PORFIDO

Physical Oceanography by

RFID

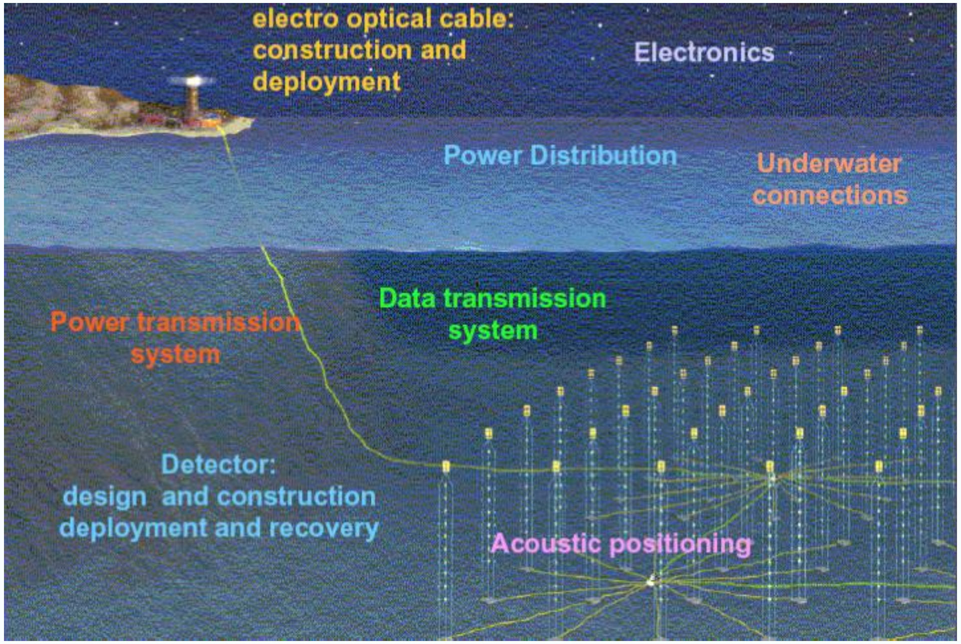
Outreach

Marco Cordelli INFN LNF - NIKHEF May 25, 2012

- Neutrino telescopes are large underwater detectors at the bottom of the sea, connected to the shore by an electro-optical cable.

- The detection of low fluxes of neutrinos, very elusive particles, requires a detector with a huge sensitive volume, which should be effectively shielded from the overwhelming background from atmospheric cosmic rays.

- A viable solution is to build a large array of light sensors in a transparent medium, such as seawater. Sensitive elements like photomultipliers can then detect the Čerenkov light emitted by neutrino interactions inside the apparatus or in its immediate surroundings.



- 1 km^3 equipped with 1 optical module every 50 m (8000) in the Mediterranean sea
- 3500 m in depth for shielding from cosmic rays
- continuous data transmission through underwater optical fiber cable to shore
- 10 years operation
- Oceanographic data for free

- The sensitive elements, Optical Modules (OM), are 12 mm thick glass spheres, containing one or more photomultiplier tubes and related electronics.

- Typical oceanographic data are collected by deploying self contained instruments anchored to the bottom of the sea.

- After a period of weeks or months when the batteries have died, the devices have to be resurfaced to collect the acquired data.

- A neutrino telescope installation offers new and revolutionary possibilities to the oceanographic community allowing to collect data continuously and in real time.

- A very small fraction of power and data bandwidth available trough the underwater electro-optical cable, which carries power to the telescope and data back to shore, is sufficient to collect relevant oceanographic data.

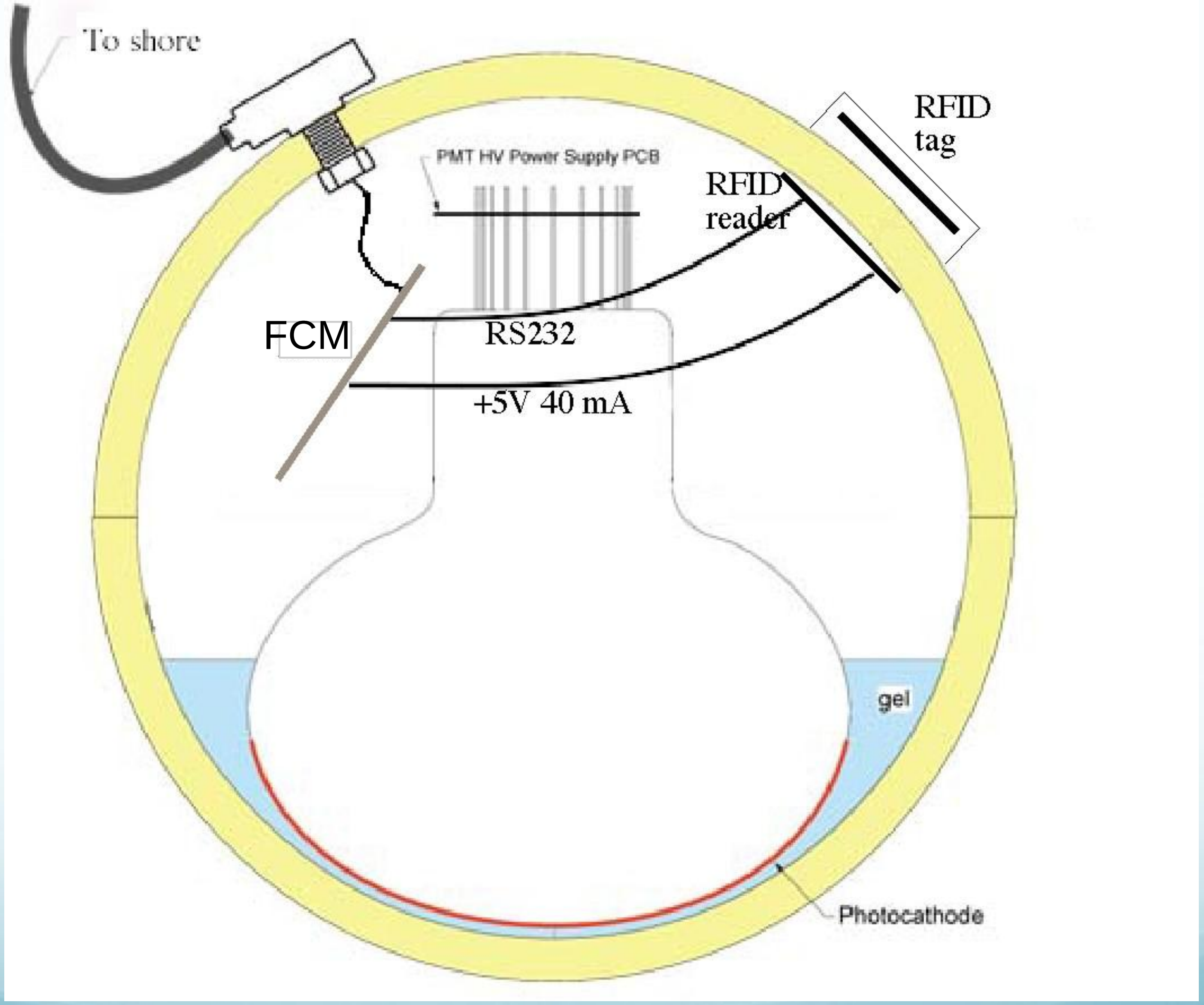
- The problem is to interfere as little as possible with the neutrino detector; this achieved by using small probes and avoiding the need of connectors or penetrators that are very expensive and that offer low reliability, a requirement that is essential in a prohibitive environment.

We have built such a system, PORFIDO, using the well established technique of RFID to gather data through the glass spheres of the Optical Modules and to supply power to the sensors with the RF itself.

PORFIDO is made up of two elements:

- The Sensor, which is glued outside of the Optical Module and gathers data directly from the seawater
- The Reader, inside the OM, reads the measured data through the glass using RFID, and communicates with the OM electronics to send the data to shore.

Optical Module with PORFIDO probe schematic



RFID

Radio **F**requency **Id**entification is a technology that has been developed for access control, and is spreading widely in this and other fields.

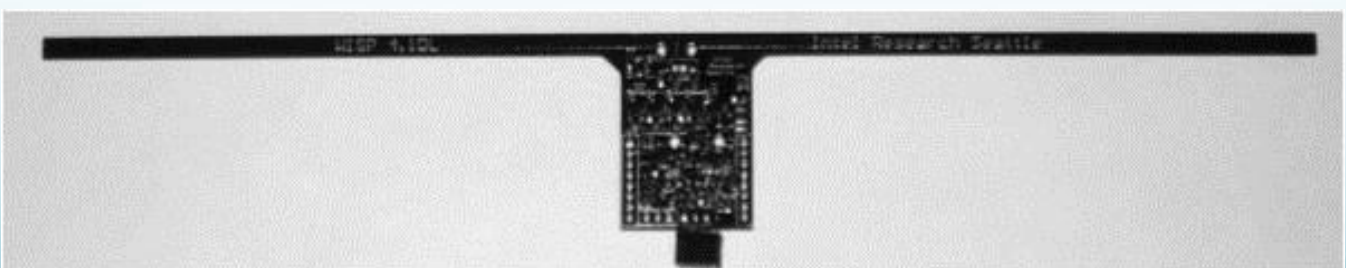
In the standard setup, a Reader emits an RF beam, and the responding unit (Tag) answers with its own identity code, parasitizing power from the RF itself and thus eliminating the need for batteries.

Recent developments have focused on adding to the Tag the possibility to take measurements in the environment and transmit them to the Reader

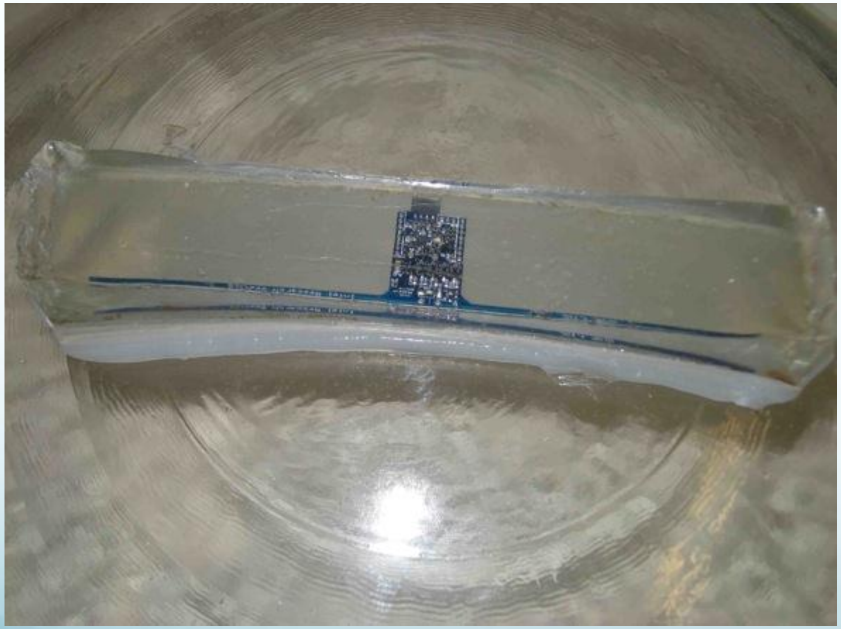
Tag - WISP

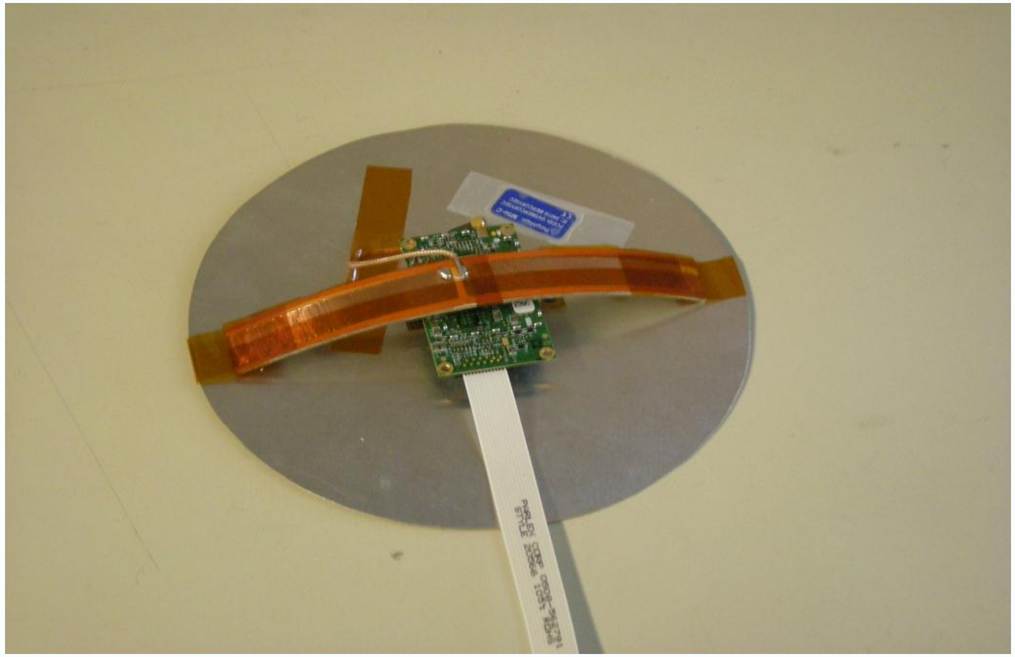
We have used as RFID Tag the WISP, developed in Seattle.

- It is passive (no batteries)
- A thermometer and an accelerometer are on board
- Designed with an open architecture to include new sensors



- It can stand very well the extreme conditions that we require, namely 30 MPa (300 atm) pressure and the exposure to seawater, if protected.
- For this purpose we potted the WISP in a marine two component epoxy.





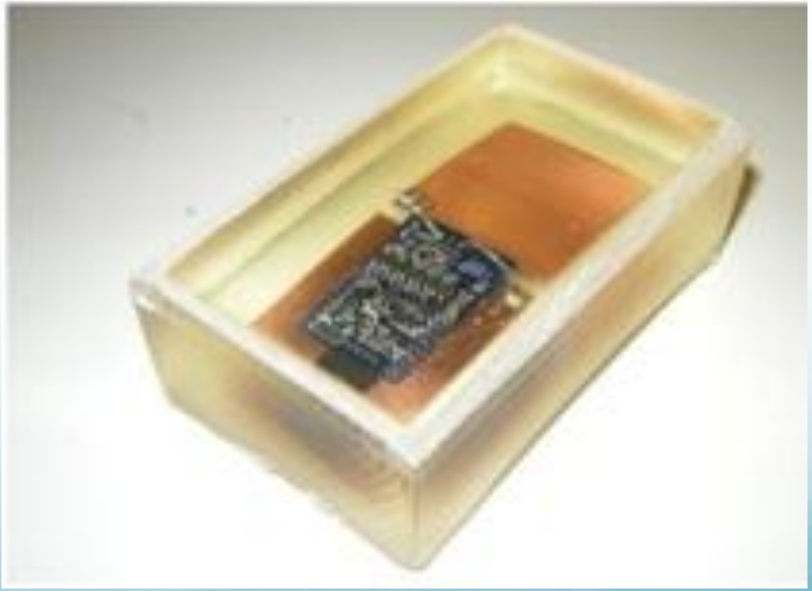
First assembly of the Rider with antenna and EM shild

The dipole antennas used for RFID proved adequate but difficult to handle, being very sensitive to the presence of conductive materials in the vicinity of the reader.

But..

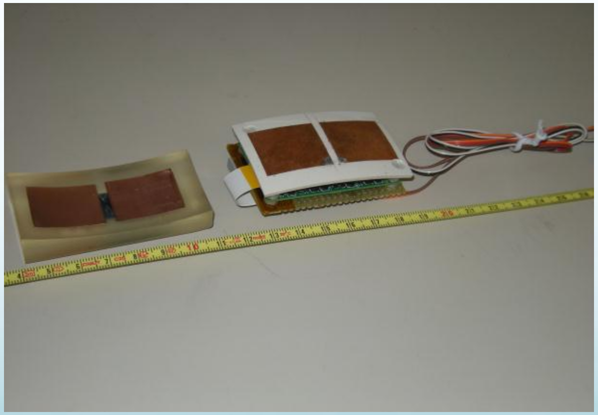
- An emitter and a receiver at a distance of only 12 mm and with glass in between, it's more similar to a capacitor than a transmitter - receiver pair.

Therefore we discarded the long dipoles, cutting the wings of the WISP, and built two capacitors using square copper pads, 25x25 mm^2, facing each other on the two sides of the glass.

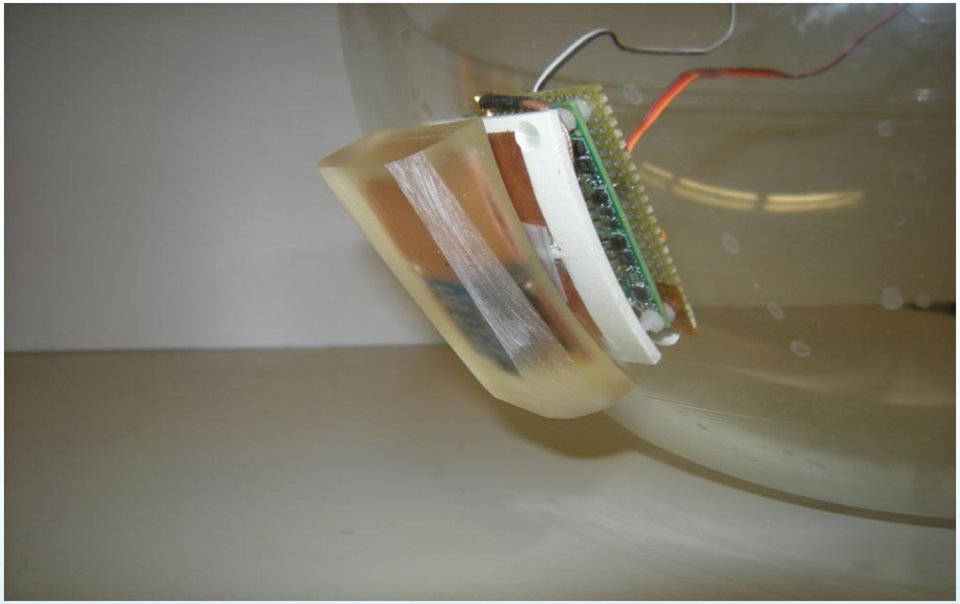


The results were excellent. The system was:

- much more stable
- immune to the presence of metal in the surrounding space
- we were able to decrease the reader RF power by a factor of 10.
- The dimensions decreased to the size of the reader (70x40 $mm^{2)}$).



The area covered by PORFIDO results very small compared to the total surface of the glass sphere, making it much easier to incorporate in any new designs for the Optical Modules.



PORFIDO on the Optical Module

We ran a long series of tests to verify the feasibility of the system and the absence of interaction with the electronics of the NEMO Phase 2 tower.

LNS pressure test

Pressure Test

The glass sphere on which PORFIDO had been mounted was immersed in seawater, then put under a pressure of 40 MPa, equivalent to 4000 m depth in sea water

RF Interference test

We also wanted to prove that the RF field generated by the reader does not interfere with the PM tube and with the electronic boards inside the Optical Module.

- OM full armed + PORFIDO
- in a Black box
- with a LED Pulser (single photon)
- Event rate from FEM using different thresholds

No effect!

Power consumption

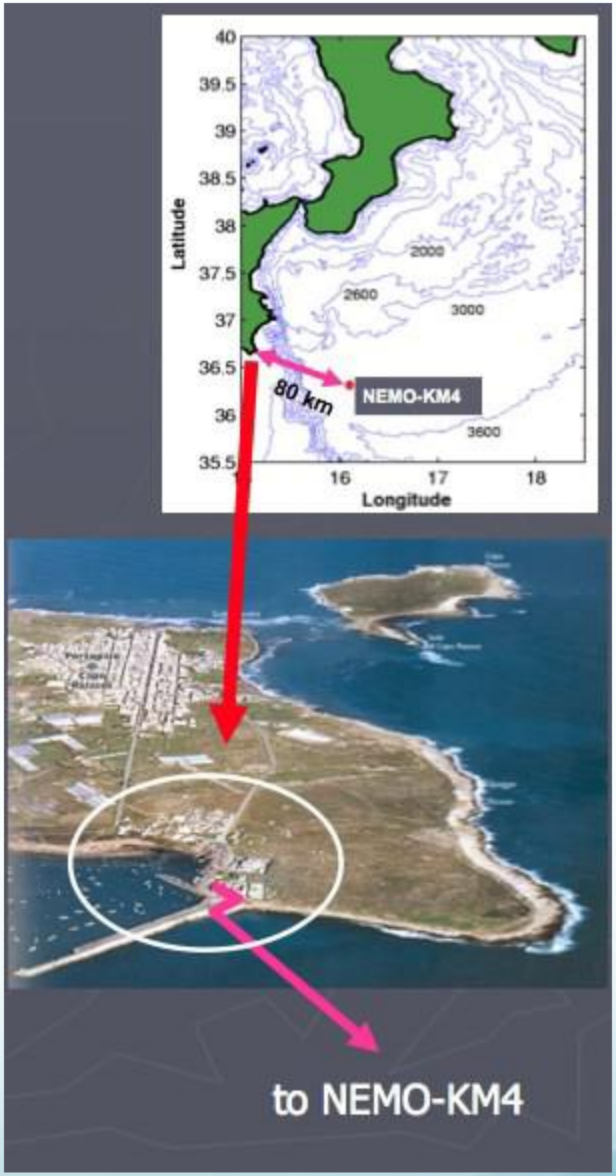
We have strict restrictions on the power available for PORFIDO.

Since the Reader draws about 0.5 A @ 5V for 200 ms, we have installed a 1 F capacitor to store the necessary energy. The capacitor recharges slowly while the reader is inactive.

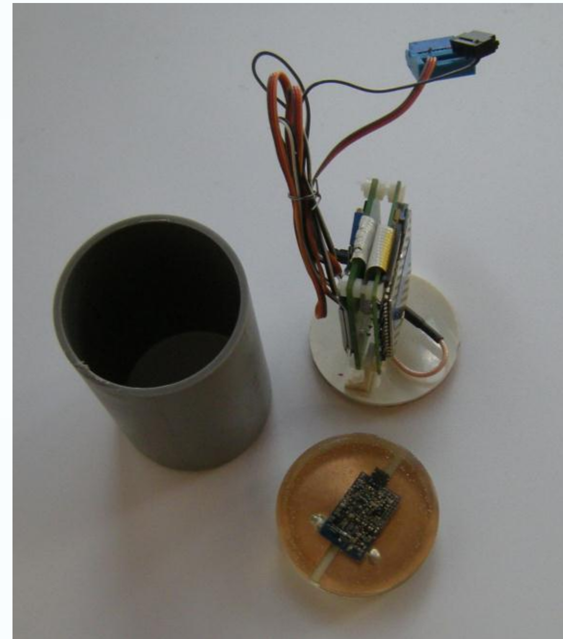
Commands to the reader are sent transparently on a simulated serial connection in the optical fiber data link of NEMO.

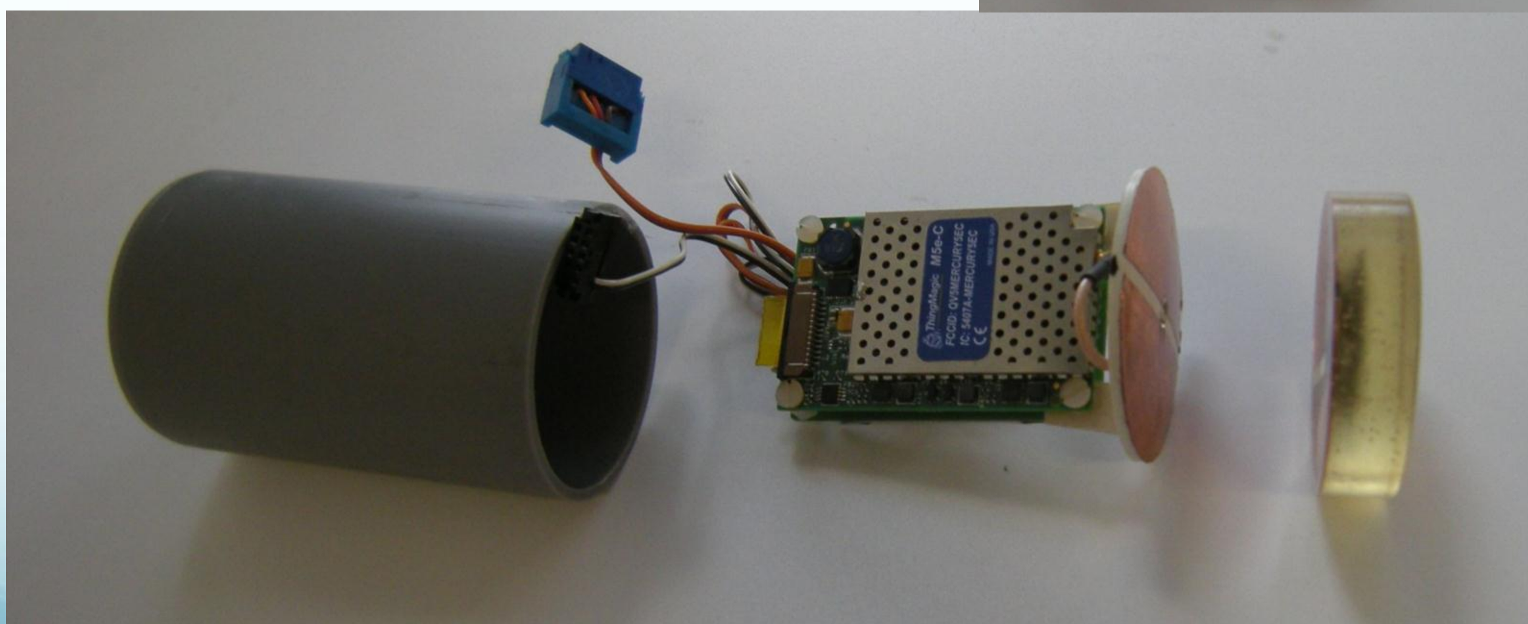
The NEMO group has approved the installation of 4 PORFIDO probes on the Phase 2 tower, that is being built in Catania (Sicily) and will be deployed in summer 2012 in the Capo Passero site.

It will consist of 32 Optical Modules and four PORFIDO probes installed in four different OM.



PORFIDO for DOM





Future Development

The WISP comes with a completely open architecture, so that different kinds of sensors can easily be implemented to work with PORFIDO.

On the first implementation we only used a temperature sensor to prove that the system was functional.

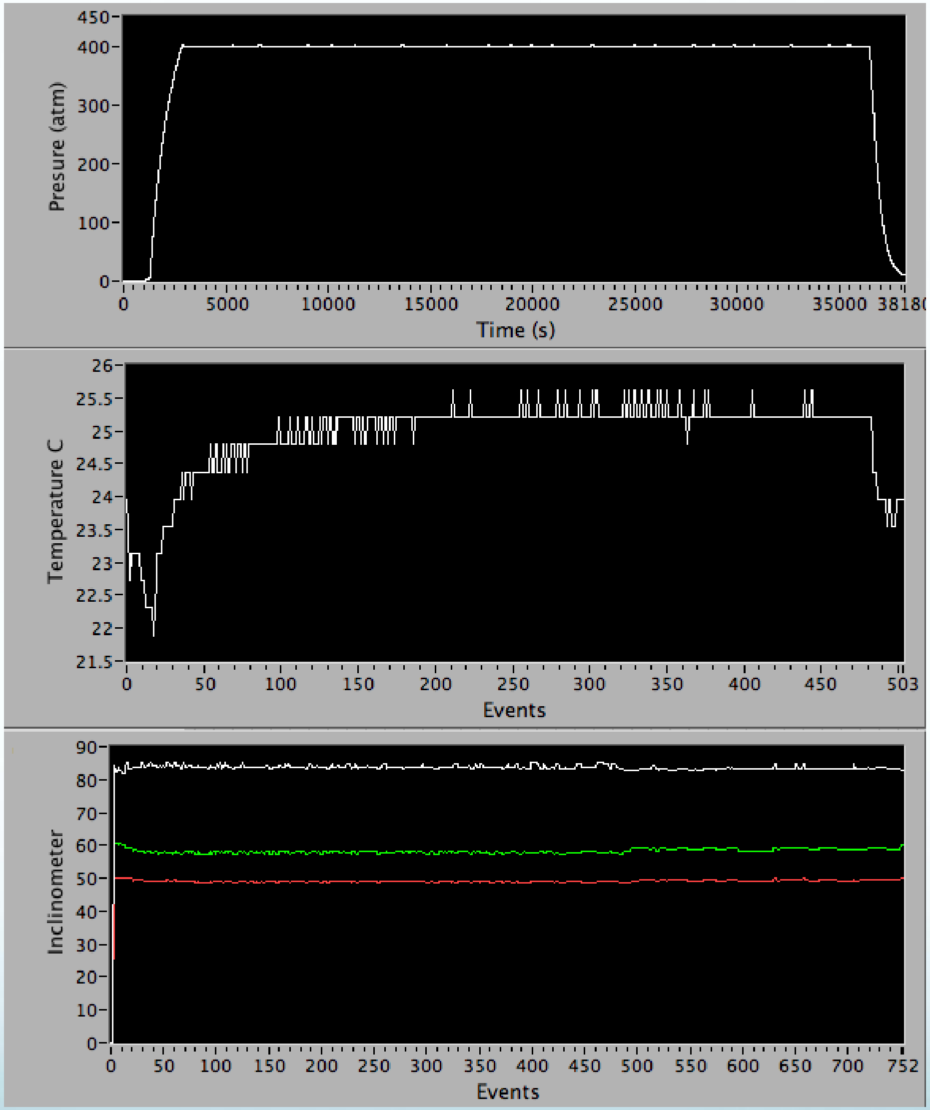
Actually we are working on a salinity sensor and a thermometer monitor with a resolution of 0.001 °C.

Conclusions

The NEMO group has approved the installation of 4 PORFIDO probes, measuring seawater temperature, on the Phase 2 tower that will be deployed in summer 2012 at a depth of 3500 m in the Capo Passero site, and we have integrated it in the system.

We believe that the oceanographic community could greatly benefit by the use of this kind of instrument, an unobtrusive parasite on the Čerenkov neutrino telescopes which will be built in the future.

LNS pressure test results



Data Logger DLOG