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Simulation of Cherenkov detectors based on wavelength-shifting (WLS) optical fibers

Water Cherenkov detectors (WCDs) based on wavelength-shifting optical fibers (WLS) coupled to silicon photomultiplier tubes (SiPMs) represent an emerging technology in astroparticle physics as an alternative to conventional photomultiplier tubes (PMTs). This work presents the simulation advances and data obtained from a prototype WCD detector integrating two internal arrays of WLS fibers. The geometry, material optical properties, and detector response were implemented using the GODDESS package (based on Geant4), with secondary radiation from atmospheric waterfalls over Lima, Peru, simulated with the ARTI tool of the LAGO project, as the incident radiation. Analysis of the charge histograms in the SiPMs demonstrates a spectral distribution consistent with that of PMT-based WCDs, preserving the characteristic muon back signature. Additionally, an electromagnetic detection threshold close to 1 MeV was identified, suggesting that the design should be optimized by increasing the density of optical fibers in future iterations to improve photonic collection efficiency. Preliminary measurements are also shown.

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