Contribution ID: **219** Contribution code: **INSTR/SW** Type: **Poster**

Performance of Small Photomultiplier Tubes with Wavelength Shifting Plates for an SWGO-like Water Cherenkov Detector Using Geant4

Wednesday 4 September 2024 08:36 (1 minute)

Water Cherenkov detectors (WCDs) detect high-energy particles from air showers in the atmosphere via the Cherenkov radiation they emit in the water. Discussed here is a novel photodetector designed for use in WCDs, such as the Southern Wide Field Gamma-ray Observatory (SWGO). Traditionally large photomultiplier tubes (PMTs) are used in WCDs; however, this study proposes the use of smaller PMTs coupled with wavelength shifting (WLS) plates to enhance the photodetection efficiency while saving costs. The WLS plate aims to increase the light capture area of a smaller PMT by 'trapping'photons and directing them towards the PMT's photocathode via internal reflection and reflective edges. This method proposes to improve the overall detection rates of a smaller PMT to achieve the same goal, without needing a larger more expensive PMT.

Geant4 Monte Carlo simulations were used to evaluate the performance of various configurations by investigating a range of thicknesses, sizes and materials to determine the optimal geometry for this design. The photodetector is designed for employment in the lower chamber of an SWGO-like double-layered WCD, used for hadronic background rejection. This tank was modelled in these simulations to compare the muon detection efficiency of this design with a larger PMT. The feasibility of implementing this design into an observatory such as SWGO will depend on meeting the requirements for accurate hadronic rejection through muon detection.

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Session Classification: Poster hang