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KM3NeT
Opens a new window on our universe

Challenges and solutions in the mechanical design of the KM3NeT ARCA Base Module

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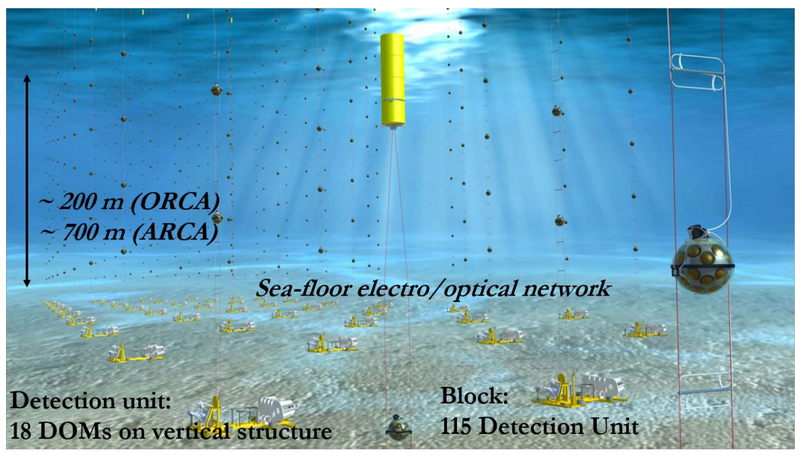
The KM3NeT detector

KM3NeT (KM^3-scale Neutrino Telescope) [1] is a research infrastructure in the Mediterranean Sea which will house two neutrino detectors: **ORCA** (Oscillation Research with Cosmics in the Abyss) for the neutrino mass hierarchy determination and **ARCA** (Astroparticle Research with Cosmics in the Abyss) to search for very high-energy cosmic neutrinos.

The neutrino telescope is made of Detection Units (DU) each consisting of 18 Digital Optical Modules (DOMs), a Vertical Electro-Optical Cable (VEOC) and a Base Module (BM). The DUs are connected through a network of nodes ,the Junction Boxes (JB), and submarine cables to a control station onshore.
The **ARCA detector** is installed at 3500 m underwater, where each DU is connected to a JB by its own BM. The JBs are connected to the Main Electro-Optical Cable (MEOC) final termination frame and the MEOC to the onshore control station located at Capo Passero site (Sicily, Italy).



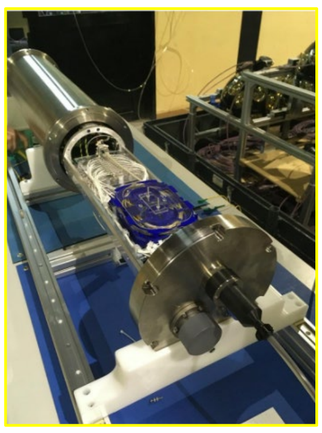
ARCA :
2 Blocks
1 Gigaton
3.5 km deep
Capo Passero (Italy) site
Astrophysical neutrinos

ORCA :
1 Block
~5 Mt
2.5 km deep
Toulon (France) site
Neutrino mass ordering

DUs installed in the deep sea – artist's view.

The BM mechanical requirements

The BM purpose is twofold: collect the data arriving from the 18 DOMs via the VEOC, pack and transmit them to the on-shore station through the sub-marine infrastructure; distribute to the DOMs the power and the communications broadcasted from shore.



BM before its closure

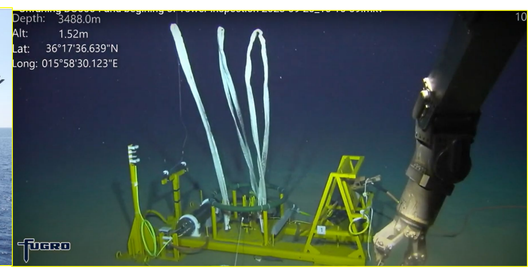
The mechanical requirements placed on BM are significant, as it represents a single point of failure for the DU.
It has been designed in order to be:
1) water tight
2) mechanically resistant to an external water pressure up to **350** bar
3) able to stand all mechanical stresses along its life
4) resistant to corrosion for at least 15 years in sea water
5) able to safely host all electro-optical components, by guaranteeing an adequate heat dissipation.

The BM is built with a titanium cylindrical container (to fulfil 4)) hosting an internal aluminium frame structure where optics, electronics and power boards are allocated.

ARCA DUs/BMs in the deep water

The first BM (DU) was deployed in 2015, and now KM3NeT ARCA comprises 28 DUs (28 BMs) working in the deep water.

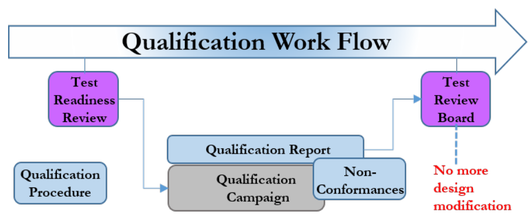
Deployment of a DU from the ship during the September 2023 sea campaign [2]



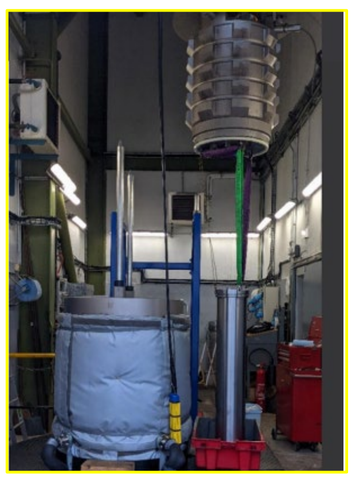
DU foot at 3500 m of depth after the deployment.

The BM qualification campaign

By a dedicated qualification campaign, the BM design has been qualified in order to confirm its performance in operating condition, including all other phases of its life cycle such as storage, handling, transportation and deployment.



Pressure tests

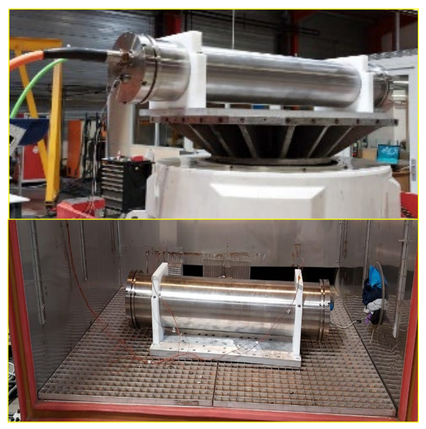


BM titanium container ready to be moved in the hyperbaric chamber at IFREMER, France

The goal was to validate requirements 1 and 2.
The test procedure consisted of:
a) 8 h at 525 bar (1,5 safety coefficient)
b) 10 cycles: 1h at 350 bar & 1h P atmospheric

Stress and vibration tests

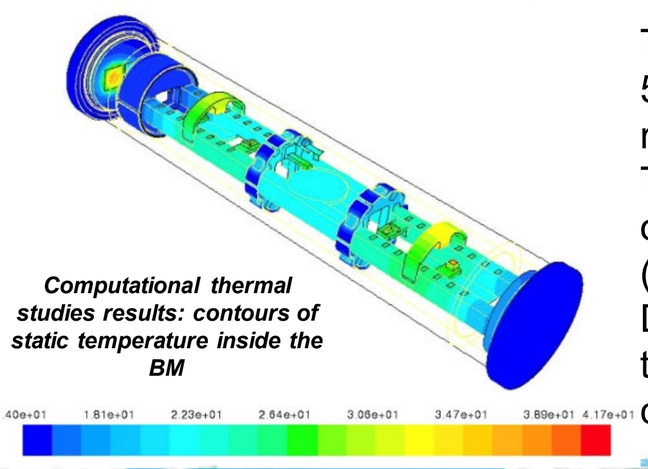
The goal was to validate requirements 3.
The test consisted in stressing the BM along its axes, up and down, with vibrations, hard (15 G) and soft (10 G) shocks.
The session test was completed with BM exposure to high temperature (70°C) and humidity (93%).



BM on the shaker bench at Sopavib (France)

BM in the climate chamber at Sopavib (France)

Cooling performance tests



Computational thermal studies results: contours of static temperature inside the BM

The goal was to validate requirement 5 in accordance with the KM3NeT reliability studies for KM3NeT BM.
The BM was submerged and operated in a tank with water at 14°C (at INFN Sez. Bari, Italy).
During the tests the internal BM temperature was monitored and compared with the simulation results.

References
[1] S. Adrián-Martínez et al. (KM3NeT Coll.), *Letter of intent for KM3NeT 2.0*, **J. Phys. G: Nucl. Part. Phys 43** (2016) 084001
[2] https://www.km3net.org/