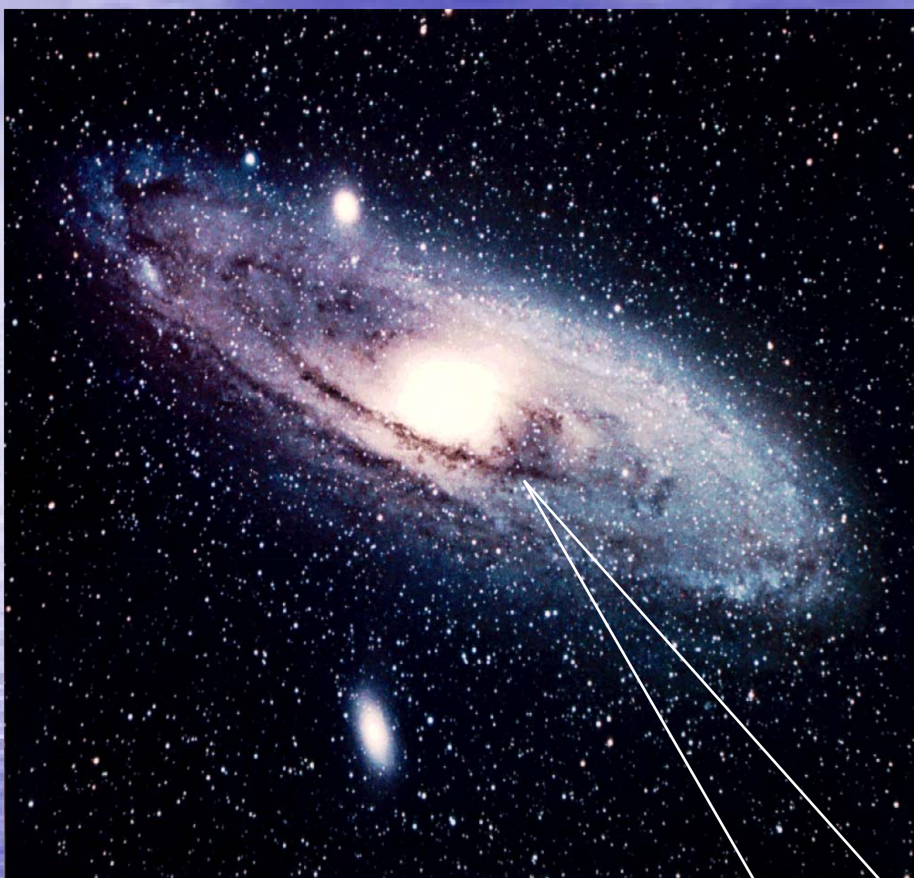
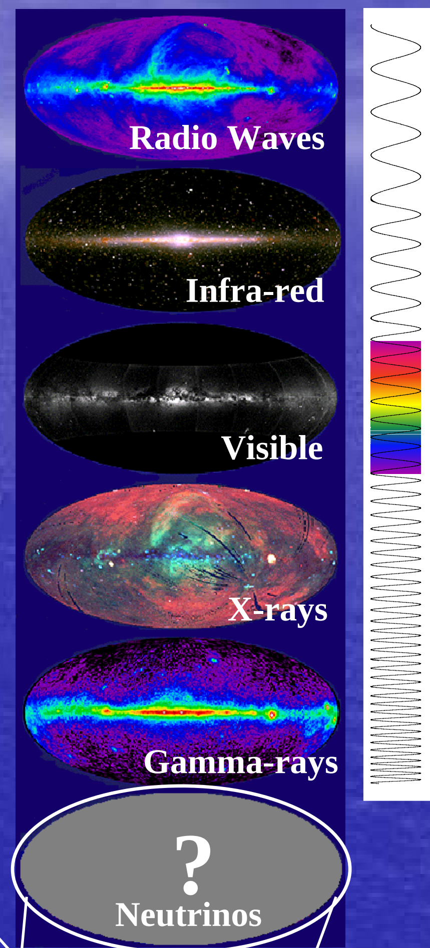
# A km$^3$-scale neutrino telescope in the Mediterranean Sea






KM3NeT will be one of the largest particle detectors and astronomical instruments ever built.
It will be constructed not on land, but in the clear waters of the deep Mediterranean Sea.

## Its missions;

- to detect high energy neutrinos, elusive particles expected from a multitude of astrophysical sources and which may be key to understanding our universe;
- to map neutrino sources for comparison with emission maps for electromagnetic radiation over a wide range of wavelengths, including the visible;
- to provide a research infrastructure for deep sea scientific observations.

**The KM3NeT consortium is a pan European effort of leading universities and research laboratories**

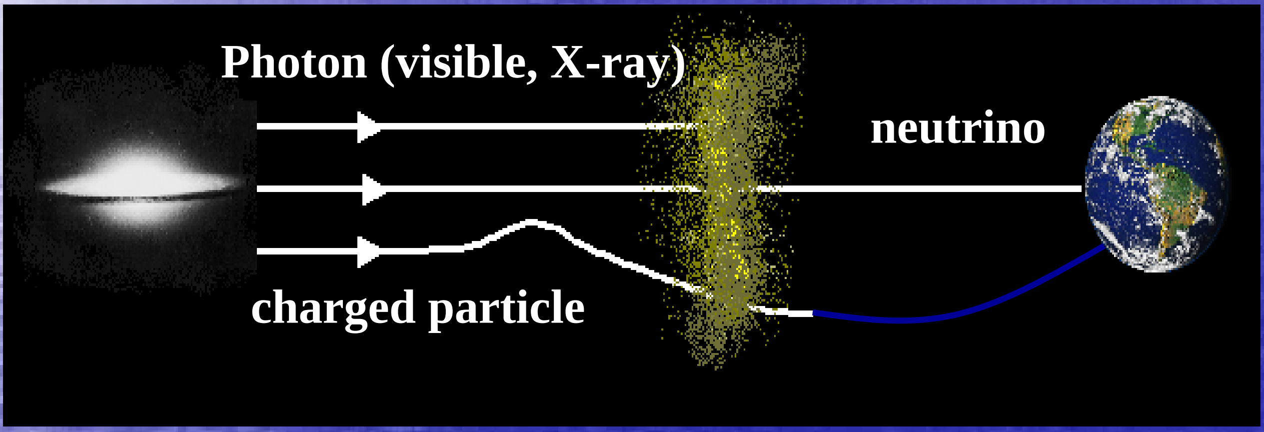
# Elusive Neutrinos

Our world is constantly bombarded by a rain of subatomic particles from space: cosmic rays. Among these are neutrinos, the smallest of the small and almost undetectable; cosmic messengers from the largest objects and most violent processes in the Universe.

*Crab Nebula: supernova remnant*

Why try to detect particles that can pass undeviated through entire galaxies without slowing down?

There are plenty of reasons; neutrinos can escape equally easily from the hidden hearts of many astrophysical enigmas; pulsars, supernova remnants, the environs of black holes or quasars - immense cosmic particle accelerators bathed in dust and intense magnetic fields that absorb photons and deflect charged particles.




**Neutrinos may also help solve a great mystery of cosmology; the nature of the universe's missing mass.**

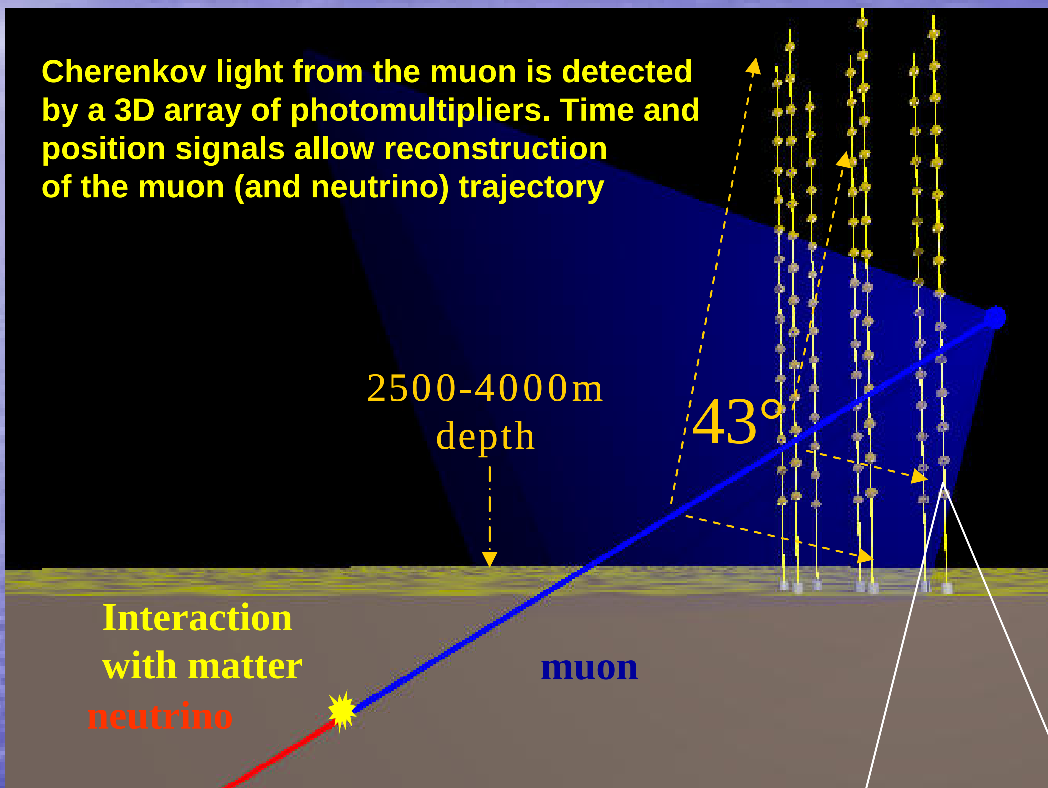
Astronomers believe that as much as 90% of the universe is made up of invisible, undetected 'dark matter'. Many cosmologists believe this to be made up of weakly-interacting massive particles (WIMPs), primordial relics of the big bang. Over the 14-billion year life of the universe WIMPs might have accumulated at the centres of stars and planets, where their interactions might produce neutrinos. The detection of a neutrino signal from the centre of the Earth or the Sun would be a striking proof of the existence of WIMPS and the nature of dark matter.

**A cubic kilometre-scale neutrino telescope will open a new window on the universe, crucial to the advance of understanding in a field which inspires thousands of scientists all over the world.**

# The challenge of neutrino detection

How can we detect a particle as elusive as the neutrino, which generally passes right through the Earth without even noticing? To catch the one in many millions that does interact, there is only one option: a truly huge detector. The depths of the Mediterranean Sea offer cubic kilometres of clear water… absolutely free!

Occasionally a neutrino will hit an atomic nucleus close to the detector. In the collision, the neutrino is converted to a related particle called a muon, which has an electric charge. Moving through the water at close to the speed of light, the muon creates a conical wake of blue light called Cherenkov radiation, and it's this radiation that KM3NeT will observe, using highly sensitive detectors called photomultipliers




# Eyes and Nerves of the telescope

Each photomultiplier can register the electronic signal created by just one photon of light – a vital requirement since the Cherenkov light is extremely faint; typically only one photon will reach a photomultiplier 40 metres from the muon track.

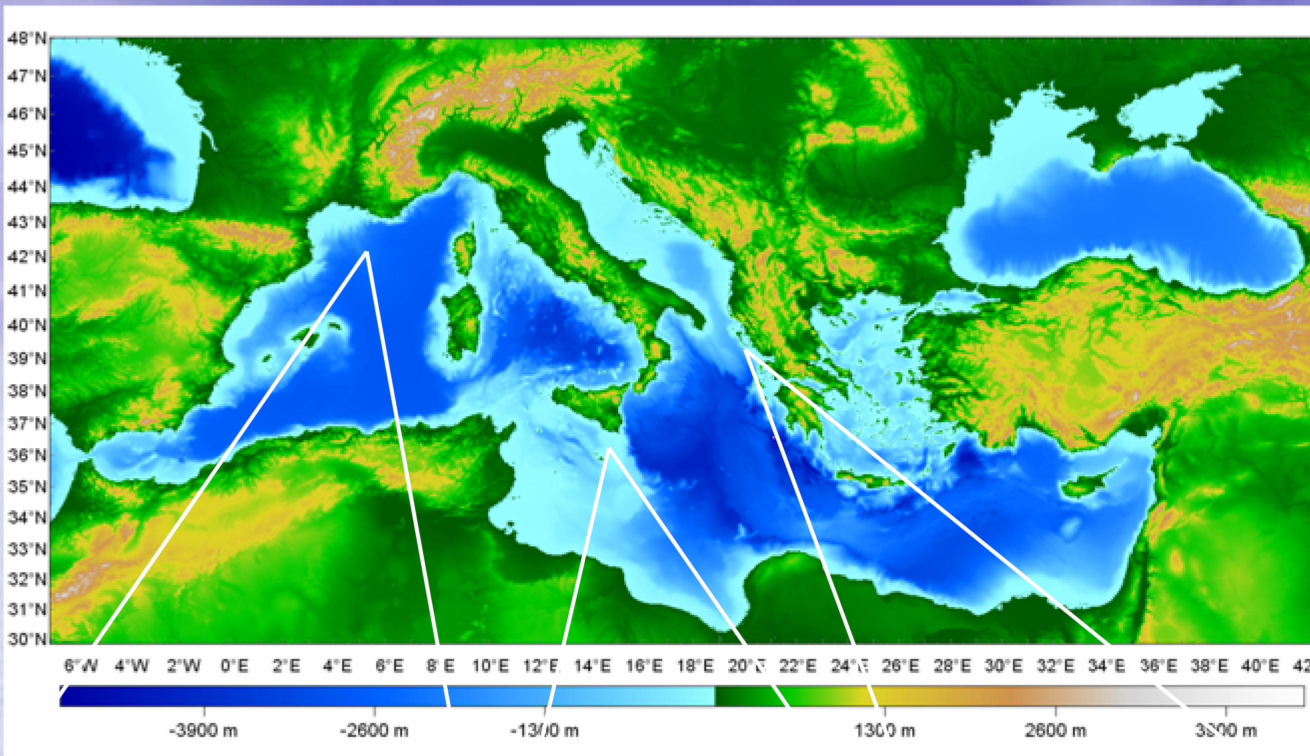
*Photomultiplier integrated into a transparent pressure vessel to make an "optical module"*

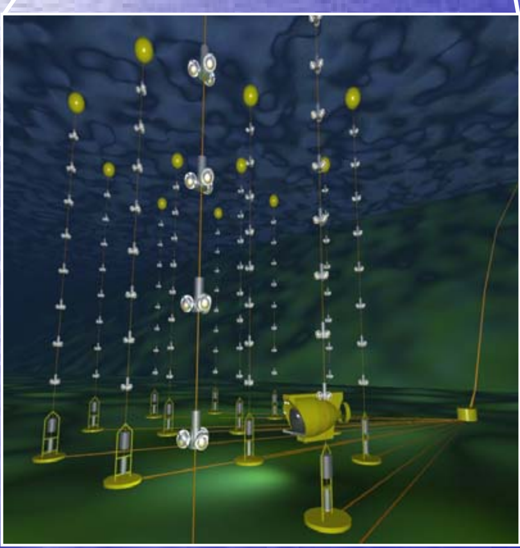
*Photomultiplier tube with a hemispherical photocathode*

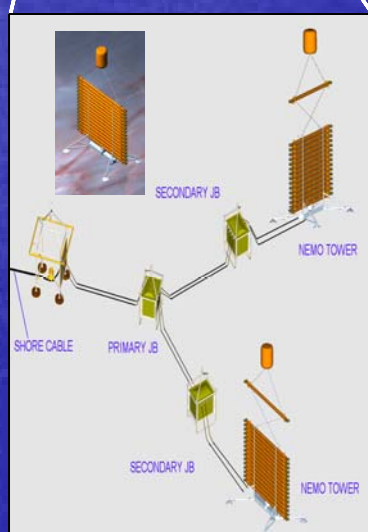
Armoured undersea cable with central stainless steel tube containing tele-communication optical fibres linking detector site with shore station 20-100 kilometres away.

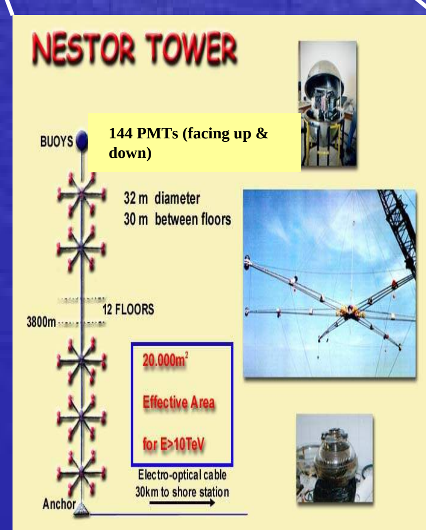
Photomultiplier tubes will be installed with other components inside commercially-made glass pressure vessels able to withstand 600 atmospheres; the sea pressure at a depth of 6 kilometres.

# A convergence of three current Mediterranean programmes






- Array with 12 detection lines in construction;
- Each line of 25 storeys, with 3 photomultipliers per storey, rising 450m from seabed anchor;
- Lines relay data to shore through seabed junction box.

- R&D project for km$^3$-scale deep sea neutrino telescope;
- Test concepts for detector deployment & interconnection, data flow, power distribution & photomultiplier development;
- Test site in Catania bay.

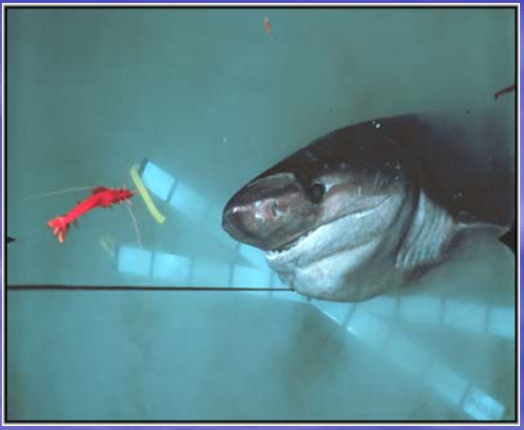
- Tower of 12 floors in construction rising 360m from seabed anchor;
- Each floor a 6-pointed star with 12 photomultipliers;
- Muons reconstructed in a single floor during 2003.

# Associated ocean sciences

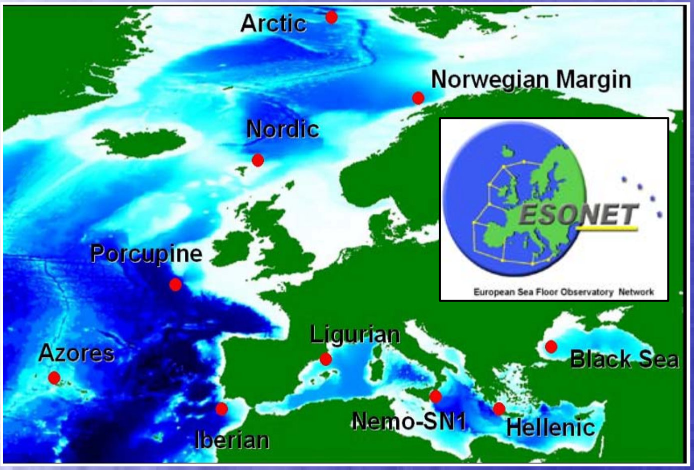
**The infrastructure of the km³-scale neutrino telescope will serve as a platform for instrumentation for ocean sciences;**

- Oceanology
- Marine Biology
- Environmental Science
- Geology and Geophysics

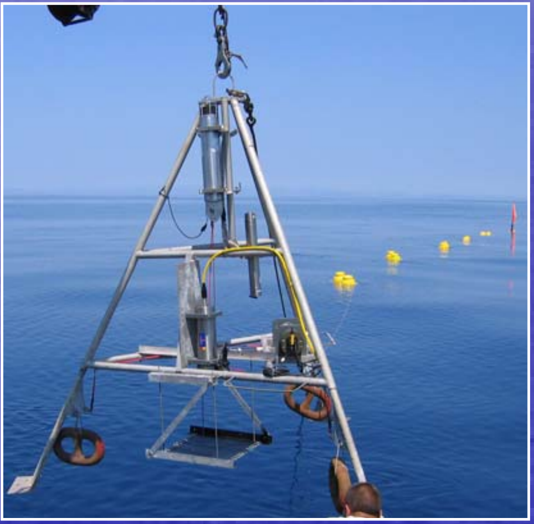
**These sciences include measurements of the deep sea environment, including water purity, undersea current, bioluminescence monitoring, biosedimentation studies and sea floor seismometry.**



*Six-gilled shark Hexanchus griseus. Found in the Mediterranean to 2000m depth: grows to more than 4m long*




*The three candidate sites considered by the KM3NeT consortium form part of the proposed ESONET chain of sea floor observatories*



*ISIT (Intensified Silicon Intensifier Target); a lander instrument of the type that may be used for boluminescence monitoring in KM3Net site survey.*

*Mora moro, the Common Mora taken at 100m in the Northeast Atlantic using the ROBIO (Robust BIOdiversity) lander*

*Analogue Doppler current profiler*

# An international consortium

**KM3NeT is a collaboration of 37 European institutes, including members of the ANTARES, NEMO and NESTOR experiments, which have joined together to design and construct a cubic kilometre-scale underwater neutrino telescope and platform for deep-sea science. Scientists and engineers from all over Europe will contribute to the project.**

- **Cyprus:** Univ. Cyprus
- **France:** CEA/Saclay, CNRS/IN2P3 (APC Paris, CPPM Marseille, IreS Strasbourg), UHA-GRPHE Mulhouse, IFREMER
- **Germany:** Univ. Erlangen, MPIK-Heidelberg, Univ. Kiel
- **Greece:** HCMR, Hellenic Open Univ., NCSR Demokritos, NOA/Nestor, Univ. Athens
- **Ireland:** Dublin Institute for Advanced Studies, Dublin
- **Italy:** CNR/ISMAR, INFN (Univs. Bari, Bologna, Catania, Genova, Napoli, Pisa, Roma-1, LNS Catania, LNF Frascati), INGV, Tecnomare SpA
- **Netherlands:** NIKHEF/FOM, Univ. Amsterdam, Univ. Utrecht, KVI/Univ. Groningen
- **Spain:** IFIC/CSIC Valencia, Univ. Valencia, Univ. P Valencia
- **UK:** Univ. Aberdeen, Univ. Leeds, Univ. Liverpool, Univ. Sheffield

**The first phase of the KM3NeT project is a 20 Million Euro design study, partially funded under the Research Infrastructure portion of the 6th framework programme of the European Community. The three-year study will address all aspects of design, construction and operation, leading to a detailed design for a cubic kilometre-scale deep-sea observatory.**

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