

Antares: A Deep-Sea 0.1 km² Neutrino Telescope

V. Bertin

► **To cite this version:**

V. Bertin. Antares: A Deep-Sea 0.1 km² Neutrino Telescope. Moriond Workshop Very High Energy Phenomena in the Universe 21, Jan 2001, Les Arcs, France. pp.1-13. in2p3-00012819

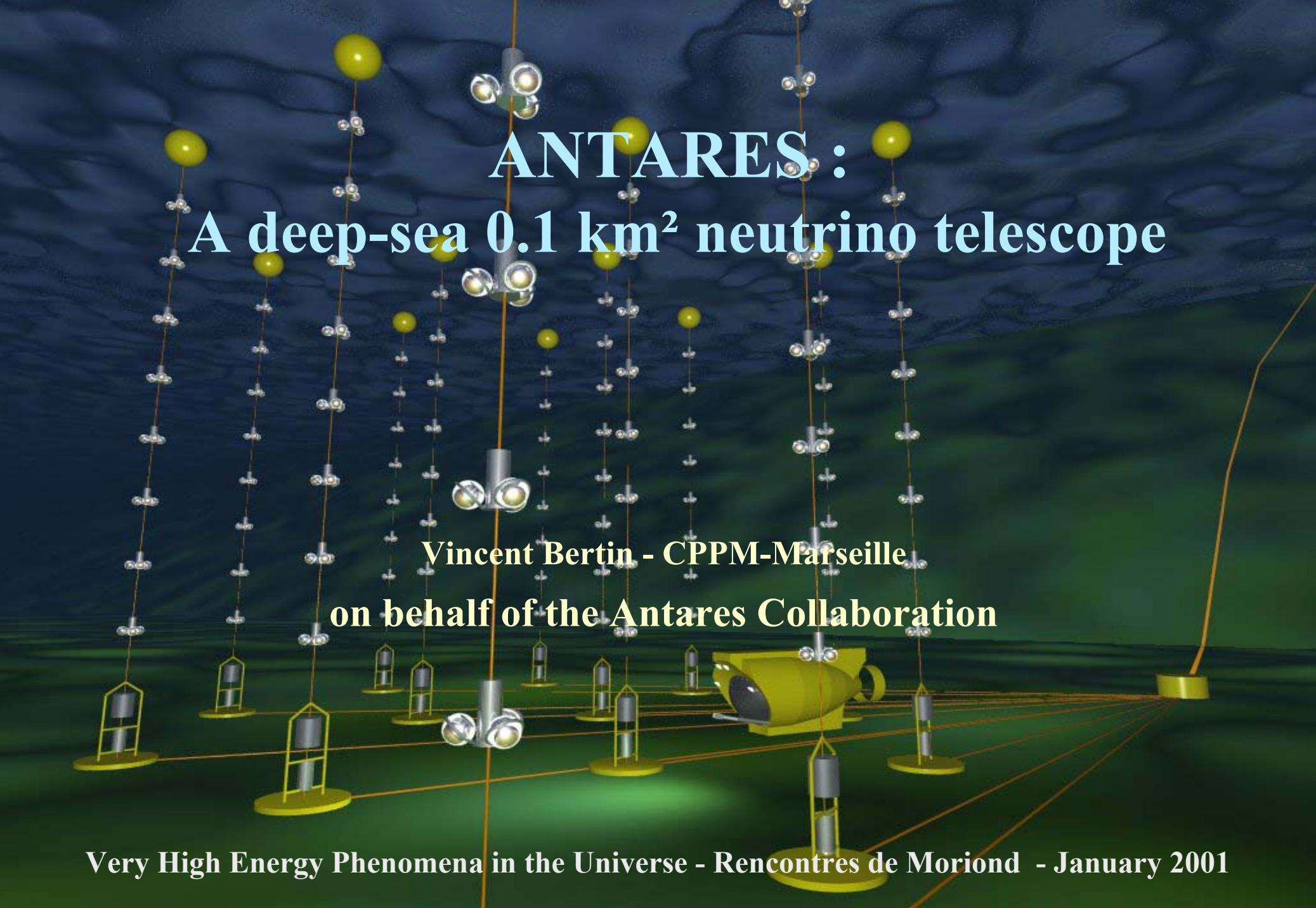
HAL Id: in2p3-00012819

<http://hal.in2p3.fr/in2p3-00012819>

Submitted on 27 May 2003

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

A 3D computer-generated rendering of the ANTARES neutrino telescope. The structure consists of numerous vertical strings of optical modules (OMs) suspended in deep-sea water. Each string is anchored to a yellow circular base on the seafloor. The OMs are arranged in a grid pattern, with some strings having yellow spherical floats at the top. The background shows the dark, rippling surface of the water and the greenish-brown seabed.

ANTARES :

A deep-sea 0.1 km² neutrino telescope

Vincent Bertin - CPPM-Marseille
on behalf of the Antares Collaboration

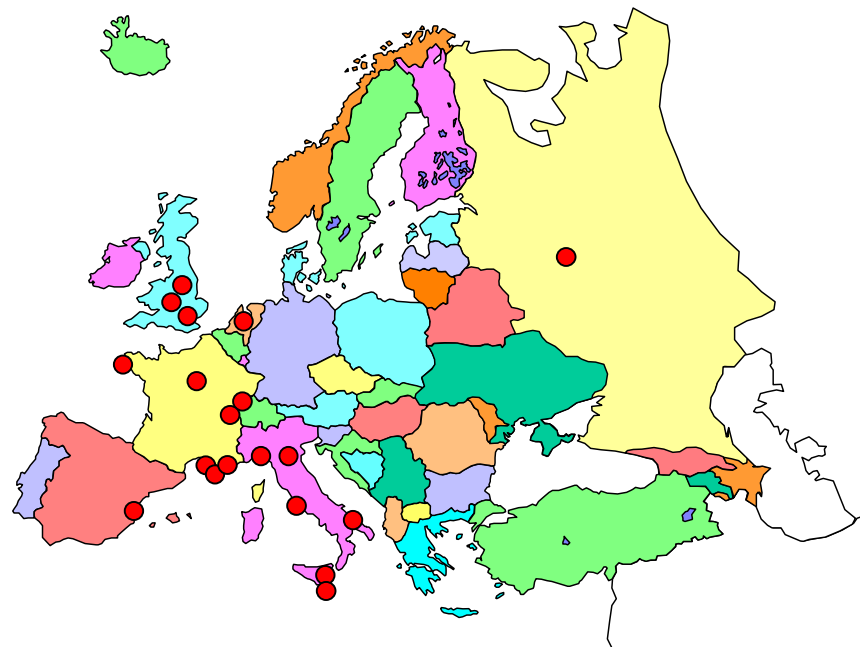
The ANTARES Collaboration



- ❖ CPPM, Marseille (IN2P3)
- ❖ DSM/DAPNIA, Saclay (CEA)
- ❖ IReS, Strasbourg
- ❖ Univ. of H.-A., Mulhouse
- ❖ C.O.M. Marseille
- ❖ IFREMER, Marseille/Brest
- ❖ IGRAP (INSU), Provence



- ❖ University of Bari
- ❖ University of Bologna
- ❖ University of Catania
- ❖ LNS – Catania
- ❖ University of Rome
- ❖ University of Genova



- ❖ University of Oxford
- ❖ University of Sheffield



- ❖ ITEP, Moscow



- ❖ IFIC, Valencia



- ❖ NIKHEF, Amsterdam

Detection Principle

Lattice of Photomultipliers : “Optical Modules”

Muon track direction from arrival time of light

Neutrino direction: $\bar{\Delta} (\theta_\nu - \theta_\mu) \approx 0.7^\circ / E^{0.6}(\text{TeV})$

Muon energy from energy loss and range

Cherenkov
light cone

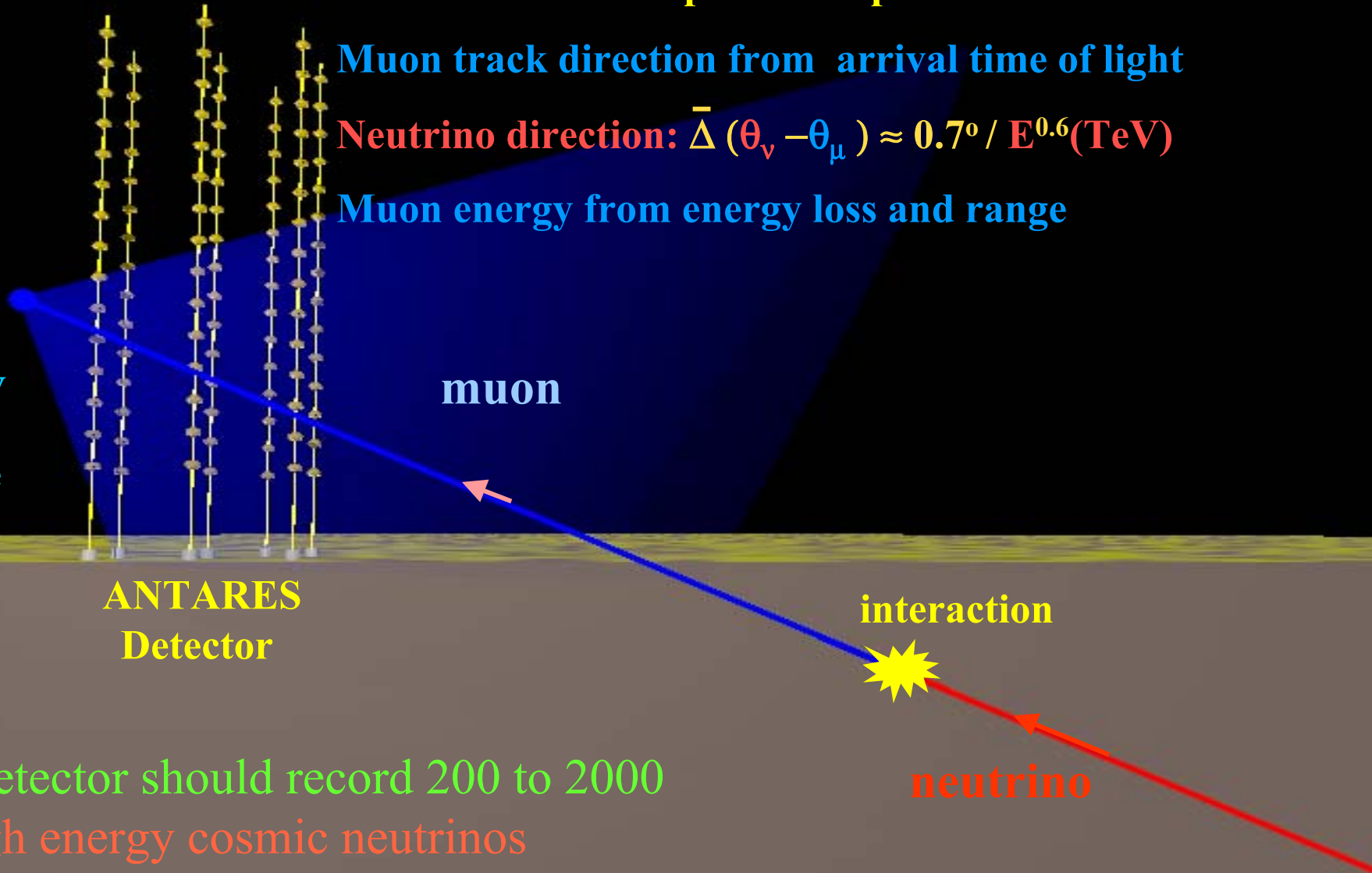
muon

ANTARES
Detector

interaction

neutrino

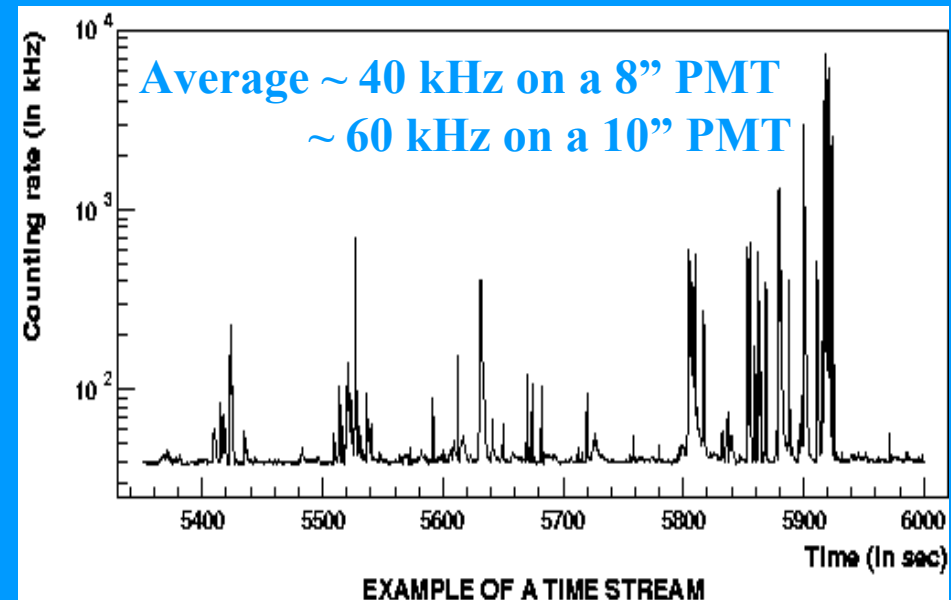
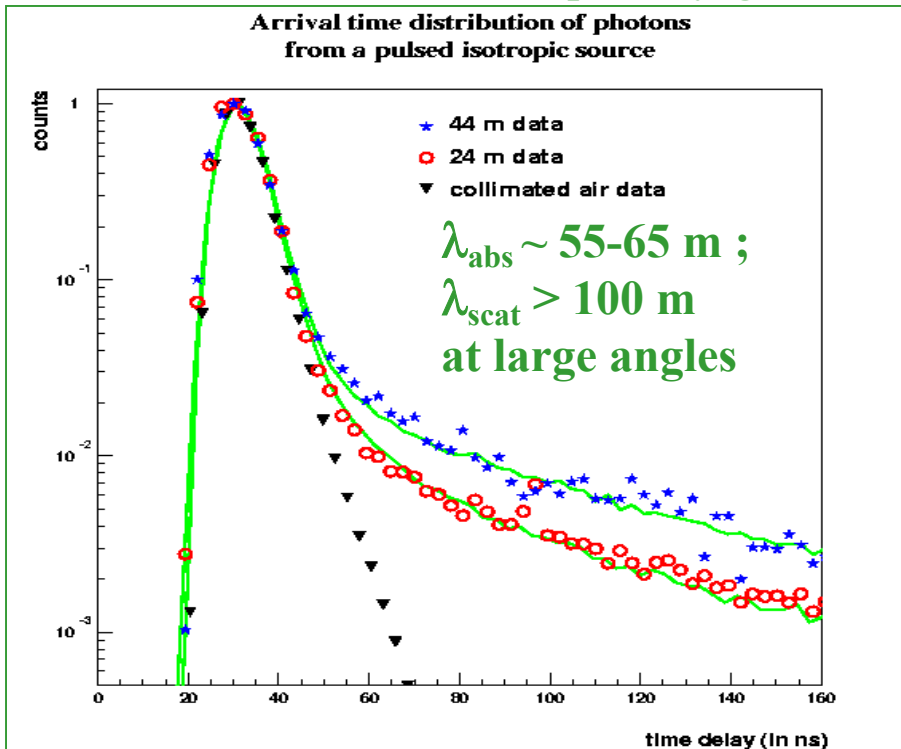
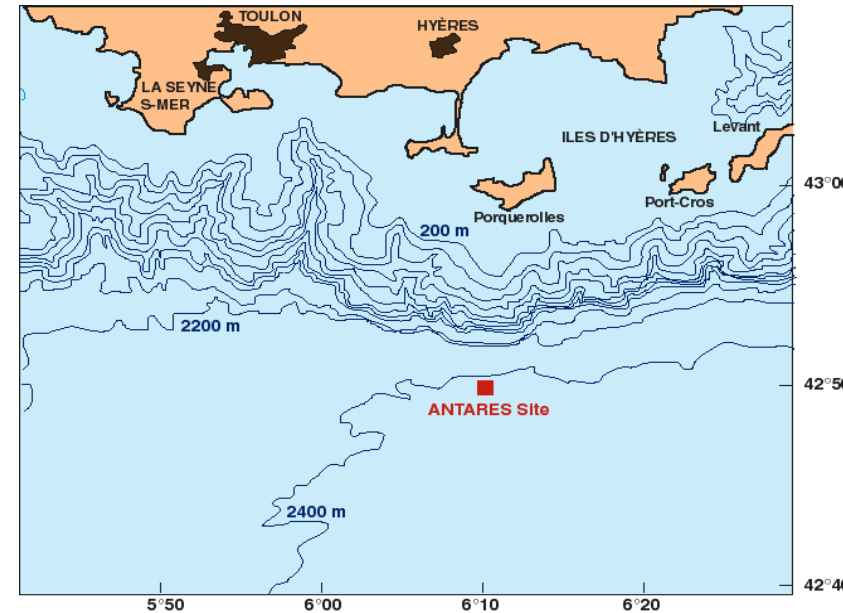
A 1km³ detector should record 200 to 2000
high energy cosmic neutrinos
per year ($E_\nu > 10\text{-}100 \text{ TeV}$).



Phase I : Water properties measurements

■ Perform precise measurements of crucial environmental parameters :

- ◆ In situ measurements on Antares site (2400 m depth off French Mediterranean coast)
- ◆ Long term measurements of optical background (^{40}K decays, bioluminescence) and biofouling of Optical Modules
- ◆ Measurement of water transparency @ 466 nm :

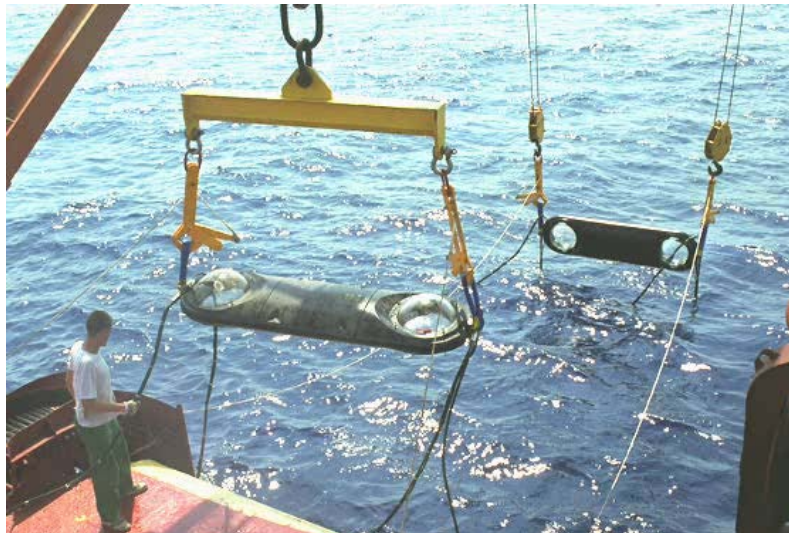


ANTARES Phase I : Demonstrator

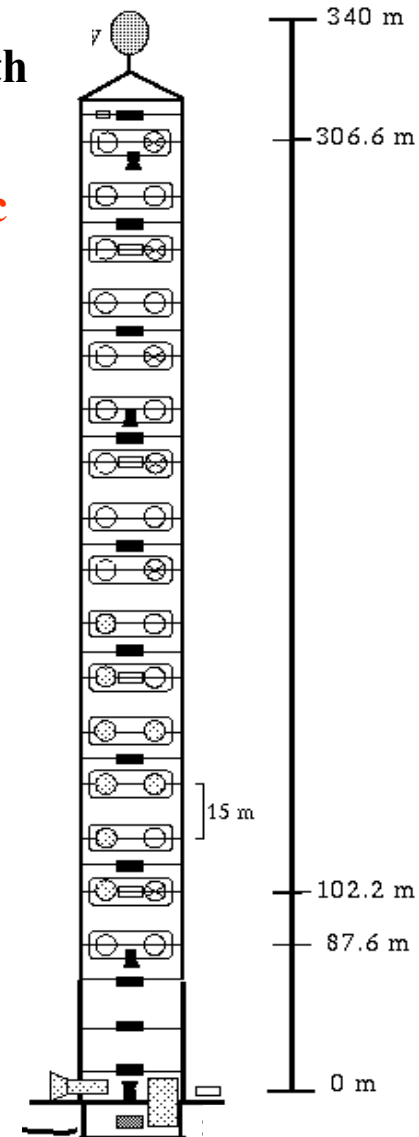
■ First line of 350m high equipped with 16 pairs of Optical Modules

- ◆ Summer 98 : successful deployment test at 2300m depth performed with Dynamical Positioning ship
- ◆ December 99-June 00 : demonstrator equipped with 7 PMTs + acoustic positioning system linked to shore station by electro-optical cable

NAUTILE



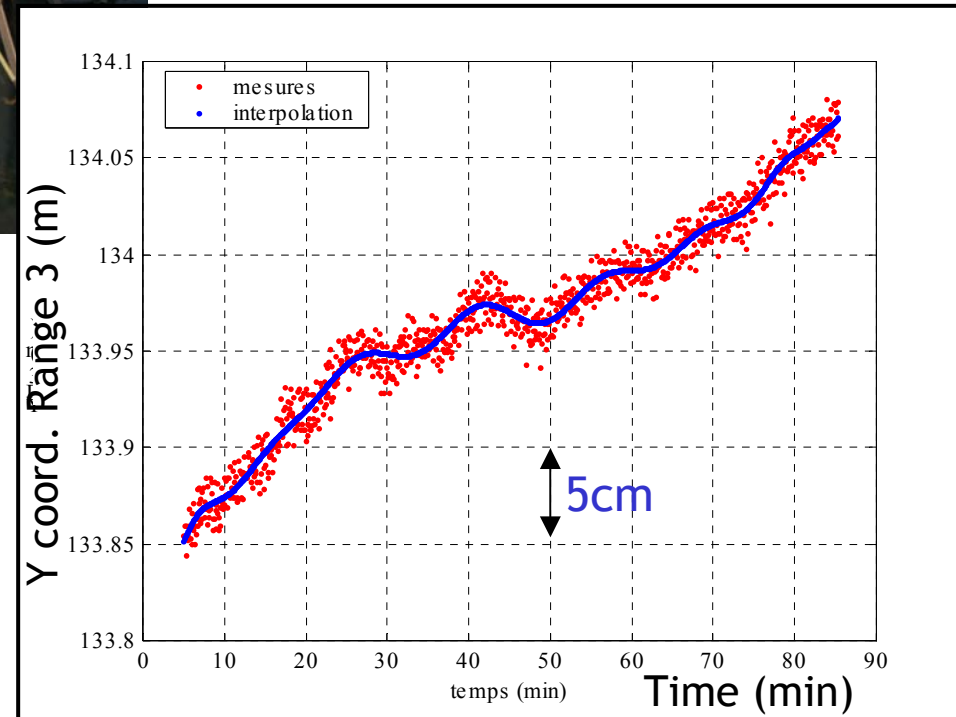
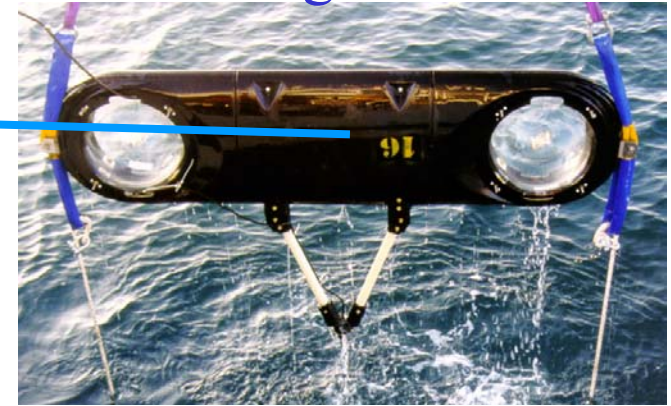
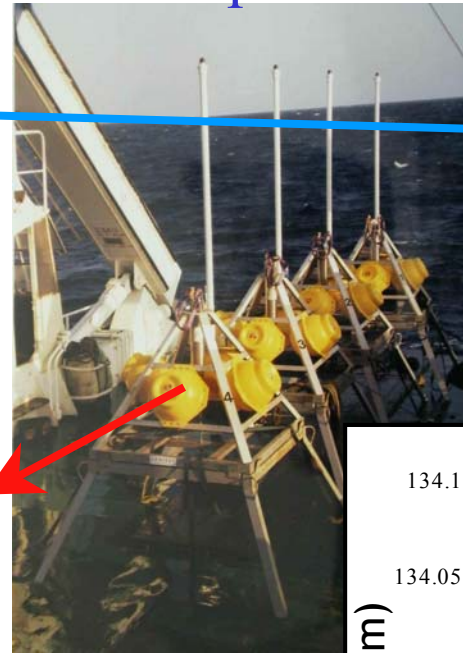
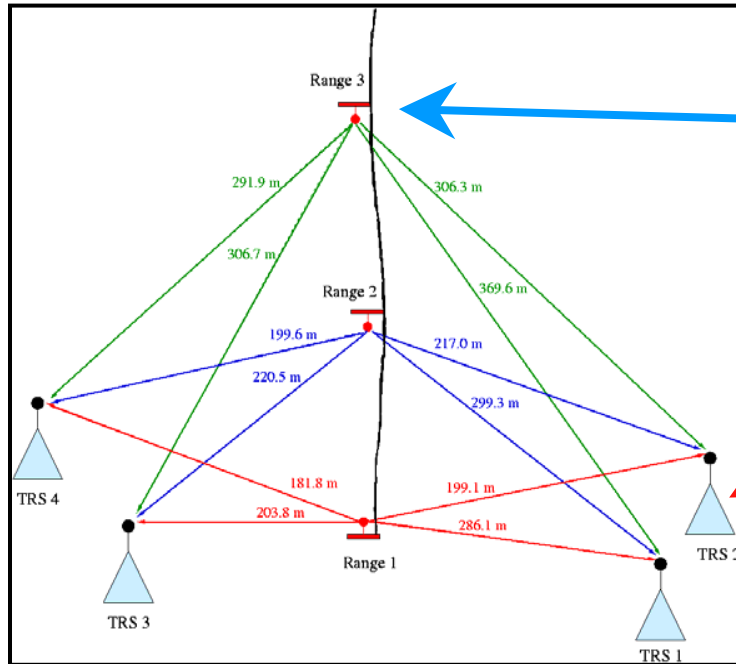
- December 98 : successful undersea electrical connection test of detector anchor performed at 2400m depth by IFREMER submarine vehicle *Nautilie*



Acoustic positioning system

4 transponders

3 rangemeters

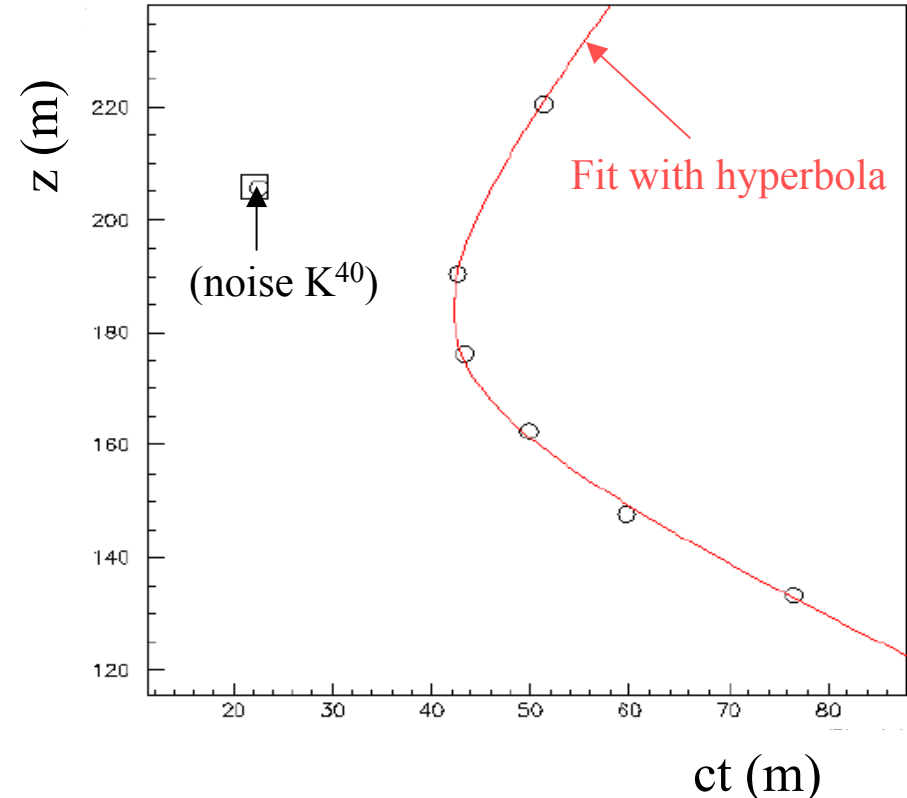
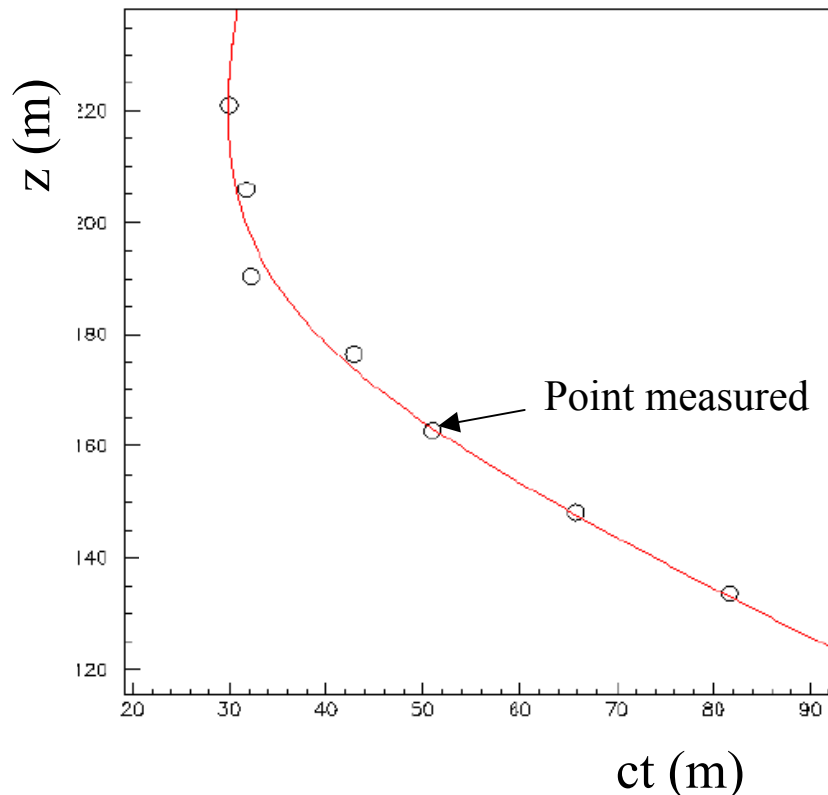


| Devices | Accuracy (σ) |
|-------------------|-----------------------|
| Inter-rangemeter | ~ 1 cm |
| Inter-transponder | ~ 1 cm |
| Rang.-Transpond. | ≤ 3 cm |

Triangulation allows ≤ 5 cm accuracy

Reconstruction of Atmospheric Muons

- More than 5×10^4 coincidences in all 7 PMTs have been recorded.
- Polar angle of down-going muons deduced from depth vs. time pattern.
- Hyperbolic fit (including multimuons).
- ^{40}K filtered out by the reconstruction software (see boxed hit in example).

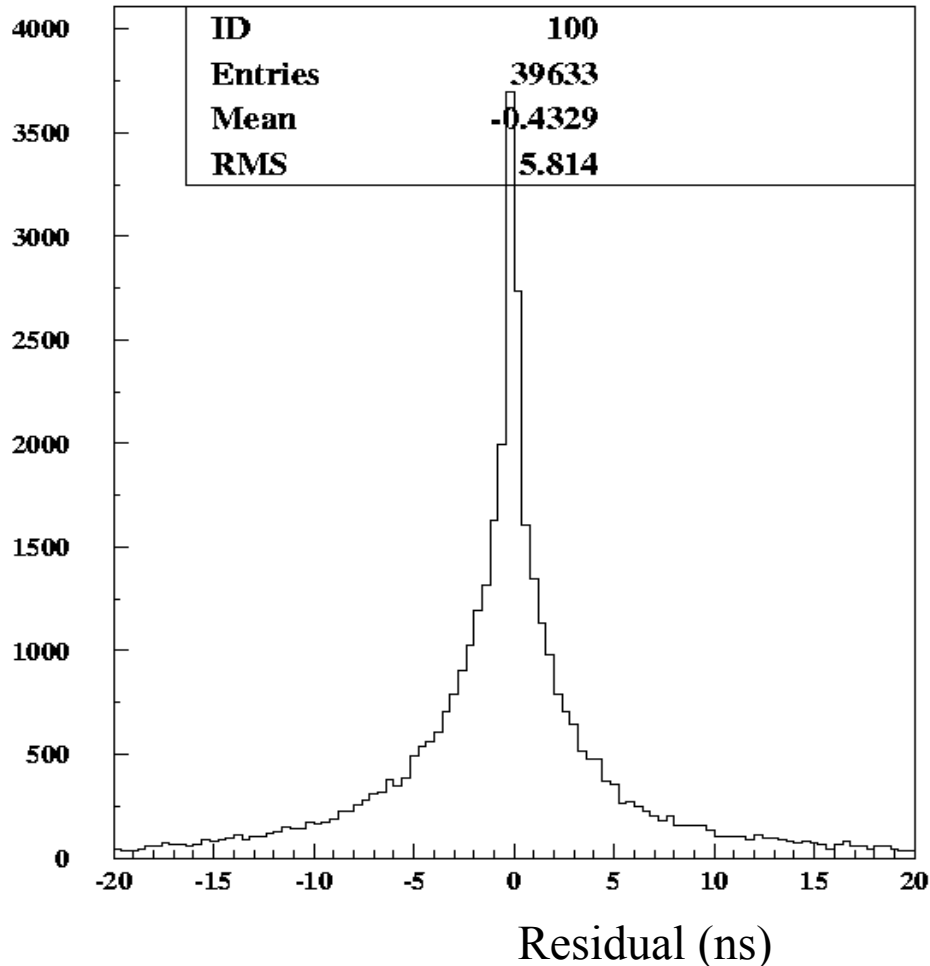


Reconstruction of Atmospheric Muons

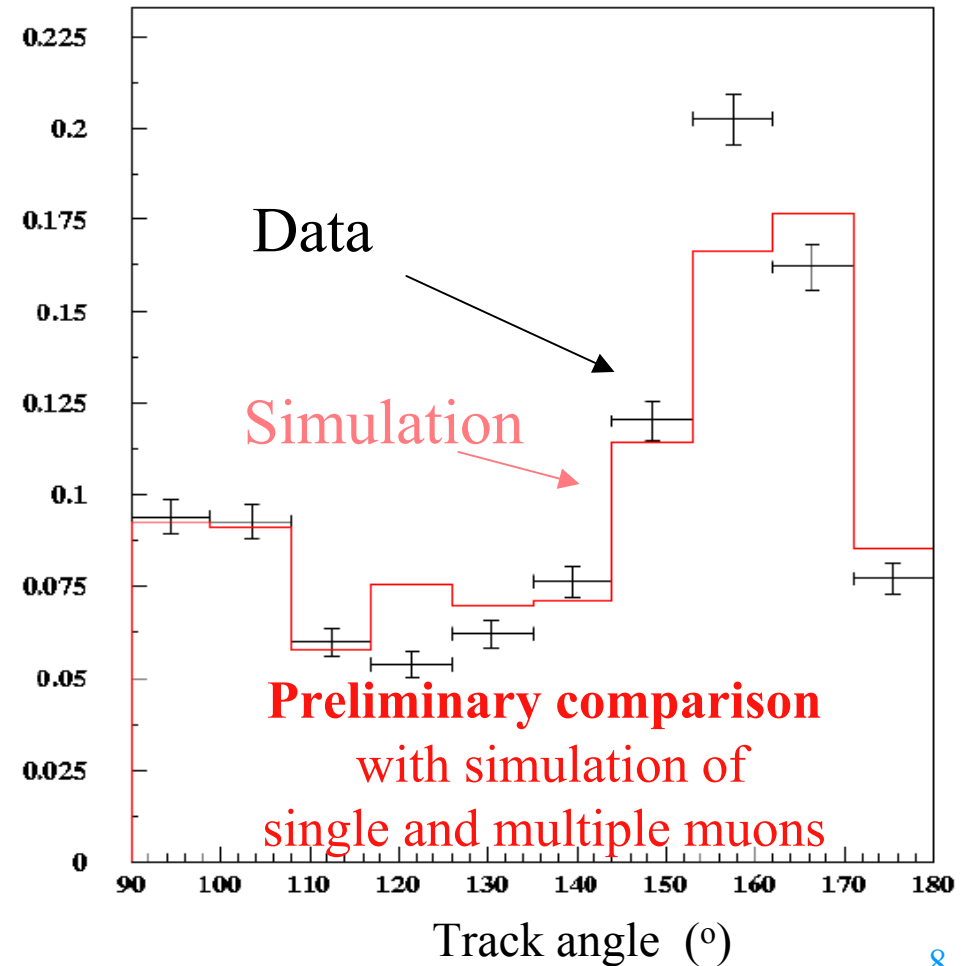
Over 50k 7-fold coincidences recorded

➡ more than **1350 reconstructed events per day**

$\Delta(\text{fit-point})$ in ns



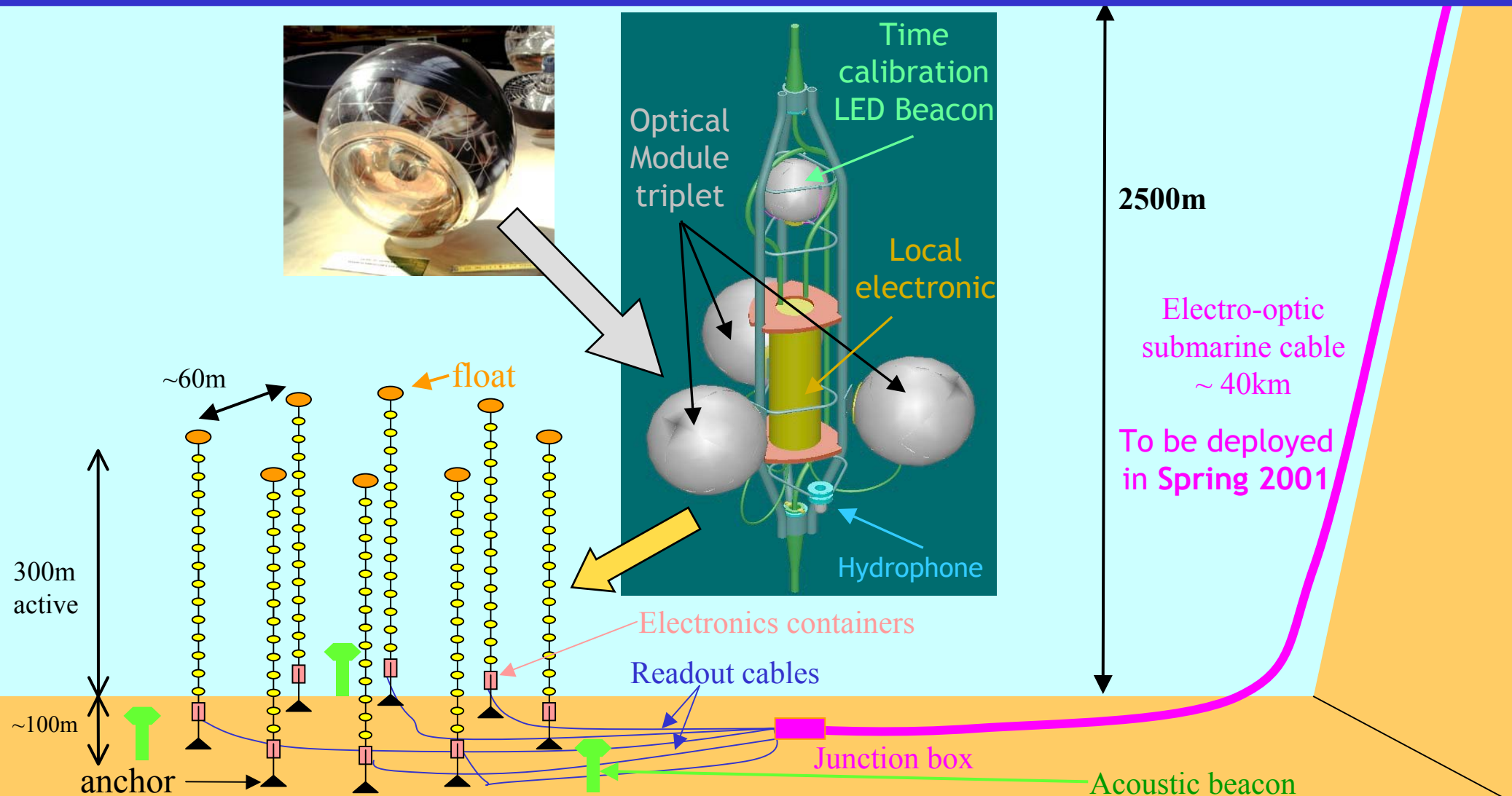
Angular Distribution



ANTARES Phase II : 0.1 km² Detector

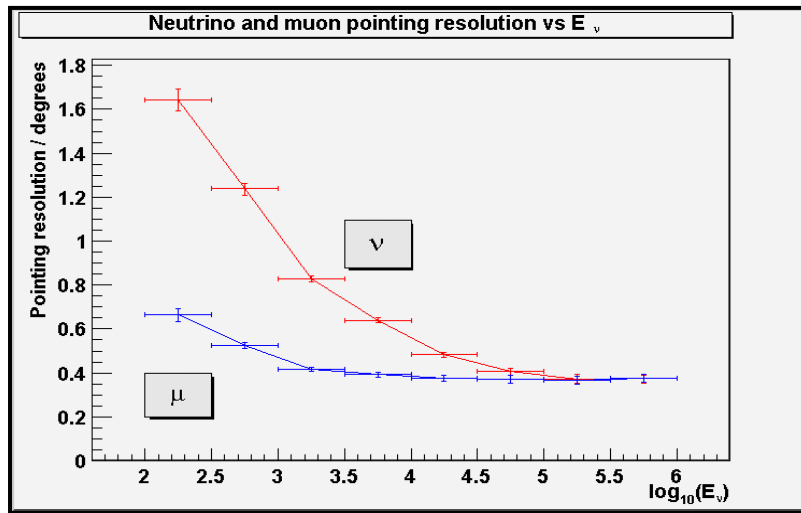
10 strings : 900 PMTs in total
Detector to be deployed at ANTARES site by 2002 - 2004

Shore station



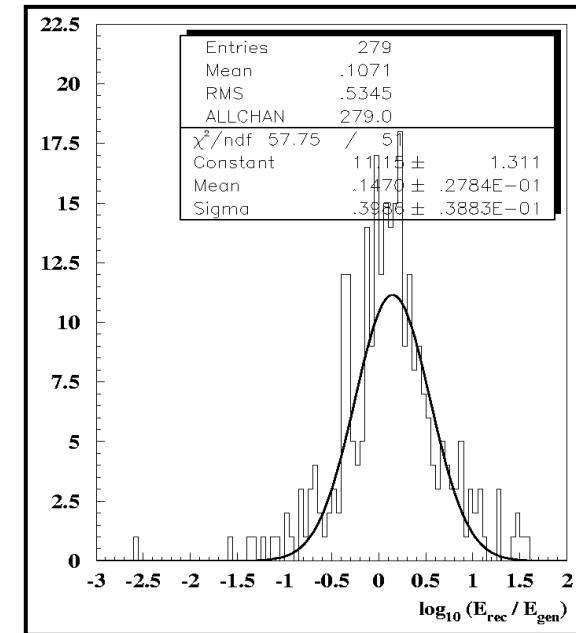
0.1 km² Detector : Expected performance

Angular resolution



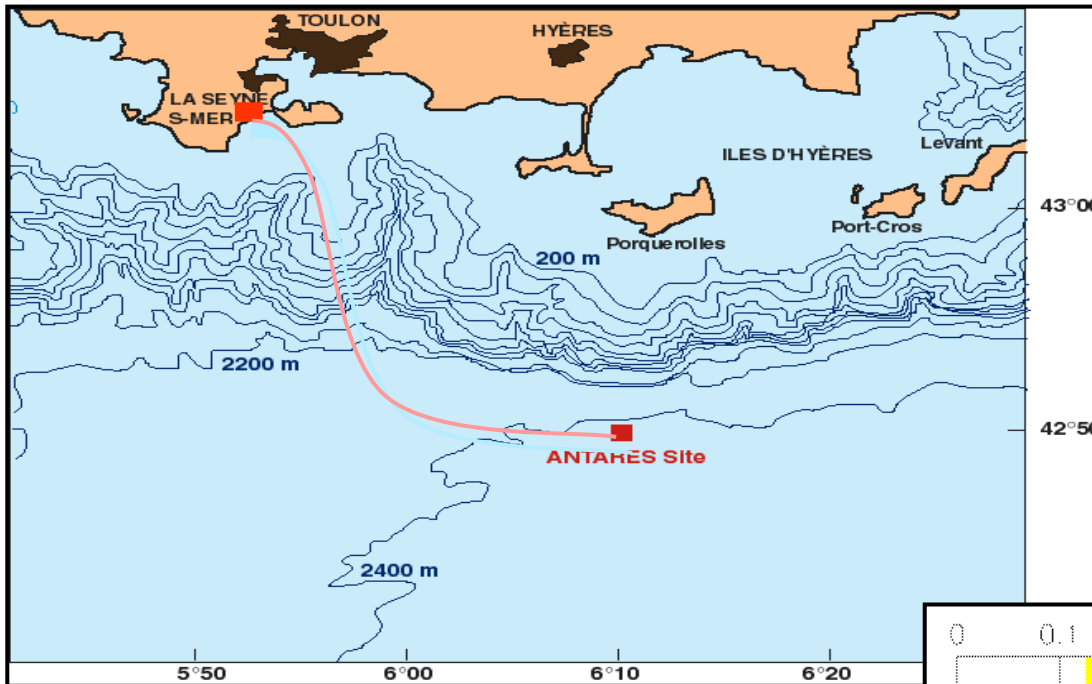
- ❖ Including effects of reconstruction and selection, PMT TTS, positioning, timing calibration accuracy and scattering.
- ❖ Below ~ 10 TeV angular error is dominated by ν - μ physical angle.
- ❖ Above ~ 10 TeV angular accuracy is better than 0.4° (reconstruction error).

Energy resolution



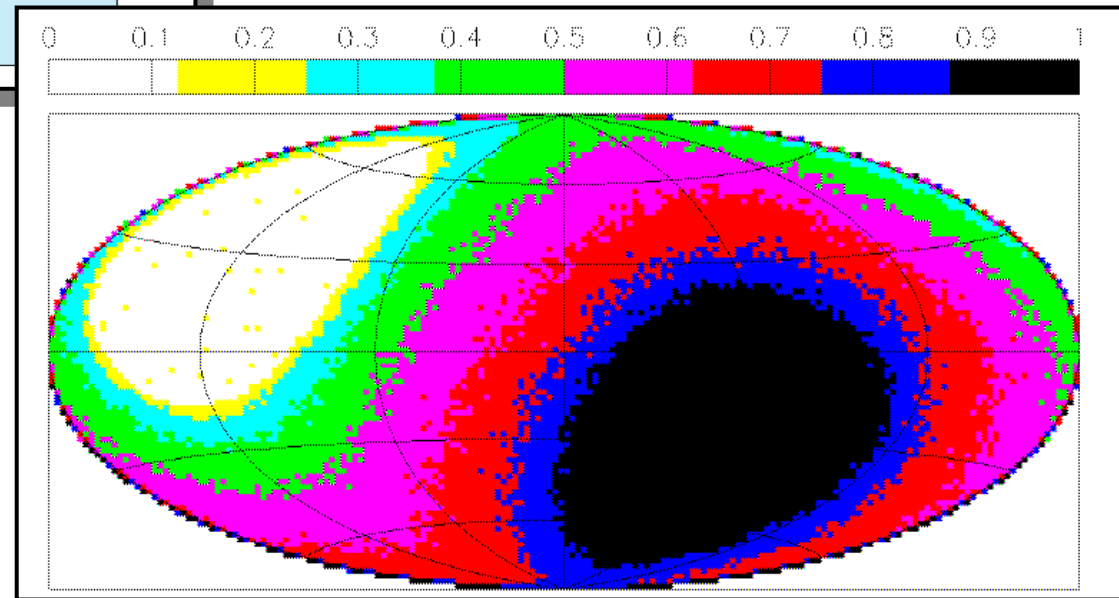
- ❖ $\sigma_E/E \approx 3$ ($E > 1$ TeV)
- ❖ Below $E \sim 100$ GeV energy estimation via muon range measurement.

ANTARES 0.1 km² Detector Site



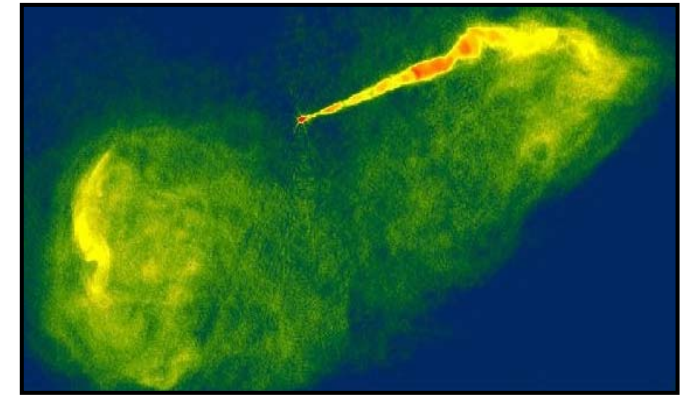
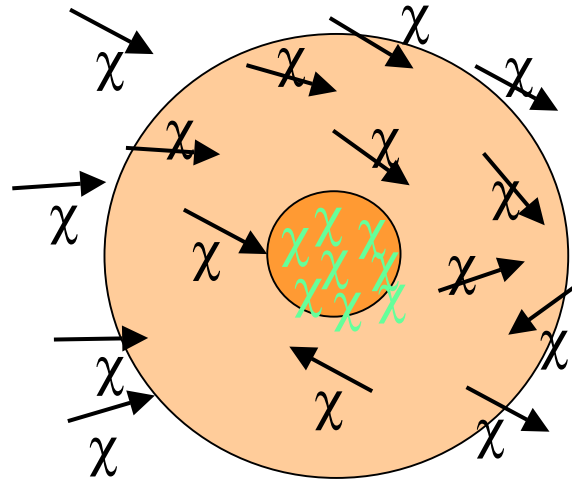
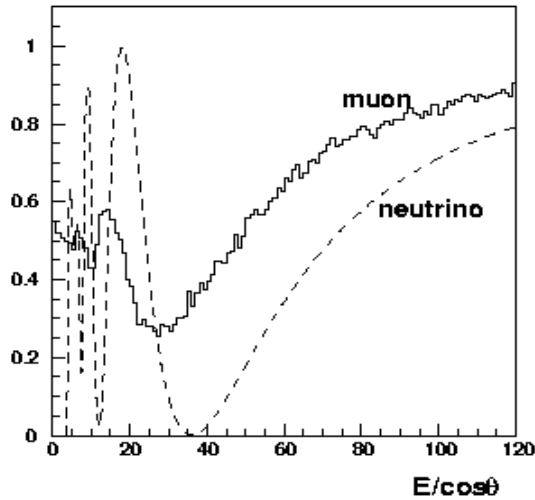
- ❖ 40 km SE of Toulon, Southern France (42° 50' N, 6° 10' E)
- ❖ Shore base at La Seyne-sur-Mer (excellent infrastructure)
- ❖ 2400 m below sea level

- ❖ 3.5π sr of the sky is covered
- ❖ 0.5π sr overlap with Amanda
- ❖ Galactic Centre surveyed



Scientific Programme

Energy



Low energy

- **Neutrino oscillations via the modification in the energy spectrum due to observation of the first oscillation minimum**

Medium Energy


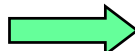
- **Search for neutralinos via their self-annihilation to products containing neutrinos at the centre of the Earth, Sun and Galaxy**

High energy

- **Observation of neutrinos from (extra-)galactic sources such as GRB, AGN, Supernovae remnants, molecular clouds, etc.**

Conclusions

ANTARES has made excellent progress over the past 4 years :

- ◆ Site environmental characterisation  **OK**
- ◆ Tests of marine technologies  **under control**
- ◆ Deployment and operation of Demonstrator String
- ◆ First down-going muons reconstructed
- ◆ Expanding Collaboration

ANTARES is well engaged in Phase II of its programme
by the design, the installation and the running
of a 10-strings 0.1 km² detector in 2002-2004

**Major step forward towards a km-scale
neutrino telescope in the Mediterranean Sea**