Referee report
on the JINR participation in the project
Tunka Advanced Instrument for cosmic ray physics and Gamma Astronomy (TAIGA)

The TAIGA gamma-ray observatory is designed to study gamma radiation and charged cosmic rays in the energy range of 10^{13} eV – 10^{18} eV. For this energy range, there are many fundamental questions, the answers to which still do not exist. First of all, this is the question of the sources of Galactic cosmic rays with an energy of about 1 PeV - the region directly adjacent to the classical "knee" in the spectrum of all particles ($3 \cdot 10^{15}$ eV), the most probable limit of proton acceleration in galactic accelerators.

In 2022, the deployment of the first stage of the TAIGA observatory, the TAIGA-1 astrophysical complex with an area of 1 km^2, was completed. Currently, the complex operates two of the most important installations for gamma-ray astronomy: TAIGA-HiSCORE (120 wide-field Cherenkov stations on an area of 1 km2) and TAIGA-IACT (3 atmospheric Cherenkov telescopes). Two more telescopes will begin operation in the next two years.

The scientific program of the TAIGA-1 complex includes the study of the energy spectrum of gamma rays from galactic sources (Crab Nebula, Dragonfly Nebula SNR: J2227+610 (G106.3+2.7), J2031+415 (Swan Cocoon), important for understanding the origin of cosmic rays, as well as long-term monitoring and study of the edge of the energy spectrum of bright blazars, the search for gamma-ray quanta associated with high-energy neutrinos detected by Ice-Cube and Baikal-GVD and gamma-ray bursts.

To date, according to the data collected during the deployment of the installation, the energy spectrum of gamma-ray quanta of the Crab Nebula in the range of 3-100 TeV has been restored, both from one, the first telescope, and from two telescopes in stereo mode. 10 events with an energy of approximately 100 TeV have been identified. For the first time, the "hybrid" method (events detected by telescopes and the TAIGA-HiSCORE installation) can be used to study the spectrum from the Crab Nebula. For 300 hours of observation of the source of gamma radiation in the Crab Nebula, the TAIGA-1 complex expects 40-60 gamma quanta with energies above 100 TeV. This number is comparable to 89 events registered by the LHAASO facility in 2500 hours.

During the last three seasons, in addition to the Crab Nebula, galactic sources have been observed at the astrophysical complex - the Dragonfly pulsar nebula, the Boomerang source associated with pulsar J2229+6114, and the supernova remnant (SNR) G106.3+2.7, the Cocoon nebula in the constellation Cygnus and two extragalactic sources – blazars Mrk-421 and Mkr-501. The signal from the Mrk-421 blazar is allocated at the level of 5 sigma, the level of significance of the signal from other sources is still at the level of 2-3 sigma. Data analysis continues.

The main goal of the next step of TAIGA project is to construct an installation TAIGA-10 with an area of approximately 10 km^2 and with sensitivity for the local sources at the level of 10^{-13} erg cm^{-2} s^{-1} in the energy range of 1 -1000 TeV. At such sensitivity, the TAIGA will compete in this energy range with the largest gamma-ray observatories CTA and the LHAAS0 . The TAIGA Observatory will be the northernmost gamma-ray observatory, and its location provides advantages for observation of sources with large declinations. So, gamma-ray source in the Tycho SNR, virtually inaccessible to HAWC and LHAASO will be in the field of view of the TAIGA-10 for 500 hours per year.

The collaboration includes representatives from 7 Russian (MSU, Irkutsk University, JINR, MEPHY, INR, IZMIRAN, Novosibirsk University) and 4 EU (Hamburg University, DESY, Max-Plank Institute for Physics (Munich), Torino University)) institutions. Since 2022, the participation of foreign partners (except the University of Turin) has been "frozen", but this has not significantly affected the work of the collaboration. Difficulties with the purchase of PMF for recording cameras 4 and 5 telescopes delayed the start of operation of these telescopes by 1-1.5 years.

The mechanical part of the fourth Cherenkov telescope was manufactured at JINR, sent and mounted at the test site, and in the spring of 2024, after preparing the recording camera, the telescope will begin observations. The mechanical part of the fifth telescope will be installed in the Tunka Valley in 2024.

The Dubna group made a significant contribution to the Monte-Karlo simulation of the installation. Currently, the group is developing an approach to the allocation of gamma quanta based on neural networks. This approach will be widely used in the analysis of experimental data in the next three years. Thus, my remark about the insufficient participation of the group in the processing and analysis of data is taken into account.

The members of the JINR group, as well as other participants of the TAIGA collaboration, can be recommended to publish the results already obtained as soon as possible. I would also like to encourage the participants of the TAIGA experiment to contact their colleagues from the Baikal experiment more closely in the analysis of particular events with similar and complementary characteristics.

In summary, the continuation of the TAIGA project is fully supported by me and I recommend to fund the request at its full volume with the first priority.

Professor Eduard Boos,
Member of PAC