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

As mentioned in my previous reports the main goal of the Gamma ray Observatory TAIGA is to study gamma-radiation and charged cosmic rays in the energy range of 10^{13} eV – 10^{18} eV. One hopes to find answers to a number of fundamental questions, in particularly, to the question of possible sources of Galactic cosmic rays with energies of about 1 PeV. The TAIGA project is designed to cover a large area of approximately 10 km^2 and reach the sensitivity for the local source flux of photons at the level of 10^{-13} erg cm^{-2} s^{-1} in the energy range of 30 -200 TeV. The TAIGA observatory will compete in this energy range with the largest planned gamma-ray observatory CTA and the Chiness LHAASO project. The expected sensitivity of the first phase of the TAIGA complex with an area of 1 km2 at an energy above 100 TeV exceeds the sensitivity of the installations currently operating in this energy field such as MAGIC, HESS, VERITAS, HAWC. The TAIGA observatory location provides certain advantages. For example, gamma-ray source in the Tycho SNR, virtually inaccessible for HAWC and LHAASO, will be in the field of view of the TAIGA for 500 hours per year. The scientific goals of the TAIGA observatory also include issues that are less related to astrophysics, but more to very fundamental problems, such as the search for photon-axion oscillations and violation of Lorentz invariance. This is closely related to experiments in the laboratories of particle physics.

The TAIGA 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 , Institute of Space Science (Bucharest, Romania, which is the JINR member state)) institutions.

The 2019-2020 season was rather successful for the collaboration. The complex's telescopes passed the important check - gamma quanta from the Crab nebula at a significance level of more than 6 sigma and from Mrk-421 blazar at a significance level of 5 sigma were highlighted.

The main responsibility of JINR group is a design of Imaging Atmospheric Cherenkov Telescope (IACT) , mechanics manufacturing and tests. The first IACT takes data since 2017. The second IACT produced during 2017 -18 is already in the Tunka valley and in operation from January of this year. The third telescope was sent to Siberia in April 2020. It should be emphasized that without the active work of the JINR group, the collaboration could not have obtained 3 telescopes successfully operating in the conditions of the Siberian climate in a short time.

After the second telescope starts operating at gamma-ray energies above 10 TeV, it becomes possible to use a stereoscopic approach - EAS from gamma-quanta is recorded by two and a large number of telescopes. This approach has been shown to be effective in modern gamma observatories (MAGIC, HESS, VERITAS) with a distance between telescopes of up to 100 m and will be used in CTA, small telescopes will be located at a distance of 250 m. TAIGA - the first installation that will begin to work in stereo regime with telescopes at a distance of 300 meters from each other. At energies above 40 TeV, a new "hybrid" approach to detecting gamma rays becomes possible - recording EAS with both telescopes and the TAIGA-HiSCORE setup (High Sensitivity COsmic Rays and gamma Explorer).

In plans of the JINR group for 2021-2023, the creation of the 4th telescope. This will lead to a further improvement in the sensitivity of the TAIGA complex, especially when operating telescopes in stereo regime.

JINR group also participates in shifts for the data taken, in MC simulation and data analysis. Following the previous recommendations, the plans for 2021-2023 include several proposals for physical analysis, in particular, the study of gamma rays from the Crab nebula, observation of the brightest galactic and extragalactic sources of gamma rays, the search for gamma rays with energies of more than 30 TeV from sources of Mkr-421 and Mrk-501 in hybrid observation mode, etc. These points describe the scientific program of all TAIGA collaboration. It can be recommended that a more specific physical task for the group be chosen in the future.

The experiment is under development, and it is currently difficult to require many publications of physical results. Nevertheless, the publication of methodological results obtained by the group should be carried out more actively.

The TAIGA project is aimed at solving very interesting scientific problems, is an international scientific project, has its own specifics and in some aspects complements or evolves other related international projects. The JINR research group plays a very prominent role in the collaboration TAIGA, has key areas of responsibility and makes significant scientific, methodological and material contributions. The financial request of the JUNE group is well justified.

Taking into account several recommendations mentioned above, I fully support the proposal of the JINR group for further participation in the TAIGA project, and I recommend financing the application with the first priority.

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