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Operation and Results of the Prototype KM3NeT Detection Unit

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KM3NeT

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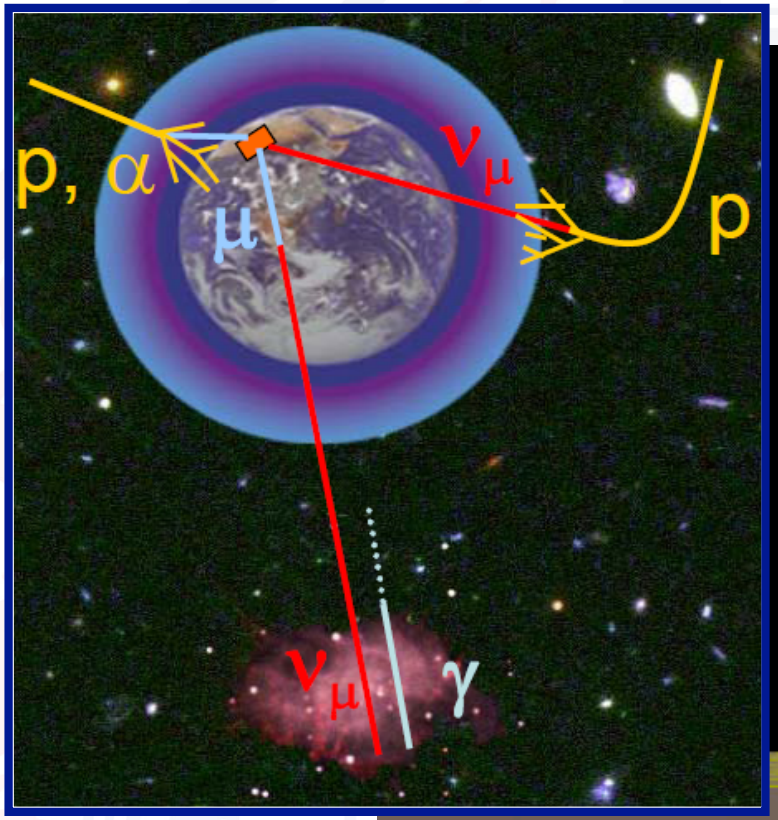
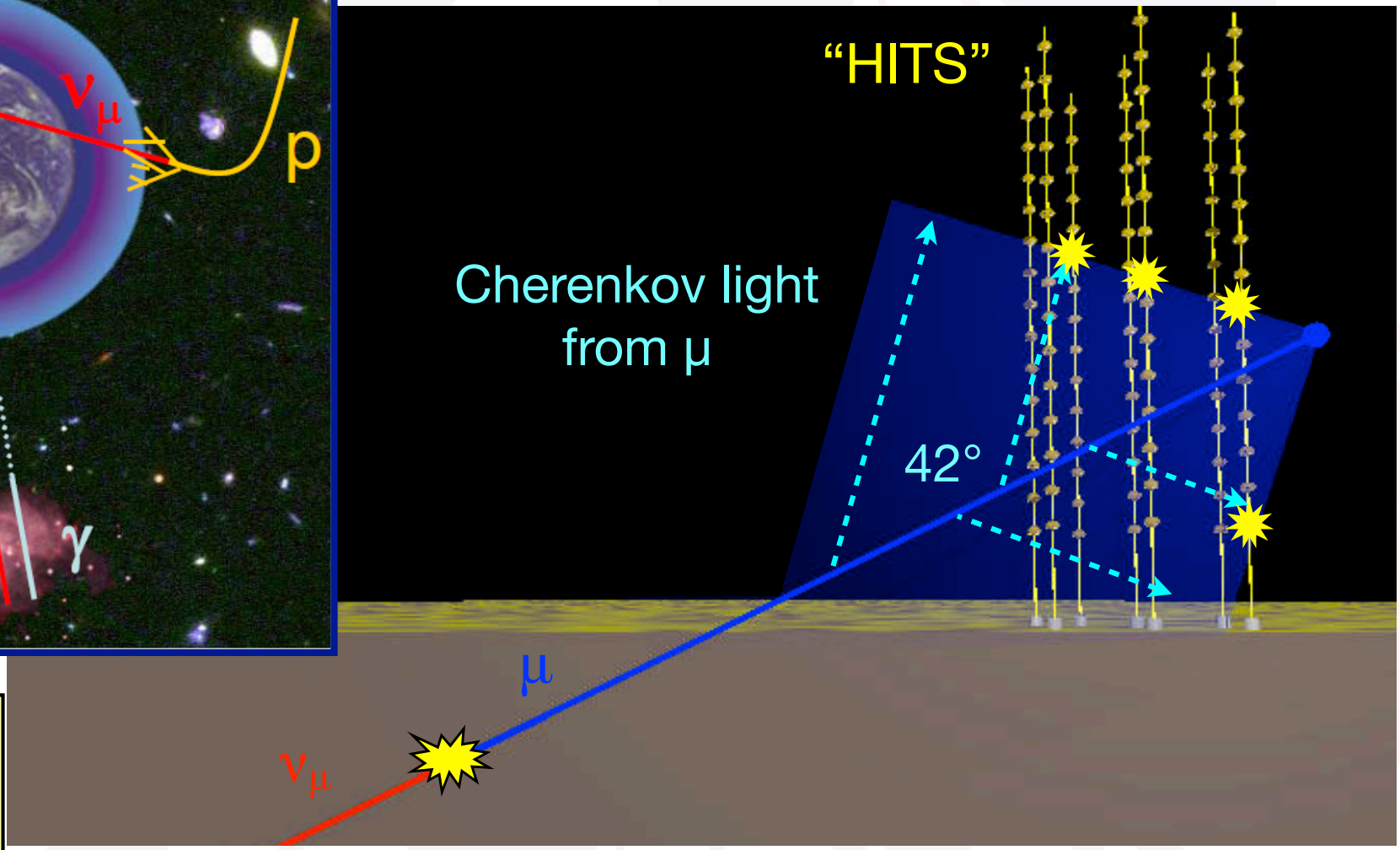
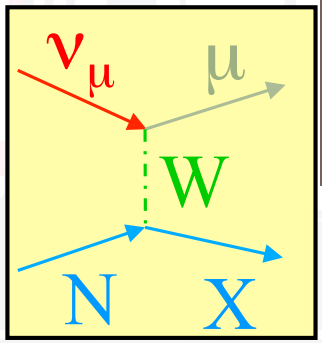
The KM3NeT Detector

- KM3NeT is a multi-purpose submarine laboratory
  - Distributed infrastructure in deep waters of Mediterranean Sea (multi-site option)
  - On-shore cable connected observatories
  - Neutrino telescope >1 km^3
- KM3NeT extends our knowledge of the Universe
  - Study of neutrino point sources
  - Measurement of cosmic neutrino diffuse fluxes
  - Multi-messenger approach and ‘exotics’
  - Synergy with Earth and Sea sciences

Neutrino Telescope: How It Works



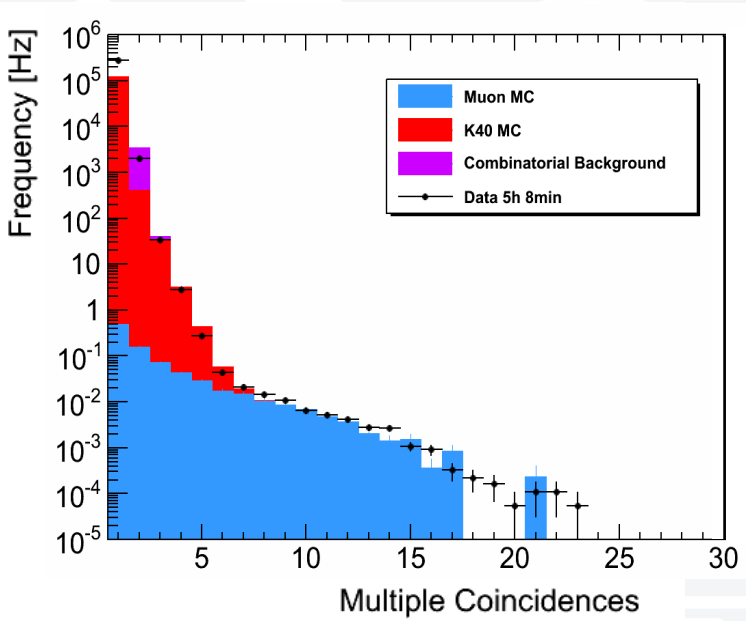




Detection of neutrino-induced particles
through the observation of Cherenkov light

Prototype and Qualification Projects (1)

- Pre Production Model Digital Optical Module (PPM-DOM) installed on one ANTARES line April 2013
  - Operating since deployment
  - Validation of DOM technology
  - Demonstrate the capability to reject optical background
  - Muon selection with local coincidences
- Preprint submitted for publication
  - **http://arxiv.org/abs/1405.0839**

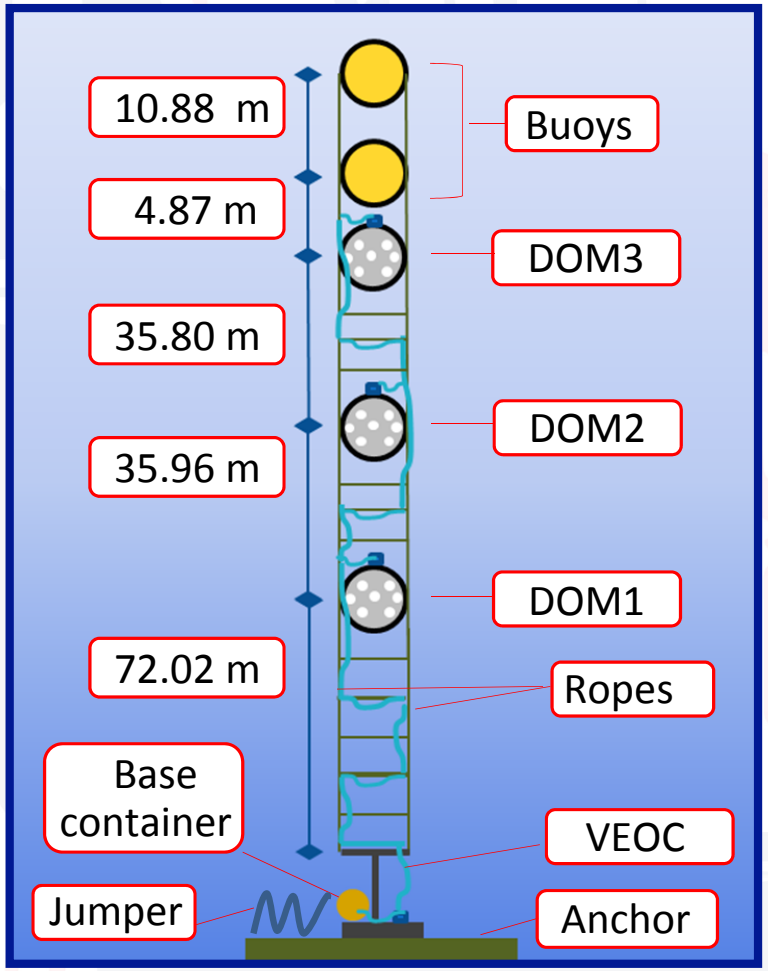


Prototype and Qualification Projects (2)

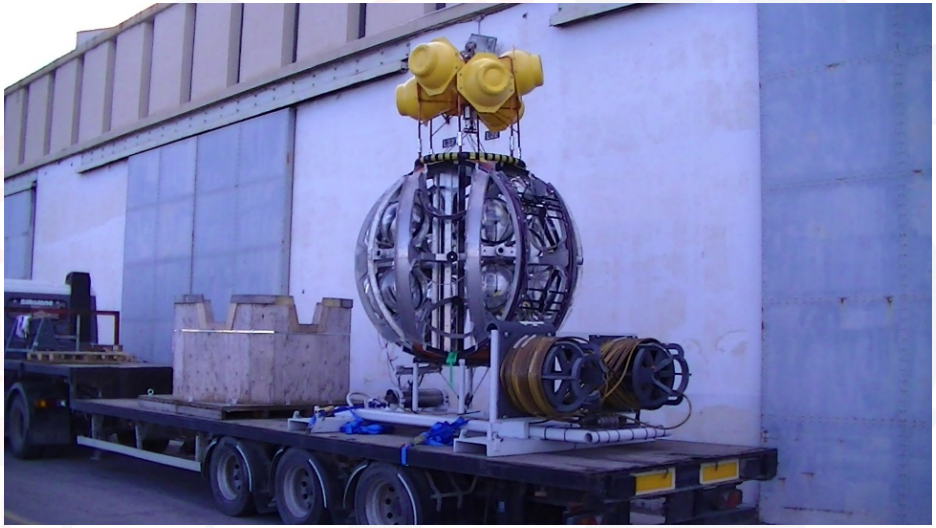
- **Pre Production Model Detection Unit** (**PPM-DU**) deployed in the Capo Passero site, off-shore the Sicilian coast May 2014
- Main purposes:
  - 'Dry run' of marine operations — string deployment, submarine connection, unfurling procedure
  - Validate the DU structure
  - Operation and data handling tools
  - Test the software architecture developed for the km^3-scale detector
  - Improve our knowledge of the site (bioluminescence)
- Great interest to have results for a publication soon!

PPM-DU

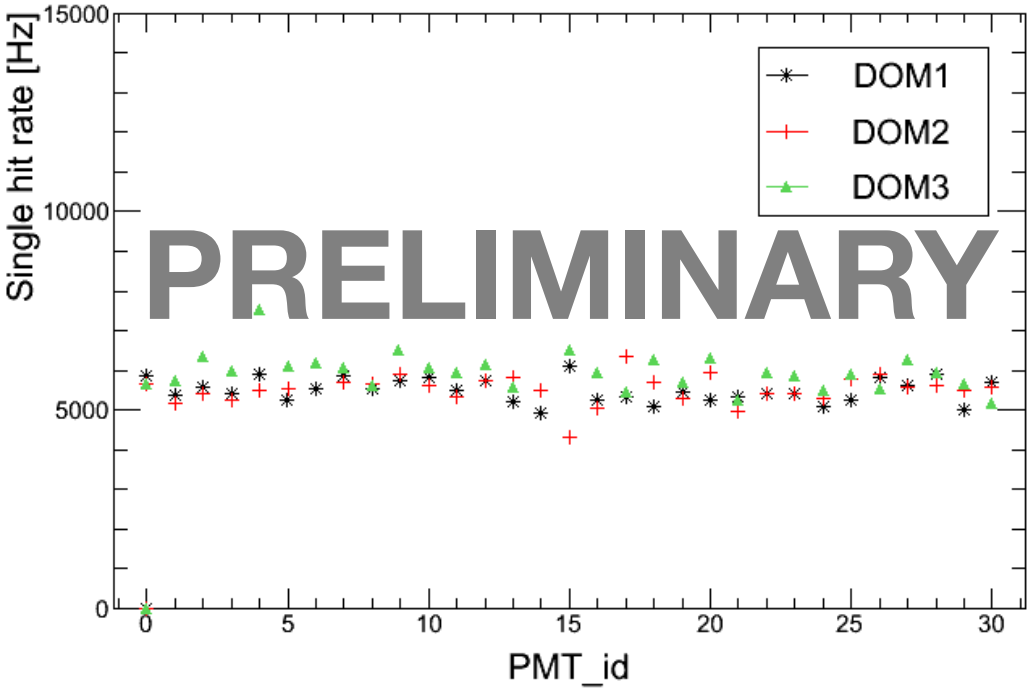
- Three DOMs contain 31 x 3” PMTs each, in a 17” glass sphere
- Arranged in a ‘small’ line — compared to the full DU with 18 DOMs
- Connected to a Junction Box with an electro-optical cable
- Each DOM contains a LED beacon for calibration and a piezo for acoustic



PPM-DU: Pictures from Deployment



PPM-DU: First Results



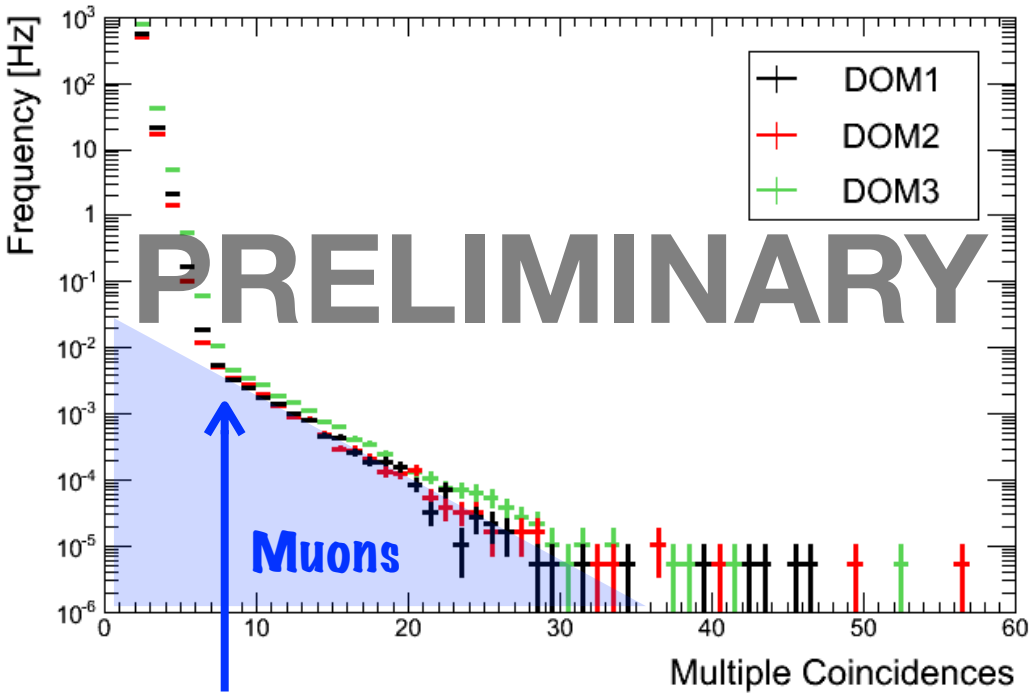
Single rates are evaluated from the distributions of time differences between consecutive hits.
The tail of the time differences distribution is fitted with an exponential:

$$f(x)=p0*\exp(-p1*dt)$$

where p0 is a scaling factor, p1 is the single rate and dt is the time differences

- The PPM-DU provides useful information to characterize the marine site and to understand our detector
- Single rates show wether the PMTs are well calibrated and give hints on the total PMT efficiency.

PPM-DU: Searching for Muons



- 2014 June-July, 52 hours of equivalent livetime
- L1 corresponds to a coincidence between two PMTs in 10 ns; multiple coincidences are selected inside the DOMs in a 130 ns time window
- The change of shape shows the region in which muons become to be dominant over the optical background

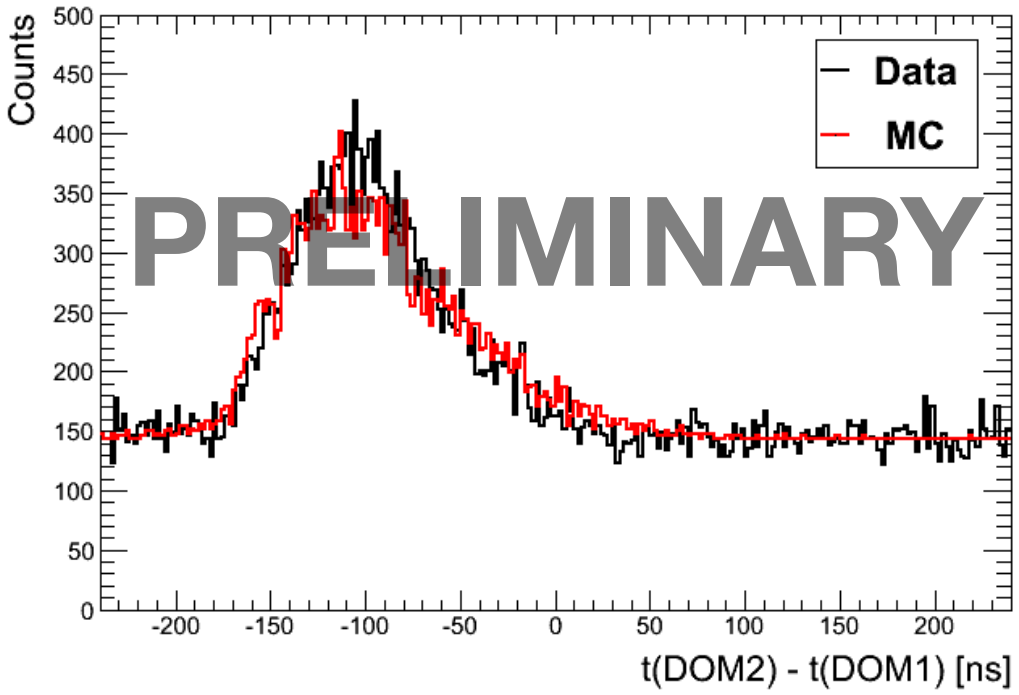
Time Calibration in Sea Water

- LED beacons flash with adjustable frequency and intensity to calibrate in time PMTs inside the DOM and with other DOMs
- Intra-DOM time offsets (between PMTs) depend on the electronics and PMTs
- Inter-DOM time offsets (between DOMs) depend on the electronics plus cable lengths — travel time of light in sea water must be taken into account in the calibration procedure
- Time accuracy ~1 ns

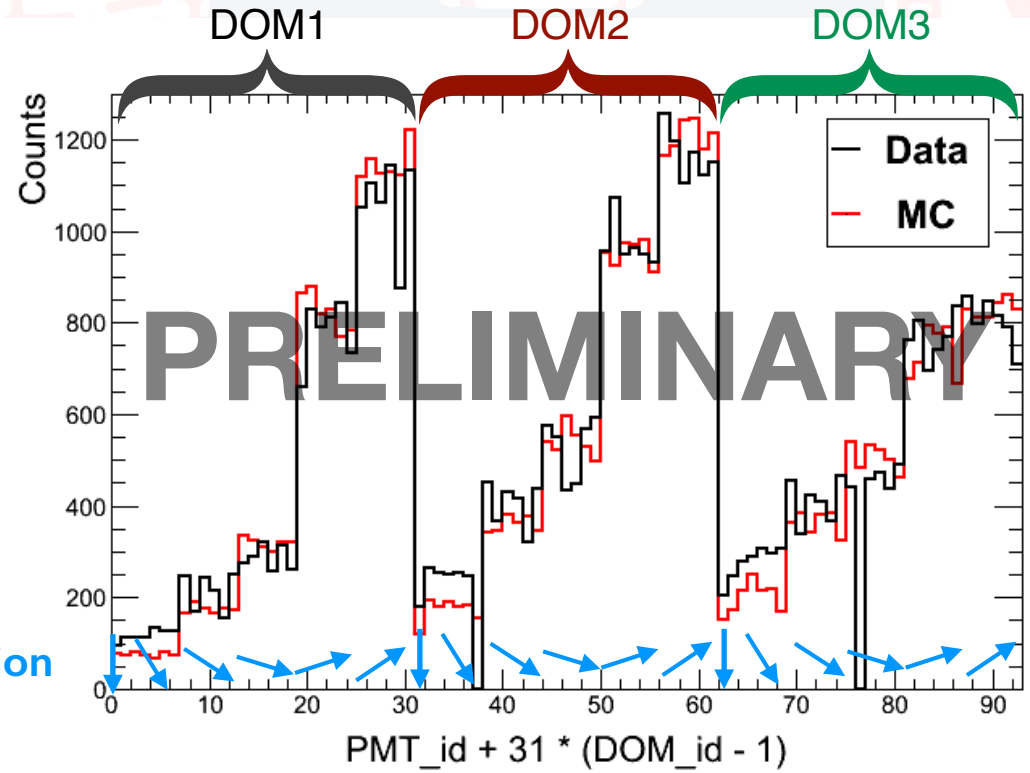
Time Coincidences between two DOMs

- 2014 June-July, 66 hours of equivalent livetime
- Data triggered to have L1 coincidences on DOM1 and DOM2
- MC normalized to data, only muon events
- Data are corrected with time offsets obtained with LED beacon calibrations

Data/MC are in good agreement



Directionality with the Multi-PMTs

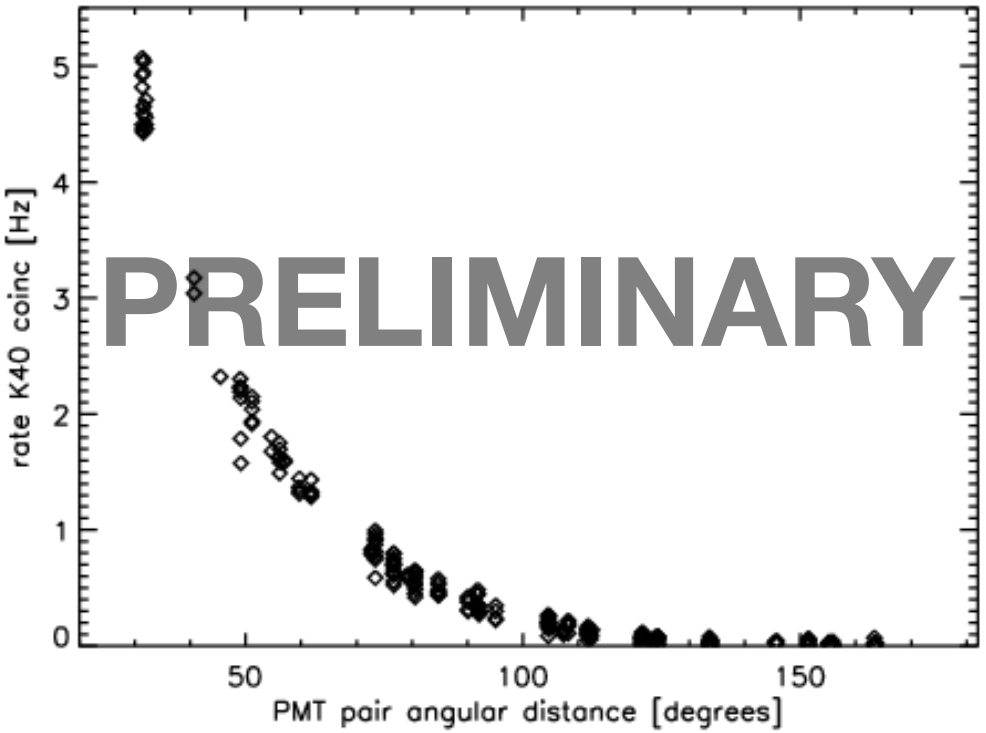


PMT orientation

Muons fire all the three DOMs

- Data triggered to have at least a L1 coincidence on all the three DOMs
- MC contains only muon events (normalized to data)
- As 3-DOM-triggered events, all these events are only muons.
- Powerful rejection of optical background.

K40 Coincidences — DOM1

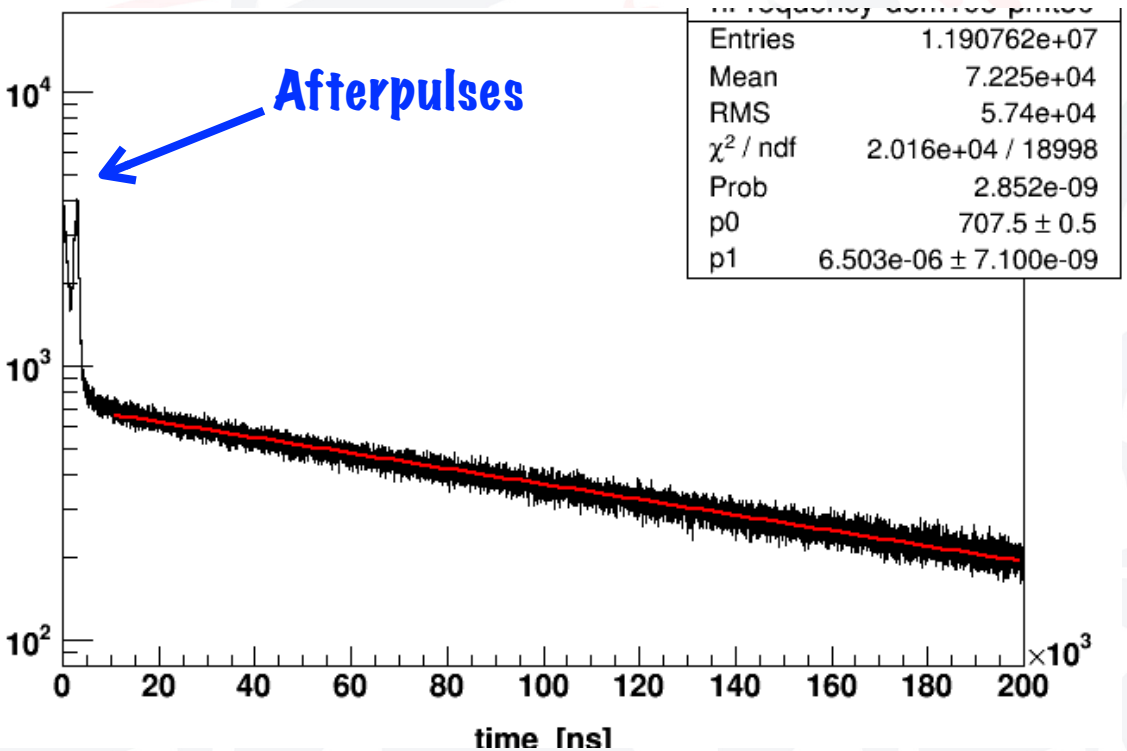


- K40 rate evaluated with L1 time window increased to 40ns.
- Every point represents a couple of PMTs in DOM1 considering all the possible combinations.

Summary

- The PPM-DU is active and taking data
- This qualification project paves the way to the forthcoming installation of 24 Detection Unit + 8 Towers in the Capo Passero area (KM3NeT-IT) and 7 Detection Unit in the Toulon site (KM3NeT-FR)
- All the subgroups in the KM3NeT collaboration (Mechanics, Electronics, Software, Data Analysis) can take profit from this prototype to get ready for the km^3-scale neutrino telescope
- The detector construction is starting, first DU is announced to be installed early 2015.

Backup



Distribution of time differences between consecutive hits,

The tail of the time differences distribution is fitted with an exponential:

$f(x)=p0*\exp(-p1*t)$

where p0 is a scaling factor, p1 is the single rate and t is the time differences.