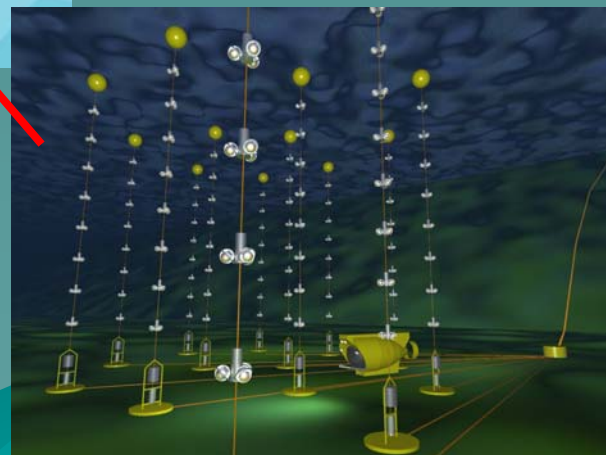
ANTARES en temps réel
Taux de comptage en 3 Modules Optiques

ANTARES : Premières données de une ligne du détecteur au fond de la mer

John CARR (Centre de Physique des Particules de Marseille)

LPSC
Grenoble
3 novembre 2005



Projet ANTARES

Astronomie Neutrino
Recherche de la Matière Noire

et recherche interdisciplinaire
dans l'océanographie, la géologie et la biologie

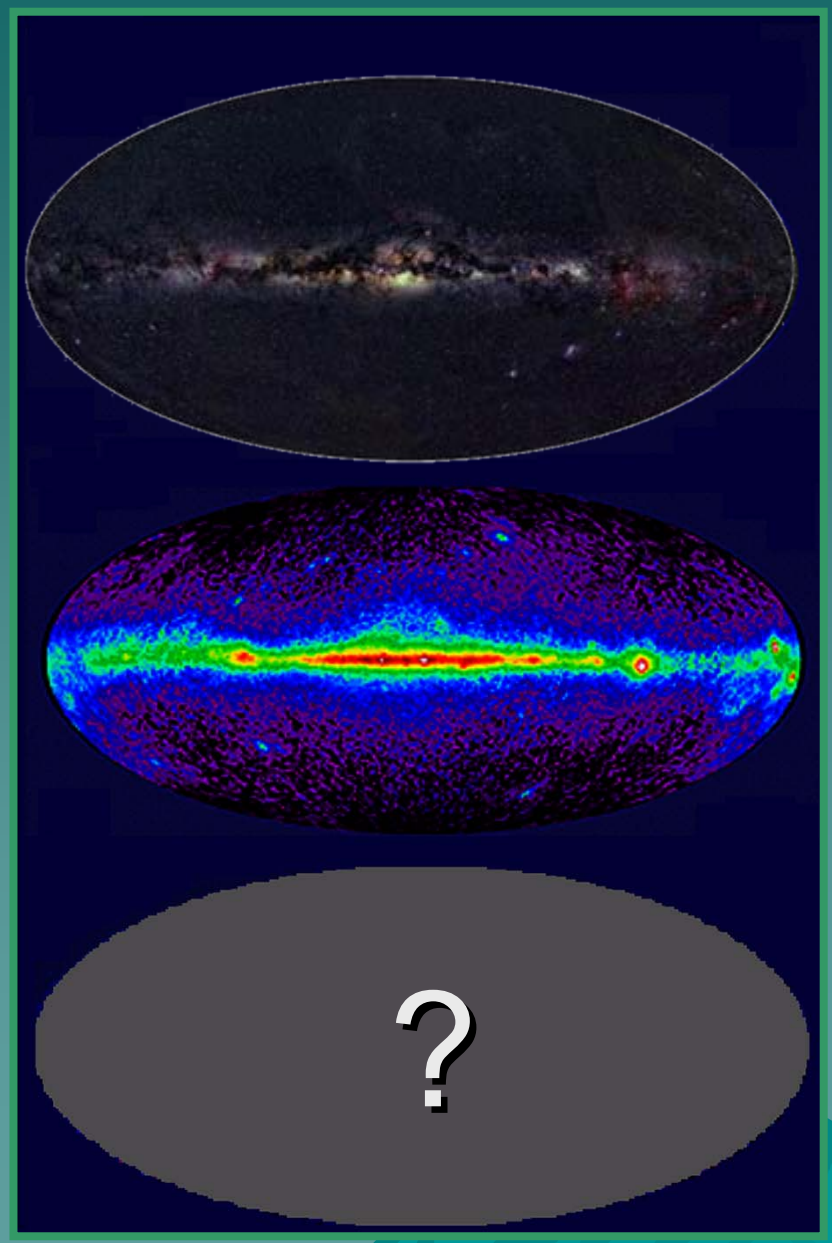
- 1996-2002 Exploration du site et R&D
  - 1999/2000 Opération de la « Ligne Démonstrateur »
- 2001-2007 Construction d'un détecteur de 12 ligne
  - 2001/2002 Déploiement du câble et boite de jonction
  - 2003 Opération des lignes « PSL » et « MIL »
  - 2005 Opération des lignes « MILOM » et « Line 0 »
  - 2006 Opération des lignes « Line 1 », « Line 2 », « Line 3,4 »
  - 2007 Complétion du détecteur 12 lignes
- 2007-2012… Opération pour la science

Astronomie Multi-Messager

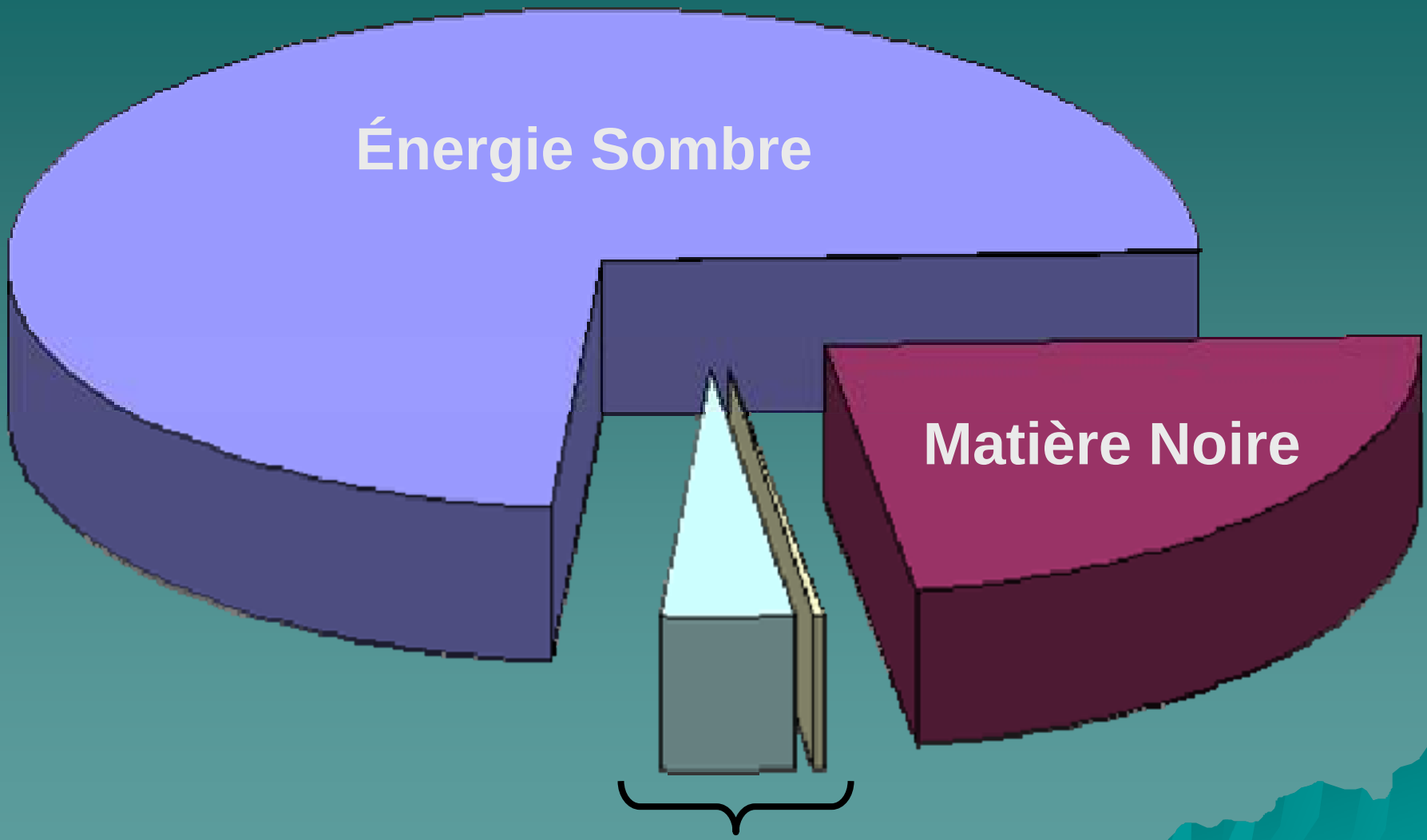
Lumière visible

Rayons Gamma

Neutrinos



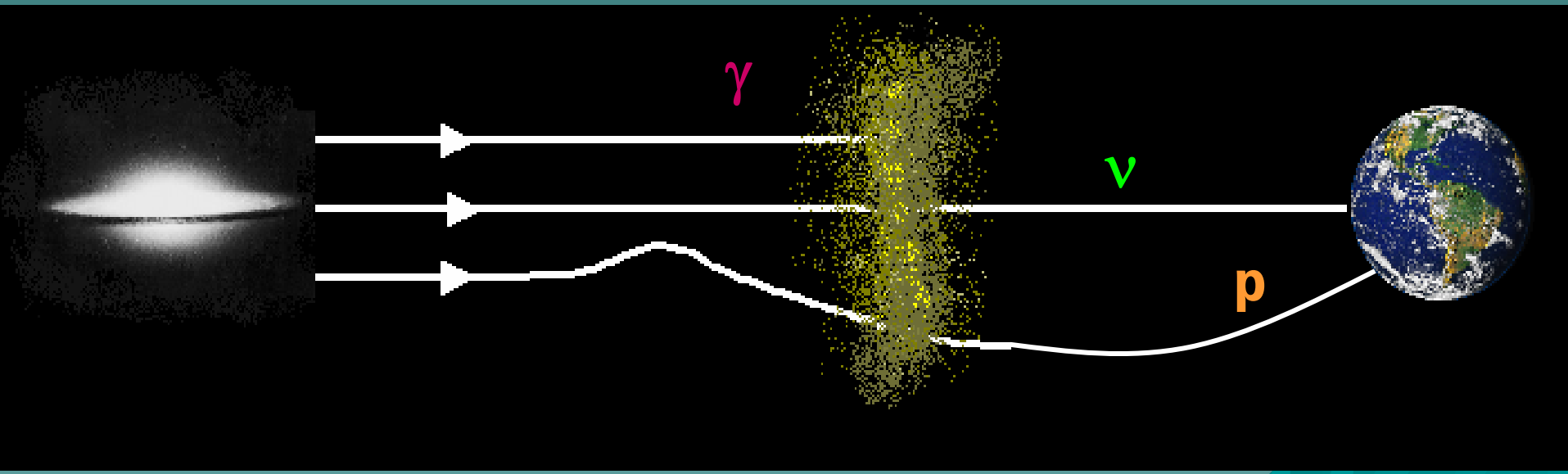
Recherche pour la Matière Noire



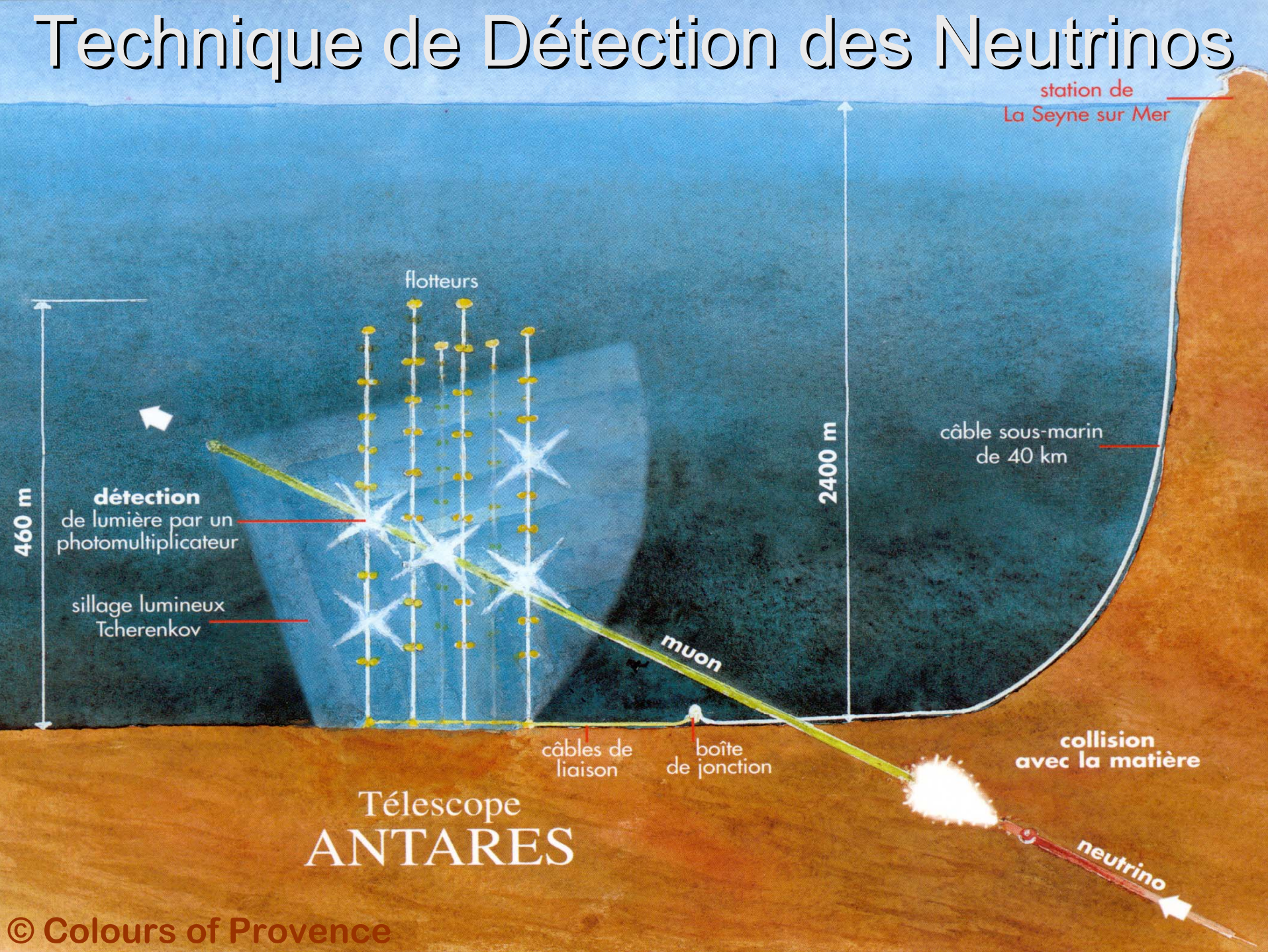
Univers Transparent aux Neutrinos

Neutrinos sont produits dans les interactions des rayons cosmiques avec la matière

$$p/A + p/\gamma \rightarrow \pi^0 + \pi^{\pm} + \ldots$$
$$\pi^0 \rightarrow \gamma\,\gamma \qquad \pi^{\pm} \rightarrow \nu_\mu\,\mu \rightarrow \nu_\mu\,\nu_e\,e$$



Technique de Détection des Neutrinos



Projets de Télescopes à Neutrinos

ANTARES La-Seyne-sur-Mer, France
(NEMO Catania, Italie)

BAIKAL: Lac Baïkal, Siberie

NESTOR : Pylos, Grèce

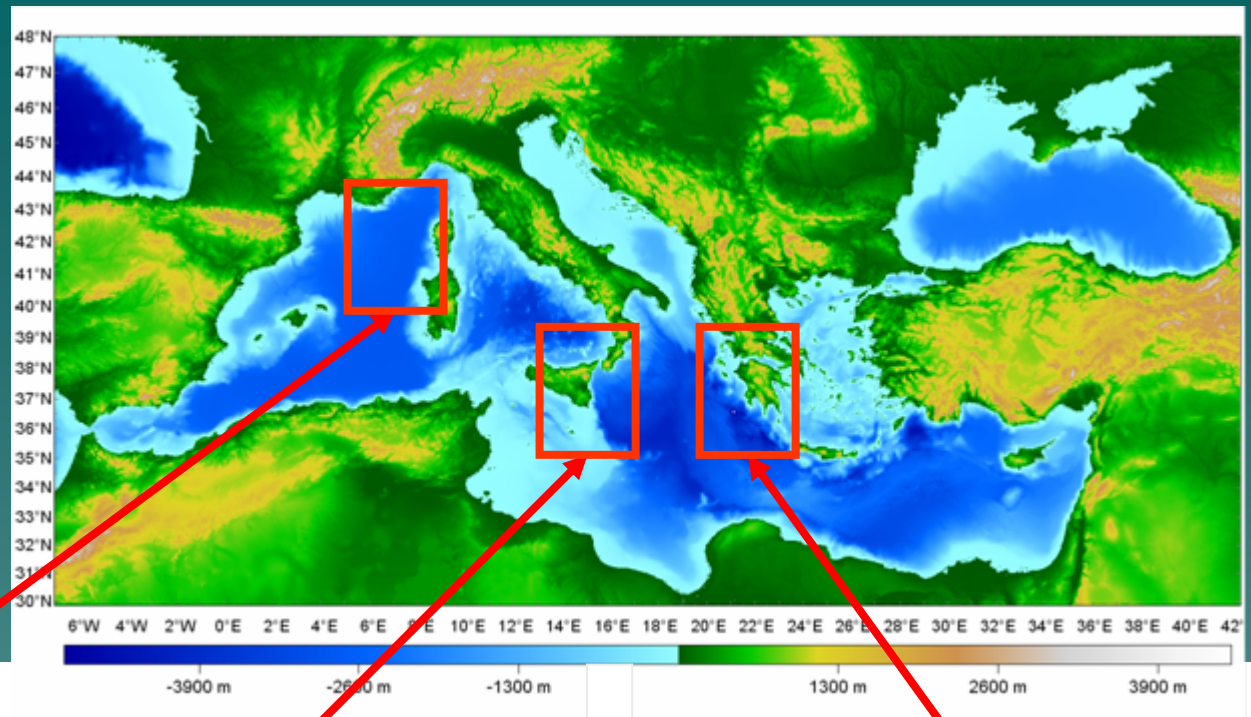
DUMAND,
Hawaii
(annulé 1995)

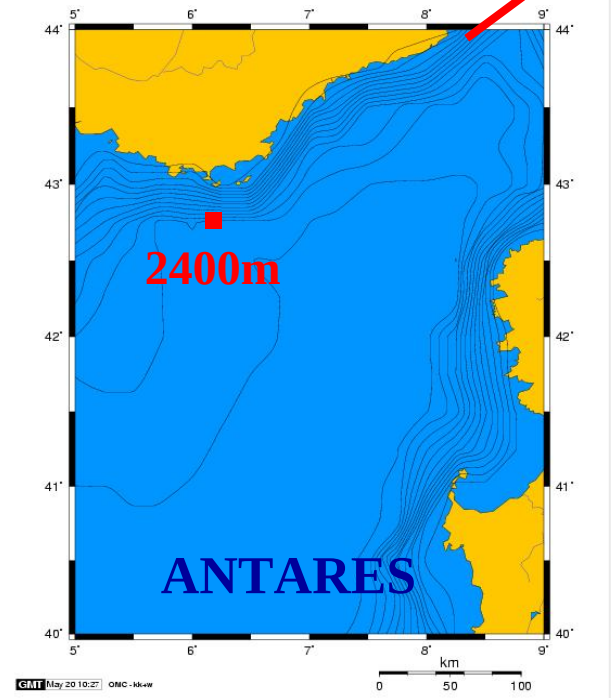
AMANDA, Pôle Sud, Antarctique

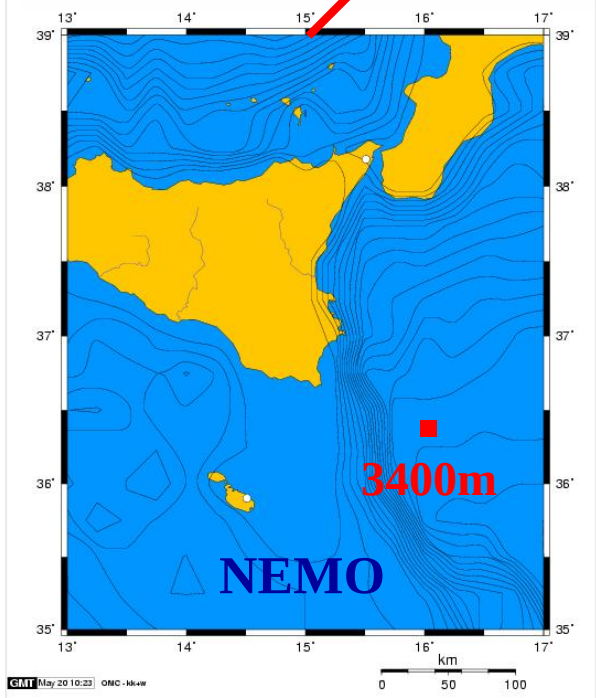
KM3NET

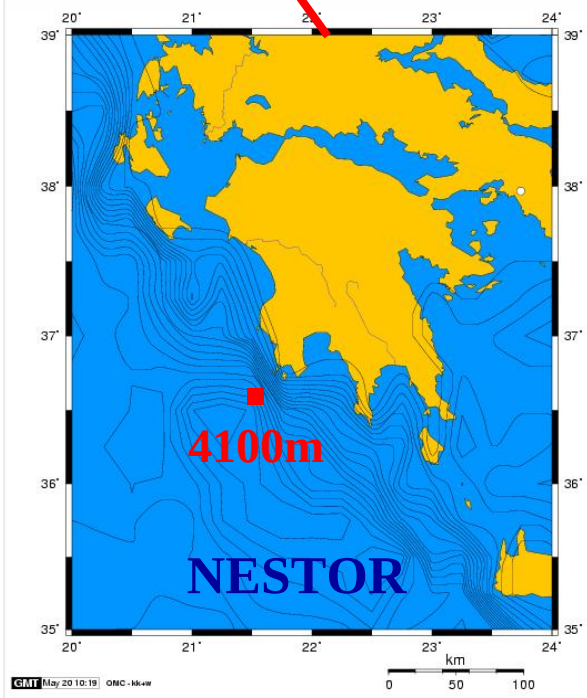
UE 6ieme PCRD
“Design Study”

2006-2009….

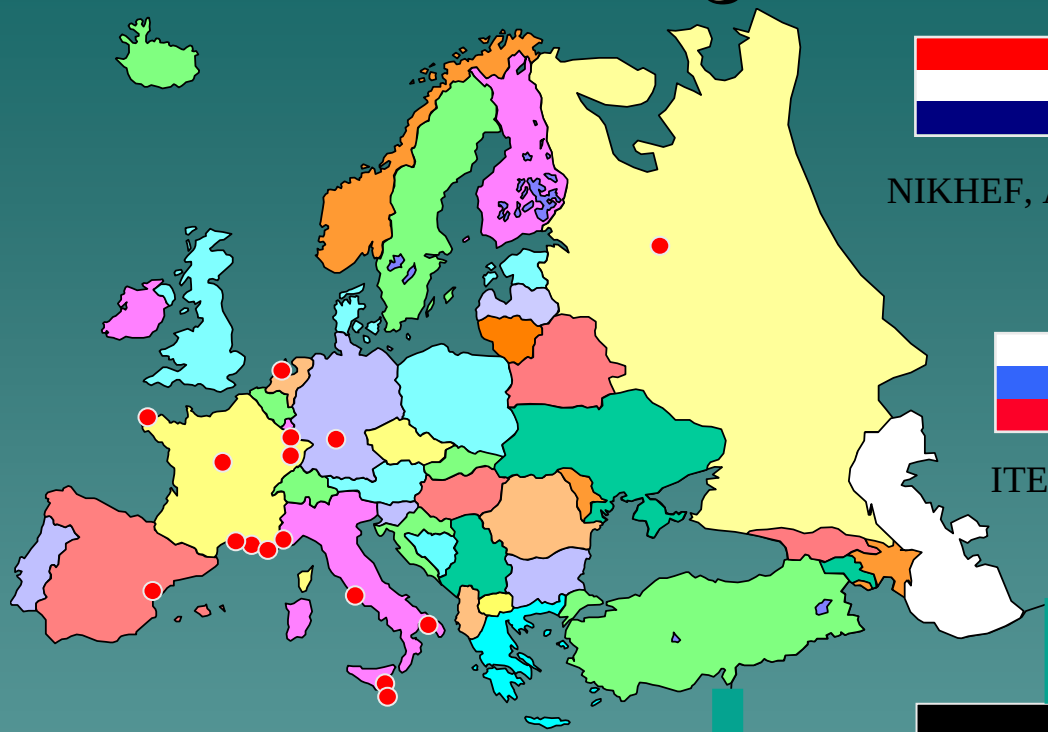








Collaboration ANTARES
200 Chercheurs/Ingénieurs



CPPM, Marseille
DSM/DAPNIA/CEA, Saclay
C.O.M. Marseille
IFREMER, Toulon/Brest
LAM, Marseille
IReS, Strasbourg
Univ. de H.-A., Mulhouse
ISITV, Toulon
LOV Villefranche

NIKHEF, Amsterdam

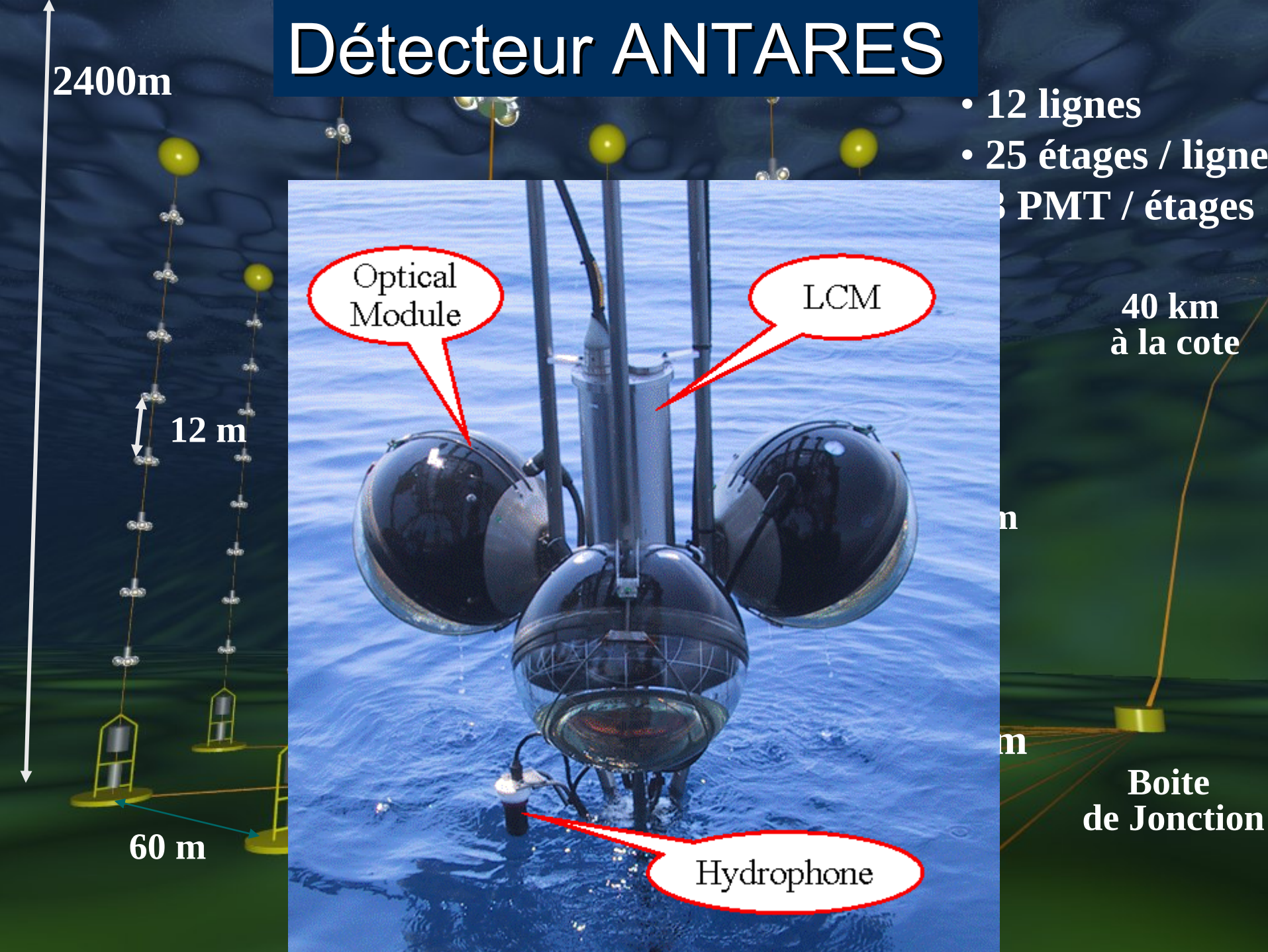
ITEP, Moscow

IFIC, Valencia

Université Bari
Université Bologna
Université/LNS Catania
Université Pisa
Université Rome
Université Genova

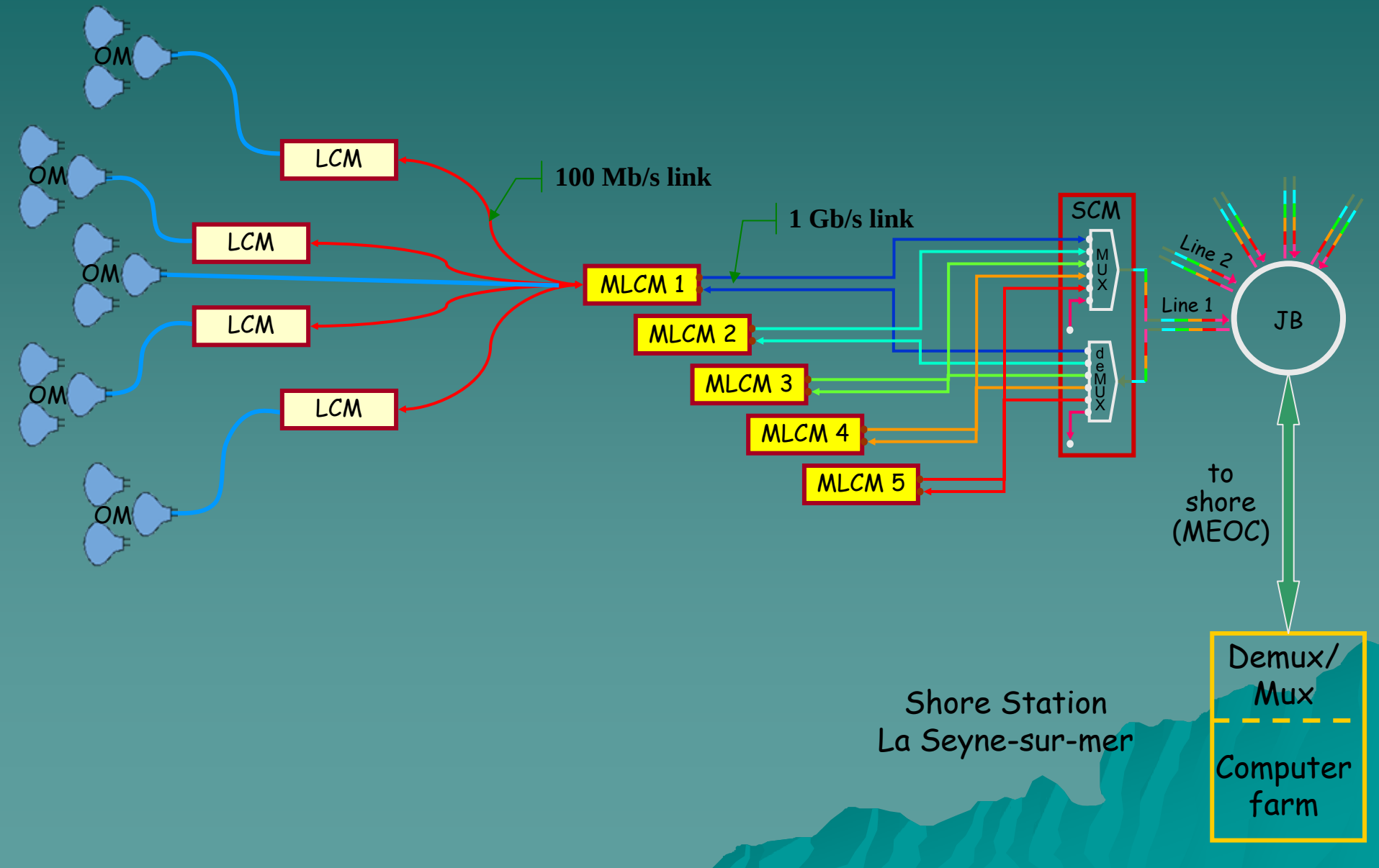
Université Erlangen

Détecteur ANTARES



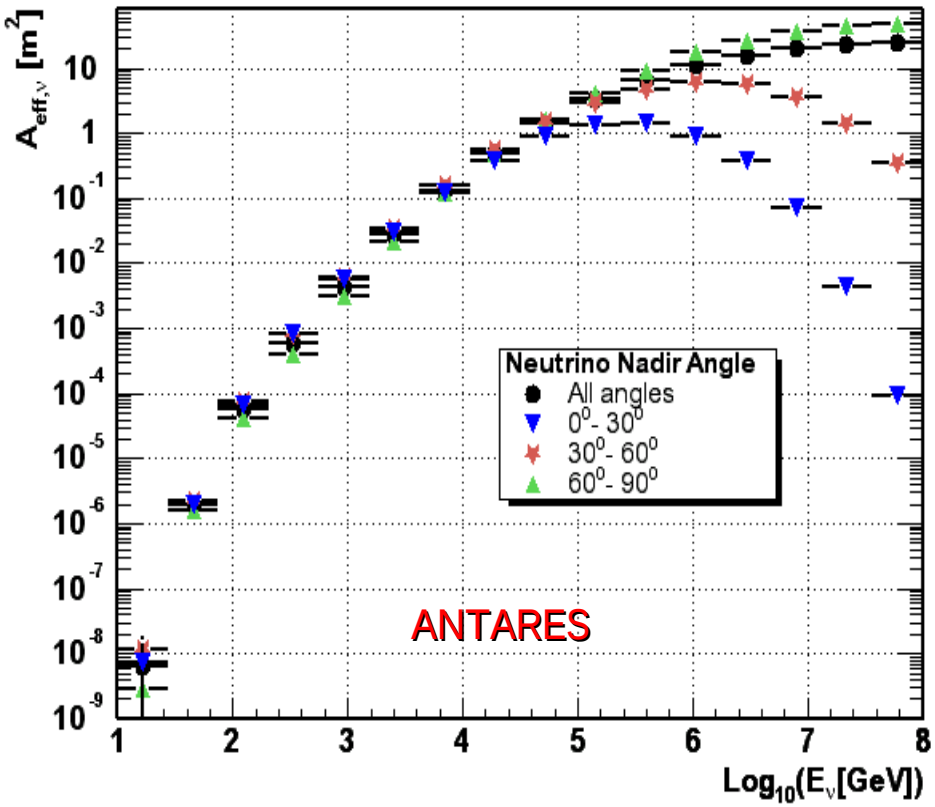
- 12 lignes
- 25 étages / ligne
- 3 PMT / étages

Architecture d'Acquisition des Données

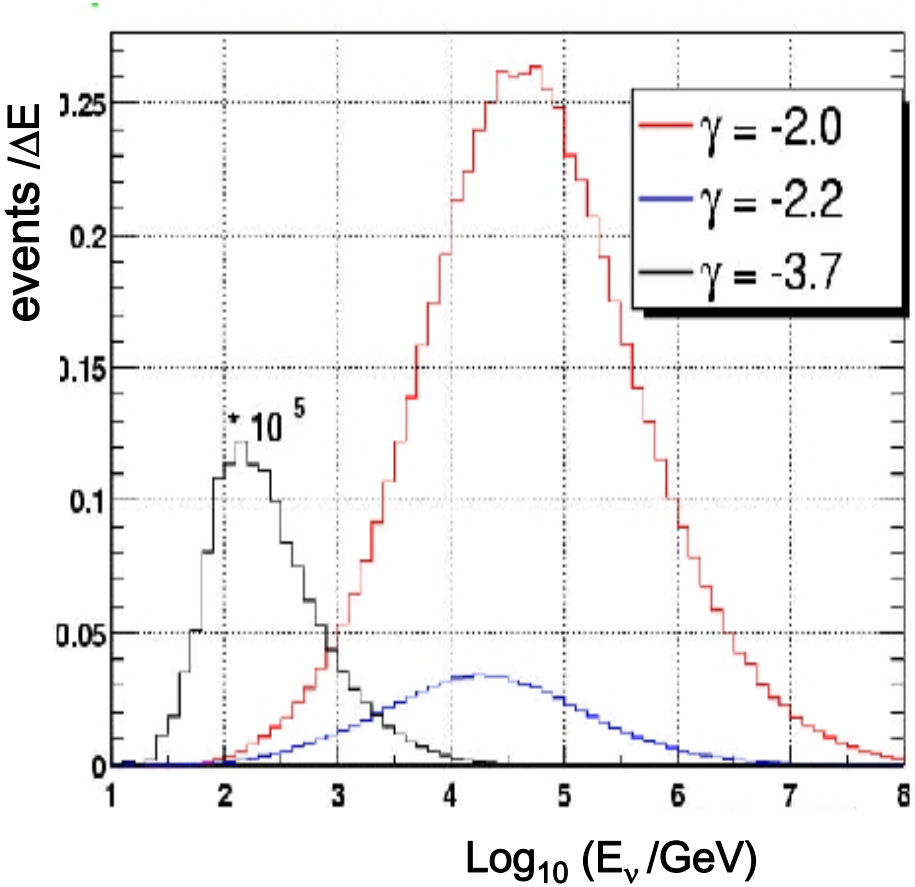


Performances Anticipées

Effective area

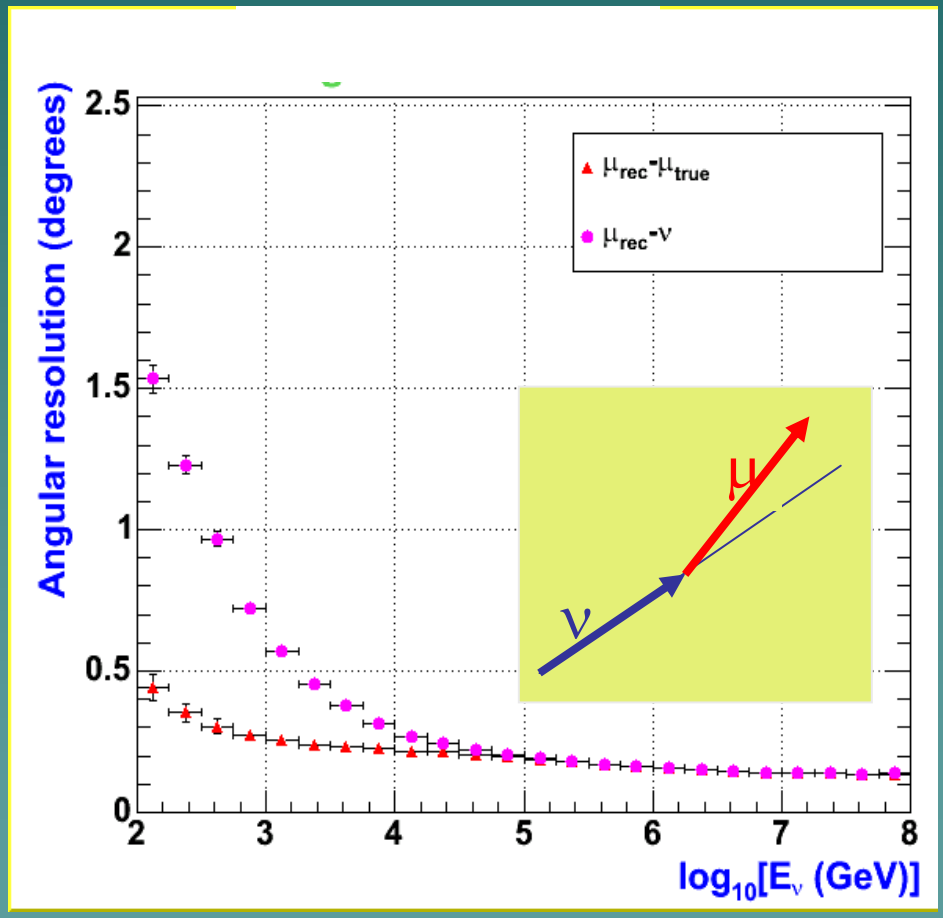


Number of events



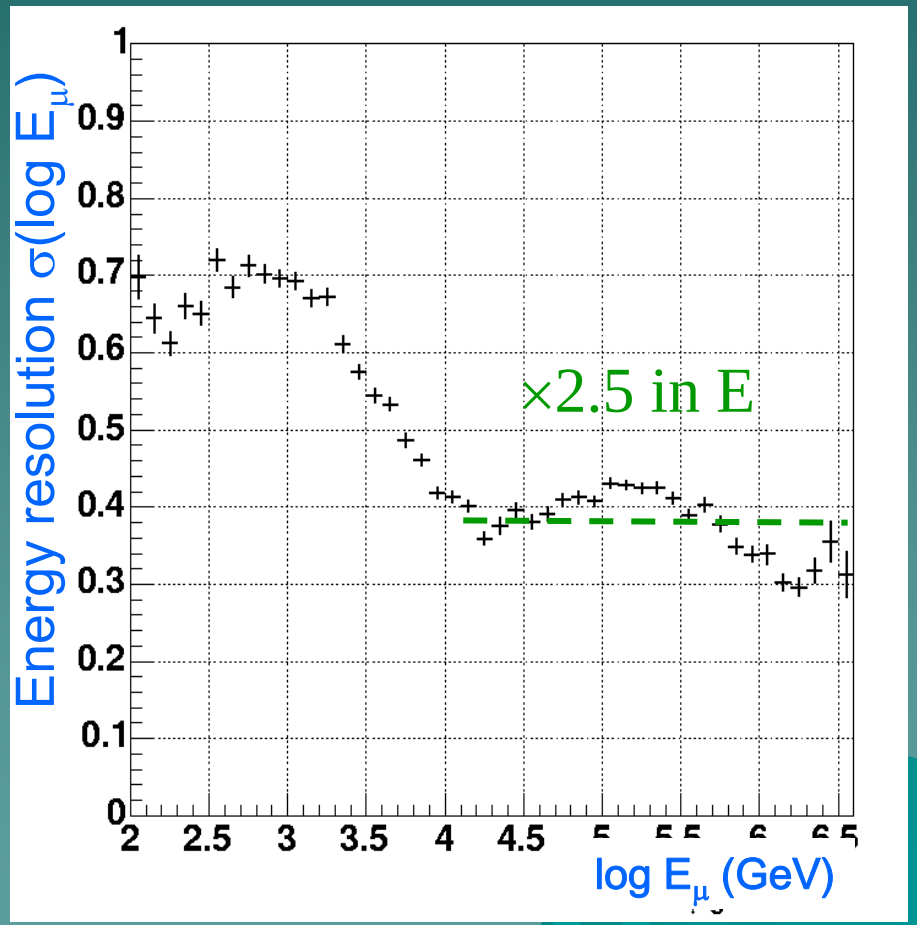
Performances Anticipées

Angular resolution



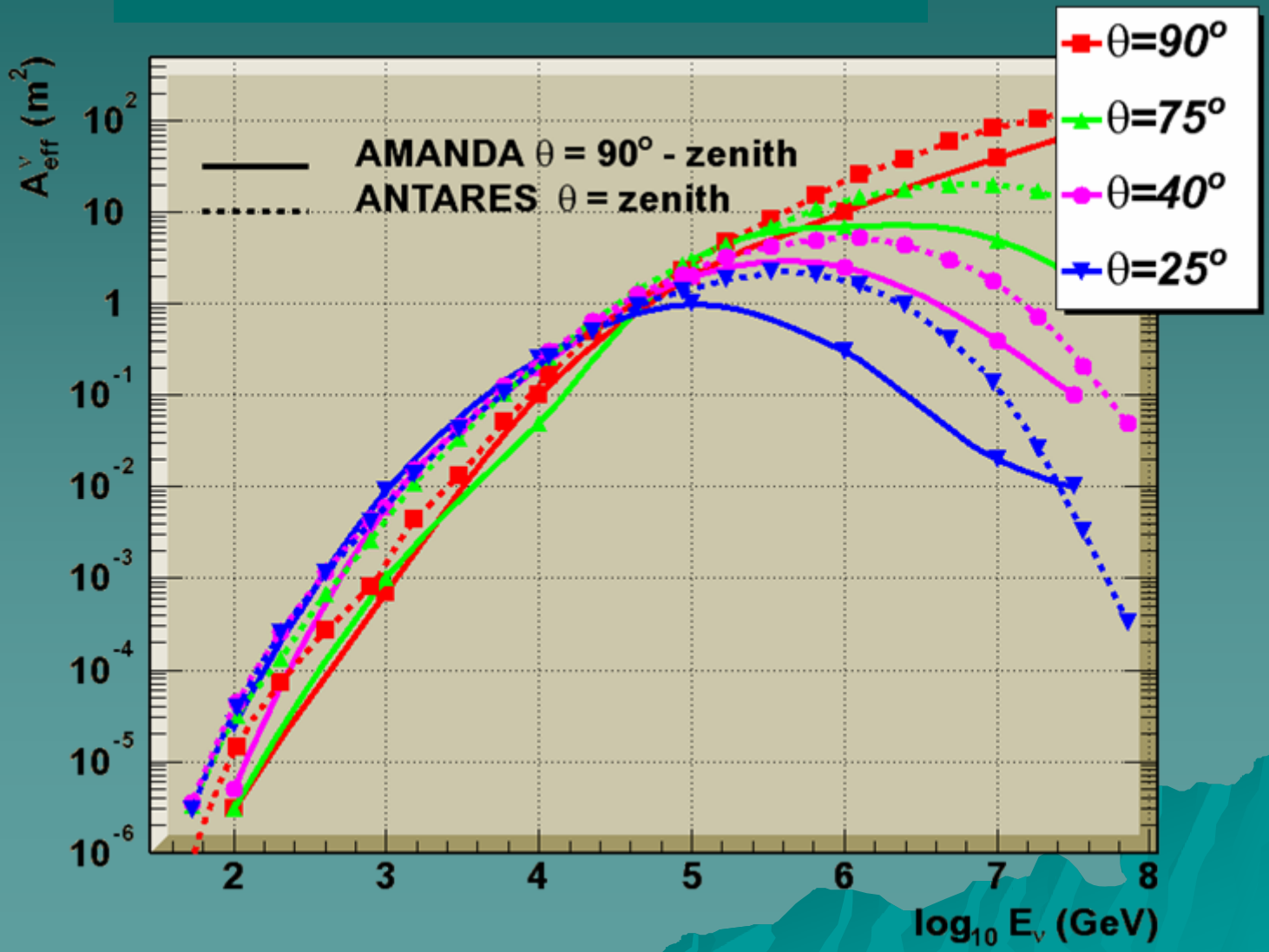
$\Delta\theta(\nu) \approx 0.2°$ for E > 10 TeV

Energy resolution



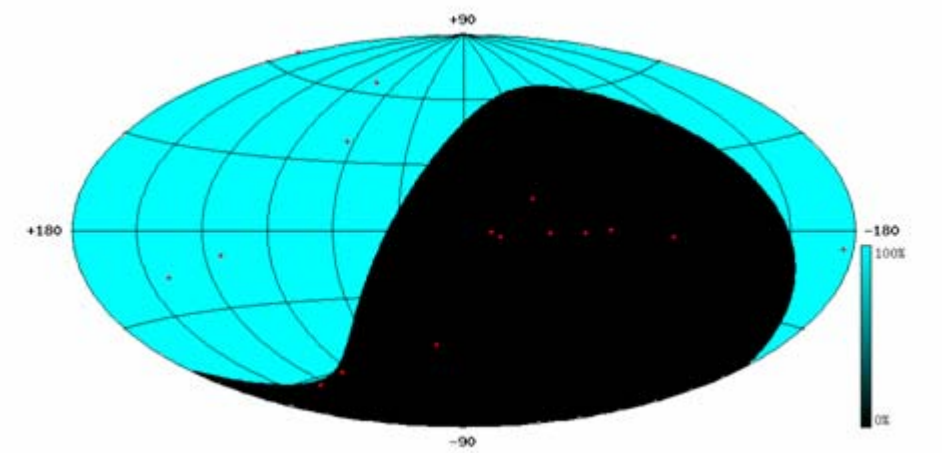
$\Delta E(\nu)/E \approx 3$ for E > 10 TeV

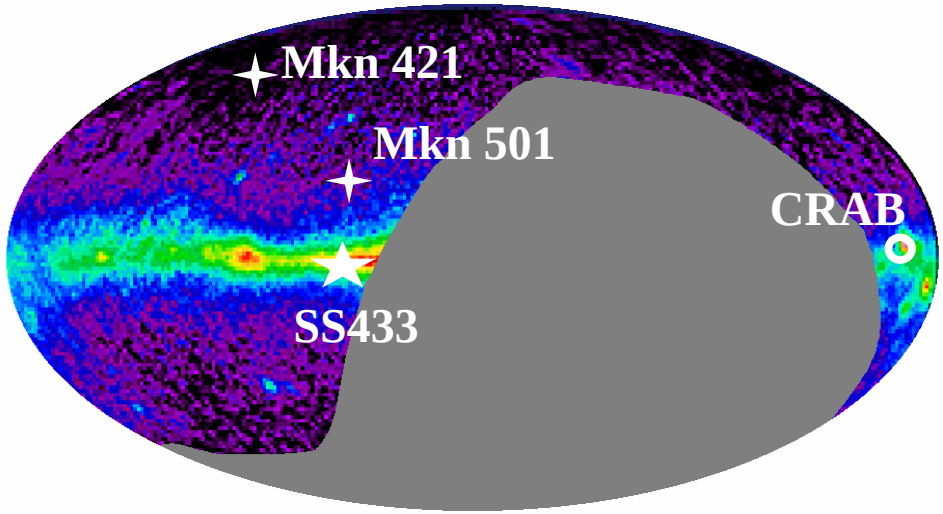
Surface Effective Neutrino AMANDA / ANTARES



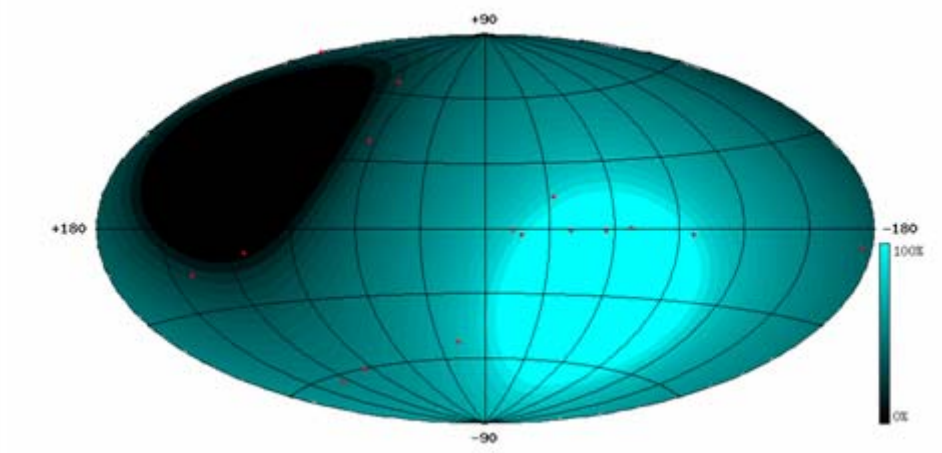
Ciel observable par des Télescopes à Neutrino

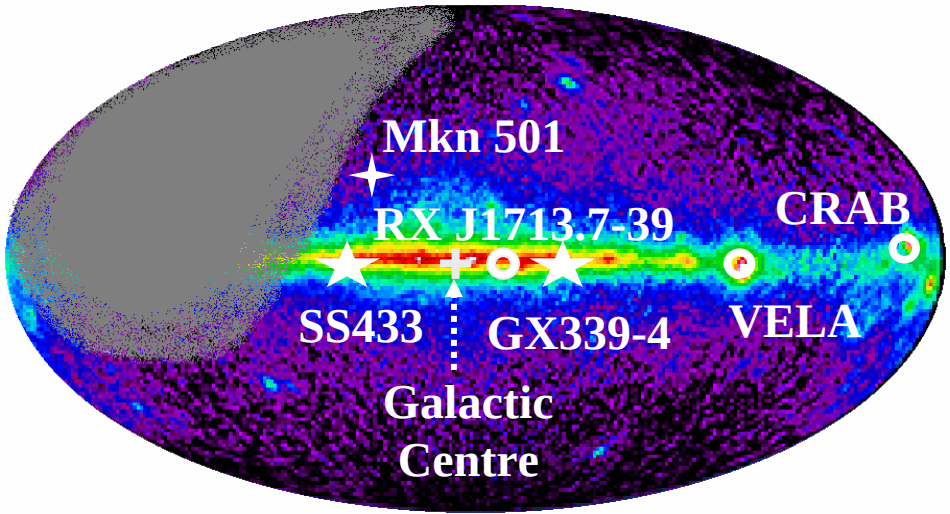
AMANDA (South Pole)





ANTARES (43° North)





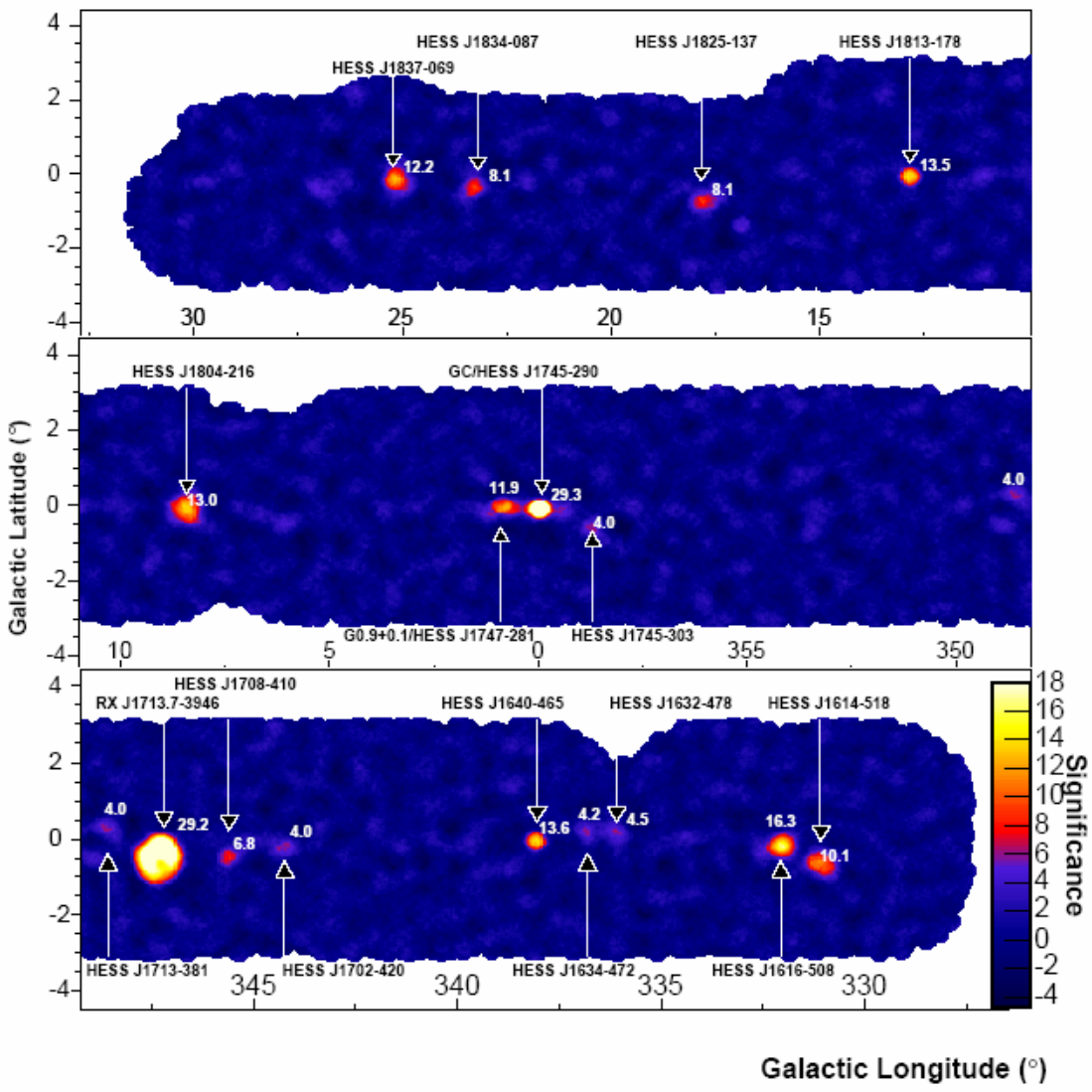
Taux d'Événements pour des Sources Galactiques

Source TypeA	Distance (kpc)	E_ν (GeV)	$N_{\nu\mu}$ (km^{-2} yr^{-1})	Ref.
Supernovae	10	$\lesssim 10^3$	~100	Waxman & Loeb 2001
Shocks		$\sim 10^2 - 10^6$	50 – 1000	Protheroe et al. 1998
pulsars		$\sim 10^5 - 10^8$	~ 100 – 1000	Beall & Bednarek 2002
		$\sim 10 - 10^8$	$\lesssim$ 1000	Nagataki 2004
Plerions	0.5 – 4.4	$< 10^3 - 10^5$	~ 1 – 12	Guetta & Amatto 2003
		$\sim 10^3 - 5\cdot10^5$	$\lesssim$ 1	Bednarek 2003
Crab	2	$\sim 10^3 - 5\cdot10^5$	a few	Bednarek & Protheroe 1997
		$\sim 10^3 - 5\cdot10^5$	~ 1	Bednarek 2003
		$10 - 10^6$	~ 4 – 14	Amato et al. 2003
Shell SNRs				
SNR RX J1713.7	6	$\lesssim 10^4$	~ 40	Alvarez-Muñiz & Halzen 2002
Sgr A East	8	$\lesssim 10^5$	~ 140	
Pulsars + Clouds				
	8	$10^4 - 10^7$	~ 2 – 30	Bednarek 2002
Galactic Centre	1.7	$\gtrsim 10^3$	a few	Torres et al. 2004
Cygnus OB2		$10^4 - 10^7$	~ 0.5	Bednarek 2003
		$\lesssim 10^6$	~4	Anchordoqui et al. 2003
Binary systems				
A0535+26	2.6	$3 \cdot 10^2 - 10^3$	a few	Anchordoqui et al. 2003
Microquasars	1 – 10	$10^3 - 10^5$	1 – 300	Distefano et al. 2002

(W. Bednarek, F. Burgio, T.Montaruli astro-ph/0404534)

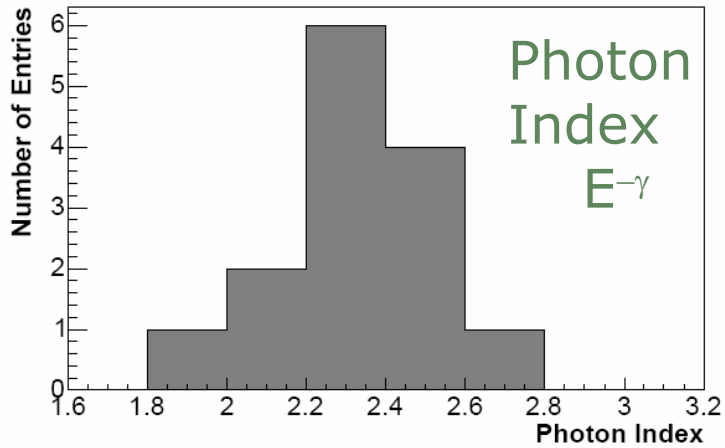
HESS Sources Galactique Rayons Gamma

15 new TeV sources + 3 known



Spectra measured for all sources relatively hard

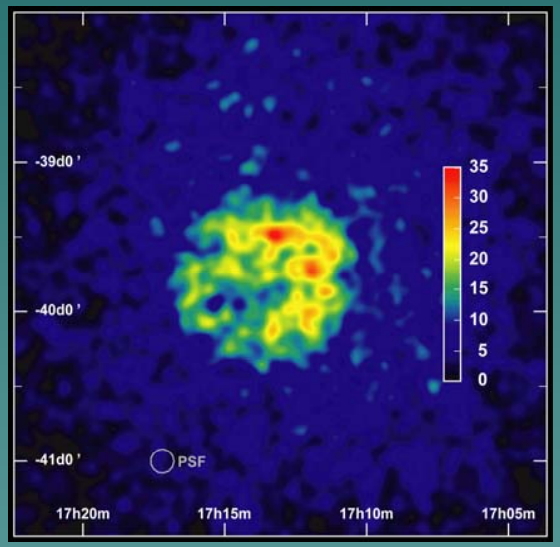
$\langle\gamma\rangle = -2.3$



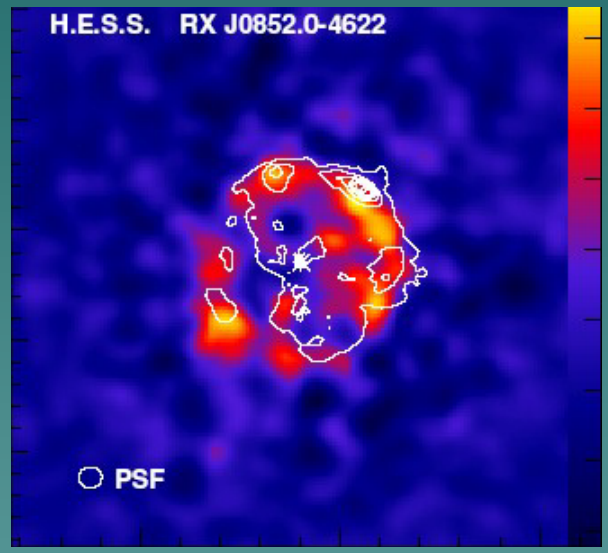
Harder ⇒ more events in neutrino telescopes

Puissant Restes de Supernova HESS

RX J1713.7-3946



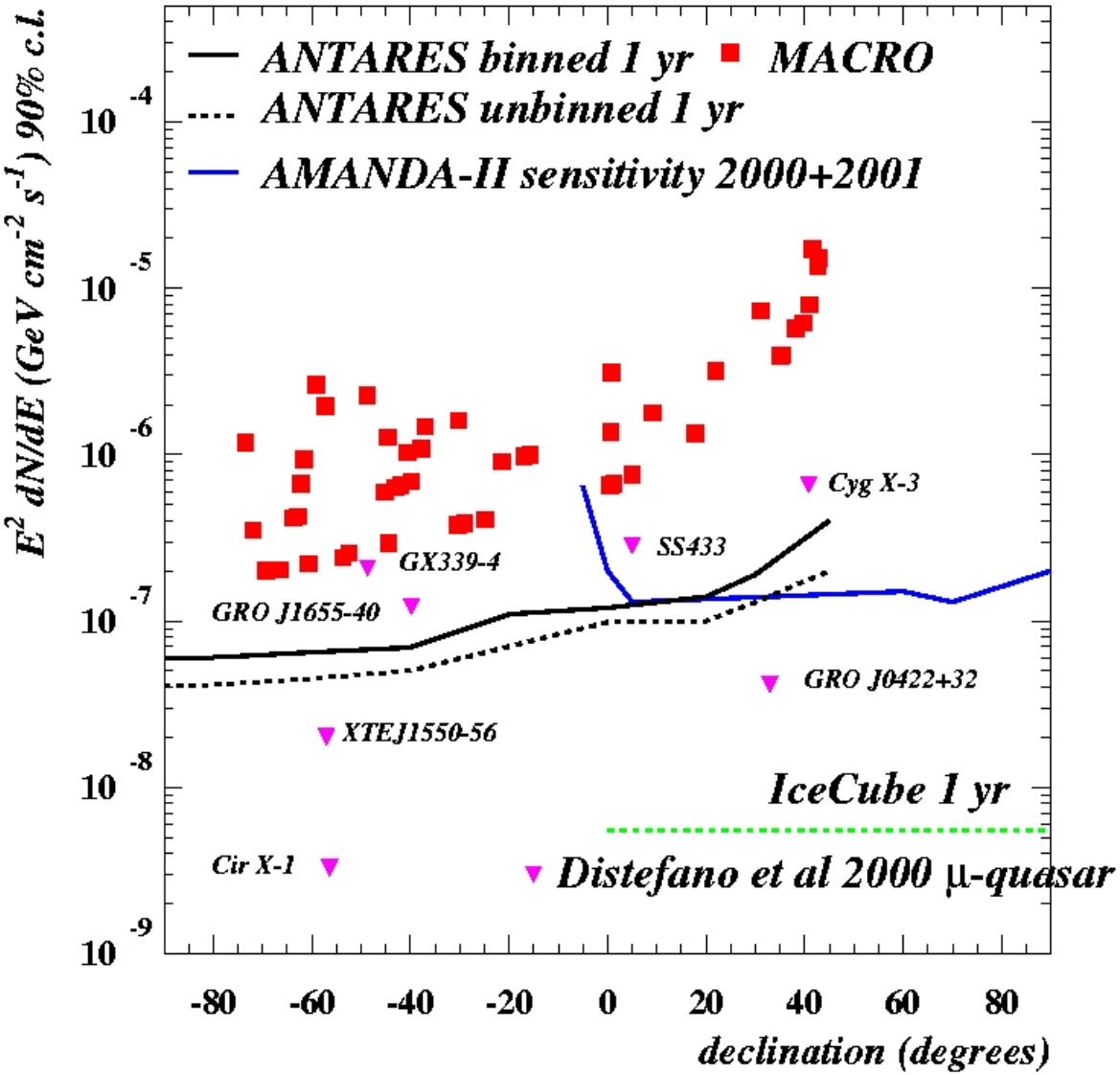
Vela Junior



~1 events / year / source in ANTARES if $\nu \approx \gamma$

Observation of neutrinos
would give clear proof for hadronic acceleration
and so of source of cosmic rays

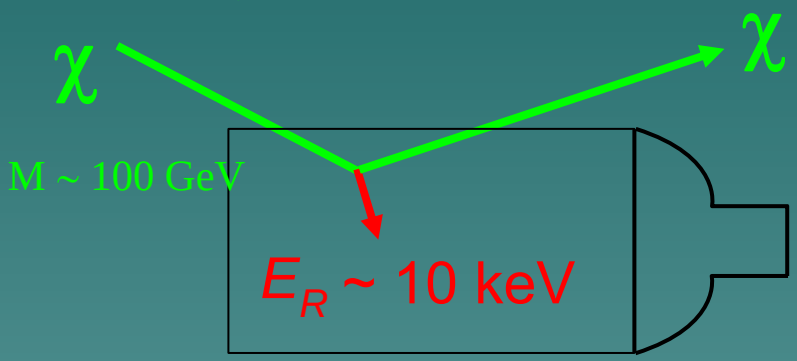
Limites sur des sources pointues

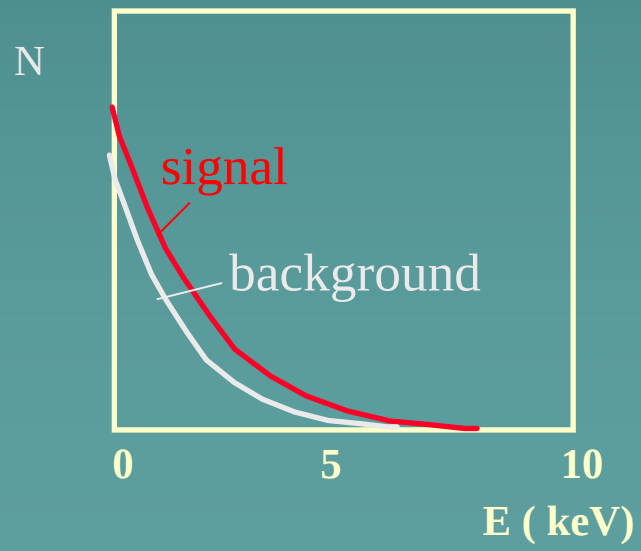


Détection des WIMPS

Direct

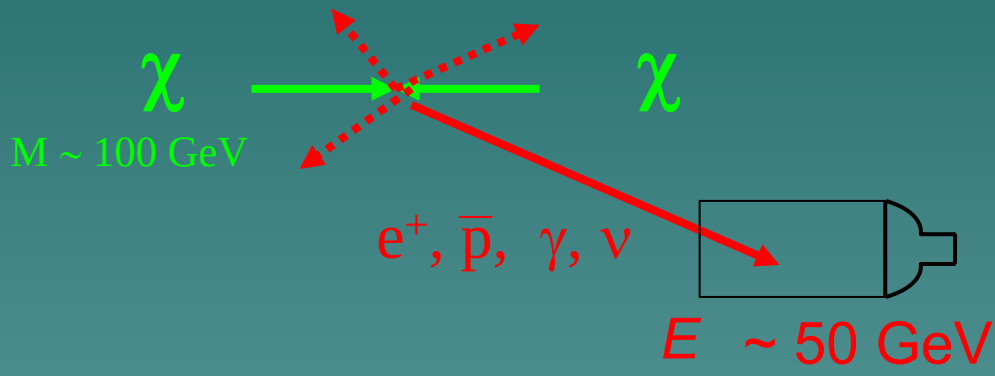
Halo: v ~ 300 km/sec

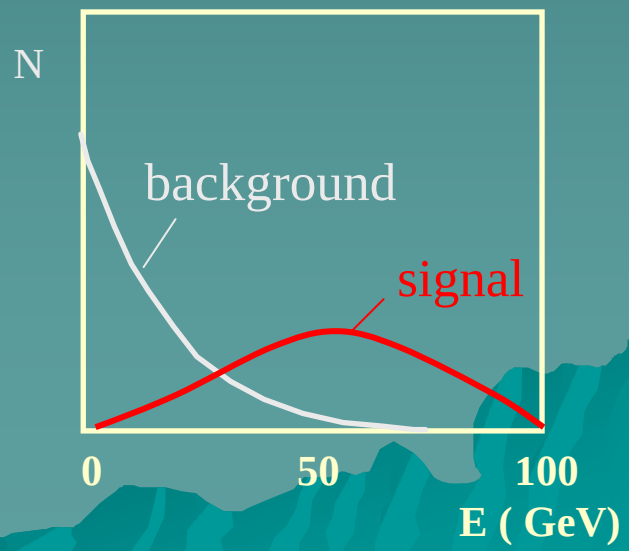




Indirect

Captured: v ~ at rest, or in Halo





Comparaison : ANTARES et Détection Direct

Using example of

mSUGRA model

A_0=0, μ>0, tanβ=10,

$M_{1/2}$=0-800 GeV,

M_0=0-1000 GeV

+ $\Omega_{wimp}h^2 < 1$

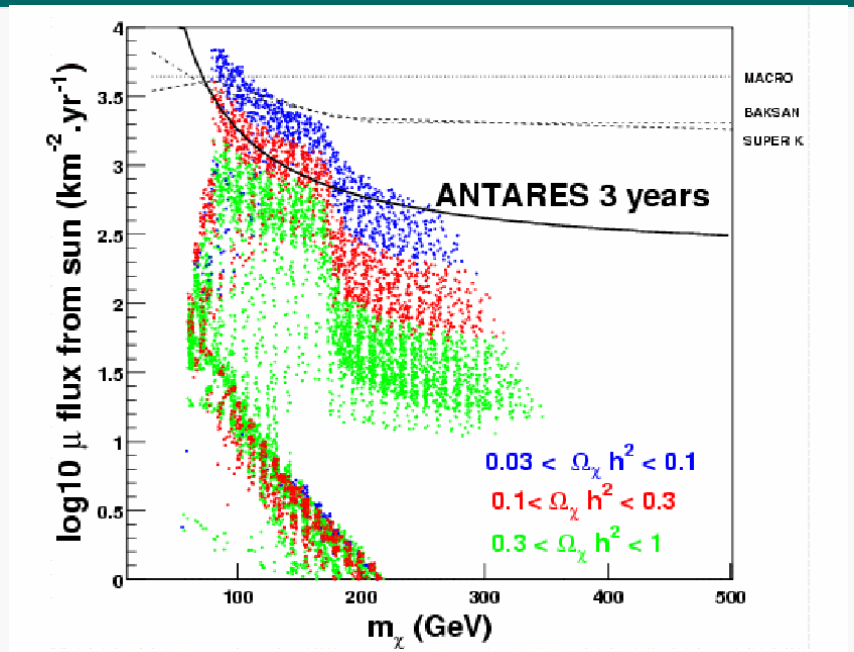
+ LEP constraint

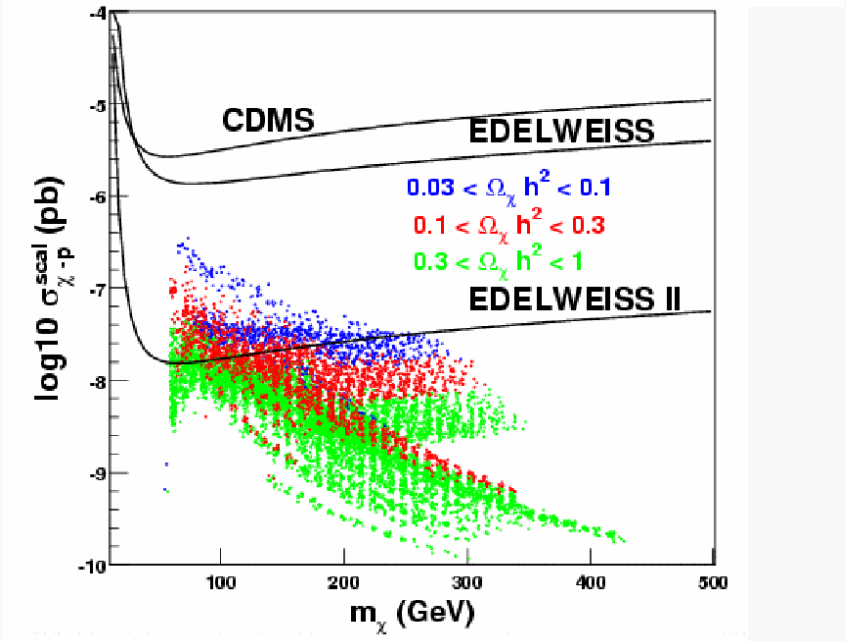
Neutrino telescope ➡

ν flux from sun

Direct Detection ➡

spin-independent cross-section





Neutrino Telescopes very competitive

for some regions of MSSM phase space

Étapes du projet

Marseille

La Seyne
sur Mer

Toulon

Vielle Câble Télcom
Marseille-Corsica

Ligne d'essai
nov 1999- juin 2000
42°59 N, 5°17 E
profondeur 1200 m

Nouvelle Câble
(2001)
La Seyne-ANTARES

Site ANTARES
42°50 N, 6°10 E
profondeur 2400 m
Construction 2001-2007
Exploitation 2007-2013

~ 50 opérations pour l'exploration du site

Explorations du Site

1) Optical background study: 15 deployments

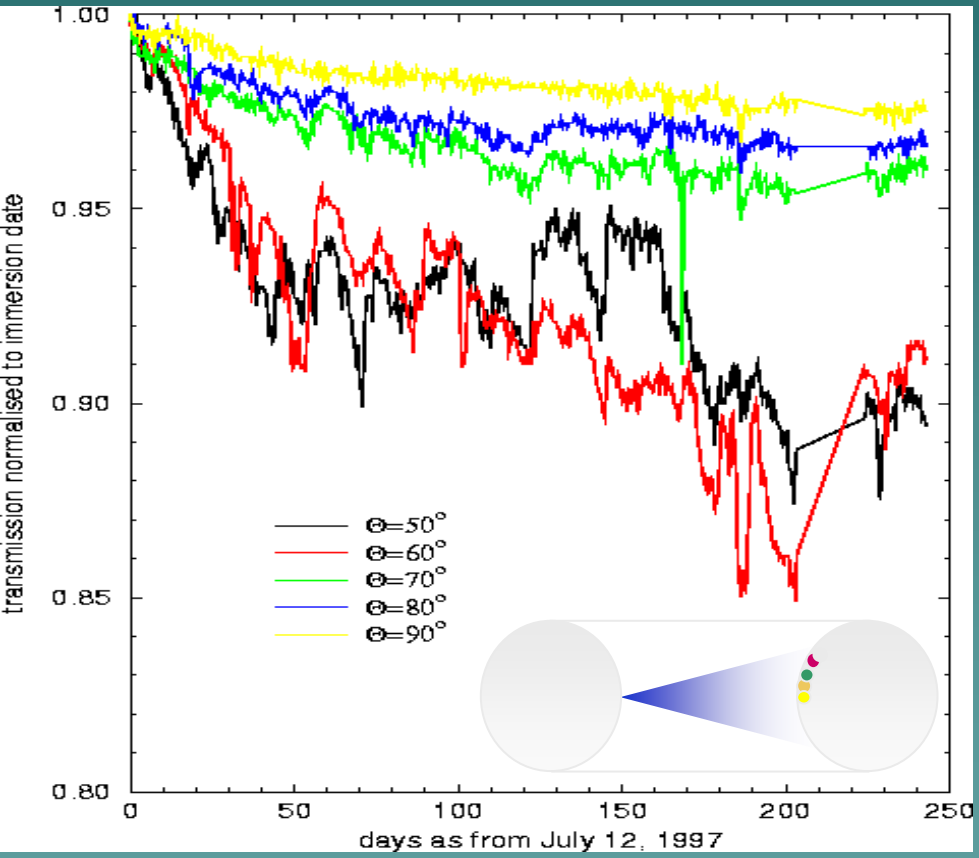
2) Biofouling-sedimentation study: 4 deployments

3) Optical properties study: 28 deployments

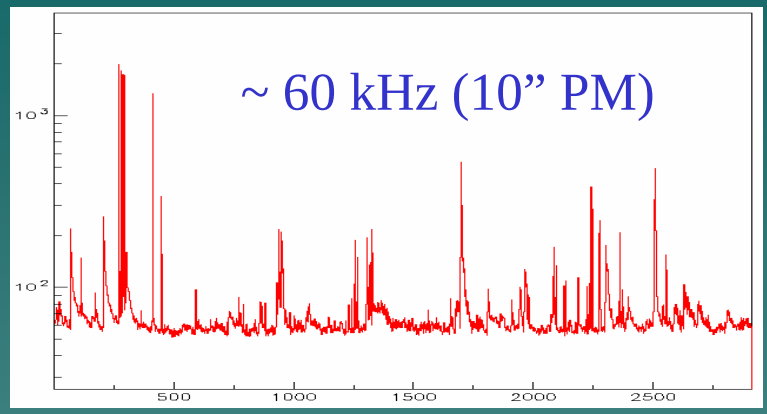




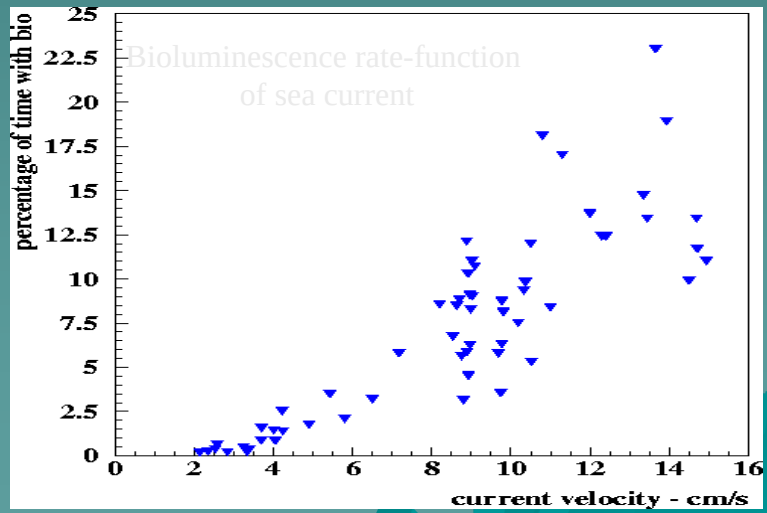

Biofouling et Bruit de Fond Optique



For θ > 90º transmission loss < 1.5% in 1 yr (and saturates)



Short bursts (bioluminescence) over a continuous background (^{40}K).

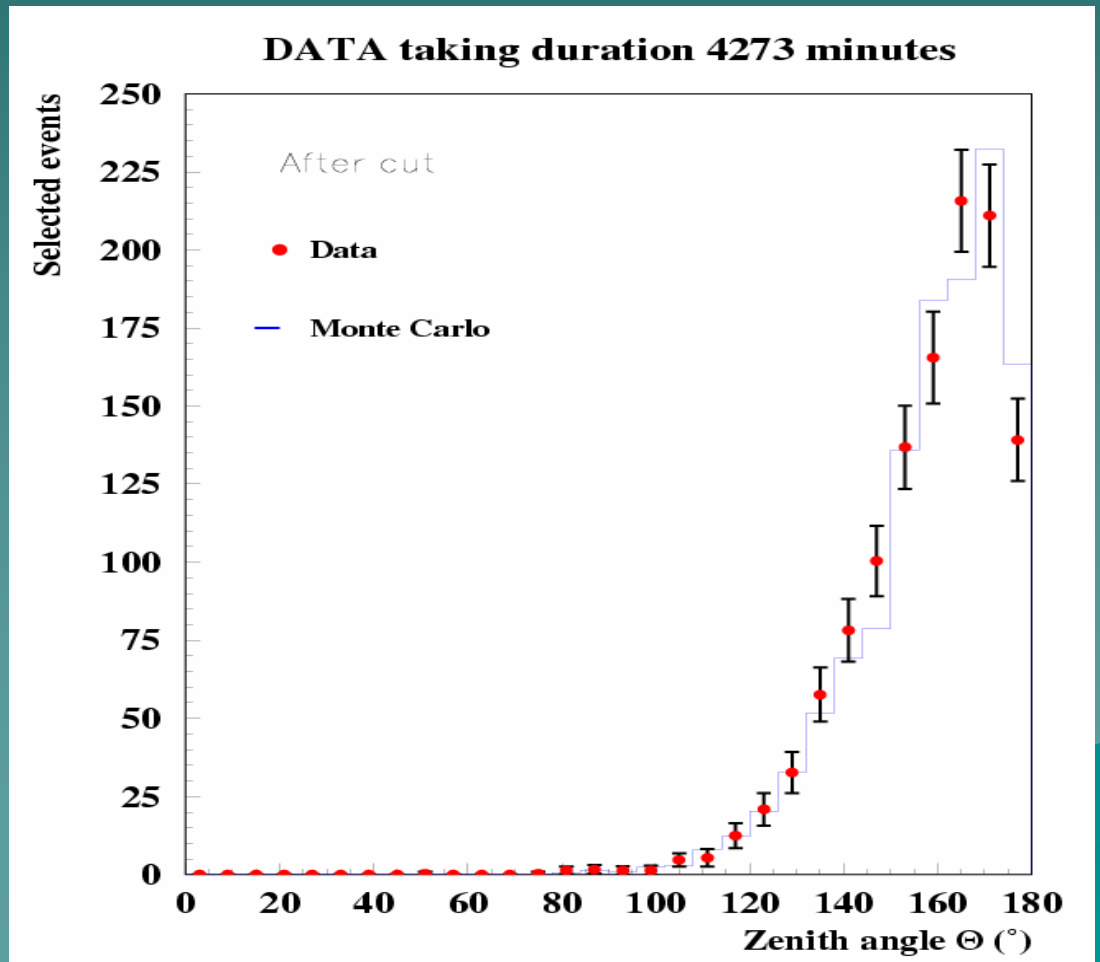


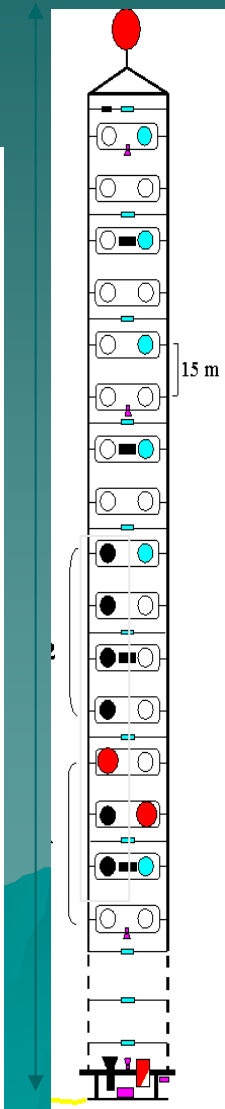
~5% of time a PMT is unusable

« Ligne Démonstrateur » 1999/2000

- Data sent to shore
- First Test of acoustic positioning system: relative accuracy ~5 cm
- Atmospheric muon zenith distribution

350 m
7 PMTs

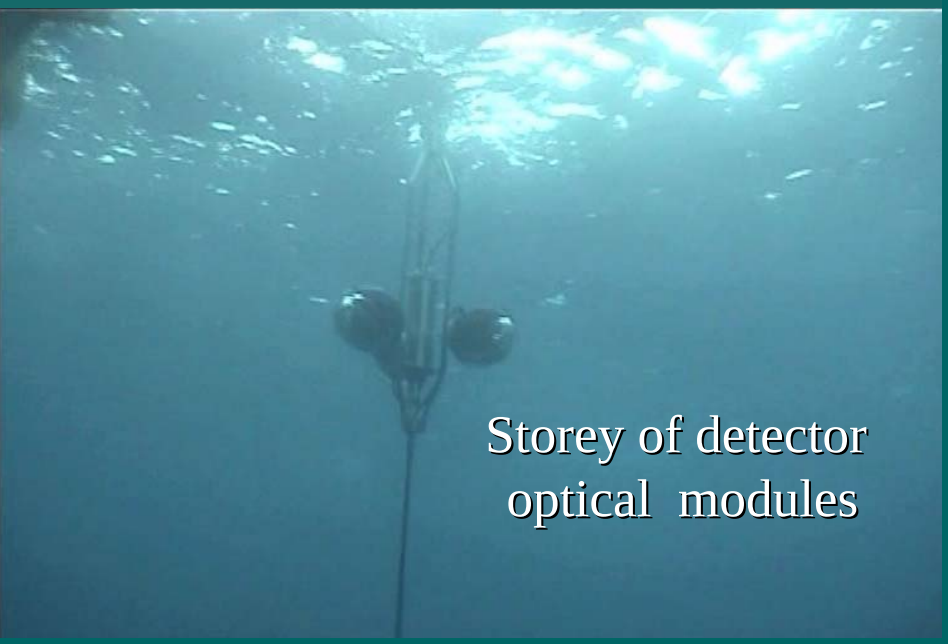




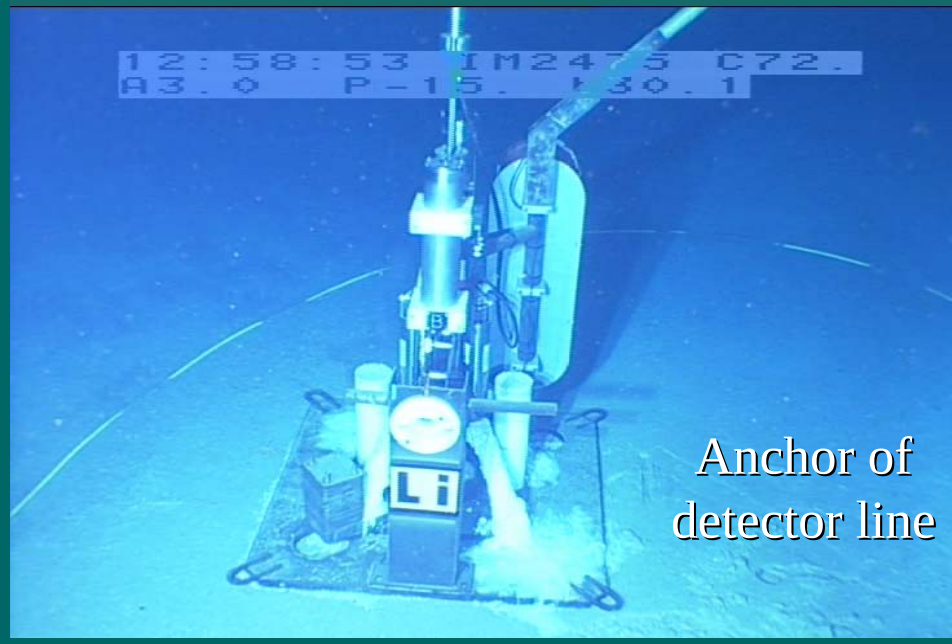
Boite de Jonction et Câble 2001/2002

In stable operation for 3 yrs

Images sous-marin des éléments détecteur

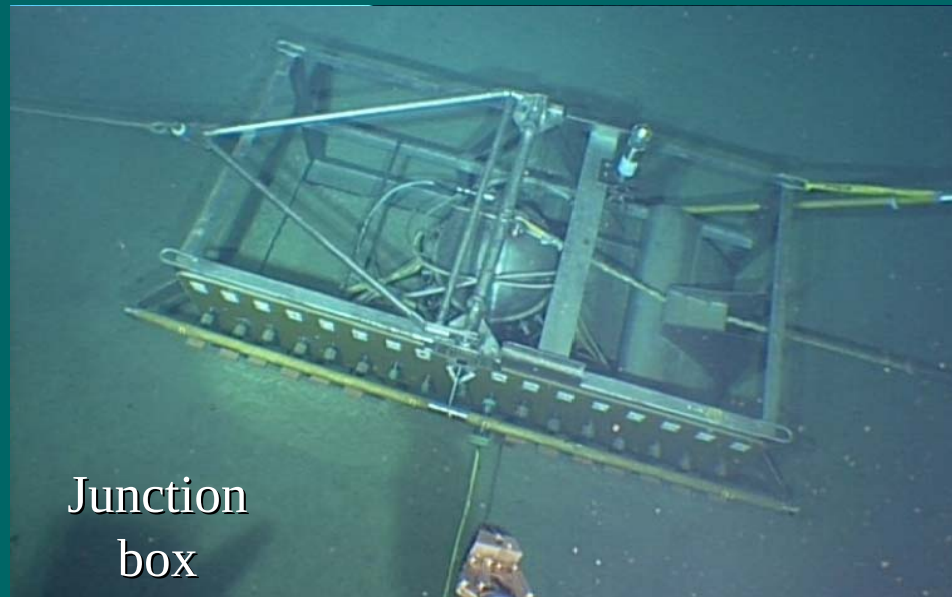


Storey of detector optical modules



Anchor of detector line

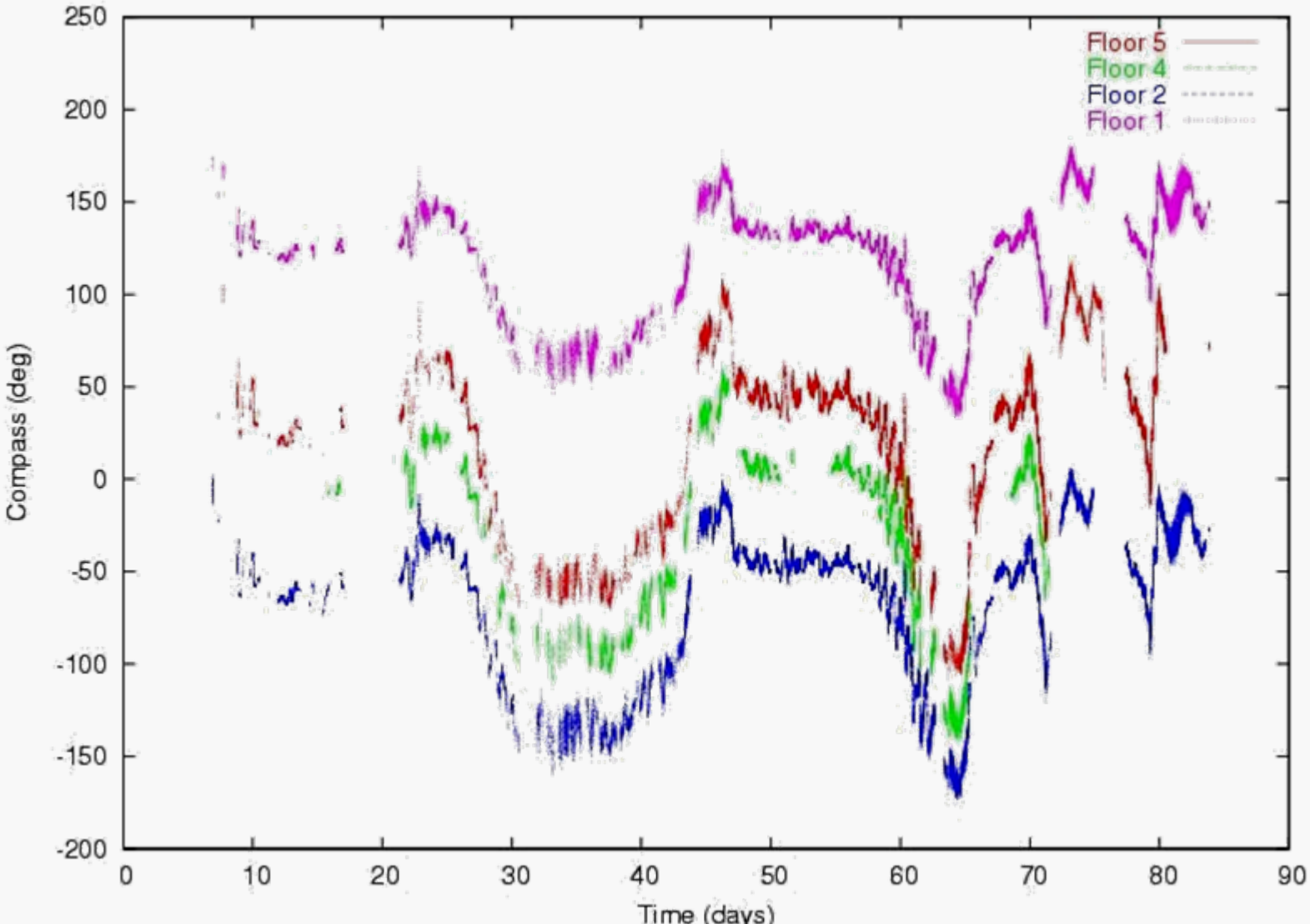
Submarine cable



Junction box

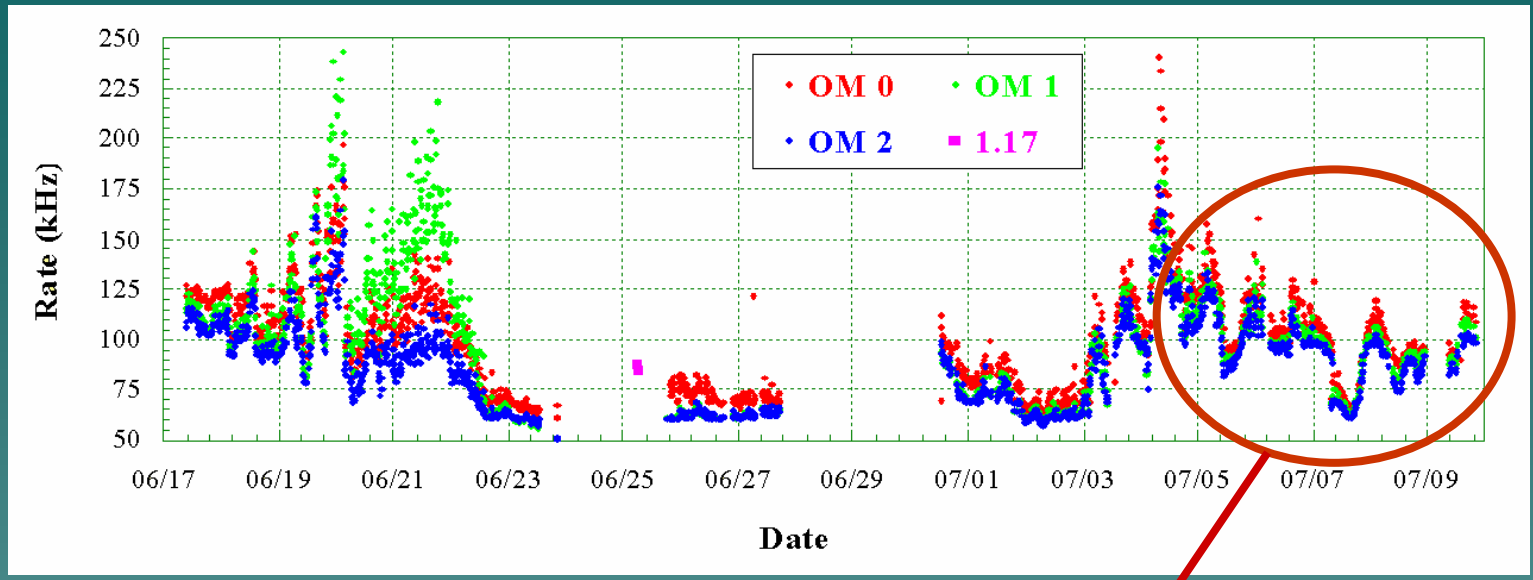
Données du « Prototype Sector Line » 2003

Heading of storeys recorded by electronic compass over 90 days

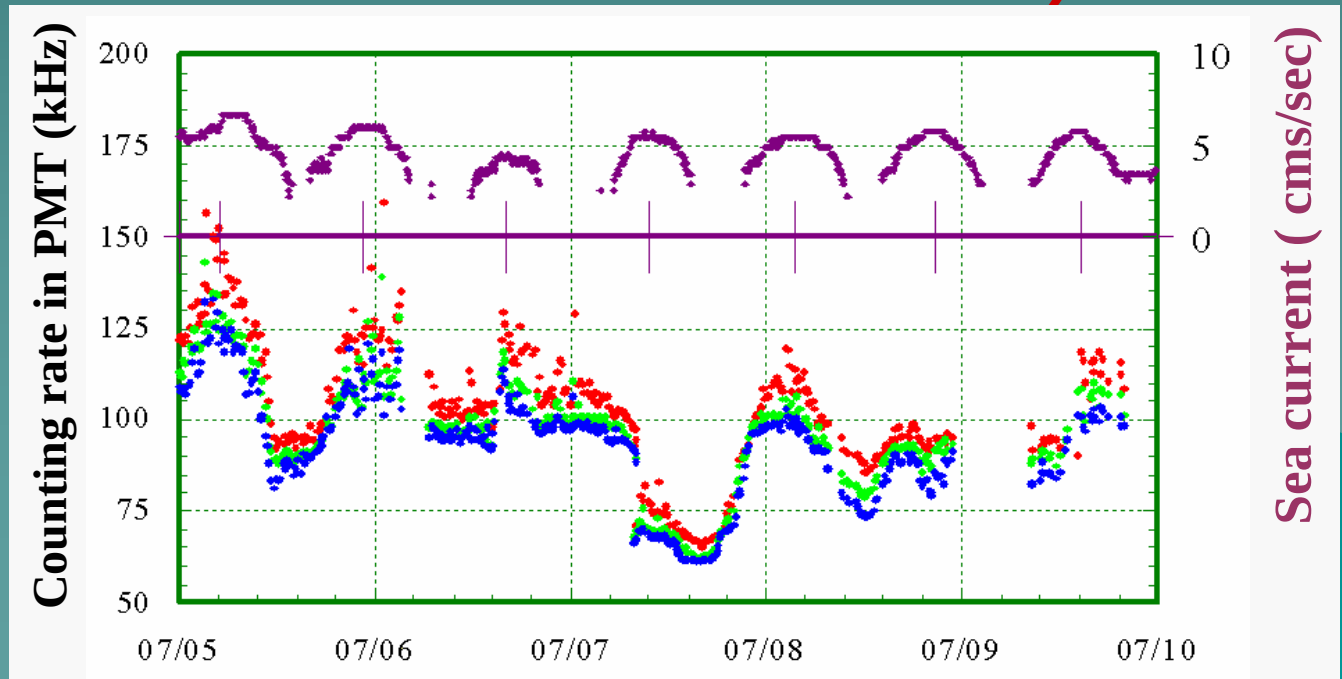


Données du « Prototype Sector Line » 2003

Counting rate of light detectors

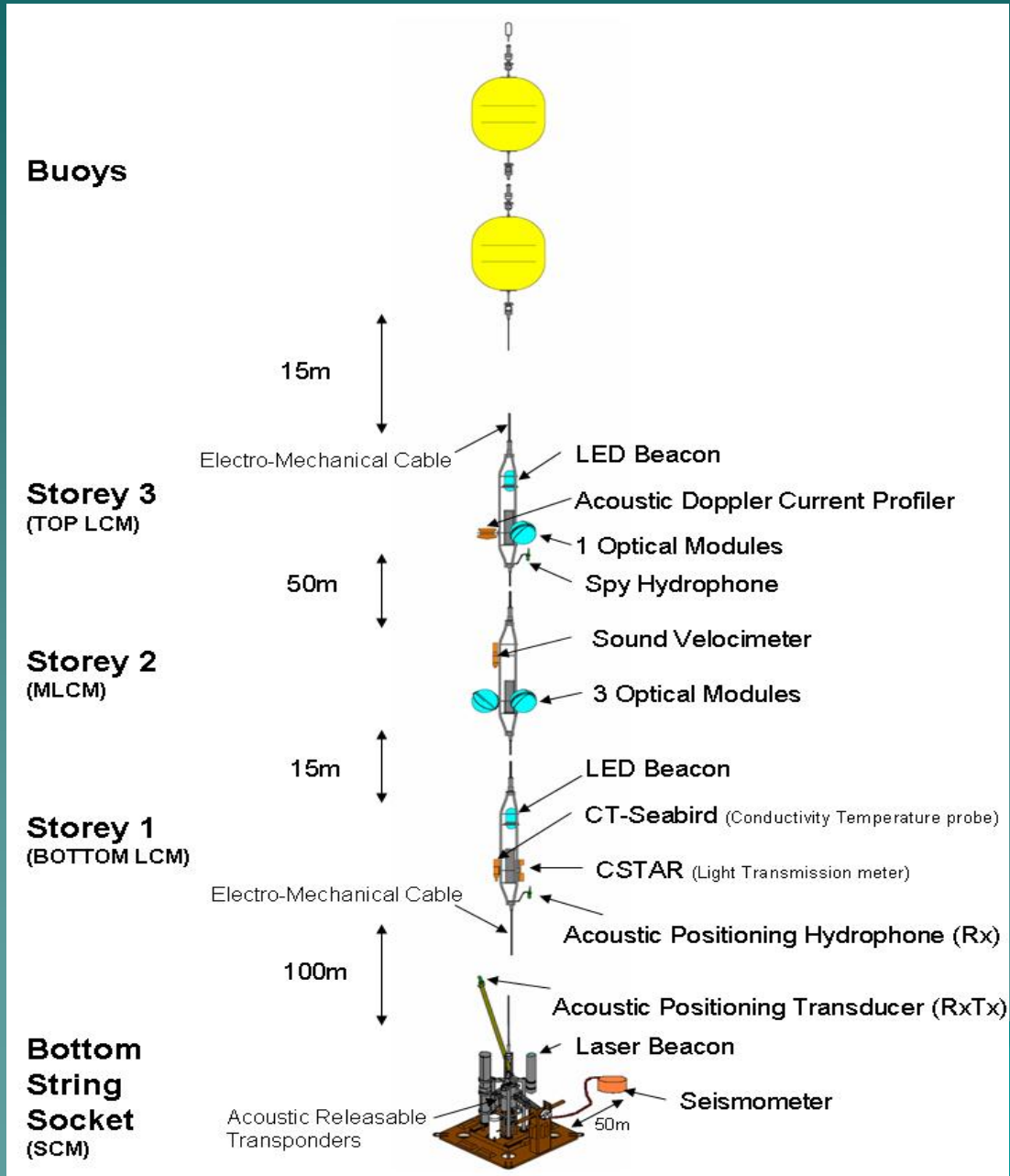


Correlation of bioluminescence with sea current



MILOM : mars 2005

Mini Instrumentation Line + Optical Modules



Line0 : mars 2005

Complete mechanical line

without

Optical Modules and Electronics

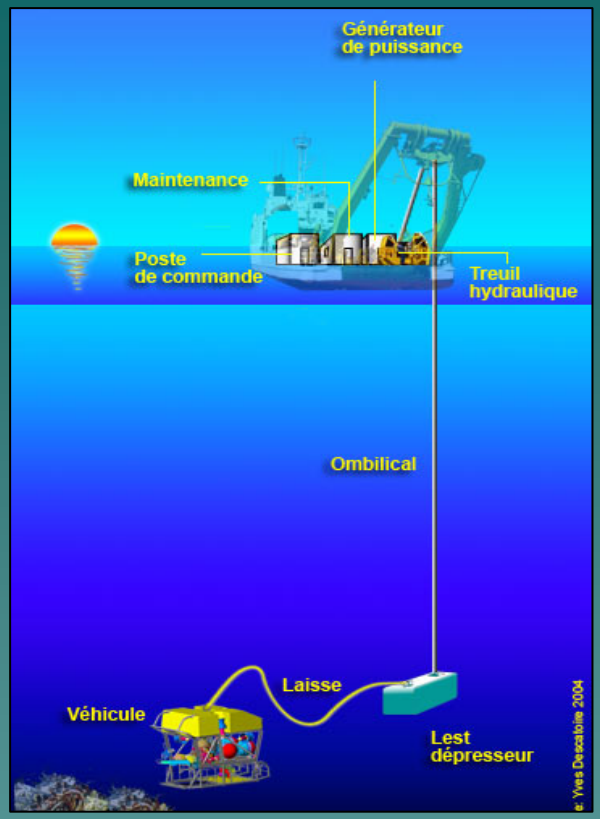
Mechanical test :

electro-optical transmission and water-tightness

Déploiement Line0 : 16 Mars 2005

MILOM Déploiement : 18 Mars 2005

Line0 / MILOM Connexion avec ROV Victor



12/13 April 2005

L9 L5

MILOM

L11 L7 L3 L1

MIL

PSL

Junction Box

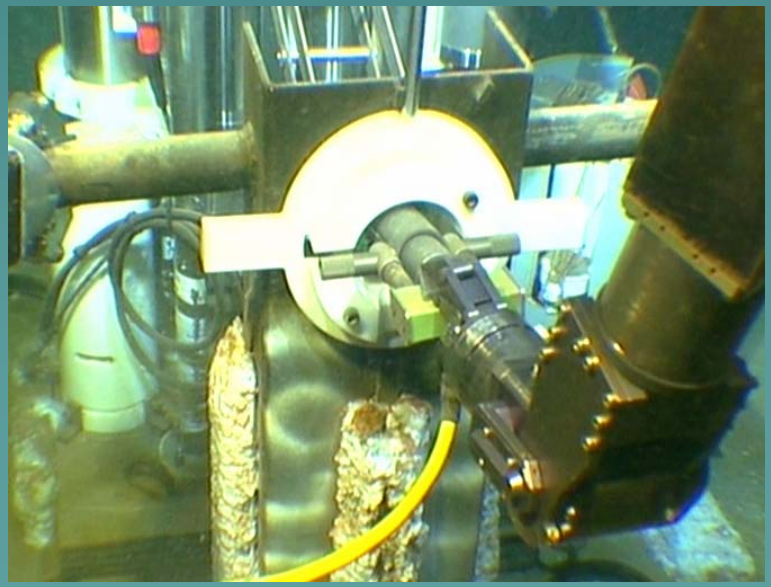
Interlink cables

L12 L8 L4 L2

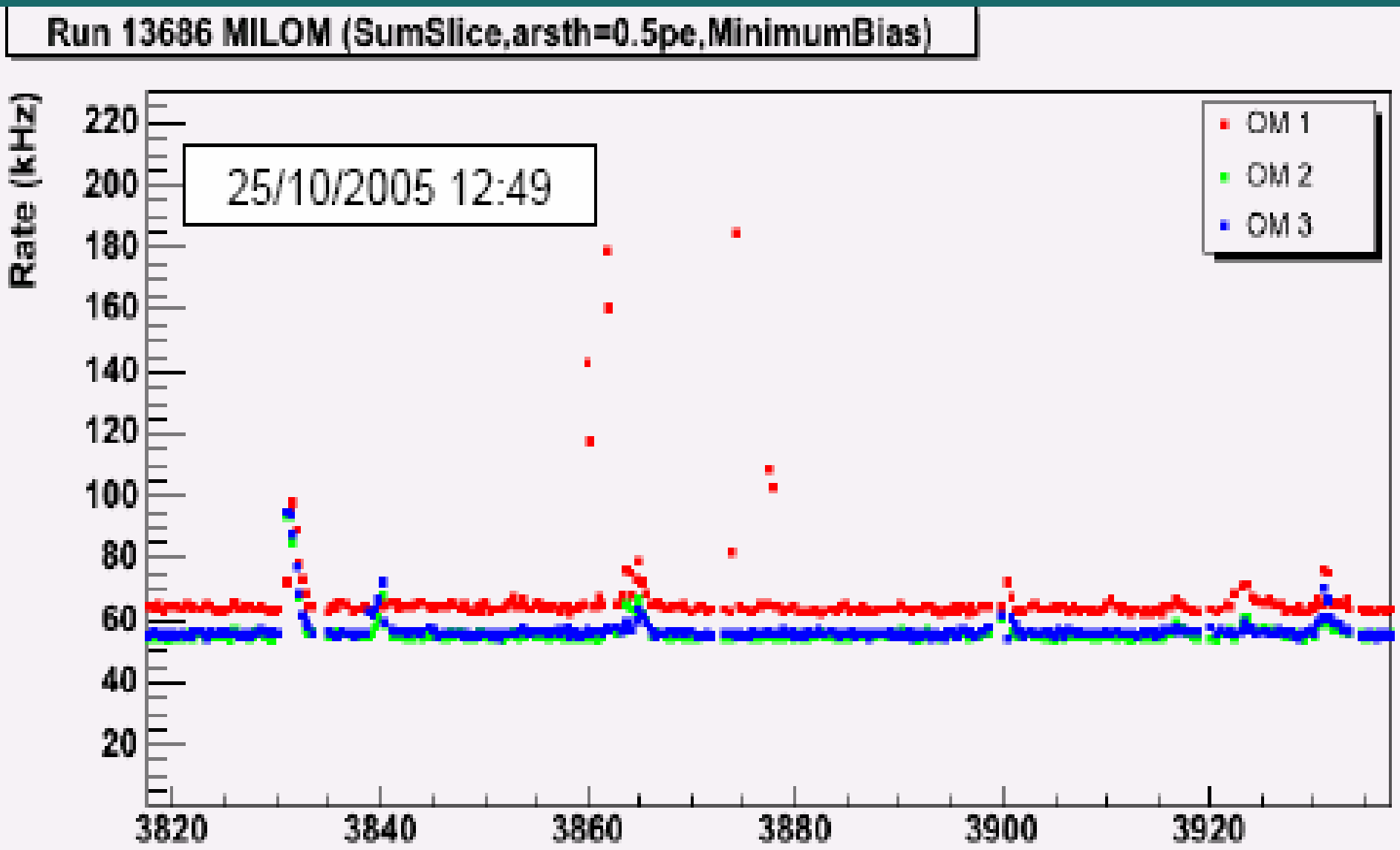
Line 0

L10 L6

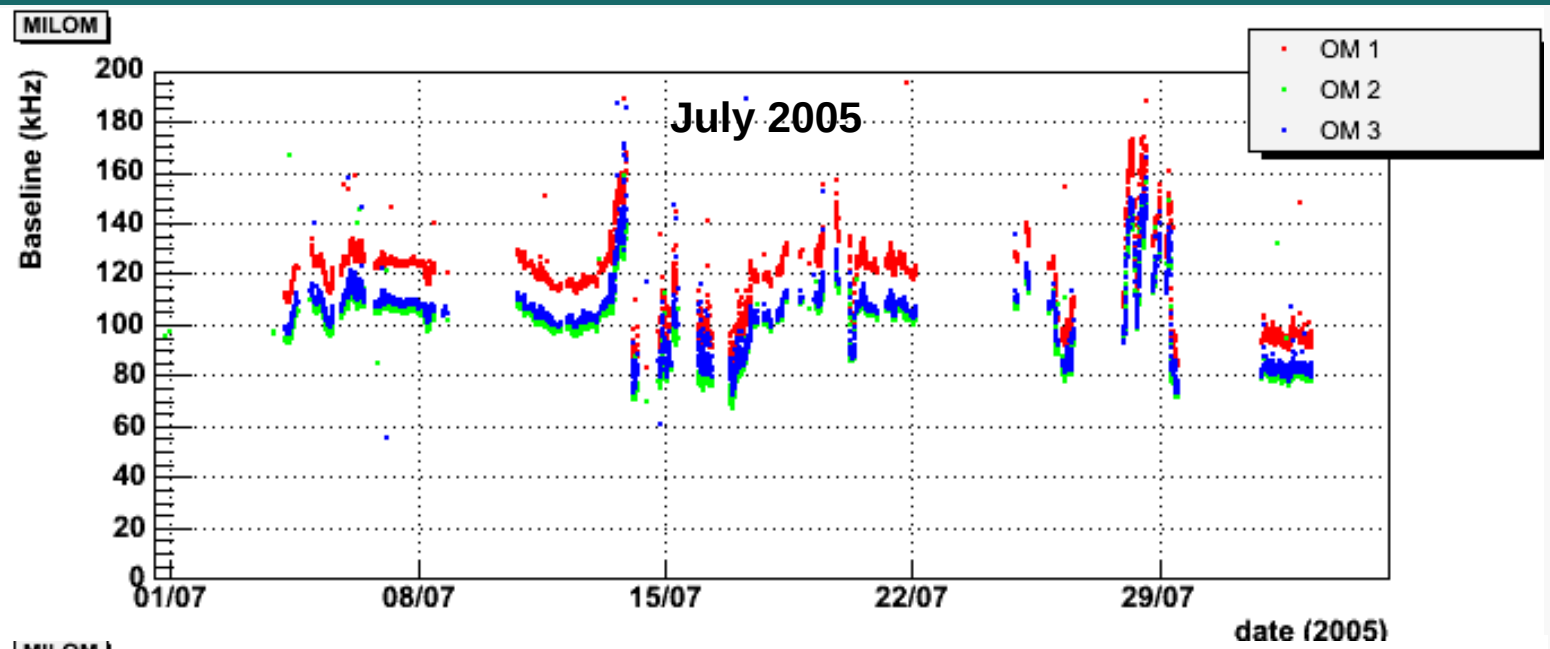
Connections avril 2005

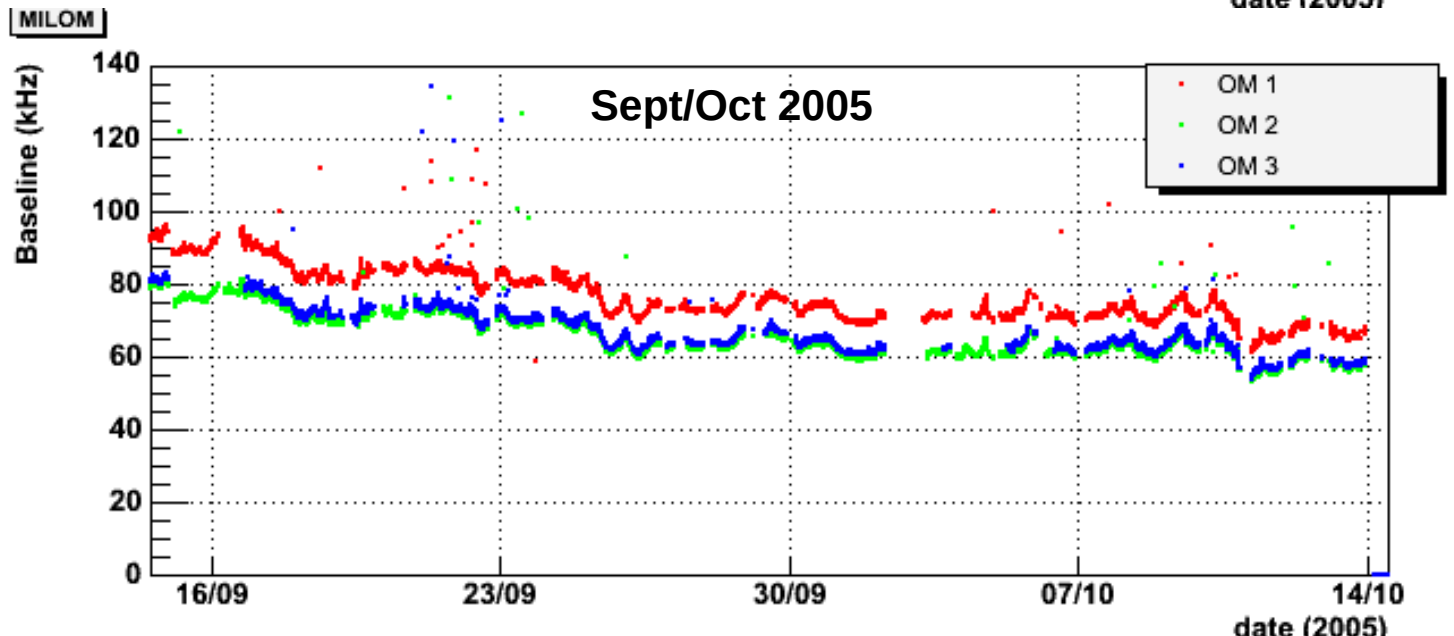


MILOM Taux de Comptage



MILOM :Taux de Comptage « baseline »

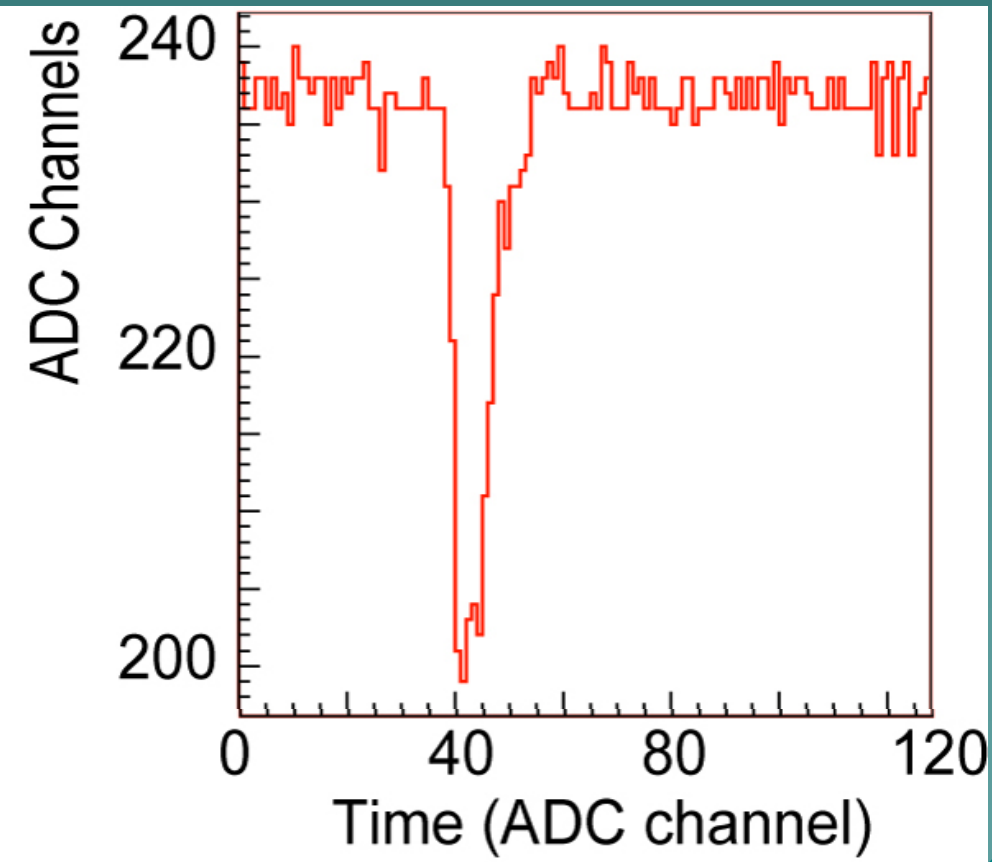




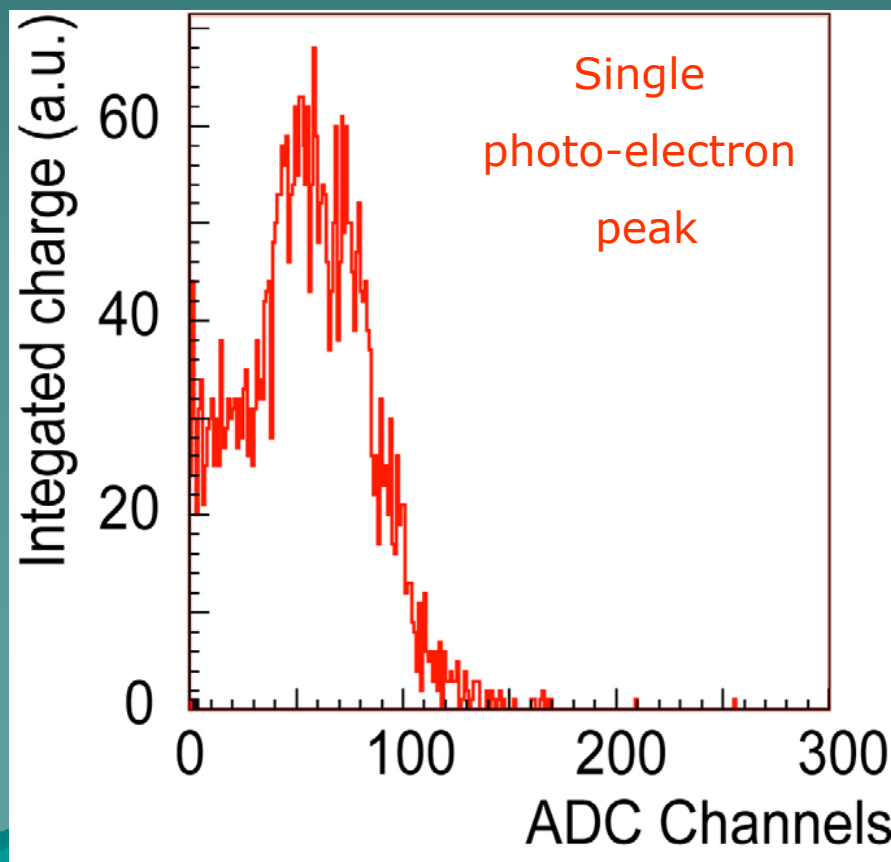
MILOM : Performance des électroniques

Front-end electronics chip « ARS » reads out in two modes:
Waveform – 128 samples at 640 MHz
SPE (single photo electron) – time over threshold plus integral charge

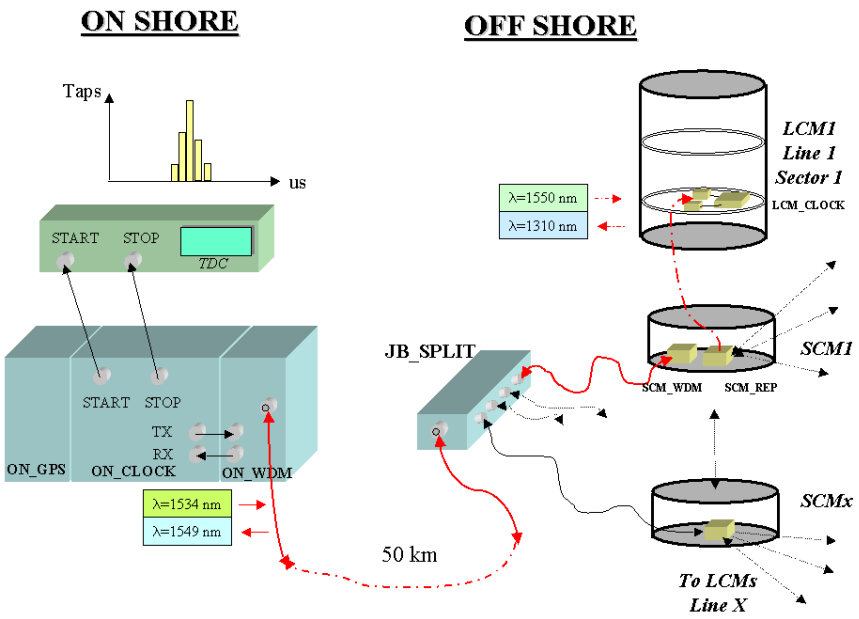
Typical raw data from ARS



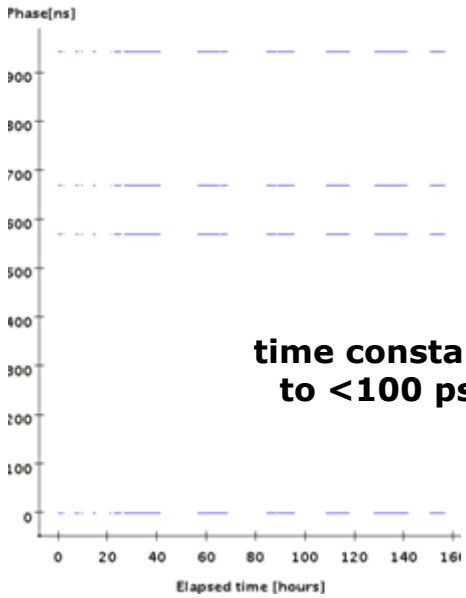
Charge spectrum



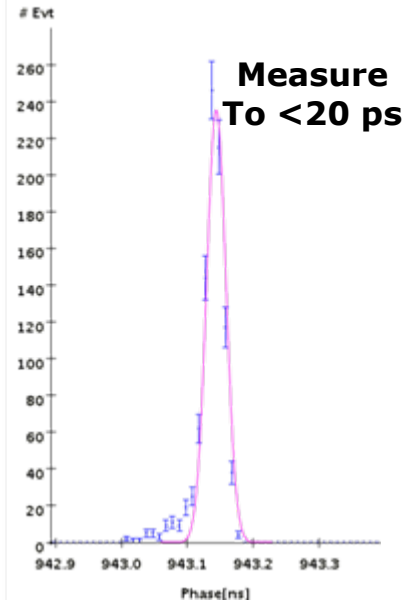
Système de Référence en temps : « Clock »



Delay within MILOM line

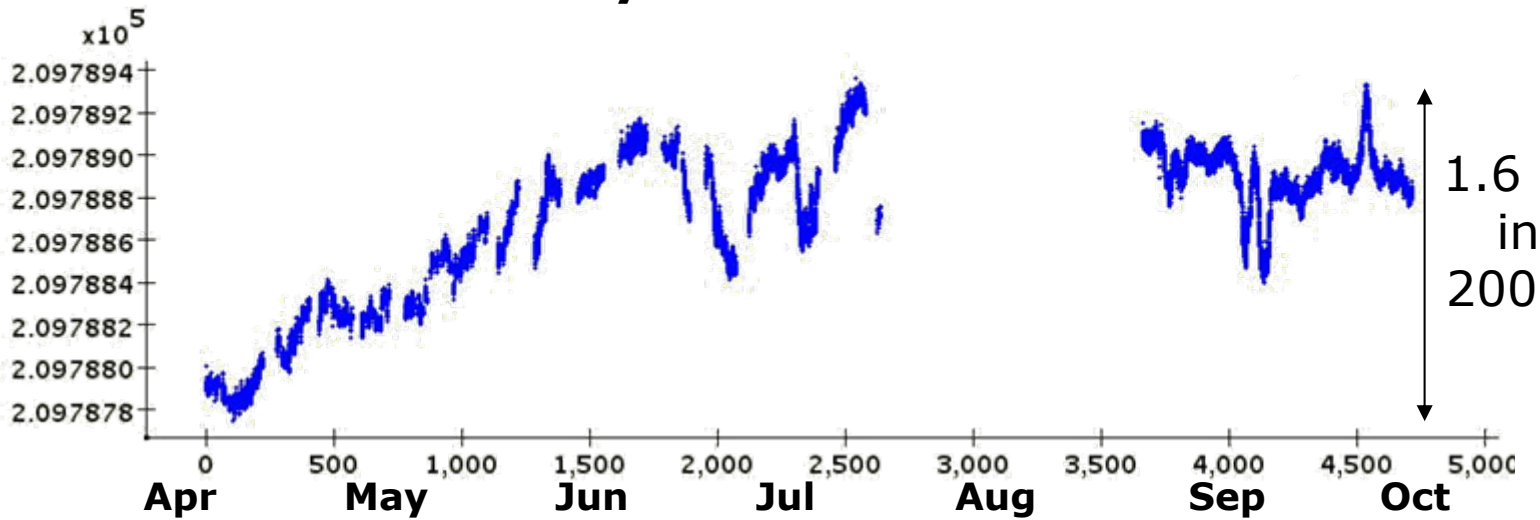


time constant
to <100 ps



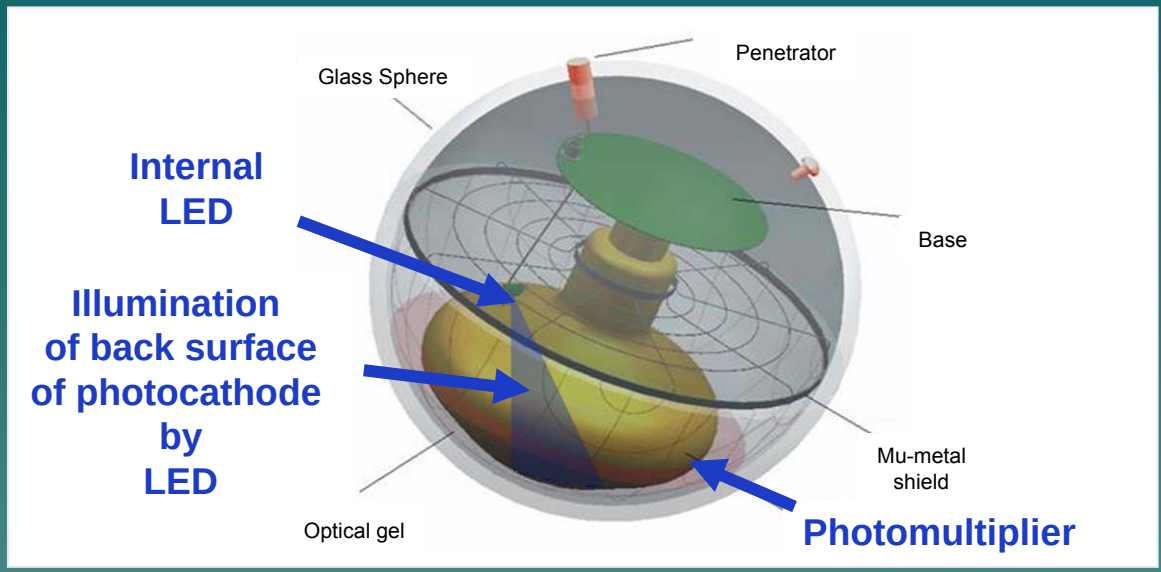
Measure
To <20 ps

Delay between shore and line



1.6 ns
in
200µs

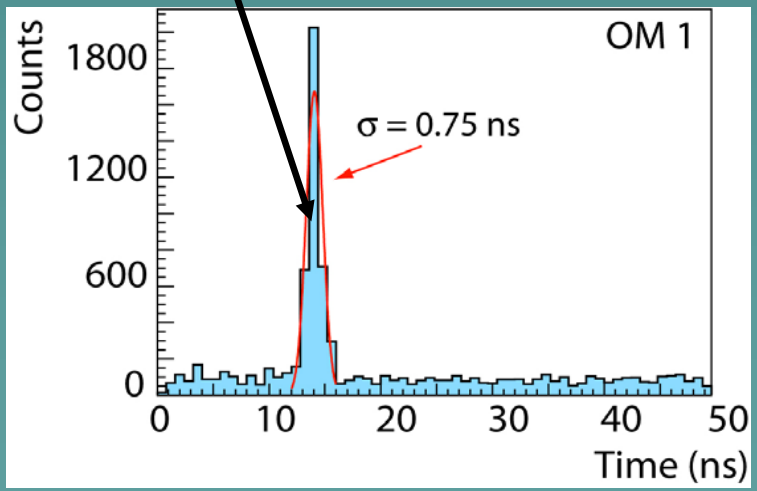
LED interne du Module Optique

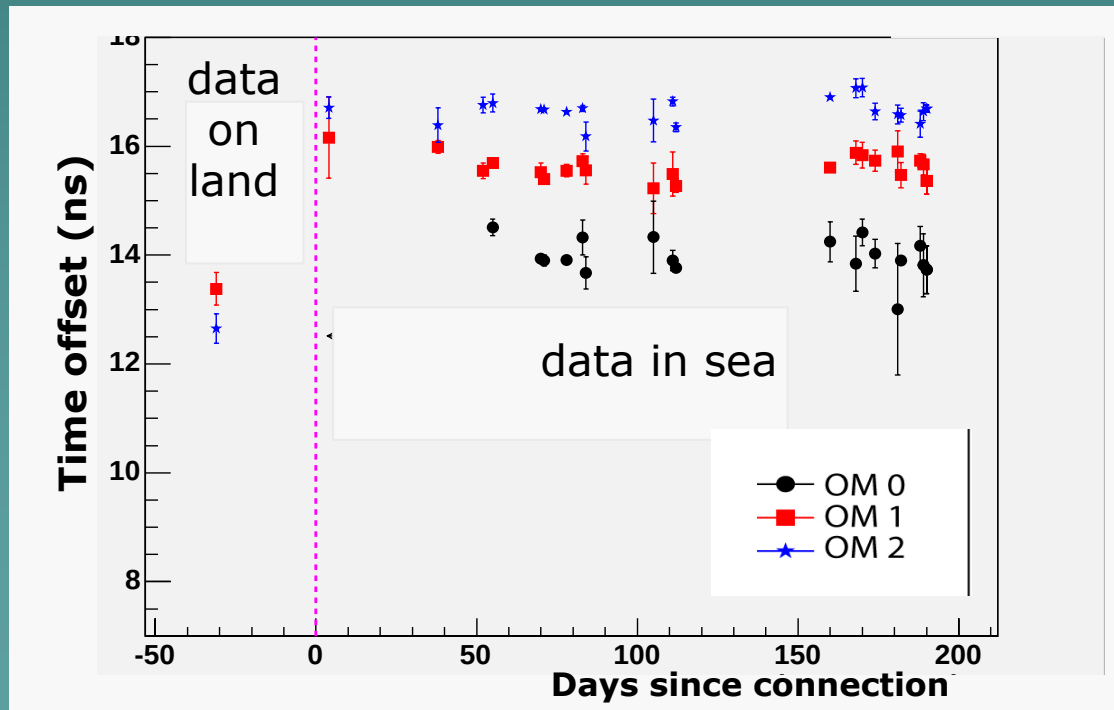


Optical module
timing
stable to
< 1ns
in sea
during
6 months operation

Arrival time of light

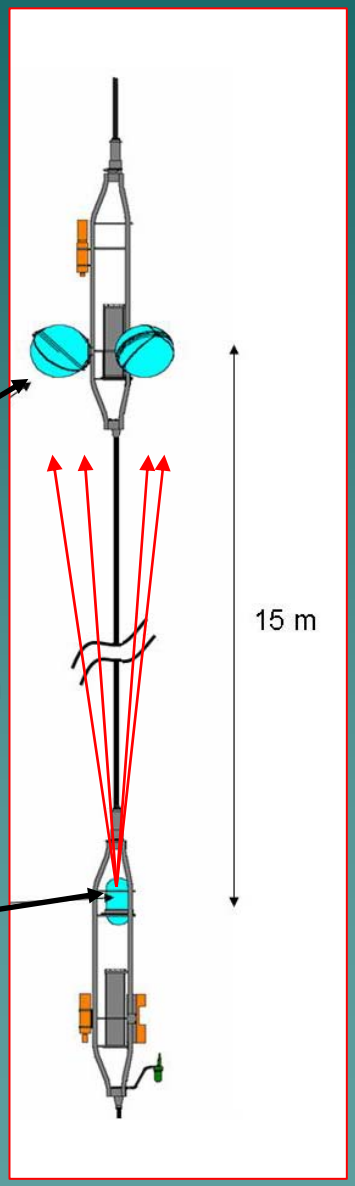
relative to LEDpulse





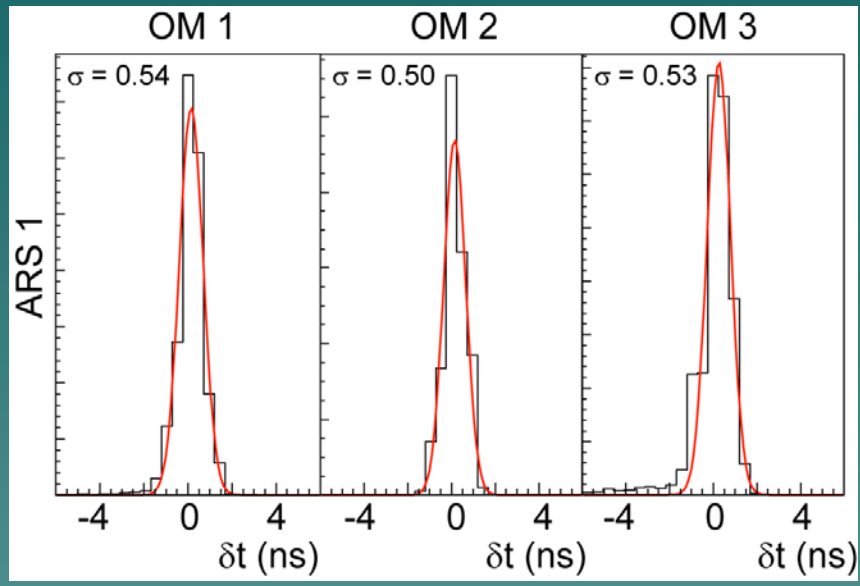
MILOM : Mesure de la résolution en temps

3 Optical Modules

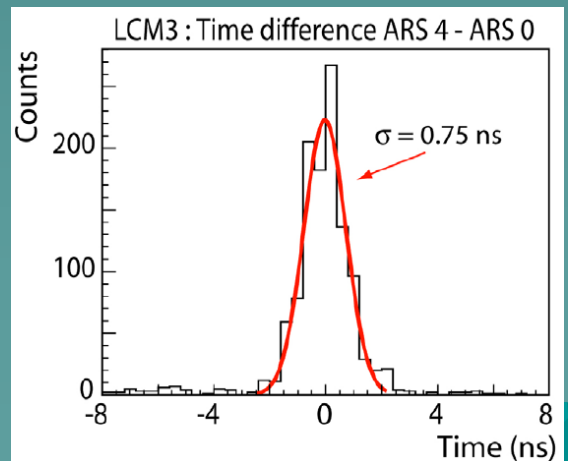


Optical Beacon
60 LEDs
+
reference PMT

Time in OMs relative to reference PMT in OB

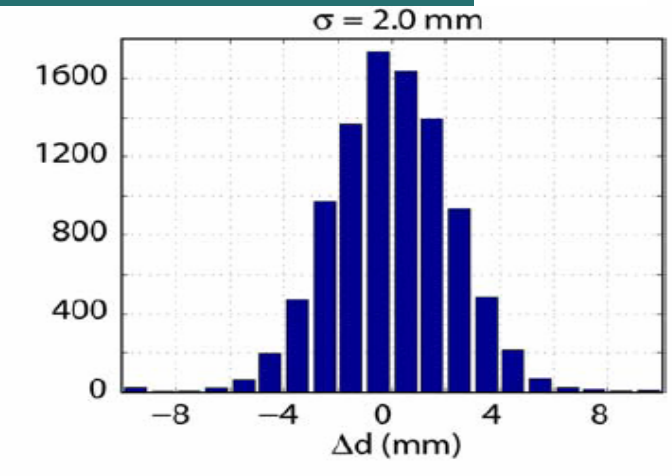


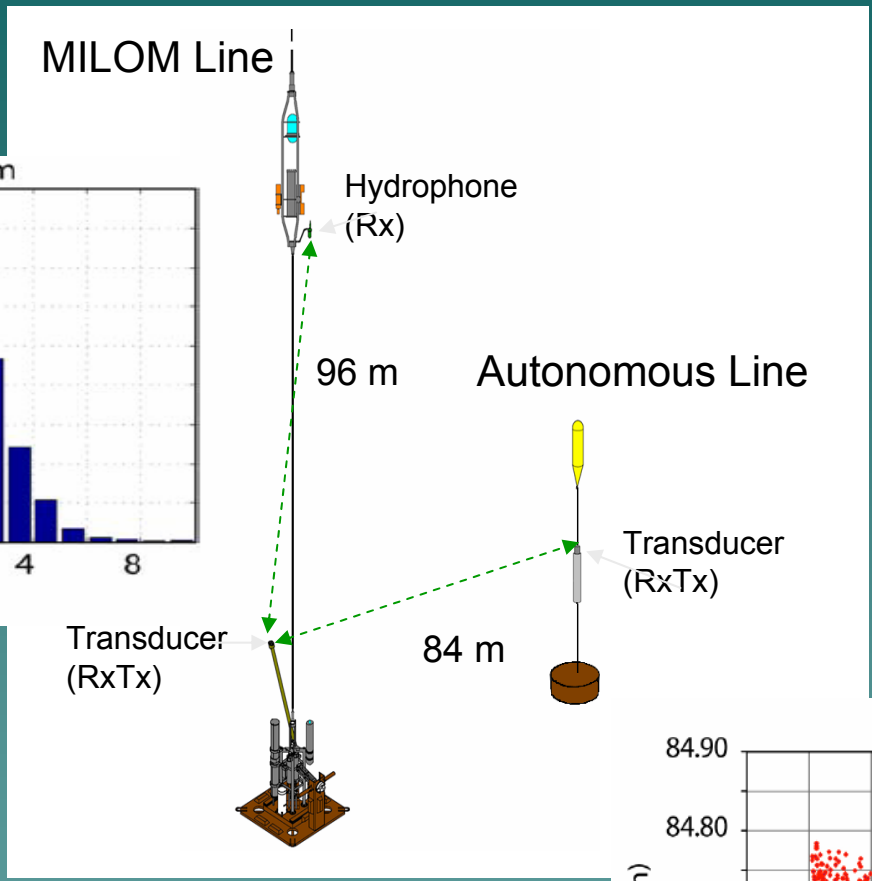
Time difference between signals from 2 OMs in a storey



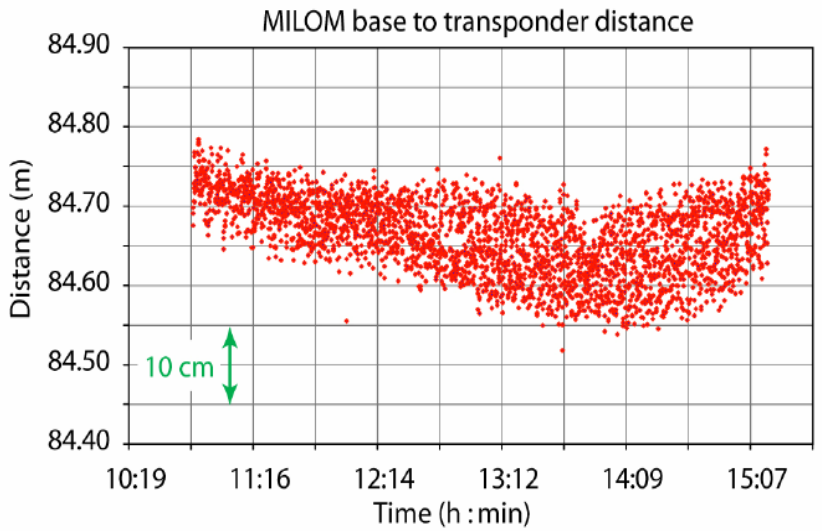
Timing resolution of electronics <0.5ns

Système de Positionnement Acoustique





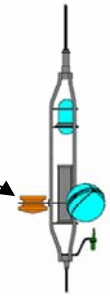
transponder/receiver
on MILOM
+
autonomous
transponder
line 84 m away

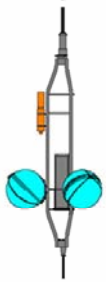


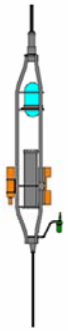
Verification of precision
<10 cms
(within specification)

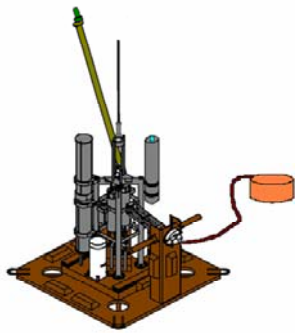
Données du courant marin

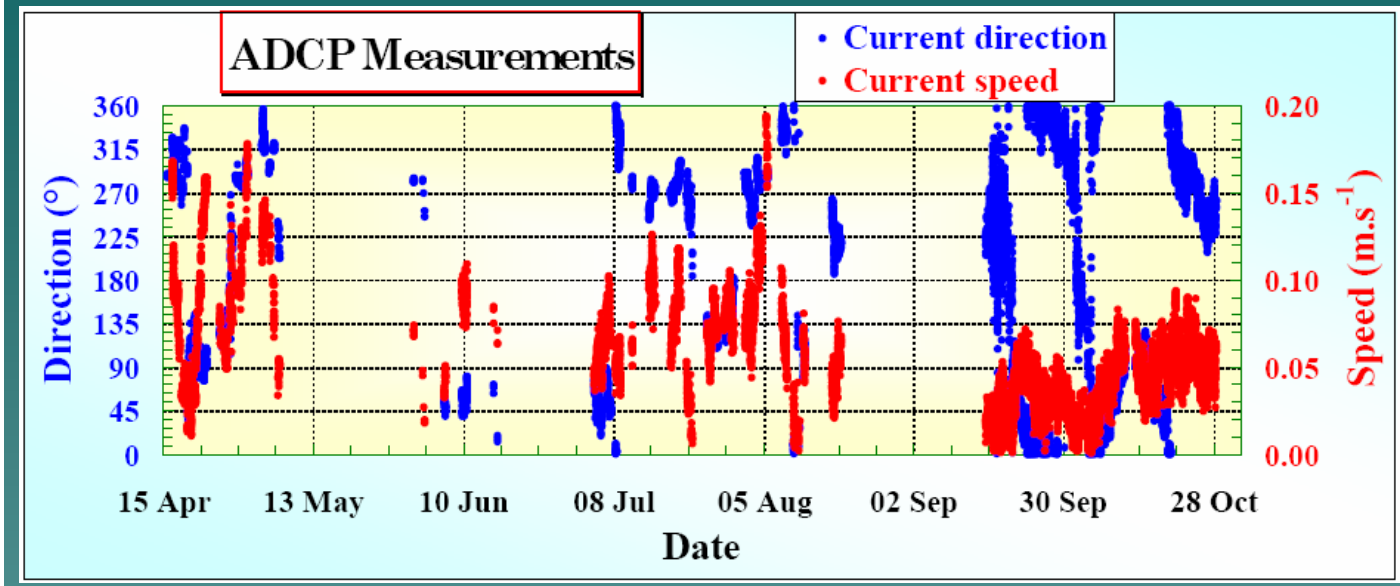
Acoustic Doppler Current Profiler (ADCP)

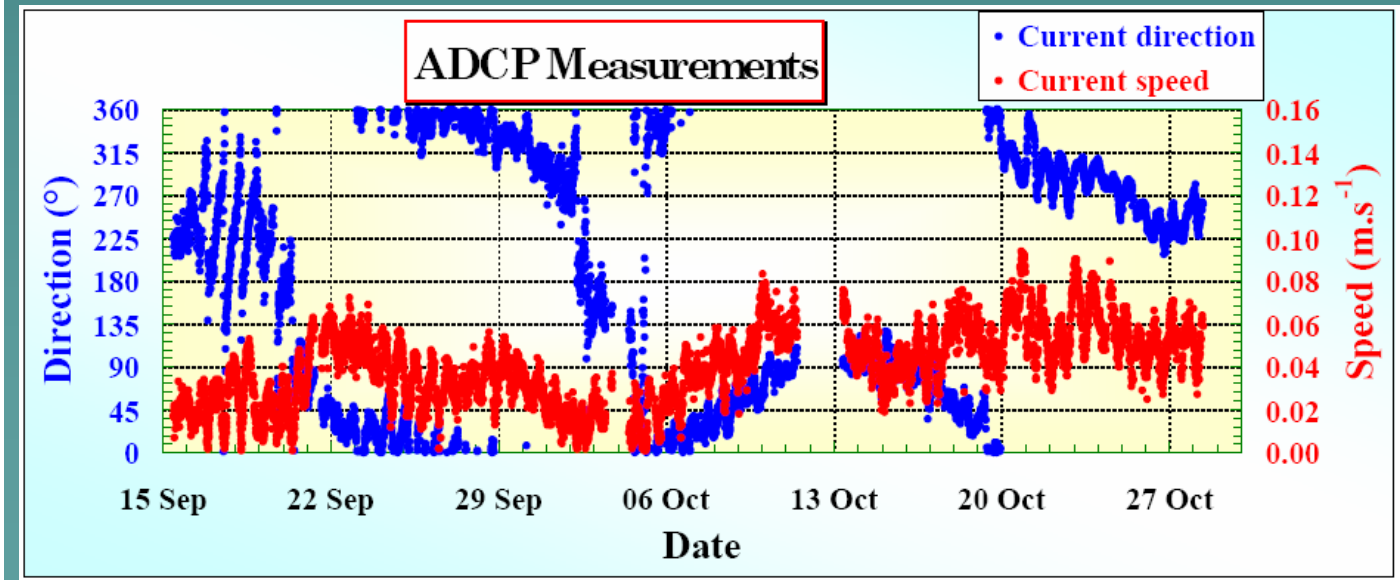




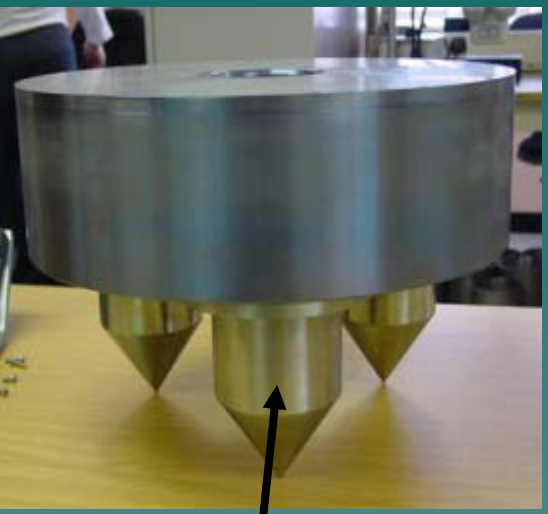








Séismographe

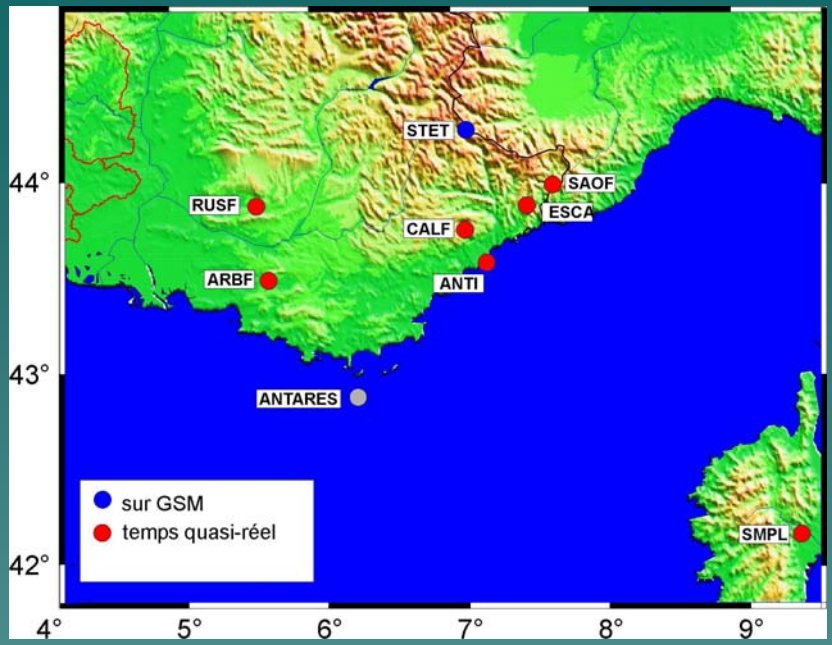


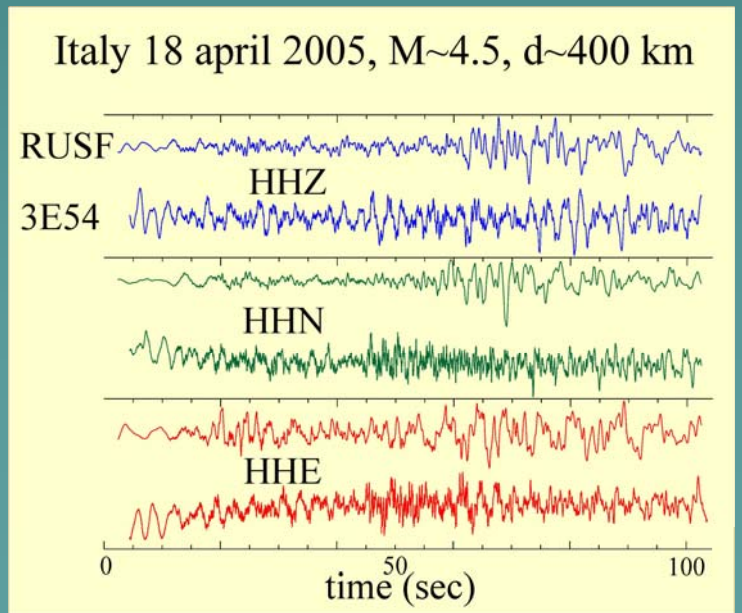
Seisometer made by GURALP

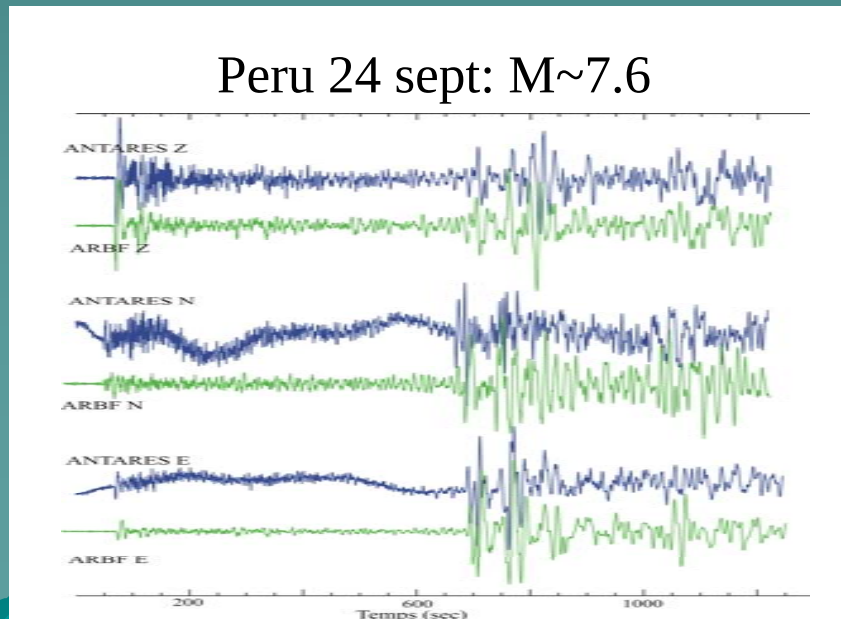
Installed by VICTOR

In place in sediment

Enregistrements du Tremblements de la Terre

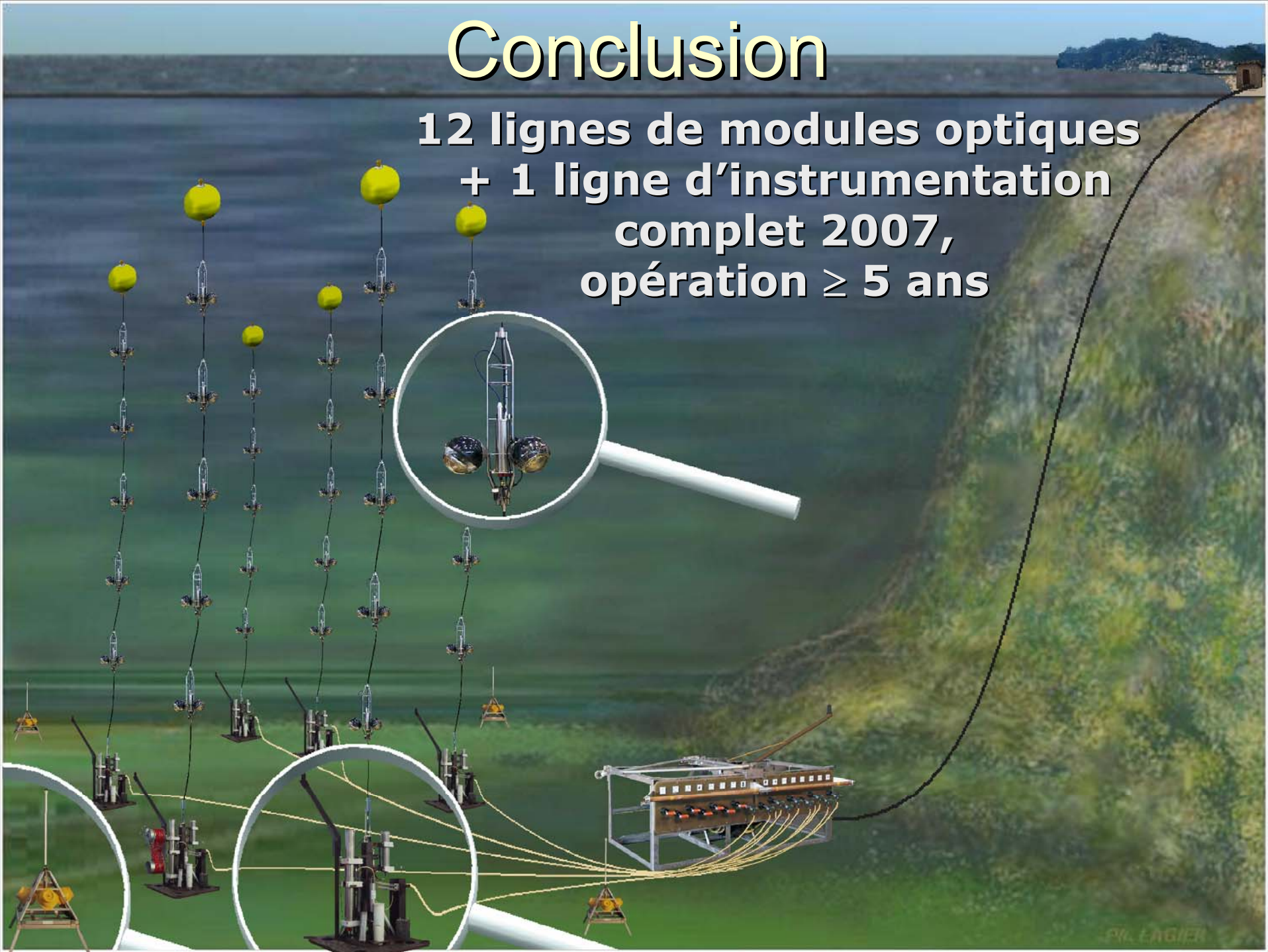






Conclusion

12 lignes de modules optiques
+ 1 ligne d'instrumentation
complet 2007,
opération ≥ 5 ans



Fin de Présentation