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Particle Physics Studies at the Pierre Auger Observatory

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The Pierre Auger Observatory is the world's largest facility dedicated to the study of ultra-high-energy cosmic rays. By observing extensive air shower cascades produced when cosmic rays interact with the Earth's atmosphere, the Observatory enables indirect measurements of hadron-air collisions at center-of-mass energies that exceed those achievable by the Large Hadron Collider.
Analyses of global shower observables, such as the depth of shower maximum and the ground-level signals associated to the muonic component have revealed significant discrepancies between experimental data and predictions from current hadronic interaction models. In particular, a persistent muon deficit in simulated showers has sparked a range of new investigations aimed at better understanding hadronic interactions at extreme energies.
To address these challenges and enhance its sensitivity to the primary mass composition, the Observatory is undergoing a major upgrade known as AugerPrime. This upgrade introduces new detector components capable of disentangling the various constituents of the air shower, opening the door to more detailed studies of its development and the underlying particle physics.

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