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## Probing hadronic interactions with the Pierre Auger Observatory

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Cosmic Rays are high-energetic particles of cosmic origin constantly bombarding Earth. Their energies extend beyond  $10^{20}$  eV, 400 TeV in the center of mass system for proton-proton collisions. Such energies are well above those achieved by LHC and therefore hadronic models in this range rely on extrapolations from energies several orders of magnitude lower. Cosmic rays offer therefore the unique possibility to test the hadronic interactions in a range unattainable by accelerators. Moreover, using cosmic rays one can explore the high pseudorapidity regime as well as high-energetic proton-nucleus and nucleus-nucleus interactions, well studied only at lower energy.

The Pierre Auger Observatory is the largest Cosmic Ray observatory ever built ( $3000 \text{ km}^2$ ), operating since 2004 in the Argentinian Pampa. In this contribution an overview of the results obtained by our collaboration will be given with a special focus on the particle physics implications. We will show the proton-Air cross section at 38.7 and 55.5 TeV. Our data indicate that hadronic interaction models fail in the predictions of the muon densities on the surface. The activities to investigate this inconsistency will be presented. Current activities for the search of hypothetical Lorentz Invariance Violation will be also briefly discussed.

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