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Muon content of air-showers - methods of studying the problem and recent results

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Observations of extensive air showers are used to probe hadronic interactions at energies much higher than in any experiments at man-made accelerators. One important observable, that can provide some constraints on the interaction models, is the muon content of air showers. This observable is also crucial in determination of the composition of the primary cosmic rays - it is expected that the muon content of air showers should increase with increasing mass of the primary particle. Recent results obtained by the Pierre Auger Observatory and other experiments show that the observed muon content is significantly larger than predicted by air shower simulations, that are performed using current hadronic interaction models. This discrepancy between results of observations and simulations is known as the muon-deficit problem. In this presentation different approaches to study the problem will be shown. The top-down method is used for comparing observed and simulated air showers, which enables calculating the rescaling factors for the muonic component of the signal; this method also allows us to calculate the beta exponent of the Heitler-Matthews model, which describes the relation between the number of air-shower muons and the primary mass and energy. New studies of the problem, that also allow changes of the depth of the shower maximum, show that the muon deficit might be smaller than previous estimates. The most recent updates of the hadronic interaction model, EPOS LHC-R, seem to lead to larger numbers of muons in air showers - this would further decrease the discrepancy. In the next years the AugerPrime upgrade, especially with new surface scintillators and underground detectors, will provide high-quality measurements enabling precise determination of the muon component of air showers.

Primary author: PĘKALA, Jan (Instytut Fizyki Jądrowej PAN, Kraków)

Presenter: PĘKALA, Jan (Instytut Fizyki Jądrowej PAN, Kraków)

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