Joint Institute for VLBI in Europe

Annual Report 2003

ANNUAL REPORT OF THE JOINT INSTITUTE FOR VLBI IN EUROPE 2003

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Foreword by the Chairman of the JIVE Board

In 2003 the Joint Institute for VLBI in Europe (JIVE) celebrated its tenth anniversary. This year was a pivotal one for the institute, in particular Prof. Richard Schilizzi resigned as director of JIVE at the end of 2002, in order to take up his new position as SKA International Project Director. Richard Schilizzi's contribution to JIVE (and the European VLBI Network in general) has been immense and we wish him well in his new position. At the end of 2002 the JIVE board thus began an intensive international search to find a new director of JIVE. In May 2003, Dr. Michael Garrett was appointed Director JIVE, having served as interim director for the first half of the year. In the second half of the year several changes were made to the organisational structure of JIVE and many of the staff's responsibilities and duties changed. This has had a beneficial effect on the efficiency of the institute, especially in terms of production VLBI correlation and network support.

In this year the new Memorandum of Understanding was finally completed – this secures base funding for JIVE over the next 5 years (2003-2007 inclusive). Associated with this, a new set of Statutes were considered by the board and are expected to enter force in 2004. At the same time, prudent changes to the spending profile of JIVE have ensured that the budget is in-balance during this period. The financial position of JIVE was also boosted by the success of the FP6 RadioNet proposal – an Integrated Infrastructure Initiative of the European Commission involving the major radio astronomy institutes in Europe, coordinated by the University of Manchester's Jodrell Bank Observatory. JIVE has also benefited from other sources of external funding, including an award by the European Space Agency to study space probe tracking with the Very Long Baseline Interferometry (VLBI) technique.

2003 was the year in which PC-based disk recorders began to replace magnetic tape units. This has led to an immediate improvement in the quality of EVN data and permitted the first transfer of VLBI data over high-speed networks – eVLBI. The EVN Board of Directors decided that each institute should buy 2 Mark 5 units – one for the telescope and one for the EVN correlator at JIVE. By the end of the year the correlator was operating transparently with six Mark 5 units in-house. The continued success of automatically pipelining EVN and Global VLBI data has led to the creation of an impressive EVN Data Archive. The archive is expected to come on-line publicly in the beginning of 2004. JIVE's support of the European VLBI Network continued a pace – in particular the introduction of ftp-VLBI tests in standard Network Monitoring Experiments is a very welcome development - it is a great boost to telescope staff to receive rapid feedback regarding their telescope's performance shortly after each VLBI observing session begins.

In concluding this foreward, I want to add that it is a pleasure to see JIVE continue to develop and expand its services to the European VLBI community. In addition, the scientific staff at JIVE are also making an outstanding scientific contribution to various areas of astronomical research quite generally. The board of directors recently decided that JIVE should co-sponsor Phd students studying in the Netherlands and JIVE has also been successful in finding external support for PhD students and Post-doctoral research positions.

I congratulate all JIVE staff on their efforts, and look forward to exciting new astronomical results and further developments in technical areas such as eVLBI. The connection of many of the major European VLBI telescopes by optical fibre is taking place much more rapidly than we might have expected, we are on the brink of transforming the way in which we think about all aspects of VLBI, including scheduling, observing, operational flexibility, and the correlation and data analysis (pipelining) process. Hopefully in the coming year we will see the realization of the first eVLBI scientific results. We shall see!

Prof. Phil Diamond

JIVE Board Chairman

1. Institute Report from the Director

Changes to the structure of JIVE

During 2003 substantial changes were made to the organisational structure of JIVE – a new director was appointed (Dr. Mike Garrett) and one of his first tasks was to review the overall organization of JIVE and the individual responsibilities and activities of JIVE staff. The new structure is best described with reference to the JIVE organogramme (see figure 1). Support scientists at JIVE are now collected together in one group, reporting to Dr. Bob Campbell (head of Science Support and Operations). In addition, Campbell's duties now include the supervision of the Correlator Operators, aided by the chief operator, Nico Schonewille. Also in Bob's group, Cormac Reynolds was promoted to Senior Support Scientist. Huib Jan van Langevelde now leads the Software Development Group - maintaining the EVN correlator on-line software but also being responsible for software development associated with post-correlation data. These are expected to be major areas of development at JIVE over the next few years, especially as eVLBI (real-time VLBI using optical fibres) becomes operational. Steve Parsley continues in his role as head of the Technical Operations and R&D group. Leonid Gurvits joined the Management Team at JIVE broadening the depth of the team especially with respect to relations with the EC and Space Agencies.

The various responsibilities of JIVE staff are presented in Appendix 3.

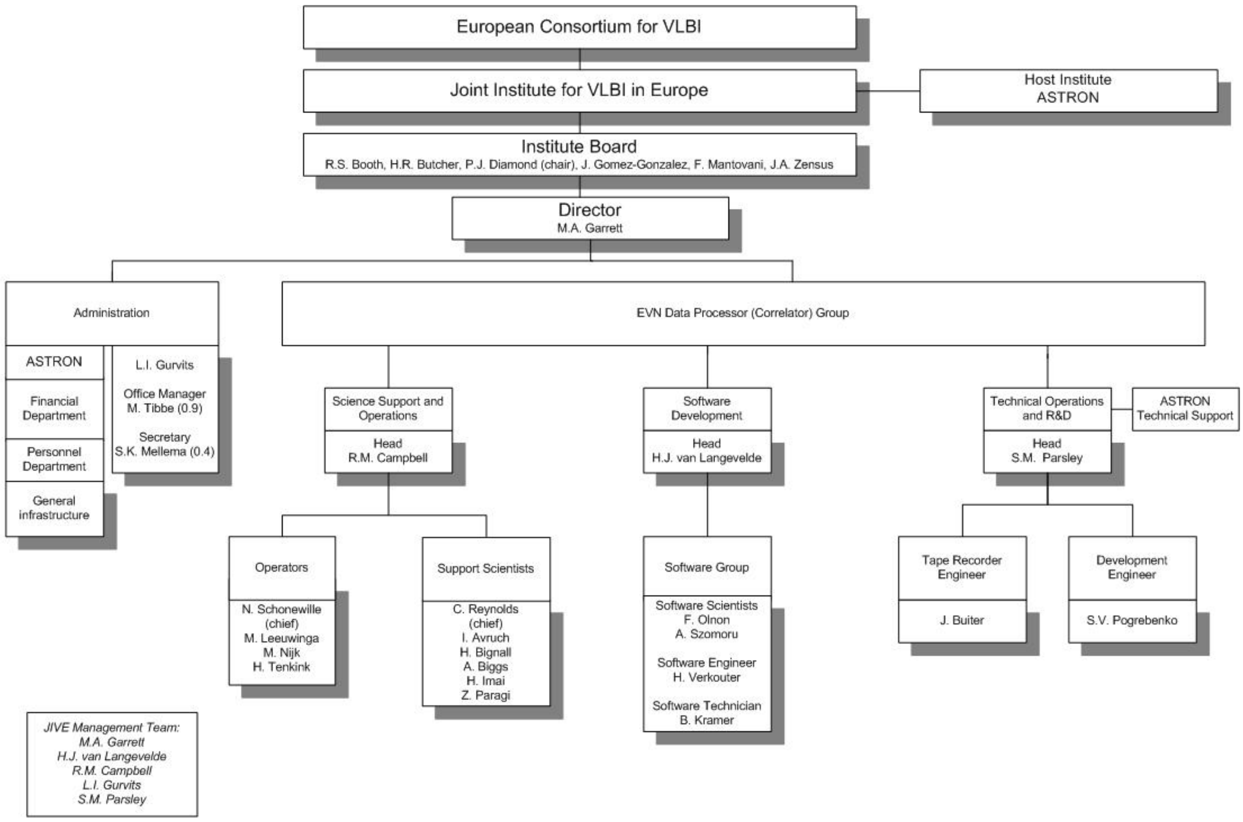

Figure 1: JIVE organogramme (2003).

European Commission Activities - RadioNet FP6, FP5 & ANGLES

JIVE staff played a leading role in the preparation of a large EC Integrating Activity proposal – RadioNet FP6. In July, we learned that the RadioNet FP6 proposal (coordinated by Prof. Phil Diamond, JBO) had been favourably evaluated by the European Commission. The proposal was awarded total funding support of 12.4 Million Euro spread over the next 5 years. JIVE is deeply involved in several of the projects to be funded, including the EVN Transnational Access programme, and the ALBUS (Advanced Long Baseline User Software) project, not to mention our participation in several key Networking Acitivities. Leonid Gurvits was appointed RadioNet FP6 Project Scientist and Marjan Tibbe forms part of the overall RadioNet administration team. The ALBUS project is led by Huib Jan van Langevelde.

At the same time, JIVE was also involved as a participating node of a Marie-Curie Research Training Network proposal - ANGLES. This project, led by Dr. I.W.A. Browne (JBO), builds on the very successful CERES network. Like its predecessor, the research theme is Gravitational Lensing and Dark Matter. This proposal was also evaluated positively and the contract is expected to begin in the first half of 2004. This support will permit JIVE to appoint a PhD student and Post-doctoral Research Assistant. The JIVE board also decided that JIVE should support an additional PhD position from the partner contributions. JIVE is expected to co-sponsor at least one PhD student at a Dutch university in any given year. The aim is to increase this programme if more external funding can be obtained.

Other EC Contract business included the final financial wrap-up procedure for the FP4 TMR-LSF RTD (after acceptance of the final report by the EC), the submission of the third RadioNet FP5 annual report and the 3rd and final report for the EVN Transnational Access contract (1999-2003). This latter contract was audited by external accountants, on behalf of the European Commission.

JIVE continued to be an active participant in preparations of the FP6 SKA Design Study proposal and in particular the *EMBRACE (Electronic Multi-Beam Radio Astronomy Concept)* project. JIVE took the lead in building the case for a SKA Array and Data Simulations work package.

New MoU Signed

In July, the new Memorandum of Understanding (MoU), was signed by all major contributors to JIVE. The last signatory was the Spanish Ministry, supported via our colleagues at the IGN-OAN in Madrid. The signatories to the new MoU include NWO, PPARC, OSO, CNR, IGN and MPIfR. The MoU secures basic funding levels for JIVE over the next 5 years.

Infrastructure

During the first 6 months of this year there was considerable disruption in the basement, where the EVN Correlator is located. Building work began (see figure 2), that divided the room in order to accommodate computer server equipment used by both ASTRON and JIVE. Careful planning by JIVE and ASTRON staff ensured that disruption of correlator operations was kept to a bare minimum. The movement of the computer servers downstairs has allowed the re-location of the JIVE Secretariat and the Directors offices to the ground floor. Bringing all the JIVE staff together in the same area is a very welcome result of these developments. Another advantage is that an additional 3-person room is also now allocated to JIVE.

Figure 2: Building work begins in the basement (left). Due to careful planning by JIVE staff, the work was completed (right) with relatively minor disruption to correlator operations.

Data Processor (Correlator) and Network Support

During this year substantial progress was made in improving the efficiency of the EVN correlator, in particular the notorious byte-slip problem was finally solved, significantly boosting the efficiency of production correlation. By May the correlator queue was empty, partially due to these efficiency gains together with a short February EVN session (due to telescope engineering work). This was very fortunate as it coincided with the building work in the correlator room and it also permitted a significant programme of testing to take place. Highlights included the first EVN image of an astronomical radio source using the new recorder/playback system, Mark 5. The new Mark 5 system is a PC disk-based recorder capable of reliably recording (and playing back) VLBI data at rates of up to 1 Gbit per second (see section 2). These new systems are expected to replace magnetic tape based VLBI data recorders over the next few years. It was agreed at the EVN CBD executive meeting, that EVN observatories buying Mark 5 systems for their telescopes, should also purchase an addition unit for JIVE. By the end of the year 9 Mark 5 units were in-house at JIVE.

The new Mark 5 systems were also used to transfer small amounts of VLBI data from the EVN telescopes to JIVE via standard internet connections, so-called ftp-VLBI. By the end of the year ftp-VLBI was well established with the data being correlated by a software correlator developed by the Japanese CRL group. The use of software correlation for these very small data sets avoids interrupting production correlation. ftp-VLBI can provide a useful and rapid “same-day” reliability check for the network and JIVE’s role has been pivotal in making this a new and reliable network tool.

The EVN Data archive became operational at JIVE during the year. The archive presents the astronomer with raw FITS files, standard plots and pipeline analysis results (e.g. calibration tables, plots and images). This represents an excellent step forward, on the path towards a VO compatible user interface. The EVN pipeline was run on all EVN and Global VLBI observing projects correlated at JIVE in 2003.

Scientific Meetings

JIVE staff were active in representing JIVE at the various international conferences that were held in 2003. We were also involved in organizing several meetings, including "Radio Astronomy at 70: from Karl Jansky to microJansky" – a symposium organised by Leonid Gurvits within the Joint European National Astronomy Meeting (JENAM) held in Budapest, Hungary. In May JIVE organised and hosted the second International eVLBI Meeting. Over 70 participants attended the two-day workshop, chaired by Steve Parsley. The meeting was a great success and included a mixed audience from the VLBI and Research Network communities. In November the regular Dwingeloo – Bonn meeting took place. Twenty three visitors arrived from the MPIfR Bonn, and as always on these occasions, both the scientific and social aspects of this meeting were appreciated by all participants. Perhaps the highlight of the day, was the presentation by the director of the MPIfR, Anton Zensus, and the chairman of the EVN TOG, Walter Alef, of a Mark 5 VLBI recorder unit for the EVN correlator (see figure 4). Huib Jan van Langevelde participated in the organizing committee of the workshop "Future direction in AGB research", honoring the retirement of Prof Harm Habing in Leiden.

eVLBI developments

Progress with the eVLBI Proof-of-Concept project received a huge boost, when we were able to demonstrate fringes between Jodrell Bank (Cambridge 32-m) and Westerbork just 15 minutes after the data arrived via optical fibres at JIVE. Recently we confirmed that it is possible to use the pan-European Research Network, GÉANT, to transfer valid VLBI data from the EVN telescopes to the correlator Station Units at JIVE by-passing the (Mark5) disk systems at either end. The next hurdle, is to persuade the correlator downstairs that it can operate in a real-time environment – by the end of the year JIVE staff were beginning to investigate how to synchronise the incoming telescope data streams. On the work-bench our best Mark 5-Mark 5 data exchange rates improved to 530 Mbit/sec. In the midst of all this activity the first tests of the new 1 Gbps fibre connections to the Onsala Space Observatory were made. This brings the number of EVN telescopes "on-line" to three (four if Jodrell Bank and the Cambridge 32-m can share the soon to be upgraded line to JBO). Future goals include the demonstration of real-time fringes and the first real-time eVLBI astronomical image.

JIVE's use of high-speed research networks such as GEANT is now well recognized and was highlighted in various promotional videos and publications produced by the EC and DANTE (the operators of GEANT).

International collaboration

For many years now, the KNAW-CAS grant for Dutch-Chinese cooperation activities in radio astronomy has been an important catalyst in underpinning the excellent collaboration that has emerged between staff in Dwingeloo and the major radio observatories in China, in particular, Shanghai, Urumqi and Beijing. In December 2003, JIVE and ASTRON staff prepared and submitted a new proposal for joint activities planned in 2004-2005. The current KNAW-CAS award continued to support collaborative activities in radio astronomy between the two countries, including the joint development of a new 6-cm receiver for the Shanghai radio telescope.

Assistance to the VLBI group at the Ventspils International Radio Astronomy Center (VIRAC, Latvia) has also been part of our international activities with Leonid Gurvits serving as a member of the VIRAC advisory board.

A contract was agreed between ESA and ASTRON/JIVE on SKA developments, and possible VLBI tracking support for the ESA Huygens mission. On JIVE's side Leonid Gurvits is the project manager and Sergei Pogrebenko is the project scientist. The contract kicked-off in January 2003 and was completed in June 2003. A second contract requiring a more detailed analysis was also conducted by JIVE and submitted to ESA at the end of the year. ESA is considering whether they would like to support VLBI observations of the Huygens probe during its descent through the atmosphere of Titan in January 2005.

Figure 3: VLBI techniques can, in principle, measure the position of the Huygens probe as it descends through the atmosphere of Titan in January 2005.

JIVE continued to be involved in preparations for the submission of the SKA Design study proposal. JIVE will coordinate the Scientific and Data Simulation work-package. The package involves several different institutes in Europe and Australia.

Figure 4: Anton Zensus and Walter Alef present JIVE with a Mark 5 unit for the EVN correlator.

ASTRON & JIVE Open Day

The annual Open Day was held in October this year. Several thousand visitors were welcomed by ASTRON & JIVE, and many of them found themselves in the basement (see figure 5), getting to grips with VLBI theory from Bob Campbell and many other volunteers. A particular highlight was the “Night Sky” presentation arranged by Hans Tenkink.

Figure 5: During the Open day in 2003, visitors to JIVE were introduced to the Data Processor.

Astronomical Research Highlights & Publications

Scientific highlights included the first publication in *Nature* of data correlated at JIVE (Kloeckner et al. 2003, Kapteyn Institute, Groningen). The paper described the results of an EVN Spectral-line and continuum observation of Mrk231 (see front cover of this report for the images). The detected hydroxyl and radio-continuum emissions reveal an edge-on dusty torus, blocking most of the other AGN emission from our view. An additional highlight was the detection and interpretation of rapid variability in PKS 1257-326 (Bignall et al 2003). A clear time delay of several minutes between the variability pattern arrival times at independent telescope sites has been observed at three different (seasonal) times of the year. During the period of this report 42 papers were published in scientific journals or conference proceedings, and a further 12 were submitted for publication. 64 oral and 11 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. Many VIPS visited the correlator this year, most notably the Dutch Minister of Education and Science. The institute was happy to host 40 visitors during the year, many of whom made extensive use of the scientific support facilities (see Appendix 4 for more details).

Personnel changes

On 10 January Hayley Bignall joined JIVE as a support scientist in the correlator group. During the months of May, June and July, van Langevelde took sabbatical leave, sharing his time between NRAO Socorro and Leiden and addressing a wide range of scientific topics. Marjan Tibbe's position as JIVE Office Manager was made permanent in March 2003. At the beginning of the year, Bauke Kramer moved from his previous position as Correlator Operator to Software Technician. Hiroshi Imai (JIVE Support Scientist) left JIVEs employ in September. Andreas Brunthaler was appointed as his replacement in December and is expected to arrive in Dwingeloo in early 2004.

2. Data Processor Operations

2.1 Introduction

The February European VLBI Network (EVN) session saw many experiments postponed or cancelled because of mechanical problems at important stations. This allowed us to clear the backlog of experiments awaiting correlation by early May, which provided some time for more dedicated testing prior to the arrival of tapes and disks from the May/June session, and minimized operational impact from the construction activities (also see chapter 1) in the basement during May.

The May/June session was quite large, owing to the many rescheduled experiments from previous cancelled sessions. There were a total of 25 user experiments, requiring an estimated 542 hours to correlate (taking into account multiple passes, job set-up time, etc., but not recorrelations or other problems that might arise). There were some "firsts" for us, in terms of user experiments:

- first 512Mb/s experiment -- it transpired that there was a bug in DRUDG that caused the two head-stacks to overwrite each other for Mark 4 stations; this bug was repaired within days.

- first >16-station experiment (which required 3 correlator passes).

- first experiment that used a sub-netted schedule - this capability had never been advertised, and indeed the job-control VEX file required a significant amount of manual massaging.

- first (2) outside EVN session target-of-opportunity experiments.

The October/November session was of a more traditional size. Prior to the session, we were more pro-active in helping PIs with their scheduling, in an effort to reduce the number of scheduling problems encountered in the May/June session, but also because the Lovell telescope participating for the first time in a C-band session caused some confusion about the frequency set-ups to use. There were a total of 10 user experiments, requiring an estimated 258 hours to correlate. A highlight of this session included Effelsberg recording exclusively on disk (except when scheduled as a VLBA), which was our first operational use of Mark 5 disks in user experiments. Recordings on disk (see chapter 4, figure 13) provide the advantages of more reliable playback and shorter job start-up times, but in mixed disk-tape operations we do not gain from the latter, since the job preparation is limited by the slower (and less reliable) tapes. This session also saw the first fully successfully observed 512 Mb/s user experiment.

A reorganization this summer saw the support scientists from the EVN Support Group join the support scientists from the correlator group in the new Science Operations & Support group (see chapter 1). This has resulted in a merger of the responsibilities of the two old groups, providing a more vertical structure as seen by the PI (the same people helping them with their project from scheduling through correlation and pipelining).

2.2 Hardware

2.2.1 Correlator

Power supplies in all crates were replaced. Apart from this and a few other minor repairs, the correlator hardware remained stable and reliable throughout the year.

2.2.2 Station Units

The so-called “midnight crossing” problem was resolved. The validity for a VLBA-format station would go to zero when a scan crossed midnight, and remained there until the SU was reconfigured (i.e., until the next sub-job or a gap between scans within a single sub-job). The fault was traced to the Station Unit TRM software and a revised version was installed.

It seems that instances of the poor connection problems addressed by the TRM re-work done by Metrum persist, though the “bad-boot” symptom has largely disappeared. As a further six re-worked boards returned from Metrum the company announced that they could no longer sustain an engineering function at Wookey Hole. The supply of DPU spares became Metrum’s only remaining interest in VLBI. A visit to Metrum was made to inspect the remaining stock of unwanted SU spares and negotiate a final handover of these plus some engineering equipment and documentation.

It was found that a large fraction of what appear to be bad tracks can actually be repaired by manually flexing the 'responsible' TRM and pushing down on its various chips to obtain a better seating. This procedure has allowed operators to take more immediate action while the production correlation is ongoing, reducing the amount of re-do's required subsequently. Further improvement in the reliability of TRMs was achieved by the use of a conductive jell on the plug-in components.

Use of Mark 5 provoked a new problem. During the first production correlation of Mark5 recordings, we noticed events in specific sub-band/polarization channels where the weight would decrease by ~15% very briefly. At the same time, the amplitude of the autocorrelation on the central lag would increase by an amount consistent with one of the magnitude bits being randomized, and the amplitude on baselines containing this station/subband/polarization would decrease. The latter two effects lasted noticeably longer than the weight decrease. This was identified as a “feature” of the TRM Xilinx modification that was introduced to combat byte slips, and a further Xilinx revision will probably be required. Meanwhile a glish programme was written to find/flag these events in the Measurement Set and significant loss of production data has been avoided.

2.2.3 Play Back Units

The single biggest specific problem has been the inability to get 16 DPUs working at the same time. The biggest culprit is the capstan motors. In total, seven of these had to be replaced. A rogue set of ~2-3 motors are continually out for repair. This often absorbs the spares holding (three) and any further failure reduces the number of stations that can be processed in one pass. Correlation of 14-16 station globals then requires multiple passes and many additional correlation hours. Miscellaneous other faults included two failed reel motors and two worn out headstacks. It is anticipated that the deployment of Mark5 will ease these problems by reducing the number of DPUs required and releasing spares as units are removed from service and cannibalised.

2.2.4 Hardware Failures & down-time

DPU	23 failures/38h 30m downtime*
SU	6 failures/18h 40m downtime**
Correlator	7 failures /12h 30m downtime***
Totals	36failures/69h 40m downtime
Number of infrastructure breakdowns	4 failures /54h 0min downtime
Mean operational time between re-starts of on-line control software	2.1 hours
Projected life-time of heads	2100 hours

* DPU excludes 2wk DPU 9 awaiting capstan motor repair
** Includes 16h TRM PROM upgrade, all units
*** Includes 8h down time, DDD platform change

2.2.5 Number of damaged thin tapes

Damaged during correlation	6
Received damaged	23
Not certain when damaged	6

2.3 Production

The table below summarizes projects observed, correlated, and distributed during 2003. The table lists the number of experiments as well as the network hours and correlator hours for each category. Here, correlator hours are the network hours multiplied by any multiple correlation required (e.g., continuum/line, more than 16 stations, 2 head stacks, different phase centers, etc.)

	User experiments			Test & Network Monitoring		
	N	Ntwk hr	Corr hr	N	Ntwk hr	Corr hr
Observed	37	452	704	27	50	61
Correlated	43	554	777	25	46	55
Distributed	40	530	666	23	33	43

Not reflected in the table are 5 projects abandoned with the agreement of the PIs: 4 user experiments because of EVN station problems in the November 2002 session and 1 test for the original software correlator, rendered unnecessary with the use of the CRL software correlator for rapid turn-around fringe checks.

The table below provides a more detailed listing of all projects having any activity during the year. Here, activity includes correlation, distribution, or release.

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 categories of experiment status (correlation, distribution, release), expressed as the sum of correlator hours over all experiments received. All plots cover the past three years, with 2003 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 at the time the backlog was cleared and construction in the basement was proceeding. Further, the burst of network tests in and immediately following sessions is 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 (by the autumn we were correlating the 16-station experiments from the May session).

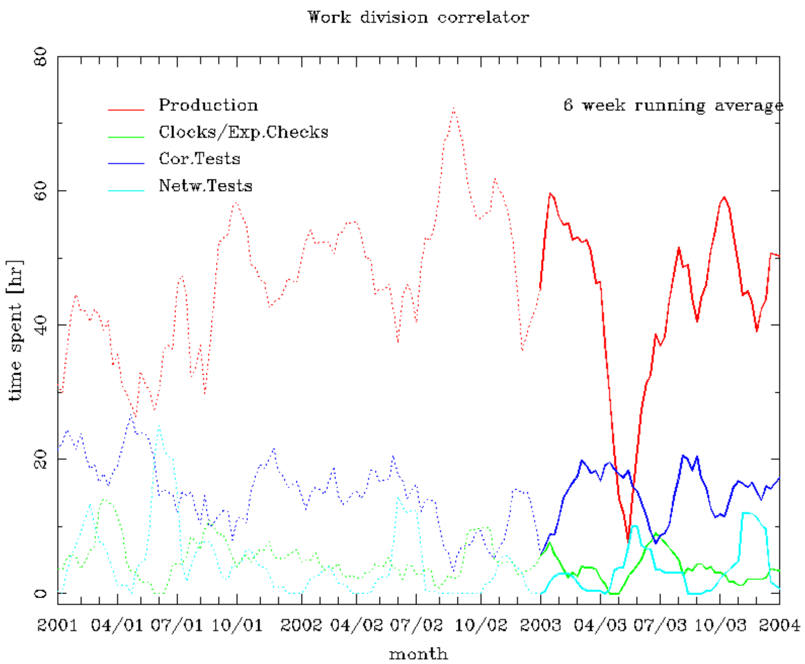

Figure 6: Work division correlator.

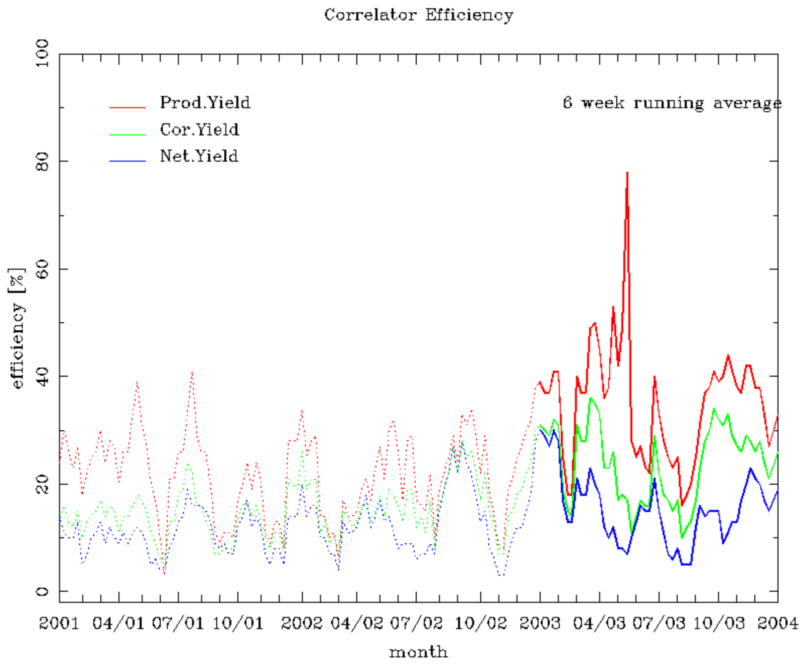

Figure 7: Correlator efficiency

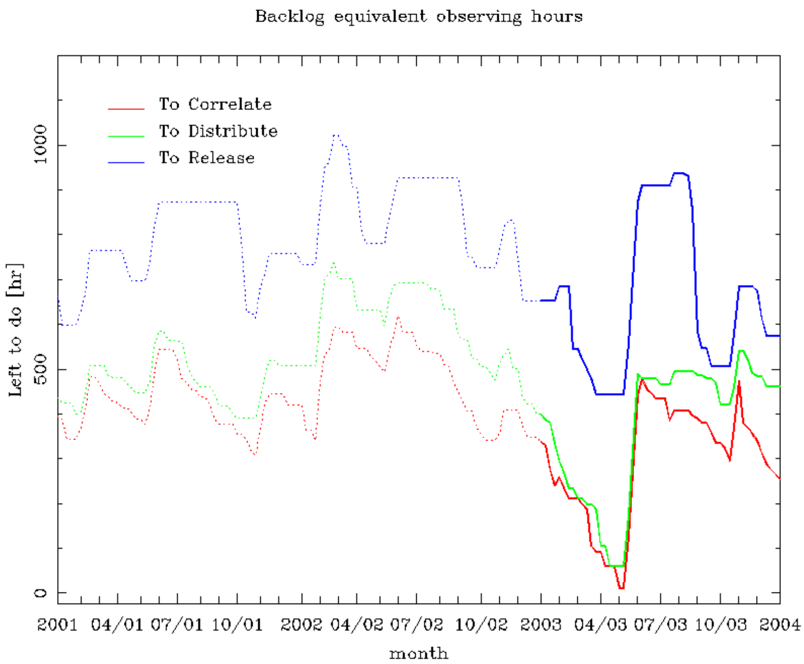

Figure 8: Backlog equivalent observing hours. The backlog of the correlator can be expressed by plotting every week the experiment hours that still need to be correlated, distributed and released respectively.

2.4 Tape and Disk media logistics

The ability to track disks as well as tapes has been added to the tape database - providing an overview per tape/disk of which experiment(s) it contains, its location in the pater noster, and whether it is releasable (i.e., all experiments on it are individually releasable). Also, we have found through experience that it is very important for stations to record properly the correct

VSN code onto a disk pack prior to using it for the first time, lest the necessary cross-communication between the field-system logs and the tape database break down.

We sent 51 tapes to Socorro to help balance the net trans-Atlantic tape flux for global experiments over the last few sessions.

Figure 9: pater noster with disks packs in place.

2.5 Infrastructure

In May the ASTRON computer room was moved to the basement. With the approval of the original architect a glass dividing wall was built to preserve an open-plan, "high-tech" character at the heart of the building. The Data Processor area was carefully sealed-off during construction to protect the delicate hardware from dust. No significant impact on correlator operations was suffered, since the production queue had already been exhausted.

There were a few alarm and power down events this year, mostly false or at least trivial in nature. A more serious incident occurred on the night of Saturday 1st March. One of the Mark 5A systems that was under test at JIVE, burned out completely. Smoke filled the correlator room and local fire fighters from Dwingeloo were called in automatically via the fire protection system. Fortunately this protection system also switched off power to the Mark5A, so that further damage to the rest of the equipment or the building did not occur. More detail of the incident and aftermath are discussed in section 4.

All network cables in the area of the Data Playback Units (DPU) TSPU and DDU were replaced by screened cables, in order to eliminate EMI. Additional fibre-optic lines were also installed between the DWDM equipment in the computer room and the DPU line. Multiple Mark 5 units can now be connected via Gigabit Ethernet lines to Amsterdam and Westerbork.

In order to store as many Mark 5 disk packs as possible, a test was done with a newly designed support structure that can be placed on the existing paternoster shelves. Using this structure approximately the same number of disk packs as thin tapes can be stored.

3. Development of the Data Processor capabilities

3.1 Software

3.1.1 High level control software

The software that runs the correlator is maintained under rather strict version control. Small bug fixes are often introduced as patches to the system, while major new features are introduced as new releases for which a detailed data comparison is performed before being approved for production correlation. In 2003 two new system releases were made. In June a version was issued which allowed mixed tape and disk operations for user experiments. Further enhancements to this were in the November release, along with the support for higher data rates through the Single Board Computers.

The work on the Mark 5 systems focused on optimizing the servo algorithm for disks. There was also effort to streamline the initializing of disk units, as well as switching between disks and tapes.

The core responsibility of the software group is maintenance of the EVN Correlator Control Software. Because both the operating system of the control computer, as well as the HP native compiler is becoming obsolete, some of the effort focuses on continuously upgrading the code to more modern standards. In 2003, this effort focused on a new make system and the initial work on the GNU 3.2 compiler, which had become the standard for aips++. The compiler enforces stricter coding standards in many places. First fringes were obtained with the new system, but it did not reach a level of maturity required for operations. It is hoped that this effort will also enable the use of ‘purify’ to chase some of the more subtle run-time errors that sometimes surface during operations. Additionally, an effort started to manage the couple of hundred scripts (Shell, and Perl) that run at the periphery of the JCCS.

Among the other features that were addressed this year is the processing of two headstack recordings. It has been JIVE policy to process these in two passes in order to minimize headwear on the playback units. This does not hold, however, for disks. Modifications were needed to allow both cases to be dealt with properly in the control software.

In 2003 the on-line normalization of the data was switched off. It was realized that the correlator algorithm was rather sensitive to biases in the sampler levels at the stations. A correction scheme for this was developed, which runs on the uncorrected output data and estimates the offset levels from the autocorrelations (below).

As is normally the case, a long list of smaller bugs were encountered and fixed over 2003. One problem failed to associate scans and tapes and prevented correlation of particular scans. We allowed the correlation of so-called system tracks. Shorter scans were allowed by relaxing some of the timing constraints. A warning message must prevent correlation in the future of 16MHz bands without the special CRM servo mode. A bug was fixed which mixed up the polarization labels in some special cases and initial work was done on dealing with LO-offsets at one of the telescopes. Several correlator configurations that were not used before required debugging. One bug in 2048 lag modes was introduced in a new release and fixed subsequently.

Besides these successful fixes, a lot of effort went into a few problems for which no cure has been found yet. The most persistent of these is the “no data” problem, when the Correlator Data Interface freezes, typically a few times per day. It is believed that the underlying problem is a timing conflict in writing and reading shared memory. Improvements were made, but a complete solution was not reached.

Another long-standing project is the implementation of speed-up correlation. It was made to work in a few specific and hard-coded cases, but the full operational solution seems rather difficult to reach.

3.1.2 Post correlation software

We usually run a rather old and stable aips++ version for our data-handling environment. Still we have to follow the aips++ infrastructural changes, as the libraries are important for maintaining the data path. In 2003 we adopted the GNU.3 C++ compiler for the JIVE specific aips++ code and we started to overhaul all other software.

The first operational processing with more than 16 telescopes, showed that some more enhancements were needed to deal with such experiments. To do the sorting efficiently some changes were needed of the Measurement Set structure. Therefore other routines had to be adopted as well.

A major effort was made to implement the JIVE specific "van Vleck" corrections in a Glish script. This algorithm corrects the data for non-optimal and variable sampler levels at the telescopes. These settings bias the distribution of particularly the magnitude bit in 2-bit recordings. Previously a static correction was made in the correlator, assuming a perfect distribution. The new scheme estimates a telescope based offset based on auto-correlation values. A correction for the auto-correlation, as well as the cross products can then be estimated. The new estimates will improve the a-priori calibration significantly and in cases where both stations have a noticeable offset, even the closure amplitudes can be improved.

The correction algorithm was implemented in Glish and requires that the on-line correction be switched off, which has become the standard operation. Unfortunately the computation is rather expensive for large datasets. A complicated scheme was necessary to circumvent Glish memory problems, which prevented long unattended processing. We have tried to advocate a solution to the Glish problems within the aips++ project.

Another effort in this area was the implementation of a baseline-based fringe fitting routine. It can be used to find clock offsets and rates in preparation for production correlation. It can produce fringe plots, useful for diagnosis and direct inputs for the clock tables in the correlation files.

In 2003 the international aips++ consortium was abandoned. Aips++ code continues to play a major role in the data handling at JIVE, including the quality control, and FITS formatting. It is important that some basic support for aips++ remains and that evolution of the code and data formats does not violate local requirements. Some contacts were made to ensure the short-term stability of the system.

3.1.3 Logistic software

Improvements were made to the scripts that prepare the experiment for correlation, in particular changes were required to deal with disk recordings.

The major effort in this area dealt with making all our administration tools ready for disk recordings, in particular the feature that a disk pack may contain data from multiple experiments. The whole web-based tape administration was rewritten for this purpose, making sure that disk packs will only get the free status when all experiments associated with them are completed. In the process the existing file system was replaced by a 'mysql' database. Access to the database is through web-based forms. Also the experiment administration was upgraded to reflect these changes. The pipeline status is now also managed from the same interface. Plots that show the history of the amount of correlation in stock proved a useful addition to the tools to monitor the production correlation.

The EVN data archive at JIVE has taken shape in 2003. The archive resides on a special RAID server and the data can be uploaded in the correct structure and naming conventions by a set of scripts, minimizing the risks of mistakes by the support staff. By the end of the year, the archive contained standard plots, pipeline products and FITS files. The archive can be accessed on the web and pages are actively created from the archive structure by 'php' scripts. Special administrative tools exist to set the access rights to specific products in order to restrict the data rights to the original PI.

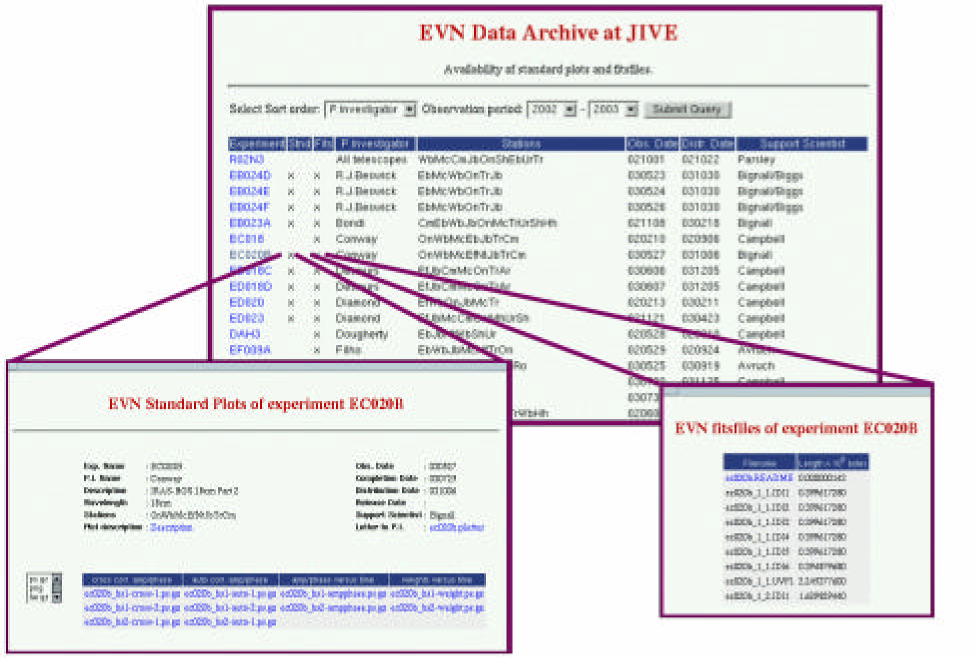

Figure 10: Interface to the EVN Data Archive at JIVE.

3.1.4 Data product

The improvement in data quality associated with the estimation of the "van Vleck" correction was already described above. There were a number of other concerns on the quality of the data product. It came to our attention that there are some short-comings in the treatment of the delay acceleration in the correlator model. Since we typically operate at low frequencies and, most importantly, with short correlator frames, these problems do not affect our product significantly. Indeed tests showed no detectable effect with changing frame-length in our most demanding experiment.

The first user experiment was processed that employed a 512 Mb/s data rate. In order to line up the visibilities between sub-bands in time, it was necessary to process this with 1second dump times. The resulted dataset was averaged-up before distribution to the PI.

By the end of 2003 we were able to process the full correlator capacity at 0.25 second dump time, enabling large field of view products.

In collaboration with the Westerbork Observatory staff, an initiative was started to participate in the Dutch Grid effort. JIVE's need for High Performance Computing were outlined in a document. By the end of the year an eight node, dual Opteron cluster was ordered.

3.2 Post Correlator Integrator (PCInt)

The Post-Correlator Integrator (PCInt) system permits the full correlator capacity to be harnassed from the correlator with very short integrations times (> 1/64 seconds). This will permit very wide-field of view VLBI observations to be made, enabling astronomers to detect (simultaneously) many radio sources across the primary beam of individual VLB telescopes.

At the beginning of 2003 the goal was to create a 'base' release that could be used to start testing. The PCInt system in this phase was able to store generated binary data on disk at a remote location, all fully under software control.

Figure 11: The correlator boards are connected to the single board computers via DSP-powered high speed serial links.

The ordered Single Board Computers (SBC) arrived in two batches, the first batch around mid January 2003 and the second one around half February 2003. The SBCs were configured, configuration files were updated and the VME-bus access was verified. Ethernet switches with multiple 100 Mbit ports and a fiber-optic uplink port were installed in the correlator racks. After that, the SBCs were mounted in the correlator racks and development of PCInt phase 0 could proceed.

Much time went into a critical piece of work for the PCInt: the development of a Linux device driver for the High-Speed Serial Link modules. No driver for this board existed. This driver had to enable the fast readout of the correlator boards, effectively decreasing integration times.

A sample gigabit Ethernet card for the SBCs was tested successfully. After the successful transfer of data via the serial links, production quantities of the GBit ethernet cards and serial links were ordered. Halfway through December these boards arrived.

Once it was demonstrated that data could be transported from the correlator boards to the SBC, discussions with vendors regarding the data-storage were begun. The accepted solution comprises a mini-cluster with 10 nodes (dual Opteron CPUs), of which 6 have internal storage (24 TB gross capacity in total). The nodes are interconnected by InfiniBand, a specific cluster-interconnect, (low latency, high bandwidth: <6ms at 10Gbit/s bi-directional). The cluster is expected to be delivered in the first quarter of 2004.

A subcontractor was hired to modify the DSP code such that it would run correctly at 64 BOCFs/second. A release-candidate was delivered before Christmas. This release-candidate of the code ran within the timing constraints (as timed on the test-setup). However, in-vivo tests with real data need to be conducted to ensure that the output is not affected (3% lower amplitudes and noisier phases), as was the case with earlier, optimized, code.

During 2003 the PCInt project moved from largely software preparation to live development on representative hardware. At the end of the year this phase was complete and orders could be placed for the full system. The remaining phases of construction and commissioning will follow in the first half of 2004.

4. Network related development

4.1 Next Generation Data Transport

4.1.1 Disk systems

At the end of 2002 the EVN board decided to adopt Mark 5 as the preferred hard disk system for the network. All engineering work on PCEVN at JIVE ceased at this point and the several high grade PCs that had been used for the project were re-cycled for desk-top use. JIVE continued to support eVLBI experiments using the Metsahovi recording system. This was accomplished using Mark 5 units as the interface to the data processor with suitable translation of the data format.

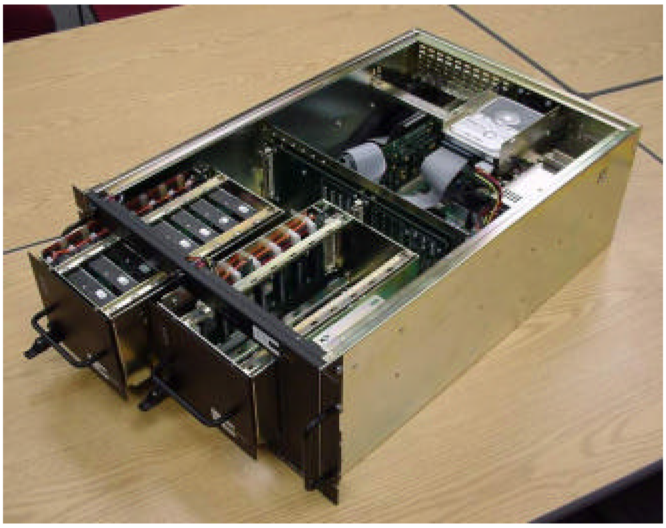

Figure 12: Mark5A unit and disk packs.

The Mark 5P units purchased in 2002 were finally upgraded to Mark5A in February. The upgrade was carried out by JIVE personnel, using a kit supplied by Haystack. Lacking detailed instructions for the upgrade, Buiter and Leeuwinga took the first unit to Bonn where a fully built Mark5A unit could be viewed as reference. The second was upgraded at JIVE where it achieved infamy by catching fire. Conduant examined the unit and discovered that the fire originated at a short between voltage planes in the backplane, close to a mounting screw. After various tests and experiments, Conduant concluded that the short resulted from "severe over-tightening" of the screw despite the fact that they were unable to reproduce the effect even after tightening the screw to the point at which the head sheared off. Their report revealed also that there is virtually no clearance in the copper around the mounting holes in this backplane. An alternative explanation is that the mounting post was not concentric with the PCB hole and the screw chewed at the inside of the hole as it was inserted. Visual inspection of other Mark 5 units at JIVE confirmed that some of the screws are indeed off-center. Conduant subsequently re-designed the PCB to allow adequate clearance around the mounting holes and distributed replacements free of charge.

Over the year the number of Mark 5 units at JIVE increased to nine comprising four units purchased by JIVE and five contributed by: Westerbork, Jodrell Bank, Medicina, Onsala and Effelsberg. Six of these were connected to the upper headstack inputs of Station Units 0, 1, 3, 4, 5 and 6 requiring re-cabling when both headstack connections were used in 1Gb/s playback.

The software project to incorporate disk systems fully into the correlator software was completed. This implementation takes full advantage of the operational characteristics of disks. The correlation control programs became able to handle tape-only, disk-only, or mixed disk-tape experiments, but there remained somewhat more manual VEX-file preparation necessary for disks; fuller automation awaited further development. Changes were made to the logistics procedures to allow multiple experiments per disk and storage of the disks in the paternoster. Overall, JIVE became ready to use Mark 5 units for production correlation.

The infrastructure consequences of switching to disk operation began to receive some attention. A scheme was devised to divide paternoster shelves in two horizontally and the issue of disk-pack transport packaging received some consideration. Ad-hoc arrangements for accommodating a few Mark 5 units at the correlator were adequate for development but became cumbersome as more units arrived. Permanent schemes were considered, the preferred option being to put two Mark5s and their respective Station Units in a common 19" cabinet.

4.1.2 Fibre optic developments / eVLBI

In 2003 eVLBI began to emerge as a realistic prospect for future VLBI observations – even in the short-term. The creation of GÉANT – the pan-European Research Network – means that it is now possible to connect the various National Research Networks (NRENs) in Europe together with high speed Gbps connections. Since 2002 the EVN correlator at JIVE has been connected to GÉANT by several Gbps optical fibre connections. By the end of 2003 several of the EVN telescopes were also on-line including Westerbork, Onsala and Jodrell Bank, with Torun expected to have a Gbps connection in the first half of 2004. eVLBI promises to transform the reliability of networks like the EVN (permitting data quality and performace to be checked in real-time) and promises to deliver much higher data rates as network hardware continues to develop via the commercial PC and Communication industries. In addition, astronomers will receive their data as soon as the observations are complete, rather than the current situation where receipt of data occurs long (typically several months) after the observations have been made.

In January 2003 a meeting hosted by DANTE gathered technical representatives from JIVE, a number of EVN telescopes and their respective National Research and Education Networks (NRENs) to discuss a "Proof of Concept" (PoC), eVLBI project.

The project aims to connect up to five EVN telescopes (and in addition Westerbork), in real-time, to the EVN correlator. The network representatives present agreed to support this project using best-effort IP service across GÉANT and the NRENs. This will be achieved without any significant upgrades to the GEANT network and using the existing NREN access ports. Operation at 512 Mb/s and 1 Gb/s will be supported with limited resilience.

The proof of concept project includes the following participants:

- DANTE/GÉANT — Pan-European Network
- GARR — Italian NREN
- UKERNA — UK NREN
- PSNC — Polish NREN
- DFN — German NREN
- SURFnet — Dutch NREN
- KTHNOC/NORDUnet — Nordic NREN
- Manchester University — Network application software
- JIVE — EVN Correlator
- Westerbork telescope — Netherlands
- Onsala Space Observatory — Sweden
- MRO — Finland
- MPIfR — Germany
- Jodrell Bank — UK
- TCfA — Poland
- CNR IRA — Italy

Progress with the PoC project was modest in the first half of 2003. Several trials confirmed that a fragment of data form each telescope can be sent to JIVE by FTP for quick turn-around fringe checks (see chapter 2). This mode of operation became the first real benefit of eVLBI and quickly became a routine part of EVN operations. In February data recorded at Westerbork were transferred to Kashima in Japan and successfully correlated after suitable format translation. Format translation was also required to enable correlation at JIVE of data recorded in March, at Metsahovi and Jodrell Bank on PC-EVN units.

In September a Mark 5 system from Medicina was installed at the Bologna PoP of GARR, the Italian National Research and Education Network (NREN). Data were transported to JIVE via GÉANT and SURFnet (the Dutch NREN). Maximum data rates achieved were 125 Mb/s in disk2net2disk tests and 700 Mb/s in UDP memory-memory tests.

In October, JIVE participated in a demonstration of eVLBI, staged by Haystack Observatory, at the Internet2 Members meeting in Indianapolis. A total of 85 Gbyte of data were uploaded to JIVE using BBFTP (broadband FTP) at a maximum data rate of 71.4 Mb/s. UDP tests showed a maximum of 612 Mb/s. Transferred data represented a VLBI test between Westford and Kashima in June. Attempts to correlate these data at JIVE were frustrated by format incompatibility problems.

'First light' on the 1Gbit/s optical fibre between Westerbork and Dwingeloo (JIVE) was achieved on 16th October. With very little adjustment, data were transferred from Westerbork to JIVE at more than 300 Mb/s using disk2net and net2disk. UPD memory-to-memory tests once again achieved rates between 700 and 800 Mb/s. Direct transfer of data using in2net was also performed for the first time (in Europe). A rate of 256 Mb/s was easily achieved but 512 Mb/s crashed almost immediately.

During L-band Network Monitoring Experiment (N03L3, 1.6 GHz, 7th November), one scan of Westerbork data were sent directly, via the Westerbork-JIVE optical fibre, to a JIVE Mark5 system and recorded on disk. A week later the Westerbork disk was correlated with Effelsberg (disk) data, producing normal fringes in all sub-bands.

In mid-November the first engineering test of real-time eVLBI was performed. During disk-disk correlation of Westerbork and Jodrell Bank data, one of the JIVE Mark5s was re-configured to pass data received from the network directly to the correlator. Jodrell Bank sent data to this unit, producing solid orange leds on the Station Unit (SU) and incrementing TOT on the SU console. From this test we concluded that, at 64Mb/s, in2net2out works, and data streaming across the network are re-constructed correctly, feeding directly into the data processor. Further engineering work is needed to synchronise the correlator to UT before genuine, real-time eVLBI will be possible.

Later in November fringes between Westerbork and Jodrell Bank were detected, just 15 minutes after the observation was completed. The 15-minutes scan was streamed directly to Mark5 disk units at JIVE, by-passing the local disks at the telescopes completely. Further details and a fringe plot (see figure 13) can be found at:
http://www.evlbi.org/eVLBI/tevlb7/tevlb7.html.
The data rate was 64 Mb/s per station, limited by the 155 Mbps link to Jodrell Bank.

Laboratory research and development continued at JIVE in December. Further parameter tuning increased the disk2net2disk data rate to > 550 Mb/s, in agreement with the highest rates achieved by Haystack. Mark5 *2net and net2* processes were adjusted to use UDP but surprisingly this was slower than TCP. Two new Intel Xeon Server-boards were purchased. These will be installed in two of the Mark5 units at JIVE to explore the apparent Mark 5 hardware limitations.

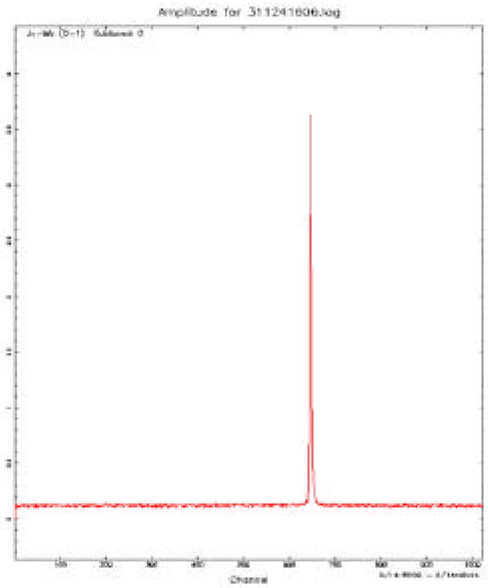

Figure 13: Westerbork -Jodrell Bank fringe detected only 15 minutes after the observation.

4.1.3 Conclusions

Two hard limits of the Mark 5 for eVLBI have been evaluated. Transfers of data from and/or to disk over a network are limited to a maximum of ~ 550 Mb/s. When no disk access is involved rates of ~ 700 Mb/s can be sustained. These results are obtained on an isolated link, away from the effect of competing network traffic. In a shared network, TCP data rates are further reduced but the UDP maximum remains about the same. Understanding of parameter tuning improved following the last cross-network test, so further tests will be needed to establish a new benchmark. In the last weeks of December, Onsala announced that their 1 Gb/s connection was ready, providing the ideal test-bed for such investigations. The PoC project runs for a further 12 months but is expected to continue via the new GEANT2 programme. Further progress will be aided by the addition of more direct telescope links, expected in the first half of 2004.

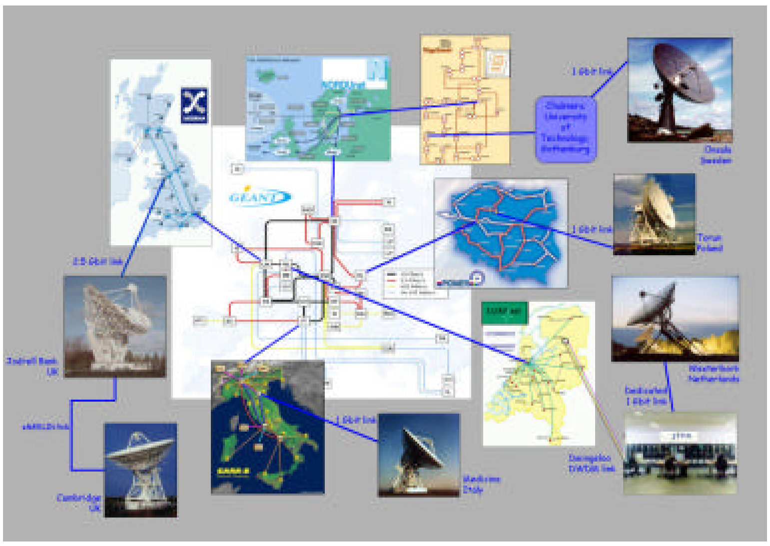

Figure 14: This is what the eVLBI network is expected to look like in 2004.

4.2 2nd eVLBI Workshop, Dwingeloo, 15-16 May 2003

The 2nd eVLBI workshop, organized by JIVE, was set up to allow scientists and engineers from both the radio astronomy and network science communities to discuss the use of international high-performance networks for VLBI data transport. Some 75 participants from all over the world were present including visitors from Japan, Korea and the USA. There were four sessions covering current and planned eVLBI experiments, international network developments, eVLBI technology and other projects in radio astronomy using high bandwidth fibre-optic networks. In total, 22 papers and 2 posters were presented. Presentations are available on-line at the JIVE web-site http://www.jive.nl/evlbi_ws/abstract.html

Impressive progress had been made since the first eVLBI workshop at Haystack Observatory one year before. Several groups were able to report successful trials of eVLBI at high data rates over international and intercontinental distances. Also noticeable was the growing interest of network developers in eVLBI as a high-demand application. Several well focused papers were presented by members of this community.

Figure 15: Participants of the 2nd eVLBI workshop held at JIVE.

4.3 Software Correlator

Imai researched the possibility of introducing the Japanese software correlator package to JIVE, which has been developed by the Radio Astronomy Application Group in Kashima Space Research Center, the Communications Research Laboratory (CRL). This software emulates the processing performed by a hardware VLBI correlator but runs on a Linux PC. Although a software correlator runs much more slowly than a purpose-built hardware correlator, it is able to handle small VLBI data sets, including short ftp-VLBI fringe tests. The package was significantly updated by the CRL development team and provided compatibility between CRL's K-5 and EVN's Mark-4/Mark-5 formats. A successful fringe test was made between the CRL 34-m telescope and WRST in project N03L1, in which a fringe of 3C84 was detected in an integration time of 14 seconds using the software correlator.

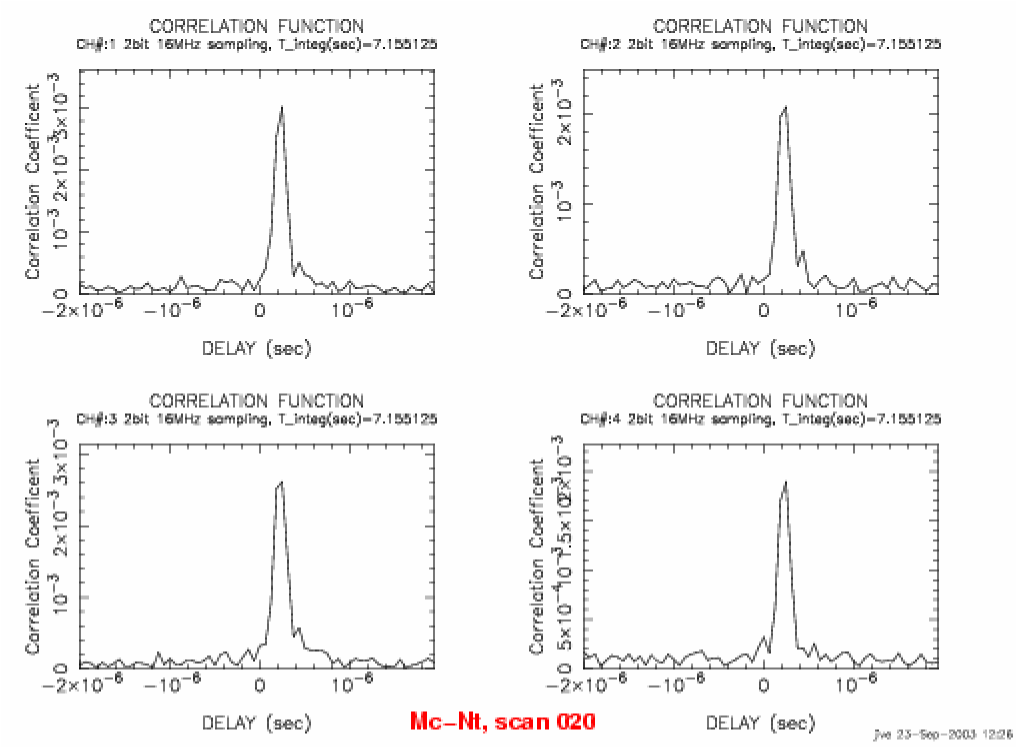

Figure 16: An example of fringes on the Medicina to Noto baseline from experiment D03C1, detected using data transferred by ftp and processed using the CRL software correlator at JIVE.

4.4 Advanced Digital Techniques In VLBI (ADiTiV)

An international team worked together to prepare this Joint Research Activity proposal submitted under FP6 as part of the overall RadioNet FP6 proposal (see chapter 1). Coordinated by JIVE, the other contributors were: ASTRON, Jodrell Bank, IRA and two institutes in Riga, Latvia: Ventspils International Radio Astronomy Center (VIRAC) and the Institute of Electronics and Computer Science (IECS).

The proposed project divided into five areas of investigation:

- Digital Baseband Converters and corresponding correlator developments
- RFI Mitigation
- Digital Alias-Free Signal Processing as applied to VLBI
- Next generation Correlators
- Software Correlators and the use of Computational Grids

The evaluators rated the proposal highly and agreed that it would have European added value. They decided however that it was a development that could be an on-going activity of the observatories themselves and declined to fund it. Some sub-projects e.g. Digital BBC Development just *have to* happen. Others will happen naturally. Hopefully with the success of the various RadioNet programmes in FP6, the observatories will find the resources to finance some of these projects. The ADiTiV proposal provides for some of these projects a firm basis on which to build.

5. Scientific Research

The scientific output of JIVE staff continues to be maintained at a very high level, despite a heavy support load. The scientific productivity of the institute is expected to grow as we begin a programme to co-sponsor PhD students at Dutch universities and appoint a Post-docs position via the ANGLES – the Gravitational Lens Research Training Network, funded by the EC.

Scientific highlights for the EVN and EVN correlator in 2003, included the first publication in *Nature* of data correlated at JIVE (Kloeckner et al. 2003, Kapteyn Institute, Groningen). The paper described the results of an EVN Spectral-line and continuum observation of Mrk231 (see front cover of this report for the images). The detected hydroxyl and radio-continuum emissions reveal an edge-on dusty torus, blocking most of the other AGN emission from our view.

During the period of this report, JIVE staff published 42 papers in scientific journals or conference proceedings, and a further 12 were submitted for publication. 64 oral and 11 poster presentations were made at scientific meetings/colloquia.

Biggs

Gravitational Lensing

The gravitational lens survey, CLASS, discovered 22 lens systems in total, 6 of these coming from the bright subset JVAS. One of these is B2114+022, a system that has proved difficult to fully explain. It consists of four components, unresolved with MERLIN, three of these fitting into a 0.5 arcsec box plus a fourth located about 2.5 arcseconds away (figure 17 and Augusto et al., 2001, MNRAS, 326, 1007). The arrangement of the components is extremely characteristic of gravitational lensing, but there is considerable doubt about whether all four components are lensed images of the same source. Whilst models can be found which fit the positions and flux density ratios of all four components (Chae et al., 2001, MNRAS, 326, 1015), VLBI observations have shown that the components have very different structures, two being core dominated (A and D) and the other two extended with no sign of any compact structure (B and C).

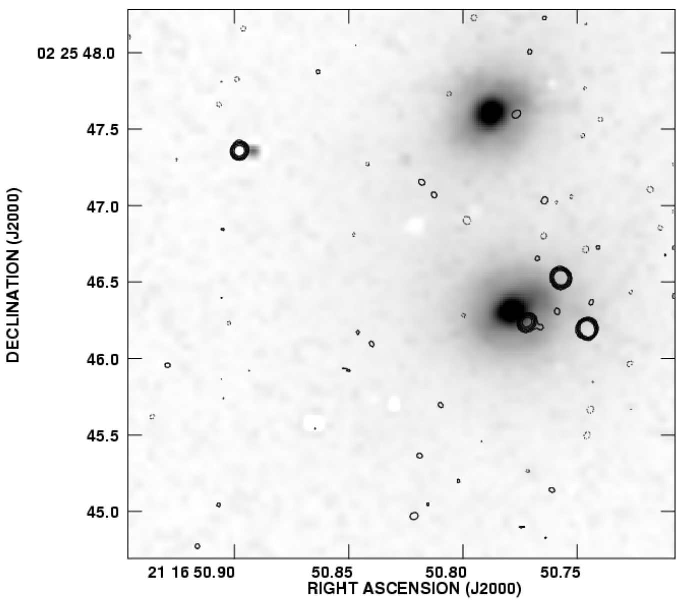

Figure 17: MERLIN 5-GHz map of JVAS B2114+022 (contours) overlaid on an HST NICMOS exposure (greyscale)].

In order to better understand the structure of the extended components and to locate a jet seen in the brighter of the two compact components in the fainter, we obtained further time with the VLBA, a full long-track at both 5 and 8.4 GHz. A map of each component at both frequencies is shown in figure 18. The compact structure of A and D is evident, as is the northward-ponting jet in A. Very close inspection of the contours of image D suggests that it is slightly extended to the east. This may be the counter-part to the jet in A, D being three times fainter (and therefore smaller) than A. As for B and C, each looks very different to A and D, but in different ways. At 8.4 GHz B is fairly featureless, but does show signs of structure. By 5 GHz it has become much more resolved and has a rather striking shape, that of an upward pointing arrowhead. C, on the other hand, is very resolved at both frequencies and very elongated. It too becomes significantly larger at the lower frequency.

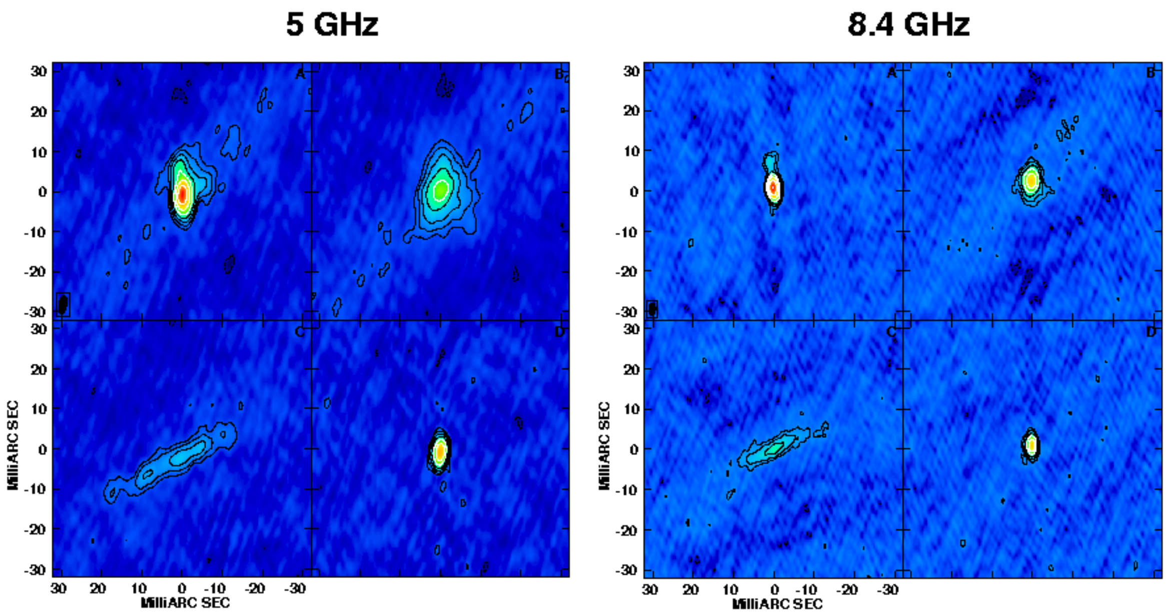

Figure 18: VLBA maps of components A, B, C and D of JVAS B2114+022 at 5 GHz (left) and 8.4 GHz (right).

Explaining these component structures is not easy. What seems clear is that A and D are true lensed images of a background radio source, their morphologies being perfectly consistent with the lens hypothesis. B and C are most likely associated with the primary lensing galaxy (there are two lensing galaxies at different redshifts). The available astrometry places C close to the centre of this galaxy and at 8.4 GHz image C is centrally peaked, resembling a weak radio core with symmetric jets. In this
scenario, B is a lobe associated with one side of this jet. The problem with this interpretation is that there is no detection of a corresponding lobe to the east. Lower frequency VLBA and Global VLBI data are still in the process of being analysed and may help to explain this intriguing lens system.

Bignall

Interstellar Scintillation of Compact Quasars

Radio waves from distant quasars are scattered as they pass through the turbulent, ionized interstellar medium (ISM) of our Galaxy. If the quasar is very compact, this results in intensity fluctuations, known as interstellar scintillations (ISS), which can be observed with radio telescopes on Earth. Observations of ISS can be used to map source structure and evolution on microarcsecond scales (Macquart & Jauncey, 2002, ApJ, 572, 786). This gives clues as to how the radio jets in distant AGN form and evolve close to the central supermassive black hole.

In order to use ISS as a probe of source structure, we need to know the velocity and dimensions of the scintillation pattern. These have been recently derived for the quasar PKS 1257-326, using a novel technique combining observations of the variability pattern time delay between two widely separated telescopes, and of the change in scintillation timescale over the course of the year (Bignall et al. 2003, ApJ, 585, 653; Bignall et al. in prep.).

Figure 19 shows a simultaneous observation of PKS 1257-326 in March 2003, with the Very Large Array (VLA) and the Australia Telescope Compact Array (ATCA). The intensity fluctuations are clearly seen at the VLA a few minutes before arriving at the ATCA, as the scintillation pattern drifts across the Earth. Both the scintillation velocity and any anisotropy in the pattern influence the observed delay.

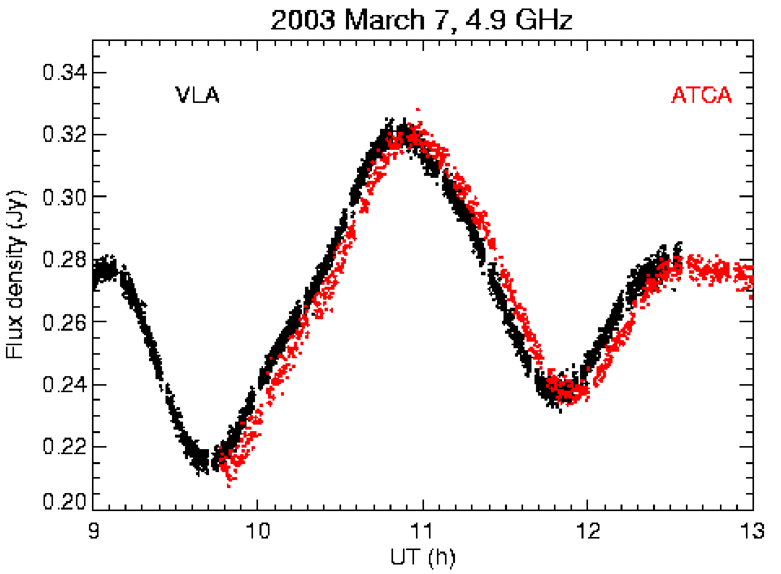

Figure 19: a simultaneous observation of PKS 1257-326 in March 2003, with the Very Large Array (VLA) and the Australia Telescope Compact Array (ATCA)

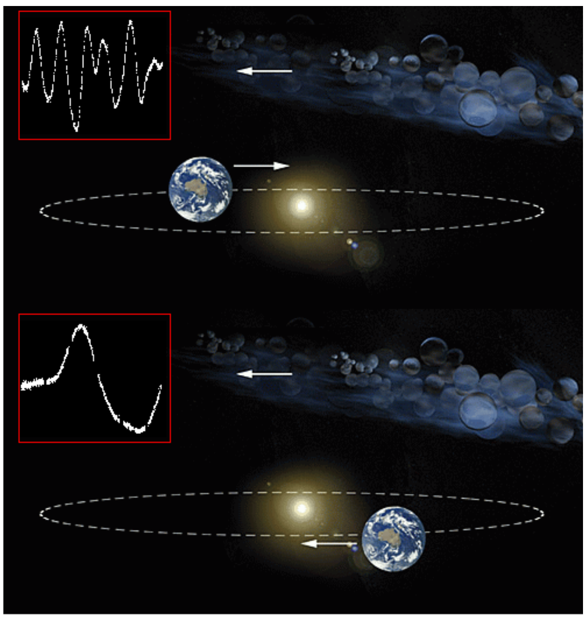

Figure 20: timescale of variability changes over the course of a year.

Figure 20 illustrates how the timescale of variability changes over the course of a year: when the Earth and ISM move in opposite directions, their relative velocity is large and the scintillation timescale short.
Six months later, the Earth and ISM move in similar directions, their relative velocity is small, and the scintillation timescale is long. ATCA data from 12h observations in January and July 2003 are shown in the red boxes. [Background graphics courtesy of Renee Dillon.]

The variations observed in PKS 1257-326 are very rapid because the scattering occurs in an unusually nearby patch of ISM turbulence, within 30 pc of the Sun. A large survey recently undertaken with the VLA to investigate ISS in a sample of 700 compact quasars (Lovell et al. 2003, AJ, 126, 1699), found that such rapid ISS is extremely rare. Most ISS occurs in more distant scattering screens, and therefore on longer timescales, requiring dedicated monitoring programs in order to derive microarcsecond-scale source properties in detail.

Campbell

Kinematics of CJF Sources

The CJF is a complete flux-limited sample of 293 bright (S >= 350mJy at 6cm), flat-spectrum (spectral index > -0.5 between 6 and 20cm) radio sources in the northern sky (Dec >= 35) and away from the galactic plane (|b| >= 10). Quasars comprise 66.9% of the CJF, radio galaxies 18.4%, BL Lac objects 11.3%, and yet unclassified objects 3.4%. Multi-epoch observations of the full CJF (led by Silke Britzen, Heidelberg) allows a statistical study of the kinematics of the sources' jet components. The accumulated motion statistics can be used to investigate correlations with redshift or source type, both bearing on unification scenarios.

VLBI observations of CJF sources have been conducted since 1990, accumulating 3-4 epochs on each source. A variant of difmap was used to fit a circular-Gaussian component model for each source at each epoch, including output of statistical uncertainties for the model parameters and the correlation matrix of the fit. A comparison of the resulting uncertainties for selected sources with those more rigorously determined via difwrap, confirmed that the automated procedure did not introduce noticeable biases.

Figure 21 shows examples of the kind of structures found. The figure caption describes the color (jet-component) and symbol (epoch) coding related to the location of the observed jet components as well as their positions based on the estimated kinematic model. 2116+818 shows a 'classic' well-fit linear jet structure, all of whose components are moving away from the core. The jet of 0836+710 has some wiggles in a otherwise linear structure, and has an apparent acceleration of jet components farther from the core until we get to the outer two components, which have (marginal) inwards motion. 1946+708 shows a jet/counter-jet structure, and some of the inner components show an inward motion. 0153+744 has broadly sweeping jet curvature, with the inner 5 components having roughly the same radial and azimuthal proper motion components. Again, by the end of the jet the outward motion is reversed or stopped. This source also illustrates some of the complications in the global analysis: component positions in the second epoch have significantly higher uncertainties (and hence greater absolute residuals); C3 has two components associated with it in the second epoch; C6 was not identified in the third epoch, so its motion may be suspect. Investigating ways to handle occurrences of such splitting/missing components in a uniform way that wouldn't introduce biases into the global kinematic statistics occupied much time.

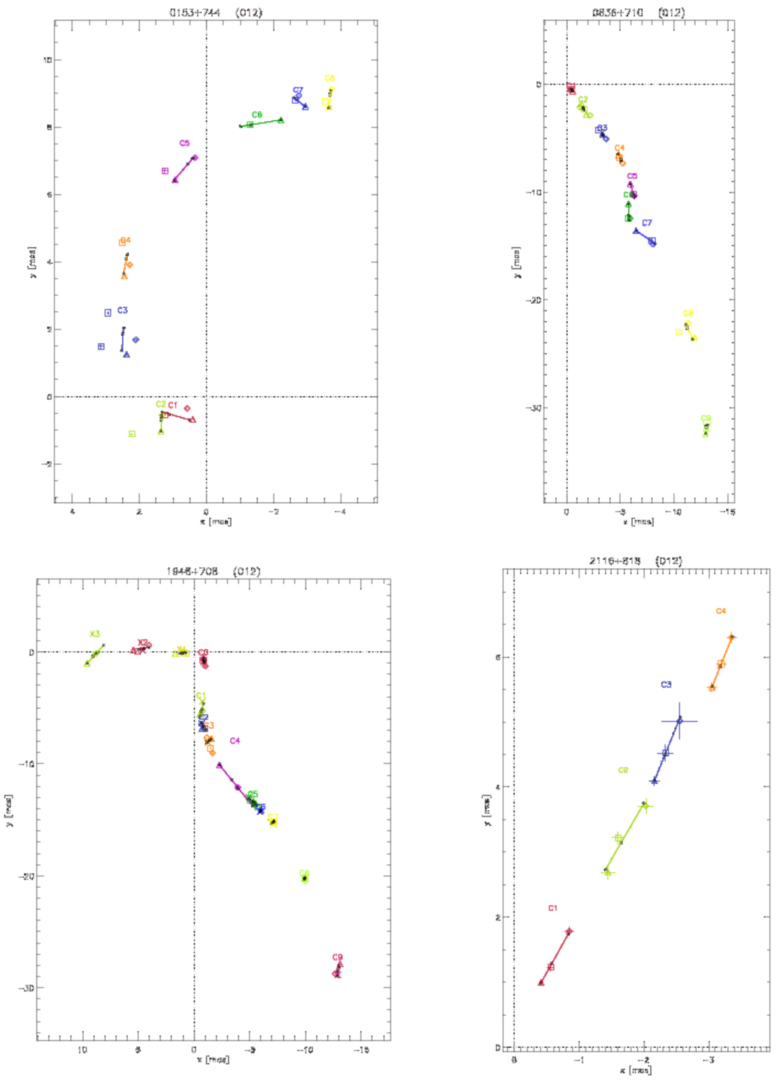

Figure 21: In all plots, the different jet components are color-coded, and the different epochs are marked by symbols (1=triangle, 2=square, 3=diamond, 4=X). Uncertainties are shown by the "+" centered on the symbols. The modeled motion is shown by the black line, and the modeled position at each epoch is marked by a small black symbol. The dotted lines define a Cartesian frame whose origin lies at the position of the assigned core.

By including the uncertainties and correlation matrices as input covariances in the subsequent kinematic modeling, retains more information -- or perhaps better, more of the lack of information - from the original observations following the fitting of simple circular Gaussian components. The kinematic model comprised, for each jet component, a position at the mean epoch and a single (Cartesian) proper motion, again with uncertainties in the model parameters and the correlation matrix of the fit. These uncertainties were scaled to a reduced chi-square of 1. Radial and azimuthal components of the proper motions follow directly from the above results.

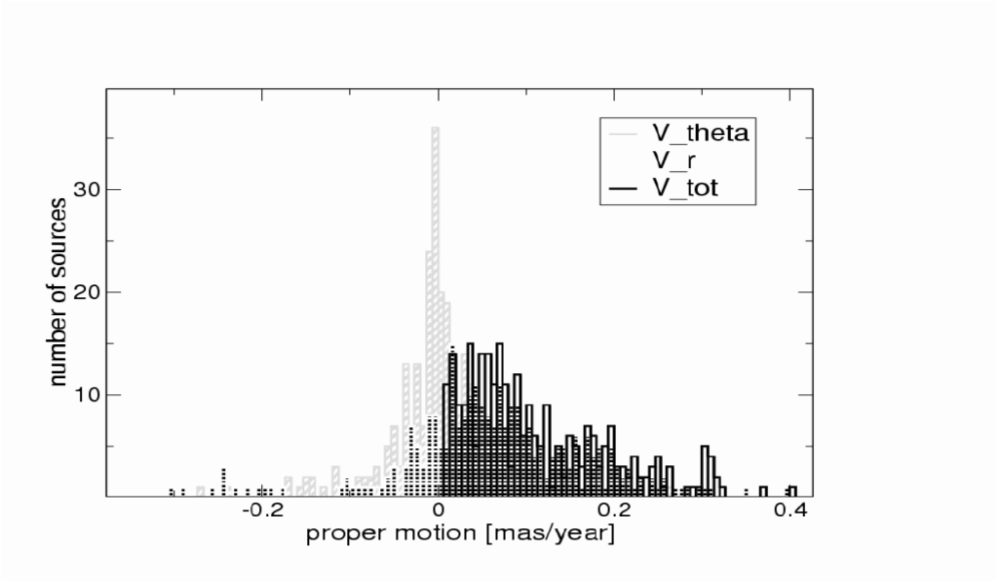

Figure 22: A preliminary histogram of radial, azimuthal, and total velocities for the subset of jet components unaffected by splitting/missing problems at all epochs.

Garrett

VLBI and WSRT deep, wide-field radio surveys

Advances in VLBI recording technology, correlation output data rates and offline analysis techniques now permit the detection of sub-mJy radio sources across a wide field of view, comparable to the FWHM of the primary beam response of individual VLBI antennas. Deep, wide-field 1.4 GHz VLBI observations have been conducted (Garrett, Wrobel & Morganti, ApJ 2004 in press) of an area of sky located within the NOAO Bootes field, using the NRAO VLBA and 100-m Green Bank Telescope. Applying wide-field VLBI techniques, a total of 61 sources, selected from a WSRT image, were surveyed simultaneously with a range of different sensitivities and resolutions (see figure 23). The inner 0-2', of the field reached an unprecedented 1-sigma rms noise level ~ 9 uJy/beam and yielded 2 detections. These are the deepest VLBI images made to date. A further 7 sources were detected in the rest of the field. All of the sources have a brightness temperature in excess of 10^5 K; suggesting they are AGN. Optical identifications are available for 8 of the 9 VLBI detections - only VLBI J142906.6095 remains unidentified (I > 25.6m). Two sources are not detected in K-band (K > 18.5m) suggesting that some significant fraction of these compact radio sources may be located at z > 1. The VLBI detection rate for sub-mJy radio sources is 8%. The VLBI detection rate for mJy sources is higher, 29%. This trend is expected if the radio emission associated with fainter sub-mJy and microJy sources increasingly arises from extended regions of star formation. The 9 VLBI detections pin-point the precise location of AGN or candidate AGN, and their VLBI positions can help to anchor the NOAO Bootes field to the ICRF. The simultaneous detection of several sub-mJy and mJy radio sources, in a single observation, suggest that their combined response may be used to self-calibrate wide-field VLBI data. Future VLBI observations of faint sub-mJy and microJy radio sources can take full advantage of this "full-beam" calibration technique.

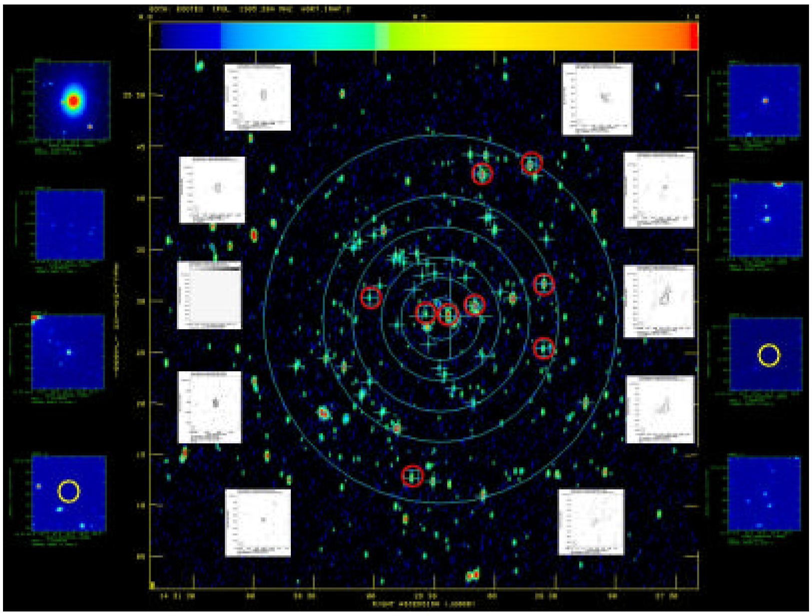

Figure 23: nine sources were detected (red circles) out of a total of 61 targets (crosses). VLBI maps of the detected sources are shown in-set, together with their corresponding optical I-band images.

Gurvits

Toward "en-masse" surveying of milliarcsecond-scale radio structures in tens of thousands of extragalactic radio sources

Recent progress in VLBI techniques makes it possible to explore parsec-scale structures in complete wide-field 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 2003 L.I.Gurvits and M.A.Garrett (JIVE), S.Frey and L.Mosoni (Satellite Geodetic Observatory, Hungary), S.T.Garrington (Jodrell Bank Observatory, UK) and Z.Tsvetanov (Johms Hopkins University, MD, USA) began 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. 2004, in press).

Extragalactic VLBI targets are distributed over a broad range of redshift reaching $z \sim 6$. 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 $10^{23} – 10^{25}$ W/Hz, which correspond to mJy-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 mJy.

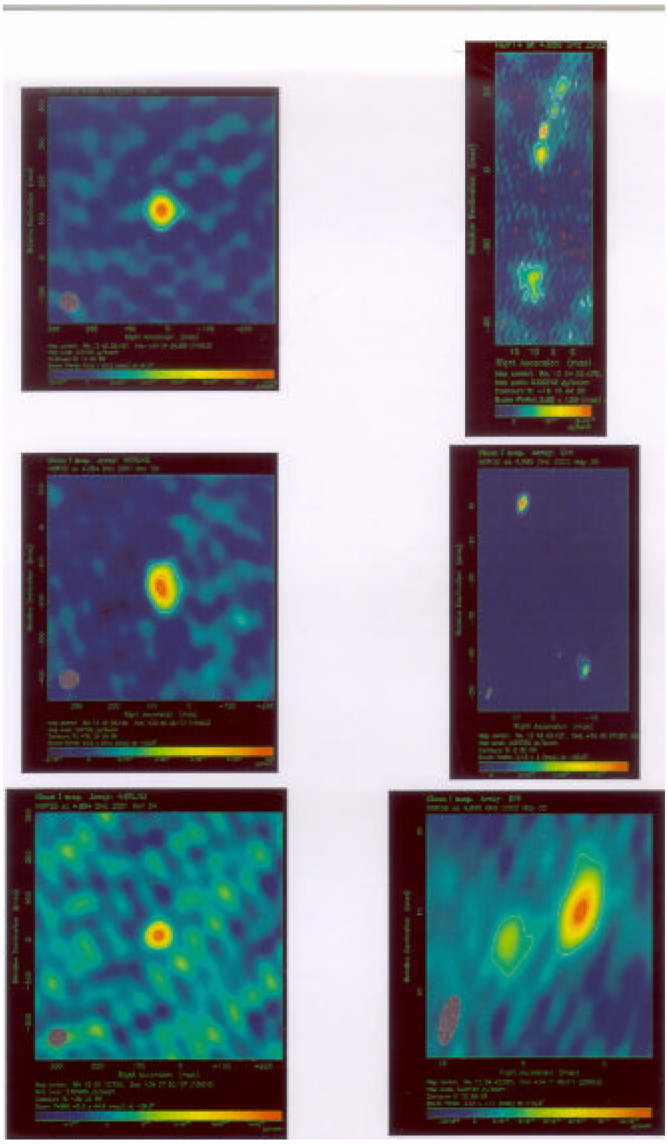

Figure 24: MERLIN (left column) and VLBI (right column) images at 5 GHz of the sources NGP14, NGP32 and NGP36. Peak brightness of the VLBI image of NGP36 (bottom left image) is 1.4 mJy/beam, the lowest detected in the pilot DEVOS project. Note a striking difference between MERLIN-scale and VLBI-scale morphologies of the sources.

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. Phase-referencing duty-cycle included 2 min pointing on the calibrator and two scans on two weak targets. Each weak target was observed in 6–7 duty-cycles providing up to 14 minutes of integration per source. The off-source image noise in these observations was about 200 µJy/beam. Twenty of the observed 37 sources turned to be below the 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. Examples of some of the images are shown in figure 24.

Based on the DEVOS pilot project one can estimate that a sample containing of order 10^4 faint radio sources in the luminosity range 10^{23} – 10^{25} W/Hz can now be surveyed at cm wavelengths with the milliarcsecond angular resolution. Such a 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 ~ 2 orders of magnitude, a new quality of astrophysical and cosmological applications is likely to emerge.

Imai

Water fountains streaming in the Milky Way

Water vapour maser emission is a good tracer of dramatic transition phases in stellar evolution, formation of protostars and hyper-compact HII regions and rapid release of stellar mass at the time of a star's death. High velocity molecular flows traced by the maser emission from evolved stars are interesting objects for understanding morphological/dynamical change of mass loss of evolved stars and the shaping mechanism of planetary nebulae. In such stellar objects, there are only three water vapour maser sources (W43A, IRAS16342-3814, IRAS 19134+2131) which have very high velocity (> 100 km/s) flows at the final stage of stellar evolution.

The morphology and kinematics of water vapour masers in W43A were elucidated by VLBA observations during 1994 -1995 (Imai et al. 2002, Nature 417, 829). The water masers exhibit an extremely-collimated precessing jet of molecular gas. A dynamical age of the jet was only about 35 years. Figure 25 shows the time variation of distributions of water maser features in W43A during 1994 -2002. The dynamical age estimated from maser proper motions for a short time scale (< 1 year) is almost equal to the true jet's age, which is estimated from an extension length of maser feature distribution per 8 years. The maser distribution is well fit by a precessing jet model.

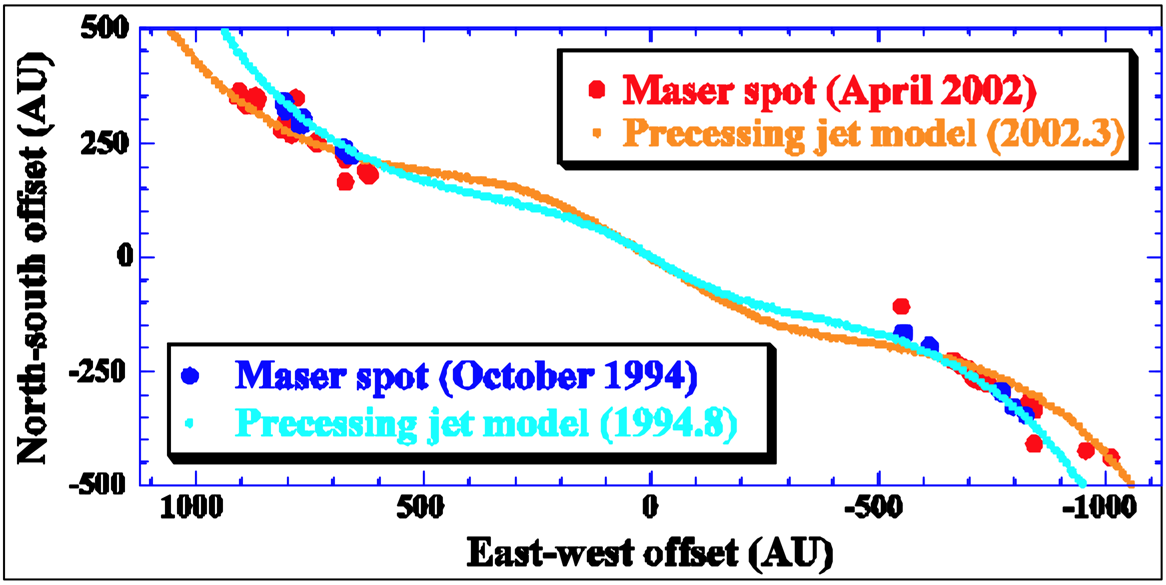

Figure 25: Proper motion of water maser features in W43A during 1994 -2002.

The morphology and kinematics of water vapour masers in IRAS19134+2131 were also elucidated by VLA and VLBA observations during 2001- 2003 (Imai et al. 2004, A&Ap 420, 265). In the case of this maser source, as shown in figure 26, proper motions of the water vapour maser features were measured with respect to an extragalactic position-reference source J1925+2106. The maser proper motions exhibit an expansion motion (approximately 120 km/s), blended with an orbital motion along the Galactic plane (around 200 km/s). A dynamical age of the expanding flow is about 50 years, which is roughly equal to that of the W43A jet. However, the jet collimation seems to have been already relaxed, which implies that the IRAS19134+2131 flow is more evolved than the W43A jet.

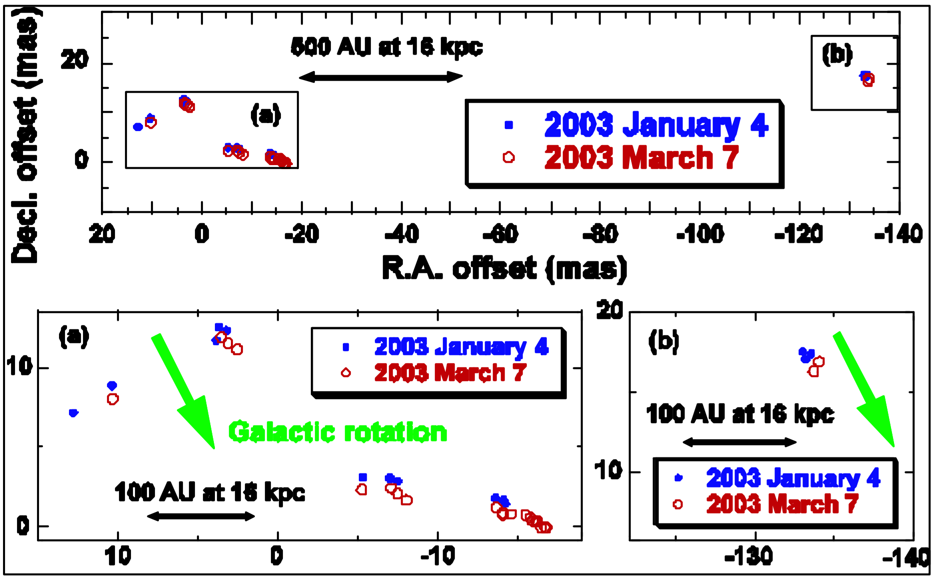

Figure 26: Water vapour maser proper motions in IRAS19134+2131.

Taking into account morphology and kinematics of these two water vapour maser sources and those of IRAS16342-3814 (Morris, Sahai and Claussen 2003, Rev. Mex. A.A. 15, 20), it is expected that such rare “water fountains” are seen for a very short period (< 100 years). Before or during that stage, an evolved star (OH/infrared-star) becomes a central object of a proto-planetary nebula, which photo-dissociates water vapour molecules in a circumstellar envelope. A collimated jet from an evolved star is also created in the same period. However, the jet formation mechanism is still unclear. Jet ejection from a binary system or from a single star by stellar dynamo action will be directly revealed by future observations.

Van Langevelde

Molecular absorption in Cen A on VLBI scales

Centaurus A, the nearest AGN shows molecular absorption in the millimeter and radio regime. By observing the absorption with VLBI, van Langevelde and collaborators try to constrain the distribution of the gas, in particular whether it resides in the circumnuclear region. Spectra taken with the VLBA show OH and formaldehyde absorption at high spatial resolution, displaying absorption from a range of components known from previous studies. At first, this seems to indicate that the molecular absorption is smooth on scales larger than a few parsec.

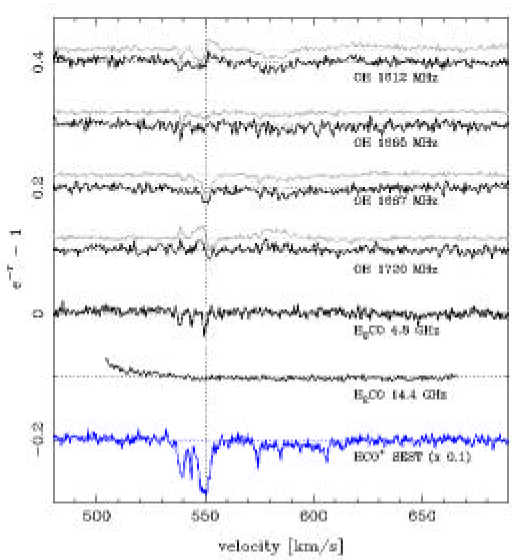

Figure 27: Spectra for OH and H_2CO from VLBA data, obtained in a sub-arcsecond beam. For comparison OH spectra obtained with the ATCA are shown as well in grey, slightly offset from the VLBA data (van Langevelde at al., 1995, ApJ 448 L123). The bottom spectrum is HCO from the SEST (Israel et al., 1991, AA 245 L13).

For the millimeter absorption, Eckart et al. have proposed absorption with a particular interesting model (1999 ApJ 516 769). This model assumes the absorption takes place in a system of tilted molecular rings with co-rotating gas at high latitudes. The model predicts the structure to be much larger than the VLBI radio source. Indeed the OH absorption images show absorption that is consistent with this at all velocity components.

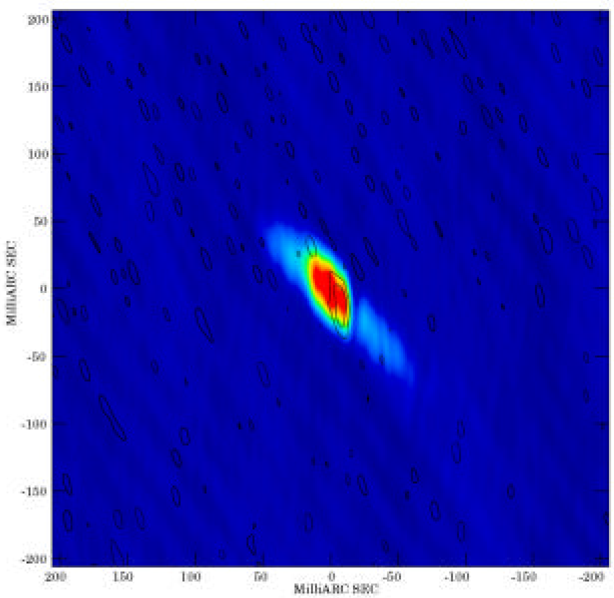

Figure 28: A map of the 4.8 GHz continuum of CenA, overlaid with the H$_2$CO absorption in the 550 km/s feature. Clearly the feature does not cover the entire structure equally.

However, the Formaldehyde absorption is less straightforward (figure 28). The data shows absorption against the core, but significantly little is seen against the jet. Naively, this seems to indicate that this structure is local to the nucleus. However, the scales are uncomfortably small. To get further constraints on the location of the molecular gas, models were evaluated that treat the excitation of the molecular species as a function of distance to the nucleus. For both OH and H_2CO the influence of nuclear emission distance closer than 100pc is deemed to be important. OH main-line masers are expected when the mid-IR becomes strong, and formaldehyde masers may occur when the radio emission is very intense. From the excitation analysis and the modest line width, we conclude that the gas must be at 200pc – 2kpc from the nucleus, consistent with the Eckart model. In this model the formaldehyde must be restricted to high density, small-scale structures in the mid-plane of the tilted rings, which also explains the absence of red-shifted components in the spectrum.

Methanol masers in W51

Methanol masers are often associated with ultra-compact HII regions and a fraction of these sources show linear velocity structures. In some cases it is reasonable to argue that these structures are the front-side of a rotating structure around a proto-star (Phillips et al., 1998, MNRAS 300 1131; Minier et al., 2003, AA 403 1095; Pestalozzi et al., 2004, astro-ph/04011535), but in general such velocity gradients could also arise in outflows. Moreover, approximately 2/3 of the methanol masers are not directly associated with an UCHII region, some are not in a known star-formation region and few actually show a clear linear gradient when mapped. This is demonstrated clearly in the EVN map of the well-known W51 region obtained by Phillips & van Langevelde, exploiting the wide-field imaging capabilities at JIVE (figure 29). Over an area of 4 arcminutes methanol masers were found in 8 distinct sites; three of these are very rich in other masers and clearly associated with sites of activity. The morphology of these methanol masers and their location with respect to the UCHII regions seems to argue for an outflow or shock origin of the masers (figure 29 insets). However, the same image also shows 5 methanol masers without a clear association in other tracers. But from excitation and chemical arguments it is clear that something must be "brewing" at these sites as well. Methanol is thought to be formed on the icy grain mantles and can only be abundant in the gas phase if these grains have been evaporated recently.

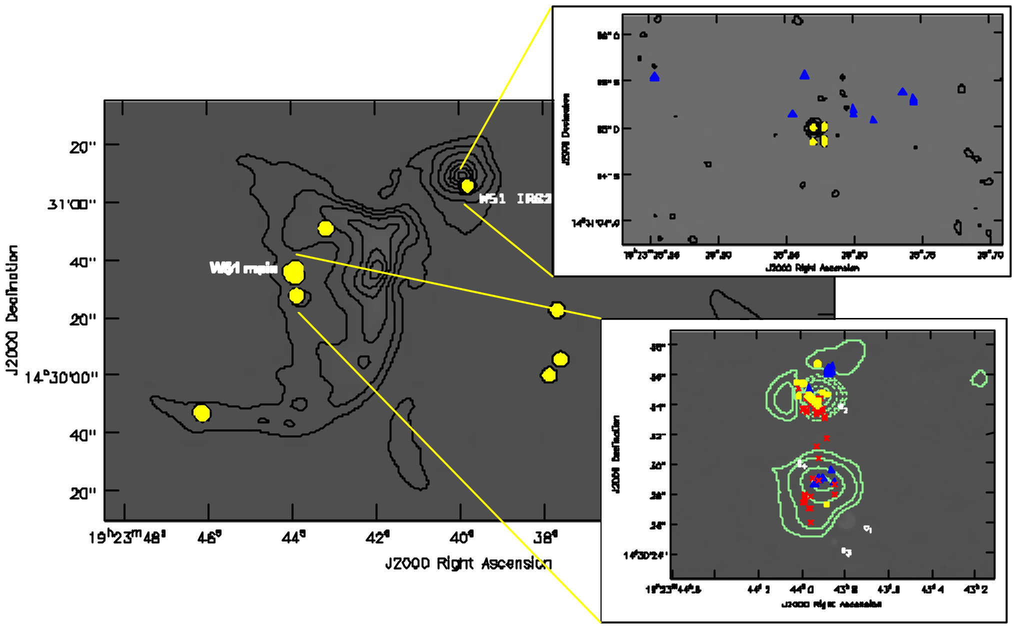

Figure 29: Circles show the positions of methanol masers towards W51A, overlaid on 4.8 GHz continuum observed with the VLA. The inset shows details of the W51 main region and the IRS2 region with various other molecular tracers and high-resolution continuum. At a distance of 7 kpc 1" corresponds to 7000 AU.

Paragi

High-redshift quasars (Frey, Gurvits, Mosoni, Paragi)

The most distant quasars discovered recently in the Sloan Digital Sky Survey have redshifts of z ~ 6 (Fan X. et al., 2001, Astron. J. 122, 2833). Observations of these sources may be fundamental in understanding the early structure formation in the Universe. It appears that black holes with masses exceeding 10^9 Solar mass already existed at z=6. This estimate comes from the measurement of the optical luminosity of these systems. However, simulations shows that up to 30% of these sources may be magnified by gravitational lensing and the corresponding black hole masses would be over-estimated (Wyithe & Loeb 2002, Nat. 417, 293).

One of these very high redshift sources, SDSS 0836+0054 (z=5.82) has detectable radio emission at cm wavelengths. Phase-referencing observations with the EVN at 18cm show that the radio structure of the source at 10 milliarcsecond angular resolution is somewhat resolved (Frey et al. 2003, MNRAS 343). The flux density detected with VLBI is equal to that measured earlier with the VLA. This suggests that the source is not multiply imaged (Frey et al. 2003).

Reynolds

Intermediate Scale Structures in BL Lac objects

BL Lac objects are a class of extragalactic radio sources. They exhibit highly variable polarized radio emission and are distinguished from optically violently variable quasars by their weak optical line emission.

The milliarcsecond (mas) and arcsecond scale jets of BL~Lac objects are often misaligned. The arcsecond scale emission is typically more diffuse indicating that the jet has become decollimated between the milliarcsecond and arcsec scales. It has also been suggested that BL Lacs are the beamed counterparts to FR 1 radio galaxies. The jets observed in FR 1 radio galaxies have lengths of one to several kpc at which point they disrupt to form diffuse plumes. IF BL Lac objects are simply FR 1 galaxies that make a small angle to the line of sight, then this transition from a well-collimated jet to a diffuse plume may take place on scales of just a few tens of mas. However, these scales are between those accessible to high-frequency (> 5 GHz) VLBI and more conventional interferometers such as the VLA, and has therefore been little explored to date. In order to investigate these changes of structure with scale, we have carried out low frequency observations with the VLBA. At the lower frequencies, more diffuse jet emission becomes more dominant allowing us to trace the development of the jet on larger scales.

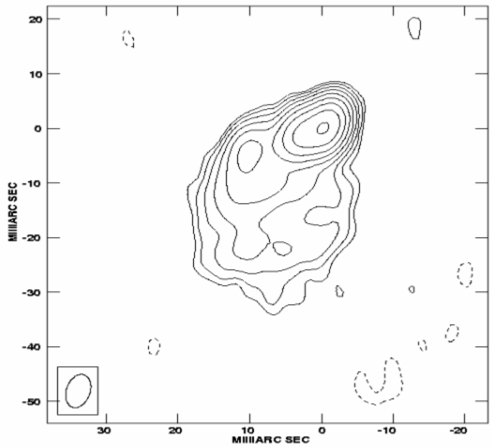

Figure 30: An image of the BL Lac object 1219+285 at 2.6 GHz.

Figure 30 is an image of the BL Lac object 1219+285 at 2.6 GHz. This source has a known mas-scale jet that extends about 10 mas to the east of the core, but is essentially unresolved on arcsecond scales. The figure shows that the jet changes direction towards the south at about 10 mas from the core, after which the jet appears to become much more diffuse.

Figure 31 shows a spectral index map of the source produced using observations at 1.7 and 2.6 GHz. It is notable that the region where the jet changes direction shows enhanced brightness and figure 31 shows that the spectral index is also flatter in this region. This is indicative of an interaction between the jet and the surrounding medium which results in the jet changing direction. It also appears that the jet has become disrupted which explains why the object is unresolved on arcsecond scales. It is tempting to associate the diffuse emission seen in these images with the plumes seen at the end of the jets in FR 1 radio galaxies, but it is also possible that what we are seeing is simply the end of an expanding jet which makes a small angle to the line of sight.

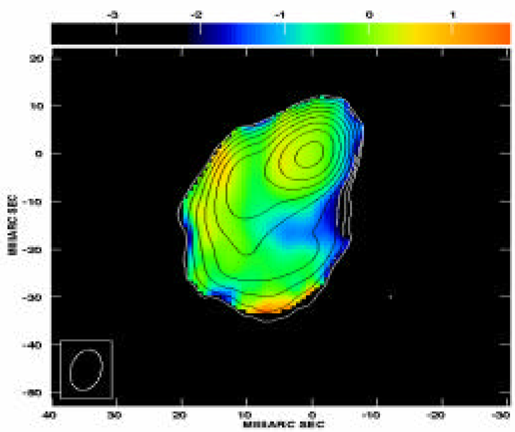

Figure 31: a spectral index map of the BL Lac object 1219+285 produced using observations at 1.7 and 2.6 GHz.

6. Publications

6.1 Refereed publications

Biggs, A.D., Wucknitz, O., Porcas, R.W., Browne, I.W.A., Jackson, N.J., Mao, S., Wilkinson, P.N., "Global 8.4-GHz VLBI observations of JVAS B0218+357", 2003, MNRAS 338, 599

Biggs, A.D., et al., "B0850+054: a new gravitational lens system from CLASS", 2003, MNRAS, 338, 1084

Bignall. H.E., Jauncey. D.L., Lovell. J.E.J., Tzioumis. A.K., Kedziora-Chudczer. L., Macquart, J,-P., Tingay, S.J., Rayner, D.P., Clay, R.W., "Rapid Variability and Annual Cycles in the Characteristic Timescale of the Scintillating Source PKS 1257-326", 2003, ApJ, 585, p. 653

Frey, S., Mosoni, L., **Paragi, Z., Gurvits, L.I.** (2003) Radio Structure of the most distant radio-detected quasar at the ten milli-arcsecond scale. Mon. Not. Royal Astron. Soc., Vol. 343, L20-L24

Garrett, M.A., Wrobel, J.M., Morganti, R., "The Deepest and Widest VLBI Survey yet: VLBA+GBT 1.4 GHz observations in Bootes", 2003, New Astron. Rev. 47, 385

Gurvits, L.I., "VLBI in the next decades: exploring the microjansky radio sky with a sub-milliarcsecond angular resolution", 2003, in New Technologies in VLBI, ed. Y.C.Minh, ASP, v. 306, 303-317

Gurvits, L.I., Jets in AGN as seen with an ultimate angular resolution", 2003, Astrophys. Sp. Science 287, 235-240

Imai, H., "Linear polarization observations of water masers in W3 IRS 5", 2003, ApJ, 595, 285

Imai, H., "A Water Fountain: Discovery of a Molecular Jet from an AGB Star", Astronomical Herald, 95, 589 (2002) (in Japanese)

Imai, H., Shibata, K.M., Sasao, T., Miyoshi, M., Marvel, K.B., Diamond, P.J., Migenes, V., Murata, Y., "The 3-D kinematics of water masers around the semiregular variable RT Virginis", 2003, ApJ, 590, 460

Jauncey, D.L., King, E.A., **Bignall, H.E.**, Lovell, J.E.J., Kedziora-Chudczer, L., Tzioumis, A.K., Tingay, S.J., Macquart, J.-P., McCulloch, P.M., "Variability in GPS Sources", 2003, PASA, 20, 151

Jauncey, D.L., Johnston, H.M., **Bignall, H.E.**, Lovell, J.E.J., Kedziora-Chudczer, L., Tzioumis, A.K., Macquart, J.-P., "Interstellar Scintillation and Annual Cycles in the BL Lac Source PKS 1519-273", 2003, AP&SS, 288, p. 63.

Jin, C., **Garrett, M.A.**, Nair, S., Porcas, R.W., Patnaik, A.R., Nan, R., "Changes in the measured image separation of the gravitational lens system PKS 1830-210", 2003, MNRAS, Volume 340, Issue 4, pp. 1309-1316.

Jin, C., **Garrett, M.A**., Nair, S., Porcas, R.W., Patnaik, A.R., Nan, R. "Changes in the measured image separation of the gravitational lens system PKS 1830-211, 2003, MNRAS, 340, 109

Klöckner, H.R., Baan, W.A., **Garrett, M.A.**, "Investigation of the obscuring circumnuclear torus in the active galaxy Mrk 231", 2003, Nature, 421, 821

Koopmans, L.V.E., **Biggs, A.**, Blandford, R.D., Browne, I.W.A., Jackson, N.J., Mao S., Wilkinson, P.N., de Bruyn, A.G, Wambsganss, J., "Extrinsic Radio Variability of JVAS/CLASS Gravitational Lenses", 2003, ApJ, 595, 712

Lovell, J.E.J., Jauncey, D.L., **Bignall, H.E.**, Kedziora-Chudczer, L., Macquart, J-P., Rickett, B.J., Tzioumis, A.K., "First Results from MASIV: The Micro-Arcsecond Scintillation-Induced Variability Survey", 2003, AJ, 126, p. 1699

Porcas, R., Alef, W., Rioja, M.J., Desmurs, J.-F., **Gurvits, L.I.**, Schilizzi, R.T., “Multiview VLBI with Arrays in Cluster-Cluster Mode”, 2003, in New Technologies in VLBI, ed. Y.C.Minh, ASP, v. 306, 39-51

Vermeulen, R.C., Ros, E., Kellerman, K.I., Cohen, M.H., Zensus, J.A., **van Langevelde H.J.**, "The Shroud Around the Twin Radio Jets in NGC1052" 2002, A&A 401, 113-127

Vlemmings, W.H.T., **van Langevelde, H.J**., Diamond, P.J., Habing, H.J., Schilizzi, R.T., "VLBI astrometry of circumstellar OH masers; proper motions and parallaxes of four AGB stars" 2003, A&A 407 213

6.2 Publications in Conference Proceedings

Campbell, R.M., "The EVN Mark 4 Data Processor at JIVE", 2003, in "Proceedings of the 16th Working Meeting on European VLBI for Geodesy and Astrometry", eds. W. Schweggmann & V. Thorandt, (BKG: Frankfurt/Leipzig), p. 23.

Edwards, P.G., Hirabayashi, H., Fomalont, E.B., **Gurvits, L.I.**, Horiuchi, S., Lovell, J.E.J, Moellenbrock, G.A., Scott, W.K., “The VSOP Survey Program of 402 AGN at 5 GHz", 2003, in Proceedings of the IAU APRM, eds. Satoru Ikeuchi, John Hearnshaw, and Tomoyuki Hanawa, ASP v. 289, 375

Gizani, N.A., **Garrett, M.A.**, “Jet Misalignment in Radio – the Unification Theory”, 2003, in “Quasar Cores and Jets”, 25th meeting of the IAU, Joint Discussion 18, 23-24 July 2003, Sydney, Australia, 18

Gurvits, L.I., "Surveys of Parsec-scale Radio Structures in AGN", 2002, in Surveys of AGN, Proceedings of the IAU Colloquium No. 184, eds. R.F. Green, E.Ye. Khachikian and D.B.Sanders, ASP v. 284, 265

Gurvits L.I., "Close look at an AGN with a VLBI magnifier", 2003, in Active Galactic Nuclei: from Central Engine to Host Galaxy, eds. S. Collin, F. Combes, I. Shlosman, ASP, v. 290, 51

Gurvits, L.I., “Milliarcsecond structures in AGN as cosmological probes”, 2003, in “Radio Astronomy at the Fringe”, eds. M.H. Cohen, A.J. Zensus, E. Ros, ASP, v. 300, 285-292

Imai, H., Obara, K., Diamond, P.J., Omodaka, T., Sasao, T., "A Collimated Jet of Molecular Gas from the AGB star W43A", 2003, in the proceedings of Winds, Bubbles and Explosions, a Conference for Honor John Dyson, eds. S. J. Authur, W, J. Henney, Review of Mexican Astronomy and Astrophysics, 15, 74

Imai, H., Watanabe, T., Omodaka, T., Nishio, M., Kameya, O., Nakajima, J., "The 3-DKinematics of Water Masers in the W51A Region", 2003, in the proceedings of Winds, Bubbles and Explosions, a Conference for Honor John Dyson, eds. S. J. Authur, W, J. Henney, Review of Mexican Astronomy and Astrophysics, 15, 202

Imai, H., “Exploring Stellar-pulsation-driven Shock Waves revealed in the Kinematics of Water Masers around RT VIR”, 2003, in “Mass-losing pulsating stars and their circumstellar

matter", Astrophysics and Space Science Library, eds. Y. Nakada, M. Honma, M. Seki (Kluwer Acad. Publishers, Dordrecht), Vol. 283, 313

Imai, H., "SiO Maser Survey towards the Stellar Cluster at the Galactic Center ", 2003, in "Mass-losing pulsating stars and their circumstellar matter", Astrophysics and Space Science Library, eds. Y. Nakada, M. Honma, M. Seki (Kluwer Acad. Publishers, Dordrecht), Vol. 283, 373

Jauncey, D.L., **Bignall, H.E.**, Lovell, J.E.J., Kedziora-Chudczer, L., Tzioumis, A.K., Macquart, J.-P., Rickett, B.J., "Interstellar Scintillation and Radio Intra-Day Variability", 2003, in ''Radio Astronomy at the Fringe", J.A. Zensus, M.H. Cohen, & E. Ros (eds.), ASP Conference Series Vol. 300

Jauncey, D.L., **Bignall, H.E.**, Lovell, J.E.J., Kedziora-Chudczer, L., Tzioumis, A.K., Macquart, J.-P., Rickett, B.J., "Beyond VLBI; Interstellar Scintillation and Microarcsecond Radio Source Structure", 2003, in 'New Technologies in VLBI', ed. Y.C. Minh, ASP Conference Series Vol. 306.

Kedziora-Chudczer, L., Rickett, B.J., **Bignall, H.E.**, Jauncey, D.L., Lovell, J.E.J., Tzioumis, A.K., Macquart, J.-P., "Seeing the Cores of Active Galaxies in the Sharpest Detail", 2003, in 'Radio Astronomy at the Fringe', J.A. Zensus, M.H. Cohen, & E. Ros (eds.), ASP Conference Series Vol. 300

van Langevelde, H.J., Vlemmings, W.H.T., "Astrometry of circumstellar masers" 2003, proceedings of "Mass-losing Stars and their Circumstellar Matter", eds Y. Nakada & M. Honma, Kluwer ASSL series, Vol 283, p 237

Lovell, J.E.J., Jauncey, D.L., Tzioumis, A.K., **Bignall, H.E.**, Kedziora-Chudczer, L., Macquart, J-P, Rickett, B.J., "The Micro-Arcsecond Scintillation-Induced Variability (MASIV) VLA Survey", in 'Active Galactic Nuclei: from Central Engine to Host Galaxy', S. Collin, F. Combes, I. Shlosman (eds.), 2003, ASP Conference Series, 290, p. 347

Murakawa, K., Yates, J.A., Richards, A.M.S., Cohen, R.J., **van Langevelde, H.J.**, "A study of the OH and H2O masers in the circumstellar envelopes around Miras" 2003, proceedings of "Mass-losing Stars and their Circumstellar Matter", eds Y. Nakada, M. Honma, Kluwer ASSL series, Vol 283, p 237

Phillips, C.J., **van Langevelde, H.J**., Ellingsen, S.P., Caswell, J.L., "The Extended Methanol Maser Emission in W51, 2003, in IAU Symposium

Richards, A.M.S., Cohen, R.J., Gray, M.D., Murakawa, K., Yates, J.A., Szymczak, M., Monnier, J.D., Masheder, M.R.W., **van Langevelde, H.J.**, "The dynamics of Red Supergiant winds" 2002, proc. IAU 206 "Cosmic Masers: From Protostars to Black Holes", eds. V. Migenes, M.J.Reid, ASP conference series, p 306

Smits, D.P., Cohen, J., **van Langevelde, H.J.**, Richards, A.M., "MERLIN and EVN Observations of 4765-MHZ Masers in MON R2", 2003, in IAU Symposium

Vermeulen, R.C., Ros, E., Kellerman, K.I., Cohen, M.H., Zensus, J.A., **van Langevelde, H.J.**, "The shroud around the 'compact, symmetric' radio jets in NGC1052" 2003, proceedings of the 3rd GPS/CSS workshop, ed. T. Tzioumis, W. de Vries, I. Snellen, A. Koekemoer, PASA, 20, 65-68

Vermeulen, R.C., Ros, E., Zensus, J.A. Kellerman, K.I., Cohen, M.H.., **van Langevelde, H.J.**, "Ionised, Atomic, and Molecular Gas around the Twin Radio Jets of NGC1052", 2003, at "Radio Astronomy at the Fringe", eds. J.A. Zensus, M.H. Cohen, E. Ros, ASP Conf. Ser. Vol. 300, p119

Vlemmings, W.H.T., Diamond, P.J., **van Langevelde, H.J.**, "Magnetic Fields in the envelopes of late-type stars: Circular Polarization of H2O Masers" 2003, proceedings of "Mass-losing Stars and their Circumstellar Matter", eds Y. Nakada, M. Honma, Kluwer ASSL series, Vol 283, p 291

Appendices

Appendix 1

JIVE Board

Prof. A. Baudry	-	Bordeaux Observatory, Bordeaux, France (Chairman) (until 3 May 2003)
Prof. R.S. Booth	-	Onsala Space Observatory, Onsala, Sweden
Prof. H.R. Butcher	-	ASTRON, Dwingeloo, The Netherlands
Dr. P.J. Diamond	-	MERLIN/VLBI National Facility, Jodrell Bank Observatory, UK (Chairman, since 3 May 2003)
Dr. J. Gomez-Gonzales	-	National Astronomical Observatory, Alcala de Henares, Spain
Dr. F. Mantovani	-	Institute for Radioastronomy, Bologna, Italy
Dr. J.A. Zensus	-	Max-Planck-Institute for Radioastronomy, Bonn, Germany (Vice-Chairman, since 3 May 2003)

Appendix 2

JIVE Financial Report for 2003

Balance (amounts x € 000)	**2003**	**2002**
ASSETS		
Fixed Assets		
Computer Equipment	70	104
Equipment under construction	227	174
Furniture	25	19
	322	**297**
Current Assets		
Work in Process	11	14
Receivables:		
NWO		40
Debtors	402	324
Other	7	20
Cash at Bank	1171	2903
	1591	**3301**
	1913	**3598**

	2003	**2002**
LIABILITIES		
Capital		
General Reserve	**1122**	**1072**
Other Liabilities		
NWO		302
ASTRON	547	1509
Creditors	16	97
Received in advance:		
PCI Contract	132	217
EU Contract	0	391
Other	96	10
	791	**2526**
	1913	**3598**

JIVE Financial Report for 2003 (cont.)

Profit and Loss statement 2003
(amounts x € 000)

Revenues		**Expenditures**	
Contributions		***Institute***	
		Salaries	1154
European Research Organisations	543	Depreciation	67
Dutch Research Council	454	Other	259
	997		**1480**
	997		
EU – contracts		***Projects***	
Access – on behalf of EVN	472	Upgrade Projects	15
		Optical Fibre Development	13
Projects		PCI	138
EVN	158	Mark V	32
European Union	43	ICN	2
		Coop NL-China	14
Other		Coop NL-Hungary	8
Other	44		**222**
	717		
Interest			
Interest	38		
	38		
TOTAL	**1752**	***TOTAL***	**1702**
		Result 2003	**50**

Appendix 3

JIVE Personnel

Dr. M.A. Garrett*	Director (since 1 May) (Interim Director 1 January-30 April)
Dr. I.M. Avruch	Data Analysis Scientist
Dr. A. Biggs	Support Scientist
Dr. H. Bignall	Support Scientist (since 10 January)
Mr. J. Buiter	Tape Recorder Engineer
Dr. R.M. Campbell*	Data Analysis Scientist / Head of Science Support and Operations (since September)
Dr. L.I. Gurvits*	Programme Manager, Senior Scientist
Dr. H. Imai	Support Scientist (until 1 September)
Mr. B. Kramer	Operator
Dr. H.J. van Langevelde*	Head of Data Processor Science Operations / Head of Software Development (since September)
Mr. M. Leeuwinga	Operator
Mrs. S.K. Mellema	Secretary
Mr. M. Nijk	Operator
Dr. F. Olnon	Online Software Engineer
Eur. Ing. S.M. Parsley*	Head of Data Processor Technical Operations/Head of Technical Operations and R&D (since September)
Dr. S.V. Pogrebenko	Senior Development Engineer
Dr. C. Reynolds	Support Scientist (Senior Support Scientist from November 2003)
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

I. Agudo	MPIfR, Bonn, Germany
W. Alef	MPIfR, Bonn, Germany
J. Azzollini Felipe	IAC, Tenerife, Spain
U. Bach	MPIfR, Bonn, Germany
G. Balodis	VIRAC, Riga, Latvia
E. Bervalds	VIRAC, Riga, Latvia
Bong Won Sohn	MPIfR, Bonn, Germany
I. Browne	Jodrell Bank Observatory, Manchester, UK
A. Brunthaler	MPIfR, Bonn, Germany
Chen Songlin	Shanghai Astronomical Observatory, China
S. Dougherty	DRAO, Penticton, Canada
S. Frey	FOMI SGO, Penc, Hungary
S. Friedrichs	MPIfR, Bonn, Germany
D. Gabuzda	University College Cork, Ireland
B. Henderson	University of Washington (WA), USA
Hong Xiaoyu	Shanghai Astronomical Observatory, China
J. Howard	University College Cork, Ireland
T. Huege	MPIfR, Bonn, Germany
A. Labiano	Space Telescope Science Institute, Baltimore, USA
Li Bin	Shanghai Astronomical Observatory, China
I. McHardy	University of Southampton, UK
E. Middelberg	MPIfR, Bonn, Germany
R. Mittal	MPIfR, Bonn, Germany
L. Mosoni	FOMI SGO, Pend, Hungary
M. Nanni	Istituto di Radioastronomia, Bologna, Italy
R. Porcas	MPIfR, Bonn, Germany
I. Pashchenko	Sternberg Astronomical Institute, Moscow, Russia
A. Polatidis	MPIfR, Bonn, Germany
T. Rector	NRAO, Socorro, USA
A. Richards	Jodrell Bank Observatory, Manchester, UK
A. Roy	MPIfR, Bonn, Germany
N. Seymour	Institute d'Astrophysique de Paris, France
L. Sjouwerman	NRAO, Socorro, USA
I. Snellen	Royal Observatory, Edinburgh, UK
R. Stark	NWO, The Hague, NL
Liu Xiang	Urumqi Astronomical Observatory, China
T. Venturi	Istituto di Radioastronomia, Bologna, Italy
J. Wrobel	NRAO, Socorro, USA
A. Zensus	MPIfR, Bonn, Germany
Zhang Xiuzhong	Shanghai Astronomical Observatory, China

Appendix 5

Presentations 2003

Avruch

"GMRT Damped Lyman-alpha absorber observations", poster, JENAM, Budapest, Hungary, 23-30 August.

Biggs

"Gravitational Lenses and VLBI", Future Directions in High Resolution Astronomy, 10th Anniversary of the VLBA, Socorro, USA Socorro, 11 June.
"New multi-frequency VLBI maps of the lens JVAS B2114+022", Bonn-Dwingeloo Neighbourhood Meeting, Dwingeloo, 5 November.

Bignall

"Radio Variability and Interstellar Scintillation of Blazars", Joint ASTRON-JIVE Colloquium, Dwingeloo, 28 March.
"ATCA radio monitoring of blazars observed with BeppoSAX" (poster), H.E. Bignall, A.K. Tzioumis, D.L. Jauncey, T. Venturi, R.W. Clay, 'The Restless High-Energy Universe' symposium, Amsterdam, 5-8 May.
"Interstellar scintillation of PKS 1257-326", NAC 2003, Kleve, Germany, 21 May.
"VLBA Snap-shot Imaging of Scintillating Sources" (poster), Ojha et al., VLBA 10th anniversary meeting 'Future Directions in High Resolution Astronomy', Socorro, New Mexico, USA, 9-12 June.
"The PKS 1257-326 Story", 'The Variable Radio Universe Workshop', Parkes Observatory, Australia, 10 July.
"Mapping the Local Interstellar Medium with Compact AGN", poster presented by Lovell (ATNF), Bignall, et al., at IAU Symposium 216 'Maps of the Cosmos', Sydney, Australia, 14-17 July.
"The Rapidly Scintillating Quasar PKS 1257-326", Joint Discussion 18 'Quasar Cores & Jets', IAU General Assembly, Sydney, Australia, 23 July.
"First Results from MASIV: the Micro-Arcsecond Scintillation-Induced Variability survey", poster presented by Lovell, Jauncey (ATNF), Bignall et al., at Joint Discussion 18 'Quasar Cores & Jets', IAU General Assembly, Sydney, Australia, 23-24 July.
"First Results from MASIV: the Micro-Arcsecond Scintillation-Induced Variability survey", poster presented by Bignall, Lovell (ATNF) et al., at 'Radio Astronomy at 70: from Karl Jansky to microjansky', JENAM-2003, Budapest, Hungary, 25-30 August.
"Interstellar Scintillation and Microarcsecond-scale Structure in Quasars", XXXIII YERAC, Bonn, Germany, 16 September.
"Using interstellar scintillation to study AGN jets at micro-arcsecond resolution", Bonn-Dwingeloo Neighbourhood Colloquium, Dwingeloo, 5 November.

Campbell

"The EVN Mark 4 Data Processor at JIVE", 16th Working Meeting for European VLBI in Geodesy & Astrometry, Leipzig, Germany, 9 May.
"Mark 5 at JIVE", EVN CBD meeting, Dwingeloo, 12 December.

Garrett

"EVN Access", "eVLBI", FP6/RadioNet proposal meeting, IRAM, Grenoble, France, 6 Feb
Various presentations, EVN CBD and JIVE Board meetings, Noto, Italy, 2-3 May.
"SKA Simulations & Massive Data Handling", FP6 SKA Design Study meeting, JBO, UK, 7-8 May
"SKA Simulations", FP6 SKA Design Study meeting, Schiphol, NL, 20 June.
"21st Century VLBI", Colloquium, Bonn, Germany, 8 April.
Various presentations to the RadioNet FP5/FP6, EVN CBD and JIVE Board Meetings, Dwingeloo, 12-13 December.
"Deep Field Radio Surveys", paper presented at JENAM, Hungary, 25-30 August.

Gurvits
“VLBI tracking of deep space probes”, SKA contract meeting, ESTEC, Noordwijk, NL, 20 January.
“Status and experience of the FP5 RadioNET contract”, FP6 RadioNet proposal meeting, IRAM, Grenoble, France, 6 February.
“VLBI as a deep space tracking tool”, ESA SKA/Huygens Project meeting, ESOC, Darmstadt, Germany, 13 March.
“VLBI technology developments and recent scientific results”, VIRAC, Riga, Latvia, 25 Mar
“News from Titan”, Astro-lunch, Dwingeloo, NL, 5 April.
“Status of the Huygens VLBI tracking project”, SKA and SVLBI meeting, ESTEC, Noordwijk, NL, 14 April.
EVN CBD and JIVE Board meetings, Noto, Italy, 2-3 May.

- FP4 TMR-LSF RTD project "Enhancing the European VLBI Network of Radio Telescopes";
- FP5 Infrastructure and Cooperation Network project RadioNET;
- Preparation of the EVN and JIVE biennial reports 2001-2002;
- Report on the visit to VIRAC (Latvia)
- Status of Space VLBI projects.

VLBA 10th anniversary meeting 'Future Directions in High Resolution Astronomy', Socorro, New Mexico, USA, 9-12 June.
“Millijansky milliarcsecond extragalactic radio sky”
“From IDV to Space VLBI and back: the story of J1819+3845”, poster
“Cores and jets in quasars at z > 4”, poster
“Millijansky extragalactic radio sky with milliarcsecond angular resolution”, D.L.Jauncey Colloquium, Parkes, Australia, 10 July.
“High-redshift quasars as beacons in protoclusters of galaxies”, IAU General Assembly, (IAU S. #216, together with A.Lobanov and S.Frey)
“Millijansky radio sky with milliarcsecond-scale resolution“, IAU General Assembly, (IAU S. #216), Sydney, Australia, 12-19 July.
“From IDV to Space VLBI and back: the story of J1819+3845”, IAU General Assembly, (IAU JD18), Sydney, Australia, 12-19 July.
“Interferometers larger than the Earth: lessons learned so far”, RSB-65 workshop on Masers and Molecules, Soro, Sweden, 18 September.
“News from EVN and RadioNet”, Work visit, VIRAC, Riga, Latvia, 23 September.
“Huygens VLBI tracking experiment”, Cassini-Huygens coordination meeting, JPL, Pasadena, CA, USA, 18 October.
“Toward 10,000 VLBI-imaged quasars”, Bonn-Dwingeloo Neighbourhood colloquium on High Resolution Radio Astronomy, Dwingeloo, NL, 5 November.
“RadioAstron status as seen by EVN”, RadioAstron meeting, Moscow, Russia, 20 November.
“Status of the Huygens VLBI tracking project”, Huygens project mid-term review meeting, 1 December.
“Status of the FP5 RadioNET project”, RadioNet meeting, Spier, NL, 11 December.
Several presentations on EC contracts, EVN Board meeting, Dwingeloo, NL, 12 December.

Imai
"The 3-D Kinematics of Water Masers in the W51A Region", VLBI Consortium symposium of Japan, Mitaka, Tokyo, Japan, 15-17 January.
"A collimated jet of molecular gas from an AGB star", Future Directions in AGB Research, on the occasion of the retirement of Harm Habing, Leiden, 10 April.
"A birth and growth of a collimated jet of molecular gas from an AGB star", LHEA Tuesday seminar, Laboratory of High Energy Astrophysics, Goddard Space Flight Center, NASA, 2 June.
"A birth and growth of a collimated jet of molecular gas from an AGB star", Future Directions in High Resolution Astronomy: A Celebration of the 10th Anniversary of the VLBA, Socorro, NM, 11 June.
"The 3-D Kinematics of Water Masers around the Semiregular Variable RT Virginis", Future Directions in High Resolution Astronomy: A Celebration of the 10th Anniversary of the VLBA, Socorro, NM, 8-12 June.

"The Kinematics, Physical Condition, and Magnetic Field of the W3 IRS5 Region Traced by Water Masers", Future Directions in High Resolution Astronomy: A Celebration of the 10th Anniversary of the VLBA, Socorro, NM, 8-12 June.

Van Langevelde

"Objectives of an archive at JIVE", Dwingeloo, 28 March.
"The status of the EVN Mark 4 correlator at JIVE", Madrid, 7 March.
"The parallax of 4 OH maser bearing variables", NAC, Kleve, 23 May.
"Astrometry of the OH masers of 4 Mira stars", poster, VLBA 10th anniversary meeting 'Future Directions in High Resolution Astronomy', Socorro, New Mexico, USA, 9-12 June.
"Magnetic fields in the Envelopes of late type stars", VLBA 10th anniversary meeting 'Future Directions in High Resolution Astronomy', Socorro, New Mexico, USA, 9-12 June. (standing in for Vlemmings)
"Molecular absorption in Cen A on VLBI scales; preserved VLBA data on formaldehyde", NRAO Socorro lunch talk, 15 July.
"Astrometry of circumstellar masers; the issue of the amplified stellar image", Booth Symposium, 19 September.
"Towards a large field of view archive for the EVN", poster, ADASS, Strasbourg, France, 12-15 October.
"Molecular absorption in Cen A on VLBI scales", Bonn-Dwingeloo exchange, Dwingeloo, 5 November.
"The status of the EVN Mark 4 correlator at JIVE", Bologna, 21 November.

Paragi

"The European VLBI Network: developments and results", Poster presented at the VLBA 10th Anniversary Conference "Future Directions in High Resolution Astronomy", Socorro, New Mexico, USA (did not participate in conference), 9-12 June 2003.
"Performance and reliability of the EVN", TOG Meeting, Robledo, Spain, 30 June.
"New Deal in European Astronomy: Trends and Perspectives", Poster at "High-resolution radio imaging of the most distant quasar", S. Frey, L. Mosoni, Z. Paragi, L.I. Gurvits, JENAM 2003 Conf., Budapest, Hungary, 25-30 August.

Parsley

"eVLBI Research in the European VLBI Network", AMPATH Conference, Miami, USA, 30 January.
"New Digital Techniques in VLBI", FP6 proposal meeting, Grenoble, France, 6 February.
"eVLBI Research in the European VLBI Network", Internet2 members meeting, Washington, USA, 10 April.
"EVN-NREN Proof-of-Concept Project", 2nd eVLBI Workshop, JIVE, Dwingeloo, Netherlands, 15 May.
"eVLBI Status", EVN TOG, Madrid, Spain, 30 June.
"VLBI as a test-bed application for GRID computing and related network infrastructure", IST Information Day, EC, Brussels, 14 July.
"Next Generation Data Transport for Very Long Baseline Interferometry", UKLight meeting, Manchester, UK, 3 November.

Reynolds

'Kinematics of the Jet in BL Lac", Reynolds, T. Cawthorne (UCLAN) and D. Gabuzda (Cork) presented a poster "10th anniversary of the VLBA", Socorro, New Mexico.
"Amplitude calibration of the EVN" , "SCHED developments" , EVN TOG mtg, Bologna, Italy, 30 June.
"eVLBI and the EVN", meeting of the 'Radio Telescope for Ireland' project in Cork, Ireland, 8 May.
"Kinematics of the Jet in BL Lac", poster, JENAM conference, Budapest, Hungary, 25-30 August.
"Kinematics of the Jet in BL Lac", YERAC conference, Bonn, Germany, 18 September.

Membership of international committees

Mr. J. Buiter

1992-	EVN Technical and Operations Group

Dr. M.A. Garrett

1997-2003	EVN Technical and Operations Group
1998-	ARISE Science Advisory Group
2003-	IAU Div X SOC
2003-	European SKA Consortium

Dr. L.I. Gurvits

1989-	RadioAstron International Scientific Council
1992-	VSOP International Scientific Council
1993-	URSI Global VLBI Working Group
1998-	ARISE Science Advisory Group

Dr. H.J. van Langevelde

1995-	EVN Technical and Operations Group
1995-	VSOP Science Review Committee (VSOP SRC)
1998-	Dutch national/NOVA education committee
1999-	EVN Programme Committee (EVNPC)
2001-	AIPS++ Users Group

Eur. Ing. S.M. Parsley

1998-	EVN Technical and Operations Group
2001-	GGF High Performance Networking Research Group

Appendix 7

Membership of professional associations and societies

Dr. I.M. Avruch

1993-	SIGMA Xi

Dr. R.M. Campbell

1983-	SIGMA Xi
1993-	American Astronomical Society
1996-	American Geophysical Union
2000-	International Astronomical Union

Dr. M.A. Garrett

1997-	International Astronomical Union

Dr. D.C. Gabuzda

2000-	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

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

Avruch

2nd eVLBI workshop, JIVE, Dwingeloo, NL, 15-16 May
JENAM, Budapest, Hungary, 22-31 August

Biggs
2nd eVLBI workshop, JIVE, Dwingeloo, NL, 15-16 May
"Future Directions in High Resolution Astronomy", VLBA, Socorro, USA, 8-12 June
JENAM, Budapest, Hungary, 22-31 August

Bignall
"The restless high energy Universe", Amsterdam, NL, 6 May
2nd eVLBI workshop, JIVE, Dwingeloo, NL, 15-16 May
Dutch Astronomers Conference, Kleve, Germany, 21-23 May
"The Variable Radio Universe", Parkes, NSW, Australia, 10-11 July
IAU General Assembly, Sydney, Australia, 12-27 July
JENAM, Budapest, Hungary, 22-31 August
YERAC, Bonn, Germany, 15-20 September

Buiter
2nd eVLBI workshop, JIVE, Dwingeloo, NL, 15-16 May

Campbell
4th IVS Analysis Workshop, Paris, France, 3-4 April
16th Working Meeting on European VLBI in Geodesy and Astrometry, Leipzig, Germany, 9-10 May
2nd eVLBI workshop, JIVE, Dwingeloo, NL, 15-16 May
IAU General Assembly, Sydney, Australia, 12-27 July

Garrett
2nd eVLBI workshop, JIVE, Dwingeloo, NL, 15-16 May
"Future Directions in High Resolution Astronomy", VLBA, Socorro, USA, 8-12 June
"The Neutral ISM in Starburst Galaxies", Gothenburg, Sweden, 23-26 June
JENAM, Budapest, Hungary, 22-31 August
ESAC meeting, Madrid, Spain, 31 Aug-1 September
"Masers and Molecules", RSB 65th, Gothenburg, Sweden, 17-19 September

Gurvits
"Future Directions in High Resolution Astronomy", VLBA, Socorro, USA, 8-12 June
"The Variable Radio Universe", Parkes, NSW, Australia, 10-11 July
IAU General Assembly, Sydney, Australia, 12-27 July
JENAM, Budapest, Hungary, 22-31 August
"Masers and Molecules", RSB 65th, Gothenburg, Sweden, 17-19 September

Imai
Future Directions in AGB Research, Leiden, NL, 10-11 April
2nd eVLBI workshop, JIVE, Dwingeloo, NL, 15-16 May

Seminar about W43A, Lab. Of High Energy Astrophysics, GSFC, NASA, Greenbelt, USA, 1-3 June
“Future Directions in High Resolution Astronomy”, VLBA, Socorro, USA, 8-12 June
JENAM, Budapest, Hungary, 22-31 August

Van Langevelde

Future Directions in AGB Research, Leiden, NL, 10-11 April
2nd eVLBI workshop, JIVE, Dwingeloo, NL, 15-16 May
Dutch Astronomers Conference, Kleve, Germany, 21-23 May
“Future Directions in High Resolution Astronomy”, VLBA, Socorro, USA, 8-12 June
“Masers and Molecules”, RSB 65th, Gothenburg, Sweden, 17-19 September
ADASS Conference, Strasbourg, France, 11-16 October

Olnon

2nd eVLBI workshop, JIVE, Dwingeloo, NL, 15-16 May
ADASS Conference, Strasbourg, France, 11-16 October

Paragi

2nd eVLBI workshop, JIVE, Dwingeloo, NL, 15-16 May
JENAM, Budapest, Hungary, 22-31 August

Parsley

2nd eVLBI workshop, JIVE, Dwingeloo, NL, 15-16 May

Pogrebenko

2nd eVLBI workshop, JIVE, Dwingeloo, NL, 15-16 May
“Planetary Probe Atmospheric Entry and Descent Trajectory Analysis and Science”, Lisbon, Portugal, 5-10 October

Reynolds

2nd eVLBI workshop, JIVE, Dwingeloo, NL, 15-16 May
“Future Directions in High Resolution Astronomy”, VLBA, Socorro, USA, 8-12 June
JENAM, Budapest, Hungary, 22-31 August
YERAC, Bonn, Germany, 15-20 September

Schonewille

2nd eVLBI workshop, JIVE, Dwingeloo, NL, 15-16 May

Szomoru

2nd eVLBI workshop, JIVE, Dwingeloo, NL, 15-16 May
ADASS Conference, Strasbourg, France, 11-16 October

Verkouter

2nd eVLBI workshop, JIVE, Dwingeloo, NL, 15-16 May
Dutch Astronomers Conference, Kleve, Germany, 21-23 May
ADASS Conference, Strasbourg, France, 11-16 October

2. International meetings attended by JIVE staff members

Buiter

EVN TOG meeting, Madrid, Spain, 30 June

Campbell

4th IVS Analysis Workshop, Paris, France, 3-4 April
16th Working Meeting on European VLBI in Geodesy and Astrometry, Leipzig, Germany, 9-10 May

EVN TOG meeting, Madrid, Spain, 30 June
Huygens Tracking Meeting, ESTEC, Noordwijk, NL, 2 July
EVN CBD meeting, Dwingeloo, NL, 12 December

Garrett

EVN-NREN Proof of Concept project meeting, Schiphol, NL, 15 January
FP6/RadioNet proposal meeting, Grenoble, France, 6 February
FP6 Information day on Research Infrastructures, Brussels, Belgium, 25 Mar ch
EVN CBD meeting, Noto, Italy, 2 May
JIVE Board meeting, Noto, Italy, 3 May
FP6 Design Study meeting, Jodrell Bank, Manchester, UK, 7-8 May
FP6 Design Study coordination meeting, Schiphol, NL, 20 June
SKA meeting, Geraldton, Australia, 26 July-4 August
FP6 Design Study Coordination mtg, Nancay, France, 10-12 September
SKA meeting, Leiden, NL, 10-14 November
FP6 SKA meeting, Arcetri Obs, Florence, Italy, 25-30 November
RadioNet Board meeting, Spier, NL, 11 December
EVN CBD meeting, Dwingeloo, NL, 12 December
JIVE Board meeting, Dwingeloo, NL, 13 December

Gurvits

SKA contract meeting, ESTEC, Noordwijk, NL, 20 January
FP6/RadioNet proposal meeting, Grenoble, France, 6 February
Mid-term review meeting ESA ASTRON & JIVE contract, Darmstadt, Germany, 12-13 March
Huygens VLBI tracking consultations, ESTEC, Noordwijk, NL, 20 March
SVLBI and Huygens project meetings, ESTEC, Noordwijk, NL, 9 April
SKA and SVLBI meeting, ESTEC, Noordwijk, NL, 24 April
EVN CBD meeting, Noto, Italy, 2 May
JIVE Board meeting, Noto, Italy, 3 May
FP6 Design study meeting, Jodrell Bank, Manchester, UK, 7-8 May
ASTRON/JIVE and RHEA ESA/SKA contract coordination meeting, Louvain, Belgium, 17 June
FP6 Design Study coordination meeting, Schiphol, NL, 20 June
SKA meeting, Geraldton, Australia, 26 Jul-4 August
FP6 Design Study Coordination mtg, Nancay, France, 10-12 September
Huygens project – Technical assessment mtg at JPL, Pasadena, USA, 15-19 October
Discussion on SKA-Huygens contract, preparation for VSOP-2 kick-off activities, ESA, Paris, France, 21 October
SKA meeting, Leiden, NL, 10-14 November
28th mtg of the RadioAstron International Science Council, Moscow, Russia, 19-22 November
Huygens project mid-term review meeting, ESTEC, Noordwijk, NL, 1 December
RadioNet Board meeting, Spier, NL, 11 December
EVN CBD meeting, Dwingeloo, NL, 12 December
JIVE Board meeting, Dwingeloo, NL, 13 December
Huygens project coordination meeting, ESTEC, Noordwijk, NL, 17 December

Imai

Meeting on IRAS 19134+2131 study, Univ. of California, LA, USA, 16-22 June

Kramer

EVN Archive meeting, Dwingeloo, NL, 28 March

Van Langevelde

EVNPC meeting, Madrid, Spain, 7 March
EVN Archive meeting, Dwingeloo, NL, 28 March
EVN PC meeting, Bologna, Italy 20-22 November
EVN CBD meeting, Dwingeloo, NL, 12 December

Leeuwinga

2nd IVS Technical Operations Workshop, Haystack, USA, 20-26 September

Olnon

EVN Archive meeting, Dwingeloo, NL, 28 March

Paragi

4th IVS Analysis Workshop, Paris, France, 3-4 April
EVN TOG meeting, Madrid, Spain, 30 June

Parsley

EVN-NREN Proof of Concept project meeting, Schiphol, NL, 15 January
AMPATH Conference, Miami, USA, 29-31 January
FP6/RadioNet proposal meeting, Grenoble, France, 6 February
Internet2 members meeting, Washington, DC, USA, 7-11 April
UKLight application meeting, University College London, UK, 3-4 June
Final SERENATE Workshop, Frankfurt, Germany, 16-17 June
EVN TOG meeting, Madrid, Spain, 30 June
IST Information day, Brussels, Belgium, 14-15 July
UKLight exploitation meeting, Manchester, UK, 3-4 November

Pogrebenko

EVLA correlator meeting, Penticton, Canada, 26-29 January

Reynolds

EVN Archive meeting, Dwingeloo, NL, 28 March
“A radio telescope for Ireland”, Cork, Ireland, 7-9 May
EVN TOG meeting, Madrid, Spain, 30 June

Schonewille

2nd IVS Technical Operations Workshop, Haystack, USA, 20-26 September

Szomoru

EVN-NREN Proof of Concept project meeting, Schiphol, NL, 15 January
SURFnet seminar, Amsterdam, 19 June

Verkouter

SURFnet seminar, Amsterdam, 19 June

3. Working visits by JIVE staff members

Buiter

Mark 5P upgrade to Mark 5A, MPIfR, Bonn, Germany, 4-6 February
Upgrade of Data Playback Units, Shanghai, China, 22 November-5 December

Campbell

Goddard Space Flight Center, Greenbelt, MD, USA, 30 October

Garrett

Re-launch of Lovell telescope, UK, 28 April
PhD Thesis examiner at Manchester, UK, 18 December

Gurvits

VIRAC, Riga, Latvia, 25-29 March
Jodrell Bank Observatory, 27-28 May
Lecturing and FP6 collaboration at VIRAC and Riga Univ., Latvia, 20-30 September

Imai
Nobeyama Millimeter Array, Nobeyama Radio Observatory, Japan, 8-14 January
Jodrell Bank Observatory, Manchester, UK, 29 April-6 May

Kramer
ASTRO-WISE, Valentijn, Groningen, NL, 16 September

Leeuwinga
Mark 5P upgrade to Mark 5A, MPIfR, Bonn, Germany, 4-6 February

Olnon
ASTRO-WISE, Valentijn, Groningen, NL, 16 September

Paragi
FOMI SGO, Penc, Hungary, 6-17 January

Parsley
Metrum Information Storage Ltd., Wells, UK, 26-28 March

Appendix 9

All project activity during 2003

Expt No.	Obs.	P.I.	Type	Correlated	Distributed	Released	Support Person
ES023	241198	Schilizzi	PILOT	(191102)	(171202)	180303	Campbell
RTC001	170200	Verkouter	ABAN	151203	151203	151203	Van Langevelde
EP037A	200900	Phillips	USER	060503	100603	050903	Bignall
ED015	230900	Desmurs	USER	(131002)	060203	280903	Avruch
EM040	240900	Minier	USER	(041002)	(111002)	210803	Imai
EP037B	270900	Phillips	USER	(100602)	(230902)	040903	Phillips
EV009B	220201	Vlemmings	USER	(260402)	(301002)	280803	Van Langevelde
GM041B	260201	Morganti	USER	(121202)	(121202)	030403	Imai
GG046	310501	Gabuzda	USER	(201201)	290103	280803	Avruch
EP039	081101	Pestalozzi	USER	(200902)	(291102)	100303	Avruch
ED018A	091101	Desmurs	USER	130103	200103	180303	Campbell
ED018B	101101	Desmurs	USER	140103	200103	180303	Campbell
EV012	121101	Voronkov	USER	(181002)	(141102)	250203	Avruch/Biggs
EP034A	211101	Pihlstrom	USER	210103	040203	250303	Van Langevelde
EP034B	221101	Pihlstrom	USER	(280202)	060203	250303	Van Langevelde
ED019B	231101	Desmurs	USER	(071102)	(151102)	240203	Imai
EP041B	070202	Phillips	USER	100203	170203	280903	Van Langevelde
ED020	130202	Diamond	USER	060203	110203	050903	Campbell
EP042A	170202	Polatidis	USER	270103	030203	280803	Campbell
EP042B	180202	Polatidis	USER	130303	200303	020903	Campbell
GP032	270202	Polatidis	USER	(100902)	(291102)	250203	Campbell
GK022	010302	Kharb	USER	(300902)	(121202)	250203	Campbell
EG024	250502	Gabuzda	USER	200203	030303	100903	Bignall
ER014	260502	Rector	USER	230103	030203	280803	Avruch
EG026	270502	Giroletti	USER	290103	130203	050903	Avruch
EG025	290502	Garrington	USER	070103	150103	250203	Campbell
GF010	300502	Frey	USER	200103	280103	250203	Campbell
ES044	040602	Stanghellini	USER	(181202)	030103	250203	Imai/Campbell
EG023	070602	Giroletti	USER	180303	020403	050903	Bignall
DT004	241002	Reynolds	TEST	200503	200503	200503	Reynolds
EB023A	081102	Bondi	USER	310103	180203	050903	Bignall
GG048A	081102	Garrington	USER	240303	080403	050903	Campbell
ES046	091102	Smith	USER	280303	070403	100903	Avruch
EB024A	121102	Beswick	ABAN	060103	060103	060103	Avruch
EB024B	131102	Beswick	ABAN	060103	060103	060103	Avruch
EB024C	151102	Beswick	ABAN	060103	060103	060103	Avruch
EF009B	151102	Filho	ABAN	210103	220103	220103	Van Langevelde
N02L3	171102	Paragi	NME	(201202)	280103	280203	Paragi
GV016	181102	Vermeulen	USER	250303	080403	030903	Van Langevelde
ED023	211102	Diamond	USER	030403	230403	050903	Campbell
R03N1	220103	All telescopes	NME	240103	250103	280203	Parsley
F03K1	040203	Polatidis	NME	170203	180203	280203	Paragi
TADU5	050203	Foley	TEST	080203	100203	180303	Biggs
EI005A	090203	Imai	USER	170403	240403	010903	Imai/van Langevelde
N03K1	090203	Paragi	NME	270303	090503	080903	Paragi
COR19	180203	Shu Fengchun	TEST	070303	100303	190303	Paragi
N03L1	250203	Paragi	NME	100303	210303	061003	Paragi
DT005	120303	Reynolds	TEST	280403	280403	030603	Reynolds

Expt No.	Obs.	P.I.	Type	Correlated	Distributed	Released	Support Person
TADU6	120303	Paragi	TEST	240303	240303	120503	Paragi
R03N2	010403	All Telescopes	NME	260503	260503	280803	Parsley
TADU7	090503	Paragi	TEST	190503	260503	050903	Biggs
F03L2	190503	Polatidis	NME	030603	030603	280803	Paragi
EM051	220503	McHardy	USER	180603	100703	050903	Avruch
EB023C	230503	Bondi	USER	260603	020903	071203	Bignall
EB024D	230503	Beswick	USER	200603	301003	191203	Bignall/Biggs
EB024E	240503	Beswick	USER	300603	301003	191203	Bignall/Biggs
EF009C	250503	Filho	USER	290703	190903	101203	Avruch
EB024F	260503	Beswick	USER	280803	301003	191203	Bignall/Biggs
EP042E	260503	Polatidis	USER	131003			Campbell
EC020B	270503	Conway	USER	250703	061003	101203	Bignall
ER16B1	280503	Rovilos	USER	181103	181203		Reynolds
N03L2	280503	Paragi	NME	160603	080903	080903	Paragi
ER16B2	290503	Rovilos	USER	251103	181203		Reynolds
GM049A	300503	Macquart	USER	240903	061103		Avruch
GM049B	310503	Macquart	USER	011003	181103		Avruch
D03C1	020603	Paragi	TEST	220903	201003	051203	Paragi
D03C2	030603	Paragi	TEST	220903	201003	051203	Paragi
GJ010A	030603	Jackson	USER	131103			Campbell/Biggs
EM053A	050603	Moscadelli	USER	161203			Bignall
ED018C	060603	Desmurs	USER	020903	051203		Campbell
EM053B	060603	Moscadelli	USER	191203			Bignall
N03M1	060603	Paragi	NME	230603	080903	080903	Paragi
ED018D	070603	Desmurs	USER	010903	051203		Campbell
EN001	080603	Niezurawska	USER	021203			Avruch
EM049	090603	Moscadelli	USER	241203			Bignall
EI005C	100603	Imai	USER	111203			Van Langevelde/ Reyolds
EL031B	110603	Van Langevelde	USER	100903	011003	081203	Van Langevelde
BF073C	300703	Fomalont	USER	201003	251103		Campbell
BF073D	310703	Fomalont	USER	241003	251103		Campbell
R03N3	230903	All telescopes	NME	171103	241103	271103	Schonewille
F03X1	201003	Polatidis	NME	161203			Paragi
F03C1	241003	Polatidis	NME	041103	051103	051203	Paragi
N03C1	291003	Paragi	NME	051203			Paragi
TEVLB4	041103	Foley	TEST	051103	061103	141103	Paragi
TEVLB5	061103	Foley	TEST	071103	131103	141103	Paragi
N03L3	071103	Paragi	NME	041203			Paragi
TEVLB6	181103	Reynolds	TEST	181103	241103		Reynolds
TEVLB7	241103	Reynolds	TEST	241103	251103		Reynolds

Appendix 10

List of acronyms

ADiTiV	- Advanced Digital Techniques in VLBI
AGB	- Asymptotic Giant Branch (stars)
AGN	- Active Galactic Nuclei
ALBUS	- Advanced Long Baseline User Software
ANGLES	- Astrophysics Network for Galaxy LEnsing Studies
ATCA	- Australia Telescope Compact Array
BBC	- BaseBand Converter
BBFTP	- BroadBand File Transfer Protocol
BOCF	- Beginning of Correlator Frame
CAS	- Chinese Academy of Sciences
CLASS	- Cosmic Lens All-Sky Survey
CNR	- Consiglio Nazionale delle Richerche (Italy)
CPU	- Central Processor Unit
CRL	- Communications Research Laboratory, Japan
CRM	- Channel Recovery Module
DDD	- Data to Disk Distributor
DDU	- Data Distributor Unit
DEVOS	- Deep Extragalactic VLBI-Optical Survey
DPU	- Data Playback Unit
DSP	- Digital Signal Processing
DWDM	- Dense Wavelength Division Multiplexing
EMBRACE	- Electronic Multi-Beam Radio Astronomy Concept
ESA	- European Space Agency
eVLBI	- electronic VLBI
EVN	- European VLBI Network
EVN CBD	- EVN Consortium Board of Directors
EVN TOG	- EVN Technical Operations Group
FITS	- Flexible Image Transport Systems
FP6	- Framework Programme 6
FTP	- File Transfer Protocol
GNU	- GNU's Not Unix
HP	- Hewlett-Packard
HST NICMOS	- Hubble Space Telescope Near Infrared Camera and Multi-Object Spectrometer
IECS	- Institute of Electronics and Computer Science
IGN	- Instituto Geografico Nacional (Spain)
IP	- Internet Protocol

JBO	- Jodrell Bank Observatory
JCCS	- JIVE Correlator Control Software
JENAM	- Joint European National Astronomy Meeting
KNAW	- Koninklijke Nederlandse Akademie van Wetenschappen
MERLIN	- Multi-Element Radio Linked Interferometer Network
MoU	- Memorandum of Understanding
MPIfR	- Max Planck Institut für Radioastronomie (Germany)
NME	- Network Monitoring Experiment
NREN	- National Research and Education Network
NWO	- Nederlandse Organisatie voor Wetenschappelijk Onderzoek
OSO	- Onsala Space Observatory (Sweden)
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
RFI	- Radio Frequency Interference
SDSS	- Sloan Digital Sky Survey
SKA	- Square Kilometer Array
SU	- Station Unit
TCP	- Transmission Control Protocol
TOT	- Telescope Observe Time
TRM	- Track Recovery Unit
PROM	- Programmable Read Only Memory
TSPU	- Test Synchronization and Pulsar gate Unit
UDP	- User Datagram Protocol
UT	- Universal Time
VEX	- VLBI Experiment Description format
VIRAC	- Ventspils International Radio Astronomy Center
VLA	- Very Large Array
VLBA	- Very Long Baseline Array
VLBI	- Very Long Baseline Interferometry
VSN code	- Volume Serial Number

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