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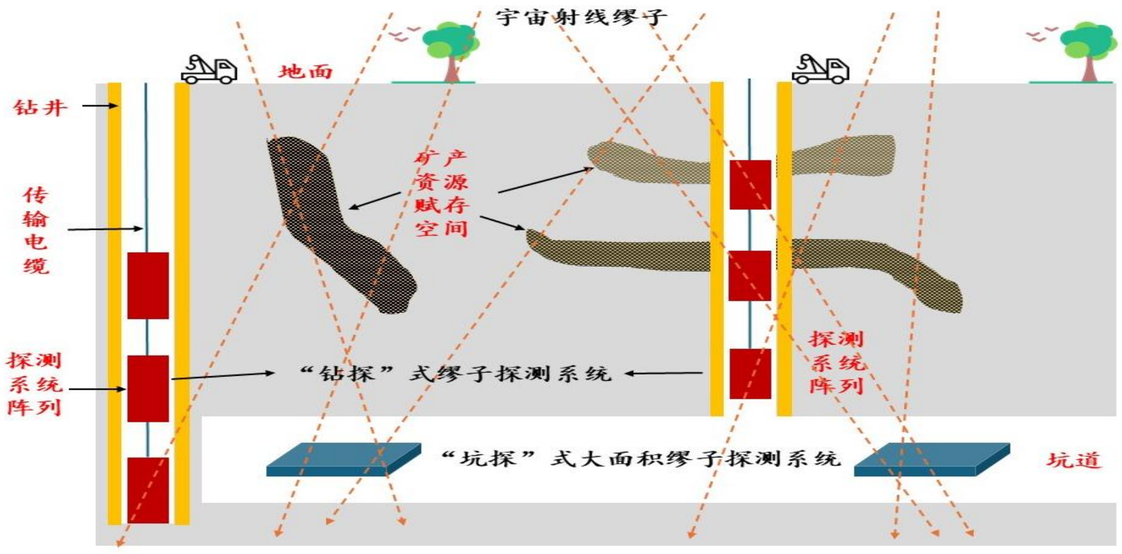
Development and Application Study of an Imaging System Based on Cosmic-Ray Muon Imaging Technology

Organization： School of Nuclear Science and Technology, University of South China, Hengyang 421001, China
Key Laboratory of Advanced Nuclear Energy Design and Safety, Ministry of Education, Hengyang 421001, China
Author： SiYuan Luo. Mao Shen. .LiZhi Wang. XuanKai Huang. ShuHao Zhao. EnZhe Cui. Xuan Liao. WenFeng Guo. XiaoDong Wang*

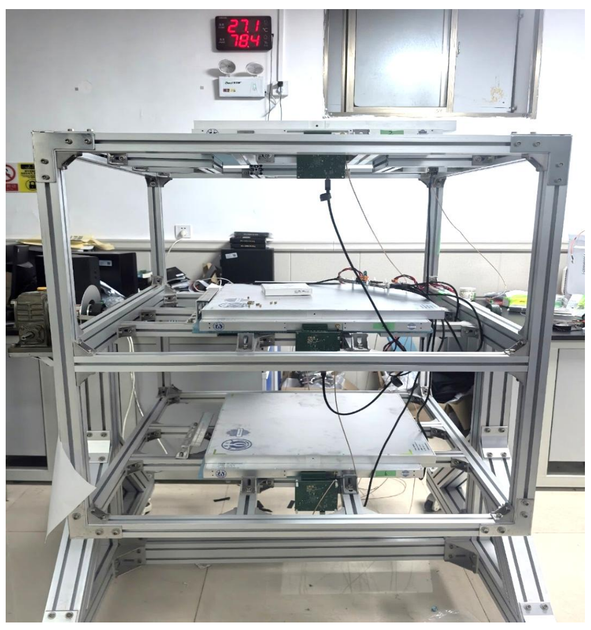
Introduction

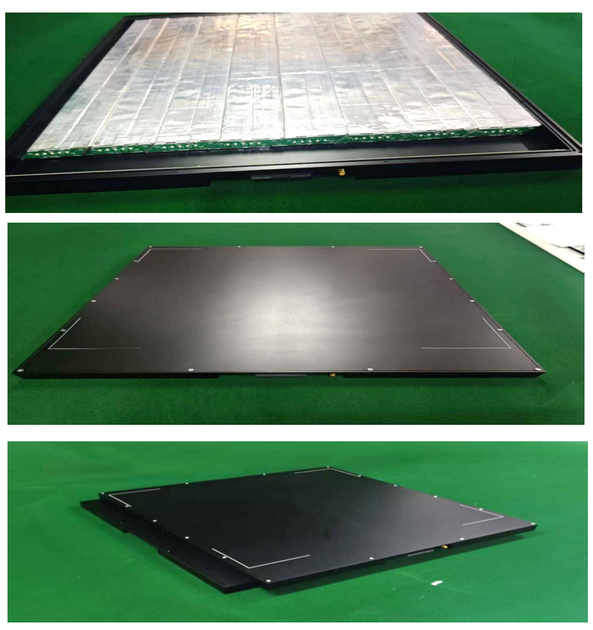
At present, cosmic-ray muon imaging for mineral exploration mainly includes tunnel-based and borehole-based methods. In tunnel-based detection, large-area planar detectors are placed in existing galleries to image the overlying strata, which is suitable for nearly vertical ore bodies. In borehole-based detection, compact detectors are deployed at different depths to form a vertical array, allowing the surrounding strata to be scanned from multiple depths and providing more comprehensive subsurface information.



1. Tunnel-Based Muon Imaging System

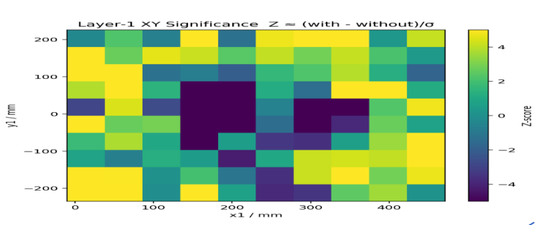
In this study, a large-area muon imaging system was developed using triangular plastic scintillators coupled with photoelectric conversion devices. The system has an active detection area of 500 mm × 500 mm and achieves millimeter-level position resolution.





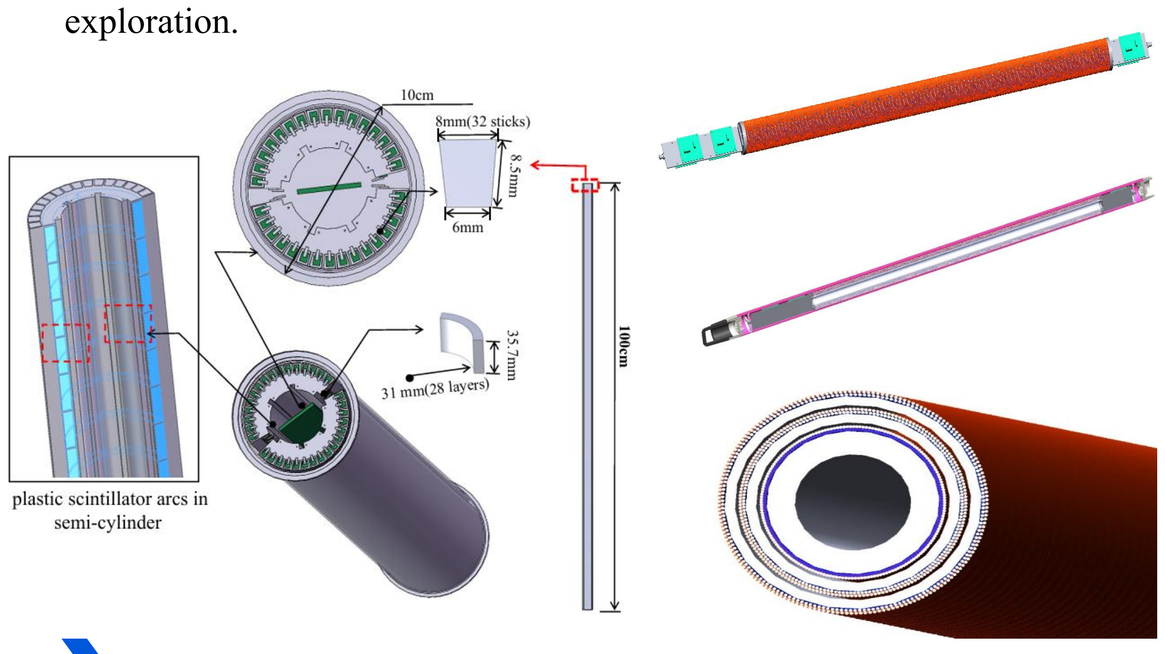
Detector System

ASIC-Based Data Acquisition System

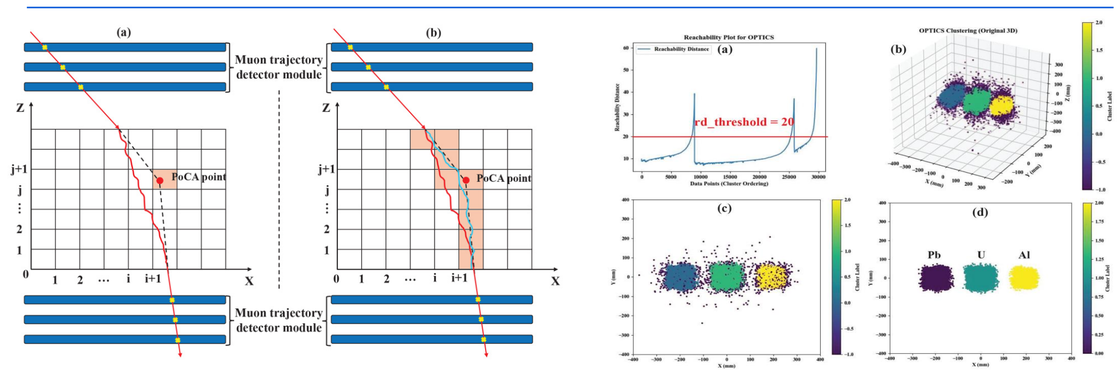


2、Borehole-Based Muon Imaging System

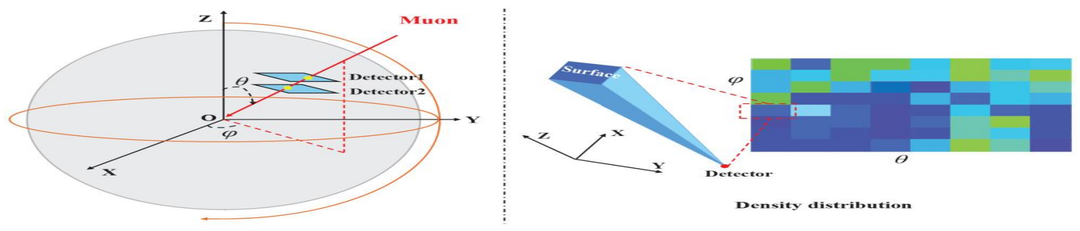
In this study, a borehole-based muon imaging system was developed using arc-shaped and wedge-shaped plastic scintillator detector units. The system supports joint detection with multiple boreholes. It can also combine muon data with subsurface density models obtained from conventional geophysical methods, such as seismic and gravity surveys, for joint inversion, thereby improving the accuracy of deep mineral resource exploration.



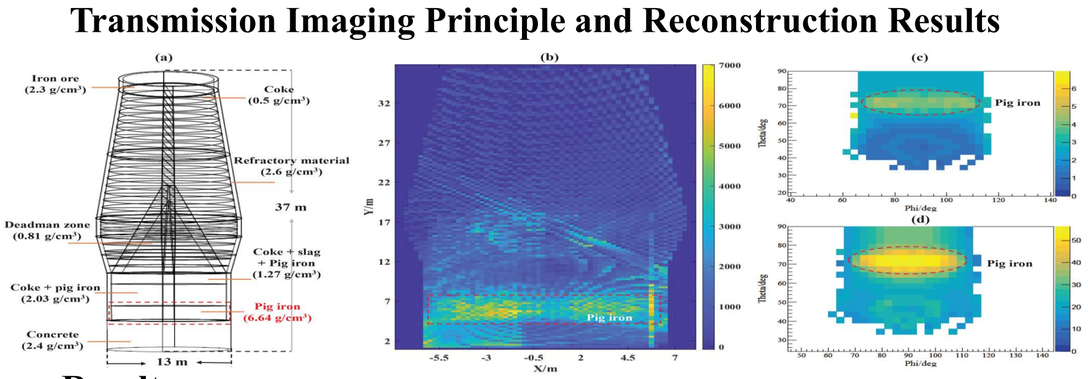
3、Imaging Algorithms and Simulation Results



Scattering Imaging Principle and Reconstruction Results



Transmission Imaging Principle and Reconstruction Results



Result

Cosmic-ray muon imaging can non-destructively provide three-dimensional density information of underground ore bodies. Combined with conventional exploration methods, it can improve exploration efficiency, reduce cost, and help identify ore-body location, morphology, and spatial structure. As a green exploration technique, muon imaging is expected to become an important supplement for deep mineral resource exploration.