Performances of a New Directional Optical Module

Andrea Bersani

INFN Sezione di Genova

Outline

- A directional Optical Module has been developed in INFN Genova in the framework of KM3net

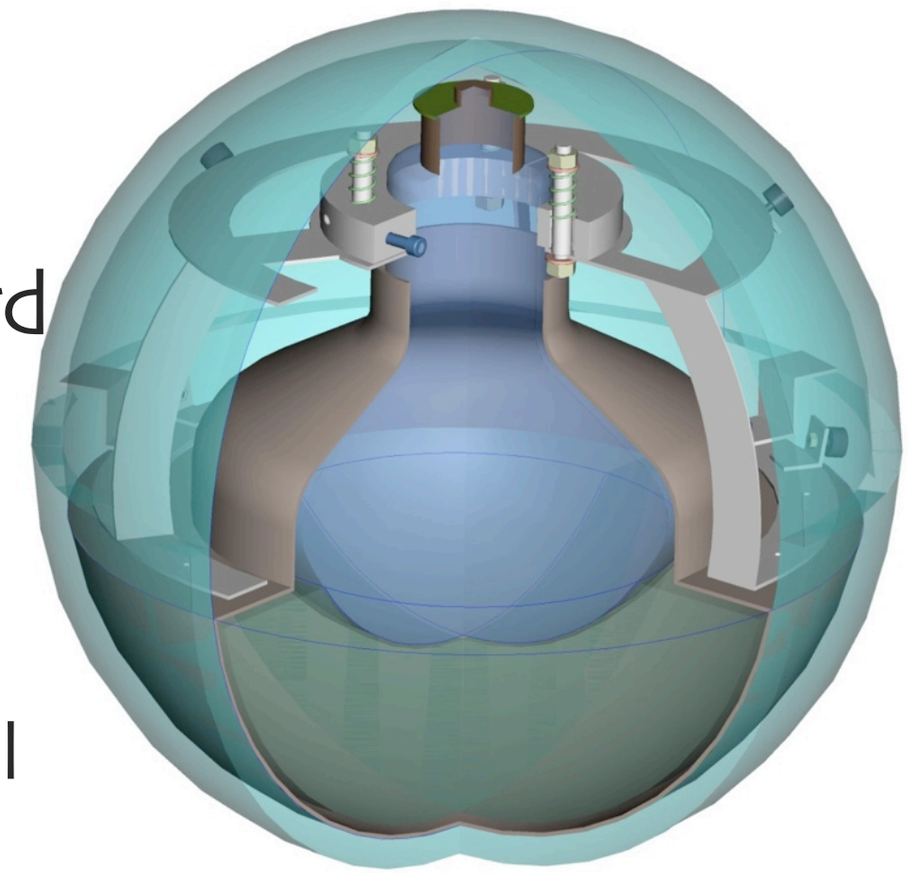
- The DOM can improve the performances of an underwater neutrino telescope

- The response of the complete DOM is being measured

- A comparison with the standard ANTARES OM is presented

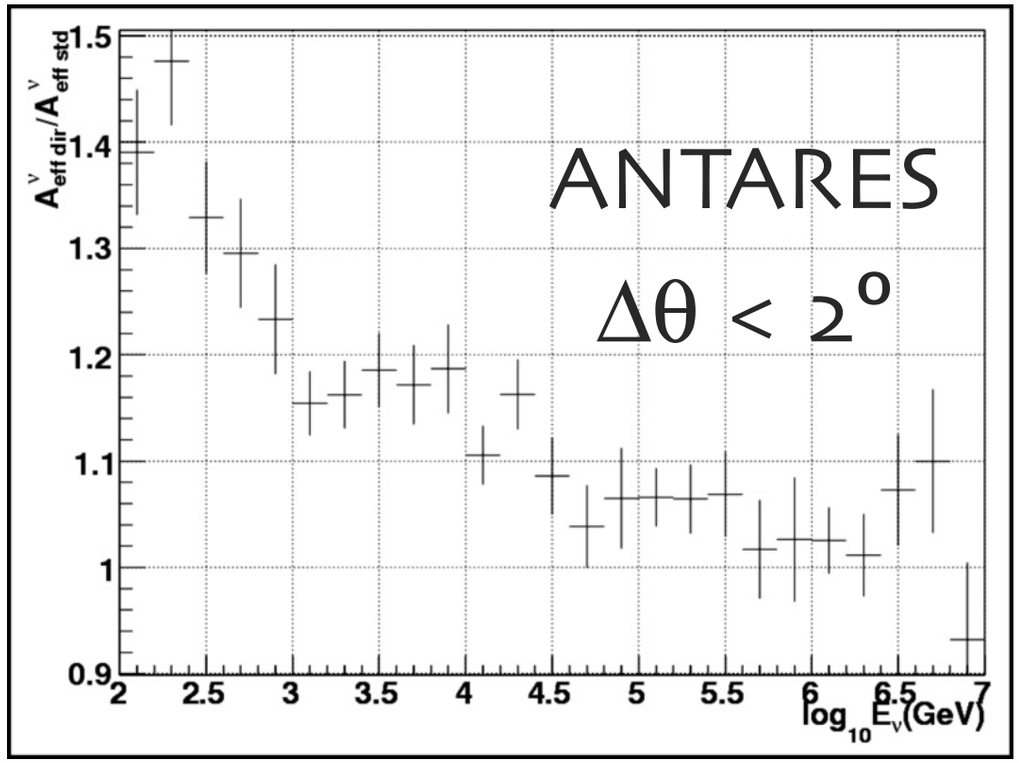
The Directional Optical Module

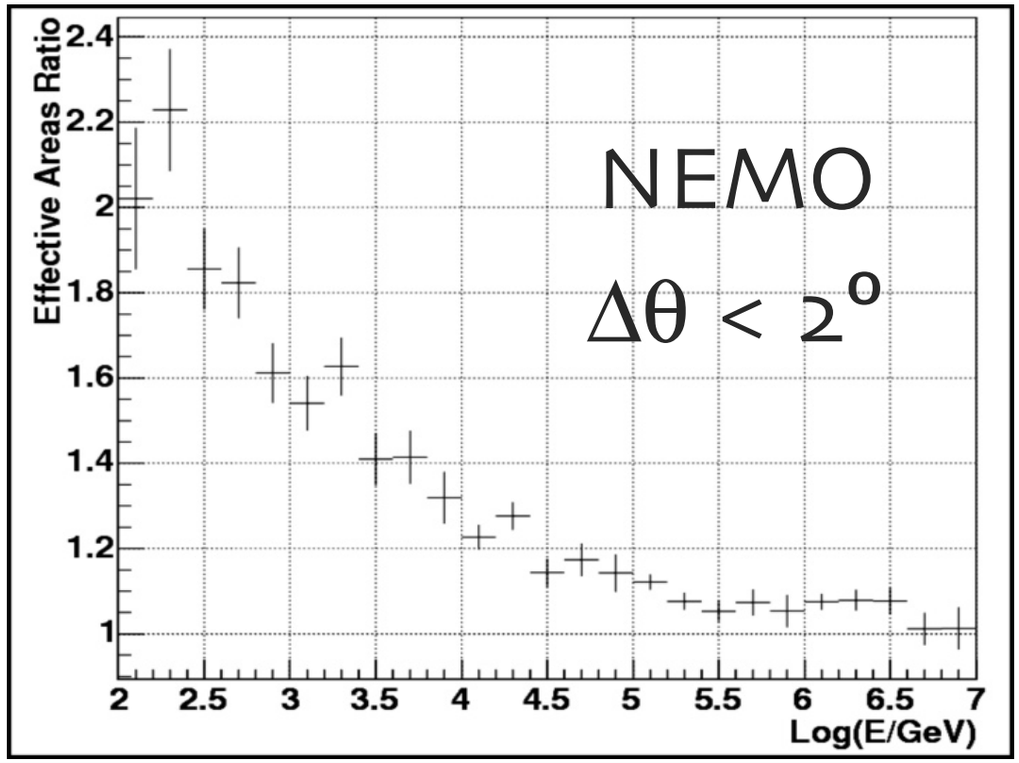
- The main actor is a 4-anodic Hamamatsu 10″ PMT
- A proper light guide provides focusing of the incoming light to the four cathode quadrants
  - Optical gel and high reflectivity mirrors are used
- The PMT is enclosed in a standard 17″ pressure resistant glass sphere
- A dedicated electronics has been developed
  - Transmits separate and total signal
  - Reduces cross-talk among anodes



The DOM in a Km³ Detector

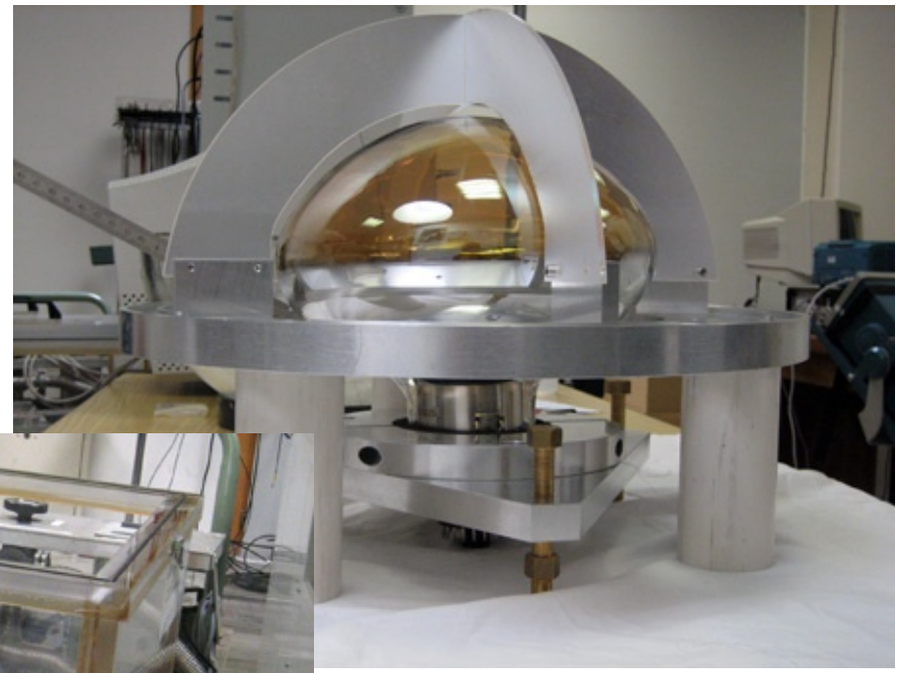
- The effective area at low energy is expected to increase both in ANTARES and NEMO geometries
- The effect in NEMO is larger due to the higher distance between the towers

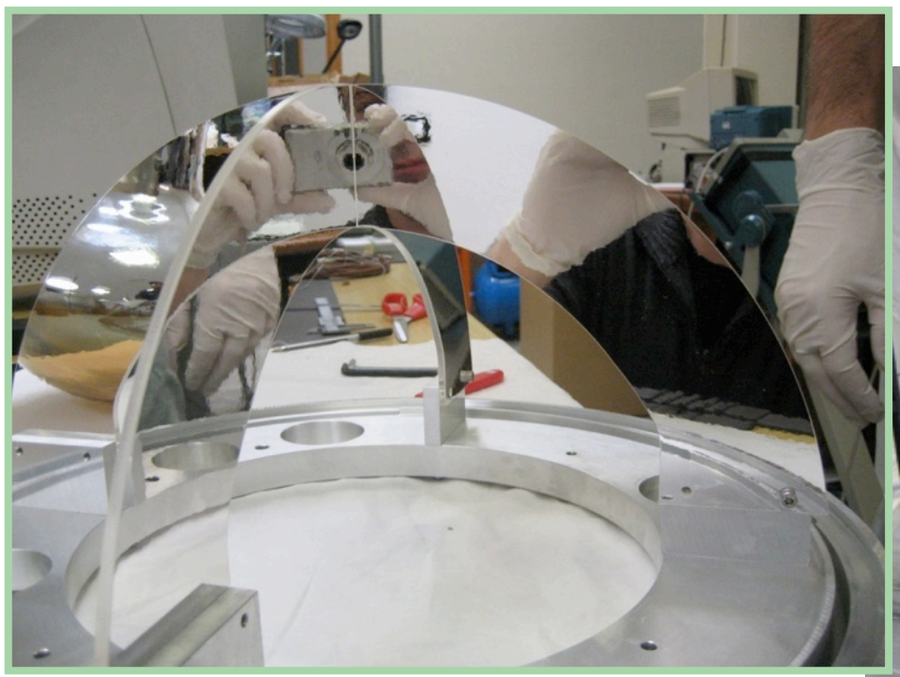


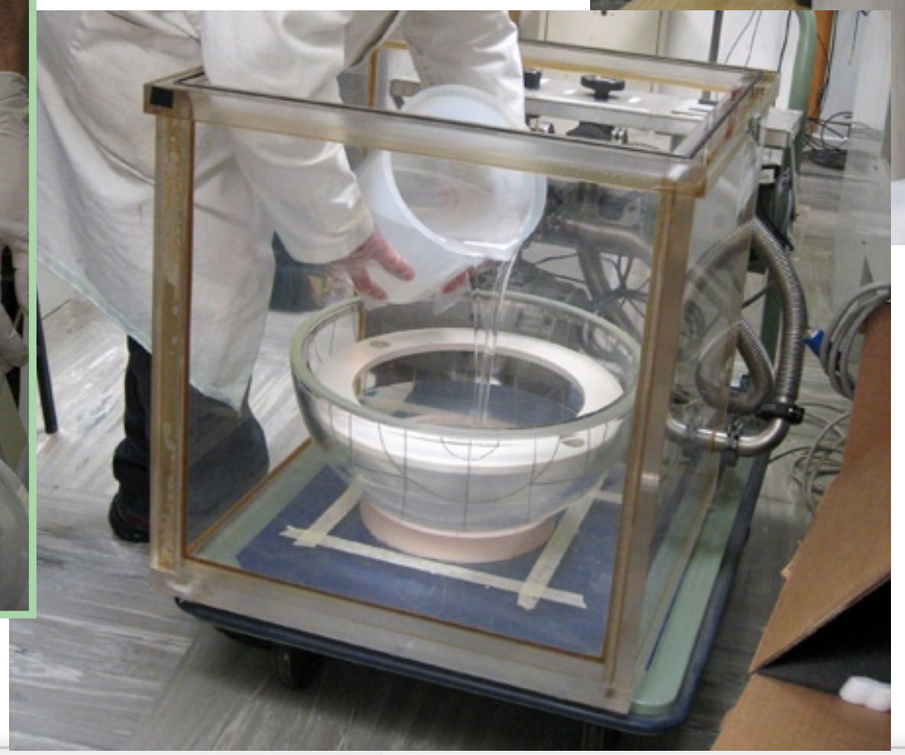


How to Build a DOM

- Mount the mirrors
- Put the mu-metal, the mirror and the light guides in the sphere
- Prepare the optical gel
- Position the PMT

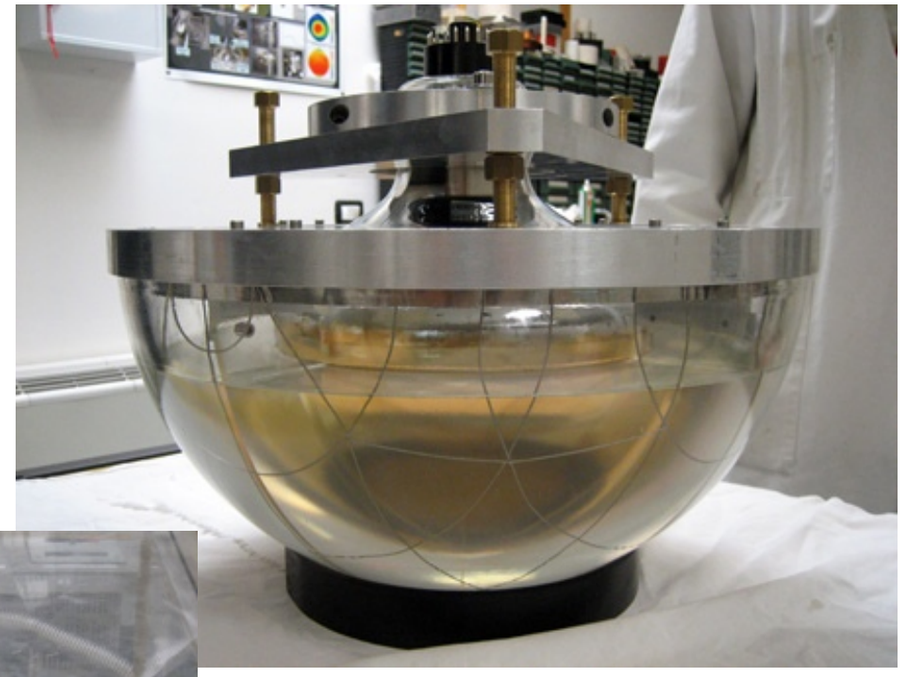


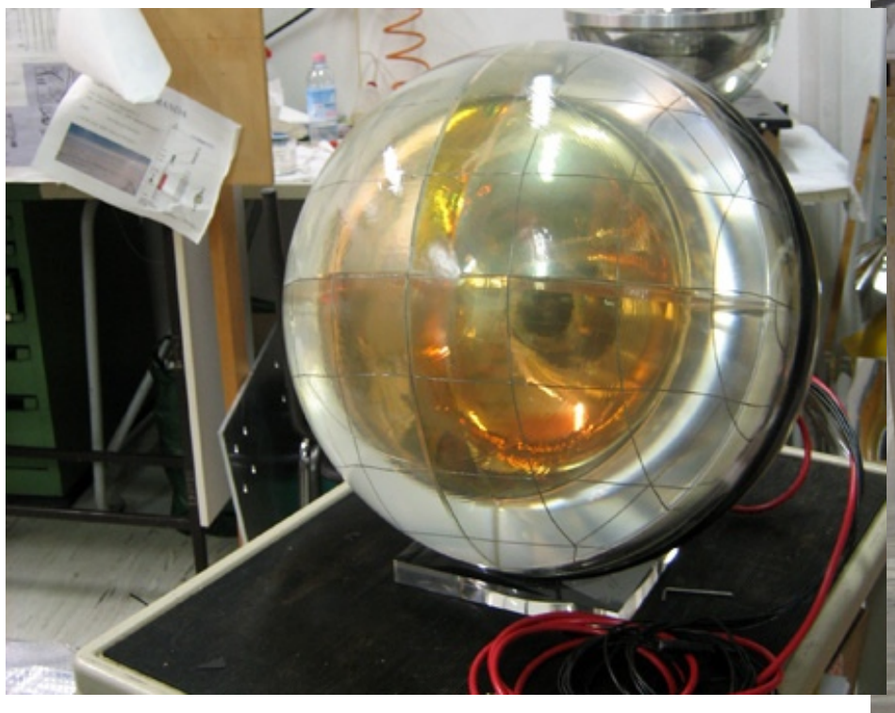




How to Build a DOM

- Put the PMT in the sphere
- Degas the gel
- Let the gel polymerise
- Install the front-end electronics
- The DOM is done





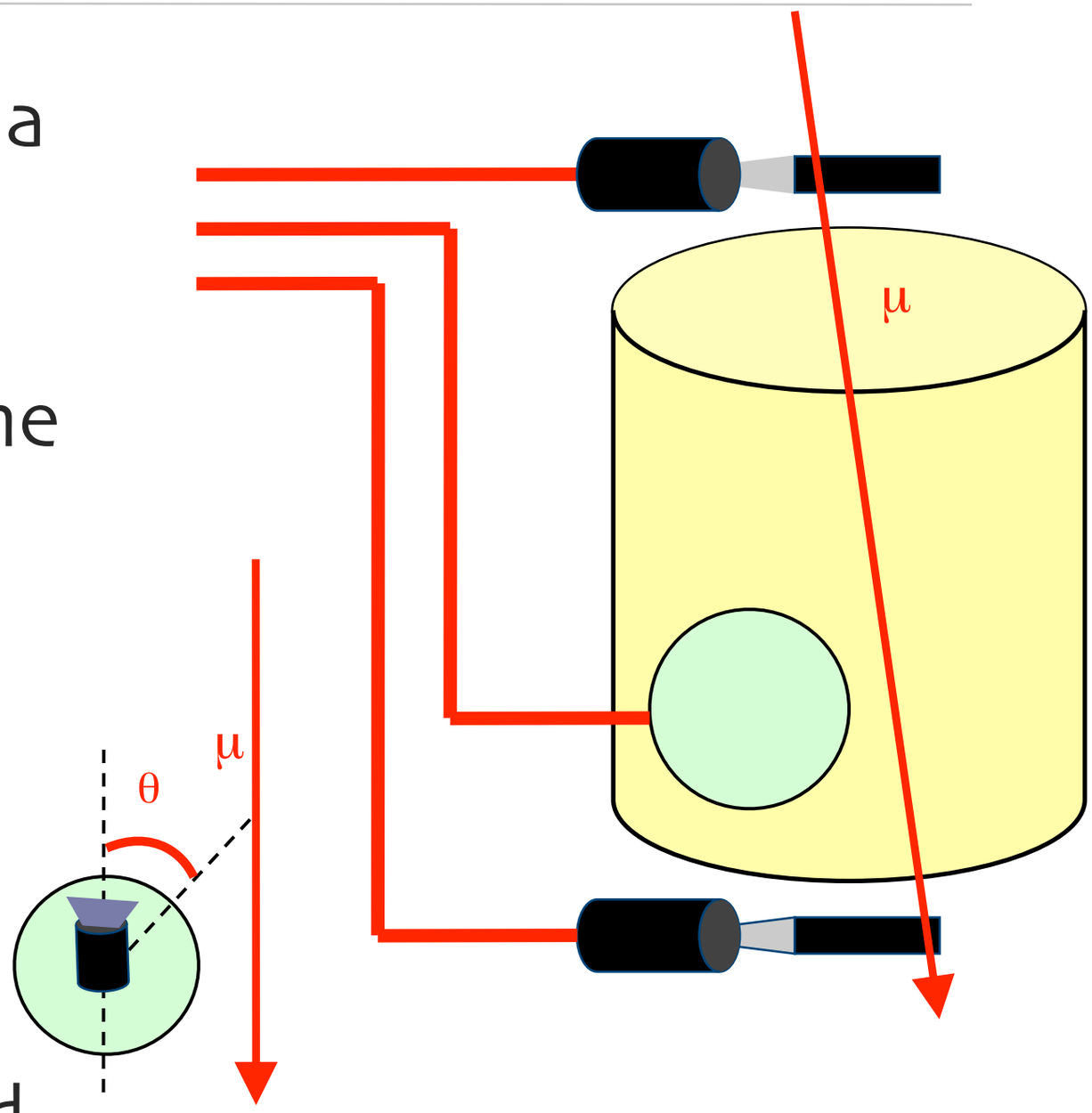
The DOM Angular Acceptance

- The DOM is inserted in a water vessel

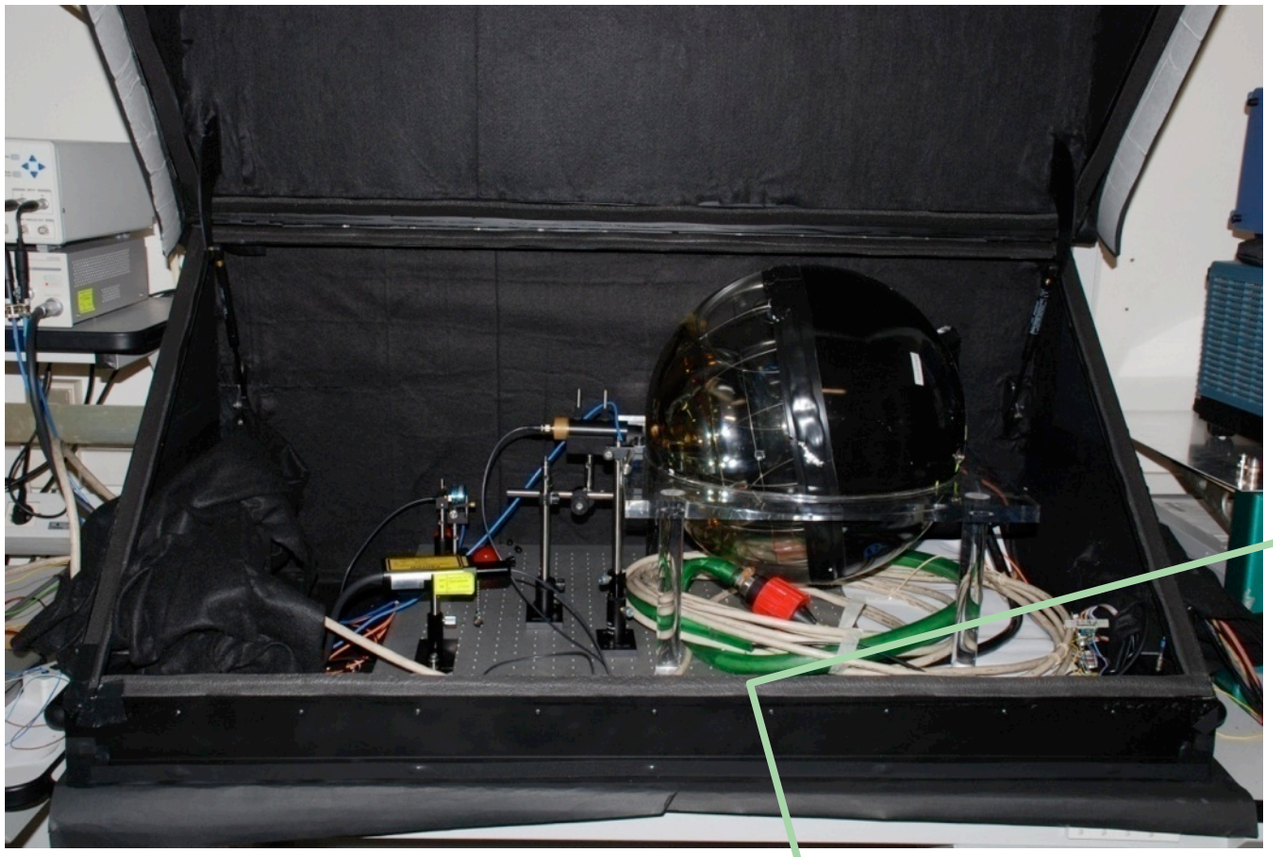
- Two scintillators give the trigger for each crossing cosmic muon

- The OM response is registered

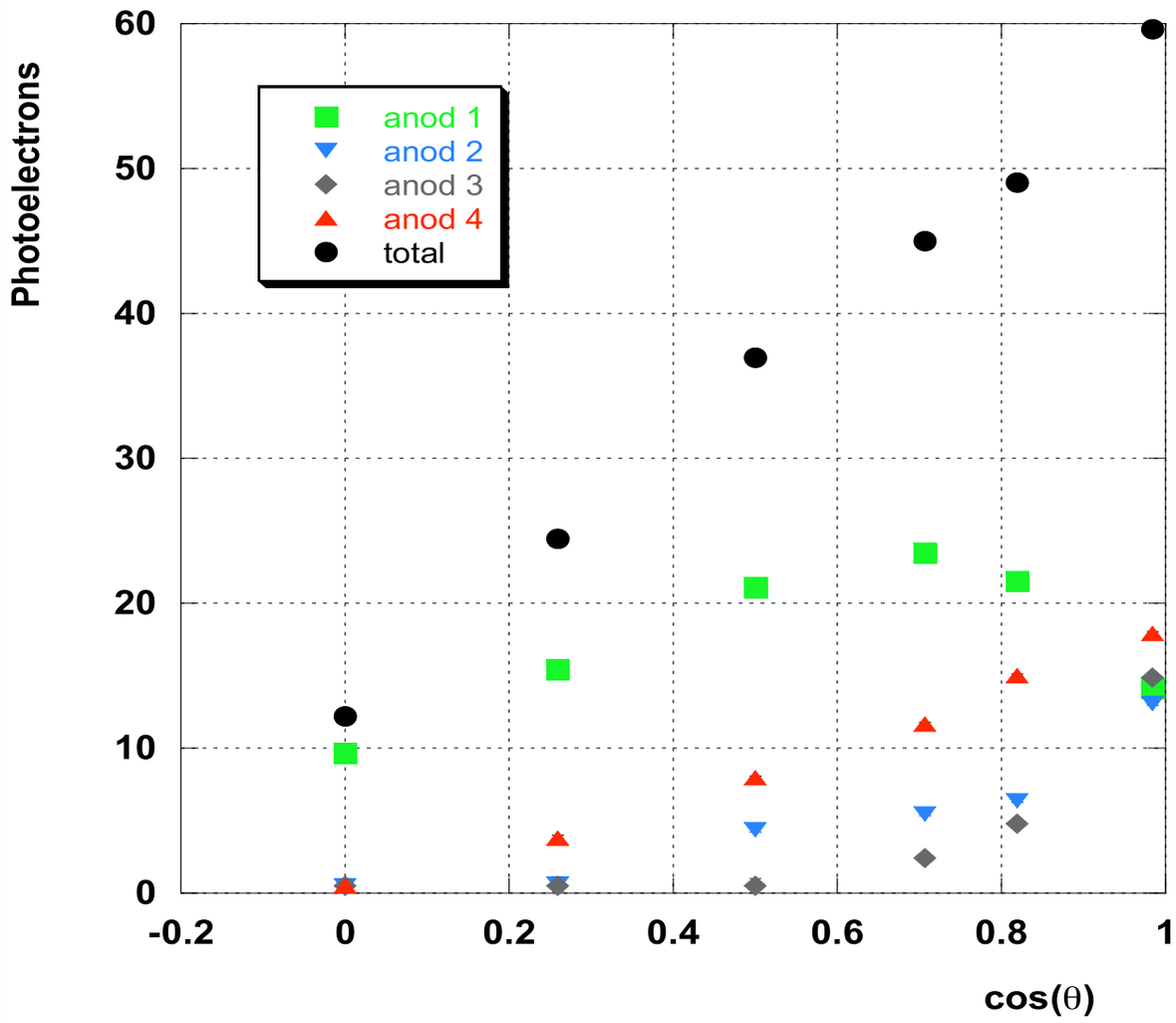
- The OM can be oriented w.r.t. The muon tracks



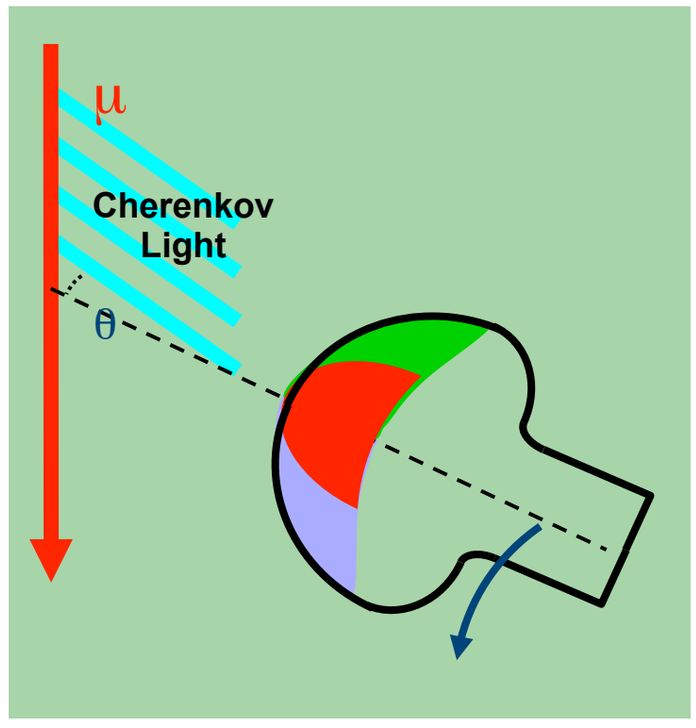
The DOM Quantum Efficiency



Angular Acceptance

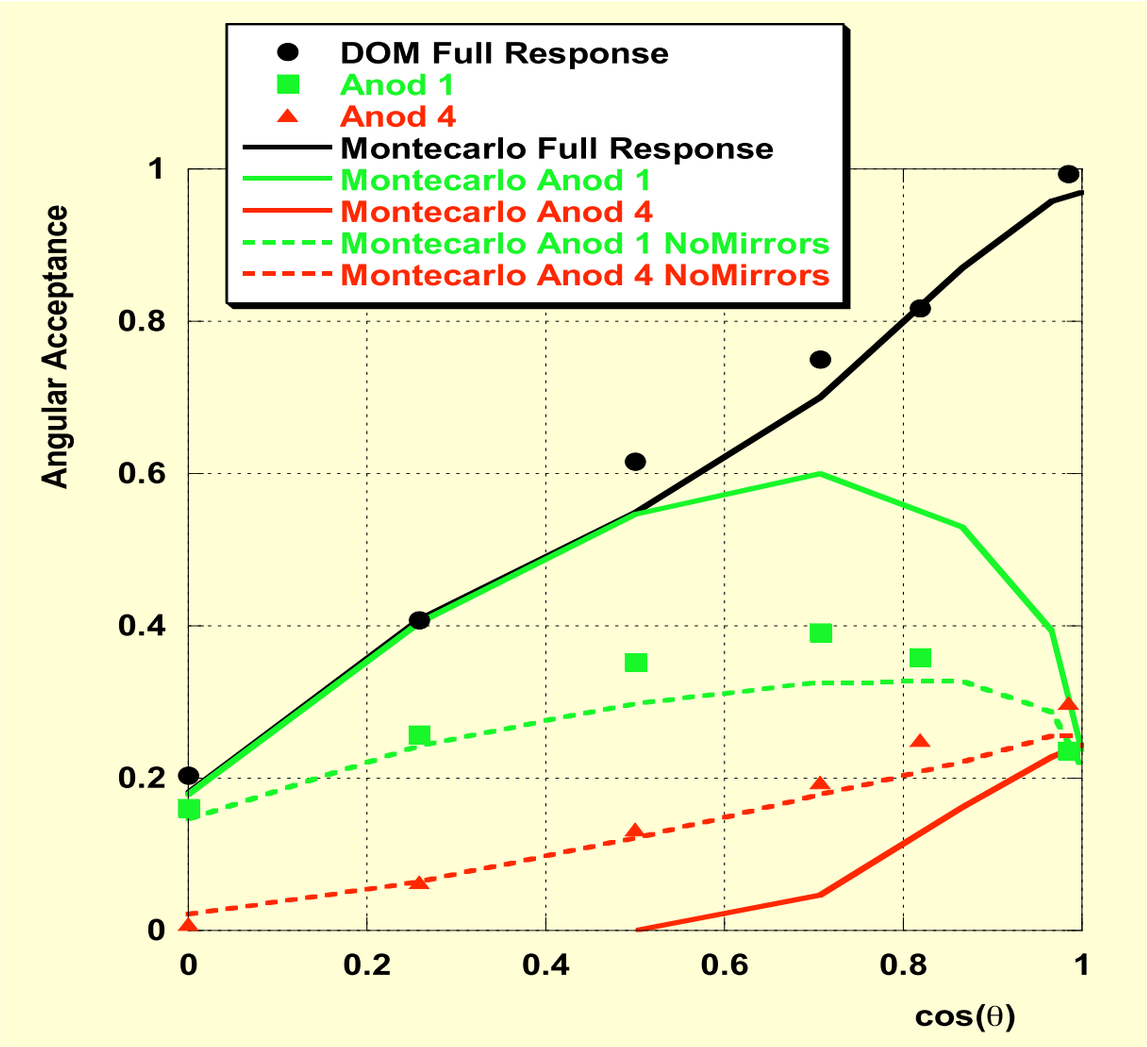


- The angular acceptance has been measured
- At θ = 0° all the sectors measure almost the same light



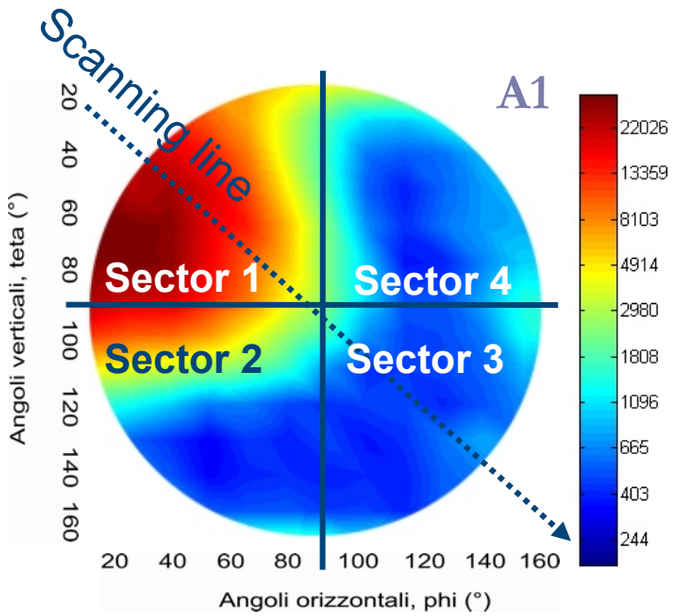
- At θ > 0° one sector dominates
- This behaviour is in agreement with the expectations

Montecarlo Comparison

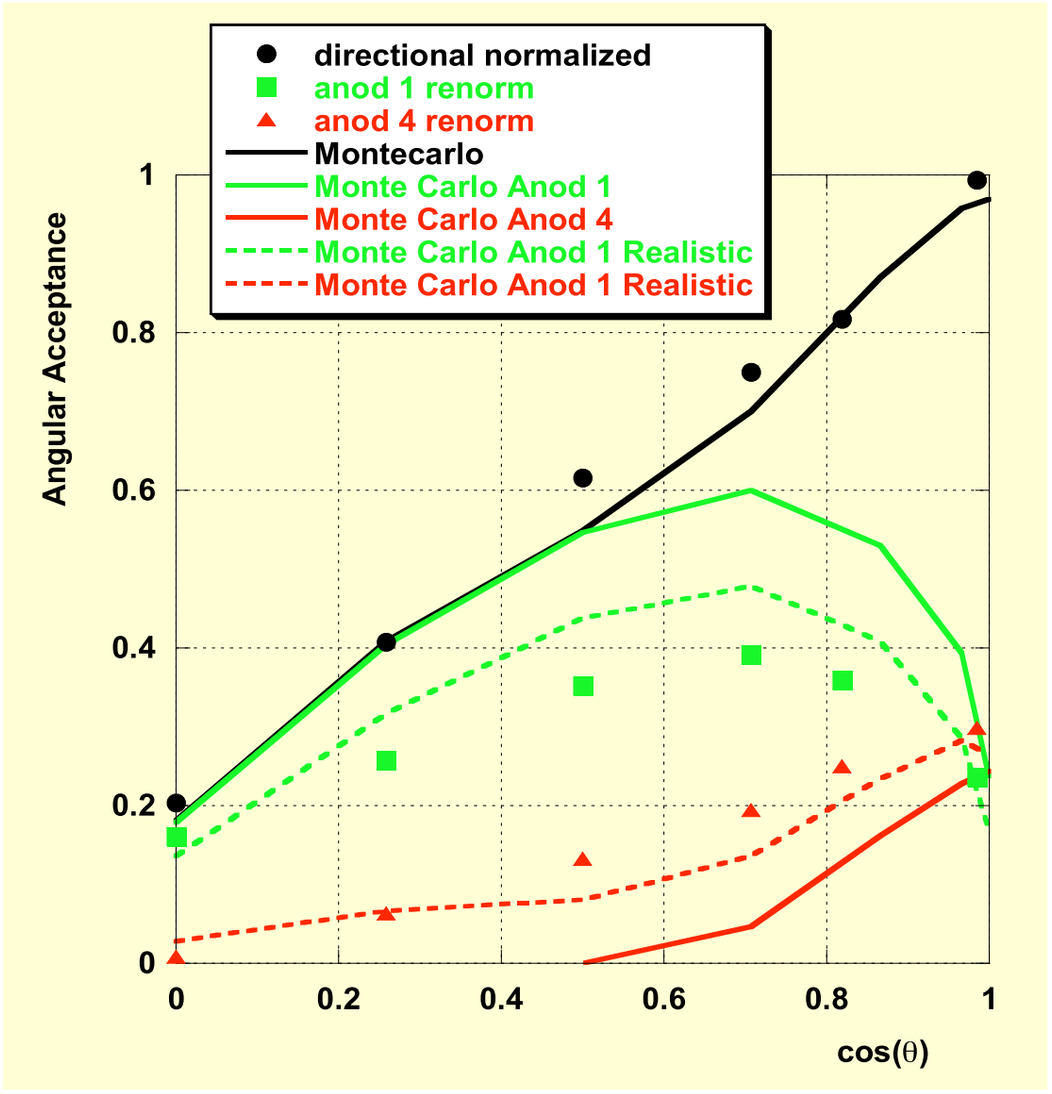


- The total signal is fairly reproduced
- The directionality is not well reproduced...

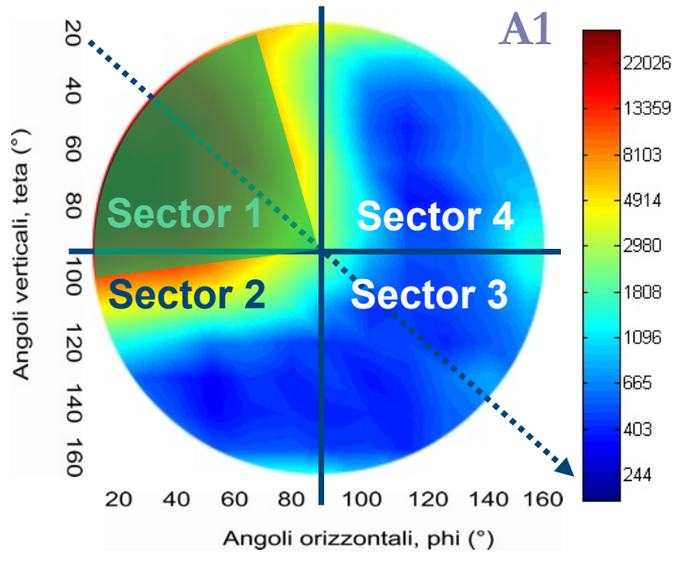
- Is the photocathode subdivision well defined?



New Montecarlo Comparison



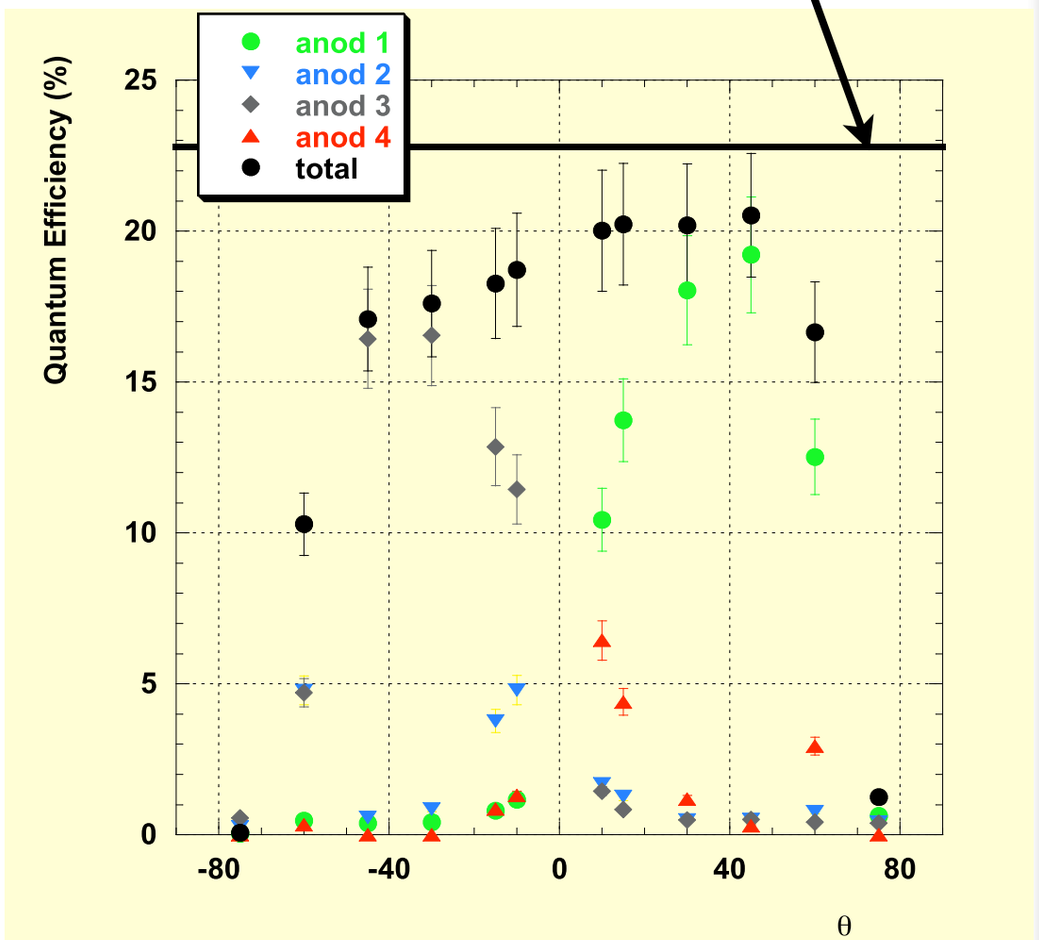
- A new definition of the sector has been implemented
- A better agreement has been achieved
- The disagreement came from a non-perfect quadrant definition



Quantum Efficiency

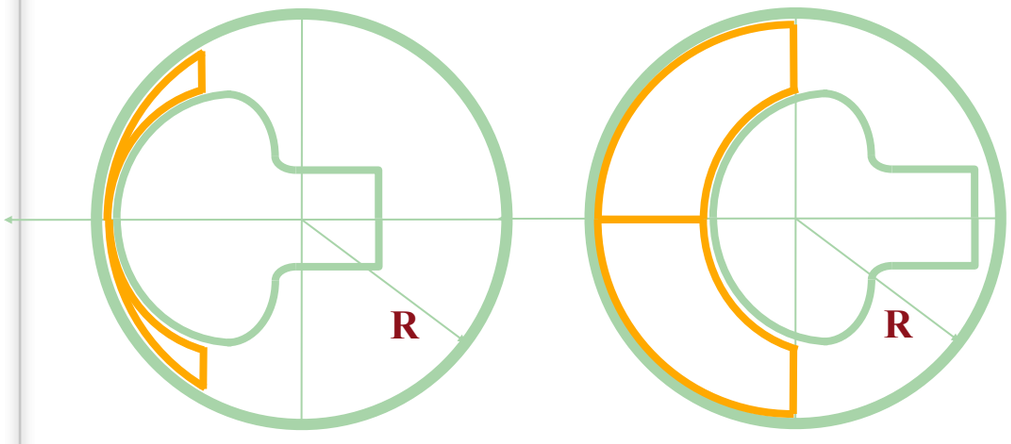
- Q.E. decreases slightly w.r.t. the bare PMT
  - Light guide effect, compatible with simulations
- Non homogeneous response
  - Dynode gain? To be investigated…
- Drop at large angles smoother than expected
  - Gel border effects? To be investigated…

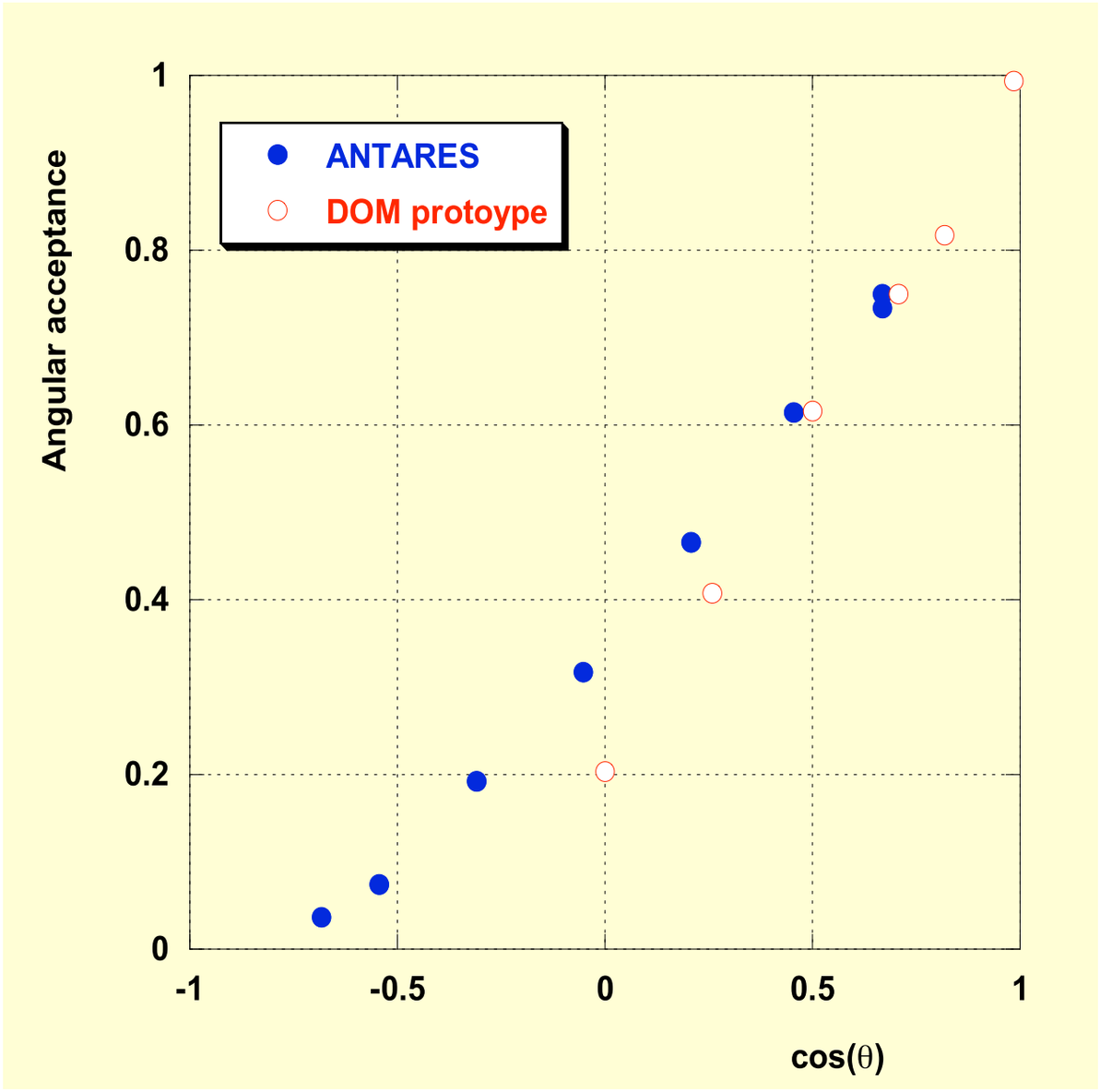
Hamamatsu result



DOM vs. ANTARES OM

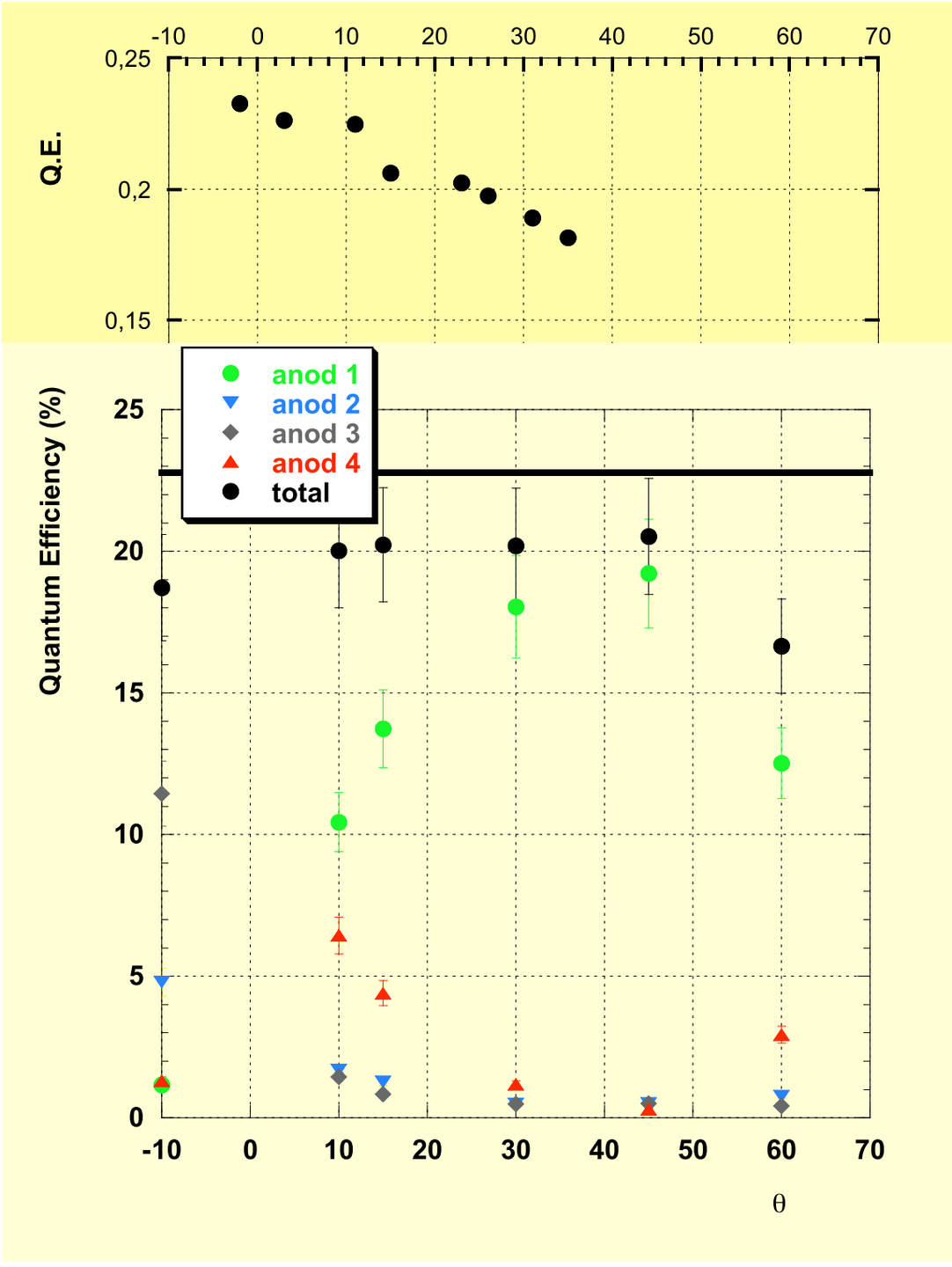
- Similar behaviour at small angle (< 60°)
- Faster drop at large angle for the DOM (due to Liouville's Theorem)





DOM vs. ANTARES OM

- Q.E. For the ANTARES OM decreases smoothly and drops at ~ 35°
- The DOM is more uniform and Q.E. drops at ~ 60°
- The drop for both the OMs is mainly due to geometry
- The increase in collected light by anode 4, lighting anode 1 at large angle is due to internal reflections



Conclusion

- Two complete Directional Optical Modules have been implemented
- The main performances are in fair agreement with the Montecarlo simulations
- Further investigation will be needed on some aspects:
  - The not well defined border between the quadrants, which affects the direction sensitivity
  - The non uniformity of the response of the different sectors
- These points are probably related to the quality of the prototype PMT