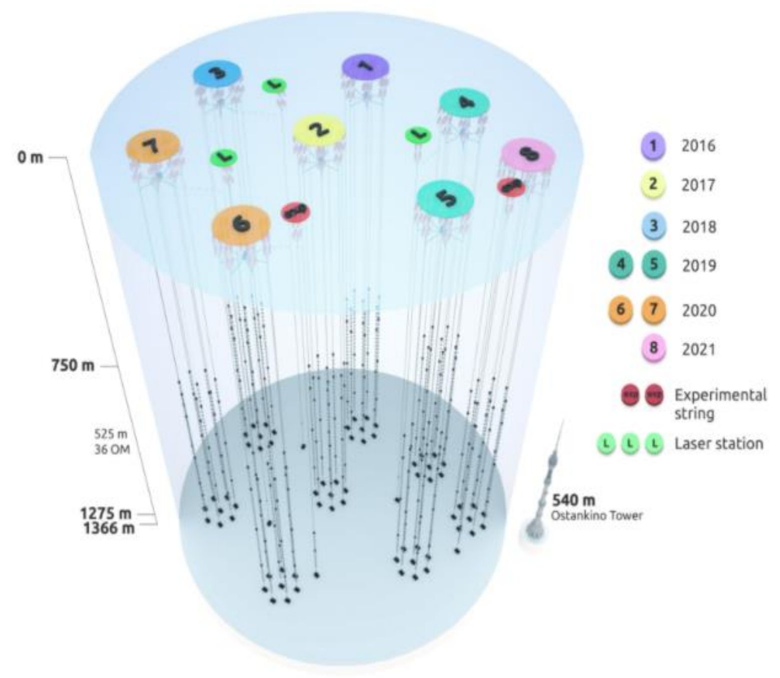
Experimental string with fiber optic data acquisition for Baikal-GVD

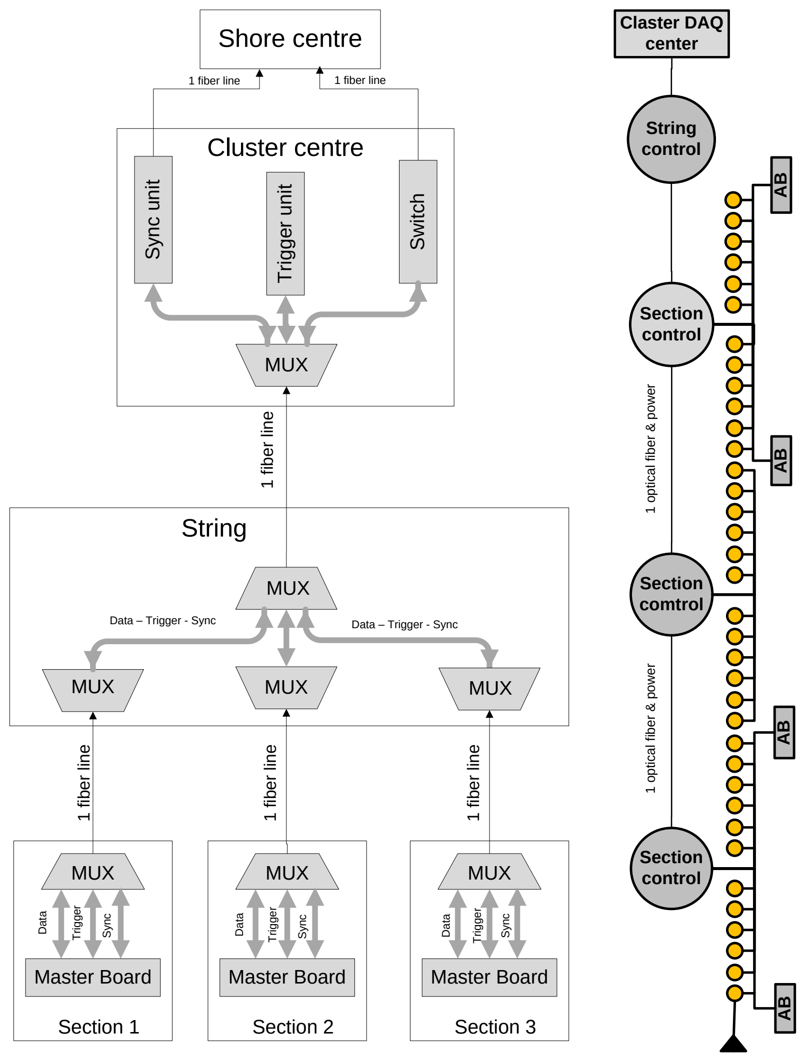
Vladimir Aynutdinov, INR RAS, for the Baikal Collaboration (see full author list on https://baikalgvd.jinr.ru/collaboration)

Baikal-GVD configuration - 2021



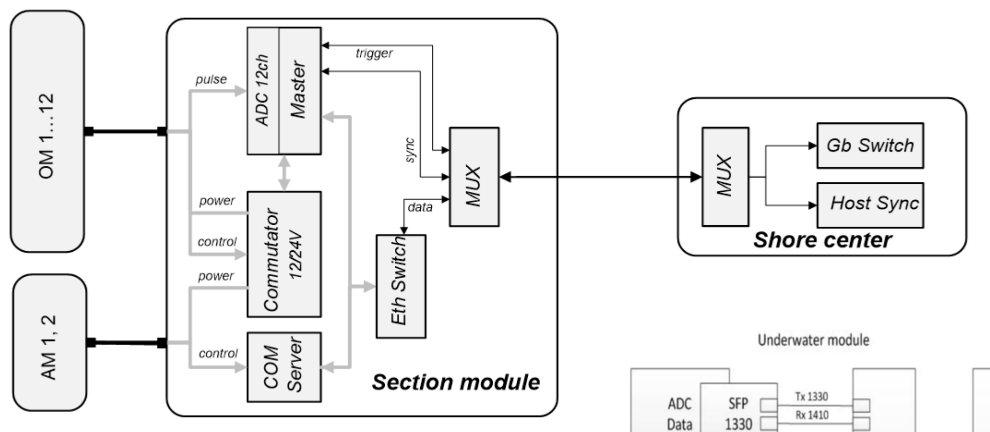
Large-scale neutrino telescope Baikal-GVD is under construction now. By 2021, eight GVD-clusters have been commissioned, and Baikal-GVD is currently the largest neutrino telescope in the Northern Hemisphere. In the next three years, it is planned to increase the number of clusters to 14, for a total effective volume of registration of astrophysical neutrinos ~0.7 km^3. The first stage of the construction of the deep underwater neutrino telescope Baikal-GVD is planned to be completed in 2024.

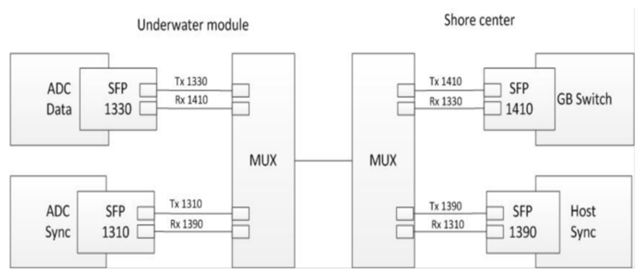
The second stage of the detector deployment is planned to be carried out using a data acquisition system based on fiber optic technologies, which will allow for an increased data throughput and more flexible trigger conditions, thus maximizing the neutrino detection efficiency. A dedicated experimental string has been built and deployed at the Baikal-GVD site to test the new technological solutions.



For DAQ implementation the CWDM technology (Coarse Wavelength Division Multiplexing) was applied. This approach makes it possible to transmit all information (the data stream, trigger, and sync) over a single optical fiber, which allows to limit each segment of the underwater network to one fiber-optic line.

Section optical network - 2020

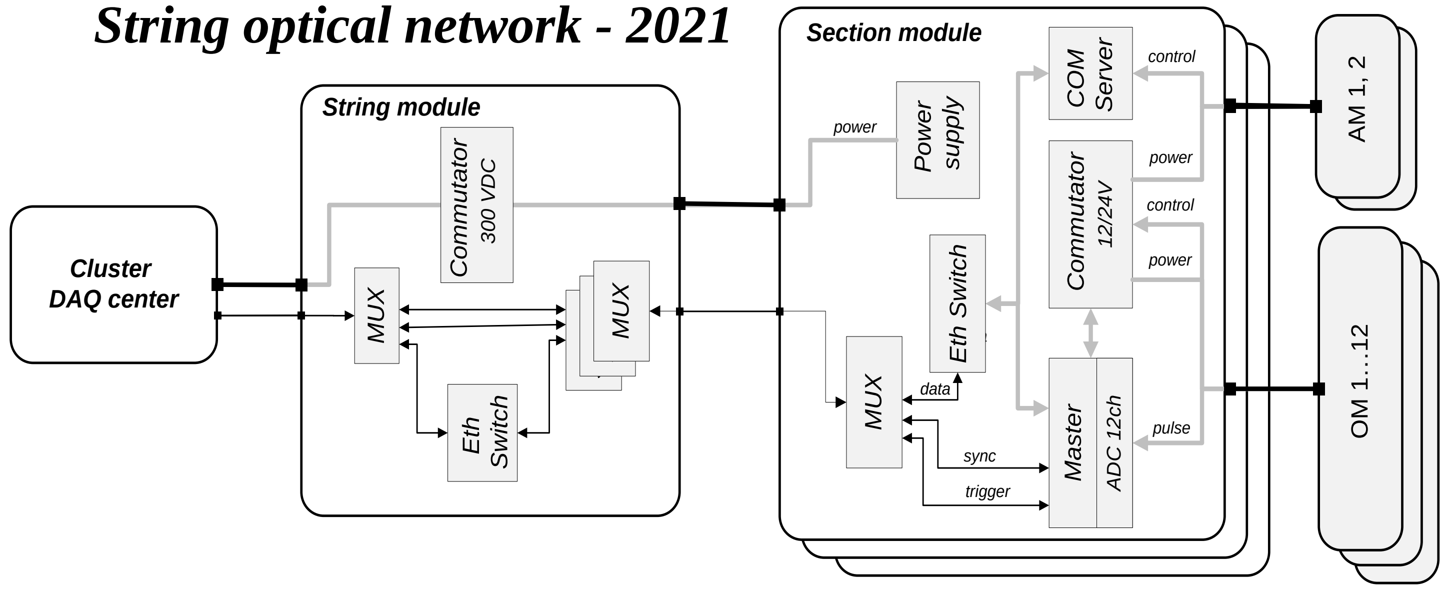




In order to test experimentally the possibilities of using CWDM technology to build the Baikal-GVD DAQ, an experimental section based on a fiber-optic data transmission system was installed in the telescope in 2020. The experimental section was tested during 2020 in the mode of operation with two joint triggers: the coincidence of signals from neighboring optical modules (the *fast* trigger) and a jump-like increase in the pulse counting rate of the optical modules (the *slow* trigger).

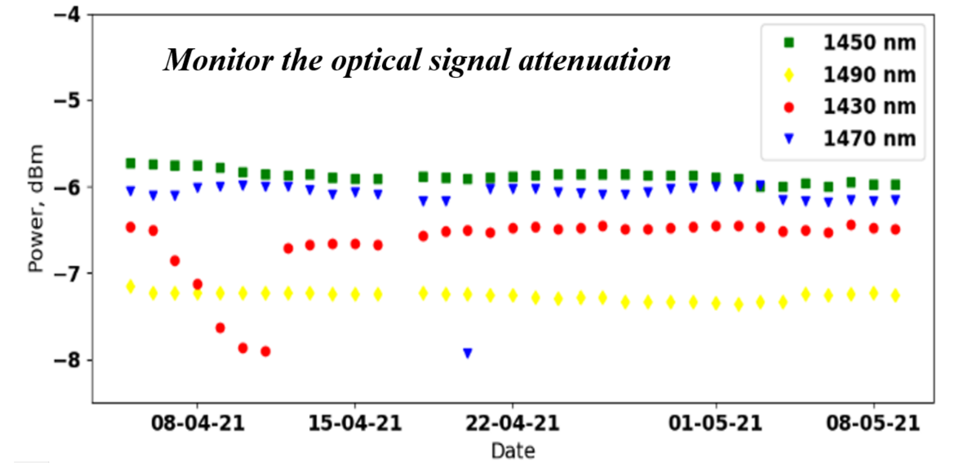
During the year of the section operation, no malfunctions of *Master* operation were detected in the conditions of joint use of two triggers. The successful operation of the experimental section made it possible to start testing the experimental string, which is a full-scale prototype of the basic string of Baikal-GVD. In April 2021 the string was installed in lake Baikal

String optical network - 2021



The experimental string consists of three sections, a string control module, and an optical cluster center. The *Master* forms two optical channels (*trigger* and *sync*) and one electrical channel (Gigabit Ethernet), which is converted to optical using an Ethernet switch. 7 physical channels are formed for three sections: 1 data channel, 3 trigger channels, and 3 sync channels. Data transmission via these channels to the cluster DAQ center is carried out via a CWDM multiplexer over a single optical fiber.

Experimental string comprises of 6 deep-water optical cable lines with different lengths from 3 to 750 m. Most of the underwater optical connections are made by commercial cable assemblies manufactured by DWTEK Co, Taiwan. One of the cables is an experimental development of the Russian enterprise NPP "Starlink". The monitor the optical signal attenuation in the cables shows that ehe signal power exceeds the threshold of the receivers by more than 10 dB. At the same time, there are fluctuations in the power of the signals. The study of this problem is in progress now.



In 2021, the experimental string, which includes three sections, was installed in Lake Baikal. In general, it is already possible to make a conclusion about the prospects of implementing a fiber-optic communication system based on CWDM technology at the Baikal-GVD. However, the problems associated with providing the installation with reliable deep-water optical cables have not been completely solved. In 2022, it is planned to continue research in this direction on the basis of additional experimental strings, which are planned to be installed in Lake Baikal. The work was partially supported by RFBR grants 20-02-00400 and 19-29-11029.