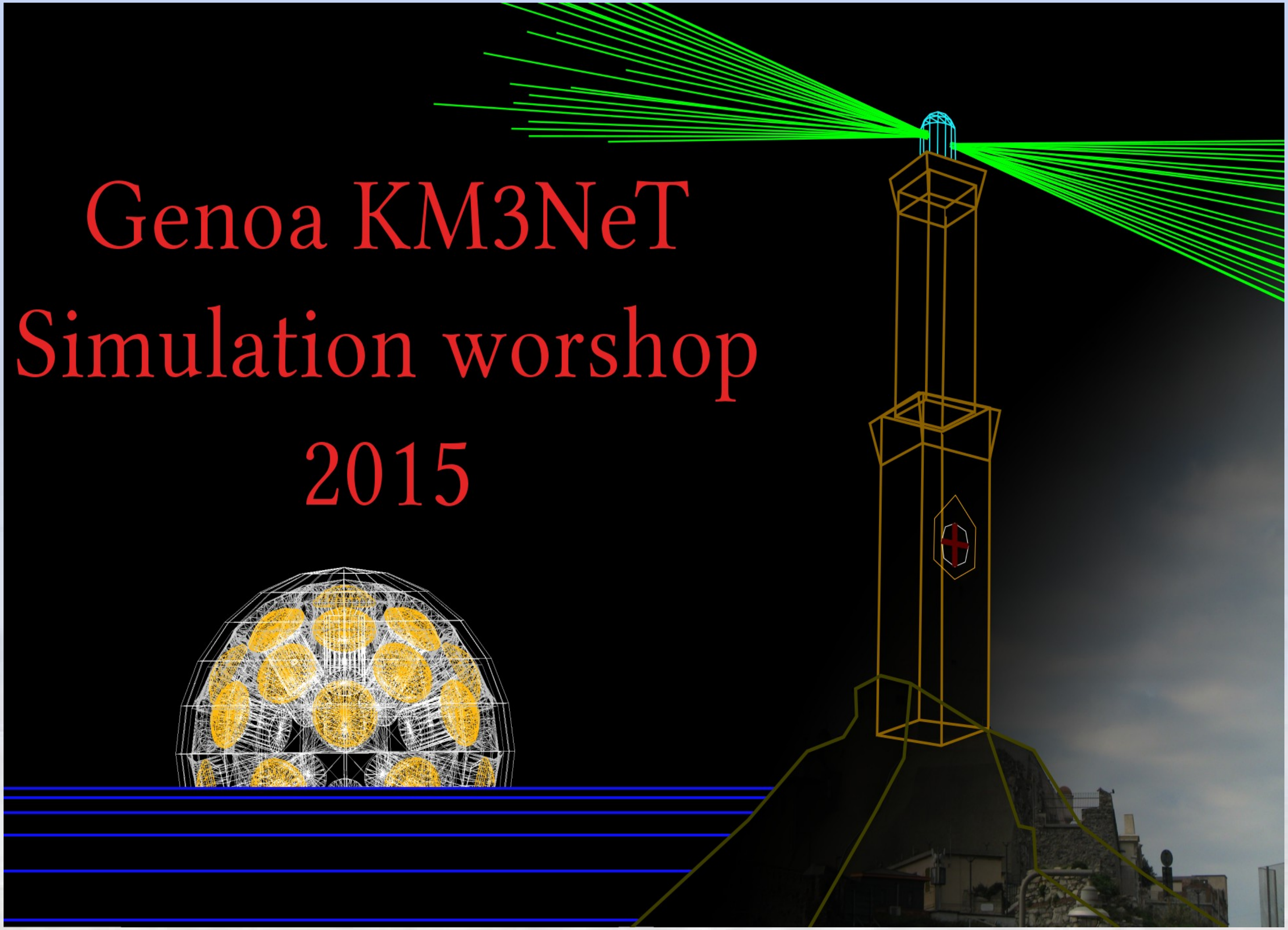
Physics of the OM Introduction



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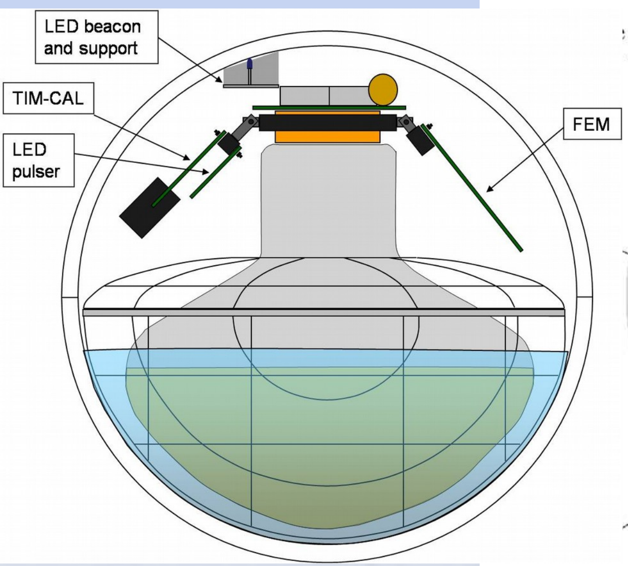
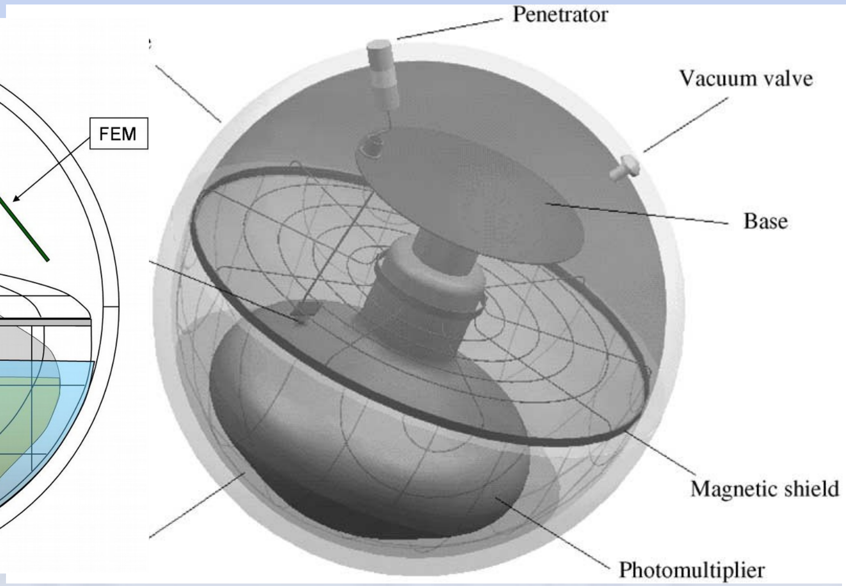
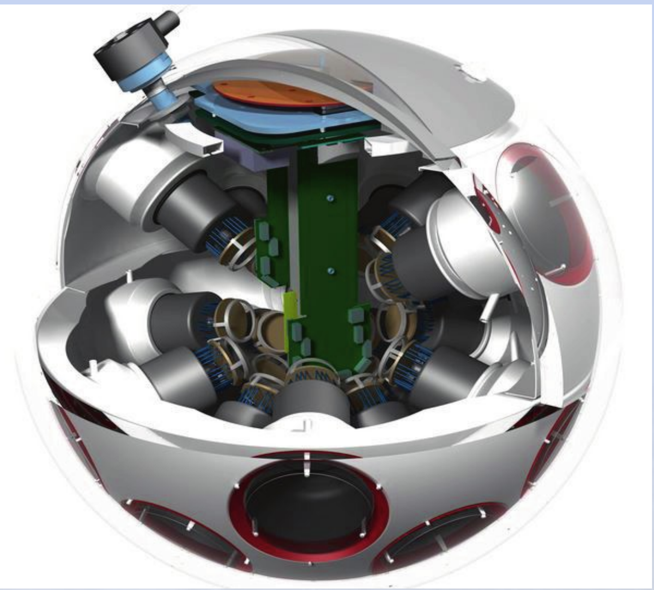
KM3NeT

Schemes view of the (D)OM







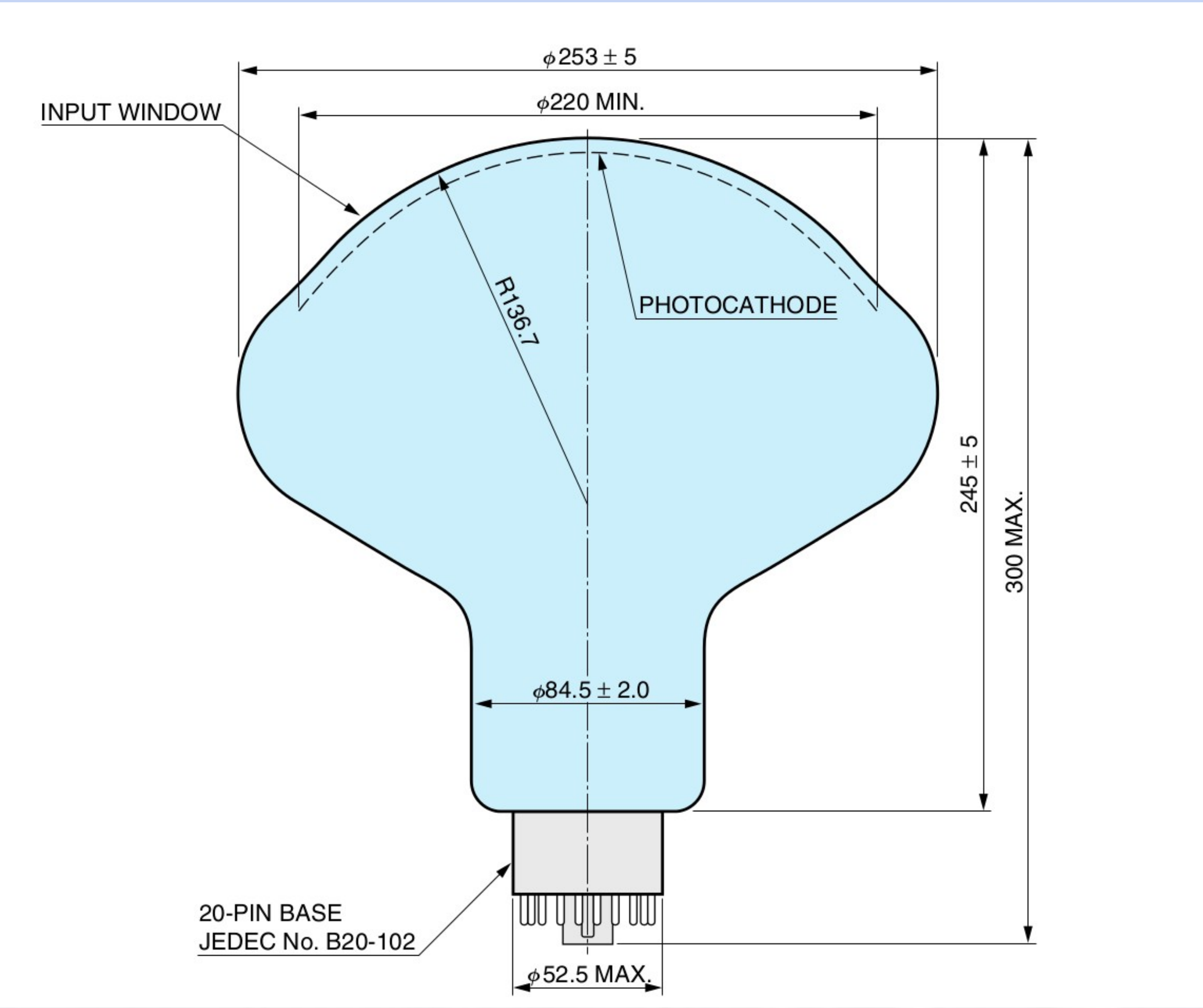
Antares/NEMO OM are similar:

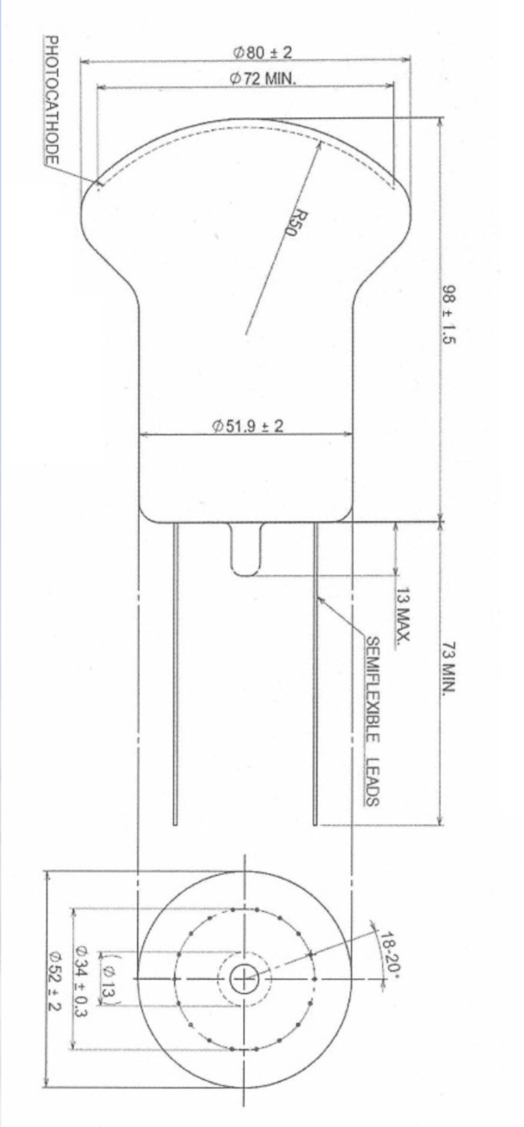
- 17/13” OM glass
- One 8” R7081-20 Hamamatsu PMT
- Similar interface gel
- Mu-metal grid

The dome is deeply different:

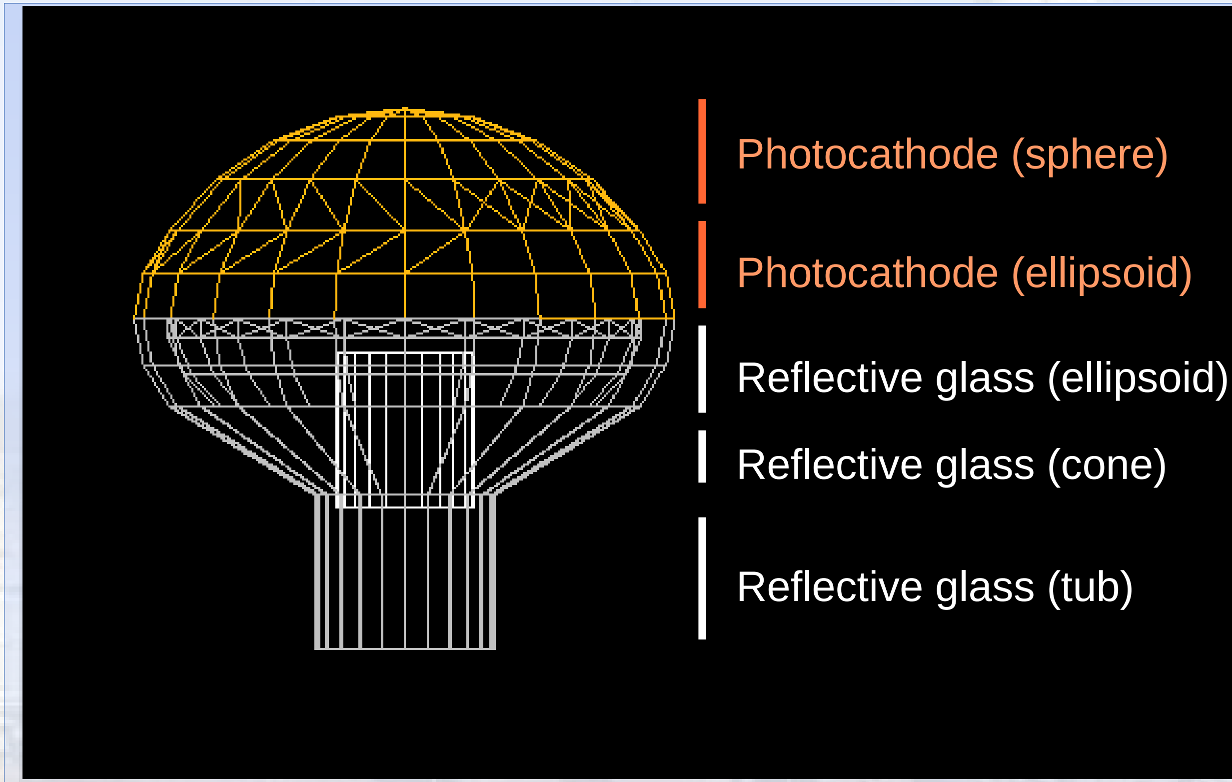
- 31 3” R12199 Hamamtsu PMT
- Non mu-metal grid
- Reflection cone

Scheme of the PMTs





Precise geometry



Only geometry is modified
It will use exactly the same physics model

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

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

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

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

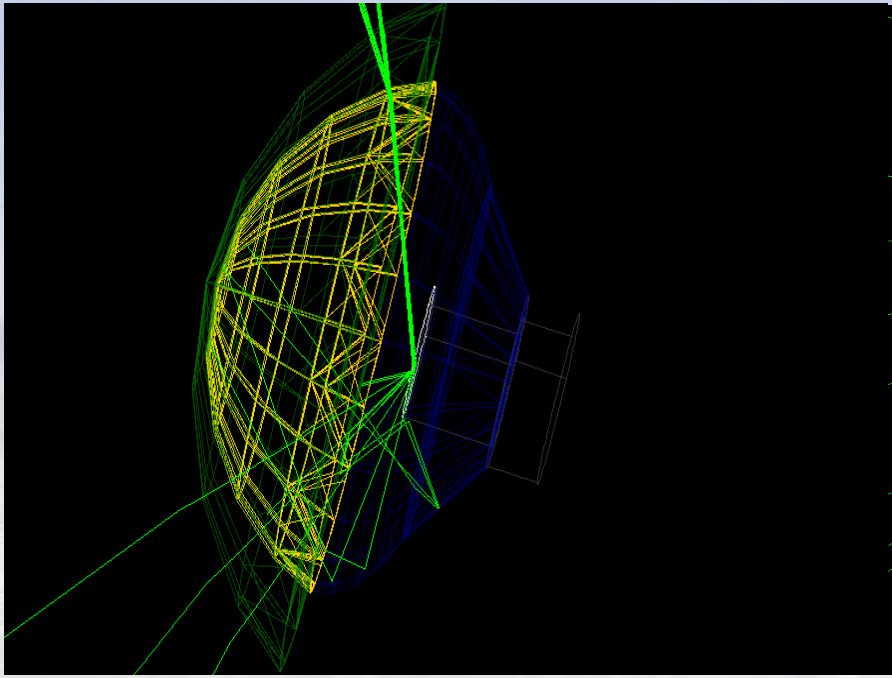
p is the projection of the photocathode, R its radius, a and b the big and small radius of the ellipsoid. Bulb is the full ellipsoid z size

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

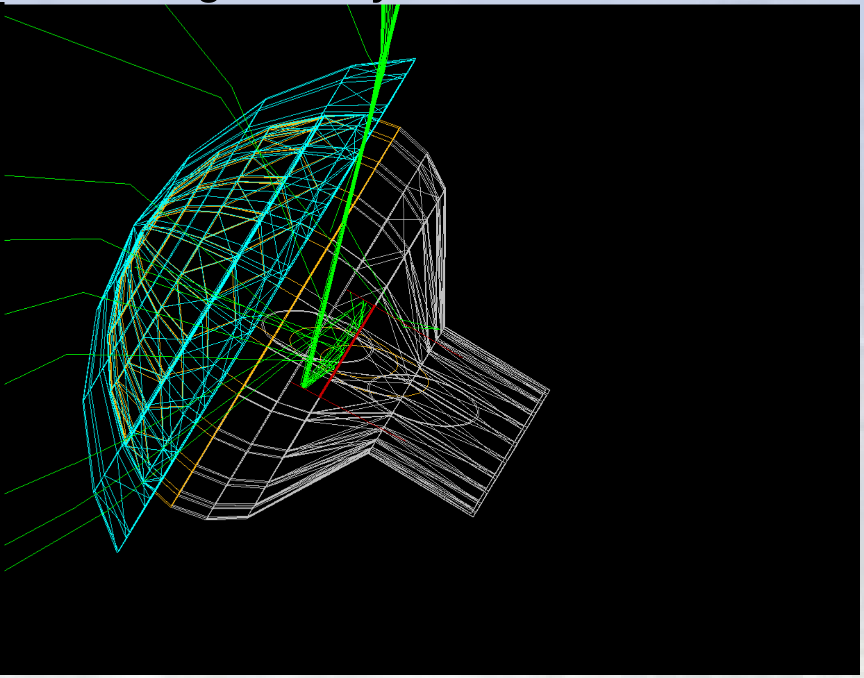
Precise geometry, in details

Furthest improvements
Internal structure :
- Dinods tube
- dinod grid

Old geometry



New geometry



Principle of the ray tracing: to take in detail every effects

- Generate the primary particle
- Calculate the propagation length in function of the different physical processes or the medium transition
- Possibly generate the secondary particles (eg. cerenkov for the electrons)
- Make it propagate “step by step”
- Eventually get if it was “detected” or not”

Chosen base library: GEANT4

Why GEANT4?

- It is a ray tracing that can cover a large part of the physics (optics, nuclear decays, cerenkov effects...)
- It is free (as freedom), so the code can be reviewed in case of doubts
- It is under active developments (regular debugs and corrections of the library)
- It was already studied and used for similar cases (ANTARES, Augier...)

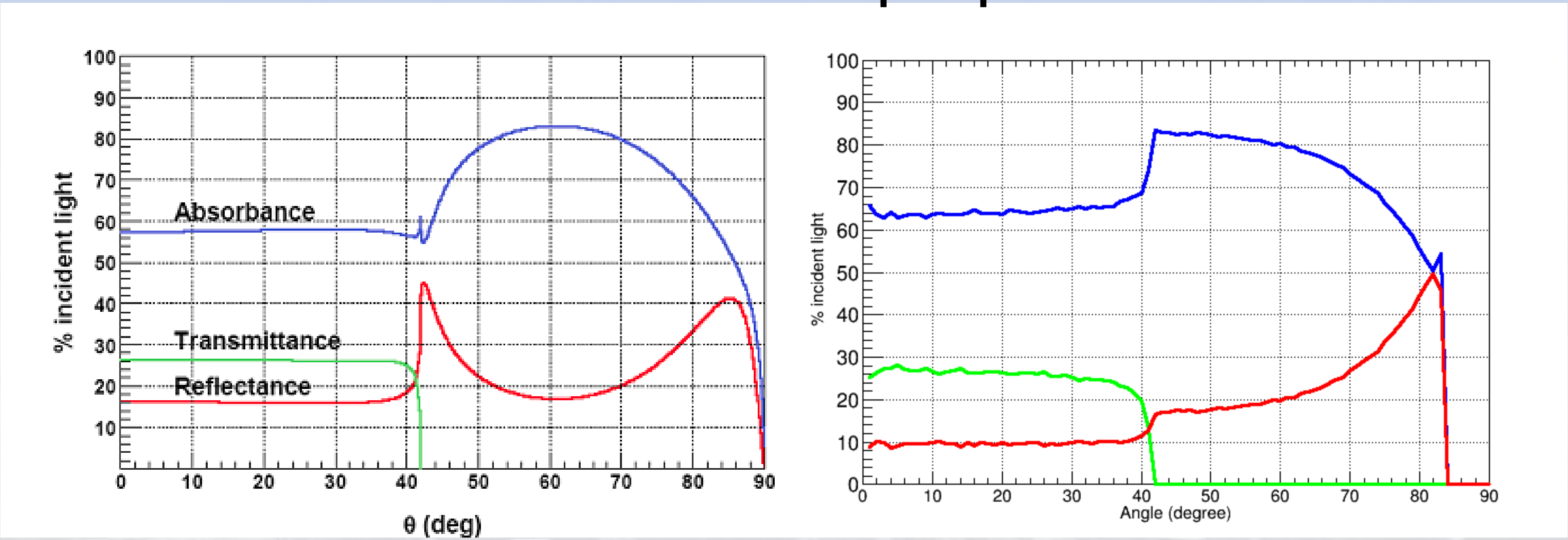
The cons

- It is not dedicated to optics
- It is not perfect
  - Correction of the Fermi transition of the ^{40}K decay (M. Taiuti, H. Costantini, 2008)
  - Along step Cerenkov process energy loss (corrected since GEANT4.9.4)
  - Thin layer and complex index effect (see Alex's slides)

The physics of the photocathode

Integration of the photocathode in the simulation

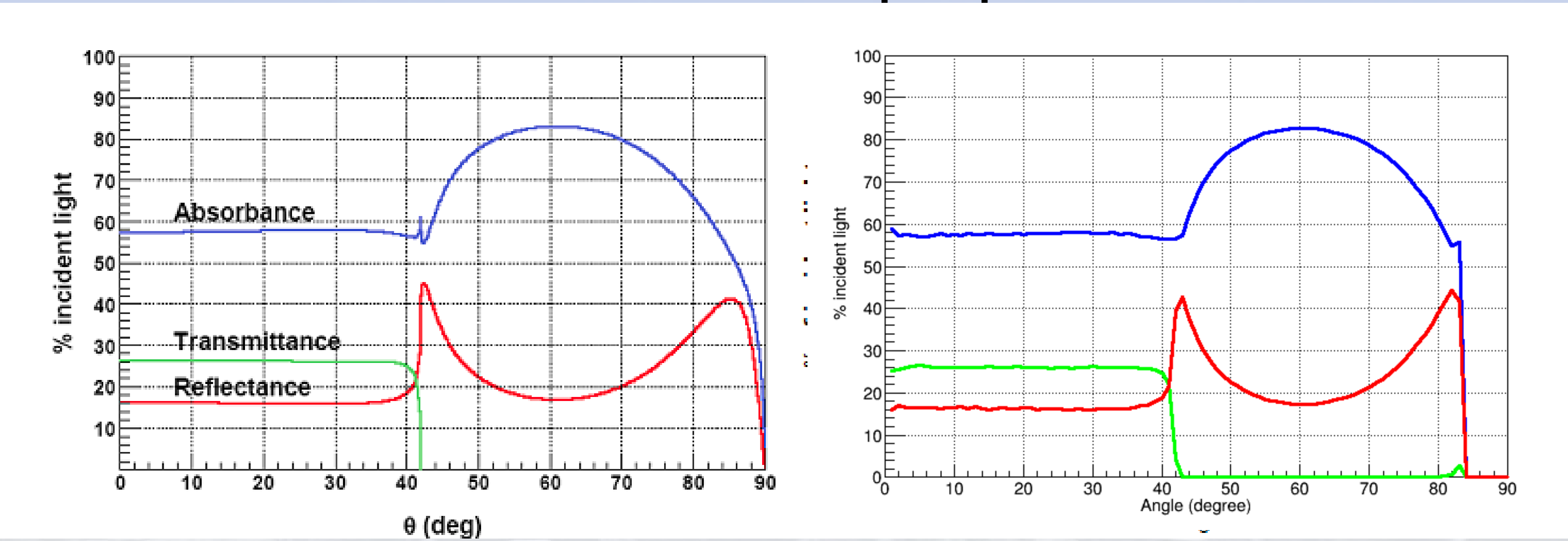
- Creation of a new physical boundary process
- Use of dedicated material properties



See the next talks on the simu description

Integration of the photocathode in the simulation

- Creation of a new physical boundary process
- Use of dedicated material properties

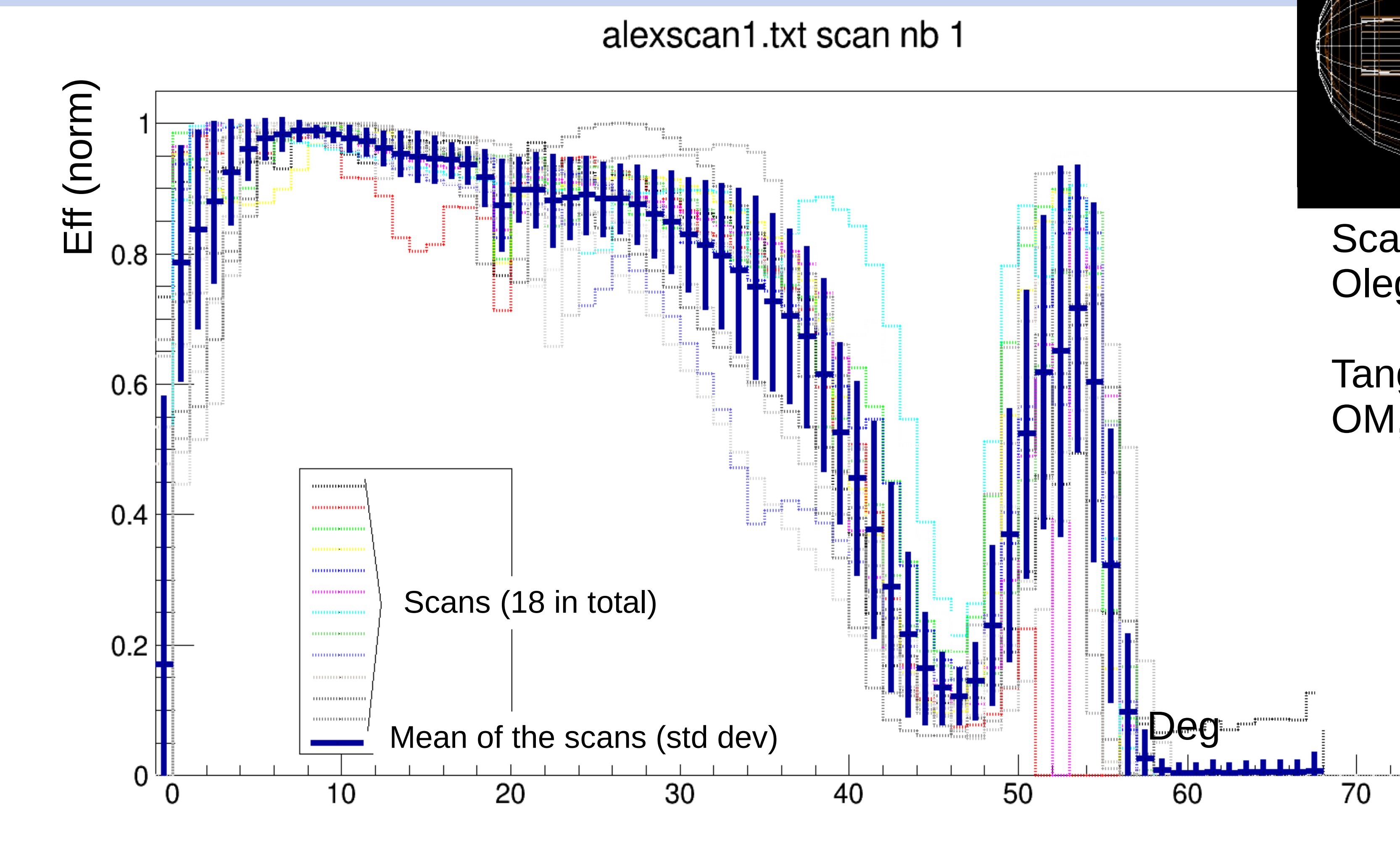


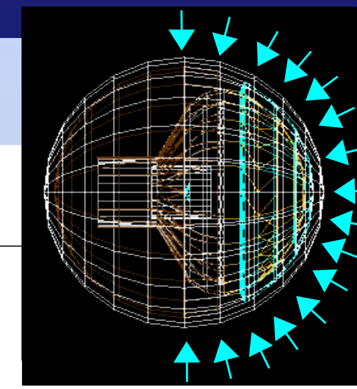
See the next talks on the simu description

The collection efficiency

- 3 steps for the final efficiency:
  - The photocathode QE (Hamamatsu data)
  - The angular collection efficiency (scans of the Oms from Alex and Oleg)
  - The total efficiency renormalization (in situ ^{40}K)

Scans

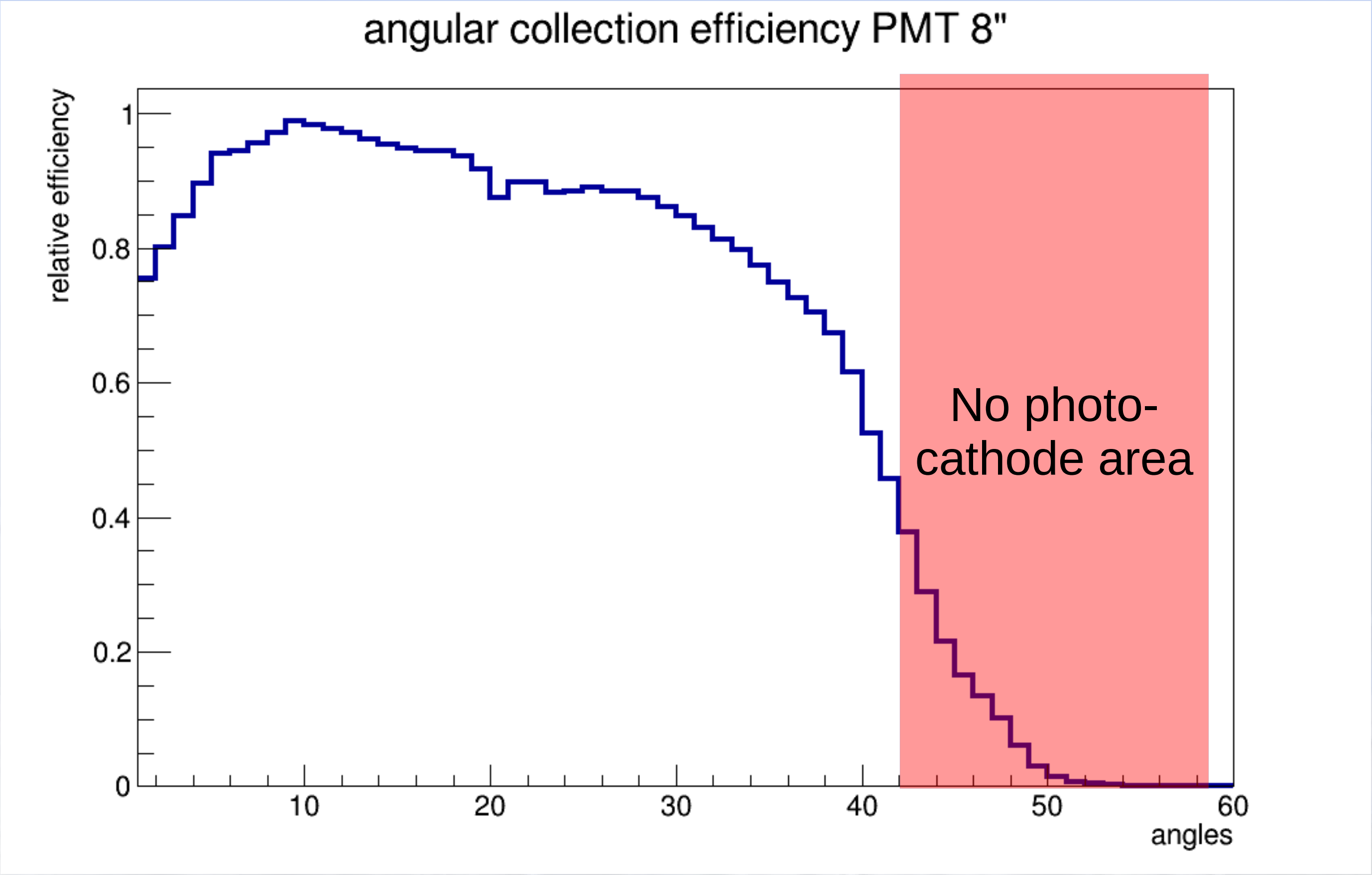




Scan done by Oleg and Alex.

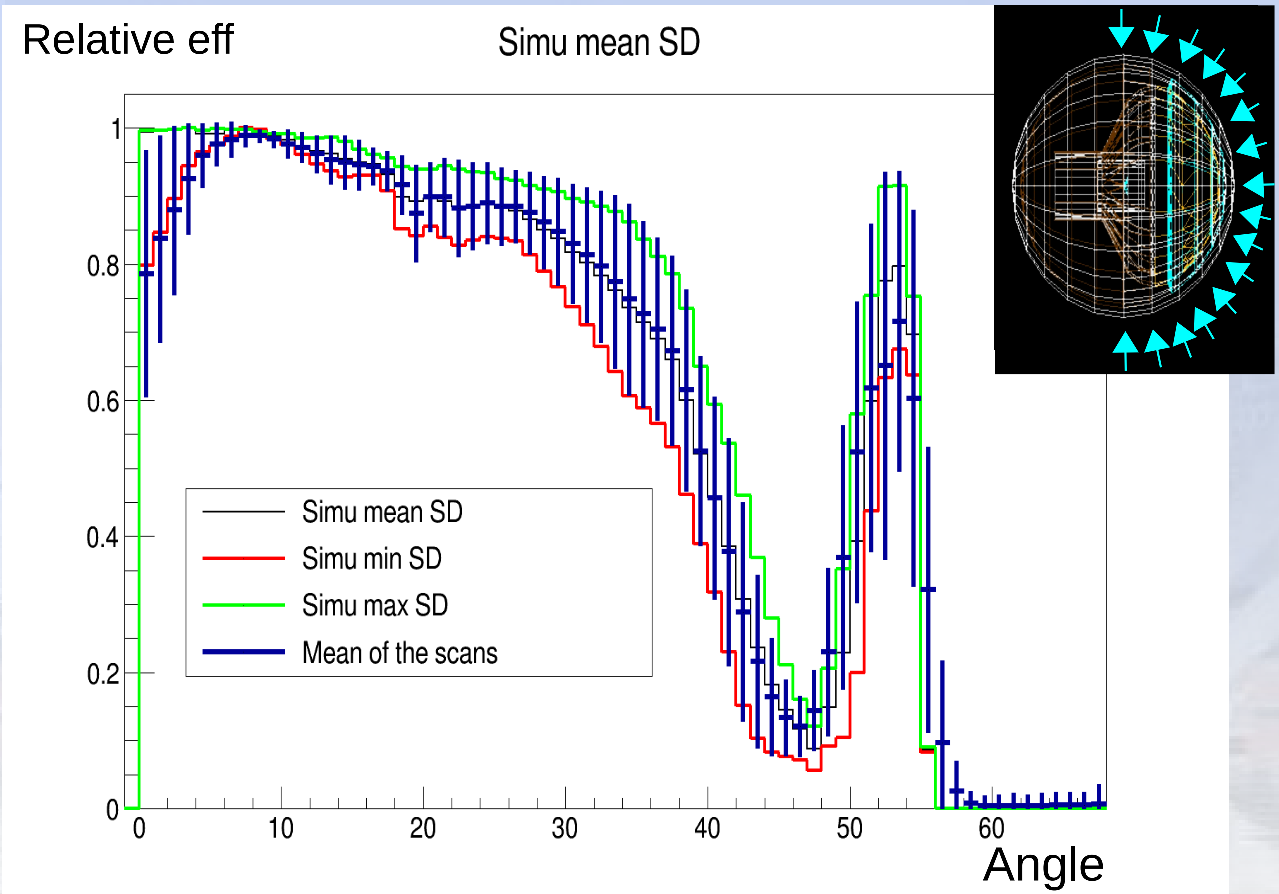
Tangent of the OM, in air

Angular Ceff



Scan fit for data and simulation

Simulation and data of OM efficiency



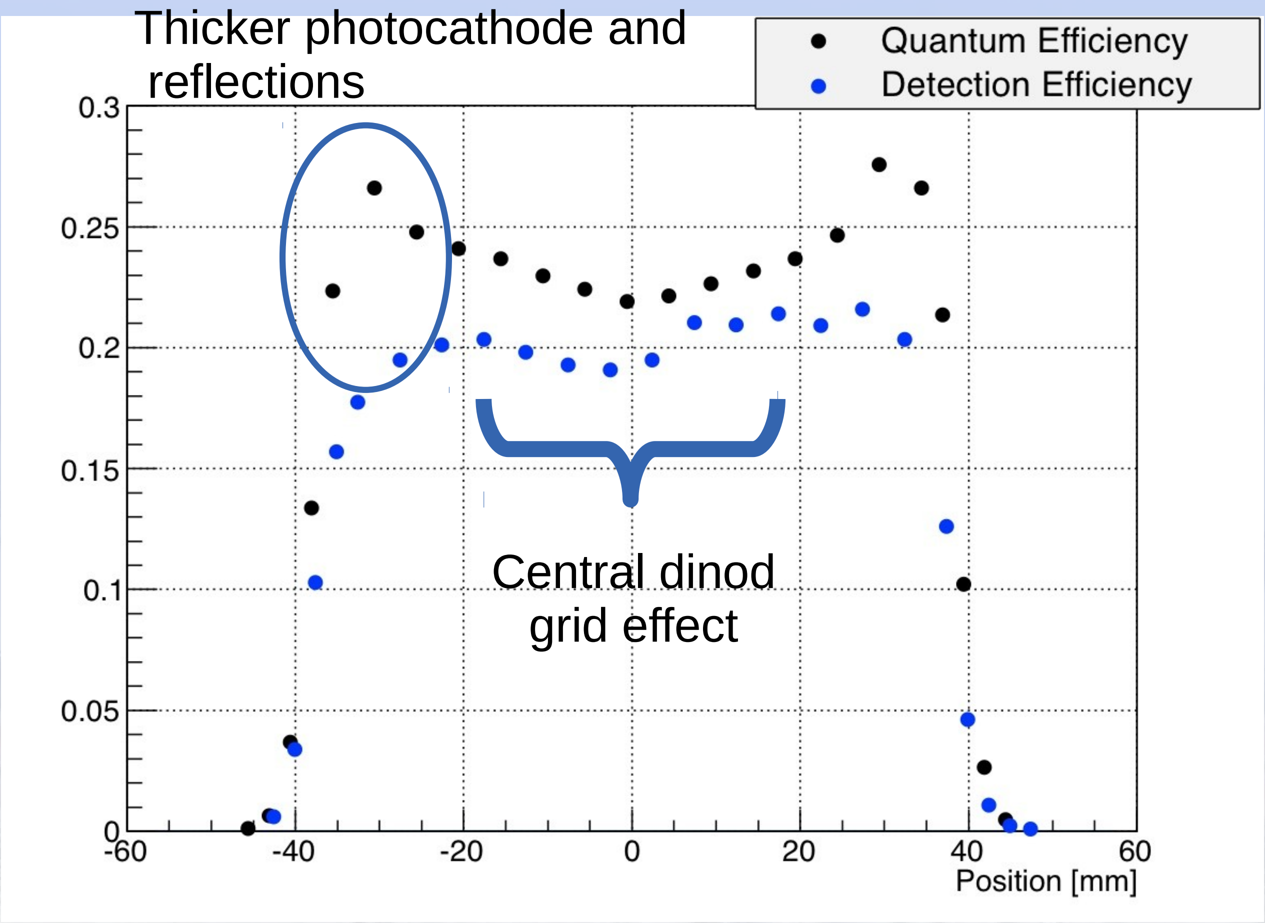
The best fit from the data was put and tried again until the data and the simu fit.

After the ^{40}K calibrationThe obtained values are coherent between the both sites:

ANTARES: 15.3 Hz
NEMO: 21.6 Hz

Expectation reminder:
for ANTARES ~16 Hz
For Nemo my last analysis gave ~22 Hz

Under studies: the 3” PMT

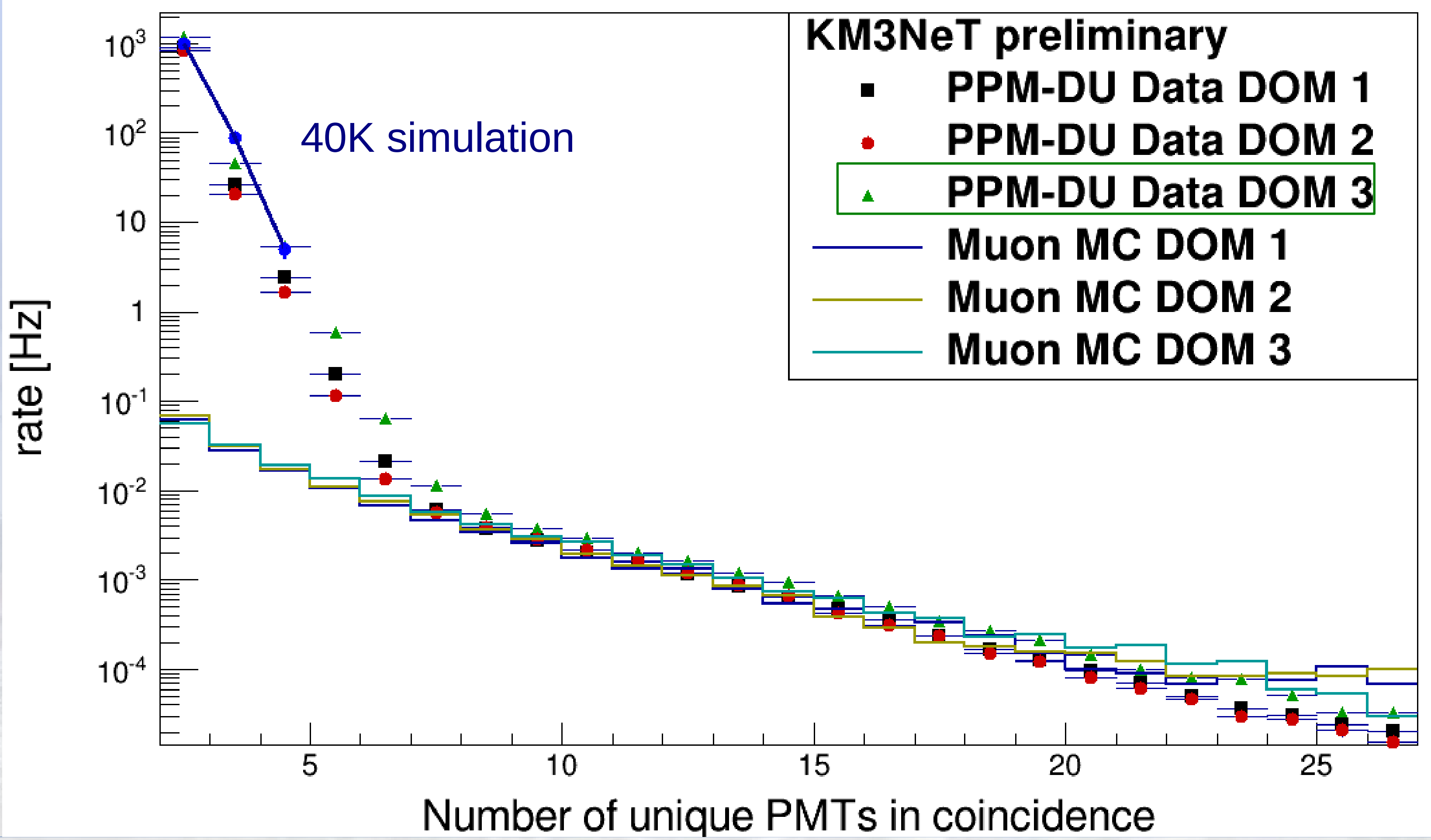


Results from Oleg's scans

In front of the photocathode, the Dinods are large, the angular effect is low.

The current simulation uses a temporary assumption based on a couple of similar scans

40K very preliminary data/simu comparison



Conclusion

- Still a lot of work to do, but
- The physics of the PMT is well integrated and undestood
- The current status of the simulation allows to reproduce the physics and results for the 3 geometries
- It allows to do a lot of diverse specifics studies and can become a reference piece!

The schedule

Monday

- 10:00 Introduction
- 10:15 - 12:00 Physics, experiments and applications
  - Generalities
  - Results and application fields (water properties, the 40K...)
- 14:00 - 15:30 The physics of the PMT.
  - The principal challenge in PMT simulation will be presented
  - The physics of the PMT (photocathode, collection efficiency etc.)
  - The solutions used in KM3RTSim
- 15:30 - 17:30 A complete overview of the simulation and the "how to use it" will be developed.
- 17:30 - 18:00 An application of the simulation out of the Astrophysics: Detector of neutron for civil transportation control

Tuesday

- Morning - General Discussion about the simulation
  - The roadmap
  - The studied physics
- Afternoon - Application workshop: Demonstration and application to various cases (classical, and proposed while the discussion). Bring your laptop!

What to expect from this workshop

- To understand the “low level” optical modules simulation
  - The efficiency an the local properties of the detector

    but
  - No full detector reconstruction
  - No muon reconstruction
- To understand how it works and to be able to contribute to it
  - New application
  - Improvments
  - ...

The lunch

- Number of persons to go to the Fuorigrotta? (reservations)