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A measurement of the muon number of extensive air showers from cosmic ray collisions using the data from KASCADE-Grande

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Recent analyses of the muon content in extensive air showers produced by cosmic rays above 100 PeV reveal an excess in the data in comparison with Monte Carlo (MC) simulations. These differences point out problems of the high-energy hadronic interaction models, which are not yet understood. In this regard, measurements of different experiments are important, since they could provide some clues to find the origin of the anomaly. This way, the measurements of the muon data from KASCADE-Grande could be helpful. In this analysis, we provided measurements of the total muon number of hadronic air-showers as a function of the primary energy from 100 PeV to 1 EeV and for three zenith-angle intervals [0°, 21.78°], [21.78°, 31.66°] and [31.66°, 40°]. The data was measured with the KASCADE shielded array for threshold energies of 230 MeV (vertical incidence). For energy calibration, we used as a reference the predictions of the MC simulations for the Global Spline Model of cosmic rays, shifted in energy to match the spectrum of Pierre Auger observatory. The analysis was carried out using the expectations from the QGSJET-II-04, EPOS-LHC and SIBYLL 2.3d hadronic interaction models. When comparing with the model predictions for iron and hydrogen nuclei, we found no excess of the measurements on the muon number, on the contrary, a deficit in the data is observed for vertical showers, and a reasonable agreement with the data for inclined events. We also found that the measured muon content in air showers has a smaller effective attenuation in the atmosphere than predicted by MC simulations in agreement with a previous KASCADE-Grande result on the attenuation length of shower muons.

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