Research Report
ICRR Inter-University Research Program 2020

Research Subject: Ultra-high-energy cosmic-ray origin studies with the Telescope Array and TAx4 surface detector

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Summary of Research Result:
The extremely low flux of ultra-high energy cosmic rays (UHECR) makes their direct observation practically impossible. For this reason all current and planned UHECR experiments detect cosmic rays indirectly by observing the extensive air showers (EAS) initiated by cosmic ray particles in the atmosphere. The world largest statistics of the ultra-high energy EAS events is recorded by the networks of surface stations: the Telescope Array Observatory at the North Hemisphere and the Pierre Auger Observatory at the South Hemisphere. The Telescope Array (TA) Surface Detector (SD) is an array of 507 stations, each containing two layers plastic scintillator with an area of 3 m^2.
We propose a novel approach for reconstruction of the arrival direction of the primary particle based on the deep convolutional neural network. The latter is using raw time-resolved signals of the set of the adjacent trigger stations as an input. The training of the model is performed with the Monte-Carlo dataset. It is shown that within the Monte-Carlo simulations, the new approach yields better resolution than the traditional reconstruction method based on the fitting of the EAS front.
The angular resolution for proton induced showers is improved from 1.35° to 1.07° at the primary energy of 1 EeV, from 1.28° to 1.00° at the primary energy of 10 EeV and from 0.99° to 0.75° at the primary energy of 57 EeV. The result is especially important for the point source search, since background flux is proportional to the square of the angular resolution.

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