Astroparticule et les Geosciences
Quelques pistes

Stavros Katsanevas
APC, Astroparticle Physics and Cosmology

Deux mots de caution

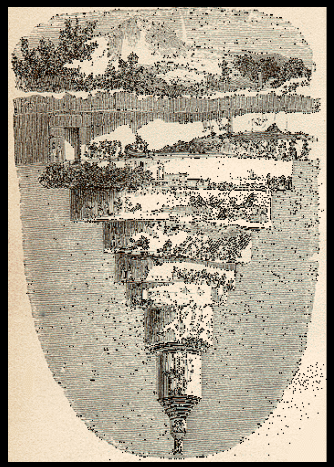
Une entreprise interdisciplinaire doit assumer pendant un certain temps une précision moindre que celle revendiquée dans les branches canoniques du savoir. Parmi les particularités des sciences confortées dans leur conscience d'elles-mêmes, il y a le fait qu'elles croient toujours savoir avec bien plus de précision qu'on ne peut savoir. En aucun cas n'a-t-on obtenu le rétrécissement et l'isolement de l'objet d'étude sans contrepartie. Parce qu'elle n'accepte pas la délimitation bien définie et éprouvée de l'objet, l'entreprise interdisciplinaire doit avoir tout d'abord pour effet de décevoir ….

Hans Blumenberg

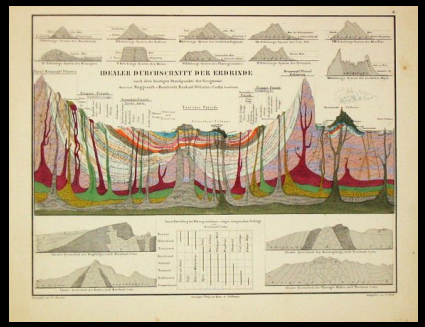
« Il y a deux types de physiciens qui mettent un pied en biologie. Les arrogants et les modestes. Les physiciens arrogants disent que la biologie a besoin de meilleurs concepts et que puisque les physiciens sont bons en concepts, leur tache est de dire aux biologistes comment ils doivent penser. Les physiciens modestes disent que la biologie a besoin de meilleures machines et que comme les physiciens sont bons en machines, leur tache est d'inventer des nouveaux outils que les biologistes pourront utiliser. Les physiciens qui inventent des nouveaux outils ont eu le plus grands impact. »

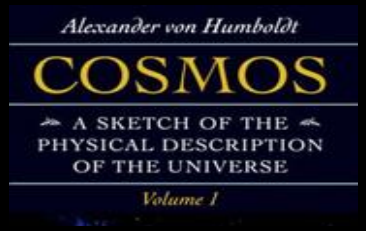
Freeman Dyson

From Gaia to Cosmos
Illustrious predecessors

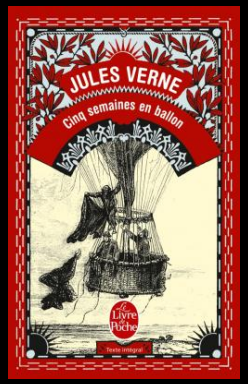


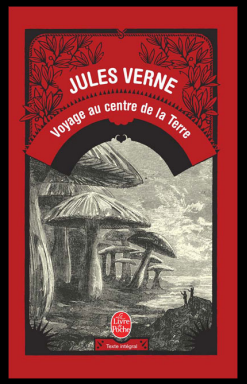
Galieleo Galilei: Two Lectures to the Florentine Academy:
On the Shape, Location and Size of Dante's Inferno
(1588)
Use of scaling arguments

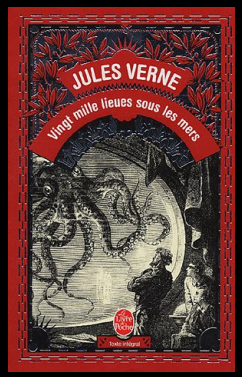




Alexander von Humboldt: Cosmos
(1845-1862)
"Unified" description of the Universe
Re-introduction of the ancient word



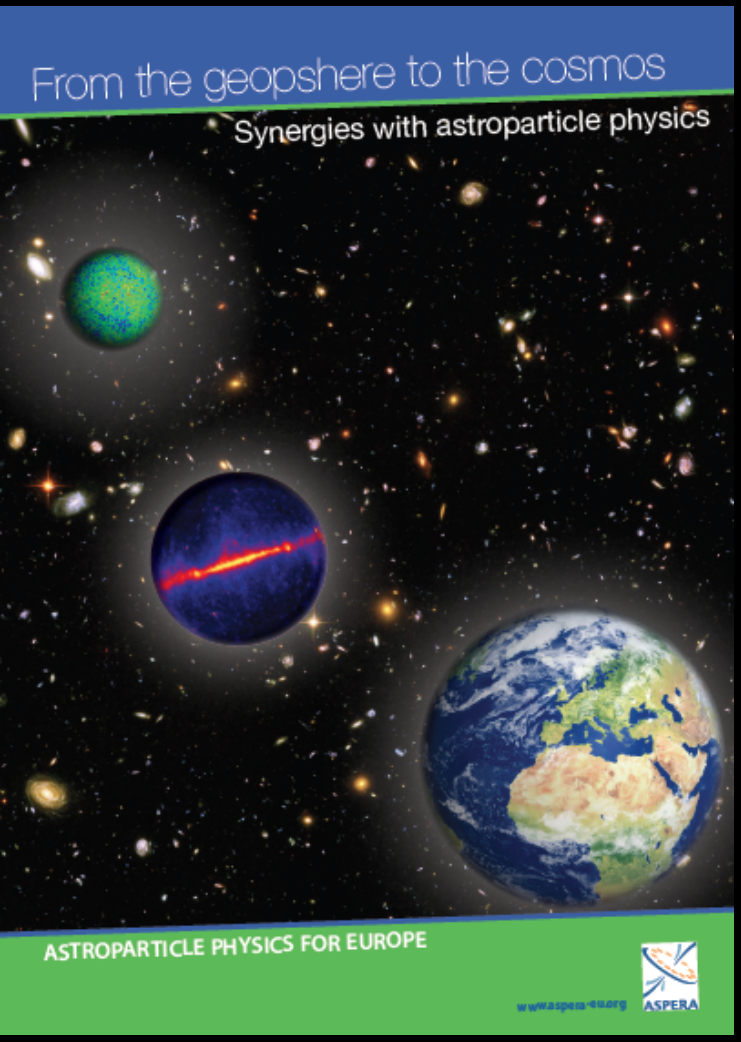




Jules Verne
Voyages Extraordinaires
(1862-1886)
I will use him as "cicerone"

A modern attempt
From the Geosphere to the Cosmos
APPEC and ASPERA

http://www.appec.org/multidisciplinarity.html



3 workshops:

- Paris 2010 : From the Geosphere to the cosmos
- Amsterdam 2012: Deep Ocean Cabled Observatories
- Durham 2012: Underground synergies

Synergy Geosciences-astroparticle: a new frontier:

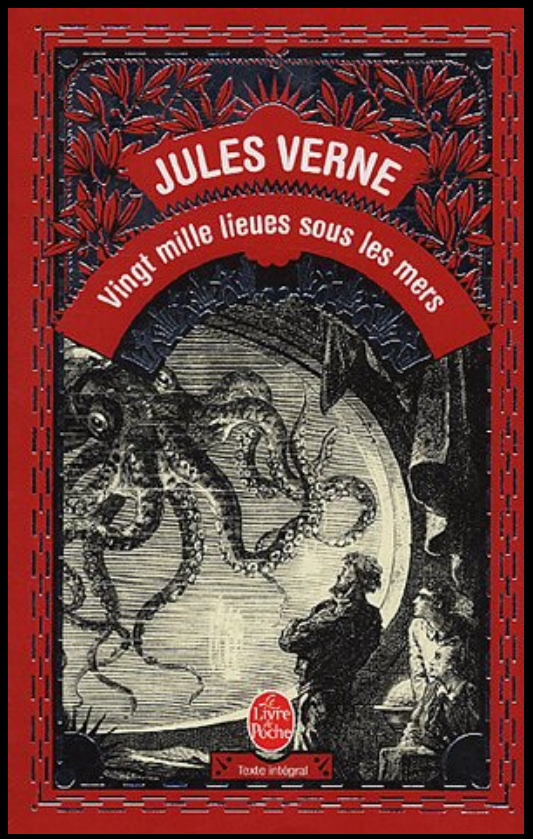
- For astroparticle the Geosphere is both the target and the detecting medium: continuous time series data by deploying large (autonomous?) sensor networks in hostile environments (sea, desert, underground)
- Dating is important: radioctivity-free platforms
- High sensitivity instruments for probing very low intensity geological effects, metrology
- Large data manipulation and worldwide networking. Distribution of alerts

The 2010 census: close to 40 points of synergy

	ATMOSPHERIC AND TERRESTRIAL	UNDERGROUND	UNDERWATER
UNDERSTANDING THE ATMOSPHERE	1. SPACE WEATHER (Section 3.1.1) 2. ATMOSPHERIC MONITORING (Section 3.1.2) 3. COSMOCLIMATOLOGY (Section 3.1.3) 4. THUNDERSTORMS and LIGHTNINGS (Section 3.1.5)	1. COSMOCLIMATOLOGY (Section 3.1.3)	1. ATMOSPHERIC TEMPERATURE VARIATION (Section 3.1.4)
UNDERSTANDING THE EARTH	1. EROSION RATE CALCULATION (Section 3.2.1) 2. VOLCANO TOMOGRAPHY (Section 3.2.5)	1. COASTAL ROCK CLIFF EROSION (Section 3.2.2) 2.CHRONOLOGY for THE PALEOENVIRONMENT (Section 3.2.3) 3. EARTH's INTERIOR - GEONEUTRINOS (Section 3.2.6)	1. PALEOCLIMATE (Section 3.2.4) 2. EARTH RADIOGRAPHY (Section 3.2.7)
UNDERSTANDING THE OCEANS		1. CORAL CHRONOLOGY (Section 3.3.6)	1. CONTINUOUS OCEANOGRAPHIC DATA (Section 3.3.1) 2. SEDIMENT TRANSPORT (Section 3.3.2) 3. OXYGEN DYNAMICS (Section 3.3.3) 4. RADIOACTIVITY (Section 3.3.4) 5. INTERNAL WAVES (Section 3.3.5)
UNDERSTANDING EARTHQUAKES	1. EARTHQUAKE MONITORING GRID (Section 3.4.1)	1. SEISMO-ELECTROMAGNETIC COUPLINGS (Section 3.4.4) 2. EARTHQUAKE PRECURSORS (Section 3.4.5) 3. SLOW EARTHQUAKE MONITORING (Section 3.4.6)	1. EARTHQUAKE AND TSUNAMI MONITORING (Section 3.4.2) 2. STUDYING THE LAKE ENVIRONMENT (Section 3.4.3)
UNDERSTANDING BIODIVERSITY		1. IMPACT OF RADIATION (Section 3.5.7) 2. EXTREMOPHILES (Section 3.5.8)	1. UNDERWATER SOUND MONITORING (Section 3.5.1) 2. DEEP SEA BIOLUMINESCENCE (Section 3.5.2) 3. BIODIVERSITY UNDER ICE (Section 3.5.3) 4. BIODEGRADATION (Section 3.5.4) 5. MICROBIOLOGY (Section 3.5.5) 6. BIOFOULING (Section 3.5.6)
APPLICATIONS		1. WINE DATATION (Section 3.6.1) 2. SALT CHARACTERISATION AOC (Section 3.6.2) 3. SOFT ERROR RATE IN ELECTRONICS (Section 3.6.3) 4. ROCK DEFORMATION (Section 3.6.4)	

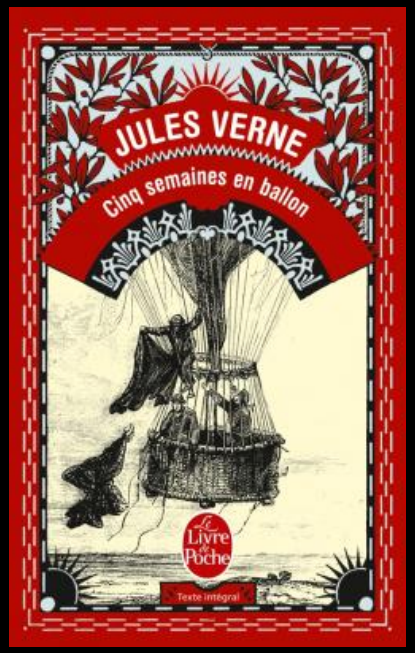
Outline

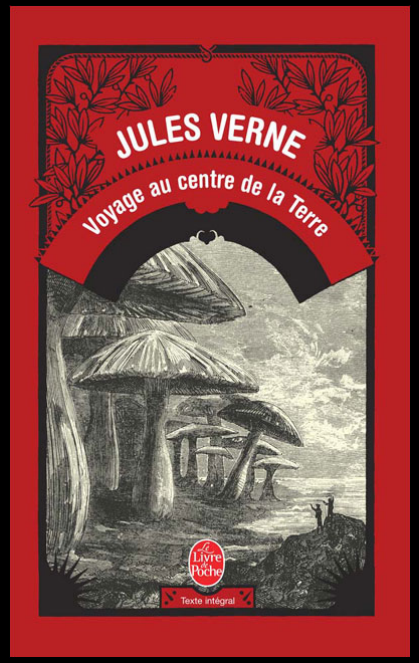
- Cosmic rays and the atmosphere
  - Atmospheric electricity
  - Meteorites
  - Activating the earth elements
  - Tomography
  - Gravitatinal wave antenna apps(see JPM)



- Underwater/Under-ice
  - Underwater instrumentation
  - Seismology
  - Oceanography
  - Biodiversity (coupling of life to matter)
  - Probing the earth core (see AT)

- Underground
  - Dating applications
  - Geoneutrinos (see AT)
  - Future

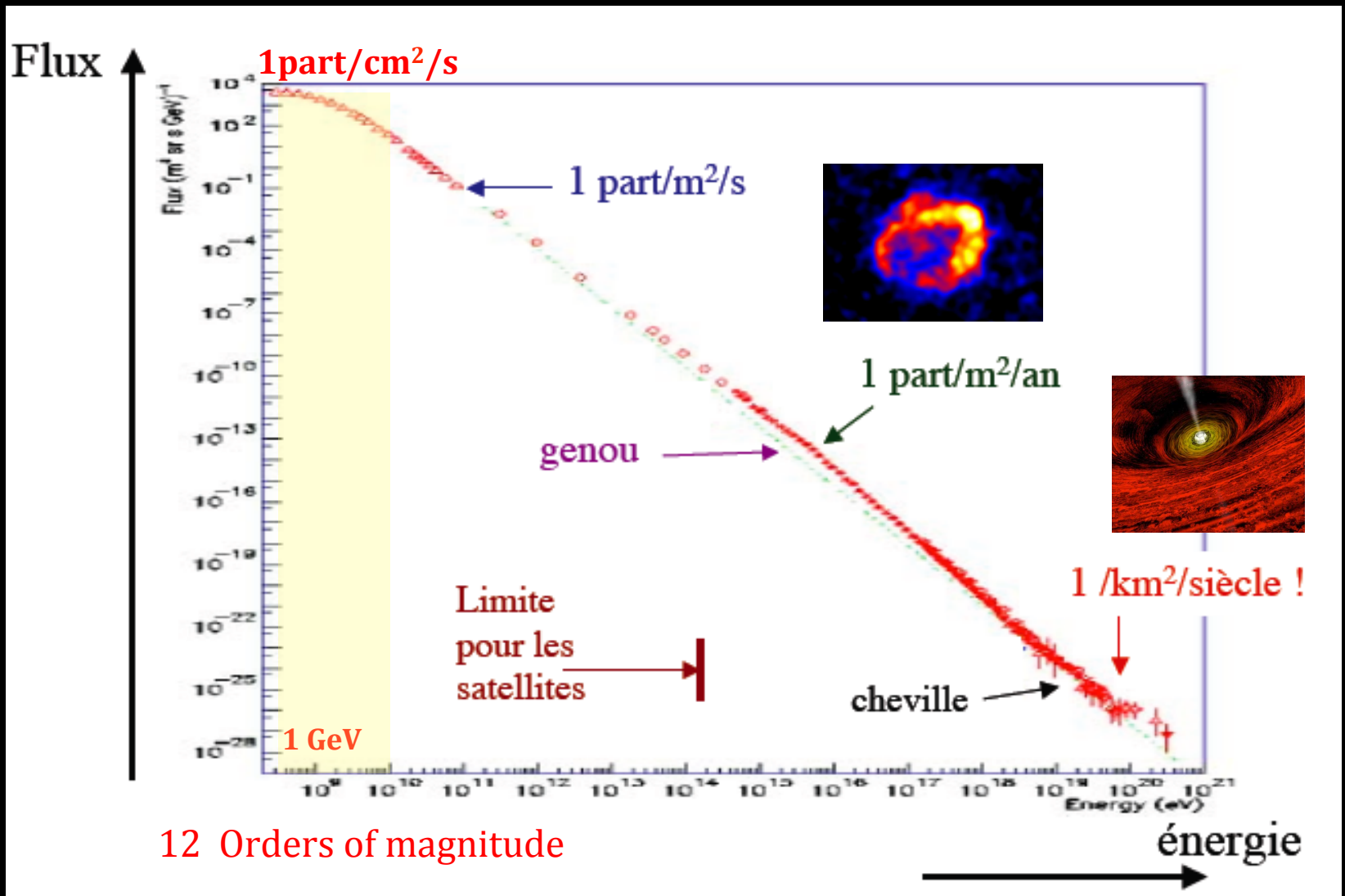




Atmospheric synergies

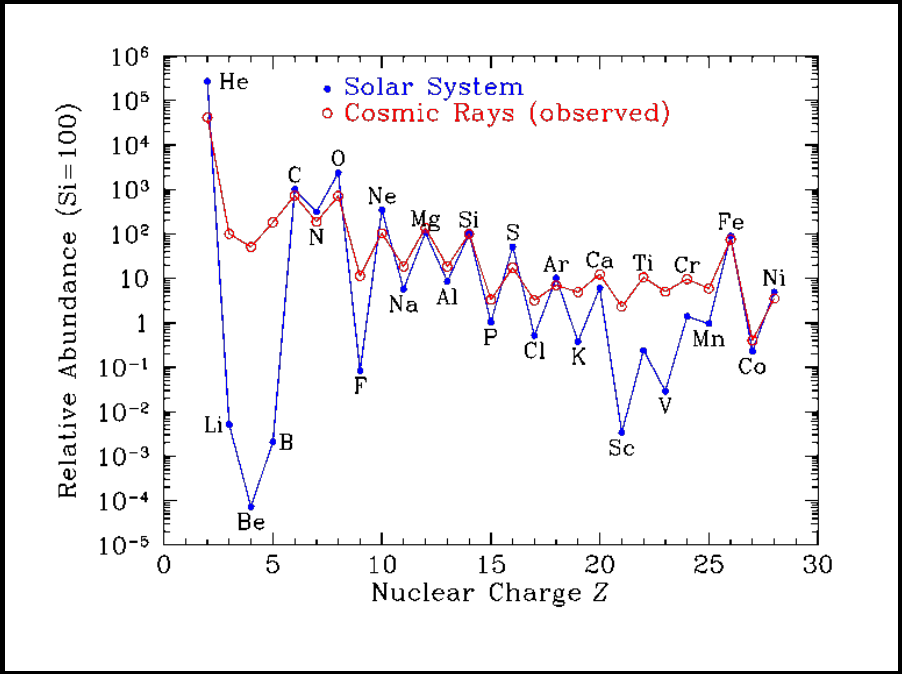
ASTRI E PARTICELLE - LE PAROLE DELL'UNIVERSO

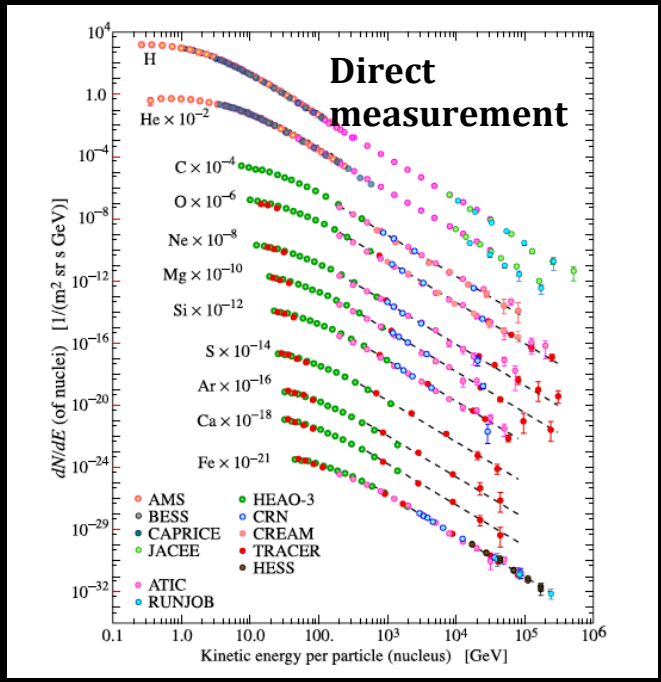
Fluxes

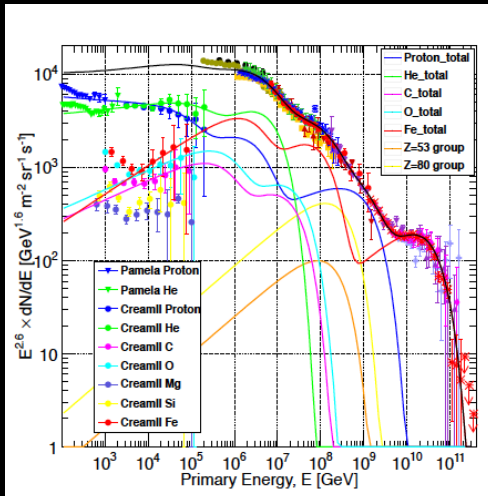


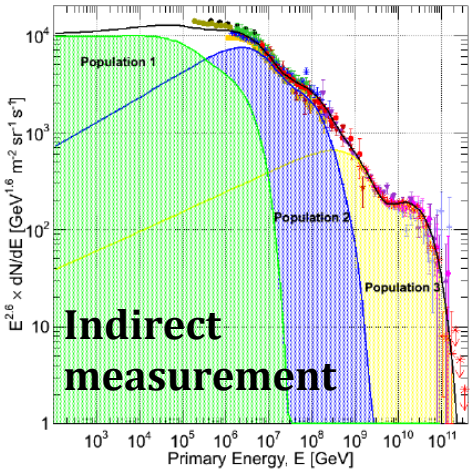
12 Orders of magnitude

Composition of cosmic rays (nuclei)

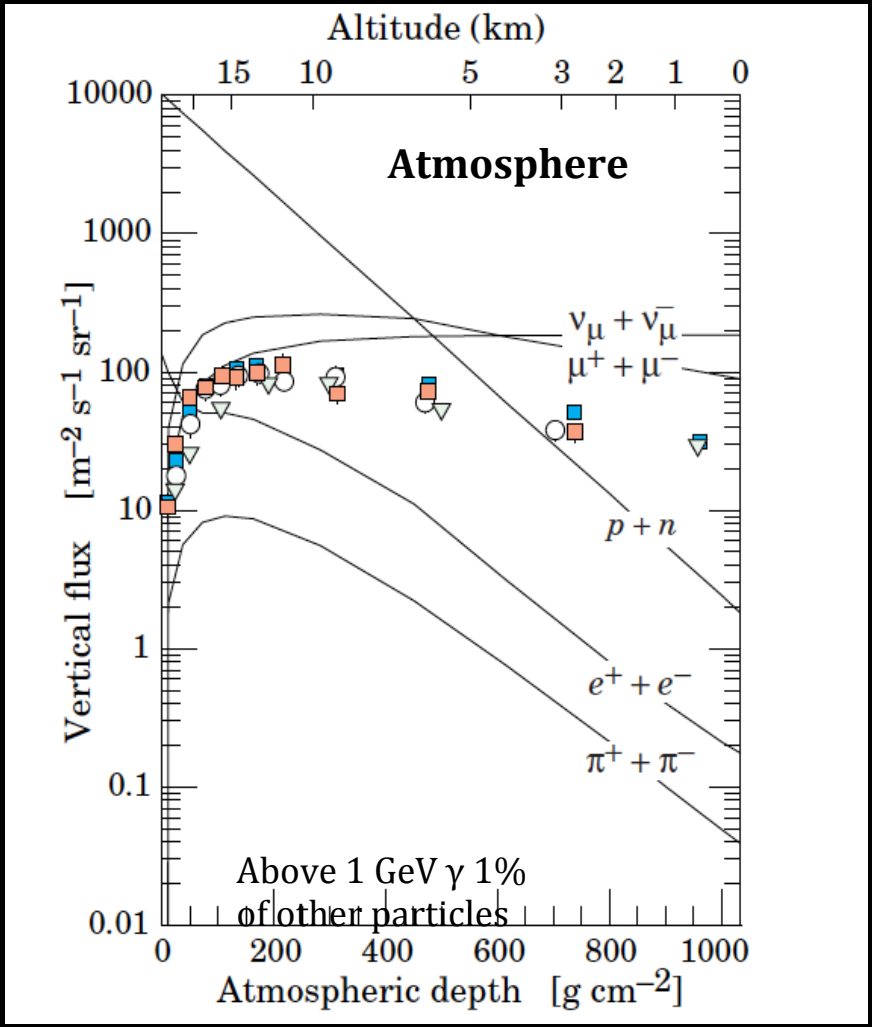




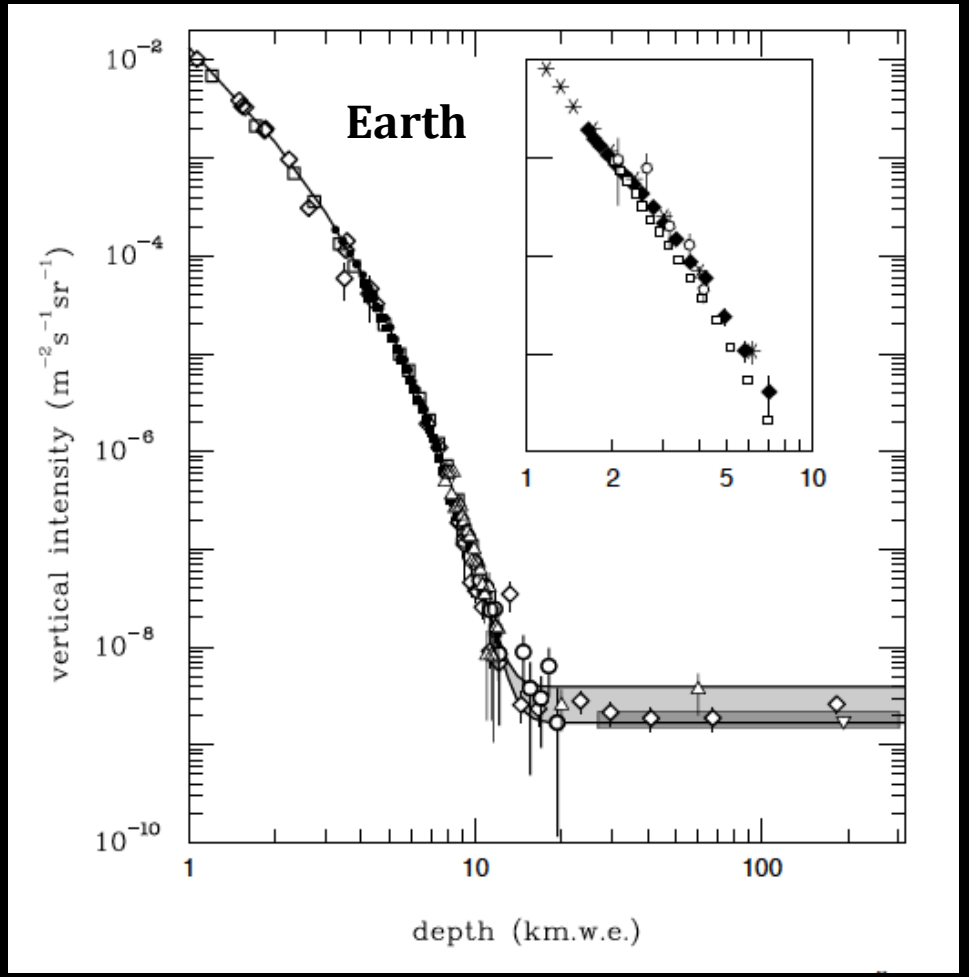




Composition of cosmic rays (particles)



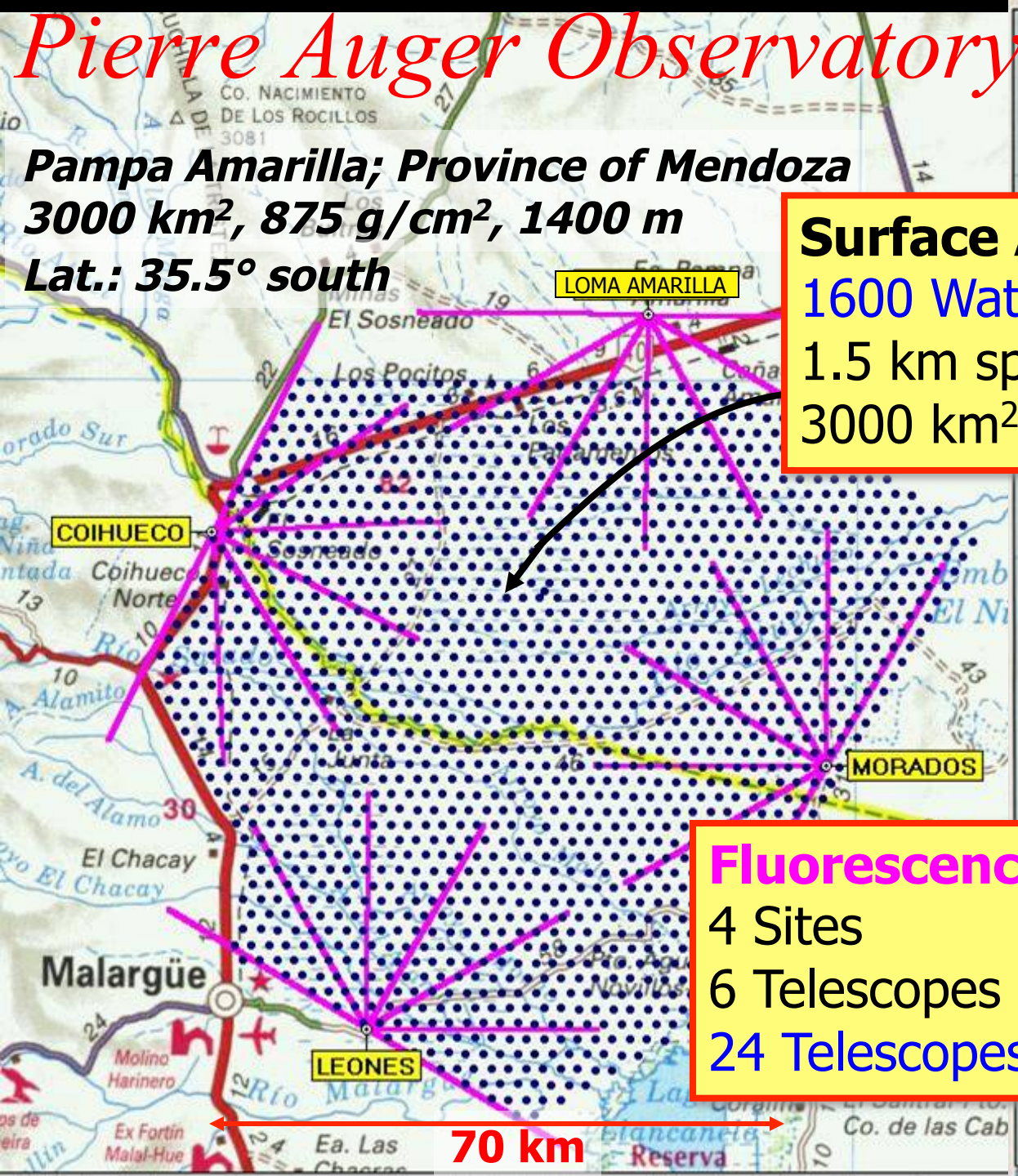
$$\pi^+ \rightarrow \mu^+ + \nu$$



Vertical muon intensity vs depth
(1km w.e = 10^5 g/cm^2 of standard rock)

Pierre Auger Observatory

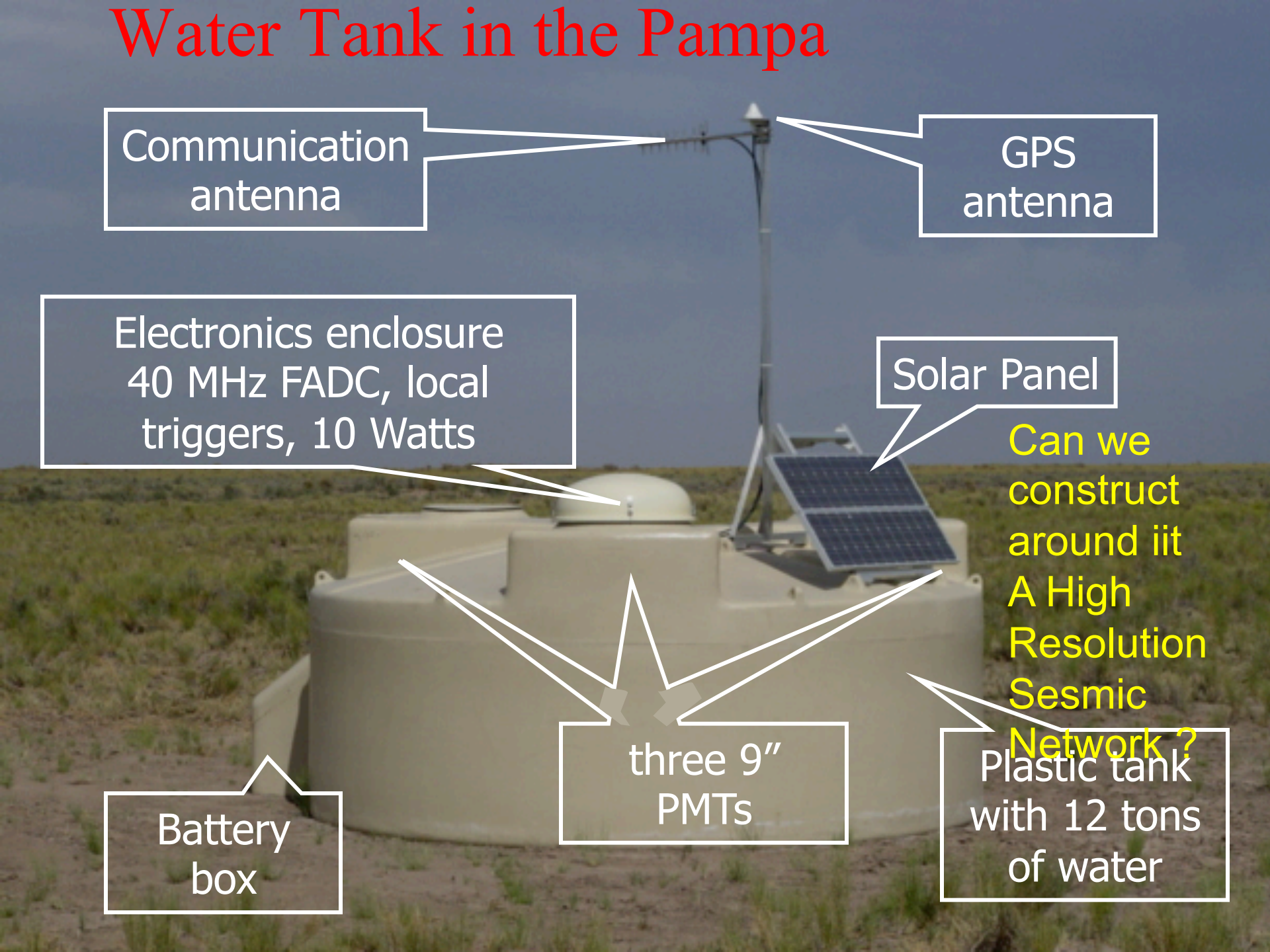
Pampa Amarilla; Province of Mendoza
3000 km², 875 g/cm², 1400 m
Lat.: 35.5° south



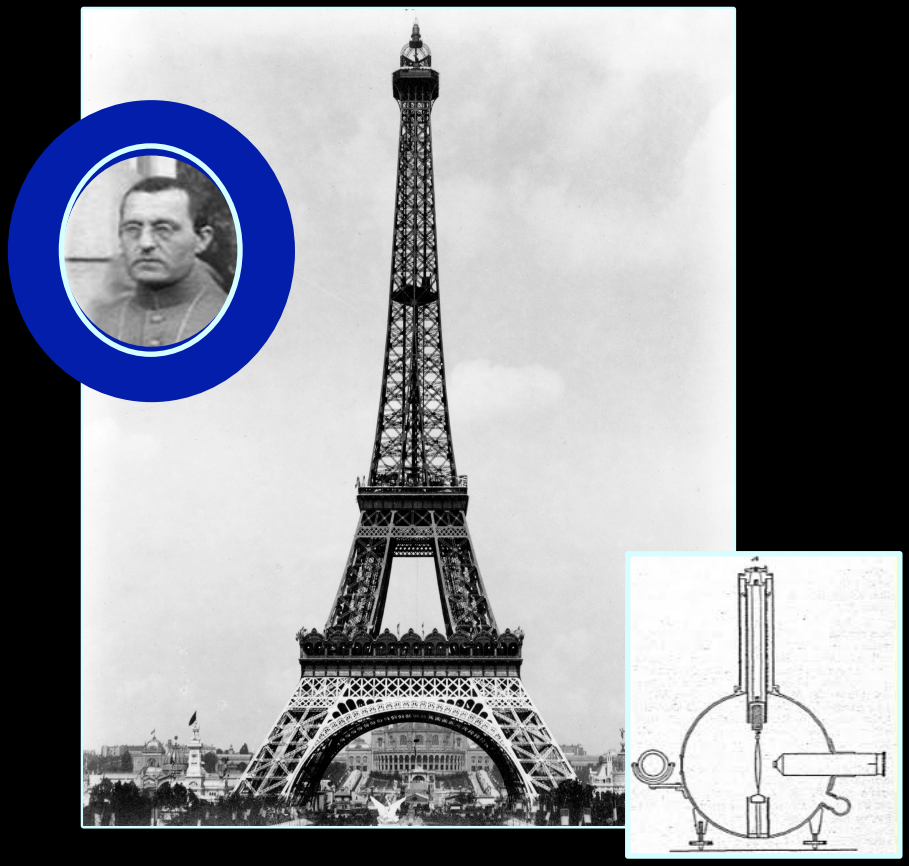
Surface Array:
1600 Water Tanks
1.5 km spacing
3000 km²

Fluorescence Detectors:
4 Sites
6 Telescopes per site (180° x 30°)
24 Telescopes total

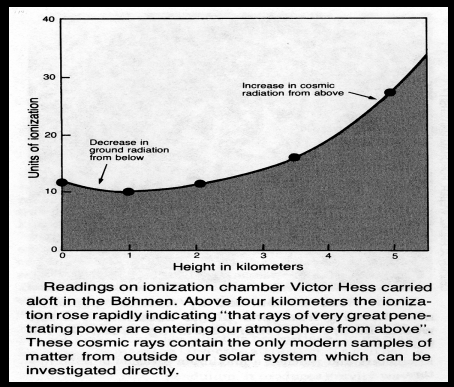
Water Tank in the Pampa



Ionisation of the atmosphere (CRT Wilson) a centenary problem coupling cosmic rays and atmospheric science



6am August 7, 1912
Aussig, Austria

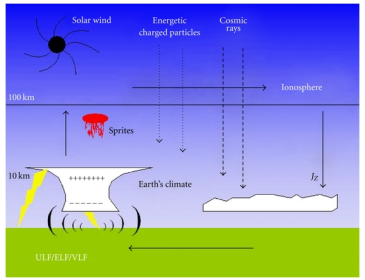


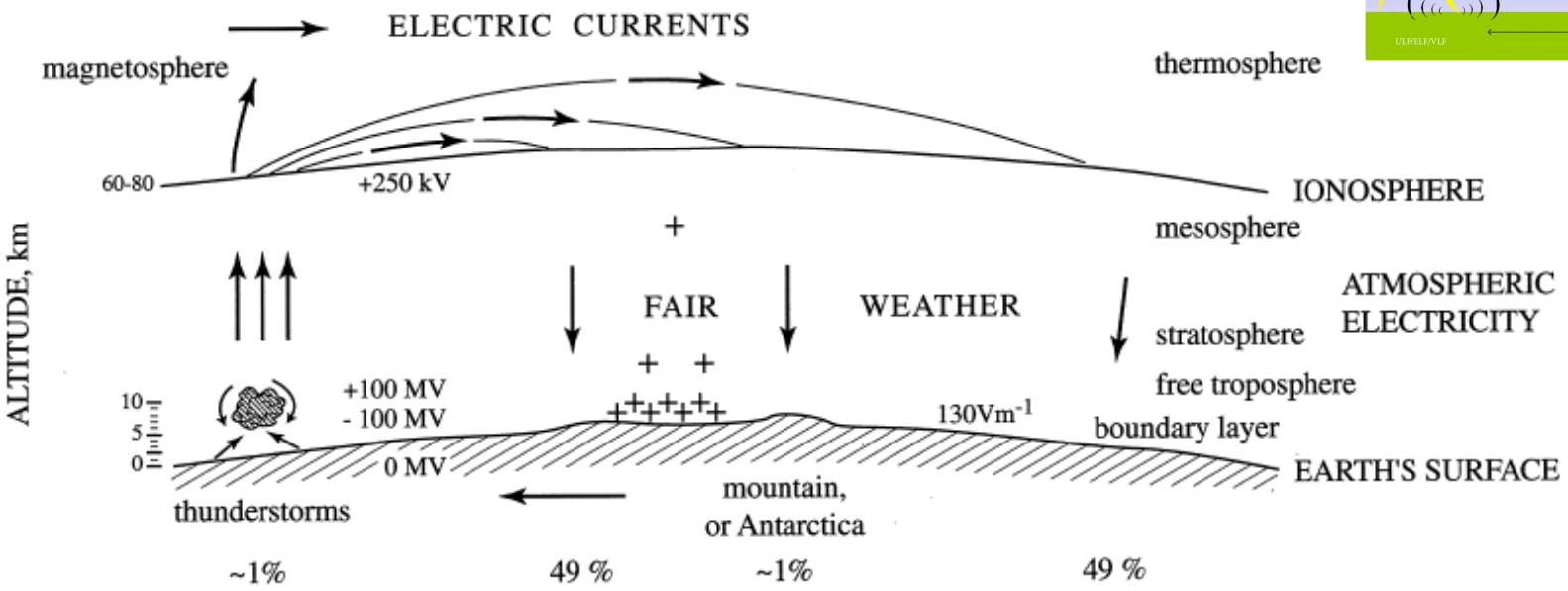
Readings on ionization chamber Victor Hess carried aloft in the Böhmen. Above four kilometers the ionization rose rapidly indicating "that rays of very great penetrating power are entering our atmosphere from above". These cosmic rays contain the only modern samples of matter from outside our solar system which can be investigated directly.

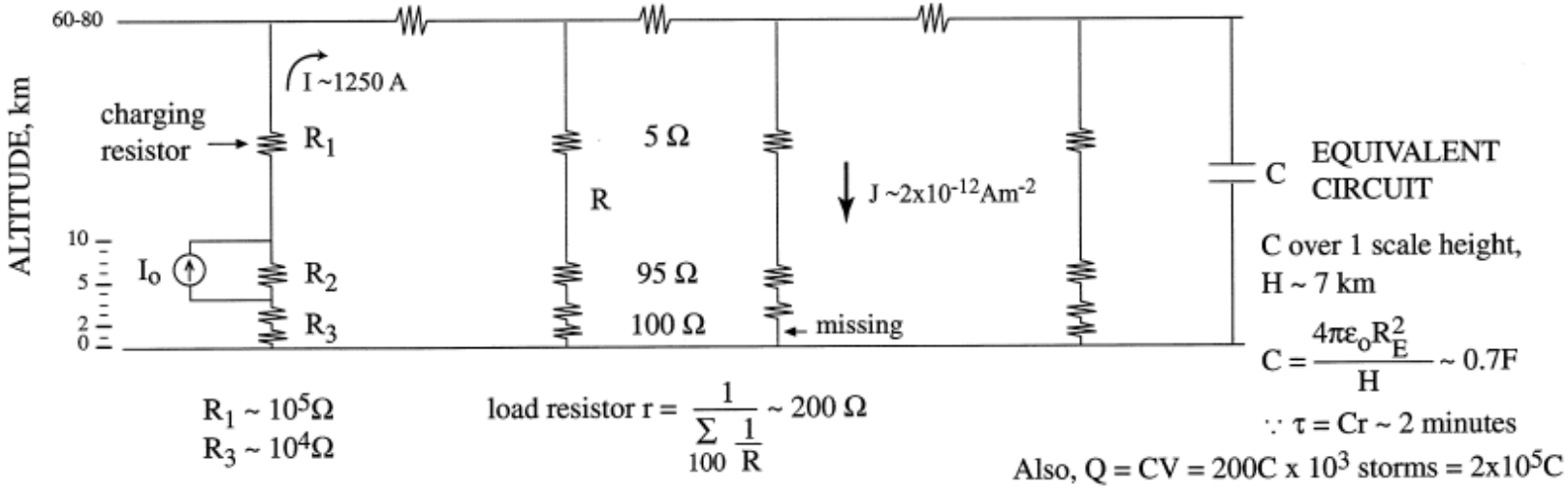
First measures T. Wulff
1909-1910 Tour Eiffel

Effectivement ces particules viennent du cosmos,

The atmosphere as an electric circuit





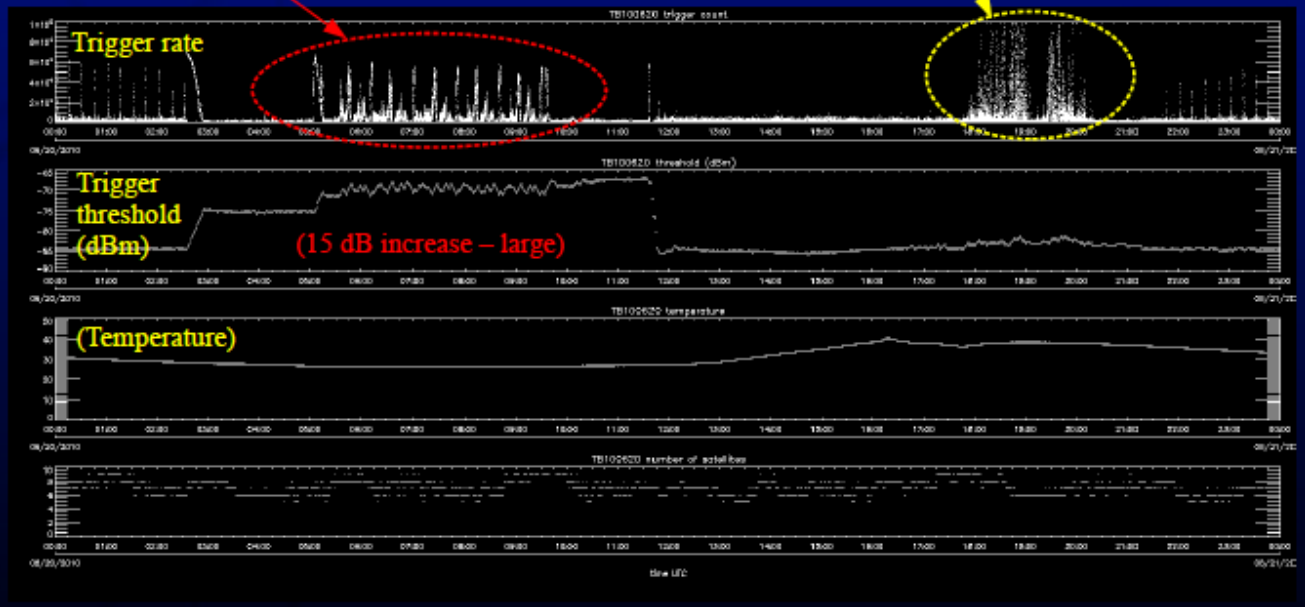


Lightnings and High Energy Cosmic Rays

Raw data from station B:
Man-made and lightning- produced signals

Local radio frequency interference (RFI) from Fluorescence Telescopes

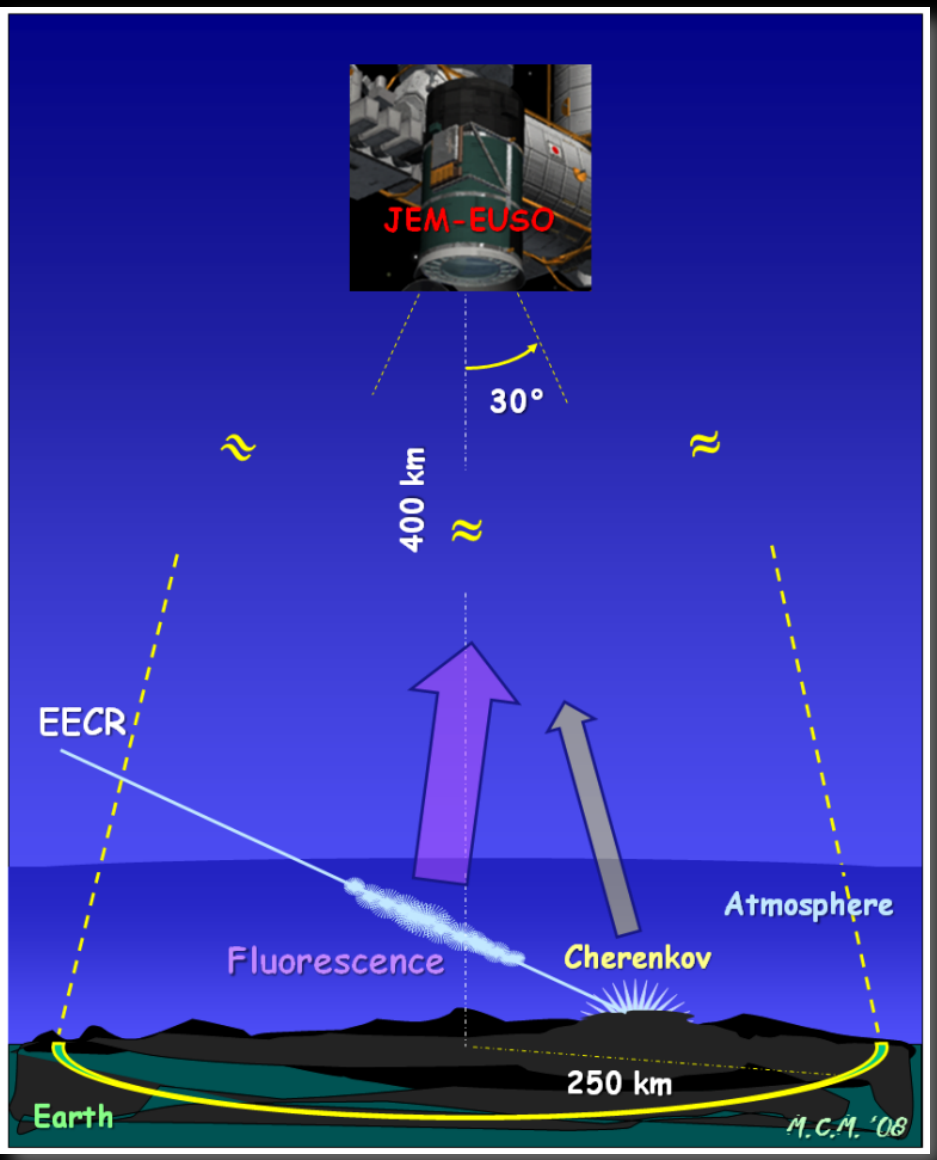
Lightning signals from somewhere over/around Pierre Auger



Can distinguish between lightning and local RFI noise by correlating signals from the two LMA stations

- Expect a couple of geolocated ultra high energy CRs through electrically active storms per year. If individual CRs have an effect on storms these should.

See the atmosphere from above



Énorme champ de vue (60° d'ouverture)

Caméra ultra-sensible dans l'UV (photon unique)

Caméra ultra-rapide (2.5 µs)

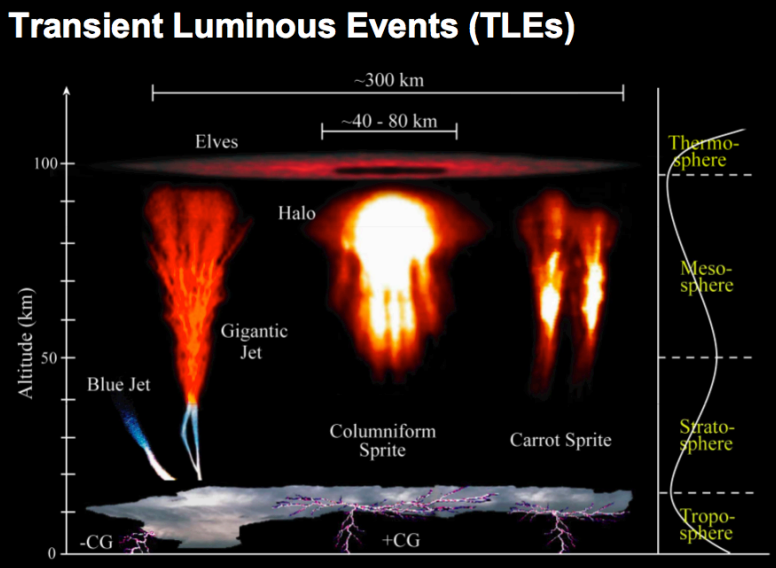
300 000 pixels

+ Caméra Infraouge
+ LIDAR
+ High power Laser

Posible synergies JEM-EUSO I

Armospheric science

TLEs (sprites, jets, elves, halos…)

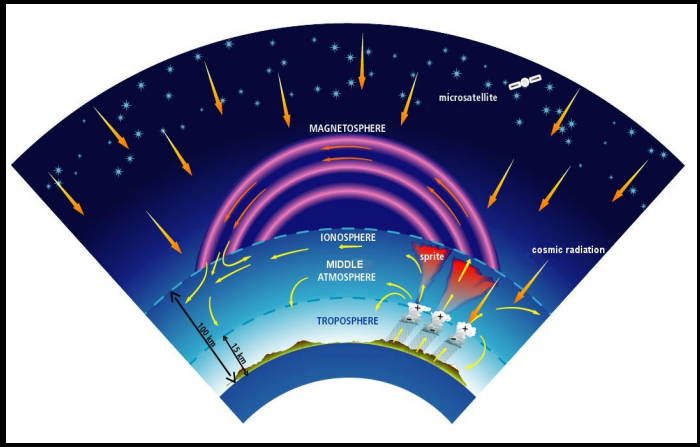


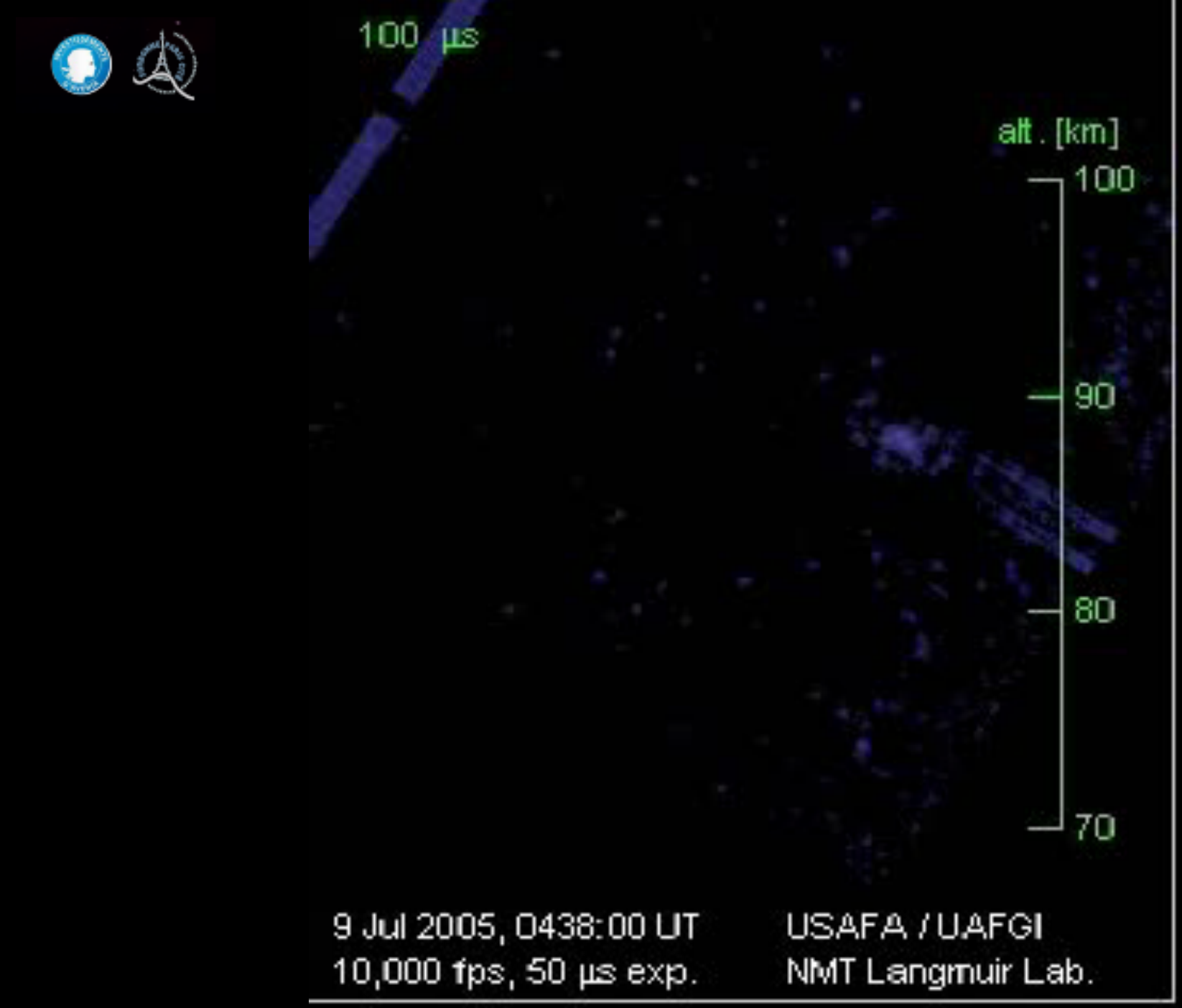
NEW : ionospheric airglow:

Imaging and modeling the ionospheric airglow response over Hawaii to the tsunami generated by the Tohoku earthquake of 11 March 2011

J. J. Makela,[1] P. Lognonné,[2] H. Hébert,[3] T. Gehrels,[1] L. Rolland,[2] S. Allgeyer,[3] A. Kherani,[4] G. Occhipinti,[2] E. Astafyeva,[2] P. Coïsson,[2] A. Loevenbruck,[3] E. Clévédé,[2] M. C. Kelley,[5] and J. Lamouroux[6]

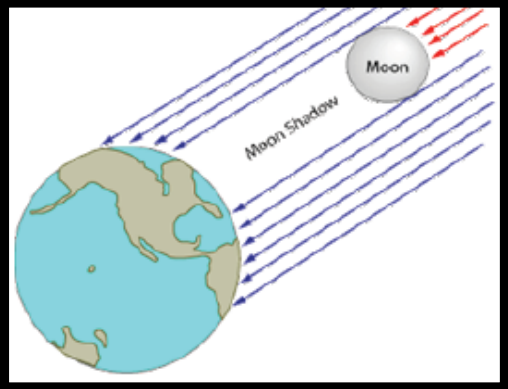
Received 19 April 2011; revised 25 May 2011; accepted 25 May 2011; published 7 July 2011.

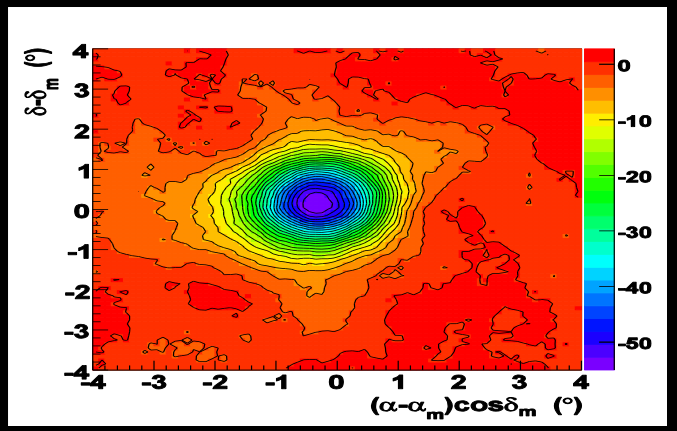


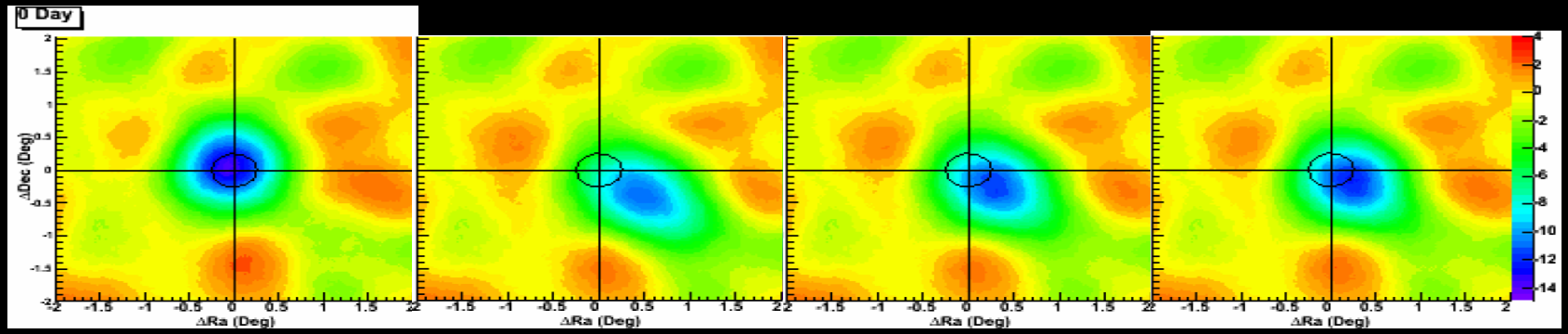

100 µs
alt . [km]
100
90
80
70
9 Jul 2005, 0438:00 UT
10,000 fps, 50 µs exp.
USAFA / UAFGI
NMT Langmuir Lab.

Yangbajing Valley & CR/γ Observatory

Predicting Interplanetary Coronal Mass Ejection by using the sun's shadow

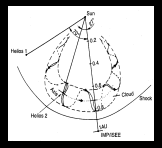


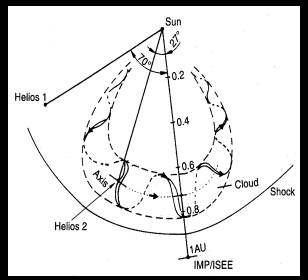


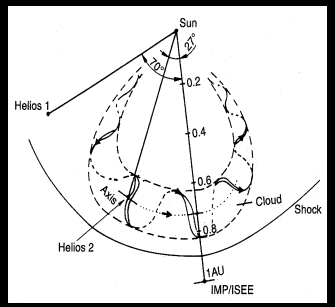


An ICME of 4 days

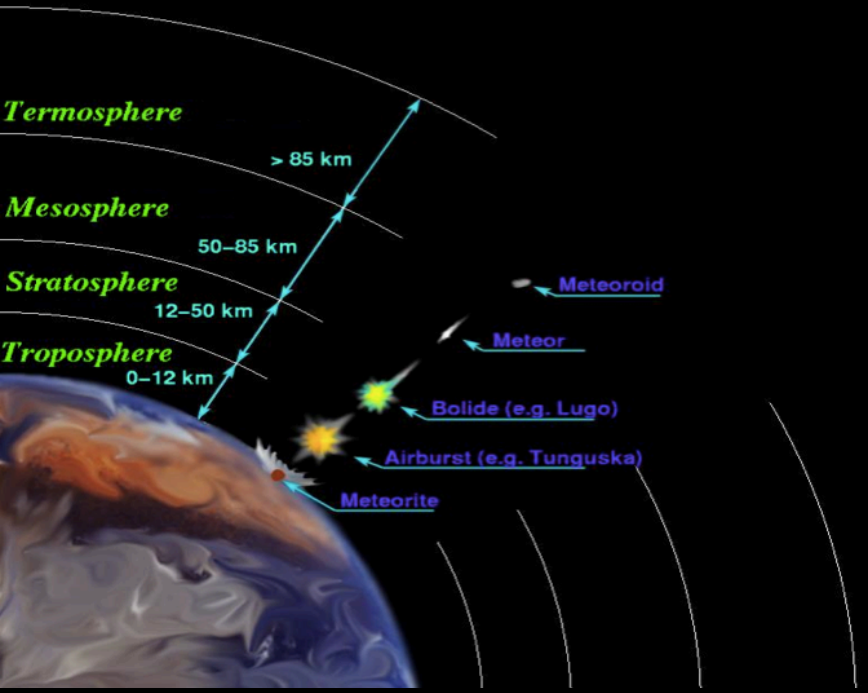
Need to decect suns' shadow in 1 day: LHASSO







Posible synergies JEM-EUSO II



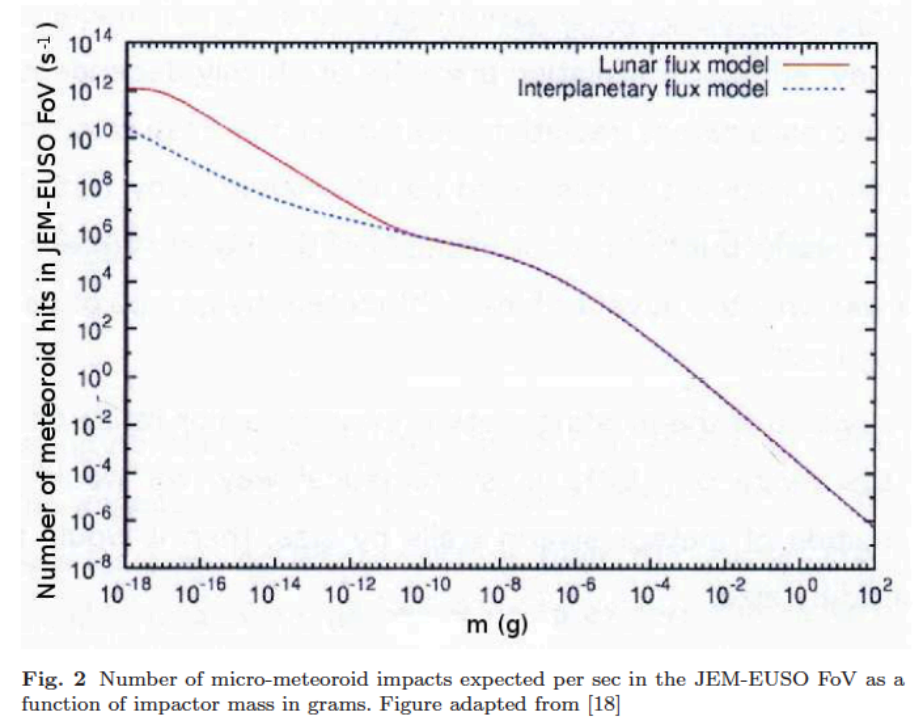
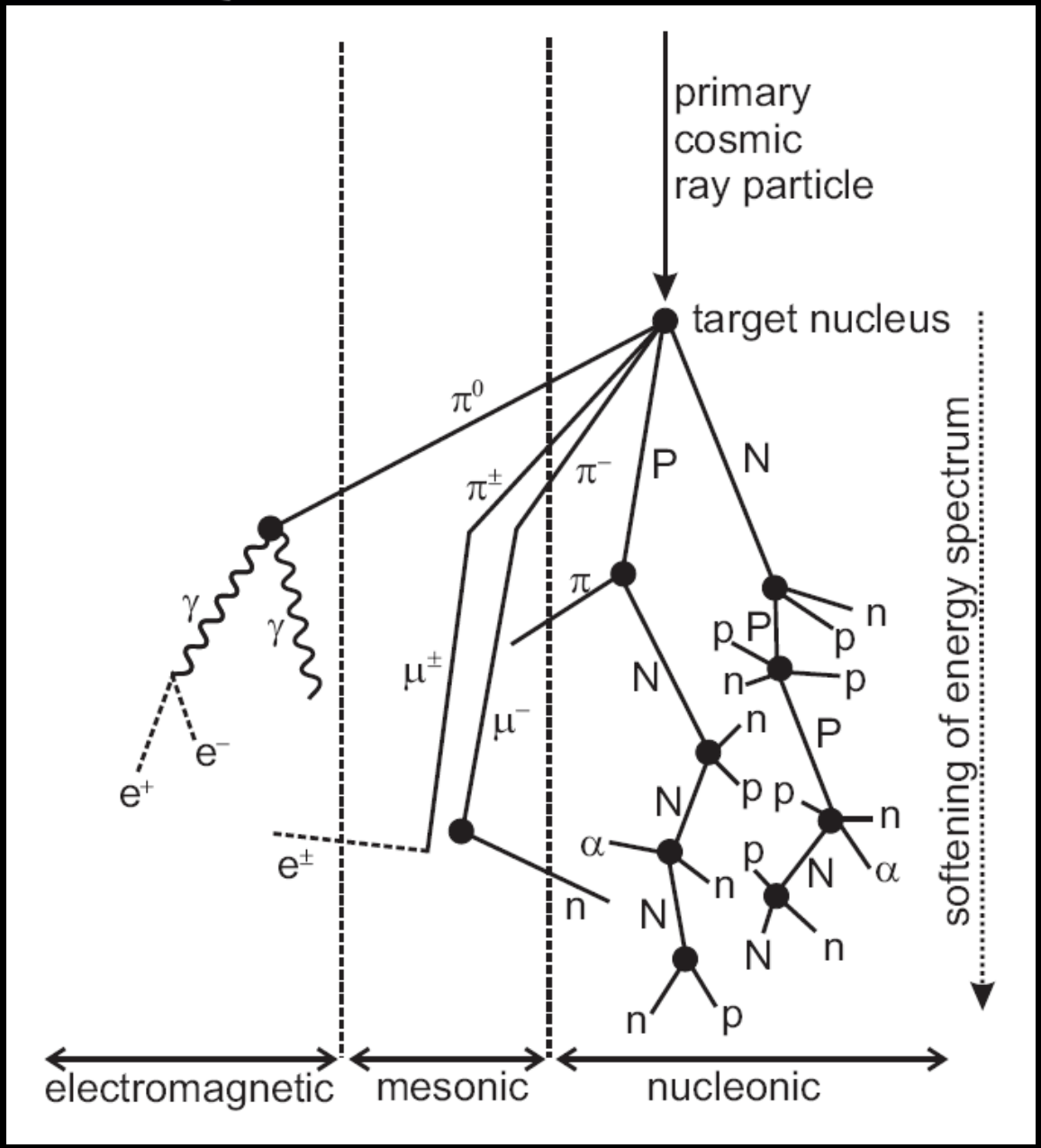


Fig. 2 Number of micro-meteoroid impacts expected per sec in the JEM-EUSO FoV as a function of impactor mass in grams. Figure adapted from [18]

Statistiques

Pour les météorites : détermination la trajectoire et la zone d'impact.
➔ récupérer avant la « pollution » par l'environnement terrestre

NEW: Associé à un laser puissant nettoyer les débris spatiaux



Transmutations in the atmosphere: The nuclear cascade

- The secondary cosmic ray flux decreases exponentially with atmospheric depth

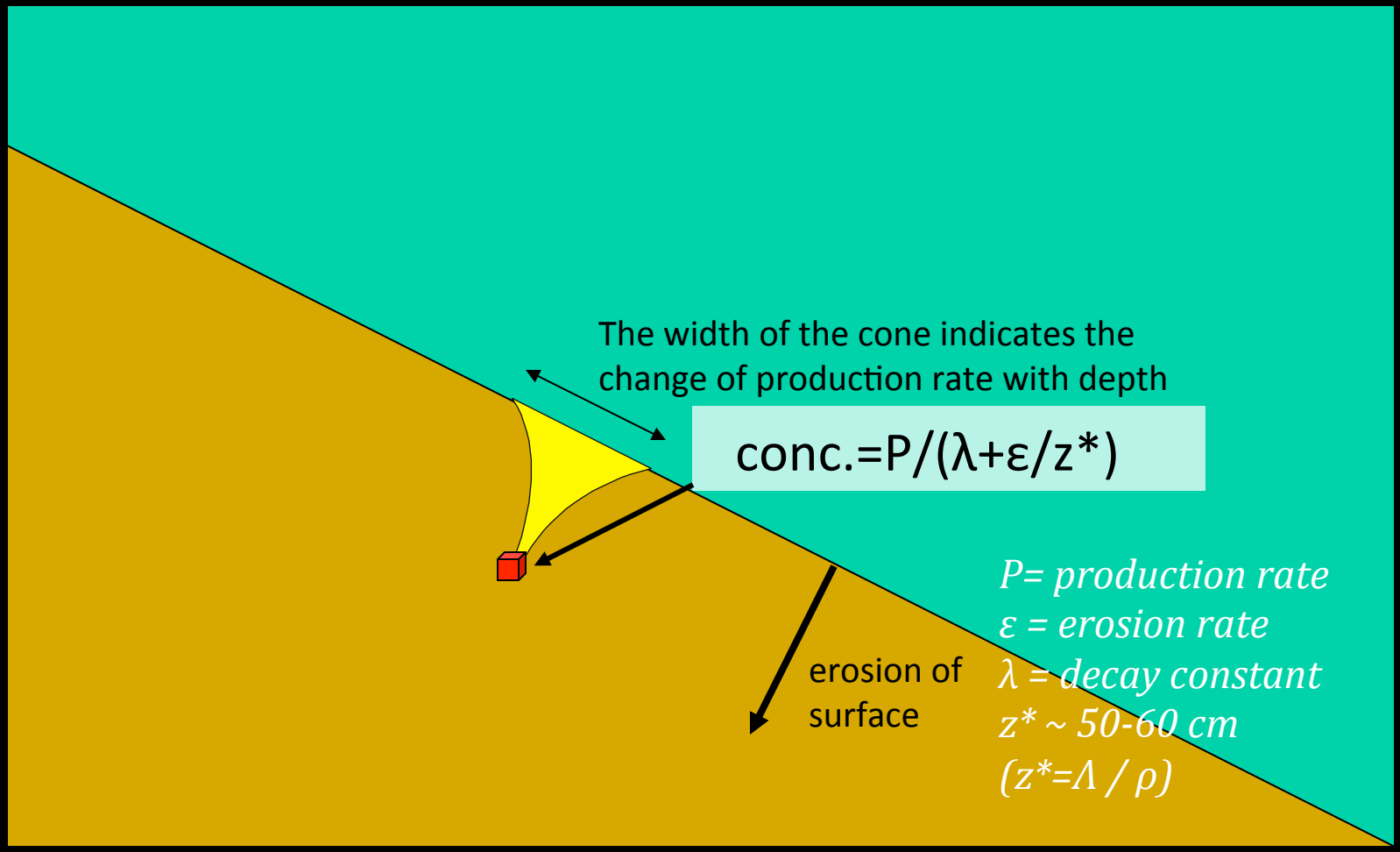
- At the Earth's surface it are the neutrons that remain (~90 % of the nucleon flux)

-They activate nuclei up to approximatively 3m of depth

Nuclides used:
^{3}He, ^{10}Be, ^{21}Ne, ^{26}Al, ^{36}Cl

➔ Measurement of erosion

The concentration of cosmogenic nuclides is a function of the erosion rate

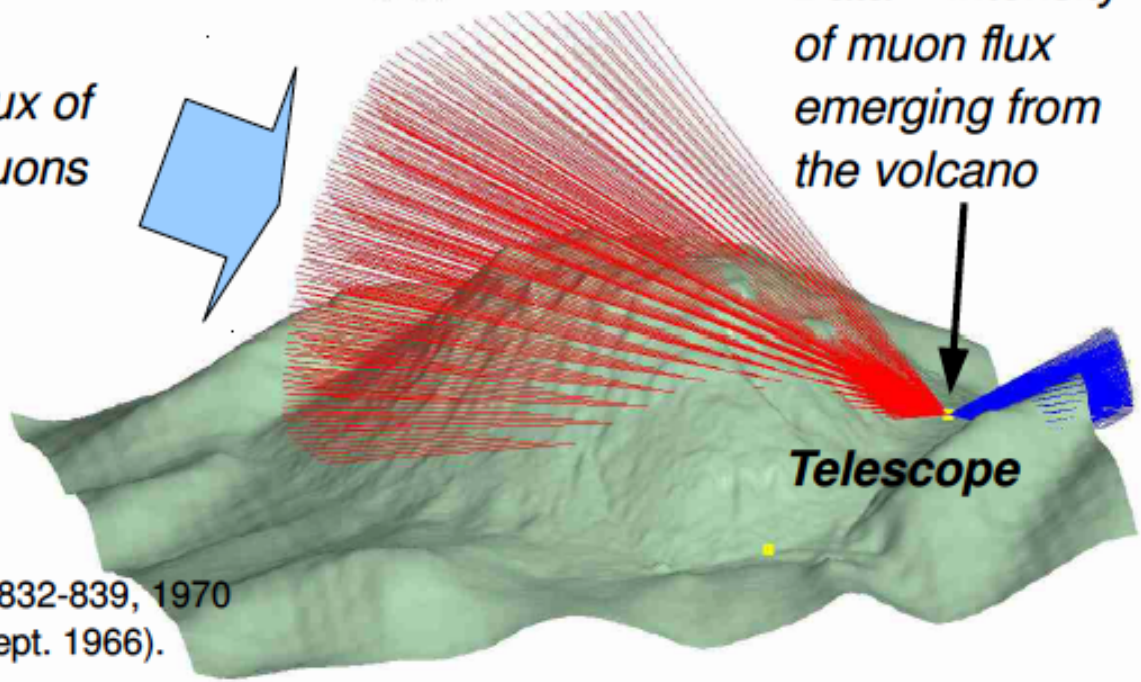


Muon tomography

Muon tomography

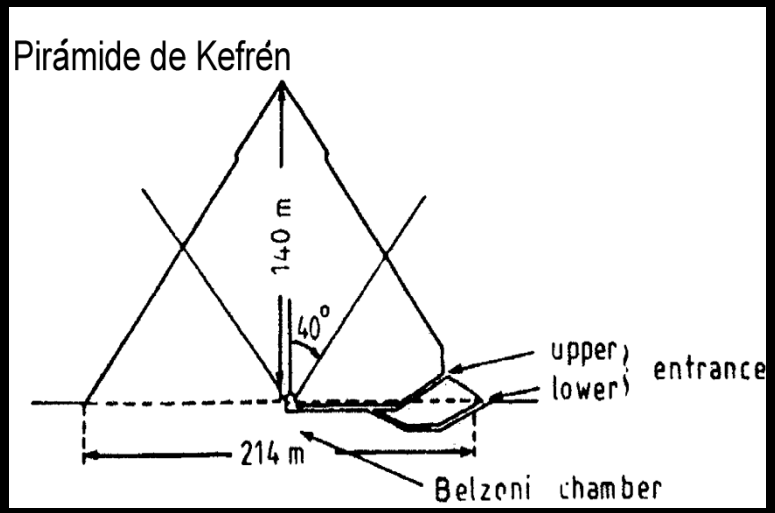
Measure the flux of muons across the volcano to determine its density structure

- Basic information = opacity $\varrho(L) \equiv \int_L \rho(\xi) \mathrm{d}\xi,$



Precursory work:
Alvarez, L.W. et al., *Science*, 167, 832-839, 1970
(see also *Physics Today*, 78-80, Sept. 1966).
Renew of interest:
Nagamine, K. et al., *NIMA*, 356, 585-595, 1995.

The Alvarez experiment, cosmic ray search for hidden chamber on the Chephren Pyramid



Lawrence Berkeley Laboratory
University of California
Berkeley, California 94720
Telephone 415/843-2740

August 2, 1978

Senorita Linda Manzanilla
Cerro Del Agua No. 106
Mexico 21, D. F.
Mexico

Dear Senorita Manzanilla:

I have not been working in Egypt for the last several years, so it won't be possible for you to be with me in Giza, in the near future.

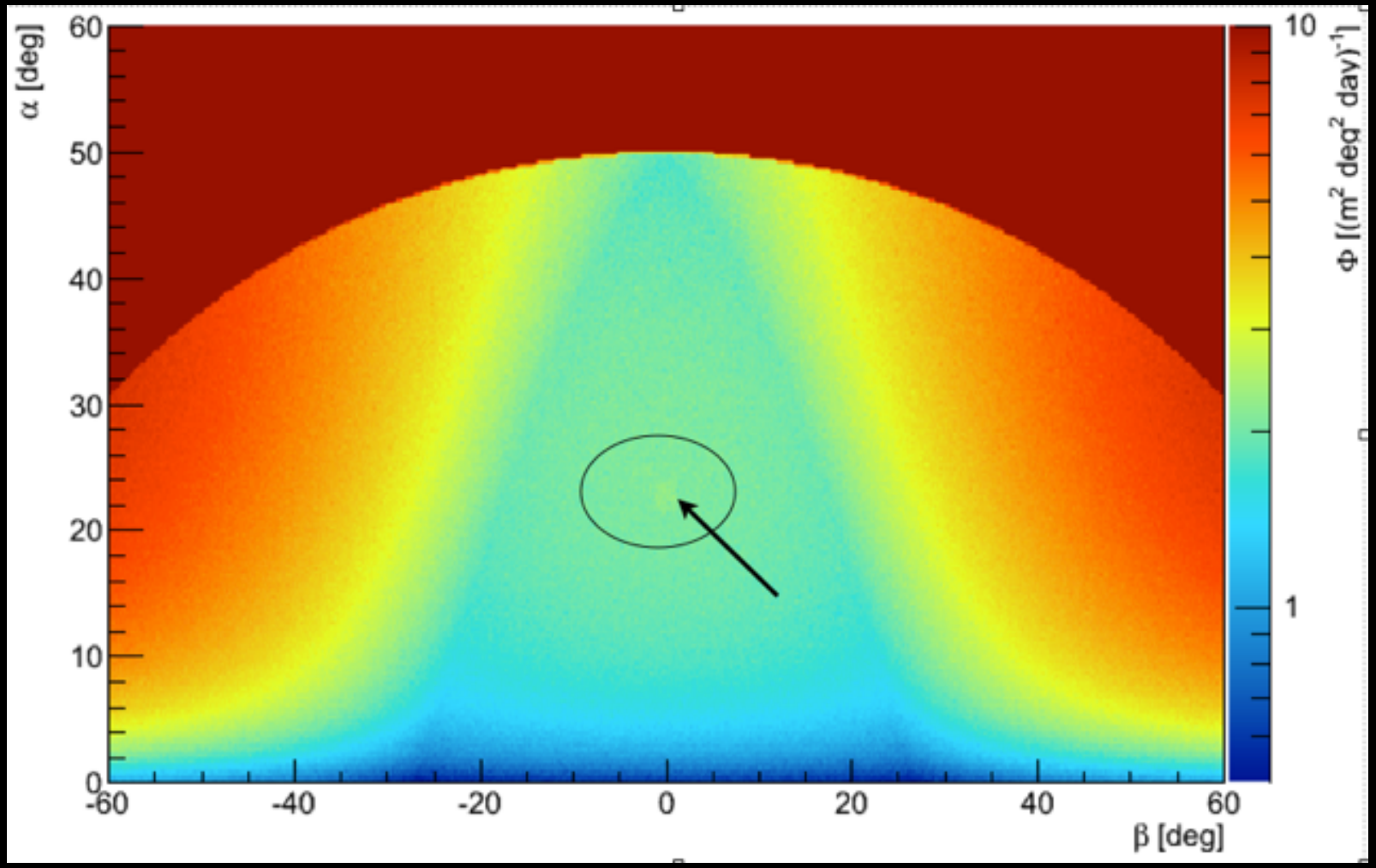
I [illegible] some printed material on the [illegible] colleagues and I did at Giza, and I can say that since those things were pu[illegible] we completed a survey of the Second Pyramid, pointing our cosmic ray telescope in six or seven different compass directions, tilted each time at 45 degrees above the horizon. We also repeated the vertical scan that is described in the material I am sending you. The results of all this is that we found the pyramid to be quite solid, with no chambers comparable in size to those found above the plateau level, in the Great Pyramid.

Very sincerely,

Luis W. Alvarez

LWA/lb
Encls.

Yes yes the one who working with his son Walter, a geologist at Berkley, developed the hypothesis that an asteroid hit the earth and produced a cloud that covered the planet for a long period of time, blocking sunlight, and eventually leading to the extinction of dinosaurs.



Today's simulation:
A pocket of air of $1m^3$ can be seen in a month

Muon tomography

Advantages

- Determination of density *via* a straight-ray geometry
  - Simple inverse Radon transform
  - Curved paths seismic and electrical tomography => non-linear inverse problem
  - Volume integral in gravity measurements
- Wide angle remote imaging => study of active volcanoes

Limitations

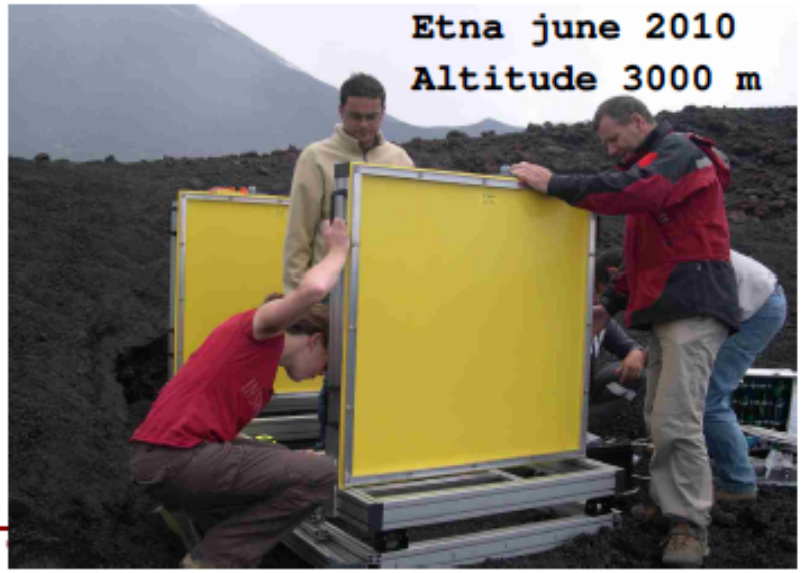
- Cannot see « below » => restricted to the top part of volcanoes
- Need to have sufficient statistics => « slow » monitoring with a weekly or monthly timescale

Field telescopes

Photovoltaic panels, wind turbine, fuel cells

Total mass: 200 to 600 kg (w/ shielding)

Angular aperture/resolution: 30°- 60°/ 1° - 2°



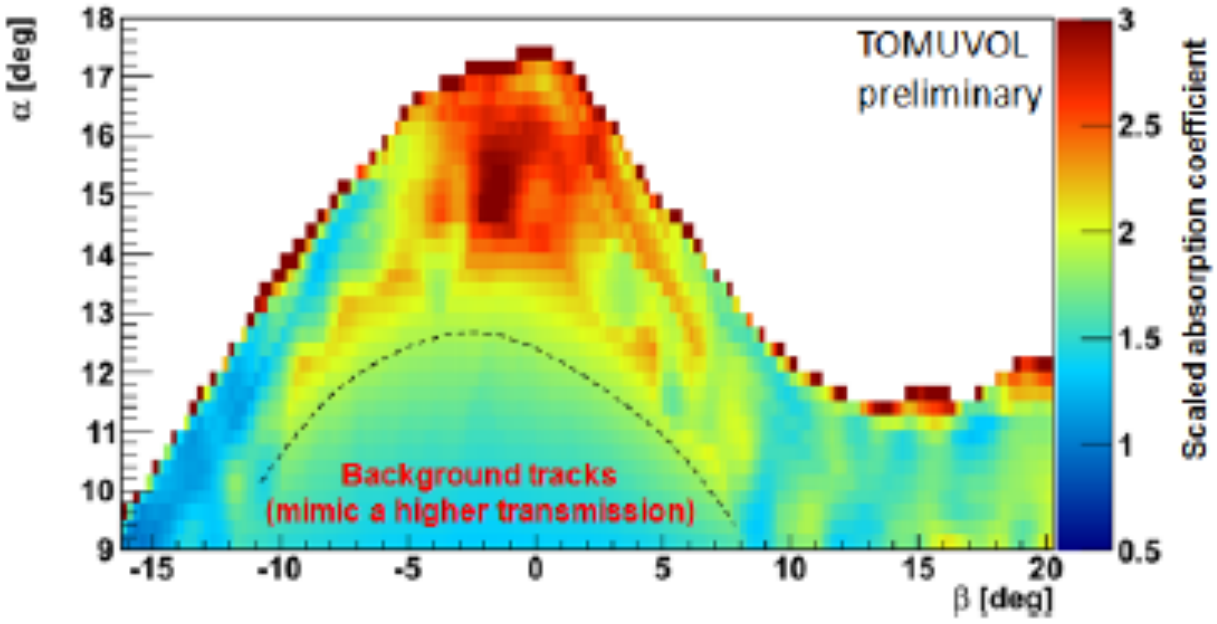
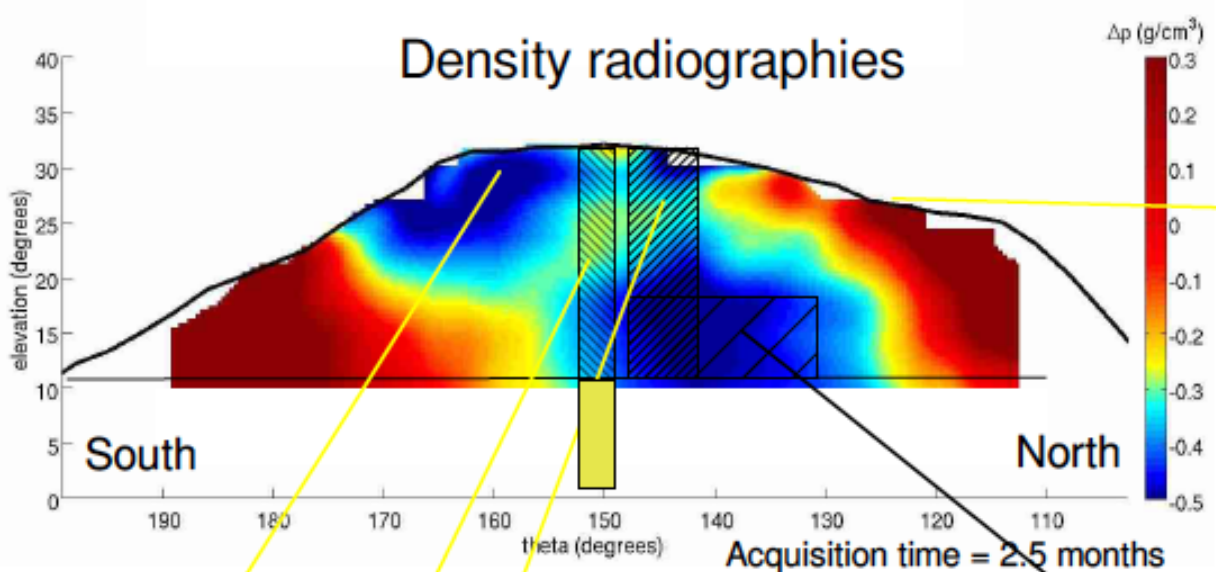
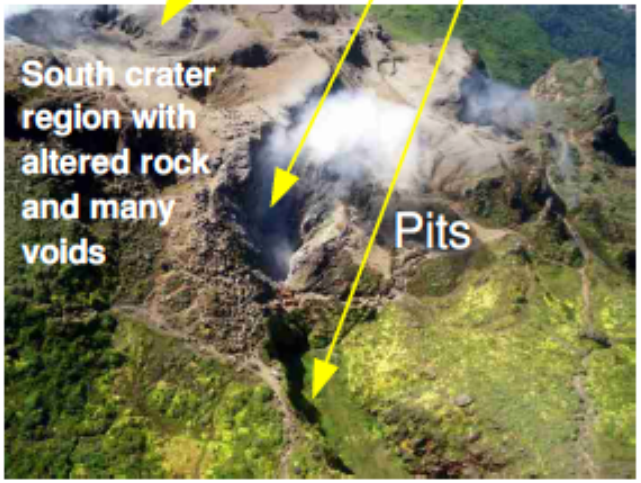


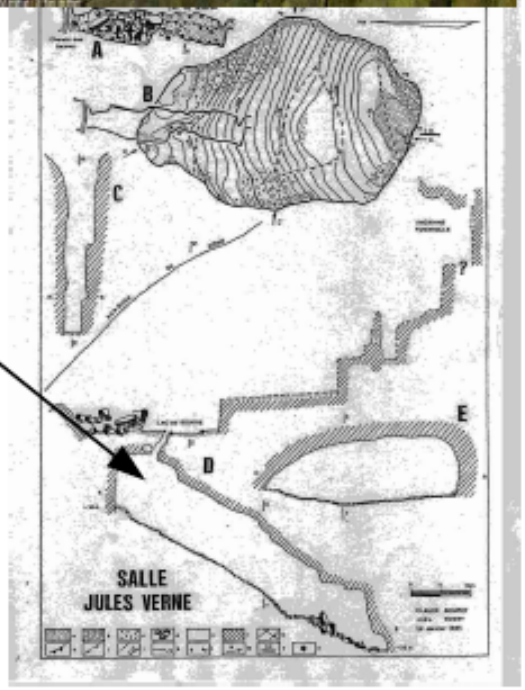
Fig. 3. Map of the scaled transmission through the Puy de Dôme as seen over seven months from the Grotte de la Taillerie with a $\sim 1/6m^2$ detector

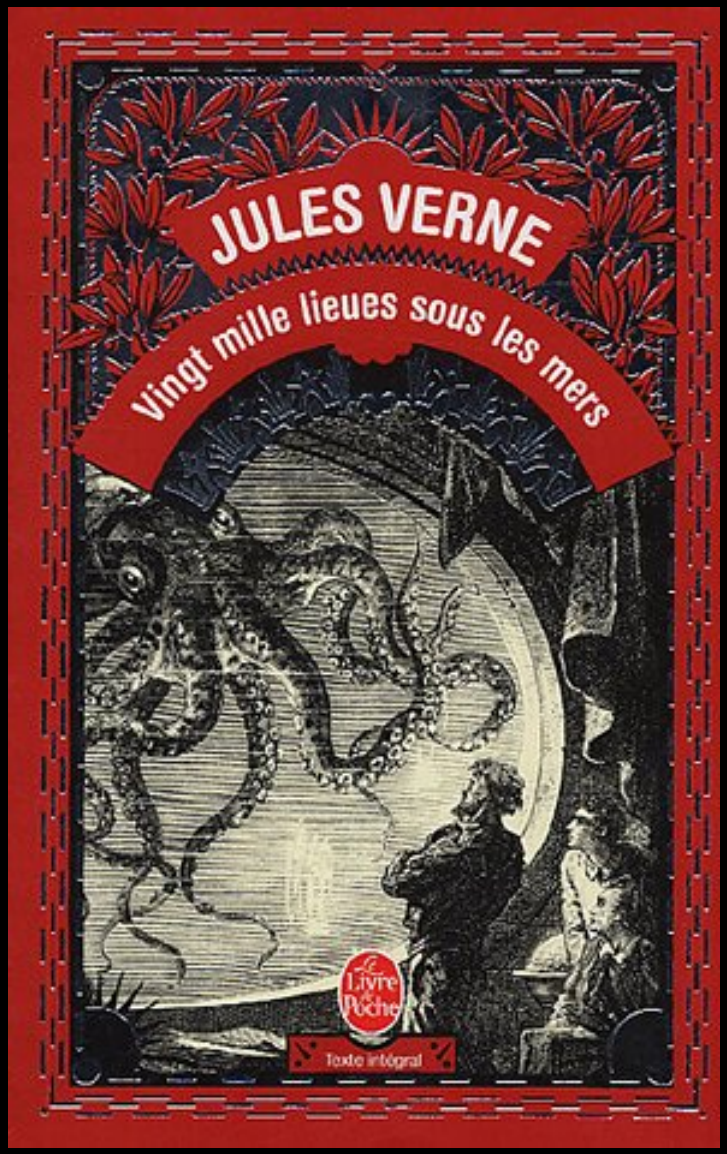
La Soufrière structural imaging



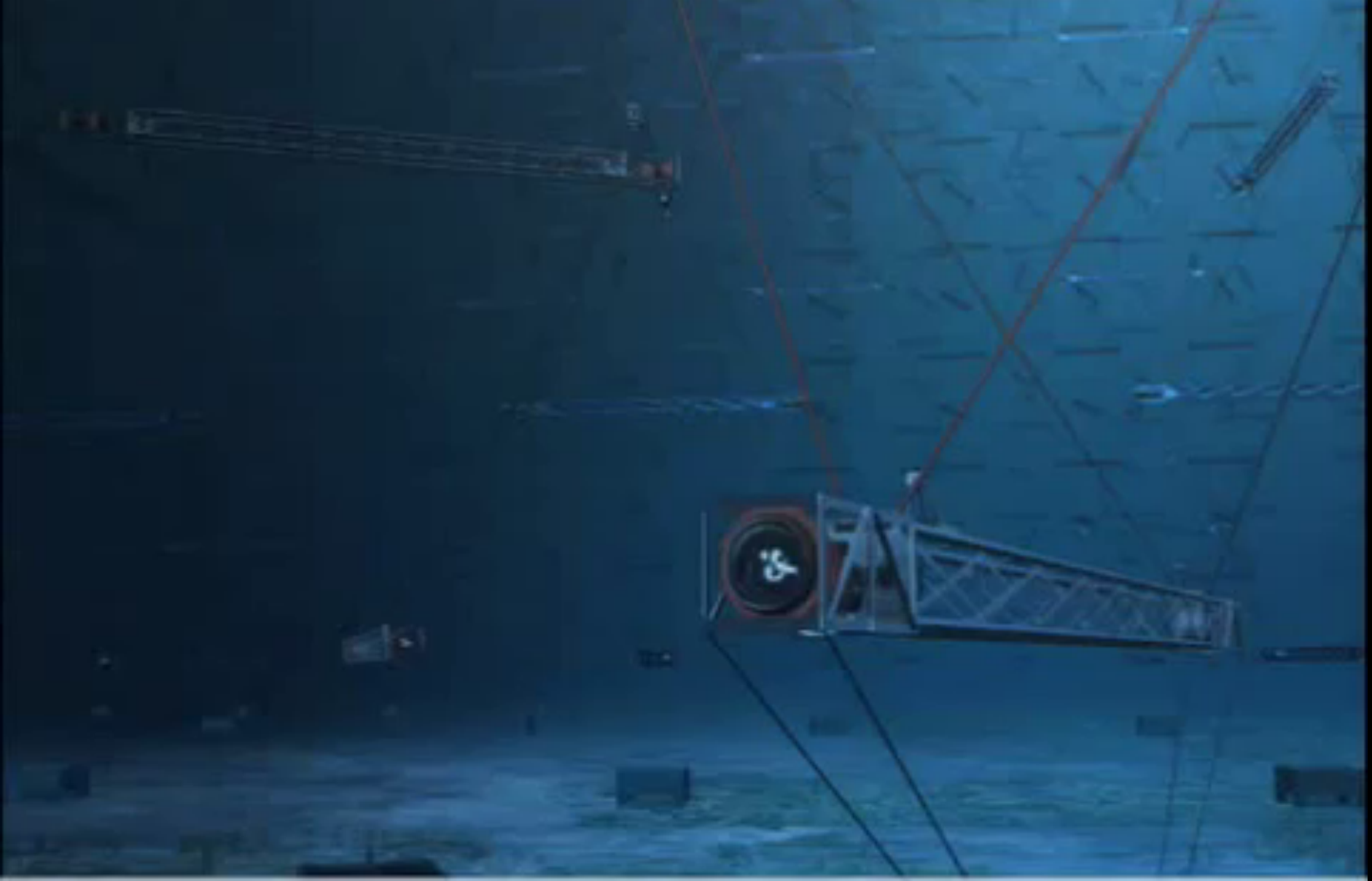


Low density region might be the Spallanzani cave described in ancient texts. No more accessible.



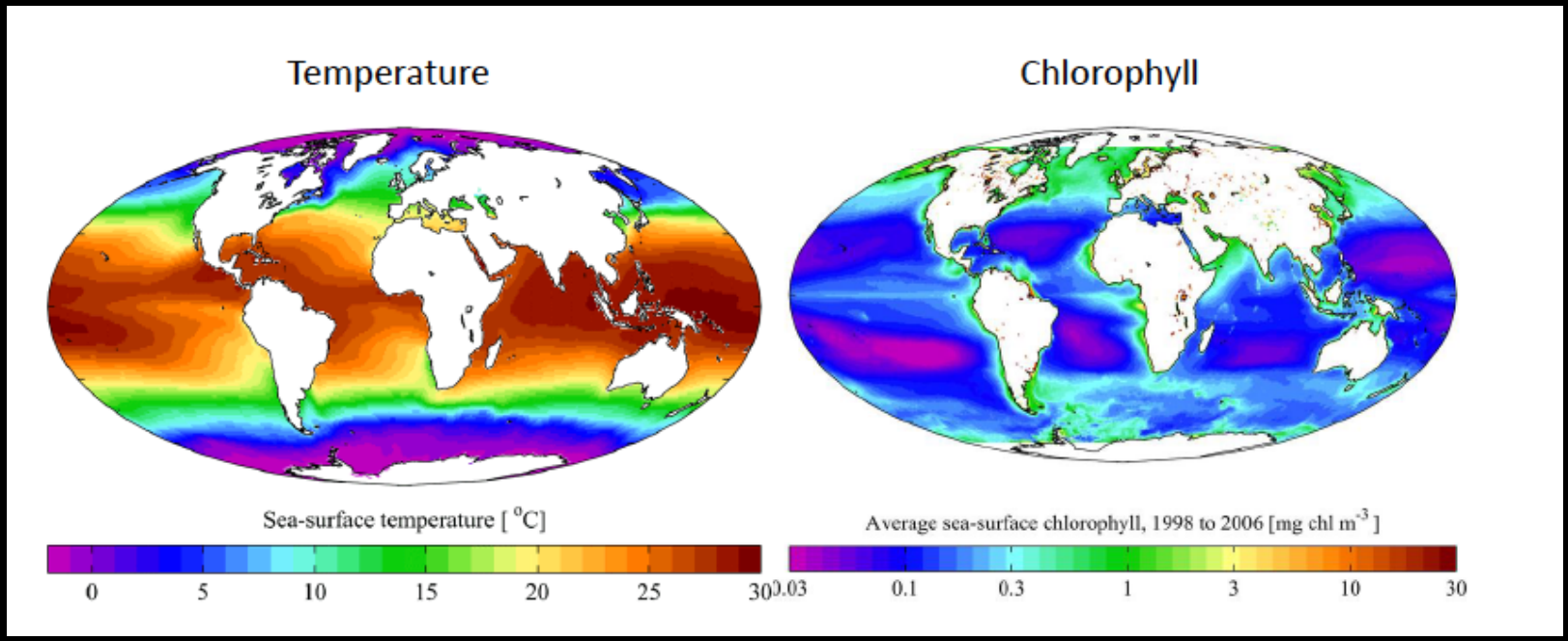


Under-water/ice synergies

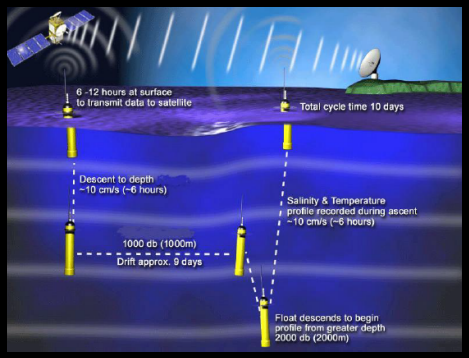


ASTRI E PARTICELLE - LE PAROLE DELL'UNIVERSO

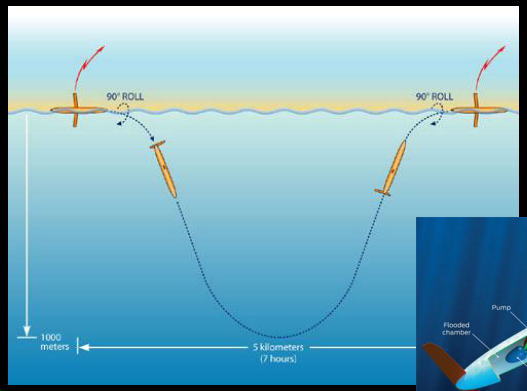
Satellite remote sensing has revolutionised oceanography but measurements are still required from the Ocean's interior

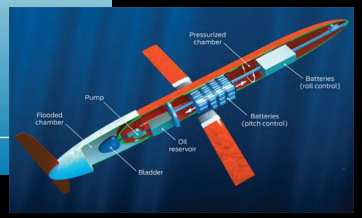


ArRGO floats, controlled boyancy emmerge every 10 days

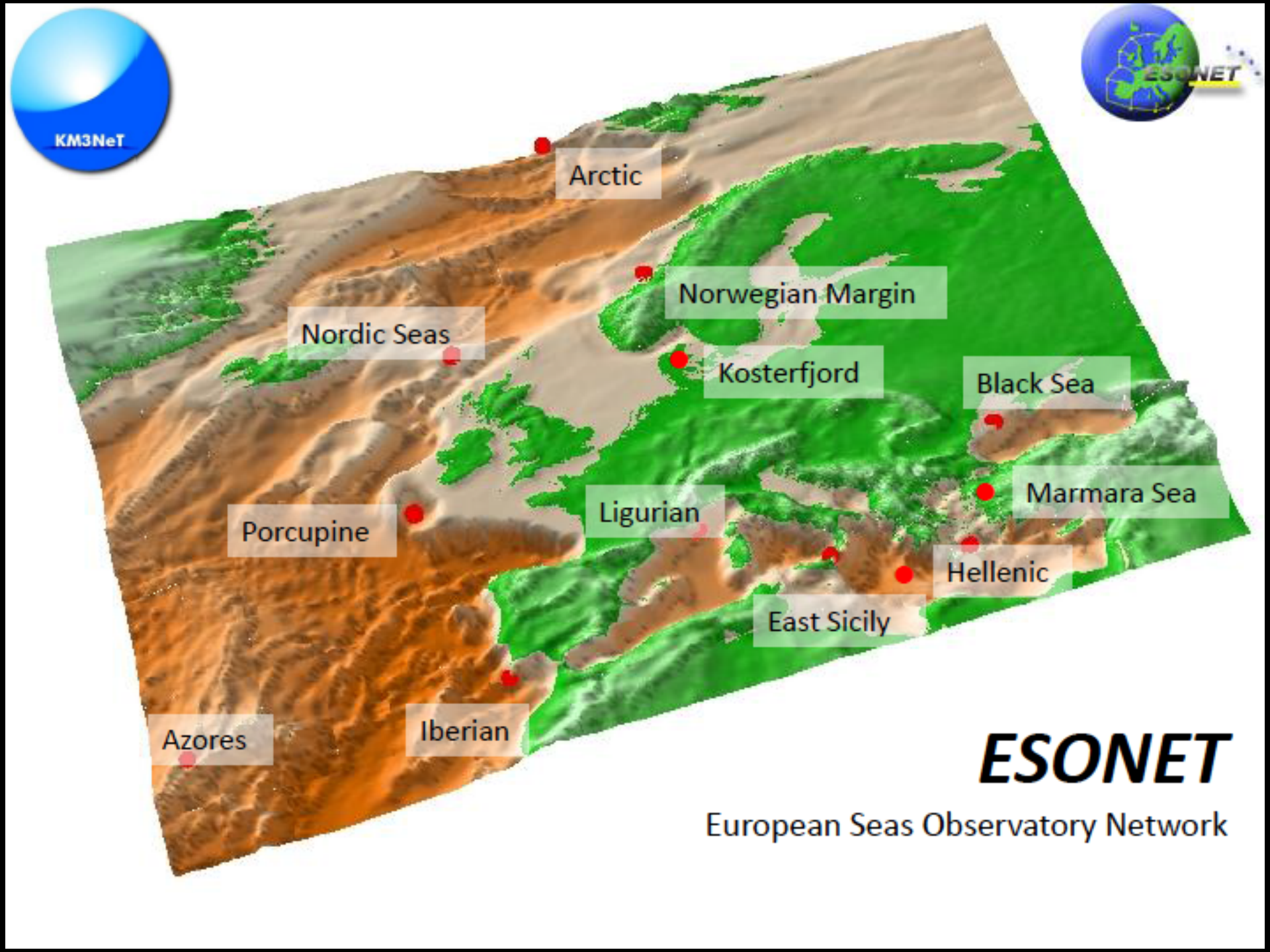


Gliders: controlled boyancy + wings +GPS

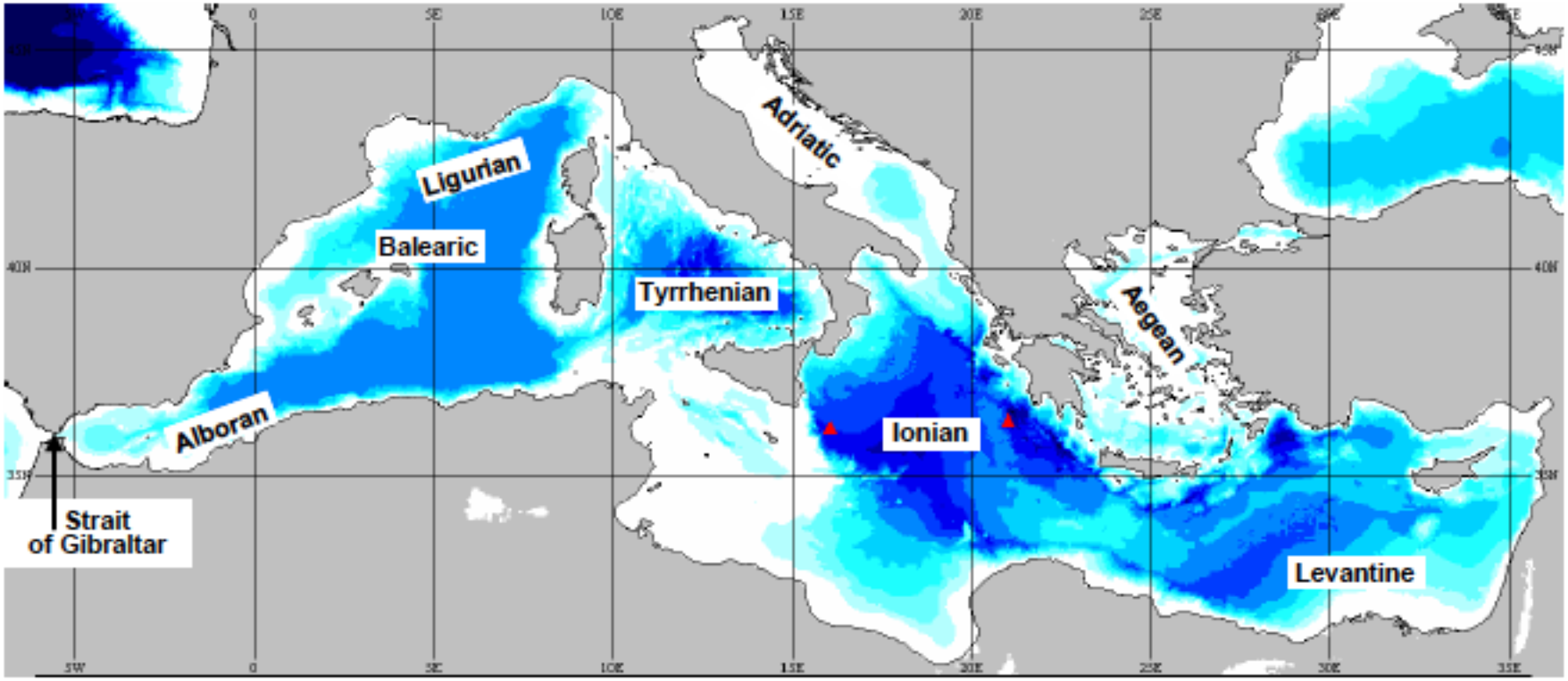




NEED DEEP OCEAN OBERVATORIES

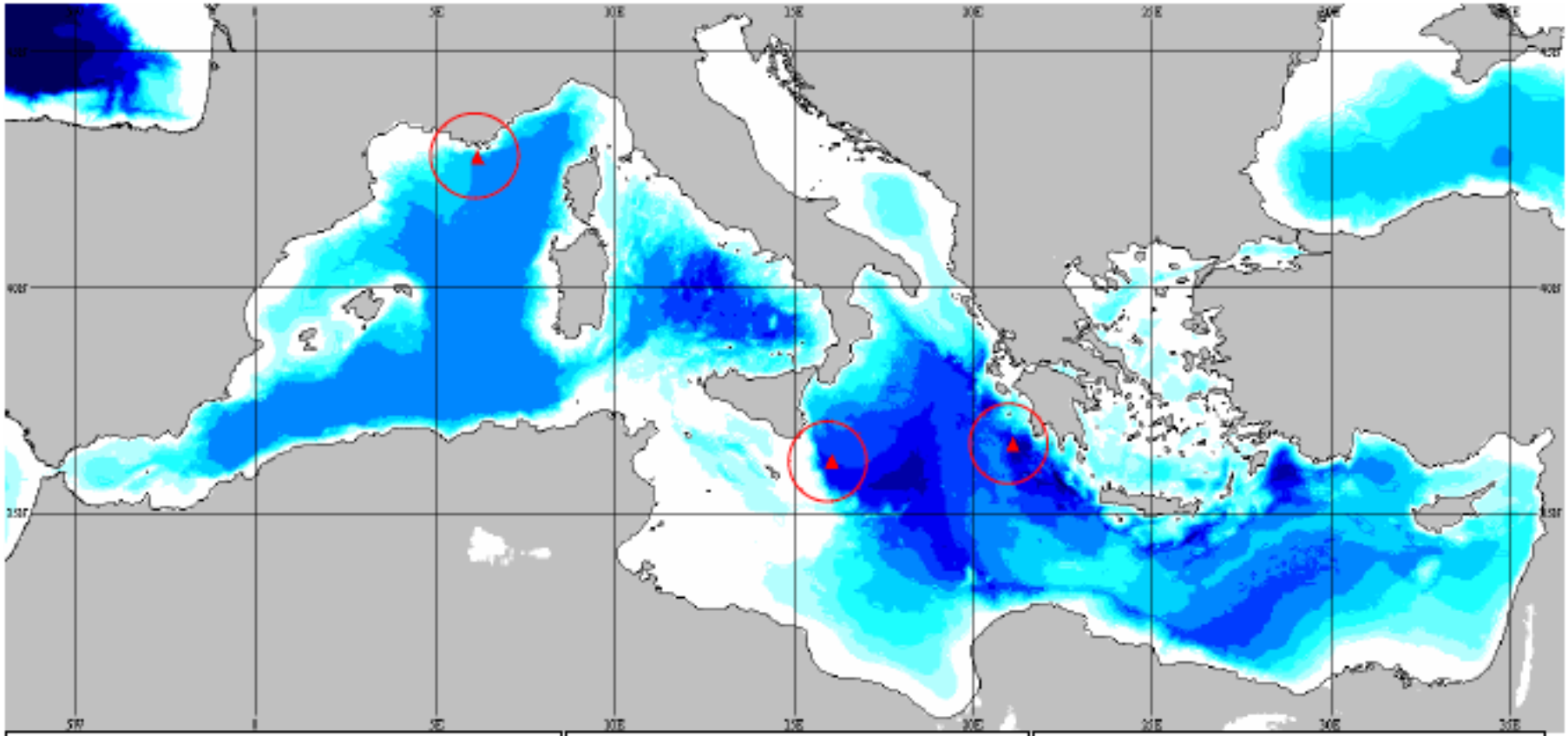

KM3NeT
ESONET
Arctic
Norwegian Margin
Nordic Seas
Kosterfjord
Black Sea
Marmara Sea
Ligurian
Porcupine
Hellenic
East Sicily
Iberian
Azores
ESONET
European Seas Observatory Network

Mediterranean Regional Seas



Colour depth contours at 500m increments.

KM3NET Sites 100km radius Potential Footprints



ANTARES- Ligurian Sea 2475 m	NEMO - Ionian Sea 3350m	NESTOR - Ionian Sea 4500/5200m

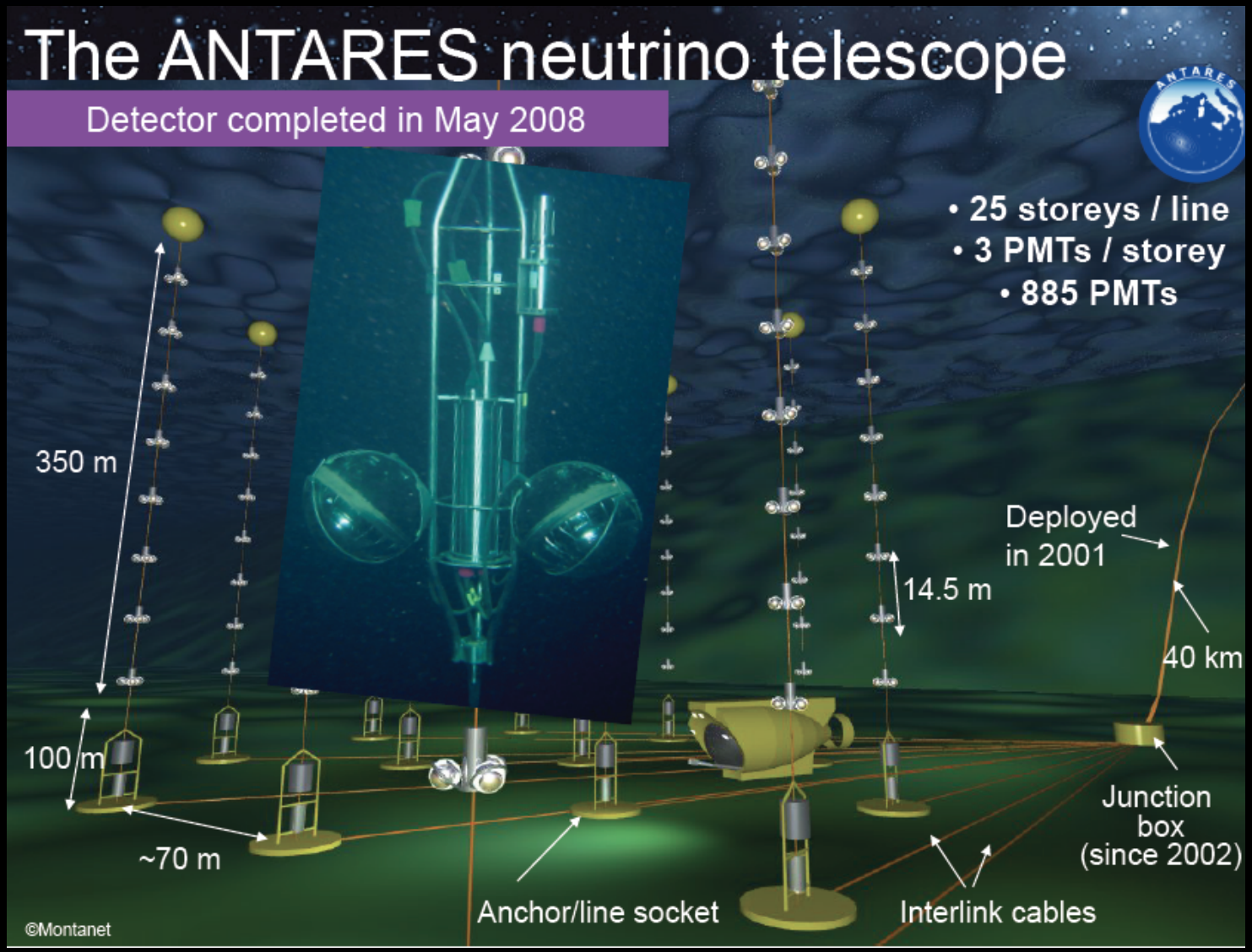
Advantages of **cabled** observatories:

- Real-time
- High bandwidth
- High frequency
- Continuous
- Long term

Oceanography (water circulation, climate change):
Current intensity and direction, water temperature, water salinity, oxygen, radionuclides...

Geophysics (geohazard):
Seismic phenomena, low frequency passive acoustics, magnetic field variations,...

Biology (micro-biology, cetaceans,...):
Passive acoustics, biofouling, bioluminescence, video, water samples analysis,...

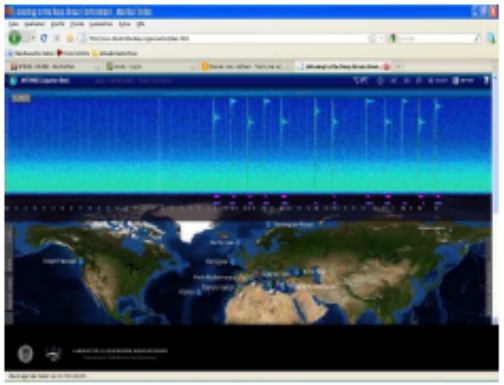


The position of the PM determined with cm precision S and P detectors ?
F. Cornet

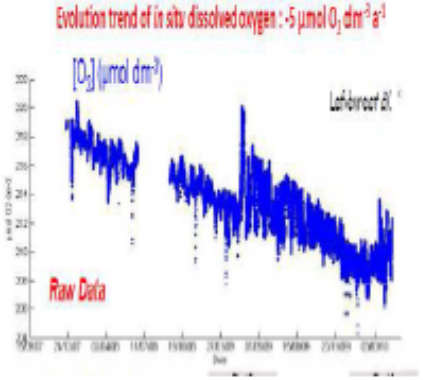
Neutrino Telescopes: Marine Sciences

Deep Ocean Cabled Observatories Aspera Workshop, Amsterdam 2011-
https://indico.cern.ch/conferenceDisplay.py?ovw=True&confId=165389

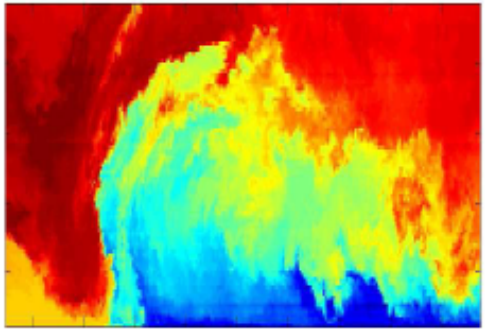
Marine Acoustics



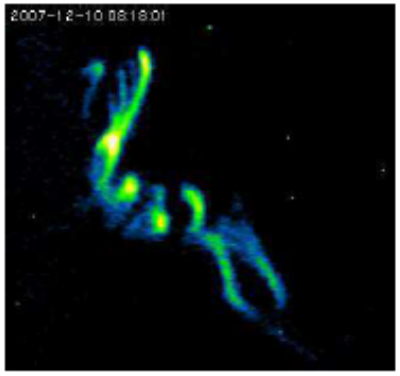
Oceanography

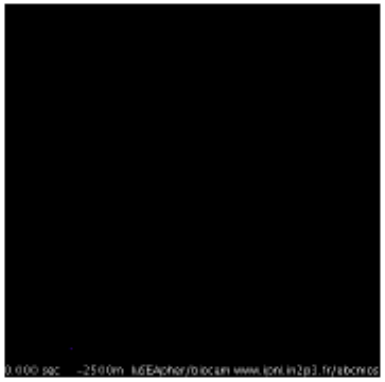


Internal wave dynamics

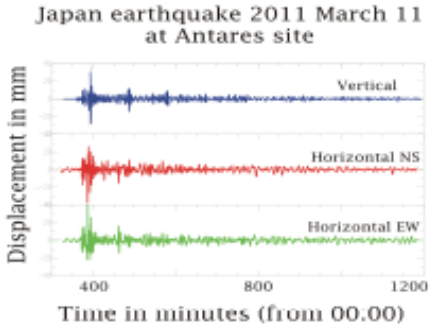


Bioluminescence





Seismology

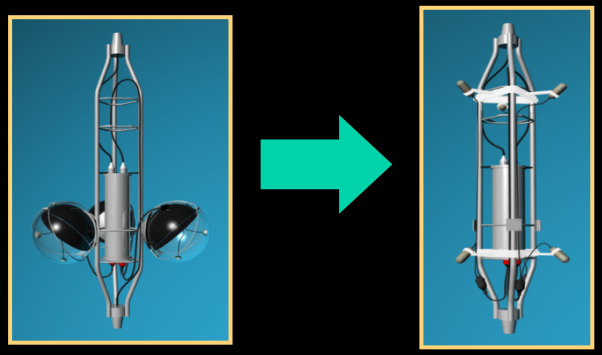


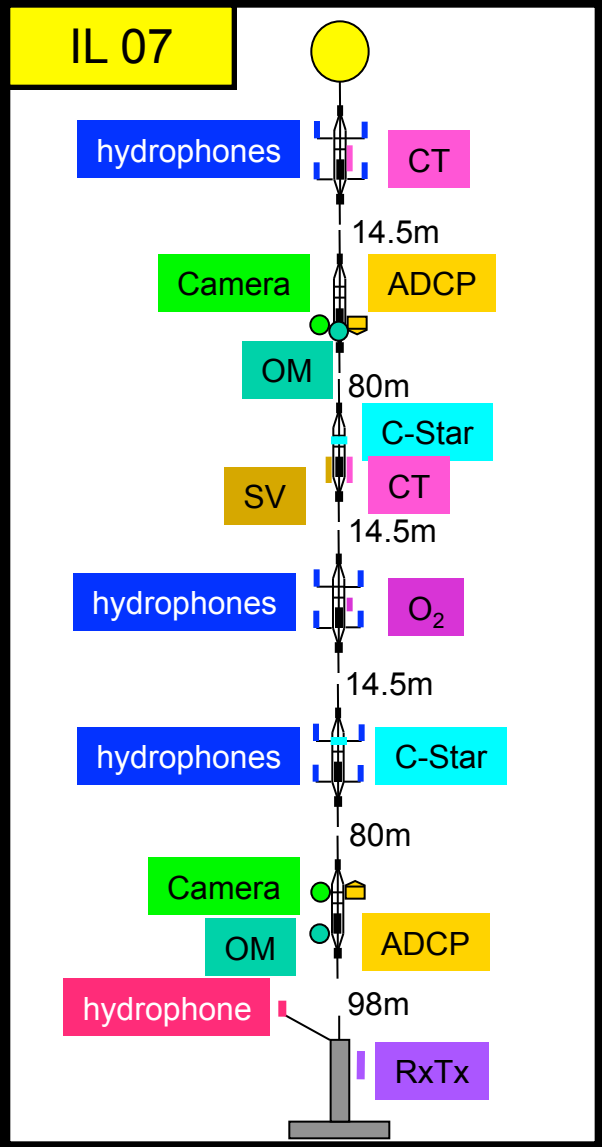
ANTARES: Instrumentation Line

Monitoring of Environmental Parameters
(reconnection planned later this year)

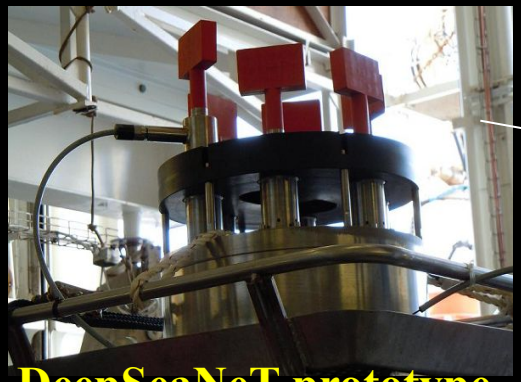
- **CSTAR** light transmission
- **CT** = Conductivity-Temperature
- **SV** = sound velocity
- **ADCP** = Current meter
- GURALP seismometer
- 2 Optical Modules
- Acoustic positioning RxTx & Rx
- Oxygen meters
- 2 cameras

  +
- 3 storeys of UHE neutrino acoustic detectors

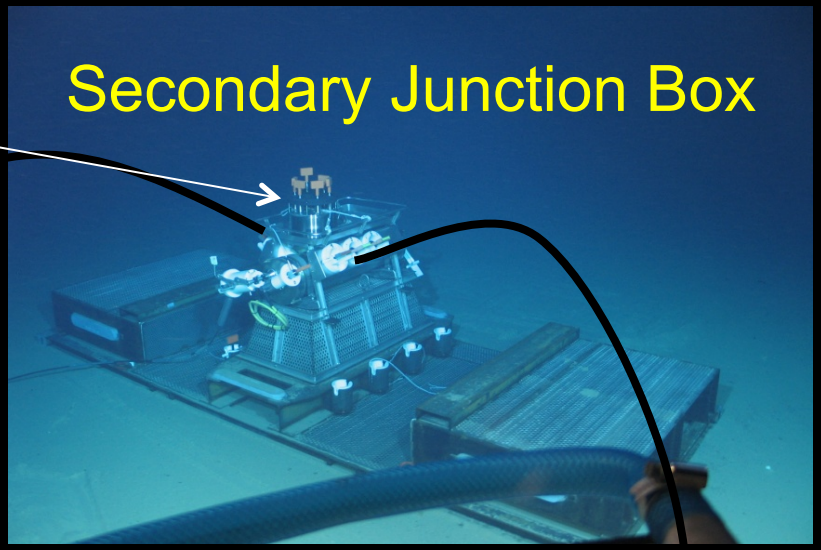


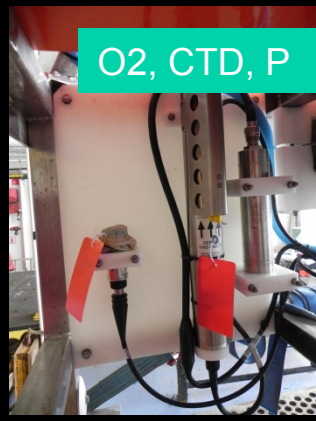


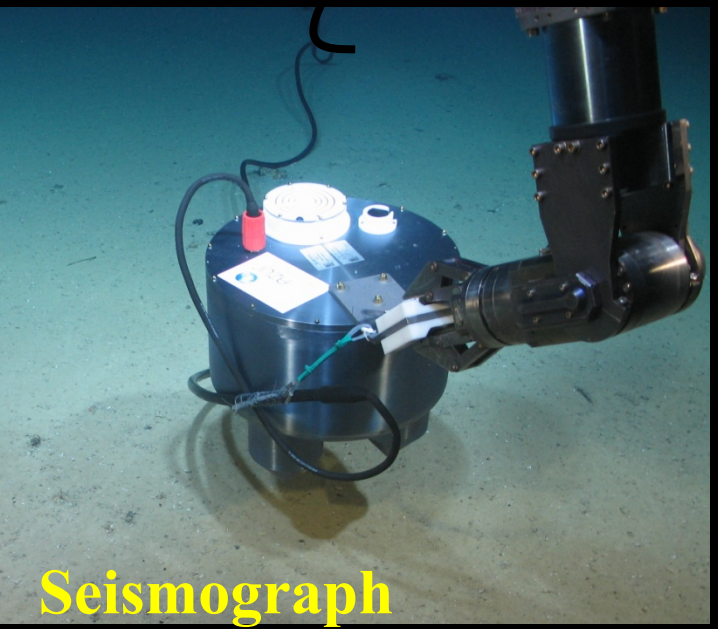
Secondary Junction Box



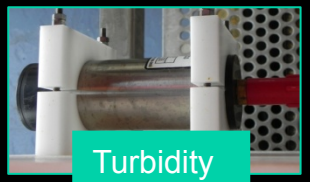
DeepSeaNeT prototype

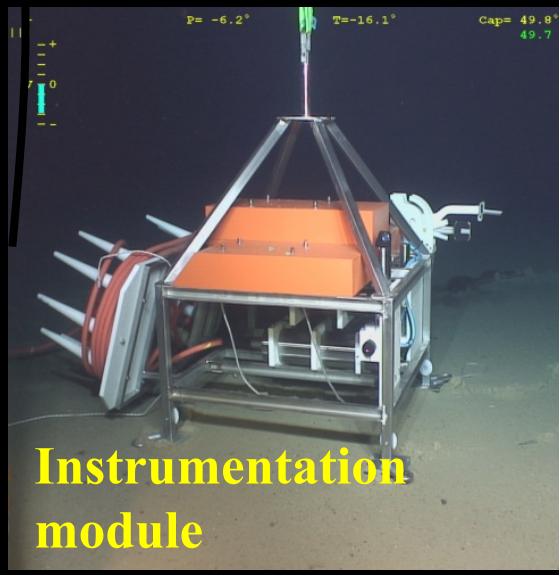






Seismograph



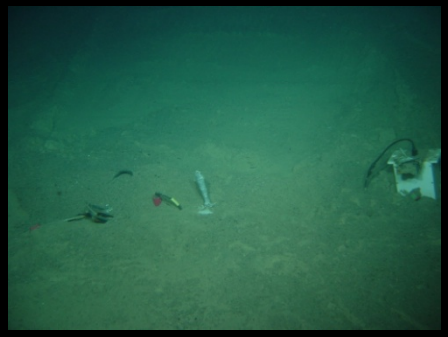


Instrumentation module

Seismology

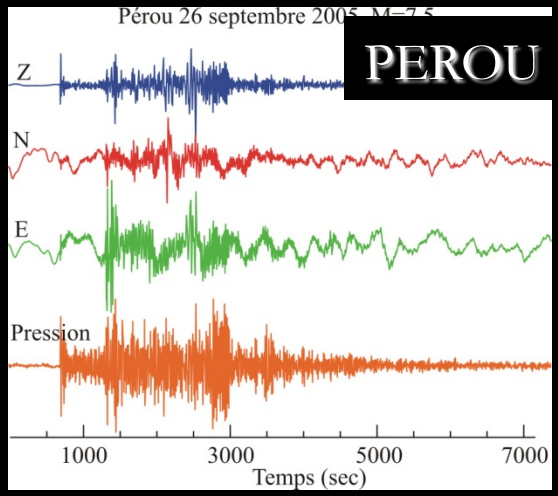
In laboratory

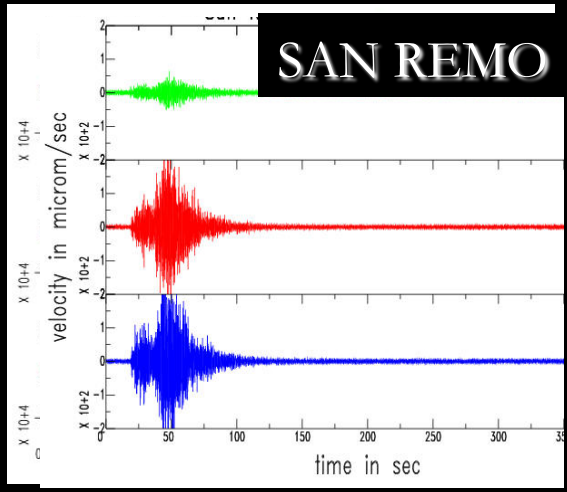
deployment



Buried at site Antares
(gain 20 dB of noise)

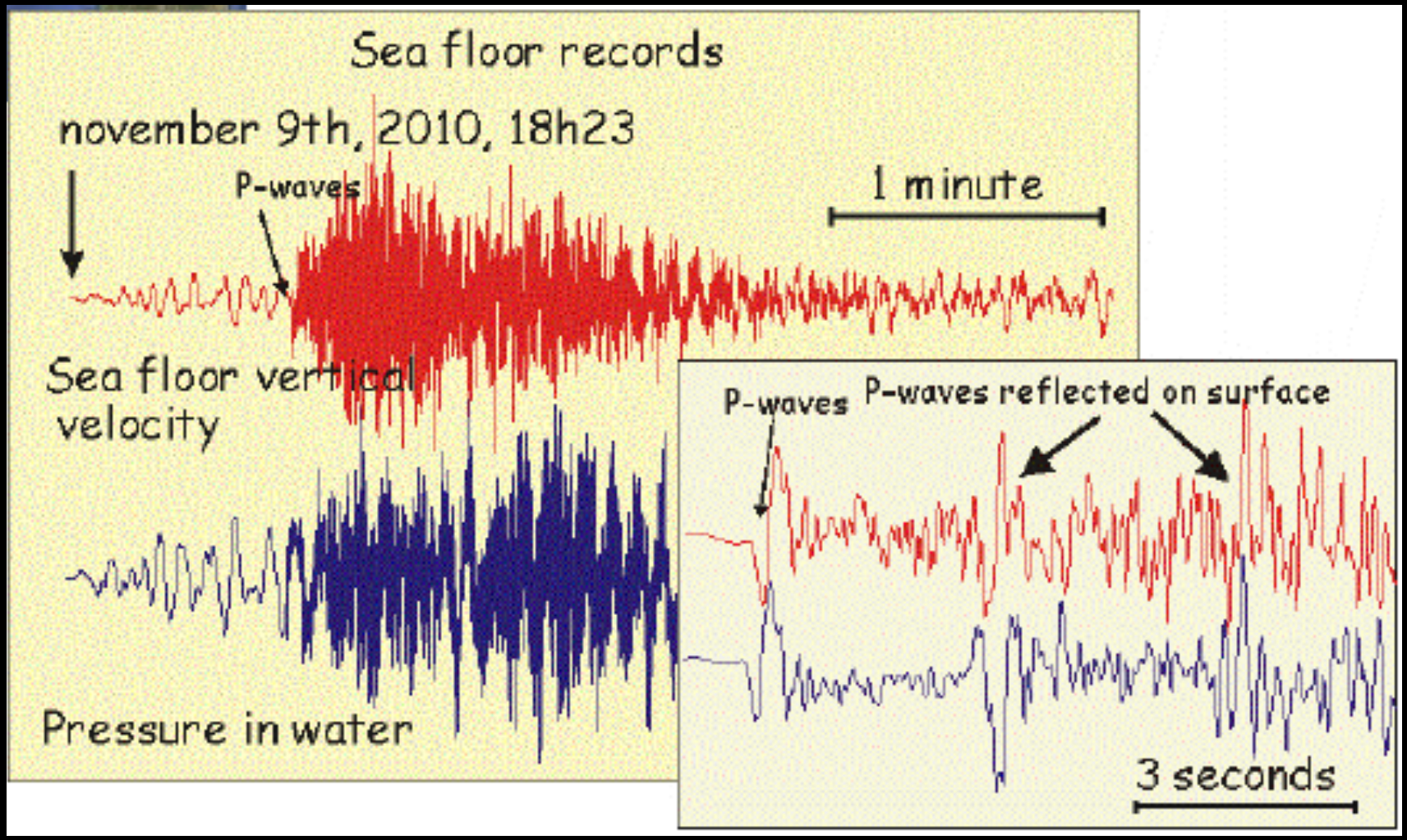
The seismograph ANTARES is part of seismic monitoring network, complementary to the terrestrial stations.



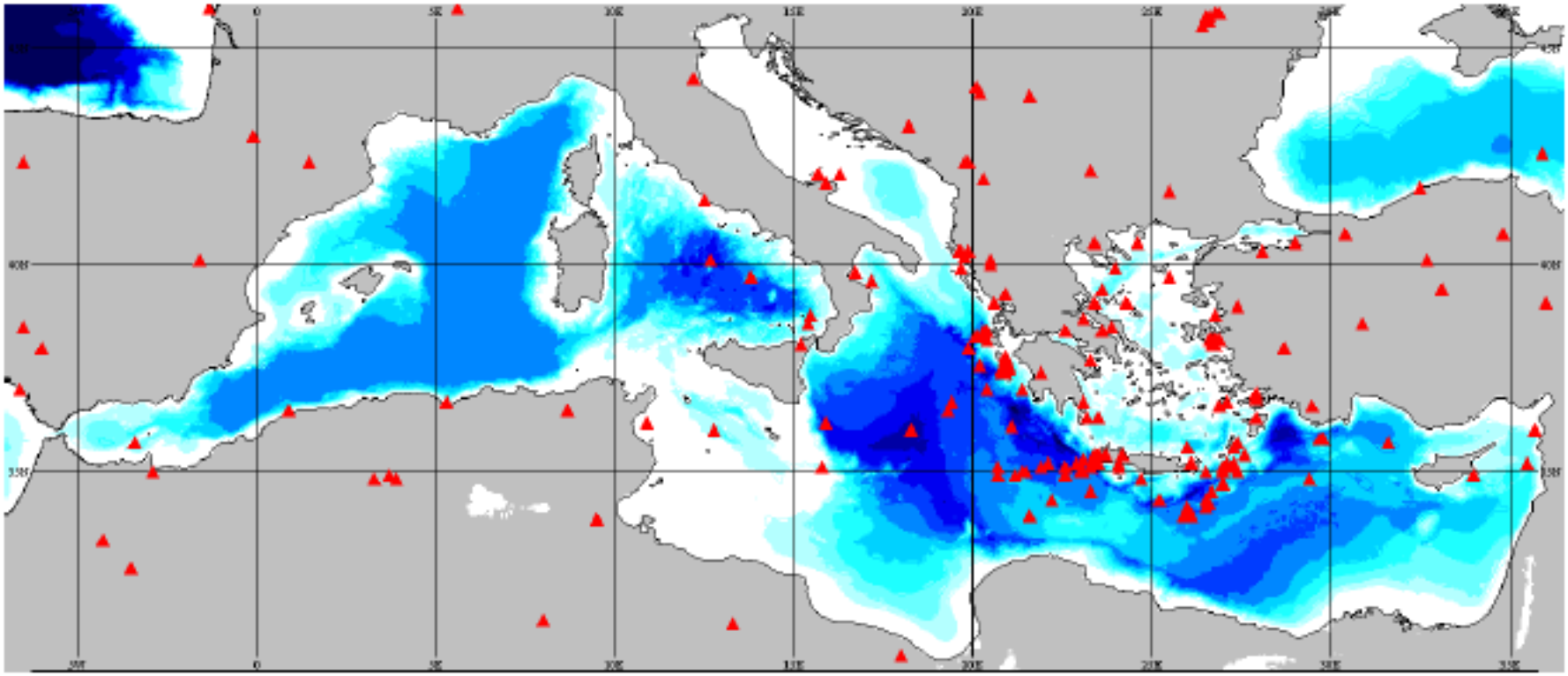


Collaboration with Laboratoire Géosciences Azur

Nov 9th, 2010: Magnitude=3.6-4.2

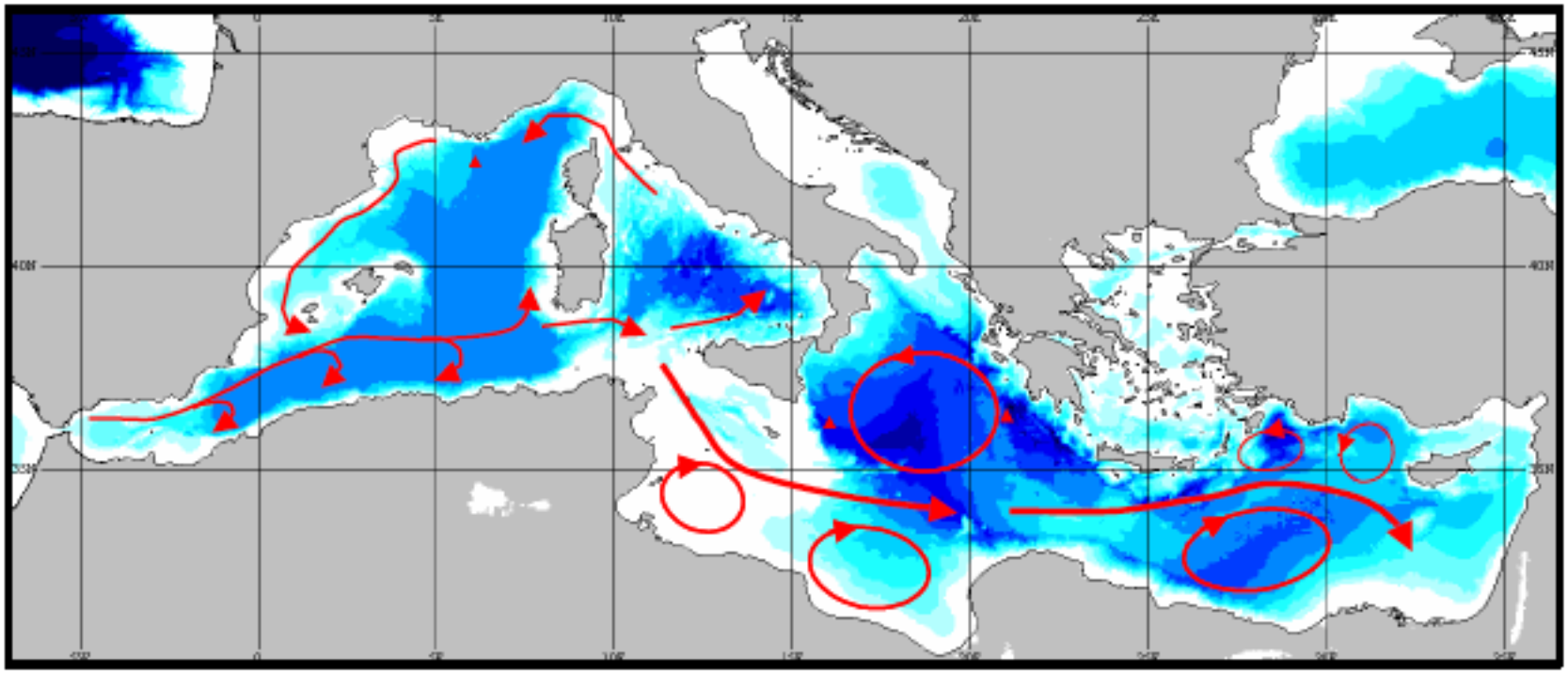


Earthquakes during 2005 and 2006.

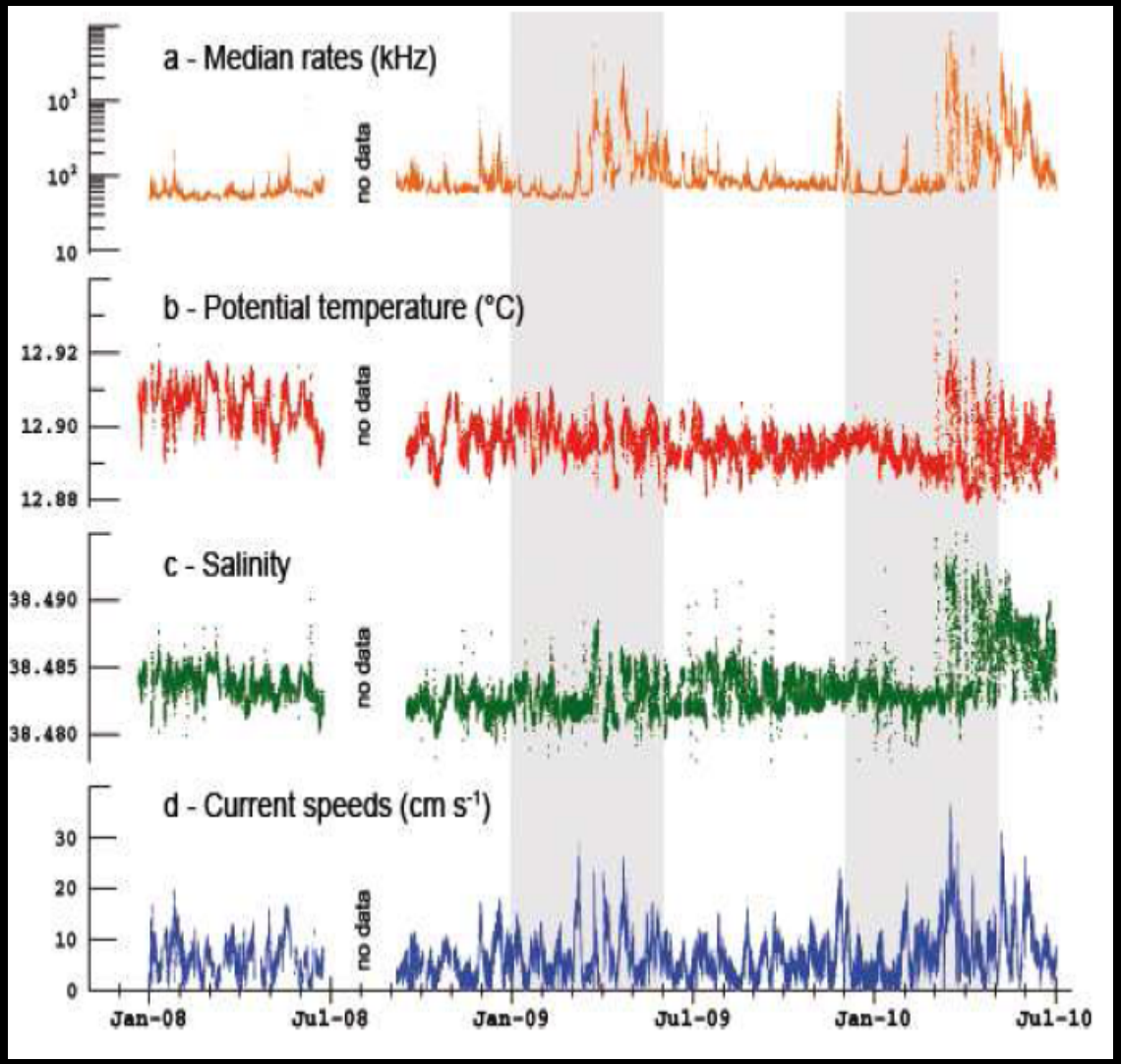


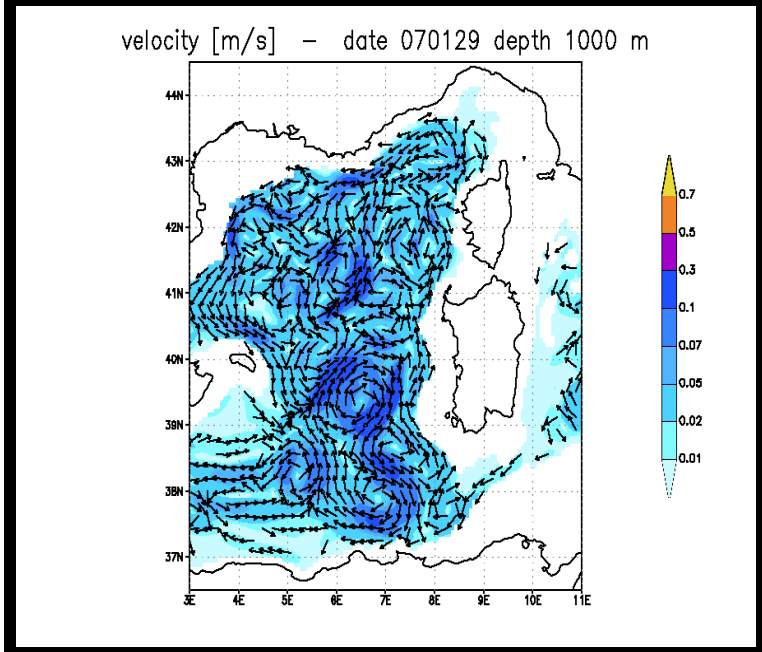
Can we instrument large areas of the Mediterranean with seismometers ?

Surface circulation



ANTARES: Long Term Oceanographic Parameters

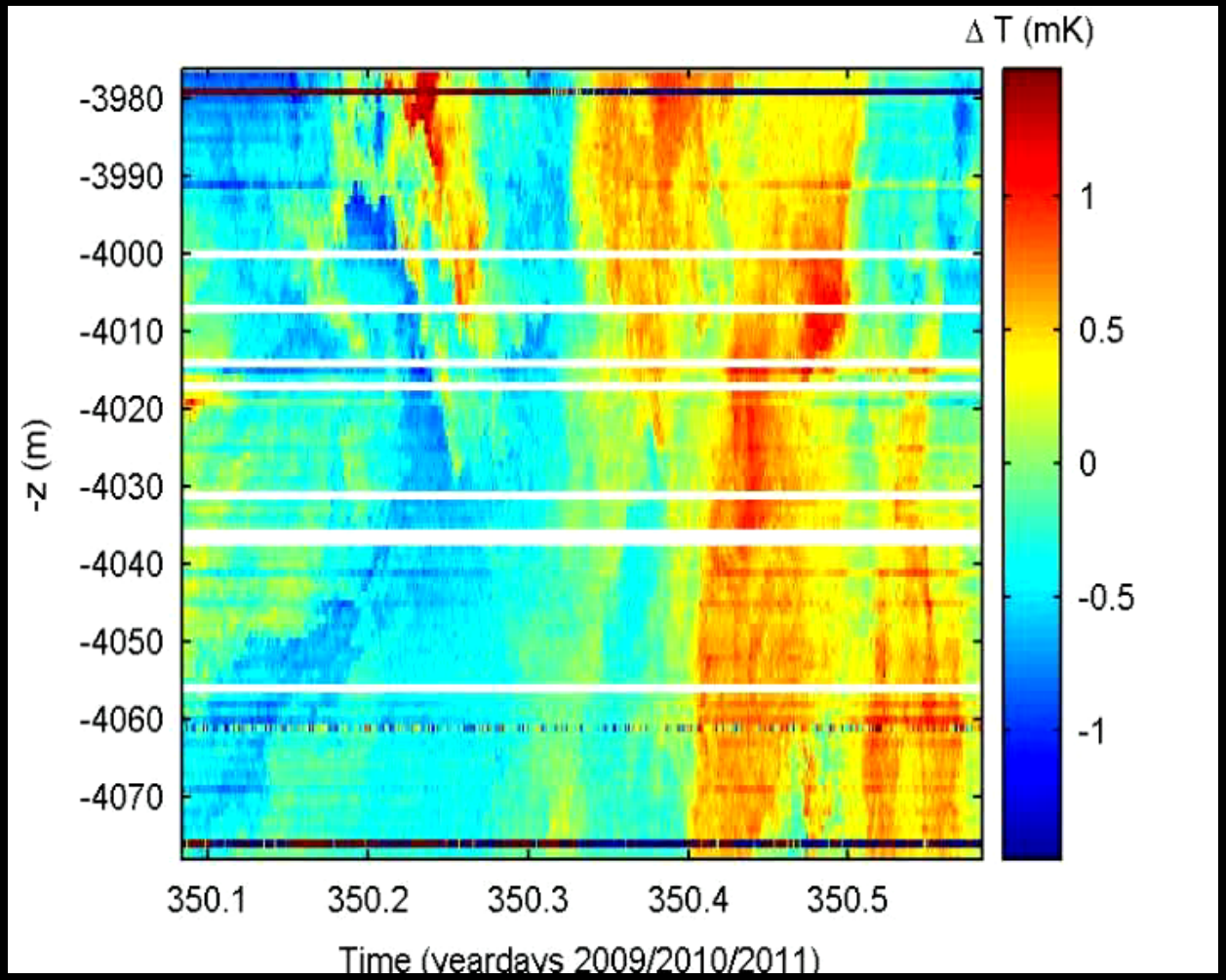




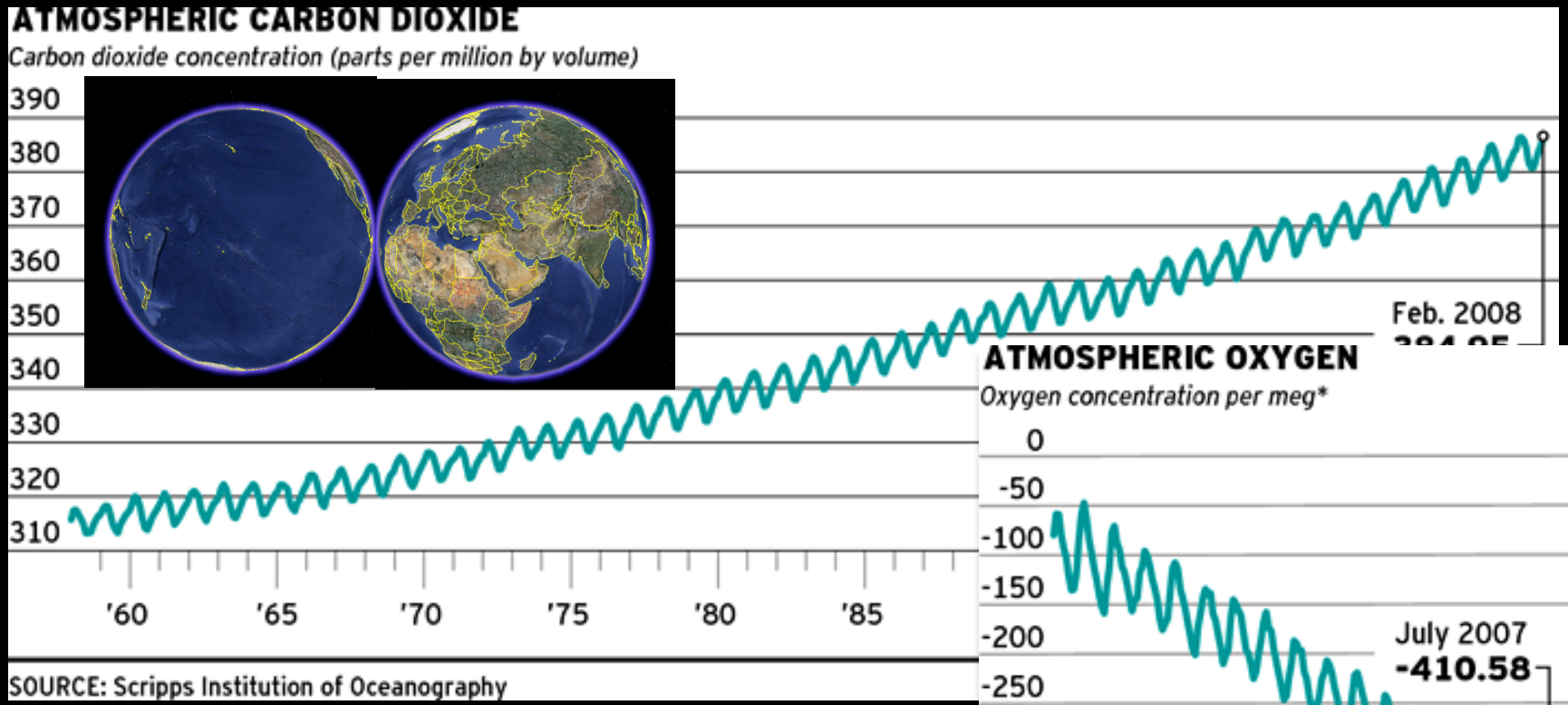
Part of hydrochanges Mediterranean network

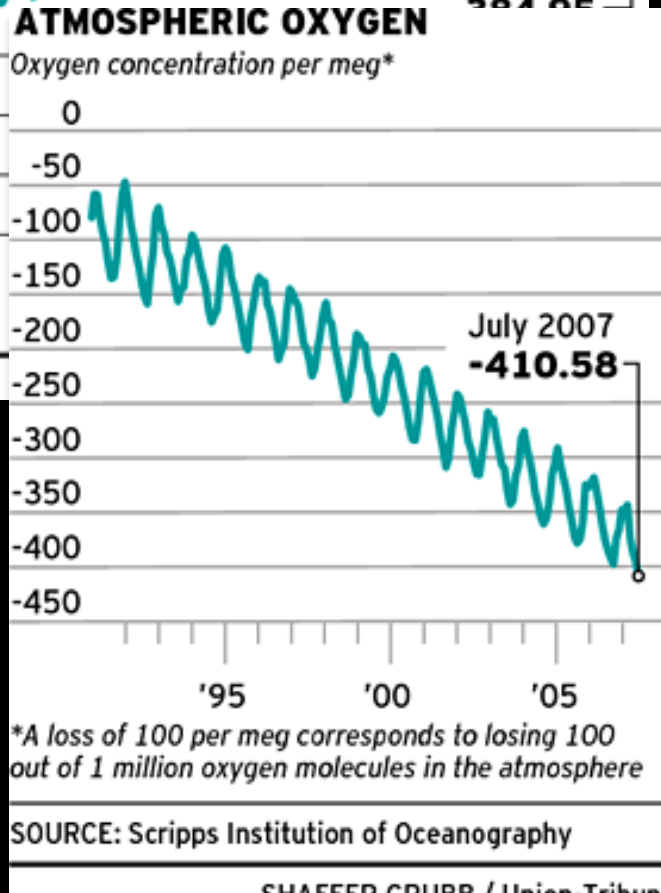
Member of Eurosites

Monitor smaller scale variability , turbulence



The Breathing Planet

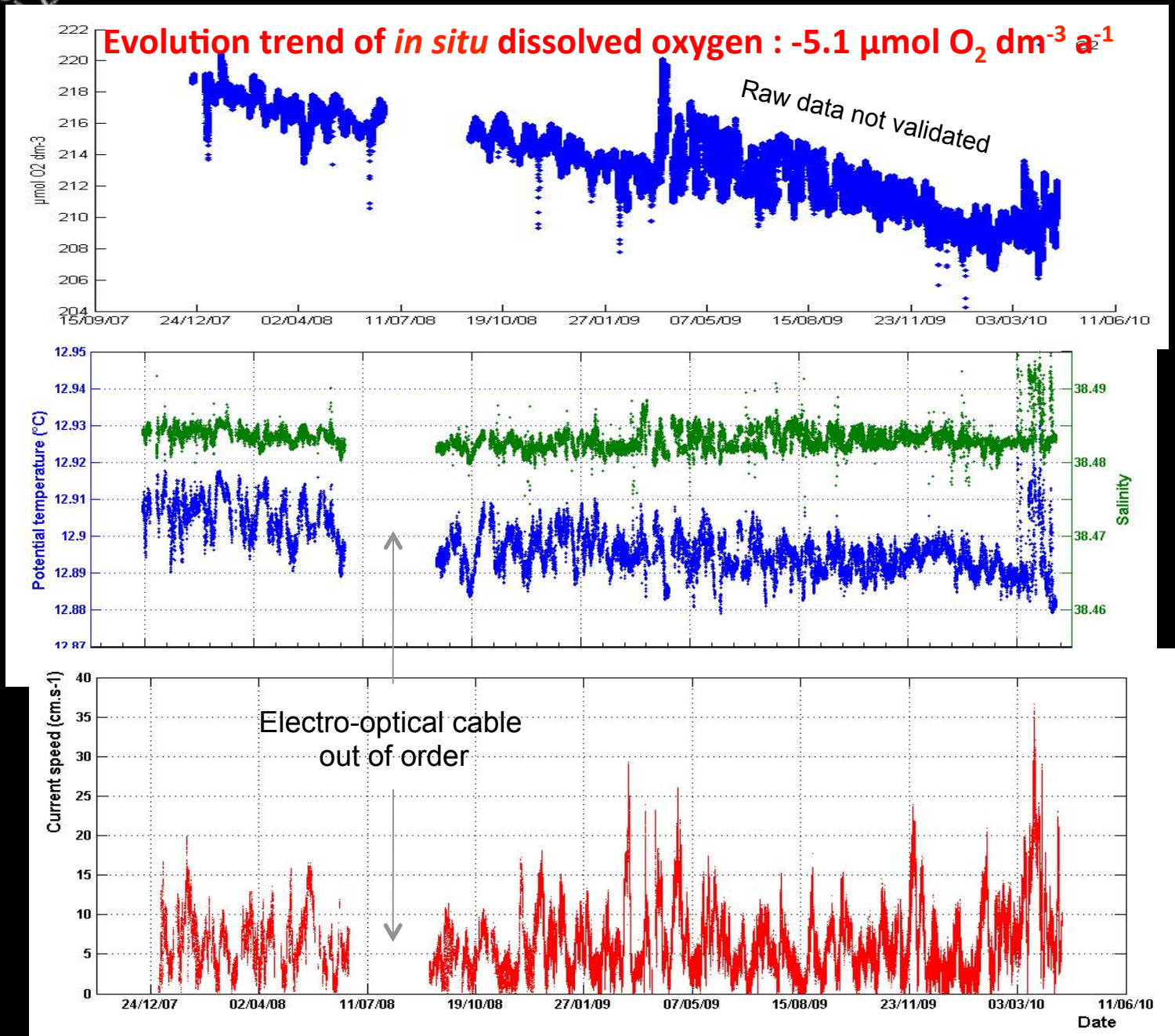




CO_2 and O_2 atmospheric trends

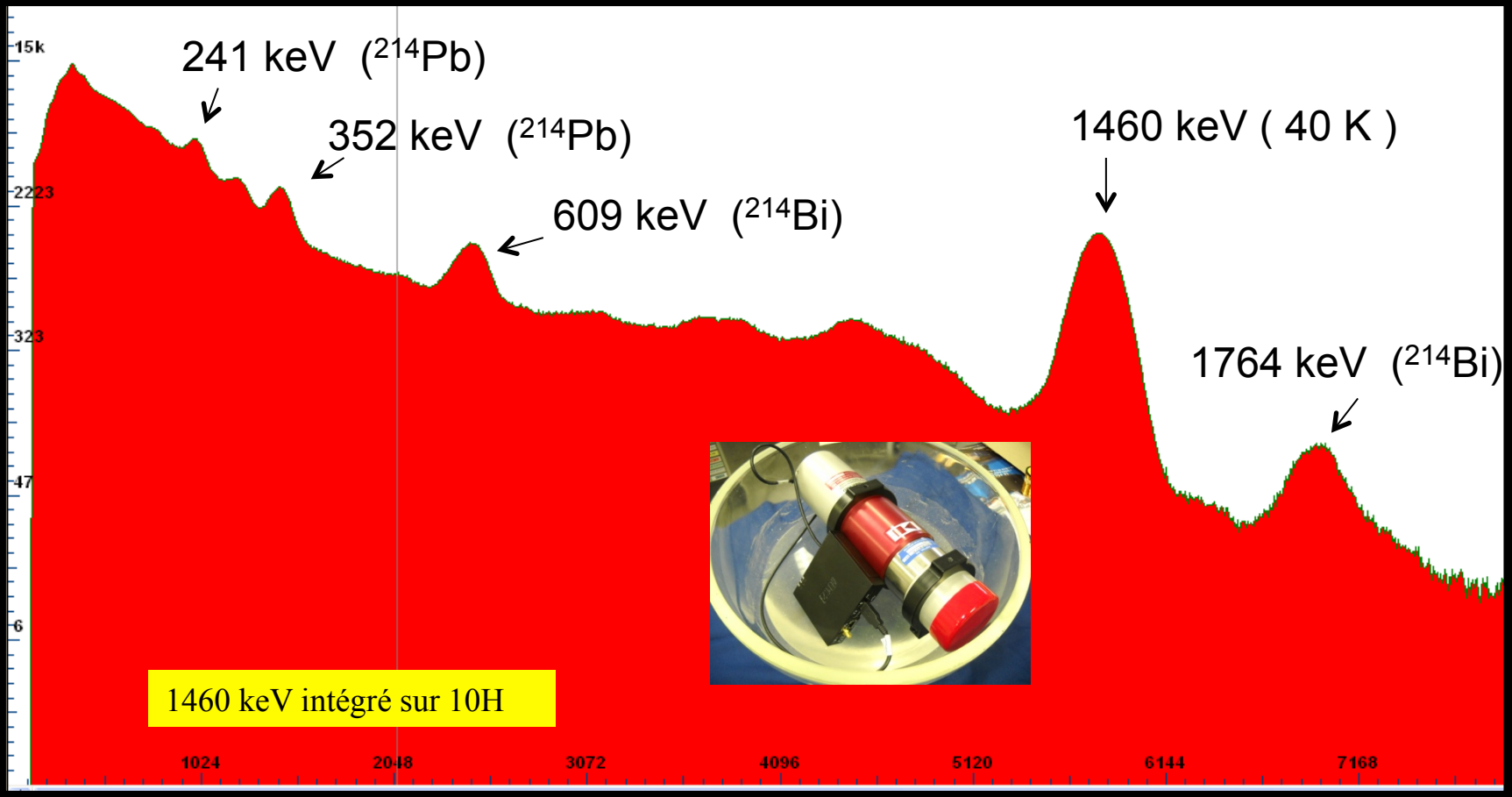
Planet earth : A living organism

Temperature, Salinity, O_2 time-series (IL07)

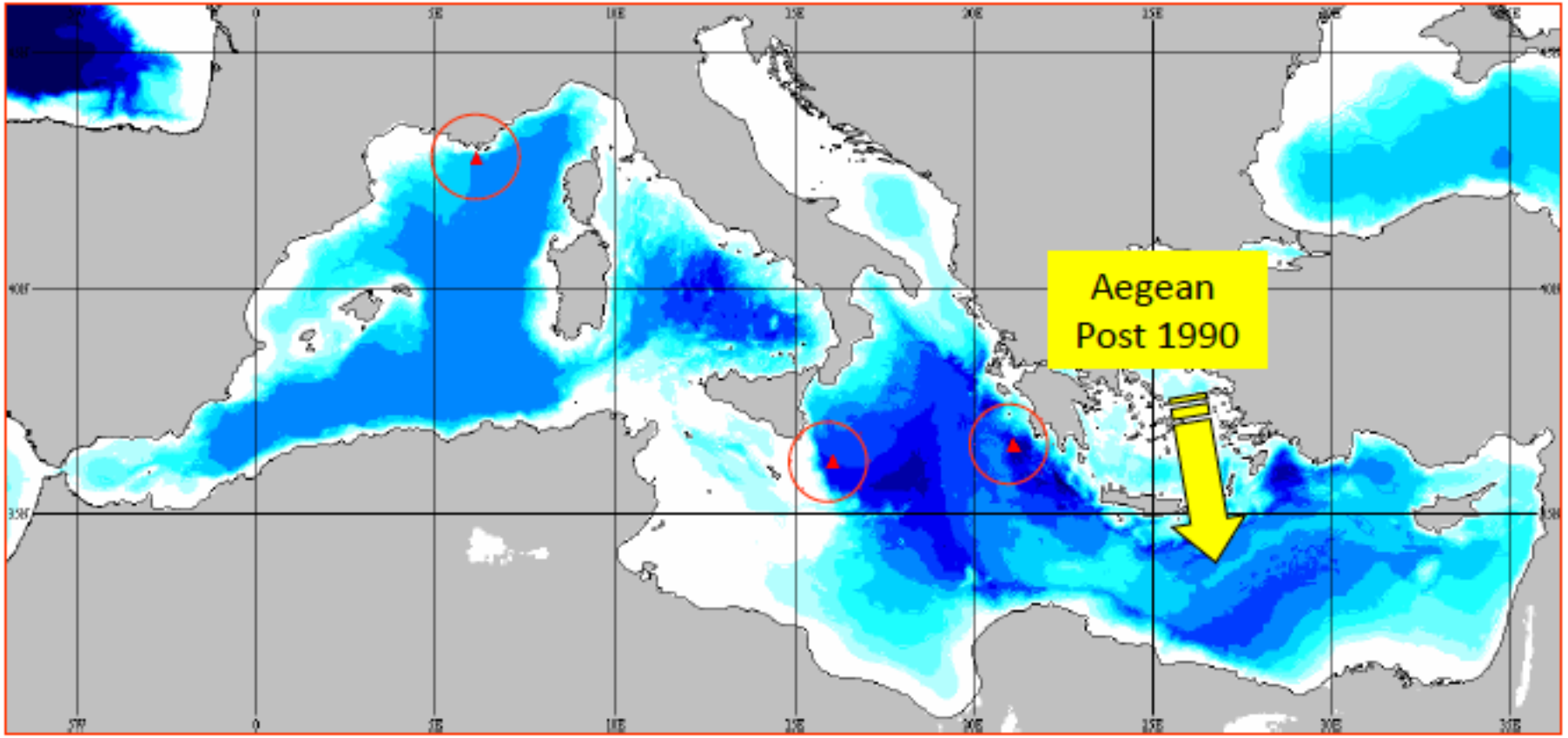


Gamma Spectra in Deep Sea

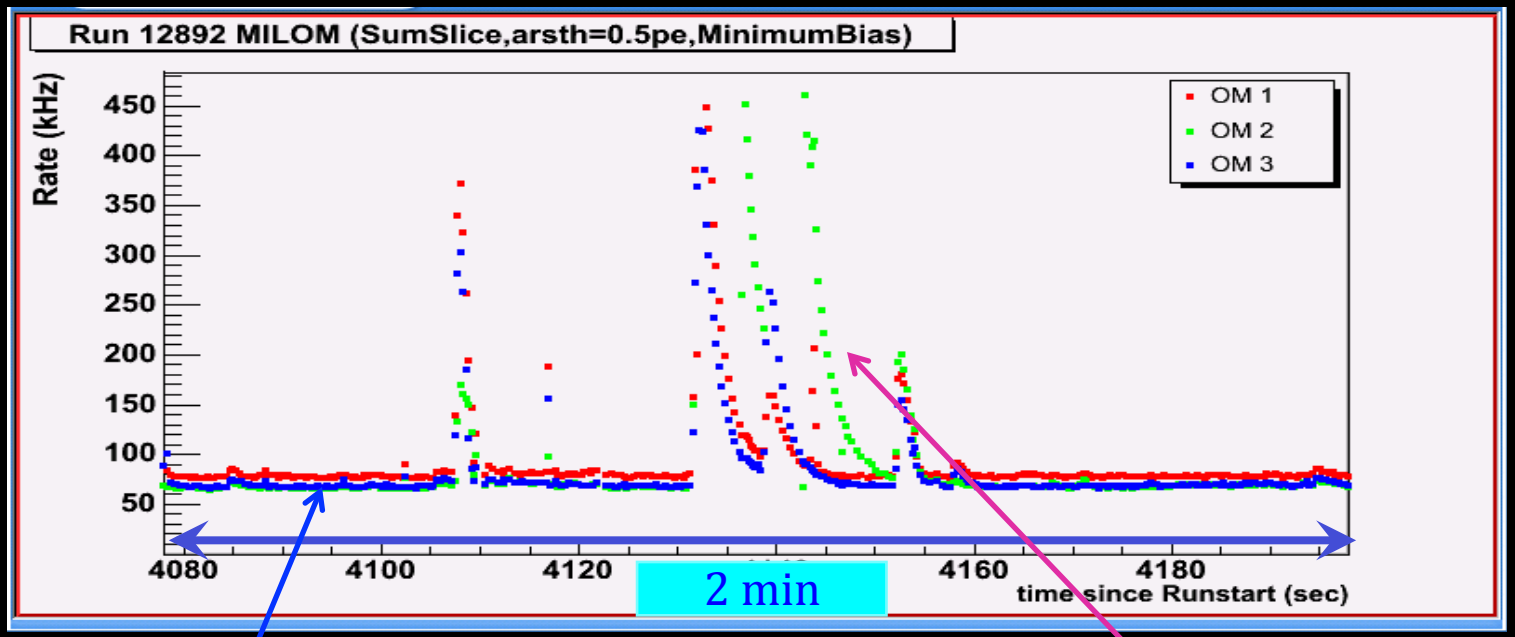
Log scale



Deep Water Formation
Eastern Mediterranean Transient 1990



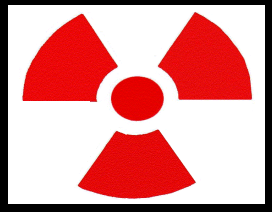
Counting Rates on Optical Modules



Continuous baseline:
Radioactivity in the sea (^{40}K)
+ bioluminescent bacteria?

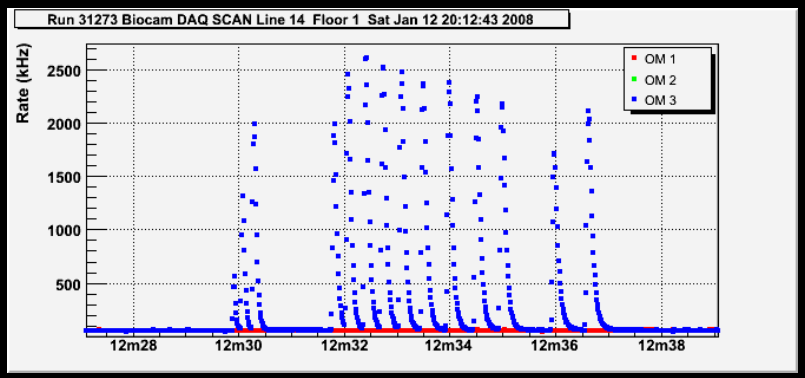
Bursts:
bioluminescence from
Macroscopic organisms

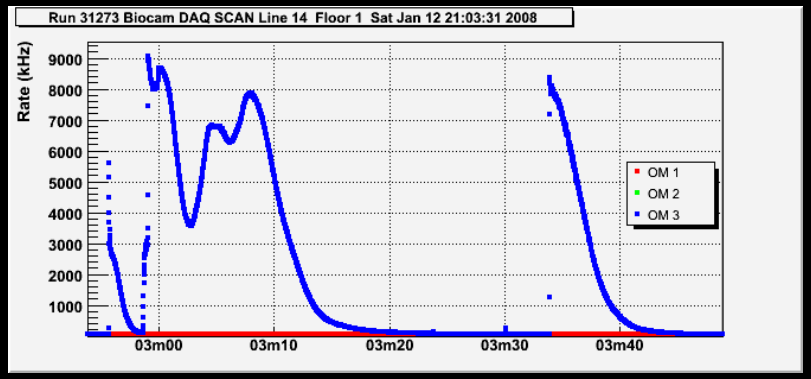
^{40}K

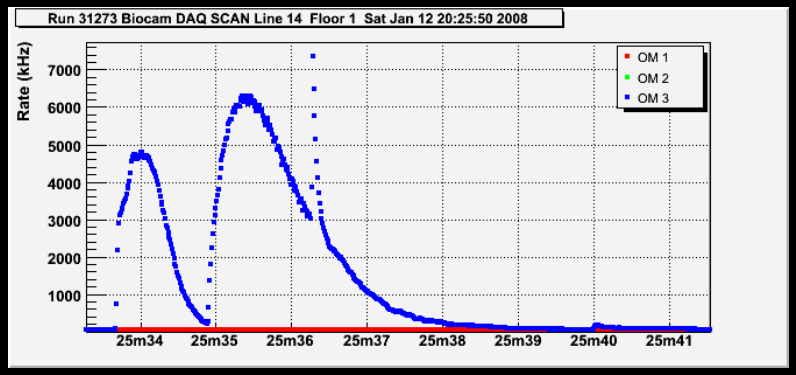


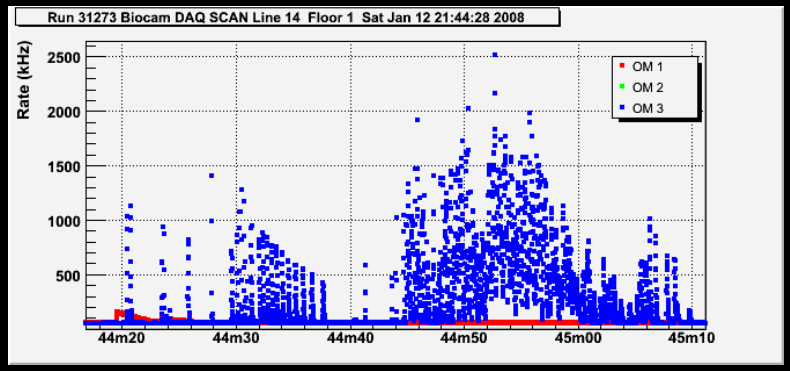
$$^{40}_{19}\mathrm{K} \rightarrow ^{40}_{20}\mathrm{Ca} + \mathrm{e} + \bar{\nu}_{\mathrm{e}}$$

Example Bioluminescence Evts Observed on PMTs

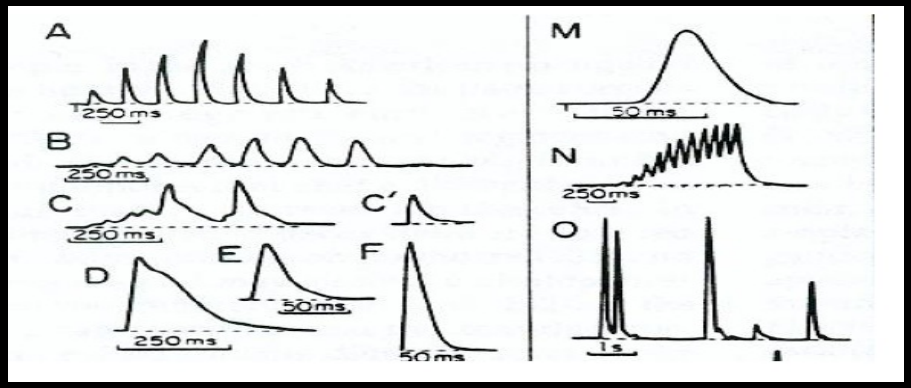




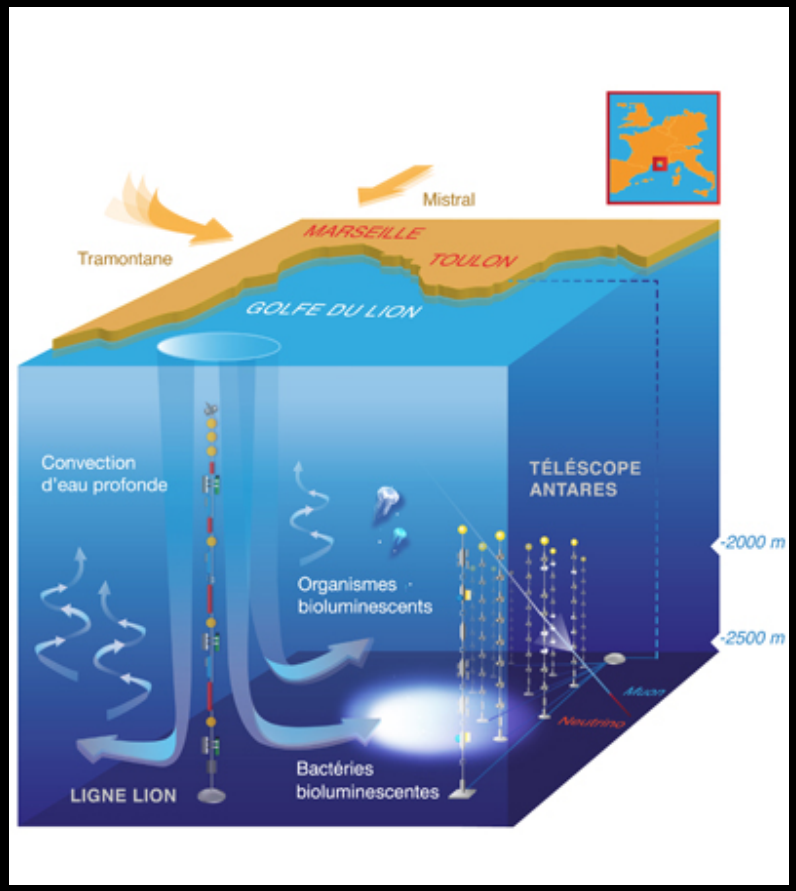


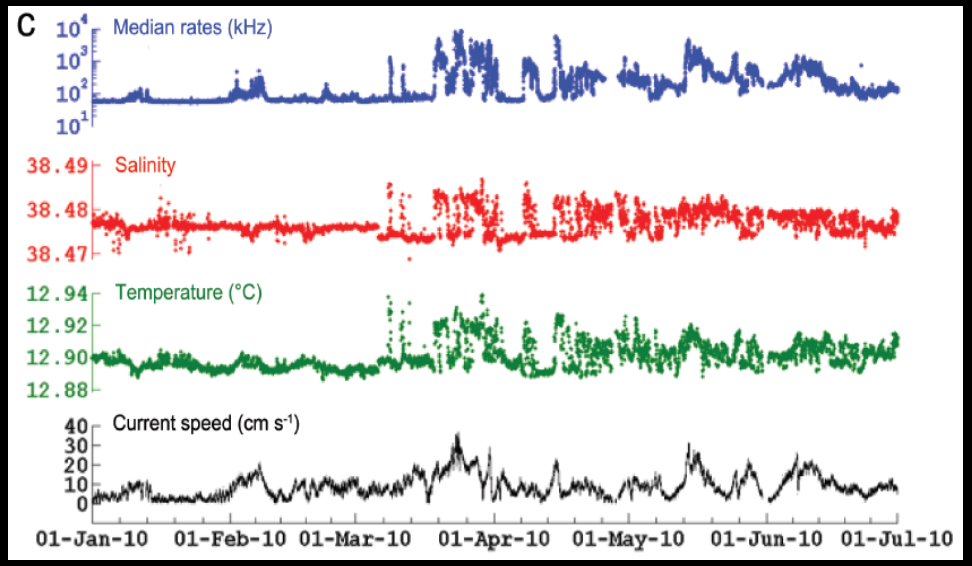


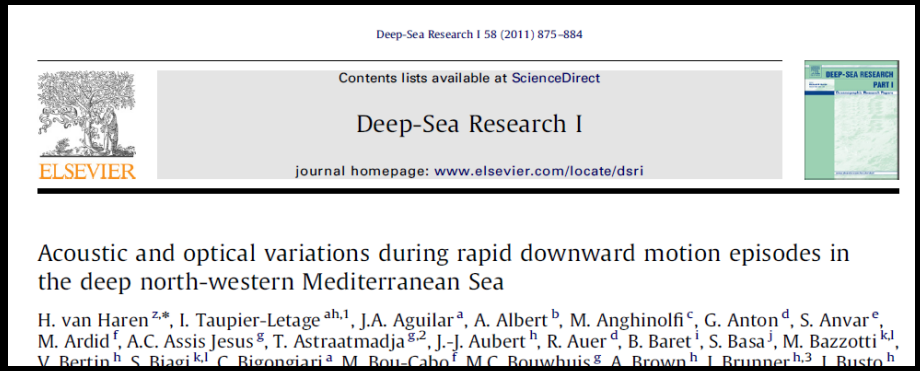
versus literature



Life as proxy of deep water formation

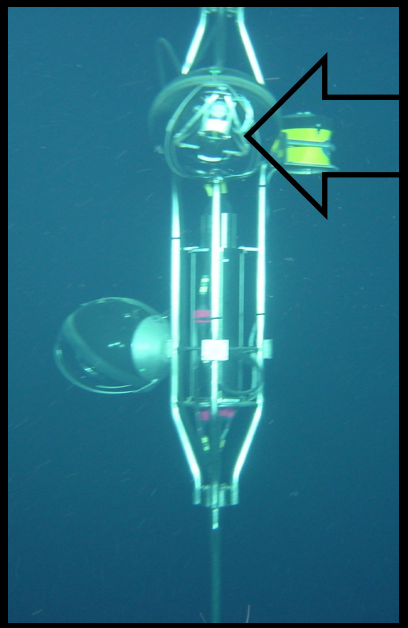






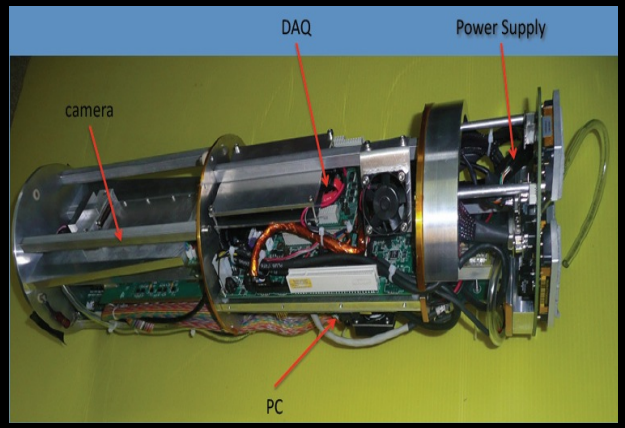
Prix de la Recherche 2014
Catégorie « coup de cœur »

Also World's Deepest Real Time Cameras



2009-06-01 01:46:22

AXIS221 vidéosurveillance
Sensistivity: 0.1 lux
Field of view: up to 90 degrees
Infra red night vision



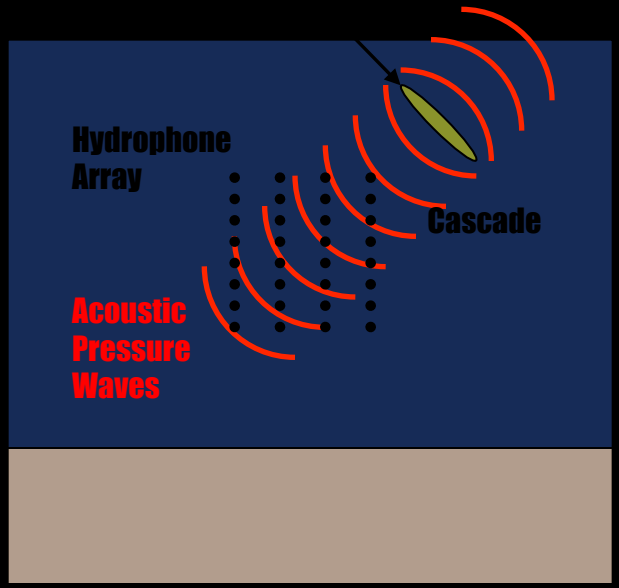
ebcmos technology
Imaging with
Single photon sensitivity
Very fast frame rate

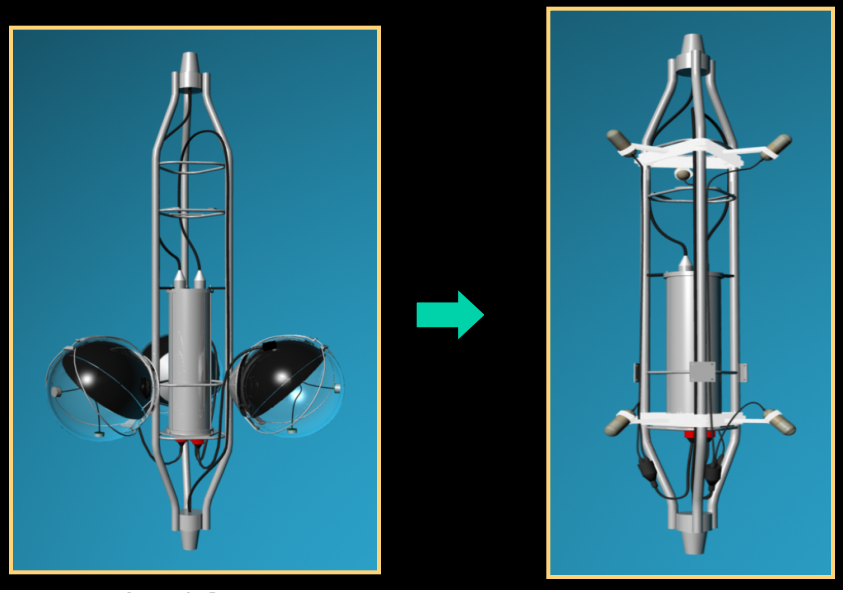
What are these things ?

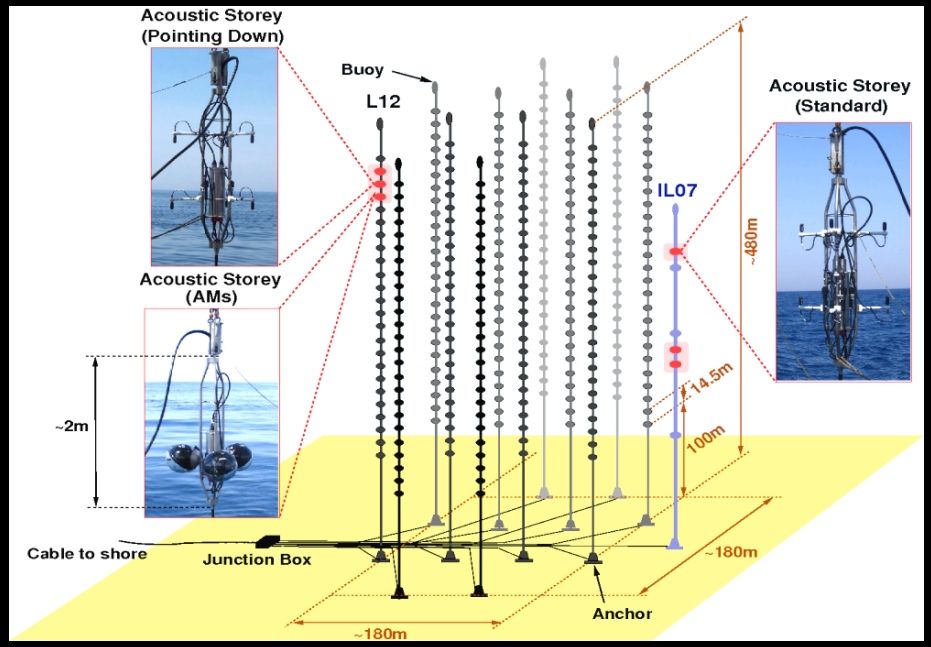
They even talk to each other

AMADEUS: Acoustic Detection of Neutrinos

neutrino



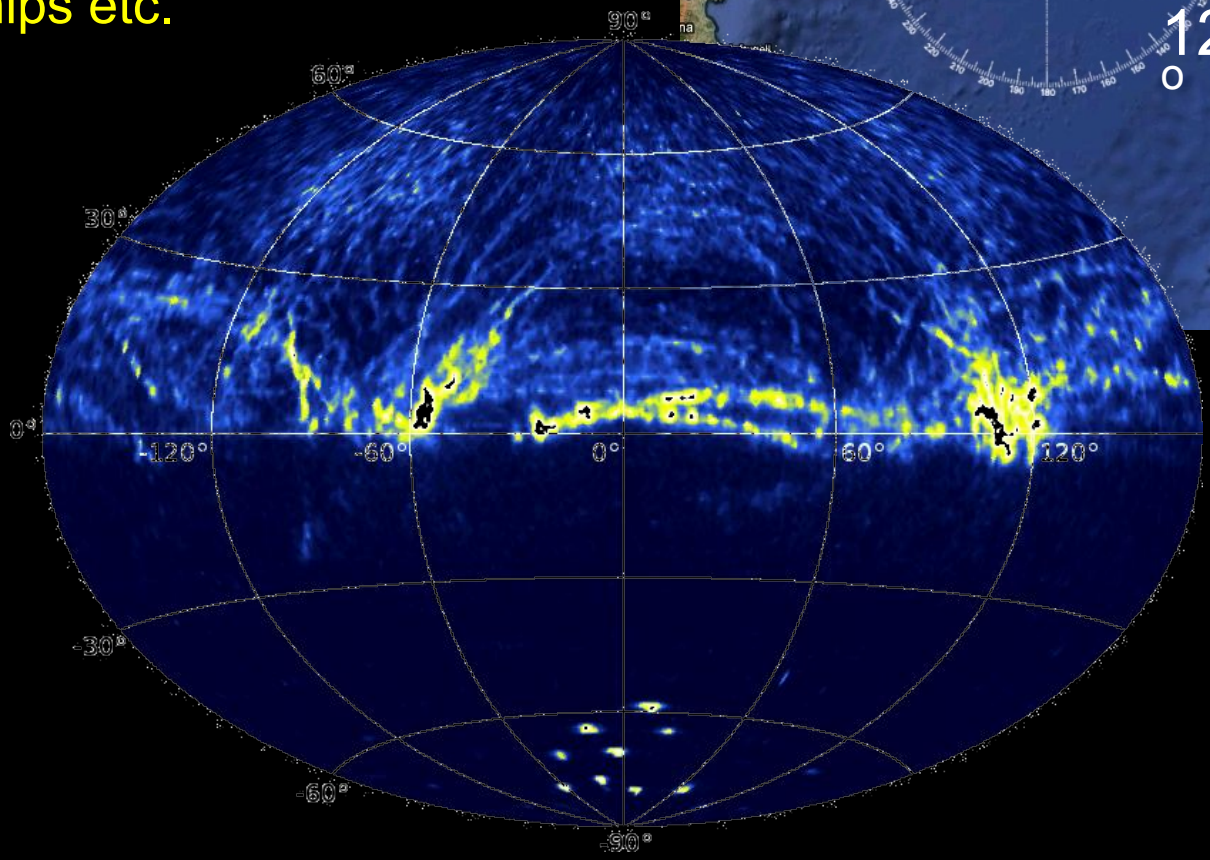


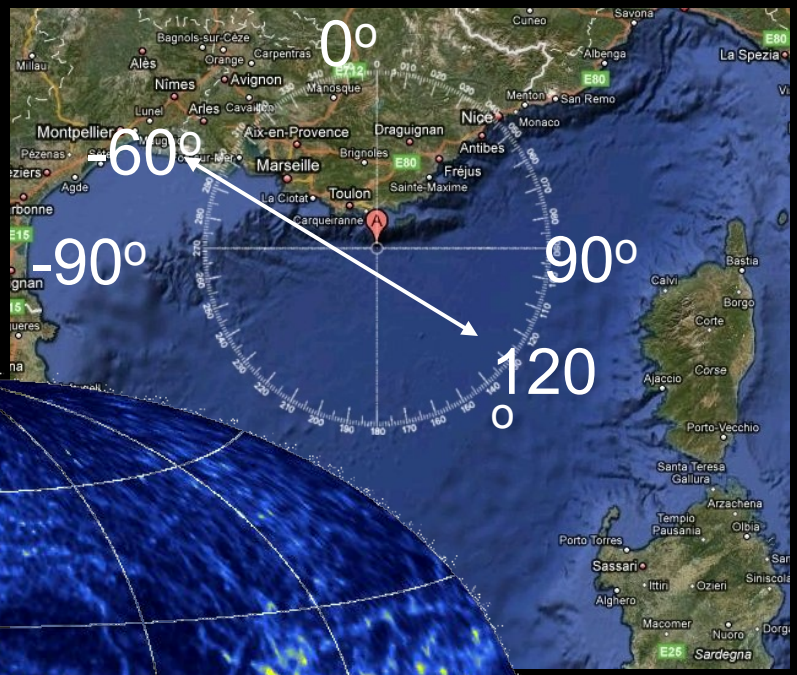


Acoustic Source Direction Distribution

Direction reconstruction from one storey on L12

All types of transient signals included, sea mammals, ships etc.





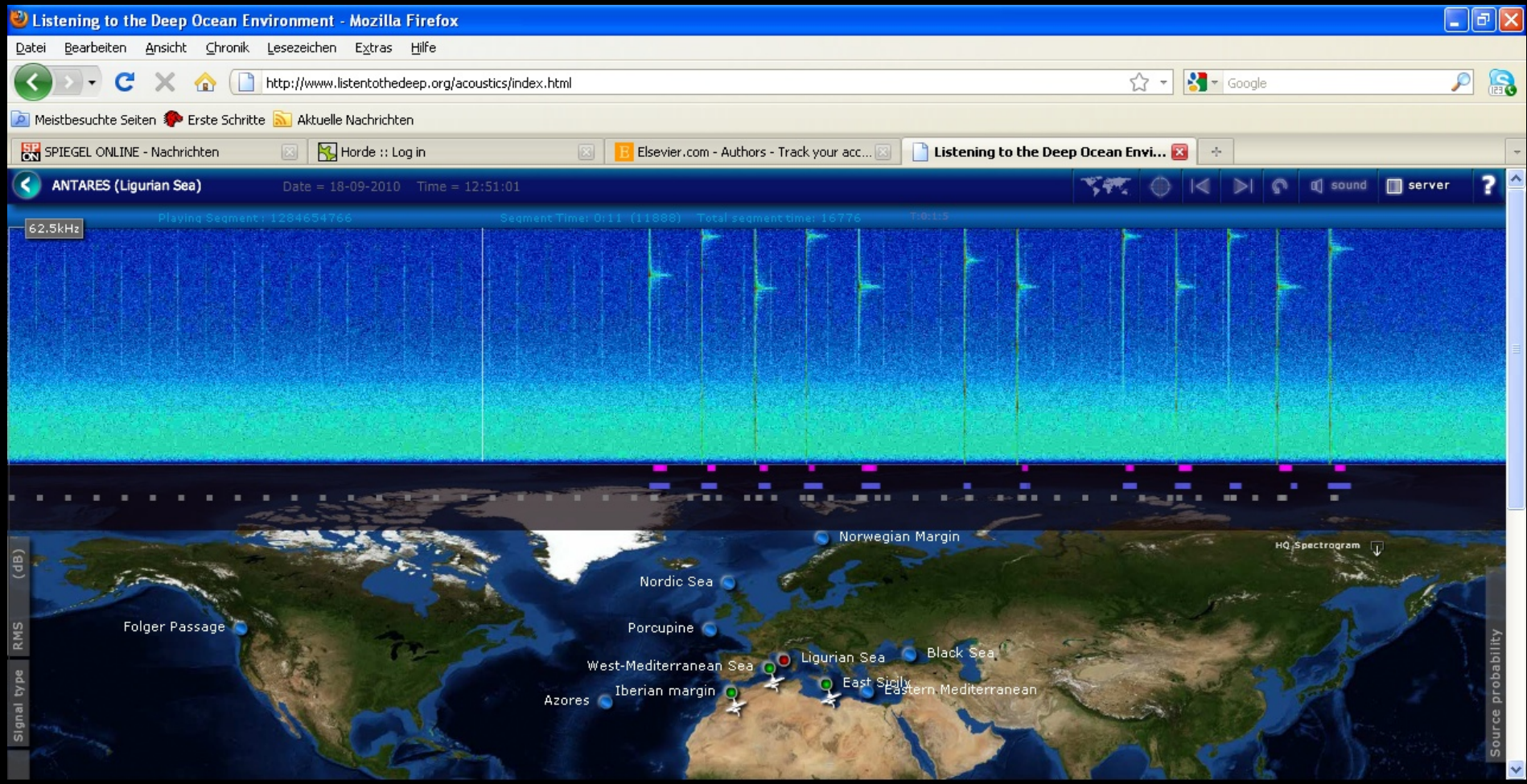
http://www.listentothedeep.com

Lido
LISTENING TO THE DEEP-OCEAN ENVIRONMENT

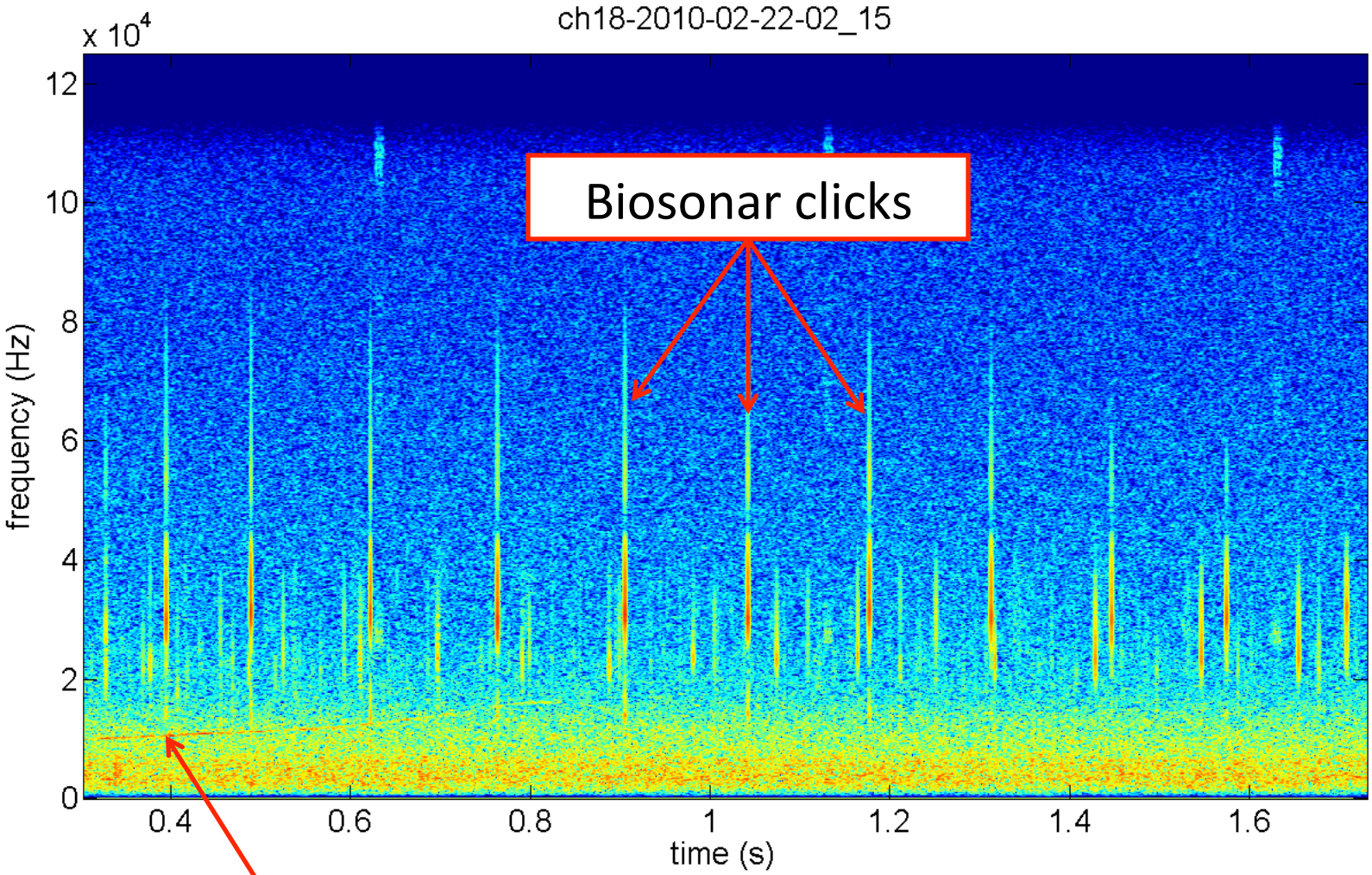
LISTEN TO ANTARES LIVE

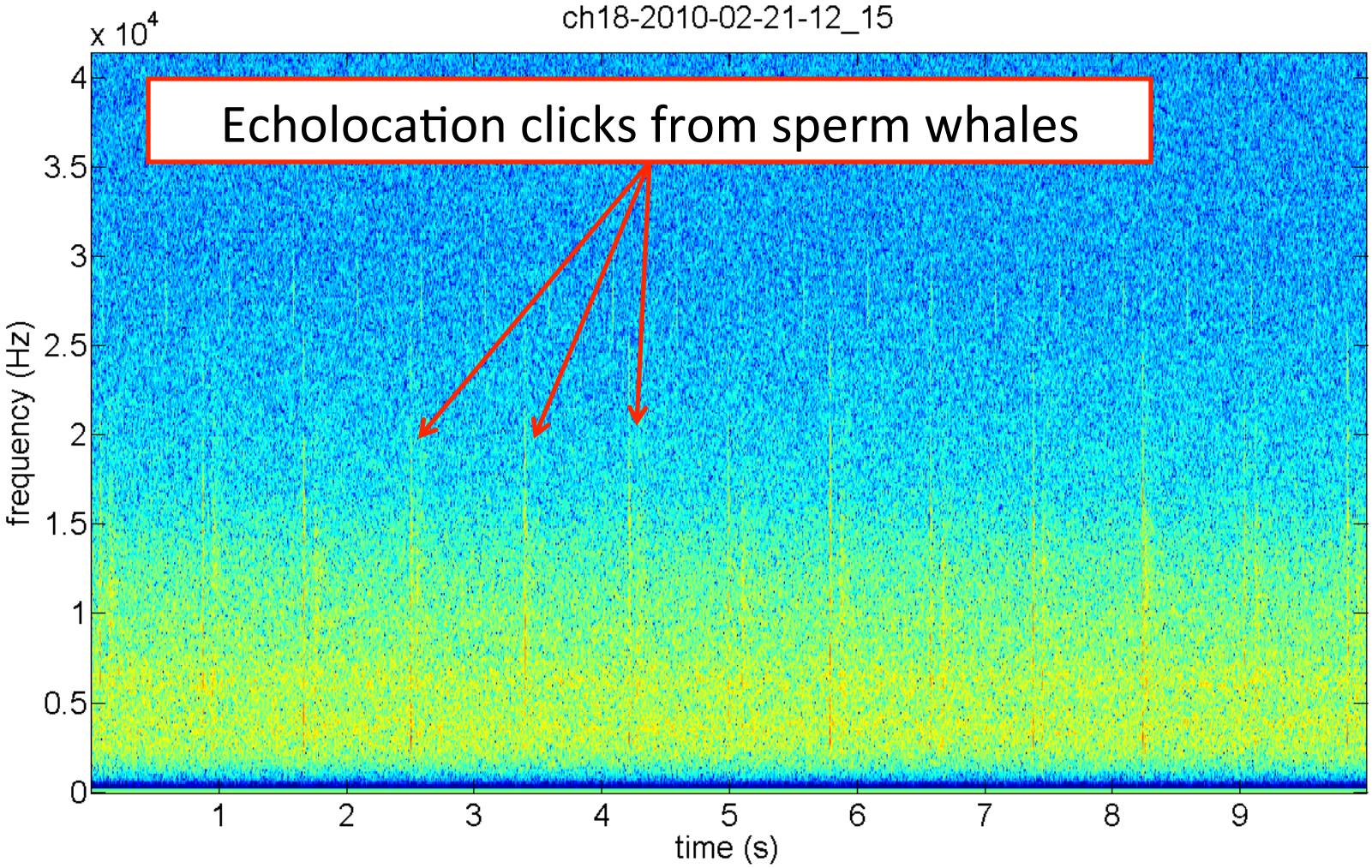
http://www.listentothedeep.org/

(click on “Enter the bioacoustics page”, then “Ligurian Sea”)



Dense series of ultrasonic clicks,
(biosonar) from beaked whales or dolphins

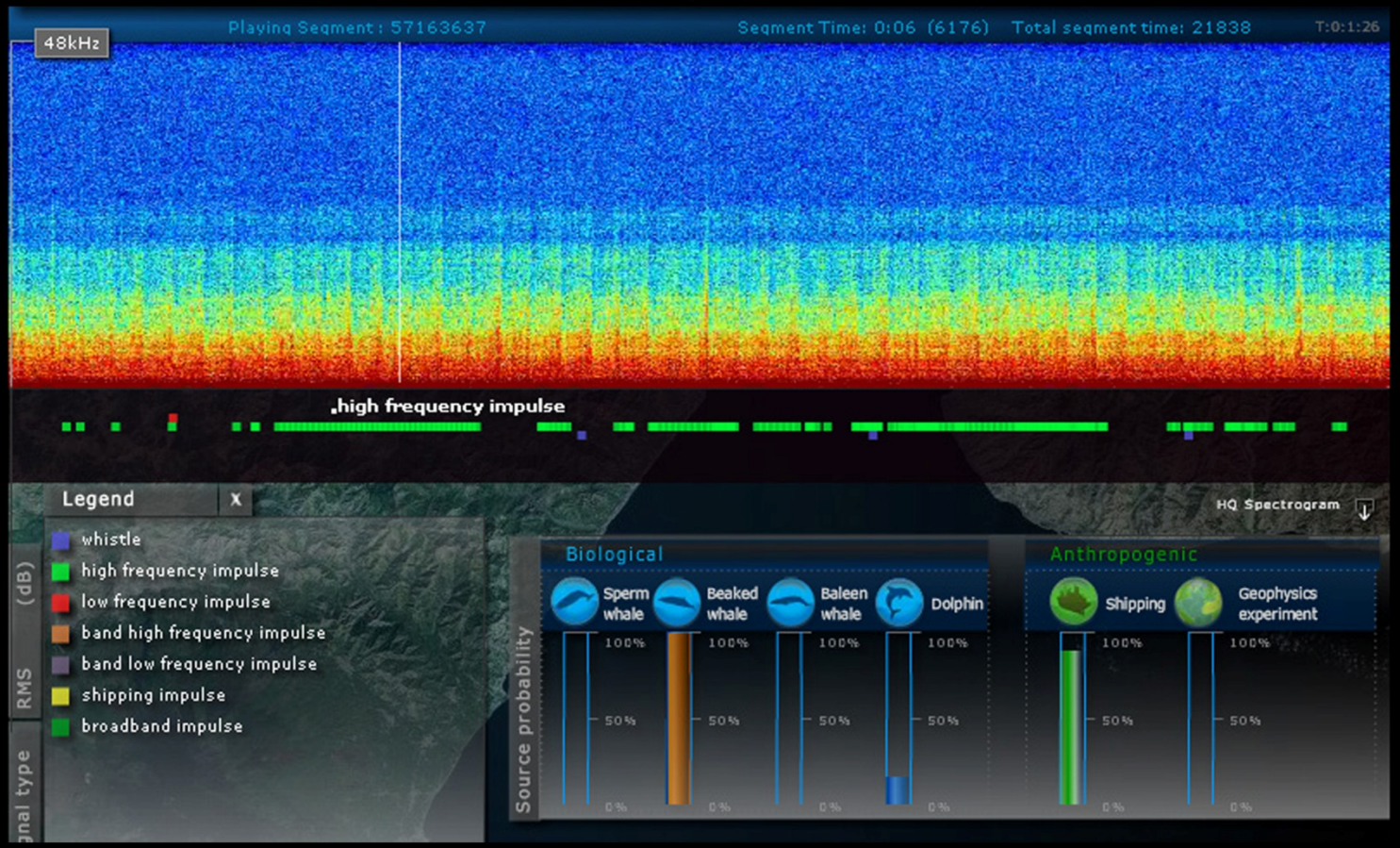



ch18-2010-02-21-12_15
x 10^4
4
3.5
3
2.5
2
1.5
1
0.5
0
frequency (Hz)
1
2
3
4
5
6
7
8
9
time (s)
Echolocation clicks from sperm whales

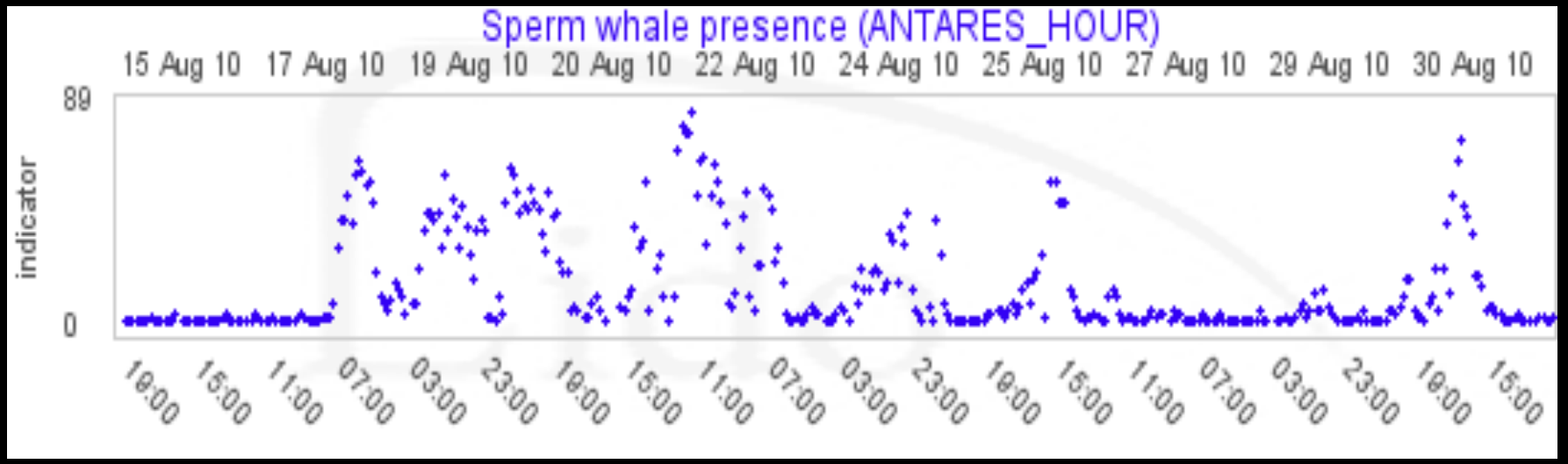
Listening to the Deep Ocean Environment

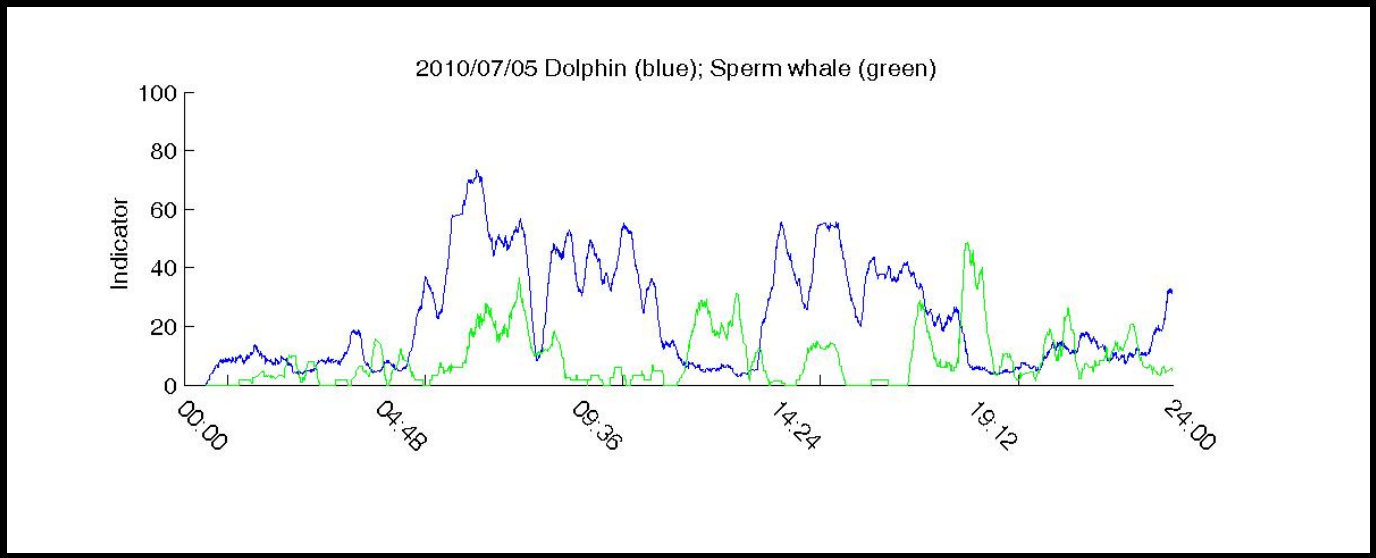
Lido

- Presentation
- Partners
- Bioacoustics
- Listen on Site
- Sound Library
- Statistical Analysis
- Help



Cetaecean Detections with ANTARES





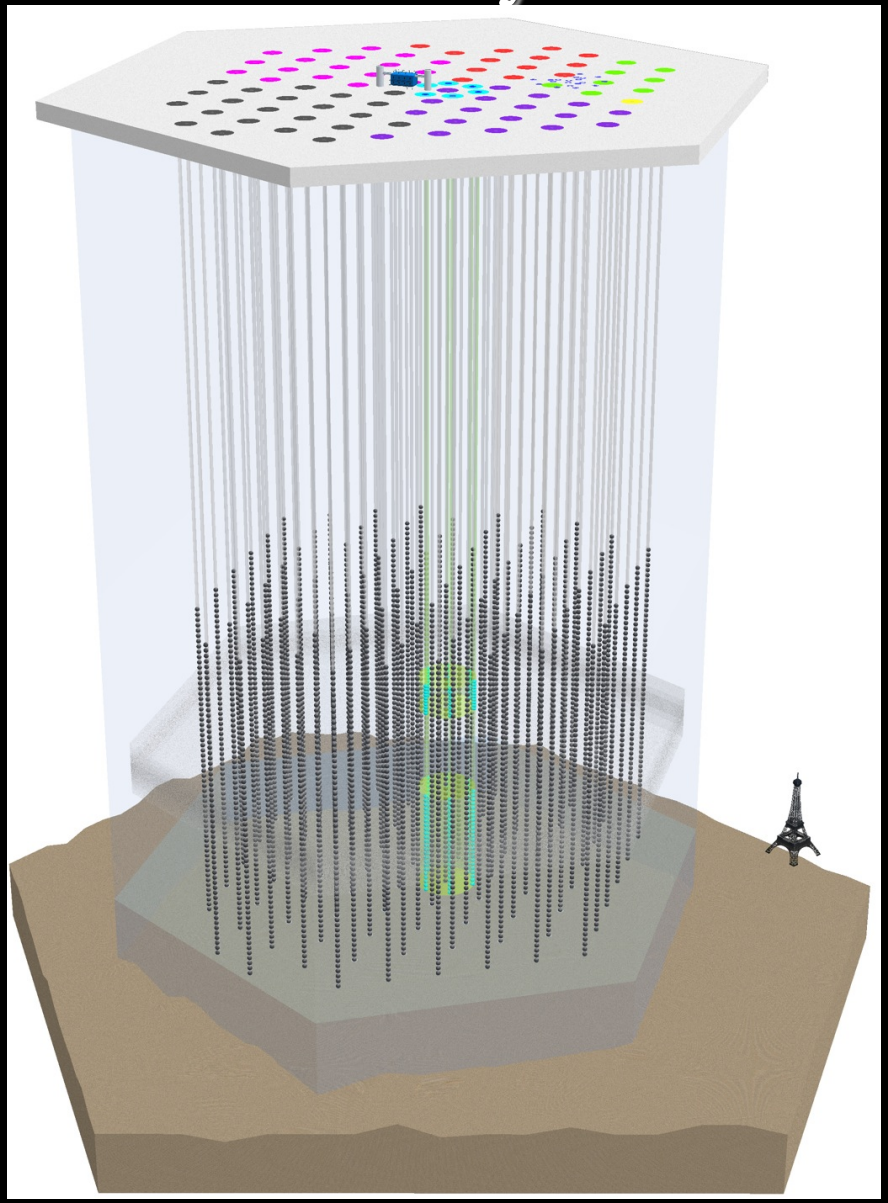
Next step trajectory tracking

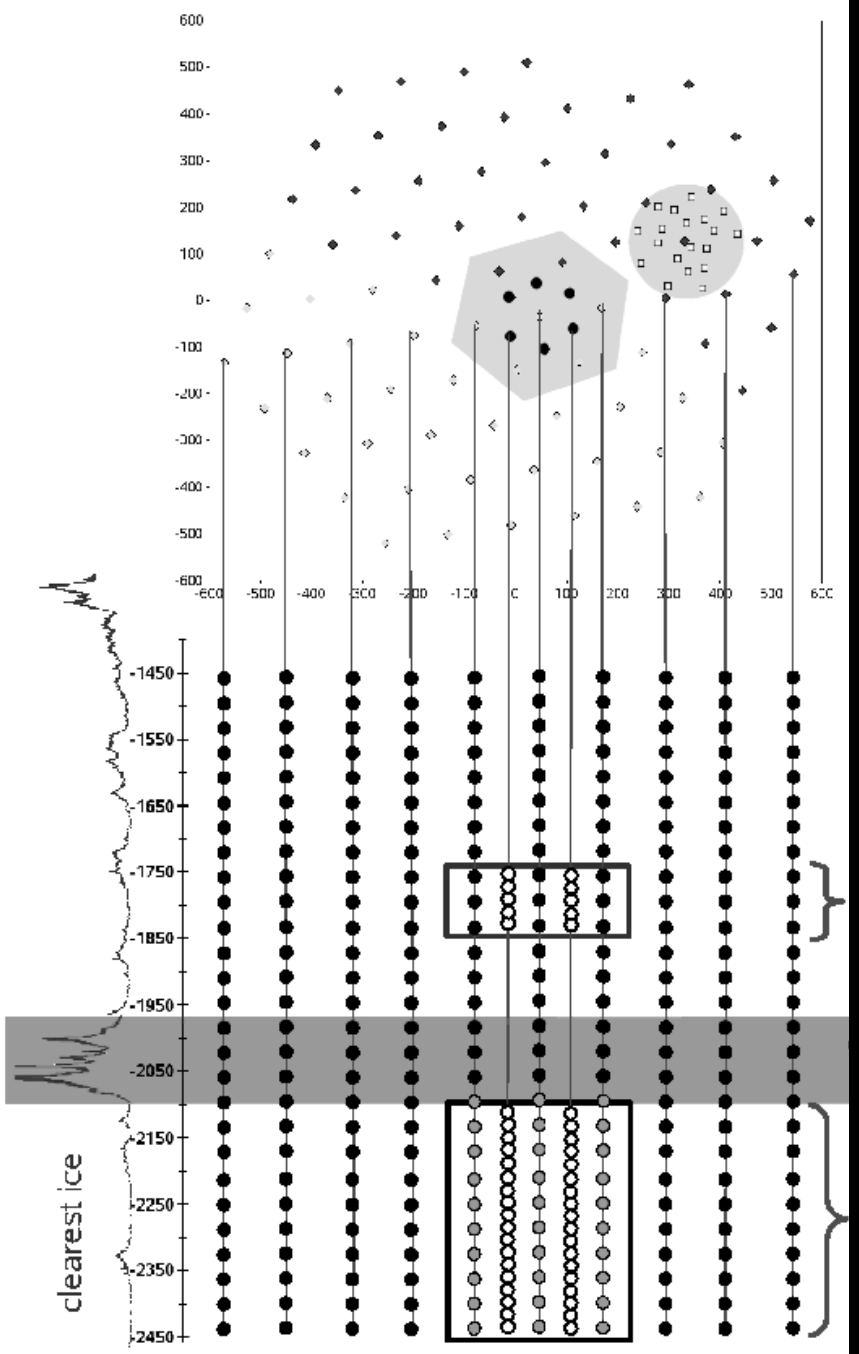
Up the dolfins and whales

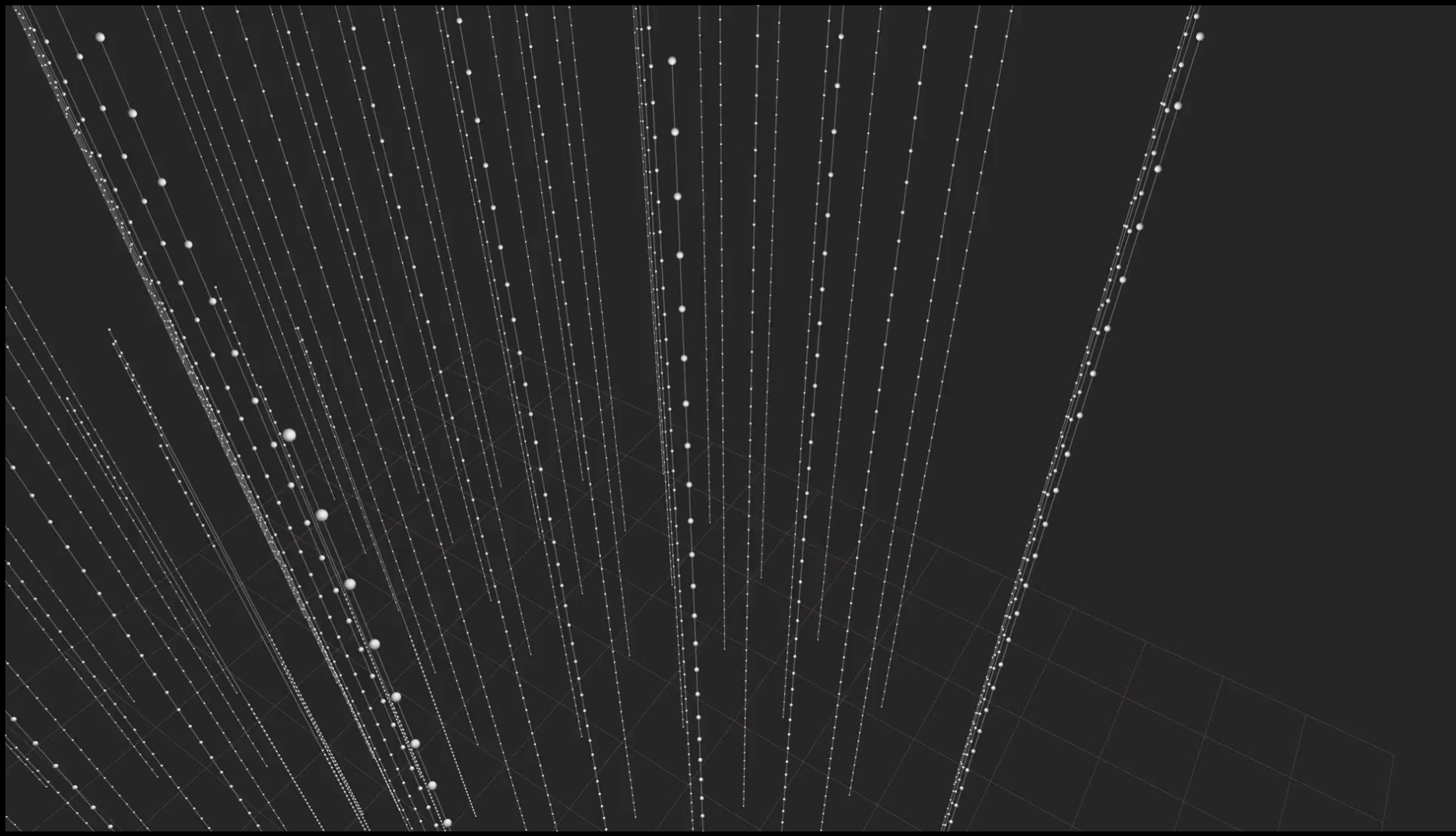
http://www.listentothedeep.org/

(click on “Enter the bioacoustics page”, then “Ligurian Sea”)

The IceCube "Dust Layer"







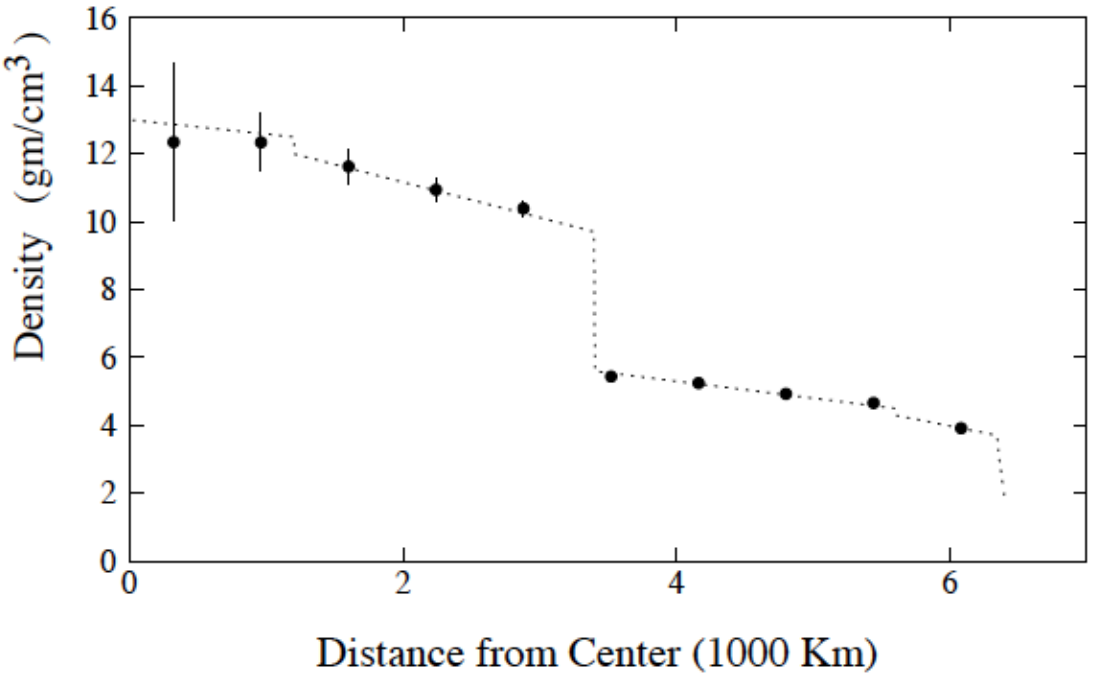
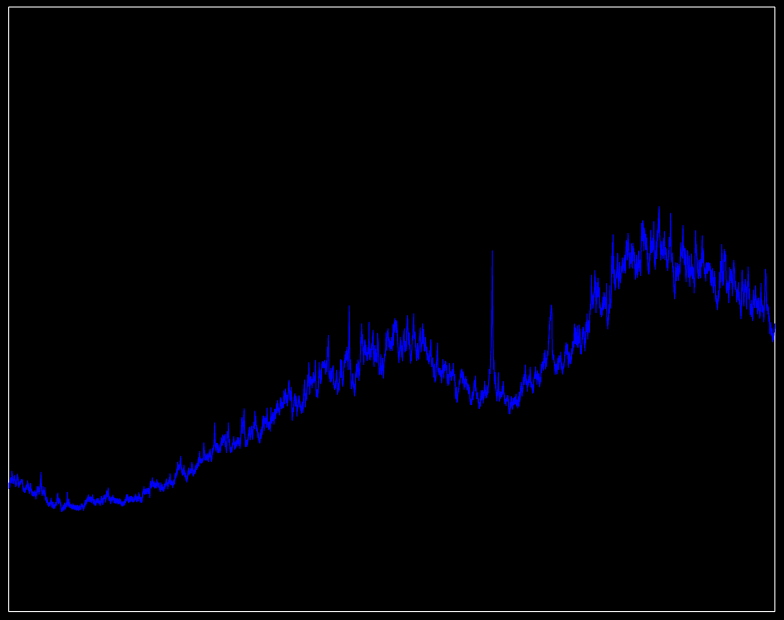
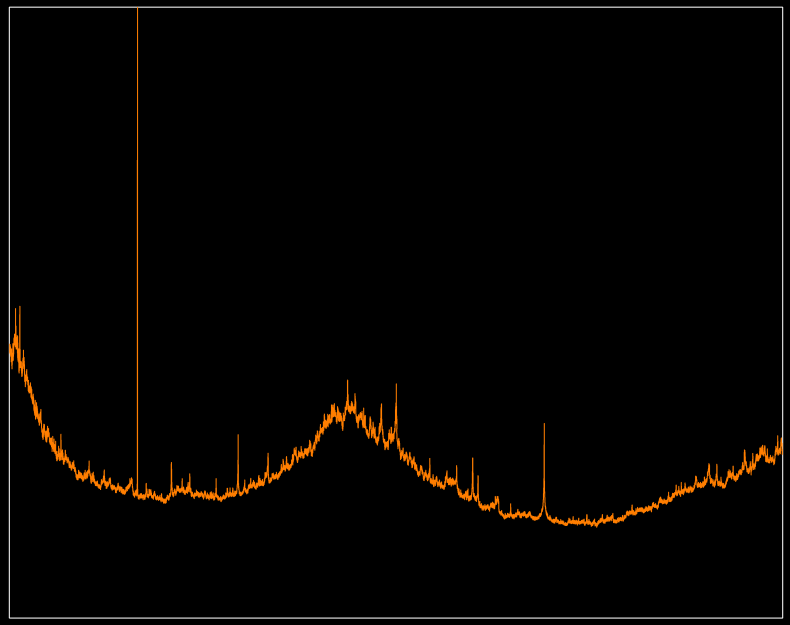
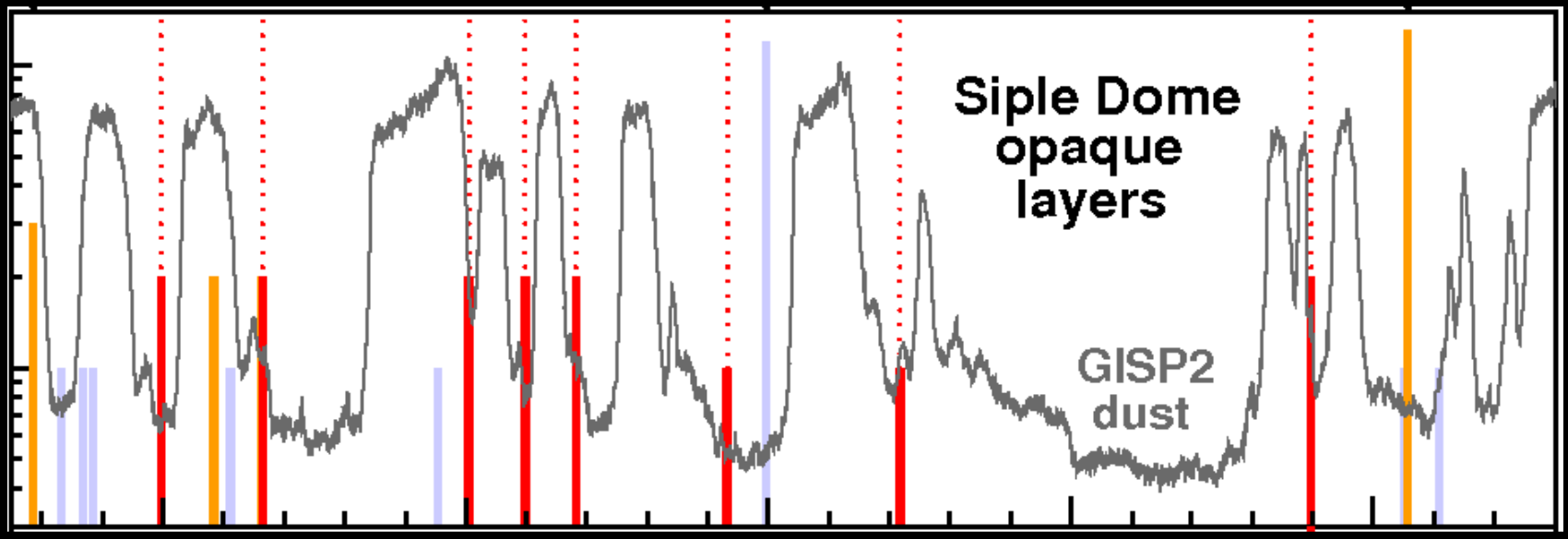


Figure 1: The extracted nucleon density using ten radial bins along with the statistical errors. The PREM model for the Earth's density, dashed curve, was used to generate data. The step between the core and lower mantle is very well resolved, while the difference between the inner and outer cores is not.

Fallout layers & millennial climate change







Dustier ice
during cold climate

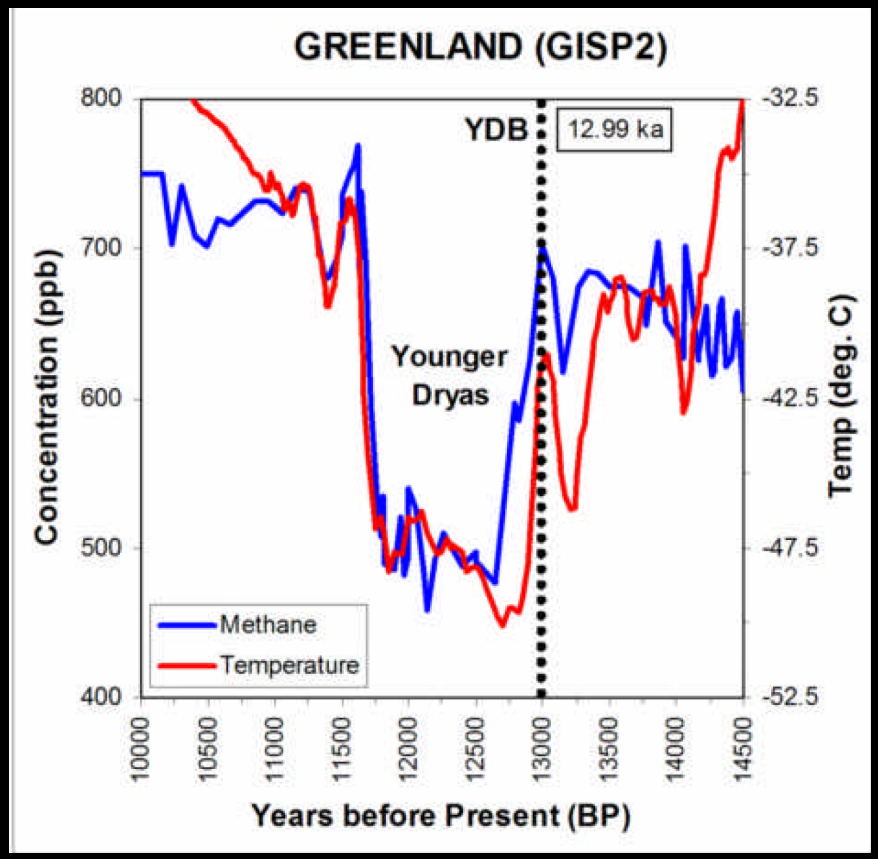
Greater dust
supply

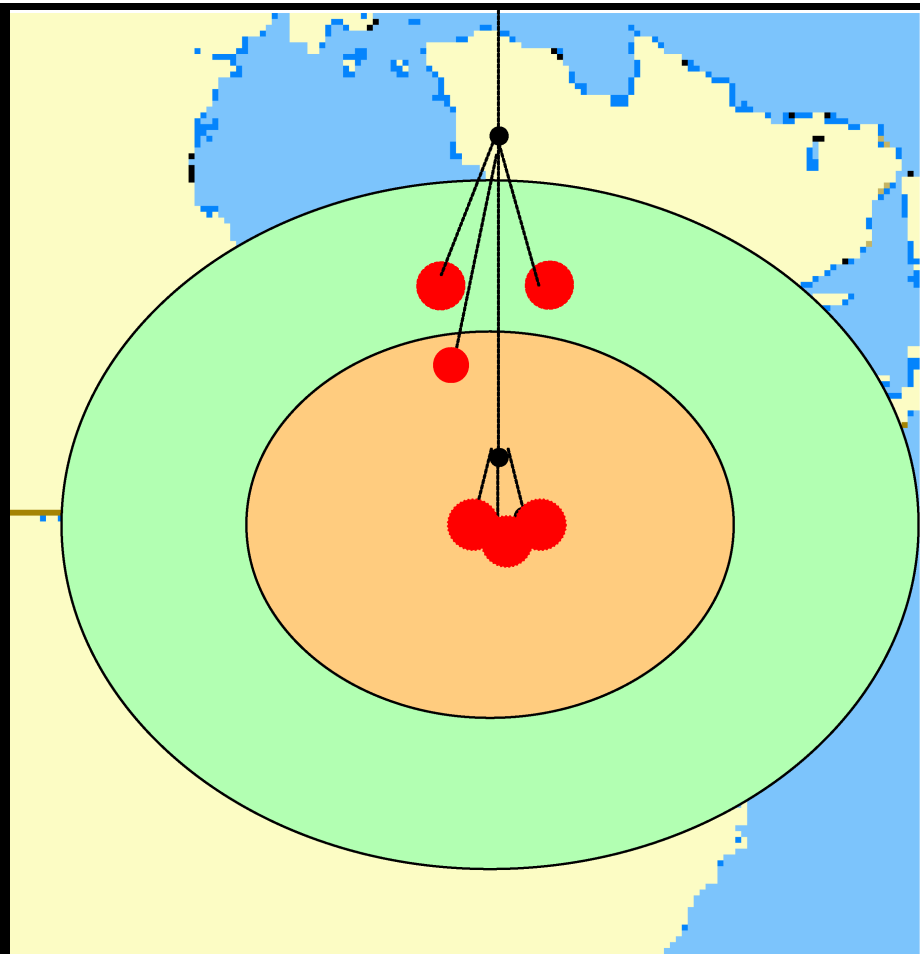
+

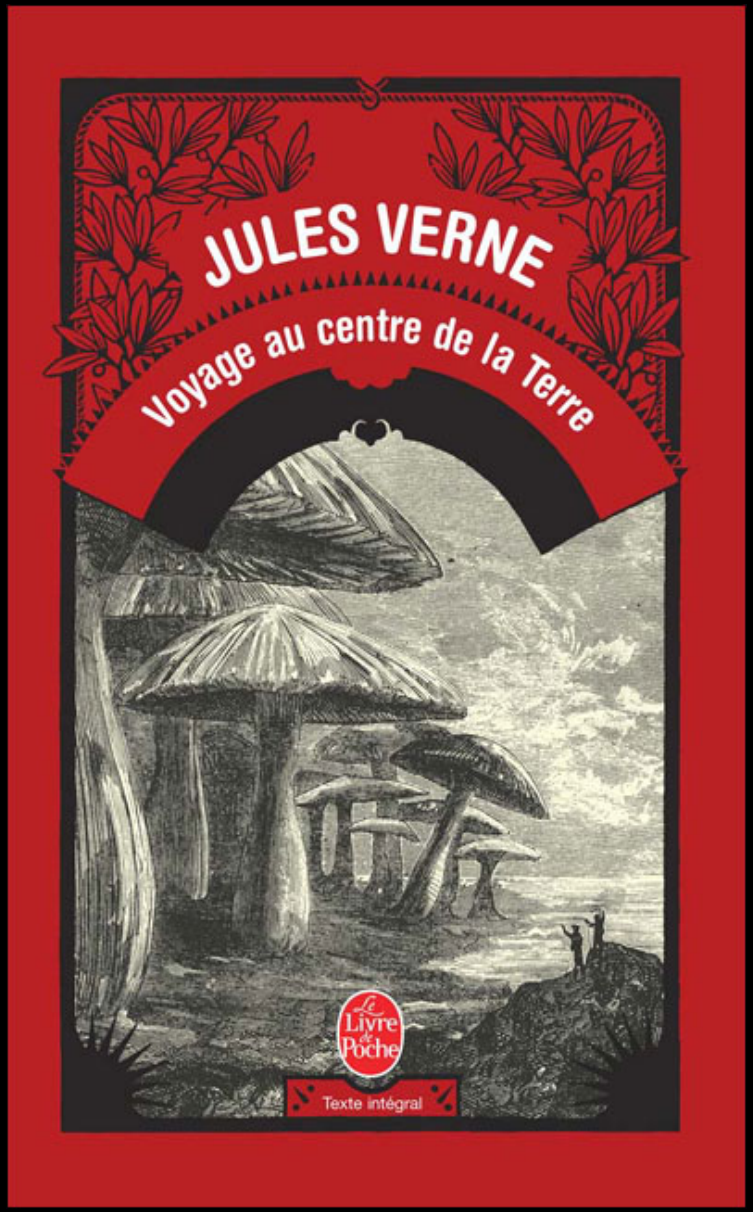
More vigorous
circulation, storms,
wind

Evidence for an extraterrestrial impact 12,900 years ago that contributed to the megafaunal extinctions and the Younger Dryas cooling

R. B. Firestone[a,b], A. West[c], J. P. Kennett[d], L. Becker[e], T. E. Bunch[f], Z. S. Revay[g], P. H. Schultz[h], T. Belgya[g], D. J. Kennett[i], J. M. Erlandson[i], O. J. Dickenson[j], A. C. Goodyear[k], R. S. Harris[h], G. A. Howard[l], J. B. Kloosterman[m], P. Lechler[n], P. A. Mayewski[o], J. Montgomery[j], R. Poreda[p], T. Darrah[p], S. S. Que Hee[q], A. R. Smith[a], A. Stich[r], W. Topping[s], J. H. Wittke[f], and W. S. Wolbach[r]







Underground synergies

Dark Matter Music

Laboratoire Souterrain de Modane

Depth: 4800 m.w.e.

Surface: 400 m2

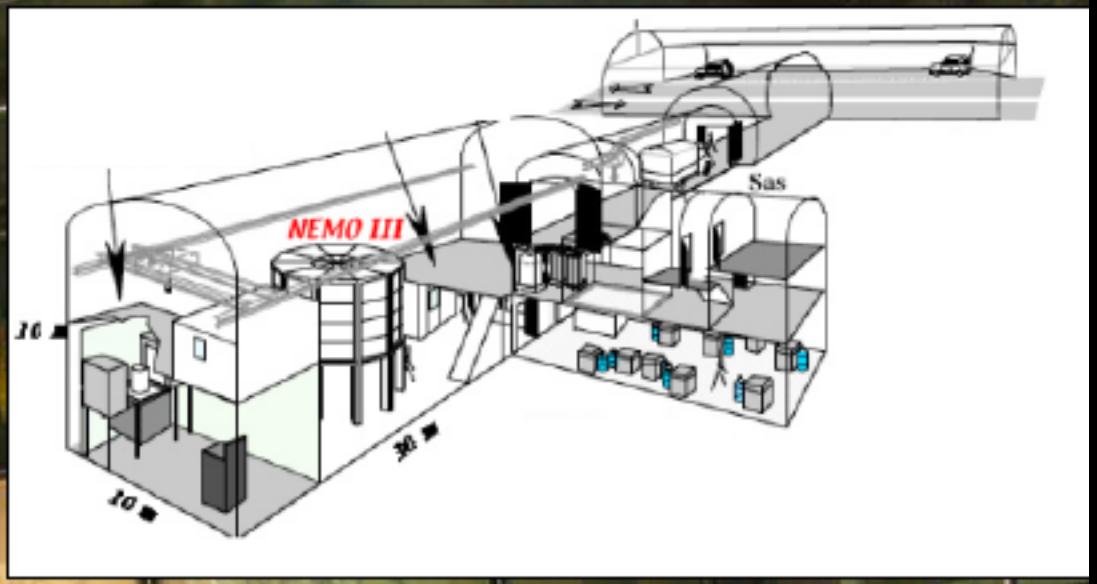
Volume : 3500 m^3

Muon flux: 4 10^{-5} $\mu.m^{-2}.s^{-1}$

Neutrons:
Fast flux: 4 10^{-2} $n.m^{-2}.s^{-1}$
Thermal flux: 1.6 10^{-2} $n.m^{-2}.s^{-1}$

Radon: 15 Bq/m^3

Access : horizontal

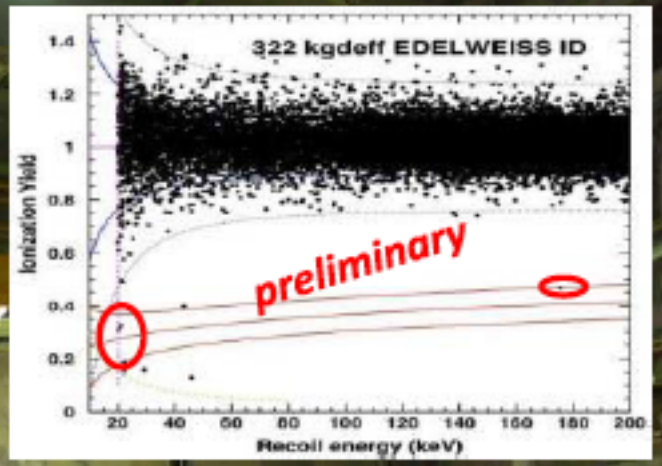


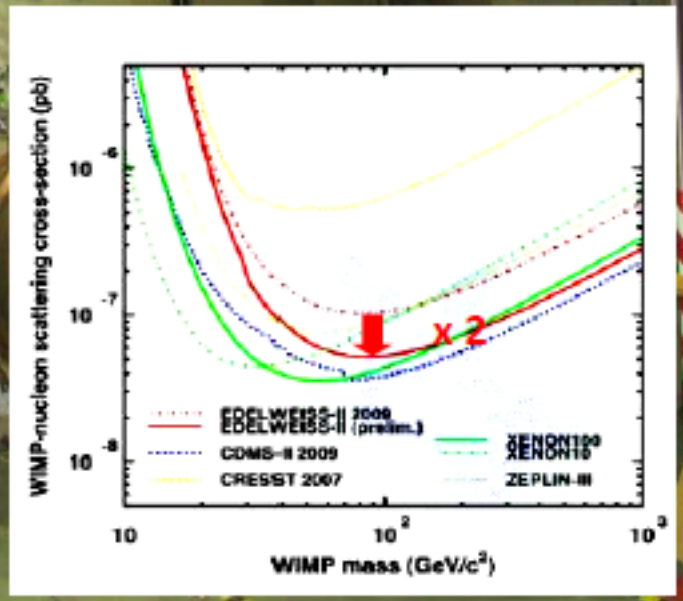
Budget (full cost): 1 M€/yr
Staff: 3 Physicists
3 Engineers
7 Technicians

International associated laboratory agreement with JINR Dubna (Russia) and CTU Prague (Czech Republic)

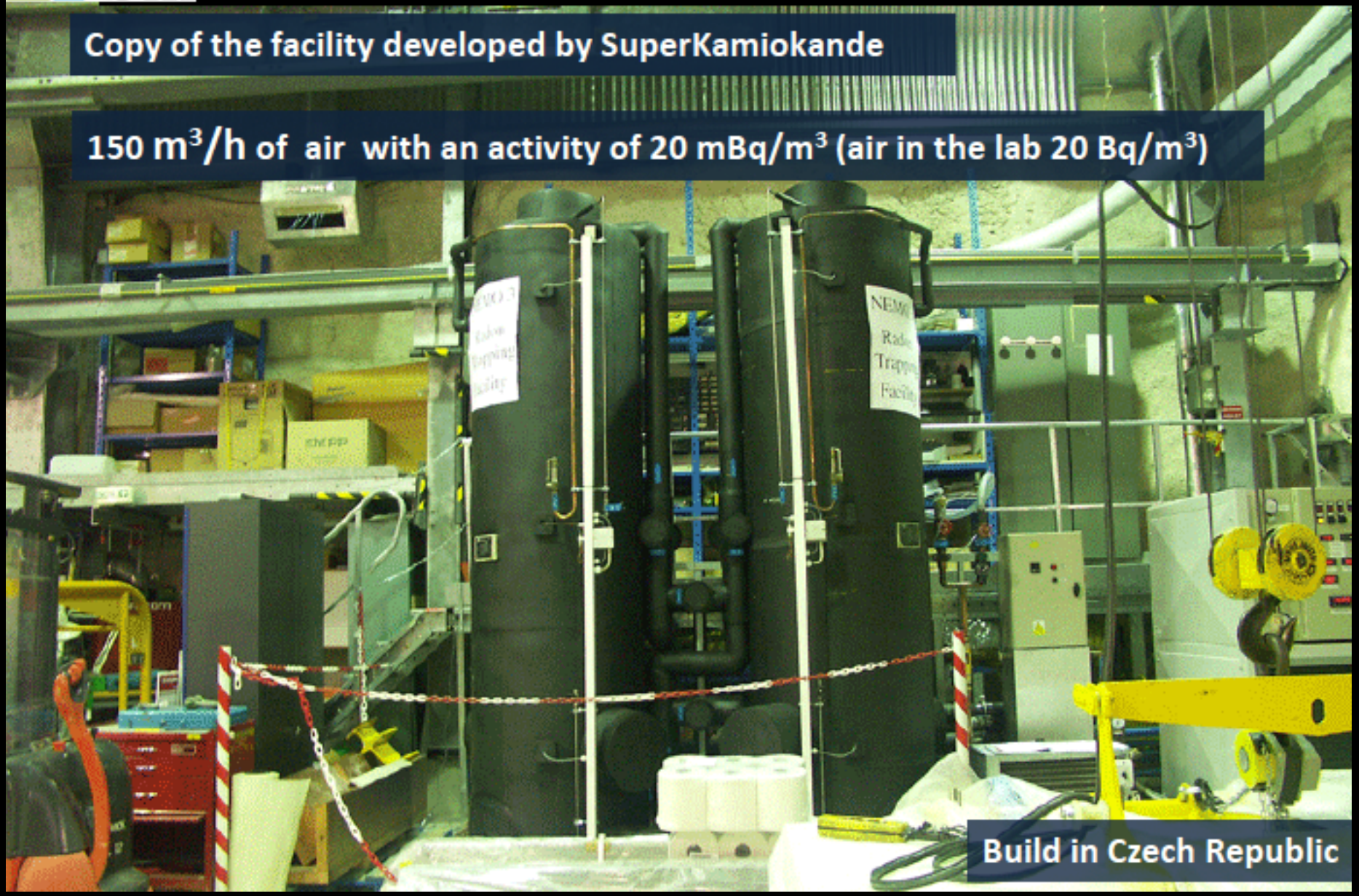
Dark matter: EDELWEISS

Bolometric technique: Heat + Ionization Ge crystals - 40 kg



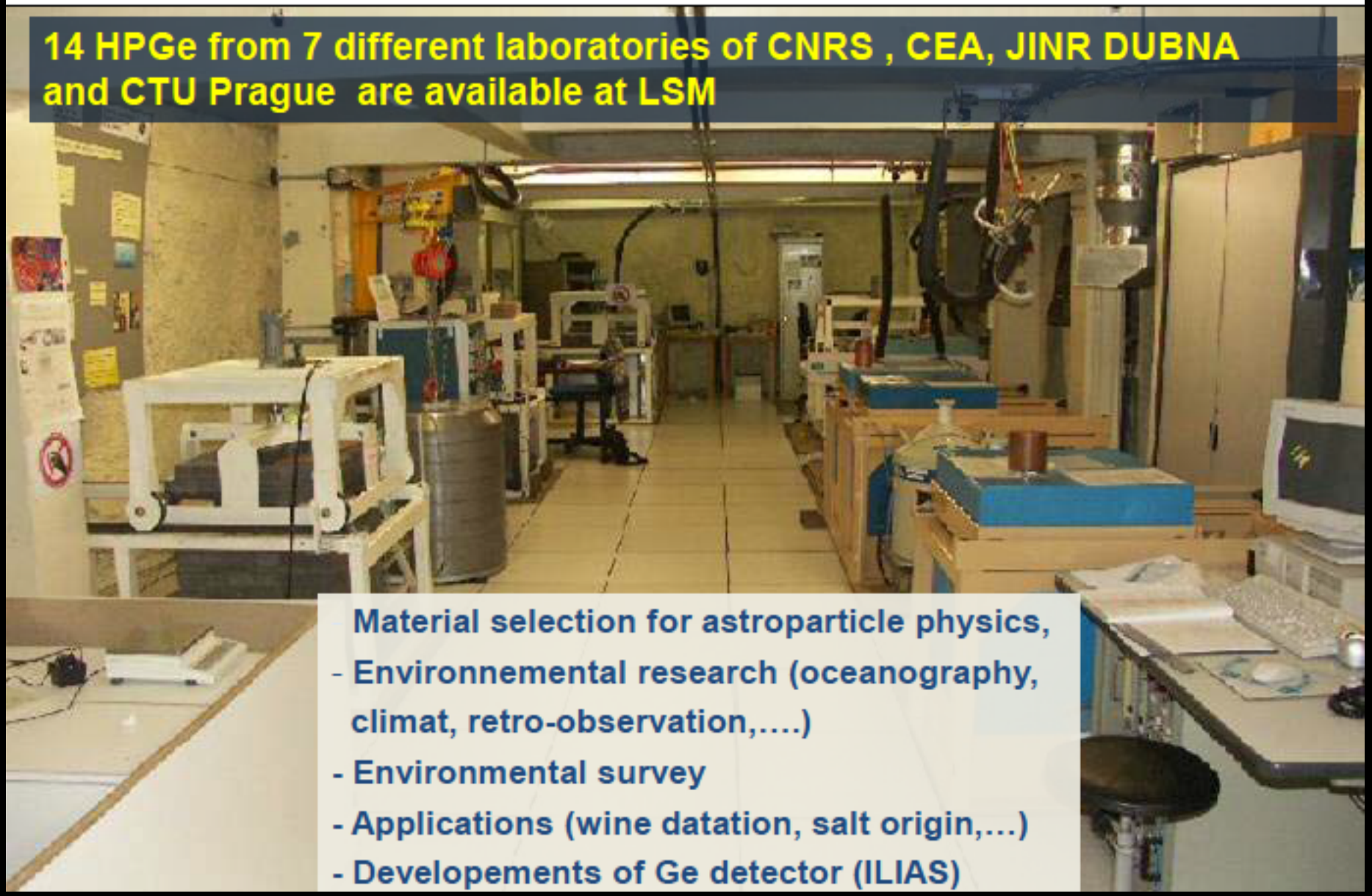


Radon free air factory



Gamma ray spectroscopy @ LSM

14 HPGe from 7 different laboratories of CNRS , CEA, JINR DUBNA and CTU Prague are available at LSM



Material selection for astroparticle physics,

- Environnemental research (oceanography, climat, retro-observation,....)
- Environmental survey
- Applications (wine datation, salt origin,...)
- Developements of Ge detector (ILIAS)

Interdisciplinary @ LSM

Use of the ulta-low gamma-ray spectroscopy

Radio-isotopes are used as tracers in the environment or as chronometers for dating of glacial or sedimentary layers.

They are used also for archaeological objects which sometimes require non-destructive measurements

Some exemples:

- Environmental survey
- Characterization the age of the suspended solids and pollutants associated with them in rivers
- Marine and continental geochemistry
- Characterization of water masses, their origin and age in the ocean
- Retro-observation (effects on human activities on the environment)
- Radioactivity in the atmosphere

Interdisciplinary @ LSM

Use of the gamma-ray spectroscopy

Applications :

- Charaterisation of water (lakes, rivers, underground water) EU directive

-For drug and food administration ex. wine dating, marine salt origin

- Judicial expertises

- Mean age of crustacean livestock for fishing regulation

- ……

Developemnt of a national ultra-low radioactivity platform measurements with

EDYTEM (University of Savoie/CNRS), LGGE (University of Grenoble / CNRS), LSCE (CNRS/CEA), LPSC (University of Grenoble / CNRS) and LSM

Wine datation by 137Cs measurement

Developed by Ph. Hubert (Centre d'etudes Nucleaires de Bordeaux-Gradignan)

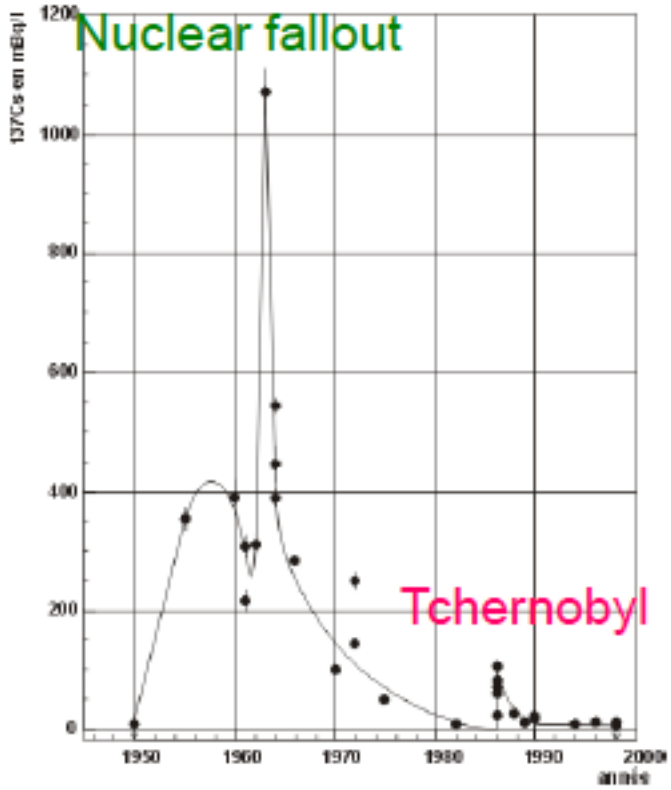
Châteaux

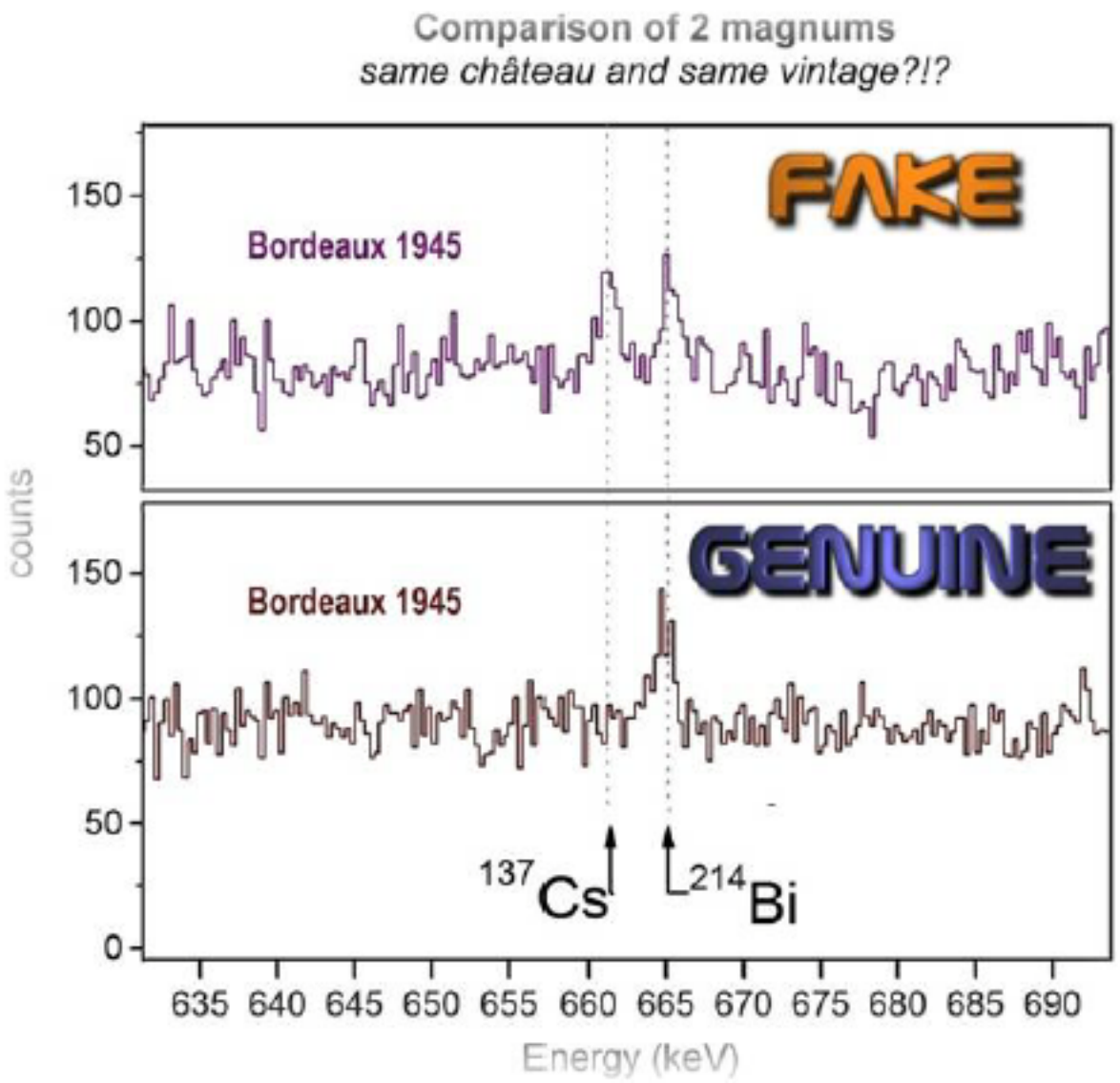
"Lafite"

&

"Margaux"

1900 ?




Comparison of 2 magnums
same château and same vintage?!?
FAKE
Bordeaux 1945
GENUINE
Bordeaux 1945
137Cs
214Bi
counts
Energy (keV)
150
100
50
0
635 640 645 650 655 660 665 670 675 680 685 690

DUSEL an ambitious program
http://www.sanfordlab.org/publications/bge-sciencedusel]

Dark Life (Biology)
- How deep does life go?
- Do biology and geology interact to shape the world underground?
- How does subsurface microbial life evolve in isolation?
- Did life on earth originate beneath the surface?
- Is there life on earth as we don't know it?

Restless Earth (Geosciences)
- What are the interactions among subsurface processes?
- Can we view complex underground processes in action?
- Can we forewarn of earthquakes?

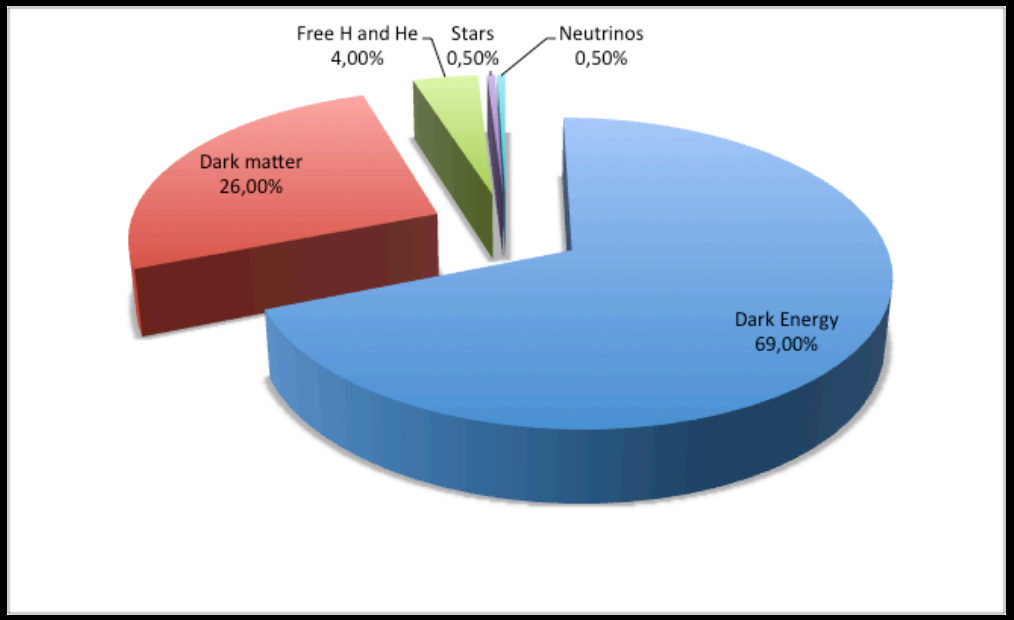
Ground Truth (Geoengineering)
- What lies between boreholes?
- How can technology lead to a safer underground?
- How do we better harness deep underground resources?

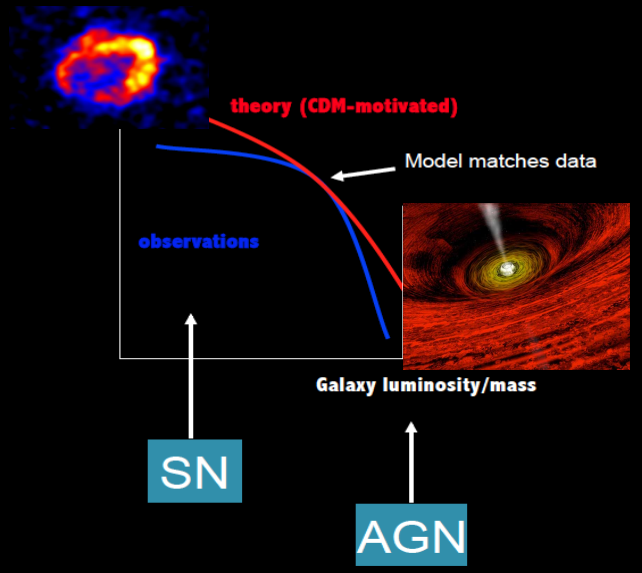
Conclusions

Synergy Geosciences-astroparticle: a new frontier:

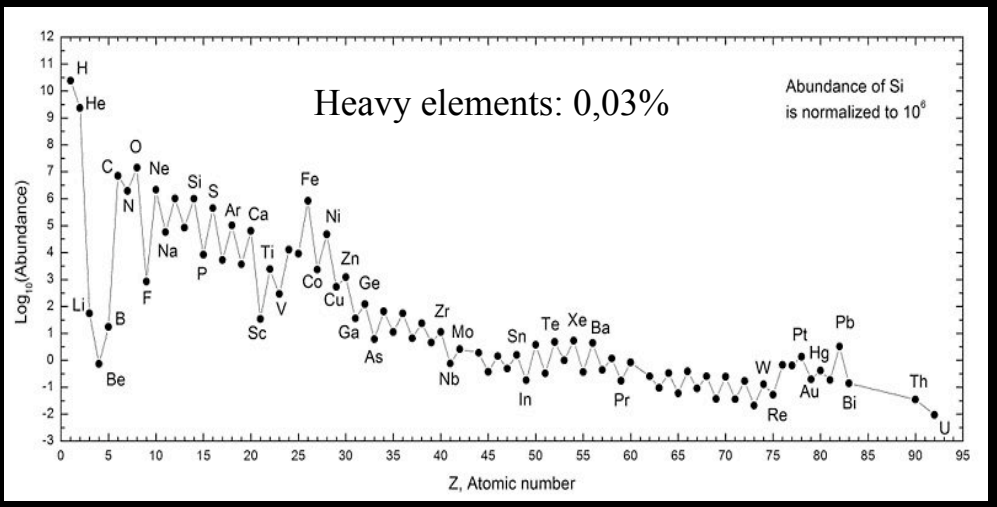
- For astroparticle the Geosphere is both the target and the detecting medium: continuous time series data by deploying large (autonomous?) sensor networks in hostile environments (sea, desert, underground)
- Dating is important: radioctivity-free platforms
- High sensitivity instruments for probing very low intensity geological effects, metrology
- Large data manipulation and worldwide networking.
- Distribution of alerts
- A COMMON AMBITION: COVER THE EARTH WITH SENSORS

Cosmos in a nutshell
composition and role of high energy phenomena





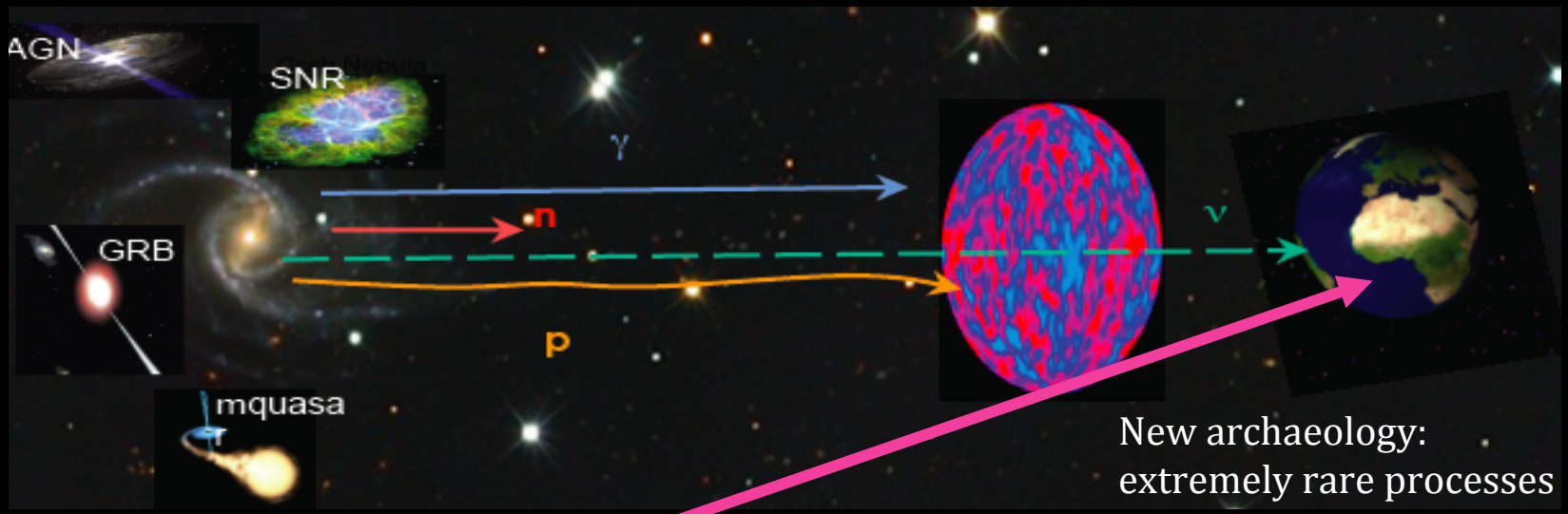
The existence of dark matter not sufficient to explain the formation of cosmic structures, one needs regulation (feedback) from violent phenomena



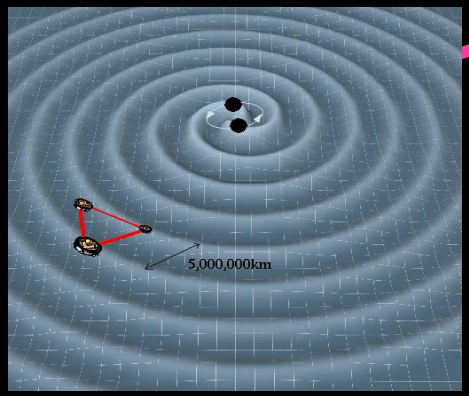
- The elements H, He (+ a little Li) mostly primordial nucleosynthesis
- The rest till Fe, Ni star nucleosynthesis
- Above Fe, Ni at the environment of violent phenomena and cosmic ray spallation

New astronomies

High energy photons, neutrinos, cosmic rays and gravitational waves



New archaeology:
extremely rare processes



- Earth changes role: from privileged optical observatory of the cosmos to a generalised detector
- Out of the 2D projection on its surface one deduces the structure of the Universe in 3D.
- Radioactive decays help dating the structure of the earth and the Universe expanding the projection to 4D.
- Holography?

Astroparticle Physics
Connecting scales

The heavenly ladder

The Astroparticle theme after LHC/PLANCK/ν results can be reduced to 2 fundamental questions:

1) Are there any intermediate scales between the EW and Inflation ? If yes where are they ? (Unification, SeeSaw, TeV, eV)
   1) Inflation, dark matter and energy
   2) Neutrino mass and proton decay

2) Are there new energy scales at work in the most violent phenomena of the Universe? How do particles and fields shape the formation and evolution of cosmic structures ?
   1) High energy photons, neutrinos, CR
   2) Gravitational waves