

NEMO – toward a km³ Neutrino Telescope in the Mediterranean Sea

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on behalf of the NEMO Collaboration



Prague, Czech Republic
From Colliders to Cosmic Rays
7-13 September 2005

OUTLINE

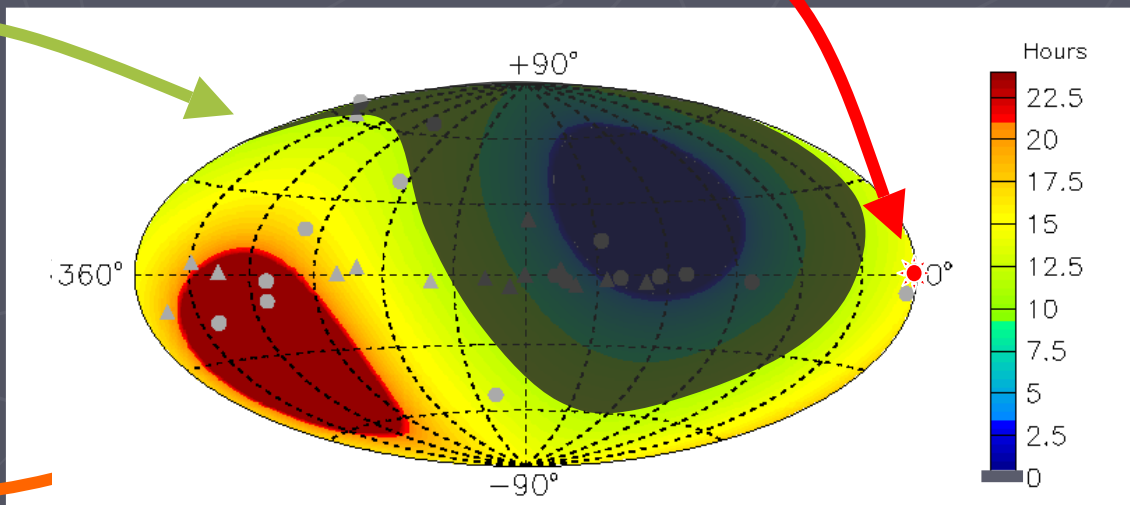
- ▶ Introduction
- ▶ The NEMO project
 - Description
 - Results
 - Perspectives
- ▶ Conclusions

Physics Motivations

- ▶ High Energy Neutrinos are a powerful tool to investigate the hadronic mechanisms of Cosmic Ray production
- ▶ Galactic candidates:
 - Pulsars
 - SuperNova remnants
 - Micro-Quasars
- ▶ Extra-galactic candidates:
 - Active Galactic Nuclei
 - Gamma Ray Bursts

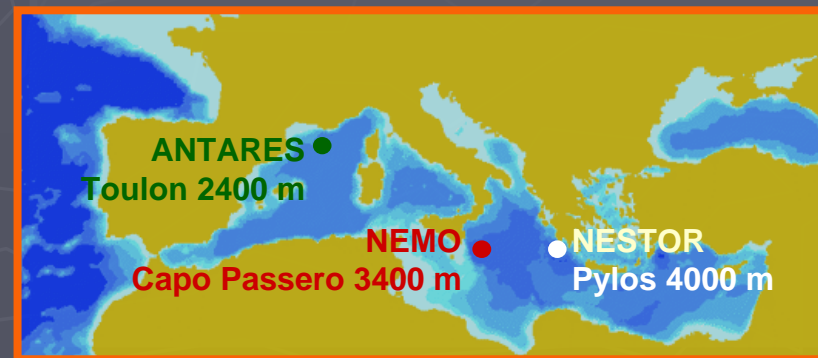
Physics Motivations

- ▶ A neutrino telescope in the Northern Hemisphere will provide:
 - Complementary sky survey to ICECUBE
 - Overlap observation region with ICECUBE
 - Study of the Galactic Center



Physics Motivation

- ▶ The small cross section and the expected low neutrino flux require
 - large volume telescope $\sim 1 \text{ km}^3$
 - long observation time $\sim \text{yrs}$
- ▶ The atmospheric muon background requires
 - a shielding $> 2000 \text{ m}$ water equivalent
- ▶ The Mediterranean Sea provides convenient sites



The NEMO Collaboration



INFN

- Bari, Bologna, Catania, Genova, LNF, LNS, Napoli, Pisa, Roma

► Universities

- Bari, Bologna, Catania, Genova, Napoli, Pisa, Roma "La Sapienza"



CNR

- Istituto di Oceanografia Fisica, La Spezia
- Istituto di Biologia del Mare, Venezia
- Istituto Sperimentale Talassografico, Messina



Istituto Nazionale di Geofisica e Vulcanologia (INGV)



Istituto Nazionale di Oceanografia e Geofisica Sperimentale (OGS)



Istituto Superiore delle Comunicazioni e delle Tecnologie dell'Informazione (ISCTI)

more than 70 researchers involved

Technical Requirements

- Issues to be solved to realize a km³ neutrino telescope in the Mediterranean Sea
 - Best site location (i.e. depth, water quality ...)
 - Optical background from ⁴⁰K-decay and bioluminescence
 - Detector deployment
 - Detector rigidity against sea currents
 - Resistance to corrosion from salt water

The NEMO Project

► R&D phase (1999-2002)

- Site selection and characterization
 - Several sites close to the Italian coasts have been studied.
- R&D Activities
 - Development of dedicated ASICS for the underwater front-end electronics
 - Development of large area hybrid photomultipliers
- Feasibility Studies
 - All detector critical components and the deployment procedures have been examined
 - A preliminary project for the km³ detector has been developed

► Phase-1 and prototyping (2002-2006)

- Realization and deployment of a prototype including all critical components

► Phase-2 (2006-...)

- Realization of an underwater infrastructure at -3500 m

NEMO R&D Activity

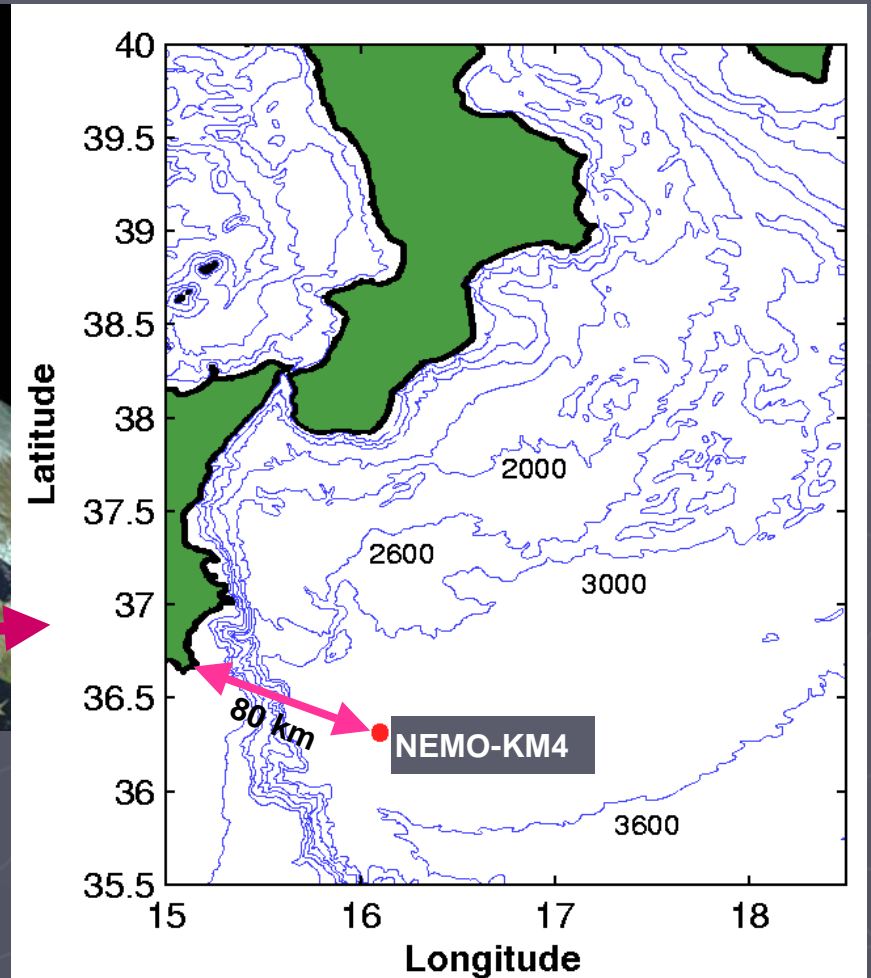
► Site location

- More than 25 sea campaigns since 1998



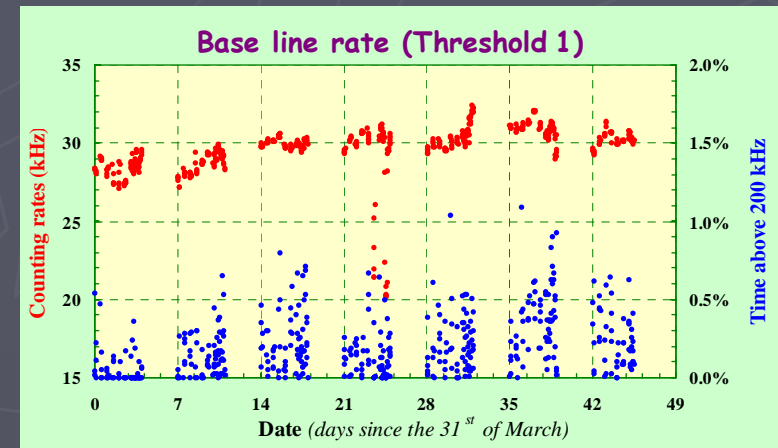
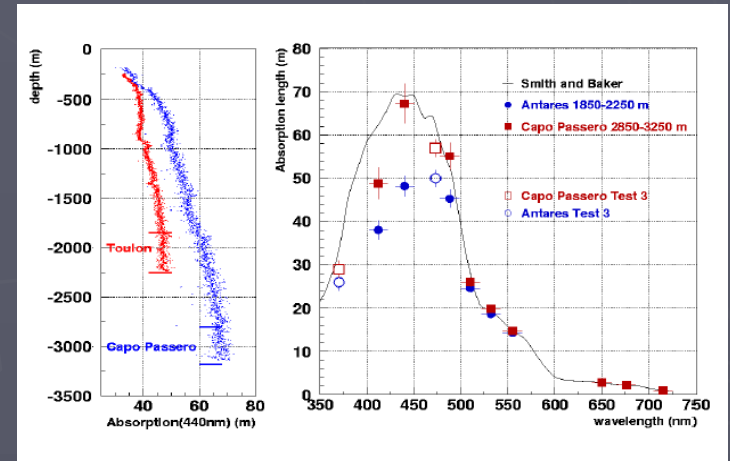
► NEMO-KM4

- 80 km off-shore
- 3500 m depth



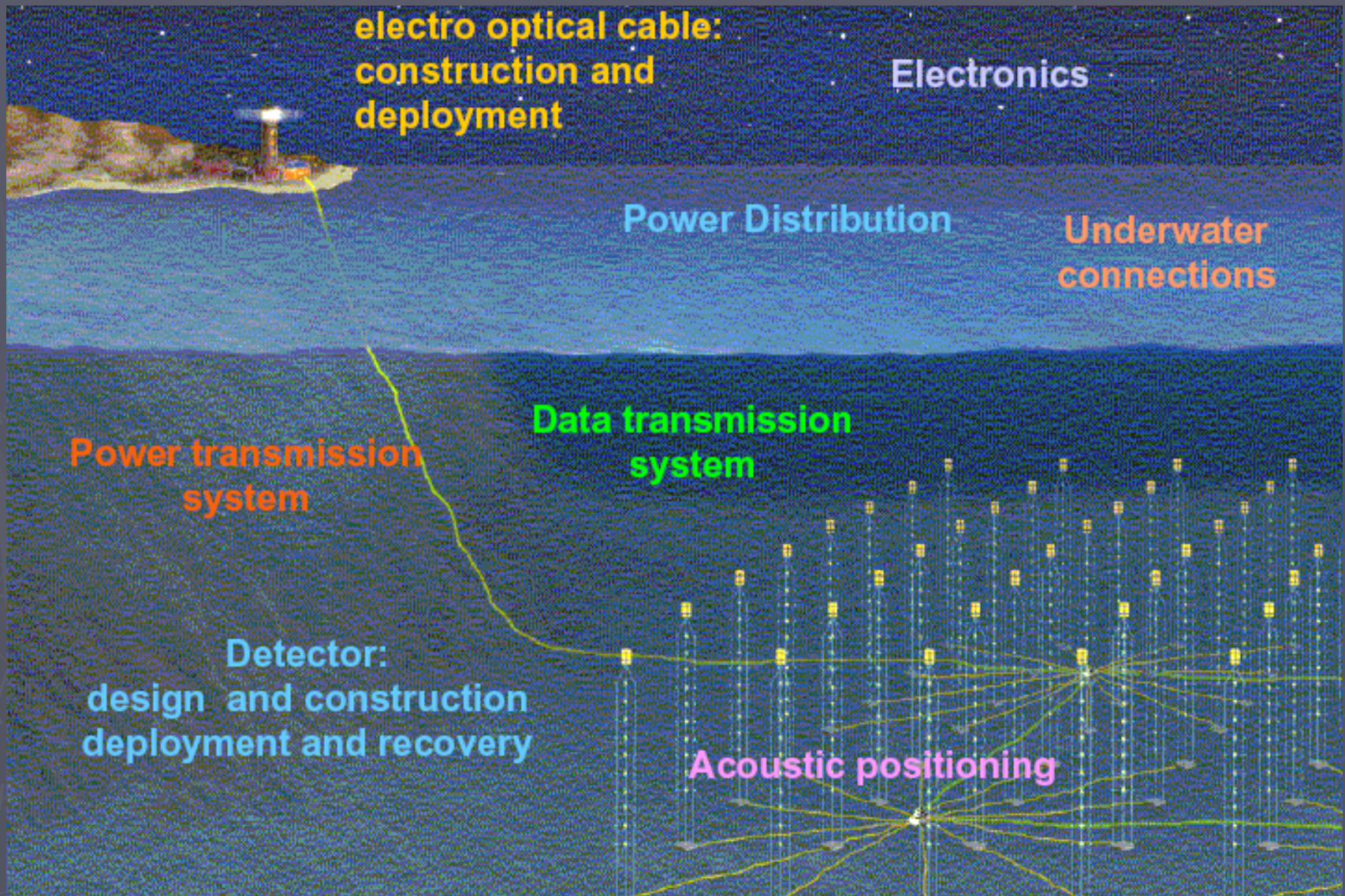
NEMO-KM4 Properties

- ▶ High water transparency
 - Data compatible with pure salt water properties
 - No seasonal variations
- ▶ Reduced background, mostly from ^{40}K decay
 - 10" PMT thres. 0.5 p.e. noise rate ~ 30 kHz
 - Bioluminescence almost absent
- ▶ Geologically stable



-3000 m

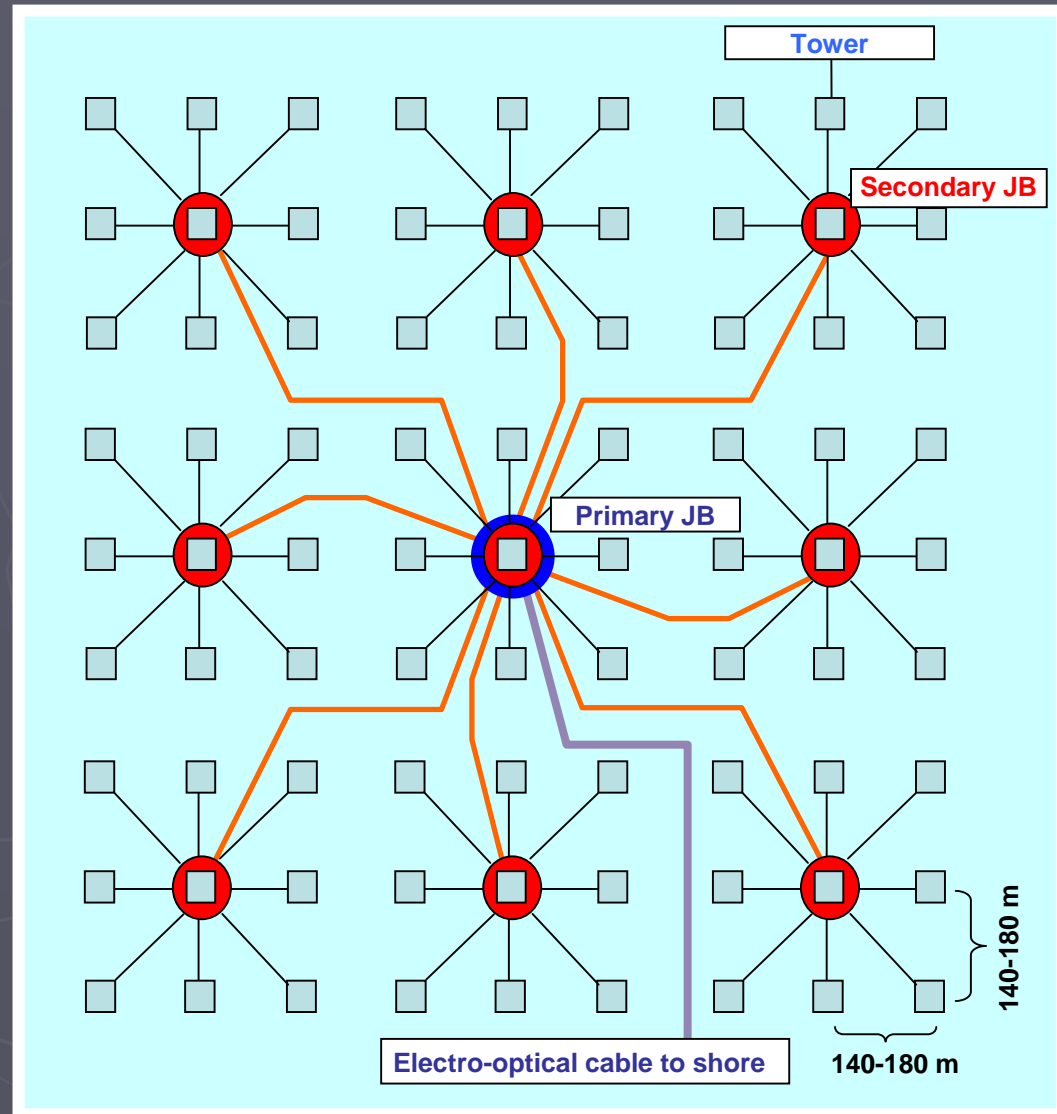
NEMO km³ Conceptual Design



NEMO km³ Conceptual Design

► Proposed lay-out

- 10 junction boxes
- 81 towers
- 5832 PMTs



Expected Performance

- ▶ Simulations show excellent angular resolution and sensitivity

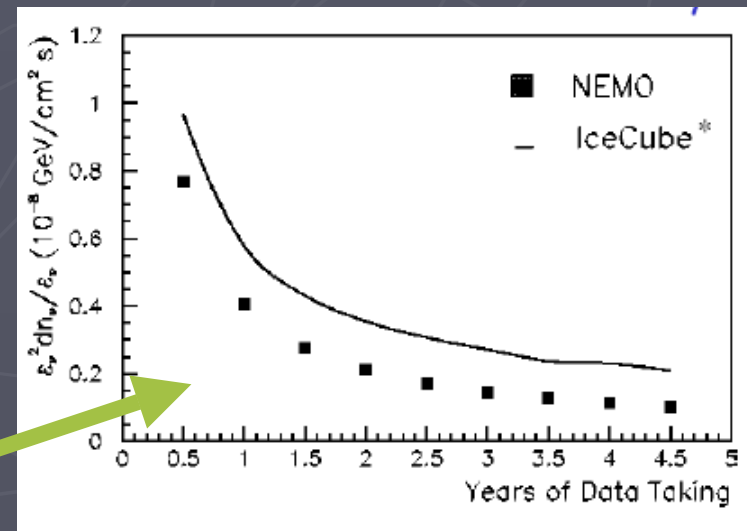
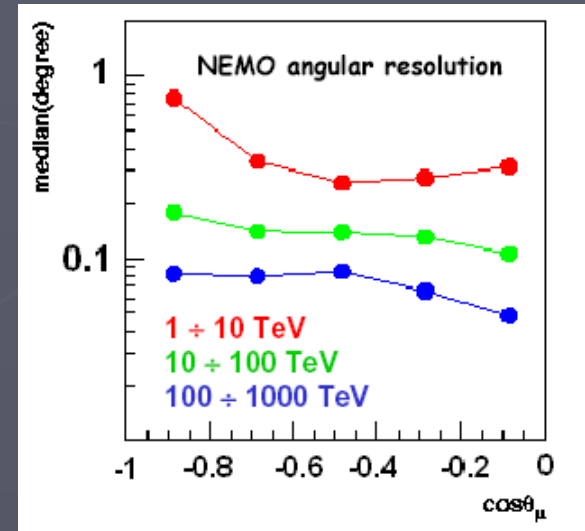
- NEMO

- ▶ 81 towers 140 m spaced
- ▶ 5832 PMTs

- ICECUBE

- ▶ 80 strings 125 m spaced
- ▶ 4800 PMTs

Sensitivity to a E^{-2} neutrino spectrum from a pointlike source



The NEMO Phase-1 Activity

Shore station in the port of Catania



The Catania test site:

- 25 km off the coast of Catania
- 2000 m depth
- already equipped with a double-termination cable

Geoseismic station SN-1 (INGV)

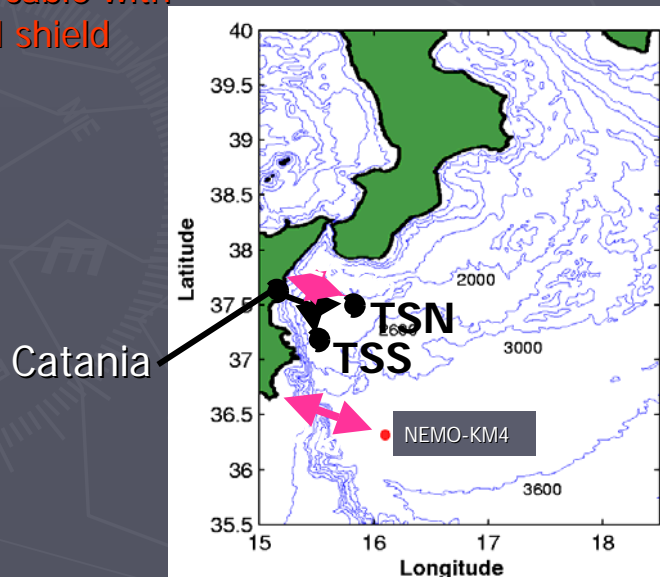


2.5 km e.o. cable with double steel shield

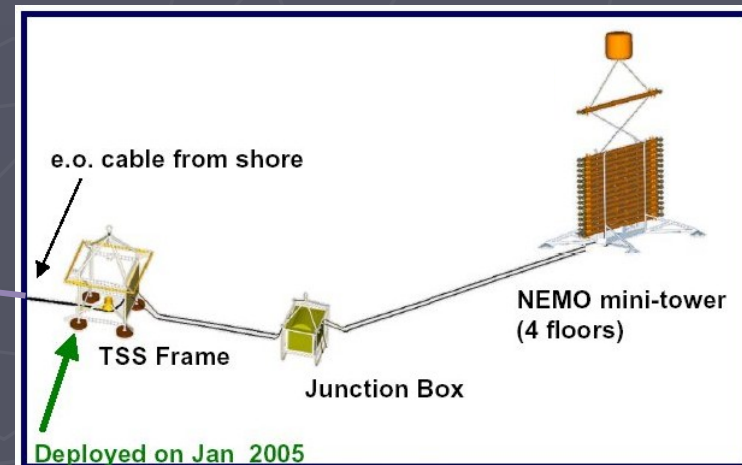
21 km e.o. cable with single steel shield

Branching Unit

5 km e.o. cable



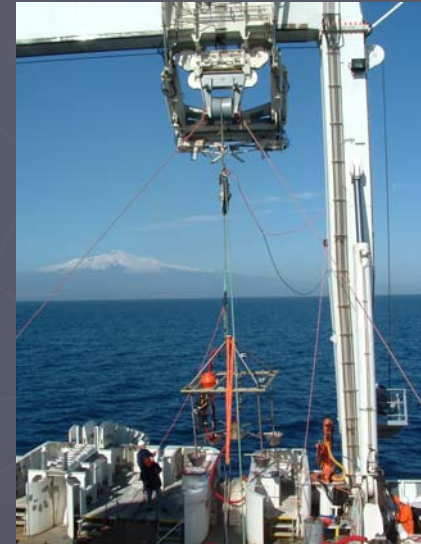
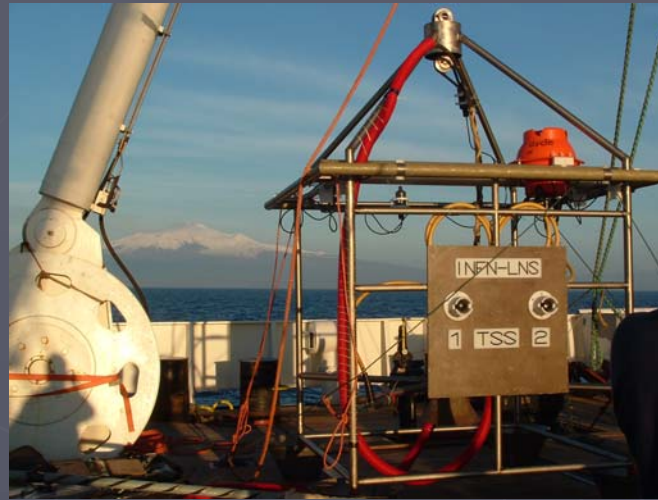
5 km e.o. cable



NEMO Phase 1

The NEMO Phase-1 Activity

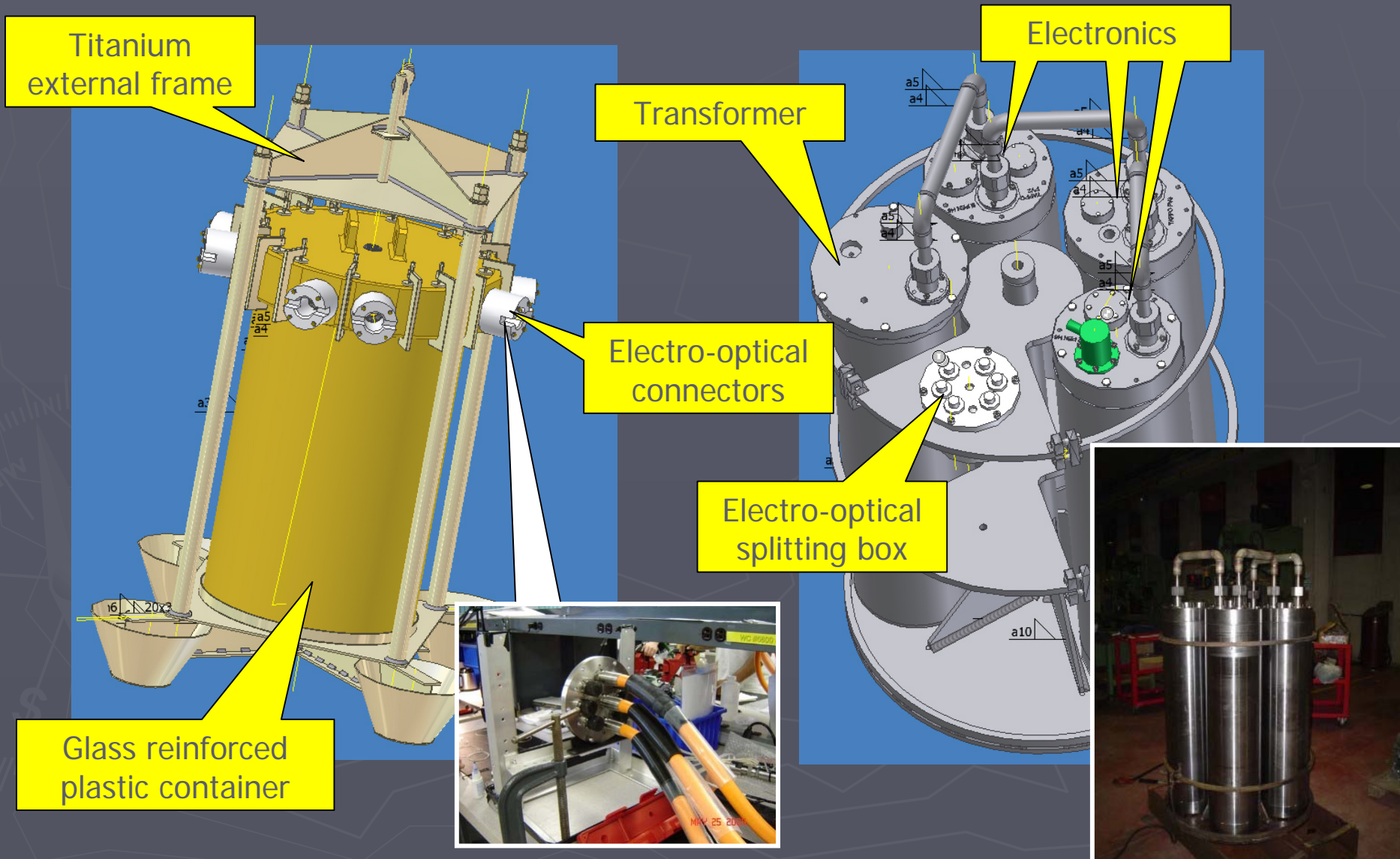
- Installation of the cable termination frames with electro-optical connectors



- Deployment and connection of
 - Acoustic detection station
 - INGV environmental observatory
- Fully operational since January 2005

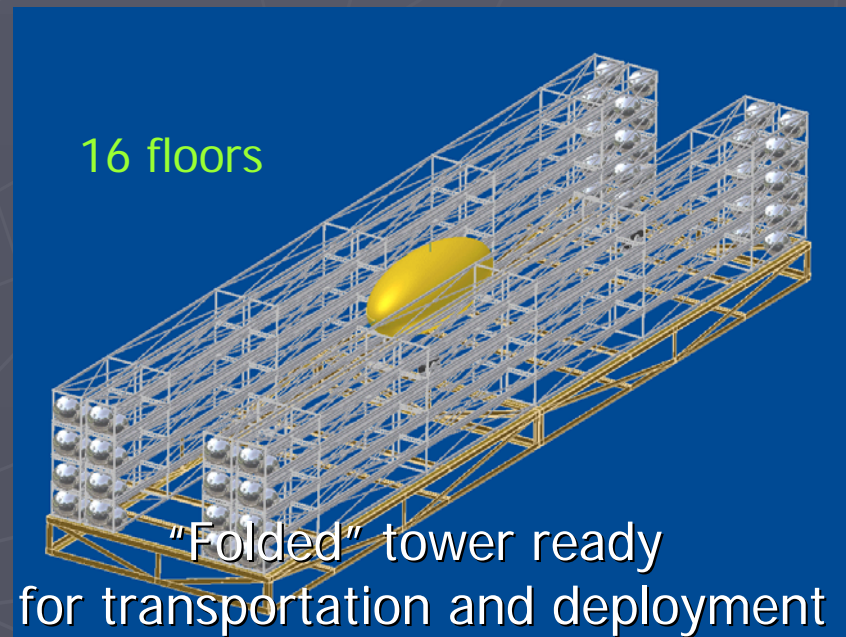
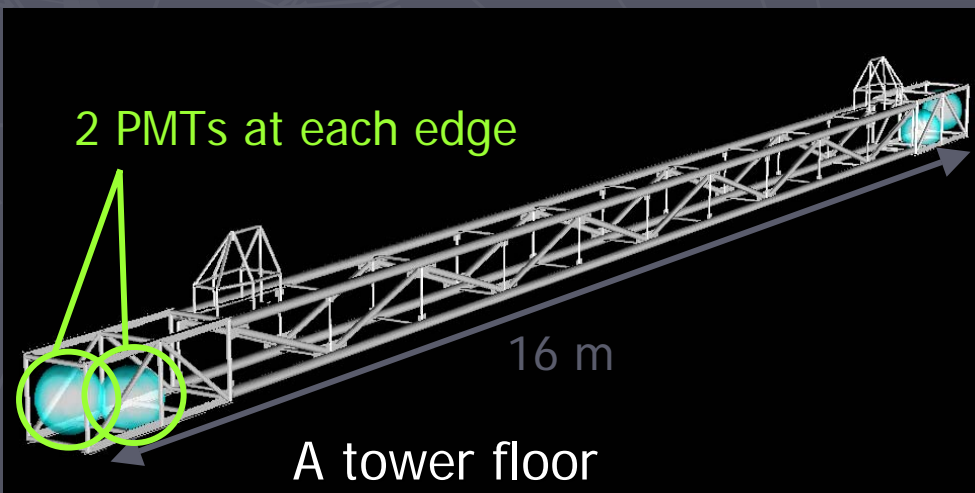


The NEMO Junction Box

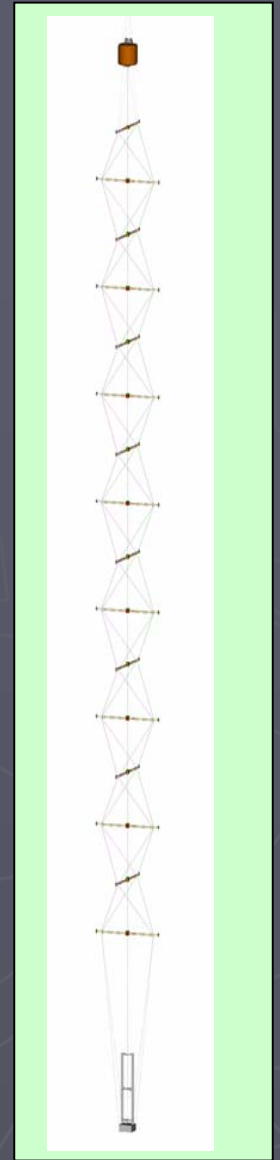
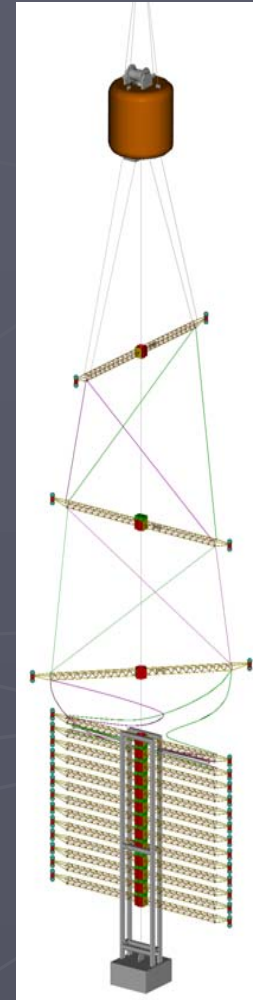
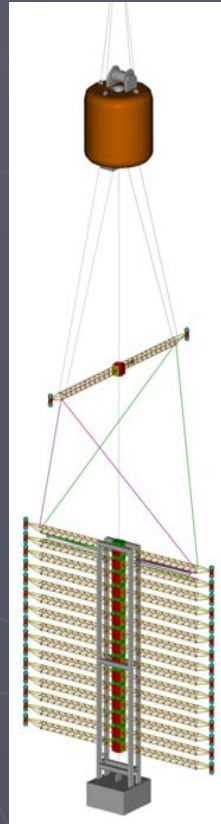
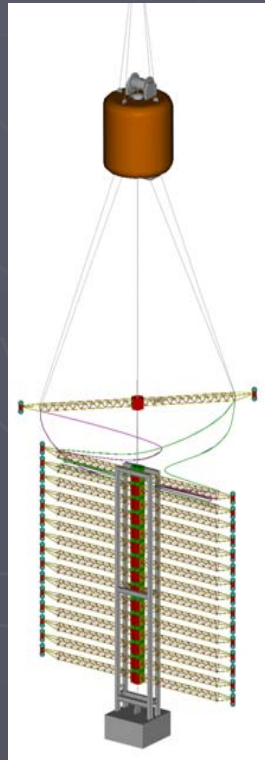
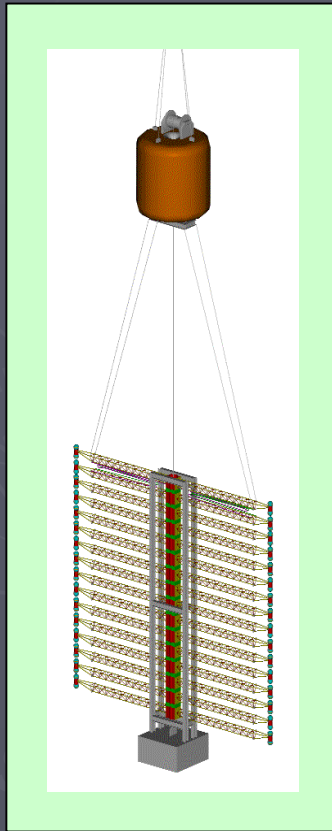


The NEMO Tower

- ▶ Semi-rigid structure provides “easy” assembly, transportation and deployment
 - A 1:5 4-floor prototype has been successfully deployed and recovered in Spring 2004



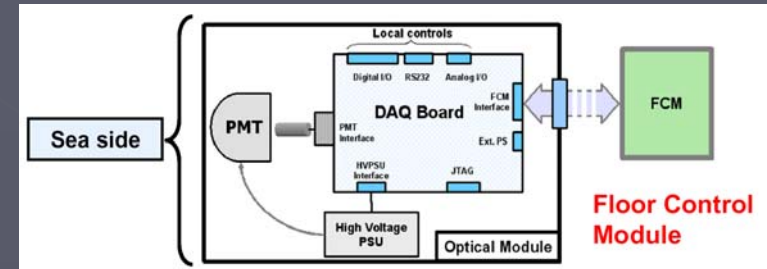
The Tower Deployment



The Read-out Electronics

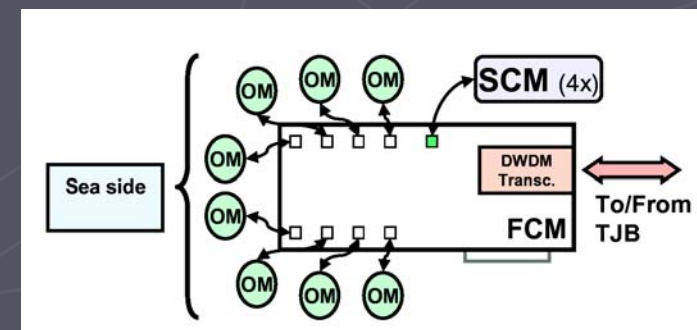
► Optical Module Electronics

- 200 Msample/s
- 8 bit range (log. compression)



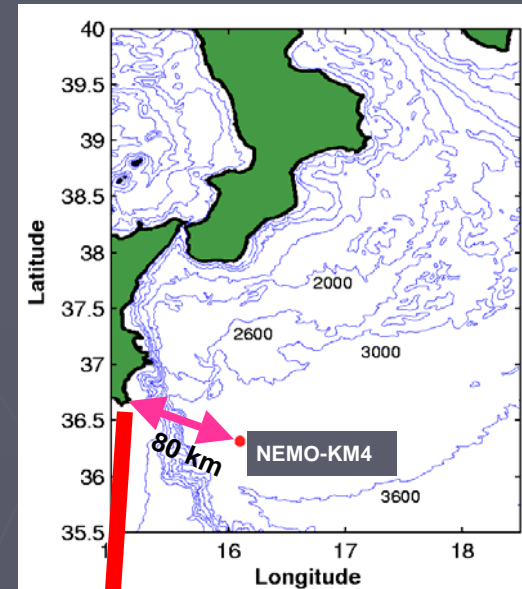
► Floor Control Module Electronics

- Collects digitized signals from up to 8 OM
- Sends to the onshore station through the Junction Box



The NEMO Phase-2

- Infrastructures for an -3500 m underwater site
 - Electro-optical cable (40 kW)
 - Purchase under way
 - Shore station in PortoPalo di Capo Passero
 - Building under renovation



to NEMO-KM4

Conclusions and Perspectives

- ▶ The NEMO Collaboration is working on a long-term R&D program toward a km^3 ν -telescope in the Mediterranean Sea
 - An optimal candidate site has been found: NEMO-KM4
 - The NEMO Phase-1, aiming to validate the proposed technologies, is under way at the Catania Test Site
 - ▶ Since Jan. 2005 the geoseismic and acoustic stations are fully operative
 - ▶ The completion is planned in the first half of 2006
 - The NEMO Phase-2, aiming to realize the deep sea station at NEMO-KM4, is in progress
 - ▶ The purchase of the electro-optical cable is in progress
 - ▶ The set-up of the onshore station is in progress
 - ▶ The deployment of a full-size tower is foreseen in 2007

Toward the ν -Telescope

- ▶ EU is funding the joint activity for an European-scale Design Study for a km^3 ν -telescope in the Mediterranean Sea
 - KM3NeT: ANTARES-NEMO-NESTOR consortium
- ▶ 2° VLVnT (Very Large Volume ν -Telescope) Workshop to be held in Catania (Italy) 8-11 Nov., 2005