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The muon deficit problem: a new method to calculate the muon rescaling factors and the Heitler-Matthew's β-exponent

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Simulations of extensive air showers using current hadronic interaction models predict too small number of muons compared to events observed in the air shower experiments, which is known as the muon deficit problem. In this work, we present a new method to calculate the factor by which the muon signal obtained via Monte-Carlo simulations must be rescaled to match the data, as well as the β exponent from the Heitler-Matthew's model which governs the number of muons found in an extensive air shower as a function of the mass and the energy of the primary cosmic ray. This method uses the so-called z variable (difference between the total reconstructed and the simulated signals), which is connected to the muon signal and is roughly independent of the zenith angle, but depends on the mass of the primary cosmic ray. Using a mock dataset built from QGSJetII-04, we show that such a method allows us to recover the muon signal from this dataset using Monte-Carlo events generated with the EPOS-LHC hadronic model, within less than 6% on average, and the average β exponent for the studied system, within less than 1%, which is a consequence of the good recovery of the muon signal for each primary included in the analysis. Detailed simulations show a dependence of the β exponent on hadronic interaction properties, thus the determination of this parameter is important for understanding the muon deficit problem.

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