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Development of a Hybrid Water Cherenkov and Liquid Scintillator Detector for Cosmic Ray Detection

This study presents a hybrid detector design integrating water Cherenkov and liquid scintillator technologies for future ultra-high-energy cosmic ray (UHECR) and gamma-ray observatories. The detector unit comprises a cylindrical structure with a cm-thick liquid scintillator layer sealed in a transparent acrylic chamber at the top, coupled with a purified water volume as the Cherenkov medium. A 3-inch waterproof photomultiplier tube (PMT) is mounted at the base to simultaneously capture Cherenkov and scintillation signals. The outer shell is constructed from light-tight, corrosion-resistant composite materials. Signal acquisition is performed using a CAEN V1743 digitizer for high-precision waveform analysis.

The hybrid design leverages the complementary advantages of the two detection techniques. The water Cherenkov component provides fast timing characteristics, enabling precise determination of the signal direction. This is critical for angular resolution of cosmic particles. On the other hand, the liquid scintillator component offers counting capabilities similar to traditional detectors, such as the LHAASO-ED, which ensures precise energy reconstruction of the detected particles.

Key performance parameters, including light yield and time resolution are systematically evaluated. The detector achieves a time resolution of approximately 1 ns. Additionally, the hybrid design enhances the dynamic range and particle identification capabilities by combining the timing precision of the Cherenkov detector with the energy measurement capabilities of the scintillator.

This hybrid design represents a significant advancement in cosmic ray detection, with potential applications in next-generation observatories.

Collaboration(s)

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