NESTOR: a Status Report

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Abstract

NESTOR is an underwater neutrino astrophysics laboratory to be located in the international waters of the southwest of Greece. The first phase of this experiment is the construction and deployment of one hexagonal tower consisting of 168 optical modules, with effective area of $20000m^2$ for $E \geq TeV$ neutrinos. Over the past few years detailed studies of the site have been carried out while many tests have been performed. The current status of the preparation of the experiment and the future plans will be presented.

1 Introduction:

The NESTOR project (Resvanis 1992) is devoted to the construction of a Mediterranean undersea neutrino telescope dedicated to high and ultra high energy neutrino astrophysics. The apparatus will consists of photomultipliers deployed at the marine depth of $3800m$ and will be able to detect the Cerenkov light emitted by relativistic muons crossing the sea water inside and surrounding the detector.

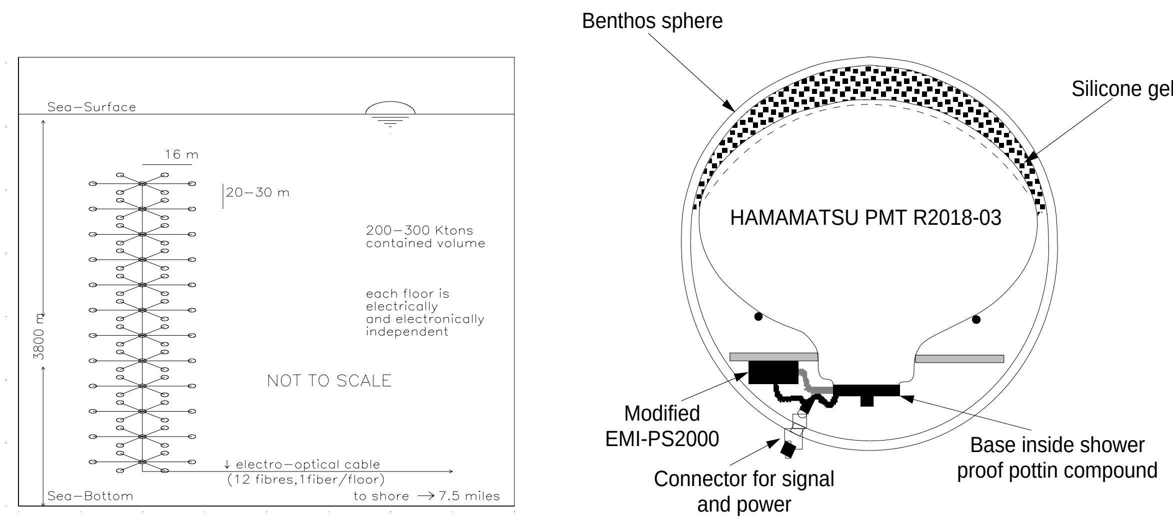

Figure 1: Schematic view of NESTOR tower and optical module

The marine site of the experiment is located at the south west of Peloponnesos, in the Ionian Sea (coordinates : $36^0\,37.5'\,N,\ 21^o\,34.6'\,E$) where has been found a plateau located both at great underwater depth ($3800m$) and at short distance from the coast (13 nautical miles). Several enviromental surveys has been performed in order to qualify the site. The main charactestics (Anassontzis 1994, 1993) are a light transmission lenght of $55 \pm 10m$ at $\lambda = 460\ \ nm$, a neglegible underwater current ($\leq\ 10cm/sec$) and an optical background of $75kHz/PMT$ with threshold of 1/4 of photoelectron (plus some intermittent burst of duration $3-5sec$ with 1% frequency of the experiment live time probably due to bioluminescence activity).

The NESTOR telescope is based on a modular and hence expandable design. The first module will a be a tower consisting of 168 PMTs, while the second step foresee the deployment of 6 more towers around the former. The first tower (fig. 1) of NESTOR consists of 12 hexagonal semirigid floors placed one above the other at $30m$ distance. In each floor a pair of PMTs is positioned at the center and at each vertex of the hexagon (at a distance of $16m$ from the floor center). The PMTs of each pair are positioned one above the other, one looking up and the other looking down, resulting in a completely up-down symmetric detector. Each floor will be electrically and electronically independent from the other floors and will have its own optical fiber for data transmission. The digital electronics for data acquisition and transmission will provide, at the shore station, the complete information on the PMTs pulse height and pulse shape (the latter is important to improve the reconstruction). A $30km$ electro-optical armoured cable, deployed from the coast to the marine site, will garantee the power, the data transmission and the remote controll of the tower. It will be possible to retrieve the tower for "servicing" by activating anchor releases and threby permitting the tower to float to the surface for recovery (see section 3). The physics goals of the project are reviewed in: Sotiriou 1998, Bottai 1997, Bottai 1998.

2 STATUS of the project

The NESTOR tower is prensently under construction and test. During the last two years several new tests has been carried out.

2.1 Deployment Test During 1997 two fully equipped floors were towed, floating, at a speed of 1.5 knots, to the NESTOR site. The two floors were lowered and connected to each other at a distance of $30m$. The structure was connected to an electro-optical cable, which was on board the *Thales*, a cable-laying boat belonging to the Greek Telecommunications Company (OTE). The whole system was deployed to a depth of $2800m$ and recovered the following day. In the return journey the whole structure was towed by the *Thales*, hanging at a depth of $200m$, at a speed of 2 knots relative to the water. Inspection of the recovered apparatus showed that there were no damages to the structure or to the optical modules or to the titanium spheres and all the closed part were free of water or vapor inside.

2.2 Bay Tests During 1998 the oceanographic vessel *Thales* layed, from the NESTOR laboratories in the town of Pylos to the shallow waters of the bay of Navarino, a $4.5km$ electro-optical cable. Since the end of the

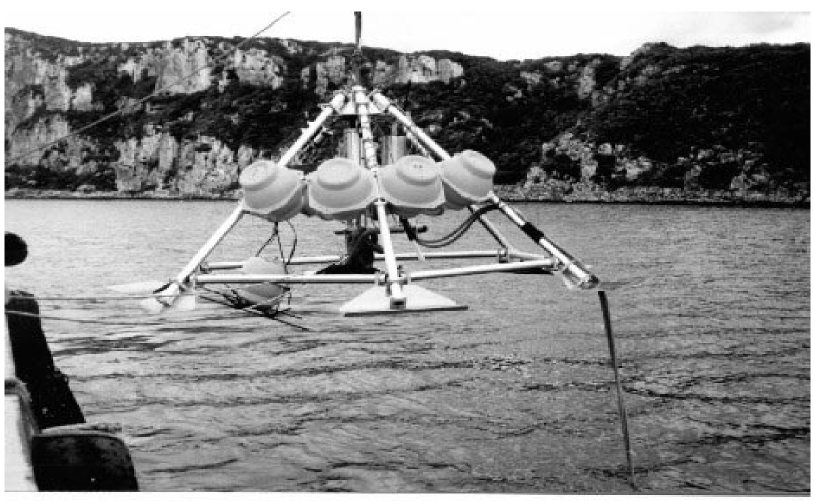

Figure 2: The Anchor + Enviromental Unit during the deployment in the shallow water

cable can be retrieved and redeployed without any limitation, it can be used as permanent and easily reachable test station. During 1998 one fully equipped NESTOR floor was deployed in the Bay of Navarino at a depth of $40m$ and at a distance of $4km$ from the shore station. The optical modules (OMs) had to be protected from the daylight, which is still too strong at $40m$ depth, by covering them with a heat shrinking black plastic. Above the floor one light-tight tube in which water could flow freely was installed, containing two unblackened OMs . A relay system was used to turn power on and off the PMTs. Data from the OMs were successfully transmitted during few days. After that the Bay Test remained operational, transmitting slow controls data coming from a compass ,one inclinometer and three termometers.

On November 1998 the Anchor plus Environmental Unit (EU) (see section 3 and fig 2), was deployed and successfully tested in the Bay test site at 35 m depth. This device a six sided pyramidal construction made out of duraluminium pipes ($70mm$ diameter), approximately 2m high and 4m diameter, with flap like feet, so that it doesn't sink into the clay. It includes 3 thermometers, 3 pressure meters and a nephelometer (measures light attenuation). Attached to the Unit is an OBS (Ocean Bottom Seismometer) that also sends information to the shore. Data is coming through the $4.5km$ electro-optical cable facilities of the Bay Test Station to the NESTOR Institute. The apparatus remaines alive, sending data correctly, during all the following winter and spring.

2.3 Present Availability of Device and Installations All the needed PMTs and Benthos Spheres have been achieved while the production of complete and fully tested OMs continues routinely. At present 40 fully tested OMs are available. The mechanics for 5 floors (2 made of Titanium, 3 of Alluminium) is almost ready and the electronics proposed in the original project (Ameli et al. 1998) is ready for two floors but only tested for 1 floor. An alternative electronics project is now under preparation (Nygren 1999). A bay test facility for long term underwater tests in shallow water is operational. A 31 km long, 18 fiber electro-optical armoured cable has been paid for and can be delivered on a notice. Its deployment is planned for summer 1999.

3 Foreseen Activities

The tests in the Bay of partially and fully equipped floors will take place during the spring and summer 1999. In the meantime the deployment of the long electro-optical cable up to the definitive NESTOR site will open a new era in the NESTOR activities, offering the opportunity for long term tests and operations in very deep water. The armoured electro-optical (EO) cable will be deployed over $30km$ from the shore station in the city of Methoni to the NESTOR marine site, through an undersea path already estabilshed and carefully mapped. The last 6 km of the EO cable will be equipped with deep sea buoys (empty benthospheres inside hard-hats for protection) in order to reduce the weight of the cable itself during the recovery operations. These buoys will be added onto the cable, during the deployment (on the deck of the THALES), in such intervals so that the weight of the cable inside the water will be approximately $100kgf/km$.

The end of the cable will be connected to an Anchor Unit which includes the environmental instruments (at present under test inside the Bay Station). Acoustic releases will be used to drop the anchor weight when requested. An other $150m$ section of cable (fig. 3), starting from the Anchor Unit and connected to a system of buoys (the Main Buoyancy), will stand vertical above the anchor as required. Every experimetal unit, or tower prototype, or the full NESTOR tower have to be attached between the Anchor Unit and the Main Buoyancy and stand vertically, holded by the appropriate positive buoyancy. From the Main Buoyancy start a 5 km buoyant rope. This rope is devoted to the deploy-recovery operations. When the system is immersed in the deep sea the rope, connect on one end to the Main Buoyancy, is fixed to the ground through two anchors, a small anchor (SA) after the first $500m$ and an anchor plus a deep sea buoy at the end. This buoy is connected to the anchor through an acoustic release which, once activated from the surface, will decouple the end of the rope from the anchor weight leaving it free to float up to the surface and enabling the recovery of the telescope with a winch. Every system's unit except the anchor units will have positive buoyancy and the small anchor (SA) is devoted to reduce the water power which is created by the underwater currents.

The activity will be divided in 3 phases, the first two are scheduled for 1999 :

Phase 1) Deploy the system of fig. 3 in which the end of the long electro-optical cable will be connected to the Anchor with the Environmental Unit (EU) and the Main Buoyancy, without any further experimental device.

Phase 2) Recover the instruments of phase 1. Then redeploy the Anchor Unit with the Environmental Instru-

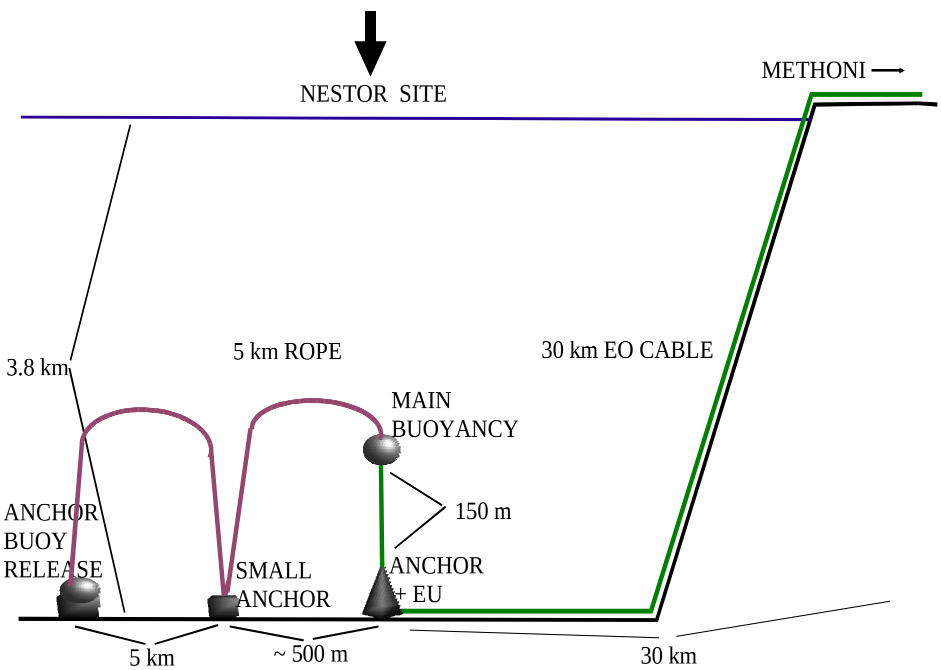

Figure 3: Schematic view of cable deployment

ments with two ”reduced” floors added (”reduced” here means shorter arms, i.e. $5m$ length rather than $15m$ so the diameter of a reduced floor is about $12m$) and the Main Buoyancy.

Phase 3) Recover the telescope of Phase 2 and deploy a NESTOR tower.

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