SMO acoustic array: calibrations and first results

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CETACEAN ECOLOCATION – OUTER SPACE NEUTRINOS

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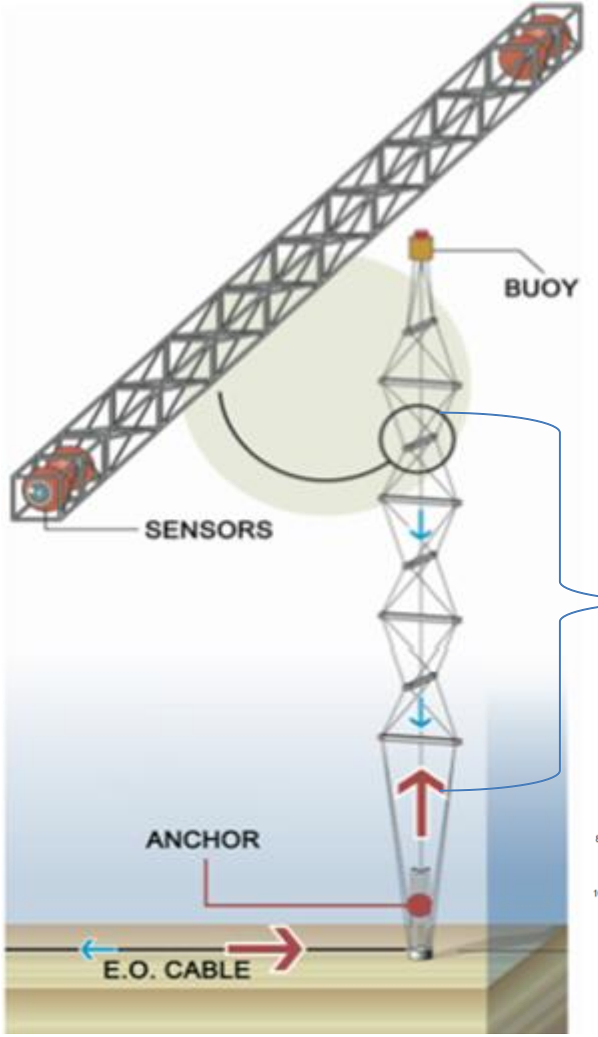
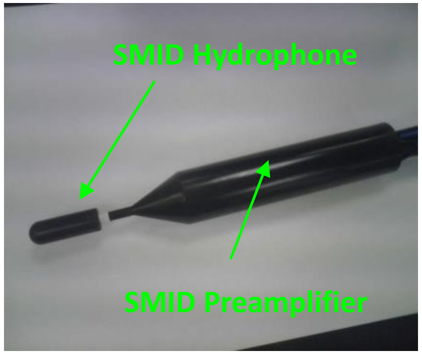
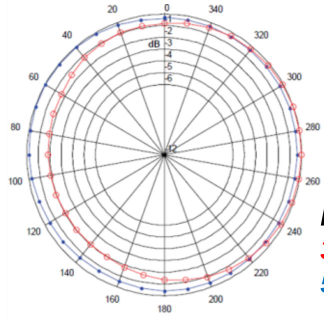
The Submarine Multidisciplinary Observatory Project

The SMO (Submarine Multidisciplinary Observatory) project, funded by MIUR – FIRB 2008, consists of a 3D array of 10 acoustic sensors installed onboard five floors of the NEMO – Phase II tower, installed in Capo Passero site at 3500 m depth.

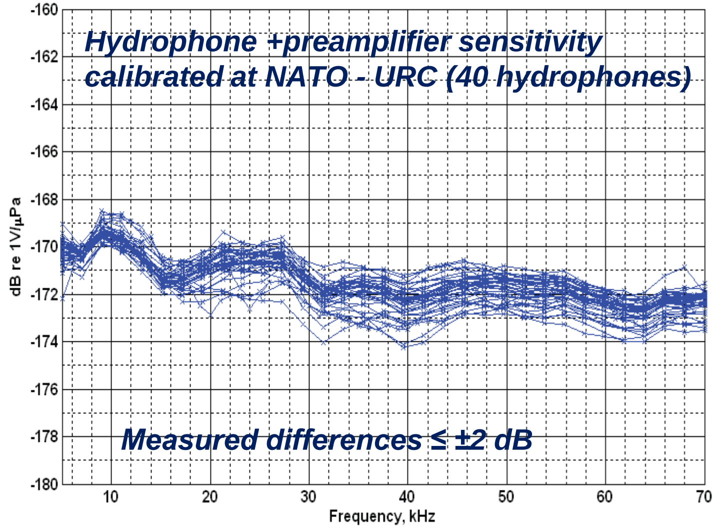


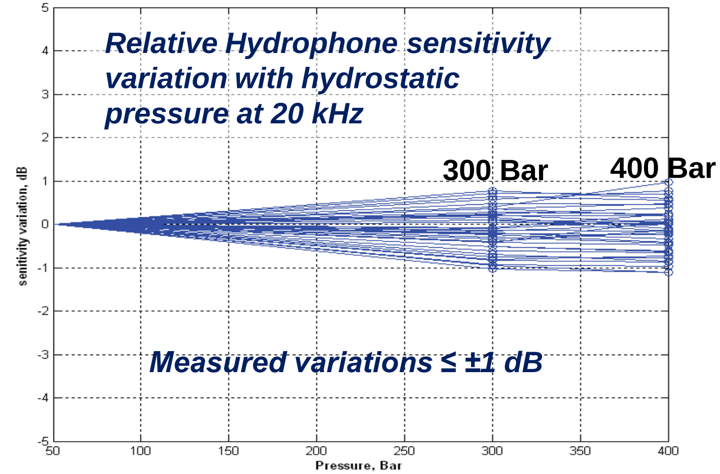
SMID TECHNOLOGY





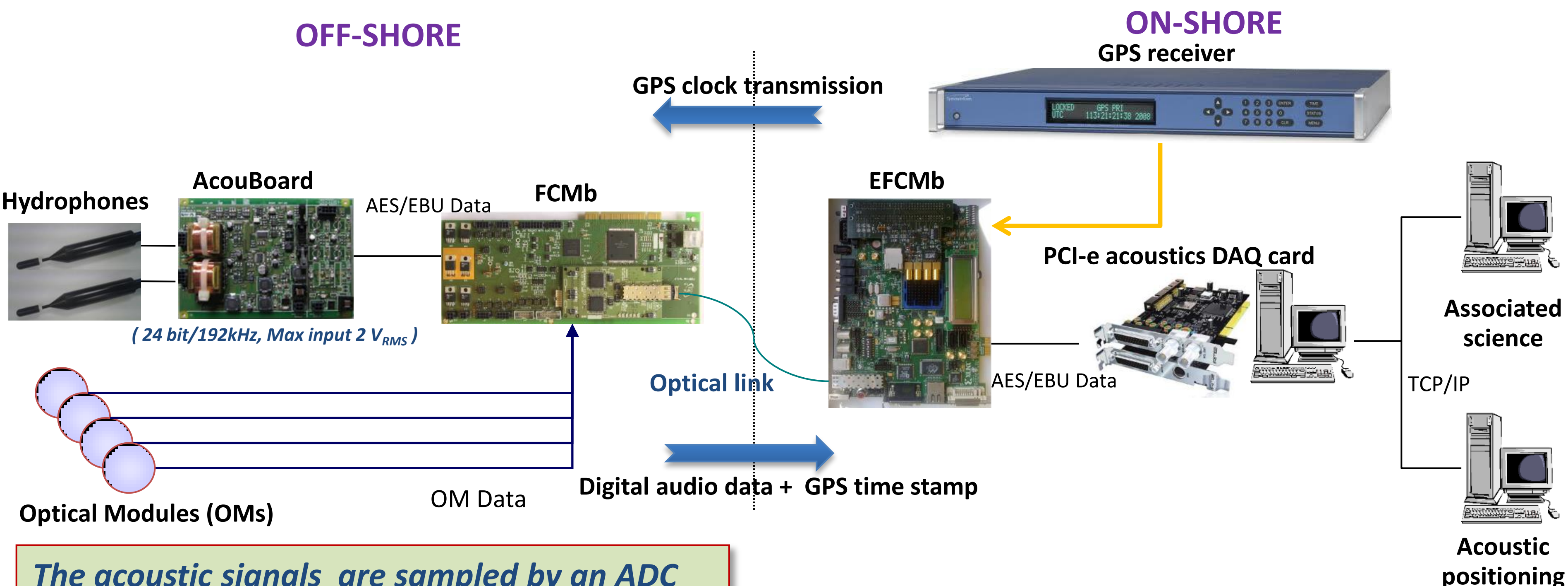
Radiation lobe
30 kHz
50 kHz





NEMO-SMO data acquisition system

The hydrophones data acquisition chain is based on "all data to shore" philosophy, raw data are continuously transmitted to shore on a local internet network at the shore station. Data from/to each floor are transmitted through a "point to point" communication on optical fibre.

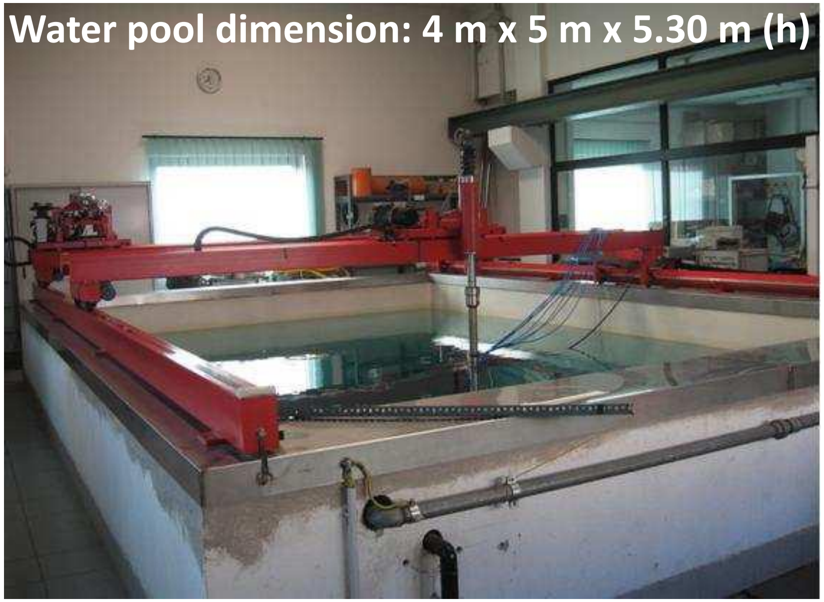


The acoustic signals are sampled by an ADC and "labeled" with GPS time by the Floor Control Module board (FCMb) off -shore

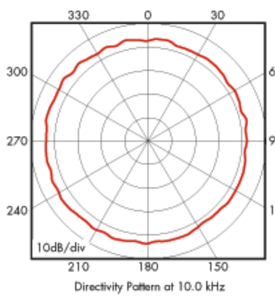
Optical and Acoustic array synchronous and phased with absolute GPS time

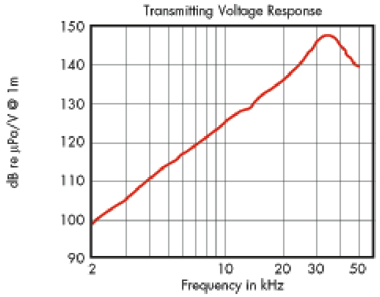
Tests in water pool

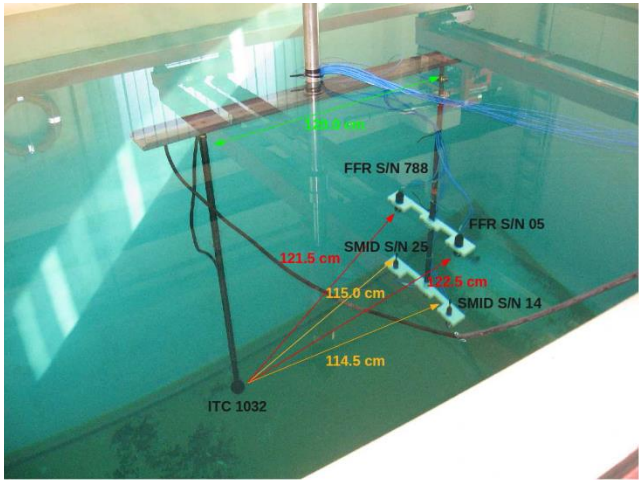
In November 2011 two full SMO floors were tested at the calibration water pool facility of CNR-IDASC (Istituto di Acustica e Sensoristica “Orso Mario Corbino”) of Rome using a calibrated acoustic source.

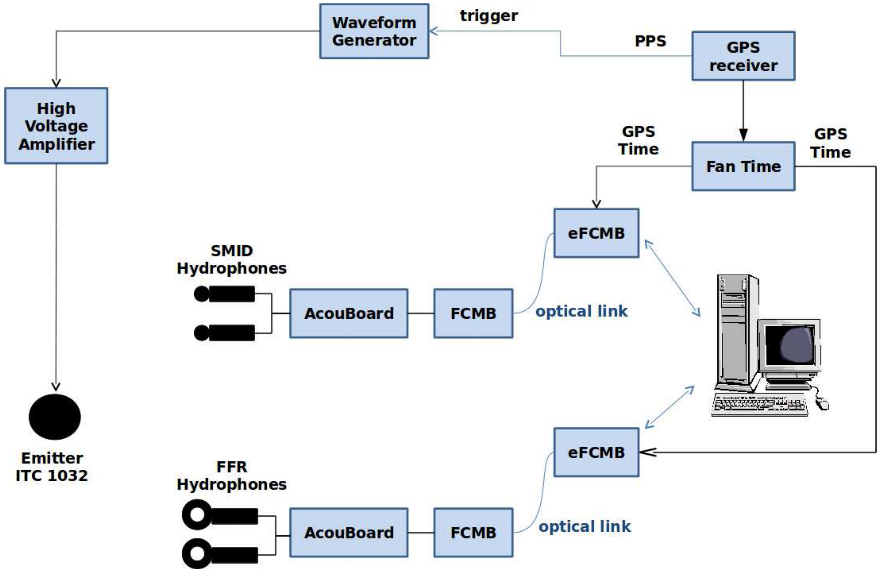


ITC 1032 Transducer



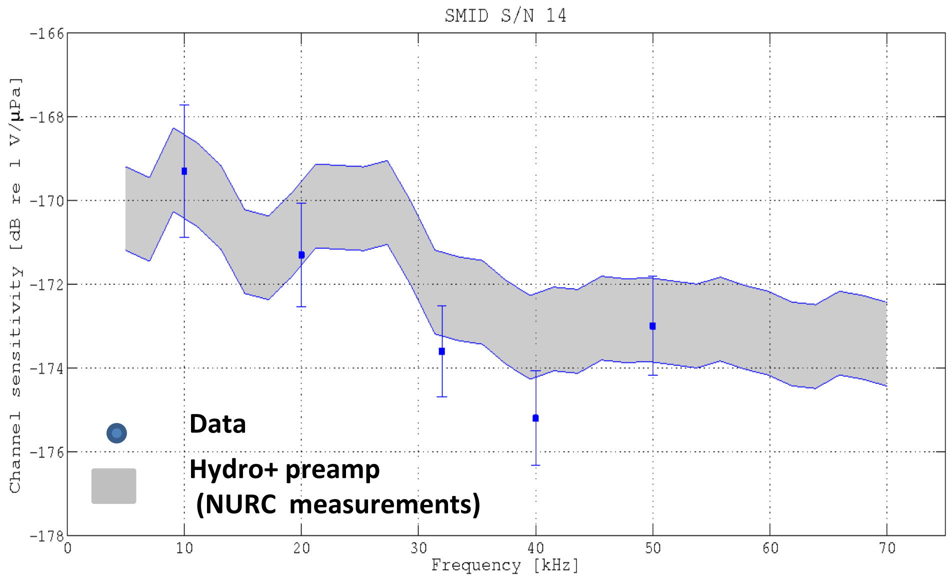




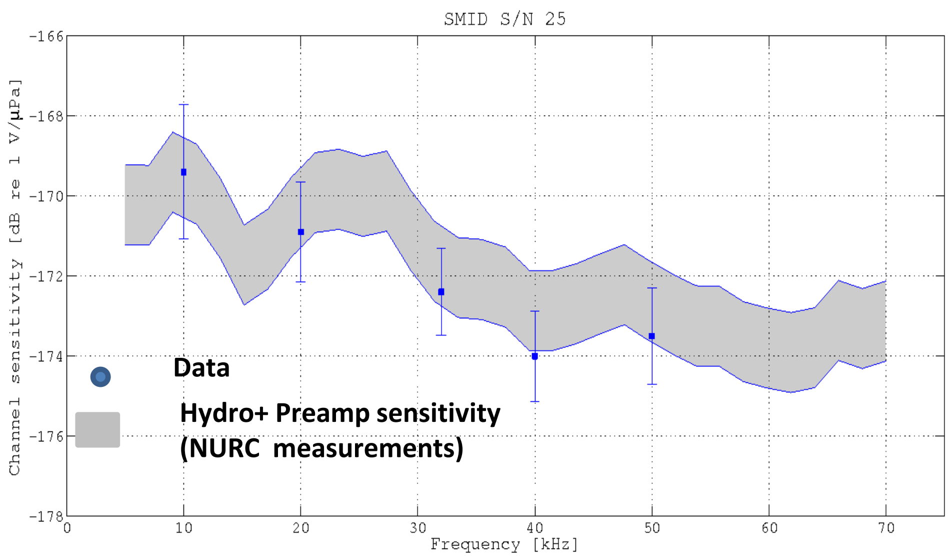


Test in water pool: sensitivity measurements

The sensitivity as a function of the frequency of the whole SMO data acquisition channel (blue dots) has been measured taking into account the transmitting voltage response of the emitter and the geometrical setup.



Data acquisition electronics of SMO does not introduce further undetermined amplification coefficients on the measurement of the acoustic wave amplitude



Time synchronization of the NEMO-SMO detector

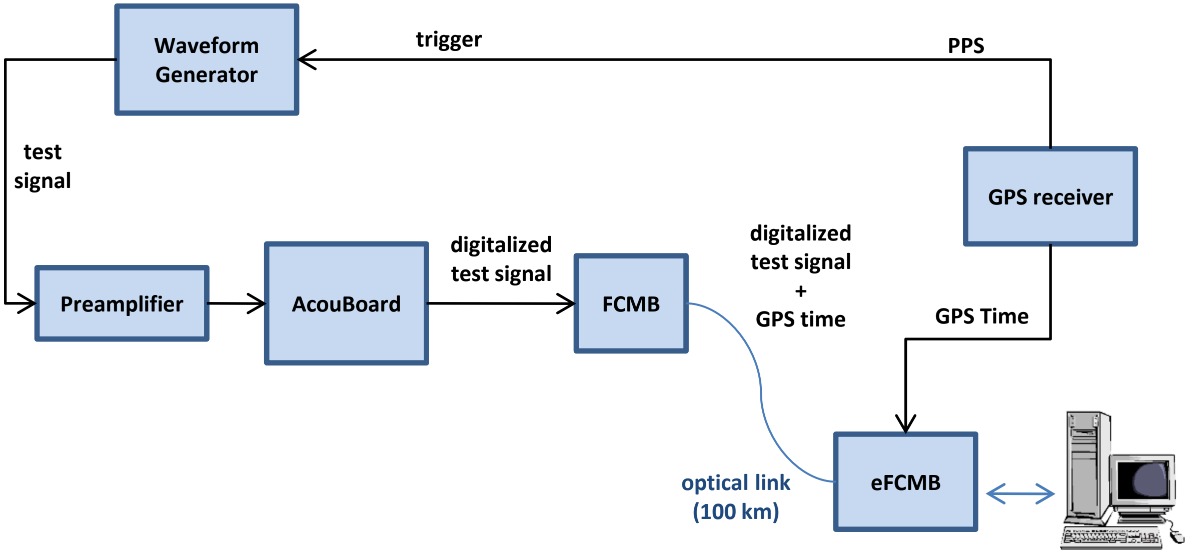
*The accuracy on the measurement of the arrival time of acoustic signals on the hydrophones depends on **the accuracy of the latency time of the whole data acquisition system.***

The latency time of whole data acquisition system depends on:

1. **Electronic boards latency**
2. **Hydrophone's ceramics latency**

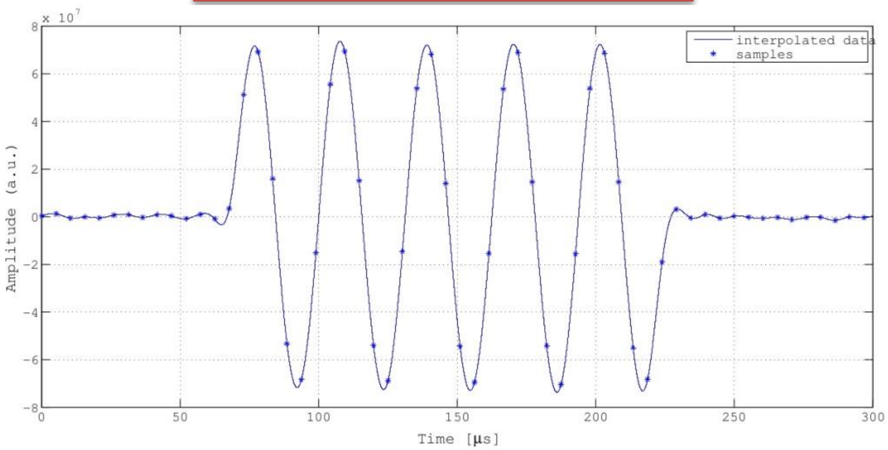
Electronics latency measurement

The electronics time latency (T_{el}) has been measured for each floor of the detector



$$T_{el} = T_{acq} - T_{PPS} - (T_{gen} + T_{cabling})$$

Test signal:



Test signal frequency: 32 kHz
Re-sampling frequency: 192 MHz

Floor #1 electronics latency = 39.325 µs ± 0.045 µs

Run	Latency time (μs)	Run	Latency time (μs)
1	39.320	11	39.350
2	39.349	12	39.268
3	39.259	13	39.359
4	39.358	14	39.267
5	39.294	15	39.319
6	39.395	16	39.341
7	39.346	17	39.285
8	39.391	18	39.337
9	39.297	19	39.278
10	39.288	20	39.380

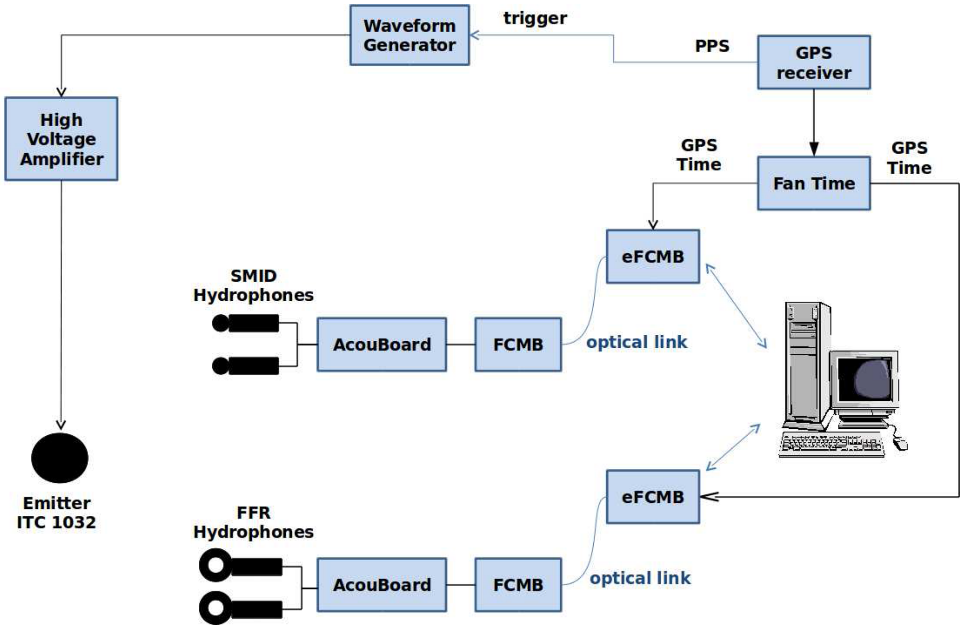
Hydrophone's ceramics latency measurement

The measurement of the ToA (Time of Arrival) of the acoustic signal to the hydrophones depends also on the latency introduced by mechanical movements of the hydrophones ceramics.

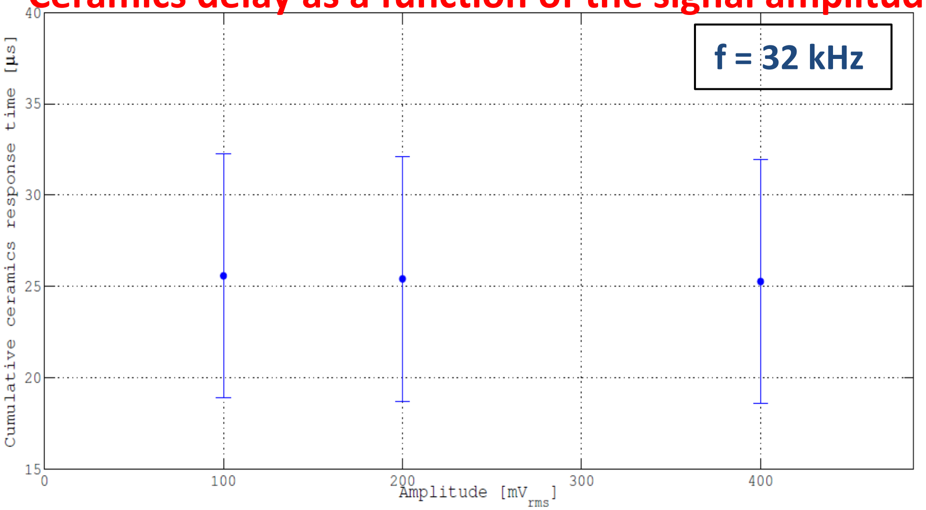
The cumulative ceramics response time of the hydrophones and of the emitting ceramics (T_{cer}) has been evaluated by the following relation:

$$T_{cer} = T_{acq} - T_{PPS} - (T_{gen} + T_{cabling} + T_{el} + T_{geom})$$

CNR-IDASC water-pool test bench



Ceramics delay as a function of the signal amplitude



Cumulative ceramics response time (emitter + receiver) as a function of the amplitude of the input electrical signal produced by the waveform generator.

T_{cer} ~ 25 µs ± 7µs equivalent to a distance of ~ 4 cm ± 1 cm

(ITC 1032 Emitter diameter = 7 cm)

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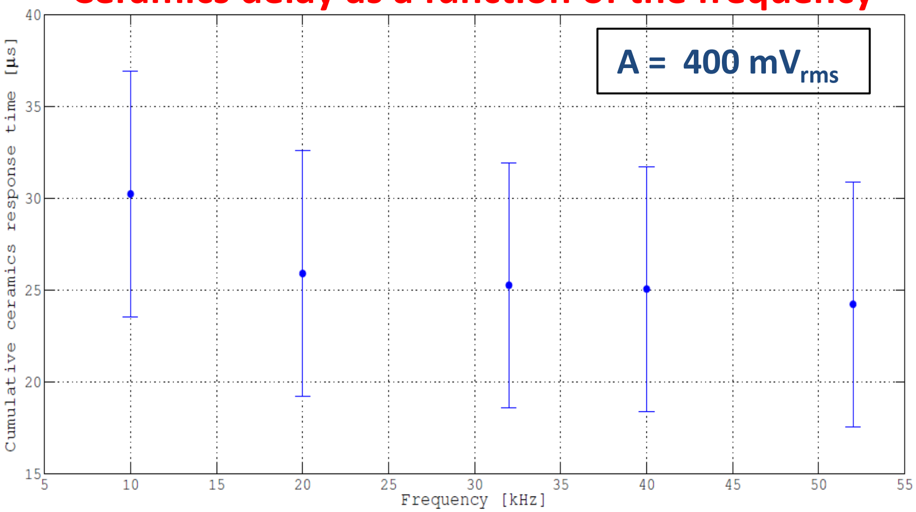
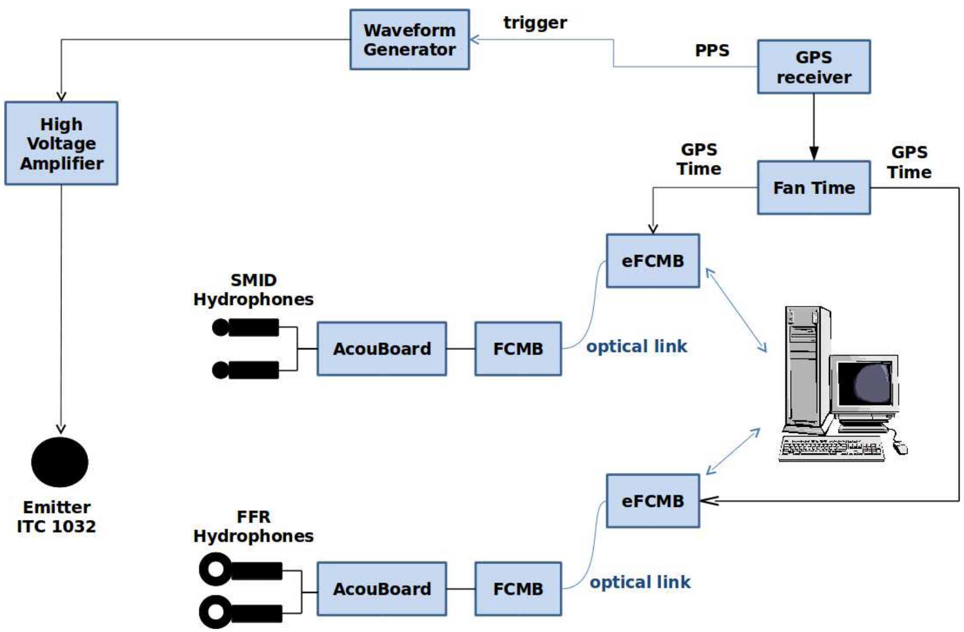
Ceramics delay as a function of the frequency



CNR-IDASC water-pool test bench



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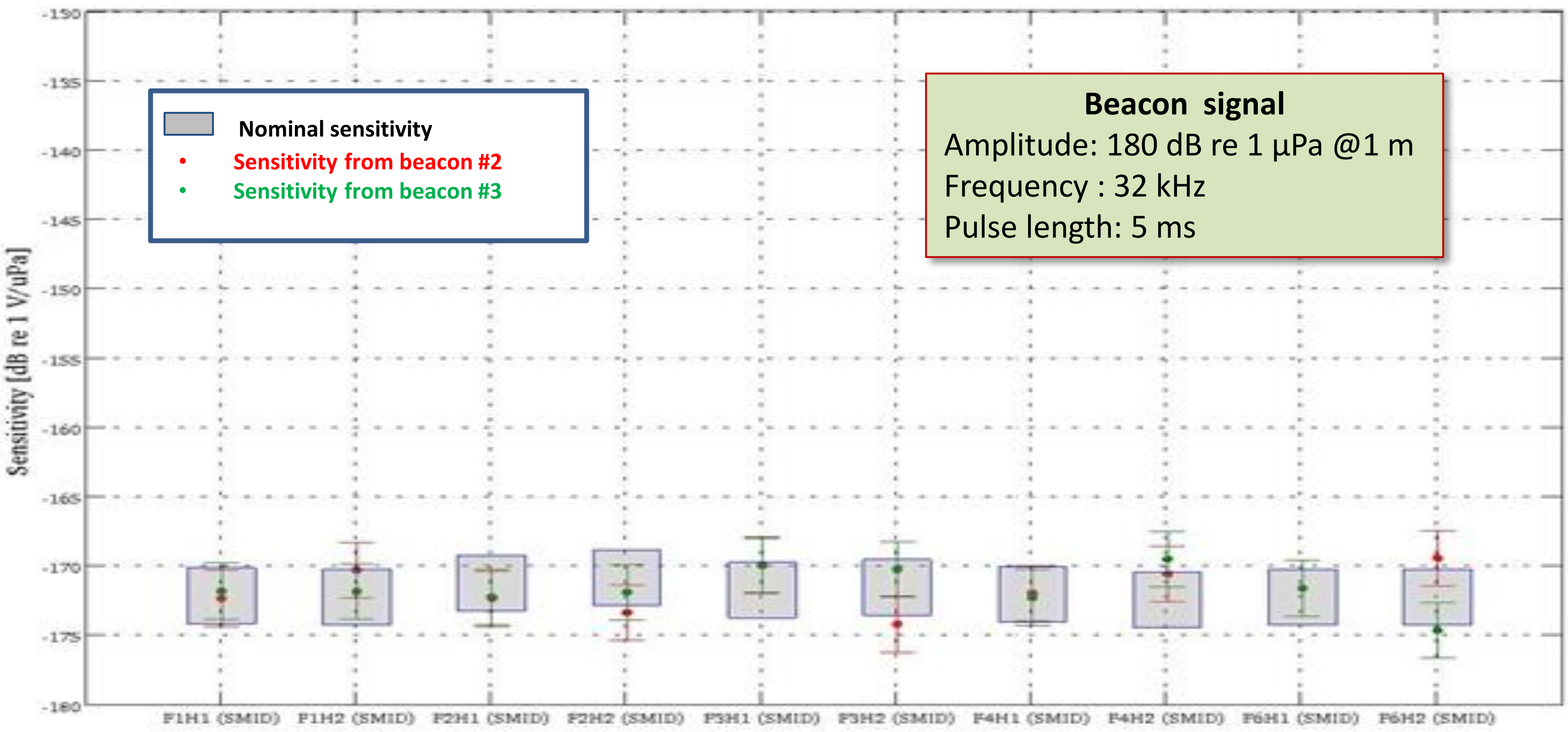
SMO first results from deep sea

Acoustic signals at 32 kHz from external beacons (about 400 m far from tower base) confirm the nominal sensitivity of SMO hydrophones.

Sensitivity has been calculated taking into account the geometrical attenuation and absorption related to the ionic relaxation of $MgSO_4$ and $B(OH)_3$.



Conclusions

- Point to point DAQ

  Calibrations on a single floor can be extended to all floors of the SMO array

- All sensors are working with the expected performances

- All acoustic data are synchronized and phased with the absolute GPS time

  → Time synchronization of extended acoustic array

  → Studies on opto-acoustic correlations for high energy neutrino detection

Thank you