Referee report on the project: BAIKAL-GVD, Deep underwater neutrino detector on Lake Baikal (Gigaton Volume Detector)

After the discovery of a diffuse neutrino flux at energies above 10 TeV by IceCube, neutrino astronomy saw its rebirth. The subject of neutrino astronomy is now a well-established and motivated research topic. The unique feature of neutrino, weakness of its interaction, guarantees that neutrino fluxes from astrophysical objects provide complementary information in addition to the other astronomy and astrophysics methods. In addition, at high energies, neutrinos represent unambiguous markers of nonthermal processes in the Universe, in particular those related to acceleration of protons. This puts high-energy neutrino astronomy in the heart of multimessenger astrophysics. Neutrino data start helping to solve long-standing problems related to the origin of cosmic rays and energetic gamma radiation, but at the same time poses new, unexpected questions. The present experimentally observed intensity of the high-energy neutrino flux is comparable to theoretical upper limits on the flux from extra-galactic sources. Thus, it was a crucial point when that high energy diffuse neutrino flux was confirmed independently by Baikal-GVD data. Even more dramatic for understanding the nature of the flux was the first statistically significant coincident observation between neutrinos and gamma rays that were observed from a blazar activity having an intriguing nature. The neutrino's observations were made by the two largest neutrino telescopes, Baikal-GVD and IceCube. It has to be mentioned that those results that undoubtedly are on the leading edge of modern science were produced while the construction and commissioning of Baikal-GVD can be described as "only started". Intensive work performed by small but highly effective collaboration already demonstrated its ability to construct a world-leading scientific facility and produce physics results complementary to those of IceCube, whose cost and manpower are however orders of magnitude higher compared to those available for Baikal-GVD.

As Baikal-GVD is currently under construction at Lake Baikal, the presented Project represents the further development of efforts over the past decades by the Baikal Collaboration on the previous phases. It has to be noted that the detection principle used by Baikal-GVD was proposed by M. Markov long back ago, in 1960. Realization of the idea in an actual experiment required a lot of work and studies. Nevertheless, in Baikal experiment now, the optical properties of the deep water are well understood, methods for detector construction from the ice in winter time was efficiently approved, and as a result, the detection of high-energy neutrinos has been successfully demonstrated. Some Baikal-GVD features make that scientific instrument of particular importance: first, it has a unique angular resolution, which is essential for the search and identification of neutrino point sources; second, it is situated in the Northern Hemisphere, complementing the IceCube experiment located in the South Pole in terms of the field of view. The latter fact becomes even more important now, after the discovery of the Galactic neutrino component in the IceCube data: Baikal-GVD has a low-background high-statistics view of the central parts of the Milky Way.

With the continuous development of Baikal-GVD and increase of the detection volume, i.e. number of light detection modules, energy and directional reconstruction are expected to be significantly improved, opening new exciting possibilities to improve statistics for astrophysical neutrinos, for point source searches, for investigation of the Galactic center; to study neutrino physics and to search for new particle-physics phenomena; to increase the sensitivity to solar dark matter annihilation signals and to even to do geophysics with neutrinos. It is widely known that the JINR team and INR RAS are playing a leading role in Baikal-GVD. JINR yield is essential, as it is responsible for several key detector constructions, software and physics analysis. It has to be pointed out that attention should be paid to further increasing the manpower for data processing and analysis, as the telescope is now giving a huge flow of data of immediate scientific importance.

In the presented document, which is the written Project for the next five years and a scientific report, the description and the status of Baikal-GVD are quite brief, but all the essential points are mentioned. Baikal-GVD has become a JINR flagship project, therefore continuation of the full support of the experiment is, no doubt, of crucial importance. Constructing modern scientific infrastructures in JINR and at the Lake Baikal sites are probably the most significant points for the project's future success, i.e. for obtaining results highly awaited today by the astroparticle physics community.

In conclusion, some results already obtained to 2023 with the telescope in its construction phase appear to be not only satisfactory but also world-leading, whereas both the requested resources and the time schedules of the Baikal-GVD Project are quite reasonable, the scientific program proposed for the next five years period appears to be very promising. Therefore, I do recommend full support of the project with the highest priority at JINR at Nuclear Physics PAC at the Scientific Council and by JINR Directorate.

Prof. Sergey V. Troitsky
RAS Corresponding Member

st@inr.ac.ru