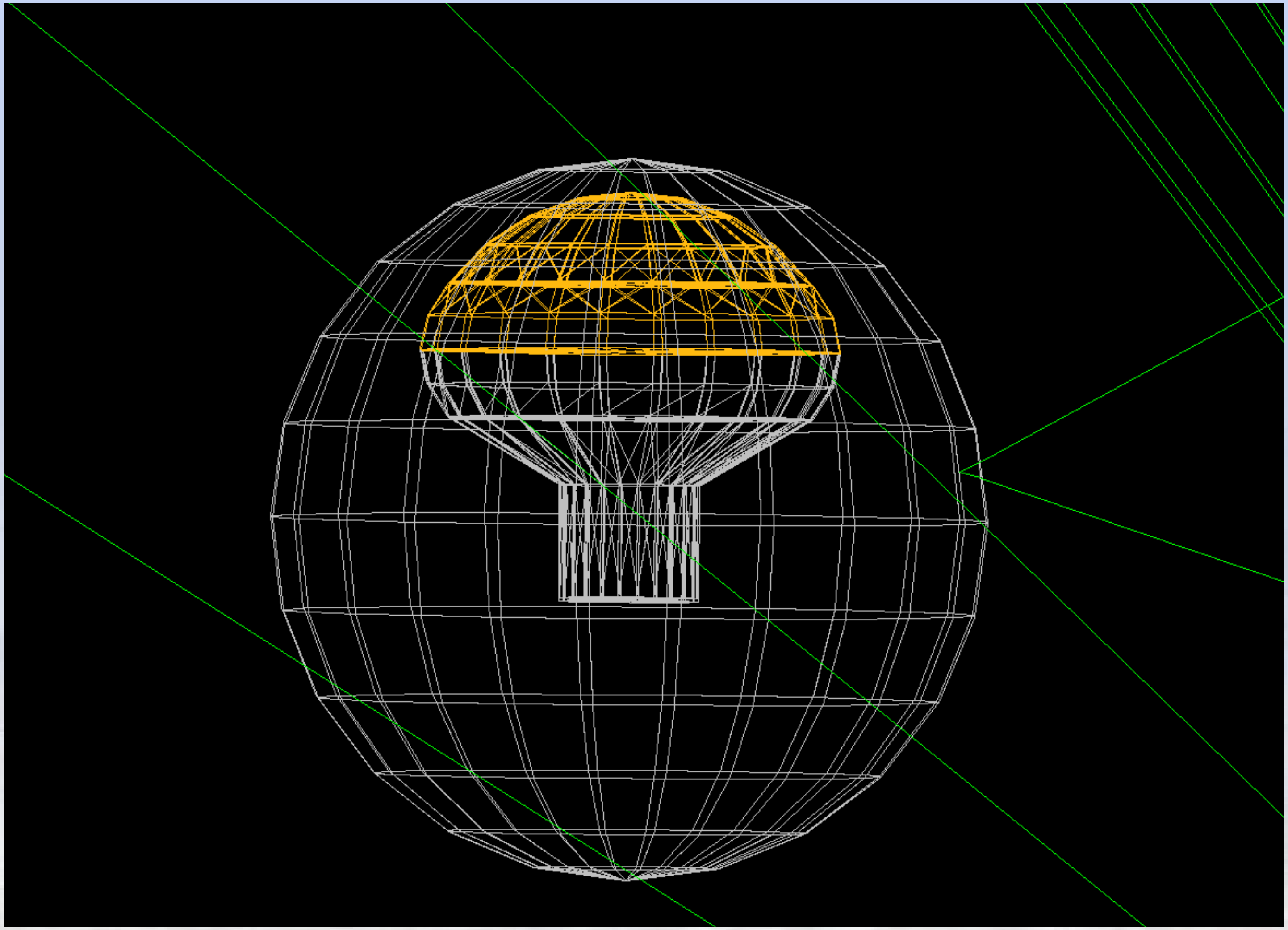
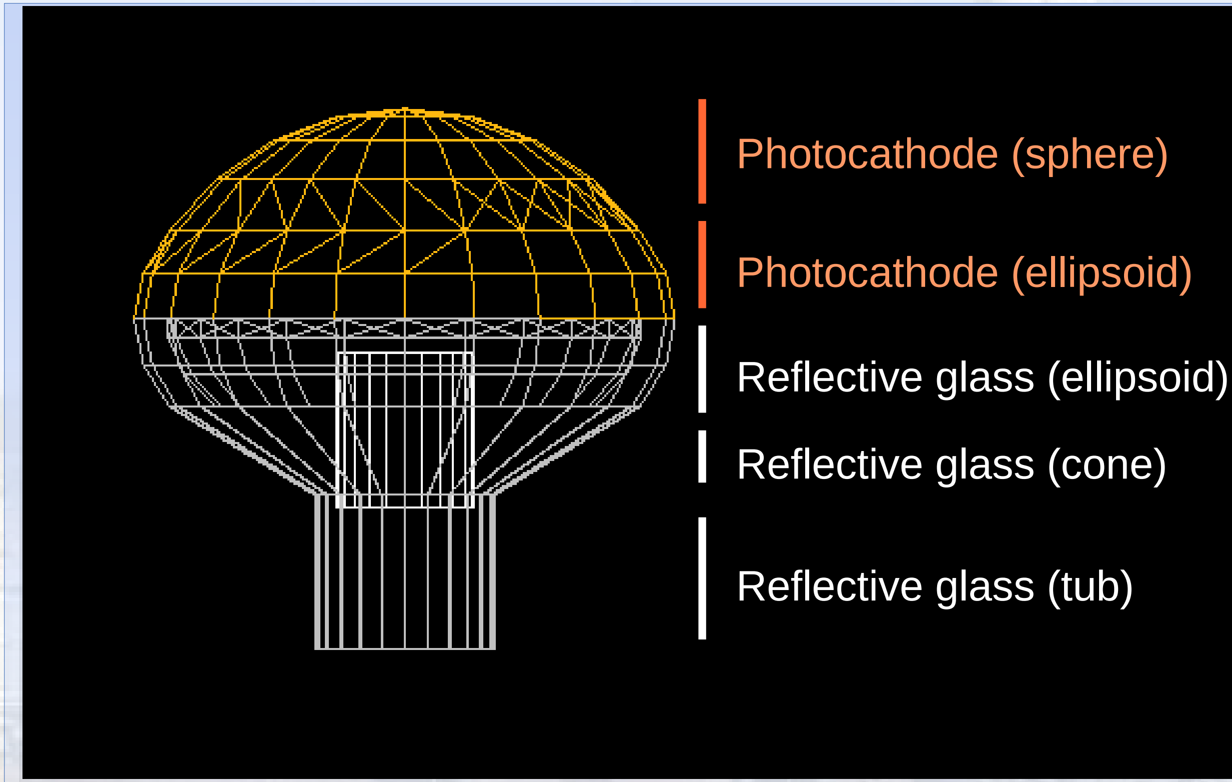
GEANT4 simulation status at Genova



Overview

- Step1: Geometry definition
- Step2: Photocathode simulation
- Step3: Collection efficiency simulation based on Scans (Alex and Oleg)
- Step4: Absolute calibration: simulation of K40
- Angular acceptance
- Scattering

Step 1:Precise geometry



**Based on some parameters,
any Antares' like PMT shape can be tested**

<u>Only geometry is modified</u>
It will use exactly the same physics model

<u>It uses mathematics calculation</u>
for each component's size/position, based on the Hamamatsu specifications

Eg : piece of sphere angle and small radius of ellipsoids :

$$\alpha = \arcsin(R_{sphere} / p_{sphere})$$

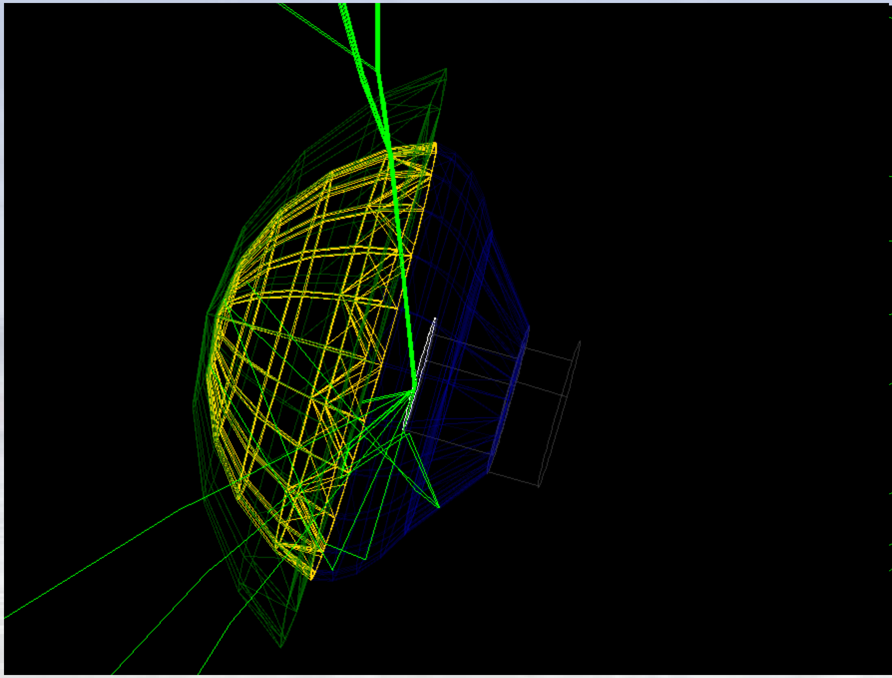
$$b_{ellips} = \sqrt{\left(\frac{(Bulb^2_{thick})}{(4*(1-p^2*a^2))}\right)};$$

p is the projection of the photocathode, R its radius, a and b the big and small radius of the ellipsoid. Bulb is the full ellipsoid z size

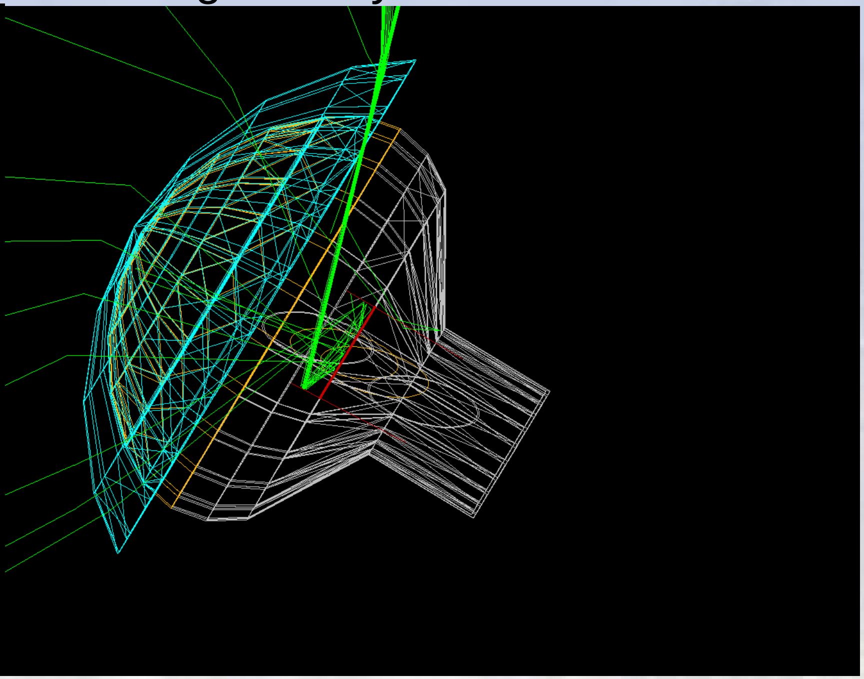
Precise geometry, in details

Furthest improvements
Internal structure :
- Dinods tube
- dinod grid

Old geometry



New geometry



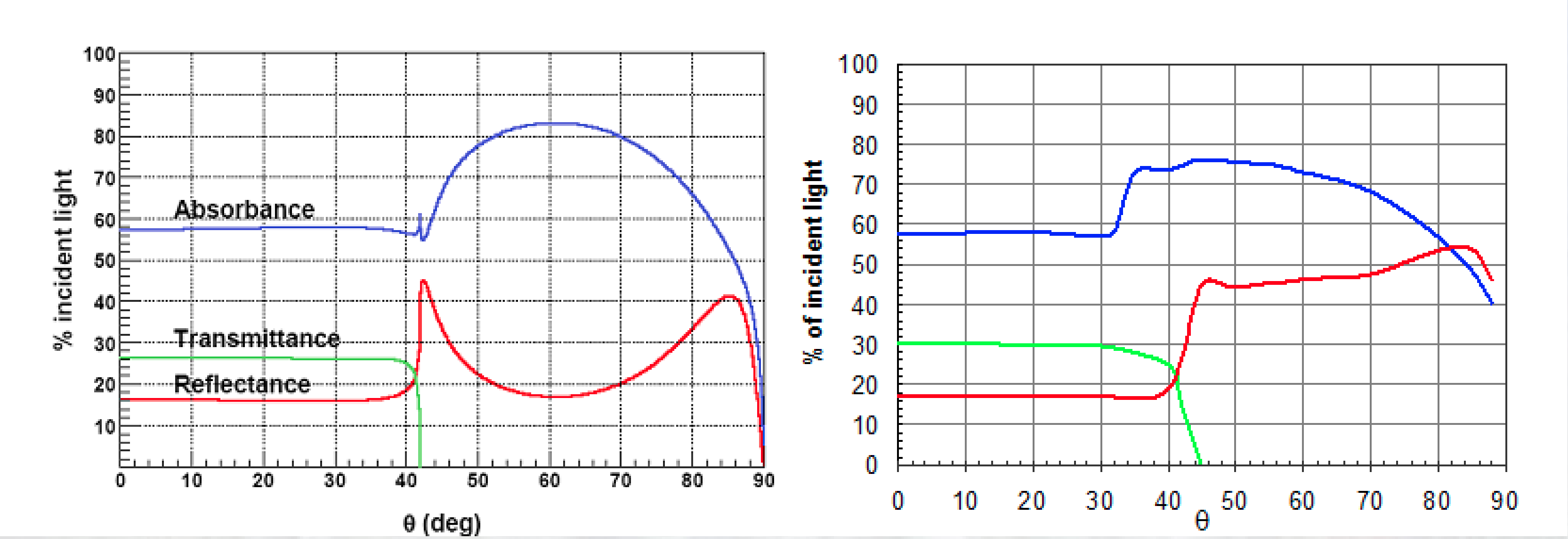
Step 2: photocathode efficiency

Photocathode properties (index, thickness...) has been measured (double chooz)

The probability of absorption and conversion depend on incident angle and wavelength.

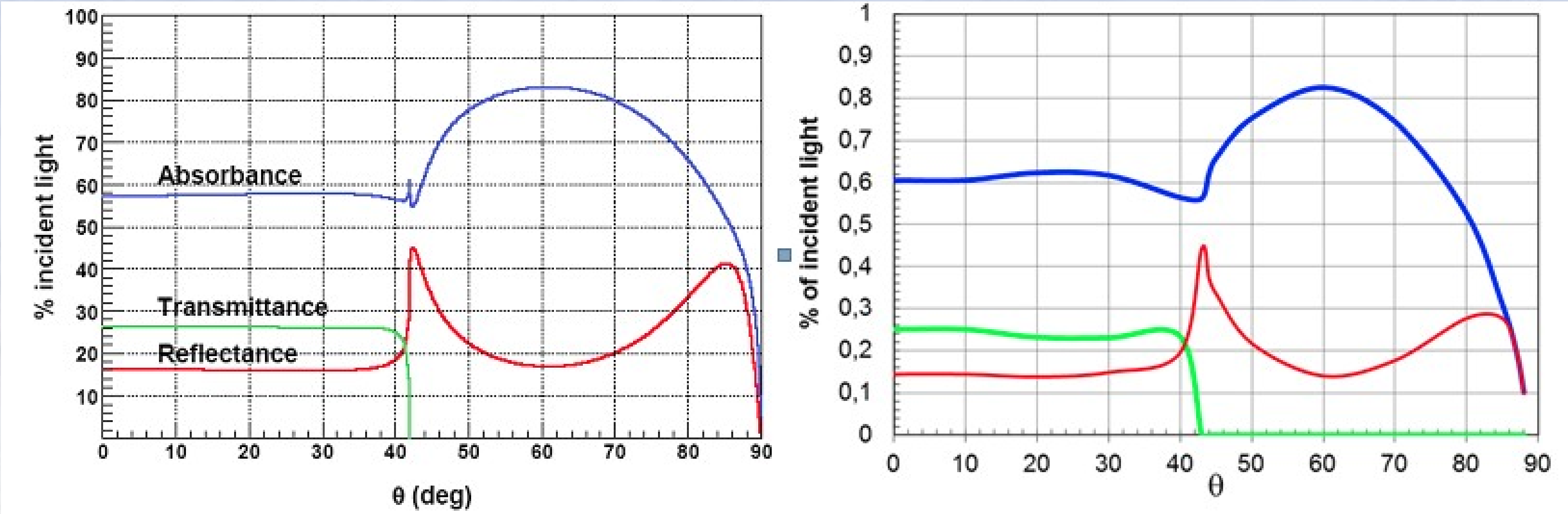
The original GEANT4 simulation code does not simulate well the photon-photocathode interaction.

=> dedicated code



Step 2: photocathode efficiency

A dedicated ray-tracing simulation was implemented to simulate it when the photon goes near the photocathode.
This simulation takes as input the glass thickness, the photocathode thickness and the interface with outside (gel).

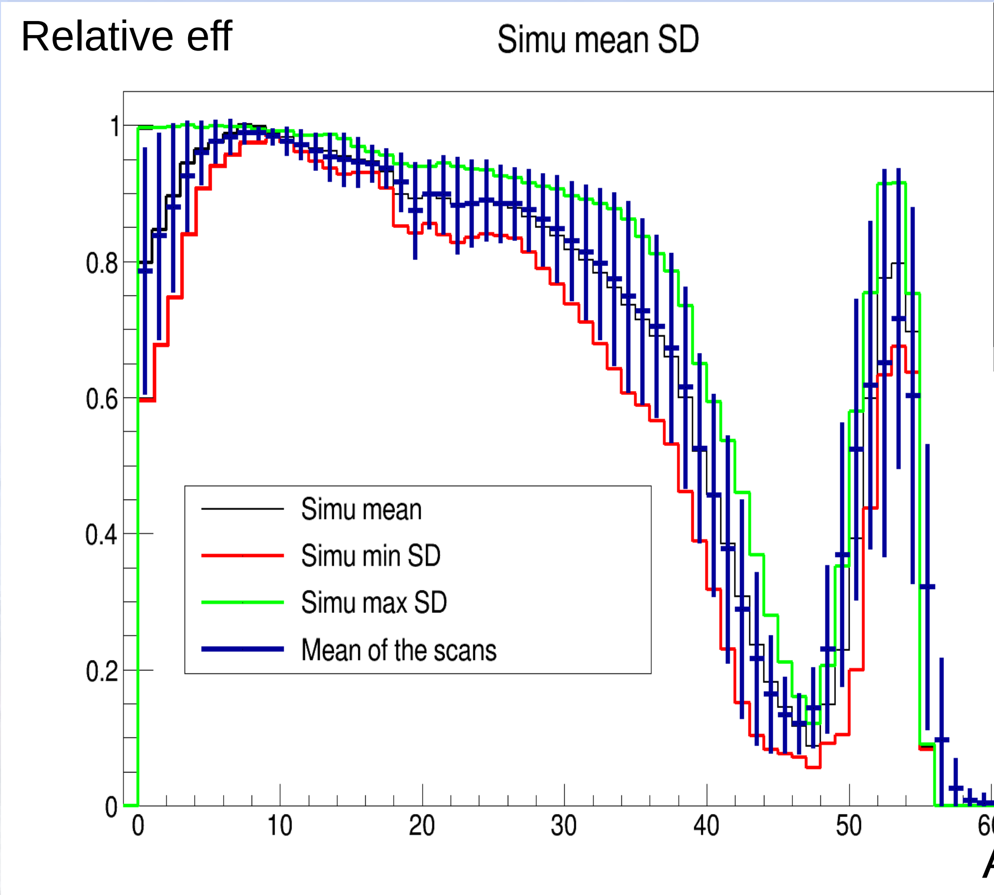


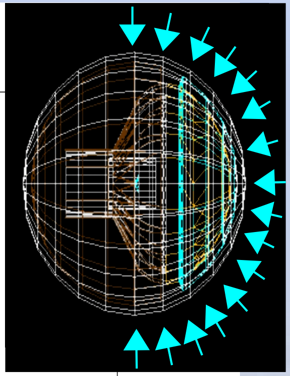
Step 3: Collection efficiency from scans and angular dependency

- Start from assumption that it is constant
- Assume that the difference between simulation and experimental measurement is intrinsic of the PM :
  - Photocathode inhomogeneity
  - Electron collection (electric field inhomogeneity)
- Tabulate the ratio between simulation and experimental inputs, report to the PM position.
- Use the difference as the collection efficiency of the PM in the simulation

Scan fit for data and simulation: First assumption

Simulation and data of OM efficiency





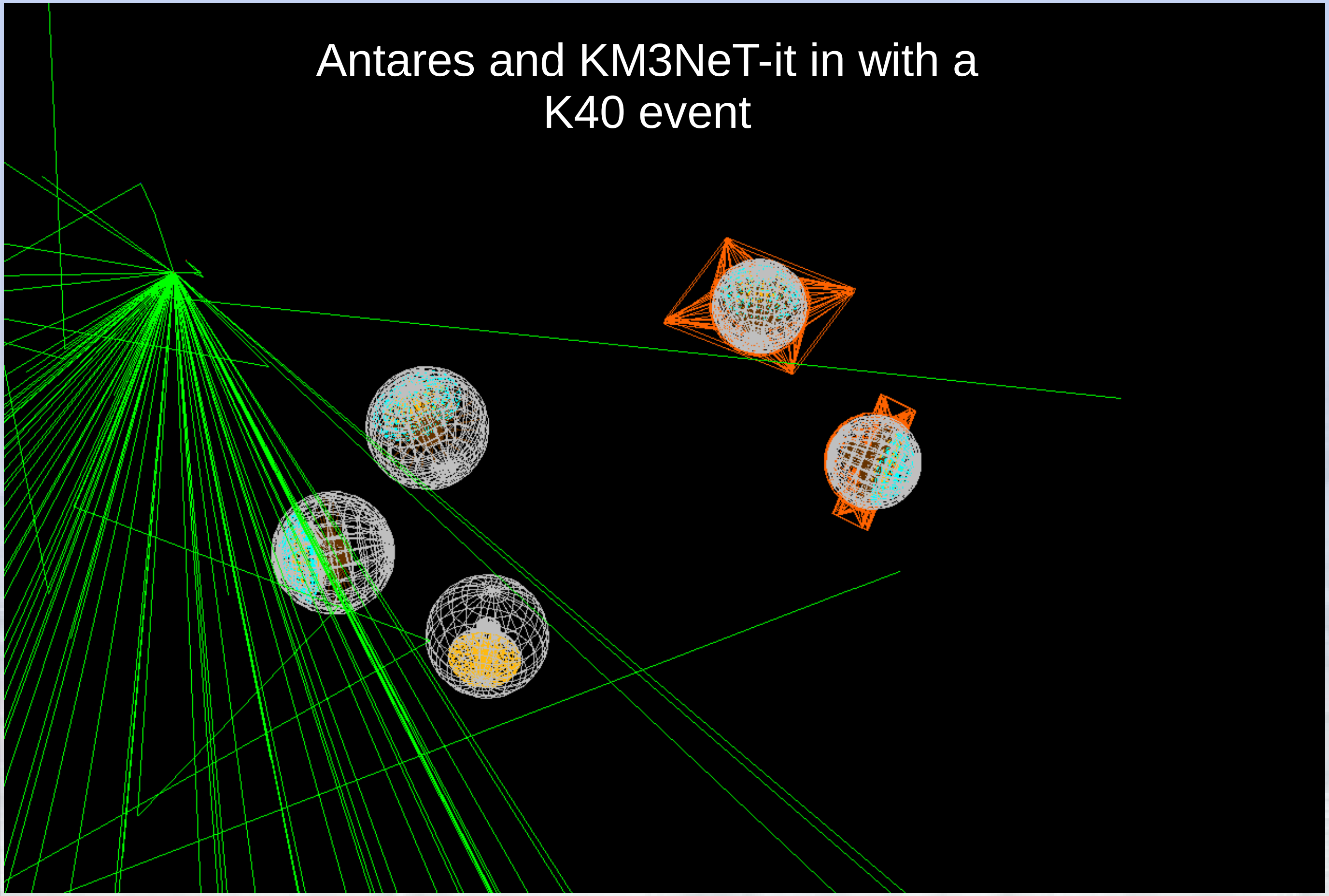
The simulation is able to provide three values

The mean: expected angular efficiency over all the Oms

The 2 standard deviations:
Expected variation.
Correspond to the order of magnitude of the experiment variations

Angle (deg)

Step 3: absolute efficiency from simulation of K40 and data



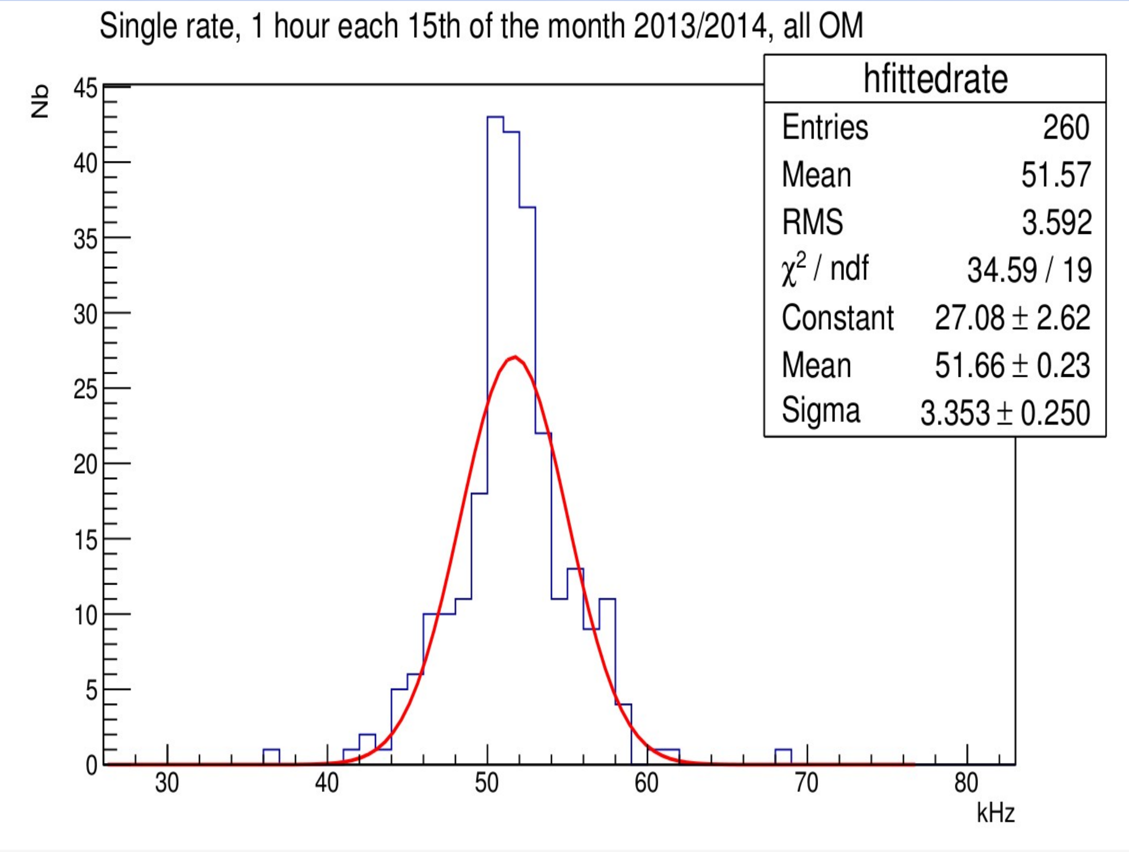
Coherent Laboratory measurements were done on two Oms

Antares and KM3NeT-it done

Simulated the trio

Results for the mean and the two limits

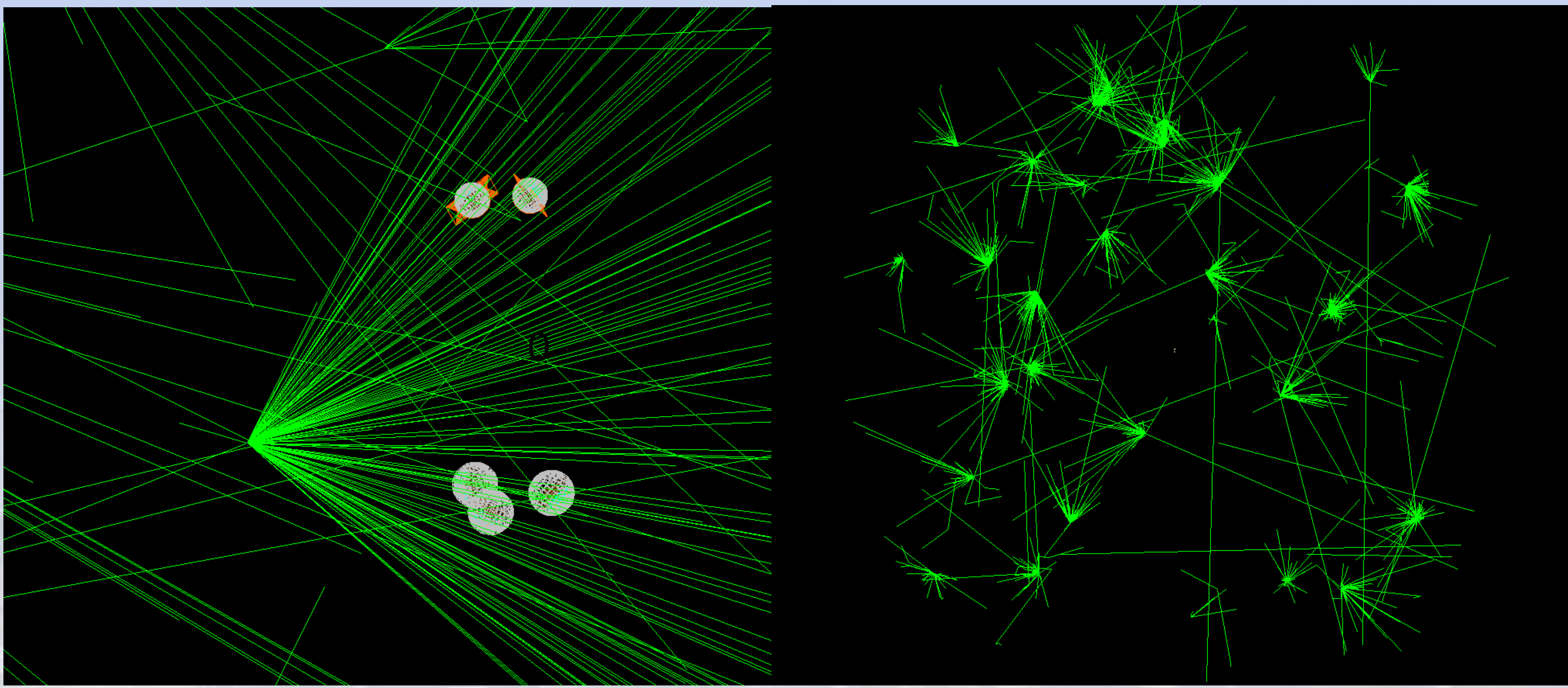
^{40}K single rate in NEMO: The data



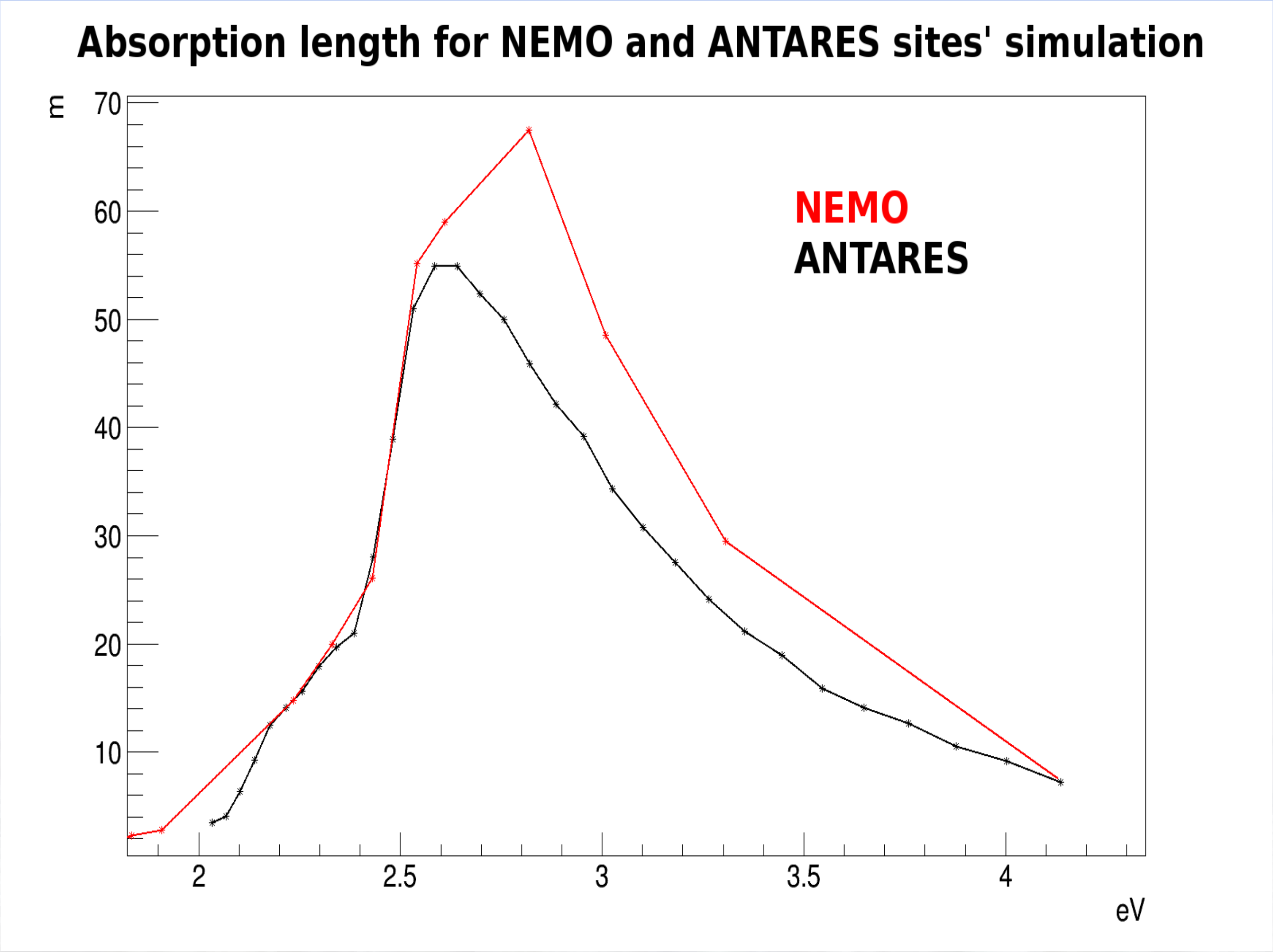
Single rate from random samples:
The baseline is extracted from samples of 1 hour (without selection) per month.

The samples showed a very good stability. Excluding the burst, almost no variation, It seems that there is a very low bioluminescence constant background.

^{40}K single rate in NEMO and ANTARES



Parameters



The single rates are independent of the scattering!

Simulation and data confrontation

Detector	set	2009	2010	2011	2012
ANTARES	coincidence rate	15.8 Hz	15.5 Hz	14.82 Hz	X
	simulation	43 ± 3 kHz	42 ± 3 kHz	41 ± 3 kHz	X
	data	51 kHz	49 kHz	46 kHz	47 kHz
	diff	8 kHz (2.7 σ)	7 kHz (2.3 σ)	5 kHz (1.7 σ)	X
KM3NeT-it	coincidence rate	X	21.6 Hz		X
	simulation	X	54 ± 3 kHz		X
	data	X	52 kHz		X
	diff	X	-2 kHz (0.7 σ)		X

The ^{40}K coincidence rate is used to calibrate the simulation,
We observe a regular decrease of the efficiency.
We consider 3.6 kHz of noise for ANTARES and 3 kHz for NEMO (glass ^{40}K and dark current)
The ANTARES single rate is in agreement with the numerical calculus (J. Brunner)
A very good agreement is found for ANTARES with the lab. measurements
An underestimation of the ANTARES single rates is observed.
A very good agreement is found for NEMO

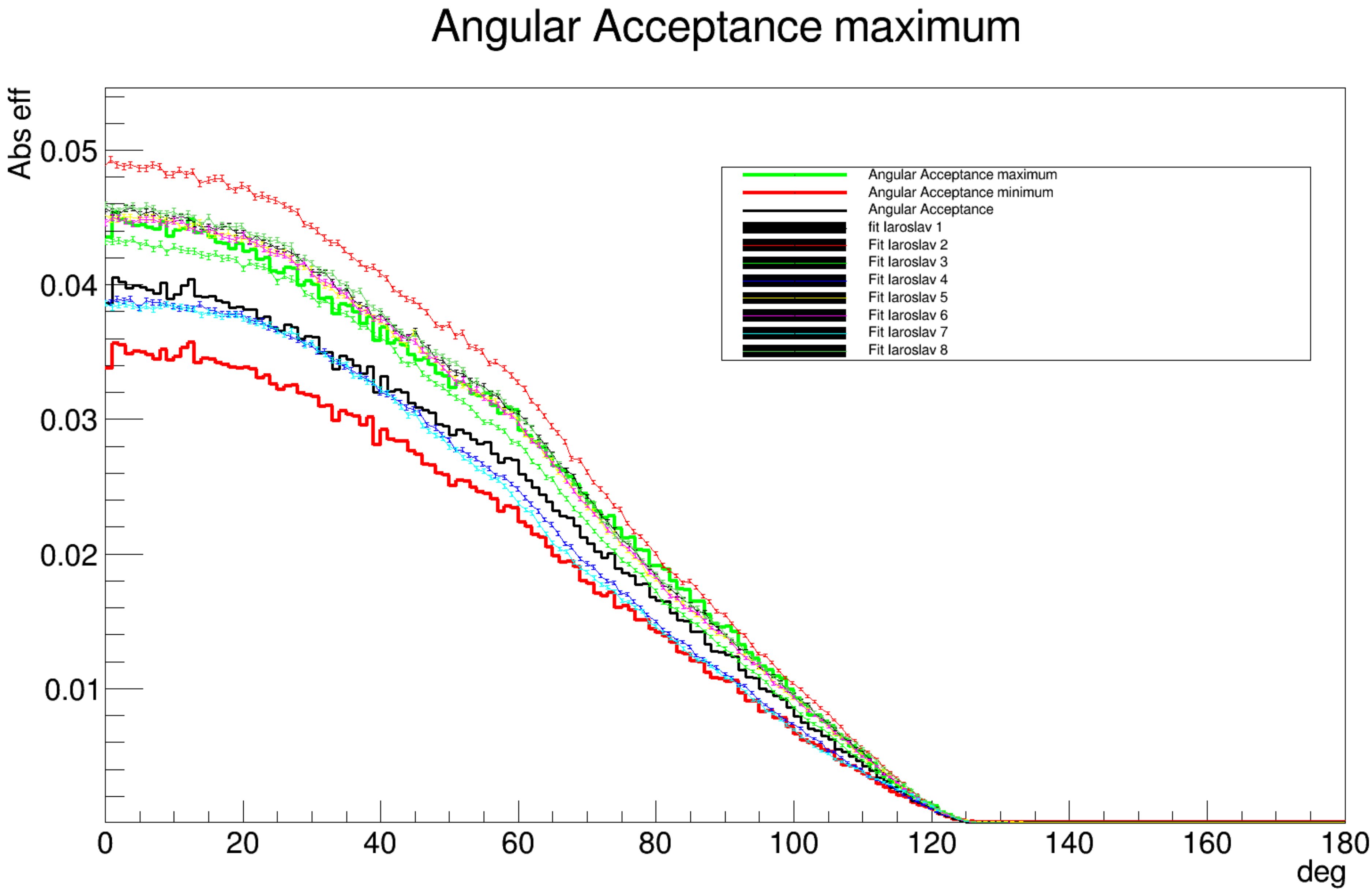
Conclusion of description

- It seems that there is an additional effect in ANTARES. The DOM on both sites seems to confirm it (see backups). Under discussions
- It works as expected on the NEMO tower
- The DOM need to be implemented (need exact geometries, PM...)
- One proceeding published on NIMA
- One publication in preparation with Heide (ANTARES/NEMO)
- Two internal notes, one on the simulation description

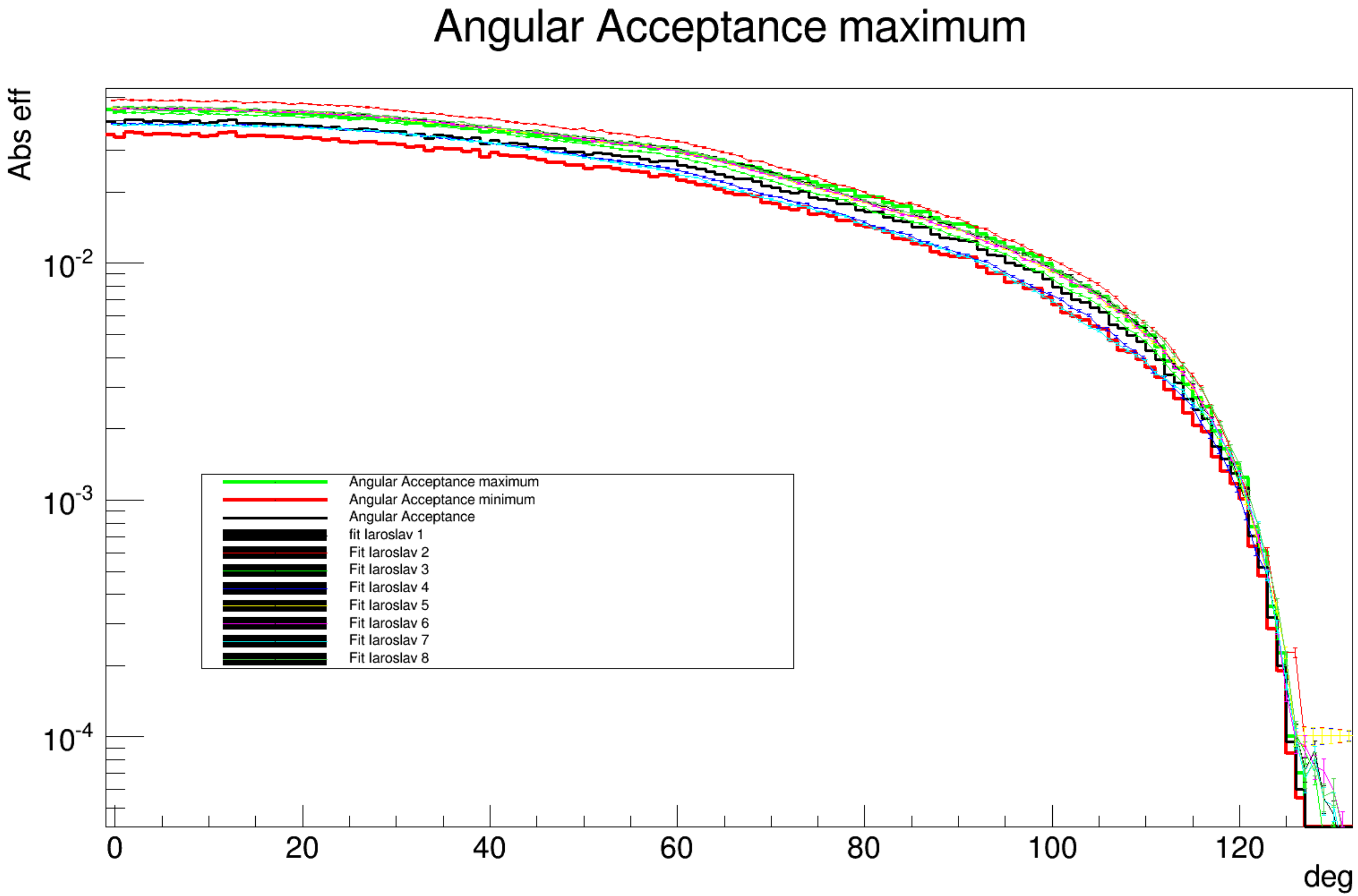
Results

- Angular accepance
- Scattering

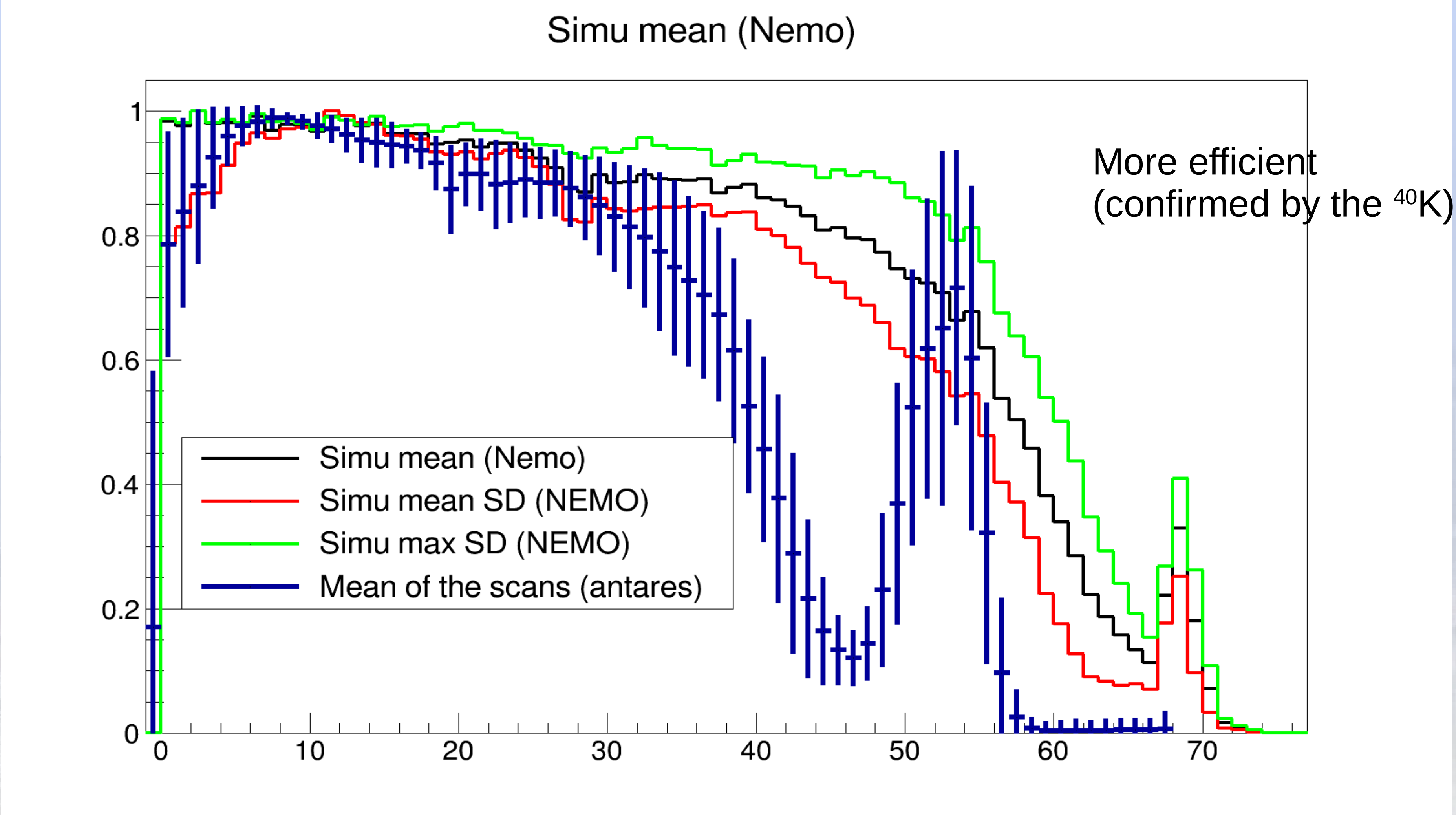
Angular acceptance antares



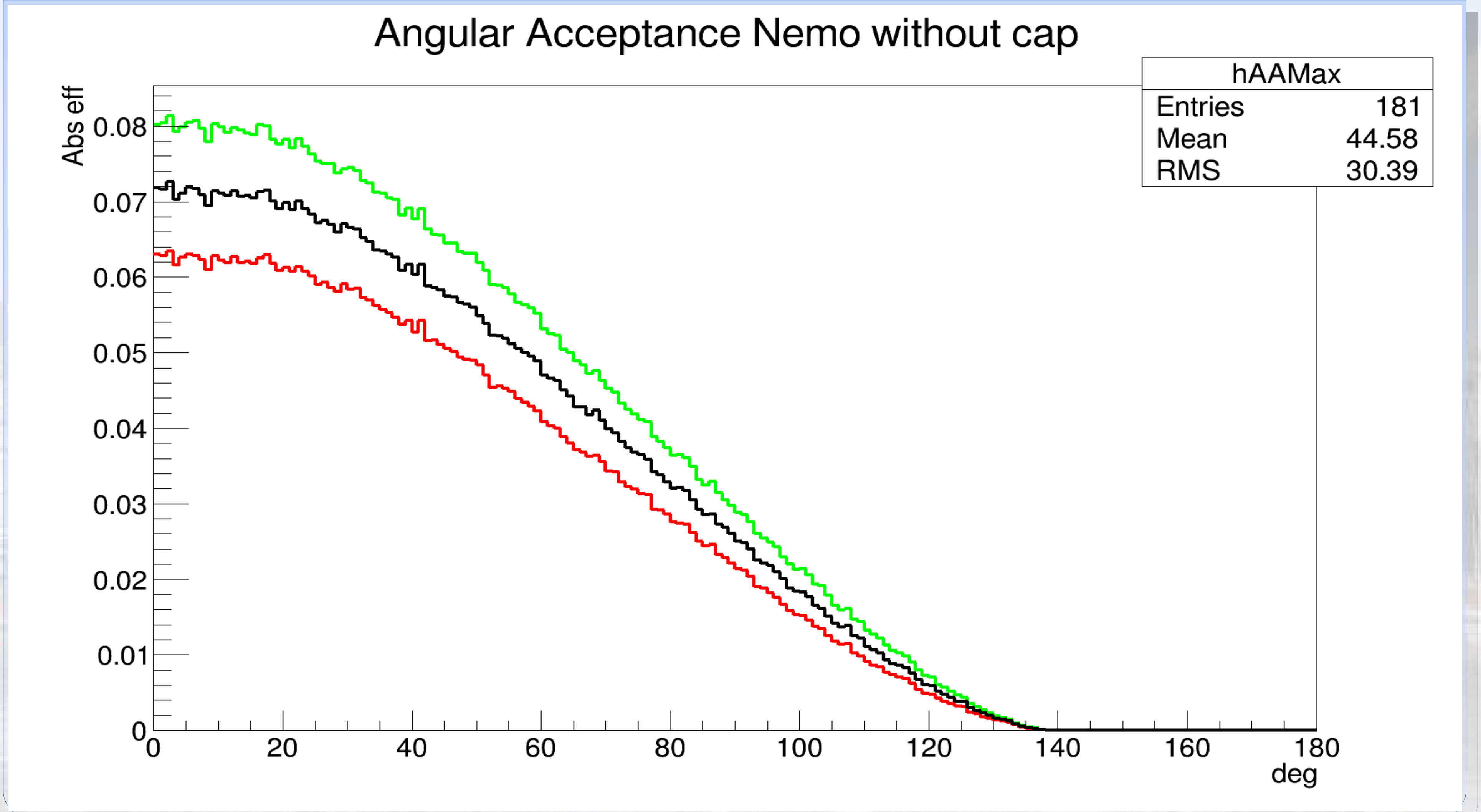
Angular acceptance antares



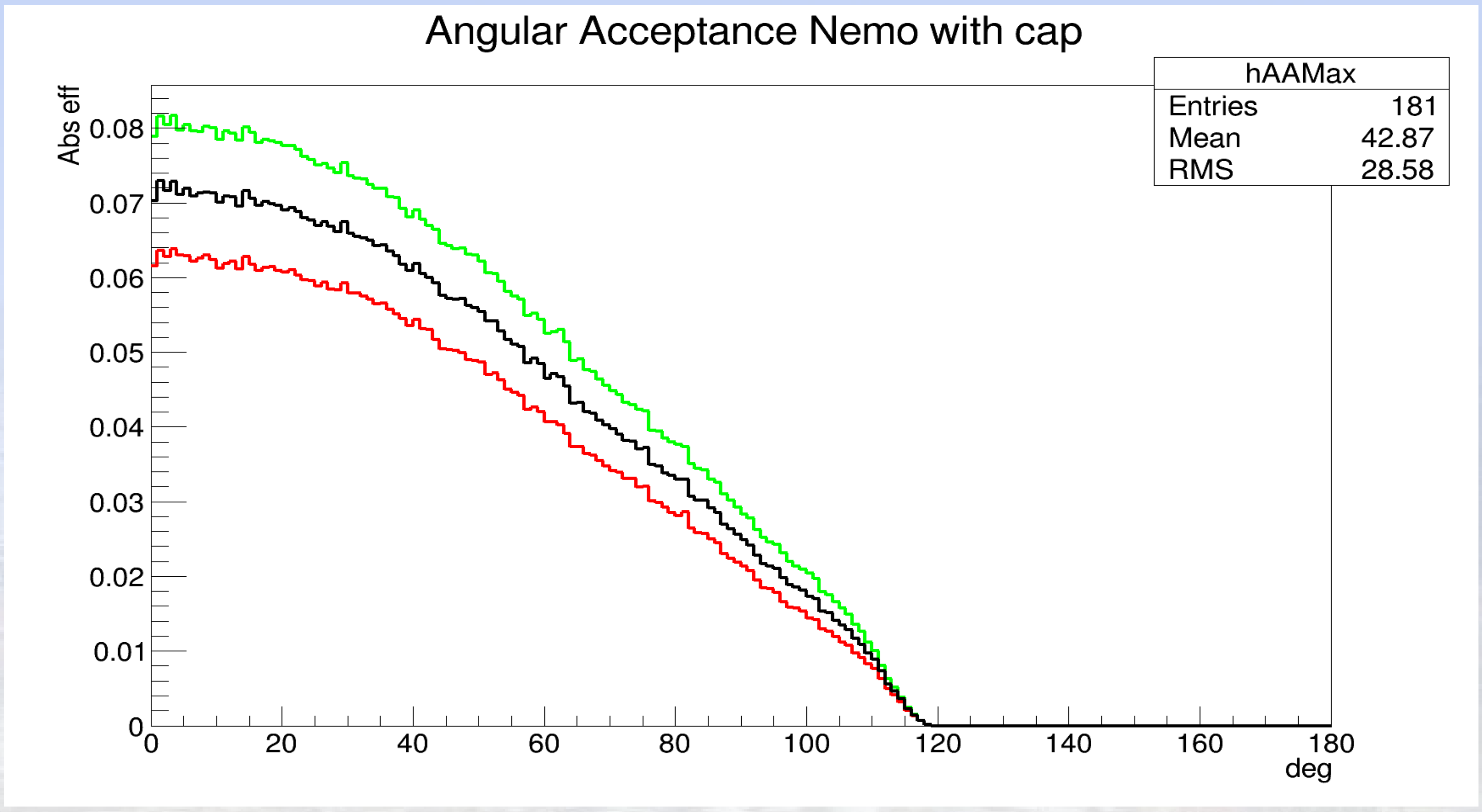
Scan of nemo module



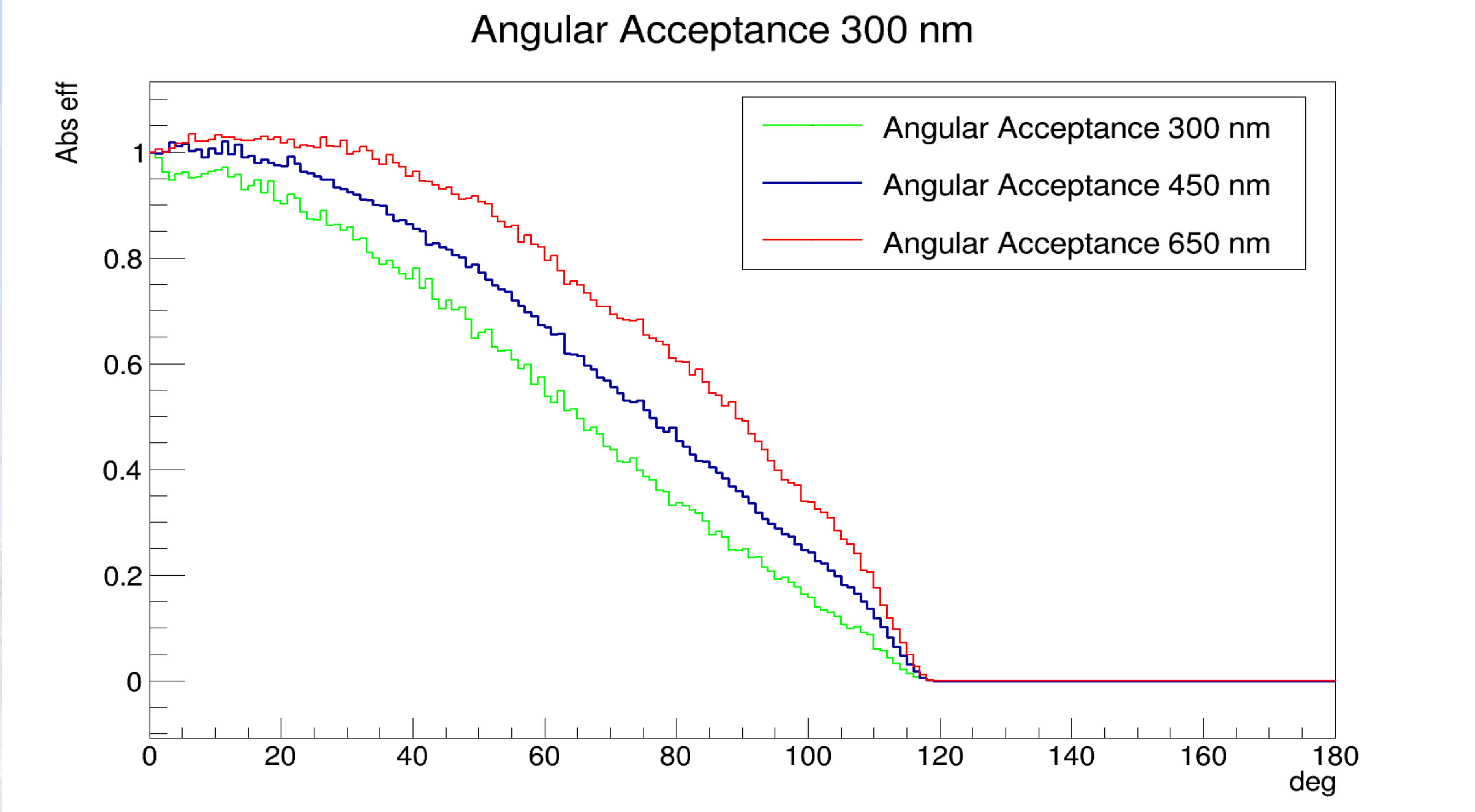
Angular acceptance nemo



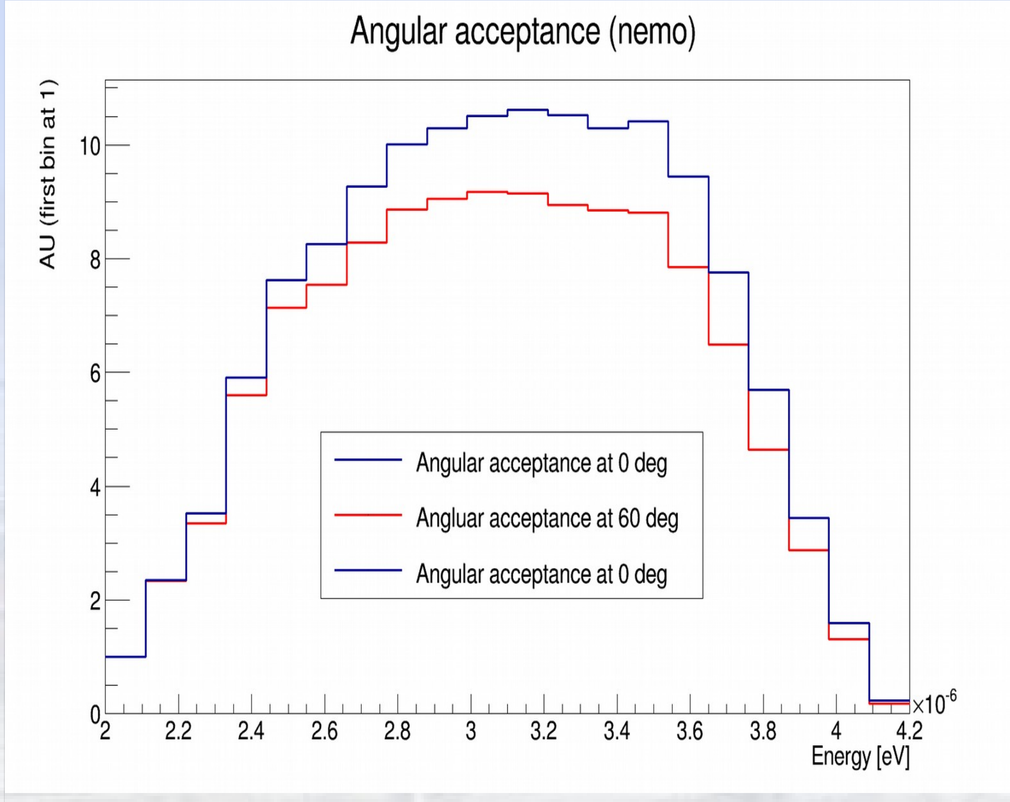
Angular acceptance nemo

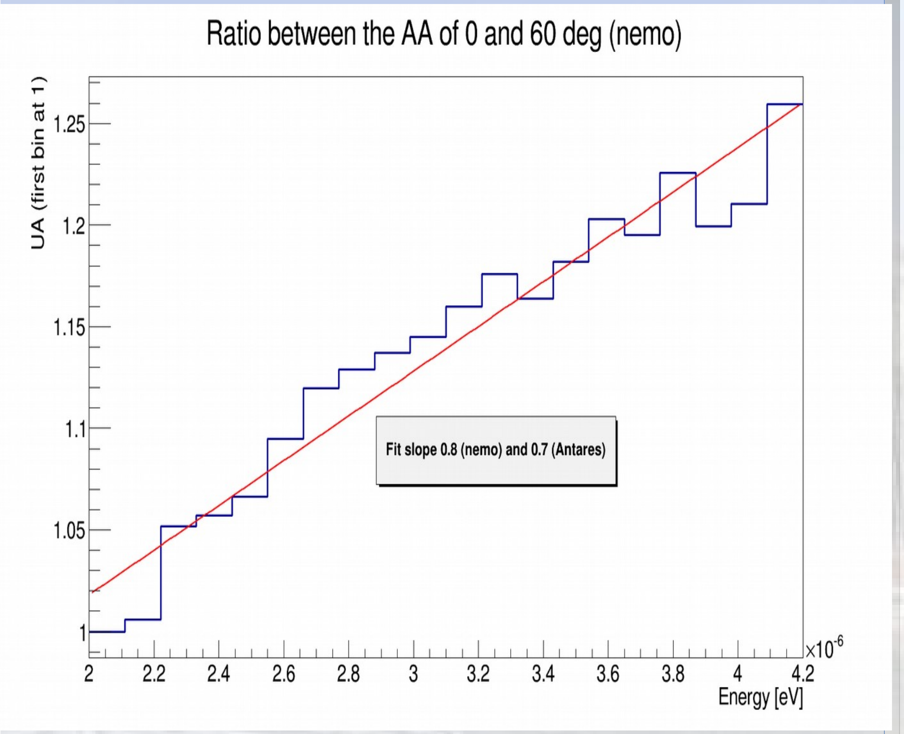


Wavelength dependency

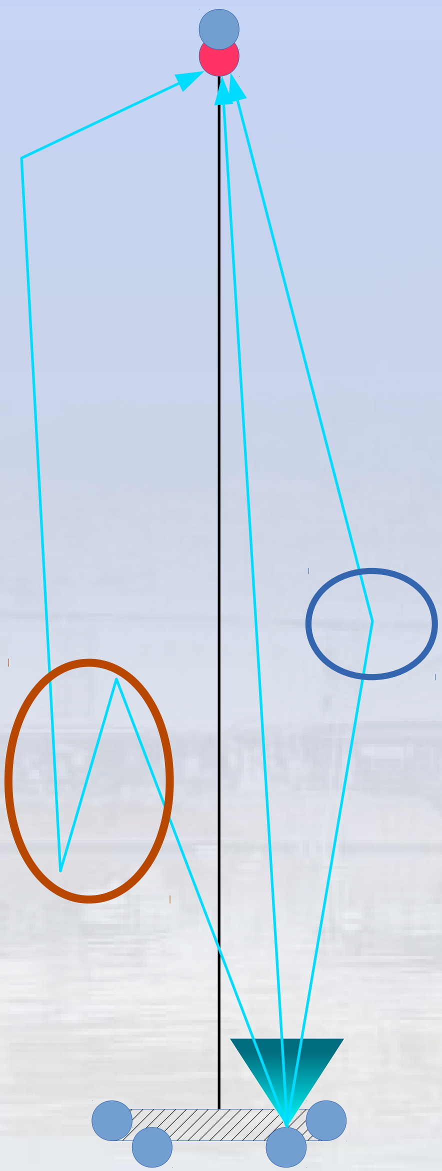


Wavelength dependency





Scattering process



$$b_P = 1.34\,\nu_S\left(\frac{550\,nn}{\lambda}\right)^{1.7} + 0.312\,\nu_l\left(\frac{550\,nm}{\lambda}\right)^{0.3}$$

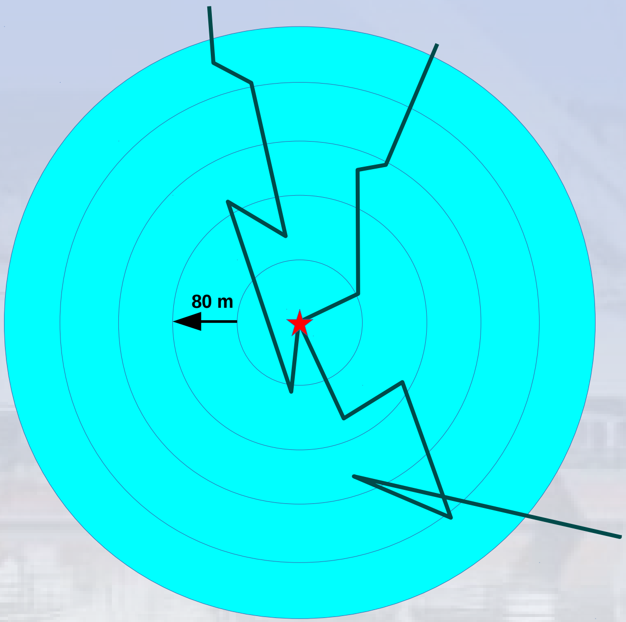
Clancy W. James
Km3 internal note

- 2 components to the scattering :
  - On molecule (isotropic angular distribution)
  - On particles (Forward going angular distribution)
- The both processes depend on the wavelength on a different exponent.
- They imply a delay in time arriving
  - In function of distance
  - In function of wavelength

Need to know the timing to deduce the water properties.
The fit method can help to extract the timing delay to the ns.

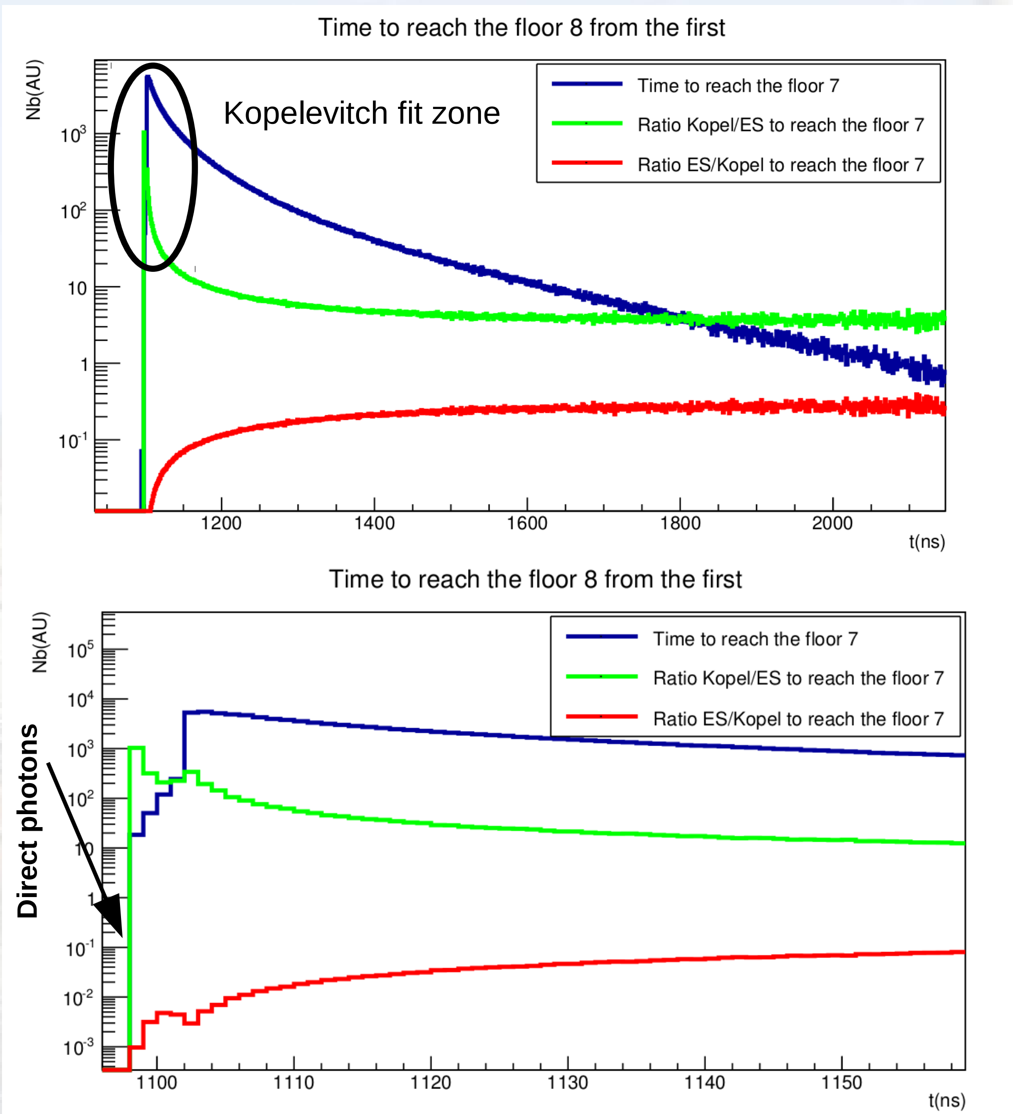
Water properties status

Principle illustration



- Concentric detection sphere
  - Separated by the real floor to floor distance
- The source is in the center
- Send photons
- All the photons are kept at each level. Data kept
  - Emission direction (in fact always (0,0,1)
  - Time arrival at each sphere
  - Angle arrival
  - Incident angle
- Then the AA and LED emission are used to put a weigh to the arrival

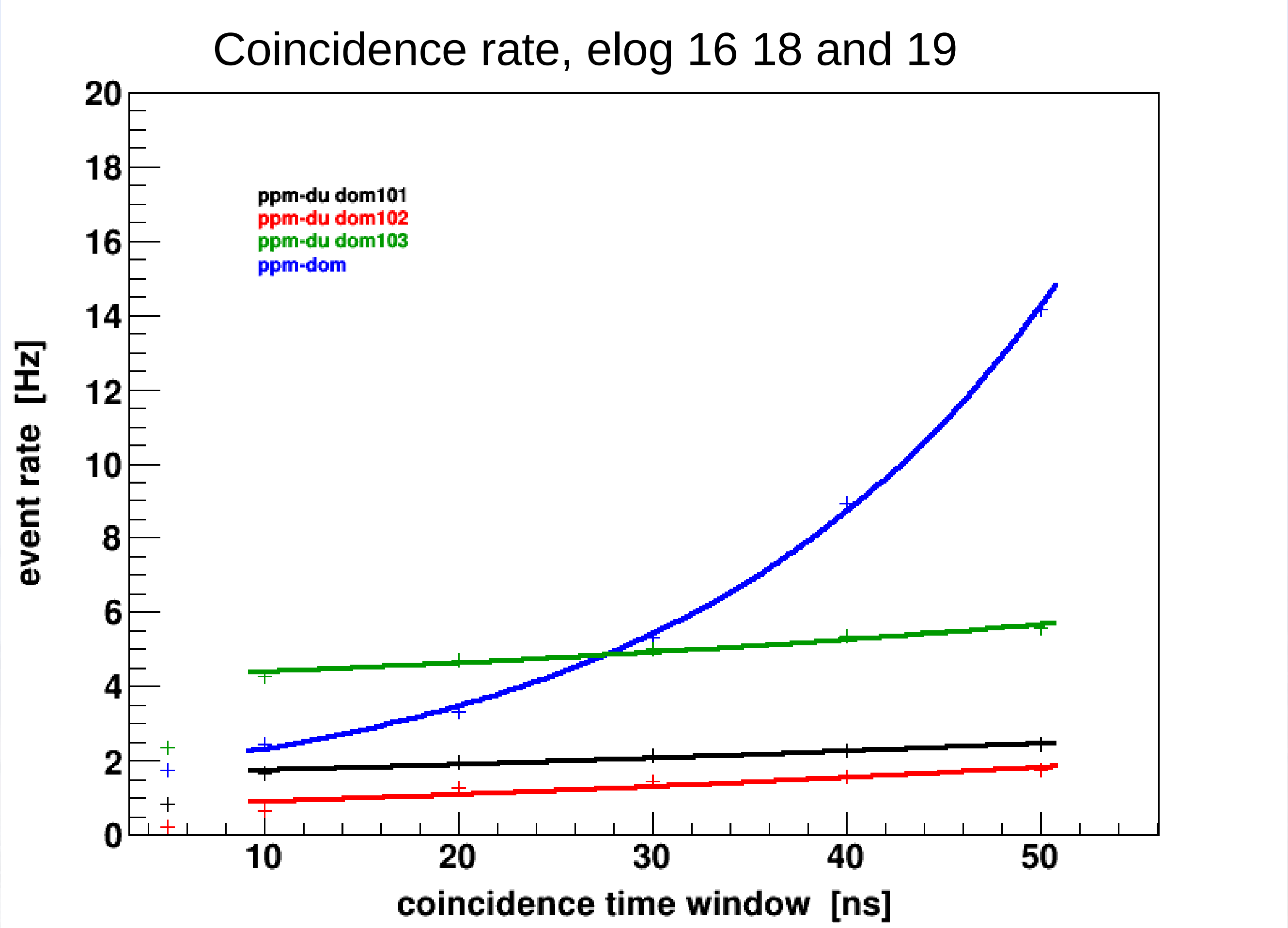
First results



- We are strongly dominated by the Kopelevitch scattering (on big particles)
- The ES scattering (on molecules) can be neglected in the peak zone
- The Kopelevitch scattering should be the one that vary (dependent on sediments, plankton..., while the ES is principally dependent on the middle density)

backups

DOM data



Coincidence rate, elog 16 18 and 19
ppm-du dom101
ppm-du dom102
ppm-du dom103
ppm-dom
event rate [Hz]
coincidence time window [ns]
0
2
4
6
8
10
12
14
16
18
20
10
20
30
40
50