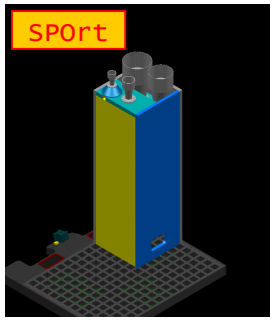
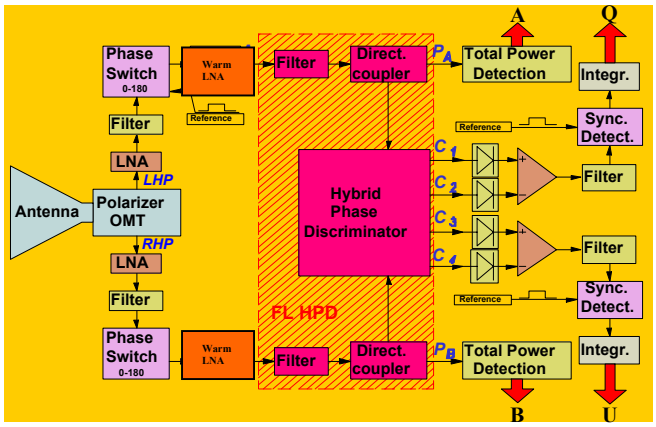
The SPORT Program

The last decade of the 20th century has seen great advances in observational cosmology due to the NASA-COBE space mission in the first place. More recently BOOMEranG and MAXIMA balloon experiments as well as DASI from ground have definitely confirmed that the early Universe was not completely homogeneous. All these experiments have collected significant data on the Cosmic Microwave Background Radiation (CMBR), a radiation filling up the Universe and representing the relic of the Big Bang. This radiation, predicted in 1948 and discovered in 1965, has a black body spectrum measured now to a very high precision. A second important feature of the CMBR is that it is really almost isotropic but not quite, as proved by the tiny temperature fluctuations ($\Delta T/T \sim 10^{-5}$) that have been observed by several experiments at different angular scales. Fundamental information is encoded in the angular power spectrum of these CMBR anisotropies, thought to be the seeds of the present cosmological structures. The detailed structure of this spectrum allows to test different cosmological models and to increase the precision in the determination of the Universe parameters. A third feature of CMBR is that this radiation can be (linearly) polarized. However, while further anisotropy information with greater sensitivity is expected shortly from present and future experiments, polarization signals are expected to be at least one order of magnitude weaker than the anisotropy. But the polarization of CMBR is essential to remove degeneracies between important cosmological parameters and it represents today's challenge for experimenters. The current available technology seems to be already suitable to attain the first detection of the low polarization signals when combined with proper observing strategies. The problem of foreground subtraction, in fact, plays a fundamental role: the galactic polarized emission (mainly synchrotron) must be known with great precision to single out genuine CMBR polarization. The SPOrt[1] (Sky Polarization Observatory) Program is facing the problem by preparing two experiments: **SPOrt@ISS** and **BaR-SPOrt**. Both of them are equipped with phase switched correlation radiometers that must have a high level of rejection for the unpolarized component, which represents, in general, only a very small fraction of the total signal (for the CMBR is $T_P/T_U \sim 10^{-6}$). In the past, the correlation process was performed after a down conversion by using a local oscillator: apart from stability problems, this is possible only for narrow band investigations. In the SPOrt project the bandwidths are of 10% (or more) centered at 22, 32, 60 and 90 GHz: such large bandwidths do not allow signals processing at lower frequencies, hence the correlation must be performed at the antenna frequency.



The SPOrt payload is realized by a consortium of industries led by ALENIA Spazio, under contract with the Italian Space Agency.

The SPOrt receivers



The SPOrt receivers provide the Stokes parameters Q and U, representing the linear polarization, by analog correlation of the two circularly polarized components of the incident electric field (A, B). After their separation by the Ortho-mode Transducer (OMT), amplification and filtering, they enter the Analog Correlation Unit (ACU), which is based on the Hybrid Phase Discriminator (HPD). The combination of the four primary outputs of the HPD, after detection, demodulation and integration provide Q and U simultaneously (100% of efficiency). The phase modulation improves offset cancellation and 1/f noise. The most stringent requirements of such configuration are those related to the parts where the two components (A, B) interact generating cross-talk and spurious polarization: the antenna system (feed, polarizer, OMT) and the HPD. Other severe requirements are those aimed at the minimization of the insertion loss, of the return loss and of the phase distortion as well as the onboard calibrator. Also, since part of the front end is cooled, some devices must be suitable for operating at cryogenics temperatures (<70K). Since CMBR polarization measurements always require long integration times for reaching the proper sensitivity, most of the technological efforts both by industrial and scientific side have been devoted to privilege long-term stability rather than noise temperature. Following this concept most of the "standard" commercially available waveguide components were not considered suitable and it was necessary to proceed with new custom designs.

$$Q_m = |C_2|^2 - |C_1|^2 = H_{qq}\Re\{AB^*\} + H_{qu}\Im\{AB^*\} + H_{qa}|A|^2 + H_{qb}|B|^2$$

$$U_m = |C_3|^2 - |C_4|^2 = H_{uq}\Re\{AB^*\} + H_{uu}\Im\{AB^*\} + H_{ua}|A|^2 + H_{ub}|B|^2$$

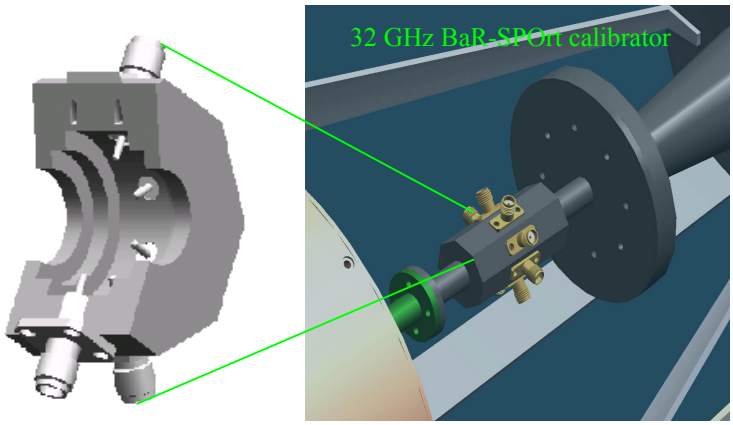
Feed cross-polarization	<-35 dB
OMT insulation	>60 dB
HPD rejection to Unpolarized component	>30 dB
Total rejection to the Unpolarized component	>70 dB
Total spurious polarization	<0.2 μK

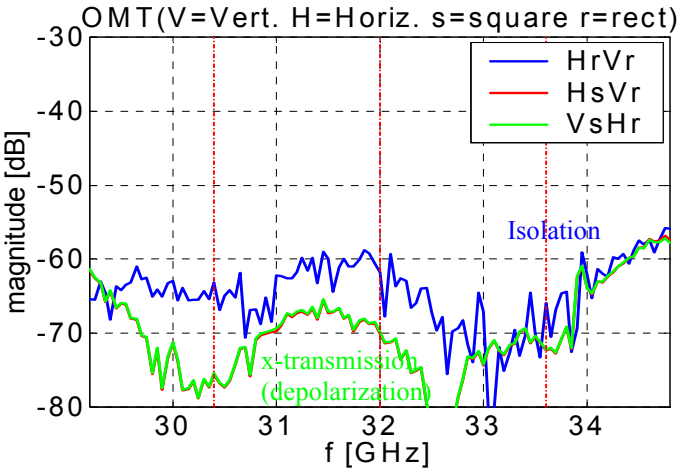
[1] http://sport.tesre.bo.cnr.it/

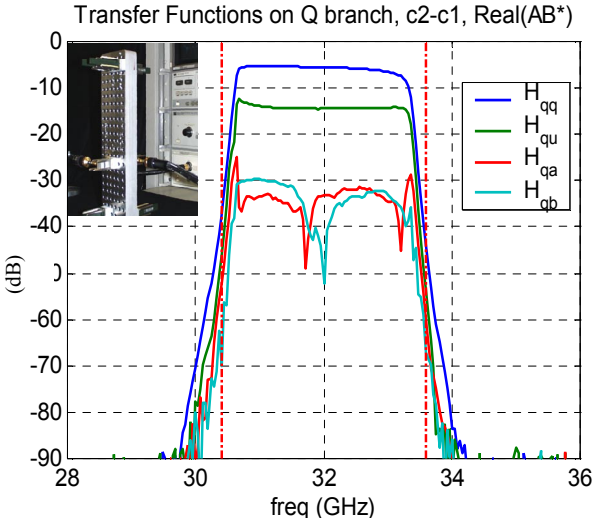
SKY POLARIZATION OBSERVATORY

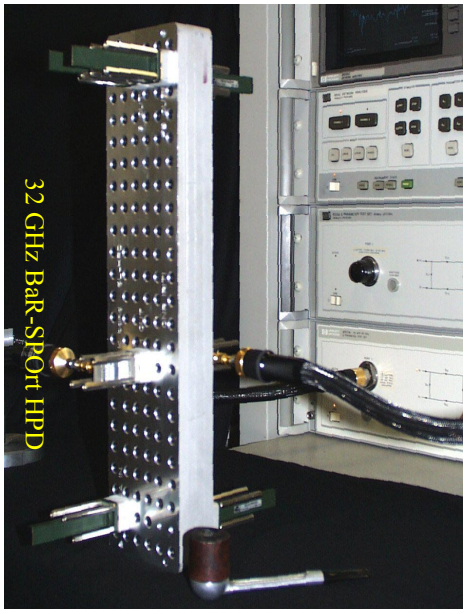
The SPOrt team designed and built the following waveguide devices at all the SPOrt frequencies:

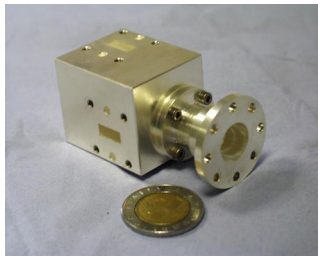
- **Corrugated Feed Horns**
- **Internal Calibration Systems**
- **Polarizers**
- **Ortho-mode Transducers**
- **Hybrid Phase Discriminators**
- **Filters**











90 GHz OMT and iris Polarizer

90 GHz feed

BaR-SPOrt cooler