

KM3NeT e PACK (e PACK-MAN)

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UNIONE EUROPEA
Fondo Europeo di Sviluppo Regionale



Ministero dell'Università
e della Ricerca



PON
RICERCA
E INNOVAZIONE
2014 - 2020

PACK
Potenziamento Appulo-Campano
di KM3NeT



Neutrino astronomy in the Mediterranean: the initiatives

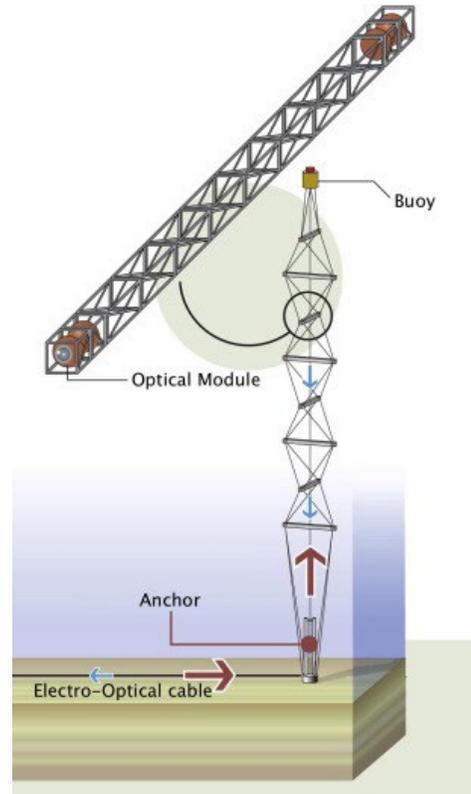
ANTARES – first undersea neutrino telescope ever built – operated from 2006 to 2022

NEMO and **NESTOR** – extensive R&D programs carried out in Italy and Greece

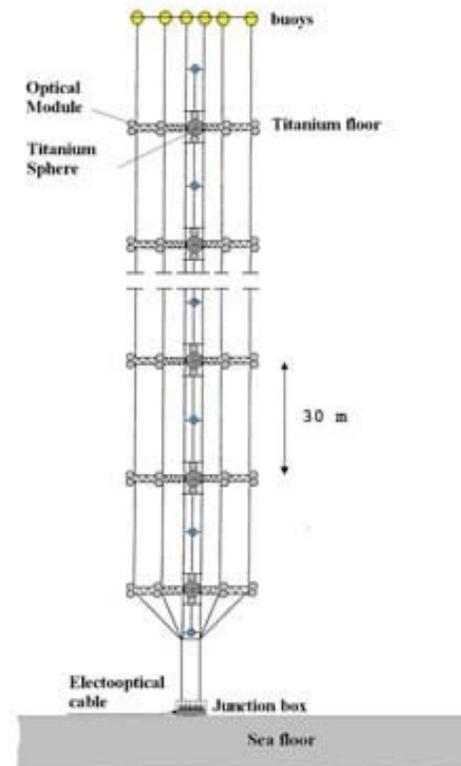
KM3NeT – construction of ARCA and ORCA ongoing



Assembly of one ANTARES 'storey'



A NEMO 'tower'



A NESTOR 'tower'



A KM3NeT 'detection unit' (DU)

Neutrino astronomy in the Mediterranean: the challenges

ANTARES – first undersea neutrino telescope ever built – operated from 2006 to 2022

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KM3NeT – construction of ARCA and ORCA ongoing

Working in the (deep) sea implies:

- High pressure
- Salted water!
- Sea currents
- Optical background (^{40}K decays and bioluminescence)
- Need to deploy and connect structures on the bottom of the sea



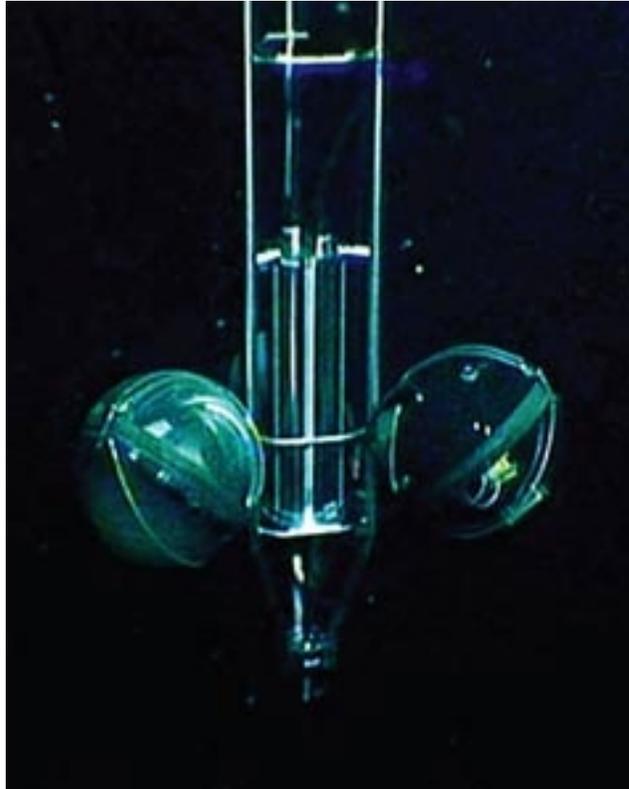
Assembly of one ANTARES 'storey'



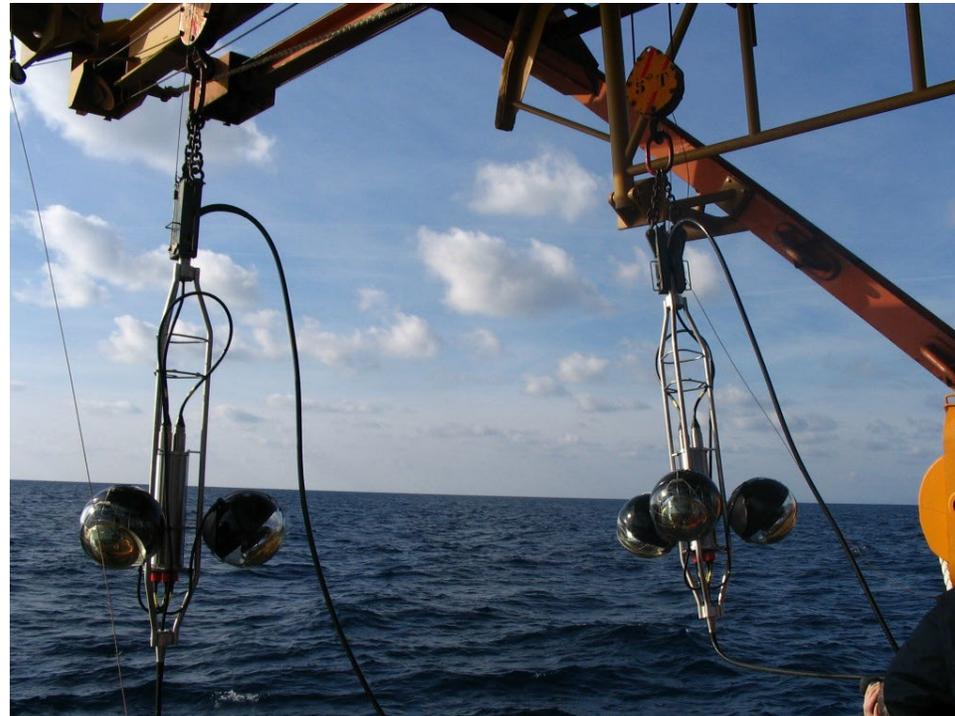
A KM3NeT 'detection unit' (DU)

The ANTARES 'storey'

- Three optical modules (each equipped with a 10" PMT housed in a 17" glass sphere)
- One electronic container
- A frame to keep all things together (including, when applicable, a hydrophone and/or a LED optical beacon)
- An electro-mechanical cable keeps the ANTARES line together



One ANTARES 'storey'
(in the deep sea)



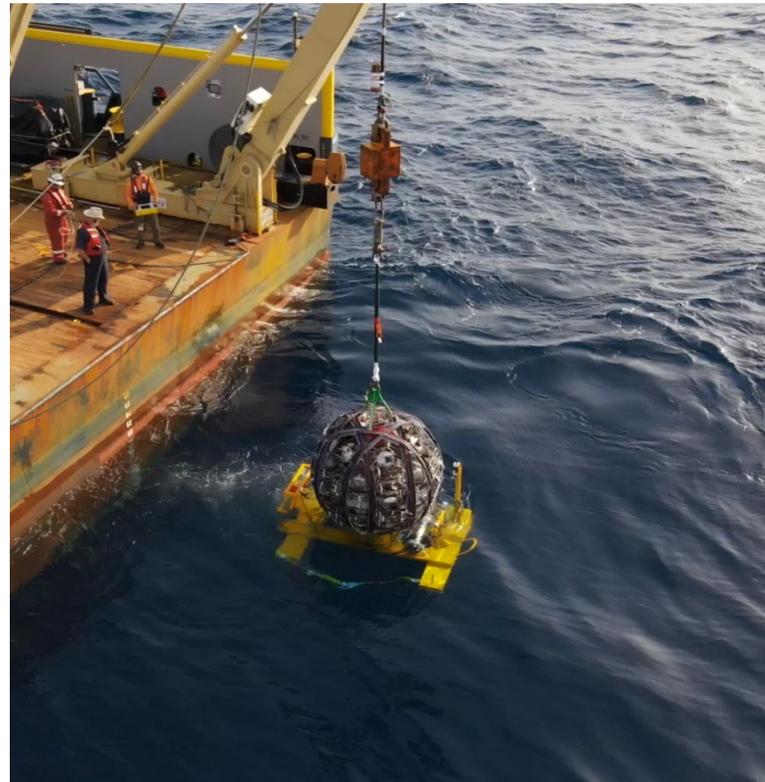
Deployment of one ANTARES line

Principles of KM3NeT design

- Push performance and reliability
- Simplify the mechanics: reduce containers and interfaces
- Go for a lean detection unit structure, easy to transport and deploy



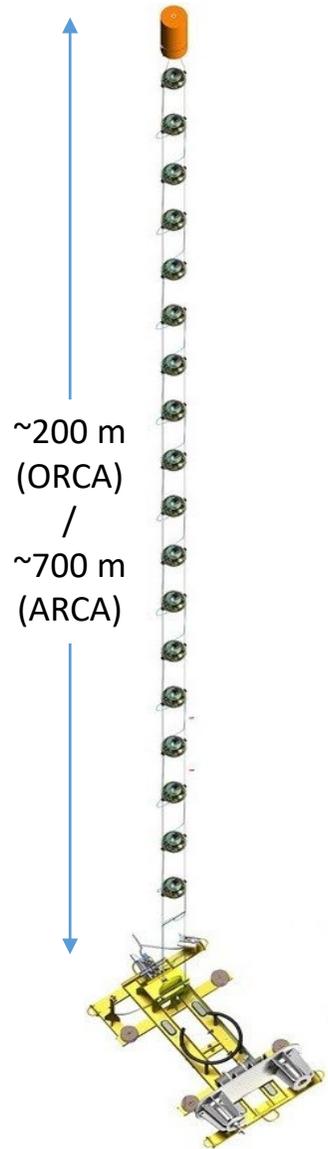
The multi-PMT Digital Optical Module (DOM) of KM3NeT



Deployment of a KM3NeT DU

KM3NeT: ARCA and ORCA

(Astroparticle/Oscillation Research with Cosmics in the Abyss)



Same technology for the two detectors – the main aim of KM3NET is:

- **ARCA:** detection of HE/VHE/UHE/etc. neutrinos from the cosmos
- **ORCA:** detection of «atmospheric neutrinos» with focus on neutrino mass ordering

The main differences in the ARCA and ORCA detectors are due to:

- Different size of the detectors (~9 m inter-DOM and ~20 m inter-DU distances in ORCA vs. ~36 m and ~90 m, resp., in ARCA)
- Different power systems (DC in ARCA vs. AC in ORCA, which is closer to shore)
- Different anchors and underwater connection systems (due to the different vehicles used at sea and the shorter inter-DU distance in ORCA)
- Slightly different optical communication systems (consequently)

The DOM (Digital Optical Module)



A KM3NeT DOM (bottom view)

- 31 3" PMTs (by Hamamatsu)
- a fast LED pulser (for timing calibrations)
- an acoustic piezo-sensor + a compass/tiltmeter (for positioning)
- electronics and DAQ for data taking and communication with the shore station

All components are packed in a 17" pressure-resistant glass sphere (by Nautilus)

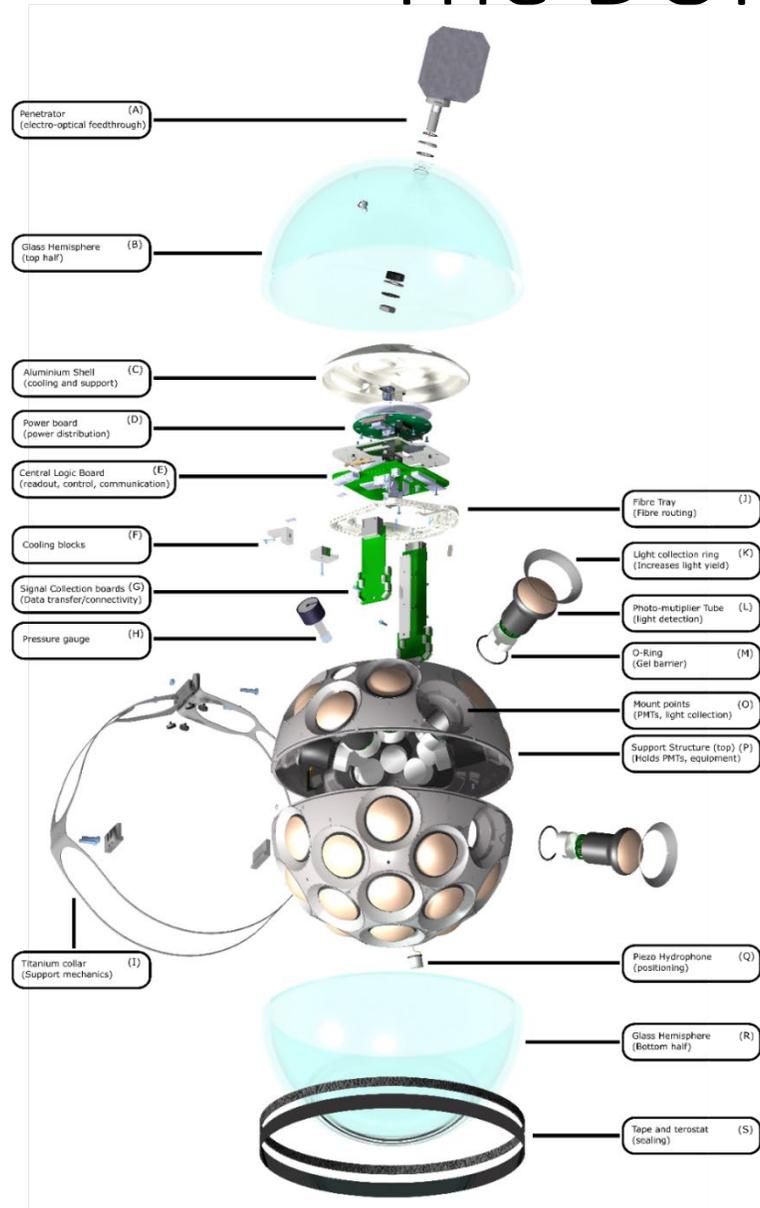
Each DOM requires: electrical power ($\sim 7\text{W}$ @12 VDC) and one optical fibre for communication (through a penetrator)

Advantages of the multi-PMT choice:

- large photocathode area
- large angular coverage
- sensitivity to photon direction
- improved photon counting capabilities
- possibility of local triggers
- simplified detector layout

For more details please check: <https://inspirehep.net/literature/2054872>

The DOM structure and components



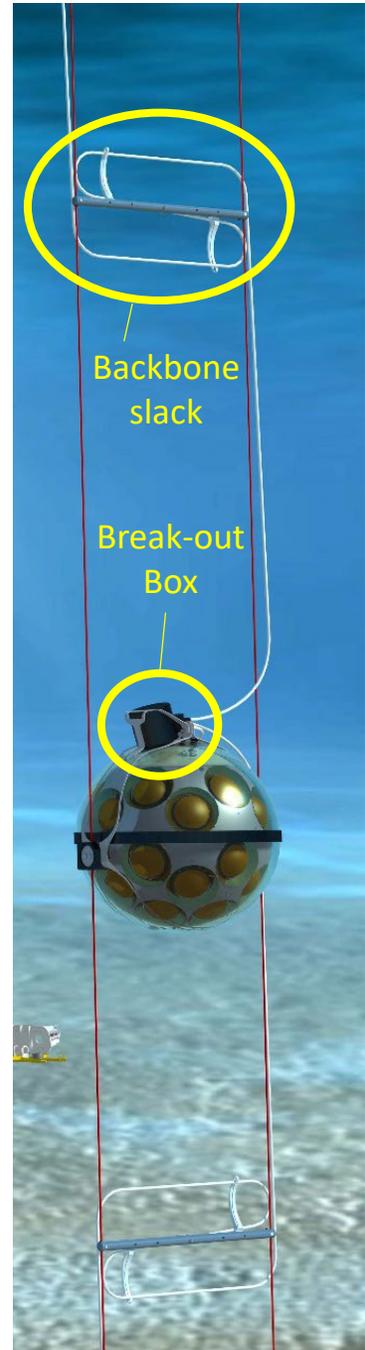
- Section of a bottom support structure
- Section of a top support structure
- Glass hemisphere (bottom)
- Bottom support structure with PMTs and light collection rings installed
- Tray for routing of optical fibres
- Cooling and support mechanics (shell with rod mounted)
- Power board
- Central Logic Board
- (Three) PMTs with base attached and light collection rings
- Pressure gauge
- Signal collection boards (2)
- Nanobeacon (led flasher) on driver board
- Penetrator flange (left) and penetrator with temporary fibre/cable routing plate (right)
- Piezo hydrophone
- Laser transceiver

The DU (Detection Unit)

Very slender design:

- Two ropes connect the DOMs to an anchor and a top (submersed) buoy
- The DOMs are attached to the ropes by means of a slim 'collar'
- An electro-optical backbone provides each DOM with power and an optical fibre for data communication
- A base module is installed on the anchor to interface the DU with the submarine cabling network

The DU can be packed on a launcher vehicle (spherical, 2 m diameter) placed on the anchor for installation



Rendition of a DOM mounted in a DU

La nascita di KM3NeT

2006-2012: Design Study e Preparatory Phase

Inizio 2013: viene costituita la Collaborazione KM3NeT



PPM-DOM: installato nella primavera 2013
sulla instrumentation line di ANTARES



PPM-DU (con tre DOM):
installata a Capo Passero nella
primavera 2014

**DU-1: installata a Capo
Passero a dicembre 2015**

Il PACK (PIR01_00021) (Potenziamento Appulo-Campano di KM3NeT)

Progetto presentato al MIUR per KM3NeT in risposta al D.D. n. 424/2018

Data di avvio: 14/6/2019 => Termine (dopo doppia proroga per COVID-19): 14/6/2023

Beneficiari: INFN (Sezioni di Bari e Napoli) + Università della Campania (Laboratorio CIRCE - Center for Isotopic Research on Cultural and Environmental heritage)

Costo totale: 17,8 M€ (16,4 M€ INFN + 1,4 M€ UniCampania)

- ~2,9 M€ per potenziamento strutture a Bari, Caserta, Napoli
- ~14,9 M€ per potenziamento telescopio sottomarino (realizzazione e installazione di 28 detection units)

Progetto estremamente complesso:

- Necessità di rispettare i vincoli di tempo e di costo imposti dal MUR
- Le detection units sono di nuova generazione (WWRS – Wet White Rabbit Switch)
- Significativo sforzo richiesto per la rendicontazione al MUR

Per fortuna il MUR ha anche finanziato il PACK-MAN! (CIR01_00021)

KM3NeT4RR



KM3NeT4RR

Progetto presentato da INFN in partenariato con:

- INAF (OA-Catania and OA-Palermo)
- Politecnico Bari
- Università Campania
- Università Catania (DFA - DEI)
- Università Genova
- Università Sapienza Roma
- Università Salerno
- Università Federico II Napoli

Budget: 67.2 M€

Durata triennale a partire dall'1/12/2022



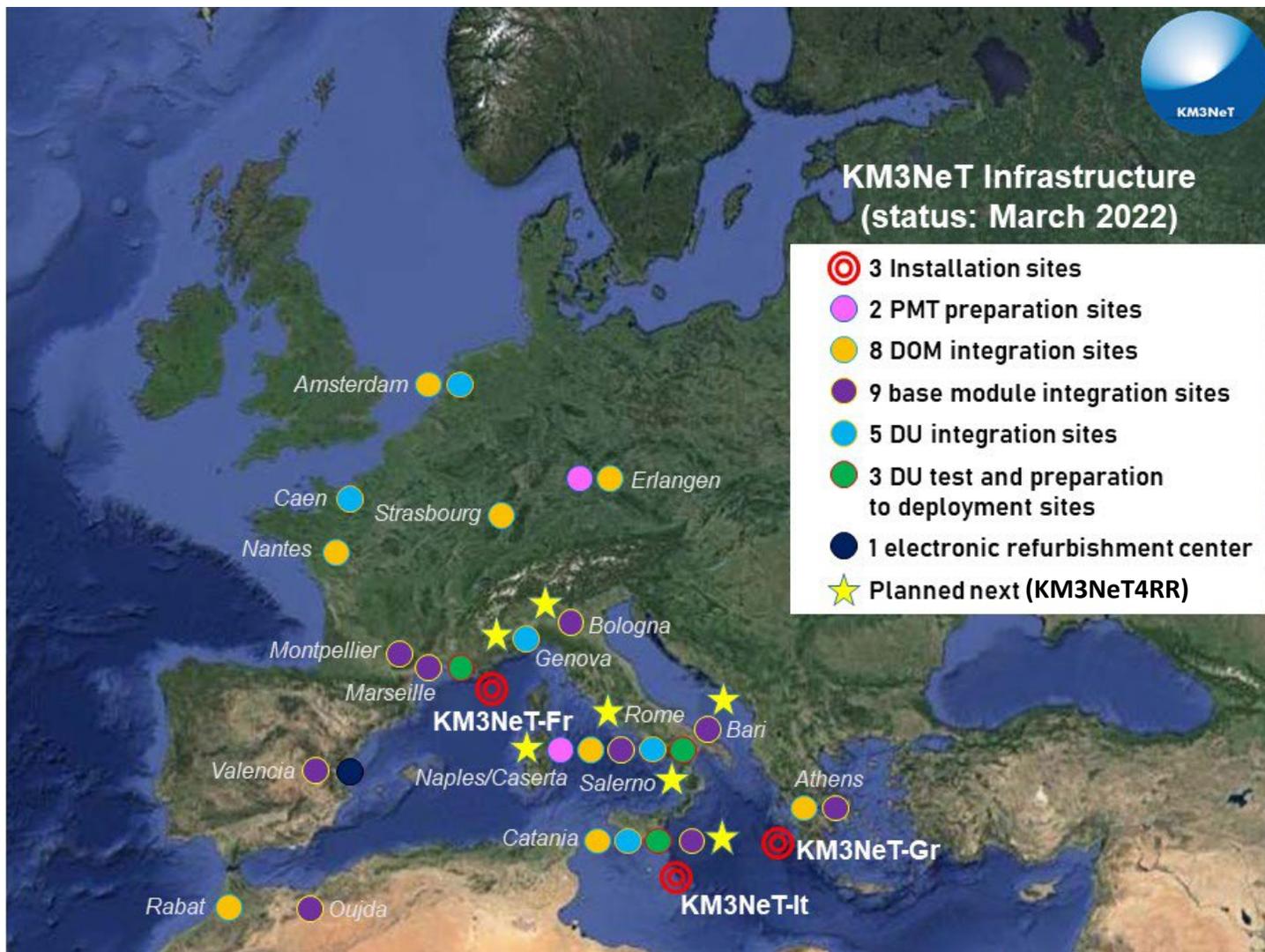
PARTNERS



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KM3NeT detector integration organization



On 1st March 2022:

- DOMs: 860 produced, 105 in production
- BM: 45 produced, 5 in production
- DU: 33 produced (19 deployed), 8 in production

Planned next (KM3NeT4RR):

- ★ New DOM integration site in Salerno
- ★ New DU integration sites in Bari and Rome
- ★ Enlargement of integration sites in Bologna, Catania (Sezione and LNS), Genoa and Naples/Caserta

- Organization defined so as to optimize construction schedule and simplify logistics
- Flexible organization: the activities in each site can be adjusted so as to better serve the construction needs

Mettendo tutto in prospettiva...

KM3NeT ARCA: 2 building blocks, 230 DU

Stato del progetto:

- Primo cavo installato, secondo cavo in completamento
- 3 Junction Boxes operative, 2 in costruzione
- 5 Junction Boxes da costruire sul PNRR

- 21 DU installate, 10 in integrazione (per completare Phase-1)
- 28 DU di PACK da costruire e installare
- 16 DU di IDMAR (POR Regione Sicilia) da costruire e installare
- 50 DU di KM3NeT4RR (su fondi PNRR) da costruire e installare

