

Section 4: Members of the consortium

4.1. Participants (applicants)

4.1.1 CNRS

4.1.1.1 Description

The French National Centre for Scientific Research (CNRS) is a government-funded research organization under the administrative authority of French Ministry in charge of research. CNRS is the main fundamental research organization in Europe and is largely involved in national, European, and international projects covering all fields of knowledge. CNRS is organized in 1211 laboratories, either intramural or in partnership with universities, other research organizations or industry. In the project, CNRS represents the laboratory AstroParticule et Cosmologie (APC) which is a Joint Research Unit between the CNRS and the University Paris Diderot (Paris 7), the Université Grenoble Alpes, the Institut d'Astrophysique de Paris, the Institut d'Astrophysique Spatiale, the Institut Neel, the Institut de Recherche en Astrophysique et Planétologie, the Laboratoire de l'Accelérateur Lineaire, and the Laboratoire de Physique Subatomique et Cosmologie.

AstroParticule et Cosmologie, UMR 7164, Paris, France (APC)

The APC laboratory has 200 staff members, among which 80 researchers (CNRS full-time researchers, university teachers and some CEA staff members), 30 PhD students and 20 post-doctorates. It is organized in five research teams, three covering the main scientific themes – Cosmology, Gravitation, High Energy Astrophysics, Neutrinos and Theory. The laboratory is involved in 8 European projects, in 10 contracts from the French Research National Agency (ANR), in 6 regional research contracts – in particular the ANR “Laboratory of Excellence” UnivEarthS. Furthermore, the APC is proud to host the Paris Centre of Cosmological Physics (PCCP) of the 2006 Nobel Laureate George Smoot.

Institut d'Astrophysique Spatiale (IAS, CNRS)

The Institut d'Astrophysique Spatiale (IAS) is a laboratory of the CNRS and of University Paris-Sud; and at the same time part of the Paris-Sud Observatory. IAS, comprising 160 researchers, engineers, technicians, administrators and graduate students, is one of the leading space laboratory in France and Europe. IAS designs, manufactures, tests, space sub-systems or instruments onboard satellites. IAS has an impressively successful track record (GOLF/SOHO, ISOCAM/ISO, EPIC/XMM-Newton, HFI/Planck, MIRI/JWST, OMEGA/MarsExpress, CIVA/PHILAE/ROSETTA, VIS/Euclid, MAJIS/JUICE). IAS hosted two ERC PI-ships and has been involved in 6 European and 6 national projects in the recent years.

The Institute of Planetology and Astrophysics of Grenoble, (IPAG, UMR5274)

IPAG has a staff of about 60 researchers (hired by the CNRS, the CNAP and the University), about 20 PhD students and 20 post-doctorates. Its areas of expertise are astrochemistry, stellar formation, plasmas and jets, planetology, exo-planetology and cosmology. IPAG is involved in the construction and the developpement of many ground based instruments (NAOS, WIRCAM, SPHERE, GRAVITY, AMBER, PIONIER, etc.) that are installed at some of the leading telescopes (VLT, VLTi, CFHT). IPAG has also responsibilities for space instruments like CONSERT and VIRTIS onboard ROSETTA. We have developed strong connections with national and international agencies both in the academic and private sectors (CNES, ESA, ESO, Sofradir, ONERA, CEA-LETI, Thales). IPAG is P.I. of one of the most ambitious projects of the 2nd generation instruments of VLT ESO (SPHERE, 10 M€) and has helped prepare 9 out of the 14 missions currently operating in the solar system.

Laboratoire de l'Accélérateur Linéaire (LAL), UMR 8607, IN2P3/CNRS et Université Paris-Sud

Research activities at LAL are centred on particle physics, complemented by a strong component in cosmology and astrophysics. LAL hosts 309 staff members including 75 researchers (CNRS and Paris universities teachers), 16 post-doctorate and 42 PhD students. The laboratory also performs its mission of transmitting knowledge through teaching and communication activities. In order to carry out scientific experiments and participate in world-wide collaborations, physicists rely on the technical and administrative departments of the laboratory, in particular high-performance mechanics and electronics design and production services, as well as a group in computational and information technologies. Since experimentation in particle physics is often associated with accelerators, the laboratory also carries out a research program and developments in this field.

LPSC-Grenoble

The "Laboratoire de Physique Subatomique et de Cosmologie de Grenoble" (LPSC) is a research laboratory operated jointly by several funding agencies: CNRS (IN2P3 and INSIS) and Grenoble University UGA. Created in 1967, the laboratory staff is composed of about 225 people. It is involved in several scientific projects driven by large international collaborations including: particle and fundamental interactions experiments (ATLAS at LHC and UltraCold Neutrons at ILL); space missions (Planck, Euclid, AMS) and ground based experiments (NIKA, Auger, LSST) for astro-particles and cosmological issues; research on electro-nuclear power (ADS GUINEVERE in SCK Mol, Molten Salt and Thorium cycle based concepts); nuclear structure studies (ILL and SPIRAL); and hadron physics (JLab experiments and ALICE at LHC). The LPSC is highly involved in the study of Cosmic Microwave Background (CMB) physics and in the preparation of the new generation of CMB experiments through the development of KID detectors.

Institut Néel, CNRS and Université Grenoble Alpes UPR 2940

The Institut Néel (IN) has around 450 staff members, almost equally shared among permanent researchers, technical staff and non-permanent collaborators. The IN is mainly devoted to fundamental Solid State Physics, nanotechnologies, very low temperatures and related world-class instrumentation. The Institut is organised in three departments. The MCBT department, formerly CRTBT, has a long tradition in cryogenics instrumentation for Astrophysics. For example, we led the Archeops project and elaborated the Planck satellite sub-Kelvin cooler. More recently, we have pioneered the Kinetic Inductance Detectors (KID) technology. Our NIKA (New IRAM KID Arrays) instrument has been the pathfinder for this technology at the international level, at least in the CMB frequency range. In 2015 we deployed a new instrument, NIKA2, comprising three thousands pixels and working in the band 120-300 GHz. The NIKA2 arrays, and the dilution cryostat, were entirely developed in house.

Institut de Recherche en Astrophysique et Planétologie (IRAP)

The "Institut de Recherche en Astrophysique et Planétologie" is a research institute combining members of CNRS and the University of Toulouse III Paul Sabatier. It has 279 staff members, including 112 researchers, 15 post-doctorates and 40 PhD students. The scientific objectives of the institute are the study and the understanding of the Universe and its content: the Earth as a planet, its ionized environment, the Sun and its

planets, the stars and their planetary systems, the galaxies, the very first stars and the primeval Big Bang. It is involved in several large international collaborations including those associated with space missions such as Planck, Euclid, SVOM and Athena, and ground-based projects such as ALMA, CTA, and MUSE/VLT.

4.1.1.2 CVs

4.1.1.2.1 François Bouchet (Male)

François Bouchet is a “Directeur de Recherches – Classe Exceptionnelle” at the CNRS’s Institut d’Astrophysique de Paris where he is the head of the Cosmic Microwave Background group. He is the Deputy Principal Investigator for the High Frequency Instrument (HFI) aboard the Planck Satellite, and the Science Coordinator for the HFI consortium. In addition, he is the Manager of the HFI data processing center, and as such is in charge of world-wide HFI data processing.

4.1.1.2.2 Andrea Catalano (Male)

The coordinator of the WP5 will be Andrea Catalano, who is 38 years old. He was strongly involved in Planck mission, working on data reduction and control of the instrumental systematic effects. In 2011 he joined the LPSC-Grenoble as a permanent researcher. He is currently involved in KID developments. He is part of the NIKA2 core team and he is a member of the NIKA2 editorial board.

4.1.1.2.3 Ken Ganga (Male)

Ken Ganga is the proposal coordinator. He is the head of the Cosmology group at the APC/CNRS labs in Paris. He has worked in the CMB field since 1992. His thesis worked confirmed the Nobel-prize-winning detection of anisotropy in the CMB. Since then he has worked on the SUZIE, BOOMERANG and Planck/HFI CMB experiments, as well as a number of others. Before coming to France, he was the head of the ISO, Herschel and Planck Satellite groups at the Infrared Processing and Analysis Center at Caltech.

4.1.1.2.4 Stavros Katsanevas (Male)

Stavros Katsanevas, professor exceptional class at University Paris Diderot, is the director of the Laboratory of Astroparticle Physics and Cosmology (APC), which hosts the Paris Centre for Cosmological Physics (president George Smoot, Nobel Prize 2006). He has been deputy director of the National Institute of Nuclear and Particle Physics (IN2P3) of CNRS responsible for Astroparticle Physics and Cosmology (2002-2012), first coordinator of the EU funded ERANETASPERA (2006-2012) gathering the European agencies funding Astroparticle Physics, and first chairman of the European Consortium of Astroparticle Physics (APPEC; 2012-2015) which succeeded ERANETASPERA. He has also been president of the European Gravitational Observatory (Pisa/Italy), the Auger Observatory for Cosmic Ray Physics (Argentina) and one of the proposing Principal Investigators of the Institute of Physics and Mathematics of the Universe (IPMU) at Tokyo.

4.1.1.3 Relevant Publications

- Mapping the kinetic Sunyaev-Zel'dovich effect toward MACS J0717.5+3745 with NIKA, Adam, R. *et al.* (including Catalano, De Petris, Désert, Monfardini, Pascale, Perotto, Pontheiu), *A&A*, 598, 2017.
- Planck 2015 results. XI. CMB power spectra, likelihoods, and robustness of parameters, Planck Collaboration (including Bouchet, Catalano, & Ganga), *A&A*, 594, 2016.
- Cosmological constraints from Archeops, Benoît, A.; Ade, P.; Amblard, A.; Ansari, R.; Aubourg, É.; Bargout, S.; Bartlett, J. G.; Bernard, J.-Ph.; Bhatia, R.S.; Blanchard, A.; Bock, J.J.; Boscaleri, A.; Bouchet, F.R.; Bourrachot, A.; Camus, P.; Couchot, F.; de Bernardis, P.; Delabrouille, J.; Désert, F.-X.; Doré, O.; Douspis, M.; Dumoulin, L.; Dupac, X.; Filliatre, P.; Fosalba, P.; Ganga, K.; Gannaway, F.; Gautier, B.; Giard, M.; Giraud-Héraud, Y.; Gispert, R.; Guglielmi, L.; Hamilton, J.-Ch.; Hanany, S.; Henrot-Versillé, S.; Kaplan, J.; Lagache, G.; Lamarre, J.-M.; Lange, A. E.; Macías-Pérez, J.F.; Madet, K.; Maffei, B.; Magneville, Ch.; Marrone, D.P.; Masi, S.; Mayet, F.; Murphy, A.; Naraghi, F.; Nati, F.; Patanchon, G.; Perrin, G.; Piat, M.; Pontheiu, N.; Prunet, S.; Puget, J.-L.; Renault, C.;

Rosset, C.; Santos, D.; Starobinsky, A.; Strukov, I.; Sudiwala, R.V.; Teyssier, R.; Tristram, M.; Tucker, C.; Vanel, J.-C.; Vibert, D.; Wakui, E.; Yvon, D.; *A&A*, 399, L25, 2003.

- A Measurement by BOOMERANG of Multiple Peaks in the Angular Power Spectrum of the Cosmic Microwave Background, Netterfield, C.B. *et al.* (including de Bernardis, Ganga, Masi, Pascale, Piacentini), *Astrophysical Journal*, Volume 571, Issue 2, pp. 604-614, 2002.

4.1.1.4 Relevant Projects

- NIKA2: See <http://ipag.osug.fr/nika2/Welcome.html>.
- The Planck CMB Satellite. See http://www.esa.int/Our_Activities/Space_Science/Planck.
- The Archoeps balloon-based CMB Experiment. See <https://en.wikipedia.org/wiki/Archeops>.
- The BOOMERANG balloon-based CMB experiment. See https://en.wikipedia.org/wiki/BOOMERanG_experiment.

4.1.1.5 Relevant infrastructure and/or equipment

Microfab facilities: Major detector fabrication work can be done with the multi-user facility at PTA-CEA. Future, more demanding projects may require process reliability which demands a focus on a platform with dedicated permanent staff performing fabrication. This option is currently under study with the help of CNES agency.

4.1.1.6 Any other relevant material

4.1.2 Milan

4.1.2.1 Description of Università degli Studi di Milano

The mission of the University of Milan (UniMI), established in 1924, is to contribute to society through the pursuit of teaching/education and research at the highest international levels of excellence. With a teaching staff of about 2.200 tenured professors and with almost 60,000 students, UniMI is the largest university in Lombardy, one of the most dynamic and internationally-oriented EU regions. UniMI offers a wide range of study programs covering Humanities, Social Sciences and Law, Medicine and Healthcare, and Natural Sciences.

UniMI has an established reputation as one of the institutions most strongly committed to basic and applied research in Europe. EU programs represent a major source of funding for the University of Milan, which has signed 147 grants under the 7th Framework Programme (2007-2013), for a total value of € 50,344,153, and 52 grants up to May 2016 under the Horizon 2020 Programme (including 9 JPI), for a total value of more than € 14,000,000. UniMI has also built relationships with different third parties such as industries, non-profit organizations, institutional entities, SMEs.

The University of Milan is constantly developing projects in cooperation with some of the most relevant international research groups, often acting as activities coordinator. The University supports researchers in accessing EU funds, in the achievement and exploitation of innovative results in different ways, including: Monitoring official EU programs websites on a daily basis; Providing information on funding opportunities through newsletters, web pages, ad hoc events, helpdesk; Supporting proposal drafting; Facilitating the grant application process; Negotiating research-related contracts and agreements; Advising on Intellectual Propriety Rights issues; Supporting University and Divisional research-related planning; Promoting the responsible conduct of research activities and compliance with regulatory requirements; Supporting Intellectual property protection of innovative results; Promoting exploitation of research results; Supporting negotiation

with third parties aimed to licensing of IPR; Assisting and supporting establishment of new innovative enterprise (i.e. spin-off).

The Department of Physics at University of Milano hosts research activities in most of the forefront fields in fundamental and applied Physics, including a strong and lasting activity in Astrophysics and Cosmology. The international excellence of the research performed in the Physics Department, is demonstrated by the award of substantial international grants. Our Cosmology group at Physics Department, University of Milano, has wide experience in Cosmic Microwave Background projects, covering instrumentation, observations and data analysis. For over two decades we have played a leading role in the design, development, testing, operation and data analysis of the Low Frequency Instrument (LFI), one of the two instruments on board the ESA Planck mission. We have also high scientific responsibility in LSPE and QUBIC, two ground-based CMB experiments currently under development. Our laboratory integrates various capabilities and skills, from design and manufacturing of hardware components, to simulations, to data analysis and scientific computing. While our core business remains astrophysics and cosmology, we are keen to identify synergies and collaborations with SME and other external partners for mutual interest and benefit.

The present project will benefit from an internal computing facility, Erebor, fully dedicated to the computational needs of our Observational Cosmology Group at the Department of Physics, University of Milano. Erebor is the front-end of the Numenor Computing Cluster, supporting computational activities ranging from instrument design and modelling, simulations, data reduction, scientific analysis. The front-end is a 4-core Intel Xeon E5-2600 processor with a total of 32 GB of RAM and a total of 3.6 TB of disk storage in the home of the users. There are 8 computing nodes each with 12-cores Intel Xeon E5-2620 processor at 2.0 GHz with a total of 8GB per core. Node are connected with Infiniband switch. Together with computing nodes the system is composed by Edoras, a data storage system which allows for a total of 22 TB of disk space (RAID 5).

4.1.2.2 Group composition and CVs

The Observational Cosmology group at University of Milano is currently composed by: Paola Battaglia, PhD Student; Marco Bersanelli, Full Professor; Francesco Cavaliere, Technician; Cristian Franceschet, Postdoc; Federico Incardona, PhD student; Davide Maino, Associate Professor; Jacopo Martelli, Junior Postdoc; Aniello Mennella, Associate Professor; Maurizio Tomasi, Staff researcher; Daniele Viganò, Technician.

The activities planned in this project will be carried out in closely collaboration with the Cosmology group at **University of Milano-Bicocca**, in particular with: Alessandro Baù, Technician; Massimo Gervasi, Associate Professor; Andrea Passerini, Technician; Mario Zannoni, Staff Researcher; as well as with the cosmology group at **SISSA, Trieste**: Carlo Baccigalupi, Full Professor; Nicoletta Krachmalnicoff, Postdoc; Francesca Perrotta, Staff Researcher; Daniela Poletti, postdoc.

Short CV's of the staff research personnel at University of Milano are reported below.

Marco Bersanelli

Date of birth: 29.01.1960

Sex: Male

Nationality: Italian

Education

1986 Graduation in Physics, Physics Department, University of Milano, Italy

Current and previous positions

2006 Full Professor of Physics and Astrophysics, Physics Department, University of Milano, Italy

2010-2015 Director of the PhD School in Physics, Astrophysics and Applied Physics, University of Milano, Italy

2000-2006 Associate Professor of Experimental Physics, Physics Department, University of Milano, Italy

1999-2000 Senior Researcher at IFCTR, CNR, Milano, Italy

1990-1995 Visiting Researcher at Lawrence Berkeley National Laboratory, University of California, Berkeley, USA

1988-1990 Staff Researcher at Istituto di Fisica Cosmica e Tecnologie Relative (IFCTR), CNR, Milano

1986-1990 Visiting Scholar at Lawrence Berkeley Laboratory, University of California, Berkeley, USA

Fellowships and awards

1990 NATO Advanced Grant.

1991 NSF Medal for Research in Antarctica.

2009 Honorary member of Universitas, Asociación para la Investigación y la Docencia, Madrid.

2010 ASI Award for contribution to Planck.

2010 ESA Award for achievements in Planck (with Planck Collaboration).

2012 Istituto Lombardo Accademia di Scienze e Lettere.

2014 NERSC Award for High Impact Scientific Achievement (Planck Collaboration).

Supervision of graduate students and research fellows

1995-2016 14 PhD students, more 50 Master students.

A number of former students of M.B.'s, are currently continuing their research career in high level Astrophysics groups in Europe and USA.

Major collaborations and key collaborators

LSPE	Italy-led CMB polarization experiment; PI of LSPE/STRIP (2013-17)
CORE	ESA-led international CMB satellite mission concept (2014-17)
Planck	ESA-funded international CMB satellite mission (1992-2017: Deputy PI and Instrument Scientist of Planck/LFI)
BEAST	US-led CMB anisotropy experiment (2000-2005)
Spectrum	US-Italy collaboration to measure the CMB frequency spectrum (1986-1992)

Publication summary

I have published 250 papers on international refereed journals, and 110 conference proceedings, resulting in a total of 24,572 citations and an *h*-index of 72 (source: ADS). Most of my papers are published in Astronomy and Astrophysics, Astrophysical Journal, Astronomical Journal, Monthly Notices of the Royal Astronomical Society, Journal of Instrumentation.

Davide Maino

Date of birth: 19.04.1969

Sex: Male

Nationality: Italian

Education

1999	PhD – supervisor: Luigi Danese, Marco Bersanelli International School of Advanced Studies, Trieste, Italy
1994	Master – supervisor: Marco Bersanelli Department of Physics, University of Milano, Italy

Current and previous positions

2011-2016	Associate Professor Department of Physics, University of Milano, Italy
2002-2011	Researcher Department of Physics, University of Milano, Italy
2000-2002	Postdoctoral fellow Astronomical Observatory, Trieste, Italy

Fellowships and awards

1996-1999	Ph. D. fellow, International School of Advanced Studies, Trieste, Italy
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Supervision of graduate students and research fellows

2002-2016 6 PhD students; more than 10 Master students

Department of Physics, University of Milano, Italy

Major collaborations and key collaborators

LSPE Italian experiments for large scale polarisation mapping
EUCLID ESA-funded international Galaxy Survey/Lensing mission
CORE ESA-led international CMB satellite mission concept
Planck ESA-funded international CMB satellite mission
BEAST US-led international CMB temperature anisotropies

Publication summary

As quantified by Scopus, I have published a total of 164 papers as of February 2017, resulting in a total of 23,080 citations and an *h*-index of 64, both excluding self-citations. Most of my papers are published in Astronomy and Astrophysics, Monthly Notices of the Royal Astronomical Society, Astrophysical Journal and Physical Review D.

Aniello Mennella

Date of birth: 07.05.1964

Sex: Male

Nationality: Italian

Education

1989 Master – supervisor: Roberto Pozzoli
Department of Physics, University of Milano, Italy

Current and previous positions

2015-2016 Associate Professor
Department of Physics, University of Milano, Italy
2005-2015 Researcher
Department of Physics, University of Milano, Italy
2000-2005 Researcher
INAF-IASF, Milano, Italy
1995-2000 Senior Researcher
Eniricerche S.p.A., San Donato Milanese, Italy

1990-2000 Researcher
 Eniricerche S.p.A., San Donato Milanese, Italy

Fellowships and awards

1993 Visiting scientist, University of Wyoming, Laramie, USA
2009-2011 Visiting scientist, Osservatorio Astronomico, Trieste, Italy

Supervision of graduate students and research fellows

2000-2016 4 PhD students; more than 20 Master students and Bachelor students
 Department of Physics, University of Milano, Italy

Major collaborations and key collaborators

LSPE Italian experiment for large scale polarisation mapping (with the position of Program Manager and Deputy PI)
QUBIC International experiment for CMB polarisation measurements aimed at B-mode detection (with the position of System scientist)
CORE ESA-led international CMB satellite mission concept
Planck ESA-funded international CMB satellite mission (with the position of Calibration Scientist)
BEAST US-led international CMB temperature anisotropies

Publication summary

As quantified by Scopus, I have published a total of 212 papers as of February 2017, resulting in a total of 10445 citations and an *h*-index of 54, both excluding self-citations. Most of my papers are published in Astronomy and Astrophysics.

Maurizio Tomasi

Date of birth: 07.02.1978
Sex: Male
Nationality: Italian

Education

2004–2007 P.h.D. in Physics (Università degli Studi di Milano, Italy)
1997–2002 Master degree in Physics (Università degli Studi di Milano, Italy)

Current and previous positions

2013–2016 Researcher (RTD-A), Università degli studi di Milano

Fellowships and awards

2011–2013 Postdoctoral fellowship, Istituto nazionale di astrofisica (INAF)

2007–2011 Postdoctoral fellowship, Università degli studi di milano

2004–2007 Postdoctoral fellowship, Istituto nazionale di astrofisica (INAF)

Supervision of graduate students and research fellows

2004–2007 2 PhD students, 8 master students

Major collaborations and key collaborators

LSPE Italy-led CMB polarization experiment; leader of the LSPE/STRIP pipeline development (2016–)

CORE++ ESA-led international CMB satellite mission concept, leader of the activities involving the simulations of calibration systematics (2016–)

Planck ESA-funded international CMB satellite mission (2002–2017): leader of the calibration activities for the 2013 and 2015 data releases

Publication summary

Number of refereed publications: 160.

h-index: 66

Number of citations: 23,749.

Most of my papers are published in *Astronomy and Astrophysics*, and *Journal of Instrumentation*.

4.1.2.3 Selected publications and previous projects

Five publications relevant for the current proposal

1. Planck Collaboration 2016, *A&A*, 594, A1, *Planck 2015 results. I. Overview of products and results*, 339 citations
2. Planck Collaboration, *A&A*, 594, A3, *Planck 2015 results. III. LFI systematic uncertainties*, 31 citations
3. Planck Collaboration, *A&A*, 571, A16, *Planck 2013 results. XVI. Cosmological parameters*, 4999 citations

4. A. Mennella, et al., 2011, A&A, 536, A3, Planck early results. III. First assessment of the Low Frequency Instrument in-flight performance, 108 citations
5. M. Bersanelli, et al. 2010, A&A, 520, A4, Planck pre-launch status: Design and description of the Low Frequency Instrument, 107 citations

Five previous projects relevant for the current proposal

1. *Planck/LFI instrument development*, Management: PI: N. Mandolesi, Deputy PI and Instrument Scientist: M. Bersanelli, PM: C. Butler. Main contributor: Italian Space Agency (ASI), for €30.5M, 1998-2009.
2. *Large Scale Polarization Experiment, STRIP instrument*, PI: M. Bersanelli, PM: A. Mennella, €1.9M, 2013-2019.
3. *Q&U Bolometric Interferometer for Cosmology (QUBIC)*, UniMI grant managed by A. Mennella (System Scientist of QUBIC), €200k for 2015-2017
4. *Advanced Technology Development for Radio and Microwave Applications*, Regione Sardegna and Regione Lombardia, PI: M. Bersanelli, , €1.6M, 2012-2015
5. *Microwave polarized emission of galactic and cosmological origin*, Italian Ministerial Grant (PRIN), PI: M. Bersanelli, €450k for 2009-2012

4.1.3 Roma I – La Sapienza

4.1.3.1 Description

Sapienza University of Rome is the largest university in Europe and the second in the world for number of students and the wide academic offer that includes over 250 degree programmes and about 80 PhD programmes. Sapienza plans and carries out important scientific investigations in almost all disciplines, achieving high-standard results both on a national and on an international level, thanks to the work of its 11 faculties, 63 departments and several centres devoted to scientific research. This is clearly shown also by the 151 grants signed in 2012 under FP7, with a total financing of almost 150 million euro. In this E4 project will be involved the Department of Physics, one of the largest in Sapienza.

The **Department of Physics** of the Sapienza University of Rome is the natural heir of the tradition of Enrico Fermi and Ettore Majorana, Edoardo Amaldi (the School of Rome), and is renowned throughout the world for high quality of research, international prestige and the variety of the courses offered. The research activity consists both in the construction of complex experimental devices operating in the Department or in the major research laboratories in the world, and in publishing scientific reports, about 600 per year, in the most prestigious international journals. The Department hosts research facilities of the major Italian institutions such as the National Institute of Nuclear Physics (INFN), the National Institute for the Physics of Matter (INFM), the Consiglio Nazionale delle Ricerche (CNR), the Italian Space Agency (ASI), the ICRA.

The **Observational Cosmology Laboratory (G31)** at the Physics Department of the Sapienza University of Rome produces and tests instrumentation for observations of the sky at submillimeter and millimeter wavelengths. The group was involved, since 1980, in many experiments from different observational sites: ground-based, balloon borne and satellite. In this laboratory has been developed and actually built hardware for the MITO observatory on the Alps, the BRAIN experiment in Antarctica, the BOOMERanG stratospheric balloon and the High Frequency Instrument aboard of the Planck satellite of ESA. Current projects include LSPE and QUBIC. The laboratory is equipped with facilities for : a) developing and assembling radiation filters and new technology detectors, like KIDs, specifically for mm-bands; b) testing and developing readout low noise electronics; c) cryogenic systems for ensuring low temperatures (< 300 mK) for detectors

and optical systems; d) calibrating photometers, polarimeters and spectrometers in the sub/mm spectral range; e) data analysis support (workstations, storage space with backup, small clusters and access to large supercomputers). Laboratory personnel contributed very significantly to the development of the analysis pipeline of the BOOMERanG experiment, one of the first large datasets for CMB anisotropy, and of the B2K experiment, one of the first large datasets for CMB polarization. These pipelines were improved further for the analysis of the data from Planck-HFI. The analysis pipelines for LSPE and QUBIC will inherit quite directly these development, and in particular the treatment of systematic effects, developed in the G31 group.

Our G31 team has deeply rooted collaborations with many research groups which are contributing to this project. In particular we want to emphasize the collaboration with the group of Rome Tor Vergata contributing to the data analysis of all our experiments (and in particular dr. Giancarlo De Gasperis), and the collaboration with IFN-CNR (and in particular dr. Gabriella Castellano) for state-of-the-art processing of KIDs wafers.

4.1.3.2 CVs

Elia Battistelli (male)

Researcher at Sapienza University of Rome. Focus on CMB, Sunyaev-Zel'dovich effect, Anomalous Microwave Emission, Microwave Instrumentation, CMB experiments. Experience in instrumentation (coherent detectors, TES bolometers, Kinetic Inductance Detectors, Calibration Methods), data-analysis and theoretical work. Member of several collaborations: ACT, OLIMPO, LSPE, QUBIC. Author of more than 120 papers on international journals, with more than 3300 citations. H-index=29 (ADS).

Gabriella Castellano (female)

Senior Researcher at the Institute for Photonics and Nanotechnologies of the National Research Council. She concentrated her work on the development of superconducting devices, both Josephson and single-electron ones, from microfabrication (with thin film technology) to characterization and applications (high sensitivity SQUIDS, hot-electron microbolometers, electrometers). A major activity of the last years has been studying the fundamental quantum properties (in particular quantum coherence) of Josephson devices, and in their application to quantum computing. Her research interests/expertises are: Condensed Matter Physics, Superconductivity, Josephson Effect, Quantum Tunnelling Phenomena in Superconductors, Physics of Superconducting Electronics Devices and Sensors, Thermal and Quantum Fluctuations in Josephson Devices, Superconducting Single-electron Devices, Quantum Computing with Superconducting Devices. Methods of Electronics Measurements at Low Temperatures of Superconducting Devices, Cryogenic Technology, Thin Film Fabrication Technology, Micro- and Nano-Technology. MGC has been manager of the Micro and Nanofabrication facility of her Institute from 2002 to 2007. Since 2011 MGC is Director Delegate of the Rome branch of IFN Institute. Co-author of more than 200 papers on international journals, with more than 1800 citations. H-index=21 (Google Scholar).

Paolo de Bernardis (male, coordinator)

Experimental Astrophysicist, focus on CMB. Full Professor at Sapienza Università di Roma. Teaches the classes of Astrophysics and Observational Astronomy. Italian PI of the stratospheric balloon experiment BOOMERanG/B2K on the anisotropy and polarization of the CMB, which detected the first time acoustic oscillations in the primeval plasma, and demonstrated the flatness of the Universe. Co-investigator of the HFI of the ESA-Planck satellite mission. PI of the Large Scale Polarization Explorer (LSPE) mission and member of the steering committee for QUBIC. Leads the development of Kinetic Inductance Detectors for the CMB funded by the Italian Space Agency. Has been assigned the Feltrinelli, Balzan, Dan David and Cocconi prizes for his research. Author of more than 400 papers on international journals, including renowned papers. More than 35000 citations, H-index=85 (ADS).

Giancarlo De Gasperis (male)

Researcher at the University of Rome “Tor Vergata”. Research focus on Cosmology, Large-scale structure, CMB anisotropy and polarization, Data Analysis methods, Numerical Simulations. Teaches the classes of Astrophysics Laboratory, Computation and Simulation Laboratory. Planck Scientist, active in the data analysis of the LFI and BOOMERanG experiments. Member of the OLIMPO, LSPE and QUBIC collaborations. Has developed the ROMA original map-making code for CMB experiments. Author of more than 100 papers on international journals; more than 8000 citations, H-index = 47 (ADS).

Marco De Petris (male)

Experimental Astrophysicist. Researcher at Sapienza Università di Roma. Teaches the class of Astronomical Optics. Main research interests in Observational Cosmology and Cosmic Microwave Background radiation anisotropies; Clusters of galaxies science with cosmological implications by Sunyaev-Zel’dovich Effect observations and simulations; Optical design for dedicated CMB observations at millimetre and sub-millimetre wavelengths; Site testing at millimetre and FIR wavelengths: instrument design and data analysis; Experimental techniques and observational strategies for cosmological and astrophysical observations, photometric and interferometric, at millimetre and far infrared regions of the spectrum; Instruments development for ground based, balloon borne and satellite projects. PI of the CASPER project (mm/submm site testing at Dome-C and MITO). More than 900 citations, H-index=17 (ADS).

Silvia Masi (female)

Experimental Astrophysicist, focus on experimental techniques for the measurements of the Cosmic Microwave Background (cryogenics, detectors, filters). Associate Professor at Sapienza Università di Roma, teaches the classes of Electromagnetism Laboratory and Methods of Space Astrophysics. Author of more than 350 papers on international journals, including renowned papers. Has been in charge of the analysis of foreground emission for the BOOMERanG and B2K experiments. Participated in 6 antarctic expeditions and 2 arctic ones. PI of the OLIMPO balloon-borne experiment. Italian PI of QUBIC and Thermal Coordinator. Scientist and member of the core-team of the HFI of the ESA-Planck satellite mission. Thermal Coordinator for the SWIPE instrument on LSPE. More than 32000 citations, H-index=81 (ADS).

Alessandro Melchiorri (male)

After a PPARC fellowship at the University of Oxford, Alessandro Melchiorri joined the staff of the Rome cosmology group as lecturer and as responsible of the theory and data analysis sector in 2002. He has been a team member of the BOOMERanG experiment, he participated to several major grants in Italy and Europe, he is currently Planck Scientist for the on-going Planck satellite mission, and he coordinated the Italian theory/weak lensing group for the EUCLID satellite mission, recently approved by ESA and scheduled for launch in 2020. Associate Professor since 2015. His scientific activity is mainly focused on the field of CMB theory and data analysis. In the past ten years, he co-authored more than 410 papers with more than 36000 citations and Hirsch Factor $h=88$ (ADS database).

Enzo Pascale (male)

Associate professor at the Sapienza University of Rome, teaching Observational Cosmology. Research interests: Observational Cosmology: Cosmic Microwave Background, CMB polarization, High Z Submillimetre Galaxies. Star Formation: in our Galaxy and galaxies at cosmological distances. Diffuse Interstellar Medium. Astronomical Instrumentation: at millimetre and submillimetre waveleghts. Extrasolar Planets. He co-authored more than 260 papers with more than 12000 citations and Hirsch Factor $h=48$ (ADS database).

Francesco Piacentini (male)

Associate professor at the Sapienza University of Rome, teaching Astrophysical Processes and Plasmas. He is an experienced researcher in Observational Cosmology, with focus on Cosmic Microwave Background

radiation. He is active in instrument design, instrument development and data analysis. He contributed effectively to the data analysis of the HFI instrument on board the Planck satellite, with particular effort on the calibration of the polarimeters, measure of detectors and electronics time response, optical response, and control of systematic effects. He is author of more than 280 papers, has more than 31000 citations, H-index=81 (ADS).

4.1.3.3 Publications

1. P. de Bernardis et al. “*A Flat Universe from High-Resolution Maps of the Cosmic Microwave Background Radiation*”, *Nature*, **404**, 955-959, (2000)
2. S. Masi et al. “*Instrument, Method, Brightness and Polarization Maps from the 2003 flight of BOOMERanG*”, *Astronomy and Astrophysics*, 458 , 687-716 (2006)
3. F. Piacentini et al. ”*A measurement of the polarization-temperature angular cross power spectrum of the Cosmic Microwave Background from the 2003 flight of BOOMERANG*”, *Ap.J.*, **647**, 833-839 (2006)
4. S. Masi, et al. “*On the effect of cosmic rays in bolometric CMB measurements from the stratosphere*”, *Astronomy and Astrophysics*, **519**, A24, (2010)
5. P. de Bernardis, et al. “*SWIPE: a bolometric polarimeter for the Large-Scale Polarization Explorer*” *Proc. SPIE 8452*, Millimeter, Submillimeter, and Far-Infrared Detectors and Instrumentation for Astronomy VI, 84523F (October 5, 2012)

4.1.3.4 Projects

1. Development (as PI institution) of CMB experiments like MITO, BOOMERanG, OLIMPO, LSPE.
2. Development of the cryogenic systems for the MITO, BOOMERanG, Pilot, BRAIN, OLIMPO, LSPE, QUBIC instruments for mm/submm astronomy and CMB observations.
3. Development of site testing instrumentation for the MITO site on the Alps and the Dome-C station on the Antarctic Plateau (BRAIN pathfinder polarimeter @ 140 GHz, CASPER interferometer in the 100-400 GHz range)
4. Study of systematic effects in polarimeters for CMB B-modes (see e.g. Pagano et al. “*CMB Polarization Systematics, Cosmological Birefringence and the Gravitational Waves Background*” *PHYSICAL REVIEW D* 80, 043522 (2009)
5. Cosmological Data fusion and optimal estimation of cosmological parameters

4.1.3.5 Infrastructure

Laboratory for astrophysics in the mm band, including:

- cryogenics equipment, such as mechanical pulse-tube coolers, Helium wet dewars, sub-K coolers (dilution down to 100 mK),
- electronics development facility (low-noise, modulators/demod for KIDs),
- detectors development facility (KIDs)
- mm-wave sources (Gunn 90, 140, 220 GHz; Hg lamp, BWO) and related optical systems
- Fourier Transform Spectrometers for filters and detectors testing (MPI, differential MPI, Lamellar Grating)
- Vector Network Analyzer (low-frequency and W band)
- Class-1000 clean room for handling detectors, filters and optics and integration of focal planes for CMB instruments; including wedge-bonder, micro(laser)-writer for detector wafers, hot press for embedded filters.

4.1.4 INFN

4.1.4.1 Description

The National Institute for Nuclear Physics (INFN) is the Italian research agency dedicated to the study of the fundamental constituents of matter and the laws that govern them, under the supervision of the Ministry of Education, Universities and Research (MIUR). It conducts theoretical and experimental research in the fields of subnuclear, nuclear and astroparticle physics. All of the INFN's research activities are undertaken within a framework of international competition, in close collaboration with Italian universities on the basis of solid academic partnerships spanning decades. Fundamental research in these areas requires the use of cutting-edge technology and instruments, developed by the INFN at its own laboratories and in collaboration with industries. Groups from the Universities of Rome, Padua, Turin, and Milan founded the INFN on 8th August 1951 to uphold and develop the scientific tradition established during the 1930s by Enrico Fermi and his school, with their theoretical and experimental research in nuclear physics. In the latter half of the 1950s the INFN designed and built the first Italian accelerator, the electron synchrotron developed in Frascati, where its first national laboratory was set up. During the same period, the INFN began to participate in research into the construction and use of ever-more powerful accelerators being conducted by CERN, the European Organisation for Nuclear Research, in Geneva. Today the INFN employs some 5,000 scientists whose work is recognised internationally not only for their contribution to various European laboratories, but also to numerous research centres worldwide. INFN is presently organized in 20 "Sezioni" (hosted in the main University cities in Italy) four National Laboratories and two National Centres, one devoted to computing (CNAF, Bologna) and the other to fundamental physics and applications (TIFPA, Trento).

4.1.4.2 CVs

4.1.4.2.1 Giovanni Signorelli (coordinator; Male)

Giovanni Signorelli is a graduate of Pisa University and Scuola Normale Superiore and he received his PhD in Physics by Scuola Normale Superiore di Pisa in 2005. He is research scientist for Istituto Nazionale di Fisica Nucleare in Pisa since 2005. He performed his research work in several foreign laboratories such as FermiLab (Chicago) and Paul Scherrer Institut (Switzerland). He started his research career in the field of experimental particle physics studying CP violation in B-meson systems, and its measure at hadron colliders. He developed a particular interest in rare-event analysis and in finding coherent approaches to systematic error evaluations in frequentistic statistics. He is involved, together with the INFN Pisa group, in the MEG experiment to search for the $\mu \rightarrow e\gamma$ decay. He has been the principal investigator of a FIRB project (grant from the Italian Ministry of Education for Young Scientists, 348k€) to study charge-scintillation hybrid cryogenic liquefied noble gases detectors for high energy physics. He is presently involved in the LSPE experiment to search for the B-mode polarization of CMB on a balloon-borne mission, as responsible of the Pisa INFN group in charge of detector and electronics development (300 k€). He is responsible of the INFN group (in charge of electronics and detector development) in the Italian Space Agency founded COSMOS project to study future ground based, balloon borne and space missions for the measurement of CMB (210 k€).

Since 2000 he has been teaching assistant at the Physics Department of Pisa University in several topics, such as Introductory Nuclear and Subnuclear Physics (prof. Carlo Bemporad), Astroparticle Physics (prof. Carlo Bemporad, dott. Alessandro Baldini), Nuclear and Subnuclear Physics (prof. Flavio Costantini) and Elementary Particle Physics (prof. Flavio Costantini). He has been advisor and co-advisor of several Master's and PhD theses.

4.1.4.2.2 Flavio Gatti

Flavio Gatti (gender: male) is presently an associate professor at the University of Genova. He is an Invited member of the Scientific Advisory Committee for the Center for Underground Physics of Korea, Member of

USA-Italy (NSF-DoE-INFN) Review Committee for the International Projects at the Gran Sasso Underground National Laboratory (LNGS) (up to 2014), member of the Local Organising Committee of The Summer School of ESAS “New Trend on Superconducting Quantum Detector”, Genova 5-9 Sept. 2013, Member of Genova University Review Panel of Physics Research Area, Associated Collaborator of the Italian Institute for Astrophysics - INAF 05/03- 04/09 Member of the Astroparticle Physics National Review Panel of the INFN. He has been involved in the organization and Chairman of the 10th International Conference on Low Temperature Detector, LTD-10, Genova (<http://ltd-10.ge.infn.it/>).

He is presently the Group Leader of Low Temperature Detector Lab, Univ. and INFN of Genova 11/01 – present Professor Associate, Experimental Physics, Faculty of Science, University of Genoa.

His research interests involve neutrino Physics: beta decay, mass of neutrinos and solar neutrinos (BOREXino project at Gran Sasso, HOLMES project ERC-INFN). Lepton Flavour Physics: Lepton Flavour Violating Decay of the Muon (MEG project at PSI). X-ray Astrophysics: Interstellar and Intergalactic Medium (ATHENA project -ESA). Cosmology: Microwave Background Polarization LSPE project ASI-INFN). Low Temperature Physics and Technology: Sub-K coolers and measurements, superconducting materials (MgB₂). Detectors: Cryogenic TES Micro-calorimeters and Bolometers, THZ detector for Homeland Security, SIS Junctions and SQUIDS electronics, superconducting Single Photon Detectors. Micro-Fabrication: all thin film and micro machined devices. Electronics: Low noise Analog Front-End electronics, Fast Data Acquisition Electronics VME and PXI, digital processing signals from detectors.

He has had total of 23 funded projects or sub project since 1993: 8 PI-ship, 15 sub-Project leadership. Funding last 5 years: ca. 3.8 M€, among which: Italian Ministry of Research Grant (MIUR-Progetto Premiale 2012) to the ASI led Consortium on Cryogenic Detector, Project Leader for Detector Design and Fabrication of ATHENA X-ray space observatory. Italian Space Agency (ASI), “Developments in the mm and sub-mm wavelength for CMB Polarization experiments”. Project leader for Design and Fabrication of the cryogenic Large Area TES Spider Bolometer (4 years, ca. 300k€). 01/08-12/08 Italian Space Agency (ASI), Phase A study for Small Mission: SAGACE -“Spectroscopic Active GALaxies and Clusters Explorer”. ProjectLeader for TES Detector Segment (1 year, 120k€). 02/07-01/09 Italian Ministry of Research, MIUR, PRIN2006, Arrays of TES Bolometers, Projectleader of planar array of bolometer with polarization sensitive design (2 years, ca.100 k€). 01/07-06/11 EU FP6- IP for SME, TERAEEYE: development of cryogenic camera with Quantum-dot at 1K for passive and spectroscopic detection of THz for Homeland Security: Co-PI (4 years, ca.700K€)

He is a Member of the IAC of Low Temperature Conferences. Member of the International Program Committee of ASC2014, Charlotte 10-15 Aug. 2014. Editor of ASC2014’s proceedings, Charlotte 10-15 Aug. 2014. Member of the Program Committee of EUCAS 2013, Genova 15-19 Sept 2013. Editor of LTD-10 Proceedings of the 10th international conf. on Low Temperature Detector. Invited External Reviewer for full Professor Position at the Phys. Dept., Stanford University, CA, USA. Invited External Reviewer for Team Leader at High Energy Astrophysics Group, NASA-Goddard, USA. Referee of the Astroparticle Physics National Review Panel of the INFN for several international project JUNO, ICARUS, WARP, GERDA, T2K, CUORE. Referee for PRL, APL, JLT, APJ, NIMA/B, Nuclear Physics and others. Member of several more than 30 Referee Panels for selection of young researcher.

4.1.4.2.3 Sabino Matarrese

Gender: Male

Date of birth: 23-09-1955 Nationality: Italian

URL for web site: <https://www.linkedin.com/in/sabino-matarrese-45615262>

Magister Philosophiae in Astronomy: SISSA, Trieste 1982

Citation count: (from ADS) 39,540. Hirsch h index: 92. riq index: 257. i-10 index: 338

av. cites per year: 1100 (over the last 10 years: 2800)

Hirsch m index: 2.49

Publications: 373 on refereed journals

Communication: ~ 70 invited talks; 6 series of lectures at International schools;

Director of 3 international PhD schools; several public outreach talks in various countries.

PhD Supervision: Supervised 22 PhD students, 9 have now a permanent position; all others are in postdoctoral positions

Postdoc Advising: 4 postdoctoral researchers, who are now in postdoctoral (3) or permanent (1) positions.

Fellowships and awards: SISSA fellowship (1980 – 1983); Invited scientist for 1 year at MPA Garching (DE).

Expertise: Specialist in inflation modeling, he pioneered the field of primordial non-Gaussianity, which he started to analyze since the mid eighties. Specialist in the analysis of non-linear and GR effects in the evolution of cosmological matter perturbations and galaxy clustering, pioneered the field of higher-order GR perturbation theory, on which he started to work in the early nineties.

4.1.4.2.4 Benno Margesin

Benno Margesin (male) was born in Bolzano, Italy, in December 1955. He received the doctor degree in physics, in 1980, from the University of Bologna with a thesis on electron optics applied to the electron microscopy. He joined the Istituto Trentino di Cultura of Trento in 1982 and started his activity as a researcher of the ion implantation group. Within the ion implantation group he was involved in the design and development of heavy ion sources and of electron-optical elements for heavy ion implanter. He joined in 1987 the Integrated Circuits Fabrication Laboratory, now the Microsystem Division (MIS) of ITC-irst, where led the ion implantation and furnace group. Since 1992 he is also involved in the development of sensors and the study of micromechanics. In particular he developed physical and chemical sensors and their fabrication processes, as there are cryogenic microcalorimeter, ISFETs, LAPS, biosensors, pressure sensors, microelectrodes and passive components for microwave circuits, for applications in research and industry. In 1997 he became the leader of the BioMEMS group at ITC-irst (now FBK). His activity on RF MEMS devices dates back to the beginning of the INCO COPERNICUS Project No. 977131 "Micromachined circuits for microwave and millimeter wave applications – MEMSWAVE". where he collaborated in the development of low loss passive RF components. In 2006 he becomes the head of the MEMS group of the MIS (MicroSystems) Division at ITC-irst. From January 2008 till December 2008 he lead the MEMSRad Research Unit and from January 2009 till December 2013 he was the head of the MEMS Research Unit in FBK. At present his scientific interest is related to development of RF passive components on silicon (switches), capacitive silicon microphones, bolometres and physical sensors for consumer and industrial applications.

He is co-author of invited talks of national and international conferences. He is also co-inventor of a patent in the field of biomedical devices for the measurement of the metabolic activity of living cells.

4.1.4.2.5 Nicola Vittorio

Gender: Male

Nicola Vittorio is full professor of Astronomy and Astrophysics at the Physics Dept. of the University of Rome Tor Vergata. He has been Dean (1999-2008) of the Faculty of Science and President (2006-2008) of the Association of the Deans of the Italian Faculties of Science. From 2010 to 2013 he has been Vice-Rector for High Education of the University of Rome Tor Vergata. He has been President of the evaluation board of the Università della Calabria (2009-2013). He has coordinated for the Ministry of Education, University and Research (MIUR) the project “Lauree Scientifiche”, aimed to have a unified view of the path that a young individual has to undertake in his/her life, from school, to the University, to the job-market. Since 2010, he is the Deputy President of the MIUR Committee for the Development of the Scientific and Technological Culture, chaired by Prof. Luigi Berlinguer. He has joined of the MIUR Technical Secretary for Scientific Policy (2012-2015) and Chairman of the Bologna Follow-Up Group – BFUG Working Group on the Third Cycle of European Higher Education Area. Since 2013 he is Vice-rector for Doctoral Education. His main research interest is in theoretical cosmology and data analysis of balloon-born and space missions. He has been member of the BOOMERANG Collaboration and Co-I of the LFI experiment of the ESA/Planck satellite, two experiments devoted to the study of the Cosmic Microwave Background anisotropy and polarization. He is coordinating a national project financed by ASI devoted to identify the future suborbital and orbital CMB missions of interest for the whole CMB Italian community. He has published more than 180 articles on refereed journals (www.nicolavittorio.eu/en/pubblicazioni-scientifiche-2). He is member of the European Academy of Sciences and Arts, of the International Astronomical Union, of the European Physical Society, of the Academy of Science of Turin, of the Italian Physical Society, of the Italian Astronomical Society and of the Italian Society for the Advancement of Science.

4.1.4.2.6 Paolo Natoli

Gender: Male. Born in Roma, March 3rd, 1971. Degree in Physics summa cum laude, 1996. PhD in Physics, 2000. Visiting scholar at UC Santa Barbara in 1998/1999. PostDoc, University of Rome "Tor Vergata", 2000-2002. Research assistance since 2002 (confirmed 2005), Department of Physics, University of Rome "Tor Vergata". Associate professor at the University of Ferrara since 2014. Field of research: cosmic microwave background anisotropies, theory and data analysis. Member of the past collaboration BOOMERanG and BEAST. Associate of the Planck Surveyor ESA space borne mission. Scientific Secretary of the Planck/LFI Core Team and coordinator of several scientific and technical working groups. Planck Scientist since 2004. Member of the LSPE, Euclid and CORE collaborations. Author or co-author of several (more than 200) papers on international refereed journals, as well as of several conference proceedings. His current h-index is higher than 70 (NASA/ADS). He has been advisor for several master and PhD students. He holds lectures in Cosmology and General Relativity for master level students. He is referee for several international journals.

4.1.4.3 Relevant Publications

[INFN/1] M. Biasotti, V. Ceriale, D. Corsini, M. De Gerone, F. Gatti, A. Orlando, G. Pizzigoni, “Fabrication and Test of Large Area Spider-Web Bolometers for CMB Measurements”, *J Low Temp Phys* (2016) 184: 642. doi:10.1007/s10909-015-1390-y

[INFN/2] M. Biasotti, D. Bagliani, D. Corsini, P. de Bernardis, F. Gatti, R. Gualtieri, L. Lamagna, S. Masi, G. Pizzigoni, A. Schillaci “Large Area Superconducting TES Spiderweb Bolometer for Multi-mode Cavity Microwave Detectors” *Journal of Physics: Conference Series*. p. 042004-1-042004-4, IOP PUBLISHING LTD, Genova, doi: 10.1088/1742-6596/507/4/042004

[INFN/3] D. Vaccaro, A.M. Baldini, F. Cei, L. Galli, G. Gallucci, M. Grassi, A. Iezzi, M. Incagli, D. Nicolò, F. Spinella, M. Venturini, Y. Venturini, G. Signorelli, “The FDM readout system for the TES bolometers of

the SWIPE instrument on the balloon-borne LSPE experiment”, Proc.SPIE Int. Soc. Opt. Eng. 9914 (2016) 99143C, DOI: 10.1117/12.2232186

[INFN/4]Giachero, P. K. Day, P. Falferi, M. Faverzani, E. Ferri, C. Giordano, M. Maino, B. Margsin, R. Mezzena, R. Nizzolo, A. Nucciotti, A. Puiu, L. Zanetti, “Development of Microwave Superconducting Microresonators for Neutrino Mass Measurement in the Holmes Framework”, J Low Temp Phys (2016) 184: 123. doi:10.1007/s10909-015-1441-4

[INFN/5]Planck collaboration, including S. Matarrese. Astronomy & Astrophysics. 594, A17, 2016. “Planck 2015 results: XVII. Constraints on primordial non-Gaussianity”.

4.1.4.4 Relevant Projects

- Large Scale Polarization Explorer (LSPE). A balloon-borne mission to search for B-modes in the CMB (<http://planck.roma1.infn.it/lspe/index.html>)
- The Planck Satellite. See http://www.esa.int/Our_Activities/Space_Science/Planck
- The HOLMES experiment. Search for neutrino-less double-beta decay with superconducting micro-calorimeters.
- ASI/COSMOS (www.cosmosnet.it) Cosmic Orbital and Suborbital ObservationS. A Feasibility study for future ground-based, balloon-borne and space CMB missions.

4.1.4.5 Relevant Infrastructure and Equipment

INFN Genova hosts a laboratory for the prototyping and production of TES detectors. INFN Pisa hosts large clean-rooms in which we are presently installing new machines for the prototyping and production of lithographed structures. Sub-Kelvin (dilution, 3He-4He, dry and wet) cryostats are present in Pisa, Genova and Trento for detector and electronics testing. Fondazione Bruno Kessler (FBK) in Trento, is a non-profit research organization founded by Provincia Autonoma di Trento, which is among the founding partners of the INFN centre TIFPA (Trento Institute for Fundamental Physics and Applications). FBK is equipped with two Clean rooms and a complete 6” line for MOS processing complemented with the process technologies for MEMS fabrication. Other interesting ability are: stoichiometric TiN films with a Tc of 4.5 K, multilayer films of Ti and TiN that allow to tune Tc from below 500 mK up to 4.5 K and fabrication on quartz wafers.

4.1.5 IAC

Description of the legal entity

The IAC is an internationalized Spanish research centre aiming to achieve major advances in the understanding of the laws that govern the origin and evolution of the various forms of matter/energy in the Universe. The Spanish Government, the Government of the Canary Islands, the University of La Laguna and the Spanish National Research Council (CSIC) support this outstanding research centre which carries out leading research and develops technology for astrophysics, leads training programmes for researchers and technicians and promotes astronomy to the public. It also manages the two international Astronomical Observatories in the Canary Islands; Roque de los Muchachos Observatory (ORM), in La Palma; and Teide Observatory (OT), in Tenerife.

The Instituto de Astrofísica de Canarias (IAC) has the most advanced equipment, state of the art facilities and highly skilled personnel, enabling it to design and develop in-house much of the technology required for its activities in astrophysical research. *CMB experiments need innovation and very advanced technologies.* The IAC has been also involved in around a dozen projects that have overcome technological challenges in fields as diverse as microwave reception, cryogenic systems and data compression.

Our expertise for the proposed project

The IAC has recognized experience in the development of instrumentation for Space and Ground based astronomy. In particular, the “Cosmic Microwave Background (CMB)” team at the IAC is a group with a long tradition in CMB research (<http://www.iac.es/proyecto/cmb/>), with more than 30 years experience in the observational study of the CMB anisotropies (Tenerife Experiment, COSMOSOMAS, JBO-IAC interferometer, Bartol-IAC interferometer, VSA, QUIJOTE and Planck). Concerning PLANCK, the IAC node had three Planck Scientists, and three LFI Core Team members. Our group has taken a leading role in the activities related to SZ clusters and secondary anisotropies, and in particular, J.A. Rubiño was the coordinator of this Working Group for the mission. We have also devoted a significant effort to carry out the characterization of the optical counterparts of those newly discovered galaxy clusters. Concerning QUIJOTE, we note that both Prof. R. Rebolo (PI of the project), and J. A. Rubiño-Martín (Project Scientist of QUIJOTE) are both members of the CMB group at the IAC. In addition, the Teide Observatory in Tenerife is the physical location of QUIJOTE. Our team is the main responsible for the integration of the QUIJOTE instruments, the scientific operations of the two telescopes, and the data reduction/analysis of the project. We finally note that our group is leading the data processing and data analysis of the QUIJOTE “Wide Galactic Survey”, a shallow survey covering 20,000 deg² of sky in intensity and polarization, which is being used within the RADIOFOREGROUNDS project (G.A. 687312). The survey has already started, accumulating more than 9 months of observations with the MFI (11–19GHz). We expect to reach final sensitivities of ~20 μ K per one degree beam in the Stokes Q and U maps.

Relevant previous projects and activities

As institute, our main participation in projects related to this proposal are detailed in the following paragraphs:

PLANCK (and HERSCHEL) satellites: The IAC was a member of the international consortia that developed the PACS (*Photoconductor Array Camera & Spectrograph*) and SPIRE (*Spectral and Photometric Imaging Receiver*), instruments for the Herschel satellite, and the LFI (*Low Frequency Instrument*) for the Planck satellite. The Herschel and Planck satellites were launched together on an Ariane rocket from Kourou in French Guyana on 14th May 2009. HERSCHEL is designed to explore the electromagnetic spectrum in the 200 to 670 micron range, whilst PLANCK was built to obtain maps of the Cosmic Microwave Background between 30 and 900 GHz at unprecedented resolution and sensitivity. The IAC supplied the REBA (Processing, Compression and Control Unit) electronic component and associated low-level and scientific software for the LFI. The IAC also designed the phase switch and designed, produced and commissioned the composite 33 and 44 GHz radiometers. The IAC also worked on the LFI's Instrument Control Centre project. Our contribution to the PACS and SPIRE instruments for HERSCHEL was the concept and development of the ICCs (Instrument Control Centres). The IAC also supplied the SPU (Processing and Data Compression Unit) electronic component for the PACS project as well as the associated low-level on board software.

QUIJOTE: The CMB group at the IAC has the leading role in developing and installing a new experiment, the so called QUIJOTE-CMB (Q-U-I JOint TEnerife CMB) experiment, with the aim of characterizing the polarization of the Cosmic Microwave Background, and other galactic or extragalactic physical processes that emit in microwaves in the frequency range 10-42GHz, and at large angular scales (1 degree resolution). Apart from the IAC, the other partners of the QUIJOTE project are the IFCA (Santander), the Departamento de Ingeniería de Comunicaciones (DICOM, Santander), University of Manchester (UK) and the University of Cambridge (UK). The experiment has two phases. In the first phase (which is fully funded and currently under construction), we installed a first telescope (QT-1) and we are building two instruments. The first one is a multi-frequency instrument (MFI), observing at four frequency bands (11, 13, 17 and 19 GHz), which had the first light in November 2012. The second instrument of QUIJOTE consists of 31 receivers at 30GHz, and is now in the commissioning phase. The second phase of QUIJOTE consists in a second telescope (QT-2), already installed and in operations, plus a third instrument at 42 GHz, now in AIV phase. The IAC has led the design and construction of the two telescopes (QT-1 and QT-2), the enclosure and the first multi-frequency instrument (MFI). It is also the main responsible for integration, operation, data reduction and

analysis for the phase I, and it is in charge of the opto-mechanics, electronics and control software of the TGI and FGI instrument, including the integration and verification of the instruments. Our node also coordinates the RADIOFOREGROUNDS project (<http://www.radioforegrounds.eu/>), with the goal of combining the nine Planck all-sky (30-857 GHz) maps and the four QUIJOTE Northern sky (10-20 GHz) maps, to provide the best possible characterization of the physical properties of polarized emissions in the microwave domain, together with an unprecedentedly thorough description of the intensity signal. This legacy information will be essential for the planning of future sub-orbital experiments, as those discussed in this proposal.

VSA: The Very Small Array (VSA) was the result of a scientific collaboration between the University of Cambridge, the University of Manchester and the Instituto de Astrofísica de Canarias. It was operated from the Teide Observatory in the period 2000-2008. The VSA was a 14-element heterodyne interferometer array, tuneable between 28 and 36 GHz with a 1.5 GHz bandwidth and a system temperature of approximately 30K. Funding for this experiment was provided by PPARC (UK) and IAC (Tenerife). The VSA was one of the first experiments measuring the first three acoustic peaks in the CMB angular power spectrum. The IAC team had an important role in the project, leading one independent pipeline, and carrying out the extraction of the cosmological implications of the project (Rubiño-Martín et al. 2003; Rebolo et al. 2004).

COSMOSOMAS: The Cosmosomas Experiment was completely designed and built by the Instituto de Astrofísica de Canarias, and started operations in 1998. It consisted in two similar instruments, COSMO11 and COSMO15, dedicated to mapping COSMOlogical Structures On Medium Angular Scales, and the diffuse emission of our Galaxy. The experiment finished the operations in 2007. COSMOSOMAS obtained one of the first (and probably the most clean and direct) evidence for anomalous microwave emission (AME) in a compact region. The COSMOSOMAS data in the Perseus molecular cloud shows a clear rising spectrum from 11 to 17 GHz. The experiment also presented evidence for diffuse AME at high galactic latitudes. Together with the Tenerife Experiment, it mapped the intensity sky in the range 10-20GHz. This range is now observed with higher sensitivity (and also in polarization) with the QUIJOTE experiment.

EUCLID: is an ESA mission in the Cosmic Vision 2015-2025 program, and its main aim is to obtain a map of the Dark matter of the Universe. The mission will investigate the distance-redshift relationship and the evolution of cosmic structures by measuring shapes and redshifts of galaxies and clusters of galaxies out to redshifts ~ 2 , or equivalently to a look-back time of 10 billion years. In this way, Euclid will cover the entire period over which dark energy played a significant role in accelerating the expansion. The IAC, in close collaboration with the UPCT (Universidad Politécnica de Cartagena) participates in the design, fabrication and operation of the ICU (Instrument Control Unit) of NISP. The IAC is in charge of the Thermal monitor and control module, the control electronics for the in-flight calibration unit, and the grism and filter wheels.

Key Personnel

Dr. José Alberto Rubiño-Martín (male) is the coordinator of the IAC node. He is a staff member of the IAC. He did his degree in Physics at the University of Granada (1993-1998), and he got his PhD in Astrophysics at the University of La Laguna (1998-2002). In the past, he was “Severo Ochoa Advanced Fellow” and “Ramon y Cajal” researcher at the IAC (2008-2014), Postdoctoral researcher at the IAC (2005-2008), and Postdoctoral researcher at the Max-Planck Institut fuer Astrophysik in Munich, Germany (2002-2004), where he was working with the group of Prof. R. Sunyaev. His research area is Cosmology, and in particular, he works in the study of the Cosmic Microwave Background, the large-scale structure of the Universe, physical processes that emit in radio wavelengths, and also galaxy clusters. He is the project scientist of the QUIJOTE experiment, and he is “Planck Scientist” and LFI Core Team member within the ESA’s Planck satellite. Within PLANCK, he also is the responsible of the Planck Working Group WG5 (“Clusters and secondary anisotropies”). He is also a member of the “Euclid NIR Consortium”.

- Publications:
 - 204 refereed publications. Almost all of them in high-impact journals, as ApJ, MNRAS or A&A (Source: NASA ADS).

- Total Number of Citations: **27.334**. H-index=**72**. (Source: NASA ADS).
 - First author publications: **13**. Second author publications: **15**.
 - Second author (with 1st author one of my PhD students): **6**.
 - There are 27 refereed papers produced by the Planck Working Group that I was coordinating (Clusters and secondary anisotropies).
 - 32 refereed papers without my PhD thesis advisors, and 9 of them as 1st author.
 - Editor of **2** books.
- Conferences:
 - More than 40 talks in international conferences and meetings.
 - More than 40 talks in internal meetings of the Planck Collaboration or the QUIJOTE consortium.
 - A large number of seminars in different research institutes in Spain (Granada, Salamanca, Santander, Madrid, Barcelona, Valencia, Teruel), Europe (Munich, Heidelberg, Cambridge, Manchester, Rome) or EEUU (Caltech, Santa Barbara, Philadelphia).
 - 31 non-refereed publications associated to conference proceedings in NASA ADS.
- Tutoring and supervision:
 - 7 PhD students. Two as solely supervisor: Carlos H. López-Caraballo (2013) and Alba E. Peláez-Santos (finishing in 2017). Five co-supervised: Beatriz Ruiz-Granados (2009), Inés Flores-Cacho (2010), Denis Tramonte (2017), Marcos Pellejero (2018), Antonio Ferragamo (2018).
 - 4 postdoctoral researchers working solely under my supervision: Ricardo Génova-Santos, Alina Streblyanska, Frederick Poidevin, Heidi Lietzen. Three more in the past: Angela Hempel, Beatriz Ruiz-Granados, Claudia Scóccola.
 - Line manager of the engineering team for QUIJOTE at the IAC, involving one Instrument Manager and six engineers.
- Teaching:
 - MSc in Astrophysics. 2006-2014. Lecturer: Radioastronomy. 1.5 ECTS/year. University of La Laguna. <http://www.ull.es/>
 - MSc in Astrophysics. 2014-2017. Lecturer: Spectropolarimetry in Astrophysics. 1.5 ECTS/year. University of La Laguna. <http://www.ull.es/>
 - MSc in Physics and Mathematics. 2007-2014 Lecturer: Astrophysics and Cosmology. 3 ECTS/year. University of Granada. <http://www.ugr.es/~fisymat/>
- Other merits:
 - Ample experience in the Management of large research groups (Coordinator of the Planck Working Group on Galaxy Clusters, Project Scientist of QUIJOTE).
 - Prize of the Spanish Astronomical Society (SEA) to the best PhD thesis in Astronomy in Spain, in the period 2002-2004.
 - Referee of MNRAS, ApJ, Phys. Rev. D.
 - Member of the Spanish Observing Time Allocation Committee of the Canary Islands Observatories, and the Observatorio Astronómico de Javalambre (OAJ).
 - PhD Thesis Examiner in 5 theses.
 - Public Outreach (in Spanish). Interviews; 10 talks; 3 articles in newspapers/journals; 1 chapter of a book (“Astronomía”, edited by the Univ. of Granada).

Prof. Rafael Rebolo (male) is IAC Director, Scientific Director of the IAC’s Severo Ochoa Centre of Excellence Programme, CSIC Research Professor at the IAC and External (Honorary) Professor of the Max Planck Institute for Astronomy in Heidelberg. He has pioneered in Spain experimental research in several fields of astrophysics and cosmology. He has been awarded several of the most important research prizes in Spain (Iberdrola Science and Technology Prize 2000, Jaime I Research Prize 2001, Canarias Research and

Innovation Prize 2002) and is member of the Spanish Royal Academy of Sciences and of the Max Planck Society. He is Doctor Honoris Causa for the Politechnic University of Cartagena. He coordinated the participation of the IAC in the ESA space missions Planck and Herschel, is a member of the science team of the 39m E-ELT and of three of its instrument science teams (CODEX, HARMONI and EPICS). He is PI of the QUIJOTE experiment, and Co-Principal Investigator of ESPRESSO for the ESO VLTs. He is PI of FastCam and Co-PI of AOLI, the Adaptive Optics Lucky imager for the WHT and GTC (a project in collaboration with Univ. of Cambridge).

Dr. Ricardo Génova-Santos (male) is a staff researcher at the IAC. Previously, between 2006 and 2008, he was a postdoctoral research associate at the Cavendish laboratory (University of Cambridge). Between 2002 and 2006 he was a PhD student at the IAC. Apart from his BSc and PhD in Physics, he also holds BSc and MSc degrees in Industrial Engineering. During his scientific career he has published a total of 67 papers in peer-reviewed international journals, 6 as first author. The total number of citations of these articles is 4241, with an h-index of 29 (according to NASA ADS). He has delivered 19 talks in international conferences and workshops. Of these, 12 after abstract submission and acceptance, and 7 after invitation. Nowadays he devotes most of his time to work within the QUIJOTE and Planck collaborations. In QUIJOTE, he is responsible for the basic data processing pipeline at the IAC. He is also responsible for the coordination, scheduling and planning of the observations with this telescope, and is supervising one PhD thesis that is focused on the characterization of the beams and optical properties. In the past he supervised three other student research works related with this project. In Planck, he is LFI Core Team member, and participates in the Working Groups dedicated to "Clusters of galaxies" and "Galactic science". He is leading one article inside the second of these working groups. He is also involved in the EUCLID consortium, in particular in the "Clusters of galaxies" Science Working Group. In the past we was part of other scientific collaborations, like AMI and VSA, where he had the role of project manager between 2006 and 2008. Since 2008 he lectures Radioastronomy, in the MSc in Astrophysics, in the University of La Laguna.

Dr. Roger Hoyland (male) currently holds the position of Microwave Engineer at the IAC since 1993. He holds a BSc Hons in Applied Physics with applied electronics from the University of Bath, UK (1988) and read his Masters in Cosmological Instrumentation at the University of Manchester, UK (1993). He read his Doctoral thesis at the Open University, UK (2010) whilst also working at the IAC as a microwave engineer. During his career at the IAC he has worked on various CMB experiments such as The Tenerife experiment, The LFI on board the Planck Surveyor mission, COSMOSOMAS and finally QUIJOTE CMB experiment. He spent 2 years (2001-2003) as a consultant to LABEN, Milan during his work on the PLANCK Mission and also was named as a PLANCK Scientist. He has been instrument scientist on both the COSMOSOMAS and QUIJOTE instruments as well as member of the management board for QUIJOTE. He held an international patent P200000841 for an innovative phase switching circuit that was incorporated into the LFI onboard the PLANCK Surveyor. Roger Hoyland is a member of the Institute of Physics, UK (MinstP). He is also an evaluator for ANEP (Spain) and ANR (France). He has co-authored 62 papers in his career, including contributions to 20 congresses and proceedings and 27 Planck papers.

Dr. Frederick Poidevin (male) graduated his PhD at Université de Montréal, Québec, Canada in 2006 under the supervision of Professor Pierre Bastien. He then completed a one-year post-doctoral position at IRAP in France, then a 3 years postdoctoral position at the IAG at the university of São Paulo in Brazil followed by a two years postdoctoral research associate position at University College London in the UK. His research is based on observational studies of the Interstellar medium of our galaxy by using polarimetry at visible, infrared, submillimeter and microwave wavelengths. He is a PLANCK HFI research associate from 2007. He is part of the ballon-borne experiment BLASTPol collaboration from 2011. He is a member of the QUIJOTE-CMB consortium meeting from October 2013, which is the date when he started a postdoctoral position at the IAC. In 2016 he obtained a Marie Curie Fellowship in the same institution. Until now, he has a total of 44 published scientific communications among which 19 articles have been refereed.

Dr. Beatriz Ruiz-Granados (female) got her PhD at the Universidad de Granada (Granada, Spain) in December 2009 under the supervision of Professor Eduardo Battaner (Universidad de Granada, UGR) and Dr. José Alberto Rubiño-Martín (Instituto de Astrofísica de Canarias, IAC). After that, she moved to the IAC for one-year postdoctoral position. From 2011 to 2014, she held a postdoctoral position at the UGR, and in 2015, she moved to the Instituto de Física de Cantabria (IFCA) in Spain with one year postdoctoral position.

Her research is based on modeling and constraining galactic, extragalactic and primordial magnetic fields by using CMB data, CMB component separation methods and the modeling dark matter in galaxies. She is a Planck HFI associated member since 2011, and a member of the LFI2 core team since 2015. She is also a member of the QUIJOTE consortium. Since September 2016, she holds a postdoctoral position within the RADIOFOREGROUNDS European project at the IAC. She published 17 scientific papers (refereed), 7 scientific communications and 2 book chapters. She has also supervised 3 Master thesis in Astrophysics and has been advisor of 1 PhD thesis.

Dr. Flavien Vansyngel (male) graduated his Ph.D. at the Institut d'Astrophysique de Paris (IAP), Université Pierre et Marie Curie, Paris, France in 2014 under the supervision of Professor Benjamin D. Wandelt. He then completed a two-year post-doctoral position at the Institut d'Astrophysique Spatiale (IAS), Orsay, France. Since January 2017, he has occupied a post-doctoral position at the Instituto de Astrofísica de Canarias. His research is focused on data analysis for CMB experiments, especially on the study of the polarized interstellar medium (ISM) for the search of CMB primordial B-modes. He co-authored two Planck ISM papers and is involved into the effort of simulations for Planck data analysis. He is involved in the simulation effort for the LiteBIRD collaboration. He is involved in the RADIOFOREGROUND project and a member of the QUIJOTE collaboration. He has five refereed papers.

Five publications relevant to the proposal

1. Watson, Rebolo, Rubiño-Martín et al. (2005), “*Detection of Anomalous Microwave Emission in the Perseus Molecular Cloud with the COSMOSOMAS Experiment*”, ApJ 624, L89.
2. López-Caraballo, Rubiño-Martín, Rebolo & Génova-Santos (2011), “*Constraints on the Polarization of the Anomalous Microwave Emission in the Perseus Molecular Complex from Seven-year WMAP Data*”, ApJ 729, 25.
3. Rubiño-Martín, Rebolo et al. (2012), “*The QUIJOTE-CMB experiment: studying the polarisation of the galactic and cosmological microwave emissions*”, Ground-based and Airborne Telescopes IV. Proceedings of the SPIE, Volume 8444, article id. 84442Y.
4. Planck Collaboration (2014), “*Planck 2013 results. I. Overview of products and scientific results*”, A&A 571, A1.
5. Génova-Santos, Rubiño-Martín, Rebolo et al. (2015), “*Measurements of the Intensity and Polarization of the Anomalous Microwave Emission in the Perseus molecular complex with QUIJOTE*”, MNRAS 452, 4169.

Description of any significant infrastructure and/or technical equipment, relevant to the proposed work

A) QUIJOTE experiment. QUIJOTE is a collaboration between the IAC (leading institution), IFCA, DICOM and IDOM in Spain, and the Universities of Manchester and Cambridge in UK, with the aim of characterizing the polarization of the CMB and other Galactic and extragalactic physical processes with 6 frequency bands in the range 10-40 GHz and at angular scales larger than 1 degree (or multipoles below $l=200$). The observing site is the Teide Observatory. The installation is operated by the IAC.

The project has two telescopes (QT1, already in operations; and QT2, already fabricated and to be installed in June 2014), and three instruments: MFI, TGI and FGI. The first instrument (MFI), devoted to the characterization of Galactic emission in the range 10-20 GHz, started the commissioning phase in November 2012 and has been observing for more than 2 years. The first scientific results of the project are presented in Génova-Santos et al. (2015, 2017). The second instrument (TGI) with 31 polarimeters at 30 GHz is now in the commissioning phase since December 2016. The third instrument (FGI) with 31 polarimeters at 40 GHz will be commissioned during 2017.



Figure 1: The first QUIJOTE telescope with the MFI instrument. The data of this telescope is providing the maps in the frequency range 10-20 GHz.



Figure 2. The two QUIJOTE telescopes, inside their dome at the Teide Observatory.

B) Teide Observatory. The Instituto de Astrofísica de Canarias (IAC) administers the “Observatorios de Canarias” (OCC), a single Singular Scientific and Technical Infrastructure (ICTS) formed by the Observatorio del Roque de los Muchachos (ORM) and the Observatorio del Teide (OT). These two astronomical reserves, protected by Law, have been open to the international scientific community since 1979, in accordance with the Agreements for Cooperation in Astrophysics. Currently, the OCC contain

telescopes and instruments belonging to 60 institutions from 18 countries. The OOC is the most important assembly of observational facilities for optical and infrared astrophysics within the territories of the European Union. Other experiments for high-energy astrophysics (Magic, CTA-N) and the study of the CMB complete the battery of facilities available.

The OT is located in the island of Tenerife, at 28°18'00" N, 16°30'35" W, and an altitude of 2.400 m above the sea level. The OT has a long tradition (more than 30 years) in the study of CMB anisotropies. At this moment, the only active CMB experiment at the OT is QUIJOTE. However, in the near future, there will be other CMB experiments in the site: STRIP (part of the Large Scale Polarization Experiment), GroundBIRD, KISS, and a CMB spectrometer at 10-20GHz.



Figure 3: Observatorio del Teide in Tenerife. Image taken from the IAC website.

C) The IAC's instrumentation division. The IAC's Instrumentation Division provides technological support, and carries out research and instrument development projects generated by the centre's scientific programme. The Division is organized into two sections, Engineering and Production (<http://www.iac.es/tecnologia.php?op1=8&lang=en>):

- Engineering comprises five departments: Optics, Mechanics, Electronics, Software, and Project Management. The Electronic Design, Electromagnetic Compatibility, Optics, Fibre Optics, Optical Surfacing, and Mechanical Integration and Verification Laboratories, together with the CAD Room, are run by the Engineering Section. There is also a microwave laboratory, currently equipped with a PNA operating in the frequency range 1-50 GHz.
- Production consists of the Mechanical Workshop, the Electronics Workshop, and the Technical Drawing Laboratory; it also oversees the Dimensional Metrology Laboratory and the AIV Room (class 100,000).

We have ample experience in the design and integration of CMB instrumentation based on HEMTs, at frequencies below 50 GHz. In our division, we have designed and integrated instruments as COSMOSOMAS, QUIJOTE MFI, QUIJOTE TGI and QUIJOTE FGI. Our team is also experienced with space CMB instrumentation. The IAC supplied the REBA (Processing, Compression and Control Unit) electronic component and associated low-level and scientific software for the PLANCK LFI. The IAC also designed the LFI millimetre-wave 180° phase switches for the PLANCK 30, 44 and 70 GHz channels. The IAC has also an educational license for the CST microwave 3D electro-magnetic design software. This software suite is very flexible and can solve completely open 3D electromagnetic problems. It also has more specific design aids for simulating specific circuits and microwave components such as microwave filters, couplers, hybrids, amplifiers and detectors. This software has been used to simulate the whole QUIJOTE telescope optics and feedhorn system from 10-50 GHz. For this use is made of the time domain and integral solvers. Due to the large size of these simulations hardware acceleration is needed. The CST software is run on a 24xCPU server with a K80 Nvidia GPU. Apart from the accurate simulation potential CST has a

powerful parametric optimisation engine that can be used in a very flexible way to design circuits, opto-mechanical and dielectric components.

4.1.6 Agencia Estatal Consejo Superior de Investigaciones Científicas (CSIC)

4.1.6.1 Description

CSIC (Spanish National Research Council) is Spain's largest public research institution, and ranks third among Europe's largest research organization. CSIC is under the responsibility of Spain's Ministry of Economy and Competitiveness through the Secretary of State for Research, Development and Innovation, and plays a key role in scientific and technological policy in Spain and worldwide. According to its Statute (Article 4), CSIC has 4 main missions:

- to foster multidisciplinary scientific and technological research
- Knowledge transfer to industry and society
- Education and training of scientific and technical staff
- Creation of Technology Based Companies

CSIC has 10.940 employees, including 3.764 researchers. CSIC has 123 Institutes spread across the country and covering different areas of Science and Technology. 70 of them are fully-owned institutes and 53 are Joint Research Units in partnership with other Spanish universities or research institutions. CSIC has also a delegation in Brussels.

CSIC supports research and training across a wide range of knowledge, from the most basic or fundamental aspects of science to the most complex technological developments; from human and social sciences to food science and technology, including biology, biomedicine, physics, chemistry and materials, natural resources and agricultural sciences. As the third largest research organization in Europe, CSIC carries out research in all fields of knowledge, throughout its 123 Institutes distributed in eight areas:

- Humanities and Social Sciences
- Biology and Biomedicine
- Natural Resources
- Agricultural Sciences
- Physical Science and Technologies
- Materials Science and Technology
- Food Science and Technology
- Chemical Science and Technology

CSIC produces 20% of the national scientific output (more than 12.000 ISI paper in 2014). CSIC remains the leading patent filer among research bodies in Spain with more than 180 patent requests published in 2014.

CSIC has a broad experience in managing large and singular infrastructures. For instance, CSIC provides services to the entire scientific community through management of the Singular Scientific and Technological Infrastructures (ICTS) such as Calar Alto Astronomical Observatory (with MaxPlanck), Doñana Biological Station, European Synchrotron Radiation Facility, Hesperides Ocean Research Vessel, Integrated Micro and Nanoelectronics Clean Room, Juan Carlos I Antarctic Base, Max Von Laue-Paul Langevin Institute and Sarmiento de Gamboa Ocean Research Vessel.

In addition, CSIC has a broad experience in conducting R&D projects funded by national and international public agencies and industry.

CSIC is a major player in the development of the European research area and therefore a significant contributor to the European integration process. Within the 7th Framework Programme CSIC has signed 723

actions (including 97 coordinated by CSIC and 47 ERC projects). As to the number of projects, CSIC is listed the 1st organisation in Spain and the 6th in Europe in the 7th Framework Programme, with a total FP7 contribution of over 263 million euros (E-CORDA).

As to the funding obtained by CSIC within each programme, the distribution is People 20%, Cooperation 47%, Capacities 8% and Ideas 25%. Taking into account the research areas, the most relevant ones in terms of funding have been Physical Science and Technology and Biology and Biomedicine.

Within the first Work Programme of H2020 (2014-2015), CSIC has actively participated in different calls, having special success in some programmes, such as Research Infrastructures, ERC and Marie Curie Actions, as well as in the Societal Challenges of “Food Security, Sustainable Agriculture and Forestry”. In June 2016, CSIC has obtained 203 projects in the first Work Programme with a total EU financial contribution of 88, 5 million euros. As E-CORDA points out CSIC is listed the 1st organisation in Spain and the 10th in Europe in H2020 funding. CSIC is also an active member in Knowledge and Innovation Communities (KIC), Raw Materials and Health, of the European Institute for Innovation and Technology (EIT).

The IFCA Observational Cosmology and Instrumentation research group

Instituto de Física de Cantabria (IFCA) is a joint research institute of the Spanish Research Council (CSIC) and the University of Cantabria (UC). The research activity of the participant team at IFCA, Observational Cosmology and Instrumentation Group, led by Enrique Martínez-González, is focused in the observation and data analysis of the cosmic microwave background (CMB) and the large-scale structure (LSS) of the universe (from galaxies to clusters of galaxies). This activity is complemented, on the one hand, by developing instrumental devices to measure the CMB and, on the other hand, by designing specific statistical tools and image processing algorithms.

The team has a large experience in all aspects of the CMB science from the instrumental design to the data exploitation. It has been part of the international collaboration that since the beginnings of the 90's proposed, developed and scientifically exploited the Planck mission. The team was the scientific responsible for the fabrication of the Back-End Modules (BEMs) of the radiometers at 30 and 44 GHz of the *Planck* Low Frequency Instrument (LFI). The design, development and tests of the prototypes were carried out within several space projects coordinated by the IFCA team and including DICOM (UC) and DTSC (UPC). Also, IFCA was the contractor for the fabrication of the flight models by the company Mier Comunicaciones (La Garriga, Barcelona). In particular we were leading the core program projects Isotropy and Statistics of the CMB, Cosmological Constraints from the Integrated Sachs-Wolfe (ISW) effect and the Planck Catalogue of Compact Sources. As part of our contribution to the DPC we have been responsible for the development of several packages of software, including Gaussianity analysis, detection of point sources and component separation. In particular, we have been responsible for the production of one of the clean CMB maps (in temperature and polarization) that have been made public to the scientific community

In close collaboration with the UC-DICOM team, and within a Spanish-British collaboration, we have participated in the design and development of the QUIJOTE experiment dedicated to the CMB observation in the low frequency range. The team leader is a member of the QUIJOTE Board. The first instrument (MFI), devoted to the characterization of Galactic emission in the range 10-20 GHz, has been observing for more than 3 years and the first results have been already published. Regarding the QUIJOTE second instrument TGI, we have contributed to the simulation and development of the radiometer chains and to the wave-guide passive components. Also in close collaboration with the UC-DICOM team we are contributing in a similar manner to the development of the third QUIJOTE instrument at 41 GHz. The TGI and FGI instruments have been partially funded with the Spanish Consolidator Ingenio-2010 project of excellence coordinated by the team leader.

Our team is developing a novel electro-optical correlator concept for the next generation of large format interferometers. A first prototype of the interferometer is being developed in collaboration with the UC-DICOM team at the 15 GHz frequency band. Also, within an international collaboration we are proposing the CORE mission to the M5 call, contributing to the instrument design as well as the scientific requirements and being the team PI a member of the executive board.

In addition, the team is currently involved in other experiments related to galaxy surveys: the Spanish-Brazilian J-PAS survey, and the ESA Euclid mission.

The CAB group for the development of state of the art superconducting detectors

Our team has a large experience in space instrumentation in the Far-IR and in observation from mm/submm ground based telescopes, covering basically all aspects from the design of instruments to its scientific exploitation. The group has been actively involved, since the very beginning (1985), in the large international collaboration of EU and USA laboratories that developed the Herschel Observatory and its scientific exploitation. For this mission, we have been leading the development of key technologies for the Instrument Control Centre of the Heterodyne Instrument for the Far-IR (HIFI) and the Key projects on the study of the Galactic centre and the nuclei nearby galaxies.

Our team at the Centro de Astrobiología (CAB) is developing state of the art superconducting detectors for space and ground based instrumentation in the mm/submm/Far-IR. The team is now leading the Spanish participation in the development of the next-generation infrared astronomy mission, the Space Infrared Telescope for Cosmology and Astrophysics (SPICA) originally lead by Japan. We are leading the instrument's optomechanic design of the Spica FAR-infrared Instrument.

In the last years, the team has made fundamental progress in the design, fabrication and characterization of the first Spanish superconducting detector arrays operating in the mm/submm/FIR. In the context of the SPACEKIDS FP7 project, we have successfully developed several demonstrators for different operating frequencies ranging from 100 GHz to 3 THz. These demonstrators are fabricated by micro and nanofabrication techniques and characterized in a dilution cryostat with optical access.

We have recently installed a new sputtering system to produce large arrays (>1000 pixels) of KID detectors. We are collaborating with the Neel team in Grenoble to upgrade the NIKA2 camera for the IRAM-30m telescope. Also, we are part of the CORE proposal as M5 to ESA for the studying of the CMB. In this context, we are part of the development of the low frequency band (60-115 GHz).

The CAB is working in close collaboration with the Spanish leading groups in microwave and detector developments for CMB experiments at the Universidad de Cantabria and nanofabrication and characterization of superconductors at IMM, UCM and IMDEA-Nanoscience.

4.1.6.2 CVs

Prof. Enrique Martínez-González (male) is CSIC Research Professor at the Instituto de Física de Cantabria (IFCA) where he acted as director during 2012-2015 and also leads the research group “Observational Cosmology and Instrumentation”. His main field of research is Cosmology, more specifically Cosmic Microwave Background (CMB) and the large-scale structure (LSS) of the Universe. In the last 10 years he has focused in the development of CMB experiments and instrumentation as well as data analysis and theoretical implications of CMB data sets. He coordinated the project for the development of the Back-end Modules of the radiometers at 30 and 44 GHz of Planck and the scientific exploitation of the data. He is Co-I of the Planck-LFI (the Co-I board is formed by about 20 senior researchers and is responsible for the delivery of the LFI instrument to ESA), Planck Scientist, coordinator of the non-Gaussianity working group and member of the Planck-LFI core team. He is a member of the management board of QUIJOTE. He also participates in the project J-PAS acting as coordinator of the inflation theme, a galaxy survey covering 8000 square degrees up to redshift 1 with the main objective of measuring the “Baryonic Acoustic Oscillations”, and in the Euclid ESA mission with the primary goal to understand the dark energy and dark matter components of the Universe. He has been the PI of 5 international and 11 national projects, and has supervised 10 PhD theses. He has been the coordinator of the first European network on the CMB funded by the Human Capital and Mobility Program of the EC and of the on-going project of excellence “Exploring the Physics of Inflation” of the Spanish Consolider Ingenio-2010 program. He has published around 300 publications in refereed journals and his work has been presented in more than 150 international conferences, a significant fraction by invitation.

Prof. Jesus Martín-Pintado (male) is a well-known astrophysicist. He worked on his PhD at the Max-Planck Institute für Radioastronomie. In late 1983 he became director the Centro Astronómico de Yebes (CAY, Guadalajara, Spain) where he was strongly involved in the commissioning of and in the development of receivers and instrumentation for the 14-m radio telescope. In 1986-1987 he moved to Granada as deputy site manager of the IRAM 30-m telescope. During his stay in Granada was appointed by ESA member of the Scientific Advisory Committee for FIRST (now Herschel). He has been Vice-director of the Centro de Astrobiología (INTA-CSIC) from 2012 to 2015.

He has extensive experience observing using radio, mm, submm and Far-IR observatories. He has been involved in the development of instrumentation for radiotelescopes and space missions. He was leading (PI) the construction of the first cryogenic heterodyne receiver in Spain, installed in the 14-m radio telescope at the Centro Astronómico de Yebes. He developed the first acusto-optical spectrometer also for the 14-m radiotelescope. PI of the Spanish contribution to HIFI, the cryogenic low noise amplifiers for HIFI. PI of the Spanish in-kind contribution to ALMA, leading the study of the accuracy of the proposed the baseline for the calibration system (semi-transparent vane) and strongly involved in the proposed revised calibration system which was finally built in Spain. He is also leading the development analysis of tools for optical astrometry and models and tools (MADCUBAIJ) for the analysis of molecular data cubes obtained with Herschel and ALMA. In last 5 years he has started the development of state-of-the-art superconducting detectors for SPICA and future mm/submm/FarIR space missions. He has been involved, since 1986, in the construction of the major international IR and Far-IR space missions like Herschel and SPICA and interferometers like ALMA and SKA. He was manager of the Area of Space Research in the Spanish National Research Plan, dealing with strategic aspects of space funding during 2011-2014. Dr. Jesus Martin-Pintado has been member of the scientific advisory committees of the major European mm/submm observatories and ESA. He was Chair of the Astronomy Working Group and member of the Space Science Advisory Committee of ESA (2010-2013), and currently he is member of the European and the international ALMA Science Advisory Committees.

Dr. R. Belén Barreiro (female) is a CSIC Tenured Scientist (Científico Titular) at the Instituto de Física de Cantabria since 2015. Previously, from 2006 to 2015, she held a Tenured Scientist position (Profesor Contratado Doctor I3) and a *Ramón y Cajal* contract (2002-2005), in the Universidad de Cantabria at the same institute. From 1999 to 2001, she was a research postdoc at the Cavendish Laboratory of the University of Cambridge (UK), after finishing her PhD at Universidad de Cantabria (1996-1999).

Her main research interest is the development and application of novel data analysis techniques for Cosmology, especially for the Cosmic Microwave Background (CMB) field. This includes diffuse and compact component separation, the study of primordial non-Gaussianity or the joint study of the CMB and large-scale structure (LSS) data. During the last years, she has been a very active member of the Planck Collaboration, where she is member of the LFI Core Team and has the status of *Planck Scientist* since 2005. She is the responsible scientist for one of the component separation pipelines (SEVEM) that was selected to produce one of the official products of the mission, one of the clean maps of the Cosmic Microwave Background Radiation. This map has been made publicly available to the scientific community with the first and second release of data. She is also a member of the QUIJOTE collaboration, belonging to the Core Team and being the coordinator of the Working Group *Power spectrum estimation*. She has participated on more than 20 competitive national and international research projects, being the PI of 7 of them, including the H2020 project RADIOFOREGROUNDS (where she is the PI of one of the partners). She is the author of around 200 publications in international peer-reviewed journals (most of them in the first quartile), as well as of 20 publications in conference proceedings, with more than 25.000 cites in total and an h-index of 71. She has supervised two PhD theses (and a third one is on-going) and also participates regularly in teaching activities of the Universidad de Cantabria, especially at the postgraduate level.

4.1.7.3 Relevant publications

1. *Planck 2013 results. XXIII. Isotropy and statistics of the CMB*, Planck Collaboration XXIII, 2014, A&A, 571, A23. Including **R.B. Barreiro, J.M. Diego, D. Herranz, E. Martínez-González** (corresponding author), **P. Vielva**.
2. "Electro-Optical Correlator for Large-Format Microwave Interferometry: Up-Conversion and Correlation Stages Performance Analysis", 2017, submitted to Review of Scientific Instruments (RSI), AIP Publishing. **D. Ortiz, F.J. Casas**, R. Ruiz-Lombera, and J. Mirapeix.
3. *The Thirty Gigahertz Instrument Receiver for the QUIJOTE experiment: Preliminary Polarization Measurements and Systematic-Error Analysis*, 2015, Sensors. 15-8, pp. 19124–19139. **F.J. Casas, D. Ortiz**, E. Villa, J.L. Cano, J. Cagigas, A.R. Pérez, B. Aja, J.V. Terán, L. de la Fuente, E. Artal, R. Hoyland, R. Génova-Santos.
4. *Development of Sub-micron Broadband Lens-Coupled LEKIDs for Sub-mm Astronomy*, 2016, Journal of Low Temperature Physics, Volume 184, Issue 1-2, pp. 148-153. **A. Gómez, P. Prieto, J. Bueno, S. Doyle, P. Barry, A. Bideaud, N. Llombart, D. Granados, J.L. Costa-Kramer, J. Martín-Pintado**, J.J.A. Baselmans.
5. *A kilo-pixel imaging system for future space based far-infrared observatories using microwave kinetic inductance detectors*, 2016, Submitted to A&A, eprint arXiv:1609.01952. J.J. Baselmans, J. Bueno, S.J.C. Yates, O. Yurduseven, N. Llombart, K. Karatsu, A.M. Baryshev, L. Ferrari, A. Endo, D.J. Thoen, P.J. de Visser, R.M.J. Janssen, V. Murugesan, E.F.C. Driessen, G. Coiffard, **J. Martín-Pintado**, P. Hargrave, M. Griffin.

4.1.7.3 Relevant projects

1. "Ultimate modeling of Radio foregrounds: a key ingredient for cosmology (RADIOFOREGROUNDS)", 2016-2018. Reference: H2020-GA-687312. Funding Agency: European Union.
2. "Probing the early universe with CMB and LSS. Development of a microwave interferometer and preparation for a space mission", 2016-2017. Reference: ESP2015-70646-C2-1-R. Funding Agency: Ministerio de Economía y Competitividad.
3. "Exploring the Physics of Inflation", 2010-2017, Reference: Consolider-Ingenio 2010 CSD2010-00064. Funding Agency: Ministerio de Economía y Competitividad. Spain.
4. "Kinetic Inductance Detectors – a New Imaging Technology for Observations In and From Space" SPACEKIDS, ", 2013-2015. Reference: FP7-SPACE-2012-1 313320. FINANCIAL ENTITY: FP7
5. "Contribución española en criogenia a misiones espaciales: Desarrollos para SPICA y Athena, post-operaciones de Herschel y explotación científica multifrecuencia", 2016-2019, Reference: ESP2015-65597-C4-1-R. FINANCIAL ENTITY: MINECO

4.1.7.4 Relevant infrastructure and/or equipment

IFCA:

The proposed project will carry out intensive analysis of a large amount of data. Therefore, the access to high-performance computing facilities is of great importance to achieve the objectives of the proposal. IFCA holds two major high-performance computing infrastructures. The first one is the Altamira supercomputer with 384 cores with access to 1.1 TB of RAM and a total of 132 TB of storage, within the Spanish Supercomputing Network (RES). 80% of the time of this facility is allocated to IFCA and UC researchers. The second one is the GRID-CSIC infrastructure, with more than 8000 CPUs and 1000 Terabytes of storage.

In particular, numerical simulation both for interferometer modelling and passive component design (wave-guide circuits) will be carried on with the Altamira supercomputer, as well as the CAD Laboratory of UC-DICOM group.

The characterization of the optical correlator's subsystems, the fabrication of some mechanical chassis for low-frequency KID designs and some wave-guide circuit prototypes will be done at IFCA. For this purpose, IFCA has the following infrastructure and equipment:

Mechanical workshop: High precision parts are produced by subtractive machining (material removing). In order to do that work, both high precision CNC milling machine and turning machine are available. A new more powerful CNC machine will be acquired in the coming months.

Cleanroom: Commonly used in microelectronics manufacturing and/or scientific research, it is able to maintain a low level of environmental pollutants like dust. According to ISO 14644, the cleanroom is class 5.5 and the access room is class 8.

Metrology lab: The laboratory has the ISO 9001 quality certificate since 2008 for parts dimensional checking and for dimensional instrumentation calibration.

Photonics lab: it is used for research in semiconductor laser based optical communication systems. It has instruments to perform time and spectrum characterization of light sources and passive optical components.

Temperature chamber: DYCOMETAL -70/180 able to perform temperature tests of devices and materials.

The IFCA team has also access to the UC-DICOM group's Radio-frequency Equipment Laboratory, for testing radio-frequency and microwave circuits and systems of any kind (test frequency range covers from tenths of Hz up to 50 GHz and from 75 to 110 GHz).

CAB:

2 Sputtering Chambers: 2 Ultra High Vacuum chamber is available for thin film deposition by DC magnetron sputtering. The system consists of a load-lock chamber for substrate preparation and loading. The main chamber, isolated from the load-lock chamber to preserve UHV conditions, consists of a magnetron sputtering source and needle valves to control gas inlet during the sputtering process. Reactive sputtering can be performed in the chamber by the injection of both Ar and N₂ gases.

Cryostat. Dilution refrigerator: A BlueFors LD250 system is available for the low temperature characterization of superconducting detectors. This system is equipped with a dilution refrigerator that, in combination with a pulse-tube cryocooler, provides continuous cooling power at temperatures below 20 mK. It is a cryogen-free refrigerator and it does not need external supply of liquid helium. The system includes thermometers, heaters and vacuum gauges connected to an external unit that controls the status of the cryostat during operation. In addition, measurement set-up for high frequency characterization of superconducting detectors has been installed.

ACCESS of CAB to IMDEA Infrastructures:

CLEAN ROOMS: Latest generation clean room, with more than 200m². Two main areas both with temperature and humidity control (22±05°C, 50±5%).

Area (ISO-5, CL-100 of 60m² devoted to lithography processes equipped with: Ultra high resolution electron beam Lithography (e-Beam), Focused Ion Beam Lithography (FIB), Gas Assisted Ion/Electron beam lithography (Multi-GIS), Mask-less Optical lithography and Nano-Imprint Lithography. This section is also equipped with a small wet chemistry room for all the processes related to nano and micro lithography.

Area (ISO-6, CL-1000) of 140m² dedicated to sample and device fabrication equipped with: several metal thin film evaporators, a unique Atomic Layer Deposition (ALD) reactor, Inductively Coupled Plasma Reactive Ion etching (ICP-RIE) for deep cryo-etching of Silicon compounds, Reactive Ion Etching for Metals and Insulators (RIE), Rapid thermal Processor (RTP), Stylus Profilometer (Dektak), Oxygen Plasma, Ozone Cleaner, Optical Microscopy, Wire Bonder, Diamond Scriber, Probe Satiation and Parameter analyser. This section is also equipped with an encapsulation room and a large wet chemistry room for all wet chemistry related processes.

4.1.7 Universidad de Cantabria (UC-DICOM)

4.1.7.1.1 University

Universidad de Cantabria (UC) is a modern public institution with an overall budget in 2016 of 105.97M€, whose main purpose is to contribute to social progress through teaching and scientific excellence. This allowed UC to confirm the “International Campus of Excellence” label in December 2014 with the highest score.

Although UC is the 44th in terms of size within the Spanish University System, it is positioned among the **5 best Spanish universities** in terms of world impact and excellence of its scientific publications (*SCIMAGO 2015 Ranking*). It is the **4th Spanish** university in research quality (ISSUE-BBVA 2015 Ranking) and the **3rd Spanish** university in terms of funds obtained per professor per projects with the private sector (*INUE 2015 Ranking*). In 2013, UC entered the *Shanghai International Ranking for the first time (positioning the Physics area among the 150-200 best universities in the world)*[1].

UC consists of around 1,600 researchers and 13,200 students (from which 740 are PhD students), 4 research institutes (two of which are joint initiatives with the Spanish Research Council, CSIC), and 160 R+D groups from 32 departments. According to its tradition and capacities, five priority specialization areas were recently established by UC in order to achieve excellence: Biotechnology, Information and communication technology, Climate action, environment, resource efficiency and raw materials, Secure, clean and efficient energy, and Advanced manufacturing and processing. This new research plan approved by the University Council is in line with H2020 and the regional plan RIS3 for strategic development.

UC is also a highly competitive university in terms of research funding. In 2015, UC attracted **28.452M€** to fund its R&D activities (26.91% of its total budget), from which 16.098M€ in competitive calls (**33% from EU funding**) and 12.354M€ on research contracts, from which **61% with the private sector**.

Considering **EU Projects**, UC has an extensive experience in international research projects and programmes, participating in more than 100 such projects. Specifically, UC has been involved in **53 FP7** for more than **10M€**, **26 H2020** projects for around **8.5M€**, and **26 projects** from other European funding schemes for almost **4M€**. It is coordinating 7 EU projects (FP7, ERC, MSCA, LIFE, Infravation ERA-NET) and in December 2014, the UC obtained its first ERC for a total of 1.5M€.

In addition to participating in more than **70 projects** from the EU Framework Programmes for Research and Innovation, UC was actively involved in **26 projects** from other European funding schemes such as: Competitiveness and Innovation Framework Programme, CIP-Pilot Actions (3), Interreg (7), LIFE+ (3), ERA-NETs (3), Research Fund for Coal and Steel (2), EPA Research Programme (1), SMA Europe (1), Civil

Protection (1), Creative Europe (1), European Investment Bank-University Research sponsorship programme EIBURS (1), Consumers, Health, Agriculture and Food Executive Agency (Chafea) (1), E-Content Plus (1), and EEA Grants (1). The information on all EU Projects from the UC is available on the European Projects Office [website](#).

Through its research institutes and groups, UC also participates in other international projects financed by multilateral financial institutions such as the [Interamerican Development Bank](#), [World Bank](#) and [United Nations](#) as well as in a EuropeAid project in Latin America. In teaching, it also participates in the [Erasmus+](#), [Erasmus Mundus](#) and [Tempus Programmes](#), among others.

With a strong track record in assisting international consortia in proposal preparation, contract negotiation, project implementation and communication, UC's [European Projects Office](#) personnel offers professional support along the whole life cycle of an EU project. [Transfer Technology and Valorization Offices](#) manage IPRs and licensing matters arising from projects. The [Office for Transfer of Research Results](#) assists in developing and exploitation of business strategies, as well as in identifying results with a potential to be translated into products for the benefit of the society.

4.1.7.1.2 UC-DICOM research group (Radiofrequency and Microwaves)

The Communication Engineering Department (DICOM) has several research groups:

- Network Planning and Mobile Communications Laboratory.
- **Radiofrequency and Microwaves.**
- Microwaves Engineering and Radiocommunication Systems.
- Systems Engineering, Antennas and Radiopropagation.
- Advanced Signal Processing.

The personnel of the Communication Engineering Department is:

- Teaching staff (Professors, assistant professors,...): 37
- Administration and Services staff: 6
- Researchers (contracted): 23
- Doctoral students (grants): 7

The personnel of Radiofrequency and Microwaves group is:

- Teaching staff (Professors, assistant professors,...): 9
- Administration and Services staff: 2
- Researchers (contracted): 6
- Doctoral students (grants): 2

The total research budget of the Radiofrequency and Microwaves group (DICOM-UC), in funded projects by public or private institutions, in the period 2009-2017 has been about 1.74 MEUR.

DICOM-UC is a multidisciplinary group with research and development activity in the next topics:

- - Design and manufacturing of radiofrequency and microwave systems.

- - Design of Monolithic Microwave Integrated Circuits (MMIC).
- - Modelling of active devices for linear and non-linear regime.
- - Electromagnetic simulation of passive structures.

Design of microwave and millimetre wave systems and subsystems has been carried out by the group for more than 20 years. Most R+D activities are addressed to collaboration with companies at regional, national and European level.

The group currently has collaboration with the next companies: INDRA Sistemas, Alcatel-Alenia-Espacio, Callisto Space, TTI-Norte, DAS Photonics, ERZIA Technologies, Fagor Electrónica and EADS CASA Espacio. The projects are addressed to RF and microwave technology development of industrial interest.

The group currently has collaborated with the next public institutions and research centers: Instituto Geográfico Nacional (IGN, Spain), Instituto de Astrofísica de Canarias (IAC, Spain), Instituto de Física de Cantabria (IFCA-CSIC, Spain), Institute for Applied Physics Fraunhofer (IAF, Germany), University of Manchester, University of Cambridge, University Roma Tor Vergata, Politecnico di Torino.

Radio astronomy polarimeters: QUIJOTE project

The QUIJOTE experiment project, First Phase started in 2007 and Second Phase started in 2011, involves the design, manufacturing and test of many different hardware subsystems for the detection and measurement of the Cosmic Microwave Background polarization. The Thirty GHz Instrument (TGI) has 31 pixels to achieve the desired high sensitivity. All the feed horns and waveguide components are cooled inside the cryostat to reduce their noise contribution.

The UC-DICOM group has designed all the opto-mechanical parts (feed horn, wave polariser, ortho-mode transducer) for the 30 and 40 GHz QUIJOTE experiment receivers (26 to 36 GHz and 35 to 47 GHz bands), currently being installed at El Teide Observatory (Tenerife, Canary Islands). In the receiver side of this experiment the group has developed cryogenic LNAs based on MMIC LNAs. The room temperature side of the receiver, the Back-End Module, has been also fully designed and manufactured by the group, containing phase-switches, amplification, microwave correlator and direct detectors by diodes.

Low Noise Amplifiers

From the results obtained in Planck Project the group started to design very low noise amplifiers. A first cryostat system was installed to perform transistors and amplifiers testing, cooling down to 15 K temperature and at a maximum frequency of 50 GHz. In order to acquire technology skills the group has collaborations agreements or contracts with different institutions: University of Manchester, Jodrell Bank Observatory (Manchester, UK), Chalmers University of Technology (Gothenburg, Sweden), IAF-Fraunhofer Institute (Freiburg, Germany) and Centro Astronómico de Yebes, (Guadalajara, Spain). The group has also participated in RadioNet, a European Infrastructure action among the main radio astronomy observatories in Europe.

MMIC Design

Group activity on MMIC started in 1989 with the project “GaAs Monolithic Microwave Circuits Design”, reference TIC89-23-C02-01, with the objectives about acquisition and diffusion of MMIC design knowledge. Results provided two research contracts with companies. Device modelling activities for MMIC design were carried out in the European project ESPRIT 6050 MANPOWER. Non-linear models of MESFET power devices are still being used by European foundries. In 1993 the project “Empirical advanced models

of MODFET: monolithic circuit design application”, reference TIC93-0672-C04-01, the group had access to HEMT technology to obtain new models and to develop demonstrators of linear and non-linear circuits.

In 1996 an EC TMR (Training and Mobility of Researchers) project started. Linear and non-linear models extraction of SiGe HBT devices (Heterojunction Bipolar Transistor) provided by Daimler-Chrysler were obtained and MMIC amplifiers at 38 GHz were designed. In 1997 the group started the project “Broadband Radio Communication multimedia systems”, reference TIC97-1129-C04, and new MMIC components for 40.5 to 42.5 GHz band were developed.

Within the activities carried out in the Planck mission project the DICOM-UC group designed monolithic amplifiers for the 44 GHz BEM and they were manufactured in the foundry OMMIC (France).

In 2008, in the framework of a direct collaboration between the DICOM-UC group and the Chalmers University of Technology (Gothenburg, Sweden), a low-noise amplifier covering the 26–36 GHz bandwidth were designed using the D01MH process from the OMMIC foundry. From 2008 to 2015, a collaboration project with the Centro Astronómico de Yebes (CAY) and IAF-Fraunhofer Institute (Freiburg, Germany) was addressed to the design of LNAs covering different microwave bandwidths. Within this project, staff of the DICOM-UC group designed low-noise amplifiers in the 4–12 GHz, 25–34 GHz, and 31–50 GHz bands using the mHEMT technology process from the IAF.

[1] *Sources*: ISSUE 2015 Ranking (Spain); Scimago Institutions Ranking World Report, 2015 (Spain); IUNE Observatory;

4.1.7.2 Curriculum Vitae – Universidad de Cantabria

CURRICULUM VITAE	
Name:	Artal
First Name:	Eduardo
Position:	Professor, Leader of Radio Astronomy Receivers Group Departamento de Ingeniería de Comunicaciones, Universidad de Cantabria, Santander, Spain
<u>Contact details:</u>	Universidad de Cantabria, Departamento de Ingeniería de Comunicaciones Plaza de la Ciencia s/n, 39005 Santander, Spain . Tel: +34 942 201397 Fax: +34 942 201488 Email: artale@unican.es
Nationality:	Spanish Citizen
Gender:	Man
Qualifications:	1976 Telecommunications Engineer, Technical University of Catalonia, (Barcelona, Spain) 1982 Ph.D. in Telecommunication Engineering, University of Catalonia, (Barcelona, Spain)
Experience and Skills:	<ul style="list-style-type: none"> - Development of microwave systems and active and passive circuits. - Monolithic microwave integrated circuits up to 50 GHz. - Low noise millimetre-wave amplifiers and receivers for radio astronomy applications. - Broadband microwave radiometers for CMB experiments.
Career Details:	
1976 to 1990	Technical University of Catalonia – Barcelona, Spain - Assistant Professor (research in microwave circuits and systems). - 1979 to 1981, in a partial leave from the university, he joined Mier Allende S.A., Barcelona, Spain, where he was involved with TV and FM radio re-emitters <u>development</u> and manufacturing
1990 to date	University of Cantabria – Santander, Spain - Professor (group leader of Microwave Radio Astronomy Receivers). - Project manager of about 28 research projects (public and private funds). -1994 to 1998: Manager of the National Program for Information and Communications Technologies. National R&D Plan, Spanish Ministry of Education and Science, Madrid. - 1998 to 2009: Project Manager of the Back End Modules for the 30 and 44 GHz <u>radiometers</u> in the Planck Mission (European Space Agency). - 2003: 3 months invited researcher at Jodrell Bank Observatory, University of Manchester, Macclesfield , UK.

CURRICULUM VITAE	
Name:	de la Fuente Rodríguez
First Name:	Maria Luisa
Position:	Associate Professor, University of Cantabria
Contact details:	Department of Communication Engineering. Laboratorios de I+D de Telecomunicación. University of Cantabria. Plaza de la Ciencia s/n Santander 39005. Cantabria- SPAIN Tel: +34 942 20 08 84 Fax: +34 942 20 14 88 Email: fuenterm@unican.es
Nationality:	Spanish Citizen
Gender:	Woman
Qualification:	1991, M.Sc. degree in physics, University of Cantabria 1997, PhD in Electronic Engineering, University of Cantabria
Experience and Skills:	<ul style="list-style-type: none"> - Design and testing of microwave circuits and systems in hybrid and monolithic technologies - Development of radiometer for space applications, in particular in low noise amplifiers and phase-switches at room and cryogenic temperatures.
Career Details:	<p>2003 to date University of Cantabria - Department of Communication Engineering -Associate Professor. -Involved in projects funded by direct contracts with private or public institutions for the design of hybrid and monolithic circuits - Involved in projects focused on the development of radiometer for space applications like the QUIJOTE project.</p> <p>1997 to 2003 University of Cantabria -Associate teacher -Involved in projects funded by direct contracts with private or public institutions for the design of hybrid and monolithic circuits. -Involved in the Back End Modules at 30 and 44 GHz for the radiometers of the Planck satellite (scientific mission of European Space Agency).</p> <p>1993 to 1997 University of Cantabria - FPI fellowship (national fellowship for raining of research personnel) to be developed in the file of monolithic microwave circuit design, in particular in microwave mixers.</p>

CURRICULUM VITAE	
Name:	Aja Abelán
First Name:	Beatriz
Position:	Ph. D. Assistant Lecturer, Department of Communication Engineering
Contact details:	<p>University of Cantabria, Dpt. Ing. de Comunicaciones Plaza de la Ciencia s/n, 39005 Santander, Spain. Tel: +34 942 200919 (103) Email: ajab@unican.es</p>
Nationality:	Spanish Citizen
Gender:	Woman
Qualification:	<p>1996 Technical Telecommunications Engineer, University of Cantabria 1999 Telecommunications Engineer, University of Cantabria 2007 Ph.D. in Telecommunication Engineering with the European Doctor mention, University of Cantabria, Spain</p>
Experience and Skills:	<p>- Analysis, design and testing of microwave circuits, including monolithic microwave integrated circuits (MMIC). Design of low noise millimetre-wave amplifiers for cryogenic applications and low noise millimetre-wave receivers</p>
Career Details:	<p>1999 - 1999 to 2015 University of Cantabria - Contracted as Doctor Engineer researcher - Design and assembly of the prototype radiometers at 30 and 44 GHz of ESA Planck mission. - Participation in the technology development, integration and deployment of a Wireless Triple Play (W3P) network. - Design of subsystems for the Radiometers at 30 GHz and 40 GHz for the polarisation instruments of the QUIJOTE (Q-U-I-Joint –Telescope) and EPI (Exploring the Physics of Inflation). - Design of cryogenic MMIC low noise amplifiers for radio-astronomy receivers. - 2003, 3 months visiting scientist at Jodrell Bank Observatory, Macclesfield, UK - Apr. 2008 to 2012, visiting scientist at Fraunhofer IAF, Freiburg, Germany - Sep. 2013 to 2015, visiting scientist at Fraunhofer IAF, Freiburg, Germany</p>

4.1.7.3 Relevant publications – Universidad de Cantabria

1. Moschetti G, Thome F, Ohlrogge M, Goliasch J, Schaefer F, Aja B, et al. “Stability Investigation of Large Gate-Width Metamorphic High Electron-Mobility Transistors at Cryogenic Temperature”. IEEE Trans Microwave Theory Tech. 2016 OCT; 64(10):3139-50.
2. Villa E, Cano JL, Cagigas J, Ortiz D, Casas FJ, Perez AR, et al. “The Thirty Gigahertz Instrument receiver for the Q-U-I Joint Tenerife experiment: Concept and experimental results.” Rev Sci Instrum. 2015 FEB; 86(2):024702.
3. Aja Abelan B, Seelmann-Eggebert M, Bruch D, Leuther A, Massler H, Baldischweiler B, et al. 4-12-and 25-34-GHz Cryogenic mHEMT MMIC Low-Noise Amplifiers. IEEE Transactions on Microwave Theory and Techniques. 2012 DEC; 60(12):4080-8.
4. Cano JL, Villa E, Cagigas J, Aja B, Vicente Teran J, Perez AR, et al. “Multi-Pixel Ka-Band Radiometer for the QUIJOTE Experiment (Phase II)”. 2012, 42nd European Microwave Conference. 2012: 37, 40 ER.
5. Artal E, Aja B, de la Fuente ML, Pascual JP, Mediavilla A, Martinez-Gonzalez E, et al. “LFI 30 and 44 GHz receivers Back-End Modules”. Journal of Instrumentation. 2009 DEC; 4:T12003.

4.1.7.4 Relevant Projects - Universidad de Cantabria

1. “Radio Astronomy Interferometer from 10 to 20 GHz”, (2016-2017). Reference: ESP2015-70646-C2-2-R. Funding Agency: Ministerio de Economía y Competitividad. Spain.
2. “Millimeter wave radio astronomy receivers”, (2013-2016). Reference: AYA2012-39475-C02-02, Funding Agency: Ministerio de Economía y Competitividad. Spain
3. “Ka Band Cryocooled Feed”, (2015-2017). Reference: 4000113406/15/D/JR. Funded by Callisto France SRL and the European Space Agency.
4. “Receivers for QUIJOTE experiment”, (2011-2014). Reference: AYA2010-21766-C03-03, Funding Agency: Ministerio de Economía y Competitividad. Spain.
5. “Very Low Noise Microwave Amplifiers for Radio Astronomy”, (2010-2012). Reference: TRA2009-0304. Funding Agency: Ministerio de Ciencia e Innovación, Spain.

4.1.7.4 Relevant infrastructure and/or equipment - Universidad de Cantabria

Communication Engineering Department (UC-DICOM)

Radiofrequency Equipment Laboratory

This laboratory has a total surface of 250 square meters. It is placed in the -1 Level of the building called “Edificio de Ingeniería de Telecomunicación”, located in Plaza de la Ciencia. In this building there are several Scientific and Technical Services of the University of Cantabria, open to provide internal and external support. There are also some technology based spin-off and research and development companies. The available equipment allows test and measurement of radiofrequency and microwave circuits and systems of any kind. Tests frequency range covers from tenths of Hz up to 50 GHz and from 75 to 110 GHz. It is possible to perform base band tests for communication systems. Most Research and Development activities are addressed to collaboration projects at local, national and international level. Investment on new equipment is done continuously through the funds achieved for new research and development projects.

The available tests with the laboratory equipment are:

- § Microwave and radiofrequency signals generation (sweep or vectorial) (18 units)
- § Signal generation: defined functions, arbitrary and pulsed (8 units)

- § Vectorial reflection and transmission (Network Analyzers) (7 units)
- § Calibration kits and stable test coaxial cables (13 calibration kits, 14 pairs of stable cables)
- § Signals spectra (Spectrum Analyzers) (9 units)
- § Digital modulation signal analysis (Vector Signal Analyzers) (2 units)
- § Power (High and low sensitivity power sensors) (4 meters and 8 sensors up to 50 GHz)
- § Noise (Noise sources. Noise figure and noise figure analyzers). (2 systems, up to 110 GHz)
- § Microwave Integrated Circuits (MMIC) (Coplanar probes stations) (2 units)
- § Cryogenic systems (Liquid Helium cryostats) (2 units)
- § Base band signals (Digital oscilloscopes and digital analyzers) (6 units, from 20 MHz up to 50 GHz by sampling)
- § LCR components characterization (LCR and impedance meters) (2 units)
- § Low frequency 1/f noise characterization (Vectorial signal analyzers: 2 units)
- § Lock-In amplifier (1 unit)
- § Antenna gain (Pattern antennae. 4 units with accessories)
- § Climatic chamber (-70 °C to + 100 °C).

Technology Laboratory. UC-DICOM

This laboratory has also a total surface of 250 square meters. It is placed in the -1 Level of the building called “Edificio de Ingeniería de Telecomunicación”. It includes a Chemical Laboratory of 70 square meters for chemical etching and metal deposition processes and a class 10.000 clean room with 50 square meters. The clean room has three separated rooms: a first one for bonding wire MMIC chips assembly, the second for photolithographic processes provided with a clean air laminar flux (class 100). The third room is equipped with high quality binocular and microscope tools for visual inspection, images acquisition and dimensions measuring.

Equipment and facilities in this laboratory allows the manufacturing and assembly of low-frequency, radiofrequency and microwave circuits and systems. Practically any kind of printed circuits and electronic assemblies can be done. Typical activities are prototypes and demonstrators building, being possible the manufacturing of small series. There are also collaboration agreements with external companies for the manufacturing of prototype circuits.

CAD Laboratory

This laboratory has a total surface of 100 square meters. It is placed in the -1 Level of the building called “Edificio de Ingeniería de Telecomunicación”. This laboratory contains 20 computers with software to perform analysis and design of active and passive circuits. The available software allows performing circuit simulation from schematic-level, layout generation and electromagnetic field analysis of passive structures. The available software tools are:

- § Advance Design System (Agilent Technologies): circuits and systems simulation.
- § EMPro (Agilent Technologies): Electromagnetic simulation.
- § Autodesk Inventor: mechanical design, 2D and 3D drawings.
- § CST Microwave-Studio: 3D Electromagnetic simulation.
- § AWR High Frequency Design Software.
- § μ Wave Wizard (Mician): 3D Electromagnetic simulation.

§ MATLAB (Mathworks): mathematical software, user defined applications.

4.1.8 Cardiff

Cardiff University is recognised in independent UK government assessments as one of Britain's leading teaching and research-intensive universities, and was ranked in the latest assessment in the top 5 Universities in the UK for its quality of research. It has approximately 20,000 undergraduate and 8,000 postgraduate students, 6,000 staff and an annual turnover of around €525M. CU had research grant income of €145M in 2013/14, CU's has a European portfolio in excess of 150 FP7 projects, with a value of €70M and 26 Horizon 2020 projects to date, with a value of €16M. The University is absolutely committed to equality and is one of only six UK universities to score full marks in a guide to LGBT-friendly universities from the Stonewall group.

The University's breadth of expertise in research and research-led teaching encompasses the natural, physical, health and life sciences; engineering, physical sciences and technology; and the social sciences, arts and humanities, as well as preparation for a wide range of professions. The University is also home to four major Research Institutes, offering new approaches to Neurosciences and Mental Health, Cancer Stem Cells, Cardiff Catalysis Institute and Sustainable Places.

The services which the University offers range from short term consultancy, training, and professional development to major collaborative Research and Development programmes. Much of the University's work with local Small and Medium Size Enterprises (SMEs) has been supported through European Structural Funds (ERDF), including a number of large-scale projects currently funded under the West Wales and the Valleys Convergence Programme (2007-13) in areas such as low carbon energy and advanced manufacturing.

Cardiff has an active and increasingly successful programme of knowledge transfer to industry through patenting and licensing and through the development of new enterprises and spin-out companies. To date, the University's investment scheme, Cardiff Partnership Fund, has invested over £4M in 61 projects leading to the creation of 15 spinout companies, which have in turn leveraged an additional £62M from a combination of venture capital, private and loan finance sources.

The School of Physics and Astronomy, now headed by Prof Matt Griffin, performed particularly well 2014 UK Research Excellence Framework (REF) exercise, with 100% of its research ranked either "world leading" or "internationally excellent" for impact, in terms of its reach and significance. Overall the School came 6th in UK.

Astronomy & Earth observation instrumentation group

The School hosts a large and World-leading astronomy and Earth observation instrumentation group. The instrumentation group consists of approximately 40 researchers with expertise in the development and integration of new technologies for ground-based, balloon-borne and space-based instruments for astronomy, Earth Observation and security applications. Cardiff has particular experience in development of technology for space-borne astronomy, with key roles in a number of past, ongoing and future instruments and missions such as SCUBA, ISO, Herschel, Planck, SCUBA-2, SPICA-SAFARI, JWST-MIRI, EChO, ARIEL and Twinkle. The group played a key role in the success of the Herschel satellite; Matt Griffin is the principal investigator on the highly successful SPIRE instrument. Prof Peter Ade is a Co-I on the Planck satellite, with Cardiff leading the integration and testing of the HFI instrument focal plane. The Cardiff instrumentation group has an excellent global reputation for IR detector design, development, test and calibration, and for building instrumentation for space.

Institute for Compound Semiconductors

Cardiff University has in the last 2 years made a major investment, together with UK funding councils and the Welsh & UK governments, in a new Institute for Compound Semiconductors (ICS).

The Institute of Compound Semiconductors is an initiative to bring world class research and translational development facilities to Cardiff University to support existing indigenous corporate strength in South Wales in compound semiconductors, and as part of the wider initiative to stimulate Europe's 5th semiconductor technology cluster.

Key Cardiff Personnel:

Dr Peter Hargrave (Male)

Dr Peter Hargrave is an academic Reader in the School of Physics and Astronomy at Cardiff University, and Director of Innovation. His primary interest is developing instrumentation for astronomy and Earth Observation, and is an author on over 130 scientific papers (h-index=30, 3965 citations). He has particular expertise and experience with satellite projects and was technical manager & systems team member for the Hershel-SPIRE instrument. He has also provided instrumentation for the Mid InfraRed Instrument (MIRI) and the NIRSPEC instruments on the James Webb Space Telescope (JWST).

He has extensive large-project management experience, having successfully led several ESA technology development programmes. He was Co-I and technical manager of the successful EU FP-7 project "SPACEKIDS" (completed March 2016).

Dr Hargrave led an international consortium to study optimal optical configurations for precision polarimetric CMB observations, on behalf of the European Space Agency. He has recently proposed a novel Earth observation instrument concept for satellite-borne atmospheric observations, for meteorology and climatology applications, and a feasibility study is funded by the UK space agency.

He is currently leading a European Space Agency funded design, development and testing campaign for low dark current LWIR HgCdTe arrays, working with AIM Infrarot Module GmbH and Caeleste CVBA. Cardiff is responsible for the detector characterisation, and array testing, and assessing suitability for the ARIEL mission (ESA M4 candidate mission).

Selected publications:

1. Hargrave, P., et al., *Final Report - Modular wide field of view RF configurations*, in *Modular Wide Field of View RF Configurations - ESTEC contract number 4000102522/10/NL/AF*. 2014.
2. Hargrave, P., et al., *Refractive telescope systems for future cosmic microwave background polarimetry experiments*, in *SPIE Astronomical Telescopes+ Instrumentation*. 2014, International Society for Optics and Photonics. p. 915314-915314-16.
3. Candotti, M., et al., *Mm and sub-mm Complete Refractive Telescope Electromagnetic Design for High Purity Electromagnetic Wave Polarization Detection*, in *ESA Workshop on large deployable antennas*. 2012, ESA: ESTEC.
4. Swinyard, B., et al., *The space infrared telescope for cosmology and astrophysics: SPICA A joint mission between JAXA and ESA*. *Experimental Astronomy*, 2009. **23**: p. 193-219.
5. Fowler, J.W., et al., *Optical design of the Atacama Cosmology Telescope and the Millimeter Bolometric Array Camera*. *Applied optics*, 2007. **46**: p. 3444-3454.
6. Griffin, M.J., et al., *The Herschel-SPIRE instrument and its in-flight performance*. *Astronomy and Astrophysics*, 2010. **518**: p. L3.

Selected Relevant Projects

"Development of low dark current MWIR/LWIR detectors". ESTEC contract number AO/1-7924/14/NL/RA

"Feasibility of using nanotechnology to improve TIR satellite imagers". ESTEC contract number 4000104986/11/NL/CBi

"SPACEKIDS: A New Imaging Technology for Observations In and From Space". EU-FP7

Significant infrastructure

The astronomy instrumentation group has a full suite of facilities for design manufacture and testing (to space flight standards) of instrumentation for ground, airborne and space-based instrumentation. Software packages include GRASP, Zemax, Comsol Multiphysics, Sonnet, HFSS, Solidworks, among others. We have a full CNC equipped mechanical workshop dedicated to the group, and test facilities including antenna test ranges, numerous cryogenic test beds (base temperatures down to <20mK), spectroscopy suites and optical tables, vector network analysers etc.

4.1.9 MPA

4.1.9.1 Description

Max Planck Gesellschaft (Max Planck Society) is Germany's most successful research organization. Since its establishment in 1948, no fewer than 18 Nobel laureates have emerged from the ranks of its scientists, putting it on a par with the best and most prestigious research institutions worldwide. The more than 15,000 publications each year in internationally renowned scientific journals are proof of the outstanding research work conducted at Max Planck Institutes – and many of those articles are among the most-cited publications in the relevant field.

Currently there are 82 Max Planck Institutes, which conduct basic research in the service of the general public in the natural sciences, life sciences, social sciences, and the humanities. Max Planck Institutes are funded primarily by German Confederation, as well as by States in which institutes are located. Max Planck Institutes focus on research fields that are particularly innovative, or that are especially demanding in terms of funding or time requirements.

Max-Planck-Institut für Astrophysik (MPA), founded in 1958 and located in Garching, Germany, is one of the 82 Max Planck Institutes. The scientific members of MPA consist of 4 directors (Guinevere Kauffmann, Eiichiro Komatsu, Rashid Sunyaev and Simon White), 11 permanent staff members, about 40 postdocs, about 40 PhD students, and about 10 master students. MPA attracts about 60 guests per year who stay for more than 2 weeks.

MPA is a world-leading institute in theoretical, computational, and interpretational astrophysics and cosmology. The members of MPA publish about 300 scientific papers per year, many of which are high-impact papers; for example, Kauffmann, Komatsu, and White are named “Highly Cited Researcher” by Thomson Reuters, in recognition of ranking among the top 1% of researchers for most cited papers in space science published in 2002– 2012.

MPA will lead the Work Package 2. The scientists at MPA have significant expertise in such analysis and theoretical interpretation of the large data sets, including the CMB data from NASA’s Wilkinson Microwave Anisotropy Probe (WMAP) and ESA’s Planck missions, and the large-scale structure data from Sloan Digital Sky Survey (SDSS). Many of the highest impact papers from MPA are the papers that deal with the analysis and theoretical interpretation of the data.

We at MPA plan to work in close collaboration with Cosmology and Structure Formation group at LMU led by Prof. Joseph Mohr. Mohr is a co-founder of the South Pole Telescope (PI: Prof. John Carlstrom, U Chicago), and he and his team have focused on the study of SZE selected galaxy clusters identified in the SPT-SZ survey. The LMU team will contribute to WP2 elements from the perspective of using CMB-S4 as a platform to extend structure formation and cosmology studies using galaxy clusters and CMB lensing. In addition, the LMU team will coordinate with the MPA team in defining the computing needs of the collaboration and in estimating the needs of this CMB-S4 computing infrastructure.

4.1.9.2 CVs

Eiichiro Komatsu (male, coordinator)

Cosmologist. Director of the department of Physical Cosmology at MPA. He was a key team member of the WMAP science team, and has 14 years of data-analysis experience with the CMB data. The papers on the cosmological interpretations of the WMAP five- and seven-year data, for which Komatsu is the lead author, were named the most highly cited papers of all science fields in 2009 and 2011 by Thomson Reuters. Recipients of numerous prizes, including the International Union of Pure and Applied Physics (IUPAP) Young Physicist’s Prize; Nishinomiya Yukawa Memorial Prize; Gruber Cosmology Prize; Lancelot M. Berkeley Prize of American Astronomical Society; and Chushiro Hayashi Prize of Astronomical Society of Japan. More than 45000 citations, h-index=58 (ADS).

4.1.9.3 Publications

1. E. Komatsu et al. “*Seven-Year Wilkinson Microwave Anisotropy Probe (WMAP) Observations: Cosmological Interpretation*”, *Astrophysical Journal Supplement Series*, **192**, 19 (2010)
2. N. Katayama & E. Komatsu “*Simple Foreground Cleaning Algorithm for Detecting Primordial B-mode Polarization of the Cosmic Microwave Background*”, *Astrophysical Journal*, **737**, 78 (2011)
3. G. Hinshaw, D. Larson, E. Komatsu et al. “*Nine-Year Wilkinson Microwave Anisotropy Probe (WMAP) Observations: Cosmological Parameter Results*”, *Astrophysical Journal Supplement Series*, **208**, 19 (2013)
4. J. Kim & E. Komatsu “*Limits on Anisotropic Inflation from the Planck Data*”, *Physical Review D* **88**, 101301(R) (2013)
5. The likelihood code of the WMAP polarization data, posted to the LAMBDA website (lambda.gsfc.nasa.gov/product/map/current/), which was used also by the Planck collaboration

4.1.9.4 Previous Projects

1. Data analysis and scientific interpretation of the temperature and polarization data from the WMAP mission for constraining the cosmological parameters and testing Gaussianity
2. Data analysis and scientific interpretation of the Planck temperature data for constraining statistical anisotropy
3. Study of the choice of the frequency channels for the proposed “LiteBIRD” mission measuring CMB polarization
4. Development of the software for simulating the large-scale structure data of the “Hobby-Eberly Telescope Dark Energy Experiment” (HETDEX) galaxy survey project

4.1.9.4 Infrastructures

MPA has access to abundant computational resources, including super computers at “Rechenzentrum Garching” (RZG; a joint computing center of the Max Planck Society and the Max Planck Institute for Plasma Physics). The main computer cluster used for the proposal work will be the “ODIN” cluster, which has 2500 computing cores, and Komatsu’s group has privileged access to this cluster.

In addition to the RZG, we plan to pursue the needed computing support for the WP2 analyses through the Computing Center for Particle and Astrophysics (C2PAP), a facility initiated by Prof. Mohr in the second round of the Excellence Initiative supported by the German funding agency (DFG). C2PAP operates within the framework of the Universe Cluster of Excellence, a physics frontier center that is a partnership between the TUM and LMU Universities, the Max Planck Institutes in Garching (including MPA), ESO and the Leibniz Computing Center (LRZ). C2PAP is staffed by five scientists, and it supports projects initiated by Universe Cluster scientists (Mohr and Komatsu are members). It has dedicated high performance computing facilities located within LRZ. Beyond the end of the Excellence Cluster Universe the C2PAP will be supported by state funds through the LMU and is likely to be incorporated into any postcursor cluster approved within the next round of the Excellence Initiative.

4.1.10 National University of Ireland, Maynooth

4.1.10.1 Description

The National University of Ireland, Maynooth (NUIM) is as an autonomous member of the federal National University of Ireland structure. It provides undergraduate and postgraduate degrees to approximately 11,000 registered students. NUIM has 28 academic Departments/Schools which are organized into three Faculties: Arts, Celtic Studies & Philosophy; Science and Engineering, and Social Sciences. The staff members who would participate in this proposal are members of the Department of Experimental Physics.

The Terahertz Optics group in the Department of Experimental Physics currently consists of 4 academic staff and 9 graduate research students and has recognised expertise in millimetre-wave and THz optics, electromagnetics, instrument qualification and astronomical observation. We have been core team members of a number of important astronomical projects (e.g. HFI on Planck, QUBIC, HIFI Herschel, QUaD, SCUBA2

and ALMA). In addition to experience with commercial software (e.g. GRASP, Zemax, CST), we have written our own code for both the electromagnetic modelling of horn antennas (SCATTER) and THz optical analysis incorporating features not available commercially (MODAL). The main tasks that we have been attributed in this proposal involve optical design, analysis and performance evaluation.

4.1.10.2 CVs

Primary responsibility:

Dr. C. O'Sullivan (Female, Senior Lecturer, Dept of Experimental Physics) is working on a number of on-going international research programmes into the development of space- and ground-based astronomical receivers with a special interest in the design and verification instruments to observe the cosmic microwave background (including the QUBIC project). Has also been involved in an EU-FP7 project on far-infrared interferometry and European Space Agency (ESA) funded Technical Research Programmes (TRPs).

Other NUIM collaborators:

Prof. J. Anthony Murphy (Male, Professor & Head of Department of Experimental Physics, NUIM) specialises in THz space optics and technology and has had co-investigator status on three large instrument projects: the HFI instrument on ESA's Planck Surveyor, the HIFI instrument on ESA's Herschel Space Observatory and the QUaD Telescope with Stanford, Caltech, JPL, Chicago and Cardiff Universities. Has also been involved in consortia working on ESA TRPs.

Dr. N. Trappe (Male, Senior Lecturer, Dept of Experimental Physics) Research interests include long-wavelength optical analysis and design extending mainly to a number of international collaborations including ALMA, the HIFI instrument for the Herschel Space Observatory and the development of the detector antennas for the SAFARI instrument for SPICA. Currently managing an ESA TRP investigating coupling to detectors over large focal planes.

Dr. M. Gradziel (Male, Lecturer, Dept of Experimental Physics, NUIM) Current research interests include the integrated modelling of complete quasi-optical systems at millimetre and THz wavelengths along with the development of the MODAL software package and the design and experimental verification of performance of imaging systems in the W band (75-110 GHz).

4.1.10.3 Publications

Bracken, C., O'Sullivan, C., Murphy, J. A., Donohoe, A., Savini, G., Lightfoot, J., Juanola-Parramon, R., "Quasi-optical analysis of a far-infrared spatio-spectral space interferometer concept", *Infrared Physics and Technology*, Volume 77, p. 171-178, 2016

Trappe, N.; Bracken, C.; Doherty, S.; Gao, J. R.; Glowacka, D.; Goldie, D.; Griffin, D.; Hijmering, R.; Jackson, B.; Khosropanah, P.; Mauskopf, P.; Morozov, D.; Murphy, A.; O'Sullivan, C.; Ridder, M.; Withington, S., "Optical modeling of waveguide coupled TES detectors towards the SAFARI instrument for SPICA", *Millimeter, Submillimeter, and Far-Infrared Detectors and Instrumentation for Astronomy VI. Proceedings of the SPIE*, Volume 8452, article id. 84520L, (2012).

J A Murphy, T Peacocke, B Maffei, I McAuley, F Noviello, V Yurchenko, P A R Ade, G Savini, J-M Lamarre, J Brossard, R Colgan, E Gleeson, A E Lange, Y Longval, G Pisano, J-L Puget, I Ristorcelli, R Sudiwala, and R J Wylde, "Multi-mode horn design and beam characteristics for the Planck satellite", *Journal of Instrumentation*, Vol. 5, doi:10.1088/1748-0221/5/04/T04001, April 2010

Maffei, B.; Noviello, F.; Murphy, J. A.; Ade, P. A. R.; Lamarre, J.-M.; Bouchet, F. R.; Brossard, J.; Catalano, A.; Colgan, R.; Gispert, R.; Gleeson, E.; Haynes, C. V.; Jones, W. C.; Lange, A. E.; Longval, Y.; McAuley, I.; Pajot, F.; Peacocke, T.; Pisano, G.; Puget, J.-L.; Ristorcelli, I.; Savini, G.; Sudiwala, R.; Wylde, R. J.; Yurchenko, V., " Planck pre-launch status: HFI beam expectations from the optical optimisation of the focal plane", *Astronomy and Astrophysics*, Volume 520, id.A12 , 2010

'The Quasi-Optical Design of the QUaD Telescope', O'Sullivan C., Cahill G., Murphy J.A., Gear W.K., Harris J., Ade P.A.R., Church S.E., Thompson K.L., Pryke C., Bock J., Bowden M., Brown M.L., Carlstrom J.E., Castro P.G., Culverhouse T., Friedman R.B, Ganga K.M., Haynes V., Hinderks J.R., Kovak J., Lange A.E., Leitch E.M., Mallie O.E., Melhuish S.J., Orlando A., Piccirillo L., Pisano G., Rajguru N., Rusholme B.A., Schwarz R., Taylor A.N., Wu E.Y.S., Zemcov M. (2008) 'The Quasi-Optical Design of the QUaD Telescope'. *Infrared Physics and Technology*, 51(4), 277-286.

4.1.10.4 Projects

FISICA (2013-2015, Far Infrared Space Interferometer Critical Assessment: Scientific Definition and Technology Development for the Next Generation THz Space Interferometer, <http://www.fp7-fisica.eu/>). The Maynooth group was part of the FISICA FP-7 project team that aimed to advance the technological development of a selected number of key components required for the design of a far-infrared interferometer in space. The project also included the reformulation of the science case for such an instrument and the resulting instrument requirements. As part of this work a comprehensive computer model of the chosen conceptual design was developed.

The Maynooth group is currently leading two European Space Agency Technical Research Programmes: one investigates horn design and optimisation for both single moded and multimoded structures towards future CMB and Terahertz space missions (New Technology High Efficiency Horn Antennas For Cosmic Microwave Background Experiments and Far-Infrared Astronomy, CONTRACT RFQ 3-6418/11/NL/CB1) and the other next generation sub-millimetre wave focal plane array coupling concepts (ITT AO/11-7393/12/NL/MH). In the past we have been involved in similar ESA TRP contracts to study far infrared optics design and verification, TES spectrometers and Modular Wide Field of View RF Configurations.

Members of the group have achieved co-investigator status on Planck and Herschel-HIFI and our involvement with these projects go back over a decade.

4.1.10.5 Infrastructures

The research group at Maynooth has access to a suite of useful mathematical & computer programming software developed in-house including:

SCATTER, a program for the modelling of waveguide structures in both single and multi-mode operation. It is based upon the technique of electromagnetic scattering by mode-matching. The technique is also applied to multi-mode horns as well as coherent single-mode horns. A high-speed implementation of the code was used for the full pixel modelling of the Planck multi-mode horns. It attains its high performance by exploiting the structure of the scattering operators and from a more thorough algebraic analysis of the scattering problem. It also incorporates run-time checks on the numerical stability and physical realism of the scattered field at every step.

MODAL: Over the past few years the research group at Maynooth have been developing a software package MODAL (Maynooth Optical Design and Analysis Laboratory) which encompasses the various elements of design and analysis required for long-wavelength receivers and other optical systems where diffraction dominates propagation. It combines an OpenGL user interface, for easy definition and manipulation of optical systems, with a powerful and flexible analysis engine that implements multiple propagation methods,

ranging from Gaussian Beam Mode decomposition to a full Physical Optics approach. It also allows SCATTER models of waveguide components to be embedded into a larger optical system. Calculations can be accelerated by running the code on a parallel computer composed of a heterogeneous collection of machines (using PVM). MODAL is by design a multi-platform package.

Experimental testing laboratory: We have at our disposal a VNA (Vector Network Analyser) based near field scanning facility that can be used to characterise waveguide components and antennas/horns in the W-band (75 to 110 GHz). Our W-band VNA is built around a standard Rohde & Schwarz ZVA-24 RF VNA and twin ZVA-110 frequency converter allowing amplitude and phase measurements in the 75-110 GHz band. The VNA is complemented by a custom multi-axis scanning system that allows all test measurements to be fully automated (for example XY scan with the angle and position of the receiver also swept). We also have a good selection of other sources and detectors that cover that band that can be used in combination or instead of the VNA frequency converter heads.

4.1.1. National Observatory of Athens (NOA)

The National Observatory of Athens (NOA) is the oldest scientific research establishment in Greece, having been founded in 1842. It has been used by Greek and foreign researchers as the basis for astronomical, meteorological, cartographical and geodynamical measurements and observations in its 175 years of history. NOA is a governmental research centre, supervised by the General Secretariat for Research and Technology of the Ministry of Education. The activities of the National Observatory of Athens are organized in 3 research Institutes: the Institute of Astronomy, Astrophysics, Space Applications and Remote Sensing, the Institute of Environmental Research and Sustainable Development, and the Institute of Geodynamics. NOA's scientific mission primarily deals with the collection of observational data from hundreds of ground-based stations and several modern space probes and with applied research dealing with astronomy, astrophysics and cosmology, the atmospheric and near-earth environment, the crust and the interior of the earth. Besides basic and applied research and services directed towards the society, these Institutes provide the facilities for graduate student training in collaboration with Greek and foreign Universities. NOA hosts the UNESCO Chair for Natural Disasters and the Greek Focal Point of the Global Earth Observing System of Systems (GEOSS) and operates the National Seismological Network and other international research networks. The Centre, with its rich scientific production and activities, is linked to entrepreneurship, culture, education and the popularization of science. NOA offers critical social services, such as the daily monitoring of seismicity on a 24/7 basis, weather forecasting, forest fire monitoring, ionospheric activity recording, continuation of a 150 years long climatic dataset and operation of one of the largest European continental telescopes. It also provides the national gate to the European Space Agency. The NOA research centre has an important contribution to public outreach via its popular visitors centres at Penteli and the Astrogeophysics Museum in Thission, housing clocks, telescopes and other instruments of the 19th century, as well as an extensive 19th century library.

The largest NOA Institute is the Institute of Astronomy, Astrophysics, Remote Sensing and Space Applications (IAASARS), which has numerous research programs in Earth Observation, space physics and astrophysics. These programs bring a revenue of over 3M€ per year mainly from the European Space Agency, the European Union and the National Secretariat of Research and technology. 24 permanent research staff are employed in the institute as well as 5 permanent scientific officers. The largest research activity of the Institute regards astrophysics with space probes like XMM-Newton, Chandra, Herschel, etc.

Brief CV of co-I.

Prof. Manolis Plionis is a Full Professor at the Physics Department of the Aristotle University of Thessaloniki and the Director & President of BoD of the National Observatory of Athens. He is also Vice-President of the Governing Board of the NOHSIS Science Centre & Technological Museum. He speaks Greek, English, Spanish and Italian and he is a member of the IAU, and a founding member both of the Hellenic Astronomical Society (founding member) and of the Hellenic Society of Relativity, Gravitation and Cosmology. His research interests span from observational, numerical and theoretical Cosmology to Extragalactic astrophysics using multi-wavelength data. He was a Human Capital and Mobility (early Marie Curie) fellow at SISSA-Italy (1994-1995). He has more than 200 publications out of which 115 in international refereed journals. Of these in 26 he is the first or single author. He has organized 6 international conferences and one international advanced school. He is a member of the Editorial Board of the International Journal of Modern Physics D. Also member of the Chandra *Active Galaxies & Quasars* time allocation panel of AO-11, and of the XMM *Surveys* time allocation panel of AO-12 & AO-13. He is a H2020 expert referee.

Relevant Publications

- *The XXL Survey. VI. The 1000 brightest X-ray point sources* by Fotopoulou, S.; Pacaud, F.; Paltani, S.; Ranalli, P.; Ramos-Ceja, M.E.; Faccioli, L.; Plionis, M.; + 32 co-authors in alphabetical order, *A&A*, 592, 5 (2016)
- *Constraining the dark energy equation of state with H II galaxies*, by Chávez, R.; Plionis, M.; Basilakos, S.; Terlevich, R.; Terlevich, E.; Melnick, J.; Bresolin, F.; González-Morán, A. L., *MNRAS*, 462, 2431-2439 (2016)
- *Direct measurement of lensing amplification in Abell S1063 using a strongly lensed high redshift HII galaxy* by Terlevich, R.; Melnick, J.; Terlevich, E.; Chávez, R.; Telles, E.; Bresolin, F.; Plionis, M.; Basilakos, S.; Fernández Arenas, D.; González Moran, A.L.; Díaz, Ángeles I.; Aretxaga, I, *A&A*, 592, 7 (2016)
- *Comparison of spatial and angular clustering of X-ray AGN* by Koutoulidis, L.; Plionis, M.; Georgantopoulos, I.; Georgakakis, A.; Akylas, A.; Basilakos, S.; Mountrichas, G., *A&A*, Volume 590, 23 (2016)
- *Testing the isotropy of the Hubble expansion*, by Migkas, K.; Plionis, M., *Revista Mexicana de Astronomía y Astrofísica* 52, 133-141 (2016)

Relevant projects

- **The Ultimate XMM Extragalactic X-ray Survey (XXL).** Member of the Scientific Committee of the Project and of the Steering Committee of the Consortium.
(http://irfu.cea.fr/en/Phoce/Vie_des_labos/Ast/alltec.php?id_ast=3015)
- **Cosmology with HII galaxies.** Collaboration with IfA-Hawai, ESO-Chile and INAOE. Member of the Scientific Committee of the collaboration.

4.1.1.1. Academy of Athens: Research Center for Astronomy & Applied Mathematics (RCAAM)

In the Academy's of Athens Founding Charter of 1926, scientific research is included in its objectives, the realization of which is provided for through the founding of 'Laboratories of Scientific Research' and through the encouragement and support of research projects. Furthermore, the Academy grants scholarships and confers awards. Since its establishment the Academy of Athens has been a member of the International Union of Academies and of the International Council of Scientific Unions (ICSU). On numerous occasions the Academy of Athens has rendered its services to the Greek state through its expert opinion and proposals, usually on issues of major national importance, education and fiscal policy. Currently there are 23 Research Centers and Offices in operation. The Academy's latest major contribution to research is the establishment of the Foundation of Medical and Biological Research.

The Research Center for Astronomy and Applied Mathematics (RCAAM), is one of the Research Institutes of the Academy of Athens. RCAAM was established in 1959, to promote scientific research in Astronomy and Applied Mathematics and to perform calculations related to these topics. Specifically, the main scientific goals for the current period include the study of the role of chaos in supporting structures in N-body simulations, the dynamics of the Milky Way and other galaxies, the study of the magnetic connectivity in the active-regions of the solar atmosphere, the investigation of particle acceleration in the pulsar magnetosphere and the time profiles of the resulting high energy radiation, the formation and evolution of structures in Cosmology as well as the nature of dark matter and dark energy. A large number of young researchers are coming to the Institute and successfully complete their PhD and Masters Theses. In this context, the teaching of the courses "Non-linear Dynamics", "Extragalactic Astronomy" and "Cosmology" for students at the University of Athens are done by members of the Institute. RCAAM organizes since 1997 on a weekly basis during the whole year a seminar with speakers leading scientists from Greece and abroad. The talks are attended by many researchers, university professors and young scientists. RCAAM has organized several international conferences on various topics and a series of talks for the broad public which are given every year. In the last decade the members of the Institute have published more than 700 scientific articles in refereed journals and conference proceedings. Finally, the members of RCAAM participate in several research programs, where funds acquired mostly through competitive calls by European and National funding agencies.

Brief CV of co-I.

Dr. Spyros Basilakos is a cosmologist with a career spanning scientific research, academic teaching and science communication. He has held a number of academic positions at various universities around Europe. Currently, he is a director of research at the Academy of Athens (Research Center for Astronomy and Applied Mathematics - RCAAM). He is a member of the Hellenic Astronomical society, an elected Councilor of the Governing Board of the Hellenic Society for Relativity, Gravity and Cosmology and a member of the committee that proposed to the Greek Ministry of Education the National council for Research and Technology for the period 2017-2021.

He completed his PhD studies in Cosmology at the University of Athens. During the period 1999-2002, he worked as a PPARC fellow at the Imperial College (UK). From 2002 to 2005, he worked within NOA's (National observatory of Athens) program searching for the clustering properties of the large scale structures. In 2005 he joined the astrophysics group at the University of Groningen (The Netherlands) as a NOVA fellow. For the period 2006-2014 he was a faculty member (Senior Researcher) at the Academy of Athens (RCAAM) and a Visiting Professor in Physical Cosmology at the University of Barcelona (2011-2012). Today he is Director of Research at RCAAM. In 2013 and 2014 he participated in the international Gravity competition organized by the Gravity Research Foundation (GRF -USA) and his scientific works received honorable mentions by GRF. He published 170 scientific articles out of which 120 in refereed journals and 50 in conference proceedings. Moreover, he supervised 1 Post-doc, 5 PhD, 5MSc and 5BSc theses and he participated in several international collaborations and scientific programs. Currently, he gives lectures in

Cosmology and General Relativity at the University of Athens and contributes to public engagement events in science.

Relevant Publications

- Kamali V., Basilakos S., Mehrabi A., 2016, Eur. Phys. J. C 76, 525, “Tachyon warm-intermediate inflation in the light of Planck data”
- Basilakos S. and Nesseris S., 2016, Phys. Rev. D., 94, 123525, “Testing Einstein's gravity and dark energy with growth of matter perturbations: Indications for new physics?”
- Basilakos S. and Barrow J. D, 2015, Phys. Rev. D..91, 103517, “Hyperbolic inflation in the light of Planck 2015 data”
- Basilakos S., Lima J. A. S, Sola, J. 2014, Intern. J. Mod. Phys. D, 23, 1442011, “A viable Starobinsky-like inflationary scenario in the light of Planck and BICEP2 results”
- Lima J. A.S., Basilakos S., Sola J., 2013, MNRAS, 431, 923, “Expansion history with decaying vacuum: a complete cosmological scenario”

4.2. Third parties involved in the project (including use of third party resources)

Please complete, for each participant, the following table (or simply state "No third parties involved", if applicable):

4.2. CNRS

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	No
<i>If yes, please describe and justify the tasks to be subcontracted</i>	
Does the participant envisage that part of its work is performed by linked third parties ¹	No
<i>If yes, please describe the third party, the link of the participant to the third party, and describe and justify the foreseen tasks to be performed by the third party</i>	
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	No

4.2.2 Milan

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	No
<i>If yes, please describe and justify the tasks to be subcontracted</i>	
Does the participant envisage that part of its work is performed by linked third parties	No
<i>If yes, please describe the third party, the link of the participant to the third party, and describe and justify the foreseen tasks to be performed by the third party</i>	
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	No
<i>If yes, please describe the third party and their contributions</i>	

4.2.3 Roma I – La Sapienza

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	No
<i>If yes, please describe and justify the tasks to be subcontracted</i>	

¹ A third party that is an affiliated entity or has a legal link to a participant implying a collaboration not limited to the action. (Article 14 of the Model Grant Agreement).

Does the participant envisage that part of its work is performed by linked third parties	No
<i>If yes, please describe the third party, the link of the participant to the third party, and describe and justify the foreseen tasks to be performed by the third party</i>	
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	No
<i>If yes, please describe the third party and their contributions</i>	

4.2.4 INFN

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	NO
<i>If yes, please describe and justify the tasks to be subcontracted</i>	
Does the participant envisage that part of its work is performed by linked third parties	NO
<i>If yes, please describe the third party, the link of the participant to the third party, and describe and justify the foreseen tasks to be performed by the third party</i>	
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	NO
<i>If yes, please describe the third party and their contributions</i>	

4.2.5 IAC

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	No
<i>If yes, please describe and justify the tasks to be subcontracted</i>	
Does the participant envisage that part of its work is performed by linked third parties	No
<i>If yes, please describe the third party, the link of the participant to the third party, and describe and justify the foreseen tasks to be performed by the third party</i>	
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	No
<i>If yes, please describe the third party and their contributions</i>	

4.2.6 CSIC

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	No
<i>If yes, please describe and justify the tasks to be subcontracted</i>	
Does the participant envisage that part of its work is performed by linked third parties	No
<i>If yes, please describe the third party, the link of the participant to the third party, and describe and justify the foreseen tasks to be performed by the third party</i>	
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	No
<i>If yes, please describe the third party and their contributions</i>	

4.2.7 UC

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	No
<i>If yes, please describe and justify the tasks to be subcontracted</i>	
Does the participant envisage that part of its work is performed by linked third parties	No
<i>If yes, please describe the third party, the link of the participant to the third party, and describe and justify the foreseen tasks to be performed by the third party</i>	
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	No
<i>If yes, please describe the third party and their contributions</i>	

4.2.8 Cardiff

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	No
<i>If yes, please describe and justify the tasks to be subcontracted</i>	
Does the participant envisage that part of its work is performed by linked third parties	No
<i>If yes, please describe the third party, the link of the participant to the third party, and describe and justify the foreseen tasks to be performed by the third party</i>	
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	No
<i>If yes, please describe the third party and their contributions</i>	

4.2.9 MPA

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	No
<i>If yes, please describe and justify the tasks to be subcontracted</i>	
Does the participant envisage that part of its work is performed by linked third parties	No
<i>If yes, please describe the third party, the link of the participant to the third party, and describe and justify the foreseen tasks to be performed by the third party</i>	
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	No
<i>If yes, please describe the third party and their contributions</i>	

4.2.10 Maynooth

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	No
<i>If yes, please describe and justify the tasks to be subcontracted</i>	
Does the participant envisage that part of its work is performed by linked third parties	No
<i>If yes, please describe the third party, the link of the participant to the third party, and describe and justify the foreseen tasks to be performed by the third party</i>	
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	No
<i>If yes, please describe the third party and their contributions</i>	

4.2.11 NOA

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	Yes
As noted in table 3.1a for work-package 1, the Research Centre for Astronomy and Applied Maths (RCAAM) of the Academy of Athens will be a subcontractor for work-package 2 (with work there being coordinated by Spyros Basilakos), and focus on the production of production of educational materials. They have experience doing this in the past.	
Does the participant envisage that part of its work is performed by linked third parties	No
<i>If yes, please describe the third party, the link of the participant to the third party, and describe and justify the foreseen tasks to be performed by the third party</i>	

Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	No
<i>If yes, please describe the third party and their contributions</i>	

Section 5: Ethics and Security

 *This section is not covered by the page limit.*

5.1 Ethics

 *For more guidance, see the [document "How to complete your ethics self-assessment"](#).*

If you have entered any ethics issues in the ethical issue table in the administrative proposal forms, you must:

- submit an ethics self-assessment, which:
 - o describes how the proposal meets the national legal and ethical requirements of the country or countries where the tasks raising ethical issues are to be carried out;
 - o explains in detail how you intend to address the issues in the ethical issues table, in particular as regards:
 - o research objectives (e.g. study of vulnerable populations, dual use, etc.)
 - o research methodology (e.g. clinical trials, involvement of children and related consent procedures, protection of any data collected, etc.)
 - o the potential impact of the research (e.g. dual use issues, environmental damage, stigmatisation of particular social groups, political or financial retaliation, benefit-sharing, misuse, etc.).
- provide the documents that you need under national law (if you already have them), e.g.:
 - o an ethics committee opinion;
 - o the document notifying activities raising ethical issues or authorising such activities

 *If these documents are not in English, you must also submit an English summary of them (containing, if available, the conclusions of the committee or authority concerned).*

 *If you plan to request these documents specifically for the project you are proposing, your request must contain an explicit reference to the project title.*

5.2 Security²

Please indicate if your project will involve:

- activities or results raising security issues: NO
- 'EU-classified information' as background or results: NO

² See article 37 of the [Model Grant Agreement](#)