



Q&U Bolometric Interferometer for Cosmology

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CMB ground based experiments - Milan 3/4 March 2019



APC Paris, France C2N Orsay, France **CSNSM Orsay, France** IAS Orsay, France **IRAP Toulouse, France** LAL Orsay, France Universita di Milano-Bicocca, Italy Universita degli studi di Milano, Italy Universita La Sapienza, Roma, Italy Maynooth University, Ireland Cardiff University, UK University of Manchester, UK **Brown University, USA Richmond University, USA** University of Wisconsin, USA Centro Atómico Constituyentes, Argentina **GEMA**, Argentina Comisión Nacional de Energía Atómica, Argentina Facultad de Cs Astronómicas y Geofísicas, Argentina Centro Atómico Bariloche and Instituto Balseiro, Argentina Instituto de Tecnologías en Detección y Astropartículas, Argentina Instituto Argentino de Radioastronomía, Argentina





















1 baseline





1 baseline



total signal (all baselines)

Quasi optical correlator





Self Calibration



Unique possibility to handle systematic errors

- Use horn array redundancy to calibrate systematics
- In a perfect instrument redundant baselines should see the same signal
- Differences due to systematics
- Allow to fit systematics with an external source on the field

Unique specificity of Bolometric Interferometry ! Bigot-Sazy et al., A&A 2013, arXiv:1209.4905



Redundant baselines : same Fourier Mode







Bolometric Interferometry

Primary horn array

Synthesized beam (on the sky)





150-220 GHz, 20x20 horns, 13 deg. FWHM, D=1.2 cm

Synthesized beam used to scan the sky as with an imager



Spectro Imaging



- Synthesized beam:
 - \star Depends on horns configuration
 - ★ AND on frequency !
 - ex: a point source emitting at 140 and 160 GHz
- There is spatial + frequency information !
- Multi-frequency map-making with the same TOD
 - ★ Spectral resolution $\Delta v/v \sim 0.05$
 - \star Shown to be quasi-optimal with simulations
 - \star article being finalized



QUBIC Spectro Imaging



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QUBIC Layout



- Outer cryostat: Roma
- 1K Box / detectors: APC, CSNSM / IRAP
- Fridges: Manchester
- Optics: Roma / Maynooth / Cardiff

Currently cold and under test at APC





QUBIC Hardware



cryostat manufactured by Roma La Sapienza



TES Detector Array





QUBIC TES array Array P87 ASIC1 black curves, data from 2018-12-14 16:08, T_{bath}=348.000mK Array P87 ASIC2 blue curves, data from 2018-12-14 16:08, T_{bath}=348.000mK bad pixels in black background. 214 good pixels out of 256 = 83.6% V_{minow} from red to blue (1.5V to 8.5V)





TES fabrication: CSNSM Readout electronics: APC & IRAP

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Optics Box at 1K



M1 Initial measured points - Mirror in HexRF



Structure: APC Mirrors + alignment: Milano, Roma, APC





Cryo system

1K and 300mK He4 fridges: U. Manchester



Both cycled successfully inside the QUBIC cryostat





Cryo Optical Components

Filters, HWP, Polarizer: Cardiff







Back to Back Horn Array

B2B platelets horn-array Milano Statale



Switches and electronics Milano Bicocca + APC







QUBIC HWP Rotator Roma - La Sapienza







QUBIC as seen from the Calibration Source

reflection of window in flat mirror

























QUBIC TES array Array P87 ASIC1 black curves, data from 2019-01-29 13:21, T_{bath}=376.113mK Array P87 ASIC2 blue curves, data from 2019-01-29 13:21, T_{bath}=376.113mK

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Scanning in Azimuth







Synthesized Beam Profile



scan of beam across one pixel





Scanning in Frequency





Summary



QUBIC is a novel instrumental concept

- ★ First Bolometric Interferometer
- \star Dedicated to CMB polarimetry and inflationary physics
- **\star** High sensitivity with ~2000 TES bolometers
- \star Optimized to handle systematics:
 - Self Calibration allowed by observing individual fringe patterns (Unique to QUBIC)
- * Spectro-Imaging with two physical bands (150 / 220 GHz) and 5-10 subbands:
 - Foregrounds contamination control and removal with up to 10 bands (unique to QUBIC)
- ★ <u>Target :</u>
 - First module (150-220 GHz): $\sigma(r)=0.01$ (incl. dust)
 - Stage IV evolution of QUBIC $\sigma(r)=0.01$ hopefully through a wider European collaboration + CMB-S4 tube(s)
- QUBIC deployment is on the way:
 - \star TD Integration and test ongoing at APC
 - \star Initial Calibration measurements in the lab
 - ★ First light in Argentina end-2019
 - ★ Upgrade to Full focal plane and 20x20 horn array in 2020