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Research Result Report
ICRR Inter-University Research Program 2025

Research Subject: Ultra-high-energy cosmic-ray origin studies with the Telescope Array and TAx4 surface detector
Principal Investigator: Grigory I. Rubtsov, Deputy director, Institute for Nuclear Research of the Russian Academy of Sciences
Participating Researchers: Oleg E. Kalashev (INR RAS), Ivan V. Kharuk (INR RAS), Maxim S. Pshirkov (INR RAS), Sergey V. Troitsky (INR RAS), Maria A. Kudenko (INR RAS), Konstantin A. Dolgikh (INR RAS), Mikhail Yu. Kuznetsov (INR RAS), Igor I. Tkachev (INR RAS), Shoichi Ogio (ICRR, University of Tokyo), Takashi Sako (ICRR, University of Tokyo), Hiroyuki Sagawa (ICRR, University of Tokyo)
Summary of Research Result: Ground-based full-sky studies of the angular distribution of arrival directions of ultra-high-energy cosmic rays require combining data from different observatories, such as the Pierre Auger Observatory (Auger) and the Telescope Array (TA), because no single array can cover all declinations. In the framework of the joint Auger and TA working group we have obtained new results using the latest data from TA. We have updated large scale anisotropy analysis using new atmospheric corrections to the energy of the TA data. Most of our results remain similar to ones obtained previously, except for those at the highest energies, where the dipole and quadrupole have become marginally more significant. The dipolar modulation is the only anisotropy that is significantly identified in the angular power spectrum. There is an indication of quadrupolar anisotropy at the highest energy bin (2.9σ). For the intermediate-scale analysis, we have introduced new data from the TA, using a dataset with looser cuts at the highest energies. For the first time in full-sky analyses, we also taken into account the energy losses of UHECRs. Furthermore, we have extended the analysis to include two more source catalogues. The correlation with starburst galaxies remains the most significant, at 4.2σ post-trial, even after the inclusion of attenuations, which primarily enhanced the correlation with the all-galaxy catalogue. We have studied the harmonic autocorrelation and cross-correlation methods. Our results show that, given an appropriate source catalogue, the cross-correlation can yield a clearer signal than the harmonic auto-

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correlation. In the future, this approach could serve as a robust tool for source matching, less sensitive to the specific characteristics of the Galactic magnetic field.

We report updated limits on the diffuse photon flux using Telescope Array's Surface Detector data collected over 14 years of operation. The method employs a neural network classifier to effectively distinguish between proton-induced and photon-induced events. The input data include both reconstructed composition-sensitive parameters and raw time-resolved signals registered by the Surface Detector stations. To mitigate biases from Monte Carlo simulations, we fine-tune the network with a subset of experimental data. We have tested the result dependence on the high-energy hadronic model, the resulting impact on the exposure does not exceed 7%.

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