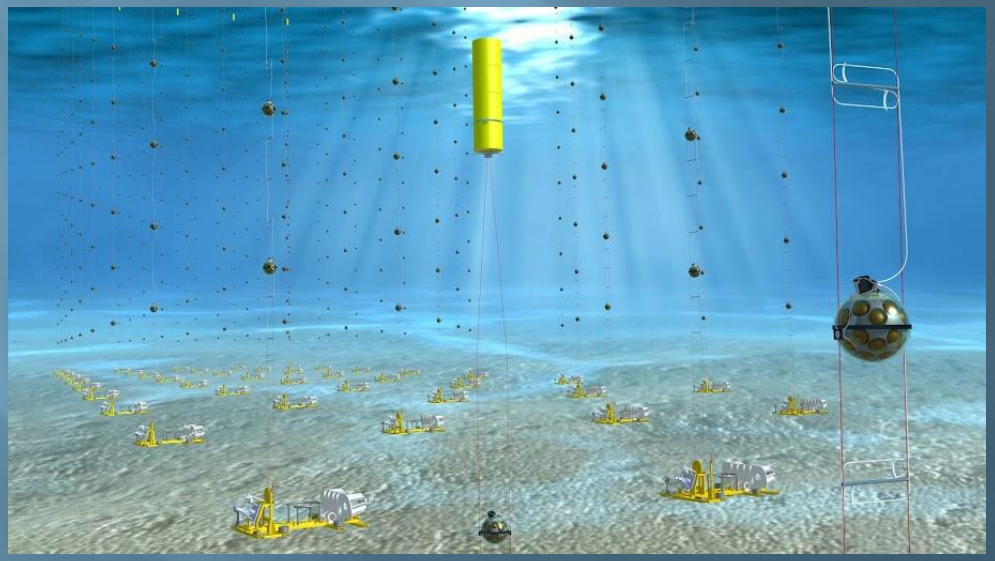
Sea operations in the MEUST NUMerEnv observatory

P.Lamare
Centre de Physique des Particules de Marseille

MEUST NUMerEnv

International deep-sea observatory for multidisciplinary research, successor of ANTARES, managed by CPPM:

- Physics research on neutrino particle with the KM3NeT Collaboration (ORCA detector)
- Earth and Sea Sciences with EMSO ERIC

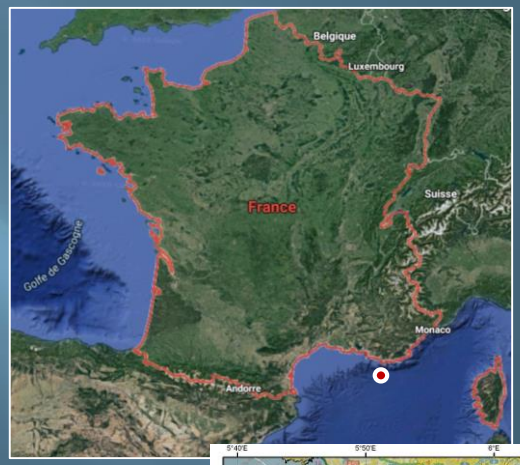


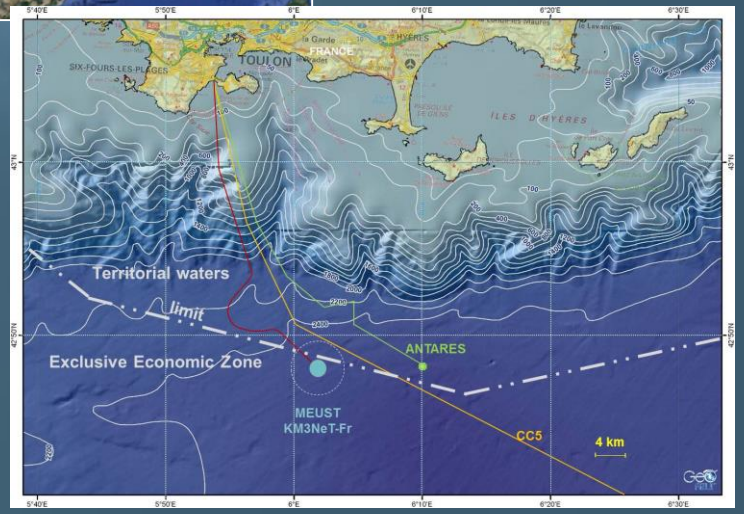
Artist view of the Detections Units (DU) of the ORCA detector

Project co-funded by CNRS, Region, the State and Europe

Submarine infrastructure

Located at 2440 m depth, 40 km off Toulon in the Exclusive Economic Zone (EEZ).





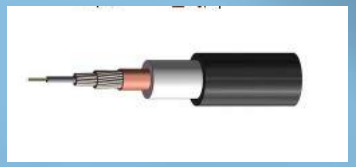
Recognized infrastructure:

- RI, France
- ESFRI, Europe
- Labeled by pôle Mer Méditerranée

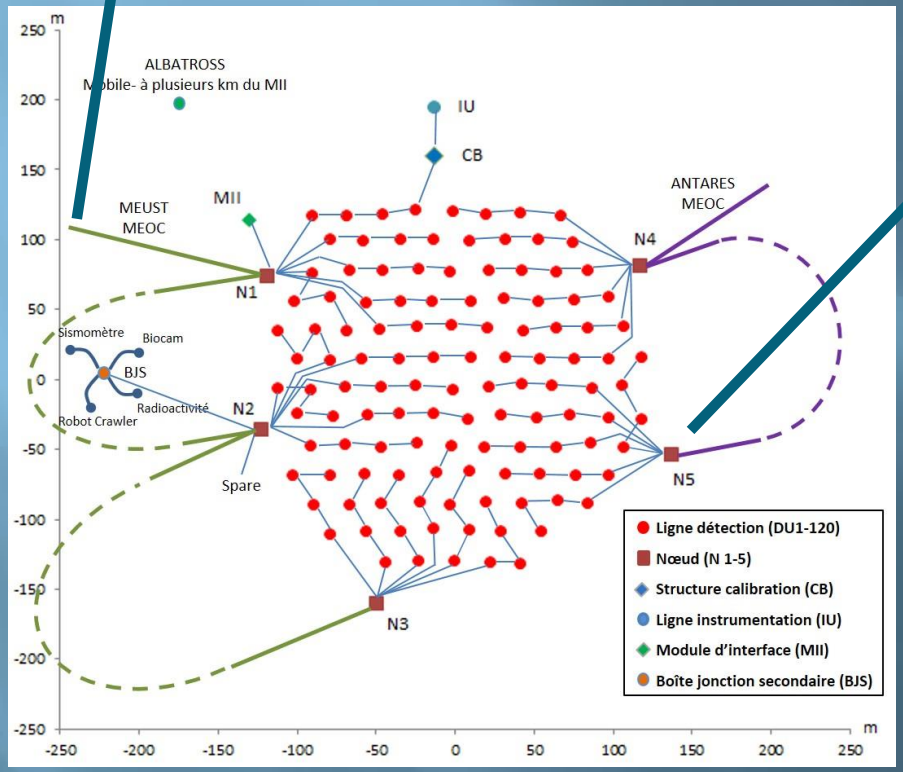
and awarded:

- Prix Cristal collectif CNRS 2018

Layout of the infrastructure

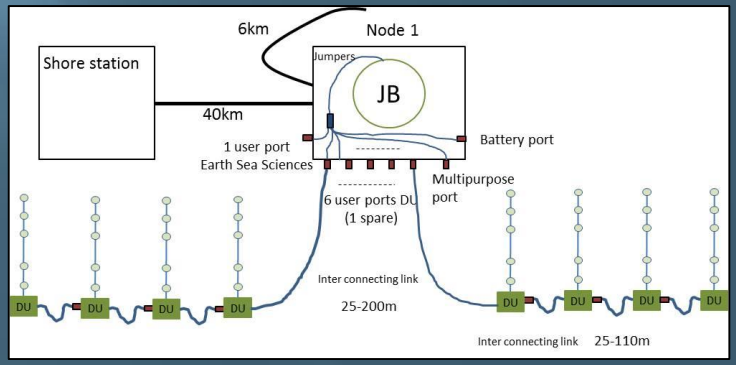


Telecom cable Alcatel (36 optical fibres), 40 km long powered in 3300 V AC



Modular, extendable, designed for up to 120 neutrino DUs

Node hosts 8 user ports for 24 DUs and Earth & Sea Sciences



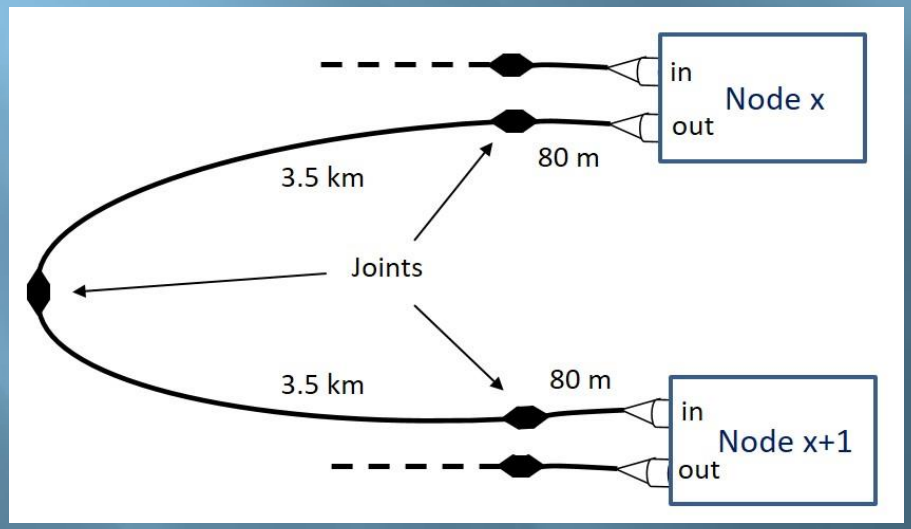
4 DUs connected in series on one user port

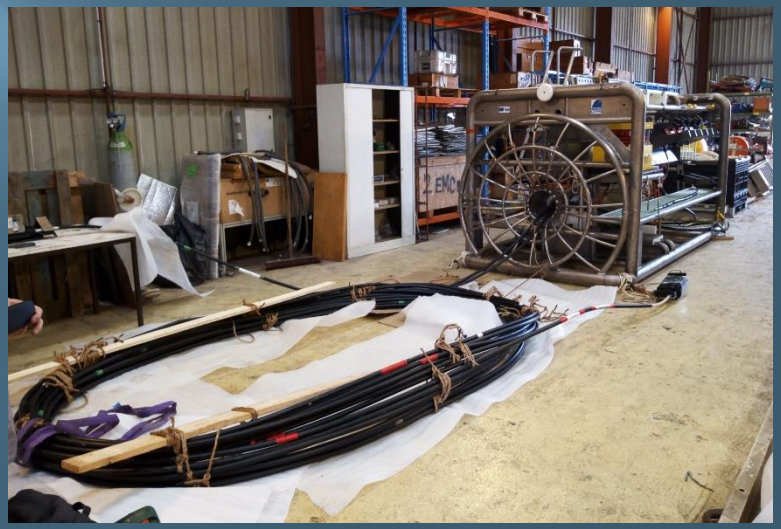
Seafloor network installation

- Study made by Orange Marine using techniques from telecommunication cables with cable jointing at the sea surface
- Installation and maintenance (MECMA) by Orange Marine
- Installation in territorial waters and EEZ in France requires authorizations, (complex) procedures followed with the help of an environmental engineering company. Some constraints for cable laying
- Phased installation (funding)
- 1st node could be installed without precise position (+/-100 m) while the next nodes requires precise position (+/- 5 m)
- Cable introduced in the MECMA consortium for maintenance inside the scientific network with HCMR, INFN, and INGV cables.

Setup for deployment

- Node assembled with 80 m of cable in (from shore or previous node) and out to next node
- 3.5 km of cable (Inter-node link) + dragging tail connected on the out of the node (to connect later the next node)
- Node laid on seabed using the inter-node link



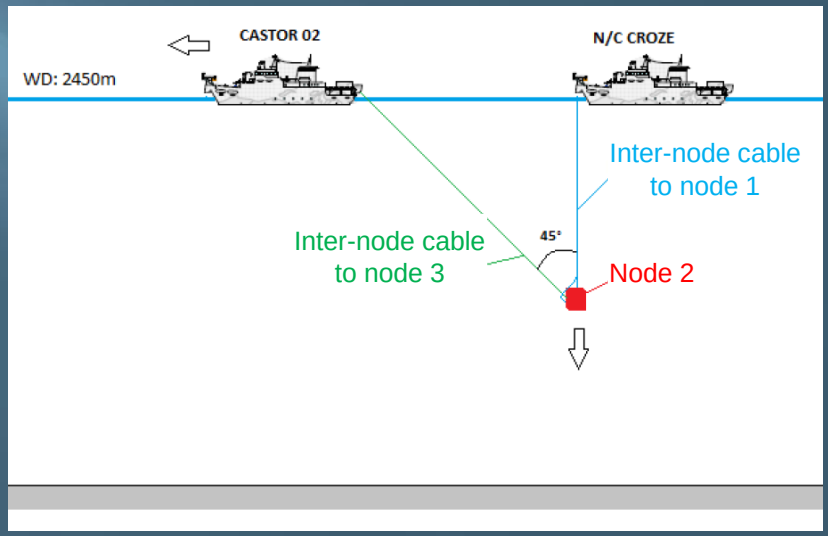


Cable and node 1 installation

- Cable laid from shore to deep-sea site with a S shape to allow repair
- 2 joints at 80 m of the node made during the sea operation
- Node 1 laid in line with the cable using acoustic positioning of R. Croze ship (USBL). Node position at 180 m from the target.

Node 2 installation

- The installation requires 3 boats for a precise node position:
  - R. Croze to deploy the node
  - Castor to deploy the inter-node link
  - Small boat equipped with our acoustic positioning system (Castor too far)
- 5 days at sea planned beginning 2020
- Main steps:
  - Cable from Node 1 recovery (dragging)
  - Node 2 cables jointing
  - Node laying under acoustic measurement
  - Inter-node cable to node 3 laying
  - Cable between node 1 and 2 jointing



Laying studied by Orange Marine, 3rd boat not represented

Outcome

- Operations on the cable as for standard telecommunication cables
- Node deployment procedure validated, to be confirmed for the node 2
- Node recovery successfully experienced using external ROV
- Team of Orange Marine very efficient

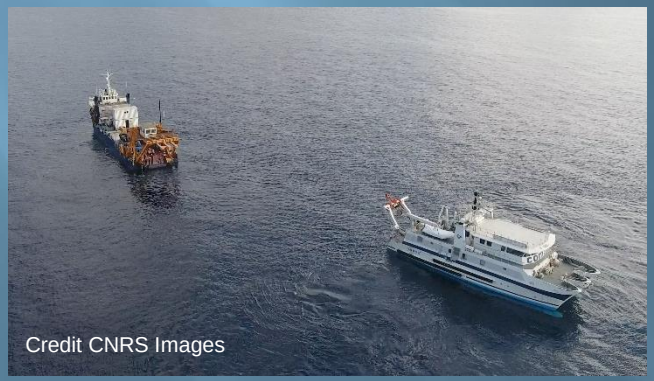
Cable jointing

Installation ORCA detector

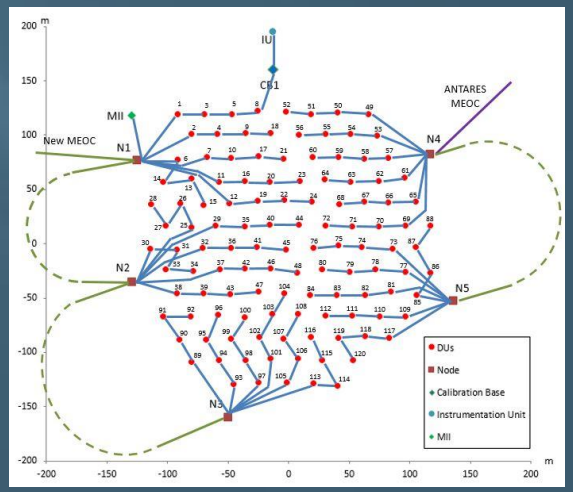
- Requirements:
  - Operations at 2500 m depth
  - Detection units spaced by 20 m on the seabed
  - ROV not moving into detection lines (ie no maintenance on DU)
  - Absolute position measurement +/- 0.5 m
  - Possible use of light ROV (availability)
  - Wet-mateable connectors require 60 kg force for connection
  - 24h/24h operation
  - Deployment/connection of 4 to 6 DUs per sea operation (12 h/DU)

Setup for sea operations

- Use of 2 boats (selected from a tender) during the sea operation:
  - Castor 02 from Foselev Marine to deploy lines
  - Janus II from COMEX with APACHE ROV for underwater work
- Development of connection tool to help the ROV for connection (force reduced to 20 kg)
- LBL acoustic positioning system purchased
- Sequence of DU installation defined to avoid ROV going into the field
- Assistance from expert in sea operation



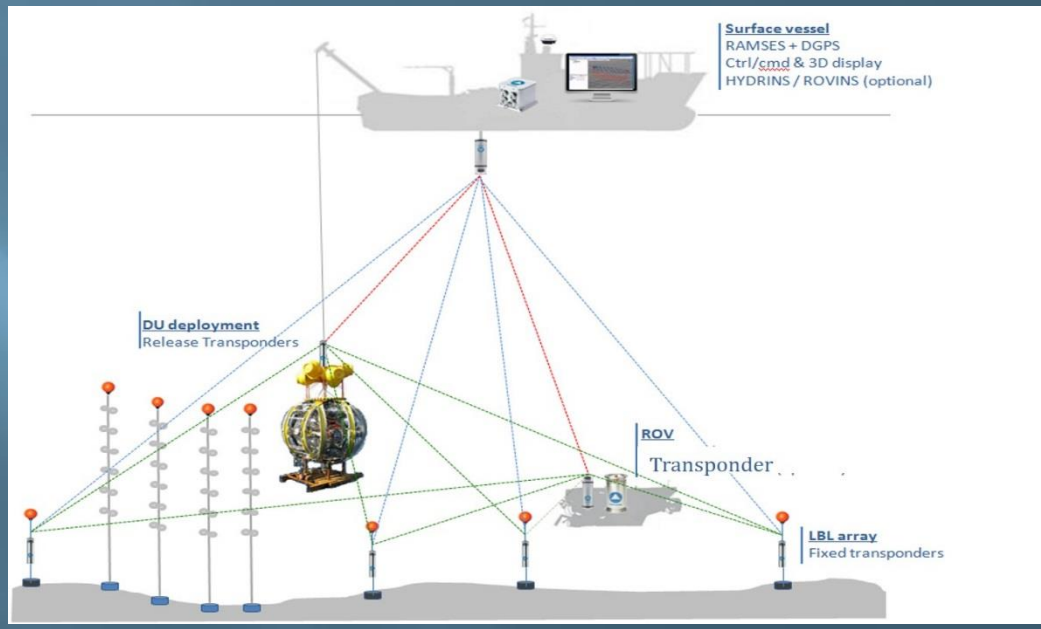
Connection tool



Acoustic positioning system

RAMSES from ixBlue :

- Measure acoustic travel times between rangemeter transducer on surface ship and fixed or mobile autonomous beacons
- Surface ship absolutely positionned by DGPS coupled to inertial central Hydrins based on optical gyroscopes (heading, tilts, accelerations…)
- Real-time positions of mobile beacons deduced from ship and fixed reference beacon positions
- 4 reference beacons anchored around KM3NeT-Fr site (1250 m – 1400 m from centre)



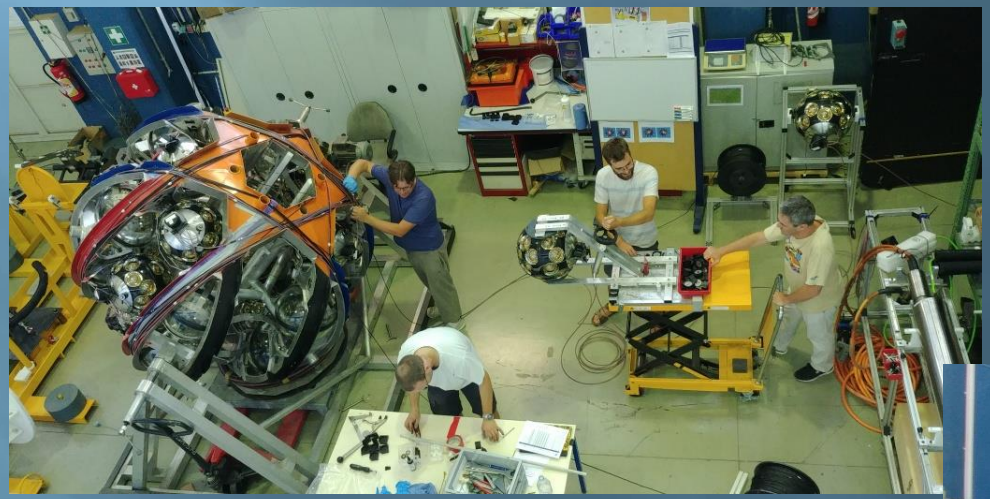
DU position measurement:
Precision during installation: +/-2 m
Precision once installed: ≤ 0.5 m

Organizational issues

- Availability of boats
- Availability of CPPM manpower
- Weather (wind <15 knots, wave < 1 m)
- Military authorizations (in principle easier now as we just got a permanent access)

Installation methodology
DU preparation

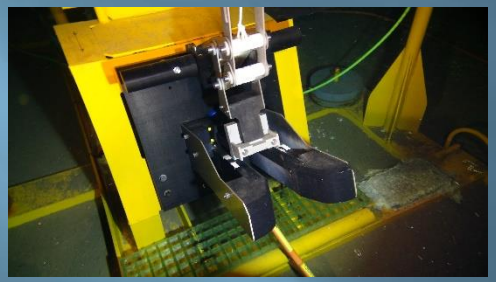
Deployment tool (LOM)

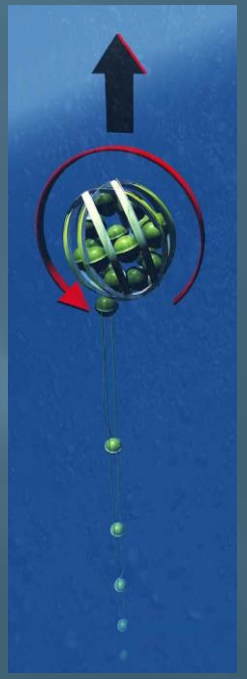


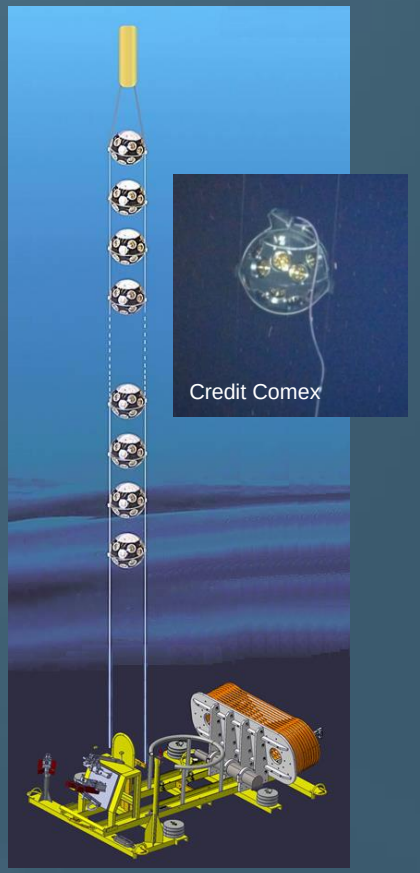
Installation of the DU on the LOM

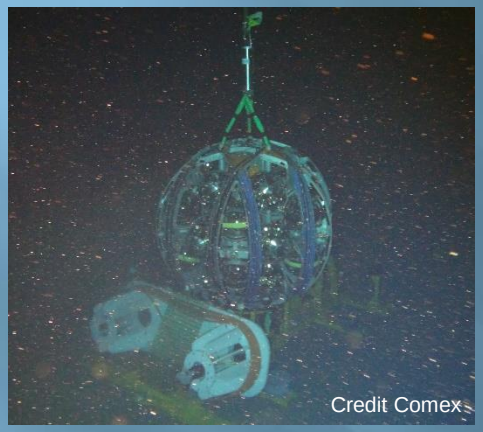
DU ready for deployment

Installation methodology
DU deployment

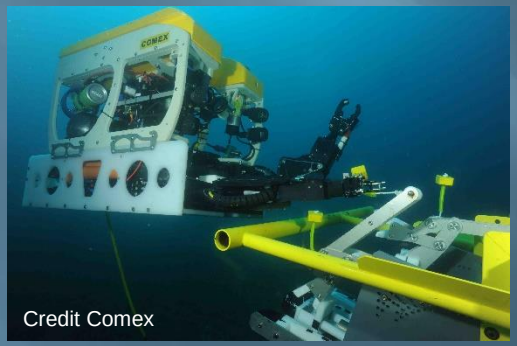








DU deployed furled on the seabed, orientation by the ROV



Connection by ROV
Tests from shore

Unfurling trigerred by ROV

DU unfurled

Instrumented module MII deployment

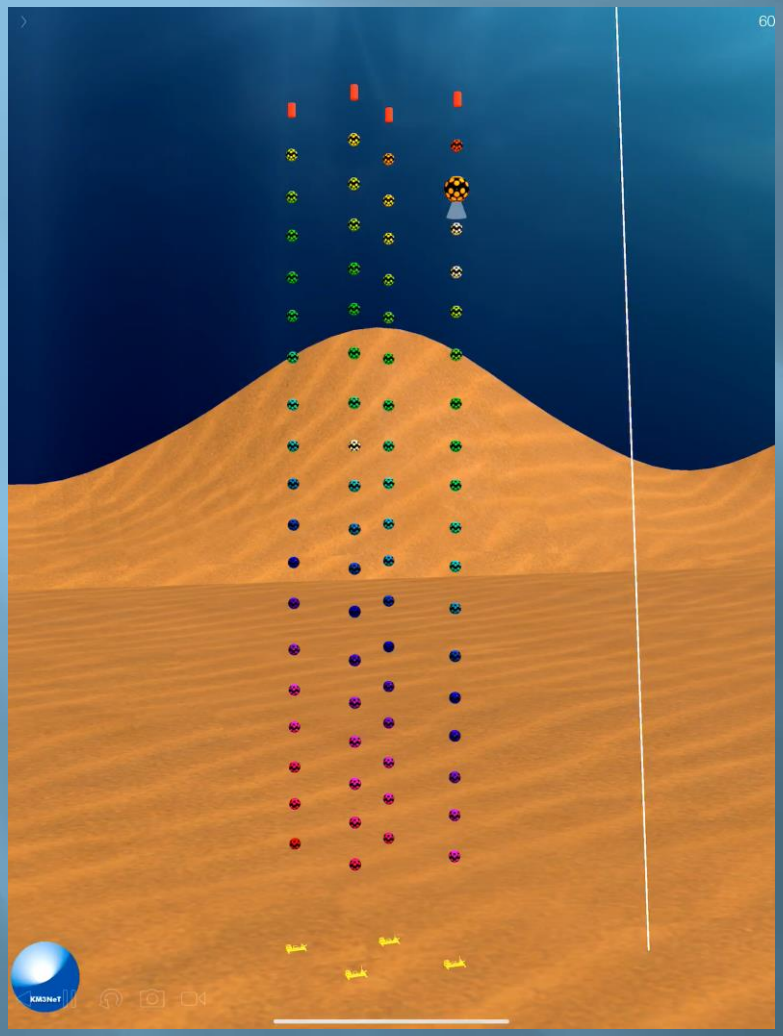
MII installation identical to DU

Outcome

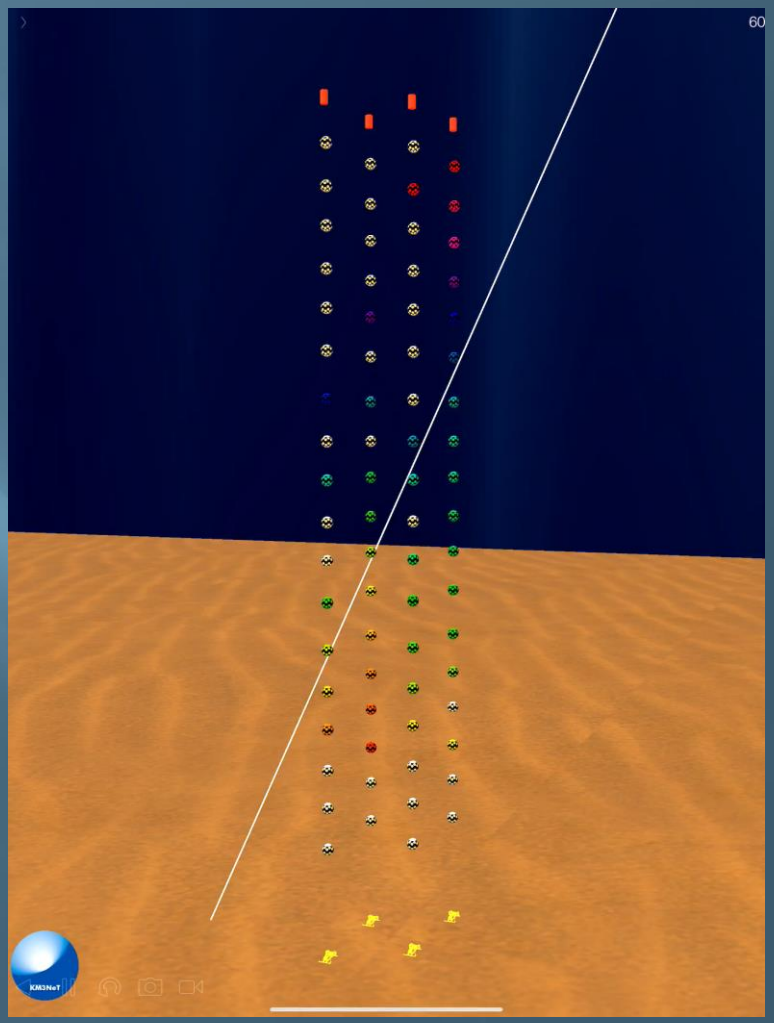
- 4 DUs and instrumented module MII installed and in operation
- Recovery of a DU possible and successfully performed
- Acoustic positioning system worked well
- Procedures validated
- Decision to go at sea at the last minute (24 or 48h)
- Organization of sea operations not simple (many parameters)
- Good experience with the teams of the boat companies

DU deployment

Reconstructed events with the 4 DUs in operation



Muon track



Neutrino track