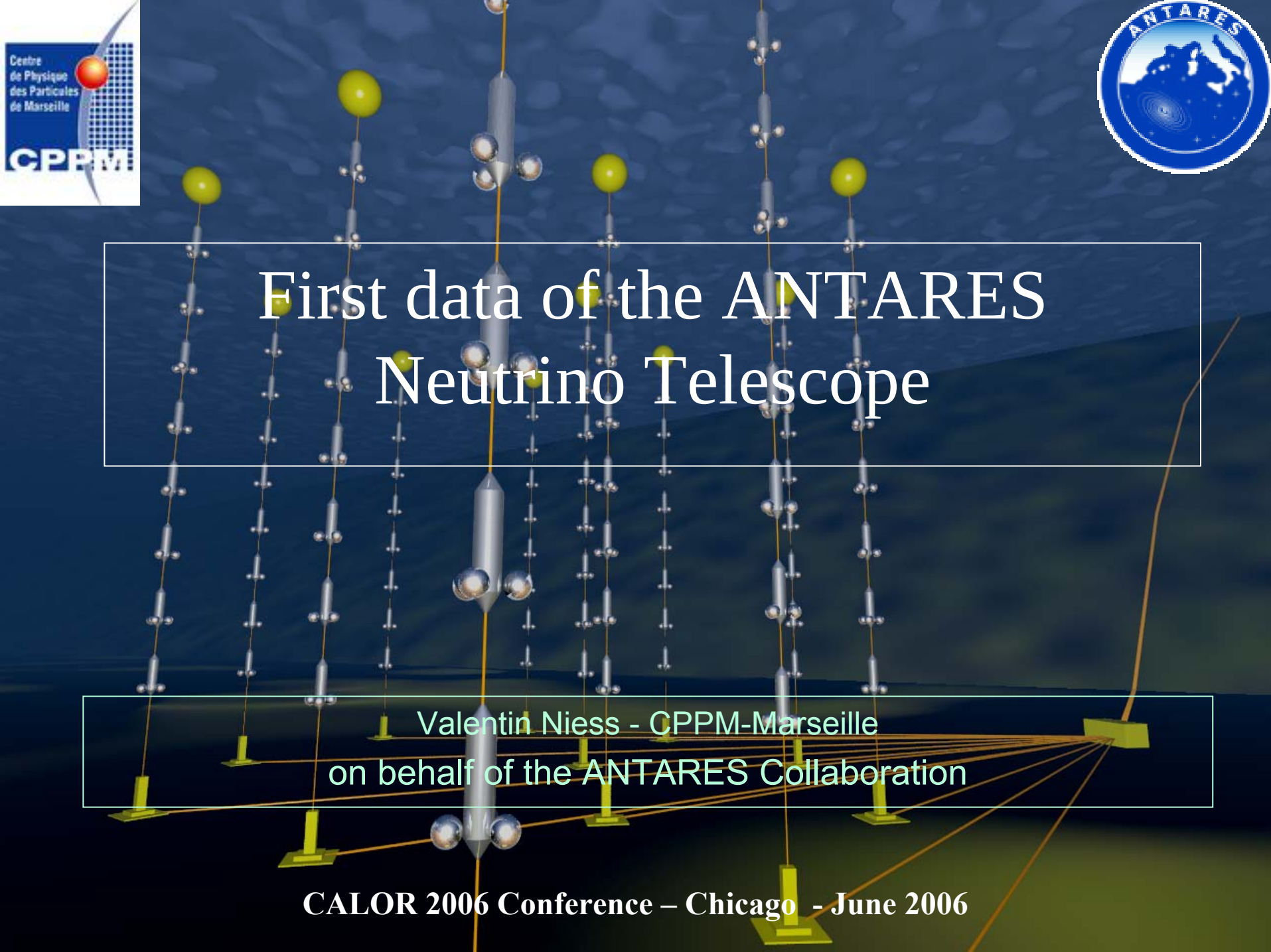
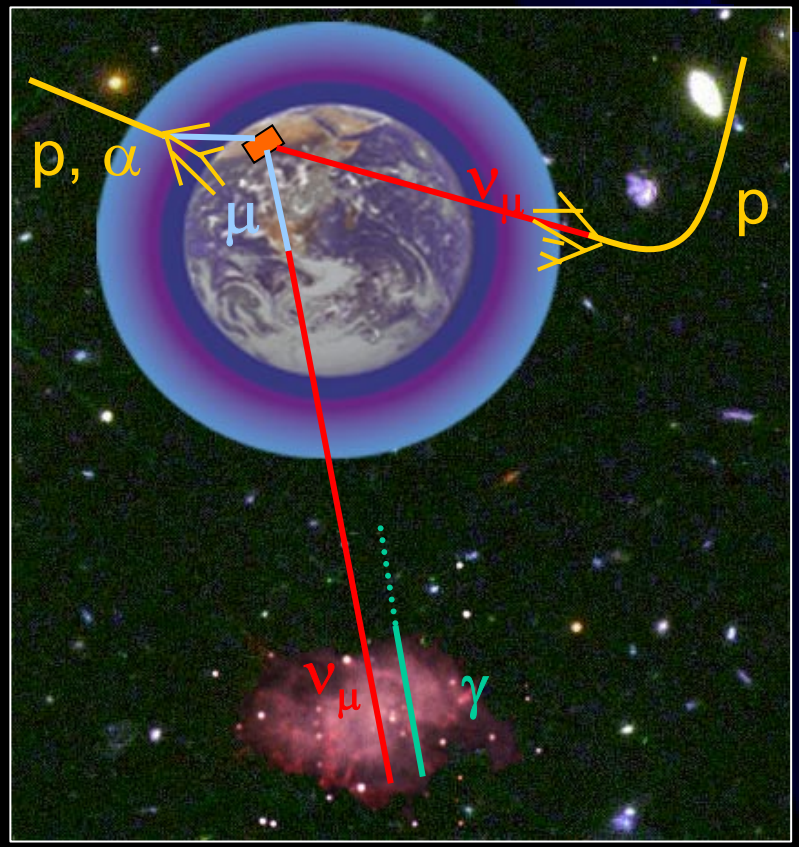


First data of the ANTARES Neutrino Telescope

Valentin Niess - CPPM-Marseille
on behalf of the ANTARES Collaboration

CALOR 2006 Conference – Chicago - June 2006

Neutrino telescope: Detection principle



Cherenkov light from μ

$\gamma_{č}$

3D PMT array

43°

Sea floor

μ

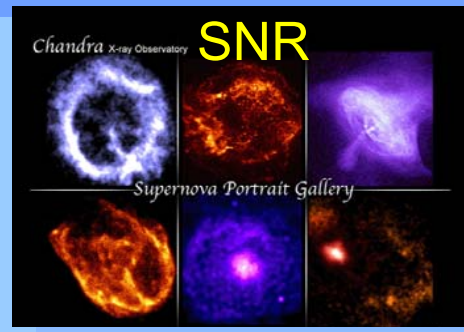
interaction

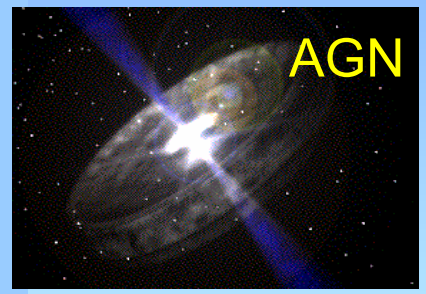
ν

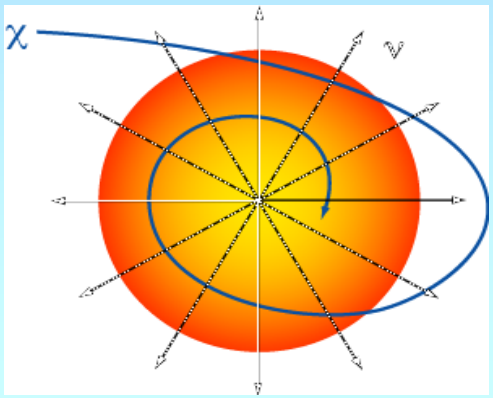
Reconstruction of μ trajectory (~ ν) from timing and position of PMT hits

ANTARES Physics topics

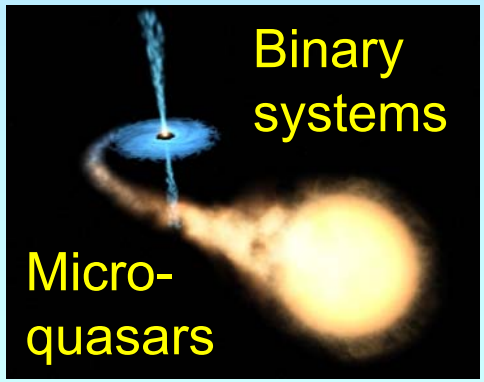
- **High energy neutrino astrophysics**: Active Galactic Nuclei, Gamma Ray Bursts, Galactic Centre, SN Remnants, μ-quasars...
- **Search for New Physics**: WIMPs annihilations, Monopoles...
- **Interdisciplinary Deep Sea Studies:** oceanography, sea biology, seismology...





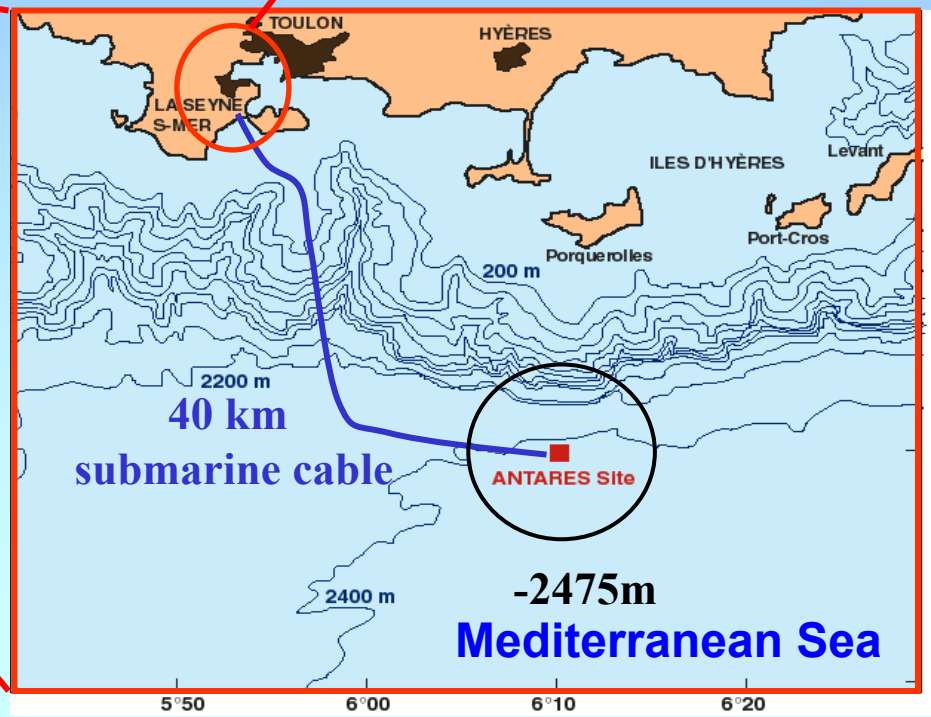


Neutralino Annihilation

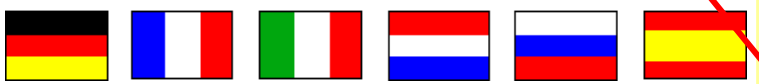


Bioluminescent Organisms

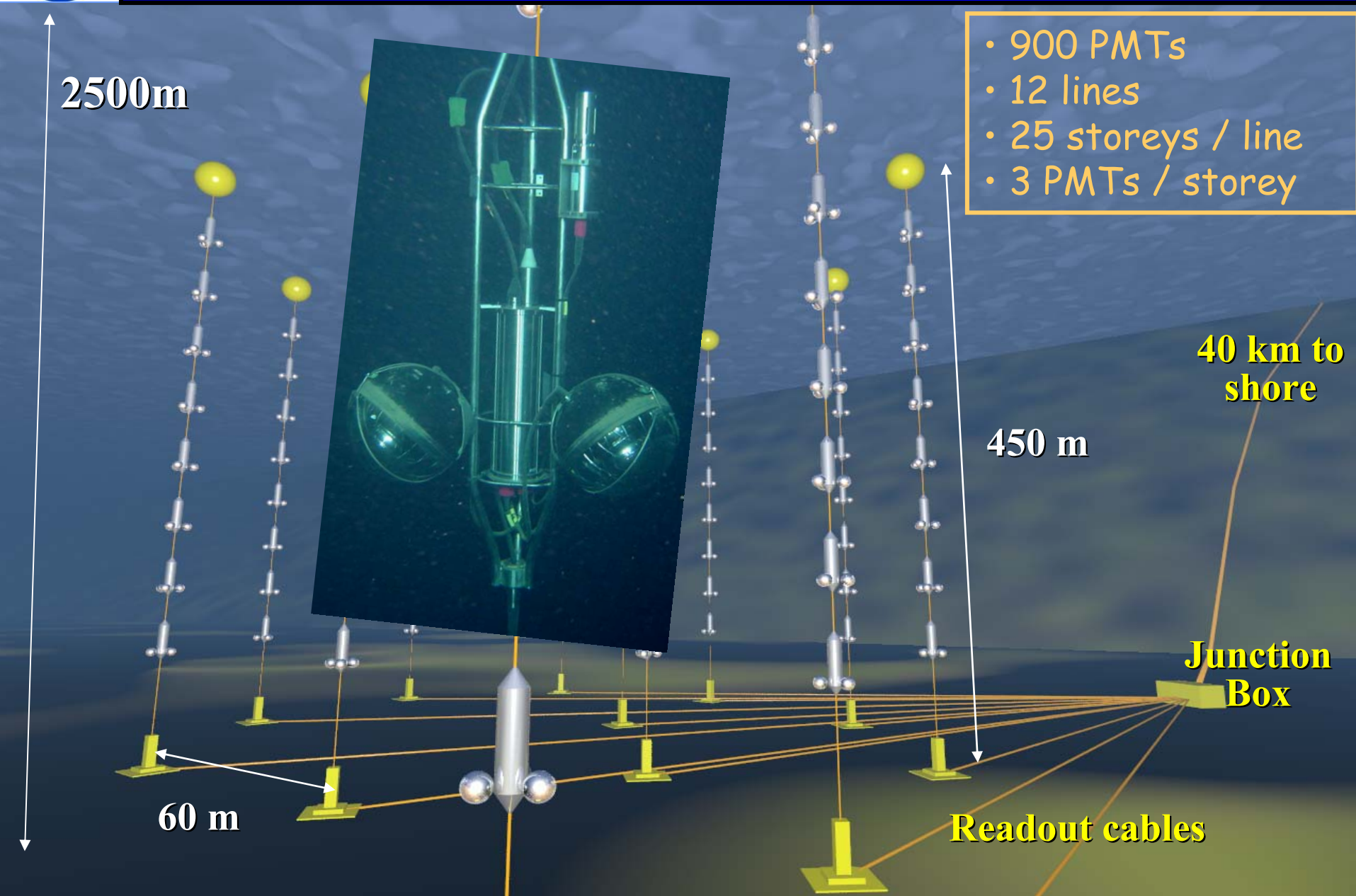
ANTARES Collaboration & detector site



21 Institutes from
6 European countries



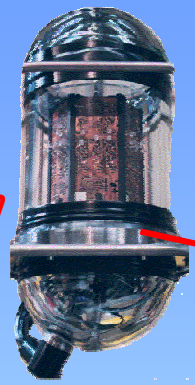
The ANTARES detector

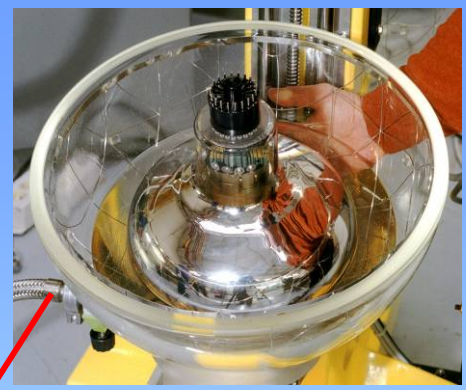


Basic detector element: storey

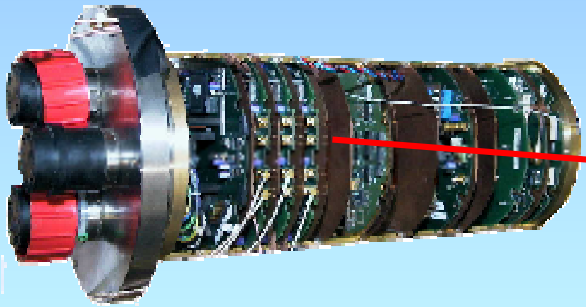
titanium frame: *support structure*

Optical Beacon
with blue LEDs:
timing calibration

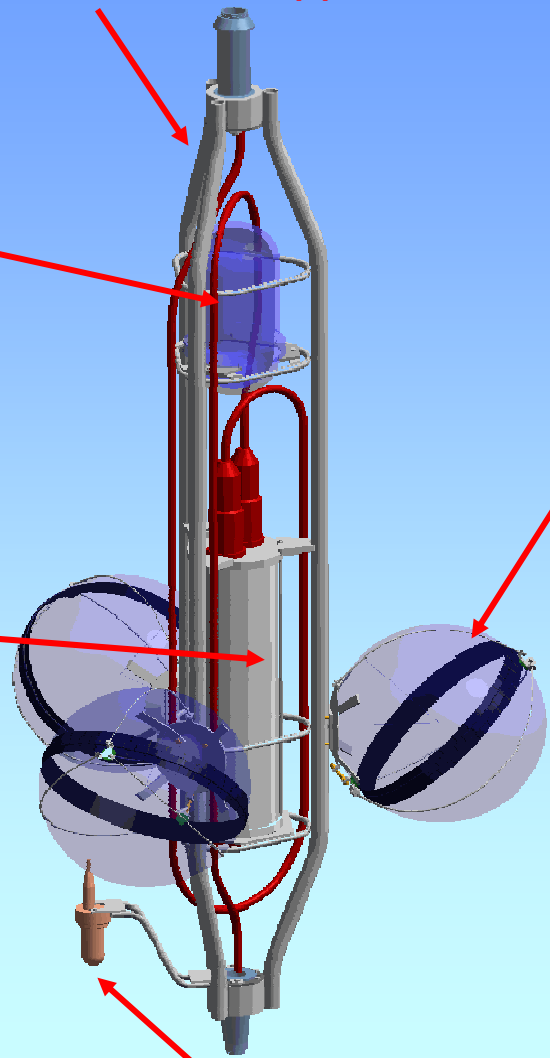




Optical Module:
10” Hamamatsu PMT
in 17” glass sphere
($\sigma_{TTS} \approx 1.3$ ns)
photon detection

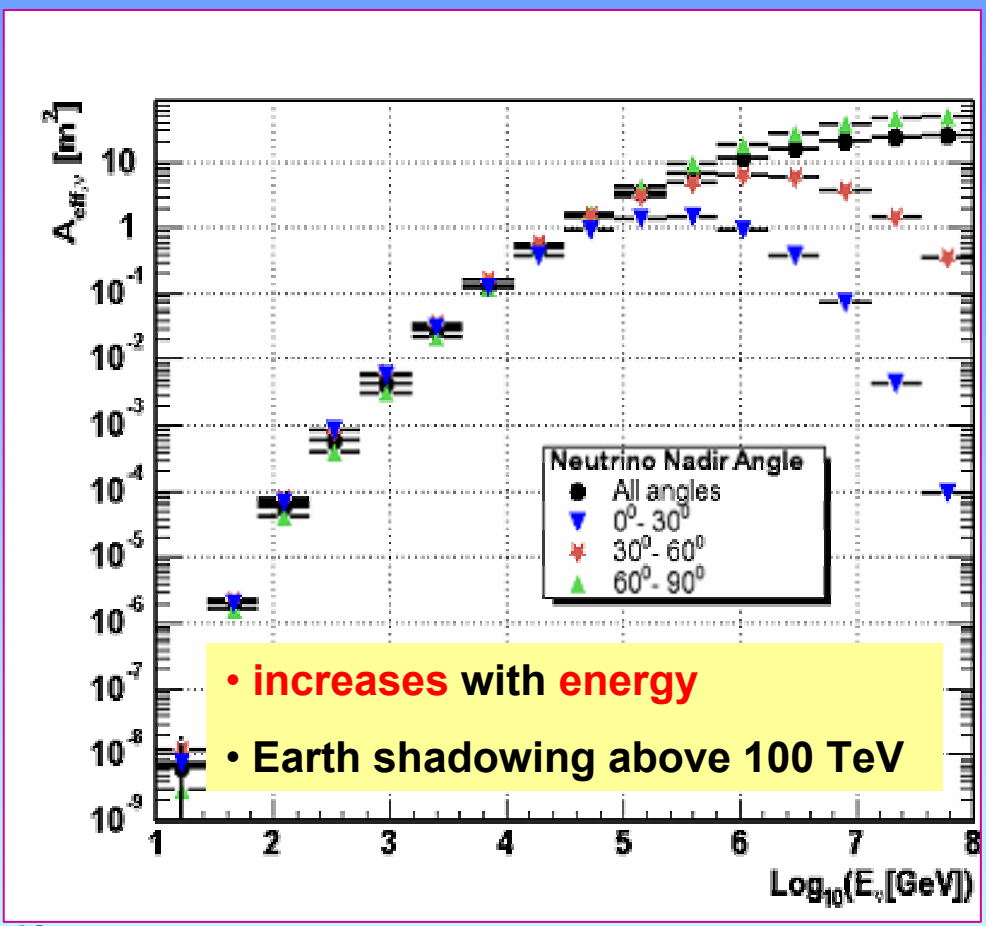


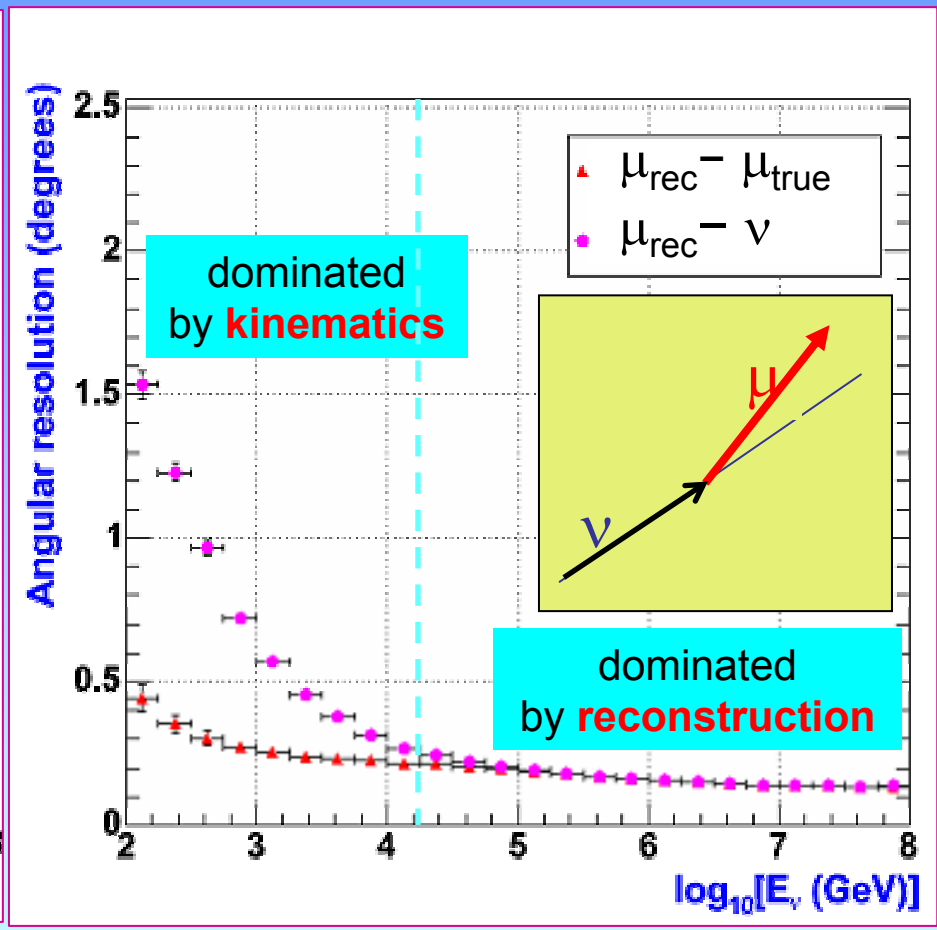
Local Control Module
(in Ti cylinder):
Front-end ASIC,
DAQ/SC, DWDM,
Clock, tilt/compass,
power distribution…



Hydrophone:
acoustic positioning

Expected performance (MC Studies)





Angular resolution better than 0.3° above a few TeV, limited by:

- Light scattering + chromatic dispersion in sea water: $\sigma \sim 1.0$ ns
- TTS in photomultipliers: $\sigma \sim 1.3$ ns
- Electronics + time calibration: $\sigma < 0.5$ ns
- OM position reconstruction: $\sigma < 10$ cm ($\leftrightarrow \sigma < 0.5$ ns)

ANTARES Construction Milestones

2005
MILOM

2001 – 2003:

- *Main Electro-optical cable* in 2001
- *Junction Box* in 2002
- *Prototype Sector Line (PSL)* & *Mini Instrumentation Line (MIL)* in 2003

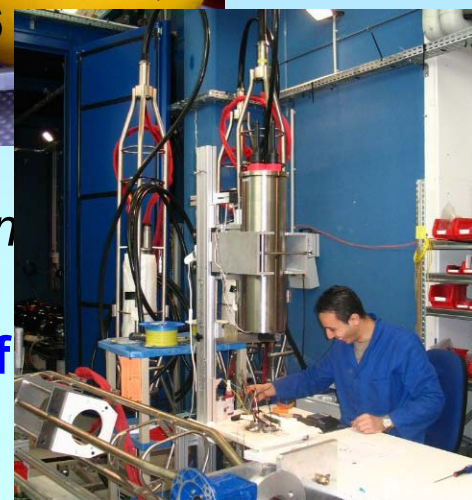
2005 – Now:

- *Mini Instrumentation Line with OMs (MILOM)* running since 12 April 2005
- *Line 1* running since 2 March 2006, first complete detector line
- *Line 2* under construction, ready in July 2006

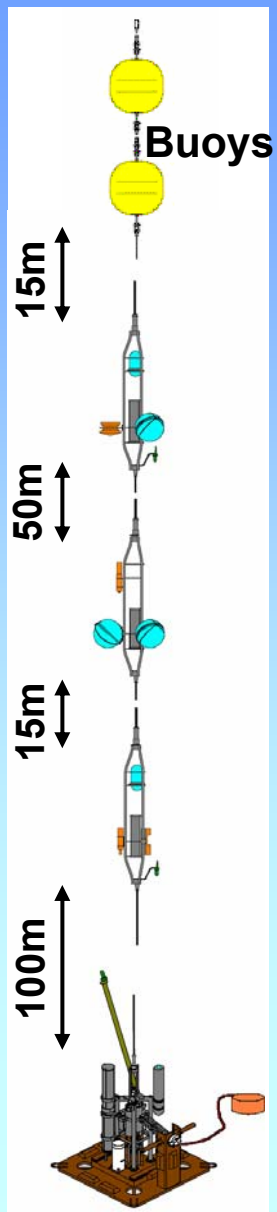
2006 – 2007:

- Installation of *ren*

2007+: Physics with f



the MILOM in operation since March 2005



Acoustic Doppler Current Profiler (ADCP)

3 Optical Modules

LED beacon

Acoustic Positioning Transducer

Seismograph

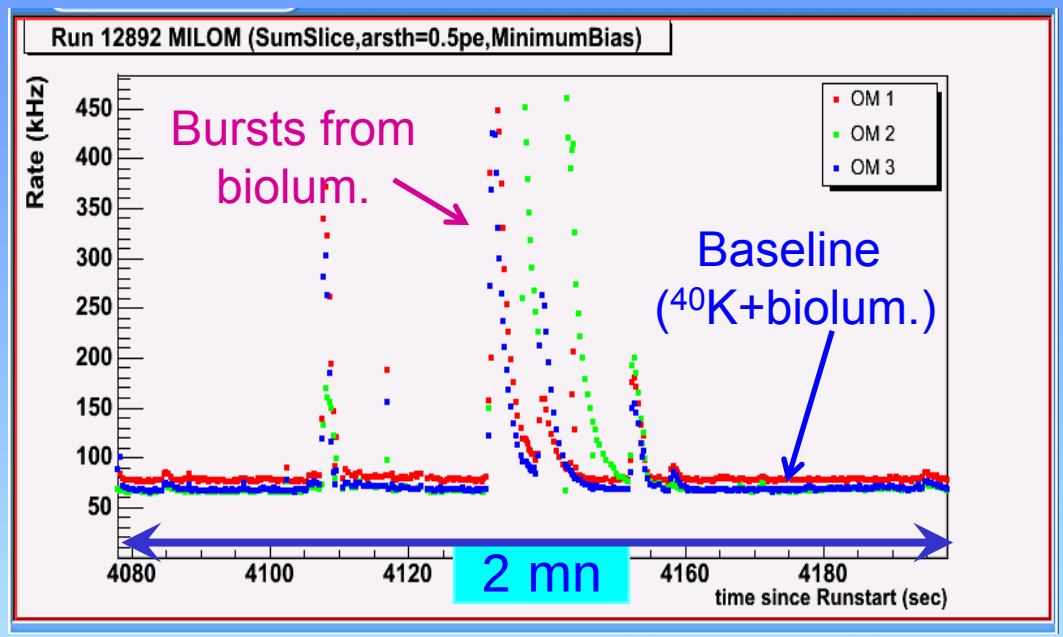
Storey 3

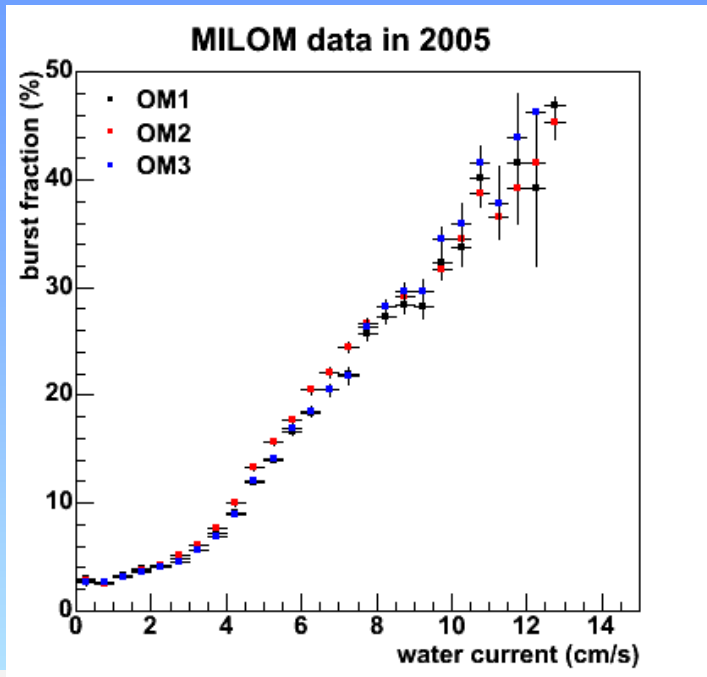
Storey 2

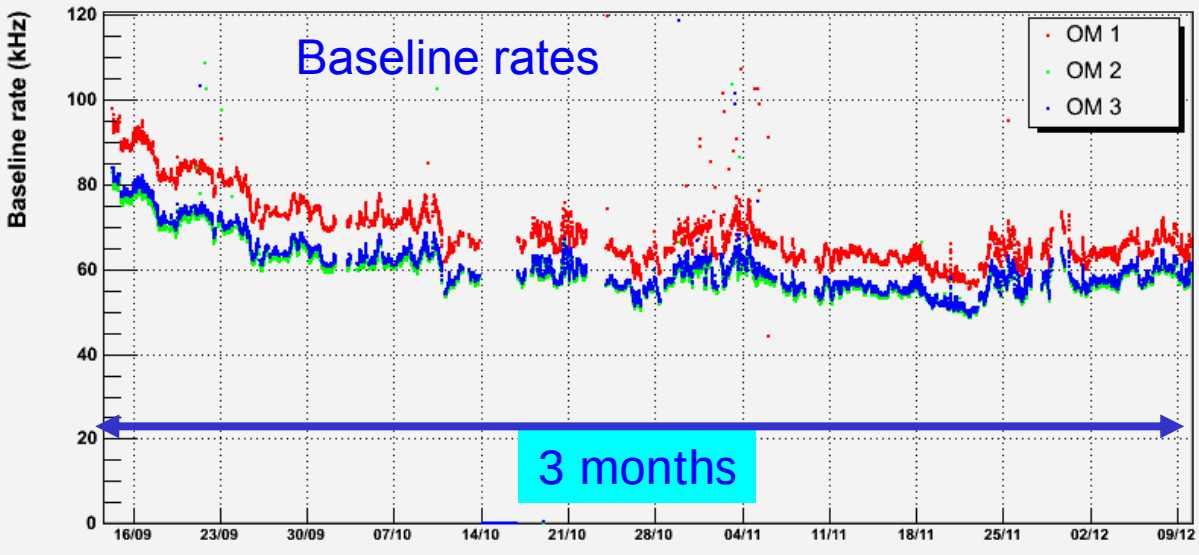
Storey 1

Bottom String Socket

MILOM Singles Counting Rates







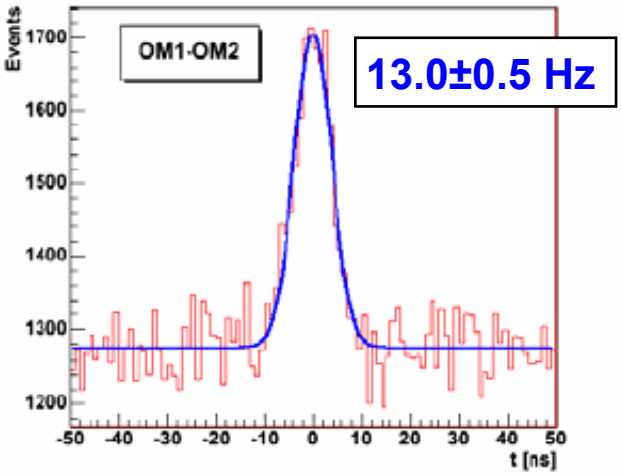
Burst-fraction:
fraction of time when rate > baseline + 20%

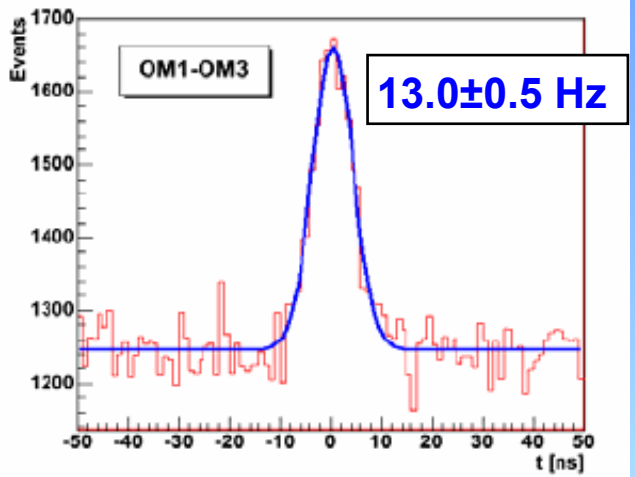
~15% higher counting rate of OM1 due to lower threshold

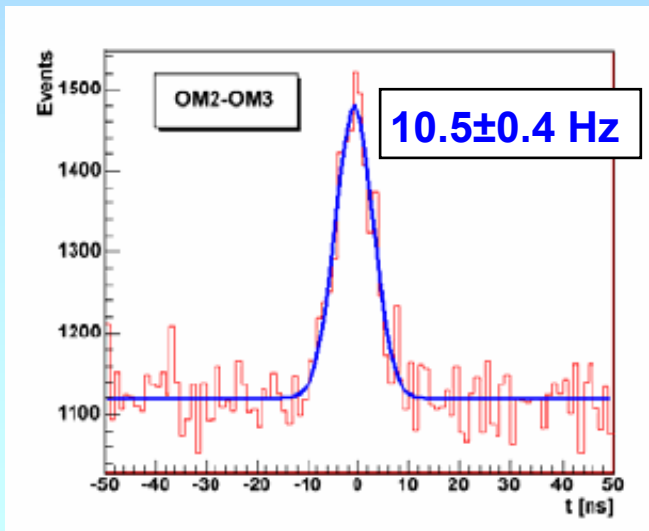
V. Niess - CPPM - CALOR'06 @ Chicago

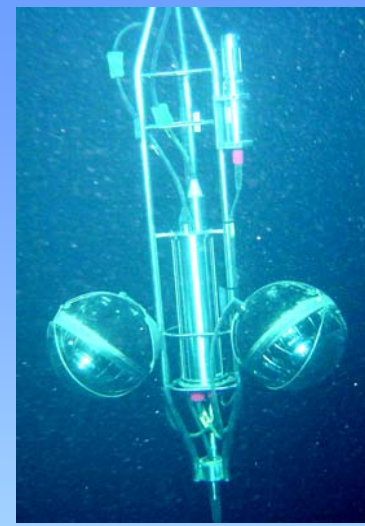
Coincidence rates from ^{40}K decays

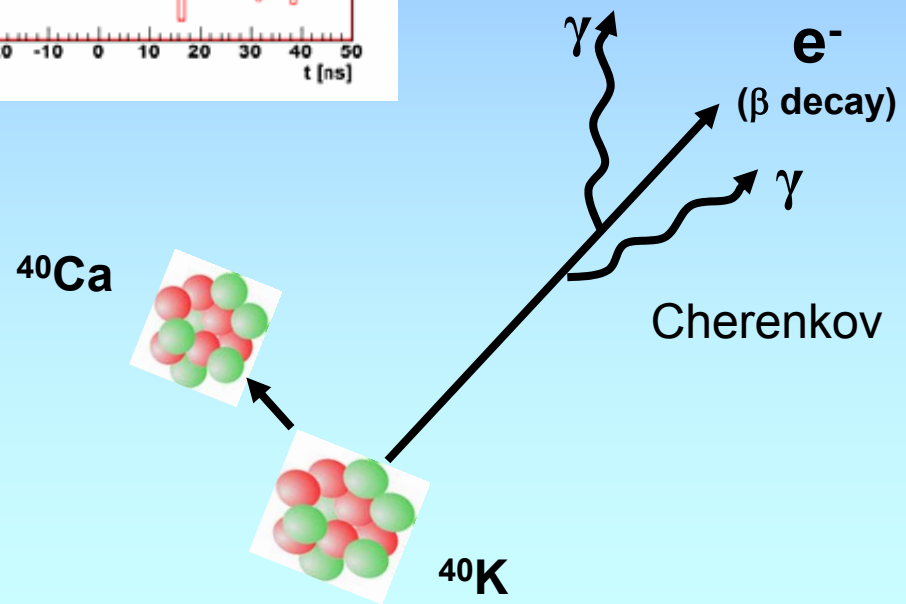
^{40}K coincidence rate from Gauss fit:







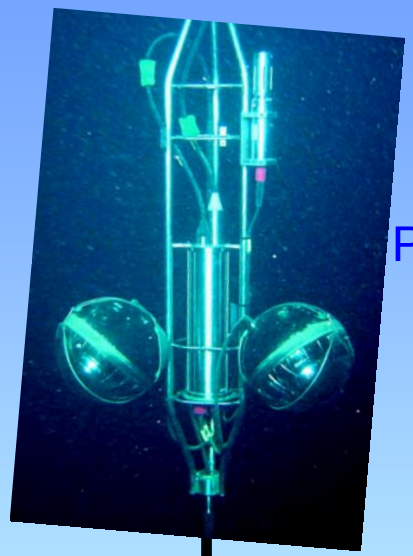




Simulation: 12 Hz ± 4 Hz (sys)

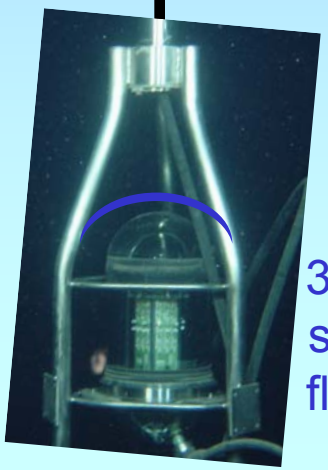
Time calibration with the MILOM Led Beacon

MILOM



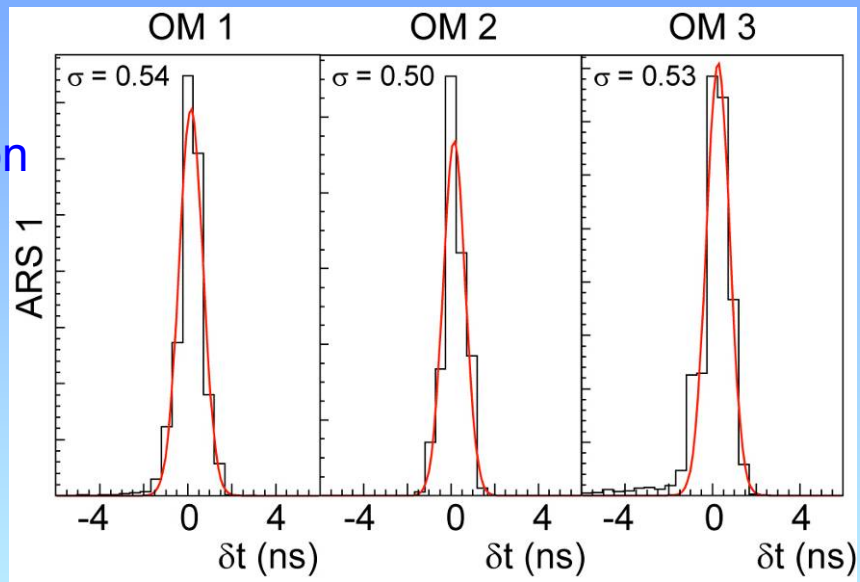
Intense light flash:
PMT TTS contribution
is negligible

15 m



Led Optical
Beacon:
32 blue LEDs
synchronised
flash < 0.5 ns

Time in OMs relative to reference PMT in OB

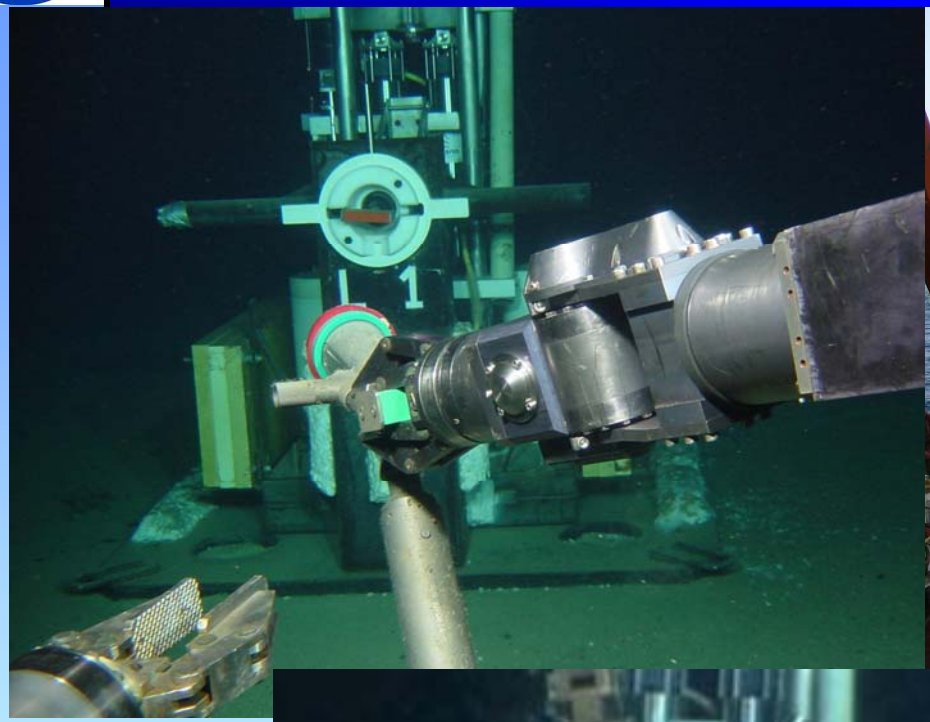


Timing resolution of electronics <0.5ns

First complete detector Line installed in 2006

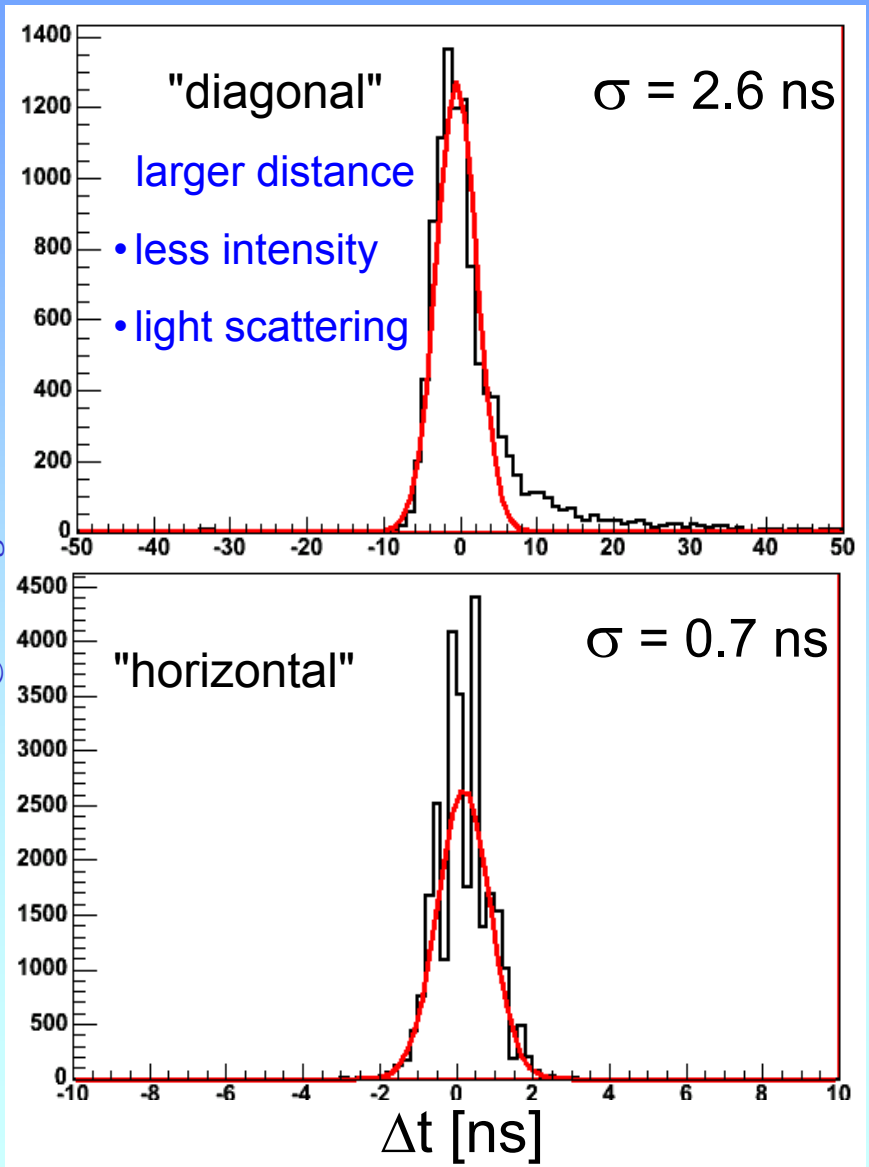
Line 1 deployed on Feb 14th…

First complete detector Line installed in 2006

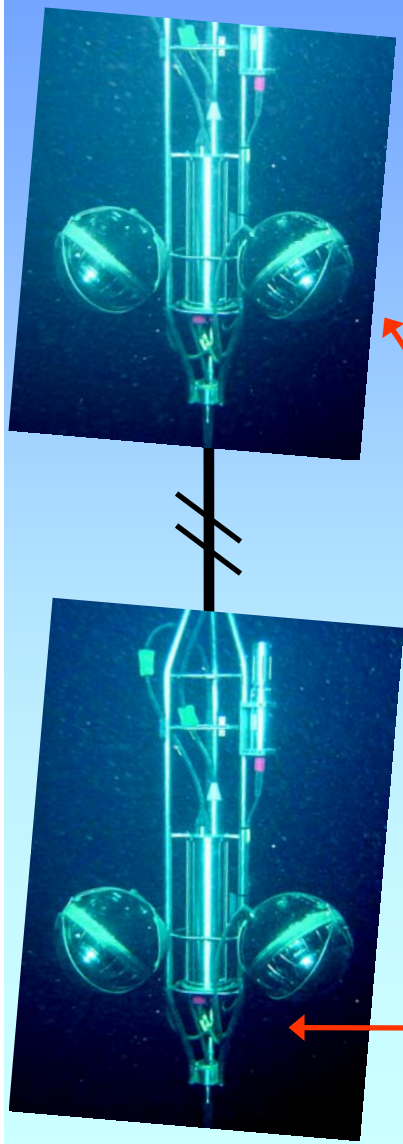


…and connected by submersible ROV Victor from Ifremer on March 2nd

Line 1 time calibration with MILOM LED beacon



Line 1

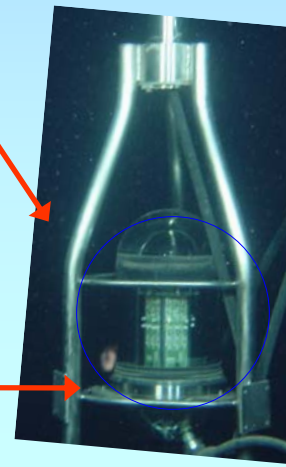


all timing measurements in good agreement with expectations

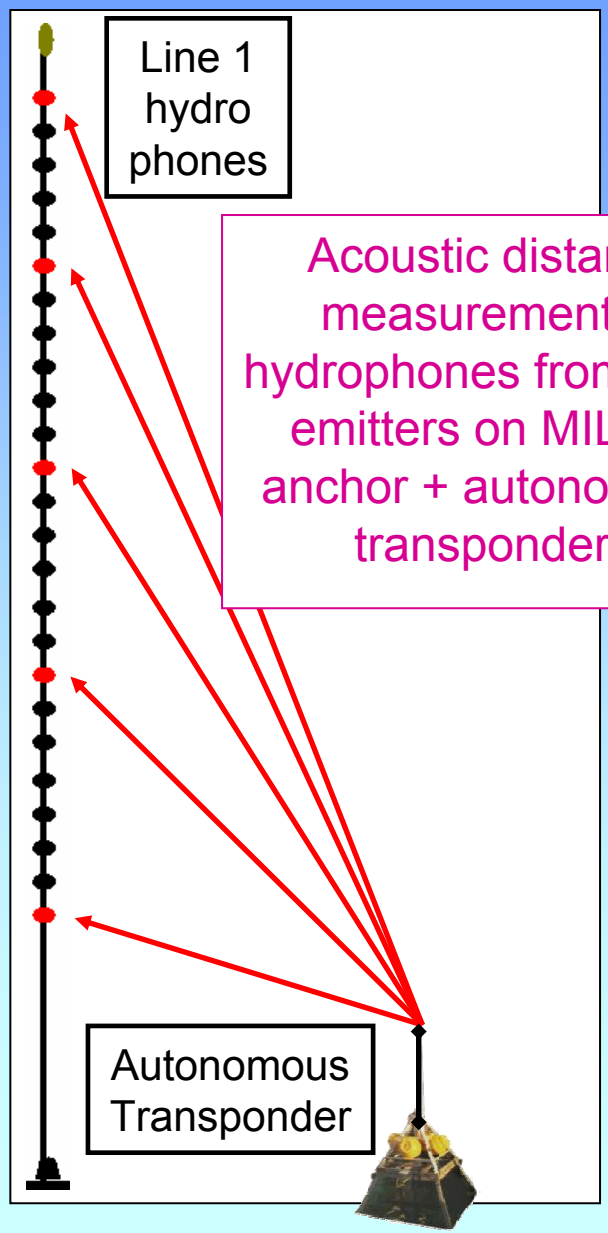
~150 m

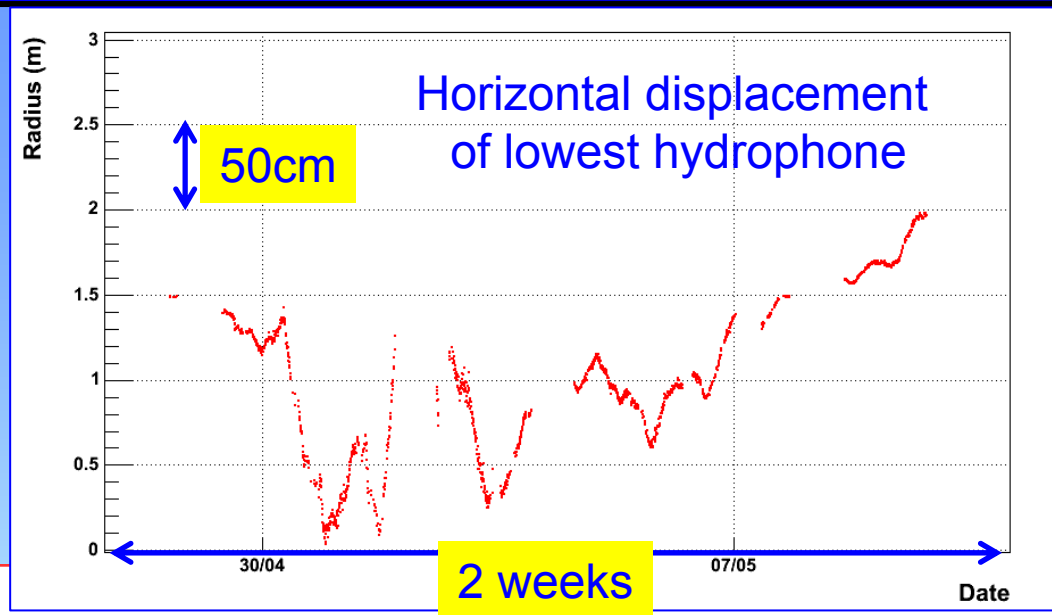
~70 m

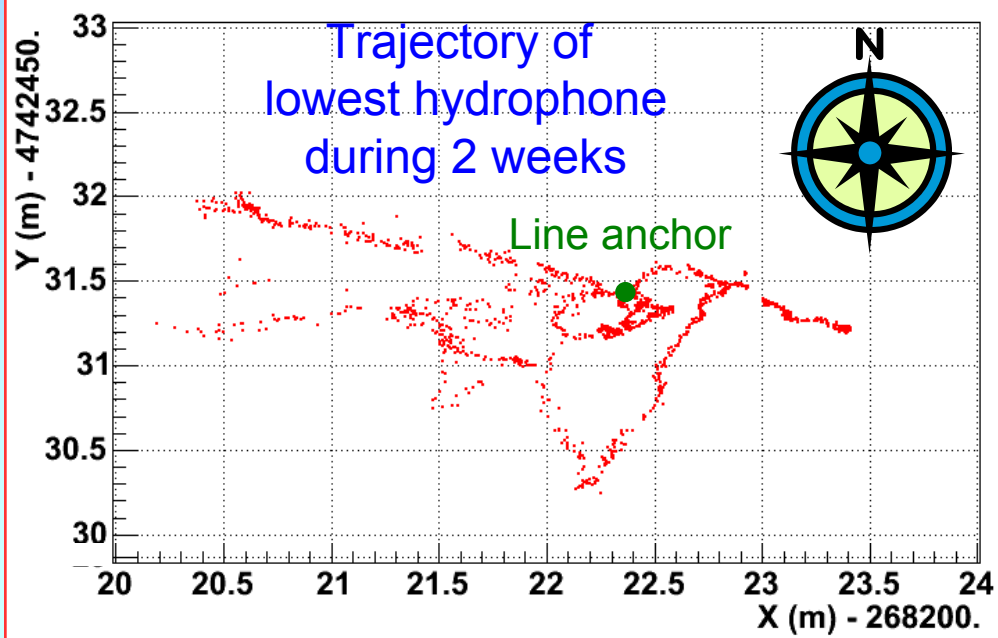
MILOM



Acoustic triangulation of Line 1 hydrophone

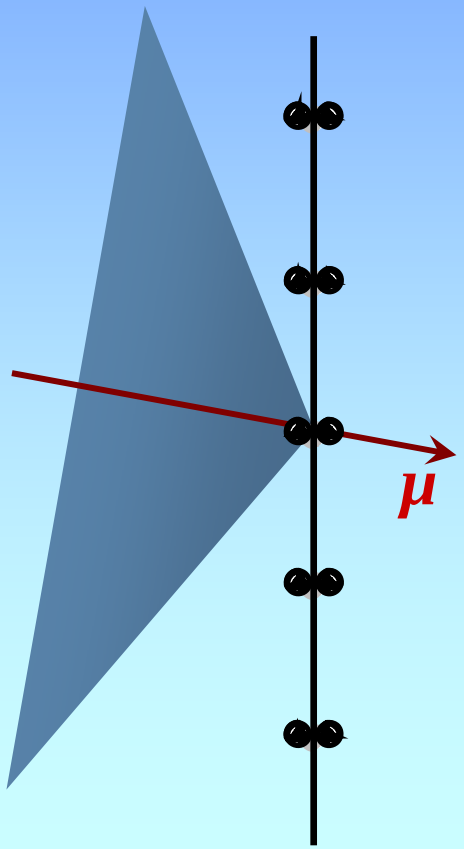


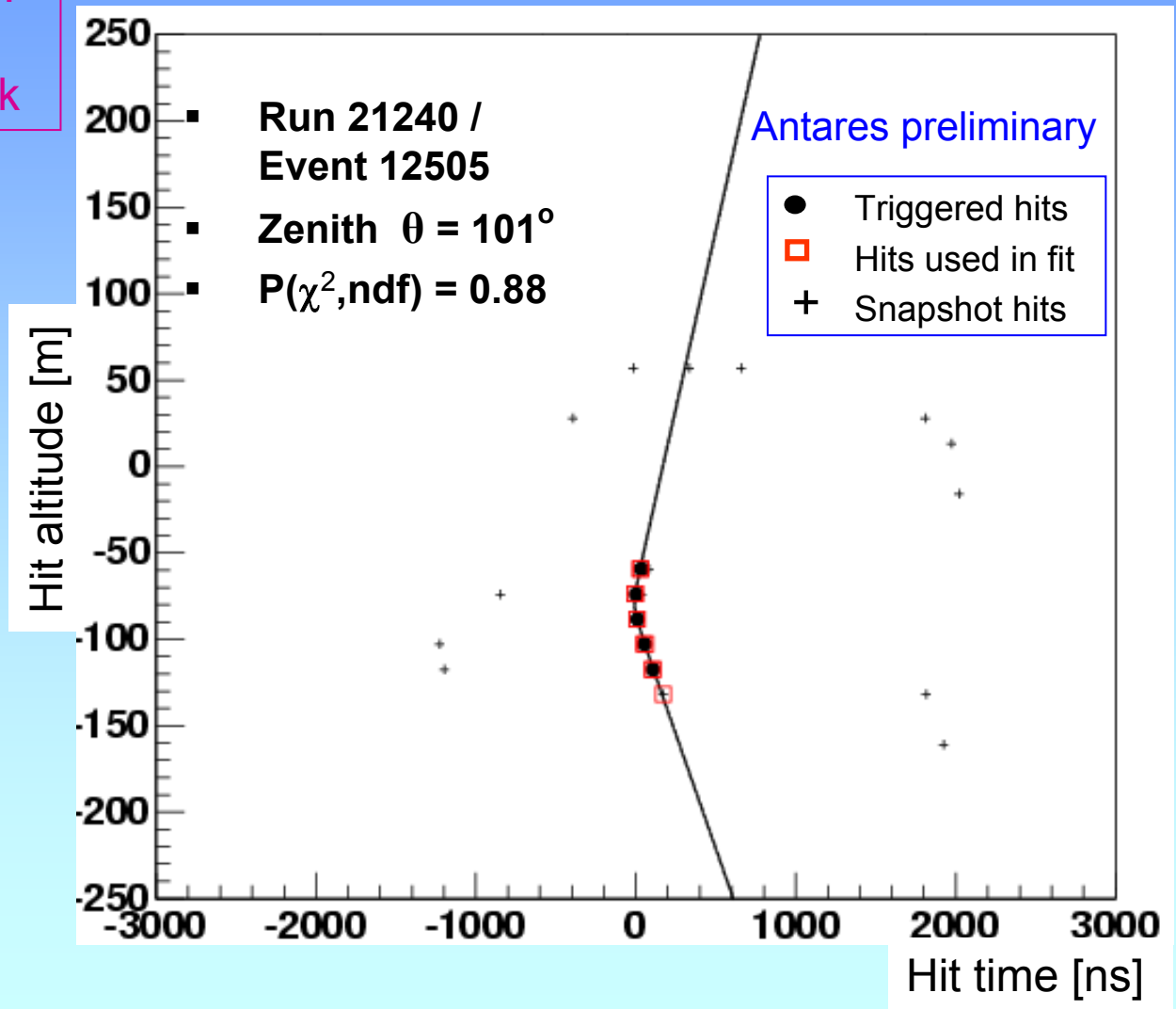




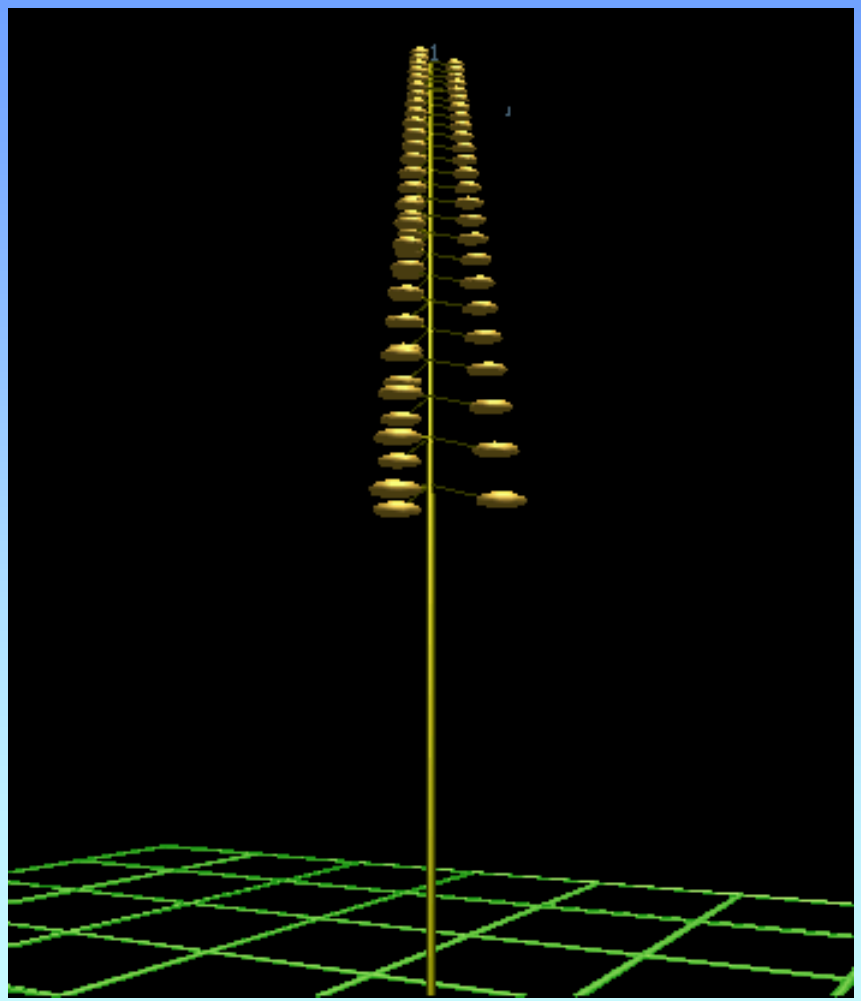
Reconstruction of atmospheric muon tracks

Reconstruction with Line1:
Algorithm minimizes $\chi 2$
to find zenith angle of track



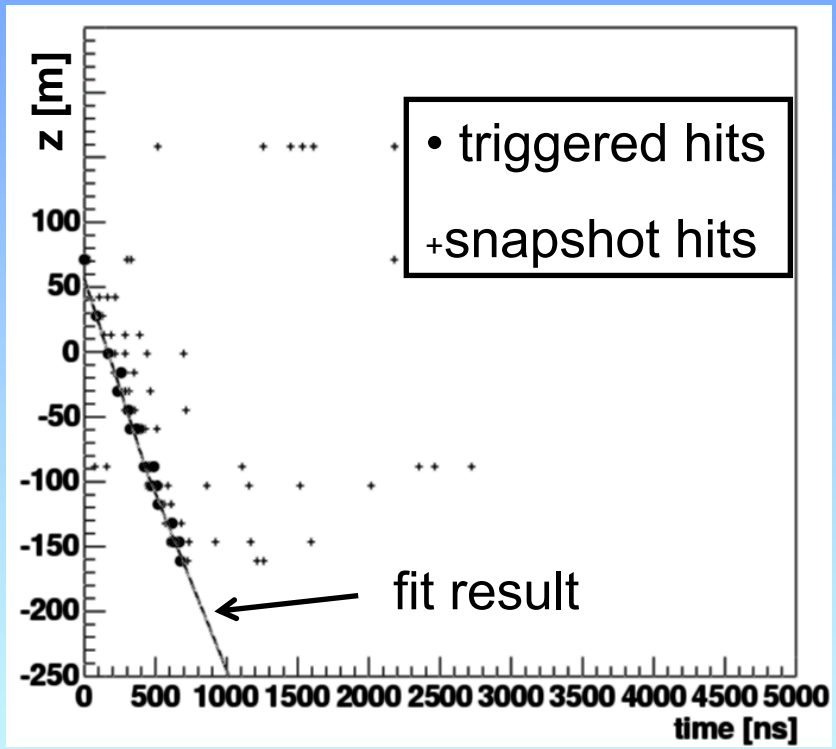


The first muon found with Line 1



Event Display by Aart Heijboer

single string muon reconstruction



✓muon reconstruction working well

✓can start to look for neutrinos !

Conclusions and Outlook

- ANTARES made a major step forward during the last year

- Detector working well within design specifications:
  - Junction Box in operation since Dec. 2002
  - Two lines delivering data on the site
  - All technical problems solved

- 12 lines detector complete end 2007 :
  Operation for science $\geq$ 5 years

- Milestone towards a KM^3 underwater detector

Stay tuned for the first undersea neutrino !!

Water versus Ice

Deployment

Ice gives solid platform to install detector

Sea experiments need boats/ platforms

Ice detectors worked first (Baikal deploys from ice)

Angular Resolution

Light scattering much less in water

AMANDA : ~ 3° (real detector)

ANTARES : ~ 0.2 ° (simulations)

Uniformity of Detector response

Water homogeneous

Ice has dust layers, bubbles

Knowledge of efficiency simpler in water

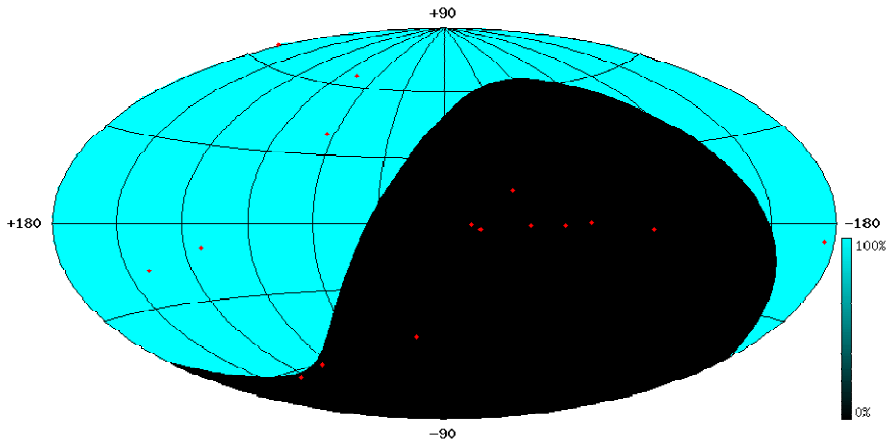
Noise Backgrounds

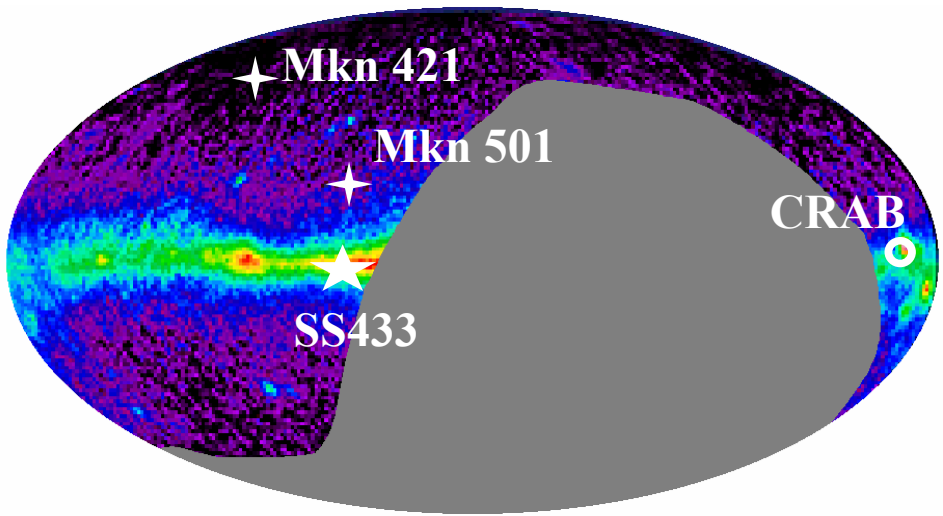
Water: ^{40}K /bioluminescence ~ 60kHz / PMT

Ice: only dark tube noise ~ 500Hz / PMT

Region of sky observable by Neutrino Telescopes

AMANDA (South Pole)





ANTARES (43° North)