

# Onsala Space Observatory – IVS Technology Development Center Activities during 2013

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**Abstract** We give a brief overview on the technical development related to geodetic VLBI done during 2013 at Onsala Space Observatory.

## 1 Activities during 2013

Our activities in technical development for VLBI concentrated on the following topics:

- The Onsala Twin Telescope project
- Broadband feeds for VLBI2010 operations
- A dual-polarized S-band system
- A new IF distribution
- A GNSS installation for local-tie measurements.

## 2 The Onsala Twin Telescope Project

We worked on the preparation of the procurement documents for the Onsala Twin Telescope (OTT). We decided to separate the procurement into two parts. One part exclusively covers the antennas while the other part covers the signal chain and electronics. The request for a building permit for the OTT and the request for an exemption from the law for shoreline protection (i.e., a permit for construction within 300 m from the shoreline) had been submitted to the Kungsbacka municipality already in late 2012. The local au-

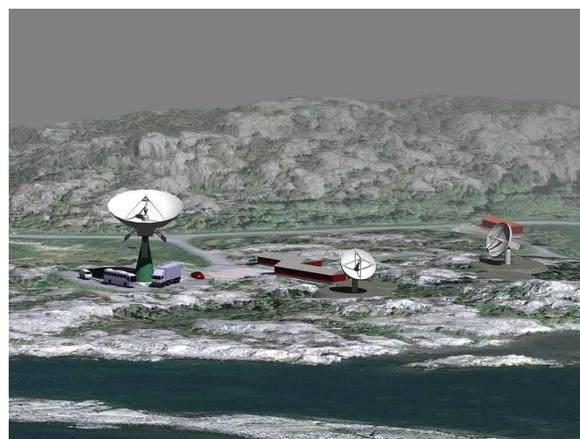
thorities in Kungsbacka community granted both necessary permits in early April 2013. The environmental department of the next level of authority, the county of Halland, inspected the planned area for the OTT in May 2013. The inspector concluded that one of the two planned telescopes, at the eastern location, could be a potential disturbance for the local birdlife and in particular disturb the breeding of waders in the area. At the time of the inspection several birds of the Northern Lapwing (*vanellus vanellus*) family were seen in the wetlands. Additionally, the county has plans to include these wetlands into a natural reserve. As a consequence, the county decided in June 2013 to withdraw the exemption from the law for shoreline protection. This meant a temporary stop for the whole project, because now a new location for the second telescope had to be found. Besides nature protection and local

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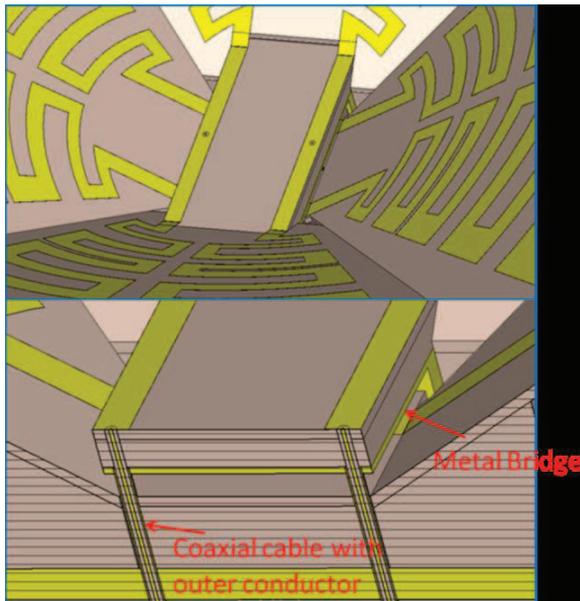


**Fig. 1** An artist's impression of the planned Onsala Twin Telescope (the two smaller antennas on the right side) together with the existing 25-m antenna (left). This is the new updated proposal of December 2013.

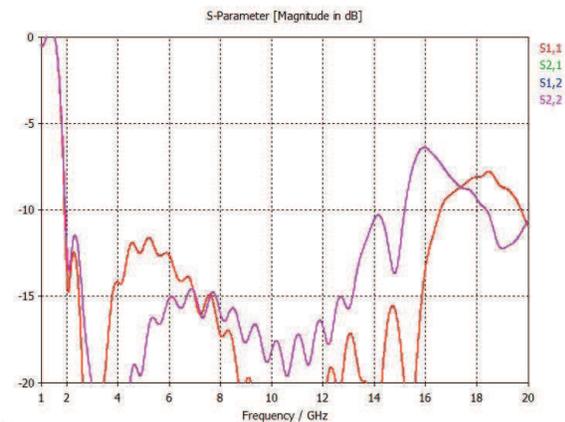
birdlife, another difficulty is a number of archeological findings from the Iron Age that need to be protected. After several discussions with the Kungsbacka authorities, an environmental consultant, and the county's archeologist, a suitable location for the second telescope was found. A corresponding request for a building permit and request for an exemption from the law for shoreline protection was submitted to the Kungsbacka municipality in December 2013. An artist's impression of the new planned OTT location is presented in Figure 1.

### 3 Broadband Feeds for VLBI2010

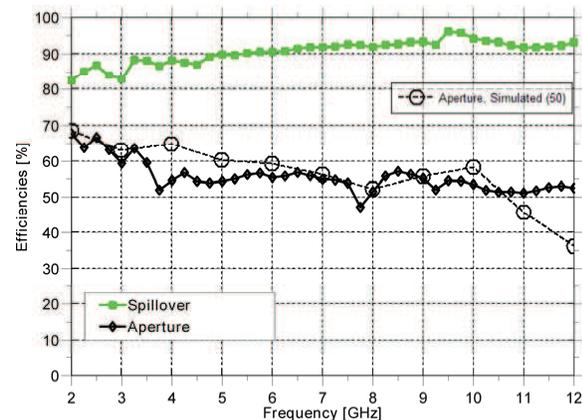
We continued our collaboration with the Gothenburg-based company Omnisys Instruments. We provided support for the cryogenic and mechanical design of a cryostat for the integration of the Eleven Feed and for further issues related to system integration and tests. We worked on three parallel tracks of the Eleven feed development. The first one is the implementation of a center-bridge connection between the opposite ports of the Eleven Feed (see Figure 2). This concept was successfully implemented in a feed for the 0.4–2 GHz



**Fig. 2** Geometry of the center-bridge connection for the Eleven feed. Upper plot: center connection. Lower plot: cross section.



**Fig. 3** Reflection coefficients for both polarization ports of the designed Quad Ridged Feed Horn (QRFH).



**Fig. 4** Aperture efficiency (black dashed line) of a prime-focus reflector antenna system with a subtended semi-angle of 50 degrees fed with the simulated far-field patterns of the designed Quad Ridged Feed Horn (QRFH). Also shown are (black solid line) corresponding results published by [1] which are based on measured patterns.

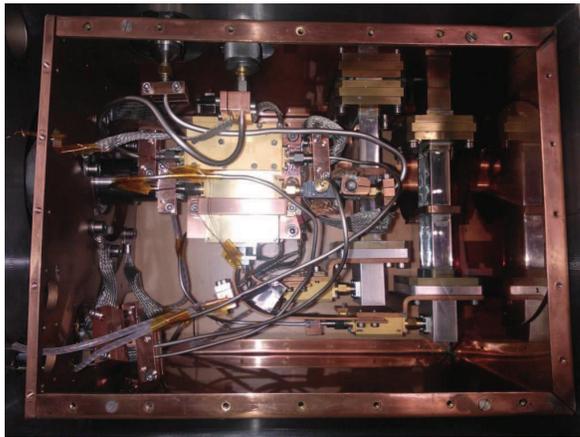
range. Currently we are investigating different fabrication approaches and technologies to implement this solution for the VLBI2010 frequency range. The second development track was the implementation of a novel balun design. This will allow, together with the previously mentioned bridge, reduction of the number of ports from eight to four. The third track is a novel idea of designing the dipole array pattern that will give the ability to control the beam shape and make the feed tunable for a given F/D.

We also worked on the design of a Quad Ridged Feed Horn (QRFH). The CST model was used to study how shaping of the tapers of the ridges, feeding point,

back-short and other parameters of the design affect the S11 and beam shape. The study was extended to optimize the performance for the 2–12 GHz band. Figure 3 depicts the reflection coefficient of the final design and Figure 4 the feed efficiency in a prime focus reflector. The same figure shows for comparison the efficiency of the QRFH design described in [1]. As seen, the achieved performance is quite close to that reported in the article. So far there is no decision about fabrication of a prototype to measure beam patterns.

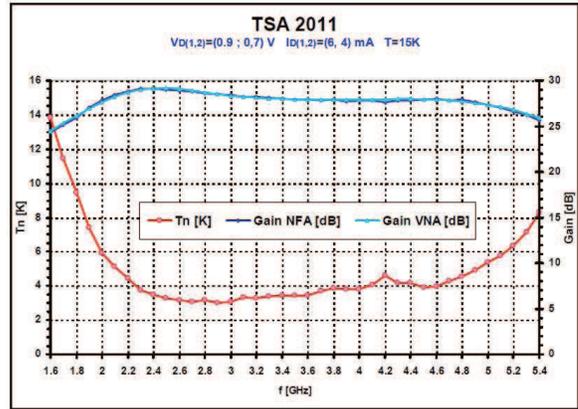
#### 4 A Dual-polarization S-band System

The currently used S-band receiver has one single circular polarization channel while the X-band receiver has both circular polarizations. To prepare for future mixed-mode observations with dual-polarized VGOS systems, we decided to upgrade the S-band receiver to dual circular polarization, too. One Low Noise Amplifier (LNA) was purchased from the Spanish company TTI. The cryogenic box accommodating the LNAs for X- and S-band was modified to integrate the new polarization channel and the new S-band LNA (see Figure 5). Gain and noise of the LNA are presented in Figure 6.

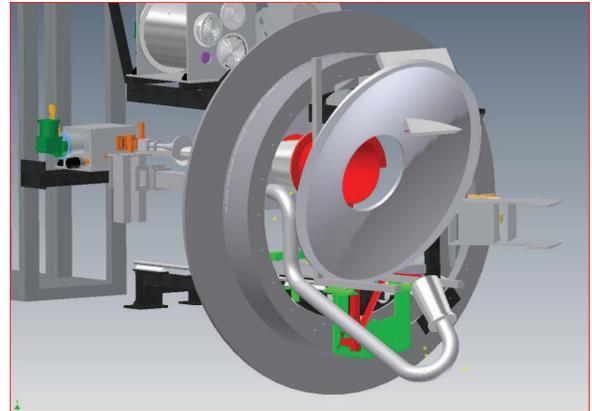


**Fig. 5** Interior of the cryogenic box for two polarizations (S- and X-band).

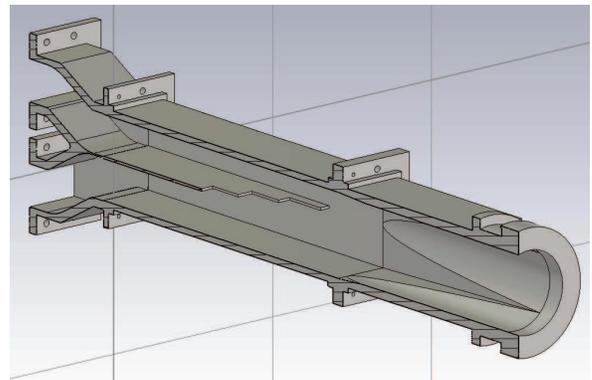
The performance of the receiver (excluding the warm part) was verified in the lab, and the receiver was installed back on the telescope in November 2013. A septum polarizer was designed for S-band and is



**Fig. 6** Gain and noise of the new LNA for S-band.



**Fig. 7** CAD drawing presenting the view towards the focal plane of the 20-m antenna with the tertiary mirror for S-band, the new design of the horn, and the waveguide for S-band.



**Fig. 8** Cross-section of the polarizer for S-band.

currently being manufactured. The waveguide for S-band was re-designed to accommodate a polarizer and room temperature waveguide couplers for noise

and phase calibration signals. Figure 7 depicts a drawing of the focal plane of the 20-m telescope with the tertiary reflector for S-band and the new design of the horn and waveguides for S-band. A cross-section of the polarizer for S-band is shown in Figure 8. The plan is to install the new waveguides and polarizer for S-band in March 2014 and to perform on-sky testing prior to CONT14.

## 5 Development of a New IF Distribution

After several months of parallel recordings with the analog Mark IV backend and the digital DBBC, and after extensive evaluation, we decided in mid 2013 to finally phase-out the Mark IV rack and to replace it with a second DBBC. A corresponding second DBBC unit was ordered in September 2013 and is expected to be delivered in April 2014. To be able to include it quickly into the VLBI system, a new IF distribution unit was developed. This new IF distribution is flexible and computer-controlled. It allows full flexibility to connect the receivers used for geodetic VLBI on the 20-m telescope, or the receivers used for astronomical VLBI on the 20-m or 25-m telescope, to either of the two DBBC units in various configurations. Extensive preparations were performed to minimize the down-time that will be caused by decommissioning the Mark IV-rack and installing the second DBBC.

## 6 A New GNSS Installation on the 20-m Telescope for Local-tie Measurements

Two GNSS antennas were mounted on each side of the prime reflector of the 20-m telescope at the height of the telescope elevation axis. Special gimbal mounts with counterweights were constructed to keep the GNSS antennas in the horizontal plane at all times, independently of the elevation angle of the 20-m telescope. The GNSS antennas are connected with coaxial cables to a pair of GNSS receivers inside the Cassegrain cabin of the 20-m telescope. The recorded data are downloaded automatically from the receivers via TCP/IP.

## 7 Future Plans

We have started a design study for the installation of a 4–12.25 GHz receiver front-end on our 20-m antenna. The system will extend the bandwidth of the current S/X system used for IVS observations. An additional advantage of this 4–12.25 GHz front-end is that it can be used not only for IVS sessions but also for C- and X-band observations for EVN. The horn will be designed by BAE Systems Australia Ltd. Preliminary results for the expected aperture efficiency of this horn are shown in Figure 9. The cryogenic front-end will use an Ortho-Mode transducer from CSIRO, Australia and LNAs of the Gothenburg-based company LNF. As part of the study we will investigate the possibility of using the horn with the current S-band tertiary, thus maintaining compatibility with the S/X band legacy systems. The plan is to complete the design study by the middle of 2014 and to decide on manufacturing and telescope installation shortly afterwards, so that the system would be available on the telescope by the end of 2014.

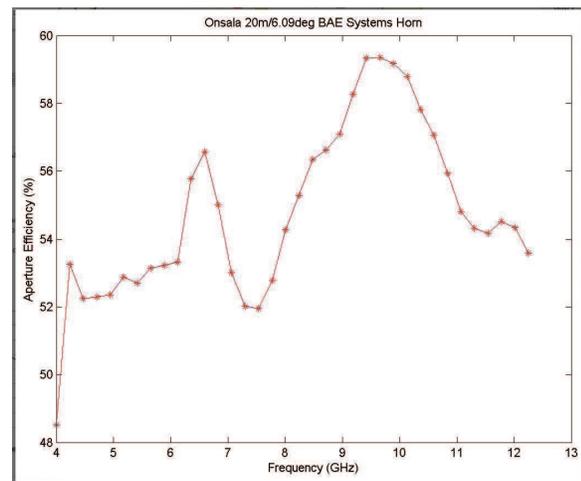


Fig. 9 Preliminary results for the aperture efficiency of the 4–12.25 GHz horn for the Onsala 20-m telescope.

## References

1. A. Akgiray, S. Weinreb, W. Imbriale, and C. Beaudoin. Circular Quadruple-Ridged Flared Horn Achieving Near-Constant Beamwidth Over Multioctave Bandwidth: Design and Measurements. *IEEE Transactions on Antennas and Propagation*, 61(3), 1099–1108, 2013.