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Deep Learning for Air Shower Reconstruction at the Pierre Auger Observatory

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The measurement of the mass composition of ultra-high energy cosmic rays constitutes one of the biggest challenges in astroparticle physics. Detailed information on the composition can be obtained from measurements of the depth of maximum of air showers, Xmax, with the use of fluorescence telescopes, which can be operated only during clear and moonless nights.

Using deep neural networks, it is now possible for the first time to perform an event-by-event reconstruction of Xmax with the Surface Detector (SD) of the Pierre Auger Observatory. Therefore, previously recorded data can be analyzed for information on Xmax, and thus the cosmic-ray composition. Since the SD operates with a duty cycle of almost 100% and its event selection is less strict than for the Fluorescence Detector (FD), the gain in statistics with respect to the FD is almost a factor of 15 for energies above $10^{19.5}$ eV.

In this contribution, we introduce the neural network particularly designed for the SD of the Pierre Auger Observatory. We evaluate its performance using three different hadronic interaction models and verify its functionality using Auger hybrid measurements.
Finally, we quantify the expected systematic uncertainties and show that the method permits to determine the first two moments of the Xmax distributions up to the highest energies.

Type of Contribution

talk

Primary author: GLOMBITZA, Jonas (RWTH AACHEN UNIVERSITY)

Presenters: GLOMBITZA, Jonas (RWTH AACHEN UNIVERSITY); FOR THE PIERRE AUGER COLLABORATION

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