

## Final project report

<i>Project ID</i>	2003/7.02
<i>Title</i>	Bolometric interferometry and polarization of the Cosmic Microwave Background
<i>Principal investigator</i>	<b>Silvia Masi</b>
<i>Institution</i>	<i>Phys. Dept. La Sapienza University of Rome</i>
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<i>Duration</i>	2 years
<i>Assigned funding</i>	50.000,00 Euro

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### Activities and results

**Fig.1:** *The BRAIN instrument installed at Dome-C*



We participated to the 2005-2006 and 2006-2007 campaigns installing the BRAIN-pathfinder instrument at Dome-C, to characterize the site for CMB polarization measurements in the microwave range of frequencies. This experiment is an international collaboration with French and UK colleagues (APC Paris and University of Manchester). We also needed to validate some technologically new choices in particular for the cryogenic system. We prepared the shelter with the help of the logistics staff, working mainly on the insulation of the container, the electrical supply system wiring and test, with our power distribution box. We also prepared and installed the telescope mount and pointing control, and tested it before starting the calibration measurements. We prepared and set up the whole instrument, including the cryogenic apparatus, which worked for the rest of the available time for our permanence in Dome-C.

That has also been the first time such an apparatus (pulse-tube + 3He refrigerator) operated at Dome-C (and in Antarctica). We then characterized the detectors in order to be able to optimize them and started

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some preliminary atmospheric emission measurements at 150 GHz. Then we tested successfully the remote control of the instrument with INMARSAT telemetry system. The limited amount of time available for the observations did not allow us to obtain scientific results of relevance, but the campaign has been important under a technological aspect, because we have been able to install the entire instrument starting from an empty shelter and ending up with a lab and an instrument set up and perfectly working, and in particular we were able for the first time in the history of Dome C to use successfully an automated cryocooler operating the detectors at 0.3 K without the use of liquids, by means of a pulse tube cryocooler. With this activity we paved the way to the 2009-2010 campaign where the same instrument acquired final data of atmospheric polarization (circular and linear) at 150 GHz above Dome-C. The data are now being analyzed. The system is now ready for operation during the Antarctic winter.

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## Products

### A – papers in scientific magazines

- 1) G. Polenta et al, The BRAIN CMB polarization experiment. *New Astronomy Reviews*, 51:256–259, 2007
- 2) S. Masi et al, A cryo-cooler based cryostat suitable for automatic observation from Antarctica, in preparation (2010)
- 3) E. Battistelli et al, Measurements of atmospheric emission and polarization at 145 GHz from Dome-C (Antarctica), in preparation (2010)

### B – book chapters

### C - proceedings of international conferences

- 1) Masi, S., de Bernardis, P. Giordano, C. Nati, F., Piacentini, F. Polenta, G. Veneziani, M. Gervasi, M. Sironi, G. Tartari, A. Zannoni, M. Peterzen, S. Bartlett, J. Giraud-Heraud, Y. Piat, M. Rosset, C. Giard, M. Pons, R. Maffei, B. Ade, P. Gear, W. Mauskopf, P. Piccirillo, L. Pisano, G. Savini, G. "Precision CMB Polarization from DomeC: the BRAIN experiment." *EAS Publications Series*, volume **14**, pages 87-92, 2005
- 2) P. de Bernardis, "CMB Observations from Dome-C", *Proc. of the 2<sup>nd</sup> 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.
- 3) 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 3<sup>rd</sup> 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
- 4) 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 3<sup>rd</sup> 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
- 5) 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

- 1) C. Cressiot, M. Piat, J. Kaplan, E. Breelle, C. Dufour, C. Rosset, S. Masi, G. Polenta, S. Peterzen, and the BRAIN collaboration. *The BRAIN Project: Looking for BMode from DomeC*. In D. Barret, F. Casoli, T. Contini, G. Lagache, A. Lecavelier, and L. Pagani, editors, SF2A2006: Semaine de l'Astrophysique Francaise, pages 237--240, June 2006.
- 2) P. de Bernardis. Il misterioso oceano dell'universo primordiale, Darwin, Marzo-Aprile 2006, 36-43

### E – thematic maps

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### F – patents, prototypes and data bases

- 1) CMB polarimeter for measurement of circular and linear polarization of the sky at 145 GHz

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**G – exhibits, organization of conferences, editing and similar**

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

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### Research units

BRAIN sas International collaboration with several groups participating in Italy, France, UK, USA, Ireland: hereafter we report the Italian side of the collaboration

#### **Università di Roma – La Sapienza:**

- Paolo de Bernardis - prof ordinario
- Armando Iacoangeli - tecnico meccanico
- **Silvia Masi (PI)** - ricercatore
- Francesco Piacentini - ricercatore
- Steven Peterzen - project manager
- Claudia Giordano - dottoranda
- Angelo Cruciani - laureando
- Elia Battistelli - assegnista post-doc
- Mauro Maiello - dottorando
- Gianluca Polenta - assegnista post-doc
- Alessandro Schillaci - dottorando

#### **Università di Milano – Bicocca:**

- Massimo Gervasi - prof associato
  - Mario Zannoni - ricercatore
  - Giorgio Sironi - prof ordinario
  - Andrea Passerini - ricercatore
  - Alessandro Baù - ricercatore
  - Andrea Tartari - assegnista post-doc
  - Sebastiano Spinelli - dottorando
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Date: 28 march 2010

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*Notes*