APPEC and Multidisciplinarity in European Deep Underground Labs

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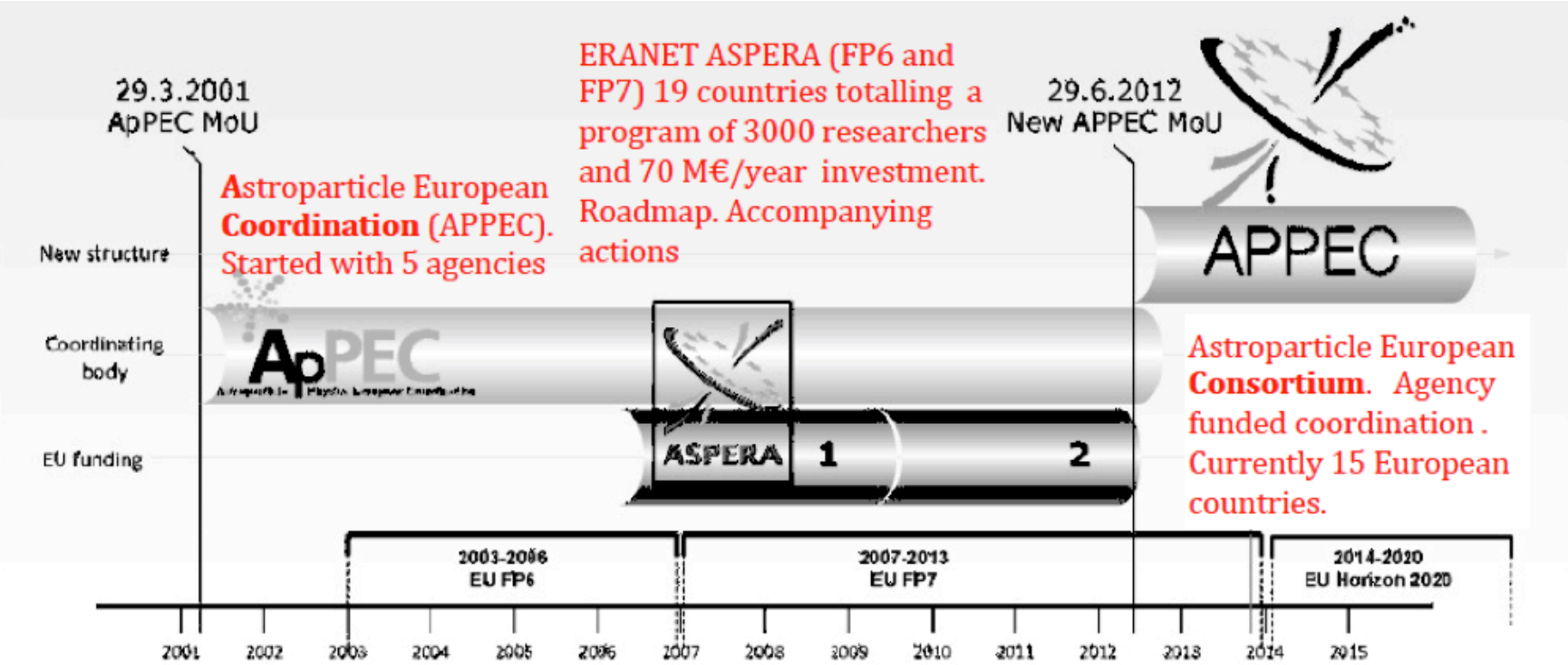
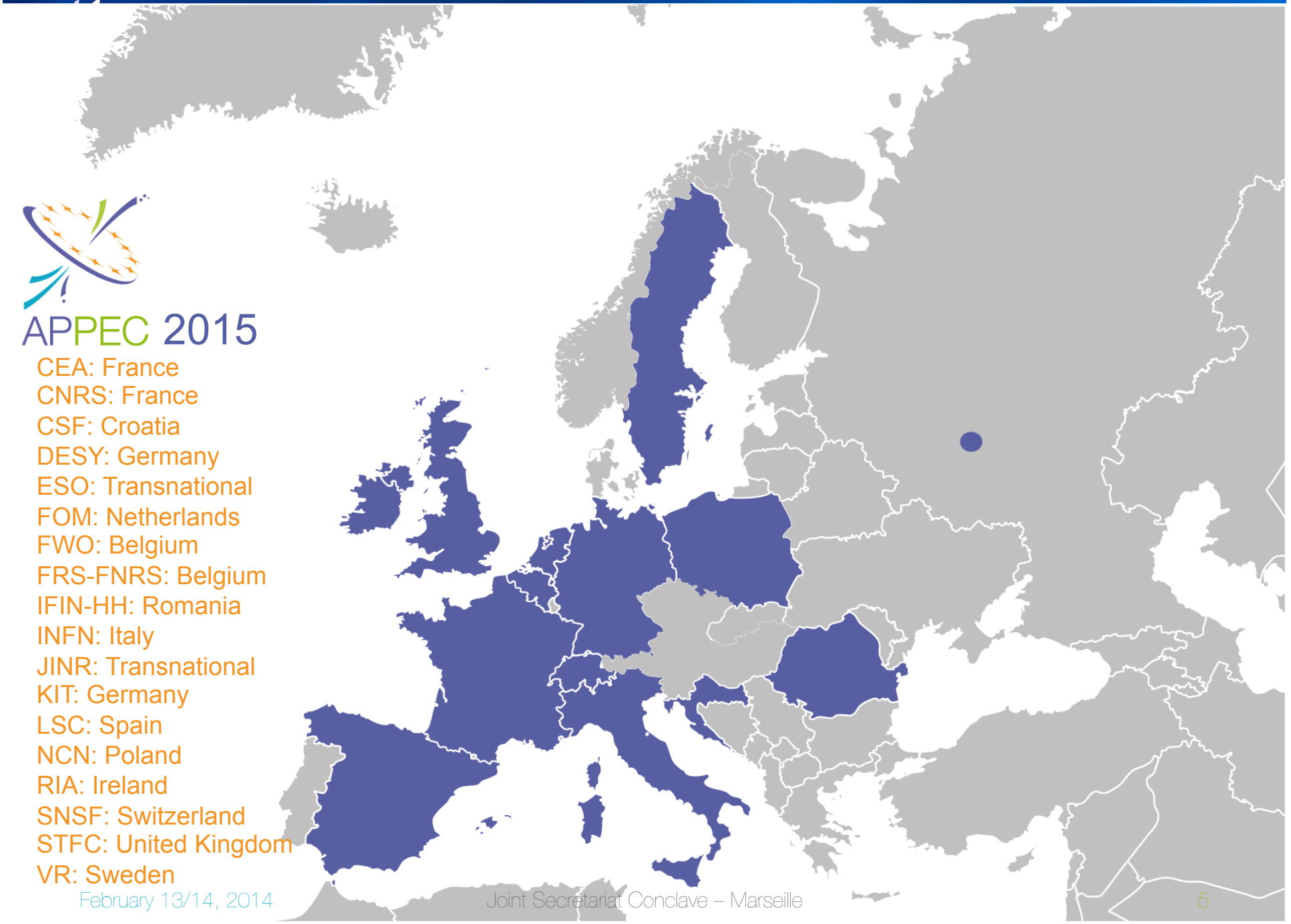
What is APPEC ?

History (2001-2015)



APPEC

- Born in 2012 through a simple MoU that fused the “old” ApPEC (Astroparticle Physics Coordination) and EU-funded ASPERA (ERANET).
- Structure
  - General Assembly (GA): strategic, decision-making and supervisory body
    - Chair: (2012-1015) S. Katsanevas (CNRS), (2015-) F.Linde (NIKHEF)
    - Vice-chair: J. Seed (STFC)
  - Joint Secretariat (JS): executive body
    - General Secretary: T. Berghoefer (DESY)
  - Scientific Advisory Committee (SAC): advisory body
    - Chair: A. Masiero (INFN)
- 2015: 15 countries
  - Minimal common fund ca 70 KE (2 KE/year smaller countries, 5KE/year larger ones



APPEC 2015

CEA: France
CNRS: France
CSF: Croatia
DESY: Germany
ESO: Transnational
FOM: Netherlands
FWO: Belgium
FRS-FNRS: Belgium
IFIN-HH: Romania
INFN: Italy
JINR: Transnational
KIT: Germany
LSC: Spain
NCN: Poland
RIA: Ireland
SNSF: Switzerland
STFC: United Kingdom
VR: Sweden

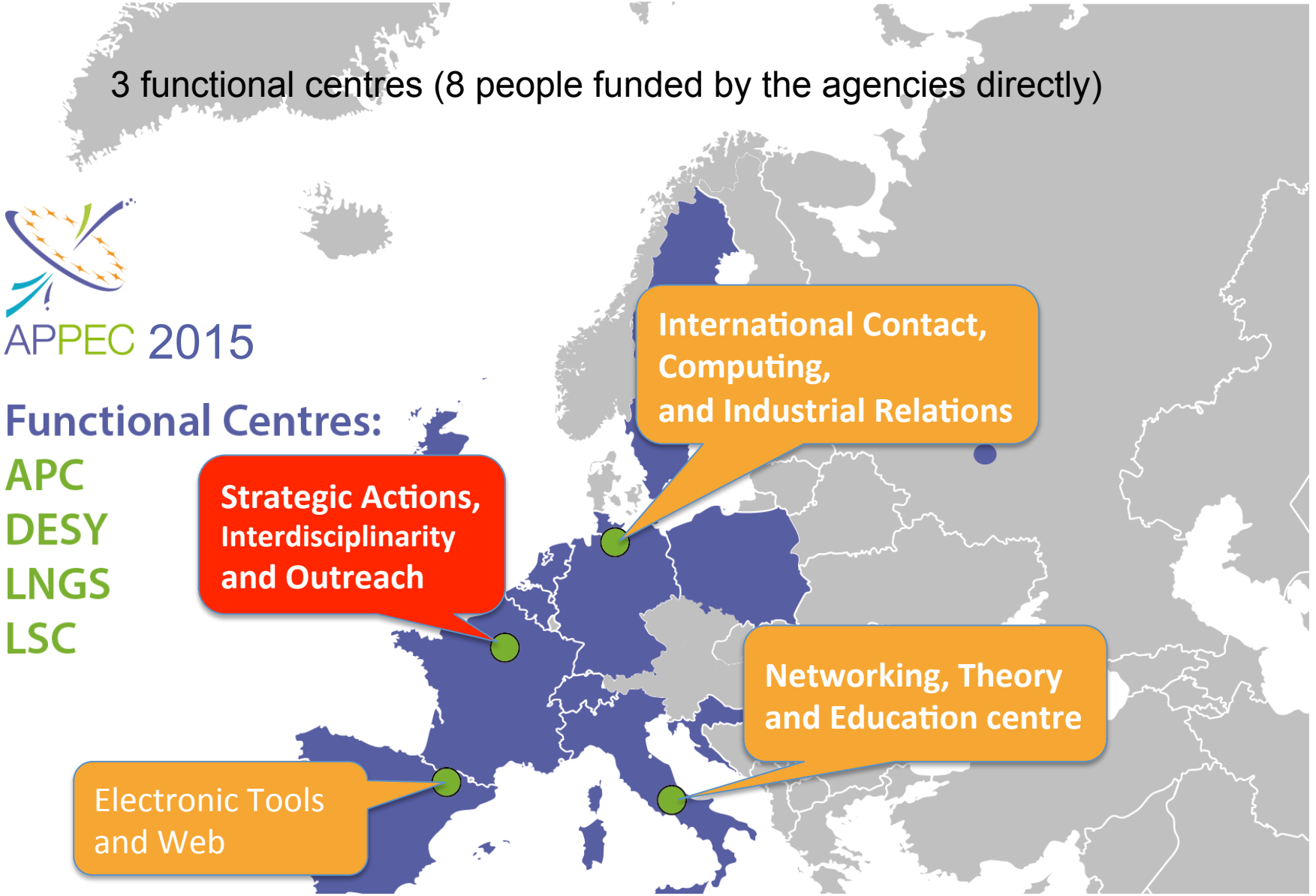
APPEC's Objectives

- Strategic objectives
  - Provide a forum for the coordination of European Astroparticle Physics;
  - Develop and update long term strategies (roadmap)
  - Participate in the European scientific strategy (CERN,ESFRI)
  - Develop closer relationships CERN, JINR, ESA and ESO;

- Implementation objectives
  - Facilitate and enhance coordination between existing/developing national activities;
  - Develop a common action plan for large Astroparticle Physics infrastructures; (INCLUDING THEIR INTERDISCIPLINARY AND INTERSECTORAL USE)
  - Facilitate the convergence of future large scale projects/facilities (SEE NEXT SLIDES)
  - Provide organisational advice for the implementation of large scale projects/facilities
  - Launch common actions including common calls funded by a virtual common pot
  - Initiate and guide activities funded by the European Commission (SEE NEXT SLIDES)

Astroparticle Physics European Consortium

3 functional centres (8 people funded by the agencies directly)



APPEC action example 1 : APPEC is proactive in global coordination

- OECD/Global Science Forum sponsored group for Astroparticle Physics: “Astroparticle Physics International Forum (APIF)”
  - APIF brings together officials and representatives of funding agencies of countries that make significant investments in astroparticle physics research.
  - It is a venue for information exchange, analysis, and coordination, with special emphasis on strengthening international cooperation, especially for large programmes and infrastructures.

APPEC action example 2: Facilitate the convergence of future large scale projects/facilities

- 1st International Meeting for Large Neutrino Infrastructures (Paris – June 2014 - https://indico.cern.ch/event/303475/) - Common press release
  - "The agencies support an international facility for short and long-baseline neutrino oscillations at Fermilab, where internationally driven collaborations are encouraged to propose a program optimised in baseline and detector technology. This approach, in parallel with the decision of Fermilab to upgrade its beam infrastructure (PIP-II) gives the opportunity for a rich international neutrino program at Fermilab."

➔ formation of global collaboration DUNE, which has recently elected its first spokespersons (M. Thompson and A. Rubbia)

APPEC action example 2: Facilitate the convergence of future large scale projects/facilities

- 2nd International Meeting for Large Neutrino Infrastructure (Fermilab – April 2015 - https://indico.cern.ch/event/356320/)
  - "The agency representatives were impressed by the rapidity, quality of convergence and momentum of the efforts of the community working on liquid argon Time Protection Chambers (LAr TPCs), to develop a credible scientific program based on:
    a) an ambitious large infrastructure effort, consisting of a long-baseline beam and detector project (LBNF/DUNE) hosted at Fermilab and SURF, based on previous design studies, but largely upgrading them, proposed by an international collaboration;
    b) a medium-scale program of short-baseline oscillation experiments at Fermilab (Short-Baseline Near Detector MicroBoone and ICARUS) aiming to test the sterile neutrino hypothesis with unprecedented accuracy;
    c) a rich R&D and prototyping program in the CERN North Area, related to the above program along with other long-baseline efforts in the world (e.g. Hyper-Kamiokande).

APPEC action example 3: Roadmapping

The last 6 years of roadmap exercises
From the "7 magnificent" to today

1st roadmap 2008 : dubbed « The Seven magnificent ». Essentially a definition of the field. It had an international fortune, definition adopted globally (eg APIF) with minor changes. Budget-wise optimistic (pre-crisis) 50% increase of budget available in a 10 year scale. No Dark Energy and CMB projects since it was concentrating on projects the majority of APPEC agencies had direct control.

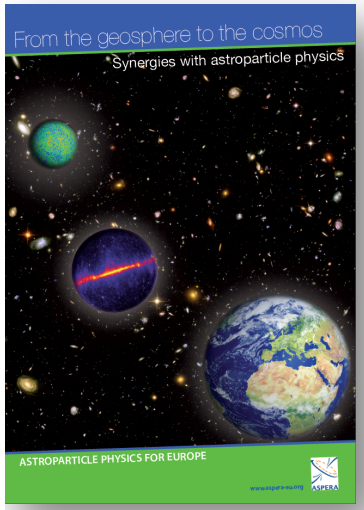
From the Nature article

2nd roadmap 2011 : A roadmap with priorities. Still our guiding principle, further elaborated as input to the European Strategy for Particle Physics early 2013 (see later)

3rd roadmap end of 2014: Mandate by APPEC General Assembly: "A roadmap in accordance with available budgets." Ok, but first task, what are the available budgets ? Collection of data in progress. Approval of scenarii by GA in June 18.
➔ Final priority and milestone report by the end of the year.

APPEC Astroparticle Physics European Consortium

FROM THE GEOSPHERE TO THE COSMOS: Multidisciplinarity in Astroparticle Physics Research Infrastructures



IT ALL STARTED WITH…

« From the Geosphere to the Cosmos »

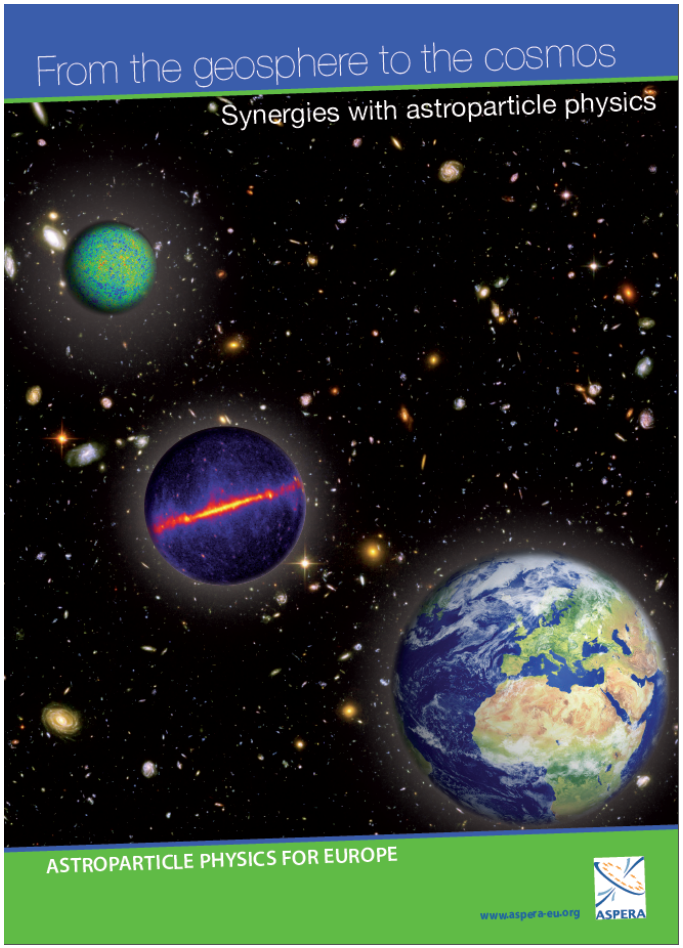
1-2 December 2010, Palais de la Découverte, Paris

Astroparticle physics
opens new horizons

Probing volcanoes, detecting whales, studying the atmosphere... Environmental sciences find new territories for research, thanks to the new infrastructures developed for astroparticle physics.

NASA

. . . WHICH LEAD TO . . .



Astroparticle Physics European Consortium

. . . a report that included 37 points of synergy!

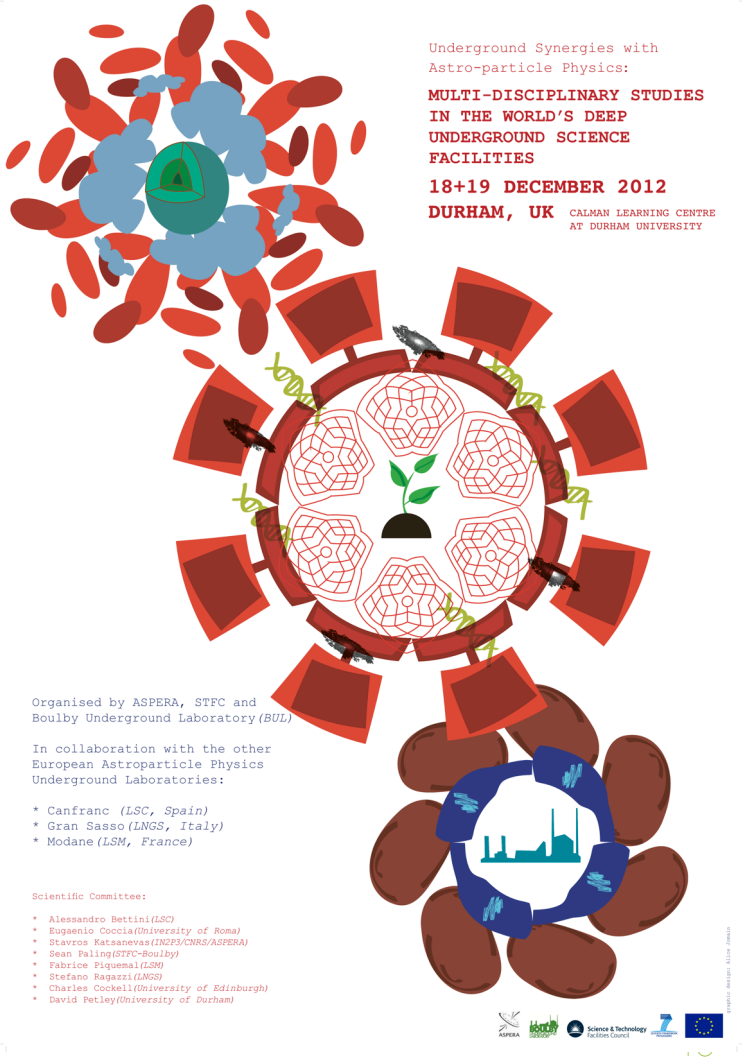
	ATMOSPHERIC AND TERRESTRIAL	UNDERGROUND	UNDERWATER-ICE
UNDERSTANDING THE ATMOSPHERE	1. SPACE WEATHER 2.ATMOSPHERIC MONITORING 3. COSMOCLIMATOLOGY 4. THUNDERSTORMS and LIGHTNING	1. COSMOCLIMATOLOGY	1. ATMOSPHERIC TEMPERATURE VARIATION
UNDERSTANDING THE EARTH	1. EROSION RATE CALCULATION 2. VOLCANO TOMOGRAPHY	1. COASTAL ROCK CLIFF EROSION 2.CHRONOLOGY for THE PALEOENVIRONMENT 3. EARTH's INTERIOR - GEONEUTRINOS	1. PALEOCLIMATE 2. EARTH RADIOGRAPHY
UNDERSTANDING THE OCEANS		1. CORAL CHRONOLOGY	1. CONTINUOUS OCEANOGRAPHIC DATA 2. SEDIMENT TRANSPORT 3. OXYGEN DYNAMICS 4. RADIOACTIVITY 5. INTERNAL WAVES
UNDERSTANDING EARTHQUAKES	1. EARTHQUAKE MONITORING GRID	1. SEISMO-ELECTROMAGNETIC COUPLINGS 2. EARTHQUAKE PRECURSORS 3. SLOW EARTHQUAKE MONITORING	1. EARTHQUAKE AND TSUNAMI MONITORING 2. STUDYING THE LAKE ENVIRONMENT
UNDERSTANDING BIODIVERSITY		1. IMPACT OF RADIATION 2. EXTREMOPHILES	1. UNDERWATER SOUND MONITORING 2. DEEP SEA BIOLUMINESCENCE 3. BIODIVERSITY UNDER ICE 4. BIODEGRADATION 5. MICROBIOLOGY 6. BIOFOULING
APPLICATIONS		1. WINE DATATION 2. SALT CHARACTERISATION AOC 3. SOFT ERROR RATE IN ELECTRONICS 4. ROCK DEFORMATION	

Astroparticle Physics European Consortium

For the underground synergies we then organised…

- in December 2012, a workshop in Durham, UK, called “Underground Synergies with Astroparticle Physics”.
  (https://indico.cern.ch/event/199223/)

- Even though these synergies have been developed independently in each lab, participants remarked the great similarities in the methodologies used within each session.



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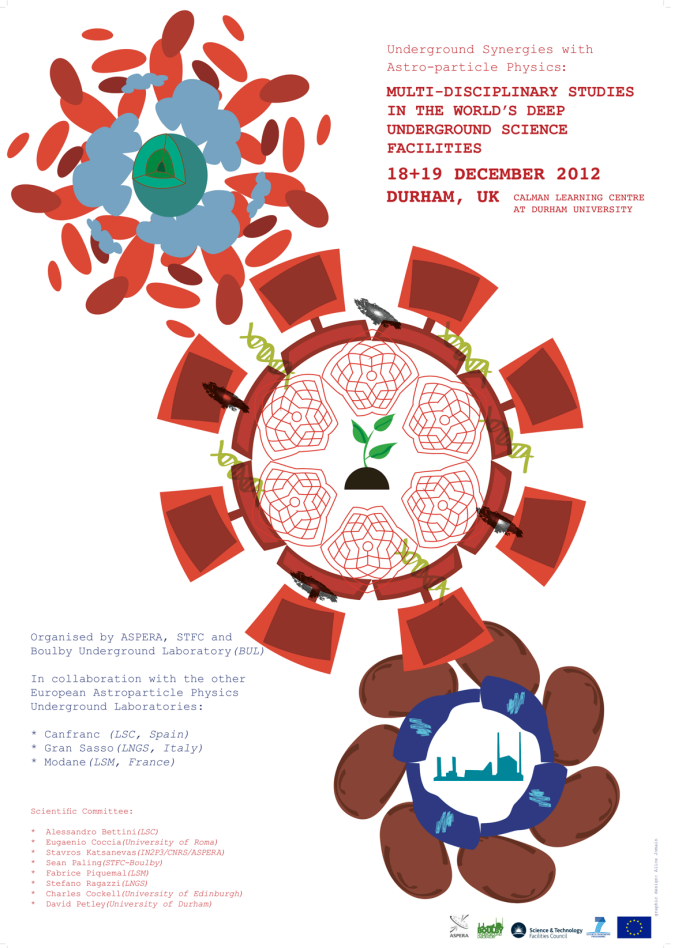
The workshop included sessions on:

- **EARTH SCIENCES**
- **CLIMATE AND ENVIRONMENT**
- **BIOLOGY AND ASTROBIOLOGY**
- **LOW BACKGROUND COUNTING**
- **GLOBAL PERSPECTIVES**
- **FUNDING**
- **COMMUNICATION**



SOME EXAMPLES

Interdisciplinarity @ 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.

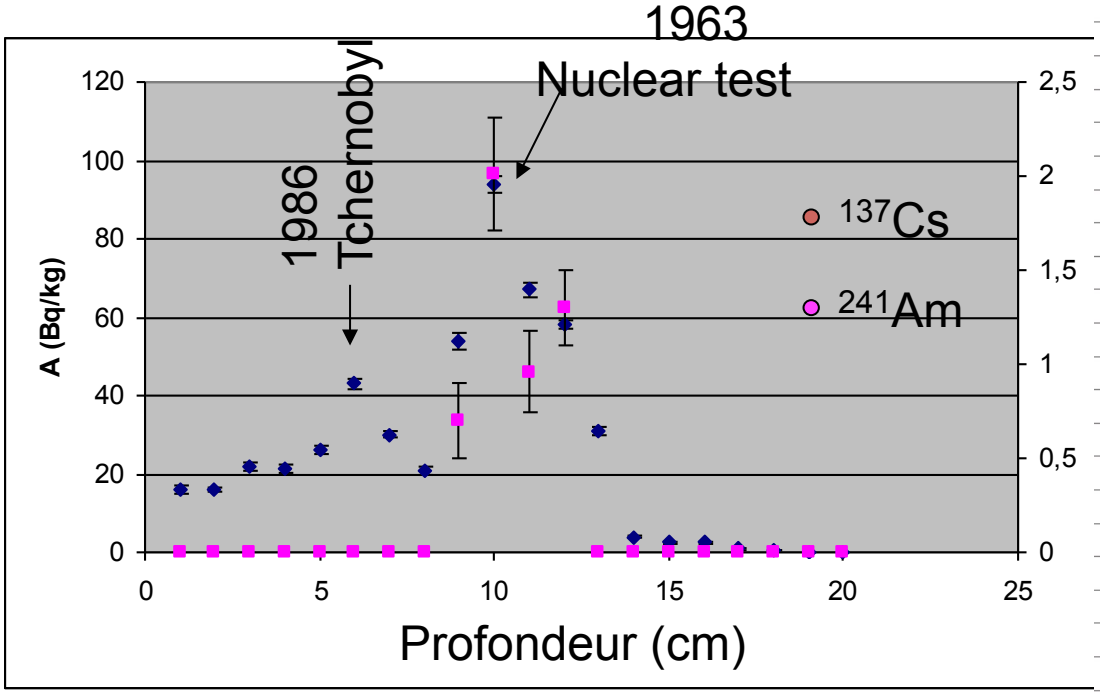
They are used also for archaeological objects which sometimes require non-destructive measurements

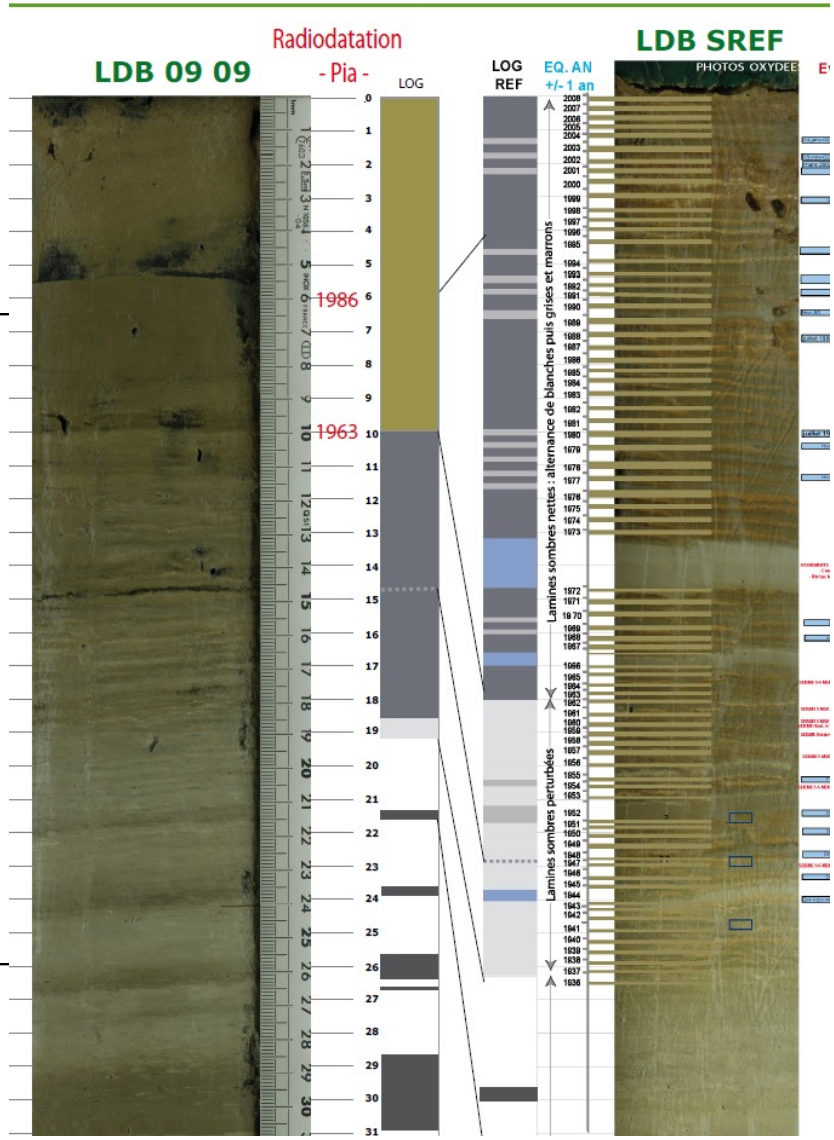
Some exemples:

- 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

Environmental researches

Datation of a carot from Bourget lake :





The scientific and societal usefulness of recent (< 250 years) Alpine lake sediment studies

An overview on LSM – Université de Savoie joint scientific progresses in paleolimnology

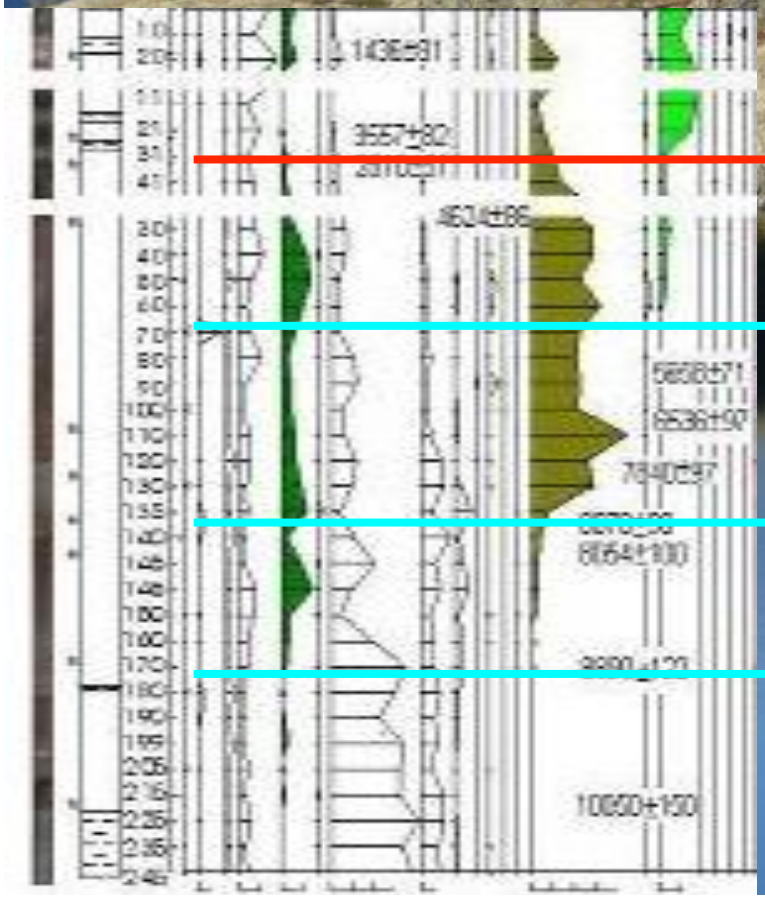
Fabien Arnaud
Charline Giguet-Covex
Bruno Wilhelm

Jean-Louis Reyss

Marie-Elodie Perga

In Europe, even remote mountain landscapes are man-made

Noisetier Epicéa
Pin cembro Sapin



Pollen data, Villy, Haute Savoie, 2250m asl

Epicéa

3600 cal. BP

Pin cembro

Epicéa Sapin

5600 cal. BP

Pin cembro

Sapin

8000 cal. BP

Pin cembro

8900 cal. BP

Noisetier

Open space: deforestation

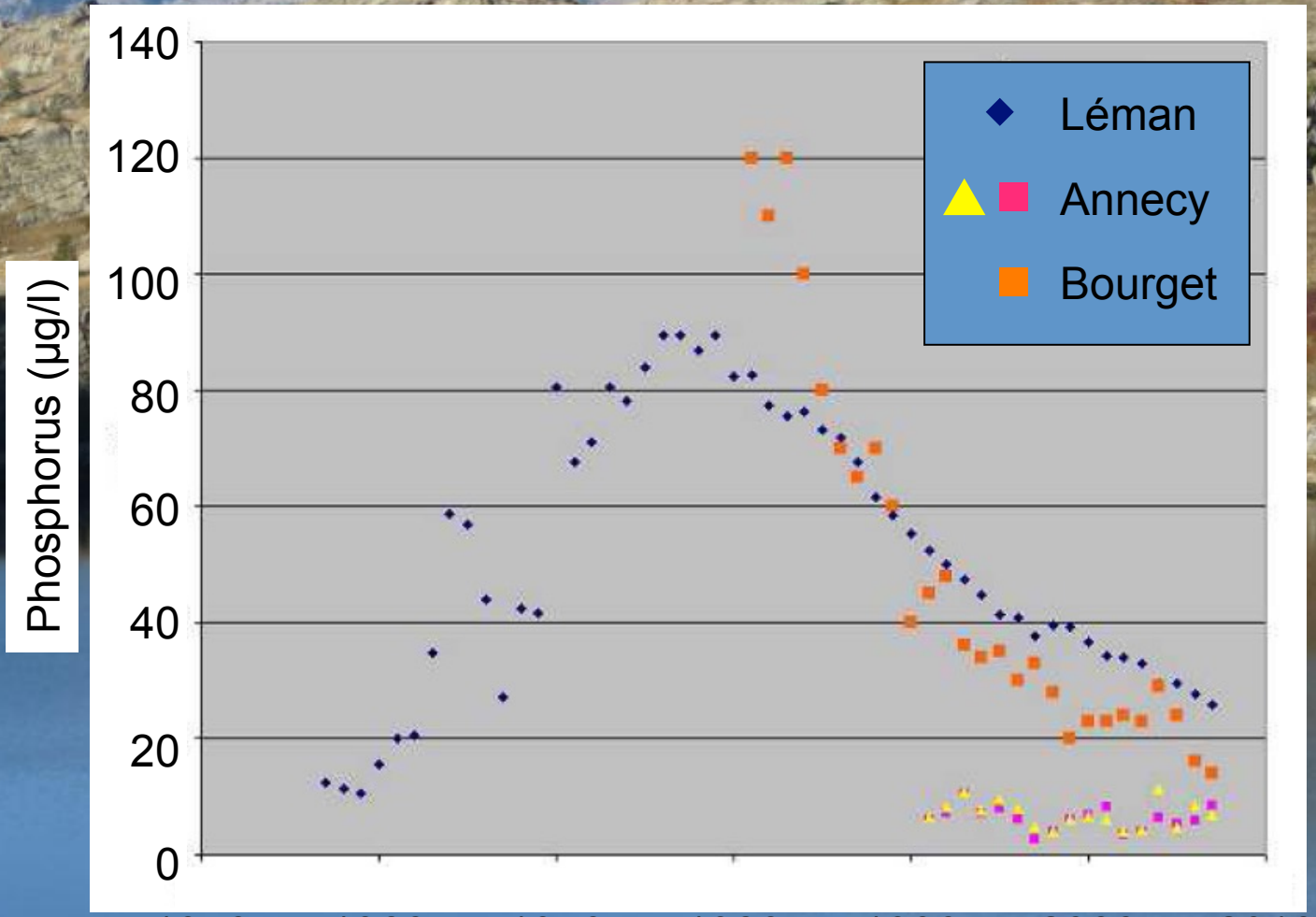
First forest opening (human or climate?)

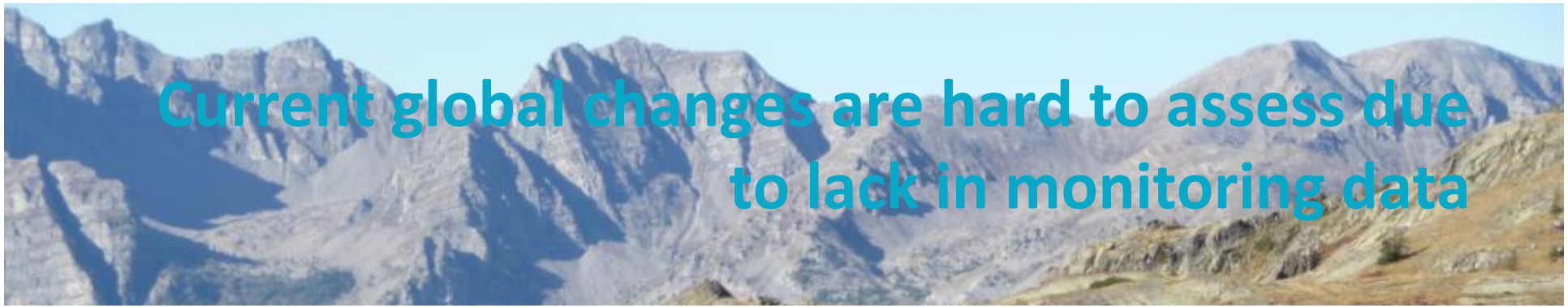
Closing of the forest space

Forest reconquest

Current global changes are hard to assess due to lack in monitoring data

Phosphorus, brought by wasted waters, is one of the main nutrients responsible of the degradation of lacustrine ecosystems





Current global changes are hard to assess due to lack in monitoring data

Lake sediment may have archived some environmental variables (climate, trophic state, pollutant inputs, erosion etc.)

Their study may thus bring useful information to evaluate the effect of past land-use and the efficiency of management policies

From a scientific point of view, such a "retro-observation" is crucial to assess the intensity and kinetics of global changes compared to a measured (i.e. non-hypothetical) "reference state"

Environmental researches

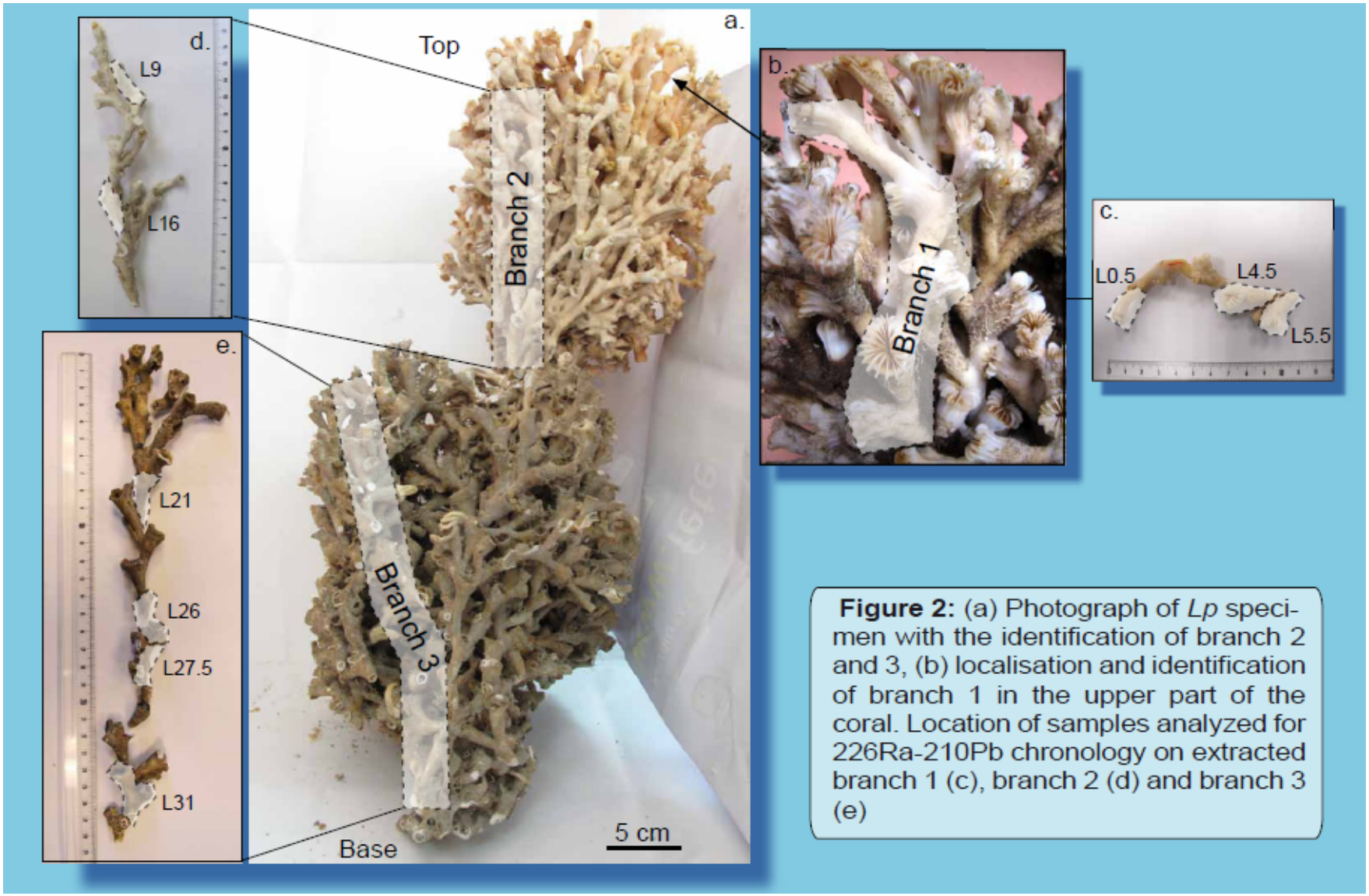
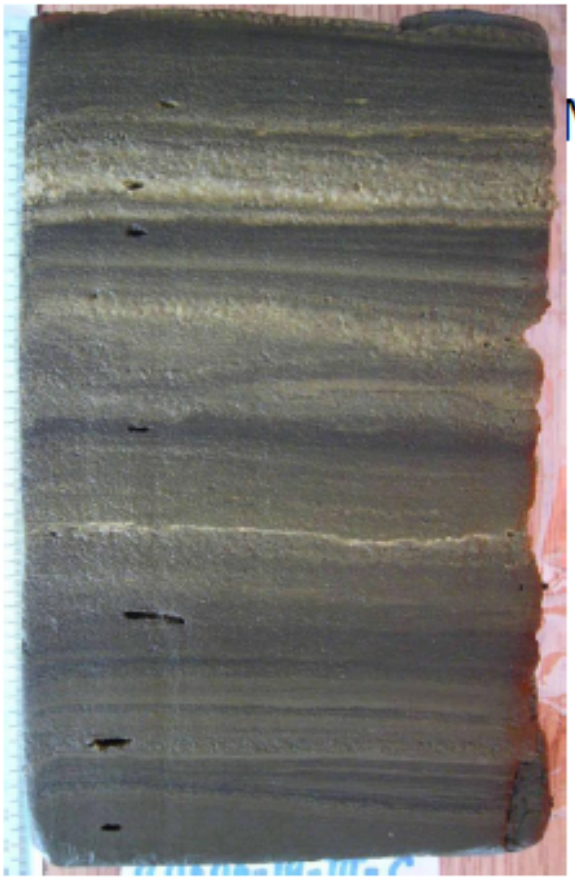


Figure 2: (a) Photograph of *Lp* specimen with the identification of branch 2 and 3, (b) localisation and identification of branch 1 in the upper part of the coral. Location of samples analyzed for 226Ra-210Pb chronology on extracted branch 1 (c), branch 2 (d) and branch 3 (e)

Deep-sea Coral are useful archives to study seasonnal, interannual and decadal paleoclimate changes using 120Pb, 226Ra, 230Th,14C

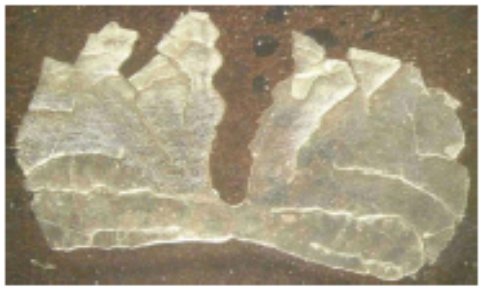
Environmental researches

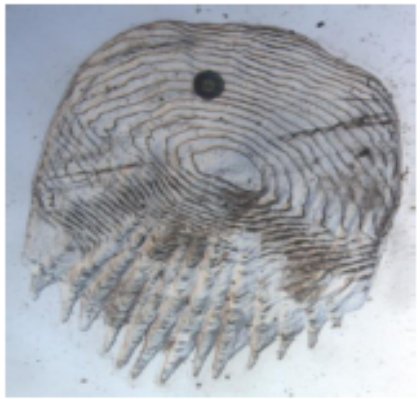


Multi-decadal to centennial scale variability in fish scale preservation and burial from marine laminated sediments off Pisco, Peru during the late Holocene

Salvatteci, R.

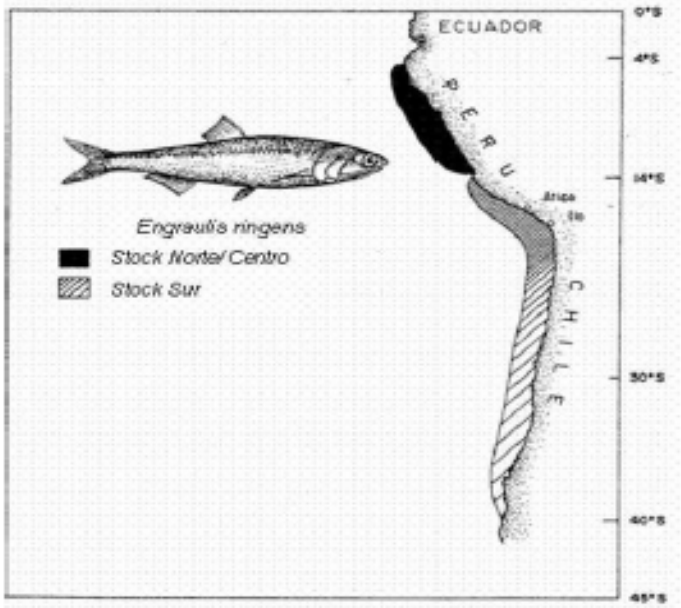
Paris, October 2010





Environmental researches

The Humboldt Upwelling Ecosystem is characterized by strong ENSO variability and the highest pelagic fish productivity



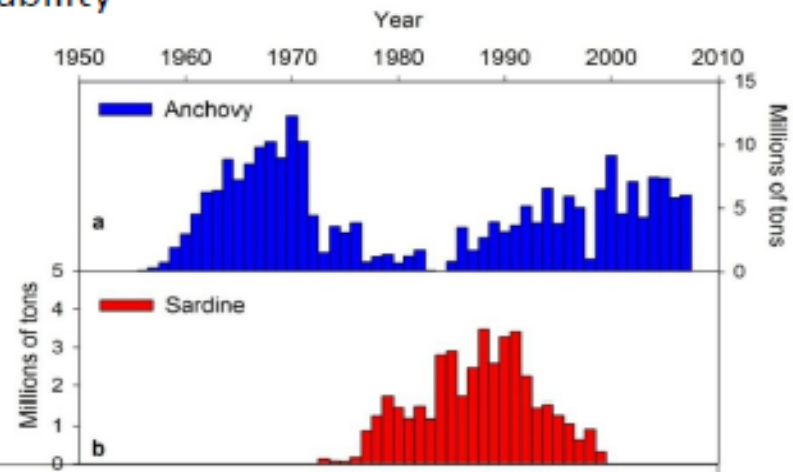
-Continuous coastal upwelling throughout the year

-The northern Humboldt Current System off Peru presently produces about 10% of the world fish catch based primarily on anchovy.

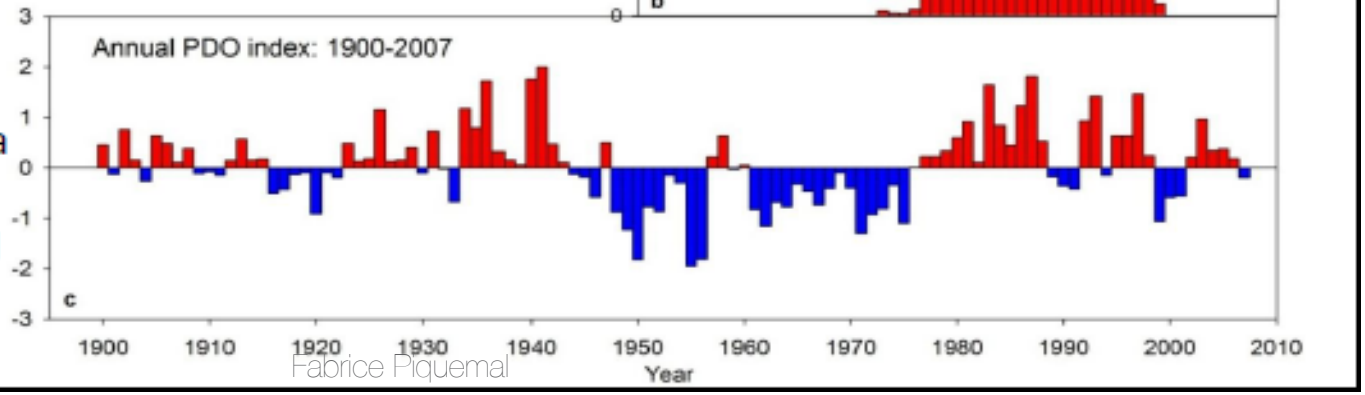
-Anchovy and sardine landings show strong annual and decadal biomass variability

Engraulis ringens

Sardinops sagax sagax

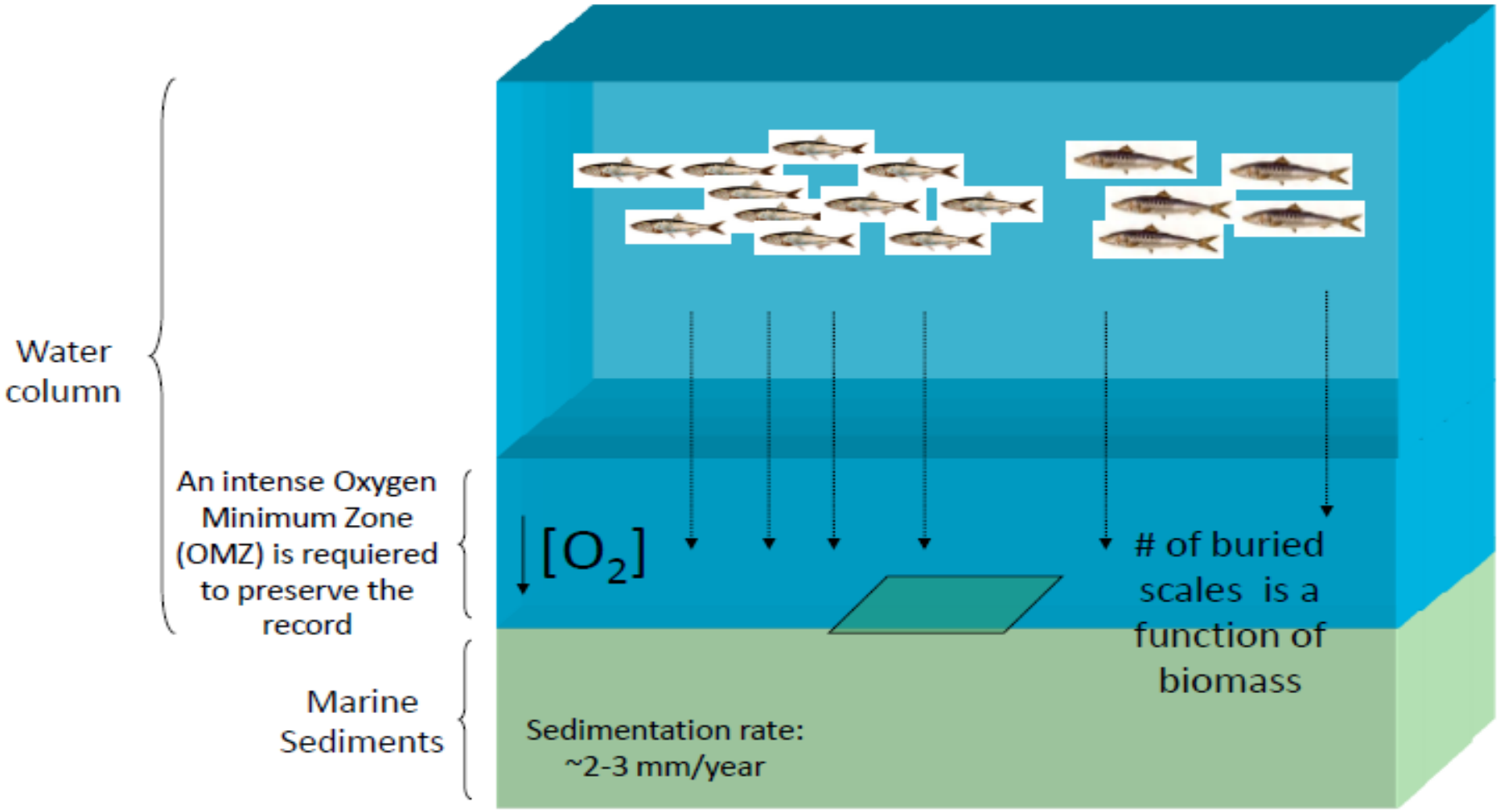


The Pacific Decadal Oscillation (PDO) Index is defined as the leading principal component of North Pacific monthly sea surface temperature variability (poleward of 20N for the 1900-93 period).

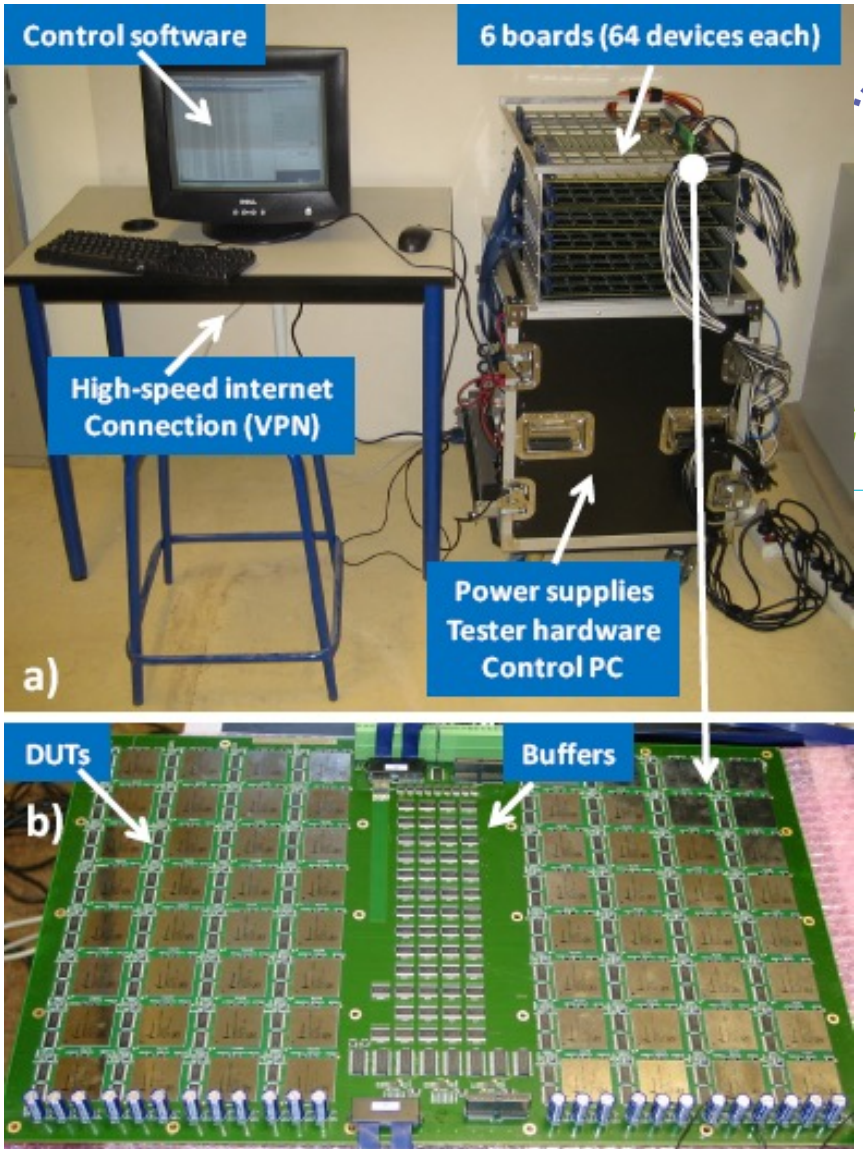


Environmental researches

Fish scales buried in marine laminated sediments can provide a record of population variability of small pelagic fishes prior to the development of the fisheries



Micro-electronics test failures



Neutrons and alpha natural radioactivity can lead to failures in micro-electronics circuits

Astroparticle Physics for Europe

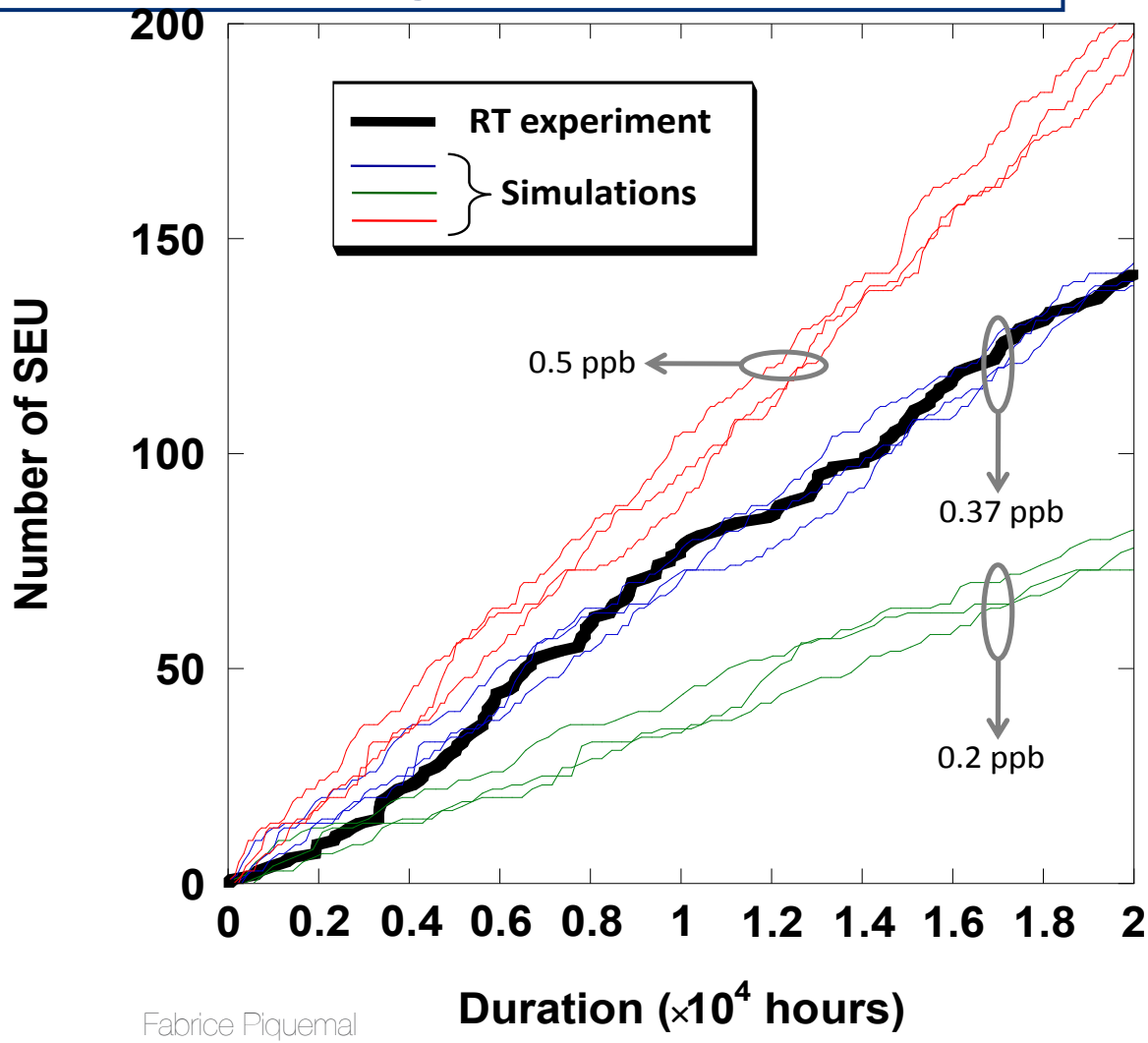
The use of « too radioactive » materials c
Lead to major industrial accidents

LSM is reference laboratory for the international JEDEC norm for the tests of mirco-circuits resistance to radiation.

Environmental researches

Monte-Carlo Simulation of Underground Experiments

- Up to 20,000 h of cave characterization
- α-SER reevaluated to 2079 FIT/MBit
- Monte-Carlo simulation gives a contamination level by ^{238}U impurities of 0.37 ppb
- Very good agreement with wafer-level characterization (alpha emissivity) in the range [0.2-0.5] ppb



Biology

- **Modeling the impact of radiation on living cells: Geant4 DNA**
- **Validation: need for relevant observables to characterize biological systems**
  - Cell survival rate
  - DNA single or double strain breaks
  - Molecular biology: genomic mutations, gene expression
- **Experimental protocol: compare observables after controlled radiation exposure**
  - In normal lab conditions
  - After beam irradiation (γ, e-, p, α)
  - Need for a reference point at zero-radiation: Modane

Biologists, computer scientists
Physicists, chemists

Geant4 DNA

- **In normal lab conditions, cultures are exposed to 10 Millions cosmic rays per day per square meter**
  - Low but significant radiation exposure
- **In Modane, down to 4 cosmic rays per day per square meter**
- **Goal: study evolution of model organisms in radiation free environment**
  - Bacteria life cycle
  - Mutation rate
  - Localization of gene mutations, gene expression
  - DNA breaks

Applications :

- Charaterisation of water (lake, river, underground water) EU directive

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

- Judicial expertises

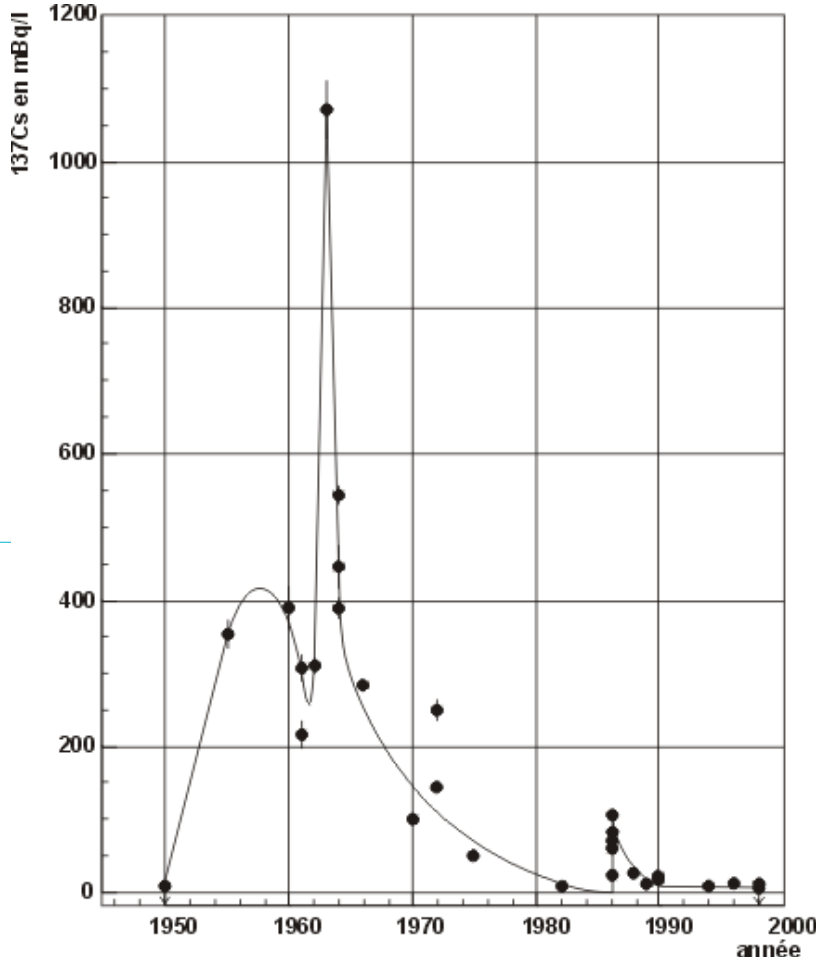
- Mean age of crustacean livestock for fishing regulation

- ……

Development 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

Application: wine dating



137Cs measurement

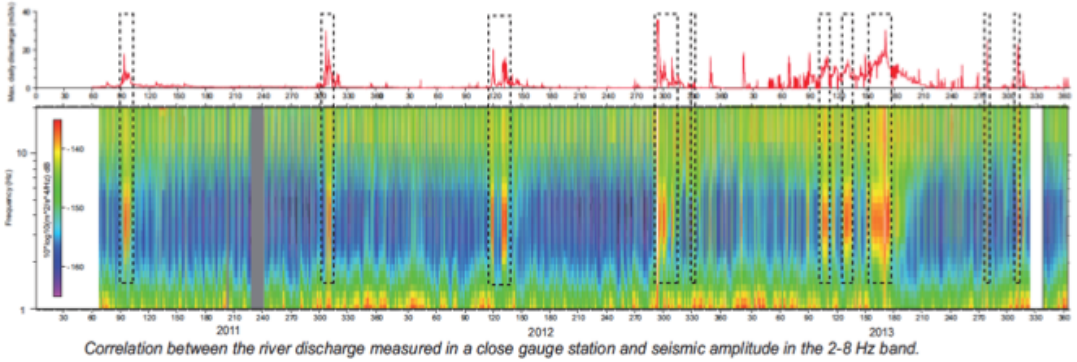
(Ph. Hubert CENBG)

LSC: GEODYNAMIC FACILITY DETECTS LINK BETWEEN SEISMIC/STRAIN NOISE AND RIVER DISCHARGE

- LSC's added-value: LSC provides a very convenient location to host an advanced integrated facility – called GEODYN – to cover the whole geodynamic spectrum, from near-field seismicity to tectonic deformation, earth tides or earth-core mutation.
  - Being underground, such a facility benefits from lower level of seismic noise than usual permanent stations, particularly at long periods more affected by changes in temperature and air circulation. In addition, meteorological data are available at the vicinity of the tunnel's entrance.
  - GEODYN currently includes a seismic station and two near-orthogonally oriented high-resolution laser strainmeters. Two external CGPS stations will be operative soon.

RESULTS: Recently it was proved that the seismic noise in the 2-8 Hz band is directly related to the discharge in the Aragon River, a typical Alpine style steam running close to LSC. The seismic (and strain) signals are useful to monitor the river discharge. This is particularly interesting in the case of severe storms resulting in large flood events or for the monitoring of the annual changes in snowmelt.

- IMPACT: Such studies are of interest to seismological, meteorological, geological and climatologic communities, but also to civil authorities in charge of the management of hydrological basins.



Correlation between the river discharge measured in a close gauge station and seismic amplitude in the 2-8 Hz band.

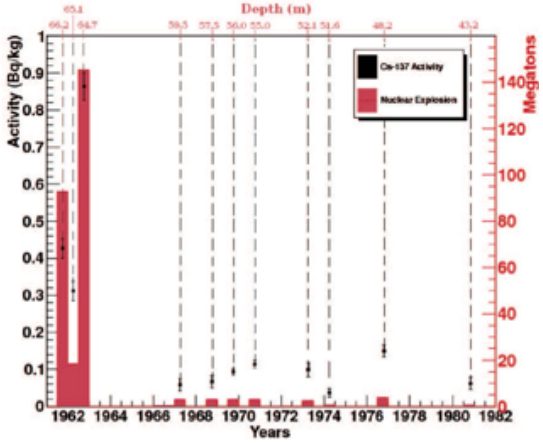
REFERENCE: Diaz J et al. (2014) "Seismic monitoring of an Alpine mountain river" Journal of Geophysical Research: Solid Earth 119(4): 3276–3289.

CONTACT: Jordi Diaz, ICTJA-CSIC, Barcelona, Spain, e-mail: jdiaz@ictja.csic.es

LNGS: MEASUREMENT OF RADIOACTIVE ISOTOPES INTRODUCED IN THE ENVIRONMENT BY HUMAN ACTIVITIES: FALLOUT DUE TO NUCLEAR ACCIDENTS/TEST EXPLOSIONS

INFN Laboratori Nazionali del Gran Sasso

- **MOTIVATION:** Due to high snow seasonal precipitation, mid-latitude continental glaciers (i.e. Tibetan and Alpine plateau) can provide a **high resolution climatic record of the environmental impact due to human activities**. High-precision dating of these ice cores is however difficult.
- **METHOD:** An analytical method for absolute dating of ice cores was proposed, based on the presence of ^{137}Cs (an isotope of anthropogenic origin) in ice layers and its detection using high sensitivity γ spectroscopy.
- **LNGS's ADDED VALUE:** Ice cores from the Lys Glacier, Monte Rosa Group (Western Alps) were analyzed using the γ spectroscopy based on low-background high-purity germanium (HPGe) detectors based at LNGS, whose sensitivity scale is of around 1 mBq/kg.
- **RESULTS:** The method developed allows to link ^{137}Cs concentrations with particular nuclear events that occurred in the last 50 years, with a direct quantification of the introduced radioactive pollution.



Comparison ^{137}Cs and MegaTons per year

- REFERENCE: *Baccolo et al. (2014). Neutron activation analysis on sediments from Victoria Land, Antarctica: multielemental characterization of potential atmospheric dust sources. J. OF RADIOANALYTICAL AND NUCLEAR CHEMISTRY, vol. 299, p. 1615-1623, ISSN: 0236-5731*
- CONTACT: Prof. Ezio Previtali, INFN/Università degli Studi di Milano-Bicocca, Milano, Italy. e-mail: Ezio.Previtali@mib.infn.it

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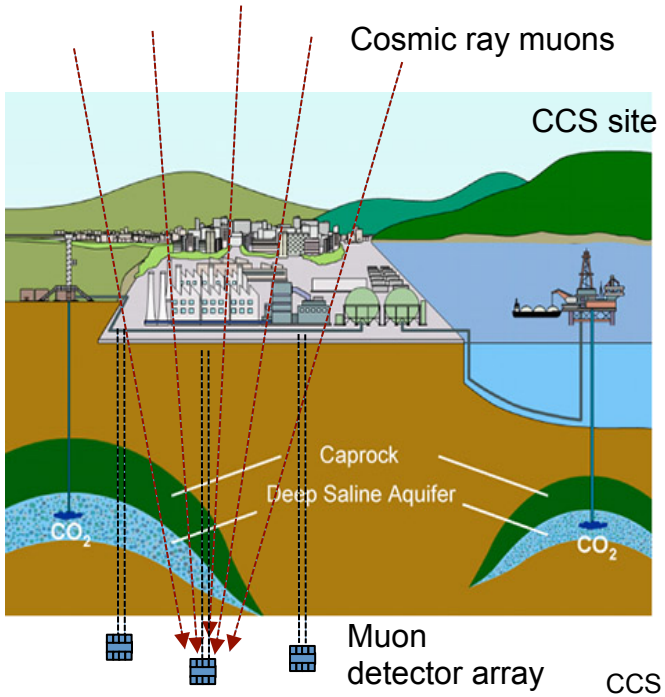
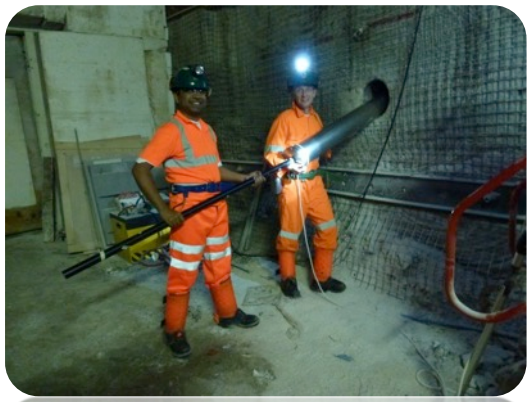
Development of a Muon Tomography techniques for deep 3D geological surveying - inc Carbon Capture @ Storage (CCS)

STFC-Boulby, Durham, Sheffield, Bath, NASA



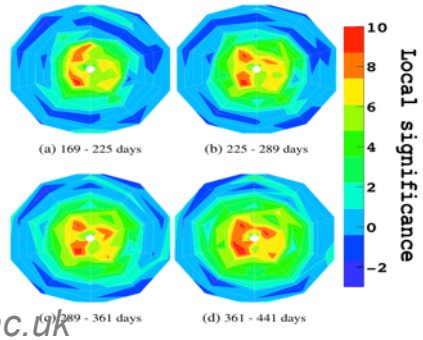
Potential for cheap, reliable, practical, real-time long-term monitoring of deep structures. Potential applications:
- Deep geological repository monitoring.
- Monitoring in Carbon Capture & Storage (CCS)


Muon-tides detector development


Bore hole detector installation

Boulby site and skills uniquely well-suited for development and testing: appropriate depth and geology, ease of access, infrastructure & expertise

CCS site simulation



Deep-Carbon Project: £1.4M funding from UK Dept of Energy & Climate change (DECC) & Premier Oil:
- Bore-hole detector development & testing @ Boulby
- Muon-Tides technology demonstrator
- Simulations of technique performance in CCS

S.M.Paling - Boulby@stfc.ac.uk

Astroparticle Physics European Consortium

Sampling life in Boulby Brine

Subsurface Astrobiology Laboratory

BISAL
Boulby International Subsurface Astrobiology Lab

A base for studies of life in Boulby rock – studies of limits of life on earth and on other planets

ALSO: An important 'Mars Analogue site' – with geology & conditions to allow explorations & astrobiology technique & instrumentation development

MINAR
Mine Analogue Research

Mining & extraplanetary exploration instrumentation development

Boulby and Instrumentation for Earth and Space Exploration

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How can the labs help promote further multidisciplinary collaboration?

Astroparticle Physics European Consortium

A distributed multidisciplinary and intersectoral doctoral school

- An EU-funded MSCA Innovative Training Network (ITN) aims **to train a new generation of creative, entrepreneurial and innovative early-stage researchers.**
- This kind of network must have the « **triple i dimension** »: **international, interdisciplinary and intersectoral (academic + industry)** combined with particular focus on an **innovation-oriented mind-set.**

A (first) doctoral school that would link the four DULs by focusing on the multidisciplinary and inter-sectorial use of the labs: « Multi-DEEP - Multidisciplinary and Innovative Training in Deep Underground Labs »

MULTI-DEEP will aim at:

1. preparing a new generation of researchers that will be equipped to open a new era for the Deep Underground Labs
2. developing intelligent devices and tools that will bring dramatic increases in performance in the fields of Astroparticle Physics, Geosciences, Biosciences and Environmental sciences;
3. starting a concerted effort to link the labs with industry, through the secondment of the students to the non-academic sector.
4. reducing the fragmentation currently present between the scientists from non-ApP fields carrying out multidisciplinary research in DULs around the world.

Multidisciplinarity in DULIA: Objectives

- To promote access to Multidisciplinary (beyond PP and APP) science users - from academic, industrial and public sectors.
- To establish a sustainable community of Multidisciplinary science users - from academic, industrial and public sectors.
- To provide a platform for exchange of information between existing collaborations to promote synergies, avoid duplications and create new collaborations through the emergence of new ideas.
- To carry out in common a strategic foresight exercise for multidisciplinary experiments through a structural foresight exercise.
- To propose a standardisation of laboratory parameter measurements required by multidisciplinary experiments.
- To propose a common way to evaluate multidisciplinary science experiments in the DULs.
- To formulate a multidisciplinary science publication policy and data management plan.

Example 1: Services offered at European DULs

- In order to strengthen and broaden the societal impact of their scientific programme, the four European DULs aim at further developing access provision to scientists from non-Astroparticle Physics disciplines.
- Specifically the services provided are mainly:
  - US: Underground Space with services (electricity, gas, safety, monitoring, computing). The labs show **great diversity in terms of depth, size, and geological/ environmental characteristics**.
  - ULB-HPGe: the labs have developed and host the **greatest "farm" of gamma spectrometers for low background measurements in the world.**
  - UA: Easy and fast **access to an underground environment** for biogeoscience studies.

Services offered at European DULs

LNGS

- US: Underground Space with services (electricity, gases, safety, environmental radiation monitoring)
- ULB-HPGe: Ultra low background service with very low background HPGe detectors. The LNGS screening facility STELLA (SubTerranean Low Level Assay) can be employed for measurement of materials and of environmental and meteorite samples as regards to their content of natural radioactivity,
- IETI: it is a He3-He4 dilution, dry cryostat (Pulse tube based), installed in 2013. The commissioning temperature obtained in 2014 is 6.75 mK. Large experimental volume (25 cm diameter, 15 cm height) that can host different types of electronics dedicated to different type of temperature sensors.
- ICP-MS: used to do trace element analysis on almost all elements. Especially for U, Th, the sensitivity is on the level of ppt (10 -12 g/g). Complex matrices (e.g. metal covered plastic materials as superinsulation) can be measured separating each single component.

LSM

- US: Underground space with services (electricity, gas, radon-free air, environmental radiation monitoring), dedicated room for biology
- ULB-HPGe: 15 low background HPGe detectors – able to reach sensitivities at a level of 60 μBq/kg in ^{208}Tl and 100 μBq/kg in ^{214}Bi – for material selection, environmental surveys and other applications.
- ME: as a reference laboratory for the JEDEC norm, LSM hosts devices to test the effects of radiation on the microelectronics circuits.
- RF: a radon free air production facility for set-ups requiring very low activity air environment.

Services offered at European DULs

LSC

- US: Underground installations and space with related services
- ULB-HPGe: Radiopurity measurements of materials thanks to seven HPGe detectors and the related simulation and analysis software packages
- CES: Radiopure copper parts manufacturing service using electroforming techniques
- CRS: Underground clean room class 1.000 (ISO 6) and class 10.000 (ISO 7)
- UA: Access to underground rock sampling for bio and geo studies

Boulby

- US: Underground Space with services (electricity, gases, safety, environmental monitoring).
- ULB-HPGe: Low background Germanium detector systems. Sensitivity down to 50ppT U/Th concentrations for material screening.
- CRS: Underground clean room class 10.000 (ISO 7)
- UA: Supported access to the wider mine workings and the various scientifically interesting/ important geologies accessible.

Astroparticle Physics European Consortium

Multidisciplinary science in European DULs presented at AGU14

From the Cosmos to the Geosphere

the quest of four European **Deep Underground Laboratories** originally built for Astroparticle Physics to understand Global Environmental Change (on behalf of the four labs)

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and Astroparticle Physics European Consortium (APPEC)
(e-mail: ino.agrafioti@cnrs-dir.fr)

A number of deep underground laboratories exists around the world, all originally developed to advance our understanding of the Universe through low-background Astroparticle Physics experiments needing **shielding from interference produced by cosmic radiation**. Over the last decade, the four European deep laboratories presented here, supported by their funding agencies, have been making great efforts towards their integration into a **single world-class distributed interdisciplinary and intersectoral infrastructure**.

Meanwhile, they have been asking **"how can our facilities, primarily built for Astroparticle Physics, be used to tackle global challenges?"**. Astroparticle Physicists have wide experience in forming large long-term international collaborations, developing innovative technologies, building unique facilities and organising data handling, reduction, storage and analysis: all this knowhow was put to the disposal of geologists, climatologists, environmental scientists and biologists from academia and public authorities. As a result, many interesting multidisciplinary projects have used either the **low-radioactivity technologies developed by the labs and/or their deep underground environment**.

Run your experiments in Europe's Deep Underground Labs!

In order to strengthen and broaden the societal impact of their scientific programme, the four European DULs aim at further developing access provision to scientists from non-Astroparticle Physics disciplines. Specifically the services provided are mainly:

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- UA: Easy and fast **access to an underground environment** for biogeoscience studies.

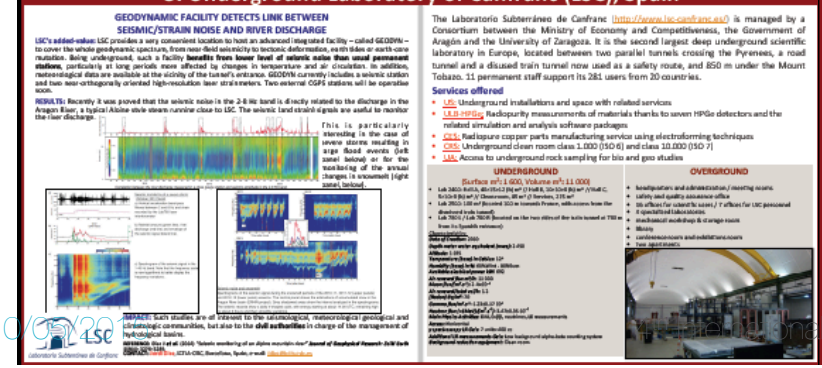
The four labs have applied to European Union for funding to help with the access costs of scientists from other disciplines and will be launching Calls for Proposals starting in 2015 (TBC).

Sheldon and Raj know that great knowledge comes to those going underground!

1. Underground Laboratory of Modane (LSM), France

2. Gran Sasso National Laboratory (LNGS), Italy

3. Underground Laboratory of Canfranc (LSC), Spain



4. Boulby Underground Laboratory, UK

"Your planet is very beautiful," [said the little prince]. "Has it any oceans?"
"I couldn't tell you," said the geographer . . .
"But you are a geographer!"
"Exactly," the geographer said. "But I am not an explorer. I haven't a single explorer on my planet. It is not the geographer who goes out to count the towns, the rivers, the mountains, the seas, the oceans, and the deserts."
Antoine de Saint Exupery

THANK YOU!

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