The Hyper-Kamiokande Outer Detector

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On behalf of the Hyper-Kamiokande Collaboration

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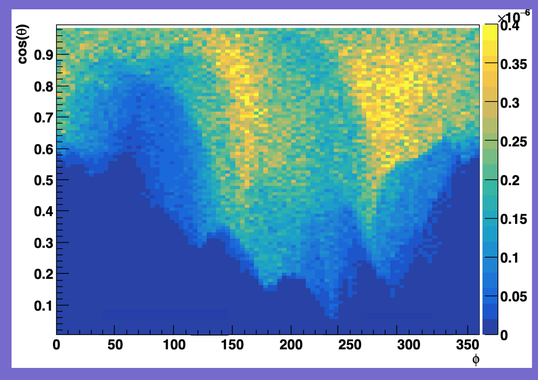
The Hyper-Kamiokande Detector

- Next generation **large-scale water Cherenkov experiment** with a broad physics programme.
- Two concentric detectors: the inner detector (ID) and outer detector (OD).
- 68 m in height and 71 m in diameter.
- ~258 kt of pure water. **Data taking from 2027.**

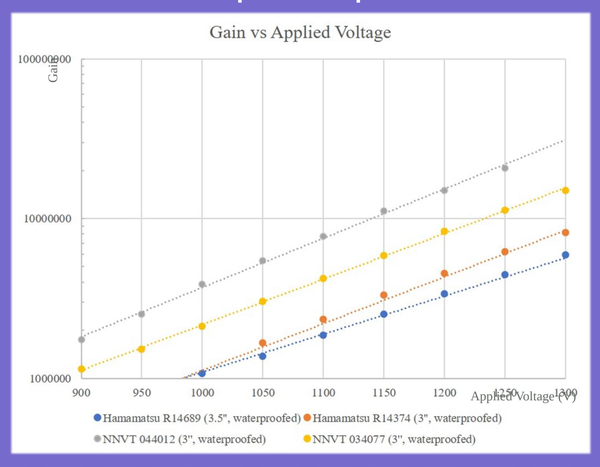
Outer Detector Purpose

- Water in OD is passive shielding from external backgrounds.
- **Cosmic muon background rate of 45 Hz** which OD should tag.
- Plot of simulated cosmic muon flux as expected at the Hyper-Kamiokande site.
- Generated using MUSIC software.



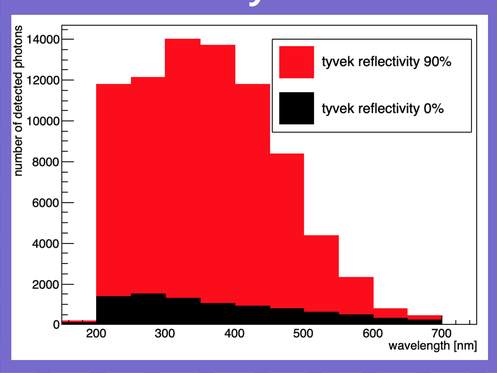
Photomultiplier Tubes (PMTs)

- **~7,200 OD 8 cm (3") PMTs**.
- PMT gain > 3×10^6.
- Operating voltage between 900 V and 1300V.
- Quantum efficiency of 27%.
- Passed multiple implosion tests.

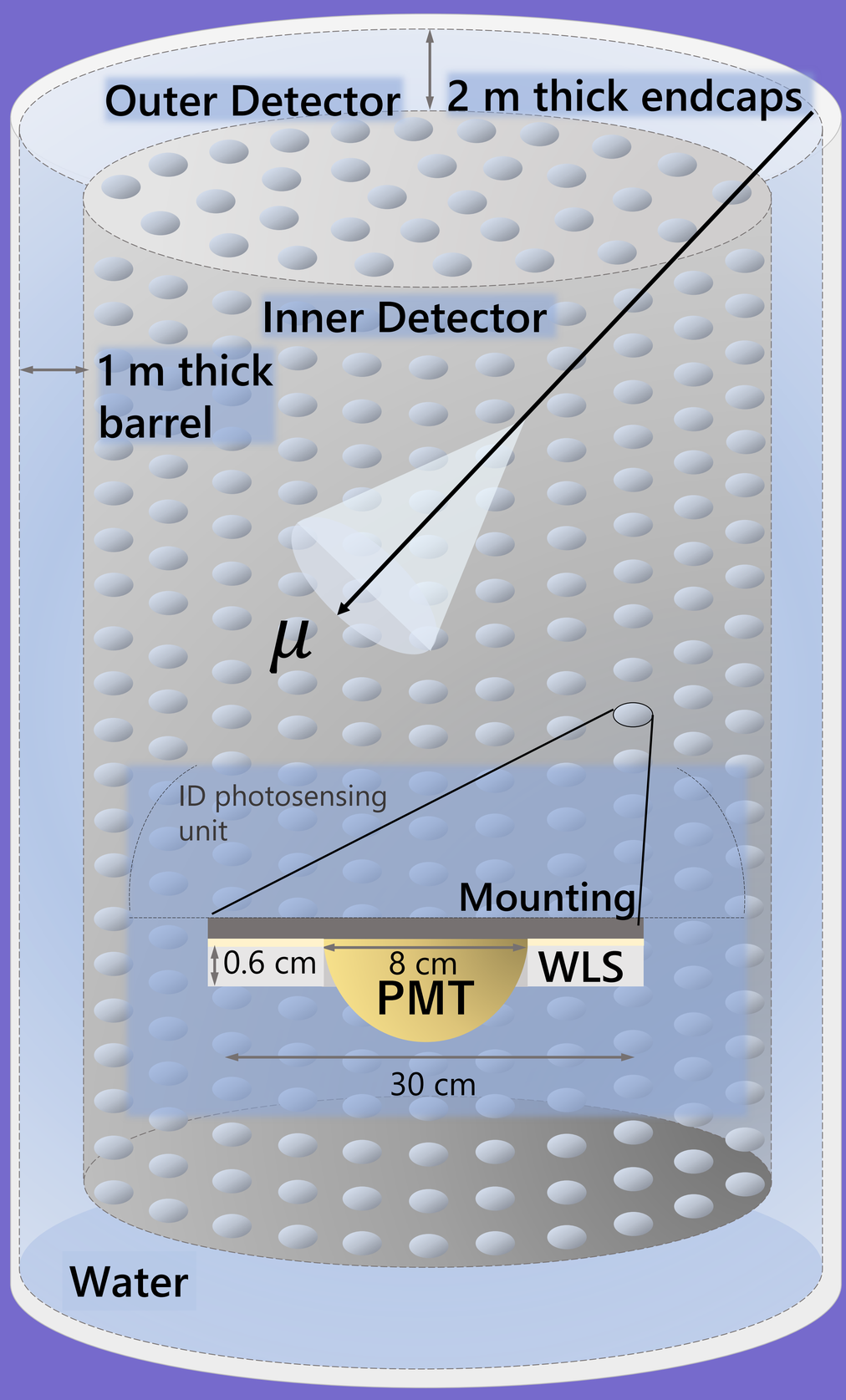


Tyvek

- Inner wall of OD fitted with black/white and outer wall with white highly reflective Tyvek.
- **Reflectivity of >90%.**

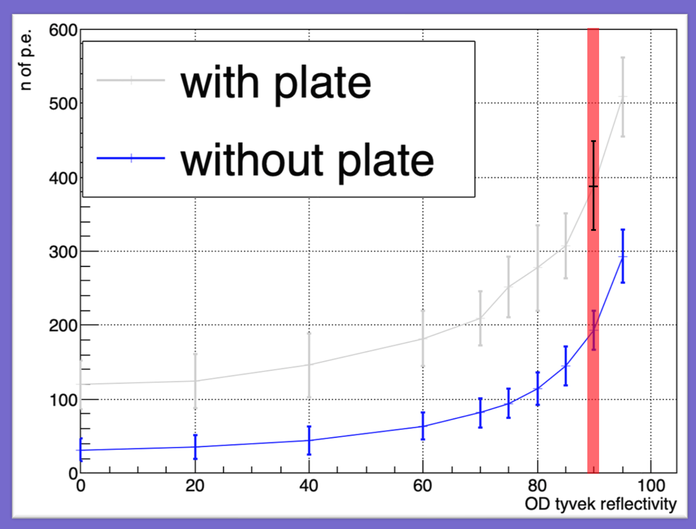


Light collection increases 800% with Tyvek.



Wavelength Shifting (WLS) Plates

- WLS plate captures Cherenkov light from region around the PMT.
- Re-emitted light trapped within the plate is directed towards the PMT.
- **Light collection 76% higher with WLS added.**



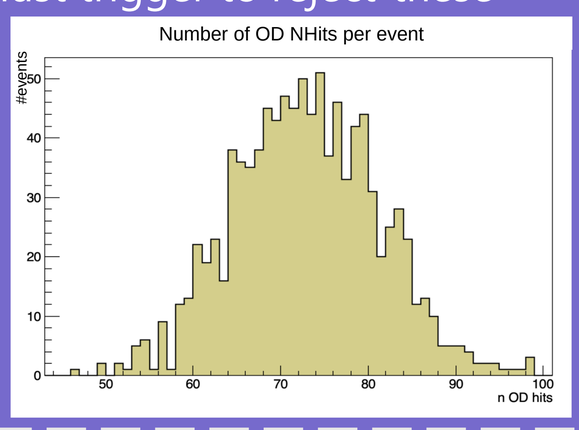
Geometry: Square, 30 x 30 x 0.6 cm^3
PMT hole: cylindrical 78 mm diameter
Base material: PMMA
Fluors: POPOP - 50 mg/l
+ PPO - 3g/L
Cladding reflector: polymeric film

Triggering

- Light generated in outer region used to generate an OD trigger.
- OD data also saved when ID issues any trigger.
- Spallation neutrons may cause delayed signal in ID. OD must trigger to reject these events at analysis level.

Two OD triggers:

1. **Nhits trigge**r: Count number of hits in entire OD in time window.
2. **Cluster trigger**: Search for small clusters of hits in space and time.



Mounting

- Injection moulded PMT mounting frame with earthquake resistance.
- Sheet of Tyvek between mounting and photosensing unit to reflect photons that are not captured.