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Indications of anisotropy at large angular scales in the arrival directions of cosmic rays detected at the Pierre Auger Observatory

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The large-scale distribution of arrival directions of high-energy cosmic rays carries major clues to understand their origin. The Pierre Auger Collaboration has implemented different analyses to search for dipolar and quadrupolar anisotropies in different energy ranges spanning four orders of magnitude. A common phase $\approx 270^\circ$ of the first harmonic modulation in right-ascension was found in adjacent energy intervals below 1 EeV, and another common phase $\approx 100^\circ$ above 4 EeV. A consistency of phase measurements in ordered energy intervals is expected to manifest with a smaller number of events than those needed for the detection of anisotropies with amplitudes standing-out significantly above the background noise. This led us to design a prescribed test aimed at establishing whether this consistency in phases is real at 99% CL. The test required a total independent exposure of 21,000 km^{2}sr yr. Now that this exposure has been reached, we report here the results for the first time. We also report the results of the search for a dipole anisotropy for cosmic rays with energy above 4 EeV including events with zenith angle between 60° and 80°. Compared to previous analyses of events with zenith angles smaller than 60°, this extension increases by 30% the size of the data set, and enlarges the fraction of exposed sky from 71% to 85%. The largest departure from isotropy is found in the energy range above 8 EeV, with an amplitude for the first harmonic in right ascension $r_1^\alpha = (4.4 \pm 1.0) \times 10^{-2}$, that has a chance probability $P(\geq r_1^\alpha) = 6.4 \times 10^{-5}$, reinforcing the hint previously reported with vertical events alone.

Collaboration

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