Towards a fast simulation of a water Cherenkov detector for gamma ray and cosmic ray experiments

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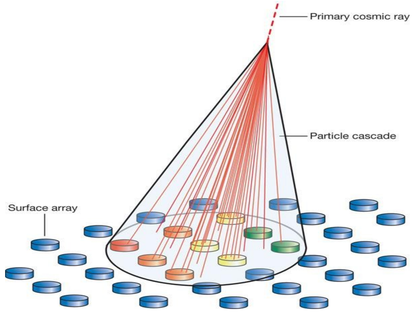
Introduction

Water cherenkov detector arrays have been used succesfully in cosmic ray and gamma ray experiments.
In the early stages of a experiment design many studies on the proposed detector performance and its relation to the scientific objetives are needed in order to select the optimal design.



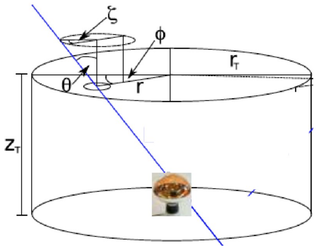
Detailed simulations are time consuming.
Faster detector simulators are desirable.

In order to get a fast simulation of the detector, the overall response of the detector was parametrised.

Simulations

Detailed simulations were done with GEANT4 for a stainless steel cylinder 4.5 m height and 3.65 m radius, whose internal walls are covered with a UV absorbing material. A single 9” central PMT positioned on the detector floor and 154 tons of hyper pure water inside

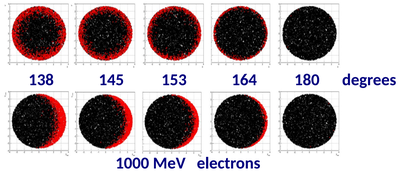
1000 events simulated for each particle type, energy and zenith angle combination with random position of particle incidence in the top of the detector.



- type of particle: e^+,e^-,γ, μ^+,μ^-
- particle energies: 10^8 , 10^7, 10^6, 10^5 , 10^4 , 10^3 , 500 y 100 MeV
- particle zenith angles: 138, 144, 152, 164, 180 degrees
- Azimuth angle between 0 to 360 degrees
- random position of incidence in the top of the tank.

Signal probability

The probability of null signal was calculated as the ratio between the number of particles that do not produce a signal and the total number of particles entering the detector.



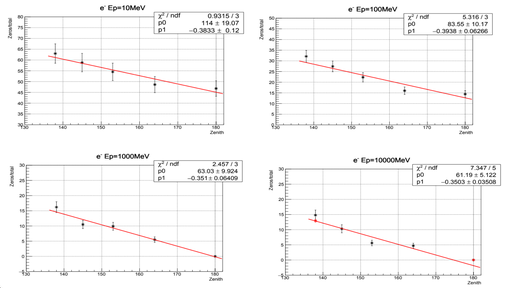
180 degrees = vertical incidence

Black: producing signal
Red: producing no signal

Position of particles in the top of the detector

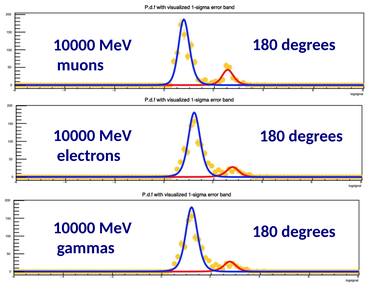
The dependence of the probability of null signal with zenith angle and energy was fitted for each type of particle for future use in the fast simulator.

Electrons: probability of producing null signals



Signal parametrization

Histograms of the signal distribution for each particle type, energy and zenith angle were build. As a first approach a combination of two Landau functions was fitted, using the RooFit framework with 5 free parameters that will depend on the energy, zenith angle and type of particle.



Summary : Full detailed GEANT4 simulations of a water Cherenkov detector were used to obtain a parametrization of the signal response. This parameterization will generate approximate signals which match the signals generated by the full detector simulation. In this way we can build a fast simulator of the detector.