KM3NeT INFRADEV – H2020 – 739560

Report on the discussion on the Memorandum of Understanding with external astronomical partners

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Abstract

This document reports the status of the discussion on the Memorandum of Understanding (MoU) with external collaborations required to fulfill the multi-messenger program of KM3NeT.

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I. DELIVERY SLIP

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II. DOCUMENT LOG

Issue	Date	Comment	Author/Partner
1	15/09/2017	1st version	D. Dornic (CNRS)
2	23/11/2017	2nd version in the official template	D. Dornic (CNRS)
3	29/11/2017	3rd version including P. Coyle comments	D. Dornic (CNRS)
4	04/01/2018	4th version including U. Katz comments	D. Dornic (CNRS)

III. 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.

IV. TERMINOLOGY

A complete project glossary is provided:

MoU: Memorandum of Understanding
EM: electromagnetic
MM: multi-messenger
ARCA: Astroparticle Research with Cosmics in the Abyss
ORCA: Oscillation Research with Cosmics in the Abyss
AMON: Astrophysical Multi-messenger Observatory Network
MWA: Murchison Widefield Array
NIR: Near Infrared
CTA: Cherenkov Telescope Array
IB: Institute Board
PMB: Project Management Board

V. LIST OF FIGURES

VI. LIST OF TABLES

None

VII. 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 the multi-messenger activities in the KM3NeT Collaboration (work package 7).

VIII. EXECUTIVE SUMMARY

The main goal of the WP7 is to implement the necessary preparatory steps to integrate KM3NeT into the multi-messenger astroparticle community. The multi-messenger approach to astronomy makes use of the messenger particles of all four fundamental forces to explore and understand the most violent phenomena in the universe (GRBs, AGNs, FRBs, supernovae, etc.).

Due to its full sky coverage and 100% duty cycle KM3NeT is ideally suited for the detection of transient astrophysical sources of neutrinos. Furthermore, the excellent angular resolution of KM3NeT is well matched to the narrow field of view of many of the photonic observatories. Rapid provision of alerts for interesting neutrino events will enable both ground and space based observatories to quickly point in the direction of the alert. This fast follow-up will be vital to catch any multi-messenger and multi-wavelength counterparts of these cataclysmic but short-lived phenomena.

The last five years mark the beginning of the multi-messenger astronomy with the detection of the first gravitational waves by LIGO/VIRGO, the identification of the first cosmic neutrino signal with IceCube and the evidence of the first PeVatron in the center of our galaxy detected by H.E.S.S.. With the arrival of upgraded or new generation instruments in the coming years, this field will grow very rapidly. The Graal of astroparticle will be to identify for the same source the gravitational wave and the associated follow-up toward the whole electromagnetic observations from radio, visible to X-ray and very high-energy gamma-ray and finally to detect the high-energy neutrino having for the first time a global picture.

The first task of the work package is to establish MoUs with the relevant external electromagnetic and multi-messenger observatories. This document summarizes the status of the discussion on the MoUs with KM3NeT.

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1. Introduction

The aim of the multi-messenger work-package (WP7) of the KM3NeT-INFRADEV project is to fully integrate KM3NeT as an indispensable partner of the astrophysics, astronomy and astroparticle communities.

A large part of the multi-messenger program of the KM3NeT Collaboration relies on the use of high-energy neutrinos to set up observational strategies in the search for the electromagnetic (EM) counterparts of the astrophysical sources. This method has been in operation since 2009 with the ANTARES neutrino telescope [1,2]. The ANTARES alerts trigger some robotic telescopes (TAROT, ROTSE, MASTER and ZADKO) as well as high-energy telescopes such as Swift, Integral and H.E.S.S., and the MWA radio telescope [3]. Reciprocally, KM3NeT should be able to receive real-time alerts from EM observatories and use them to enhance the KM3NeT detection sensitivity for a short period around the time of the external alert.

The agreements between ANTARES and each of these EM observatories is set via a Memorandum of Understanding (MoU). This agreement assures that at least minimal follow-ups of the neutrino alerts are performed by the EM observatories, specifies a direct contact point with the EM partners and grants access to non-public alerts. KM3NeT is setting up a similar follow-up project [4]. To fulfil this program, KM3NeT needs to have access to a large diversity of EM telescopes from radio, visible/NIR to X-ray and the high-energy gamma ray regime located all around the world. Figure 1 illustrates the panorama of instruments available in 2020.

As the online data from KM3NeT will, at least initially, be proprietary, bilateral agreements are needed between KM3NeT and the external observatories. In the future, after a commissioning phase, KM3NeT might decide to make the alerts public. This point will be important for the future discussions with the EM partners.

The other important topic in the KM3NeT multi-messenger program is to perform analysis between multi-messenger probes, i.e. real-time follow-up with KM3NeT of gravitational wave alerts from LIGO / VIRGO Consortium, very high-energy neutrino alerts from IceCube, Pierre Auger Observatory, CTA very high-energy gamma-ray transients... Offline analysis will also be performed looking for correlation between the different messengers as for example correlation between ultra-high-energy cosmic rays and KM3NeT neutrinos, between gravitational wave events and KM3NeT neutrinos… As most of the astroparticle alerts are private, MoU agreements between these collaborations are also necessary.

This document is reporting the status of the discussion on the MoU with the relevant astronomical EM observatories. Part 2 describes the template of MoU and part 3 presents the results of the main discussion with the astronomical partners. Part 4 summarizes the main limitations in this discussion. The part 5 shows the next steps after the end of Task 7.1.

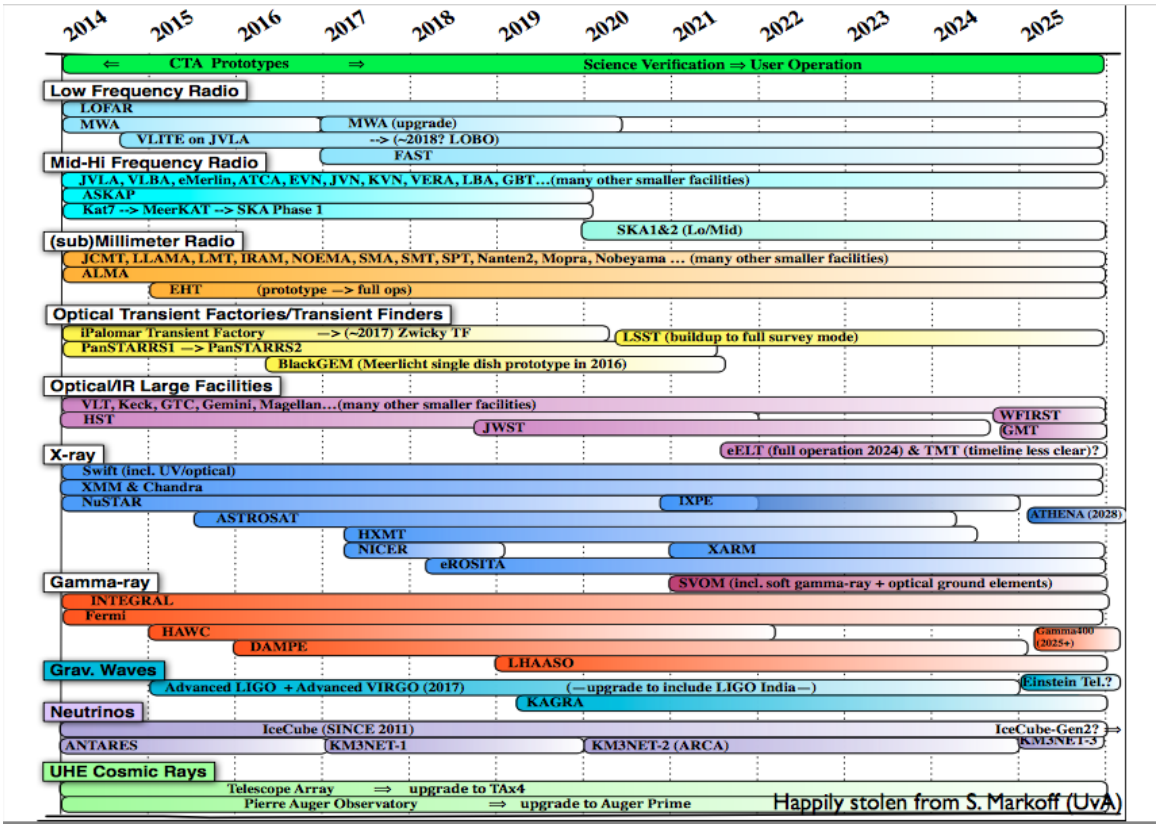

Figure 1: Panorama of the electromagnetic and multi-messenger observatories in the future.

2. Content

To fulfil this project, bilateral agreements are needed between KM3NeT and the external observatories. A draft template of the corresponding Memorandum of Understanding has been created based on the ANTARES MoUs and submitted to the KM3NeT management for internal review. The Institute Board has also approved this document as official on 23/10/2017.

It is a one-way MoU, which will be applicable only for standard astronomy telescopes (radio, visible/NIR, X-ray). This MoU describes mainly the follow-up of the neutrino alerts by the EM observatories. In general, alerts of EM, interesting for the neutrino telescopes, are public and distributed widely to the astrophysics communities. The MoU describes the follow-up and/or analysis strategy (number of followed KM3NeT neutrino alerts, observational and common analysis strategies…). It formalizes the transmission of the neutrino alerts, the confidentiality of the neutrino and the EM results and the rules for joint analysis. The MoU also provides the rules for advertising the observation results to the community and the regulations for joint publications.

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******** **MoU template (approved by KM3NeT IB 23/11/2017)** ********
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Memorandum of Understanding

KM3NeT-XXXX

Follow-up of neutrino events

from the KM3NeT telescope with XXXX

The KM3NeT neutrino telescope has the potential to detect transient sources emitting high-energy neutrinos, such as gamma-ray bursts (GRBs), core-collapse supernovae (SNe), and flares of active galactic nuclei (AGNs). Detection of transient or variable sources of electromagnetic radiation coincident with the neutrino events can provide better positional localisation and potential identification of the progenitors. The KM3NeT Collaboration has implemented fast online track and cascade reconstructions (all-flavour neutrinos) with a good angular resolution, allowing electromagnetic telescopes to be triggered in a search for transient or variable electromagnetic counterparts. This Memorandum of Understanding formalizes an agreement between the KM3NeT and XXXX Collaborations regarding [optical/X-ray/radio/gamma-ray] follow-up of KM3NeT neutrino alerts. The project is named KM3NeT-XXXX.

Introduction:

It is reasonable to expect that the astrophysical objects that produce neutrinos detectable by KM3NeT also produce associated electromagnetic radiation. Thus, a very powerful tool to identify the neutrino sources is a search for electromagnetic counterparts, coincident in position and with correlated variability characteristics. KM3NeT can rapidly transmit information on the neutrino event position, error circle, and detection time to a telescope, triggering observations and the search for possible electromagnetic counterparts.

The purpose of this Memorandum of Understanding is the use of the XXXX telescope for the follow-up of KM3NeT neutrino alerts resulting from triggers transmitted to XXXX from KM3NeT. The XXXX is [DESCRIPTION OF XXXX TELESCOPE].

Agreement:

The XXXX telescope will receive KM3NeT alerts and will override observations on the XXXX at the discretion of the XXXX Director. The number of followed alerts will be agreed by the both managements. XXXX observations will be scheduled as soon as possible after reception of the alert; this response time may be constrained by the availability of the telescope. The analysis of the XXXX data taken after one alert will be available as soon as possible. Due to the nature of any plausible electromagnetic emission, additional follow-up observations are likely to be scheduled hours, days, and weeks after the trigger, to monitor variability on long timescales.

The Collaborations will appoint KM3NeT-XXXX coordinators to ensure the fulfilment of the MoU.

The KM3NeT Collaboration will assure that its selection criteria for alert events are in agreement with the observation rates manageable by XXXX, via periodic consultation with the XXXX Director.

The XXXX Collaboration agrees to treat as confidential the data received from KM3NeT and will not use that data for any other purpose than this joint analysis, nor disclose to any third party. The XXXX Collaboration remains free to perform any analysis or use of its own data triggered by KM3NeT alert. In such a case, a reference to the KM3NeT alert should be discussed by both parties. Permission for a KM3NeT member to participate in an XXXX meeting can be obtained from the XXXX Director.

The KM3NeT Collaboration agrees to treat any data received from XXXX as confidential, agrees it shall be used only for improving KM3NeT data analysis, and will not be used for any other purpose, nor disclosed to any third party. The alert information and the report of analysis will be stored in a private repository. The access to these data will be controlled via a web site or an e-log secured by password. Permission for XXXX members to participate in a KM3NeT Collaboration meeting can be obtained via the KM3NeT Spokesperson. The KM3NeT Collaboration remains free to use its own data independent of the outcome of the follow-up observations.

The MOU is expected to be valid for the duration of the existence of the two Collaborations. At any moment either Collaboration can request the termination of the agreement.

* Rules for the utilisation of these common data (neutrino alert and electromagnetic data) for joint analysis:

The KM3NeT and XXXX Collaborations can only use these data internally. No result, positive or negative, can be communicated beyond the two Collaborations without the agreement of the KM3NeT-XXXX coordinators, the KM3NeT Spokesperson and XXXX Director.

The KM3NeT Collaboration agrees that those alerts which are confirmed by the follow-up will be sent to the GCN (Gamma-ray burst Coordination Network) via a circular after the agreement of the two

managements. This will allow crucial information of the source to be disseminated. This circular will be sent as early as possible after the XXXX data analysis by the KM3NeT-XXXX coordinators. This result may also be published in The Astronomer's Telegram. The author list has to be approved by the KM3NeT-XXXX coordinators and the KM3NeT Spokesperson and XXXX Director.

* Rules for publication and communication of a joint analysis:

The discovery of any transient sources possibly connected to KM3NeT alerts cannot be published or communicated without the agreement of the KM3NeT Collaboration.

Any conference presentations making use of the data of KM3NeT-XXXX will follow the standard rules of each Collaboration. The presentation should state:

Xxx on behalf of KM3NeT and XXXX Collaborations

The goal of the cooperation between the KM3NeT and XXXX is joint publication of shared results. Any publications based on the KM3NeT-XXXX data will be signed by the whole KM3NeT author list and a list of XXXX authors nominated by the XXXX Collaboration. The lists of authors and their appearance order will be defined by each collaboration. The order of the two lists will reflect the relative contributions of the individual authors to the publication and the balance of analysis between KM3NeT and XXXX. This choice should be approved by the XXXX Director and the KM3NeT Publication Committee. This criterion is extended also in the case of additional authors from optical, X-ray etc. collaborations. The publication will follow the standard internal refereeing procedures adopted by the KM3NeT and XXXX Collaborations.

The KM3NeT Collaboration retains the right to publish independently an analysis of its own data without using XXXX data.

The XXXX Collaboration retains the right to publish independently an analysis of its own data without using KM3NeT data, including the alert information. The discovery of any transient sources, which potentially emit high-energy neutrinos (e.g., gamma-ray bursts, supernovae, microquasars), following KM3NeT alerts cannot be published without the agreement of the KM3NeT Collaboration.

Signed on behalf of the KM3NeT Collaboration by SPOKESPERSON

Signed on behalf of the XXXX Collaboration by DIRECTOR

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This template does not cover the more specific agreements we will have with collaborations whose data are proprietary, such as the high-energy gamma-ray telescopes H.E.S.S., VERITAS, CTA, HAWC, LHAASO and the multi-messenger observatories such as the Pierre Auger Observatory, Telescope Array, radio neutrino telescopes, and the LIGO/VIRGO gravitational wave detectors. For these observatories, we will have bi-directional exchange of information (send neutrino alerts and receive proprietary EM/MM alerts). These specific cases will have to be treated case-by-case as a general template cannot cover the full agreements. However, the joint rules (use of data, joint communication) still remain the same.

3. Results

As of November 2017, only one MoU has been signed between KM3NeT and the Murchison Widefield Array (MWA). The M.W.A. is a low frequency (80 - 300 MHz) radio telescope, precursor of the Square Kilometre Array located in Australia. Its huge field of view (700 square degrees at 150 MHz) is particularly valuable for follow-up of neutrino candidates, which have rather large direction uncertainties.

During finalisation of the MoU template, we have reached oral agreements with others observatories, TAROT, ZADKO, MASTER, Swift, and SVOM. TAROT and MASTER are two robotic telescope networks, which comprise 3 and 6 telescopes, respectively, located all around the world. ZADKO is a one-meter telescope located in Australia. Swift is the current gamma-ray satellite, which currently provides most of the transient alerts and follows neutrino alerts. SVOM is a gamma-ray satellite that will be the successor of Swift in 2021-22. SVOM also comprises a ground-based telescopes of SVOM (Ground Wide Angle Camera telescope, GWAC) which is already in operation and used for the ANTARES follow-ups.

To complete the multi-wavelength coverage of neutrino follow-ups, there are discussions on-going with other observatories such as the high-energy gamma-ray telescopes: HESS, MAGIC, CTA, HAWC, LHAASO, and the radio facilities: Parkes, Superb, UTMOST, CHIME, ASKAP. It could be also interesting to contact additional robotic networks such as GROWTH, LCOGT (need to buy obs. time), BlackJAM and the large field of view telescope ZTF (Zwicky Transient Facility).

For the multi-messenger coverage, agreements will be needed with the Pierre Auger Observatory, the Telescope Array and the gravitational wave detectors LIGO/VIRGO. The discussions with these observatories are expected to take time and should be start as soon as possible.

The Astrophysical Multi-messenger Observatory Network (AMON) is a program currently under development that seeks to perform a real-time correlation analysis of the high-energy signals across all known astronomical messengers - photons, neutrinos, cosmic rays, and gravitational waves [5]. It will enhance the combined sensitivity of the collaborating observatories to astrophysical transients by searching for coincidences in their sub-threshold data and to enable rapid follow-up imaging. KM3NeT will provide events (direction, energy, time, reconstruction quality) to the AMON database via the VO event format and protocol. KM3NeT participation in AMON will be established through a MoU.

4. Main limitations

To pursue the discussions with external collaborators, there are two main open points: Uncertainties of the timelines and the status proprietary/public of the neutrino alerts.

Clearly, the main limitation comes from the uncertainties in the deployment and operation schedule for the futures lines for the ORCA detector and especially for the high-energy ARCA detector. The first question we are usually asked is when will we send the first alert? The KM3NeT management will have to provide clarifications and an update of the planning at the time of the negotiation.

The question of the public/proprietary status of the neutrino alerts is important for the EM partners since it affects their internal/external communication and therefore the visibility of their work for funding agencies. This point has been raised in the KM3NeT Collaboration and will need discussions with the Institute Board.

5. Next steps

The results of this project have provided a framework (MoU template, rules for joint works/publications, …) for the future agreement with the list of EM and MM observatories needed to fulfil the multi-messenger program. KM3NeT will proceed to sign the MoUs with external partners, so that we can set up rapidly the multi-messenger programs once KM3NeT will have on-line data.

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