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RPC-Scintillator Hybrid Detection System for Muon Scattering Experiments at HIAF-HFRS

This work presents a novel detector design enabling muon scattering experiments at the High-energy FRagment Separator[1] (HFRS) at the High Intensity heavy-ion Accelerator Facility[2] (HIAF), offering new capabilities to probe dark matter[3], dark bosons, quantum entanglement phenomena[4], and the charged lepton flavor violation[5] (CLFV). Building upon the muon tomography detector from the Probing and Knocking with Muons (PKMu) initiative, we developed the upgraded detection system specifically adapted for beamline scattering experiments.

The core tracking system employs Resistive Plate Chambers[6] (RPCs) inherited from PKMu's architecture, achieving <1 mm spatial resolution for precise muon trajectory reconstruction. To differentiate secondary particles generated through scattering processes and suppress background signals from extraneous particles, we integrated a dedicated particle identification (PID) subsystem combining scintillators and time-of-flight measurements.

The detector performance and particle identification efficiency on the beamline have been studied by simulation. And according to the simulation results, dark matter search on high-intensity muon beamline is expected to achieve a detection sensitivity better than the current cosmic-ray muon experiment in even shorter measure time. Additionally, as a preliminary joint tuning of the RPC-scintillator detection system, a performance-test platform made up of two RPCs for scintillators has been trailed, which provides a valuable technical guidance for the complete prototype.

Reference:

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