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Status of the early construction phase of Baikal-GVD

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Abstract

The second-stage neutrino telescope BAIKAL-GVD in Lake Baikal will be a research infrastructure aimed mainly at studying astrophysical neutrino fluxes by recording the Cherenkov radiation of the secondary muons and showers generated in neutrino interactions. The prototyping/early construction phase of the BAIKAL-GVD project which is directed towards deployment and operation of the first demonstration cluster has been started in April 2011. An important step on realization of the GVD project was made in 2014 by the deployment of the second stage of the demonstration cluster which contains 112 OMs arranged on five strings, as well as equipment of an acoustic positioning system and instrumentation string with an array calibration and environment monitoring equipment. Deployment of the demonstration cluster will be completed in 2015.

Keywords: Neutrino telescopes, Lake Baikal;

1. Introduction

The next generation neutrino telescope BAIKAL-GVD in Lake Baikal will be a research infrastructure aimed primarily at studying astrophysical neutrino fluxes and particularly at mapping the high-energy neutrino sky in the Southern Hemisphere including the region of the galactic center. The detector will utilize Lake Baikal water instrumented at depth with light sensors that detect the Cherenkov radiation from secondary particles produced in interactions of high-energy neutrinos inside or near the instrumented water volume. The configuration of the telescope consists of clusters of strings - functionally independent sub-arrays, which are connected to shore by individual electro-optical cables. The site chosen for the experiment is in the southern basin of Lake Baikal. Here, the combination of hydrological, hydro-physical,

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and landscape factors is optimal for deployment and operation of the neutrino telescope. The water depth is about 1360 m at distances beginning from about of three kilometers from the shore. The flat lake bed throughout several tens of kilometers from the shore provides a practically unlimited water volume for a deep underwater Cherenkov detector. An up to 1 m thick ice cover from February to the middle of April allows the deployment of the telescope, as well as maintenance and research works directly from the ice surface, using it like a solid and fixed assembling platform. The light propagation in the Baikal water is characterized by an absorption length of about 20 - 25 m and a scattering length of 30 - 50 m [1]. The water luminescence is moderate at the detector site.

The first prototype of the GVD electronics was installed in Lake Baikal in April 2008 [2]. It was a reduced-size section with 6 optical modules (OMs). This detection unit provided the possibility to study basic elements of the future detector: new optical modules and a Flash Analog-to-Digital Converter (FADC) based measuring system. During the next two years different versions of a prototype string were tested as a part of the NT200+ detector. The 2009 prototype string consisted of 12 optical modules with six photomultiplier tubes (PMTs) R8055 and six XP1807 [3]. In April 2010, a string with 8 PMTs R7081HQE and 4 PMTs R8055 was deployed. . The operation of these prototype strings in 2009 and 2010 allows a first assessment of the DAQ performance [4,5].

The prototyping/early construction phase of the BAIKAL-GVD project which aims at construction and operation of the first demonstration cluster has been started in 2011. In April 2011 the first autonomous engineering array which includes preproduction modules of all elements, measuring and communication systems, as well as a prototype of acoustic positioning system of GVD-cluster was installed and commissioned [6,7,8]. The array was connected to shore by an electro-optical cable which was also deployed in 2011. In April 2012 an extended version of the engineering array which comprises 36 OMs was deployed [9]. This array consists of two short strings and the first full-scale string of the GVD demonstration cluster with 24 OMs.

The next important step in the realization of the GVD project was made in 2013 by deployment of an enlarged engineering array - the first stage of the demonstration cluster, which comprises 72 OMs arranged on three 345 m long strings, as well as an instrumentation string with an array calibration and environment monitoring equipment [10]. The first stage of the demonstration cluster was successfully operated from April 2013 to February 2014 in several testing and data taking modes. A total of $5.5 \cdot 10^7$ events has been recorded which corresponds to 216 days of array live time.

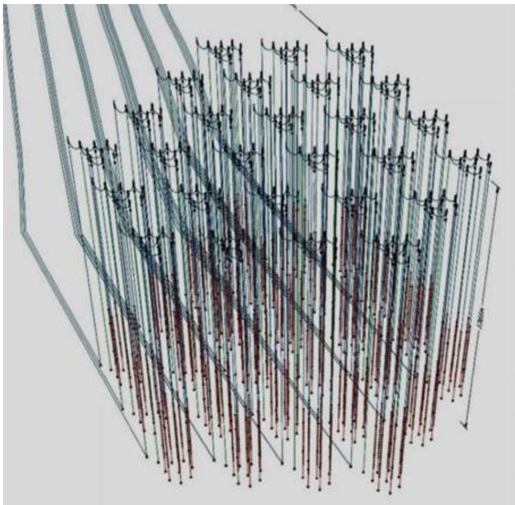

Figure 1: Artistic view of the GVD-telescope.

2. GVD design

The BAIKAL-GVD is a 3-dimensional lattice of optical modules (OMs) – photomultiplier tubes enclosed in transparent pressure spheres. The OMs are arranged on vertical load-carrying cables to form strings. The telescope will consist of clusters of strings - functionally independent sub-arrays, which are connected to shore by individual electro-optical cables (see figure 1). Each cluster comprises eight strings – seven peripheral strings uniformly arranged at a 60 m distance around a central one. The OMs are spaced by 15 m along each string and face downward. The OMs along a string are combined in sections – the functional detection unit of the telescope. The distances between the central strings of neighboring clusters are 300 m.

The muon effective areas for two optimized GVD configurations are shown in figure 2. The curves labeled GVD*4 and GVD correspond to configurations with 10368 OMs and 2304 OMs, respectively. The muon effective area for GVD*4 (6/3 event selection requirement – at least 6 hit channels on at least 3 strings) rises from 0.3 km^2 at 1 TeV to about of 1.8 km^2 asymptotically. The muon angular resolution (median mismatch angle between generated and reconstructed muon directions) is about 0.25 degree.

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