

First results from the NEMO Test Site

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Abstract. The NEMO (NEutrino Mediterranean Observatory) Collaboration is constructing, 25 km E from Catania (Sicily) at 2000 m depth, an underwater test site to perform long-term tests of prototypes and new technologies for an underwater high energy neutrino detector in the Mediterranean Sea. In this framework the collaboration deployed and operated an experimental apparatus for on-line monitoring of deep-sea noise. The station is equipped with 4 hydrophones operational in the range 30 Hz - 40 kHz. This interval of frequencies matches the range suitable for acoustic detection of high energy neutrino-induced showers in water. Hydrophone signals are digitized underwater at 96 kHz sampling frequency and 24 bits resolution. A custom software was developed to record data on high resolution 4-channels PCM file. Data are used to model underwater acoustic noise as a function of frequency and time, a mandatory parameter for future acoustic neutrino detectors. Results indicate that the average noise in the site is compatible with noise produced in condition of sea surface agitation (sea state.)

1. Introduction

An important issue in experimental astroparticle physics is the realization of underwater km^3 neutrino telescopes for high energy neutrinos. Proposed affordable detectors (NEMO [1], ICECUBE [2]), equipped with ~ 5000 PMTs, are expected to reach detection areas of km^2 at $E_\mu = 1\div 100$ TeV and to detect astrophysical point-like and diffuse neutrino fluxes originated by several astrophysical sources. At higher energies (more than 10^{18} EeV) however, the expected neutrino fluxes are fainter and detectors with detection areas $>10 \text{ km}^2$ are required. The advantage of acoustic detection [3] is the long absorption length of sound in water: in this frequency range, it is of the order of km. A pioneering work on identification of acoustic neutrino signatures has been recently conducted using military arrays of hydrophones [4, 5]. Due to the small amplitude of the bipolar signal, it is mandatory to measure the acoustic noise in the sea as a function of frequency in order to study the performances of a future acoustic detectors as a function of number of sensors [6]. At present, only few measurements of acoustic noise have been carried out at very large depth, where acoustic detectors should be presumably located. In order to measure the level of acoustic noise in deep Mediterranean Sea, we have constructed and operated the experimental station $O\nu\text{DE}$ (Ocean noise Detection Experiment), a real-time experiment to monitor acoustic signals in deep sea. The detector was deployed on January 2005 at 2000 m depth, 25 km E offshore the port of Catania (Sicily) where the NEMO Collaboration is installing a *Test Site* to test prototypes for the future km^3 detector. The station is still in operation and it will be disconnected when the NEMO Phase 1 will be installed (November 2006).

2. The O ν DE acoustic station

The O ν DE apparatus is designed to perform on-line monitoring of the acoustic noise at large depth. The station is equipped with four large bandwidth hydrophones (30 Hz - 40 kHz) located on a tetragon of 1 m side at about 2.5 m above the seabed (2000 m). Each hydrophone (hereafter H1, H2, H3 and H4) is mounted on an aluminum alloy vessel, pressure resistant, which also hosts the hydrophone preamplifier. We used TC-4042C hydrophones, manufactured by *RESON* for NEMO to operate at 250 bar pressure for long term deployment. The TC-4042C are piezoelectric omnidirectional sensors with differential output, having a nominal receiving sensitivity of -193 ± 3 dB re $1\text{V}/\mu\text{Pa}$, linear over a wide range of frequencies: from few tens Hz to about 50 kHz. On channel H4 a hydrophone TC-4042 series (with lower sensitivity) was mounted. The differential output of the hydrophone is feeded into a preamplifier, developed also by *RESON*, which have a gain of 20 db. We modified two preamps (namely the ones of H2 and H4) applying a hi-pass filter (> 1 kHz, 6 db per octave) to reduce most of the expected low frequency ambient noise, which has typically $1/f$ spectrum. This was done to better investigate the range of frequency more interesting for neutrino detection (> 10 kHz). On the other hand the use of a pair of unfiltered large-bandwidth hydrophones allows the comparison with bibliographic data, more abundant for low frequency measurements. The analog signals from preamps are transmitted, through underwater cables suitable for audio applications, to a glass housing that hosts the digitization, data transmission and power distribution electronics. Analog signals are digitized, at 96 kHz sampling rate and 24 bits resolution by means of a pair of CS5360 sigma delta stereo ADC. Signals are translated into optical and sent to shore through optical fibers. On shore, optical signals are reconverted into electrical and recorded using a PC, in which a pair of professional PCI audio boards are mounted. A custom software (*SeaRecorder*), running under Windows-XP was developed by CIBRA [7] to store data from the 4 channels into a single .wav audio file. In Figure 1 we plot the average power spectral density of signals recorded by the the four hydrophones during July 8. As expected H4 shows a sensitivity about 6 dB less than the other hydrophones. The peaks at 3, 16 and 18 kHz are attributed to the filtering stage in the preamplifier (the peak at 3 kHz is also present in H2). Moreover a dip at 10 kHz is observed for all channels, this effect, not observed in air calibration, is attributed to a reflection effect on the aluminum vessel which hosts the hydrophone. A more detailed analysis of these effects is under way.

3. Data analysis and results

After an initial period of continuous recording we have decided to record data for 5 minutes every hour. This choice allows to sample underwater noise with good statistic and reduce the storage space required daily to about 10.2 GB.

In Figure 1 we present the average noise sound pressure level recorded by the uppermost hydrophone (H3), from June 2005 to December 2005. Since a complete detector calibration could not be afforded before the deployment, we determined the sensitivity of the channel as -175 ± 3 dB re $\text{V}/\mu\text{Pa}$; a better estimation of the channel sensitivity is under study. In the same figure we plot, for comparison, Urick's [8] data of underwater noise as a function of sea state. Results indicated that at high frequency (> 10 kHz) acoustic noise is about 24 ± 3 dB re $\mu\text{Pa}^2/\text{Hz}$ with small statistical variations, at lower frequencies the noise increases due to biological, seismic and (mainly) navigation noise.

4. Conclusions

The O ν DE station is fully operational at the NEMO test site of Catania since Jan 22nd 2005. The station transmits data 24h/24h. Data analysis is presently addressed to characterize the underwater noise level and its variations as a function of time. The analysis of data recorded in the time interval June-December 2005, shows that the average noise level is 24 ± 3 dB re $\mu\text{Pa}^2/\text{Hz}$

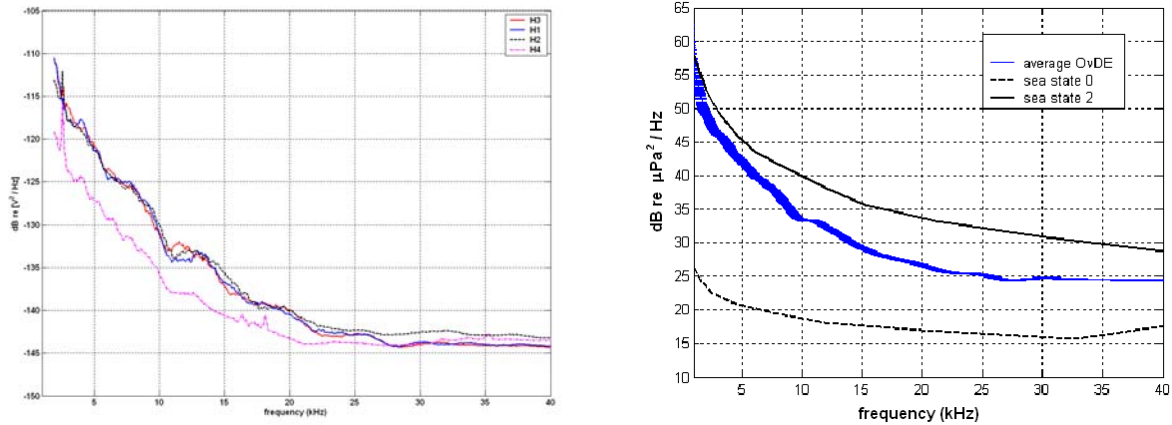


Figure 1. Left: Average power spectral density of signals recorded by the four hydrophones on July 8. Noise is indicated in dB re $V^2/\mu\text{Hz}$. Right: Average sound pressure level of underwater noise recorded between June and December 2005. We estimate hydrophone and DAQ chain sensitivity to be -173 ± 3 dB re $V/\mu\text{Pa}$. Statistical errors are reported.

in the frequency range of interest for acoustic detection (>15 kHz). Localization of noise sources using the 4 hydrophones data together is presently under development. Recorded data set is also extensively used for interdisciplinary studies mainly addressed to search for cetaceans in the region.

References

- [1] Riccobene G for the NEMO Collaboration 2006 *Results from NEMO and Km3Net, these proceedings*
- [2] Ahrens J et al. 2004 *Astrop. Phys.* **20** 507
- [3] Askarjan G 1957 *Atomnaya Energia* **3** 153
- [4] Vandenbroucke J et al. 2005 *Astroph. J.* **621** 301 <http://www-zeuthen.desy.de/arena>
- [5] Danaher S et al. 2006 *Proc. of 2nd ARENA Workshop* (Newcastle, UK) <http://www.shef.ac.uk/physics/arena>
- [6] Karg T et al. 2005 *Proc. of 1st ARENA Workshop* (DESY Zeuthen, Germany) <http://www-zeuthen.desy.de/arena>
- [7] www.unipv.it/webcib
- [8] Urlick R J 1983 *Principles of underwater sound* McGaw-Hill