Metsähovi Radio Observatory - IVS Network Station

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Abstract

In 2012, Metsähovi Radio Observatory together with Finnish Geodetic Institute officially became an IVS Network Station. Eight IVS sessions were observed during the year. Two spacecraft tracking and one EVN X-band experiment were also performed. In 2012, the Metsähovi VLBI equipment was upgraded with a Digital Base Band Converter, a Mark 5B+, a FILA10G, and a FlexBuff.

1. General Information

Aalto University Metsähovi Radio Observatory and Finnish Geodetic Institute (FGI) are two separate institutes which together form the Metsähovi IVS Network Station. Metsähovi Radio Observatory operates a 13.7 meter radio telescope at the premises of Aalto University at Metsähovi, Kylmälä, Finland about 35 km from the university campus. In the same area, near Metsähovi Radio Observatory, there is the Metsähovi Research Station of FGI.

Figure 1. Metsähovi Radio Observatory.

2. Component Description

The Metsähovi Radio Observatory has been operational since 1974. The telescope was upgraded in 1992-1994. The radome was replaced with a new one, and new surface panels were installed. Metsähovi together with FGI started observing IVS T2 and EUROPE sessions in 2004. Approximately six to eight sessions are observed per year. The antenna speed of the Metsähovi antenna is 1.2 degrees per second. The surface accuracy of the present telescope is 0.1 mm (rms). The geodetic VLBI receiver of Metsähovi uses right circular polarization and 8.15-8.65 and 2.21-2.35 GHz frequency bands. Astronomical orbservations are also carried out. Metsähovi is known for its long-term quasar monitoring. Astronomical VLBI observations are carried out with the 22 GHz receiver.

2.1. Metsähovi Fundamental Station

Finnish Geodetic Institute (FGI) is running the Metsähovi Fundamental Station. It is a part of the IAG GGOS Core station network. The instrumentation includes geodetic VLBI (in co-operation with Aalto University), Satellite Laser Ranging (SLR), DORIS, GNSS, and absolute

and superconducting gravimeters. Currently, instrumentation is being renewed based on special funding from the Ministry of Agriculture and Forestry. During the next five years, the plan includes e.g. a new VLBI2010 compatible radio telescope. FGI is committed to maintain and develop Metsähovi as a geodetic fundamental station.

3. Staff

FGI is responsible for the geodetic VLBI observations and is the owner of the S/X receiver. The radio telescope is owned and operated by the Aalto University, and an annual agreement is made on its use for geodetic VLBI sessions. It is not possible to increase the number of annual sessions (currently six to eight), because the telescope is mainly used for astronomical observations. Operation during the geo-VLBI sessions and technical questions are handled jointly; all other technical work, telescope maintenance, and maintenance of instrumentation and data connections are done by the personnel of the radio telescope.

Metsähovi personnel working with geodetic VLBI observations in 2012 are listed in Table 1. Dr. Elizaveta Rastorgueva-Foi is in charge of all VLBI observations at Metsähovi. The theses are listed in the sub-section: Data analysis. The preparation, operation of GeoVLBI observations, and submission of data are provided by staff from FGI. The personnel engaged in the work are listed in Table 2.

Table 1. Metsähovi Radio Observatory personnel involved in geodetic VLBI observations during 2012.

Name	Title	Responsibility
Lic.(tech.) Juha Kallunki	Laboratory manager	VLBI equipment, NEXPReS
M.Sc.(tech.) Ari Mujunen	Laboratory manager	NEXPReS
Dr. Elizaveta Rastorgueva-Foi	VLBI friend	VLBI observations
M.Sc. Minttu Uunila	Doctoral candidate	VLBI equipment
M.Sc.(tech.) Petri Kirves	Operating engineer	Receivers
Tomi Salminen	Research assistant	NEXPReS

Table 2. FGI personnel involved in geodetic VLBI observations during 2012.

Name	Title	Responsibility
Prof. Markku Poutanen	Head of the Department of Geodesy and Geodynamics	Metsähovi research station
Dr. Nataliya Zubko	Senior research scientist	preparation of GeoVLBI sessions, operation of GeoVLBI observations, e-transfer of data
M.Sc. Veikko Saaranen	Special research scientist	operation of GeoVLBI observations
M.Sc. Ulla Kallio	Senior research scientist	Local ties measurements
M.Sc. Simo Marila	Research scientist	operation of GeoVLBI observations

4. Current Status and Activities

4.1. Geodetic VLBI Experiments

Metsähovi together with FGI observed eight IVS sessions in 2012. Also two spacecraft tracking experiments were performed. Metsähovi radio antenna contributed to the following EURO and T2 IVS sessions: EUR115, EUR116, EUR117, EUR118, T2082, T2083, T2084, and T2086. Most of the observations were achieved properly. However, some technical problems also occurred during the observations. In particular, within the EUR115 session, the problems with antenna slewing appeared a few times, so most of the scans were not recorded. Besides, time differences between the Field System and the formatter clocks were found during some sessions. Troubles with the Mark 5 recording system happened, but because the observations are simultaneously recorded with two independent systems, namely Mark 5 and PC-EVN, all the observations were successfully recorded. For the period of 2012, most of the sessions were observed without antenna cable calibration, due to technical reasons. Therefore, the possible changes in the cable's length were not monitored. Most of the sessions were correlated at the Bonn correlator. The data were sent there via e-transfer using the Tsunami protocol. In accordance with the correlation reports, the amounts of correlated observations varied from 60% to 80%.

4.2. Technical Activities and Issues

In December 2012, Metsähovi successfully tested the new equipment consisting of DBBC and Mark 5B+ during a Venus Express spacecraft tracking experiment. Also the new standalone FILA10G together with the new FlexBuff data storage computer developed in the EU NEXPReS project were successfully deployed.

4.2.1. BBC/DBBC Status

The status of the old VLBI hardware is not as good as it could be: some rack BBCs are broken. Two of the broken BBCs were repaired, and now a total of 12 BBCs are being used in the experiments. The repair was done by replacing the BBC's oscillator chain with a $300 synthesizer. The DBBC ordered from Hat-Lab arrived in September with the standalone FILA10G. Also, a new Mark 5B+ arrived in spring of 2012. We successfully tested the new equipment in parallel with the old equipment in December 2012.

4.2.2. Recording Systems

We have developed a new DAQ system, the FlexBuff, using COTS components. Local UDP streaming performance tests were performed with wirespeed 10GE. Long (30 minute) tests demonstrated the ability to write at maximum wire speed with zero packet loss. Writing to 34 disks without a network (using local machines), the architecture can handle 40 Gbps, and it can always handle > 30 Gbps. We have fixed our Mark 5A 1 Gbps recording problems by changing an R25 resistor to a 27-ohm resistor in the Mark 5A I/O board. We also purchased a Mark 5B+ system, which is now ready to be used.

4.2.3. Other Technical Issues at Metsähovi

Metsähovi has been suffering from the old formatter being out of sync during various sessions. After deploying the Mark 5B+ and the DBBC these problems will vanish. Because the phase cal box is temperature dependent, and because there has been a lot of drifting and phase jumps, the box will be temperature stabilized. A phase coherence problem due to the 5 MHz reference signal was found and corrected with a new 5 MHz distribution unit. The 1PPS distributor destroyed the Metsähovi 1PPS going to the old VLBI equipment. A new distributor has been purchased.

4.3. Data Analysis

In 2010 FGI and Metsähovi Radio Observatory received four-year funding from Academy of Finland to start geodetic VLBI data analysis. During 2012 one doctoral dissertation (Guifré Molera Calvés: "Radio spectroscopy and space science with VLBI radio telescopes for Solar System research") and one master's thesis (N. Kareinen: "Geodetic Very Long Baseline Interferometry and the effects of Tohoku Earthquake — Case analysis of Tsukuba station") were finished. In addition one doctoral dissertation (M. Uunila: "Improving geodetic VLBI: UT1 accuracy, latency of results and data quality monitoring") was sent to the pre-examination process in late 2012. Data analysis at FGI is performed by N. Zubko. The research of stochastic model selection for GeoVLBI data analysis has been done. Also, the project of source structure study and its influence on estimated geodetic VLBI parameters has been started with E. Rastorgueva-Foi from Metsähovi Radio Observatory. Diego Meschini is responsible for correlation.

4.3.1. Local Ties between VLBI and GPS at Metsähovi

The local ties measurements between the co-located instruments at Metsähovi are provided by Ulla Kallio. A local tie between IGS station METS and the VLBI antenna reference point was regularly performed with kinematic GPS measurements during the geo-VLBI campaigns starting in 2008. Testing shows that a millimeter level accuracy can be achieved in local tie vector determination with the kinematic GPS method. In July 2012, the local tie vector between the new Doris and Regina (GPS) antennas was determined by Thomas Donal and Jean-Claude Poyard (IGN) in June 2012. The local tie between Regina and VLBI was measured in July with kinematic GPS during the EUROPE-118 geo-VLBI session. The SINEX file of the tie vector is available.

5. Outlook

In the upcoming years Metsähovi will continue spacecraft tracking experiments and participating in IVS sessions together with FGI. Five T2 and two EUROPE sessions have been scheduled for Metsähovi in 2013. The FlexBuff development and geodetic VLBI data analysis will continue in 2013.

Acknowledgements

Both the FGI and Metsähovi teams acknowledge support from the Academy of Finland (grant number 135101).