Metsähovi Reports
Espoo 2004

HUT-KURP-28

Metsähovi Radio Observatory
Annual Report 2003

M. Tornikoski, A. Mujunen (editors)

Metsähovi Radio Observatory
Helsinki University of Technology

Director:
Dr. Merja Tornikoski
Tel. +358-9-2564 423
Email: Merja.Tornikoski@hut.£

Secretary:
Ms. Solveig Hurtta
Tel. +358-9-2564 831
Email: Solveig.Hurtta@hut.£

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

Metsähovin radiotutkimusasema
Teknillinen korkeakoulu
Metsähovintie 114
02540 KYLMÄLÄ

ISSN 1455-9579

Contents

List of Figures

1 Introduction

The Metsähovi Radio Observatory, a separate research institute at the Helsinki University of Technology since May 1988, operates a 14 m diameter radio telescope at Metsähovi, Kylmälä, about 35 km west from the university campus. The institute also has premises in the Electrical Engineering Faculty building, Otakaari 5, Espoo. The main users of the station are the Helsinki University of Technology, the University of Helsinki, and the University of Turku. In the same area, near Metsähovi Radio Observatory, there are also the buildings of the Metsähovi Observatory (University of Helsinki; optical astronomy) and the Metsähovi Space Geodetic Station (Geodetic Institute; geodesy).

The Metsähovi Radio Observatory has been operational since 1974. The upgrading of the telescope was done during 1991−1994. The radome was replaced with a new one and new surface panels were installed. The surface accuracy of the present telescope is 0.1 mm (rms). The old analog servo system of the telescope was replaced by a new digital servo system in 1998−1999. Planning of new observing programmes was started in 1999.

The Metsähovi Radio Observatory is active in the following £elds:

- Research in radio astronomy,
- Development of instruments needed in radio astronomy,
- Development of methods for radio astronomical measurements,
- Space research, and
- Education.

The activities at Metsähovi are concentrated on millimeter waves and microwaves. The used frequencies are 2 $\cdots$ 150 GHz, and the corresponding wavelengths 150 $\cdots$ 2 mm. The research in technology includes development of microwave receivers, development of receiving methods, development of data processing and development of antenna technology. The objects of radio astronomical research are: solar millimeter and microwave radiation, variable quasars, active galaxies, molecular line radiation, and very long baseline interferometry (VLBI). Metsähovi participates in the education at the Helsinki University of Technology by organizing courses and exercises for students, and graduate students can study for a licentiate's or doctor's degree at Metsähovi.

Around 15 scientists, engineers, or research assistants, and support personnel from the Helsinki University of Technology work at the institute. In addition about 10 students did radio astronomical observations under the guidance of Metsähovi staff. Five of the employees are paid by the Helsinki University of Technology, and the others are employed by research projects £nanced mainly by the Academy of Finland. The other users of the Metsähovi telescope are the radio astronomy group at the University of Helsinki, and the radio astronomy group at the University of Turku.

In 2003 the total expenditure of the Metsähovi Radio Observatory was about 700 000 euros, including salaries. This was £nanced by:

Helsinki University of Technology 72 %
Academy of Finland 24 %
Others 4 %

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.

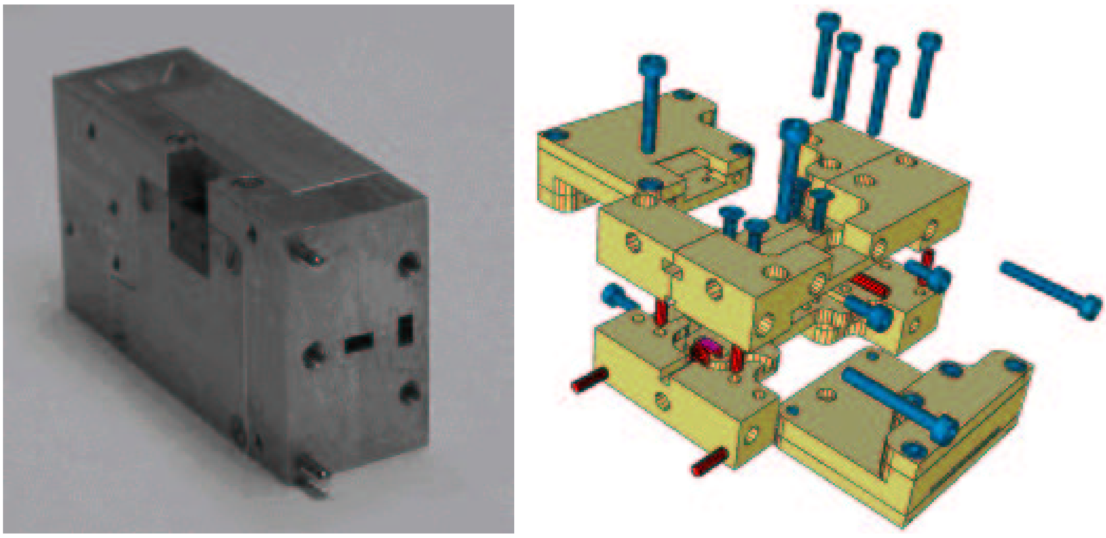
2.1 Radio Astronomical Instrumentation

Research Group at Metsähovi: Urpo, Peltonen, Mujunen, Oinaskallio, Ritakari, Rönnberg, Sjöman

2.1.1 Planck 70 GHz Receiver

Project Team: Sjöman, Peltonen, Rönnberg

During year 2003 Metsähovi was involved in the Planck 70 GHz receiver building and measurements. Metsähovi contribution was about one man-year for the work. The Planck satellite 70 GHz Elegant BreadBoard (EBB) receiver, Figure 1a and 1b, was £nalized at the beginning of the year 2003. The receiver passed almost all requirements. The only point where more work is still needed was power consumption. That work was decided to be made with the EM-receivers because of lack of the LNA and phase switch MMIC chips.



a) b)

Figure 1: a) EBB-receiver Front End Module (FEM) b) The exploded view of the FEM.

The test system was updated for the EM-receiver test, where two full receivers (4xEBB) were mounted inside the cryochamber. Also data collection system and all other external electronics were updated for the EM-receivers.

The EM-receiver tests were almost £nished at the end of the 2003 and it seems promising. The average noise temperature was about 30K over the 63-77 GHz operation bandwidth, 1/f-knee frequency was less than 50 MHz and the power consumption problems with the EBB were solved and the power was also within requirements. For the one FEM (8xLNAs, 4xphase switches) the power consumption was about 20 mW at 20 K physical temperature.

Figure 2: EM-receiver test system with open cryochamber.

2.1.2 3 and 2 mm SIS Receivers

Project team: Peltonen, Mujunen, Oinaskallio, Urpo

The completely new mm-wave receiver for 3 and 2 mm wavelengths designed at Institute of Applied Physics, Russian Academy of Sciences, Nizhny Novgorod, Russia was delivered to Metsähovi in May 2003. This is the £rst SIS mixer receiver with closed cycle helium cooling system in Metsähovi Radio Observatory. During the year 2003 IAP personnel made three campaigns to Finland in order to make the receiver operational.

This very complex receiver consists of a vacuum dewar, quasioptical system in front of the dewar windows, two phase-locked LO sources for both bands, IF processing unit and remote control system for the tuning of the receiver. Inside the vacuum dewar three SIS mixers are installed, two for 3 mm (84-115.5 GHz, possibility for simultaneous circular dual-polarization measurements) and one for 2 mm (129-175 GHz). These are tuned by noncontacting backshorts with the remote control unit. Depending on the backshort position either DSB- or SSB-operation can be achieved, the latter being desirable for VLBI-observations. SIS mixer mounts inside the dewar are cooled down to 4.5 K with a helium closed cycle refrigerator RDK-415E (Sumitomo Heavy Industries, Tokyo, Japan). Cryogenic HEMT IF ampli£ers with center frequency of 4 GHz and bandwidth of 1 GHz together with compatible cryogenic isolators are also placed inside the dewar.

The local oscillator source for the 3 mm band is an InP Gunn-oscillator manufactured by Radiometer Physics, Meckenheim, Germany. The tuning range of this oscillator is from 80 to 115 GHz with minimum output of 6 mW. During the preliminary tests one diode failed probably due to bias oscillations caused by the power supply. The Gunn mount was sent back to Germany to be repaired and after replacement of a new diode the LO source has operated since properly. For phase locking the Rohde & Schwarz synthesizer is used with a harmonic mixer to create the PLL IF signal at 275 MHz. This mixing product is divided by 11 and the 5 MHz frequency standard is multiplied by 5 in order to make the phase comparison at 25 MHz. For 2 mm band the basic LO source is a wideband tunable BWO with a high voltage power supply. The phase locking scheme is otherwise quite the same as described above.

The complete receiver system was lifted up to the antenna (shown in Figure 3) to test that it will mechanically £t into the antenna ring with complicated quasioptical feed system (Dicke chopper, etc.) in front of the receiver. Many parts of the receiver are already operational, however the IF processing unit still needs some improvements before £nal operational tests can be carried out.

Figure 3: Picture of the 3/2 mm SIS receiver on the antenna.

2.1.3 Geo-VLBI Receiver

Project team: Peltonen, Mujunen, Oinaskallio, Rönnberg

The large subre¤ector with diameter of 1.7 m needed for the low frequency (center frequencies 8.4 and 2.28 GHz) Geo-VLBI receiver was designed at Geodetic Observatory by M. Paunonen. The dish with a hyperboloidal shape was manufactured from carbon £ber and silver plated at ET-Tuote Oy, 51980 Lauteala (Esa Takkinen) and delivered to Metsähovi in 2003. The support structure for this subre¤ector has been constructed in our workshop. The dimensions for the feed system were originally given in the operation manual prepared by TTI (Tecnologías de Telecomunicaciones y de la Información, Santander, Spain) personnel and some corrections given by the Geodetic Observatory. The £nal focalisation system is shown in Figure 4.

The new subre¤ector is placed in front of the original one, therefore simultaneous observations with millimetric receivers are not possible. The arrangement is shown in Figure 5.

The £rst operational check of the receiver was done successfully for the X-band channel. At room temperature the noise temperature is around 180 K and at cryogenic temperatures (T amb = 13.6 K) 94 K, respectively. The S-band sensitivity cannot be measured due to the large coaxial antenna structure which would need an extremely large nitrogen load for the Y-factor measurement. The noise temperature for S-band given by the TTI manual at cryogenic temperatures is 102 K.

2.1.4 Maintenance and Upgrades of Receivers

Project team: Peltonen, Oinaskallio

In 2003 both the 22 GHz Dicke-switched continuum and the 22 GHz cryogenic VLBI receivers operated without any failure. Heavy thunderstorms during the summer caused for the 37 GHz receiver a failure in the remote control system. The waveguide switch which selects between continuum or Sun observations had to be switched manually in the antenna tower. The switch driver unit has been since repaired successfully, thus the remote control is again operational.

Ylinen Electronics delivered two new LNA's for the dual channel 43 GHz VLBI receiver. These ampli£ers (based on the MMIC techniques) were installed in the receiver to replace the old defective ones. The mechan-

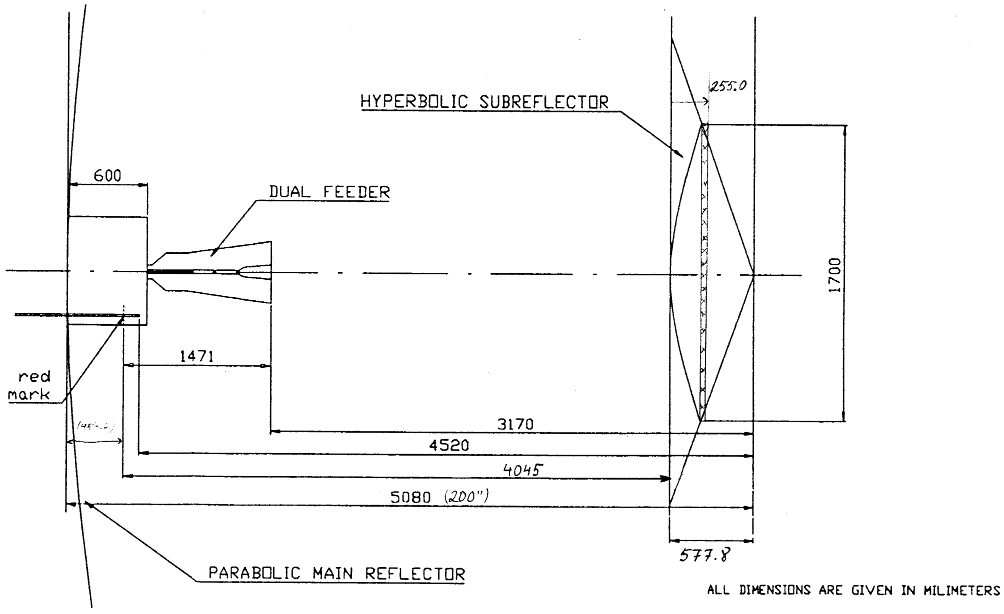


Figure 4: Focalisation system of the geodetic VLBI receiver.

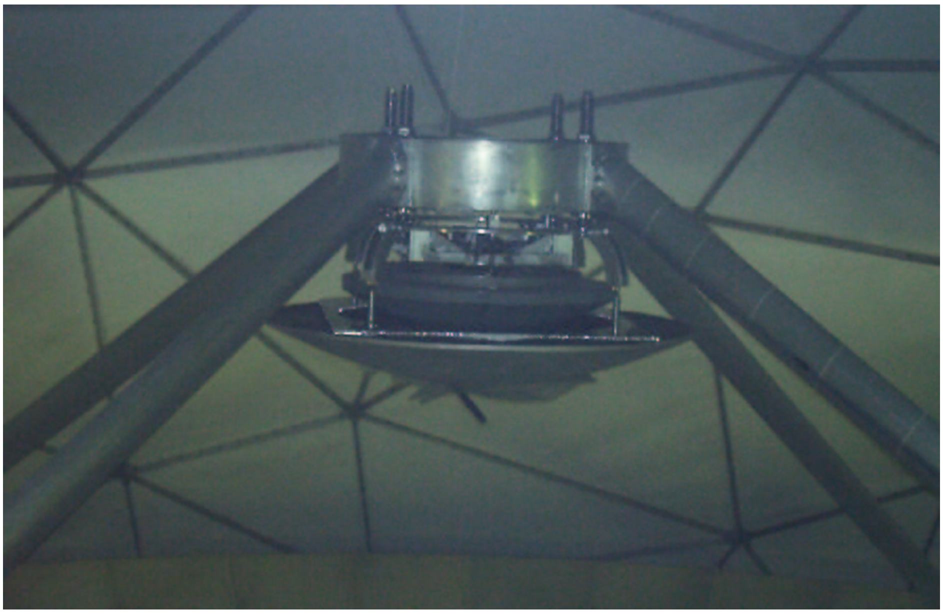


Figure 5: Picture of the subre¤ector with the supporting structure.

ical dimensions and connectors are the same for old and new ampli£ers, thus the replacement was easily done. From the complex power supply unit the old bias circuitry was removed and the new one installed in a position to allow easy adjustment of the optimum bias points. The connecting cable between the new bias board and the dewar is still needed before operational tests of the receiver are possible.

2.1.5 IT Infrastructure

Project Team: Mujunen, T. Lindfors

Metsähovi computing facilities are based on networked Linux computers. A core set of Linux servers offer general-purpose and observational data storage. Another set of dedicated Linux control computers manage the telescope, data acquisition, and auxiliary services such as GPS receivers and weather stations. Finally, a larger set of Linux workstations running the X Window System provide access to Metsähovi personnel.

Apart from the central servers, the installed base of general-purpose workstations is ageing rapidly with the mean age of more than 5 years. This has to be addressed in the near future. After severe thunderstorm damage in July 2003, the local area networking equipment is, on the other hand, suf£ciently advanced, featuring a gigabit Ethernet £ber-optic backbone and four 24-port 10/100 megabit port wire-speed switches. Two Allied Telesyn switches were acquired to allow for the lengthy repair process of the existing two Hewlett-Packard switches. In addition to these, the experimental four-PC VSIB VLBI disk-acquisition "tower" (see section 2.1.9) features its internal 8-port gigabit switch. The new Allied Telesyn switches allow easy server connectivity with their extra copper-based gigabit Ethernet ports, and this is planned for the central "`/home`" and "`/data`" NFS servers. This equipment can be seen in Figure 6.

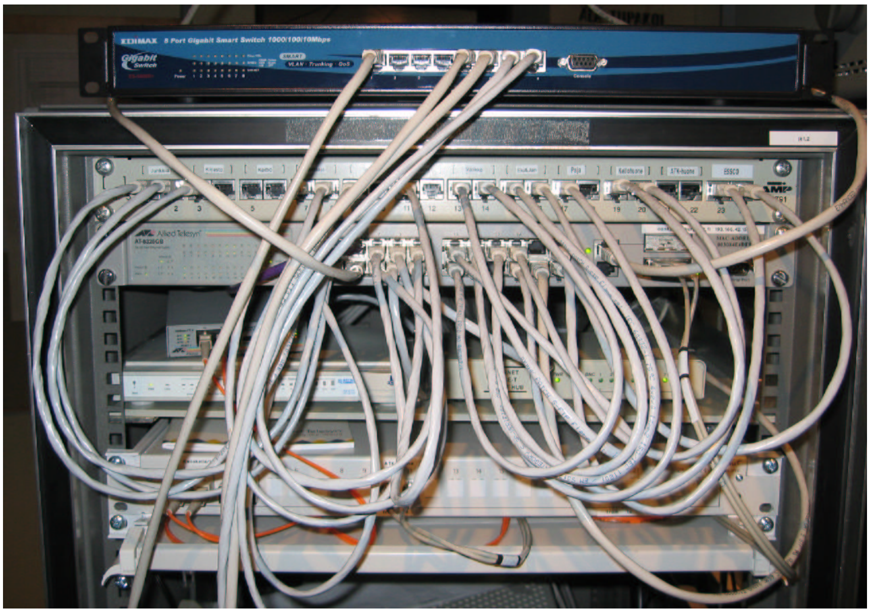


Figure 6: The 8-port Edimax gigabit switch together with an Allied Telesyn 24-port 100 Mbit switch with two gigabit ports.

The observatory site is connected to the Internet using a 2 Mbit/s dedicated leased line to university computing center and to the Finnish University Network, FUNET. It has been realized using ageing leased copper-line technology, and a more cost-effective way to achieve such low bit rates would be to use virtualized commercially-available ADSL connections. However, the emerging eVLBI data transfer tests (see section 2.1.9) would necessitate a signi£cantly faster 1–2 gigabit link to the FUNET backbone. Initial request for a quotation was sent to several service providers, and indeed solutions are generally available, including the preferable solution of leased dark £ber giving access to multi-gigabit bandwidths with COTS low-cost equipment. The costs associated with such leased £ber are still relatively high and the application for funds at the university was subsequently rejected.

Both the "`/home`" and "`/data`" NFS servers with AMD Athlon 1GHz-class processors, 512MB of memory, and Linux RAID0 75GB IDE disk subsystems are running at their capacity and an immediate upgrade to 250GB for both is planned in 2004. The "`/home`" RAID0 pair of 40GB disks failed in August 2003 and it was replaced with a single 80GB disk, resulting in no noticeable performance degradation. Thus the future 250GB is planned with no RAID setup for simplicity. The existing setup of an equal amount of non-RAIDed IDE backup storage for both "`/home`" and "`/data`" areas will be supplemented with an off-site "`rsync`" remote backup server with a perpetual daily snapshot capability. This kind of triple redundancy will eliminate the need for DAT tape-based backups which have proved to be impossible to make without an automated tape switcher.

IDL remains at version 5.4 on “`kurp.hut.fi`” (2 ¤oating licenses) and the maintenance contract on two Linux computers dedicated to solar research was dropped. Matlab with shared license support from university computing center also remains at version 6.0 on “`kurp.hut.fi`”.

For electronics development, PADS (Mentor) PowerLogic and PowerPCB 5.1 were used, together with Xilinx Foundation v2.1i VHDL tools for FPGA development. For future FPGA projects, an upgrade to the latest Xilinx ISE VHDL environment is planned.

2.1.6 New Hydrogen Masers

Project Team: <u>Oinaskallio</u>, Mujunen

Despite extensive isolation efforts the main station timing maser, Kvarz69 was severely damaged in thunderstorms in July 2003. Luckily the backup maser Kvarz70 allowed us to continue operations and the manufacturer of masers to perform maintenance and re-tuning of Kvarz69. Normal operation was resumed in approximately one month.

The performance characteristics of Kvarz CH1-75 masers surpass those of our previous EFOS-9 signi£cantly, as seen in Figure 7. After tuning the drift rate remains linear and small for weeks if not months and it does not follow the previously common parabolic “ageing” pattern. The control electronics is robust and allows “hot-swapping” of most boards without disturbing the normal operation of the maser.

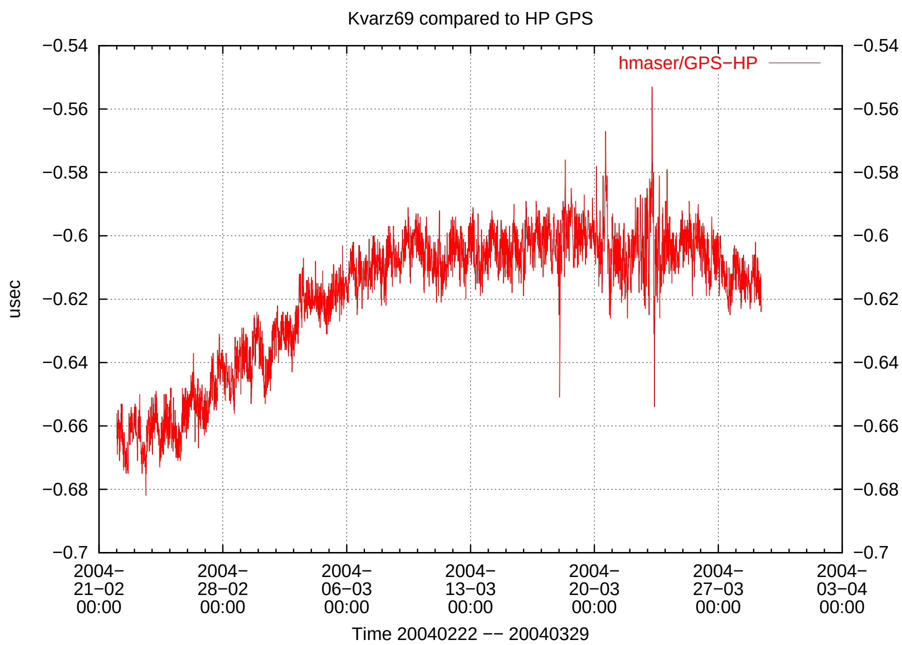


Figure 7: The comparison of Kvarz69 CH1-75 H maser and HP GPS receiver 1pps pulses shows minimal linear long-term drift.

The air conditioning of the new maser cellar reamined a problem throughout the year. Despite a multitude of experiments, the vendor of the air conditioning system was unable to achieve temperature stability within $\pm 1^\circ$C as speci£ed in the contract. At the end of the year the automation supplier Siemens £nally found an experienced con£gurer for their PID controllers and stability within $\pm 0.5^\circ$C was easily achieved. Temperature spikes associated with on-off transitions of the de-humidifying system are still present and we hope that these will be completely eliminated in the near future and, after 2.5 years of trial and error, the maser cellar delivers the required environmental conditions to match the £ne performance of the masers.

2.1.7 Clock Difference Measurements

Project team: Koski, Oinaskallio, Mujunen

There was a need to design a new clock difference counter to replace the old one. For VLBI measurements the clock difference has to be known. New counter couldn't be bought because if there were any in the market they were very expensive.

In Figure 8 is the block diagram of the new clock difference counter Clodi 5.

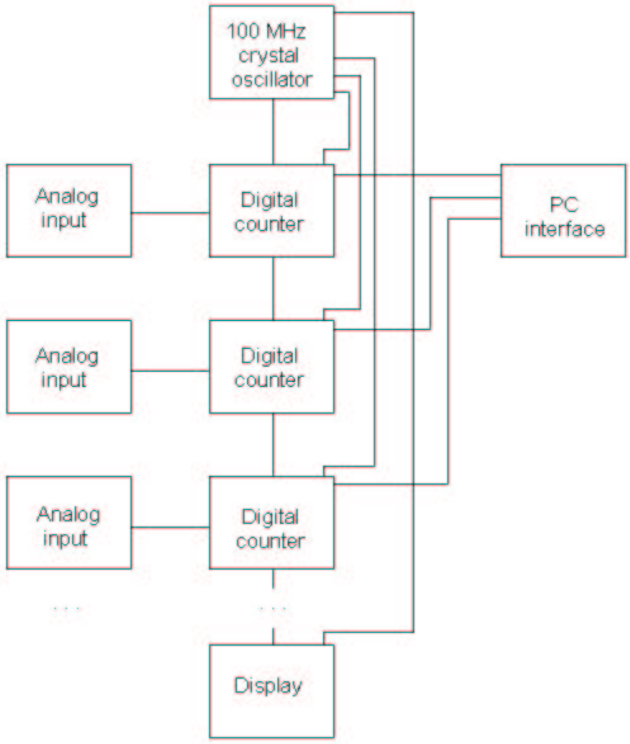


Figure 8: The block diagram of the designed clock difference counter.

The old VTT ATA clock comparator measured the clock difference once in ten minutes. Some of its channels were broken. Now it doesn't work at all.

The new counter will compare the clock difference every second. It will have inputs for Master PPS signal and ten clock signals. It has a crystal oscillator of 100 MHz. The counter calibrates itself by comparing the oscillators value to the value of Master PPS produced by the H-masers. The CPLDs (Complex Programmable Logic Devices) are nowadays so fast they can be used to make counters. The Master PPS signal is delayed by one clock period on a CPLD. One period is 10 ns for the frequency of 100 MHz. In a system that has ten channels the delay before the last CPLD is 100 ns.

The new clock difference comparator will have an eight character display. The uncalibrated clock difference between two channels, the other being the signal from the H-masers, can be easily read. The calibrated values of all channels will be saved.

In Figure 9 is a measurement from December 2003 by the prototype.

A two channel prototype was designed and built. After being tested it replaced the old clock comparator, Figure 10 and Figure 11.

The new ten channel counter is now designed and being assembled and is soon ready to be tested.

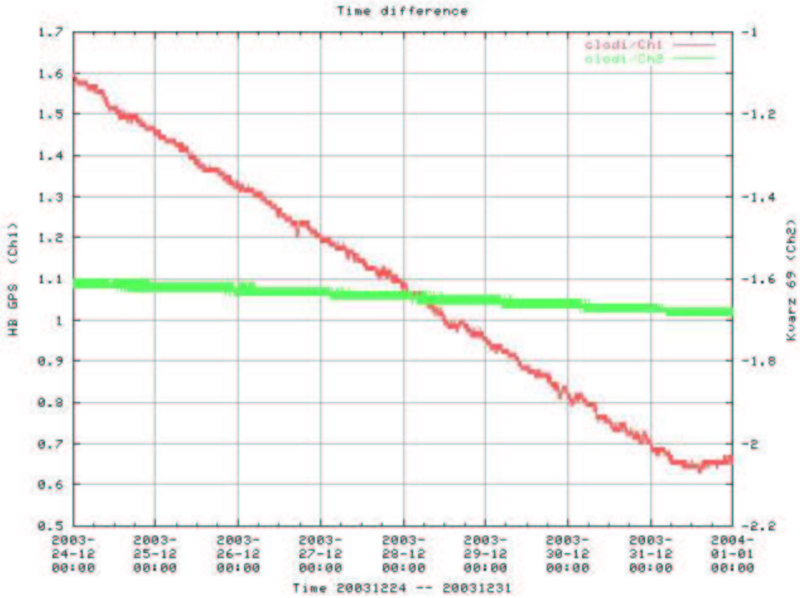


Figure 9: Data from the prototype.

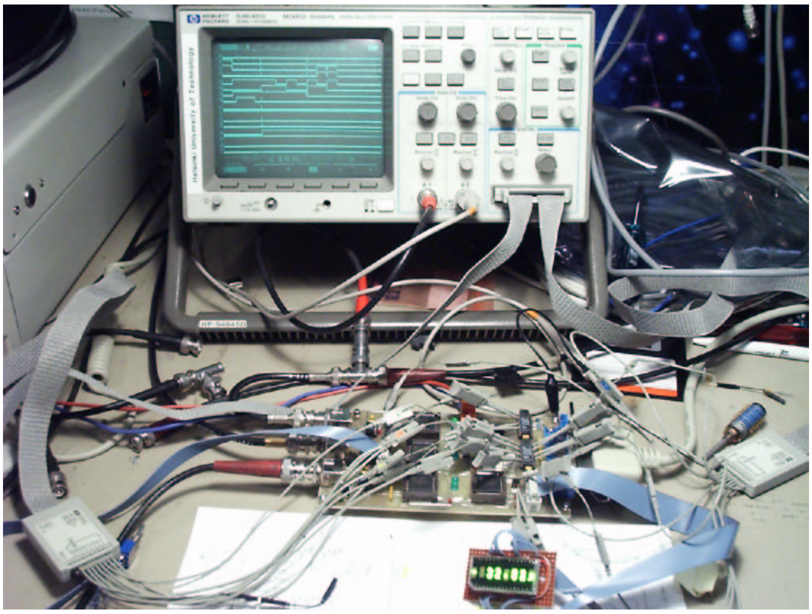


Figure 10: The prototype is being tested

2.1.8 New Observational Software

Project Team: <u>Mujunen</u>

This project was effectively halted due to manpower problems.

2.1.9 Development of Next Generation VLBI Recording Systems

Project team: <u>Ritakari</u>, Mujunen

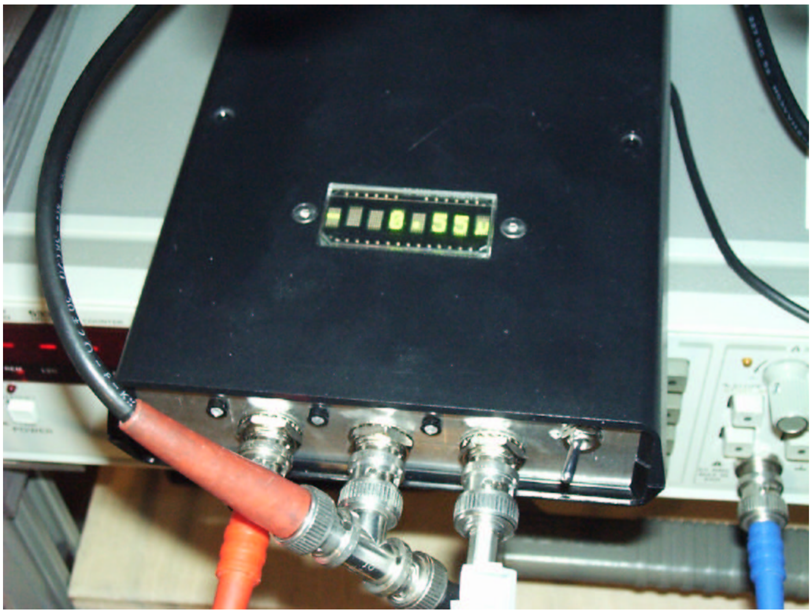


Figure 11: The prototype has replaced the old clock comparator.

The MRO disk recorder design was completed in year 2002 and a total of one hundred VSIB data acquisition boards and VSIC converter boards were produced.

In year 2003 the successful 1Gbit/s VLBI experiment series was continued: Metsähovi and CRL/Kashima succeeded in getting the £rst international 1Gbit/s continuum fringes in February 2003.

In March 12th 2003 Metsähovi and Jodrell Bank Observatory succeeded in the £rst European 1Gbit/s VLBI experiment. The data was recorded with MRO-designed systems, transferred to JIVE via Internet and played back with Mark5A terminals. This proved the interoperability of MRO disk recorders and Mark5A terminals.

In June 17th 2003 Metsähovi and CRL/Kashima succeeded in the £rst international 2Gbit/s experiment. Data was recorded with MRO-designed terminals at Metsähovi and PC-VSI terminals at Kashima. Metsähovi data was transferred via Internet to Kashima and correlated with a high-speed software correlator.

In the fourth quarter of 2003 interest has been focused in evaluating high-speed Internet protocols for eVLBI. Several candidate protocols have been found: Sabul, UDT, Tsunami, Fobs, Reliable Blast UDP and GTP. In the preliminary data transfer tests to JIVE the MRO team achieved an order of magnitude improvement to the normal TCP/IP transfer speed.

2.1.10 Solar Monitoring Telescope

Project Team: Urpo, Mujunen, Oinaskallio

Sun antenna is a separate small size receiver system designed to observe the total ¤ux of the solar microwave radiation with a pass band of about 1 GHz around center frequency of 11.7 GHz. Rather simpli£ed construction consists of standard commercial microwave front end, self designed IF-electronics and data acquisition by 16-bit A/D-converter. The size of the mainbeam in radiation pattern of the antenna is approximately 1.1°, which is enough to observe the total ¤ux of the Sun's hemisphere.

Receiver has got two channels, linear and logarithmic from which the linear is the only calibrated one at the moment. Thus, the receiver offers now a dynamical range up to approximately 5000 K in antenna temperature, corresponding up to 400 Solar Flux Unit radio burst in the Sun when the system noise and silent Sun background level is subtracted.

Figure 12: Sun antenna.

Control system of the antenna is using quite largely the same computer and electronics architecture as the main telescope of Metsähovi observatory, although some new design for example with SSI encoder interfaces was implemented. The out-door part of the receiver consists of diameter of 1.8 m commercial satellite dish and small accessory compartment. Main electronics for servo system and data acquisition with two computers are £tted into one rack inside the control room.

This instrument has been observing the Sun continuously since August 2000 excluding some calibration measurements, maintenance and twilight/night time. An example of observed events is included in chapter 2.6.3.

2.2 VLBI Observational Activities

2.2.1 Geodetic VLBI Project

Project Team: Mujunen, Urpo, Oinaskallio, Rönnberg

The swap-in/swap-out mountings for the new 1.7 m geodetic subre¤ector were designed and manufactured. The subre¤ector is made of silver particle suspension coated carbon £ber (under a contract by the Geodetic Institute to ET-Tuote Oy). An additional aluminium honeycomb supporting backstructure with four mounting studs was manufactured in-house to facilitate a tool-less repeatable installation of the re¤ector to the telescope secondary focus.

A new lift system was devised and installed inside radome aluminium support frame. This makes it possible to steer and manage the subre¤ector into the correct position before snapping it into the support lugs of the secondary focus mount.

The S/X band receiver was split in two halves to facilitate lifting it into the pedestal. The feedhorns were separated at SMA (S) and waveguide (X) joints to reduce the weight of the halves to a manageable level.

After laser alignment and distance gauging the focusing of the subre¤ector was veri£ed in a series of trial total power observations of Cygnus A and Cassiopeia A which produced the beam patterns illustrated in Figure 13.

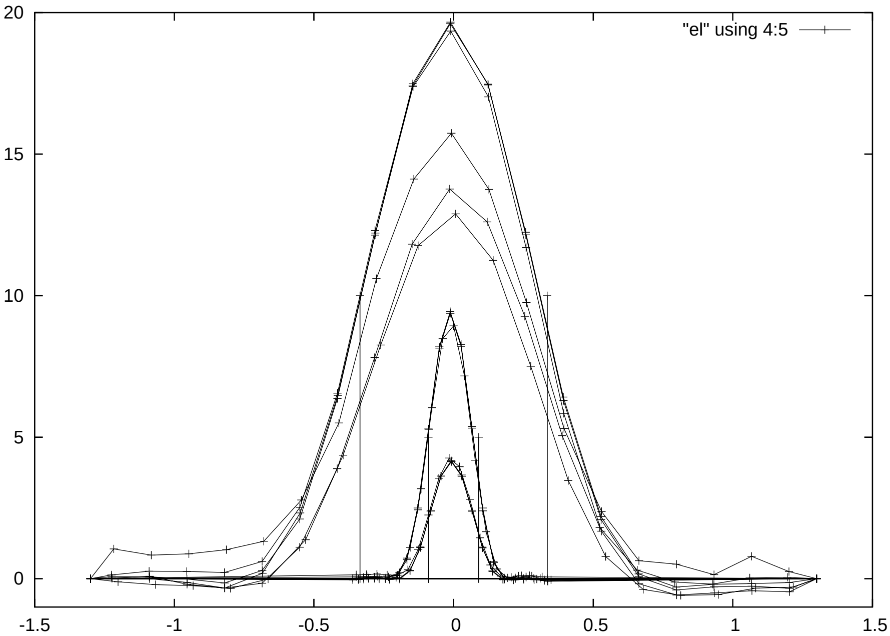


Figure 13: Observations of CasA and CygnusA at S-band and X-band (from top S-CasA, S-CygA, X-CasA, X-CygA) con£rm that the current subre¤ector position is suf£ciently focused.

There are a few remaining problems regarding to receiver autonomous control system and auto-controlled vacuum pump and cryocooler power switches. Additionally, the phase cal injector needs a new pedestal-mounted enclosure with power supply and RF electronics, and the cable length measuring system must be added for routine geodetic S/X band observations.

2.2.2 Station Hardware/Software

Project Team: Mujunen, Oinaskallio, Ritakari

The recording quality of our single-headstack VLBA4 recorder remains less than desirable. Numerous attempts to reveal the underlying problem have all failed, and only vague speculations of headstack wear-out or miscontouring remain.

One -15VDC power supply of our VLBA data acquisition rack failed just before the June 2003 session and had to be replaced with a temporary setup. It was properly replaced after the session. Future failures can be expected since the DAR is already 11 years old.

The total power detectors of IF distributor C/D still have a fault resulting in zero readouts, preventing full-band Tsys measurements of the astronomy RCP channel. Approximately £ve BBCs have synthesizer/PLL faults and/or TPI problems—8 BBCs remain available.

2.2.3 VLBI Sessions in 2003

Project Team: Mujunen

Only two EVN VLBI sessions contained observations at K band, 22 GHz, in February and June 2003. A total of eight thin tapes were shipped to the JIVE correlator. Due to manpower limitations, Metsähovi did not participate any Coordinated Millimeter VLBI Array (CMVA) sessions in 2003. The array itself was restructured in 2003 as the coordination responsibility was transferred from Haystack Observatory to Max-Planck Institut für Radioastronomie, under the new name of the Global mm-VLBI Array.

2.3 Extragalactic Radio Sources

Research Group at Metsähovi: Urpo, Lähteenmäki, Teräsranta, Tornikoski

2.3.1 Monitoring of Quasars

Project Team: Teräsranta, Hovatta, T. Lindfors

The quasar monitoring with the Metsähovi radio telescope continued for the 23rd year. Even the total observing time was less than 40% from total time, nearly 3900 observations were done. This was due from the specially dry year, which resulted in good observing weather. About 60% of the observations were at 22 GHz, while the rest were at 37 GHz. During the year 2004 we should have the new 2/3 mm cooled receiver in operation. Taking in account the local attenuation level from sky and radome, it is unlikely that monitoring of quasars at 90 or 150 GHz will ever be realistic here. The new receiver is still helpful in studying the antenna performance.

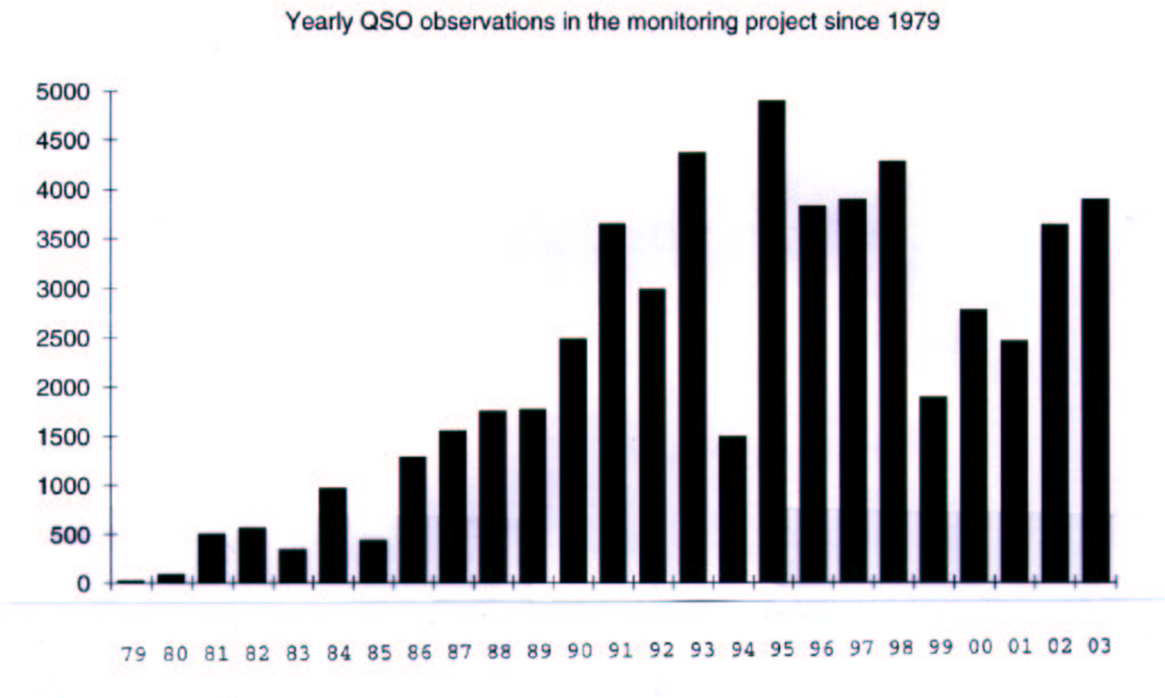


Figure 14: Yearly QSO observations in the monitoring program since 1979.

The poor £nancial situation forced us to do over 70% of the observations in automatic mode. Many nights observations were naturally lost as dew fell on the radome. The total number of observations since 1979 is now over 56000. The number of yearly observations are shown in Figure 14.

Preparation for the next gamma-ray satellites AGILE and GLAST continued by observing a large sample of ¤at spectrum AGN at 22 and 37 GHz. With the Metsähovi receiving system it is not possible to really monitor a sample of AGN down to 0.5 Jy levels, currently not even to 1.0 Jy. The stronger sources get a fair sampling, while we must be satis£ed to a few yearly points for the weaker sources.

The launch-time of AGILE seems to drift forwards; now it is expected to ¤y from the year 2005. This should give a special opportunity to have both AGILE and GLAST observing at the same time for a while. The ground support teams should then double their efforts, if the satellites observe most times different parts of the sky. With such small telescopes as Metsähovi, this would be quite dif£cult.

Another interesting mission will be the Japanese MAXI, an all sky X-ray monitor, which will be installed on the ISS. Continuous ¤ux curves are the key for analysing the variability in all wavebands. The connections between the X-ray ¤ux coming from the inner accreation disc and the ejection of fresh components along the superluminal jet will be studied when MAXI is operational.

During the year 2003 the monitoring team participated in numerous campaigns, mostly supporting X-ray observations with XMM and RXTE. Also the WEBT campaigns were supported when possible. An example of a long-term variable AGN is shown in Figure 15, which shows the ¤ux of NRAO 150 at 22 GHz since 1982. This source lies behind the galactic plane and thus there is not yet an optical identi£cation. In these long term variables precession is a noteworthy explanation for the behaviour. It is clear that very long term monitoring is needed to con£rm if these variations come in a periodic way.

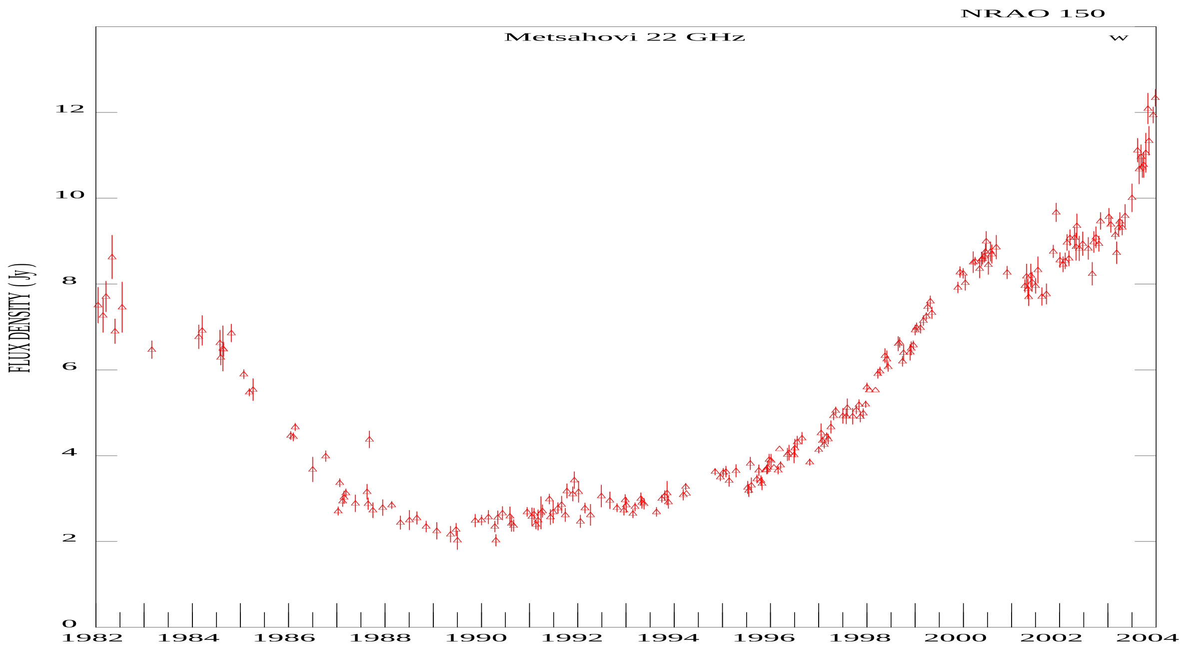


Figure 15: The ¤ux density of the quasar NRAO 150 at 22 GHz since 1982.

2.3.2 AGN Science

Team: Tornikoski, Lähteenmäki, Torniainen, Parviainen, Hovatta, Tröller, E. Lindfors, Saloranta, Nieppola, Valtaoja (Turku), Ojala (Turku), Lainela (Turku)

Inverted-spectrum sources and candidates

As part of our work on the Planck-satellite's extragalactic foreground science (see 2.4) we continued our study of the inverted-spectrum sources and candidates. This includes the so called GPS (Gigahertz Peaked Spectrum) sources as well as sources that at least sometimes (during certain activity stages) have continuum spectra that become inverted. Our earlier studies have shown that the behaviour of these sources can be extremely interesting, and historically some of the activity behaviour has been misinterpreted and sources misclassi£ed because scienti£c conclusions have sometimes been made using too sparse data sets.

When studying inverted-spectrum sources it is essential to collect as much data as possible from different frequencies in order to outline the spectral shape. In our study we originally wanted to identify new inverted-

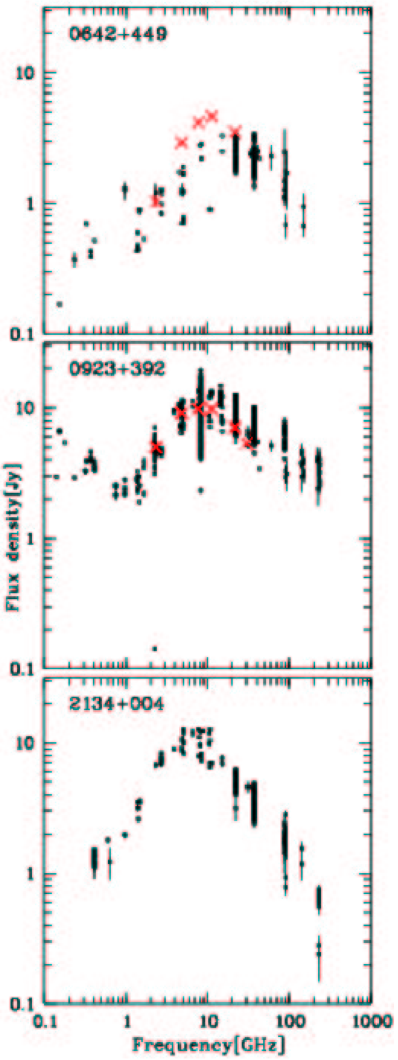


Figure 16: Some, but only very few, sources classi£ed as GPS sources in the literature seem to have a genuinely convex spectrum, the shape of which remains the same during all the activity stages, also during simultaneous multifrequency data taking (red crosses for the RATAN–600 data for 0642+449 and 0923+392).

spectrum sources and gathered data from the literature, made observations and plotted the continuum spectra for sources in the Metsähovi quasar sample. Surprisingly most of the 'bona £de' inverted-spectrum sources turned out to be ¤at spectrum sources with spectra that become inverted only during outbursts. A draft manuscript of our study on inverted-spectrum sources was prepared in 2003, but the work was temporarily paused due to Ilona Torniainen's maternity leave and the paper will be submitted in the £rst half of 2004.

We have also studied a comparison sample of inverted-spectrum radio galaxies. Statistical analysis of the various types of inverted-spectrum sources and candidates may reveal some connections between different populations and clarify the classi£cation of the sources. We have already gathered a relatively large set of observations for these sources, and the actual scienti£c analysis, consisting of cluster analysis and analysis of variance of the clusters, will continue in 2004.

In collaboration with Kaj Wiik from ISAS, Japan, and Tuomas Savolainen from Tuorla we have studied a set of newly identi£ed GPS sources by using VLBI observations. The sources were chosen from our group's suggestions for new GPS source candidates presented in Tornikoski et al. 2000, AJ 1739 & 2001, AJ 121. The VLBI observations were multifrequency (5, 8, 15, 22 and 43 GHz, including polarization) observations made using the VLBA network. The VLBI images were reduced in 2003, and now we are in the process of making scienti£c conclusions about the data sets and writing papers presenting our data and scienti£c results.

During our Metsähovi continuum observations of the inverted-spectrum sources we have also caught some of the sources in exceptionally active states and initiated multifreqeuency observations for those sources. Some of these sources were also part of our collaboration's VLBA observations in 2003. The data will be reduced in

2004.

High-peaked BL Lacertae Objects

The BL Lacertae (BLO) observing project is also an important part of our group's Planck foreground science work (see also section 2.4).

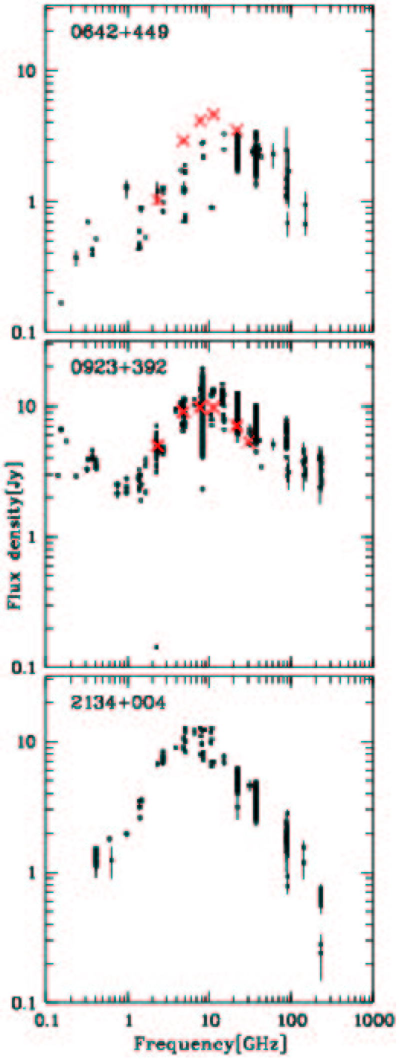


Figure 17: BL Lacertae Objects which were faint according to their historical low-freqeuency data, but which were found to have $S_{37} \approx 1$ Jy in our Metsähovi observations. The instantaneous RATAN–600 spectra were taken closer to the 37 GHz observing epoch than the historical data points, and it can be seen that these sources indeed seem to be in an active state now.

The two main BLO subclasses, the radio-selected BLOs and the X-ray-selected BLOs (≈ HBLs), are a product of different discovery techniques. Currently it is not known whether these two classes of objects are two extremes of the BLOs, the observed properties of which are de£ned by the jet orientation, or whether they have intrinsically different properties. The newly discovered class of IBLs seems to consist of sources intermediate to the radio-selected and X-ray selected samples. It is still unclear whether the detection of the IBLs was due to a selection effect when producing the sample, or whether the sample represents the actual distribution of BLOs, showing a continuous distribution of properties from the HBLs to the LBLs.

In general, the HBLs/XBLs have been excluded from high-frequency radio studies, because they are assumed to be very faint. In 2001 our group started to observe a complete sample of BLOs, including many IBLs and HBLs, and the work continued in 2002–2003. The sample consists of 462 BLOs or BLO candidates from the Veron-Cetty & Veron 2000 catalogue, but some of the sources in the original list are too Southern to be observed in Metsähovi. The observations in Metsähovi were made at 37 GHz, but we have also made some 90 and 250 GHz observations for these sources using the SEST, and in our SEST observations we have also been able to include some of the more Southern sources.

The purpose of this study is to get a full understanding of the spectral energy distribution of the BLOs, all the way from the radio-selected to X-ray selected BLOs, and to see if there is a continuity from subsample to subsample and if this £ts within the framework of the uni£cation models.

By the end of 2003 we had observed almost all of the sources in our BLO sample at least once, and for many of the sources we had gathered several epochs of 37 GHz data. The interpretation of the scienti£c results is now in process, but we can already see that there have been many cases where a BLO initially thought to be too faint to be detected at our frequency band has after all been relatively bright, either because it happened to be in an active state, or because it possesses an inverted continuum spectrum. In order to better understand their variability behaviour we are continuing our observations, and we have also started a collaborative effort with a group lead by Dr. S. A. Trushkin from the Special Astrophysical Observatory in Russia, where we use the RATAN–600 telescope to obtain instantaneous 2–22 GHz continuum spectra for a large set of our sources. We already had a very successful RATAN–600 observing run on November 10–15, and are scheduled for more observations in 2004.

Gamma-ray and radio emission in Active Galactic Nuclei

Our group has continued to study the relationship of the gamma-ray and radio emission in AGNs.

One of our main multifrequency observing efforts in 2003 was the use of the Metsähovi telescope (and to a certain extent, also SEST) for millimetre-domain support of INTEGRAL satellite's gamma-ray observations of blazars. We were co-investigators in several INTEGRAL observing projects in 2003. We made radio observations for the target sources during the INTEGRAL pointings, but also tried to get a good sampling before and after the actual multifrequency sessions in order to get a better understanding about their current activity behaviour. It turned out that some of our INTEGRAL sources were in a very faint state, but at least one of them was in an exceptionally bright multifrequency state (see subsection "ENIGMA network" for more information).

We also continued our theoretical work on radio to gamma-ray connections in AGNs. We £tted the radio spectra of 21 AGNs to obtain as accurate as possible estimates of the synchrotron peak frequencies. In the past the spectral £ts have omitted the radio data almost completely, and so the derived peak frequencies have been unreliable. We wanted to study the sequence in AGN properties according to the observed synchrotron peak frequency ν_{peak}, suggested by Ghisellini et al. (1998, MNRAS, 301, 451). Our preliminary results suggested correlation between ν_{peak} and the "Compton dominance" (calculated simply as the relation between gamma-ray and radio emission). A closer inspection proved that the dependencies were actually due to the Doppler factor, and the correlation disappeared when using Doppler-corrected values. The same happens with the correlation of ν_{peak} and the luminosity. However, there is a signi£cant correlation ($>$ 99.9 %) between ν_{peak} and the Lorentz factor of the relativistic jet (i.e. the speed of the jet) – the higher the speed, the lower the synchrotron peak frequency.

This study was part of Pia-Maria Saloranta's Master's thesis. Her thesis work was started in summer 2003 and completed by the end of the year.

Continuing the research started in her Master's thesis, Elina Lindfors has been studying the emission mechanism and origin of gamma-rays from quasars. Common approach in previous works has been that the gamma-rays would originate close to the apex of the relativistic jet, while Lindfors et al. have studied the possibility that most of the gamma-ray emission would originate from shocks propagating downstream in the jet. It is well established that most of the radio emission originates in these shocks. Using ¤ux monitoring data from Metsahovi and other radio observatories the group has modeled the spectra of the radio emission and calculated the resulting gamma-ray spectra and compared it to gamma-ray observations from Compton satellite. The study on blazar 3C 279 showed that it can not be ruled out that the gamma-ray emission would originate from the shocks and therefore the work on this model continues.

ENIGMA network

2003 was the £rst year of operation of the EC-funded research training network ENIGMA ("European Network for the Investigation of Galactic nuclei through Multifrequency Analysis"). This is a lively collaborative effort between eight European institutes that have been actively involved in AGN studies. The Metsähovi coordinator for this project is M. Tornikoski.

The science activities of this network are addressed in six complementary research themes which are closely connected to each other. The empirical projects are aimed at maximizing ef£ciency by teaming up observational resources and coordinated campaigns. The two theoretical themes have many links between themselves, and clear connections to the empirical subjects.

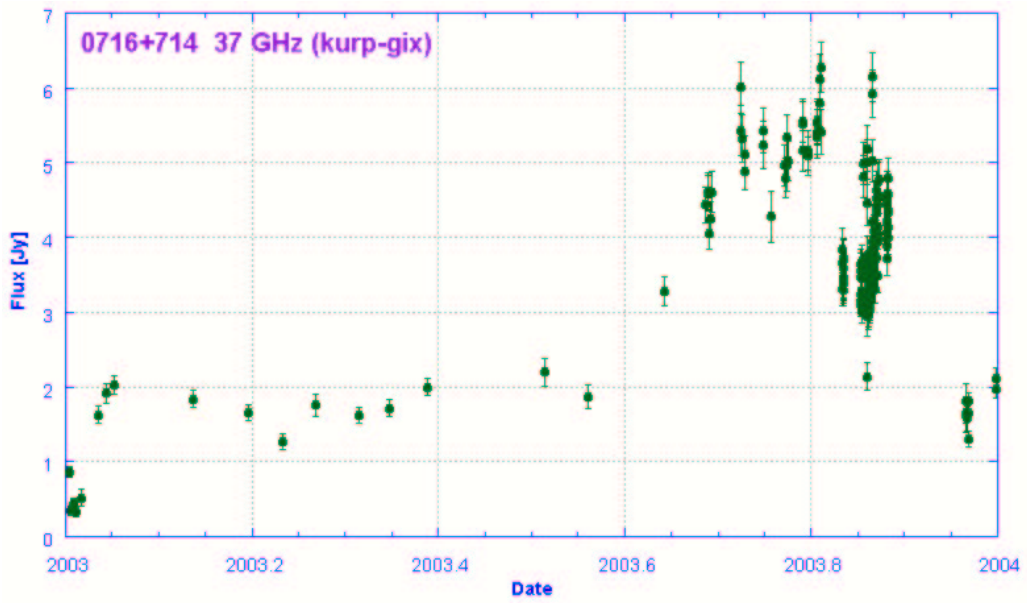


Figure 18: In August 2003 the source 0716+714 was observed to be brighter than ever at 37 GHz. Because this source was to be the target of the ENIGMA-network's multifrequency observations in November, we immediately alerted our collaborators to observe it more intensely. The ¤ux behaviour of 0716+714 at the end of 2003 was very complex and we received lots of interesting multifrequency data during these activity stages.

During the £rst ENIGMA year we participated in two network symposiums and actively took part in preparing for the £rst ENIGMA multifrequency observing campaign. The campaign turned out to be extremely interesting because the source was in an exceptionally active state especially in the radio wavebands. Our team made already pre-campaign observations before the planned observing epoch (which was centered around the INTEGRAL pointings of the source) and we were able to alert other teams to also intensify their observing efforts. Our team used Metsähovi and the James Clerk Maxwell Telescope (JCMT) on Mauna Kea, and we also collaborated with Wiik & Savolainen in making VLBI observations using the VLBA network.

In November 2003 a PhD student funded by ENIGMA, Mirko Tröller from Heidelberg, Germany, started to work in our team.

AGN science with the SEST telescope

Our group has been using the Swedish–ESO Submillimetre Telescope, SEST, already since 1987, and also in 2003 we had several observing sessions at SEST (projects related to INTEGRAL-satellite's multifrequency support as well as observations of BLO and GPS source samples). This year, however, was exceptional, because SEST was to be decomissioned in August, and so it is time to brie¤y look back and summarize what we have achieved with SEST.

The Metsähovi-Tuorla collaboration has used SEST for continuum observations of various types and classes of AGNs at 90 and 230 GHz, and in 2003 with the SIMBA bolometer array also at 250 GHz. We have been very successful in applying for observing time, often having been allocated an observing session (or even two!) every "Swedish" month, resulting in as many as six or even more observing sessions every year during the £rst 10 years of SEST operation. After that our scienti£c emphasis was shifted towards few-epoch observations of certain source samples, resulting in longer but fewer observing sessions. In total we have been allocated an incredible 2614 hours of SEST telescope time!

Figure 19: Rest in peace, SEST! You served us well. (The Swedish-ESO Submillimetre Telescope in its earlier days).

The scienti£c output from our SEST data taking has been overwhelming. So far, we have used SEST data in 30 papers published in international refereed astronomical journals, in more than 50 presentations in scienti£c conferences, and in one Master's and three PhD Theses. We are still in the process of analysing our SEST data sets in detail, and the results will be used in many additional papers that will be submitted to astronomical journals.

Now that SEST will no longer be available, we are already preparing ourselves for new challenges. We have already used other submillimetre telescopes for our observing projects, and we are eagerly looking forward to Finland's ESO membership and the access to modern ESO instruments, including APEX and ALMA.

2.4 Planck Satellite Science

Project Team: Lähteenmäki, Tornikoski, Parviainen, Torniainen, Urpo, Valtaoja (Turku)

2.4.1 Introduction

The Planck satellite is designed to map the sky at several radio frequencies and to measure the cosmic microwave background (CMB) radiation. At the same time all foreground radio sources in the sky, including extragalactic radio sources, will be measured, too. Our Metsähovi Radio Observatory and Tuorla Observatory Planck collaboration team is an active core member of the Planck Extragalactic Point Sources Working Group. The satellite launch is scheduled for February 2007.

The main tasks for our team have been the development of the Planck Quick Detection System software and the de£nition of its triggering criteria, the construction of the Planck Pre-launch Catalog of point sources (including observations and analysis as well as the delivery of the data for the Catalog), and analysing the scienti£c data of extragalactic point sources (see the following sections).

The Extragalactic Point Sources Working Group held monthly teleconferences for WG coordinators (A. Lähteenmäki), and the £rst dedicated Working Group meeting took place in September 15 — 16 in London, United Kingdom. Our representatives in the meeting were A. Lähteenmäki, M. Tornikoski, E. Valtaoja, and M. Parviainen.

The homepage of the Metsähovi and Tuorla Planck collaboration can be found at http://kurp.hut.£/quasar/planck/.

2.4.2 Quick Detection System (QDS)

The purpose of the Quick Detection System is to provide us with Planck point source data within one week from the initial observation (almost a whole year before the release of the Planck Early Release Compact Source Catalog). This is a novel idea, and such software for a satellite is now being developed for the £rst time. QDS will pick out point sources from the time-ordered data stream of the satellite according to pre-determined criteria, compare the source ¤ux with catalog information (is there a known source at these coordinates, how strong has it been in the past, has the ¤ux increased signi£cantly in a short time etc), and if necessary, send out an alarm to an operator who will decide whether follow-up observations should be initiated (Figure 20). The system has been tested with 30 GHz simulated data and the other Planck LFI frequencies will be implemented next (Figure 21). The system will probably be placed in the beginning of Level 2 of the Low Frequency Instrument DPC pipeline.

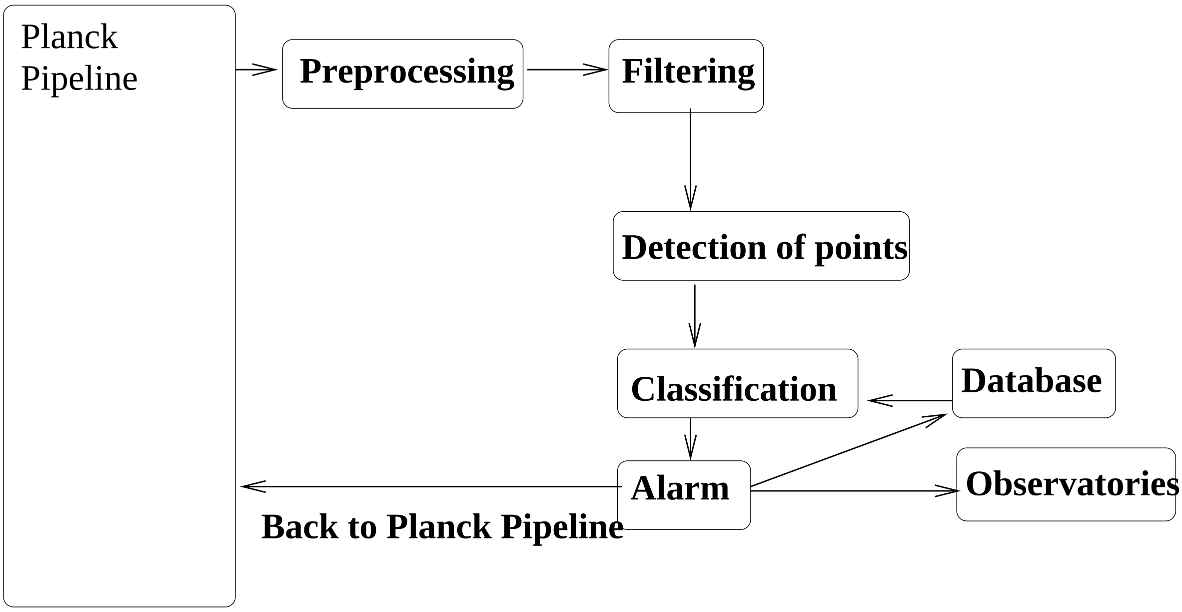
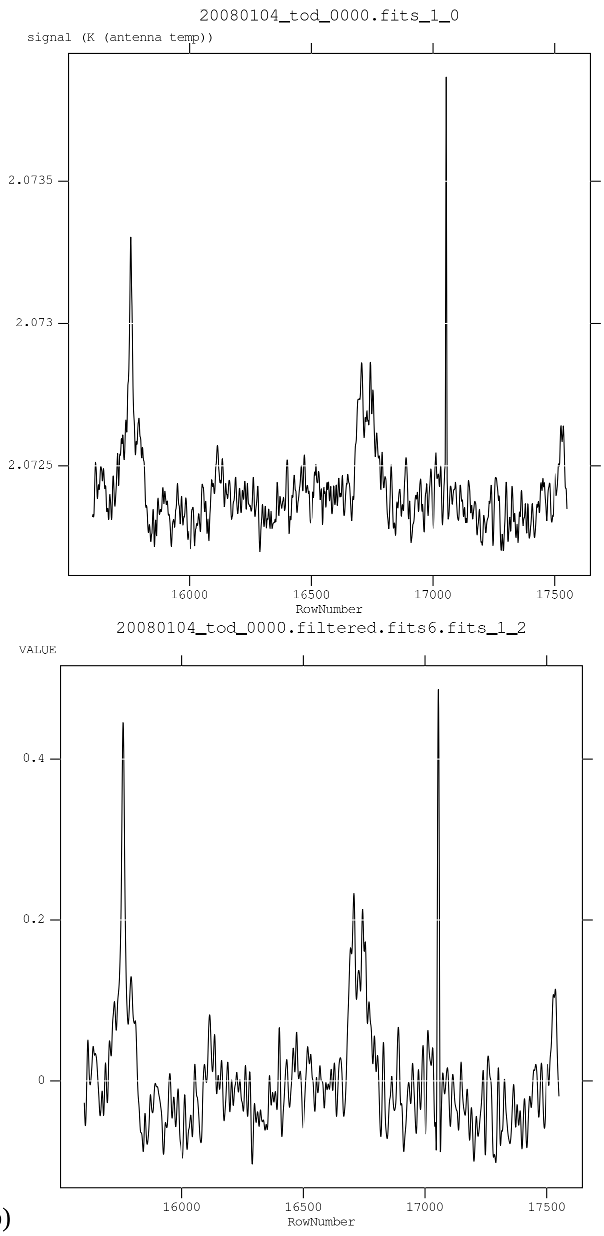


Figure 20: Structure of the Planck satellite Quick Detection System (QDS). It will be replicated, from preprocessing to alarm, for each detector.

We have recently extended the scope of the QDS also for galactic sources, in cooperation with Planck Galactic Working Group. M. Parviainen, who is in charge of the coding of the software, will £nish his M.Sc. thesis on QDS in early 2004.

2.4.3 Observations and Scienti£c Analysis of the Data

We have started new observing and data analysis programmes for the Planck project. The source samples include objects that have never been observed at these frequencies before, and the amount of data analysed is unprecedented. Not only are the observations for the Pre-launch Catalog important in themselves, but we need to know the behaviour and physics at work in these sources as well. This knowledge is required both for the success of the CMB mapping as well as for the non-CMB science.



a)
b)

Figure 21: a) Un£ltered, simulated signal from Planck satellite. b) Signal after £ltering with a Mexican hat wavelet £lter.

The idea was to study new source populations and to get an estimate of how they affect the Planck mission. These include, for example, X-ray and intermediate BL Lac objects and Gigahertz-peaked spectrum sources. The number of sources observed so far is more than four hundred. We are continuously expanding our source samples to include more objects. In the past most of these sources have been excluded from high frequency studies because they are believed to be weak in the radio domain. However, our new observations show that many (possibly hundreds) of these sources are so bright in their active state that the Planck satellite can easily detect them. For detailed results, see 2.3.2.

In cooperation with the Extragalactic Point Sources Working Group we have also observed the unidenti£ed and multiple identi£cation WMAP point sources immediately after the release of the WMAP catalog, and have been able to identify several of them. We have also started a programme, in cooperation with the Special Astrophysical Observatory and other Russian institutes, to study the fainter ¤at-spectrum sources with RATAN-600. The £rst observations were made in autumn 2003, and further sessions are planned through 2004 and onwards.

One of the tasks in both de£ning the parameters for our Quick Detection System as well as in planning multifrequency AGN observing campaigns during the Planck mission, is to study the long term millimetre variability of a large sample of sources, and so better understand their variability and variability timescale behaviour. Typical variability timescales of AGNs at 22 and 37 GHz have been studied earlier by our team, and currently we are studying a complete set of high-frequency radio data at 90 and 230 GHz of ca. 150 sources. As a special interest for the Planck project, we are also looking at the possibility of predicting activity in a source based either on statistics or observed ¤ux behaviour of the source. For detailed results, see 2.3.2.

2.5 Observations with Other Facilities

Swedish-ESO Submillimetre Telescope (SEST), Cerro La Silla, Chile:
14.–17.2., 32 hours of 90 GHz continuum observations for the project "Millimetre to high-energy connection in blazars", P.I. M. Tornikoski, Co–I Lähteenmäki, Torniainen; observer T. Savolainen.
1.–3.4., 32 hours of 90 GHz continuum observations for the project "Millimetre to high-energy connection in blazars", P.I. M. Tornikoski, Co–I Lähteenmäki, Torniainen; observer M. Lainela.
1.–3.6., 32 hours of 1.2 mm SIMBA bolometer array observations for the project "Millimetre to high-energy connection in blazars", P.I. M. Tornikoski, Co–I Lähteenmäki, Torniainen; observer M. Tornikoski.

James Clerk Maxwell Telescope (JCMT), Mauna Kea, Hawaii:
9.–13.11., 16 hours of SCUBA bolometer array 450/850 μm photometry and polarimetry for the project "Multifrequency Observations of Two Intraday-Variable AGNs", P.I. and observer M. Tornikoski.

INTEGRAL-satellite:
5.–7.1., 11.1., 17.–18.1., 16.6., 18.7., project "The Physics of AGN: a Deep Understanding of the Quasar 3C 273" P.I. T. Courvoisier, Co–I M. Tornikoski
1.–5.6. project "The Hard X-Ray and Correlated Multifrequency Properties of the Blazar 3C 279", P.I. W. Collmar, Co–I M. Tornikoski
10.-17.11. project "Inverse Compton Catastrophe and Pair Creation in the Intraday-Variable Sources 0716+714 and 0836+71", P.I. S. Wagner, Co–I M. Tornikoski.

Very Long Baseline Array:
VLBI observations, including polarization maps, at several frequencies on the ¤aring blazars CTA102, OA129 and 0716+714, various epochs. P.I. Kaj Wiik, Co–I M. Tornikoski.

RATAN–600 telescope of the Special Astrophysical Observatory, Russian Academy of Science:
10.–15.11. instantaneous 2–22 GHz observations of a sample of BL Lacertae Objects and GPS candidates, P.I. S. A. Trushkin, Co–I Valtaoja, Tornikoski, Lähteenmäki.

2.6 Solar Research

Research Group at Metsähovi: Urpo

2.6.1 Solar Observing Campaigns

Project Team: Urpo, Hurtta

Solar observations continued at Metsähovi in 2003. Receiver working at 37 GHz was used. Number of observing days was 21. More than 100 solar radiation maps were measured and active regions were tracked for 25 hours in order to detect energy burst and releases at radio waves. No major radio release events were detected. Analysis of measured data continued in international cooperation.

2.6.2 Solar Data Analysis

Project Team: Urpo

Metsähovi solar data analysis continued in international cooperation with Russia. Solar bursts measured with the Metsähovi main telescope was analysed using Wigner-Ville method. Metsähovi solar maps were analysed using improved IDL programs.

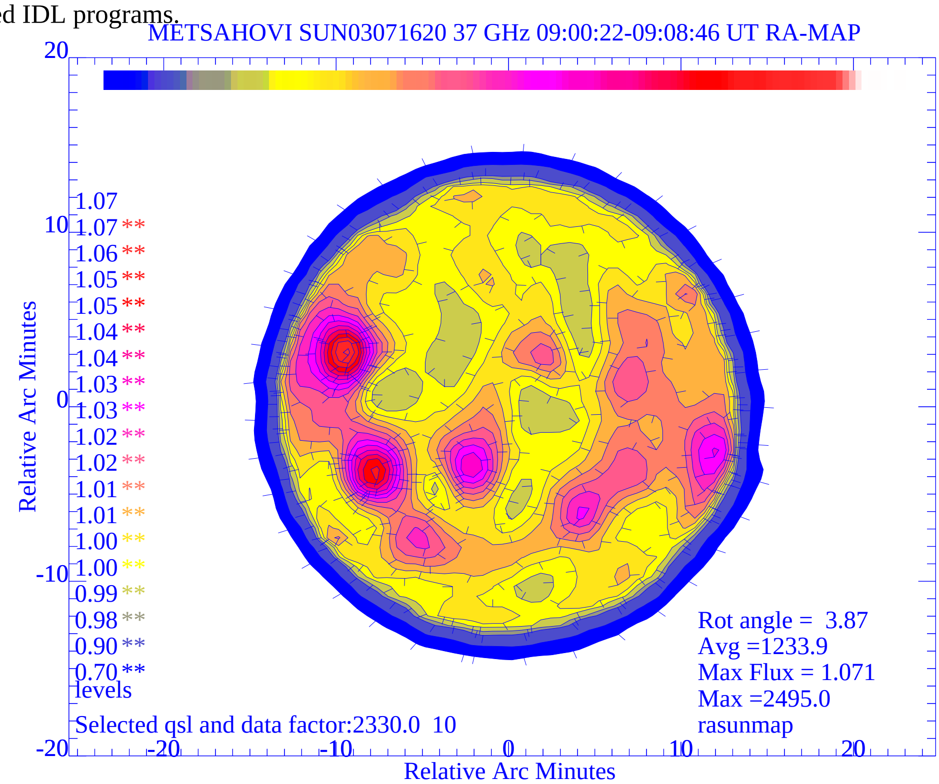


Figure 22: Solar map measured in 37 GHz with the Metsähovi main telescope on July 16, 2003. Several active regions are visible.

2.6.3 Space Weather Observation at 11.7 GHz

Project Team: Urpo, Mujunen, Oinaskallio

Sun antenna is dedicated for continuous solar observations while the main telescope could be used for that purpose only few weeks annually. Operation of the instrument started in August 2000. Radioevents starting from few Solar Flux Units up to approximately 400 SFU can be recorded. Logarithmic channel will increase the dynamical range from that essentially. All together over 100 events during 2003 were observed.

2.7 Radio Spectroscopy

2.7.1 Spectroscopic Space Research with the Submillimetre Wave Satellite Odin

Project Team: Liljeström

Odin is a satellite with a combined astronomy and aeronomy mission. It is designed for observations of species dif£cult or impossible to observe from ground, especially water and oxygen. It consists of a 1.1 m

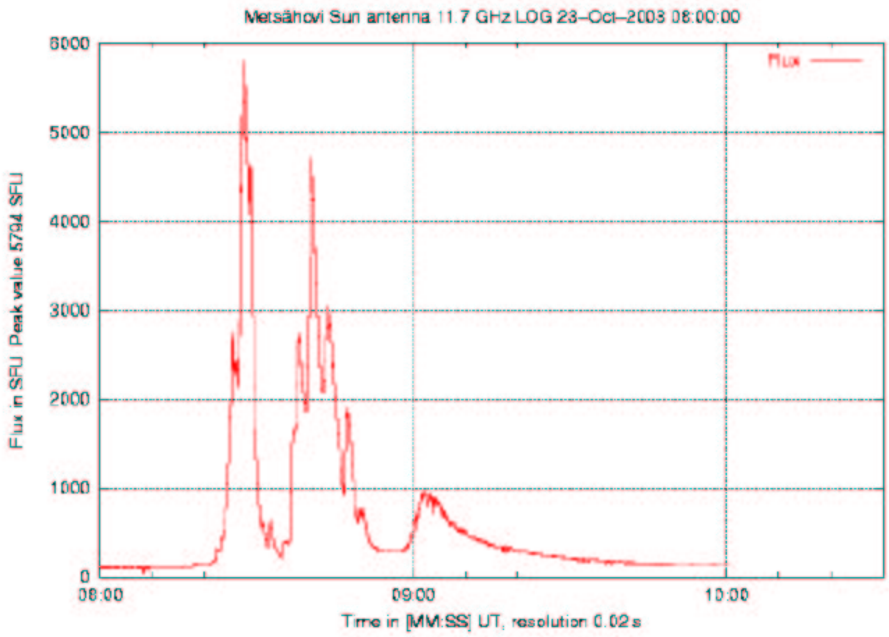


Figure 23: Time series of solar radiation on October 23, 2003, frequency 11.7 GHz. The source event was observed also in other observatories at other frequencies. At 8.86 GHz it was 6200 SFU and at 15.4 GHz 10000 SFU.

diameter telescope with four tuneable heterodyne receivers covering the frequency ranges 486-504 GHz, and one acousto-optical spectrometer £xed at 118.75 GHz.

Odin was developed on behalf of the space agencies in Sweden, Canada, France and Finland. It was launched into a Sun synchronous circular orbit in February 2001 and will continue to observe until May 2004. Odin's high angular resolution, high frequency resolution, large spectrometer bandwidths, high sensitivity and/or frequency tuning capability have been crucial in obtaining the many interesting results.

Some of the highlights to be mentioned are the H_2O line mapping of Orion KL, W 3, DR 21, S140 regions, and four comets. In addition, broad water absorption lines have been detected toward the circumnuclear disk and molecular clouds of the Galactic centre. Shock enhanced water has been detected toward the supernova remnant SNR IC 443 and in the candidate infall source IRAS 16293-2422 (containing a protostar in its formation process). Spectral scans have detected new spectral lines (e.g., PH at 553.4 GHz and the ground transition of the 15 NH3 isotope at 572.1 GHz). Deep Odin searches for molecular oxygen at 118.75 GHz have resulted in very low abundance limits, which are dif£cult to accommodate in chemical models. A Special Letters Edition (Astronomy and Astrophysics 402, May II, 2003) published 11 papers of the First Science with the ODIN satellite; Metsähovi was involved in seven of these £rst Odin papers.

3 Publications

3.1 International Journals

1 Riehokainen, A., Valtaoja, E., Pohjolainen, S.: A comparison between the CaII(k_3), H_α SOHO/MDI and radio-enhanced temperature regions of the Sun. *Astronomy and Astrophysics*, Vol. 402, pp. 1103-1113, 2003.

2 Hjalmarson, Å., Frisk, U.O., Olberg, M., Bergman, P., Bernath, P., Biver, N., Black, J.H., Booth, R.S., Buat, V., Crovisier, J., Curry, C.L., Dahlgren, M., Encrenaz, P.J., Falgarone, E., Feldman, P.A., Fich, M., Florén, H.G., Fredrixon, M., Gerin, M., Gregersen, E.M., Hagström, M., Harju, J., Hasegawa, T., Horellou, C., Johansson, L.E.B., Kyrölä, E., Kwok, S., Larsson, B., Lecacheux, A., Liljeström, T., Lindqvist, M., Liseau, R., Llewellyn, E.J., Mattila, K., Mégie, G., Mitchell, G.F., Murtagh, D., Nyman, L-Å., Nordh, H.L., Olofsson, A.O.H., Olofsson, G., Olofsson, H., Pagani, L., Persson, G., Plume, R., Rickman, H., Ristocelli, I., Rydbeck, G., Sandqvist, Aa., von Scheele, F., Serra, G., Torchinsky, S., Tothill, N.F., Volk, K., Wiklind, T., Wilson, C.D., Winnberg, A., Witt. G.: Highlights from the £rst year of Odin observations. *Astronomy and Astrophysics*, Vol. 402, pp. L39-L46, 2003.

3 Olofsson, A.O.H., Olofsson, G., Hjalmarson, Å., Bergman, P., Black, J.H., Booth, R.S., Buat, V., Curry, C.L., Encrenaz, P.J., Falgarone, E., Feldman, P., Fich, M., Florén, H.G., Frisk, U., Gerin, M., Gregersen, E.M., Harju, J., Hasegawa, T., Johansson, L.E.B., Kwok, S., Larsson, B., Lecacheux, A., Liljeström, T., Liseau, R., Mattila, K., Mitchell, G.F., Nordh, H.L., Ohlberg, M., Olofsson, H., Pagani, L., Plume, R., Ristocelli, I., Rydbeck, G., Sandqvist, Aa., von Scheele, F., Serra, G., Tothill, N.F., Volk, K., Wilson, C.D.: Odin water mapping in the Orion KL region. *Astronomy and Astrophysics*, Vol. 402, pp. L47-L54, 2003.

4 Wilson, C.D., Mason, A., Gregersen, E., Bergman, P., Black, J.H., Booth, R., Buat, V., Curry, C.L., Encrenaz, P., Falgarone, E., Feldman, P., Fich, M., Frisk, U., Gerin, M., Harju, J., Hasegawa, T., Heikkilä, A., Hjalmarson, Å., Juvela, M., Kwok, S., Larsson, B., Liljeström, T., Liseau, R., Mitchell, G., Nordh, L., Olberg, M., Olofsson, H., Olofsson, G., Plume, R., Ristorcelli, I., Sandqvist, Å., Tothill, N.: Submillimeter Emission from Water in the W3 Region.*Astronomy and Astrophysics*, Vol. 402, pp. L59-L62, 2003.

5 Sandqvist, Aa., Bergman, P., Black, J.H., Booth, R.S., Buat, V., Curry, C.L., Encrenaz, P.J., Falgarone, E., Feldman, P., Fich, M., Florén, H.G., Frisk, U., Gerin, M., Gregersen, E.M., Harju, J., Hasegawa, T., Hjalmarson, Å., Johansson, L.E.B., Kwok, S., Larsson, B., Lecacheux, A., Liljeström, T., Lindqvist, M., Liseau, R., Mattila, K., Mitchell, G.F., Nordh, H.L., Olberg, M., Olofsson, A.O.H., Olofsson, G., Pagani, L., Plume, R., Ristocelli, I., von Scheele, F., Serra, G., Tothill, N.F.H., Volk, K., Wilson, C.D., Winnberg, A.: Odin observations of H_2O in the Galactic Centre. *Astronomy and Astrophysics*, Vol. 402, pp. L63-L67, 2003.

6 Larsson, B., Liseau, R., Bergman, P., Black, J.H., Buat, V., Curry, C.L., Encrenaz, P., Falgarone, E., Fich, M., Frisk, U., Gerin, M., Gregersen, E.M., Harju, J., Hjalmarson, Å., Kwok, S., Liljeström, T., Mitchell, G.F., Nordh, L.H. Olberg, M., Olofsson, G., Ristorcelli, I., Tothill, N.H.F., Wilson, C.D.: First NH_3 Detection of the Orion Bar. *Astronomy and Astrophysics*, Vol. 402, pp. L69-L72, 2003.

7 Liseau, R., Larsson, B., Bergman, P., Black, J.H., Brandeker, A., Buat, V., Curry, C.L., Encrenaz, P., Falgarone, E., Fich, M. Frisk, U., Gerin, M., Gregersen, E.M., Harju, J., Hjalmarson, Å., Kwok, S., Liljeström, T., Mitchell, G.F., Nordh, L.H., Olberg, M., Olofsson, G., Ristorcelli, I., Tothill, N.F.H., Wilson, C.D.: First Detection of NH_3 $(J_K = 1_0 \rightarrow 0_0)$ from a Dark Cloud. *Astronomy and Astrophysics*, Vol. 402, pp. L73-L76, 2003.

8 Pagani, L., Olofsson, A.O.H., Bergman, P., Black, J.H., Booth, R.S., Buat, V., Curry, C.L., Encrenaz, P.J., Falgarone, E., Feldman, P., Fich, M., Floren, H.G., Frisk, U., Gerin, M., Gregersen, E.M., Harju, J., Hasegawa, T., Johansson, L.E.B., Kwok, S., Larsson, B., Lecacheux, A., Liljeström, T., Lindqvist, M., Liseau, R., Mattila, K., Mitchell, G.F., Nordh, L.H., Olberg, M., Olofsson, G., Ristorcelli, I., Sandqvist, Å., van Scheele, F., Tothill, N.F., Volk, K., Wiklind, T., Wilson, C.D., Hjalmarson, Å.: Upper Limits on the Abundance of O2 from the Odin Satellite. *Astronomy and Astrophysics Letters*, Vol. 402, pp. L77-L81, 2003.

9 Liljeström, T.: Water Masers as Diagnostic Astrophysical Tools. *Recent Research Developments in Astrophysics*, ed.: S.G. Pandalai, Vol. 1, pp. 27-58, 2003.

10 Rantakyrö, F.T., Wiik, K., Tornikoski, M., Valtaoja, E., Bååth, L.B.: Multifrequency interferometer and radio continuum monitoring observations of CTA 102. *Astronomy and Astrophysics*, Vol. 405, pp. 473-485, 2003.

11 Lähteenmäki, A., Valtaoja, E.: Testing of Inverse Compton Models for Active Galactic Nuclei with Gamma-Ray and Radio Observations. *Astrophysical Journal*, Vol. 590, pp. 95-108, 2003.

12 Sjöman, P., Ruokokoski, T., Hughes, N.J., Jukkala, P., Kangaslahti, P., Ovaska, S., Eskelinen, P.: Planck Satellite 70 GHz EBB-Version Back End Module. *IEEE AESS System Magazine*, pp. 22-25, 2003.

13 Kimura, M., Nakajima, J., Ritakari, J., Mujunen, A.: First detection of 2-Gbps wideband fringes between two PC-based VLBI systems. *IVS CRL-TDC News*, p. 5, 2003.

14 Zaitsev, V.V., Kislyakov, A.G., Urpo, S., Stepanov, A.V., Shkelev, E.I.: Spectral-temporal evolution of low-frequency pulsations in the microwave radiation of solar ¤ares. *Astronomy Reports*, Vol. 47. pp. 873-882, 2003.

15 Böttcher, M., Marscher, A.P., Ravasio, M., Villata, M., Raiteri, C.M., Aller, H.D., Aller, M.F., Teräsranta, H., Mang, O., Tagliaferri, G., Aharonian, F., Krawczynski, H., Kurtanidze, O.M., Nikolashvili, G., Ibrahimov, M.A., Papadakis, I.E., Tsinganos, K., Sadakane, K., Okada, N., Takalo, L.O., Sillanpää, A., Tosti, G., Ciprini, S., Frasca, A., Marilli, E., Robb, R., Noble, J.C., Jorstad, S.G., Hagen-Thorn, V.A., Larionov, V.M., Nesci, R., Maesano, M., Schwartz, R.D., Basler, J., Gorham, P.W., Iwamatsu, H., Kato, T., Pullen, C., Benitez, E., de Diego, J.A., Moilanen, M., Oksanen, A., Rodriquez, D., Sadun, A.C., Kelly, M., Carini, M.T., Miller, H.R., Catalano, S., Dultzin-Hacyan, D., Fan, J.H., Ghisellini, G., Ishioka, R., Karttunen, H., Keinänen, P., Kydryavtseva, N.A., Lainela, M., Lanteri, L., Larionova, E.G., Matsumoto, K., Mattox, J.R., McHardy, I., Montagni, F., Nucciarelli, G., Ostorero, L., Papamastorakis, J., Pasanen, M., Sobrito, G., Uemura, M.: Coordinated multiwavelength Observations of BL Lacertae in 2000. *Astrophyscal Journal*, Vol. 596, pp. 847-859, 2003.

16 Brunthaler, A., Falcke, H., Bower, G.C., Aller, M.F., Aller, H.D., Teräsranta, H., Krichbaum, T.P.: III Zw 2: Evolution of radio galaxy in a Nutshell. *Publications of the Astronomical Society of Australia*, Vol. 20, pp. 126-128, 2003.

17 Raiteri, C.M., Villata, M., Tosti, G., Nesci, R., Massaro, E., Aller, M.F., Aller, H.D., Teräsranta, H., Kurtanidze, O.M., Nikolashvili, M.G., Ibrahimov, M.A., Papadakis, I.E., Krichbaum, T.P., Kraus, A., Witzel, A., Ungerechts, H., Lisenfeld, U., Bach, U., Cimo, G., Ciprini, S., Fuhrmann, L., Kimeridze, G.N., Lanteri, L., Maesano, M., Montagni, F., Nucciarelli, G, Ostorero, L.: Optical and radio behaviour of the BL Lacertae object 0716+714. *Astronomy and Astrophysics*, in press, 2003.

18 Ciaramella, A., Bongardo, C., Aller, H.D., Aller, M.F., De Zotti, G., Lähteenmäki, A., Longo, G., Milano, L., Tagliaferri, R., Teräsranta, H., Tornikoski, M., Urpo, S.: A multifrequency analysis of radio variability of blazars. *Astronomy and Astrophysics*, submitted, 2003.

19 Bloom, S.D., Peters, C., Dale, D.A., Cool, R., Miller, C., Haugsjaa, A., Tornikoski, M., Wallace, P.: An optical survey of the position error contours of unidenti£ed high energy gamma-ray sources at galactic latitude $b > |20°|$, submitted 2003.

3.2 International Conferences

1 Jorstad, S.G., Marscher, A.P., Lister, M.L., Stirling, A.M., Teräsranta, H.: Measurement of the VLBI Core Proper Motion of OJ 287 at 43 GHz. *Bulletin of the American Astronomical Society*, Vol. 34, 4, p. 1180, 2003.

2 Teräsranta, H.: Ground support for the gamma-ray observatories by monitoring the 200 strongest AGN at 22 and 37 GHz. *Proceedings of an International Workshop, Maxi Workshop on AGN variability*, Nikko, Japan, 10-11.3.2001, Eds.: N. Kawai, H. Negoro, A. Yoshida, and T. Mihara, pp. 61-64, 2003.

3 Lähteenmäki, A., Valtaoja, E.: Inverse Compton models for Gamma-ray AGNs. *Proceedings of High Energy Blazar Astronomy, ASP Conference Series*, Vol. 299, eds. L.O. Takalo, E. Valtaoja, Tuorla Observatory, Finland, 17-21.6.2002, pp. 161-166, 2003.

4 Rantakyrö, F., Wiik, K., Tornikoski, M., Valtaoja, E., Bååth, L.: Curvature of the CTA 102 jet. *Proceedings of High Energy Blazar Astronomy, ASP Conference Series*, Vol. 299, eds. L.O. Takalo, E. Valtaoja, Tuorla Observatory, Finland, 17-21.6.2002, 2003.

5 Tornikoski, M., Lähteenmäki, A., Lainela, M., Valtaoja, E., Jussila, I., Parviainen, M.: Radio spectra and variability of EGRET blazars. *Proceedings of High-Energy Blazar Astronomy, ASP Conference Series*, Vol. 299, eds. L.O. Takalo, E. Valtaoja, Tuorla Observatory, 17-21.6.2002, pp. 229-234, 2003.

6 Teräsranta, H., Wiren, S., Koivisto, P.: The radio events during the strongest gamma outbursts in Blazars. *Proceedings of High-Energy Blazar Astronomy, ASP Conference Series*, Vol. 299, eds. L.O. Takalo, E. Valtaoja, Tuorla Observatory, Finland, 17-21.6.2002, pp. 235-237, 2003.

7 Pyatunina, T.B., Rachimov, I.A., Zborovskii, Gabuzda, D.C., Jorstad, S.G., Teräsranta, H., Aller, M.F., Aller, H.D.: Quasi-periodic activity in Blazar 0059+581. *Proceedings of High-Energy Blazar Astronomy, ASP Conference Series*, Vol. 299, eds. L.O. Takalo, E. Valtaoja, Tuorla Observatory, Finland, 17-21.6.2002, pp. 89-92, 2003.

8 Marscher, A.P., McHardy, I.M., Aller, M.F., Balonek, T.J., Villata, M., Raiteri, C.M., Ostorero, Luisa., Tosti, G., Teräsranta, H.: The connection between X-ray and radio-optical emission in Blazars. *Proceedings of High-Energy Blazar Astronomy, ASP Conference Series*, Vol. 299, eds. L.O. Takalo, E. Valtaoja, Tuorla Observatory, Finland, 17-21.6.2002, pp. 173-182, 2003.

9 Raiteri, C.M., Villata, M., Lanteri, L, Ostorero, L., Tosti, G. Ciprini, S., Nucciarelli, G., Nesci, R., Massaro, E., Maesano, M., Montagni, F., Papadakis, I.E., Kurtanidze, O.M., Nikolashvili, M.G., Ibrahimov, M.A., Aller, M.F., Aller, H.D., Teräsranta, H.: S5 0716+71 from 1994 to 2001: Optical and radio variability. *Proceedings of High-Energy Blazar Astronomy, ASP Conference Series*, Vol. 299, eds. L.O. Takalo, E. Valtaoja, Tuorla Observatory, Finland, 17-21.6.2002, pp. 225-228, 2003.

10 Virtanen, J., Vainio, R.: Simulations on the effect of internal structure of shock fronts on particle acceleration. *Proceedings of High-Energy Blazar Astronomy, ASP Conference Series*, Vol. 299. eds. L.O.Takalo, E. Valtaoja, Tuorla Observatory, Finland, 17-21.6.2002, pp. 157-160, 2003.

11 Nakajima,J., Kimura, M., Kondo, T., Koyama, Y., Masato, T., Kashuga, T., Mujunen, A., Ritakari, J.: Versatile scienti£c interface and success of internet fringe detection between Japan and Finland. Japan Astronomical Society of Japan Seasonal Meeting, Tohoku University, 26.3.2003.

12 Tornikoski, M., Torniainen, I.: Radio variability of inverted-spectrum sources. *Proceedings of the 2nd ENIGMA meeting*, Portovenere, Italy, 11-14.10.2003, eds. C.M. Raiteri, M. Villata, pp. 84-91, 2003.

13 Tornikoski, M.: Session III: Variations of source structure and ¤ux. *Proceedings of the 2nd ENIGMA meeting*, Portovenere, Italy, 11-14.10.2003, eds. C.M. Raiteri, M. Villata, pp. 80-83, 2003.

14 Ciprini, S., Tosti, G., Raiteri, C.M., Villata, M., Teräsranta, H., Ibrahimov, M.A., Nucciarelli, G., Lanteri, L., Aller, H.D.: Optical and radio variability of the BL Lac Object 0109+224. *Proceedings of the 2nd ENIGMA meeting*, Portovenere, Italy, 11-14.10.2003, eds. C.M. Raiteri, M. Villata, pp. 147-157, 2003.

15 Marchili, N., Villata, M., Raiteri, C.M., Tosti, G., Crapanzano, S., Lanteri, L., Aller, H.D., Aller, M.F., Teräsranta, H.: A multiwavelength study of the OJ 287 variability. *Proceedings of the 2nd ENIGMA meeting*, Portovenere, Italy, 11-14.10.2003, eds. C.M. Raiteri, M. Villata, pp.160-168, 2003.

16 Agudo, I., Bach, U., Krichbaum, T.P., Alef, W., Graham, D., Bremer, M., Ungerechts, H., Grewing, M., Terässranta, H., Witzel, A., Zensus, J.A.: The new 11 Jy radio outburst of NRAO 150: VLBI study at the resolution limit. *Proceedings of the 2nd ENIGMA meeting*, Portovenere, Italy, 11-14.10.2003, eds. C.M. Raiteri, M. Villata, pp. 123-131, 2003.

17 Pursimo, T., Rector, T., Tornikoski, M.: The search for radio quiet BL Lacertae objects. Multiwavelength AGN Surveys, Cozumel, Mexico 8-12.12.2003, 10 p., 2003.

18 Parviainen, M., Lähteenmäki, A., Tornikoski, M., Valtaoja, E.: Quick Detection System (QDS) for Planck. 2nd Planck Symposium, submitted, 2003.

19 Lähteenmäki, A., Tornikoski, M., Parviainen, M., Torniainen, I., Valtaoja, E.: The Metsähovi/Tuorla Planck collaboration: observations and analysis of the data. 2nd Planck Symposium, submitted, 2003.

20 Tornikoski, M., Lähteenmäki, A., Torniainen, I., Parviainen, M., Nieppola, E., Tröller, M., Valtaoja, E., Trushkin, S.: Identi£cation of new inverted-spectrum sources. 2nd Planck Symposium, submitted, 2003.

21 Tuovinen, J., Kantanen, M., Karttaavi, T., Karvonen, A., Lahdes, M., Varis, J., Vähä-Heikkilä, T., Hughes, N., Jukkala, P., Sjöman, P.: Advances in millimetre wave low noise receivers and on-wafer test methods. TSMMW 2003 Conference, Japan, September 2003.

22 Valtaoja, E., Savolainen, T., Wiik, K., Lähteenmäki, A.: Variability and brightness temperature, Proceedings of "Radio astronomy at the fringe", eds. J.A. Zensus, M.H. Cohen, E. Ros, Astronomical Society of the Paci£c, 169, 2003.

23 Lähteenmäki, A., Tornikoski, M.: Millimetre observations as a tool for studying gamma-ray emission in blazars, Proceedings of "The 1st ENIGMA Meeting", Mayschoss, Germany, 11-14.5.2003 (http://www.lsw.uni-heidelberg.de/users/swagner/E£les/proceedingsEM1.pdf) (Talk by A. Lähteenmäki)

24 Tornikoski M: "AGN Science at Metsähovi", talk at the £rst ENIGMA symposium (held in Mayschoss, Germany, 11-14.5.2003).

25 Tornikoski M: "Long term radio variability: statistics and predictions", talk at the the £rst ENIGMA symposium (held in Mayschoss, Germany, 11-14.5.2003).

26 Tornikoski M: "Millimetre Variability: Statistics and Predictions", talk at the Planck Working Group 6 Workshop in London, England, September 15-16, 2003.

27 Tornikoski M., Torniainen I.: "Radio Variability of Inverted-spectrum Sources", Proceedings of the second ENIGMA symposium (held in Portovenere, Italy, 11-14.10.2003), http://www.lsw.uni-heidelberg.de/users/swagner/E£

28 Osterman M A, Miller H R, Aller H, Aller M F, Fried R, Kurtanidze O, Tornikoski M: "Results and discussion of simultaneous monitoring of the BL Lacertae Object PG 1553+11 in the radio, optical and X-ray regimes", American Astronomical Society Meeting 203, nr.79.03, 2003.

29 Tornikoski M: "Millimetre Variability: Statistics and Predictions", talk at the Planck Working Group 6 Workshop in London, England, September 15-16, 2003.

30 Tornikoski M, Lähteenmäki A, Torniainen I, Parviainen M, Nieppola E, Valtaoja E: "Metsähovi source samples, recent results", talk at the Planck Working Group 6 Workshop in London, England, September 15-16, 2003.

3.3 Laboratory Reports

1 Zaitsev, V.V., Kislyakov, A.G., Urpo, S., Stepanov, A.V., Shkelev, E.I.: Solar millimeter wave bursts: time-frequency analysis. *Metsähovi Publications on Radio Science HUT-MET-44*, 15 p., 2003.

2 Könönen, P.: Monitoring the GPS clock offset at Metsähovi Radio Observatory. *Metsähovi Reports HUT-KURP-27*, 12 p., 2003.

3 Urpo, S., Mujunen, A. (editors): Metsähovi Radio Observatory Annual Report 2002. *Metsähovi Reports HUT-KURP-26*, 33 p., 2003.

4 Tornikoski, M, Urpo, S. (toim.): Astrofysiikan ratkaisemattomat kysymykset. *Metsähovi Publications on Radio Science, HUT-MET-45*, 2003.

5 Urpo, S., Puhakka, P., Oinaskallio, E., Mujunen, A., Peltonen, J., Rönnberg, H., Hurtta, S., Tornikoski, M., Teräsranta, H., Könönen, P.: Selected radio maps and major solar radio ¤ares measured at Metsähovi in 1996-2001. *Metsähovi Publications on Radio Science, HUT-MET-46*, 78 p., 2003.

6 Urpo, S., Puhakka, P., Oinaskallio, E., Mujunen, A., Peltonen, J., Rönnberg, H., Hurtta, S., Tornikoski, M., Teräsranta, H., Könönen, P.: Selected radio maps and major solar radio ¤ares measured at Metsähovi in 2002. *Metsähovi Publications on Radio Science, HUT-MET-47*,89 p., 2003.

7 Ovaska, S., Sjöman, P., Eskelinen, P.: Theoretical susceptibility of Planck 70 GHz radiometer to systematic effects. *Metsähovi Publications on Radio Science, HUT-MET-48*, 15 p., 2003.

8 Kislyakov, A.G., Stepanov, A.V., Urpo, S., Zaitsev, V.V., Mujunen, A.: Evidences of photosphere £veminute oscillations in solar ¤are microwave emission. *Metsähovi Publications on Radio Science, HUT-MET-49*, 18 p., 2003.

3.4 Other Publications

1 Koski, M.: Tarkkojen kellojen vertailujärjestelmän kehittely. Insinöörityö, Helsingin ammattikorkeakoulu Stadia, 2003.

2 Saloranta, P-M.: Aktiivisten galaksien energiaspektrin ja gammasäteilyn välinen riippuvuus. Pro gradututkielma, Turun yliopisto, Fysiikan laitos, 2003.

4 Visits to Foreign Institutes

European Southern Observatory, Cerro La Silla, Chile, 29.5-6.6.2003, M. Tornikoski.

Joint Astronomy Centre, Hilo, Hawaii, 7.11. & 13.–14.11., M. Tornikoski.

University of Oxford, Astrophysics, United Kingdom, several visits, A. Lähteenmäki.

5 Visiting Scientists

Igor Zinchenko, IAP, Russia, 13-18.5.
Vladimir Perminov, IAP, Russia, 26.9-2.10., 20-28.10. and 13-19.12.
Alexander Eliseev, IAP, Russia, 1-7.10., 10-20.11., and 13-19.12.
Igor Kutznetsov, IAP, Russia, 1-7.10., 10-20.11., and 13-22.12.
Alexander Shtanyuk, IAP, Russia, 12-27.5., 26.9-8., 20.10-4.11., and 13-22.12.
Vladimir Maltsev, IAP, Russia, 13-18.11.
Vyatcheslav Vdovin, IAP, Russia, 12-27.5., 26.9-8.10., 13-14.11., and 17-20.11.
Vladimir Nossov, IAP, Russia, 26.9-2.10.
Vladimir Gavrilov, IEM Kvarz, 1-8.4., 29.9-6.10.
N. Demidov, IEM Kvarz, 8.7., 19.12.
Alexander Stepanov, Central Astronomic Observatory, Russia, 1-10.10.
Albert Kislyakov, IAP, Russia, 1-10.10.

6 Thesis

Thesis for the degree of B.Sc.
Minttu Koski: A Design for a Comparing System of Precise Clocks.

Master's thesis at Turku University
Pia-Maria Saloranta: Correlation between the spectral energy distribution and gamma-ray emission in Active Galactic Nuclei.

7 Teaching

Radioastronomy demonstration for HUT Space Technology students, 9.4.2003, M. Tornikoski, S. Urpo

Supervisor for Mikko Parviainen’s Master’s Thesis / M. Tornikoski

Post-graduate course “Unsolved Probelms in Astrophysics”, spring 2003, M. Tornikoski and S. Urpo

8 Other Activities

8.1 Participation in Boards and Committees

Hvar Observatory Bulletin, Board of Editors, S. Urpo

AAS, American Astronomical Society, member, S. Urpo

EAS, European Astronomical Society, founding member S. Urpo.

IAG, International Association of Geodesy, associate member S. Urpo.

AMS, Tekes Guiding Group, member S. Urpo.

Planck, Tekes Steering Group, member, S. Urpo.

COSPAR, Committee on Space Research, Finnish National Committee, member, S. Urpo.

COSPAR, Commission E2, Solar Physics, member S. Urpo.

EVN, European VLBI Network Board of Directors, member S. Urpo.

IAU, Finnish National Committee, member S.Urpo.

RISC, Radioastron International Science Committee, member S. Urpo.

Tuorla Observatory, member of the Board S. Urpo.

URSI, Union of Radio Science International, Finnish National Committee, vice member S. Urpo.

Working Group for Finnish-Russian Cooperation in Space Field, member S. Urpo.

Member of the steering committee of the ANTARES Space Research Program, M. Tornikoski.

URSI Comission J (Radio astronomy) delegate, M. Tornikoski.

Finnish Astronomical Society, Vice president, M. Tornikoski.

Metsähovi Coordinator of the EC Research Training Network ENIGMA (“European Network for the Investigation of Galactic nuclei through Multifrequency Analysis”), M. Tornikoski.

Member of the Finnish Astronomical Advisory Group for the ESO project “Development of distributed data analysis system for extensive astronomical data”, M. Tornikoski.

8.2 International Meetings and Talks

EVN directors meeting, 2-3.5.2003, Noto, Italy, S. Urpo.

Seminar talk about radio astronomical research at Metsähovi, Jodrell Bank Observatory, United Kingdom, 19.3.2003, A. Lähteenmäki

Lähteenmäki, A., Tornikoski, M., Parviainen, M., Valtaoja, E.: Review of the Metsähovi/Tuorla Planck collaboration activities in the Extragalactic Working Group 6, The 1st Planck Extragalactic Working Group Workshop, London, United Kingdom, 15-16.9.2003 (Talk by A. Lähteenmäki)

Tornikoski, M., Lähteenmäki, A., Torniainen, I., Parviainen, M., Nieppola, E., Valtaoja, E.: Metsähovi sources samples, recent results; The 1st Planck Extragalactic Working Group Workshop, London, United Kingdom, 15-16.9.2003

Tornikoski M: “AGN Science at Metsähovi”, talk at the £rst ENIGMA symposium (held in Mayschoss, Germany, 11-14.5.2003).

Tornikoski M: “Long term radio variability: statistics and predictions”, talk at the the £rst ENIGMA symposium (held in Mayschoss, Germany, 11-14.5.2003).

Tornikoski M: “Millimetre Variability: Statistics and Predictions”, talk at the Planck Working Group 6 Workshop in London, England, September 15-16, 2003.

Tornikoski M: “Metsähovi source samples, recent results”, talk at the Planck Working Group 6 Workshop in London, England, September 15-16, 2003.

Tornikoski M “Introduction to Session III: Variations in source structure and ¤ux”, talk at the second ENIGMA symposium (held in Portovenere, Italy, 11-14.10.2003).

Tornikoski M: “Radio Variability of Inverted-spectrum Sources”, talk at the second ENIGMA symposium (held in Portovenere, Italy, 11-14.10.2003).

Tornikoski M: “ “15 years of AGN science with SEST: What have we learnt – and why am I here now?”, talk given at the Joint Astronomy Centre, Hilo, Hawaii, 7.11.

ICEAA Conference, Torino, Italy, 7-13.9.2003, P. Sjöman.

2nd eVLBI Workshop, Dwingeloo, The Netherlands, 14-17.5.2003, A. Mujunen, J. Ritakari.

EVN TOG Meeting, Madrid, Spain, 28.6-1.7.2003, J. Ritakari.

AMS Technical Interchange Meeting, CERN, Geneve, Switzerland, 27-31.7.2003, A. Mujunen, J. Ritakari.

EVN CBD and Board Meetings, Dwingeloo, The Netherlands, 13-12.12.2003., A. Mujunen.

The 1st Planck Extragalactic Working Group Workshop, London, United Kingdom, 15-16.9.2003, M. Parviainen.

8.3 National Meetings and Talks

Lähteenmäki, A., Valtaoja, E., Tornikoski, M., Parviainen, M., Torniainen, I., Urpo, S.: Planck extragalactic foreground sources: the Metsähovi/Tuorla quasar research team, Antares Final Seminar, Helsinki, Finland, 30.10.2003 (Talk by A. Lähteenmäki)

8.4 Public Relations

Space 2003 -exhibition 31.10-2.11.2003, A. Lähteenmäki, S. Urpo, A. Mujunen, P.-M. Saloranta, T. Hovatta, M. Koski.

General Metsähovi tours and short talks about radio astronomical research to many visiting groups, S. Urpo, H. Teräsranta, M. Tornikoski, E. Oinaskallio.

TV: 29.10. 17:10. YLE 1, Prisma, A documentary about quasar research at Metsähovi, M. Tornikoski and A. Mujunen (Replay on 31.10.)

18.11. A lecture about space-VLBI and quasars at the amateur astronomy association URSA, M. Tornikoski.

Lecture to the astronomy speciality group of the Anttila Junior High School: radio astronomical research, recent developments in astronomy, and the work of an astronomer, 9.1., M. Tornikoski

9 Personnel in 2003

Permanent Positions funded by the Helsinki University of Technology

Urpo, Seppo, Prof., Dr.Tech.	Director of the institute Docent	Seppo.Urpo@hut.£
Hurtta, Solveig, Ms.	Secretary, part time	Solveig.Hurtta@hut.£
Mujunen, Ari, Dipl.Eng.	Laboratory engineer	Ari.Mujunen@hut.£
Oinaskallio, Erkki, Mr.	Technician	Erkki.Oinaskallio@hut.£
Peltonen, Juhani, Dr.Tech.	Laboratory engineer, part time	jussi@kurp.hut.£

Scienti£c and Technical Staff Funded by Research Contracts

Hovatta, Talvikki, student	Research aid, full time 27.5-31.8.2003, part time from 1.9.2003	tho@kurp.hut.£
Koski, Minttu, Engineer	Research aid, part time Researcher from 1.6.2003	minttu@kurp.hut.£
Könönen, Prisse, student	Research aid until 30.9.2003	prisse@kurp.hut.£
Liljeström, Tarja, Lic.Phil.	Researcher, part time	tml@hut.£
Lindfors, Elina, M.Sc.,	Researcher, from 1.8.2003	
Lindfors, Timo	non-military service	lindi@kurp.hut.£
Lähteenmäki, Anne, Dr.Tech.	Researcher	alien@kurp.hut.£
Nieminen, Jussi, student	Systems administration, until 30.6.2003	
Nieppola, Elina, student	Research aid, 1.6-31.8.2003	
Parviainen, Mikko, student,	Research aid	pare@kurp.hut.£
Ritakari, Jouko, Dipl.Eng.	Researcher	jr@kurp.hut.£
Rönnberg, Henry, Mr.	Mechanic	
Saloranta, Pia-Maria, student,	Research aid, part time from 1.2.2003	pia@kurp.hut.£
Sjöman, Pekka, Dipl.Eng	Researcher, part time	psj@kurp.hut.£
Teräsranta, Harri, Dr.Tech.	Researcher	hte@kurp.hut.£
Torniainen, Ilona, Dipl.eng.	Researcher,	ilo@kurp.hut.£
Tornikoski, Merja, Dr.Tech.	Docent of Radio Astronomy and Space Technology Academy Research Fellow, Academy of Finland, Research Council for Natural Science and Engineeering	Merja.Tornikoski@hut.£
Tröller, Mirko, M.Sc.,	Researcher from 1.11.2003	mtr@kurp.hut.£

Metsähovi Advisory Committee

Korpela, Seppo, Dir.	Tanskanen, Pekka, Prof.
Pellinen, Risto, Prof.	Tiuri, Martti, Prof.emer., M.P. (Chair)
Somervuo, Pekka, Dr.Tech.	Urpo, Seppo, Prof. (Secretary)