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Flux and Threshold Estimation of Ultra High Energy Deep Underground Muons

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Deep underground muons are high-energy muon that can travel a certain distance through rock or water and enter underground detectors. They are mainly derived from the decay of π and K mesons which are produced by cosmic ray interactions with Earth's atmosphere and may also be produced by charged-current reactions of high-energy atmosphere muon neutrinos or astrophysical muon neutrinos as they travel through rocks or sea. For distance about 10 km through rocks, these muons can correspond to energy scales of more than 100 TeV. In the Daya Bay experiment, for example, the muon energy scale running horizontally through the two halls reaches 10 PeV. By investigating these muons, behaviors of quarks and gluons under extreme conditions can be observed, validating and exploring the applicability of QCD under high-energy, high-density scenarios. At the same time, we have the opportunity to study the atmospheric charged kaon/pion ratio, the seasonal variations of the underground muon flux, and the composition of primordial cosmic rays. In my work, using the Daya Bay Neutrino Experiment as an example, starting the simulation from the primordial cosmic ray with H3A model, we simulate the reaction of different components of primordial cosmic rays with the atmosphere, and from the results it is possible to obtain the atmospheric charged kaon/pion ratio and the muon fluxes and energies from all zenithal directions. We then simulate these muons as they travel through 20 km of water and 10 km rock until their energy is less than 10 MeV. We can give flux and threshold cases based on the results of the simulation and comparison with different QCD models. Finally, by transforming the atmospheric density model to simulate seasonal temperature variations, we can also give seasonally varying underground muon flux profiles.

Collaboration (if any)

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