The ANTARES ν Telescope

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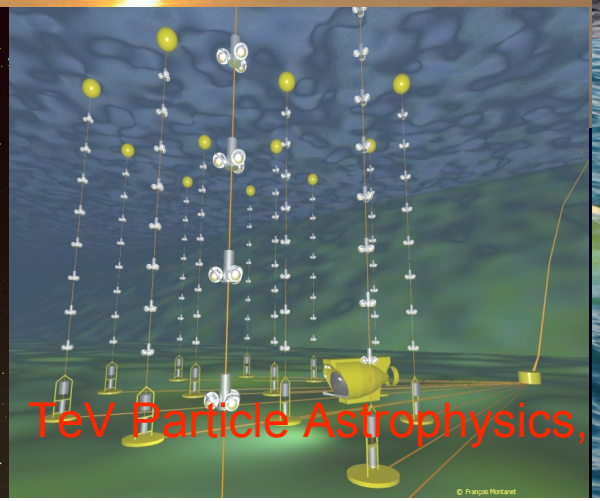


Physics Issues

- **High energy ν astrophysics:**

Galactic/Extra-Galactic sources
X-ray binaries, SNRs, Microquasars,
AGNs, GRBs,..
Diffuse fluxes:
Waxman-Bahcall limit
for extra-galactic, optically thin sources up to
~250/ev/year/km^2 (without oscillations)

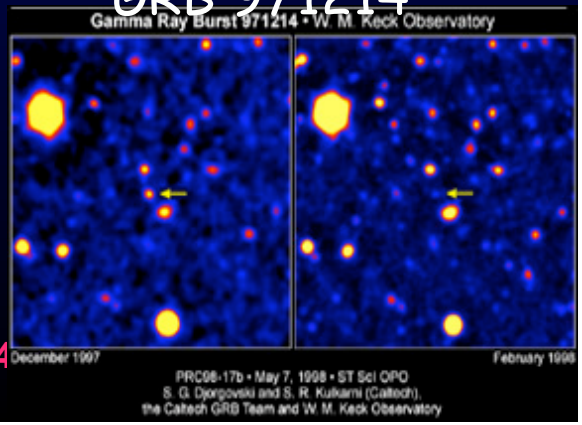
- **Dark matter:** WIMPs, Monopoles

- **Atmospheric ν's**

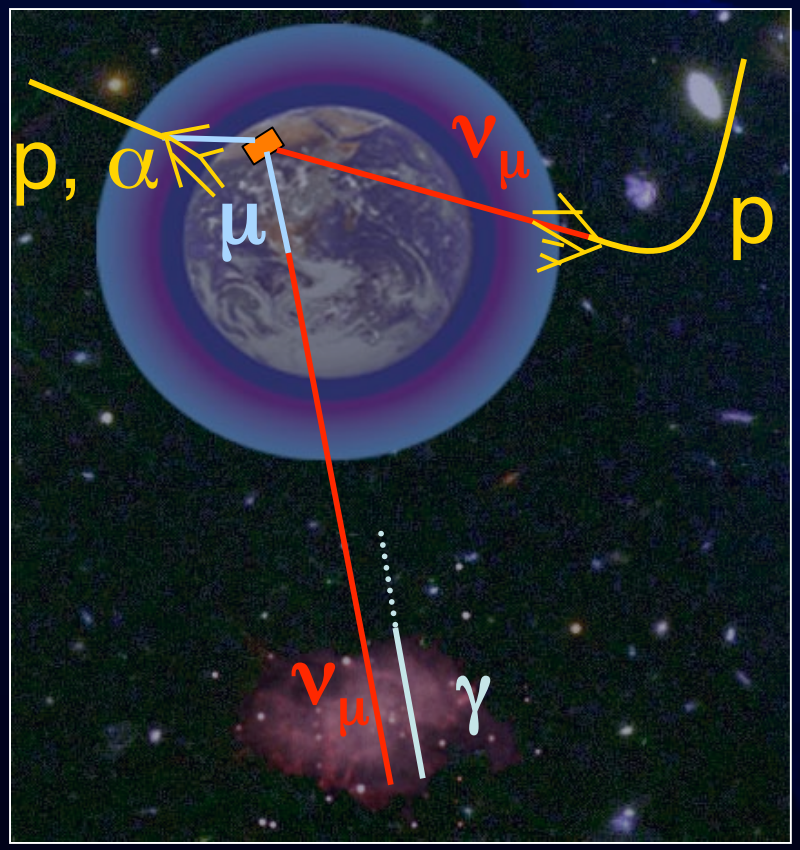
- **Oceanographic interest**

Crab Nebula

GRB 971214



Neutrino detection principle



3D PMT array

Cherenkov light from μ

$\gamma_{č}$

2500 m depth

43°

Measurement : Time & position of hits

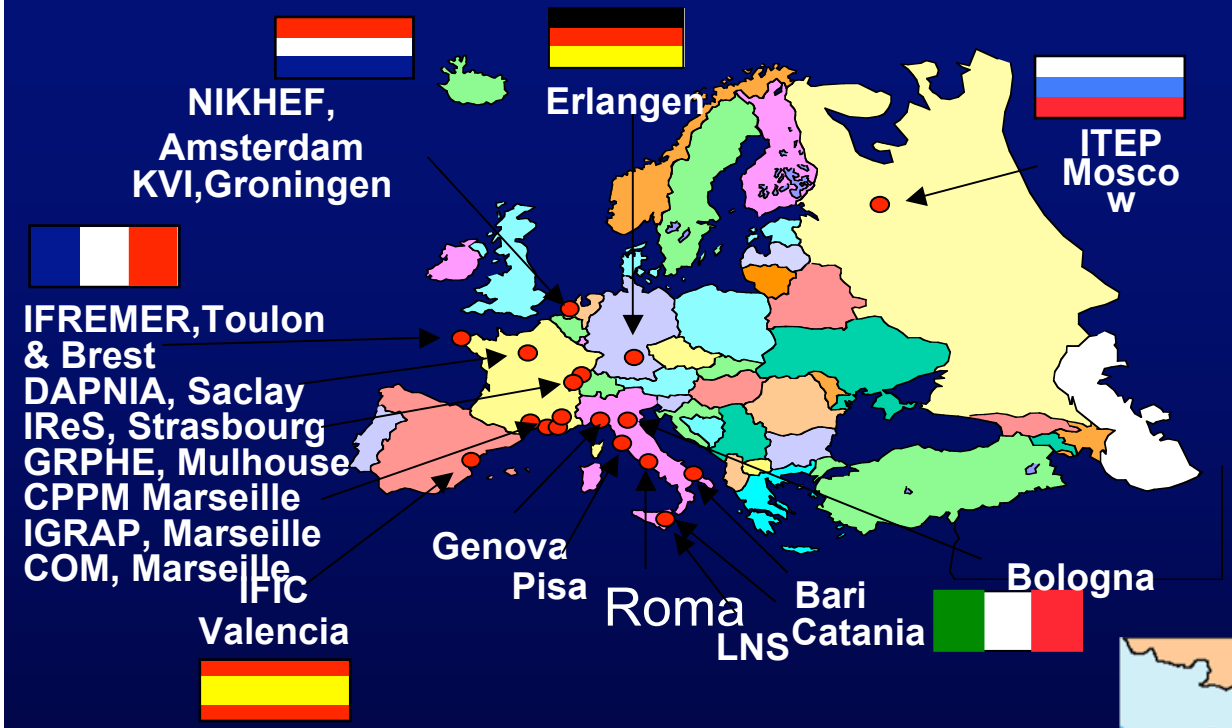
μ

interaction

ν

μ (≃ ν) trajectory

ANTARES collaboration and site

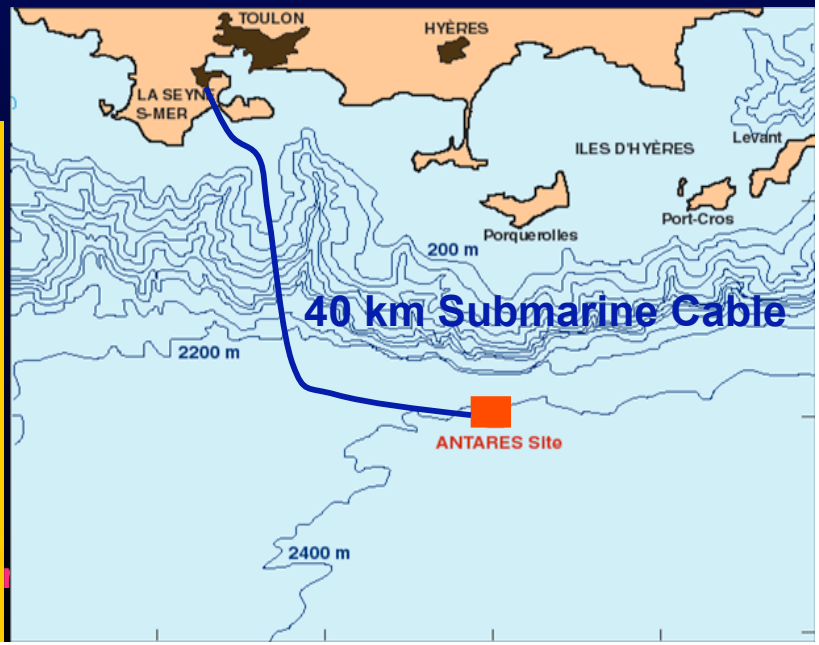


Location: Toulon (France)

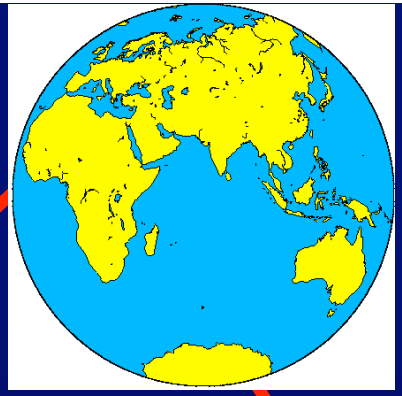
42°50'N, 6°10'E

Depth: 2500 m

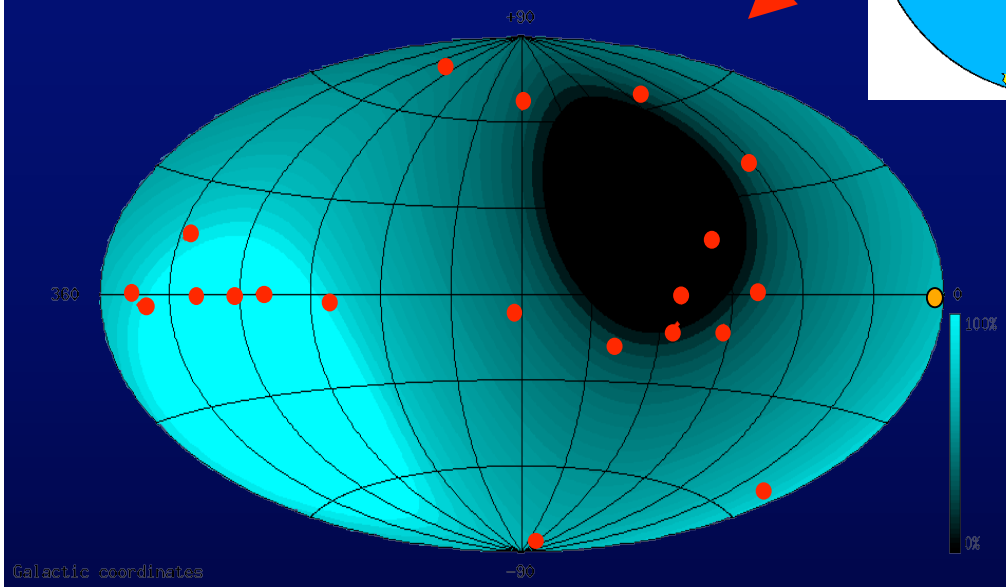
Shore station : La Seyne-sur-Mer



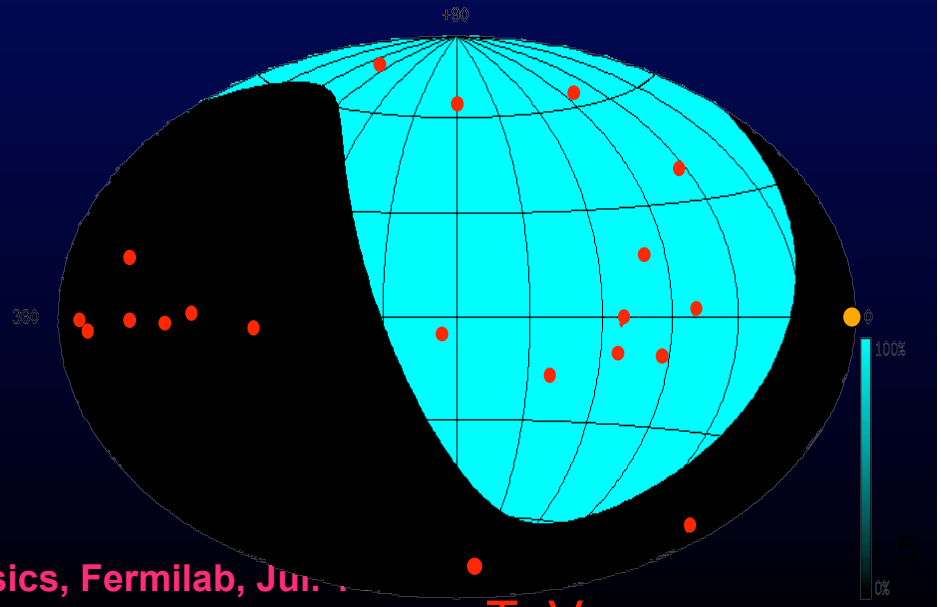
Sky Visibility with upgoing μs



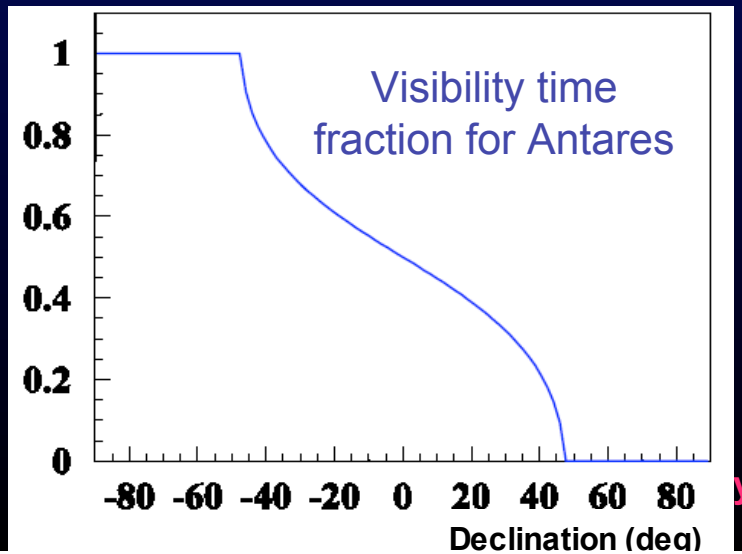
Mediterranean
2/3 of time: Galactic Centre



AMANDA, IceCube
South Pole (Karle's talk)



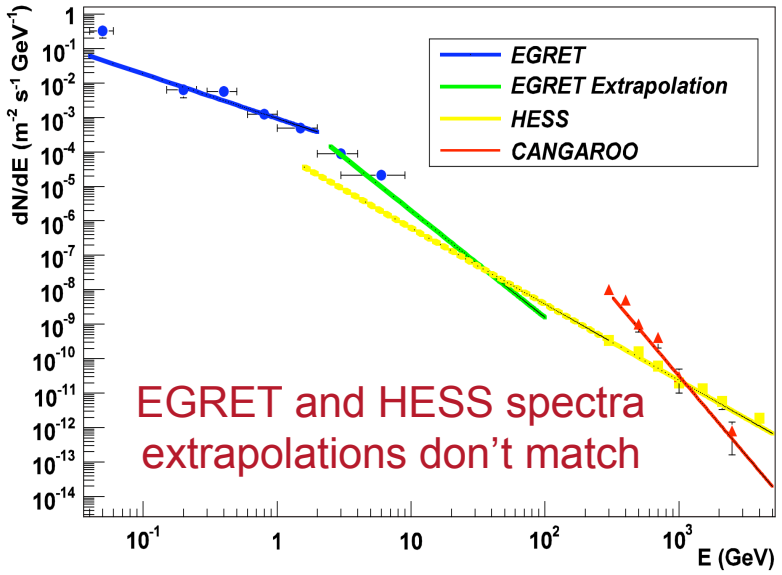
3.5 π sr
covered



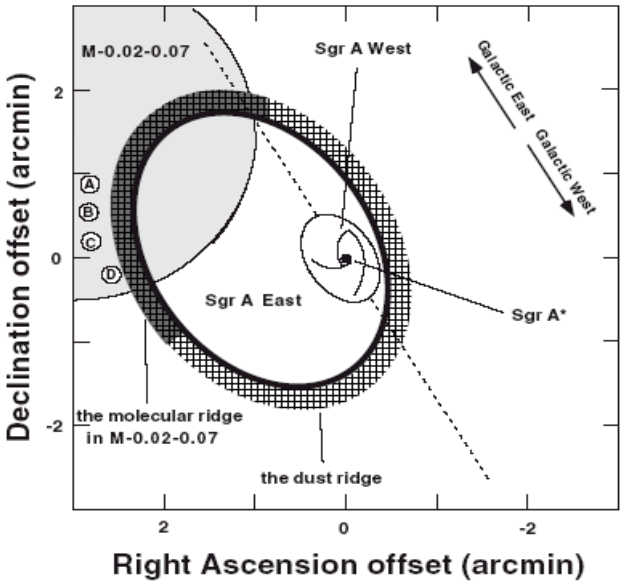
ysics, Fermilab, Jun.

TeV γ sources

Rates in ANTARES and a km^3 detector from the Galactic Centre



E_μ>1TeV
dΩ=0.5°
Not optimized
PRELIMINARY

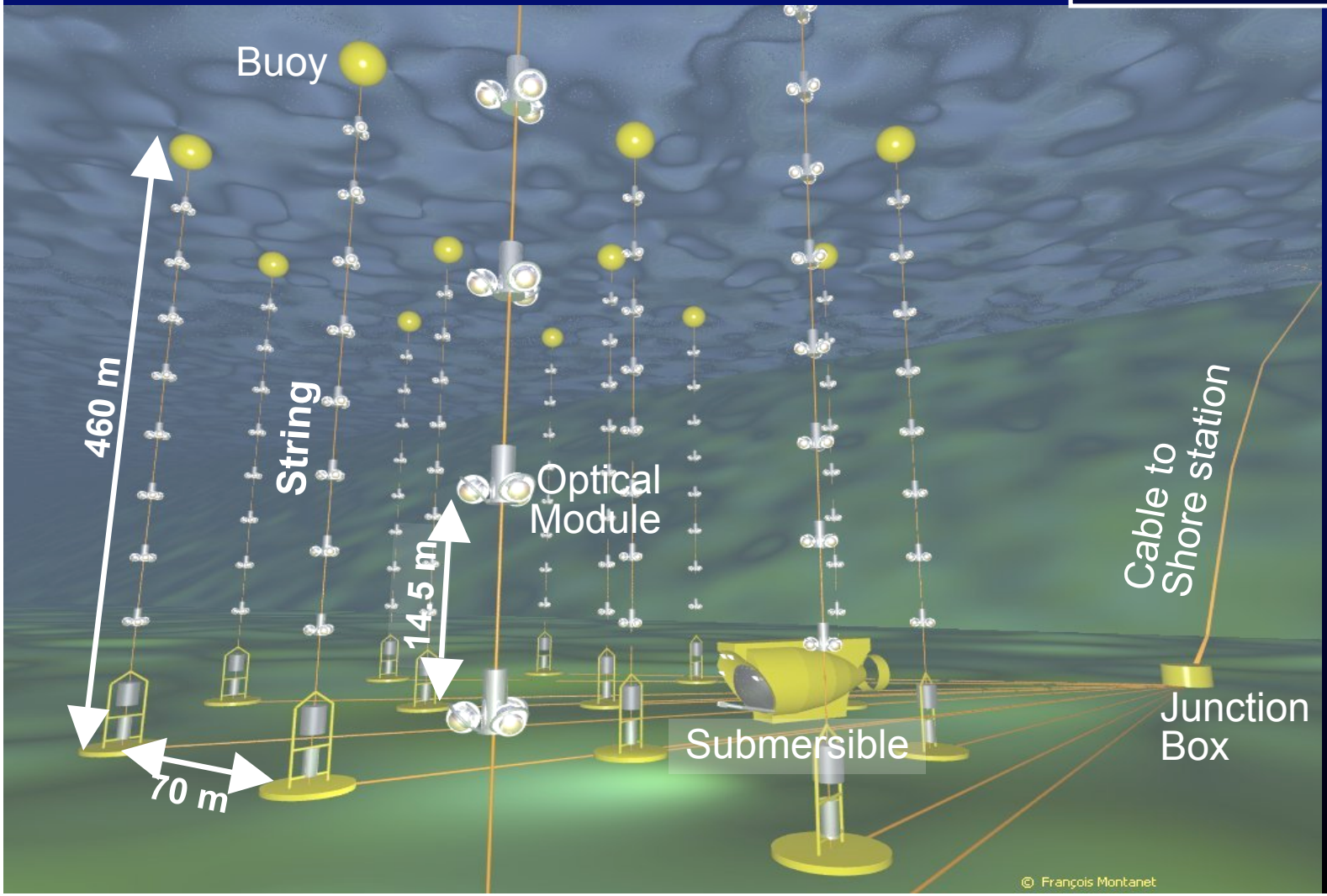


		ANTARES			KM3
		Signal events /year	Bkg events /year	Time for detection (4 σ CL)	Time for detection (4 σ CL)
GC	HESS	$2\cdot10^{-2}$	$7\cdot10^{-3}$	247 yr	6.2 yr
	HESS+EHECR	$5\cdot10^{-2}$		64 yr	1.7 yr
	EGRET+EHECR	2		0.4 yr	week
RX J1713.7-3946	Constantini et al (2005)	0.16	$9\cdot10^{-3}$	15 yr	0.4 yr
	Halzen et al (2002)	0.95		1.8 yr	3 weeks
PSR B1509-58	HESS	0.11	$1.1\ 10^{-2}$	22 yr	0.6 yr

The ANTARES Detector

12 lines each holding 75 PMTs
5 sectors/line ⇒5 storeys/sector ⇒3 PMTs/storey

Hostile environment:
- pressure up to 240 bar
- sea water (corrosion)



Deployment of Line 1: Fall 2005

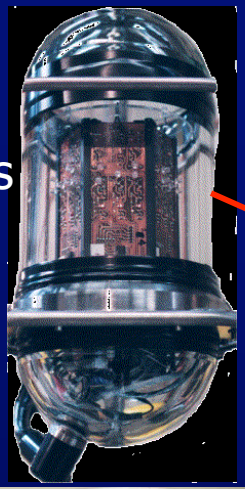
1 Line/month In 2006

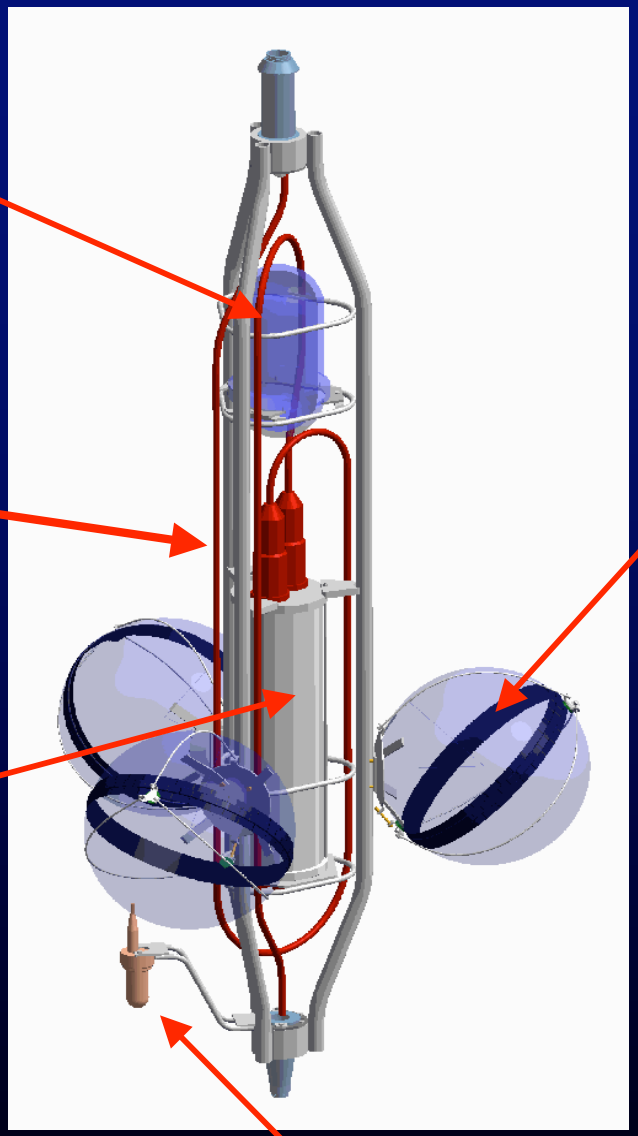
Full detector in early 2007

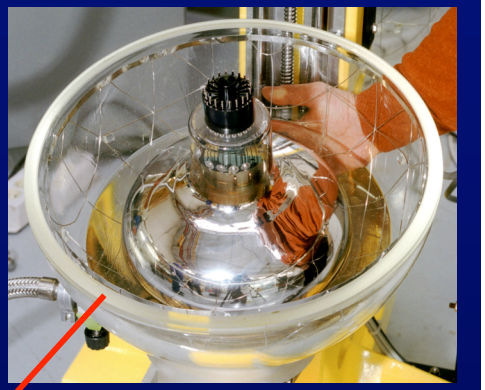
artist´s view (not to scale)

Basic detector element: storey

Optical Beacon
for timing calibration
(blue LEDs) 1/4 floors

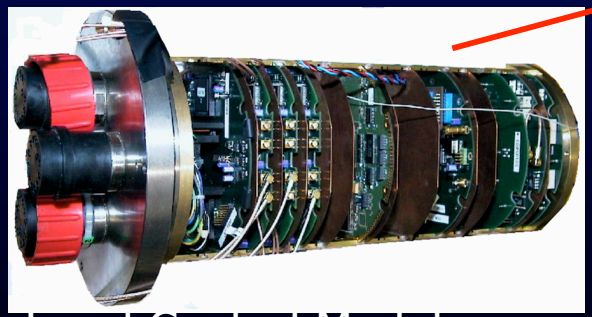






10" PMT Ham. R7081-20
14 stages TTS FWHM <3 ns
900 PMTs fully characterized
Specs for OMs: resistant to
700 bars

Connectors
in Tytanium
(Subconn)

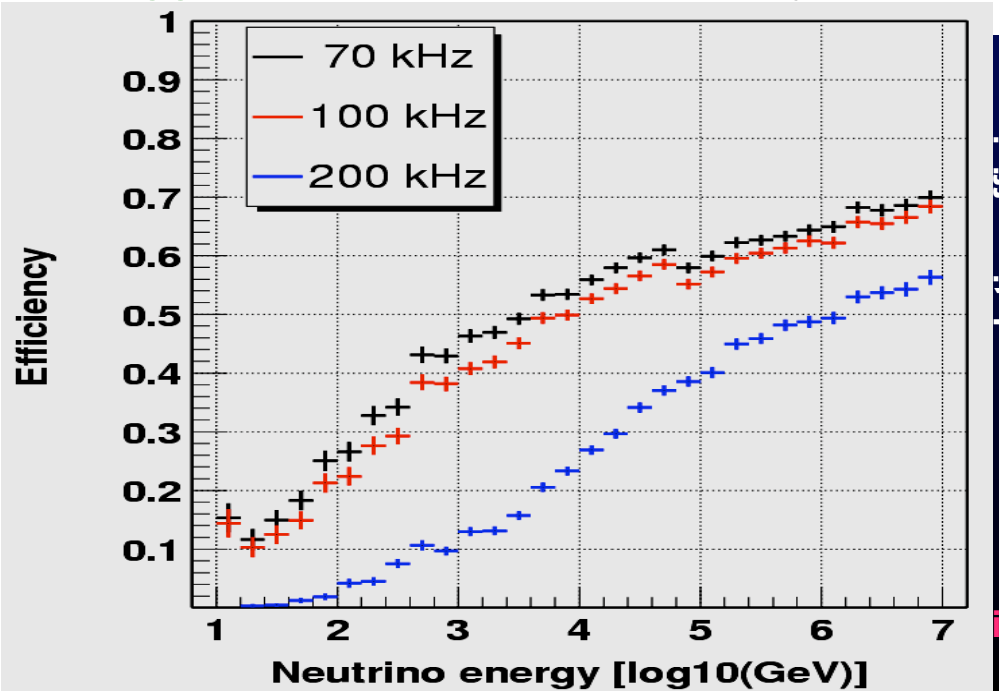


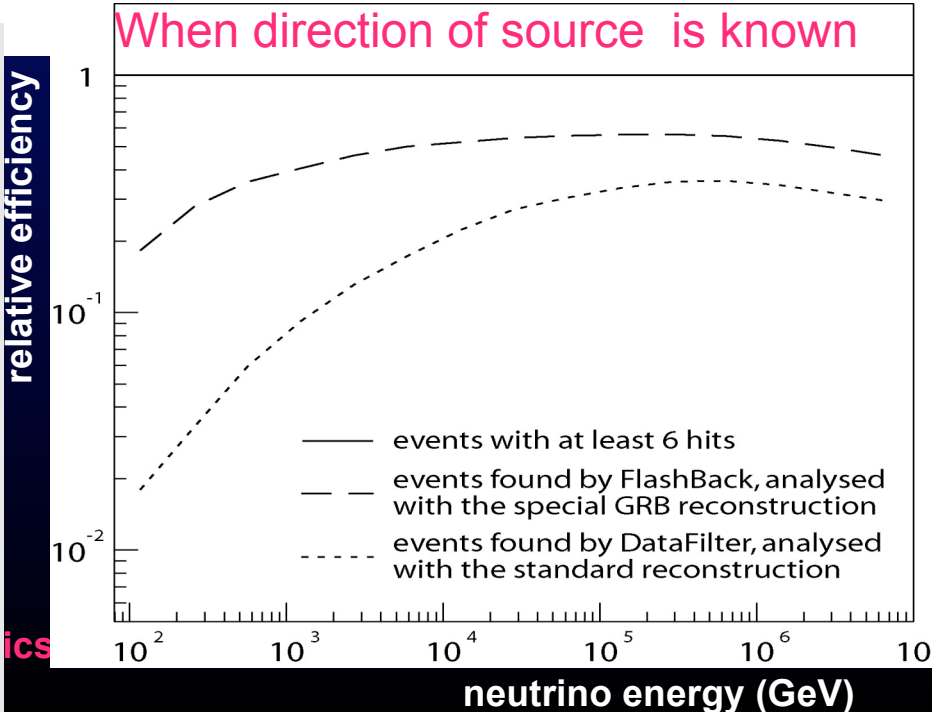
Local Control Module
(in the Ti-cylinder)

Hydrophone RX

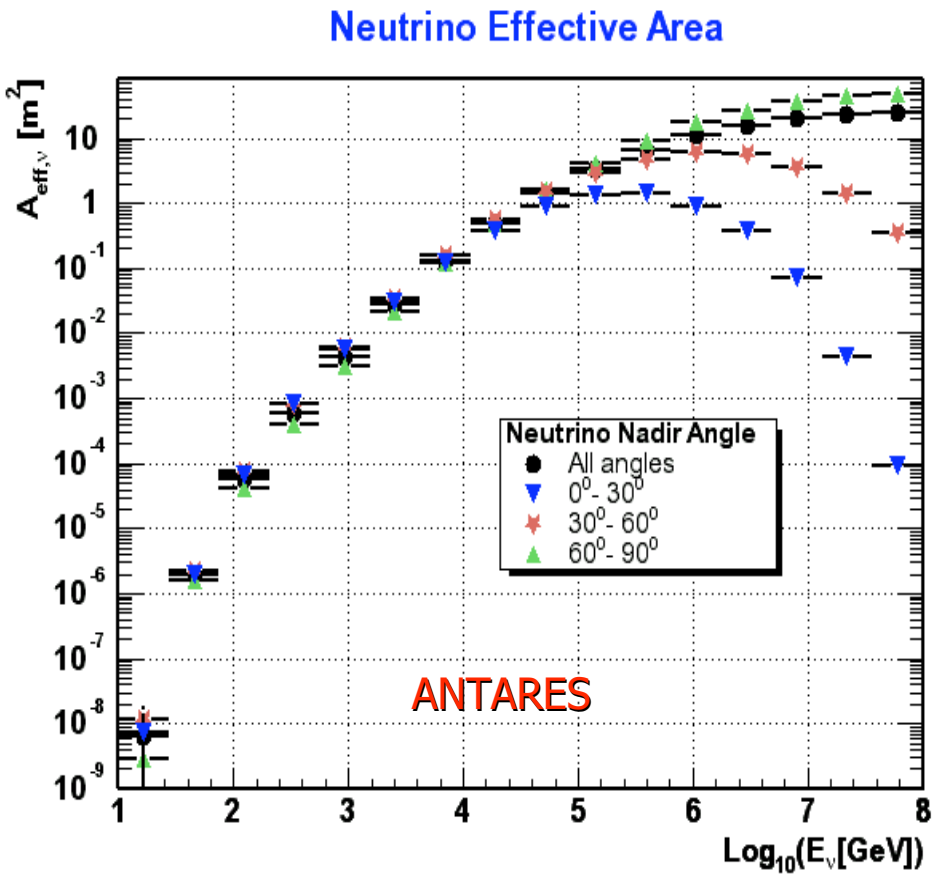
DAQ and Online Trigger

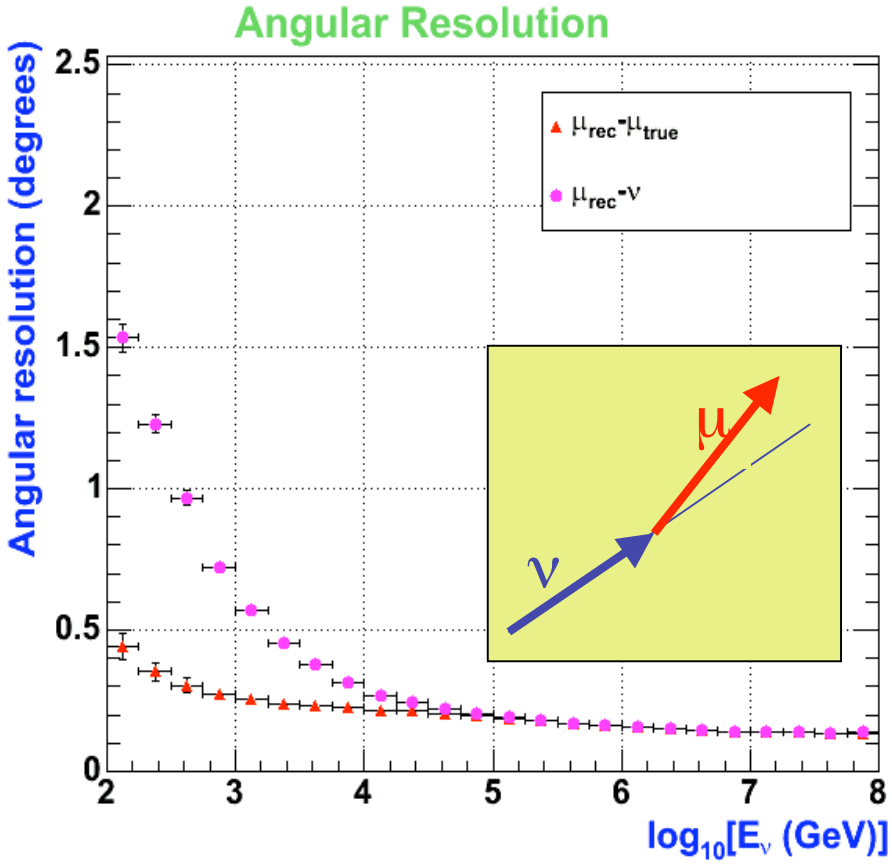
- **Data acquisition:**
- signals digitized in situ (SPE + ~2%WF)
- all data above low threshold (0.3 SPE) to shore (data rate from detector ~1GB/s)
- **Online trigger:**
- computer farm at shore station (~100 PCs)
- trigger criteria: **L1:** $\Delta t < 20$ ns coincidences @ 1 storey or large hit amplitudes, **L2:** casuality condition $\Delta t < n / c \cdot \Delta x$, **L3:** many causally related hits
- trigger output ~1MB/s = 30 TB/year





Performance





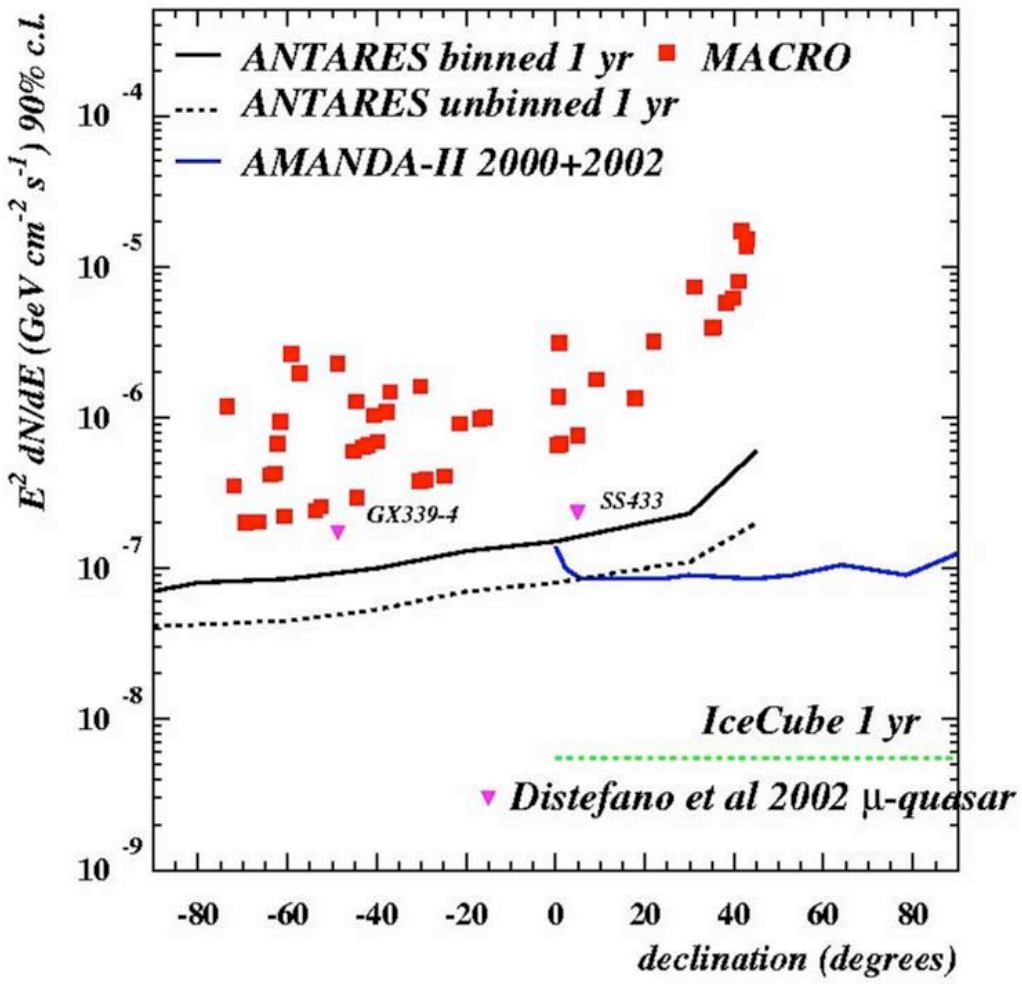
$$N_\mu = \int A^{\nu}_{eff}(E_\nu, \theta_\nu, \phi_\nu) \frac{d\Phi_\nu}{dE_\nu d\Omega_\nu} dE_\nu \, d\Omega_\nu$$

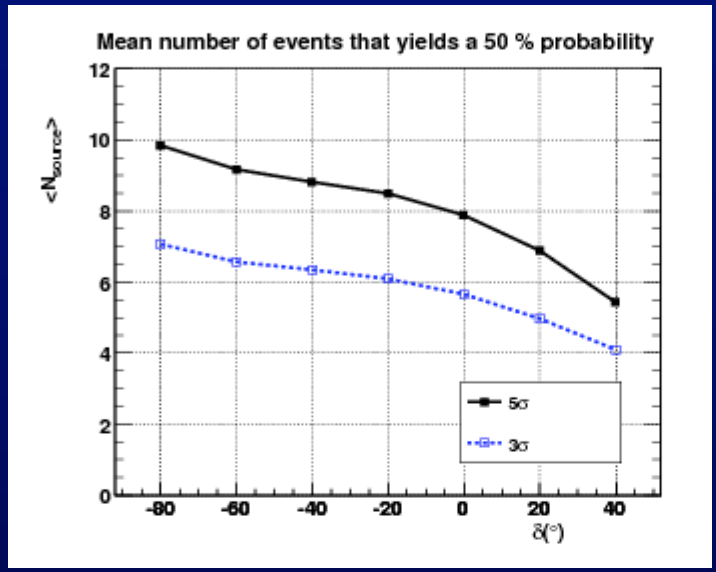
λ_{abs} ~ 26/60 m @ 370/470 nm

λ_{eff} (scattering)~ 100/300 m @ 370/470 nm

log10 Eμ rec/Eμ gen ~ 0.5-0.25 in 1 – 10^4 TeV ⇒ factor 3.2-1.8

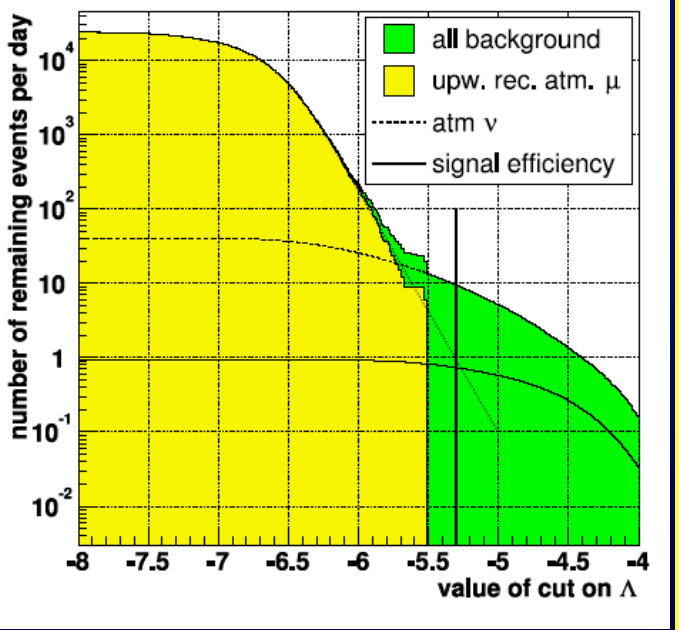
Sensitivity to point sources



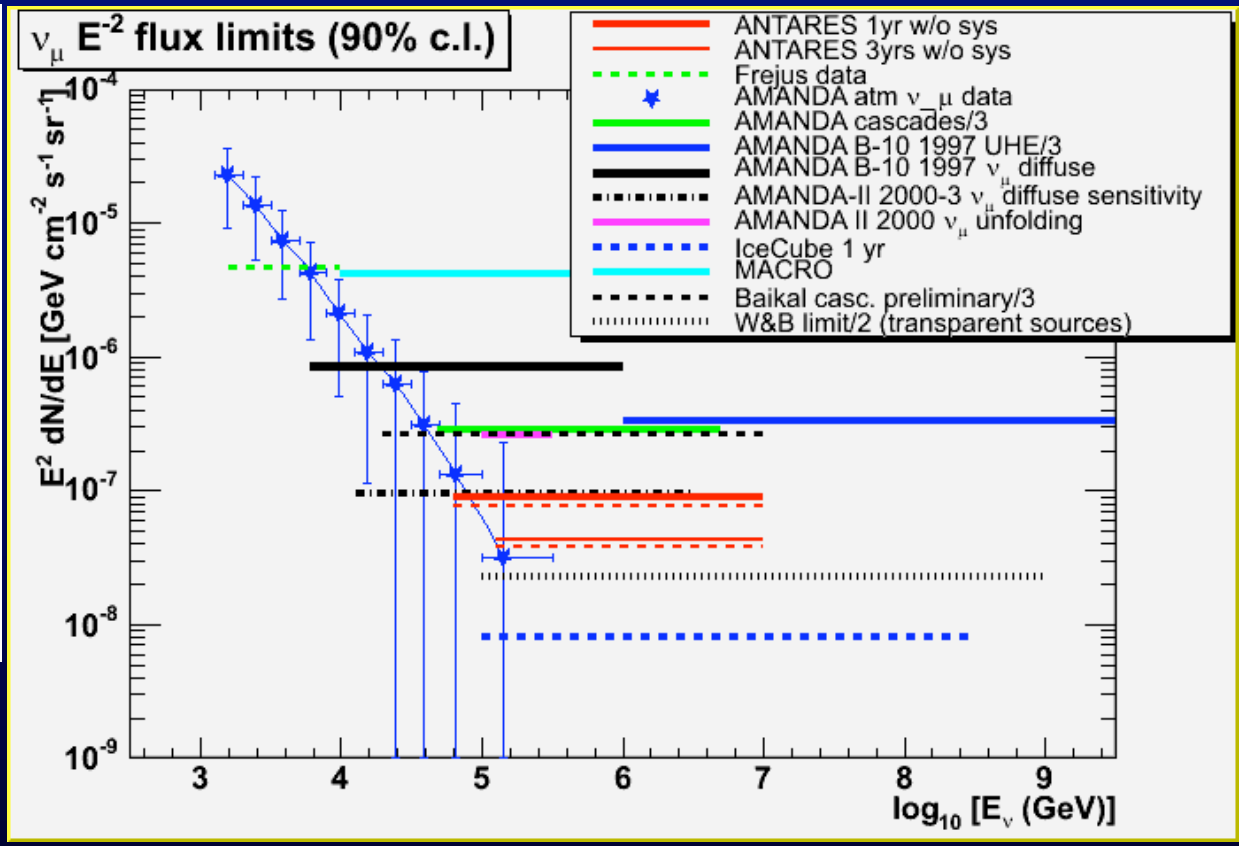


Discovery potential (5σ cl) with a maximum likelihood method for 1 yr
(Aguilars et al., ICRC2005)

Expected sensitivity for diffuse fluxes

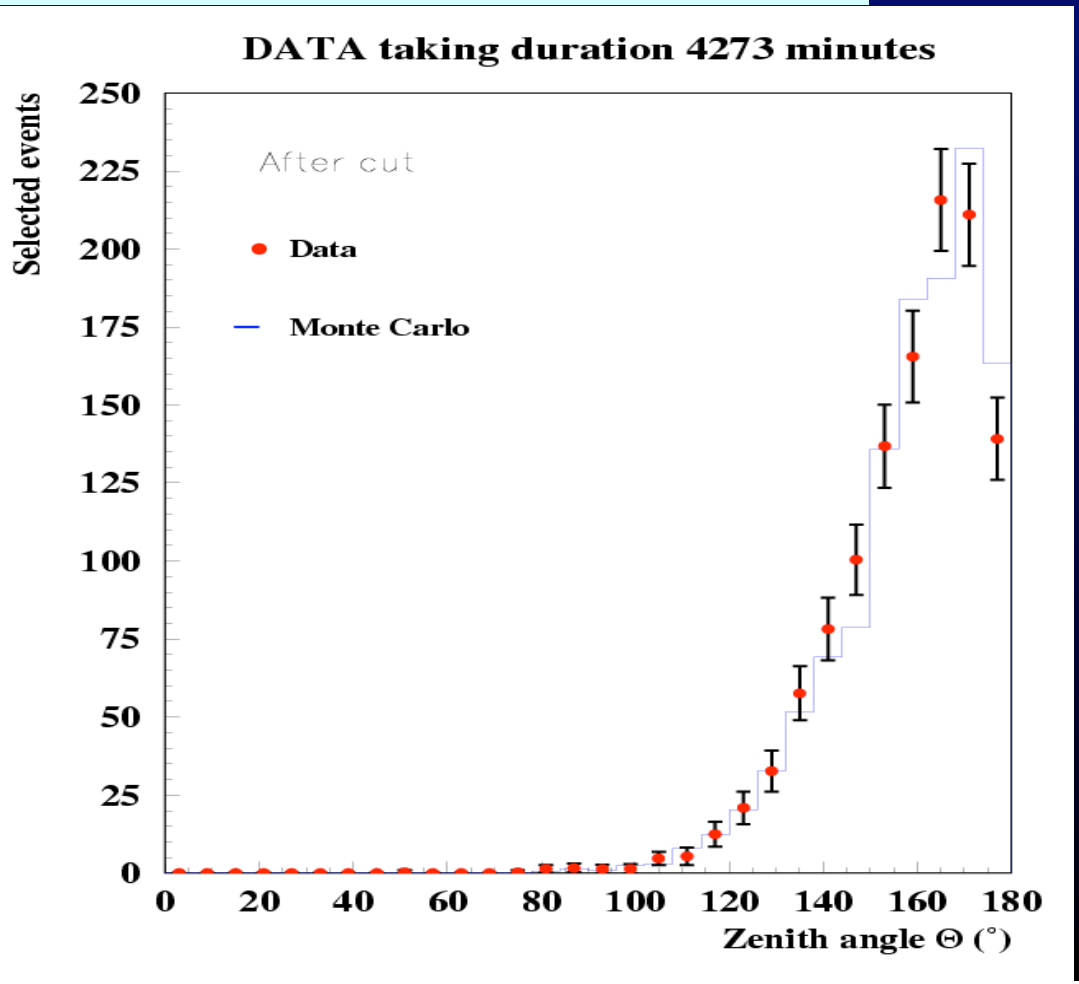


Separation of badly reconstructed atm μ backgrounds using quality of tracking

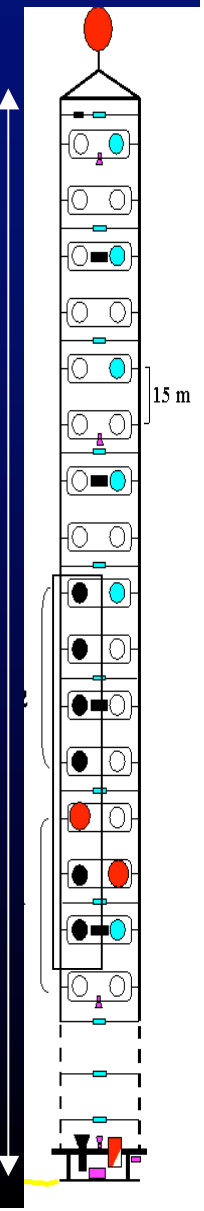


First Prototype lines: the Demonstrator line

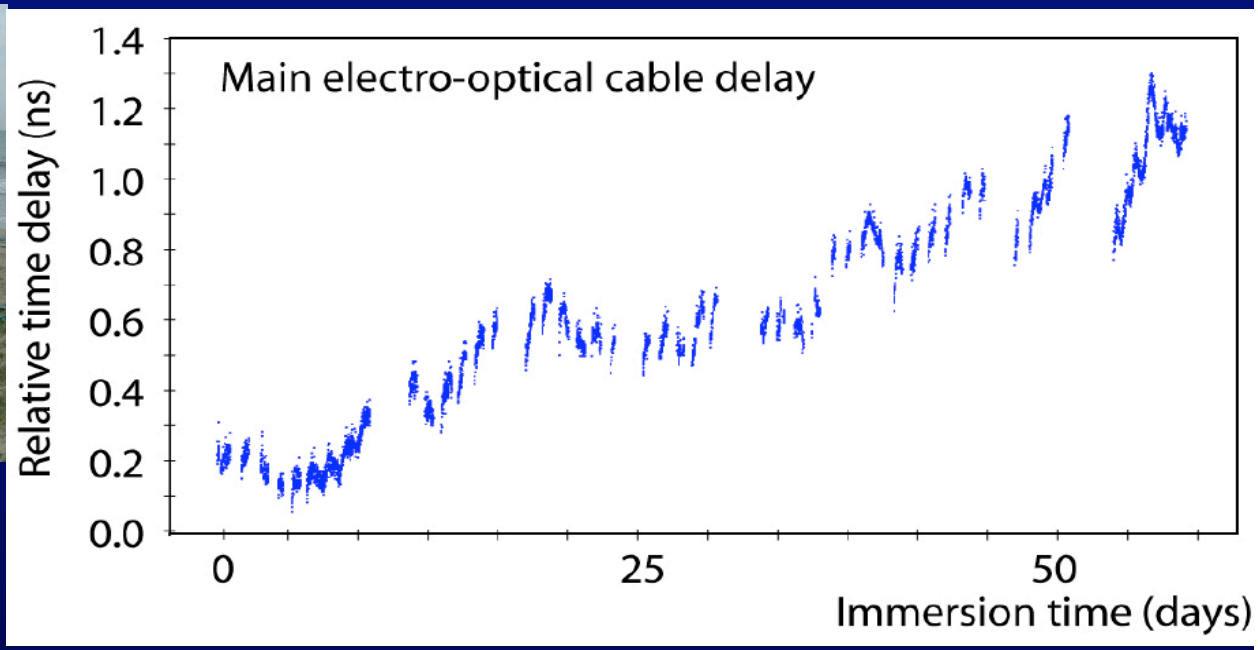
Operated between Nov 99 - Jun 00 at 1200 m depth
Data sent to shore
First Test of acoustic positioning system: relative accuracy ~5 cm
Atmospheric muon zenith distribution



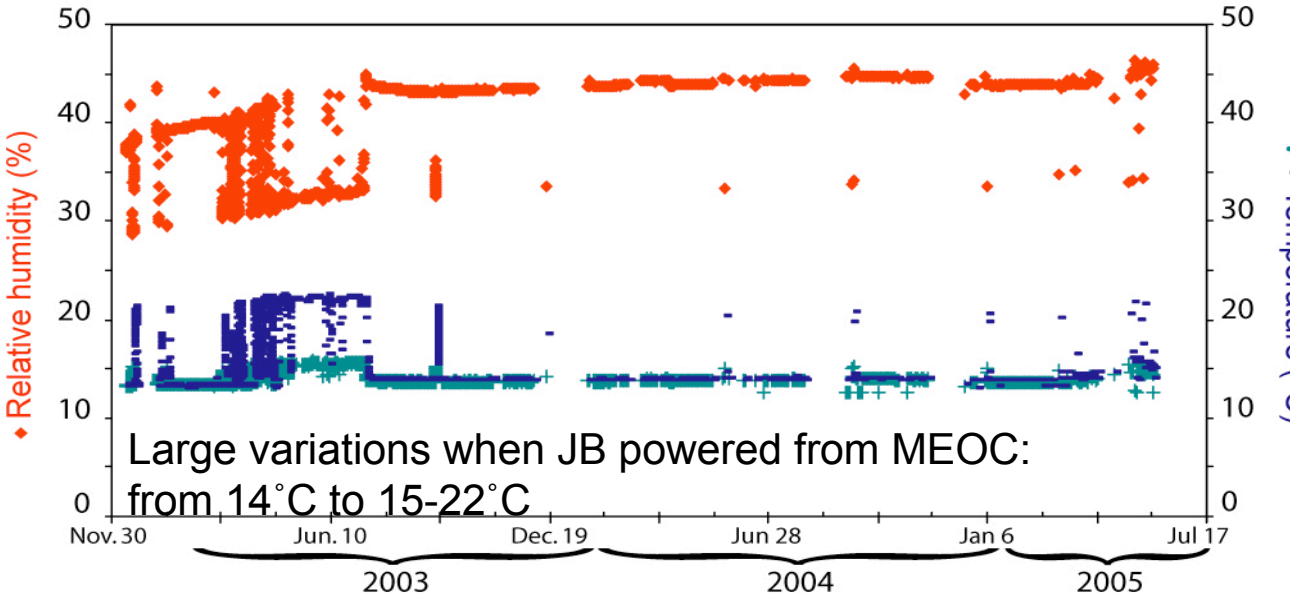
350 m
7 PMTs



Detector Infrastructure: Junction Box and MEOC



Data from the battery operated slow control in the JB

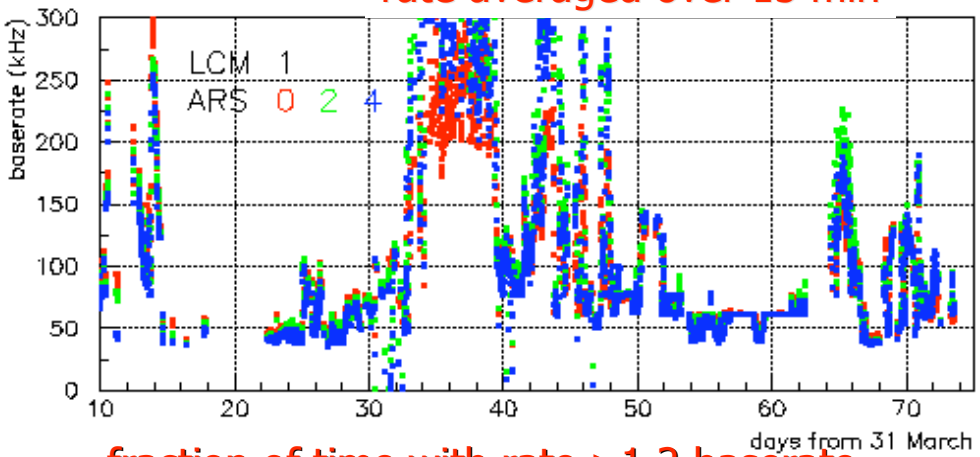


In stable operation
for 2 ½ yrs!

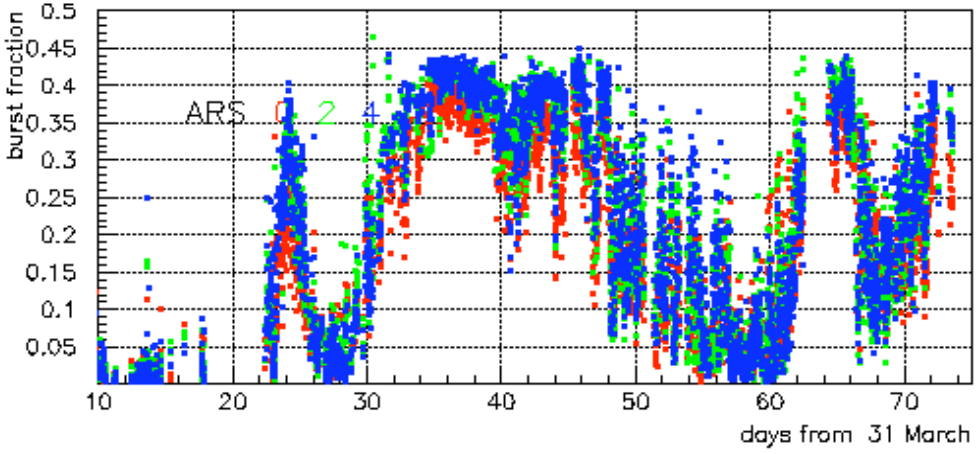
Results from 2003 prototypes

Mini Instrumentation Line: for environmental parameter measurement
PSL: 1/5 of a line (5 storeys)
Successful sea operations (connections with submarine)

rate averaged over 15 min



fraction of time with rate >1.2 baserate



Long term measurements of optical background in the deep sea:

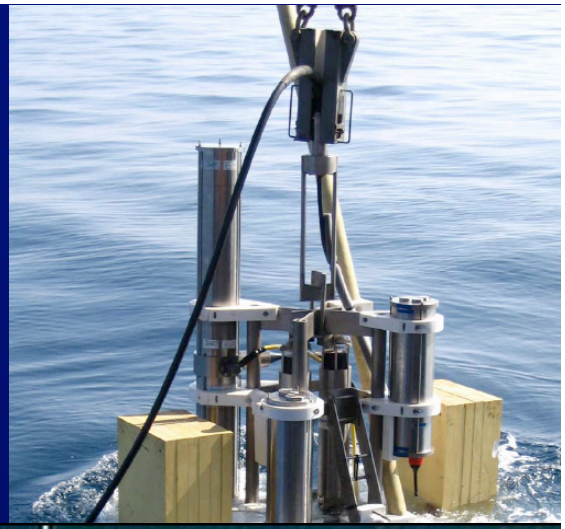
- Large variability due to bioluminescence, correlations with sea current
- More than 90% of time below 200 kHz

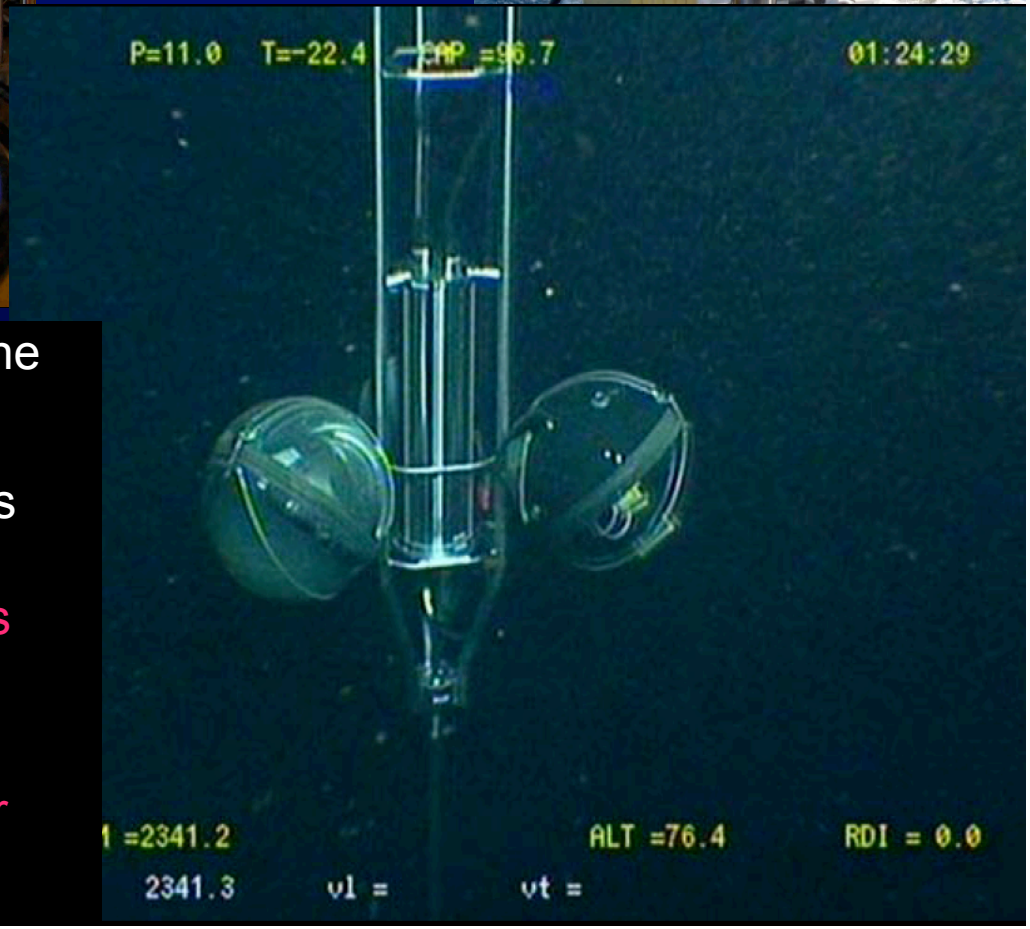
Problems and Solutions:

No ns data due to damaged optical fibre ⇒ use steel tubes

Water leak in electronic container ⇒ change connector
and more quality control

Spring 2005: Line0



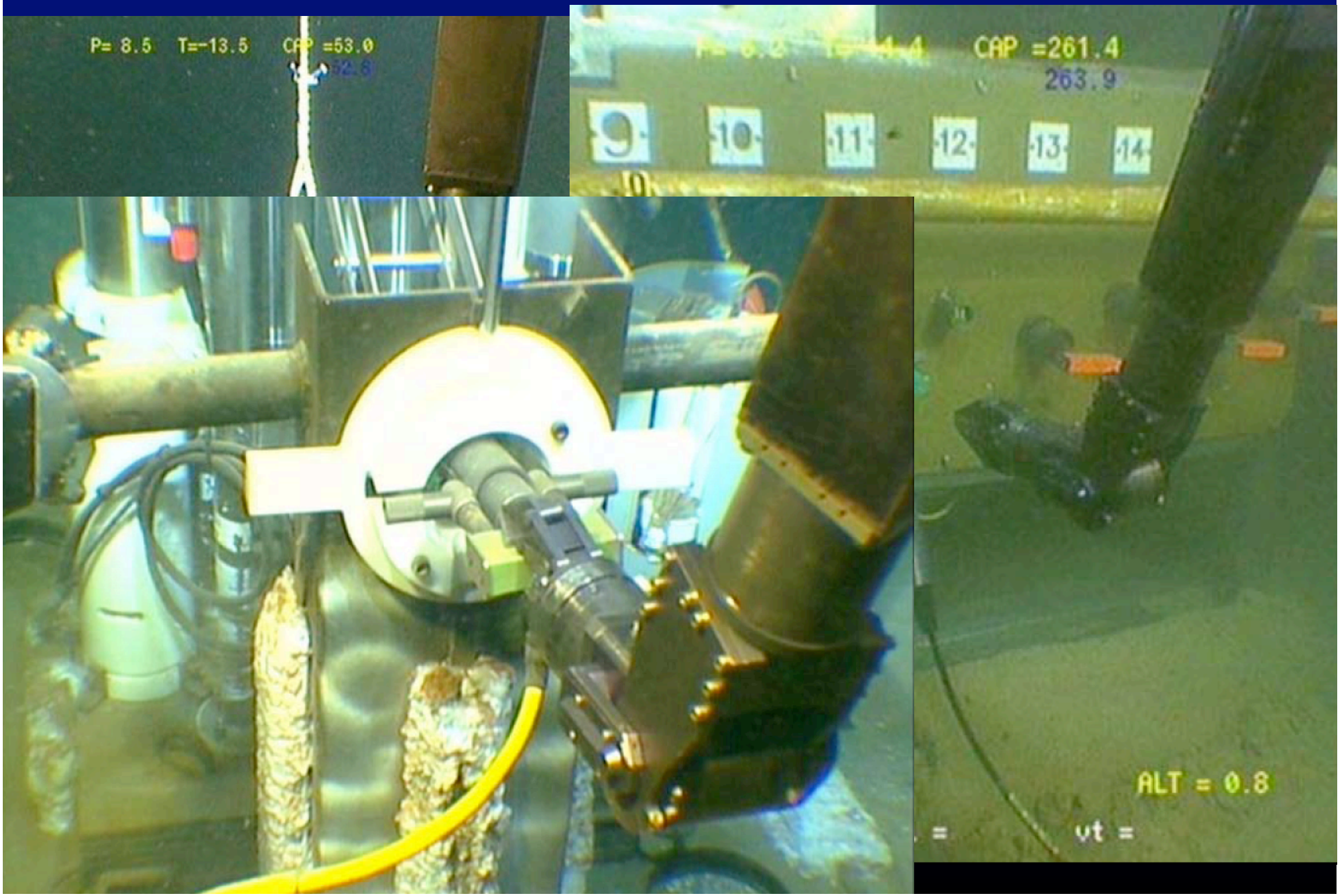


- test of mechanical structure of a full line (23 storeys)
- equipped with water leak sensors and sensors for attenuation measurements

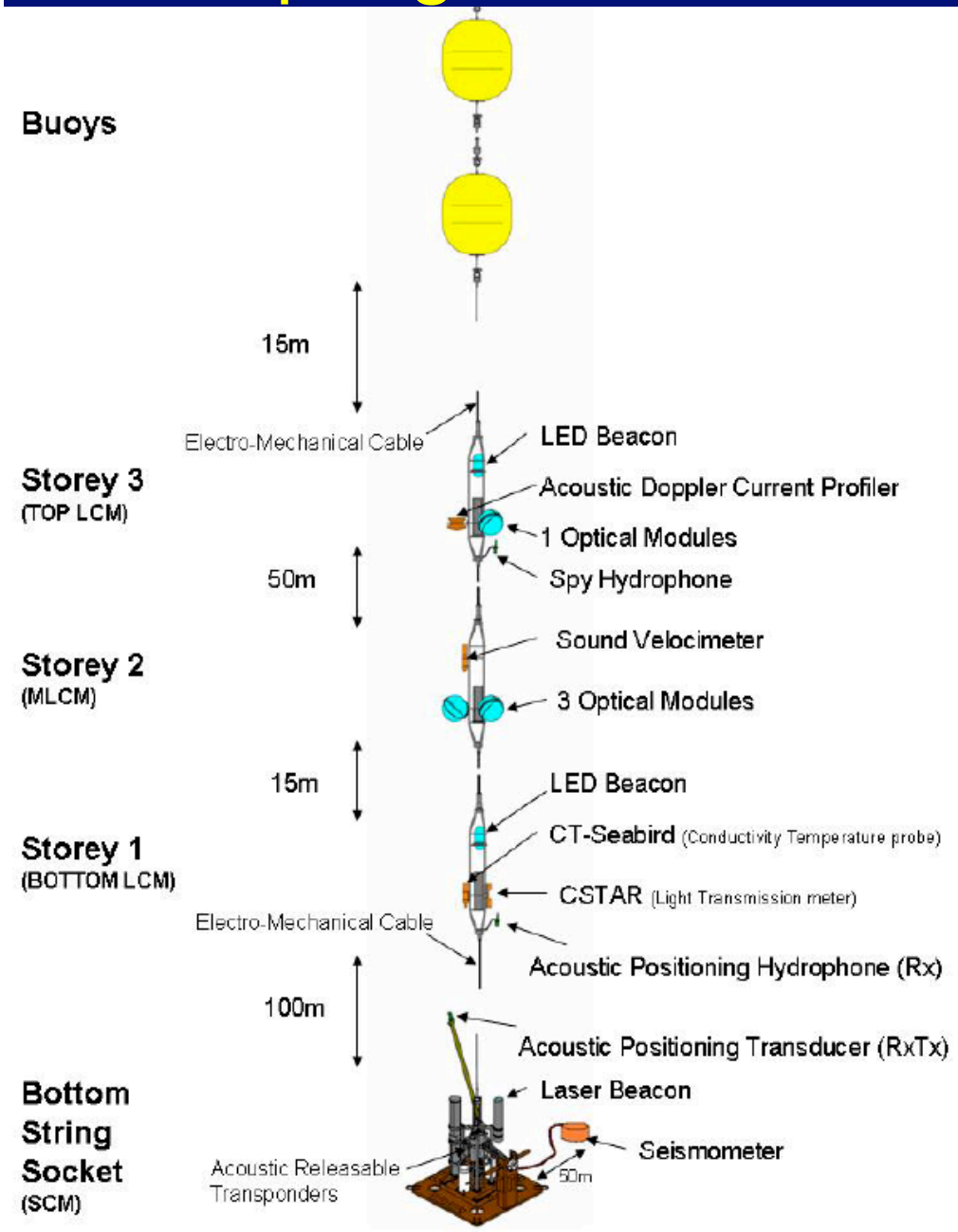
Recovered in May 2005:

- no water leaks in electronic containers
- optical transmission losses between EMC penetrators and the electronics containers since the EMC is not sufficiently well fixed ⇒ solution under study

Connections with Victor ROV



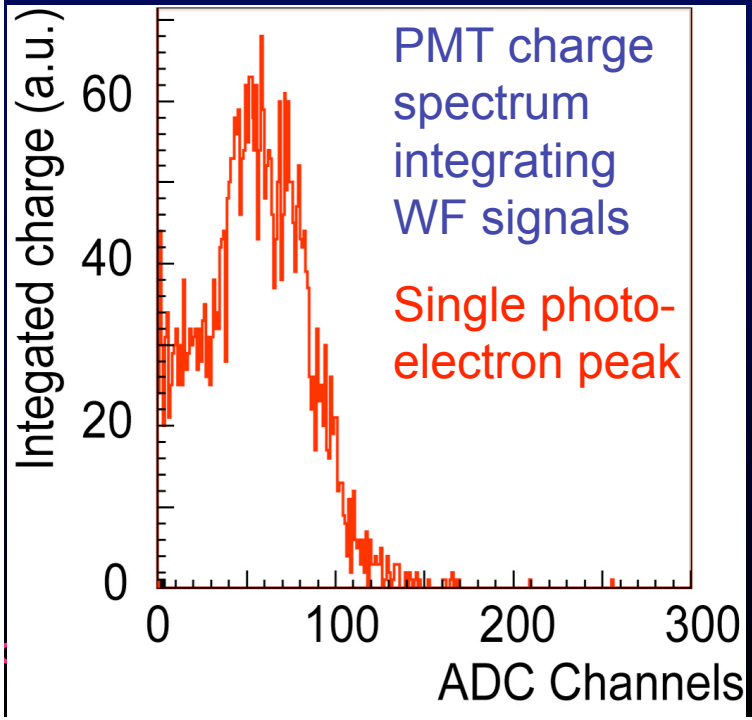
Spring 2005: MILOM setup and results



Validation of electronics cards and OMs, of optical calibration and acoustic positioning systems + environmental parameter measurement and long term monitoring

Continuous evolution of instruments ⇒ will be frequently recovered and deployed

Typical raw data from ARS



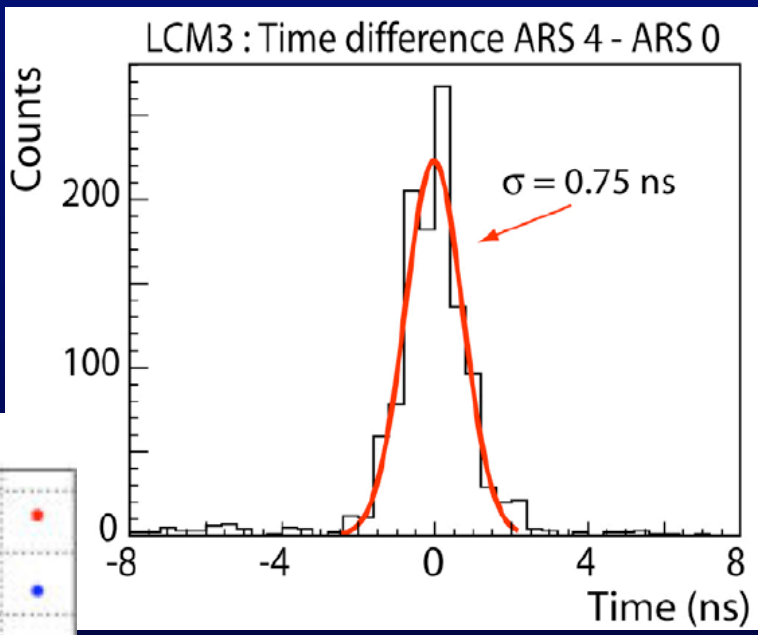
Results from the MILOM: timing precision

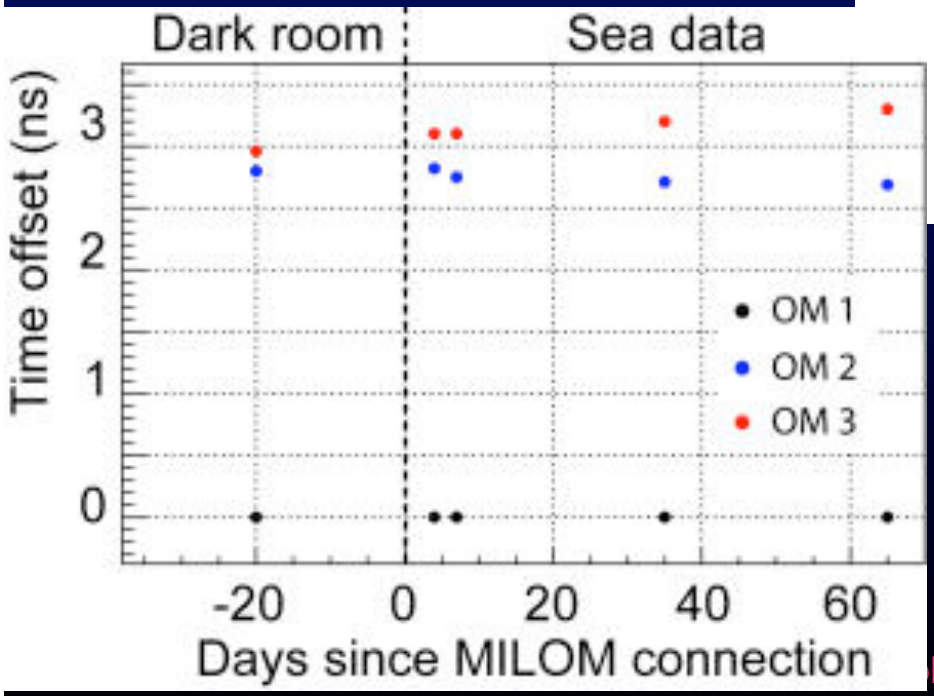
Angular resolution of 0.2˚ for E_ν > 10 TeV limited by PMT TTS (σ~1.3 ns)

resolution of time calibration and electronics should contribute <0.5 ns

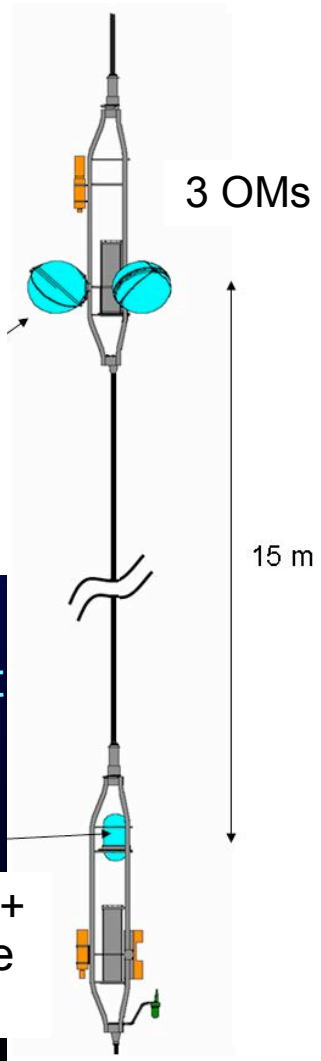
Time difference between signals between 2 OMs in a storey (2 OMs 0.5×√2 = 0.75 ns)

For large pulses (not determined by TTS but by electronics)





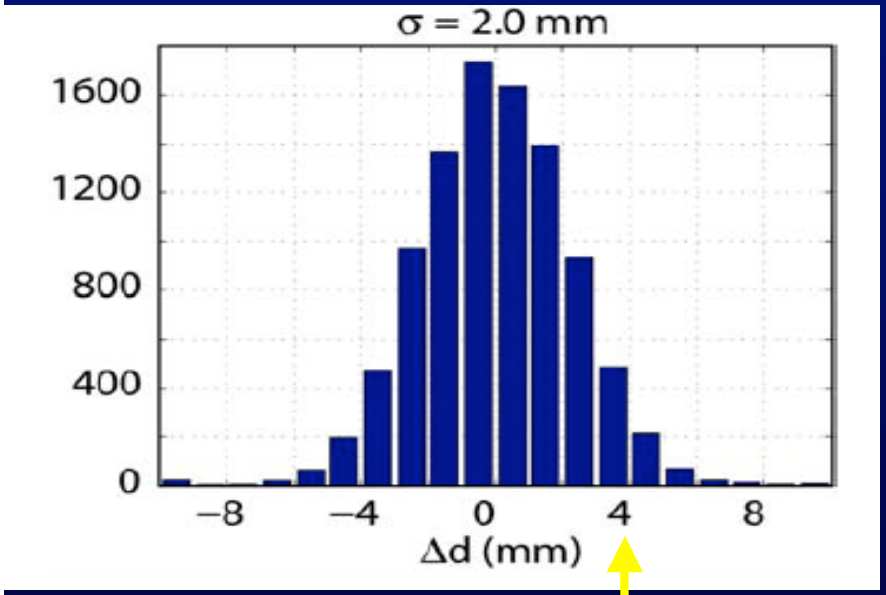
Mean of distribution of time difference of hits on 2 adjacent OMs ⇒ stability of calibrations in the sea respect to dark room



60 LEDs + reference PMT

Results from the MILOM: acoustic positioning system

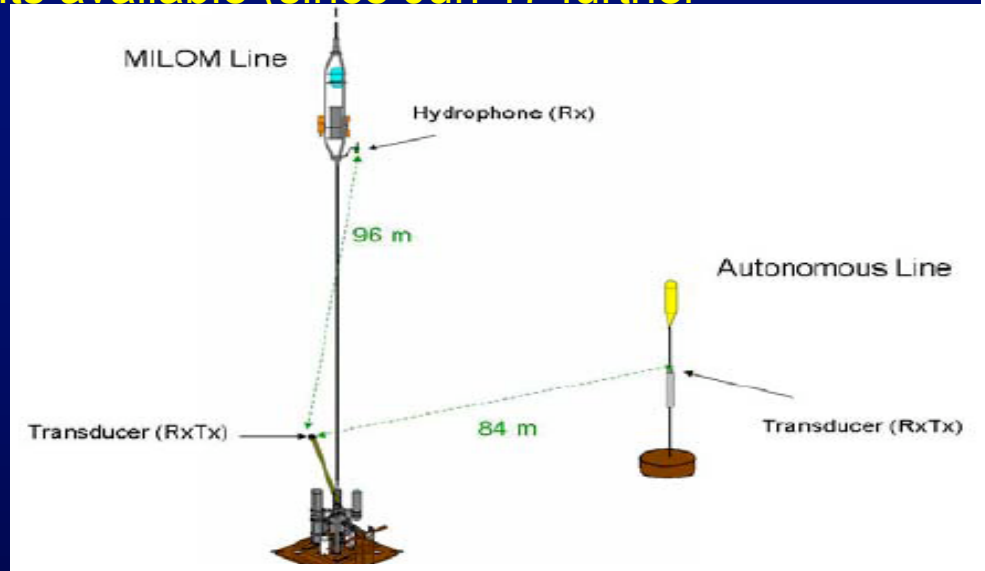
Transponder+receiver on MILOM + autonomous transponder line at 84 m distance
Currently only results from 1D measurements available (since Jun 17 further transponders deployed will allow 3D)

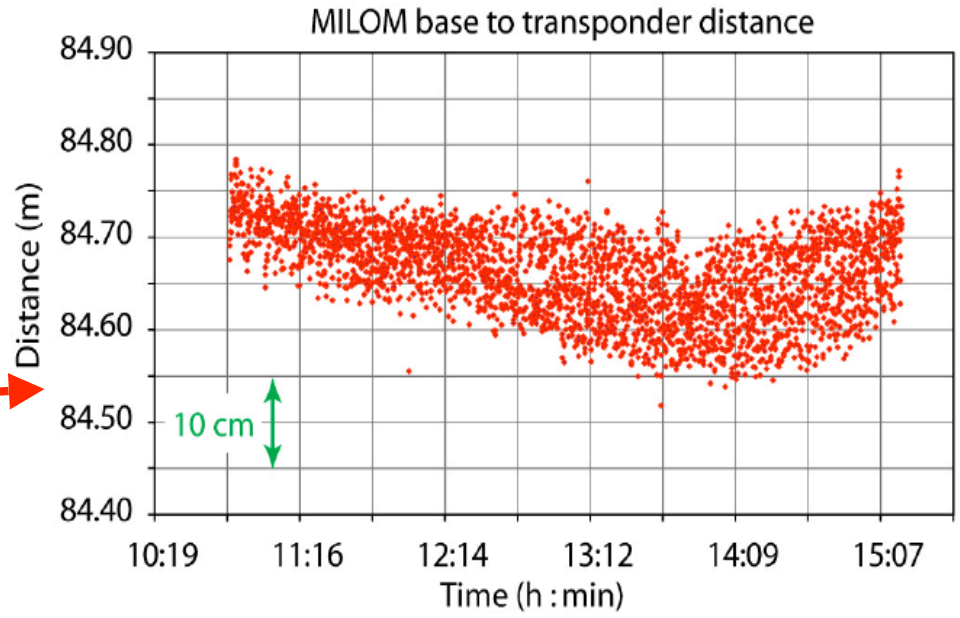


Acoustic distance measurement between Rx-RxTx on MILOM for 20 d. Systematic effects under control on the level of 2 mm.

Acoustic distance between the base of MILOM and the autonomous line (5 hrs, resolution 3 cm over 84 m)

Specs: resolution < 10 cm





Conclusions

- **MILOM and Line 0 has been a success since no water leaks in containers and cables (contrary to previous prototypes)**
- **Problem on optical transmission is being solved**
- **MILOM results:**

  - **d**ata readout working as expected

  - in situ timing and position resolution proved inside specs to achieve angular resolution ~ 0.2^{o} for neutrinos with E > 10 TeV

  - more data to analyse
- **Line1 assembly has started and OMs available**
- **Detector should be completed by early 2007**
- **KM3Net http://www.km3net.org**
- **250 kEuros: tender concluded last week for the first 2 NEMO towers**