Onsala Space Observatory – IVS Technology Development Center

Rüdiger Haas, Miroslav Pantaleev, Leif Helldner, Lars Pettersson, Hans-Georg Scherneck, Gunnar Elgered

Abstract

This report summarizes the technical development related to the geodetic VLBI activities that were performed at the Onsala Space Observatory during 2009. Most of the tasks planned for the year were addressed, and some new tasks were initiated. The focus was on:

- the development of a dual-polarized broadband Eleven feed for VLBI2010
- optical fiber tests for the transfer of VLBI IF-signals
- the new superconducting gravimeter
- the microwave radiometer Konrad
- the time and frequency laboratory

1. Development of a Cooled Version of an Eleven Feed for VLBI2010

During 2009 the project to develop a cooled version of an Eleven Feed [1] for VLBI2010 was continued. This project is headed now by Miroslav Pantaleev from the Electronics Lab at the Onsala Space Observatory (OSO). It is a collaboration of OSO, the Antenna Group at the Chalmers University of Technology, the Department of Microelectronics and Nanoscience at Chalmers, and the Hartebeesthoek Radio Observatory. Additional partners of the project are the California Institute of Technology and the Haystack Observatory.

The electrical, mechanical, and cryogenic design was continued, and five prototypes of the Eleven Feed were produced in 2009 at Onsala. The reflection coefficients of the feed at room temperature were measured both at Chalmers and at the California Institute of Technology. The measurement results agree very well with each other and with the design simulations (within 1–3 dB), and they are below –10 dB for the frequency range 2–13 GHz. The radiation pattern was measured at the Technical University of Denmark. Both directivity and radiation intensity agree well with the simulations (within 1 dB).

A prototype receiver cryostat was designed and built at OSO. The cryostat integrates the Eleven Feed together with LNAs at 20 K cryogenic temperature. A number of measurements were done with the cooled receiver to determine, for example, the reflection coefficient and the system noise. The reflection coefficient of the feed does not change when cooling, as compared to room temperature, and agrees within 1 dB with the design values. For the system noise measurements we used two-stage single-ended GaAs cryogenic HEMT amplifiers for the 4–8 GHz band. The measured average noise temperature over this band was 29 K. Similar tests were done at the Haystack observatory with single-ended InP HEMT amplifiers for the 2–12 GHz band, and the average noise temperature of this system was 18 K over the whole band and 20 K over the 4–8 GHz band. The results for the 4–8 GHz band are presented in Figure 2. The lower system noise measured at Haystack is due to the better LNAs used in their receiver.

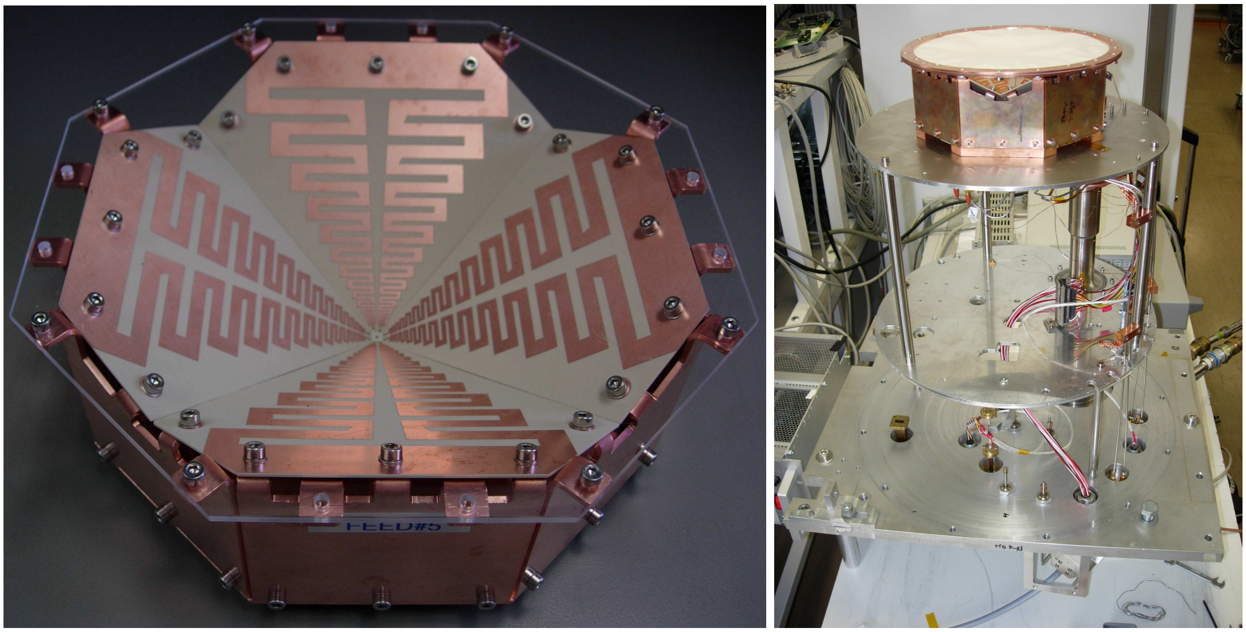

Figure 1. Left: One of the prototypes of the Eleven Feed for VLBI2010, built at the Onsala Space Observatory. Right: The feed prototype mounted on the cryostat.

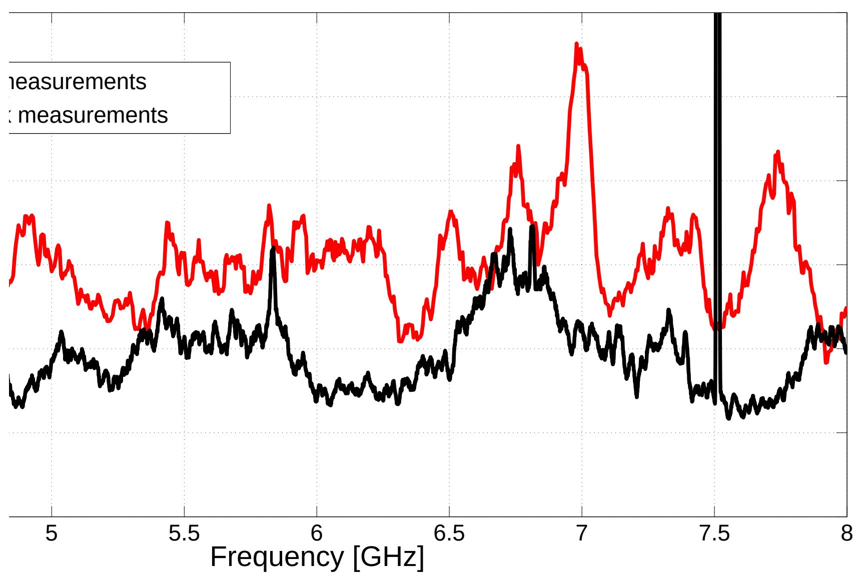

Figure 2. Comparison of the noise temperature measurements done at Haystack and at Onsala. A 15 point moving average is applied to the raw data. The mean values over the 4–8 GHz band are 20 K for the measurements at Haystack and 29 K for the measurements at Onsala.

2. Tests of an Analog Optical Fiber for the Transfer of VLBI IF-signals

The tests of optical fibers for the transfer of VLBI IF-signals [2] have continued, and the results have been summarized in a report [3]. The study shows that the fiber is temperature sensitive and that both the transmitter and the receiver of the optical fiber system need to be temperature controlled. Temperature changes do not influence the signal amplitude, but they influence the signal phase. Thus a phase-calibration system is necessary for VLBI operations. The fiber shows also a slight sensitivity to the elevation angle of the telescope, but no significant sensitivity to the azimuth angle. Based on these studies, it was decided to equip the 20-m telescope at Onsala with an analog optical fiber for frequencies up to 15 GHz.

3. The Superconducting Gravimeter at Onsala

In the spring of 2009 the new gravimeter house was completed and the superconducting gravimeter was finally installed in June 2009. Figure 3 shows the new gravimeter house and the instrument. Data have been recorded continuously since June 2009.

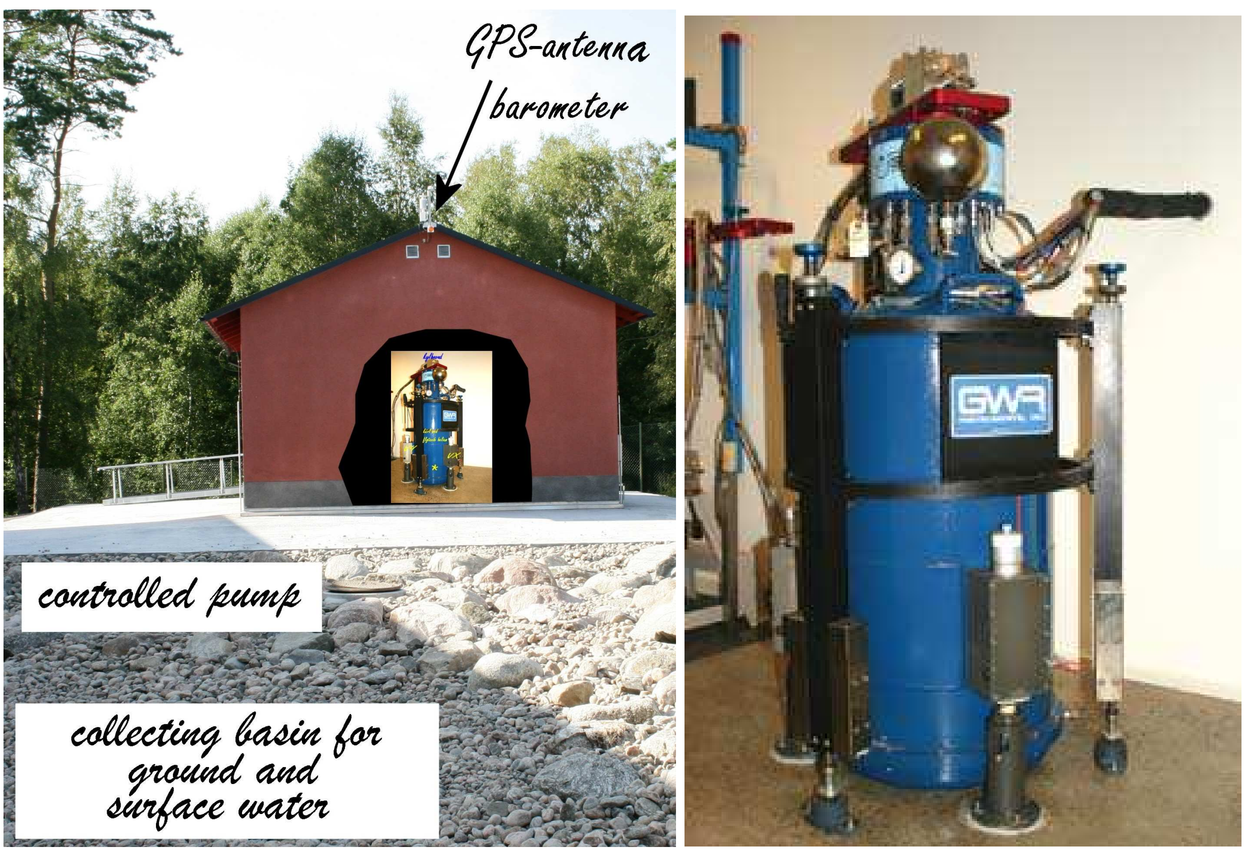

Figure 3. Left: The new gravimeter house at Onsala. Ground and surface water are collected, and the basin level is controlled by a pump. A barometer and a GPS time-receiver are located at the top of the new gravimeter house. Right: The new superconducting gravimeter “Hans” inside the gravimeter house.

4. The Microwave Radiometer Konrad

The microwave radiometer Konrad [4] was maintained during 2009. The drive system was partly removed, and work to repair the instrument is still ongoing. We expect that the instrument can be taken into operation again in the summer of 2010.

5. The Onsala Time and Frequency Laboratory

In 2009 the time and frequency laboratory at Onsala was equipped with a Cesium clock. Now it contains two H-masers, one Cesium clock, and several GPS timing receivers.

6. Outlook and Future Plans

- During 2010 we will continue the development of a prototype Eleven Feed for VLBI2010. The plan is to integrate cryogenic differential LNAs into the feed. System noise tests will be done in 2010. A design study for the installation of the feed on the Onsala 20-m telescope during 2010 will be performed. In collaboration with the Microwave Electronics Laboratory at Chalmers, the integration of room temperature LNAs will also be prepared. Tests with broad band room temperature LNAs at one of the Onsala 2.5-m telescopes are planned.
- We plan to install an optical fiber covering frequencies up to 15 GHz on the 20-m telescope and to develop a corresponding calibration system.
- We will install the GNSS-based tide gauge at the Onsala Space Observatory and develop an automated data flow and analysis.
- We plan to install various sensors to monitor environmental parameters such as ground water at the new gravimeter house.
- We will try to develop the ability to read and monitor important parameters of the S/X-receiver directly with the FS.
- We will focus on an upgrade of the azimuth and elevation drives of the Konrad radiometer.

References

[1] Olsson, R., Kildal, P.-S., and Weinreb, S.: The Eleven Antenna: A Compact Low-Profile Decade Bandwidth Dual Polarized Feed for Reflector Antennas, *IEEE Trans. Antennas and Propagation*, **54(2)**, 368–375, 2006.

[2] Haas R, Helldner L, Pantaleev M, Löfgren J, Elgered G (2009) Onsala Space Observatory IVS Technology Development Center. In: *International VLBI Service for Geodesy and Astrometry 2008 Annual Report*, edited by D. Behrend and K. Baver, **NASA/TP-2009-214183**, 329–332.

[3] Pettersson L (2009) Optical Fiber Tests. Internal report, Onsala Space Observatory, 36 pages.

[4] Stoew, B., and Rieck, C.: Dual Channel Water Vapour Radiometer Development. In: W. Schlüter and H. Hase (Eds.): *Proceedings of the 13th Working Meeting on European VLBI for Geodesy and Astrometry*, 261–264, 1999.