From MAD to SAD: the Italian experience for SKA-LFAA

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The National Institute for Astrophysics (INAF) is deeply involved in the designing phase of the Low Frequency Aperture Array (LFAA) of the Square Kilometer Array (SKA). In particular, the technological contributions of INAF are basically spread in three main areas: *(i)* antenna and array pattern characterization and calibration, *(ii)* analog and photonic receiver design, and *(iii)* development of digital back-ends FPGA-based.

In order to verify the operation and the performance of the algorithms and the hardware we developed, an experimental test bed has been set up. The main purpose was to test each single element connected to the whole system. Therefore, a small regular array composed of 3x3 dual-polarized Vivaldi antennas, called Medicina Array Demonstrator (MAD), was designed and installed in the premises of the Medicina radio observatory (Bologna, Italy). Each antenna included two front-ends, mainly composed by a Low Noise Amplifier and a RF-optical converter, to transmit the amplified signal to the back-end unit. The acquisition system is based on an A/D converter and a high performance processing board with a Xilinx Virtex 5 FPGA that performs beam-forming and correlation.

An artificial radio frequency source based on a micro Unmanned Aerial Vehicle (UAV) with a transmitting dipole antenna was successfully applied to calibrate MAD. Then, the calibrated array patterns and several baselines fringes were measured with the same source. Comparison with numerical results obtained with commercial electromagnetic simulators show an excellent agreement and a good reliability of the UAV system.

The main limitation of MAD was its sensitivity. Therefore, as a next step, a larger array called Sardinia Array Demonstrator (SAD) was proposed and then funded by Regione Autonoma Sardegna. SAD is a reconfigurable array based on 128 dual-polarized Vivaldi antennas randomly distributed in one big station of 64 m in diameter or in 8 smaller stations with a maximum distance of about 200 m. Another important difference between SAD and MAD is that the latter was a narrow-band system centered at 408 MHz, whereas SAD will process about 200 MHz bandwidth in the frequency window 250-450 MHz. As a consequence of the higher number of antennas and of the larger bandwidth, SAD is expected to have a sensitivity sufficient for testing calibration techniques based on celestial sources. Additionally, a new high performance acquisition board, Tile Processing Module, under development in the SKA framework will be installed in SAD. SAD is currently along the design phase and should start observing in late 2015.

In the SKA-LFAA context, MAD and SAD represent powerful test benches where the different technological contributions can be applied, tuned and improved in a real operative environment located in Europe rather than in the Australian desert.