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Il progetto KM3NeT e la Sicilia: il mare come telescopio

What's the INFN

TRASPARENZA E MERITO

INFN

www.infn.it

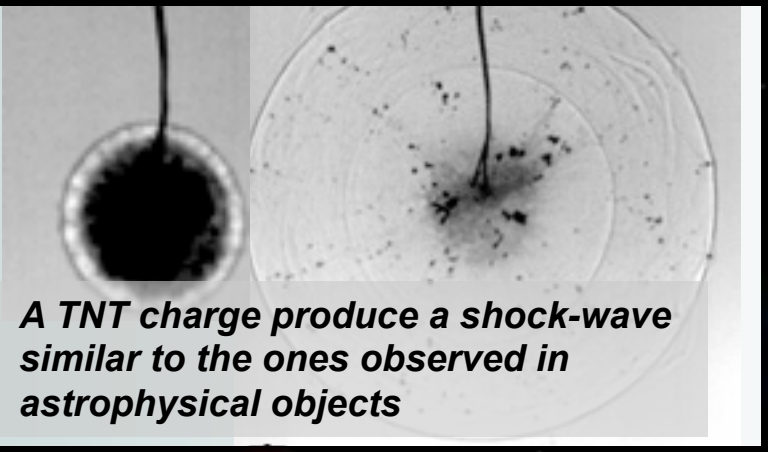
INFN is the Italian research agency dedicated to the study of the fundamental constituents of matter and the laws that govern them, under the supervision of the Ministry of Education, Universities and Research (MIUR). It conducts theoretical and experimental research in the fields of subnuclear, nuclear and astroparticle physics.

Laboratori Nazionali del Sud (LNS) is one of the four national laboratories o INFN. Founded in 1976 it currently empoyes about 150 people and it represents one of the most advanced centres for science technology in Italy

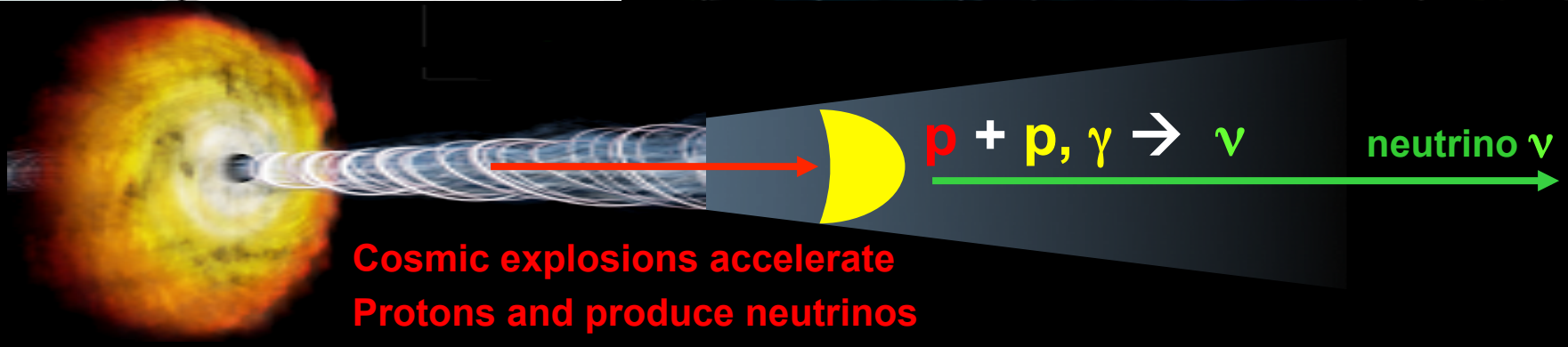
The research activity is mainly devoted to the study of structure and properties of atomic nuclei, in collaboration with researchers coming from several countries.

Why a neutrino telescope

Several astrophysical objects in the Universe produce violent explosions: the energy release is so high that a single object may become as luminous as the whole sky. In these explosions neutrinos are copiously produced. Differently from other particles neutrinos can travel unperturbed the entire Universe carrying direct infromation on the source



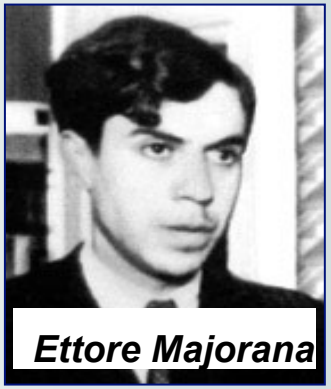
A TNT charge produce a shock-wave similar to the ones observed in astrophysical objects



Neutrinos the “messenger” of the high energy Universe

Neutrinos have extremley low mass and no electrical charge:

They travel in straight line between the source and the Earth

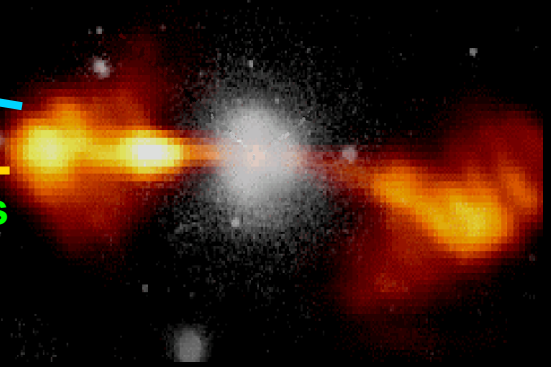


Ettore Majorana

Proton apparent direction

Very high energy protons reach the Earth after deflection the galactic and extragalactic magnetic fields

Cosmic “accelerator”

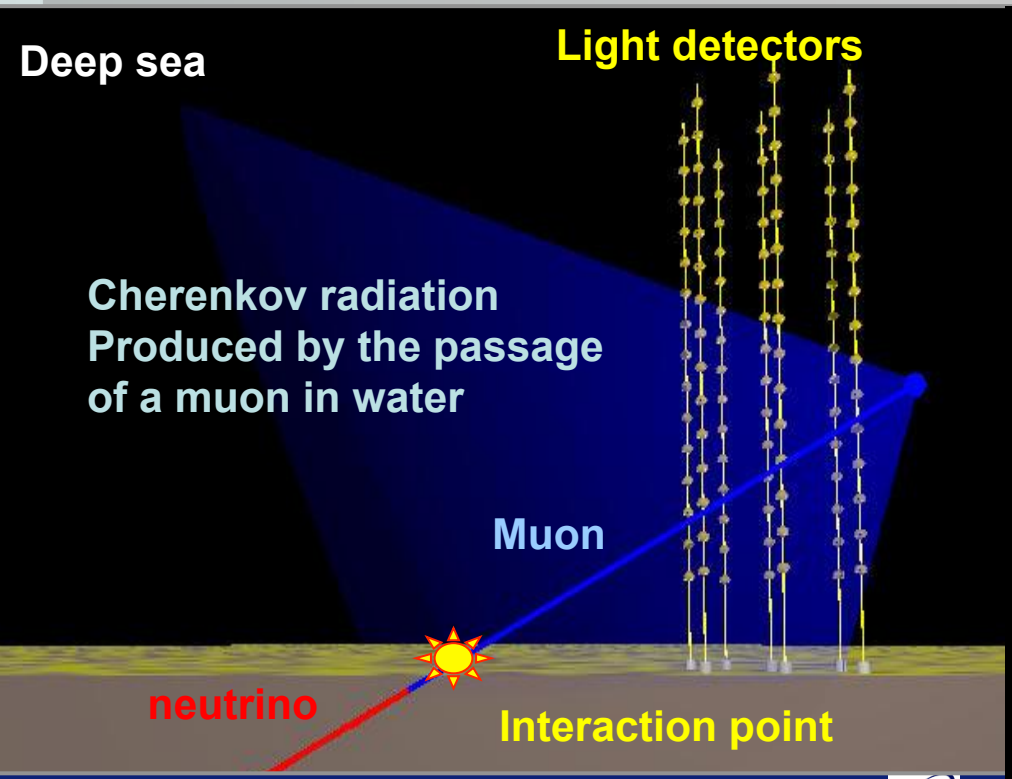


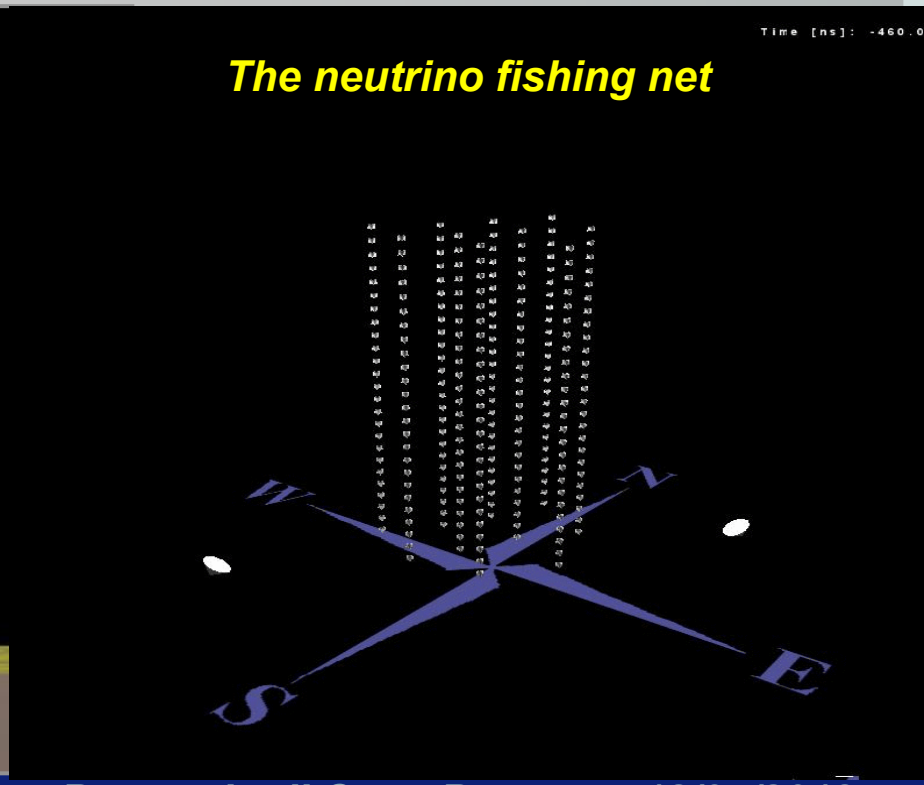
Gamma rays (very high energy photons) are absorbed by the cosmic dusts and microwaves

Neutrinos reach the Earth undeflected

How to observe cosmic neutrinos

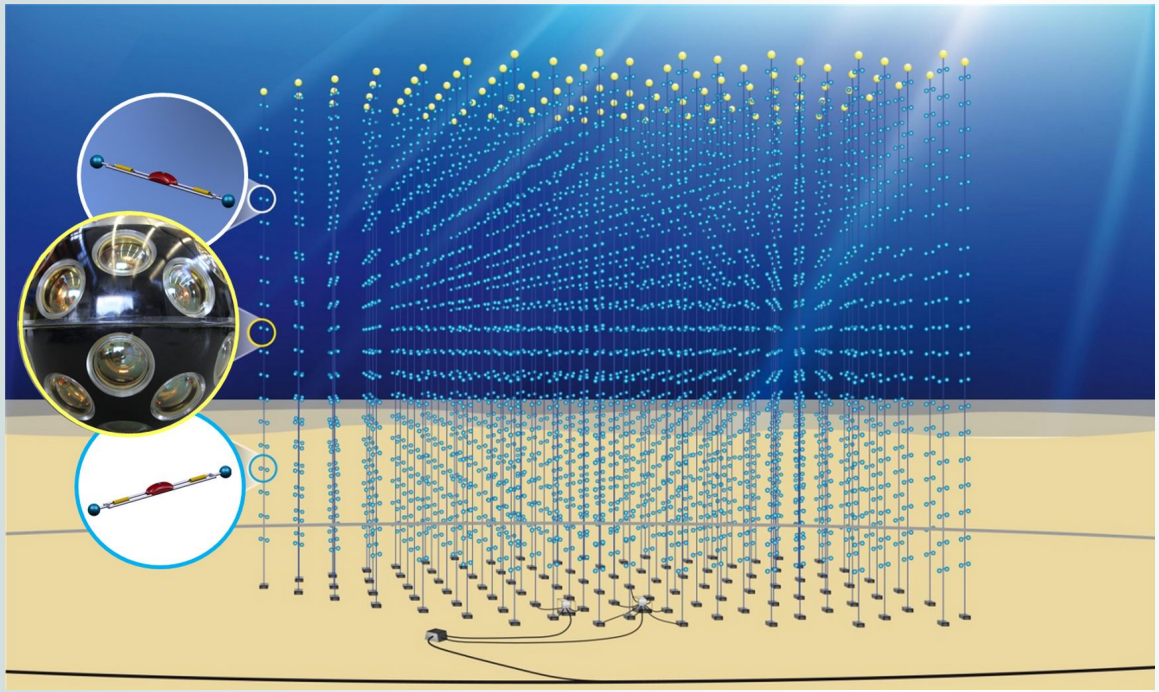
When neutrinos reach the Earth it is a small but finite probability of interaction. The interaction produces a muon (an "heavy" electron) that can be observed through its Cherenkov light emission.
The neutrino "fishing net" is an antenna of optical sensors achored in the abysess.





The giant-scale detector KM3NeT

Faintness of neutrino fluxes and small interaction probabilities oblige to use large natural target such as sea-water: a volume of 5 km^3 of seawater will be instrumented with optical detectors.



5 building blocks
120 Detection Units (DU)
750 m DU height
180m DU distance
5 km^3 volume
Budget 250 M€

KM3NeT-Italia is funded by INFN since 1999 (NEMO)
In 2010 the project was awarded with a PON grant of 20 M€

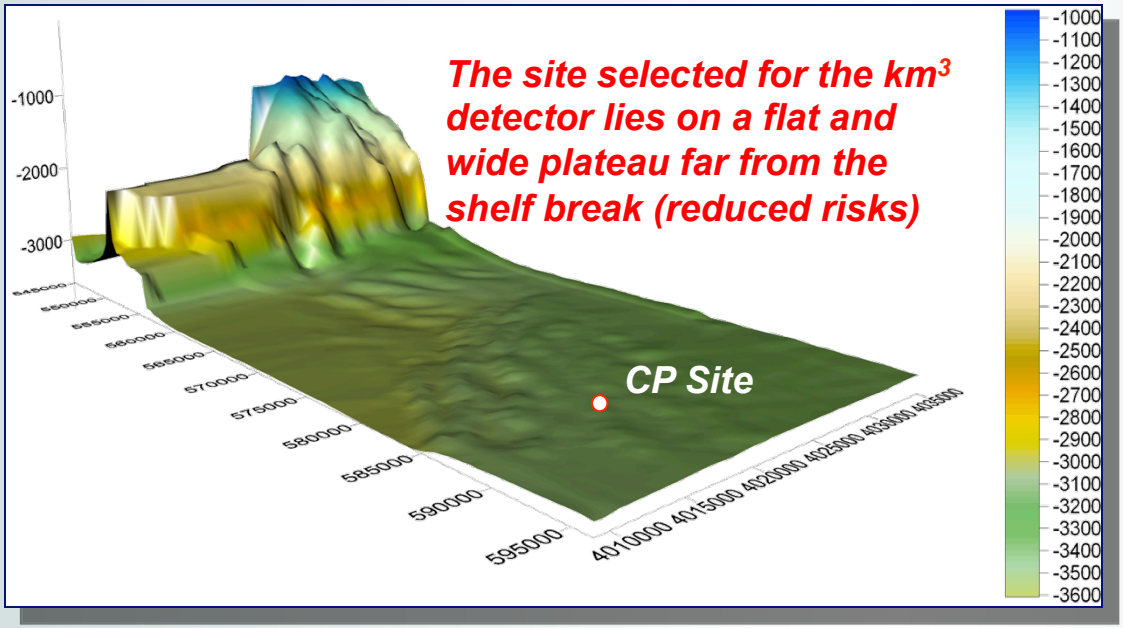
KM3NeT is a EU funded ESFRI Infrastructure since 2006.
INFN leaded the Prparatory Phase

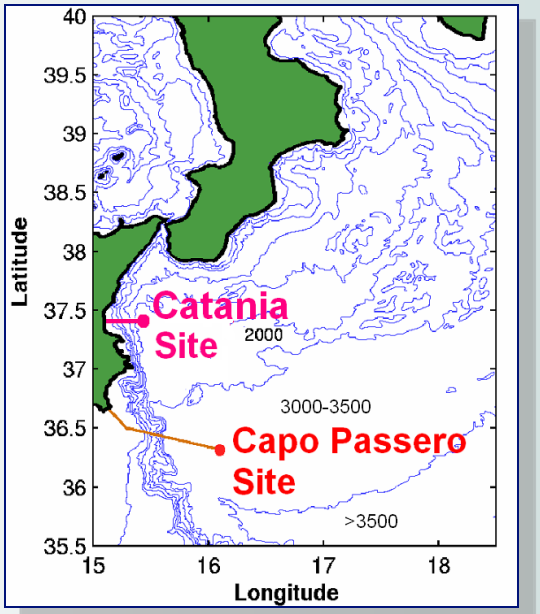
Site Properties

The Capo Passero Site

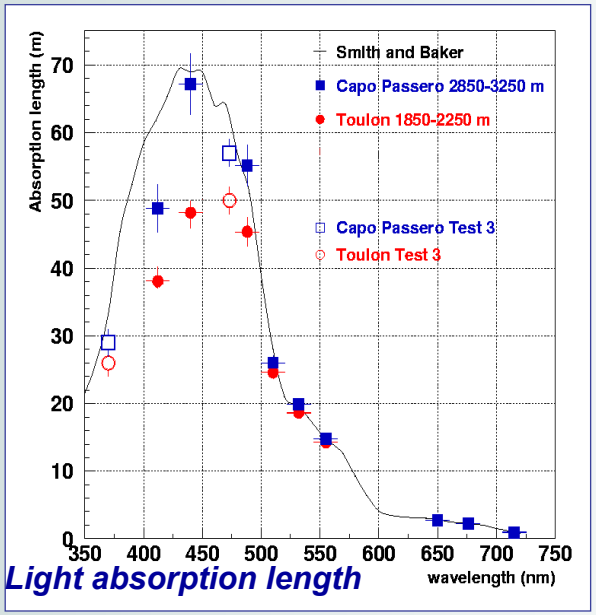
More than 30 naval campaigns seeking deep sea sites in the Mediterranean Sea. Capo Passero is an optimal site.

- ***Depth >3500 m, 90 km distance from the shore***
- ***Excellent water optical properties ($L_a \approx 70$ m @$\lambda = 440$ nm)***
- ***Optical background from bioluminescence extremely low***
- ***Deep sea water currents are low and stable (3 cm/s avg, 10 cm/s max)***
- ***Wide abyssal plain: large extension of the detector***

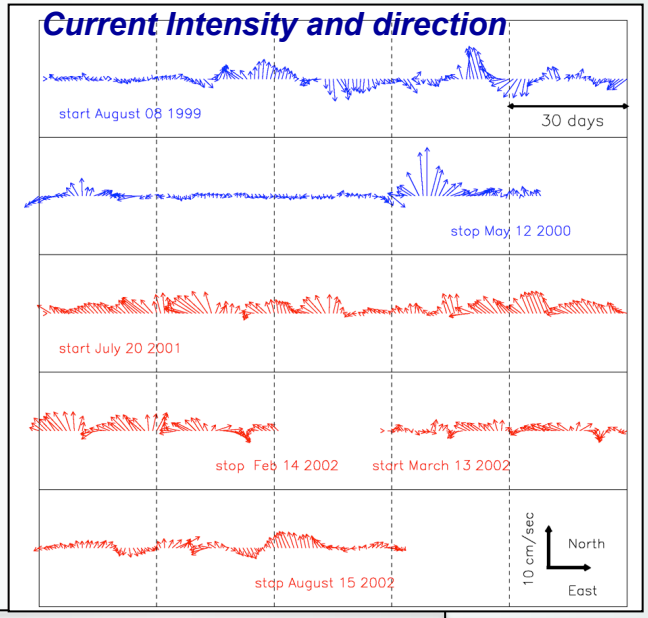


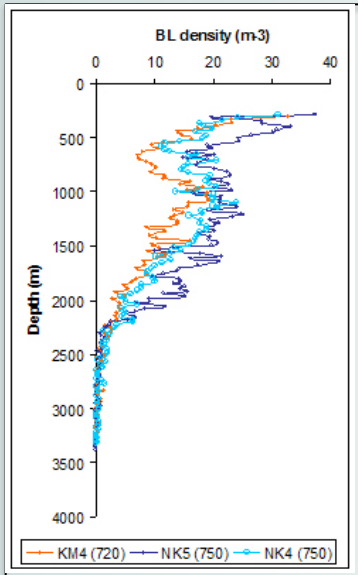


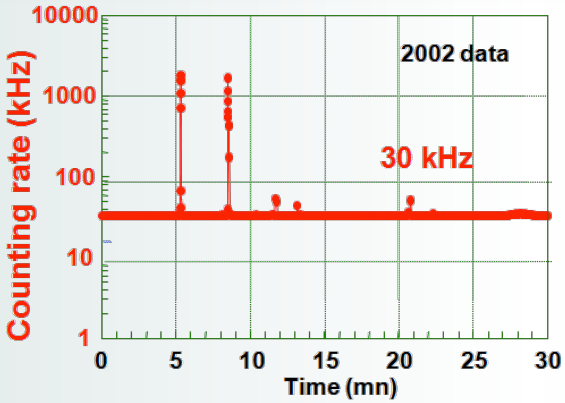
Site seeking activity results (since 1999)



Light absorption length







Bioluminescent bacteria concentration and optical background rate (measured with 8' PMTs, 0.5 s.p.e)

A long story of collaboration with Marina Militare Italiana

INFN Naval Campaign aboard Nave Urania
2001 Capo Passero

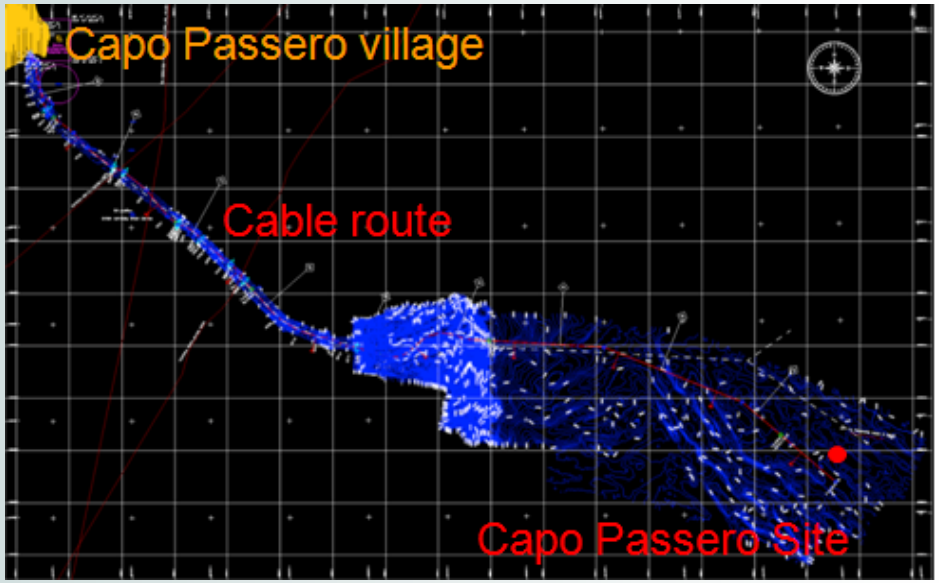
INFN Acoustic modem test
2000 Maristaeli

INFN-CNRS Campaign aboard R/V Alliance
NATO-CMRE
2001 Capo Passero

From the CMRE-NATO home page:
The CMRE participated in the KM3NeT project, which involved the recent installation of the first 400-meter tall underwater neutrino observation system at depth of 3500 meters off the coast of Sicily.

Site Infrastructure: Status

The Capo Passero Site infrastructure

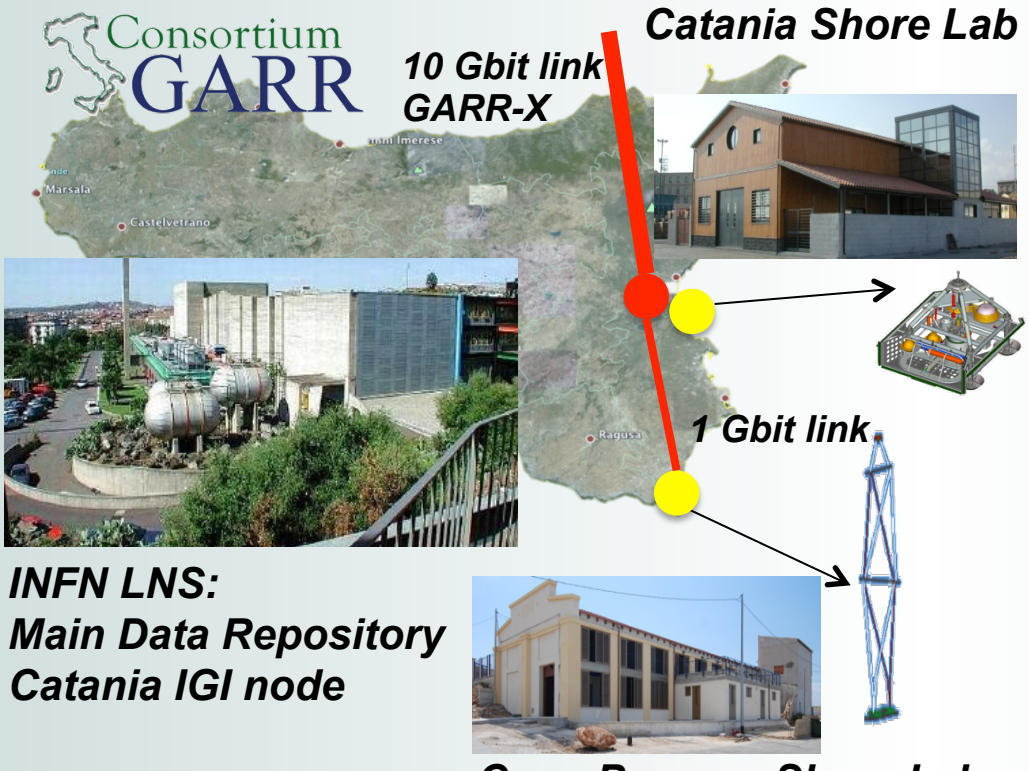


Shore Laboratory:
Electronics Labs
Data Acquisition Room
Control Room
Guest House 4 rooms
Power Feeding Equipment (UPS protected)
1Gb/s (upto 10) Optical-fibre link GARR-X

Submarine cable and infrastructure:
96 km
20 fibres ITU655-NZDSF
Single conductor with DC-sea return
Cable Termination Frame:
Medium Voltage Converter: 10kV to 375V
3 ROV-mate e.o. output connectors

Deployment of NEMO Phase II – March 2013
Deployment of KM3NeT PPM
Construction of KM3NeT Italia
Construction of KM3NeT Phase 1

Capo Passero: optical fibre link from deep-sea to LNS



INFN is a main partner of GARR and of the Italian GRID-computing Infrastructure

INFN Catania is a major site of the Italian GRID

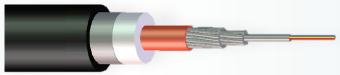
Capo Passero is the first KM3NeT site with direct optical fiber high speed connection from deep-sea to a node of the European GRID-computing Infrastructure

Existing Deep Sea Infrastructure

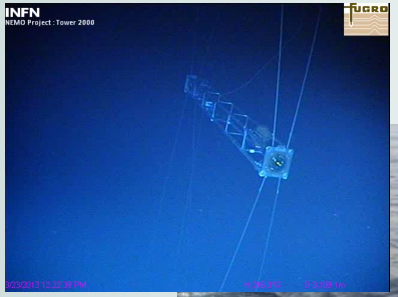
UPS

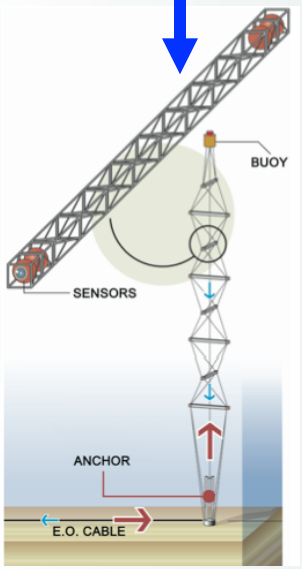
Power Feeding Equipment
50 kW, 10 kV max

Electro optical cable

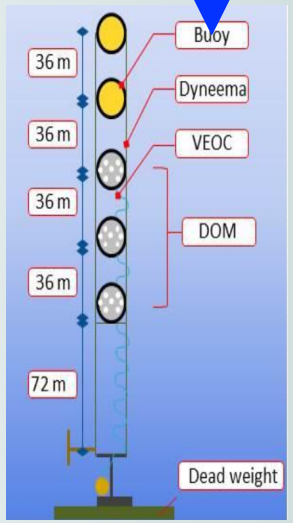


Input voltage: 400VAC 3-phases
Power factor: > 0,9 Output: 0-10 kV DC, 5 A





Prototype KM3NeT tower
3 o.f. , 2 e.c. 375 VDC



KM3NeT PPM-DU
2 o.f. 2 e.c. 375 VDC

Recent Sea Operations: MSV Nautical Tide

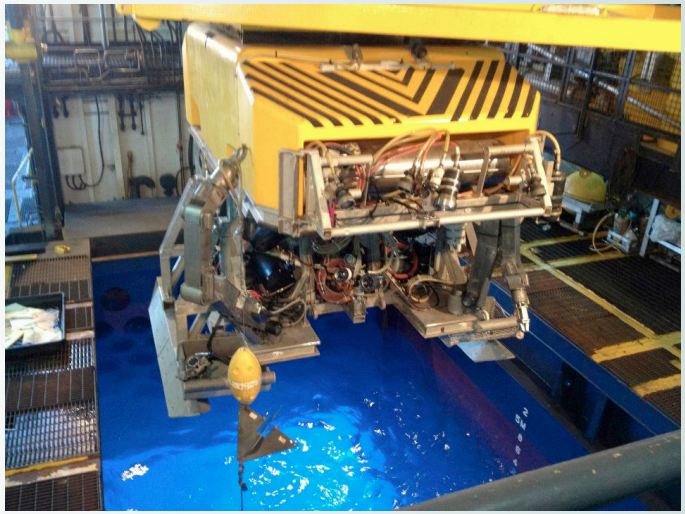
Multi Service Vessel- 75 meters long

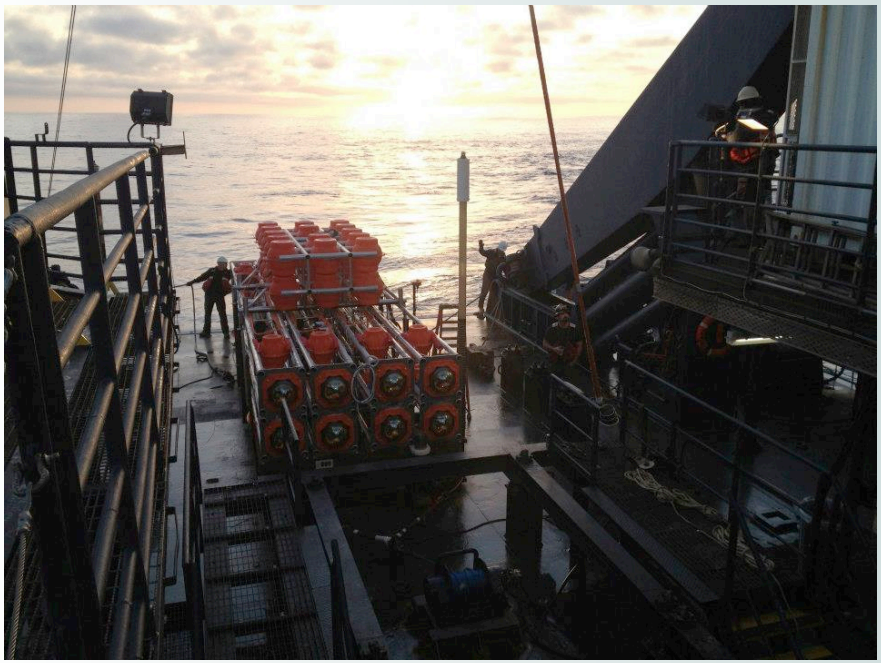
Deck Space 252 sqm

80kT hydraulic A-Frame

Deck Cranes 30T,10T,5T

Heavy work class ROV rated up to 5000 mwd

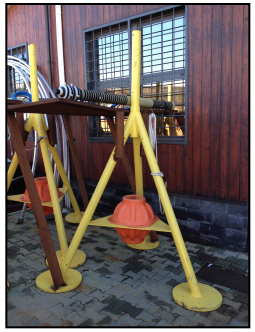




Deep-Sea Field Status

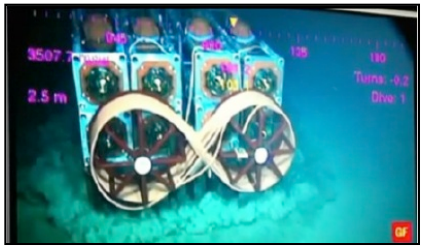
4017800 N

LBL : Acoustic Long Baseline
CTF : Cable Termination Frame



LBL Beacon #3 (soon)

Main Cable



Strain Relief

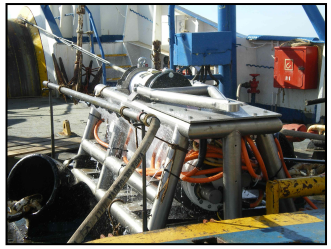
Cable Splice

Cable Spice

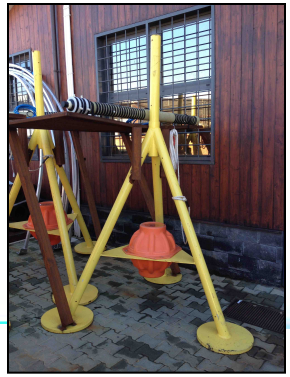
CTF (8 fibers, 3 output)

● Tower Prototype

400 m



LBL Beacon #2



587700 E

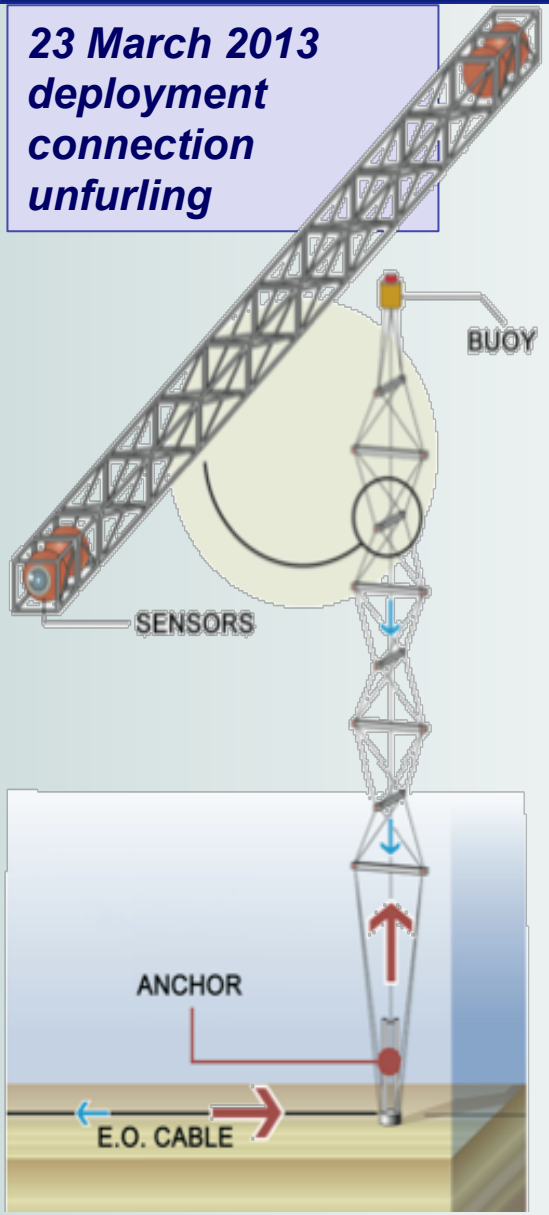
588500 E

4017000 N

End of the year - the KM3NeT PPM-DU

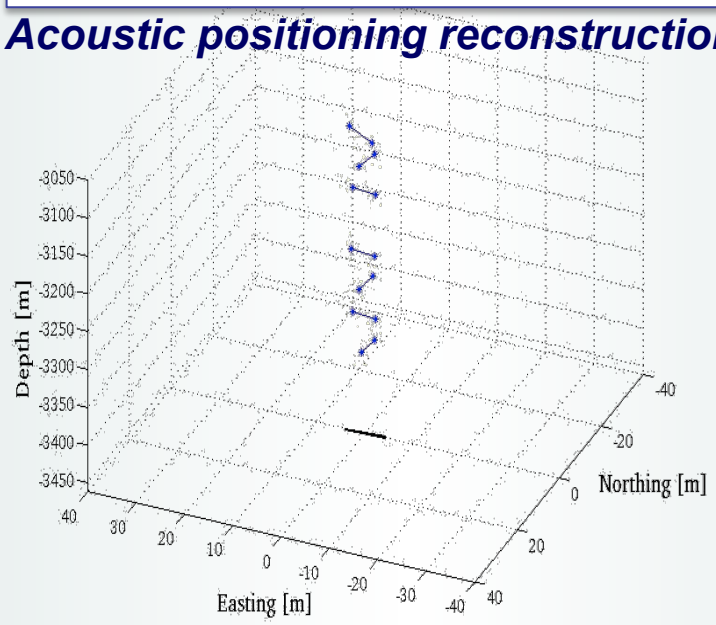
The KM3NeT Tower Prototype

23 March 2013 deployment connection unfurling

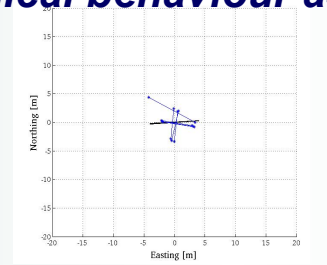


- *8 floors, 8 m bars, vertical dist. = 40 m, H_{tot} = 450 m*
- *32 OM, 12 hydrophones , 2 OAM (opto-acoustic modules)*
- *CTD, DCS, transmissometer, laser beacon, acoustic beacon*

Acoustic positioning reconstruction



Mechanical behaviour as expected



The OM: 10" Hamamatsu R7081, Front End Module, Time Calibration, LED beacons

Hydrophones: acoustic positioning and bioacustics (INFN/SMID/NATO)

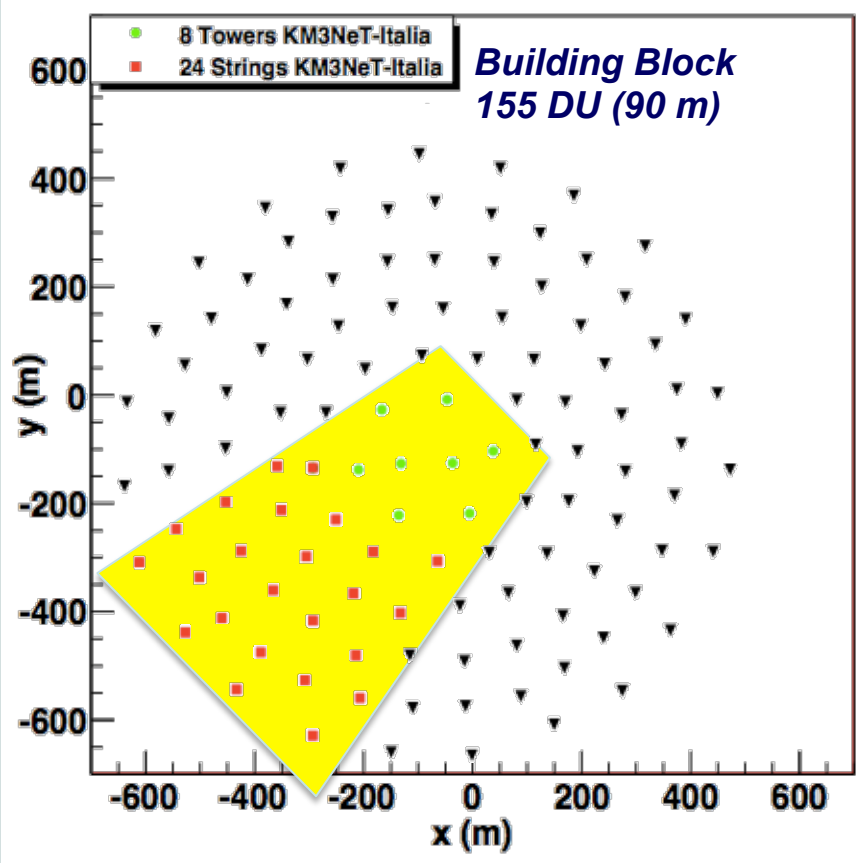
Site Development

KM3NeT Installation Plan

→ 8 Detection Units in 2014
→ 26 Detection Units in 2016
→ A full Building Block before 2020

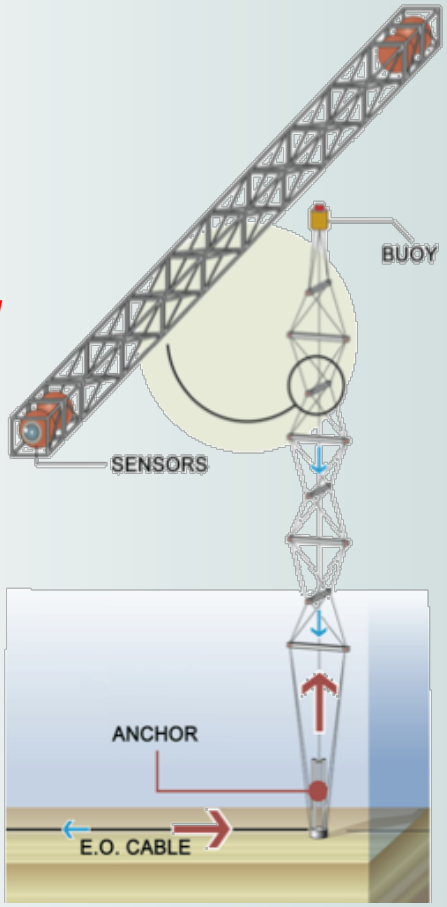
Next year:
Ready to host the KM3NeT phase 1

Marker buoys will be placed soon to ease future deployment operations



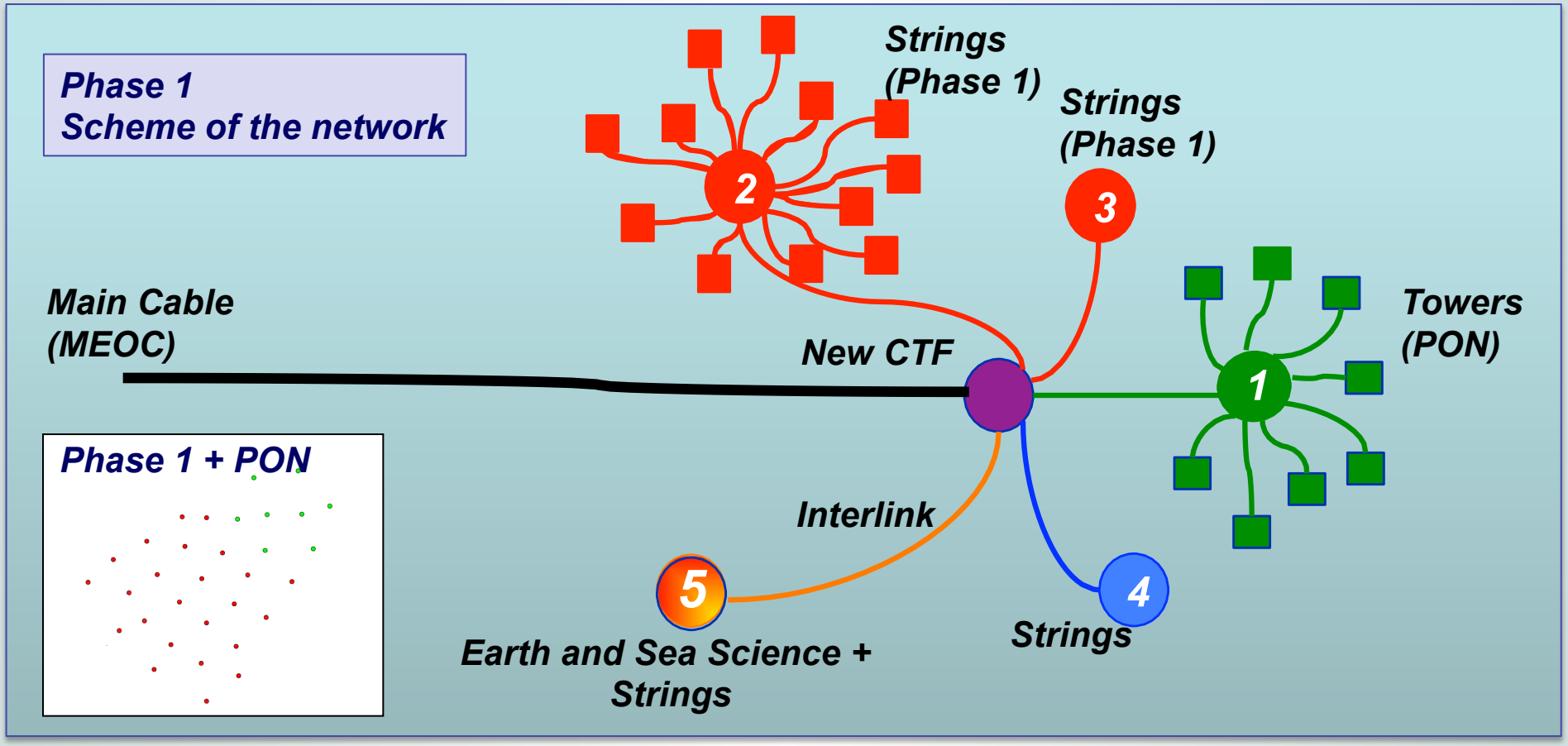
10.000 light sensors
1000 hydrophones
tens of CTDs, CMs,..

The largest deep-sea observatory in the world



Seabed Network Development

New CTF : 20 fibers, 8.5 kW, 5 ROV-mate e.o. outputs
Detector blocks
Junction Box 1 → KM3NeT-IT DU towers
Junction Boxes 2-4 → KM3NeT DU strings
Junction Box 5 → ESS node (EMSO) + KM3NeT DU strings



KM3NeT and EMSO

Common efforts with the Earth and Sea Science Community

KM3NeT

european multidisciplinary seafloor observatory emso

Real Time Environmental Monitoring

Toulon, Sicily and Hellenic: sites of common interest for KM3NeT and EMSO

Oceanography (water circulation, climate change):
Current intensity and direction, Water temperature, Water salinity ,...

Geophysics (geohazard):
Seismic phenomena, low frequency passive acoustics, magnetic field variations,...

Biology (micro-biology, cetaceans,...):
Passive acoustics, Biofouling, Bioluminescence, Water samples analysis,...

The Catania Test Site: a multidisciplinary deep sea-lab

The EMSO East Sicily Node: Catania and Portopalo

european multidisciplinary seafloor observatory emso

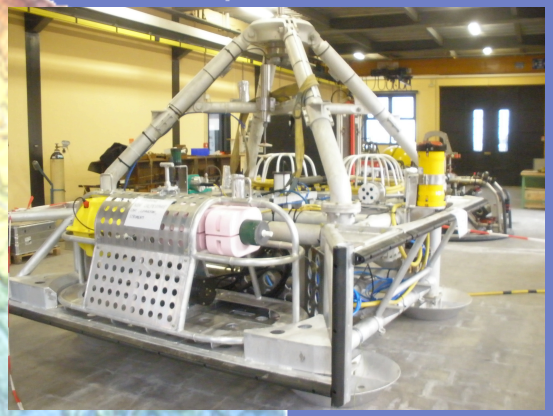
200 Mbps Internet Radio Link

LNS Test Site Laboratory at the port of Catania

20 km

5 km

5 km



North Branch

6 hydrophones
CTD, ADCP,
Seismometers
magnetometers
pressure gauges
GPS time stamping

South Branch

4 hydrophones
Underwater GPS
time stamping

Optical and oceanographic properties of deep-sea water at Capo Passero site are optimal.

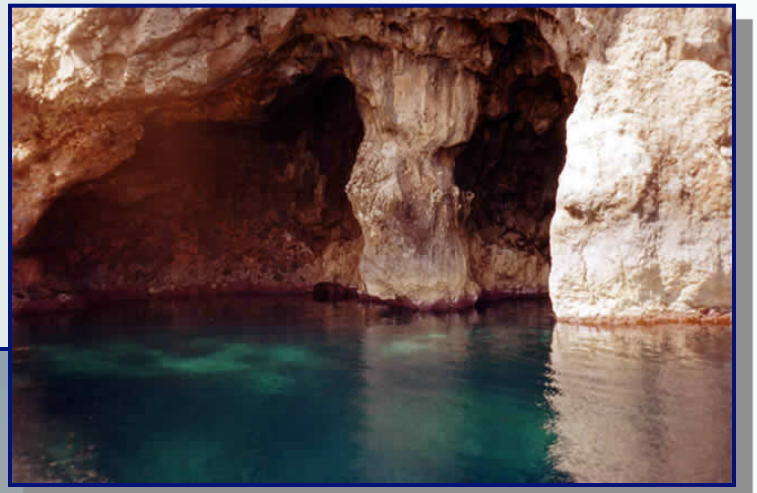
New real-time mesurements with the tower prototype confirm that the optical background is low.

Succesfull and very rapid deployment of the tower prototype demonstrates that the deep site is fully operative. The shore infrastructure is ready.

Plan for the deep sea infrastructure almost defined. PON fundings available to build towers, JB and strings.

Advanced collaboration with the Earth and Sea Science Community.

Capo Passero Seascapes



www.km3net.org

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