KM3NeT DETECTION UNIT LINE FIT RECONSTRUCTION USING POSITIONING SENSORS DATA

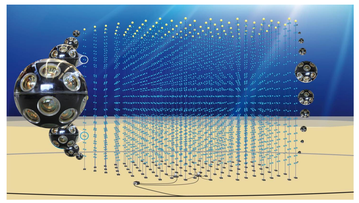
Chiara Poirè[1], Dídac Diego-Tortosa[1] on behalf of the KM3NeT Collaboration
[1] *Universitat Politècnica de València (UPV) – Institut d'Investigació per a la Gestió Integrada de Zones Costaneres (IGIC)*

Summary

KM3NeT is constructing two large neutrino detectors in the Mediterranean Sea: KM3NeT/ARCA, and KM3NeT/ORCA. These detectors are built in the form of 3D arrays of optical modules for detecting the Cherenkov light produced after the neutrino interactions.
To properly reconstruct the direction of the incoming neutrino, the position of each optical module, which could be affected by sea current, must be known precisely with an accuracy of less than 10 cm. For this purpose, we present here a position reconstruction method that uses a Mechanical Method and a Detection Unit Line Fit Reconstruction Model.
The results shown in this poster are obtained using compass data from the 6-line KM3NeT-ORCA detector.

KM3NeT

KM3NeT consists in:
- 3 blocks → two for KM3NeT/ARCA, one for KM3NeT/ORCA
- Each block → 115 Detection Unit (DU)
- DU → 18 Digital Optical Module (DOM)
- DOM → 31 Photomultipliers (PMT)



Positioning

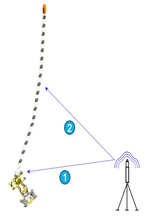
Different types of sensors that allow the reconstruction of the position and the orientation of each DOM are installed in the detector. The present study is based on data from the Attitude Heading Reference System (AHRS) sensors, that provide the tilt and compass measurements and are installed on the Central Logic Board (CLB) of each DOM. Data from the Acoustic Positioning System (APS), comprising piezo-ceramic sensors and hydrophones, are not considered here.

APS

Acoustic receivers in KM3NeT:
- Hydrophone (fixed) in DU-base
- Piezoceramic sensor in DOMs

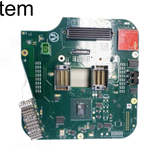
The Acoustic Beacons (ABs) in KM3NeT work in cycles of 10 minutes emitting every 5 s: 1 min ON + 9 min OFF

With these components it is possible to calculate X,Y,Z by acoustic triangulation method



AHRS

Attitude Heading Reference System



The chip contains:
- Accelerometer [A_x, A_y, A_z]
- Magnetometer [H_x, H_y, H_z]

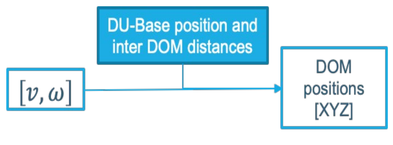
With these components it is possible to calculate Yaw, Pitch and Roll (YPR)
The AHRS board is taking data every ~10 seconds

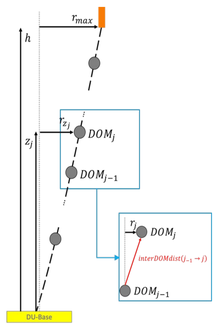
Mechanical Model (MM)

Used to reconstruct the DOM positions from input data and effective sea current (velocity v, and direction ω) as fit parameter.

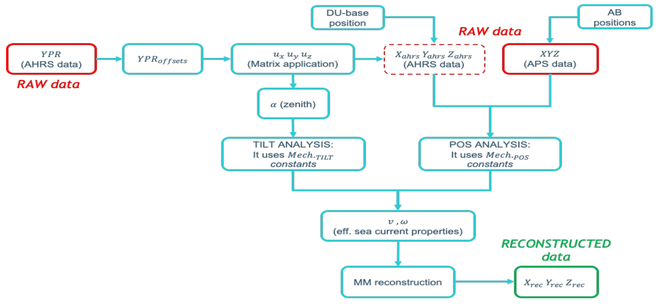
$\mathrm{Tan}(\alpha) = M_{TILT} \cdot v^2$
$r = M_{POS} \cdot v^2$

Where α is the zenith angle of the tilted line w.r.t. the vertical, and M_{TILT} and M_{POS} are the mechanical constants for tiltmeter and positioning, respectively.

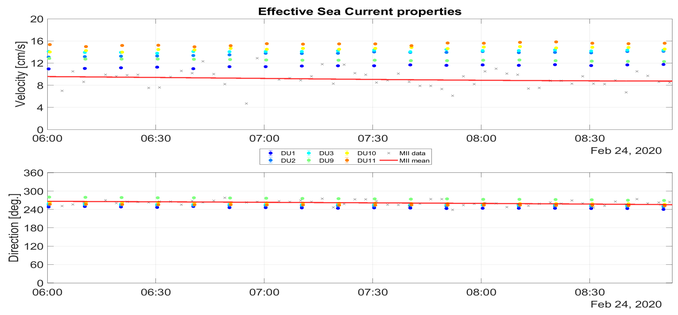




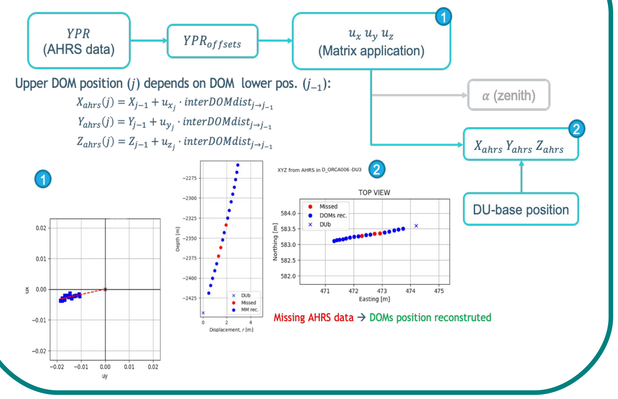
DU Line Fit Model



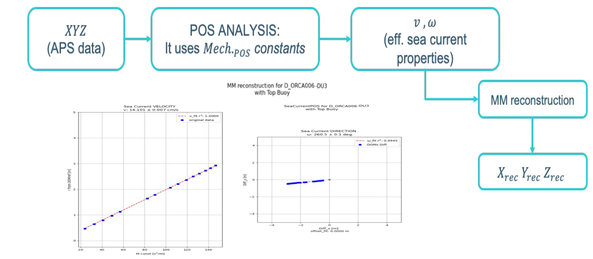
Sea current properties from DU Line Fit Analysis



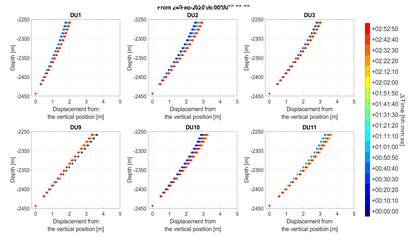
Positioning from AHRS data



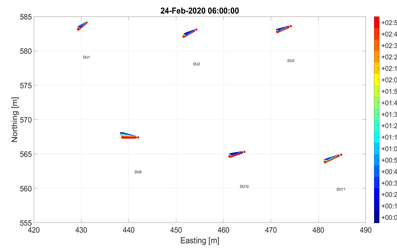
Position reconstruction by Position Analysis



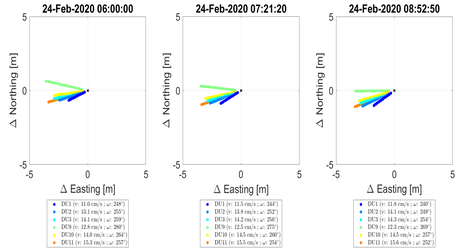
DU Line Fit Results



Vertical displacement during the three hours considered



Top view during the three hours considered



Three different moment in the time window considered for all DUs

Conclusions

The results presented here are the reconstructed positions of DOMs using compass data taken with the 6-line KM3NeT-ORCA detector. 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.
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.

References
[1] S. Adrián-Martínez et al., Letter of intent for KM3NeT 2.0. J. Phys. G Nucl. Part Phys. 2016, 43, 084001. doi:\href{https://iopscience.iop.org/article/10.1088/0954-3899/43/8/084001}{10.1088/0954-3899/43/8/084001} [2] M. Ageron et al., ANTARES collaboration, "ANTARES: The first undersea neutrino telescope", Nucl. Inst.. and Meth. in Phys. Res. A 656 (2011) 11-38, arXiv:1104.1607; [3] S. Adrián-Martínez et al., ANTARES collaboration, "The positioning system of the ANTARES Neutrino Telescope", JINST 2012, 7, T08002. doi:10.1088/1748-0221/7/08/t08002; [4] Diego-Tortosa, D., "Mechanical Line Fit Model to Monitor the Position of KM3NeT Optical Modules from the Acoustic and Compass/Accelerometer Sensor System Data"; [5] Riccobene, G. "The Positioning System for KM3NeT", EPJ Web Conf. 2019, 207, 07005. doi:10.1051/epjconf/201920707005; [6] Viola.,S. "KM3NeT acoustic positioning and detection system", EPJ Web of Conferences 216, 02006 (2019), doi:10.1051/epjconf/201921602006