BAIKAL-GVD: The New-Generation Neutrino Telescope in Lake Baikal

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Abstract—The 1-cubic km deep Baikal-GVD underwater Cherenkov detector, a new-generation neutrino telescope, is now being deployed in Lake Baikal. The telescope’s status is described and the first physical results from its operation are presented.

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INTRODUCTION

Deep underwater neutrino telescopes are designed for studying high-energy processes in the Universe and astrophysical objects using high-energy neutrinos. The first-generation neutrino telescopes were deployed at Lake Baikal (NT200, 1998), in Antarctica, at the South Pole (AMANDA, 2000), and in the Mediterranean Sea (ANTARES, 2008). The successful operation of these detectors led to the creation of next-generation neutrino telescopes 1 cubic km in size. IceCube, Baikal-GVD, and KM3NeT, which form the Global Neutrino Network, are among the most important neutrino telescopes already commissioned or now being designed. The schedule for creating the Baikal-GVD telescope [1] includes two stages. A setup of 2304 optical modules with an effective volume of 0.4 km³ is to be created in the first stage (2020–2021). In the next stage, the effective volume will be increased to 1.5 km³.
that contain up to 12 OMs [3]. Analysis of the pulse shape allows us to determine the number of signals from PMTs, their charge, and the recording time. The pulse recording time and charges estimated for all activated telescope channels determine the main parameters of events, i.e., the direction and energy of muons and cascade showers formed from neutrino interactions. The accuracy of reconstructing the direction of a muon track is \(\sim 0.5^\circ\). The accuracy for the energy of cascade showers is \(\sim 20\%\).

The ADC units are equipped with quartz oscillators that measure the PMT pulse recording time. A common trigger signal is used to refer the pulse recording times measured by different ADC units within a cluster to a single time scale. To synchronize the operation of the clusters, the time required for the formation of a common trigger signal is measured at each cluster with an accuracy of around 2 ns using a single clock source. The signals from the latter are transmitted to all telescope clusters via fiber optic communication lines. The clock source is referenced to Universal time using GPS/GLONASS and a GMR-5000 precision time server with a built-in rubidium oscillator; the accuracy of time referencing is 15 ns. The coordinates of the gravitational wave (the NGC 4993 zenith angle was 93.3° at the time of detection). No events were recorded in the direction of NGC 4993 in the specified time intervals. In the absence of a signal, upper limits to neutrino fluxes were established that were comparable in magnitude to those obtained at the ANTARES, Ice Cube, and Pierre Auger telescopes [5].

Galaxy NGC 4993, in which two neutron stars have merged, has recently become the most interesting source of variable luminosity for researchers. The gravitational wave induced by that event was detected by the LIGO and Virgo detectors on August 17, 2017 (GW170817). A search for neutrino events in the direction from that source was performed at the Baikal–GVD telescope in cascade mode with time intervals of \(\pm 500\) s and 14 days after the detection of the gravitational wave (the NGC 4993 zenith angle was 93.3° at the time of detection). No events were recorded in the direction of NGC 4993 in the specified time intervals. In the absence of a signal, upper limits to neutrino fluxes were established that were comparable in magnitude to those obtained at the ANTARES, Ice Cube, and Pierre Auger telescopes [5].

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