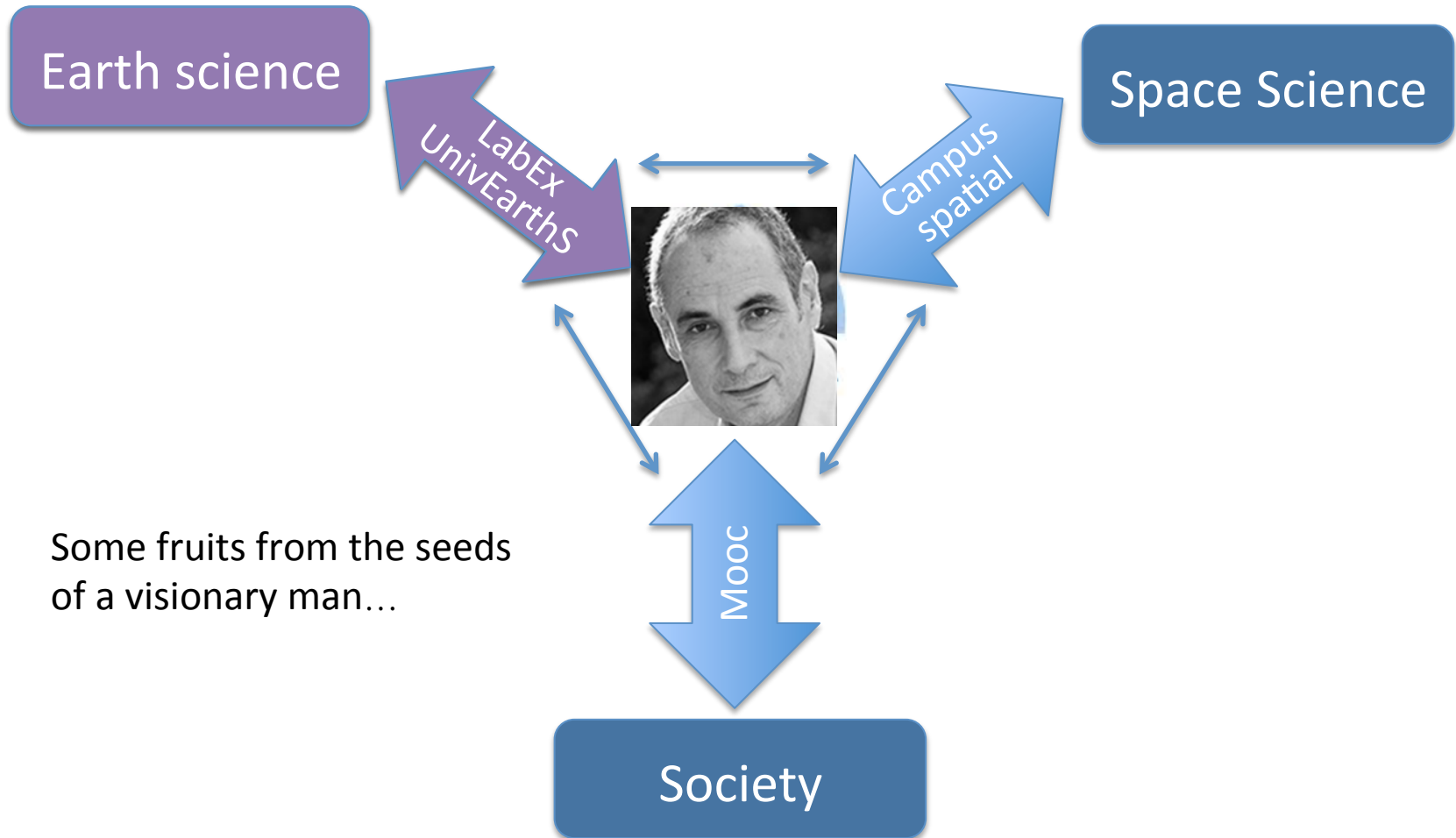


Conférence Pierre Binétruy

Antoine Kouchner

INTERDISCIPLINARITY



Some fruits from the seeds
of a visionary man...

Terre - Planète - Univers

[Home](#)

[Overview](#)

[Projects](#)

[Publications](#)

[Educational](#)

[Team](#)

[Ressources](#)

<http://www.univearths.fr/>

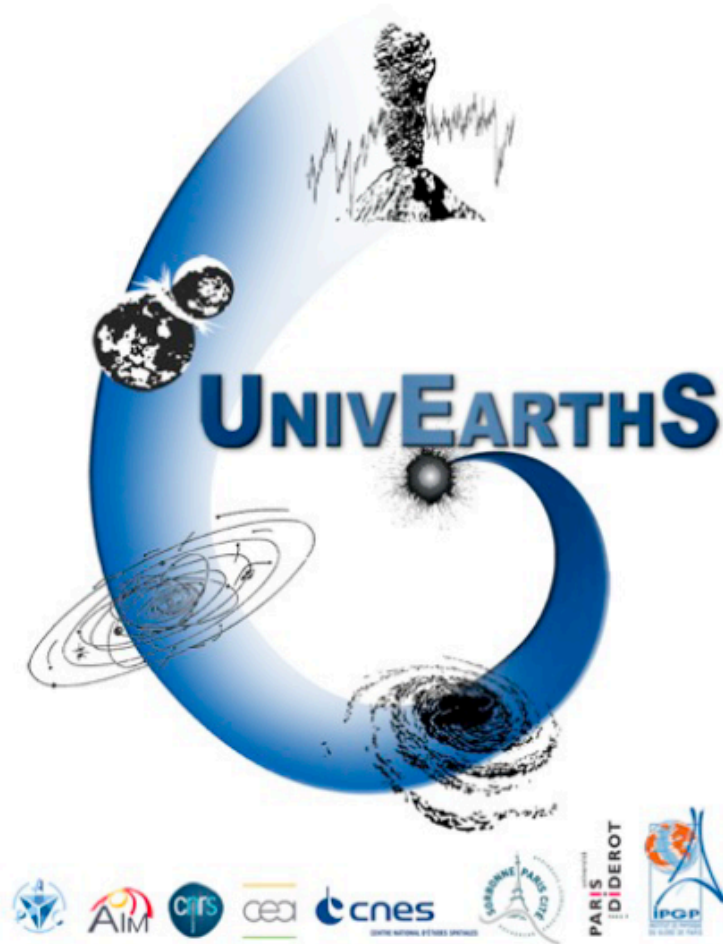
Pierre Binétruy: From theory to strategy of discovery

On 3 & 4th May, 2018, this conference is organized in memory of Pierre Binétruy (1955-2017) [...]

Read more »

UnivEarthS: Proposal 2011

Earth Planets Universe
observation - theory - modeling - transfer



Scientific committee members

Chair: George Smoot

Vice-chair: Vincent Courtillot, IPGP

Pierre-Oliver Lagage, AIM

Eric Plagnol, APC

Marc Chaussidon, CRPG Nancy

Stéphane Mazevet, LUTh

Piercarlo Bonifacio, GEPI

Jacques Laskar, IMCCE

Pierre Touboul, ONERA

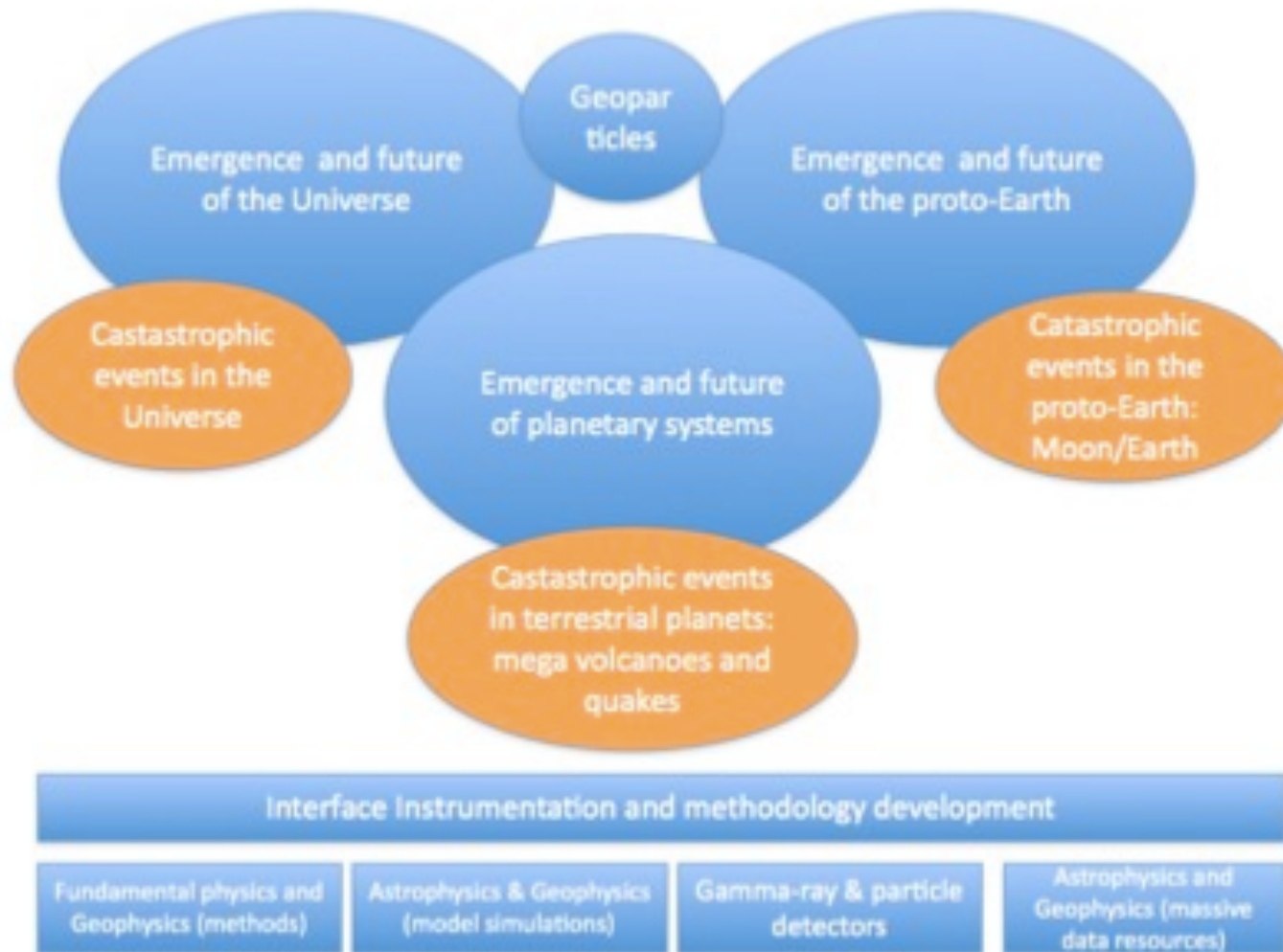
Richard Bonneville, CNES

Neil Gehrels, NASA

Ed Stolper, Caltech,

Lars Stixrude, UCL

UnivEarthS: Proposal



Graphical synopsis of the UnivEarthS project

UnivEarthS as of today

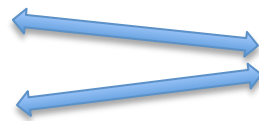
in the context of “Excellence initiatives” of ANR: 9M€ for 2011-2019

- Federating 3 laboratories



~20 projects, of 3 types

- Frontier (one main theme per lab)
- Interface
- Exploratory



INTERDISCIPLINARITY

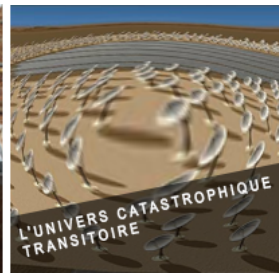
“Astroparticle messengers to study the Earth”

+ Education + Valorisation

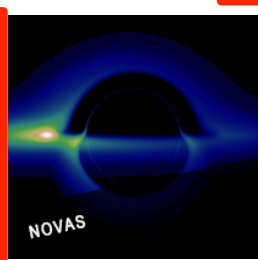
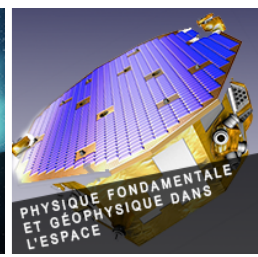
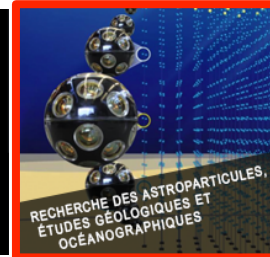
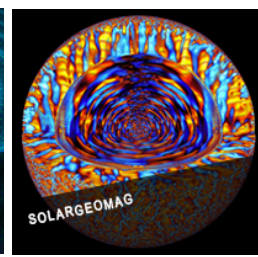
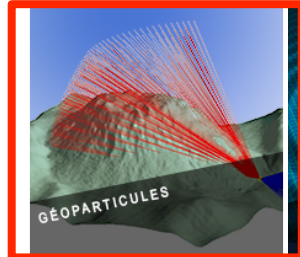
200 FTE, 30 post-doc,
26 PhD and 120 researchers

Work Packages

PROJETS FRONTIERE



PROJETS INTERFACE



PROJETS EXPLORATOIRES



PROJETS JEUNE EQUIPE



PROJETS ENSEIGNEMENT



PROJET VALORISATION

Focus: Geophysics & GW interferometric detectors

M.Barsuglia (APC) and J.-P.Montagner (IPGP)

Mission: Explore synergies between Geophysics and gravitational-wave (GW) detectors

- How geophysics experience and instrumentation can contribute to GW science? **GEO→GW**
 - How GW experience and instrumentation can contribute to geosciences and to geophysical applications? **GW→GEO**
- Can we detect the gravity perturbation due to an earthquake before the arrival of the seismic waves?
 - Can we use the gravity perturbation to improve the current earthquake early-warning systems ?

Focus: Geophysics & GW interferometric detectors

Benefits of early-warning systems

Control trains

Control factory lines

Prevent traffic accidents

Control lifts

People executing dangerous work

Permit individual protection

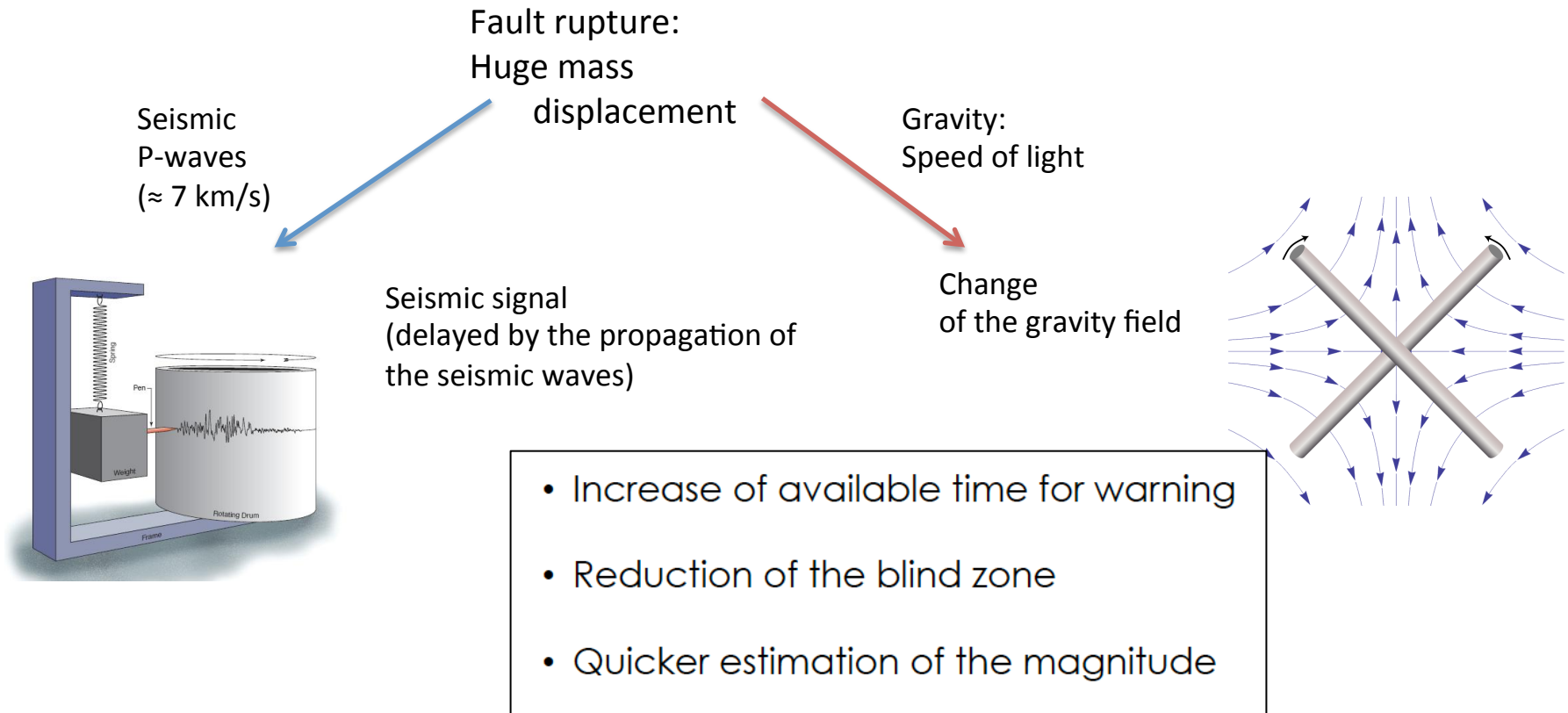
Suspend work in progress

Alert schools and meetings

Credit: Jan Harms

Focus: Geophysics & GW interferometric detectors

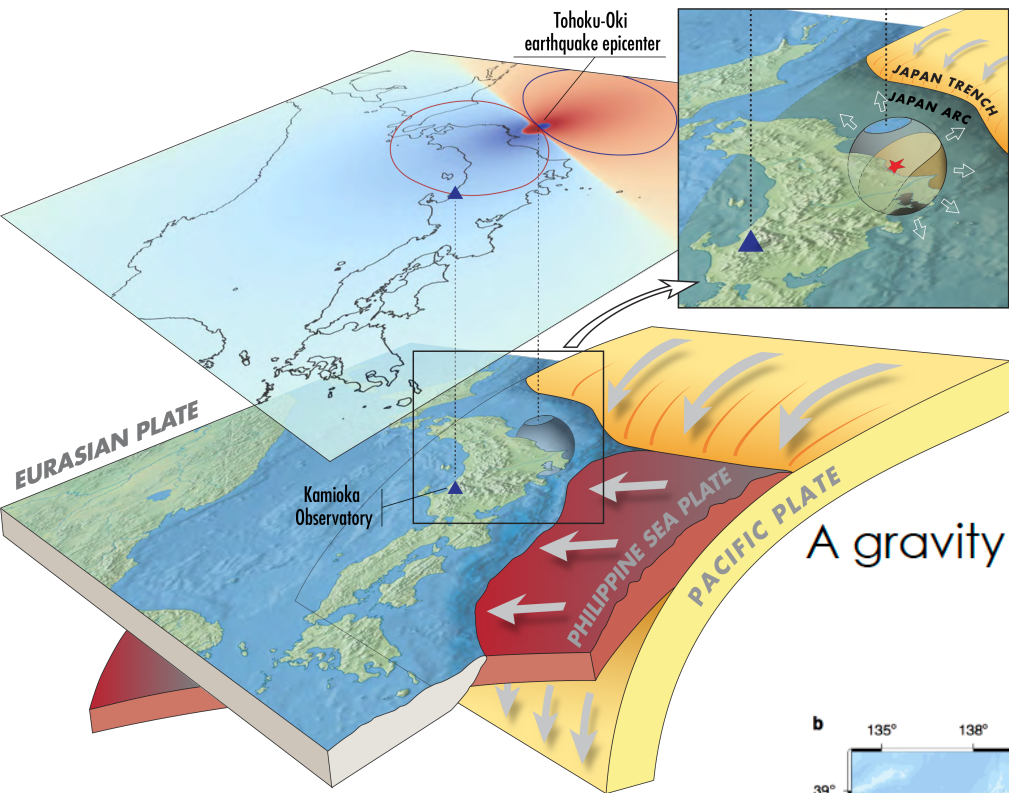
- New directions in seismology using gravity detectors (strainmeters)
- International cooperation (CalTech, INFN, U. Florida)



- Strong links with Virgo and GW detection techniques.

Study of the local gravity noise useful also for future gravitational-wave experiment

Focus: Geophysics & GW interferometric detectors



Magnitude 9

A gravity signal from the Tohoku-oki earthquake:
"First act"

Superconducting gravimeter
& broadband seismometers



ARTICLE

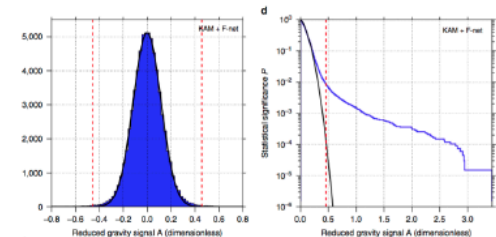
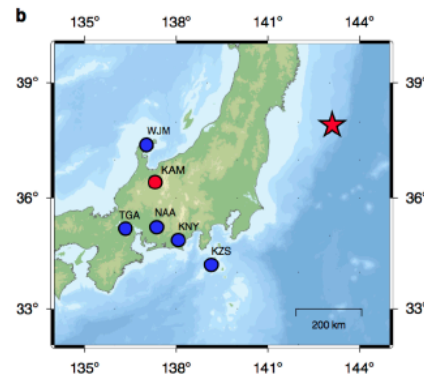
Received 25 Jan 2016 | Accepted 26 Sep 2016 | Published 22 Nov 2016

DOI: 10.1038/ncom13341 OPEN

Prompt gravity signal induced by the 2011 Tohoku-Oki earthquake

Jean-Paul Montagne¹, Kévin Juhel¹, Matteo Barsuglia², Jean Paul Ampuero³, Eric Chassande-Mottin², Jan Harms⁴, Bernard Whiting⁵, Pascal Bernard¹, Eric Clévédi³ & Philippe Lognonné¹

Blind analysis: 99% statistical significance



Detection of the gravity signal from the Tohoku earthquake: **second act**

GEOPHYSICS

Science, 1/12/2017

Observations and modeling of the elastogravity signals preceding direct seismic waves

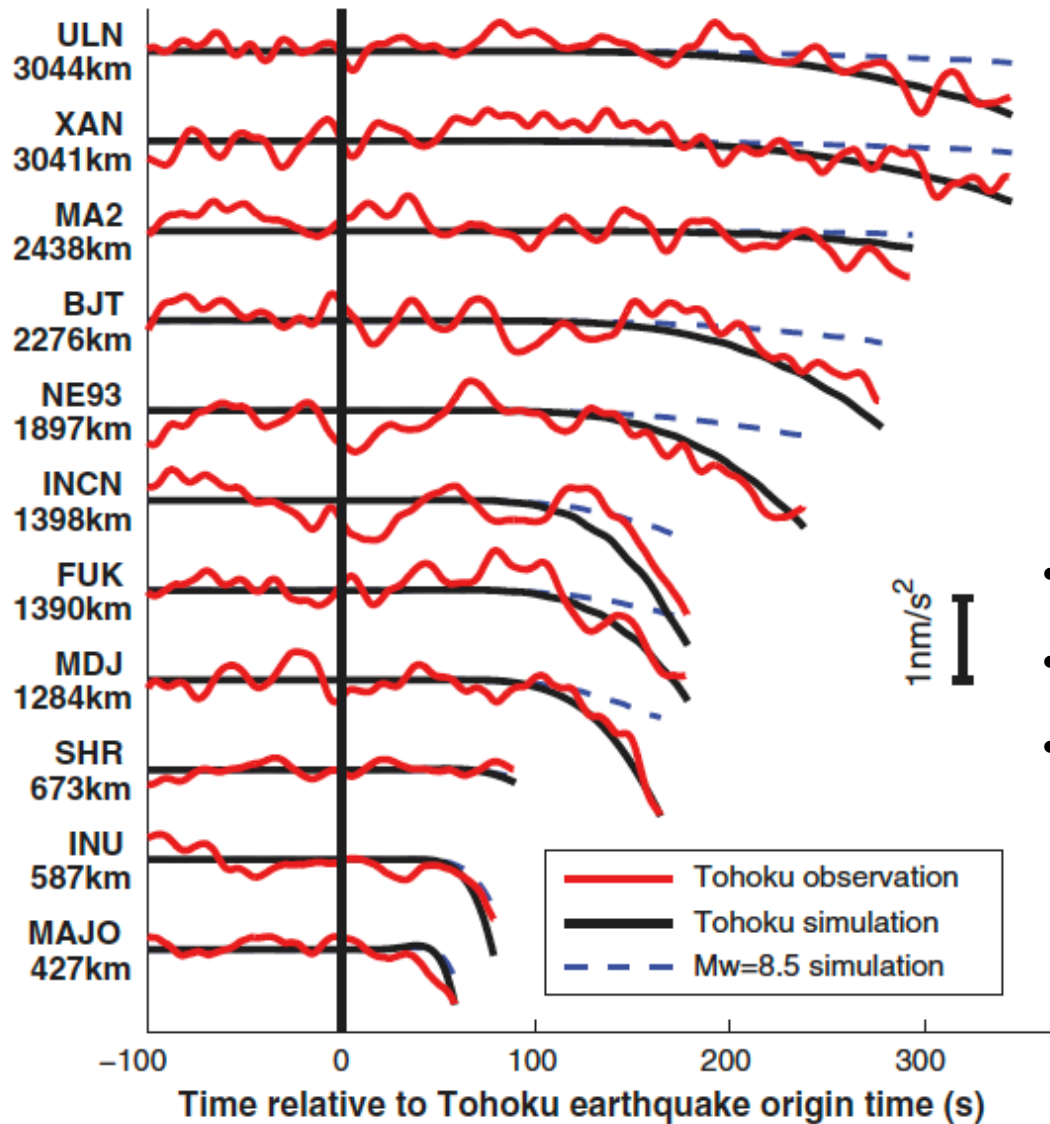
Martin Vallée,^{1*} Jean Paul Ampuero,² Kévin Juhel,¹ Pascal Bernard,¹
Jean-Paul Montagner,¹ Matteo Barsuglia³



Gravity gets into the earthquake game

Earthquakes generate large movements of mass, which slightly change the gravitational field. Unlike the elastic waves that propagate from the earthquake, the gravity perturbations travel at the speed of light. Vallée *et al.* have finally observed these gravity perturbations in seismometer records from the great Tohoku earthquake in Japan in 2011. The signal would have allowed an accurate magnitude estimation in minutes, rather than hours, for this catastrophic earthquake.

Focus: Geophysics & GW interferometric detectors



Some Results

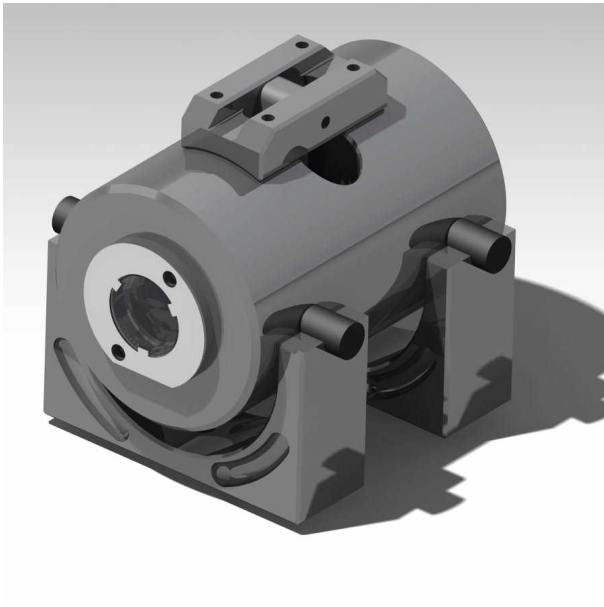
Good agreement at all distances
Large amplitude differences related to the magnitude...

- Stronger signal
- More accurate modelling
- Assessment of the magnitude

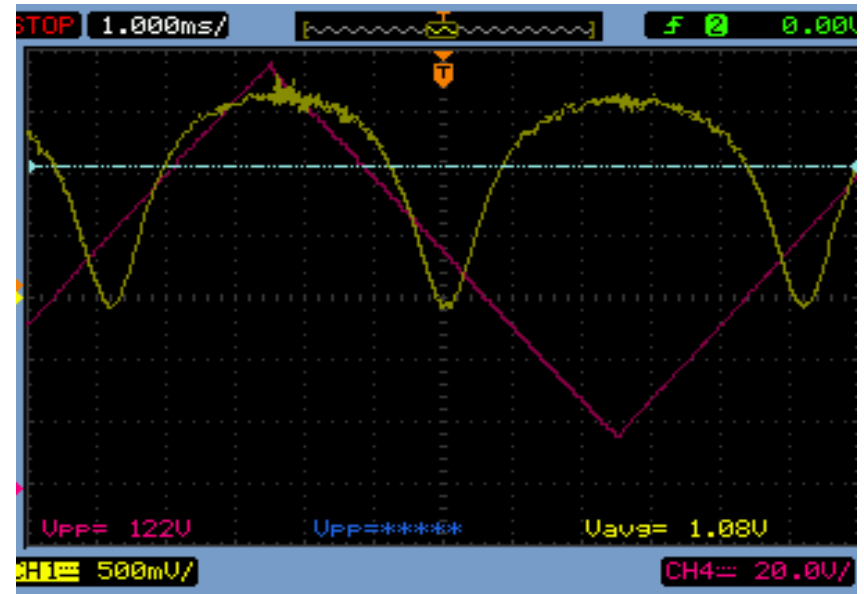
Focus: Interferometric readout for seismometers

- Strong links with gravitational-waves detection techniques ...

Prototype (few cm)



First measurements in lab



Hope to gain 1 order of magnitude sensitivity

Focus: Future of Gravitational Waves on the Moon

Moon Normal modes might be excited resonantly by gravitational waves

Inspired from Lunar Surface Gravimeter Experiment (1972 Apollo 17) and relevant in the context of Mars Insight mission...

Next Steps might be even more sensitive Instruments, to be possibly deployed on the Moon in +2035. UnivEarthS is developing such an ultra-sensitive sensor.

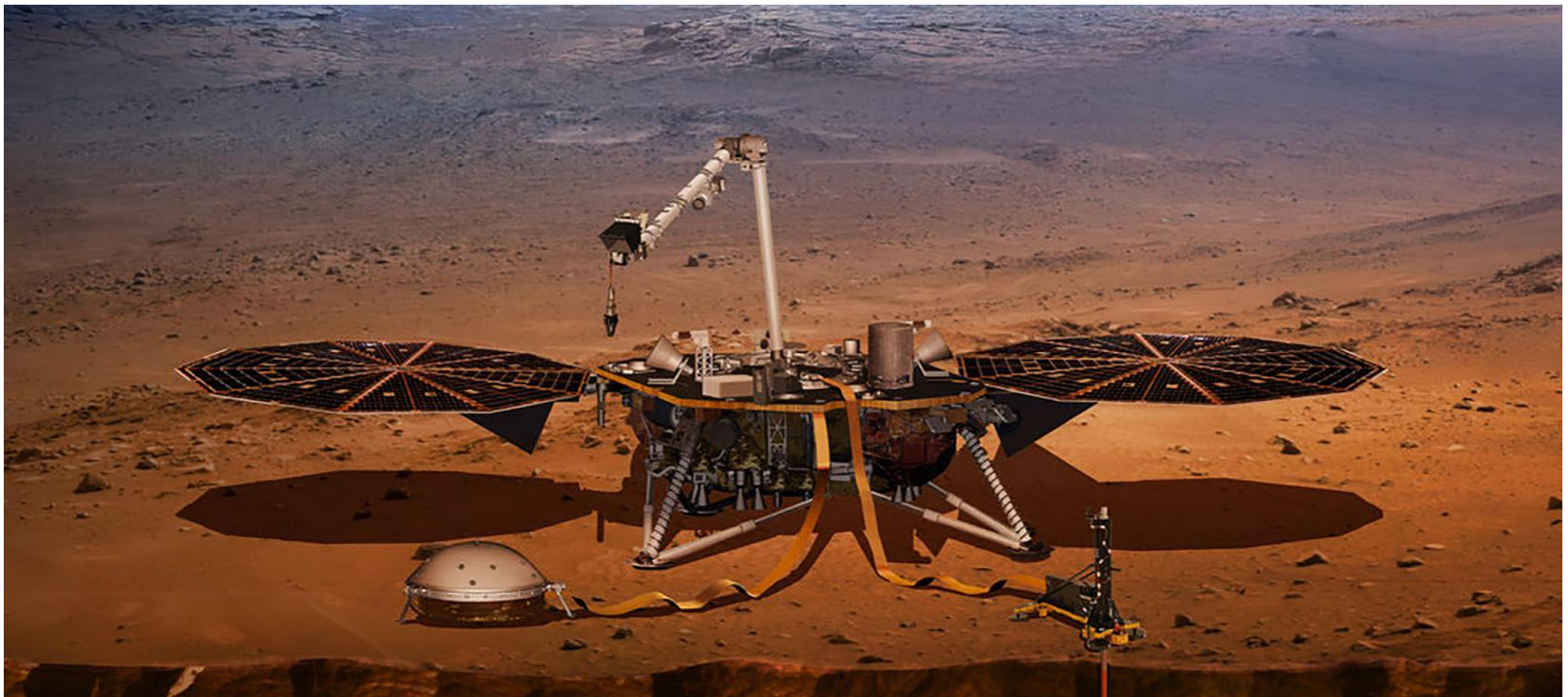
Known white-dwarf binaries exciting normal modes ?

Both geophysics and physics can dream of wave detectors on several terrestrial bodies and in space in 2025+, which might be future goals for **UnivEarthS+**



InSight launch tomorrow...

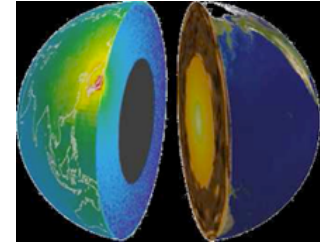
- On May 5, 2018, the InSight probe will take off from the Vandenberg Space Center in California. This 12th mission of the NASA Discovery program will allow to deposit for the first time a seismometer on the surface of Mars.



Focus: particles for geosciences

Geo-neutrinos:

antineutrinos from the decay of radioactive elements inside the Earth are unique messengers on the structure and composition of the Earth's interior



Latest result by **Borexino**

5σ measurement of geo- ν + U/Th Ratio

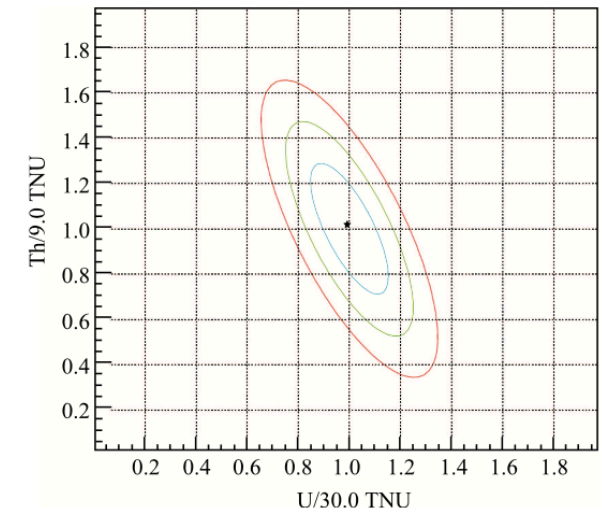
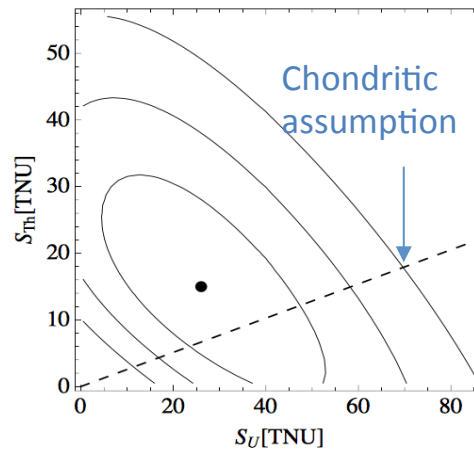
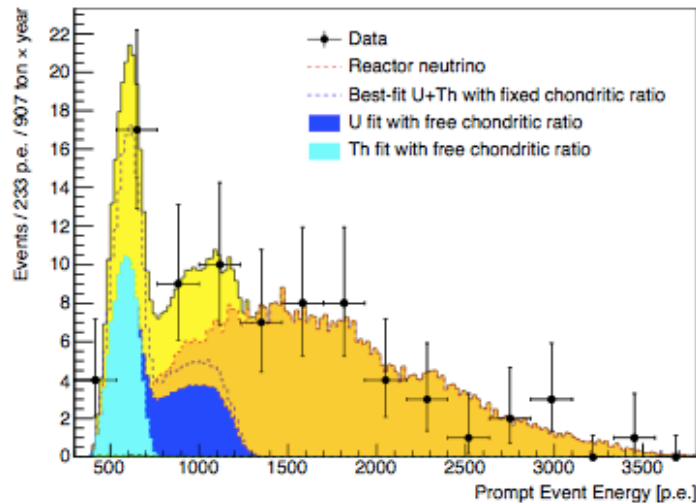
Phys. Rev. D92 (2015) 3, 031101

Prospects with **JUNO**

Measure flux with O(10%) error

Measure Mantle contribution

Precision on U/Th ratio (discriminate models)

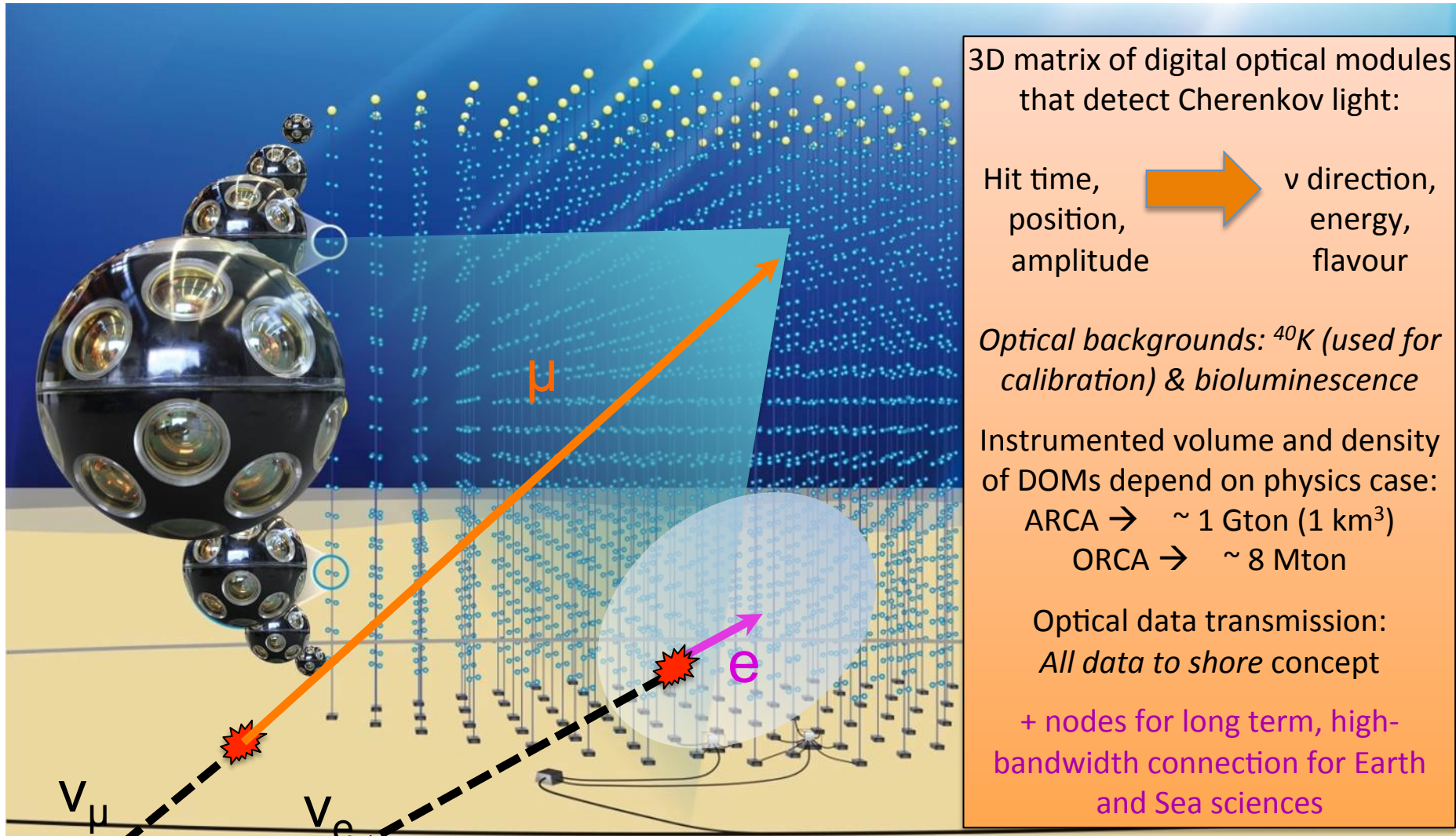


Chinese Phys. C **40** 033003 (2016)

Focus: particles for geosciences

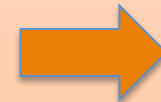
Atmospheric neutrinos

(also funded by IdEx SPC 2015-2017)



3D matrix of digital optical modules that detect Cherenkov light:

Hit time,
position,
amplitude



ν direction,
energy,
flavour

Optical backgrounds: ^{40}K (used for calibration) & bioluminescence

Instrumented volume and density of DOMs depend on physics case:

ARCA \rightarrow ~ 1 Gton (1 km^3)

ORCA \rightarrow ~ 8 Mton

Optical data transmission:
All data to shore concept

+ nodes for long term, high-bandwidth connection for Earth and Sea sciences

Focus: particles for geosciences

...Use atmospheric neutrinos to probe deep Earth composition ?
 oscillation patterns depend on electron density

$$N_e = \frac{N_A}{m_n} \times \left(\frac{Z}{A}\right) \times \rho_{matter}$$

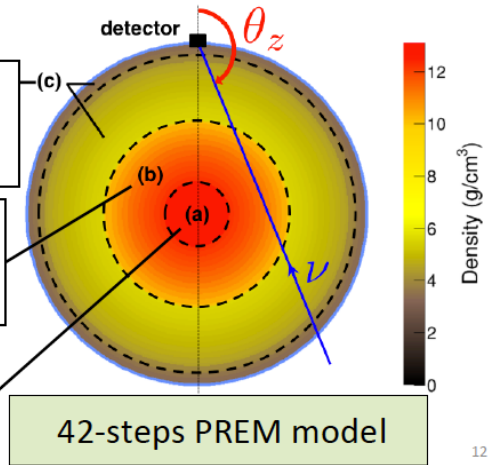
Assume matter density profile from PREM model

→ 3 chemically distinct layers
 → Z/A uniform in each layer

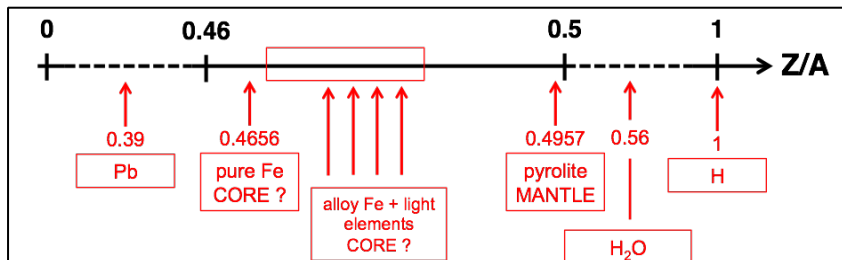
Mantle-crust: $R_{ext} \approx 6400$ km
 pyrolite (rock model)
 $Z/A = 0.496$

Outer core: $R_{ext} \approx 3480$ km
 pure Fe (+ 5% Ni)
 $Z/A = 0.4656$ (0.4661)

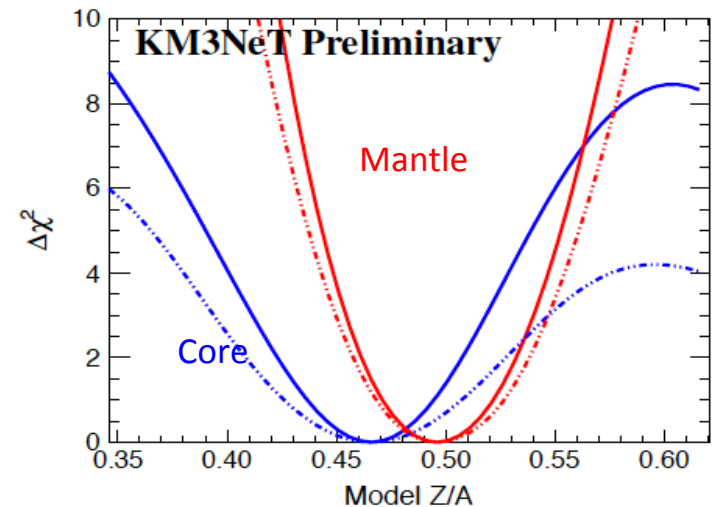
Inner core: $R_{ext} \approx 1220$ km
 pure Fe
 $Z/A = 0.4656$



Constrain Z/A in core/mantle



Typical values of Z/A for chemical elements or alloys present in the Earth



Synergies beyond geosciences

Labex **UnivEarthS**   **USPC**
Université Sorbonne
Paris Cité

Terre - Planète - Univers

Home Overview Projects Publications Educational Job Opportunity Toolkit

KM3NeT and associated sciences workshop on the 6th of December at IPGP

2 December 2016 | 18: ARGOS, Interface Project, News, Non classé, UnivEarthS Workshop



On the 6th of December, at the IPGP, a “KM3NeT and Associated Sciences” workshop will be held to identify ways of collaboration between colleagues of the APC and the IPGP, on the sismo / oceano aspects in relation to the instrumentation available on KM3NeT. This workshop is part of the ARGOS interface project of LabEx UnivEarthS.

This workshop is organized by Antoine Kouchner (APC), Véronique Van Elewyck (APC) and Edouard Kaminski (IPGP).

Search ... 

Scientific Committee 2016



Défi
Instrumentation aux limites
MI
Mission Interdisciplinarité

Environmental studies
for the monitoring of climate
change in the deep sea.

Advantages of cabled observatories:

Real-time

High power

High bandwidth

High frequency

Multiple sensors in same location

Continuous

Long term

Trigger for studies with other sensors (AUV, boat,...)

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,...):

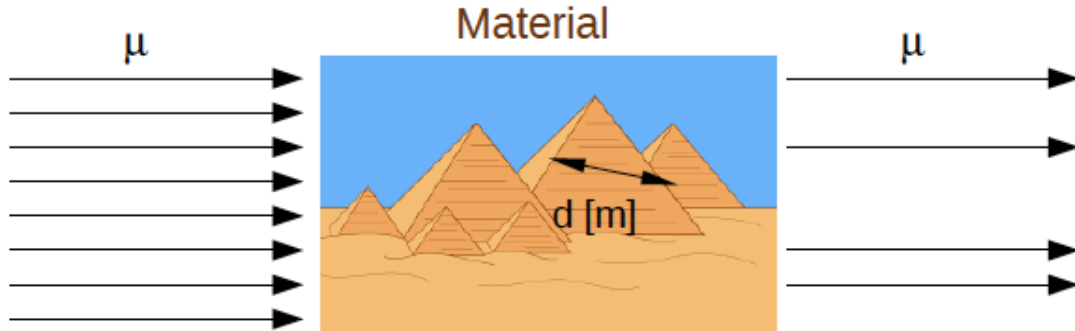
Passive acoustics, biofouling, bioluminescence, video, water samples analysis,...

Focus: particles for geosciences

Muon tomography

to map and monitor density variations of volcanoes

- Non invasive, non destructive
- Complementary to other techniques (electric resistivity...)



Initial flux ϕ_i

Density: ρ [g/cm³]

($\rho \cdot d$)

Final flux ϕ_f

Recent news (November 2nd, 2017)

nature

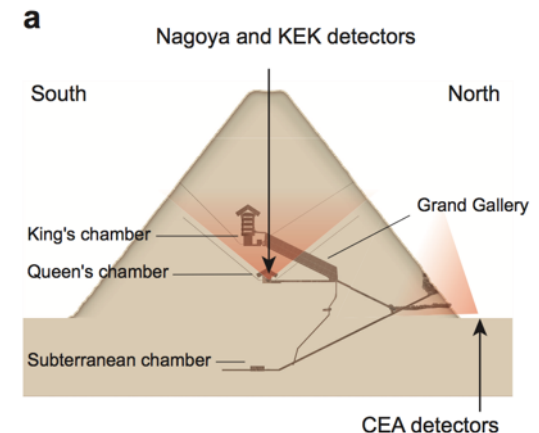
Accelerated Article Preview

LETTER

doi:10.1038/nature24647

Discovery of a big void in Khufu's Pyramid by observation of cosmic-ray muons

Kunihiro Morishima, Mitsuaki Kuno, Akira Nishio, Nobuko Kitagawa, Yuta Manabe, Masaki Moto, Fumihiko Takasaki, Hirofumi Fujii, Kotaro Satoh, Hideyo Kodama, Kohei Hayashi, Shigeru Odaka, Sébastien Procureur, David Attié, Simon Bouteille, Denis Calvet, Christopher Filosa, Patrick Magnier, Irakli Mandjavidze, Marc Riallot, Benoit Marini, Pierre Gable, Yoshikatsu Date, Makiko Sugiura, Yasser Elshayeb, Tamer Elnady, Mustapha Ezzy, Emmanuel Guerriero, Vincent Steiger, Nicolas Serikoff, Jean-Baptiste Mouret, Bernard Charlès, Hany Helal and Mehdi Tayoubi

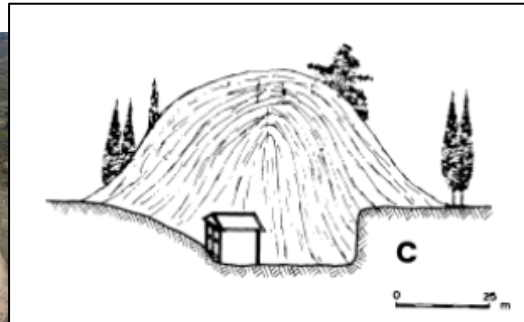


Focus: particles for geosciences

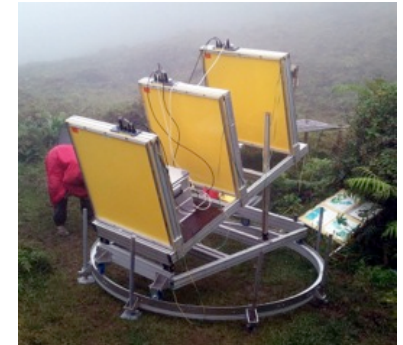
Muography of archaeological structures

Identification of internal structures (cavities, tombs)

In Macedonian burial tumuli



The detector



Transport and installation

Plans de scintillateur 170x220



Potentially more challenging than pyramids:

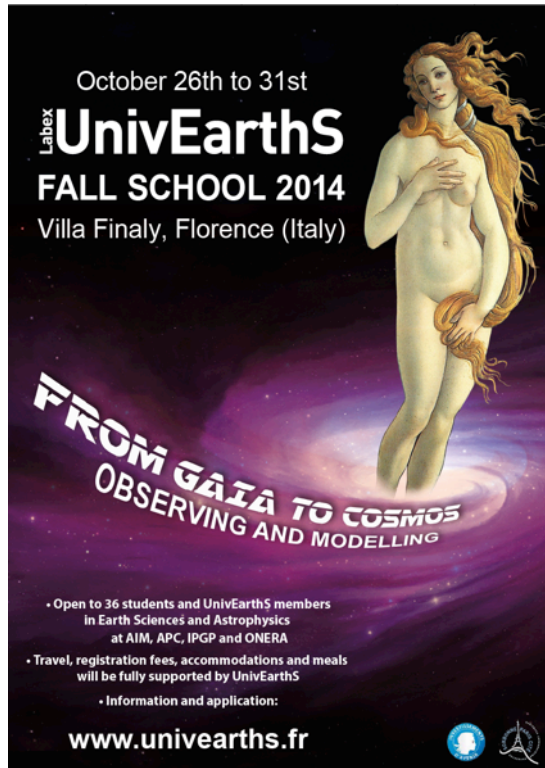
- smaller size of the cavities/tombs
 - lower muon flux (more inclined)
 - backgrounds
- ➔ need full simulations and dedicated analysis techniques

Feasibility studies based on simulations developed in 2016

Data taking will start next July

UnivEarthS Schools

October 26th to 31st
UnivEarthS
FALL SCHOOL 2014
Villa Finaly, Florence (Italy)



FROM GAIÀ TO COSMOS
OBSERVING AND MODELLING

- Open to 36 students and UnivEarthS members in Earth Sciences and Astrophysics at AIM, APC, IPGP and ONERA
- Travel, registration fees, accommodations and meals will be fully supported by UnivEarthS
- Information and application:

www.univearths.fr

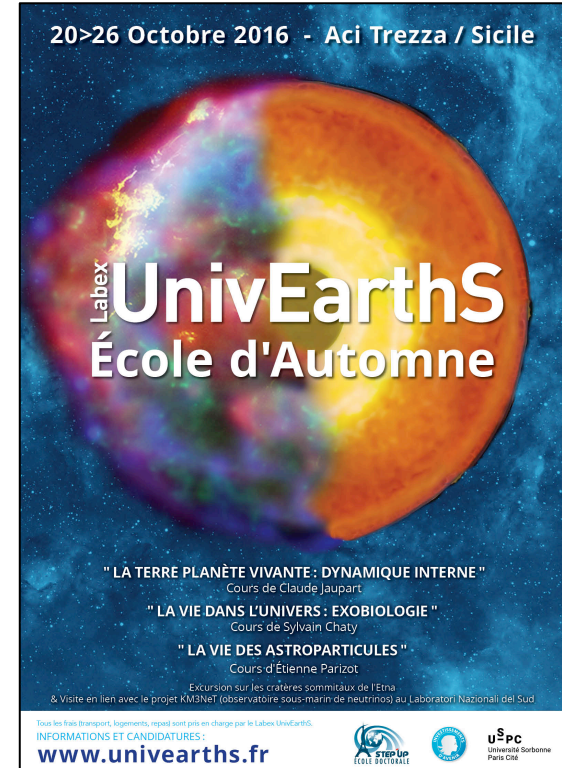
UnivEarthS
FALL SCHOOL
17>23 October 2015
SANTORIN



Open to UnivEarthS members, PhD students of Doctoral School STEP-UP, students in Master degrees associated with UnivEarthS laboratories in Earth Sciences and Astrophysics at AIM, APC, IPGP and ONERA.
Travel, registration fees, accommodations and meals will be FULLY SUPPORTED by UnivEarthS.
INFORMATIONS AND APPLICATIONS:
www.univearths.fr

**PHASE CHANGES
AND ERUPTIONS
IN THE UNIVERSE**

20>26 Octobre 2016 - Aci Trezza / Sicile



UnivEarthS
École d'Automne

" LA TERRE PLANÈTE VIVANTE: DYNAMIQUE INTERNE "
Cours de Claude Jaupart

" LA VIE DANS L'UNIVERS: EXOBIOLOGIE "
Cours de Sylvain Chaty

" LA VIE DES ASTROPARTICULES "
Cours d'Étienne Parizot

Excursion sur les cratères sommitaux de l'Etna
& Visite en lien avec le projet KM3NET (observatoire sous-marin de neutrinos) au Laboratori Nazionali del Sud

Tous les frais (transport, logements, repas) sont pris en charge par le Labex UnivEarthS.
INFORMATIONS ET CANDIDATURES:
www.univearths.fr

- About 40 participants: PhD, postdocs, M2, engineers, high-school teachers
- Lectures on Astro(Particle)Physics, Geo-science, Common tools
- Posters and mini-presentations by the students

Particle phys. & Geosciences at doctoral level



International Summer Institute

Using Particle Physics to understand and image the Earth
Geoneutrinos, Muography, Cosmogenic Nuclides

L'Aquila – July 11-21, 2016

Gran Sasso Science Institute

Viale Francesco Crispi, 7 – 67100 L'Aquila (Italy)

Addressed to physicists and geologists

Lectures and activities

Student poster session

Pre-school for the two audiences

(physicists and geologists) to acquire the know-how needed to follow the school

Participation limited to 25 students selected on the CV basis

School fee: € 70

Organizing Committee

Matteo Agostini (GSSI)
Gianpaolo Bellini (Milan Univ. and INFN)
Stefano Davini (GSSI)
Livia Ludhova (RWTH Aachen Univ. and FZ Jülich IKP-2)
Fabio Mantovani (Ferrara Univ. and INFN)
Simone Marocci (GSSI)
Nicola Rossi (LNGS)
Francesco Vissani (GSSI and LNGS)

Scientific Committee

Gianpaolo Bellini (Milan Univ. and INFN – co-chairman)
Mark Chen (Queen Univ.)
Eugenio Coccia (GSSI and Rome "Tor Vergata" Univ.)
Steven Dye (Hawaii Pacific University)
Gianni Fiorentini (Ferrara Univ. and INFN)
Antoine Kouchner (APC – Paris VII Univ.)
Aldo Ianni (Canfranc Laboratory and LNGS)
Kunio Inoue (Tohoku University)
Vedran Lekic (Maryland Univ.)
Livia Ludhova (RWTH Aachen Univ. and FZ Jülich IKP-2)
Fabio Mantovani (Ferrara Univ. and INFN)
Frank Marzano (Rome "La Sapienza" Univ.)
William McDonough (Maryland Univ. – co-chairman)
Giacchino Ranucci (Milan INFN)
Paolo Strolin (Naples Univ. and INFN)
Hiroyuki Tanaka (University of Tokio)
Taku Tsuchiya (Ehime Univ.)
Francesco Vissani (GSSI and LNGS)
Hiroko Watanabe (Tohoku Univ.)
and
the ISAPP Scientific Committee

Secretariat

Irene Sartini (GSSI)

Website: <http://agenda.infn.it/event/SIPP2016>

Contact: isapp.summerinstitute@gssi.infn.it

G S GRAN SASSO
S I SCIENCE INSTITUTE
CENTER FOR ADVANCED STUDIES
Istituto Nazionale di Fisica Nucleare



Fellowships for the living expenses in L'Aquila can be assigned, if requested, on the CV basis



2-12 juillet 2018

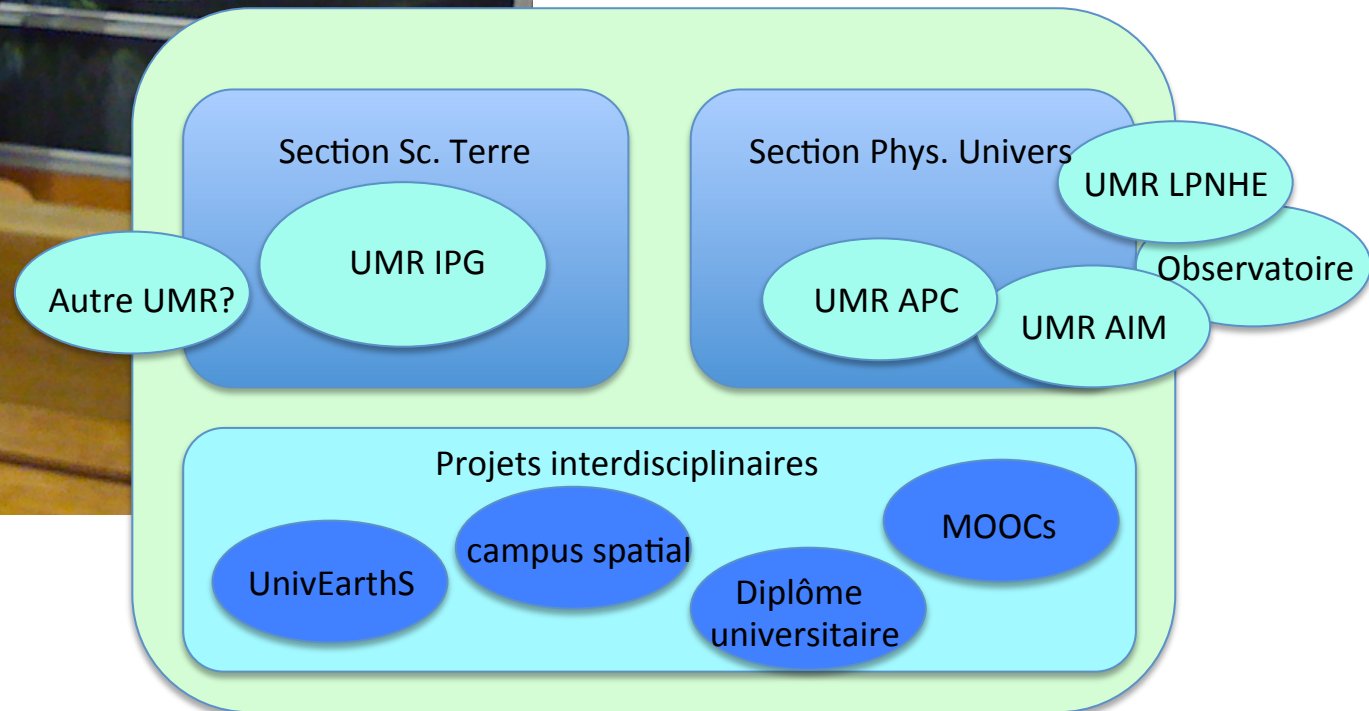
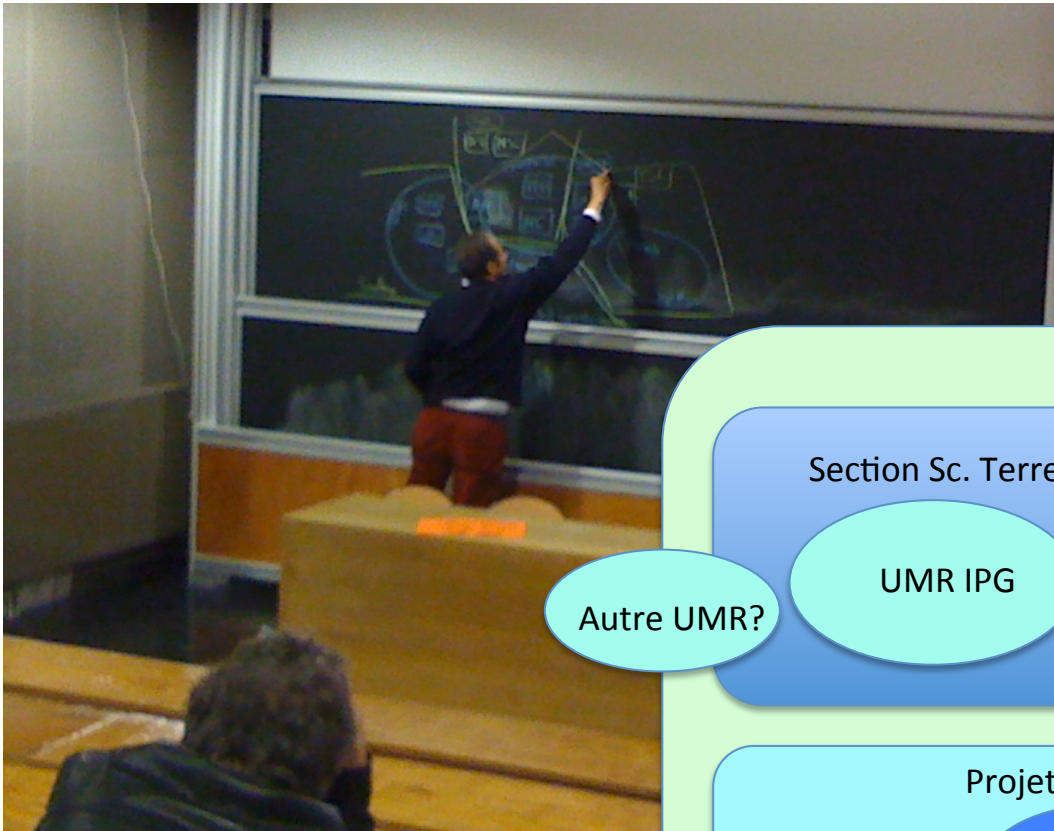
University of Ferrara - Institute for Higher Studies, IUSS - Ferrara 1391 (Italy)

Department of Earth & Universe Sciences

An idea supported by Pierre in 2012...

which did not make it ...

... but was the seed of other actions



Local Doctoral Schools

Merging of 2 doctoral schools into STEP'UP

Sciences de la Terre et de l'Environnement
et Physique de l'Univers de Paris



~ 300 scientists (170 HDR)
~ 200 PhD students (50-60 / an)

Towards a future Graduate School ?

- Earth-Planets-Universe relying on the Labex UnivEarthS
- Would integrate Master formation in addition

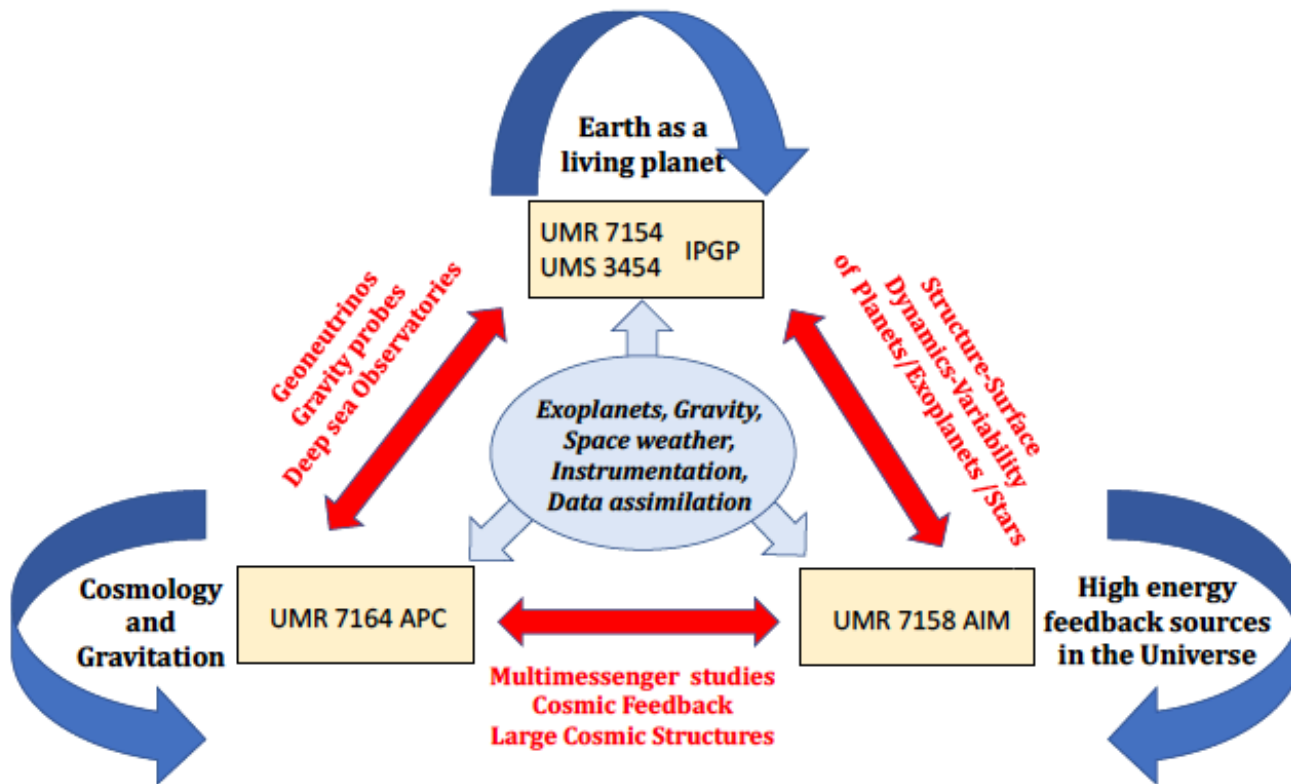


Fig. 2.1: overview of the scientific scope for the future of UnivEarthS

- Likely resubmission next year

A further glance at the Future

- UnivEarthS had very positive evaluation in 2015
→ « The UnivEarthS consortium is a bold and unique marriage of scientific communities that have traditionally not spoken with each other ... »
- Strong links established between geophysics and astrophysics open towards Society in many ways.
- Uniqueness partnership in France and abroad

We want to enlarge and reinforce the synergy !

Meeting Geo.8 + APPEC

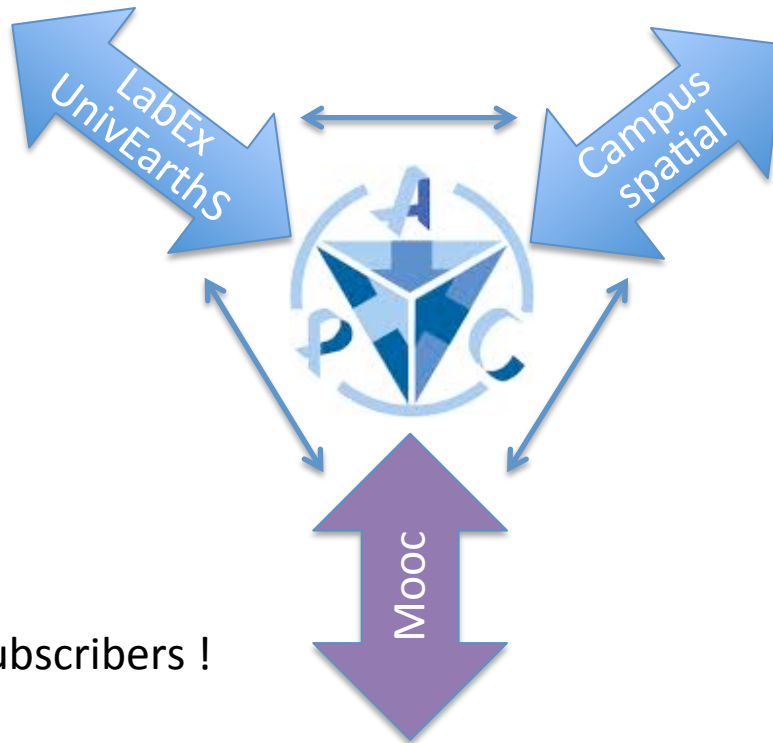
UnivEarthS+

Geo.8 : European Network for Earth Sciences

APPEC : Astroparticle Physics European Consortium

Earth science

Space Science



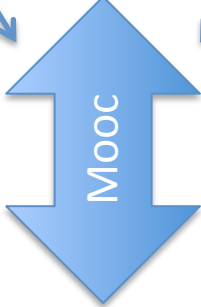
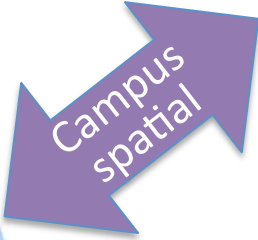
“Gravity!”
More than a 100 000 subscribers !



Society

Earth science

Space Science



Society

Space Sciences: “Campus Spatial”

“Action pluridisciplinaire” since 2009

- Univ. Paris Diderot and IPGP
- 9 research laboratories: Earth, Planets, Universe
- Different UPD departments: Physics, Chemistry, Maths, STEP, GHSS

Aim: develop the “space” role of Université Paris Diderot and multidisciplinary around “space”



- Paris Rive Gauche Campus established as one of French sites hosting “space” laboratories
- 20 scientific or technological projects funded up to now
- Education: Master with Vietnam, Masters related to space science, IgoSat student satellite

Key role of **APC and its instrumental platforms** (clean room, low-noise room, 3D measurement machines, experimental hall) in preparing for space missions for 2019+ (Taranis, InSight, Lisa...)

Space Sciences: IGOsSat

IGOSat Ionospheric and Gamma-ray Observation Satellite

Educational project of the LabEx UnivEarthS

Lab partners : IPGP + APC

Main objective:

Training students to space engineering

Scientific Payload:

GPS receiver for studying the Electronic Content of the Ionosphere

Scintillator for characterizing Electrons and Gamma-rays content

Mission profile :

3U CubeSat (10x10x34 cm, <4kg, ~4W)

Quasi polar orbit at 650 km altitude

Partnerships:

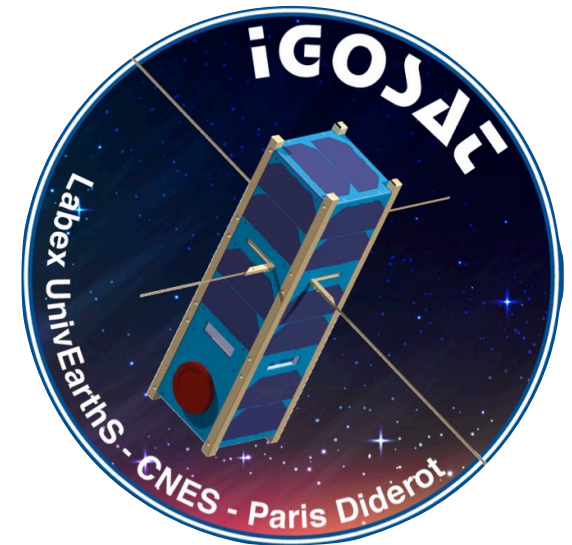
Funding : LabEx UnivEarthS + CNES + Space Campus

Educational : Universities of Hanoï and Ho-Chi-Minh City

Status:

Phase C completed in Sept. 2017

Ready for a launch planned in 2019 (1 year nominal mission duration)



www.igosat.fr

IGOsat: nice outreach oportunities



The 2nd edition of the student Cubesat workshop, held by the IGOsat team

- More than 100 participants from France and other countries. This is the yearly rdv of the student community working on nanosatellites
- So far, **more than 230 students** have been working on IGOsat. Each year, about 15 interns (from bachelor to master level) are joining APC and IPGP.

FACe : François Arago Center – Data Science

APC data analysis center for space missions, since 2010.

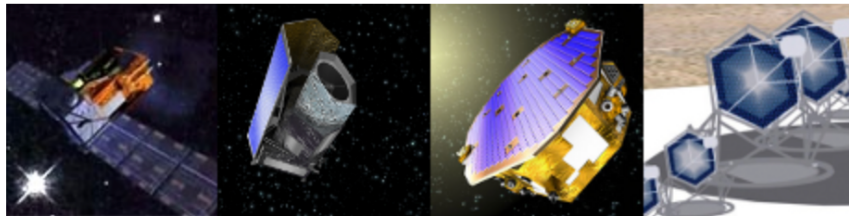
Location: Biopark but moving to Condorcet and IPGP in 2018.

Strong link with the **CC-IN2P3**.

Resources:

Offices, meeting rooms, video-conference rooms, computing room, CDF.

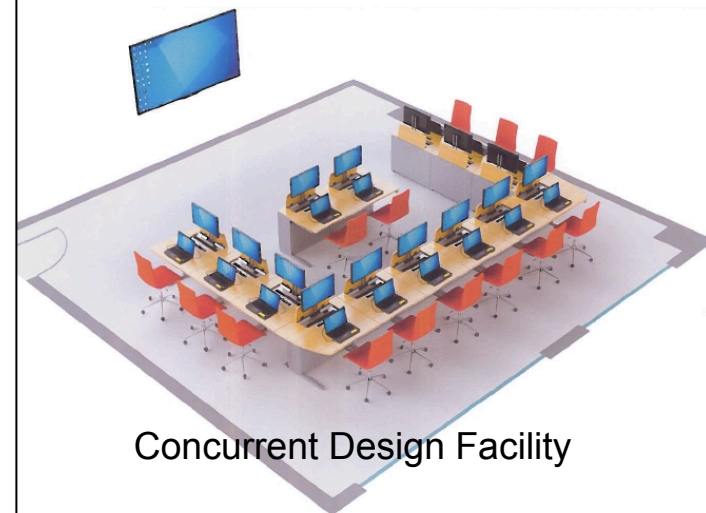
Projects: CTA, EUCLID, LISA, SVOM...



<http://www.apc.univ-paris7.fr/FACe/>

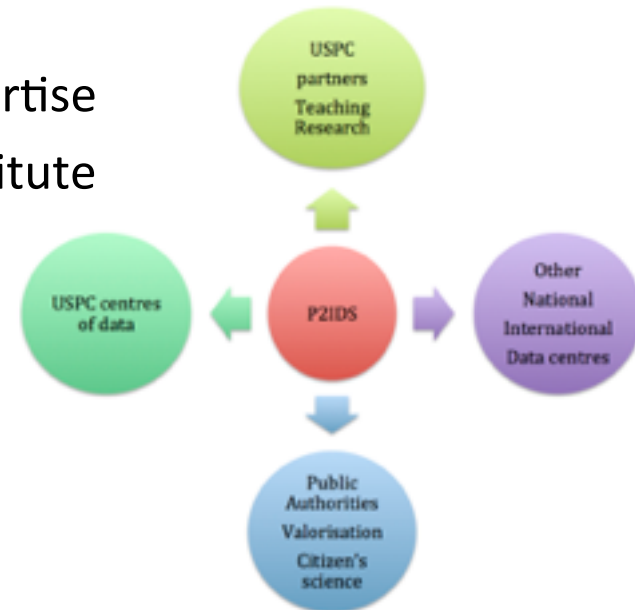
Welcome to the FACe website!

You find on these pages an [introduction about the purpose of the FACe](#), information about the [projects we provide services for](#). There is a description [how to reach the François Arago Centre](#), a list of the [staff members](#) of the centre, news from the centre as well as [news about the status of building the centre](#), and a description of the [partners](#) who enable us to provide services to the community.



DANTE : MULTI DATA ANALYSIS AND COMPUTING ENVIRONMENT FOR SCIENCE

- Context:
 - Moving out of the FACe
 - Merge IPGP computing center S-CAPAD and FACe
 - USPC platforms: Campus Spatial
 - Funds from Region IdF : 2 years
- Goals:
 - A scientific instrument
 - A center of innovative and multidisciplinary expertise
 - A key centre of P2IDS (Paris Interdisciplinary Institute for Data Sciences)
- Scientific challenges:
 - Numerical laboratory: explore Big Data
 - Center of expertise: machine shop/MarketPlace



Other babies from Pierre

Last year of Master 1997-1998



Master 1997-1998 – Ile d'Oleron



Pierre's last email to all APC members

- About a summer school...(école d'été d'Alpbach, CNES)

Si je peux ajouter un commentaire, j'ai participé à une de ces écoles en tant qu'enseignant. Je peux témoigner que c'est un cadre exceptionnel pour comprendre ce qu'est une mission spatiale auprès des meilleurs spécialistes de l'ESA et du domaine. Il y règne une ambiance de premier ordre, en particulier grâce aux travaux en équipe, et vous avez toutes les chances de faire connaissance avec ceux de votre génération qui animeront les missions de demain.

En plus, Alpbach est un superbe village du Tyrol et l'hôtel est à 50 m de la tombe de Schrödinger: vous aurez tout le loisir de vous demander s'il est vivant ou s'il est mort.

Pierre

If I can add a comment, I attended one of these schools as a teacher. I can testify that it is an exceptional place to understand what a space mission is with the best specialists of ESA. [...] and you have every chance to get to know those of your generation who will animate the missions of tomorrow.

In addition, Alpbach is a beautiful village in Tyrol and the hotel is 50 m from the tomb of Schrödinger: you will have the opportunity to ask yourself if he is alive or if he is dead.

Pierre