KM3NeT Detection Unit Line Fit reconstruction using positioning sensors data

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KM3NeT is constructing two large neutrino detectors in the Mediterranean Sea: KM3NeT/ARCA, located near Sicily and aiming at neutrino astronomy, and KM3NeT/ORCA, located near Toulon and designed for neutrino oscillation studies. The two detectors, together, will have hundreds of Detection Units (DUs) with 18 Digital Optical Modules (DOMs) maintained vertical by buoyancy, forming a large 3D optical array for detecting the Cherenkov light produced after the neutrino interactions.

The main goal of KM3NeT is to detect neutrinos; in order to do this, it is necessary to reconstruct particle tracks, so it is very important to know the position and the orientation of each DOM. Since the detector is anchored on the sea bed, it is affected by the sea current that can move, displace and rotate the Detection Lines (DUs).
For this purpose, there are acoustic and orientation sensors installed inside the DOMs. An Attitude Heading Reference System (AHRS) chip provides the components values of the Acceleration and Magnetic field every 10 seconds, from which it is possible to calculate Yaw, Pitch and Roll (YPR). A piezo sensor detects the signals emitted from fixed acoustic emitters on the sea floor, so to position it by trilateration. The acoustic emitters emit an individual sweep signal (one per AB to distinguish the emitter) in a work duty cycle of 10 minutes (1 minute of emissions and the device is kept off to save energy from the battery pack). During the minute of emissions, the signal is sent every 5 seconds. From this data it is possible reconstruct the position of the DOMs in the space [X, Y, Z].
Another important ingredient necessary to properly reconstruct the position of the DOMs is the called Mechanical Model (MM), which provides the line shape (DOMs positions) based on the sea current properties (sea current velocity ν, and direction ω).
The Detection Unit Line Fit Model allow to reconstruct the position of the DOMs in the space [X, Y, Z] from a raw input data. The raw input data can be of two types: raw data from AHRS or raw data from APS. In this work, only results and procedure with AHRS data as input are presented.
As described before AHRS system provides the acceleration and magnetic field components and from these it is possible compute Yaw, Pitch, and Roll. To properly compute the orientation of the DOMs, it is necessary apply some corrections, offsets, to the value of the Pitch and Roll value. The offsets are obtained by studying the positions of the lines in periods in which strong sea currents are absent and assuming that the line is perfectly vertical. The next step is to translate YPR into XYZ, to do this a matrix, given by the product of three rotation matrices, is applied.
After these preliminary steps, with the positioning method, described before, one can obtain the sea current properties and finally apply the Mechanical Model to get the reconstructed position XYZ.

The results presented at this conference are an example of the application of a DU Line Fit Model for the data taken the 24th February 2020, from 6:00 am to 9:00 am, for the six Detection Line of KM3NeT/ORCA. During these three hours a strong sea current was present.
These results are important because they show the possibility to reconstruct the positions of the main components of the detector independently of the acoustic positioning system.
This Method has also been applied to one of the lines (DU9) on which there is no floating buoy, which allows greater vertical displacement, and this condition makes it less stable than the other lines even in periods of low sea current.
The next step of the analysis is to include data from the acoustic positioning system, in order to have an alternative reconstruction, as well as a redundancy in the position reconstruction.