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Development and Testing of a Large-Area Cosmic Ray Telescope with Millimeter-Level Positioning Precision

Cosmic ray muons, as important "natural probes," have been widely used in particle physics experiments. We have developed a cosmic ray telescope with an effective detection cross-section of one square meter to achieve high-precision tracking of high-energy cosmic ray muons. The instrument employs a modular design, innovatively combining a plastic scintillator strip with a layer of scintillating fibers for collaborative detection. The scintillator strip (measuring 1000×55×10 mm) is responsible for muon triggering and coarse positioning, while the fiber layer (with a double-layer structure, each layer densely packed with 54 fibers of 1 mm diameter) accomplishes fine position resolution. The scintillation light signals are read out by photomultiplier tubes (PMTs). Additionally, we developed a dedicated FPGA program for data acquisition. To meet the positional resolution requirements, the width of the fiber group is set to 3 mm, with each single layer measuring one-dimensional coordinates. Two orthogonal single layers form a large layer, and the upper and lower large layers are spaced 1 meter apart, resulting in a tracker capable of achieving millimeter-level spatial resolution.

This research encompasses the entire process from the design of the tracker, Geant4 simulation optimization, and systematic testing of key components, to the assembly of the cosmic ray tracker, followed by detailed performance testing. The results indicate that the cosmic ray tracker has a detection efficiency of approximately 85%, and a single-layer fiber detection efficiency of about 95%, with a positional resolution better than 2 mm. This poster will showcase the cosmic ray tracker's design principles, manufacturing processes, and performance testing. Our work not only provides a reliable technical foundation for the precise detection of muons but also serves as an important reference for future developments in cosmic ray tracking technology, thereby advancing scientific progress and technological innovation in the field of cosmic ray detection.

We hope that our research will resonate with the themes of ICRC 2025 and contribute to the insightful discussions during the conference. We appreciate your consideration of our submission and look forward to the possibility of sharing our findings in Geneva.

Collaboration(s)

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