

Final project report

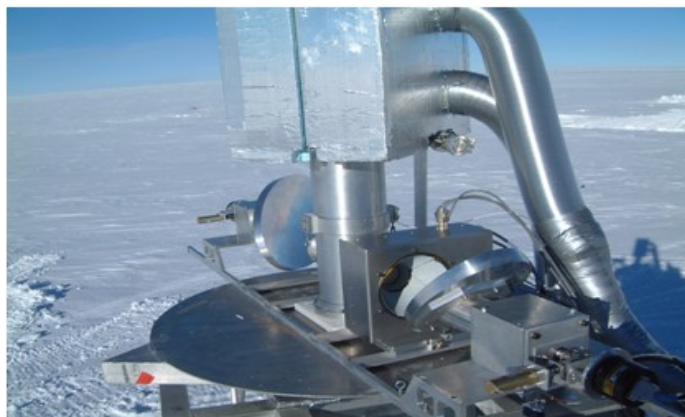
<i>Project ID</i>	2006/7.01
<i>Title</i>	BRAIN: Interferometria Bolometrica e polarizzazione del fondo cosmico a microonde (BRAIN)
<i>Principal investigator</i>	S. Masi
<i>Institution</i>	Dipartimento di Fisica, Università La Sapienza
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<i>Duration</i>	3 years
<i>Assigned funding</i>	100.000,00 Euro

Activities and results

We have built and operated in Dome-C a pathfinder experiment for the BRAIN interferometer. The experiment consisted in two bolometric detectors working at 140 GHz, mounted on a 2m baseline, one sensitive to polarization (modulated by a rotating quarter-wave-plate QWP) and the other one sensitive to total intensity. The main purpose of this pathfinder experiment was to test the Dome-C site in terms of logistics for a pulse-tube cooled cryogenic experiment, and of polarization purity of the atmosphere, in view of precision measurements of the polarization of the CMB, to be carried out in the continuation of this activity.

The measurements and the experimental apparatus have been designed and built in collaboration with our colleagues at APC Paris (the group of Yannick Giraud Heraud) and University of Manchester (Bruno Maffei). We have worked with the instrument in Dome-C during four Antarctic campaigns now. We have routinely reached the operating temperature (0.3K) and have performed measurement of atmospheric emission and polarization. We were able to set an interesting upper limit (<1% polarization degree) on the linear polarization of the atmosphere in the 140 GHz window (resulting from zeeman splitting of a neighbor O₂ line), and to measure routinely the optical depth of the atmosphere at 140 GHz (>90% at the zenith for all the clean days during the Antarctic summer).

After an initial optimization phase, the modulator, based on a rotating QWP has worked flawlessly, as well as the two off-axis parabolic concentrators mounted on an alt-azimuth mount together with the cryostat. Inside the cryostat the cold stage of the detectors at 0.3K has been insulated from the ³He refrigerator and the pulse tube refrigerator vibrations, using an original support which connects (and supports) the detector directly to the external massive vacuum shell of the cryostat. In an ancillary effort we have built a spectral hygrometer sensitive enough to be used with the moonlight, for measurements of precipitable water vapor during the Antarctic winter. This instrument is being used by our winter-over in the winter campaign of 2011.



The Brain pathfinder experiment, mounted in Dome-C. The two off-axis parabolooids, the rotating waveplate and the cylindric vertical cryostat are evident. The top box includes the pulse-tube head and the two tubes are used to connect the pulse tube to the compressor. All these parts are protected and heated to 20C for correct operation of the system.

Products

A – papers in scientific magazines

- 1) G. Polenta, P.A.R. Ade, J. Bartlett, E. Breelle, L. Conversi, P. de Bernardis, C. Dufour, M. Gervasi, M. Giard, C. Giordano, Y. Giraud-Heraud, B. Maffei, S. Masi, F. Nati, A. Orlando, S. Peterzen, F. Piacentini, M. Piat, L. Piccirillo, G. Pisano, R. Pons, C. Rosset, G. Savini, G. Sironi, A. Tartari, M. Veneziani, M. Zannoni, *"The BRAIN CMB polarization experiment"*, *New Astronomy Reviews*, 51 (2007) 256-259
- 2) Martino Calvo, Claudia Giordano, Roberto Battiston, Paolo de Bernardis, Benno Margesin, Silvia Masi and Alessandro Monfardini, *Development of Kinetic Inductance Detectors for Cosmic Microwave Background experiments*, *Experimental Astronomy* (2010) 28: 185–194
- 3) The QUBIC collaboration, E. Battistelli, A. Baù, D. Bennett, L. Berge, J.-Ph. Bernard, P. de Bernardis, G. Bordier, A. Bounab, E. Bréelle, E.F. Bunn, M. Calvo, R. Charlassier, S. Collin, A. Coppolecchia, A. Cruciani, G. Curran, L. Dumoulin, A. Gault, M. Gervasi, A. Ghribi, M. Giard, C. Giordano, Y. Giraud-Heraud, M. Gradziel, L. Guglielmi, J.-Ch. Hamilton, V. Haynes, J. Kaplan, A. Korotkov, J. Lande, B. Maffei, M. Maiello, S. Malu, S. Marnieros, J. Martino, S. Masi, A. Murphy, F. Nati, C. O'Sullivan, F. Pajot, A. Passerini, S. Peterzen, M. de Petris, F. Piacentini, M. Piat, L. Piccirillo, G. Pisano, G. Polenta, D. Prele, D. Romano, C. Rosset, M. Salatino, A. Schillaci, G. Sironi, R. Sordini, S. Spinelli, A. Tartari, P. Timbie, G. Tucker, L. Vibert, F. Voisin, R.A. Watson, M. Zannoni. QUBIC: The QU Bolometric Interferometer for Cosmology, *Astroparticle Physics*, 34, 705–716, (2011), astro-ph/1010.0645, doi:10.1016/j.astropartphys.2011.01.012

B – book chapters

- 1) S. Masi, P. de Bernardis, *"Measurements of CMB Polarization with bolometers"* in *"Cosmic Polarization"*, pg. 46, R. Fabbri editor, Research Signpost, (2006) ISBN 81-308-0089-6

C - proceedings of international conferences

- 1) P. de Bernardis, *"CMB Observations from Dome-C"*, Proc. of the 2nd ARENA Conference "The Astrophysical Science Cases at Dome C", Potsdam, 17-21 September 2007, H. Zinnecker, H. Rauer & N. Epchtein eds., EAS Publications Series, **33**, 175-182 (2008), EDP Sciences.
- 2) P. de Bernardis, D. Barbosa, Y. Giraud-Heraud, M. Gervasi, E. Kreysa, B. Maffei, S. Masi, P. Mauskopf, F. Pajot, L. Verde, *"Cosmic Microwave Background science from Dome-C"*, in 3rd ARENA Conference: "An Astronomical Observatory at CONCORDIA (Dome C, Antarctica)", EAS Publications Series, **40**, 391-398 (2010), L. Spinoglio and N. Epchtein eds., ISBN: 978-2-7598-0485-6
- 3) D. Barbosa, P. de Bernardis, M. Gervasi, Y. Giraud-Héraud, E. Kreysa, B. Maffei, S. Masi, P. Mauskopf, F. Pajot and L. Verde, *"Foregrounds: Unveiling the Galactic Weather to the CMB"*, in 3rd ARENA Conference: "An Astronomical Observatory at CONCORDIA (Dome C, Antarctica)", EAS Publications Series, **40**, 437-442 (2010), L. Spinoglio and N. Epchtein eds., ISBN: 978-2-7598-0485-6
- 4) A. Tartari, J.G. Bartlett, E. Battistelli, A. Baù, D. Bennett, L. Bergé, J.-P. Bernard, A. Bounab, E. Bréelle, E. Bunn, R. Charlassier, A. Cruciani, S. Collin, G. Curran, P. De Bernardis, L. Dumoulin, A. Gault, M. Gervasi, A. Ghribi, M. Giard, C. Giordano, Y. Giraud-Héraud, M. Gradziel, L. Guglielmi, J.-C. Hamilton, V. Haynes, A. Iacoangeli, J. Kaplan, A. Korotkov, J. Lande, B. Maffei, M. Maiello, S.S. Malu, S. Marnieros, S. Masi, A. Murphy, C. O'Sullivan, F. Pajot, A. Passerini, S. Peterzen, F. Piacentini, L. Piccirillo, M. Piat, G. Pisano, G. Polenta, D. Prêle, C. Rosset, A. Schillaci, G. Sironi, S. Spinelli, G. Tucker, P. Timbie, F. Voisin, B. Watson, M. Zannoni, "BRAIN/MBI: a bolometric interferometer dedicated to the CMB polarization" proc. of the 5th ESA Workshop on Millimetre Wave Technology and Applications & 31st ESA Antenna Workshop, 18-20 May 2009 ESTEC, ESA-SP-XXX, (2009)

D – proceedings of national meetings and conferences

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E – thematic maps

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F – patents, prototypes and data bases

- 1) The BRAIN pathfinder instrument, including two bolometers and filters operating at 140 GHz, optimized for operation with a pulse-tube cryogenerator.
- 2) The quarter wave plate modulator and its rotation system, suitable for operation down to -80C.
- 3) The altazimuth mount, suitable for operation down to -80C
- 4) Measurements of atmospheric emission and polarization at 140 GHz.

G – exhibits, organization of conferences, editing and similar

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Programma Nazionale di Ricerche in Antartide (PNRA)

H - formation (PhD thesis, research fellowships, etc.)

"Assegno di ricerca" for two years at the Physics Department.

Research units

Dipartimento di Fisica, Università di Roma La Sapienza:

P. de Bernardis, S. Masi, E. Battistelli, G. Polenta (ASDC), A. Schillaci, S. Peterzen (ISTAR), M. Maiello (Università di Siena), R. Sordini.

Date: 07/April/2011

Notes