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Probing Extensive Air Shower Primaries and Their Interactions by Combining Individual Muon Tracks and Shower Depth

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Abstract : The current large area cosmic ray detector surface arrays typically measure only the net flux and arrival-time of the charged particles produced in an extensive air shower (EAS). Measurement of the individual charged particles at a surface array will provide additional distinguishing parameters to identify the primary and to map the very high energy interactions in the upper layers of the atmosphere. In turn, these may probe anomalies in QCD interactions at energies beyond the reach of current accelerators. The recent attempts of studying the individual muon tracks are limited in their expandability to larger arrays and can only probe primary particles with energy up to about 10^15.5 eV. New developments in detector technology allow for a realistic cost of large area detectors, however with limitations on energy resolutions, directional information, and dynamic range. In this study, we perform a simulation study using CORSIKA to combine the energy spectrum and lateral spread of the muons with the longitudinal depth (Xmax) of an EAS initiated by a primary at ultra high energies (10^{16} – 10^{19}) eV. Using proton and iron as the shower primaries, we show that the muon observables and Xmax together can be used to distinguish the primary. This study can be used to design a future detector for the surface array, which will be able to enhance our knowledge of primaries and QCD interactions.

Keywords : ultra high energy extensive air shower, muon tracking, air shower primaries, QCD interactions
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