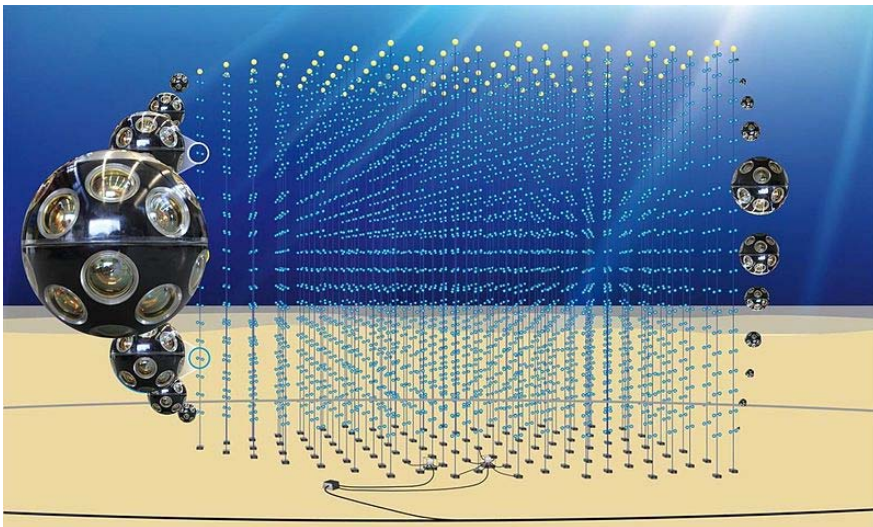# NEMO AND KM3NET

Carla Distefano – INFN, LNS

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.
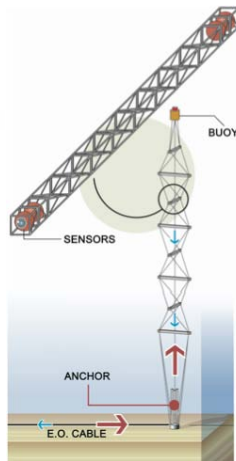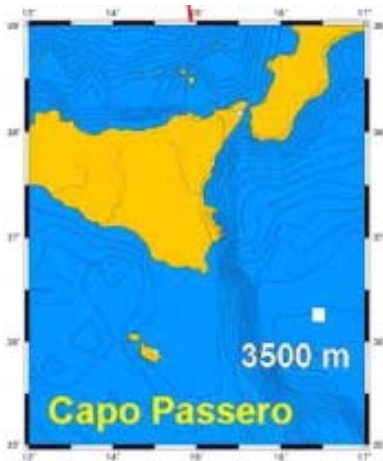

5 building blocks
115 Detection Units (DU)
750 m DU height
180m DU distance
5 km^3 volume
Budget 250 M€

KM3NeT-Italia is funded by
INFN since 1999 (NEMO)
In 2010 the project was
awarded with a
PON grant of 20.8 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
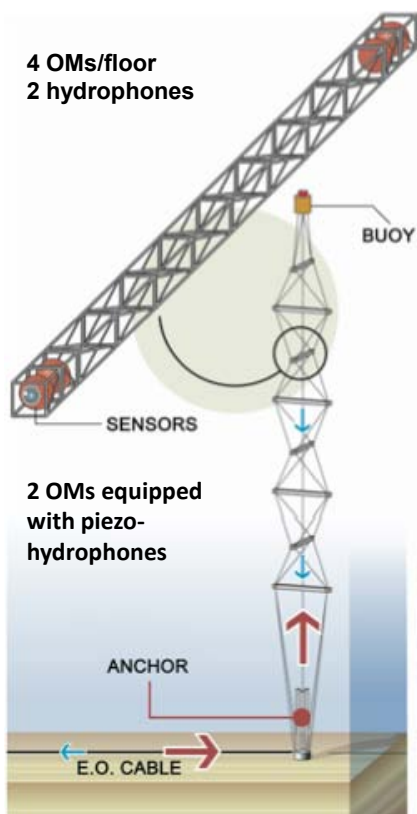
Submarine cable and infrastructure:
96 km
20 fibres ITU655-NZDSF
Single conductor with DC-sea return
Cable Termination Frame:
Medium Voltage Converter: 10kV to 375V
3 ROV-mate e.o. output connectors

Off-shore Laboratory:
NEMO Phase-2 tower since 23 March 2013
Depth=3458 m

C. Distefano, INFN-LNS Users committee 2013-12-06

The NEMO Phase-2 tower: main components

4 OMs/floor
2 hydrophones

SENSORS

BUOY

2 OMs equipped with piezo-hydrophones

ANCHOR

E.O. CABLE

- 8 floors
- 8 m bars, vertical dist. = 40 m, H_{tot} = 450 m
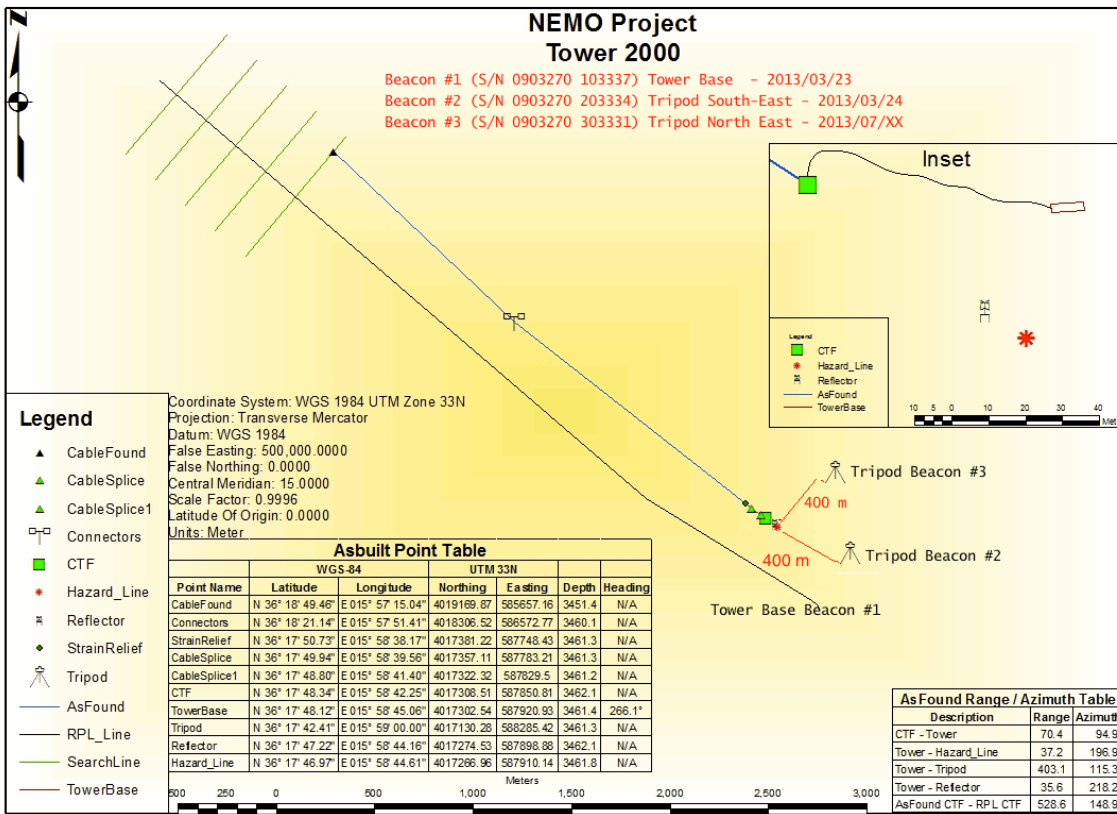- 32 OM, 14 hydrophones
- oceanographic instrumentation

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

Hydrophones: acoustic positioning and bioacustics

C. Distefano, INFN-LNS Users committee 2013-12-06

The deep-sea field
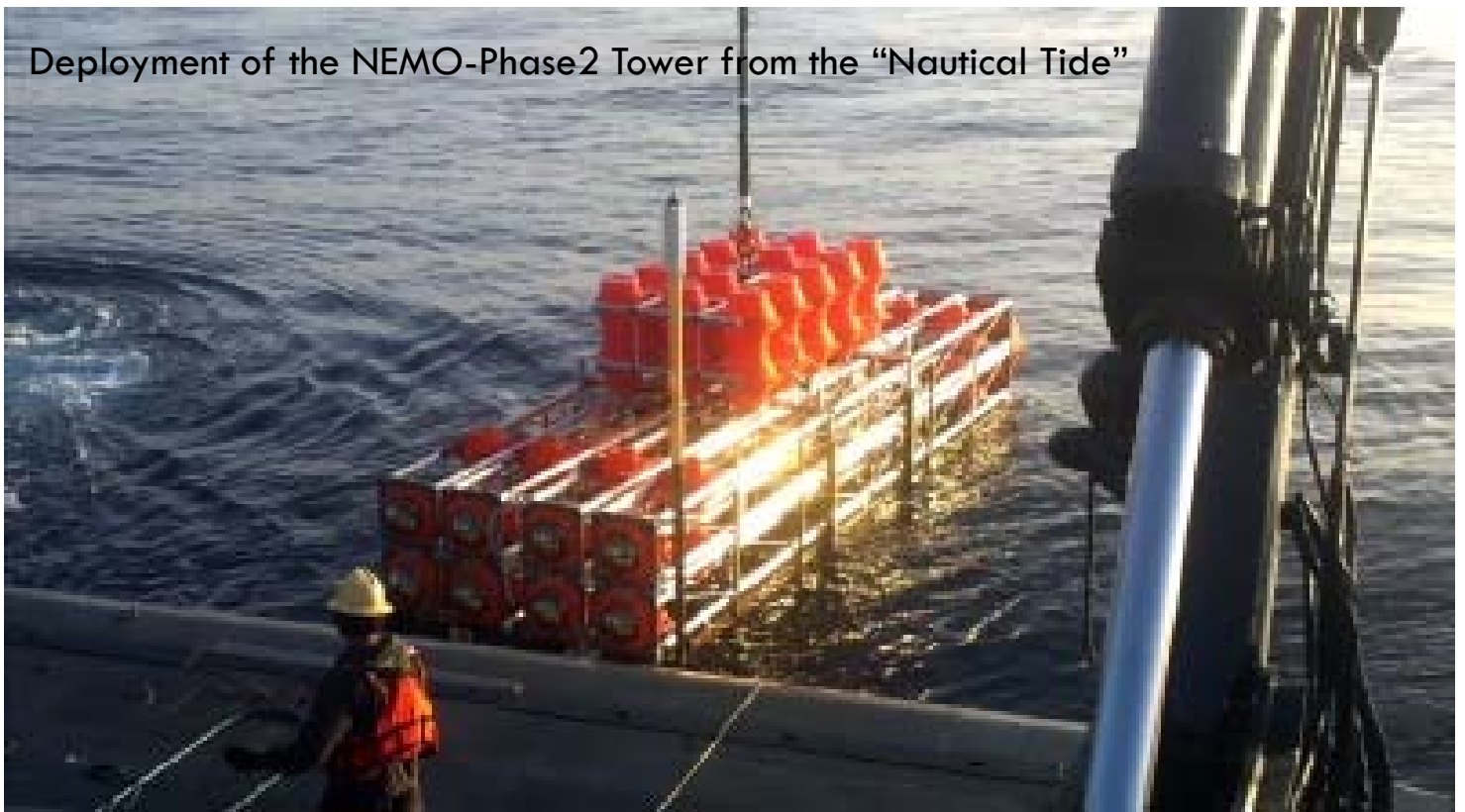
C. Distefano, INFN-LNS Users committee 2013-12-06

NEMO-Phase2 under test in Malta before boarding on "Nautical Tide"

The tower on the "Nautical Tide"

Deployment of the NEMO-Phase2 Tower from the "Nautical Tide"

C. Distefano, INFN-LNS Users committee 2013-12-06

The "Nautical Tide" ROV and its launching system

The tower touches the sea-bottom at 3500m depth

Inspecting the tower with the ROV

C. Distefano, INFN-LNS Users committee 2013-12-06
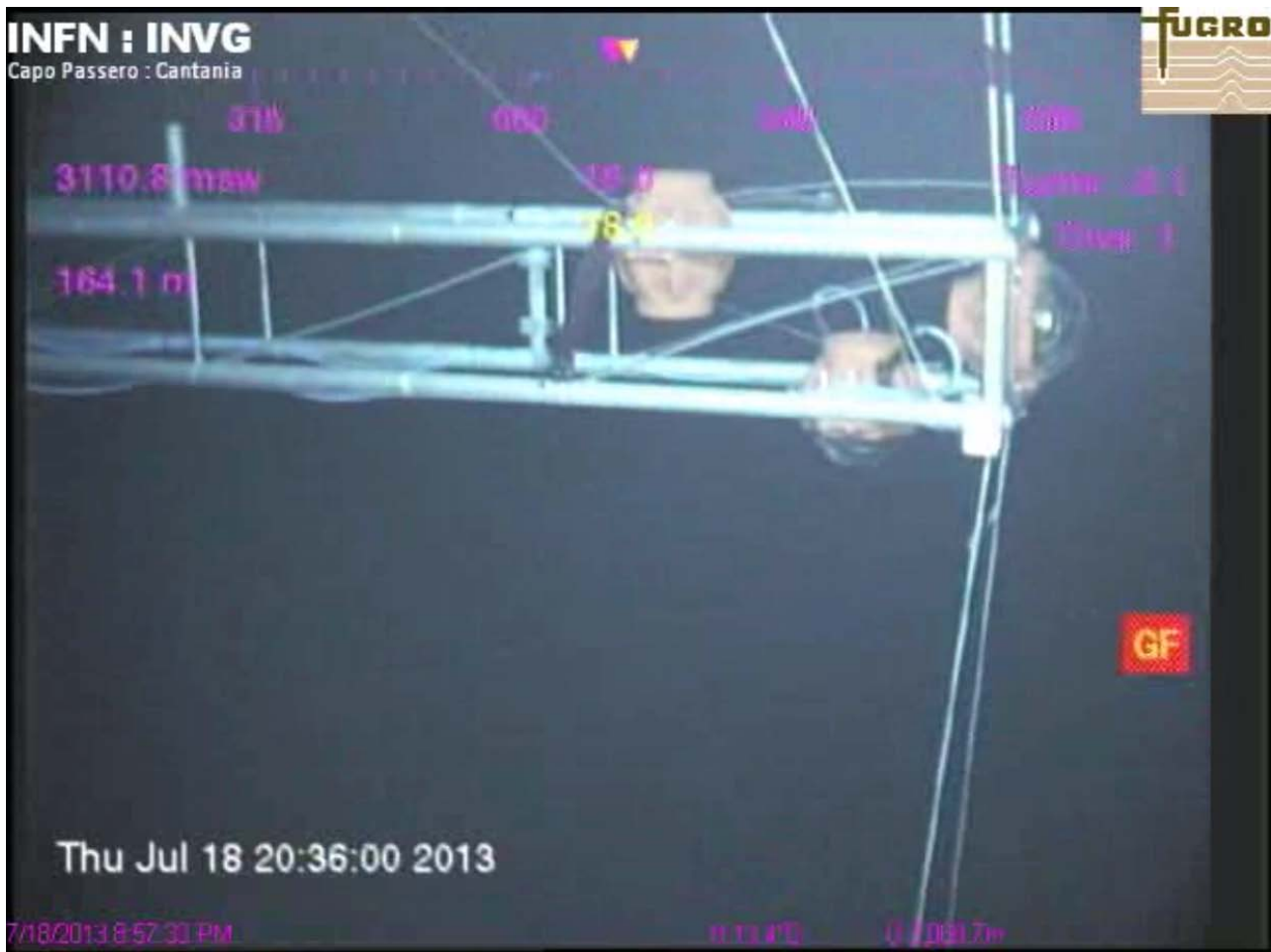
C. Distefano, INFN-LNS Users committee 2013-12-06

Brief summary of the status

- In operation since the deployment date (23 March 2013)
- All Optical transmission parameters OK
- Optical Modules
  - 31 out of 32 OMs are sending data (1 OM internal electrical malfunction)
- Acoustics (in coll. with France: CPPM, Spain: UPV, Germany: ECAP)
  - No hydrophones on floor 5
  - 2 Piezo on floor 8
  - All hydrophones are sending data
  - LBL: 2 external beacons (autonomous) and 1 tower base beacon (autonomous clock) working, 1 tower base beacon (triggered) under commissioning
- Time calibration (in coll. with Spain: IFIC)
  - Led-beacon on floors 1-4, working
  - Tower base laser-beacon under commissioning
- Environmental instrumentation
  - 2 CTD probes working and sending data
  - 1 Current metre working and sending data
  - 8 Compasses working and sending data
- DAQ and TRIGGER system working
- Slow Control working

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PMT Rate Monitoring

□ The rate is sampled once per second by the PMT Front-End electronics;

□ Rate is measured in a time window Δt=10ms;
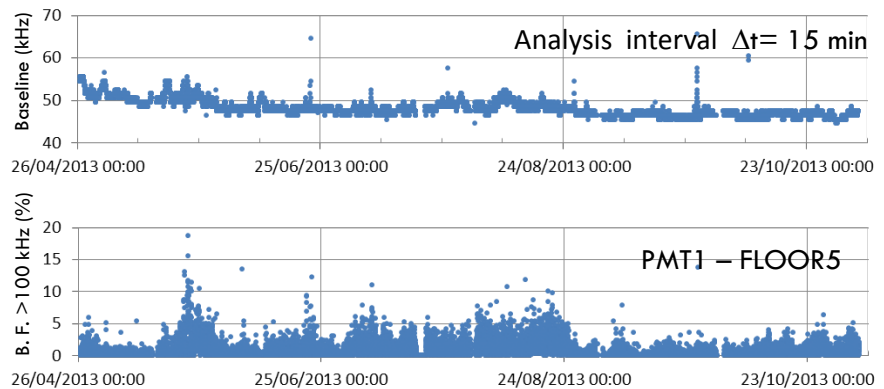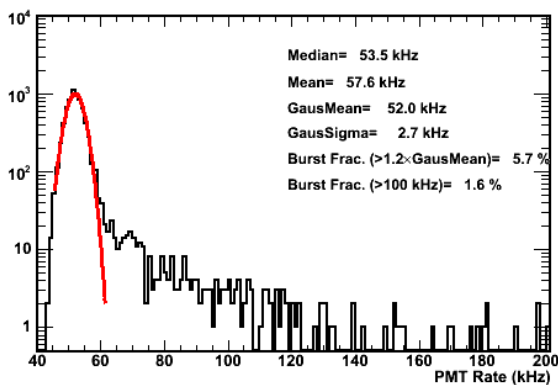
□ Baseline values are quite constant for over 8 months;
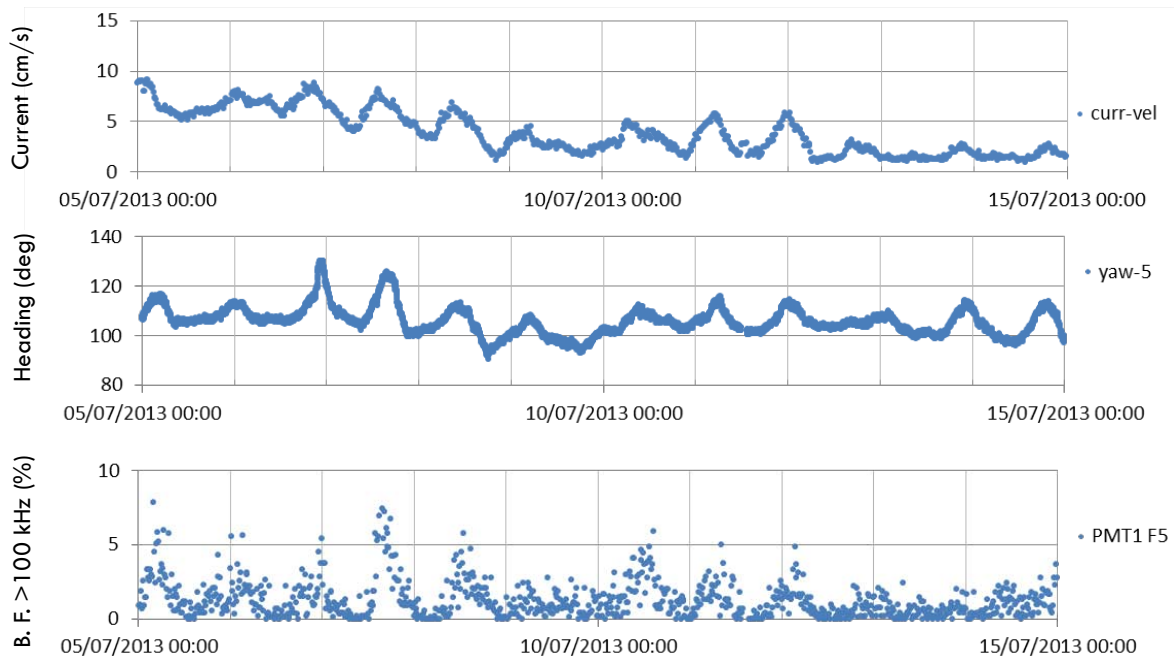
□ There is a small burst percentage.

CTD probes

- ☐ Two CTD probes: Conductivity, Temperature, Pressure and Depth, Density, Salinity, Sound Velocity;

- ☐ Both working;

- ☐ Sampling every 10 min;

- ☐ Depths and sound velocity used as input for positioning algorithm.
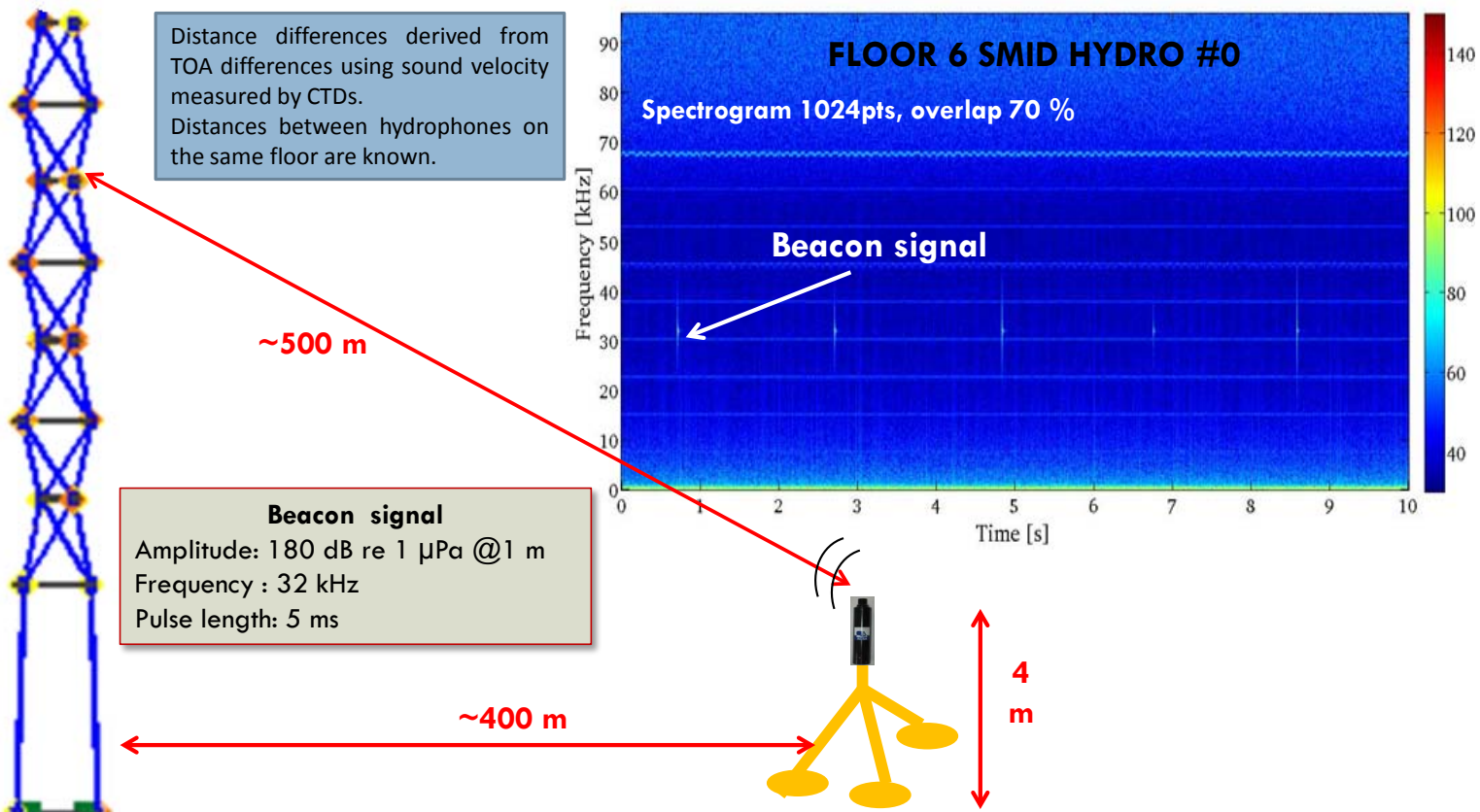
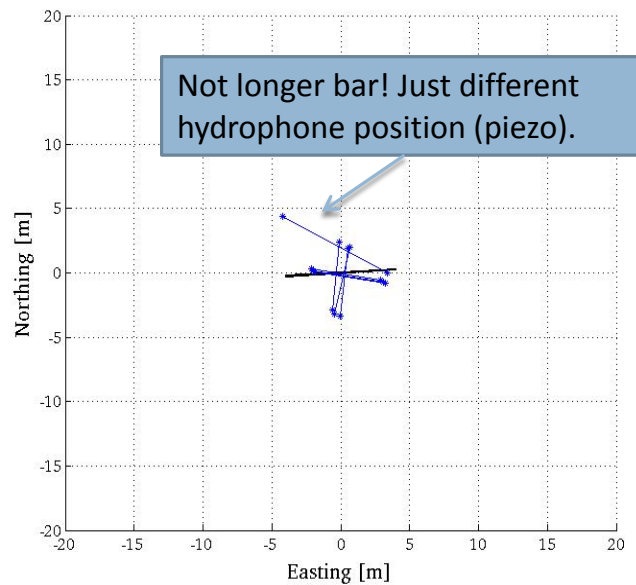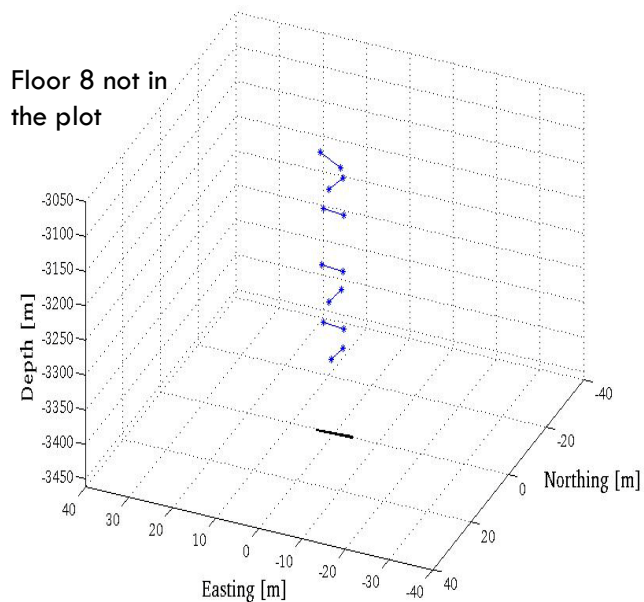C. Distefano, INFN-LNS Users committee 2013-12-06
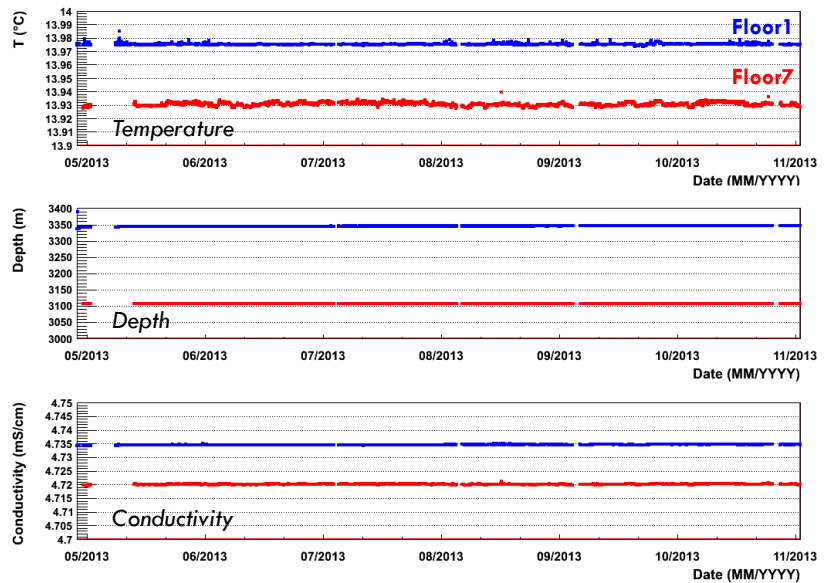
DCS probe and Compasses

Inertial currents are evident at the same time in b.f., current intensity and heading variations

C. Distefano, INFN-LNS Users committee 2013-12-06

Acoustic detection: status

Distance differences derived from TOA differences using sound velocity measured by CTDs.
Distances between hydrophones on the same floor are known.

FLOOR 6 SMID HYDRO #0

Spectrogram 1024pts, overlap 70 %

Beacon signal

~500 m

Beacon signal
Amplitude: 180 dB re 1 µPa @1 m
Frequency : 32 kHz
Pulse length: 5 ms

~400 m

4 m

C. Distefano, INFN-LNS Users committee 2013-12-06

Reconstruction with acoustics pos.

Floor 8 not in
the plot

Not longer bar! Just different
hydrophone position (piezo).

**07/05/2013
00:00 UTC**

Reconstruction possible with accuracy O(1m)

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Muon Triggers

L1 triggers →

SC (20 ns)	FC (100 ns)	$Q_{threshold}$ && SC	Random
1:100 or all if #≥2	(SC in 20 ns + PMT)	($Q_{first10\ samples}$ > 500 adc)	(1 ms @ 1 Hz)
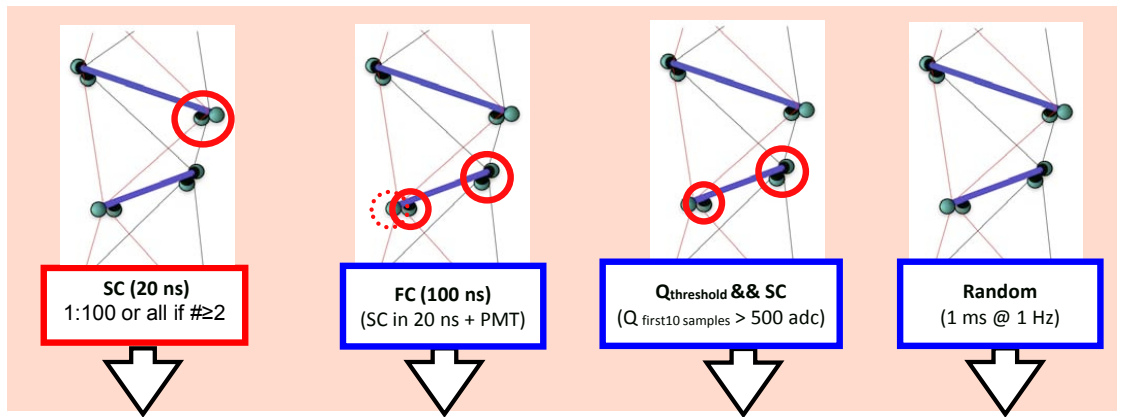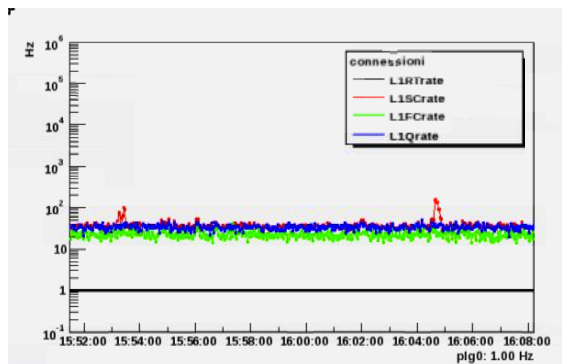
Trigger rates →

- Event trigger rate: ~100 Hz
- Muon purity: ~10^{-3}
- More selective trigger strategies under study

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Data taking and Shifts

- The tower takes data continuously (h24). It's controlled by automatic systems and monitored by a shift crew during the daytime.

- The shift crew is composed of two persons, responsible of the operation, calibration and monitoring of the detector for a period of 1 week.

- All INFN sections participating to the experiment (Bari, Bologna, Catania, Genova, LNF, LNS, Napoli, Pisa, Roma, Salerno) contribute to the shifts.

- Up to August: only local shifts. Since September: 50% of shifts in remote.

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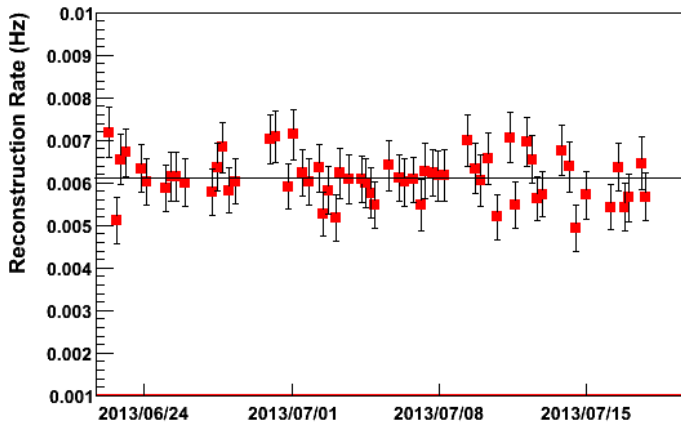
Live time and accumulated events
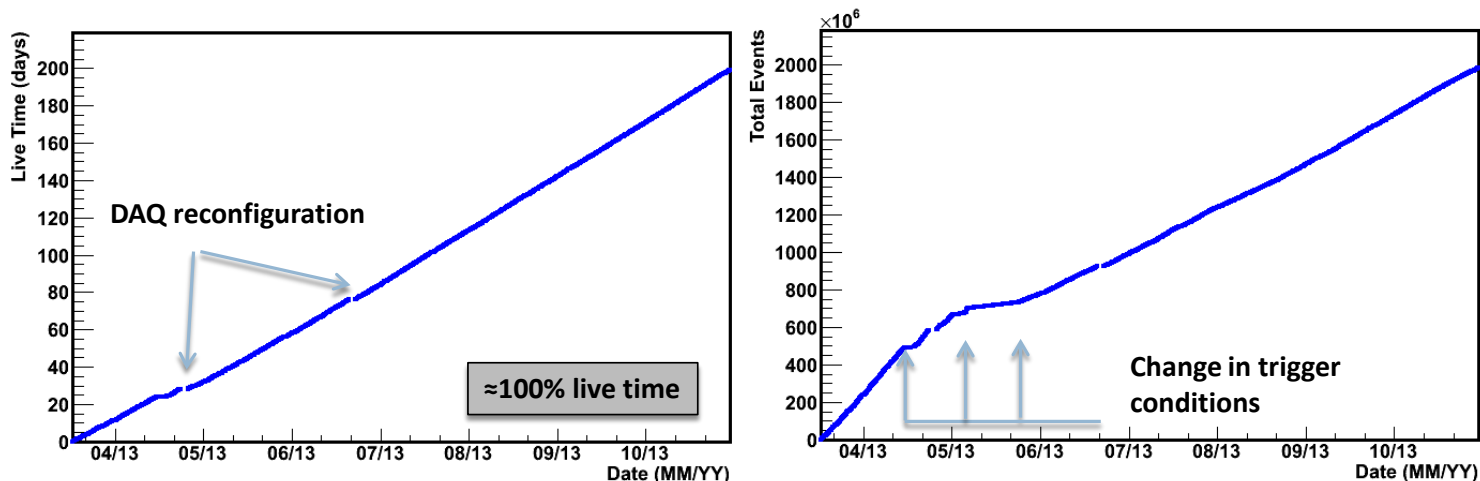
Live time and total number of events accumulated since April 16 2013

Atmospheric muon analysis: first results

### Single PT files reconstruction rates

Track reconstruction level

DATA: 7741
MC: 9504
Ratio: 1.23

Live time: 13.4 days
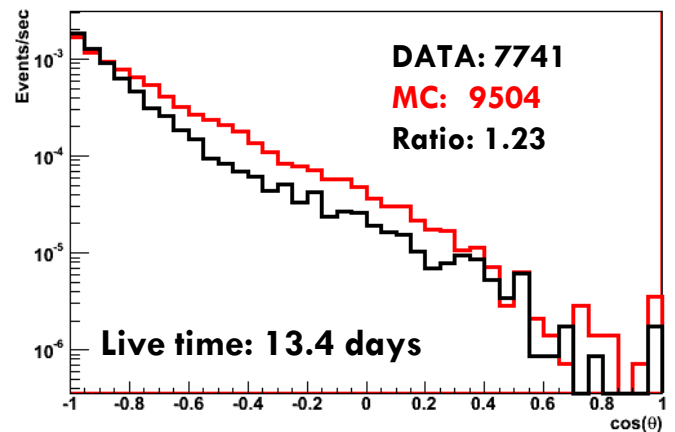
- Post Trigger files selected between 2013-06-22 and 2013-07-17.
- Reconstruction rate stable in time. Mean value of 0.0065 Hz (consistent with Depth=3500m).
- Agreement with MC but excess in simulations: under investigation.
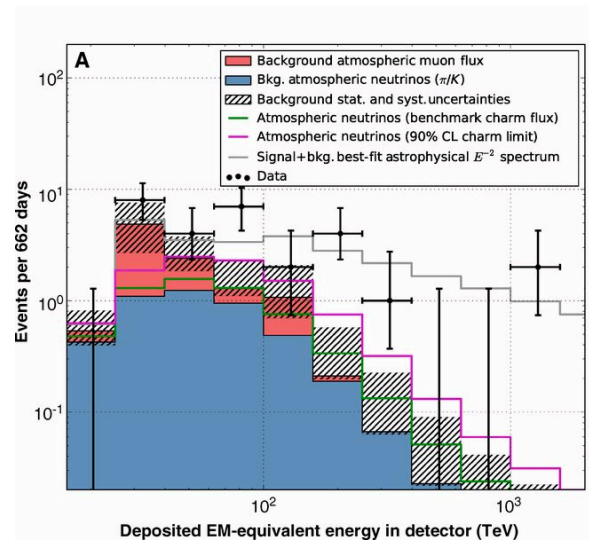- In progress: analysis of the whole data set

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The future
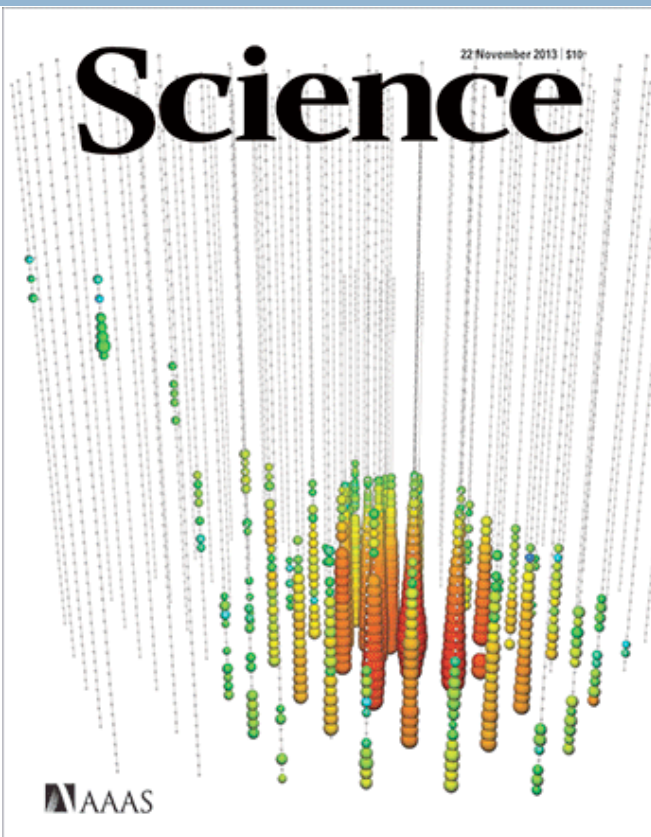
IceCube Neutrino Observatory reports first evidence for extraterrestrial high-energy neutrinos.

28 neutrino candidate events, substantially more than the expected from atmospheric backgrounds (4σ level).
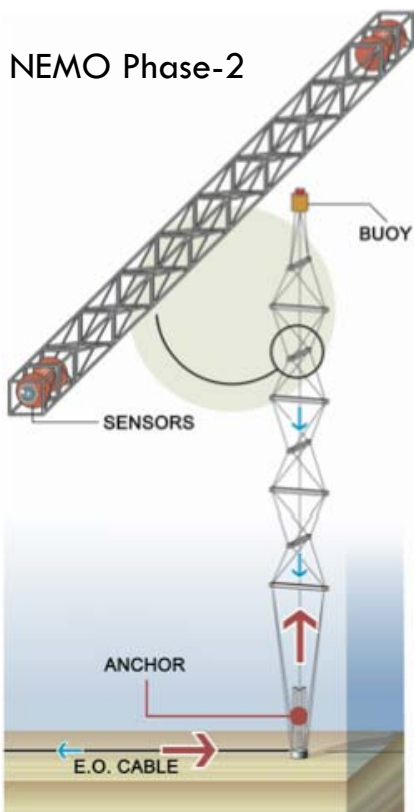
KM3NeT Phase-1 at Capo Passero Site

- 8 Towers + 24 Strings

- New CTF with 5 outputs (4 fo, 2 e)

- Up to 5 Secondary JB
    - 1 SJB x 8 towers
    - 2 SJBs x 12+12 strings
    - 1 SJB for EMSO

C. Distefano, INFN-LNS Users committee 2013-12-06
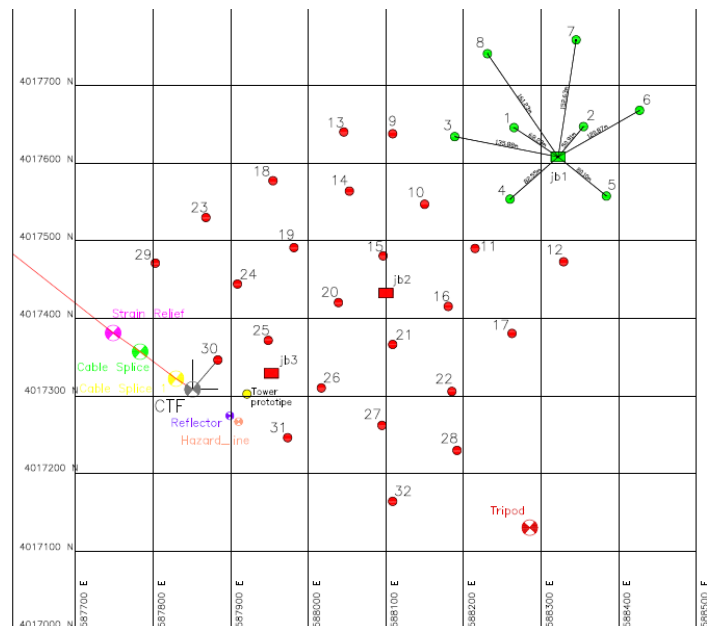
The NEMO Phase-3

NEMO Phase-2

- 8 towers
- 14 floors/tower
- 8 m bars, vert. dist. = 20 m, H_{tot} ~ 450 m
- 6 OMs + 2 hydrophones/floor
- oceanographic instrumentation
- towers at ~ 100 m horiz. dist.

NEMO Phase-3

Shorter vertical distance and larger number of PMT/floor → lower energy threshold

C. Distefano, INFN-LNS Users committee 2013-12-06
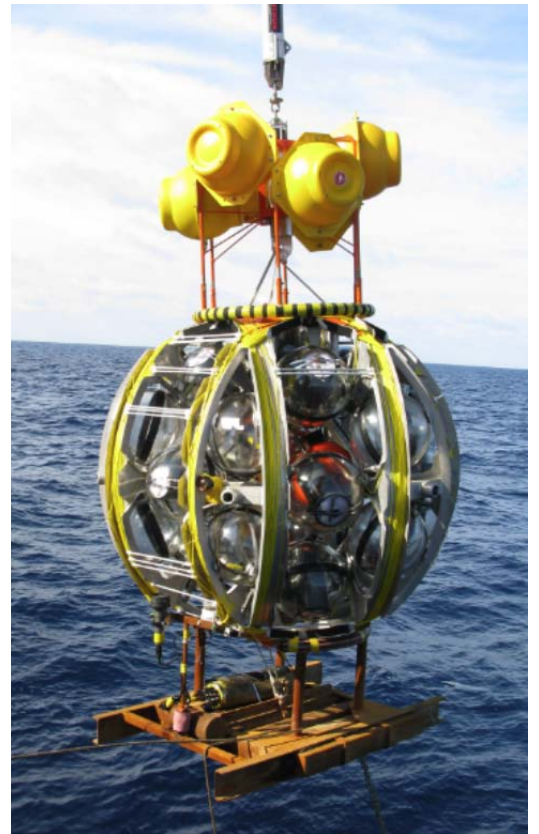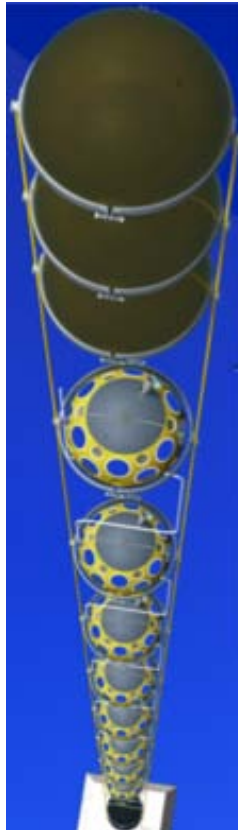
Multi-PMT DOM Strings

Digital Optical Module
31 small, 3" PMTs in one glass sphere
Photon counting

Detection Unit with 18 storeys
36 m inter-storey distance
Compact deployment

Prototype DOM tested successfully on ANTARES instrumentation line
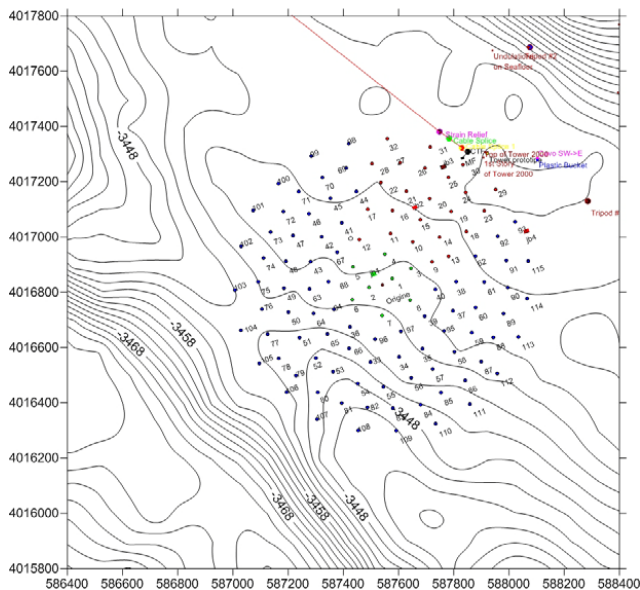
Prototype DU with 3 DOMs to be deployed in Capo Passero in March 2014

C. Distefano, INFN-LNS Users committee 2013-12-06

Capo Passero Site Future Layout

→ 8 Detection Units in 2014 (towers)
→ PPM Detection Unit in March 2014 (string)
→ 24 Detection Units in 2015 (strings)
→ A full Building Block before 2020 (≈1.5 IceCube)

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

The largest deep-sea
observatory in the world

C. Distefano, INFN-LNS Users committee 2013-12-06
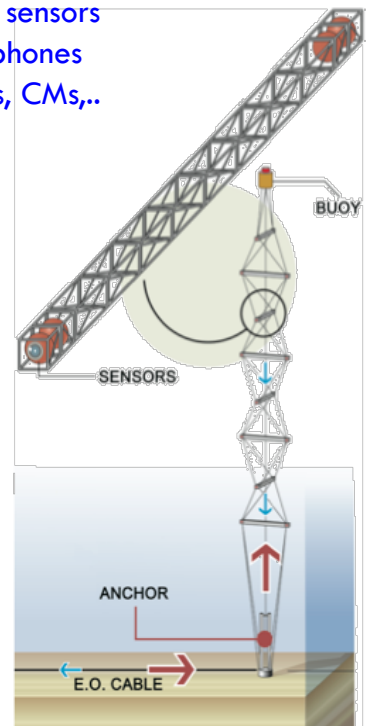
KM3NeT and EMSO

Common efforts 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 ,...
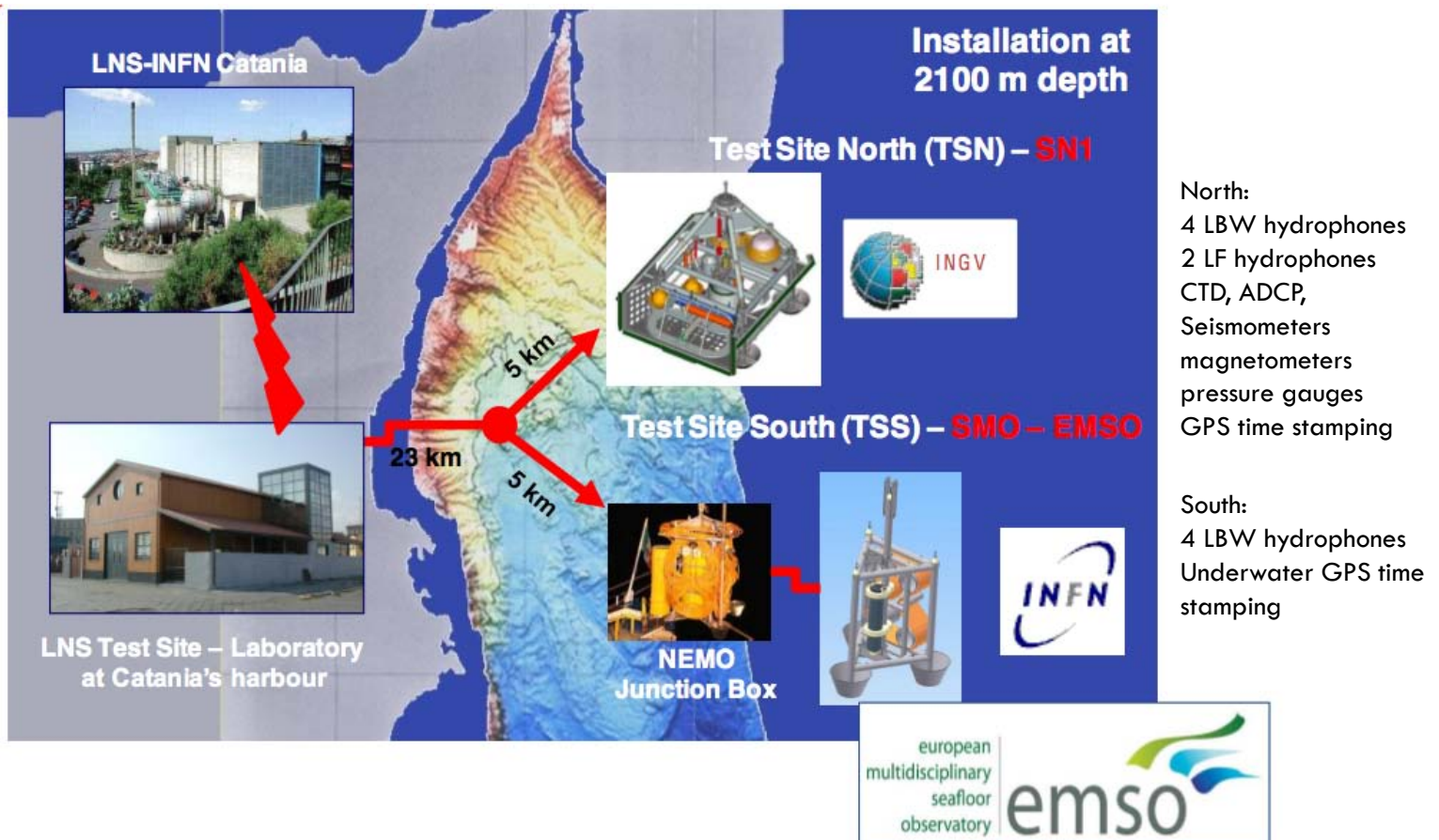**Geophysics (geohazard):**
Seismic phenomena, low frequency passive acoustics, magnetic field variations,...
Biology (micro-biology, cetaceans,...):
Passive acoustics, Biofouling, Bioluminescence, Water samples analysis,...

The Catania Test Site:
a multidisciplinary deep sea-lab

North:
4 LBW hydrophones
2 LF hydrophones
CTD, ADCP,
Seismometers
magnetometers
pressure gauges
GPS time stamping

South:
4 LBW hydrophones
Underwater GPS time
stamping

Summary

- 8 storey tower deployed on March 23 2013

- Operational since then

- First results and in particular
    - Very low background rates (compatible with 40K background with few bioluminescence bursts)
    - Acoustic positioning: still in progress but accuracy O(1m) reachable
    - First results from muon track reconstruction analysis

- Toward KM3NeT telescope
    - Nemo Phase-3: an 8 tower detector (2014)
    - PPM Detection Unit (March 2014)
    - KM3NeT Phase-1: 8 towers plus 24 strings equipped with Multi-PMTs (2015)
    - km^3-scale detector before 2020