Palermo, Area della Ricerca CNR
31 Marzo – 2 Aprile 2014

INFN

SUD
LABORATORIO
DIGITALE

L'innovazione digitale di scuola, università e ricerca parte dal Sud

www.garexprogress.it

Il progetto KM3NeT e la Sicilia: il mare come telescopio

Neutrinos the “messenger” of the high energy Universe

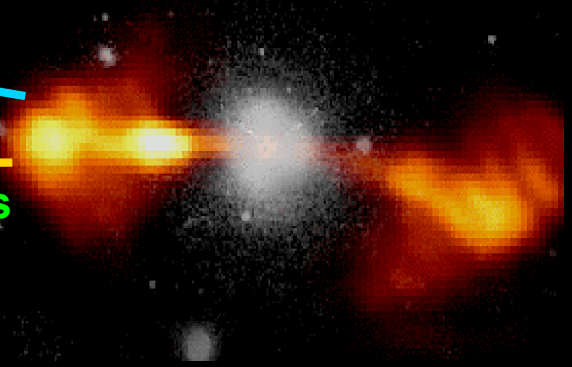
Neutrinos have extremley low mass and no electrical charge: they travel in straight line between the source and the Earth, thus they are an optimal high-energy astrophysical probe

Proton apparent direction

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

Cosmic “accelerator”

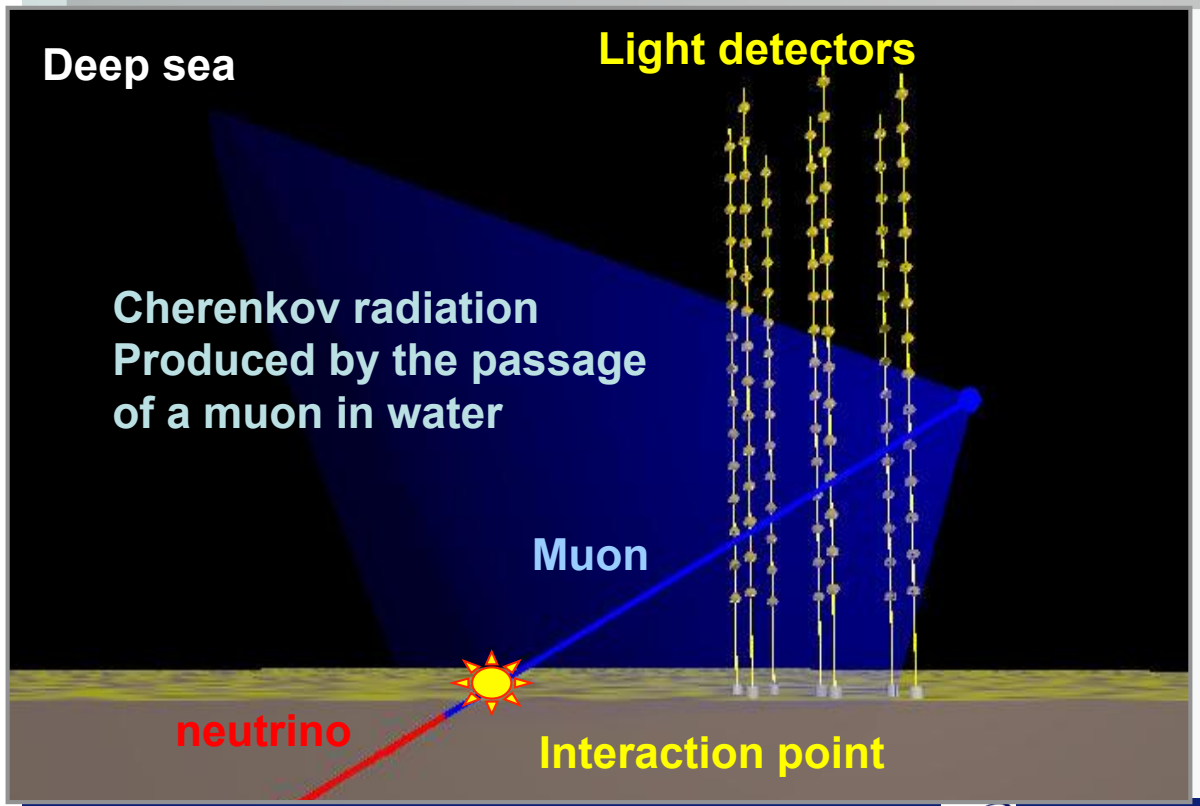
Gamma rays (very high energy photons) are absorbed by the cosmic dusts and microwaves

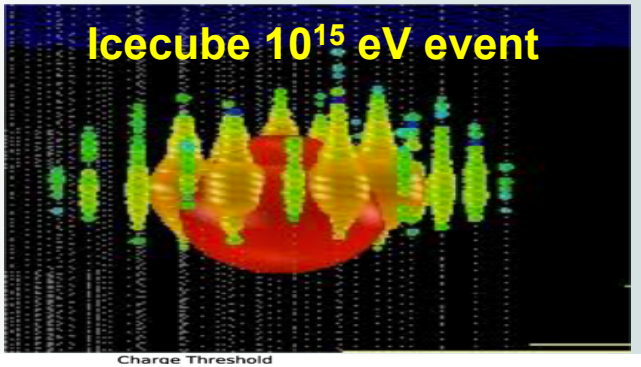


Neutrinos reach the Earth undeflected

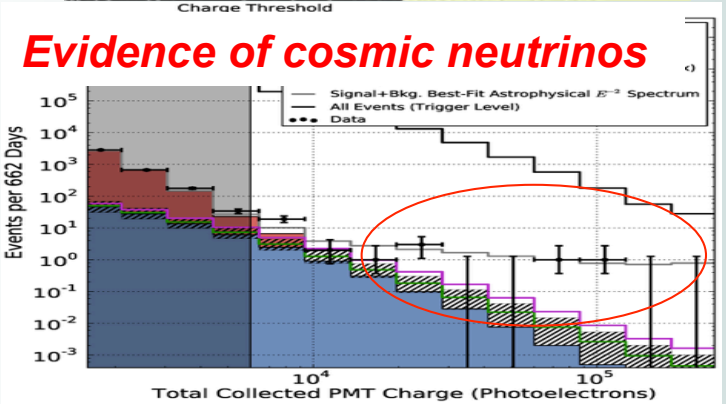
How to observe cosmic neutrinos

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.



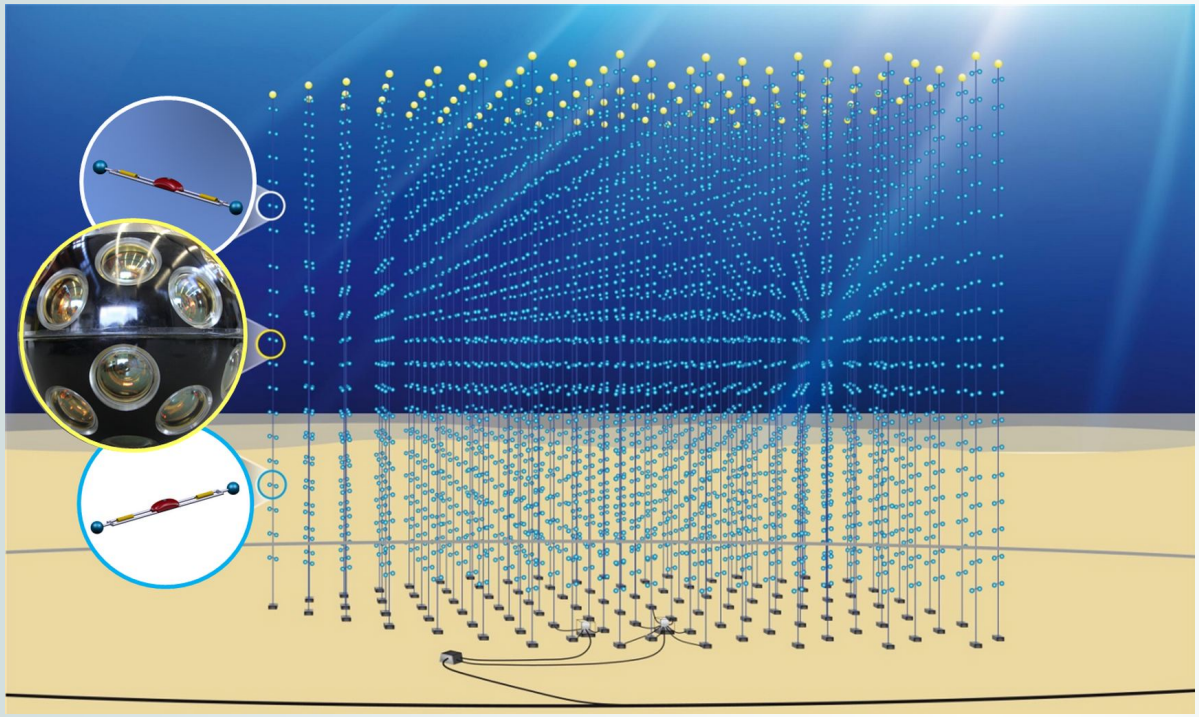


Evidence of cosmic neutrinos



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.

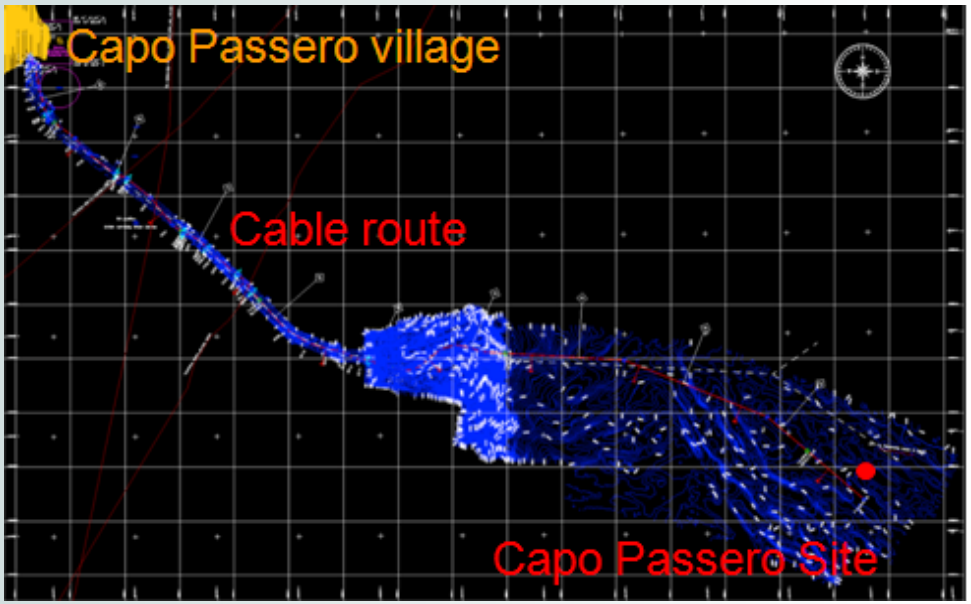


5 building blocks (≥2 in Italy)
120 Detection Units (DU)
750 m DU height
180m DU distance
5 km^3 volume
Budget 250 M€

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 Preparatory Phase

The Capo Passero Site infrastructure

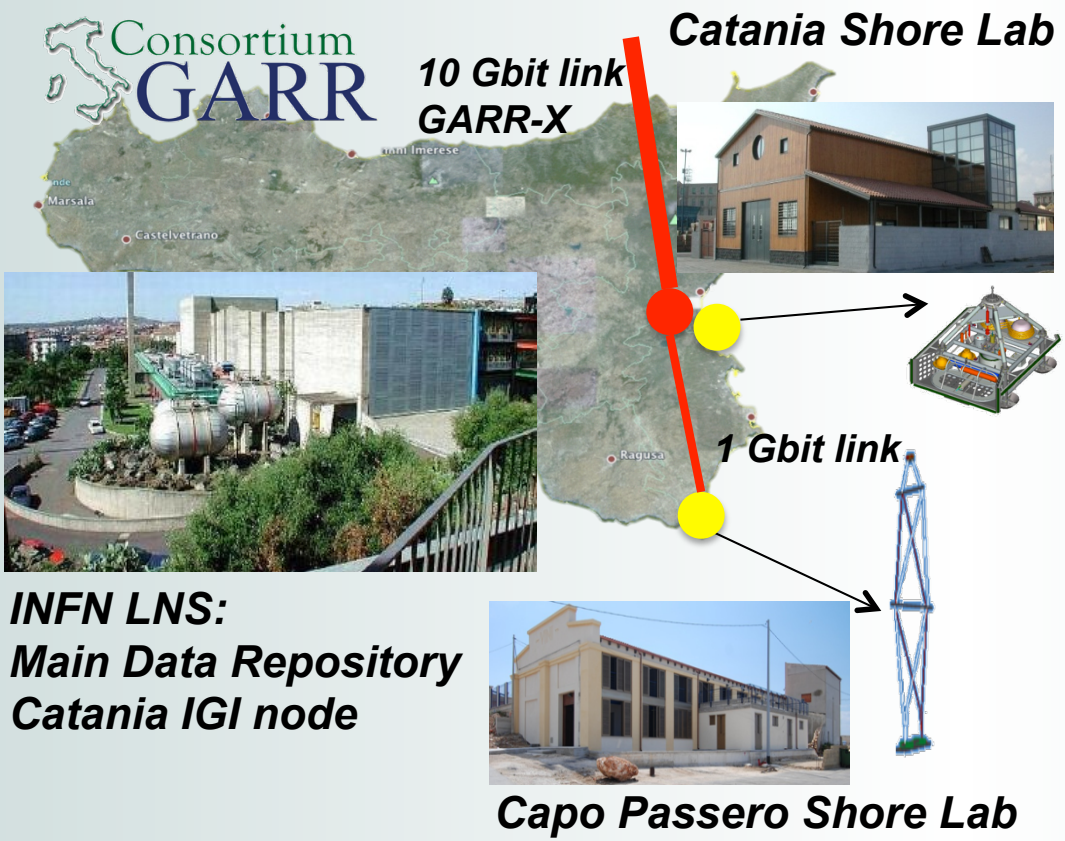


Shore Laboratory:
Electronics Labs
Data Acquisition Room
Control Room
Guest House 4 rooms
Power Feeding Equipment (UPS protected)
1Gb/s (upto 10) Optical-fibre link GARR-X

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
Construction of EMSO Node

KM3NeT Italia: A gateway to deep sea



INFN LNS:
Main Data Repository
Catania IGI node

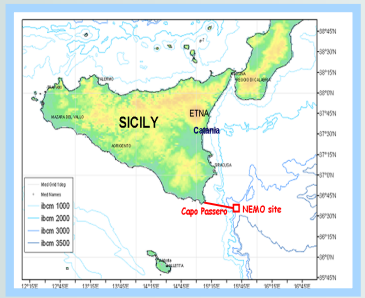
Capo Passero Shore Lab

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

KM3NeT Italia: High speed connections to the abysses



LNS

Backup Link
Portopalo
CDN 2 Mb

Internet

GARR POP CT

VLAN- MAN
University

Dark fiber Link
GARR-X

F.O.
Link

INFN S CT

Su ze Politiche

New: 12 fibers

Alcoma R Link
Up to 660 M

Fiber Link

New fiber link Garr-X
(in progress)

Gri FN-CT

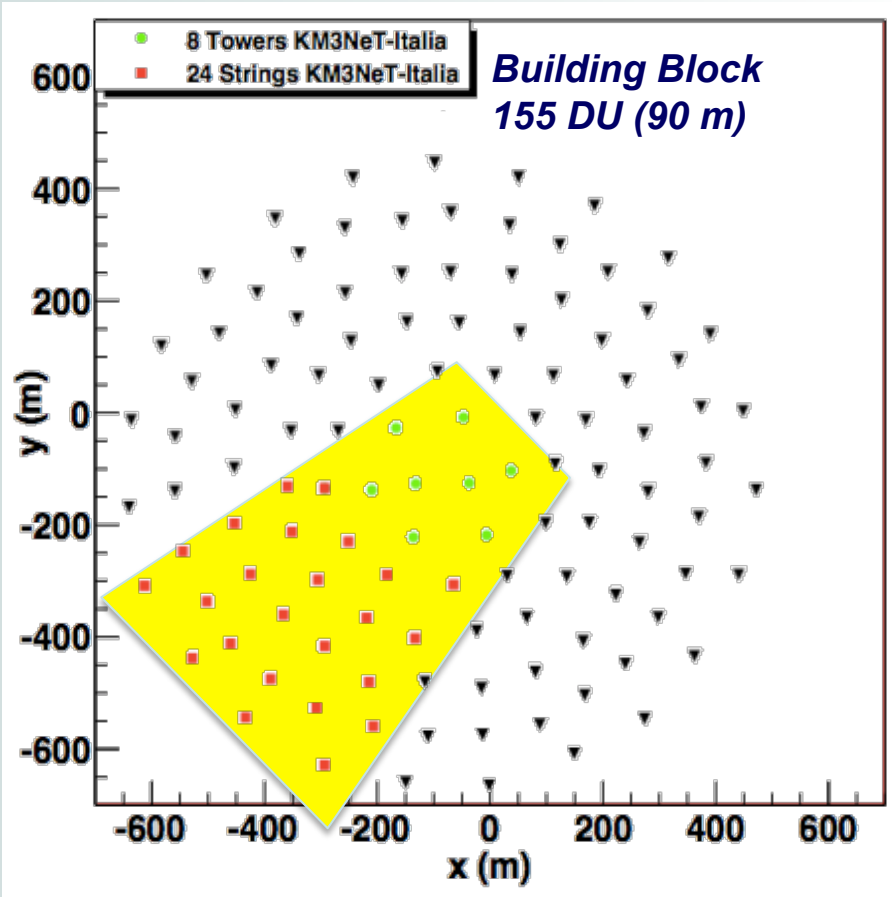
Fiber link

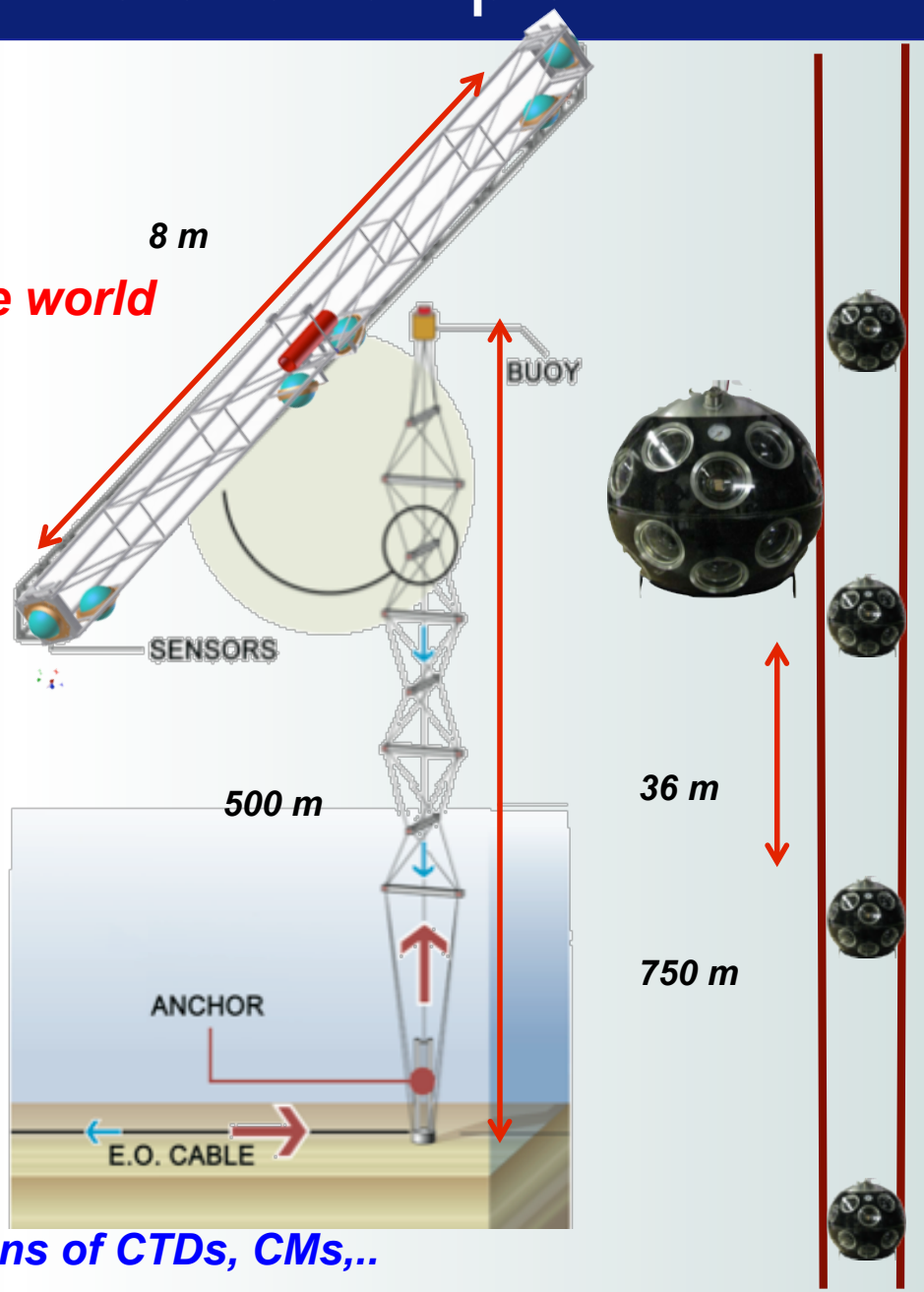
Catania Harbour

KM3NeT – Italia Installation plan

- → *8 Detection Units in 2015*
- → *24 Detection Units in 2016*
- → *A full Building Block before 2020*

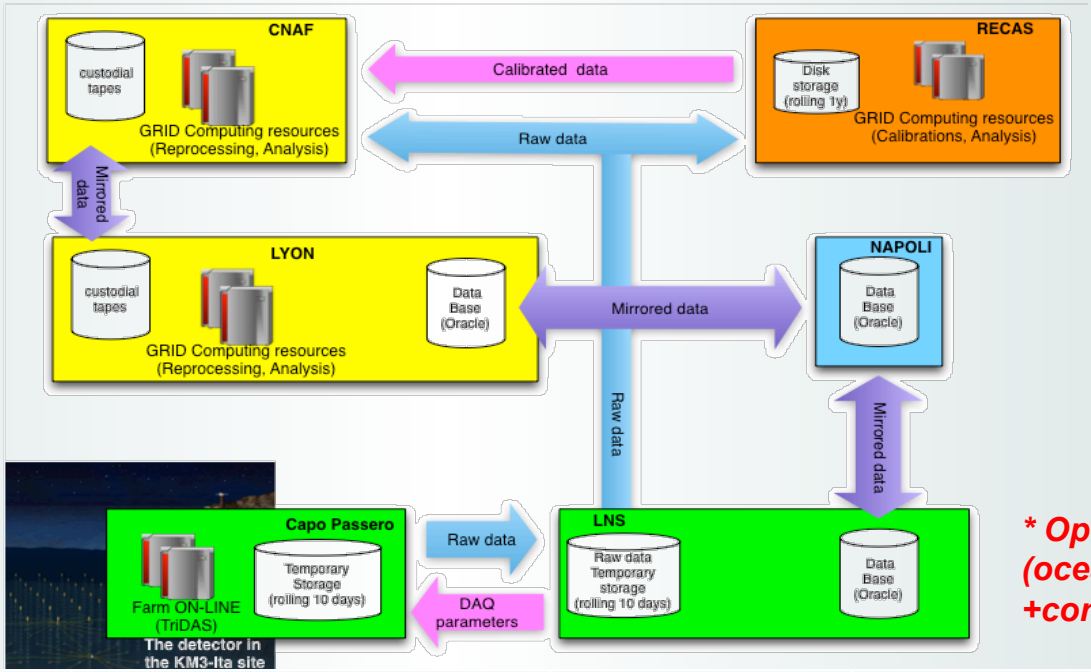
The largest deep-sea observatory in the world





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

Computing Model: data and simulations



**** Optics+acoustics + (oceanographic +controls)***

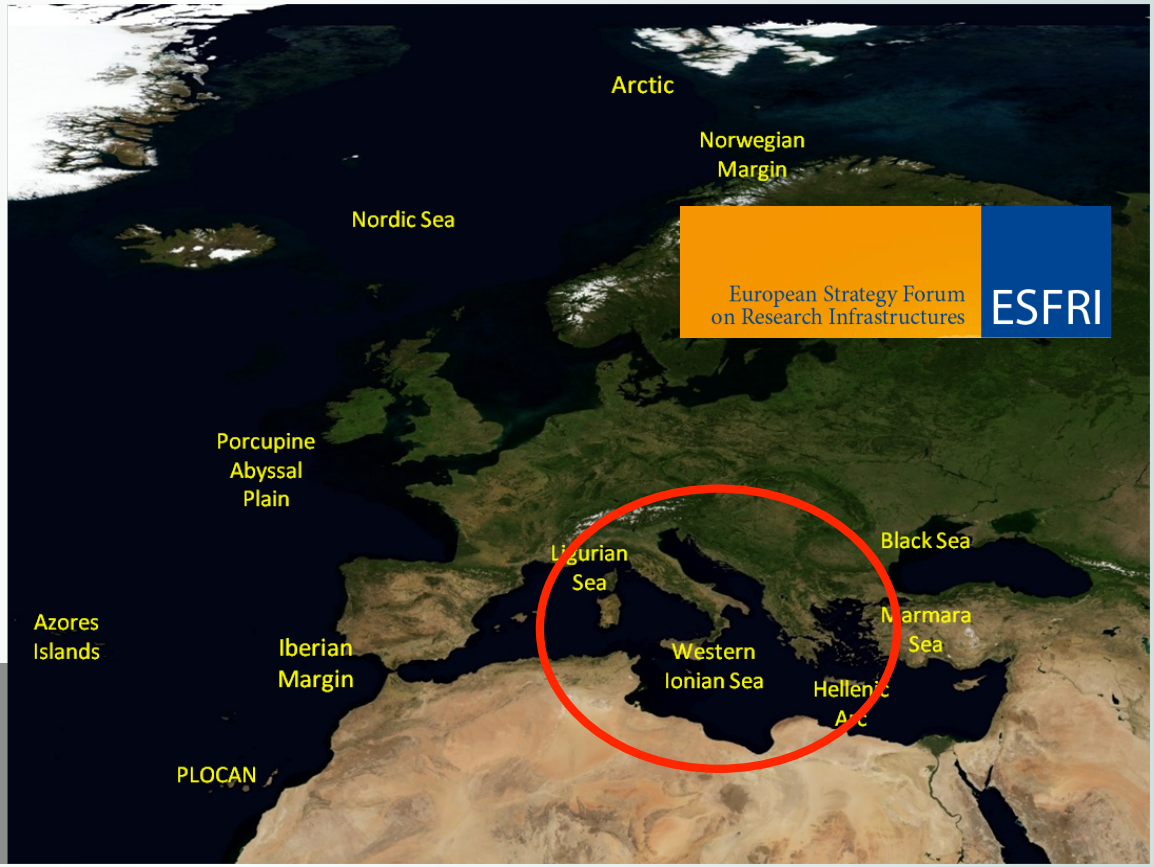
Tier	Computing Facility	Processing steps	Throughput* (phase 1 : 1.5)	Storage* (phase 1:1.5)	Access
Tier-0	detector site (each)	triggering, online-calibration, quasi-online reconstruction	20 : 120 Gb/s (100 cores: 600 cores) + Cisco 7009 + WR switches	100 TB/y	direct access, direct processing
Tier-1	computing centres (each)	calibration and reconstruction, simulation	100 cores : 600 cores	300 : 2000 TB/y	direct access, batch processing - or grid access
Tier-2	local computing clusters	simulation and analysis			varying

KM3NeT and EMSO

Common effort with the Earth and Sea Science Community

Real Time Environmental Monitoring

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



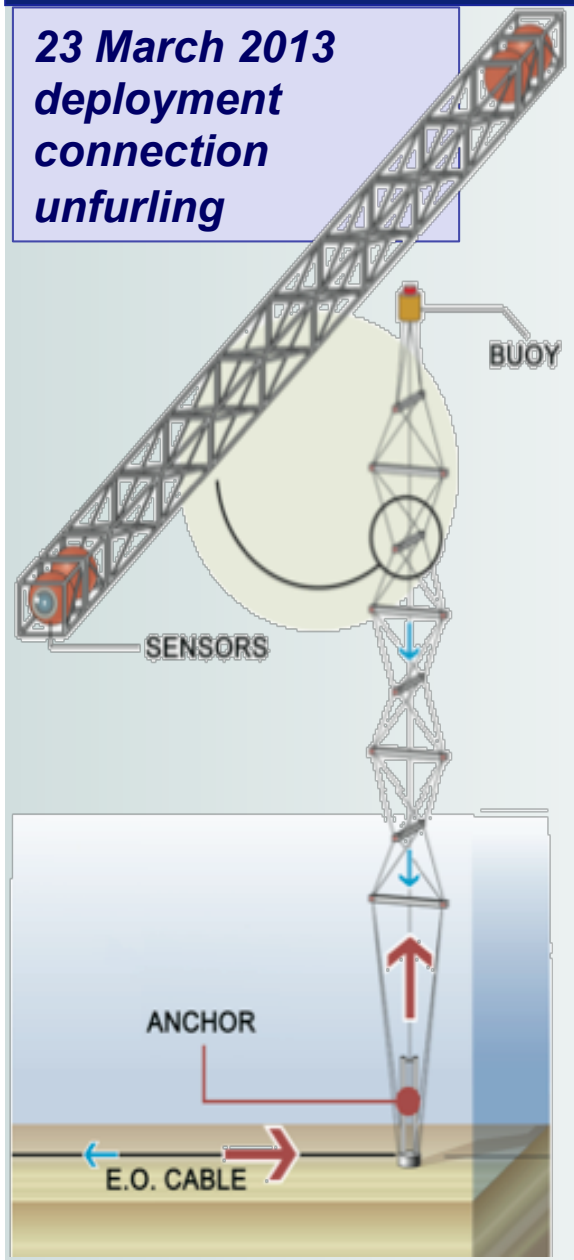
Oceanography (water circulation, climate change):
Current intensity and direction, Water temperature, Water salinity ,...
Geophysics (geohazard):
Seismic phenomena, low frequency passive acoustics, magnetic field variations,...
Biology (micro-biology, cetaceans,...):
Passive acoustic monitoring, Biofouling, Bioluminescence, Water samples analysis,...

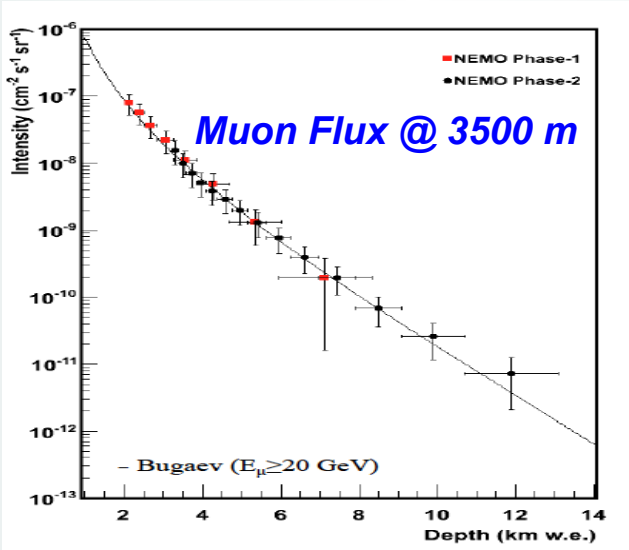
Thank you !

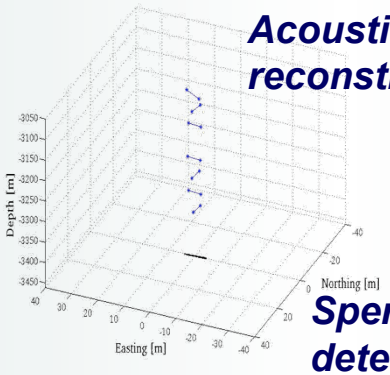
The KM3NeT Tower Prototype: the deepest one

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

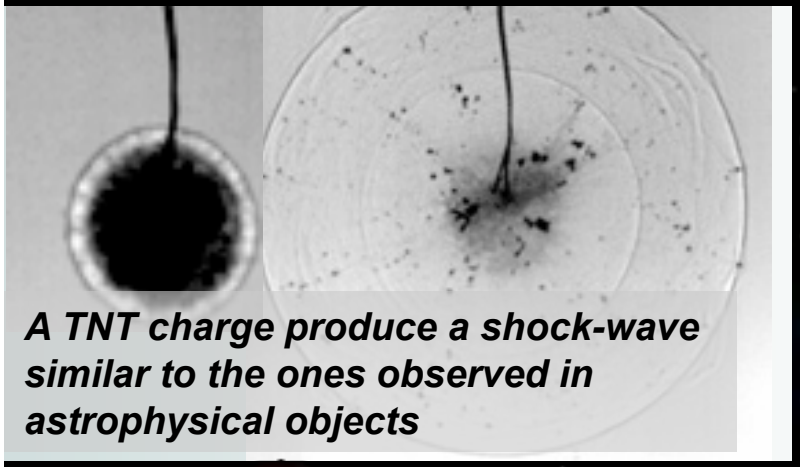
Sperm whales detected

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

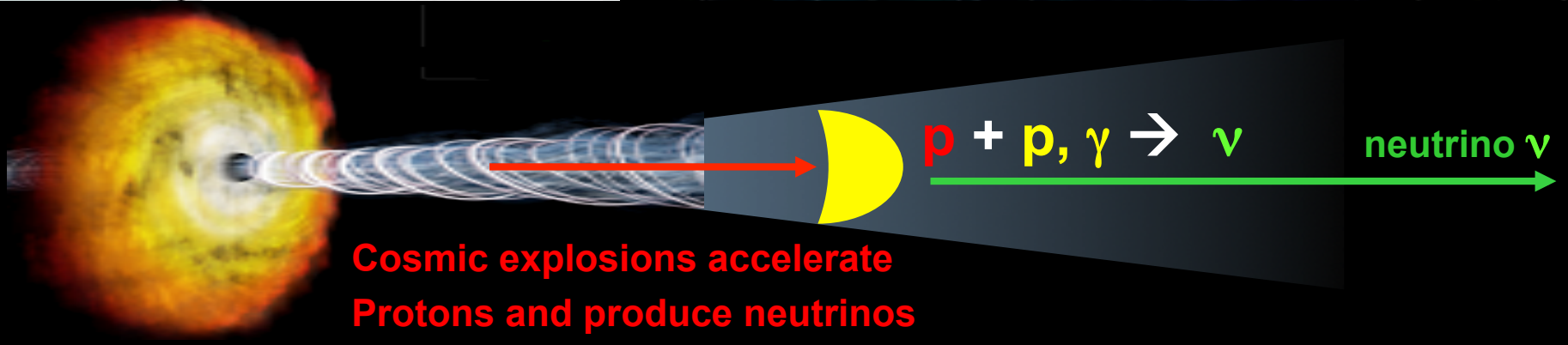
Hydrophones: acoustic positioning and bioacustics (INFN/SMID/NATO)

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



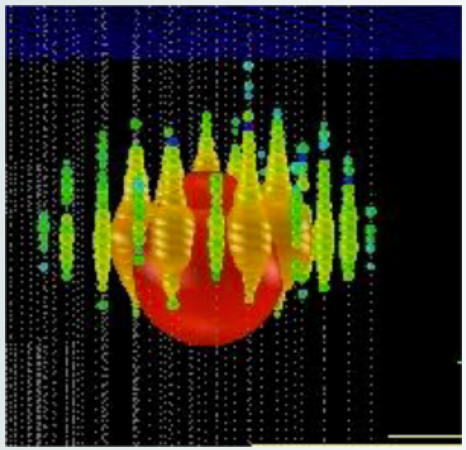
A TNT charge produce a shock-wave similar to the ones observed in astrophysical objects

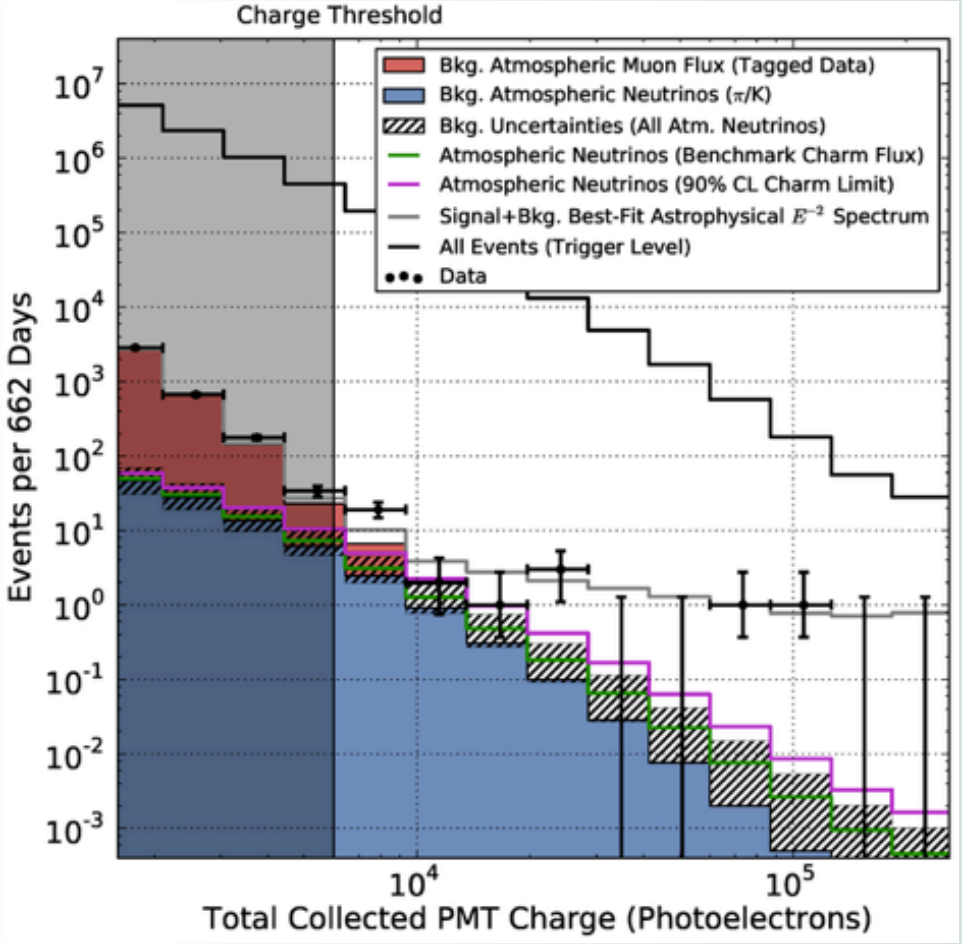


Cosmic explosions accelerate Protons and produce neutrinos

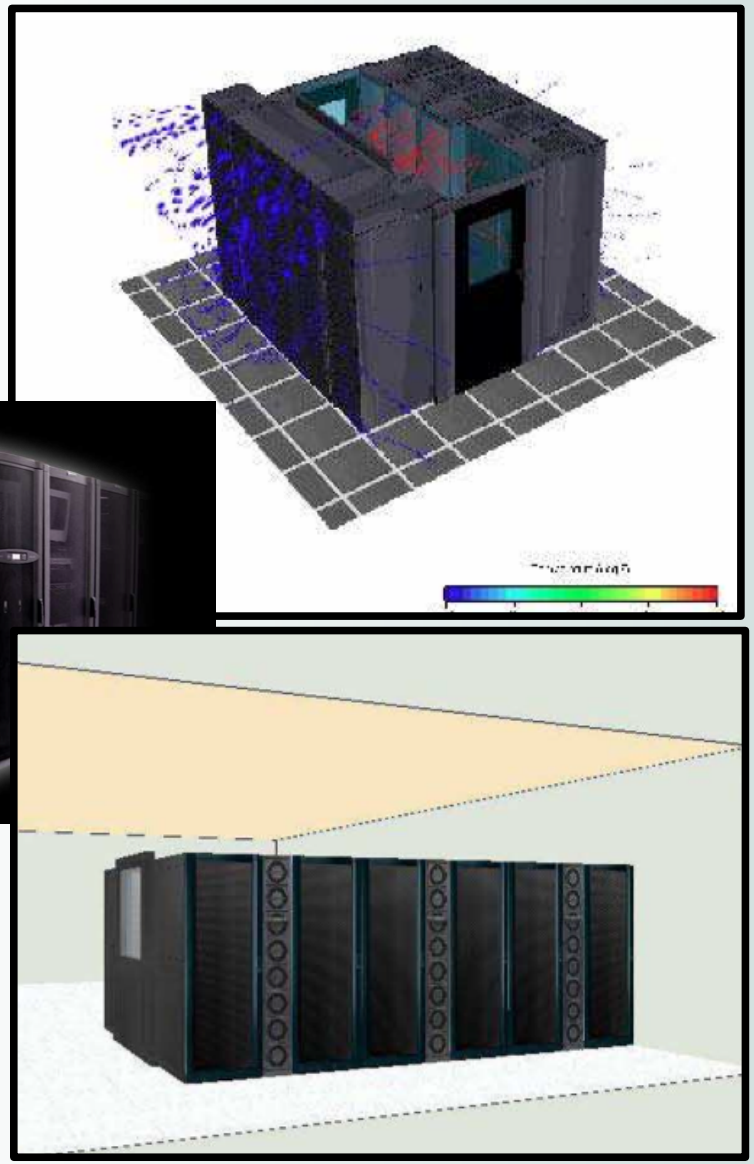
Astrophysical neutrinos: observed!

The Icecube Telescope buried in the deep ice of South Pole has discovered the first signature of astrophysical high energy neutrinos





A gateway to deep sea



New Computing Hall infrastructures @ LNS and Portopalo di C.P.

APC Technology: high density

Start: June 2014

IT needs

Input parameters (conservative)

KM3NeT-Ita

KM3NeT-Eu

Case	n_{DU}	n_{layers}	$n_{pmt/layer}$	ν_{single} (kHz)	$\nu_{trigger}$ (Hz)	hit size (bit)
NEMO–F2	1	8	4	70	100	370
KM3Ita (8 Towers)	8	14	6	70	30	370
KM3NeT–Ph1	31	18	31	10	40	50
KM3NeT–Block	115	18	31	10	220	50
KM3NeT–Ph1.5	230	18	31	10	440	50
KM3NeT–Ph2	690	18	31	10	1320	50

Throughputs

INCOMING **POST TRIGGER**

Case	Layer thp (Mb/s)	DU thp (Gb/s)	Det thp (Gb/s)	Sel thp (MB/s)	Sel thp (TB/day)	Stored (TB/y)	event size(kB)
NEMO–F2	99.0	0.8	0.8	0.2	0.01	4.8	0.6
KM3Ita (8 Towers)	150.0	2.0	16.0	2.4	0.20	74.0	13.0
KM3NeT–Ph1	15.0	0.3	8.1	1.3	0.11	38.0	6.3
KM3NeT–Block	15.0	0.3	30.0	8.9	0.73	270.0	23.0
KM3NeT–Ph1.5	15.0	0.3	60.0	28.0	2.30	840.0	47.0
KM3NeT–Ph2	15.0	0.3	180.0	200.0	17.00	6200.0	140.0

The Catania Test Site: a multidisciplinary deep sea-lab

The EMSO East Sicily Node: Catania and Portopalo

european multidisciplinary seafloor observatory emso

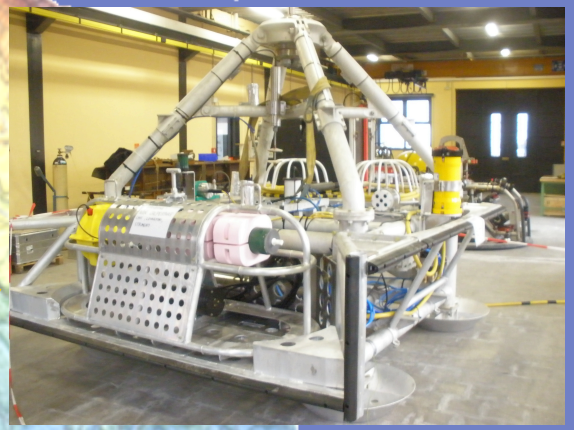
600 Mbps Internet Radio Link → optical fibre GARR

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