Probing UHECR and cosmic ray ensemble scenarios with a global CREDO network

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Executive summary

Among theoretical approaches in unveiling the physics of ultra-high-energy cosmic rays (UHECR) one can distinguish the models assuming interactions of exotic super-heavy matter (including extra dimensions, Lorentz invariance violation, cosmic strings, dark matter particles or particles beyond the standard model etc.) and acceleration scenarios describing processes, in which the particles are accelerated by a particular astrophysical object (shocks in relativistic plasma jets, unipolar induction mechanisms, second-order Fermi acceleration, energy transfer from black holes or compact stars etc.). Primary UHECR particles can produce cascades already above the Earth atmosphere, which may be detected as the so-called cosmic ray ensembles (CRE) – the phenomena composed of at least two cosmic ray particles, including photons, with a common primary interaction vertex or the same parent particle with correlated arrival directions and arrival times.

In this contribution, we give a brief summary of a novel approach to the cosmic ray scenario tests by the global Cosmic Ray Extremely Distributed Observatory (CREDO) network. In parallel to testing astrophysical scenarios the CREDO Collaboration develops the algorithms that will make us prepared to notice the unexpected physics effects if they come. These algorithms are based on identification of anomalies in the signals received by known and stable detectors. Once cosmic ray anomalies are efficiently identified, they should feed the global multi-messenger and multi-mission programs searching for correlations between different data channels, not only in astrophysics. Detailed explanation of the CREDO aims, its objectives, methods and tools is given in a recent review [1] and summarized in the proceedings of the ICRC2021 under the article ID 1448 "Invitation to the Cosmic Ray Extremely Distributed Observatory".

[1] P. Homola et al. for the CREDO Collaboration, "Cosmic-Ray Extremely Distributed Observatory", **Symmetry**, 12 (11), 1835, November 2020.