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Metsähovi Radio Observatory
Annual Report 2007

M. Tornikoski, M. Uunila, S. Hurtta (editors)

Metsähovi Radio Observatory
Helsinki University of Technology TKK

Director:
Dr. Merja Tornikoski
Tel. +358-9-2564 423
Email: Merja.Tornikoski@tkk.fi

Secretary:
Ms. Solveig Hurtta
Tel. +358-9-2564 831
Email: Solveig.Hurtta@tkk.fi

Metsähovi Radio Observatory
Helsinki University of Technology TKK
P.O. Box 3000
FIN-02015 HUT
Finland

Metsähovin radiotutkimusasema
Teknillinen korkeakoulu
Metsähovintie 114
02540 KYLMÄLÄ

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1 Introduction

Metsähovi Radio Observatory, a separate research institute of the Helsinki University of Technology (TKK) since May 1988, operates a 14 m diameter radio telescope in Metsähovi, the village of Kylmälä in Kirkkonummi, about 35 km west from the Otaniemi university campus.

Metsähovi is active in the following fields: radio astronomical research, multifrequency astronomy and space research, development of instruments and methods for radio astronomy, and (radio) astronomical education. Since 2004 also geodetic VLBI observations are done at Metsähovi in collaboration with the Finnish Geodetic Institute.

In year 2007 twenty scientists, engineers, research assistants and support personnel worked at the institute. In 2007 the total expenditure of Metsähovi Radio Observatory was 855 312 euros including salaries and the rent of the office and laboratory space at the Metsähovi premises. This was funded by TKK, Academy of Finland, European Union, and other outside sources. We have also obtained a considerable additional funding in the form of radio astronomical equipment to be delivered to Metsähovi in 2008-2009, a project funded by a debt conversion agreement between Finland and Russia.

Towards the end of 2007 Metsähovi was getting ready for some major changes at the administrative level: At the beginning of 2008 Metsähovi was to be merged to the new faculty of Electronics, Communications and Automation, but still maintaining its status as a separate research institute. We confidently look into the future and are ready to take the new steps as part of the faculty and proceedings towards the Innovation University.

Merja Tornikoski
Director of the TKK / Metsähovi Radio Observatory

2 Research Activities

In this chapter the main research activities at Metsähovi are introduced. Some of the project teams include also scientists working at other institutes. The contact person at Metsähovi is underlined in each project team list.

2.1 Radio Astronomical Instrumentation

Research Group at Metsähovi: Tornikoski, Peltonen, Mujunen, Kallunki, Oinaskallio, Ritakari, Rönnberg

2.1.1 3 and 2 mm SIS Receivers

Project team: Peltonen, Mujunen, Oinaskallio, Kallunki, Rönnberg

The 3 mm SIS receiver was used again twice for VLBI observation sessions in 2007. During the May session the measured noise temperatures for LCP and RCP channels were around 90 K and 140 K, respectively. In the October session the same values were 80 K and 160 K. These were measured with the power meter in the control room by changing liquid nitrogen and room temperature loads in front of the input horn on the telescope (long cables included in the system). The original specification for the sensitivities for both channels was 50 K and that has been achieved only once, during the April session in 2005.

Official negotiations to design and construct a completely new 3 mm receiver based on HEMT technology were continued with IAP (Institute of Applied Physics) as a Supplier and with Machinoimport as a Seller. The new receiver should be cooled to the 20 K ambient temperature compared to 4 K required for the SIS-receiver. Hence the weight of the new receiver will be much less and particularly the compressor needed for the cooling is much smaller and the weight is decreased from 140 kg to 60 kg. The main benefit will be of course the higher reliability and that HEMT receiver is much easier to operate on the telescope. Also the sensitivity should be constant every year during the consecutive sessions.

On the intergovernmental level the contract between Metsähovi and IAP was accepted in Russia on October 12, 2007 by the Ministry of Trade and Economical Development and the Ministry of Finance of the Russian Federation. Thereafter the contract was send to the Ministry of Trade and Industry of Finland and Finnvera PLC for approval from the Finnish side. Finnvera legal affairs suggested some changes to the main Contract and according to these remarks an Addendum No 1 was negotiated with Macinoimport and the same time some corrections were made to the technical Appendices. This contract with the Addendum as an integral part was accepted by the Ministry of Trade and Industry on November 30, 2007.

Although the offical negotiations were unfinished, Metsähovi and IAP personnel started the technical consultations first about the new 3 mm VLBI receiver on October 10, 2007 and secondly about the new 22 and 37 GHz radiometers on November 1, 2007. From these separate meetings two Memorandums were prepared and signed. For the 86 GHz receiver Pekka Sjöman's company (DA-Design Oy) should be used as a subcontractor to design all cryogenic parts, especially the low noise MMIC HEMT preamplifiers. The block diagram after the mm-wave mixers is quite similar to the old receiver, only the phase calibration possibility was added to the IF-part. In the old system the frequency reference for the phase locking at 82.301 GHz was derived from Rohde & Schwarz synthesizer giving an output at 9.114 GHz locked to 5 MHz. This bulky equipment should be preserved to generate test signals and a smaller synthesizer with the same spectral purity must be constructed to be an integral part of the 86 GHz receiver. If this receiver will be tuned in the future also to higher frequencies (115 GHz signal frequency) then the R&S source could be used temporarily.

When the 3 mm components from the SIS-dewar will be removed this can be exploited in the future

solely for a 2 mm SIS-receiver where HEMT devices might yet show higher noise temperatures. Also the critical cooling capacity will be now enough because the 2 mm receiver has only one mixer (both right and left circular polarizations cannot be measured simultaneously). This receiver has not yet been tested because it has a BWO (high voltage DC- power source required, short lifetime of the electron tube) as a local source. This could be easily replaced by a Gunn-oscillator at 71.5 GHz followed by a frequency doubler. Because the power level needed for a SIS-mixer is negligible even with a low efficiency doubler, the adequate power could be generated.

For the 22/37 GHz radiometers it was agreed that both receivers are based on the pseudocorrelation topology and are capable to detecting two linear polarizations. Thus both radiometers are constructed with four cryogenic LNA's, two linear OMT's plus noise calibration injection and two magic-tee's at 20 K ambient temperature. At room temperature the signals are further amplified with LNA's and in the other branch a phase shift of 180 degrees is accomplished by a phase switch. The detailed block diagram of the Q-band radiometer is shown in Figure 1. The K-band receiver has a similar scheme. The phase switch allowes fast switching compared to an old Dicke switching mode. Moreover a cryogenic Dicke switch cannot be realised for these frequencies (and it would limit the bandwidth to 20 %) and a chopper structure becomes impractically large.

At the beginning of the meeting on November 1, 2007 Dr. Kaj Wiik from Tuorla Observatory, Turku, gave a presentation of the benefits of the pseudocorrelation topology compared to the Dicke switched configuration. According to his calculations for the new receiver, compared with the existing radiometer (lower noise temperature, broader bandwidth plus change of topology), the speedup factor (observation time reduction) varies between 20 and 50, depending on atmospheric conditions.

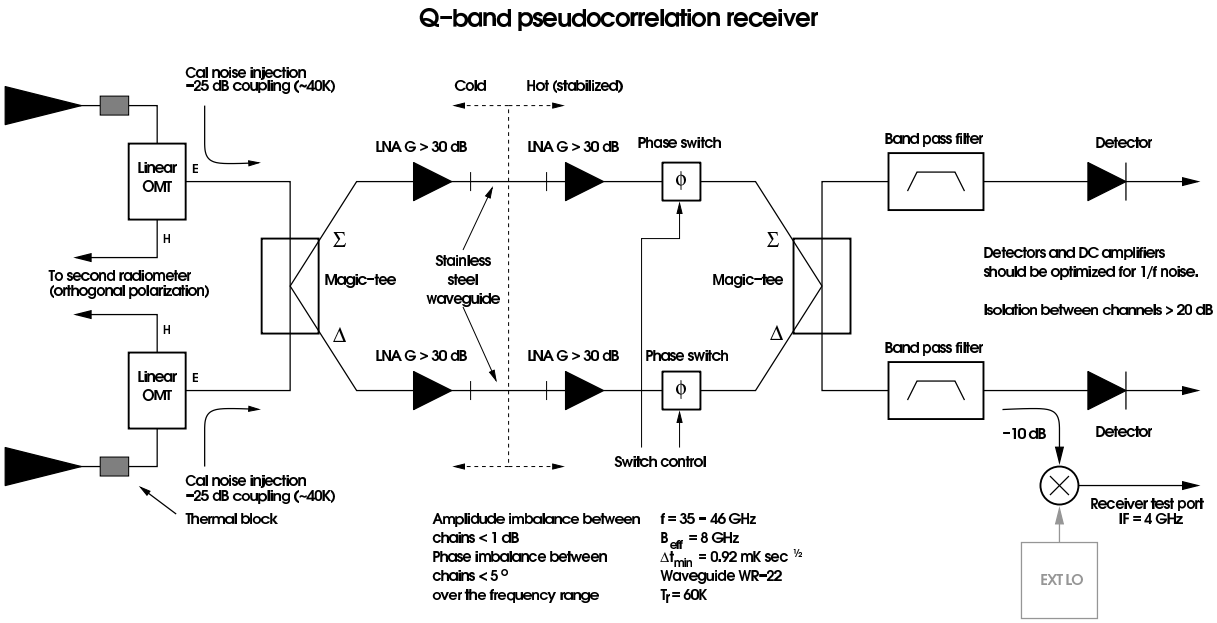

Figure 1: Block diagram of the Q-band radiometer.

2.1.2 Receiver Maintenance and Upgrades

Project team: Peltonen, Mujunen, Oinaskallio, Kallunki, Rönnberg

In 2007 the 2/8 GHz Geo-VLBI receiver had a failure in the S-band LO source at 1530 MHz. The phase locking circuitry had an electronic component failure causing a constant loss of phase lock although the basic oscillator was operational. During two sessions the receiver was operated with a Rohde & Schwarz synthesizer as a spare LO source. However the spectral purity of a synthesizer is always worse (over 20 dB higher phase noise) compared to a fixed frequency, high Q ceramic resonator stabilized bipolar transistor oscillator. Therefore a new LO unit was purchased from Herley-CTI, New

Jersey, USA and the Metsähovi technical group made the repair successfully. In this case the whole LO unit box had to be disassembled completely and the new electrical connections made carefully. The operation of this new LO source has proved to be reliable.

2.1.3 IT Infrastructure

Project Team: Mujunen, Lindfors

Since 2006 Metsähovi has been connected to CSC/Funet with a leased fiber link running at 10 Gbps, as the first radio observatory in the world in this speed class. The connection was made possible with the joint financing from both TKK and EU FP6 "EXPReS" contract.

The local connectivity hardware was enhanced in 2007 with a new HP 6400cl 10GE switch and new local fiber cabling. A "metsahovi.fi" DNS domain was hosted at Funet name servers to ease the managing of new 10GE nodes. Metsähovi local area network was extended to the entry gate area with a pair of Zyxel VDSL modems and this enabled the replacement of old aging Philips analog surveillance cameras with new Sony SNC-Z20P IP-based surveillance cameras. The old analog video switch and CRT monitor were replaced with up-to-date image archival and real-time display system ("moniscreen.kurp.hut.fi").

Several aging Pentium I class desktops were replaced with new Dells from Hansel government contract. Some of the new computers were installed with Ubuntu 7.10 based desktops which, as a Debian derivative, fit well in the existing Debian-based Linux infrastructure of Metsähovi. Practically all desktops were equipped with lightweight Mustek PowerMust 600 UPSes and NUT UPS control software to help with frequent power outages and glitches at Metsähovi, due to our remote location.

The central Windows Server 2003 based Windows Terminal Server, "winapps" was updated with the latest versions of TKK-licensed Microsoft and Adobe software. A single Windows instance has greatly simplified Windows system administration while still offering legacy Windows applications to every desktop wishing to use them via the "rdesktop" RDP remote access. Of our commercial applications only Unistat had problems with licensing in Windows TS environment; at Linux side, the FlexLM "lmgrd" of our IDL installation needed special attention when the server hardware was upgraded. The maintenance contract of IDL was terminated due to minimal demand.

Our legacy continuum observation program "CONTOBS", written in Ada in VAX/VMS environment was ported to Linux with the GNAT (GNU Ada) environment. This was made to enable careful comparisons between the old VAX system and the new Linux-based observation system, that is, three-way comparisons between old CONTOBS, new CONTOBS, and the new Linux-based software.

A new Linux driver was written for the Datel PCI-416M data acquisition A/D converter card. Unlike the old driver, the new driver is of general-purpose and supports, at least theoretically, the full range of the card's capabilities. The new driver also works on modern 2.6 kernels, both 32-bit and 64-bit little-endian. Big-endian support is straightforward to add if needed, but cannot be done without testing (Metsähovi does not have any big-endian computers).

The hardware and operating system of the computer housing the card was upgraded at the same time ("daqqer.kurp.hut.fi"). This revealed some new problems with the card, which was already known to have compatibility problems with newer hardware. The known hardware problems of the card are: lost samples if using DMA, spurious DMA completion interrupts, and interrupts not delivered if ACPI APIC IRQ routing is enabled.

The aging analog PABX voice phone system has to be replaced, and the investigation has started whether the open-source Asterisk VoIP PABX software running under Linux, together with a new set of VoIP (SIP) phone sets would be a viable replacment. The first experiments look promising, and the full migration is planned for 2008.

2.1.4 Hydrogen Masers

Project Team: Oinaskallio, Kallunki, Mujunen

In February 2007 frequency comparator (in Maser 69) was replaced by a new one. The faulty comparator caused missing pps (Pulse Per Second) signal. The molecular hydrogen source was also replaced (Maser 69) at same time. For the rest of the year Maser 69 worked without any failures. The last part of the year Maser 70 started to lose pps signal every now and then. Maser 70 will be fixed in early 2008. In Figure 2 the time differences between the two H masers and several GPS clocks are being illustrated.

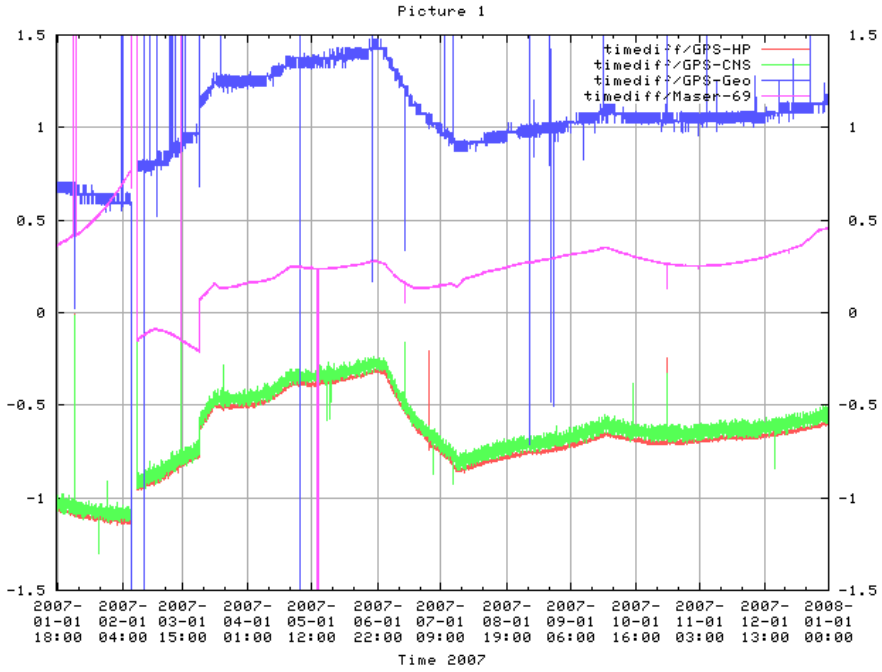

Figure 2: Time differences of H maser and GPS clocks, in microseconds.

2.1.5 Clock difference measurement

Project Team: Mujunen, Kallunki, Oinaskallio, Rönnberg

The clock difference measurement system (called "Clodi") worked without any failures for the whole year 2007.

2.1.6 New Hardware

Project Team: Mujunen, Kallunki, Oinaskallio, Rönnberg

Harmful frequency measurement system

Harmful frequency measurement system was completed during the 2007. The spectum analyzer was renewed becauce Instek spectrum analyzer did not fulfill the specs. The new Agilent spectrum analyzer (CSA, N1996A, 100 kHz - 3GHz) proved to be more reliable, and controlling is much easier. The new spectrum analyzer can be controlled via Telnet protocol. The data collection and antenna controlling software was also reprogrammed (spektr3.pl).

Sunant

The pointing of the Sunant antenna was renewed. The new pointing model is much more accurate. New parameters were added to pointing equations and old parameters were updated.

The multiple plate clutch in the azimuth axis was worn out. The clutch was changed to a new one. During the years it has been noticed that Sunant is vulnerable to weather effects (especially to gusts). Wind causes vibration of the antenna. A brake was added to azimuth axis to prevent this vibration.

Figure 3: Radome camera.

Monitoring

The amount of oil in the radome heater's oil tank can be read remotely with the new sensor. The sensor was delivered by Seseon Automaatiopalvelu Oy.

A new camera was installed for monitoring the condition of the radome (snow). It is possible to move and zoom the camera to a desired position. Figure 3 illustrates the installation of the camera, the lower picture shows an example picture taken with the radome camera. The camera was delivered by Nordic Lan & Wan Oy.

Cloud sensor

A new cloud sensor was installed on the roof of the old part of the Metsähovi building. The sensor measures, for example, temperature, humidity and wind speed. A new feature is that the sensor

measures also cloudiness level. The measurement of cloudiness level is based on the temperature differences between the sky and the ground. The cloud sensor was delivered by Boltwood Systems Corporation.

Receiver crane

The crane for lifting receivers up to the antenna was finally completed. Both the mechanical and the electrical parts were successfully tested in the test bench. The crane construction will be completed and run in during the year 2008. Figure 4 illustrates the construction of the crane (the crane is in the test bench).

Figure 4: Receiver crane in the test bench.

Building maintenance in Metsähovi

The clock cellar temperature and humidity controllers (clock and machine room) were renewed in the fall 2007. The parameters of the controllers can be fixed much more easily than the ones of the previous controllers; also remote control is possible. The controllers were delivered by Siemens.

The four security cameras were updated with Ethernet based Sony SNC-Z20P cameras. The cameras were delivered by Nordic Lan & Wan Oy.

2.2 VLBI Instrumentation

Project team: Ritakari, Mujunen

The VLBA data acquisition rack is aging and an increasing number of problems plague especially the

baseband converters, BBCs. A couple of BBC synthesizer board replacements helped but still two or three (out of 14) BBCs have difficulties achieving lock at all frequencies.

To enable full participation in standard IVS geodetic VLBI sessions, Metsähovi and Finnish Geodetic Institute (FGI) have started enquiries from Gino Tuccari at Noto Station (Italy) to equip Metsähovi with a "dBBC" fully-digital FPGA-based VLBA rack replacement system.

2.2.1 eVLBI and EU FP6 EXPReS

Project team: Ritakari, Mujunen, Lindfors, Wagner, Molera

2007 was the second year of "EXPReS", an EU FP6 three-year project to create a distributed astronomical instrument of continental and intercontinental dimensions using e-VLBI. [1] "e-VLBI" constitutes means of using modern networks to connect radio telescopes to each other and to data processors (correlators) to avoid delays inherent in shipping physical recordings around. Metsähovi takes part in this project developing a next-generation data acquisition system architecture dubbed "4G-EXPReS", enabling versatile realtime/near-realtime/storage mode VLBI data acquisition at 4 Gbps and beyond using commercial off-the-shelf (COTS) IT equipment.

Add-on e-VLBI

VSIB plus Tsunami have been added onto regular Mark5A+FS experiments. This has been tested with regular IVS geodetic experiments by Onsala, Metsähovi and Bonn. Mark5A takes disk backup, and VSIB sends data from Mark5A outputs via VSIC in real-time with Tsunami to the correlator. We have used automated scripts to directly use the regular FS schedule files for maximum compability with regular operational VLBI procedures. These have demonstrated real-time Tsunami data acquisition control and FS compability and have been used in all Metsähovi IVS geodetic experiments recently.

Quick UT1 with e-VLBI

Onsala, Metsähovi, Tsukuba and Kashima did long-distance transcontinental e-VLBI transfers at rates of 256 and 512 Mbps for geodetic near-real-time UT1 observations. Using Tsunami to K5 software correlator facilitated getting the UT1 result 30 minutes after transfer. This is an unprecedentedly quick turn-around time for processing the so-called "intensive" type IVS experiments where hour-long sessions with one long baseline yield one timely UT1 measurement daily. Long baselines imply long (typically transcontinental) data paths for e-VLBI and this is where the Tsunami protocol has been proved useful to attain comfortably high transfer speeds.

Software items

The iBOB/iADC boards have arrived, the DiFX software correlator porting to run on the Cell processor (Linux on PS3) is currently on hold. However, the high-speed computational core needed in software correlators as implemented on the Cell processor was named the "minicorrelator on PS3" and made available at $'\texttt{http://cellspe-tasklib.cvs.sourceforge.net/}'$. This supports the elementary FFT and sin/cos operations needed in software correlators, and it makes highly efficient use of the multiple SPU computational cores available in Cell processors.

Another software item that was developed to facilitate the integration of the operational Mark5A playbacks into the software correlation process is "fuseMk5A". This user space (FUSE) Linux file system driver makes Mark5 proprietary 8-disk-pack recordings readable as regular Linux files and thus immediately available for software correlators running on Linux. The source code for this can be found at $'\texttt{http://fusemk5a.sourceforge.net/}'$.

[1] EXPReS is an Integrated Infrastructure Initiative (I3), funded under the European Commission's Sixth Framework Programme (FP6), contract number 026642, from March 2006 through February 2009.

Tsunami file system is another user space Linux file system layer being developed on top of connections to Tsunami server(s). Its intention is to make remote (and local) Tsunami servers (whether real-time or disk-based) to appear as local Linux file systems. This would enable not only Linux software correlation of data stored in disk files but also on-the-fly software correlation of real-time networked Tsunami e-VLBI data streams with the same correlation software which is being used for disk-based data. The further development is currently on hold, pending the completion of the data acquisition system.

iBOB/iADC status

At the end of October 2007 Digicom finally delivered the boards which had been ordered in March 2007. Onsala received one iBOB and one iADC, Metsähovi three iBOBs and three iADCs and Jodrell Bank had already 10 iBOBs but no iADCs. The long delivery time has somewhat delayed the actual data acquisition tests but on the other hand, it enabled both data acquisition control software development (automated FS control scripts, transcontinental Tsunami, described above) and exploration of software correlators (DiFX on the Cell processor) and gaining experience on both parallelized multi-core software algorithms and the structure of sw-based correlator software, and led us to a better understanding of the requirements sw-based correlation imposes on data acquisition architecture.

Also while waiting for iBOB/iADC boards, several 2048.0/1024.0 MHz iADC sampling clock synthesizer boards were tested. The test report by Guifré Molera can be found at:
'http://www.metsahovi.fi/en/vlbi/ibob/Comparing-ADI-NAT.pdf'. The first data acquisition system prototype in an 1U enclosure was built. It consists of one iBOB board with one iADC board, supplemented by one PLL synthesizer board and a power supply.

iBOB development

Xilinx ISE, EDK/XPS, Matlab Simulink and Xilinx SysGen were easy to install and maintain. Old versions are still needed for UC Berkeley CASPER MSSGE design flow. With help from Jodrell Bank, now we are finally able to build MSSGE-based designs. Linux expansion board for iBOB with memory and SD flash still needs to be tested. The next challenge is to feed the data acquisition PC with udp2raid software with iBOB.

10 gigabit Ethernet COTS performance

The enhanced 10 gigabit Ethernet (10GE) environment (see SA2 for a list of enhancements) was tested extensively with commercial off-the-shelf Linux computers and networking boards. The main findings are as follows.

"Out-of-box" (all Linux networking settings at their un-tuned default values), but with "jumbo packets" (MTU setting of 4470 or 9000 bytes) resulted in 9 Gbps using TCP, 8 Gbps using UDP and 1.5 Gbps using unmodified, original Tsunami protocol. After some TCP tweaking, TCP resulted in 9.5 Gbps. This is with a fairly generic, dual-processor, quad-core AMD Opteron PC with twelve Serial ATA disks. We have also purchased two Myri-10GE boards with one CX4 and one XFP with SR module, and a pair of Chelsio 10GE-CX4 boards and one Asus LIN64-WS.

Both brands of 10GE Ethernet PCIe x8 networking boards exhibited similar performance. Recommendations from Jodrell Bank/RHJ that Myrinet and Chelsio PCIe boards perform well backed up with results and the boards were quite unexpensive also.

We noticed that both Chelsio and Myrinet benefit a lot from switching off UDP data payload checksums (SO_NO_CHECK setting). Checksummed iperf resulted in 4.9 Gbps per one core and no checksums resulted in 9.9 Gbps per one core. Several shortcomings at 10 Gbps speed levels were discovered in the design and implementation of the original Tsunami protocol, and thus a new v1.2 "Petabit Tsunami" was developed. Its source code can be found at 'http://tsunami-udp.sf.net/'.

The original protocol parameters of 32-bit are not enough for 10 Gbps. Interpacket timing had only 50 microsecond resolution and now it is 1 microsecond. This improved version of Tsunami resulted in 7 Gbps memory-to-memory and 3.5 Gbps memory-to-raid-XFS performance. These results are reasonable for an entry-level PCIe x8 PC. The improvement factor over the previous generation of computers is approximately: net x10, disks x4, CPU x2, memory bandwidth x1.5.

Internet connectivity

A 10 Gbps Ethernet connection to CSC/Funet was installed and is fully operational. It has been tested in multiple experiments together with the telescopes at Onsala (Sweden), Kashima, and Tsukuba (Japan), mainly in the geodetic VLBI context, but Metsähovi have also participated in SA1 JIVE correlator tests at 1.3 cm wavelength (see the deliverable D133). Numerous remote recording type experiments (data flies directly to the correlator disk buffers) have been performed, and also some experiments with feeding a Japanese software correlator in near real time. Planning of tests for data transfer between MRO - JBO (U.K.) - OSO (Sweden) at 4 Gbps are underway.

Enhanced 10 Gigabit Networking at Metsähovi

Metsähovi have extended their 10 Gbps Internet connection equipment, an Extreme Summit X450 switch, with a 10GBASE-SR module. This allows additional 10GE devices to be connected to the Internet at Metsähovi. To facilitate multiple iBOBs and Linux 10GE computers to be connected at the same time, we have purchased an additional HP 6400cl 10GE switch with six 10GBASE-CX4 integral copper ports and two 10GBASE-SR additional fiber modules (X2, not XFP). This forms the extension of Metsähovi 10GE Internet connection to multiple ports for multiple simultaneous 10GE devices.

Applying Tsunami in operational e-VLBI

Work in e-VLBI continues successfully. Lately a series of geodetic VLBI ultra-rapid UT1 experiments with Onsala, Kashima and Tsukuba have been performed at 128 and 256 Mbps data rates, both in real-time and near-realtime. The correlation results were obtained at world-record turn-around time delay.

Several improvements to the Tsunami e-VLBI software have been implemented, and increased support to its users has been also provided. It is also gratifying to see that other stations and institutes are starting to use the Tsunami protocol for e-VLBI. Recently MPIfR and Wettzell have joined the group. As Tsunami popularity is increasing, e-VLBI experiments between a wider range of countries become feasible.

2.3 VLBI Observational Activities

Project team: Mujunen, Ritakari, Wagner, Molera

Metsähovi takes regularly part in three global VLBI observation networks: the European VLBI Network (EVN), the Global mm-VLBI Array (GMVA), and the International VLBI Service (IVS).

2.3.1 VLBI Sessions in 2007

Project Team: Mujunen

In 2007 there was only one EVN VLBI session which featured Metsähovi observation frequencies, March 2007 with three test experiments and one EVN user experiment at 22 GHz. The Global mm-VLBI Array (GMVA) semi-annual sessions were conducted in May and in October, with 3.5 and 5 days of observing at 86 GHz.

The IVS geodetic VLBI sessions observed in cooperation with the Finnish Geodetic Institute (FGI) continued with the most comprehensive observing program ever: eight 24-hour experiments belonging to both "EURO" regional campaign and to "IVS-T2" Terrestrial Reference Frame (TRF) campaign were conducted. These were supplemented by experimental rapid turnaround dUT1 observations together with Onsala (SE) and Tsukuba and Kashima (JP) where Tsunami real-time e-VLBI protocols (developed at Metsähovi) were heavily exercised to get the data to the Japanese software correlator quickly enough to have an accurate estimate of the current dUT1 value as quickly as 30 minutes after the observations had been completed.

2.4 AMS-02

Project Team: Ritakari, Molera

The construction of the detector is progressing well at CERN in a specially-built clean room at the CERN Prévessin site. The data acquisition tests with the detector have been initially performed with ad-hoc software made by the detector groups, but the common HRDL/UDP-based data acquisition developed by Metsähovi will be tested later, probably in 2008. The current launch estimate for AMS-02 to be shipped to the ISS is at 2009/2010 timeframe.

2.5 Extragalactic Radio Sources

2.5.1 BL Lacertae Objects

Project Team: Tornikoski, Nieppola, Hovatta, Kotiranta, Lähteenmäki, Torniainen, Valtaoja (Turku)

The publication of Metsähovi 37 GHz datapoints of BL Lacertae object (BLO) observing campaign took place in May 2007 in the *Astronomical Journal*. The data have been collected in the years 2001-2005. To ensure an easy access to the data for the whole astronomical community, they were submitted to and published also by the Centre for astronomical data in Strasbourg (CDS).

The main focus in the study of BLOs and blazars in 2007 was on the intrinsic, Doppler corrected blazar sequence. The cornerstone of the blazar sequence scenario is the anticorrelation of the synchrotron peak frequency and luminosity. However, so far all observational studies have neglected to take into account the effect of Doppler boosting, although it could have a considerable effect on the correlations. As a continuation to the extensive study on the spectral energy distributions (SEDs) of BLOs published in 2006, we examined the dependence between the synchrotron peak frequency and the synchrotron peak luminosity in the source frame, i.e., using Doppler-corrected values. We chose a source sample comprising of all radio-loud, northern active galactic nuclei (AGN) observed at Metsähovi, 135 objects in total, 23 % of which were BL Lac objects. For these sources, we collected a large amount of archival multifrequency data to plot their SEDs, and quantified their synchrotron emission using a parabolic fit. The peak frequency and luminosity obtained from the fit were corrected for Doppler boosting using a new set of Doppler factors, calculated from Metsähovi variability data (Hovatta et al., in preparation).

The results show that the Doppler factor is not constant between the sources, but is actually strongly dependent on the peak frequency. As a consequence, the apparent blazar sequence is totally eradicated when both the peak frequency and the peak luminosity are corrected for Doppler boosting. In fact, the correlation between the two quantities turns marginally positive. This is particularly apparent in the case of BLOs. This result, although unexpected, can help to explain previous contradictions in the blazar sequence scenario, for example the number counts of low-energy (LBL) and high-energy (HBL) BLOs. Several surveys have shown that HBLs are less numerous than LBLs, which is difficult to explain if HBL are less luminous than LBLs, as stated by the original blazar sequence. The work on the intrinsic blazar sequence was nearly finished by the end of 2007, and will be submitted in early 2008.


Figure 5: The AGN team semi-regularly convenes to check the status of papers in preparation and to plan future projects.

Work on the manuscript on the long-term variability of radio-bright BL Lac objects resumed in 2007. It presents two sides of the variability: the computational time scales using the structure function, the discrete correlation function and the Lomb-Scargle periodogram, and the observed variability as defined by flare parameters, e.g., duration, peak flux, rise time and decay time, determined directly from the flux curve. There are 24 BLOs for which the time scales could be computed, and 13 of them had a good enough flux curve to be included in the flare analysis. To get a full understanding of the variability behaviour in the radio regime, we use 7 frequencies: 4.8, 8, 14.5, 22, 37, 90 and 230 GHz. Data from the three lowest frequencies are courtesy of Margo and Hugh Aller from the University of Michigan Radio Astronomy Observatory. Results so far indicate that BLO variability has a wide range. The BLO flares seem roughly to adhere to the generalized shock model, albeit incomplete sampling makes the time lags between frequencies very difficult to decipher. The radio variability study on BLOs is expected to be finished in the first half of 2008.

2.5.2 Long-term variability

Project Team: Tornikoski, Hovatta, Lähteenmäki, Torniainen, Nieppola, Valtaoja (Turku), Lainela (Turku)

In 2007 we continued our work on long-term variability of the well-monitored sources in Metsähovi. The paper on statistical analysis of variability timescales, for which the analyses were mainly done in 2006, was accepted for publication in Astronomy & Astrophysics in spring 2007 and published later in the summer.

We continued to work on the same sample of 80 sources studied in the first paper. This time we used the wavelet-method to study the timescales and used only frequencies 22, 37 and 90 GHz. Our first results showed that with wavelets we get similar timescales as with the Fourier-based methods of Paper I, but the timescales are not necessarily present during the whole 25 years the sources have been monitored, and either change or get fainter over long time. This shows that the variability in these sources is not strictly periodic and the structure of the flux curves is very complex. This work has been done in collaboration with Harry Lehto from Tuorla observatory and the paper on this work will be submitted in 2008.

In addition to variability timescales, we have studied the flare characteristics of 55 well-monitored sources. The basic analyses were mainly done already in 2005 in the Master's thesis of Talvikki Hovatta. We calculated various flare parameters for 159 well-monitored flares using data at 8 different frequency bands between 4.8 and 230 GHz. The lower frequency data at 4.8, 8 and 14.5 GHz were provided by the University of Michigan Radio Astronmy Observatory. We calculated, e.g., the

amplitude, the duration and, if possible, the time delays between the different frequency bands. We found that at 22 and 37 GHz the flares last on average for 2.5 years. When this is combined with the results from the timescale analyses, which show that on average flares happen every 4 years we may need 5-7 years to see a source in its highest and lowest activity states. This clearly shows that long-term monitoring is essential in understanding the behaviour of these sources. Furthermore we studied the correspondence of the observations with the generalized shock model, which is used to explain the radio variations. Our results show that in general the observations follow the model, altough there is still a lot of scatter in the data. Especially the time delays between the frequency bands are difficult to determine accurately due to gaps in the data. The results of this work will be published in 2008.

2.5.3 Planck Satellite Science

Project Team Lähteenmäki, Tornikoski, Aatrokoski, Torniainen, Valtaoja (Turku)

The Planck satellite will map the sky at nine high radio frequencies from 30 GHz to 857 GHz, and measure the cosmic microwave background (CMB) radiation. At the same time all foreground radio sources in the sky, including extragalactic radio sources, will be observed, too. Planck will produce unique all sky catalogs of sources at several high radio frequencies. They will, finally, fill the gap in the present radio survey data. The launch of the satellite is scheduled for October 2008.

A dedicated Planck Extragalactic Point Sources Working Group (WG6) meeting took place in Orsay, France, in February. A. Lähteenmäki, M. Tornikoski, and E. Valtaoja participated. In view of the upcoming deadline of the final Planck science programme, science areas to be developed into proposals were discussed. In May the science proposals defining the final science programme for Planck were submitted, in preparation for the approaching launch. The proposals were then iterated between the Working Groups and the Planck Science Team (PST), and the final science programme is expected to be ready in spring 2008. A. Lähteenmäki is the leader of "The Astrophysics of Quasars and BL Lac Objects" proposal, which was accepted to the Planck final science programme. Our team participates also in two other WG6 proposals as dedicated team members ("The Astrophysics of Extreme GPS and Inverted Spectrum Sources" and "Statistical properties of radio and submillimeter sources in the Planck Point Source Catalogue"). A. Lähteenmäki was also invited to join the Planck Galactic source Working Group (WG 7) proposal "Late stages of stellar evolution", in which the QDS software will be used for detecting galactic flares.

The annual Planck LFI and HFI Consortia meeting was held in Toulouse, France, in June. A. Lähteenmäki and I. Torniainen participated. WG 6 also met and discussed the latest developments and plans. Concerns about the minimal funding of Finnish Planck science were expressed during the LFI Co-I meeting by A. Lähteenmäki. The Co-Is, including PI R. Mandolesi, offered their support if such is needed.

In 2007 also the Planck LFI and HFI Core Teams (CT) sprung into action. Their purpose is to coordinate the practical, hands-on work starting at launch, even though some areas, such as component separation methods, are already active. The membership is limited, and 0.7 FTE contribution is required from the members. A. Lähteenmäki is a member of the Non-CMB Core Team Area (CTA-09). The CTs organise meetings every few months, with the frequency increasing towards and after the launch. In addition, CTA-09 stays in touch with telecons twice a month. In November A. Lähteenmäki participated in a Joint LFI and HFI CT meeting in Bologna, Italy, where a myriad of practical issues of handling the satellite, its instruments, and data were thoroughly discussed.

Our observing proposal for the Herschel satellite called "Target of Opportunity observations of interesting Active Galactic Nuclei detected with the Planck Quick Detection System" will be endorsed by the PST, even though it could not be submitted in the first Herschel Announcement of Opportunity cycle due to the fact that it is not a Key Project. However, it is expected that because of the PST endorsement, Herschel Discretionary Time can be given to interesting QDS Target of Opportunity projects.

The preparatory work for Planck continued. Observations, analysis, and publication of our Planck-related AGN data were carried out in Metsähovi in cooperation with our collaborators worldwide. The Quick Detection System (QDS) software has been integrated to the LFI Data Processing Centre (DPC) in Trieste, Italy. A closer account on the QDS status will be given in Section 2.6.

The Finnish Planck science group, led by A. Lähteenmäki, met several times during the year. The awkward financial situation of the Finnish Planck research groups was relieved considerably by the positive funding decisions of the Academy of Finland in September. This means that the extremely important work, which was started almost 10 years ago, can now continue, and Planck data can be fully exploited also in Finland. A common funding application to the Helsinki Institute of Physics (HIP) was submitted by the cosmology group of University of Helsinki, led by H. Kurki-Suonio, and the Metsähovi team. The application was successful and resulted in 50 000 EUR per year for three years, starting in 2008. The science group is now enthusiastically looking forward to the launch and to working hard for mission success.

2.6 Quick Detection System (QDS)

QDS is a software package designed to detect interesting point sources (for example, active galactic nuclei, AGNs) in the time-ordered datastream of the Planck satellite within one or two weeks from the time of the observation. AGNs are rapidly variable, in the timescale of a few days to a few weeks, and any significant event must be investigated without delay. QDS makes this possible by alerting observatories for follow-up observations when it detects something interesting in the Planck data.

The software was completed in 2006. In 2007 only some features, enhancements and bugfixes were added. The most notable of these was updating the interface to the Planck Low Frequency Instrument's Data Processing Center (LFI DPC) database, which now uses the final format that will be used during the Planck mission.

2.6.1 Multifrequency Observing Campaigns

Project Team Tornikoski, Lähteenmäki, Torniainen, Hovatta, Nieppola, Kotiranta, Turunen

As usual, we took part in several multifrequency campaigns in 2007, and did individual observing requests, too. Typically we support the campaign with daily observations, and continue regular monitoring also before and after the core campaign. Metsähovi radio data are in high demand, and the number of campaigns and requests have steadily increased during the last few years.

Examples of recent campaigns are the WEBT collaboration on 3C 454.3, and the relentless monitoring of OJ 287 in order to catch the predicted outbursts in 2006 and 2007. We are also regularly observing a handful of sources for VERITAS Blazar Science Working Group multiwavelength campaigns (1ES2344+514, 1ES1959+650, MARK 421, H1426+428, and MARK 501) and support VERITAS Target of Opportunity campaigns. Prof. Alan Marscher (Boston University, USA), for whom we observe a list of sources in connection with VLBA monitoring programme, is one of our long-standing and valued collaborators.

2.7 Solar Research

Project Team: Tornikoski, Kallunki, Riehokainen (University of Turku, Tuorla Observatory)

In 2007 we continued to use the 37 GHz frequency band (of the bigger telescope) for observing Solar maps during the summer months. The number of observation days was around 30. Additionally, the 86 GHz SIS-receiver was tested successfully for Solar observations in October 2007.

The small telescope (diameter 1,8 m) was used for continuous monitoring of the whole Solar disk at 11,7 GHz. The data of the small telescope was used to detect solar oscillations during solar minimum

(time of low activity). It seems to be that it is possible to observe oscillation behavior at a time interval between 3-15 minutes. Origin of these oscillations might be the sunspot structures.

2.8 Recreational events & keeping fit

In 2007 we continued to encourage our staff members to take care of their physical well-being.

Our PhD student and a trained aerobics instructor Ilona Torniainen continued organising short "coffee-break stretching sessions" to the staff ca. twice a week. Additionally, she offered some after-hours aerobics classes on the Metsähovi backyard lawn during the summer months.

In May we once again participated in the Helsinki City Run half marathon with a team of three runners. Also some other Metsähovi staff members have eagerly taken up running and are planning to enter the event in the coming years.

Due to the remote location of the observatory it is considered very important that the staff members have some basic knowledge of first aid and also know how to react in emergency situation. In June we organised an event where the Metsähovi staff were trained up in the basics of first aid, fire distinguishing and accident & fire prevention.

Figure 6: Mikko Kotiranta checking what's wrong with Anne the Dummy.

Figure 7: Solveig Hurtta giving first aid.

Figure 8: The Metsähovi fire crew getting ready.

Figure 9: Mikko Kotiranta practising with the fire blanket.

Figure 10: Juha Kallunki putting out fire

Figure 11: Talvikki Hovatta's stylish escape during power failure.

In September we had our annual recreational day. This year the event was organised in the form of an adventure trail in Karjaa. First we spent several hours on the trail, trying out the rides and challenges, and afterwards there was lunch and sauna.

Figure 12: The Killer Instinct (Merja Tornikoski).

Figure 13: Talvikki Hovatta climbing.

Figure 14: Juha Kallunki flying in the air (just before the attachment system crashes!!!).

Figure 15: Learning teamwork.

Figure 16: Guifré Molera getting up into the air...

Figure 17: The Metsähovi staff and our visitors from the Helsinki University cosmology group enjoying their Christmas lunch.

Figure 18: The multitalented Reijo Keskitalo from the HU cosmology group sang some traditional Finnish Christmas songs.

The traditional Metsähovi Christmas party was held on December the 18th. In addition to the Metsähovi staff we also invited some colleagues from Tuorla Observatory, and the Helsinki University cosmology group.

3 Publications

3.1 International Journals

1 Villata, M.; Raiteri, C.M.; Aller, M.F.; Bach, U.; Ibrahimov, M.A.; Kovalev, Y.Y.; Kurtanidze, O.M.; Larionov, V.M.; Lee, C.-U.; Leto, P.; Lähteenm'äki, A.; Nilsson, K.; Pursimo, T.; Ros, J.A.; Sumitomo, N.; Volvach, A.; Aller, H.D.; Arai, A.; Buemi, C.S.; Coloma, J.M.; Doroshenko, V.T.; Efimov, Yu.S.; Fuhrmann, L.; Hagen-Thorn, V.A.; Kamada, M.; Katsuura, M.; Konstantinova, T.; Kopatskaya, E.; Kotaka, D.; Kovalev, Yu.A.; Kurosaki, M.; Lanteri, L.; Larionova, L.; Mingaliev, M.G.; Mizoguchi, S.; Nakamura, K.; Nikolashvili, M.G.; Nishiyama, S.; Sadakane, K.; Sergeev, S.G.; Sigua, L.A.; Sillanpää, A.; Smart, R.L.; Takalo, L.O.; Tanaka, K.; Tornikoski, M.; Trigilio, C.; Umana, G.: The radio delay of the exceptional 3C 454.3 outburst. Follow-up WEBT observations in 2005-2006. Astronomy and Astrophysics, Vol. 464, pp.L5-L9, 2007.

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3.2 International Conferences

1 Lähteenmäki, A., Tornikoski, M., Hovatta, T., Valtaoja, E.: Total flux density radio observations as a tool for understanding AGN behaviour. 5th Stromlo symposium, Disks, winds & Jets from Planets to Quasars, Canberra, Australia, 3-8.12.2006. Astrophysics and Space Science, in press, 2007.

2 Ciprini, S.; Raiteri, C.M.; Rizzi, N.; Agudo, I.; Foschini, L.; Fiorucci, M.; Takalo, L.O.; Villata, M.; Sillanpää, A.; Valtonen, M.; Ostorero, L.; Tosti, G.; Wagner, S.J., Hovatta, T., Lähteenmäki, A., Nieppola, E., Torniainen, I., Tornikoski, M., The activity of the blazar OJ 287 in 2005: XMM-Newton observations and coordinated campaign. AIP Conference Proceedings, Vol. 921, The 1st Glast Symposium, pp. 327-328, eds. S. Ritz, P. Michelson, C. Meegan, 2007.

3 Lindfors, E.J.; Valtaoja, E.; Türler, M.; Takalo, L.; Sillanpää, A.; Lähteenmäki, A.; Tornikoski, M.: Gamma-ray Emission in blazar 3C 279. AIP Conference Proceedings, Vol. 921, The 1st Glast Symposium, pp. 341-342, eds. S. Ritz, P. Michelson, C. Meegan, 2007.

4 Tornikoski, M., Lähteenmäki, A., Hovatta, T., Valtaoja, E., Lindfors, E., Savolainen, T., Wiik, K.: Radio to gamma-ray connection in blazars. AIP Conference Proceedings, Vol. 921, The 1st Glast Symposium, pp. 367-368, eds. S. Ritz, P. Michelson, C. Meegan, 2007.

5 Lichti, G.G.; Bottacini, E.; Charlot, P.; Collmar, W.; Horan, D.; vonăKienlin, A.; Lähteenmäki, A.; Nilsson, K.; Petry, D.; Sillanpää, A.; Tornikoski, M.; Weekes, T.: INTEGRAL and Multiwavelength Observations of the Blazar Mrk 421 during an Active Phase. AIP Conference Proceedings, Volume 921, The 1st Glast Symposium, pp. 371-372, eds. S. Ritz, P. Michelson, C. Meegan, 2007.

6 Valtaoja, E., Lindfors, E., Saloranta, P-M., Hovatta, T., Lähteenmäki, A., Nieppola, E., Torniainen, I., Tornikoski, M.: Hydrodynamics of Small-Scale Jets: Observational Aspects. Extragalactic Jets: Theory and Observation from Radio to Gamma Ray, Girdwood, Alaska, USA May 21-24.2007, eds. T. A. Rector and D. S. De Young, ASP conference series, submitted, 2007.

7 Türler, M., Lindfors, E.: Synchrotron Outbursts in Galactic and Extra-galactic Jets, Any Difference? Proceedings IAU Symposium No 238, Black Holes: from stars to galaxies, Prague 21-25.8.2006, editors: V. Karas, G. Matt, 2007.

8 Lindfors, E.J., Türler, M., Hannikainen, D.C.: Synchrotron Flaring Behaviour of Cygnus X-3. A Population Explosion, The Nature and Evolution of X-ray Binaries in Diverse Environments, 28.10.- 2.11.2007, St. Petersburg Beach, USA, editor C.R. Gelino, 2007.

9 Savolainen, T., Wiik, K., Valtaoja, E., Tornikoski, M.: Magnetic Field Structure in the Parsec Scale Jet of 3C273 from Multifrequency VLBA Observations. Extragalactic Jets: Theory and Observation from Radio to Gamma Ray, Girdwood, Alaska, USA May 21-24.2007, eds. T. A. Rector and D. S. De Young, ASP conference series, submitted, 2007.

10 Lindfors, E.: Observations of BL Lacertae with Magic Telescope. The Nuclear Region, Host Galaxy and Environment of Active Galaxies, RevMexA, submitted, 2007.

11 Lindfors, E., Türler, M.: Synchrotron Flaring in Galactic and Extragalactic Jets. ASP Conference Series. submitted 2007.

12 Sekido, M.; Takiguchi, H.; Koyama, Y.; Kondo, T.; Haas, R.; Wagner, J.; Ritakari, J.: Ultra-rapid UT1 measurement by e-VLBI. American Geophysical Union, Fall Meeting 2007, abstract #G43C-1479, http://adsabs.harvard.edu/abs/2007AGUFM.G43C1479S, 2007.

13 Poutanen, M., Haas, R., Wagner, J., Ritakari, J., Mujunen, A., Sekido, M., Takiguchi, H., Koyama, Y., Kondo, T.: Status report on the Fennoscandian-Japanese project for near real-time UT1-observations with e-VLBI, http://syrte.obspm.fr/journees2007/index.php?page=poster, Journées "Systèmes de référence spatio-temporels", France 17-19 Sept 2007.

14 Haas, R., Muskens, A., Wagner, J., Dulfer, C., Mujunen, A., Ritakari, J., Bertarini, A.: e-VLBI data transfer from Onsala and Metsähovi to the Bonn correlator. 18th Working Meeting on European VLBI for Geodesy and Astrometry, Wien April 12-13, 2007, www.evga.org/Meetings/evga2007_meeting/S1-8.pdf, Geowissenschaftliche Mitteilungen, Schriftenreihe der Studienrichtung Vermessung und Geoinformation, Technische Universität Wien, (79) pp. 27-32. CPL 45297, 2007.

15 Molera, G.: Ultra rapid dUT1 measurements by eVLBI, Tsunami File System. 6th International e-VLBI Workshop, Bonn, Germany, 17-18.9.2007. http://www.mpifr-bonn.mpg.de/div/vlbi/6th_evlbi/eVLBI_presentations, 2007.

16 Wagner, J., Ritakari, J.: A playstation 3 -based correlator for eVLBI. 6th International e-VLBI Workshop, Bonn, Germany, 17-18.9.2007. http://www.mpifr-bonn.mpg.de/div/vlbi/6th_evlbi/eVLBI_presentations, 2007.

17 Ritakari, J.: New ideas for eVLBI. 6th International e-VLBI Workshop, Bonn, Germany, 17-18.9. 2007, http://www.mpifr-bonn.mpg.de/div/vlbi/6th_evlbi/eVLBI_presentations, 2007.

18 Wagner, J.: Real-time e-VLBI developments in the EVN, Tähtitieteilijäpäivät 2007 (Finnish Astronomers Meeting 2007), Turku Tuorla Observatory, 1.6.2007, http://www.astro.helsinki.fi/tt-seura/ttpaivat_07_ohjelma.html, 2007.

19 Wagner, J.: iBOB Developments at the Metsähovi Radio Observatory. Bits & Bytes, Jodrell Bank Observatory, England, 17 Dec 2007.

3.3 Laboratory Reports

1 Tornikoski, M., Mujunen, A., Hurtta, S. (editors): Metsähovi Radio Observatory Annual Report 2006. Metsähovi Reports HUT-KURP-33, 37 p., 2007.

3.4 Other Publications

1 Alitalo, P., Jylhä, L, Karttunen, A., Luukkonen, O., Molera, G., Vaaja, M., Venermo, J., Podlozny, V., Sihvola, A., Tretyakov, S., Wallén, H.: Realization of an electromagnetic invisibility cloak by transmittion-line networks. 2007.

2 Molera, G., Mujunen, A., Ritakari, J., Wagner, J., Anderson, B.: EXPReS JRA1 FABRIC Data Acquisition Design. http://www.jive.nl/dokuwiki/doku.php/fabric:wp1_scalable_connectivity, 2007.

3 Molera, G., Wagner, J., Ritakari, J., Mujunen, A.: Comparison of two frequency synthetisizers: LMX2531 and ADF4360. http://www.metsahovi.fi/en/vlbi/ibob/Comparing-ADI-NAT.pdf, internal report, 2007

3.5 Computer Software

1 Wagner, J.: Cell SPE Task Library. http://cellspe-tasklib.sourceforge.net/

2 Wagner, J.: IBM Cell Miniature 6-station 1024-point correlator. http://cellspe-tasklib.cvs.sourceforge.net/cellspe-tasklib/cellspe-taskli b/minicorrelator/

3 Wagner, J.: User-space file system for Conduant StreamStor. http://fusemk5a.sourceforge.net/

4 Wagner, J.: Tsunami UDP Protocol - Tsunami version 1.2 for Petabit networks. http://tsunami-udp.sourceforge.net/

5 Wagner, J.: Metsähovi PC-EVN Automated Observation Scripts. http://www.metsahovi.fi/vlbi/instr/mro-vsib-pc/recexpt/

4 Visits to Foreign Institutes

ESA Headquarters, Paris, France, 18.-19.1. and 8.-10.10., M. Tornikoski
Stanford University, USA, 3.-9.2., M. Tornikoski, A. Lähteenmki
Wettzell, Germany, August 2007, PC-EVN setup and consultation, J. Wagner
ESTEC, Noordwijk, Netherlands, 17.-18.4. and 11.-13.9., M. Tornikoski
Osservatorio Astronomico di Trieste, Trieste, Italy, 21-26.10.2007, J. Aatrokoski
Chalmers University of Technology, Göteborg, Sweden, 11.12., M. Tornikoski
Yebes, Spain, December 2007/January 2008, PC-EVN setup and consultation, G. Molera

5 Visiting Scientists

Vladimir Gavrilov, IEM Kvarz, Russia, 5-9.2.2007
Dr.Vyacheslav Vdovin, RAS Institute of Applied Physics, Russia, 8-11.10.2007, 31.10-1.11.2007
Alexander Shtanyuk, RAS Institute of Applied Physics, Russia, 8-16.10.2007
Oleg Bolshakov, RAS Institute of Applied Physics, Russia, 8-16.10.2007
Vladimir Nosov, RAS Institute of Applied Physics, Russia, 31.10-2.11.2007
Igor Zinchenko, RAS Institute of Applied Physics, Russia, 1.11.2007
Prof. Alexandr Stepanov,RAS, Pulkovo Observatory, Russia, 22.5.2007
Dr. V.V. Zaitsev, RAS, Pulkovo Institute of Applied Physics, Russia, 22.5.2007
Dr. Marat Mingaliev, Special Astrophysical Observatory, Nizhnij Arkhyz, Russia, 14-16.8.2007
Julia Sotnikova, Special Astrophysical Observatory, Nizhnij Arkhyz, Russia, 14-16.8.2007
Dr Walter Brisken, NRAO Socorro, USA, 27.5.2007
Rafael Bachiller, National Radio Astronomy Observatory, Spain, 27.5.2007

6 Thesis

Wagner, Jan M.Sc.(Tech) thesis: Development of Real-time Very Long Baseline Interferometry Systems at the Metsähovi Radio Observatory. Helsinki University of Technology, Department of Computer Science and Engineering.

7 Teaching

S-92.4605 Post-graduate seminar on Space Technology II: Satellite astronomy, M. Tornikoski, A. Lähteenmäki

8 Other Activities

Evaluator of a docenture application of Dr. Jaan Pelt, University of Helsinki. M. Tornikoski

Evaluator for a research grant application to the Research Council of Norway, M. Tornikoski

Evaluator for European Space Agency's "Cosmic Vision" satellite proposals, M. Tornikoski

Referee for Proceedings of Fifth Stromlo Symposium "Disks, winds & jets –from planets to quasars", A. Lähteenmäki

Planck satellite Co-Investigator, Planck Scientist, A. Lähteenmäki

Planck satellite's LFI consortium, Scientific Associate, M. Tornikoski

Academy of Finland Research Fellow 1.8.2005 — 31.7.2010, A. Lähteenmäki

"Planck –unlocking the secrets of the Universe" Outstanding Junior Research Group of Helsinki University of Technology for the academic years 2006 — 2007 and 2007 — 2008, A. Lähteenmäki

Very Energetic Radiation Imaging Telescope Array System (VERITAS) collaboration, associate member, M. Tornikoski, A. Lähteenmäki

8.1 Participation in Boards and Committees

International Union of Radio Science (URSI), Finland's delegate to the Scientific Comission J (Radio Astronomy, M. Tornikoski

European Southern Observatory, Finland's representative to the Users Committee, M. Tornikoski

Global Millimetre VLBI Array, referee of observing proposals, M. Tornikoski

European Space Agency, member of the Astronomy Working Group, M. Tornikoski

Onsala Space Observatory Time Allocation Committee, M. Tornikoski

Research Council of Norway, evaluator for research funding application, M. Tornikoski

Europan Space Agency, evaluator of the ESA Cosmic Vision 2015 satellite proposals as a member of the ESA AWG, M. Tornikoski

Publications of the Astronomical Society of Japan, referee, M. Tornikoski

EXPReS Consortium Board, chairman, A. Mujunen

ESF Committee for Radio Astronomy Frequencies, CRAF, Finland's representant, J. Ritakari

Finnish Astronomical Society, vice chairman from 1.6.2007, Elina Nieppola

Finnish Astronomical Society, secretary until 1.6.2007, Ilona Torniainen

EVN CBD and EXPReS Board meetings, Espoo, Finland, 28-29.5.2007, LOC, A. Mujunen

Steering group member of the Ministry of Education graduate school of astronomy and space physics, A. Lähteenmäki

Member of the Planck/TEKES 70 GHz instrument steering group, A. Lähteenmäki

Member of the EXPReS eVLBI Science Advisory Group, A. Lähteenmäki

8.2 International Meetings and Talks

AMS-02 Technical International Meeting, Houston, USA, 6.1.-13.1.2007, G. Molera

ESA AWG, ESA Headquarters, Paris, France, 18-19.1.2007, M. Tornikoski

The First GLAST Symposium, Exploring the high-energy universe, Stanford University, Palo Alto, California, USA, 3-9.2.2007, M. Tornikoski, A. Lähteenmäki

Planck Working Group 6 (Extragalactic point sources) meeting, Orsay, France, 13-14-2.2007, M. Tornikoski, A. Lähteenmäki

EXPReS EU Project Annual Review at Commission, Brussels, Belgium, 16-18.4.2007, A. Mujunen

ESA AWG, ESTEC, Noordwijk, The Netherlands, 17-18.4.2007, M. Tornikoski

Bologna Digital Receivers Conference and dBBC Critical Review meeting, Bologna, Italy, 22-25.4.2007, A. Mujunen

European VLBI Network Consortium Board of Directors + Executive meeting, Espoo,Finland, 28.-29.5.2007, M. Tornikoski, A. Mujunen, A. Lähteenmäki, J. Ritakari, J. Wagner, G. Molera

Planck Consortium meeting 2007, Toulouse, France, 18-20.6.2007, A. Lähteenmäki, I. Torniainen

Esa AWG, ESA Headquarters, Paris, France, 11-13.9.2007, M. Tornikoski

DiFX software correlator meeting, Bonn, Germany, 13-14.9.2007, G. Molera, J. Wagner, J. Ritakari

Fabric meeting Conference, Bonn, Germany, 17-19.9.2007, G. Molera, J. Wagner, J. Ritakari

6th International eVLBI Workshop, MPIfR, Bonn, Germany, 13-19.9.2007, J. Ritakari, J. Wagner, G. Molera

EU EXPReS-Fabric WP1 Meeting in MPIfR and FP7 mmVLBI prep meetings Bonn, Germany, 19-22-9.2007, A. Mujunen, J. Wagner

ESA AWG, ESA Headquarters, Paris, Prance, 8-10.10.2007, M. Tornikoski

Nordunet eVLBI meeting, Nordunet, Copenhagen, Denmark, 31.10.2007, J. Ritakari

AMS-02 Financial Review Committee meeting, CERN, Geneve, Switzerland, 7-8.11.2007, A. Mujunen

Planck LFI Core Team meeting, Bologna, Italy, 5-9.11.2007, A. Lähteenmäki

EVN Technical Operation Group and Consortium Board of Directors meetings, Madrid, Spain, 12-14.11.2007, A. Mujunen, J. Ritakari

Onsala Space Observatory, OSO 20 m + APEX meeting, Gothenburg, Sweden, 11.12.2007, M. Tornikoski

eVLBI Bits and Bytes meeting, Jodrell Bank, Manchester, England, 17-18.12.2007, J. Ritakari

8.3 National Meetings and Talks

Radio variability of AGN, Suurenergia-astrofysiikan ja kosmologian seminaari, Helsingin yliopisto, 19.9.2007. Talvikki Hovatta.

Cospar 2007, 4 — 5.10.2007, Espoo, A. Lähteenmäki, M. Tornikoski

8.4 Participation in winter and summer schools

The George Washington University, The 5th International X-ray Astronomy School, Washington DC, USA, 5-12.8.2007, T. Hovatta, E. Nieppola

Summer School on Time Series Analysis, Elva, Estonia, 3-7.9.2008, E. Nieppola, T. Hovatta

International summer school of VLBI, Bonn, Germany, 10-14.9.2007, G. Molera, J. Wagner

8.5 Public Relations

Tiede 2/2007 “About gamma-ray astronomy and the GLAST symposium”, A. Lähteenmäki

Tiede 4/2007 “Kvasaarit tehtailevat aina vain uusia mysteerejä”, A. Lähteenmäki, M. Tornikoski

Forum för ekonomi och teknik 5/2007 “Planck ska lyssna till Ursmällen”, A. Lähteenmäki

9 Personnel in 2007

Permanent Positions funded by the Helsinki University of Technology

Tornikoski, Merja, Dr.Tech.	Director of the institute Docent of Radio Astronomy and Space Technology	Merja.Tornikoski@hut.fi
Hurtta, Solveig, Ms.	Department Secretary, part-time	Solveig.Hurtta@hut.fi
Mujunen, Ari, M.Sc. (Tech)	Laboratory engineer	Ari.Mujunen@hut.fi
Oinaskallio, Erkki, Mr.	Technician	Erkki.Oinaskallio@hut.fi
Peltonen, Juhani, Dr.Tech.	Laboratory engineer, part-time	jussi@kurp.hut.fi
Rönnberg, Henry, Mr.	Mechanician	

Scientific and Technical Staff Funded by Research Contracts

Aatrokoski, Juha, M.Sc.(Tech)	System administrator	jha@kurp.hut.fi
Hovatta, Talvikki, M.Sc. (Tech)	Researcher	tho@kurp.hut.fi
Kainulainen, Jouni, M.Sc.	Civilian serviceman from 27.12.2007	jtkainul@kurp.hut.fi
Kallunki, Juha, M.Sc. (Tech)	Operations engineer	kallunki@kurp.hut.fi
Kirves, Petri, M.Sc. (Tech)	Operations engineer from 26.11.2007	pkirves@kurp.hut.fi
Kotiranta, Mikko, student	Research assistant, part-time 1.1-31.5.2007, full time from 1.6.2007	mko@kurp.hut.fi
Lindfors, Elina, M.Sc.	Researcher 1.10-31.12.2007	
Lindfors, Timo, student	Research assistant, part time 1.1-31.5.2007 and 1.9-31.12.2007, full time 1.6-31.8.2007	lindi@kurp.hut.fi
Lähteenmäki, Anne, D.Sc.(Tech.)	Academy Research Fellow	alien@kurp.hut.fi
Molera Calvés, Guifré, M.Sc. (Tech)	Researcher	gofrito@kurp.hut.fi
Nieppola, Elina, M.Sc.	Researcher	eni@kurp.hut.fi
Ritakari, Jouko, M.Sc. (Tech)	Researcher	jr@kurp.hut.fi
Torniainen, Ilona, M.Sc. (Tech)	Researcher	ilo@kurp.hut.fi
Turunen, Miika, student	Research assistant part-time 1.1-31.5.2007 and 1.9-31.12.2007, full time 1.6.2007-31.8.2007	maturun@kurp.hut.fi
Wagner, Jan, student	research assistant	jwagner@kurp.hut.fi

Metsähovi Advisory Committee

Korpela, Seppo, Dir.	Tanskanen, Pekka, Prof.
Koskinen, Hannu, Prof.	Tiuri, Martti, Prof.emer., M.P. (Chair)
Nygren, Tuomo, Prof.	Tornikoski, Merja, Director (Secretary)
Somervuo, Pekka, Dr.Tech.	Valtaoja, Esko, Prof.