

Research Report

ICRR Inter-University Research Program 2021

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 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 m².

We have developed an architecture of the deep learning method for identifying primary particle types of the TA SD events. The method is based on the chain of two neural networks. The first works as a classifier for individual events, while the second predicts fractions of elements in an ensemble of events based on the inference of the first network.

An upper limit on the flux of ultra-high-energy down-going neutrinos for $E > 10^{18}$ eV has been derived with the nine years of data collected by the TA SD (05-11-2008 - 05-10-2017). The method of the analysis is based on the multivariate analysis technique, so-called Boosted Decision Trees (BDT). The proton-neutrino classifier is built upon 16 observables related to both the properties of the shower front and the lateral distribution function. The new method have been developed based on the deep convolutional neural network. The preliminary results show substantial improvement of the sensitivity to the primary photons.

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