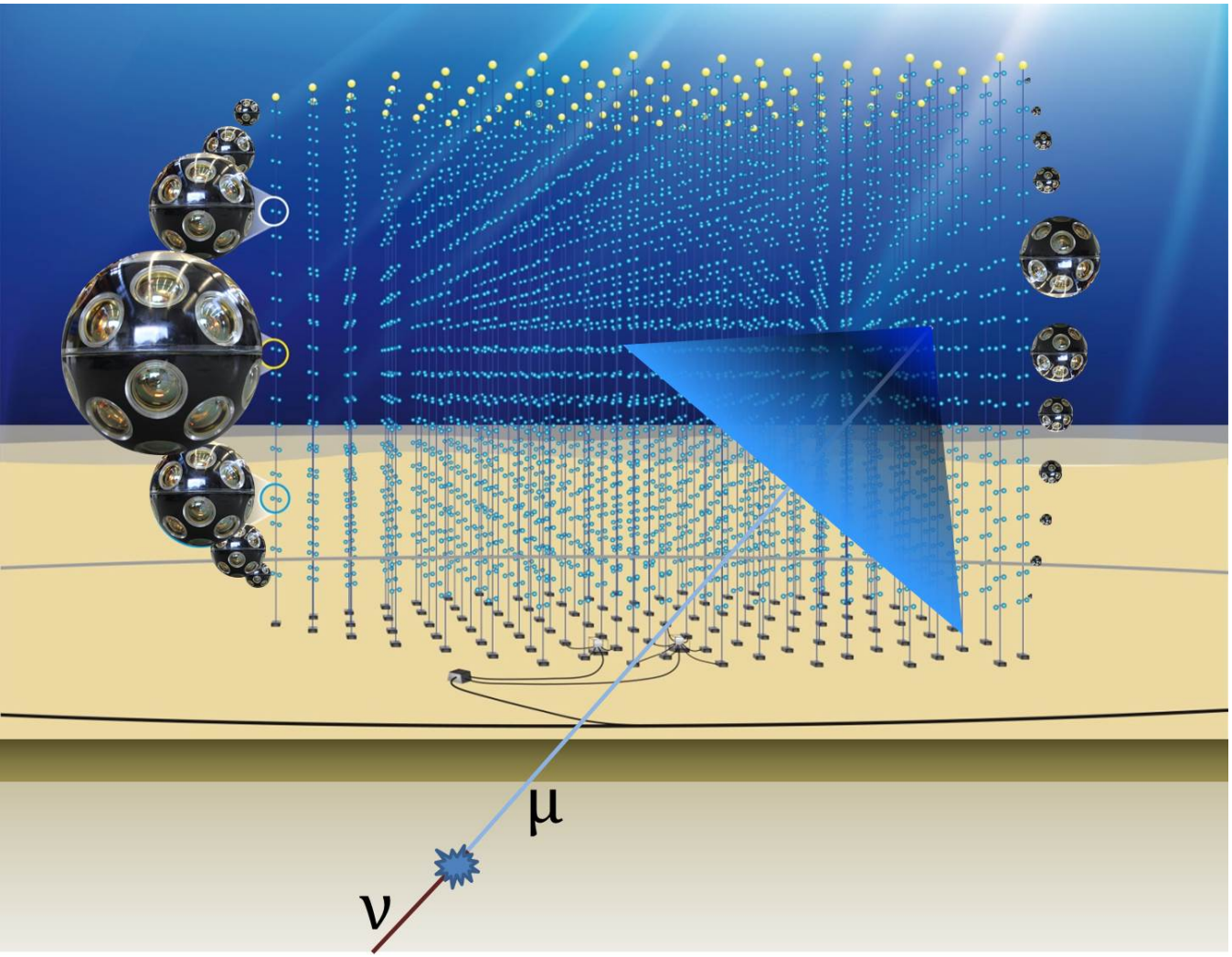
Journée des doctorants APC - 2016

Optical module tests in watertank for neutrino telescopes

Avgitas Theodoros

Neutrino Group

Neutrino telescope detection principle



1) Neutrinos traverse the earth

2) They interact under or inside the detector

3) Secondary particles are produced with high energies

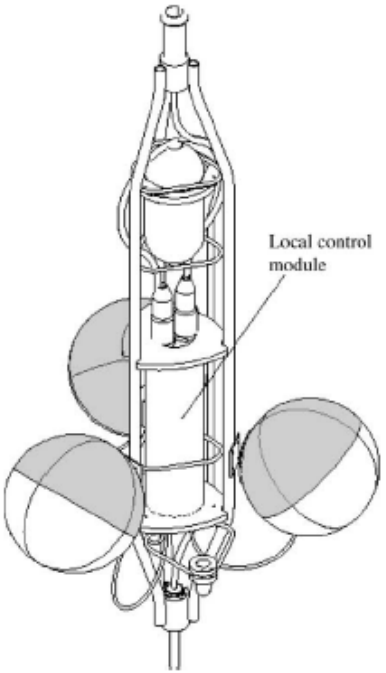
4) While traveling this particles emit Cherenkov light

5) We collect this light with the Optical Modules

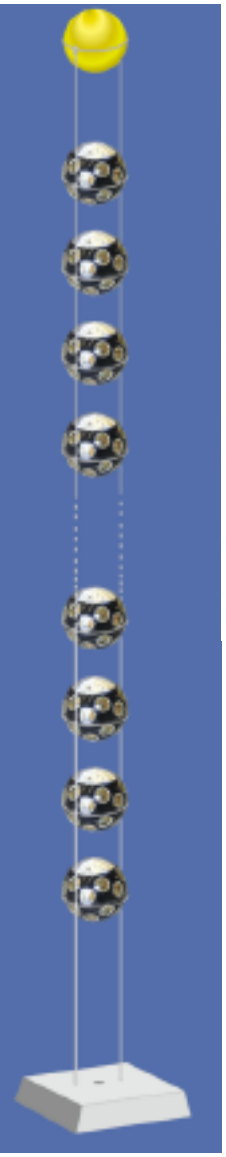
Mediterranean Neutrino Telescope evolution: ANTARES

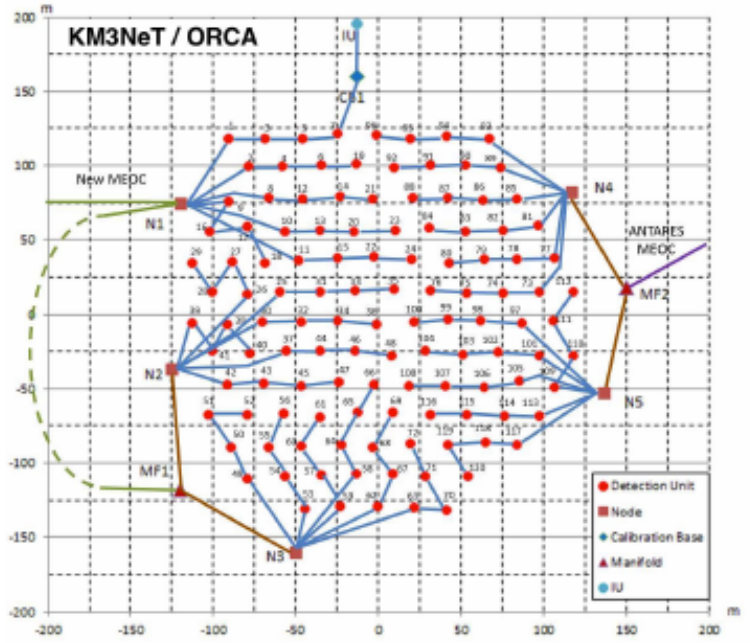
10'' PMTs

Photocathode area	500 cm^2
High voltage	1760 V
TTS (FWHM)	2.6 ns
P/V	2.7
σ_E/E	40%
DC rate	~1900 Hz



Mediterranean Neutrino Telescope evolution: KM3NeT





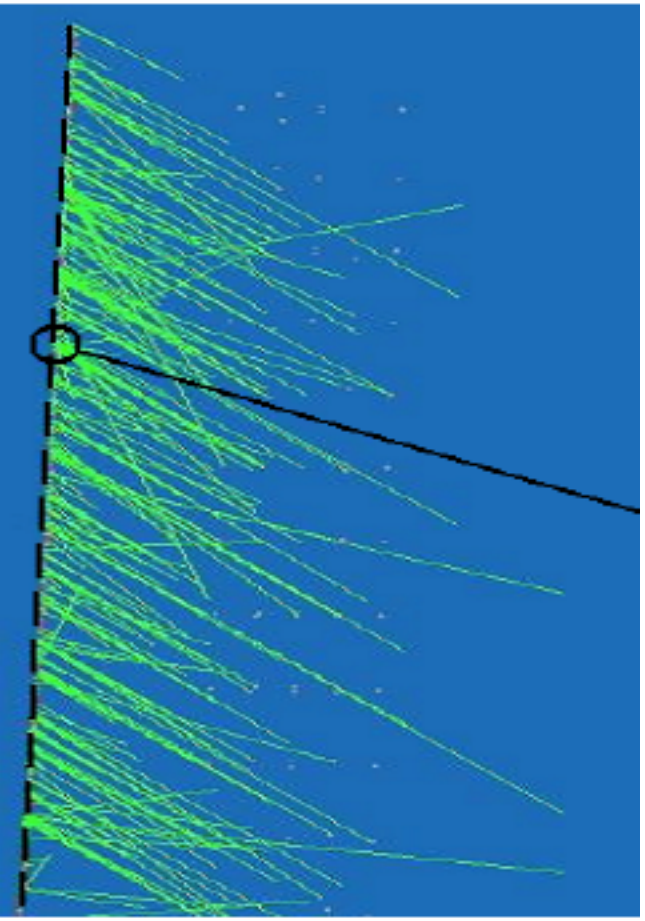
2 Sites: ORCA @ France
ARCA @ Italy

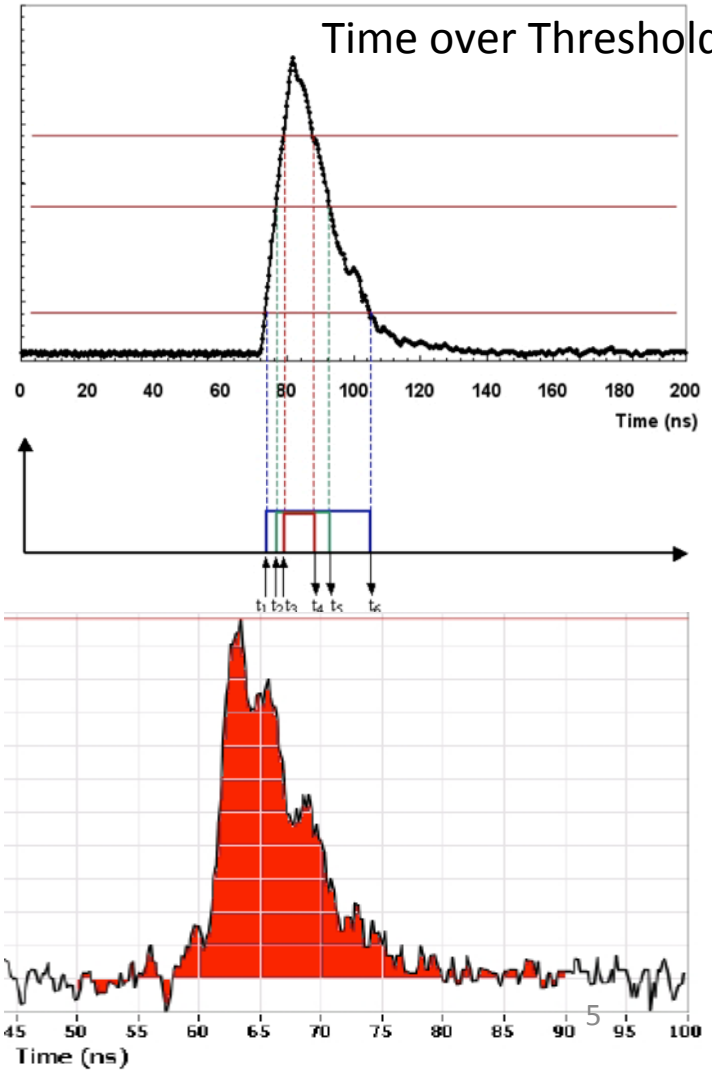
31 PMTs
3 inches diameter
Cost effective OM design
Better event reconstruction

Radiant blue sensitivity at 404 nm	130 mA/W
Quantum efficiency (QE)	20% @ 470 nm and 28% @ 404 nm
Inhomogeneity of cathode response	10%
Supply voltage for a gain of 3×10^6	900–1300 V
Dark count at 15°C and 0.3 photo-electron threshold	1.5 kHz
Transit time spread (TTS)	4.5 ns (FWHM)
Peak to valley ratio	2.5

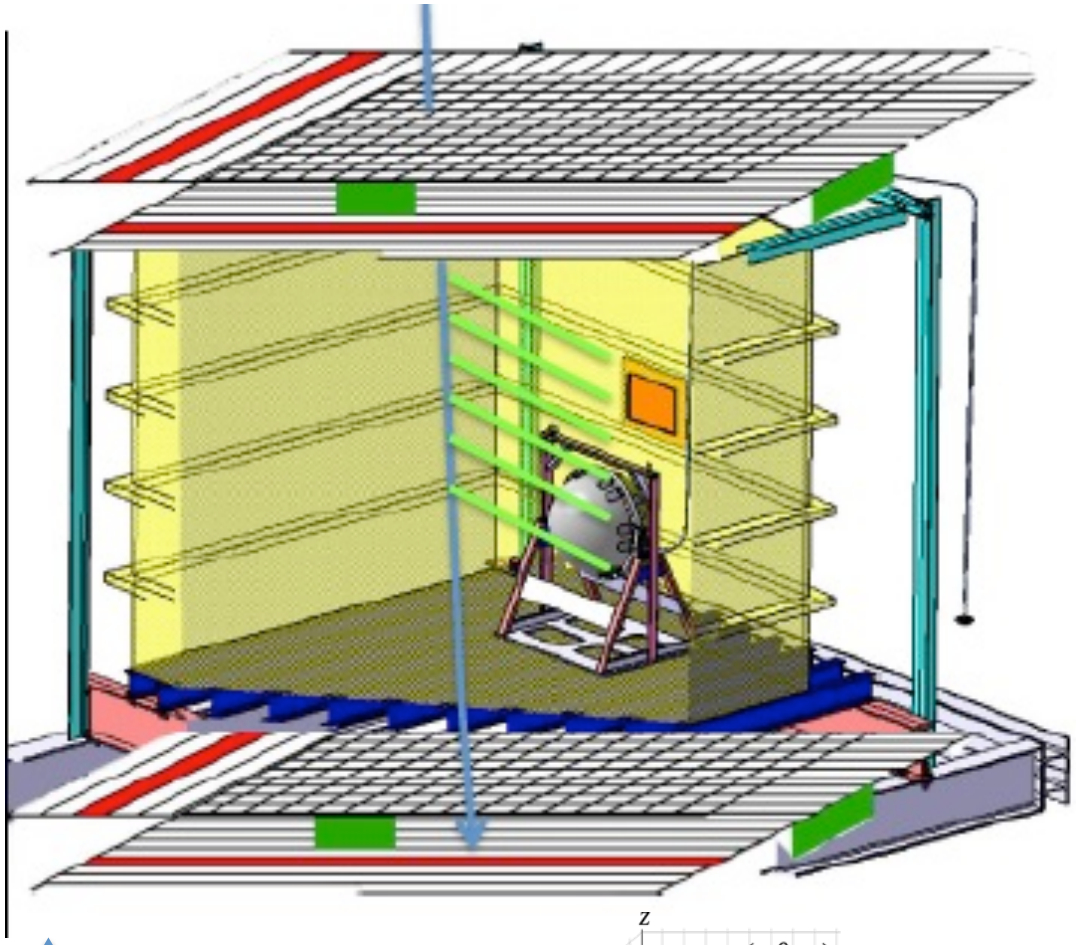
Optical Module Calibration Principle

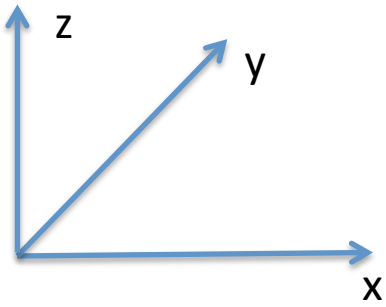
Known down going muon Tracks → Cherenkov light → Response of The OM

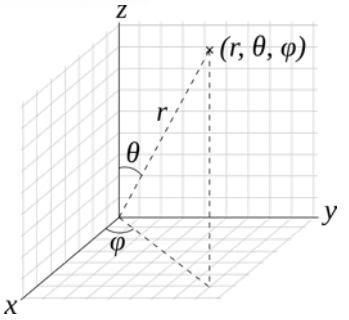




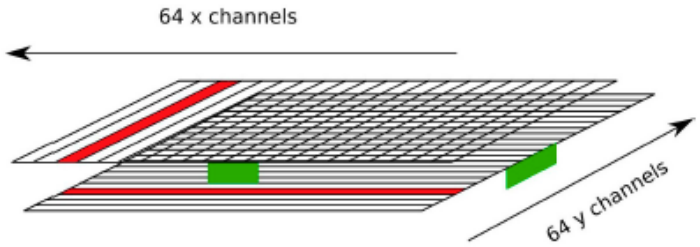
Using Known Muon Tracks (Hodoscope)

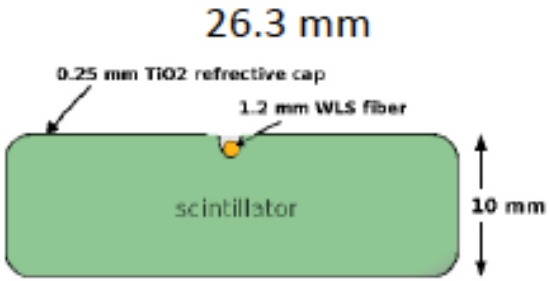


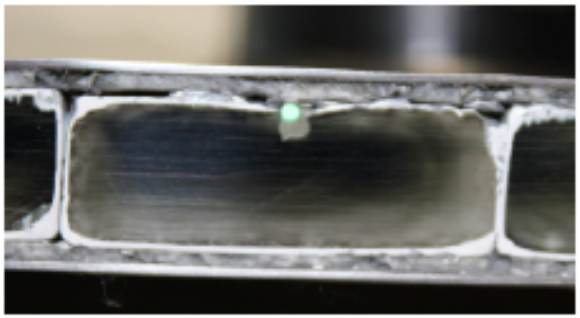


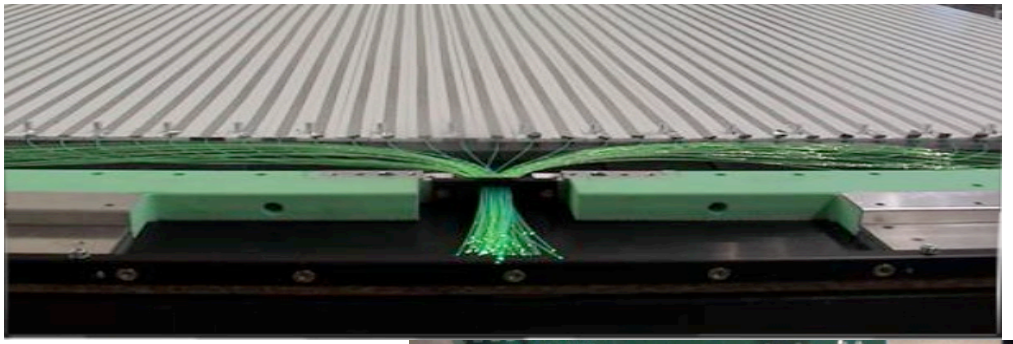


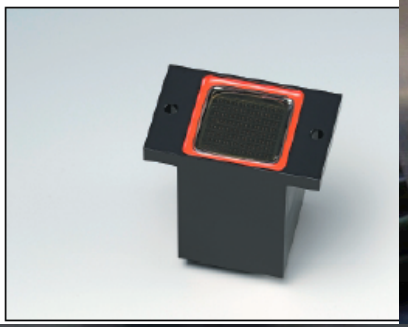
Hodoscope

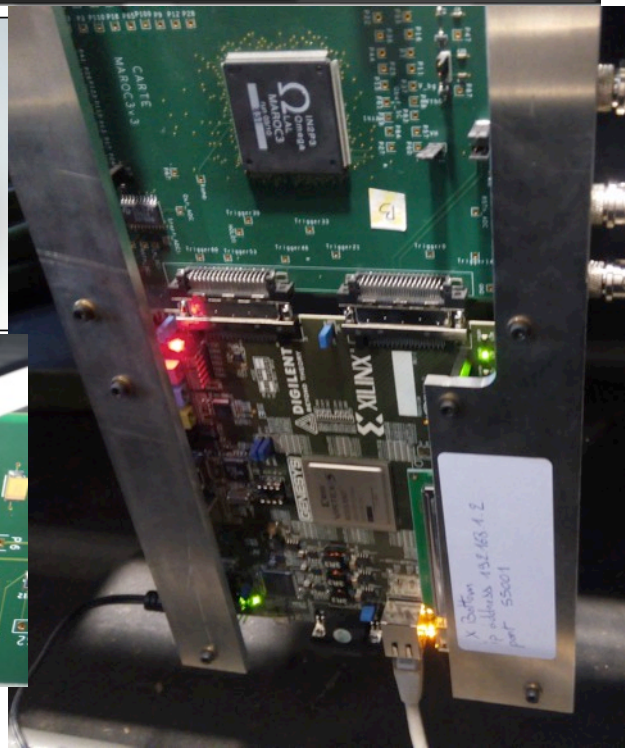












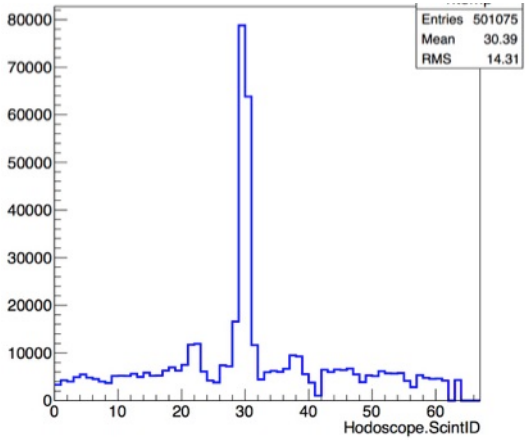
0.76x0.76 cm^2 position accuracy
Eff. Area: 1.6m x 1.6m

Hamamatsu 8804 multi anode pmts
Read Out Electronics: Maroc3 + FPGA

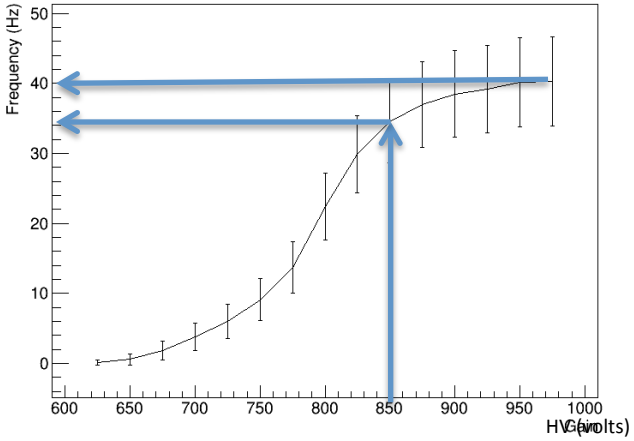
All data are stored and the analysis is done offline

Hodoscope Studies

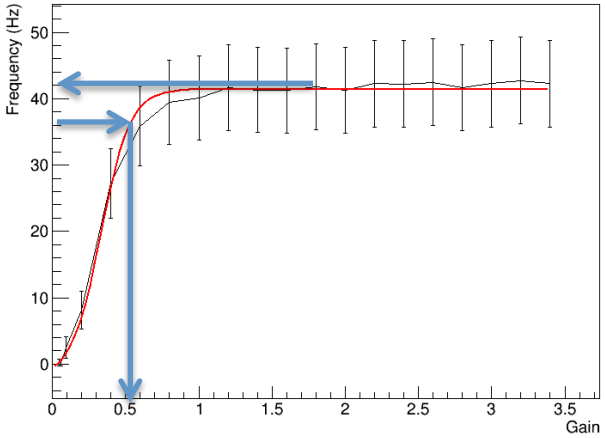
Radioactive source above channel 30



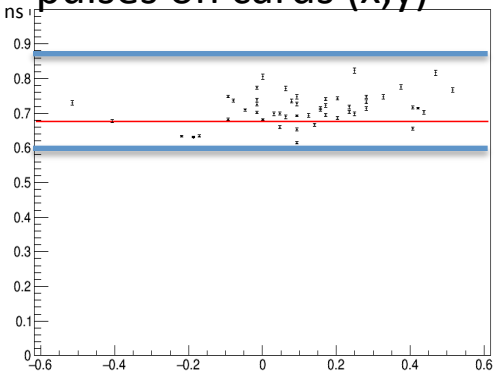
PMT HV Determination (plot for 1 of 64 channels)



Card Channel Gain (set @ 90% max. freq)

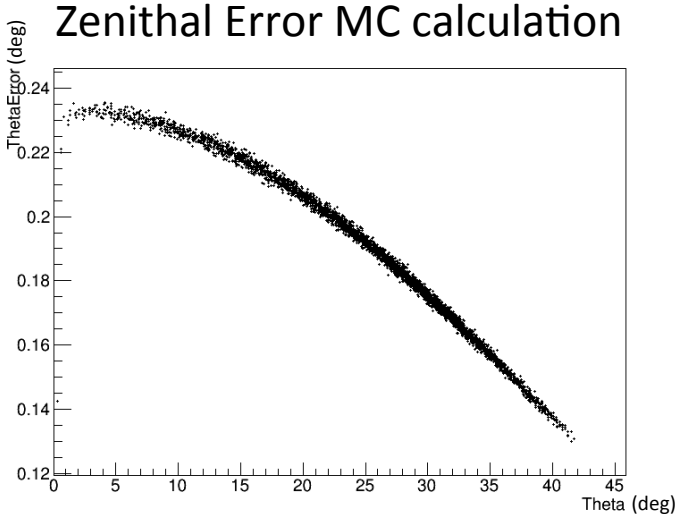


electronic tests by sending pulses on cards (x,y)



Gain difference between channels x and y

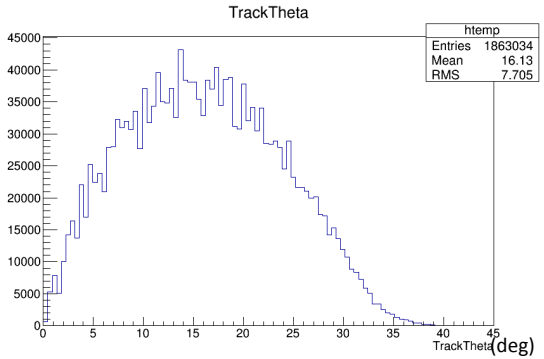
Zenithal Error MC calculation



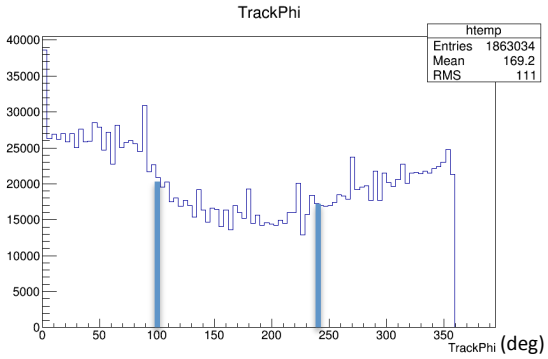
Fully Operational
Long Run DAQ
Very precise
Optimized for time and position accuracy

Muon flux & Building Shadowing

Theta Distribution

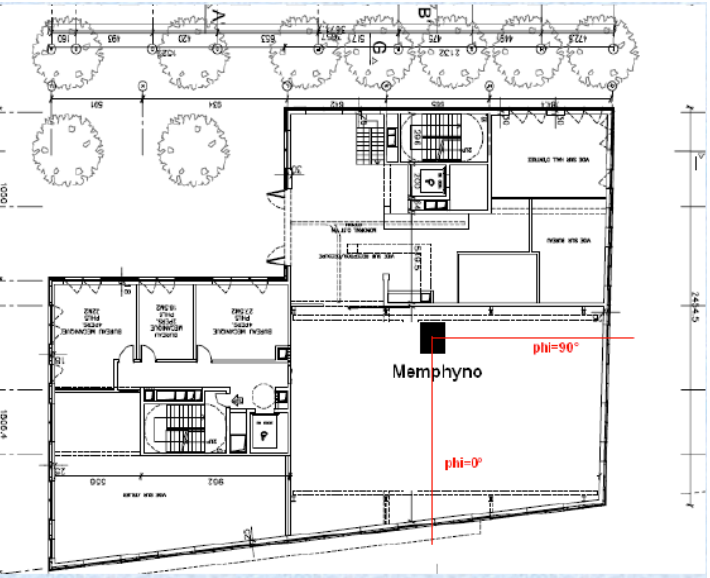


Phi Distribution

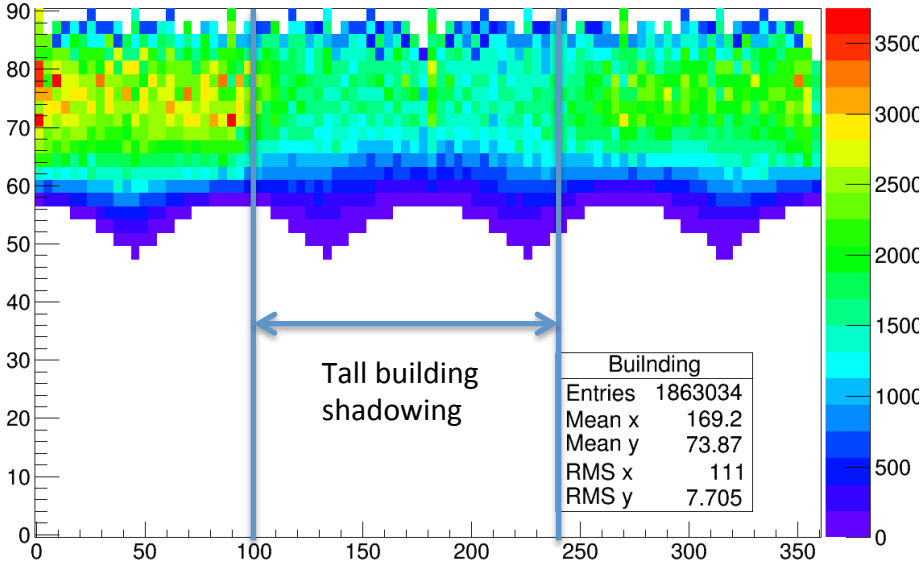


We consider muon tracks the 4 fold coincidences between Hodoscope planes.
The orientation of the tracks is defined by the (x,y) coordinates of the hodoscope planes above and below the tank.

Building Schematic

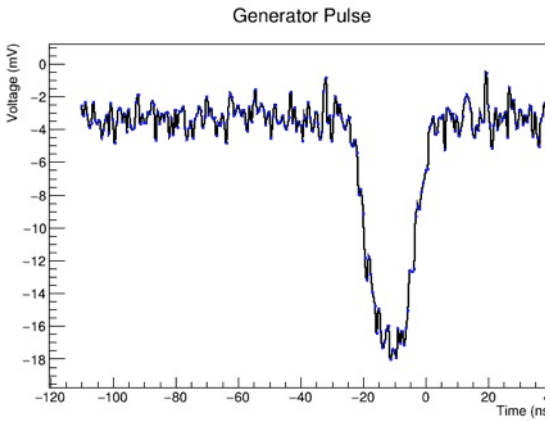


Hodoscope Response

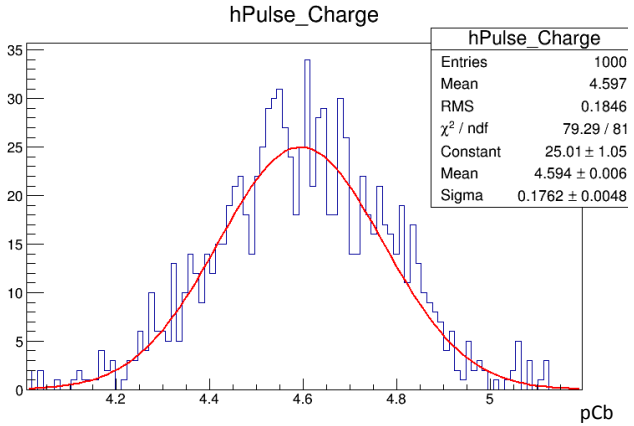


Antares OM DAQ card Calibration

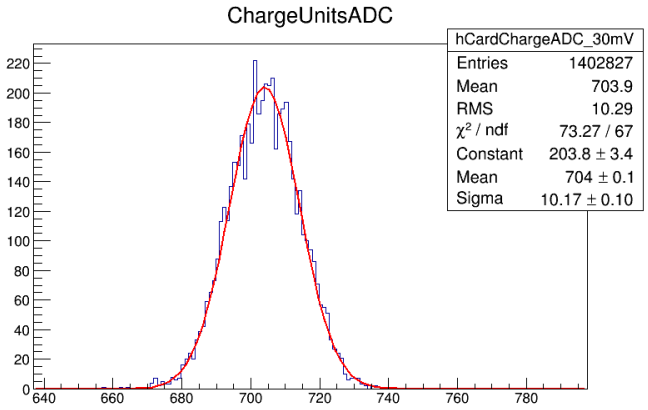
Function Generator
Known pulse



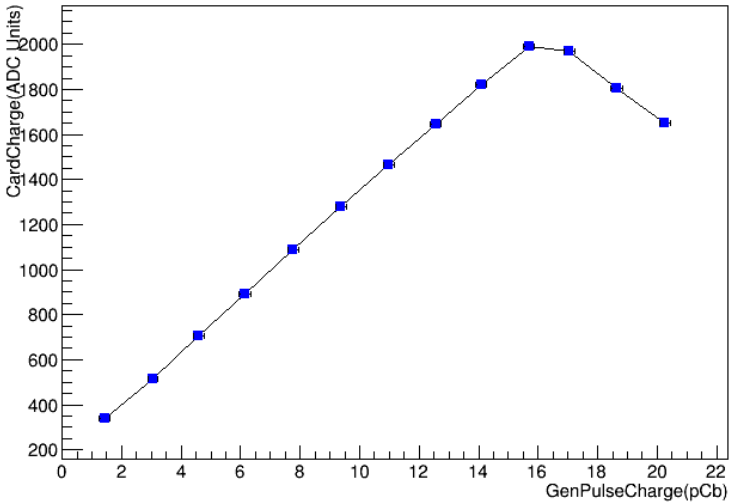
Pulse charge distribution



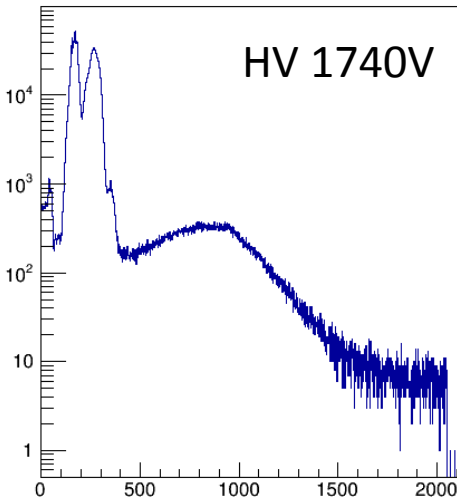
Card ADC charge distribution



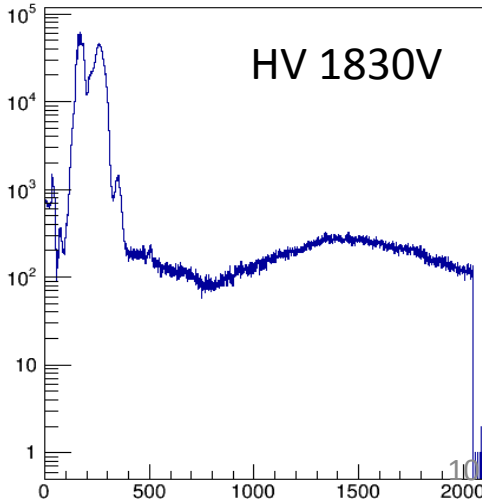
Charge Calibration Curve
(gain = 1)



OM Charge distribution
(1pe = 8pCb @ 1740V)

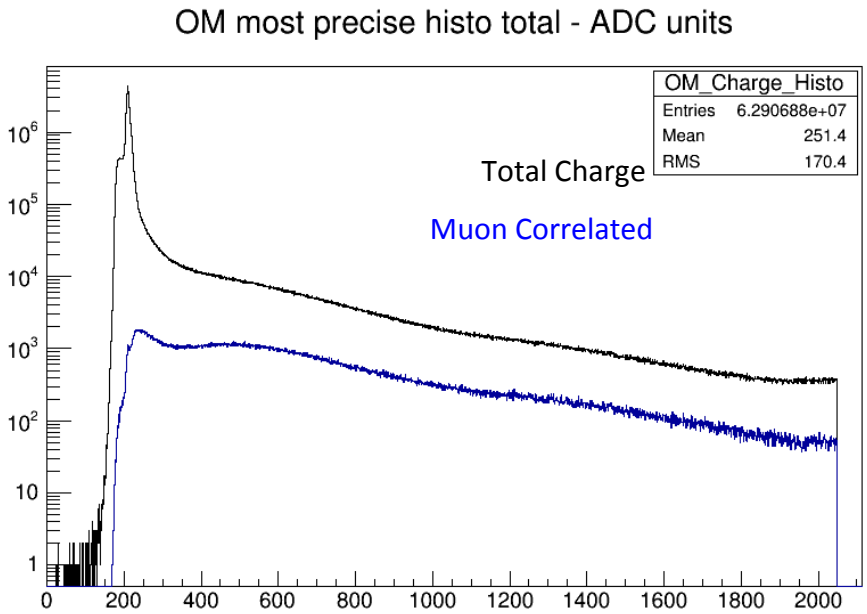


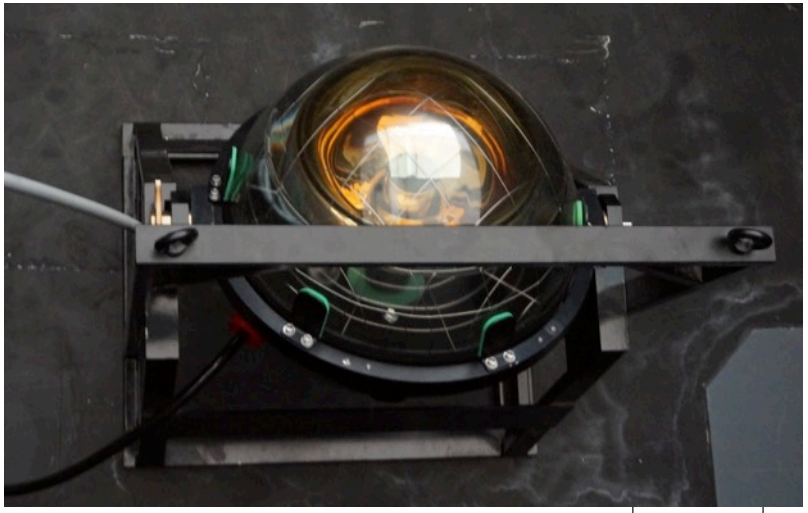
(1 photo electron is called the electron escaping the photocathode after interacting with a photon.)

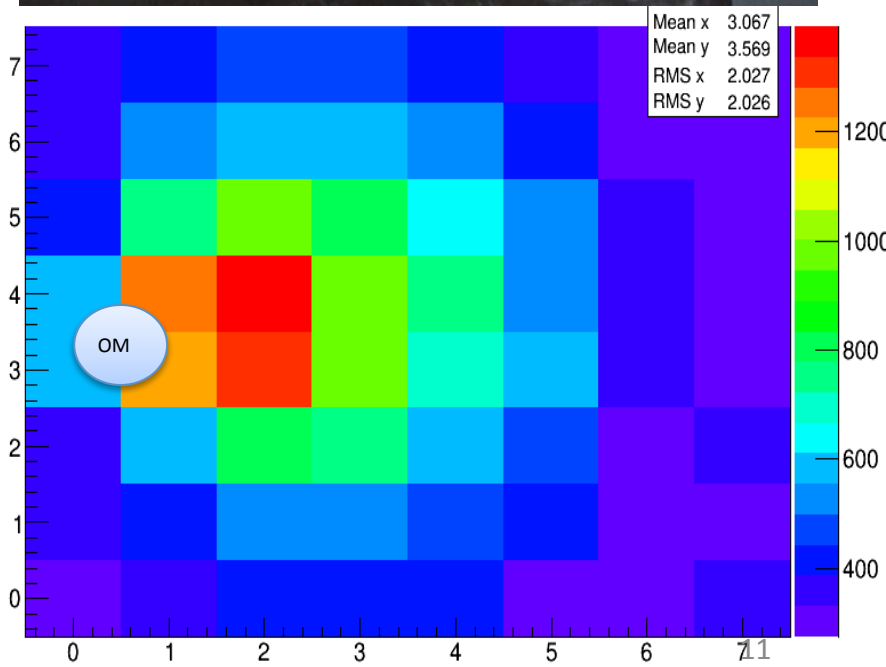


OM measurements with Muons

Charge Distribution
With and Without muon track correlation

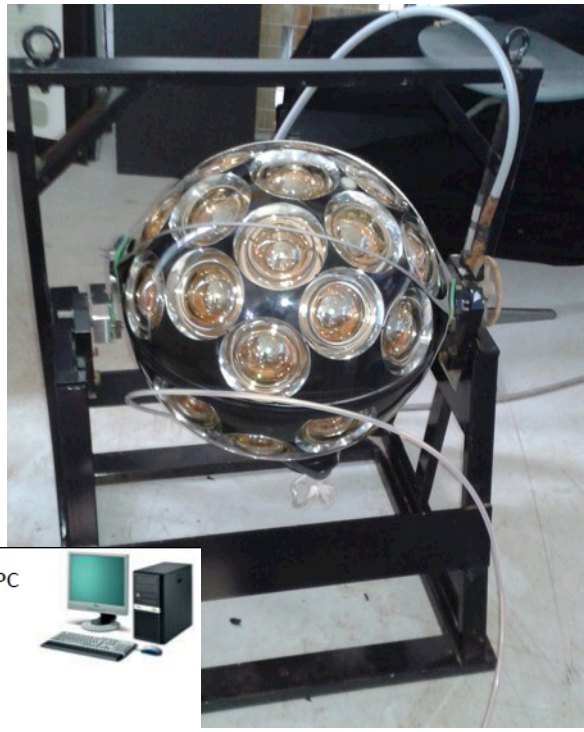


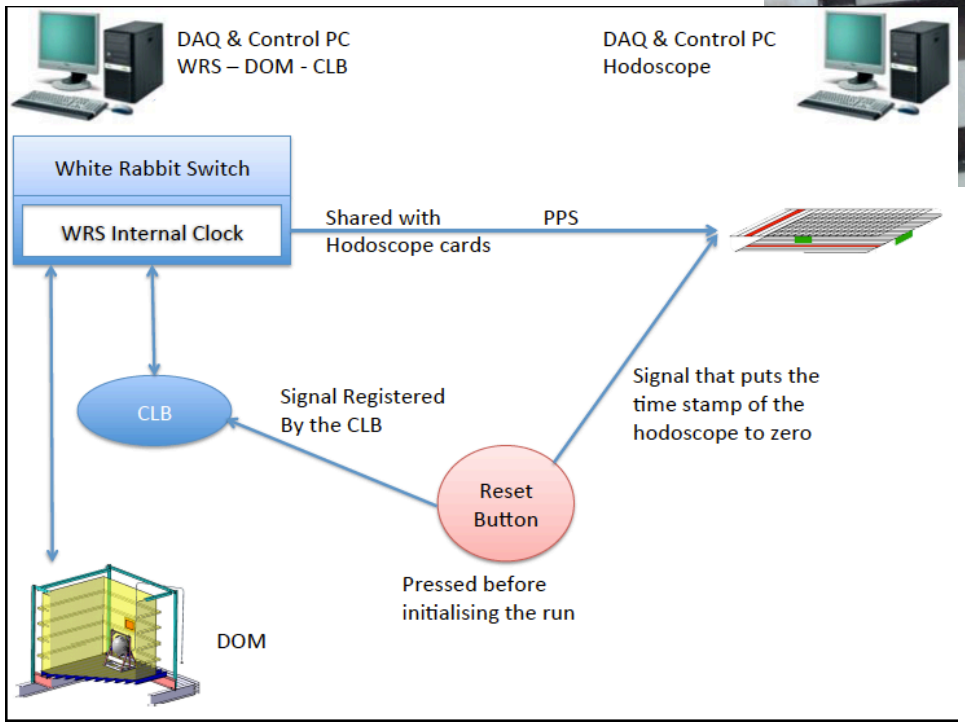




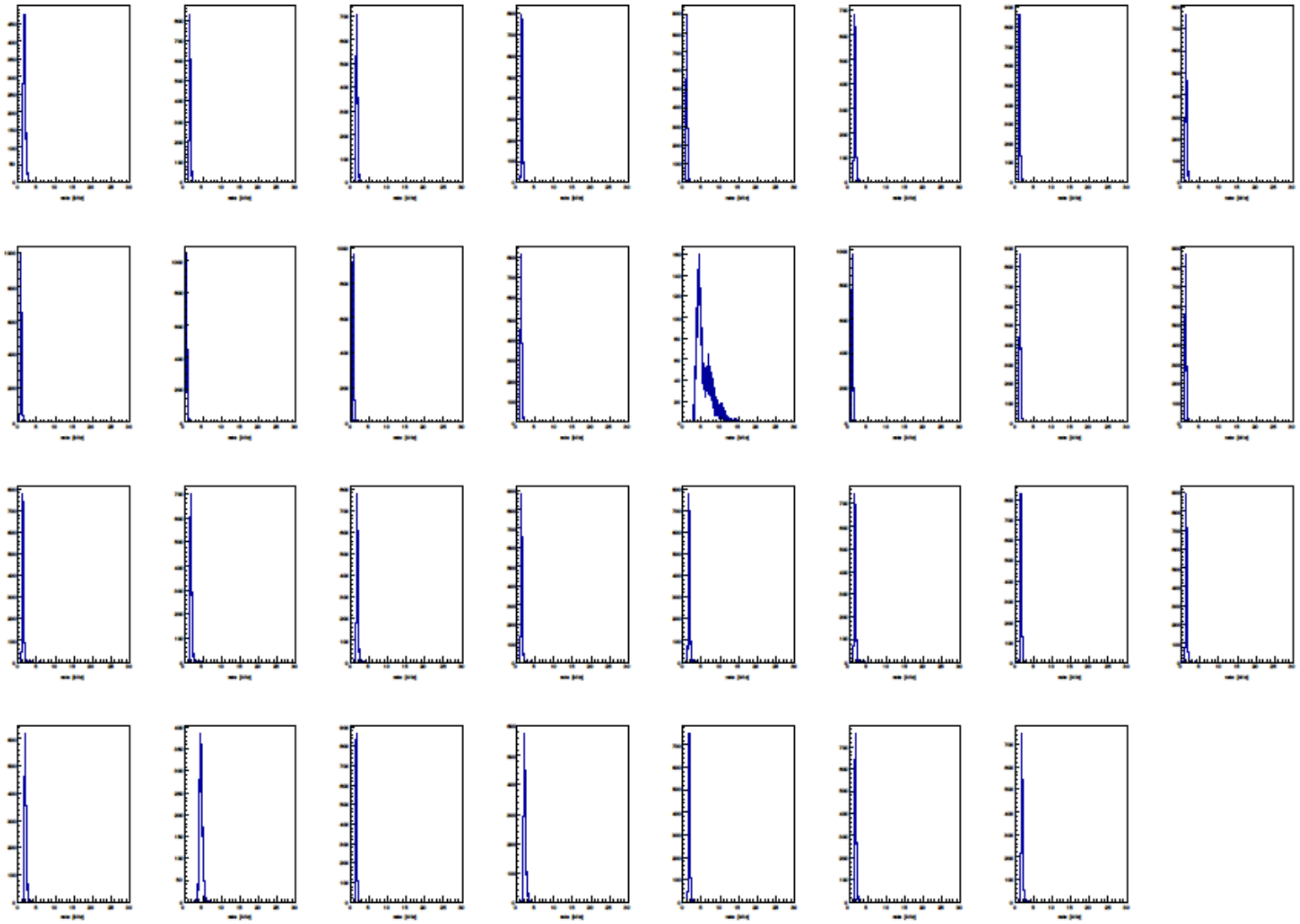
OM charge response for vertical muons (θ -> 0 – 5deg)
20cm x 20 cm hodoscope regions
OM facing upwards

Current Work – KM3NeT DOM

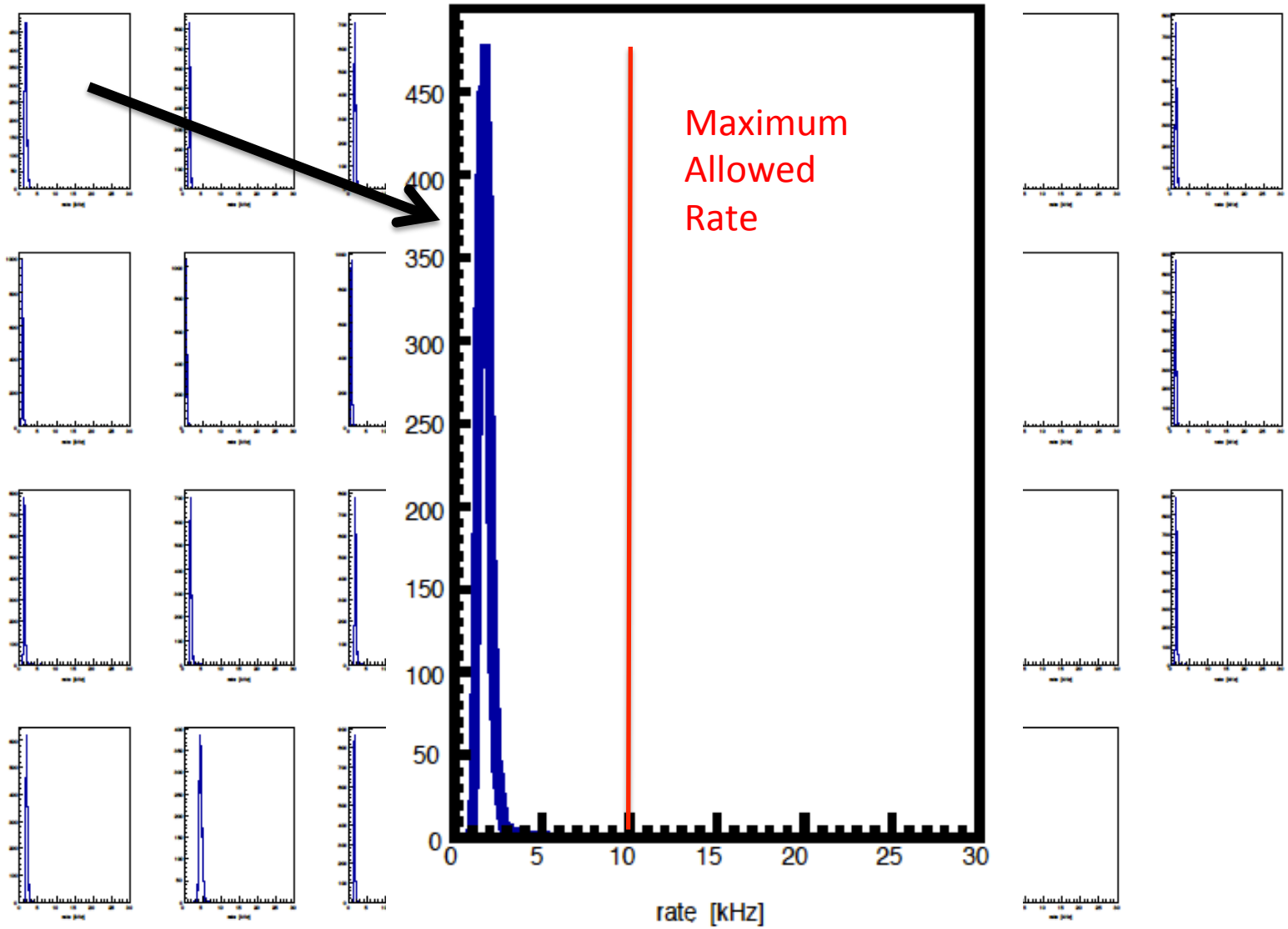




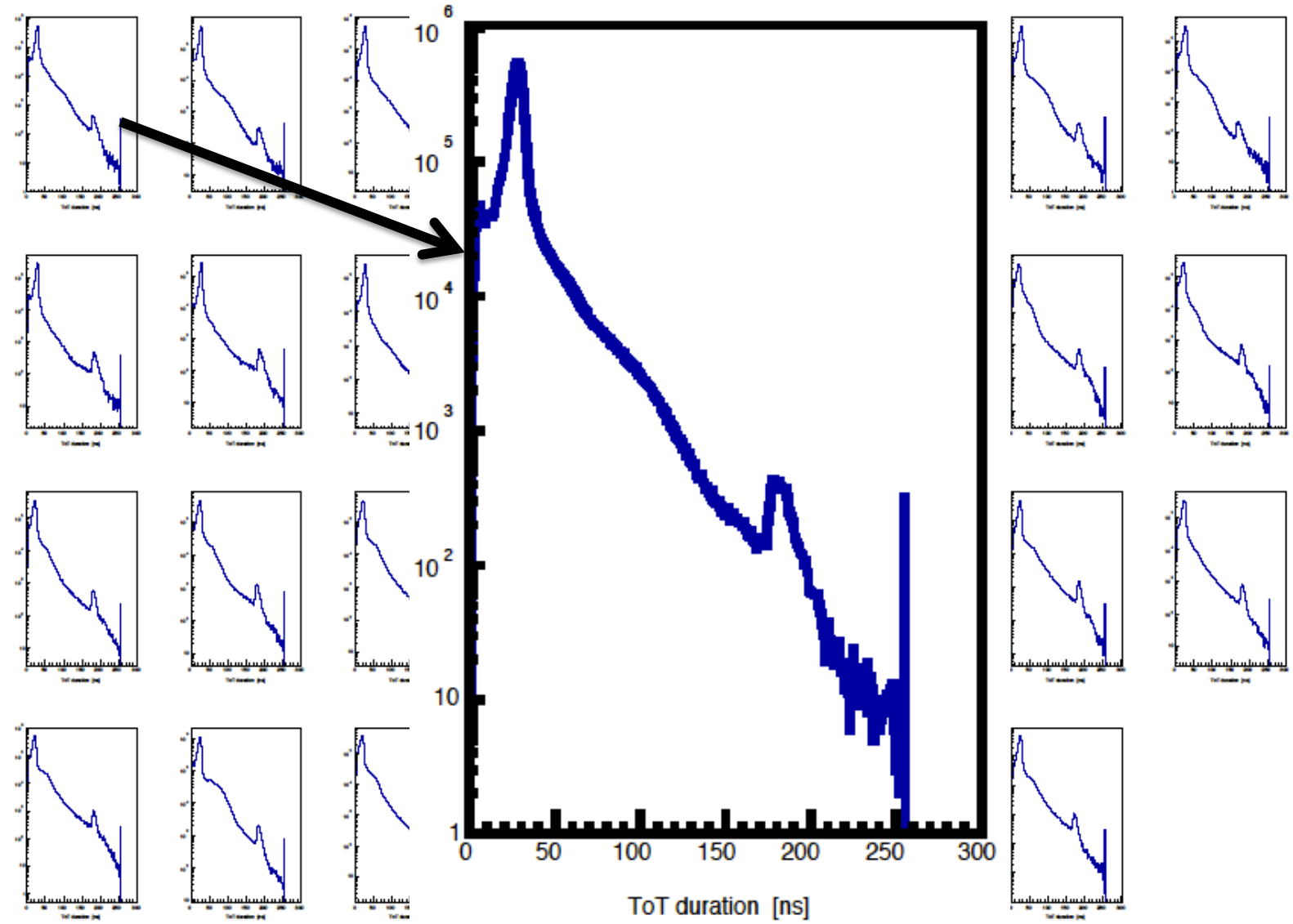
KM3NeT DOM – Measurements
31 PMTs Rates (kHz)



KM3NeT DOM – Measurements
31 PMTs Rates (kHz)



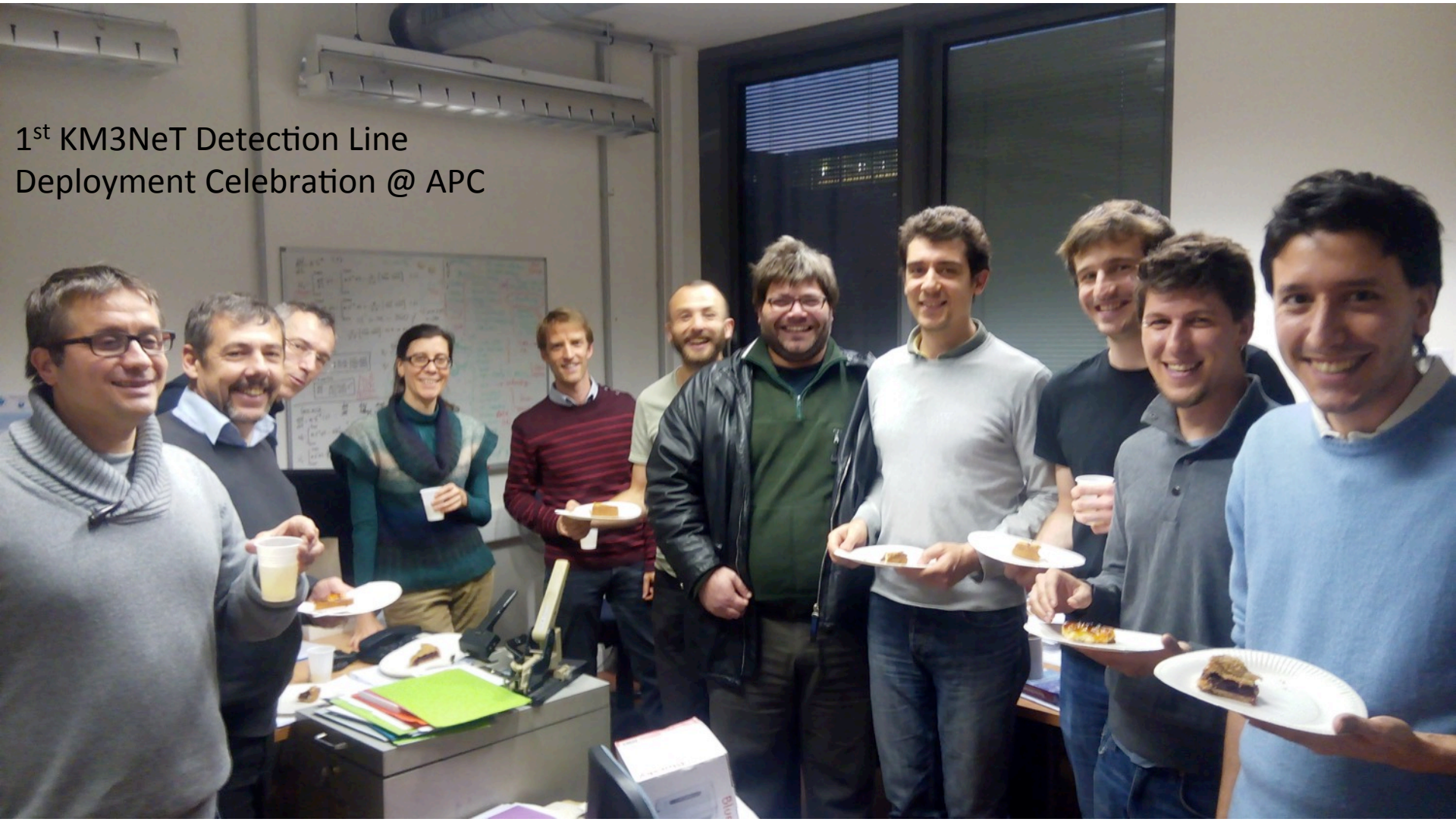
KM3NeT DOM – Measurements
31 PMTs Time over Thresholds (Charge)



Other on-going studies

- Drop of the OM efficiency in Antares due to bio-fouling (data since 2007)
- Estimation of the bio-fouling profile
- Calibration of the Antares Telescope for 2016

  Charge – Thresholds – Pedestals (with existing tools)



THANK YOU!!!