7-beam total-power receiver at 9mm wavelength for the 100m telescope

F. Schäfer, S. Lenz, W. Meiers, S. Türk, V. Chetik, B. Klein, H. Mattes

Max-Planck-Institut für Radioastronomie

MAX-PLANCK-GESELLSCHAFT

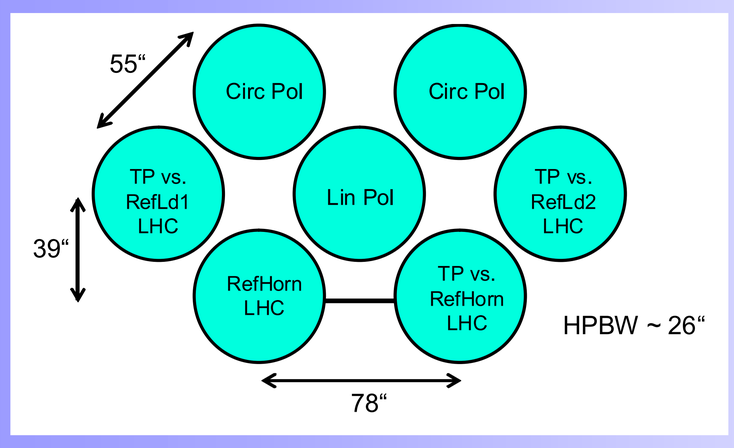
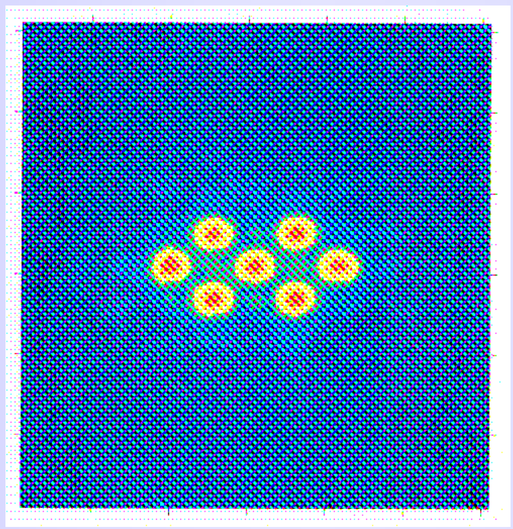
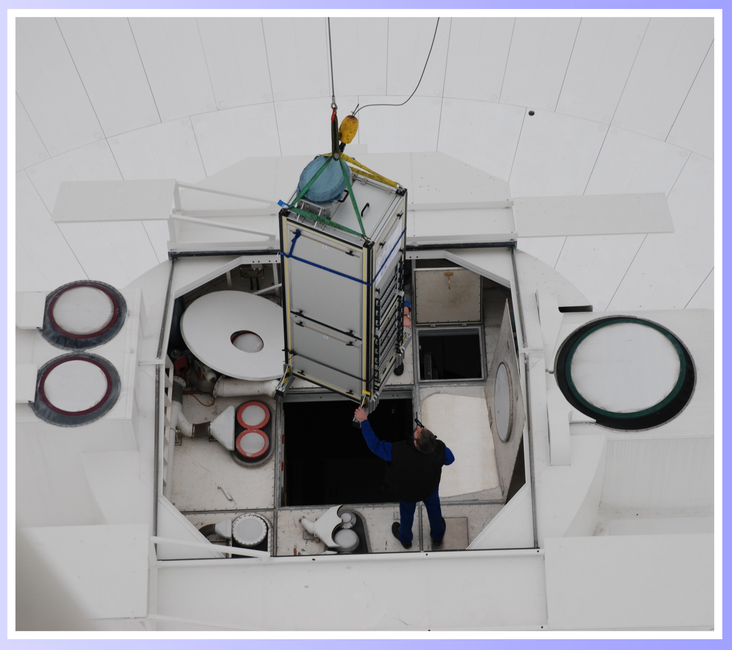


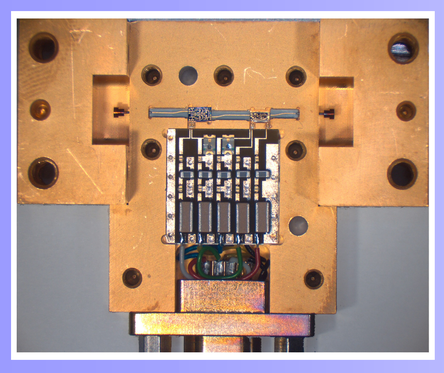
Fig. 1: Arrangement of the 7 horns



Map of the array on 3C273 in total-power



Installation of Rx into the 100m‘s apex cabin



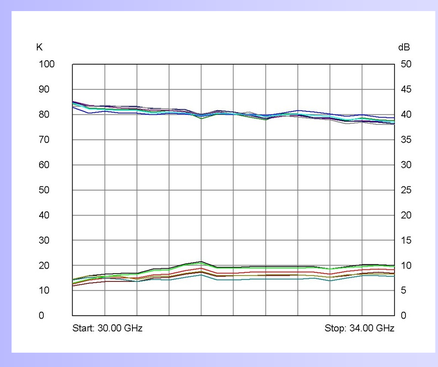
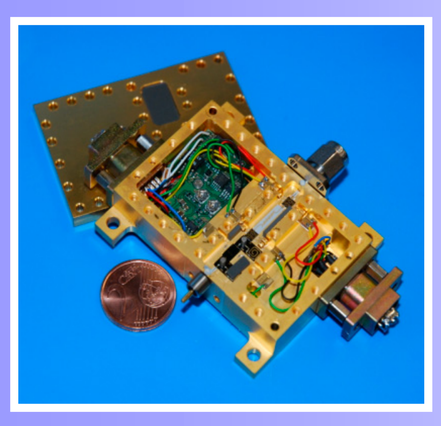
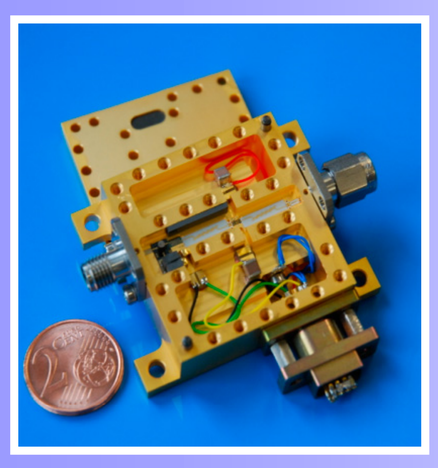


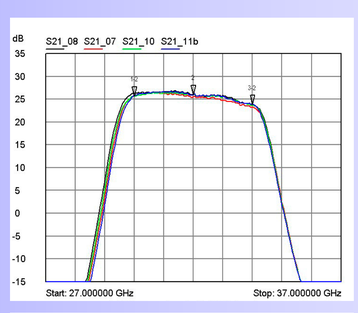
Fig. 2: Cryogenic LNA with 2 MMICs (InP + GaAs)

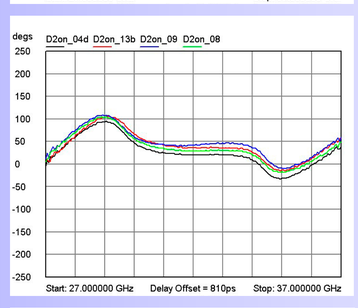
Features of the design :

- Rx delivers 12 RF channels at 30-34GHz from totally 7 horns in an elliptical arrangement (Fig. 1).
- Rx is laid out as a direct detection receiver, no mixing to a lower IF is carried out, all processing down to the final direct detection step is done at 30-34GHz. This implies in particular that all RF modules had to fulfill stringent requirements on uniformity of transmission gain and phase (Fig. 2 / 3).
- The receiver is a pseudocorrelation design similar to those used for WMAP / PLANCK that offers suppression of the 1/f noise resulting from gain fluctuations which are inherent to cryogenic InP HEMTs.
- There will be three polarimetry pixels available, 2 circular, 1 linear polarized. Another two pixels will be total power LCP, each referenced to an internal cold waveguide load whose temperature is accurately measured synchronously with the data from the RF detectors. Finally there is beam switch implemented in hardware with two horns differenced by means of a waveguide magic tee. (Fig. 4)









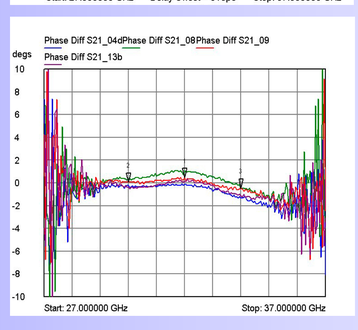
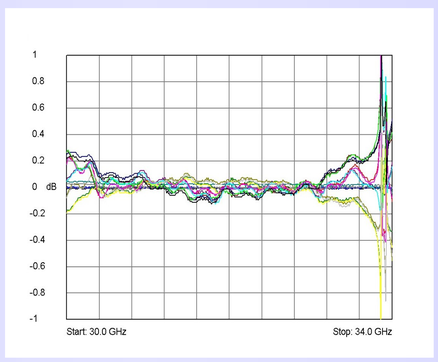


Fig. 3: Two ambient temperature modules per RF channel



Typical ellipticity of the commercial (Atlantic Microwave) septum polarizers after tuning

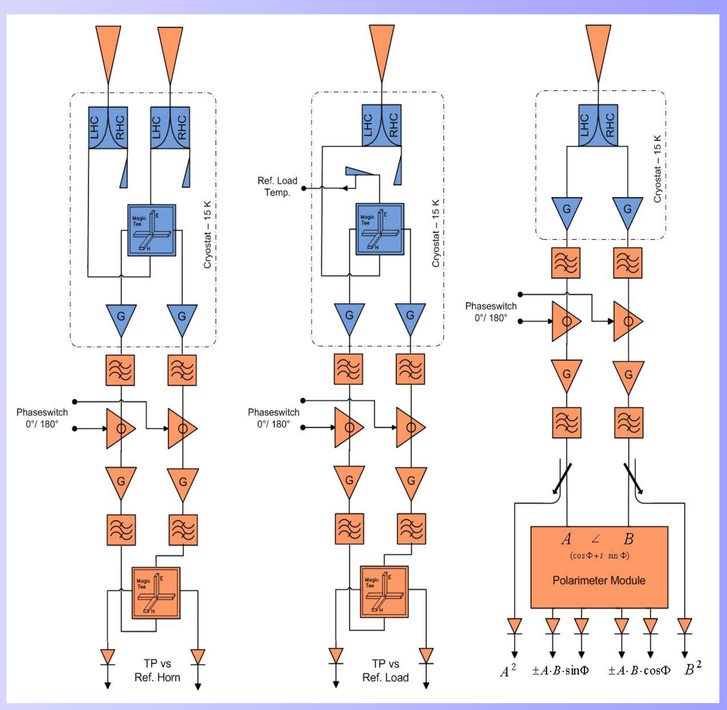


Fig. 4: Schematic of the different channel types

New implentations for an Effelsberg Rx:

- Since Rx was meant to be a test vehicle for building large arrays, the design is entirely based on InP / GaAs MMICs: 24 LNAs at cryogenic temperature, 48 LNAs at ambient temperature and 12 phase switches. 1st stage cryogenic LNA MMICs are InP from the NASA CHOP program, 2nd stage cryogenic LNA are commercial GaAs, all room-temperature amplifiers are commercial GaAs, 180° phase switch is PLANCK design from NASA CHOP program.
- Calibration signal is injected via a transmitter horn located at the rim of the 100m telescope’s secondary mirror.
- A pseudocorrelation receiver needs a backend driving the phase switches and taking data of all channels at ~ 4kHz synchronously. This called for the development of a new backend that interfaces with the common Effelsberg data reduction system via optical fiber link. The backend is based on FPGA technology, integrated within the Rx and was designed using thorough shielding and filtering guidelines to avoid RFI. (Fig. 5)

Fig. 5: 32-channel digital backend