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

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 hoping 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 region includes the area of the classical "knee" in the spectrum of all particles ($3 \cdot 10^{15}$ eV), the most likely limit of the acceleration of protons in the galactic accelerators. The energy of gamma rays originated in such accelerators would extend up to 300 TeV, however so far there was not registered a single photon with energy greater than 100 TeV. The TAIGA project is designed to cover a large area of approximately 5 km^2 and to 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 gamma-ray observatory CTA , the Chiness LHAAS0 project and already operating American-Mexican HAWC array. 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 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.

Most of the ongoing efforts of the TAIGA collaboration are focused on the construction of the first stage of the detector TAIGA. The detector prototype will consist of ~ 100 wide angle timing Cherenkov stations (TAIGA-HiSCORE) and three imaging atmospheric Cherenkov telescopes (IAC) deployed over an area of ~ 1 km^2. The array installation is scheduled to be completed in 2019, and data collection can begin as early as the commissioning phase. The first seasons of operation of the TAIGA-HiSCORE and of the TAIGA-IACT demonstrated a good performance of the installation and showed yet preliminary but interesting results. During the winter season 2018-2019 the TAIGA configuration will include 54 operational wide angle stations arranged over the area of 0.5 km^2 and one IACT. Over the next year, it is planned to complete the deployment of the first phase of TAIGA. The joint reconstruction of energy, direction, and core position of the imaging and non-imaging detectors will allow to increase the distance between the IACTs up to 800 m, therefore providing a low-cost, highly sensitive detector. The relatively low cost, combined with a high sensitivity to energies $\geq$ 30-50 TeV, make this innovative technique very attractive for the study of galactic PeV cosmic rays. The first phase of TAIGA will begin observations in 2020, a few years earlier than competing projects (CTA, LHASS0) start to operate.

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 main responsibility of JINR group is the IACT design, 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 the production of the third telescope is going on now. 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.

JINR group organized a full production cycle of glass mirrors. It very important as for all atmospheric telescopes, the mirror mirrors cycle does not exceed 4-6 years, after which it is necessary to carry out recoating of mirrors. New mirrors will be useful for future Cherenkov telescopes and fluorescent detectors planned as part of the TAIGA installation.

JINR group participates in shifts for the data taken, in MC simulation and data analysis. One can recommend that this part of the group's activity should be expanded in the future.

In the presented work plan of the group, it is necessary to end up with a specific physical task, and not to describe the scientific program of the entire collaboration. One can recommend that in the near future the group will choose such a task.

The experiment is in the process of development and it is difficult to require the publication of serious physical results at the present time. Nevertheless, the publication of the methodological results obtained by the group should be carried out more actively.

The requested funding should be sufficient to carry out the planned program, taking into account the fact that the construction of cameras for telescopes was supported by the funds of the Ministry of Science of the Russian Federation. However, as far as is known, the experiment needs additional financial support. Therefore, it would be very desirable to provide the necessary funding from JINR for the full implementation of the project as soon as possible, given that the pace of construction of the facility is already behind the original schedule by 1 year.

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 team plays a very prominent role in the TAIGA collaboration, has certain areas of responsibility and makes significant scientific, methodological and material contributions. The JINR group's financial request seems quite reasonable.

Taking into account several recommendations mentioned above, the proposal of the JINR group for participation in the TAIGA project is fully supported by me, and I recommend funding the application in full.

E.Boos
Professor
Member of PAC