BAIKAL-GVD

Deep underwater muon and neutrino detector on Lake Baikal

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The construction of the Baikal-GVD neutrino telescope [1] is motivated by its discovery potential in astrophysics, cosmology and particle physics. Its primary goal is the detailed study the diffuse flux of high-energy cosmic neutrinos and the search for their sources. It will also search for dark matter candidates (WIMPs), for neutrinos from the decay of super heavy particles, for magnetic monopoles and other exotic particles. The high angular resolution of GVD for track-like or cascade-like events (~0.25-0.5° for muon tracks and ~2-3° for cascades, respectively) provides a high capability for identifying point-like cosmic-ray accelerators. It will also be a platform for environmental studies in Lake Baikal.

The concept of BAIKAL-GVD is based on a number of evident requirements to the design and architecture of the recording system of the array: the utmost use of the advantages of array deployment from the ice cover of Lake Baikal, the extendibility of the facility and provision of its effective operation even in the first stage of deployment, and the possibility of implementing different versions of arrangement and spatial distribution of light sensors within the same measuring system.

With all above requirements taken into account, the following conceptual design of BAIKAL-GVD has been developed. The Data Acquisition System of BAIKAL-GVD is formed from three basic building blocks: optical modules (OM), sections of OMs and clusters of strings. The OM consists of a photomultiplier tube with large hemispherical photocathode and attendant electronics, which are placed in pressure-resistant glass sphere.

The detector will utilize the deep water of Lake Baikal instrumented with OMs, which record the Cherenkov radiation from secondary particles produced in interactions of high-energy neutrinos inside or near the instrumented volume. The Infrastructure will consist of a network of autonomous subdetectors - so-called clusters – each of them with 288 OMs arranged at eight vertical strings attached to the lake floor. The coordinates of the optical modules are determined using an acoustic positioning system. Acoustic positioning system of the cluster comprises 32 acoustic modems (AM). The clusters are connected to shore via a network of cables for electrical power and high-bandwidth data communication. The large cubic-kilometer scale detection volume, combined with high angular and energy resolutions and moderate background conditions in fresh lake water allows for efficient study of cosmic neutrinos, muons from charged cosmic rays and exotic particles. It is also an attractive platform for environmental studies.

During the Design Study (2008–2010) and the Preparatory Phase (2011–2015), design, production and comprehensive in-situ tests of all elements and systems of the future detector have been performed. The Preparatory phase was concluded in 2015 with the deployment of a demonstration cluster "Dubna" comprising 192 OMs. The construction of the first phase of Baikal GVD (GVD-I) was started in 2016 by deployment of the first cluster in its baseline configuration (see fig.1).

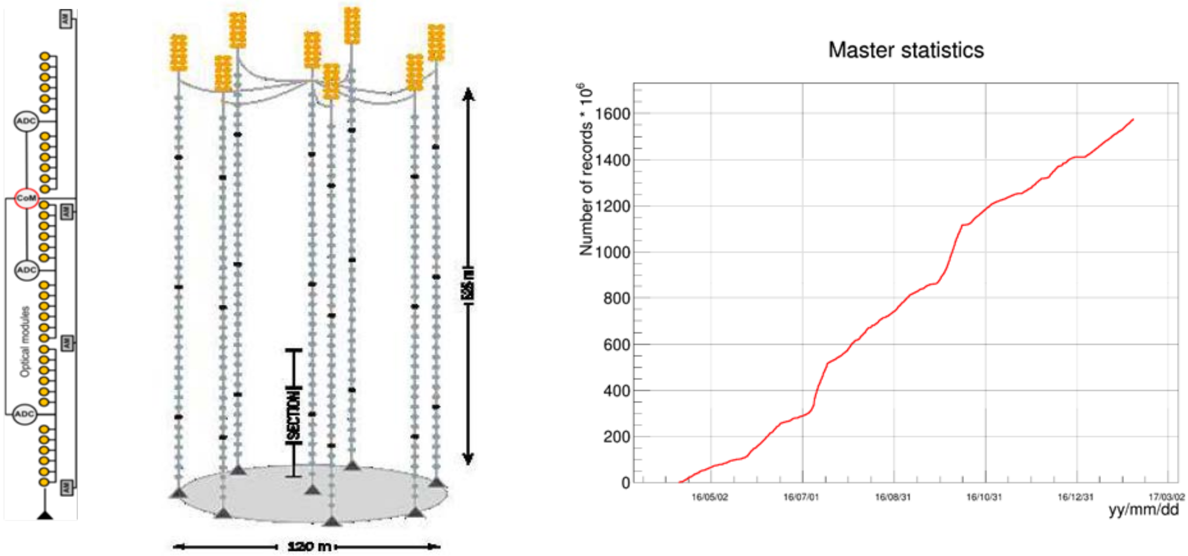

Fig. 1. Block diagram of the string and view of a cluster of Baikal-GVD (left), and cumulative number of the master records detected by first cluster (since April 10 to February 16 of 2017 - 4.9×10^{8} events).

An analysis of the data recorded by the “Dubna” cluster allowed collect first neutrino events, reconstruct the angular distribution of atmospheric muons and select very high-energy shower events that are candidates for extraterrestrial neutrino.

In 2017, the array was upgraded by the deployment of the second GVD cluster. The second full-scale GVD cluster was installed and commissioned in April 2017. The laser calibration source is mounted on a separate station (Laser string) between two clusters. Two additional acoustic modems are installed on the Laser string to measure its coordinates. To date, the two GVD clusters about 0.1 km^3 effective volume, with high angular and energy resolution for high-energy neutrino detection are data taking in Lake Baikal. Fig. 2. shows the present layout of the array.

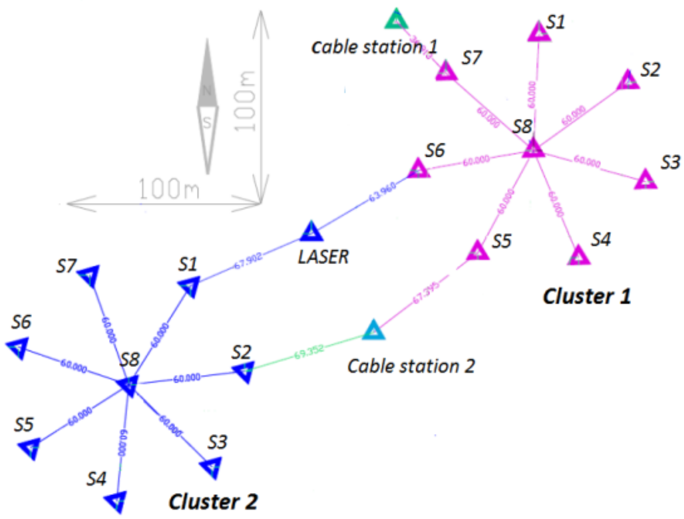

Fig. 2. Layout of the installation that was put into operation on April 13 of 2017.

Timeline for GVD Phase-1

2017	2018	2019	2020
2 clusters (de-ployed)	4 clusters	6 clusters	8 clusters

GVD Phase 2: extension to 14 (possibly technologically upgraded) Timeline Phase-2:

2021	2022	2023
10 clusters	12 clusters	14 clusters

A further extension of Phase 2 to more 14 clusters will depend on the worldwide physics situation in the 2020s, on additional funding from new partners, and last but not least on the performance and physics output of the BAIKAL-GVD detector.

Contribution of JINR Members

JINR Members are playing significant roles in all key parts of the BAIKAL experiment:

- Assembly and test of OMs and strings
- Participation in winter deployment campaigns
- Access and security service.
- Data archive processing and analysis.
- Detector calibration and mass processing of data.
- Remote control and monitoring systems of detector
- Simulation software and MK production.
- On-line software
- Development of new methods of event selection and reconstruction.
- Data analysis with respect to high-energy neutrinos and neutrinos from dark matter annihilation.

References

[1] BAIKAL Collaboration. *BAIKAL - GVD.* Tech. rep. Gigaton Volume Detector in Lake Baikal(Scientific-Technical Report). 2011. URL:http://baikal.jinr.ru/~belolap/GVD/BAIKAL-GVD_En.pdf.