

International Workshop on Muon Physics at the Intensity and Precision Frontiers (MIP 2026)

Development of a Novel Muon Detector and Imaging System for Deep Borehole Applications

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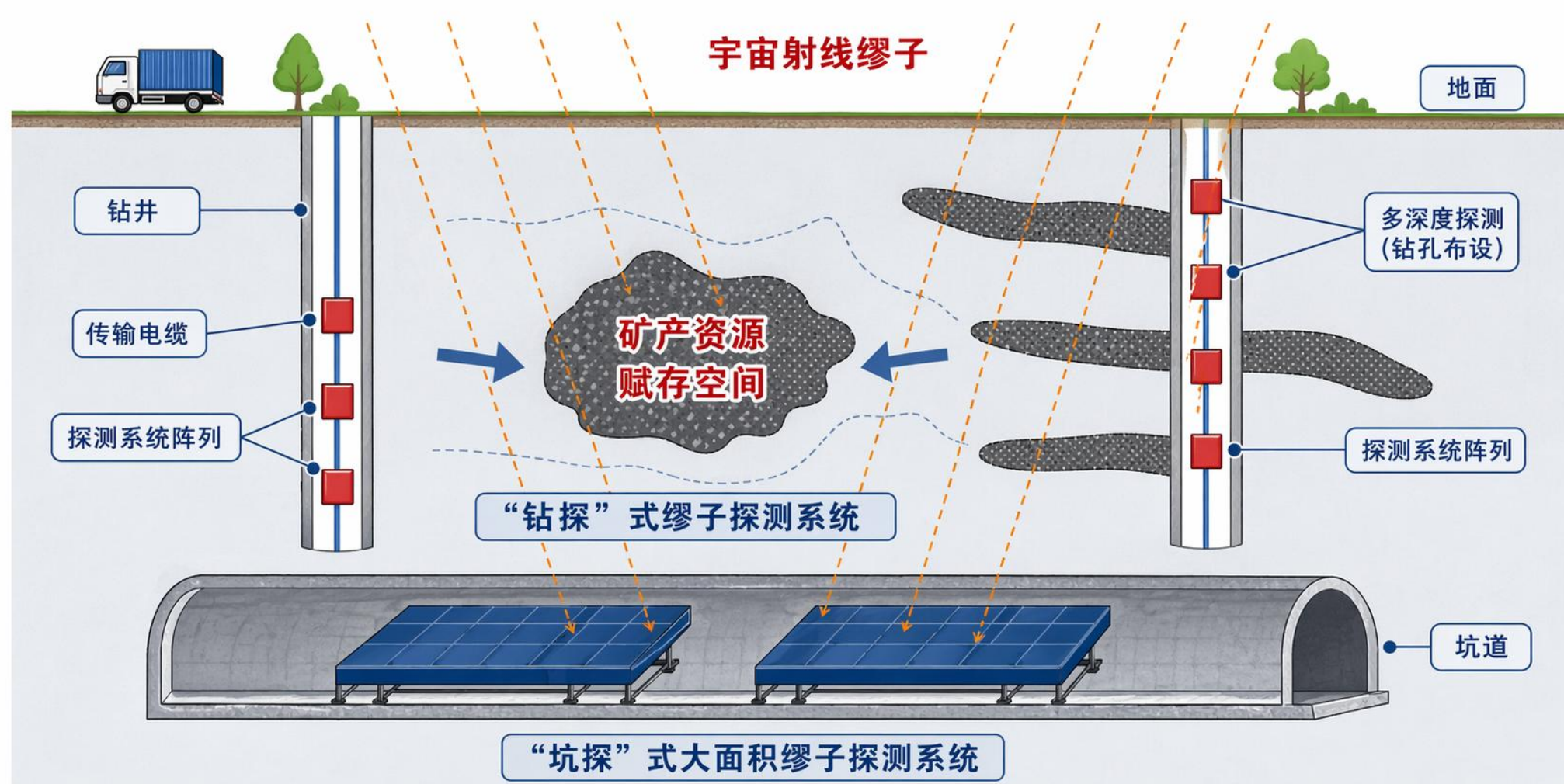
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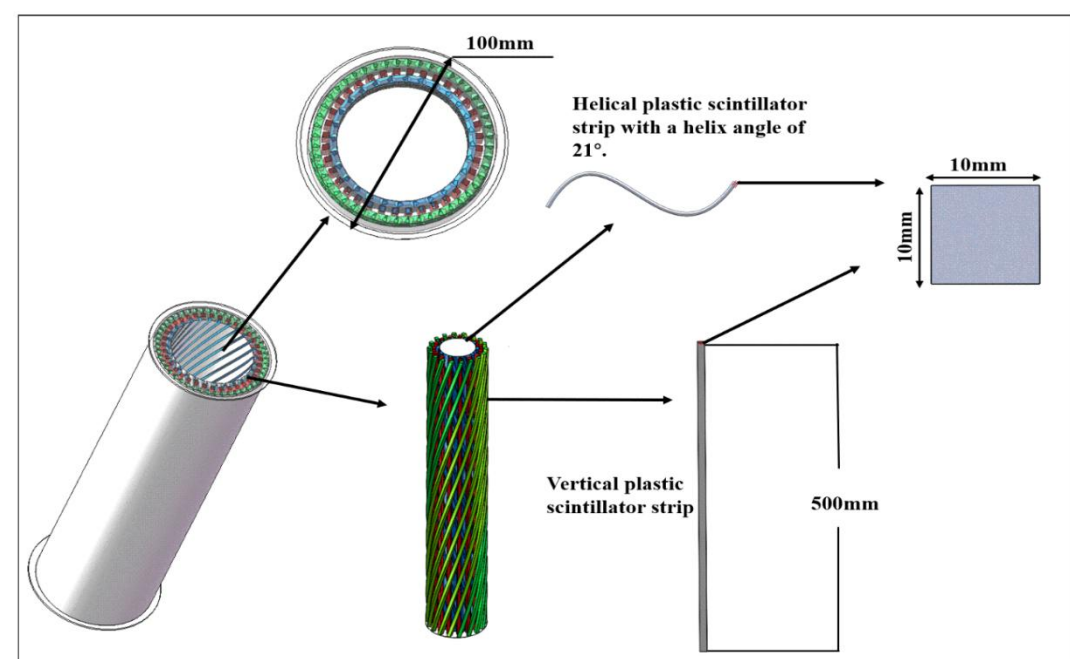
Introduction

Cosmic-ray muons are generated by interactions between high-energy cosmic rays and atmospheric nuclei. Their strong penetrating capability enables density reconstruction from subsurface muon flux variations for deep ore vein exploration.

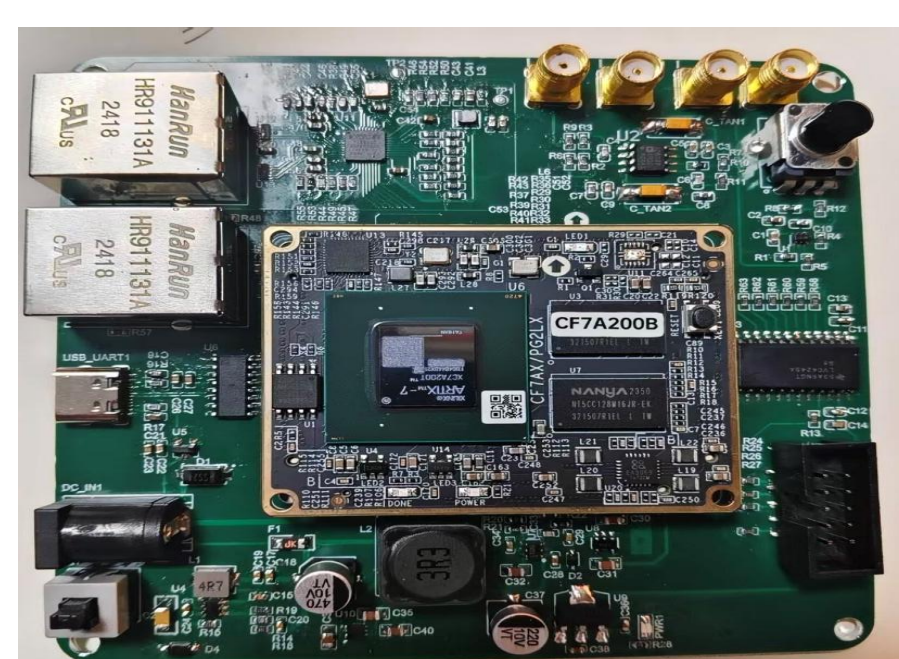
宇宙射线缪子成像勘探示意图



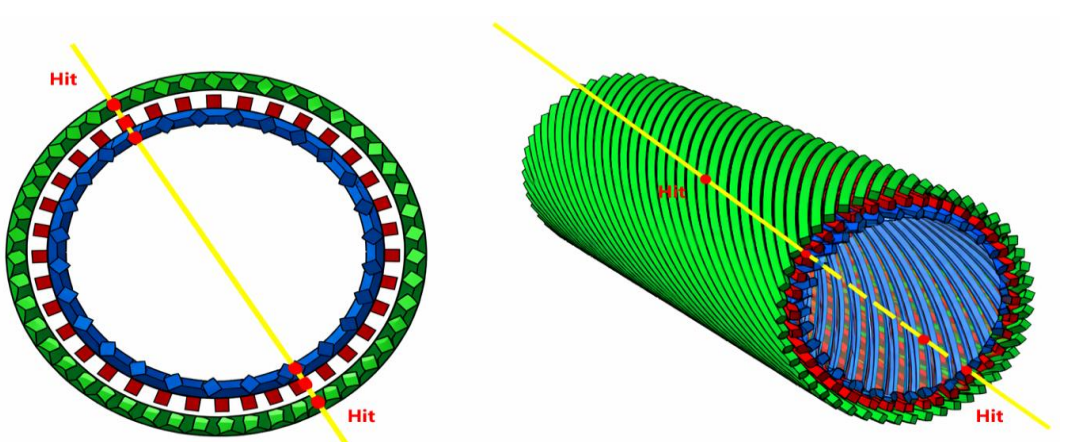
Detector and electronics design



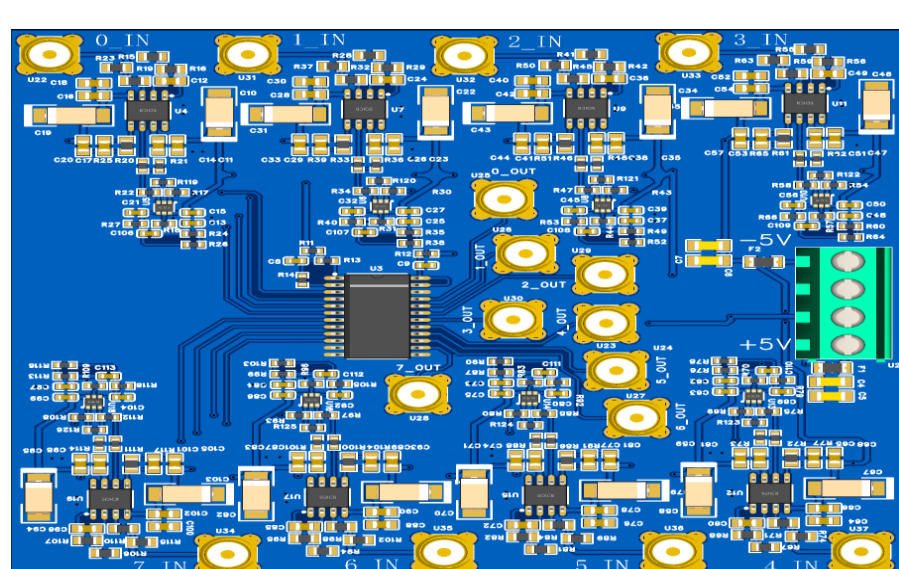
Detector model design



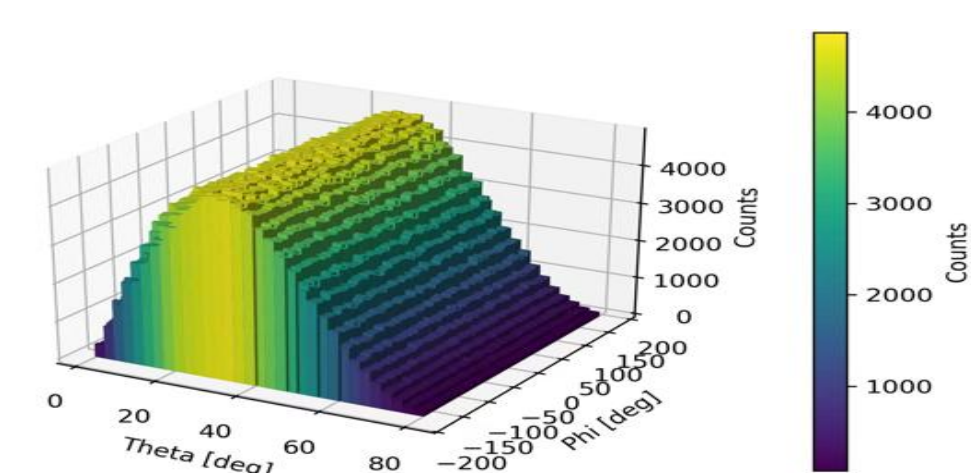
FPGA+FEE



Schematic diagram of muon detection by the detector



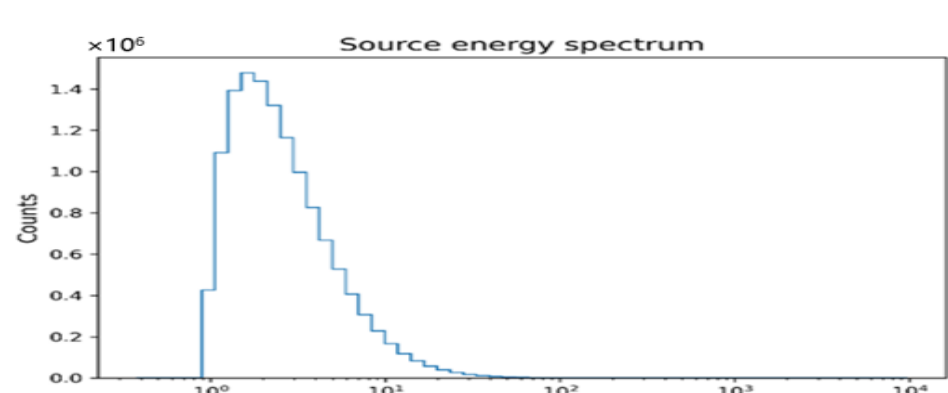
Amplification discrimination and logic level conversion



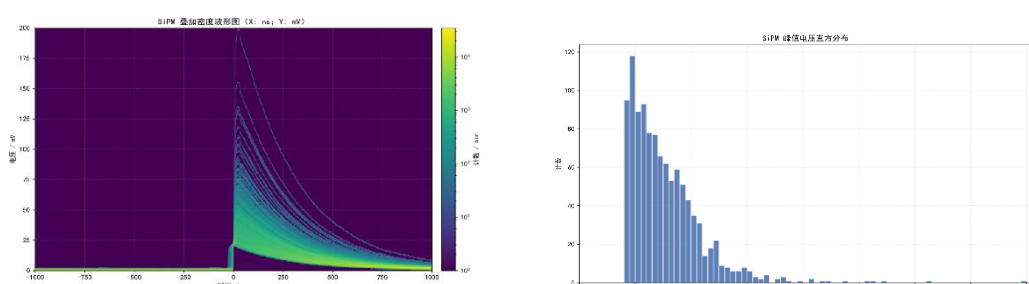
Muon Theta-Phi distribution



Internal wiring of the detector prototype

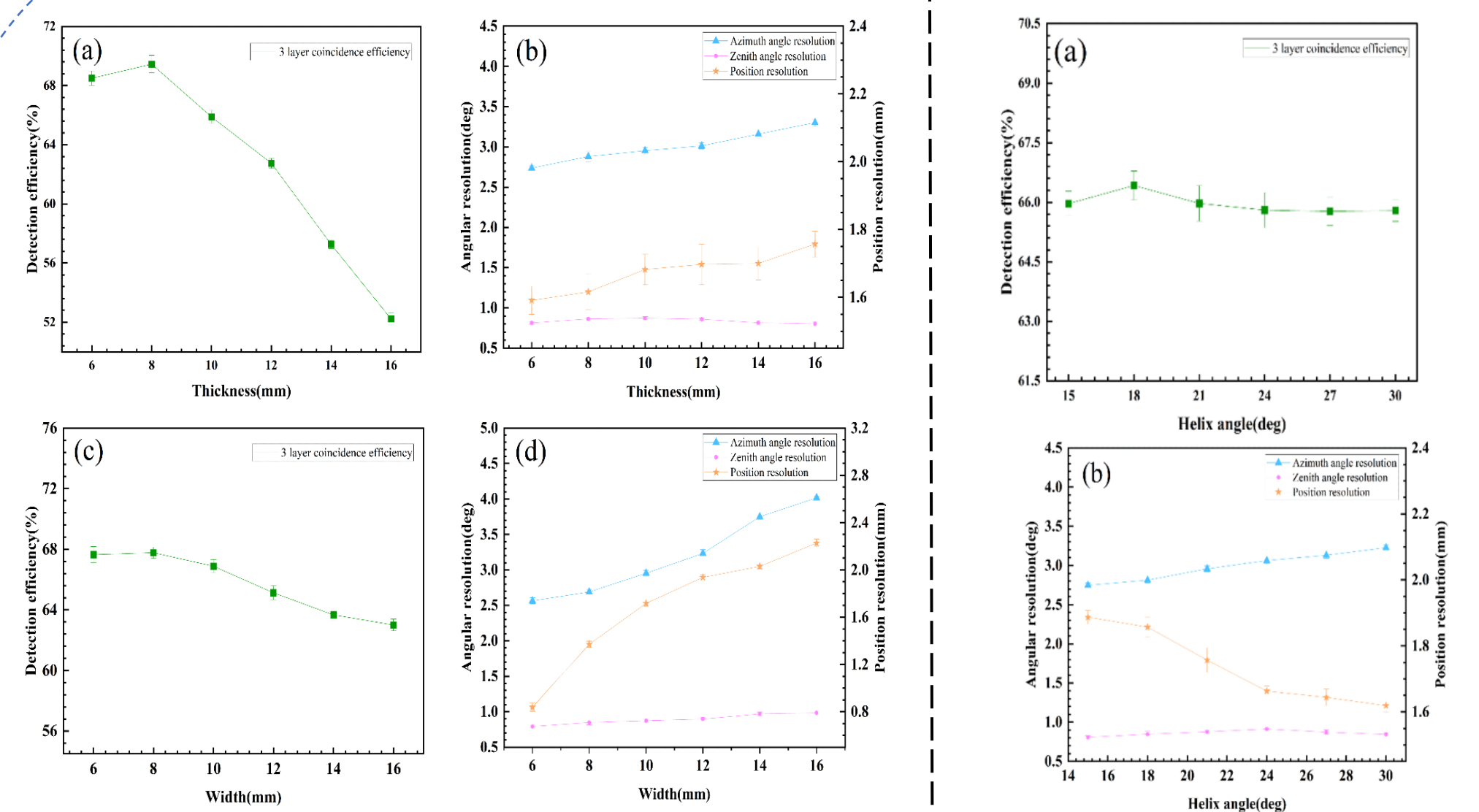


Muon Kinetic Energy (GeV)



Muon pulse signals and pulse peak voltage distribution

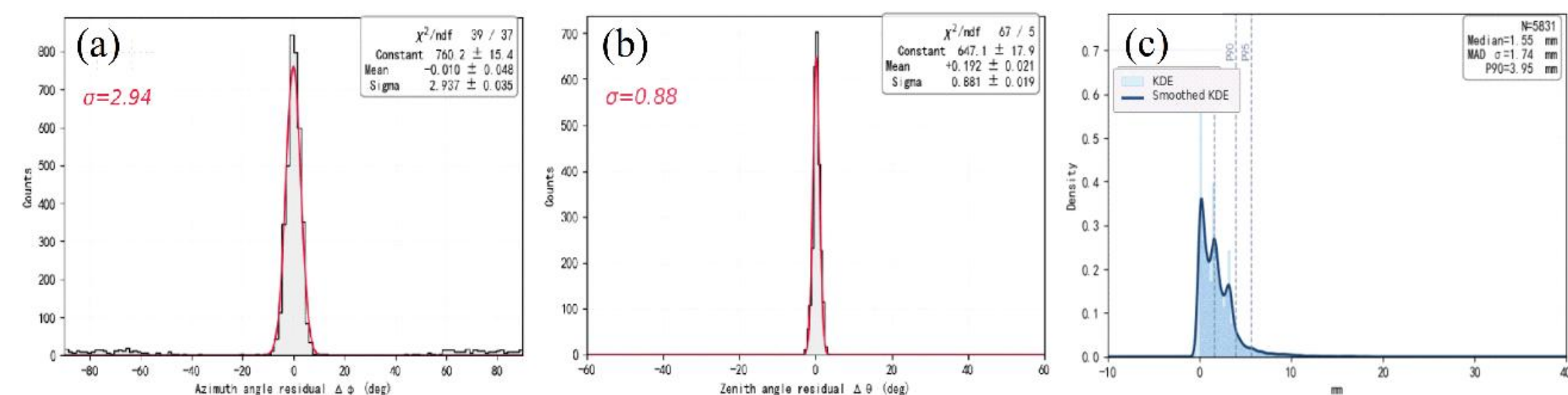
Simulation tests of detector-related parameters



Detection efficiency and resolution of the detector with different plastic scintillator sizes

Detection efficiency and resolution of the detector with different helical angles

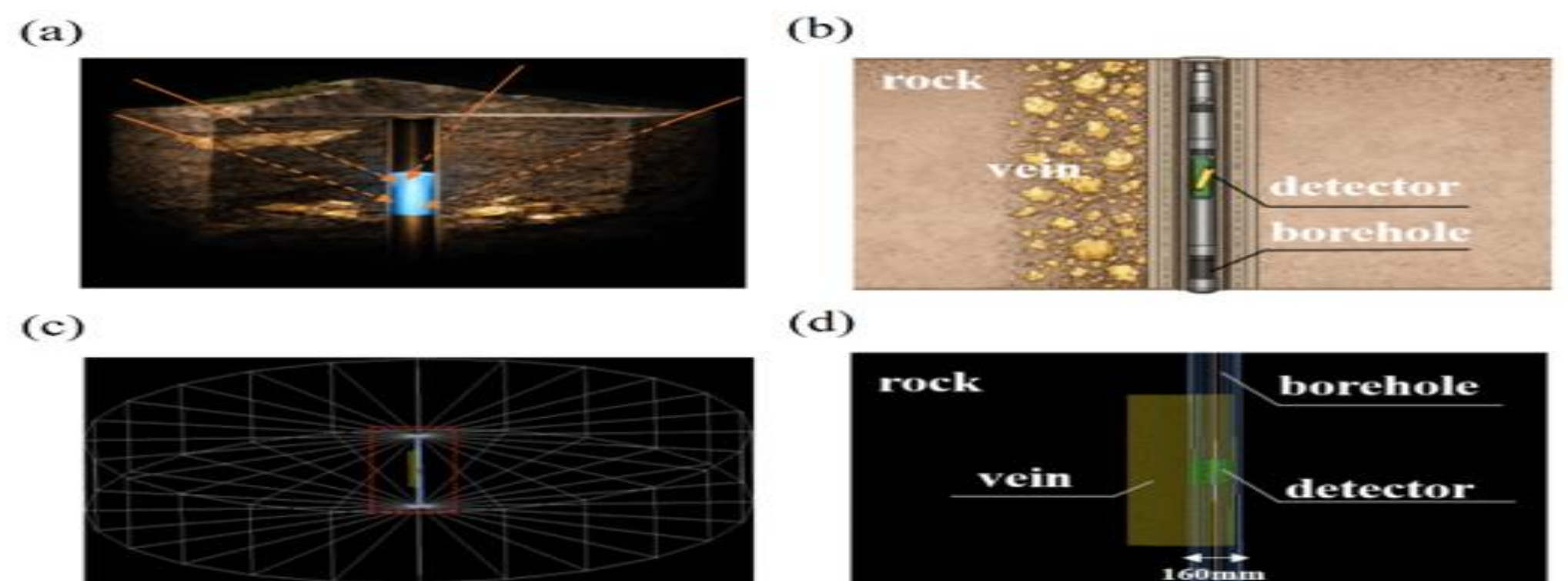
For a test with 20 million incident muons, 5,831 valid background counts were recorded.



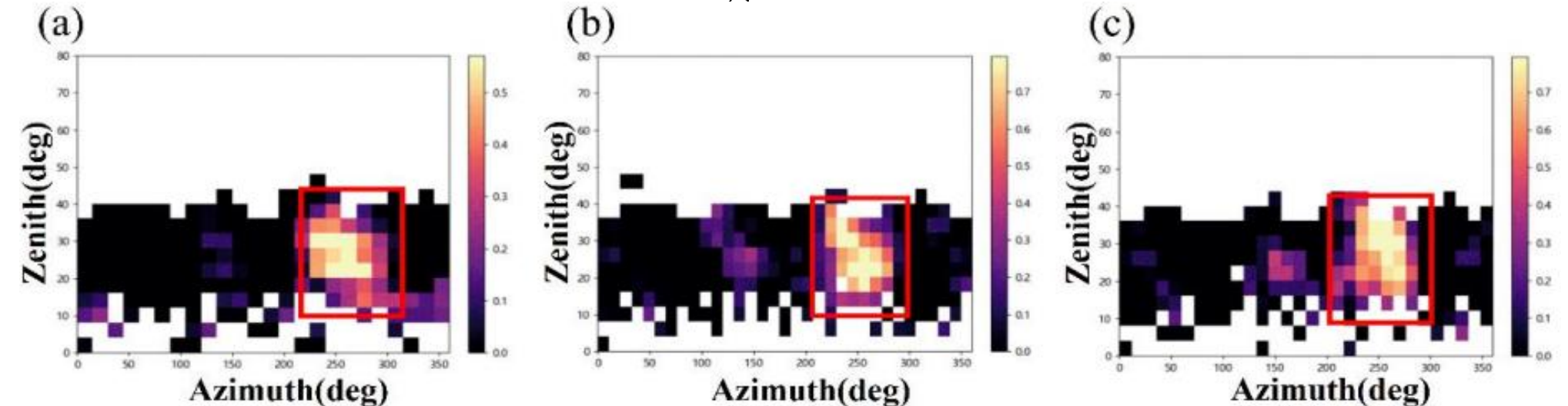
The simulated detector exhibits an azimuthal resolution of 2.94, a zenith resolution of 0.88, and a position resolution of 1.74 mm.

Simulated imaging results

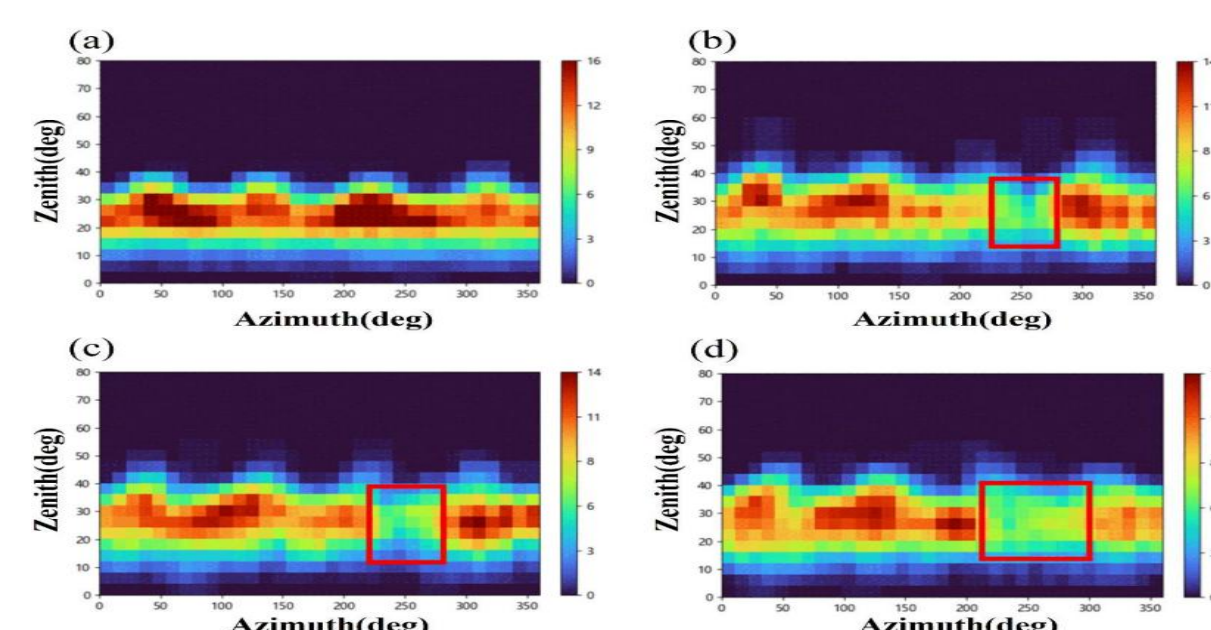
Schematic diagram of the simulation model



Schematic diagram of the simulation



Opacity images of chalcopyrite, hematite, and uranium ore



Muon flux maps with and without ore bodies