

## Brief information about the project

Name of the project	AP09058049 «Study of extensive air showers with delayed fronts»
Relevance	The HORIZON-T installation consists of 10 temporal points with a resolution of ~6 ns distributed at distances of up to 1 km. In addition, there is a calorimeter is running at the station and a burst detector with an area of 200 m <sup>2</sup> is in the electronics modernization stage. Indirect data indicate that unusual EAS can consist of several jets having different geometric paths and corresponding delays.
Purpose	The addition of the HORIZON, calorimeter and BD installations, which are located on the basis of TSHMSS, with temporary detectors and the organization of their work.
Objectives	<ol style="list-style-type: none"> <li>1. To achieve the project aim, the following tasks should be completed:</li> <li>2. Development of the design of temporal detectors.</li> <li>3. Calibration of detectors by single muons or accelerator beams.</li> <li>4. Adjustment and development of the registration system and an electronic part of the detectors.</li> <li>5. The inclusion detectors in the HORIZON-T installation.</li> <li>6. Development of a wizard for launching a new system of detectors of the HORIZON-T installation.</li> <li>7. Synchronize the joint operation of the HORIZON-T installations, the calorimeter and the burst detector.</li> </ol>
Expected and achieved results	<p>The hardware part was developed, and a project describing the design of this hardware part was drawn up. The optimal solution for use as a scintillator was decided to use optical glass of the K8 brand. This choice is due to several of its advantages, such as the absence of color, high uniformity, resistance to carbon dioxide, the ability to retain shape and ease of processing. The hardware, created based on optical glass, allows to register the air showers arrival direction.</p> <p>The algorithm of the installation management program was designed and created. To determine the angle of arrival of the EAS, the location of the detectors plays a major role. Based on the information about the detector operation and using the plane equations, the angle of incidence (zenith and azimuth angles) of air showers is determined.</p> <p>In this study, the energy losses of cosmic ray muons during their passage through an optical glass were analyzed. The characteristics of the initial distribution of energy losses, known as the Landau distribution, were evaluated by analyzing the response of optical glass when measuring the spectrum of single electrons of the photomultiplier.</p> <p>The integration of detector systems into the installations of HORIZON-T, calorimeter, and BD has been carried out. During the reporting period, the HORIZON-T system, the calorimeter, and the BD were integrated. At the moment, work is underway to establish electronics and synchronization</p>

	<p>with other installations. The purpose of the adjustment is to achieve the resolution of pulses from the EAS in the range of 5-10 ns. The integration of the detector system will allow to select events on the delayed fronts of the EAS from different installations. Also, work is underway to "standardize" data from all installations, i.e., so that all data is in a single format for further processing.</p> <p>The test launch of the expanded complex on the basis of TSHVNS at an altitude of 3340 m above sea level was carried out.</p>
<p>Research team members with their identifiers (Scopus Author ID, Researcher ID, ORCID, if available) and links to relevant profiles</p>	<ol style="list-style-type: none"> <li>1. Kalikulov Orazaly, PhD, h-index - 4. ORCID 0000-0003-1597-4935 Scopus Author ID 57191293718.</li> <li>2. Baktorz Aliya, PhD student, h-index – 1; ORCID 0000-0002-5103-8397 Scopus Author ID 57216946672.</li> <li>3. Utey Shynbolat, Индекс Хирша – 1; ORCID 0000-0001-6139-6107 Scopus Author ID 57200421098.</li> <li>4. Yerezhep Nurzhan, h-index - 1 ORCID 0000-0002-7457-2189 Scopus Author ID 57216954323.</li> <li>5. Shinbulatov Saken, h-index - 1 ORCID 0000-0002-5296-2530 Scopus Author ID 57200407833.</li> </ol>
<p>List of publications with links to them</p>	<ol style="list-style-type: none"> <li>1. О.А. Каликулов, Н.О. Садуев, С.Б. Шаулов, А.Н. Седов, В.В. Оскомов, Н.О. Ережеп, А.Е. Бактораз, Ш.Б. Утей, А.И. Жумабаев, Е.С. Мухамеджанов, С.К. Шинбулатов ПРОТОТИП УСТАНОВКИ ВРЕМЕННЫХ ДЕТЕКТОРОВ ДЛЯ ИССЛЕДОВАНИЯ ОСИ ПРИХОДА ШАЛ // Recent Contributions to Physics. – 2021. – №4 (79).</li> <li>2. A. Baktorz, N. Saduyev, O. Kalikulov, D. Beznosko, Y. Mukhamejanov, Sh. Utey, S. Shinbulatov, N. Yerezhep, A. Zhumabayev, V. Zhukov, A. Shepetov "CHRONOTRON" TIMING DETECTORS FOR EAS STUDIES // Proceedings of Science, 37th International Cosmic Ray Conference ICRC. – 2021. – Т. 395.</li> <li>3. S. Shinbulatov, N. Saduyev, D. Beznosko, O. Kalikulov, V. Zhukov, Y. Mukhamejanov, D. Kostunin, B. Karibayev, T. Namazbayev, A. Baktorz, N. Yerezhep, Sh. Utey, A. Zhumabayev, P. Bezyazeev, O. Fedorov HIGH-MOUNTAIN HYBRID INSTALLATION FOR MULTICOMPONENT DETECTION OF AIR-SHOWERS INDUCED BY ULTRA-HIGH ENERGY COSMIC RAYS // Proceedings of Science, 37th International Cosmic Ray Conference ICRC. – 2021. – Т. 395.</li> <li>4. Kalikulov O.A., Saduyev N.O., Shaulov S.B., Zhukov V.V., Beznosko D., Mukhamejanov Y.S., Yerezhep N.O., Baktorz A.Y, Shinbulatov S.K, Utey, Sh., Zhumabayev A.I., Sedov A.N., Oskomov V.V. STUDY OF THE SPATIOTEMPORAL STRUCTURE OF EXTENSIVE AIR SHOWERS AT HIGH ENERGIES // Journal of Instrumentation, 17 (4), 2022. (DOI 10.1088/1748-0221/17/04/C04014) (59-й перцентиль по Scopus).</li> </ol>
<p>Patents</p>	<p>-</p>