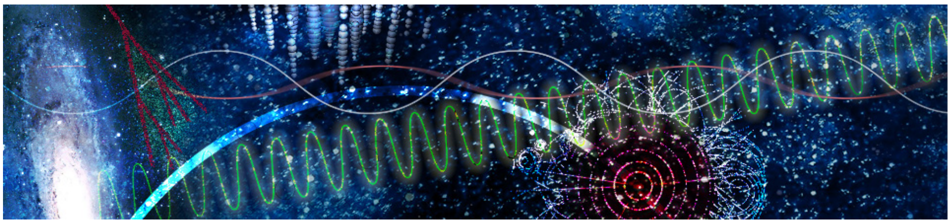

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# Reconstruction of muon number of air showers with the surface detector of the Pierre Auger Observatory using neural networks

To understand the physics of cosmic rays at the highest energies (above $10^{18}$ eV), it is essential to have an accurate knowledge of their mass composition. At these energies the direct detection of cosmic rays is unfeasible due to their scarcity. However, using Earth's atmosphere as a calorimeter, it is possible to observe the cascade of secondary particles. Hence, to gain insight into the composition of cosmic rays, we must rely on the analysis of mass-sensitive observables related to these cascades. A promising observable for this purpose is the number of muons at the ground relative to that of an air shower induced by a proton primary of the same energy and inclination angle, commonly referred to as the relative muon number $R_\mu$.

Due to the complexity of shower footprints, the extraction of $R_\mu$ from measurements is a challenging task and intractable to solve using analytic approaches. We, therefore, reconstruct $R_\mu$ by exploiting the spatial and temporal information of the signals induced by shower particles using artificial neural networks. Using this data-driven approach permits us to tackle this task without the need of modeling the underlying physics and, simultaneously, gives us insights into the feasibility of such an approach.

In this contribution, we summarize the progress of the deep-learning-based approach to estimate $R_\mu$ using simulated surface detector data of the *Pierre Auger Observatory*. Instead of sticking to one single architecture, we present different network designs verifying that they achieve similar results. Moreover, we demonstrate the potential for estimating $R_\mu$ using the scintillator surface detector of the *AugerPrime* upgrade.

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