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Design and Optimisation of a Novel Light-Guiding Water Cherenkov Photodetector

This project explores a novel photodetector configuration for water Cherenkov detection by integrating smaller photomultiplier tubes (PMTs) with wavelength shifting (WLS) plates, which aims to improve the photon detection efficiency cost-effectively. A custom-built water tank at the University of Leicester will be used to test a range of modifications for this design and assess the impact on light collection. The small PMT is partially embedded in the centre of a WLS plate, designed to absorb UV Cherenkov photons and re-emit them at longer wavelengths, which will match more closely with the PMT's optimal sensitivity. The WLS plate will guide the re-emitted light towards the edge of the PMT's photocathode via total internal reflection and additional reflective edges.

This investigation will evaluate the influence that the WLS plate positioning has on the PMTs' photon detection efficiency. We aim to quantify the gain in detected signal due to changes in angular acceptance by varying the WLS plates' vertical height on the photocathode. Furthermore, we will test the effects of reflective coatings on the WLS plate to determine the optimal configuration for maximising light guiding toward the PMT.

This configuration will specifically focus on atmospheric muon detection and selectively trigger on these with a prototype muon telescope. The system comprises two 6×6 mm² silicon photomultipliers (SiPMs) - used for the CTA Small-Sized Telescope (SST) selection process - coupled to small WLS scintillator blocks, vertically aligned and separated with a thin lead sheet. The lead will act as a low-energy background radiation veto, favouring muons. Coincidence logic is used to identify events where both SiPMs have been simultaneously triggered, generating a logic pulse that serves as an external trigger for the Oscilloscope to monitor the PMT output. This system will improve the signal-to-noise ratio by measuring only muon-induced signals.

This study aims to determine the feasibility of this configuration in water Cherenkov detectors for application in high-energy astroparticle physics. This technique could offer a cost-effective alternative to the traditionally used larger PMTs in these systems.

Secondary track

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