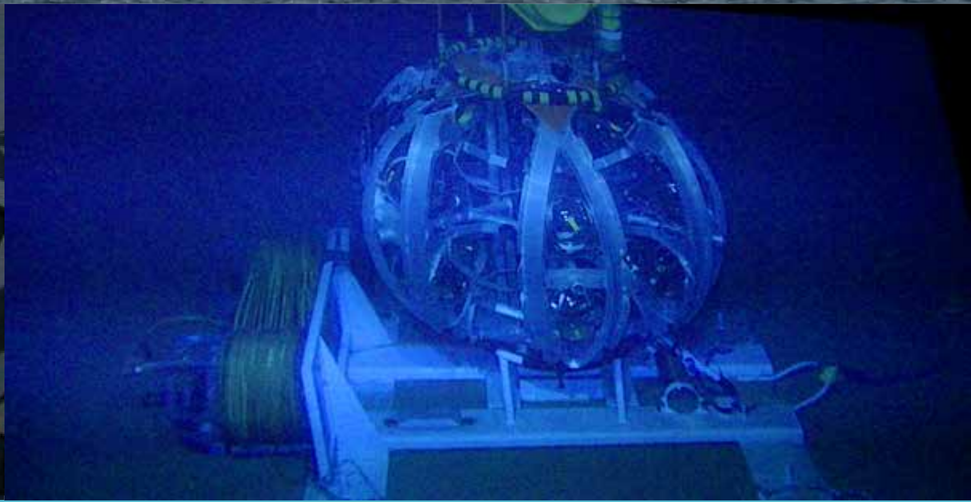
Status of KM3NeT in Italy



Giorgio Riccobene LNS-INFN

MSU – 29 Jan 2015

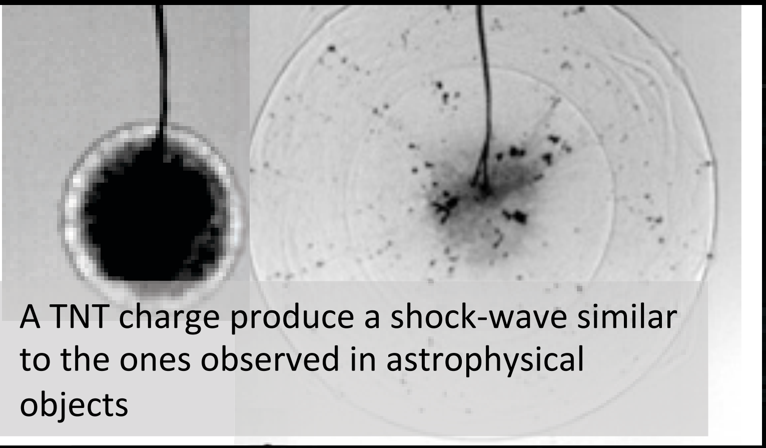
Outline

- The detector and its physics goals
- Research infrastructure
- Design and construction
- Demonstrators
- Production
- Next steps

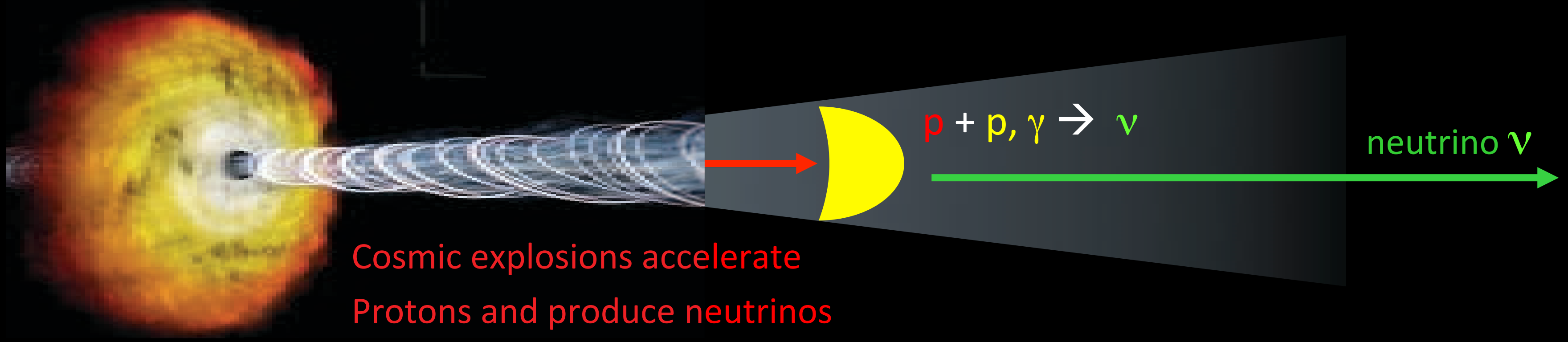
Why a neutrino telescope

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.

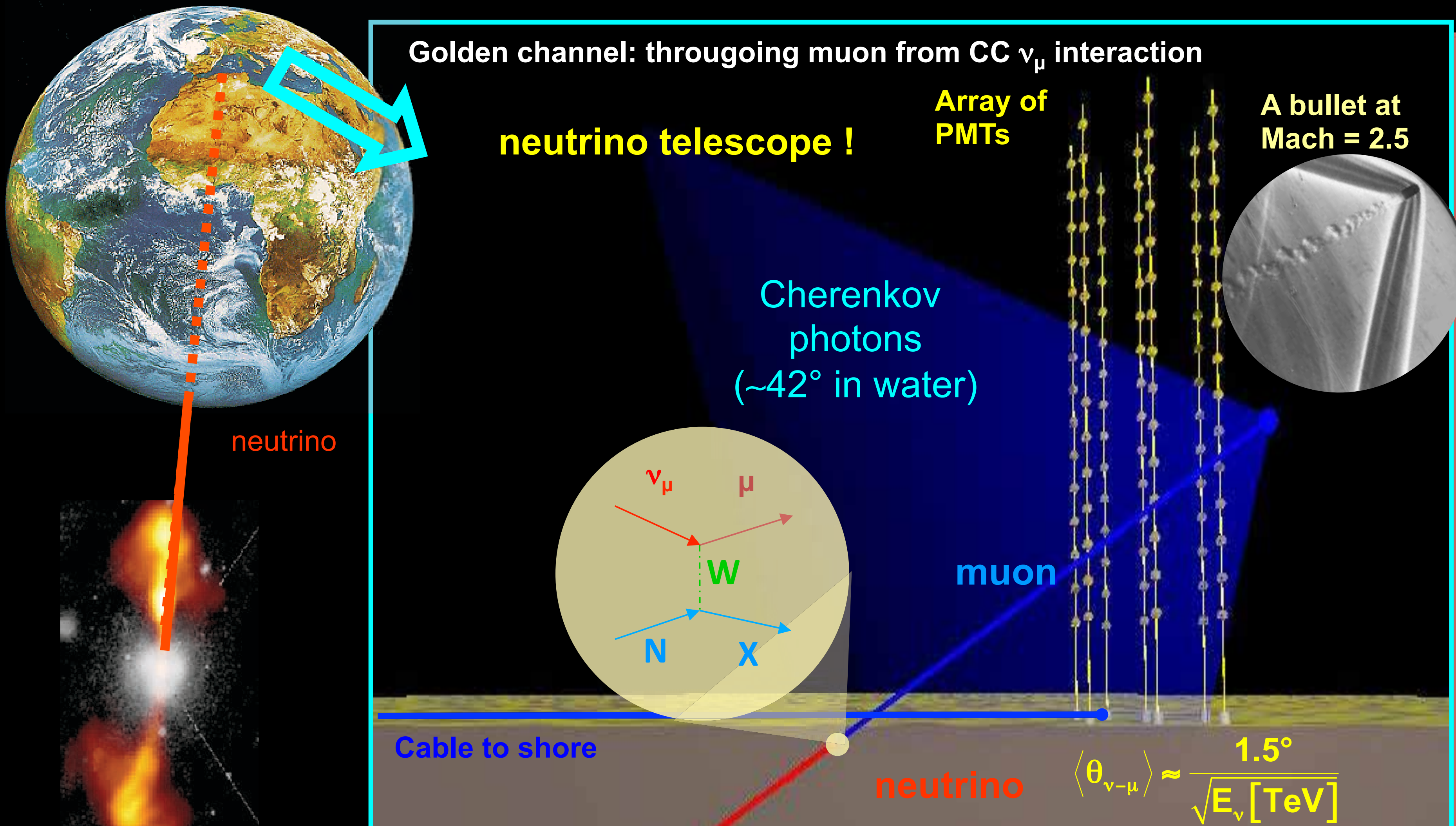
Differently from other particles neutrinos can travel unperturbed the entire Universe carrying direct infromation on the source



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

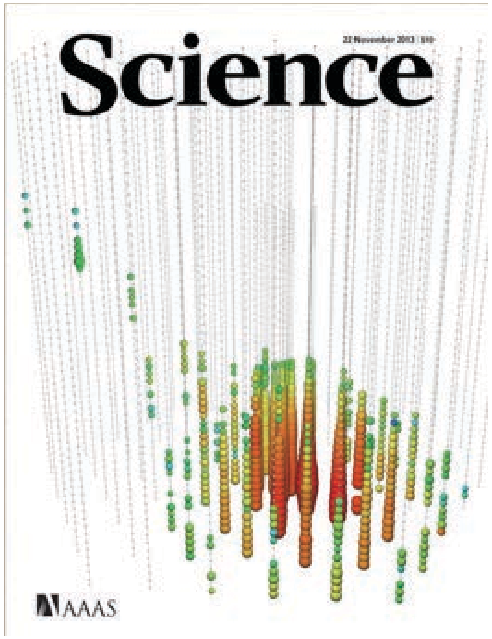


Operational Scheme

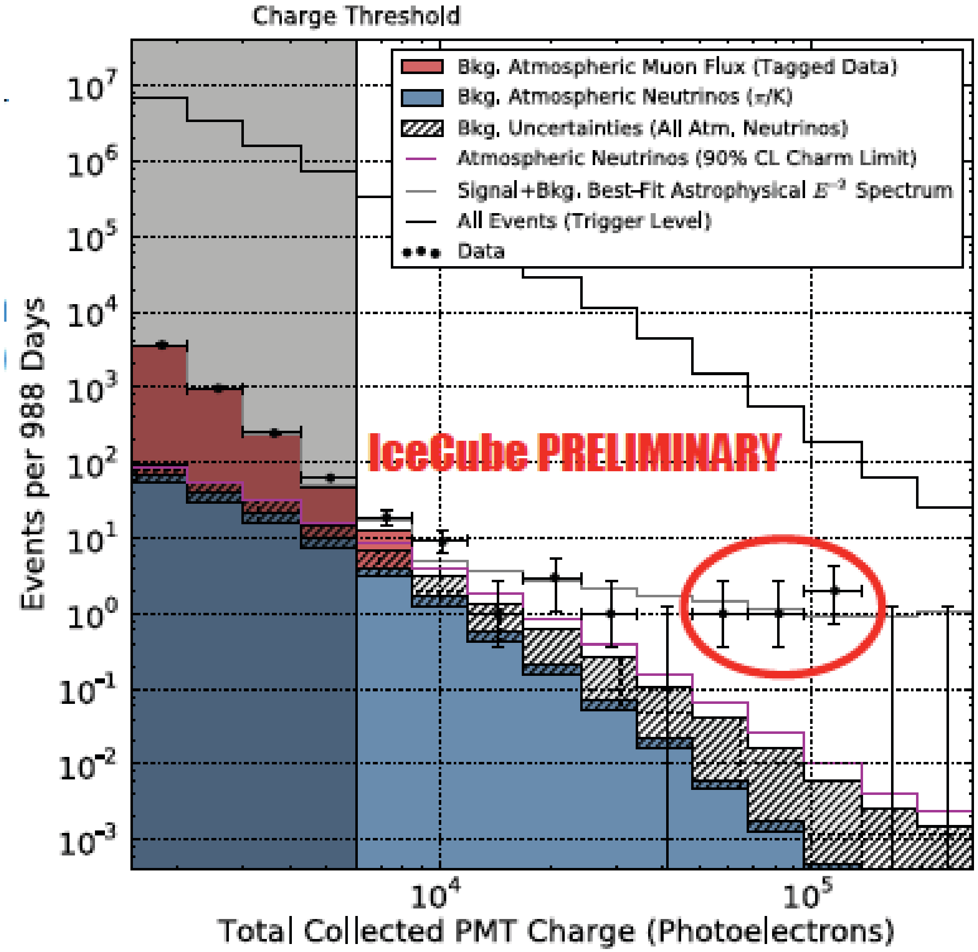


Look at upgoing muons: use the Earth as a filter
Only atmopheric and astrophysical neutrinos can cross the Earth

Icecube



Aartsen et al. Science 342 (2013) 1242856
+ 1 year



3 events at > PeV and 37 in total

Physics Goal

- Measurement of HE neutrino flux and observation of high-energy neutrino sources in the Universe
    - Multi-messenger approach
    - Point sources search
    - Galactic Centre Region investigation

- Particle physics below 1 TeV: ORCA a denser detector
    - Neutrino mass hierarchy problem
    - Dark matter indirect search

- Synergy with Earth & Sea sciences →EMSO

The underwater choice

- Detection principle measure optical Cherenkov radiation produced by energetic charged particle interactions in water
- Faintness of atrophysical HE neutrino fluxes and small neutrino cross section oblige use of large natural target sea-water:

 2000 m < depth < 4500 m

 L_{abs} 50-70m, L_{scatt} > 100 m

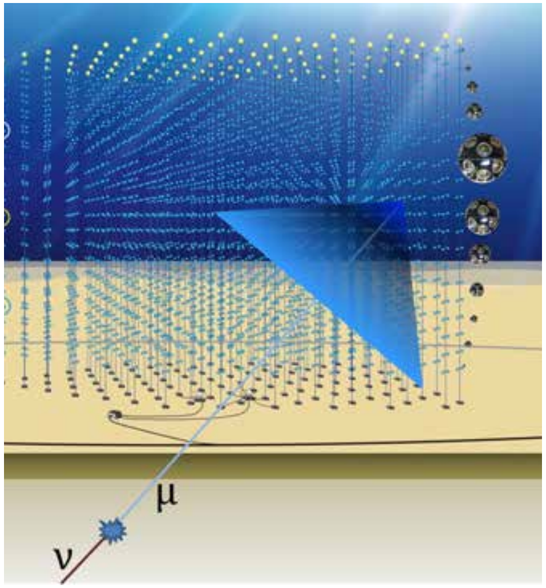
time resolution 1ns

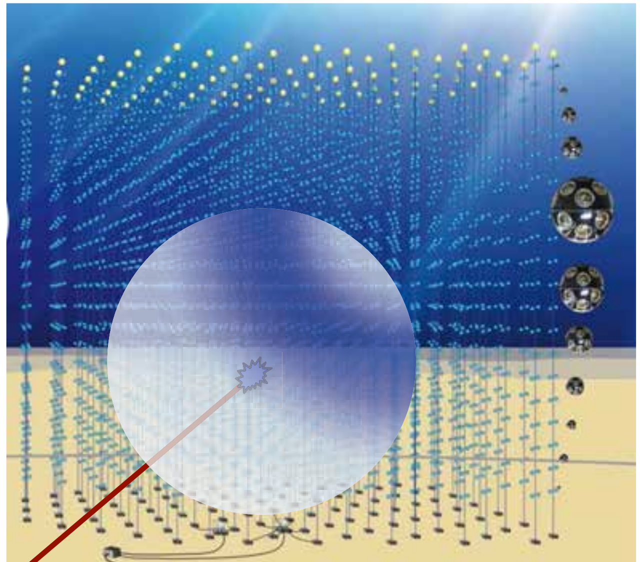
position resolution 10cm

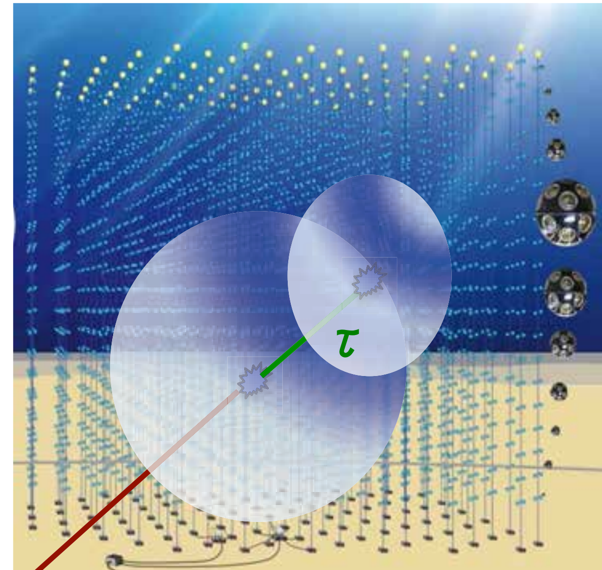
Very good angular resolution :

0.1° for tracks (E> 10TeV) - <2° cascades (E > 50 TeV)

Neutrino detection channels







ν

ν

$$\nu_\mu \xrightarrow[CC]{} \mu + \text{shower}$$

Muons:
highest effective area, good angular resolution (~0.1°)
High atmospheric muon background: look at events from below only

$$\nu_\ell \xrightarrow[NC]{} \nu'_\ell + \text{shower}$$

$$\nu_e \xrightarrow[CC]{} \text{shower}$$

Showers:
Remove atmospheric muon background: studies over 4π.
'Good' energy resolution, worse directional resolution: diffuse flux!

$$\nu_\tau \xrightarrow[CC]{} \tau + \text{shower}$$

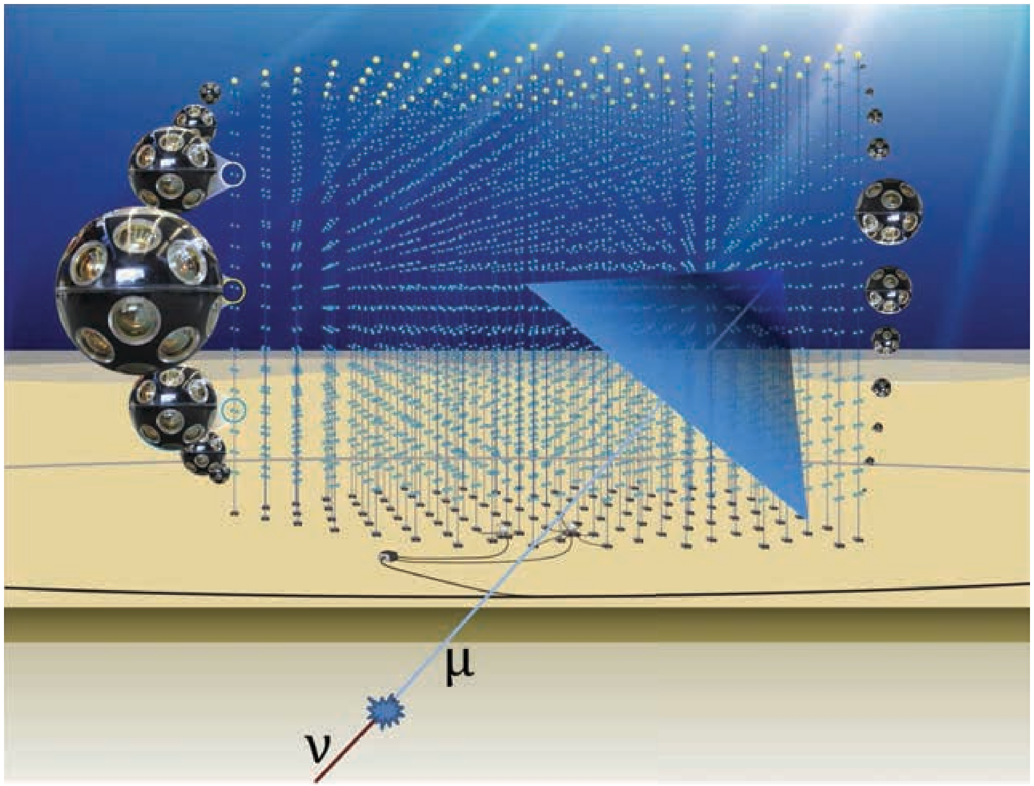
$$\tau \xrightarrow[\sim 83\%]{} \nu_\tau + \text{shower}$$

$$\tau \xrightarrow[\sim 17\%]{} \nu_\tau + \mu + \bar{\nu}_\mu$$

Taus:
Unambiguous topology

The giant-scale detector KM3NeT

KM3NeT is a EU funded ESFRI project since 2006.



6 building blocks
115 Detection Units(DU)/Bblock
90-120 m inter-DU distance

700 m DU height
0.5-0.8 km^3 Bblock volume

3.5 x IceCube
photocathode area

DU:vertical slender string with multi-PMT digital optical modules (DOM)

Seafloor network provide data and power distribution

Phased implementation

Phase	Total costs [M€]	Primary deliverable	Status
1	31	Proof of feasibility of network of distributed neutrino telescope ***24 strings in Capo Passero*** ***7 strings in Toulon*** ***8 towers in Capo Passero***	***Funded***
1.5	+(50:60)	Measurement of neutrino signal reported by IceCube ***2 building blocks (> IceCube)***	***Letter of Intent***
2	+(130:160)	Neutrino astronomy ***6 building blocks***	ESFRI road map

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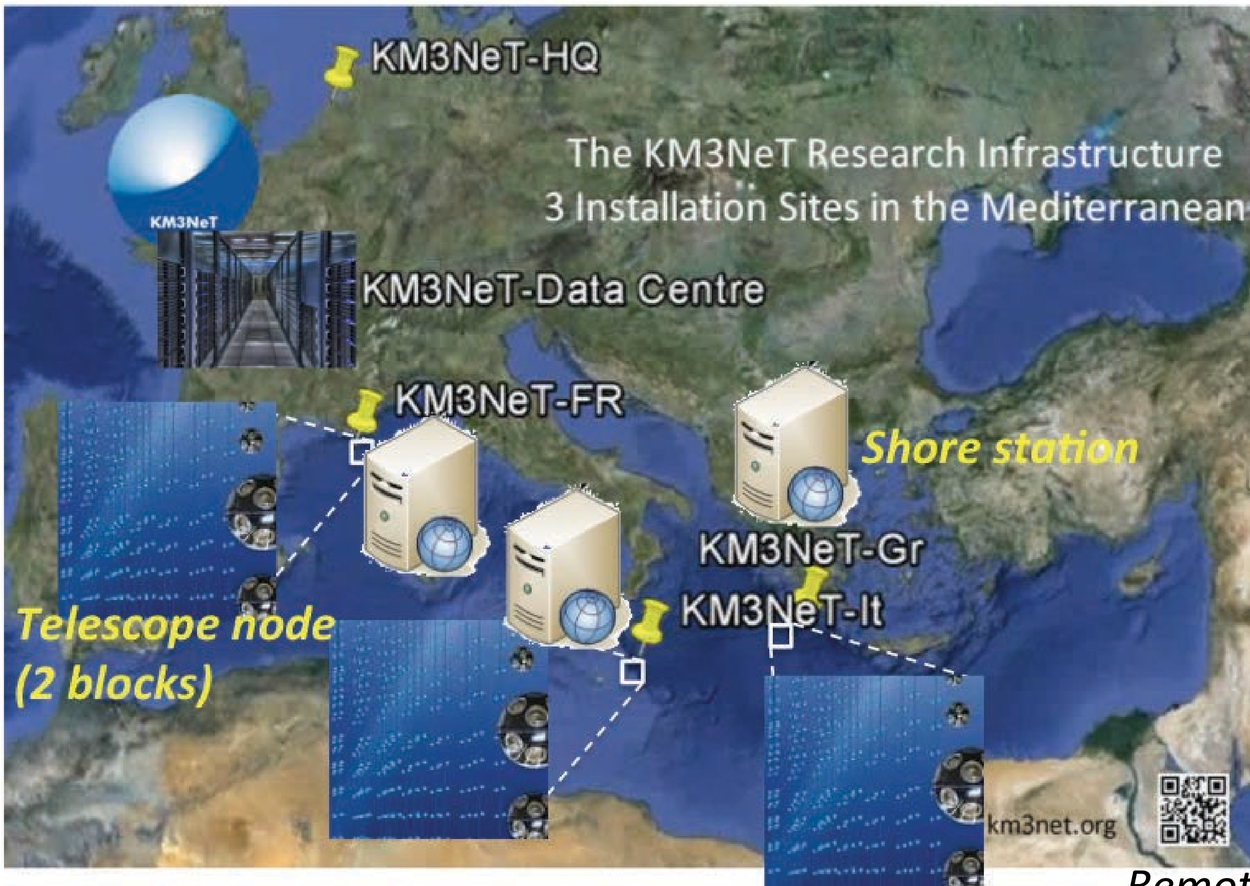
Distributed Research Infrastructure

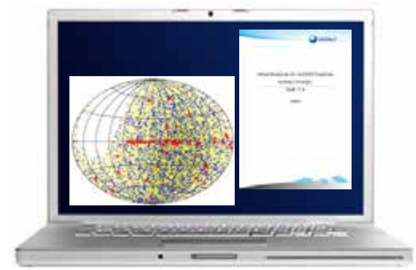
Network of cabled observatories located in deep waters of the Mediterranean Sea.

Centrally managed: common hardware, software, data handling and control



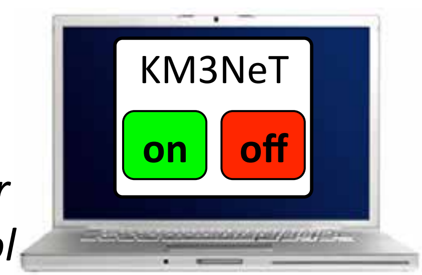
Node → Shore Station
1 Tbps

Shore Station → Data Centres
> 100 Mbps



Remote access to data

Remote detector operation control



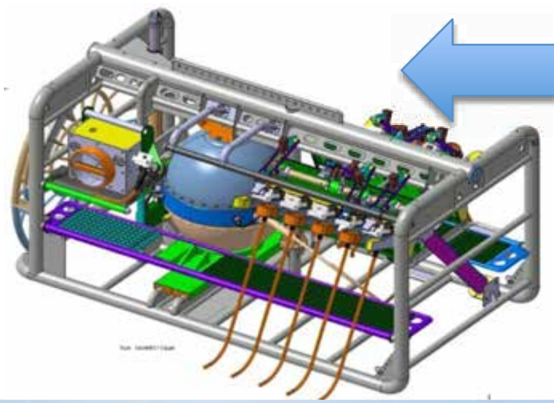
KM3NeT-FR MEUST

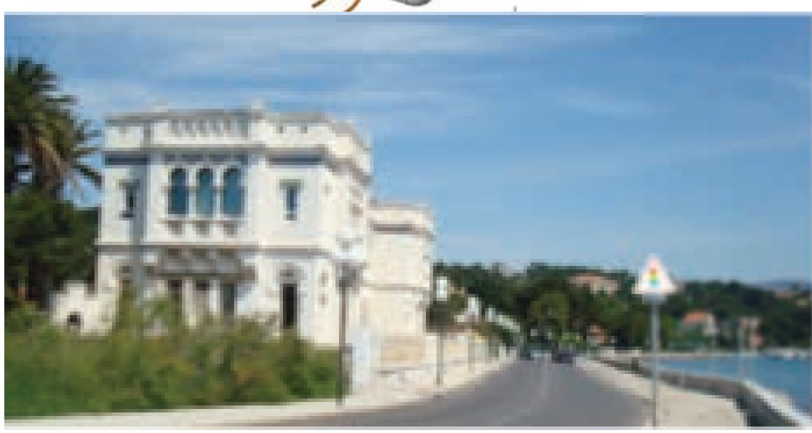
3 nodes per MEOC

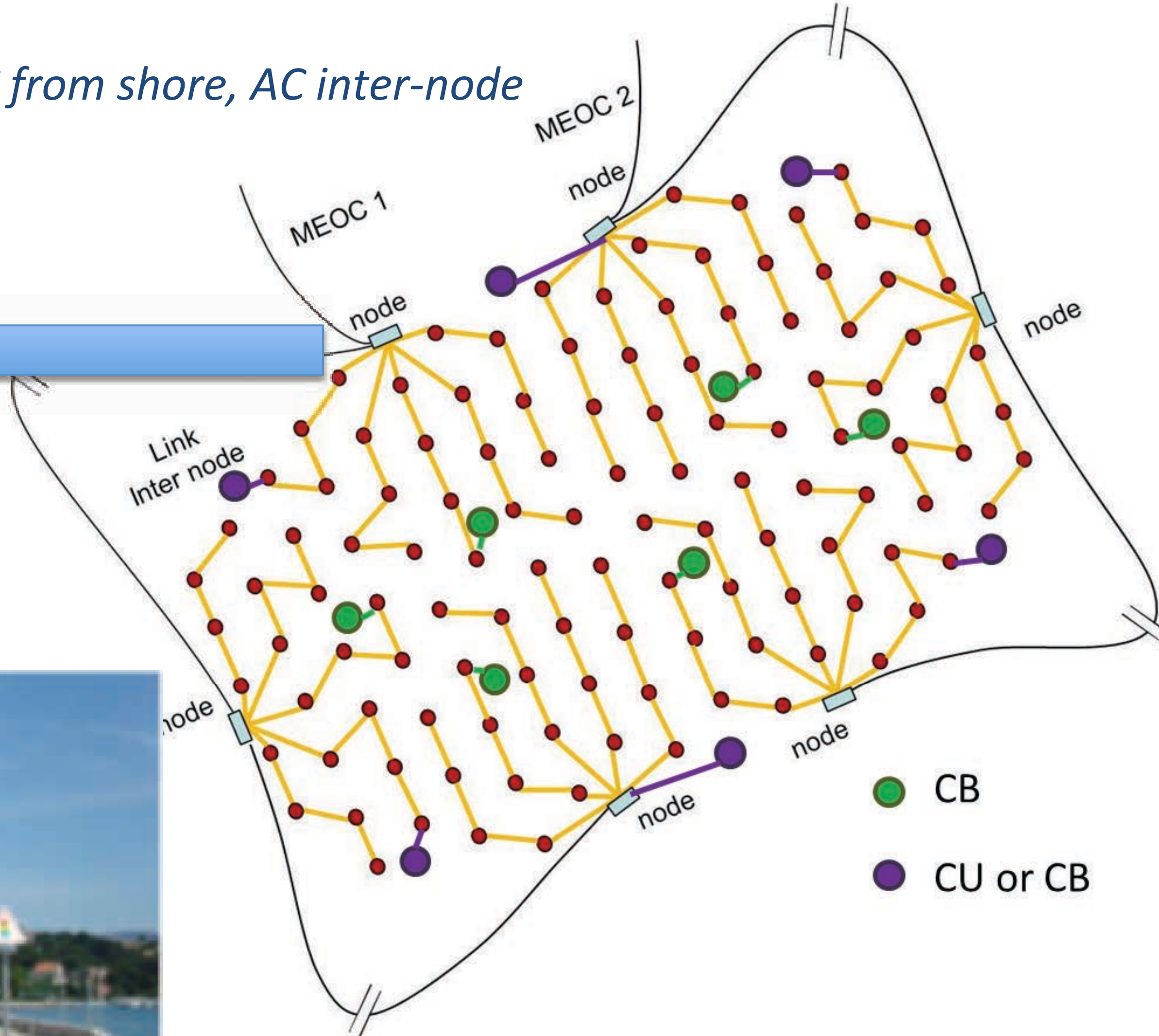
24-36 Optical fibres in MEOC. DC from shore, AC inter-node

20 strings per node

sets of 4 strings in series



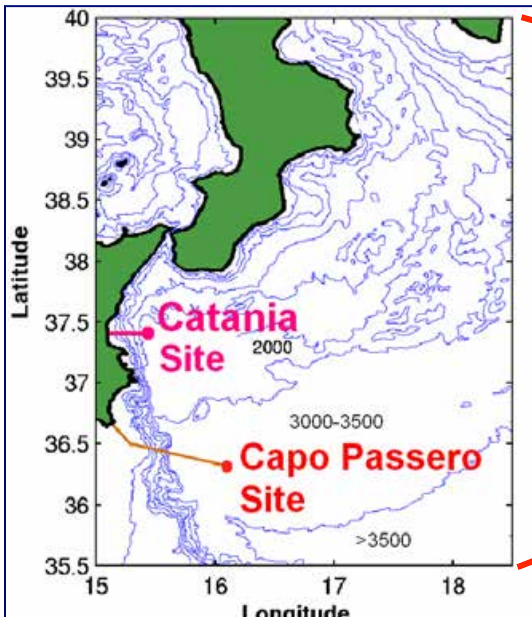




KM3NeT-Italia

The INFN funded the NEMO Project aiming at the construction the Mediterranean km^3 underwater neutrino telescope.
Two deep sea infrastructures are operational in Sicily

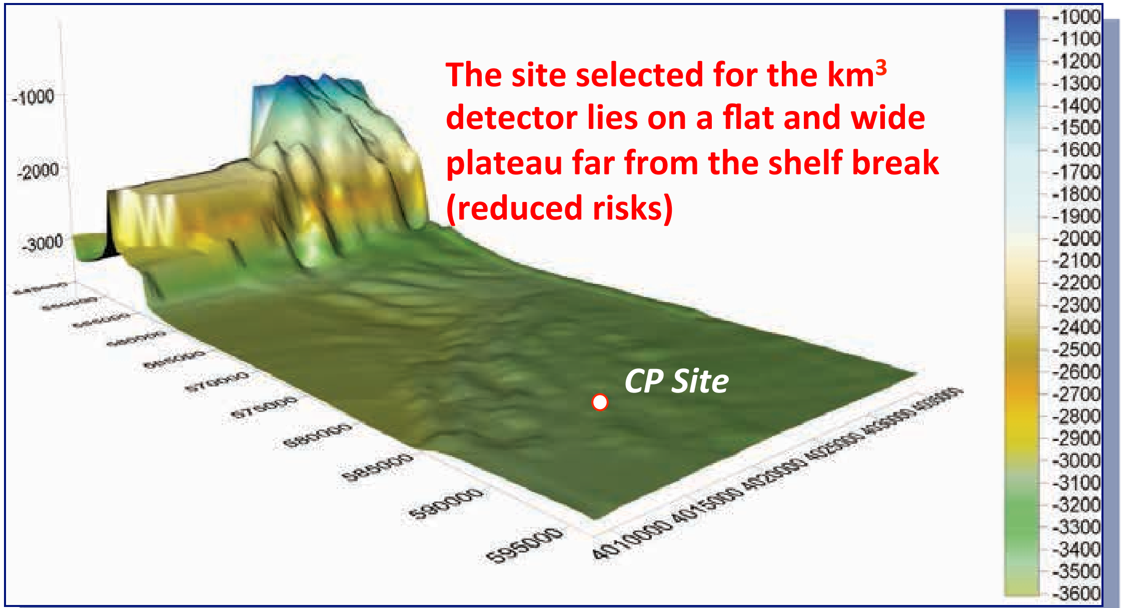
Capo Passero Site (candidate for KM3NeT):
90 km South East offshore Capo Passero, 3500 m depth
Catania Test Site (first multidisciplinary abyssal laboratory in Europe):
25 km East offshore the port of Catania, 2100 m depth

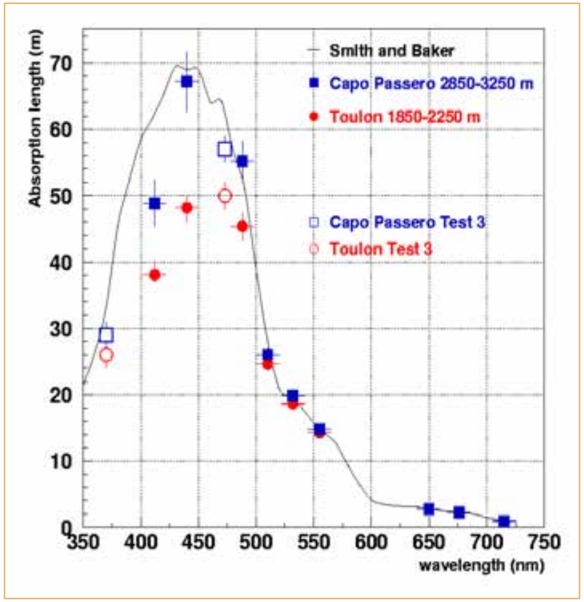


The Capo Passero Site

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***

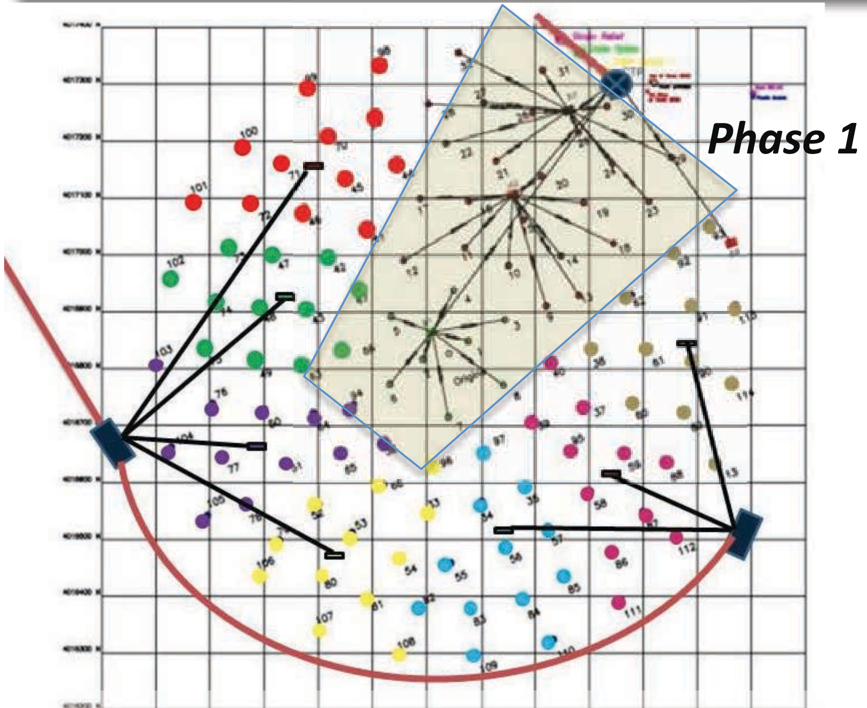




KM3NeT-IT Capo Passero

Shore Laboratory:
Electronics Labs
Data Acquisition Room, Control Room
Guest House
Power Feeding Equipment (UPS protected)
Upto 10 Gbps direct Optical-fibre link GARR-X

Submarine cable and infrastructure (now):
96 km - 20 fibres ITU655-NZDSF
Single conductor with DC-sea return
Phase 1: Cable Termination Frame
Medium Voltage Converter: 10kV to 375V



Phase 1 in KM3NeT Italia: 24 strings + 8 towers

KM3NeT NEMO Tower Phase 2 (11/2013)
KM3NeT PPM-DU (05/2014)
Junction Box 1 (11/2014)
KM3NeT-IT Tower 2008 (11/2014)

Junction Box 2 (04/2015)
KM3NeT Tower 2007 (04/2015)

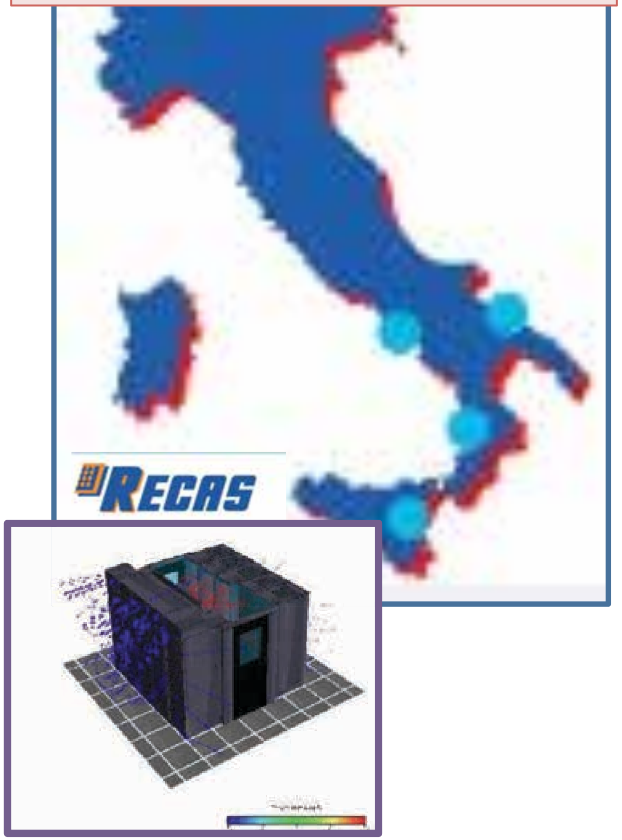
KM3NeT-IT Capo Passero

INFN LNS:
Main Data Repository
Catania IGI node

Capo Passero Shore Lab

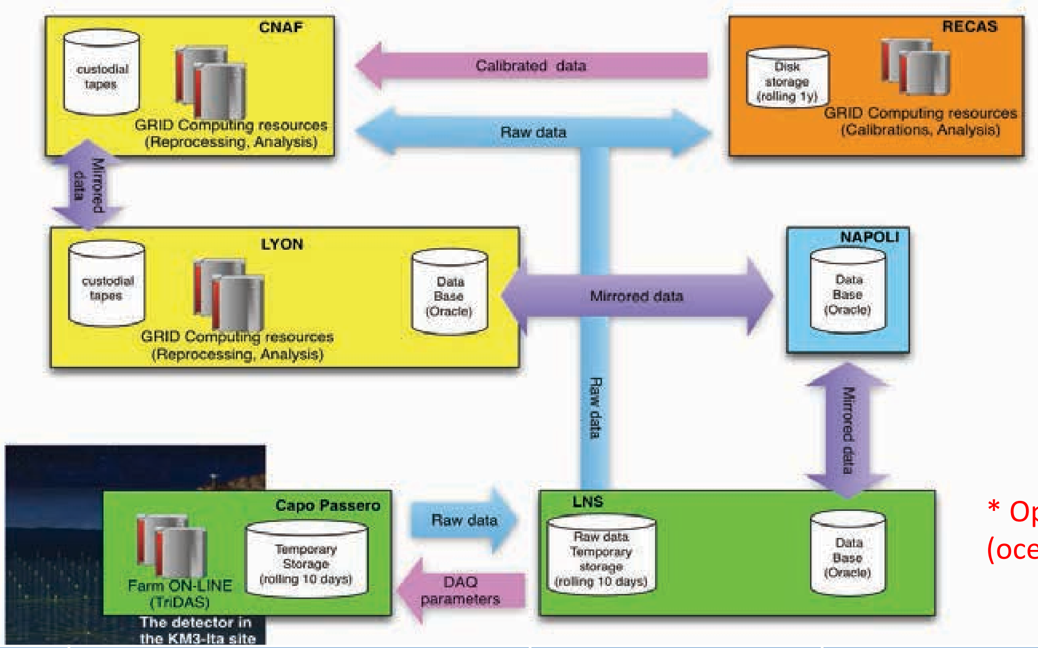
INFN is a main partner of GARR and of the Italian GRID-computing Infrastructure

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

Computing sketch



* 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

Outline

- The detector and physics goals
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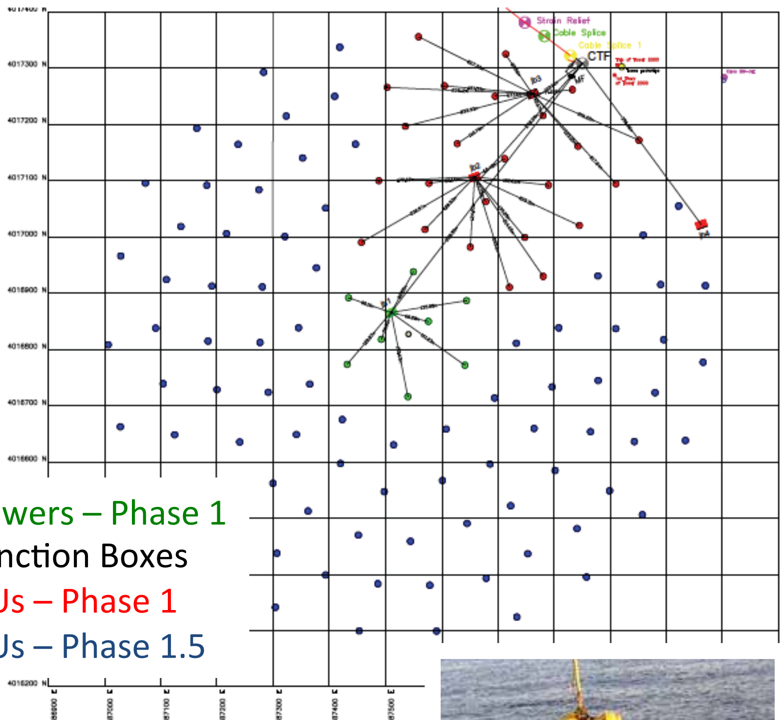
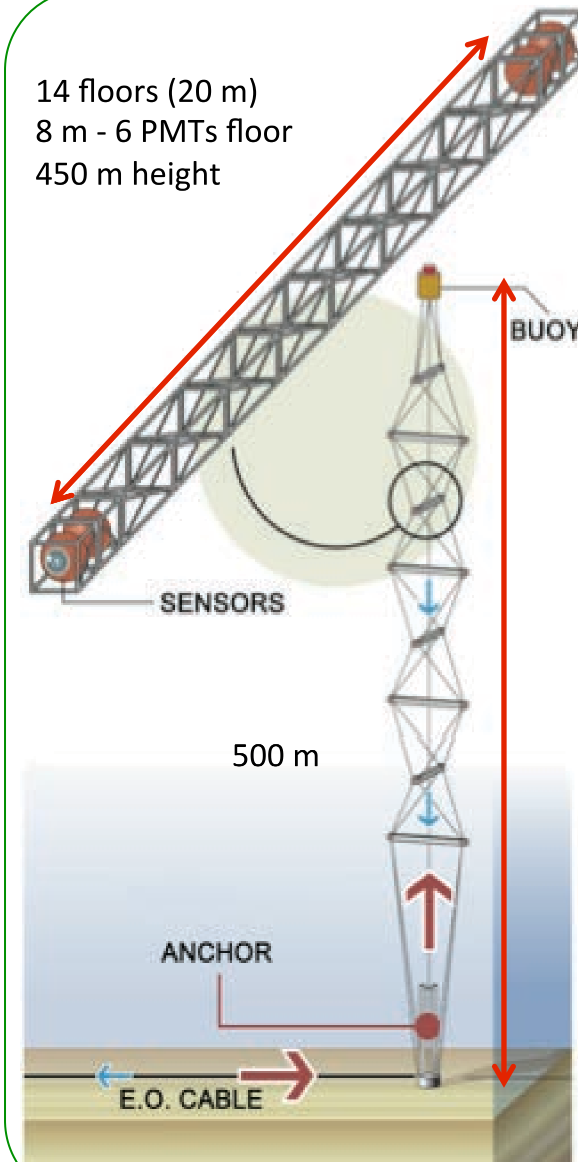
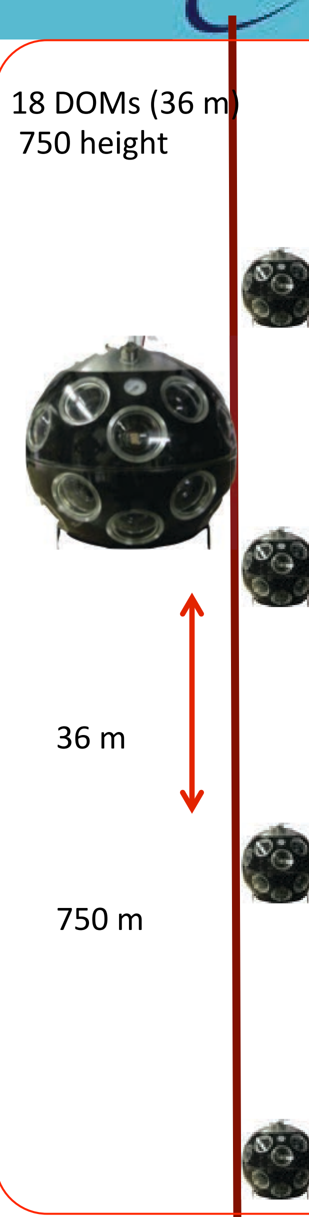
Installation Plan



14 floors (20 m)
8 m - 6 PMTs floor
450 m height



18 DOMs (36 m)
750 height



The Junction Boxes

Control system
Power and fiber splitting
Aux Calibration devices

- Laser beacon
- LBL beacon
- Hydrophone

4 Junction Boxes for Phase 1
JB1 – 8 Towers
JB2, JB2 – 12 x 2 Dus
JB4 ESS node (EMSO)

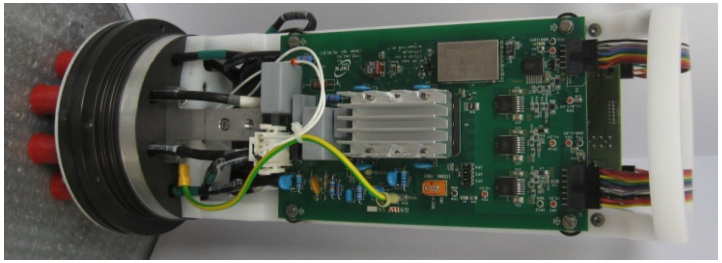
The Junction Boxes

Independently pre-integrated and tested devices

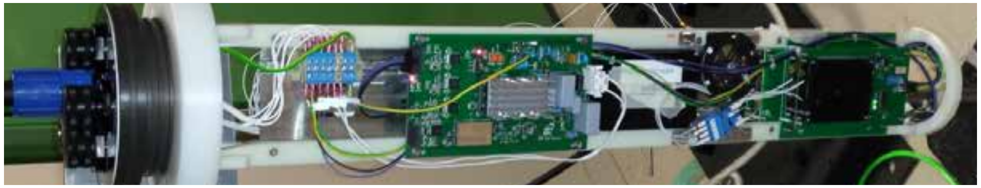
Eventually assembled and tested

Passive manifold
(e.o. connection distribution)

Power System POD
(Protective Oceanic Device)

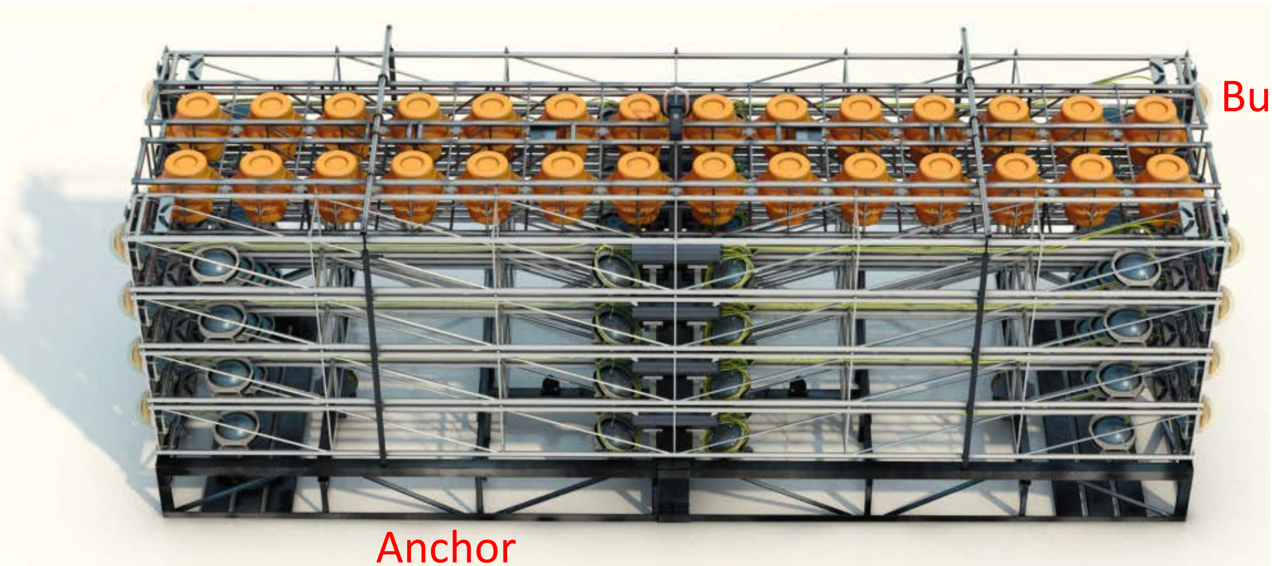


Data and Contol board
POD



Photonic system
POD

The Tower

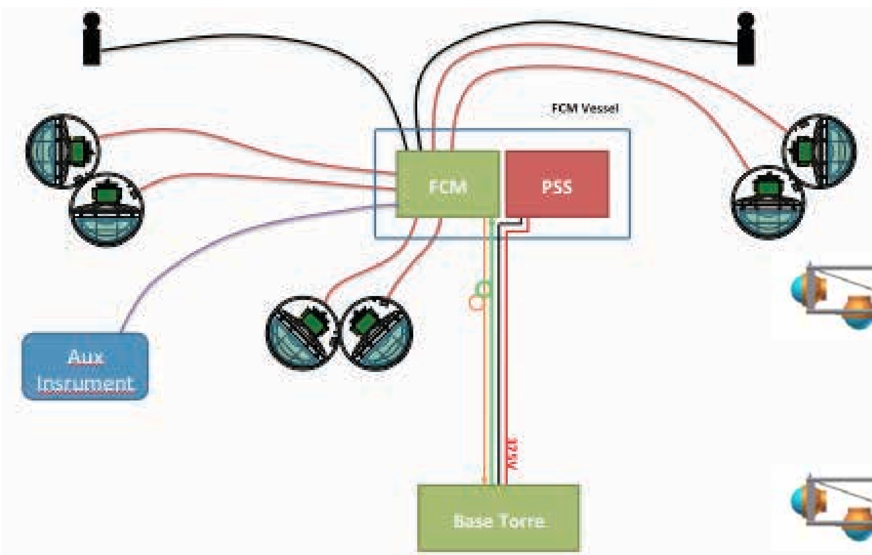


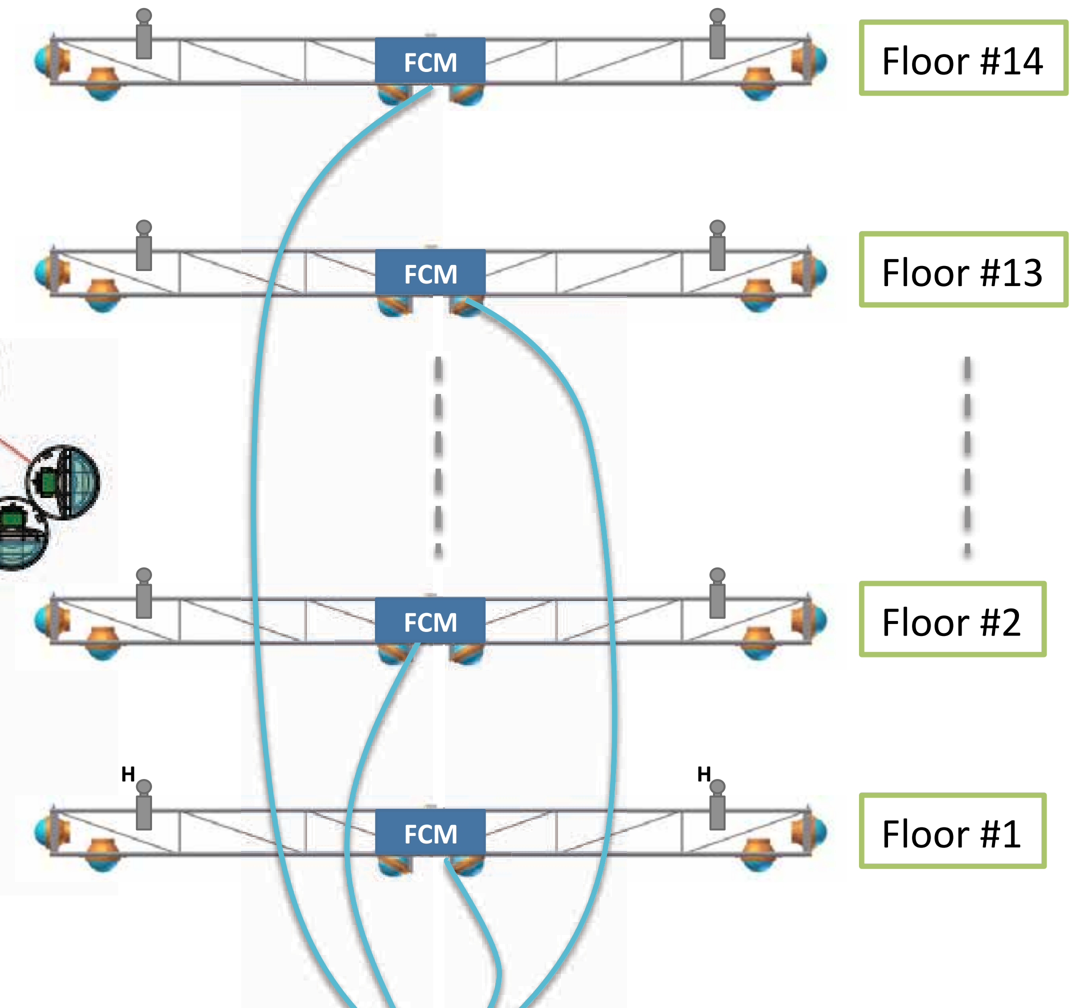
14 floors
1 tower base

6 OMs
2 Hydrophones
1 compass
Floor control module
Aux instruments: CTD, SV, absolute pressure gauge

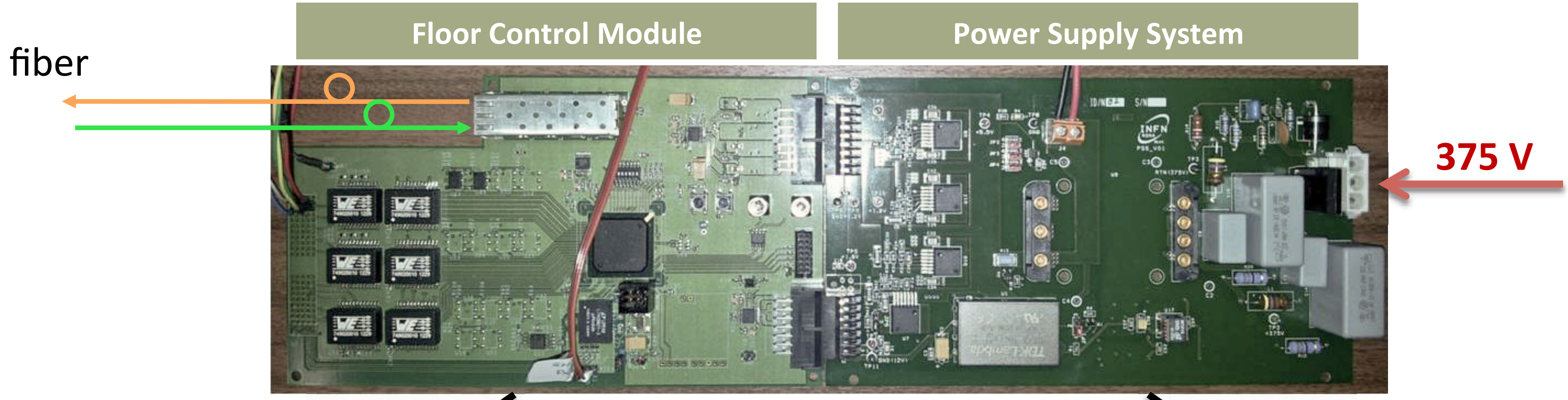
The Tower

New backbone:
Point-to-point e.o. connection to the base





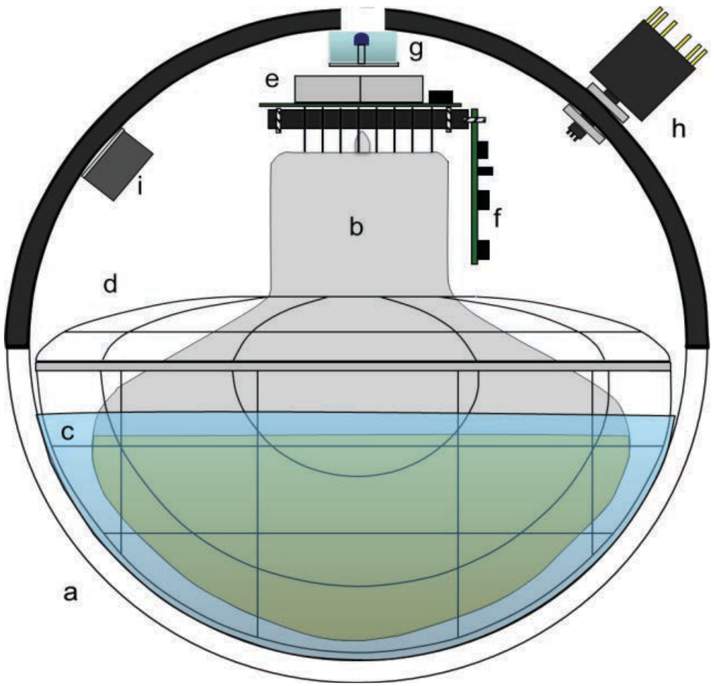
The FCM



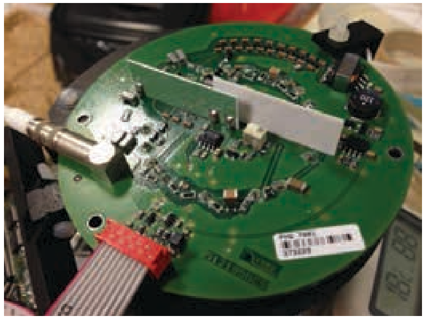
- Xilinx Spartan 6 FPGA
- Transceiver fixed latency (upto 2.5Gbps)
- 6 x Interfaces for OM
- 2 x AES3 stereo inputs (hydros)
- AHRS (compass & tilt)
- Sensors (H/T)
- 2 x RS232 opto-insulated (AUX instrument)
- Riconfigurability (“dual” boot)
- Consumption (FCM): ~2 W

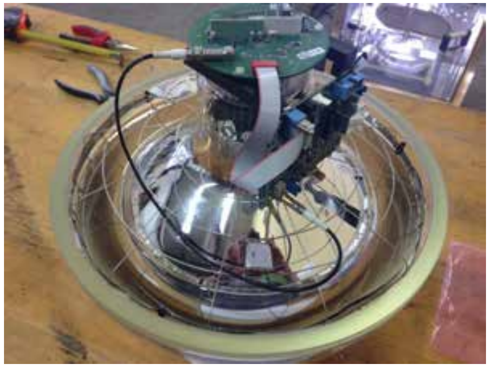
- DC/DC (375 V -> 5 V -> 1.2, 2.5, 3.3, 12 V)
- On-line urrent read-out

The tower OM

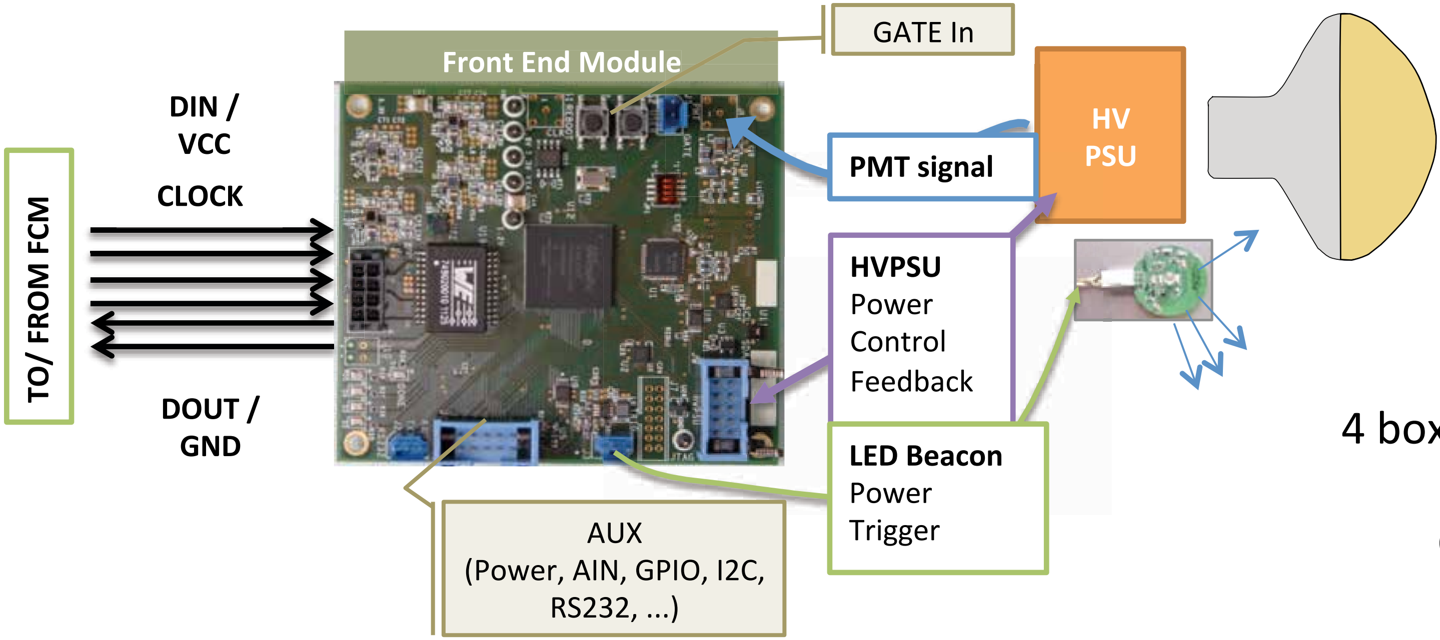


a. 13” glass sphere by BENTHOS
b. PMT 10” R7081 by Hamamatsu
c. Wacker silicon optical gel 612 bi-component A / B
d. Mu-metal cage (JINR)
e. HV base voltage supply by ISEG
f. FEM (Front End Module) board
g. LED beacon
h. 8-pin submarine connector
i. Manometer





The Tower OM



4 box for vacuum
Nitrogen flux
OM closing

Test of the Tower

The Detection Units

Launcher vehicle

- rapid deployment
- small space on the boat
- autonomous unfurling
- recoverable

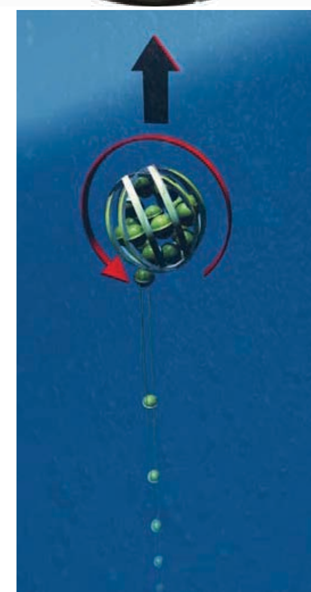
Detection Unit

~ 600+100 m

–Buoy
–2 Dyneema ropes
–18 storeys (one OM each)
– 36m distance
– 100m anchor-first storey

Electro-optical backbone:
–Flexible hose ~ 6mm
–Oil-filled
–fibres and copper wires

DOM 17”



The Digital Optical Module

31 x 3" PMTs
active base & digital signal readout (ToT)
light collection cone

1AHRS (tilt, compass)
1 digital piezo receiver
1 LED emitter (time calibration)

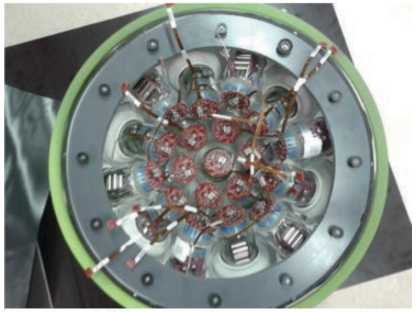
Central logic board (CLB)

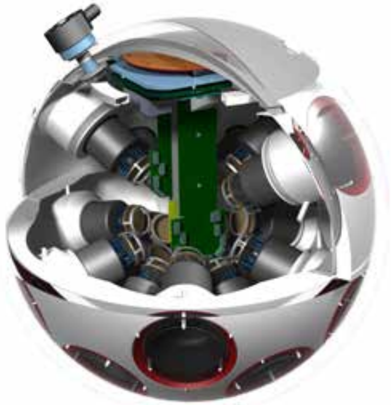
FPGA-based, white rabbit (T_{GPS})

DWDM optical comm(1 color/DOM)

power board

3d printed support structure
cooling structure (mushroom)
penetrator

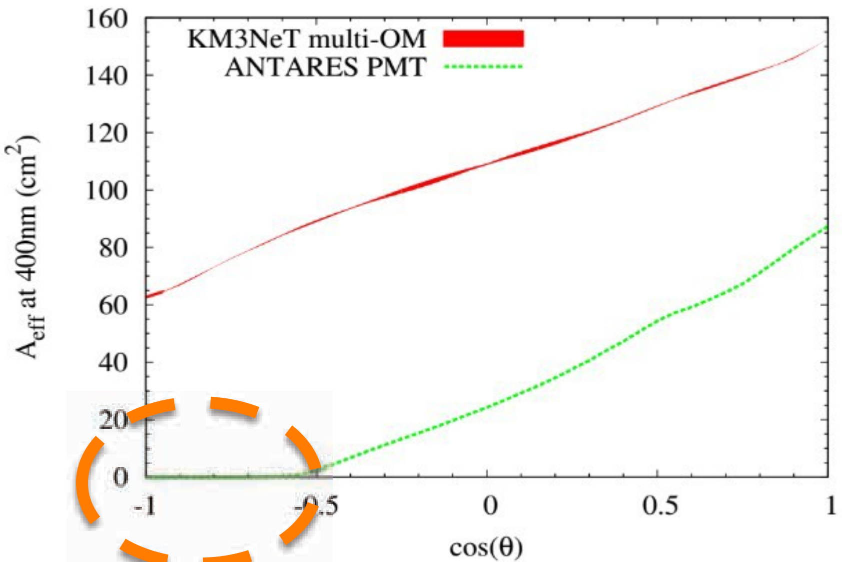




DOM performances

1 DOM = 1 ANTARES Storey

Allows photon counting: very powerful
Allows direct track direction reconstruction



Key features of 3'' PMTs:

– Timing	≤ 4.5 ns (FWHM)
– QE	≥ 25-30%
– collection efficiency	≥ 90%
– price/cm^2	≤ 10'' PMT


Hamamatsu R12199


ETEL D792

See V. Giordano's Talk


HZC XP53B20

The Central Logic Board

SFP connector: LASER for optical communication

Octopus connectors: 31 PMTs signals

Tunable oscillators: White Rabbit compliant

External Instrumentation:
Nanobeacon LED
Acoustic (Piezo)

Expansion: FMC connector

Embedded Instrumentation:
Temperature & Humidity
Tilt & Compass

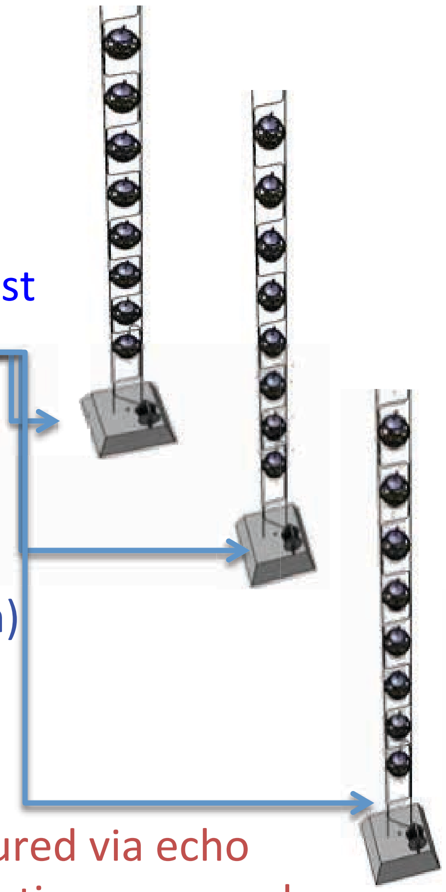
Reset & Configuration: Quad-SPI Flash Reset circuit

Test & Debug:
GPIO Header
Dip-Switch
USB-UART

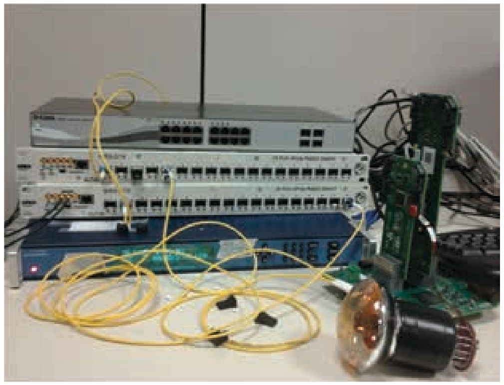
Synchronous Data Transport

GPS

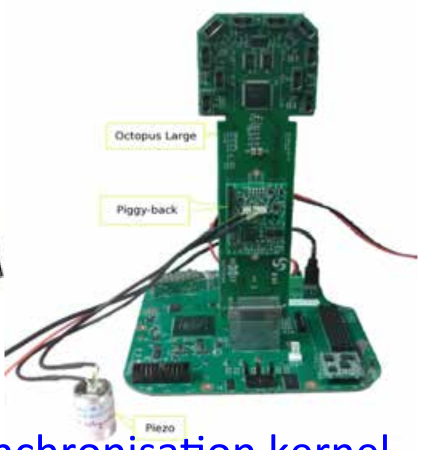
Master clock broadcast



White Rabbit Switch Fabric
Nano-sec precision-time-protocol
on Ethernet (synchronicity, phase reconstruction)



Optical path measured via echo
Optical fiber properties measured

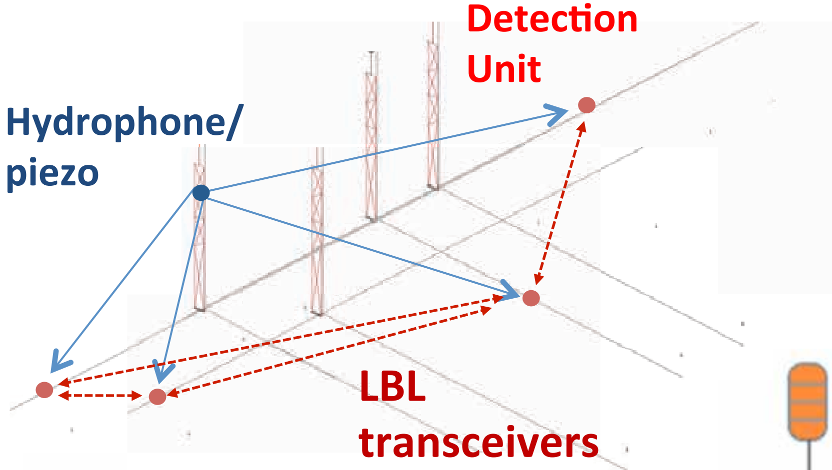


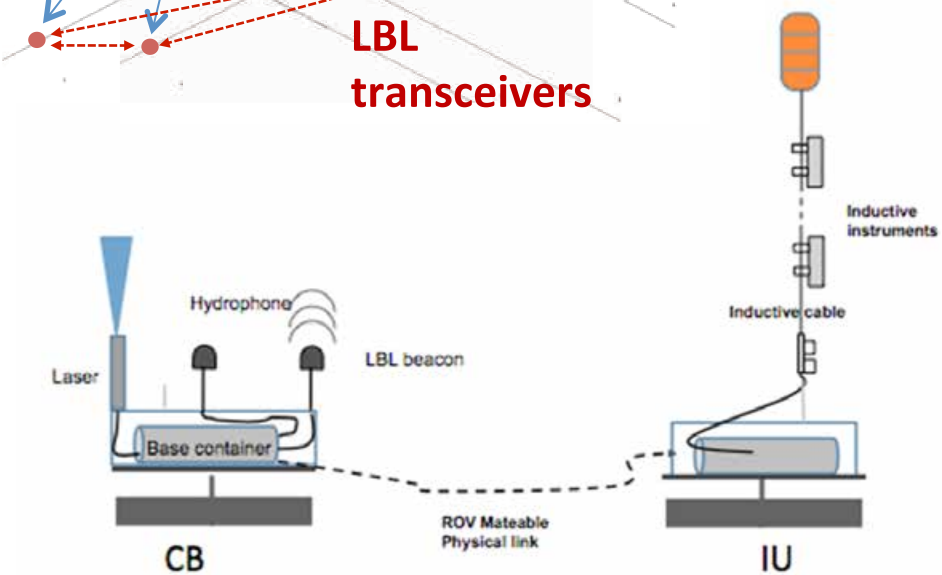
CLB running White Rabbit synchronisation kernel
PMT and piezo data time stamped by the CLB

Detector Positioning

DU base

Hydrophone





Calibration Base
Acoustic Long Base-Line
Laser Beacon (time calib)

Instrumentation Unit
Currents
Sound Velocity

Outline

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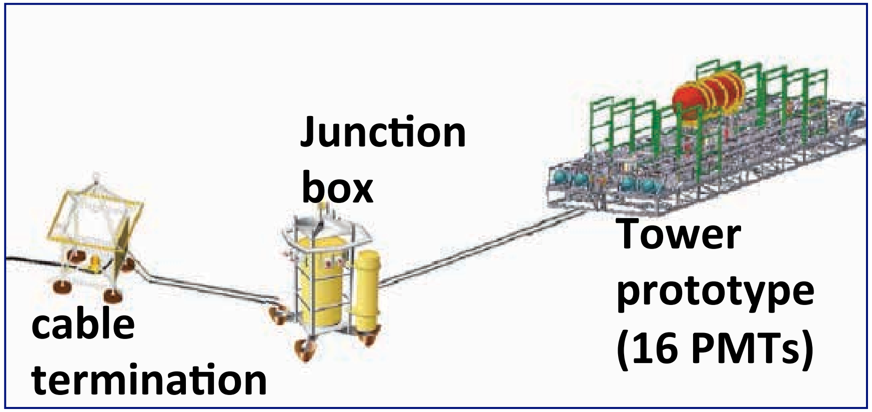
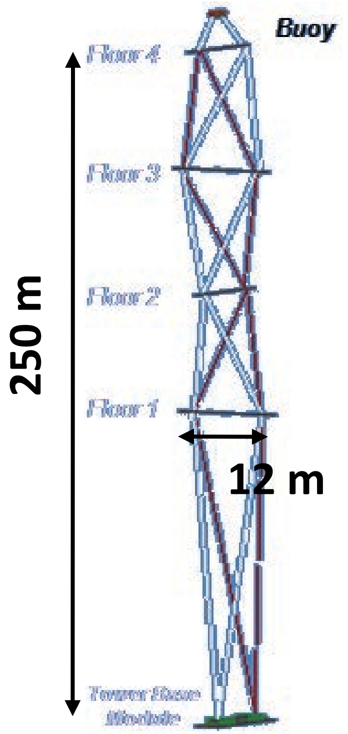
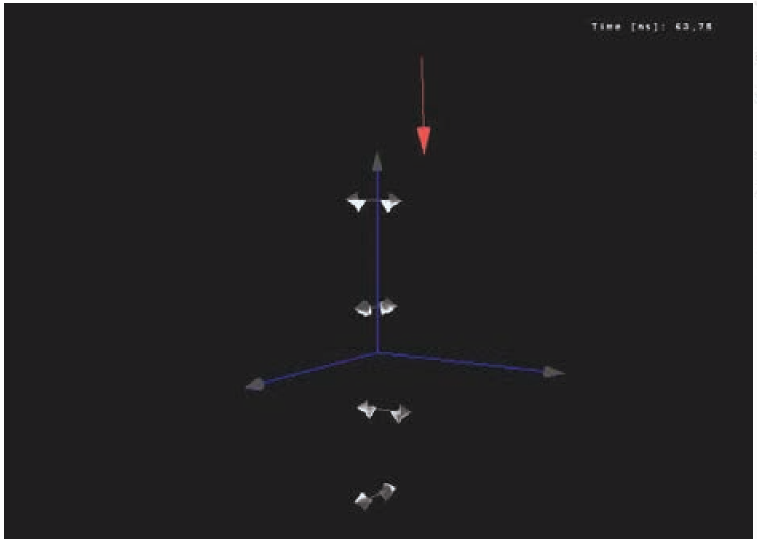
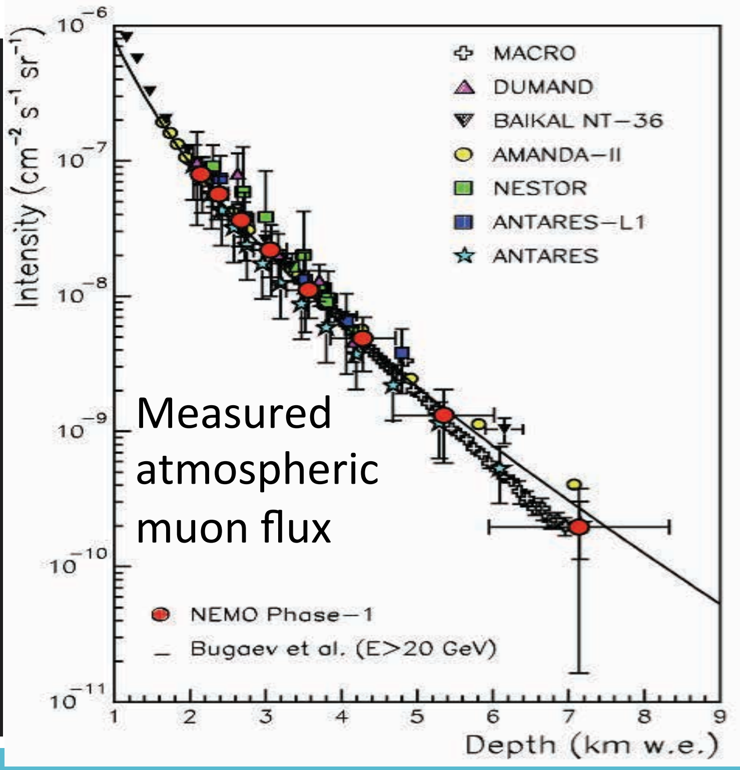
NEMO Phase 1 (Catania)







A down-going muon event (atmospheric μ) detected by NEMO Phase-1



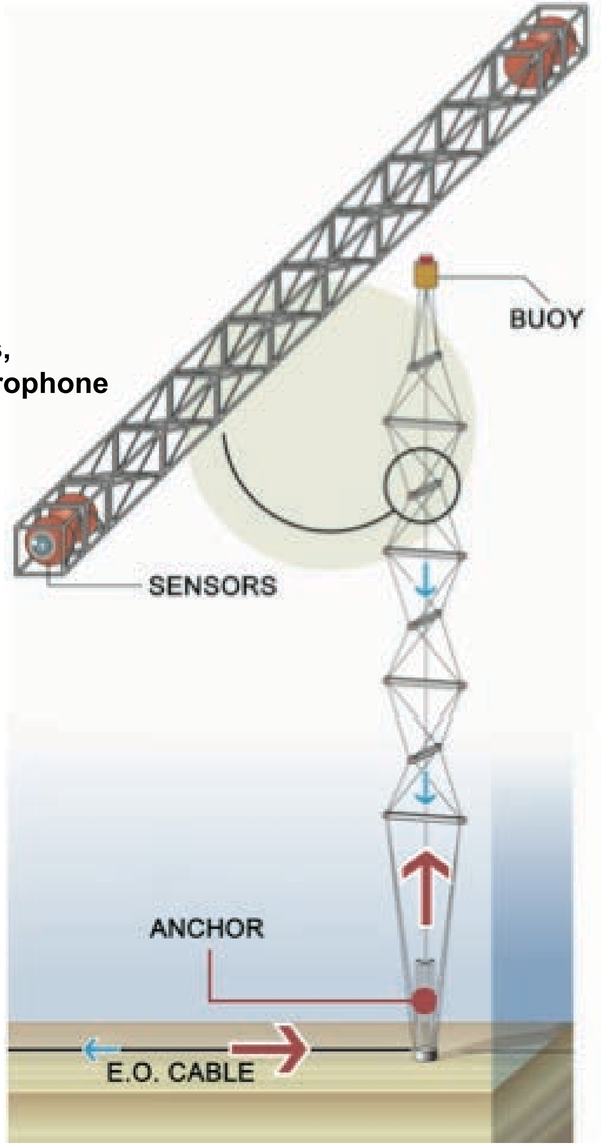
NEMO Phase 2 (Capo Passero)

8 floors plus a tower base
floor length 8m, inter-distance 40 m, total height 450 m
32 optical modules and 18 acoustic sensors,
2 CTDs, 1 Doppler Current Metre, 1 light transmissometer


NEMO OM
10” PMT inside 13” housing


NEMO/SMO hydrophones

2 OMs,
1 hydrophone




NEMO Phase II Tower under integration at LNS


NEMO Phase II floor control module

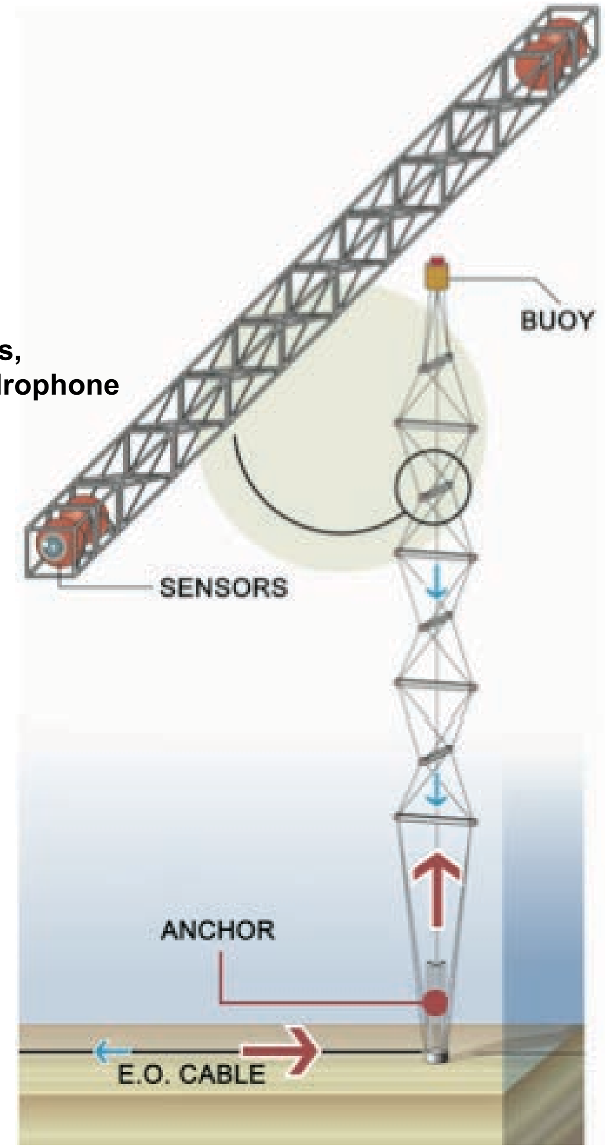
NEMO Phase 2 (Capo Passero)

8 floors plus a tower base
floor length 8m, inter-distance 40 m, total height 450 m
32 optical modules and 18 acoustic sensors,
2 CTDs, 1 Doppler Current Metre, 1 light transmissometer


NEMO OM
10” PMT inside 13” housing


NEMO/SMO hydrophones

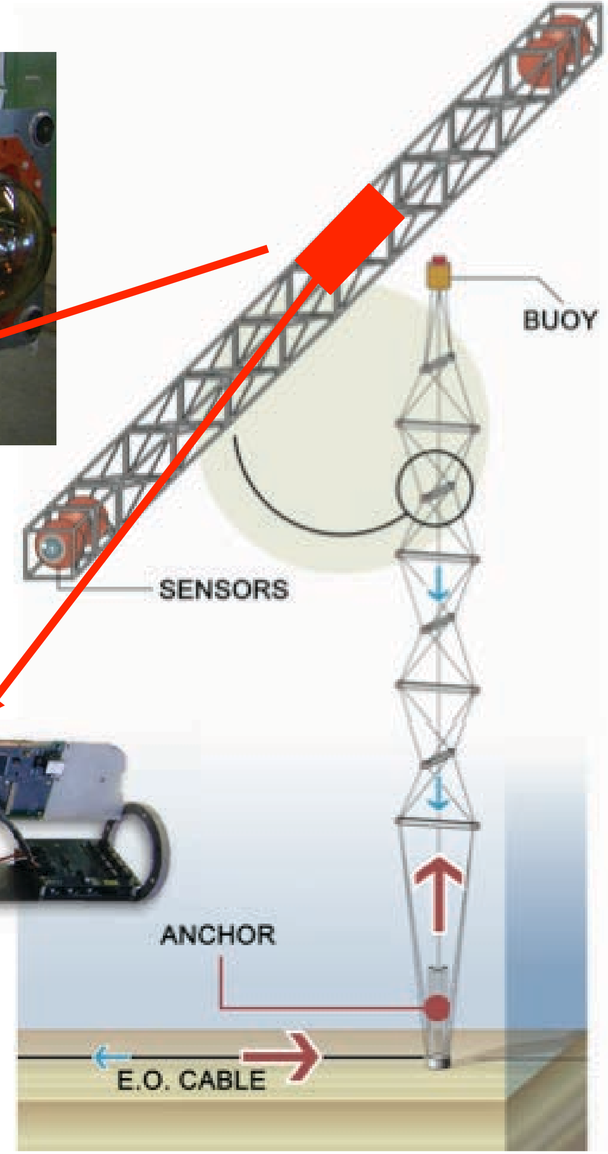
2 OMs,
1 hydrophone



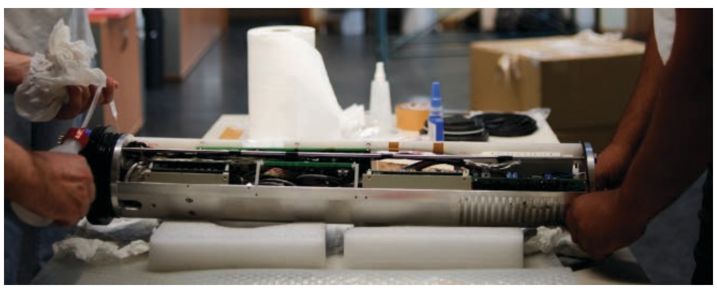

NEMO Phase II Tower under integration at LNS

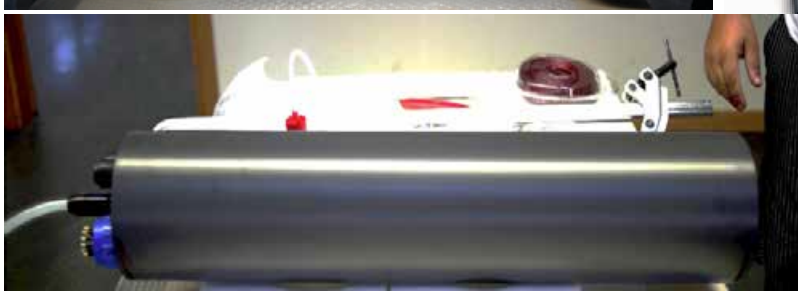

NEMO Phase II floor control module

NEMO Phase 2 (Capo Passero)

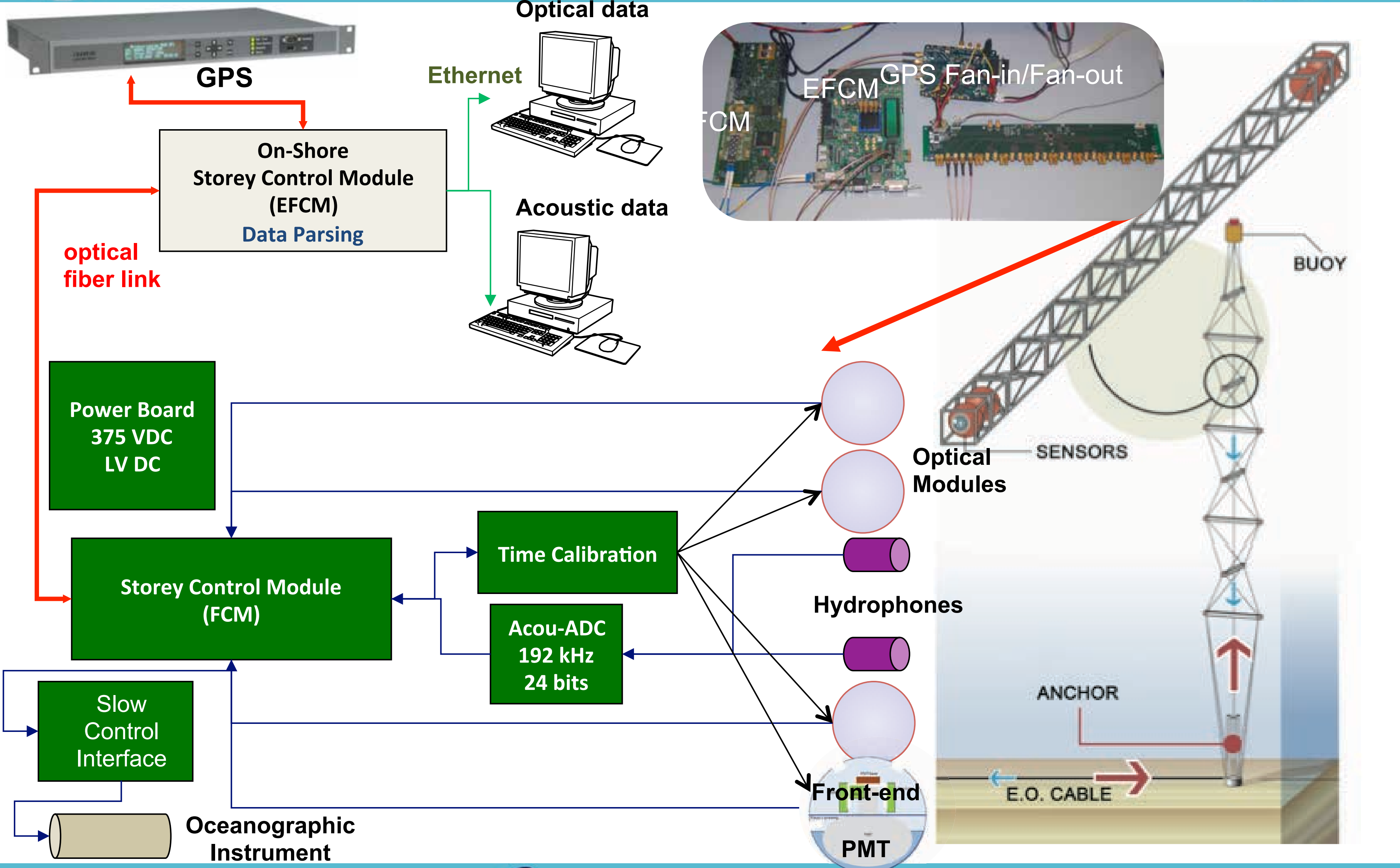


Upgraded pressure vessels and floor control module racks
Designed and built, all modules assembled





NEMO Phase 2(Capo Passero)



Upgraded optical fiber link:

On-Shore: Raman Amplifier

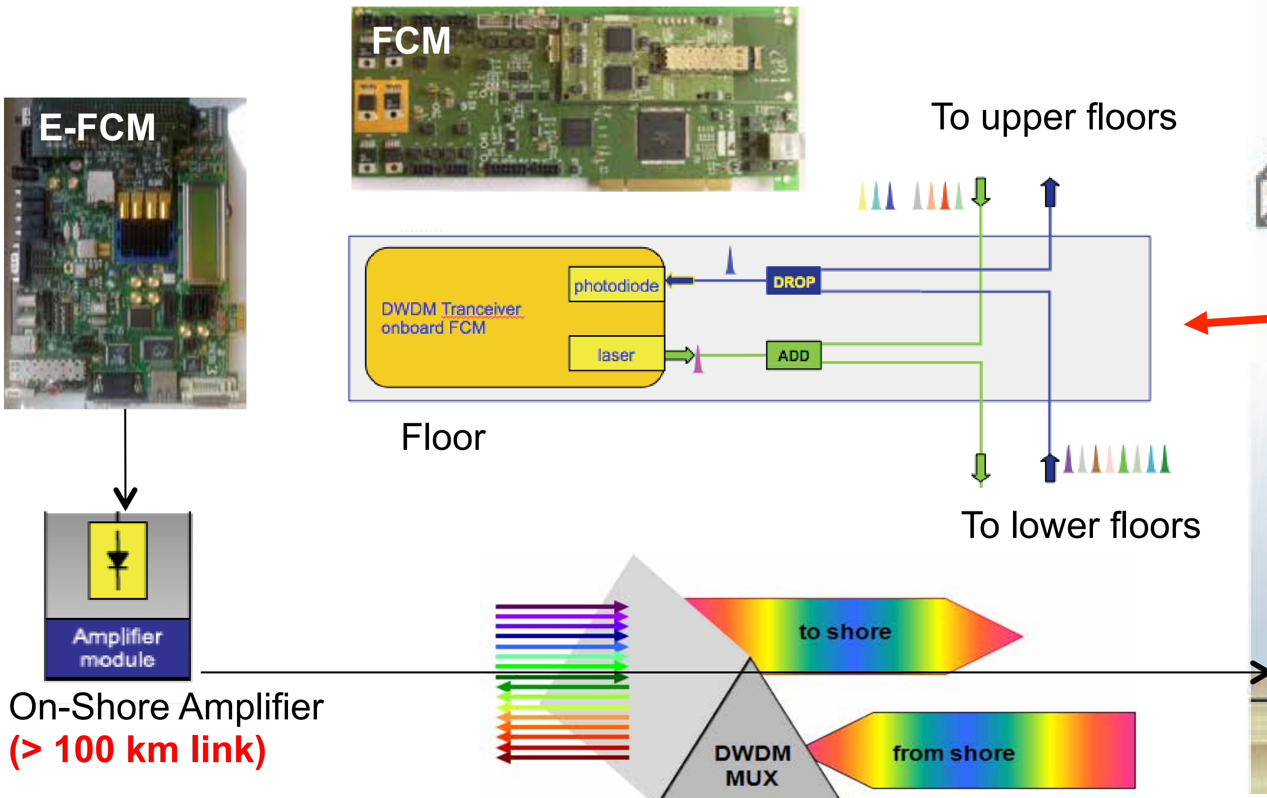
Off-Shore: vertical backbone with add/drop filters

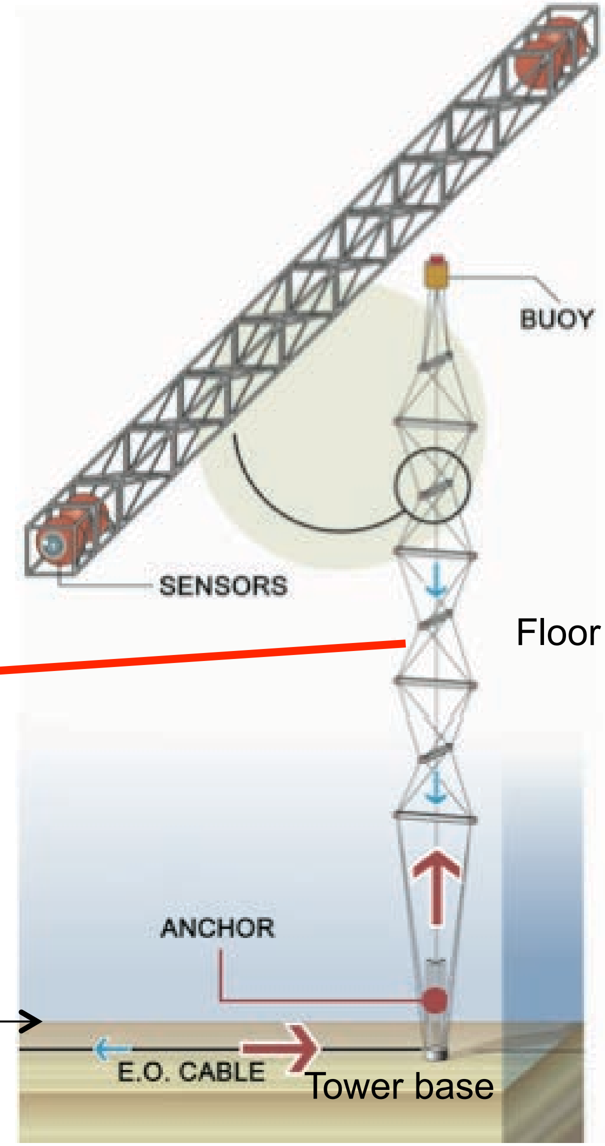
Upgraded power distribution system:

On-Shore: Power supply (6 kVDC)

Off-Shore: MVC 6:10kVDC→375VDC

Floor Power Boards: 375VDC→LVVDC





NEMO Phase 2 – Live time

Deployment and operation: 23 March 2013

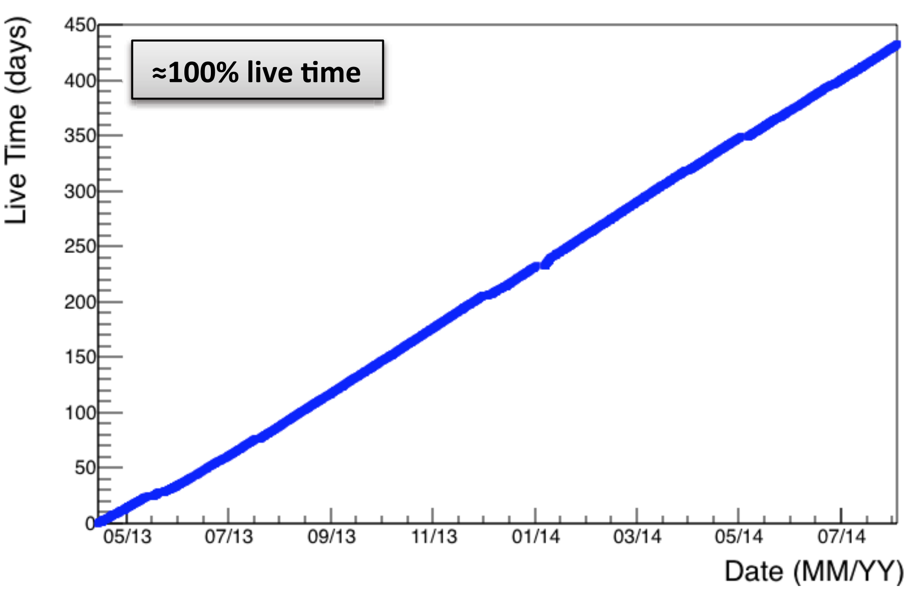
Detector turning off: 4 August 2014

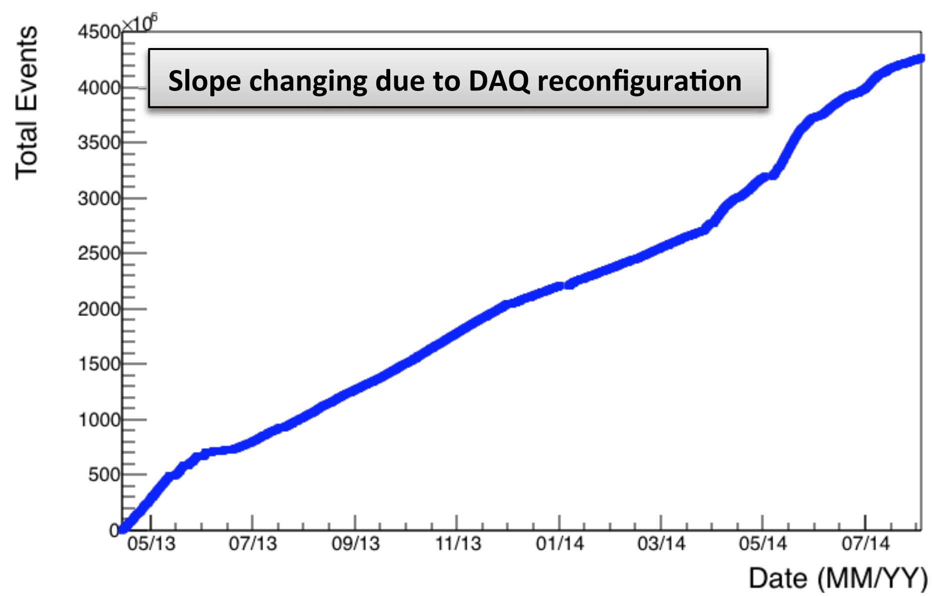
Detector operation time: 500 days

Total live time: 432.3 days

Total accumulated events: 4.3E9

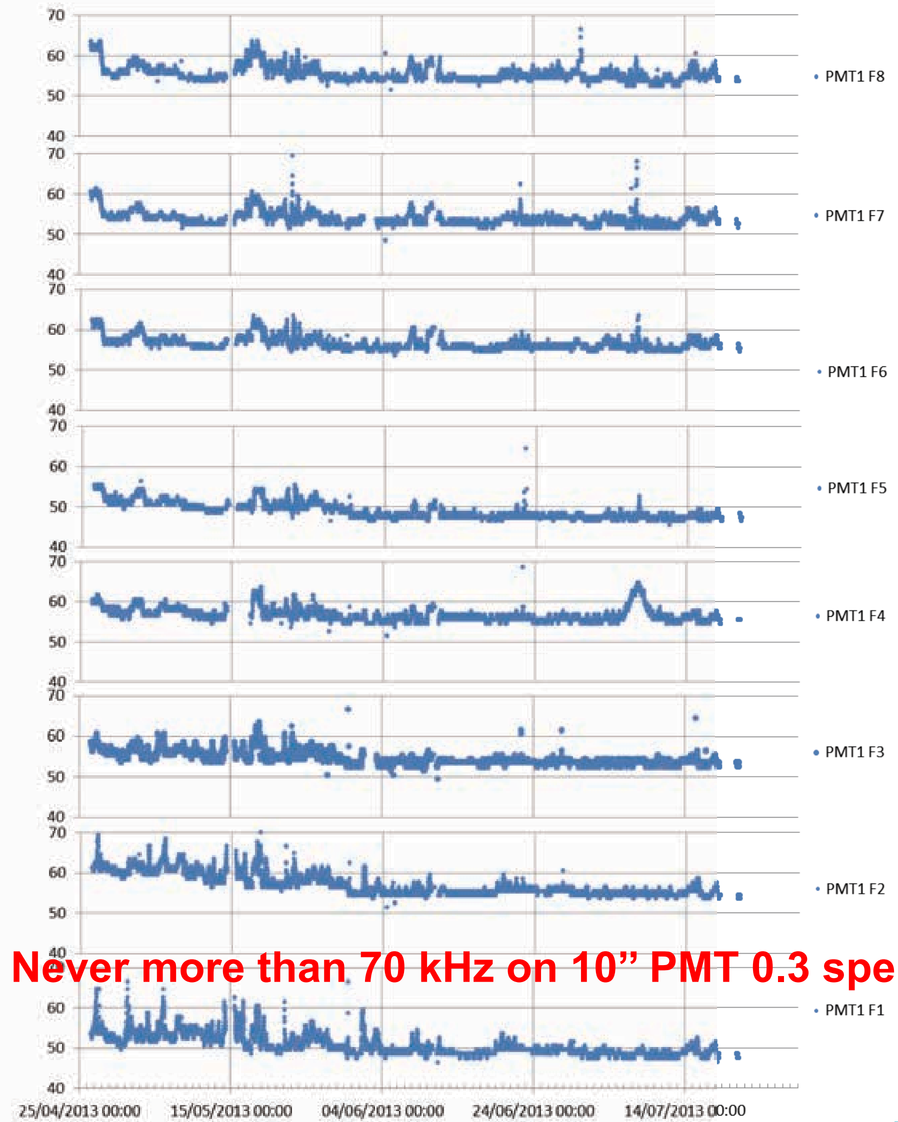
(since 16 April 2014, commissioning phase ending)



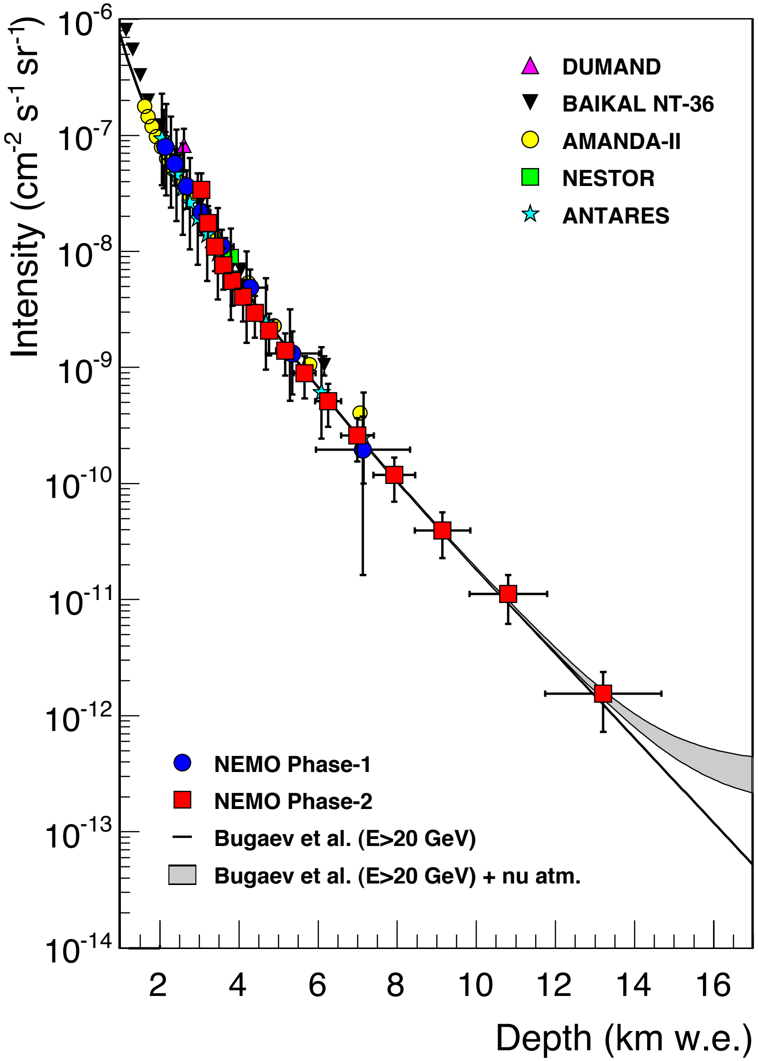


NEMO Phase 2 – Results

Measured Opical rates on all floors



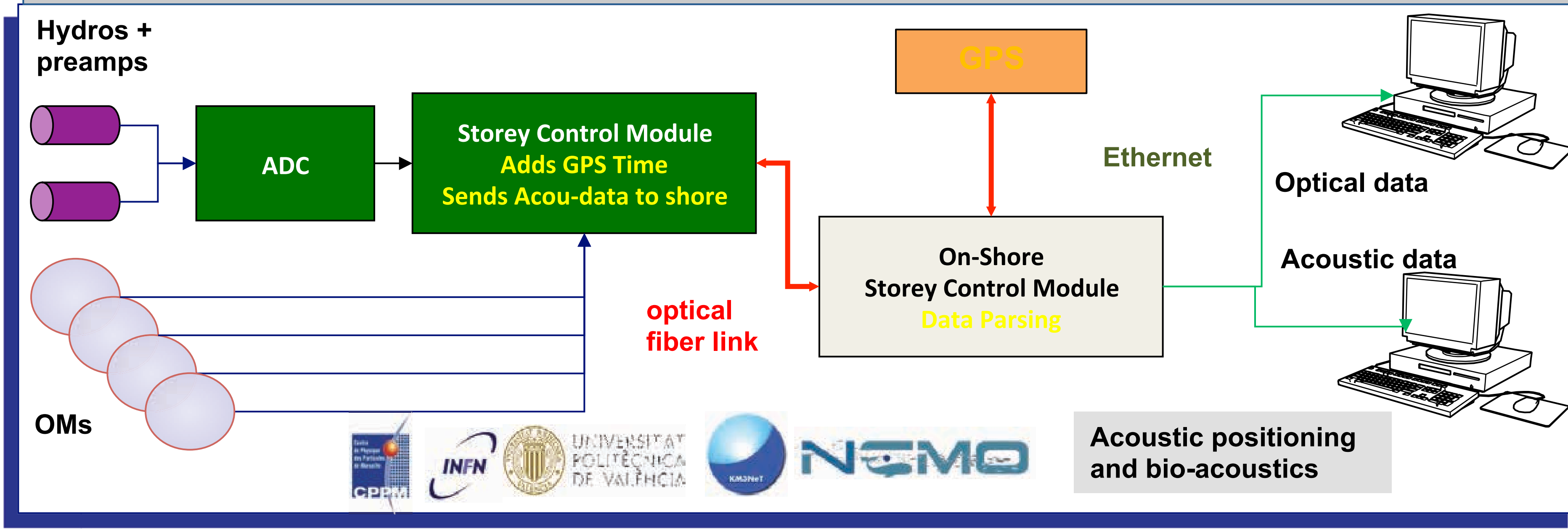
Never more than 70 kHz on 10" PMT 0.3 spe



DIR in water extended up to 13 km !

NEMO Phase 2 - Acoustics

Point to point storey connection , "All data to shore" , underwater GPS synchronisation



Deep Sea Detetcor

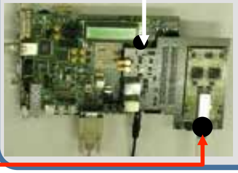
- Sensor data acquistion
- GPS time stamping
- Data transmission
  - fixed latency
  - known optical walk

INFN Shore Laboratory

Capo Passero

Trigger
Storage

GPS receiver



GPS clock transmission
Data parsing/distribution

INFN-LNS

GRID

Main storage
Analysis

Acoustic Positioning

The detector positioning system is a mandatory subsystem for the detector providing:

1) Guide during the deployment of the telescope structures and infrastructures

2) Optical module position during the telescope operation for muon track reconstruction

- *relative positioning accuracy: <20 cm (less than PMT diametre)*
- *absolute positioning accuracy: <1 m to optimize pointing resolution*
- *no interference with the optical detectors*
- *easy installation*
- *data acquisition/transmission system compliant with detector electronics*

Use acoustic positioning systems

Key elements

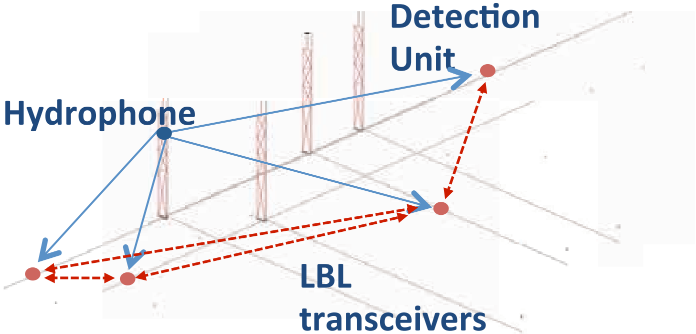
- *Auto-calibrating Long Baseline of acoustic transceivers anchored in known and fixed positions.*
- *Array of acoustic sensors (hydrophones) moving with the Detection Unit mechanical structure*
- *Auxiliary devices: compasses, CTD , sound celerimeters, current metres*
- *Data analysis system on-shore*

Hydrophone position calculation

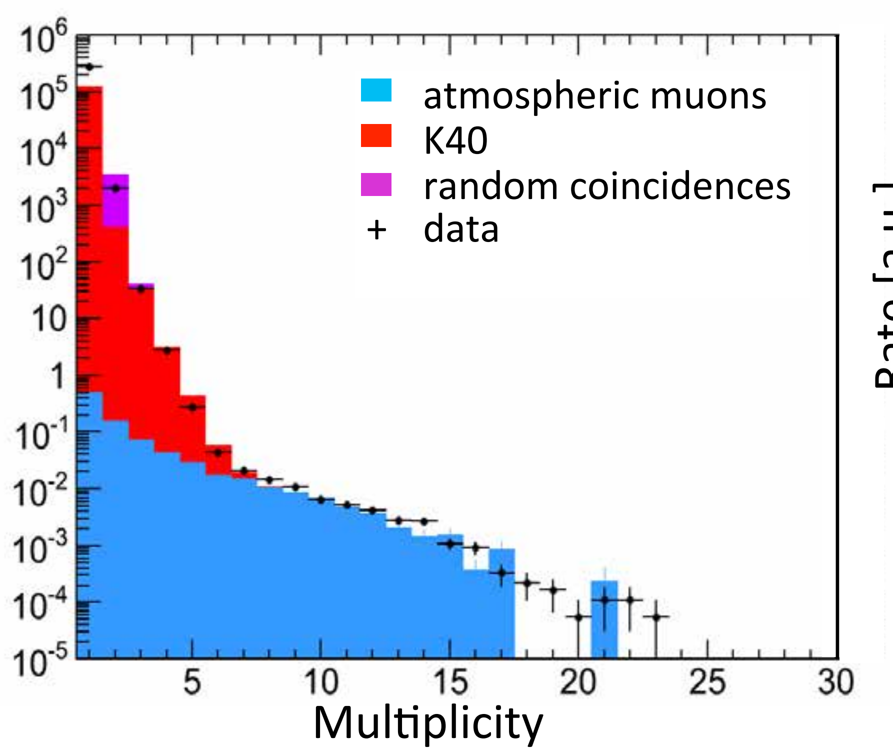
TDoA (Time Difference of Arrival)

$T^{Emit}(LBL) - T^{Receive}(Hydrophone)$

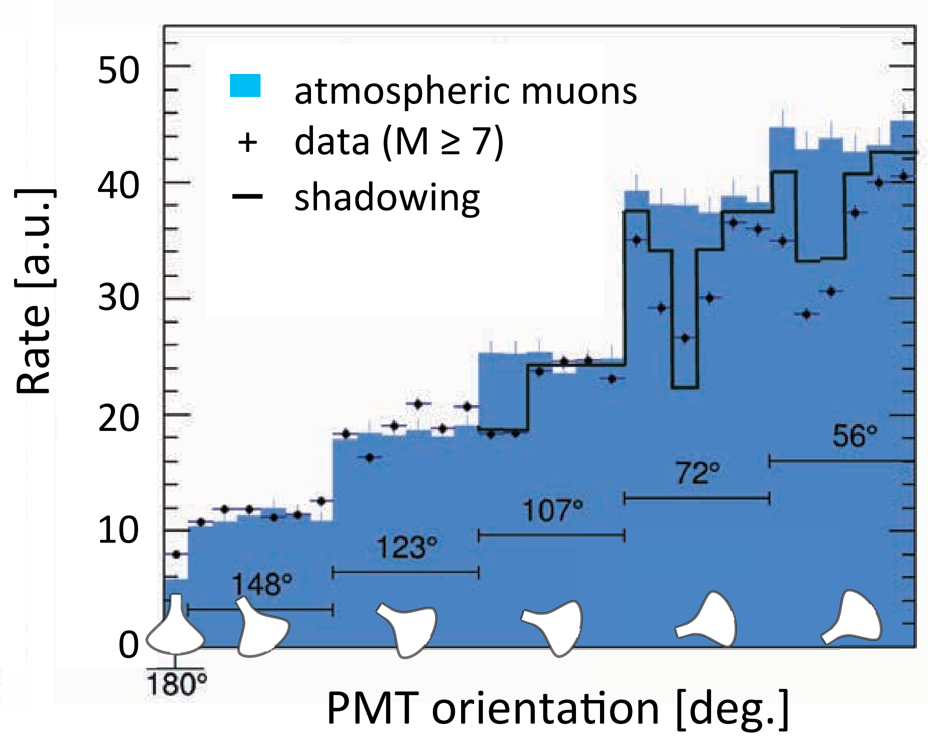
Geometrical Triangulation



The PPM DOM: deployed March 2013 at Toulon in the ANTARES facility



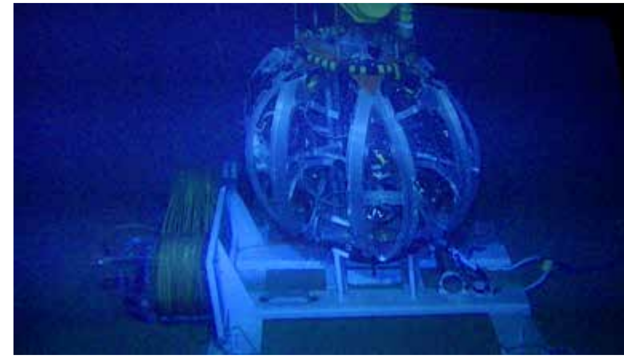
>6 coincidences within 20ns ⇒ reduced K40, dominated by atmospheric muons

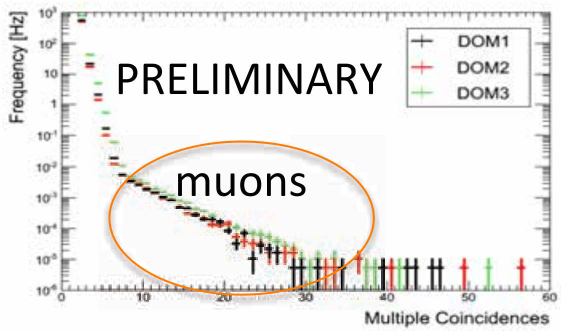


More upper PMTs in multi-hit events ⇒ directional information from single storey

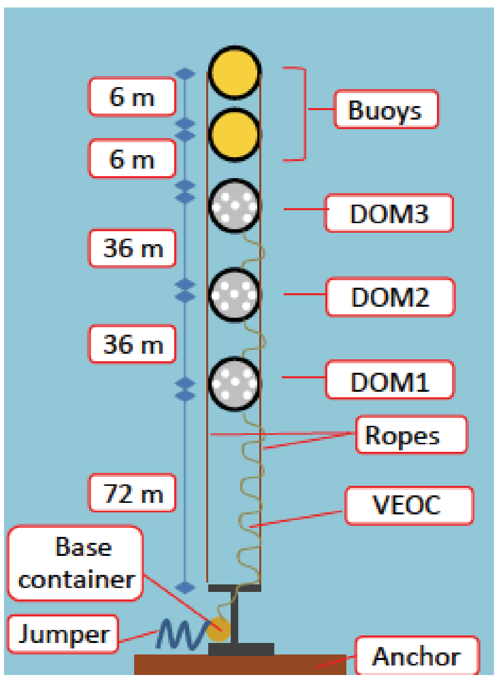
PPM-DU (Capo Passero)

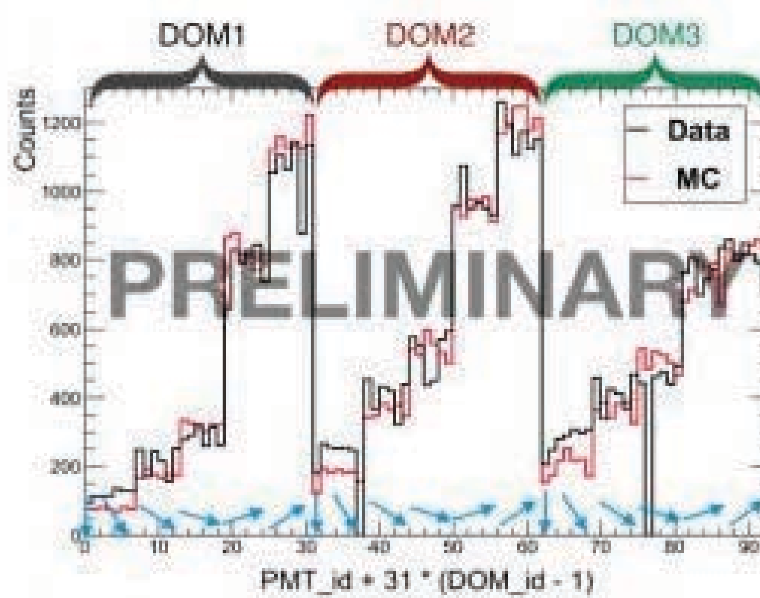
The PPM DU:
deployed May 2014
at Capo Passero Site





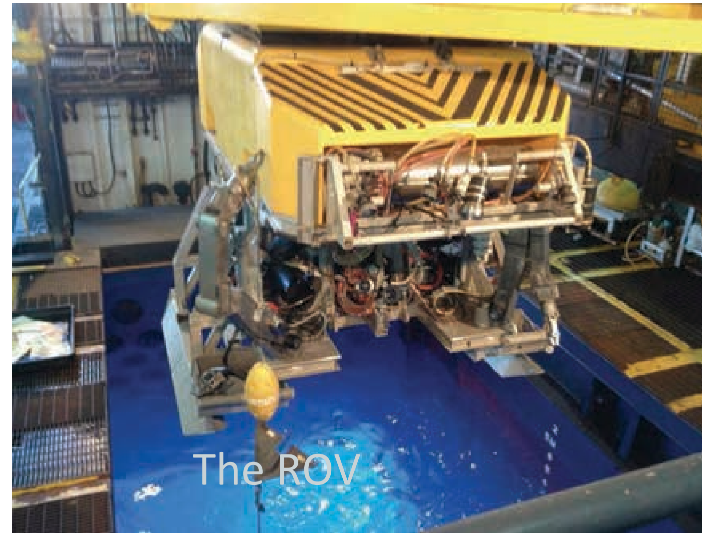
Same as per PPM-DOM





Sea Operations

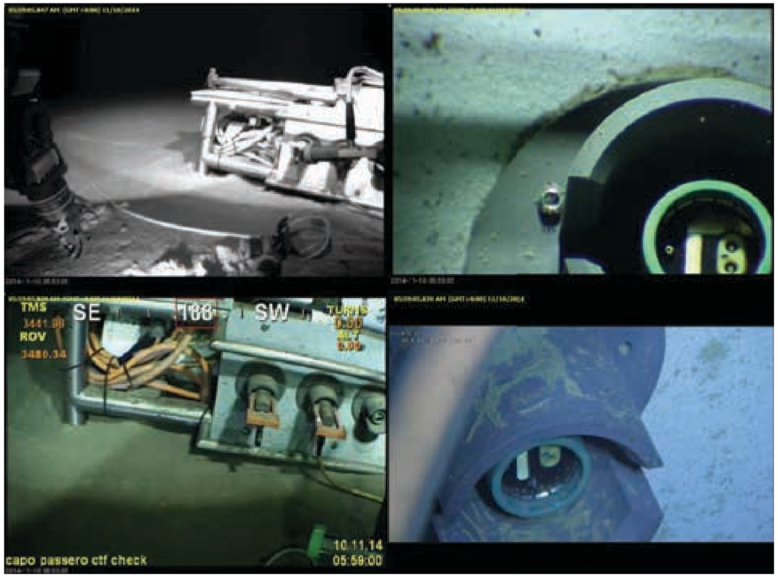
The DSV Nautical Tide

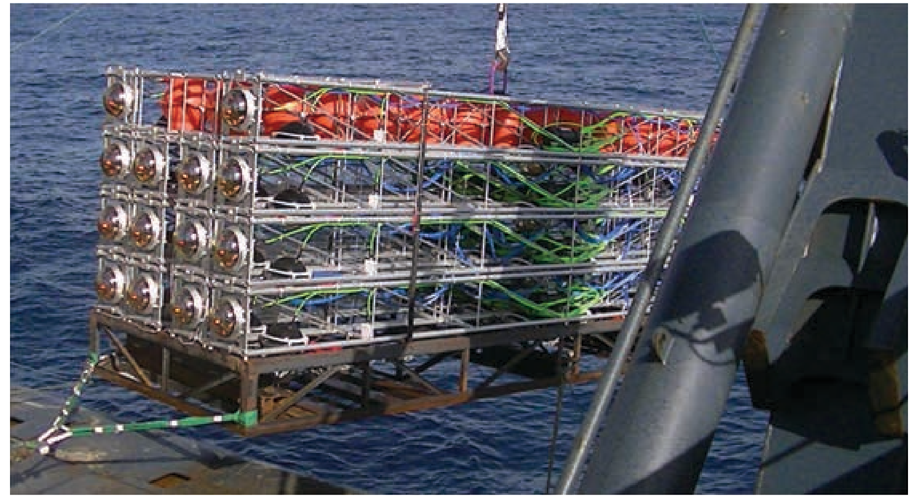

The ROV

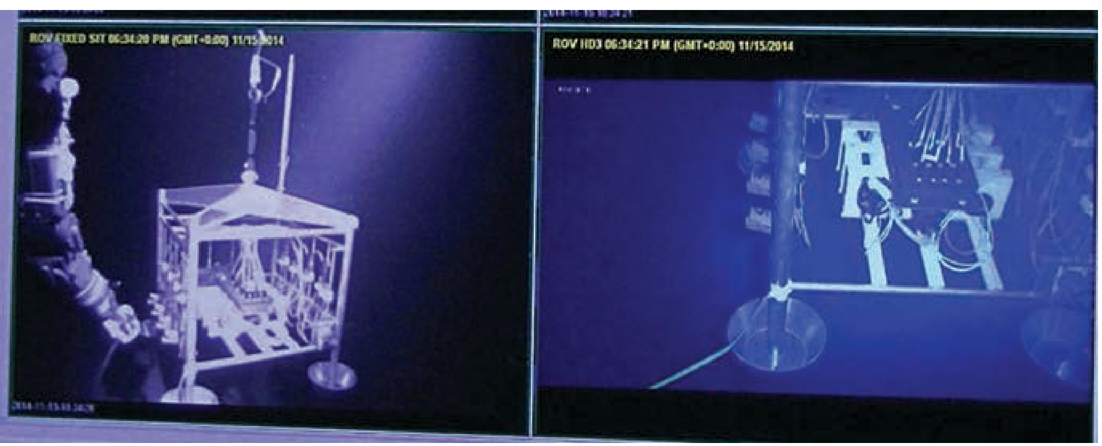
Tower Deployment April 2013

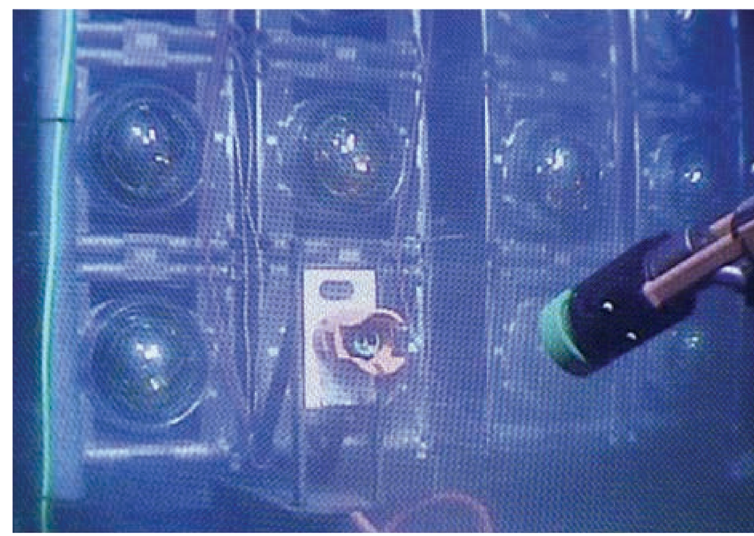

PPM-DI Deployment May 2014

Sea Operations









Outline

- The detector and physics goals
- Research infrastructures
- Design and construction
- Demonstrators
- Production
- Next steps

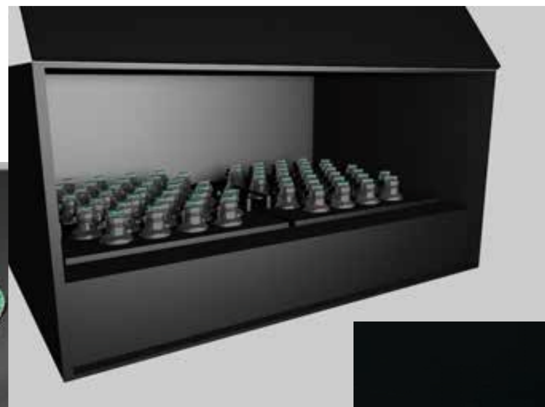
PMT massive tesing

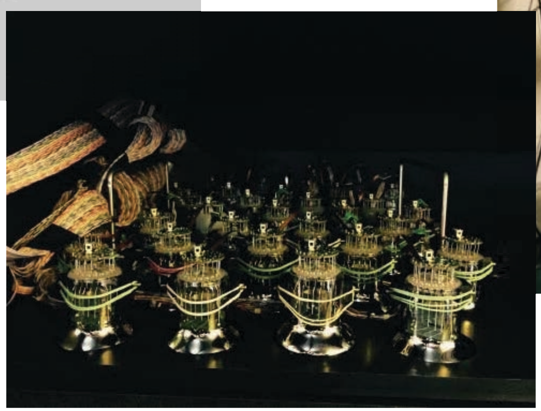
PMT and active base Test and calibration: 2 sites → PMTs (40 DOMs) / week

Pre-qualified DOM components → DOM assembly, test, calibration: 4 sites → 20 DOMs / week

DU Integration, test and calibration: 2 sites → 2-4 DUs/week

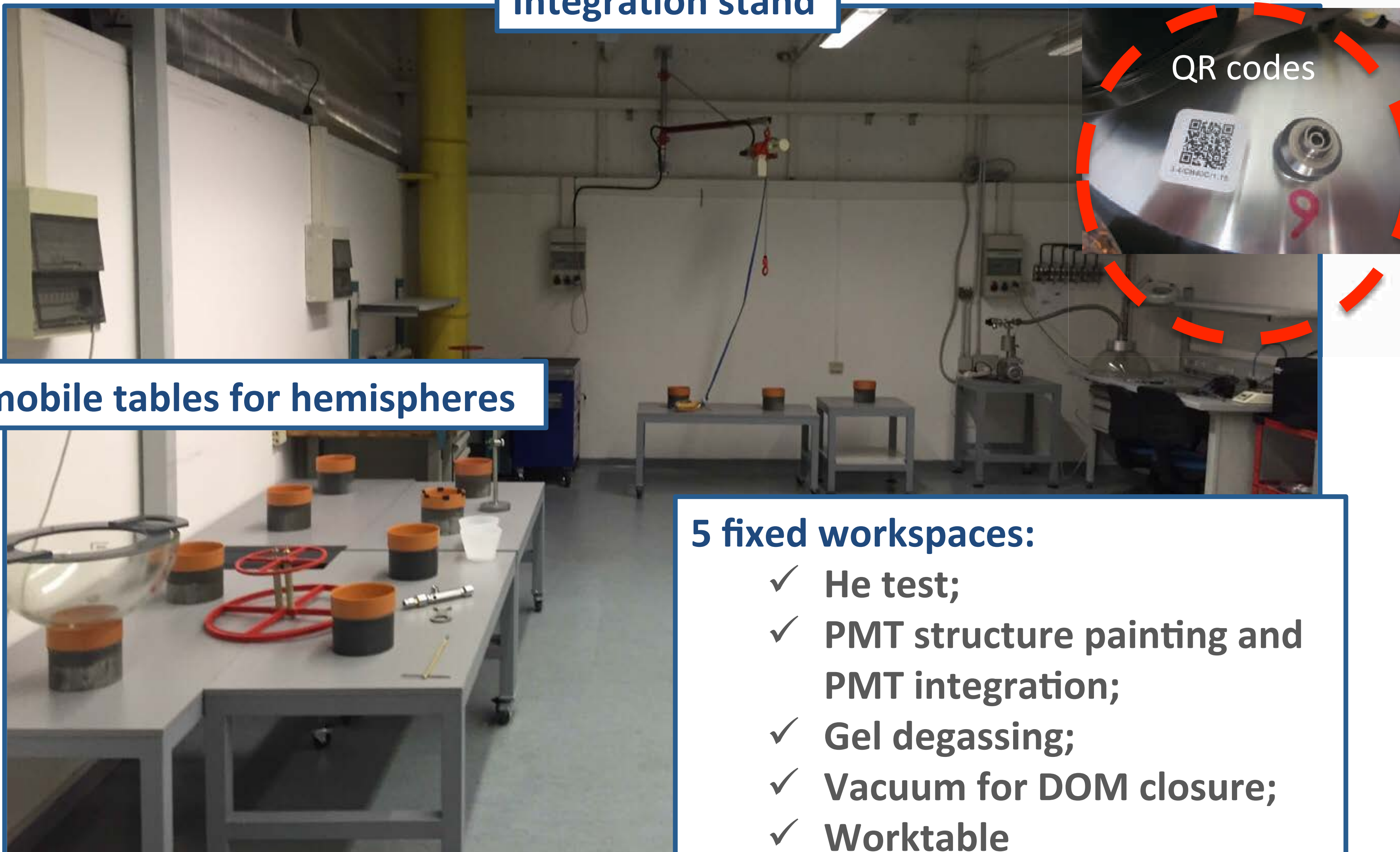
DU Deployment: > 4 DU deplyoyed in a single sea operation





DOM Integration Site

Integration stand



5 mobile tables for hemispheres

5 fixed workspaces:

- ✓ He test;
- ✓ PMT structure painting and PMT integration;
- ✓ Gel degassing;
- ✓ Vacuum for DOM closure;
- ✓ Worktable

DOM testing

Same procedures and tools in all sites, for assembly, test and calibration

Absolute time
Piezo
AHRS
PMT DC and timing

Timeline

Set-up of mass production tools and procedures

first DU:

- All DOMs and Veoc ready
- Now integrating the DU base (CPPM)
- Tests next weeks
- Deployment in Toulon March 2015

Completion of Phase 1 (2015/16): Assesment of Technology & Commissioning

Outline

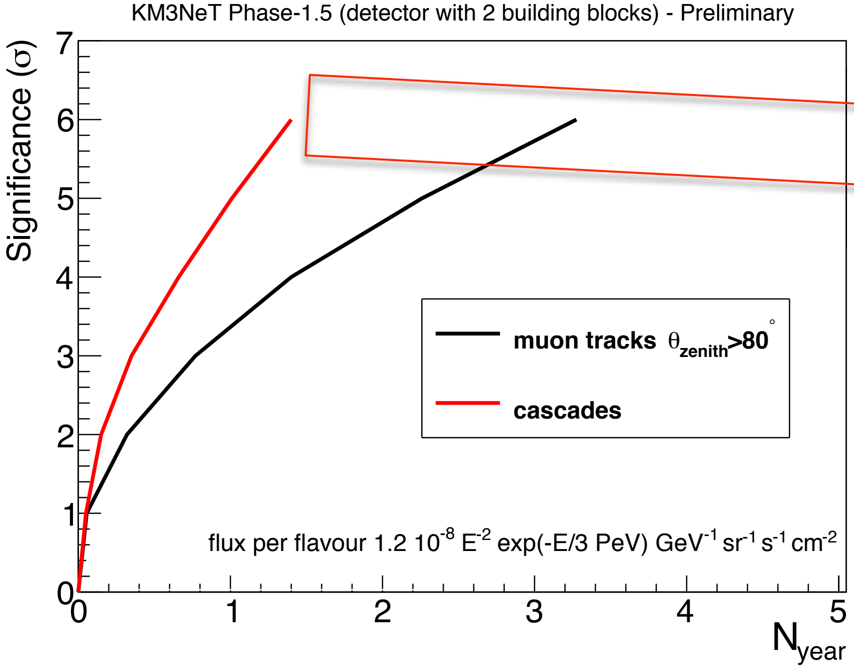
- The detector and physics goals
- Research infrastructures
- Design and construction
- Demonstrators
- Production
- Next steps

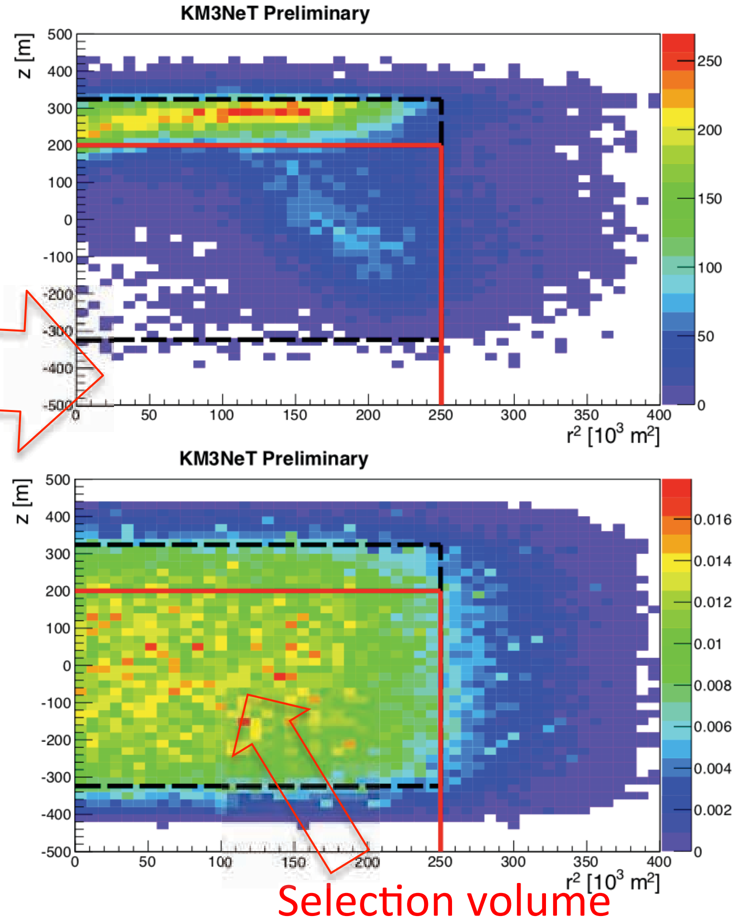
IceCube Neutrino signal search and Measurement

Search for an all-sky excess of high-energy events

Cascade-Background: Cascades from atmospheric neutrinos, Mis-reconstructed muon bundlles

Expected measurement of IceCube signal in 1 year (tracks + cascades)

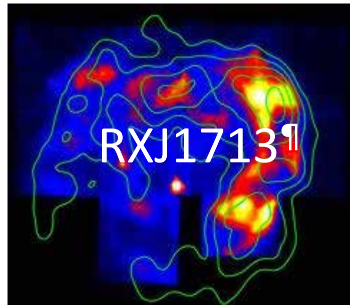


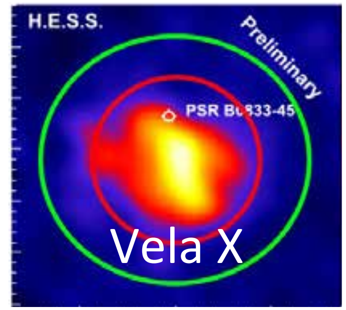


See L. Fusco's Poster

Phase 2

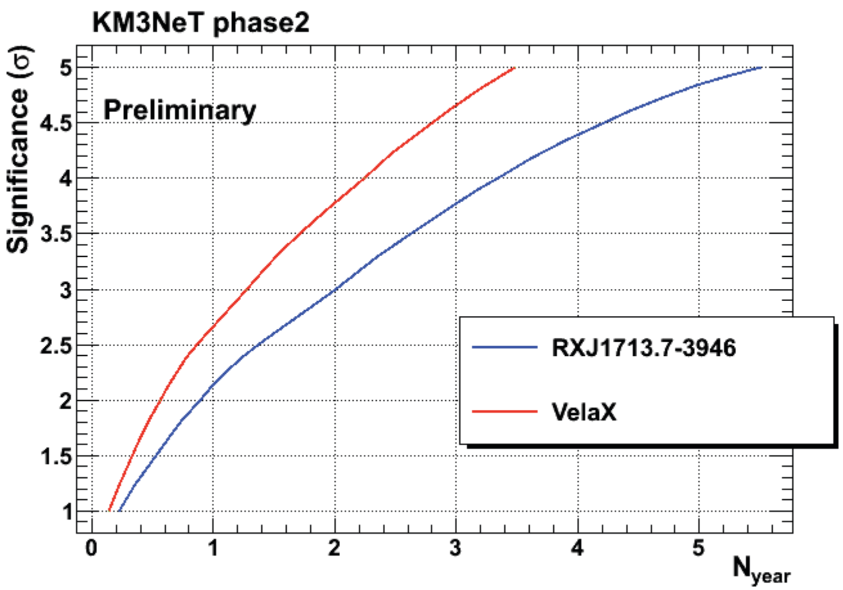
Astronomy era

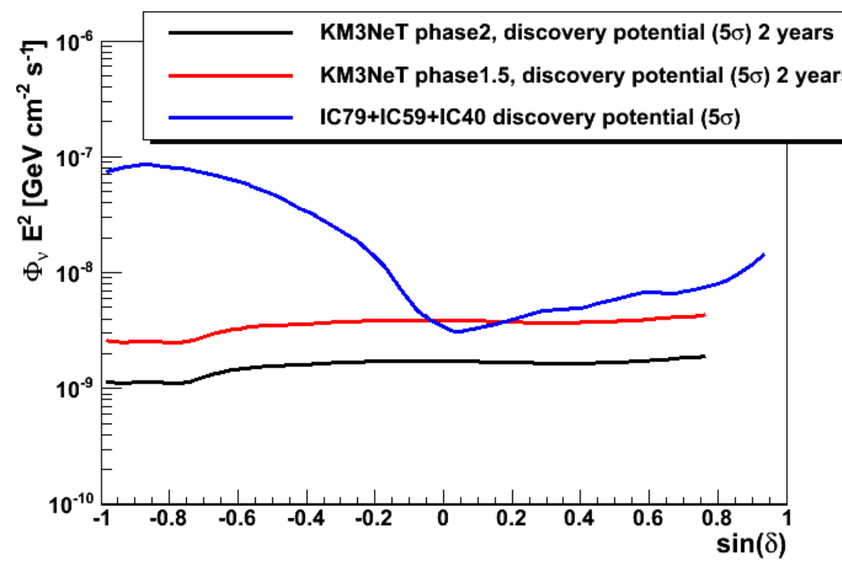




Other promising sources , stacking analisys…

Room for improvement (include morphology, energy dependence)



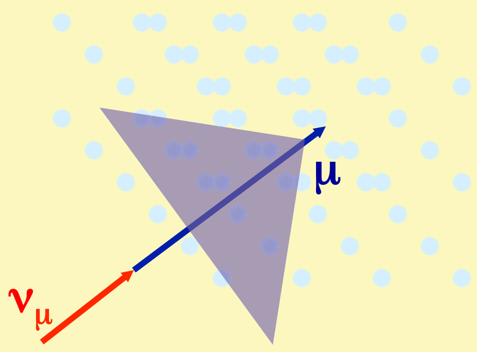


See A. Trovato's Talk

Extensions for UHE neutrinos

1 TeV | 100 PeV | 1000 ZeV

Optical Detection (ICECUBE-KM3NeT)



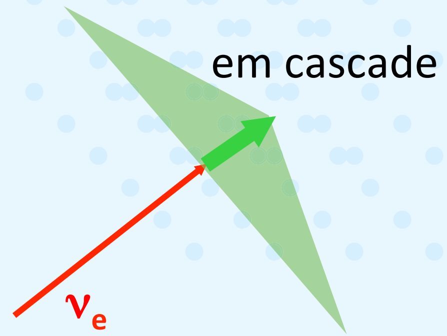
Medium: Seawater, Polar Ice

ν_μ (throughgoing and contained)
$\nu_{e,\tau}$ (contained cascades)

Carrier: Cherenkov Light (UV-visible)
Attenuation length: 100 m

Sensor: PMTs
Instrumented Volume: 1 km^3

Radio Detection (ANITA, RICE, ICERAY)



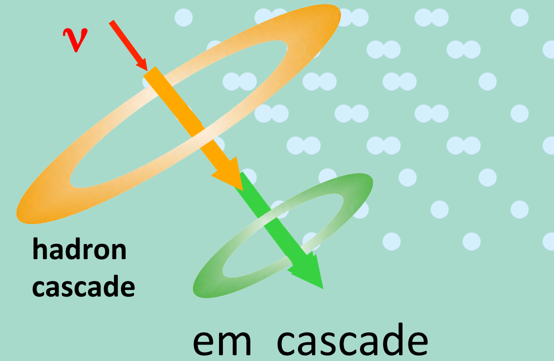
Medium: Salt domes, Polar Ice

ν (cascades)

Carrier: Cherenkov Radio
Attenuation length: 1 km

Sensors: Antennas
Instrumented Volume: >>1 km^3

Acoustic Detection (Prototypes)



Medium: Seawater (Polar Ice, Salt Domes)

ν (cascades)

Carrier: Sound waves (tens kHz)
Attenuation length: ~ 1÷10 km

Hydro(glacio)-phones
Instrumented Volume: >>1 km^3

Acoustic Detection ?

$E_\nu = 10^{20}$ eV
in water: p = 0.6 Pa @ 1 km → 20 mPa (neglecting attenuation)
in Ice : p = 6 Pa @ 1 km → 200 mPa (neglecting attenuation)

Underwater Cherenkov detectors
Upgoing events – 100 TeV

$$P_{\nu\mu}\left(E_\nu, E_\mu^{min}\right) = R_\mu^{eff}\sigma_{CC}N_A = 10^{-4}$$

$$\frac{N}{A_{eff}\cdot T} = \Phi_\nu P_{\nu\mu}\, 2\pi e^{-D(N_A\sigma_{Tot}\rho_{Earth})} \approx 100\ \frac{\text{events}}{\text{km}^2\text{y}}$$

WB flux

Underwater Acoustic detectors
Downgoing events – 10^{20} eV

$$P_{det}(E_\nu, p_{min}) = H_{det}^{eff}\sigma_{Tot}N_A \approx 10^{-3}$$

$$\frac{N}{A_{eff}\cdot T} \approx 10^{-3}\ \frac{\text{events}}{\text{km}^2\text{y}}$$

Sound absorption length in ocean O(10 km), noise O(10 mPa)

Several groups developing and improving simulation codes for large acoustic detectors
What we can do with 1 km^3 filled with hydrophones ?

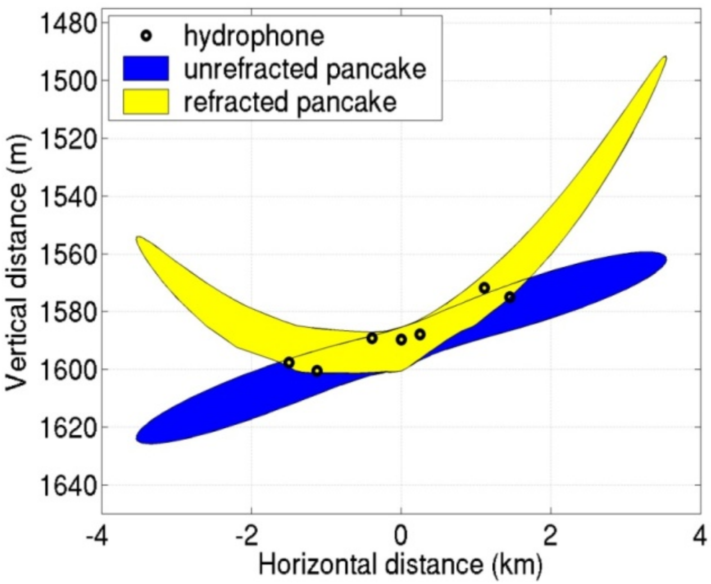
Acoustic Detection ?

Acoustic event signatures:

→ **bipolar signal (10 ÷ 40 kHz)**

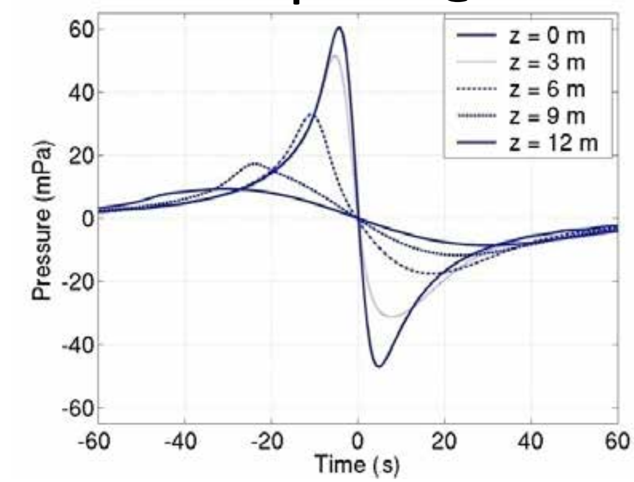
→ **pancake shaped wave-front**

Sound velocity gradient in the medium: wave refraction

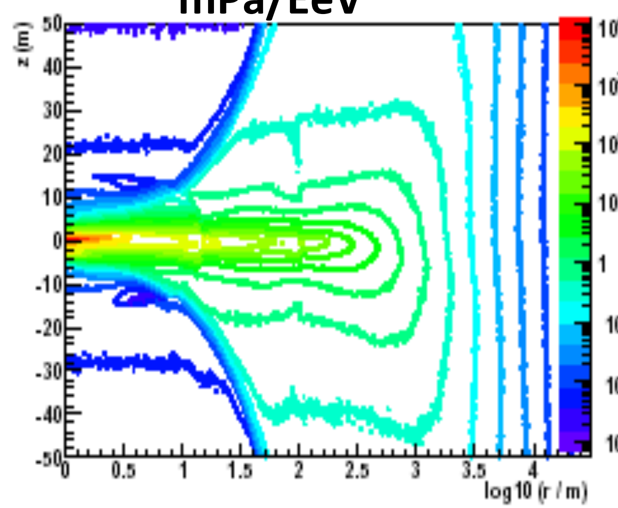


Thanks to Prof. L. Dedenko!

10^{20} eV proton @ 1 km



The “sonic pancake” mPa/EeV



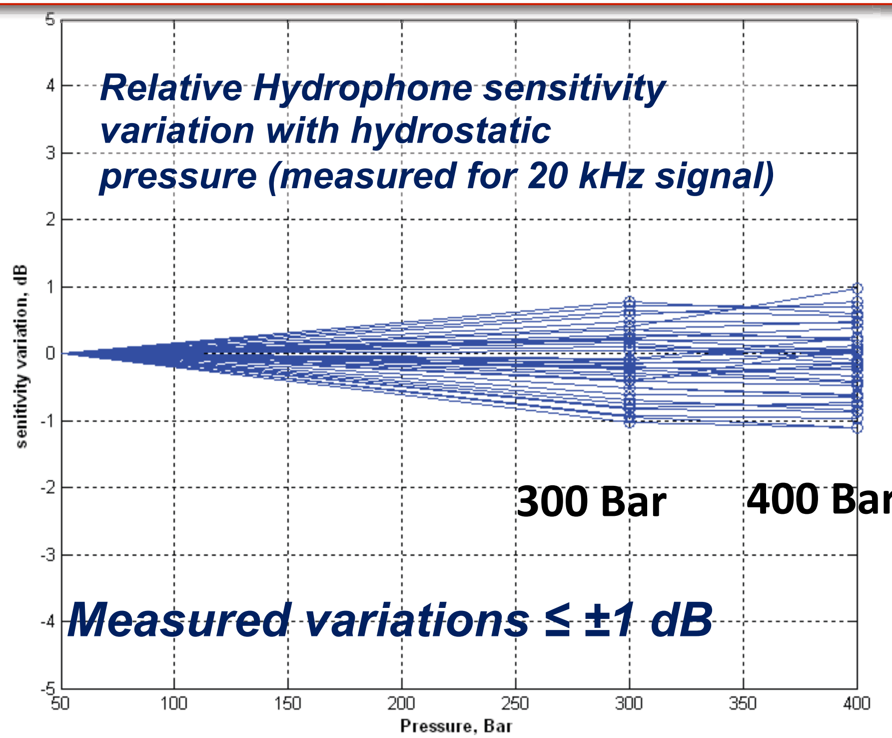
R&D for hydrophones

Commercial hydrophones are typically factory calibrated:

But for many hydrophones sensitivity changes as a function of pressure (~ -3 dB/1000 m)

NEMO and an italian company (SMID) have developed low cost hydrophones for 4000 m depth, with no change of sensitivity as a function of depth.

INFN has developed standard procedure for calibration under pressure
New technology: Digital Hydrophones (double gain, 192 kHz 24 bits) from Colmar



KM3NeT and EMSO

Common effort with the Earth and Sea Science Community

european multidisciplinary seafloor observatory emso

Real Time Environmental Monitoring

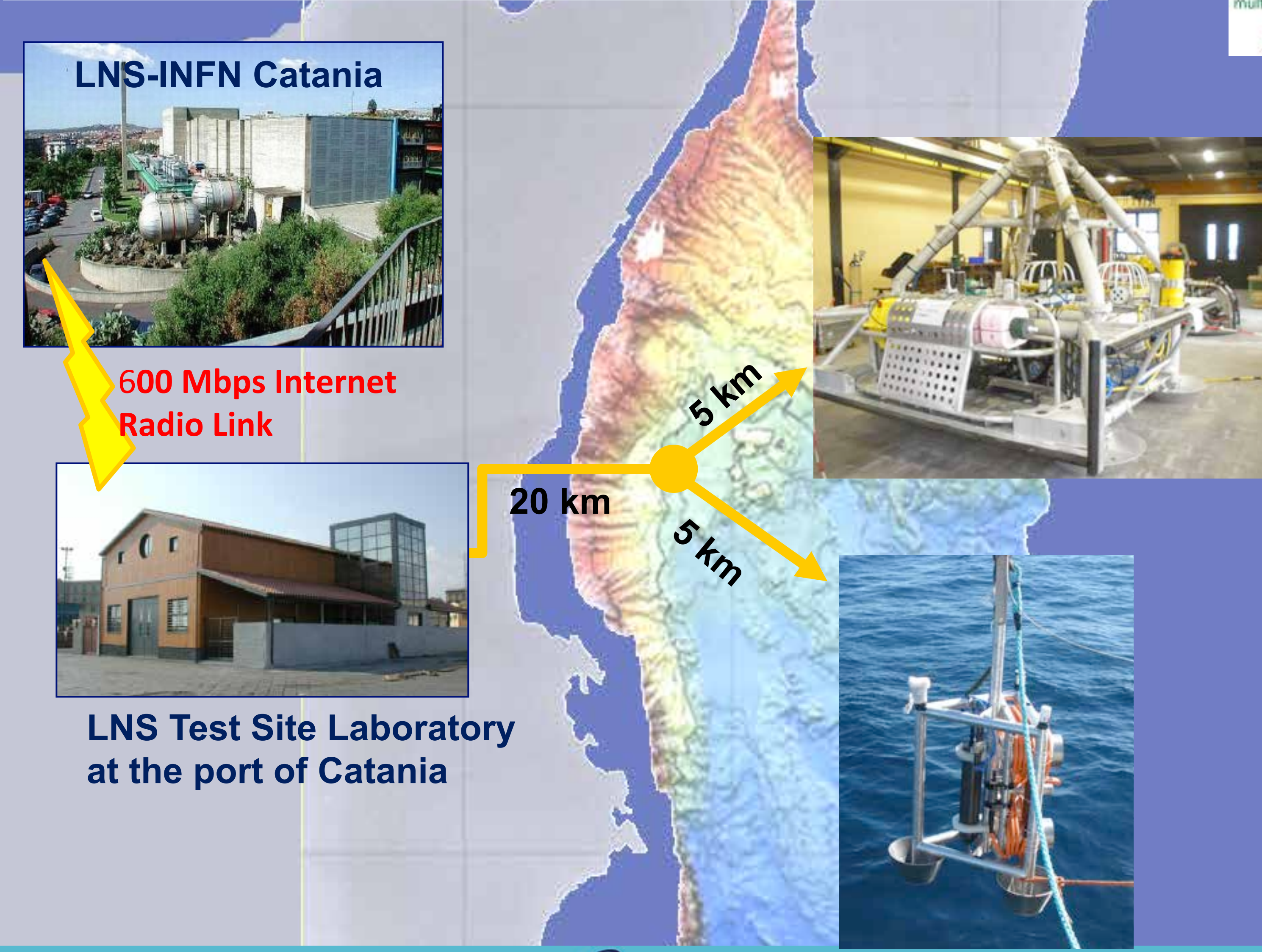
Toulon, Sicily and Hellenic: sites of common interest for KM3NeT and EMSO

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 acoustic monitoring, Biofouling, Bioluminescence, Water samples analysis,...

The Catania Site

The EMSO East Sicily Node: Catania and Portopalo

european multidisciplinary seafloor observatory emso



North Branch

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

South Branch

4 hydrophones
Underwater GPS time stamping

The Catania Site

- Monitoring of volcanic and seismic activity in Sicily
- Development of Tsunami early warning systems

Sensor	Sampling rate
Three-component broad-band seismometer	100 Hz
Hydrophone (geophysics)	100 Hz
Gravity meter	1 Hz
Scalar magnetometer	1 sample / 10 min
Three-axes single-point current meter	2 Hz
CTD	1 sample / 12 min

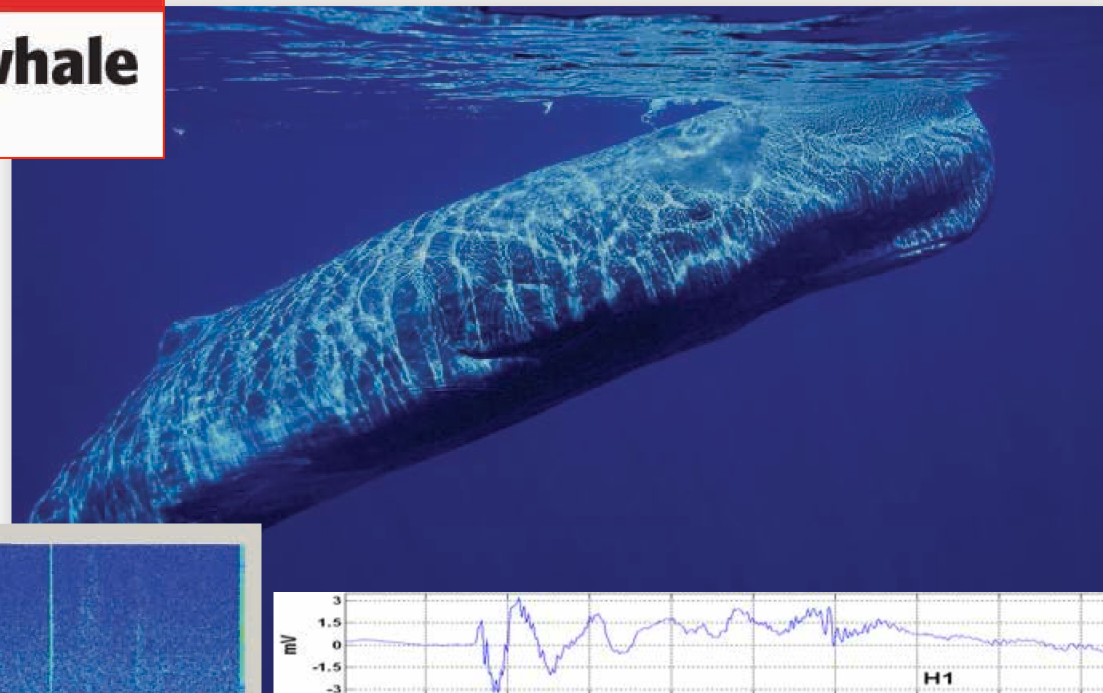
Bioacoustics

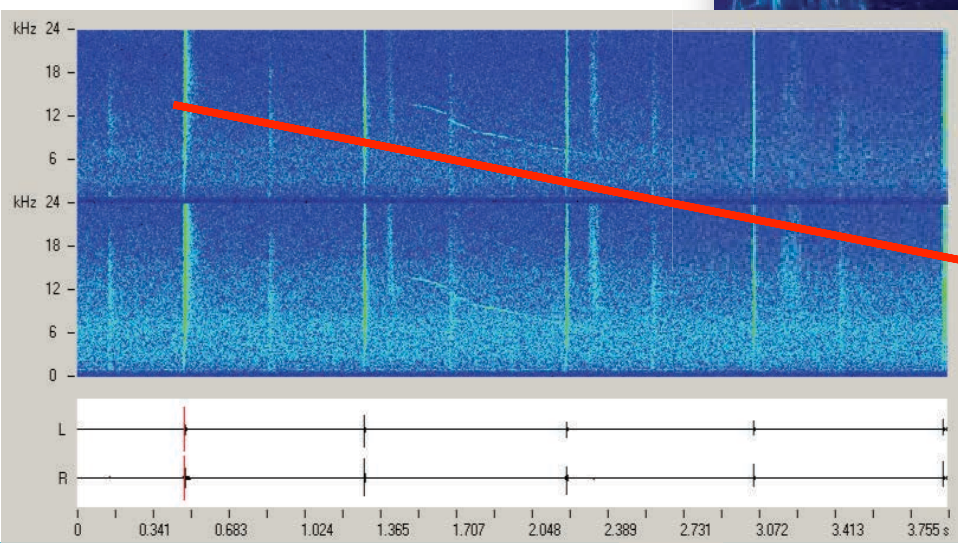
NEWS FEATURE

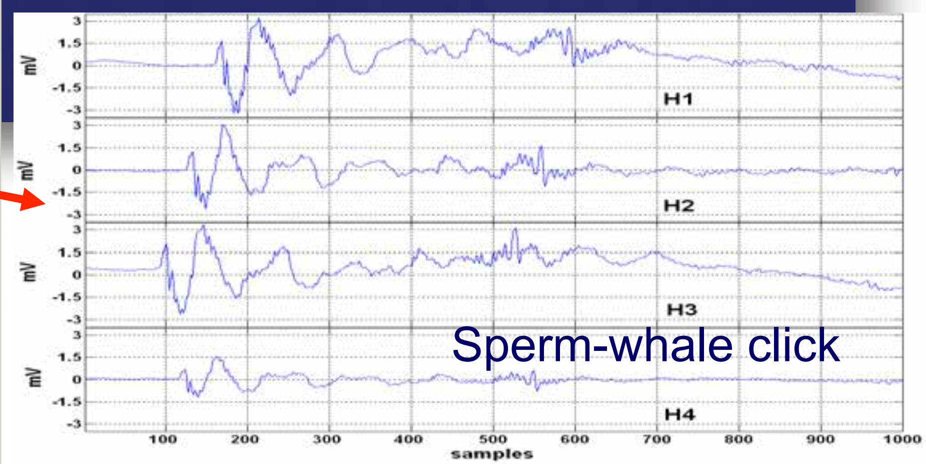
The neutrino and the whale

N. Nosengo, G. Pavan, G. Riccobene

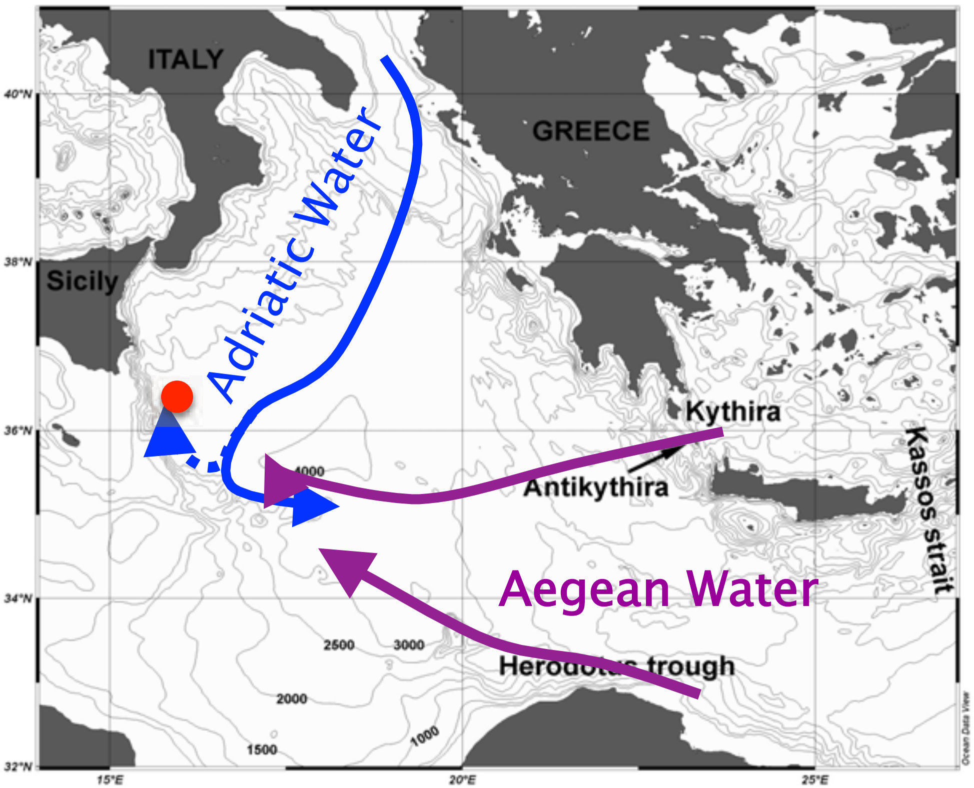
NATURE Vol 462 - 3 December 2009







Oceanography




nature COMMUNICATIONS

ARTICLE

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DOI: 10.1038/ncomms1836

Abyssal undular vortices in the Eastern Mediterranean basin

A. Rubino[1], F. Falcini[2], D. Zanchettin[3], V. Bouche[4], E. Salusti[4,5], M. Bensi[6], G. Riccobene[7], G. De Bonis[5], R. Masullo[4,5], F. Simeone[5], P. Piattelli[7], P. Sapienza[7], S. Russo[7,8], G. Platania[7], M Sedita[7], P. Reina[7], R. Avolio[7], N. Randazzo[9], D. Hainbucher[10] & A. Capone[4,5]

Such an abyssal NW current (Adriatic?) in this region, its mesoscale activity, and the T, S variability could be due to a local origin or……to recent climate changes, **waters of Aegean origin replaced waters of Adriatic origin in the abyssal Ionian basin**

Long term monitoring of currents and oceanographic data recieved in real time by new detectors in Capo Passero are expected to contribute to solve the problem:

- **NEMO Phase II and KM3NeT-Italia**

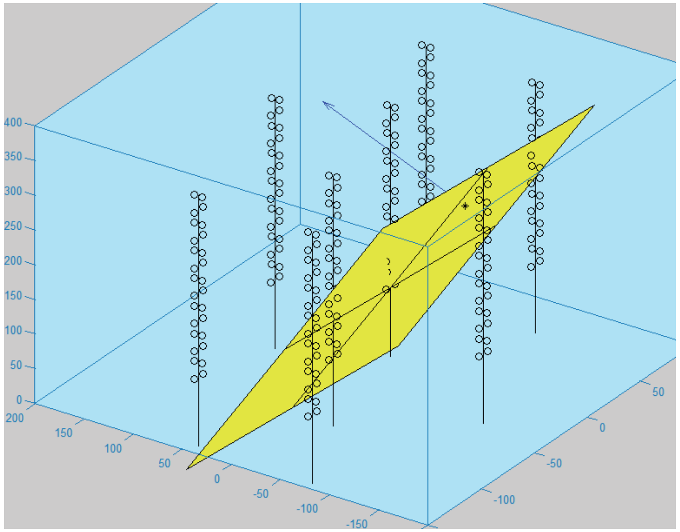
Dedicated optical fiber link from deep sea to internet: Science Gateway to the deep Sea

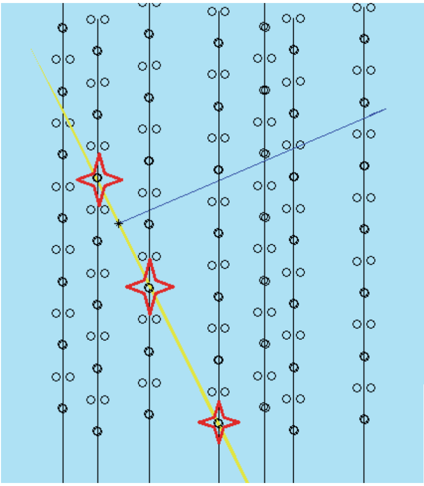
Summary

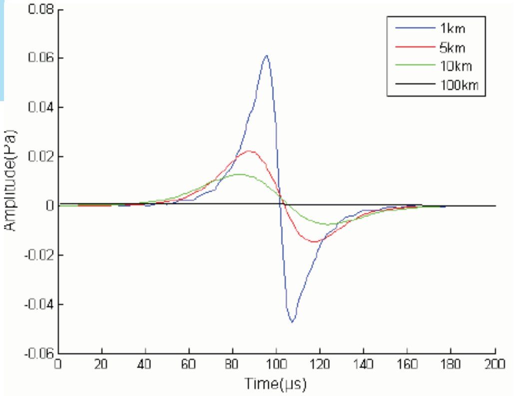
- KM3NeT will be a distributed, networked research infrastructure.
- Technical design is fixed and decided, infrastructures (IT and FR) are close to be ready.
- Construction of Phase 1 started.
- Path to Phase 1.5 (IceCube size) paved.
- Astronomy era with KM3NeT-Phase 2.
- Many multidisciplinary activities in progress
- Acoustics detection for UHE?

D. Betsis, E. Shirokov

Input parameters:
energy of the neutrino → the amplitude of the pulse
direction of the neutrino → pancake propagation
coordinates of the interaction (source) (X0, Y0, Z0)
coordinates of detector units A(i).(X, Y, Z), B(i).(X, Y, Z) … H(i).(X, Y, Z
sample of noise
a least 3 hydros laying in the plane of acoustic wave propagation







Simulation of the pulse:
Shower size and energy distribution
thermo acoustic-model
Sound attenuation and refraction

СПАСИБО