

Light beacon for calibration of the Lake Baikal Neutrino Telescope NT-200

B. Lubsandorzhev¹, P. Pokhil¹, R. Vasiliev¹, and R. Il'yasov¹

¹Institute for Nuclear Research, Moscow, Russia

Abstract. *Light beacon* designed to calibrate the lake Baikal Neutrino telescope *NT-200* is described. Its main characteristics are presented and its further developments are discussed.

1 Introduction

Most of large scale Cherenkov detectors such as Neutrino Telescopes need bright light sources with short pulse duration for time and amplitude calibrations. Calibration sources should have emission spectra in blue region to suit Cherenkov spectrum. Currently in the lake Baikal Neutrino Telescope *NT-200* (Belolaptikov et al., 1997) there is a laser system for time calibration.

2 Laser system of *NT-200*

Laser system of *NT-200* (Balkanov et al., 1999) consists of two identical laser modules (Mikolaiski, 1995). One of them illuminates the whole array through water and another one illuminates each optical channel of *NT-200* via fiber optics. The laser module contains a pulsed nitrogen laser emitting light at 337 nm. This nitrogen laser in turn pumps a dye laser reemitting light at 475 nm. The light yield after a dye laser is about 10^{12} photons per pulse. On the other hand by our experience it seems the value of 10^9-10^{10} is quite enough for *NT-200*. The light output of the laser system can be adjusted in five steps by an attenuation disk driven by a step motor in five steps from 100% to 0,3% of the laser intensity. All

Correspondence to: B. Lubsandorzhev
(lubsand@pcbai10.inr.ruhep.ru)

parts of the laser system including a micro-computer driving the laser are encapsulated into a glass pressure house (Mikolaiski, 1995) of 155mm diameter and 1m length. To diffuse the laser system output beam a hollow sphere with a diffusely reflecting inner surface is used. The laser system generates cycles of light pulses. Each cycle consists of 5 series of 200 equally intense pulses. The intensities of consecutive series differ by a factor 3 or 4. So the laser module is completely autonomous and uses just 300V power supply from outside. As one can see the laser system is rather complicated and expensive and put some problems for further operation and repair.

3 Experimental string

A special experimental string is now under development in frame of the lake Baikal Neutrino Experiment. The main goal of the string is to test technological innovations for future Neutrino Telescopes at the lake Baikal namely new versions of optical modules, detector electronics, data acquisition systems, calibration light sources etc. In the course of the last expedition at the lake we have started to work with first pilot sample of this string (see fig.1) which consists of three conventional Baikal optical channels (Bagduev et al., 1999), one new two-channel optical module (Lubsandorzhev et al., 2001) based on two-channel QUASAR-370 phototube (Lubsandorzhev et al., 1997) and a new calibration light source - *light beacon*. For data taking we have used ordinary Electronic Modules (SM), String Electronic Module (SEM), Detector Electronic Module (DEM) and data acquisition system from Neutrino Telescope *NT-200* (Belolaptikov et al., 1997). Simultaneously with tests of some innovations we measured

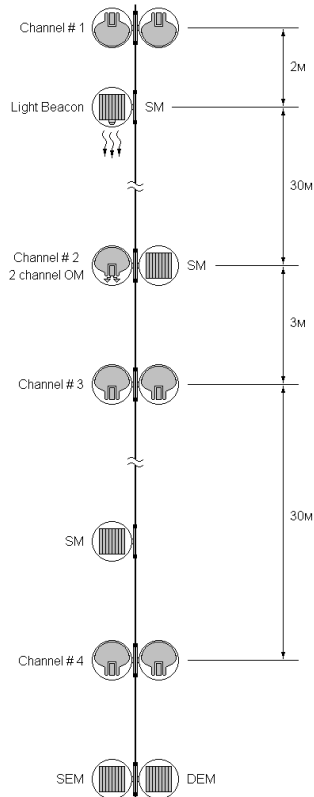


Fig. 1. Schematic view of the experimental string.

group velocity of light in Baikal water at two different wavelengths and water parameters of the lake namely scattering and absorption coefficients.

4 Light Beacon

To replace above described laser system we have developed simple inexpensive nanosecond light source - *light beacon*. This *light beacon* consists of a matrix of LEDs. To drive LED we have developed a circuit which uses avalanche transistor ZTX415, for more details concerning an electric circuit of this driver, see (Vasiliev et al., 2000). We use bright blue LED NICHIA NSPB510S (NICHIA, 1997) with an emission maximum at 470nm. LED light pulse has a width of 1ns (FWHM) and light yield of $10^8 - 10^9$ photons per pulse. To increase light yield we assembled 5 LEDs in a matrix. Each LED in a matrix has its own driver. Fig.2 presents LED matrix system. All drivers are triggered by one common positive input pulse from a generator. Conventional System Module of *NT-200* is used for this purpose just slightly modified. Another output signal of generator is used as *light beacon* synchronization signal and fed to discriminator unit to form signal *Local Trigger* for further analysis in String Electronic Module to form *Master* signal for the string. The existence

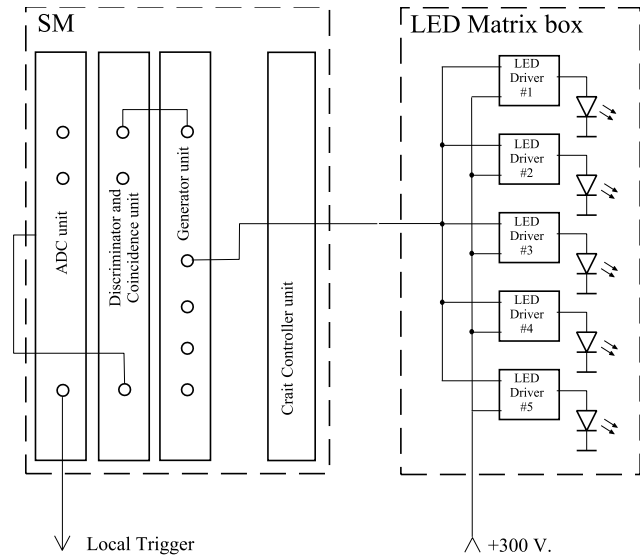


Fig. 2. Scheme of LED matrix system

of *light beacon* synchronization signal facilitates very much an unambiguous definition of T_0 which is important in time measurements in *NT-200*. Another important thing is a wide range of repetition rate of *light beacon*. It can work at repetition rate up to 1MHz.

The generator synchronization signal is well related to *local trigger* signal. The time jitter of this relation is about 100 ps (FWHM). LEDs are arranged in a circumference of 1cm diameter. To avoid electromagnetic cross-talks LEDs and drivers were placed into a metallic box which is fixed on the surface of a glass vessel of System Module just under electronic crate. The level of concurrence between individual LEDs in matrix should be rather high to get a light pulse as short as possible. To check it the time differences between transistor avalanche breakdowns in two drivers and trigger pulse were measured. One can see the time differences are quite small and the two breakdowns occur almost simultaneously, see left part of fig.3. The time difference spectra are characterized by FWHM of less than 200ps.

LED light pulse widths were measured in a single photoelectron mode by a fast photomultiplier for each individual LED separately and finally for two drivers working simultaneously. One can see from time spectra in the right part of fig.3 that there is no observable light pulse widening effect due to simultaneous work of two drivers and at the same time total light pulse width is well below 1ns. It's interesting to note that as in case of two avalanche breakdowns light pulses from two LEDs come to pmts photocathode almost simultaneously too. So for a matrix of such LED drivers it is possible to reach more than 10^9 light yield with 1ns pulse width. In fig.4 the amplitude spectrum of *light beacon* pulses detected by optical channel at the distance of 68m from *light beacon* is shown. The mean value of this spectrum is about 30 photoelectrons which is in good agreement with about 10^9 photons per pulse light yield of *light beacon*.

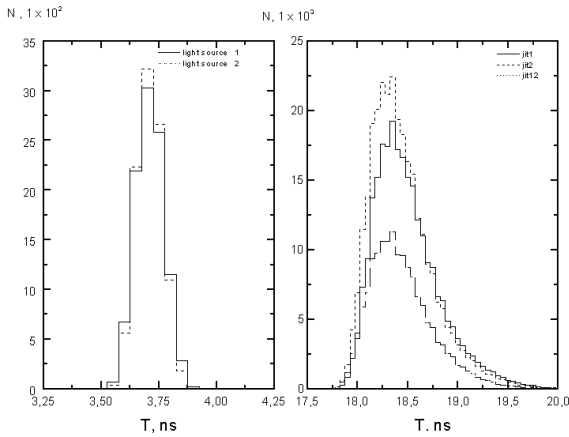


Fig. 3. Left: Distributions of time differences between trigger pulse and transistor avalanche breakdown for two LED drivers; full line – for driver # 1 and dash line – for driver # 2.

Right: Single photoelectron transit time distributions measured with a fast pmt. Full line – under illumination with LED driver # 1; dash line – with LED driver # 2; Dot line – with LED drivers # 1 and 2 working simultaneously.

5 Conclusion

Light beacon is being developed for calibration of the lake Baikal Neutrino Telescope *NT-200*. First tests of *light beacon* pilot sample show rather promising results. At the moment we reached 10^9 photons per pulse light yield with 1ns pulse width. As a next step it's necessary to increase the number of LEDs in a matrix up to several dozens to get light yield close to 10^{10} and to develop drivers with adjustable amplitude of output signals.

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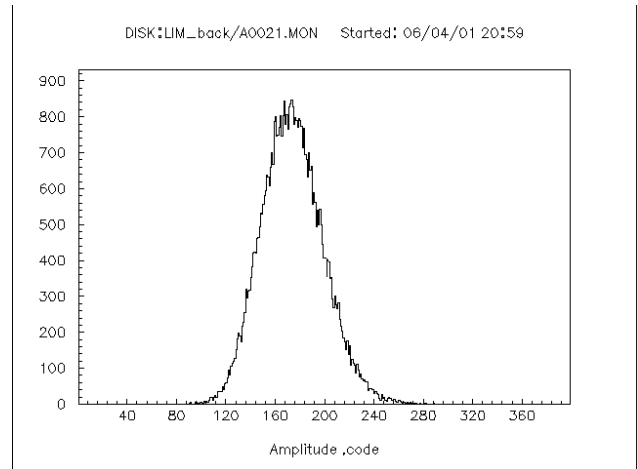


Fig. 4. Amplitude spectrum of *light beacon* pulses detected by conventional Baikal optical channel at the distance 68m from *light beacon*

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