BaR SPOrt: Balloon-borne Radiometer for Sky Polarisation Observations

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BaR-SPOrt **is a 32 GHz balloon - borne correlation polarimeter for direct measurement of Q and U Stokes parameters with an angular resolution of ~0.5 deg. The instrument shares most of the SPOrt know-how. Its aim is the study of the polarisation of the diffused Galactic Background as well as the Cosmic Microwave Background (CMB). The study of the linearly polarised emission is fundamental to understand the physical processes taking place in our Galaxy. Moreover, the Galactic emission represents a foreground noise for CMB experiments. The polarised component of the CMB can be related to cosmological parameters, providing information about the nature of the primordial fluctuations and the reionization era, thereby allowing to discriminate among different cosmological models.**

The main scientific goals and the instrument design of the experiment are presented. Particular emphasis is put on the hardware solutions adopted to reduce the systematics effects in high sensitivity polarisation measurements.

THE SCIENCE

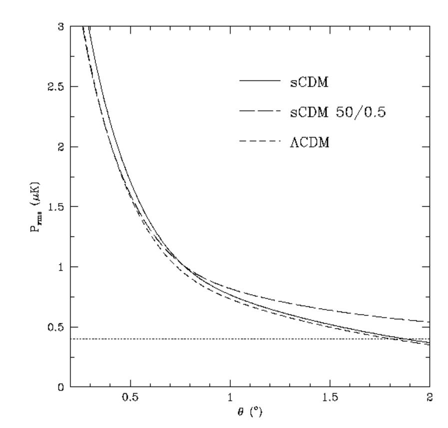
The scientific goal of BaR-Sport is the builiding of linear polarisation maps of sky patches. The first candidate should be that already observed by BOOMERanG, cenetred at RA = 5h, DEC = - 45°.

The instrument, having a beam of ~ 0.5°, should be able to detect the CMB polarisation independently of the presence of a reionization period. The picture on the right shows the expected rms polarisation (P_{rms}), as a function of the pixel size, for three different cosmological models. The BaR-SPOrt sensitivity over the patch is also plotted for comparison. The features of the models are:

1) a standard CDM model with 50% of the cosmic medium reionized at z_{ri} = 50.
2) a standard CDM model;
3) a flat ΛCDM model with matter density parameter Ω_m = 0.3, Hubble parameter h_{100} = 0.7, and a primeval spectral index giving a fair number of expected clusters.

The expected rms polarization is evaluated taking into account the sample variance.

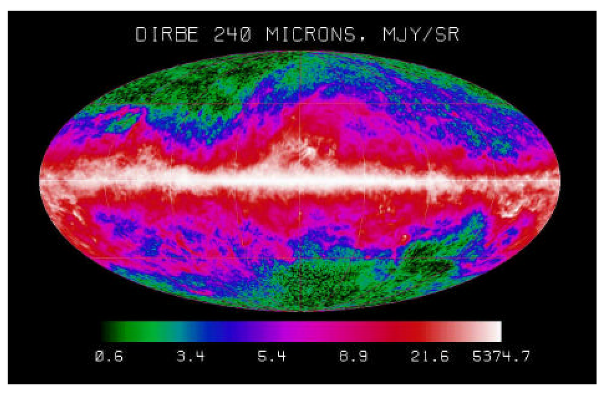
As it is clear from the plot, the expected P_{rms} is only slightly dependent on the model. At these angular scales, even in the fairly extreme case of reionization considered here, the part of the angular spectrum which mostly contributes to P_{rms} is only moderately damped.

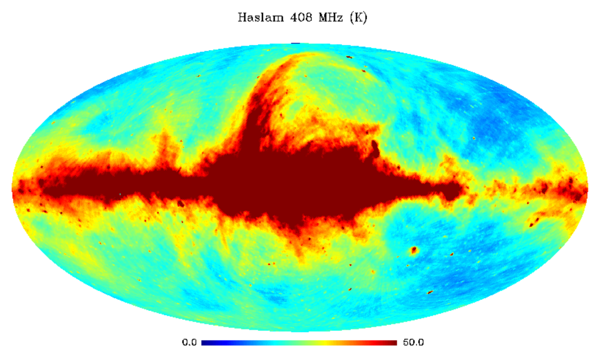


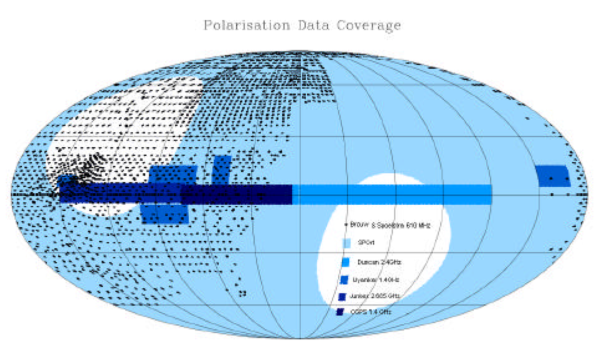
In this plot the BaR SPOrt rms sensitivity for 2 weeks integration time (horizontal line) is compared to the sky rms polarisation predicted by different models. The P_{rms} expected signal depends on the beamwidth q. A sky area of 20°x20° was considered.

On the right side, form top to bottom, we show total intensity maps of the sky (DIRBE and Haslam) as well as the current sky coverage in polarisation. The covered frequency range for the third map is 0.408 - 2.7 GHz.

The two total intensity maps suggest the BOOMERanG patch (l = 250°, b = - 40°) should be a low emission place. Morover no polarisation data are available in this area.

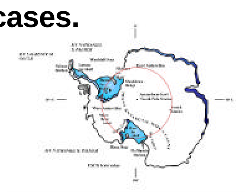






BaR SPOrt should be flown from Antartide (~ 2 weeks flight). Other possible sites are the Milo ASI base (Trapani - Italia ~ 24 h flight) and the Palestine NASA-NSBF base (Texas ~ 5 days flight). The different flight duration is due to the different site conditions. Table 1 shows the expected sensitivities for the three cases.

This picture shows the typical trajectory of the paylod (red circle) during the antarctic summer.



Integration time	Sensitivity [μK]	
	PIXEL	rms on 20°x20°
24 h	64	1.6
5 dd	29	0.7
2 weeks	17	0.4

Table 1: BaR-SPOrt expected sensitivity for different flight duration at 32 GHz. See text for details.

THE INSTRUMENT

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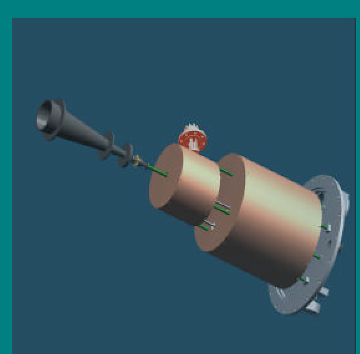

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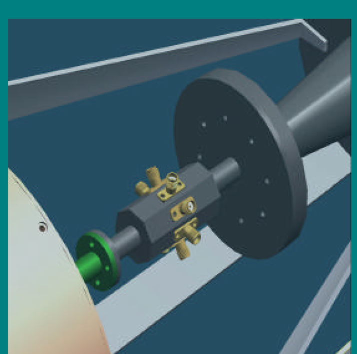

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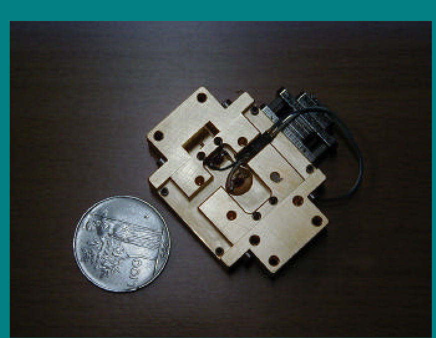

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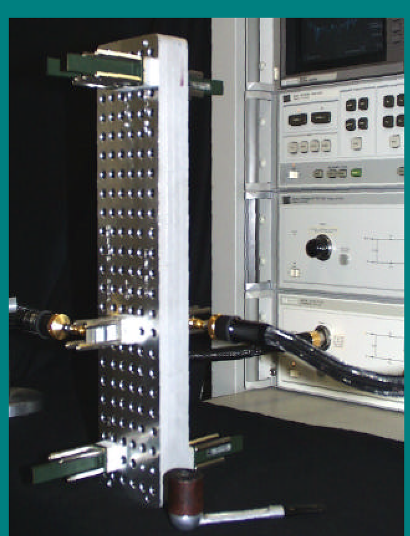

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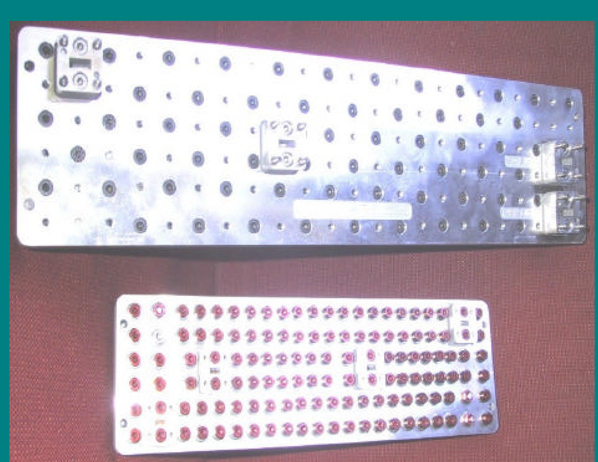

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The polarimeter design has been developed to minimize instrumental effects and to increase long term stability in order to reduce 1/f noise effects.

The main instrumental characteristics are:

a) low cross-polarisation optics (< -40 dB) providing HPBW of ~ 0.5°

b) a cryostat to cool (< 80 K) LNAs, circolators, polariser and OMT (see Figg. 1, 2, 3, 4, 6) by a closed loop cryocooler. The feed might be cooled as well. A thermal shield, temperature regulated, is located inside the cryostat to increase the thermal stability

c) custom design internal calibrator for polarised signal (see Fig. 5)

d) custom design waveguide Hybrid Phase Discriminator device, inserted in the correlation unit, with unpolairsed component rejection > 30 dB (see Figg. 7, 8)

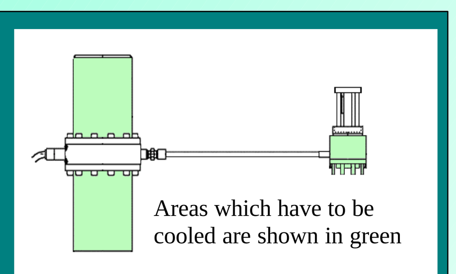
e) custom design OMT with high isolation between channels (> 60 dB) to limit the unpolarised component contamination

BaR SPOrt Characteristics

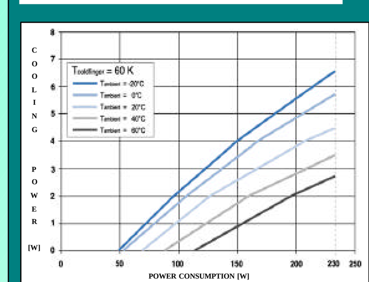
FREQUENCY	BANDWIDTH	ANGULAR RESOLUTION	INSTANTANEOUS SENSITIVITY	LIFETIME
32 GHz	10 %	~ 30′	0.5 mK $s^{-1/2}$	~ 2 weeks

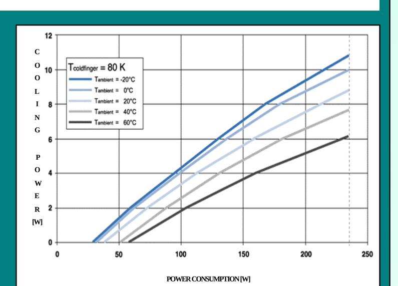
Thermal Specifications

COLD environment	WARM environment
80.0 ± 0.1 K	300.0 ± 0.1 K



Areas which have to be cooled are shown in green

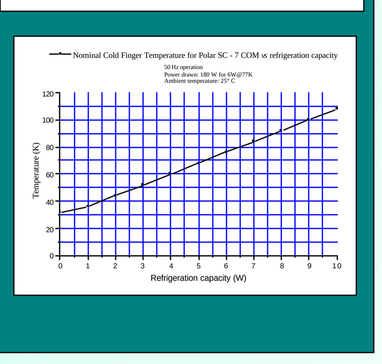


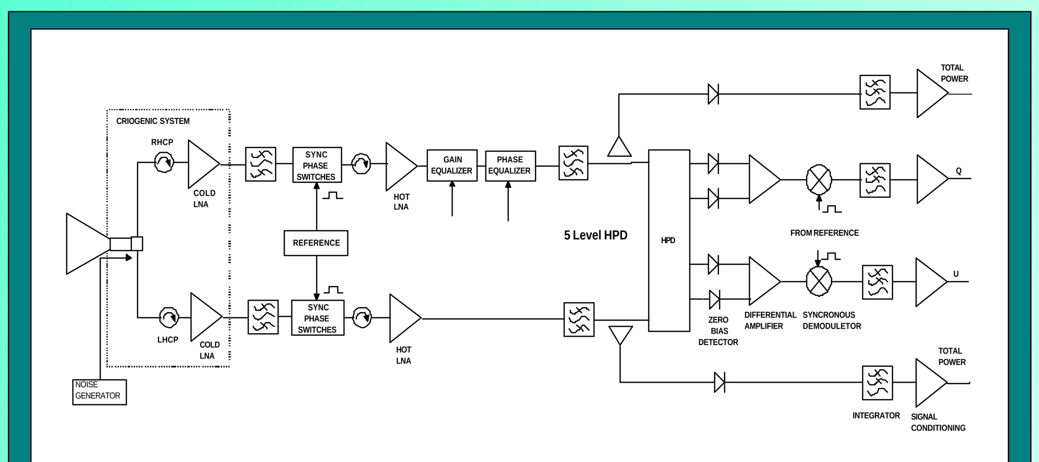


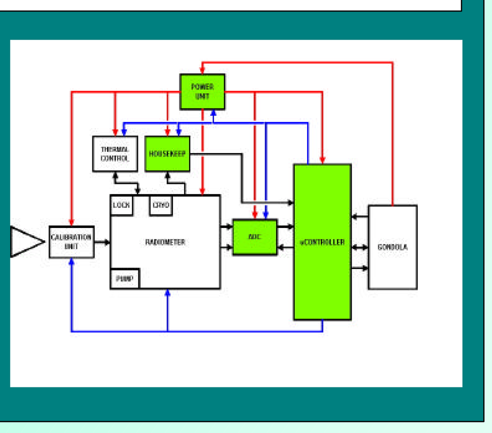
Technical specifications of the adopted closed loop cryocooler.

The thermal project foresees a conductive link between the cooler hot areas and the radiating system of the gondola.

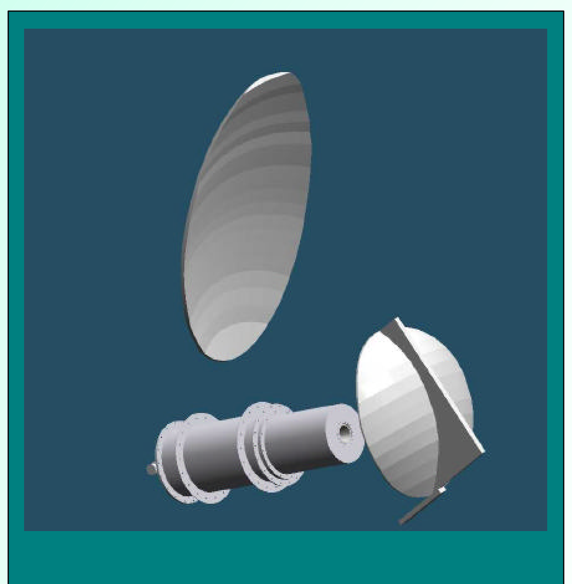
The plots show the performances guaranteed by the manufacturer.







The schematic diagram of the correlation polarimeter (top). The control unit and the electric interfaces between the instrument and the gondola (right).



Conceptual vision of optical coupling. Off axis reflective system is not in scale.

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