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Recent achievements of the NEMO project

E. Migneco[a,*], S. Aiello[d], A. Aloisio[o], F. Ameli[i], I. Amore[a,j], M. Anghinolfi[e], A. Anzalone[a], G. Barbarino[o], E. Barbarito[b], M. Battaglieri[e], M. Bazzotti[l], R. Bellotti[k], A. Bersani[n], N. Beverini[p], S. Biagi[l], M. Bonori[q], B. Bouhdaef[p], M. Brescia[o,r], G. Cacopardo[a], C. Cali[a], A. Capone[q], L. Caponetto[m], G. Carminati[l], B. Cassano[b], E. Castorina[p], A. Ceres[b], T. Chiarusi[l], M. Circella[b], R. Cocimano[a], R. Coniglione[a], M. Cordelli[f], M. Costa[a], A. D'Amico[a], C. D'Amato[a], V. D'Amato[a], G. De Bonis[q], G. De Rosa[g], G. De Ruvo[b], R. De Vita[e], C. Distefano[a], E. Falchini[p], V. Flaminio[p], K. Fratini[e], A. Gabrielli[l], S. Galeotti[h], E. Gandolfi[l], G. Giacomelli[l], F. Giorgi[l], G. Giovanetti[q], A. Grimaldi[d], A. Grmek[a], R. Habel[f], E. Leonora[m], A. Lonardo[i], G. Longo[o], D. Lo Presti[m], F. Lucarelli[q], L. Maccione[p], A. Margiotta[l], A. Martini[f], R. Masullo[q], F. Maugeri[a], R. Megna[b], S. Minutoli[e], M. Mongelli[b], T. Montaruli[k,s], M. Morganti[p], P. Musico[e], M. Musumeci[a], C.A. Nicolau[i], A. Orlando[a], M. Osipenko[e], G. Osteria[g], R. Papaleo[a], V. Pappalardo[a], C. Petta[d], P. Piattelli[a], D. Piombo[e], G. Raia[a], N. Randazzo[d], S. Reito[d], G. Ricco[n], G. Riccobene[a], M. Ripani[e], A. Rovelli[a], M. Ruppi[k], G.V. Russo[m], S. Russo[o], P. Sapienza[a], M. Sedita[a], E. Shirokov[e], F. Simeone[q], V. Sipala[m], C. Sollima[p], F. Speziale[a], M. Spurio[l], M. Taiuti[n], G. Terreni[h], L. Trasatti[f], S. Urso[d], V. Valente[f], M. Vecchi[q], P. Vicini[q], R. Wischnewski[i]

[a]*Istituto Nazionale di Fisica Nucleare, Laboratori Nazionali del Sud, Via S. Sofia 62, 95123 Catania, Italy*
[b]*INFN Sezione di Bari, Via E. Orabona 4, 70126 Bari, Italy*
[c]*INFN Sezione di Bologna, V.le Berti Pichat 6/2, 40127 Bologna, Italy*
[d]*INFN Sezione di Catania, Via S. Sofia 64, 95123 Catania, Italy*
[e]*INFN Sezione di Genova, Via Dodecaneso 33, 16146 Genova, Italy*
[f]*Laboratori Nazionali di Frascati INFN, Via Enrico Fermi 40, 00044 Frascati (RM), Italy*
[g]*INFN Sezione di Napoli, Via Cintia, 80126 Napoli, Italy*
[h]*INFN Sezione di Pisa, Polo Fibonacci, Largo B. Pontecorvo 3, 56127 Pisa, Italy*
[i]*INFN Sezione di Roma 1, P.le A. Moro 2, 00185 Roma, Italy*
[j]*Dipartimento di Fisica e Astronomia Università di Catania, Via S. Sofia 64, 95123 Catania, Italy*
[k]*INFN Sezione di Bari and Dipartimento Interateneo di Fisica Università di Bari, Via E. Orabona 4, 70126 Bari, Italy*
[l]*INFN Sezione di Bologna and Dipartimento di Fisica Università di Bologna, V.le Berti Pichat 6/2, 40127 Bologna, Italy*
[m]*INFN Sezione di Catania and Dipartimento di Fisica e Astronomia Università di Catania, Via S. Sofia 64, 95123 Catania, Italy*
[n]*INFN Sezione di Genova and Dipartimento di Fisica Università di Genova, Via Dodecaneso 33, 16146 Genova, Italy*
[o]*INFN Sezione di Napoli and Dipartimento di Scienze Fisiche Università di Napoli, Via Cintia, 80126 Napoli, Italy*
[p]*INFN Sezione di Pisa and Dipartimento di Fisica Università di Pisa, Polo Fibonacci, Largo B. Pontecorvo 3, 56127 Pisa, Italy*
[q]*INFN Sezione di Roma 1 and Dipartimento di Fisica Università di Roma "La Sapienza", P.le A. Moro 2, 00185 Roma, Italy*
[r]*INAF Osservatorio Astronomico di Capodimonte, Salita Moiarello 16, 80131 Napoli, Italy*
[s]*Department of Physics, University of Wisconsin, Madison, WI 53711, USA*

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*Corresponding author.
E-mail address: migneco@lns.infn.it (E. Migneco).

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Abstract

The status of the activities towards the realization of a km^3 Cherenkov neutrino detector carried out by the NEMO Collaboration is described. The realization of a Phase-1 project, which is under way, will validate the proposed technologies for the realization of the km^3 detector on a Test Site at 2000 m depth. The realization of a new infrastructure on the candidate site (Phase-2 project) will provide the possibility to test detector components at 3500 m depth.

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1. Introduction

Due to the expectations on neutrino fluxes from galactic and extragalactic sources, mainly based on the measured cosmic ray fluxes and the estimated fluxes from theoretical models [1], the opening of the high-energy neutrino astronomy era can only be afforded with detectors of km^3 scale.

A first generation of "small" scale detectors has been realized (AMANDA [2] at the South Pole and NT-200 [3] in the Baikal lake) and have set limits on neutrino fluxes, while others are at different stage of realization (ANTARES [4] and NESTOR [5]). Following the success of AMANDA the realization of the IceCube km^3 detector [6] is now progressing at the South Pole. On the other hand, many issues, as the full sky coverage, strongly support the construction of a km^3-scale detector in Mediterranean Sea.

The activity of the NEMO collaboration has been mainly focused on the search and characterization of an optimal site for the detector installation and on the development of key technologies for the km^3 underwater telescope.

A deep sea site with optimal features in terms of depth and water optical properties has been identified at a depth of 3500 m about 80 km off-shore Capo Passero and a long term monitoring of the site has been carried out. Results of these measurements have been previously reported [7–9].

One of the efforts undertaken by the NEMO collaboration has also been the definition of a feasibility study of the km^3 detector, which included the analysis of all the construction and installation issues and the optimization of the detector geometry by means of numerical simulations. The validation of the proposed technologies via an advanced R&D activity, the prototyping of the proposed technical solutions and their relative validation in deep sea environment is presently carried out with the two pilot projects NEMO Phase-1 and Phase-2.

2. General layout of the NEMO km^3 detector

The considerations leading to the definition of a proposed architecture for the km^3 detector have been described elsewhere [10]. We will here briefly recall the main characteristics of the detector.

The proposed NEMO architecture is a modular array of detection units, called "towers", arranged in a 9×9 square lattice.

Performances of this detector, like effective area, angular resolution and sensitivity to point-like neutrino sources were evaluated by means of numerical simulations [10]. These simulations were carried out using the software [11] developed by the ANTARES collaboration and adapted to km^3 scale detectors [12]. In the simulation site dependent parameters such as depth, optical background, absorption and scattering length, have been set accordingly with the values measured in Capo Passero at a depth of about 3500 m.

3. The NEMO Phase-1 project

The NEMO Phase-1 project has allowed a first validation of the technological solutions proposed for the km^3 detector. The apparatus includes prototypes of the critical elements of km^3 detector: the junction box (JB) and the tower.

The apparatus has been installed at 2000 m depth at the Underwater Test Site of the Laboratori Nazionali del Sud in Catania, connected to the shore by means of a 28 km electro optical cable.

3.1. The junction box

The JB (Fig. 1) is a key element of the detector. It must provide connection between the main electro-optical cable and the detector structures and has been designed to host and protect from the effects of corrosion and pressure, the opto-electronic boards dedicated to the distribution and the control of the power supply and digitized signals.

The NEMO Phase-1 JB has been built following the concept of double containment. Pressure resistant steel vessels are hosted inside a large fiberglass container. This last one is filled with silicone oil and pressure compensated. This solution has the advantage to decouple the two problems of pressure and corrosion resistance.