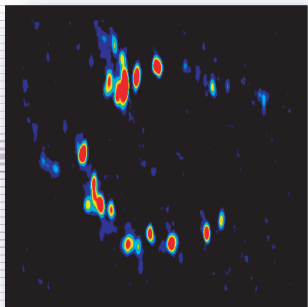
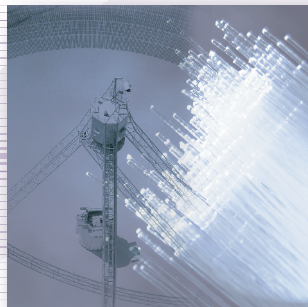
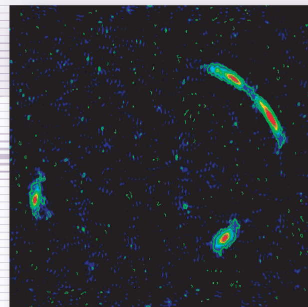
JIVE

JOINT INSTITUTE FOR VLBI IN EUROPE







# Annual Report 2004

NWO Netherlands Organisation for Scientific Research

PPARC

INAF

Max-Planck-Institut für Radioastronomie

ASTRON

**The Joint Institute for VLBI in Europe (JIVE) has been established as a scientific foundation since December 1993. JIVE's mandate is to support the operations of the European VLBI Network (EVN) in the widest sense.**

**JIVE's operations are supported via multi-national funds from the following organisations:**

**Netherlands Organisation for Scientific Research (NWO), the Netherlands;**

**Particle Physics and Astronomy Research Council (PPARC), UK;**

**Italian National Institute of Astrophysics (INAF), Italy;**

**Onsala Space Observatory (OSO), Sweden;**

**National Geographical Institute (IGN), Spain;**

**Max Planck Institute for Radio Astronomy (MPIfR), Germany;**

**Netherlands Foundation for Research in Astronomy (ASTRON), the Netherlands.**

## ANNUAL REPORT OF THE JOINT INSTITUTE FOR VLBI IN EUROPE 2004

## TABLE OF CONTENTS



**Appendices**

## Foreword by the Chairman of the JIVE Board

During 2004, the Joint Institute for VLBI in Europe (JIVE) made considerable progress in many areas of its remit, a particular highlight was the completion of the upgrade of the European VLBI Network (EVN) data processor to the Mark 5 disk-based recording system – the correlator at JIVE is now fully populated with 16 Mark 5 disk-based recording systems. This “silent upgrade” occurred on an unexpectedly short timescale, financed by various partners, including the EVN observatories and the European Space Agency (ESA), the latter support coming via the ESA-Huygens VLBI project, as coordinated by JIVE. The total cost of upgrading the correlator to the new Mk5 system represents a total investment of 400 kEuro. In addition, members of the EVN have aggressively procured the associated PC disk packs that were required to replace the now redundant tape pool; this represents a further investment on at least the same scale as the correlator upgrade itself. These developments have taken place on unexpectedly short timescales, and have led to an immediate and substantial break-through in EVN data quality. It is hoped that global VLBI observations will also begin to take advantage of this new disk based technology in the course of 2005.

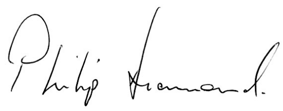
In addition, to these one-off investments, JIVE has also benefited from its participation within the 5 year long Radio Astronomy FP6 Integrated Infrastructure Initiative – known as “RadioNet”. The RadioNet contract began on 1 January 2004 and JIVE is involved in, and benefits substantially from, several key RadioNet programmes, including RadioNet Management and the EVN Transnational Access programme. In addition, JIVE leads the RadioNet ALBUS (Advanced Long Baseline User Software) Joint Research Activity. This project represents the first substantial investment in VLBI user software for over a decade, and will hopefully lead to a revival in the contribution Europe can make to the area of radio Interferometry software more generally.

It is impossible to ignore the substantial progress that has been made in e-VLBI during this year. The first real-time EVN e-VLBI image was made (including transatlantic baselines to Arecibo) and the first e-EVN science observations were highly successful. Additional telescopes are expected to join the fibre-based network during the next year, including the 32-m IRA telescope at Medicina. Although there are still many challenges ahead, the prospects of realising a reliable and scientific productive e-VLBI network within Europe seem good. However, significantly more resources are required in order to fully realise this dream, and it is hoped that the EXPReS proposal (as led by JIVE) will be successful in securing funds from the EC in 2005.

JIVE’s support of the European VLBI Network continued to be a prominent part of the institute’s activities – ftp-VLBI tests are now standard within each EVN session and efforts to improve EVN calibration continued to make steady progress. The systematic checking of EVN observing schedules was also implemented during the year, with several (potentially fatal) errors being discovered, well in advance of the observations being made. The EVN pipelining software produced calibrated data for all experiments and preliminary images were made where requested. All the pipeline products are now available on the EVN data archive at JIVE, together with the raw data and a-priori calibration tables. A large fraction of the archive is expected to enter the public domain in the middle of next year, with the adoption of a new EVN data archive policy (as recently decided upon by the EVN Consortium Board of Directors).

In concluding this foreward, I want to add that it is a pleasure to note the outstanding contribution made by JIVE staff to various areas of astronomical research and VLBI in particular. The growing number of Dutch PhD students associated with JIVE or being supervised by JIVE staff is also a very welcome development, and I expect these efforts to increase over the coming years. I congratulate all JIVE staff on their efforts, and in particular look forward to the impact of the proposed VLBI and radio astronomy tracking observations of the ESA Huygens probe as it descends through the atmosphere of Titan in early January 2005. I suspect a few surprises are in store for all of us!

Prof. Phil Diamond



JIVE Board Chairman

## 1. Institute Report from the Director

### e-VLBI comes of age

The highlight of this year must surely be the successful “first science” *e*-VLBI observations of hydroxyl maser emission associated with IRC+10420 - a supergiant star in the constellation of Aquila. The first science observations included the participation of six EVN antennas (including the Arecibo 300-m telescope in Puerto Rico, USA) connected to JIVE in real-time via the pan-European GÉANT network and the local SURFnet optical fibre research network. The successful observations enabled Dr. Anita Richards & Prof. Phil Diamond (Jodrell Bank Observatory) to produce a very nice image of this system, as presented in figure 1.

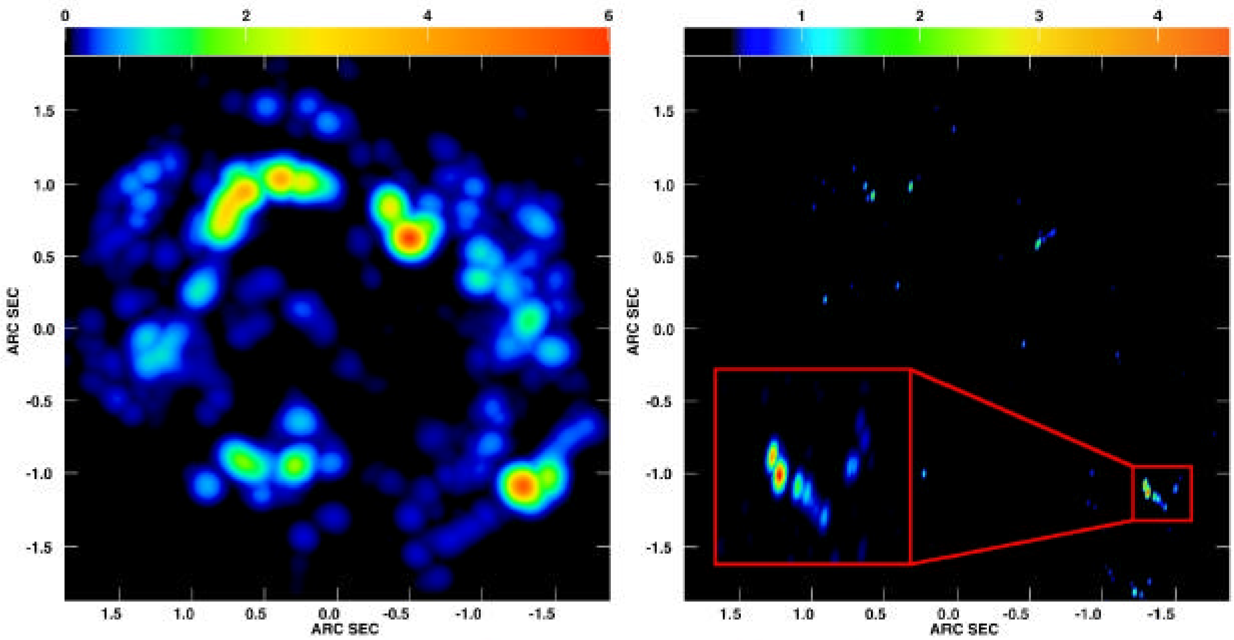



*Figure 1: First e-VLBI Science image, courtesy Richards et al. JBO. A low resolution image taken with MERLIN (left) shows the shell of maser emission at the frequency of 1612 MHz. The corresponding e-VLBI image (right) shows the much finer structure of the masers. IRC+10420 is a supergiant star, with a mass of about 10 Msun, at a distance of ~5kpc. Recent estimates (Klochkova et al. 1997) put its temperature at 8500 degrees, a much higher temperature than usually associated with molecular winds. However, in the 1970's it had a spectral type G0-F8, (Humphreys et al. 1973), a bit hotter than the Sun. In 20 yr it has undergone an extraordinary temperature rise of ~3000 degrees. It has a mass-loss rate equivalent to ~200 Mearth/yr. The OH maser shell is 7500 AU in radius with an expansion velocity of about 40 km/s, implying that the matter was ejected from the star about 900 years ago, when it was presumably still a late M-type red supergiant. VLBI resolves the individual maser clumps for the first time and will help us understand how dusty knots can protect molecules from the overheated star.*

This result marks the beginning of an exciting new era in astronomical VLBI. In addition to the first e-VLBI science observations, JIVE played a major role through the year in realising other major advances in European e-VLBI, including the first real-time EVN e-VLBI image and the first real-time e-VLBI image using transatlantic baselines. The Software Development Group at JIVE was particularly active in this area - efforts made to improve the reliability of the EVN correlator at JIVE during e-VLBI experiments were given high priority during the second half of the year. A very welcome by-product of these efforts is that the efficiency of normal correlation operations has also improved, as a result of enhancements made to the on-line correlator software.

The EVN e-VLBI network also expanded during the course of the year with Torun (PL) and Arecibo (USA) joining the network, observing together with other e-VLBI capable telescopes (Onsala, Westerbork, Jodrell Bank and Cambridge). While the first science results were obtained at relatively low data rates (32Mbps per telescope), other e-VLBI developments have focussed on stressing the GEANT network and telescope connections to the limit – our colleagues at Metsähovi were recently able to demonstrate data rates of up to 600 Mbps between Finland (Espoo) and JIVE. Real-time fringes at data rates of 128 Mbps were also demonstrated between Onsala and Westerbork. Jodrell Bank and Cambridge are also expected to routinely achieve such data rates once the fibre connection is upgraded to 2.5 Gbps. All these results have been widely reported (see Figure 2), especially in the Research Network press.

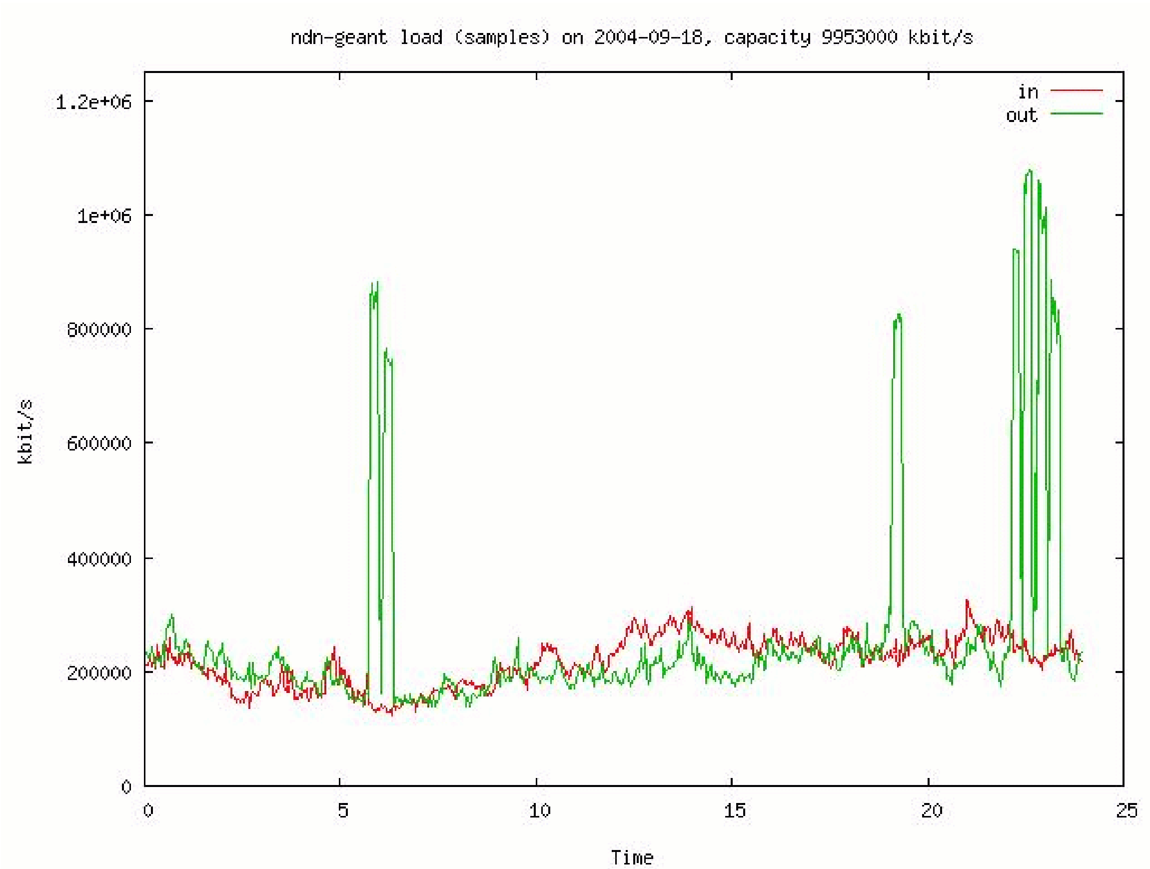



*Figure 2: The effect of e-VLBI on the GEANT network was clearly visible during e-VLBI data transfer tests between Finland (Espoo) and JIVE, as conducted by staff from Metsähovi. The e-VLBI traffic dominates the network load, though it should be noted that even the e-VLBI load represents only 10 percent of the total capacity of the GEANT link.*

JIVE has also been active in seeking support for e-VLBI activities at the European Commission (EC) funding level – in particular we have participated in various IST related meetings and an EU delegation to North America. Our long-term goal is to see if we can get funding to support the current level of e-VLBI activities and significantly expand upon them. The aim is to realise a reliable and robust e-VLBI instrument that can routinely perform VLBI observations in real-time – this would be particularly important for time-critical observations such as Target-of-Opportunity observations of GRB and other radio transient phenomena.

By the end of the year, work had already started in preparation of the submission of a large proposal to the EC Research Infrastructure Grid programme – Communication & Network Developments. The proposal called EXPReS (Express Production Real-time *e*-VLBI Service) seeks to make e-VLBI a production grade astronomical instrument. This requires a significant upgrade to the correlator software and hardware; the proposal also addresses the last-mile connection problem of some of the European telescopes. A key feature of the proposal is to ensure that e-MERLIN and e-VLBI can operate as a single instrument – the transparent combination of the two arrays would represent an unbeatable combination boasting an angular resolution ranging from arcsecond to milliarcsecond scales, and sub-microJy noise levels. If all goes well the proposal will be submitted in March 2005, and the outcome should be known in June 2005. Fingers crossed…

**Correlator hardware and software**

As e-VLBI came of age in 2004, the first of the original Penny & Giles tape recorders was retired. This was necessary in order to make room for the new PC based Mark 5 disk recording systems. By the end of the year, 16 Mark 5 units had been procured via internal funding, and additional support from the EVN observatories and the ESA Huygens contract. It was possible to configure the EVN correlator to process data using a flexible mixture of both tape and Mark 5 disk systems. Several new features were added to the correlator software (including the possibility to handle local oscillator offsets), in addition to making it e-VLBI capable. A particular highlight of the year was the start of the ALBUS (FP6 RadioNet) project led by JIVE. The PC Integrator hardware (that will permit much higher correlator data output rates to be generated for wide-field and spectral-line applications) was installed in March, and apart from a few teething problems the performance looks good. However, there is still a lot of software and hardware development required before the system can become operational.

**ESA-JIVE Huygens Space Science Project**

In the beginning of 2004, JIVE continued to discuss with ESA a possible contract that would support JIVE in organising and coordinating global VLBI observations designed to track the path of the Huygens planetary probe, as it descends through the atmosphere of Titan, early next year (see figure 3). The data will be correlated at JIVE, the idea being to use the VLBI observations to reconstruct the three-dimensional path of the probe from the top of the atmosphere all the way through to landing. The new contract was drawn-up and formalised in the summer and supported the procurement of new hardware at the correlator (including 8 additional Mk5 systems and disk media), plus the employment of additional man-power at JIVE. If the observations and subsequent data processing are successful, we expect to be able to pin-point the location of the Huygens spacecraft with a precision of a few kilometres or better. The first shakedown tests of the Huygens VLBI network took place in August and November with encouraging results. By the end of the year, engineers and radio astronomers across the world were gearing-up and preparing their telescopes and VLBI data acquisition systems for this once-in-a-life-time event. "Reconnaissance" observations of the "Huygens Field" with the WSRT, ATCA, MERLIN, VLA and EVN have also been successfully conducted – essential data in support of the main observations.

Related to the ESA Huygens contract, JIVE was recently invited to join a new EC funded Coordinated Activity project called EUROPLANET. This is similar in scope to RadioNet, but the topic here is planetary science. Together with ESTEC, JIVE represents the Netherlands contingent in this interesting new project.

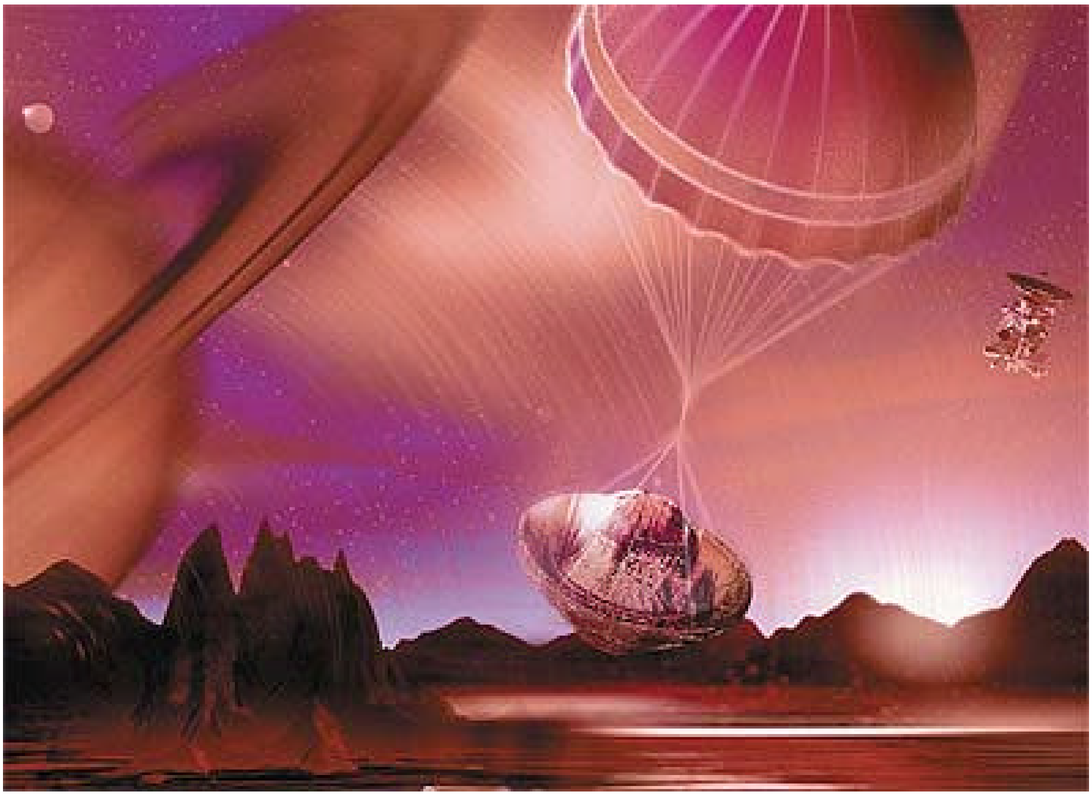


*Figure 3: Artist's impression of Huygens descending onto the surface of Titan by parachute.*

**FTP-VLBI and EVN Telescope Performance**

Related to e-VLBI developments is the introduction of ftp-VLBI - an important new tool in monitoring the reliability and performance of the EVN telescopes. In 2004 this became a standard feature of EVN sessions with small amounts of VLBI data being ftp'd to JIVE and then correlated using the Japanese NICT (formerly CRL) software correlator. This permits JIVE staff to give feedback to the EVN telescopes on their performance at short notice - within 24 hours or less depending on the speed of the internet connection. "First ftp fringes" were obtained from several telescopes in 2004, including Shanghai (CN), Urumqi (CN), Metsähovi (FI) and the MERLIN telescope Darnhall (UK). The arrival of a new Linux PC cluster (funded by the NL-GRID project, ASTRON & JIVE) speeded-up the ftp-VLBI correlation process by a factor of 30, spreading the data by baseline across many CPU nodes. In 2005 the aim will be to automate these Ftp-VLBI tests and to increase their frequency.

The performance of the EVN telescopes was very satisfactory in 2004, the wide-spread use of disk based recording systems has largely removed the playback problems that dogged tape-based VLBI, especially at the highest data rates. The Mark 5 systems are capable of essentially perfect playback at the highest data rates – in 2005, high-sensitivity 1 Gbps VLBI observations should be conducted routinely.

**JIVE visit to China**

In December 2004, JIVE staff together with the chairman of the JIVE board, traveled to Beijing, China, in order to present the activities of JIVE to the vice-president of the Chinese Academy of Science and other high-level scientific officers of the Academy. Prof. Xiaoyu Hong (Director of the Shanghai VLBI Observatory) also accompanied the delegation. The talks with CAS were very positive, and given the rapid expansion of VLBI in China, we are hopeful that they will play a more significant role within JIVE in the coming years. Prof. Hong was also able to show at first hand the enormous progress that is being made in the construction of the new VLBI antenna in Miyun, located near Beijing (see figure 4). An additional VLBI telescope is also under construction in Kunming, in the south east of China. This means that two new Chinese telescopes will fully participate within EVN sessions from about 2007 onwards, in addition to the existing EVN telescopes at Urumqi and Shanghai. The collaboration between JIVE and the Shanghai Astronomical observatory is already strong and there are plans to expand the range of activities in 2005 – including both joint astronomical research and various common engineering developments. In particular, the group in Shanghai (like JIVE) is already building up considerable expertise in the area of software correlation. During the visit to China the director of JIVE and Prof. Hong attended an EC-China "Bridges" meeting – it is hoped to include the Shanghai Observatory as major partners within the EC e-VLBI EXPReS proposal (see above).

*Figure 4: Prof. Philip Diamond (JIVE Board Chairman), Dr. Leonid Gurvits (JIVE) and Prof. Xiaoyu Hong (ShAO) inspect work at the Miyun 50-meter telescope site.*

**RadioNet FP5 & FP6**

The RadioNet FP6 I3 formally started on the 1 January 2004. JIVE's role in RadioNet is substantial. The network is coordinated by Prof. Phil Diamond (JBO) and Leonid Gurvits (JIVE) is the RadioNet Project Scientist. Although the main project administration is located at Jodrell Bank, Marjan Tibbe (JIVE) also provides additional administrative support, in particular for those aspects of the RadioNet administration for which JIVE is responsible – this includes the management of the RadioNet travel funds for the Transnational Access Programmes and Network Activities. JIVE is also responsible for the EVN Access Contract. As RadioNet FP6 started, so RadioNet FP5 ended with the successful submission of the RadioNet and EVN Access FP5 annual and final year reports.

**SKA Design Study Proposal**

Like many other major European radio astronomy institutes, JIVE was closely involved in the preparation of the proposal to the European Commission on the SKA Design Study (SKADS) project. JIVE's specific task deals with the SKA science and data simulations for which it is the PI. The overall coordinators are Arnold van Ardenne (ASTRON) and Peter Wilkinson (JBO). The proposal was submitted to the Commission in March 2004 and contract negotiations began before the end of the year. SKADS is expected to formally start in July 2005.

**JIVE staff numbers continue to grow**

The new Huygens contract with ESA, plus the success of the recent RadioNet & ANGLES FP6 proposals were responsible for bringing the complement of staff at JIVE to a record high of 26 employees in 2004. New appointments during the year included: Drs. Mark Kettenis and James Anderson - both working on post-processing software in the ALBUS project; Alicia Alba Berciano the ANGLES (JIVE/Kapteyn) PhD student, and Ruud Oerlemans who will contribute to the Huygens Software Correlator efforts. At the November JIVE board meeting, Cormac Reynolds was appointed to the permanent position of Senior Support Scientist. Figure 5 shows the JIVE organogramme as of December 2004***.***

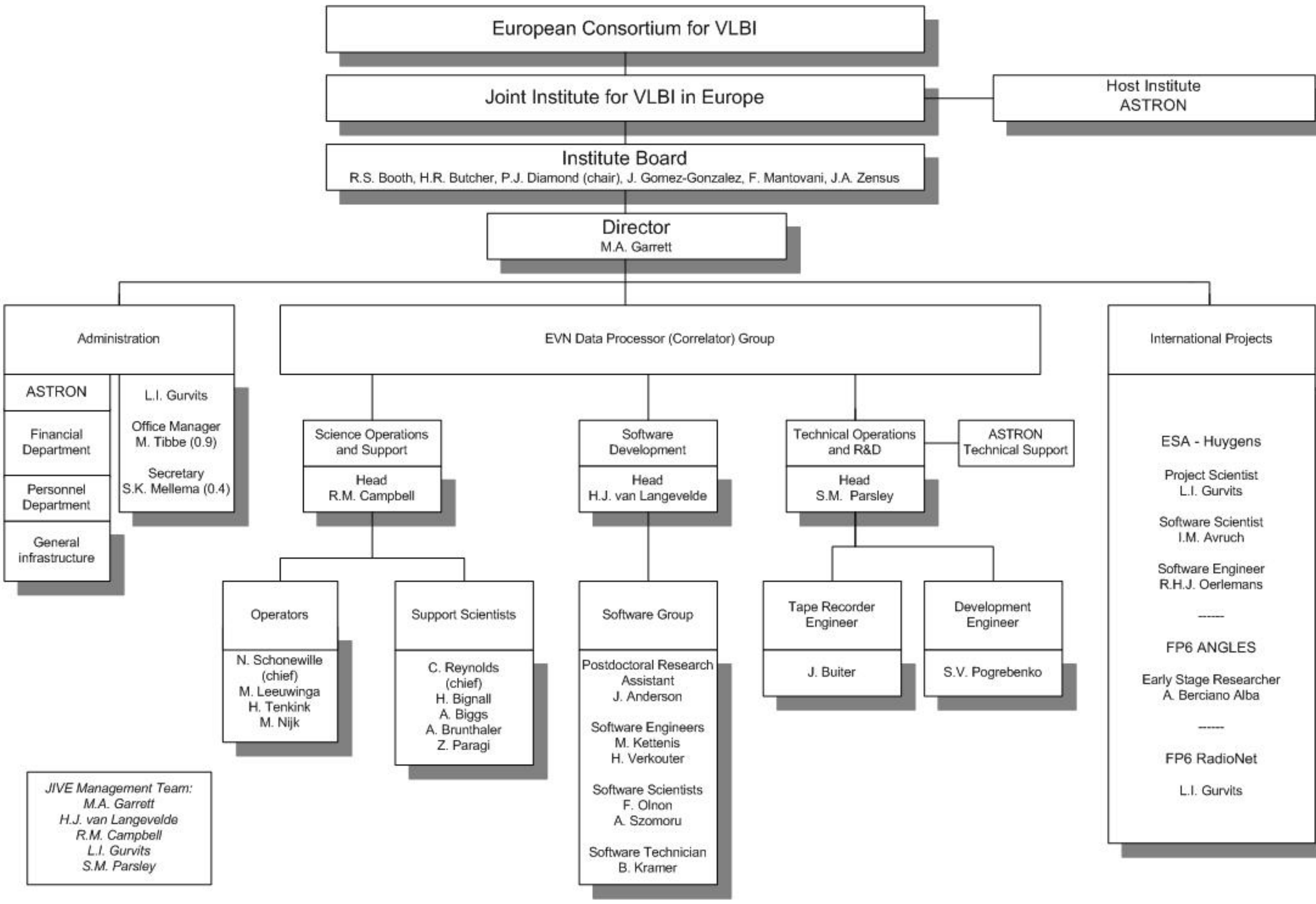



*Figure 5: the JIVE organogramme as of December 2004.*

**Staff science output**

JIVE staff led or were involved in several exciting new results, including an impressive EVN 1.4 GHz image of the gravitational lens system CLASS B0128+437 (Biggs et al, in preparation) – see also the front cover of this annual report). Other highlights include: the detection of multiply lensed radio emission associated with the massive cluster A2218, VLBI imaging of rapidly variable (scintillating) radio sources and the acceptance of a paper to appear in the journal *Science*, presenting recent results on the geometric distance and proper motion of M33. JIVE was also involved in evaluating the possibility of the JCMT's participation in the eSMA (extended Sub Millimetre Array) project. JIVE staff were prominent in the number of presentations they made at the 7th EVN symposium – held in Toledo and organised by the National Astronomical Observatory (OAN, ES). The symposium included a visit to the new 40-m EVN telescope at Yebes. The Yebes telescope is capable of high frequency observations (up to 115 GHz) and is expected to become operational by the end of 2005. An EVN Users meeting was also held during the symposium and it was particularly pleasing to see the high level of user satisfaction and appreciation of the astronomer support provided by JIVE.

*Figure 6: Participants of the 7th EVN symposium – major elements of the new 40-m telescopes (still under construction) can be seen in the background.*

In 2004, JIVE was also involved in co-sponsoring and organising two workshops – one on "Astronomical Molecules" (held in Zwolle) and the other on "Interstellar Scintillation of Extragalactic Radio Sources" (held in Dwingeloo). The proceedings of the "Astronomical Molecules" meeting were published in a special issue of Astrophysics and Space Science.

During 2004, 41 papers were published in scientific journals or conference proceedings, and a further 7 were submitted for publication. 107 oral and 8 poster presentations were made at scientific meetings/colloquia, as well as a number of other presentations at management meetings and during tours of the correlator. The institute was happy to host 31 visitors during the year, many of whom made extensive use of the support facilities.

# 2. Science Operations and Support

## 2.1 Production Correlation

### 2.1.1 Sessions and Their Experiments

The February 2004 EVN session had a total of 13 user experiments. A notable milestone was the first sub-second integration-time user experiments (5 of them). Three stations were regularly recording onto Mark 5 disks. Six experiments required multiple correlation passes:

- 512 Mbps experiments using at least one tape (3)

- Experiments whose requested correlator load required separate correlation passes by subband/polarisation (3).

The May/June 2004 EVN session had a total of 14 user experiments. A UHF session was included for the first time since September 1999. A wheel girder on the Lovell telescope showed early signs of a fatigue crack, which limited its slewing during the session to 1 source-change cycle per 10min, so many PIs opted to use Jb2 for phase-referencing observations, even at L-band. There was a large fraction of global experiments (more than half of the non-UHF experiments). Several experiments used ambitious frequency schemes within L-band to address redshifted HI in absorption and OH in emission. There was an additional sub-second integration time experiment, and one experiment that required multiple passes (continuum/line, with the line pass itself requiring separate passes by polarisation). Up to eight EVN stations regularly recorded onto Mark 5 disks, but there were no all-disk user experiments yet (a couple of experiments used 8 disks and 1 tape).

Before the October/November 2004 EVN session, there were seven ad-hoc user experiments -- three short EVN observations arranged to coincide with independent GMRT and X-ray observations of SS433, two global experiments in preparation for the Huygens-Titan encounter, and two real-time e-VLBI spectral-line experiments. The October 2004 session itself had a total of 14 user experiments. Among these were our first P-band and our first Gbps user experiments. There were three more sub-second integration-time experiments and six experiments required multiple correlation passes. There were eight 5cm experiments; these had 8-9 stations participating successfully. In these experiments, Darnhall (Da) replaced the Jodrell Bank Mk2 telescope, producing good fringes throughout. This was Darnhall's first participation as an independent VLBI telescope correlated at JIVE. All the 5 cm observations were recorded exclusively on Mark 5A, providing us our first taste of the efficiency gains of all-disk correlation. In the C-band portion of the session, Noto had to swap out their H-maser for a Rb frequency standard. The noise in phase increased noticeably, but fringes were found for all experiments during clock-searching. They were able to return to the H-maser by the 5 cm portion of the session. After the session, there was another ad-hoc user experiment -- the global 'dress-rehearsal' experiment for the Huygens encounter.

Table 1 summarises projects observed, correlated, distributed, and released in 2004. The table lists the number of experiments as well as the network hours and correlator hours for both user and test/NME experiments. Here, correlator hours are the network hours multiplied by any multiple correlation passes required (e.g., continuum/line, >16 station, 2 head stacks, different phase centers, etc.).

| | User Experiments | | | Test & Network Monitoring | | |
|---|---|---|---|---|---|---|
| | N | Ntwk_hr | Corr_hr | N | Ntwk_hr | Corr_hr |
| Observed | 49 | 593 | 869 | 46 | 98 | 106 |
| Correlated | 45 | 522 | 705 | 48 | 104 | 112 |
| Distributed | 49 | 581 | 812 | 51 | 120 | 130 |
| Released | 53 | 628 | 805 | 48 | 107 | 117 |

*Table 1: Summary of projects observed, correlated, distributed, and released in 2004.*

Not reflected in the table is GI001A, which was abandoned with the agreement of the PC, because it was scheduled in a way that would have required correlation with over-sampling x8 – a mode of correlation not yet available (or advertised).

Table 2 summarises by session the user experiments still in the queue as of 31 December 2004 (entries = remaining to do / total). Ad-hocs are listed chronologically between sessions as they were observed. The actual correlator time is typically between 1.5-2.5 times these estimates, depending on the number of redos or other problems.

| | N_exp | Corr_hr |
|---|---|---|
| May/Jun'03 | 1/25 | 11/447 |
| ad-hocs | 0/2 | 0/28 |
| Oct/Nov'03 | 0/9 | 0/127 * |
| Feb'04 | 3/13 | 132/294 |
| May/Jun'04 | 0/14 | 0/237 |
| ad-hocs | 0/6 | 0/40 |
| Oct/Nov'04 | 11/14 | 202/280 |
| ad-hoc | 1/1 | 18/18 |

*Table 2: Experiments by session still in the queue for correlation as of 31 December 2004.*
** totals adjusted for the abandonment of GI001A*

Experiments remaining from previous sessions are described below:
May/June'03:
- EM048 - awaiting PIs to provide revised coordinates for their targets based on a preliminary correlation pass we did for them using only short baselines and a short integration time.

Feb'04:
- GG053a/b/c - require 4 passes each (each subband/polarisation uses the full correlator). Awaiting next stage of PCInt development (full correlator read-out in 1/8s).

The following plots show (a) the work division among various correlator tasks (production, clock-searching, network tests, correlator tests) as a number of hours per week; (b) correlator efficiencies (completed correlator hours per production time, completed correlator hours per total time, completed network hours per total time) as percentages; and (c) backlogs of the various experiments status (correlation, distribution, release), expressed as the sum of correlator hours. All plots cover the past three years, with 2004 highlighted. Plots (a) and (b) show 6-week moving averages; plot (c) shows a snapshot every week. In plot (a), you can see the drop in production hours in the Spring of 2003, when we cleared the backlog and construction in the basement was proceeding. The more recent drop in production hours in the Autumn of 2004 corresponds to having completed all possible correlation prior to the experiments from the October/November session arriving. Further, the bursts of time spent on network tests in and immediately following sessions are apparent. In plot (b), the ratio between the production yield (red) and correlator yield (green) lines is simply another measure of the ratio between production and total hours. The difference between the correlator yield (green) and network yield (blue) lines stems from experiments that need multiple passes (around autumn 2003 we were correlating the >16-station experiments from the May/June'03 session).

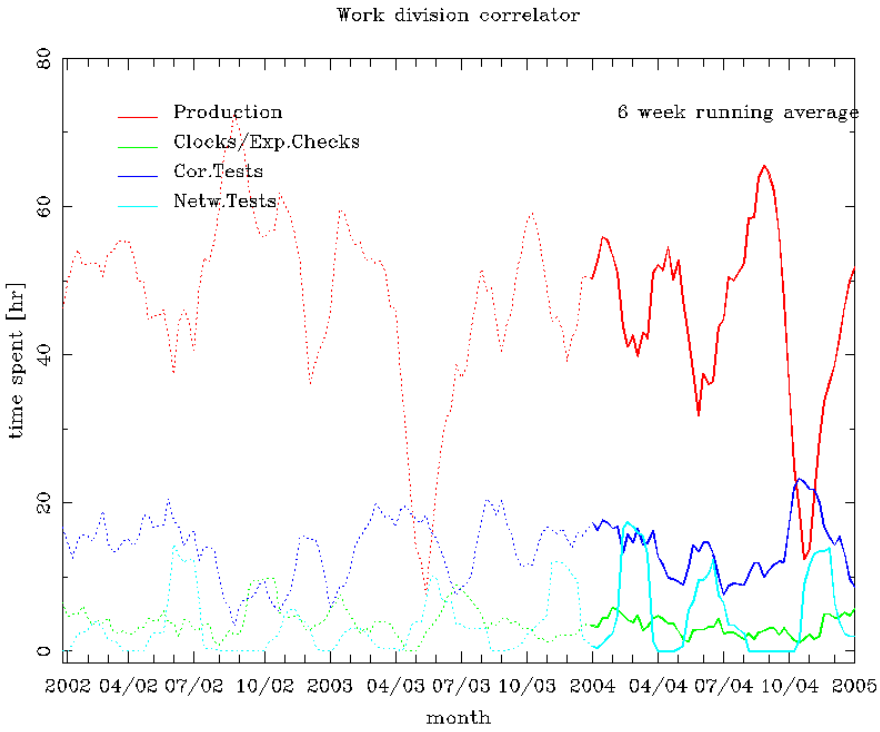



*Figure 7: Work division correlator.*

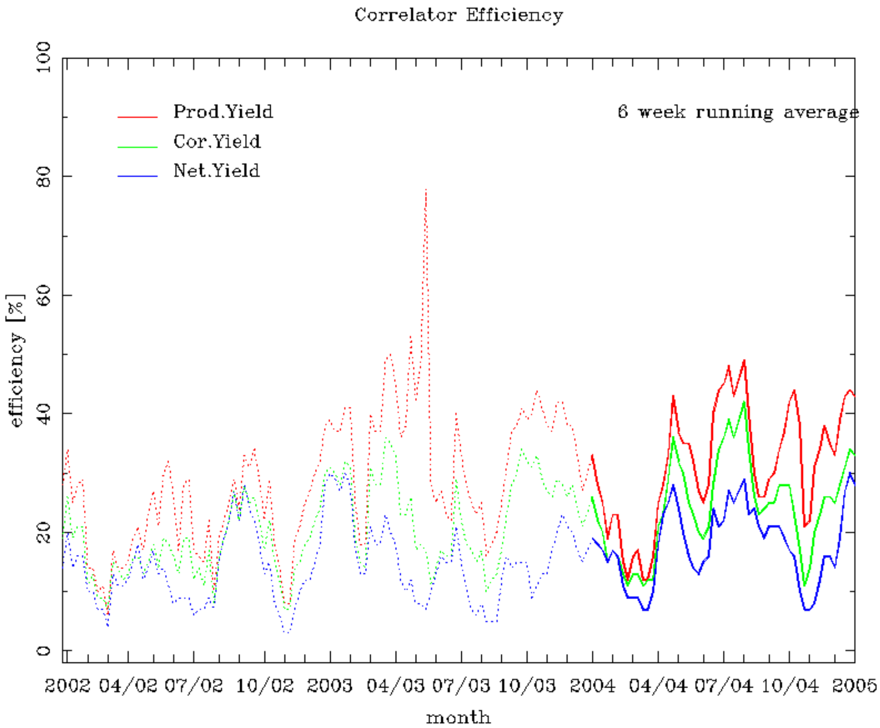



*Figure 8: Correlator efficiency.*

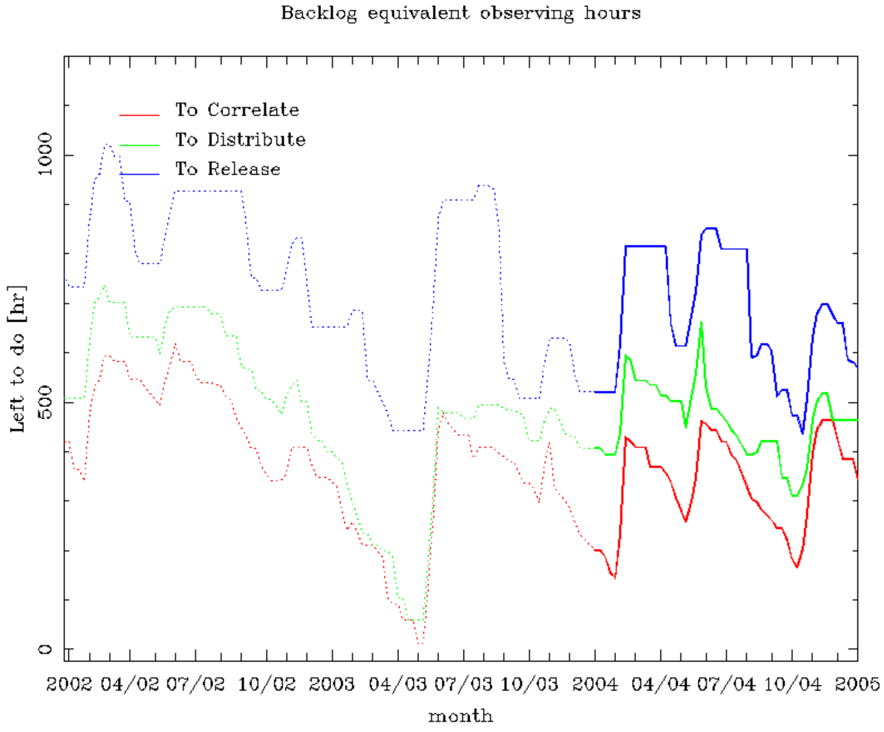



*Figure 9: Backlog equivalent observing hours. The backlog of the correlator can be expressed by plotting every week the experiment hours that still need to be correlated, distributed and released respectively.*

### 2.1.2 Logistics and Infrastructure

In 2004, 13 working tape playback units (DPUs) and 15 Mark 5A units were attached to the station units (SUs) for operations -- 3 fully connected to their SUs and 12 sharing an SU with a DPU. One Mark 5A unit was placed on loan to Metsähovi, expected to be returned at the end of the February 2005 session.

Correlator operations were able to keep up with the fundamental rule for recycling Mark 5 disk-packs within two sessions, as seen in Table 3. Disks were distributed more efficiently than required, allowing somewhat broader participation in disk-based recordings. Anticipated increases in the disk resources required per session as recording bandwidths increase is expected to put pressure on existing disk supplies.

The columns in table 3 show the number of disk packs and total capacity received by JIVE and shipped back out to the stations, with each row grouping sessions according to the rule that we should recycle disks within 2 sessions. The syntax of the entries is N (disk packs) for X (TBytes).

| IN | OUT | NET OVERDISTRIBUTION |
|---|---|---|
| Nov'03 20 for 22.000 | May'04 28 for 30.520 | 8 for 8.520 |
| Feb'04 53 for 63.689 | Oct'04 68 for 86.312 | 15 for 22.623 |
| May'04 78 for 111.516 | due to stations by Feb'05 | |
| Oct'04 87 for 122.529 | due to stations by May'05 | |

*Table 3: Disk logistics for sessions that have used Mark 5 recording.*

Shipping tapes prior to the 2004 sessions proved very simple. The explanation is of course that more stations are going over to disk, so the demand for tapes is decreasing. The situation of a disk-based EVN and a tape-based VLBA, where most global-experiment correlation occurs at JIVE, raises the need to balance the trans-Atlantic tape flux by sending tapes to NRAO. 60 Tapes were sent to Socorro to cover the May/June 2004 session, and later in the year we sent another 120 tapes, meant to anticipate future imbalances (and thus could be sent by sea much more economically). These tape shipments did not affect EVN operations, as all EVN stations had already transferred over to Mark 5 disk-based recording.

## 2.2 EVN Support

### 2.2.1 Network Monitoring, Reliability, and Performance

We continue to process NMEs via the pipeline, with results being posted to the EVN web pages and EVN Reliability Indicators (ERI) calculated. There were considerably more NMEs and fringe tests in the first two sessions of the year than usual. The February 2004 NMEs focused on 1 Gbps – actually observed as 512 Mbps one-bit experiments to allow stations without a Mark 5 to participate. A key goal was to characterise the available bandwidth at the four common bands (L, C, X, K). There were an additional two new-receiver fringe tests: at UHF (Westerbork, Onsala, Noto, Urumqi, Torun fringes) and 5cm (Westerbork, Noto, Hartebeesthoek fringes, but not to Medicina). In May 2004, the C- and L-band NMEs doubled as phase-reference tests, and there was an additional 1 Gbps test for stations who were not able to participate in the previous session, as well as a special test experiment investigating a phase-referencing tactic using both the Lovell and the Mark 2 telescopes at Jodrell Bank, in light of the Lovell’s reduced slewing capabilities.

In addition to routine network monitoring, NMEs since the May/June 2004 session have been used for ftp fringe tests for stations recording with Mark 5, in addition to the existing separate ftp fringe-test experiments. We have ported the NICT (formerly CRL) software correlator in routine use for processing ftp'd data to the JIVE/ASTRON NL-GRID cluster computer. Ftp fringe tests have been very successful in identifying station problems early in the session (initial results are reported on the same day as the experiment is observed) and have contributed to an overall increase in the ERI in recent sessions. Examples include lack of fringes to Effelsberg in the Feb'04 C-band fringe-test experiment; rapid feedback allowed them to find an LO problem and repair it before the C-band session itself started. Also, in the October 2004 session, an unlocked BBC at Noto was detected during the ftp fringe-testing, and was repaired by the next user experiment. We also had our first-ever ftp fringes to Urumqi, Shanghai, Metsähovi and Darnhall in that session.

The pipeline provides stations with feedback on gain corrections for all experiments correlated, both NMEs/fringe-tests and user experiments. These data are being used to identify stations/frequency bands with particular problems e.g., K-band was shown to have severe problems, and so an NME in the first session of 2005 will be used to investigate the origin of this problem (e.g., pointing errors, opacity, etc.). The EVN Reliability Indicator (ERI) is also calculated for each experiment during the pipelining. The ERI takes into account all failures that were detected while reviewing the data. A related statistic, ERI*, excludes problems that were outside of the EVN's control (e.g., bad weather). Fgure 10 plots ERI* for pipelined user experiments up through the October/November 2004 session.

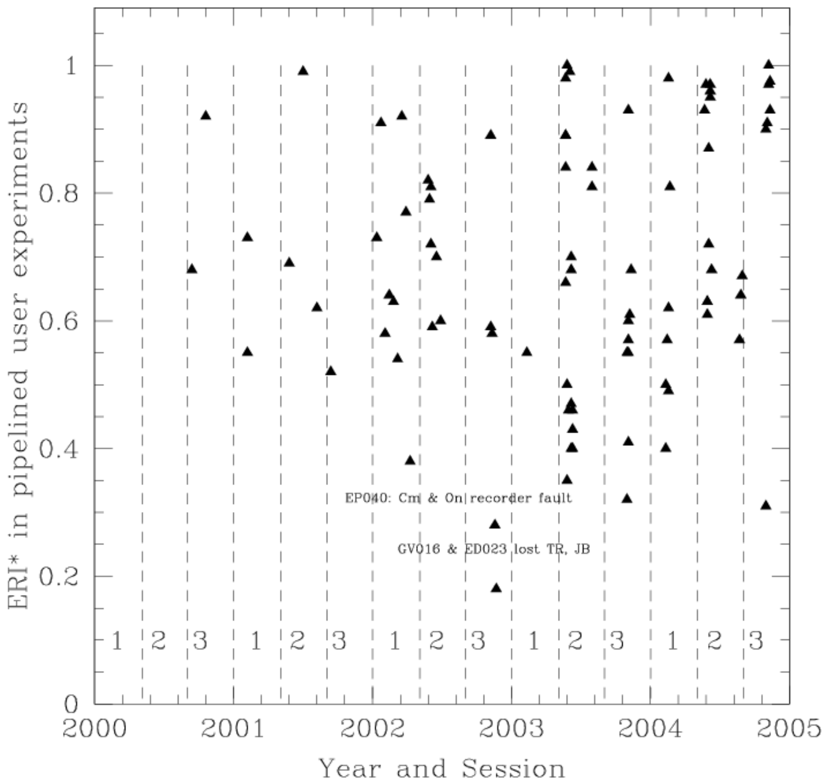



*Figure 10: EVN Reliability Indicator for pipelined user experiments up through the October/ November 2004 session.*

Stations have made strides in measuring their T_cal as a function of time and frequency, although of course improvements could still be made, especially in the timeliness of creating the RXG files. We have compiled median gain corrections over the past few sessions, and the overall situation is improving, especially for the most-used bands. K-band is still a problem, and there is a tentative suggestion that stations with VLBA racks seem to require larger corrections than stations with MkIV racks. The pipeline provides stations with feedback on gain corrections for all experiments correlated, both NMEs/fringe-tests and user experiments.

A new release of the field system is expected soon. It should provide more transparent control of e-VLBI operations and improve the monitoring of remaining disk capacity. A new release of sched with support for native Mark 5 schedules and transparent ftp, and e-VLBI scheduling will be released for use in the first session of 2005.

### 2.2.2 PI Support

The EVN archive at JIVE entered service in 2004. This provides web access to the station feedback, standard plots, pipeline results, and FITS files. Public access to source-specific information is governed by the EVN Archive Policy -- sources identified by the PI as "private" have a one-year proprietary period, starting from distribution of the last experiment resulting from a proposal, prior to their FITS data and pipeline results being made public. Password protection in enabled for proprietary data. The EVN catalogue of observations (Bologna) can be used to search for observations of particular sources and provides a link to the relevant experiments on the EVN data archive for experiments correlated at JIVE. In addition, a prototype was completed for searching FITS files in the archive. A database contains all the meta-data for the projects that are on-line. Searches are for example allowed on source names or coordinates, observing frequency and participating telescopes.

We began a targeted effort to initiate PI (Principal Investigator) help with scheduling for the May 2004 EVN session, in order to minimize the occurrence of "avoidable" problems arising from PIs making schedules that would be impossible to correlate or from use of outdated sched versions. This was useful, especially in light of the experiments at unusual frequencies (UHF, highly red-shifted HI, OH) and the number of inexperienced PIs. All PIs were contacted a couple weeks prior to the schedule due-date, and all but one received help in some form in the scheduling process. Nonetheless, post-schedule-deposit review caught a couple of problems that could have compromised observations. These were cleared up following some iterations with the PIs. The relative success of this evolution, which was compressed into a day-and-a-half around the schedule due-date, gives rise to some optimism for the future idea of having a few-day period to check over schedules once deposited by the PIs and prior to the stations beginning to download them. This effort was continued prior to the October/November session, again with scheduling mistakes detected in a few experiments that would have compromised their results. As a side benefit, there have been fewer "corrected" versions of schedules posted, which reduces the likelihood that different stations observe using different versions of the schedule.

We have overhauled the JIVE and EVN web pages, giving them a more user-friendly and attractive appearance while at the same time making them easier to maintain. Much of the content was updated, including a new document going over the field-of-view improvements resulting from the shorter integration times. We tested the wider fields of view enabled by the shorter integration times by correlating an NME with coordinates offset by 120" and comparing the resulting image with that from the original correlation; loss of peak brightness and image broadening were consistent with expectations (see figure 11).

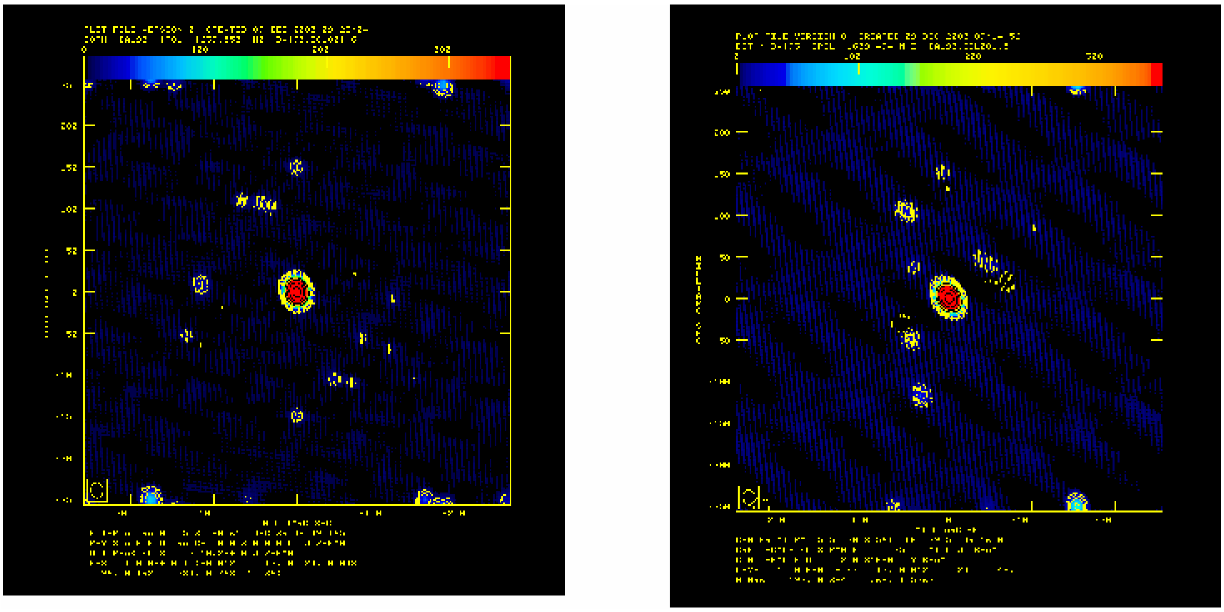


*Figure 11: Wide field mapping NME test.*

The February 20004 session marked the first opportunity to request sub-second integration times; five user experiments did so (one of these experiments holds a new JIVE record for resulting-FITS-size: 94 GB). We have also added some field-of-view capabilities to the increasingly popular "EVN calculator" on the EVN web pages. These are currently reported as the FoV having a <10% reduction in the response to a point source for the specified observing/correlation configuration; we aim to add more flexibility by allowing computations of percent loss at a specified radius, as well as considering image broadening. The EVN calculator also shows whether the specified correlation configuration can be processed in a single pass.

Two PCs (one windows, one linux) were replaced with upgraded models in the visitors' room during the course of 2004.

# 3. Software Development

## 3.1 Correlator Software

The main activity of the software team is the support of continuous and reliable operation of the EVN Data Processor. The operator logs are systematically monitored to keep track of any performance problems. It is regularly required to respond to problems associated with exceptional observing modes and experiment specific features. Every month small changes to the logic are needed in order to cope with all incoming experiments. The software group also takes the responsibility for testing, which in some cases takes a lot of time.

In the beginning of 2004 there was continued effort to port the correlator control software to a modern compiler. By the end of June this resulted in a new version of the JIVE Correlator Control Software (JCCS) built with the GNU3.2 compiler. This should have allowed the use of the Purify package to check against run-time problems, but unsupported platform features (HP-UX 10) frustrated this, as well as some problems in third party libraries.

In the second half of the year a goal was formulated to improve the code in such a way that longer uninterrupted operations would become possible. In combination with disk recording this will allow unattended processing, which will boost productivity. This functionality is also vital for e-VLBI, as there is no opportunity to re-process the data streams that are coming in over the fibre. The smooth operation of the correlator during e-VLBI runs is an important aspect of the new correlator code. Improvements were made to allow pseudo real-time control, which impacts on the schedule logic amongst other things. Improvements were made to the code that makes the connections with the hardware and the logic of selecting sub-jobs. Solving these issues required attention to properly manage the version control and a new policy for the use of CVS was enforced.

During the year a number of enhancements of the correlator capabilities were made. For instance, the correlator at JIVE can now deal correctly with LO offsets. New code was added to enable phase-cal detection in the correlator, as required for the ALBUS effort on calibration methods. Additionally, several problems were fixed, including the configuration for 16MHz/LSB measurements, polynomials around midnight, and a problem with truncated source names, as well as one with mixed fan-outs in a single job. A problem with timing mismatches in reading data frames from the correlator occurred several times, requiring the attention of the software group. Another recurring problem concerns the logic of gaps in the schedules, especially related to servoing issues of the Mark 5 units.

The use of Mark 5 units required some code adaptation to perform well in all cases. The Huygens project delivered the first Mark 5 recording with VLBA formatting and 64 tracks enabled, which required considerable changes. The software of the Mark 5 units themselves is also regularly updated and new network interface cards were installed on several units. This effort is mostly motivated by e-VLBI. A program was created that allows direct display of the resulting e-VLBI fringes on a web page. This means that telescopes participating in e-VLBI observations can monitor their own performance. The operational flexibility for mixed disk/tape configurations was improved by initiating a database, which describes the tape- or disk drive connection of each station unit. This allows changes of the correlator set-up without modifications to the project description files. The software to exercise the station units in an offline fashion was upgraded to work with disk systems as well.

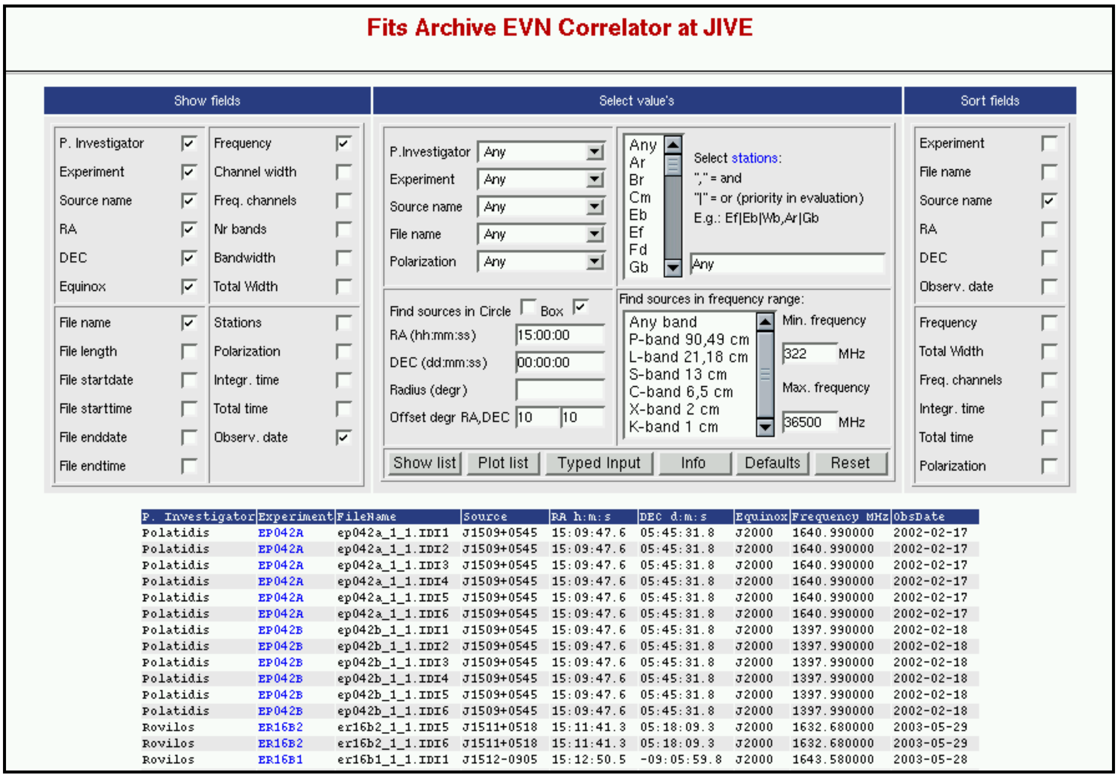
An effort was made to support data files larger than 2GB. At the highest dump-rate, 8-minute scans would run into this problem. This was not a trivial change because in the previous data format only 32bits were reserved for file-offsets. The upgrade to 64bits thus required a change of the layout of the files. In the same area the upcoming changes related to PCInt required us to port the entire correlator software to Linux, as the future data handling will be based on this platform. Downstream, the tools that convert the binary data to aips++ MeasurementSets and FITS were also modified in order to work transparently on different platforms. Precise comparisons between the data from both systems were made. This allows the massive storage and computing power available in the PCInt backend to be used for off-line data processing.

The tool that performs the van Vleck correction was ported from a glish script to compiled aips++ code, improving the performance considerably. Enhancements were also made to the standard plotting routines.

## 3.2 Logistic Software

Several enhancements were made to the software that deals with the logs and other interfaces to the correlator operations. The software that maintains the correlator logbook was upgraded to use a proper database and can now be accessed over the web. The tape database was updated to allow the extended VSN format in use for disk-based recording.

Considerable effort was put in the new EVN data archive that keeps output of the correlator on-line for authorised users. This implied work on protection issues for web access, as user groups have proprietary rights on the data for the first year. The archive web pages were upgraded to include the pipeline products. The data archive was outfitted with a FITS finder script, which allows outside users to search interactively for observations around sky coordinates (see figure 12). The sky coverage of the archive can be plotted interactively. In addition one can search the whole data base for data with a whole range of observational parameters (from participating antennas, to observing frequency). A start was made to expand the capacity from 2 to 10 TByte and to make a mirror system at the Westerbork site.




| P. Investigator | Experiment | FileName | Source | RA h:m:s | DEC d:m:s | Equinox | Frequency MHz | ObsDate |
|---|---|---|---|---|---|---|---|---|
| Polatidis | EP042A | ep042a_1_1.IDI1 | J1509+0545 | 15:09:47.6 | 05:45:31.8 | J2000 | 1640.990000 | 2002-02-17 |
| Polatidis | EP042A | ep042a_1_1.IDI2 | J1509+0545 | 15:09:47.6 | 05:45:31.8 | J2000 | 1640.990000 | 2002-02-17 |
| Polatidis | EP042A | ep042a_1_1.IDI3 | J1509+0545 | 15:09:47.6 | 05:45:31.8 | J2000 | 1640.990000 | 2002-02-17 |
| Polatidis | EP042A | ep042a_1_1.IDI4 | J1509+0545 | 15:09:47.6 | 05:45:31.8 | J2000 | 1640.990000 | 2002-02-17 |
| Polatidis | EP042A | ep042a_1_1.IDI5 | J1509+0545 | 15:09:47.6 | 05:45:31.8 | J2000 | 1640.990000 | 2002-02-17 |
| Polatidis | EP042A | ep042a_1_1.IDI6 | J1509+0545 | 15:09:47.6 | 05:45:31.8 | J2000 | 1640.990000 | 2002-02-17 |
| Polatidis | EP042B | ep042b_1_1.IDI1 | J1509+0545 | 15:09:47.6 | 05:45:31.8 | J2000 | 1397.990000 | 2002-02-18 |
| Polatidis | EP042B | ep042b_1_1.IDI2 | J1509+0545 | 15:09:47.6 | 05:45:31.8 | J2000 | 1397.990000 | 2002-02-18 |
| Polatidis | EP042B | ep042b_1_1.IDI3 | J1509+0545 | 15:09:47.6 | 05:45:31.8 | J2000 | 1397.990000 | 2002-02-18 |
| Polatidis | EP042B | ep042b_1_1.IDI4 | J1509+0545 | 15:09:47.6 | 05:45:31.8 | J2000 | 1397.990000 | 2002-02-18 |
| Polatidis | EP042B | ep042b_1_1.IDI5 | J1509+0545 | 15:09:47.6 | 05:45:31.8 | J2000 | 1397.990000 | 2002-02-18 |
| Polatidis | EP042B | ep042b_1_1.IDI6 | J1509+0545 | 15:09:47.6 | 05:45:31.8 | J2000 | 1397.990000 | 2002-02-18 |
| Rovilos | ER16B2 | er16b2_1_1.IDI5 | J1511+0518 | 15:11:41.3 | 05:18:09.3 | J2000 | 1632.680000 | 2003-05-29 |
| Rovilos | ER16B2 | er16b2_1_1.IDI6 | J1511+0518 | 15:11:41.3 | 05:18:09.3 | J2000 | 1632.680000 | 2003-05-29 |
| Rovilos | ER16B1 | er16b1_1_1.IDI1 | J1512-0905 | 15:12:50.5 | -09:05:59.8 | J2000 | 1643.580000 | 2003-05-28 |

*Figure 12: Display of the interactive FITS finder tool.*

## 3.3 FP6 RadioNet ALBUS project

Work on the FP6 RadioNet ALBUS project started this year. The ALBUS project is managed by JIVE (PI, Van Langevelde) and considerable effort went in to organising the project and defining the work-packages. During the year two new people joined the software group. There was work in the following areas:

*Calibration transfer*
Considerable progress was made on the part that concentrates on system temperature calibration information being incorporated into the data product. Software was written to channel system temperature and telescope flagging information into the intermediate correlator data product (aips++ measurement sets), as well as telescope gain curves. The conversion into FITS files was verified and this software was undergoing operational tests by the end of 2004. Some effort was made to streamline the calibration of the sampler levels at the telescopes, which is an essential step in the amplitude calibration. Additionally, first runs were made on the EVN Mk4 data processor with phase-cal detection enabled. The first efforts resulted in convincing detections, but the invocation of phase-cal detection seems to affect the robustness of the correlation process. This needs to be fixed before further progress can be made.

*Ionospheric calibration*
Initial studies for this started late in the year; ionospheric calibration schemes based on either global datasets or local GPS receivers were discussed in a number of meetings.

*Infrastructure Software*
An important issue for the ALBUS project was to define the software environment in which most of the project software can be implemented. In a number of meetings the options were discussed, focusing on the problems associated with distributing calibration algorithms and parallel computing. By the end of 2004 consensus was reached to pursue a Python scripting interface for classic AIPS. A few small tests were carried out for this project (named “ParselTongue”) and a project plan was drafted.


*Figure 13: JIVE ALBUS personnel went all the way to the top of the Effelsberg prime focus cabin in December to inspect the new water vapour radiometer.*

# 4. Technical Operations and R&D

## 4.1 Data Processor maintenance

### 4.1.1 Data Playback Units

Problems with capstan motors continued to dominate Date Playback Units (DPU) failures this year. One reel motor also failed, and a few headstacks wore out and had to be replaced. Aided by the growing use of disk-based Mark 5A units, it was possible to juggle available working units to avoid any serious impact on the production schedule. With the exception of capstan motors, all problems were repaired in-house.

Metrum IS Ltd. moved premises and, as a consequence, offered for sale a large stock of redundant components. A list was placed on the JIVE web pages and some items were purchased for the EVN spares pool.

### 4.1.2 Station Units

The 6.25s low-weight, high auto-correlation problem identified at the end of 2003 was traced to a “feature” of the byte slip fix. Before Mark 5, all byte-slips were positive and the Xilinx modification was able to repair the offset in one track frame. With Mark5 data negative byte slips also occur, and these take 2499 frames to be repaired. Why the use of Mark5 provokes negative byte slips is unknown. Possibly the highly synchronised transitions in the data cause a different kind of cross-talk. A new design, able to fix any byte-slip within a single frame was prepared and deployed throughout. Other Mark4 correlators were notified of the change.

Reliability problems with Track Recovery Modules (TRM) persisted. Cleaning the contacts on the Dynamic Random Access Memories (DRAM) produced some improvement but plans to find a more “scientific” approach to trouble-shooting were made. The TRMs, and other boards in the SU, use a Motorola microcontroller that has an on-board, Background De-bug Mode (BDM) facility. Via a port on the micro it is possible to view and control the processor externally from a PC. The BDM port is brought to a front panel connector on all of the relevant Station Unit (SU) boards. A special interface and software are also needed; these were "rescued" from Metrum IS in 2003. One of the original SU software designers was contacted and accepted a contract to set up a test station using the BDM facility and to write some test software. One of the spare Station Units was commissioned and set to work as a test bed for this purpose. Mark5 provides a convenient data source and off-line test software enables a thorough checkout of TRMs in an operational state. A sample of faulty TRMs were tested and a simple set of diagnostic procedures were developed. The conclusion of this exercise was that most problems are indeed caused by bad connections to plug-in devices: mostly the DRAMs and associated Xilinx devices.

During this exercise a serious problem was discovered. Many of the TRM modules, were found to suffer from copper track corrosion (see figure 14). An outside company, who specialise in PCB manufacture and salvage, were called in to give an evaluation. Their conclusion was that the corrosion was caused by a flux residue. They also found that the quality of the solder resist on the TRMs was poor compared to the other boards. These factors have contributed to an on-going degradation of the copper traces on the component side of the boards.

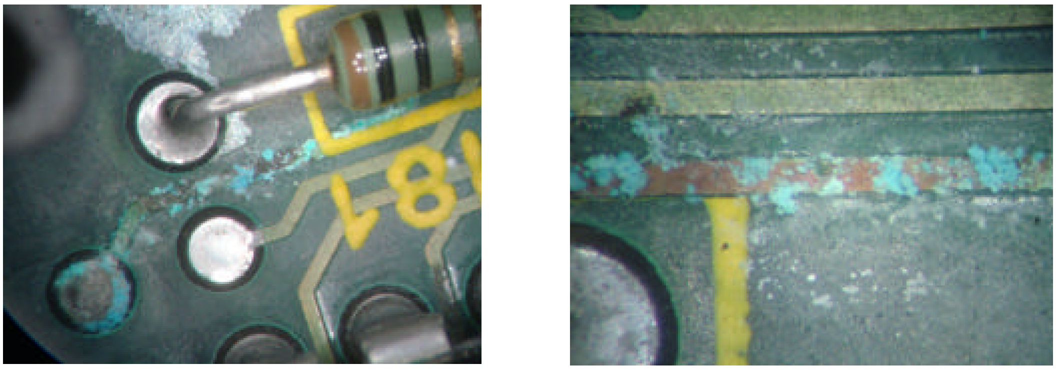


Figure 14: TRM Corrosion.

Other users of the Station Unit were contacted to see if any had similar problems with their TRMs, but none of them did. It is believed that the JIVE TRMs were assembled by a different sub-contractor which may explain the difference.

A company (Azteco) was found who were able to clean and re-coat the boards. A first test was done with 2 boards. After evaluation of these, a further order was placed to clean another 20.

### 4.1.3 Production Mark 5 units

By the end of 2004 the total number of JIVE Mark 5 units had grown to 16 and on 22 December 2004 a total of 15 were in use at the EVN data processor. One unit was loaned to Torun to allow them to take part in Mark 5 tests during the May session and to participate in FTP fringe tests. Later in the year a Mark 5 unit was loaned to Metsähovi.

Generally the Mark 5s performed reliably and became a stable platform for production correlation. Some initial problems were related to the variety of software and firmware versions in use. Action was taken to ensure that all were brought to a common standard and that future revisions would be applied universally.

The only major failure was in one of the backplanes. The fault was investigated and repaired by JIVE personnel. Conduant were informed and, after some investigation, they acknowledge that the failure was thoroughly diagnosed by JIVE and the fault was probably a manufacturing/inspection error at the company they use for PCB assembly.

### 4.1.4 Infrastructure

There was some down-time due to failures of the cooling system. Most of these were trivial but one occurred at the weekend and temperatures in the data processor began to climb enough to cause concern. One set of alarms produced by the cooling machine itself had been switched off to inhibit false alarms from the humidity control system. This is safe because another system automatically switches off power if the temperature gets too high. Nevertheless, it was decided that an advance warning would be useful so additional sensors were installed and connected into the alarm system. Subsequent similar failures were indeed alerted to the standby personnel.

*Figure 15: New Mark 5 Cabinets.*

## 4.2 Data Processor developments and upgrades

### 4.2.1 Mark 5

On all Mark 5 I/O interface boards a programming cable, with a fixed connector on the back panel of the board, was installed. It is now possible to do “on board” reprogramming of these boards, without the necessity to dismantle the Mark 5 units and take the boards out of the unit.
The I/O panel was also re-positioned to allow access to the Gigabit Ethernet boards installed in JIVE Mark 5 units for e-VLBI.

*Infrastructure*

As the number of Mark 5 units at JIVE gradually increased over the year, a phased series of changes were made to accommodate these units as they arrived (see figure 15). The oscilloscope cabinet was disconnected and removed and three DPUs were taken out of service. This left enough room for three new cabinets to be installed. By the end of 2004 a total of ten Mark5s were integrated into the data-processor data-replay system. The dimensions of the new cabinets do not match the footprint of the DPUs so changes in cable and cooing air routing were also required.

*Other infrastructure changes*

Fibre-optic lines were installed under the floor, and into the adjacent computer room for the e-VLBI, Gigabit Ethernet connections to Amsterdam and Westerbork.

A new UPS with more power was installed. This UPS is able to drive all the network stations that are in use in the processor room.

To accommodate Mark5 disk-packs and shipping boxes, modifications were made to the paternoster. The upper room of the paternoster was modified, along with one of the tape trolleys and all thick tapes were removed from the paternoster and disposed of.

## 4.3 Technical R&D projects

### 4.3.1 PCInt

*Hardware*

In March 2004, the PCInt cluster was delivered by TTEC (see figure 16). After some days of configuring and experimenting with the setup the delivery was accepted. The hardware performed very well. Measured transfer speeds to disk were at least 160 MBytes per second per unit (we required 40 MBytes per second per unit) so this was well beyond our specification. Gigabit Ethernet links were installed and the measured performance from the Single Board Computers (SBC) to the cluster nodes was ~ 80 Mbps average speed (under ideal circumstances). We require 20 Mbps for reliable operation. The performance of the inter-cluster node InfiniBand link was also deemed acceptable. Cables were constructed to connect up to four correlator boards to one High Speed Serial Link (HSSL) module. With one correlator rack fully wired up (eight correlator boards connected to two HSSL modules) testing could commence. Initial tests with the Linux device driver outside the test-environment revealed some bugs. When these had been fixed, testing of the data path from correlator board to the SBCs main memory could proceed. Some bottlenecks were found and it was decided to break up testing of the full data path into its separate steps. It was found that the necessary data rate across the links into the HSSL module could be achieved.

In November the last remaining HSSL cables were installed and tested. With this, the new hardware data path was fully in place (all correlator boards connected to SBC’s via a HSSL and SBCs connected to the PCInt cluster via Gigabit fibers) and the PCInt cluster was up and running. This part of the project can be closed.

*Software*

Data hardware path validation tests were done after all hardware was fully installed. Intermittently the full correlator could be read out at one eighth of a second integration time. The tests revealed the following: at high level the PCInt software proved to be reliable but a well isolated problem caused some (dynamic) processes to crash. This bug was traced and fixed. The tests also showed that some fine-tuning was needed (e.g. longer time-out periods) and that a few diagnostic messages were not propagated through the system. These issues were also resolved. Some components were improved, enhancing their usability. The locking scheme for multithreaded access to shared blocks was re-implemented (the previous incarnation could produce inconsistent status of the objects, possibly leading to a hardware crash).

The system was made 64-bit safe; this required a very small effort but proved to be a useful exercise since the 64-bit compilation revealed two very subtle (but very important) bugs that were not detectable in the standard 32-bit compilation environment. Moreover, being able to run 64-bit code was possible immediately, yielding on the order of a 12% speed-up improvement 'for free', i.e. without optimisation: No effort was made to optimize or fine-tune for the 64-bit environment. The command line interface controlling PCInt was completely re-done in order to feature command line history and command line editing, and make it provide more flexibility and intelligence. Maintenance was performed on the software: an upgrade to a newer compiler implied that some obsolete constructs had to be changed. The new compiler was also more stringent, and modifications had to be made throughout the whole software suite.

#### 4.3.2 Mark 5

Intel Xeon Server boards purchased at the end of 2003 were installed in two Mark 5 units. This took some time due to problems with incorrect connectors and memory devices. Apart from this, the change was straightforward and both Mark5s operated normally afterwards. The intention was to use these to see if they would influence the data rate limitations of Mark 5. Also, these motherboards come with on-board Gigabit Ethernet interfaces that operate independently of the PCI bus. In fact, no great improvement in transfer data rate was observed when Mark 5 disks were involved. Transfers to normal disks however were much faster.

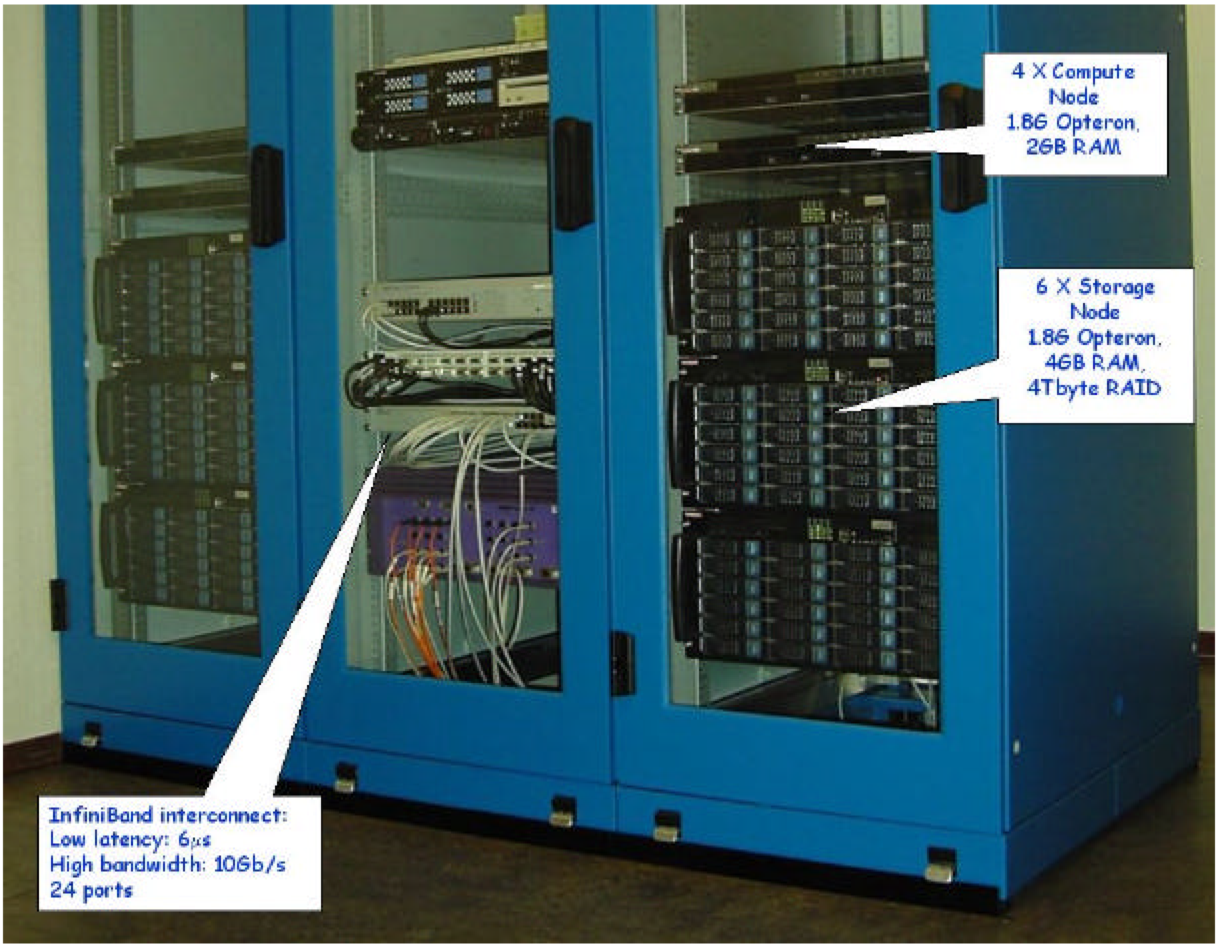



*Figure 16: PCInt Computation and Storage Cluster.*

### 4.4 e-VLBI

#### 4.4.1 First EVN e-VLBI Image

On 15th January, Onsala, Cambridge and Westerbork observed 2007+777 at 6cm, in an e-VLBI test that yielded the first EVN e-VLBI image (see figure 17). Onsala and Westerbork data were sent directly to JIVE, without local buffering, and recorded on Mark5 disk units. Due to the slower link to Jodrell Bank, data from Cambridge were sent directly at 64 Mbps only, and higher rate data were recorded and transferred overnight. In all cases the custom-Mark5, TCP based, data transfer processes were used. Good fringes were detected between Onsala and Cambridge at 256Mbps, and on all baselines at 128 Mbps allowing an image to be formed less than 24 hours after the observation. The production, European research networks

(SUNET, NORDUnet, UKERNA, SURFnet and GÉANT) were used in this experiment without any special action or provision.

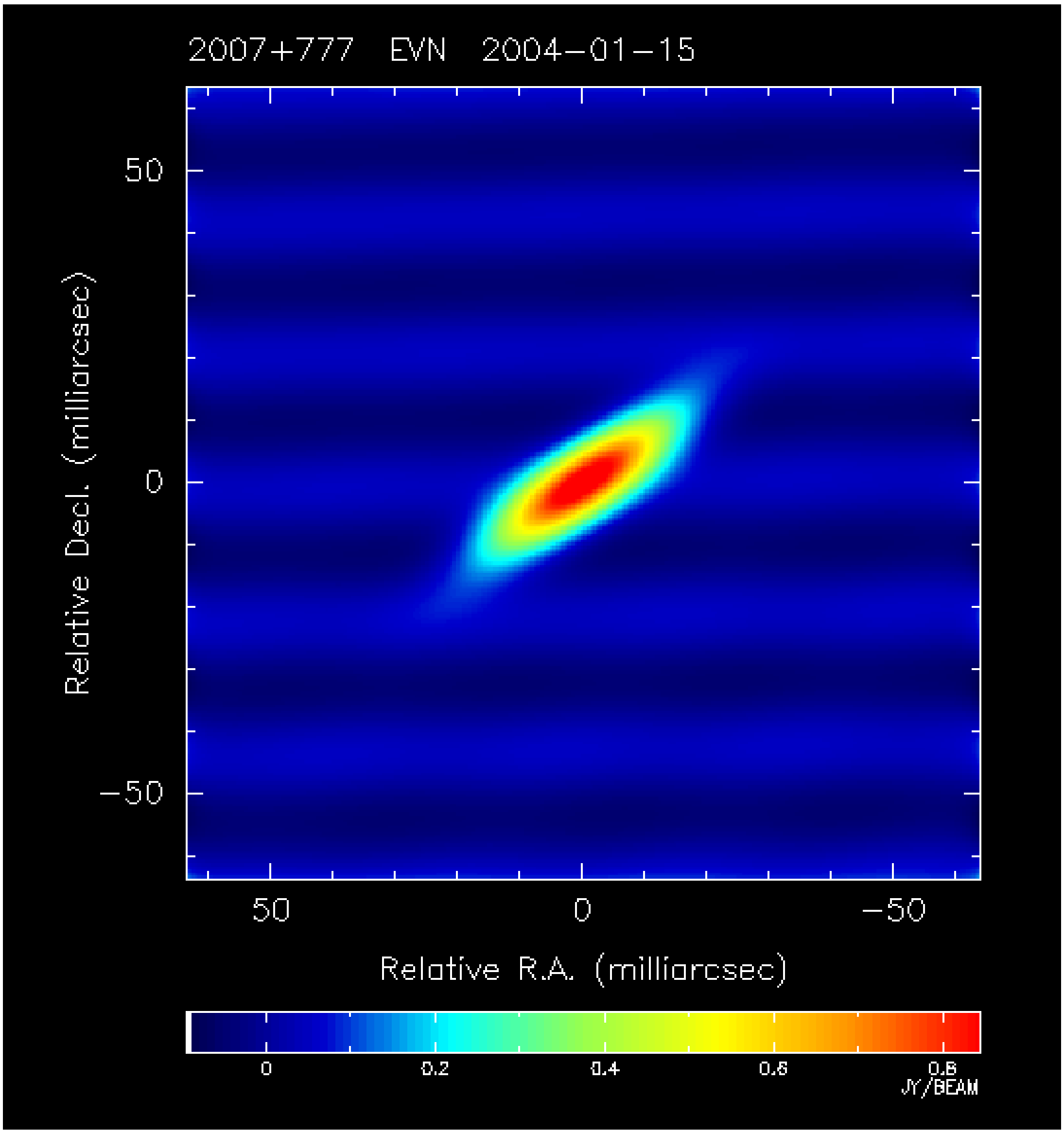



*Figure 17: The first EVN e-VLBI Image.*

### 4.4.2 2nd Proof-of-concept meeting

The second meeting of the EVN-NREN proof-of-concept project was held at Schiphol in the last week of January. The overall conclusion was that the project was on schedule. Developments for real-time operation were seen as the next priority. Prospects for high bandwidth connections to participating telescopes had changed somewhat in the year since the first meeting. It was clear that there were good prospects for a Gigabit connection to Torun, but other telescopes, including Jodrell Bank and Medicina, did not expect to get a Gbps connection until the end of 2004. Including the 100-m Effelsberg telescope within the e-VLBI network is a clear priority, but the cost of the connection is very expensive. DANTE and the NRENS will continue to support the project via GEANT2 - enabling UK and Italian telescopes to participate in early 2005.

The technical objectives of the project were also reviewed. The meeting agreed that the original goal of six telescopes in real-time at 1Gbps was unrealistic. Many stations are unlikely to get more than one Gigabit Ethernet connection, and Gigabit Ethernet is actually limited to something less than 1 Gbps. The existing VLBI system with Mark 5 is also restricted to fixed octaves- 64 Mbps, 128 Mbps, 256 Mbps, 512 Mbps, 1024 Mbps.

The revised goals agreed were real-time e-VLBI at 512Mbps with at least three telescopes participating. Non real-time tests will be performed to maximise network loading up to the limits of Mark5 and Gigabit Ethernet.

#### 4.4.3 Real-Time e-VLBI Development

In February and March work continued in the laboratory at JIVE to explore the problems of streaming data into the correlator directly from the network: i.e. real-time e-VLBI. A bench test environment was created using three Mark 5s, one acting as a dummy formatter and the others representing the telescope and correlator network interfaces. In this way it was possible to simulate the data path at up to 256 Mbps, proving that data transmitted over a network and sent directly to the Mark 5 output arrived intact. Further development was possible when Haystack released a version of Mark 5 software and firmware that enabled control of the output buffer in net2out mode.

#### 4.4.4 First Real-Time EVN e-VLBI Image

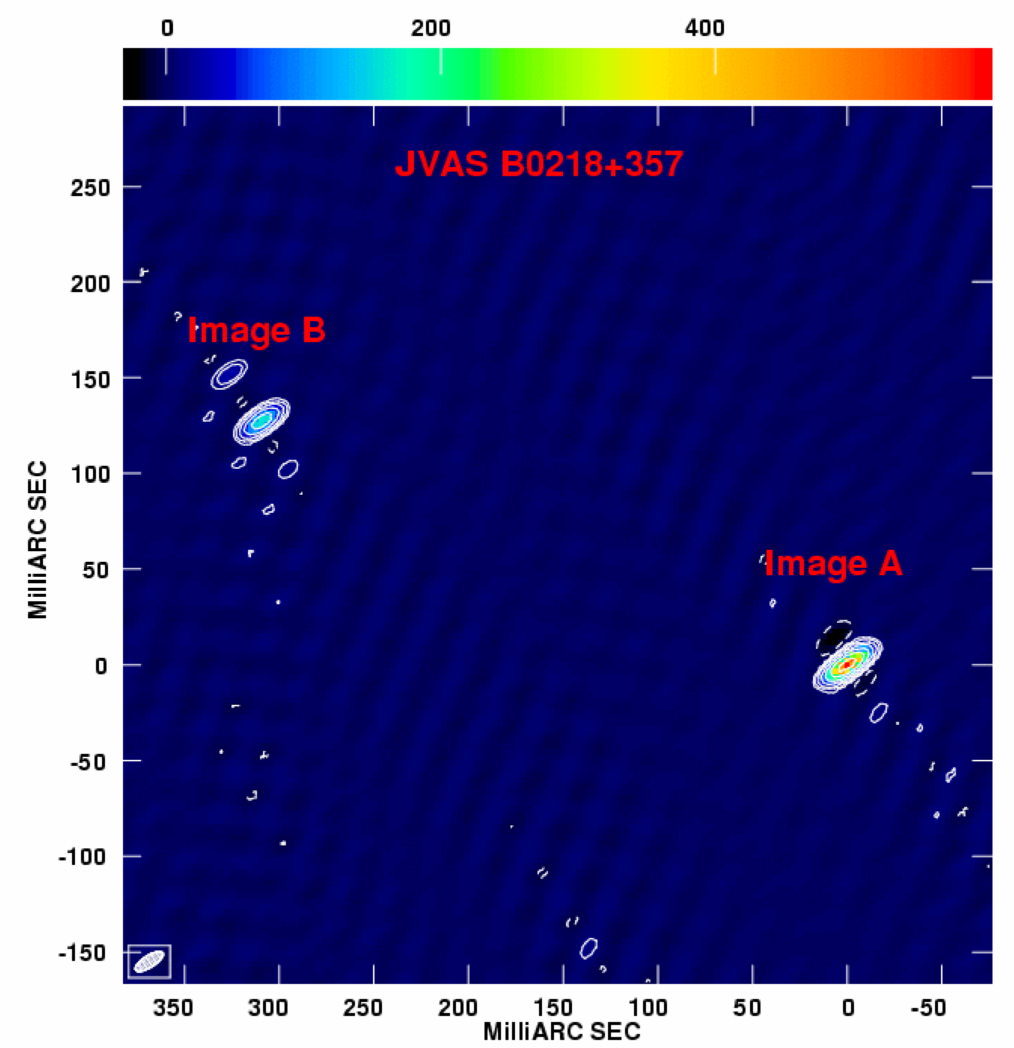



*Figure 18: First real-time e-VLBI image made from observations of the gravitational lens system B0218+35.*

The image in Figure 18 of the gravitational lens system JVAS B0218+357, was produced from data transferred directly from telescope to data processor and correlated in real-time. The observation took place on Thursday 28th April. Participating telescopes were Onsala, Jodrell Bank and Westerbork, observing in RR & LL polarisations, each with a bandwidth of 4 MHz, resulting in a total data rate of 32 Mbps per station. Time synchronisation between incoming data and the correlator observe-time clock was achieved in two stages. First the observe-time clock was set to UT minus a few seconds. Fine-tuning was then implemented using the normal servo system operating between the Mark 5 output buffer and the Station Unit. No intermediate recording of the data was used. Good quality data were received from all three telescopes throughout the 1.5 hours of observation (see figure 19).

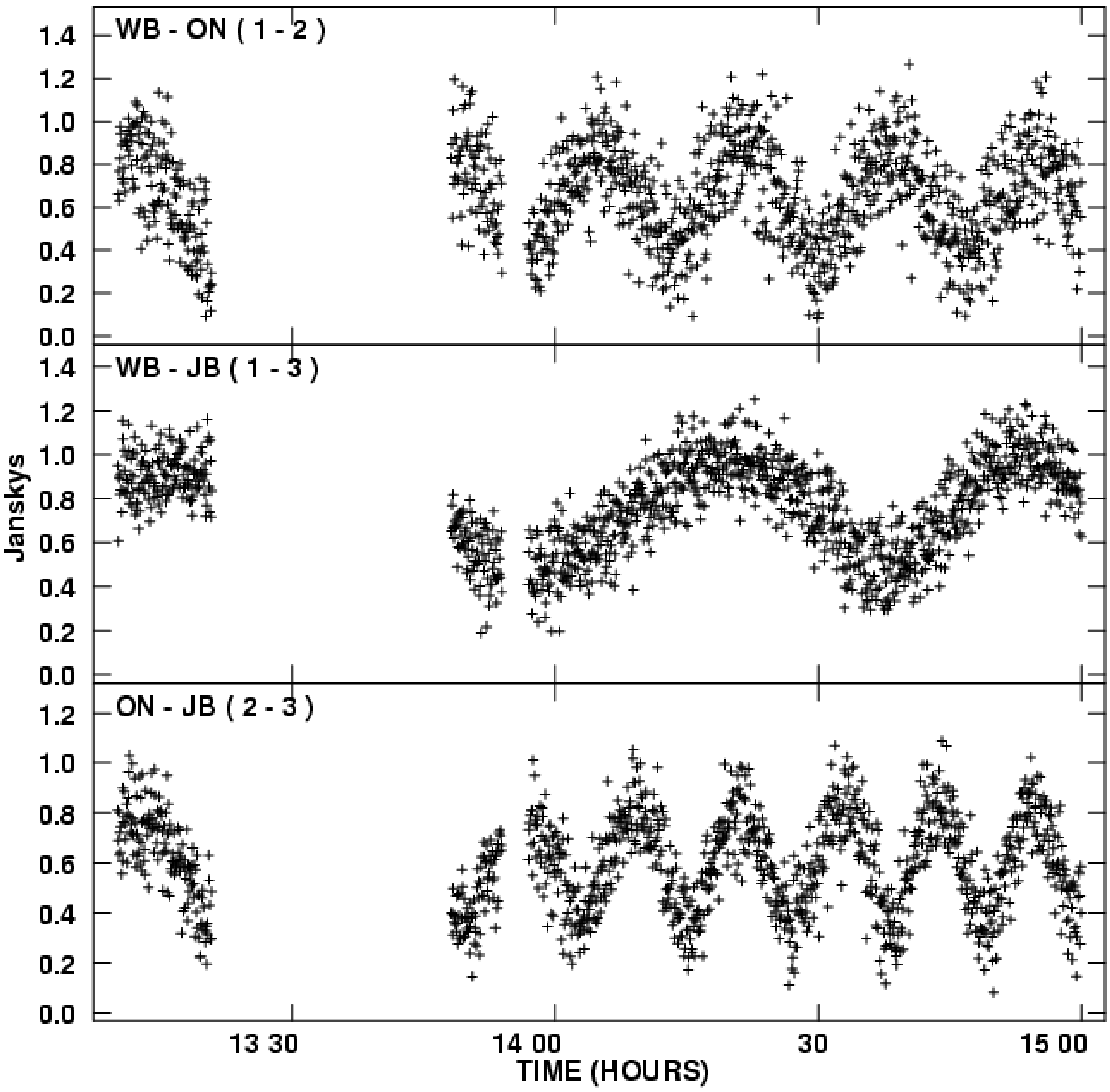



*Figure 19: The visibilities (correlated in real-time) of B0218+357 showing the characteristic beating of a double source.*

### 4.4.5 Telescope connections

Torun's fibre connection was completed early in the year. Data transfer tests to JIVE became possible in May when Torun received a Mark 5 unit, on-loan from JIVE. In June a network test was performed between JIVE and three "telescopes". Onsala and Torun participated using Mark5s and their direct network connections, whilst, in lieu of Medicina, GARR installed a suitable machine at their POP in Bologna. The test used IPERF, and so measured memory-to-memory performance using test data and no disk access.

Results are summarised below:

| Source | Destination | Data Rate – Mbps | | |
|---|---|---|---|---|
| | | Min | Max | mean |
| Onsala | JIVE | 40 | 134 | 65 |
| Torun | JIVE | 68 | 344 | 156 |
| Bologna | JIVE | 237 | 601 | 499 |
| JIVE | Onsala | 238 | 390 | 333 |
| JIVE | Torun | 174 | 207 | 192 |
| JIVE | Bologna | 109 | 111 | 110 |

The above results were for TCP tests. UDP tests failed due to a configuration error. The network providers assisted during the test, helping to establish the connection to Torun, and after the test they provided expert advice that may enable us to understand the results obtained.

On Friday 10th September real-time fringes were detected between Arecibo and three European radio telescopes. In the one hour experiment, EVN telescopes in Cambridge, UK; Torun, Poland and Westerbork, Netherlands joined Arecibo to observe ICRF reference source, 0528+134. Four, 1 MHz subbands were observed in two polarisations with 2-bit sampling, resulting in a data rate of 32 Mbps per telescope. Data flowed into the EVN correlator at JIVE with negligible packet loss throughout the test, and normal fringes were found on all baselines.

### 4.4.6 First e-VLBI Spectra-line Science demonstration

Two weeks later, the first e-EVN science observation yielded the image shown in section 1, figure 1. On the left, a low-resolution image of IRC+10420 taken with the UK's MERLIN radio telescope array shows the shell of 'maser' emission at a frequency of 1612 MHz. The higher resolution EVN e-VLBI image (right) reveals fine structure in the maser spots. This image was presented at the 3rd e-VLBI Workshop, held in Tokyo in October and again at the EVN Symposium in Toledo. A more detailed report was also given in a press release.

### 4.4.7 3rd e-VLBI Workshop, Japan

In October, the 3rd e-VLBI Workshop, hosted by Kashima Space Research Centre, attracted 67 people from 13 countries (see figure 20). Up-to-date presentations were given by e-VLBI practitioners, high energy physicists and network developers. Many successful demonstrations of e-VLBI had been realised since the last workshop in Dwingeloo, and it was agreed that e-VLBI technology is advancing at a very satisfactory pace. The next workshop will take place in July 2005 in Sydney, hosted by ATNF, CSIRO.


*Figure 20: Participants of the 3rd e-VLBI Workshop.*

### 4.4.8 e-VLBI demonstration

e-VLBI was exhibited in November at the IST2004 Event in the Hague, The Netherlands. The demonstration was hosted by GÉANT, the pan-European R&E network, on their stand in the e-Infrastructures area. An e-VLBI session involving telescopes in Cambridge, Onsala, Torun and Westerbork was conducted during the event. Live fringes, detected directly from the EVN correlator at JIVE were displayed in the exhibition hall along with webcam pictures of the telescopes and JIVE operations.

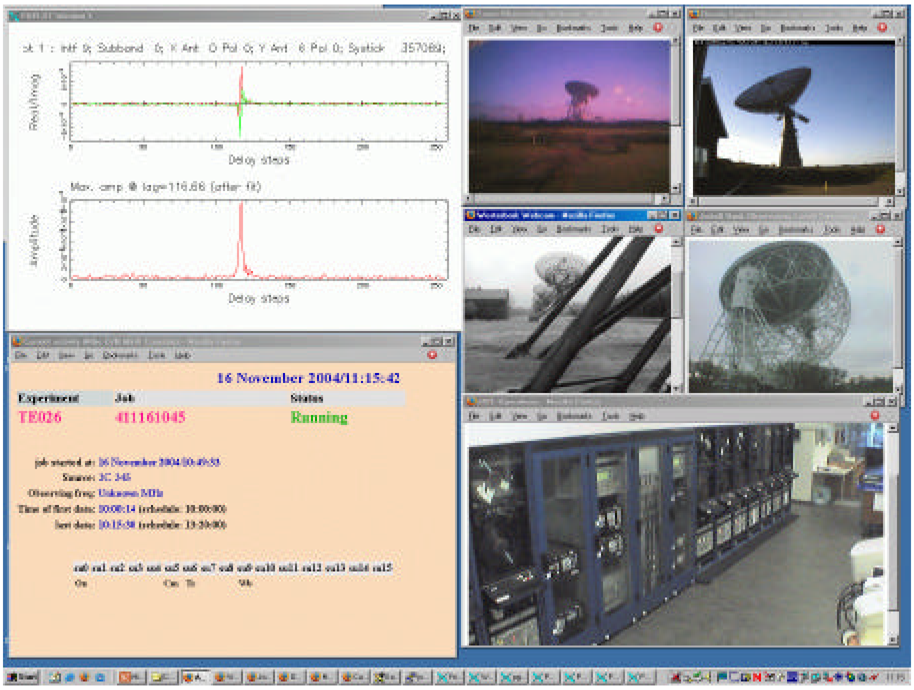



*Figure 21: IST2004 e-VLBI Demonstration Displays.*

Jodrell Bank's new 2.5 Gbps connection was used in an e-VLBI test for the first time in December. Real-time fringes to Jodrell were detected from Westerbork, at 128 Mbps, and from Torun at 256 Mbps. These were the highest real-time e-VLBI data rates achieved in Europe so far, quadrupling the previous record. A series of further e-VLBI tests are planned for 2005, at intervals of about six weeks.

Some work on alternative e-VLBI platforms was also investigated at JIVE. In preparation for the Huygens project, but also for general purpose developments and tests, a hardware test setup was built. This included two PCs with Athlon64 CPU and Nvidia NForce3 chipsets and two huge (~1 TB) SATA and PATA RAIDs on each. These PCs were connected to 2 Mark 5 units via copper Gigabit Ethernet lines and to Amsterdam via the SURFnet DWDM Gigabit Ethernet lines, thus providing a universal and nearly format independent platform.

Several different test were performed, including data transfers between JIVE, Metsähovi, Kashima and Sydney using MkIV, MRO/ATNF and K5 formatted data. Data rates were achieved up to 640 Mbps on Metsähovi-JIVE line and up to 300 - 360 Mbps on lines Kashima-JIVE and ATNF-JIVE. This work was performed using data transport software developed by J. Ritakari (MRO) in cooperation with A.Mujunen (MRO), C.Phillips (ATNF) and T.Kondo and H. Takeuchi (Kashima).

### 4.4.9 Software Correlator design and evaluation

Intensive analytical development and testing work continued on different aspects of the Huygens Software Correlator, including the data pre-processing, delay/phase correction and correlation engine modules. Although these modules were tested on Huygens-related data sets, the software correlator will have a general purpose application.

## 5. Scientific Research

### Anderson

Anderson continued work on the numerical modeling of the advection dominated accretion flow component of his thesis (e.g., figure 22). In addition, he has been involved in a VLA project (PI Schmitt) to image approximately 150 low-luminosity AGNs at 3.5 and 6 centimeters using the VLA to obtain a complete sample of nearby active galaxies. Observations for this project were continuing through the end of the year.

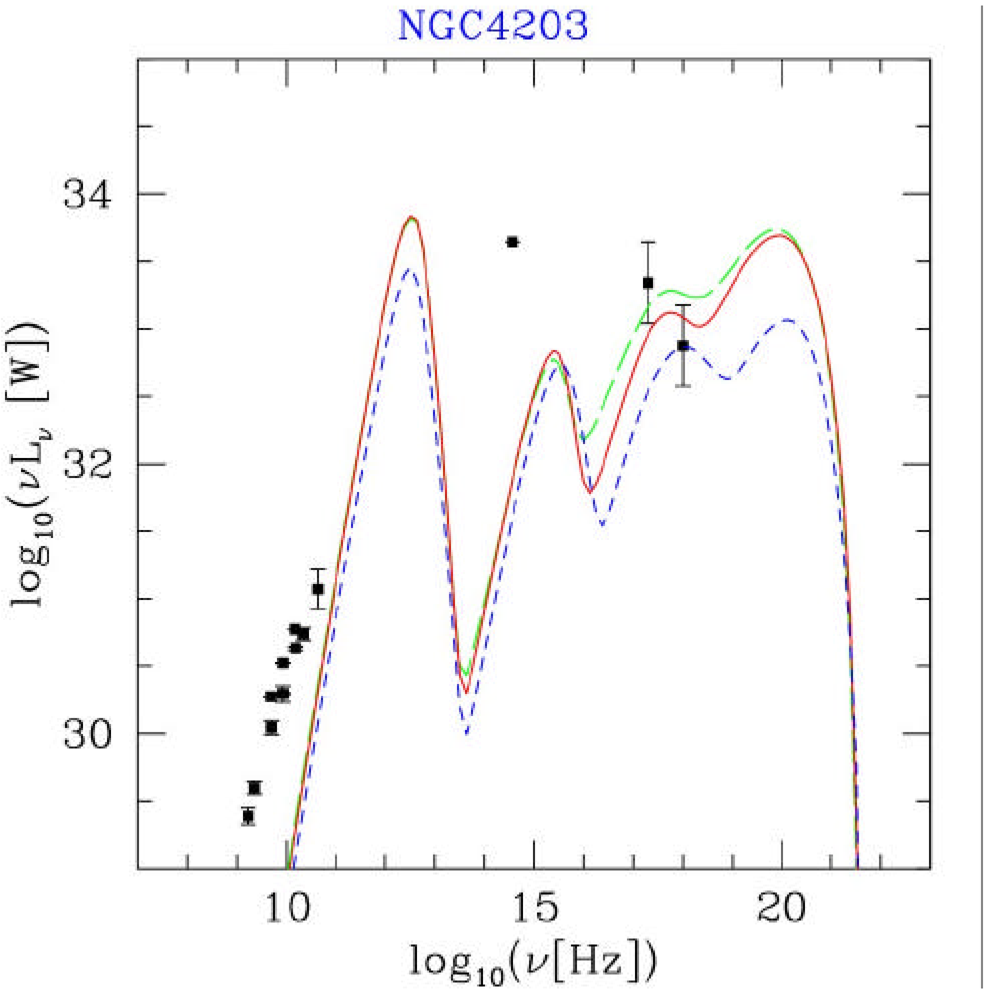



*Figure 22: NGC 4203 integrated spectral behavior for the simple ADAF model. The radio data are from Anderson et al. (2004) (see also Ulvestad & Ho 2001) and unpublished VLA data. The optical point is from Chiaberge et al. (2005), and the X-ray points are from Roberts & Warwick (2000) and Ho et al. (2001). The three curves show different ADAF model predictions for different initial conditions (accretion rate, flow velocity, and so on). Although the ADAF models can reproduce the X-ray fluxes and spectral shapes (the optical data serves only as an upper limit in this figure), the luminosity and spectral shape of the predicted radio emission is always inconsistent with the observed emission.*

## Avruch

Avruch has been involved in the studies for VLBI tracking support of the Huygens Probe on Titan. EVN experiment EA029, an investigation of potential phase reference sources in the Titan field, was performed in February, using six Mark 5 recorders and three tapes. The first correlator pass with the six disk-based stations (Effelsberg, Westerbork, Jodrell Bank, Medicina, Noto, Onsala) confirmed J0744+2120 as a suitable reference source: 40 mJy and 30arcmin from Titan. A second correlator pass including the tape stations (Hartebeesthoek, Shanghai, and Urumqi) was completed in early July. Dr. Tao An, a visiting scientist from the Shanghai Astronomical Observatory helped in the analysis of the correlation products in September.

The two Huygens Tracking Rehearsal Observations, GG057A and GG057B, were scheduled. They were meant to test the array under the unusual observing conditions of the final experiment, and to gather more data on sources in the field. The first took place on August 27th, was correlated in October and shortly after partially reduced by Dr. An. GG057B was observed on November 17th, correlated in December, and partially reduced by Brunthaler in December and January.

Detailed scheduling for the observations of the actual Huygens descent onto Titan, GG057C, started in early December. The quite unusual observing conditions necessitated several iterations of an involved schedule; diligent vetting by collaborators at telescopes around the world should ensure that the observations are a success.

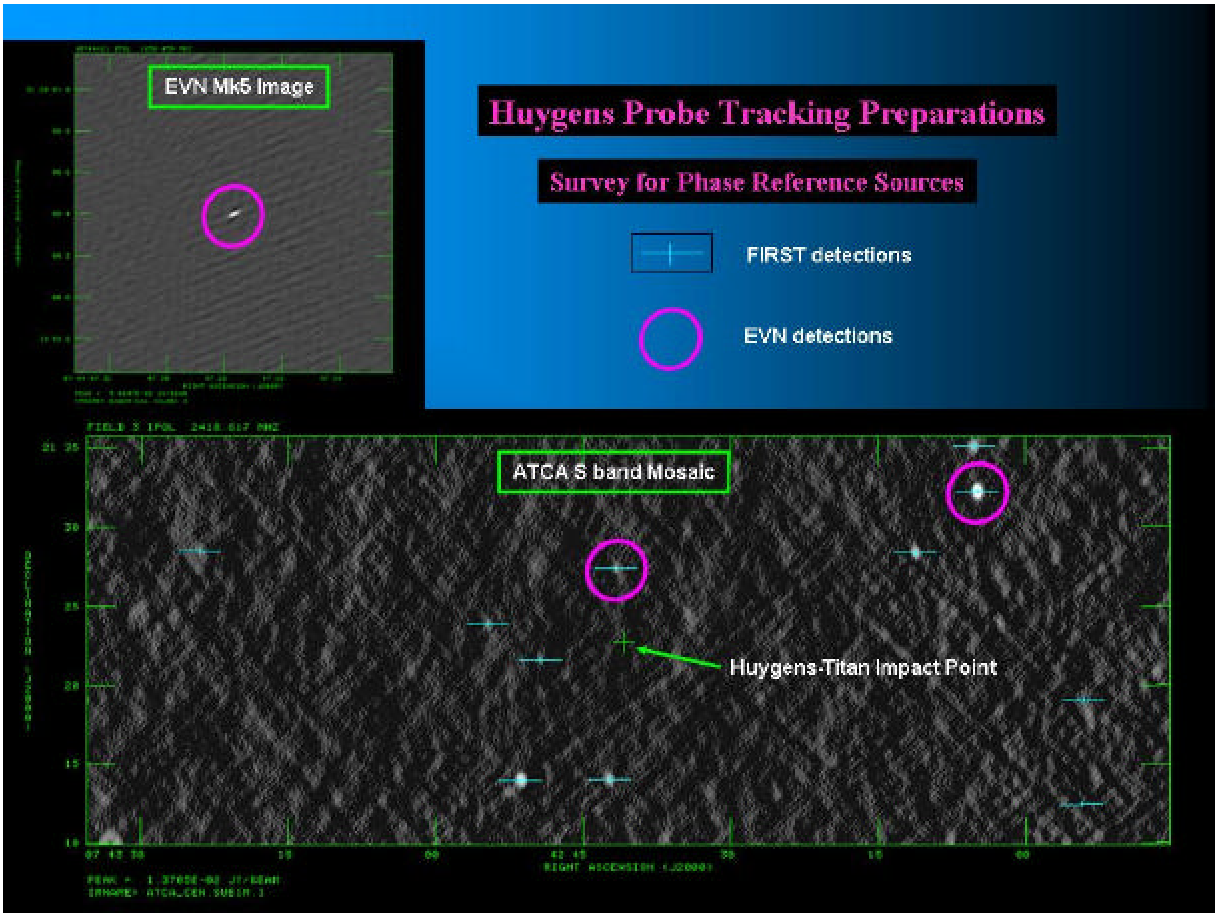



*Figure 23: Selected results of the Huygens Probe Tracking Preparatory Experiments. A wide-field survey at 2GHz was conducted with ATCA, yielding spectral indices between L (FIRST Survey) and S band. Follow-up observations on potential phase reference sources with the EVN yielded detections circled in pink, and our prime reference source candidate (upper left).*

Avruch has also assisted in workstation configuration and software prototyping for the Huygens Processing platform, with which non-Mark 5 formatted data have been translated for correlation and processed for narrow-band signal tracking, and with which data transfers were accomplished from Japan to JIVE at 400 Mbps, and from Finland to JIVE at 640 Mbps; in both cases the limit was due to software or hardware on the transmitting or receiving computers.

## Biggs

Biggs' VLBI observations of the gravitational lens system CLASS B0128+437 have been published in MNRAS and have also appeared as the "VLBA Image of the Month" for March 2004. Work continues apace on this system, with new EVN and HST NICMOS data having been acquired in the last six months. The new EVN data (Project code EB025) were observed at a wavelength of 21cm, the longest to date for this system (13, 6 and 3.4cm having already been observed) and where the source is brightest and the postulated scatter broadening greater.

The most striking aspect of maps made from these data is the continued increase in size of the images towards longer wavelengths (figure 24).

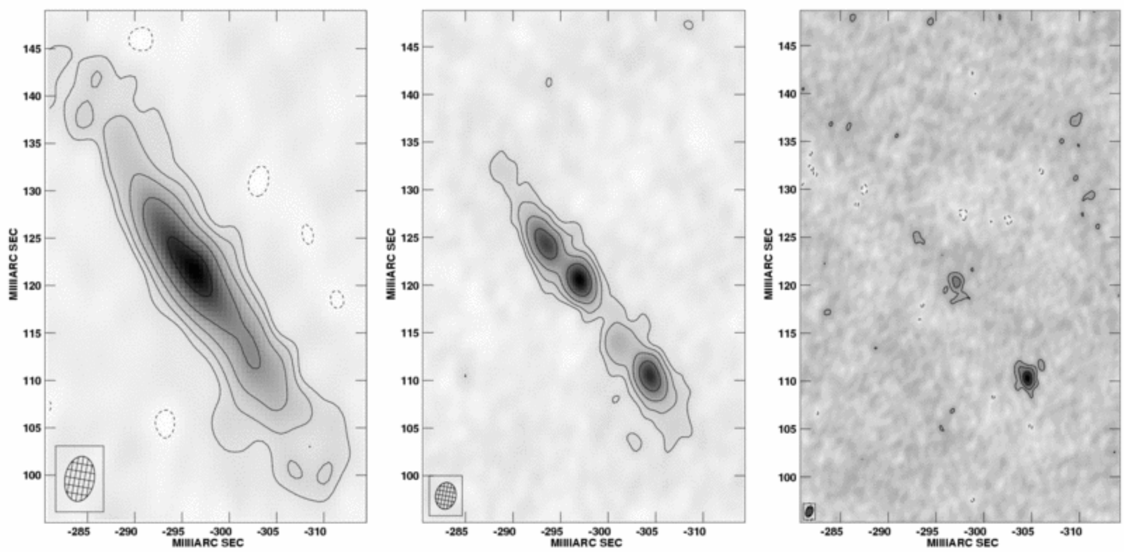



*Figure 24: VLBA maps of image A of B0128+437 at 2.3 GHz (left), 5 GHz (middle) and 8.4 GHz (right).*

One result of this is that the two merging images are now actually seen to merge, with a pair of components marking the probable location of the critical curve (figure 25). This will lead to better mass models. The scattering region is clearly visible as a pronounced "hole" in image B. Preliminary analysis of the HST data is underway and shows that image B is completely obscured, presumably due to dust associated with the gas responsible for the scattering.

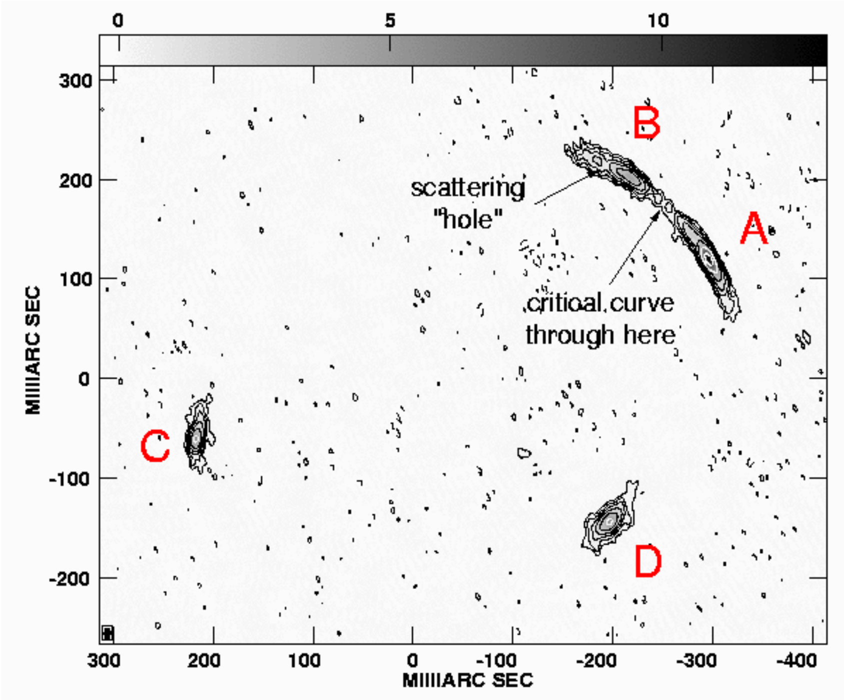



*Figure 25: EVN 1.4 GHz map of B0128+437. The area of scattering in image B is marked, as is the position of the critical curve that passes between images A and B.*

Analysis was completed of WSRT monitoring, at 5 GHz, of the gravitational lens system CLASS B2045+265. Twenty epochs of data collected over a period of ~4 months showed that the total flux density of the images (WSRT cannot resolve the individual images) was varying on a timescale of days, with variations typically at the few per cent level and a maximum change of 5 per cent between consecutive epochs. This monitoring campaign was initiated as a means of confirming the variability of the individual lensed images that had previously been seen with MERLIN; WSRT, unlike MERLIN, has a proven track record of gravitational lens monitoring. Examination of archival VLA data (8 epochs at 8.4 GHz) also provided evidence for significant variability. Due to the low Galactic latitude of B2045+265 and its close proximity to the turbulent Cygnus region of the sky, the variability is probably a consequence of interstellar scintillation.

Work has also been carried out on the calibration of VLA archival monitoring data of another lens system, B0218+357. It is planned to combine this data with existing data in an effort to more tightly constrain the time delay in this system. Improvements in the mass model for this system should be met with attempts to improve the time delay and analysis of archival data is the first step to hopefully begin re-monitoring of this system; B0218+357 has not been regularly monitored since the beginning of 1997.

## Bignall

Bignall is PI on a project using the Nançay Radio Telescope (NRT) to study refractive scintillation of intraday variable (IDV) radio sources. Pilot observations were carried out in Feb-March 2004. Bignall visited the NRT in June 2004 in order to reduce these data with the assistance of P. Colom (Observatoire de Paris-Meudon). Following initial analysis of these pilot observations, a follow-up proposal was submitted to observe a smaller sample of 3 sources over a longer period (2 months), for which time has been awarded in the first semester of 2005. To complement the NRT observations, a monitoring campaign was started with the Goldstone-Apple Valley Radio Telescope (GAVRT) in California. Bignall and D.

Jauncey (ATNF) attended a teleconference in April with US school students and teachers involved in this GAVRT program. In December Bignall visited SHAPE High School to talk to students who will be participating in the GAVRT program.

Preliminary VLBI images of the intra-hour scintillating quasar PKS 1257-326 were produced from VLBA data observed and correlated in June 2004. Interestingly, these show a mas-scale jet aligned with the direction of anisotropy in the scintillation pattern, and also with the arcsecond-scale jet (see figure 26).

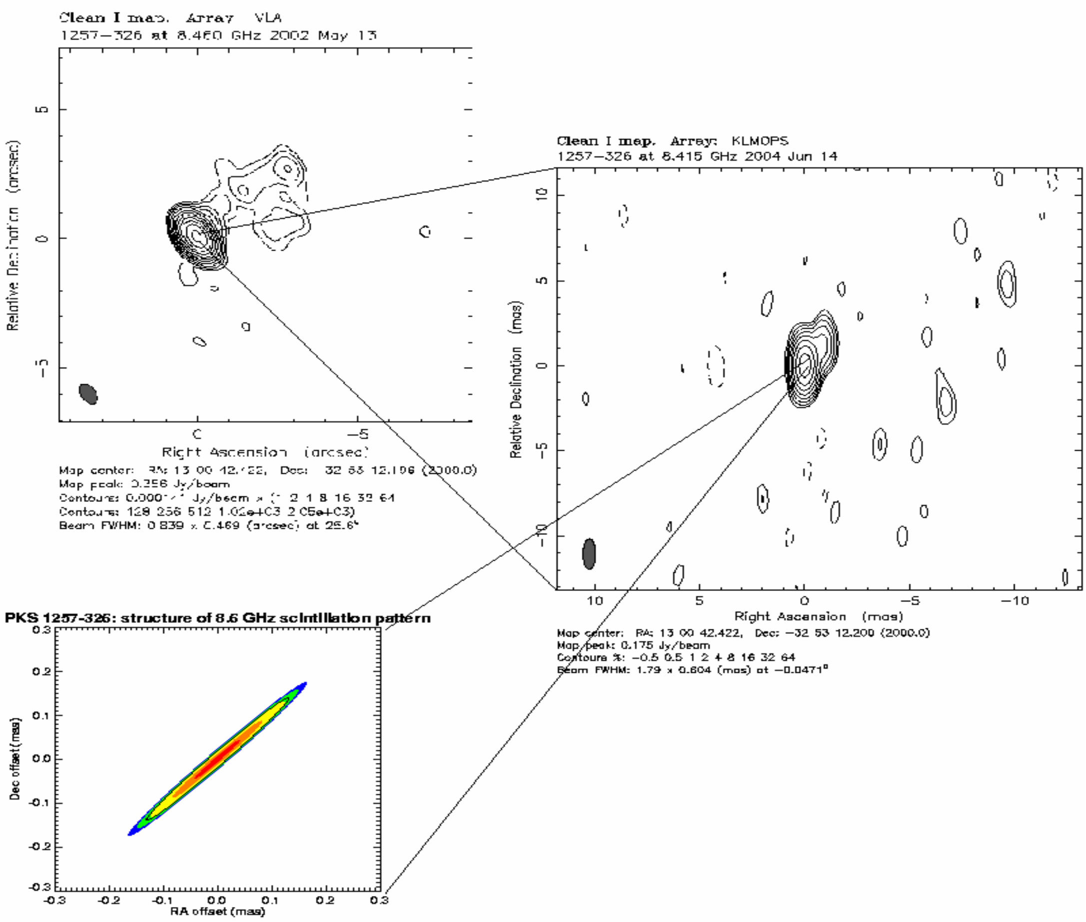



*Figure 26: VLA and VLBA images of PKS 1257-326 at 3.5cm, showing a jet extending to the north-west, the same direction as the elongation in the scintillation pattern. The direction of anisotropy in the scintillation pattern is determined from ATCA monitoring of the annual cycle in scintillation timescale and from observations of the pattern arrival time delay between the VLA and ATCA.] This result suggests that the scintillation of PKS 1257-326 may be strongly influenced by an elongated source structure on sub-mas scales. Alternatively, it has also been suggested that anisotropy in the scintillation pattern is due to anisotropy in the scattering medium. The origin of the anisotropy may be resolved through investigation of the polarized flux density scintillations. Bignall continued work to complete a paper on the scintillation parameters of PKS 1257-326 based on two-station time delay and annual cycle fitting, in collaboration with J-P. Macquart (Kapteyn Inst.) and D. Jauncey (ATNF). These results, combined with the angular size measured from VLBI, constrain the distance to the scattering medium.*

Bignall is PI on an ATCA proposal to observe a faint sample of BL Lac objects, part of a project in collaboration with H. Landt (CfA) et al. Observations of the remaining southern objects in the sample were done in January 2004, and preliminary calibration, imaging and analysis was performed in order to include preliminary results in a VLA proposal (PI Landt) to image the remaining objects in the sample.

Bignall is a co-author on a paper by Winn et al. on "The Radio Variability of the Gravitational Lens PMN J1838-3427" presenting results of an ATCA monitoring campaign, which was published in the Astronomical Journal in December 2004.

She imaged ATCA data on the Huygens Field which was observed at 13 cm in November, to check flux densities of calibration sources to be used for the "live" spacecraft tracking experiment. Longer integration times on the central field resulted in a much deeper image than previously obtained with the ATCA, so that mJy sources in the central field were easily detected.

Bignall worked with summer student Carmen Blasco in collaboration with Van Langevelde and Reynolds, studying extragalactic scattering in galaxy-quasar pairs through low-frequency VLBI measurements. Preliminary results were presented at the EVN Symposium in a poster by Blasco et al.

## Brunthaler

Brunthaler finished and submitted his PhD thesis "Proper Motions in the Local Group" and passed the required exams at the University of Bonn.
He continued his work on proper motions of Local Group galaxies. Motion of ~30 microarcseconds per year of water masers in M33 with respect to the background quasars was detected, with uncertainties on the order of 5 microarcseconds per year. Because of the separation of the water maser clumps in M33 (figure 27), translation of the galaxy as a whole could be decoupled from rotation of the galaxy.

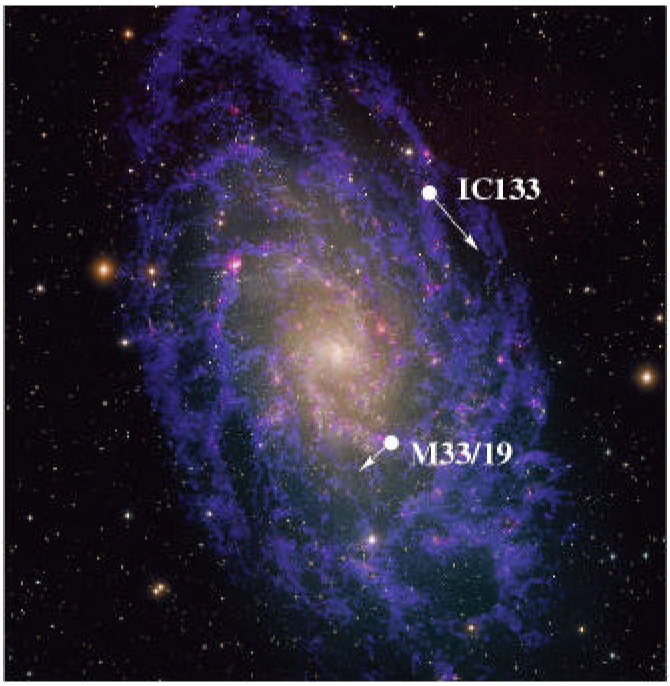



*Figure 27: The positions of two regions of maser activity and their proper motion relative to the nucleus of M33 as measured by the VLBA. The image of M33 is courtesy of Rector, Thilker (NRAO) and Braun (ASTRON).*

The VLBI rotational rate, together with the inclination and rotational speed from neutral-hydrogen spectroscopy of M33's gas disk, yields a geometric distance to M33 of 730 kpc, with an uncertainty of 135 kpc due to uncertainties in the derived M33 rotation and 100 kpc due to observational uncertainties in the VLBI proper motions. The translational motion of M33 is directed towards M31, at a speed of 190 km/s relative to the Milky Way (figure 28).

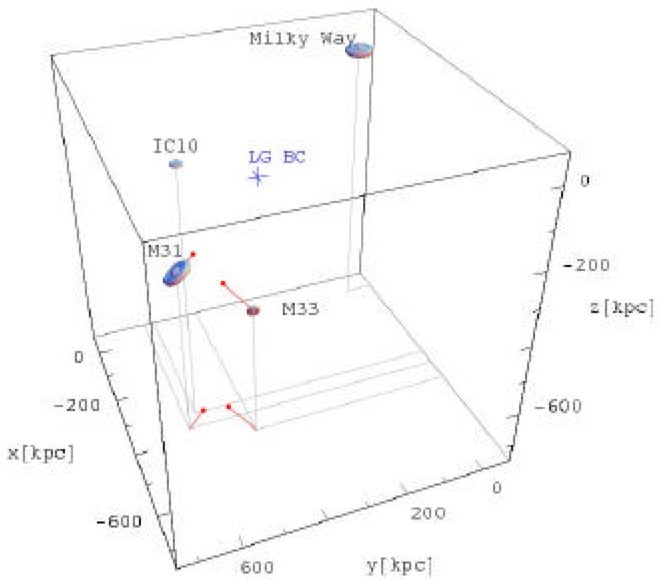



*Figure 28:M33's motion in the local group, relative to the Milky Way.*

Brunthaler is first author on a paper about the geometric distance and proper motion of M33. This paper was submitted to Science and will appear in March 2005.

The galaxy M33 was observed with the VLA to search for more water maser sources. This lead to the detection of at least one additional source. Brunthaler submitted a proposal to the VLBA to observe this new maser source. This proposal was accepted and the observations should begin soon.

Brunthaler is PI on a VLBA proposal to search for calibrator sources with small angular separations to known IDV sources. The goal of this project is to search for position wander of IDV sources, caused by interstellar scattering.

He reduced a VLBA+GBT+VLA experiment to detect water vapour maser emission in the nucleus of 3C403 (PI Tarchi). This source is the first radio-loud quasar with water vapour maser emission in the nucleus. Unfortunately, the source was too weak to be detected and the observation failed. An EVN observation at 6 cm of the same source was conducted in the May/June session and was successful.

Brunthaler is a co-author on a paper by M. Reid (CfA) & A. Brunthaler, presenting results of an proper motion study of Sgr A*, the radio source at the Galactic Center. The paper appeared in ApJ in December 2004.

He is first author on a paper about the Seyfert galaxy III Zw 2. This paper describes the structural and specral evolution of the nuclear radio jet and was accepted by A&A and will appear in early 2005.

Also, Brunthaler was involved in a project (PI Hachisuka) to measure the distance of W3OH by VLBI observations of water masers in this source. Preliminary results were presented at the EVN symposium in Toledo by the PI.

## Campbell

Campbell continued to provide ionospheric simulations to D.Lebach (CfA) in support of VLBI astrometry related to the Gravity Probe-B guide-star program (the satellite launched on 20apr; see einstein.stanford.edu, particularly FAQ #6 and the Launch Companion for a description of the astrometry effort). He also collaborated with S. Britzen (MPIfR) on statistical studies of the jet -component kinematics of CJF sources. Work focussed on estimating proper motions for each jet component from the elliptical Gaussian component parameters, uncertainties, and correlation matrices derived by our difmap variant, including means of taking individual-epoch behaviour of specific components into account in the ensemble statistics.

## Garrett

Garrett (together with co-Is Knudsen & van der Werf in Leiden) analysed 1.4 GHz WSRT and 8.2 GHz VLA data of the rich cluster Abell 2218 (see figure 29), detecting the first example of multiple imaging of a radio source due to a foreground cluster of galaxies (see figures 30 and 31).

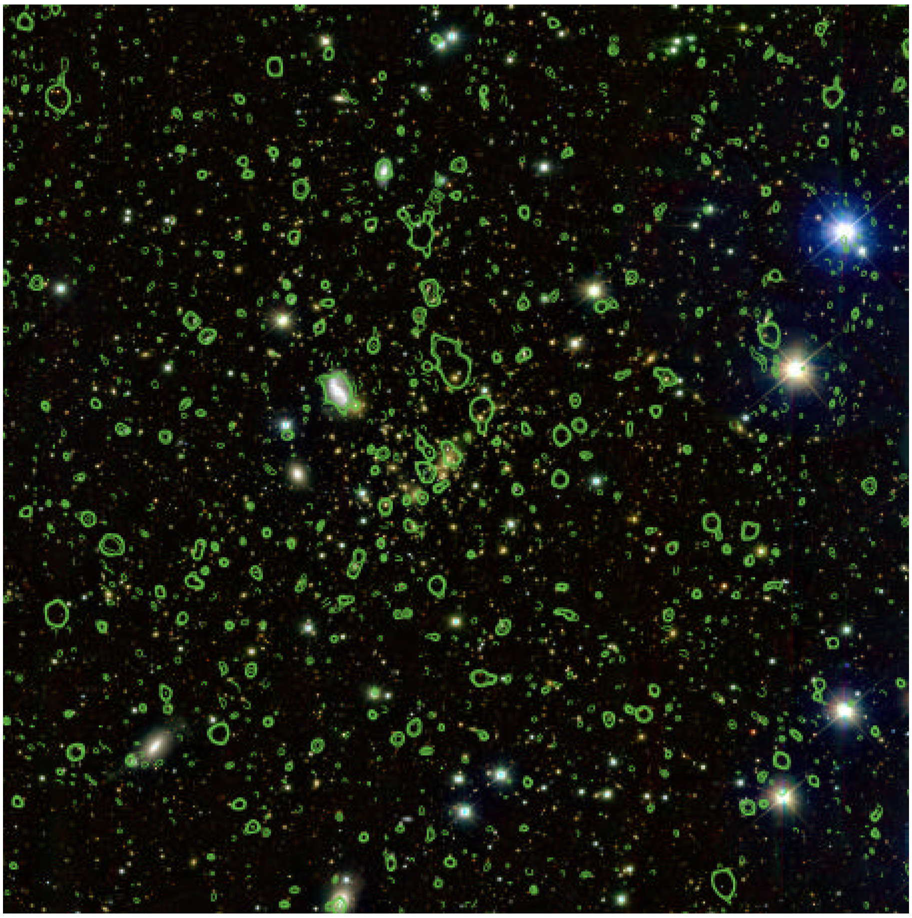


*Figure 29: A deep WSRT 1.4 GHz contour map superimposed on top of an optical image of the field centred on the massive cluster A2218. Multiply imaged, faint radio sources are detected within the central part of the cluster potential.*

The lensed radio source, a z=2.516 submillimetre selected galaxy, SMM J16359+6612 is a three image system with the radio source positions found to be coincident with the associated SCUBA sources.

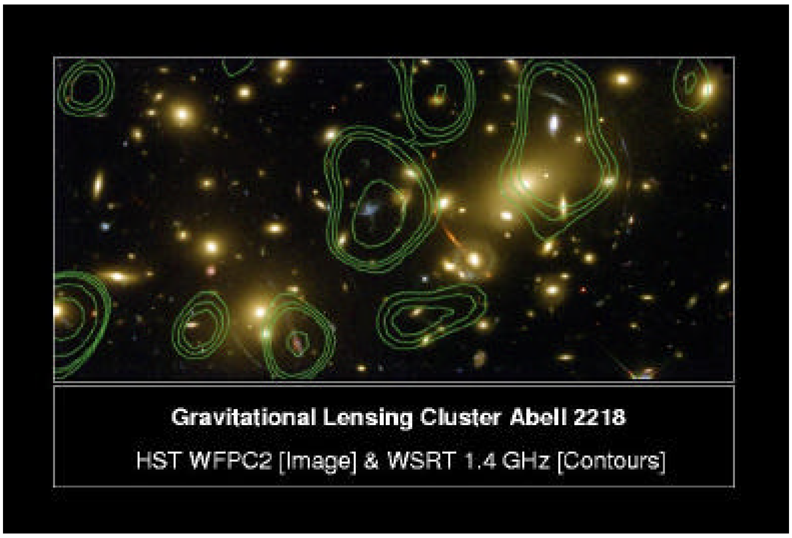



*Figure 30: The central part of the WSRT 1.4 GHz contour map of Abell 2218, presenting several lensed radio sources, superimposed on an HST WFPC 2 image of the field.*

This is the widest separation lens system to be detected in the radio so far (see figure 31), and the first time that multiply imaged lensed radio emission has been detected from a star forming galaxy (all previous multiply-lensed radio systems being associated with radio-loud AGN).

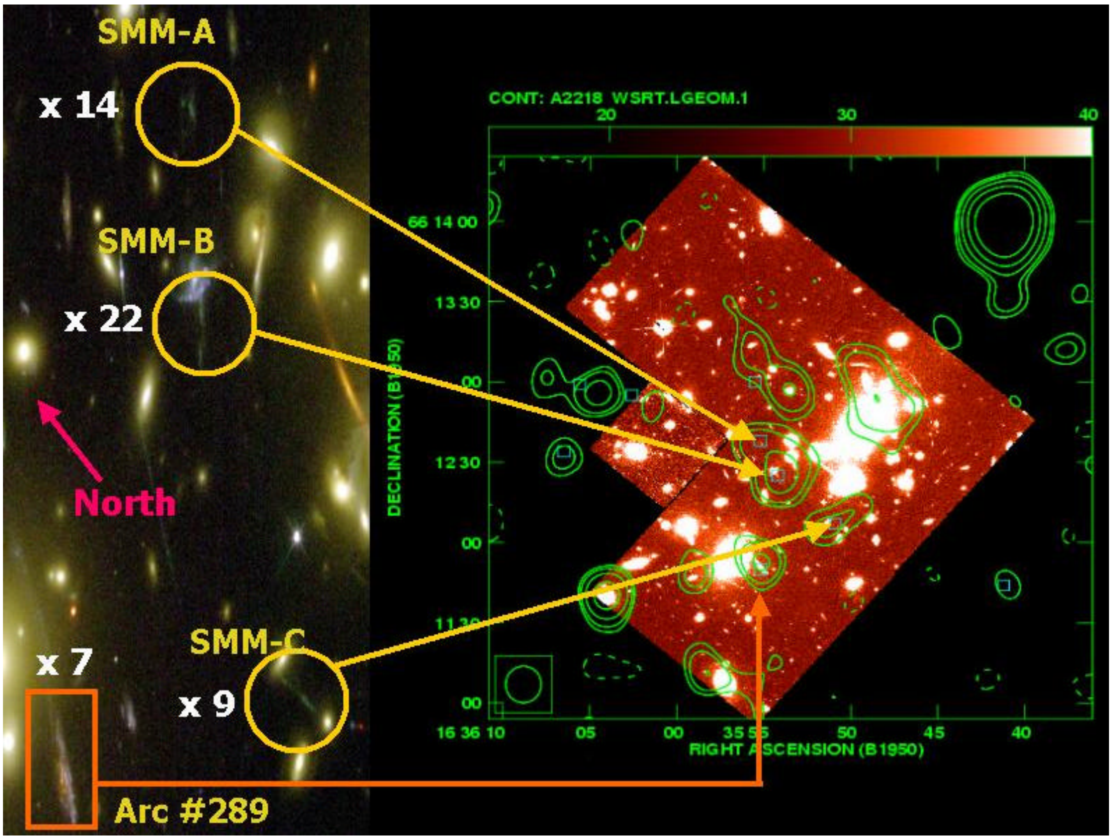



*Figure 31: Right - The WSRT 1.4 GHz contour map of SMM J16359+6612 A,B,C superimposed on a HST archive image of the field. The green squares show the position of the sub-mm emission. Left: the optical identification of the highly magnified lensed images (HST WFPC-2) associated with the sub-mm and radio emission. Also shown is the highly magnified singly imaged system, SMM J16359+66118 (Arc #289).*

Taking into account the total magnification of ~45, the WSRT 1.4 GHz observations suggest a star formation rate of 500 solar mass per year. The source has a steep radio spectrum and an intrinsic flux density of only 3 microJy at 8.2 GHz. Three other SCUBA sources in the field are also detected by the WSRT, including SMM J16359+66118, a singly imaged (and magnified) arclet at z=1.034. Higher resolution radio observations of SMM J16359+6612 (and other highly magnified star forming galaxies) are planned. This will provide a unique opportunity to study the general properties and radio morphology of intrinsically faint, distant and obscured star forming galaxies. They can also help to constrain the technical specification of the next generation radio telescope, the Square Kilometre Array. A paper was submitted and accepted by A&A letters before the end of the year.

A paper by Garrett et al. was accepted by ApJ, presenting a definitive description of deep, wide-field GBT & VLBA 1.4 GHz observations of the NOAO Bootes field. The associated images are the deepest published VLBI maps to date, reaching an r.m.s. noise level of 9 microJy per beam in the centre of the field. Nine radio sources were detected across the 16 arcminute field. About 30% of the mJy radio source population is detected, but the detection rate falls to only 10% for sub-mJy sources. This result is entirely expected, due to the strong evolution in the radio source counts around 1 mJy, due to the growing dominance of (extended, low surface brightness) star forming galaxies at sub-mJy flux densities. A total of 60 sources were targeted in the full field of view. Two of the VLBI detected sources have no optical identification in very deep I and K band optical images of the field. This suggests that a significant fraction of the faint AGN radio population may be located at high-redshift.

Garrett was also involved in the prepration and submission of a paper presenting deep WSRT observations of the Spitzer First Look Survey (Morganti et al. 2004 - see figure 32). Another paper was submitted with Wrobel et al., concerning VLBA observations of bright mJy sources in the same field - these will be used as in-beam calibrators in future Global VLBI Deep Field observations of the field. A paper with Frayer et al. concerning the IR properties of radio-selected submillimeter galaxies (SMG) in the Spitzer FLSv field was also submitted. Monica Orienti visited JIVE as a summer student to work on a detailed comparison of the Spitzer Mid-IR and WSRT faint radio source populations in the FLSv.

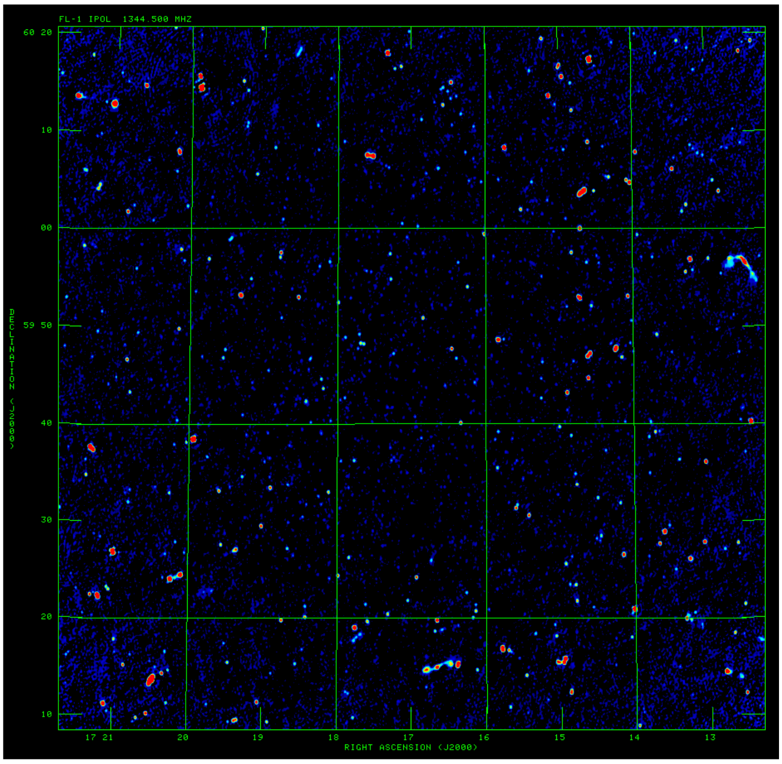



*Figure 32: The WSRT mosaic image of the central part of the Spitzer First Look Survey – the radio image reaches a uniform r.m.s. noise level of ~ 20 microJy (Morganti et al. 2004).*

Garrett also wrote-up a description of the “full-beam” self-calibration technique. This uses random sources in the beam to self-calibrate VLBI data relying on the preservation of a wide-field of view. At low-frequencies (a few GHz) the summed response of sources in the primary beam of a VLBI antenna can be used to self-calibrate the data (see figure 33). A paper was presented at the EVN Symposium in Toledo.

He made various presentations at scientific meetings during the year, highlighting the scientific possibilities of e-VLBI and wide-field VLBI imaging.

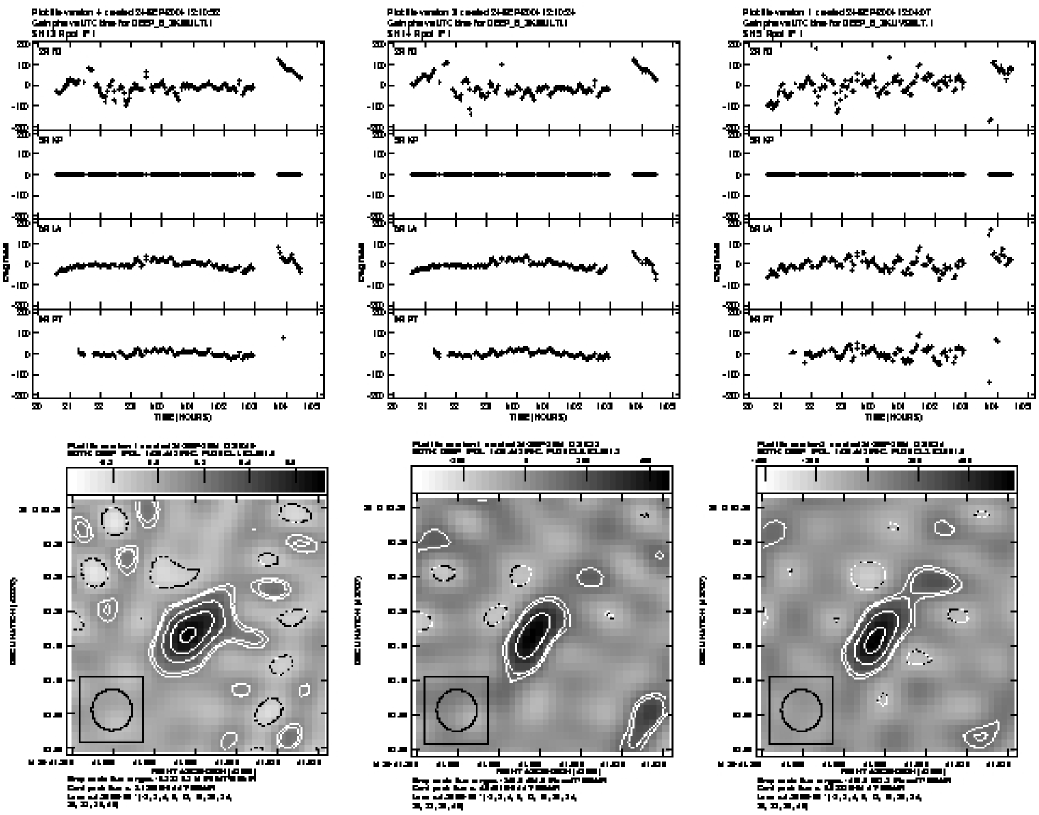


*Figure 33: Phase corrections (top) and associated images (bottom) using various sources in the Bootes field (Garrett, Wrobel & Morganti 2004), including - Left: using only the original in-beam calibrator, middle: using 6 random sources in the field (excluding the in-beam calibrator), right: using 5 random sources in the field (excluding the in-beam calibrator and the next brightest source in the field).*

## Gurvits

Gurvits continued to work on various aspects of massive VLBI surveys of extragalactic radio sources. These included the VSOP Survey Programme (three papers with his participation submitted during the first half of 2004), the VLBA 15 GHz survey and the Deep Extragalactic VLBI-Optical Survey (DEVOS). Results of these studies found their application in the paper published in the new book “Science with SKA” (eds. C.Carilli and S.Rawlings, New Astronomy Review, 2005).

Several recent global and Space VLBI surveys of quasars, AGN of other types and star-burst galaxies provide a wealth of material on milli- and sub-milliarcsecond radio structures in hundreds of sources. Results of these projects are presented with an emphasis on the statistics of redshift- and angular-scale-dependent properties of the milli- and sub-milliarcsecond radio structures. These studies make possible disentanglement of intrinsic (possibly, evolutionary) phenomena of parsec-scale radio structures and the imprints of the cosmological model. The studies indicate a very promising potential of high-resolution applications of the Square Kilometre Array. Based on the pilot projects, it is estimated that a sample containing of the order of $10^4$ faint radio sources in the luminosity range $10^{22}$ – $10^{26}$ W/Hz can be surveyed with a high-resolution SKA with the milliarcsecond resolution at cm wavelengths. Such the high resolution radio survey, including those conducted jointly by SKA and Space VLBI missions, in conjunction with data from other domains, will provide a new ground for cosmological tests.

Recent progress in VLBI techniques makes it possible to explore parsec-scale structures in complete samples of tens of thousands of faint radio sources. In combination with state-of-the-art optical surveys such as the Sloan Digital Sky Survey (SDSS) this permits a census of the small-scale radio structures of faint active and starburst galaxies. In 2004 L.I.Gurvits and M.A.Garrett (JIVE), S.Frey (Satellite Geodetic Observatory, Hungary), L.Mosoni (Konkoly Observatory, Hungary), S.T.Garrington (Jodrell Bank Observatory, UK) and Z.Tsvetanov (Johms Hopkins University, MD, USA) continued a pilot project called DEVOS (Deep Extragalactic VLBI-Optical Survey) aimed at working out observing methodology and data processing algorithms for massive VLBI surveys of optically identified extragalactic radio sources (Gurvits et al , in Future Directions in High Resolution Astronomy: The 10th Anniversary of the VLBA, eds. J.D.Romney & M.J.Reid, ASP, 2005, in press).

Extragalactic VLBI targets are distributed over a broad range of redshift reaching z˜ 6. In order to achieve conclusive results on the intrinsic properties of sources as well as possible imprints of cosmological models, one has to match in luminosity sources detected and imaged with VLBI at low redshift (e.g. z = 0.1) with those at high redshift (z = 1). This requires VLBI study of high-redshift sources with luminosities as low as $10^{23}$ W/Hz, which correspond to microJy-level flux densities. With the present-day VLBI instrumentation, such the level of sensitivity can be studied by using the phase-referencing technique.

In the DEVOS pilot observations conducted in 2001, a demonstration sample of 47 radio sources from the VLA FIRST survey (Faint Images of the Radio Sky at Twenty-centimeters) were chosen in the North Galactic Pole region within 2° from the strong compact source J1257+3229. The latter was used as a reference calibrator. The sample sources were denominated NGP01 through NGP47 in the order of decreasing FIRST flux density. The weakest sources in the sample, NGP47 has the FIRST flux density of 30 microJy.

In the first step of the project, all 47 sources were observed with the Multi-Element Radio-Linked Interferometer (MERLIN) at 6 cm. These observations resulted in filtering out those sources which are resolved at the angular scale of tens milliarcseconds. The remaining 37 sources were observed with the Global VLBI array at 5 GHz in one observing run of ~21 hours. The off-source image noise in these observations was about 200 microJy/beam. Twenty of the observed 37 sources turned to be below detection limit of the experiment. The remaining 17 sources (about 1/3 of the original sample of 47 sources) turned to be bright enough for VLBI imaging. An example of DEVOS images is shown in figure 34.

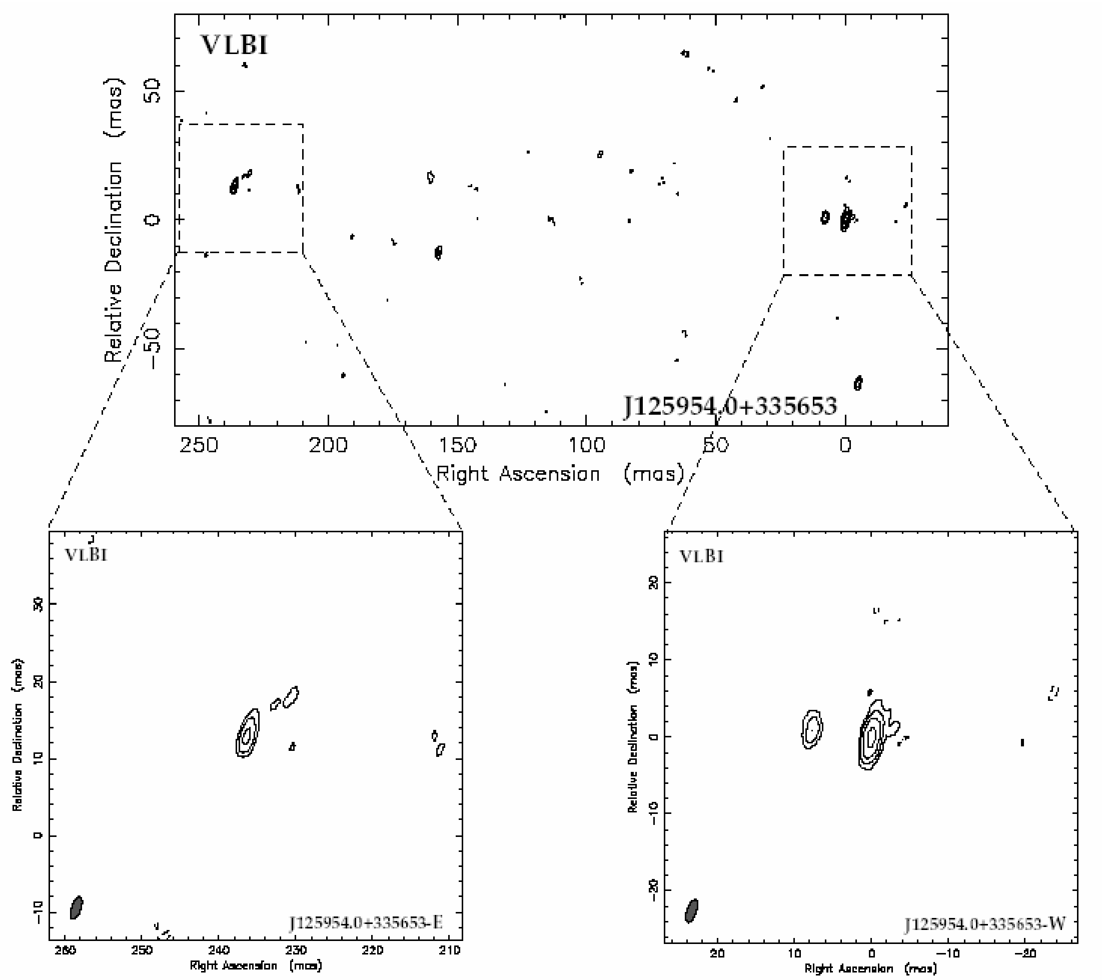



*Figure 34: Naturally weighted 5 GHz MERLIN (top) and VLBI (middle) images of one of the DEVOS sources, J125954.0+335653. The positive contour levels increase by a factor of 2. The coordinates are relative to the VLBI brightness peak. The restoring beam is indicated with an ellipse in the lower-left corner. The two panels in the bottom show an expanded view of the two brightest VLBI components. The peak brightness of the secondary (eastern) component (bottom left) is 3.9 mJy/beam.*

Based on the DEVOS pilot project one can estimate that a sample containing an order of $10^4$ faint radio sources in the luminosity range $10^{22}$ – $10^{26}$ W/Hz can be surveyed at cm wavelengths with the milliarcsecond angular resolution. Such the high resolution radio survey in conjunction with optical photometric and spectroscopic data from the SDSS will provide a new ground for extragalactic studies. By increasing the number of VLBI-imaged sources by ~two orders of magnitude, a new quality of astrophysical and cosmological applications is likely to emerge.

## Van Langevelde

Van Langevelde continued to work in collaboration with Pihlström (NRAO), on a project that deals with molecular absorption against the Centaurus A core. Progress was made on the interpretation side and several presentations were made in lunch talks and conferences.

With Vlemmings (Cornell), Van Langevelde continued to work on the parallax of OH-bearing Miras. To improve on the results data were taken with in-beam calibrators.

Anna Niezurawska visited JIVE from Torun to collaborate with Van Langevelde on methanol maser observations. Several detections were made and initial maps produced. There remained problems with the astrometry, and fringe-rate mapping was explored, but this proved of little use for the objects close to the equator. Further MERLIN observations were deemed necessary.

Van Langevelde started collaboration with Phillips (ATNF) and Hogerheijde and van Dishoeck (Leiden) to follow up methanol maser work with (sub)-millimeter interferometry. This project focuses on masers with no obvious radio continuum counterpart, assuming that the methanol abundance and excitation at these sites must be indicative of activity associated with very early high mass star formation. Funding for a PhD student was requested for this project.

In collaboration with Phillips (ATNF) and Hogerheijde, observations were made of a sample of nearby methanol masers. These observations were done in astrometric and wide-field mode. The schedules proved to be quite complicated, but successful observations took place in the November EVN session.

Van Langevelde was asked by NOVA to visit Hawaii in order to investigate a possible Dutch contribution to the eSMA project. He visited the JCMT and evaluated the required engineering to make the JCMT compatible for observing with the Sub-Millimeter Array. Two documents were produced, one dealing with the detailed project plan for the first phases, the other with recommendations for the Dutch role in this project. In addition, a proposal was formulated for a Dutch contribution to the establishment of the eSMA, in which the JCMT observes along with the SMA. This proposal was favorably evaluated by NWO referees.

Van Langevelde was a participant in the first e-VLBI science observation (see chapter 4, figure 19) and manned the correlator for a fraction of the experiment. The results showed the high brightness regions in the circumstellar shell of IRC+10420.

He participated in the Dutch discussions on a local node in the European ALMA regional centre, as well as the SRON initiative for a space born far-infrared interferometer called ESPRIT.

## Paragi

With Yang Jun and Leonid Gurvits, Paragi worked on VSOP data reduction of high redshift quasars. Data from two experiments were fully processed. With Liu Yi and Leonid Gurvits, Paragi worked on VSOP data reduction of high redshift quasars.

Paragi was co-I on the EVN project EF0011.The goal was C-band follow-up observation of the highest redshift radio-detected quasar J0836+0054 (z=5.82).The experiment was observed in session 3/2003. The data were processed together with Frey, Mosoni, and Gurvits at JIVE. The target source is detected at 6cm with the EVN. Results of this and other EVN and VLBA observations (18cm and 6cm) of J0836+0054 were presented at the 7th EVN Symposium in Toledo, Spain.

Paragi showed that intermediate-mass black holes (IMBH), if they exist, might be detected in nearby galaxies. If these systems produce radio jets analogous to microquasars and active galactic nuclei, we can estimate their radio flux density. The EVN has the sensitivity to detect an IMBH with masses of several 100s to 1000s of Solar mass. This result was presented at the 5th Microquasar Workshop.

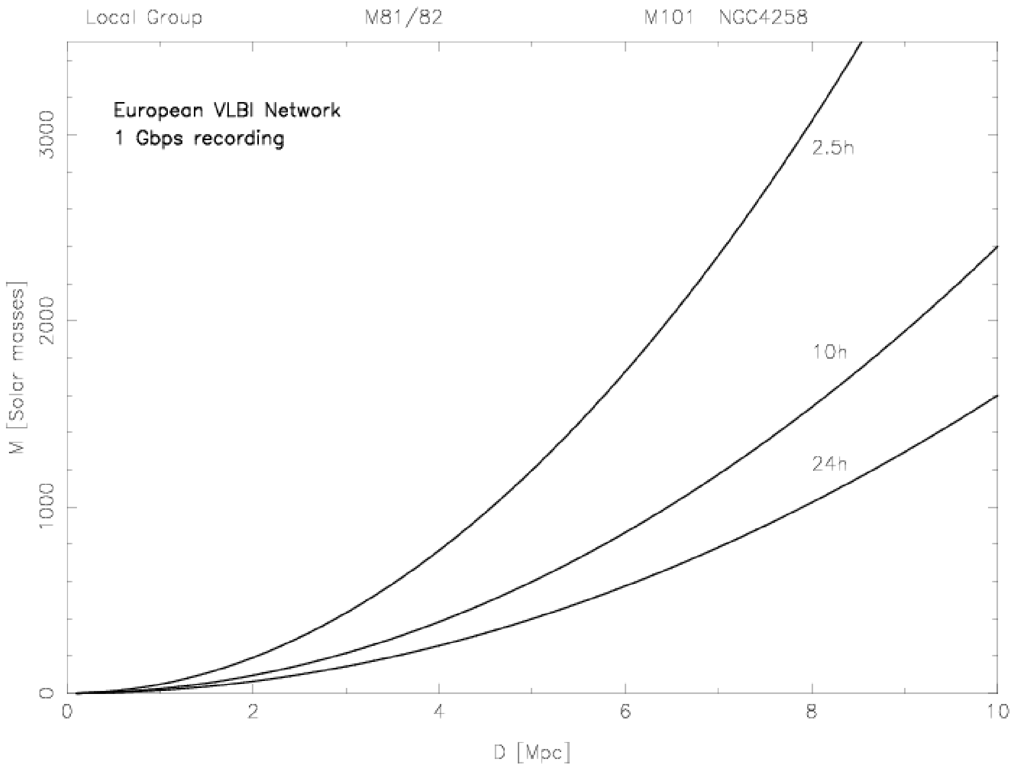



*Figure 35: The minimum detectable mass of a radio-jet intermediate black hole system in nearby galaxies. The EVN has the potential to observe these objects at 1 Gbps recording rate. The minimum detectable mass is shown with respect to the distance (in megaparsecs), for different on-source integration times (2.5, 10, and 24 hours).*

Paragi gave a talk at the 7th EVN Symposium on dedicated circular- polarisation VLBI observations of the Galactic radio-jet source SS433 (see figure 36). This work was carried out in a big collaboration with many researchers involved from various institutes. They detect neither linear nor circular polarisation in the source on milliarcsecond scales, with a 3 sigma upper limit of 300 microJy/beam. Further analysis of the Westerbork synthesis array data showed that indeed the source was not circularly polarized at this epoch. Future observations are planned.

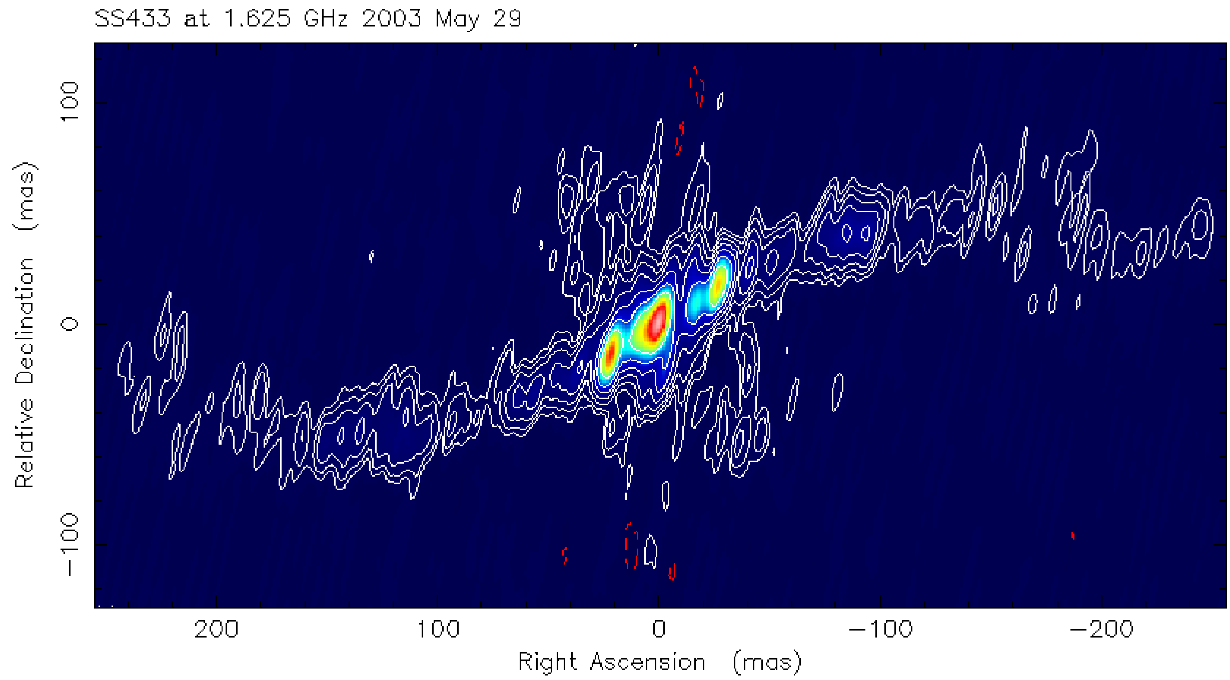



*Figure 36: The precessing beams and the equatorial outflow in SS433 observed in a global VLBI experiment in 2003. The goal was to identify the location of the circular polarization discovered earlier in the system. At the epoch of observations, there was no detectable circularly polarized emission in the source.*

In August 2004 Paragi organised ad-hoc EVN observations of SS433, to support a multi-wavelength observing campaign initiated by S.K. Chakrabarti (SNBNCBS, Kolkata, India). The source was monitored for a week in the radio regime with the EVN and the GMRT, and in the X-rays with the RXTE satellite.

Figure 37 shows images from the EVN observations, each taken two days apart. The goal of this project is to observe SS433 in special companion star-accretion disk geometries, which may help to understand the relation between the accretion flow and structural changes in the radio jets. The preliminary results are in broad agreement with the ejection of the jet material occurring in bullets from a non-Keplerian disk, as predicted by magnetized two-component advective flow models.

Paragi and Garrett observed SN2004aw with the VLA, in a broad collaboration with theorists and X-ray astronomers. SN2004aw was an extremely bright SN Ic-type supernova, which suggested that this source may have been related to a gamma-ray burst. However, no GRB was ever associated with this source. If this object was an off-axis GRB, one might expect to see radio emission from the decelerated radio jets some time after the explosion. SN2004aw was not detected with the VLA at the epoch of the observations.

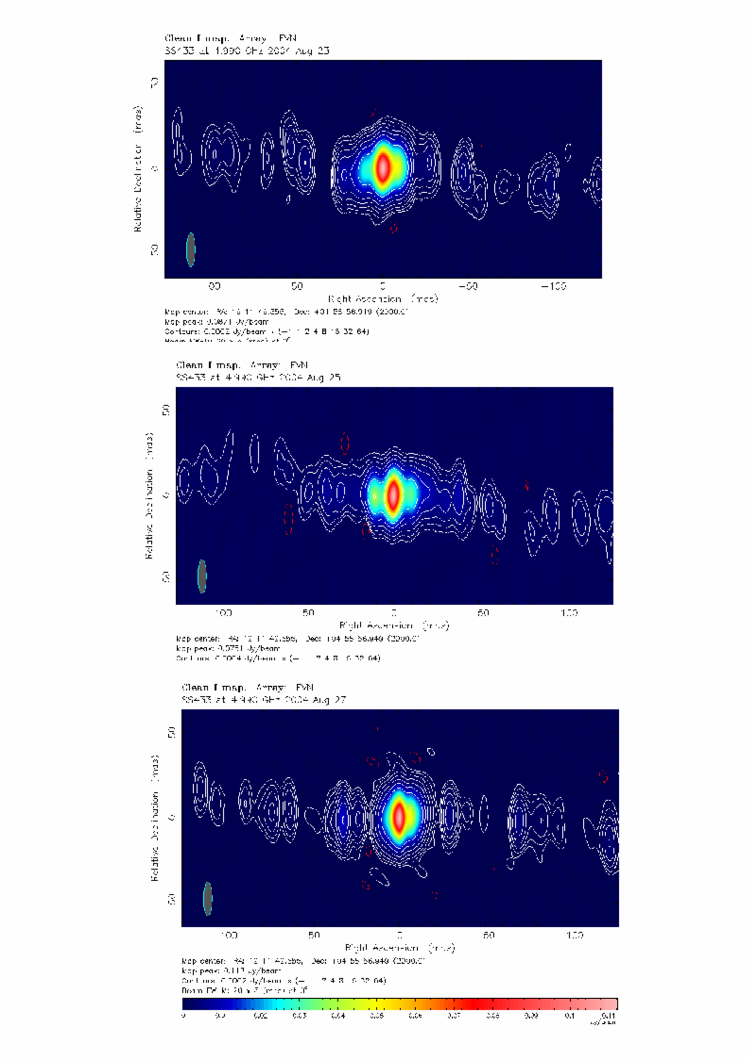


*Figure 37: Ad-hoc VLBI observations of SS433 in a multi-frequency campaign. In parallel, RXTE and GMRT observations were carried out. In the X-rays there was a sudden drop in flux at around 24 August. At the same time the low-frequency emission increased significantly. There was no dramatic change observed at 5 GHz, the EVN images show the usual core-jet structure.*

## Reynolds

A VLBA proposal was submitted by Reynolds in collaboration with Bignall and R. Ojha (ATNF) to observe the IDV quasar PKS 1257-326. Observations and correlation were performed in June 2004. Reynolds also participated in a proposal in collobaration with Zhang (SHAO), Gabuzda (UCC), Nan (SHAO), Gurvits and Jin (SHAO) to observe rotation measures in sources with very bent jets. The experiment was observed and correlated in February 2004. Reynolds carried out analysis on low frequency VLBA observations of BL Lac objects. The results were presented at the EVN symposium in October 2004. He was involved with Liu Xiang (UAO) in analysis of EVN observations of a sample of Compact Symmetric Objects (project ES044), resulting in an accepted A&A paper.
Reynolds visited Tim Cawthorne (University of Central Lancashire) to continue work on a paper titled 'Kinematics of the Jet in BL Lacertae'.

# 6. Space Science related Projects

## ESA- JIVE Huygens Project

During the first half of 2004, JIVE has completed two contracts with ESA on the preparation for the Huygens VLBI tracking Project. The first contract (period October 2003 - February 2004) dealt with preparatory observations of the "Huygens Field" using WSRT, VLA, ATCA, MERLIN and EVN. The second contract (March-June 2004) was used to outsource development of Huygens-related data processing algorithms to Astro-Tech Holding BV (supporting the employment of former JIVE employee Max Avruch). Reports on both contracts were submitted and accepted by ESA in due time. The report's conclusion confirms feasibility of VLBI tracking of the Huygens probe in the atmosphere of Titan with kilometre accuracy.

In March-June 2004, two other contracts between ESA and JIVE were under preparation. The first one dealt with the main body of work on the Huygens VLBI tracking project. It is expected to run for one year beginning in the third quarter of 2004. The other project addresses potential applications of the VLBI technique for future ESA missions as a tool for precise interplanetary navigation. The project is expected to commence in August 2004 and run for 9 months.

JIVE Personnel involved in the Huygens VLBI Tracking project include Gurvits (Project Manager), Pogrebenko (Project Scientist), Avruch, Bignall, Brunthaler, Campbell, Garrett and Tibbe.

## Other Space Science projects

JIVE participated in the preparation of the proposal to ESA "Cosmic Vision" programme. The theme of the proposal is Long Wavelength radio astronomy in space. The proposal was submitted to ESA in May 2004. JIVE personnel involved included Gurvits (coordinator of the proposal in collaboration with G. Miley, Leiden) and Garrett.

JIVE participated in the initiative "Towards a European Infrastructure for Lunar Observatories" in collaboration with ASTRON, EADS Space Transportation and other industrial and scientific organisations. The first working meeting of the initiative group was conducted in December 2004 in Bremen. It is expected that the group will organize a symposium on this subject in March 2005.

Gurvits participated in the preparation of the proposal on a series of experiments onboard the ESA BepiColombo mission. The mission is expected to be launched in 2012 for studies of Mercury and the near-solar environment. The proposal has been accepted for assessment study to be conducted in 2005. The experiment proposed includes a nuclear physics and radio astronomy segments and is being supported by an international group of scientists from Belgium, France, Japan, Italy, the Netherlands, Russia and the USA.

# 7. EC and International Projects

### FP6 I3 RadioNet Project

JIVE was actively involved in the implementation of the EC FP6 I3 Project RadioNet. The contract commenced in January 2004. The Institute was involved in the following RadioNet tasks:

- L. Gurvits is the RadioNet Project Scientist and member of the RadioNet Management and Executive teams;

- H.J. van Langevelde is the leader of the RadioNet Joint Research Activity ALBUS (development of user data reduction software for radio astronomy, see section 3.3 of the present report) and a member of the RadioNet Executive team;

- M. Tibbe is administrative assistant;

- L. Gurvits coordinates the RadioNet Trans-National Activity "Access to the EVN". This activity is a natural contribution of the previous Access contracts.

The Institute acts as the banker for the RadioNet travel budget (Networking Activities and Transnational Access).

### EuroPlaNet

From June 2004, JIVE is involved in the EC FP6 Coordination Action EuroPlaNet. The project is related to the JIVE involvement in the ESA/NASA mission Cassini/Huygens and other planetary science projects that require VLBI support. In particular, JIVE participates in the coordination of the ground-based observations in support to the Cassini/Huygens mission. The project also considers several prospective ESA missions e.g. the Mercury BepiColombo mission.

### SKA Design Study

JIVE contributed to the EC FP6 proposal on the SKA Design Study project, SKADS. The Institute's specific task deals with the SKA science and technology simulations. Representatives of the Institute (Garrett, Reynolds, Gurvits) participated in a number of preparatory meetings on this project. JIVE is the coordinator of SKA Design Task 2 – Science and Array Simulations. The proposal was submitted to the Commission in March 2004 and was under negotiations through the rest of the year.

### KNAW-CAS

JIVE continued active participation in the collaboration with the radio astronomy groups in China under the KNAW-CAS contract. Gurvits coordinated this contract together with R. Strom (ASTRON). The highlight of the first half of 2004 was delivery to the Shanghai Observatory of a new dual- polarisation L-band receiver developed and build in Dwingeloo by the Dutch-Chinese team of engineers. The receiver will become involved in EVN operations in the second half of 2004. Garrett, Gurvits and Diamond visited China for talks at the Chinese Academy of Sciences on Chinese participation in the JIVE Foundation.

### Other international projects

Following the decision by the EVN Consortium Board of Directors, Gurvits continued to coordinate EVN efforts to assist the Ventspils International Radio Astronomy Centre (Latvia) and the Institute for Radio Astronomy of Ukraine to upgrade the telescopes in Irbene (32 m) and Evpatoria (70 m) respectively, to EVN compatibility and operational standards. Gurvits visited VIRAC (Riga, Latvia) for a progress meeting with the scientific and engineering staff. He also discussed procedures of VIRAC admission in the RadioNet collaboration.

## Access to the European VLBI Network

In February 2004, the EC FP5 IHP contract HPRI-CT-2001-00142 "Access to the European VLBI Network" was completed. Within its framework, in the period from February 2002 through February 2004, EVN delivered 185.5 hours of observing time via this contract. The minimum deliverable was 181 hours. Nine users directly benefited from the contract. In addition, many other external users also benefited. The users came from six different EU and Associate state countries. In total, 182 person-days of visits to the infrastructure were associated with the contract. By April 2004, 5 papers (published or in press) were directly associated with observing time supported by this contract. Many more publications are expected over the next few years.

The last Annual and the Final reports were submitted in April 2004 and accepted by the Commission two months later.

## FP5 RadioNET

The EC Contract N HPRI-CT-1999-40003 "Infrastructure Cooperation Network in Radio Astronomy. RadioNet" was completed. It ran during the period March 2000 through February 2004. The RadioNet (FP5) tasks included enhancing the quality of operations and making more effective use of the existing European VLBI Network of radio telescopes (EVN), and building up the necessary scientific, technical and organisational consensus for the two major future radio astronomy facilities, the Atacama Large Millimetre Array (ALMA) and the Square Kilometre Array (SKA).

During the four years of the FP5 contract, RadioNET supported coordination activities at nine EVN institutes aimed at improved quality and interoperability of the network and improving the access to the research infrastructure. Special operations training workshops were held over the period of the contract to exchange best practices of VLBI operations, specifically focusing on the modern data acquisition procedures and calibration procedures. The contract supported two EVN Symposia (2000 and 2002) and one EVN VLBI School (2001). In addition, RadioNET participated in sponsorship of the JENAM-2003 Symposium "Radio Astronomy at 70: from Karl Jansky to microjansky" (Budapest, August 2003). The network supported publication of the book of proceedings, which contains materials directly related to and based on studies conducted at the institutes RadioNET supported in part a number of meetings on ALMA science, operations and management. These meetings produced documents which created a basis for the ALMA project implementation commenced in 2003.

Finally, RadioNET supported participation of the European radio astronomical community in the world-wide effort of designing the Square Kilometre Array. The major events included International (world-wide) SKA Science meetings. The meetings helped to work out major topics which would form the science case for the SKA project and be published as a book in 2004.

The overall ICN FP5 RadioNET contract was implemented on schedule and on budget. It also has enabled the European radio astronomy community to get the award under the FP6 programme (the much larger FP6 RadioNET I3 project).

The Fourth Annual and Final reports on the contract were submitted to the Commission in June 2004.

## 8. Publications

**(JIVE staff is marked bold).**

### 8.1 Refereed publications


**Biggs, A.D.**, Browne, I.W.A., Jackson, N.J., York, T., Norbury, M.N., McKean, J.P., Phillips, P.M., "Radio, optical and infrared observations of CLASS B0128+437", 2004, MNRAS, 350, 949

Cotton, W.D., Mennesson, B., Diamond, P.J., Perrin, G., Coude du Foresto, V., Chagnon, G., **Van Langevelde H.J.**, Ridgway, S., Waters, R., Vlemmings, W., Morel, S., Traub, W., Carleton, N., Lacasse, M., "VLBA Observations of SiO Masers Towards Mira Variable Stars" 2004, A&A 414, 275-288

Frayer D.T., Chapman S.C., Yan L., Armus L., Helou G., Fadda D., Morganti R., **Garrett M.A**., Appleton P., Choi P., Fang F., Heinrichsen I., Im M., Lacy M., Marleau F., Masci F.J., Shupe D.L., Soifer B.T., Squires G.K., Storrie-Lombardi L.J., Surace J.A., Teplitz H.I., Wilson G., 2004, “Infrared Properties of Radio-selected Submillimeter Galaxies in the Spitzer First Look Survey Verification Field”, ApJS, Vol 154, p 137

**Gurvits L.I.**, “Surveys of compact extragalactic radio sources”, 2004, New Astronomy Reviews, 48, 1211-1220

Hong, X. Y., Jiang, D. R., **Gurvits, L. I**., **Garrett, M. A.**, Garrington, S. T., Schilizzi, R. T., Nan, R. D., Hirabayashi, H., Wang, W. H., Nicolson, G. D., “A relativistic helical jet in the ?-ray AGN 1156+295”, A&A 417, 887

Horiuchi S., Fomalont E.B., Scott W.K., Taylor A.R., Lovell J.E.J., Moellenbrock G.A., Dodson R., Murata Y., Hirabayashi H., Edwards P.G., **Gurvits L.I.,** Shen Z.-Q., 2004, “The VSOP 5 GHz AGN Survey: The Angular Size/Brightness Temperature Distribution” ApJ, 616, 110-122

Lovell J.E.J., Moellenbrock G.A., Horiuchi S., Fomalont E.B., Scott W.K., Hirabayashi H., Dodson, R.G., Dougherty, S.M., Edwards, P.G., Frey, S., **Gurvits, L.I**., Lister, M.L., Murphy, D.W., **Paragi, Z.,** Piner, B.G., Shen, Z.-Q., Tingay, S., Asaki, Y., Moffett, D., Murata, Y., 2004, “The VSOP 5 GHz AGN Survey: II. Data Calibration and Imaging”, ApJ Suppl. 155, 27

Morganti R., **Garrett M.A.,** Chapman S., Baan W., Helou G., Soifer T., 2004, “A deep WSRT 1.4 GHz radio survey of the Spitzer Space Telescope FLSv region”, A&A, Vol 424, p 371

Reid, M.J., **Brunthaler, A**., 2004, "The Proper Motion of Sgr A*: II. The Mass of Sgr A*", ApJ, 616, 872

Scott, W.K., Fomalont, E.B., Horiuchi, S., Lovell, J.E.J., Moellenbrock, G.A., Dodson, R.G., Edwards, P.G., Coldwell, G.V., Fodor, S., Frey, S., **Gurvits, L.I**., Hirabayashi, H., Lister, M.L., Mosoni, L., Murata, Y., **Paragi, Z**., Piner, B.G., Shen, Z.-Q., Taylor, A.R., Tingay, S.J., 2004, “The VSOP 5 GHz AGN Survey. III. Imaging Results for the First 102 Sources”, ApJ Suppl. 155, 33

Stirling, A.M., Spencer, R.E., Cawthorne, T.V., **Paragi, Z**., 2004, “Polarisation and kinematic studies of SS433 indicate a continuous and decelerating jet”, MNRAS 354, 1239

Winn, J.N., Lovell, J.E.J., **Bignall, H.E**., Gaensler, B.M., Getts, T.J., Kedziora-Chudczer, L., Ojha, R., Reynolds, J.E., Tingay, S.J., Tzioumis, A.K., Wieringa, M.H., 2004, "The Radio Variability of the Gravitational Lens PMN J1838-3427", 2004, AJ, 128, 2696

Wrobel J.M., **Garrett M.A.**, Condon J.J., Morganti R., 2004, “VLBA Astrometry of Compact Radio Sources in the Spitzer First-Look Survey”, AJ, Vol 128, p103

Wucknitz, O., **Biggs, A.D.**, Browne, I.W.A., "Models for the lens and source of B0218+357 - A LensClean approach to determine H0", 2004, MNRAS, 349, 14

## 8.2 Publications in Conference Proceedings

Bartkiewicz, A., Szymczak, M., **Van Langevelde, H.J**., “Methanol masers in environments of three massive protostars”, 2004, in proceedings of the 7th EVN Symposium on New Developments in VLBI Science and Technology, eds. R. Bachiller, F. Colomer, J.-F. Desmurs, and P. de Vicente, 187

**Biggs, A.D.**, "EVN observations of the lens system B0128+437", 2004, in proceedings of the 7th EVN Symposium on New Developments in VLBI Science and Technology, eds. R. Bachiller, F. Colomer, J.-F. Desmurs, and P. de Vicente, 163

**Bignall, H.E.**, Tzioumis, A.K., Jauncey, D.L., Venturi, T., Clay, R.W., "ATCA radio monitoring of blazars observed with BeppoSAX", 2004, Nuclear Physics B Proceedings Supplements, 132, 149

**Bignall, H.E.**, Jauncey, D.L., Lovell, J.E.J., Kedziora-Chudczer, L., Macquart, J.-P., Tzioumis, A.K., Rickett, B.J., Ojha, R., Carter, S., Cimó, G., Ellingsen, S., McCulloch, P.M., "Interstellar scintillation as a probe of microarcsecond scale structure in quasars", 2004, in proceedings of the 7th EVN Symposium on New Developments in VLBI Science and Technology, eds. R. Bachiller, F. Colomer, J.-F. Desmurs, and P. de Vicente, 19

Blasco, C., **Bignall, H.E., Reynolds, C., Van Langevelde H.J**., “Extragalactic Scattering in Galaxy/Quasar Pairs”, 2004, in proceedings of the 7th EVN Symposium on New Developments in VLBI Science and Technology, eds. R. Bachiller, F. Colomer, J.-F. Desmurs, and P. de Vicente, 131

**Brunthaler A.**, "M33 - Distance and Motion", in "Reviews in Modern Astronomy", Vol. 18, S. Roeser (Ed.), Astronomische Gesellschaft 2004

**Campbell, R.M.**, “Recent Results from the EVN MkIV Data Processor at JIVE”, 2004, in proceedings of the 7th EVN Symposium on New Developments in VLBI Science and Technology, eds. R. Bachiller, F. Colomer, J.-F. Desmurs, and P. de Vicente, 245

**Campbell, R.M.**, "Recent Results from the EVN Mk4 Data Processor at JIVE", 2004, "International VLBI Service for Geodesy and Astrometry 2004 General Meeting Proceedings", eds. N.R. Vandenberg & K.D. Baver, (Washington: NASA/CP-2004-212255), 123

Frey, S., **Paragi, Z.**, Mosoni, L., **Gurvits, L.I.**, 2004, “The highest redshift radio quasar as seen with the EVN and the VLA”, Proceedings of the 7th European VLBI Network Symposium, Bachiller, R., Colomer, F., Desmurs J.F., de Vicente, P. (eds.), p. 125

**Garrett, M.A**., “Ground based VLBI facilities: the European and Global VLBI Network”, 2004, in Procs of the NATO Advanced Study Institute, held September 17-29, 2001, in Bologna, Italy. Series II, mathematics, physics and chemistry, Vol. 135. Edited by Franco Mantovani and Andrzej Kus.

**Garrett, M.A.,** “Deep fields: the faint sub-mJy and microJy radio sky: a VLBI perspective”, 2004, in Procs of the NATO Advanced Study Institute, held September 17-29, 2001, in Bologna, Italy. Series II, mathematics, physics and chemistry, Vol. 135. Edited by Franco Mantovani and Andrzej Kus.

**Garrett, M.A.**, Wrobel, J.M., Morganti, R., “Discovering the microJy VLBI sky via ‘Full-Beam’ self-calibration”, 2004, in proceedings of the 7th EVN Symposium on New Developments in VLBI Science and Technology, eds. R. Bachiller, F. Colomer, J.-F. Desmurs, and P. de Vicente, 35

**Gurvits, L.I.**, “Precise VLBI tracking of planetary probes revisited”, 2004, in proceedings of the 7th EVN Symposium on New Developments in VLBI Science and Technology, eds. R. Bachiller, F. Colomer, J.-F. Desmurs, and P. de Vicente, 337

**Gurvits L.I.**, “Christiaan Huygens, Huygens the probe and radio astronomy in Titan: from Discovery to Encounter”, 2004, ESA SP-1278, p. 408

Hachisuka K., **Brunthaler A.**, Hagiwara Y., Menten K.M., Imai H., Miyoshi M., Sasao T. "Distance to W3(OH) by VLBI annual parallax measurement", 2004, in proceedings of the 7th EVN Symposium on New Developments in VLBI Science and Technology, eds. R. Bachiller, F. Colomer, J.-F. Desmurs, and P. de Vicente, 317

**Van Langevelde, H. J., Olnon, F. M., Verkouter, H., Kramer, B., Garrett, M. A., Szomoru, A., Parsley, S. M.**, Bos, A., “Towards a Large Field of View Archive for the European VLBI Network”, 2004, procs of ADASS XIII, Strasbourg, eds. F. Ochsenbein, M.G. Allen, D. Egret. ASP vol. 314, 50

**Van Langevelde, H. J., Garrett, M. A., Parsley, S., Szomoru, A., Verkouter, H., Reynolds, C., Olnon, F., Biggs, A. D., Kramer, B., Paragi, Z., Pogrebenko, S. V.,** “eEVN: a Pan-European radio telescope”, 2004, SPIE--The International Society for Optical Engineering, Vol. 5489, p. 324

**Van Langevelde, H.J., Verkouter, H., Parsley, S.M., Garrett, M.A., Olnon, F., Kramer B.**, “High output data rates with PCInt on the EVN MkIV data processor”, 2004, in proceedings of the 7th EVN Symposium on New Developments in VLBI Science and Technology, eds. R. Bachiller, F. Colomer, J.-F. Desmurs, and P. de Vicente, 249

Mittal, R., Porcas, R.W., Wucknitz, O., **Biggs, A.D**., “A VLBI Study of the Gravitational Lens JVAS B0218+357”, 2004, in proceedings of the 7th EVN Symposium on New Developments in VLBI Science and Technology, eds. R. Bachiller, F. Colomer, J.-F. Desmurs, and P. de Vicente, 167

Orienti, M., **Garrett, M.A., Reynolds, C.**, Morganti, R., “Spitzer 24 µm imaging of Faint Radio Sources in the FLSv: a new radio-loud, Mid-IR/optically obscured population?”, 2004, in proceedings of the 7th EVN Symposium on New Developments in VLBI Science and Technology, eds. R. Bachiller, F. Colomer, J.-F. Desmurs, and P. de Vicente, 129

**Paragi Z.**, Vermeulen, R.C., Homan D.C., Wardle J.F.C., Fejes I., Schilizzi R.T., Spencer R.E., Stirling A.M., “Probing the polarisation characteristics of SS433 on mas scales”, 2004, in proceedings of the 7th EVN Symposium on New Developments in VLBI Science and Technology, eds. R. Bachiller, F. Colomer, J.-F. Desmurs, and P. de Vicente, 221

**Parsley, S.M**., “e-VLBI Research in the European VLBI Network”, IVS 2004 General Meeting Proceedings, eds. N.R. Vandenberg and K.D. Baver, NASA/CP-2004-212255

**Pogrebenko, S.V., Gurvits, L.I., Campbell, R.M., Avruch, I.M**., Lebreton, J.-P., Van 't Klooster, C.G.M., “VLBI tracking of the Huygens probe in the atmosphere of Titan”, 2004, in Planetary Probe Atmospheric Entry and Descent Trajectory Analysis and Science, ed. A.Wilson, ESA SP-544, 197.204

**Reynolds, C**., Cawthorne, T.V., Gabuzda, D.C., “Intermediate Scale Structures in BL Lac objects”, 2004, in proceedings of the 7th EVN Symposium on New Developments in VLBI Science and Technology, eds. R. Bachiller, F. Colomer, J.-F. Desmurs, and P. de Vicente, 45

Richards, A.M.S., Masheder, M.R.W., **Van Langevelde, H.J**., Cohen, R.J., Gray, M.D., Yates, J.A., Diamond, P.J., Vlemmings, W.H.T., Szymczak, M., Murakawa, K., “Hidden bipolarity in red supergiant winds”, 2004, in proceedings of the 7th EVN Symposium on New Developments in VLBI Science and Technology, eds. R. Bachiller, F. Colomer, J.-F. Desmurs, and P. de Vicente, 209

Ringwald, F.A., Morgan, G.E., Chase, D.W., Culver, J.M., Endler, S.S., **Garrett, M.A.,** Hathaway, A.J., Lake, P.A., Lin, S.M., Meyers, M.W., Prigge, J.W., Reynolds, D.S., Rodarte, A. L., Severson, R.W., Walters, S.E., “Imaging and Science at Fresno State's Campus Observatory”, 2004, American Astronomical Society Meeting 205, #151.06

**Szomoru, A., Biggs, A. D., Garrett, M., Van Langevelde, H. J., Olnon, F., Paragi, Z., Parsley, S., Pogrebenko, S., Reynolds, C.** “From truck to optical fibre: the coming-of-age of e-VLBI”, 2004, in proceedings of the 7th EVN Symposium on New Developments in VLBI Science and Technology, eds. R. Bachiller, F. Colomer, J.-F. Desmurs, and P. de Vicente, 257

**Other publications**

**S.M.Parsley, C.Reynolds,** “A Telescope as Big as the World”, JISC Inform magazine, issue 6, Autumn 2004.

**Paragi, Z.,** Microquasars (in Hungarian), Annual of the Hungarian Astronomical Society, p. 238, Budapest, 2004

JIVE Research note #0004 “VLBI Observations of the Huygens Probe”, Gurvits, L.I., Pogrebenko, S., Campbell, R.M., Avruch, I.M.

JIVE Research note #0005 “VLBI Tracking of the Huygens Titan probe”, Gurvits, L.I., Pogrebenko, S., Avruch, I.M., Bignall, H., Campbell, R.M., Szomoru, A.

## Appendices

**Appendix 1**

### JIVE Board

| | | |
|---|---|---|
| Prof. R.S. Booth | - | Onsala Space Observatory, Onsala, Sweden |
| Prof. H.R. Butcher | - | ASTRON, Dwingeloo, The Netherlands |
| Prof. P.J. Diamond | - | MERLIN/VLBI National Facility, Jodrell Bank Observatory, UK<br>Chairman |
| Dr. J. Gomez-Gonzalez | - | National Geographical Institute, Madrid, Spain |
| Dr. F. Mantovani | - | Institute for Radioastronomy, Bologna, Italy |
| Dr. J.A. Zensus | - | Max-Planck-Institute for Radioastronomy, Bonn, Germany<br>Vice-Chairman |

**Appendix 2**

## JIVE Financial Report for 2004

| ***Balance (amounts x € 1000)*** | **2003** | **2004** |
|---|---|---|
| ***ASSETS*** | | |
| ***Fixed Assets*** | | |
| Computer Equipment | 70 | 220 |
| Equipment under construction | 227 | |
| Furniture | 25 | 22 |
| | **322** | **242** |
| ***Current Assets*** | | |
| Work in Process | 11 | 167 |
| Receivables: | | |
| Debtors | 402 | 37 |
| Other | 7 | 17 |
| Cash at Bank | 1171 | 2033 |
| | **1591** | **2254** |
| | **1913** | **2496** |

| | **2003** | **2004** |
|---|---|---|
| ***LIABILITIES*** | | |
| ***Capital*** | | |
| General Reserve | **1122** | **1118** |
| ***Other Liabilities*** | | |
| NWO | | |
| ASTRON | 547 | 447 |
| Creditors | 16 | 61 |
| Received in advance: | | |
| PCI Contract | 132 | 132 |
| EU Contracts | 0 | 658 |
| Other | 96 | 80 |
| | **791** | **1378** |
| | **1913** | **2496** |

## JIVE Financial Report for 2004 (cont.)

### *JIVE - Profit and Loss statement 2004*
***(amounts x € 1000)***

| Revenues | | | Expenditures |
|---|---|---|---|
| ***Contributions*** | | | ***Institute*** |
| European Research Organisations | 770 | 1216 | Salaries |
| Dutch Research Council | 454 | 107 | Depreciation |
| | | 255 | Other |
| | **1224** | **1578** | |
| ***EU – contracts*** | | | ***Projects*** |
| Access | 68 | | |
| | | 35 | Access |
| ***Projects*** | | 169 | FP6 RadioNet |
| FP6 RadioNet | 400 | 9 | FP6 ANGLES |
| FP6 Angles | 9 | 39 | ALBUS |
| ALBUS | 39 | 12 | Upgrade Projects |
| ICN | 21 | 10 | ICN |
| Huygens contracts | 316 | 289 | Huygens contracts |
| ***Other*** | | | |
| Other | 22 | | |
| | **875** | **563** | |
| ***Interest*** | | | |
| Interest | 38 | | |
| | **38** | | |
| ***TOTAL*** | **2137** | **2141** | |
| | **Result 2004** | **-4** | |

**Appendix 3**

## JIVE Personnel

| | |
|---|---|
| Dr. M.A. Garrett* | Director |
| Dr. J.M. Anderson | Postdoctoral Research Assistant (since 15 November) |
| Dr. I.M. Avruch | Data Analysis Scientist |
| Ms. A. Berciano Alba | Early Stage Researcher (Marie Curie, since 1 December) |
| Dr. A. Biggs | Support Scientist |
| Dr. H. Bignall | Support Scientist |
| Dr. A. Brunthaler | Support Scientist (since 5 January) |
| Mr. J. Buiter | Tape Recorder Engineer |
| Dr. R.M. Campbell* | Head of Science Support and Operations |
| Dr. L.I. Gurvits* | Programme Manager, Senior Scientist |
| M.M. Kettenis | Software Engineer (since 1 July) |
| Mr. B. Kramer | Software Technician |
| Dr. H.J. van Langevelde* | Head of Software Development |
| Mr. M. Leeuwinga | Operator |
| Mrs. S.K. Mellema | Secretary |
| Mr. M. Nijk | Operator |
| Dr. F. Olnon | Online Software Engineer |
| Dr. Z. Paragi | Support Scientist |
| Eur. Ing. S.M. Parsley* | Head of Technical Operations and R&D |
| Dr. S.V. Pogrebenko | Senior Development Engineer |
| Dr. C. Reynolds | Senior Support Scientist |
| Mr. N. Schonewille | Chief Operator |
| Dr. A. Szomoru | Online Software Engineer |
| Mr. H. Tenkink | Operator |
| Ms. M. Tibbe | Office Manager |
| Drs. H. Verkouter | Offline Software Engineer |

* member of JIVE Management Team

**Appendix 4**

## Visitors to JIVE

| | |
|---|---|
| T. An | Shanghai Astronomical Observatory, China |
| C. Blasco | LAEFF, Madrid, Spain |
| K. Borkowski | Torun Center for Astronomy, Poland |
| J. Chevers | DANTE, UK |
| B. Cotton | NRAO, Socorro, USA |
| P. Edwards | ISAS, Japan |
| S. Frey | FOMI Satellite Geodetic Observatory, Budapest, Hungary |
| P. Hazell | Avonsoll Ltd, UK |
| X. Hong | Shanghai Astronomical Observatory, China |
| N. Jackson | Jodrell Bank Observatory, UK |
| C. Jin | Beijing Astronomical Observatory, China |
| K. van 't Klooster | ESA/ESTEC, Noordwijk, NL |
| K. Krajberg | Leiden University, NL |
| M. Krips | Universität Köln, Germany |
| J. McCollum | University of Tasmania, Australia |
| A. Mujunen | Metsähovi Radio Observatory, Finland |
| A. Niezurawska | Torun Center for Astronomy, Poland |
| M. Orienti | IRA, Bologna, Italy |
| C. Phillips | ATNF, Australia |
| R. Porcas | Max Planck Instiute for Radio Astronomy, Bonn, Germany |
| N. Pradel | Observatoire de Bordeaux, France |
| D. Robertson | DANTE, UK |
| A. Roy | Max Planck Instiute for Radio Astronomy, Bonn, Germany |
| L. Sjouwerman | NRAO, USA |
| S. Tingay | Swinburne Center for Astrophysics and Supercomputing, Australia |
| W. Vlemmings | Cornell University, USA |
| O. Wucknitz | University of Potsdam, Germany |
| L. Yi | Shanghai Astronomical Observatory, China |
| J. Yang | Urumqi Astronomical Observatory, China |
| M. Zhang | Jodrell Bank Observatory, UK |
| X. Zhang | Beijing Astronomical Observatory, China |

**Appendix 5**

# Presentations 2004

**Biggs**
"B0128+437 -- recent VLBA results", ANGLES inaugural meeting, Bonn, Germany, 5-6 April
"Missing images in the lens B0128+437", 2004 Young European Radio Astronomer's Conference, Cork, Ireland, 30 August - 3 September
"EVN observations of the lens system B0128+437", 7th European VLBI Network Symposium and Users Meeting, Toledo, Spain, 12-15 October
"Radio flux density monitoring: a practical guide", 1st ANGLES School, Santander, Spain, 10-14 December
"Radio flux density monitoring: recent MERLIN results", GL Workshop, Santander, Spain, 15-17 December

**Bignall**
"The microarcsecond-scale evolution of quasar PKS 1257-326", workshop on 'Interstellar Scintillation of Extragalactic Radio Sources', Dwingeloo, 6 April
"The 'Interstellar Telescope': scintillation as a high resolution probe of AGN radio jets",
ATNF, Sydney, Australia, 16 April
University of Melbourne, Australia, 20 April
University of Adelaide, Australia, 30 April
Kapteyn Institute, University of Groningen, 7 June
"Interstellar scintillation and the sub-pc scale structure of quasar PKS 1257-326" (poster), NAC 2004, Vlieland, 26-28 May
"Variability of extragalactic radio sources", lecture to summer students, Dwingeloo, 26 July
"The `Interstellar Telescope' as a probe of micro-arcsecond scale structure in AGN", YERAC, Cork, 31 August
"Interstellar scintillation as a probe of microarcsecond-scale structure in quasars", EVN Symposium, Toledo, 12 October
"Extragalactic scattering in galaxy/quasar pairs", poster by Blasco (LAEFF), Bignall, Reynolds and Van Langevelde, EVN Symposium, Toledo, 12-15 October
"Twinkling quasars, VLBI, and the GAVRT quasar campaigns", presentation at SHAPE High School, Belgium, 8 December

**Brunthaler**
"Detections of Proper Motion in the Local Group", PhD colloquium, Bonn, 21 June
"The Geometric Distance and Proper Motion of M33", Highlight talk at the Annual Meeting of the Astronomische Gesellschaft, Prague, 23 September

**Campbell**
"Recent Results from the EVN Mk4 Data Processor at JIVE", IVS 3rd General Meeting, Ottawa, Canada, 10 February
"e-VLBI Developments in Europe", IVS 3rd General Meeting, Ottawa, Canada, 10 February
"Recent Results from the EVN Mk4 Data Processor at JIVE", EVN Symposium #7, Toledo, Spain, 12 October

**Garrett**
Various presentations at the EVN CBD and JIVE Board Meetings, Onsala, May
"e-VLBI a Wide-field Imaging Instrument with milliarcsecond Resolution & microJy Sensitivity", SKA-NGST-ALMA meeting, Berlin, May
"Introduction to JIVE and the EVN", Colloquium, Shanghai Astronomical Observatory, Shanghai, April
"The JIVE/Kapteyn/ASTRON ANGLES node", ANGLES Kick-off meeting, MPIfR, Bonn, April
"e-VLBI and Network Policy", e-Infrastructures Meeting, Dublin, April
Various presentations about e-VLBI and e-Science within the EU IST Delegation to North America, June
"Expertise at JIVE relevant for a Dutch ALMA regional centre", Sterrewacht Leiden, July

“Deep Fields”, lecture to ASTRON-JIVE Summer students, July
“e-EVN: a real-time telescope as large as Europe with sub-microJy sensitivity”, NL Astronomical Strategy meeting, Amersfoort, September
“The e-EVN”, Future of Radio Astronomy in Europe, Schiphol**,** September
“Full-beam Self-calibration & something a wee bit more interesting”, EVN Symposium, Toledo, Spain, October
“e-VLBI – Creating a telescope as large as Euro-Asia”, EC-China Bridges meeting, Shanghai, December
“21st Century VLBI”, Beijing Astronomical Obs., China, December
“Joint Institute for VLBI in Europe”, Chinese Academy of Science, Beijing, China, December
Various presentations on JIVE: EVN Consortium and JIVE Board Meetings, Jodrell Bank, UK, November
“21st Century VLBI” Colloquia presented at various Dutch universities including: Anton Pannekoek Institute, Univ. of Amsterdam; Leiden Sterrewacht; Univ. of Utrecht; December.

**Gurvits**
“A Christmas story of Beagle-2 in Drents”, Astro-lunch, 7 January
“Feasibility study of Huygens VLBI tracking experiment: final presentation”, ESTEC, 16 January
“Frontiers of VLBI”, Beijing, China, 12 February
“Toward 10,000 VLBI-imaged quasars”', Shanghai, China, 13 February
“Parsec-scale environment of super-massive black holes in AGN as seen at radio waves”, IAU Symp 222, Gramado, Brazil, 3 March
“Project Scientist Report”, RadioNet Board mtg, Tenerife, 11 March
“Digging down to the core: on the highest brightness and massive non-MASIV surveys”, ISS workshop, Dwingeloo, 6 April
“Budgetary considerations for Huygens VLBI tracking”, ESTEC, 7 Apr
“Precise tracking of the Huygens Probe in the atmosphere of Titan’, Titan Conference, ESTEC, 14 April
“Status of RadioNet”, AMSTAR kick-off mtg, Oxford, UK, 26 April
“Parsec-scale radio structures throughout the Universe: hunting for shining diamonds”, Oort Workshop, Leiden, 27 April
“Radio Universe as seen by RadioNet”, ILIAS kick-off meeting, Paris, France, 29 April
“RadioNet: the status and news”, PHAROS kick-off mtg, Dwingeloo, 12 May
“Aspiring Network Radio Telescopes”, EVN CBD mtg, Gothenburg, Sweden, 14 May
“Design of near-term next generation Space VLBI mission VSOP-2” (poster), Exploring the Cosmic Frontier, Berlin, 18 May
“Space VLBI in the era of LOFAR. ALMA and SKA”, Exploring the Cosmic Frontier, Berlin, 19 May
“Status of the Huygens VLBI Tracking project”, ESTEC, 6 July
“1713+218: a mystery at z=4”, Astro-lunch, 7 July
“Phase-referencing issues for spacecraft VLBI navigation”, Vancouver, Canada, 18 July
“VLBI images of quasars at z>4”, Penticton, 20 July
“VLBI tracking of planetary missions”, (poster), TTC2004, Darmstadt, Germany, 6 September
“Precise tracking of the Huygens Probe in the atmosphere of Titan”, Univ Valencia, Spain, 13 September
“Cores and jets in extremely high-redshift quasars as seen in X-ray and radio domains”, Multi-band approach to AGN, Bonn, Germany, 1 October
“Precise VLBI tracking of planetary probes revisited”, 7th EVN Symposium, Toledo, Spain, 15 October
“RadioNet Networking activities review”, Jodrell Bank, UK, 17 November
“Considerations for RadioNet public outreach activities”, Jodrell Bank, 17 November
“Status of EVN candidate members”, Jodrell Bank, UK, 18 November
“Space horizons of VLBI: from planetary science to cosmology”, Lecture, Leiden University, NL, 1 December
“Introduction to VLBI”, EADS, Bremen, Germany, 3 December
“Radio astronomy from the Moon”, EADS, Bremen, 6 December
“Huygens probe under a VLBI magnifier”, Beijing, China, 14 December

**Van Langevelde**
"Molecular absorption in CenA on VLBI scales", lunch talk, Leiden, 13 January
"ALBUS", ALBUS kick-off meeting, Schiphol, 30 January
"Molecular absorption in CenA on VLBI scales", conference talk, Zwolle, 18 February
"ALBUS" RadioNet Board meeting, Tenerife, 11 March
"Fundamental properties of Mira Variables through VLBI observations" Science talk at RadioNet Board, Tenerife, 12 March
"ALBUS", lunch talk, Dwingeloo, 25 March
"Astrometry of circumstellar masers", colloquium, JAC Hilo, Hawaii, 21 April
"ALBUS", Inter Group Lunch, Dwingeloo, 29 April
"eSMA", lunch talk, Dwingeloo, 12 May
"Computing at JIVE", at NWO meeting astronomy- informatics, Utrecht, 25 May
"The extended Methanol maser in W51", poster NAC, Vlieland, 26–28 May
"eSMA" a Dutch opportunity for sub-mm interferometry" NOVA ICM meeting, Amsterdam, 14 June
"Options for user software", ALBUS meeting, Dwingeloo, 18 June
"eEVN: a Pan-European radio-telescope" SPIE conference talk, Glasgow, 22 June
"Een telescoop zo groot als Europa" rondleiding Probus club, Dwingeloo, 28 June
"Galactic masers and VLBI", lecture to summer students, Dwingeloo, 12 July
"Spectral line VLBI", interferometry lecture, Leiden, 6 October
"Masers around young and old stars", lecture NOVA herfstschool, Dwingeloo, 8 October
"Future capabilities of the EVN Mk4 data processor" EVN users meeting Yebes, Spain, 13 October
"What is ALBUS", EVN users meeting Yebes, Spain, 13 October
"High output data rates with PCInt", (poster) EVN symposium, Toledo Spain, 12-15 October
"The European VLBI Network", tour of JIVE for CREST, 24 October
"Een telescoop zo groot als Europa", Open Day at Westerbork, 24 October
"Interview TROS on-line; e-VLBI", Dutch national radio, 26 October
"VLBI in beweging", annual meeting of Dutch amateur astronomers, Tilburg, 6 November
"JIVE correlator report", EVN PC, Jaen, Spain, 10 November
"ALBUS", RadioNet board, Jodrell Bank, 17 November

**Paragi**
"Performance and reliability of the EVN", TOG Meeting, Wettzel, Germany, 1-2 April
"Detecting sub-mJy sources with the EVN", (poster by Paragi, Garrett and Biggs), 5th Microquasar Workshop, Beijing, 6-12 June
"eEVN: a Pan-European radio telescope", (poster by Van Langevelde, Garrett, Parsley, Szomoru, Verkouter, Reynolds, Olnon, Biggs, Kramer, Paragi and Pogrebenko) SPIE Europe International Symposium, Glasgow, Scotland, United Kingdom, 21-25 June
"Probing the polarisation characteristics of SS433 on mas scales", Paragi Z., Vermeulen, R.C., Homan D.C., Wardle J.F.C., Fejes I., Schilizzi R.T., Spencer R.E., Stirling A.M., Presented at the 7th European VLBI Network Symposium, Toledo, Spain, 12-15 October
"The reliability and performance of the EVN", TOG Meeting, Jodrell Bank, UK, 22 November

**Parsley**
"*e-VLBI* Developments in Europe", Third IVS General Meeting, Ottowa, Canada, 10 February (presented in absentia by R. Campbell)
"EVN-NREN Project Status Report", EVN Technical and Operations Group Meeting, Wettzell, Germany. 1-2 April
"Very Long Baseline Interferometry (VLBI) and the European VLBI Network-National Research and Education Networks (EVN-NREN) Project", Networkshop 32, Keele University, UK. 8 April
"High Bandwidth, Radio-Astronomy Data Transport" TERENA Network Conference, Rhodes, Greece, 7-10 June
"*e*-VLBI in Europe, a General Perspective", 3rd e-VLBI Workshop, Tokyo, Japan, 6 October
"*e*-VLBI Demonstration - An Astronomical Telescope as Big as Europe", IST 2004 event and exhibition, The Hague, Netherlands, 15-17 November

**Reynolds**

presentation and workshop on amplitude calibration, and a presentation on scheduling, EVN TOG meeting, Wettzel, 1-2 April
"Intermediate Scale Structures in BL Lac objects", 7th EVN Symposium, Toledo, Spain, 12-15 October
"What Happens to the Data at the Correlator and After", EVN Users Meeting, Toledo, Spain, 12-15 October
"Polarized Radio Sources", Lecture, Leiden University, November
"Amplitude Calibration", EVN TOG, Jodrell Bank, UK, 22 November
"Developments in SCHED", EVN TOG, Jodrell Bank, UK, 22 November

**Szomoru**
“Recent e-VLBI developments at JIVE”, 3rd *e-VLBI* Workshop, Tokyo, Japan, 6 October
“From truck to optical fibre: the coming-of-age of *e-VLBI*”, 7th European VLBI Network Symposium, Toledo, Spain, 12-15 October
“e-VLBI status at JIVE”, TOG meeting, Jodrell Bank, UK, 22 November
“e-VLBI @ JIVE”, ASTRON lunch talk, 10 December

## Membership of international Boards and committees

**Mr. J. Buiter**

| | |
|---|---|
| 1992- | EVN Technical and Operations Group |

**Dr. M.A. Garrett**

| | |
|---|---|
| 2003- | IAU Division X Organizing Committee |
| 2003- | SKA International Science Advisory Committee |
| 2003- | EVN Consortium Board of Directors |
| 2004- | RadioNet Board of Directors |

**Dr. L.I. Gurvits**

| | |
|---|---|
| 1993- | Global VLBI Working Group (GVWG) |
| 2000- | VIRAC (Latvia) Advisory Board |
| 2003- | IAU Division XI Organizing Committee |
| 2004- | RadioNet Management Team |
| 2004- | ESA-BepiColombo Science Working Group |
| 2004- | ESA-Huygens Science Working Group |

**Dr. H.J. van Langevelde**

| | |
|---|---|
| 1998- | NOVA education committee |
| 1999- | EVN Programme Committee (EVNPC) |
| | NWO Beoordelings Commissie Astronomie |
| 2004- | RadioNet Executive Committee |

**Eur. Ing. S.M. Parsley**

| | |
|---|---|
| 1998- | EVN Technical and Operations Group |

## Membership of professional associations and societies

**Dr. I.M. Avruch**

1993- Sigma Xi

**Dr. H.E. Bignall**

1997- Australian Institute of Physics
1998- Astronomical Society of Australia

**Dr. A. Brunthaler**

1995- Deutsche Physikalische Gesellschaft

**Dr. R.M. Campbell**

1983- Sigma Xi
1993- American Astronomical Society
1996- American Geophysical Union
2000- International Astronomical Union
2002- URSI

**Dr. M.A. Garrett**

1997- International Astronomical Union

**Dr. L.I. Gurvits**

1992- American Astronomical Society
1994- Nederlandse Astronomen Club
1997- International Astronomical Union
1998- COSPAR Associate
1999- URSI

**Dr. H.J. van Langevelde**

1985- Nederlandse Astronomen Club
1997- International Astronomical Union
1999- URSI

**Dr. F. Olnon**

1972- Nederlandse Astronomen Club

**Dr. Z. Paragi**

2001- Roland Eotvos Physical Society
2001- Hungarian Astronautical Society

**Eur. Ing. S.M. Parsley**

1983- Institution of Electrical Engineers
1995- Federation of European Engineering Institutions

**Dr. S.V. Pogrebenko**

2000- International Astronomical Union

**Appendix 8**

# Meetings attended

## *1. Scientific conferences attended by JIVE staff members*

**Biggs**
"Impact of gravitational lensing on cosmology", IAU Symp 225, Lausanne, Switzerland, 19-23 July
Young European Radio Astronomer's Conference, Cork, Ireland, 30 August - 3 September
7th European VLBI Network Symposium and Users Meeting, Toledo, Spain, 12-15 October
GL Workshop 2004, Santander, Spain, 15-17 December

**Bignall**
'Interstellar Scintillation of Extragalactic Radio Sources', ASTRON/JIVE, Dwingeloo, NL, 5-7 April
Dutch Astronomers Conference, Vlieland, NL, 26-28 May
YERAC, Cork, Ireland, 30 Aug - 3 September
7th EVN Symposium, Toledo, Spain, 12-15 October

**Brunthaler**
"European Workshop 2004 on Astronomical Molecules", Zwolle, NL, 17-20 February
"Interstellar Scintillation of Extragalactic Radio Sources", ASTRON/JIVE, Dwingeloo, NL, 5-7 April
Annual Meeting of the Astronomische Gesellschaft, Prague, 20-25 September

**Campbell**
IVS 3rd General Meeting, Ottawa, Canada, 9-11 February
IVS 5th Analysis Workshop, Ottawa, Canada, 12 February
Fundamental Astronomy: New Concepts & Models for High-Accuracy Observations, Paris, France, 20-22 September
7$^{th}$ EVN Symposium and Users meeting, Toledo, Spain, 12-15 October

**Garrett**
"Exploring the Cosmic Frontier", Berlin, Germany, 18-21 May
7$^{th}$ EVN Symposium and Users meeting, Toledo, Spain, 12-15 October
Toward large-scale science infrastructure on the Moon, EADS, Bremen, Germany, 5-6 December

**Gurvits**
"The Interplay among Balck Holes, Stars and ISM in Galactic Nuclei", IAU Symp 222, Gramado, Brazil, 27 February-7 March
Titan conference, ESTEC, Noordwijk, NL, 13-16 April
"Exploring the Cosmic Frontier", Berlin, Germany, 18-21 May
Huygens VLBI project mtg, Vancouver, Canada, 17-18 July
JENAM-2004, Granada, 13-17 September
Multiband approach to AGN, MPIfR, Bonn, 30 September – 2 October
7$^{th}$ EVN Symposium, Toledo, Spain, 12-15 October
Toward large-scale science infrastructure on the Moon, EADS, Bremen, Germany, 5-6 December

**Van Langevelde**
"Dense Molecular Gas around Protostars and in Galactic Nuclei", European Workshop on Astronomical Molecules, Zwolle, 17-20 February
"Nederlandse Astronomen Conferentie", Vlieland, 26-27 May
"Astronomical Telescopes", SPIE International Symposium, Glasgow, 21-24 June
ALMA users meeting, Garching Germany, 24 September

$7^{th}$ EVN Symposium and Users meeting, Toledo, Spain, 12-15 October

**Olnon**
Dutch Astronomers Conference, Vlieland, NL, 26-27 May

**Paragi**
5th Microquasar Workshop, Beijing, China, 6-12 June
$7^{th}$ EVN Symposium and Users meeting, Toledo, Spain, 12-15 October

**Reynolds**
“Interstellar Scintillation of Extragalactic Radio Sources”, ASTRON/JIVE, Dwingeloo, NL, 5-7 April
$7^{th}$ EVN Symposium and Users meeting, Toledo, Spain, 12-15 October

**Szomoru**
$7^{th}$ EVN Symposium and Users meeting, Toledo, Spain, 12-15 October

## *2. International meetings attended by JIVE staff members*

**Anderson**
Software meeting, Nottingham, UK, 20-21 December

**Biggs**
ANGLES inaugural meeting, MPIfR, Bonn, 5-6 April
1st ANGLES School, Santander, Spain, 10-14 December

**Buiter**
TOG meeting, Jodrell Bank, UK, 22 November

**Campbell**
Mark 5a,b/DBBC Meeting, Bonn, Germany, 29 March
EVN TOG Meeting, Wettzell, Germany, 1-2 April
TOG meeting, Jodrell Bank, UK, 22 November

**Garrett**
EVN-NREN Meeting, Schiphol, 28 January
FP6 SKA design study meeting, Oxford, UK, 29 January
FP6 SKA design study meeting, Madrid, Spain, 3-4 February
FP6 RadioNet board meeting, Tenerife, Spain, 11-13 March
Launch fo ARTI project, Dublin, Ireland, 26 March
ANGLES Consortium kick-off meeting, 5-6 April
Workshop on eInfrastructures, Dublin, Ireland, 15-16 April
EVNCBD meeting, Gothenburg, Sweden, 14 May
JIVE Board meeting, Gothenburg, Sweden, 15 May
Dutch Astronomy Strategy mtg, The Hague, 11 September
Dutch Astronomy Strategy mtg, Amersfoort, 20 September
RadioNet Board meeting, Jodrell Bank, UK, 17 November
EVN CBD meeting, Jodrell Bank, Uk, 18 November
JIVE Board meeting, Jodrell Bank, UK, 19 November
Nançay Radio Telescope Evaluation Committee, Nançay, France, 24-25 November
EC-Bridge Conference, Shanghai, China, 9-10 December
JIVE-Chinese Academy of Sciences mtg, Beijing, China, 12-15 December
SKADS Coordination meeting, Zaandam, NL, 21 December

**Gurvits**
FP6 RadioNet Board meeting, Tenerife, 11-13 March
AMSTAR kick-off meeting, Oxford, UK, 26 April
ILIAS kick-off meeting, Paris, France, 29 April

EVNCBD meeting, Gothenburg, Sweden, 14 May
JIVE Board meeting, Gothenburg, Sweden, 15 May
Huygens Project meeting, 16-17 July
International SKA meeting, Penticton, Canada, 19-24 July
Huygens Project meeting, NASA HQ, Washington DC, USA, 21-22 August
Dutch Astronomy Strategy mtg, The Hague, 11 September
Dutch Astronomy Strategy mtg, Amersfoort, 20 September
RadioNet-AMSTAR meeting, IRAM, Grenoble, France, 29 September
RadioNet-VIRAC meeting, Riga, Latvia, 29 October
FP6 I3 mtg, EC, Brussels, Belgium, 12 November
RadioNet Board meeting, Jodrell Bank, UK, 17 November
EVN CBD meeting, Jodrell Bank, Uk, 18 November
JIVE Board meeting, Jodrell Bank, UK, 19 November
JIVE-Chinese Academy of Sciences mtg, Beijing, China, 12-15 December

**Van Langevelde**
RadioNet ALBUS kick-off meeting 30 January
RadioNet Board meeting, Tenerife, 11-12 March
EVN Discussion on Mark 5 and DBBC systems, Bonn, 29 March
LOFAR calibration meeting, Dwingeloo, 10 May
NWO computing meeting Utrecht 24 May
NWO beoordelings Commissie, 25 May
ICM meeting Amsterdam, 14 June
ALBUS discussion on the future of user software for radio data reduction, Dwingeloo, 18 June
ESPRIT workshop, SRON Utrecht, 2-3 September
Dutch strategy meeting, NWO, Den Haag, 10 September
Dutch strategy meeting, Amersfoort, 20 September
EVN PC, Jaen, Spain, 8-10 November
RadioNet board, Jodrelll Bank, 17 November
EVN directors meeting, Jodrell Bank, UK, 18 November
ALBUS field trip, Bonn and Effelsberg, 30 November – 1 December
Blue Gene users meeting, Groningen, 7 December

**Leeuwinga**
TOG meeting, Wettzell, Germany, 1-2 April

**Olnon**
Data Processing Future, Dwingeloo, 18 June

**Paragi**
TOG Meeting, Wettzel, Germany, 1-2 April
TOG Meeting, Jodrell Bank, UK, 22 November

**Parsley**
EVN-NREN Meeting, Schiphol, 28 January
DBBC Operative Meeting, Wettzell, Germany, 31 May
EVN Technical and Operations Group Meeting, Wettzell, Germany. 1-2 April
Neworkshop 32, Keele University, UK, 8 April
TERENA Network Conference, Rhodes, Greece, 7-10 June
RadioNet ‘Digital Backends’ workshop, Bonn, Germany, 6 September
DBBC meeting, MPIfR, Bonn, Germany, 6 September
Digital Baseband Converter working group, MPIfR, Bonn, Germany, 7 September
3$^{rd}$ e-VLBI Workshop, Tokyo, Japan, 6-7 October
IST 2004 event and exhibition, The Hague, Netherlands, 15-17 November

**Pogrebenko**
RadioNet ‘Digital Backends’ workshop, Bonn, Germany, 6 September
DBBC meeting, Bonn, Germany, 7 September

**Reynolds**
ALBUS kick-off meeting, Schiphol, 30 January
EVN TOG meeting, Wettzell, Germany, 31 March-2 April
ALBUS meeting, “The Future of User Data Processing Software for Radio Interferometry”, Dwingeloo, 18 June
TOG meeting, Jodrell Bank, UK, 22 November
SKADS Coordination meeting, Zaandam, NL, 21 December

**Schonewille**
TOG meeting, Jodrell Bank, UK, 22 November

**Szomoru**
EVN-NREN meeting, Schiphol, 28 January
ALBUS meeting, Schiphol, 30 January
ALBUS meeting, Dwingeloo, 18 June
3rd e-VLBI Workshop, Tokyo, Japan, 6-7 October
TOG meeting, Jodrell Bank, UK, 22 November

**Tenkink**
TOG meeting, Wettzell, Germany, 1-2 April

### *3. Working visits by JIVE staff members*

**Anderson**
MPIfR, Bonn, Germany, 30 November-1 December
Institute of Engineering Surveying and Space Geodesy (IESSG), Nottingham, UK, 20 December

**Avruch**
Huygens Observation, Greenbank, USA, 15-26 November

**Biggs**
Jodrell Bank Observatory, UK, 5-9 July

**Bignall**
Nançay Radio Telescope, France, 24-25 June.

**Garrett**
DANTE, Cambridge, UK, 20 January
Shanghai Astronomical Observatory, Shanghai, China, 30 March-2 April
Meeting with European Commission, 8 June
Participant in EU delegation on eInfrastructures, Washington-Chicago-Ottawa, 20-27 June

**Gurvits**
Beijing and Shanghai Astronomical Observatories, China, 11-19 February
CfA – Harvard Univ., Cambridge, USA, 8-15 August
Huygens VLBI Test Observation, Green Bank, USA, 23-28 August
Huygens/Titan Test Observation, ESOC, Darmstadt, Germany, 9 December
Huygens VLBI Tracking Experiment, JAXA and NIICT, Tokyo, Japan, 17 December

**Van Langevelde**
Leiden, 13 January
Leiden, 13 April
JAC Hilo, 5-23 April
Groningen, 8 June
Leiden, PhD defense Messineo, 30 June
Sackler lecture, Leiden, 9 December

**Paragi**
Jodrell Bank Observatory, UK, 23-26 November

**Pogrebenko**
Huygens VLBI Test Observation, Greenbank, USA, 23-28 August

**Reynolds**
University of Central Lancashire, 23-25 November

**Appendix 9**

## All project activity during 2004

Empty fields mean that the actions are not yet completed.

| Expt No. | Obs. | P.I. | Type | Correlated | Distributed | Released | Support Person |
|---|---|---|---|---|---|---|---|
| ED018D | 070603 | Desmurs | USER | (010903) | (051203) | 010704 | Campbell |
| ED018C | 060603 | Desmurs | USER | (020903) | (051203) | 010704 | Campbell |
| GM049A | 300503 | Macquart | USER | (240903) | (061103) | 210404 | Avruch |
| GM049B | 310503 | Macquart | USER | (011003) | (181103) | 210404 | Avruch |
| EP042E | 260503 | Polatidis | USER | (131003) | 240104 | 190404 | Campbell |
| BF073C | 300703 | Fomalont | USER | (200103) | (251103) | 200404 | Campbell |
| BF073D | 310703 | Fomalont | USER | (241003) | (251103) | 200404 | Campbell |
| GJ010A | 030603 | Jackson | USER | (131103) | 100604 | 090804 | Campbell/Biggs |
| TEVLB6 | 181103 | Reynolds | TEST | (181103) | (241103) | 250204 | Reynolds |
| ER16B1 | 280503 | Rovilos | USER | (181103) | (181203) | 010704 | Reynolds |
| TEVLB7 | 241103 | Reynolds | TEST | (241103) | (251103) | 250204 | Reynolds |
| ER16B2 | 290503 | Rovilos | USER | (251103) | (181203) | 010704 | Reynolds |
| EN001 | 080603 | Niezurawska | USER | (021203) | 170204 | 220404 | Avruch |
| N03L3 | 071103 | Paragi | NME | (041203) | 080304 | 190404 | Paragi |
| N03C1 | 291003 | Paragi | NME | (051203) | 230104 | 230104 | Paragi |
| EI005C | 100603 | Imai | USER | (111203) | 100204 | 200404 | Van Langevelde/ Reyolds |
| F03X1 | 201003 | Polatidis | NME | (161203) | 230104 | 230104 | Paragi |
| EM053A | 050603 | Moscadelli | USER | (161203) | 190204 | 260404 | Bignall |
| EM053B | 060603 | Moscadelli | USER | (191203) | 190204 | 260404 | Bignall |
| EM049 | 090603 | Moscadelli | USER | (241203) | 020304 | 260404 | Bignall |
| GT005 | 011103 | Taylor | USER | 090104 | 060404 | 090804 | Campbell |
| TEVLB8 | 150104 | Reynolds | TEST | 160104 | 010304 | 010304 | Campbell |
| D03L1 | 300903 | Paragi | TEST | 190104 | 190104 | 190104 | Paragi |
| EH015A | 021103 | Harlaftis | USER | 190104 | 100204 | 051004 | Bignall |
| D03C3 | 021103 | Paragi | TEST | 200104 | 210304 | 210404 | Campbell |
| EH015B | 041103 | Harlaftis | USER | 260104 | 100204 | 051004 | Bignall |
| EM050 | 031103 | Marecki | USER | 300104 | 010304 | 220404 | Bignall |
| EJ006 | 051103 | Jiang | USER | 040204 | 050304 | 010704 | Biggs |
| F04C1 | 120204 | Polatidis | NME | 060204 | 080304 | 190404 | Paragi |
| F04K1 | 040204 | Polatidis | NME | 110204 | 080304 | 190404 | Paragi |
| F04C0 | 050204 | Paragi | NME | 110204 | 080304 | 190404 | Paragi |
| EH016B | 101103 | Hagiwara | USER | 110204 | 260204 | 190404 | Biggs |
| EH016A | 301003 | Hagiwara | USER | 270204 | 230304 | 260404 | Biggs |
| EH013 | 311003 | Hong | USER | 050304 | 010604 | 051004 | Reynolds |
| N04C1 | 140204 | Paragi | NME | 090304 | 050404 | 220404 | Paragi |
| N04L1 | 200204 | Paragi | NME | 090304 | 230404 | 220604 | Paragi |
| F04U1 | 260204 | Paragi | NME | 100304 | 130404 | 260404 | Paragi |
| N04X1 | 120204 | Paragi | NME | 110304 | 050404 | 220404 | Paragi |
| N04K1 | 110204 | Paragi | NME | 120304 | 050404 | 220404 | Paragi |
| F04M1 | 240204 | Paragi | NME | 190304 | 130404 | 260404 | Paragi |
| EB022C | 240503 | Bann | USER | 250304 | 110504 | | Campbell/Avruch |
| TE010 | 250304 | Reynolds | TEST | 250304 | 250304 | 250304 | Reynolds |
| EP044 | 110204 | Pradel | USER | 130404 | 230404 | 090804 | Biggs |
| TE011 | 190404 | Paragi | TEST | 200404 | 260404 | 030504 | Paragi |
| GM052A | 130204 | Mantovani | USER | 210404 | 100604 | 090804 | Brunthaler/Campbell |
| TE012 | 230404 | Paragi | TEST | 230404 | 260404 | 030504 | Paragi |
| TE015 | 230404 | Paragi | TEST | 230404 | 260404 | 030504 | Paragi |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| TE013 | 230404 | Paragi | TEST | 230404 | 260404 | 030504 | Paragi |
| TE014 | 230404 | Paragi | TEST | 230404 | 260404 | 030504 | Paragi |
| GM052B | 140204 | Mantovani | USER | 260404 | 100604 | 090804 | Brunthaler/Campbell |
| TE016 | 280404 | Paragi | TEST | 280404 | 030504 | 100504 | Biggs |
| TE018 | 280404 | Paragi | TEST | 280404 | 030504 | 100504 | Biggs |
| TE017 | 280404 | Paragi | TEST | 280404 | 030504 | 100504 | Biggs |
| TE019 | 280404 | Paragi | TEST | 280404 | 030504 | 100504 | Biggs |
| EB025 | 180204 | Biggs | USER | 290404 | 140504 | 090804 | Biggs |
| ER017 | 100204 | Rioja | USER | 040504 | 100604 | 060904 | Brunthaler/Bignall |
| EK019 | 150204 | Kunert | USER | 060504 | 220704 | 140904 | Paragi |
| EB027A | 140204 | Bondi | USER | 130504 | 140604 | 090804 | Bignall |
| EB027B | 190204 | Bondi | USER | 210504 | 140604 | 090804 | Bignall |
| EB026 | 170204 | Beswick | USER | 090604 | 140704 | 140904 | Campbell |
| N04C2 | 200504 | Paragi | NME | 090604 | 260704 | 160804 | Paragi |
| HUYG12 | 100604 | Avruch | TEST | 140604 | 060804 | 060804 | Avruch |
| F04C2 | 170504 | Polatidis | NME | 140604 | 050704 | 260704 | Paragi |
| F04C4 | 260504 | Gunn | NME | 140604 | 230604 | 140904 | Campbell |
| TE020 | 160604 | Conway | TEST | 160604 | 230604 | 160804 | Reynolds |
| EC022 | 260504 | Caccianiga | USER | 170604 | 020704 | 140904 | Brunthaler |
| N04L2 | 030604 | Paragi | NME | 220604 | 250704 | 260704 | Biggs/Brunthaler |
| EP046A | 290504 | Pihlstrom | USER | 290604 | 200904 | 201004 | Paragi |
| GI001A | 071103 | Imai | ABAN | 290604 | 290604 | 290604 | Reynolds |
| EB028A | 210504 | Bode | USER | 300604 | 050704 | 140904 | Bignall |
| N04U1 | 300504 | Paragi | NME | 060704 | 230704 | 260704 | Reynolds |
| GK029 | 220504 | Krips | USER | 130704 | 280704 | 140904 | Brunthaler |
| F04C3 | 270504 | Paragi | NME | 150704 | 180804 | 130904 | Brunthaler |
| EB029 | 200504 | Brunthaler | USER | 190704 | 270704 | 140904 | Brunthaler |
| TEVLB9 | 270204 | Reynolds | TEST | 230704 | 230704 | 230704 | Reynolds |
| GI001B | 070604 | Imai | USER | 050804 | 051204 | | all |
| TE021 | 040804 | Reynolds | TEST | 050804 | 160804 | 160804 | Reynolds |
| GS021A | 240504 | Snellen | USER | 100804 | 051004 | 221204 | Biggs |
| EP046B | 290504 | Pihlstrom | USER | 130804 | 200904 | 201004 | Paragi |
| EP046C | 300504 | Pihlstrom | USER | 170804 | 200904 | 201004 | Paragi |
| TE022 | 260804 | Reynolds | TEST | 190804 | 300804 | 130904 | Reynolds |
| EA029 | 190204 | Avruch | USER | 250804 | 051004 | 181004 | Avruch |
| GP036B | 290503 | Paragi | USER | 250804 | 200904 | 211004 | Paragi/Campbell |
| GS021B | 050604 | Snellen | USER | 020904 | 051004 | 221204 | Biggs |
| GM053 | 040604 | McHardy | USER | 070904 | 031104 | 031204 | Biggs |
| TE023 | 080904 | Reynolds | TEST | 080904 | 270904 | 041004 | Reynolds |
| TE024 | 100904 | Reynolds | TEST | 100904 | 270904 | 041004 | Reynolds |
| D04C1 | 050904 | Paragi | TEST | 170904 | 270904 | 041004 | Paragi |
| GM051 | 010604 | Mack | USER | 170904 | 240904 | 221204 | Bignall |
| RAH2 | 220904 | Richards | USER | 220904 | 240904 | 041004 | Reynolds |
| SAH7 | 220904 | Salter | USER | 220904 | 240904 | 041004 | Reynolds |
| EB028B | 080604 | Bode | USER | 290904 | 011104 | 221204 | Bignall |
| CHAKB | 250804 | Chakrabati | USER | 300904 | 221004 | 031204 | Paragi |
| CHAKA | 230804 | Chakrabati | USER | 300904 | 221004 | 031204 | Paragi |
| CHAKC | 270804 | Chakrabati | USER | 011004 | 221004 | 031204 | Paragi |
| TE025 | 080904 | Gurvits | TEST | 041004 | 041004 | 041004 | Avruch |
| EG030 | 030604 | Ghosh | USER | 041004 | 291004 | 201204 | Campbell |
| GG57A1 | 270804 | Burvits | USER | 071004 | 101104 | | Avruch/Campbell |
| GG57A2 | 270804 | Gurvits | USER | 081004 | 181104 | | Avruch/Campbell |
| EF011 | 041103 | Frey | USER | 121004 | 271004 | 071204 | Paragi |
| F04P1 | 211004 | Paragi | NME | 011104 | 011104 | 071204 | Paragi |
| F04M2 | 041104 | Paragi | NME | 111104 | 151104 | 071204 | Paragi |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| TE026 | 161104 | Reynolds | TEST | 161104 | 171104 | 071204 | Reynolds |
| N04P1 | 251004 | Bignall | NME | 181104 | 061204 | 131204 | Bignall |
| N04K2 | 011104 | Paragi | NME | 191104 | 061204 | 131204 | Paragi |
| N04C3 | 281004 | Paragi | NME | 231104 | 061204 | | Paragi |
| TE027A | 261104 | Reynolds | TEST | 261104 | 061204 | | Reynolds |
| N04M1 | 071104 | Brunthaler | NME | 291104 | 061204 | 131204 | Brunthaler |
| EN003A | 101104 | Bartkiewicz | USER | 071204 | | | Campbell/Van Langevelde |
| EN003B | 111104 | Bartkiewicz | USER | 091204 | | | Campbell/Van Langevelde |
| EI006A | 031104 | Imai | USER | 151204 | | | Paragi |
| TH024 | 061004 | Gurvits | TEST | 161204 | 231204 | | Avruch |
| TE028 | 201204 | Reynolds | TEST | 201204 | 221204 | | Campbell |
| D04C2 | 031204 | Conway | TEST | 211204 | 221204 | | Bignall |

**Appendix 10**

## List of acronyms and definitions

| | |
|---|---|
| AGN | - Active Galactic Nuclei |
| ALBUS | - Advanced Long Baseline User Software |
| ALMA | - Atacama Large Millimeter Array |
| ANGLES | - Astrophysics Network for Galaxy LEnsing Studies |
| ASTRON | - Stichting Astronomisch Onderzoek in Nederland |
| ATCA | - Australia Telescope Compact Array |
| ATNF | - Australia Telescope National Facility |
| BBC | - BaseBand Converter |
| BDM | - Background De-bug Mode |
| CAS | - Chinese Academy of Sciences |
| CfA | - Center for Astrophysics (Cambridge, MA, USA) |
| CLASS | - Cosmic Lens All-Sky Survey |
| CNR | - Consiglio Nazionale delle Richerche (Italy) |
| CPU | - Central Processor Unit |
| CRL | - Communications Research Laboratory, Japan |
| DEVOS | - Deep Extragalactic VLBI-Optical Survey |
| DPU | - Data Playback Unit |
| DRAM | - Dynamic Random Access Memory |
| DWDM | - Dense Wavelength Division Multiplexing |
| EC | - European Commission |
| ESA | - European Space Agency |
| e-VLBI | - electronic VLBI |
| EVN | - European VLBI Network |
| EVN CBD | - EVN Consortium Board of Directors |
| EVN PC | - EVN Programme Committee |
| EVN TOG | - EVN Technical Operations Group |
| FITS | - Flexible Image Transport Systems |
| FLSu | - (Spitzer) First Look Survey |
| FP6 | - Framework Programme 6 |
| FTP | - File Transfer Protocol |
| GAVRT | - Goldstone-Apple Valley Radio Telescope (California) |
| GNU | - GNU’s Not Unix |
| HP | - Hewlett-Packard |
| HSSL | - High Speed Serial Link |
| HST NICMOS | - Hubble Space Telescope Near Infrared Camera and Multi-Object Spectrometer |
| IGN | - Instituto Geografico Nacional (Spain) |

| | |
|---|---|
| INAF | - Istituto Nazionale di Astropisica (Italy) |
| JBO | - Jodrell Bank Observatory (UK) |
| JCCS | - JIVE Correlator Control Software |
| JCMT | - James Clerk Maxwell Telescope (Hawaii, USA) |
| JENAM | - Joint European National Astronomy Meeting |
| KNAW | - Koninklijke Nederlandse Akademie van Wetenschappen (Netherlands) |
| LO | - Local Oscillator |
| Mk4 | - a VLBI data format/recording system |
| Mark 5 | - PC based disk recording system developed by Haystack Observatory |
| MERLIN | - Multi-Element Radio Linked Interferometer Network |
| Mbps | - Megabit per second |
| MPIfR | - Max Planck Institut für Radioastronomie (Germany) |
| MRO | - Metsähovi Radio Observatory (Finland) |
| NICT | - National Institute of Information & Communications Technology (Japan) |
| NME | - Network Monitoring Experiment |
| NRAO | - National Radio Astronomy Observatory (USA) |
| NREN | - National Research and Education Network |
| NRT | - Nançay Radio Telescope (France) |
| NWO | - Nederlandse Organisatie voor Wetenschappelijk Onderzoek |
| OSO | - Onsala Space Observatory (Sweden) |
| PATA | - Parallel Advanced Technology Attachment |
| PCB | - Printed Circuit Board |
| PCInt | - Post-Correlator Integrator |
| PI | - Principal Investigator |
| PoC | - Proof of Concept |
| PPARC | - Particle Physics and Astronomy Research Council (UK) |
| RAID | - Redundant Array of Independent Disks |
| SATA | - Serial Advanced Technology Attachment |
| SBC | - Single Board Computer |
| SDSS | - Sloan Digital Sky Survey |
| SHAO | - Shanghai Astronomical Observatory (China) |
| SKA | - Square Kilometer Array |
| SKADS | - SKA Design Study |
| SU | - Station Unit |
| TCP | - Transmission Control Protocol |
| TRM | - Track Recovery Module |
| UAO | - Urumqi Astronomical Observatory (China) |
| UCC | - University College Cork (Ireland) |
| UDP | - User Datagram Protocol |
| VIRAC | - Ventspils International Radio Astronomy Center (Latvia) |

| | |
|---|---|
| VLA | - Very Large Array |
| VLBA | - Very Long Baseline Array |
| VLBI | - Very Long Baseline Interferometry |
| VSN code | - Volume Serial Number |
| WSRT | - Westerbork Synthesis Radio Telescope (Netherlands) |

## Contact information

Joint Institute for VLBI in Europe
P.O. Box 2
7990 AA Dwingeloo
The Netherlands

Street address:
Oude Hoogeveensedijk 4
7991 PD Dwingeloo
The Netherlands

Phone +31 (0)521 596500

Fax +31 (0)521 596539

E-mail: jive@jive.nl

Internet:

www.jive.nl (for JIVE)

www.evlbi.org (for EVN)