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A New Method for Measuring the Pion-Air Cross Section at Multi-TeV Energies Using Muon Bundle Properties in Deep Underground Detectors

The interaction cross section of charged pions with air nuclei is a critical parameter for accurately simulating extensive air showers. Improving the modeling of high-energy pion interactions is essential for addressing the muon puzzle—the observed deficit of muons in simulations compared to indirect experimental estimates. As collider experiments cannot directly probe these interactions, we propose a novel measurement approach using muon bundles detected in deep-underground water Cherenkov detectors, such as IceCube and KM3NeT. This method aims to constrain the pion–air inelastic cross section, thereby reducing uncertainties in air shower simulations and advancing our understanding of cosmic ray interactions.

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