# PMT measurements in Antares

Oleg Kalekin on behalf of Antares collaboration

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Erlangen

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Friedrich-Alexander-Universität
Erlangen-Nürnberg

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# Motivation

**Reduction of differences between Monte Carlo and real Antares data**

- charge distribution of the background hits
- $^{40}$K coincidence rate in two adjacent optical modules
- hit residual time distribution

**Improvement in the analysis quality**

**Parameters of Antares PMTs and optical modules**

- Late pulses and after pulses
- Quantum efficiency
- Angular acceptance

**New measurements and simulations**



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# Angular acceptance of optical modules

## Measurements:

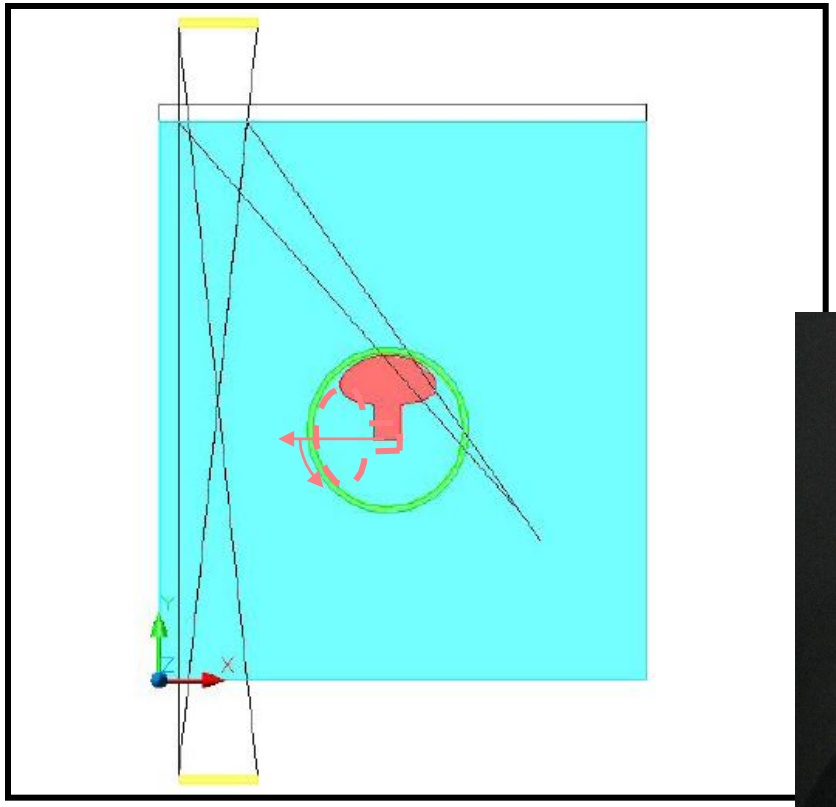
- INFN, Genova – water tank, atmospheric muons
- ECAP, Erlangen – scan of surface; water tank, LED
- APC, Paris – scan of surface

## Simulations:

Geant 4, thin film theory

# Angular acceptance, INFN Genova

## The experimental apparatus:

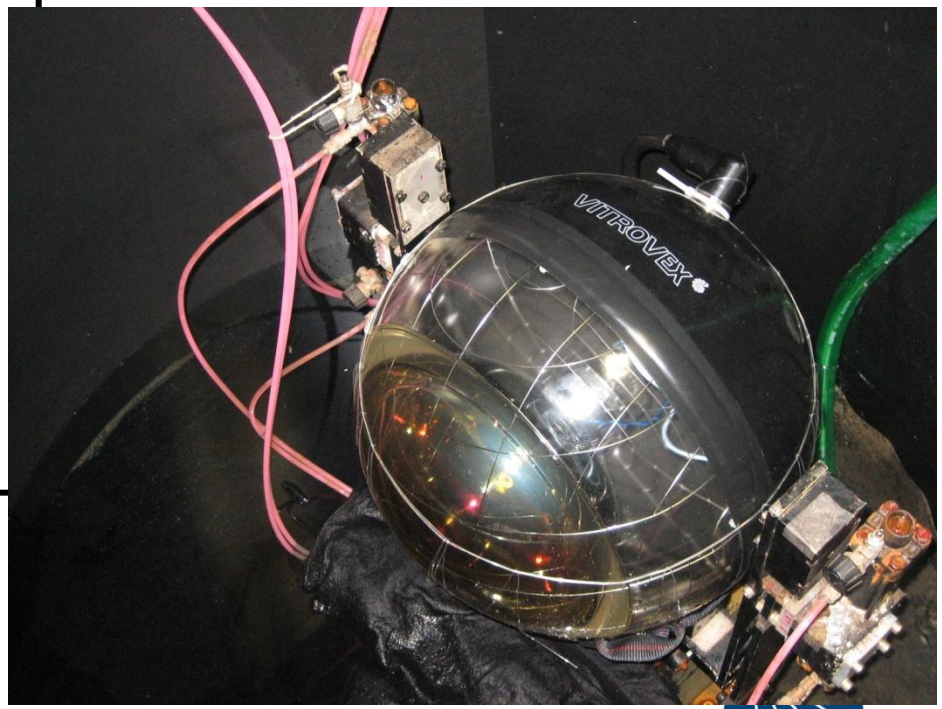


- 2 plastic scint to detect μ track
- water tank (130x150 cm)
- black absorbing walls
- OM support allows rotations

$0° < \theta < 90°$

$90° < \theta < 180°$

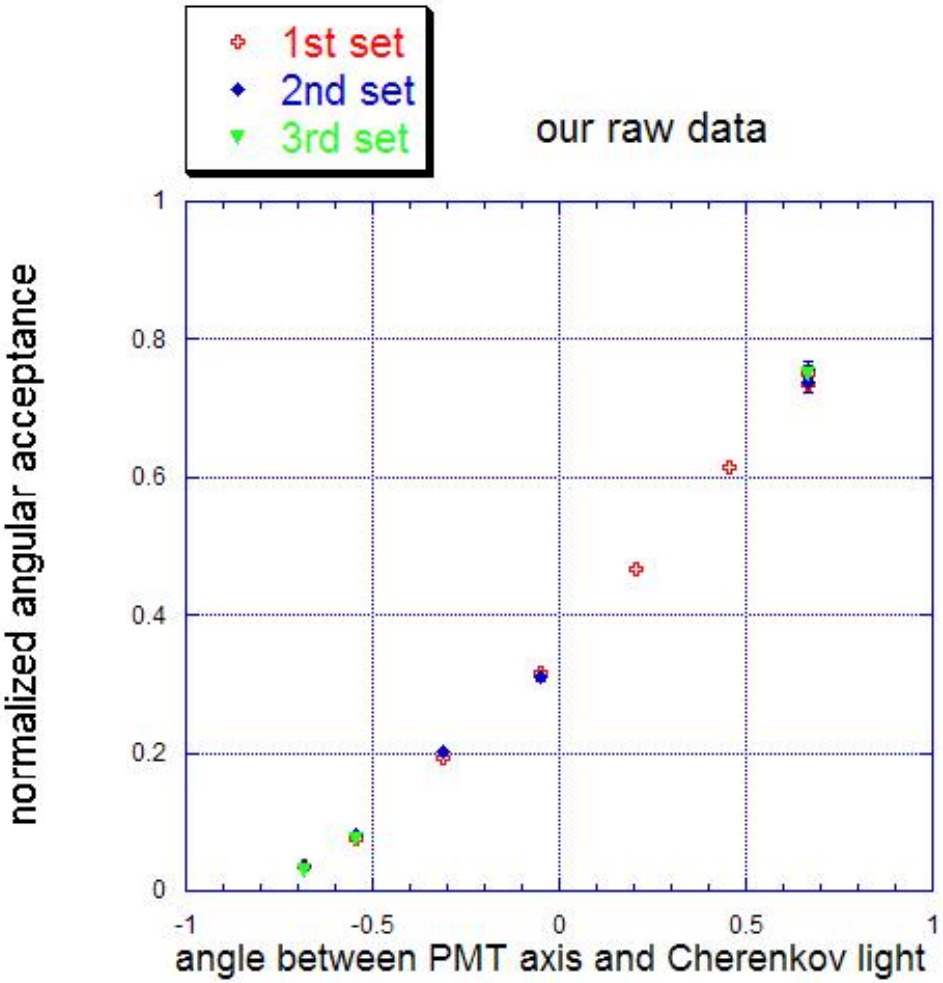
$0° < \phi < 180°$




**unfortunately the water level is limited.... measurements from $\theta$ >90°**

# Angular acceptance, INFN Genova

## Measurements:




1st set:

First set of measurement done with improved stable conditions

2nd set:

A further absorbing tissue was positioned in the tank

3rd set:

Measurements performed to check reproducibility



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# Scans of OMs, ECAP

Goniometer like scanner

Step motors, steps 1 deg

Optical fibre 1mm diameter

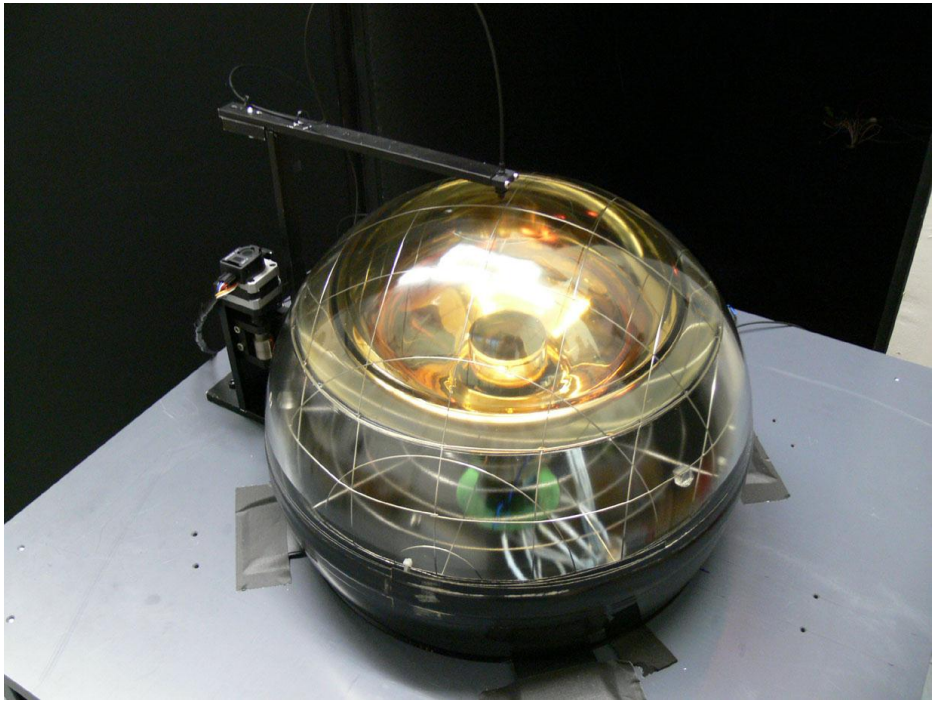
LED pulses, ~10 ns FWHM

A few tens photoelectrons (phe)

A few hundred pulses in each measured point

Charge recorded with ADC

Mean charge – gauss fit

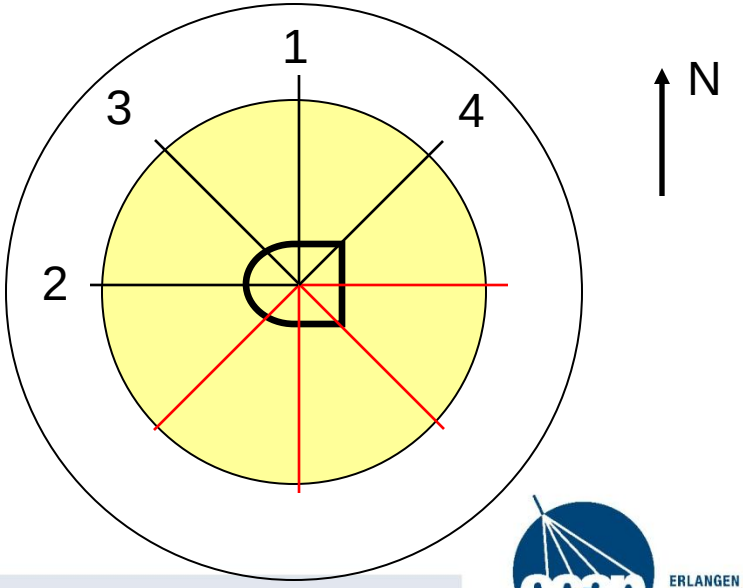


OM orientation, top view:

Dynode window shown at centre

Pins 19 and 20 on the right side

Scan numbers shown

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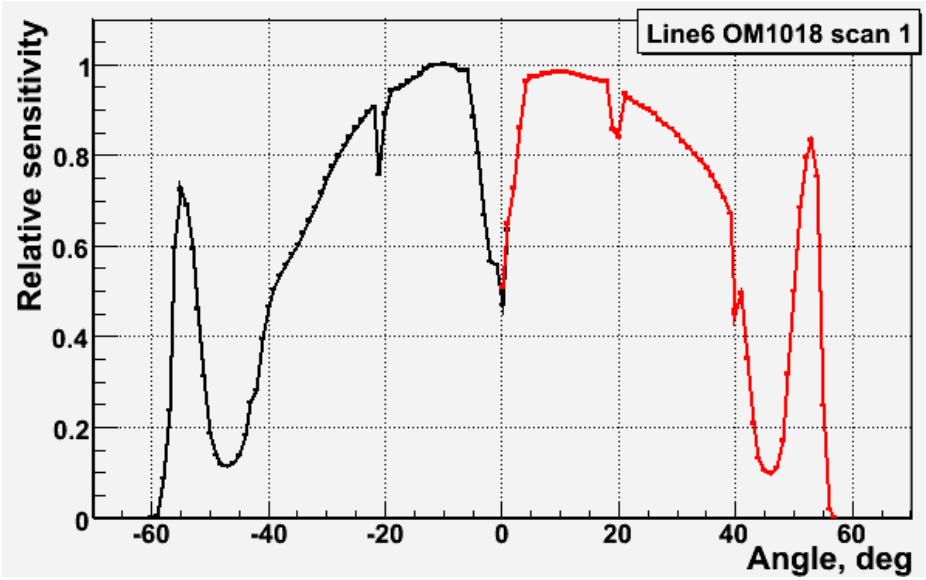
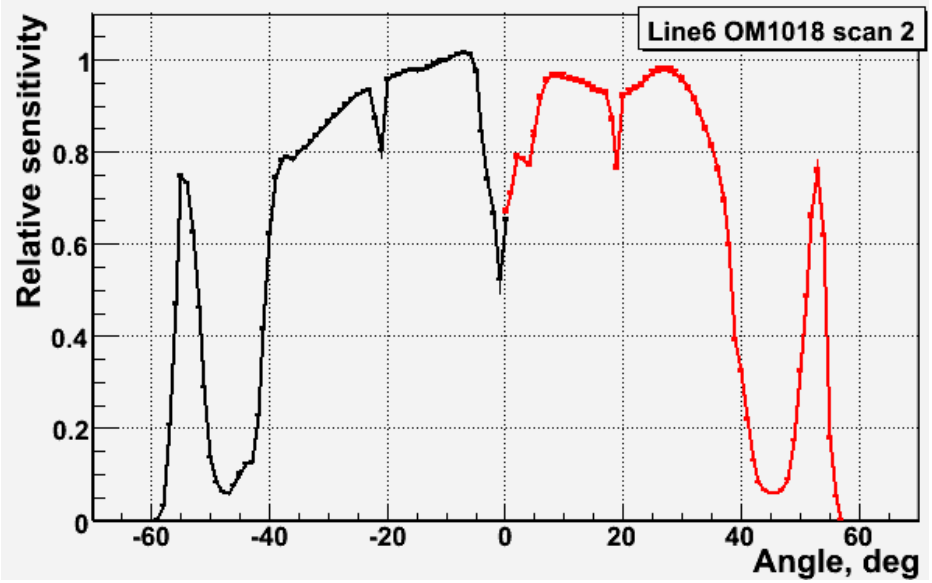
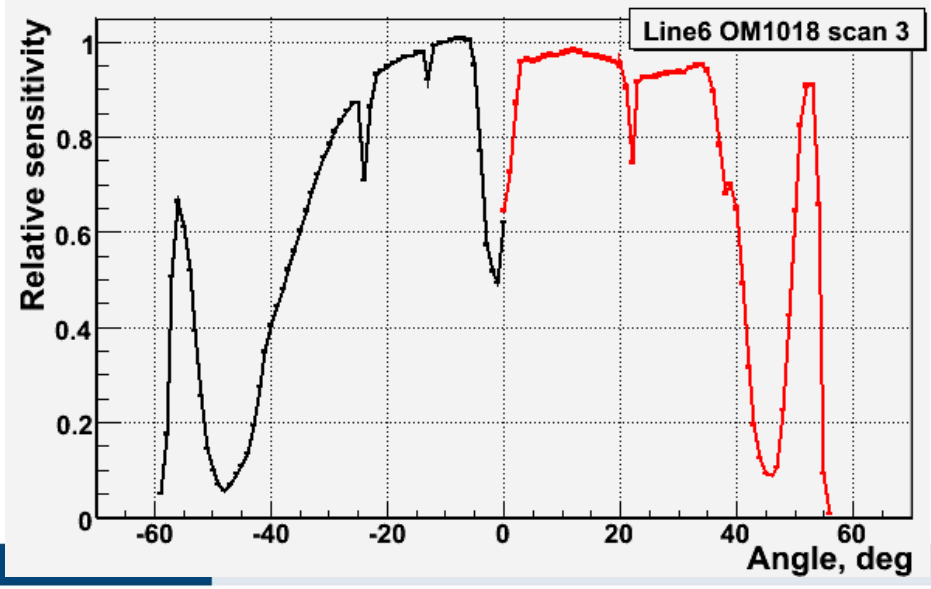
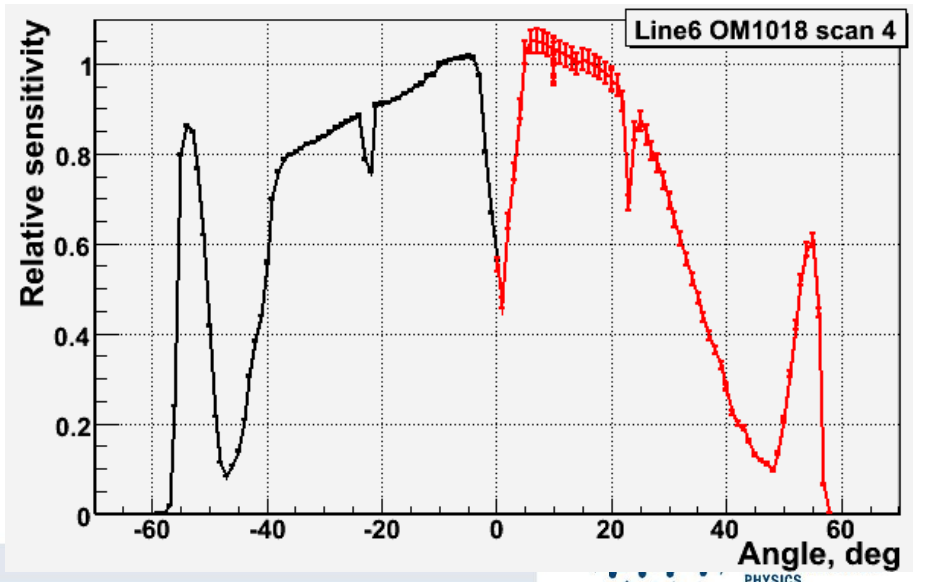
# Scans of OMs, ECAP

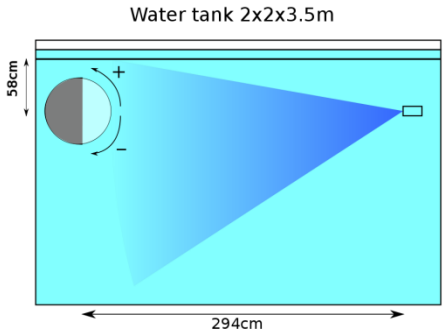


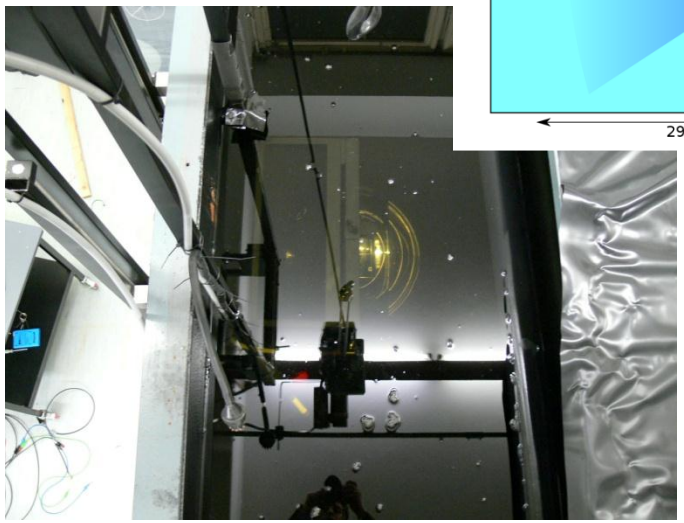



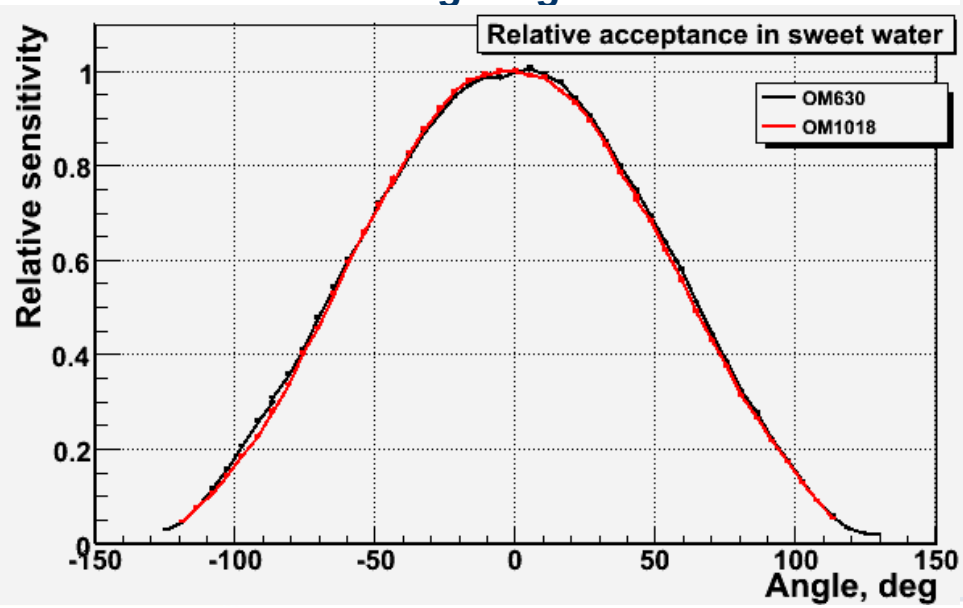



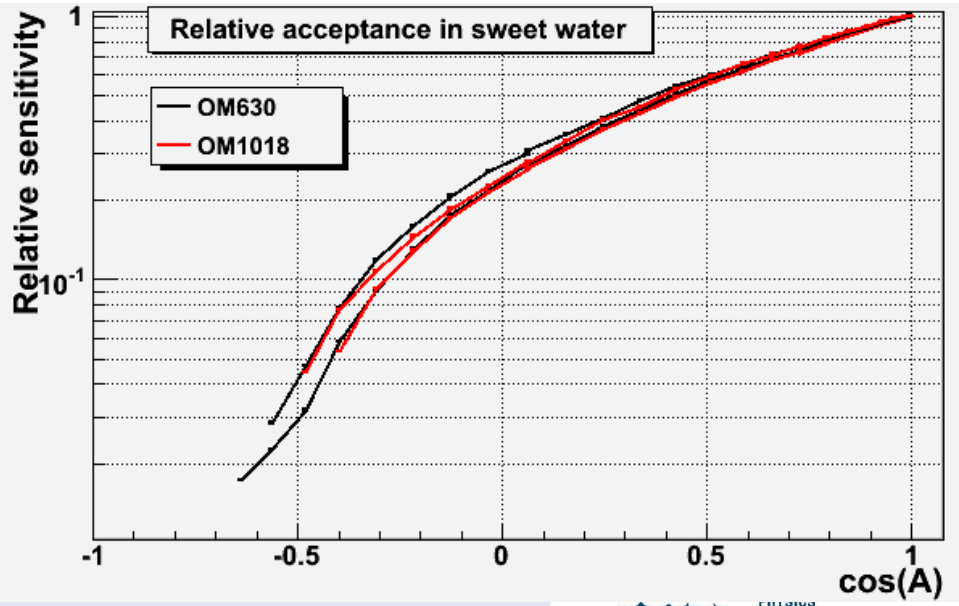
# Angular acceptance, ECAP




Water-tank 2x2x3.5 with sweet water
LED pulses, ~10 ns FWHM
2.5cm diameter diffuser
Distance diffuser – OM geometrical centre 294cm
A few tens photoelectrons (phe)
A few hundred pulses in each measured point
Charge recorded with ADC
Mean charge – gauss fit





# Scans of OMs, APC

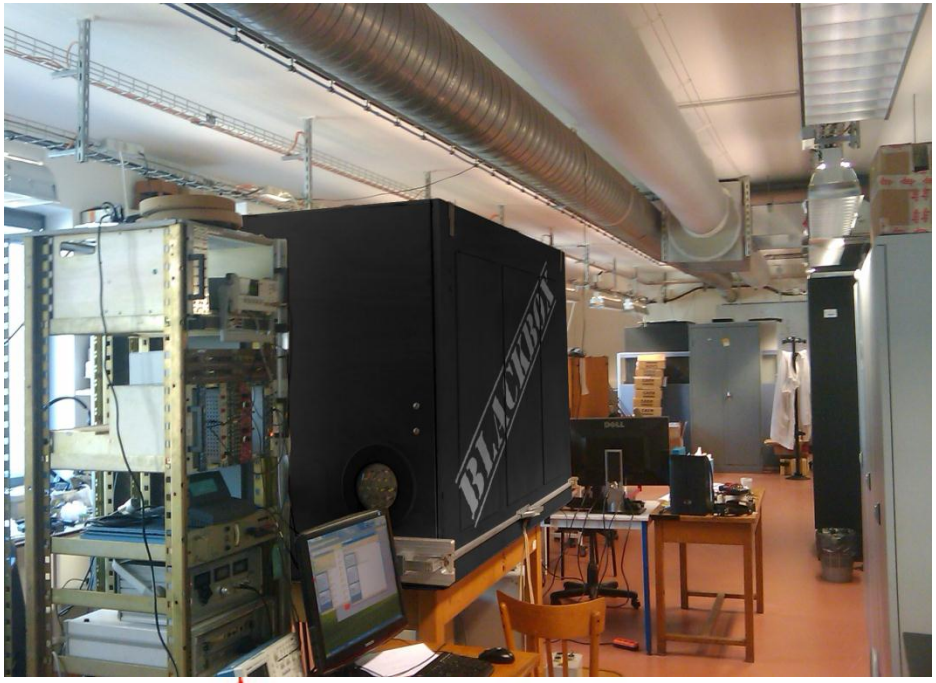
**Black box 1m x 1m x 2m**

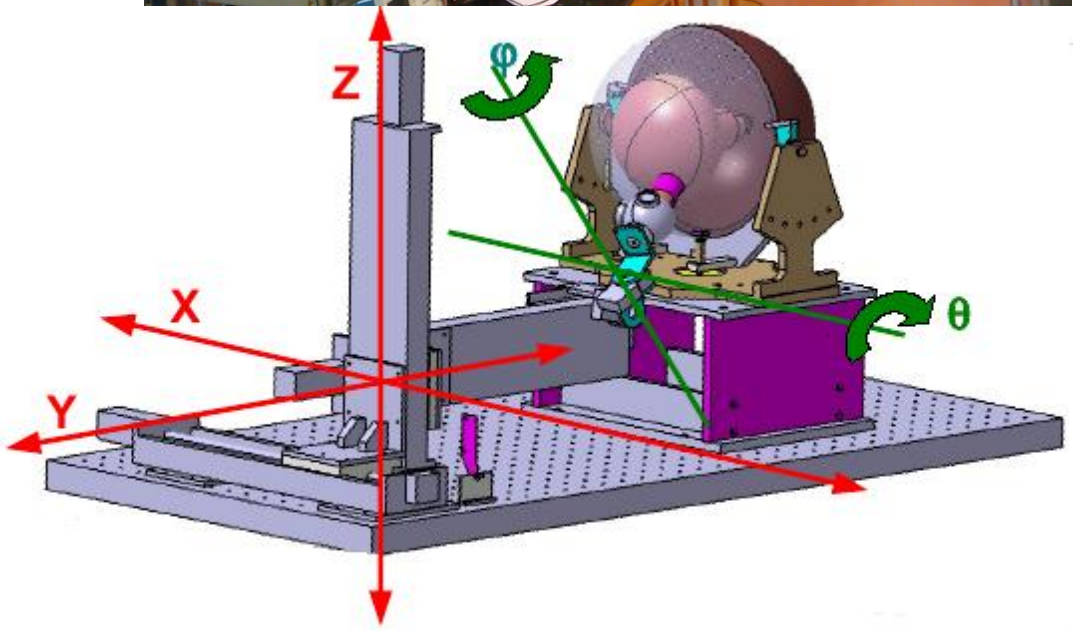
**Robot – all positions, angles**

**LED inside of diffusive sphere**

**NIST photodiode to control light intensity – absolute calibration**

**Output hole 0.067 μm²**



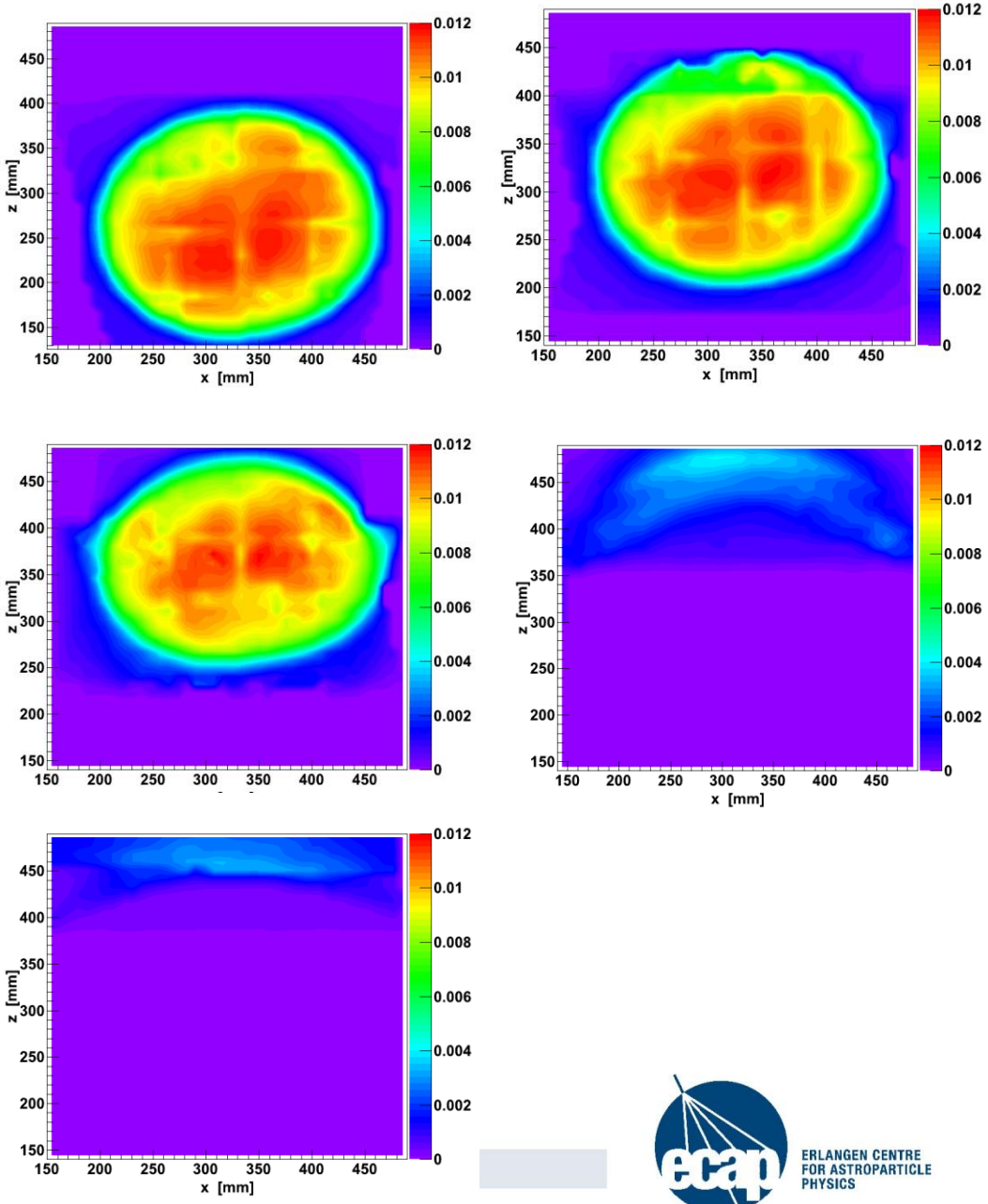



# Scans of OMs, APC

**Parallel beam:**

**756 points**
**1 cm spacing**
**106 triggers per point**

**5 dierent angles:**
**0, 23, 38, 120 and 138**



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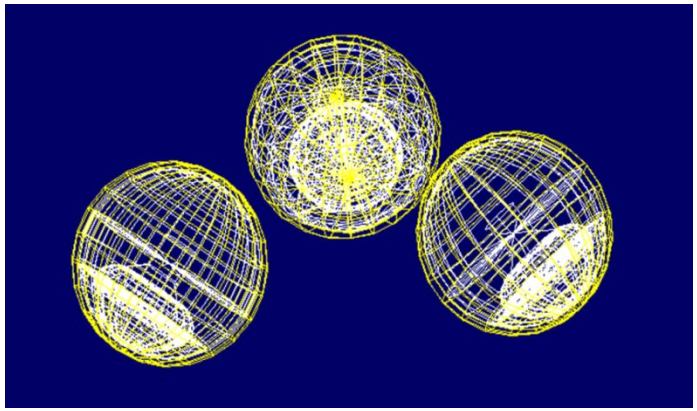
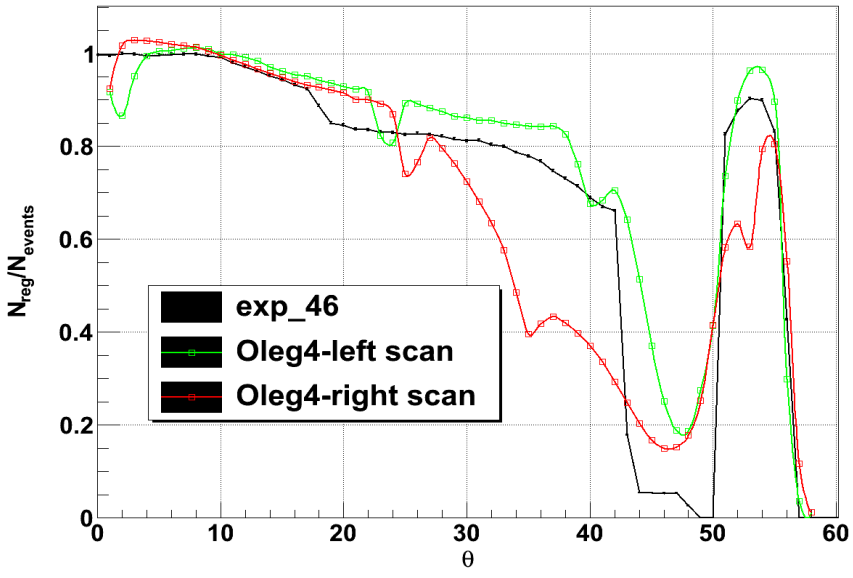
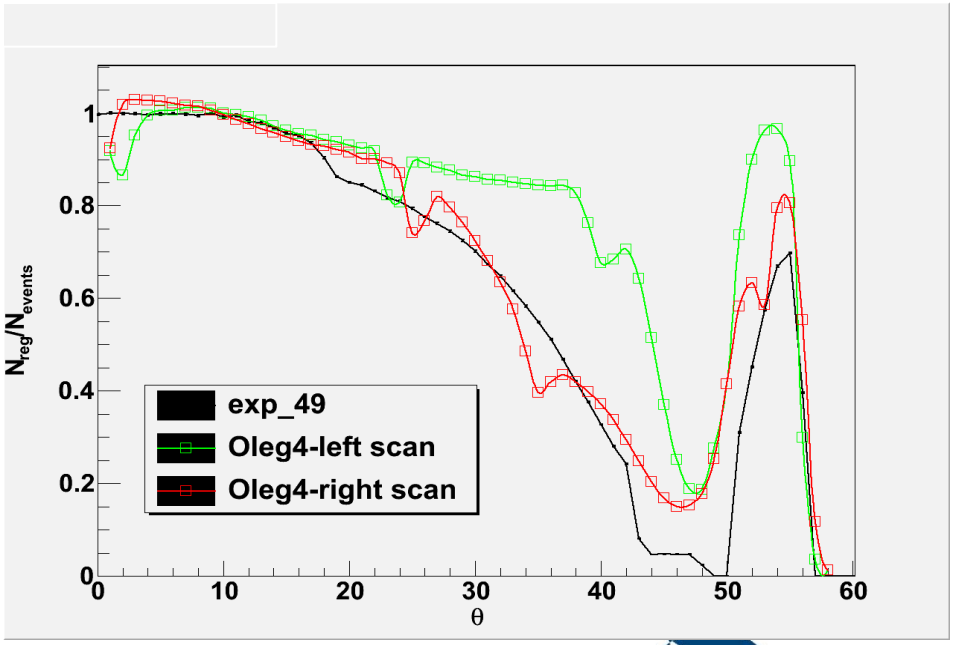
# Angular acceptance – simulations

## Geant4 with thin layer theory implemented

## PMT angular acceptance tuned to fit measurements (scans)



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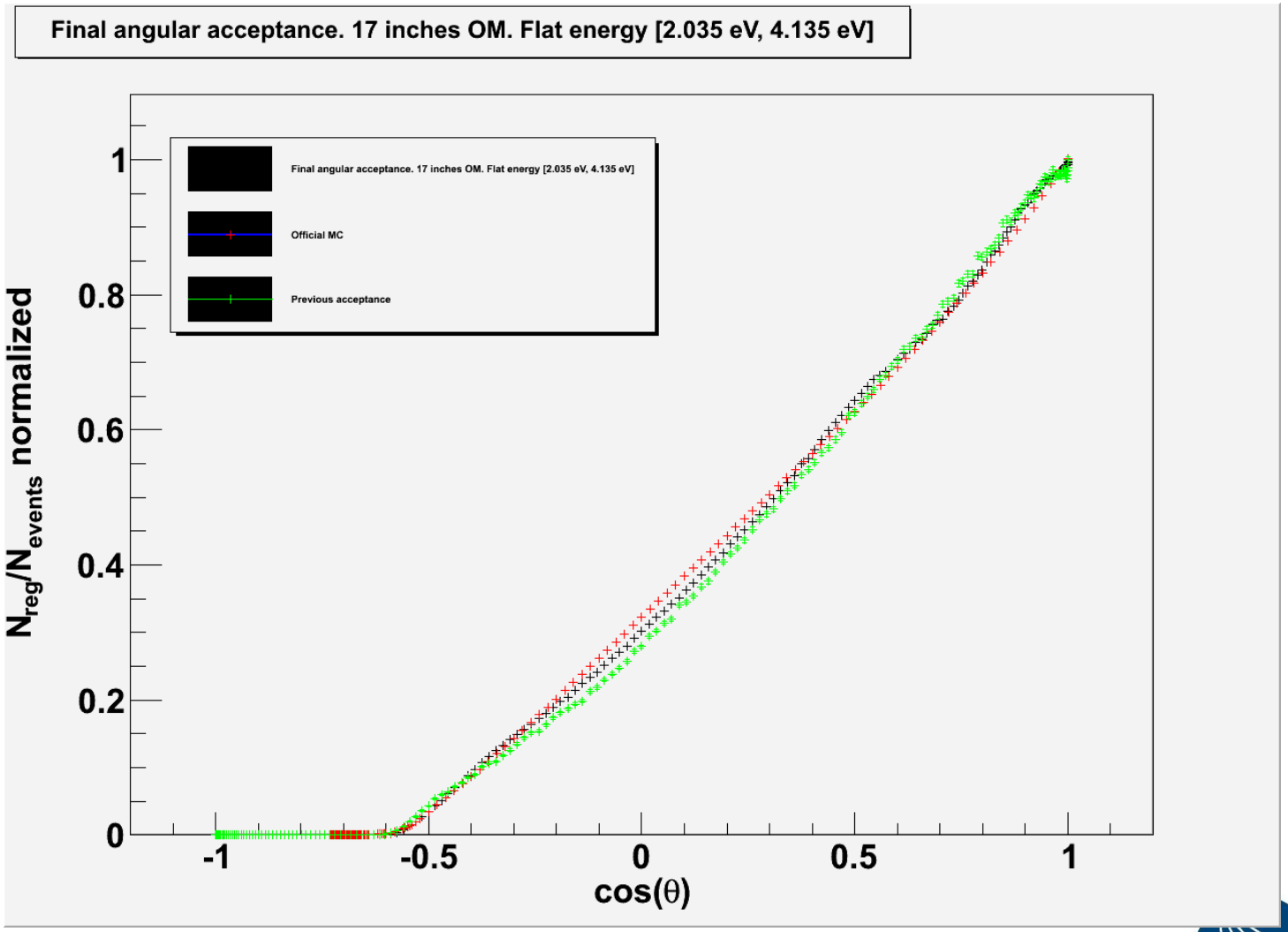
# Angular acceptance – simulations



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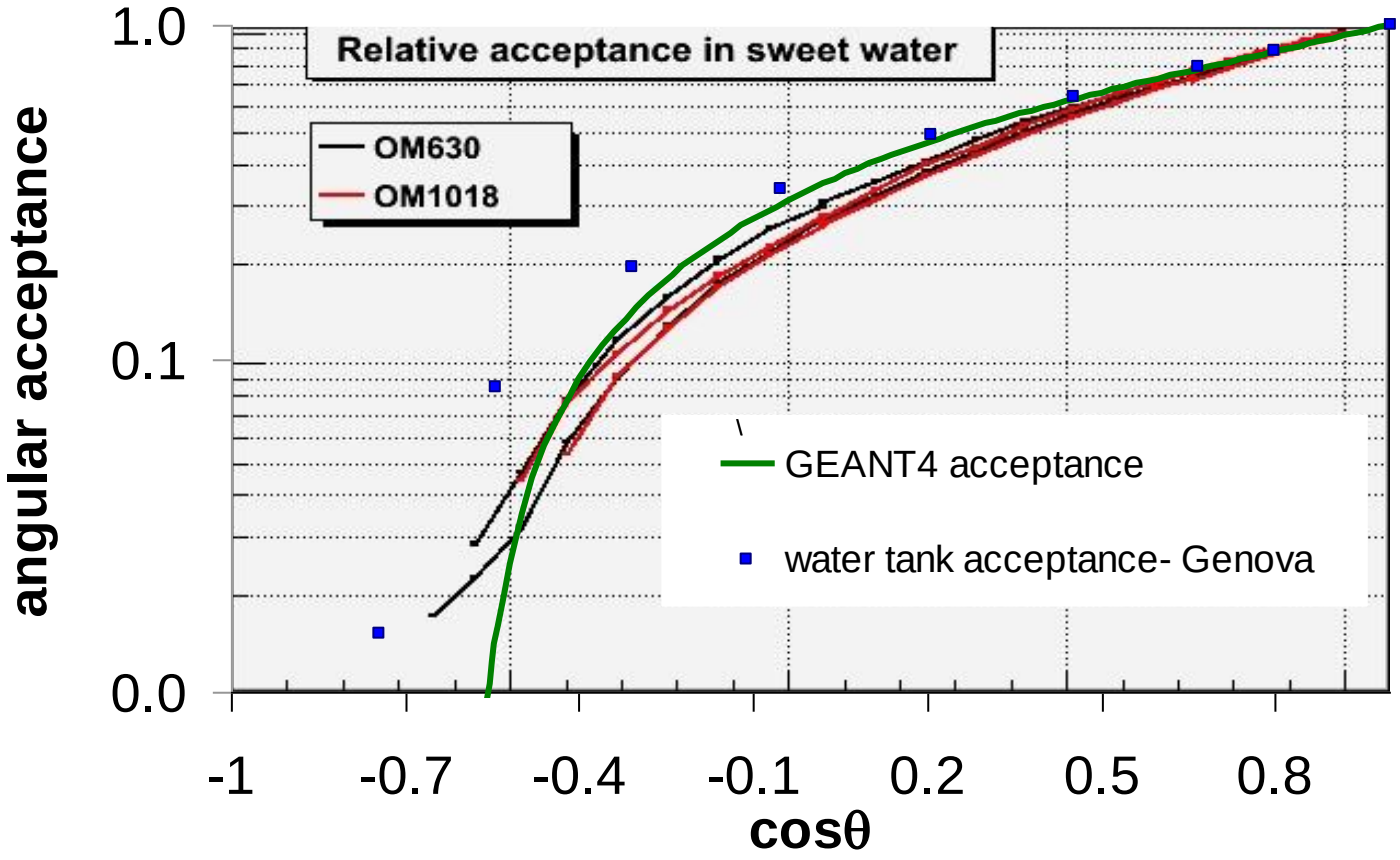
# Angular acceptance

## Simulation vs measurements in water tanks



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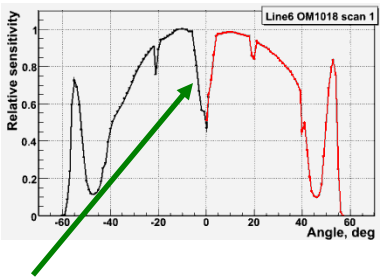
# Absolute calibration




**APC: OM Efficiency 15.1%**

**ECAP: OM1018 11.7% - bad glass transparency in the central part**
**OM630 15.5%**

**OM and photodiode illuminated simultaneously with LED pulses**
**OM – diaphragm ~0.75mm diameter, photodiode – full size 1.5x1.5mm**
**OM in a box, 316cm from LED; photodiode – 6cm lower, 13cm closer**

**Measured:**
**OM – charge with ADC, 60ns window, at 1kHz an at 200kHz**
**Photodiode – current at 500kHz and at 2MHz**



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# Afterpulses

**INFN, Genova**

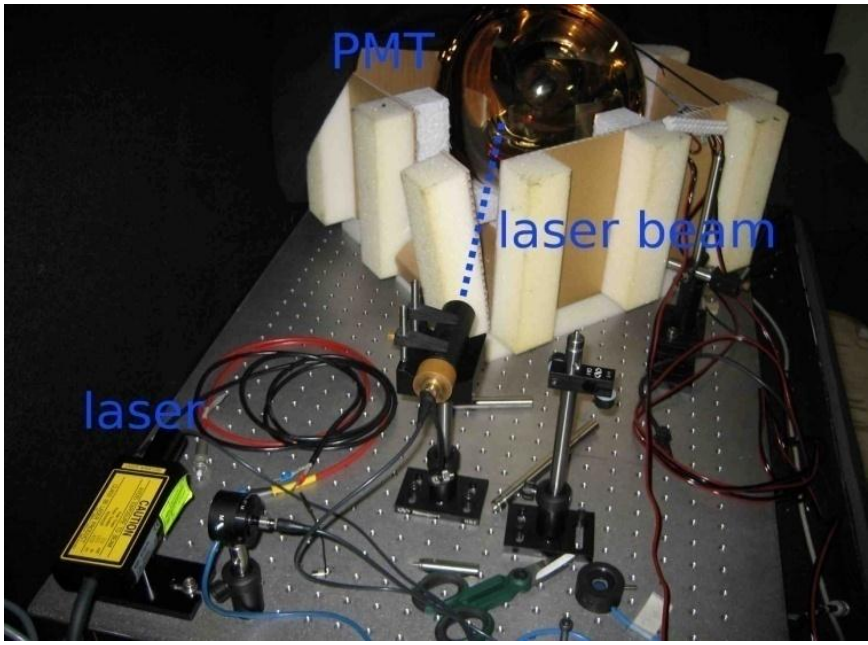
**R7081 10inch PMT, active ISEG base**

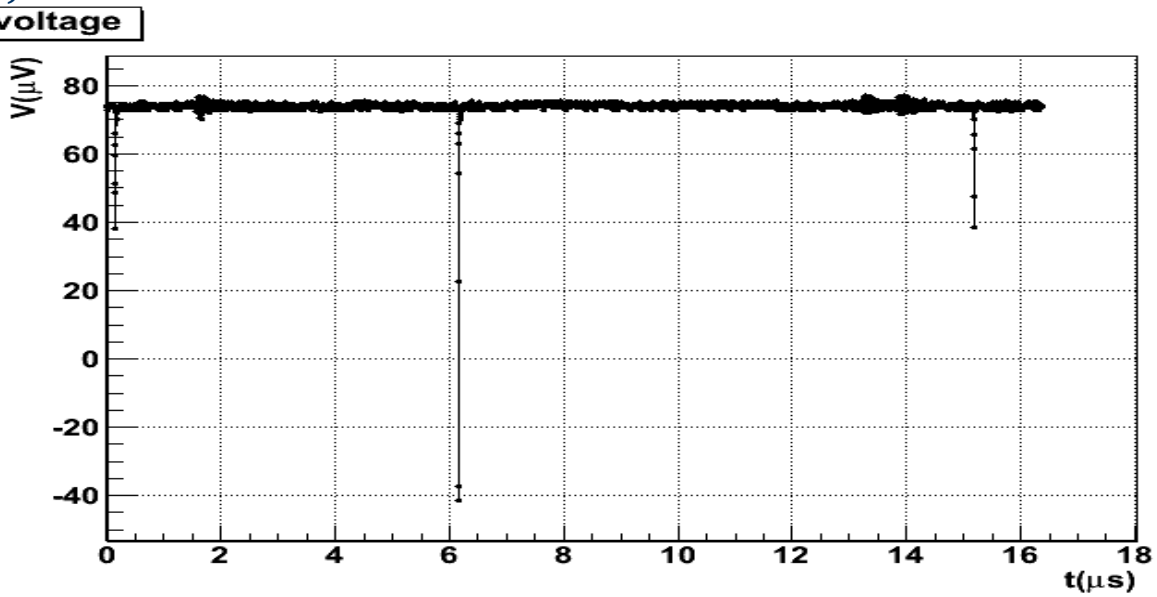
**Hamamatsu Picosecond Light Pulser PLP10-044C, 440nm wavelength**

**0.3 photoelectron threshold discriminator**

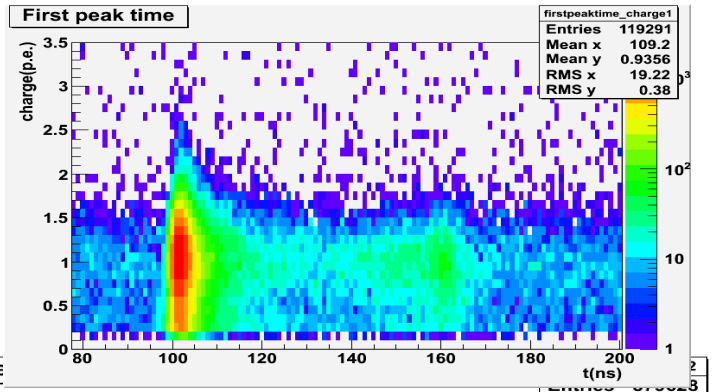
**CAEN digitizer V1731, 1GHz**

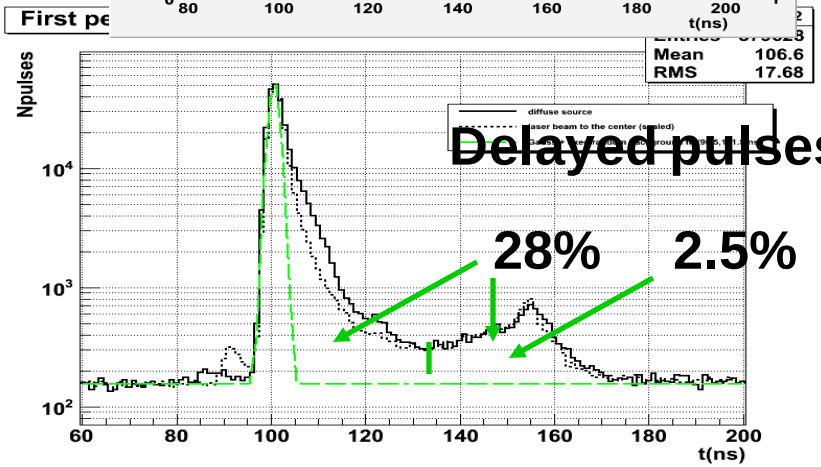
**~$10^{-2}$ photons/pulse**

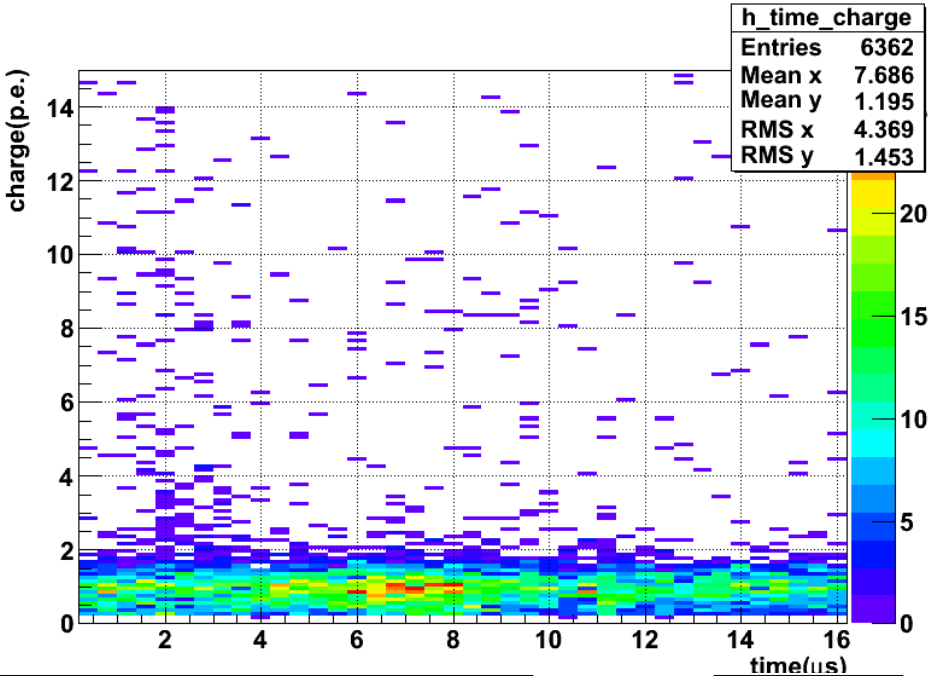


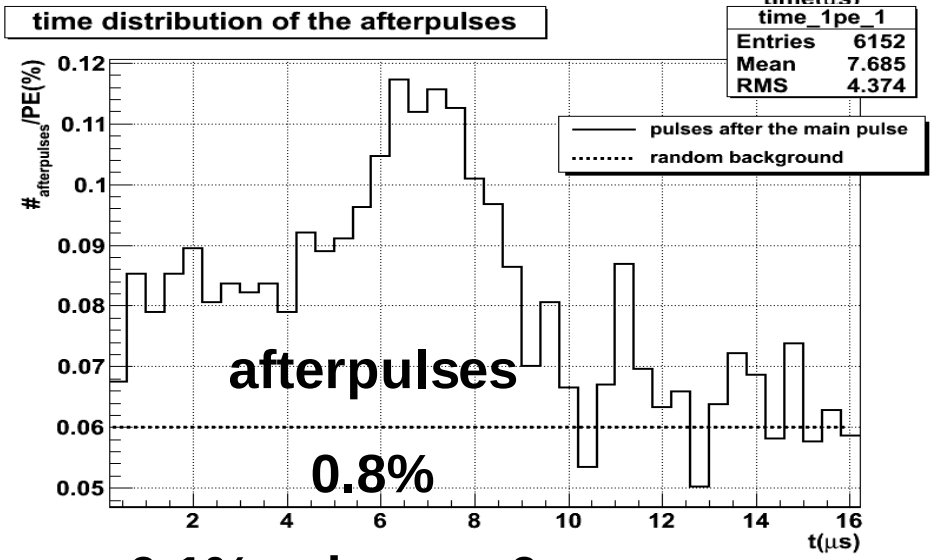



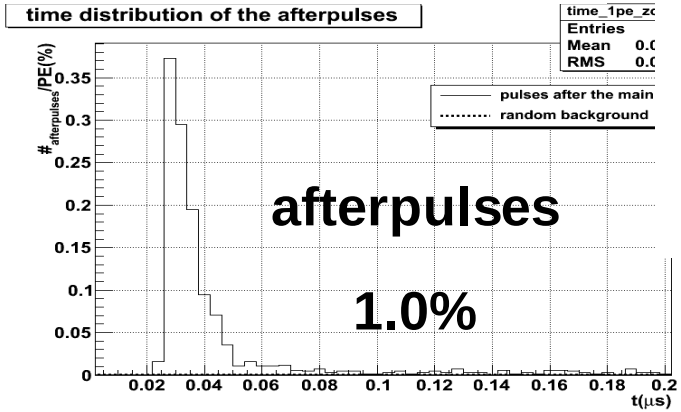
# Afterpulses




0.1% - charge>6pe



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# Summary

**Successful PMT/OM tests at different Antares groups**

**Better understanding of the detector response**

**Extension and improvement of test benches expected:**

**APC – water tank, ECAP – afterpulsing**