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GEANT4 simulation of optical modules in neutrino telescopes

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Neutrinos have a very important role in the multi-messenger astronomy, therefore, in recent years, larges underwater and under-ice neutrinos telescopes have been designed to allow the detection of high energy neutrinos. The neutrino energy spectrum and direction are inferred based on the detection of the Cherenkov light induced by the secondary charged particles in the medium.
Optical modules (OMs), i.e. glass spheres containing the photomultiplier tubes (PMTs) for light detection at the single photon level, and the associated electronics, are central components of such neutrino telescopes. They require detailed simulations which are usually based on parametrized results of laboratory measurements. Here an alternative approach is presented, where the light detection in OMs is simulated using the latest GEANT4 simulation library. This simulation is close to the experimental conditions, easily allowing the definition of any geometry of the OMs and common PMT types to simulate precisely the photon propagation in various detection units geometry. It is able to perform a precise simulation of the interaction of the photon in the photocathode, taking in account the optical properties of bialkali photocathodes and a dedicated algorithm.
This simulation has been applied to 10-inch Hamamatsu PMTs in 17-inch spheres (ANTARES), 10-inch Hamamatsu PMTs in 13-inch spheres (NEMO), and multiple 3-inch PMTs in 17-inch spheres (KM3NeT). The methods, the results achieved and their relevance for data analysis in neutrino telescope will be presented.

Collaboration

KM3NeT

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Author: Dr HUGON, Christophe (INFN)

Co-authors: Dr COSTANTINI, Heide (INFN-Genova (ITALY)/ University of Notre Dame (USA)); ANGHINOLFI, Marco (Genova); TAIUTI, Mauro (University of Genova, INFN); KULIKOVSKIY, Vladimir (LNS)

Presenter: Dr HUGON, Christophe (INFN)

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