

## The data acquisition system of the KM3NeT detector

S. Biagi<sup>1</sup>, T. Chiarusi<sup>2</sup>, P. Piattelli<sup>1</sup>, and D. Real<sup>3</sup> on behalf of the KM3NeT Collaboration

<sup>2</sup>INFN, Sezione di Bologna, Bologna, Italy <sup>3</sup>IFIC, CSIC - Universitat de València, València, Spain

KM3NeT (KM3-scale Neutrino Telescope) [1] a future European research facility in the Mediterranean Sea which will house a neutrino telescope of cubic kilometer scale (Fig. 1). The Digital Optical Module (DOM) is a high pressure resistant glass vessels with 31 3" Photomultiplier Tubes (PMT) inside (Fig. 2). The PMTs collect the Cherenkov light produced by charged leptons and convert it into electronic signals [2]. 18 DOMs are arranged on stringlike structures, the detection units, anchored on the sea bed and kept vertical by a buoyancy system. The

detection units are connected with submarine junction boxes and through them to shore for power feed and data transmission. The all-data-to-shore data taking approach follows the choice done by ANTARES [3]. No trigger is done underwater; all signals from PMTs arrive onshore where they are triggered and processed by farm of computers. The Trigger and Data Acquisition System (TriDAS) must be able to handle an extremely large throughput of data arriving from off-shore; the DAQ modularity and scalability are needed properties.

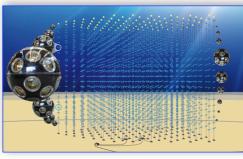


Fig. 1 — A sketch of the KM3NeT detector.

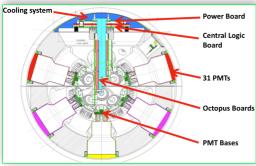
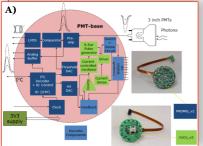


Fig. 2 — The Digital Optical Module

The 31 PMTs are suspended in a foam support structure: 19 PMTs in the lower hemisphere and the remaining 12 in the upper hemisphere. Each PMT has its own adjustable high voltage supply integrated in the PMT Base. In order to translate these signals into the arrival time of the photons, they are processed by Time to Digital Converters (TDC) core embedded in the Field Programmable Gate Array (FPGA) of the Central Logic Board (CLB) [4]. The CLB integrates the White Rabbit Protocol [5], a fully deterministic Ethernet-based network for general

purpose data transfer and synchronization, that allows to synchronize all the KM3NeT DOMs with 1 ns resolution. The data provided by the PMT Bases is collected and distributed to the CLB by means of two boards, the Octopus Boards. The CLB contains the electronic components for an optical link to shore. All necessary DC power is provided by the **Power Board** [6]. An aluminium structure provides heat conduction between the electronics inside and the exterior of the sphere. The electronic boards contained inside the DOM are shown in Fig. 3.



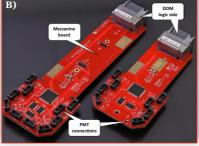






Fig. 3 — The electronic boards inside the DOM. A) Diagram and pictures of the PMT Base. B) Large and small Octopus Boards. C) The Power Board. D) The Central Logic Board.

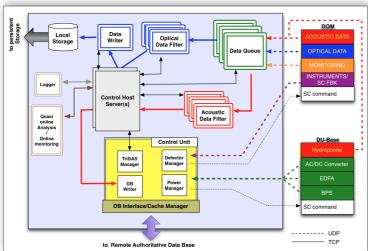


Fig. 4 - General architecture of the TriDAS for KM3NeT.

[1] http://www.km3net.org

[2] S. Adrián-Martinez et al. (KM3NeT Collaboration), Expansion cone for the 3-inch PMTs of the KM3NeT Optical Modules, JINST 8 (2013) T03006.
[3] M. Ageron et al. (ANTARES Collaboration), ANTARES: the first undersea neutrino telescope,

Nucl. Instr. Meth. A 656 (2011) 11.
[4] S. Biagi and A. Orzelli (KM3NeT Collaboration), The Central Logic Board and its auxiliary boards

for the optical module of the KM3NeT detector, JINST 9 (2014) C12033.

[5] http://www.ohwr.org/projects/wr-cores/wiki/wrpc\_core

[6] E. Anassontzis et. al. (KM3NeT Collaboration), Design and development of the Power Converter

Board within the Digital Optical Module in KM3NeT, PoS(TIPP2014)188 (2014)

[7] http://root.cern.ch

[8] A. Creusot (KM3NeT Collaboration), Calibration, performances and tests of the first detection unit

The ensemble of hardware infrastructures and software collections in charge of the data acquisition, aggregation, filtering and save-to-disk is called TriDAS (Trigger and Data Acquisition System, Fig. 4). All the TriDAS elements are connected within a local 10 Gbps network which comprises also the underwater detector.

The first step of the data aggregation onshore is the DataQueue process (DQ), that distributes unfiltered data arriving from a sector of the detector to the computer farm that takes care of the trigger, the DataFilter (DF). There are two different types of DF: the acoustic DF is responsible of the online analysis of data from acoustic sensors for the positioning system; the **optical DF** is the software devoted to the trigger of PMT data. Each optical DF receives from all the active DQs a block of data related to a specific time window (the timeslice) with a typical length of 100 ms. The optical DF handles the data of the entire apparatus with respect to the assigned timeslice. The filtered data

are finally sent to a DataWriter, that writes on disk a ROOT file [7].

Each acoustic DF receives all data arriving from a DQ in a continuous stream, calculates the sound arrival time produced by the underwater positioning system and sends the result to a DataBase. The ControlUnit, the user interface of the detector, coordinates all the operations of the TriDAS and operates the DOMs using a dedicated Slow Control protocol. The number of necessary DFs scales with the detector throughput and with the algorithms complexity without changing the DAQ design. The data reduction is more than a factor 103 with respect to the throughput from the detector.

About 120 Gbps throughput is expected from the full detector composed of 690 detection units, assuming a photon-hit rate of 6 kHz for each 3" PMT. The first detection unit of KM3NeT that uses all the technologies described here will be installed soon offshore the French coasts near Toulon [8].