

ART AND ASTROPHYSICS IN CONVERSATION WITH KM3NeT IN THE MEDITERRANEAN SEA

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on behalf of the KM3NeT
Collaboration

KM3NeT: searching for neutrinos in the Mediterranean sea

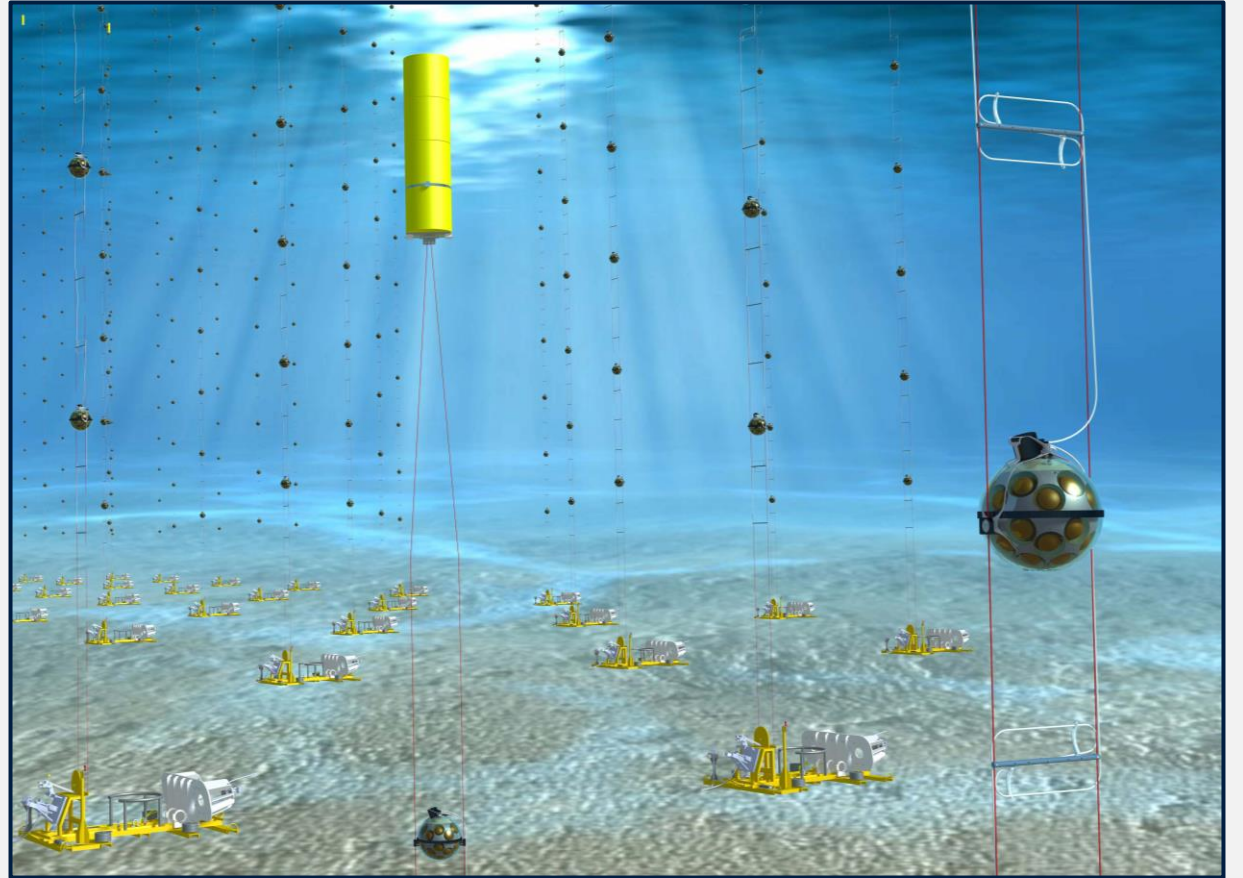
KM3NeT is a Cherenkov neutrino telescope currently being deployed in at the bottom of the Mediterranean sea

It consists of two discrete detector arrays:

KM3NeT/ORCA situated at a depth of 2.5 km off the coast of Toulon, France, and

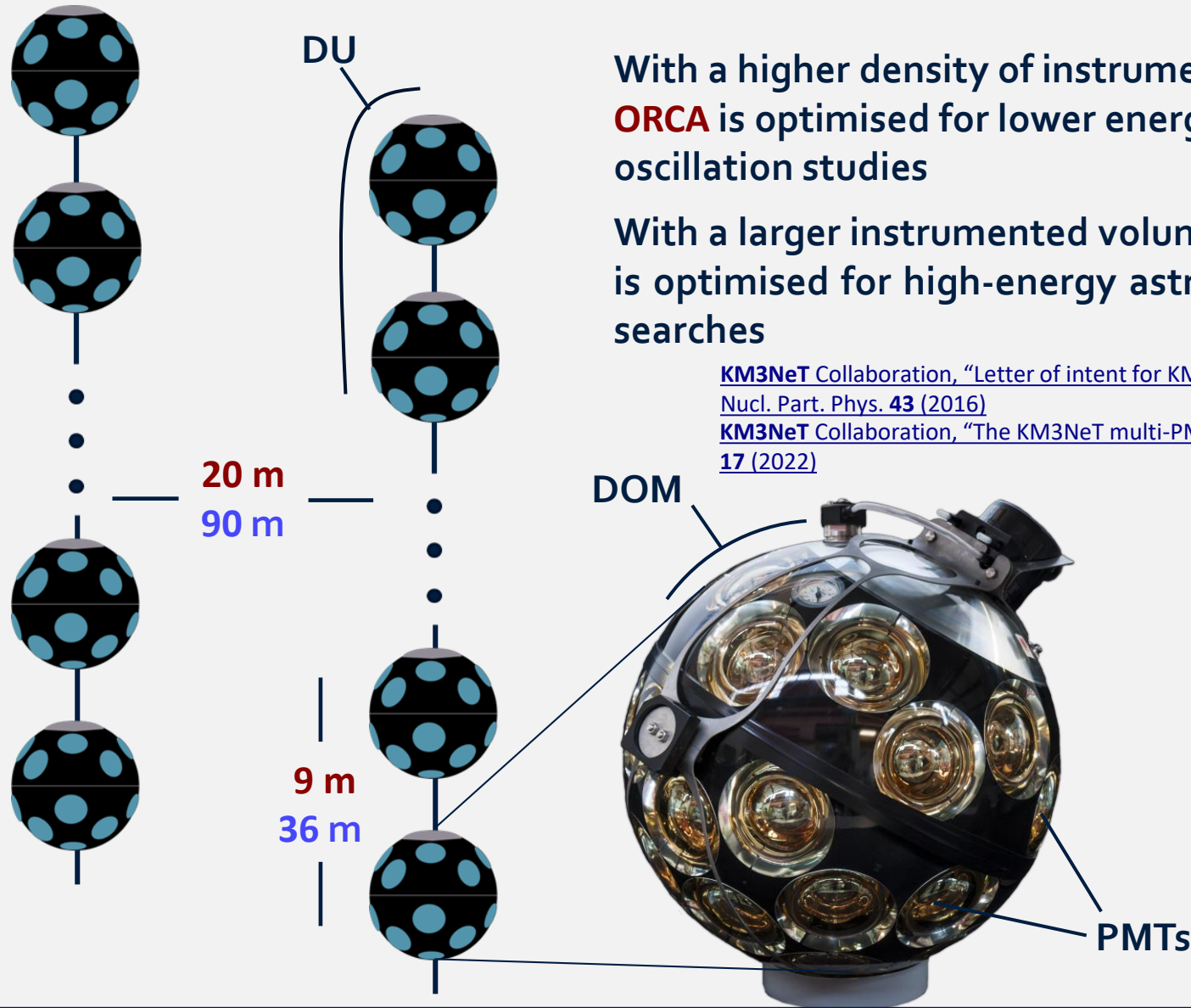
KM3NeT/ARCA at depth of 3.5 km situated off the coast of Sicily, Italy

In its final configuration, KM3NeT will result in an **instrumented volume of about a cubic kilometre.**



Artist's Rendering of the ORCA Array

KM3NeT: searching for neutrinos in the Mediterranean sea



With a higher density of instrumentation, **ORCA** is optimised for lower energies and oscillation studies

With a larger instrumented volume, **ARCA** is optimised for high-energy astrophysical searches

[KM3NeT Collaboration, "Letter of intent for KM3NeT 2.0", J. Phys. G: Nucl. Part. Phys. **43** \(2016\)](#)

[KM3NeT Collaboration, "The KM3NeT multi-PMT optical module", JINST **17** \(2022\)](#)

DU = Detection Units
DOM = Digital Optical Modules

115 DUs in ORCA

115 × 2 DUs in ARCA

18 DOMs per DU

31 PMTs per DOM

There are currently
**19 active DUs in ORCA, and
21 active DUs in ARCA**

[\(7A\) Neutr. and Astrophys., S.R. Gozzini, 'Latest Results with the KM3NeT Neutrino Telescope'](#)

[\(7A\) Neutr. and Astrophys., C. F. Lastoria, 'Tau neutrino appearance measurement in KM3NeT/ORCA 6'](#)

[\(7A\) Neutr. and Astrophys., A. Lazo, 'Results on Neutrino Non-Standard Interactions with KM3NeT/ORCA6 and ANTARES'](#)

Donald Fortescue



“Donald Fortescue is an artist, writer, curator and educator. He is a full professor of art and design at the California College of the Arts (CCA) [...].

Donald creates sculptural ‘instruments’, installations, video, sound works and images which reframe our view of the world [...].

His work highlights the rich history of human engagement with the natural world and our evolving efforts to find our place within it.”



Instrument (90°S)



On the Level



Covert Transducer #1

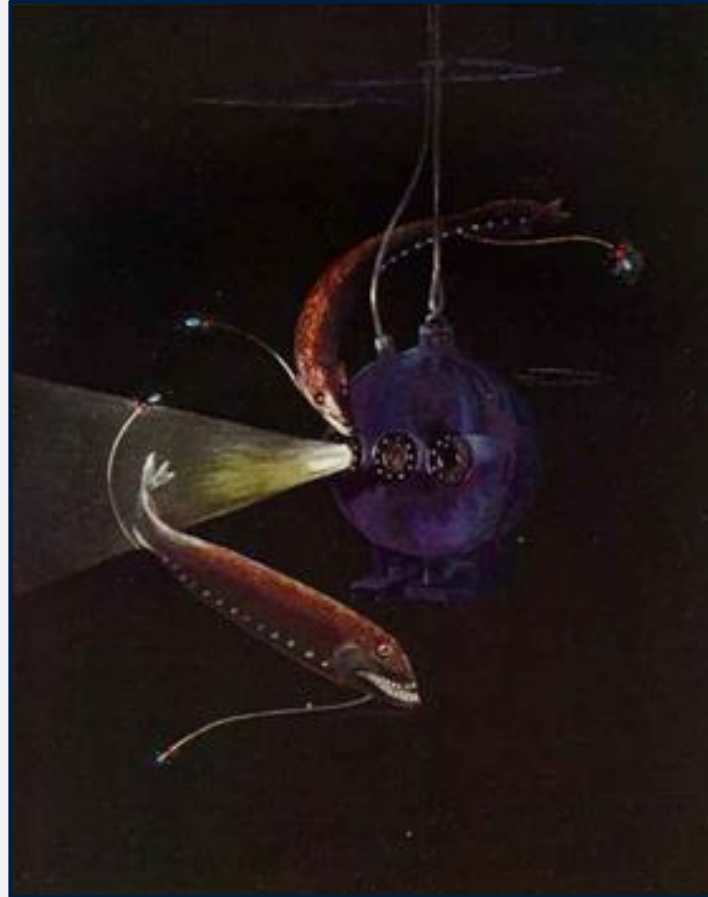


Heliographs

The Bathysphere

Donald's latest work in collaboration with KM3NeT is named after William Beebe and Otis Barton's Bathysphere

The Bathysphere was the first pressurized vessel used for deep sea explorations, and in the early 1930s reached a record depth of ≈ 920 m



E. Bostelmann, W.Beebe, "A Half Mile Down: Strange Creatures Beautiful and Grotesque as Figments of Fancy, Reveal Themselves at Windows of Bathysphere", National Geographic (1934)



WCS photo collection (DTR)

The 'Bathysphere'

The 'Bathysphere' is composed of an analogical instrument with 6 concentric hemispheric bells and 5 hammers

It is enclosed inside one of KM3NeT's pressurised glass sphere, and has a flotation buoy.

The movement of the 'Bathysphere' causes the hammers to hit or rub against the bells producing sounds.



The 'Bathysphere's' internal mechanism

The 'Bathysphere' with its ballast



KM3NeT's multi-PMT DOM



'Below the surface'



Tests for the
'Bathysphere'
in San Francisco



The 'Bathysphere'
offshore
La Seyne-sur-Mer

On the 23rd of September 2021 the 'Bathysphere' was brought on a boat to the site of ORCA for deployment.

The 'Bathysphere' was attached to the boat through a line with height markers, allowing to measure its reached depth, and to retrieve the instrument after the flotation buoy was released and the 'Bathysphere' sank.

The 'Bathysphere' was equipped with a GoPro to record images of the sea surface, and a digital audio recorder to capture the sound of the bells caused by the waves.

At the time of deployment, ORCA had 6 active DUs, and the 'Bathysphere' reached 300 m depth.

The recordings of the dive were used to produce 'Below the Surface', a short film with a cyclic structure which will be shown together with the 'Bathysphere' at exhibitions.

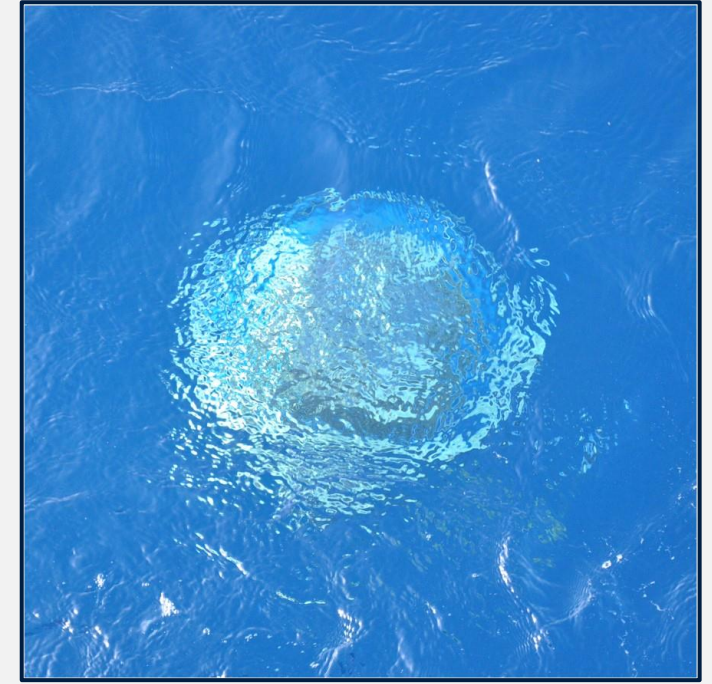
'Below the surface'

watch the full video [here](#)

'Below the surface' is a 6:06 minutes-long video which is composed of **4 main sections:**

While the bathysphere floats, it is possible to hear the bells clearly, and the sky is visible from **just below the surface**.

During **the dive** portion, the images progressively get darker as less light propagates through the water, and the analog sound gets quieter.



Once the 'Bathysphere' is deep in the sea, where you can no longer hear the bells, a digital track is played, which was obtained through sonification of KM3NeT data.

Finally, as the 'Bathysphere' reaches the **surface again**, the sonified-data track fades out, and it is again possible to hear the bells.

‘Below the surface’: data sonification

The sonified data in ‘Below the surface’ is obtained through a careful mapping of each DU to the notes from the chromatic scale, covering 6 octaves.

The PMTs in each DOM were divided into 4 groups, and when these would detect a photon a note is played with volume proportional to the detected charge.

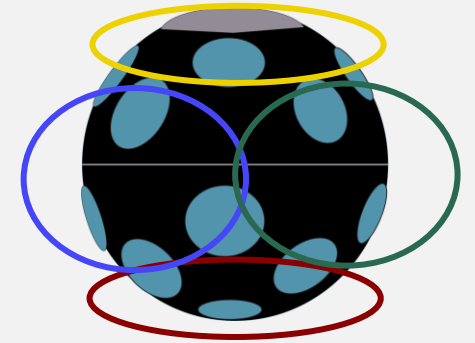
Groups of 3 DOMs complete an octave. Lower octaves are mapped to the bottom of the detector, and higher octaves to the top.

The data that has been sonified is low-level data with a threshold on the coincident cumulative charge per DOM.

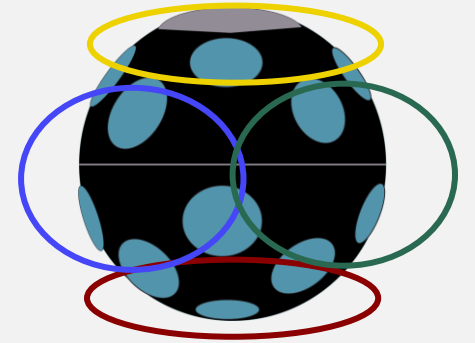
We listen to high-luminosity events which are expected to be caused by a mixture of K40 decay and bioluminescence, as well as atmospheric muons and neutrinos.

The portion of data that was used correspond to about 0.4 s of data starting from the time of maximum depth of the ‘Bathysphere’

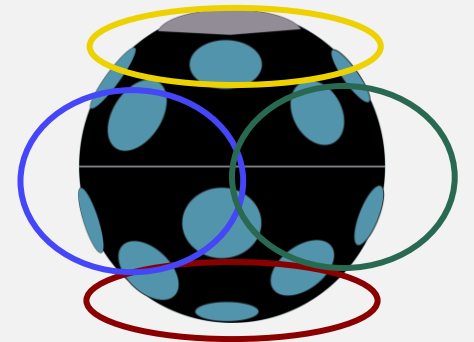
B, E, G, C



F, Bb, Eb, Gb



Ab, Db, D, A





Conclusions

“Below the Surface” highlights the extraordinary environment in which the KM3NeT array is being created and operates.

The craftsmanship of the “Bathysphere” echoes the technical sophistication of the unique instrumentation of KM3NeT.

The data sonification for “Below the Surface” offers new perspectives on the data collected by KM3NeT.

The durable art/science collaboration developed by the authors over many years provides a successful model for imbedding artists within science teams to facilitate new perspectives and audiences

Thank you!!!

The deployment team



KM3NeT Collaboration in Salerno (2023)



FINE