Positioning System for neutrino telescopes: SMO and KM3NeT-Italia in Capo Passero

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CETACEAN ECOLOCATION – OUTER SPACE NEUTRINOS
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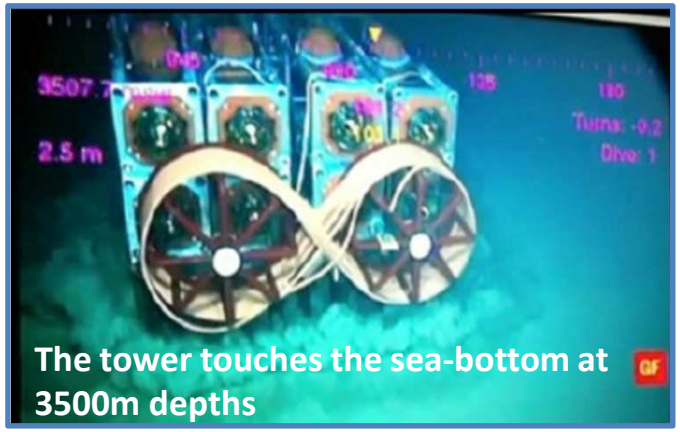
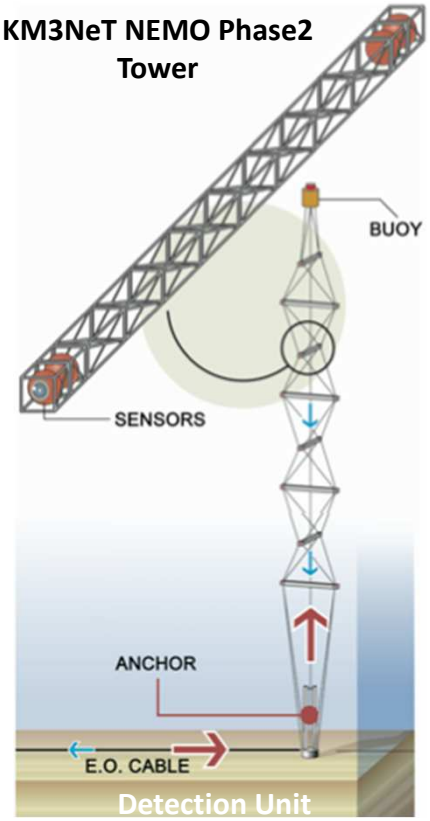
KM3NeT- Italia

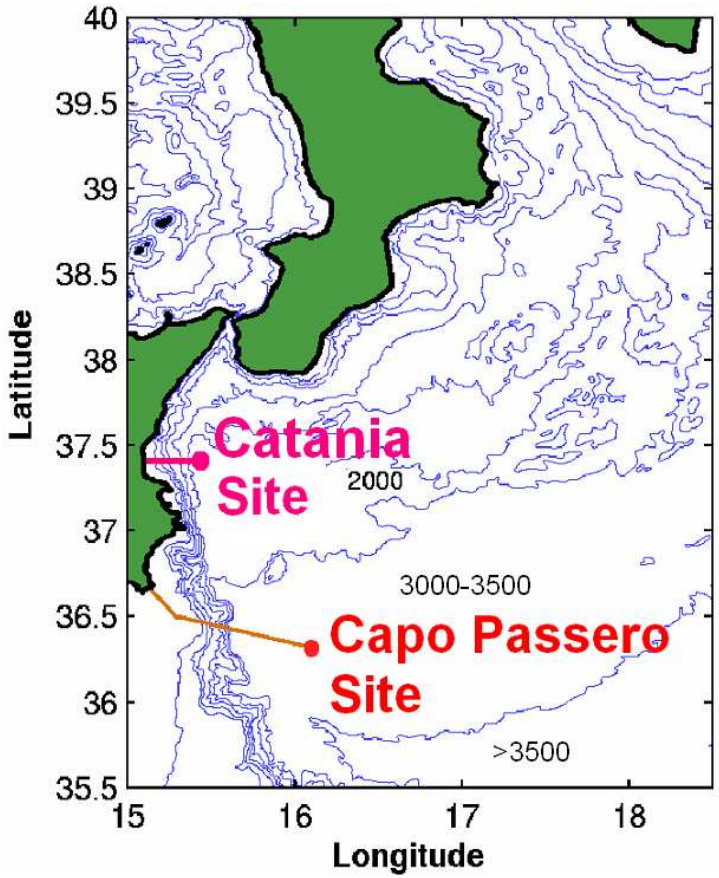
A prototype detection unit has been deployed on 23rd March 2013 at a depth of 3500 m, about 90 km offshore the village of Capo Passero (Sicily), composed by 8 horizontal structures called floors, kept vertical by appropriate buoyancy on the top (see talk F. Simeone).


The tower on the "Nautical Tide"



The tower touches the sea-bottom at 3500m depths





Capo Passero site (3500 m depth)

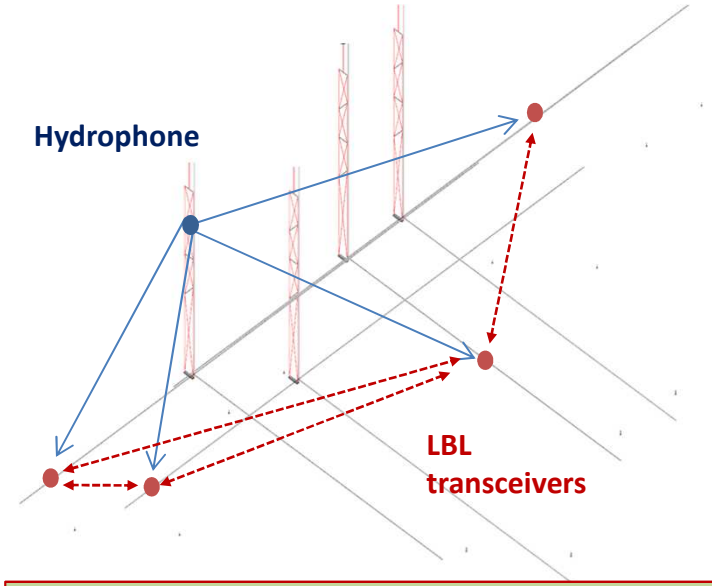
Acoustic positioning system

The acoustic positioning system is a mandatory subsystem for an underwater neutrino telescope.

Aims:

1. **Provide optical module positions during the telescope operation for muon track reconstruction.**

2. **Give a guide during the deployment of the telescope structures and infrastructures.**



Key elements:

1. **Long Baseline of acoustic transceivers anchored in known and fixed positions.**
   - **In future auto-calibrating and time synchronization with detector Master clock.**

2. ***Array of acoustic sensors (hydrophones) rigidly connected to the mechanical structure.***

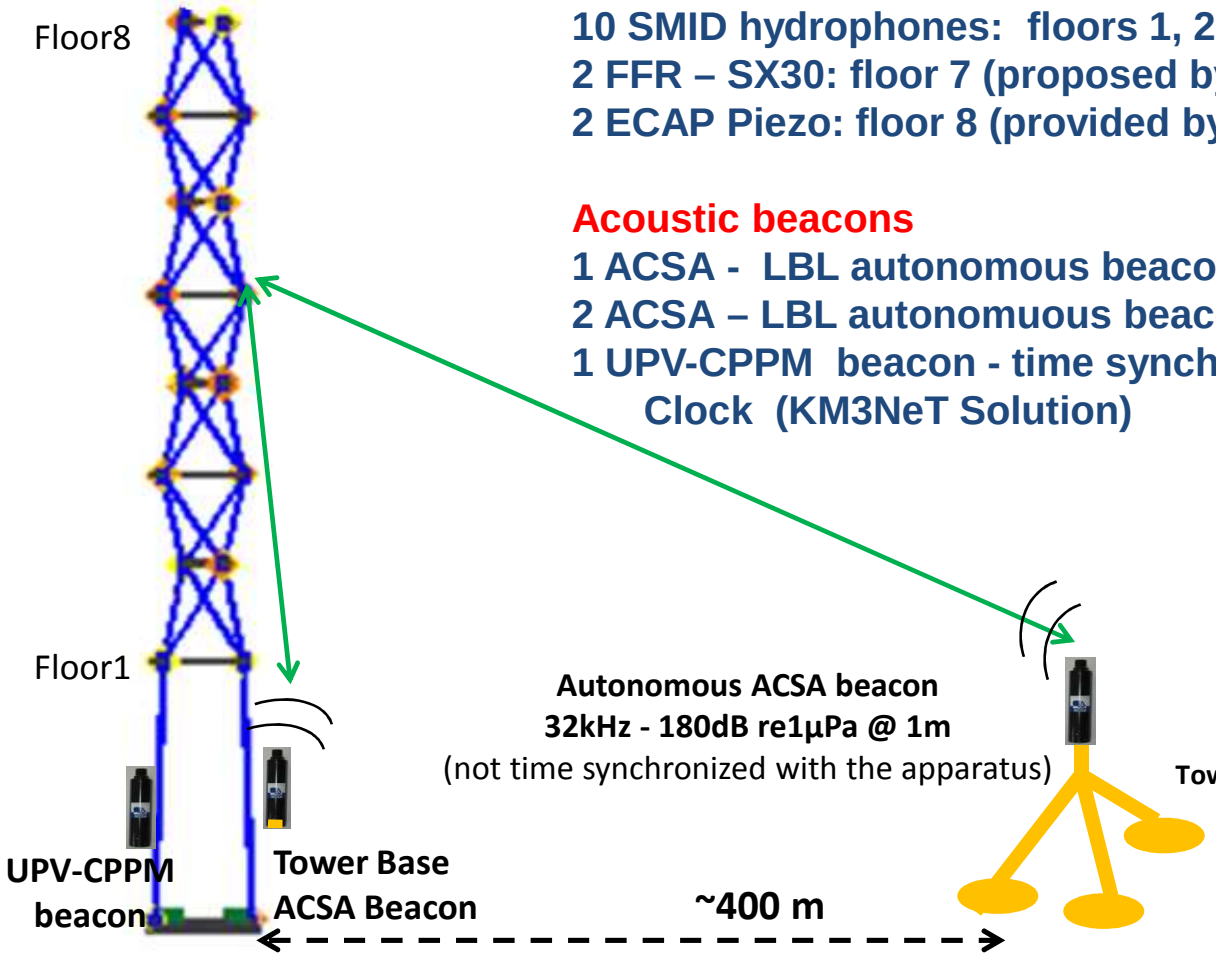
3. ***Auxiliary devices: compasses, CTD , sound celerimeters, current meters.***

The array permits real-time study of acoustic biological sounds and acoustic background monitoring.

NEMO – SMO acoustic positioning system

The acoustic positioning system for the towers of KM3NeT-Italia detector have been based on the positioning system developed by NEMO-SMO teams in collaboration with ACSA for KM3NeT NEMO Phase-2 prototype.

KM3NeT NEMO Phase-2 prototype



14 acoustic sensors

10 SMID hydrophones: floors 1, 2, 3, 4, 6 (no F0 monitoring station)

2 FFR – SX30: floor 7 (proposed by UPV-CPPM)

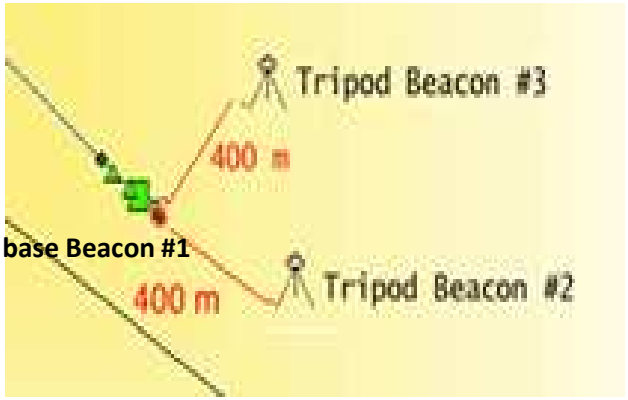
2 ECAP Piezo: floor 8 (provided by ECAP)

Acoustic beacons

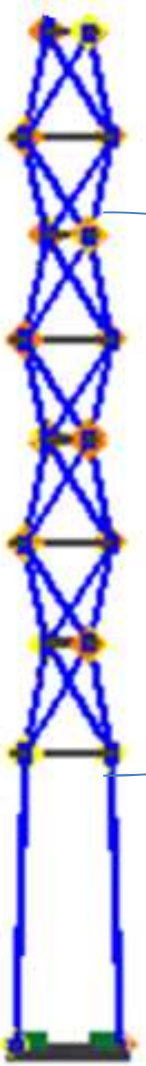
1 ACSA - LBL autonomous beacon on tower base

2 ACSA – LBL autonomuous beacon (~400 m far from tower base)

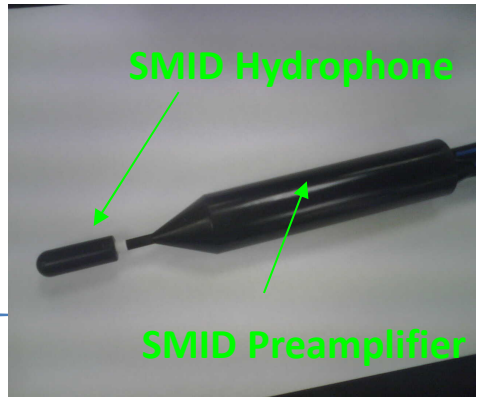
1 UPV-CPPM beacon - time synchronized with the detector Master Clock (KM3NeT Solution)

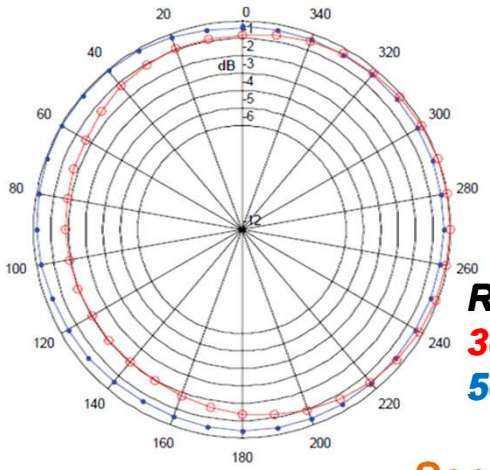


NEMO-SMO acoustic sensors



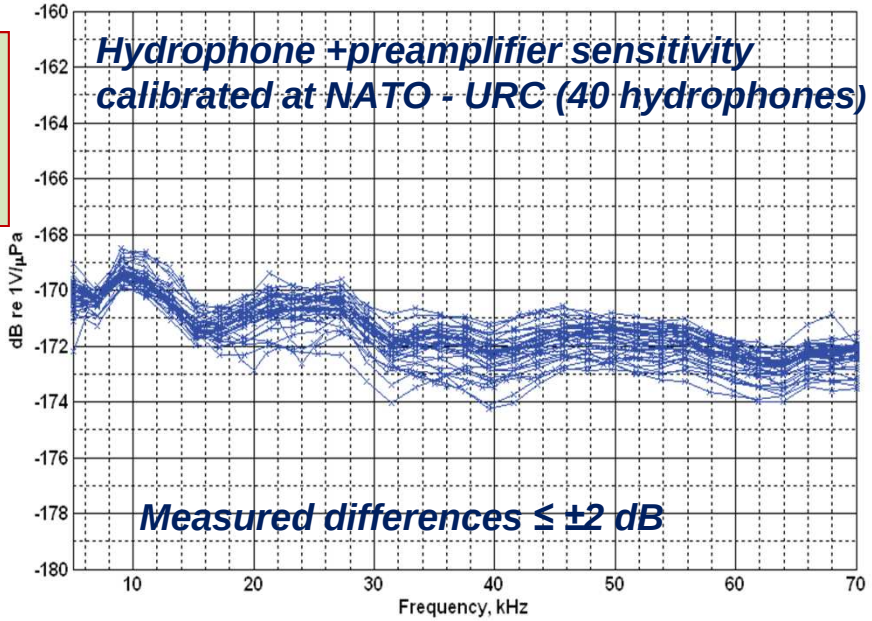
Floor #1 ÷Floor #6
SMID Hydrophones
+ SMID preamplifiers (gain: +38 dB)

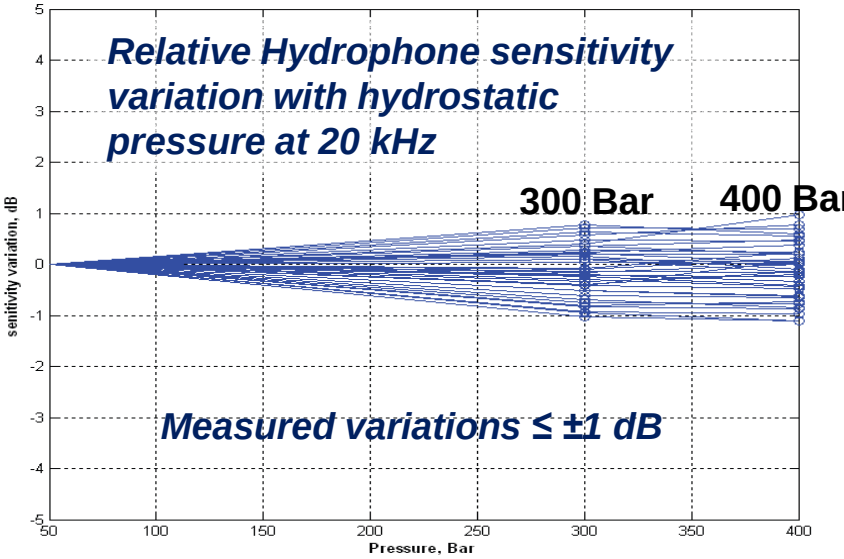




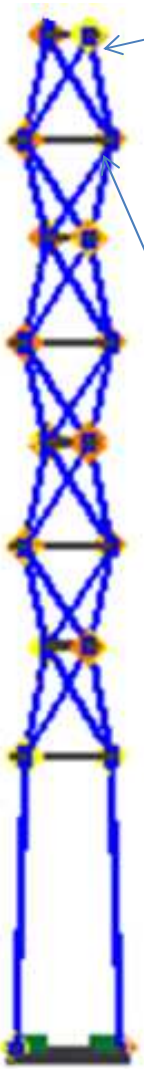
Radiation lobe
30 kHz
50 kHz

See talk S. Viola

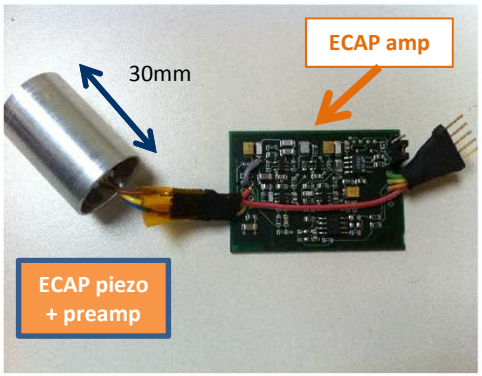


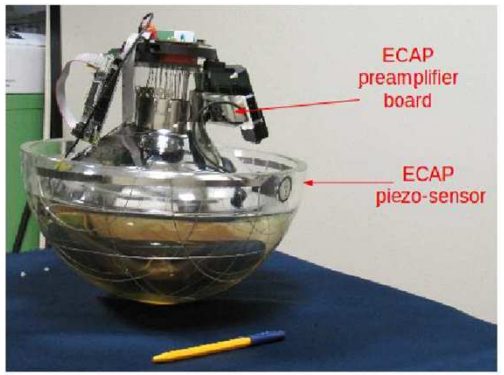


Additional acoustic sensors



Floor #8
ECAP Piezo sensors + ECAP preamplifiers





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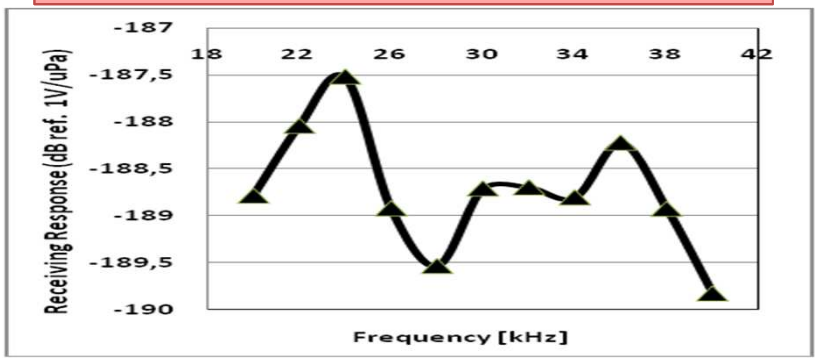
Floor #7
FFR (Free Flooded Rings) Hydrophones + SMID preamplifiers (gain :+38 dB)

Sensor Technology STD
FFR - SX30

Receiving Response of the System



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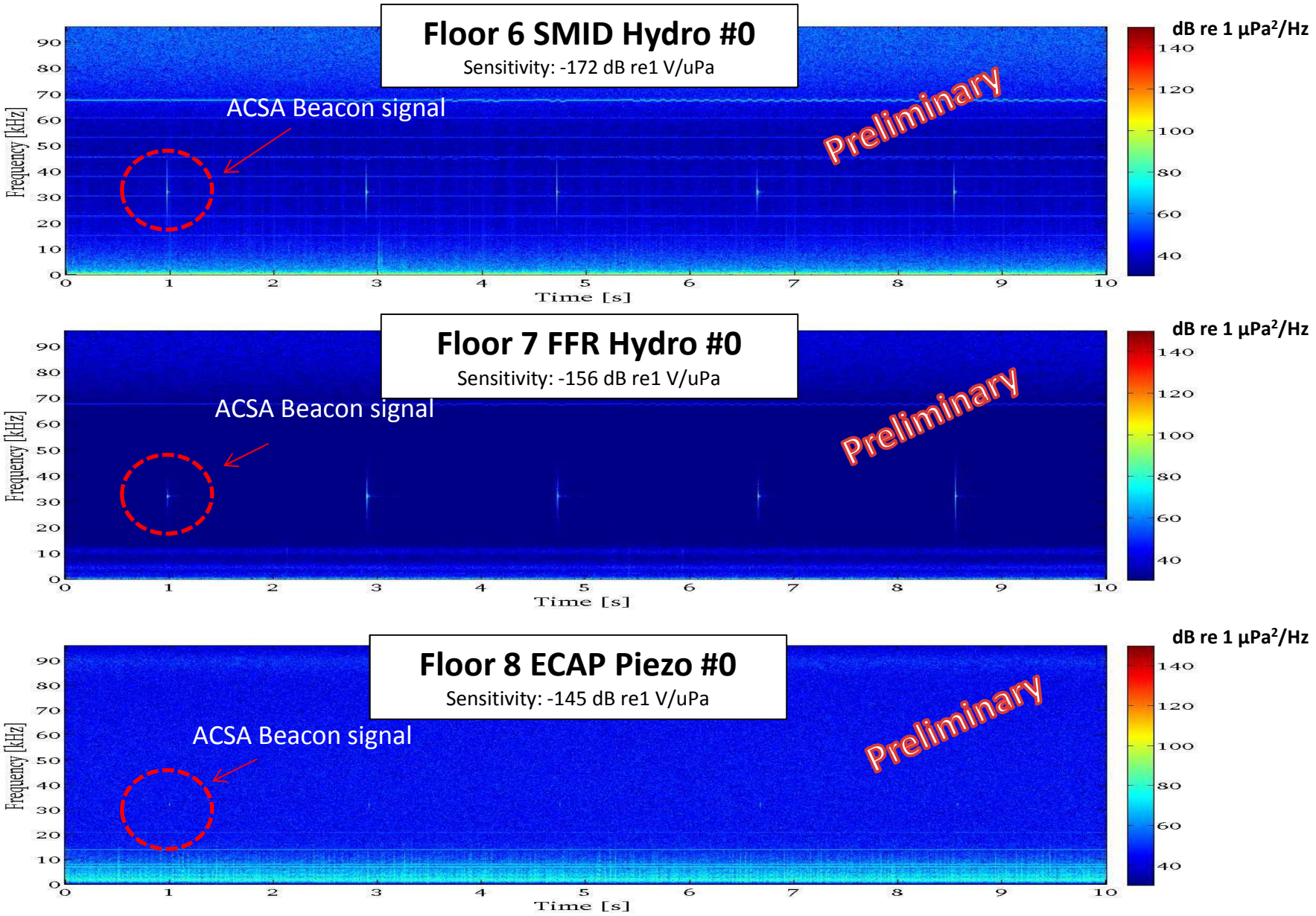
NEMO-SMO: sensors performances



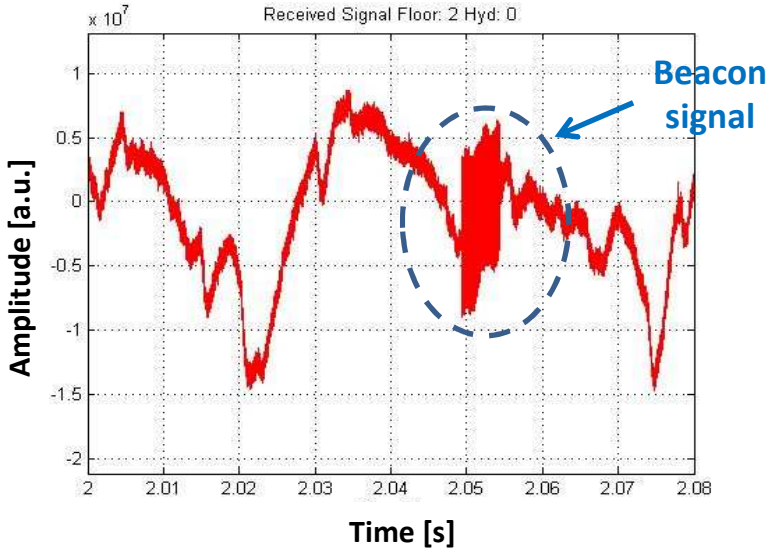
KM3NeT-Italia: real time positioning

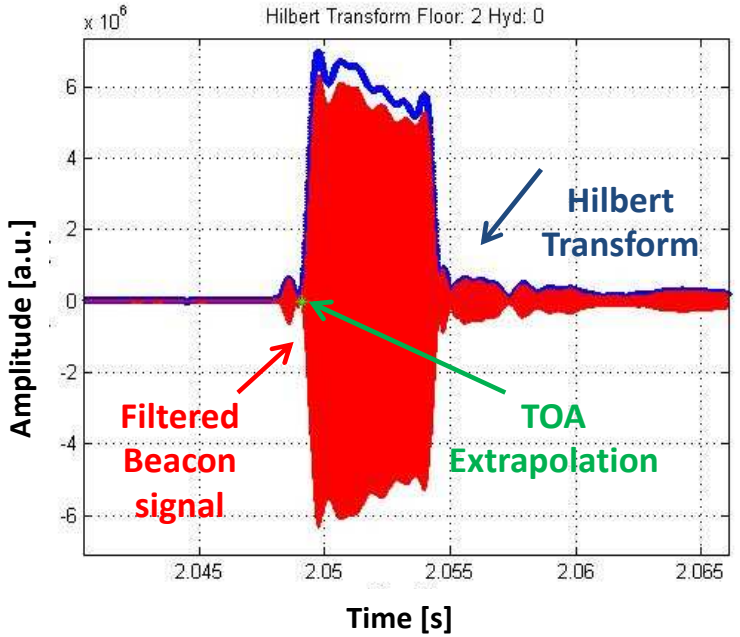
The procedure to evaluate hydrophones positions consists of 3 steps:

1. Recognition of the beacon pulses (5 ms signal, 32 kHz)

2. TOA estimation by rising edge of the signal

3. Geometrical Triangulation (TOAs of LBL beacons)



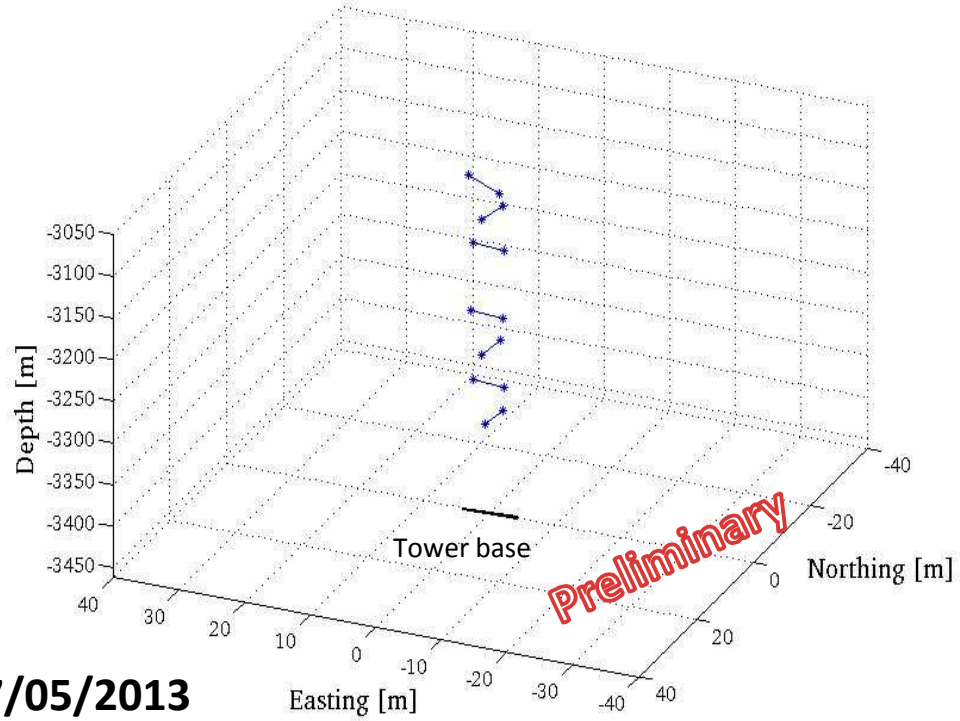


Acoustic positioning: first results

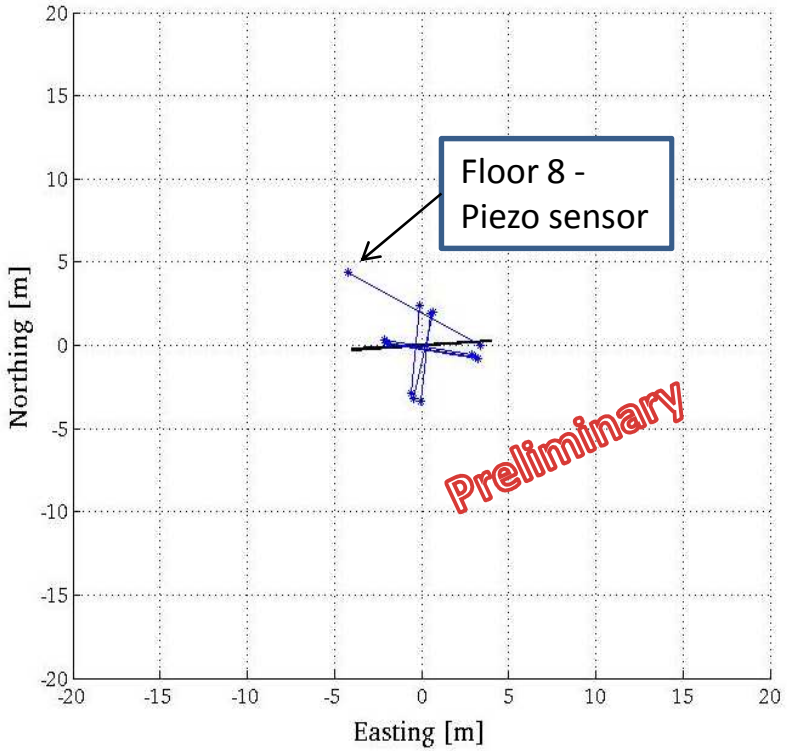
Hydrophones positioning script

Input:
- Beacons positions
-TOAs
- Depths of floor 1 and floor 6 from CTDs
- Distances between hydrophones in the same floor
- Sound velocity (CTDs data)

The code finds iteratively a root (zero) of a system of nonlinear equations.



07/05/2013
00:00 UTC



Conclusions

- NEMO-SMO acoustic array fully functional since deployment.

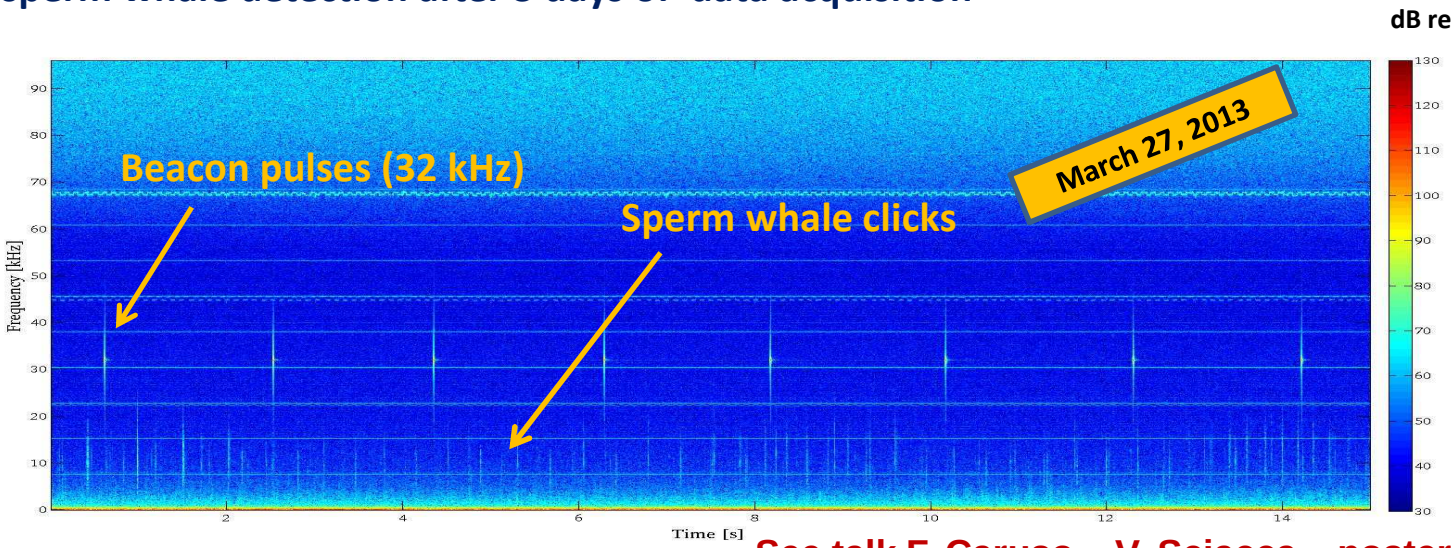
- All hydrophones working with the expected performances.

- Acoustic beacon's signals can be easily disentangled from the underwater background acoustic noise.

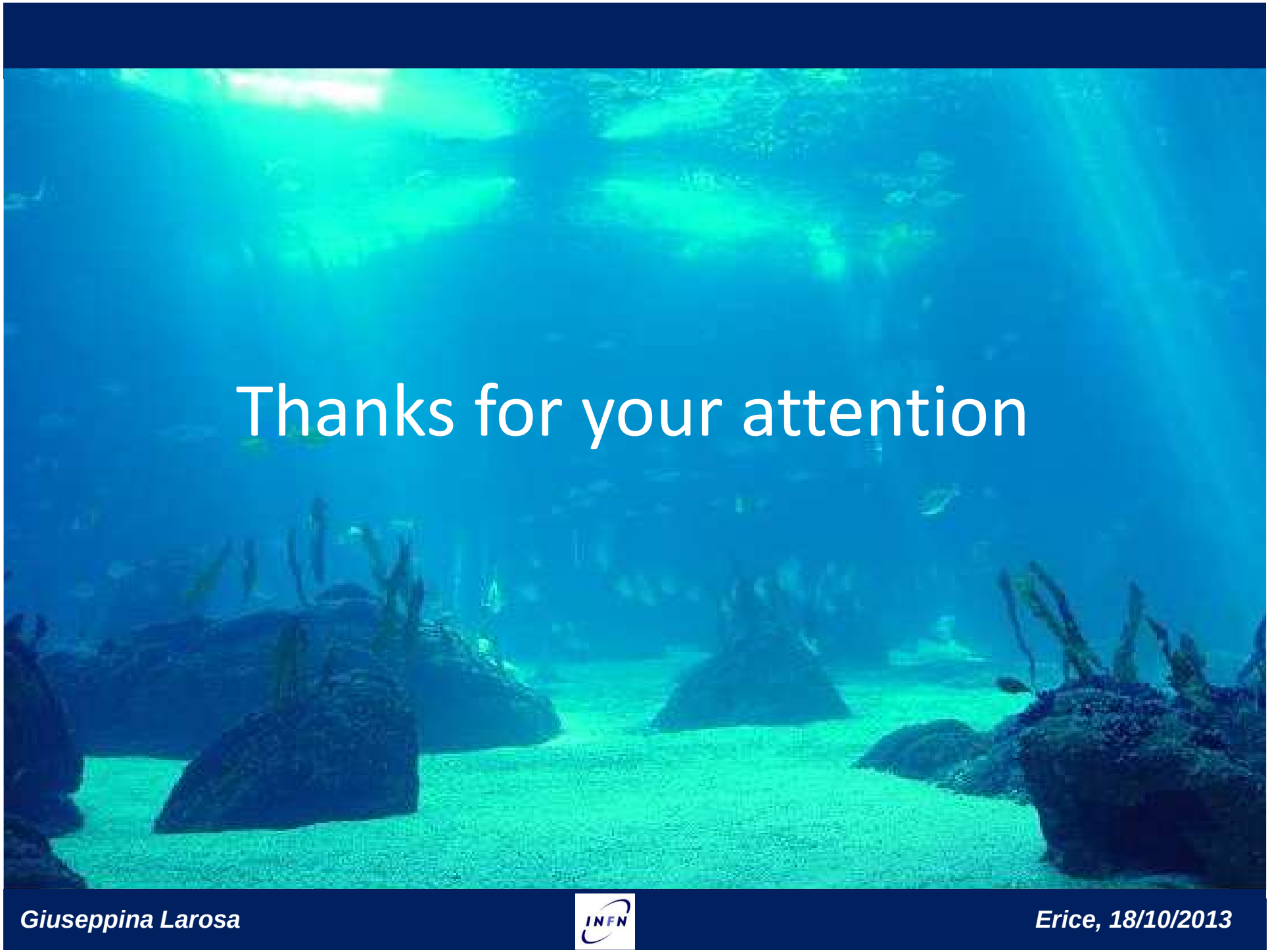
- Positioning code completed and improved.

Multidisciplinary approach successful

- Automatic codes for acoustic sperm whale detection and evaluation of their size
- First sperm whale detection after 3 days of data acquisition



See talk F. Caruso. , V. Sciacca – poster R. Grasso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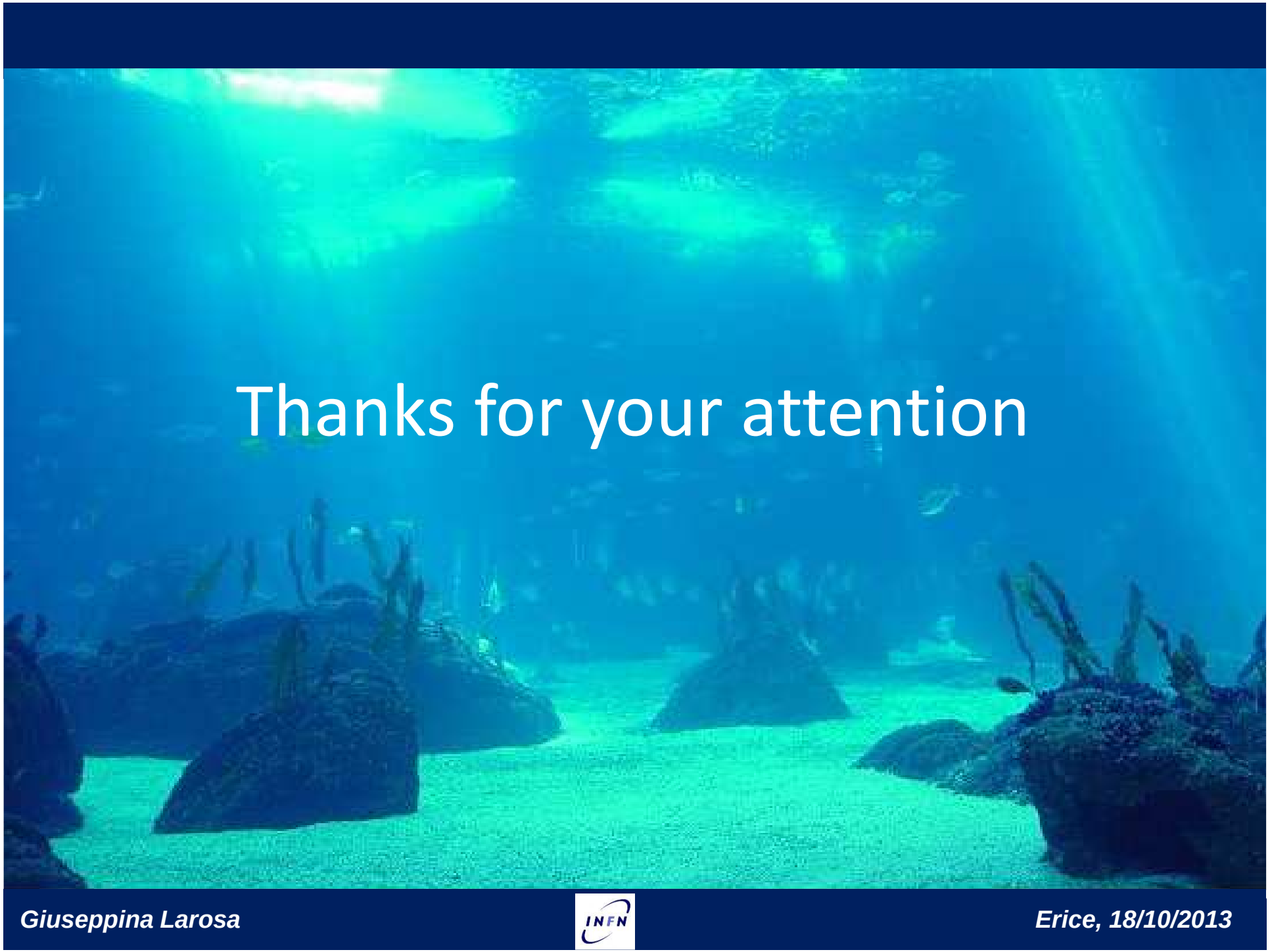
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