

MEMBERS OF SCIENTIFIC COMMITTEE

You'll find here a short presentation of the SC members and their research interests.

JOËL BERGE

- ONERA - The French Aerospace Lab
- Experimental tests of gravitation
- Observational cosmology
- Data analysis / signal processing

PIERCARLO BONIFACIO

- GEPI - Galaxies, Stars, Physics and Instrumentation
- Thesis "Chemical composition of three Population II stars".
 2014 publication: "Galactic globular cluster 47 Tucanae: new ties between the chemical and dynamical evolution of globular clusters?"

DONALD DINGWELL

- LMU Munich Department of Earth and Environmental Sciences, Section of Mineralogy, Petrology and Geochemistry
- Dingwell's principal research interest is the physico-chemical description of molten rocks and their impact on volcanic systems.
 2015 publication: Experimental constraints on phreatic eruption processes at Whakaari (White Island volcano) Journal of Volcanology and Geothermal Research.

EDOUARD KAMINSKI

- IPGP - Institut de physique du globe de Paris
- Theoretical, experimental and numerical study of the dynamics of geological fluids.

STAVROS KATSANEVAS

- APC - AstroParticule et Cosmologie
- Theory of strong interactions
 - Standard model of weak and electromagnetic interactions
 - Neutrino and astroparticle physics
 - Interdisciplinary studies

PIERRE-OLIVIER LAGAGE

- AIM - Astrophysique, Instrumentation, Modelisation
- 2014 publication: "Metrology calibration and very high accuracy centroiding with the NEAT testbed".
 2013 publication: "First experimental results of very high accuracy centroiding measurements for the neat astrometric mission"

BERNARD MARTY

- CRPG Nancy - Centre de Recherches Pétrographiques et Géochimiques
- Origin of isotopic variations in the Solar System
 - Geochemistry of volatile elements (C, N, water, noble gases)
 - Early Earth geodynamics and environments
 - Mantle geodynamics -ridges, mantle plumes, volcanic provinces
 - Fluid circulations in the crust

STÉPHANE MAZEVET

- LUTH - Laboratoire Univers et Théorie
- 2014 publication: "Ab initio calculation of x-ray absorption of iron upto 3 Mbar and 8000K"
 2014 publication: "Melting and metallization of silica in the cores of gas giants, ice giants and super Earths"

ALESSANDRO MORBIDELLI

- OCA - Observatory of Nice
- Morbidelli specializes in solar system dynamics, especially planetary formation and migration and the structure of the asteroid and Kuiper belts.

GEORGE F. SMOOT

- LBNL and PCCP - Laboratoire national Lawrence-Berkeley & Paris Centre for Cosmological Physics
- George Fitzgerald Smoot is an astrophysicist, cosmologist, Nobel Prize in Physics in 2006 for his work on the Cosmic Background Explorer to the «discovery of the black body form and anisotropy of the cosmic microwave background radiation».

EDWARD STOLPER

- Caltech - Division of Geological and Planetary Sciences
- Involved in a wide range of experimental, analytical, theoretical, and computational studies principally aimed at understanding the origin and evolution of igneous rocks on the earth and other planets (Melting of the mantle, Deep drilling into a Hawaiian volcano, Generation of arc and back-arc magmas, Diffusion of water in volcanic gases, Concentration and isotopic composition of CO₂ in air in the Los Angeles Basin)

PETER VAN BALMOOS

- IRAP - Research Institute in Astrophysics and Planetology
- developing a new type of telescope, a «gamma lens» to look for antimatter and radioactivity produced by the stellar explosion.
 2014 publication on High Energy Astrophysical Phenomena: "Antimatter in the Universe : Constraints from Gamma-Ray Astronomy"

WP FRONTIER F2

From Big Bang to the future of the Universe

WP-leaders : E. Aubourg, Y. Giraud-Héraud, J.-Ch. Hamilton, D. Langlois, M.Piat

with J. Bartlett, K. Ganga, M. Bucher, R. Stompor, G. Patanchon, L. Grandsire
Postdoc and PhD funded by UnivEarthS: A. Tartari, M. Salatino, Hoang D. T.

Outline:

- General objectives of the project
- Report on the 2017: CMB activities – joint analysis of cosmological probes
- Objectives for 2018-2020

General objectives of the project

Frontier Project 2 sub-workpackages:

F2.2 B-mode polarization of the CMB:

- Contribute to **new technologies** for next generation projects (TES, MKIDs, bolometric interferometry, ...)
- Support participation in current (QUBIC, Polarbear/Simons Array) and future projects where the labex team plays or should play a **leading role**

F2.3 Understanding the nature of Dark Energy :

- Help develop, at FAcE, the capacity to process the large amount of data which will come from forthcoming galaxy surveys
- Build an interdisciplinary team able to produce mock catalogs of galaxies; support theoretical investigations of the nature of dark energy

APC/UnivEarthS team as a key contributor towards the future CMB projects

1. **Detector developments** : thanks to UnivEarthS our specificities are:
 - Polarization sensitive MKIDs
 - Time Domain Multiplexing for TES arrays
2. **Leading role in the ESA/M5 CORE proposal** : Jacques Delabrouille (APC) – spokesperson of the CORE consortium (**unfortunately unsuccessful**)
3. **QUBIC** : the only ground-based European CMB experiments to look for B mode polarization
 - UnivEarthS supports TESs readout with 128 multiplexing rate
 - software tools to analyse the bolometric interferometer data
 - Integration hall equipment for the technological demonstrator
4. **Polarbear and Simons Observatory** : contribution to a US CMB-S3 experiment



QUBIC

Target: $\sigma(r)=0.01$
2 years of data
2019-2021

✓ B-modes search

- Smoking-gun for inflation

✓ Novel instrumental concept

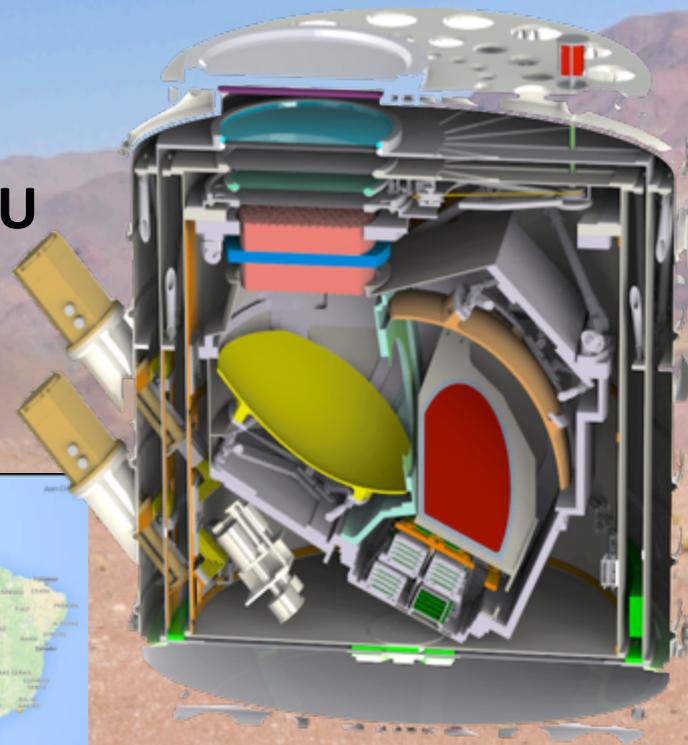
- Bolometric Interferometry

✓ Single large scale ground based project in EU

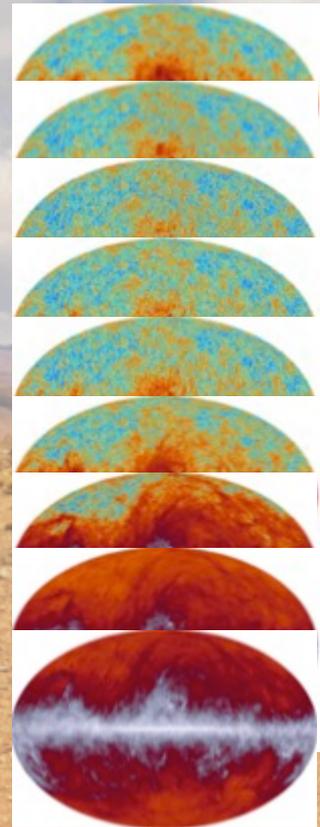
- Leadership at APC
- France-Italy-Argentina-UK-Ireland
- Stepping-stone for CMB S4/E4

✓ Site: San Antonio de los Cobres, Arg.

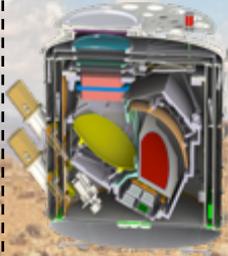
- 5000m a.s.l.
- Logistics + mount : Argentina
- NEW: Access road built



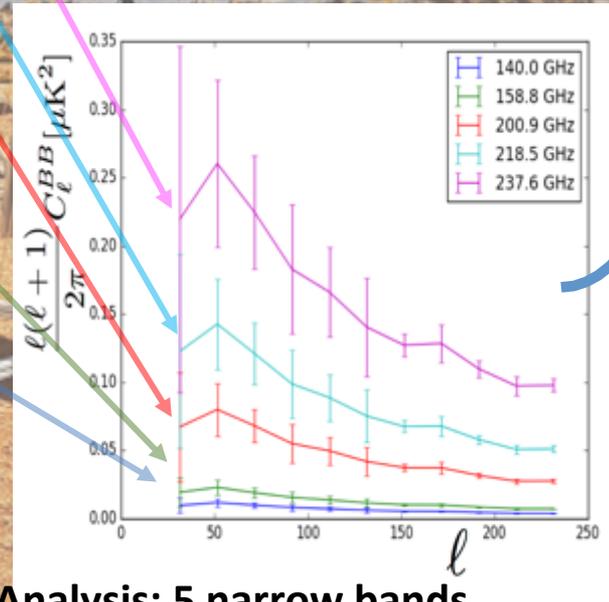
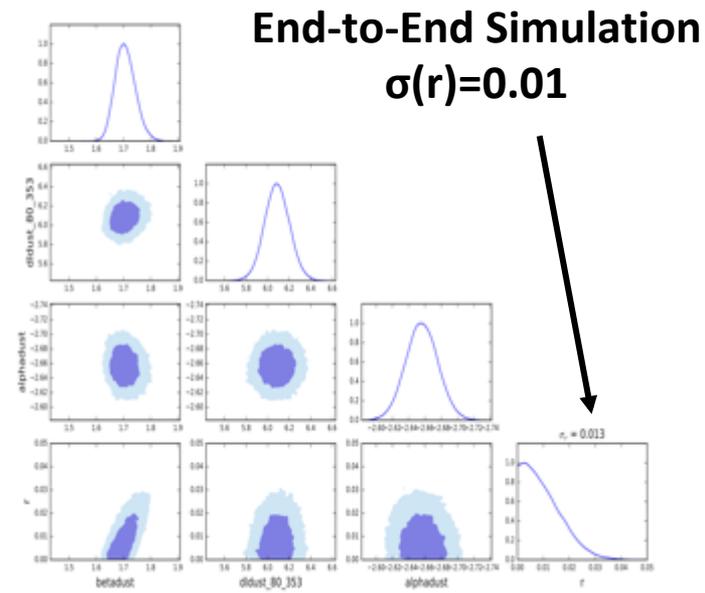
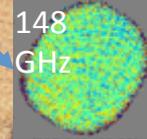
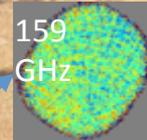
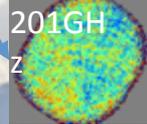
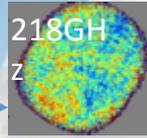
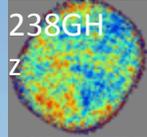
QUBIC IS A SPECTRO-IMAGER



TOD(220 GHz)



TOD(150 GHz)

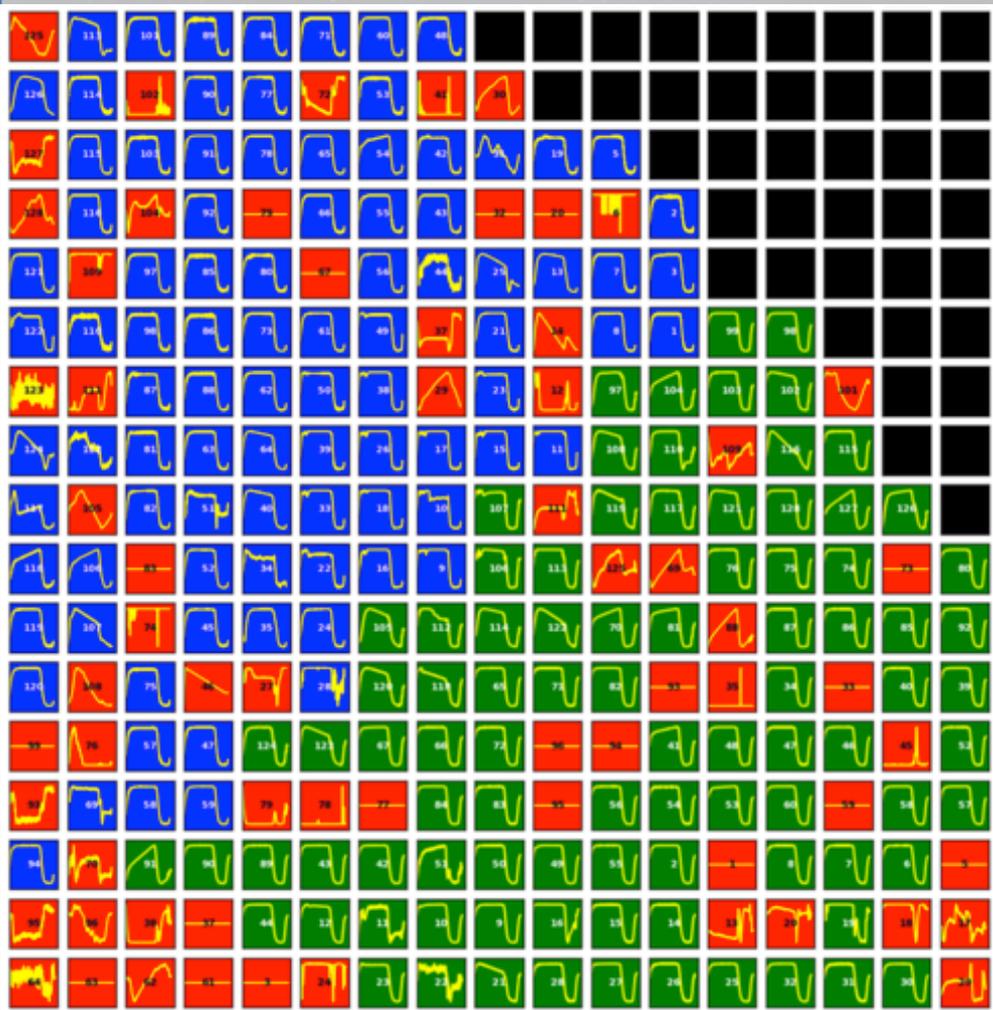


Data Analysis: 5 narrow bands
 => Increased Spectral Resolution
 => Improved Dust subtraction

Sky:
« Infinite # bands »

Instrument:
2 wide bands

TES array P73: signal from a C Fiber source

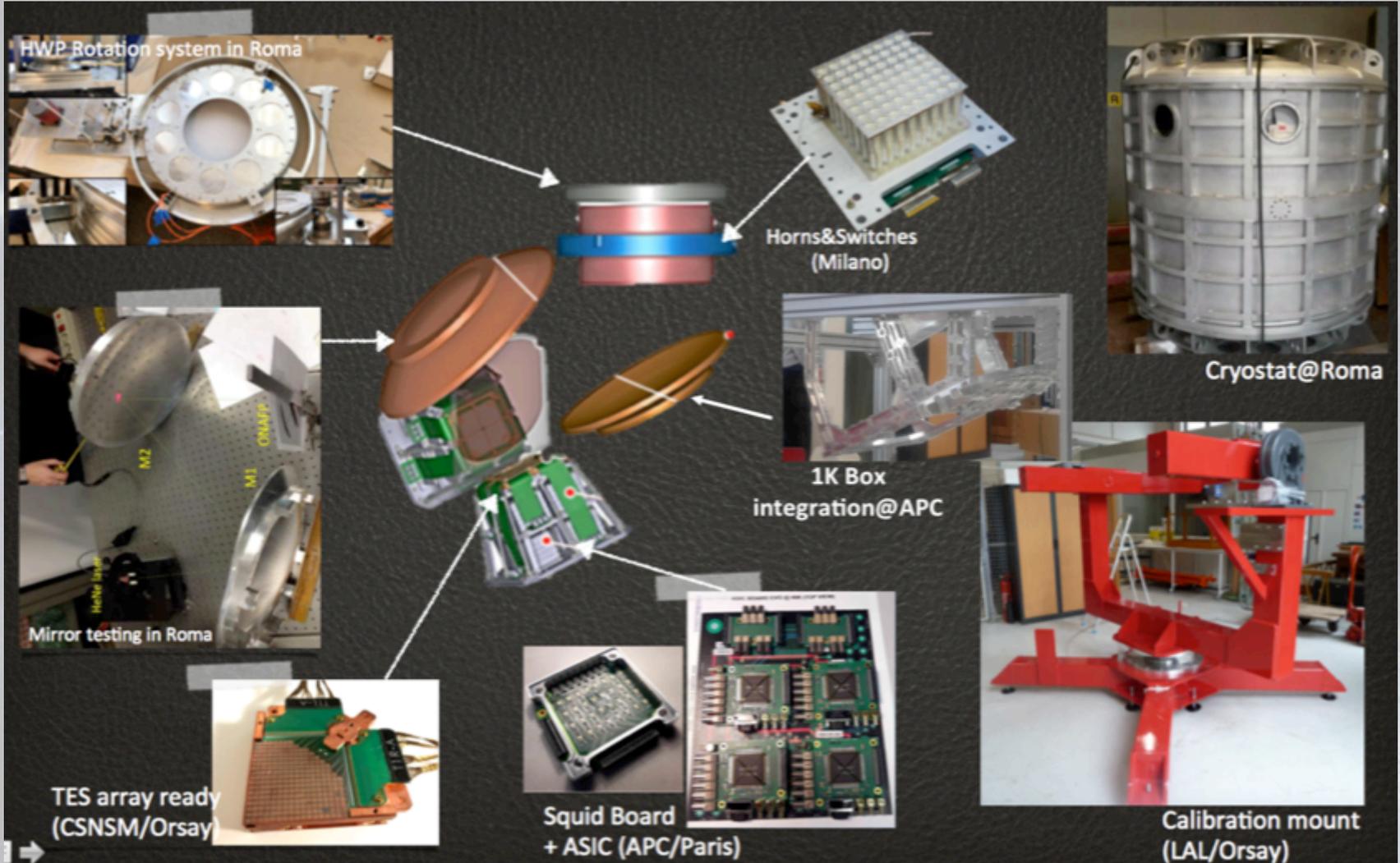


- Pulse signal on the detectors
 - ASIC 1
 - ASIC 2

- C fiber source provided by LAL
 - At 1 K, in front of the array

- Other measurements: glitches with Am source

QUBIC assembly and integration



QUBIC DEPLOYMENT PLAN

✓ 2017-2018 : at APC

- Integration started
- Early 2018: Technological Demonstrator (reduced QUBIC)
 - 1/4 focal plane, 64 horns, small mirrors
- April 2018: Upgrade to full size mirrors and 400 horns

In-lab Demonstration of Bolometric Interferometry

• 2018 : Argentina

- mid-2018: Integration with mount, Installation on site
- First Light Sept. 2018 with ¼ focal plane

On-Sky Demonstration of Bolometric Interferometry

• 2019 : Argentina

- Upgrade to QUBIC 1st module (2 focal planes 150 and 220 GHz)
- First Light March 2019
- Data taking: 2-3 years $\sigma(r)=0.01$

Stage III
 $\sigma(r)=0.01$

• 2020-... : QUBIC evolves towards Stage-IV

- European extension of the collaboration
- Improved designs already being investigated
- Excellent quality site open to development

Evolution to Stage IV
 $\sigma(r)=0.001$

POLARBEAR/SIMONS ARRAY

PB/SA is one of the major CMB B-mode observatories currently in operation. It is based on the Atacama Desert in Chile on the altitude of over 5,100 m.

Currently it is undergoing major technological upgrade (Simons Array), **but starting in early 2018 it will observe the sky with over 25,000 detectors** deployed on three different telescopes and operating in 3 different frequency bands.

The first campaign of the POLARBEAR experiment produced some of world-first constraints on the B-mode power spectrum at small angular scales. These results published in 2014 were updated in 2017 improving the overall statistical significance of the detection to $\sim 4\sigma$.

The APC team has been involved in the project since 2009, playing since a major role in the data analysis effort. In 2017 the APC team was responsible for one of the two data analysis pipelines used in the production of the 2017 results update. A student from APC, J. Peloton, was a corresponding author of the 2017 paper (Radek Stompor, Josquin Errard, Maude Le Jeune, **Dominic Beck, Clara Vergès**) – Phd defenses : **Errard (2012), Fabbian (2013), Peloton (2015), Poletti (2016)**

We also led work on scientific optimization of the instrumental design and instrument operations for the new, upgraded instrument and the forthcoming observational campaign.

Labex support was instrumental in permitting an effective collaboration between the APC group and the POLARBEAR team based predominantly in the US. Labex funds were used to finance trips of the APC team members to attend collaborations meetings in the US, as well as longer research visits of the PhD students (via its PhD travel grant program). Labex also supported the organization of the Data Analysis Face-to-Face working meeting of the collaboration at APC in December of 2016.

B-mode polarization of the CMB:

Consolidation of what has been achieved during the first years of the labex

- ~~KIDs development~~: now in the F2A project
- QUBIC: the technological demonstrator will be installed in Argentina in 2018. Support of the labex asked for data analysis
- POLARBEAR/Simons Array: one of the major US CMB-S3 projects
- ~~CORE (ESA/M5)~~

Exploring new projects to extend our expertise

- LiteBIRD: a eventual JAXA/NASA/ESA CMB space mission
- CMB Stage 4 prospective and its precursors like Simons Observatory (ground)

LiteBIRD is a new CMB satellite mission (phase A study in Japan). The mission is focused on detecting primordial gravity waves via constraining the amplitude of the large-scale CMB B-mode polarization with unprecedented precision. The project, if selected for phase B in the fall 2018 in Japan, will be launched in 2026/27.

LiteBIRD will provide unique and complementary information to this expected from the ground based effort.

The French and European CMB communities have expressed interest in getting involved

APC members have played key roles in building a potential involvement in LiteBIRD in France and Europe. [They coordinated the CNES proposal preparation and co-lead the on-going discussions with European Space Agency.](#) They have also directly contributed to the project by working on the optimization of the LiteBIRD design, realistic forecasting of its performance, as well as simulations of some crucial instrumental effects and evaluation of their potential impact on the science goals of the mission. (Radek Stompór, Josquin Errard, Martin Bucher, Guillaume Patanchon, Michel Piat, Fabrice Voisin, Damien Prêle, [Hoang Duc Thuong](#))

[Labex supported trips of the APC-based LiteBIRD team for the European level, organizational LiteBIRD meeting in Cardiff and the organization of the second meeting at APC in Paris. It also supports forthcoming trips to the global LiteBIRD collaboration meeting in the US in December this year. Labex also supports research visits of the APC scientists to work with Japanese researchers in Japan.](#)

Simons Observatory (SO) is a new, fully funded CMB observatory, which combines two current and major CMB polarization experiments, POLARBEAR/Simons Array and AdvACT. SO will observe the sky in up to 5 frequency bands, with as many as 6 telescopes of different apertures and a resolution ranging from ~ 1 arcminute to tens of arcminutes.

SO is expected to be deployed by 2021 at the Atacama Desert becoming the most advanced CMB effort at that time and a pathfinder towards the 'ultimate' ground-based CMB observatory, a so-called Stage-IV experiment.

The APC team has been involved in SO as the only France-based team since its inception in 2015 and is an official, full institutional member of the international collaboration. We have been playing important and leading roles in scientific optimization of the instrumental design and instrument operations. We coordinate the data analysis pipeline and data management work within the collaboration. We are also in discussions with our partners on potentially extending our involvement in SO to include hardware contributions. paper (Radek Stompor, Josquin Errard, Maude Le Jeune, [Dominic Beck](#), [Clara Vergès](#))

Labex support was essential in enabling us to participate in the SO collaboration meetings and workshops and thus in maintaining our visibility and impact on the project. The Labex team should increase a lot in the coming years

CMB Stage-4 will be the next generation of ground-based Cosmic Microwave Background cosmology. Led by the US, it is being planned now ([Report on the Concept Definition Task Force to NSF: 23/10/17](#))

The LabEx has been invaluable to us as a means to remain in contact with the S4 community and attend the preparatory meetings

This effort is made considering what is done on QUBIC and Simons Observatory which could become our contribution to S4



Figure 1: *Left:* the CMB telescope sector at South Pole Station in Antarctica. *Right:* CMB telescopes at Cerro Toco in the Chilean Andes.

Joint analysis of cosmological probes: Should become a priority for next years

Various astrophysical probes of dark energy

→ different degeneracies between cosmological parameters

→ joint analysis of the different probes measured with different instruments

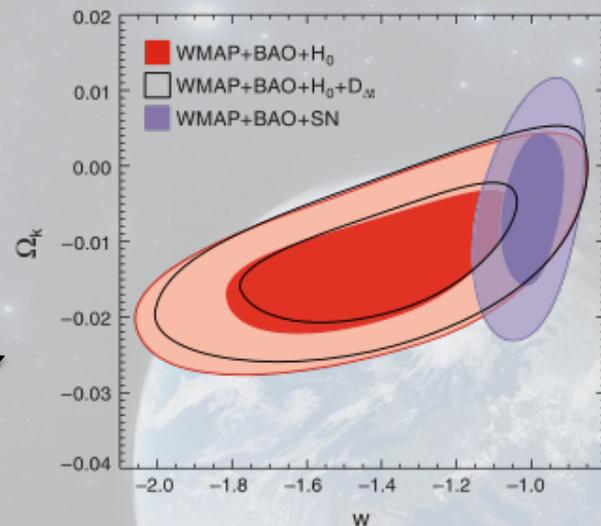
Planck, Herschel, BOSS, eBOSS, Euclid, LSST, ...

- Planck, QUBIC, CORE, CMB-S4, ... as probes of the early Universe
- BOSS, eBOSS, Euclid and LSST as probes of matter distribution in the Universe

Example : WMAP (Komatsu et al. 2010)

w (dark energy equation of state parameter)

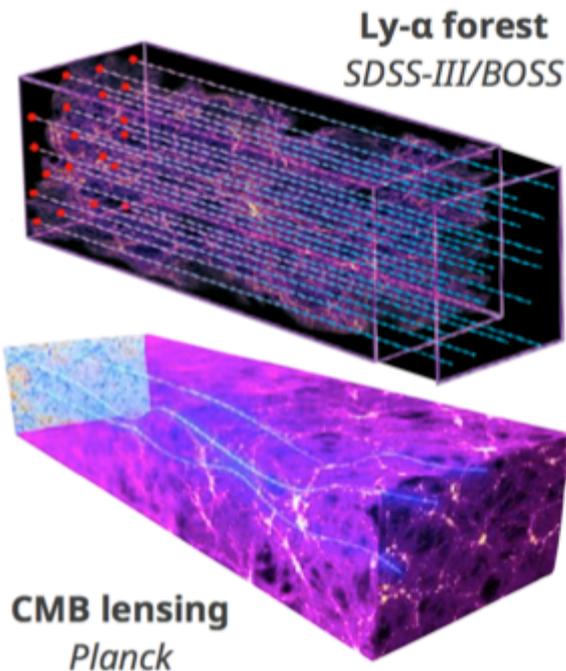
versus Ω_k (curvature parameter)



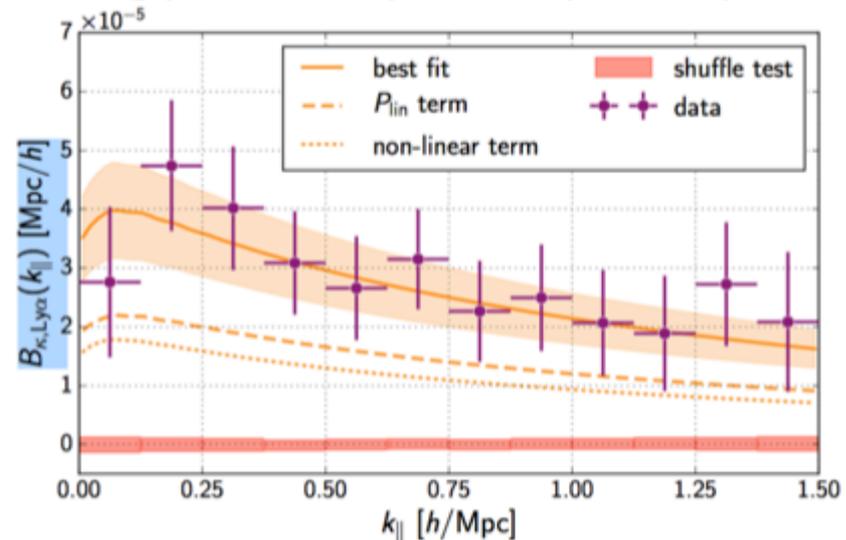
Cross-correlation studies at APC

Combining multiple cosmological probes can

- reveal new effects : CMB lensing \times Ly- α forest, kinetic SZ effect
- break degeneracies and improve constraints on cosmological parameters
- test extensions of Λ CDM (forecasts): f_{NL} , Σm_{ν} , modified GR



Measuring position-dependent power spectrum



F2: From the Big Bang to the future of the Universe

ITEM DESCRIPTION	INITIAL BUDGET	COMMITTED COSTS	DESCRIPTION
Human ressources	55 000 €	55 000 €	One year-postdoc for QUBIC: Maria Salatino
Consumables and missions costs	40 000 €	37 740 €	<ul style="list-style-type: none"> - travels CMB-S4 : 5.2 k€ - travels POLARBEAR/SO : 7 k€ - travels LiteBIRD : 9 k€ - conferences/workshops organization : 3,2 k€ - Master interships + PhD summer schools : 6 k€ - Communication : 2,2 k€ - Small equipments : 2,6 k€
Equipment costs	0 €	2 260 €	AB millimeter : 2,3 k€
TOTAL COSTS	95 000 €	95 000 €	

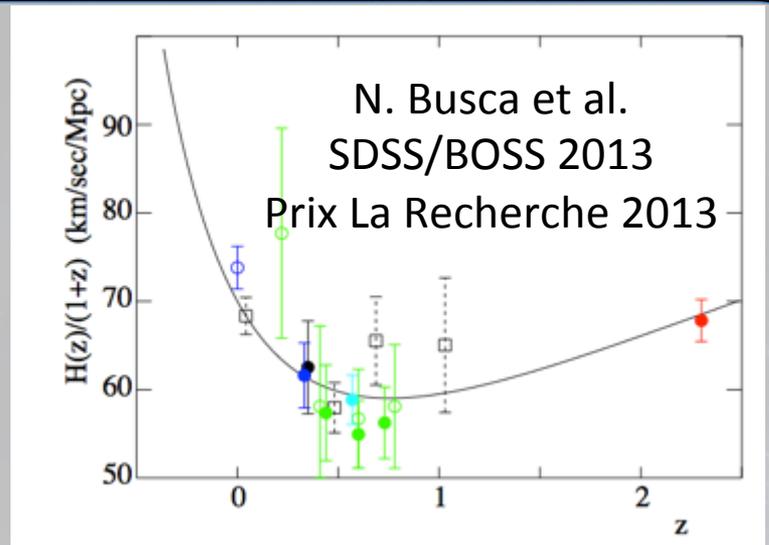
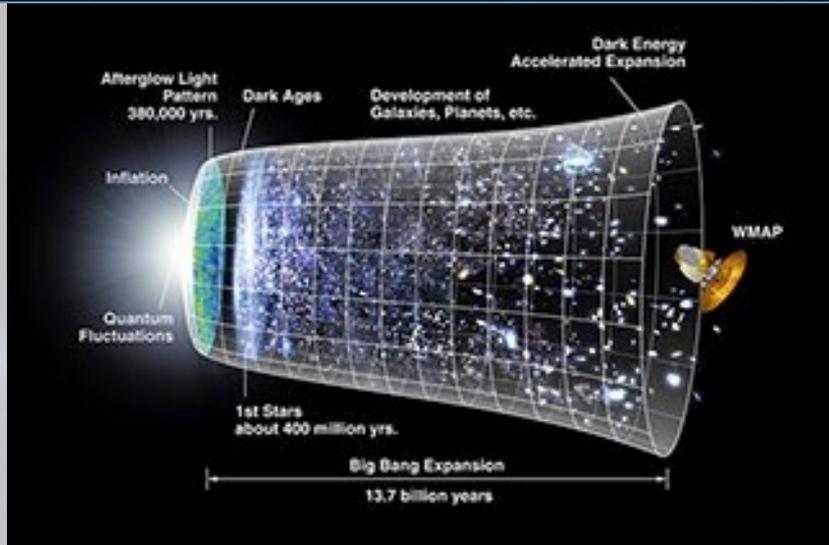
LABEX EFFECTIFS	DESCRIPTION
New hires (postdocs/engineers/..)	1 post-doc on QUBIC: Maria Salatino
Continuing/terminated contracts	
Initiated PhD theses	Starting October 1, 2016 : Dominic Beck (Polarbear/SO) Starting October 1, 2017 : Clara Vergès (Polarbear/SO)
Continuing/Defended PhD theses	Cyrille Doux – cosmological probes – 3 rd year Alessandro Traini – instrumentation-QUBIC – 2 nd year Hoang Duc Thuong – LiteBIRD-QUBIC – 2 nd year Dominic Beck - Polarbear/SO – 1 st year
Master students linked to Labex research	Panagiotis Mantaounis – Euclid – Master internship

F2: From the Big Bang to the future of the Universe

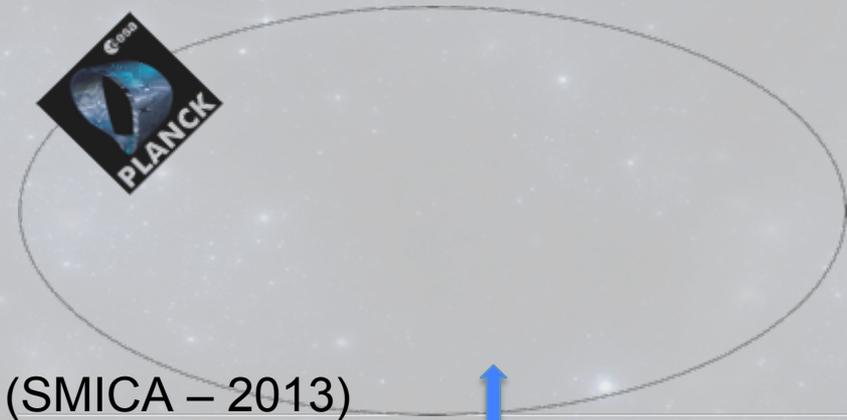
ITEM DESCRIPTION	REQUIRED BUDGET	PRIORITY	DESCRIPTION
Human ressources	150 000 €	1	<ul style="list-style-type: none"> - one year post-doc for Maria Salatino - one year post-doc for CMB data analysis (QUBIC or complement to 1-year B3DCMB ANR funding) - one year post-doc for jointed cosmological probes analysis
Consumables and missions costs	65 000 €	1	<ul style="list-style-type: none"> - Polarbear and LiteBIRD : 10 k€ - Prospective CMB-S4 (including Simons Observatory) : 20 k€ - Joint analyses of cosmological probes : 25 k€ which includes invitations and the organization of a workshop - Funding for internship s and support for PhD sttudents : 10 k€
Equipment costs			
TOTAL COSTS	215 000 €		

ITEM DESCRIPTION	REQUIRED BUDGET	PRIORITY	DESCRIPTION
Human ressources	100 000 €	1	<ul style="list-style-type: none"> - second year post-doc for CMB data analysis (QUBIC) or one year CMB post-doc (half-funded by B3DCMB ANR) - one year post-doc for jointed cosmological probes analysis
Consumables and missions costs	65 000 €	1	<ul style="list-style-type: none"> - Polarbear and LiteBIRD : 5 k€ - Prospective CMB-S4 (including Simons Observatory) : 25 k€ - Joint analyses of cosmological probes : 25 k€ which includes invitations and the organization of a workshop - Funding for internship s and support for PhD sttudents : 10 k€
Equipment costs			
TOTAL COSTS	165 000 €		





Expansion speed of the Universe as seen by supernova and galaxy surveys

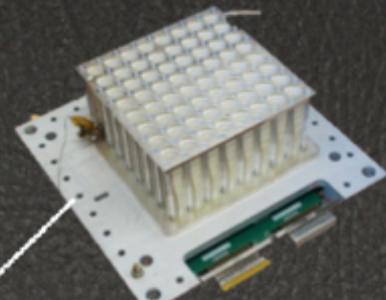


(SMICA – 2013)

The Universe as seen by Planck
 (ESA mission – launched in 2009)

Parameter	Planck+lensing	
	Best fit	68% limits
$\Omega_b h^2$	0.022242	0.02217 ± 0.00033
$\Omega_c h^2$	0.11805	0.1186 ± 0.0031
$100\theta_{MC}$	1.04150	1.04141 ± 0.00067
τ	0.0949	0.089 ± 0.032
n_s	0.9675	0.9635 ± 0.0094
$\ln(10^{10} A_s)$	3.098	3.085 ± 0.057

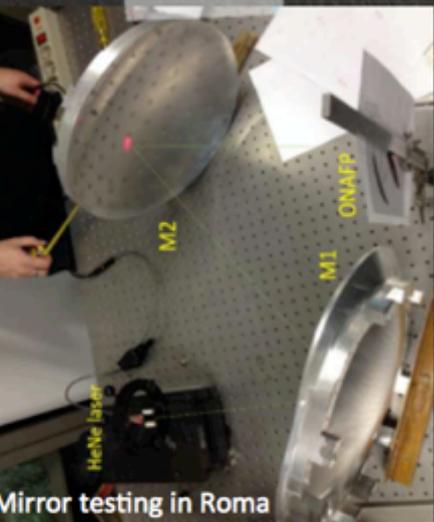
WP Rotation system in Roma



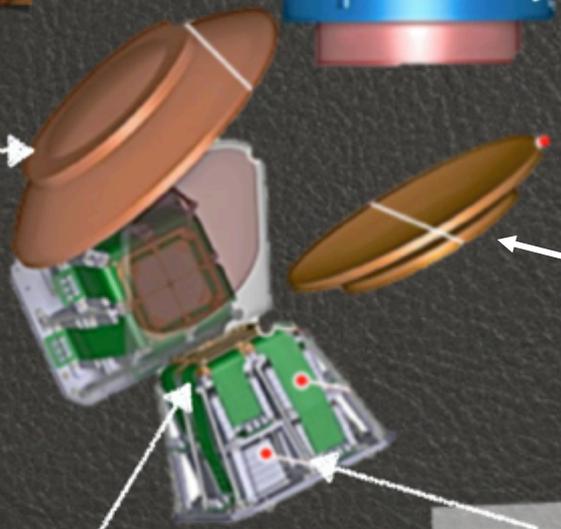
Horns&Switches (Milano)



Cryostat@



Mirror testing in Roma



1K Box integration@APC



Calibration m (LAL/Orsay)



TES array ready (CSNSM/Orsay)



Squid Board + ASIC (APC/Paris)

