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Analysis of the time structure of extensive air showers with E<=10¹⁶ eV based on data from the Horizont-T facility at the Tien Shan high-mountain scientific station of the Lebedev Physical Institute

The Horizont-T installation at the Tian Shan High-Mountain Scientific Station of the Lebedev Physical Institute (LPI/FIAN), located at an altitude of 3350 meters above sea level, is designed for the detection of extensive air showers (EAS) of ultra-high energies with axis inclinations up to 70°. The capabilities of the equipment allow for digitization of signals recorded by scintillation detector stations with a resolution of 2 ns, enabling studies of the time structure of EAS, including so-called multimodal events or events with delayed particles signals that appear as multiple pulses separated in time.

In the first stage, a simplified simulation of EAS signals with energies of $10^{16}-5 \times 10^{18}$ eV in the detectors of the Horizont-T prototype was performed using the classical Corsika-77500 code with the commonly used QGSJETII-04 hadronic interaction model. It was shown that the occurrence of multimodal events can be explained without invoking exotic particles or interactions, but rather by the arrival of several particles or groups of particles from a single EAS within the detector's time gate.

The second stage of the study was based on the analysis of specially collected experimental data from Horizont-T, consisting of random low-energy background events. The potential contribution of low-energy ($E \le 10^{12}$ eV) showers to the recorded signals from high-energy EAS was investigated. Low-energy events simulated using Corsika-77500 were analyzed, and conclusions were drawn regarding the optimal parameters for simulations and the contribution of random low-energy showers to the time profiles registered from high-energy EAS events.

In the third stage of the work, the developed event processing algorithms for Horizont-T were applied to analyze a dataset of EAS events with energies near the detection threshold of the installation—approximately 5×10^{16} eV. This experimental dataset is used to study the phenomenology of multimodal events in comparison with artificial EAS events generated using Corsika-77500.

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