PMT simulation for the surface detector of the Pierre Auger Observatory

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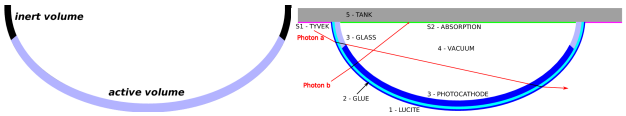
Introduction

- detailed PMT simulation
- similar to Antares PMTs
- solve the discrepancy between simulation and experiment
  $\rightarrow$ the photon excess in the simulation
- crucial for the estimation of the muonic component of the shower
  $\rightarrow$ hadronic physics

The PMT simulator - evolution

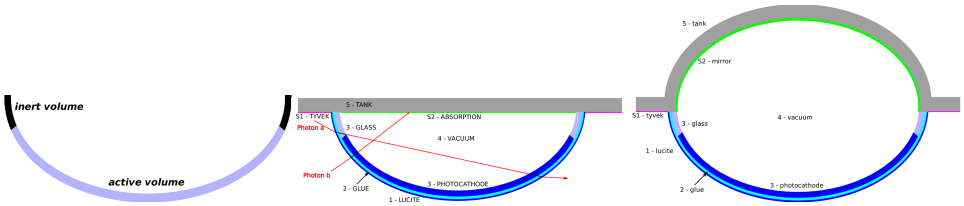
- simple model

The PMT simulator - evolution



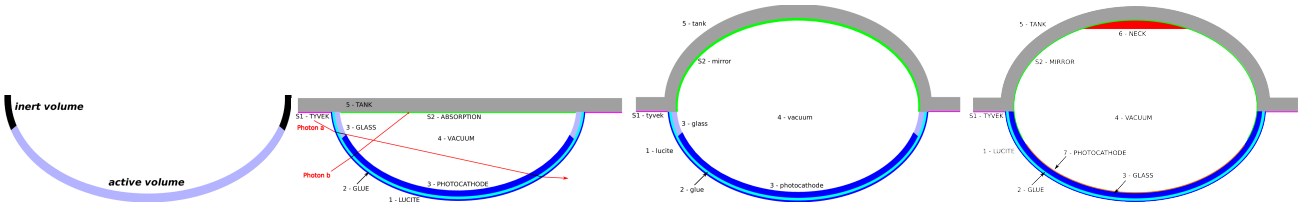
- simple model
- access to the intern part

The PMT simulator - evolution



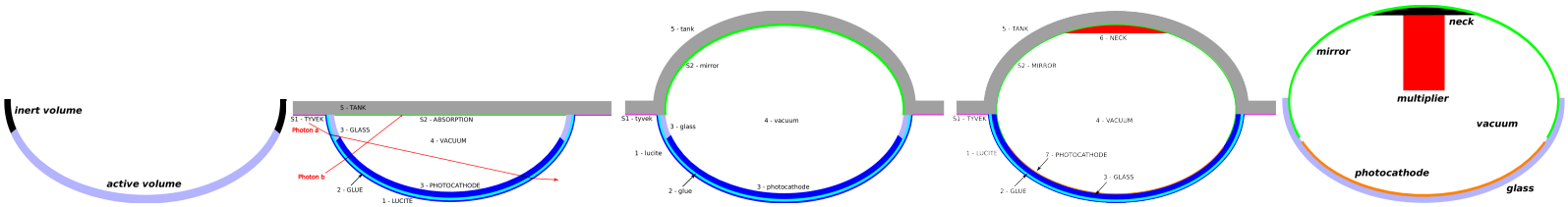
- simple model
- access to the intern part
- full geometry with the back side mirror

The PMT simulator - evolution



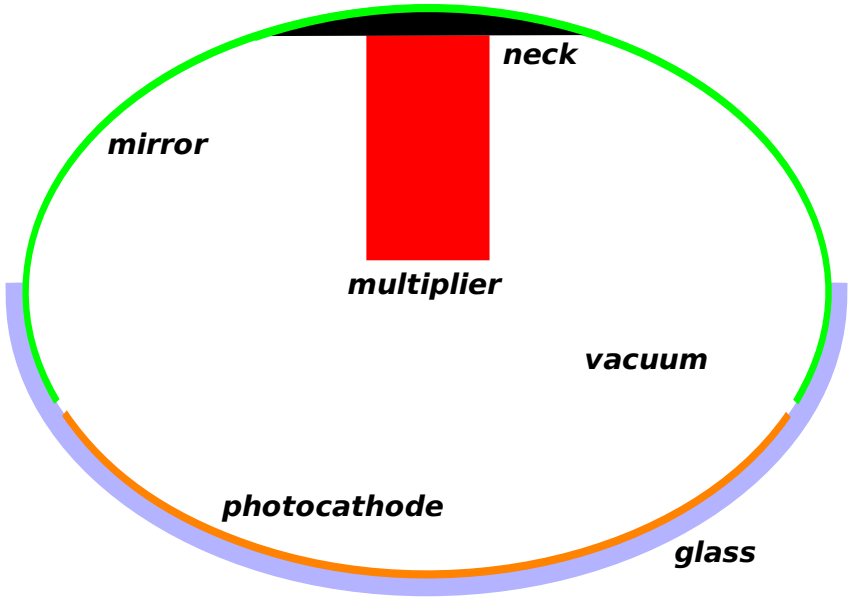
- simple model
- access to the intern part
- full geometry with the back side mirror
- first implementation of the neck

The PMT simulator - evolution



- simple model
- access to the intern part
- full geometry with the back side mirror
- first implementation of the neck
- thin film implementation

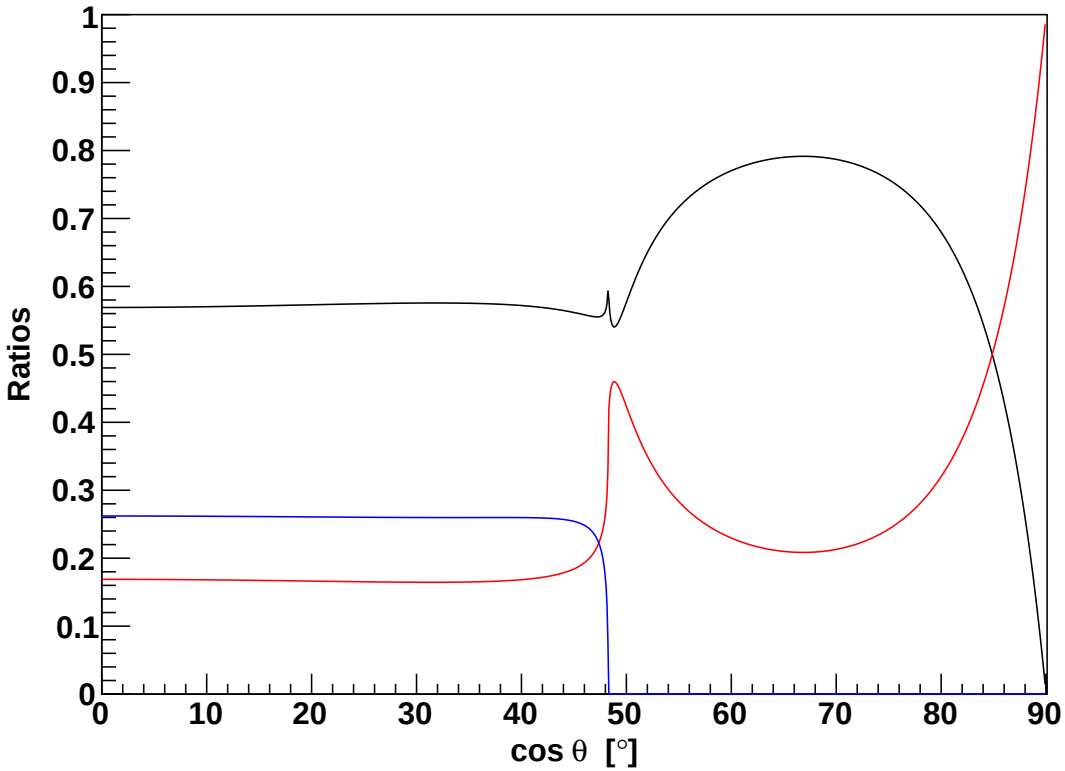
The PMT simulator - Characteristics



- mirror absorption: 3% (specular reflection)
- multiplier reflectivity: 30% (diffusive reflection)
- neck absorption: 100%
- glass index: 1.47

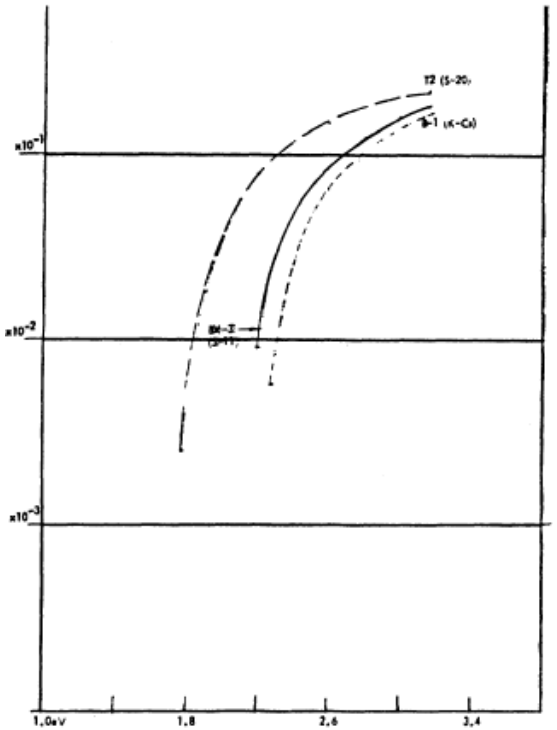
The PMT simulator - thin metal film

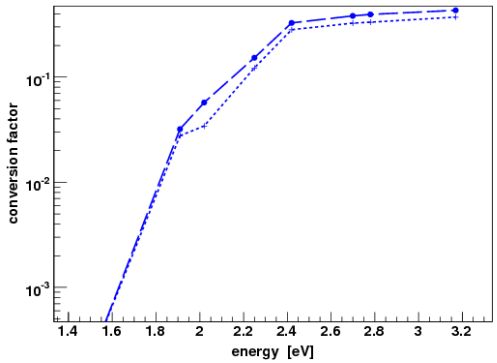
See other presentation



The PMT simulator - conversion factor

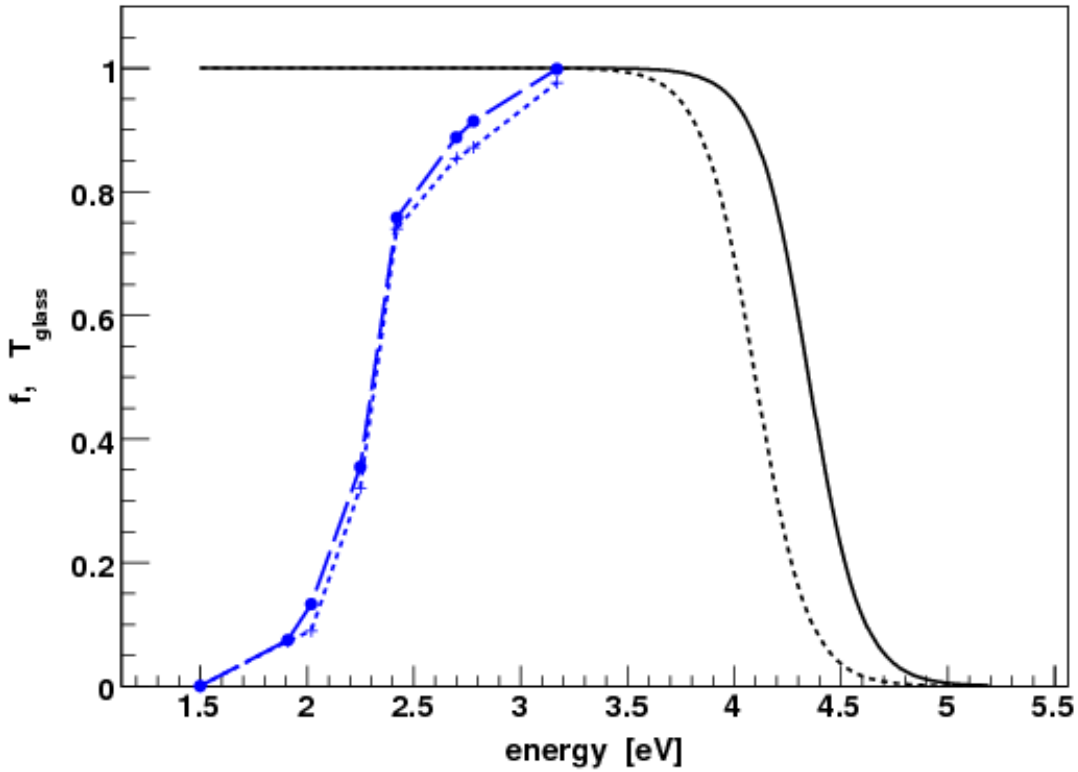
- probability for the photoelectron to escape the metal film
- film thickness dependent
- energy dependent
- Ref: IEEE Transactions on Nuclear Science, Vol. NS-28, No. 1, February 1981





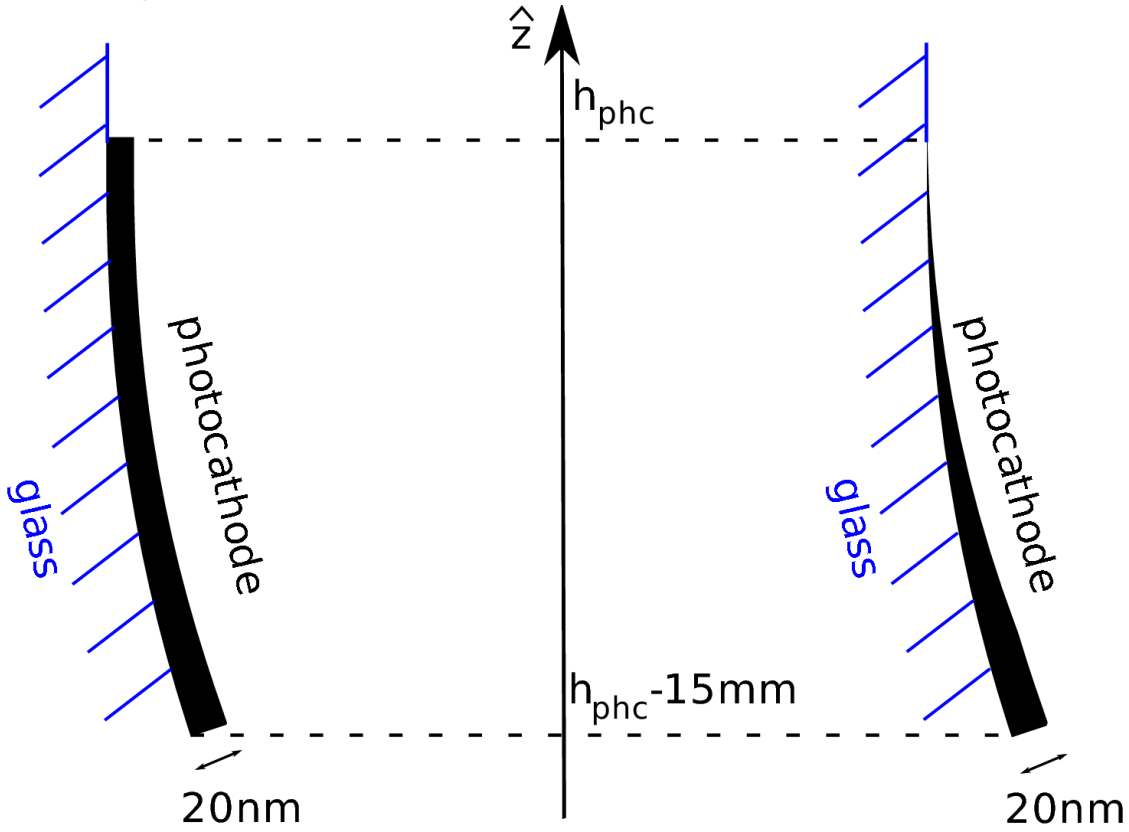
The PMT simulator - glass cut-off

- Fermi function
- adjustment of the water and glass cut-off



The PMT simulator - photocathode border

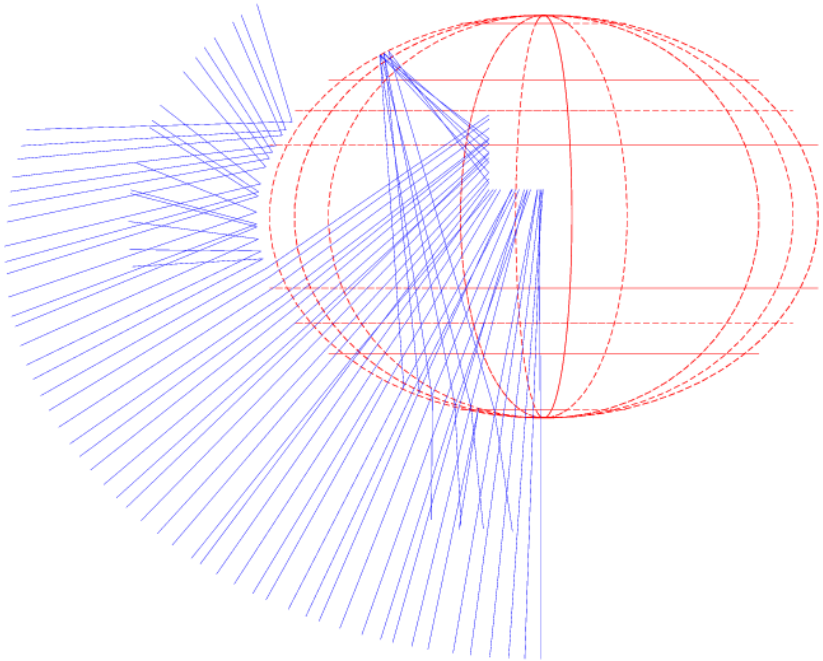
- thickness constant except on the border
- linear decay down to 0

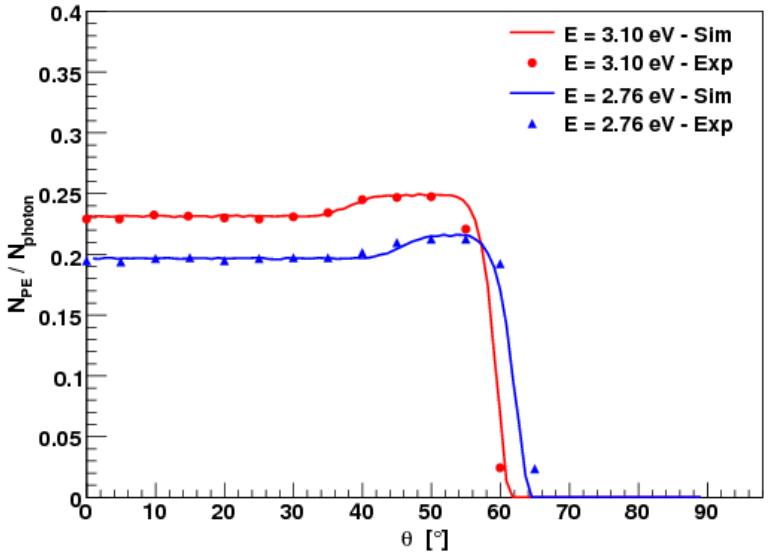


a - step border

b - linear border

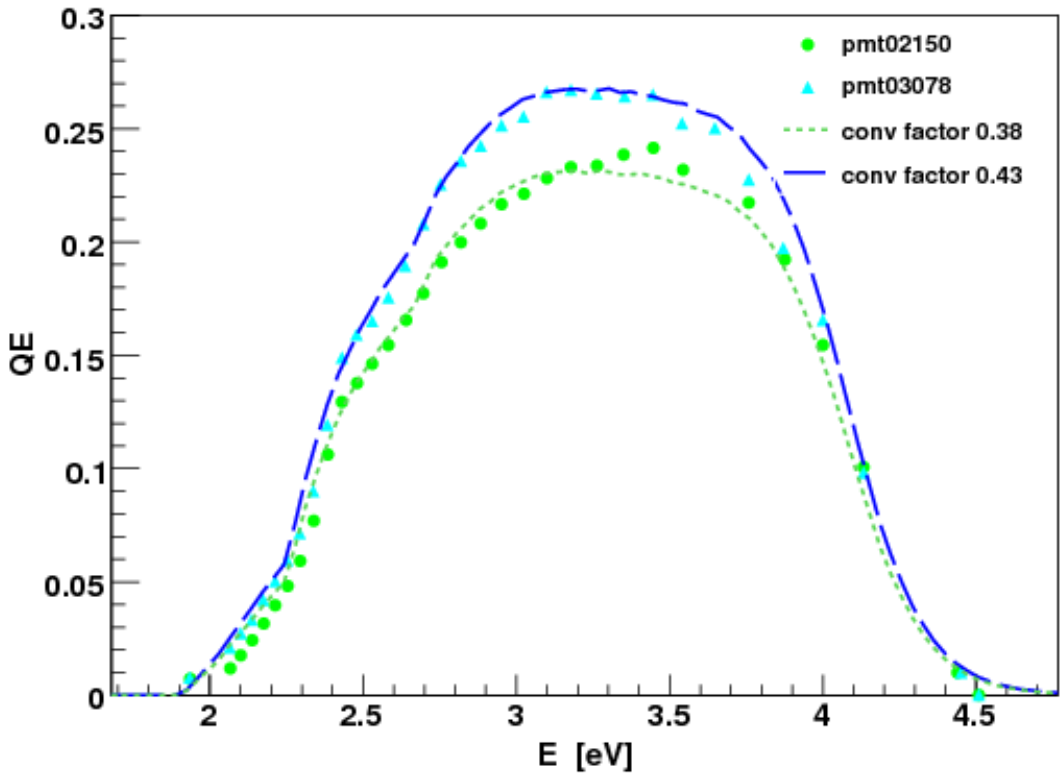
Comparison with measurements - angular dependence





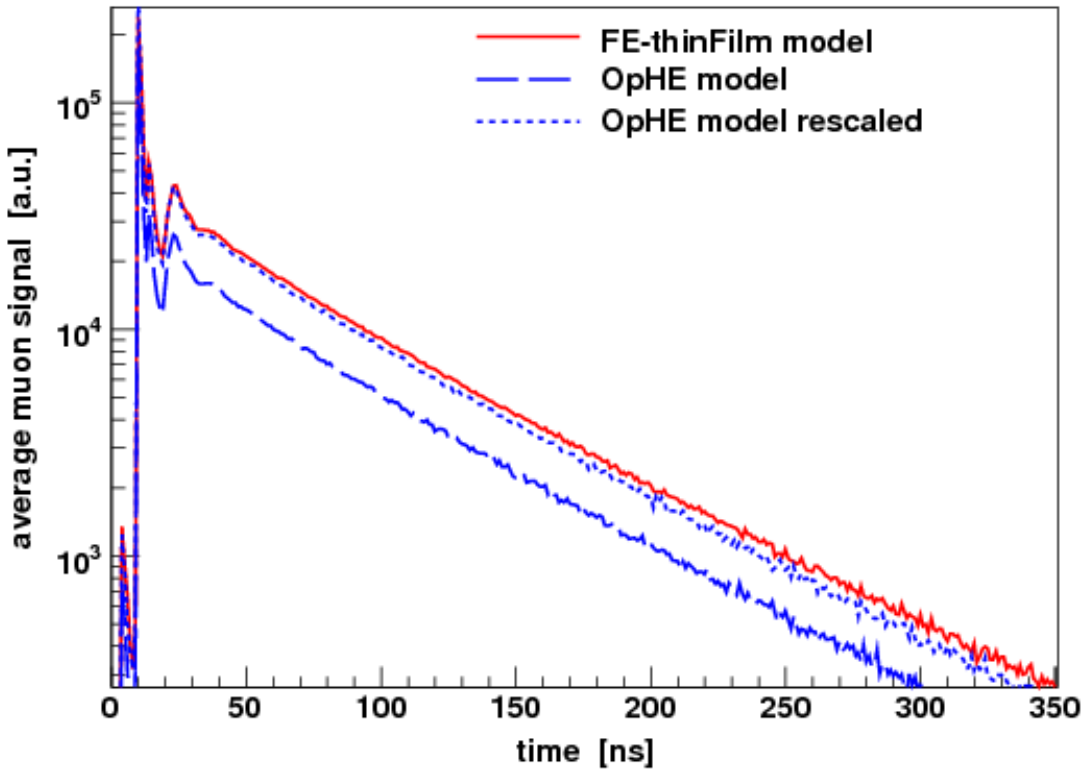
- measurements driven by a Spanish group (Granada)
- thin beam not centered on the PMT center
- 5 mm shift of the light source in the simulation

Comparison with measurements - energy dependence



- same campaign of measurements
- small adjustments of the simulation parameters

Comparison with measurements - vertical muon signal



- for information
- signal given by the PMT
- vertical centered muon

Conclusions

- simulation and experiment in good agreement
- only few parameters to modify in order to reproduce the change from one PMT to another
- the collection efficiency was constant for this study
- the simulation has been improved up to the first dynode (very simple model)
- results not shown but it could be used to simulate (faithfully?) afterpulses and delayed pulses