Onsala Space Observatory – IVS Technology Development Center

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Abstract

This report briefly describes the technical development relevant for geodetic/astrometric VLBI done during 2010 at the Onsala Space Observatory.

1. A Cryogenic Receiver for VLBI2010 with the Eleven Feed

We have continued our collaboration with the Antenna Group at the Department of Signals and Systems at Chalmers University of Technology concerning the improvement of the Eleven feed design [1]. The activities related to the integration of the Eleven feed in a cryogenic receiver for VLBI2010 are summarized as follows:

- Cryogenic tests to verify the expected system noise performance.
- Design and prototype tests aiming to decrease the size of the feed.
- Design and tests of different descrambling alternatives.
- Development of a model for the system noise temperature.

One Eleven feed was integrated in a test cryostat to measure reflection coefficients and system noise temperatures. Figure 1 shows the construction drawing of the test cryostat and the measured S11 reflection coefficients of the Eleven feed at room temperature and at cryogenic conditions. The reflection coefficient does not change when the feed is cooled to cryogenic temperature. This proves that the mechanical and cryogenic designs are good and that the feed can be used at cryogenic temperatures. The small variations can be explained by the change of the permittivity with temperature. The fact that S11 at cryogenic and at room temperatures are similar confirms that there are no significant deformations of the petals or the twin lead line.

For the noise temperature tests presented already in last year's report we used single ended cryogenic LNAs for the 4–8 GHz band from the Group for Advanced Receiver Development at the department [2], [3]. During 2010 we replaced these with cryogenic differential amplifiers from Sander Weinreb's group at the California Institute of Technology and started tests with these.

Two alternative descrambling solutions allowing a reduction of the number of ports from eight to four were designed, fabricated, and tested. The first alternative is based on an ultra wide-band balun designed as a continuously scaled, gradually curved, end-fire traveling wave structure [5], realized on microstrip, similar to the concept of the Vivaldi antenna. The measured result showed acceptable performance in the operated bandwidth, but generally the performance degraded around 5 GHz. The second alternative aims to resolve these issues. It is based on tapered transitions from symmetrical to single ended ports on microstrip, and a prototype development started.

A model for the system noise temperature was developed [4], based on the multiport network method. Figure 2 shows the predicted system noise temperature over the frequency band from 2 to 13 GHz. However, work is continuing to derive more accurate noise models. There is also ongoing work to verify these simulated results experimentally.

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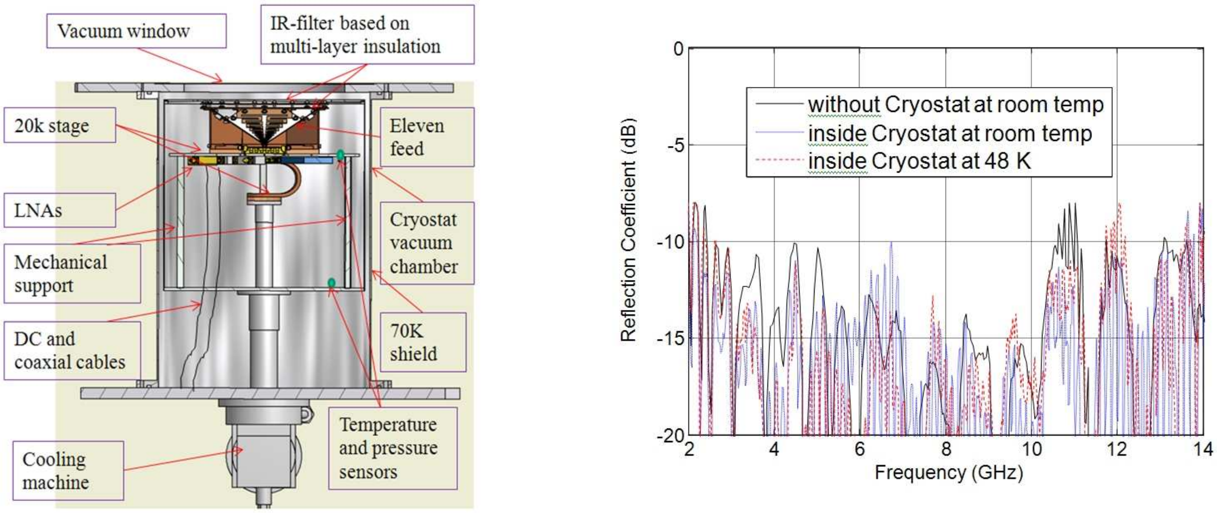

Figure 1. Left: Construction drawing of the test cryostat. Right: Measured S11 reflection coefficients at room temperature without and inside the cryostat, and at cryogenic temperatures inside the cryostat.

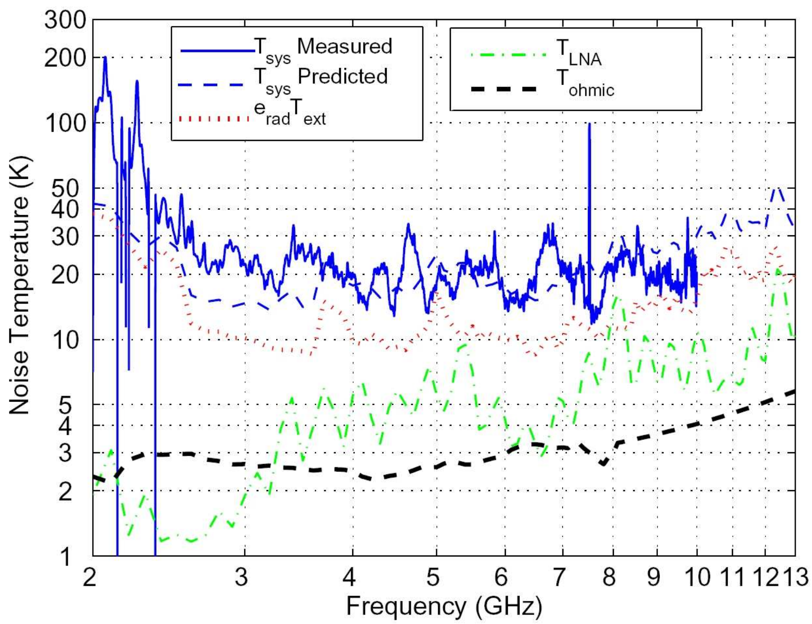

Figure 2. Measured (solid blue line) and predicted (dashed blue line) system noise temperatures T_{sys} when the cryostat with the Eleven feed is pointing at the zenith, including different contributions to T_{sys}. The measurements were done at the Haystack Observatory.

2. RFI Monitoring and Mitigation

A MSc thesis project developed a radio frequency interference (RFI) monitoring system [6]. A software application was developed that communicates with different types of digital receivers (spectrum analyzers) and a control unit for omnidirectional and steerable antennas (Fig. 3). The detection of interference signals uses the generalized spectral kurtosis (GSK) estimator [7]. A file containing frequencies, power levels, and the indication of any interference is saved, and corresponding plots are generated (see Fig. 3).

Another MSc thesis project had the goal of developing a software application which can be used to identify RFI. This work was based on the Interconnect Break-out-Board (iBOB) providing real-time power spectrum density (PSD) estimates with 2048 frequency channels [8]. The PSD estimates are fed into a Spectral Kurtosis (SK) algorithm implemented in MatLab for the calculation and flagging of RFI.

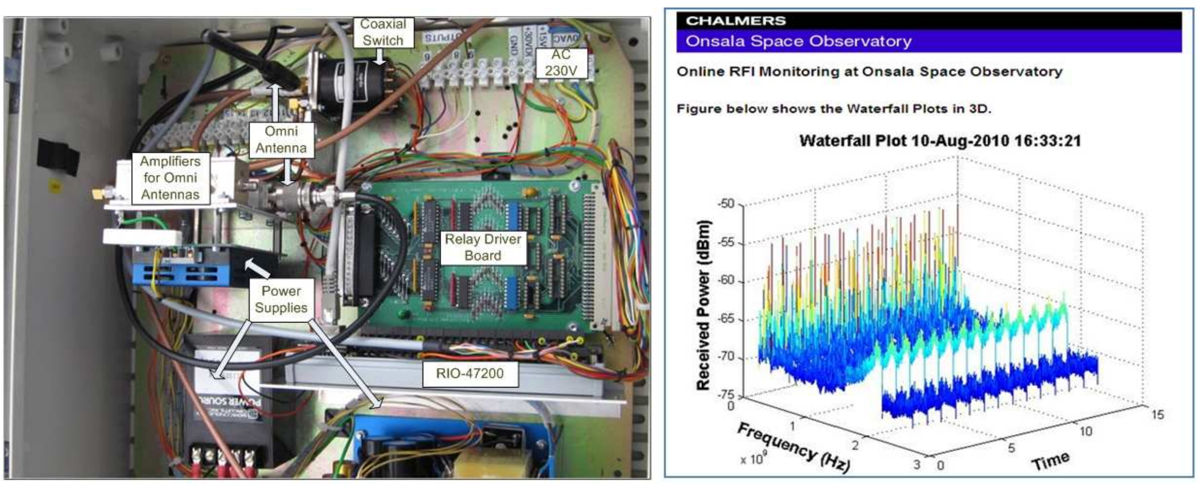

Figure 3. Left: The main antenna control unit. Right: The Web-based interface for RFI monitoring.

3. Further Technical Development

A number of additional technical projects were carried out in 2010. The upgrade and repair of the microwave radiometer Konrad continued. The system to monitor the vertical height changes of the 20-m radio telescope was upgraded. New temperature sensors were installed and the measurements made available on a Web page, see `http://wx.oso.chalmers.se/pisa/`.

4. Outlook and Future Plans

We will continue to develop the cryogenic receiver for VLBI2010 using the Eleven feed. New prototypes will be produced in 2011. We plan to install an RFI monitoring station at Onsala and will include RFI mitigation in the telescope control system.

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