Onsala Space Observatory – IVS Technology Development Center

Miroslav Pantaleev, Ulf Kylenfall, Leif Helldner, Karl-Åke Johansson, Rüdiger Haas, Marianna Ivashina, Oleg Iupikov

Abstract

We report 2012 activities and plans for 2013.

1. Improved Eleven Feed for VLBI2010

We completed the mechanical implementation and prototype fabrication of a new circular Eleven feed designed by the Antenna Group at Chalmers. Figure 1 shows a photo of the first prototype. The circular Eleven feed is constructed of curved folded dipoles on a flat printed circuit board (PCB), with the aim of making this antenna structure more rotationally symmetrical at a low manufacturing cost. The measurements showed an efficiency of better than -1 dB over a decade bandwidth of 1.3 – 14 GHz [1].

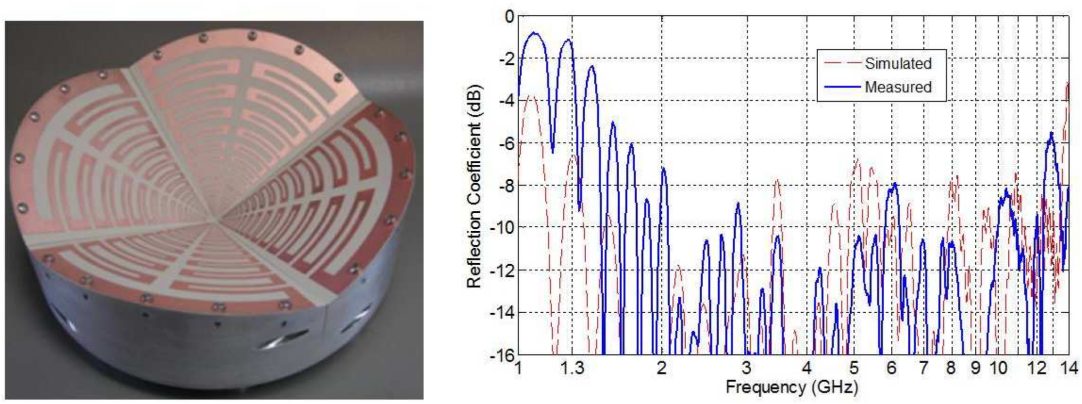

Figure 1. Left: The circular Eleven feed. Right: Simulated and measured reflection coefficient.

2. Broadband Feed Comparison

Following up on the decision of the IVS Technical Workshop in Wettzell in March 2012, we did extensive work to compare the performance of two broadband feeds considered for VLBI2010, the Eleven feed and the QRFH feed. Figure 2 depicts a comparison of the two feeds in a real VLBI2010 system, a 12-m shaped reflector system manufactured by Intertronics Solutions. The efficiency plot for the QRFH is calculated via physical optics software at JPL using measured feed beam patterns as input. The efficiency plot for the Eleven feed is calculated using GRASP software, also using measured feed patterns as input.

The performance of the feeds is comparable: the Eleven feed has slightly higher efficiency than the QRFH over the 3 – 5 GHz band, while the QRFH has slightly higher efficiency over the

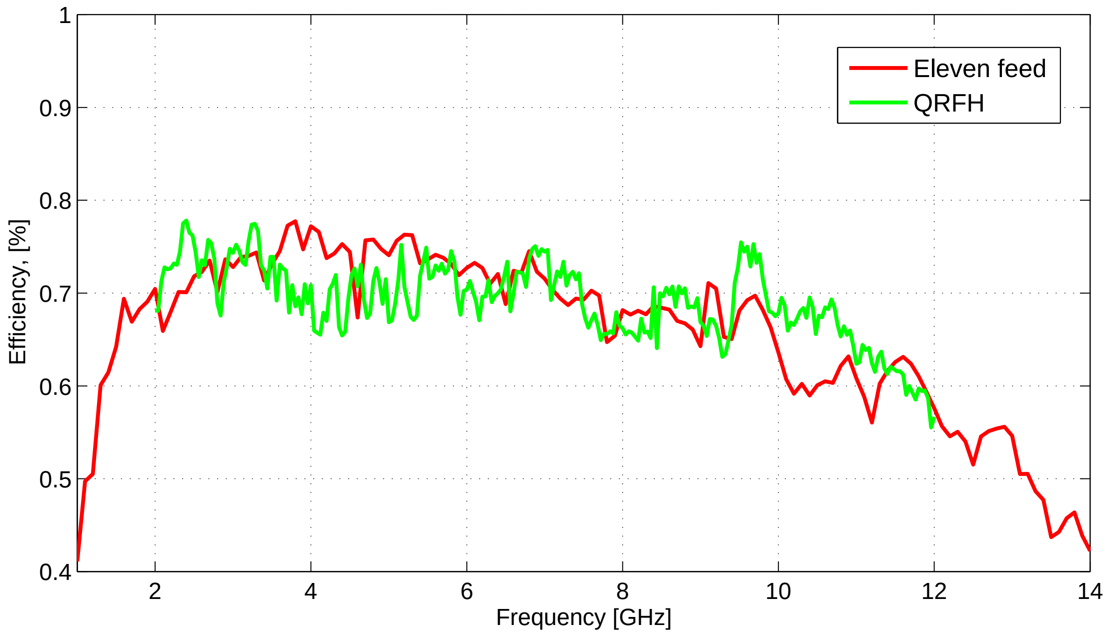

Figure 2. Comparison of the aperture efficiencies of the Eleven feed and the QRFH in a 12-m Cassegrain shaped reflector antenna system. The red curve shows the results for the Eleven feed, calculated with the GRASP software using simulated far field patterns. The green curve shows the calculated aperture efficiency for the QRFH calculated with physical optics software using measured beam patterns.

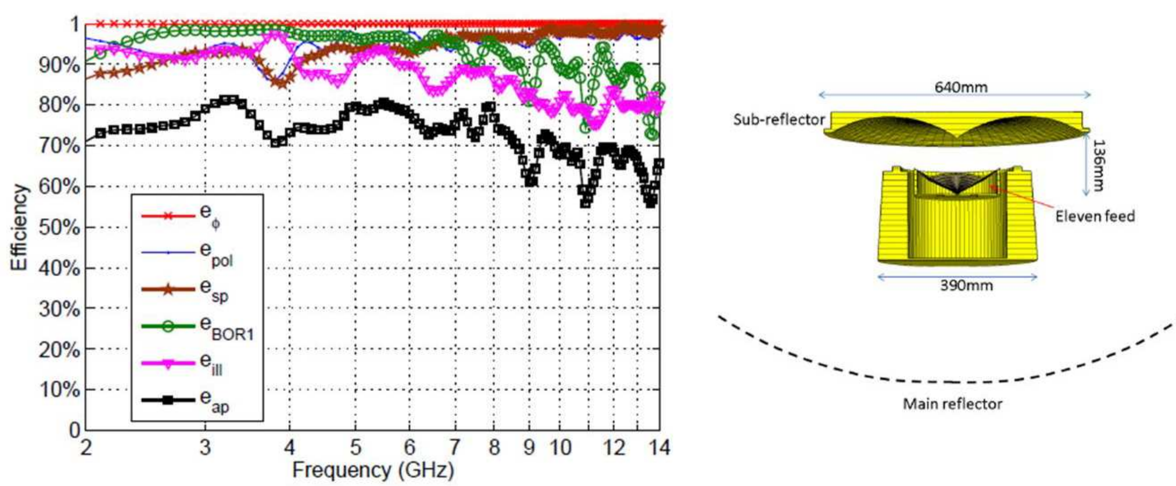

Figure 3. Left: calculated aperture efficiency and its sub-efficiencies based on a simulated radiation function when the circular feed illuminates a dual-reflector antenna (including a sub-reflector) with a subtended angle of $2 \times 80^\circ$ for the main reflector. Right: geometry of the main and the sub-reflector.

9 – 11 GHz band. Data for the QRFH for the 12 – 14 GHz were unfortunately not made available for us for this study.

We have also studied the performance of the Eleven feed in a dual-reflector antenna with subtended angles of $2 \times 67°$ and $2 \times 80°$ for the sub-reflector and the main reflector, respectively. The reflection coefficient of the feed is almost not affected by the sub-reflector, and the aperture efficiency of the whole antenna is calculated, as shown in Figure 3, which indicates a good performance. As reported in [2], Eleven feeds provide an optimal performance when the subtended angle is from $2 \times 55°$ to $2 \times 70°$ for the primary reflector systems. By using a dual-reflector arrangement, the Eleven feed can be used in an optimal performance for different subtended angles.

3. Characterization of the RFI Environment at Onsala

In order to characterize the RFI environment and its potential impact on the future broadband observations for VLBI2010, we have carried out a survey over the frequency band from 0.85 – 26.5 GHz. The setup used for the test (see Figure 4) was borrowed from Yebes Observatory. The measurements were performed on the location of the new twin-telescope (see Figure 4).

The measurement setup and the calibration are described in detail in [3]. Each spectrum has been taken with the analyzer in MAX-HOLD mode (which keeps the maximum measured value) during one complete turn in azimuth of the antenna. The measurements were performed at 0° elevation angle and used vertical polarization. For this antenna location the nearby trees obscure about 15° – 20° of the sky above the horizon for more than 180° in azimuth, but probably the attenuation and scattering effects are negligible. The full spectrum is presented in Figure 5 to give an overall impression of the situation. There are interferences from GSM/UMTS links, flight radars (around 1.1 GHz), GPS signals, WLAN (2.6 GHz), navy radars and military applications (2.9 – 3.1 GHz), radio links and navy radars (9.25 – 9.5 GHz), and radio links (22.5 GHz).

Figure 4. Left: setup for RFI-measurements. Right: map showing the location of the setup.

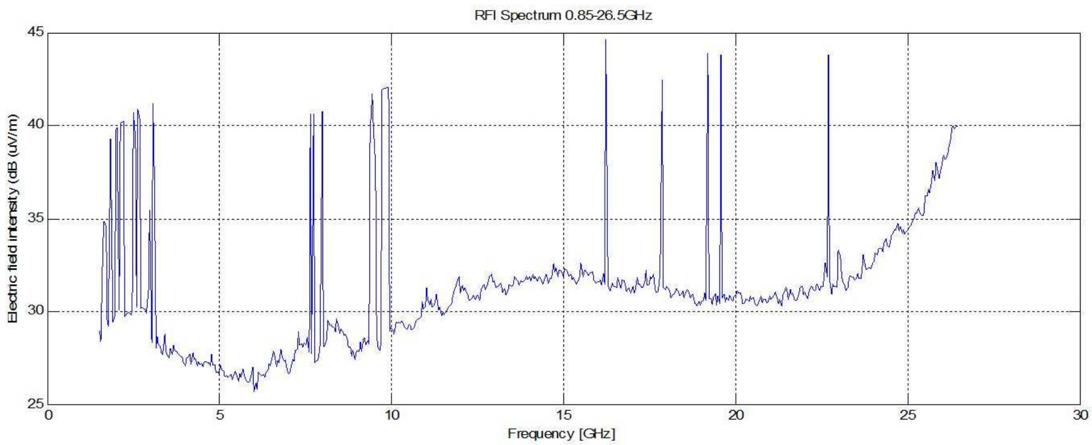

Figure 5. Measured spectrum over the $0.85 - 26.5$ GHz band. See text for an explanation of the observed RFI signals.

4. Improvement of the IF-distribution for S/X-band

As part of the transition to a fully digital system using the DBBC and Mark 5B+ we had to improve the IF-distribution for S/X-band. An interdigital filter was designed for S-band following [4], using the software CST Microwave Studio and tuning for the proper frequency range. The results from the simulation matched well to the actually produced filter. An amplification and attenuation system was installed for X-band to counteract the slope of the bandpass. After several tests with parallel observations and recording with both the analog system (Mark IV rack and Mark 5A recorder) and the new digital system (DBBC and Mark 5B+ recorder), fringes could be found successfully.

5. Outlook and Future Plans

We will continue to work on the development of an Eleven feed for VLBI2010. Starting in 2013, we will extensively work with the establishment of the Onsala Twin Telescope. We also aim at keeping the 20-m telescope interoperable for geodetic observations with the twin telescope.

References

[1] Yang J, Kildal P-S, Pantaleev M (2012) Overview of Developments of Eleven Feeds. Accepted for publication at EuCAP 2013, Gothenburg.

[2] Yang J, Pantaleev M, Kildal P-S, Klein B, Karandikar Y, Helldner L, Wadefalk N, Beaudoin C (2012) Cryogenic 2—13 GHz Eleven feed for reflector antennas in future wideband radio telescopes. IEEE Transactions on Antennas and Propagation, 59(6), 1918–1934.

[3] Lopez-Perez J-A, Lopez-Fernandez J-A (2011) Radio-frequency interference measurements in Tenerife island for the selection of the RAEGE antenna site, available on-line at `http://www1.oan.es/informes/archivos/IT-OAN-2012-4.pdf`.

[4] Metcalf W. S. (1967) Graphs speed design of Interdigital Filters. *Microwaves Magazine*.