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Investigation of use of Wavelength Shifting Materials in Water Cherenkov Detectors for Gamma Ray Astronomy

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Water Cherenkov detectors for wide-field gamma-ray astronomy, such as HAWC and LHASSO and the upcoming Southern Wide-Field Gamma-Ray Observatory (SWGO) utilize a large number of water tanks at high altitudes to directly detect the gamma-ray-produced charged particle shower via the Cherenkov radiation generated within each tank. SWGO will be the first such wide-field survey instrument to explore the southern hemisphere, allowing access to areas that cannot currently be observed such as the Galactic Centre, and complementing the higher angular resolution but smaller field of view of the Cherenkov Telescope Array (CTA).
Water Cherenkov detectors typically utilize a large number of water tanks (6000-8000 for SWGO) instrumented with several PMTs per tank, meaning that costs are a major driver if large PMTs are required.
We discuss a technique that uses wavelength shifting (WLS) material to capture Cherenkov light over a larger area and couple it into a PMT, allowing the use of a smaller PMT at a lower cost. This solution is only useful for the lower muon tagging tank, which does not require as high a time resolution
We discuss simulations using Geant4 of a modified design where a smaller PMT is embedded in a WLS plate, which collects incoming Cherenkov photons over a larger area and downshifts their wavelength to more effectively match the quantum efficiency of the PMT.
We present simulation results showing the effect of the WLS on the time resolution and sensitivity of Cherenkov photon detection and discuss performance and cost trade-offs compared to a conventional design using a large PMT with no additional WLS material.

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