Joint Institute for VLBI in Europe



Annual Report 2001

# ANNUAL REPORT OF THE JOINT INSTITUTE FOR VLBI IN EUROPE 2001

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# Foreword by the Chairman of the JIVE Board

This is the first time in four years that JIVE is publishing its report on activities separately from EVN. The EVN Consortium Board of Directors decided in 2000 to issue its reports every two years.

In 2001 a total of 61 experiments counting both EVN user projects and Network Monitoring Experiments (NMEs) have been successfully processed by the EVN correlator at JIVE. The NMEs are now processed using an automatic data analysis pipeline that allows rapid and comprehensive feedback to the Network on telescope performance. A reliability indicator has been defined for the EVN performance; the goal is a maximum of 10% of data lost. The good reliability of the processor and the relatively short time elapsed before correlation of the EVN projects allowed the staff to improve the processor capabilities. Digital Signal Processors were installed to improve the data rate with now all 32 correlator boards usable simultaneously. Work has also started to diminish the dump time when all correlator chips are used, and a new plan has been accepted to implement the Post Correlation Integrator.

In parallel with service duties and new technical developments the JIVE staff has remained extremely active in scientific programs and in training and education activities. Important science results have been obtained in AGNs and in distant extragalactic sources as well as in spectral line studies. The publication record of the JIVE staff is excellent with a total of 31 refereed and conference proceedings papers.

Reorganization of the JIVE Processor Group has been appropriately implemented for better efficiency in the two divisions of the Group involved in science and technical operations and in R&D activities. In addition, JIVE continues to successfully manage the European IHP Access to Research Infrastructures Programme for the EVN and the benefit of all EVN users.

Following the ESF Panel's recommendations on long-term financing of JIVE the Board held a number of meetings on JIVE operations and the first results of discussions with National Research Councils. The current consensus for a solid financial basis and future organizational structure implies a modification of the statutes of the JIVE foundation. The Board is taking action to be ready for this new situation and a conclusion, which keeps the original mission of JIVE untouched, is expected in 2002.

I warmly congratulate the JIVE Director and staff for their successful effort to maintain the European data processor activities at the highest level, and for their constant efforts in promoting VLBI techniques and research.

Alain Baudry, Observatoire de Bordeaux, France

# 1. Report from the Director

The institute continued to flourish during the year with a lively mix of activities from front-line astronomical research to state-of-the-art technical innovations, in addition to its support for most phases of VLBI operations in Europe. JIVE was also host to a substantial number of visitors, many of whom were supported by the EC IHP Access to Major Research Infrastructure Programme.

This last year has been one of consolidation for data processor operations in JIVE, but at the same time one of expansion of capabilities. The correlator is now the processor of choice for most EVN observations; a total of 41 user observations and 20 Network Monitoring Experiments and other Test observations were processed during the year. This was sufficient to keep up with the flow of data from the network despite 50% of the time being used for development and fringe search work rather than production.

Several important developments to improve the capabilities of the data processor were implemented. These include DSP chips installed on the correlator boards to greatly increase the capacity of the processor; the correlation of 16+ station observations; and the expansion of the output data rate to allow readout of the 4 correlator racks in parallel. The EVN data processor and support group also played a pivotal role in testing and successfully demonstrating the capability of the EVN to operate at a sustained rate of 512 Mbit/sec. Feedback of data quality to the EVN stations from the NMEs was streamlined early in the year with the successful implementation of a pipeline data reduction system based on the MERLIN pipeline. One noteworthy result from an NME experiment at 5 GHz was the demonstration that the theoretical noise limit (33 micro Jansky/beam for a 4-hour observation at 256 Mbit/sec) can be achieved with the EVN on weak sources where dynamic range limitations are not an issue. This augurs well for faint source VLBI observations.

2001 also saw the initiation of several key developments that will form a significant part of our research and development focus over the next year. In particular, mention should be made of the Post Correlation Integrator project designed to increase the data output rate of the correlator by a factor of 500. The PCI design was re-evaluated after the summer and a decision taken to abandon the (now obsolete) Monaco board in favour of a non-DSP solution involving low-cost single board computing. Full funding for the PCI has been obtained from NWO and the EVN institutes. The EVN's participation in the next generation of VLBI data transport systems also gathered pace. In addition to supporting Haystack Observatory's Mk5 system, the EVN Consortium also encouraged staff at JIVE and Metsähovi Radio Observatory to collaborate on the PC EVN project. This aims to develop a single, off-the-shelf and scalable PC platform that will support both disk and eVLBI (fibre) systems. Our plans for eVLBI were given a considerable boost by the news late in the year that the financial resources had been found in the Gigaport project and NWO to connect the institutes in Dwingeloo to the SURFnet point of presence at SARA in Amsterdam by managed dark fibre with an initial capacity of 1 Gbit/sec per wavelength.

Following deliberations on the report of the Review Panel on the EVN and JIVE set up by the European Science Foundation (see the Annual Report for 2000), NWO agreed to contribute its 30% share (€453000 per annum) of the JIVE operating costs, on the condition that commitments on the contributions to cover the remaining 70% of the operating costs were forthcoming from Research Organisations in the other EVN countries within a year. The aim is to create a stable financial structure for the institute on a recurring 5-year basis and to embed it organizationally within the Research Organisations. At year's end, progress had been made in a number of countries, and the expectation is that a decision will be made by mid-2002.

JIVE staff continued to contribute to a number of different areas of astronomical research. Highlights of the astronomical research include comprehensive polarization studies of BL Lac objects, including BL Lac itself, with both Space and ground-based VLBI arrays. Clear evidence of absorption occurs in 0735+178 at the first bend in the jet suggesting that these bends are caused by interactions with dense clouds in the nucleus. Small-scale structure has been detected in global VLBI observations of the gravitational lens system 0218+357, which should supply tight constraints on the lens model. The far IR-radio luminosity 4



Figure 1. His Royal Highness, the Crown Prince of the Netherlands Willem-Alexander, and his fiancée Ms. Maxima Zorreguieta visit the EVN Mk4 Data Processor at JIVE, 16 November 2001 (Photo W.J. Kleppe)

correlation for star-forming galaxies has been shown to continue out to redshifts of at least 1.3. And the VSOP Survey of extragalactic sources is nearing the end with a public release of this unique database expected in 2002. During the year, 31 papers were published and a further 19 were either in press or submitted for publication. Fifty-seven presentations were made outside Dwingeloo.

A proposal to the European Commission for a continuation of the IHP Access to Research Infrastructures Programme for the EVN was favourably received; the new contract will be in force for 2 years starting in January 2002. A proposal to the Commission to fund a pilot project for an optical fibre-linked EVN via the Grid test beds and deployment action was not successful. It was decided to implement a scaled-down version of the project from our own resources, and reapply for Commission support at a later stage.

Finally, we were honoured to receive His Royal Highness, the Crown Prince of the Netherlands Willem-Alexander, and his fiancée Ms. Maxima Zorreguieta during their visit to ASTRON and JIVE in November 2002 (Fig. 1).

**R.T. Schilizzi** 5

# 2. Scientific research

The scientific staff of the Institute continued to combine their service duties with astronomical studies in a broad range of research fields, mostly but not exclusively, using VLBI techniques.

#### 2.1. VLBI and other surveys of extragalactic sources

M. Garrett completed an analysis of the FIR/Radio correlation for high-z star forming galaxies in the Hubble Deep Field. The analysis, based on the WSRT observations, shows that the famous correlation continues to apply to the most distant ISO/WSRT detections (out to  $z \sim 1.3$ , Fig. 2). Outliers from the linear correlation are easily identified as AGN (in particular, two of the outliers were detected by the EVN HDF wide-field observations). A letter summarizing this study is to appear in Astronomy and Astrophysics.



**Figure 2.** A logarithmic plot of the FIR vs Radio luminosity of the high-z WSRT/ISO HDF sample. The FIR-radio correlation extends towards at least z ~ 1 (Garrett 2002, A&A 384, L19).

Multi-epoch 6 cm VLBI snapshot observations of 241 of the 293 Caltech-Jodrell flat-spectrum (CJF) sample were discussed in last year's report. S. Britzen (U Heidelberg), R. Campbell, and others have completed model-fitting these observations, and have prepared an initial

statistical description of the kinematics of the jet components of these CJF sources. Proper motion and  $\beta_{app}$  are investigated as a function of source class (viz., quasar, galaxy, BL Lac, unclassified), redshift, and luminosity (Fig. 3). The behavior of the innermost jet component in each source is treated separately from the ensemble statistics of all jet components.



**Figure 3.** Apparent proper motion,  $\beta_{app}$ , as a function of redshift (top panel) and luminosity (bottom panel) for CJF sources of different classes (Britzen et al. 2002, in preparation).

Possible biases from the number of observing epochs or total time spanned across observations per source have been investigated. Finally, the relationships between velocities and redshift or luminosity provide a means to infer



**Figure 4.** VLBI images of the quasar 0133+476 (J0136+4751) from (a) Polatidis et al. 1995 (ApJS 98, 1) at 1.6 GHz, (b) USNO RRFID survey at 2.3 GHz, (c) VLBApls by Fomalont et al. 2000 (ApJS 131, 95), (d) USNO RRFID survey at 8.6 GHz, (e) VSOP Survey at 5 GHz by Hirabayshi et al. 2000 (PASP 52, 997), and (f) VSOP 15 Ghz support survey at 15 GHz by Gurvits et al. (2002, in preparation). The RRFID images are obtained at the US Naval Observatory, courtesy A.Fey (see also Fey & Charlot 2000, ApJS 128, 17). For further details see Gurvits 2002, Proceedings of IAU Colloquium No. 184, in press.

characteristics (e.g., intrinsic distributions of Lorentz-factors, jet orientations, unbeamed luminosities) of the parent populations of the various classes within the framework of AGN unification models.

L.Gurvits together with K. Kellermann. E. Fomalont (NRAO, USA) and H. Zhang (NAO, China) continued post-correlation data processing of the 15 GHz VLBA survey conducted in support of the VSOP Survey of extragalactic sources. The survey consists of 95 sources from the VSOP Survey sample which otherwise have not been observed at 15 GHz with VLBA by Kellermann et al. (1998 AJ 115, 1295). The survey will complete the groundbased VLBI support for the VSOP Survey and together with other VLBI surveys will create a comprehensive database of milliarcsecond-scale radio structures in several hundred AGN. Fig. 4 shows an example of images of one AGN, 0133+476, from various VLBI surveys.

I. Avruch and L. Gurvits continued to participate in the VSOP Survey data reduction. This Survey has been carried out at 5 GHz by the VSOP mission and includes about 290 of the strongest flat-spectrum extragalactic radio sources, mostly AGN. The Survey will create a unique database of sub-miiliarcsecond-scale radio structures in these sources, accessible at this frequency only with baselines larger than Earth. An example of VSOP Survey image is given in Fig. 4e. A public release of the VSOP Survey database is scheduled for 2002 (http://www.vsop.isas.ac.jp/).

S. Garrington (Jodrell L. Gurvits, Bank Observatory, UK), S. Frey (FÖMI Satellite Geodetic Obsevatory, Hungary) and M. Garrett conducted MERLIN observations of two fields (one equatorial and one near the North Galactic Pole) containing AGNs identified in the Sloan Digital Survey. These observations form part of the pilot project for the Deep Extragalactic VLBI - Optical Survey (DEVOS). The observations were aimed at selecting targets for future VLBI observations. During a visit to the Jodrell Bank Observatory, Gurvits produced preliminary MERLIN images of all 89 targets in both fields observed. The VLBI part of this pilot project will be conducted in 2002.

L. Gurvits and K. Berzins (Ventspils International Radio Astronomy Center, Latvia) worked on a sample of extragalactic sources with flat or 8 inverted spectra at frequencies above 10 GHz observed with the global VLBI network at 22 GHz. These sources are believed to be the younger counterparts of what will become Compact Symmetric Objects later in their evolution.

# 2.2. Studies of AGN and other types of extragalactic radio sources

C. Revnolds completed a study of Faraday rotation in the VLBI core of BL Lacertae (MNRAS, 327, 1071). Fig. 5 shows a rotation measure (RM) map of BL Lac. The RM in the core is ~450 rad  $m^{-2}$ , much higher than expected from the low integrated RM measured in previous VLA observations. This indicates that the amount of thermal gas in the immediate vicinity of this source may be larger than previously thought. The jet also has a small RM (~ 110 rad  $m^{-2}$ ), probably due to a foreground screen. The value of the jet RM is inconsistent with the previously accepted value of the foreground RM towards this object (inferred from VLA observations) and so this result has important consequences for the interpretation of the magnetic field alignment in this source. Two further epochs of observations were obtained in 2001 to study variability in the RM of a small sample of BL Lac objects.



**Figure 5.** Colour rotation-measure map of BL Lac made from observations at 5, 8 and 15 GHz. The overlaid contours are the 5 GHz total intensity image. The contours are at 0.3, 0.6 ... 76.8 % of the peak of 1.7 Jy/beam (Reynolds et al. 2001, MNRAS 321, 1071)

D. Gabuzda and V. Chernetskii (Moscow State University) worked on the analysis of multiepoch dual-frequency (8 and 22 GHz) VLBI data for the BL Lac object 1803+784. The images show superluminal motion of a component between the core and a quasi-stationary feature about 1.5 mas from the core. Although the emission from the inner part of the jet is steep, as expected, the spectral index of this stationary feature is relatively flat, suggesting the presence of low-frequency absorption, or possibly reacceleration of electrons at this location.



**Figure 6.** Joint analysis of VSOP and VLBA polarization observations of 0735+178 enabled the detection of low-frequency absorption in the VLBI jet (red region to the east of the core, top), and gave hints of regions with enhanced rotation measure in the VLBI structure (bottom) (Gabuzda, Gomez & Agudo 2001, MNRAS 328, 719).

One additional epoch for which four-frequency (5, 8, 15, and 22 GHz) data were available had earlier revealed the presence of a non-uniform distribution of thermal plasma in the vicinity of the VLBI structure. These multi-epoch data allow the investigators to place limits on variability of the distribution of Faraday rotation near the core and inner VLBI jet.

Comparison of Gabuzda's earlier 5 GHz VSOP Space VLBI total intensity and polarisation images of the BL Lacertae object 0735+178 with 15 GHz VLBA images (with nearly the same angular resolution) obtained by J.-L. Gomez about a month later revealed appreciable absorption near the first of two nearly 90-degree bends in the VLBI jet, consistent with free-free absorption (Fig. 6). This suggests that these bends are associated with a collision or interaction with a dense cloud. More recently, a comparison of the two polarisation images has suggested that there are regions of enhanced rotation measure (thermal plasma) near these bends, consistent with the presence of lowfrequency absorption in this region.

A. Biggs has been working on the reduction of an 8.4-GHz Global VLBI dataset of the lens system B0218+357, the smallest Einstein ring (Fig. 7). This study resulted in detection of previously unknown lensed structure in both the lensed images. This should make it possible to eventually better constrain the lens model and hence the Hubble parameter.

D. Gabuzda, M. Garrett, L. Gurvits and R. Schilizzi continued to be actively involved in collaboration with Chinese colleagues sponsored through a special grant by the Royal Dutch Academy of Science (KNAW) and the Chinese Academy of Sciences (CAS). In 2001, two PhD theses were defended by graduate students in China under co-supervision by JIVE staff members: Zhang Hai-Yan (Beijing Normal University), co-supervised by L. Gurvits, and Jin Cheng-Jin (Beijing Astronomical Observatory), co-supervised by M. Garrett. Several VLBI studies of AGN and radio galaxies have been completed in 2001 and are in different phases of publication. In particular, the JIVE-ShAO collaboration studied two radio- and Gammaloud quasars, 1156+295 and 1624+416, which are distinguished by well pronounced 'core-jet' radio structure with bent jets. Fig. 8 shows radio spectral index distribution in these.



JVAS B0218+357

**Figure 7.** Global VLBI image of the two images (A - top, B - bottom) of the gravitational lens system JVAS B0218+357 at 8.4 GHz with an angular resolution of ~ 1 mas. Both are dominated by two bright core components. These observations, for the first time, show also the extended emission of the radio jet (Biggs et al. 2002, in press).

R. Schilizzi and L. Gurvits together with H. Zhang and R. Nan (Beijing Astronomcal Observatory, China) revised the paper on low-frequency VLBI observations of three high-z radio galaxies (1345+245, 1809+407 and 2349+289). At a resolution of 0.1 arcsecond, all three sources are characterized by two components with asymmetry both in flux density and in size which may be explained in terms of mild relativistic beaming. The paper has been published in Astronomy and Astrophysics (Cai et al. 2002, A&A 381, 401).



*Figure 8.* Two-point spectral index distributions in the mas-scale structures of the quasars 1156+295 (top, Hong et al. 2001, in preparation) and 1624+416 (bottom, Jiang et al. 2001, ApJ, submitted) shown in colour, overlapped with total intensity contours at 5 (left) and 15 (right) GHz images.

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Figure 9. Evolution of the separation of individual jet components of S5 1803+784 from the core, as derived from model-fitting 43 epochs of geodetic observations over 6 years. Colour-perjet component key: green square - D, red triangle – B, blue triangle – C, black diamond - A (reconfiguration-shock), pink diamond – Z, amber star – X, purple dot - Y. Component A is the brightest, and does not exhibit the superluminal separation shown by the innermost components. The behaviour of this component is reasonablv consistent with its being the manifestation of a reconfiguration shock (Britzen et al. 2002, in preparation).

S. Britzen (U Heidelberg), R. Campbell, and others have used 43 epochs of geodetic observations of the BL Lac object S5 1803+784 spread over 6 years to investigate the kinematics of the jet components (Fig. 9). The specific focus was reconciliation of the existence of apparently stationary jet components with others that are clearly superluminal. The source appears to have a single bent jet path, as sampled by the three innermost (superluminal) components. The brightest jet component, at ~1.5 mas appears more stationary, but with episodes when it appears to approach the core, correlated with the emission of a new jet component from the core. Much of the apparent kinematic behavior of the jet components, as well as general features of their luminosity evolution, can be put into the framework of the existence of a reconfinement shock, induced by pressure gradients in the external medium through which the jet propagates, at about the position of the bright, stationary jet component.

# 2.3. Galactic and extragalactic spectral line VLBI studies

C. Phillips worked on a range of ATCA, EVN (Fig. 10) and BIMA (Fig. 11) observations of northern methanol masers. The methanol sources are associated with regions of massive star formation and the EVN observations suggest that the masers may delineate an edgeon "disc" around the star. BIMA observations of two of these sources allow us to detect the presence of thermal molecular lines which trace regions of very high molecular density. These observations confirm that the methanol is associated with a molecular core, but do not have high enough angular resolution to image potential molecular discs associated with the central star.

L. Sjouwerman and M. Messineo (Leiden University) conducted from MPIfr (Bonn, Germany) remote observations of 86 GHz masers in the ISOGAL AGB sources in the Galactic center with the Pico Veleta 30-m IRAM telescope. Early preliminary results of this study were compiled and presented at the IAU Symposium No. 206 "Cosmic masers" in Brazil in March 2001.

Under the supervision of L. Sjouwerman, summer student Suzanne Fodor (Whittier College, CA, USA) started the reduction and analysis of VLBI calibratiors around M31 for future phase-referencing VLBI observations. This was a follow-up to the earlier analysis by L. Sjouwerman of deep 18 cm MERLIN data observations of the core of M31.

With W. Vlemmings (Leiden University), H.J. van Langevelde continued work on the proper motion of U Her, adding one more epoch to the sequence of data.



**Figure 10.** EVN observations of the 6.7-GHz methanol masers in G59.78+0.06. The length scale assumes a (far) kinematic distance of 6.9 kpc. Spots represent the (channel averaged) position of individual spectral components found by Gaussian fitting in the image plane and the area is proportional to the peak flux density. The spectrum is derived from these fits and so is weaker than the single dish flux density as the individual components are partially resolved (Phillips et al. 2002, in Cosmic Masers, Proc. IAU Symp. 206, in press).

# 2.4. New radio astronomy instruments and techniques

JIVE staff members contributed to various aspects of the design study of the Low Frequency Array, LOFAR (http://www.lofar.org/). In particular, M. Garrett investigated the levels of distant star-formation that could be detected by low-frequency radio arrays, and R.Campbell 12 investigated the ionospheric impact on the observing capability of LOFAR (together with J. Attridge, Haystack Observatory, USA).

M. Garrett helped organise an SKA High Resolution workshop at the MPIfR in Bonn (December 2001). The meeting was organised under the auspices of the European Square Kilometre Array Consortium and co-sponsored by the Infrastructure Cooperation Network, RadioNET. Twenty-five people attended the meeting and many useful discussions arose. The need for high resolution SKA simulations was identified. M. Garrett and R. Porcas (MPIfR, Bonn, Germany) created a web site where all the presentations were made available on-line (<u>http://www.euska.org/</u>). A report from the meeting was given to the SKA community at the meeting in Bologna in January 2002.



**Figure 11.** BIMA observations of  $HCO^{+}(1-0)$  towards G 59.78+0.06. Each panel represents the molecular emission at a different velocity (from 18.6 to 21.0 km/s). The colours represent the strength of the emission, from blue (weak) to strong (red/white). The two blue dots at the centre of each subplot mark the position of the methanol masers (Phillips et al. 2002, in Cosmic Masers, Proc. IAU Symp. 206, in press).

L. Gurvits continued to coordinate the European involvement in the next generation Space VLBI project study VSOP-2 led by the Institute of Space and Astronautical Science (Japan, <u>http://www.vsop.isas.ac.jp/vsop2/</u>).

R. Campbell provided predictions for ionospheric Faraday rotation to J. Rankin (University of Vermont, USA) and R. Ramachandran (University of Amsterdam) for future WSRT observations. He also worked with R. Braun (ASTRON) to identify a source of interference in the new WSRT 20-MHz-bandwidth system as the new GPS L3 signal at 381 MHz. Other collaborations include that with O. Smirnov (ASTRON) on incorporating PIM ionospheric models and GPS constraint into AIPS++, and with D. Lebach (CfA, USA) to provide ionospheric simulations in support of VLBI astrometry related to the GP-B guide-star program.

# 3. EVN MkIV Data Processor

In 2001 major changes were made to the data processor software. In the first half of the year the DSP's on the correlator boards were made operational, resulting in a four-fold increase in correlator capacity. This was followed by efforts to improve the data output rate. In the second half of the year, the correlator software was transferred to a new compiler which improved the robustness of operations. During this time operational the required efficiency was maintained to keep up with EVN observing and tape demand. A number of complicated correlator effects required very careful data analysis. In the end progress was made in understanding, circumventing and fixing a substantial number of subtle effects. The corrections to the EVN station positions turned out to be an important improvement of the data quality as perceived by the users.

# 3.1. Operations

## 3.1.1. Production

During 2001 several new capabilities were introduced. Most importantly, the limits on the spectral points per baseline were reduced. By using the whole correlator, PI's can request 2048 spectral points per baseline for 8 station experiments (512 for more stations). The data rate limitation requires the correlator dump time in this configuration to be 8s. However, the initial estimate was 4s, and a number of projects have had to be put on hold until the parameters requested by the PI can be met. Faster read-out times are possible for experiments requesting less spectral points. Initially there was also a fastest dump time limit of 2s, but this constraint was lifted during the year. Oversampling was also declared operational, albeit with some delay as testing results were difficult to interpret. A bug in the correlator configuration software for the case of  $\leq$  4 antennas and many spectral points delayed processing of many spectral line experiments.

The first Global VLBI experiments came to JIVE in 2001, after methods to deal with experiments recording more than 16 tapes spinning simultaneously were implemented. Three Globals were processed; one of them had many mode changes and turned out to be a major challenge to the correlator staff. The first (and last?) Mk3 experiment was completed. This experiment, and one other, used 1 bit mode, which first needed a bug fix.

Averaged over the whole year, approximately 20 hours each week were spent on testing; both the DSP implementation and the code overhaul required a lot of correlator time. The NME's are now often dual head, thus two passes, and require full correlation in order to do an imaging test. The efficiency of the production has been limited by the large fraction of re-correlations that are required after inspection of the data. In most cases these occur because of playback problems; notably a large number of 80 ips experiments which were correlated before the tape path upgrade, required re-correlation. Another reason for re-correlation is the detection of byte-slips. Despite these pressures a rate of one experiment completed per week was maintained

Tapes for 35 user projects and 19 tests and NME's were received in 2001, corresponding to approximately 475 hours of observing time. 39 user projects and 22 NME's and tests were correlated. For an almost equal number of projects, (37+22), the data were distributed to the PI's. By the end of the year tapes from (32+16) projects had been released for new observations.

In November 2001 a policy of automatic tape release was adopted. JIVE staff released the first 3 projects unilaterally. However, most older projects and a number of projects with special features still require agreement by the PI, which remains a time consuming process.

Some correlation time was reassigned to preparations for the visit of the Dutch Crown Prince and his fiancée (Fig. 1). The visit was originally planned for September 12, but was then delayed until November 16. The work of the processor and highlights of VLBI science were demonstrated and explained to the couple. The event received considerable coverage on local and national TV.

#### 3.1.2. Hardware

Early in 2001 the DSP project was completed. Digital Signal Processors were installed on the correlator boards, thereby greatly increasing the capacity of the correlator. The operational mode of the correlator is now switched to DSP integration.

In the last half of 2001 all 16 Play Back Units

were upgraded with special hardened stainless steel parts, made in the ASTRON workshop (Fig. 12). In the process the complete tape path, including the reel motor positions, had to be readjusted and re-calibrated. This led to noticeable improvements in the playback quality. On several occasions, throughout the year, capstan motors needed to be replaced.



Figure 12: DPU precision plate with new tape path guides

Procedures were defined to regularly check the DPU playback quality. Special new software by B.Kramer allows us to use standard tapes to measure the playback quality (see Fig. 13 for the example of the recorder test printout). Each session recorder tests by the stations were analyzed at JIVE. Recorder test results are presented graphically on the JIVE web pages. An additional recorder test was done for two head recording, which required further updates of the programs. A lot of attention was also given to 80 ips playback and the effects of autopeaking. Investigations were done after the occasional crashes of the embedded DPU software. Some enhancements in the tape positioning software were issued.

Metrum UK agreed to take on the large number of unusable Station Unit boards with intermittent

faults that have defied local diagnosis and repair. A working test unit and a number of faulty boards were delivered to Metrum for evaluation. The majority of faults are due to poor IC socket connections. Metrum propose to replace the sockets and treat the boards with a contactenhancing agent.

Through JIVE, the EVN ordered an additional 150 thin tapes. These were re-reeled on a dedicated playback unit. The new tapes were put into newly prepared cassettes and added to the tape-pool (Fig. 14), which allowed the EVN to start thin tape-only operations from the third session of 2001. It is clear that this will improve the quality of the recordings; however at JIVE there are still many thick tapes that require processing.

There were several fire alarms during the year. Often these alarms were caused by the build-up of calcite deposits in the humidifier. A water softening system was installed to solve this problem.



**Figure 13.** An example of a recorder test showing the head position which is sampled once every 100 ft. The nominal position is shown by the green line.

# 3.2. Development and data quality

#### 3.2.1. Control Software

The correlator software is maintained under rigorous version control by F.Olnon. Only a few software releases were made over the year, and a limited number of patches were applied. This makes it possible to switch between operational and test versions cleanly. With major code changes taking a lot of testing, this proved to be a very good strategy in 2001.

In the second half of the year the software group started a code overhaul to run the software under the latest ANSI GNU c++ compiler, instead of the native HP compiler. This switch will allow us to easily port the correlator control software to other platforms, to make use of the many powerful facilities provided by the Standard Template Library and to tune the code using modern commercial run-time error detection tools. The new compiler revealed a number of problems in the memory management. After dealing with many initial runtime errors, the system proved to be much more robust under the new compiler.



**Figure 14.** Newly re-reeled thin tapes ready for shipment to the observatories.

Furthermore, several improvements were made to deal with exceptional cases in the observing schedules. The introduction of the new compiler allowed the start of writing of software to deal with more complex observing schedules, notably those in which the mode changes during the observations. The work on the experiments database also benefited from the new compiler. Adjustments to the persistency mechanism improved the robustness.

#### 3.2.2. Data rate

Throughout the year the focus of the software development was on increasing the capacity of the correlator. In the first half of the year the DSP's on the correlator boards were switched on. This allows one to use all 32 correlator boards simultaneously, where before there was a limit of 2 per crate, a total of 8. As a demonstration a very high spectral resolution dataset was produced. As a demonstration a very high spectral resolution dataset was produced. This spectrum of a methanol maser source is shown in Fig. 15.



**Figure 15.** The first high-resolution spectrum from the correlator. The data are from a 2 MHz bandwidth observation of a methanol maser source, correlated with 2048 spectral points. Red is LCP emission and blue is RCP. This gives a velocity coverage of 90 km/s and a spectral resolution of 0.044 km/s.

The next bottleneck is the total read-out capacity of the correlator. The DSP's allow use all correlator chips simultaneously, but a dump time of 8 seconds is necessary to transfer all data to the off-line computers. A project was defined to address this issue and it was estimated that after this upgrade 0.5 or 1 second dump time should be possible. The plan included multithreaded read-out, dedicated hardware for data transfer and reduced data block size. By the end of the year most of these issues were being tested. Tests and analysis by I. Avruch also showed that it is possible to gain an additional factor of two by adjusting the TCP parameters for the correlator traffic.

The ultimate solution to the correlator capacity bottleneck is the PCInt project. See section ??? for details of this development.

#### 3.2.3. Software logistics

A GUI was produced to do most of the updates of the experiments queue. This allows the chief operator to carry out most of this administration. Software has also been developed to produce email messages to the PI's on their experiments.

Improvements were made in the log2vex software to deal with the latest telescope position information, allowing a quick responce to improvements in the EVN telescope positions. The software has also been improved with respect to the handling of log information about tape footages and missed scans. Changes were made in the software for the tape database and the tape release procedures.

# 3.2.4. Astronomical capabilities

An AIPS++ tool has been developed to allow the correlation of experiments with more than 16 stations.

C. Phillips investigated and implemented correlation of oversampled data. The most efficient means of implementing oversampling on the MkIV correlator is to do delay tracking and fringe rotation on the oversampled data and then decimate the data to the Nyquist sampling rate before making the actual correlation. Detailed tests have shown that this results in roughly a 4% reduction in the amplitude of the data. After a detailed investigation, it was decided that this is probably unavoidable.

A decision was made to process future observations recorded using 2 headstacks, with 2 passes on a single headstack DPU and not to mount 2 headstacks on the DPU's. An analysis was made of the software changes required for 2 pass correlation and initial enhancements were made which allow processing of 2 head test recordings. Tests were done to investigate the work required to do speed-up correlation.

Initial tests were done of the pulsar gating hardware. Although the absolute timing is not available yet, consistent results were obtained that show that the gating hardware can be used to enhance the signal to noise on pulsed radiation. Correlations were done to prove the concept of multi–field–centre processing.

## 3.2.5. Off-line processing

Software has been developed to compile statistics on tape playback quality and link them to playback and recorder units. Most significantly, a tool was implemented that allows a quick inspection of the playback quality, directly from the raw data.

Progress was made on the aips++/Glish software that produces the "standard plots". These plots represent the minimum amount of diagnostic plots that will be produced before a project can be automatically released. The new plots were presented to the EVN CBD for approval before automatic experiment release by JIVE staff could be initiated.

Phillips visited Socorro to work on several areas in the AIPS code where JIVE/EVN specific calibration is required, especially for spectral line processing. A few small changes were necessary, for example in the amplitude corrections. But the most complicated issue is to get the spectral line Doppler tracking correct. It turned out that the MkIV correlator uses an antenna based fringe rotation with a different reference antenna than the MkIII processors.

After new positions for EVN stations were reported by P.Charlot (Bordeaux Observatory), R.Campbell reanalysed the phase-reference test experiment FR005 with these positions, and found that the new positions improved the quality considerably. The new positions were used in production processing and a recipe to correct old data was published. Later, the origin of residual phase rates for the Westerbork array was understood and additional corrections were made.

## 3.2.6. Data Quality Issues

It had been known for a while that some autocorrelation functions have the right shape, but the values come out considerably less than unity. This was shown to originate from the sampler statistics of the 2-bit data. The way the autocorrelations are formed is very sensitive to non-optimal sampler settings at the stations. The problem was analysed and a correction for this behaviour is anticipated.

When a test observation applied the rarely–used 16 MHz filters, a correlator problem was encountered. The fringes disappeared a few minutes into a correlator pass and reappeared later, shifted from the original fringe location. After many elaborate tests, it was realised that this problem was related to a buffer in the SU being overwritten. The problem could be fixed by switching to a different mode of use of the SU, already coded in the SU software.

Another interesting problem was the offset of the delay zero crossings for the Westerbork array. This was finally understood as being due to the internal fringe rotation of the phase-cal signal in the Westerbork array.

Apart from playback issues, byte slips were the main operational problem. They occasionally cause the correlation function to be shifted by 8 lags. In 2001 it became clear that there are two distinct sorts of byte slips. The DMM byte slips shift the entire subband data and can be avoided by replacing suspicious boards. A distinct sort of byte slip originating in the TRMs was recognized as causing a secondary fringe

peak, 8 times the fan-out factor away from the original fringe (in lags). The unrelated sampler statistics/autocorrelation amplitude effect currently provides us with a reasonably convenient diagnostic test for these TRM byte slips. Metrum UK, successors to P&G who designed the Station Unit, agreed to evaluate the task of a Xilinx re-design to detect and cancel TRM byte slips when they occur.

# 4. EVN Support

The EVN Support Group at JIVE continued to monitor the performance of the EVN, supporting EVN operations in general, and providing support to EVN users in particular. Many JIVE staff were involved in these activities including I. Avruch, A. Biggs, R. Campbell, D. Gabuzda, M. Garrett, H.J. van Langevelde, C. Phillips, C. Reynolds and L. Sjouwerman.

# 4.1. Network Monitoring, Reliability and Performance

Network Monitoring Experiments (NMEs) were scheduled and correlated for all three sessions in 2001. The associated reports (both formal written reports and short messages to EVNtech e-mail exploder) were distributed in a timely manner (well in advance of the next session). The NMEs continue to be an essential element in monitoring the reliability and performance of the network. Feedback from the NMEs was considerably enhanced by the development of an automatic data analysis pipeline. This pipeline operates within AIPS and provides a very detailed analysis of each NME, generating all the usual diagnostic plots available within the analvsis AIPS package (see http://www.evlbi.org/tog/pipeline.html). With the pipeline in place an EVN Reliability Indicator (ERI) was introduced - essentially the ratio of the number of good visibilities used to create the final image, compared to the number of visibilities that were expected from the original block schedule.

Infrastructure Cooperation The Network, RadioNET (European Commission contract HPRI-CT-1999-40003), is providing funds to the EVN observatories for coordinated improvements to VLBI observing setps and practice. The aim is sustained reliable operation for the EVN such that the ERI is  $\geq$  0.9. i.e. that no more than 10% of the expected data are lost due to operational problems. The evaluation of the EVN performance conducted under the auspices of the ICN RadioNET is shown in Fig. 16.

In addition to the NMEs, regular Fringe Test Tapes (FTT, another short test experiment ran several days in advance of the session proper) were scheduled and correlated at JIVE. Feedback to the telescopes was generated within about 1 week of the observations being made.



Figure 16. The ERI plot shows an upward trend towards the goal of 0.9 (10% of data lost). Triangles show the ERI values based on the preliminary analysis of NME data before an in-depth analysis has been carried out (usually ending with the production of a radio image). In 2001, pipeline processing software was introduced to enable a fully automated analysis of NME data. The ERI values for the years 2001 and 2002 are presented as "preliminary" (triangles) and "full pipeline" (squares) evaluations. The values for 1997 and 1998, before RadioNET support for EVN operations was established, reflect the initial poor performance of several new telescopes in the EVN during the commissioning phase of their equipment.

# 4.2. Network Calibration

C.Reynolds produced ANTAB calibration data for all three EVN observing sessions in 2001. The number of errors in the format of the tables has decreased over the last year, but errors do still occur for non-standard set-ups.

# 4.3. Data Correlation Support in Socorro

This is the last year that JIVE provided support for the correlation of EVN and Global VLBI projects at the NRAO processor. From session 2 onwards the vast majority of EVN projects were correlated at JIVE following session 1, support was provided for 8 global VLBI experiments.

# 4.4. General Network Support

In April 2001 the EVN (via JIVE) contracted NVI to implement a Field System (FS) development programme. A subset of the main developments include: off-source flagging, improved TSYS monitoring, an antenna calibration package, and 2-head recording capability within the FS.

Efforts within the support group also centred on trying to understand some of the effects that limit the EVN's sensitivity - in terms of image noise. A specially designed NME was conducted in phase-reference mode and pipelined automatically. The compact target - a relatively faint 10 mJy source - was easily detected by the EVN at 6 cm (purely via the telescope corrections derived from the calibrator) and after self-calibration it was possible to reach the thermal noise level expected from theoretical considerations (Fig. 17). A noise level of 32 microJy/beam was achieved for a 4 hour observing run. In principle, longer integrations (with in-beam phase referencing for example) could generate VLBI images of faint targets with similar sensitivities to connected arrays such as the VLA and WSRT.

The format of NME experiments evolved over the course of the year. From session 2 onwards the observations were made in phase-reference mode after feedback from EVN users analysing data at JIVE suggested problems in this area. In particular, reports that the inclusion of the WSRT actually degraded phase-referenced maps of weak targets was followed up in some detail via the NME and other test experiments. An offset in the position of the tied array (w.r.t the Westerbork antenna RT7) was later identified as the main source of error. The offset had been in common use for many years but only showed up as a limiting factor once the position of RT7 was better determined.



**Figure 17.** An EVN image of a 10 mJy source obtained in the NME at 6 cm. The off-source noise of the image, 32 microJy/beam, is close to the theoretical thermal noise limit.

A qualitative comparison of the effects of the improved EVN positions determined in the test experiment TP001 (Charlot et al. 2001) on phase-reference mapping is illustrated in Fig. 18. The figure shows results from a 6 cm phase-reference test observation comprising 1 hour of interleaved observations of the close pair 3C345/J1635+380, with a network of: Effelsberg, Jodrell Bank Mk2, Medicina, Noto, Onsala-85, Toruń, and Westerbork–phased array.

The EVN Technical Operations Group (TOG) met in Bonn this year. The TOG is currently chaired by the head of the EVN support group at JIVE (M. Garrett). About 40 people participated in the main meeting. The day before a subset of the participants had attended a mini technical workshop in Effelsberg - focusing on 2-head recording and the new Mk5 system. The focus of the main meeting was to establish a coordinated plan to introduce 2-head recording (512 Mbits/sec) across the EVN. The plan was implemented in the third quarter of the year and drew on expertise across the EVN and beyond. The first 2-head fringes were obtained only 3 months after the first recording tests were made (Fig. 19). The EVN's ability to perform sustained 512 Mbit/sec operations was confirmed by the end of the year. Presentations (and written) reports regarding the performance and reliability of the EVN were made at both the EVN CBD (Toruń &



**Figure 18.** The left-hand panel shows a phase-reference map of J1635+380 using 3C345 as the reference source, with the "original" telescope positions. The right-hand panel shows the same phase-reference map after correcting the phases for the new telescope positions and axis offsets for 4 stations as in the following table:

Station	Position Correction [m]	Axis-Offset correction
Jodrell Bank Mk2	[+4.13, -2.15, -1.30]	0.458 m
Onsala-85	[-1.981, -0.988, -0.123]	0
Torun	[+0.54, -2.70, -4.24]	0
Westerbork-array	[+4.14, +2.54, -1.51]	4.9 5m

The peak brightness in the original phase-reference map is 0.49Jy/beam, improving to 1.55Jy/beam with the improved station positions (both panels are plotted with the same colour scale, ranging from -0.1 to 0.9Jy/beam). More significantly, the improved station positions also provide a much better "focussing" of the flux density into the source at its proper location on the sky, and greatly reduces the off-source noise level.

JBO) in addition to the TOG. The 2-head tests and other tests recommended by the TOG (e.g. formatter upgrade test).

# 4.5. Support for individual investigators

During the year JIVE staff supported PIs in scheduling more than 18 EVN experiments. Assistance was also provided for the preparation of several EVN and Global VLBI proposals. JIVE staff maintained and updated the SCHED

software and associated catalogues for MkIV observations and EVN telescopes.

Visitors to JIVE (for the purposes of data analysis) included: P. Barthel (U Groningen), S. Beck (U Tel Aviv), K. Berzins (VIRAC, Latvia), A. Caccianiga (U Lisbon), P. T. Cawthorne (U Central Lancashire), Charlot (Bordeaux Observatory), V. Chernetskii (Moscow State U), Dougherty (NRC/DRAO), K. Exter (Queens's U, Belfast), I. Fejes (FÖMI SGO), W. Flemmings (U Leiden), E. Fomalont (NRAO), S. Frey (FÖMI SGO), M. Giroletti (U Bologna), N. Gizani (U Madeira), S. Kopeikin (U of Missouri), J. Lovell (ATNF), M. Marcha (U Lisbon), M. Messineo (U Leiden), A. Papageorgiou (U Central Lancashire), Z. Paragi (FÖMI SGO), Y. Pihlström (Onsala Space Observatory), A. Polatidis (Onsala Space Observatory), I. Snellen (Royal Observatory Edinburgh). H. Sol (Paris-Meudon Observatory), A. Stirling (U Central Lancashire), A. Tarchi (U Bonn), W. Tschager (U Leiden), Wang Weihua (Shanghai Observatory), Zhang Haiyan (Beijing Normal U).

In addition, JIVE staff supervised three summer students: S. Fodor (Whittier College, CA, USA), P. Kharb (RRI, Bangalore, India) and K. Berzins (VIRAC, Riga, Latvia).



*Figure 19.* A plot of the "POSSM" output from the second and completely successful EVN 512 Mbit/sec test experiment. Each telescope recorded 64 MHz (2 bit sampled) in both right and left polarisations. A simple image of the target source (NRAO512) made from the first (partially successful) 512 Mbit/sec test is also shown (bottom right).

#### 4.6. Toruń Recorder Upgrade

During September 2001 the P&G recorder in Toruń was upgraded by J. Buiter and S. Parsley

at JIVE, where similar machines are used on the correlator. The primary objective was to install 2headstack capability but several other enhancement and general maintenance actions 23 were carried out at the same time. These included replacement of fixed guides with hardened parts, replacement of roller bearings and installation of tension arm damping adjusters. Tension compensation was also set to work correctly eliminating uneven headstack wear.

The upgrade to two headstacks required installation of a new precision plate with two independent head blocks and actuators. New LVDTs and associated cabling and buffers were also needed. The recorder firmware was revised

to enable separate control of the two headstacks.

Under some pressure to enable Toruń to join the November 2001 session, J. Buiter carried out additional re-work on-site in Torun. Recording problems were caused by a partly worn headstack that was replaced. "Work-arounds" for Field System communication troubles were provided by W.E. Himwich and S. Parsley. Further FS and firmware work will be required to establish full compatibility.

# 5. Technical Research and Development Activities

# 5.1. Post Correlator Integrator (PCInt)

H. Verkouter and S. Parsley re-evaluated the hardware implementation after an announcement by Monaco, the manufacturer of the selected DSP board, that the board was obsolete. This led to a new design: no online processing, try to capture the data as fast as possible and perform user processing offline. This will be implemented by using dedicated single board computers (Fig. 20) in the correlator. Eventually, sub-second read-out will be possible, even in the very high resolution modes that will be provided by re-circulation. Initial purchases were made and development started at the end of 2001.



*Figure 20.* Pentium III/850 MHz single board computer from Concurrent Technologies used in PCInt project.

# 5.2. Hard-disk, tape replacement systems

Midway through 2001 the EVN received a request to participate in the funding of the development of the Haystack Mark5, hard-disk recorder. In August a group of EVN technical

experts met to discuss the proposal, and agreed that the development should be supported but also that other ideas in the EVN should be given the chance to mature. Early in November groups at JIVE and Metsähovi met in Finland and merged their efforts into a single project that called PCEVN.



Functional diagram of PCs based 1 Gbps VLBI unit

**Figure 21**. Block diagram of PC-based 1 Gbps VLBI unit consisting of several VSI-core recorder/playback units and Mk4 envelope unit for direct interfacing to Mk4 formatter and JIVE correlator Station Units

The project aims to develop a single platform for transportable hard-disks and eVLBI. PCEVN is characterised by the view that a philosophical shift is needed to realise the full potential of using off-the-shelf technologies (Fig 21). In the past the best equipment available was taken, adapted to the needs and then progressively made better. Each upgrade was a new development of a similar magnitude. The next generation should take advantage of the technology provided by industry and conspire to let someone else make it better for us. It is important to respect the limitations of the off-theshelf technology to obtain the simplest possible scalable system. All adaptations for VLBI use should be restricted to the extreme edge of the data transport technology so that future upgrades can be achieved in the same way that we upgrade our desk top PC: by replacing it.

These arguments apply equally to the transportable media and eVBLI initiatives.

The Project outline is as follows:

- The target will be to complete an initial test before August 2002 and to be ready for further tests, run in parallel with the November 2002 EVN session.
- A total of four units will be developed and built. Two "station recorder units" and two "data processor replay units". These will be built and tested to a common basic specification at Metsähovi and JIVE respectively.
- This prototype system will be capable of recording 256 Mbps at two stations and replaying these to the JIVE data

processor. Upgrade to 512 and 1024 Mbps will be by multiple units. At station and data processor the disk systems will be installed along side the existing, tape based terminals enabling comparative operation and evaluation.

The teams met again in mid December to present initial specifications. At this point the software interface for tape drive emulation was agreed; as far as possible this will follow the Mk5 command set. In support of Mk5 evaluation two units were ordered for delivery in April 2002. JIVE also placed orders on behalf of Noto and Medicina.



Figure 22. Map of the Netherlands with possible fibre link to JIVE and ASTRON in Dwingeloo

## 5.3. Fibre optics development

Work on the definition of a pilot experiment for optical fibre connected EVN (eEVN) became focused on the preparation of a proposal to the European Commission requesting funds to finance the project. A number of potential collaborators and advisors were identified. Meetings were held at CERN in Geneva and NIKHEF in Amsterdam to gather information. The CERN meeting was attended by representatives of several EVN institutes forming the basis of a contact group for the project. Various industrial companies were also contacted to explore and evaluate technical aspects and to quantify material costs.

Regrettably the proposal was rejected. This came as a surprise to everyone, including the many experienced advisors and collaborators who had been involved in the preparation of the proposal document. It seems that the major criticism was that the project included too many unanswered questions. The assessors were unable to identify the project milestones clearly enough to facilitate adequate monitoring.

Late in the year confirmation was received that a fibre optic link to the Dwingeloo site would be

installed providing, initially, two colours at 1Gbps directly into the Amsterdam Internet Exchange at SARA. eVLBI developments using this link will proceed in parallel with PCEVN development and Mk5 evaluation using these units as link interface platforms (Fig. 22).

# 6. EC–supported Activities

During 2001, JIVE managed three EC contracts, dedicated to enhancement of European research potential in the field of radio astronomy, especially VLBI.

## 6.1. Training and Mobility of Researchers RTD project "Enhancing the European VLBI Network of Radio Telescopes"

The TMR-LSF RTD project "Enhancing the European VLBI Network of Radio Telescopes" (contract No. ERBFMGECT 980101) has been awarded to the EVN in 1998 for the period of 42 months. The project was managed by JIVE (coordinator – R.Schilizzi, project manager – L.Gurvits). It consisted of four parts (sub-projects) totaling 1 M  $\in$ ::

1 Development of the DSP-based signal processing electronics (the so called "postcorrelation integrator", PCI) to upgrade the EVN data processor at the Joint Institute for VLBI in Europe (JIVE, Dwingeloo, The Netherlands) to provide high speed readout of the correlated data.

The coordinating institute was JIVE, and participating institutes were the ASTRON (formerly the Netherlands Foundation for Research in Astronomy, NFRA, Dwingeloo) and the Institute for Radio Astronomy (IRA-CNR, Bologna, Italy).

2 Development of radio frequency interference suppression techniques for radio astronomical receivers.

The coordinating institute was ASTRON, and participating institutes were the Max Planck Institute for Radio Astronomy (MPIfR, Bonn, Germany), the Jodrell Bank Observatory (JBO, formerly NRAL; UK) and the Institute of Radio Astronomy (IRA. Bologna, Italy)

# 3 Development of new experimental techniques in radio astronomy and VLBI

The coordinating institute was IRA-CNR and the participating institutes were the Metsähovi Radio Observatory (Helsinki University of Technology,

MRO, Finland), MPIfR, the National Astronomical Observatory (OAN, Spain), the Onsala Space Observatory (OSO, Sweden) and JIVE.

An additional sub-contract was signed with the NVI, Inc. (MD, USA) in March 2001 for the further development of the VLBI Field System software for astronomical use. The sub-project was coordinated by JIVE and financed via a part of the contribution originally assigned to the Helsinki University of Technology.

4 A feasibility study of optical fibre communications between radio telescopes.

The sub-project was conducted by JBO with participation by JIVE.

#### 6.1.1. Results and achievements

1). The EVN MkIV correlator at JIVE has been upgraded with the performance-enhancing DSP software. The design study of the novel hardware item, the Post Correlator Integrator (PCI) was completed. The design was shown to be suitable for replication for a full production system. Successful tests of the new hard- and software elements of the PCI have been conducted.

2). All observatories participating in the subproject 2 continued monitoring of the RFI situation. RFI monitoring data are being produced routinely since the end of 1999. The RFI monitoring will continue after completion of the present contract.

The design concept of the Feed Forward System (FFS) for the RFI-robust receiver was accepted as a basis for the detailed design of the receiver. The design study resulted in the production of a laboratory prototype of the FFS system and its successful tests at the ASTRON Technical Laboratory (NFRA) in Dwingeloo.

3). A special test observation using the EVN telescopes was completed to demonstrate the wide-field capability of the new MkIV correlator. The result of correlation and post-processing indicated that the test had been successful (more details in the report on this subject).

A Cluster-Cluster VLBI experiment was conducted, and the data analysed (see details in the final report on the Cluster-Cluster VLBI technique).

The first Pulsar-gating experiment was successfully correlated at the MkIV correlator at JIVE.

The VLBI Field System has been developed by joint efforts of the university of Helsinki and the NVI, Inc. (USA) sub-contracted by JIVE.

4). The preliminary design of optical fibre links for EVN and respective cost estimates were prepared. Further work aimed at a "live" demonstration of real-time fibre links between several EVN telescopes and the MkIV correlator at JIVE commenced. The work is based on the results published in the final report on the subproject 4 "Optical Fibre Communications between Radio Telescopes in the European VLBI Network" (released in June 2000).

The TMR-LSF RTD project "Enhancing the European VLBI Network of Radio Telescopes" (contract No. ERBFMGECT 980101) was completed in October 2001 and Final Report submitted to the European Commission in December 2001.

#### 6.2. Access to Research Infrastructures

The EVN (via JIVE, coordinator M. Garrett) is in receipt of a 1500 k€ award from the European Commission's IHP programme: Access to Research Infrastructures. The award (Contract No. HPRI-CT-1999-00045) runs for three years (1 January 2000 - 31 December 2002). The contract supports European researchers that are not affiliated to the EVN institutes. In this the second year of the contract 7 different user groups (8 projects) have recieved access to the EVN. A total of 11 users (drawn from 6 different countries) visited JIVE or one of the other EVN institutes on at least one occassion. In total 130 hours of observing time were made available to these users. This together with the 129 hours of access associated with the first year of the contract, represents more than half of the total access to be delivered by the contract. Another 146 hours of observing time have been provided but these await correlation or a visit from the PI before they can be claimed.

During the year the EVN was successful in obtaining a "top-up" of 595 kEuro to the current access contract. This top-up (HPRI-CT-2001-00142) will run until the end of February 2004.

The programmes of research supported by the Access contract include varied and wide-ranging investigations of many different class of astrophysical phenomena: from high resolution studies of masers in star forming regions of our own galaxy to observations of active galaxies and quasars located at the edge of the universe. So far two publications have resulted from the contract and several others are in the final stages of preparation.

Visits of IHP supported users to the JIVE facility in 2001 included: N. Gizani (U of Athens), W.Tschager (U Leiden), A. Caccianiga and M. Marcha (U Lisbon), K. Exter (Queen's Univ, Belfast), Z. Paragi, I. Fejes and S. Frey (FÖMI SGO, Budapest), P. Charlot (Obs. Bordeaux), A. Stirling (U Central. Lancashire), A. Tarchi (U Bonn), S. Beck (U Tel Aviv), and I. Snellen (Royal Observatory Edinburgh).

# 6.3. Infrastructure Cooperation Network in Radio Astronomy – RadioNET

In 2000 the European Commission awarded a Network of 11 European Radio Astronomical Institutes (nine of them – members of the EVN) an 800 k€ contract under the IHP Programme. Coordination of this Infrastructure Cooperation Network in Radio Astronomy, RadioNET, takes place in JIVE (contract number HPRI-CT-1999-40003, coordinator – R.Schilizzi, project manager – L.Gurvits). The contract commenced in March 2000 and will last for four years.

RadioNET coordinates new initiatives in the field of radio astronomy. These include enhancing the quality of operations and making more effective use of the existing European VLBI Network of radio telescopes (EVN), and building up the necessary scientific, technical and organizational consensus for the two major future radio astronomy facilities, the Atacama Large Millimetre Array (ALMA) and the Square Kilometre Array (SKA).

During the vear. RadioNET supported coordination activities at the nine EVN institutes aimed at improving the quality and interoperability of the network and improving the access to the research infrastructure. A special workshop was held at the Effelsberg Observatory to exchange experience on VLBI operations. The newly established EVN Reliability Index (ERI - see section 4.1) was used as a measure of the quality of operations. RadioNET participated in sponsorship of an EVN Summer School (San Pietro, Italy, September 2001 – see section \*.\*) and publication of its proceedings. The Network is also involved in the preparation for the EVN Symposium 2002 (Bonn, Germany, June 2002).

RadioNET supported in part two ALMA working meetings for European astronomers on the ALMA project development (Grenoble, February 2001; Cambridge, June 2001). This resulted, in particular, in progress on issues such as ALMA configuration design and calibration strategy.

Finally, RadioNET supported participation of the European radio astronomical community in the world-wide effort of designing the Square Kilometre Array. This activity was coordinated through the European Square Kilometre Array Consortium established under aegis of RadioNET in 2000. In particular, the network supported the HighResolution SKA Workshop at MPIfR in Bonn (December 2001) – see http://www.euka.org/workshops/.

# 7. Institute Management

The management structure of the Data Processor Group was changed in October. The changes better reflect the lines of responsibility as they operate in practice, and better balance the numbers of people in the two sections. The changes are as follows:

- the Science Operations section has been renamed Science Operations and Software with Huib van Langevelde as Head of Section. The Technical Operations section has been renamed Technial Operations and R&D with Steve Parsley as Head of Section,
- 2) Friso Olnon and Arpad Szomoru have transferred from the (old) Technical Operations section to the Science Operations and Software section to form a software group together with Harro Verkouter. The Operators Group (Nico Schonewille (chief), Bauke Kramer, Martin Leeuwinga and Hans Tenkink) have transferred from the (old) Science Operations section to the Technical Operations and R&D section.

## 7.1. Staff changes

Dr Lorant Sjouwerman completed his 4 year appointment as support scientist in the EVN Support Group and took up a position at the NRAO in Socorro. Dr Andy Biggs was appointed as Lorant Sjouwerman's replacement; he began work in November. Mrs Marjan Tibbe joined the institute as Office Manager in March with responsibility to support the Director and Management Team, run the Institute Secretariat, and participate in the management of contracts with the European Commission.

# 7.2. Publications

The annual reports for the EVN and JIVE for 2000 (chief editor: Leonid Gurvits) were issued as a single volume, as has been the practice for the last 4 years. Interim reports on JIVE activity were issued as quarterly reports for the first two quarters and as a half yearly report for the second half of the year. The change was made to reduce the administrative load.

Staff member	Activity
Avruch, Campbell Gabuzda, Phillips Reynolds, Sjouwerman	Minute-taking at JIVE Plenary meetings
Biggs	Contact person for visitors to JIVE (from November)
Gabuzda	Contact person for visitors to JIVE (until November)
Garrett	Chair EVN Technical and Operations Group Coordinator EC Access contract Member of European SKA Consortium WSRT VLBI Target Team JIVE coordination with System management EVN home page webmaster Computing resources for visitors
Gurvits	Manager EC RTD contract (Enhancing the EVN) Manager EC ICN contract (RadioNET) Coordinator NWO–OTKA (Hungary) grant Co-coordinator KNAW–CAS (China) grant Coordinator Space VLBI activities Editor EVN and JIVE Annual Reports Minute-taker at JIVE Board meetings

## 7.3. Additional tasks and responsibilities of JIVE staff

Van Langevelde	EVN PC
_	VSOP Program Committee
	ALMA Advanced Backend Committee
	AIPS++ Users committee
	Nova Education Committee
	Computer system management
	Coordinator data processor queue
Parsley	GVWG Task Force on Future Data Transport Systems
5	Global Grid Forum High Performance Networking Working
	Group
Reynolds	JIVE computer environment for visitors
-	AIPS Manager
	SCHED station catalogues
Phillips	Maintain bug list for correlator
Buiter	ARBO committee
Kromor	Data archive for data processor
Riamer	Data archive for data processor
Schonewille	Experiment database for data processor
	JIVE Webmaster
	ASTRON Ondernemingsraad

# 8. Education and Outreach

During the year the scientific staff of JIVE supervised several under-graduate and PhD projects presented in the overview on the next page. All students mentioned in the table are affiliated with universities in The Netherlands and abroad.

JIVE also contributed to the organization of the NATO Advanced Study Institute Summer School "The Role of VLBI in Astrophysics, Astronomy and Geodesy" held in Castel San Pietro Terme (Bologna, Italy) in September 2001 by managing the ICN RadioNET support to the school. M.Garrett gave two lectures at this school.

JIVE staff was actively involved in the National Science Day 7 October 2001. JIVE received several hundred visitors (Fig. 23).

M. Garrett prepared a press release associated with the successful EVN imaging of 3 faint submJy radio sources in the HDF. The press release was extremely successful, appearing on APOD (Astronomical Picture of the Day - 8 February 2001) and various other web sites, radio programmes, newspapers and TV broadcasts.

L. Gurvits gave an invited talk "Interferometry in astrophysics" at the XXXI International Symposium on Multiparticle Dynamics (Datong, China, September 2001). and continued to work on issues of mutual interest for astrophysical and particle physics interferometry.



Figure 23. National Science Day at JIVE in Dwingeloo, 7 October 2001

# Supervision of student projects by JIVE staff

Staff member	Student	Institute	Degree	Subject
Gabuzda A. Pushkarev		ASC, Moscow, Russia	PhD	Multi-frequency polarization studies of the compact radio structure of BL Lac Objects: thesis successfully defended on June 4, 2001
Gabuzda	D. Vir Lal	IIA, Bangalore, India	PhD	Seyfert Galaxies: nuclear radio structures and unification
Gabuzda	V. Chernetskii	Sternberg Astronomical Institute, Moscow, Russia	Masters student	Multi-epoch, multi- frequency study of the BL Lacertae object 1803+784, to be defended Jan. 9, 02
Gabuzda	N. Garnich	Sternberg Astronomical Institute, Moscow, Russia	Masters student	Characteristic structural evolution of BL Lac objects on parsec scales
Gabuzda	P. Kharb	IIA, Bangalore, India	PhD student	Synchrotron emitting nuclei of radio galaxies
Gabuzda	L. Rastorgueva	Sternberg Astronomical Institute, Moscow, Russia	Undergraduate research student	Correlations between optical and radio properties of AGN
Gabuzda	I. Pashchenko	Sternberg Asatronomical Institute, Moscow, Russia	Undergraduate research student	VLBI polarization structure of BL Lac objects possibly residing in spiral host galaxies
Gurvits	Zhang Haiyan	Beijing Normal University, China	PhD	Parsec-scale radio structures in AGN
Gurvits	K.Bērziņš	VIRAC, Riga, Latvia	Summer student	Sub-milliarcsecond structures in inverted- spectrum extragalactic radio sources
Van Langevelde	W. Vlemmings	Leiden, NL	PhD	Astrometry of maser stars
Schilizzi	W. Tschager	Leiden, NL	PhD	Faint Compact Steep Spectrum Radio Sources
Sjouwerman	S. Fodor	Whittier College CA, USA	Summer student	Study of VLBA calibrators around M31 as a feasibility study for future VLBI observations of M31*, the central object in Andromeda

# 9. Publications 2001

This list includes VLBI and other publications by the JIVE staff (shown in bold).

# 9.1. Refereed publications

I. Agudo, J.L. Gomez, J.C. Guirado, A.P. Marscher, A. Alberdi, J.M. Marcaide, **D.C. Gabuzda**, "Changes in the trajectory of the radio jet in 0735+178", MNRAS 328, 873

S. Britzen, J. Roland, J. Laskar, K. Kokkotas, **R.M. Campbell**, A. Witzel, "On the origin of compact radio sources: the binary black hole model applied to the gamma-bright quasar PKS 0420-014", A&A 374, 784

C. de la Force, R. Spencer, A. Stirling, M.A. Garrett, R. Fender, 2001, Astrophysics and Space Science 276, 121

**D.C. Gabuzda**, J.L. Gomez, "VSOP Polarisation Observations of the BL Lacertae Object OJ287", MNRAS 320, L49

**D.C. Gabuzda**, J.L. Gomez, I. Agudo, "Evidence for Parsec-Scale Absorption from VSOP Observations of the BL Lacertae Object 0735+178", MNRAS 328, 719

**D.C. Gabuzda**, A. Pushkarev, N. Garnich, "Unusual Radio Properties of the BL Lac Object 0820+225", MNRAS 327, 1

**M.A. Garrett**, T.W.B. Muxlow, S.T. Garrington, W. Alef, A. Alberdi, **H.J. van Langevelde**, T. Venturi, A.G. Polatidis, K.I. Kellerman, W.A. Baan, A. Kus, P.N. Wilkinson, A.M.S. Richards, "AGN and starbursts at high redshift; High resolution EVN radio observations of the Hubble Deep Field", A&A 366, L5

J.M. Hutchison, T.V. Cawthorne, and **D.C. Gabuzda**, "Parsec-scale polarisation of the jet in quasar 4C71.07", MNRAS 321, 525

A.P. Lobanov, L.I. Gurvits, S. Frey, R.T. Schilizzi, N. Kawaguchi, I.I.K. Pauliny-Toth, "VSOP observation of the quasar PKS 2215+020: a new 'core-jet' laboratory at z=3.57", ApJ 547, 714

A.R. McDonald, T.W.B. Muxlow, A. Pedlar, **M.A. Garrett**, K.A. Wills, S.T. Garrington, P.J. Diamond, P.N. Wilkinson, "Global very long-baseline interferometry observations of compact radio sources in M82", +MNRAS 322, 100

**C. Reynolds**, T.V. Cawthorne, **D.C. Gabuzda**, "Faraday rotation in the VLBI core of BL Lacertae", MNRAS 327, 1071

M. Sevenster, **H.J. van Langevelde**, R. Moody, J. Chapman, H.J. Habing, N. Killeen, "The ATCA/VLA OH 1612 MHz survey; III. Observations of the Northern Galactic Plane", A&A 366, 481

**R.T. Schilizzi**, W.W. Tian, J.E. Conway, R. Nan, G.K. Miley, P.D. Barthel, M. Normandeau, D. Dallacasa, **L.I. Gurvits**, "VLBI, MERLIN and HST observations of the giant radio galaxy 3C236", A&A 368, 398

R. Spencer, C. de la Force, A. Stirling, M.A. Garrett, R. Fender, R. Ogley, 2001, Astrophysics and Space Science 276, 255

A.M. Stirling, R.E. Spencer, C.J. de la Force, **M.A. Garrett**, R.P. Fender, R.N. Ogley, "A relativistic jet from Cygnus X-1 in the low/hard X-ray state", 2001, MNRAS 327, 1273

W. Vlemmings, P.J. Diamond, H.J. van Langevelde, "Circular polarization of Circumstellar Water Masers around S Per", A&A 375, L1

P.M. Vreeswijk, R.P. Fender, **M.A. Garrett**, S.J. Tingay, A.S. Fruchter, L. Kaper, "The star-formation rate in the host of GRB 990712", 2001, A&A 380, L2

#### 9.2. Publications in Conference Proceedings

S. Britzen, R.C. Vermeulen, G.B. Taylor, **R.M. Campbell**, I.W. Browne, P.N. Wilkinson, T.J. Pearson, A.C.S. Readhead, "CJ-F: The kinematics of 241 AGN", in Proc IAU Symp. 205, eds. **R.T. Schilizzi**, S.N. Vogel, F. Paresce, M.S. Elvis, 106

S. Britzen, R.C. Vermeulen, G.B. Taylor, **R.M. Campbell**, I.W. Browne, P. Wilkinson, T.J. Pearson, A.C.S. Readhead, "The Properites of the Gamma-ray Blazars in the CJF VLBI Sample", in "High Energy Gamma-Ray Astronomy", eds. F.A. Aharonian & H.J. Volk (Melville, NY: AIP) 721

**R.M. Campbell**, "VLBI Pulsar Astrometry", in Proc IAU Symp. 205, eds. **R.T. Schilizzi**, S.N. Vogel, F. Paresce, M.S. Elvis, 404

**R.M. Campbell**, "The EVN MkIV Data Processor at JIVE", in Proc. of the 15<sup>th</sup> Working Meeting on European VLBI for Geodesy and Astrometry, eds. D. Behrend, A. Ruis, 40

P. Charlot, **R.M. Campbell**, W. Alef, K. Borkowski, J. Conway, T. Foley, S. Garrington, A. Kraus, A. Nothnagel, O. Sovers, C. Trigilio, T. Venturi, H. Xinyong, "ITRF2000 Positions of Non-geodetic Telescopes in the European VLBI Network", in Proc. of the 15<sup>th</sup> Working Meeting on European VLBI for Geodesy and Astrometry, eds. D. Behrend, A. Ruis, 194

**D.C. Gabuzda**, J. L. Gomez, "The Compact Magnetic Field Structures of AGN from Space VLBI Polarization Observations", in Proc IAU Symp. 205, eds. **R.T. Schilizzi**, S.N. Vogel, F. Paresce, M.S. Elvis, 134.

S. Garrington, T. Muxlow, **M.A. Garrett**, "High Resolution Studies of mJy and µJy Radio Sources", in Proc IAU Symp. 205, eds. **R.T. Schilizzi**, S.N. Vogel, F. Paresce, M.S. Elvis, 102

**L.I. Gurvits**, "The "Number – Flux Density" Relation for Milliarcsecond Structures in Extragalactic Radio Sources", Proc IAU Symp. 205, eds. **R.T. Schilizzi**, S.N. Vogel, F. Paresce, M.S. Elvis, 146

X.Y. Hong, D.R. Jiang, **R.T. Schilizzi**, G. Nicolson, Z.-Q. Shen, W.H. Wang, "VLBI Observations of a Sample of 15 EGRET-detected AGN's at 5 GHz", in Proc IAU Symp. 205, eds. **R.T. Schilizzi**, S.N. Vogel, F. Paresce, M.S. Elvis, 116

A.R. McDonald, T.W.B. Muxlow, A. Pedlar, **M.A. Garrett**, K.A. Wills, "Global VLBI Observations of M82", in Proc IAU Symp. 205, eds. **R.T. Schilizzi**, S.N. Vogel, F. Paresce, M.S. Elvis, 374

T.W.B. Muxlow, A. Pedlar, A.R. McDonald, S.T. Garrington, W.M. Trotman, P.N. Wilkinson, P.J. Diamond, **M.A. Garrett**, K.A. Wills, "VLBI Observations of SNR in M82 – Is 41.95+575 and Anomalous SNR or Something Else?", in Proc IAU Symp. 205, eds. **R.T. Schilizzi**, S.N. Vogel, F. Paresce, M.S. Elvis, 376

Z. Paragi, I. Fejes, R.C. Vermeulen, **R.T. Schilizzi**, R.E. Spencer, A.M. Stirling, "The Central Radio Gap and the Equatorial Emission Region in SS433", in Proc IAU Symp. 205, eds. **R.T. Schilizzi**, S.N. Vogel, F. Paresce, M.S. Elvis, 266

A. Pushkarev, **D.C. Gabuzda**, T.V. Cawthorne, "Frequency Dependence of the Parsec-Scale Polarization Structures of BL Lacertae Objects", in Proc IAU Symp. 205, eds. **R.T. Schilizzi**, S.N. Vogel, F. Paresce, M.S. Elvis, 140.

**R.T. Schilizzi**, S.N. Vogel, F. Paresce, M.S. Elvis, eds, "Galaxies and their constituents at the highest angular resolutions", Proceedings of IAU symposium No. 205, ASP:San Francisco

## 9.3. Ph.D. Theses

Jin Cheng-Jin, "VLBA observations of the gravitational lens system PKS 1830–211 and the cross-selfcalibration method", Beijing Astronomical Observatory, China, co-supervised by **M.A. Garrett** 

A.B. Pushkarev, "Multifrequency polarimetric studies of compact radio structures in BL Lac objects", P.N. Lebedev Physical Institute, Moscow, Russia, supervised by **D.C. Gabuzda** 

Zhang Hai-Yan, Investigation of Milliarcsecond-scale Radio Structures in Active Galactic Nucli, Department of Astronomy, Beijing Normal University, China, co-supervised by **L.I. Gurvits** 

# 9.4. EVN Technical and Operational documents

- Doc 112, PCInt Design Specification, S.M. Parsley, Dec 2001
- Doc 113, PC-EVN Project Plan, S.M. Parsley, Dec 2001

# 8. Appendices

# Appendix A1

# JIVE Board

Prof. A. Baudry	-	Bordeaux Observatory, Bordeaux, France (Chairman)
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
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

# **JIVE Financial Report for 2001** (Audited by KPMG Accountants NV)

	Balance as		cember 31,2001 resp 2000		
	<u>2001</u>	2000		2001	2000
ASSETS			LIABILITIES		
Fixed Assets			Canital		
Tangible Assets	123	111	General Peserve	1283	864
Tangible Assets	123	<u> </u>	Total Capital	1200	004 964
Total of Fixed Assets	123	111	Total Capital	1283	864
Current Assets			Current Liabilities		
Receivables	419	543	Short term debts	2072	4154
Cash at bank	<u>2813</u>	<u>4364</u>	Total of Current Liabilities	2072	4154
Total of Current Assets	3232	4907			
Total Assets	3355	5018	Total Liabilities	3355	5018
	Statement o	of Profit	& Loss for 2001 resp 2000		
	<u>2001</u>	2000		<u>2001</u>	2000
EXPENDITURES			<u>R E V E N U E S</u>	-	
Grants/expenditures			Contributions		
EU financed projects	103	644	European Research Organisati	333	333
Upgrade projects	29	28	Dutch Research Council	468	272
Special projects	36	0	Total of Contributions	801	605
Thin Tape Purchase	170	319			
Total of Grants	338	991	Subsidies		
			EU-access to Facilities	591	794
			EU-projects	205	578
Operations			Total of Subsidies	796	1372
Personnel Costs	1158	1054			
Other cost	296	200	Other income		
Total of Operations	1454	1254	Thin Tape Purchase	179	255
			Various Income	285	126
			Total of Other Income	464	381
Result					
Positive balance	407	264	Interest		
			Total of Interest	138	151
Total	2199	2509	Total	2199	2509

# **JIVE Personnel**

Prof. R.T. Schilizzi\* Dr. I.M. Avruch Dr. A. Biggs Mr. J. Buiter Dr. R.M. Campbell Dr. D.C. Gabuzda Dr. M.A. Garrett Dr. L.I. Gurvits Mr. B. Kramer Dr. H.J. van Langevelde\* Mr. M. Leeuwinga Mrs. S.K. Mellema Dr. F. Olnon Eur. Ing. S.M. Parsley\* Dr. C.J. Phillips Dr. S.V. Pogrebenko Mr. C. Reynolds Mr. N. Schonewille Dr. L.O. Sjouwerman Dr. A. Szomoru Mr. H. Tenkink Ms. M. Tibbe Drs. H. Verkouter

Director Data Analysis Scientist Support Scientist (since 5 Nov 2001) Tape Recorder Engineer Data Analysis Scientist Support Scientist Head of EVN Support Group Programme Manager, Senior Scientist Operator Head of Data Processor Science Operations Operator Secretary Online Software Engineer Head of Data Processor Technical Operations Data Analysis Scientist Senior Development Engineer Support Scientist Chief Operator Support Scientist (until 1 Nov 2001) Online Software Engineer Operator Office Manager (since 1 Mar 2001) Offline Software Engineer

\* member of JIVE Management Team



# Visitors to JIVE

W. Alef P. Barthel S. Beck K. Berzins A. Caccianiga T. Cawthorne P Charlot V. Chernetskii S. Dougherty J. Eisimbek K. Exter I. Fejes S. Fodor E. Fomalont S. Frey M. Giroletti N. Gizani Y. Hagiwara Huang Xinyong P. Kharb S. Kopeikin J Lovell M Marcha M. Messineo A. Papageorgiou Z. Paradi Y. Pihlstrom A. Polatidis R. Porcas J. Romnev I. Snellen H. Sol A. Stirling A. Tarchi W. Tschager W. Vlemmings Wang Weihua Wei Wenren Ye Shuhua Zhang Haiyan

MPIfR, Bonn, Germany University of Groningen, NL Tel Aviv Univ. Israel Ventspils International Radio Astronomy Centre, Riga, Latvia Univ. of Lisbon, Portugal Univ. of Central Lancashire, UK Obs. de Bordeaux, France Moscow State University, Russia NRC, Canada Urumqi Astronomical Observatory, China Queen's University, Belfast, UK FÖMI SGO, Budapest, Hungary Whittier College, CA, USA NRAO, Charlottesville, USA FÖMI, SGO, Hungary Univ. of Bologna, Italy Univ. of Madeira, Portugal MPIfR, Bonn, Germany Shanghai Astronomical Observatory, China IIA, Bangalore, India University of Missouri, USA ATNF, Australia Univ. of Lisbon, Portugal Univ. Leiden, NL Univ. of Central Lancashire, UK FÖMI SGO, Budapest, Hungary Onsala Space Observatory, Sweden Onsala Space Observatory, Sweden MPIfR, Bonn, Germany NRAO, Socorro, NM, USA ROE, Edinburgh, UK Obs. de Paris-Meudon, France Univ. of Central Lancashire, UK Univ. of Bonn, Germany Univ. of Leiden, NL Univ. of Leiden, NL Shanghai Astron. Obs., China Shanghai Astronomical Observatory, China Shanghai Astronomical Observatory, China Beijing Astron. Observatory, China

# **Presentations 2001**

#### Campbell

- "Radio Astronomy and VLBI", U.S. Naval Academy, Annapolis, MD, USA, 14 Feb.
- "Pulsar Astrometry and the Ionosphere", U.S. Naval Academy, Annapolis, MD, USA, 15 Feb.
- "The EVN MkIV Data Processor at JIVE", Barcelona, Spain, 7 Sep
- "EVN station locations: first JIVE geodesy", Dwingeloo, NL, 30 Oct

#### Gabuzda

- "Technique and Science of VLBI Polarization Observations", Radio Astronomy School, Pushchino, 20 Apr
- "VSOP Polarization Observations of OJ287 and 0735+178," Current Problems in Extragalactic Astronomy, Pushchino, 25 Apr
- "Total Intensity and Polarization Variability in AGN," review talk, AGN Variability across the Electromagnetic Spectrum, Sydney, 26 Jun
- "The rotation measure distribution in 1803+784 from sub-parsec to dekaparsec scales", Dwingeloo, NL, 30 Oct

#### Garrett

- "Faint radio sources, AGN and Starbursts", La Palma, 11 May
- Various presentations, EVN TOG, MPIfR, Bonn, 25 Jun
- "A High Resolution Deep Field SKA", SKA meeting, Berkeley, 10 July
- "The Faint Radio Sky", NATO VLBI School, Bologna, 27 Sep
- "VLBI facilities", NATO VLBI School, Bologna, 27 Sep
- "The FIR/Radio correlation at high-z", Dwingeloo-Bonn Neighbourhood meeting, Dwingeloo, NL, 30 Oct
- "Deep Field VLBI Continuum Surveys", SRT Workshop, Cagliari, 10 Nov
- TOG report, EVN Reliability and Performance reports, EVN CBD, Jodrell Bank, 22 Nov
- "EVN Reliability Programme", ICN RadioNET meeting, Jodrell Bank, 23 Nov
- "The need for a High resolution SKA", SKA High Resolution Workshop, Bonn, 10 Dec

## Gurvits

- "A European segment of VSOP-2 under the ESA's flexi-mission proposal", ISAS, Japan, 24 Jan
- "Tracking options for the VSOP-2 mission", ISAS, Japan, 25 Jan
- "Milliarcsecond radio structures in AGN across the redshift space", ShAO, China, 5 Feb
- "Very Long Baseline Interferometry and how it sees the radio Universe", OTKA-NWO, Hungary, 23 Feb
- "Update on the VSOP-2 tracking options", VSOP-2 tracking meeting (via teleconfernce link), 12 Mar
- "The Universe as seen by Very Long Baseline Interferometers" University of Nijmegen, NL, 5 Apr
- Presentations on:
  - TMR-LSF RTD project "Enhancing the European VLBI Network of Radio Telescopes";
  - Infrastructure and Cooperation Network project RADIONET;
  - Preparation of the EVN and JIVE Annual Reports 2000;
  - Status of Space VLBI projects.
  - EVN CBD and JIVE Board meetings, Torun Radio Astronomy Observatory, Poland, 4-5 May
- "A European view on the VSOP-2 mission's specifications", ISAS, Japan, 15 May
- "Update on tracking options for the VSOP-2 mission", ISAS, Japan, 15 May
- "Recent results from VLBI surveys of AGN", ASTRON & JIVE ASTRO-lunch, 13 Jun

- "Surveys of pc-scale radio structures in AGN" (invited review), IAU Coll #184, Byurakan, Armenia, 21 Jun
- "Milliarcsecond radio structures in AGN as cosmological probes", Landau Institute of Theoretical Physics, Moscow, Russia, 19 Jul
- "RadioAstron Project development", Astro Space Center, Moscow, Russia, 20 Jul
- "VSOP-2: European developments", ISAS, Japan, 28 Aug
- "Interferometry in Astrophysics", XXXI ISMD, Datong, China, 5 Sep
- "Second generation Space VLBI project proposals", ESA HQ, Paris, France, 23 Oct
- "VLBI in Space after HALCA", Dwingeloo-Bonn Neighbourhood meeting, Dwingeloo, NL, 30 Oct
- Presentations on
  - TMR-LSF RTD project "Enhancing the European VLBI Network of Radio Telescopes";
  - Infrastructure and Cooperation Network project RADIONET;
  - Preparation of the EVN and JIVE Annual Reports 2000;
  - Status of Space VLBI projects.
  - EVN CBD, JIVE Board and RadioNET meetings, Jodrell Bank Observatory, UK, 22-24 Nov
- "SKA as a ground segment of Space VLBI", Workshop "High resolution Options for SKA", Bonn, Germany, 10 Dec

#### Van Langevelde

- "Current Status of the JIVE processor", EVN-PC, Bordeaux, 23 Mar
- "6 Years of Astrometric Monitoring of OH in U Her", Cosmic Masers, Brazil, 8 Mar
- "The EVN MkIV system and the Correlator at JIVE", Cosmic Masers, Brazil, 9 Mar
- "Astrometric monitoring of circumstellar masers", Colloquium, Groningen, NL, 27 Apr
- "Sched report", EVN TOG meeting, Bonn, 25 Jun
- "Current Status of the JIVE processor", EVN TOG meeting, Bonn, 25 Jun
- "Current Status of the JIVE processor", EVN-PC, Torun, 27 Jun
- "Circular polarization of circumstellar H2O masers", Dwingeloo-Bonn meeting, NL, 30 Oct
- "De JIVE correlator", Open Day during National Science Week, Dwingeloo, NL, 7 Oct
- "De JIVE correlator", visit HRH Willem Alexander & Maxima, Dwingeloo, NL, 15 Nov

#### Phillips

- "The circumstellar environment of methanol masers", IAU Symposium 206, Cosmic Masers: From Protostars to Black Holes. Mangaratiba, Brazil, 6 Mar
- "Methanol Masers: Probes of Massive star formation", ATNF, Sydney, Australia, 19 Sep
- "Methanol Masers: Probes of Massive star formation", Uni of NSW, Sydney, Australia, 20 Sep
- "Methanol Masers: Probes of Massive star formation", Uni of Tasmania, Hobart, Australia, 21 Sep
- "Spectral line VLBI", ATNF Astronomical Synthesis Imaging Workshop, Narrabri, Australia, 27 Sep
- "Methanol Masers as tracers of Massive Star Formation", 2nd ICM meeting, Uni of Leiden, Leiden, NL, 8 Nov

#### Schilizzi

- "eEVN", NIKHEF, Amsterdam, NL, 10 Jan
- "*e*EVN", DG-IST Brussels, 17 Jan
- "VLBI: the sharpest view of the universe", CERN, Geneva, 7 Feb
- "eEVN", Global Grid Forum 1, Amsterdam, NL, 7 Mar
- "Future developments in VLBI", NOVA Instrumentation day, Utrecht, NL, 13 Mar
- "FP6-IST and astronomical infrastructure in Europe", Program Consultation Meeting for 6<sup>th</sup> Framework Program, Brussels, 2 May
- "Research networks and astronomy", Annual Meeting of the Trans-European Research Networks Association (TERENA), Antalya, 18 May

- "RadioNET, the Infrastructure Cooperation Network in Radio Astronomy", JENAM, Munich, 11 Sep
- "High angular resolution radio astronomy", 5<sup>th</sup> Hellenic Astronomical Conference, Crete, Greece, 21 Sep
- "VLBI and the Sardinia Radio Telescope", SRT Workshop, Cagliari, Sardinia, 8 Nov
- "The early days of VLBI in Europe", Harry van der Laan Symposium, Leiden, NL, 30 Nov
- "Summary of the Workshop", SKA High Resolution Workshop, Bonn, Germany, 10 Dec

#### Sjouwerman

- "86 GHz SiO Masers in Late-type Galactic Bulge Stars", M. Messineo, H.J. Habing, L.O. Sjouwerman, A. Omont, K. Menten, poster at the IAU Symposium 206, Cosmic Masers: From Protostars to Black Holes. Mangaratiba, Brazil, 6 Mar
- "OH/IR stars as signposts for ancient starburst activity in the Galactic center", Jodrell Bank, UK, 15 May
- "New radio supernova remnants in the core of M31", Jodrell Bank, UK, 15 May

# Membership of international committees

#### Mr. J. Buiter

1992- EVN Technical and Operations Group

#### Dr. D.C. Gabuzda

1998- ARISE Science Advisory Group

#### Dr. M.A. Garrett

1997-	EVN Technical and Operations Group
	2000 – present: Chairman
1998-	ARISE Science Advisory Group

#### 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
- 2001- Science Advisory Commttee of the Ventspils International Radio Astronomy Center

#### 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

## Prof. R.T. Schilizzi

- 1989- "Experimental Astronomy", Editor
- 1989- RadioAstron International Scientific Council
- 1991- URSI Global VLBI Working Group
- 1997- present: Chairman
- 1992- VSOP International Scientific Council
- 1996- Member of the Board of the European Consortium for VLBI
- 1999- SKA International Steering Committee
- 2000- IAU Working Group on Future Large Scale Facilities, Chairman
- 2001- European SKA Consortium

# Membership of professional associations and societies

#### Dr. I.M. Avruch

1993-	SIGMA Xi
1333-	

#### 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 Engineers1995- Federation of European Engineering Institutions

#### Dr. S.V. Pogrebenko

2000- International Astronomical Union

#### Dr. C.J. Phillips

1994- Astronomical Society of Australia

#### Prof. R.T. Schilizzi

- 1967- Astronomical Society of Australia
- 1970- Royal Astronomical Society
- 1976- International Astronomical Union
- 1978- Nederlandse Astronomen Club
- 1984- URSI
- 1984- COSPAR Associate
- 1991- European Astronomical Society

# Membership of scientific organizing committees

#### L.I. Gurvits

• SOC Symposium "New Technologies in VLBI", Gyeong-ju, Korea, 5 – 8 November 2002

#### H.J. van Langevelde

- SOC workshop on "Mass-losing Pulsating Stars and their circumstellar matter", Sendai, Japan, 13-16 May 2002
- URSI-GA session convenor "Radio-Astronomy at high data rates", Maastricht, August 2002
- LOC/SOC workshop on "Future directions in AGB research", on the occasion of the retirement of H.J. Habing, April 2003

#### R.T. Schilizzi

- SOC Workshop on "CSS and GPS Radio Sources", Greece, 29-31 May 2002
- SOC Symposium "New Technologies in VLBI", Gyeong-ju, Korea, 5 8 November 2002

# **Meetings attended**

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

#### Avruch

- EVN Summer School, S. Pietro, Italy, 16-29 Sep
- Dwingeloo-Bonn Neighbourhood meeting, Dwingeloo, NL 30 Oct

#### Campbell

- 2nd IVS Analysis Workshop, Goddard Space Flight Centre, MD, USA, 12-14 Feb
- 15th Working Mtg. on European VLBI for Geodesy and Astrometry, Barcelona, Spain, 7-8 Sep
- Dwingeloo-Bonn Neighbourhood meeting, Dwingeloo, NL, 30 Oct

#### Gabuzda

- Annual School for Young Radio Astronomers, Pushchino, Russia, 18-21 Apr
- Annual conference "Current Problems in Extragalactic Astronomy", Pushchino, Russia, 23-27 Apr
- Workshop "AGN Variability across the Electromagnetic Spectrum," Sydney, Australia, 25-29 Jun
- Dwingeloo-Bonn Neighbourhood meeting, Dwingeloo, NL, 30 Oct

#### Garrett

- Conference on AGN and Starbursts, La Palma, 7-11 May
- EVN Summer School, S. Pietro, Italy, 23-29 Sep
- Dwingeloo-Bonn Neighbourhood meeting, Dwingeloo, NL, 30 Oct
- SRT Workshop, Cagliari, Sardinia, 6-10 Nov
- High resolution Options for SKA, Bonn, Germany, 10-11 Dec

#### Gurvits

- NWO-OTKA Science Workshop, Budapest, Hungary, 21-24 Feb
- IAU Coll #184 "AGN Surveys", Byurakan, Armenia, 17-24 Jun
- XXXI International Symp on Multiparticle Dynamics, Datong, China, 1-7 Sep
- JENAM, Munich, Germany. 10-11 Sep
- Dwingeloo-Bonn Neighbourhood meeting, Dwingeloo, NL, 30 Oct
- H. van der Laan Symposium, Leiden, NL, 29 Nov
- High resolution Options for SKA, Bonn, Germany, 10-11 Dec

#### Van Langevelde

- IAU Symp # 206 "Cosmic Masers", Mangaratiba, Brazil, 4-10 Mar
- National Mtg. on Interstellar and Circumstellar Matter, Anton Pannekoek, Amsterdam, NL, 10 Apr
- Nederlandse Astronomen Conferentie, Dalfsen, NL, 16-18 May
- Dwingeloo-Bonn Neighbourhood meeting, Dwingeloo, NL, 30 Oct

#### Olnon

• Dwingeloo-Bonn Neighbourhood meeting, Dwingeloo, NL, 30 Oct

#### Phillips

- IAU Symp # 206 "Cosmic Masers", Mangaratiba, Brazil, 4-10 Mar
- National Mtg. on Interstellar and Circumstellar Matter, Anton Pannekoek, Amsterdam, NL, 10 Apr
- ATNF Astronomical Synthesis Imaging Workshop, Narrabri, Australia, 24-28 Sep
- Dwingeloo-Bonn Neighbourhood meeting, Dwingeloo, NL, 30 Oct

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#### Reynolds

- EVN Summer School, S. Pietro, Italy, 16-29 Sep
- Dwingeloo-Bonn Neighbourhood meeting, Dwingeloo, NL, 30 Oct

#### Schilizzi

- JENAM, Munich, Germany. 10-11 Sep
- 5<sup>th</sup> Hellenic Astronomical Conference, Crete, Greece, 20-25 Sep
- LOFAR workshop, Haystack, USA, 13-17 Oct
- Dwingeloo-Bonn Neighbourhood meeting, Dwingeloo, NL, 30 Oct
- SRT Workshop, Cagliari, Sardinia, 6-10 Nov
- H. van der Laan Symposium, Leiden, NL, 29 Nov
- High resolution Options for SKA, Bonn, Germany, 10-11 Dec

#### Szomoru

• Dwingeloo-Bonn Neighbourhood meeting, Dwingeloo, NL, 30 Oct

#### Sjouwerman

- National Mtg. on Interstellar and Circumstellar Matter, Anton Pannekoek, Amsterdam, NL, 10 Apr
- EVN Summer School, S. Pietro, Italy, 16-29 Sep

#### Verkouter

• Dwingeloo-Bonn Neighbourhood meeting, Dwingeloo, NL, 30 Oct

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

#### **Buiter**

- IVS Technical Operations Workhop, Haystack, USA, 6-7 Mar
- EVN TOG meeting, Bonn, Germany, 25 Jun

#### Garrett

- NOVA instrumentation day, Utrecht, NL, 13 mar
- EVN CBD and JIVE Board meetings, Torun, Poland, 4-5 May
- WSRT user meeting, Dwingeloo, NL, 30 May
- EVN TOG meeting, Bonn, Germany, 25 Jun
- Mark V meeting, Schiphol Airport, Amsterdam, NL, 16 Aug
- EVN CBD meeting, ICN RadioNET 2<sup>nd</sup> Annual meeting, Manchester, UK, 22-23 Nov

#### Gurvits

- VSOP Operations and VSOP-2 coordination meetings, ISAS, Sagamihara, Japan, 23-27 Jan
- EVN CBD and JIVE Board meetings, Torun, Poland, 4-5 May
- VSOP-2 meeting, ISAS, Sagamihara, Japan, 10-16 May
- ESA Space Science presentation, MOCenW, Zoetermeer, NL, 31 May
- 26<sup>th</sup> RadioAstron meeting, Moscow, Russia, 17-20 Jul
- VSOP-2 meeting and VSOP Survey workshop, ISAS, Japan, 27-31 Aug
- KNAW-CAS working visit, NAOC- BAO, Beijing, China, 31 Aug
- ICN RadioNET and OPTICON Joint meeting, Munich, Germany, 11 Sep
- EVN CBD meeting, ICN RadioNET 2<sup>nd</sup> Annual meeting, JIVE Board meeting, Jodrell Bank, UK, 22-24 Nov

#### Van Langevelde

- AIPS++ Users Group, Urbana Champaign, II, USA, 28-30 Jan
- 2nd ALMA BEE meeting, Dwingeloo, NL, 6-7 Feb
- NOVA instrumentation day, Utrecht, NL, 13 Mar

- EVN-PC meeting, Bordeaux, France, 23 Mar
- EVN technical workshop, Effelsberg, Germany, 24 Jun
- EVN TOG meeting, Bonn, Germany, 25 Jun
- EVN PC meeting, Torun, Poland, 27 Jun
- Mark V meeting, Schiphol Airport, Amsterdam, NL, 16 Aug

#### Olnon

 5<sup>th</sup> European Conference on Software Maintenance and Engineering, Lisbon, Portugal, 14-16 Mar

#### Parsley

- Euroglobus Conference, Marina Di Ugento, Italy, 18-20 Jun
- EVN TOG meeting, Bonn, Germany, 25 Jun
- Global Grid Forum 2, Washington, USA, 16-18 Jul
- Mark V meeting, Schiphol Airport, Amsterdam, NL, 16 Aug
- International Lambda Workshop, Amsterdam, NL, 12-13 Sep
- Global Grid Forum 3, Frascati, Italy, 6-8 Oct
- PCEVN project meeting, Metsahovi, Helsinki, Finland, 3-6 Nov

#### Phillips

- WSRT users meeting, 30 May
- Mark V meeting, Schiphol Airport, Amsterdam, NL, 16 Aug

#### Pogrebenko

- Mark V meeting, Schiphol Airport, Amsterdam, 16 Aug
- PCEVN project meeting, Metsahovi, Helsinki, Finland, 3-6 Nov

#### Schilizzi

- International SKA Steering Committee meeting, Boston, USA, 4-7 Jan
- DG-IST, Brussels, Belgium, 17 Jan
- Global Grid Forum 1, Amsterdam, NL, 6-7 Mar
- NOVA instrumentation day, Utrecht, NL, 13 Mar
- GRID workshop, Brussels, 23 Mar
- Program Consultation Meeting for 6<sup>th</sup> Framework Program, Brussels, 2 May
- EVN CBD and JIVE Board meetings, Torun, Poland, 4-5 May
- Annual Meeting of the Trans-European Research Networks Association (TERENA), Antalya, Turkey14-18 May
- SRON Wetenschapsraad, Utrecht, NL, 6 Jul
- CNR, Rome, Italy, 19 Jul
- Mark V meeting, Schiphol Airport, Amsterdam, NL, 16 Aug
- Dutch ICT conference, The Hague, NL, 6 Sep
- ICN RadioNET and OPTICON Joint meeting, Munich, Germany, 11 Sep
- EVN CBD meeting, ICN RadioNET 2<sup>nd</sup> Annual meeting, JIVE Board meeting, Jodrell Bank, UK, 22-24 Nov

#### Schonewille

• EVN TOG meeting, Bonn, Germany, 25 Jun

#### Szomoru

 5<sup>th</sup> European Conference on Software Maintenance and Engineering, Lisbon, Portugal, 14-16 Mar

#### Sjouwerman

• EVN TOG meeting, Bonn, Germany, 25 Jun

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

#### Buiter

- Thin Tape Path Upgrade, Shanghai Observatory, China, 11-31 May
- Repair Toruń recorder, Toruń, Poland, 20-23 Nov

#### Gabuzda

• Astro Space Center, Moscow, Russia, 30 Aug-7 Sep

#### Gurvits

- Beijing Astronomical Observatory, Beijing, China, 28 Jan 2 Feb
- Shanghai Astronomical Observatory, Shanghai, China, 2-9 Feb
- Jodrell Bank Observatory, UK, 27 Mar-1 Apr
- ESTEC, Noordwijk, NL, 25 May
- ESA HQ, Paris, France, 21-23 Oct

#### Van Langevelde

• Sterrewacht Leiden, NL, 5 Jul, 28 Aug, 13 Sep, 26 Sep, 11 Oct

#### Parsley

- NIKHEF, Amsterdam, NL, 10 Jan
- NIKHEF, Amsterdam, NL, 1 Feb
- CERN meeting, Geneva, Switzerland, 7 Feb
- Honeywell Technology Solutions Inc., Washington, USA, 19 Jul
- US Naval Observatory, Washington, USA, 20 Jul

#### Pogrebenko

- NIKHEF, Amsterdam, NL, 10 Jan
- NIKHEF, Amsterdam, NL, 1 Feb
- CERN meeting, Geneva, Switzerland, 7 Feb

#### Schilizzi

- NIKHEF, Amsterdam, NL, 10 Jan
- CERN meeting, Geneva, Switzerland, 7 Feb
- Meeting with IGN, Madrid, Spain, 4 Dec

#### Sjouwerman

- Sterrewacht Leiden, NL, 18 Jan
- Jodrell Bank Observatory, UK, 10-16 May
- MPIfR, Bonn, Germany, 22-29 May

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