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Metsähovi Radio Observatory
Annual Report 2002

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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 1992−1994. 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 10 $\cdots$ 150 GHz, and the corresponding wavelengths 30 $\cdots$ 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 2002 the total expenditure of the Metsähovi Radio Observatory was about 800 000 euros, including salaries. This was £nanced by:

Helsinki University of Technology 64 %
Academy of Finland 24 %
Others 12 %

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, Koistinen, Ritakari, Rönnberg, Sjöman

2.1.1 Planck 70 GHz Receiver

Project Team: Sjöman, Peltonen, Rönnberg

During year 2002 the EBB-phase (Elegant Bread Board) was completed in the Planck 70 GHz receiver's building project. The project was maintained as co-operation project between Metsähovi, Millilab and Ylinen Electronics as in the previous years. The participation of the Metsähovi Radio Observatory is mostly receiver building and some measurement equipment loans to Ylinen Electronics. In the EBB-phase a large number of measurements were done in the cryogenic chamber owned by Metsähovi.

A cryogenic 70 GHz highly integrated ultra low noise receiver was built and measured in the EBB-phase, Figure 1.

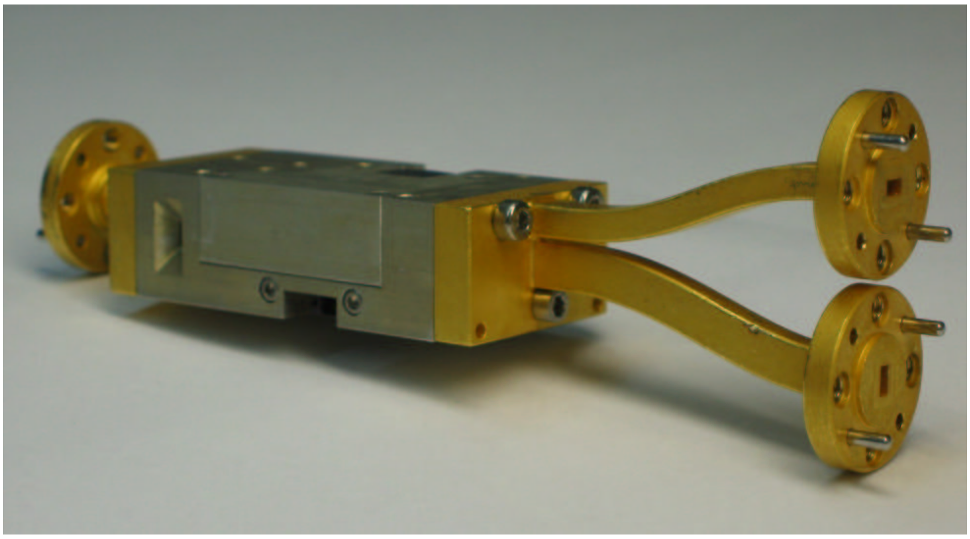

Figure 1: A ultra low noise Planck 70 GHz receiver front end Module with external waveguides.

The receiver front end module showed promising results giving more than 35 dB gain and about 25 K noise temperature between 63 and 77 GHz frequency bandwidth at 20 K physical temperature, Figure 2.

Also the Back End Module (BEM) was built and measured to have promising results giving about 70 dB(mV/mW) sensitivity factor using 20 dB RF gain and 20 dB video gain, Figure 3 and Figure 4.

2.1.2 3 and 2 mm SIS Receivers

Project team: Peltonen, Oinaskallio, Urpo

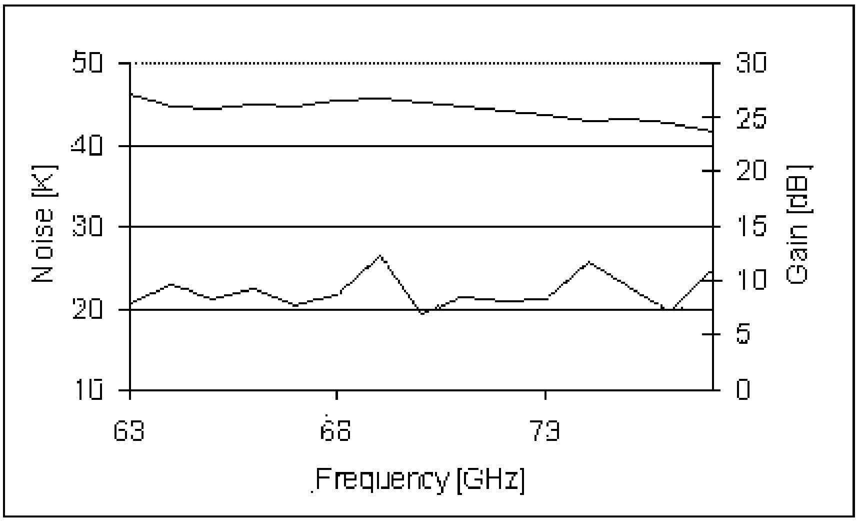

Figure 2: Planck 70 GHz front end module gain and noise at 20 K physical temperature. Upper curve is gain.

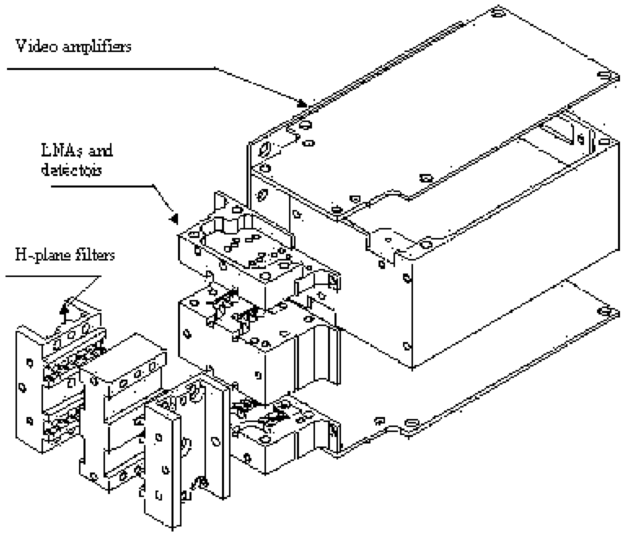

Figure 3: BEM layout structure.

The 2 mm SIS receiver borrowed from Instituto de Radio Astronomia Milimetrica (IRAM) was disassembled after the last 150 GHz VLBI session. All the parts (although the receiver is old it is still operational) were placed in a container and sent back to IRAM.

A new 2 and 3 mm SIS receiver has been ordered from Nizhny Novgorod, Russia. With this receiver at 84–115.5 GHz simultaneous circular dual-polarization measurements should be possible, at 129–160 GHz only right or left hand polarization can be chosen at a time. The receiver will operate in a SSB mode for both bands. As a local oscillator for the 3 mm band a Gunn diode oscillator is used, for the 2 mm band instead a BWO (with a high voltage power supply) generator had to be chosen. Both will be phase locked to the 5 MHz frequency standard. The receiver has a broadband (1 GHz bandwidth centered at 3,95 GHz) continuum output and standard VLBI outputs at 500–1000 MHz.

In 2002 a meeting with the Russian designers was arranged at Metsähovi to clarify the technical details of this complex receiver.

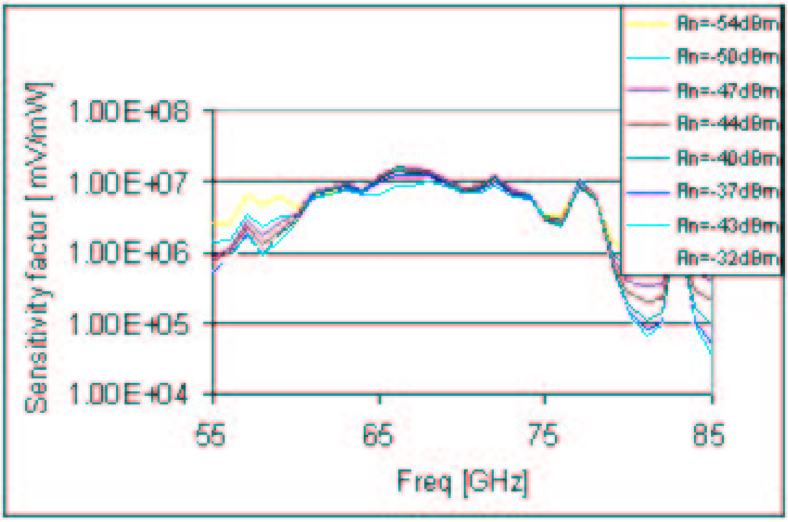

Figure 4: BEM one channel sensitivity factor with different input powers.

2.1.3 Geo-VLBI Receiver

Project team: Urpo, Oinaskallio, Peltonen, Könönen

Geodetic Observatory has ordered a new receiver from the TTI Norte, Santander, Spain which will be used at Metsähovi for geodetic VLBI observations. The receiver operates at two different bands i.e. 8.150–8.650 MHz (X-band, BW=500 MHz) and 2.210–2.350 MHz (S-band, BW=140 MHz). The right hand circular polarization can be observed for both bands. The system temperature of this receiver is around 80 K when the LNAs are cooled to 15 K and the bulky feed system and polarizers are at room temperature.

The receiver was delivered to Metsähovi in December by the TTI Norte personnel. Some mechanical changes to the receiver and a new, larger subre¤ector is also needed before the actual observations are possible.

2.1.4 Maintenance and Upgrades of Receivers

Project team: Peltonen, Urpo, Oinaskallio

Attempts to repair the right channel LNA for the 43 GHz VLBI receiver (originally designed at National Radio Astronomy Observatory, USA) were unsuccessful. The fourth stage seems to have a catastrophic failure and also the £fth stage showed instability problems.

In order to repair the dual channel receiver to be operational and reliable in the future completely new LNAs were ordered from Ylinen Electronics. These are based on the MMIC techniques with two cascaded INP-HEMT chips (each chip contains 4 HEMT stages). The frequency response is broadband from 40 to 46 GHz. At the center frequency of 43 GHz the gain and the noise temperature are (at cryogenic temperatures) 45 dB and 20 K, respectively. The receiver will be assembled with these new ampli£ers and the corresponding power supplies in 2003.

2.1.5 IT Infrastructure

Project Team: Mujunen, Nieminen

Sharpening the role:

During the year 2002 computer management (network and system administrators team) started to use special naming for IT operations called IT Infrastructure Management, ITIM. They added this acronym into their new system documentation, too. The expanded role of is re¤ected in changing the name of this chapter from “Computing Environment” to “IT Infrastructure” which better describes the new role of multi-hosted measuring and calculating. It is highly probable be that the role of networking and Internet will still become more important in coming years.

Segmentation of hosts into different administrative domains was started, mainly because a possible and probable upgrade path to network equipment for a future VLAN and Layer3 switched 1000/100/10 Mbit/s Ethernet environment. These segments are illustrated in Figure 5 which describes the Metsähovi network topology.

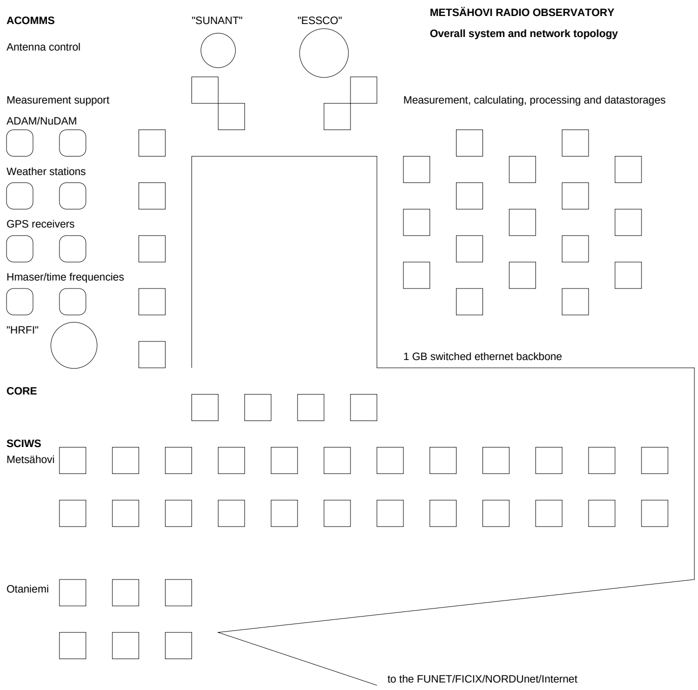

Figure 5: Overall system and network topology.

In Figure 5, the major segments are:

ACOMMS: Antenna hosts are now under ACOMMS, “Antenna control, maintenance and measurement segment”.

SCIWS: Workstations and special workstations are now under SCIWS, “Scienti£c Workstations”. These are the general-purpose hosts for individual users for performing everyday tasks.

CORE services: These are all critical IP and network services in Metsähovi in order to handle daily operations.

There has been no major changes in LAN area. Local area network is built upon a 1 GBit/s Ethernet backbone with switched 10/100 Mbit/s Ethernet for host links. There are still a couple of 10Base2 “thin Ethernet” NICs still in hosts. They will removed if favor of direct 10/100 Mbit/s Ethernet switch connections.

There were no changes in WAN gateways. However, for high speed measurement requirements such as e-VLBI, VLAN and Layer3 switching/routing plans are ready. Reservations for 1 Gbit/s both £ber and copper Ethernet links across the Metsähovi site are ready.

The host environment of Metsähovi continues to feature a full “OS rainbow”: DOS, Linux, MacOS, VAX/VMS, and Windows hosts are all being continuously used. Although the vast majority of computers run a version of Debian/GNU/Linux and MacOS and VAX/VMS are being phased out, some Windows hosts seem mandatory for running legacy applications as well as embedding DOS in a few control computers. Different OS revision levels makes updating sometimes a bit complicated. A well-documented esting procedure, the new system documentation structure and a good reference model help a lot in this process. Running platforms were partially updated to Debian 2.2 “potato” and 3.0 “woody”.

In “CORE Services” segment, the DHCP server was taken to test phase via Debian 2.2 upgrades and after roll-out testing it was taken to production use. All new (and upgraded) Linux and Windows hosts (except “CORE” hosts) receive their TCP/IP networking settings from the DHCP service. Full reliance on DHCP exclusively is waiting for the completion of upgrading all Linux hosts to at least Debian 2.2, preferably 3.0.

Identi£cation of “Scienti£c Tools”, a set of recommended software, license management (where applicable), and application guides to different measurement, research and production processes has started. As an example of this process, StarOf£ce 5.2 was tested but not accepted for production. Later in 2002, OpenOf£ce 1.0 was evaluated during summer and it was taken to supported stage with its packaged Debian version 1.0.1.

Towards end of the year new documentation started to get a formalized shape called ITSDS (IT System Documentation Structure). This includes regular IT system status reports will will be seen under the subcategory ITISTATR within the harmonized documentation structure.

2.1.6 New Hydrogen Masers

Project Team: Oinaskallio, Mujunen, Nieminen

Stable station time and a reliable frequency standard are the foundation of all of our measurement work. Our previous time/frequency system was based on a single EFOS-9 hydrogen maser frequency reference and we used GPS receivers to check and monitor the difference between EFOS-9 and GPS-transmitted UTC time.

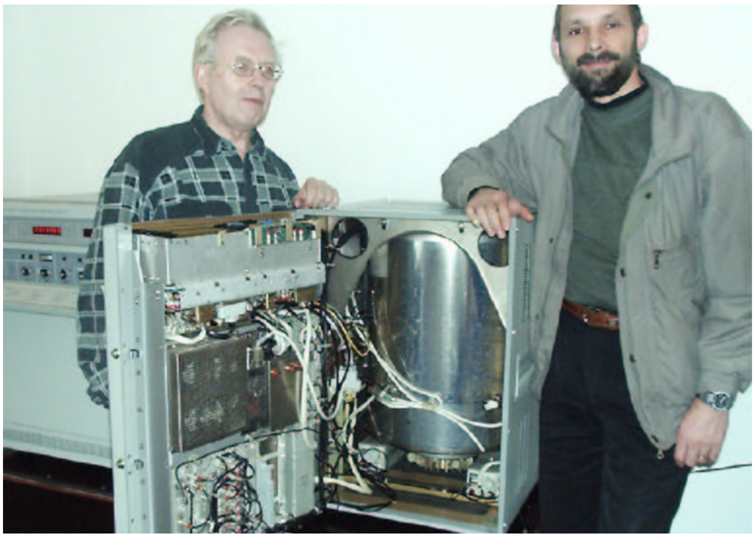

Figure 6: Installation team from Kvarz company.

Improvement of our frequency equipment begun with building a new “clock basement” to stabilize environmental in¤uence against the new H maser “clocks”. Operational environment in Metsähovi can vary between -30° and $+30^\circ$C so it was a challenge to build a stable room where both temperature and humidity are well-controlled.

We received two Kvarz “CH1-75” active H-masers from the Institute Of Applied Physics, Nizhny Novgorod, Russia. Two units, otherwise identical, were labeled “Kvarz-69” and “Kvarz-70” according to their serial numbers. After a calibration session they were ready for use.

The chart in Figure 7 shows how stable they are. It can be easily seen that Kvarz-70 (dark blue) is extremely stable when compared to GPS-HP (magenta, a time-recovering HP58503A GPS receiver). The older navigation GPS receiver, Magnavox (green), shows its typical peaks in the recovered 1pps timing pulse, and the ailing EFOS-9 (turquoise) is running completely its own ways. After the week shown in chart it did not operate any more and it was retired.

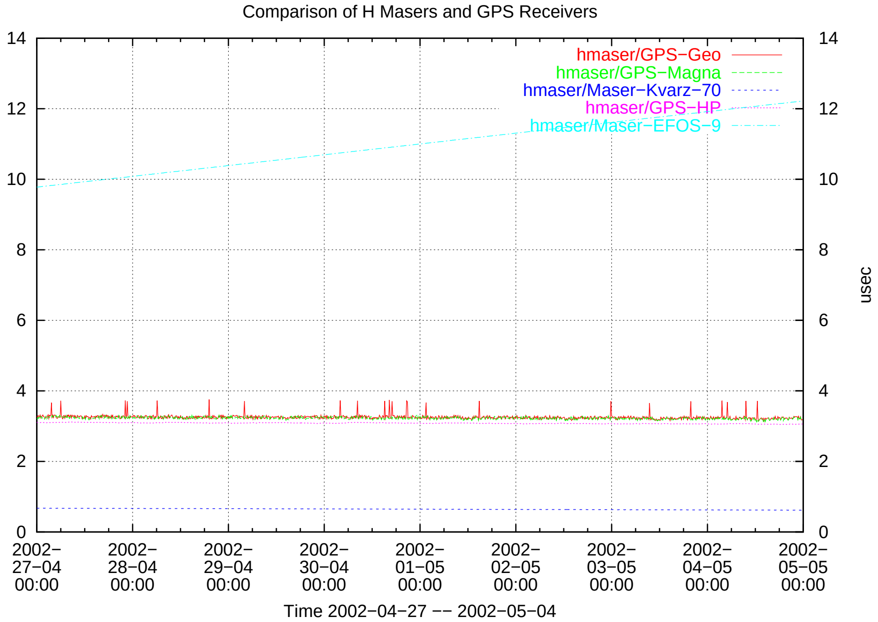

Figure 7: Comparison of different time/frequency standards at Metsähovi. Reference is made to the Kvarz-69 H-maser, 0 in y-scale where numbers are in μs.

In November we experienced problems with the Kvarz-69 as it stopped functioning. While still under manufacturer's warranty, the problem is being analyzed and the repair process is underway.

A possible future development is the development of £ber optic interfaces to the 1pps and 5 MHz signals of the new H masers. There might be advantages in using £ber technology instead of copper cables to avoid electrical interference. Currently the 1pps signal has been isolated with an optocoupler and the 5 MHz reference frequency with an isolation transformer.

2.1.7 The Development of New Observational Programs for Metsähovi

Project team: Könönen, Mujunen

Basic outline

The renewal of the observing system, including the update from the old micro-VAX computer into the Linux PC environment, has forced the solar and quasar continuum observing programs to be revised. Major changes in the observing system are its digitalization and decentralization. A single observing computer is no longer responsible for all tasks. In the renewed system separate observing sub-systems manage lower level operations such as antenna control, source positioning, and data sampling. The sub-system control and monitoring is available via computer network, since it is based on Linux PCs and Adam/NuDAM modules which are connected to Metsähovi LAN. Therefore new observing programs may function on a higher level, in a role of a "communicating commander".

If the new observing programs would be £xed like the old ones, it would be dif£cult to take the full bene£t of the modularity of the renewed observing system. Therefore a new approach was chosen. The old separate observing programs will be replaced by a command interpreter that executes any commands which obey the newly created observing program syntax and the new observing programs will be pre-written procedures which can be renewed and complemented if necessary. This approach offers ¤exibility and many means, as it makes updates, extensions, and new utilities easier to accomplish.

The basic requirements for the command interpreter and the syntax are: simple syntax that enables writing of “observing procedures” which allows reliable observing, communicative control of sub-systems, and tools for executing speci£c operations and monitoring the results.

The interpreter input is ASCII lines, which are read either from the online input or from a text £le. The syntax of each line determines whether the interpreter will execute it as a TCP command to an observing sub-system, a condition sentence, a timing command, a procedure de£nition or execution command, substitution, operation or as a perl evaluation sentence. In addition to this the interpreter must also provide various functions and procedures which perform essential tasks in astronomical observing (for example, pointing, calibration, source coordinate libraries, storage of data in FITS format, and graphical monitoring of the data).

The interpreter is programmed in Perl programming language that has excellent text manipulating capabilities and allows ¤exible exploitation of various other utilities such as system commands, C programs, and plotting utilities.

Project status

As the year started a simple test version of the command interpreter already existed. During the year 2002 this project continued periodically. Several update versions of the interpreter were written and the syntax was preliminarily speci£ed. By the end of the year the command interpreter managed most of the basic syntax interpretation and command evaluation. Procedure de£nition and execution were partly untested, and array structure and more sophisticated utilities (for example, data conversion into the FITS format, pointing, source coordinate libraries) were still missing.

The interpreter was tested in action in two occasions during the year 2002. Pekka Puhakka used a very early interpreter version for the 2m solar radiometer measurements. Another test occasion was in spring when the pointing and calibration were determined for the 2 mm VLBI experiment. These tasks were complicated by the complexity of the receiver and by the fact that the new back-end system turned out to be yet un£nished. Only a temporary voltage regulator card enabled the test usage. During the rest of the year 2002 further testing of the interpreter was executed by “virtual observing”, i.e. by directing all TCP commands to a server program that had been written speci£cally for test purposes.

The £nal location of the interpreter will be at the directory “`/local/meacon/`” of “meacon” Linux PC. Meacon is located in the middle of the control room racks and it is connected to the Metsähovi LAN. Meacon had a mounted access to "data:/data" directory and in early 2002 the access to “`kurp:/home/`” was also granted. This makes observing data and user home directories available for meacon. The interpreter utilizes several Debian Linux packages of which some are critical like Perl Data Language (PDL) that provides fast array-oriented numerical operations and basic utilities for handling data in FITS format. Due to the on-going Debian Linux updates, requested program packages had not yet been installed to meacon by the end of the year.

The timetable estimate is that that the new observing programs will be taken into usage in May, 2003.

2.1.8 Development of Next Generation VLBI Recording Systems

Project team: Ritakari, Mujunen

During the year 2001 it became obvious that the speed and capacity of normal personal computers and hard disks would quickly surpass the tape-based recorders normally used in VLBI.

MRO started a project to develop a commercial-off-the-shelf VLBI data acquisition system.

The development was based on the following assumptions:

- MRO will only develop minimal data acquisition hardware. Commercial companies take care of the personal computer development.

- Data is treated as normal £les in Linux £lesystem, not as special VLBI data.
- The system must be low-cost and scalable. Because the cost of one data acquisition system is low, several units can be used to achieve high data rates.
- The system must support common VLBI standards: Mk4, VLBA, VSI-based gigabit VLBI and S2.

The data acquisition system would consist of two hardware modules: An VSI-H standard compliant data acquisition board for a personal computer and a multi-standard to VSI-H converter module.

The PCB design of the prototype data acquisition and converter boards was completed in January, the boards were assembled and tested in February-March and the design was adopted for mass-production in April. One £nal production-quality VSIB data acquisition board is shown in Figure 8.

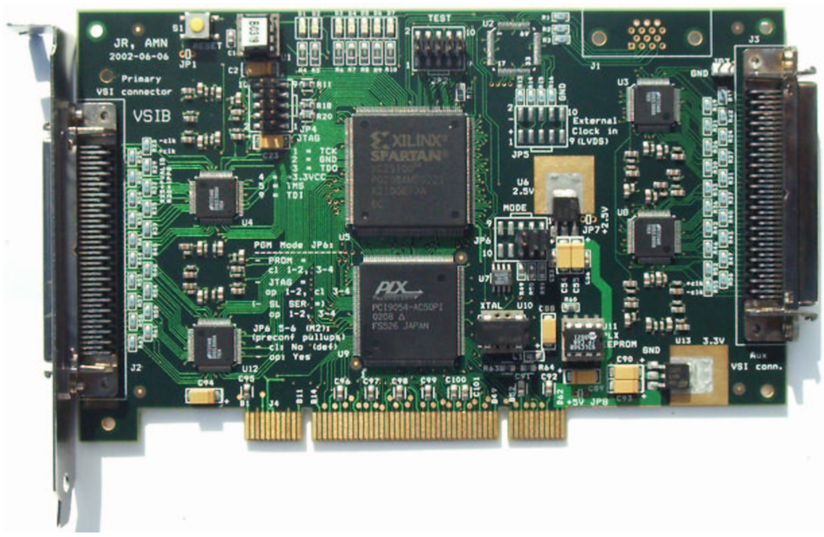

Figure 8: VSIB PCI-based VSI-H data acquisition board.

The operation of the data acquisition system was demonstrated at JIVE, Netherlands in July. A series of 93 data acquisition and converter boards were produced at the start of August using the automated SMT production line of the HUT Laboratory of Electronics Production Technology.

The MRO data acquisition system was successfully tested in the Jodrell Bank Observatory - JIVE e-VLBI demonstration in September.

In October 16th, Metsähovi and Kashima Space Research Center performed the world's £rst intercontinental gigabit e-VLBI experiment using the MRO developed data acquisition system at Metsähovi and the Japanese PC-VSI2000-DIM data acquisition system at Kashima. The prototype equipment is shown in Figure 9.

2.1.9 Solar Monitoring Telescope

Project Team: Urpo, Mujunen, Sjöman

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.

Figure 9: The two-PC prototype used to record gigabit VLBI data.

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 substracted.

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. Some examples of observed events are included in chapter 2.6.3.

2.2 Extragalactic Radio Sources

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

2.2.1 Monitoring of Quasars

Project Team: Teräsranta, Iso-Markku, Koivisto, Wiren

The quasar monitoring with the Metsähovi radio telescope continued for the 22nd year. Even the observing time was cut nearly to half from the previous year, the project still managed to outnumber last years observations. This was mostly due to the long dry season. Also the salaries for the observers were cut deeply, which resulted to mostly automatic observations during the second half of the year. The total number of observations since 1980 is now over 52000.

The preparation of the new larger sample for supporting the next gamma-ray observatories, AGILE and GLAST continued. Higher radio frequency monitoring of quasars is essential for the success of those observatories. Our studies of the mm-properties of earlier detected gamma-ray sources have indicated, that the common selection criteria is a ¤at spectrum to very high radio frequencies. From the ¤at spectrum result some other properties, like Blazar type behaviour with frequent ¤ares and also the ejection of superluminal components, which can be tracked with VLBI observations. The gamma radiation is supposed to form just in the beginning of the millimeter ¤are, as the new blob is seen to emerge from the core of the Blazar. To better detect the fresh components, one should use the highest possible frequency and largest possible base-line.

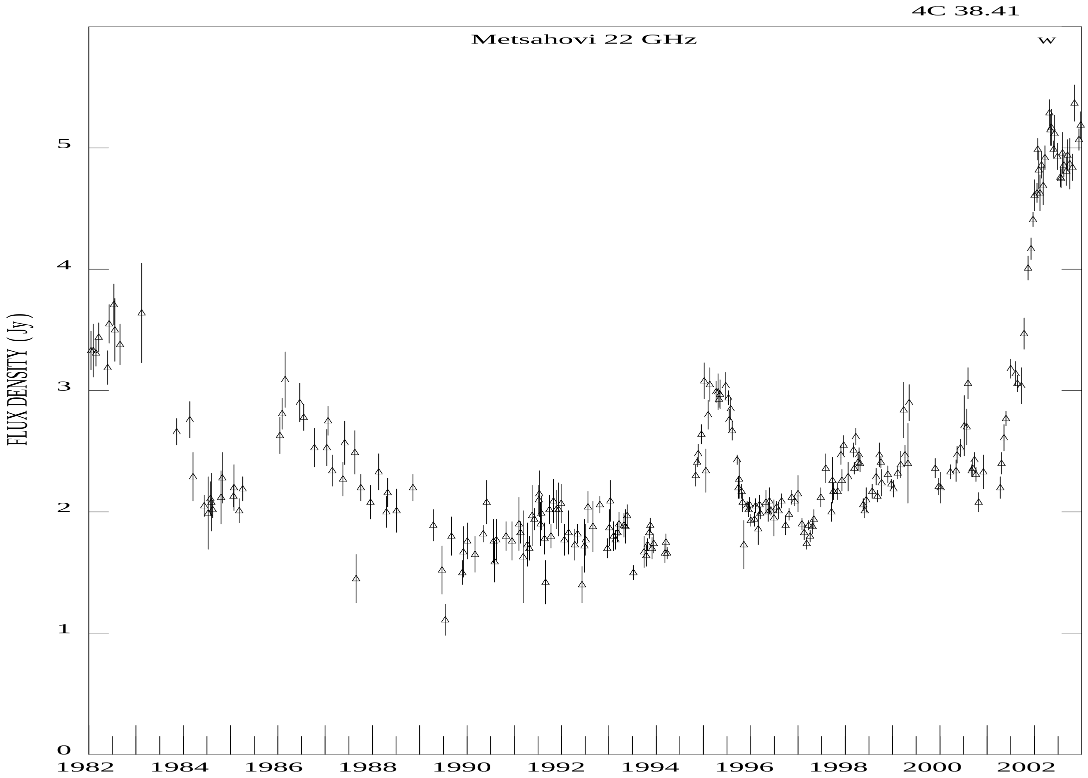

Figure 10: The ¤ux density of the quasar 4C 38.41 at 22 GHz since 1982.

Space borne 22 and 43 GHz VLBI observations would be needed.

Collaboration with optical observatories has been mostly through the WEBT, which is also strongly supporting the AGILE mission. In the radio regime common programs with the teams of Thomas Krichbaum and Heino Falcke have continued. In Figure 10 is shown the weekly mean ¤ux density of 4C 38.41 since 1982, which has lately received a lot of attention, mostly in the radio bands due to the longlasting outbursts peaking at very high frequencies. Periodic variations in some sources have been studied with T. Paytunina.

In the VLBI area, the long term monitoring project observing gamma-ray detected Blazars with the VLBA at 22 and 43 GHz lead by Alan Marscher was also supported.

In the end of 2002 the X-ray satellite Integral was launched. Even its frequency band is not reaching the harder gamma-ray area, which should be best correlated with the millimeter behaviour of quasars, our team has still been asked to support some observations.

2.2.2 AGN Science

Team: Tornikoski, Lähteenmäki, Jussila, Parviainen, Saloranta, Virtanen, Hakala, Ranta, Valtaoja (Turku), Lainela (Turku)

Gamma-ray and radio emission in AGNs

We have studied the relationship between radio and gamma-ray emission in AGNs to £nd out by which mechanism the gamma-ray emission is produced in these sources.

According to our study the strong gamma-ray emission clearly occurs after the formation of the radio shock in the relativistic jet. Thus the site of the gamma-ray emission must be at a distance from the point where the jet starts. We have calculated the time delay from the onset of the mm radio ¤are to the gamma-ray detection (for strong detections), and the delay we get is approximately two months. This translates into a linear distance of about 5 pc from the AGN core, well outside the accretion disk or even the broad line region usually considered to be responsible for the gamma-ray emission.

Whether gamma-ray emission is detected or not, depends also on the type of the source. Most detected sources are high polarization quasars, or even low polarization quasars, but BL Lac objects are observed to be weak at gamma-ray frequencies. This leads us to conclude that strong gamma-ray emission in quasars is produced by the synchrotron self-Compton mechanism in the same shocks in the relativistic jet that also produce the radio ¤ares. The weaker ‘baseline’ gamma-ray emission detected from BL Lac objects and some quasars could be produced by the external Compton mechanism.

We have also studied the sequence in AGN properties according to the observed synchrotron peak frequency ν_{peak}, suggested by Ghisellini et al. (1998, MNRAS, 301, 451). Preliminary results suggest that the properties of the sources change according to increasing ν_{peak}, from high and low polarization quasars to BL Lac objects. We also found that as the ν_{peak} increases, the Doppler boosting factor and Lorentz factor both decrease but the viewing angle, the Compton dominance (simply calculated as the relation between gamma-ray and radio emission), and the luminosity increase. However, one should bear in mind that our sample consists almost exclusively of quasars while other studies, e.g., Ghisellini et al., have used a mixed sample of both quasars and BL Lac objects.

The synchrotron peak frequencies that are presently available are not suf£ciently accurate because of the almost complete omission of radio data in the spectral £ts. We are currently looking into £tting also the radio part of the spectra of a sample of sources in order to obtain reliable estimates for the synchrotron peak frequencies.

We also continued our work on the radio-to-gamma -connection of the EGRET sources that were not £rmly identi£ed with known AGNs. Our observations con£rmed that many of the sources assumed to be relatively faint at high radio frequencies (90, 230 GHz) – and thus always excluded from the earlier millimetre studies – were actually brighter than expected, especially close to the EGRET observing epochs. Since there seems to be a clear connection between the activity in the millimetre and gamma domains, £nding sources close to the EGRET position being in an active radio state when they are detected in gamma-rays makes them promising candidates for the identi£cation.

Our paper about Southern EGRET sources and candidates was published in 2002. In this paper we were able to con£rm the identi£cation of several sources classi£ed as “possible identi£cations with an AGN” in the Third EGRET Catalog, and suggested a handful of new AGN counterpart identi£cations for the previously unidenti£ed EGRET sources. (See Figure 11.) We presented these results at the High-Energy Blazar Symposium held in Turku in June, together with some suggestions for using the information about radio-to-gamma connection in triggering Target-of-Opportunity observations with gamma-ray satellites.

We have recently started applying the theoretical knowledge gained in the interplanetary transport and acceleration of energetic particles to jets and shocks in active galaxies. This work is a collaboration with the Turku University and is led by Dr. Rami Vainio.

In 2002 we were also preparing for the INTEGRAL gamma-ray satellite’s observations. Our team members are co-investigators in many INTEGRAL observing projects, and we are also offering ground-based multifrequency support in the form of radio observations with SEST and Metsähovi. In December we started our frequent monitoring of the INTEGRAL sources accepted for the £rst observing period.

Inverted-spectrum sources and candidates

In 2002 we continued our study of inverted-spectrum radio sources.

Ilona Jussila’s £nished her Master’s thesis work on Gigahertz Peaked Spectrum (GPS) sources. The original goal of the thesis was to identify new GPS sources and to study the variability of the known ones. After gathering data from the literature and observing the source sample with both Metsähovi and SEST telescopes

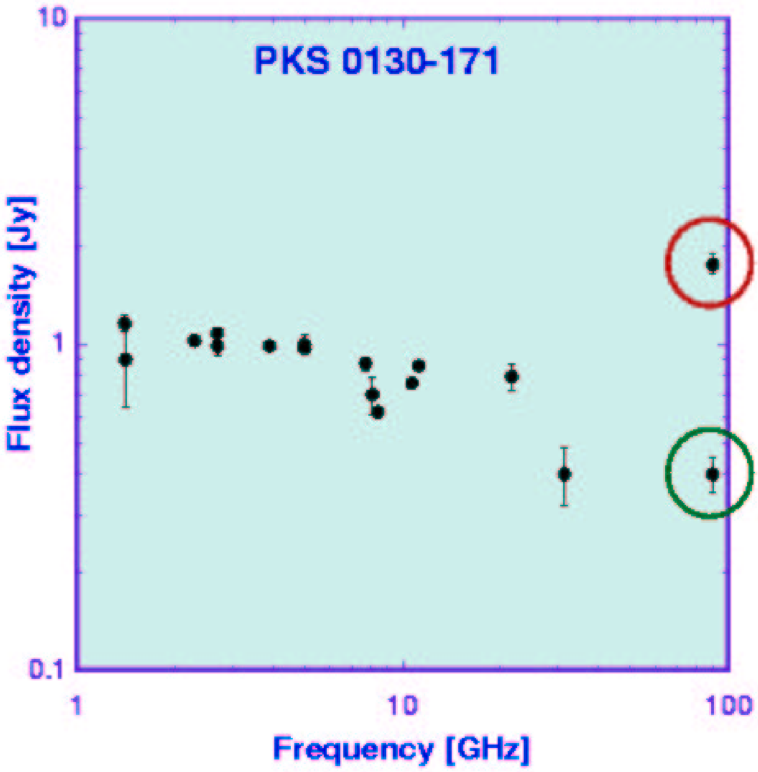

Figure 11: The typical radio spectrum of an AGN is falling at high radio frequencies, which would mean a 90 GHz data point like the one indicated by the green circle, observed in 1986 by Steppe et al. (A&AS, 1988). The red circle, however, shows a 90 GHz data point observed by our group in 2000. Even though there are now only two high-frequency data points available, we can see that the source PKS 0130−171 can be highly variable in the millimetre domain and is also a good candidate for gamma-ray activity.

we were able to identify six new inverted-spectrum sources (see Figure 12). However, we noticed that almost a half of the studied “bona £de” GPS sources really have a ¤at spectrum and the earlier convex spectral shape was only due to selection effect.

This study revealed most of the known inverted-spectrum sources to have characteristics differing from the original classical concept of GPS sources: the variability of the GPS sources is said to be insigni£cant but the sources we observed turned out to be even strongly variable at high radio frequencies. The samples, which have been used when deciding the de£nition for the GPS sources, have included sources that genuinely do not have an inverted spectrum and this has caused over-interpretation of the characteristics.

Prompted by the interesting results in Ilona Jussila’s thesis, we have now extended our observing sample to include a yet larger set of inverted-spectrum quasars and candidates. We are also studying a comparison sample of inverted-spectrum galaxies, sources that have rarely if ever been observed at the higher radio frequencies.

The GPS project is an important part of our Planck foreground work (see also section “Planck Science”).

<u>High-peaked BL Lacertae Objects</u>

The two main BL Lacertae Object (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

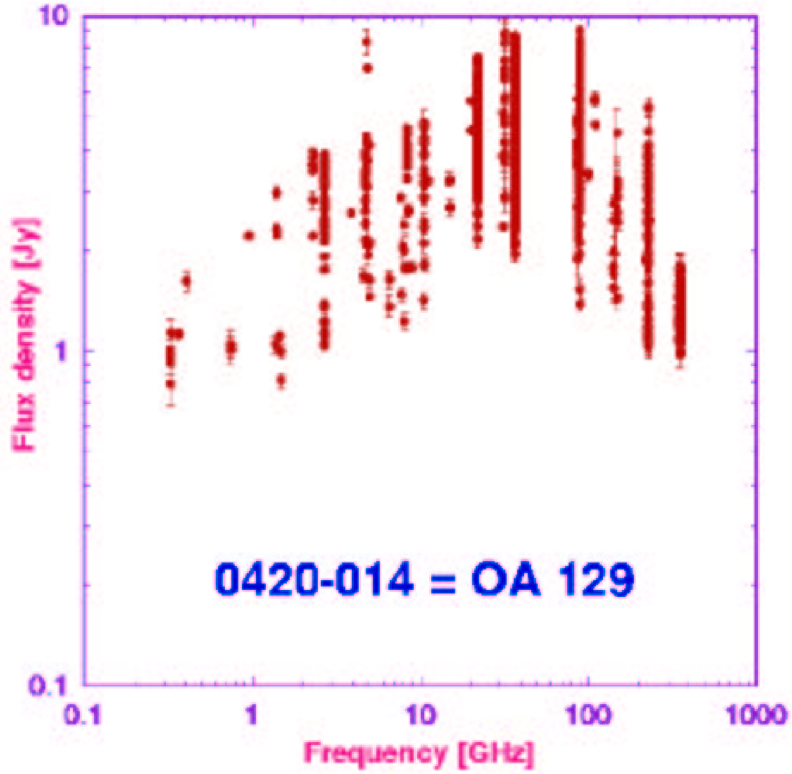

Figure 12: B0420-014: This new high-peaking inverted-spectrum source is very variable at all radio frequencies and still the spectral shape remains inverted at all stages of activity.

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. If we study a full sample of BLOs, we can 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 we can see if there is a continuity from subsample to subsample and if this £ts within the framework of the uni£cation models.

We started to observe a large sample of IBLs and HBLs in 2001, and the work continued in 2002. By the end of 2002 we had covered roughly 2/3 of our original sample. The preliminary analysis of the data is foreseen for summer 2003.

The BLO project is an important part of our Planck foreground work (see also section "Planck Science").

AGN variability statistics

We have compiled a large set of variability data from our high radio-frequency SEST observations and are working on the variability statistics. This work is part of the Planck foreground science, especially related to the investigation of the triggering criteria for the Planck's Quick Detection System that our group is responsible for (see "Planck Science" for more details). The results from our SEST analysis will be published in 2003, along with our complete SEST data sets. We will extend our analysis to also lower frequencies and larger source samples.

AGN classi£cation

We have investigated the use of some advanced methods for studying the classi£cation of AGNs. Using a sample of radio variability data from our own observations of Southern sources, complemented with data from the literature, we studied how the various sources fall into groups without any *a priori* assumptions about their group memberships. The methods we investigated included advanced statistical methods like the Principal Component Analysis and Cluster Analysis, and the neural network-based Kohonen Self-Organised Map. We will continue the use of some of the most promising methods and investigate their applicability to other £elds of AGN research, including activities related to our Planck foreground work.

2.3 Planck Science

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

2.3.1 Introduction

The Planck satellite is a mission capable of mapping the whole sky at several radio wavelengths. The ultimate purpose of the satellite is to measure the cosmic microwave background (CMB) radiation, but at the same time all foreground radio sources in the sky, including extragalactic radio sources, will be measured, too. Thus the by-products of the CMB map cleaning process, the foreground source maps, will be useful scienti£c results in themselves. The satellite launch is scheduled for February 2007.

Our Planck Extragalactic Radio Sources research team consists of scientists from both Metsähovi Radio Observatory and Tuorla Observatory (University of Turku). There were two main tasks for our team this year. First, to see through the of£cial kick-off of the Extragalactic Radio Sources Work Group (i.e. WG 6), and to maintain and possibly increase our involvement and responsibilities in the work group. Second, to start actively developing the quick detection system. Smaller tasks include various aspects of scienti£c work and collaboration with other Planck researchers in Europe and in the US. Our team was also well represented at the Planck Joint Consortium Meeting in Santander, Spain, October 14 – 16 (A. Lähteenmäki, M. Tornikoski, M. Parviainen)

2.3.2 Extragalactic Radio Sources Work Group Kick-off

The kick-off meeting of the Work Group 6 took place in Paris, France, November 25 – 26. Our team was represented by A. Lähteenmäki. The purpose of the meeting was to de£ne of£cial work packages and the people responsible for them.

Various members of our team were trusted with several leaderships of these work packages. The Work Group 6.1 (Quick Detection System), including subgroups 6.1.1 – 6.1.8, is the exclusive responsibility of our team. We are also responsible for arranging the supporting observations at the RATAN-600 facility (as part of 6.2.1, Pre-launch surveys in support of the Planck mission), arranging all supporting observations of BL Lac and related objects such as faint QSOs (as part of 6.2.3, Supporting observations of known sources), and for Herschel follow-up of strong variable sources found in time ordered data (6.4.4). We are actively participating in supporting observations of GPS and rising spectrum sources (as part of 6.2.3), supporting optical observations (as part of 6.2.3), developing special routines to examine, e.g., slowly variable sources (6.3.4), developing simulations of time ordered data for variable sources (6.5.5), and in several liaison tasks. An important scienti£c effort on our part will also be assisting in the compilation of the Planck Pre-launch Point Source Catalogue. The catalogue itself will most likely be constructed within the NASA/IPAC Extragalactic Database (NED). Responsibilities for work packages that are to be completed during or after the ¤ight of the satellite (exploitation of results etc.) have not yet been de£ned.

The tentative schedule of the most urgent work packages shows that our team is actively involved in all work in the scales of 3 months, 6 months, and up to one year. This urgent work of all members of WG 6 will be reviewed in the dedicated WG 6 meeting in London in September 2003.

2.3.3 Quick Detection System (QDS)

This special software will be used for detecting strong, possibly ¤aring, radio sources in the time ordered data stream of the Planck satellite within two or three weeks from the time of the observation. This is essential for follow-up observations since the actual data product of the satellite will not be available until after two years after the mission has started, and even the Early Release Compact Source Catalogue (ERCSC) is available only approximately nine months after the £rst full sky observation cycle has been completed.

The development of the system has started from both theoretical and technical sides. The theoretical problems include, for example, de£nition of the criteria of when a source is interesting (i.e. strong) enough to trigger follow-up observations, avoidance of false alarms, and the handling of incoming data. The technical work packages concerning the development of the actual software were de£ned together with the Low Frequency Instrument (LFI) Data Processing Centre (DPC) in Trieste, as this work will be our common effort. M. Parviainen, who is in charge of the software development, has visited the DPC twice during 2002, and good working collaboration has been established.

2.3.4 Scienti£c results

Our dedicated Planck-related observing programmes (already over 300 sources observed) have produced interesting, new results concerning source populations like GPS sources and BL Lac objects. (See 2.2.2 ”AGN Science“ for details)

2.4 Observations with Other Facilities

SEST: 23.-28.8. “Millimetre Observations of High-Peaked Southern AGNs”, P.I. M. Tornikoski, Observers: I. Jussila, M. Lainela.
20.-21.12. “Millimetre to High-Energy Connection in Blazars”, P.I. M. Tornikoski, Observer: A. Lähteenmäki.

VLBA: 11.-12.9. “PKS 0521-365”, P.I. S. Tingay, Co–I M. Tornikoski

HALCA: 5.-6.2. “Two-epoch 5 GHz observations of PKS0506-612 and PKS0522-610”, P.I. P. Edwards, Co–I M. Tornikoski.

Observations with the VLA: 3 times during the year 2002: A. Brunthaler et al.: “Monitoring the radio-intermediate quasar PG2209+184”

Observations with the VLBA network: one observation during the year 2002: T.P. Krichbaum et al.: “VLBA Monitoring of 1633+382 during a major millimeter-¤are”

2.5 VLBI Observational Activities

Research Group: Könönen, Mujunen, Ritakari

2.5.1 Geodetic VLBI Project

Project Team: Urpo, Ritakari, Mujunen, Könönen, Oinaskallio, Paunonen (Geodetic Institute)

Finnish Geodetic Institute’s project to start geodetic VLBI observations at Metsähovi advanced. The supply of six new BBCs was received from Signatron in April and tested by the staff of Geodetic Institute under the supervision of Jouko Ritakari by the end of October. Also the construction of the new 1.7m secondary mirror for S/X observations was completed in October. The work was done by Finnish ET-Tuote (Juva, Esa Takkinen) based on the design of TTINorte, Spain. The new mirror still lacks an antenna support. The ordered

S/X receiver arrived from Santandor, Spain, in December (see chapter: Geo-VLBI Receiver). The man-power at the Geodetic Institute is very limited, the person-in-charge for the project is the director of the institute, Matti Paunonen. The optimistic approximation is that geodetic VLBI observations will start at Metsähovi by the end of the year 2003. Contact person for this project is Dr Matti Paunonen, Finnish Geodetic Institute.

2.5.2 Station Hardware/Software

Project Team: Könönen

Field System Updates

A new FS version 9.5.3 was installed at Metsähovi in April. Since then several update versions of FS have been distributed.

GPS Clock Offset Data

At Metsähovi the stability of the station frequency reference is monitored against several clocks. The clock offset data has so far been produced by VTT ATA clock comparator. The old comparator will be replaced by a new one of Metsähovi design by the end of the year 2003. A student, Minttu Koski, from the Helsinki Polytechnic, “Stadia”, is doing her graduate thesis in Metsähovi on the subject under the supervision of two Metsähovi employees, Ari Mujunen and Erkki Oinaskallio.

Normally the stability performance of a H-maser is monitored against a Global Positioning Satellite System (GPS) clock. The time difference is called GPS clock offset. Since 1996 EVN has required that all its member institutes log their daily GPS clock offset data monthly to a common FTP archive for the correlator use. At Metsähovi the reference GPS clock is HP58503A GPS clock which is compared to the station frequency reference. The clock offsets have been monitored by using a separate CGI program and the creation and transfer of the GPS clock offset logs has required manual usage of an old matlab script and FTP program.

Due to two new Russian Kvarz H-masers the old clock offset scripts needed to be modi£ed. It was decided that the modi£cation would be done more thoroughly. In order to synchronize data formats, short scripts were written to automatically produce clock offset logs in Metsähovi data format from the log £les in “clod” format. This conversion made the clock offset data available for the common Metsähovi data browsing CGI-program, “MB”. Furthermore, due to a newly built optimized maser cave and good reputation of new H-masers, it was considered that the moment was suitable for writing a perl script to automatize the creation and transfer of monthly clock offset log £les to the EVN archive. These scripts are executed automatically by using “cron”, a management utility for regular background processing.

A laboratory report “Monitoring the GPS clock offset at Metsähovi Radio Observatory” will be published in Metsähovi Reports Series HUT-KURP in the beginning of the year 2003. It describes new scripts more thoroughly.

New BBCs

The supply of six new BBCs was received from Signatron in April. Metsähovi Radio Observatory took care of their installation to the VLBI rack. (Plastic BBC edges had to be cut in order to £t the BBCs into the rack.) The BBC testing was done by October by the Geodetic Observatory.

New H-Masers and Maser Room

The construction of a new isolated maser room was completed in January. By May it was found out that the temperature control system of the cave had to be revised. The local constructor was in charge of the required operations which were completed by November.

Metsähovi received two new Russian Kvarz H-masers in April. The installation took less than a week. The Russian H-maser, Kvarz-69, replaced the old EFOS-9 H-maser as the station frequency reference. The other Russian H-maser, Kvarz-70, is used to monitor the performance of the Kvarz-69 and, if necessary, to tune it by using automatic frequency control.

By the year 2002 the EFOS-9 H-maser functioned with an external turbo pump only and in May it was £nally shut off.

Receivers

The 22 GHz and 86 GHz receivers are functioning as before.

The 43 GHz receiver is being repaired for its broken RCP HEMT. A new pair of 43 GHz (LCP/RCP) HEMTs was purchased from the “YLINEN Electronics Ltd.” in September. The installation of the new HEMTs is still pending. In October Olli Koistinen, a former Metsahovi RX specialist who is currently working for Nokia, took the LCP HEMT bondage into examination one more time.

An old 150 GHz SIS receiver that was borrowed for the 2 mm VLBI experiments from Pico Veleta, IRAM-Spain, was returned to PV in December. During the second 2 mm VLBI experiment in April there had been more signs of the RX aging, for example, an external vacuum pump and a helium re£ll every other day were needed.

Metsähovi has ordered a new dual-feed, dual-polarization 80-115/150 GHz SIS receiver from Nizhny Novgorod. The expected delivery will be in 2003. The new receiver will replace the old 86 GHz RX.

Recorder

After the 2 mm experiment feedback it was decided that Metsähovi will not use thick tapes in the future. It is known that some of the recorder tracks are corrupted. In autumn Jouko Ritakari and Ari Mujunen investigated the recorder for £nding out if the recording quality can be improved. The head stack was found to be slightly (app. 20 micrometers) but not dangerously (app. 30 micrometers) worn out. The second head installation is still pending.

Ventilation of VLBA/4 rack

New cooling fans were installed to the BBC rack in April. In September the BBCs were blow-cleaned, guiding walls were added to the BBC rack, and even more ef£cient cooling fans were installed to both BBC and MK IV formatter racks.

2.5.3 VLBI Sessions in 2002

Project Team: Könönen, Mujunen, Ritakari

The second 2 mm VLBI experiment was organized in April with Pico Veleta (Spain), SEST (Chile), Heinrich Hertz Telescope (HHT, Arizona, U.S.) and Kitt Peak (KP, Arizona, U.S.). Metsähovi used again a He-cooled 150 GHz SIS receiver, a 150 GHz noise generator and a LCP quarter-wave plate that were all borrowed from PV. The 2 mm experiment PI Albert Greve from IRAM-France visited Metsähovi in 4.4 - 9.4 and Dave John from PV in 2.4 - 9.4 for the receiver setup and calibration. The observations were performed in 18.4 - 19.4. At Metsähovi weather conditions were mostly good during the three day session but half of the observing time was lost due to following reasons: a helium re£ll in the middle of the session, SIS chamber pressure instabilities and RX speci£cations that restricted antenna’s maximum elevation to 35 degrees. Almost all scans on the strongest source, i.e. 3C 279, succeeded. The data were correlated in Bonn. Transcontinental fringes of two sources (1633+382 and 3C 279) were detected on consecutive days with SNR 20-75 on baselines HHT-KP-PV. Two other sources (3C 345 and NRAO 150) caused a fringe detection with SNR 7 on the transatlantic baseline HHT-PV on a single day. On the baseline Metsähovi-PV only the source 3C 279 was detected with SNR 7. Weaker sources were undetectable. In 2001 2 mm experiment both 3C 279 and 3C 273 were detected on the baseline Metsähovi -PV on each observing day with SNR 10. The major reasons for the degraded performance of Metsähovi were bad recorder head tracks combined with thick tape recording in barrel rolling mode. As much as 75 % of the recorded data was lost. The £nal results from the experiment are still pending.

CMVA organized two observing sessions in 2002, one in April and another one in October. Metsähovi did not participate in either one due to the limited staf£ng.

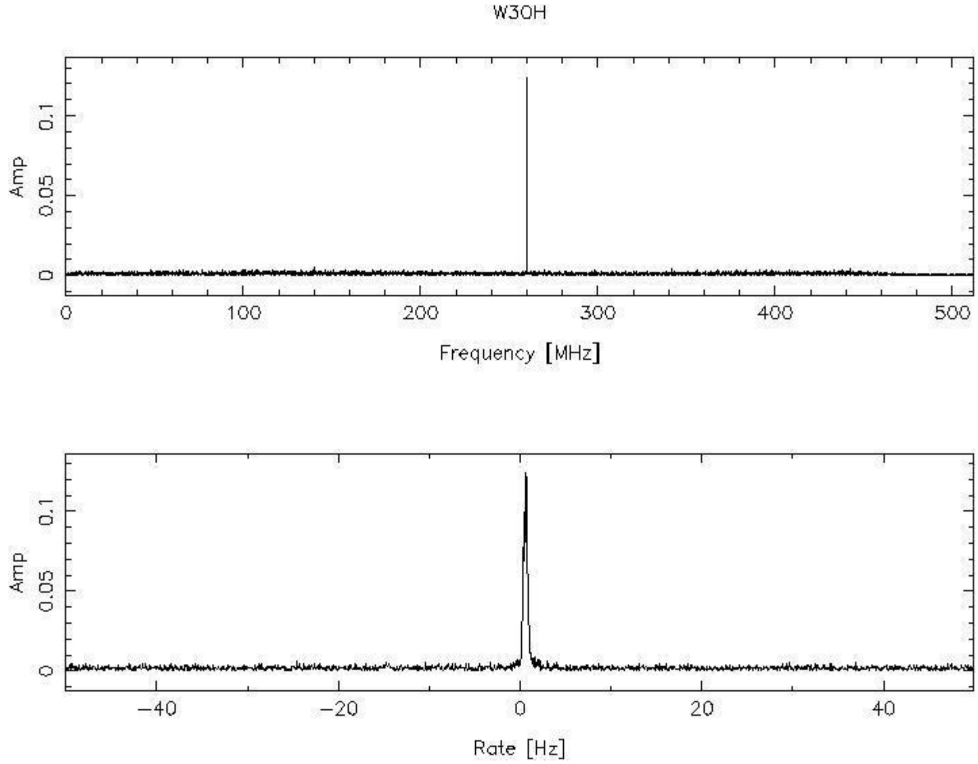

Figure 13: The fringes of the maser source W3OH were found at the Kashima-Metsahovi e-VLBI 1 Gbit/s 22 GHz experiment (the baseline was about 8500 kilometers).

In October Metsähovi performed a successful 1 Gbit/s e-VLBI experiment at 22 GHz together with the Japanese Kashima 34m telescope. This was the £rst successful transcontinental 1 Gbit/s VLBI experiment ever. Although weather was not optimal at either one of the stations, the experiment went smoothly. Both Metsahovi and Kashima used direct IF sampling. The IF band from 0 to 500 MHz was sampled with the CRL / Digitallink ltd. ADS-1000 samplers at 1G (1024M) samples/s rate. The Kashima team recorded the data with the CRL PC-VSI disk-based recorder equipped with PC-VSI2000-DIM data acquisition board working at 1G (1024M) bit/s speed. At Metsähovi the data was recorded with the VSIB system. Data was stored in normal Linux £les that were transferred to Japan with normal networking tools. Data was correlated in Kashima with a high-speed software correlator. No data conversions were needed since the £les contained raw sampler data starting at the hydrogen maser 1PPS marker. Fringes were found in exactly the place predicted by the GPS-hydrogen maser 1PPS time difference.

EVN only organized one VLBI session at 22 GHz in 2002. This was held in November. Metsähovi participated in the session, although the weather conditions were not favourable, it was snowing most of the time. Despite this, fringes were found in the Network Monitoring experiment N02K1. The playback data quality in tracks 23–33 is next to unusable.

In November Metsähovi and Jodrell Bank made a joined effort for an European 1 Gbit/s VLBI experiment using VSIB card systems. Unfortunately the experiment failed due to problems in the LO of Jodrell Bank 22 GHz receiver.

2.6 Solar Research

Research Group at Metsähovi: Urpo, Koistinen, Puhakka

2.6.1 Solar Observing Campaigns

Project Team: Urpo, Puhakka, Hurtta

Solar observations continued at Metsähovi in 2002. Receiver working at 37 GHz was used. Number of observing days was 44. More than 100 solar radiation maps were measured and active regions were tracked for more than 200 hours in order to detect energy burst and releases at radio waves. 47 main events were detected. Analysis of measured data continued in international cooperation.

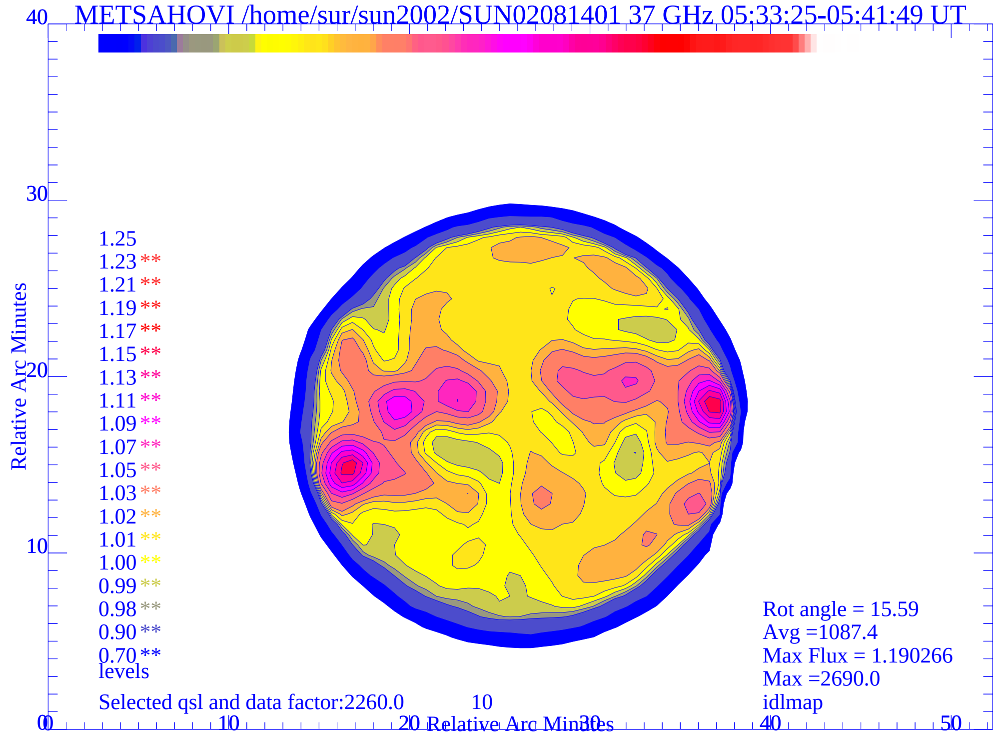

Figure 14: Solar map measured on August 14, 2002, frequency = 37 GHz.

2.6.2 Solar Data Analysis

Project Team: Urpo, Puhakka

Metsähovi solar data analysis continued in international cooperation with Russia. Solar bursts measured with the Metsähovi main telescope was analysed using Wigner-Ville method. Simultaneous bursts measured with the main telescope and 1.8 m “space weather telescope” were compared. Metsähovi solar maps were analysed using improved IDL-programs.

2.6.3 Space Weather Observation at 11.7 GHz

Project Team: Urpo, Puhakka, 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 200 events during 2002 were observed and few of them simultaneously with 37 GHz receiver of the main telescope.

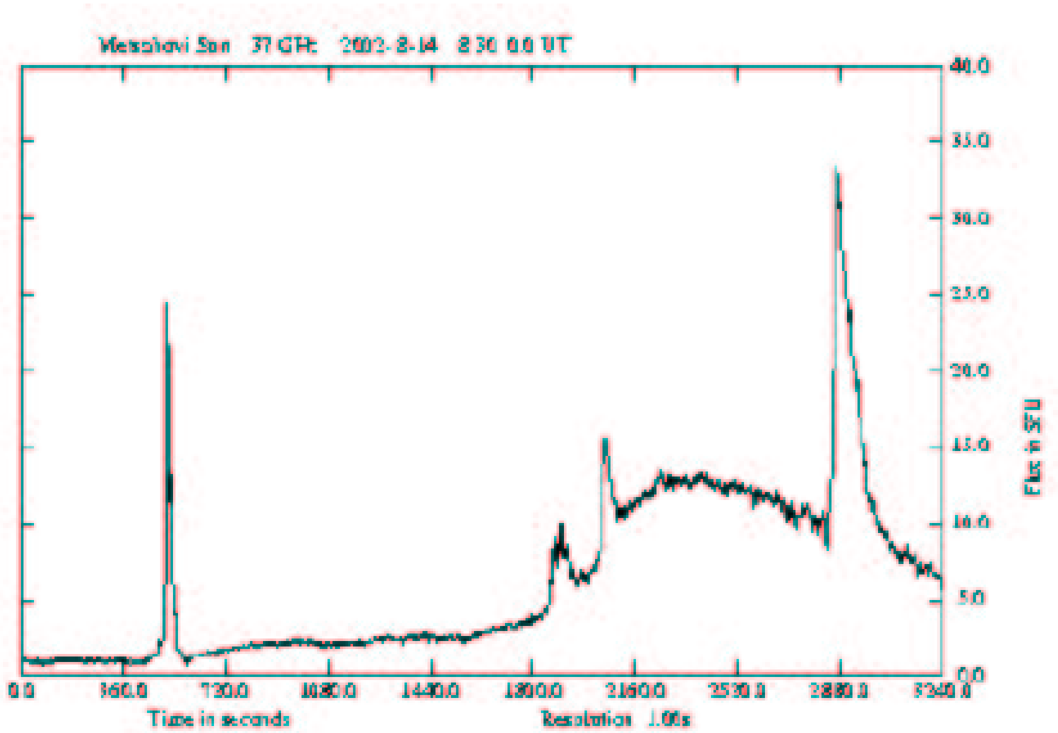

Figure 15: Series of solar microwave events on August 14, 2002, frequency 37 GHz. Optical flares were reported at 09.04 UT and 09.12 UT

3 Publications

3.1 International Journals

1 Lyytinen, J., Johansson, P., Esko, E., Hackman, T., Hall, D.S., Henry, G.W., Kontinen, S., Könönen, P., Maisala, S., Palviainen, A., Ryynänen, K.: Time series analysis of V511 Lyrae photometry. *Astronomy and Astrophysics*, Vol. 383, pp. 197-201, 2002.

2 Koistinen, O., Lahtinen, J., Hallikainen, M.: Comparison of analog continuum correlators for remote sensing and radio astronomy. *IEEE Transactions on Instrumentation Measurement*, Vol. 51, No 2, 2002.

3 Marscher, A.P., Jorstad, S.G., Gómez, J-L., Aller, M.F., Teräsranta, H., Lister, M.L., Stirling, A.M.: Observational evidence for the accretion-disk origin for a radio jet in an active galaxy. *Nature*, Vol. 417, pp. 625-627, 2002.

4 Greve, A., Könönen, P., Graham, D.A., Wiik, K., Krichbaum, T.P., Conway, J., Rantakyrö, F., Urpo, S., Grewing, M., Booth, R.S., John, D., Navarro, S., Mujunen, A., Ritakari, J., Peltonen, J., Sjöman, P., Oinaskallio, E., Berton, M.: 147 GHz VLBI observations: detection of fringes on the 3100 km baseline Metsähovi - Pico Veleta. *Astronomy and Astrophysics*, Vol. 390, pp. L19-L22, 2002.

5 Salvi, N.J., Page, M.J., Stevens, J.A., Wu, K., Mason, K.O., Aller, M.F., Aller, H.D., Teräsranta, H., Romero-Comenero, E., Cordova, F.A., Priedhorsky, W.C.: Correlated multiwavelength emission from the X-ray-bright Seyfert galaxy III Zw 2. *Monthly Notices of the Royal Astronomical Society*, Vol. 335, pp. 177-188. 2002.

6 Savolainen, T., Wiik, K., Valtaoja, E., Jorstad, S.G., Marscher, A.P.: Connections between millimetre continuum variations and VLBI structure in 27 AGN. *Astronomy and Astrophysics*, Vol. 394, pp. 851-861, 2002.

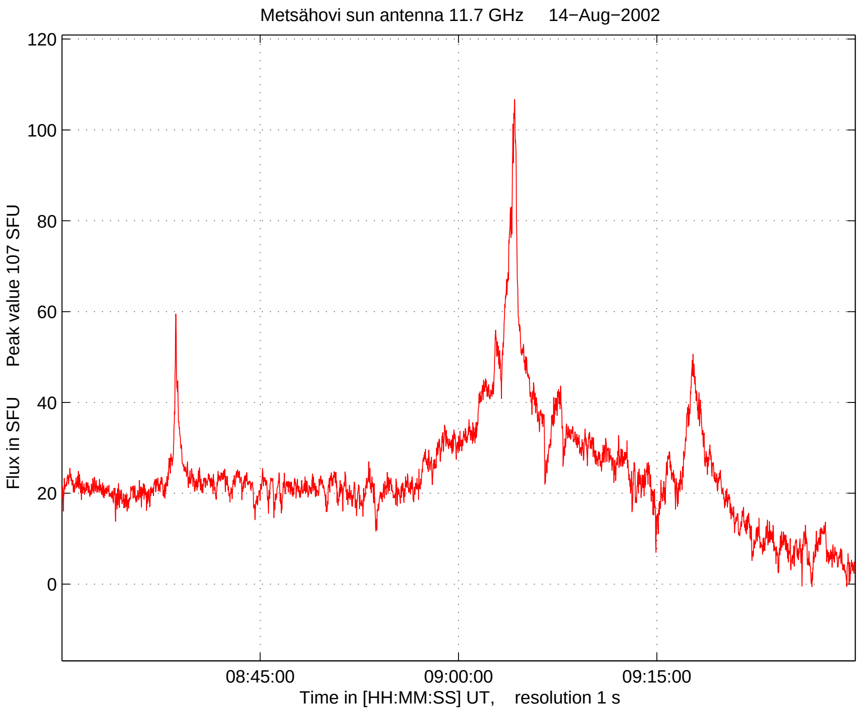

Figure 16: Time series of solar radiation on August 14, 2002, frequency 11.7 GHz. Time interval is the same as in £gure 15. Observe that the relative intensities of the peaks are different at 11.7 GHZ and at 37 GHz (£gure 15). This can be explained by different magnetic £eld strengths at different points of the active region.

7 Tornikoski, M., Lähteenmäki, A., Lainela, M., Valtaoja, E.: Possible Identi£cations for Southern EGRET Sources. *Astrophysical Journal*, Vol. 579, p. 136, 2002.

8 Pian, E., Falomo, R., Hartman, R.C., Maraschi, L., Tavecchio, F., Tornikoski, M., Treves, A., Urry, C.M., Ballo, L., Mukherjee, R., Scarpa, R., Thompson, D.J., Pesce, J.E.: Broad-band continuum and line emission of the gamma-ray blazar PKS 0537-441. *Astronomy and Astrophysics*, Vol. 392, p. 407, 2002.

9 Zaitsev, V.V., Kislyakov, A.G., Urpo, S., Stepanov, A.V., Shkelev, E.I.: Solar microwave bursts: Wigner-Ville analysis. *Astronomy and Astrophysics*, submitted, 2002.

10 Lähteenmäki, A., Valtaoja, E.: Testing Inverse Compton models for active galactic nuclei with gamma-ray and radio observations. *Astrophysical Journal*, submitted, 2002.

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3.2 International Conferences

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3.3 National Conferences

1 Ritakari, J., Mujunen, A.: The Metsähovi solution for gigabit VLBI. *Helsinki University of Technology, Radio Laboratory Publications, Report S 257, URSI/IEEE XXVII Convention on Radio Science*, Espoo, Innopoli 17-18.10.2002., eds.: S. Tretyakov and J. Säily, pp. 192-194, 2002.

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6 Tornikoski, M.: Radio observations as a tool for understanding gamma-ray emission in Active Galactic Nuclei. *The IX Meeting of Finnish National COSPAR and ANTARES Fall Seminar 2002*, University of Oulu, 30.10-1.11.2002. Eds.: J. Jussila, T. Nygren and V. Kelhä, p. 46, 2002.

7 Hakala, T., Tornikoski, M.: Multivariate statistics in AGN classi£cation. *The IX Meeting of Finnish National COSPAR and ANTARES Fall Seminar 2002*, University of Oulu, 30.10-1.11.2002. Eds.: J. Jussila, T. Nygren and V. Kelhä, p. 82, 2002.

8 Parviainen, M.: Quick point source extraction from Planck satellite data. *The IX Meeting of Finnish National COSPAR and ANTARES Fall Seminar 2002*, University of Oulu, 30.10-1.11.2002. Eds.: J. Jussila, T. Nygren and V. Kelhä, p. 43, 2002.

9 Jussila, I.: Inverted-spectrum radio sources and Planck foreground science. *The IX Meeting of Finnish National COSPAR and ANTARES Fall Seminar 2002*, University of Oulu, 30.10-1.11.2002. Eds.: J. Jussila, T. Nygren and V. Kelhä, p. 43, 2002.

10 Könönen, P.: 147 GHz VLBI observations at Metsähovi Radio Observatory. *The IX Meeting of Finnish National COSPAR and ANTARES Fall Seminar 2002*, University of Oulu, 30.10-1.11.2002. Eds.: J. Jussila, T. Nygren and V. Kelhä, p. 47, 2002.

11 Mujunen, A., Ritakari, J.: The Metsähovi Gigabit VLBI data acquisition system. *The IX Meeting of Finnish National COSPAR and ANTARES Fall Seminar 2002*, University of Oulu, 30.10-1.11.2002. Eds.: J. Jussila, T. Nygren and V. Kelhä, p. 81, 2002.

3.4 Laboratory Reports

1 Rantakyrö, F.T., Wiik, K., Tornikoski, M., Valtaoja, E., Bååth, L.B.: Multifrequency Interferometer and Radio Continuum Monitoring Observations of CTA 102. *Metsähovi Publications on Radio Science HUT-MET-37*, 31 p., 2002.

2 Savolainen, T., Wiik, K., Valtaoja, E., Jorstad, S.G., Marscher, A.P.: Connections Between Millimeter Continuum Variations and VLBI Structure in 27 AGN. *Metsähovi Publications on Radio Science HUT-MET-38*, 12 p., 2002.

3 Greve, A., Könönen, P., Graham, D.A., Wiik, K., Krichbaum, T.P., Conway, J., Rantakyrö, F., Urpo, S., Grewing, M., Booth, R.S., John, D., Navarro, S., Mujunen, A., Ritakari, J., Peltonen, J., Sjöman, P., Berton, M.: 147 GHz VLBI Observations: Detection of Fringes on the 3100 km Baseline Metsähovi - Pico Veleta. *Metsähovi Publications on Radio Science HUT-MET-39*, 4 p., 2002.

4 Urpo, S., Mujunen, A. (editors): Metsähovi Radio Observatory Annual Report 2001. *Metsähovi Reports HUT-KURP-23*, 27 p., 2002.

5 Urpo, S.: Aurinkomittausohjeet Metsähovissa 2002. *Metsähovi Reports HUT-KURP-24*, 10 p., 2002.

6 Puhakka, P.: Metsähovin radiotutkimusaseman aurinkoantennin suuntausvirheistä. *Metsähovi Publications on Radio Science HUT-MET-40*, 12 p., 2002.

7 Puhakka, P.: Gain measurements of total power radiometer. *Metsähovi Publications on Radio Science HUT-MET-41*, 15 p., 2002.

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9 Wiik, K.: VLBI and total ¤ux density investigations of the structure of active galactic nuclei. *Metsähovi Publications on Radio Science HUT-MET-42*, 105 p., 2002.

10 Sjöman, P.: Planck 70 GHz LFI, elegant breadboard FEM/BEM receivers. *Metsähovi Publications on Radio Science HUT-MET-43*, 20 p., 2002.

11 Jussila, I.: Extragalactic inverted-spectrum radio sources. Master's Thesis, March 2002.

12 Puhakka, P.: Kokonaistehoradiometri auringon mikroaaltosäteilyn tutkimuksessa. Pro gradu -tutkielma, Helsingin yliopisto, Fysiikan suuntautumisvaihtoehto. Toukokuu 2002.

13 Ritakari, J., Mujunen, A.: The Metsähovi Solution for Gigabit VLBI. *IVS CRL Technology Development Center News, Serial No. 20.* Published by Communications Research Laboratory, Nukui-kita, Koganei, Japan, pp. 2-3, 2002.

3.5 Other Publications

1 Jussila, I.: Extragalactic inverted-spectrum radio sources. Master's Thesis, March 2002.

2 Puhakka, P.: Kokonaistehoradiometri auringon mikroaaltosäteilyn tutkimuksessa. Pro gradu -tutkielma, Helsingin yliopisto, Fysiikan suuntautumisvaihtoehto, 2002.

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4 Visits to Foreign Institutes

Astronomical Observatory of Trieste, Italy, 26.2–15.3.2002, M. Parviainen.

Landessternwarte Heidelberg, Germany, 1.–3.3.2002, M. Tornikoski.

Joint Institute of VLBI in Europe, Hollanti, 15.–20.6.2002, A. Mujunen.

Joint Institute of VLBI in Europe, Hollanti, 9.–18.7.2002, A. Mujunen.

Observations at the SEST telescope, Chile, 18.8.–2.9.2002, I. Jussila.

Astronomical Observatory of Trieste, Italy, 6.11.–21.11.2002, M. Parviainen.

Observations at the SEST telescope, Chile, 14.–23.12.2002, A. Lähteenmäki

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

5 Visiting Scientists

Bill Cotton, NRAO, USA, 25.–27.1.2002

Alexei Klimentov, CERN, Switzerland, 28.2.–4.3.2002.

Dave John, IRAM, Spain, 2.–9.4.2002

Albert Greve, IRAM, Spain, 4.–9.4.2002

Dr. Marc Tuerler, INTEGRAL Science Data Centre, Geneva, Switzerland; in Metsähovi 13.6.2002

Junichi Nakajima, CRL, KSRC, Radio Astronomy Applications, Japan, 26.8.–28.8.2002

Dr. Peter T. Poon, Dr. Pamela T. Wolken, NASA JPL, Telecommunications and Mission Operations Directorate, International VLBI Operations, 23–25.9.2002

Dr. Igor Zinchenko, Russian Academy of Science, Institute of Applied Physics, Venäjä, 6.–9.10.2002.

6 Thesis

Master's thesis:
Jussila, Ilona: Extragalactic inverted-spectrum radio sources.

Master's thesis at Helsinki University:
Puhakka, Pekka: Kokonaistehoradiometri auringon mikroaaltosäteilyn tutkimuksessa.

Thesis for the degree of Doctor of Technology:
Wiik, Kaj: VLBI and total ¤ux density investigations of the structure of active galactic nuclei.

7 Teaching

Supervisor for Ilona Jussila's Master Thesis, M. Tornikoski.

Supervisor for Pekka Puhakka's Master Thesis, S. Urpo

Basic course on “Radio Astronomy” at HUT, S. Urpo

Visiting lecturer to the course “Radio Astronomy” at HUT, M. Tornikoski.

Assistant to the course “Radio Astronomy” at HUT, I. Jussila.

8 Other Activities

Evaluation of Dr. Rami Vainio’s scienti£c work for a docenture (Turku University), M. Tornikoski.

Evaluation of Dr. Tauno Turunen for professorship for University of Oulu, S. Urpo.

Solar Physics, referee, S. Urpo.

Hvar Observatory Bulletin, Board of Editors, S. Urpo

8.1 Participation in Boards and Committees

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.

ESA, European Space Agency, SPC Science Programme Committee, 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 Internationa, 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.

Metsähovi Coordinator of the EC Research Training Network “Quasar Variability”, M. Tornikoski.

Finnish Astronomical Society, Board member, M. Tornikoski.

8.2 International Meetings and Talks

Talk “A VSI-H Compatible Recording System for VLBI and e-VLBI”, Second IVS General Meeting, Tsukuba, Japan, 4.–7.2.2002, J. Ritakari.

Gamma-ray AGNs + Planck foreground science collaboration work with A. Lähteenmäki, Harringworth, England, 18.-24.2.2002, M. Tornikoski.

Planning Meeting of 2 mm VLBI, 28.–30.2.2002, Bonn, Germany, S. Urpo.

Talks “A simple software architecture and proposed data formats for e-VLBI” and “The EVN Gbit/s e-VLBI Data Acquisition and Playback System”, e-VLBI Workshop “Connecting the Global VLBI Array in the New Era of High-Speed Networks”, MIT, Haystack, USA, 6.–10.4.2002, J. Ritakari, A. Mujunen.

Talk “AGN radio monitoring at the Metsähovi and Michigan observatories”, 23.24.5.2002, Milan, Italy, H. Teräsranta.

Talk “Radio spectra and variability of EGRET blazars” in the High-energy blazar astronomy meeting, held in Turku, Finland 17.-21.6.2002, M. Tornikoski.

Poster “The radio events during the strongest gamma outbursts in Blazars”,in the High-energy blazar astronomy meeting, held in Turku, Finland 17.-21.6.2002, H. Teräsranta.

Poster “Quasi-periodic activity in Blazar 0059+581”,in the High-energy blazar astronomy meeting, held in Turku, Finland 17.-21.6.2002, H. Teräsranta.

Poster “Simulations on the effect of internal structure of shock fronts on particle acceleration” in the High-energy blazar astronomy meeting, held in Turku, Finland 17.-21.6.2002, J. Virtanen, R. Vainio.

Talk “Inverse Compton modeling of AGNs”,in the High-energy blazar astronomy meeting held in Turku, Finland 17.–21.6.2002, A. Lähteenmäki.

RISC, Radioastron International Science Committee, 24.–28.9.2002, participation and chairman of a session, S. Urpo.

ESF - Committee on Radio Astronomic Frequency, Cagliari, Italy, 9.–13.10.2002, J. Ritakari.

Planck LFI consortium meeting Santander, Spain 12.-17.10., A. Lähteenmäki, M. Tornikoski, M. Parviainen. Talk “Review of the Work Group 6.1 activities”, A. Lähteenmäki.

Planck Work Group 6 Kick-off Meeting, Paris, France, 25.-26.11.2002, A. Lähteenmäki

Poster “Multifrequency monitoring of 3C 120, 3C 279, and PKS 1510-089”, Frascati, Italy, 10.-11.12.2001, H. Teräsranta.

Poster “Millimeter band observations of a large sample of Northern spectrum Blazars”, Frascati, Italy, 10.-11.12.2001, H. Teräsranta.

Poster “The relationship between X-Rays and relativistic jets”, Frascati, Italy, 10.-11.12.2001, H. Teräsranta.

8.3 National Meetings and Talks

FMI/GEO, Planning Meeting for the Cooperation Group for Space Research Institute, Helsinki, 23.1.2002, S. Urpo.

Resource Committee of the Helsinki University of Technology, Espoo, 6.3.2002, S. Urpo.

Academy of Finland, ESO Seminar, Helsinki, 31.5.2002, S. Urpo, M. Tornikoski.

Metsähovi Spring Training Meeting, 3.–5.6.2002, Stockholm, Sweden, P. Iso-Markku, I. Jussila, S. Hurtta, A.

Mujunen, Nieminen, J., E. Oinaskallio, M. Parviainen, P. Puhakka, J. Ritakari, S. Urpo.

Metsähovi Radio Observatory Advisory Committee, Metsähovi, 10.6.2002, S.Urpo.

Working Group for Finnish-Russian Cooperation in Space Field, Helsinki, 11.6.2002, S. Urpo.

Finnish Space Committee, Strategy Meeting, Helsinki, 22.8.2002, S. Urpo.

Tekes, Planck Steering Group, Espoo, 20.9.2002, S. Urpo.

URSI/IEEE XXVII Convention on Radio Science, Espoo 17.–18.10.2002, participation and chairman of a session, S. Urpo.

Poster URSI/IEEE XXVII Convention on Radio Science, Espoo 17.–18.10.2002, A. Mujunen.

URSI/IEEE XXVII Convention on Radio Science, Espoo 17.–18.10.2002, M. Tornikoski, I. Jussila, M. Parviainen.

Academy of Finland, Coordination of Science Meeting, Helsinki, 23.10.2002, S. Urpo.

Talk “Solar Monitoring at 11.7 GHz for Space Weather Applications”, The IX Meeting of Finnish National COSPAR held in Oulu, Finland, 30.10.–1.11.2002, S. Urpo.

Antares fall seminar 2002, Oulu 31.10.2002, S. Urpo.

Talk “Radio observations as a tool for understanding gamma-ray emission in Active Galactic Nuclei”, The IX Meeting of Finnish National COSPAR held in Oulu, Finland, 30.10.–1.11.2002, M. Tornikoski.

Talk “Inverted-spectrum radio sources and Planck foreground science”, The IX Meeting of Finnish National COSPAR held in Oulu, Finland 30.10–1.11.2002, I. Jussila.

Talk “Quick point source extraction from Planck satellite data”, The IX Meeting of Finnish National COSPAR held in Oulu, Finland 30.10.–1.11.2002, M. Parviainen.

Graduate School of Astronomy and Space Research, Steering Group Meeting, Oulu, 22.11.2002, S. Urpo.

Tekes, Planck Steering Group, Espoo, 26.11.2002, S. Urpo.

8.4 Participation in summer schools

Mission concept and payload design in X- and gammaray astronomy. International Advanced School Leonardi da Vinci, Italy, 30.6.–13.7.2002. I. Jussila.

8.5 Public Relations

Radioma£a pressiklubi 4.10., M. Tornikoski was interviewed about radio astronomy.

Lecture to the amateur astronomy club Lohjan Ursa 4.4. and to the amateur astronomy club Kirkkonummen Komeetta 18.12, M. Tornikoski.

TV interview by ATV channel at Metsähovi, 19.12.2002, S. Urpo, A. Mujunen, E. Oinaskallio.

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

9 Personnel in 2002

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Valtonen, Mauri, Prof.
Urpo, Seppo, Prof. (Secretary)

METSÄHOVI PUBLICATIONS ON RADIO SCIENCE

HUT-MET-27 Silja Pohjolainen (ed.): CESRA Workshop on Coronal Explosive Events. 1998.

HUT-MET-28 Anne Lähteenmäki, Esko Valtaoja: Total ¤ux density variations in extragalactic radio sources. III. Doppler boosting factors, Lorentz factors and viewing angles for active galactic nuclei. 1999.

HUT-MET-29 V.V. Zaitsev, S. Urpo, A.V. Stepanov: Dynamics of energy release in single ¤are loop. 1999.

HUT-MET-30 V.V. Zaitsev, S. Urpo, A.V. Stepanov: Radiation signatures of solar energy release at mm-wavelengths: Advanced circuit model. 1999.

HUT-MET-31 Anne Lähteenmäki: Total ¤ux density variations extragalactic radio sources: observations and analysis. 1999.

HUT-MET-32 V.V. Zaitsev, A.G. Kislyakov, S. Urpo, A.V. Stepanov, E.I. Shkelev: The Wigner-Ville Analysis of Solar Microwave Emission, 2000.

HUT-MET-33 P. Sjöman, N.J. Hughes: Planck Technology 70 GHz Demonstrator Test Report. 2001.

HUT-MET-34 T. Liljeström, C.R. Gwinn: Water Masers Probing Magnetic Pressure and Alfvénic Turbulence in W49N. 2001.

HUT-MET-35 T. Liljeström: Radio Spectroscopic Studies on Cosmic Water Masers. 2001.

HUT-MET-36 V.V. Zaitsev, A.G. Kislyakov, S. Urpo, A.V. Stepanov, E.I. Shkelev: Low-Frequency Modulations in Solar Millimeter Wave Bursts. 2001.

HUT-MET-37 F.T. Rantakyrö, K. Wiik, M. Tornikoski, E. Valtaoja, L.B. Bååth: Multifrequency Interferometer and Radio Continuum Monitoring Observations of CTA 102. 2002.

HUT-MET-38 T. Savolainen, K. Wiik, E. Valtaoja, S.G. Jorstad, A.P. Marscher: Connections Between Millimeter Continuum Variations and VLBI Structure in 27 AGN. 2002.

HUT-MET-39 A. Greve, P. Könönen, D.A. Graham, K. Wiik, T.P. Krichbaum, J. Conway, F. Rantakyrö, S.Urpo, M. Grewing, R.S. Booth, D. John, S. Navarro, A. Mujunen, J. Ritakari, J. Peltonen, P. Sjöman, M. Berton: 147 GHz VLBI observations: Detection of Fringes on the 3 100 km Baseline Metsähovi - Pico Veleta. 2002.

HUT-MET-40 Pekka Puhakka: Metsähovin Radiotutkimusaseman aurinkoantennin suuntausvirheitä. 2002.

HUT-MET-41 Pekka Puhakka: Gain measurements of a total power radiometer. 2002.

HUT-MET-42 Kaj Wiik: VLBI and total ¤ux density investigations of the structure of active galactic nuclei. 2002.

HUT-MET-43 Pekka Sjöman: Planck 70 GHz LFI, elegant breadboard FEM/BEM receivers. 2002.

HUT-MET-44 Zaitsev, V.V., Kislyakov, A.G., Urpo, S., Stepanov, A.V., Shkelev, E.I.: Solar millimeter wave bursts: time-frequency analysis. 2003.

METSÄHOVI REPORTS

HUT-KURP-13 Silja Pohjolainen (ed.): Metsähovi Radio Observatory Annual Report 1997. 1998.

HUT-KURP-14 Ari Mujunen, Mika Perttula, Jan Engelberg: Using CVS at Metsähovi. 1998.

HUT-KURP-15 S. Urpo, A. Mujunen (eds.): Metsähovi Radio Observatory, Annual Report 1998. 1999.

HUT-KURP-16 J. Engelberg, A. Mujunen, E. Oinaskallio: Radio Spectrum Monitoring System – spektrd. 2000.

HUT-KURP-17 Esa Vilenius, Prisse Könönen: Calibration of the “GroWeather” weather stations at Metsähovi. 2000.

HUT-KURP-18 Prisse Könönen: “Weather@Metsähovi” – weather monitoring system at Metsähovi. 2000.

HUT-KURP-19 S. Urpo, A. Mujunen (eds.): Metsähovi Radio Observatory, Annual Report 1999. 2000.

HUT-KURP-20 J. Engelberg, A. Mujunen: EFOS Monitoring System – efosd. 2000.

HUT-KURP-21 P. Könönen: “Efos9@Metsähovi” – Efos 9 Hydrogen Maser Monitoring System at Metsähovi. 2000.

HUT-KURP-22 S. Urpo, A. Mujunen (eds.): Metsähovi Radio Observatory, Annual Report 2000. 2001.

HUT-KURP-23 S. Urpo, A. Mujunen (eds.): Metsähovi Radio Observatory, Annual Report 2001. 2002.

HUT-KURP-24 S. Urpo: Aurinkomittausohjeet Metsähovissa 2002. 2002.

HUT-KURP-25 P. Puhakka: Aurinkoantennin radiopurkausten kalibrointiohjeet. 2002.

HUT-KURP-26 S. Urpo, A. Mujunen (eds.): Metsähovi Radio Observatory, Annual Report 2002. 2003.

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