Abstract: The KM3NeT Collaboration aims at the construction of a multi-km$^3$ neutrino telescope in the Mediterranean Sea, a convenient location to look for high-energy neutrino sources in the inner part of the Galaxy. The apparatus, which will also serve as a multidisciplinary science platform, will comprise blocks built at three installation sites (40 km offshore Toulon, France at a depth of 2500 m; 80 km offshore Capo Passero in Sicily, at a depth of 3500 m; 20 km offshore Pylos, Greece at depths of 2500-5000 m). The detector will consist of a three-dimensional array of large diameter pressure-resistant spheres, the so-called DOMs (Digital Optical Modules), arranged on detection units, vertical strings anchored on the sea floor, each equipped with up to 20 DOMs. In this poster the main features of the DOMs will be described. The DOMs are designed so as to act as independent measurement nodes, communicating directly to shore through an optical fiber network with a DWDM technique. Each DOM comprises 31 photomultipliers with 3” photocathode diameter and related electronics.

Keywords: neutrino, astronomy.

1 Introduction

Neutrinos are the perfect probe to explore the far Universe, since they have no electrical charge, are insensitive to magnetic fields and interact only weakly. However, because of the same properties that make them unique messengers of high-energy processes, there are severe limitations to detectability of high-energy neutrinos. Very large detection volumes, at least 1 km$^3$, are required in order to have an unambiguous signal due to astrophysical neutrinos together with an effective shield against the overwhelming background due to atmospheric muons, residuals of the high-energy cosmic ray showers.

KM3NeT is a second-generation neutrino telescope meant to be installed in the Mediterranean Sea, an ideal location for searching for high-energy neutrino sources in the inner part of the Galaxy.

KM3NeT has been designed based on the experience gained with three pilot projects: ANTARES, the first undersea neutrino telescope, which is taking data at 2500 m depth offshore Toulon, France [1, 2], NEMO and NESTOR, two comprehensive R&D programs respectively in Italy and Greece. KM3NeT will be built in three modules at three installation sites in France, Italy and Greece. It will support real-time measurements for a variety of research fields, including environmental monitoring, seismology, oceanography and bioacoustics.

In this paper the basic detection element of the apparatus, the so-called DOM (Digital Optical Module), is described.

KM3NeT is described in more details elsewhere [3] at this conference. The qualification campaign is illustrated in [4]. The scientific program of KM3NeT will be illustrated in other presentations at this conference [5, 6, 7, 8].

2 The Digital Optical Module

The active part of a neutrino telescope is the optical module. The solution chosen for KM3NeT is based on multi-PMT optical modules, built by means of a large number of small-size PMTs housed in a pressure-resistant glass sphere. This solution offers some advantages compared to more traditional designs based on large-area PMTs, such as a larger photocathode surface inside the optical module, insensitivity to the Earth’s magnetic field, directionality in photon detection. In addition, the segmentation of the detection area in the optical module helps for rejection of the environmental optical background.

The Digital Optical Module (DOM) of KM3NeT comprises 31 PMTs of 3” diameter housed in a sphere of 17-inch diameter (see figure 1).

Figure 1: The Digital Optical Module (DOM) of KM3NeT.
A breakdown structure of the DOM is shown in Figure 2. The internal arrangement has been designed so as to make maximum usage of the available room. The PMTs are equipped with active bases, which allow to have individual control from the shore of the HV and threshold settings for each tube. The bases are equipped with ASICs which perform a digitization of the hits, so that the threshold crossing time and the time-over-threshold can be recorded and sent to shore. The PMTs are installed in a properly shaped support structure. Light collection lenses are installed in front of the PMTs so as to increase the light-sensitive effective area. Optical gel is installed between the PMTs and the glass sphere in order to maximize light transmission. Each DOM acts like an independent measurement node. The system has been designed in such a way that faults taking place in a DOM will not propagate to the other DOMs of the apparatus.

A main Central Logic Board (CLB) manages the data acquisition and communication with shore of one DOM. The CLB is equipped with an optical interface for long-range transmission to shore in a DWDM technique with 50 GHz spacing. The electronics will be arranged on proper supports designed so as to efficiently transfer heat to the sea through the glass sphere.

All DOMs of the apparatus are synchronized to the sub-nanosecond level by means of a clock signal broadcast from shore. A White Rabbit application will allow to monitor and correct in real-time for the propagation delays between the shore and each single DOM of the apparatus. The time offsets of the individual PMTs will be calibrated onshore before deployment, and will be continuously monitored in situ by means of a system of light beacons meant to illuminate groups of DOMs at known times; this system comprises laser beacons located on the sea bottom and LED pulsers (the so-called 'nanobeacons') inside the DOMs.

The instrumentation mounted in each DOM comprises a piezo-sensor for acoustic positioning purposes, a tiltmeter and a compass, as well as sensors of the temperature and humidity inside the DOM for monitoring purposes.

As part of the qualification campaign of KM3NeT, a first prototype DOM, adapted to be operated inside the ANTARES apparatus, has been installed in the instrumentation line of ANTARES in April 2013. A new prototype line, equipped with 3 DOMs, is under construction, with the goal of a deployment at 3500 m depth in Sicily in late 2013. A mass production of DOMs will be launched next year. Installation of the first complete line of KM3NeT is announced for summer 2014.

Figure 3: Assembly of a prototype DOM of KM3NeT.

3 Conclusions

Based on the experience from the ANTARES, NEMO and NESTOR pilot projects, the KM3NeT Collaboration is preparing the construction of a multi-km$^3$ neutrino telescope in the Mediterranean Sea. The DOM, equipped with 31 PMTs of 3-inch photocathode, is the basic detection node of this apparatus. As a first step of an ongoing, extensive qualification campaign, the first prototype DOM has been recently installed in the deep sea, where it performs nominally. As a next step in the qualification program, a small-size model of detection unit, equipped with 3 DOMs, will be built and installed at 3500 m depth. A mass production of DOMs will start next year.

References

[2] A. Kouchner et al., these proceedings
[3] M. Circella, these proceedings
[4] S. Henry, these proceedings
[5] M. de Jong, these proceedings
[6] A. Trovato, these proceedings
[7] R. Coniglione, these proceedings
[8] P. Kuijman, these proceedings