KM3NeT –INFRADEV – H2020 –739560

Report on the manuals for external users

KM3NeT –INFRADEV GA DELIVERABLE: D8.2

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Abstract

The KM3NeT Research Infrastructure will offer to the Earth and Sea Science community a wide opportunity of using data or accessing the infrastructure to perform deep-sea experiments. The present document describes some of the possibilities offered by the KM3NeT RI to external users for the study of underwater environment. A set of calibration data suitable for the sharing with external scientific communities have been identified and the related access policy and restrictions are outlined. This document provides general guidelines for the final manuals, which will need to be improved through a continuous process in synergy with the ESS community.

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DELIVERY SLIP

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DOCUMENT LOG

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APPLICATON AREA

This document is a formal deliverable for the GA of the project, applicable to all members of the KM3NeT– INFRADEV project, beneficiaries and third parties, as well as its collaborating projects.

TERMINOLOGY

CTD	Conductivity-Temperature-Depth probe
DAQ	Data Acquisition System
DOM	Digital Optical Module
DU	Detection Unit
ESFRI	European Strategy Forum on Research Infrastructures
ESS	Earth and Sea Sciences
IB	Institutional Board (KM3NeT governing body)
IU	Instrumentation Unit
JB	Junction Box
PMB	Project Management Board
PMT	Photomultiplier Tube
RI	Research Infrastructure

LIST OF FIGURES

PROJECT SUMMARY

KM3NeT is a large Research Infrastructure that will consist of a network of deep-sea neutrino telescopes in the Mediterranean Sea with user ports for Earth and Sea sciences. Following the appearance of KM3NeT 2.0 on the ESFRI roadmap 2016 and in line with the recommendations of the Assessment Expert Group in 2013, the KM3NeT-INFRADEV project addresses the Coordination and Support Actions (CSA) to prepare a legal entity and appropriate services for KM3NeT, thereby providing a sustainable solution for the operation of the research infrastructure during ten (or more) years. The KM3NeT-INFRADEV is funded by the European Commission's Horizon 2020 framework and its objectives comprise, amongst others, the preparation of services to provide access of users external to the astroparticle physics community to the RI (work package 8).

EXECUTIVE SUMMARY

The scientific goals of the KM3NeT Collaboration require a deep knowledge of the physical properties of the underwater installation sites. Underwater environment is continuously monitored through large arrays of optical and acoustic sensors, and oceanographic instrumentation.

The growing interest of Earth and Sea Science community in KM3NeT data and the inputs coming out from a dedicated workshop (see deliverable D8.1), organized in the framework of the KM3NeT-INFRADEV project, have identified a set of calibration data to be made accessible to external users for scientific purposes in the fields of Earth and Sea Sciences.

Access to off-shore and on-shore infrastructure, including sea operation vessels, have been also evaluated. Underwater electro-optical connections to shore will be provided to a limited number of selected experiments. Issues related to access policy have been considered and analyzed.

Table of Contents

1. Introduction

KM3NeT, the large Research Infrastructure (RI) that will host the latest generation of deep-sea neutrino detectors in the Mediterranean Sea, will open a new window on our Universe, but also advance the research into the properties of neutrinos. KM3NeT will be a distributed infrastructure with deep-sea instrumentation east of the Sicilian Coast (Italy), south of Toulon (France) and off the South-West coast of Peloponnese (Greece). The main science objectives, a description of the technology and a summary of the costs are presented in the KM3NeT 2.0 Letter of Intent[1].

A first survey of options of access to the RI was performed through a dedicated "Earth and Sea Science with KM3NeT" workshop held in Athens on 4-6 December 2017 (https://indico.cern.ch/event/676718/). This survey is described in the WP8 deliverable D8.1.

As reported in D8.1, although successful this workshop, being the first encounter between KM3NeT and representatives of the Earth and Sea Science community, did not provide clear and conclusive indications on the preferred options on how to provide potential users with data or services. Nevertheless, the ideas brought forward during the workshop can been considered. This report briefly lists some of the possibilities and outlines for the work to be done in the following.

As a reminder (see D8.1 for a more detailed description) the access options can be divided in three main branches:

- Access to recorded data
- Access to User Ports (on-shore and off-shore)
- Symbiotic access to infrastructure and sea operations vessels

For all the three, modalities of access will be defined in the framework of the KM3NeT Legal entity.

[1] *Letter of Intent for KM3NeT 2.0.* **Adrián-Martínez, S., et al.** 2016, Journal of Physics G: Nuclear and Particle Physics, Vol. 43 (8), p. 084001. arXiv:1601.07459 [astro-ph.IM]. DOI: 10.1088/0954-3899/43/8/084001

2. Access to recorded data

The KM3NeT Collaboration identified as suitable data to be made available to external users, among these:

- Data from photon sensors (photomultiplier tubes, PMTs);
- Data from acoustic sensors (hydrophones and piezo sensors);
- Data from compasses;
- Data from oceanographic sensors.

These data are collected by the KM3NeT Collaboration for the calibration of the detector and the monitoring of the environmental conditions during its operation. The KM3NeT Collaboration foresees two kinds of access to recorded data for external users:

- Open access without restrictions to a sub-sample of calibrated data, certified by the Collaboration
- Access with restrictions to real-time or pre-analyzed data (agreed through a Memorandum of Understanding)

Data without restriction will be made available through an open access web portal, provided by the KM3NeT Collaboration. Calibrated data or alternatively raw data and related calibration procedures will be indexed and made accessible to external users through a search engine.

The web portal will be the unique access point for open access KM3NeT data mining and retrieval.

In the following of this section some options that will be considered in the future work are outlined.

Data from photon sensors

The basic detection unit of the KM3NeT neutrino telescope is the Digital Optical Module (DOM). Each DOM comprises 31x 3'' photomultiplier tubes (PMTs) enclosed inside a pressure resistant 17-inch glass sphere. The PMTs are read separately by a front-end electronics capable to send to shore time and amplitude information on detected light signals (400-700 nm).

The data Acquisition System (DAQ) system, installed on-shore, records:

- Events, which are approximately 100 µs long dump of data from all PMTs, when a default coincidence trigger, i.e. a coincidence of 2 Photons in 1 DOM in a 25 ns time window, is present;
- The instantaneous PMT photon hit rate, as an average over 100 ms.

Data are saved in the collaboration database.

Event data, which contain information relevant for the neutrino detection, can be made available according to the policies defined within work package 4 of the KM3NeT-INFRADEV project.

Average optical rates, will be made public through a dedicated web portal according to the request of the ESS community. Some parameters, such as the time frame over which the average rate is computed or the frequency of average rates provided, will be adjusted according to specific requests. This will be the subject of further studies by work package 8.

Compass and positioning data

These data can be provided as a tool to infer the intensity and direction of deep-sea currents. The monitoring of the movements of the underwater mechanical structures can be used as a proxy for the study of underwater currents along the water column. In KM3NeT DOM orientation (yaw, pitch, roll) is recorded through a compass with a time resolution of 1 second.

According to the requests of the external scientific communities, compasses data will also be provided to users averaged at different time resolutions.

The 3D positions of all DOM are continuously monitored through an acoustic positioning system. Spatial coordinates of each DOM are stored in the KM3NeT database and will be made available for offline analysis.

Oceanographic data

KM3NeT will incorporate special mooring lines dedicated to monitoring of oceanographic parameters of the water column. The so-called instrumentation unit (IU) hosts standard oceanographic probes such as CTDs, Sound Velocimeters and current metres.

Collected data will be averaged underwater and sent to shore every 20 min approximately, following the standard recording strategy of oceanographic mooring lines.

Oceanographic data will be recorded on the collaboration database.

Instantaneous rates from each PMT, averaged at different time resolution, and a daily average will be provided.

Acoustic data

The telescope is also equipped with acoustic sensors: 1 piezo-electric ceramic sensor is installed in each DOM, 1 hydrophone on each DU base and on the junction boxes of the seafloor network. Main purpose of these sensors is to provide real time positioning of each DOM with cm accuracy.

The sensors are piloted by the detector master clock forming a synchronous antenna. Data are sampled in situ at 24 bits, 195 kHz and the full stream is transmitted to shore.

The hydrophone sensitivity (ominidirectional) is about -173 dB re 1V/uPa over the frequency band between few tens Hz and 70 kHz, that makes this sensor also suitable for interdisciplinary studies. The sensitivity of the each piezo cannot be easily derived since it strongly depends on the coupling with glass under pressure. An average value of -170 dB re 1V/uPa at 30 kHz can be fairly assumed in the band 20-40 kHz.

The default KM3NeT DAQ has been designed to identify only the (known) acoustic signals emitted by a long baseline of acoustic sensors among the full data stream .

For calibration purposes, periodically a subset of raw acoustic data is acquired from a limited number of sensors, sprinkled in the detector volume. This subset of acoustic recordings is used by the KM3NeT Collaboration to adapt software parameters of automatic signal detection software at different environmental conditions and to monitor sensors performance as a function of time.

This subset of acoustic data will be used to extract integrated data which will made available through a web portal. In particular, the related acoustic power spectra density and spectrograms will be provided at selectable time resolution through a custom application.

An implementation of the DAQ are foreseen in KM3NeT 2.0, permitting on-line analysis, display and recording of the underwater noise spectrum through a J-Ligier.

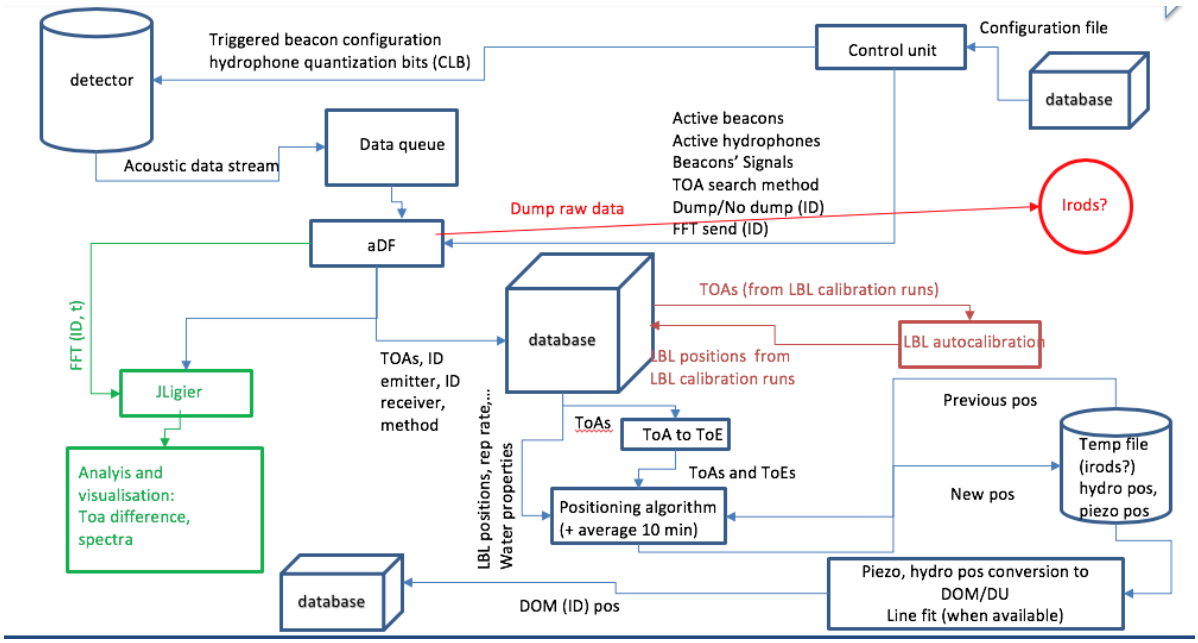

Figure 3 - The KM3NeT Acoustic Data Acquisition and analysis flow. The chain is designed to detect Time of Arrival of acoustic signals emitted by the long baseline of acoustic beacons deployed on the sea-bed.

Furthermore, a duplication of the full acoustic stream is planned to provide full acoustic data access to the ESS (see section Access to User Ports).

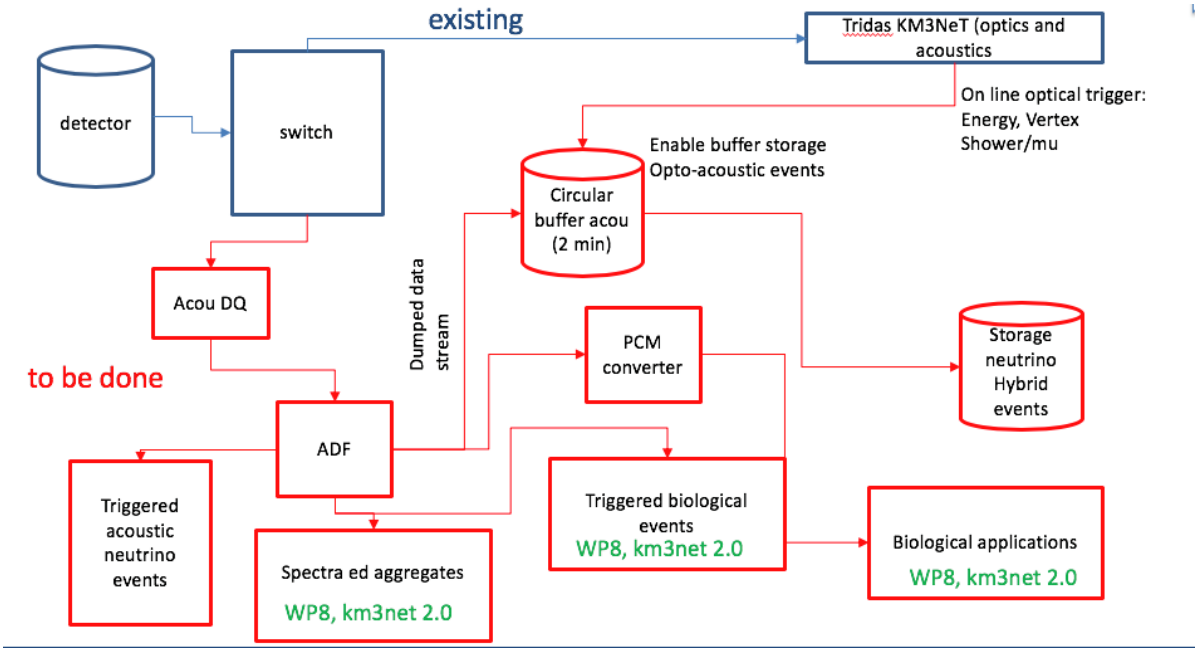

Figure 4 - Design of the on-shore user port for acoustics. Streaming the full raw acoustic data flow to ESS community is foreseen. The architecture will also enclose analysis tools for biological signals and noise monitoring.

3. Access to user ports

The KM3NeT Collaboration identified two kinds of user ports, suitable to allow external users to the connect to the infrastructure:

- A physical connection (hardware user port) to the underwater power and data transmission system, foreseen for a limited number of dedicated experiments proposed by the ESS community and refereed by the project committee.
- A software connection(software user port) to the onshore IT infrastructure to get access to the whole acoustic raw data flow produced by the apparatus.

The marine infrastructural backbone (shore station, electro-optical cable and seabed network) is designed to provide the detection units (DU) and the external users with electrical power and high-speed communication lines based on optical fibers. A schematic block of the JB, the last layer of this infrastructure, directly connected to the DU and/or to the external users, is shown in Figure 3. A dedicated experiment could be connected to the infrastructure by means of one of the user ports shown in Fig. 3; each underwater electro-optical connection to shore will be provided with the following characteristics:

- Connector type: ROV mateable Teledyne/ODI NRH 2 electrical, 2 optical;
- Power: 375VDC+-10%, max 1 A;
- Maximum data rate sustainable: up to 1.25Gb/s for each optical fiber.

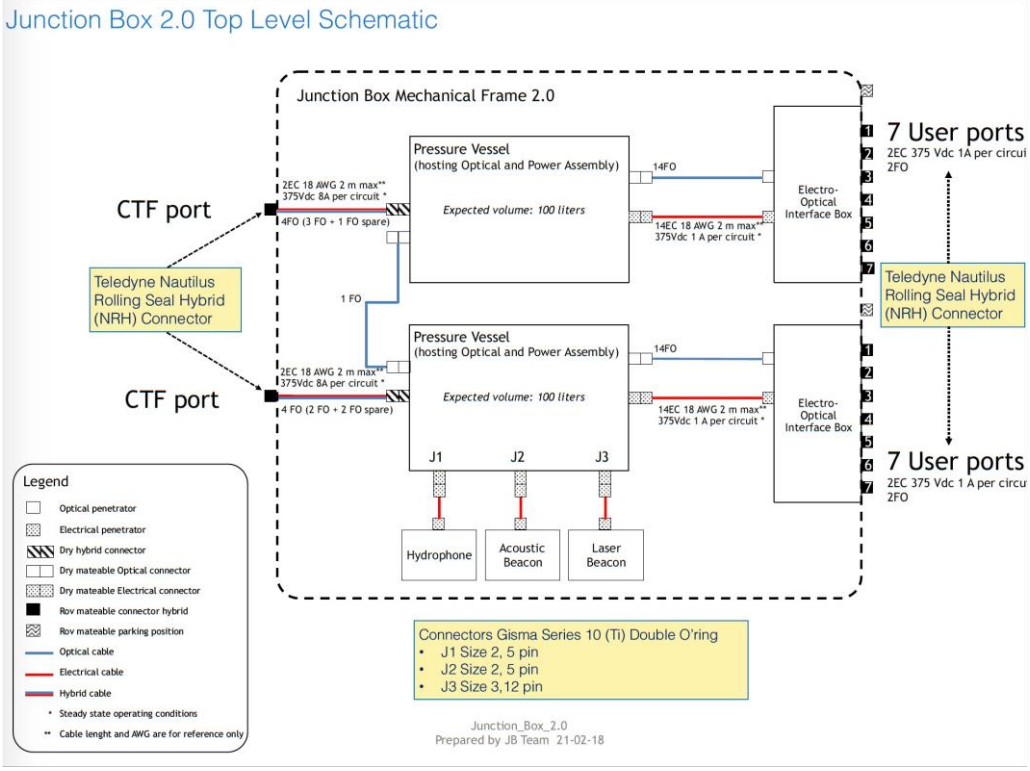

Figure 3 - Schematic block diagram of the JB foreseen for the KM2NeT-2.0 RI.

Optical data transmission used by the KM3NeT experiment is based on White Rabbit precision time protocol and allow to time stamp the data; this option will be available for the user port although it's not binding. The physical connection provided to the external users through the hardware user port will consist of two fiber optic that can be used to implement a custom, per experiment, data transmission protocol.

The software user ports will allow to gain access in real time, to the whole acoustic data flux. The KM3NeT Collaboration has designed the IT infrastructure to allow a duplication of the raw data flux at switch level; this option, schematically reported in Fig. 2, is transparent to the normal operation of the experiment. The duplication of the raw data flux will allow maximum flexibility to handle, select and analyze data. However, this requires to design, implement and maintain the IT infrastructure.

It is intended to adapt the design proposed after a further deep discussion with experts of the ESS community.

4. Access policy

The access policy to data will be defined in synergy with WP4 and subject to the approval by the PMB and the KM3NeT Collaboration. It is foreseen that some data that do not require any analysis or calibration will be made public in real time. Other data will be made publicly available after an embargo time of expectedly two years under an open-access policy on a web-based service. The embargo time is given the KM3NeT collaboration as a return for hosting and operating the facility and allows the collaboration to process and exploit the generated data first.

The development of the software solutions for open data access is a continuous process pursued inside work package 4 (WP4) of KM3NeT-INFRADEV and regularly presented to the PMB and the KM3NeT Collaboration. Similarly to what pursued within WP4, some decisions on key parameters need to be taken during the remainder of the KM3NeT-INFRADEV project and need to be endorsed by the current KM3NeT governance or, alternatively, may become part of the ERIC statutes. These are:

- The embargo time during which the KM3NeT data remain proprietary. As a working hypothesis, an embargo time of two years is currently assumed.
- The level of data to be made public. This decision is tightly bound to the availability of human and computing resources for implementation of open data access. Even though this implementation will not be part of KM3NeT-INFRADEV, a guideline on the objectives to be targeted will be provided.

For what concerns the installation of sensors from ESS community, proposal will be accepted through a peer review process whose modalities have still to be defined.

5. Conclusions

The KM3NeT Collaboration has explored the possibility to make available part of data and infrastructure to Earth and Sea Science community. The present document describes some of the possibilities offered by KM3NeT 2.0 to external users for the study of underwater environment.

A set of calibration data suitable for the sharing with external scientific communities have been identified and the related access policy and restrictions have been discussed.

The KM3NeT collaboration will also offer to external users software tools for data mining and extraction of aggregated information. This document provides general guidelines for the final manuals, which will need to be improved through a continuous dialogue with the ESS community and input coming from potential users.