



# The KM3NeT project: a $\text{km}^3$ neutrino telescope in the Mediterranean Sea

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on behalf of the KM3NeT Consortium

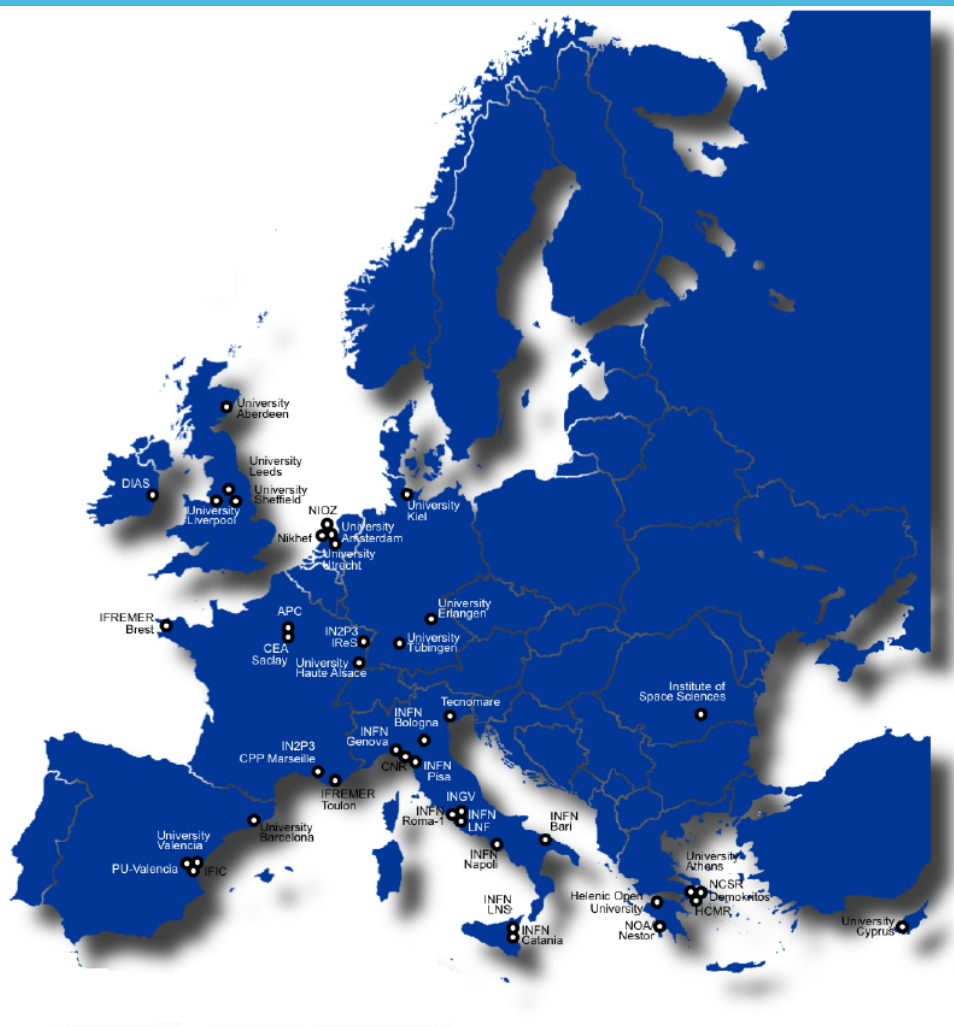


# The KM3NeT project

- International consortium
- more than 300 scientists from 10 EU countries
- main goal: high energy neutrino **telescope** under the Mediterranean Sea ==> complementarity to the IceCube detector at the South Pole
- KM3NeT is one of the pan european research infrastructures on the ESFRI EU roadmap

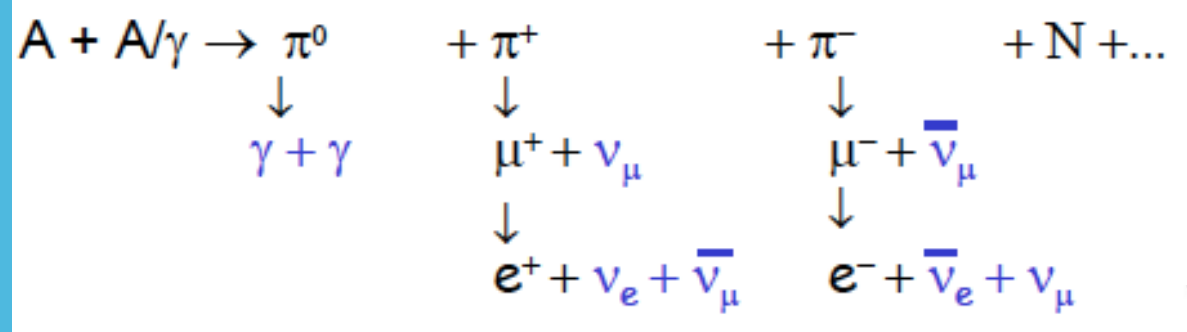
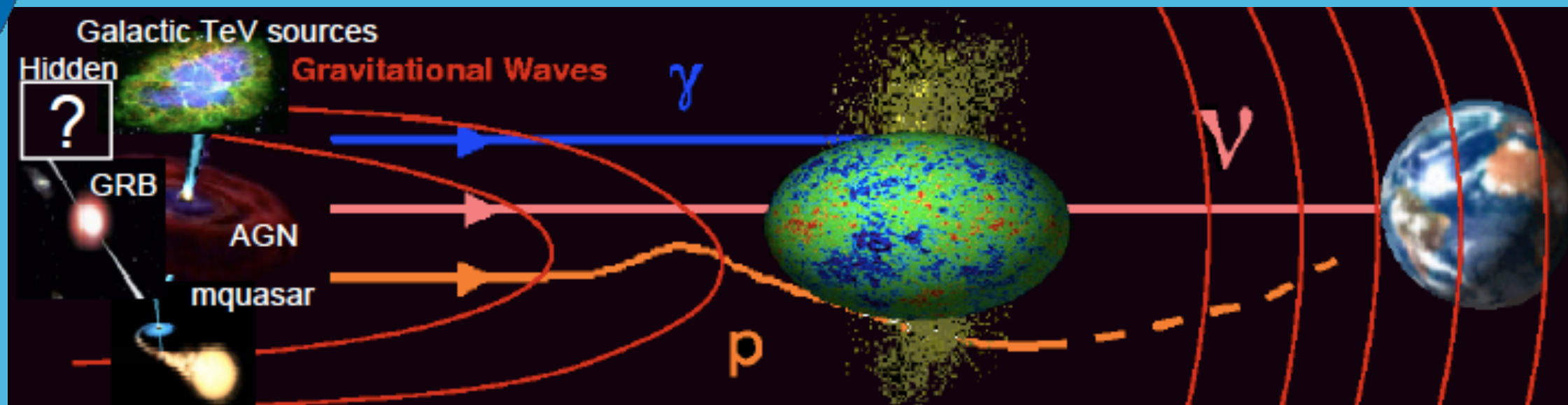
## Brief history of KM3NeT

- February 2006: Design Study project started: co-funded under the EC FP6 - Coordinator: Prof. Uli Katz (Erlangen University)
  - **TECHNICAL DESIGN REPORT**
- 2008 : Preparatory Phase co-funded under the EC FP7 - Coordinator: Prof. Emilio Migneco (Laboratori Nazionali del Sud - INFN)
  - **FINAL DECISIONS ON TECHNOLOGICAL SOLUTIONS**
- February 2012: Conclusion of the Preparatory Phase



KM3NeT

# The science case : neutrino astronomy



No absorption → Cosmological distances  
 Weakly interacting → Core of dense objects  
 No deflection by B → Point sources

Primary acceleration («Bottom-Up»)  
 Stochastic shocks (Fermi mechanism)

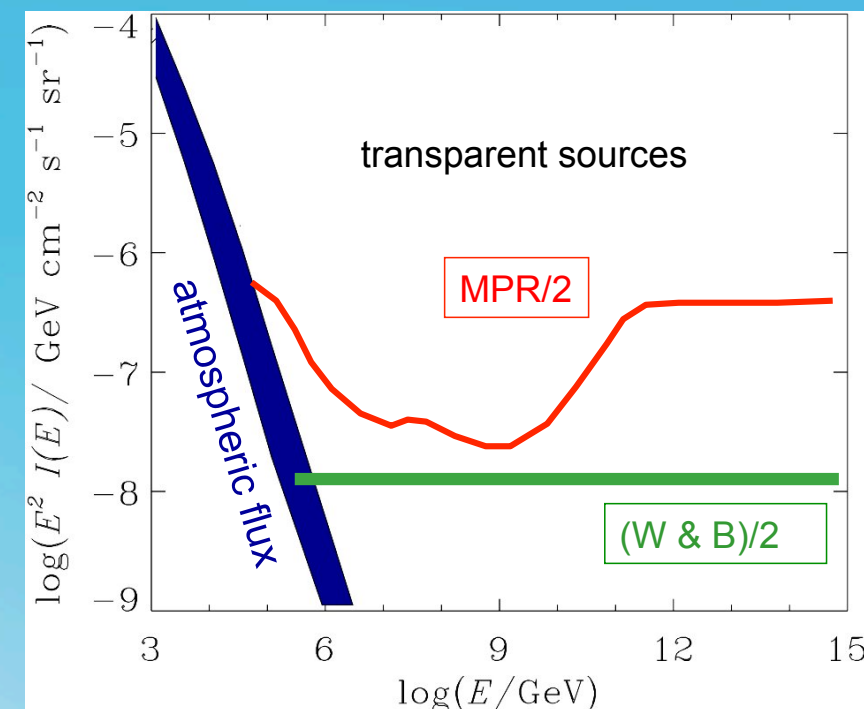
Benchmark extragalactic muon neutrino flux

Waxman & Bahcall, 1999

Mannheim, Protheroe, Rachen 2001

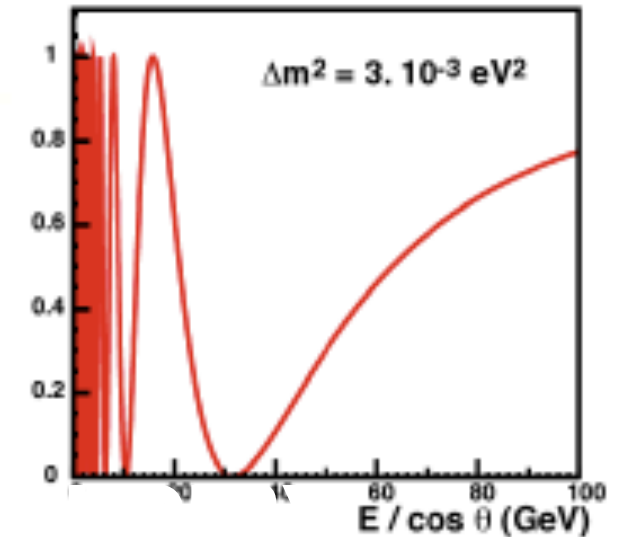
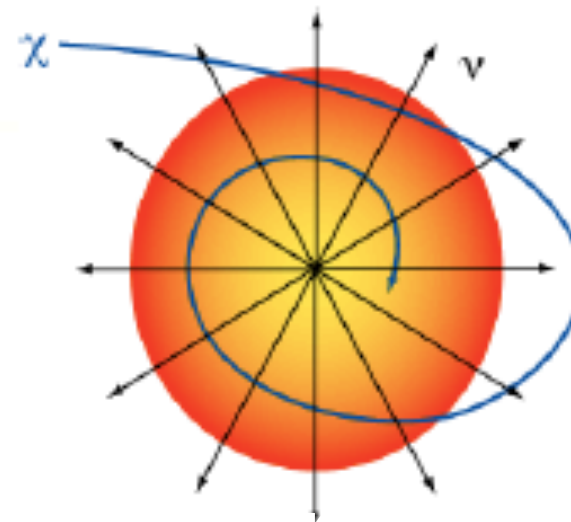
Set the effective scale of  $\nu$  telescopes to  $\text{km}^3$

Neutrinos can open a new window on the Universe





# The science case : neutrino astronomy



High Energy  
 $E_\nu > 1 \text{ TeV}$

Medium Energy  
 $10 \text{ GeV} < E_\nu < 1 \text{ TeV}$

Low Energy  
 $10 \text{ GeV} < E_\nu < 100 \text{ GeV}$

$\nu$  from extra-  
terrestrial sources

Dark matter search

$\nu$  oscillations

Origin and production  
mechanism of HE CR

Primary goal

Exotic particle physics  
Monopoles, nuclearites,...

Marine sciences: oceanography, biology, geology...

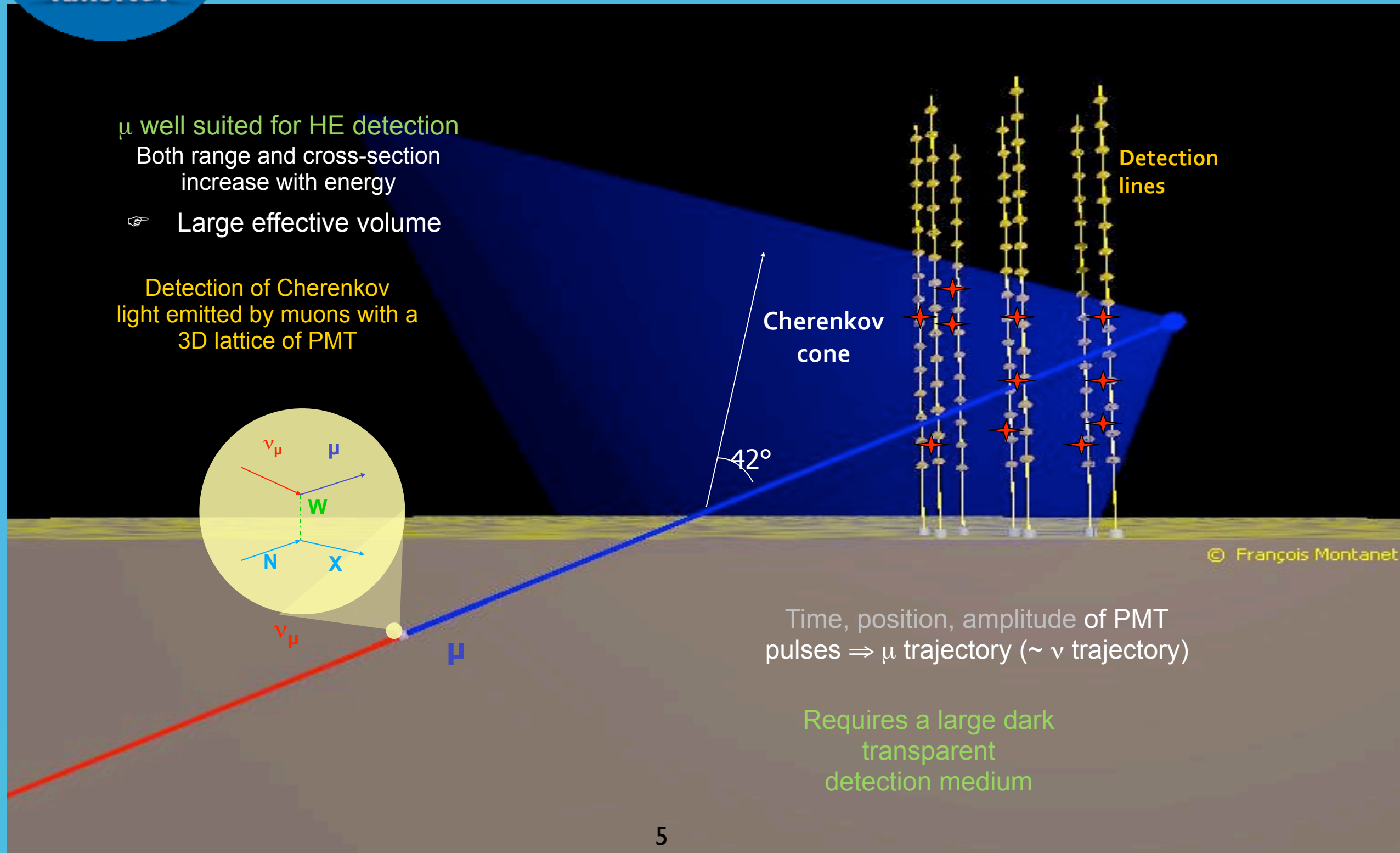
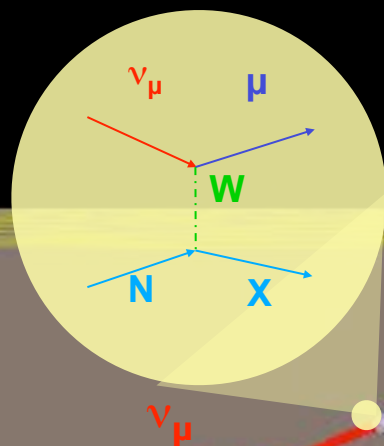
# Detection principle

$\mu$  well suited for HE detection

Both range and cross-section  
increase with energy

☞ Large effective volume

Detection of Cherenkov  
light emitted by muons with a  
3D lattice of PMT



© François Montanet

Time, position, amplitude of PMT  
pulses  $\Rightarrow \mu$  trajectory ( $\sim \nu$  trajectory)

Requires a large dark  
transparent  
detection medium



# Why Mediterranean Sea

## Sky view (Galactic Coordinates)

South Pole

Mediterranean Sea

- Complementarity to South Pole

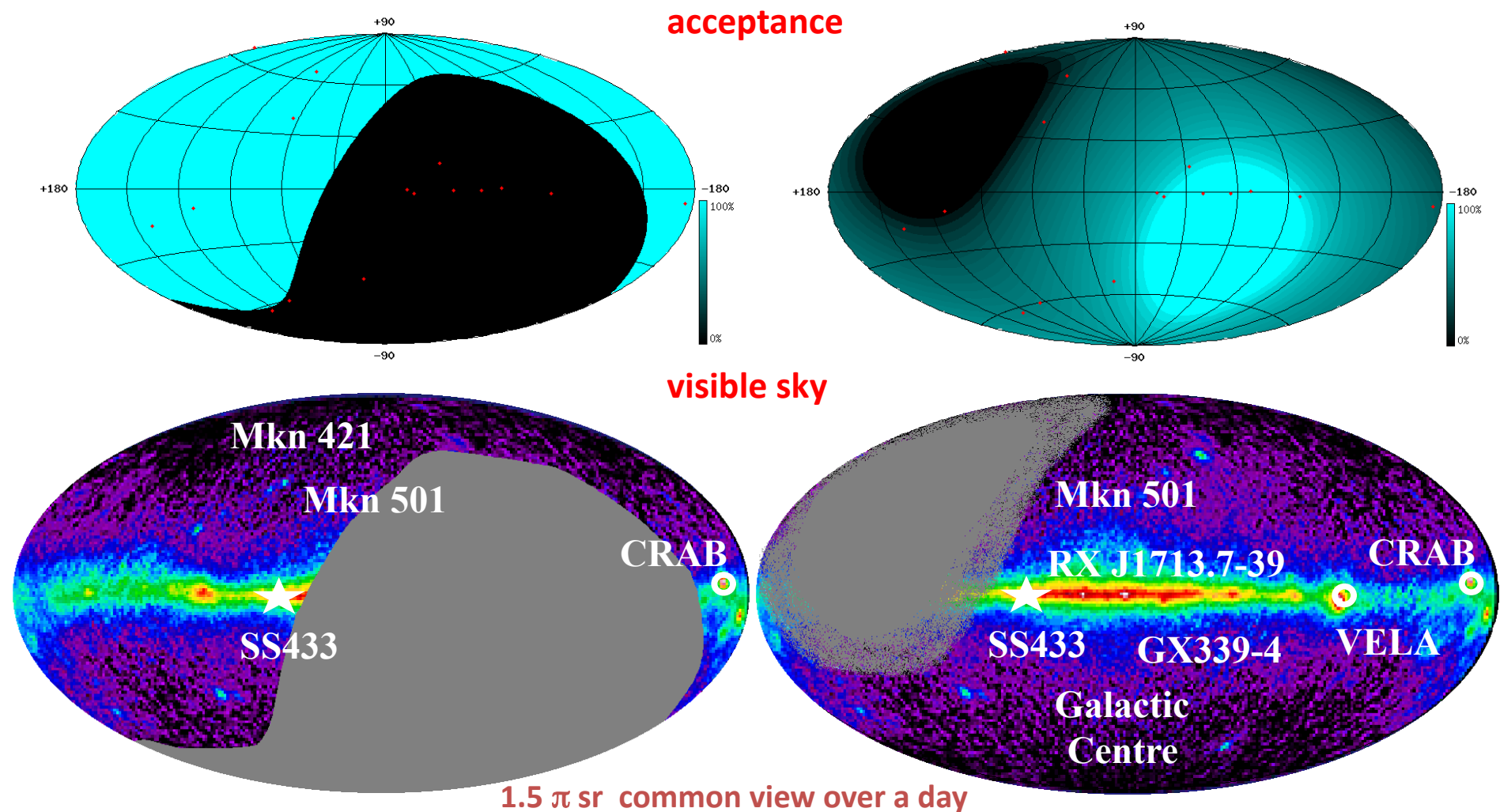
Galactic centre

Galactic plane

- Deep sites -> up to 5000 m

- long scattering length

good pointing capability





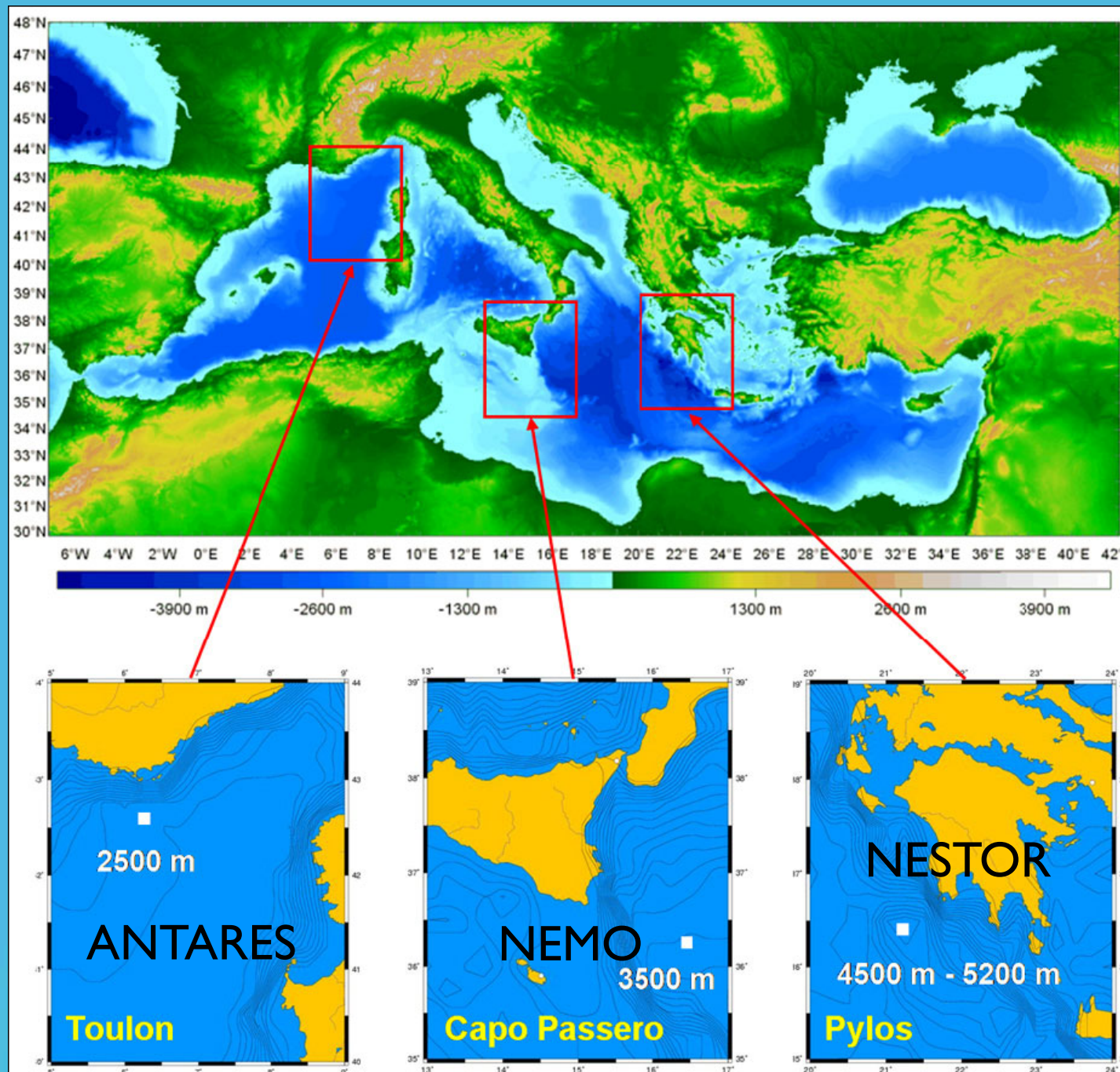


KM3NeT

# Where in the Mediterranean Sea

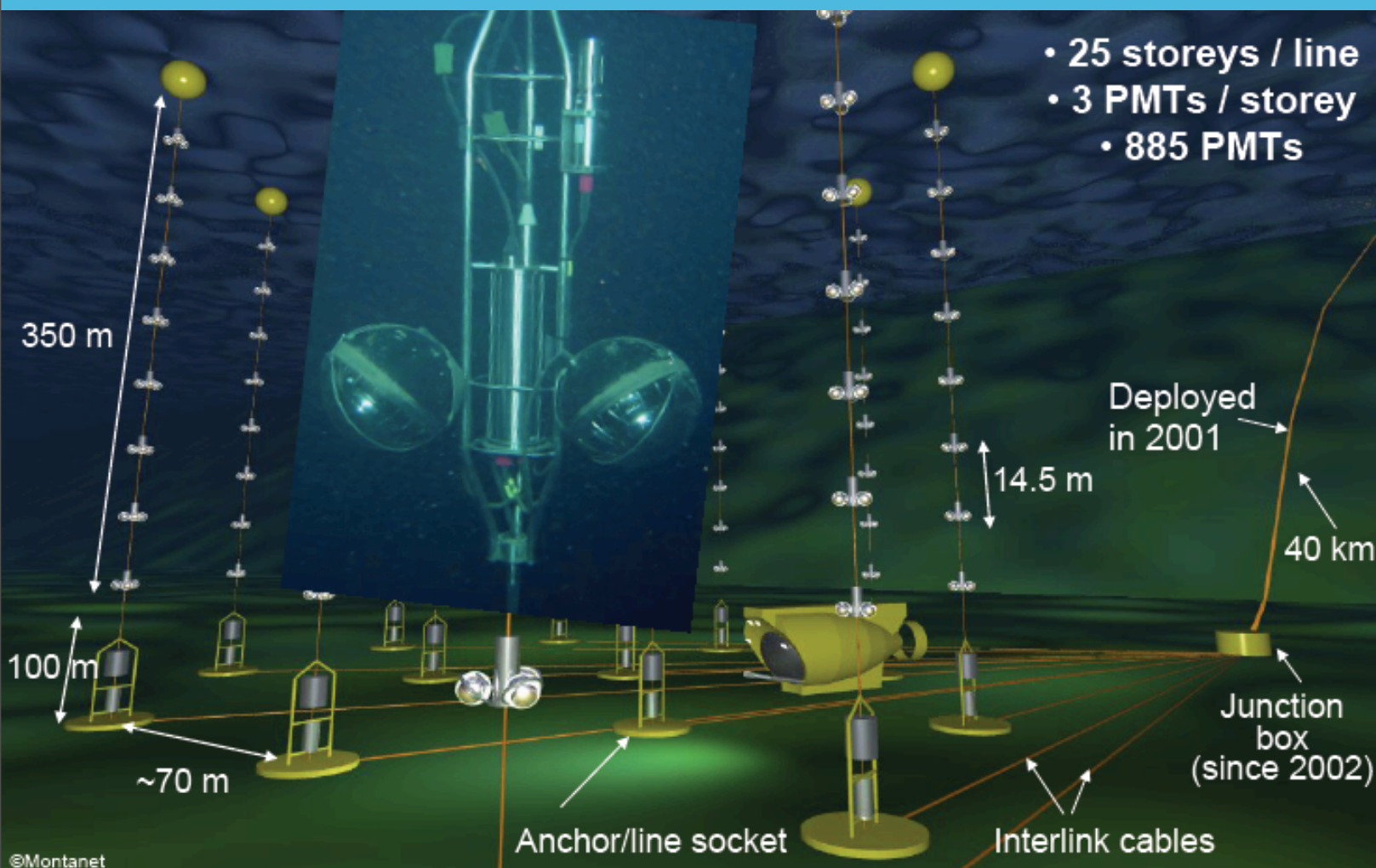
- KM3NeT is the result of a joined effort of the ANTARES, NEMO and NESTOR Collaborations
- 3 good sites have been identified after a long activity of site characterization
- Funds in France, Italy and Greece are “site”-linked

multi site solution





# ANTARES: a precursor of undersea neutrino telescope

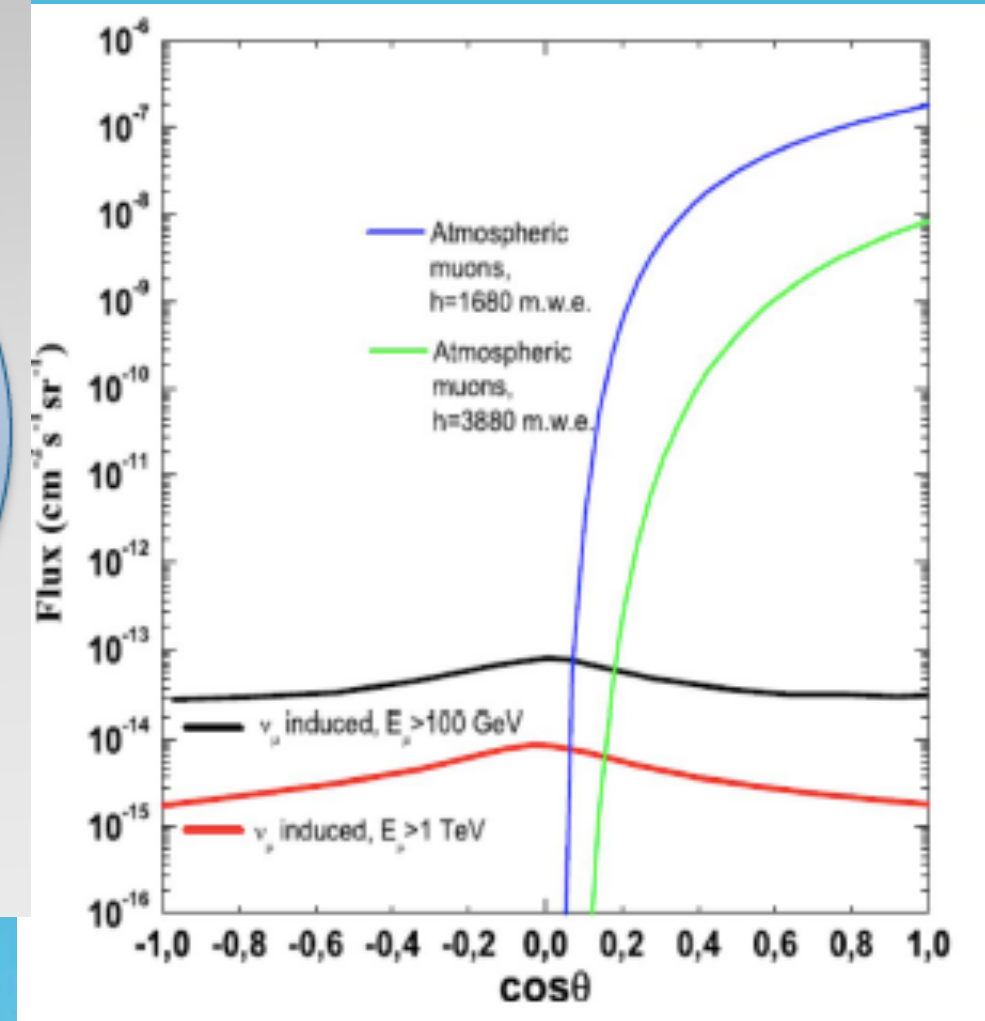
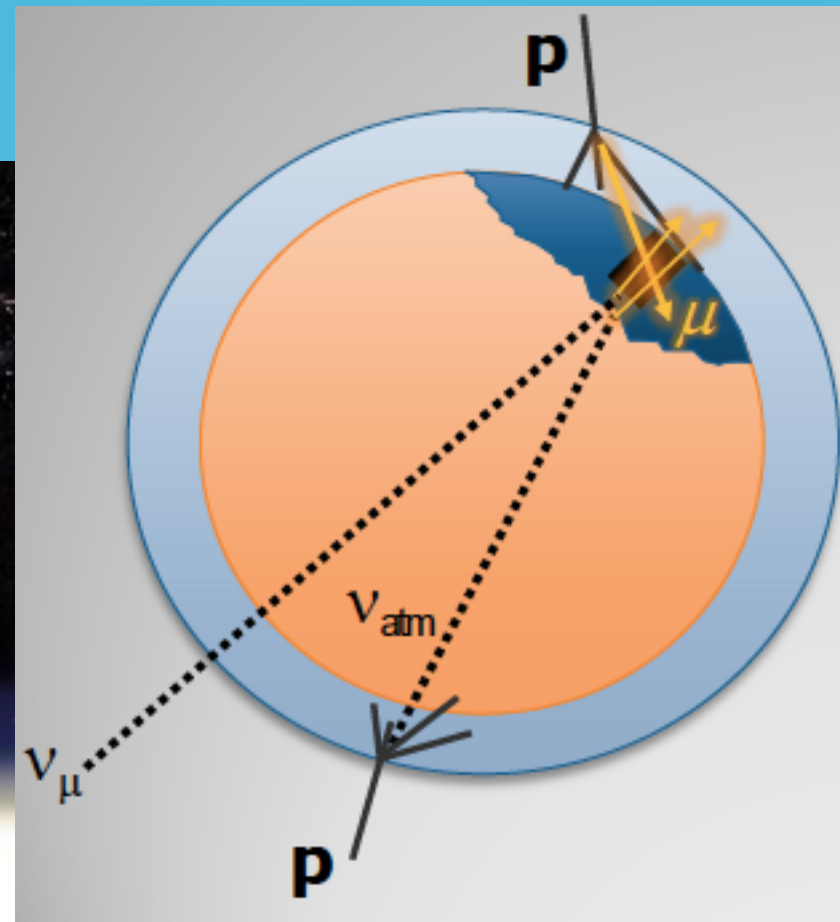
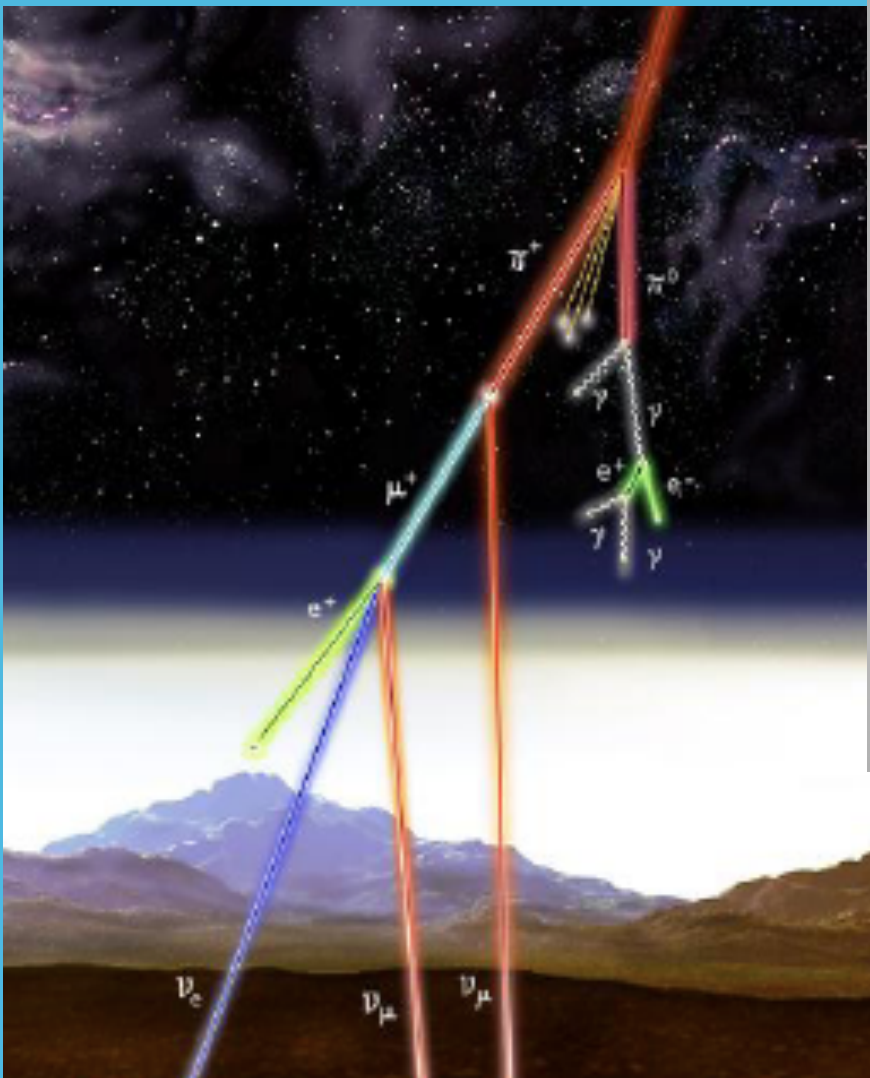


- the largest undersea neutrino telescope (Toulon site)
- has shown the feasibility of this technology
- in data taking since May 2008
- size is not large enough for expected neutrino fluxes ( $0.1 \text{ km}^2$ )



KM3NeT

# Physics background sources



Atmospheric muons: only downgoing

shield detector & identify upward muons



# Atmospheric vs cosmic neutrinos

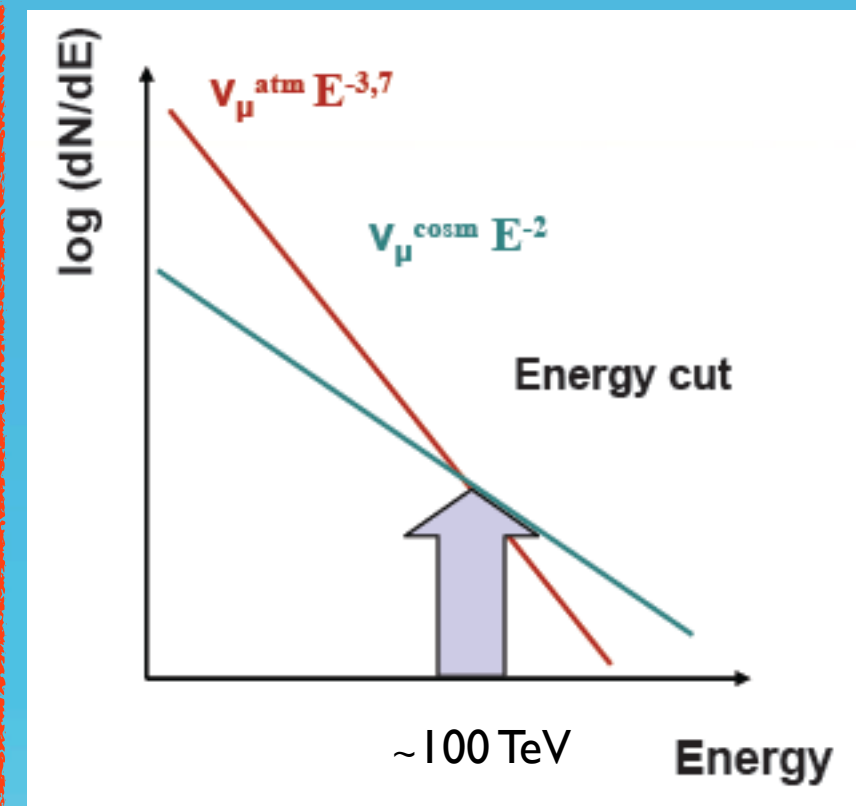
First signal in a  $\nu$  telescope due to atmospheric neutrinos

cosmic neutrinos selected through :

search for anisotropy → pointlike sources

dedicated cuts in energy → diffuse flux

time/space coincidences  
with other cosmic probes → GRB,  $\gamma$ -ray emitters

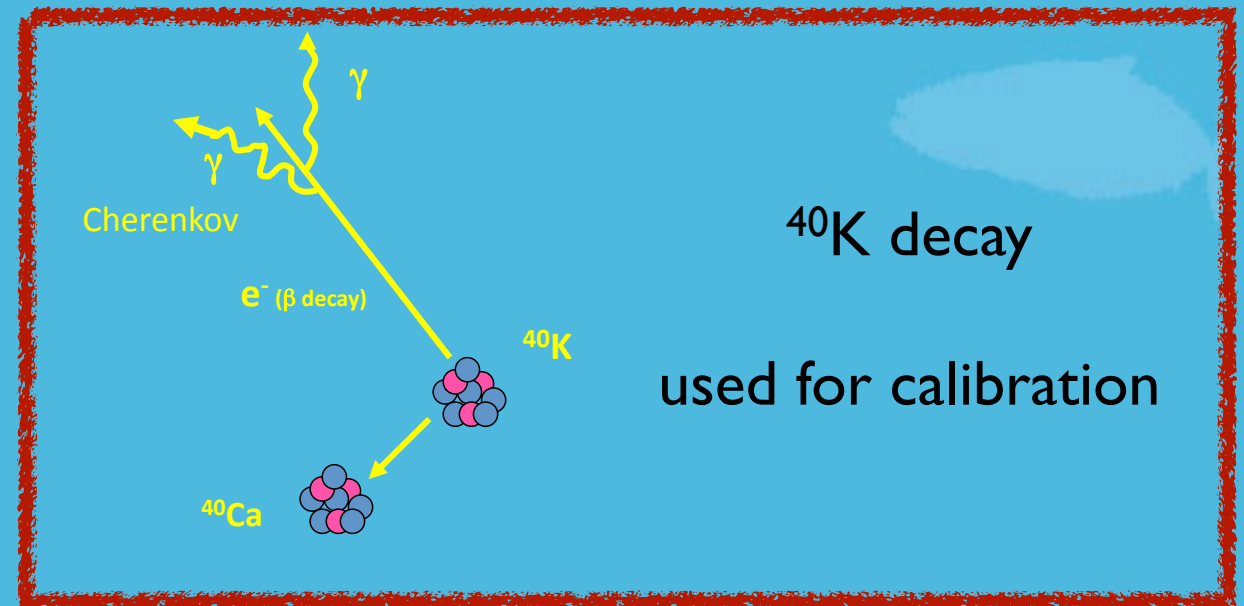




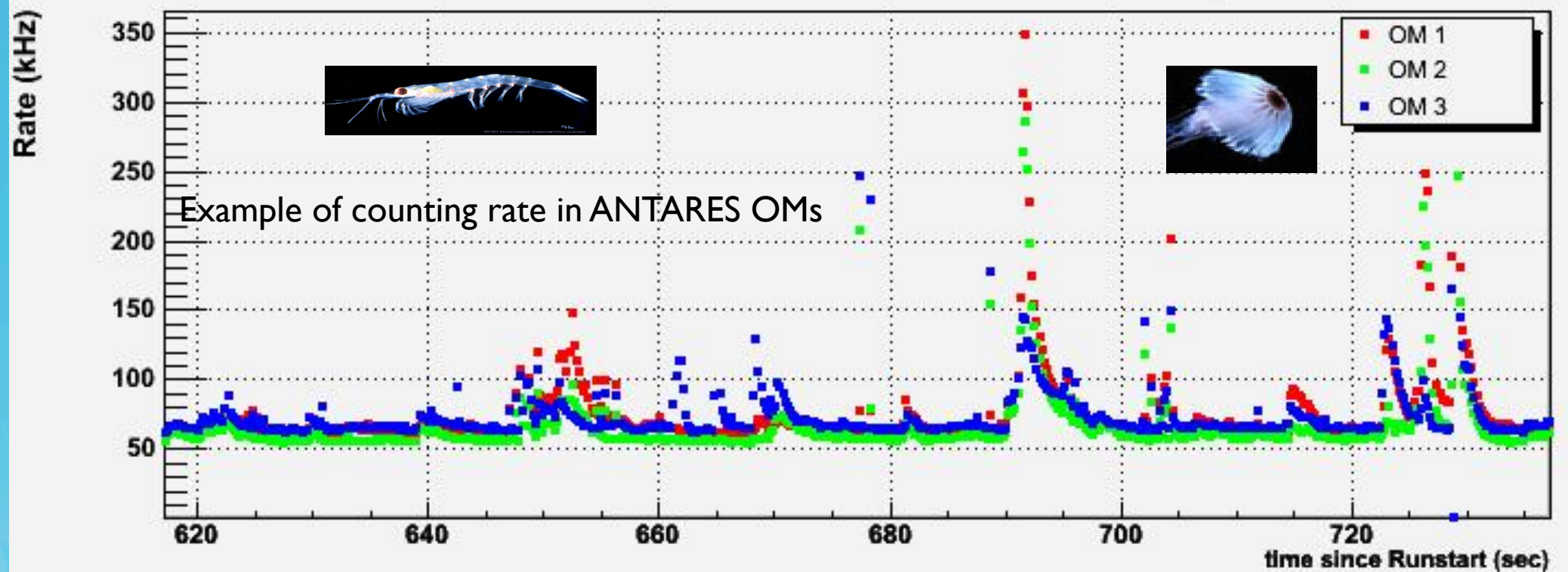
# Environmental background

Interesting  
scenarios for  
Earth and Sea  
Sciences

biology,  
physics  
oceanography....



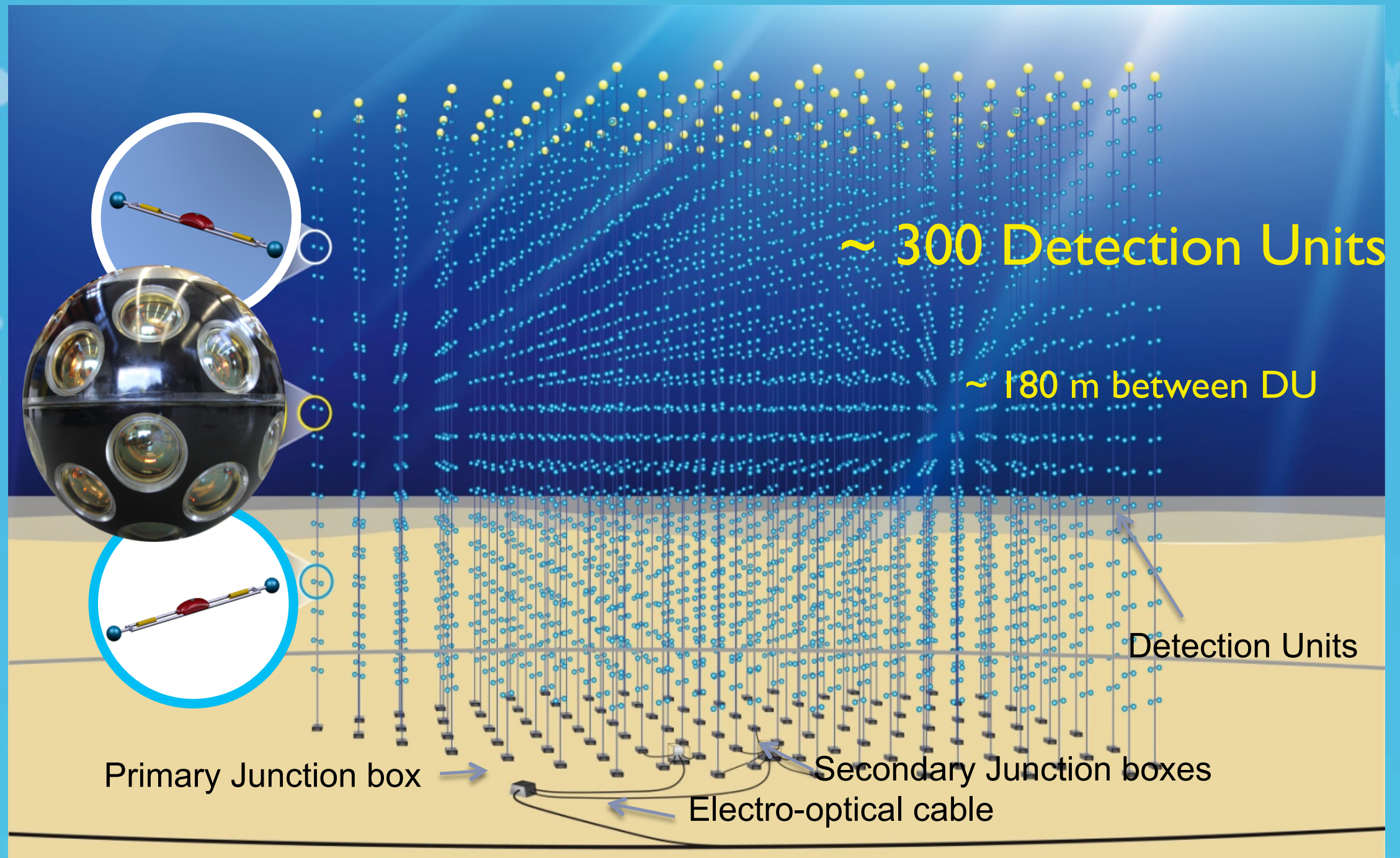
Run 27812 Line 1-5 Physics Trigger (thr=tuned, allsamp=1, HRV=500kHz) Line 4 Floor 13 Mon May 21 17:39:37 2007





KM3NeT

# An artist impression of the KM3NeT





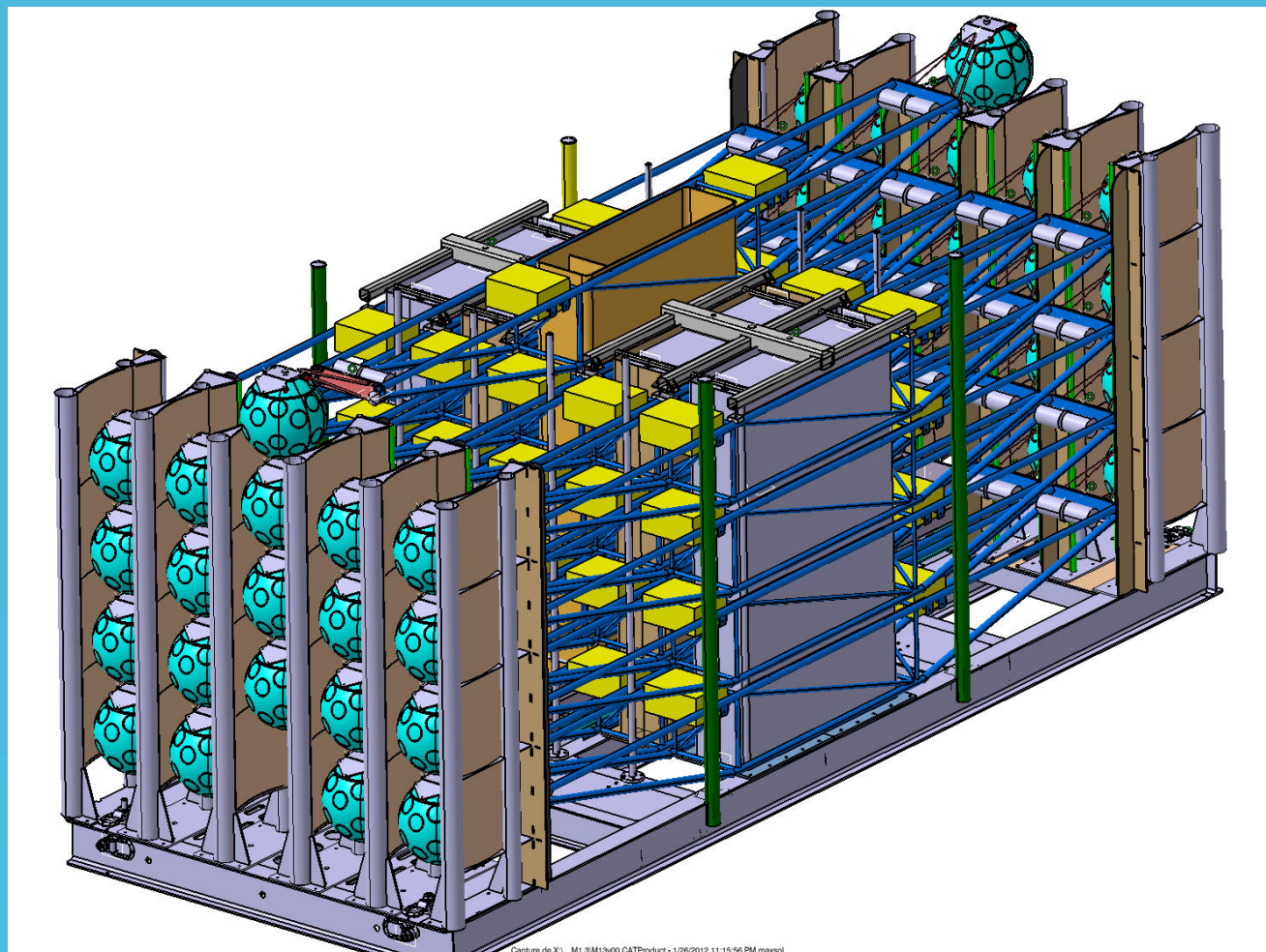
KM3NeT

Packed flexible tower

# The flexible tower

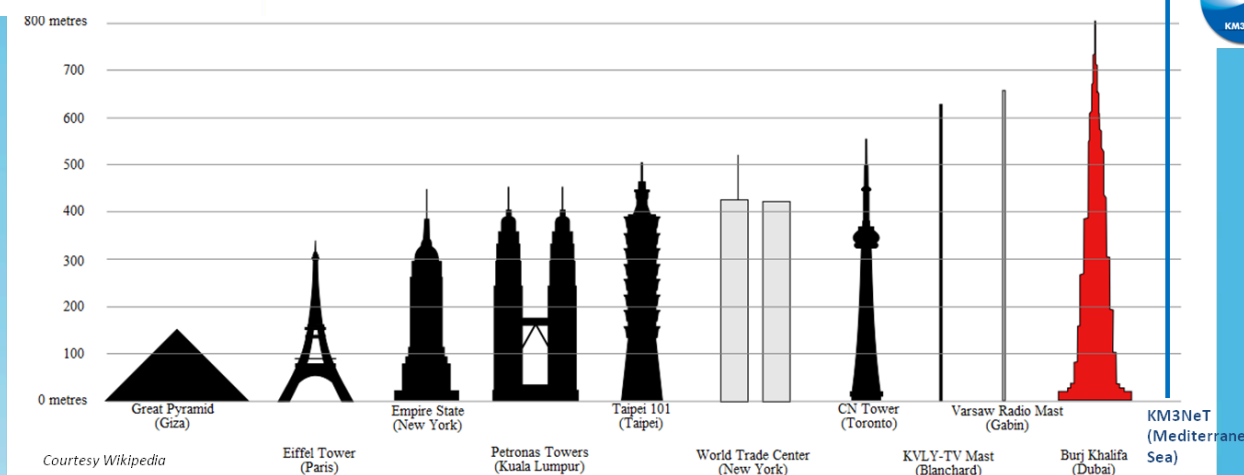
- Compact package
- Self unfurling - about 1 km high
- Connection to seabed network by Remotely Operated Vehicle
- **by end 2012 several tests of deployment and unfurling**

Detector Unit



<b>Storeys</b>	<b>20</b>
<b>Height</b>	<b>900 m</b>
<b>Compact Package</b>	<b>6 x 2.5 x 2.5 m</b>
<b>Top drift@30 cm/s</b>	<b>120 m</b>

13





KM3NeT

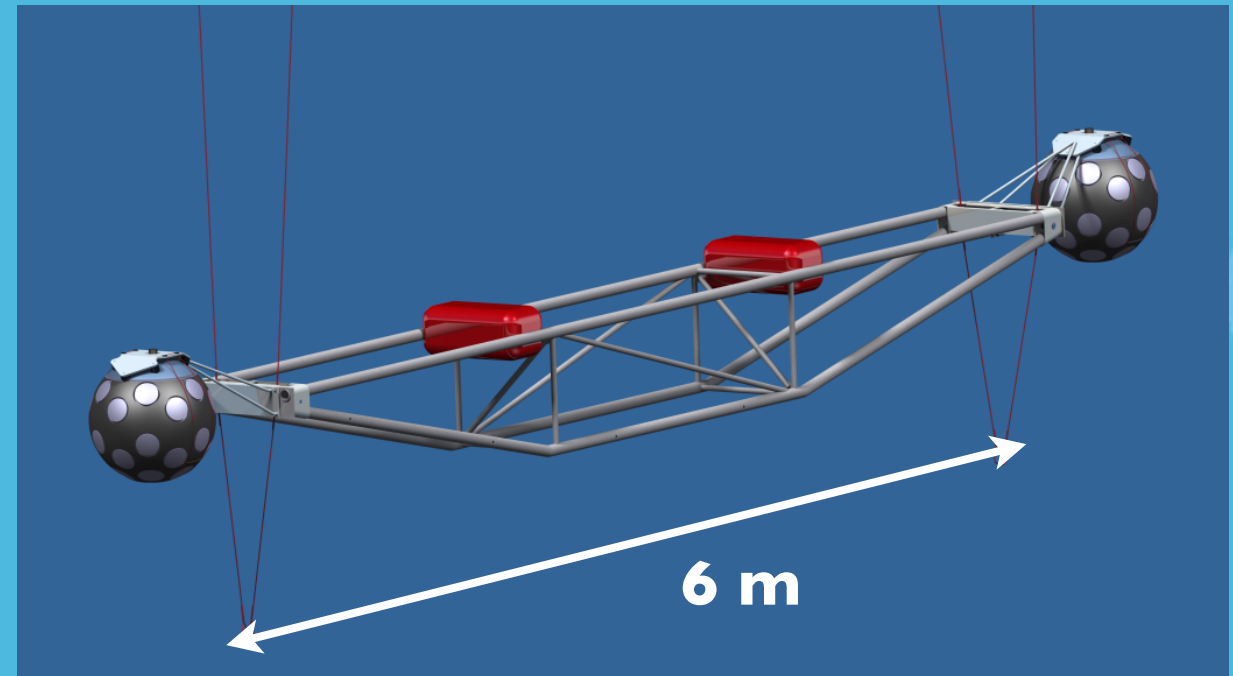
## Multi-PMT Optical Module



Self-contained “plug-and-play” module (17” pressure-resistant sphere)

- Photo-sensors 31 (19+12) 3” PMTs
  - Equivalent of 4 x 8” PMTs
- Includes:
  - All read-out/control electronics
  - Calibration devices
- Single colour point to point connection via DWDM between each OM and the shore station.

## The KM3NeT storey



### Distinguish single from multiple photon hits:

- Photon counting = PMT counting
- Background rejection – 40K

### Looking upward:

- Background rejection – atmospheric muons
- More uniform angular acceptance

### Directionality:

- Signal photons from one side

### Ageing:

- lower gain  $\sim 10^6$
- charge spread over multiple dynode chains



# The storey

the storey design fits with the following specifications:

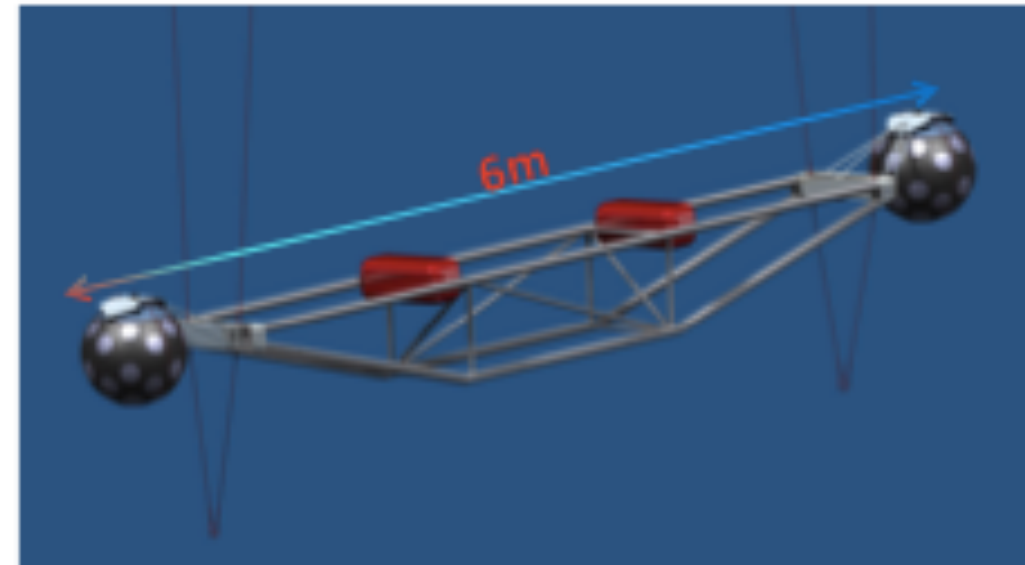
- maintain the DOMs at the assigned horizontal spacing
- host the ropes management system and the backbone
- keep the ropes system in the correct configuration
- minimize the drag
- stand to the stresses imposed by the surrounding environment and by the deployment
- minimize the shadowing on the DOMs (less than 2%)

the storey are made by slender tubes (40mm OD) welded to made a lattice girder  
a sea water resistant aluminium alloy (5000 series, peralluman) is the material chose for the tubes

the tapered shape of the beam aims to:

- minimize the shadowing on the PMTs
- maximize the strength of the girder
- maintain the centre of buoyancy above the centre of gravity

two further simplified and non instrumented beams, called "separator", will be installed between the anchor and the first storey to guarantee to the DU stiffness against torsion around the vertical axis

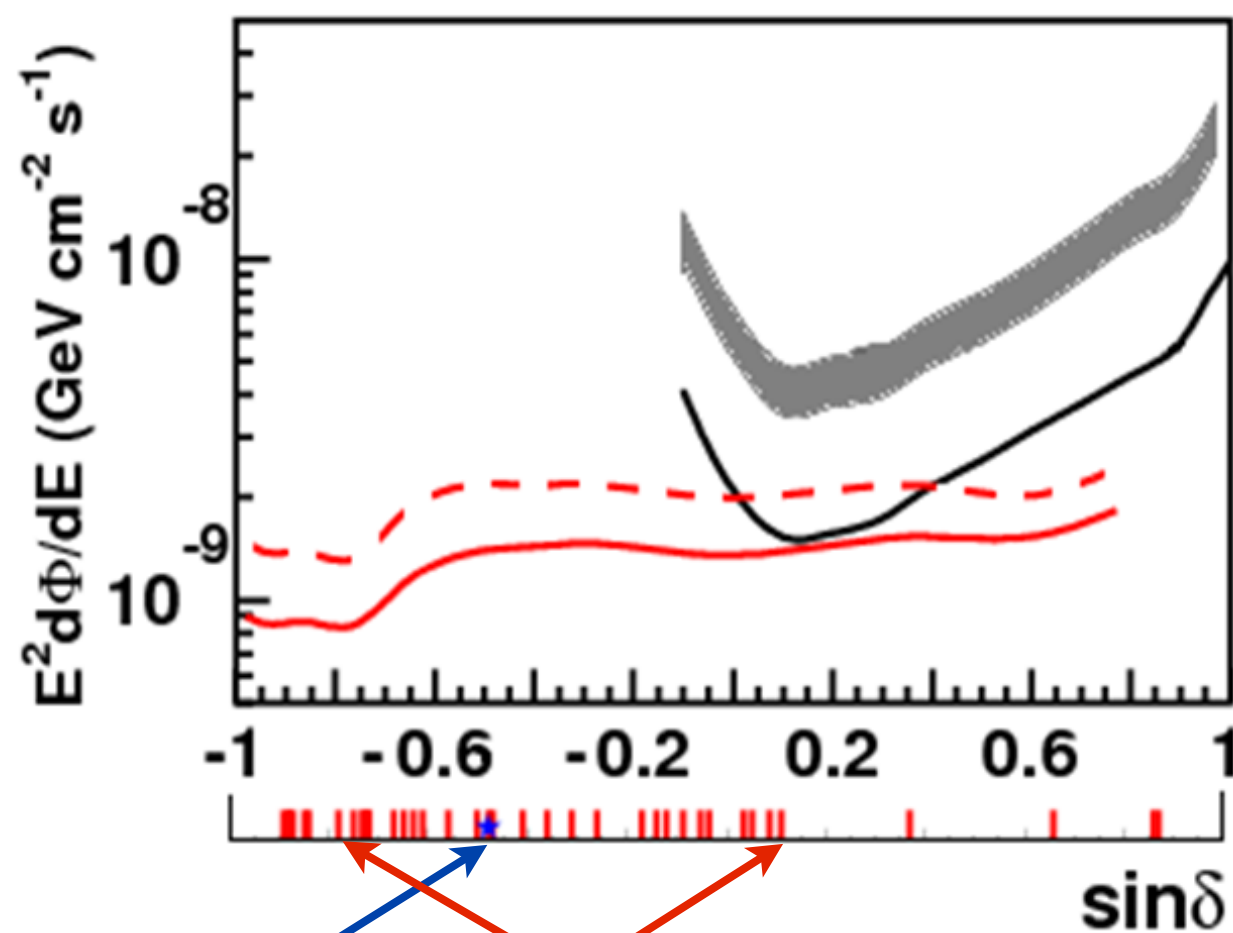


the red bricks, made of syntactic foam, arranged in the middle of the storey are used to distribute the buoyancy over the DU, in according with the KM3NeT TDR, in order to avoid that a top buoy's failure could have destructive effects.



# KM3NeT Performances

Sensitivity and discovery fluxes for point like sources ( $E^{-2}$  spectrum) for 1 year of observation time



★ Galactic Centre

Observed Galactic TeV- $\gamma$  sources  
(SNR, unidentified, microquasars)

F.Aharonian et al. Rep. Prog. Phys. (2008)

Abdo et al., MILAGRO, Astrophys. J. 658 L33-L36 (2007)

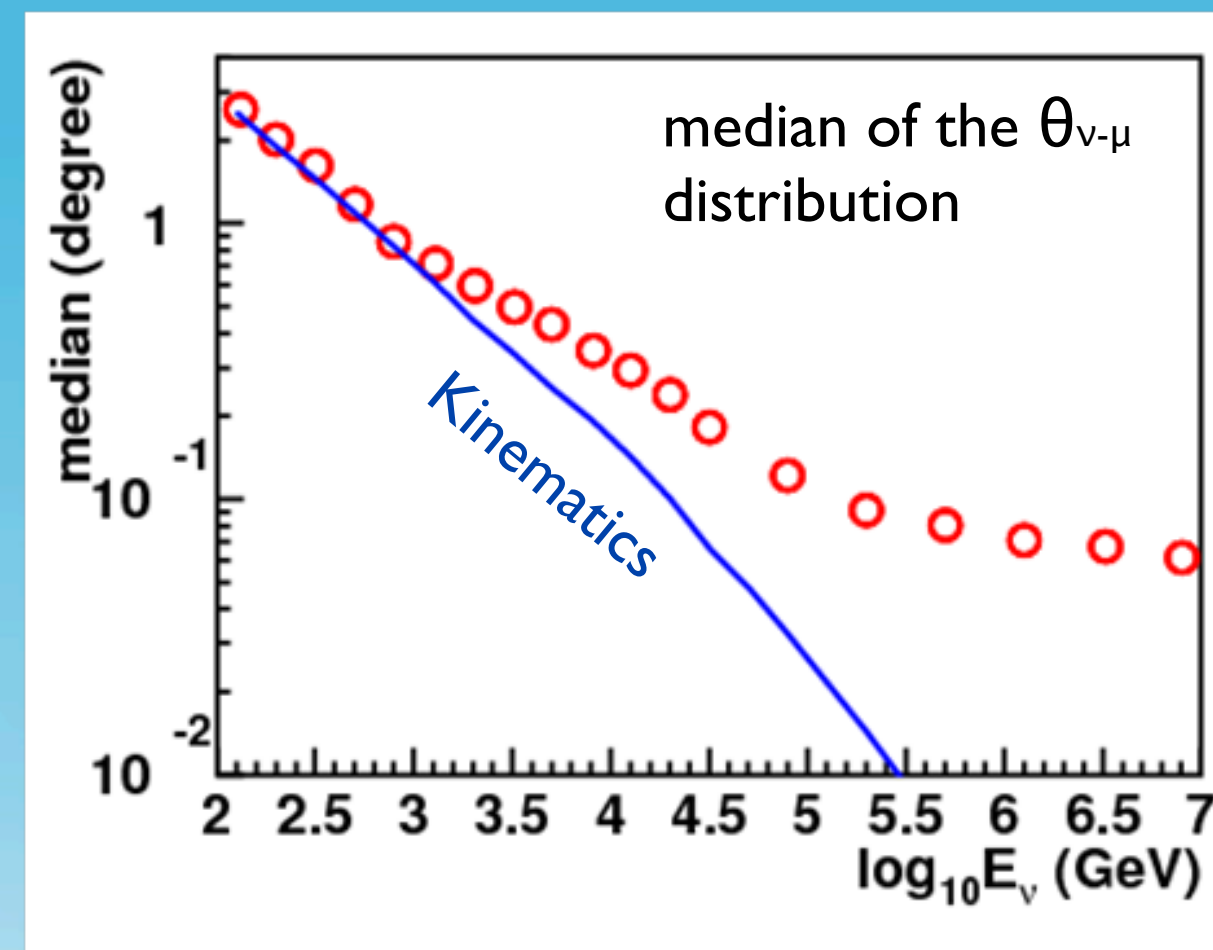
IceCube discovery  $5\sigma$  50 %  
2.5 ÷ 3.5 above sensitivity flux

IceCube sensitivity 90 %

KM3NeT discovery  $5\sigma$  50 %

KM3NeT sensitivity 90 %

Detector resolution



median of the  $\theta_{\nu-\mu}$   
distribution

Kinematics

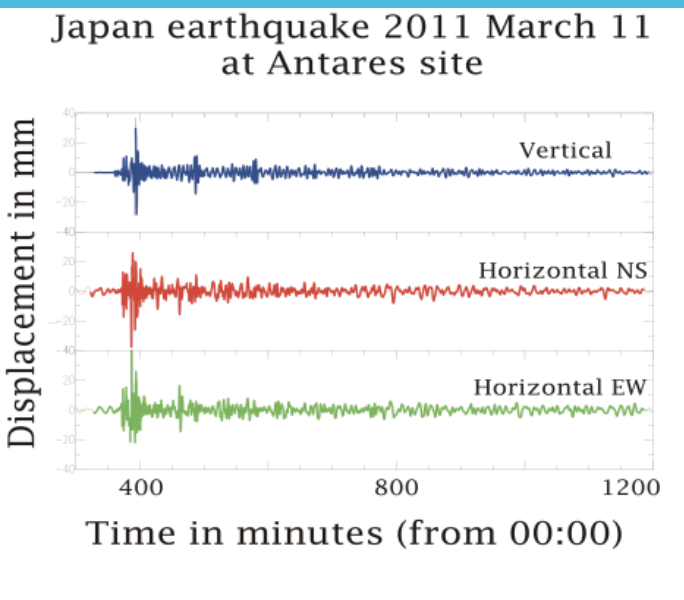




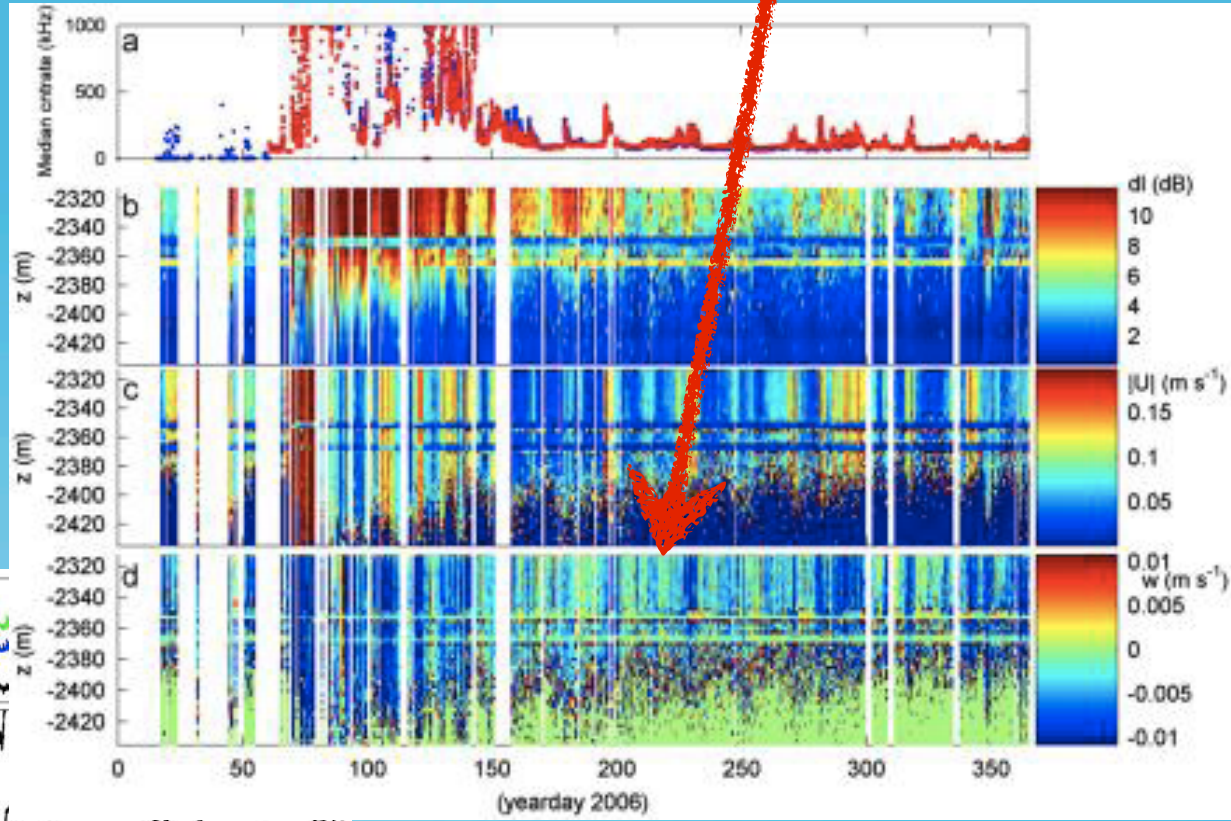
# Science case - Marine science

- The KM3NeT project will be a multidisciplinary observatory. More technical details in the talk of Claude Vallée.
- Some examples from the presently active installations:

## Seismology




Extremely high biological activity in 2006 associated to water vertical movements



## Marine biology

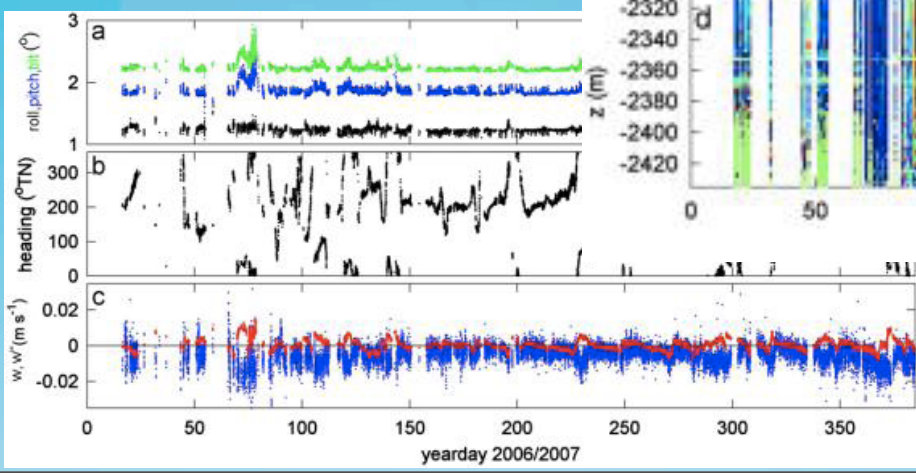
Hang on, that's not a neutrino

Dec 1st 2010, 16:10 by J.P.



**The Economist**

PHYSICISTS are often accused by the public and other scientists of spending inordinate sums on fancy kit that does little apart from merely satisfying human curiosity. Besides stressing that there is nothing more about knowledge, the boffins will typically respond by trotting out a long list of blue-sky projects that yielded serendipitous results, from microwave ovens to the internet. They can also offer plenty of examples of how their own research has aided colleagues in other fields, from climate science to, somewhat more improbably, marine biology.



## Physics oceanography





# Conclusions

- After a very long R&D activity the KM3NeT construction will start soon
- Major funding may come from EU structural funds and be “site”-linked
- First funds will allow the installation of the about 20 KM3NeT towers in Capo Passero and of some infrastructures in the Toulon site (C.Vallée’s talk).
- A dense program of validation of some technological solutions (multiPMT optical module + readout electronics, deployment and unfurling of the tower) and of the PreProduction Model is under way.
- A MoU is in preparation to define the rules of the KM3NeT Collaboration.



# Timeline

