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Ultra-High-Energy Cosmic Rays at the Pierre Auger Observatory: Insights and Future Directions

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For about 20 years, ultra-high-energy cosmic rays (UHECRs) have been studied using data from the Pierre Auger Observatory, the world's largest cosmic ray detector. A key feature of the observatory is its hybrid set-up, which detects UHECRs by observing the associated extensive air showers (EAS) using various complementary techniques. Analyses of the multi-detector data have enabled high-statistics and high-precision investigations into the UHECR energy spectrum, mass composition, and arrival direction distribution. This presentation summarizes the resulting scientific findings on UHECRs. While no discrete source of UHECRs has been identified, the extragalactic origin of the particles has recently been confirmed based on arrival directions above 8 EeV, and the possible source regions at higher energies are gradually being narrowed down. The presentation also discusses future prospects in light of the extensive upgrade program currently underway to further enhance the Observatory's capabilities.

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