THE 2ND PIETRO BARACCHI CONFERENCE

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Digital beamforming with the cryogenic C-band PHAROS2 PAF

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We describe the development of a multi-channel "warm receiver section"(WS) and of a digital beamformer for the PHAROS2 Phased Array Feed (PAF), a PAF demonstrator for radio astronomy application across the 4-8 GHz radio frequency (RF) band. The project is carried out as an international collaboration in the framework of the PAF Advanced Instrumentation Programme for the Square Kilometer Array (SKA).
The PAF is based on an array of 10×11 dual-polarization Vivaldi antennas cryogenically cooled at 20 K along with low noise amplification modules (LNAs). The WS receiver can process the signals from a subset of 24 antenna elements of the array by downconverting them to an intermediate frequency (IF) range, 375-650 MHz, suitable for digitization by the digital beamformer. The latter is based on the iTPM (Italian Tile Processing Module), developed for the SKA Low Frequency Aperture Array (LFAA). We modified the iTPM firmware to synthesize four independent beams across the IF 275 MHz instantaneous bandwidth in the iTPM FPGAs (Field Programmable Gate Arrays). The 24 signals are sent from the WS to the iTPM through analogue IFoF (IF over fiber) optical links.
We will present the design and performance of the WS for PHAROS2 and report on laboratory test-bench results of the beampattern characterization and digital beamforming performed with the Vivaldi array at room temperature cascaded with the WS and iTPM.
PHAROS2 is going to be installed on the primary focus of the e-Merlin 25-m diameter Pickmere antenna at the Jodrell Bank Observatory-University of Manchester for few weeks with the goal of calibrating it, verifying the main system functionalities and performing preliminary scientific observations of strong radio astronomy sources.
The beamoformer has been programmed to operate in the two following observing modes: 1) "Imaging and Pulsar search Mode,"delivering four integrated beams (spectral channel width 0.81 MHz) across 275 MHz instantaneous bandwidth with integration time from 50 μsec to 1 sec; 2) "Spectroscopic Mode,"delivering a single beam with about 25 frequency channels covering approximately 20 MHz instantaneous bandwidth. Fine channelization, achieved through FFT by polyphase filterbank on GPU, provides a frequency resolution down to 100 Hz.

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