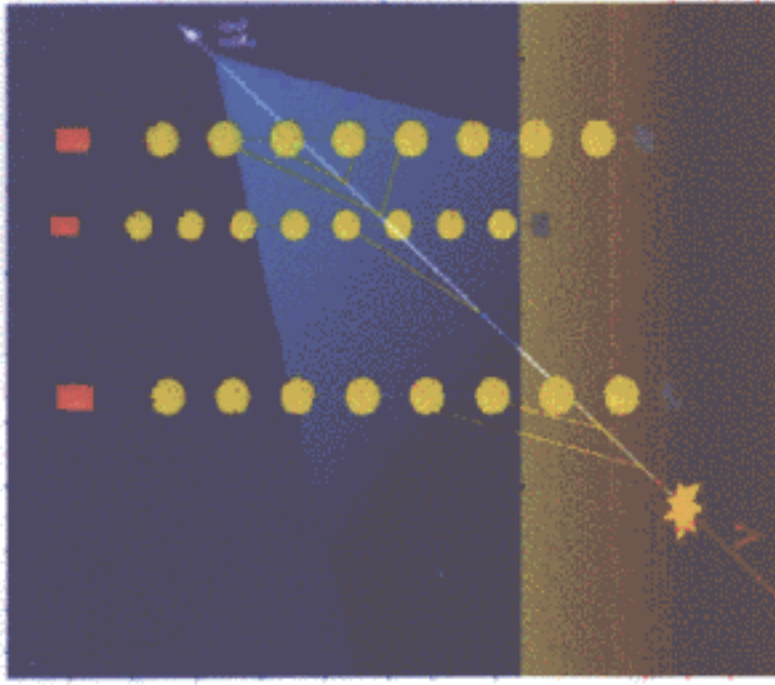


# ANTARES experiment

Nathalie Palanque-Delabrouille

(DAPNIA, CEA/Saclay)

On behalf of the ANTARES collaboration



- ANTARES R&D

- Demonstrator string

- 0.1 km<sup>2</sup>  $\nu$  telescope

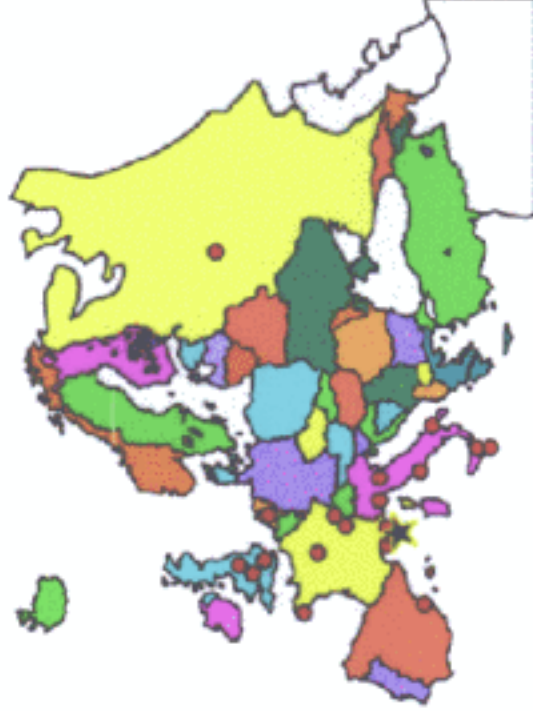
# ANTARES collaboration



- ◆ 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

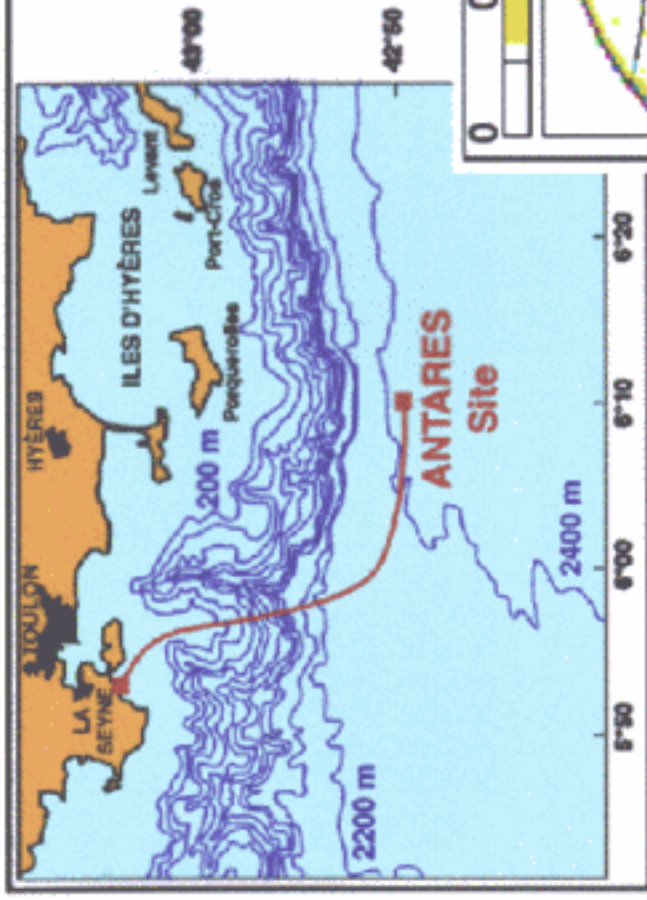


- ◆ IFIC, Valencia

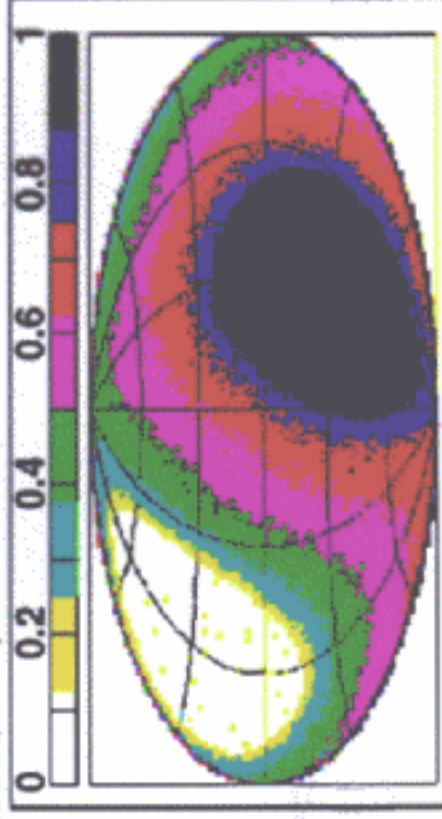


- ◆ NIKHEF, Amsterdam

# ANTARES 0.1 km<sup>2</sup> site

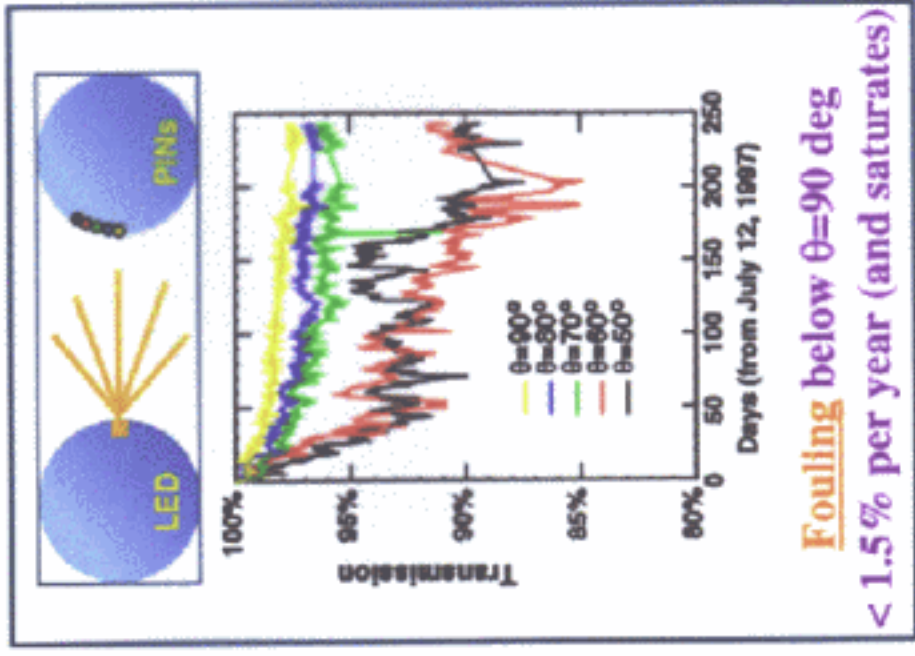
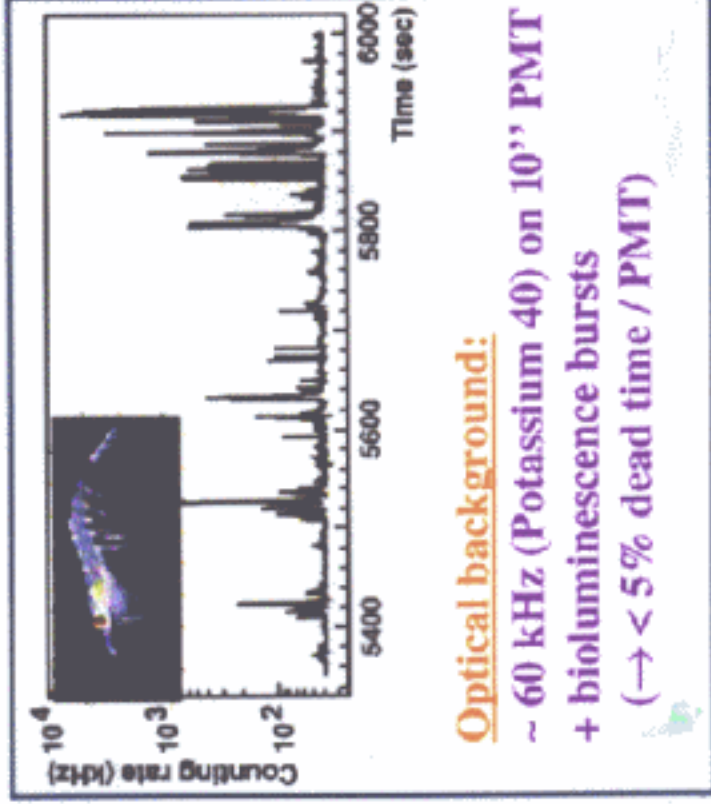


- Excellent infra-structure (boats, submarine vehicles...)
- 2400 m below sea level
- Adequacy of sea bed
- Assessment via deployment of ~30 autonomous strings



- Sky coverage:  $3.6\pi$  sr
- 0.6 $\pi$  overlap with AMANDA
- Galactic Center surveyed

# Water optical properties



# Water optical properties

## Water transparency:

- Blue light (470 nm)

$$\lambda_{\text{abs}} \sim 55 \text{ m}$$

$$\lambda_{\text{scat eff}} \sim 300 \text{ m}$$

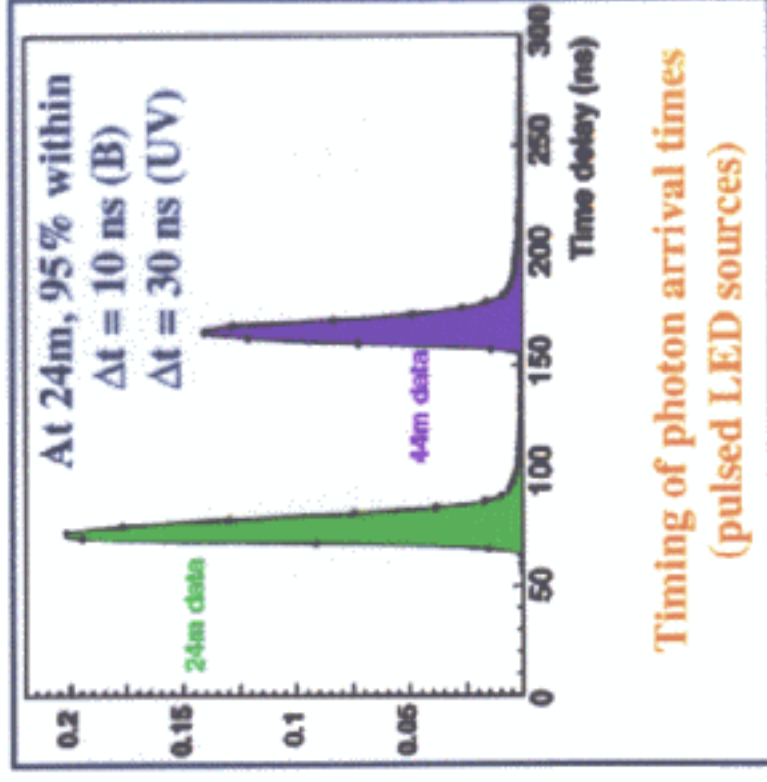
- UV light (370 nm)

$$\lambda_{\text{abs}} \sim 25 \text{ m}$$

$$\lambda_{\text{scat eff}} \sim 120 \text{ m}$$

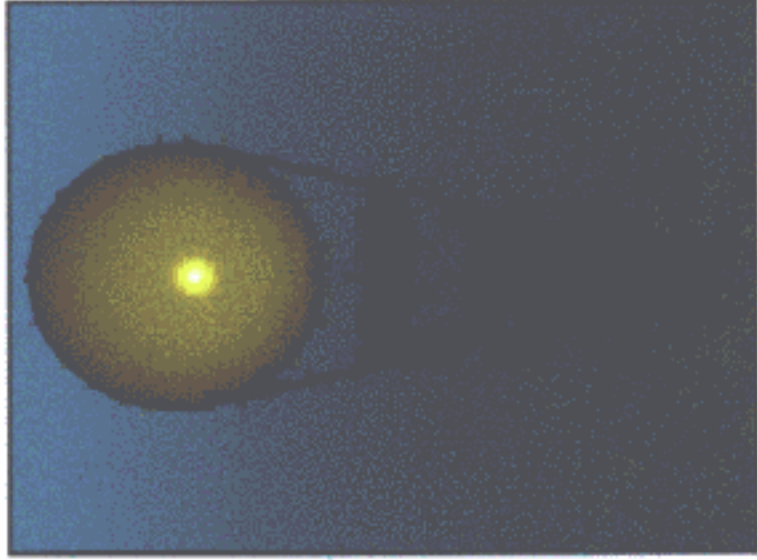


$$\lambda_{\text{scat eff}} = \frac{\lambda_{\text{scat}}}{1 - \langle \cos \theta \rangle}$$

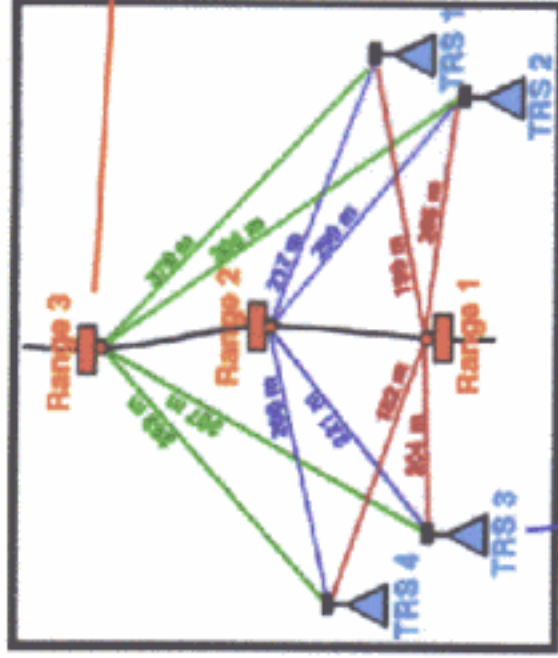


## ANTARES demonstrator line

- First line controlled and readout via 37 km electro-optical cable, analog transmission (digital for 0.1 km<sup>2</sup> ready)
- Immersed: Nov. 99 - June 00
- Depth of 1100 m
- 7 PMTs, acoustic positioning system
- 350 m line height, 16 storeys



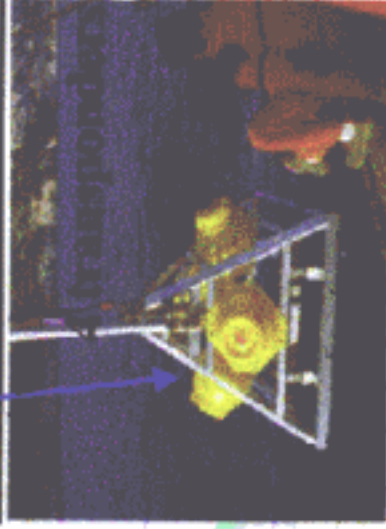
# Acoustic positioning system



High currents, yet  
small line inclination ( $2.5^\circ$ )

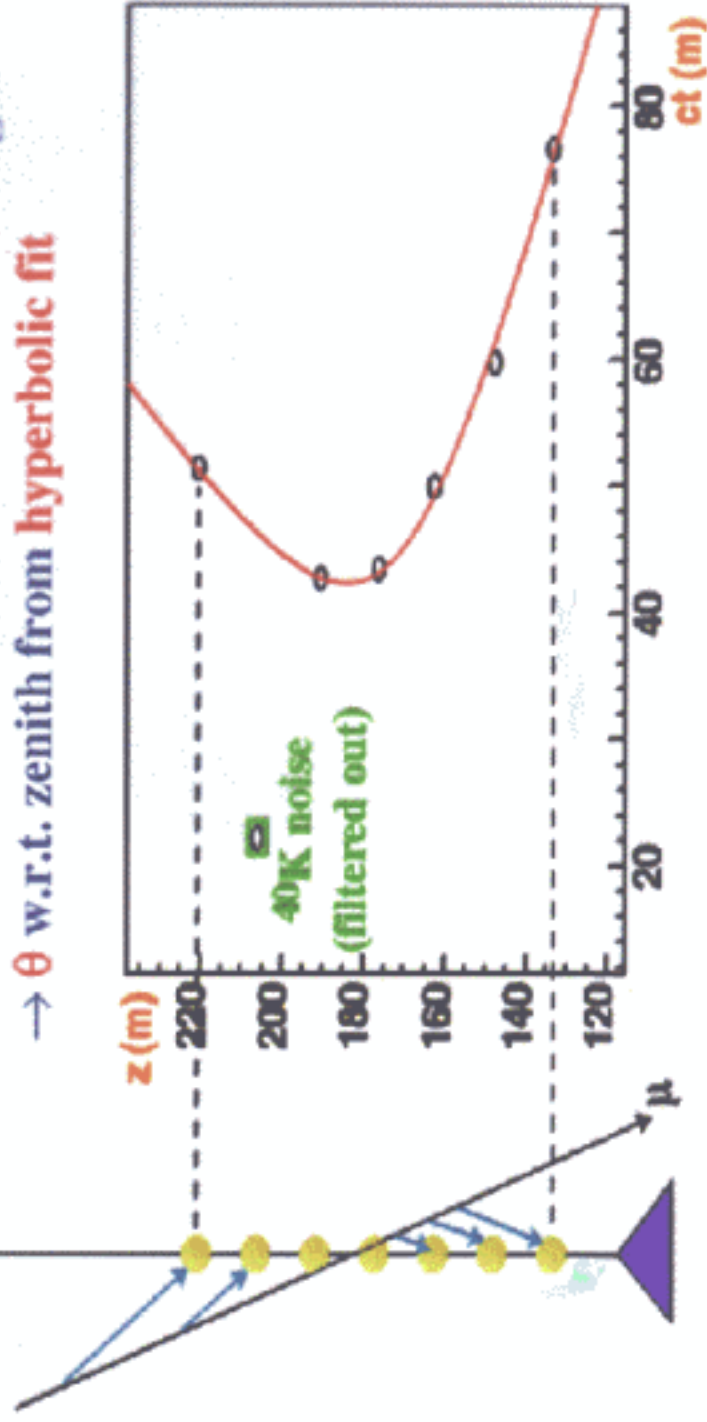
Relative positioning  $\leq 5$  cm,  
confirmed with tiltmeters

**FINAL SYSTEM**  
to be used for  $0.1 \text{ km}^2$



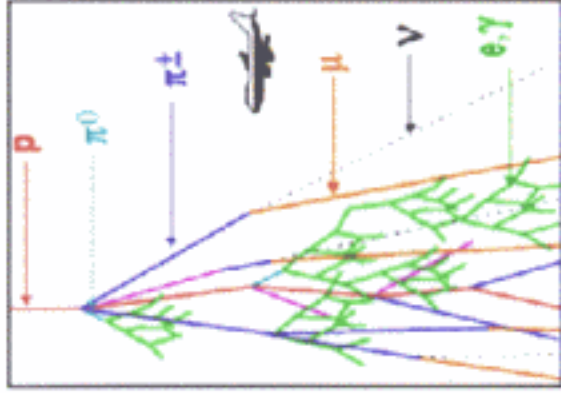
# Atmospheric $\mu$ events

- > 50 000 events with 7-fold coincidences
- Photon arrival time  $t$  function of PM height  $z$   
→  $\theta$  w.r.t. zenith from **hyperbolic fit**





# Multi- $\mu$ contribution

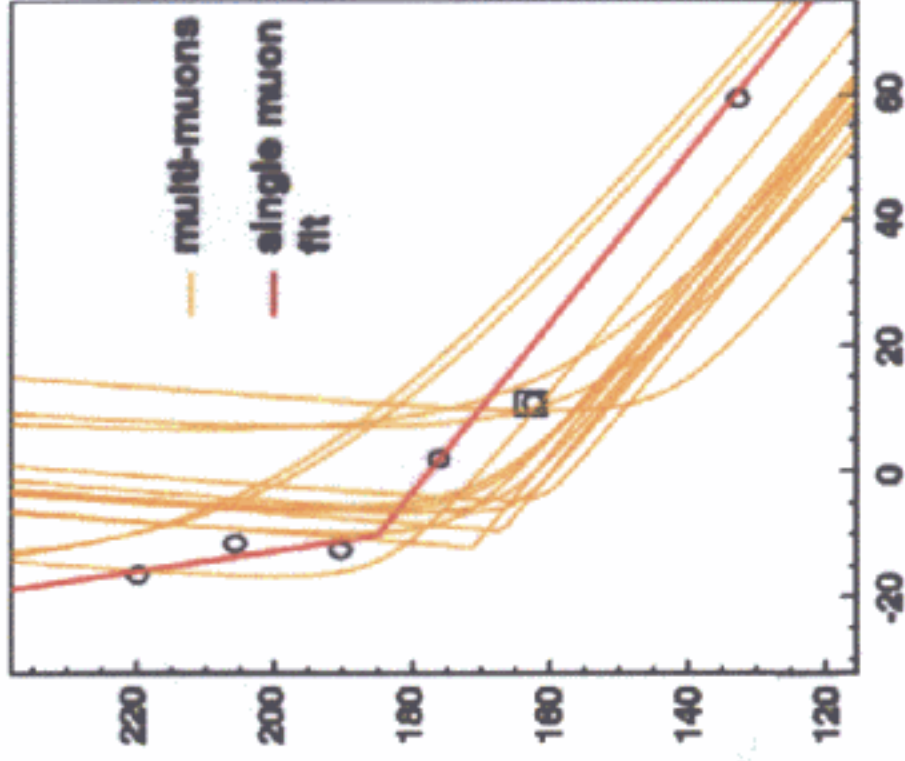


Atmospheric shower



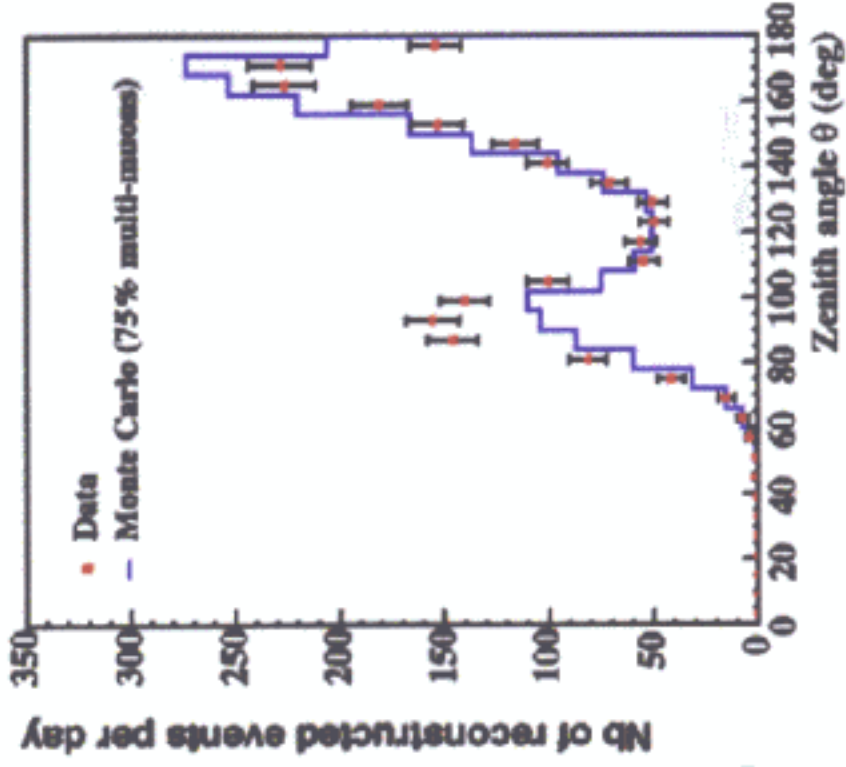
Parallel muons

Dominant at reconstruction level



Fraction of multi-muons	At detector	Fitted
Multiplicity	16.5 %	76 %
	3.3	13

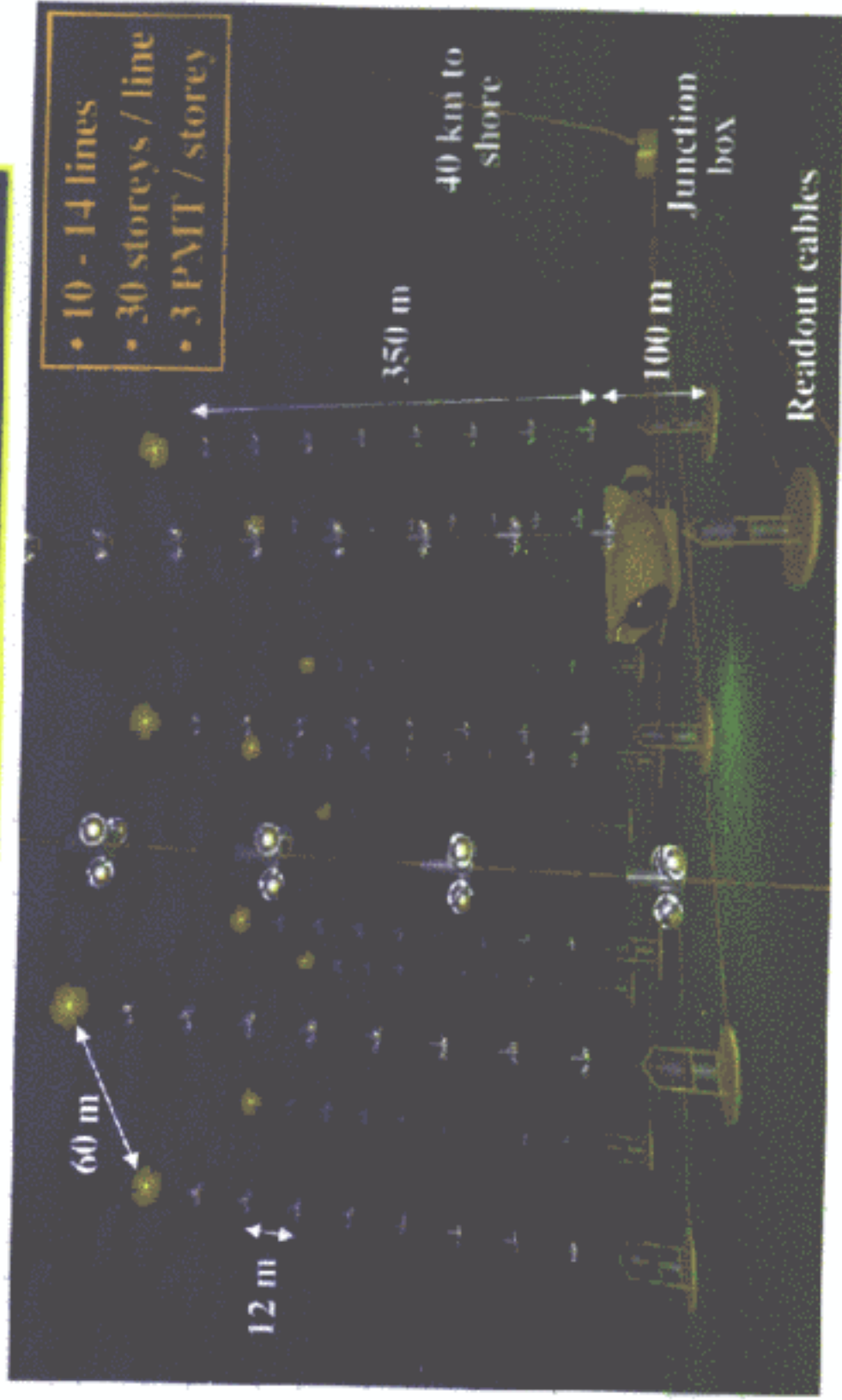
# Angular distribution



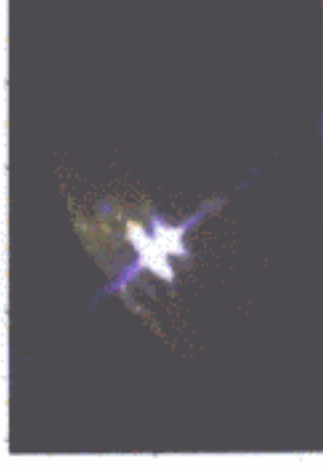
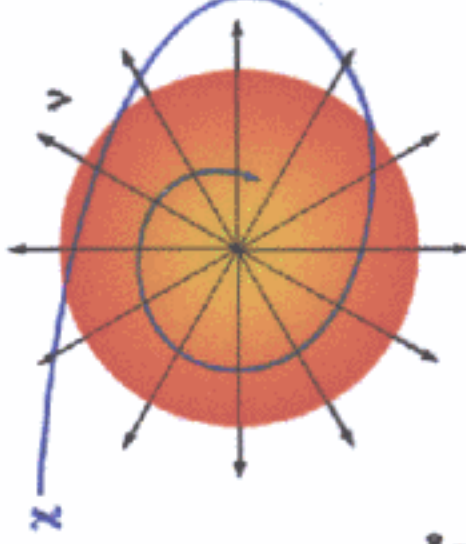
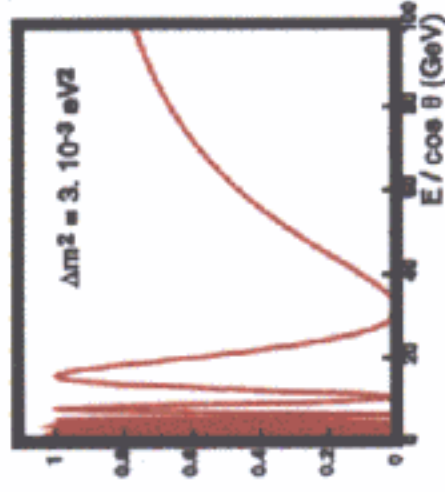
Over 1350 reconstructed events per day

Shape reproduced by MC with single + multi muons

# ANTARES 0.1 km<sup>2</sup> detector



# Scientific program



## Low Energy

**$\nu$  oscillations**  
 (Observation of first  
 oscillation minimum)

## Medium Energy

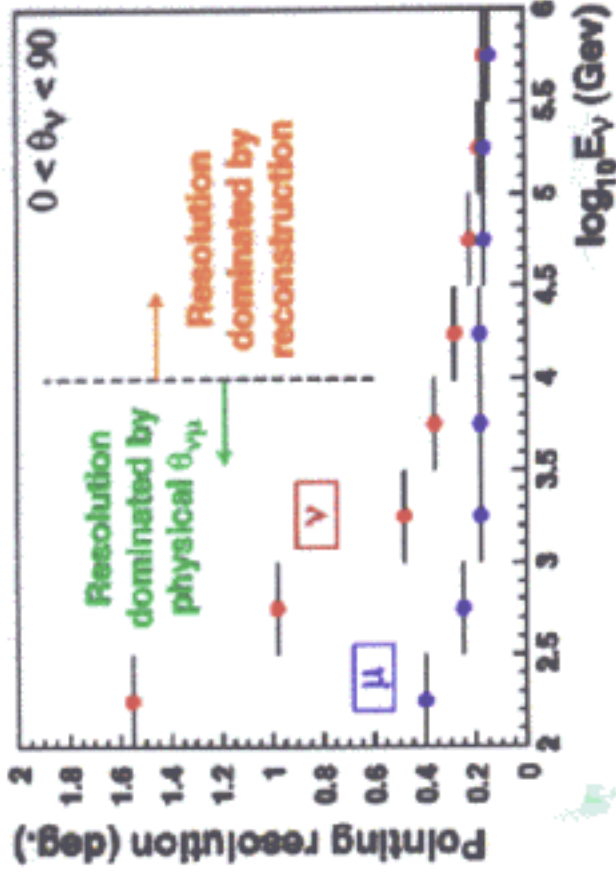
**Neutralino search**  
 Self-annihilation at center  
 of Earth, Sun, Galaxy  
 $\chi\chi \rightarrow X \rightarrow \nu$

## High Energy

**$\nu$  from (extra-) galactic sources**  
 SN remnants,  
 AGN, GRB, ...

# 0.1 km<sup>2</sup> detector: expected performance

## Angular resolution



(including scattering)

## Energy resolution

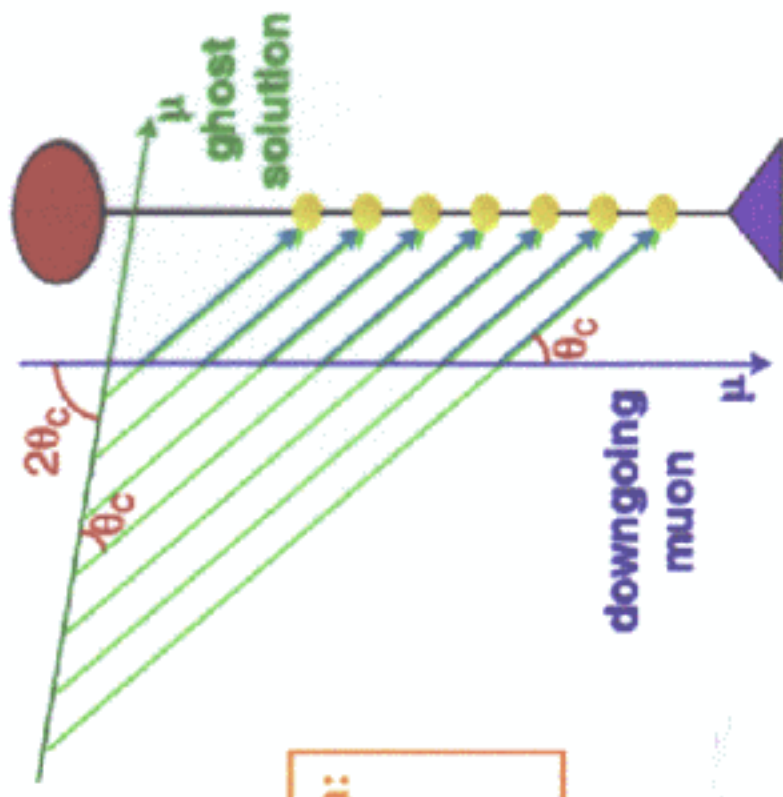
- 5 GeV < E < 100 GeV  
Energy estimated from μ range
- E > 1 TeV  
 $\sigma_E / E \sim 3$

## Conclusions

- 1996 - 2000: R & D phase
  - study of site water properties (fouling, transparency, optical background) → **OK**
  - Test of marine technology → **under control**
  - Operation of demonstrator string → **First down-going muons reconstructed**
  - Expanding collaboration
- Present phase: Construction and deployment of 0.1 km<sup>2</sup>
  - 2001 - 2002: Cable deployment, sector (5 storeys) immersion
  - 2002 - 2004: Deployment of 0.1 km<sup>2</sup> 10-string detector

First step towards **1km<sup>3</sup> detector in Mediterranean Sea**  
(search for site in collaboration with NEMO project)

## “ Ghost solution ”



Degeneracy raised with:

- more PMTs
- 3D network
- use of amplitude