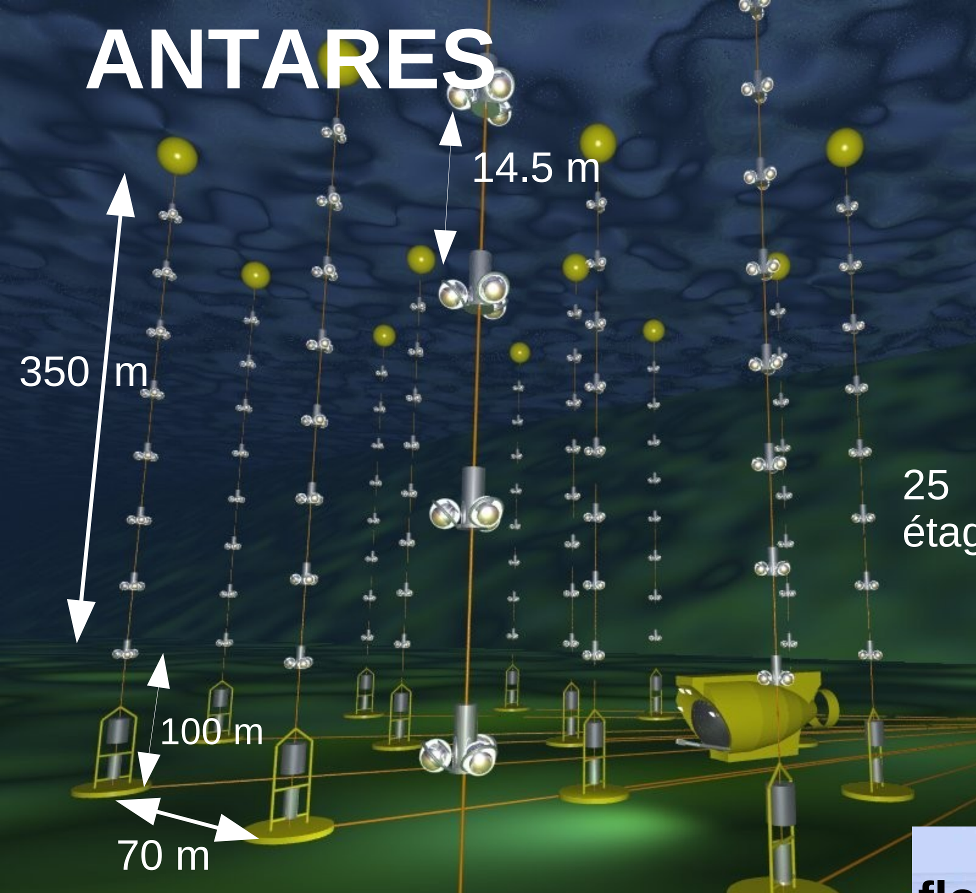
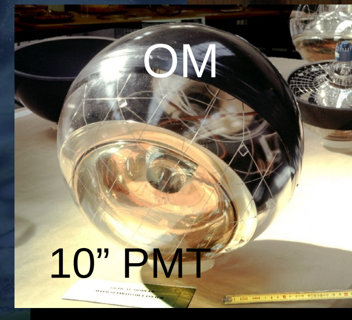
SURFACE ARRAY Détecteur de surface pour ANTARES

JP Ernenwein
CPPM

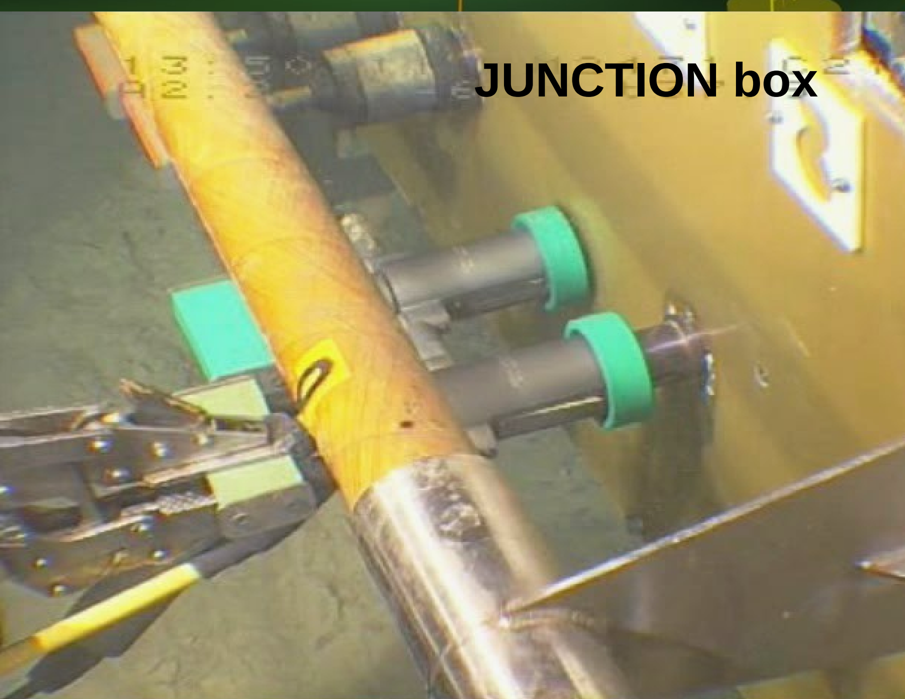
GDR ν
29/10/2009

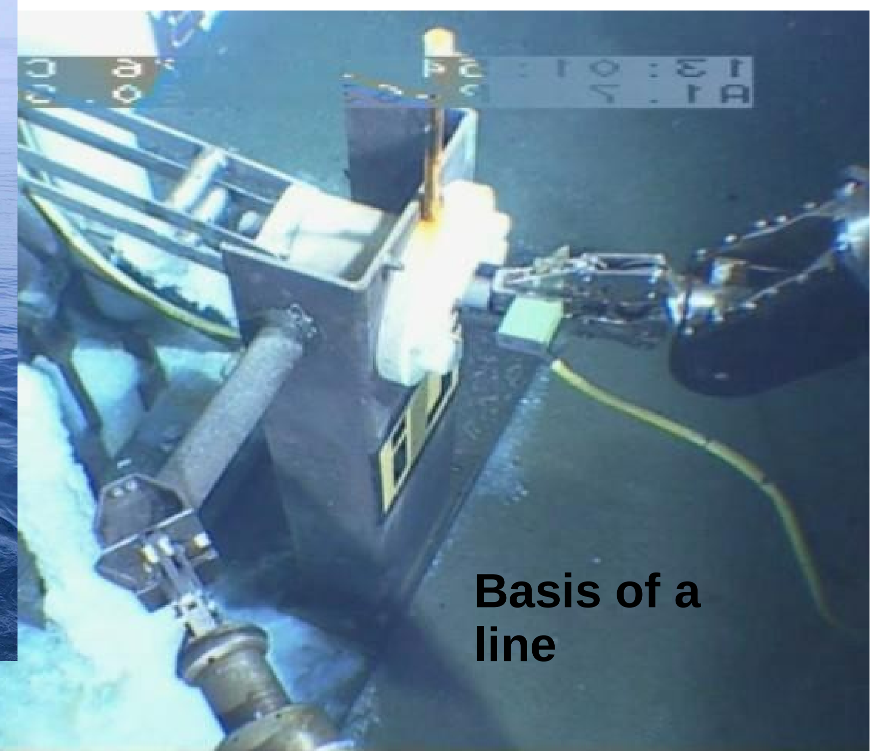


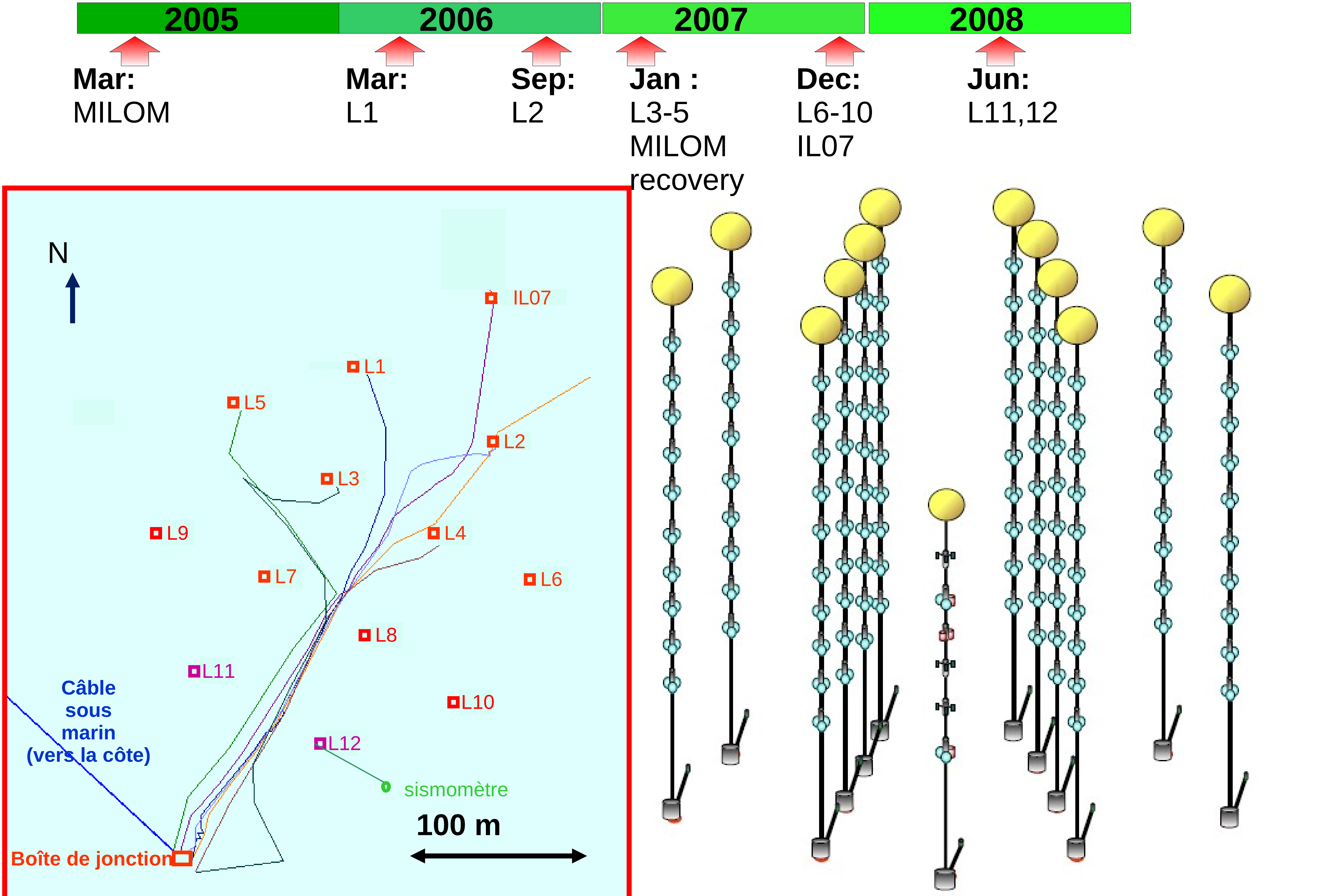


ANTARES, 2475m, 3 PMT/floor

12 lines of 25 floors 885 PMTs



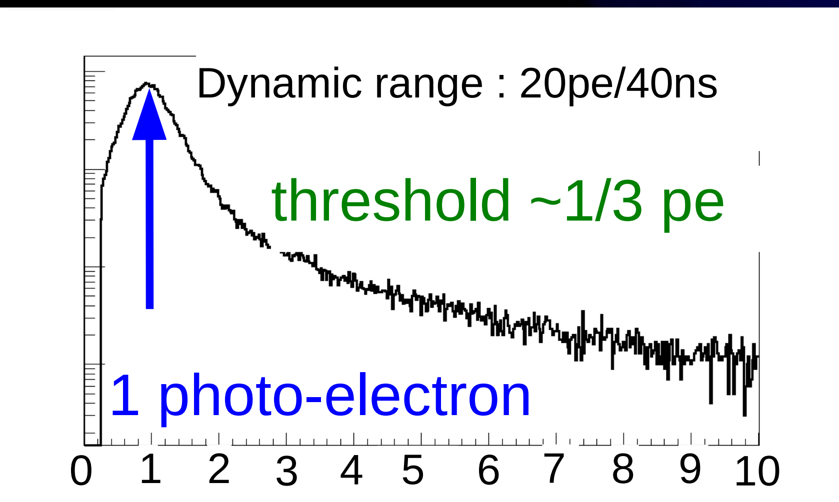


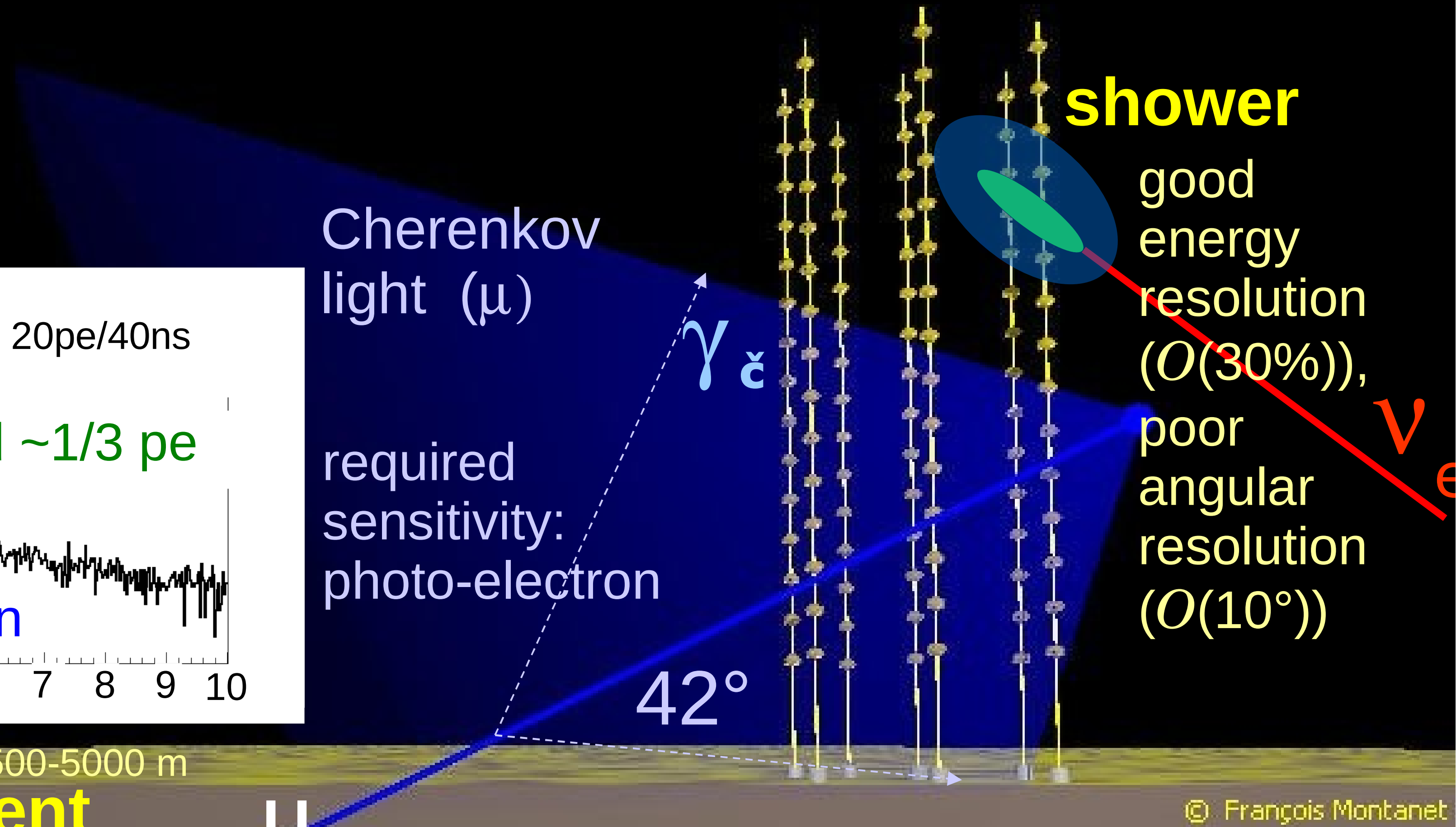


Connection of lines

Detection principle

3D matrix





required sensitivity: photo-electron

shower
good energy resolution (O(30%)), poor angular resolution (O(10°))

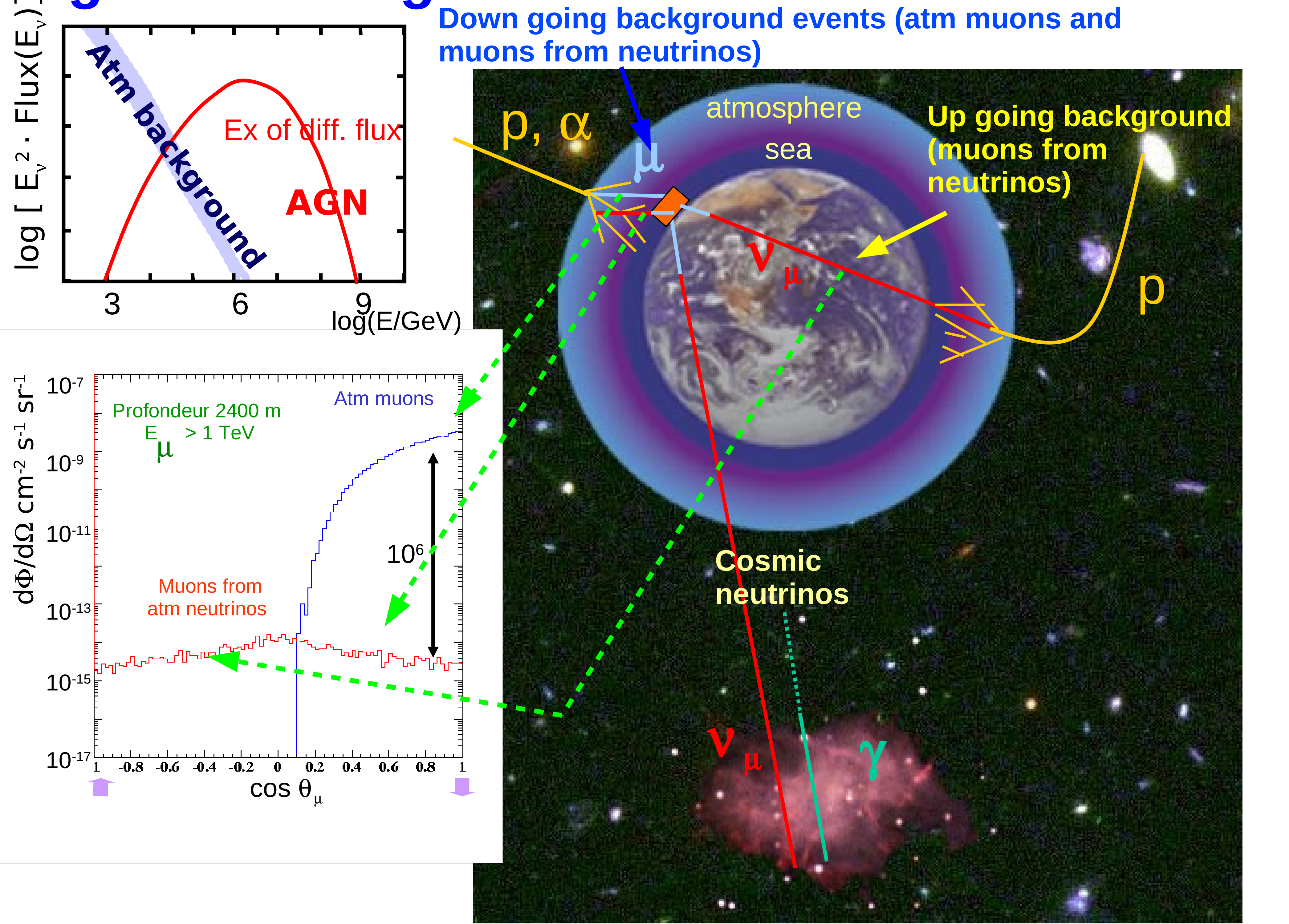
Charged current interaction (W)

track:
Good angular resolution (O(degree) @ E>10 TeV), Poor energy resolution (factor 2-3)

Measurements
time (O(ns)), amplitude (30%)
& hit position(O(10 cm))

Muon track or shower measurement

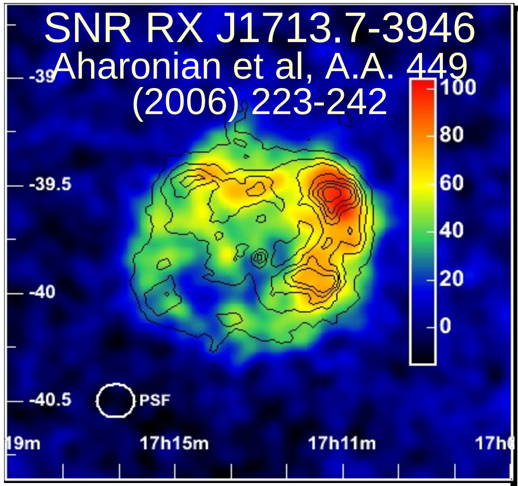
Signal & background

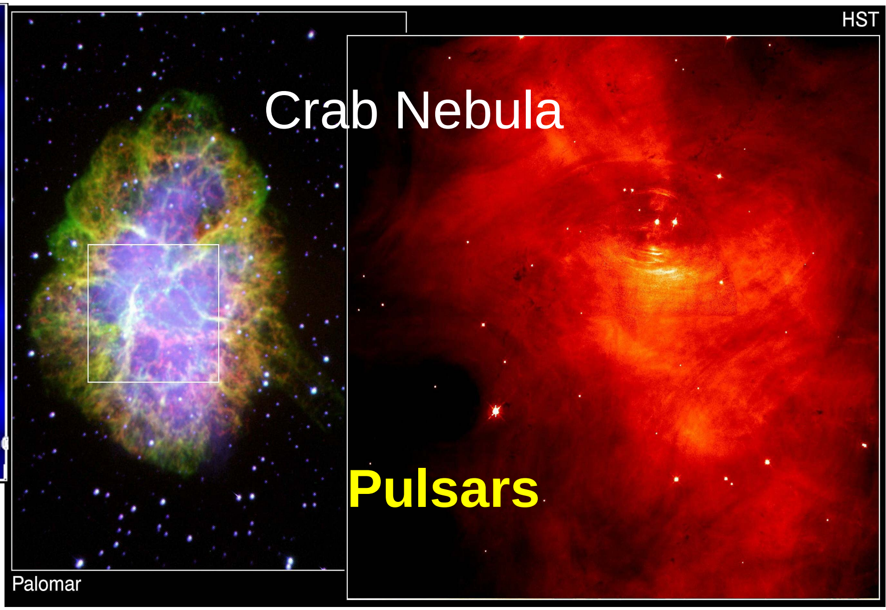


Expected neutrino sources

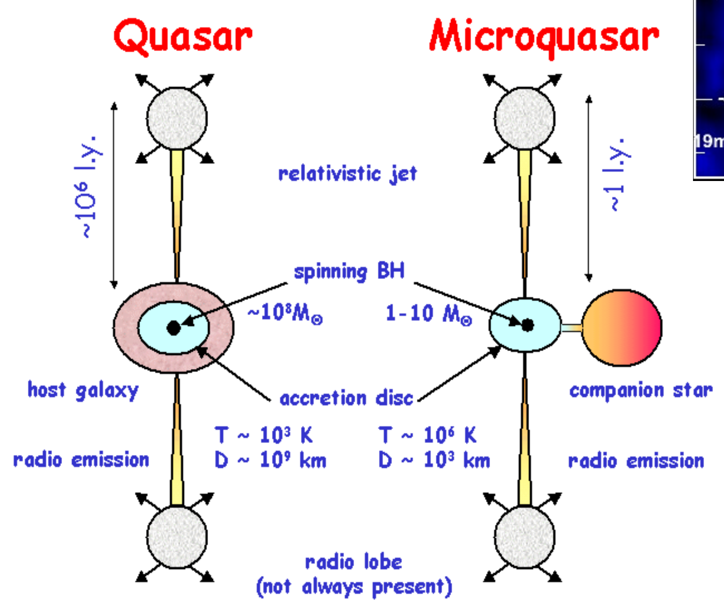
Galactic:

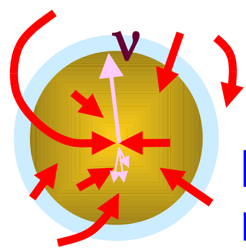
Supernovae,
Supernovae remnants,





Micro Quasars:

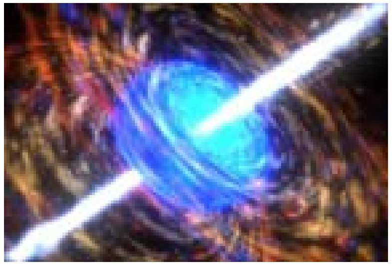


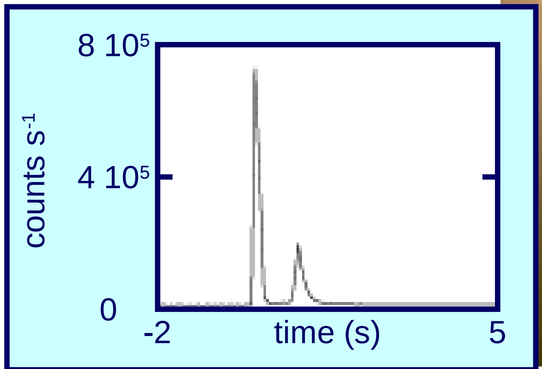


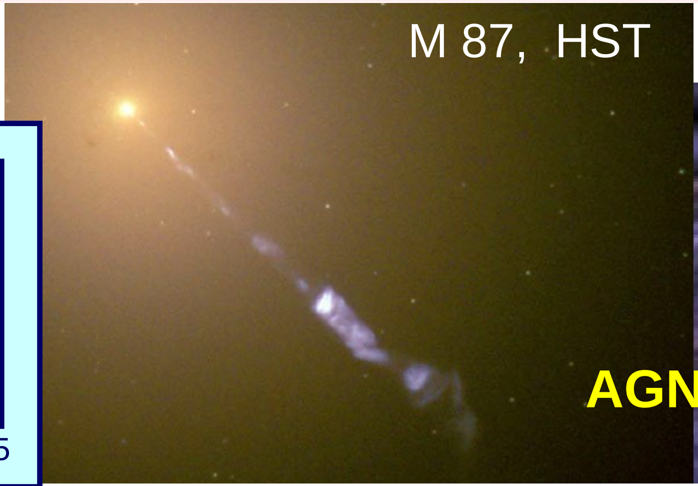
Dark Matter : neutralino annihilation in massive objects (Sun, Earth, GC)

EXTRA GALACTIC:

GRB

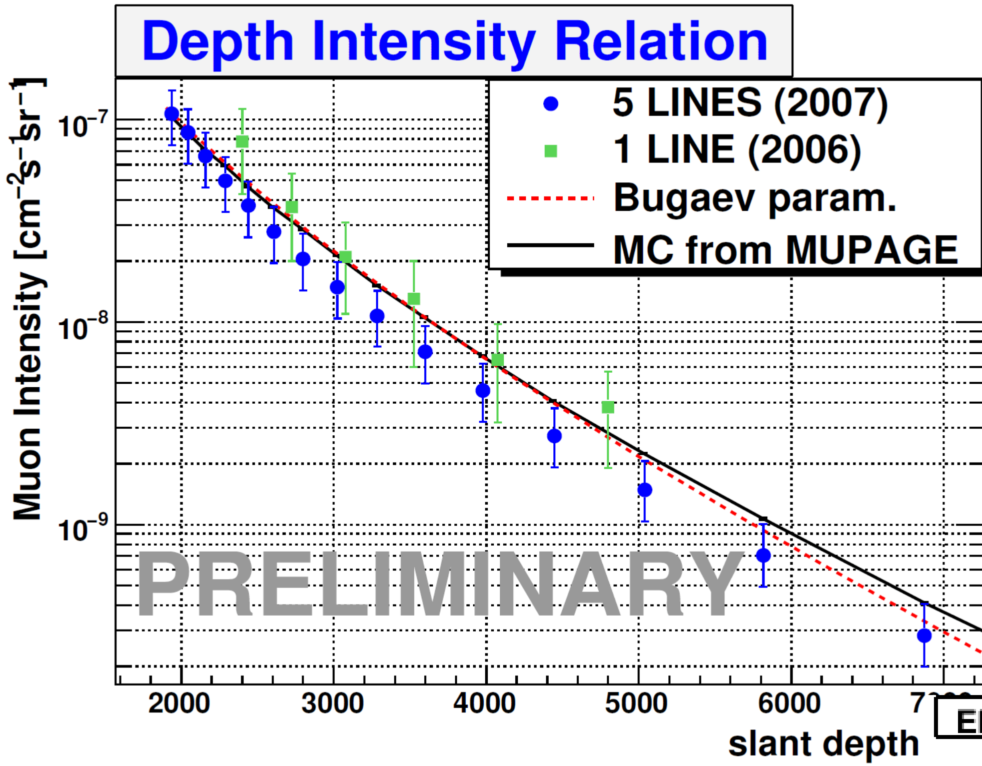






Current results

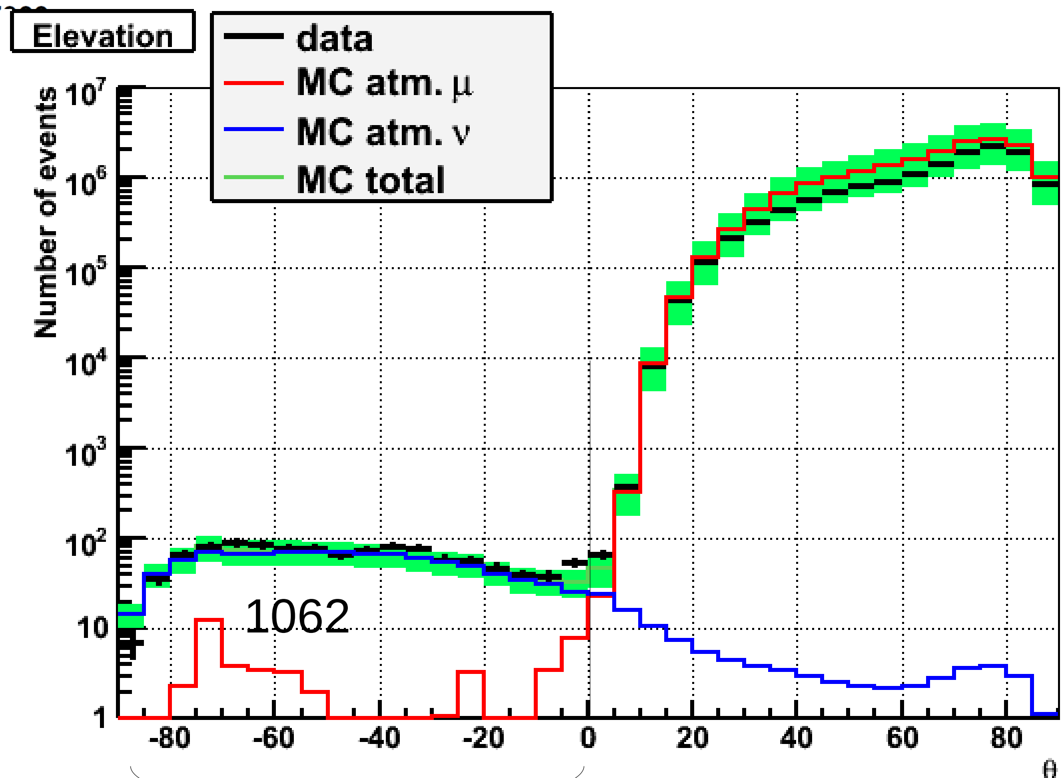
Atmospheric muons



Neutrinos & muons

341 days in 2007/2008

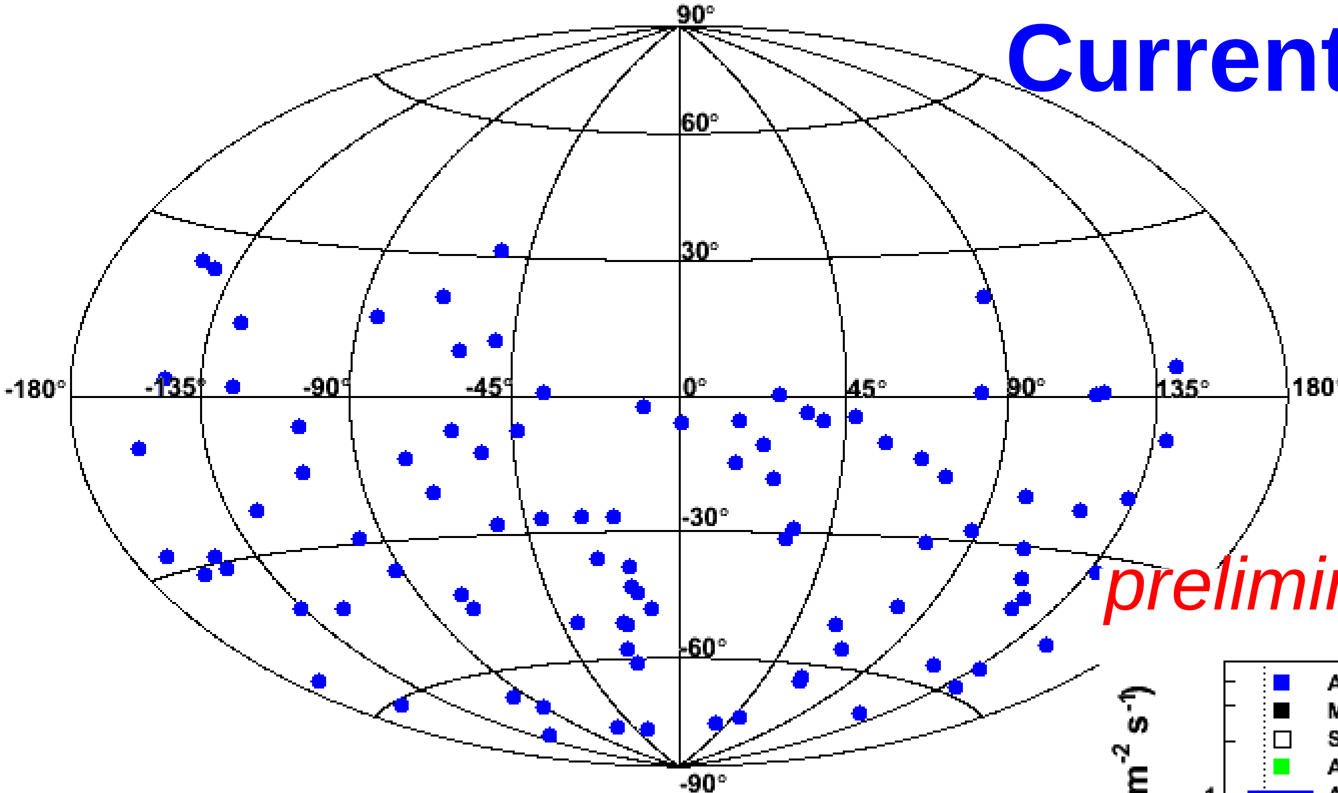
(5 lines, 9, 12 lines)



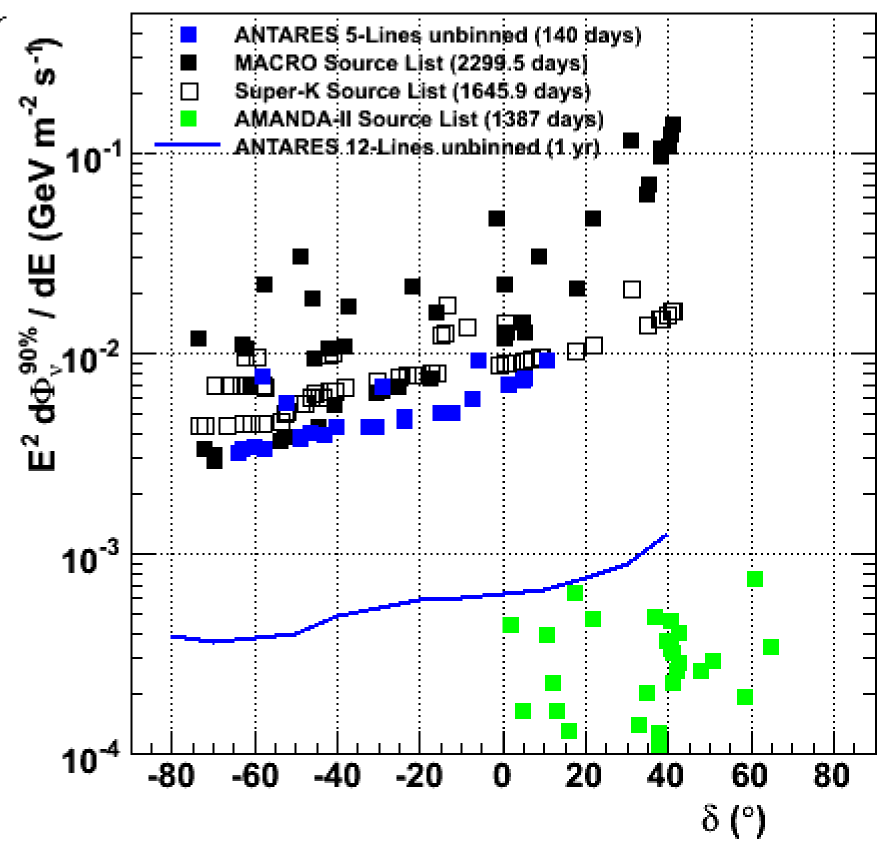
Region for neutrinos

Current results

140 days



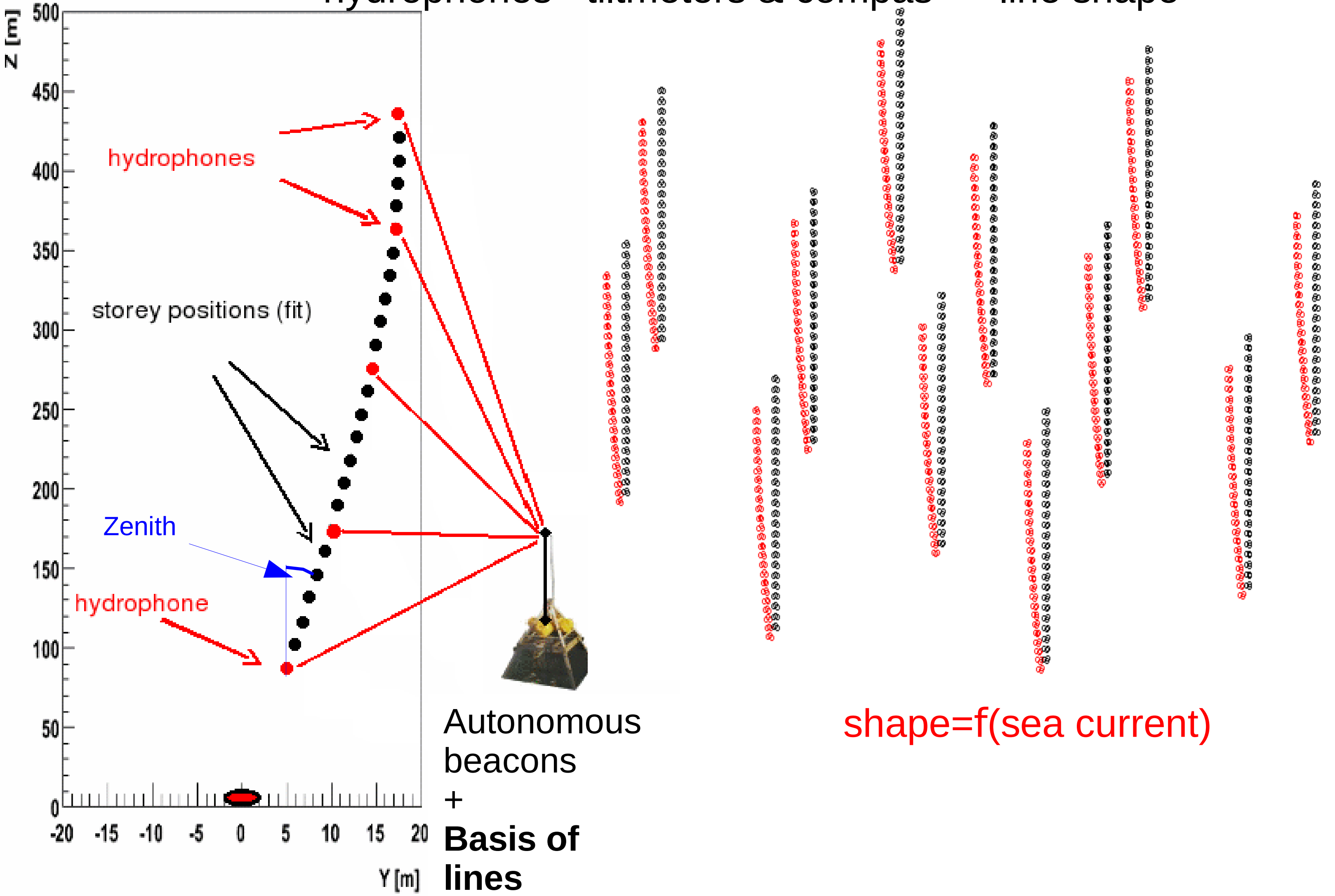
preliminary



Point source search with ANTARES in its 5 lines stage

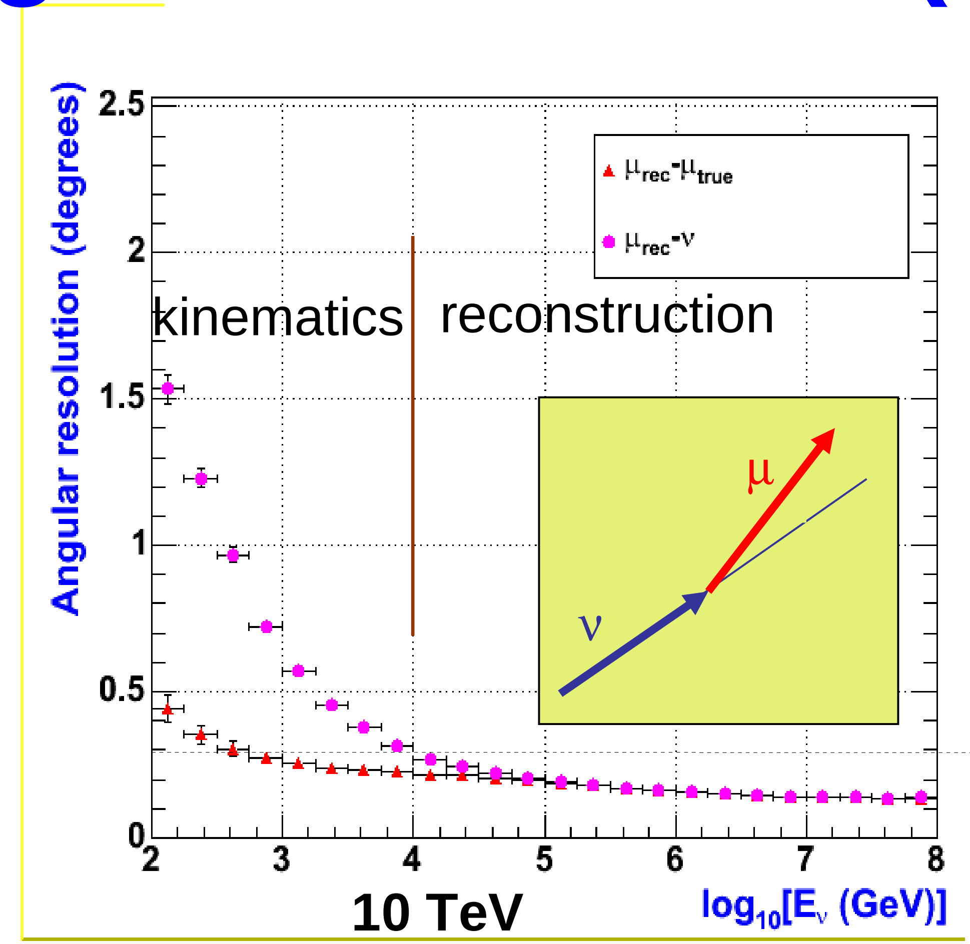
Measurement of the position of the lines

hydrophones+ tiltmeters & compas ► line shape



Position of line anchor : acoustic measurements from boat, itself positioned with a GPS.

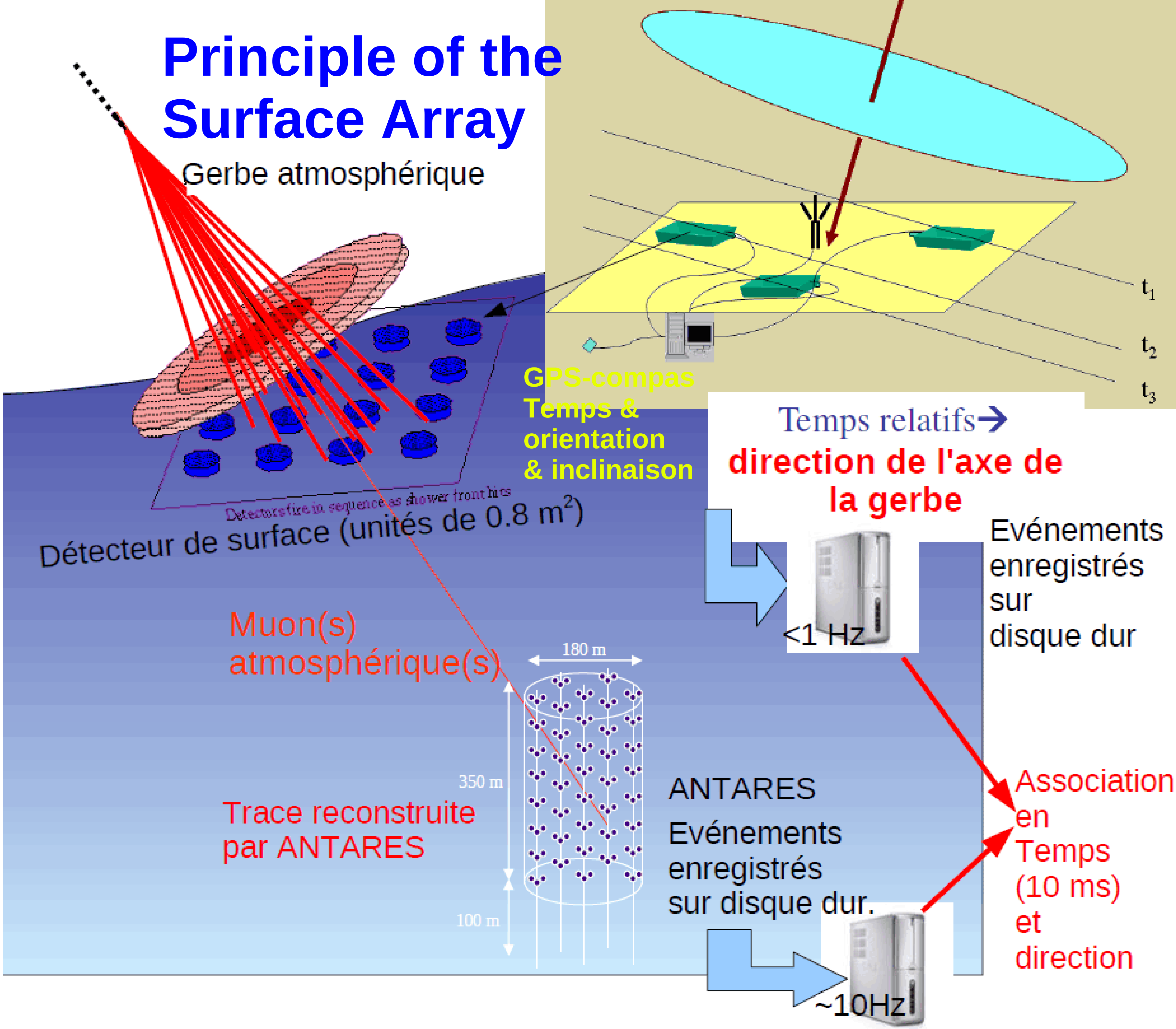
Angular resolution (median)



0.3°

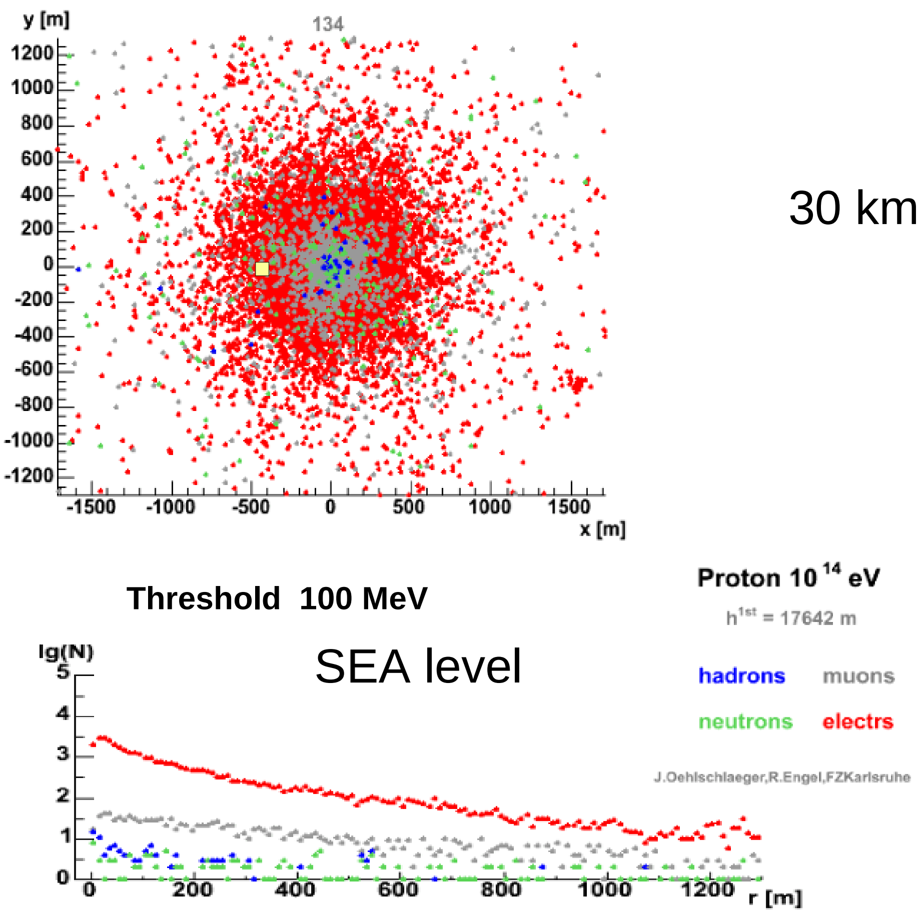
Can be cancelled by the uncertainty on the absolute pointing:
To be measured independently :
Moon shadow, cliff shadow : O(year) but free,
Surface Array : O(week) but not free!

Principle of the Surface Array

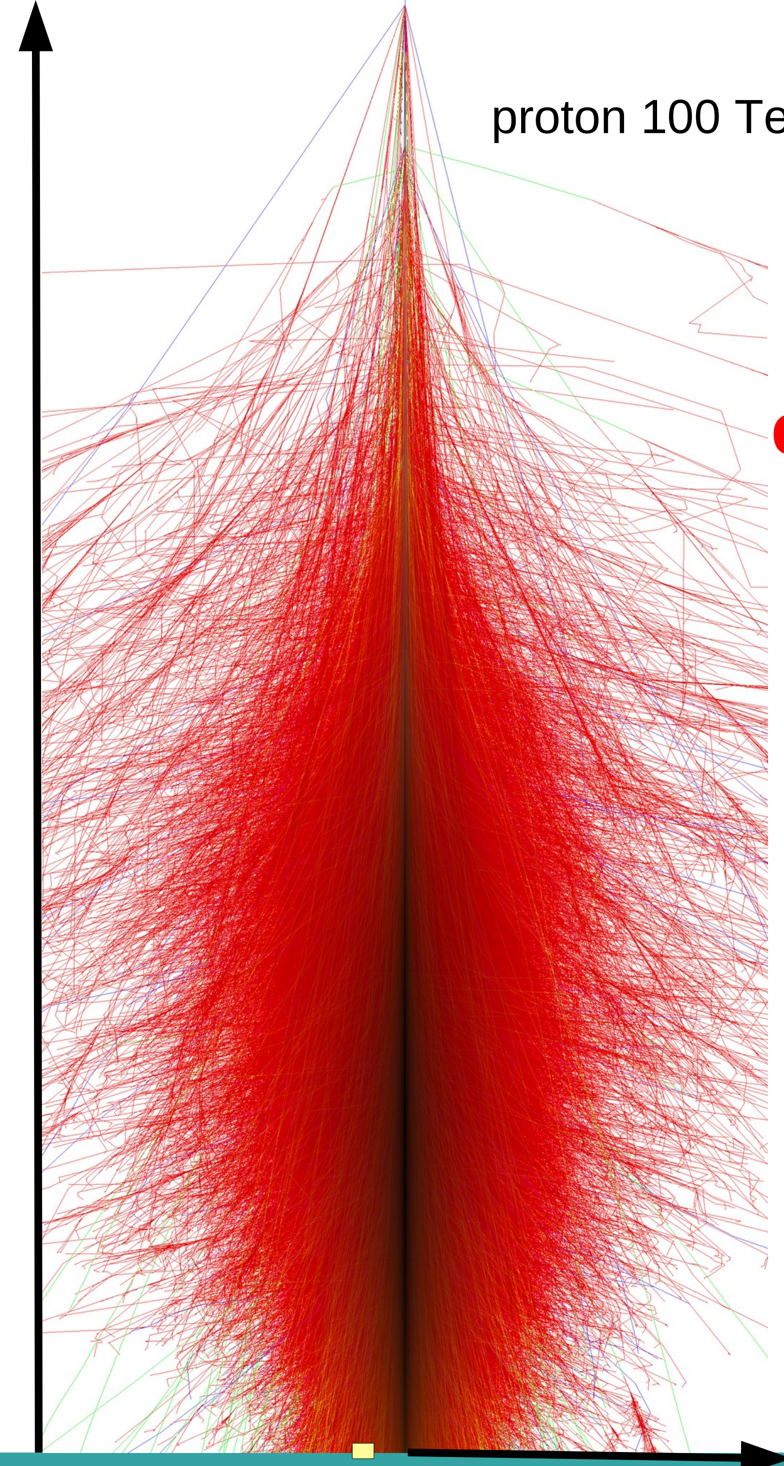


Atmospheric showers

CORSIKA



F. Schmidt, "CORSIKA Shower Images",http://www.ast.leeds.ac.uk/~fs/showerimages.html



e,γ > 100 keV

μ > 100 MeV

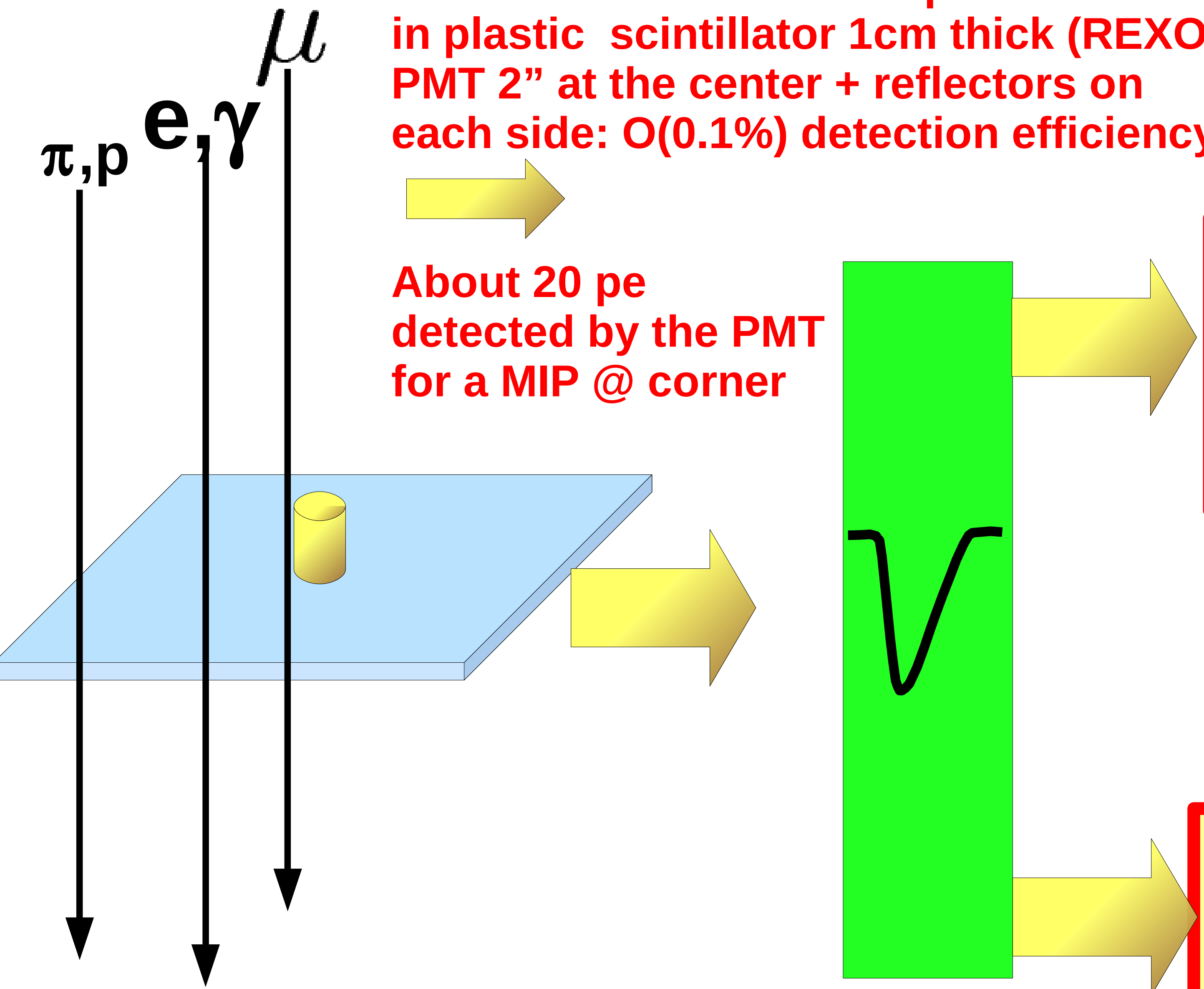
hadrons > 100 MeV

SEA

Required properties of a detection unit :

1 MIP = 2.1 MeV ~ 20 000 photons
in plastic scintillator 1cm thick (REXON RP200).
PMT 2” at the center + reflectors on
each side: O(0.1%) detection efficiency

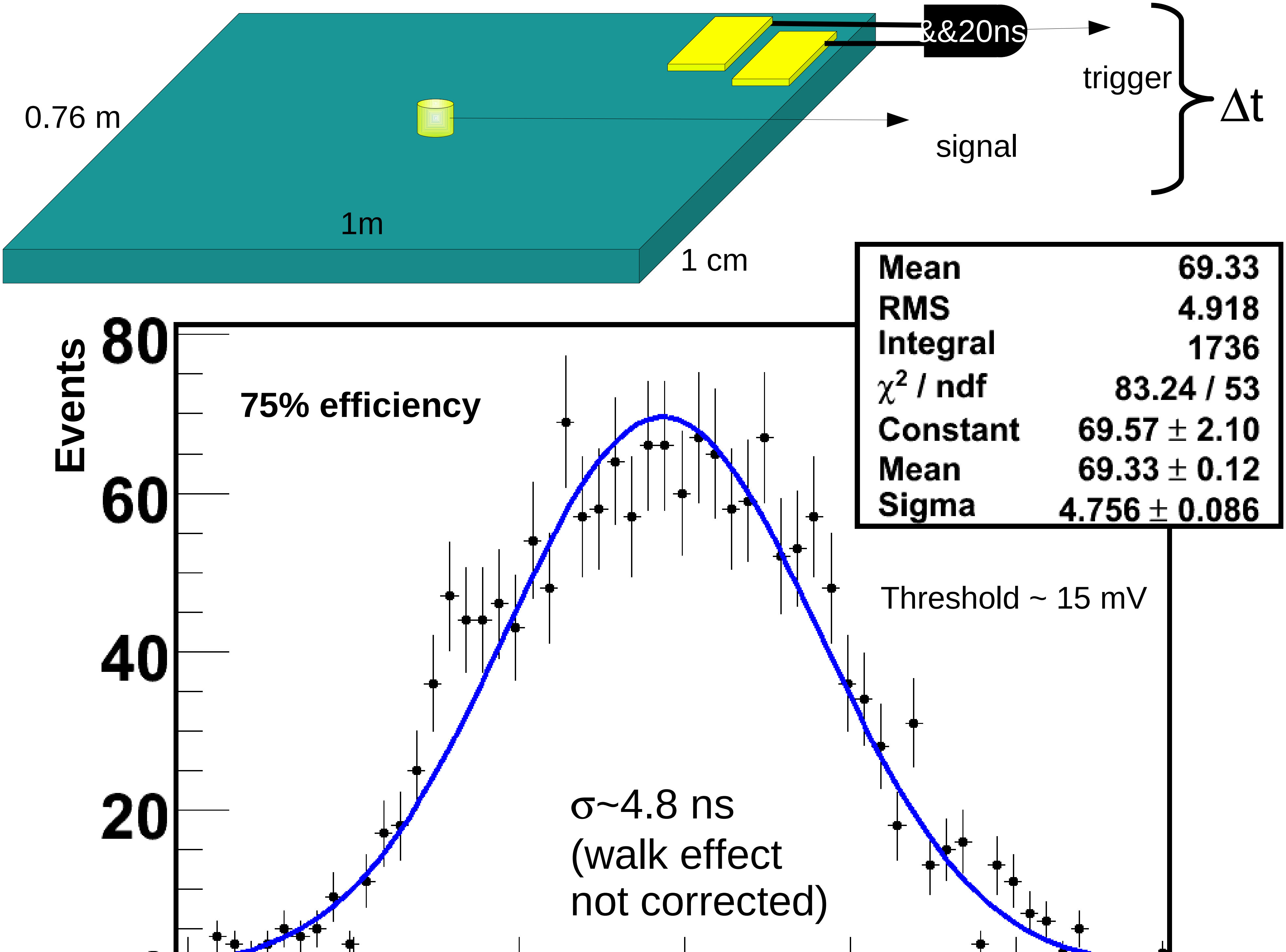
About 20 pe
detected by the PMT
for a MIP @ corner



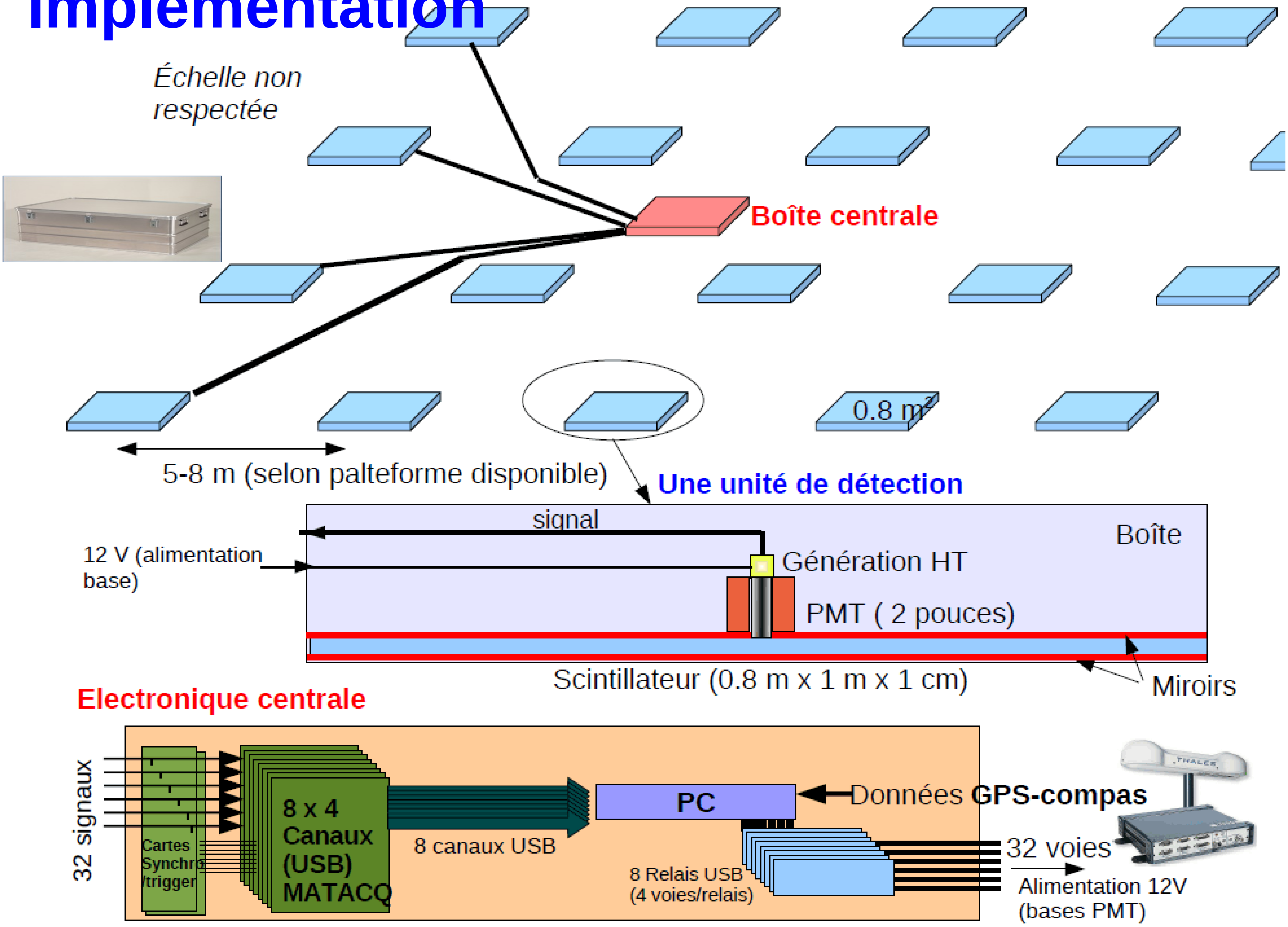
Gain 3 10^5
(Hamamatsu R6231)
threshold ~ 15 mV
for one MIP

Time resolution
Crossing of the
threshold:
σ of a few ns

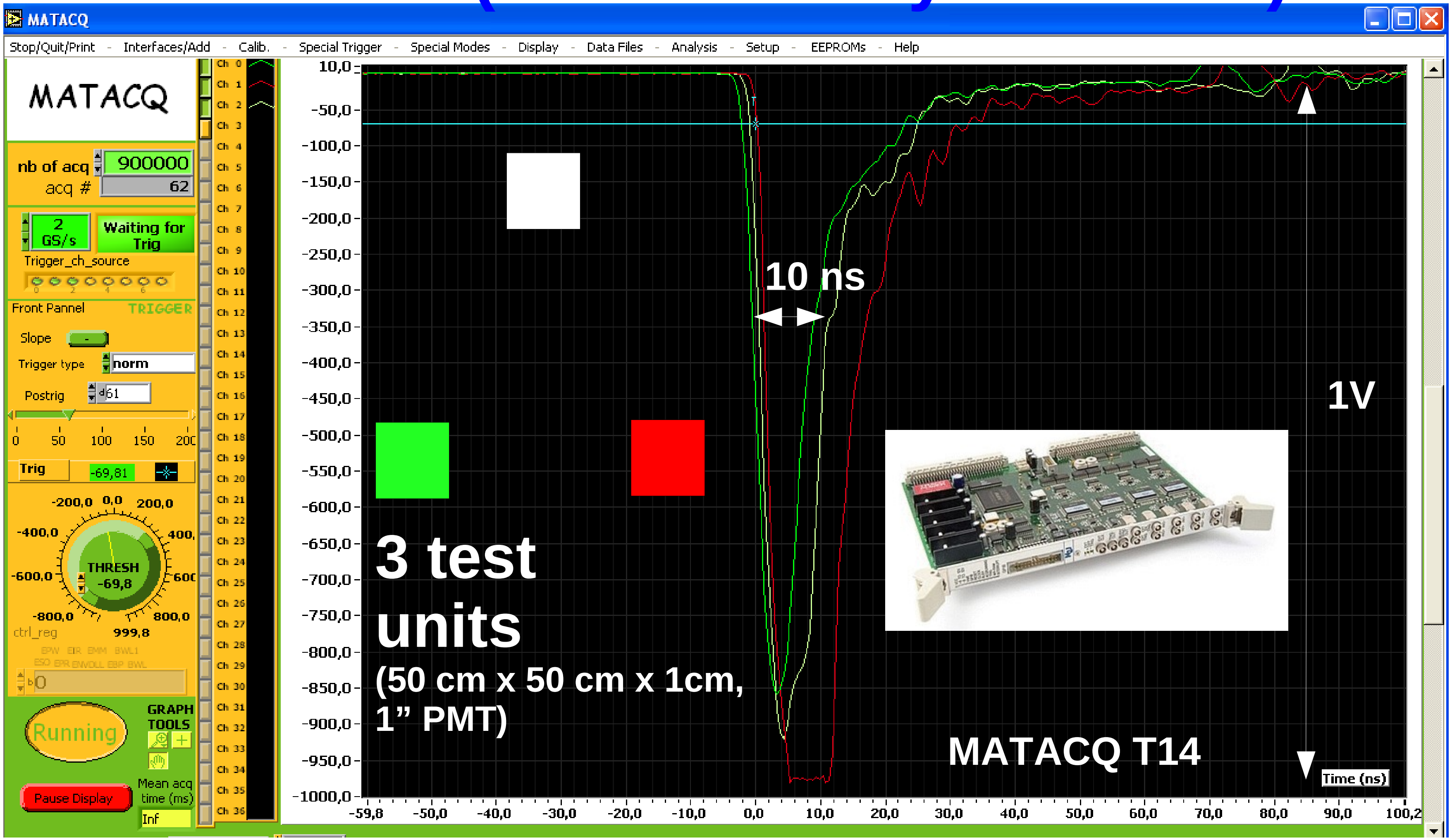
Measurement of time resolution

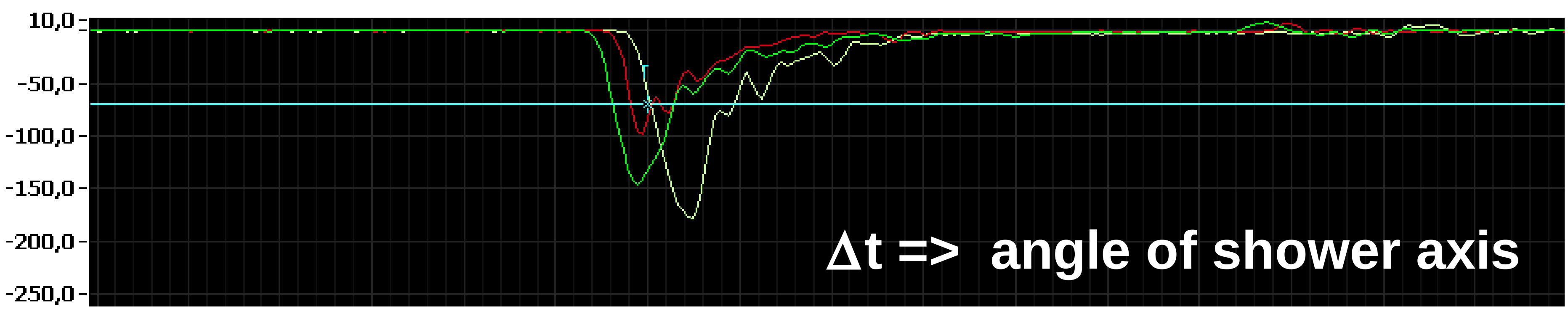


Implementation



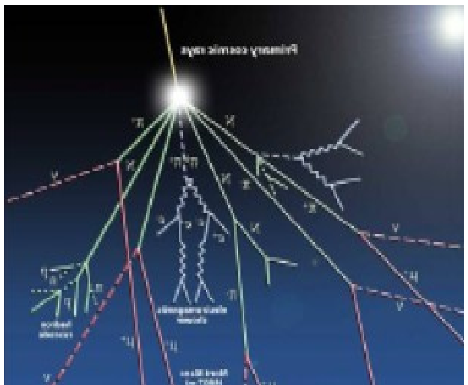
Electronics (commercially available)





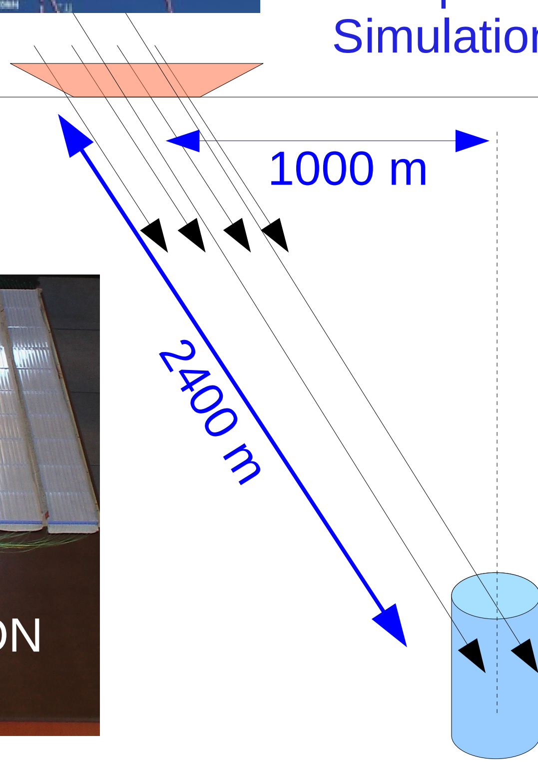
We search for some offset in the mean of $\Delta\theta$ and $\Delta\phi$:
simulations of performances

event by event comparison of :
zenith, azimuth of reconstructed tracks (SA vs ANTARES).
Estimate of the event rate.



Corsika shower simulation :
protons with E in $[10^5, 5.10^6]$ GeV
5 or 8 days equivalent ($55\ 10^4$ showers / day).

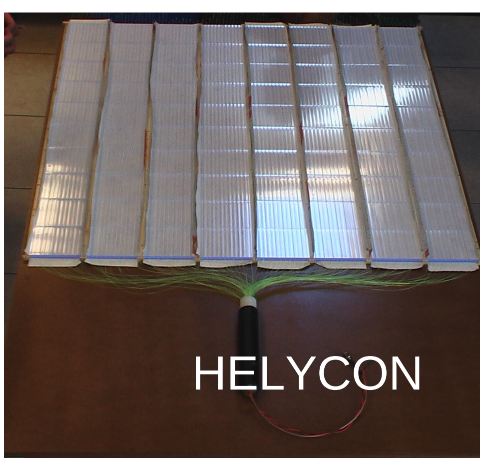
Reconstruction based on Δt from a least 3 scintillators requiring 4 MIPs of threshold for each (resolution ~ 3° rms for setups with ~10 detectors) : ~3 rec evts / min.
Simulation made in coll with HOU (HELYCON detectors)



2 tested distances :

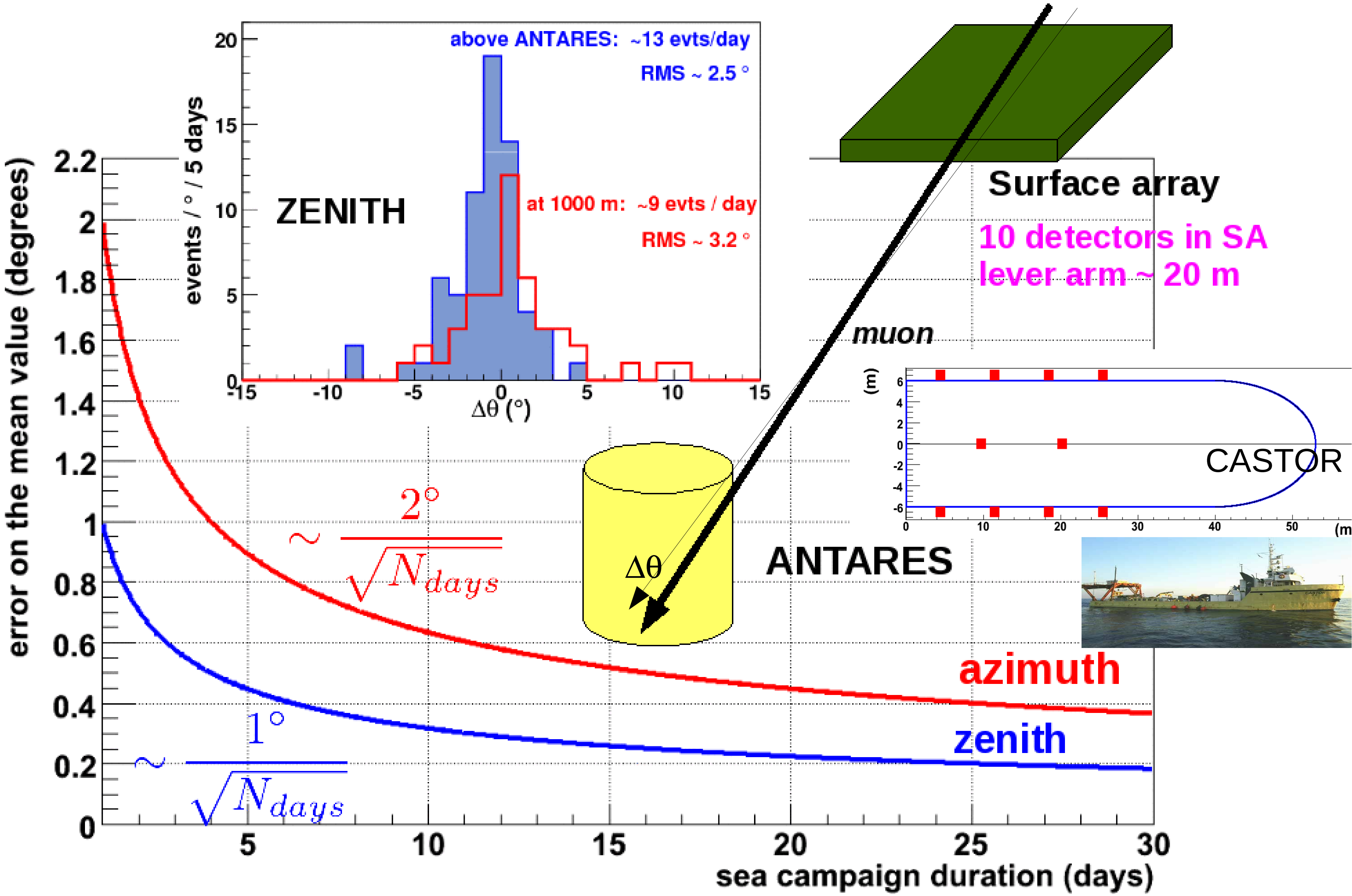
just above ANTARES (0m)

1 km apart (1000m, zenith ~ 24°)



VLVNT08, JPE & A Tsirigotis

Results of simulations for 10 detection units



COSTS

3.6 k€ per detection unit including electronics for digitization (MATACQ)

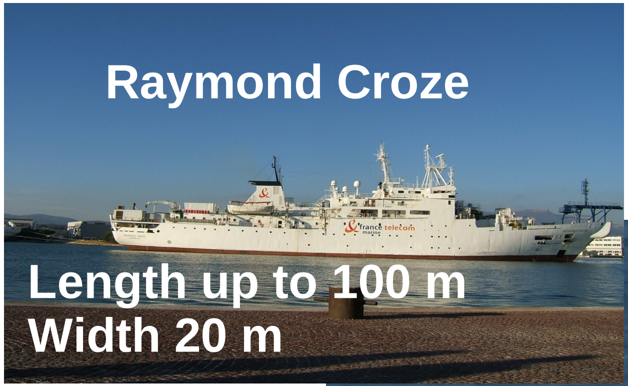
90 k€ for 5 effective days of sea campain

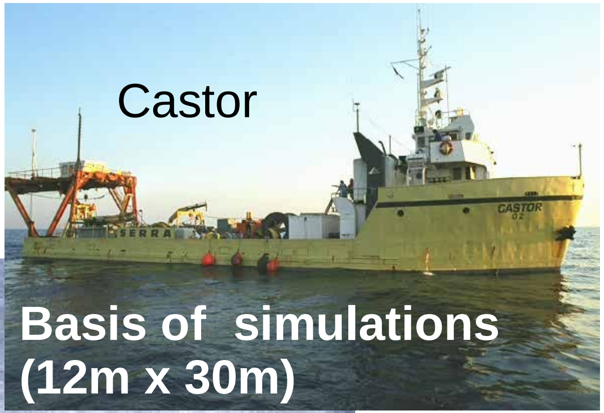
FULL APPARATUS

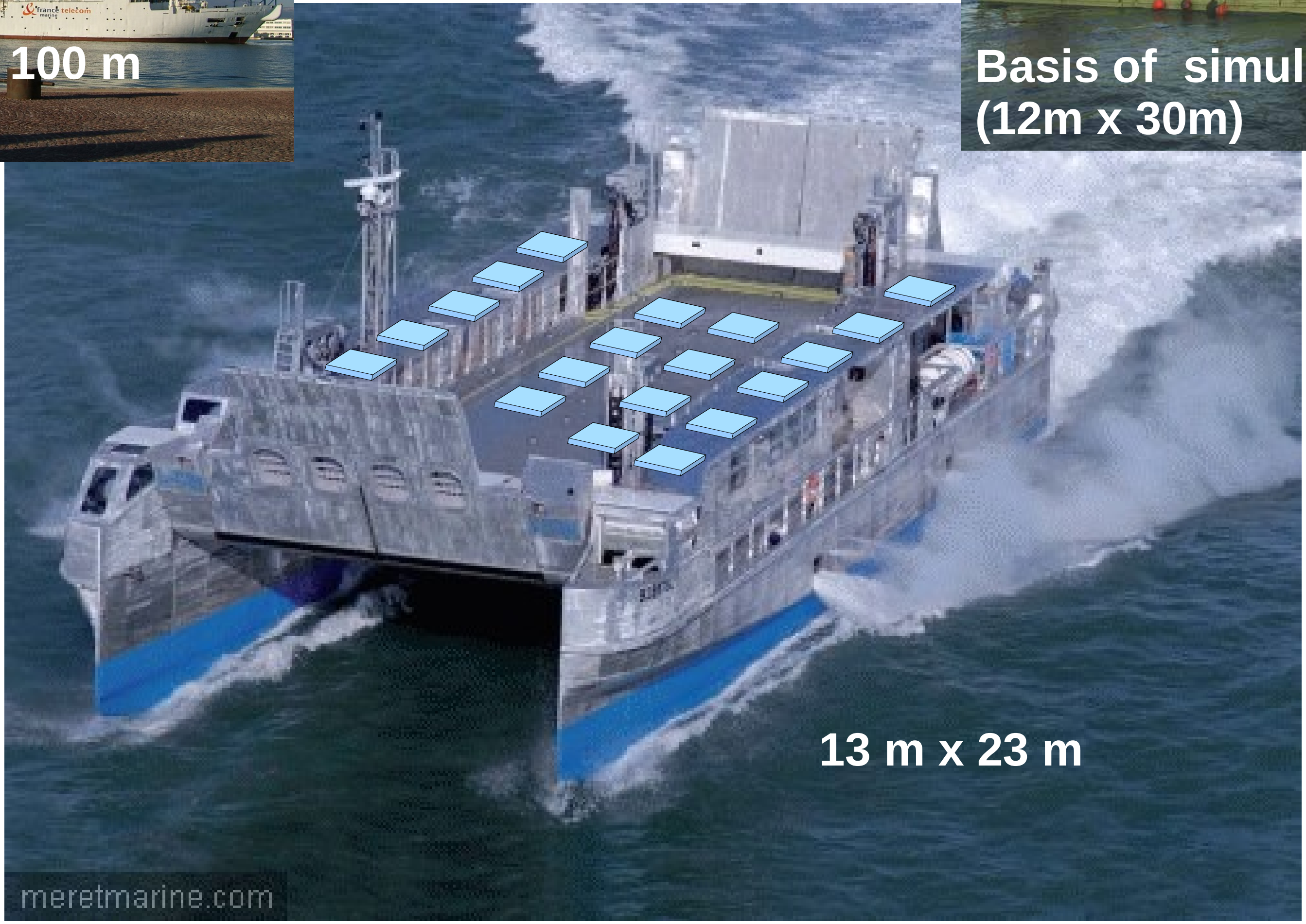
32 Detection Units on a platform 35m x 15m or a boat
(limitation: size of the vessel, electronics channels)

VESSELS ...

Boat or platform + boat



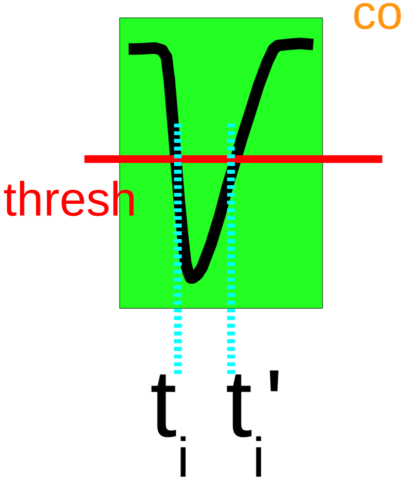




How to make it cheaper: electronics

CPPM home made solution for electronics (under study) :
from 1200€ / channel to 200€/channel :
re-use and adaptation of an existing solution.

For each DU, the 12V required by the HT generation are provided through a coaxial cable. On the same cable is transmitted a positive logical signal built from the PMT signal
(pre-amplifier inverter, x5, with time over threshold info)



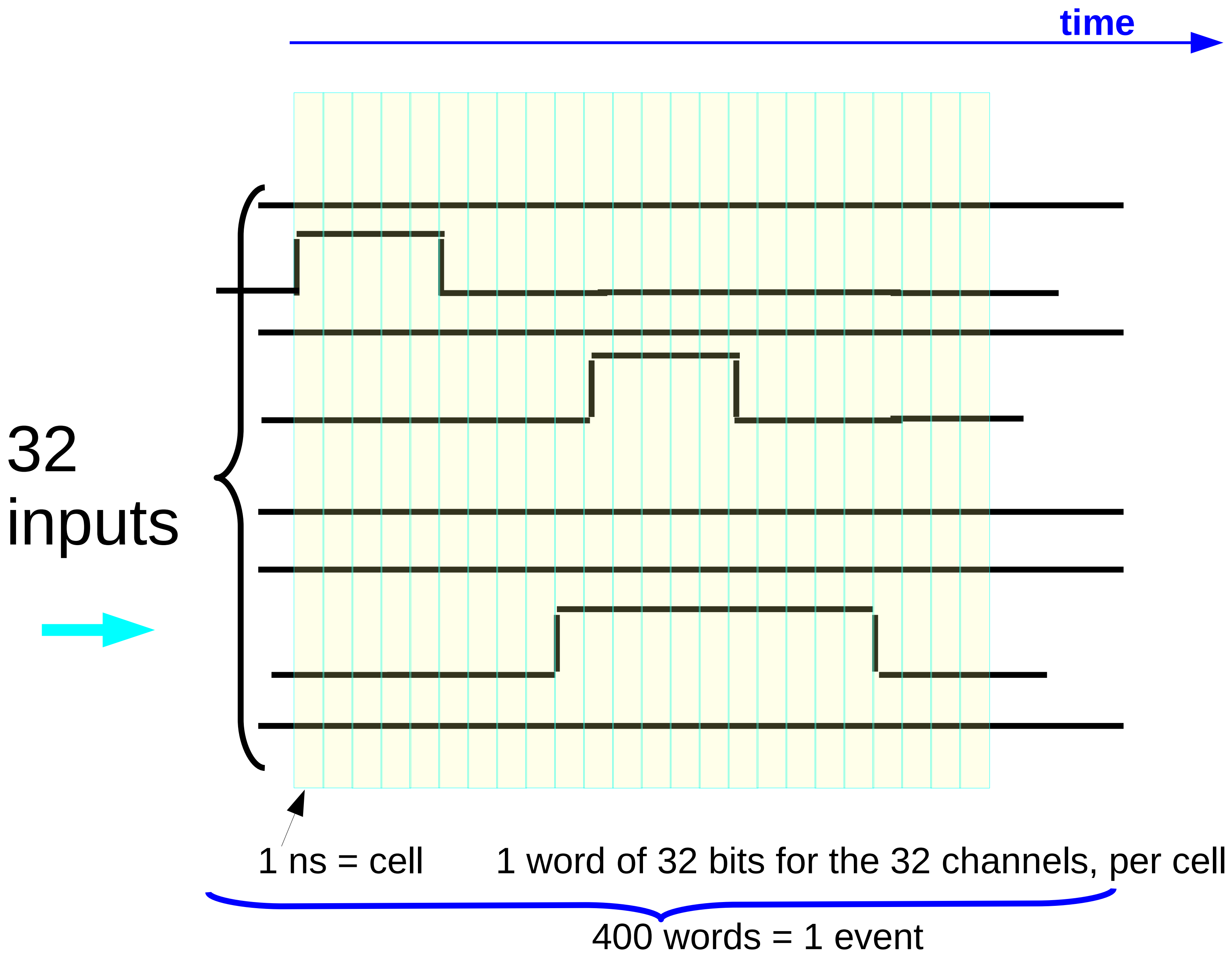
Logical signal (~1 V)

Transmission on
20 to 50 m

All 32 channels connected to a single central card sampling the signals with a 1-2 ns cell.

sampling

How to make it cheaper: electronics



Size of 1 event :
400 * 32 bits =
1600 bytes.

Repetition :
~ 3/minute

Communication
with PC:
TCPIP

Steps of the project :

November 2009: 4 units under test (1 MATACQ card)

January 2010: 8 units (2 MATACQ card,
measurement of angular resolution by splitting detector)

March 2010: decision on the choice *commercial electronics/home made*

Summer 2010: N units ready (depending of the funding) for sea operation

Achievable constraint in 10 days, 32 units :
0.2° in zenith and 0.4° in azimuth.