

Onsala Space Observatory – IVS Technology Development Center Activities during 2014

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Abstract We give a brief overview on the technical development related to geodetic VLBI done during 2014 at the Onsala Space Observatory.

1 Activities during 2014

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

- The Onsala Twin Telescope project
- Broadband feeds for VLBI2010
- A new 4.00–12.25 GHz front-end for the 20-m radio telescope
- FlexBuff and FILA40G

2 The Onsala Twin Telescope Project

The procurement of the telescopes for the Onsala Twin Telescope project was started in June. Several tenders were received. After a thorough study of the submitted tenders, a contract was signed in December to buy two 13.2-m VGOS telescopes from MT Mechatronics. In parallel to the procurement, preparations for the infrastructure work started. Figure 1 depicts the planned location of the northern telescope. Both telescope locations consist of bed rock and at the same height within a few centimeters. The distance between the telescopes

is 75 m. The surrounding area around the northern location has been partially filled with blasted rockshot rock, and the construction of a small road to connect the two locations has been started.



Fig. 1 Aerial view of the planned location for the northern telescope of the Onsala Twin Telescope project. The southern telescope location is just outside the photo to the right.

3 Broadband Feeds for VLBI2010

We continued our collaboration with the Gothenburg-based company Omnisys Instruments and provided support for the cryogenic and mechanical design of a cryostat for the integration of the Eleven feed, and further issues related to system integration. We also supported receiver Y-factor tests which were performed at the observatory during July 2014. Results are shown in Figure 2. The three lines represent three successive measurements of the receiver temperature, performed with ten-minute intervals in order to study the system stability.

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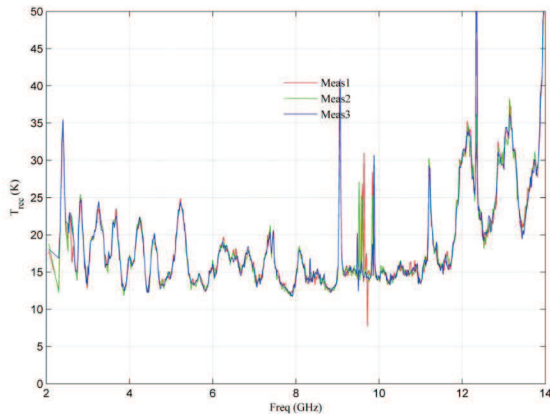


Fig. 2 On-sky tests of the VLBI2010 receiver developed by Omnisys in collaboration with the Onsala Space Observatory.

4 A New 4.00–12.25 GHz Front-end for the 20-m Radio Telescope

We started the design work for a 4.00–12.25 GHz cryogenic receiver for the 20-m telescope. The IVS observations at the 20-m antenna are currently conducted with a dual S/X system. The S-band (see Figure 3) uses an offset horn and a tertiary reflector that has a small dichroic window through which the X-band signal is collected by the current X-band horn.

One of the issues of the current S/X system is that it is located off-axis, with the center of the aperture of the current X-band horn being located at the position $x = 379$ mm and $y = 240$ mm. Furthermore, the design of both feeds is narrow band and does not allow extension of the S-band bandwidth beyond 250 MHz.

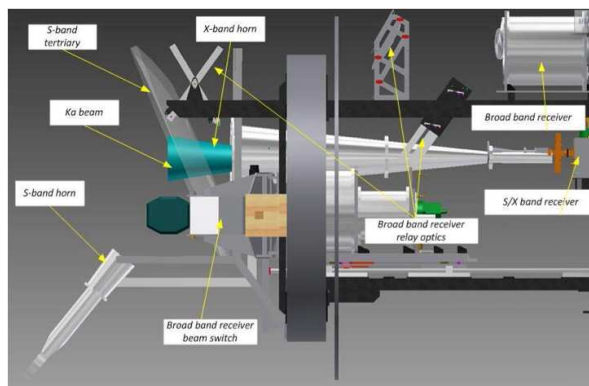


Fig. 3 The current S/X feed system on the 20-m radio telescope.

The interest for a wider bandwidth from both the IVS and the EVN communities initiated a survey study to localize a suitable design of components and suppliers that will allow extending the bandwidth for continuous coverage from C- to Ku-band. The survey study concluded that, because the geometry of the 20-m telescope is designed for mm-wave optics, it will be very challenging to find a commercial feed horn. The sub-reflector of the antenna has a half-subtended angle of only 6.09° and to achieve an edge taper of -12 dB at 6.09° , a horn with very high gain must be designed. After some investigation, we made an agreement with BAE Systems to make a feasibility study for the design of such a horn covering the 4.00–12.25 GHz band.

The next critical component in the receiver chain is the Ortho Mode Transducer. The design made by CSIRO Astronomy and Space Science (CASS) for the Australia Telescope Compact Array (ATCA) 22-m telescope was found to be very suitable for our application. In order to provide input to BAE for the mechanical layout and position of the feed we made a preliminary mechanical design of the receiver and the location of the feed-receiver system in the cabin.

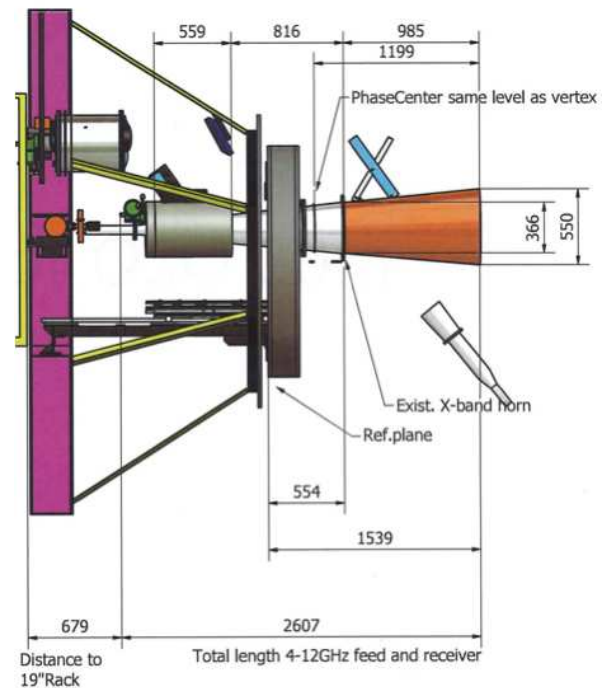


Fig. 4 The proposed mechanical arrangement of the 4.00–12.25 GHz horn for the 20-m telescope.

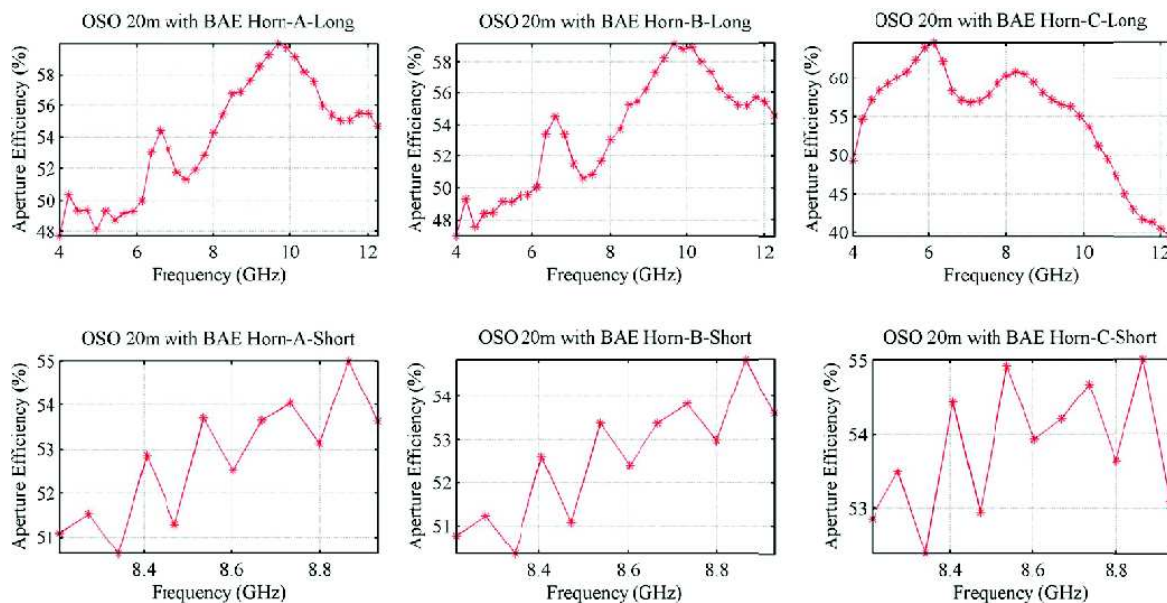


Fig. 5 Theoretical aperture efficiency with the “long” geometries (top) and the “short” geometries (bottom) of Horn-A, Horn-B, and Horn-C (left, middle, and right, respectively).

One of the constraints in the design was to provide a legacy mode for IVS observations in S- and X-band and also provide the primary operation in the wide-band 4.00–12.25 GHz. Therefore, the horn will be designed in sections, with at least one mechanical flange at a position of 816 mm from the input of the horn and a diameter of no more than 366 mm (see Figure 4), thus the existing tertiary with the dichroic window can then be used for S/X observations. This feed geometry is referred to as the “short” feed. The overall length of the complete 4.00–12.25 GHz horn will be set to be 1800 mm with an aperture diameter target of around 550 mm. This geometry is referred to as the “long” feed. This modular design with two sections will allow both operation modes, i.e., legacy S/X and wide-band 4.00–12.25 GHz, however not simultaneously.

During the feasibility study done by BAE, a number of different optimization runs were performed with various degrees of weighting for the different parameters and optimization goals. The following results report on the performance of three distinct horn geometries, all with the same input diameter and length, but with different profiles and performance. The three optimized horns are labelled Horn-A, Horn-B, and Horn-C and can be used in either their “long geometries” or “short geometries”. The Horn-A and Horn-B geometries were optimized to try to have even performance

over the whole 4.00–12.25 GHz band while the Horn-C geometry was optimized to improve the performance over the restricted 4.3–7.5 GHz to the detriment of the upper band (7.50–12.25 GHz).

The theoretical aperture efficiency of the antenna, with the various feeds on axis and at the correct position with respect to their phase-center positions, are presented in Figure 5. This feasibility study shows that the project can be carried out successfully.

5 FlexBuff and FILA40G

The FILA40G has been designed at Onsala Space Observatory within the FP7 RadioNet3 DIVA work package, as a unit to receive 4 x 8 Gb/s UDP (User Datagram Protocol) streams and then perform any needed processing on these streams, before ultimately writing the data out to sets of disks, retransmitting via a 40 Gigabit Ethernet (GbE) interface, or a combination of the two. It is intended to be connected to a DBBC3 [1] to allow the transmission and/or recording of the sampled data, but it is generic enough to allow for connection to other sampling equipment so long as they can provide data via Ethernet links. The current FILA40G software is based on a modified ver-

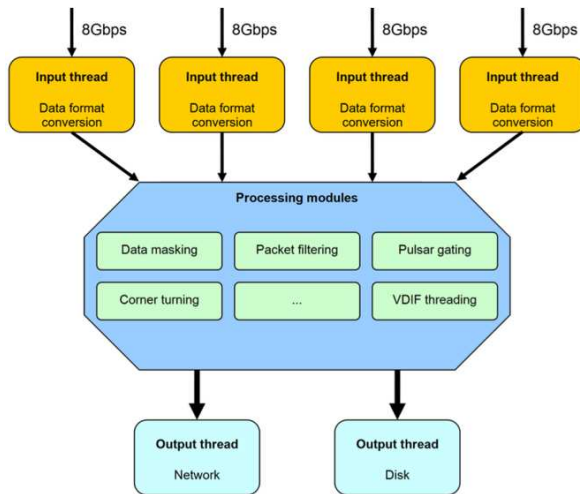


Fig. 6 Flow diagram and features for the FILA40G board.

sion of the jive5ab-2.5.1 software. A selection of features intended to be offered by the FILA40G, as well as a general flow diagram is presented in Figure 6. Currently VDIF threading and packet filtering are implemented and verified, corner turning is partially implemented, and plans are being made for pulsar gating. The FILA40G also acts as a timekeeper for the DBBC, transmitting short UDP packets containing the current timestamp over the 10 GbE links to the DBBC3s' CORE3 boards. The timestamps are generated from the FILA40G's system clock, which can be synchronized by NTP (Network Time Protocol), or a GPS receiver if a network connection is unavailable.

References

1. Tuccari G (2012) DBBC3 – A Full Digital Implementation of the VLBI2010 Backend. In: Proc. of the IVS 2012 General Meeting, 76–80, edited by D. Behrend and K. D. Baver, NASA/CP-2012-217504. <http://ivscc.gsfc.nasa.gov/publications/gm2012/tuccari.pdf>