

Astroparticle and Cosmology (APC)

CNRS & Université de Paris
CEA, Observatoire de Paris, CNES



Introduction for the Scientific Committee – March 19-20, 2020
Held in extraordinary circumstances

Antoine Kouchner





Institutional Changes

Renewal for 5 years of the Convention d'Unité Mixte de Recherche

- Primary Supervision Bodies : CNRS and Université de Paris

Primary Institute of CNRS : IN2P3

Secondary Institutes of CNRS : INSU, INP

- Partnership: CEA, Observatoire de Paris, CNES

→ *Gradual Decrease of endowment*

UMR n° 7164

Intitulé : Astroparticule et Cosmologie (APC)

Directeur : M. Antoine KOUCHNER, Maître de conférences

Etablissement cotutelle principale avec le CNRS : UNIVERSITE PARIS DIDEROT

Tutelles secondaires : COMMISSARIAT A L'ENERGIE ATOMIQUE ET AUX ENERGIES ALTERNATIVES,
CENTRE NATIONAL D'ETUDES SPATIALES, OBSERVATOIRE DE PARIS

Instituts secondaires : Institut de physique (INP), Institut national de sciences de l'univers (INSU)

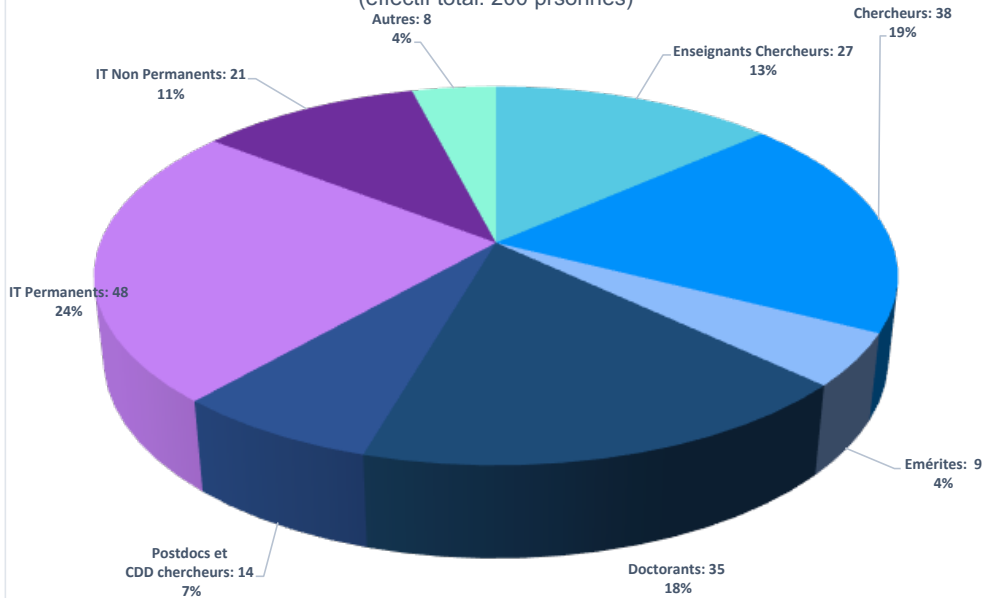
Sections : 1, 2, 4, 17

Durée : 5 ans

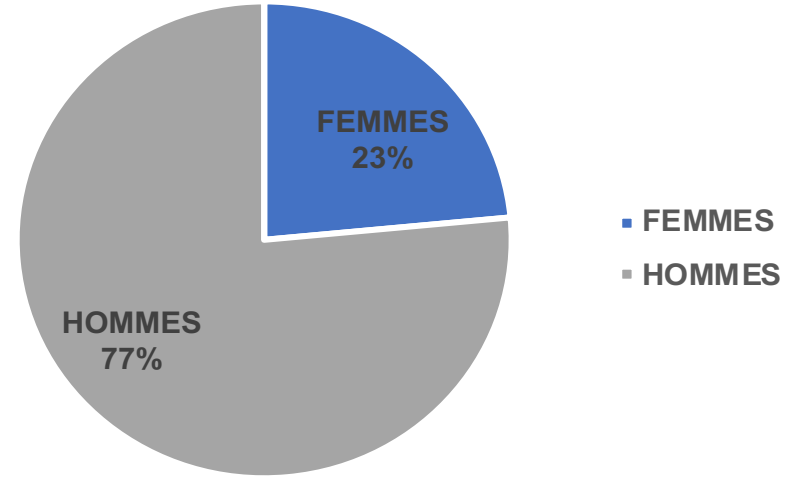


A few Numbers

Composition du laboratoire
(effectif total: 200 prsonnes)



Parité hommes/femmes à l'APC





A few Numbers

Ratio of Engineers-technicians over researchers

This low ratio already pointed out in previous meeting of the CS is not so common in IN2P3

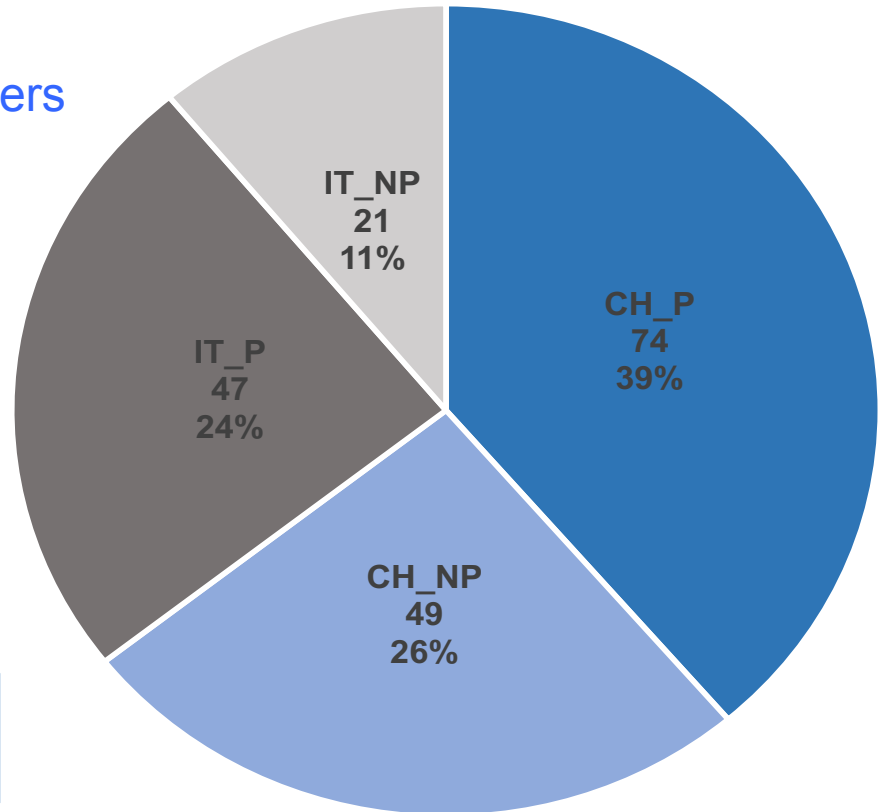
Consequences:

- R&D
- specific activities
- No mass realizations

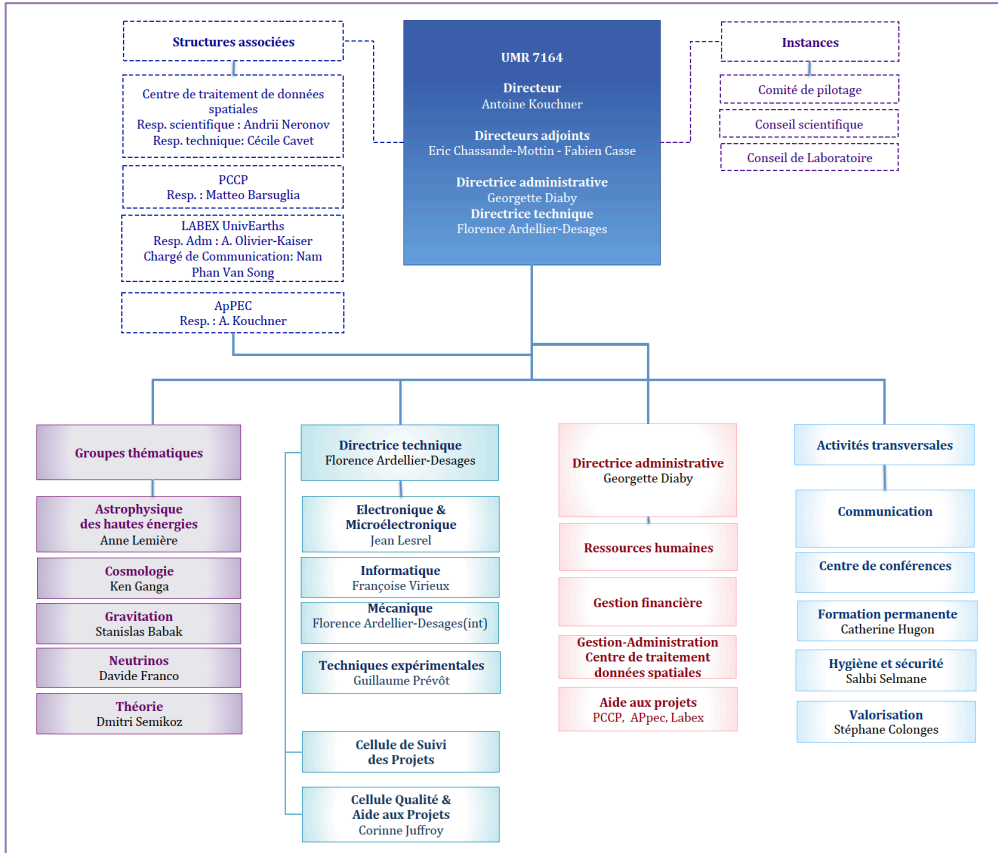
Recruit instrumentation physicists

Recommendation HCERES

“Increase the number of scientist-instrumentalists to ensure a tight connection between the science and hardware“



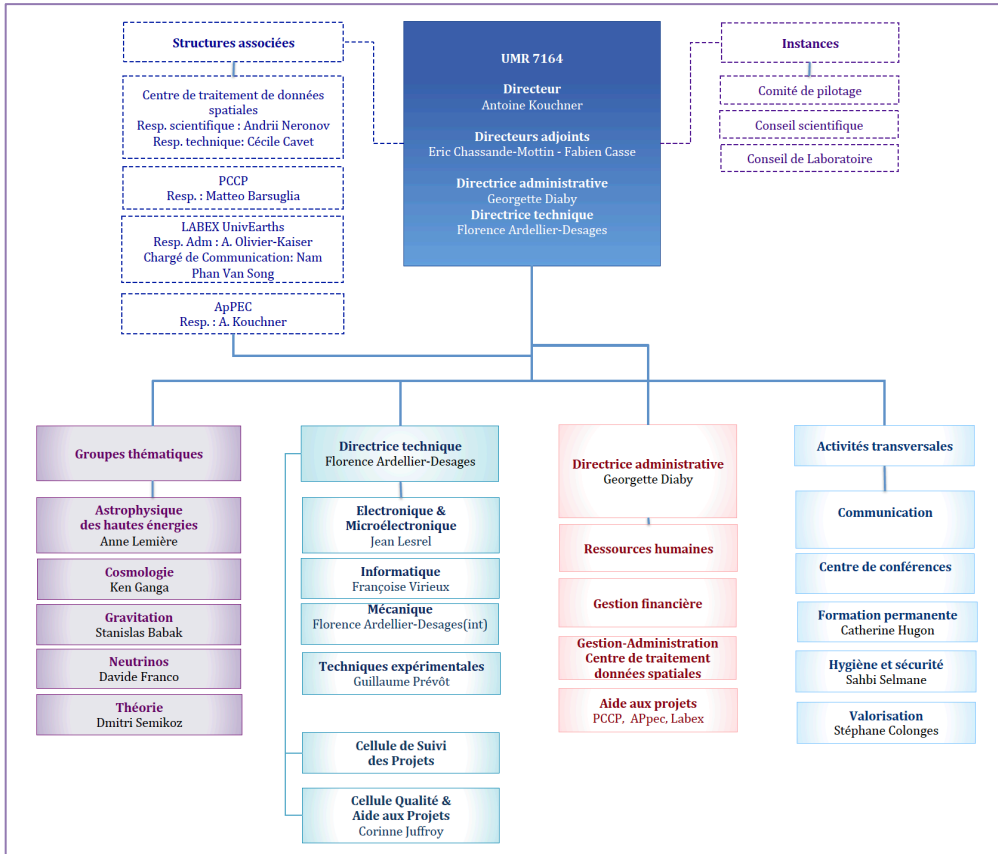
Organization of the laboratory



New direction team progressively put in place to ensure some continuity

Director	Deputy Faculty	Deputy Research	Technical	Admin
Katsanevas	Kouchner	Loucatos	Zerguerras	Foissac
Loucatos (01/01/18) interim		Kouchner	Zerguerras	Foissac
Kouchner (01/07/18)	Casse	Loucatos	Zerguerras	Aubry
Kouchner	Casse	Chassande-Mottin	Ardellier	Diaby

Organization of the laboratory

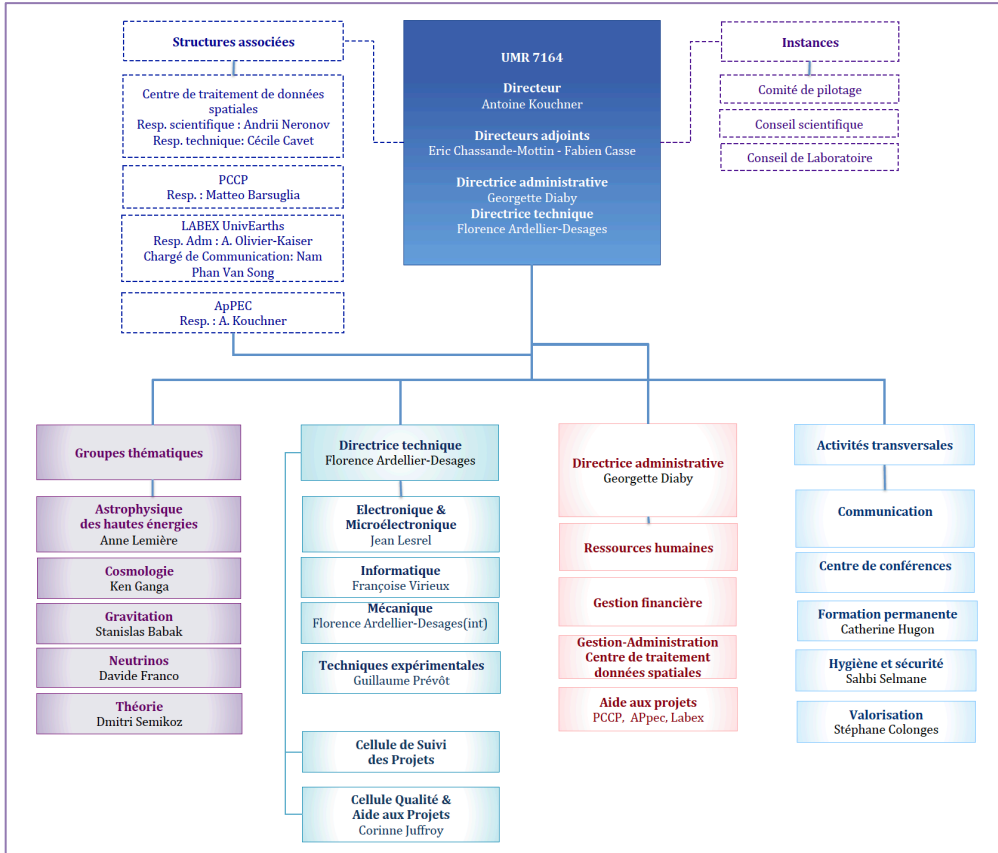


“Comité de vie”

12 page document
Distributed & presented in Gen. Assembly

- 1 Foster conviviality
- 2 Improve exchanges & internal communication
- 3 Building maintenance
- 4 Scientific / technical management discussed

Organization of the laboratory



Renewed “Conseil de Laboratoire”
(Elections: December 2018)

5 Engineers, technicians & administrative
5 Researchers
1 Postdoc
1 PhD Student

5 appointed members

4 meetings since September 2018

Carbon Footprint as a initiative of the CDL

Quantitative assessment of the lab's carbon footprint

Goal: produce this assessment once a year

Kick-off with a team of 5 students from Master "Energie Ecologie Société"

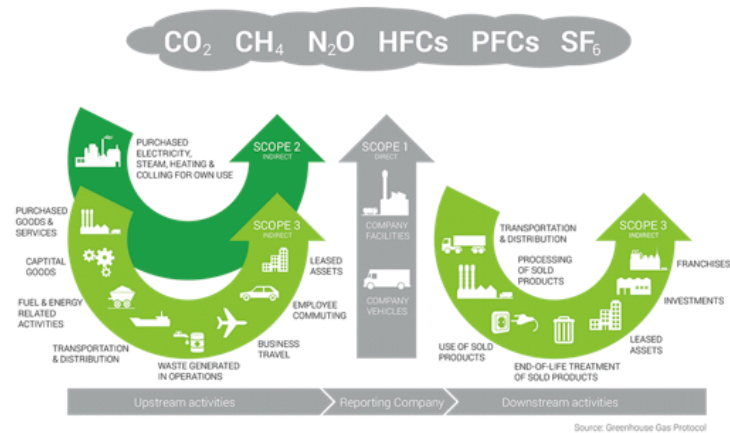
B. Friso Bellemo, S. Couhault, C. Jacq, A. Hamitou, M. Toledo

& advisor A. Passalacqua and local contacts (M Lejeune, M Souchal)

Collection of data about working environment and habits (e.g., building, experiments, travel, home/work commute, computing usage)

Analysis and reporting following a standard methodology and protocol

Will be converted into scripts interfaced with the lab's databases to automatize the process



Organization of the laboratory



Vast reorganization of the office spaces after the move of FAcE

Relocation of the FAcE people end of August 2018

24 people tightened within Condorcet Building + Clusters (LPNHE)

Loss of more than 200 m²

After 2 years, we got 100 m² back...

New comers (permanent)

Andrii Neronov (Pr. 2018 – Theory/HEA)

Alexis Coleiro (Assistant Professor 2018 - HEA)

Julien Aublin (Assistant Professor 2019 – HEA)

Vincent Vennin (CNRS 2017 - Theory)

Sabrina Sacerdoti (CNRS 2018 - Neutrinos)

Gabriel Chardin (CNRS)

+ New administrative staff

+ New technical staff

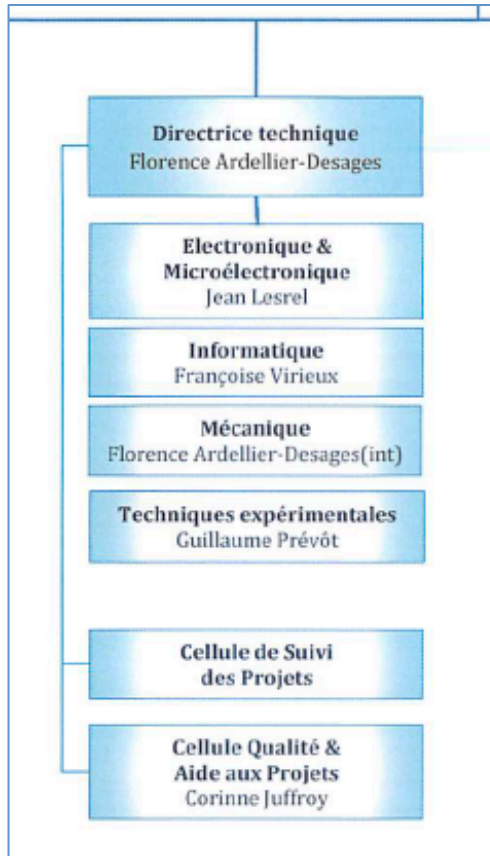
2020 expectations

Assistant-Professor on CTA

Assistant-Professor in Instrumentation

Micro-electronics Engineer.

Organisation of the laboratory



Technical Services

Cf. talk by Florence Ardellier-Desages

Reorganization of “Cellule de Suivi de Projets”

Electronics and micro-electronics merged
(J. Lesrel recently joined the Lab)

Mechanics
(A. Givaudan mid-2020)

Computing
(V. Virieux, recently appointed)

François Arago Center (FACe)

Part of Computing Service

Tech. resp: C. Cavet
Scientific resp: A. Neronov

Data processing center for multi-messenger projects

- High Energy Astrophysics (SVOM, INTEGRAL, CTA)
- Gravitational waves (LISA)
- Cosmology (LSST, Euclid)

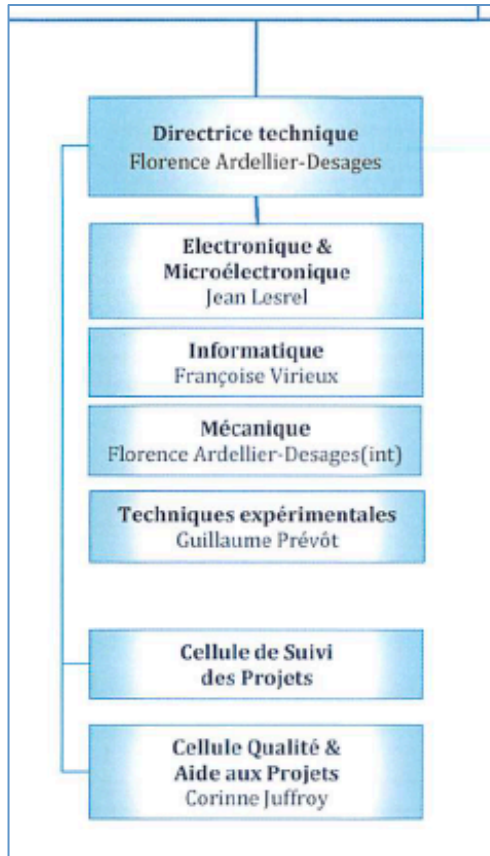
Support to the use of state-of-the-art data processing technics

- Deep learning and neural networks
- Virtualization, cloud computing and containers (project ComputeObs)

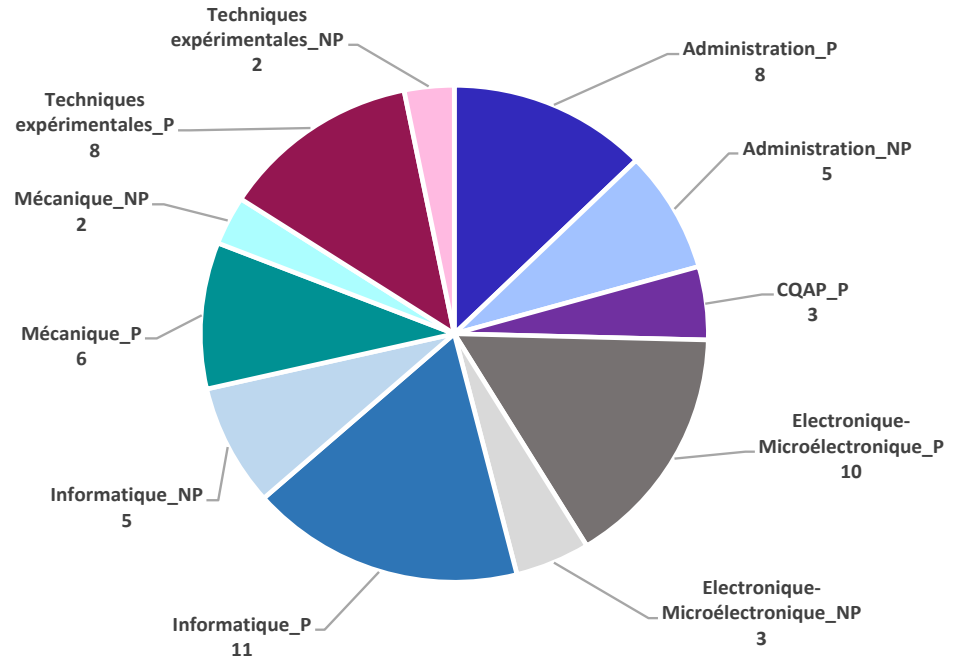
High performance computing (HPC)

- Co-management of the DANTE HPC machine with IPGP (~3,000 cores - 1.15 M€ Région IdF)
- Shared expertise with IPGP in the context of the LabeX UnivEarths and spatial campus of the University

Organisation of the laboratory



Composition des services
(P:Permanents / NP:: Non Permanents)



Organization of the laboratory



Administration

Largely renewed

Human ressources

2 (new) permanent agents

Finances

5 (3new) permanent agents + 1 non-permanent

Communication

1 permanent + 1 non-permanent

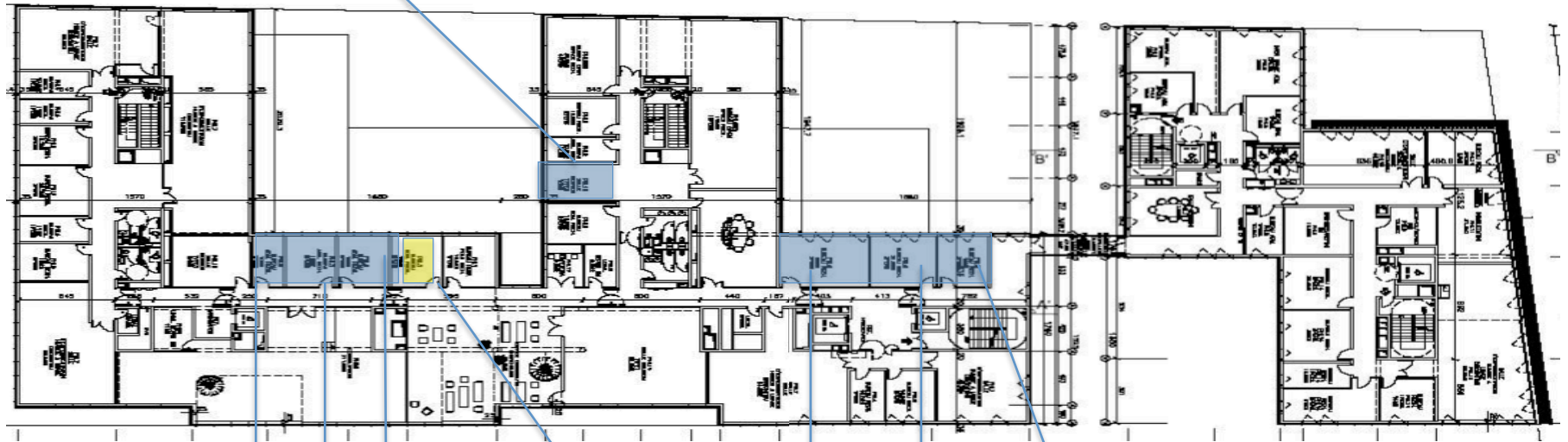
On-going recruitment of a steward (non permanent)

Organization of the laboratory

Administration

Gathering on the team on same floor

Resp. Admin.



HR

F

HR

Steward?

F

Com

F

F: finance
HR: Hum. Res.

Science: astroparticle physics and cosmology

Cosmology

- What is the **origin and fate of the Universe**?
- Is the theory of cosmic **inflation** correct?
- What is **dark energy**?
- What is the identity of **dark matter**? ...

Gravitation

- Is gravitation described by **general relativity** or an alternative theory?
- Is general relativity valid in the **strong field regime**?
- Are there extra gravitational wave polarizations?
- How many **black holes** are there? What are their mass and spin distribution? ...

High-energy astrophysics

- What are the physical processes at work close to **neutron stars and black holes**?
- How do **relativistic jets and winds** really work?
- Where do **ultrahigh energy cosmic rays** come from? How are they accelerated? ...

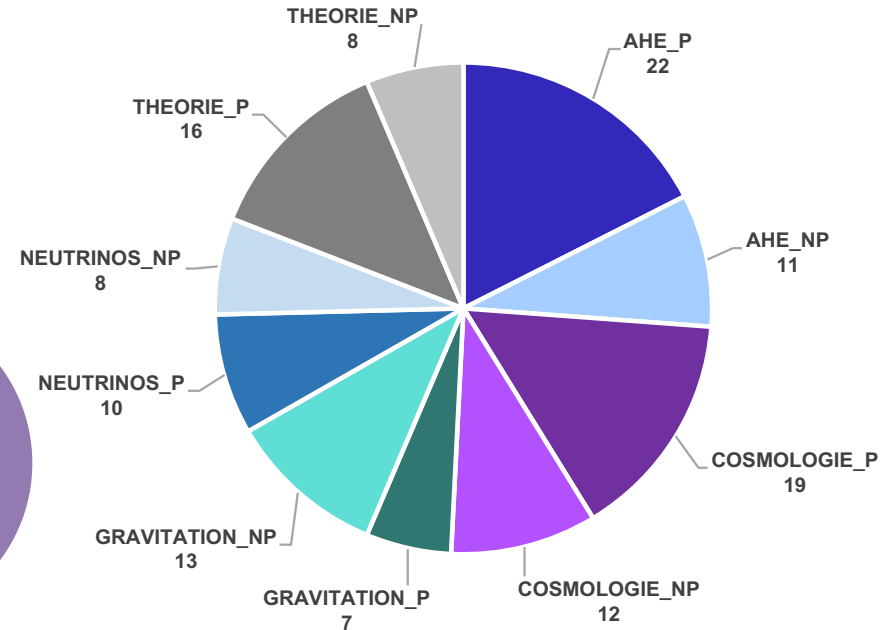
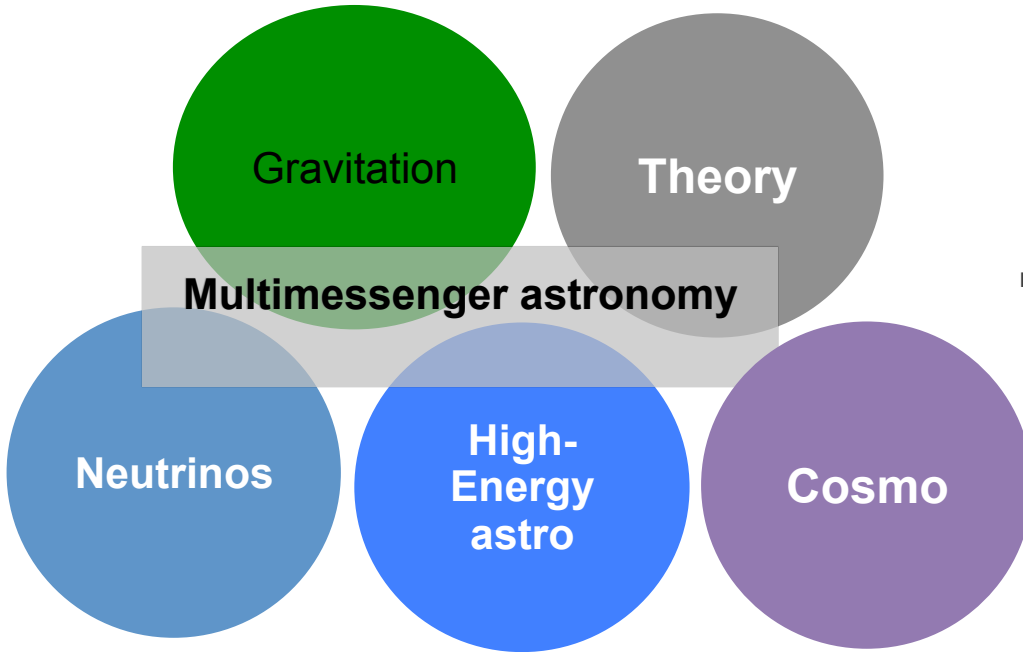
Neutrino physics

- Do neutrinos have **mass**?
- Do neutrinos follow **Dirac or Majorana** statistics?
- Is the **mass ordering** normal or inverted?
- Direct search for Dark Matter ...

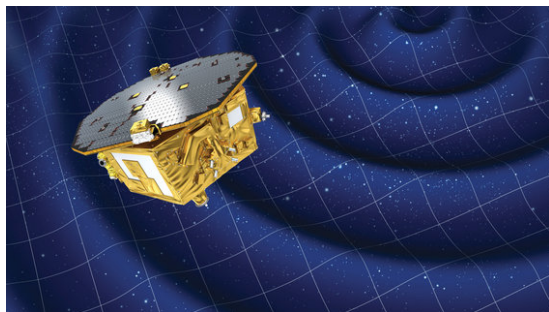
And theory in all these fields...

Topical groups and related observables

(P:Permanent / NP: Non Permanent)



Gravitation



LISA

Currently in phase A > B1
Mission adoption 2023



Advanced Virgo

Currently observing: science run O3

What's next?

Advanced Virgo+ & Einstein Telescope

M. Barsuglia is the Virgo national coordinator

Gravitation – Recent Highlights

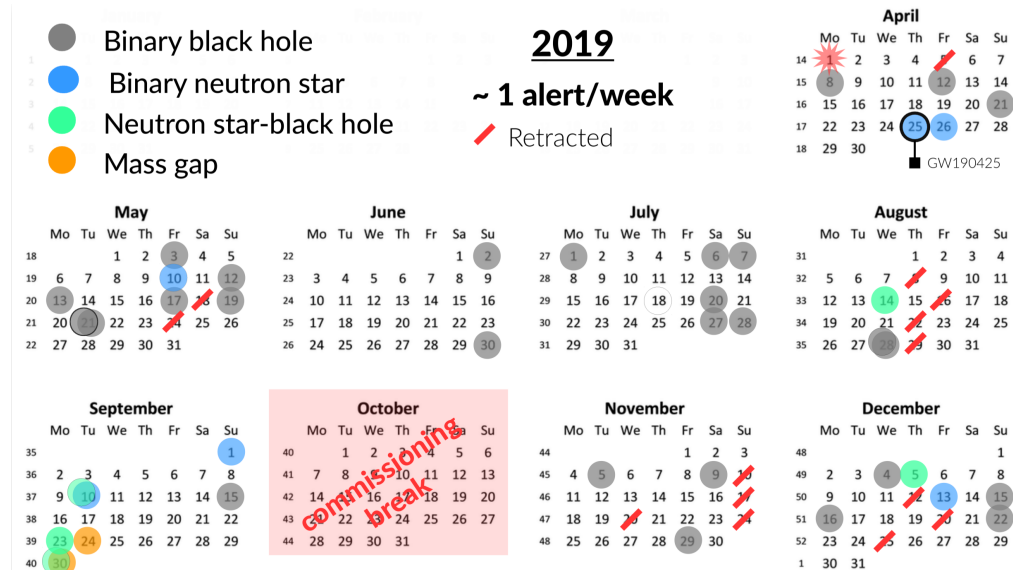
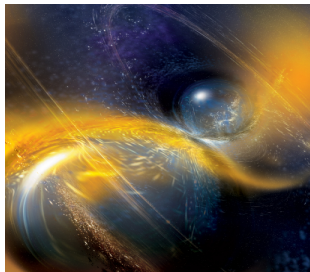
Science run O3 started in April 2019
1 GW alert per week

st

1 results published recently

GW190425 – binary neutron star candidate
Unusual masses: new/unobserved population?

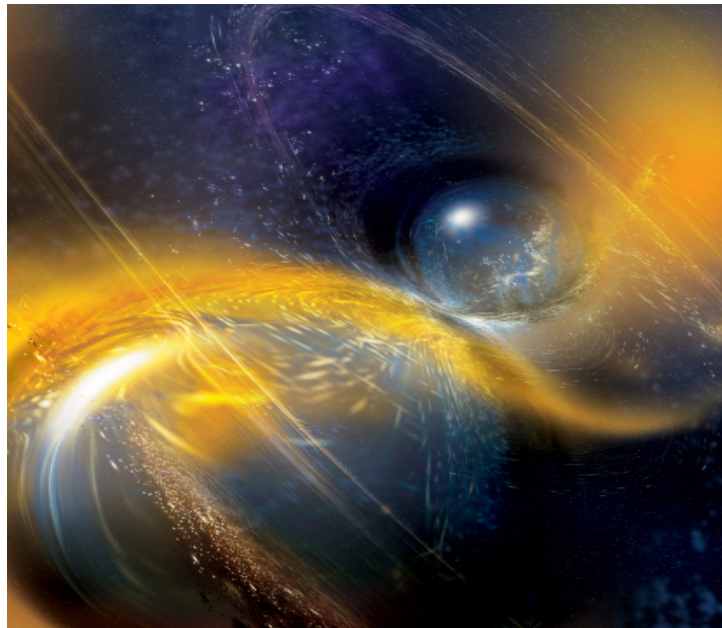
More to come soon...



Gravitation – Recent Highlight

GW190425

- No neutrino or electromagnetic counterpart
- Total mass $\sim 3.4 M_{\odot}$ to be compared to $2.7 \pm 0.2 M_{\odot}$ for all known binary neutron-stars
- New population of yet unobserved binaries?
- VIRGO National Coordinator
→ M. Barsuglia



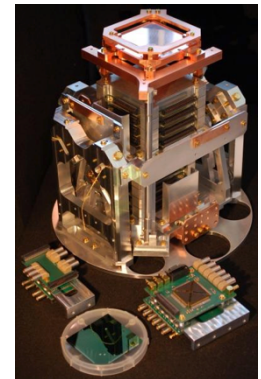
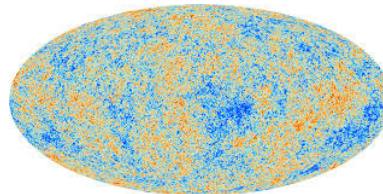
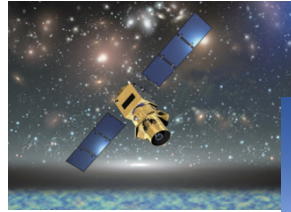
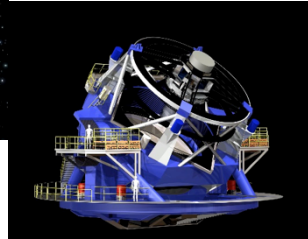
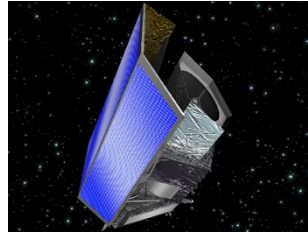
Cosmology

Wide-field galaxy surveys

- Euclid
- LSST

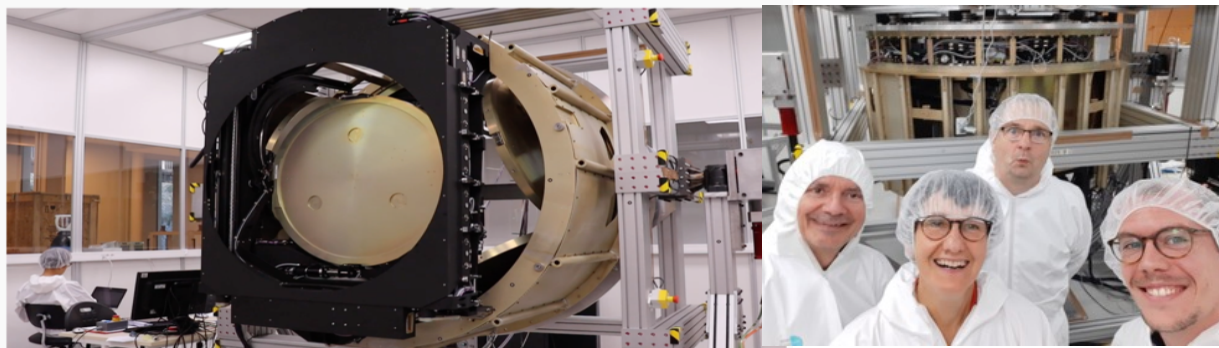
Cosmic micro-wave background

- Litebird ?
- Simons array
- Qubic



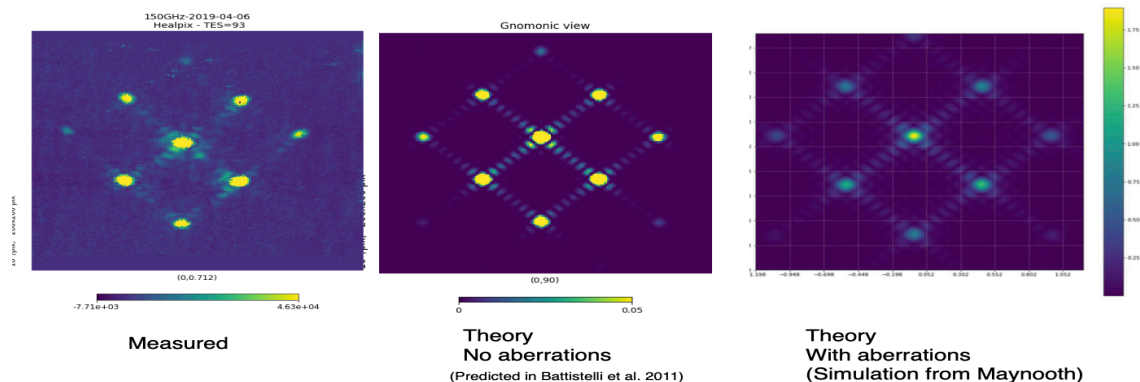
Cosmology – Recent Highlights

Filter changer sent to SLAC for integration with LSST camera



QUBIC : 1st confirmation of bolometric interferometry !

150 GHz (TES 93)



High-energy astrophysics, from keV to EeV

Gamma- and X-rays

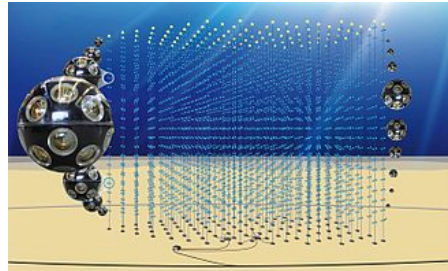
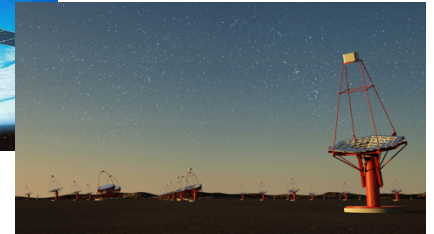
- SVOM
- Athena
- CTA

High-energy neutrinos

- KM3NeT/ARCA

Cosmic rays

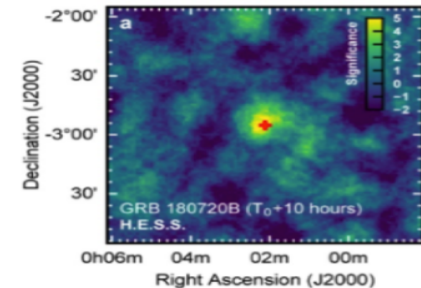
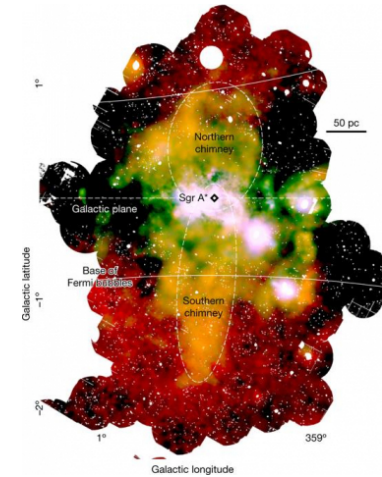
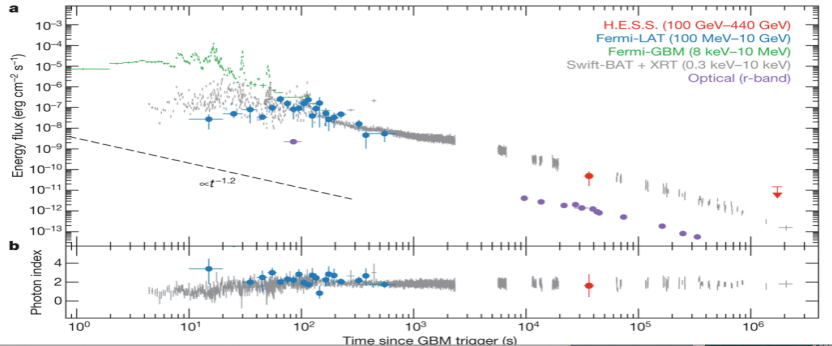
- JEM-EUSO



HE astrophysics – Recent Highlights

X-ray chimney extending hundreds of parsecs above and below the Galactic Centre
Nature, 2019

Gamma-ray bursts at the TeV
Nature, 2019



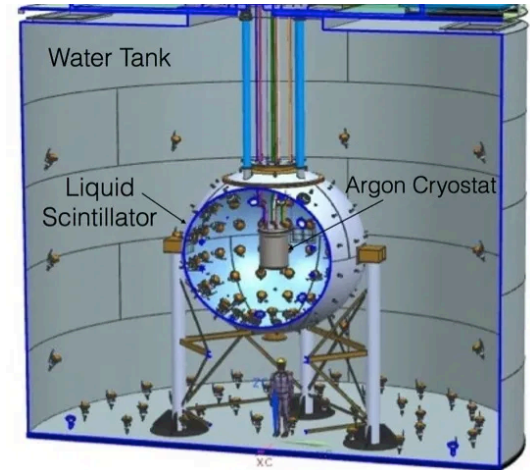
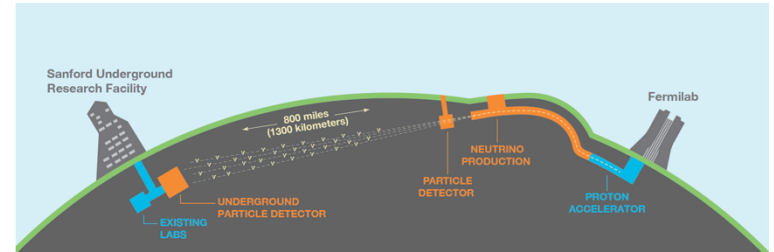
Neutrinos and dark matter

Neutrino experiments

- DUNE
- KM3NeT/ORCA

Dark matter experiments

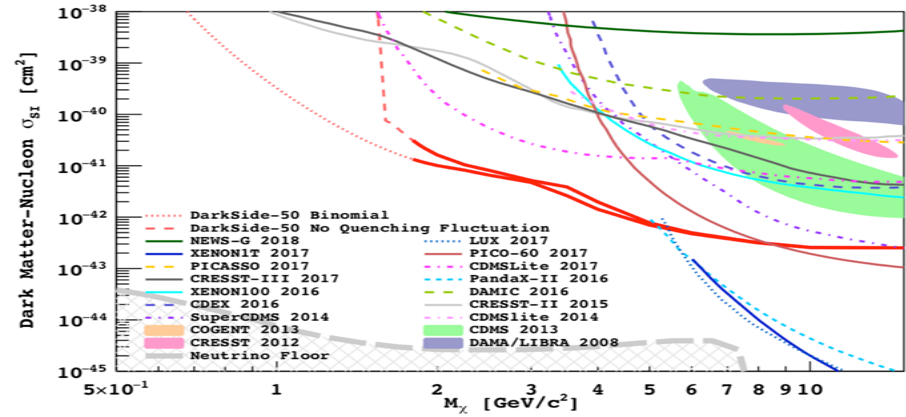
- Darkside



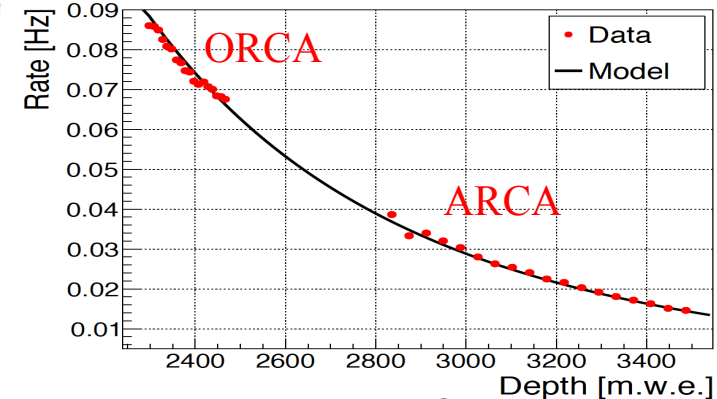
Neutrino – Recent Highlights

Phys. Rev. Lett. 121 (2018) 081307

- DarkSide
- Best limits for the low-mass range



- KM3NeT
- 1 strings deployed
- (6 active strings ORCA)



Journ. Eur. J. Phys C

Theory

Cosmology, gravity and string theory

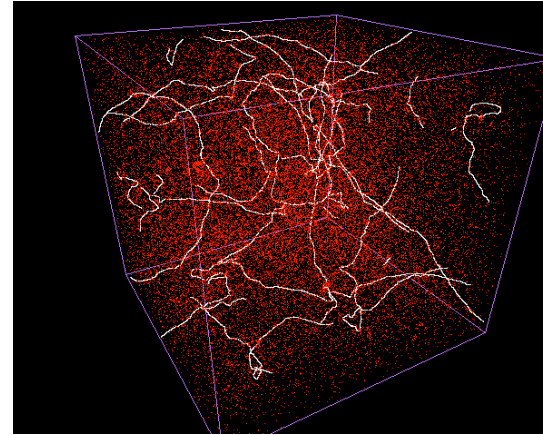
- Inflation, dark energy and cosmological perturbations
- Topological defects
- General relativity, modified gravity theories
- Gravitational waves
- Duality and holography

Quantum Field Theory

- Non-abelian gauge theories and deconfinement
- QFT in curved geometries

Astroparticle and neutrino physics

- Neutrino physics and astrophysics
- MHD and astroparticle propagation simulations
- Cosmic rays physics



Stronger effective
links between Theory and
Other groups

Theory – Recent Highlights

Details in D. Semikoz's talk

- Development of a framework for the self-tuning of the cosmological constant, based on the holographic duality
- Quantum field theory in de Sitter space-time, and cosmological implications.
- Mechanism of production of primordial black holes from reheating instability in early universe. Consequences for stochastic GW background.
- Cosmological constraints on Degenerate Higher-Order Scalar-Tensor theories
- Stochastic GW background from cosmic strings. Stochastic GW background in first order phase transition, compared with the estimated sensitivity curve of the interferometer LISA
- First identification of fast modes (very short-scale modes) in multi-dimensional simulations of supernovae.
- Minimal model which explain ultra-high energy cosmic rays, astrophysical neutrinos and extragalactic diffuse gamma-ray background
- New galactic component in diffuse gamma-rays at TeV energies was found, it is consistent with IceCube excess at multi-TeV energies and with excess of electron plus positron spectrum in HESS. Models of nearby astrophysical source and heavy dark matter was constructed.

Technical platforms and our know-how

Detectors at millimetric wavelengths

- Cryogenic detection chains and detectors (TES & KIDS)

Laser interferometry and high-precision metrology

- Low-loss optics

Photodetection

- Prototyping and integration of photodetection elements (PM, MaPMT, SiPM)

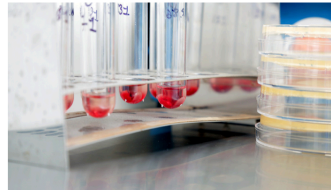
Space-qualified experiment design

- Micro-electronics and electronic chains, mechanical engineering

Université de Paris: a new environment

University Descartes and Diderot and IPGP merged on Jan 1st 2020

64,100	students
21	doctoral schools
7,250	researchers
4,500	admin & techn staff
138	research labs



Faculté de santé



Faculté des sciences



Faculté des sociétés et
humanités

Université de Paris: a new environment

Faculty of Sciences includes

chemistry, computer science, engineering, mathematics, physics, biomedical and life sciences

12 100 students, 3 450 staff, 50 laboratories, 19 science and technology platforms

University Institute of Technology and an Engineering school

Dean: Pr. Alain Zider – Genetics

Vice Dean for Research: Pr. Thomas Patzak – Physics

Vice Dean for Education: Pr. Marie-Agnès Sari – Bio-Chemistry



Associated Structures

LabEx
UnivEarthS



Renewed for 5 years
New Project Manager

PCCP
Foundation Universe



New Director appointed
New Project Manager
New board members for
the associated foundation
"Physique de l'Univers"

Boost in activities
Dedicated talk by M. Barsuglia

APPEC



APC ambitions to be a
"central host"
Needs to be reinforced

Labex UnivEarthS

A unique partnership between **Earth Sciences and Physics of the Universe** financed by the French government

Three founding members: APC, IPGP and AIM, and the aerospace center ONERA

Enables the development of **innovative interdisciplinary projects**

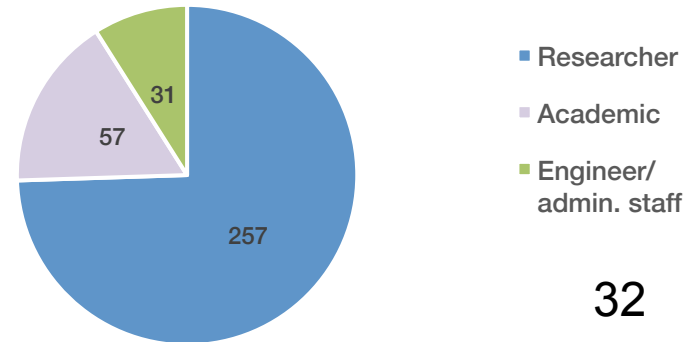
Objectives: study the evolution processes which modelled the history of the Universe and of the Earth and which govern their present dynamics

Directors:

M. Chaussidon

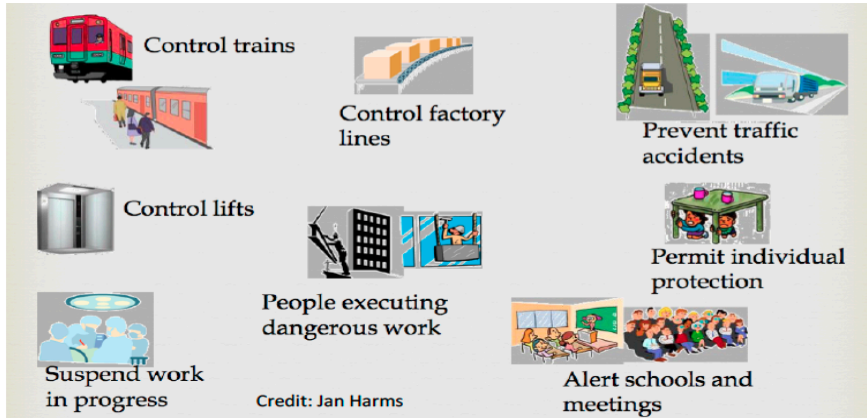
A. Kouchner

President of scientific
council: G. Smoot

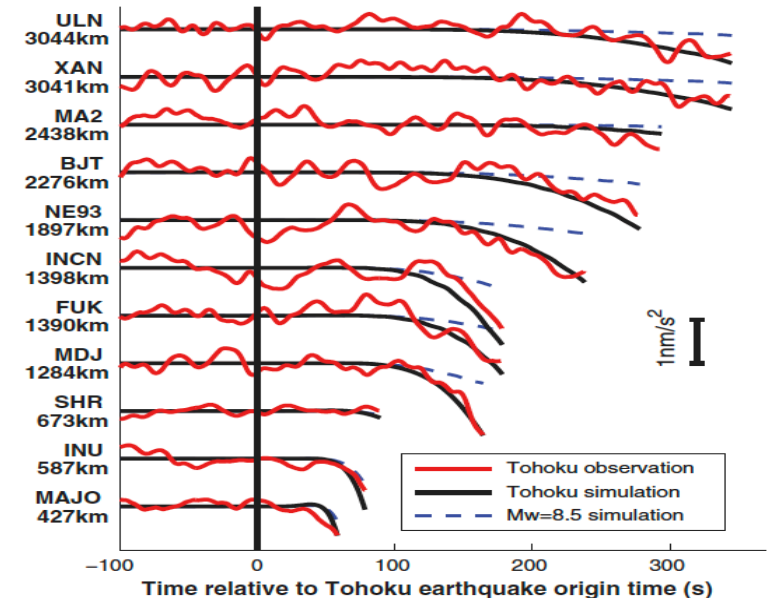


Labex UnivEarthS – Highlight

Can we detect the **gravity perturbation** due to an earthquake before the arrival of the seismic waves?
Can we **improve earthquake early-warning** systems?



Nature Com. (20216), 7, 13349
Science (2017) 358, Issue 6367



→ ERC Synergy Grant deposited

Labex UnivEarthS – Highlight

Educational project of the LabEx UnivEarthS

Since 2012, IGOSat has trained more than 250 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

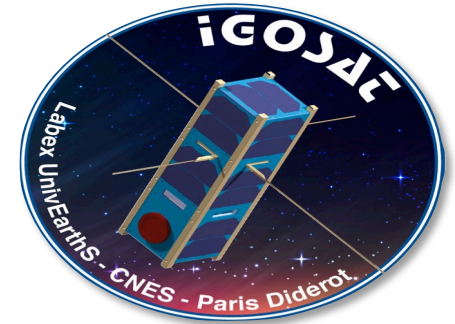
3U CubeSat (10 x 10 x 34 cm, <4kg, ~4W)

Quasi polar orbit at 650 km altitude

Partnerships

Funding: LabEx UnivEarthS + CNES + Space Campus

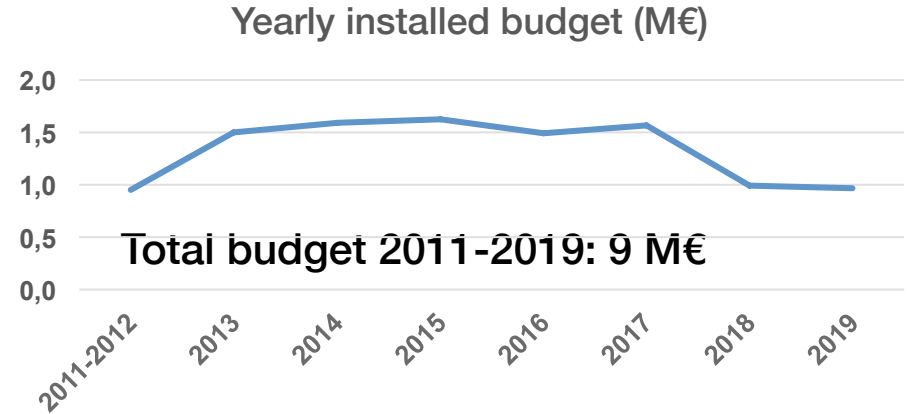
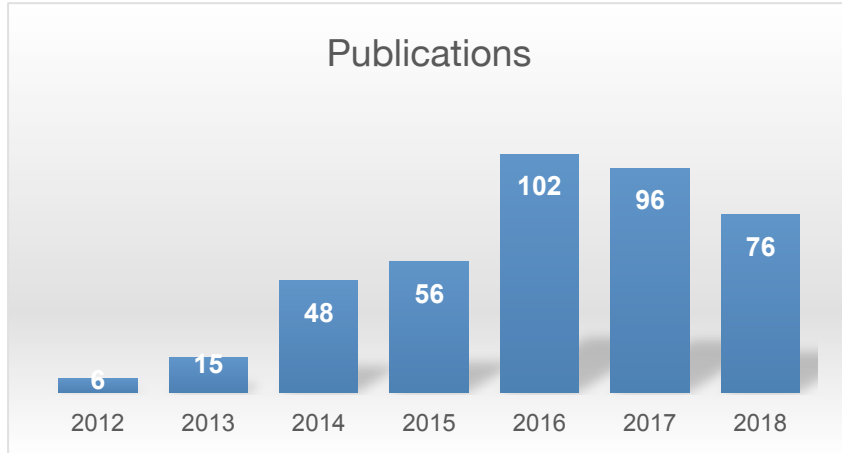
Educational: Universities of Hanoi and Ho-Chi-Minh City



Ionospheric and Gamma-ray
Observation Satellite

IGOSat scheduled to be 'ready for launch' during the 2nd semester of 2021

Labex UnivEarthS



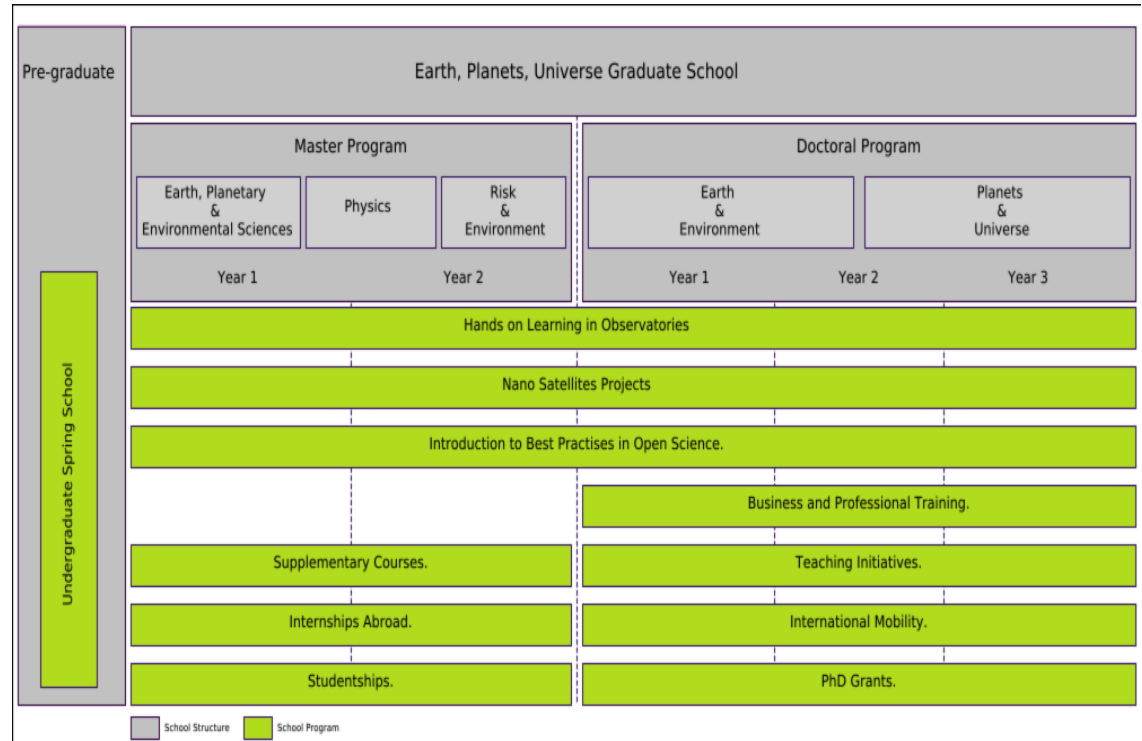
February 2019: an extension granted for 2020-2024 with a budget of 4,38 M€

September 2019: 26 projects have been proposed including 18 new ones

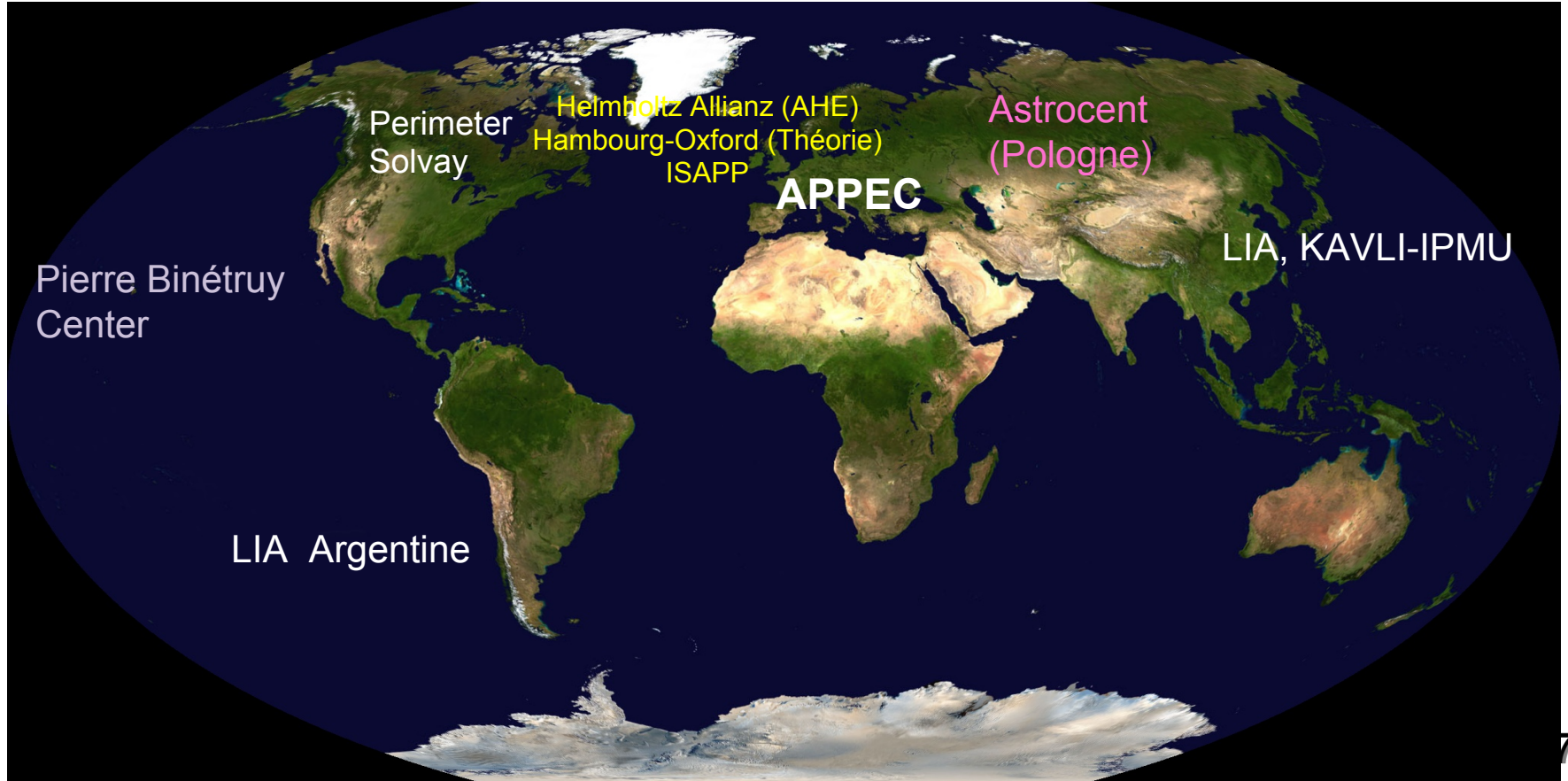
November 2019: 19 projects selected

Labex UnivEarthS – Related initiatives

- Dante computing facilities
- Pôle spatial within U. de Paris
- Doctoral School STEP'UP
- **Graduate School ?**
Project to be submitted by the Université de Paris



International Positioning



International Positioning

- CNRS-UCB International Research Laboratory.
- Initial mandate for 5 years.
- Official start date of Jan 01, 2020.



French Director : R. Stompor (APC)
US Director : S. Perlmutter

Goals:

- Conduct research in the area of **astroparticle and cosmological physics**
- Support projects involving groups in France and Berkeley.

Science:

- Understand the nature of major components of the Universe: dark energy, dark matter, light particles.
- Understand the physical mechanism responsible for the generation of initial perturbations in the Universe.
- Explore the potential of the gravitational wave astronomy in constraining fundamental physics.
- Promote multi-disciplinary aspects, e.g., data science, in addressing the science topics listed above.

International Positioning – AstroCent

Particle Astrophysics Center for Science and Technology

<https://astrocent.camk.edu.pl/>

Warsaw, Poland

❖ International Research Agenda (started 1 July '18)

❖ Funding: 38 MPLN (~9 MEuro) for 5 years

source: FNP

Main objectives:

- Studies of the invisible Universe (gravitational waves, dark matter,...)
- Ultra-sensitive instruments to detect extremely faint signals
 - Seismic sensors, modules of silicon photomultipliers (SiPMs), **Big Science**
- Big data collection and processing
- Applications to hi-tech industry and medicine (e.g., PET) **Innovative technologies**
- ...

Main partners: APC (Paris), Princeton, GSSI,
McDonald Institute, Snolab
locally NCBJ, Warsaw Univ. of Technology

❖ Job opportunities for researchers
and engineers at any level

❖ Connections with commercial sector

FNP: Foundation for Polish Science, APC: Astroparticule et Cosmologie Laboratory,
NCBJ: National Centre for Nuclear Research, CAMK PAN: Nicolaus Copernicus Astronomy
Center of Polish Academy of Sciences, WUT: Warsaw University of Technology

LESZEK ROSZKOWSKI, 11/02/2020

Director:
Leszek Roszkowski



International Positioning – AstroCent

Team I
**SiPM Systems for Astroparticle Physics
and Medical Physics**
(leader: Marcin Kuźniak)

Team II
**Seismic sensors
for gravitational waves**
(leader: Tomasz Bulik)

Team III
**Electronics and Data
Acquisition and Processing**
(leader: TBA)

Typical team structure:

- leader
- 2-3 postdocs
- 2-3 PhD students

Team IV
**Ultrapure SiPMs and
Associated Readout Electronics**
(leader: Masayuki Wada)

Team V
**Scientific Computing and
Information Technology**
(leader: Piotr Gawron)

Team VI
Particle astrophysics
(leader: Leszek Roszkowski)

Plus:

- technicians
- senior postdocs
- visitors, collaborators

- **With current grant, Astrocent is expected to employ some 30 researchers.**

International Positioning – AstroCent

APC - Astrocent Cooperation Agreement

	Work Program	State of implementation
1	Joint PhD program (co-tutor, cotutelle)	Started 1 Oct '19: one 1 PhD student (French)
2	Joint postdocs	Not yet (postdoc recruitment still in progress)
3	Visitors program	Being implemented: two small grants awarded (NAWA & Copin)
4	Astrocent-APC joint workshops	One held in Warsaw in Jan '19, next planned for Spring '20 in Paris
5	Astrocent-APC joint education and dissemination program	Not yet (end of year 2+)
6	Astrocent-APC and international collaboration	Not yet (end of year 2+) (...KM3Net...)
7	Astrocent-APC joint R&D	Started, see also 3.

International Positioning – AstroCent

APC-Astrocent Executive Committee

- members:
 - APC: A. Kouchner (director), S. Loucatos, D. Franco
 - Astrocent: L. Roszkowski (director), T. Bulik, M. Kuźniak
- to oversee/coordinate APC-Astrocent cooperation
- meetings held on: 15 July '18, 4 Sept. '18 (Paris), 28 Jan '19, 20 May '19, 2 Sept. '19, 8 Nov. '19, plus many electronic contacts

Main joint areas of research activity:

- **Dark matter:**
 - DarkSide, collaboration of M. Kuźniak and M. Wada with D. Franco
 - Joint PhD (cotutelle) student of Kuźniak and Franco (APC): Theo Hugues
 - Two small grants for scientific exchange (from NAWA and Copin)
 - One big grant (H2020 Twinning) submitted, PI: M. Kuźniak
 - D. Franco visited us on 4-7 Dec. '18 and 28-29 Jan. '19
- **Seismic sensors and gravitational waves:**
 - Advanced Virgo, Einstein Telescope (Bulik)
 - GW, seismic sensors and geophysics (Bulik & Suchenek: being explored...)
- **KM3Net – Astrocent joined in February 2020**

KIPMU-IN2P3 International Lab

- **Goal :**
 - To fund visits & exchanges between IN2P3 and KIPMU scientists working on identified projects (SO, SSP, ...)
 - Organize a workshop ~ every 2 years, on lab activities
 - Funded by IN2P3 and IPMU (up to 20k-25k / year)
- **Several ongoing collaborations between KIPMU and IN2P3 teams**
 - CMB working on identified projects (SO, SSP, ...)
 - SN Cosmology Organize a workshop ~ every 2 years, on lab activities
 - Possible extension to neutrino physics (T2K), gravitational waves ...

KIPMU-IN2P3 International Lab: CMB

a selection of our collaborators

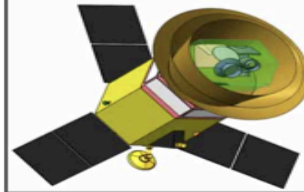
PB = POLARBEAR
SA = Simons Array
SO = Simons Observatory
LB = LiteBIRD

In France, affiliated to IN2P3 :

- Jim Bartlett (APC) [SO]
- Dominic Beck (APC) [PB,SA,SO]
- Hamza El Bouhargani (APC) [PB,SA,SO]
- Josquin Errard (APC) [PB,SA,SO,LB]
- Ken Ganga (APC) [LB]
- Sophie Henrot-Versillé (LAL) [LB]
- Maude Le Jeune (APC) [PB,SA,SO,LB]
- Baptiste Josquin (APC) [PB,SA,SO]
- Martin Bucher (APC) [LB]
- Guillaume Patanchon (APC) [LB]
- Julien Peloton (LAL) [PB,SA,SO]
- Radek Stompór (APC) [PB,SA,SO,LB]
- Matthieu Tristram (LAL) [LB]
- Clara Vergès (APC) [PB,SA,SO]

Affiliated to IPMU :

- Masaya Hasegawa (KEK) [PB,SA,SO]
- Masashi Hazumi (KEK) [PB,SA,SO,LB]
- Hirokazu Ishino (Okayama Univ.) [LB]
- Nobu Katayama (IPMU) [SO,LB]
- Akito Kusaka (Univ. of Tokyo) [PB,SA,SO]
- Tomotake Matsumura (JAXA/IPMU) [PB,SA,SO,LB]
- Haruki Nishino (KEK) [PB,SA,SO,LB]
- Yutaro Sekimoto (NAOJ) [LB]
- Osamu Tajima (KEK) [PB,SA,SO]
- Satoru Takakura (Osaka Univ.) [PB,SA,SO]
- Anne Ducout (IPMU) [PB/SA/SO/LB]
- Eiichiro Komatsu (MPA, IPMU) [LB]
- Frederick Matsumura (IPMU) [PB/SA/SO]
- David Spergel (IPMU) [SO]



LiteBIRD

- space mission for the observation of the large angular scale CMB polarization
- it has been selected by JAXA as a Strategic Large Mission for a launch in 2027
- IN2P3 and IPMU are intensively collaborating on the design, forecast and development of analysis pipelines for the mission



POLARBEAR/Simons Array

- observatory located in the Atacama desert since 2012
- first direct detection of the B-modes CMB polarization
- on-going analysis and hardware upgrades

Simons Observatory

- construction of a new generation observatory
- first light planned in 2021
- IN2P3 and IPMU are collaborating on the design development and analysis/scientific exploitation of the data sets



LIA ALFA-AC International Lab

Associated Laboratory France-Argentina on Astroparticle physics and Cosmology

Goal

Strengthen ties in projects of common interest, around three key astroparticle-physics

infrastructures:

Pierre Auger Observatory (ultra-high energy cosmic rays, taking data)

QUBIC (CMB telescope, under construction)

Underground laboratories: Modane (existing) and ANDES (project)

Institutions

CNEA & CONICET (Argentina), CNRS (France), ex U. Paris-Sud (now U. Saclay), ex UPD (now U. Paris), IPG, UGA

French laboratories involved: APC, ex-IPNO, ex-LAL, ex-CSNSM (now IJCLab), LPSC (now including LSM) Scientific Committee

Two directors: Alberto Etchegoyan (Arg.) and Piera Ghia (Fra.)

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LIA ALFA-AC International Lab

Activities

- Strategy discussed and agreed during the meeting of SC in December 2018
- At the heart of it: fostering the exchanges of scientists, in particular of PhD students/postdocs/young researchers for the purpose of training them.
- In general: the country of residence funds the travel, the receiving country pays all expenses in situ.

Adrien Laviron (CSNSM), Julien Souchard (LPSC), Thibault Vieu (APC) [PhD students]	Contribution to mission to participate to the ISAPP School 2019, Malargue, Argentina
12 Argentinian PhD students	Payment of the registration fees for their attendance to the ISAPP School 2019, Malargue, Argentina
Carla Bleve	0.5 month @ Auger Observatory
Manuel Gonzales	1.5 months @ APC, QUBIC
Alejandro Almela	1.5 months @ APC, QUBIC
Martin Gamboa	2.5 months @ APC, QUBIC
Louise Mousset	2.5 months @ La Plata and Bariloche, QUBIC
Jean-Christophe Hamilton	0.4 month @ITEDA, Buenos Aires, QUBIC
Xavier Bertou	0.5 months @IPNO/LPSC, Modane/ANDES

Summary

- APC has continued with the same scientific strategy (sometimes not in the core of IN2P3 projects) :

- Reducing the numbers of projects and reinforcing strategic activities.
- Following recommendations of the scientific council

- It is asked to the Scientific Council to express opinion about recent choices of the laboratory:
 - Advanced Virgo+ & ET
 - Athena (not so recent choice...)
 - DarkSide
 - LiteBird



THANKS FOR YOUR ATTENTION !