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Measurement of cosmic ray mean mass around the knee region by muon content in air showers with LHAASO-KM2A

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The number of muons observed at the ground from air showers is sensitive to the mass composition of cosmic rays. The KM2A sub-array of the Large High Altitude Air Shower Observatory (LHAASO) can measure the size and muon content of an air shower simultaneously with high precision for cosmic rays with energies in the knee region. In this paper, the performance of the KM2A is validated in that the experimental data agree well with simulation data. The mean number of muons in air showers is measured by analyzing the signal of muon detectors in the first KM2A quarter-array for cosmic rays with energies from hundreds of TeV to tens of PeV. The energy is reconstructed with one new combined variable $N_{\mu e}$, which is weakly dependent on the components of cosmic rays. There is no obvious excess in muon abundance at least up to 30 PeV form comparison with the simulation results of protons and irons. The mean logarithmic mass of cosmic rays as derived from the mean number of muons is presented along with systematic errors from the energy scale and hadronic models and compared with that from other experiments. We find the mean mass of cosmic rays is almost constant before the knee region and afterwards becomes heavy.

Primary authors: Prof. FENG, Cunfeng (shandong university); ZHANG, Hengying (Shandong University)

Co-authors: Dr LI, Cong (IHEP); Prof. HE, Huihai (Institute of High Energy Physics, CAS); Mr CHEN（陈）, songzhan（松战）(中科院高能物理研究所)

Presenter: ZHANG, Hengying (Shandong University)

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