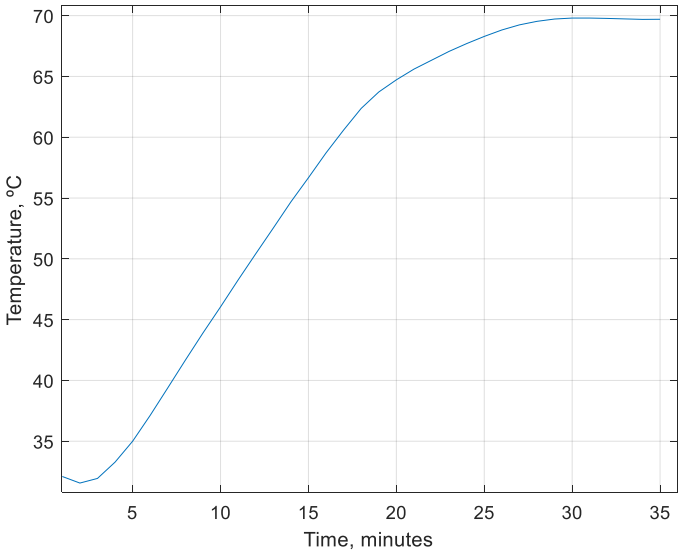
- Climate chamber for electronics board ageing tests
- Temperature range 0 ºC to 100 ºC Humidity from 10 to 90%
- From 32 ºC till 70 ºC - 29 minutes

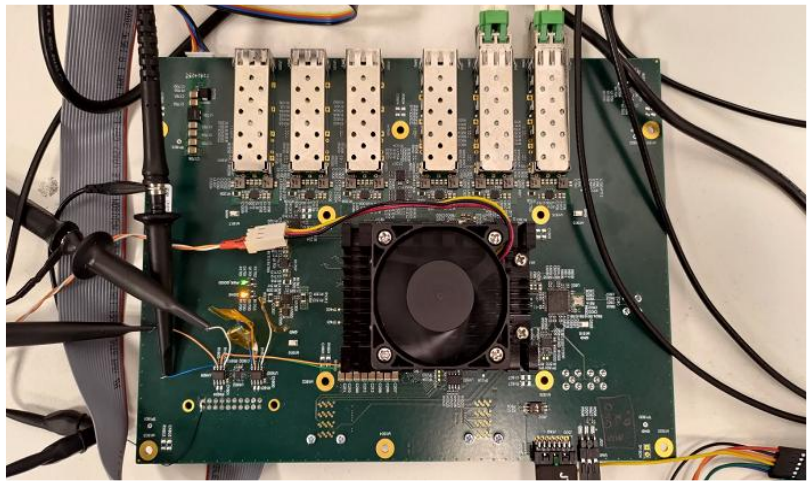




- Preparation of the 136 room for the climate chamber
- Improving the electrical circuits in the room
- HASS and HALT procedures for board testing
- Dedicated test boards

M. Suchenek

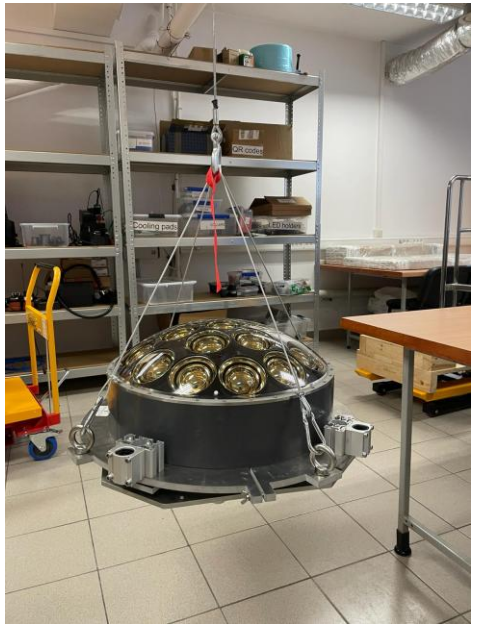


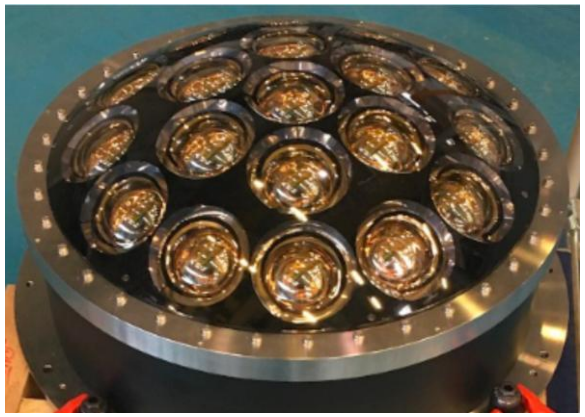


Multi-PMTs

- Completed production of 55 units of the IWCD-type mPMT modules
- Finalized QA procedures
- Optimized assembly proces
- Sorted-out logistics issues

PREPARING FOR FD module PRODUCTION





Summary

- Many milestones reached in 2024
  - Completion of WCTE detector, incl. commissioning and first beam data
  - Completion of test production of IWCD-type multi-PMTs
  - Optimization of mPMT production line
  - Evaluation of integrated underwater vessels for the far detector
  - Preparation of NP08 Neutrino Assembly project at CERN
  - Launching aging tests of electronics
- Many things still to be done
  - Defninition of protocols: assembly, calibration, burn-in strategy
  - Papers:
    - WCTE mPMT construction paper, target: NIM A (internal review)
    - WCTE mPMT electronics paper, target: NIM A (starting to write)
    - WCTE beam telescope paper, target: JINST (internal review)
    - HK Supernova Sensitivity (target: PRL, internal review)
  - Technical notes:
    - Protocol for Hyper-Kamiokande electronics acceptance test at the assembly site
    - Protocol for calibration of Hyper-Kamiokande digitizers
    - Protocol for burn-in tests of Hyper-Kamiokande electronics at the companies
  - Procurements
    - 6000 PMTs for FD multi-PMT modules (done), 1600 PMTs for IWCD multi-PMT modules
    - 1160 Underwater feed-throughs for FD electronics
    - 22800 HV and front-end cards for mPMT modules
    - 500 data concentrator cards for the FD

BACKUP

Activities in Poland (2025)

- Management:
  - Executive Board membership (*prof. Ewa Rondio from NCBJ*)
  - Speakers Board chair
  - Three deputy conveners for far detector working groups (**electronics**, calibration, **mPMTs**)
  - **Deputy convener** – IWCD and WCTE detectors (photodetectors & electronics)
  - Technical coordinator, working group level (multi-PMTs)
  - **Steering Committee membership** (IWCD, WCTE)

Over 40 people in Poland from 9 institutions; WUT/CAMK/AGH/UJ -> 17 people, ≈13 FTE

- R&D + production:
  - Linear accelerator (NCBJ)
  - Far detector electronics (CAMK, WUT, UJ)
    - Data processing module (DPB)
    - Data concentrator card for multi-PMTs (MCC)
    - Reliability estimations
    - Ground system design
    - Design reviews
  - IWCD electronics (WUT, UJ, AGH, CAMK)
    - Multi-PMT front-ends
    - High voltage supplies
    - Data concentrator card for multi-PMTs (MCC)
    - Quality asurance (incl. dedicated test hardware)
    - Design reviews
  - multi-PMTs (WUT, CAMK)
    - Photosensor characterization
    - Optimization of assembly strategy
    - Mass production (completed for WCTE, preparing for FD)
    - Quality assurance
  - WCTE (CAMK, WUT)
    - Electronics for beam tests, detector construction & comissioning
  - Analysis + simulations + computing

Collaboration with UPV (Valenzia)

Close collaboration with TRIUMF and INFN Naples