European Consortium for VLBI

and

Joint Institute for VLBI in Europe

Annual Reports 2000

A. ANNUAL REPORT OF THE EUROPEAN CONSORTIUM FOR VLBI 2000

Foreword by the Chairman of the Consortium

This is the report of VLBI activities at the member institutes of the European Consortium for Very Long Baseline Interferometry, which operates the European VLBI Network (EVN); it includes the statutory report of the Joint Institute for VLBI in Europe (JIVE).

The EVN is a network of observatories extending well beyond Europe to include two radio telescopes as far away as China. In all, up to 16 telescopes in nine countries are operated as a VLBI array in observing sessions of about three weeks duration, some four times per year. The EVN regularly joins the US Very Long Baseline Array (VLBA) to form a Global array, and during the past four years the network has operated jointly with a telescope in Space, the Japanese orbiting observatory, HALCA, the space-borne component of the VLBI Space Observatory Programme (VSOP), extending baselines to 30,000 km. The Arecibo and the Hartebeesthoek Radio Observatories formally joined the network as associate members, and the Deep Space Network continues to cooperate in observing run as an affiliate of the network. Negotiations with further potential members of the network are underway.

This report once again impressively reflects the high quality of research conducted with the EVN and especially at the member institutes. The JIVE correlator facility is now operational as the EVN correlation facility. A number of scientific projects have been completed on this system and results are beginning to appear in the literature.

The European Science Foundation conducted a review of the EVN and JIVE and concluded that the EVN is in a healthy state offering attractive and important observing opportunities to the scientific community. The report also recommended implementing secure funding arrangements and less dependence on soft money. Multilateral negotiations are now underway to reach this goal in times of decreasing research budgets.

Following the upgrade program of the last few years, the EVN has received an Infrastructure Cooperation grant from the European Union's Fifth Framework Program to coordinate improving its performance and reliability through a number of technical and organizational initiatives, especially in the areas of operational reliability and flexibility and of pre- and post-correlation quality control. This RadioNET programme includes activities to foster and organise expert discussions planning the Atacama Large Millimeter Array and the Square Kilometer Array. These and VLBI are important activities towards providing excellent research tools for the community for years to come.

We gratefully acknowledge the substantial financial support of VLBI in Europe by the member observatories and the national funding research councils and foundations. We also once again acknowledge funding by the European Commission under the Fourth Framework Program to enable access to the EVN by inexperienced users from institutes that are not members of the VLBI Consortium.

Very Long Baseline Interferometry in Europe remains an excellent example for a longstanding successful international collaboration between scientific partners at various national observatories. To this end, it is important to note that the EVN is vitally dependent on the financial investment and innovative and skilled contributions at the individual observatories not only during the radio-astronomical observations, but also in new technical developments.

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Executive summary

VLBI in Europe continued to grow in terms of user interest and breadth of application in 2000. The basis for this is the continuing effort at the EVN telescopes to improve the reliability of their operations, and the gradual increase in capability of the data processor at JIVE. The EVN Technical and Operations Group has played a crucial role in coordinating the improvement in reliability with financial support from the EC-funded Infrastructure Cooperation Network in Radio Astronomy, RadioNET.

EVN operations
The EVN spent a total of 949 hours observing 79 projects during the four sessions in 2000. Of these, 34 were projects observed with the EVN alone, 28 were observed together with the VLBA, and 3 were projects observed together with HALCA, the Japanese orbiting radio telescope. Observing frequencies used at different times during the year were 1.4-1.6, 2.3, 5, 6, 8.4 and 22 GHz; 70% of the observing time was spent at 5 and 1.6 GHz. The EVN data processor at JIVE began to assume more of the processing load and correlated 32 EVN user projects and 17 test and monitoring experiments during the year. The MkIIIA processor at Bonn continued to operate through September until it was closed down to make way for the new MkIV processor; 14 EVN projects were correlated in 2000. The NRAO/VLBA correlator continued to help the EVN by processing 6 EVN-only and 31 EVN+VLBA experiments observed in 2000. By the last quarter of the year, the EVN correlator had taken over all EVN-only projects.

Science highlights
The sensitivity of the EVN and its unique range of frequencies have been exploited by the community in a number of innovative ways. Many of these were reported at the 5th EVN Symposium hosted by the Onsala Space Observatory in Gothenburg, Sweden, mid-year. Of particular note are the results of deep integrations on the Hubble Deep Field which have pinpointed 3 radio sources in the field as having faint (few 100 micro-Jansky) cores, thereby identifying them as probable AGN. The other radio sources in this field are likely to be starburst galaxies. These results show the power of the EVN for work on faint compact radio sources, not only in extragalactic objects, but also in our own galaxy.

Another highlight has been extensive studies of methanol masers in young massive stars using the EVN at 6.7 GHz. In many of the sources observed, the masers show elongated morphologies with linear velocity gradients consistent with the masers arising in circumstellar disks of radius ~ 1000 astronomical units. Assuming these are rotating disks, the enclosed masses are consistent with massive (5-50 solar mass) stars or proto-stars.

A rotating torus has been discovered in the nucleus of Mkn 231 by EVN observations of the OH megamasers in this Ultra-Luminous Infrared Seyfert I Galaxy. There had always been a suspicion that the OH molecules are part of a torus structure on scales of 20 to 100 parsec in the centres of ULIRGs, but these observations provide the first example.

Strong deceleration has been observed in the expansion of SN 1979C in M100. The current size of the supernova remnant is 3.60 milli-arcsec, and there is strong evidence that it slowed down substantially 5 to 10 years after the explosion in 1979, probably coincident in time with an abrupt change in the trend seen in the total flux density curves. In another and more famous supernova remnant, SN1993J in M81, there is evidence for unexpectedly large initial magnetic fields, in addition to a similar deceleration seen in the expansion.

References are given for these researches in the list of 192 VLBI-related publications by EVN staff members and others who made use of the EVN for their research.

Technical highlights
The capabilities of the EVN data processor at JIVE continued to expand in 2000 with the advent of 16-station correlation as one of the highlights. Other noteworthy points include the first demonstration of pulsar gating, and the completion of the prototype post-correlation integrator which is designed to increase the output data rate from the correlator by a substantial factor. The new MPIfR/BKG MkIV correlator in Bonn came on line in December 1999, and gradually ramped up its capabilities during 2000.

New technical developments
The EVN provided financial support for a technical development program begun by Haystack Observatory on a new data acquisition system based on commercial off-the-shelf tape recorders. The aim is to replace the current MkIV system on a timescale of several years from now. Another line of development was started in Europe with contacts being made with academic research networks operating wide bandwidth fibre connections in the various European countries. The initial aim is to establish a pilot project linking a small number of EVN telescopes to the correlator at JIVE, as a precursor to upgrading the full EVN to a real-time facility.

ESF review
In 1999, a review of the EVN and JIVE by the European Science Foundation was initiated by the Dutch Research Council, NWO, acting on behalf of the other Research Councils cooperating in the EVN and JIVE. The review was completed in June 2000 and a report was issued in September. The terms of reference were to review developments and operations in the period from 1994-1999 and evaluate plans for the coming 5-year period from 2000-2004. The scope of the evaluation was to cover the scientific case as well as the basic issues of the technical and organisational-managerial case.

The three main conclusions of the Review Group can be summarised as follows:

- The scientific-strategic case and impact of the EVN are convincing
- The EVN user community is of sufficient critical mass to justify continued operation of the facility
- The financial structure supporting JIVE operations should be re-examined, as should the legal basis of both the EVN and JIVE

These conclusions were under examination by the Research Councils at the end of the year.

EC contracts
The ongoing Access contract was instrumental in allowing 13 user groups to access the EVN in 2000. Each of these groups visited JIVE during the data reduction process or visited one of the EVN stations during the observations. Considerable progress was made in the FP4 RTD contract with the completion of the prototype of the post-correlation integrator for the data processor and initiation of the design of a prototype RFI-robust receiver.

Two new contracts with the European Commission in Brussels came into force early in the year. The first extends the Access programme until February 2004 and the second involves the Infrastructure Cooperation Network in Radio Astronomy called RadioNET Three main lines of activity are being undertaken by RadioNET. The TOG with RadioNET support is coordinating activities leading to increased reliability for the EVN as a whole; a number of workshops are to be to organised on various subjects concerning reliability, to be followed by implementation at EVN stations, and measurement of the results. Other workshops are to be held in connection with scientific and technical questions related to the development of the Atacama Large Millimetre Array (ALMA). The third theme concerns the Square Kilometre Array (SKA). RadioNET's role will be to provide support for coordination activities in Europe leading to a proposal for financing the facility. The first of the workshops for the EVN and ALMA activities took place in 2000, while an important step in the SKA development was achieved with the establishment of the European SKA Consortium involving many of the radio astronomy institutes in Europe.

1. The European Consortium for VLBI

The European VLBI Network (EVN) was formed in 1980 by a consortium of five of the major radio astronomy institutes in Europe (the European Consortium for VLBI). Since then, the EVN and the Consortium has grown to include 12 institutes with 16 telescopes in Spain, UK, the Netherlands, Germany, Sweden, Italy, Finland, Poland and China, a 16 station data processor at JIVE in Dwingeloo and a 9 station data processor at MPIfR in Bonn. Together, these individual centres form a large scale facility, a continent-wide radio telescope.

The EVN is linked on a regular basis to the 7-element Jodrell Bank MERLIN interferometer in the UK to create a very sensitive "regional network", to the US NRAO Very Long Baseline Array and the NASA Deep Space Network to create a "Global Network", as well as to the NAIC Arecibo Observatory in Puerto Rico and the Hartebeesthoek Radio Observatory in South Africa. The EVN, in stand-alone or global mode, also observes together with the orbiting radio telescope HALCA launched in February 1997 by the Institute of Space and Astronautical Science (ISAS) in Japan as part of the first dedicated Space VLBI mission VSOP (VLBI Space Observatory Programme).

The member institutes of the Consortium are (in alphabetical order):

Radio Astronomy

1) ASTRON (the Netherlands Foundation for Research in Astronomy), Dwingeloo, The Netherlands
2) Institute of Radio Astronomy (CNR IRA), Bologna, Italy
3) Jodrell Bank Observatory (JBO), University of Manchester, Jodrell Bank, UK
4) Joint Institute for VLBI in Europe (JIVE), Dwingeloo, the Netherlands
5) Max-Planck-Institute for Radio Astronomy (MPIfR), Bonn, Germany
6) Metsähovi Radio Observatory (MRO), Helsinki University of Technology, Espoo, Finland
7) National Astronomical Observatory (OAN), Alcala de Henares, Spain
8) Onsala Space Observatory (OSO), Chalmers University of Technology, Onsala, Sweden
9) Shanghai Astronomical Observatory, National Astronomical Observatories, Shanghai, P.R. China
10) Toruń Centre for Astronomy, Nicolaus Copernicus University, Toruń, Poland
11) Urumqi Astronomical Observatory, National Astronomical Observatories, Urumqi, P.R. China

Geodesy

12) Bundesamt für Kartographie und Geodäsie (BKG), Wettzell, Germany

2. Reports on scientific research

2.1. ASTRON (Netherlands Foundation for Research in Astronomy), The Netherlands

2.1.1. Emission structure of OH megamasers and the nuclear continuum of ULIRGs

Elaborate studies are underway on the line emission and continuum characteristics of OH Megamasers (OHMM) and Ultra-Luminous Infrared Galaxies (ULIRGs) using the EVN, MERLIN and the VLBA conducted by W.Baan (ASTRON), H.Klöckner and F.Briggs (Kapteyn Laboratory, Univ. Groningen). VLBA data on the source IRAS 14070+0727, a weak OH megamaser at a redshift of 79000 km/s, has been analyzed but no detections have yet been made of the emission. The nearby OHMM source IC 694 has been mapped using VLBA and EVN data and a fraction of the maser emission, as well as the nuclear continuum emission, have been detected. Because the line emission of this OHMM is partially over-resolved with the EVN, the data will be combined with MERLIN data. EVN studies are also underway to investigate the nuclear continuum emissions of some ULIRGs. According to optical, near-infrared, and radio classification schemes many of these sources are powered by a starburst distributed across the nuclear region.

EVN observations of the OH emission region in the Seyfert 1 galaxy Mkn 231 have resulted in a clear image of half the torus structure surrounding the nucleus (Klöckner et al. 2001, in preparation). The molecular torus in this system is inclined such that we look at its underside and we see emission from half of the torus. The FIR radiation from the nuclear region serves as a pump for the OH molecules within 100pc from the nucleus. This image of the OH emission torus around Mkn 231 is the first time that a molecular/dust torus around in a galactic nucleus has been imaged.

2.1.2. HI absorption and the interstellar medium around radio galaxies

HI absorption is often detected in compact/small radio galaxies. Indeed, the scale of the radio continuum in these objects represents an effective background against which the absorption can be observed. The HI absorption is often interpreted as due to the presence of a nuclear torus/disk. However, the situation can be more complicated in some (or perhaps many) cases as the absorption can be produced in the regions around the radio lobes and not only against the nucleus and the gas can be affected by the interaction with the radio plasma. This is illustrated by the results of the HI absorption observations, made with the Australian LBA, of two compact radio galaxies PKS 1549-79 and PKS 1814-63) conducted by R.Morganti and T.Oosterloo (ASTRON) in collaboration with C.Tadhunter and K.Wills (Univ of Shefield, UK), A.Tzioumis and J. Reynolds (ATNF, Australia)

PKS 1549-79 is a young source where the nucleus is surrounded by a cocoon of material left over from the event, which triggered the nuclear activity. The obscuring material that causes some of the peculiar optical characteristics of this galaxy is probably the cause for the detected HI absorption. In PKS 1814-63, the HI absorption is observed against the entire radio emission (see Fig.1) and most of the absorption is blueshifted compared to the systemic velocity of the galaxy. This indicates that, at least part, of the HI absorption comes from diffuse gas surrounding the radio lobes and interacting/expanding with them.

Thus, in both radio galaxies, the HI appears to give us information about the environment in which the radio sources are embedded, the effect that the ISM can have on the observed characteristics and the possible presence of interaction between the ISM and the radio plasma.

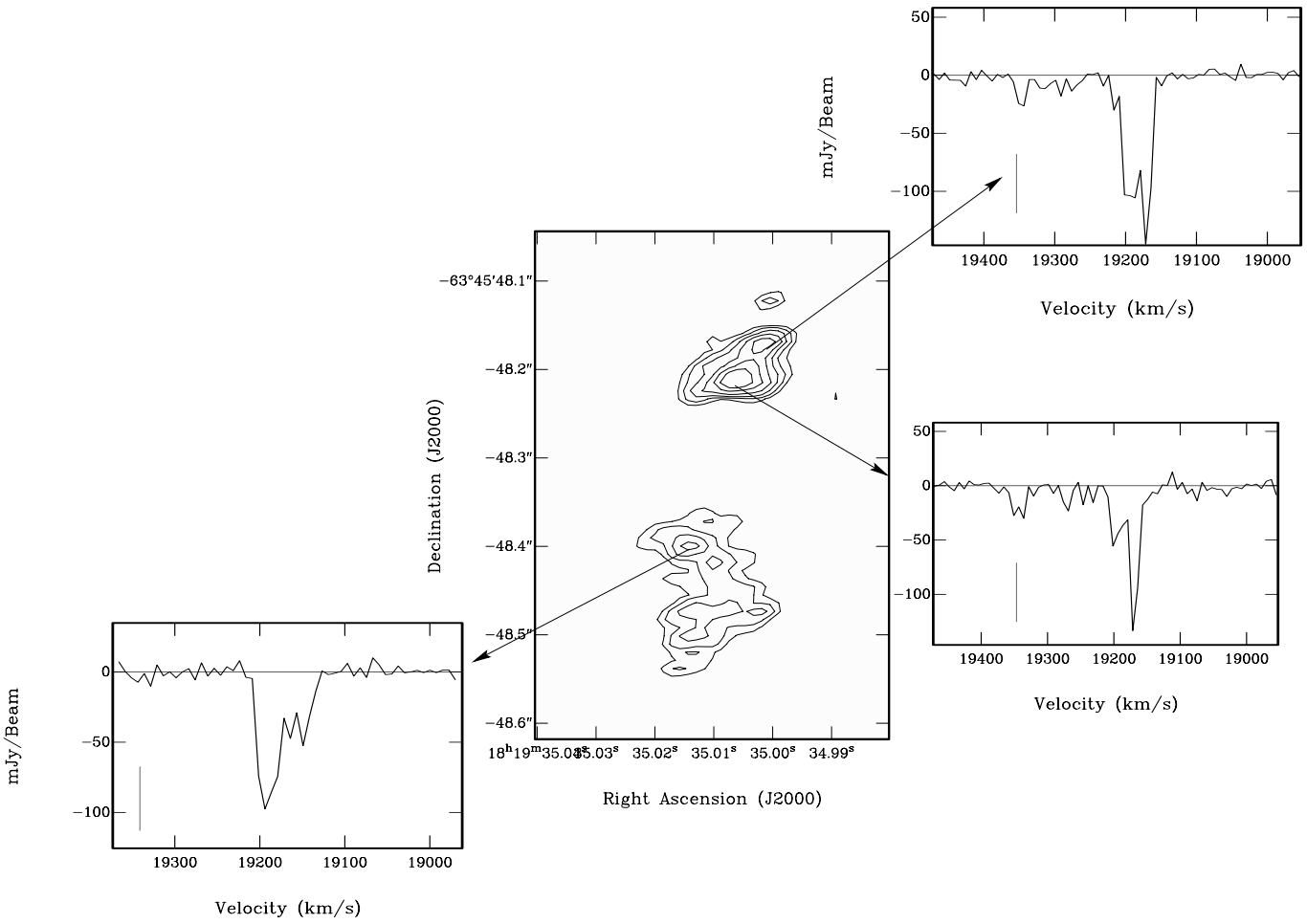

Figure 1. *Continuum image of PKS 1814--63 at 21 cm (obtained from the line-free channels) and spectra of the HI absorption obtained at three different locations in the source. The vertical line indicates the systematic velocity.*

2.1.3. Statistics of apparent proper motion in AGN

S.Britzen (ASTRON/University of Heidelberg) together with R.Vermeulen (ASTRON), R.Campbell (JIVE) and others continued to study the statistics of the morphologies of 293 Caltech-Jodrell flat-spectrum sources (the so called CJF sample drawn from the 6 and 20 cm Green Bank surveys, such that S_6 > 350 mJy, 6-20 cm spectral index ≥ -0.5, declination ≥ 35°, and |b| ≥ 10°). Multi-epoch VLBI snapshot observations at 6 cm have been carried out for 241 sources from the sample. It has been shown in previous studies that GeV gamma-ray AGN sources are preferentially radio-bright compact-core flat-spectrum sources. The CJF represents a suitable base to investigate this preference. A study of the curvature of the jets in the CJF sources shows that some sources demonstrate 50-100 degrees of curvature on pc scales. All gamma-bright sources in the CJF show significant curvature (Fig. 2), with multiple jet components in a given source following a single smoothly bent jet. The existence of curvature complicates the interpretation of jet-component motion statistics, in terms of conversion to meaningful linear velocities, and is currently under review.

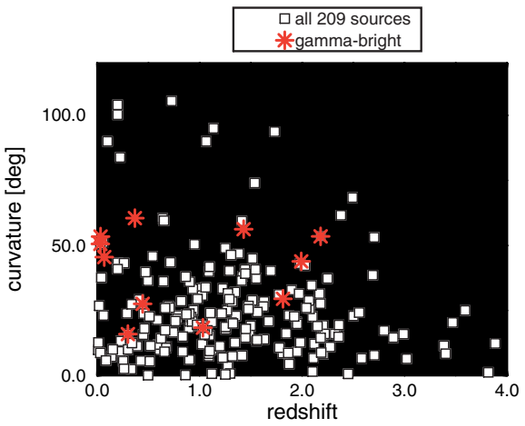

Figure 2: *Curvature observed over pc scales in CJF sources vs. redshift. Red asterisks are gamma-bright sources in the CJF; white squares are the other CJF sources having detectable jet structure.*

2.2. Institute of Radio Astronomy, Italy

VLBI scientific activity at the Istituto di Radioastronomia in the course of 2000 covered various topics in extragalactic and galactic radio astronomy, including both the detailed study of individual objects and of samples of radio sources.

2.2.1. Radio galaxies, BL Lacs and unification

2.2.1.1. Parsec-scale properties of radio galaxies.

All 27 objects belonging to the Bologna Sample of low-intermediate luminosity radio galaxies have been imaged at parsec-scale resolution at 5 GHz by the group of researchers which includes G.Giovannini (Bologna University and IRA-CNR), T.Venturi, L.Feretti (IRA-CNR), W.Cotton (NRAO, USA), L.Lara (IAA-CSIC, Spain). For a number of sources multi-epoch and multi-frequency observations are also available. The analysis and discussion of the parsec-scale properties for the sample was completed and a comprehensive paper is in press in the Astrophysical Journal. Most FRI and FRII radio galaxies in the sample are characterised by an asymmetric morphology, with the parsec-scale jet aligned with the large scale one. Two symmetric sources were found, i3C338 (FRI) and 3C452 (narrow line FRII, Fig. 3), and the observational constraints for these sources indicate that their extension is close to the plane of sky. Relativistic parsec-scale jets are common both in FRI and FRII galaxies. For both classes, the estimated Lorentz factor is in the range 3 - 10. Their orientation is generally in agreement with the expectations from unification. Proper motion was detected in three FRIs (NGC315, B2 1144+35 and 3C338) and in the two BL Lacs in the sample (Mkn 421 and Mkn 501). Another relevant result is the limb-brightened jet in B2 1144+35 and Mkn 501.

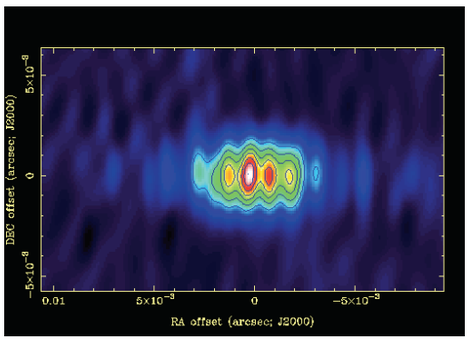

Figure 3: *3C452 at 5 GHz with mas-scale resolution. Symmetric structure is clearly visible.*

The observations and data analysis of the Bologna second sample of low luminosity radio galaxies, unbiased with respect to Doppler favoritism, are in progress. Further telescope time was obtained, and multiepoch observations of the most interesting sources is being carried out.

Imaging and analysis of six radio galaxies selected from the 2-Jy sample was completed by T.Venturi (CNR IRA), R.Morganti (ASTRON, the Netherlands), J.Reynolds and A.Tzioumis (ATNF, Australia). The radio galaxies, characterised by intermediate radio power, were observed with EVN+MERLIN, LBA and VLBA, at different frequencies. Mildly relativistic speeds for the parsec-scale jets and intermediate viewing angles to the line of sight were derived, The most stringent orientation limit was found for 3C317, $33° \leq \theta \leq 45°$, consistent with the fact that it is a broad line radio galaxy. The analysis of 3C317 suggested that this source is very young, and that its parsec-scale jets disrupt on the sub-kpc region, possibly as consequence of the cooling flow at the centre of the host galaxy.

2.2.1.2.Surveys of BL Lacs

The study at VLBI resolution of flat spectrum low power radio galaxies and BL Lac objects selected from the 200-mJy sample is being continued by M. Bondi and C. Stanghellini (IRA-CNR), D.Dallacasa (Astronomy Department, Bologna University), M.Marcha (Observatorio astronomico de Lisboa, Portugal) and A.Polatidis (OSO, Sweden). The authors are completing the VLBI observations of the 200-mJy sample. BL Lac objects belonging to the 200-mJy sample have intermediate properties (the core prominence parameter, the ratio between X-ray and radio flux, α_{ro}- α_{ox} diagram) between radio selected and X-ray selected samples. Furthermore, the data indicate that there is a continuation of properties at optical and radio wavelengths going from the flat spectrum radio galaxies to the BL Lacs.

2.2.1.2. Imaging monitoring survey of X--ray selected BL Lacs

In order to study the statistics of the nuclear properties of BL Lacs, a sample of 23 BL Lacs was selected on the basis of their X--ray flux density by T.Venturi and D.Dallacasa. EVN observations at 5 GHz were carried out in 1995 and 1997 and the data reduction was performed during 2000. All sources are resolved at the resolution of the observations, and comparison of the images at the two epochs will allow a study of the proper motion and of the related intrinsic source parameters, such as the Lorentz factor of the relativistic parsec-scale jets and the orientation to the line of sight. A master's student, G. Di Ciero, is involved in this project.

2.2.2. Morphological changes in the nuclear regions of radio sources

2.2.2.1. Search for structure changes in two blazars with long-term optical luminosity trend.

Recent radio images of the BL Lac object ON 231 (W Com, 1219+285) show remarkable new features in the source structure if compared to those previously published. The images were obtained by F.Mantovani and T.Venturi (IRA-CNR), R.Fanti (Bologna University, Italy), E.Massaro and R.Nesci (Universita la Sapienza, Italy) and G.Tosti (Universita di Perugia, Italy) from observations made with the EVN plus MERLIN at 1.6 and 5 GHz after the exceptional optical outburst occurred in the spring of 1998. The up-to-date B band historic light curve of ON231 has been also analysed together with the R band luminosity evolution in the period 1994--1999. The source core in the radio images was identified with the brightest component, on the basis of it having the flattest spectrum. A consequence of this assumption is the existence of a two-sided emission in ON 231 never detected in previous VLBI images. A further new feature is a large bend in the jet at a distance of about 10 mas from the core. The emission extends for about 20 mas after the bend, which might be due to a strong interaction with the environment surrounding the nucleus.

2.2.2.2. Radio cores in blazers.

VLBI polarimetry imaging and analysis of the first epoch observations of 5 γ-ray loud blazars at 8.4 and 22 GHz was carried out by T.Venturi, D.Dallacasa and F.Mantovani. The sources were 0048-097, 0235+164, 0954+658, 1510-089 and 1749+096. The first two sources are unresolved even at the resolution of ~1 mas, while the remaining sources exhibit a core-jet morphology and are good candidates for the detection of superluminal motion. Comparison with images from the geodetic database suggests an apparent superluminal velocity along the jet of 0954+658 and 1510-089 of the order of a few units of the light velocity. Furthermore, the observations suggest that for 0954+658 the magnetic field is parallel to the jet direction, as expected for BL Lacs, while in 1510-089 the magnetic field structure and orientation is much more complicated. Second epoch imaging was performed for the resolved blazars in this small sample, and the data reduction is in progress.

The source 1510-089 was also observed with VSOP at 5 GHz in August 1999 and May 2000.

2.2.2.3. Hot spot advance speed in OQ208.

The CSO quasar OQ208 has been observed in January 2000 with the VLBA at several frequencies by C.Stanghellini and M.Bondi (IRA-CNR), D.Dallacasa and Liu Xiang (Urumqi Observatory, China). The new observations added an epoch at 8.4 GHz to the 6 short snapshots already available from 1994 to 1997 (the RRFID data base), and allowed the investigators to compare the new 6 cm observations with global VLBI observations of OQ208 made in 1993 (Stanghellini et al. 1997). With the new data at 8.4 and 5 GHz, an apparent motion between the 2 main

components of around 0.03 mas/year at the 2.5σ level has been estimated. The current estimate of the velocity at which the hot-spot propagates in the ambient medium is still not very precise but in any case consistent with the values expected, being very similar to the values found in other CSOs. The data at L-, S-, C- and X-bands were used to determine a separate radio spectrum for the 2 main regions of the source confirming the existence of a region of very steep inverted spectral index inconsistent with the synchrotron self-absorption model, as already shown by Kameno et al. (2000). This implies that free-free absorption may play an important role in OQ 208 and similar compact extragalactic radio sources.

2.2.2.4. Polarimetric VLBI in 4C39.25.
From multi-epoch multi-frequency VLBI images at 15, 22, and 43 GHz of the compact polarized radio structure of the quasar 4C 39.25 spanning the period 1995 - 1999, significant changes in the polarized intensity images have been detected by A.Alberdi and J.-L.Gomez (IAA, Spain), M. Perez-Torres (IRA-CNR, Italy), J.M. Marcaide (Universidad de Valencia, Spain), and A.Marscher (Boston University, USA). These changes in the polarized structure trace in great detail the interaction between moving and stationary components. The stationary feature is interpreted as a bend in the jet trajectory in a plane that does not contain the observer, and the moving one as a shock turning around the bend.

2.2.3. Gravitational lenses

M. Perez-Torres and collaborators observed the quadruple gravitationally lensed image of MG J0414+0534 on 23 November 1997 with a global VLBI array at 8.4 GHz. They reported wide-field imaging results of its four components at submilliarcsecond resolution, displaying complex core-like and jet-like extended structures. A simple model combining a single isothermal ellipsoid to represent the main lens galaxy, external shear, and a single isothermal sphere to represent an additional, nearby object accounts well for the core positions and flux densities of the VLBI images. This model predicts delays between the different lensed images of several weeks.

2.2.4. Probing the nuclear environment of AGN

The data analysis of VLBA polarization observations of the two CSS sources, 0548+165 and 1524-136, at 8.4 and 5 GHz was completed by F.Mantovani, R.Ricci (IRA-CNR) and their collaborators. At 5 GHz, the sources were observed at 4 widely separated frequencies making use of the wide-band receivers available at the VLBA antennas. These observations made possible to estimate values of the rotation measure (RM) in several highly polarized regions along the jets. Values as large as >4000 *rad* m^{-2} and up to 10^4 *rad* m^{-2} for 0548+165 and 1524-136, respectively, were found. Such large values of rotation measure are suggestive of an external screen in the case of 1524-136 and an external screen plus a NLR in the case of 0548+165. Estimates of the magnetic field in the external screen as seen along the line of sight were possible assuming an `a priori' electron density of $n_e \sim 0.1\text{-}1$ *cm*$^{-3}$ and slab thickness of 1 *kpc*. The values obtained for 1524-136, up to 100 *μG*, are larger than those for 0548+165, which were in the range of 1.5 - 15 *μG*. Since X-ray measurements are not available and the angle of the jet axis to the observer's line-of-sight is not known, for either of the sources, the parameters cannot be constrained better. The depolarization might occur in the beam. For 1524-136, inhomogeneities in the magnetic field, and/or in the electron density of the external screen, can also account for the depolarization.

As a follow-up observing project of the results presented by Mantovani et al. (1990, 1997), the same group of investigators studied the source 3C99 with MERLIN and the EVN at 5 GHz and more recently with the VLBA in dual polarization at 1.6 and 5 GHz. 3C99 is a Compact Steep-Spectrum (CSS) source. In the radio band, 3C99 shows a triple asymmetric structure on the arcsecond scale; the central component, made up of two different parts which don`t show relative motion, contains the radio nucleus of the source, which, however, was not clearly detected by VLBA. A possible explanation of the radio asymmetry is based on a combination of relativistic effects and a strong asymmetry of the external medium. This explanation is consistent with the Scheuer-Baldwin model (one of the so called “continuous streaming models") under an assumption that the external gas density decreases slower in the northeast direction,

toward the side of the most brightest and shortest jet. In this model, the jet's major axis is at 30°-40° to the line of sight, with an almost relativistic jet of β_1~*0.6* and a counter jet with β_2~*0.04*. The hypothesis that the gas density is proportional to r^{-2} (where *r* is the linear distance from the central region) on the side of the longest and less bright jet, and that it doesn't depend on *r* on the opposite side, is compatible with the data and with the Scheuer-Baldwin model. The age of 3C99, $(4\text{-}7.5)\cdot 10^5$ years, estimated by three different methods and based on the model parameters listed above indicates that the source is young.

2.2.5. Galactic jets and supernovae

2.2.5.1. EVN Observations of the galactic superluminal source GRS 1915+105.

The source GRS1915+105 is an X-ray transient source at the distance of 11 kpc, which represents the first case of apparent superluminal motion in a source within our own Galaxy. The source, constantly monitored in radio by the Green Bank Interferometer (GBI) in Virginia, USA, shows quiescent periods, with radio flux densities of a few mJy, periods of radio activity, with fluxes around 200-300 mJy at 2.2 GHz, and rapid major flares, up to 1 Jy or even more. EVN observations of this source during a radio-loud state were performed during gaps of the official observing schedule in 1998 at 6 and 18 cm by L.Feretti, G.Giovannini, M.Tordi, T.Venturi and their collaborators (Fig. 4). A radio flare took place between two consecutive VLBI observations several days apart. In the two images obtained before the major flare, the source is resolved, showing two opposite asymmetric jets. The VLBI flux density is in rough agreement with the total power GBI flux density In the third observation, obtained after the flare, the source is unresolved. The total VLBI flux density is much lower than the GBI flux. This would imply the presence of an extended structure undetected in the present observations, supporting the idea that during the flare strong high velocity components have been ejected. The observations reveal that steady jets exist in the source also before a major flare. Assuming that the jets are relativistic and intrinsically symmetric, an estimate of the velocity from the jet to counter-jet brightness ratio and from the jet-length ratio can be derived. The result is of the order of 0.2-0.6*c* up to a distance of ~8 mas (~90 AU). Such a velocity would imply proper motion between the first two epochs (31/5/98 and 2/6/98). However, no proper motion of a discrete component was detected. The absence of visible proper motion could be due to a continuous ejection in a stable jet.

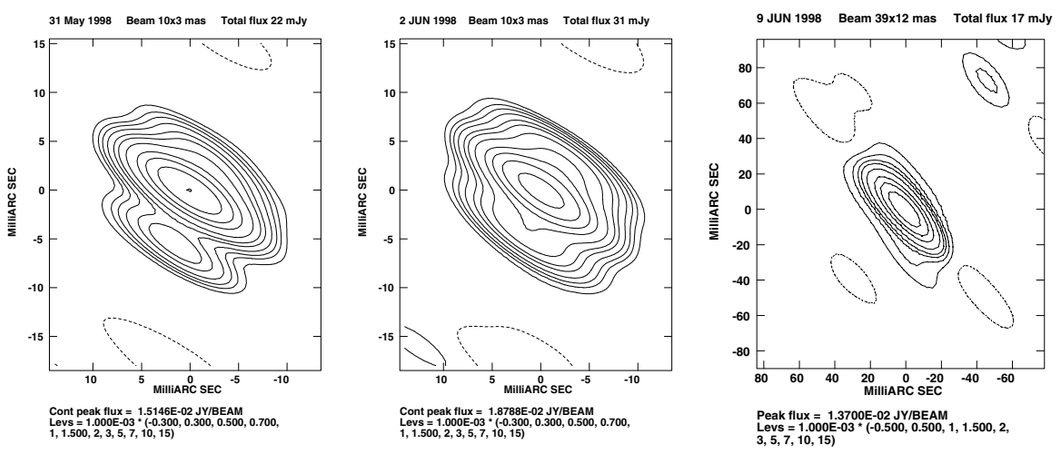

Figure 4. *EVN images of the galactic superluminal source GRS 1915+105.*

2.2.5.2. The radio supernovae SN1993J and SN1979C.

M. Perez-Torres and collaborators reported the results of model calculations, applied to the radio light curves of the supernova SN 1993J. Taking synchrotron self-absorption into account, they found that a good fit to the radio light curves of SN 1993J requires unexpectedly large initial magnetic fields, about *30 G*. In addition, they show that while at early epochs the main absorption mechanism is external absorption by thermal electrons, at late epochs it is synchrotron self-absorption that dominates. If such a model is correct, SN 1993J is expected to show a break in its spectrum above 90 cm at the present epoch. Sensitive single-dish monitoring of SN 1993J at wavelengths around and above 90 cm is necessary to test this prediction.

2.2.6. Astrometry and geodesy

2.2.6.1. Ground- and Space VLBI astrometry.

M. Perez-Torres and collaborators have demonstrated the feasibility of precision phase-delay differential astrometric VLBI techniques from simultaneous dual-frequency measurements at 2.3 and 8.4 GHz for two sources (the QSO 1150+812 and the BL Lac object 1803+784) separated by 15 degrees on the sky. They obtained comparably accurate and consistent relative positions of the radio sources compared with single frequency observations supplemented with GPS-based ionosphere corrections. This demonstrates that dual-frequency observations are not required for state-of-the-art accuracy in VLBI astrometry.

The feasibility of precision phase-delay differential astrometric VLBI techniques at millimeter wavelengths has been demonstrated with 43 GHz VLBA observations of the pair of radio sources 1928+738 and 2007+777,

VSOP observations at 5 GHz of the quasar pair B1342+662 and B1342+663 demonstrated the feasibility of the phase-referencing technique with the HALCA satellite. From the residual referenced phases, Perez-Torres and collaborators derived an upper bound to the uncertainties of the HALCA's orbit reconstruction of 10 meters. An analysis of the phase-reference maps of the observed sources also suggests that these orbit prediction uncertainties are in fact as small as 3 meters.

2.2.7.2. Geodesy.

M.Perez-Torres, W.Schwegmann (IRA-CNR, Italy) and P.Tomasi (ITIS-CNR, Italy) carried out a careful analysis of more than 50 VLBI observing epochs, spanning a 10-year temporal baseline, with the aim of studying the atmospheric mapping function effects on the estimates of baseline lengths for the European Geodetic VLBI network. A master's student, F.Falcioni, was also involved in this project.

2.3. Jodrell Bank Observatory, UK

2.3.1. Global VLBI measurements of SNR in M82

A.McDonald et al (MNRAS 322, 100, 2001) have made observations of the starburst galaxy M82 with a 20 station global VLBI array at 18cm. Widefield imaging techniques were employed giving a field of view of ~1 arcmin and a 3 mas angular resolution.

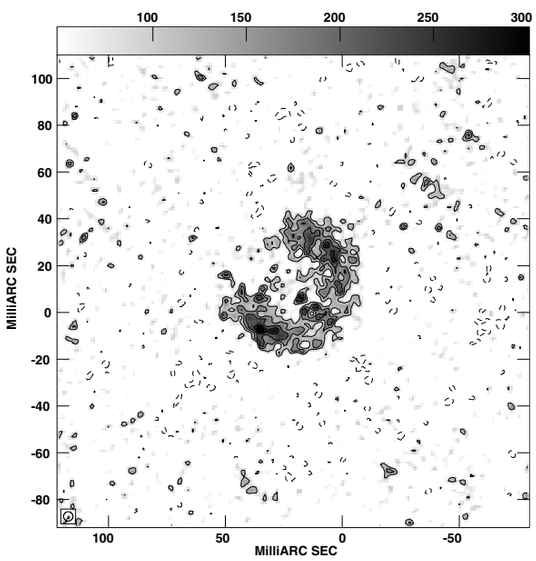

Figure 5. *Global 18 cm VLBI image of the shell SNR 43.31+59.2. The resolution is 4 mas and the lowest contour is 0.1 mJy/beam*

This angular resolution has enabled the young supernova remnants to be studied on scales of 0.05 pc revealing a number of compact knots of radio emission expanding at ~10000 km/s (Fig. 5). By comparison with earlier work, limits can be set on the deceleration of these knots confirming that the remnants have not reached the adiabatic (Sedov) phase. Further global observations, currently being analysed, will allow accurate measurement of the deceleration of the knots on a time scale of ~5 years.

The most luminous, most compact source (41.95+575, Fig. 6) does not resemble a shell, or even a partial shell. This source, which has been studied with VLBI for the last 15 years has shown a remarkably constant decline in flux density of 8.5% per year. Between 1990 and 1998, the separation of the emission peaks increased by ≤ 2 mas, indicating an expansion speed of < 2000 km/s, less than one-fifth of the expected speed of other SNR in M82. 41.95+575 is certainly anomalous and although the simplest explanation might be a supernova explosion in a high-density environment, a satisfactory model which explains the morphology and evolution has yet to be constructed. It has been suggested that in its youth, this source may have resembled the extremely luminous radio supernovae in Arp220.

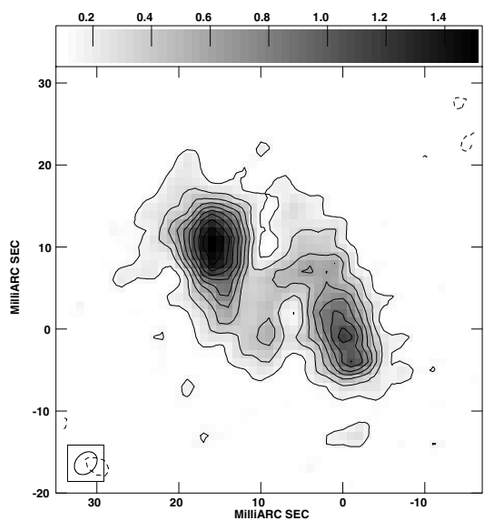

Figure 6. *Global 18 cm VLBI image of the compact source 41.95+57.5 in M82. The resolution is 4 mas and the grey scale ranges from 0.1 to 1.5 mJy/beam.*

2.3.2. Global VLBI Observations of Arp 220

P.Diamond, along with Carol Lonsdale (Caltech), Colin Lonsdale (Haystack) and H.Smith (U. California, San Diego) have continued VLBI monitoring of the luminous radio supernovae in Arp 220. High resolution VLBI observations offer a unique insight into the compact, dusty nuclear starburst region of this archetypal ultra-luminous IR galaxy merger. The initial detection of over a dozen compact sub-mJy sources by Global VLBI, interpreted as radio supernovae, has been followed by several epochs of VLBA monitoring (Lonsdale et al IAU Symp. No. 205).

The flux densities of the radio sources are, in general, decreasing systematically but not smoothly. Two new sources have been detected since 1994, implying an occurrence rate of roughly 0.3 per year (Fig. 7). Higher sensitivity Global VLBI observations are due to take place in 2001 and these will sample the lower luminosity RSN.

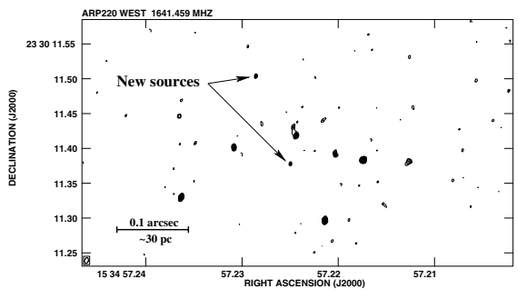

Figure 7. *VLBA 18 cm image of the western nucleus of Arp 220. The resolution is 5 mas (1.5 pc) and the noise level is 80 microJy/beam.*

Diamond and Rovilos are combining MERLIN and VLBI observations to study the diffuse component of the OH megamaser in Arp220.

In collaboration with Nakai, Ishihara (Nobeyama Radio Observatory, Japan), P.Diamond has been working on VLBA and Nobeyama 45-m observations of the H_2O megamaser in the nucleus of IC2560. The masers appear to lie in a rotating disc around the nucleus like the masers in NGC4258. The combination of data from the two instruments reveal an acceleration of the masers in the systemic group, the detection of high-velocity masers (210-420 km/s from the systemic velocity) and an estimate of the mass

density in the nuclear region of $2.1 \cdot 10^9$ M_{solar}/pc^3. The results are currently in press (Ishihara et al 2001, PASJ 53, 215).

2.3.3. *MERLIN + VLBI Observations of HI absorption in 3C293*

R.Beswick, A.Pedlar and A.Peck (MPIfR) have combined MERLIN and global VLBI data to study the HI absorption in the radio galaxy 3C293. This peculiar radio galaxy shows signs of interaction with a neighboring galaxy and several dust lanes cross the central region. Large quantities of neutral gas are revealed by HI absorption across this 3 kpc source and the highest optical depths are co-spatial with the optical dust lanes. Continuum images and HI cubes have been made using VLBI+MERLIN (Fig. 8).

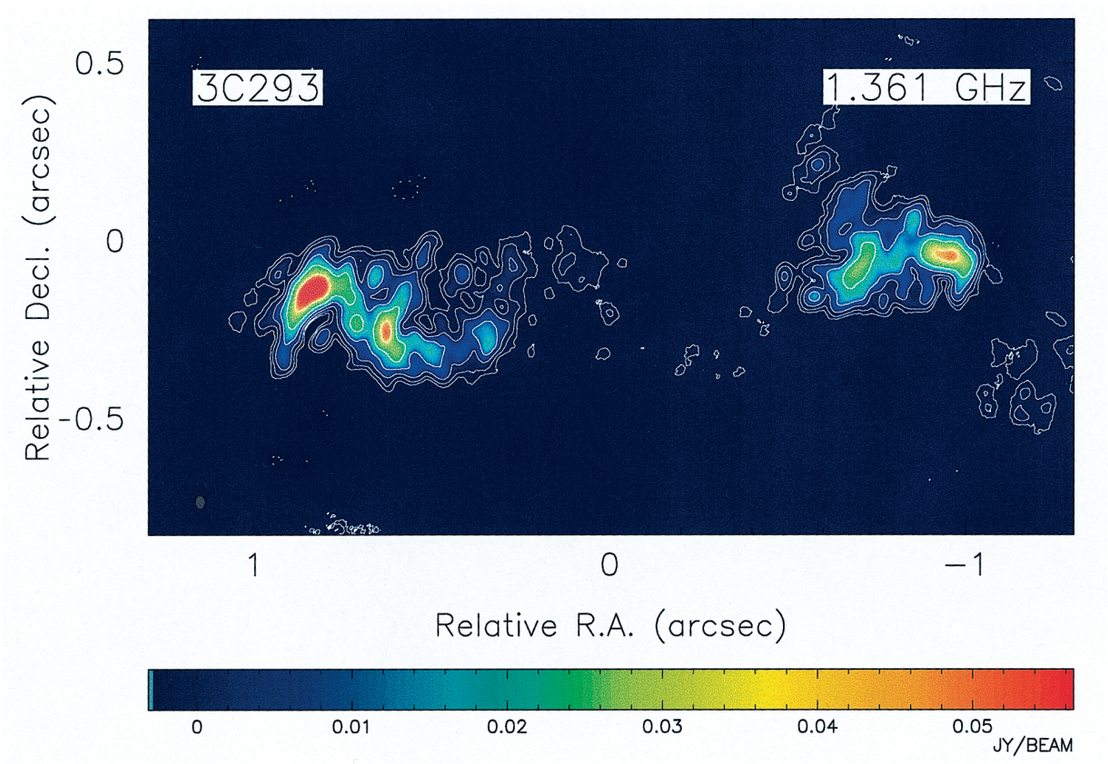

Figure 8. *Global VLBI + MERLIN continuum 21 cm image of 3C293, restoring beam 30x40 mas, lowest contour 1.3 mJy/beam.*

2.3.4. *VLBI observations of mJy and microJy radio sources*

S.Garrington and M.Garrett (JIVE) have used Global VLBI to observe a number of steep-spectrum mJy radio sources, originally selected from a unbiased small-area survey around the bright quasar J1159+291 (Garrington et al, IAU Symp. No. 205). The new observations show these sources have compact linear structures approximately 10 mas across. One source, which had initially attracted attention because it appeared as an isolated 5-mas diameter ring (Garrington et al 1999), turned out to be a 70-mas compact steep-spectrum object, in which the earlier snapshot had only revealed one lobe. The compact sources are thought to be nascent low luminosity radio galaxies.

S.Garrington and T.Muxlow have worked with M.Garrett (JIVE) on EVN observations of the Hubble Deep Field (Garrett et al. 2001).

2.3.5. Circumstellar Masers

A.Richards, R.J.Cohen, M.Masheder (U Bristol) and collaborators have carried out OH and H_20 observations of Mira and red supergiant winds using the EVN, Global VLBI and MERLIN. EVN and Global VLBI observations of the OH mainline masers in VX Sgr have used the detection of Zeeman splitting to measure the magnetic fields and show that the OH overlaps the H_20 maser region (mapped using MERLIN). The presence of OH mainline masers this close to the star presents a challenge to maser theories (Gray et al. 2001 MNRAS, in press).

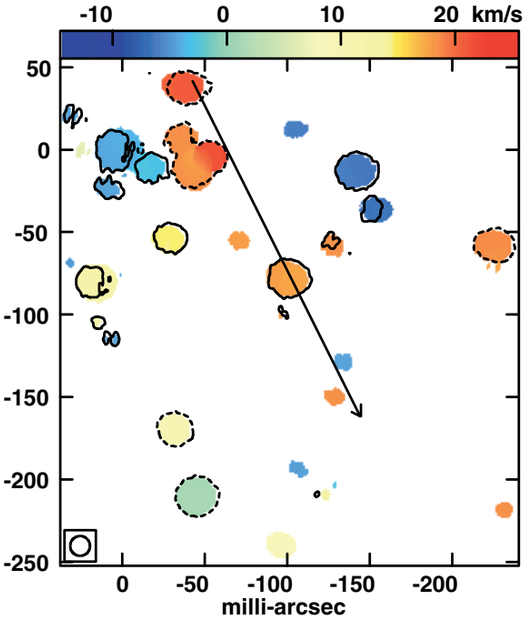

Figure 9. *OH masers in VX Sgr. The colours represent velocity and solid/dashed contours show the sense of circular polarization (solid contours are V/I > 0.3). The arrow shows the proposed magnetic field direction at 30 degrees to the line of sight.*

P.Diamond, in collaboration with A.Kemball (NRAO, USA), has continued the VLBA monitoring of the 43 GHz SiO masers in the envelope surrounding the Mira variable TX Cam. At the time of writing, 76 epochs of data have been collected covering a period of 4 years or 2.6 pulsation periods of the star. A paper (Diamond & Kemball) has just been submitted to the Astrophysical Journal.

P.Diamond, in collaboration with H.J.van Langevelde (JIVE), W.Vlemmings (U Leiden) and R.Booth (OSO), conducted 13-telescope global VLBI observations of the bright, blue-shifted 1612 MHz OH maser feature from the OH/IR star OH127.8-0.0 (Fig. 9). EVN observations in the 1980s and global observations in 1990 had previously revealed that the blue-shifted peak was the only compact maser in the star's envelope. It was hypothesized that this was due to its special location directly along the line of sight to the central star. The observations in 1990 revealed a double structure with a separation of ~10 mas. Surprisingly, the recent observations showed a similar structure. This is unexpected since if the masers are amplifying bright spots on the stellar surface then we would expect them to vary semi-randomly. Further data analysis is underway.

S.Etoka has used the EVN to observe eruptive events in the OH maser shell of R Leo Minor.

2.3.6. SS433

SS433 is an archetypal x-ray binary with relativistic jets whose motion has been studied using VLBI and MERLIN for many years. Radio emission roughly perpendicular to the jets has now been detected independently by two groups using MERLIN+VLBI. Paragi et al (1999, 2001), who first detected the equatorial emission, agued that it is produced by a separate mechanism, perhaps related to an outflow in the orbital plane of the central binary system.

Observations at 6 cm of SS433 (Fig. 10) have been made simultaneously using a combined total of 43 antennas of MERLIN, the VLA and the VLBA by K.Blundell and R.Podsiadlowski (Oxford) with T.Muxlow (JBO) and M.Rupen (NRAO). These observations have revealed very smooth emission associated with the base of the jets, distributed approximately orthogonally to the jet axis. The emission extends out from the jet axis by over 400 mas. A very similar structure is also seen in interleaved observations at 20 cm with the VLBA.

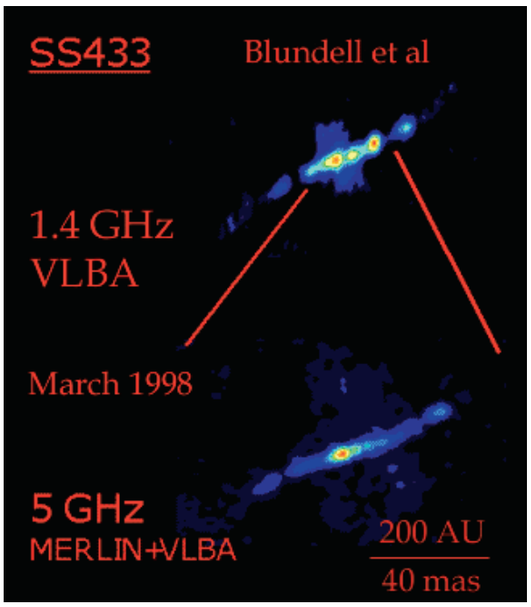

Figure 10. *VLBA and MERLIN+VLBA images of SS433.*

2.3.7. Gravitational Lenses

A. Biggs et al., in collaboration with R. Porcas and A. Patnaik (MPIfR), carried out Global VLBI observations of the gravitational lens 0218+357, in order to detect the strongly demagnified third image. Only one probable detection of a third image in any lens has been reported to date. This important constraint will greatly reduce the uncertainty in the value of H_0 found from this system. Data reduction is in progress.

E.Xanthopoulos and P.Wilkinson, in collaboration with R.Porcas (MPIfR) continued global VLBI observations of the gravitational lens B1030+074 in order to see whether this source could be used to measure a time delay in this potentially 'golden' lens. JBO staff and students were involved in VLBA observations of the six-image lens B1359+154, confirmed using VLBA observations (astro-ph/0011505); the discovery of a new two-image lens B0739+366, which used the VLBA, VLA, MERLIN and HST (astro-ph/0008037); and follow-up MERLIN, VLBA and HST observations of B1152+199, another two-image lens which shows strong optical extinction (Rusin et al., in prep). VLBA 5 GHz observations of the quad CLASS lens B0128+437 have revealed significantly more substructure in each image than is usually the case; each consists of a long jet of at least three distinct components (cf 0957+561), offering an exceptional number of model constraints which are being used to improve the mass model.

K-Y Chae and S.Mao (astro-ph/0104467) have worked on the interpretation of the gravitational lens 2114+022 found by P.Augusto (U Madeira). Augusto et al used the VLA, MERLIN, EVN and the VLBA to study this system in detail, which shows an unusual configuration of what appears to be two compact lensed components on either side of an unlensed small double radio galaxy. Chae et al use a two-plane lensing model to reproduce the two compact radio cores in the system. Further Global VLBI observations have been made in an on-going study of this enigmatic system.

2.4. Joint Institute for VLBI in Europe, The Netherlands

During 2000 the scientific staff of JIVE continued to pursue a broad variety of astrophysical studies. The emphasis was made on the studies related to the new capabilities of the European VLBI Network and the new MkIV Data Processor at JIVE.

2.4.1. Galactic nuclei

VLBI and optical observations of PKS0420-014 have been investigated by S.Britzen (ASTRON/Heidelberg University), R.Campbell (JIVE) and others in the light of the binary black hole model. This model implies that the central engine of the AGN comprises two (bound) black holes and an accretion disk, one of the black holes emitting the plasma forming the VLBI jets characterized by a two-fluid model. The paths and motions of the VLBI jet components can be explained by the precession of the accretion disk, and outbursts in the optical light curve by motion of the black hole emitting the radio jets. From the viewpoint of the data, the VLBI observations can constrain the geometry of the system (inclination angle, angle between the accretion disk and the binary black-hole orbital plane, the precessional period, etc.), and the amplitudes of the light curve peaks can constrain the black-hole mass ratio. The binary

black hole hypothesis could also help explain the distinction between radio loud and quiet AGN: radio-loud AGN are typically hosted by elliptical galaxies, which as merged systems would be more likely to have a central binary black-hole system; the more predominant radio-quiet AGN with a spiral host would have only a single central black hole.

M.Garrett continued to collaborate with N.Gizani (University of Madeira) on EVN observation of Her A, a bright but extremely extended radio source. In spite of the large extent of the structure, the radio core was strong enough to allow self-calibration. The core is slightly resolved on EVN baselines, indicating the need for further global VLBI observations.

Garrett worked with A.Tarchi (PI, University of Bonn) on EVN and VLBA phased referencing observations of the nearby starburst galaxy NGC2146. Both the EVN 6 cm and VLBA 18 cm phase-referenced observations detected compact features, some of which are certainly SNRs, although the brightest one may be the active nuclei of the galaxy.

D.Gabuzda together with T.Cawthorne (U Central Lancashire, UK) made 1.3 cm VLBI total intensity and polarization images of seven BL Lacertae objects and the OVV quasar 3C279 from data taken by the VLBA and 100-m Effelsberg telescope. These are among the first such high-resolution polarization images of AGN.

Gabuzda together with J.-L.Gómez (IAA, Spain) made 6 cm VSOP Space VLBI images of the compact BL Lacertae object OJ287 (Fig. 11). The Space VLBI data were analysed in concurrence with the 2 cm VLBA images (with nearly the same resolution) obtained by J.-L. Gomez only two weeks earlier. The extra resolution provided by the space-ground baselines showed that the compact "core" detected in earlier ground-based VLBI observations was actually made up of an extended emission region dominated by the contribution of the bright optically thin inner VLBI jet. The weaker core is optically thick at 6 cm, as shown both by its spectral index and a 90-degree rotation in the core polarization angle between 6 and 2 cm (2001, MNRAS 320, 649).

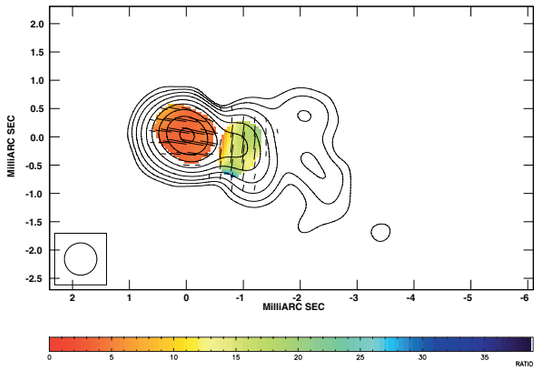

Figure 11. *VSOP I and P image of the BL Lac object OJ287 at 6cm. The superposed sticks show the direction of the magnetic field, and the degree of polarization is shown in color.*

Comparison of 6 cm VSOP space VLBI total intensity and polarization images of the BL Lacertae object 0735+178 with 2 cm VLBA images (with nearly the same resolution) obtained by J.-L. Gomez about a month later revealed very good correspondence in the structures at the two wavelengths in some places and intriguing discrepancies in others. Analysis of the two images together with VLBA images at 1.35 cm and 7 mm indicates the presence of appreciable absorption near the first of two nearly 90-degree bends in the VLBI jet, suggesting that this bend may be associated with a collision or interaction with a dense cloud.

With Dickel (ASTRON/University of Illinois), Sjouwerman reduced 8.4 GHz archive VLA data of the center of the galaxy M31 (M31*) and discovered a number of SNR's and point sources of yet unknown origin. Sjouwerman prepared a poster presentation of this result for a Maryland workshop on Young Supernova Remnants in October 2000. In collaboration with Dickel and Garrett, possible phase-reference sources for further VLBI observations of these unknown sources at 1.6 and 5 GHz (in particular the nuclear source M31*) have been observed with MERLIN at several epochs and partly analysed. Arrangements were made to obtain near-simultaneous MERLIN and Chandra X-ray observations of the nuclear source with Garcia (CfA). These measurements would indicate a possible (anti-)correlation between the radio and X-ray luminosity of the presumed black hole and provide a test for the ADAF models.

2.4.2. *Surveys of extragalactic radio sources*

M.Garrett together with JBO collaborators (T.Muxlow and S.Garrington) and several other co-investigators analysed deep, wide-field phase-referenced EVN observations of the Hubble Deep Field (North). The EVN (including on this occasion DSN Robledo) recorded data at a sustained rate of 256 Mbits/sec for 32 hours (resulting in ~14 hours of “on-source" data). This sustained data rate capability is unique to the EVN and will soon be available at 512 Mbits/sec. The EVN imaged out an area of about 3 arcmin^2 simultaneously targeting six HDF-N radio sources that were previously detected by the VLA-MERLIN. The final r.m.s. noise achieved, ~30 μJy/beam, is considerably larger than that expected from thermal noise calculations - the images are probably limited by the inclusion of bad (non phase-stable) data that is difficult to identify by inspection. Three of the six sources were detected above the 175 μJy/beam (~5σ) limit: J123644+621133 (a z=1.013, early type, low-luminosity FR-I radio galaxy which is clearly resolved by the EVN into a core-jet morphology); J123642+621331 (a dust enshrouded, optically faint, z=4.424 starburst system), and the faintest detection (total flux density of 180 μJy/beam) J123646+621404 identified with a spiral galaxy at z=0.96 (Fig. 12).

The VLBI detections of all three sources suggest that most of the radio emission of these particular sources is generated by an embedded AGN. The detection of the dust-enshrouded starburst is particularly interesting, here is at least one optically faint radio source where an AGN is very likely responsible for the bulk of the radio emission. In principle, much deeper VLBI observations will be possible, global VLBI observations may be the only way to distinguish between AGN and starburst phenomena on optically faint systems.

M.Giroletti (summer student from the University of Bologna), supervised by Garrett, was involved in the optical identification of radio sources detected by the WSRT in the Hubble Deep Field. The identification process was automated via software that implemented the standard likelihood ratio (LR) analysis. Identification of the WSRT radio catalogue with the ISO 6 and 15 micron catalogue was also completed. Giroletti also created an on-line, "clickable" web based catalogue available at www.jive.nl/~mag/hdf.

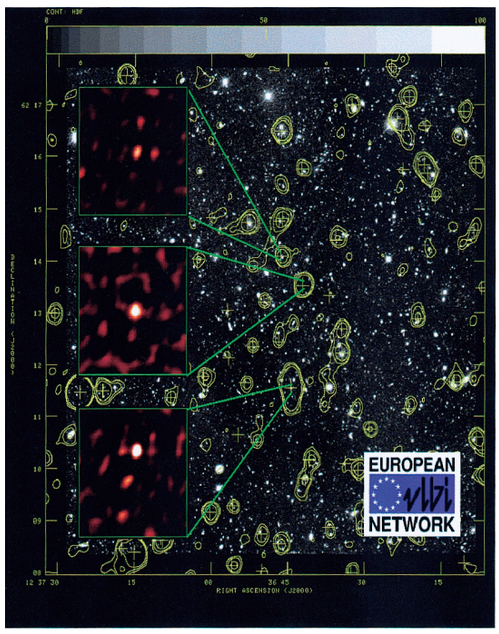

Figure 12. *The EVN detected three radio sources simultaneously in the central region of the HDF-N. The faintest source has a total flux density of 180 microJy. By using wide-field techniques a region of 4 square arcmins was mapped out to an rms noise level of 33 microJy/beam.*

L.Gurvits together with E.Fomalont (NRAO), S.Frey and Z.Paragi (FÖMI SGO), W.Scott and A.R.Taylor (University of Calgary), P.Edwards and H.Hirabayashi (ISAS) finalised data reduction of the VLBA pre-launch VSOP imaging survey of 374 extragalactic radio sources at 5 GHz (VLBApls). This is the largest VLBI imaging survey at this frequency to date. Images of 349 extragalactic radio sources with typical dynamic range better than 200 were produced. They were used in particular to refine the VSOP Survey Programme observations. The VLBApls data represent also a useful test-bench for various statistical studies of milliarcsecond-scale radio structures in AGN, in particular establishing the range of self-similarity of radio structures in AGN at different angular scales (Gurvits, 2001, Proceedings of the IAU Symp. No. 205). The VLBApls data are published (Fomalont et al. 2000, ApJS 131, 95) and available at www.jive.nl/jive/jive/svlbi/vlbapls/

and several mirror sites in Hungary, Canada, Japan and USA.

I.Avruch and L.Gurvits also continued to participate in the reduction and analysis of VSOP Survey data. Several papers containing preliminary results of the Survey were presented at the Symposium “Astrophysical Phenomena Revealed by Space VLBI” (ISAS, Japan, January 2000) and the IAU Symposium No. 205 (Manchester, UK, August 2000). Fig. 13 shows an example of images obtained in various VSOP-related VLBI surveys.

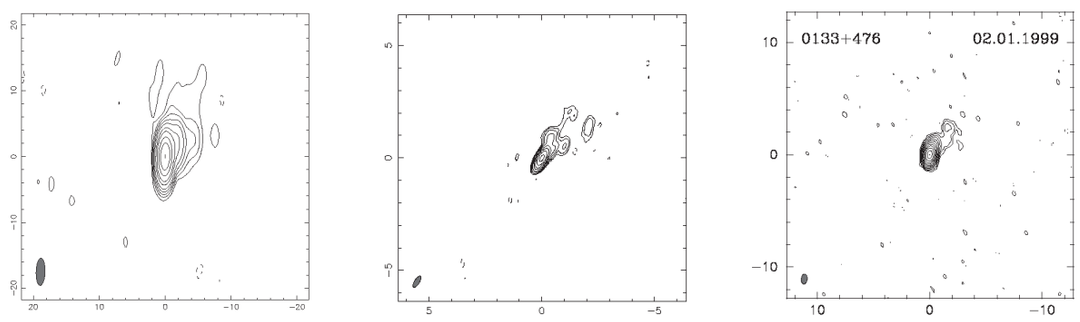

Figure 13. *VLBApls (left, Fomalont et al. 2000, ApJS 131, 95), VSOP Survey (centre, Hirabayashi et al., 2000, PASJ 52, 997) and 15 GHz VLBA survey images (right, Gurvits et al. 2001, in preparation) of the quasar 0133+476.*

2.4.3. Interstellar and circumstellar masers

H.J. van Langevelde, W.Vlemmings (Leiden) and collaborators obtained VLBI data which allowed the U Her proper motion measurements to be extended from 6 to 9 epochs. The project now also includes 7 other Mira variables with OH-masers. During a visit to Socorro it was demonstrated that even during the time of maximum solar activity phase-referencing still works over at least 3 degrees. Seven of the eight stars were detected, about 50% in two transitions. In collaboration with R.C.Walker an investigation was made in order to see whether a GPS based ionospheric model can improve phase-referencing, but this turned out to produce very little improvement.

In a related project in collaboration with P.Diamond (JBO) they investigated the evolution of the amplified stellar image in OH127.8. In spite of some technical difficulties (i.e. very high brightness of the maser on short baselines) an image with quite reasonable signal to noise could be obtained.

Vlemmings, Diamond and van Langevelde also collaborated on a project to detect for the first time the Zeeman splitting of circumstellar water masers. As the effect is very small, the requirements on the calibration procedures are very demanding. After long and hard work all the problems were understood and a detection of circular polarization of the water maser in the giant star S Per could be made. The interpretation in terms of the different hyperfine lines contributing to the effect, also turned out to be quite involved.

Vlemmings and collaborators have modeled the radiative transfer in circumstellar OH maser using a Monte Carlo approach.

In a pilot study for the JIVE correlator, Sjouwerman and van Langevelde detected the 1612 MHz OH maser of V720 Oph. The aim was to determine an approximate size of the OH masing shell in order to resolve the question whether it is a member of the globular cluster NGC 6171. If so, V720 Oph provides an unique opportunity to study the formation of OH masing shells at the low metallicity, low mass, and low mass-loss range of the OH/IR star phenomenon. The MERLIN part of the data are calibrated, however, the EVN part awaits re-correlation.

Sjouwerman, in collaboration with van Langevelde, Winnberg and Lindqvist (both Onsala) and Diamond (JBO), observed their ~50 newly found OH/IR stars in the Galactic center

with the VLA at 43 GHz for J=1->0 SiO maser emission. Stars detected in the SiO maser line could be used for future proper motion studies and the dynamics of the Galactic center.

In Onsala, Sjouwerman discussed the results of recent H_2O and SiO maser surveys with Winnberg and Lindqvist, as well as the results of the 86 GHz SEST observations of the Galactic Center. A draft has been submitted, but the few weak detections at 86 GHz probably are not worthwhile to be followed up with high frequency VLBI techniques.

With Messineo and Habing (both Leiden University), and in collaboration with Omont (IAP) and Menten (MPIfR), Sjouwerman observed 86 GHz masers in ISOGAL AGB sources in the Galactic center with the 30-m IRAM telescope. This detection experiment was very successful (with a detection rate of about 70%), most likely because of proper selection criteria. A follow-up proposal was submitted and will allow more sophisticated dynamical modeling of the inner Galactic potential with at least 200 more point source detections as test particles.

Phillips continued to process EVN and ATCA observations of a number of methanol maser sources. The ATCA observations provide accurate (arcsecond) positions for many sources, which are difficult to obtain in the Northern Hemisphere. He has discovered that a number of the sources detected earlier in single dish observations are actually double sources separated by tens of arcseconds. The EVN observations provided detailed images of three of these sources. Supporting earlier work, two of these sources show a linear morphology which is indicative that the methanol emission delineates an edge-on disc around a young massive star.

2.4.4. New radio astronomy techniques and instrumentation

With C.Pearson (Imperial College, UK), I. Avruch was investigating the use of sensitive observations with upcoming instruments (eg. ALMA, SKA) as constraints on models of galaxy formation and cosmology. Current models for source counts in the infrared, where star forming galaxies are prominent, can be extended to other wavelengths and perhaps constrained through multi-frequency observations.

R.Campbell continued to provide ionospheric simulations to D.Lebach (CfA) in support of VLBI astrometry related to the guide-star program of the Gravitational Probe B (GP-B) mission and to B.Corey (Haystack Observatory) in conjunction with the IVS working group on GPS phase-center mapping.

R.Campbell worked with N. van der Valk (Delft TU and Fokker Space) on ionospheric considerations related to a future P-band synthetic-aperture biomass mapping satellite.

Together with R.Campbell, C.Phillips and F.Olnon, S.Pogrebenko developed low-level software for the manual control of pulsar gating processing in the MkIV Data Processor at JIVE. Test observations of the pulsar PSR B0329+54 were processed with no gating and with gating 1:2, 1:4 and 1:8. Correlation results show the increase of signal to noise ratio in the "gated" processing consistent with the theoretical predictions. The results of this test processing were reported at the IAU Symposium No. 205 (Manchester, August 2000).

S.Parsley, S.Pogrebenko and R.Schilizzi worked on definition of a pilot project for the optical fiber connection between EVN telescopes and the Data Processor at JIVE.

M.Garrett participated in producing the science case for the Low Frequency Array (LOFAR) project. In particular, he prepared a section of the proposal describing future studies of faint radio sources at high redshift. He also contributed to the e-MERLIN science case published in 2000.

2.5. Max Planck Institute for Radio Astronomy, Germany

2.5.1. VLBI studies at 86 GHz

A.Lobanov, T.Krichbaum, D.Graham and collaborators have completed an 86 GHz VLBI survey which included observations of 28 very compact radio sources; all but two (Sgr A* and Cygnus X-3) are Active Galactic Nuclei (AGN). The measured brightness temperatures are typically in the range between $5 \cdot 10^7$ K or less in the jets, and $1 - 4 \cdot 10^{11}$ K in the VLBI cores.

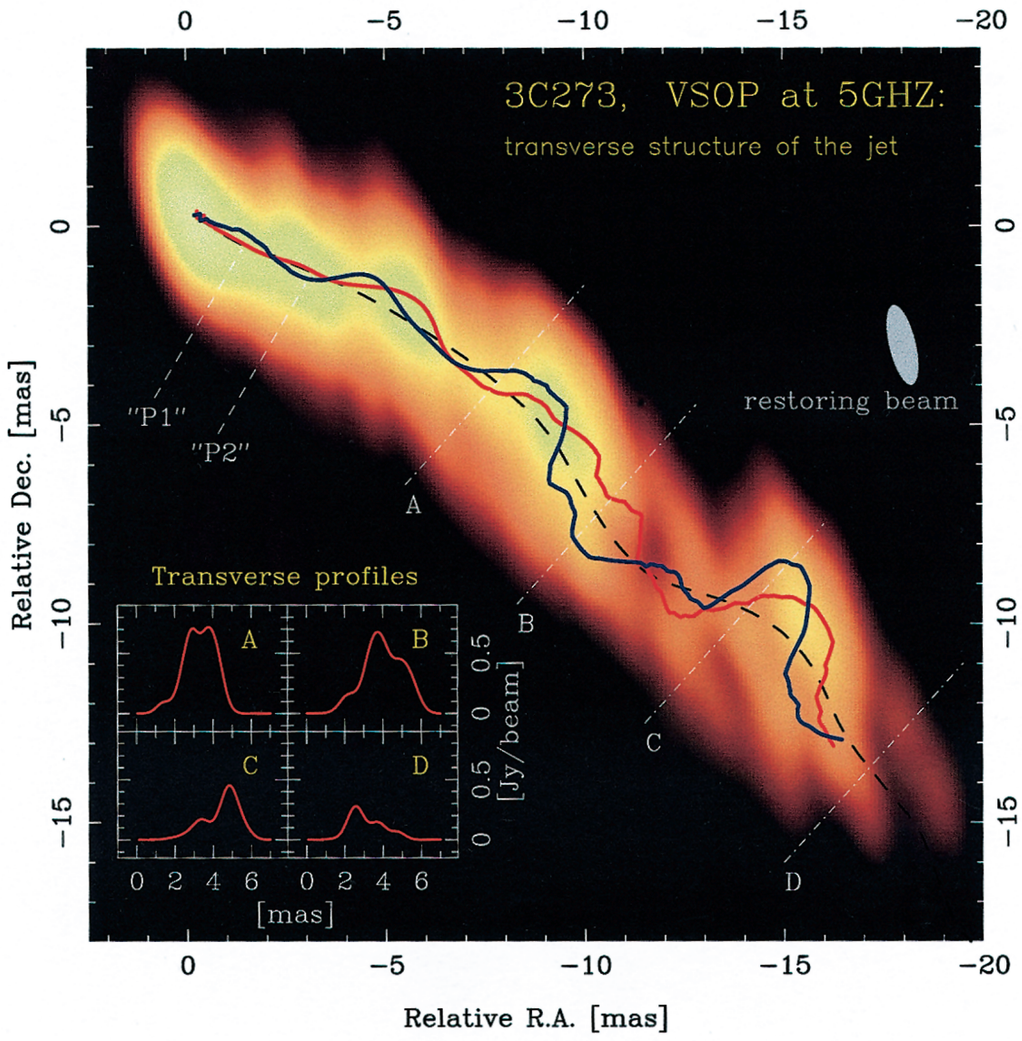

Figure 14. *VSOP image of 3C273 (Lobanov and Zensus 2001, Science 294, 128).*

A program for monitoring structural changes in the jets of the bright sources 3C454.3, BL Lac, 3C345, 3C84, 3C273 was continued by T.Krichbaum, A.Witzel, J.A.Zensus and collaborators, using 12 telescopes of the CMVA, distributed over Europe and the United States. The results demonstrate the progress in very high frequency VLBI and are encouraging with regard to further improvement of the techniques.

A.Roy is leading teams from MPIfR and the Geodetic Institute of University of Bonn to build a water-vapour radiometer and a permanent GPS reference station for remote sensing of the atmosphere above the Effelsberg telescope. These will provide independent estimates of the atmospheric contribution to the VLBI phase and amplitude measurements thus improving phase-referencing performance at the highest frequencies.

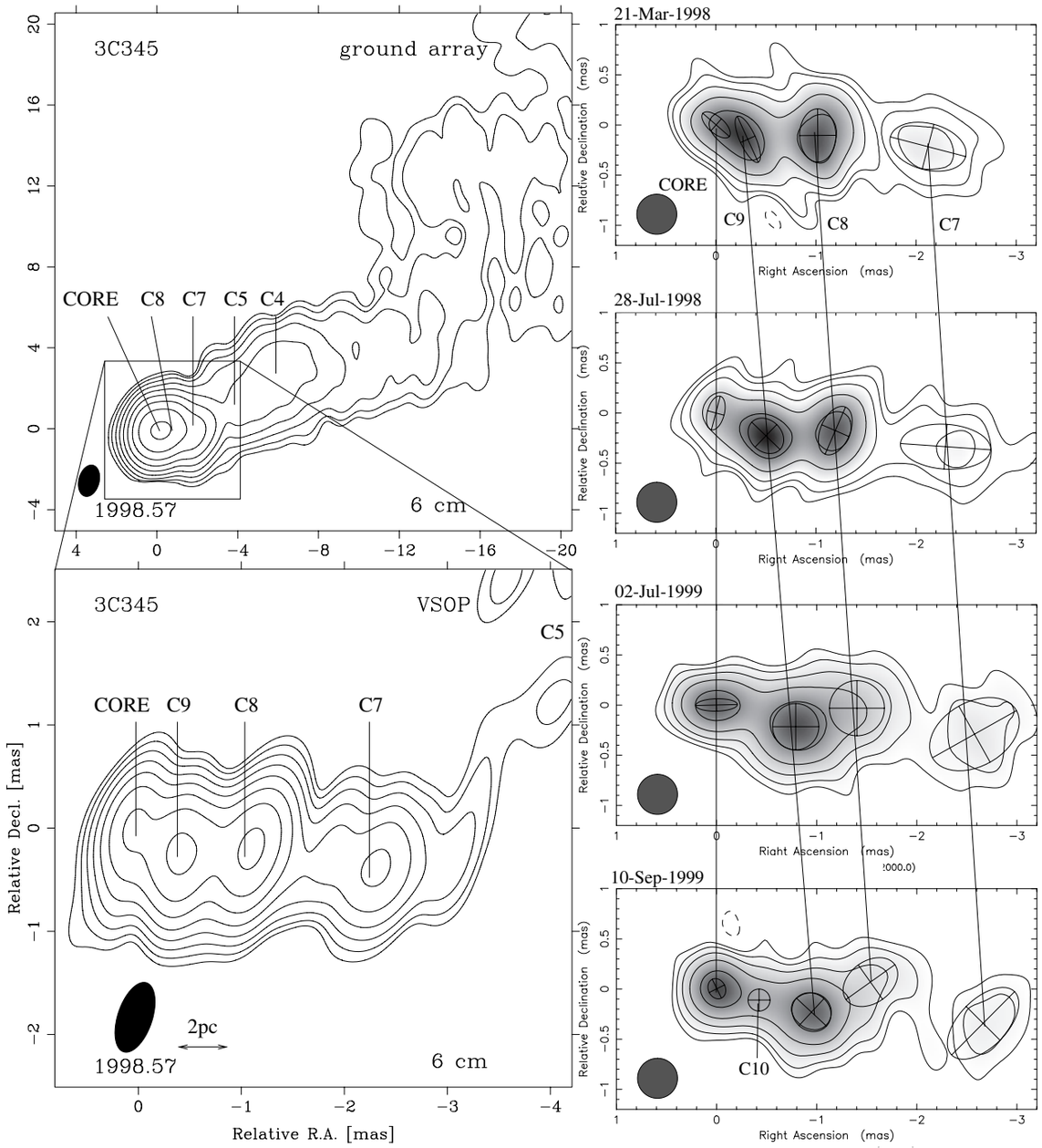

Figure 15. *Total intensity images of 3C 345 - Left: space-VLBI observations at 6 cm resolve the nuclear region into several components. Right: space-VLBI observations trace the evolution of the inner jet components at a resolution of 350 microarcsecond. The ellipses are the model-fit components.*

2.5.2. Space VLBI of selected quasars and blazars using VSOP

In order to search for, and detect rapid structural variations in Intraday Variables (IDVs), T. Krichbaum, A. Witzel, A. Zensus and collaborators carried out several polarimetric VLBI experiments at 5 GHz on prominent IDVs using VSOP. The data analysis is still in progress. First results indicate that structural variability is detected on timescales of days and weeks. These variations point to positional changes and possible variations of the polarisation on milliarcsecond scales. The VLBI cores, as seen from ground, seem to break up

into subcomponents on which detailed kinematical studies are being performed.

A.Lobanov, together with J.A. Zensus, T. Krichbaum and A. Witzel, has made an in-depth study of the internal structure of the jet in 3C273, based on 5 GHz VSOP observations (Fig. 14). These observations resolve, for the first time, the transverse structure of an extragalactic radio jet, and yield an unprecedented degree of detail concerning the intrinsic composition and dynamics of the jet. The VSOP image shows two very distinct, thread-like features, which form a strikingly regular "double-helix" pattern which exists throughout the entire extent of the jet. This pattern is the best and most direct evidence for the presence of Kelvin-Helmholtz instability in extragalactic jets.

A.Lobanov and I.Pauliny-Toth, together with L.Gurvits and R.Schilizzi (JIVE), S.Frey (FÖMI SGO) and N.Kawaguchi (NAOJ), observed the high redshift quasar PKS 2215+020 (z=3.57) at 1.6 GHz with VSOP. The milliarcsecond resolution image of the quasar reveals a prominent `core-jet' structure on linear scales from 5 to 300 pc (H0=100 km/s/Mpc). The brightness temperatures and sizes of bright features identified in the jet are consistent with emission from relativistic shocks dominated by adiabatic energy losses. The jet is powered by the central black hole with estimated mass of 4 x 10**9 solar masses. Comparisons with VLA and ROSAT observations indicate the possible presence of an extended radio/X-ray halo surrounding 2215+020.

To get better constraints on the physics of jets, J. Klare and collaborators imaged the quasar 3C 345 (Fig. 15) at the highest possible resolution, using VSOP at 5 GHz (0.35 mas resolution) and mm-VLBI (0.07 mas). The jet components can be traced in the vicinity of the central engine, assumed to be a supermassive black hole, and show strong variations in their paths, flux densities, velocities and sizes. This information should help constrain different jet models for AGN.

2.5.3. Quasars, radio galaxies, Seyferts and low-luminosity AGNs

A.Zensus, together with K.Kellermann (NRAO, USA), R.Vermeulen (ASTRON, NL) and M.Cohen (Caltech, USA) continued the program to image and monitor the structure of 132 strong compact AGN using the VLBA at 15 GHz with a resolution better than one milliarcsecond and a dynamic range typically exceeding 1000 to 1. The measured data allow basic object parameters in the framework of relativistic jet models to be determined, some of which can be used to test cosmological models. T.Krichbaum and U.Bach have used Global VLBI observations at 1.6, 5 and 8.4 GHz to map the core of the radio galaxy Cygnus A. These confirm the existence of a weak, extended counter-jet and permit a first measurement of relative motion of components with sub-luminal velocities. The ratio of the measured velocities of jet and counter-jet can be used to derive the orientation of the jet axis and true jet velocity within the framework of the relativistic jet model.

The program of observations of Seyfert galaxies has been continued by A.Roy, E.Middelberg, T.Krichbaum, A.Kraus, H.Falcke, and U.Bach with a second-epoch VLBI observation of NGC 1068, which yielded a strong upper limit on the relative velocity of compact jet components in the galaxy nucleus of 7.5% of the speed of light. The low speed is consistent with the bulk jet speed inferred indirectly by Bicknell et al. from a collision between the jet and a gas cloud that lies further along the jet. Thus, in five out of the six Seyfert galaxies for which jet speeds have been measured, the jets are sub-relativistic, which differs from the jets in powerful radio sources.

Observations with EVN+MERLIN provided images with good surface brightness sensitivity and lower resolution of four nearby Seyfert galaxies (NGC 2110, NGC 5506, NGC 7674 and Mkn 1210). These were made in order to look for possible extended structure in the jets and for possible interaction between the jets and narrow-line region clouds. Observations at both 18 cm and 6 cm have been reduced and will be compared to optical images, to attempt to constrain the amount of energy transferred from the jet to the surrounding gas. This may reveal to what extent the observed slow jet speeds might be due to deceleration of a fast jet by interaction with the gas, or alternatively, whether the jet is launched sub-relativistically.

H. Falcke, together with N. Nagar, A. Wilson (Univ. of Maryland), L.C. Ho (Carnegie Inst.,

Pasadena) and J. Ulvestad (NRAO, Socorro), have surveyed a well-defined sample of the 96 closest low-luminosity AGN with the VLA to search for flat-spectrum radio cores, similar to Sgr A* in the Galactic Center. Roughly one third of all galaxies are detected (roughly one half if LINER/HII-transition objects are excluded), many of which have flat-spectrum cores. Follow-up observations with the VLBA have confirmed that these cores are non-thermal in origin, with brightness temperatures of about 100 million K or greater. Some of the cores are resolved into linear structures. Structure and spectral indices indicate that the emission is dominated by jets and not ADAFs (Advection Dominated Accretion Flows) at these frequencies. The radio flux densities also scales with the emission-line flux and radio cores in elliptical galaxies are found to have more radio emission relative to H alpha.

2.5.4. Megamasers

Y.Hagiwara and C. Henkel, together with N. Nakai (NRA Nobeyama) and P.J. Diamond (Jodrell Bank) have monitored the flux density and velocity drift of around 20 water megamaser sources associated with AGNs with the Effelsberg 100m telescope since 1999. They also searched for new megamasers. Various objects showed outbursts (including M51, NGC5793 and Mkn 348), whereas others, such as NGC315, became weaker or even undetectable. Objects which showed strongly increasing flux density were observed with VLBI at 22 GHz to measure their structural changes. It is hoped that these measurements will help in understanding the megamaser phenomenon, and lead to estimates of central mass condensations and accretion rates if circumnuclear gaseous disks are found.

Alison Peck, in collaboration with C. Henkel, H. Falcke, K. Menten and others, has recently made VLBA observations of a flaring H2O megamaser in the Seyfert galaxy Mkn 348. The broad maser line was discovered in March 2000 using the Effelsberg telescope, and the follow-up VLBI observations in June indicated that the maser emission was coming from a collision between the radio jet and a molecular cloud in the galaxy. Mkn 348, with a peak line flux of 17 mJy at the time of observation, is by far the weakest water maser line ever observed using VLBI techniques.

2.5.5. Spectral line absorption studies

Alison Peck and Greg Taylor (NRAO-Socorro) have made Global VLBI studies of redshifted 21cm HI absorption in compact radio galaxies. The two most recent sources observed are the Compact Symmetric Object 1946+708, and nearby elliptical galaxy NGC3894 (1146+596). In the first source, they find strong evidence of a circumnuclear torus comprised of mainly neutral atomic gas. This model is supported by the detection, through free-free absorption mapping, of ionized gas in a disk with the same orientation as the torus. The broadest width of the HI line near the core of the radio source is ~350 km/s. In NGC3894, the HI absorption consists of several components of various widths, making interpretation more difficult.

Y. Hagiwara has made VLBI absorption observations of the OH radical in NGC5793. The direction of the OH velocity field shows a reversal of the sense of rotation with respect to that of the outer galactic disk observed in CO (J=1-0). This result implies the existence of an independent kinematical system in the central 10 parsec region of the galaxy.

2.5.6. Phase-referencing and astrometry techniques

E. Ros, together with J.M. Marcaide and J.C. Guirado (U. Val`encia) and M.A. P'erez-Torres (IRA/CNR), is continuing work using phase-connection techniques to obtain VLBI astrometry with much greater accuracy than can be obtained using the traditional group-delay observable. They are carrying out a long-term astrometric programme at 8.4, 15 and 43 GHz to determine the absolute kinematics of radio source components in the 13 members of the complete S5 polar cap sample. For each epoch, all 13 sources are phase-connected throughout the observations. An accurate registration of the maps of the radio sources at different frequencies will allow the study of jet components with unprecedented precision and provide spectral information. This observing scheme could be extended to other regions of the sky and eventually to phase-delay global astrometry, providing a significant improvement in the accuracy of the international astrometric reference system, the best possible realization of a cosmic inertial system available.

R.Porcas and W. Alef, together with M.Rioja & J-F Desmurs (OAN) and collaborators at JIVE, ASTRON, Jodrell Bank and NRAO, continued the analysis of "cluster-cluster" observations made in 1999. VLBI observations of 4 sources were made simultaneously at 18 cm at 3 multi-antenna VLBI "sites". The array comprised 4 antennas of the VLA, 4 sub-clusters of the WSRT array and 3 antennas from Jodrell Bank and MERLIN. Multi-channel (and multi-tape) Mk3 recording was used to record the 4 sources in 4 "parallel interferometer arrays" (the Mk2 telescope at Jodrell was switched rapidly to provide the 4th channel there). The complicated correlation of the data was performed using the MPIfR Mk3 correlator during its last days of operation in 2000. Fringes were successfully found on all 4 sources in all sub-channels of all antennas. Analysis of the data is continuing. The 4 sources are very close to each other on the sky; the change of the relative phase between the sources provides a powerful means of studying ionospheric phase fluctuations on small angular scales.

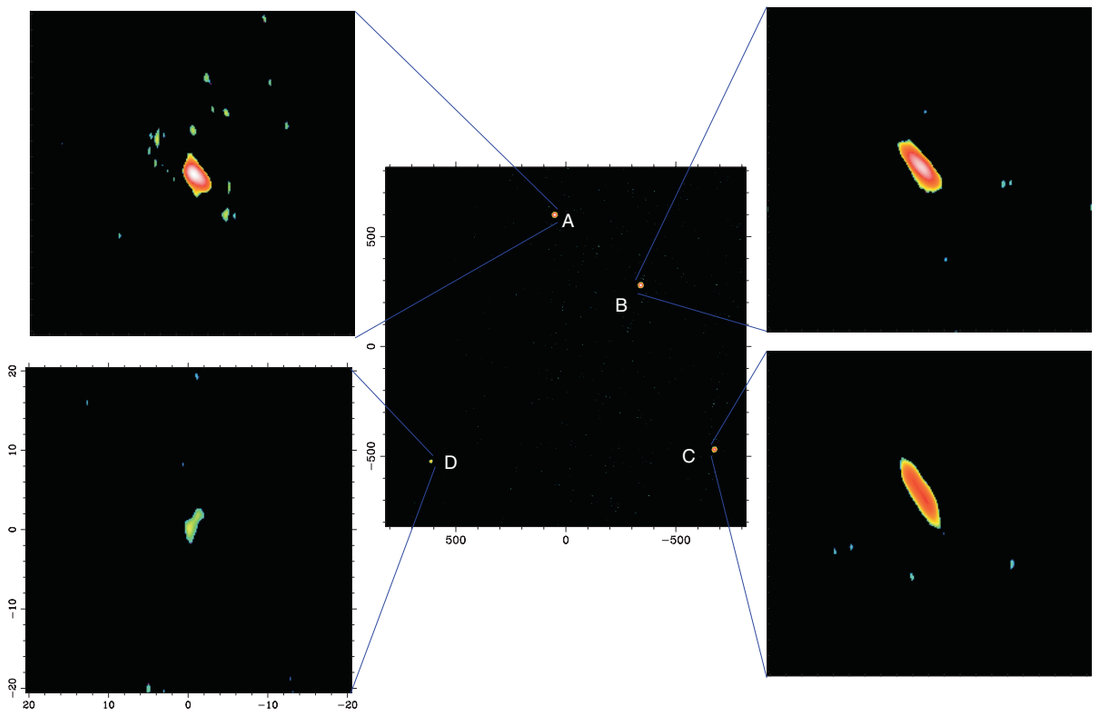

Figure 16. *The 4 images of the gravitational lens system B1422+231*

2.5.7. VLBI studies of gravitational lenses

R.Porcas and A. Patnaik, together with E.Xanthopoulos and collaborators at Jodrell Bank, continued a VLBI study of the gravitational lens 1030+07. Observations with the VLBA+Effelsberg and a global array at 18cm have revealed a 40 milliarcsecond jet in the stronger image of this 2-image system. The weaker image is ca. 15 times fainter; it has proved very difficult to convincingly detect the jet in this image. VSOP observations at 18cm have shown that the core of the stronger image is itself resolved, with a position angle slightly different from the 40 mas-scale jet. Higher frequency VLBA observations confirm the position angle of this core, and also resolve a faint jet in the weaker image. Analysis of these observations continues, and further observations are planned.

A.Patnaik, together with A.Kemball (NRAO) observed the gravitational lens B1600+434 at 15 GHz using the VLBA. Rapid radio variability in one of its two images, not matched in the other, had previously been reported by Koopmans and de Bruyn. Since this cannot be explained by intrinsic source variability, micro-lensing in the lens galaxy, combined with superluminal motion in the background source, could cause the variations. These new observations show that neither image exhibits a core-jet structure, as might be expected for a superluminal source, and furthermore, the surface brightness of the images is not the same (the stronger image is more compact). This suggests that the weaker image is scatter-broadened by the lens galaxy. The variations in only the stronger (compact) image may then be caused by scintillation in our Galaxy.

E. Ros, together with J.Marcaide and J.Guirado (U. València), M.Pèrez-Torres (IRA CNR), E.Falco (Harvard-CfA), J.Muñoz (IAC) and A. Alberdi and L. Lara (IAA/CSIC), imaged the quadruple gravitational lenses B1422+231 (Fig. 16) and MG J0414+0534 using global VLBI observations at 8.4 GHz and wide-field mapping techniques. This is part of a project of multi-epoch observations to compare possible structural changes in the lensed images and measure possible shifts in the relative positions of the sub-images. The map of 1422+231 for the first epoch (Nov 1997) shows that the 3 bright image components (A, B and C) are stretched along the tangential direction, in accordance with (general) lens modeling. The much weaker D image shows some elongation towards the lensing galaxy. The images are consistent with a background compact radio source without a prominent, extended jet-like structure. The results for J0414+0534 show the four individual images, A1, A2, B and C, exhibiting radio structures extending up to 100 milliarcsecond. A lens model has been produced which reproduces the core positions and flux densities of the VLBI images.

2.5.8. Strong deceleration in the expansion of radio supernova SN 1979C

E. Ros, together with J.M. Marcaide and J.C. Guirado (U. Val`encia), M.A. P'erez-Torres (IRA/CNR), A. Alberdi (IAA/CSIC), P.J. Diamond (Jodrell Bank), S.D. van Dyk (IPAC/Caltech) and K.W. Weiler (NRL), observed SN 1979C in M100 on 1999 June 4, about twenty years after explosion, using a very sensitive four antenna VLBI array (Effelsberg, Robledo, phased-VLA and Goldstone) at 18 cm (Fig. 17). The total flux density was about 5.4 mJy. A model, assuming spherical symmetry and a shell width of 30 % that of the outer radius, yielded a size estimate of 3.60 milliarcsecond, corresponding to a shell radius of 0.0781 pc. This implies an average supernova expansion velocity of 5800 km/s for the 20.12 years elapsed since the explosion. From a comparison with earlier measurements, they conclude that the supernova shock was in free expansion for 5-10 years and then experienced strong deceleration, sometime after 1985 when a previous measurement had been made, and possibly coincident in time with an abrupt change in the trend in radio total flux density curves.

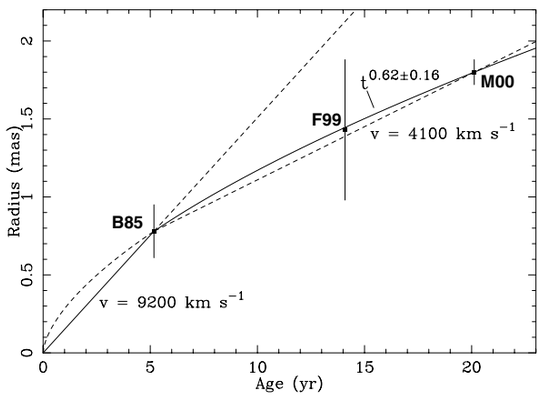

Figure 17. *Expansion plot of SN1979C in M100.*

2.6. National Astronomical Observatory, Spain

2.6.1. Late-type stars

Several projects to study SiO masers in the circumstellar envelopes of late-type stars are being developed by Colomer, Desmurs, Bujarrabal, Alcolea, and collaborators in other institutes. Analysis of the data obtained with the EVN at 43 GHz is complicated by the low number of antennas and the absence of strong calibrators. Related observations of these masers at 86 GHz with the CMVA have been carried out in October 2000; they will provide both v=1 and v=2 J=2-1 SiO data on several sources.

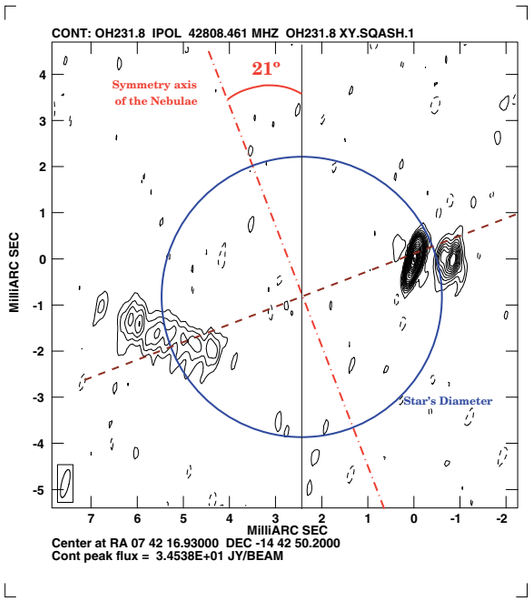

Figure 18. *A map of the SiO maser line v=2 J=1-0 at 42.82 GHz in the Proto Planetary Nebulae (PPN) OH231.8+4.2 as observed with the VLBA, showing the integrated flux with a resolution of about 0.3 mas and a SNR of about 43 mJy. The blue circle represents the star diameter (9 AU) while the red line is the symmetry axis of the bipolar nebulae in the plane of the sky. We note that the two components detected are more or less placed on a line perpendicular to the symmetry axis and that the separation between both is equivalent to the star diameter. Moreover, thanks to the velocity information, the results may be interpreted as the possible detection, for the first time, of an inner torus in rotation/accretion in a PPN.*

A project to study SiO masers in the protoplanetary nebula OH231.8+4.2 by Sanchez-Contreras, Desmurs, Bujarrabal, Colomer, and Alcolea with the VLBA at 43 GHz is progressing . The observations have provided full polarization data of the v=1 and v=2 J=1-0 SiO masers, with a spatial resolution of 0.3 mas and spectral resolution of 0.2 km/s. Structures along a direction perpendicular to the symmetry axis of the PPN are detected (Fig. 18). The data are compatible with the existence of an inner torus, which is both rotating and accreting material. The analysis of the polarization data will help placing the central star, and also the interpretation of the object characteristics.

Desmurs, Alcolea, Bujarrabal, and Colomer are studying the mechanism that produces the clear bipolar structure in the very young protoplanetary nebula M1-92 (Minkovski's footprint). EVN+MERLIN observations have been performed, and data analysis is in progress, with the goal of studying the magnetic field and its influence on the structure of the bipolar jet in M1-92.

2.6.2. Star-forming regions

A project to study the 6 GHz OH masers towards the high mass star formation region ON1 is being developed by Desmurs and Baudry (Bordeaux). The project aims to study the densest zones of the region. The magnetic field will be measured thanks to the Zeeman effect, and maps with high SNR and position precision are expected.

In collaboration with Codella (IFSI, Rome), Desmurs, Tafalla, and Bachiller have studied the collimation of outflows in six low mass stars using two epochs of water maser observations. Only one source has been detected at one epoch, the source NGC1333-IRAS4. A very highly collimated jet was detected, with a position angle of the outflow (~15°) in agreement with that of the flow observed in CO. The projected size of the maser emission outflow is about 20 mas, or 6 AU at the assumed distance of 300 pc. A velocity gradient of 1.6 km/s/arcsec has been measured on the maps. These results were presented during the 5th EVN/JIVE symposium held in Onsala in June 2000.

2.6.3. Astrometry

The application of phase reference techniques to the study of close pairs of sources provides micro-arcsecond precision in the estimated relative separations. A project to develop these techniques continues between Rioja (OAN/IMAFF) and Porcas (MPIfR) in the temporal and spectral domain, with new epochs of observations at a wide range of frequencies and including in some cases VSOP data. The astrometric measurements provide an important and independent constraint that is useful to interpret potential changes in the structure of the sources between different observational epochs or frequencies.

On the other hand, astrometric studies of water maser proper motions detected around YSOs, are being performed by Rioja, Moscadelli (IRA) and Cesaroni (Arcetri). High resolution VLBI maps are needed to check the validity of the model, in which the masers are located on the surface of a conical bipolar jet, and move away from the central star position. Global observations are scheduled.

A new project to study the feasibility of detecting weak (15 mJy) sources with VLBI is being developed by Desmurs in collaboration with Abada-Simon (Paris) and Charlot (Bordeaux). The goal is twofold: technical, in the use of phase-referencing to allow detection of weak sources with global arrays, and scientific, to measure the size and expansion velocity of the plasmoid ejected by the magnetic cataclysmic variable star AE Aqr.

2.6.4. Geodesy

The project of implementing external GPS tropospheric estimates in the geodetic VLBI analysis continues by Rioja in collaboration with Tomasi (IRA), with the goal of obtaining a better measure of the vertical coordinates. The new technique may have a great impact in astronomy as well, in particular, for observations at millimeter wavelengths, as it would allow longer integration periods.

On the other hand, an European project to determine the phase center of a VLBI antenna is being developed by Rioja and Tomasi. The study is being carried out on the 20-m antenna in Ny Alesund (Svalbard, Norway). The purpose is to establish the stability of the antenna reference point (phase center) by comparing the measures at two epochs referred to a local network. GPS receivers were installed in August 2000 on different points of the antenna structure, and the data obtained are being compared with classic topographic measurements taken in September 1999 with theodolites.

2.6.5. Cluster-Cluster VLBI

M.Rioja is leading a project to make a systematic comparison between the results of the Cluster-Cluster observational technique and standard phase-referencing "nodding" observations, in collaboration with Desmurs, Colomer (OAN), Porcas (MPIfR), Fomalont (NRAO), Gurvits, Schilizzi (JIVE), Sasao, Asaki (NAOJ) and Mantovani (IRA). The campaign, performed at L-band with several antennas of WSRT, VLA, MERLIN, plus VLBA, Effelsberg and Medicina in 1999 (project GR019), has been successfully correlated at MPIfR in Bonn. A new proposal to exploit the capabilities of the EVN MkIV correlator at JIVE (and MkIV observation modes) has been submitted. This project is part of the development of new experimental techniques in which OAN is involved within the framework of the EU project entitled "Enhancing the European VLBI Network of Radio Telescopes".

2.7. Onsala Space Observatory, Sweden

2.7.1. VLBI methanol observations of protostars

During 2000 V.Minier pursued extensive VLBI observation of methanol masers at 6.7GHz as part of his PhD thesis which was awarded in December 2000.

Minier, Booth and Conway (2000) presented methanol VLBI maps for a sample of 14 sources. In 10 of these 14 sources the masers showed elongated morphologies with linear velocity gradients. For many of the sources the morphologies are consistent with the masers arising in circumstellar disks of radius ≈ 1000 AU. Assuming that we are only seeing maser action in the parts of the disks directly in front of the star, where velocity coherence is largest, then the enclosed masses are consistent with massive (5 - 50 solar mass) stars or proto-stars. However in addition to linear structures some maser sources have more complex structures which Minier et al (2000) argue arise in stellar outflows of shocks.

In the case of the most powerful (5000 Jy) methanol maser in the Northern hemisphere (G9.62+0.20), the maser's proper motions have been measured for the first time (Minier et al 2000). The structure in this unusual source consists of two lines of masers, which have no overall linear velocity gradient. Multi-epoch observations show that the two lines are moving apart at a speed of ~4 km/s (Minier et al. 2000). It is argued that these two lines are tracing expanding shock fronts in a wide-angle outflow.

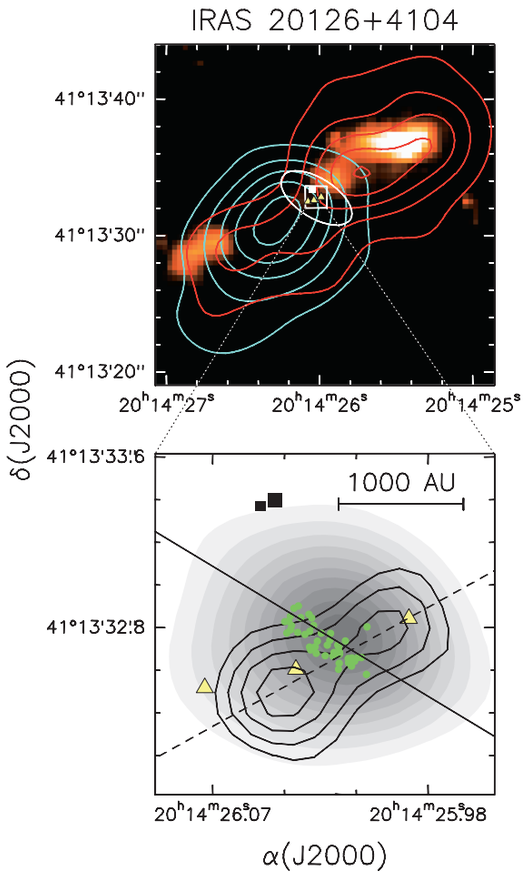

Figure 19. *Different tracers of the massive protostar IRAS 20126+4104 at the 6.7 GHz methanol maser lines (from Minier et al. 2001, the diagram made by R. Cesaroni).* ***Top:*** *The coloured contours represent the blue-shifted and redshifted components of the HCO+ outflow observed at IRAM; the grayscale represents the H_2 emission.* ***Bottom:*** *Close-up of the hot-core region. The grayscale represents the 3mm continuum emission. The contours indicate the radio continuum emission at wavelength 3.6 cm that is believed to trace a bipolar jet (dashed line). The yellow triangles are H_2O masers along the jet direction. Roughly perpendicular to this (solid line) is a probable disk traced by CH_3CN thermal line emission (green dots). The positions of the 6.7 GHz methanol masers mapped by the EVN are shown by the black squares and are consistent with these masers occurring in the outer part of the circumstellar disk.*

As part of his thesis work Minier has also compared the positions of the methanol masers with other tracers of young massive stars (Minier 2000, Minier, Conway and Booth 2001). These tracers include other masers, ultra-compact HII regions, or molecular hot cores. In eight cases out of thirteen the methanol masers lie within 2000 AU of the earliest tracers of massive star formation such as outflows or hot molecular cores. A good example is the source 20126+4104 where the 6.7 GHz methanol masers mapped by the EVN are coincident with the outflow and disk around this protostar (Fig. 19). In contrast only in two sources out of thirteen do the methanol masers coincide with ultra-compact HII regions which are thought to be a later phase of high mass stellar evolution. Finally in a couple of objects there is only an IR source associated with the methanol masers. These objects could be deeply embedded proto-stars; in which the methanol masers might be the first signs of stellar activity.

Finally as part of his thesis work Minier (2000) has shown that many methanol masers consist of a bright core of size < 5 mas plus a diffuse halo of size 10 – 50 mas. The presence of these low brightness temperature diffuse structures has implications for pumping mechanisms. Further study of these extended structures using shorter baselines may also help elucidate the overall dynamics of the circumnuclear regions.

PhD Student Pestalozzi during 2000 has been using the EVN at 6.7 GHz to map methanol masers detected in the Onsala 25m telescopes galactic plane survey. This is a blind survey and picks up maser sources without using any IR or other pre-selection criteria. It will be interesting to see if these sources differ systematically from the brighter sources observed by Minier.

2.7.2. HI absorption in AGN

PhD student Y.Pihlström in collaboration with supervisor J.Conway continued her work on probing circumnuclear gas in AGNs using VLBI atomic absorption observations. A paper on HI absorption in the Seyfert 2 galaxy NGG5793 was published (Pihlström 2000). This galactic nucleus hosts a water megamaser similar to the one which in NGC4258 rotates around a 10 million solar mass black hole at 0.1 pc radius. The atomic absorption is this object has very high opacity (greater than 1). The absorption showed a velocity gradient in the same sense as that detected on kpc scales by CO molecular emission. The larger velocity gradient suggests that the HI absorption occurs at a radius of a few

hundred parsecs. The high opacity suggests this gas disk is viewed almost edge-on and is part of a structure which feeds gas to the putative water maser disk.

Pihlström also played a major role in reducing the HI absorption observations of the FRI galaxy NGC4261 (van Langevelde et al. 2000). This was the first scientific paper to be published using the JIVE correlator. HI absorption was detected at a projected distance from the nucleus of about 6 pc - almost entirely against the VLBI counterjet. It was argued the that the inferred HI disk is the inner continuation of the 100pc scale dust disk detected by HST. Comparison of the line width with the orbital velocity suggested a relatively thin atomic disk (full width 14°) disk. This is consistent with other lines of evidence suggesting thin disks in FRI sources.

Conway and Schilizzi (JIVE) presented global VLBI observations of HI absorption in the 1 kpc scale central structure of the giant radio galaxy 3C236. In this source the absorption appears to be associated with a jet-ISM interaction. Deep but relatively narrow (50 km/s) absorption was detected towards the tip of the jet, with much broader (200 km/s) but weaker absorption further back. It is argued that the overall structure was due to a restarting jet. The deep absorption at the head of the jet is thought to be due to molecular gas dissociated by shock precursor UV radiation while the broader HI absorption further back comes from shocked gas.

2.7.3. Circumstellar SiO masers

Yi and collaborators described simultaneous observations of the v=1 and v=2, J= 1-0 maser transitions of SiO toward the Mira variable stars TX Cam and R Cas. These two spectral lines are separated by 300 MHz at 43 GHz and special observing techniques were required to determine the relative positions of features in the two maser transitions. It was found for TX Cam that the v=2 ring of masers had a smaller diameter than the v=1 ring. The relative distributions of the two maser transitions can be used to constrain pumping mechanisms and test in detail maser models. Humphreys et al. (2000) have generated such a model, which predicts that the relative diameters of the v=1 and V=2 rings should vary with the phase of the stellar pulsation. The predictions are so far consistent with the observations of Yi et al. A more extensive series of SiO observations is now being carried out spanning a whole stellar pulsation period in order to check the model in detail.

2.7.4. Continuum emission from radio stars

In collaboration with A.Benz and M.Gűdel (ETH Switzerland) Onsala PhD student M.Pestalozzi and J.Conway published observations of two nearby dMe stars (Pestalozzi et al. 2000). One of the two target stars, YZ Cmi (distance 5.9 pc) was resolved and shown to have a diameter of 0.98 mas at 8.4 GHz. This radio diameter which is about 1.7 times the optical diameter. The large radio diameter is consistent with dynamo theories where the radio photosphere scales with the rapid rotation and large magnetic fields expected in young stars. The measured brightness temperature was $7 \cdot 10^7$ K. This is the first time that the brightness temperature of a dMe star has been measured and constrains the radio emission mechanism to be non-thermal gyro-synchrotron or synchrotron radiation.

In collaboration with Benz and Smith (ETH), Pestalozzi and Conway have carried out VLBI observations at 8 GHz of a sample of T Tauri stars. Preliminary analysis of the data shows fringes on long VLBI baselines for at least two of the sources (T Tauri S and Hubble 4).

2.7.5. Compact symmetric objects

Analysing multi-epoch global VLBI observations of CSOs from the Caltech-Jodrell bank VLBI survey (CJ1), A.Polatidis measured a hotspot separation velocity of $\mu = 0.395 \cdot h^{-1}c$ in CSO 1843+356. This implies a kinematical age of ~600 years. Owsianik (MPIfR), Conway and Polatidis (Onsala) have refined the measurement of the expansion velocity of the prototype CSO 2352+495 using seven epoch global VLBI measurements over a 20-year period. (Owsianik et al. 2001, in prep). The expansion velocity is $0.141 \cdot h^{-1}c$, implying a kinematical age of 2700 years.
Polatidis with Marcha (OAN), Bondi, Dallacasa and Stanghellini (IRA) have been studying the parsec scale structure of sources in the 200 mJy flat spectrum sample. Whereas the BL Lac sources in the sample showed core-jet VLBI

structure, it was found that most of the weak emission line radio galaxies in that sample have compact symmetric structure. Recent multi-frequency VLBA observations have confirmed the CSO classification in six of these objects. (These are all nearby radio sources (z<0.1)). An example of a classic CSO structure is J1755+626, while the most interesting object is 1245+676, where the CSO is at the centre of a 2 Mpc 'double-double' radio galaxy (de Bruyn et al., in preparation).

2.8. Shanghai Astronomical Observatory, P.R. China

2.8.1. VLBI observations of EGRET-detected AGNs

Hong Xiaoyu and collaborators observed a sample of 15 EGRET-detected AGNs with VLBI and the VLA to search for possible relationship between the alignment of jet of AGNs and gamma ray emission. The data were acquired at two epochs of EVN at 5 GHz, one epoch of VLBA at 1.6 GHz and two epochs of VLA at 8.4 and 22 GHz for 8 sources from the sample. The data reduction and analysis are in progress.

2.8.2. Morphological studies of AGN

Hong and collaborators are studying the helical jet of the blazar 1156+295 and the connection between the pc- and kpc-scale structures. Eight epochs of VLBI and 3 epochs of MERLIN observations have been obtained. At various epochs, the observations were conducted at frequencies of 1.6, 5, and 15 GHz during the period from June 1996 to February 2000. The result of the research will be presented in 2001.

A thorough analysis of the radio flares in the radio blazar PKS 0420-014 led to the interpretation of its lightcurve in terms of two different classes of radio flares, the so called *core flares* and *jet flares*. The analysis was carried out by J.F.Zhou, X.Y.Hong and D.R.Jiang in collaboration with T.Venturi (IRA CNR) using a set of 5 GHz EVN images, coupled with the total flux density monitoring data over a wide range of frequencies available in the literature. It was shown that *Core flares* originated from the radio core, were characterised by large lags between the light curves at different frequencies and probably led to the ejection of new components. *Jet flares* arise from the jet component and may result from the Doppler boosting effects of rotating knots moving along a helical jet. Jet flares vary simultaneously at different frequencies.

Jiang Dongrong and collaborators studied the quasar 1642+416 using VLBI data at 5, 15 and 22 GHz attempting to determine which component is the core, whether the jet is twin-sided or has a bent one-sided structure. Analysis is continuing.

2.9. Toruń Centre for Astronomy, Poland

2.9.1. CSS and GPS sources

Since the publication of the very first paper defining the class of Compact Steep Spectrum (CSS) sources (Peacock & Wall, 1982, MNRAS, 198, 843) virtually only a few dozens of the strongest ones have been studied. In particular, the so-called 3CR PW sample (Spencer et al.1989, MNRAS 240, 657) used to be the canonical sample of CSSs for last decade. However, with the advent of the Faint Images of Radio Sky at Twenty cm (FIRST) survey, a new, effective tool to find even weaker CSS sources exists. Indeed, using an early release of FIRST covering a stripe of the sky limited by 28° < DEC < 42° Marecki and collaborators selected a flux density limited complete sample consisting of 58 candidate sources fulfilling the basic criteria of the CSS class: steep spectra between 365 and 8400 MHz and high compactness - the angular sizes of sources are less than a few arcseconds. The candidates are, of course, much weaker than known objects selected in a similar manner - their C-band fluxes listed in the GB6 survey were in a range: 150 mJy < S_5 < 550 mJy. Marecki et al. observed them with MERLIN at C-band in a snapshot mode.

The attention was focused on a group of objects with angular sizes of about 0.2 arcsec i.e. those which happen to be much more compact than "classical" CSSs, thought to represent even earlier stage of radio-loud AGN evolution. Eight of those objects were observed with the EVN at 6 cm and the VLBA at 18 cm. Three of them seem to be particularly interesting: they are the most compact examples of Medium-sized Symmetric Objects (MSOs). Such objects - being only slightly larger than 1 kpc - are

adjacent to CSO class in terms of linear sizes, so their existence is yet another underpinning of the widely accepted theory of the nature of CSSs: they are young objects evolving towards classical large scale radio sources.

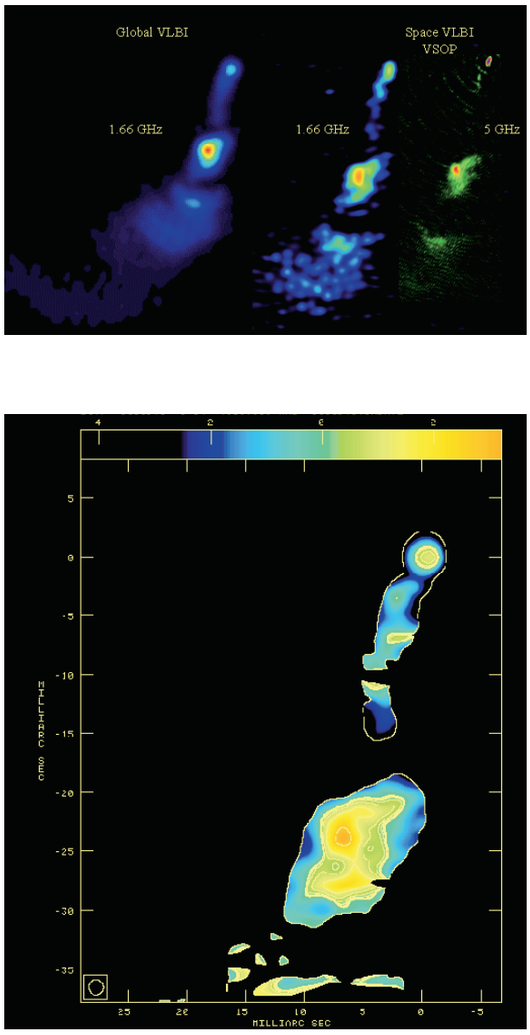

Figure 20. *3C309.1 images obtained at 1.7 and 5 GHz with global network + HALCA (top) and the spectral index distribution based on VSOP and global VLBI data.*

The study of 3C309.1 (Kus, Booth, Wilkinson, Gawronski) continued in 2000. Observations with VSOP and Global VLBI have been used to analyse the brightness and spectrum evolution of complex jet (Fig. 20). The results are being investigated by PhD student M.Gawronski and are being prepared for the publication.

Theoretical aspects of emission in AGNs jets were investigated by Katarzynski, Sol and Kus (2001 in press). A detailed model of emission from the radio band up to gamma range has been presented for the active galaxy Mkn 501. Based on the total flux density measurements the paper describes processes present in relativistic jets observed by VLBI technique. The theoretical results obtained closely follow the observational facts.

2.9.2. Galactic masers, late-type stars

M. Szymczak in close collaboration with colleagues at JBO analysed the EVN+MERLIN 18 cm data on OH masers in late-type stars. An evidence for episodic variations in the mass loss rates has been found in two OH/IR objects which are probably in a stage of transition from AGB to PN. MERLIN full polarization data of those objects indicated a globally ordered magnetic field in the 1612 MHz OH maser regions (Szymczak & Richards, 2001, in press).

Following a comprehensive 6.7 GHz methanol maser survey done with the Toruń telescope (Szymczak et al. 2000) a sample of 16 sources has been selected for VLBI studies. The source positions were determined with the Effelsberg telescope. Thirteen targets were observed in a snapshot mode with 4 EVN antennas and Hartebeesthoek in May 2000 and correlated at the NRAO. The objects are associated with IRAS sources of infrared colours typical for ultracompact HII regions. Data reduction is in progress in order to measure the absolute positions of the sources and to study in statistical way the structure of excited regions and their relations with other phenomena associated with massive star formation.

Szymczak is also involved in the EVN project carried out during all four 1999 sessions (P.I. Yates, Harts University) on the proper motion studies of OH masers in Mira and semiregular variables. The data are being analysed.

2.9.3. Star-forming regions

Following the discovery of excited OH masers at 4.7 GHz in the two star-forming regions W75N and Cep A with the 32 m Toruń telescope

(Szymczak et al. 2000), further observations of these targets undertaken with the EVN in 1999 by Szymczak, Hrynek and Kus in collaboration with Baudry (Bordeaux), Cohen (NRAL) and Desmurs (OAN/JIVE), are in the reduction process. The aim is to determine the spatial location of excited masers and to observe the temporal changes in their structures.

2.10. Urumqi Astronomical Observatory, P.R. China

In February 2000, Liu Xiang visited Jodrell Bank, for data reduction of MERLIN observations of a sample of CSO's. He also continued to analyse the EVN and VLBA data on proper motion in the source OQ208.

2.11. European Geodetic VLBI Network

The European geodetic VLBI observations have been continuing through 1998, 1999 and 2000 at a rate of six experiments per year with slightly different station configurations. In the final phase of the project, a major part of the work has been concentrated on the comparison and combination of the VLBI results with the most recent GPS results from the European Network of Permanent stations. First comparisons have been made by the CGS Matera (Centro di Geodesia Spaziale) with the involvement of the ITIS-group. In parallel, the groups at the University of Bonn and BKG have made comparisons with GPS using the solutions from the CODE analysis centers in Frankfurt and Berne. It is encouraging to see that the main features of height change are found both in the VLBI and the GPS solutions:

- in relation to Wettzell fixed, the sites of Onsala and Ny Alesund are rising at 1 to 2 mm/y (mainly due to postglacial uplift);
- the subsidence of Medicina (also relative to Wettzell) of -2 to -3 mm/y is possibly related to ground water and natural gas withdrawal or other man-induced effects in the Po-plain;
- the uplift at Madrid of +1 to +3 mm/y is confirmed by the nearby GPS site (Villafranca);
- neither Noto nor Matera shows any significant vertical motions with respect to Wettzell.

The horizontal motions of Noto and Matera continue to show a pronounced northward trend, but are distinctly smaller (4 mm/yr) than the values determined earlier from the shorter time series. The Medicina motion is also significant (3 mm/yr), but is directed more to the east.

At several of the VLBI stations the investigations for local effects have gained momentum and are producing promising results:

- the influence of thermal expansion on the telescope reference points is being monitored and models are compared to direct measurements (e.g. with invar wires);
- at the sites of Effelsberg (100 m radio telescope), Madrid (Robledo DSN complex, 34 m antenna) and Medicina (32 m antenna), extensive local geodetic measurements have been carried out to check the location (and possible motion) of the VLBI reference points on the antennas after the repair of the wheel-and-track support structures;

This year, members of several of the VLBI groups in the project have been involved in local measurements at the 25 m antenna of Ny Alesund under the EU Programme 'Access to Large Scale Facilities'.

The 14th Working Meeting of the European VLBI Network for Geodesy and Astrometry was held in Castel San Pietro Terme, near Bologna, 8-9 Sept 2000, hosted by the Istituto di Radioastronomia of the CNR. The full proceedings have been published by the Istituto di Radioastronomia, Consiglio Nazionale delle Ricerche, Bologna, Italy in December 2000.

A presentation of the CNR2000 VLBI solution and its geological and geodynamical implications was made by E. Gueguen at the WEGENER symposium in San Fernando, Spain, 18-20 Sept. 2000. The Proceedings are in preparation at the ROA, San Fernando, Spain. Special training activities have been carried out in the reporting period:

- Course on Crustal Loading Effects in Theory and Practice at Chalmers Technical University, Gothenburg, Sweden, 22 – 24 May 2000.

- Course on aspects of VLBI in Astronomy and Geodesy at the Istituto di Radioastronomia (CNR), Bologna, Italy, 11 – 13 Sept. 2000.

A course on geophysical aspects of geodetically observed site motions is being planned by the Norwegian National Mapping Agency for May 2001. Further information on the European Geodetic VLBI Project is available at:
http://giub.geod.uni-bonn.de/vlbi/europe/eu.html

2.12. Major European VLBI groups outside the Consortium: Bordeaux Observatory, France

2.12.1. Masers

Baudry in cooperation with colleagues at Jodrell Bank, JIVE and OAN has continued to work on both compact HII regions and late-type stars.

Further interpretation of the first epoch 13.4 GHz OH observations of the ultra-compact HII region W3(OH) in relation with the massive star(s) powering W3 was presented at a special conference on high-mass star formation by A.Baudry and P.Diamond. Due to technical difficulties the second epoch VLBA observations of the 13.4 GHz OH maser in the same source have been re-scheduled for November 2000.

Monitoring of 18 cm OH masers in several AGB stars continued (PI - W.Vlemmings, Leiden) in view of determining distances and mass-loss rates. In U Herculis data covering 10 epochs over 6 years are now available for astrometric interpretation as well as for constraining the amplified stellar image model.

2.12.2 Astrometry

Charlot, Viateau and Baudry in collaboration with colleagues at NASA/GSFC, USNO and JPL have initiated an astrometric project for densifying the International Celestial Reference Frame (ICRF). The ICRF, which is the newly adopted celestial reference frame of the IAU, is the most accurate VLBI celestial frame available to date. It currently contains 667 sources distributed over the entire sky. The aim of this project is to add 150 new sources at carefully selected locations to fill the “empty” regions in the northern sky and improve the overall source distribution. Most notably, the addition of these new sources will reduce the angular distance to the nearest ICRF source for any randomly-chosen location in the northern sky from a maximum of 13° (as it is now for the current ICRF frame) to a maximum of 6°, thus making the future ICRF a useful catalog of calibrators for phase-referencing observations. As an initial step, 50 of these new sources have been observed on May 31, 2000, using the EVN and four external telescopes (Goldstone and Green Bank in USA, Algonquin in Canada, and Hartebeesthoek in South Africa) that agreed to join the EVN for this project. The new sources were scheduled jointly with a set of 10 highly accurate ICRF sources so that their positions can be linked to the ICRF.

2.12.3. Geodesy

Charlot in collaboration with Garrington (JBO) has organized an experiment to determine the geodetic positions of four EVN telescopes (Cambridge, Jodrell Bank, Toruń, Westerbork). The positions of these telescopes were poorly known (to a few meters only) because they had not participated in the past in the dual-frequency (S– and X–band) VLBI campaigns permitting highly accurate (at the cm level) geodetic determination. This experiment was carried out on November 23, 2000, using a bandwidth synthesis observing mode at 5 GHz, the highest frequency available at all antennas. Because of the single-frequency observing scheme, it is expected that ionosphere will be the major limiting factor of accuracy and as such will require careful modeling. For such modeling, several approaches will be tested, in particular the use of estimates of the ionospheric electron content derived from measurements by the Global Positioning System (GPS) network. The future improved geodetic positions will be attached to the ITRF2000 frame. These should largely improve correlation and analysis of phase-referencing experiments conducted with the EVN in the future.

3. European VLBI Network report

3.1. EVN Program Committee

The EVN Programme Committee carries out scientific and technical assessments of all EVN and Global VLBI proposals. All observatories of the EVN consortium are entitled to representation on the EVN PC and there are currently seven observatory members. Observatory members have particular responsibility for assessing the technical feasibility of proposed observations from their observatory's perspective. In addition there are four 'at large' members, chosen from non-EVN institutes to complement the astronomical experience of the observatory members. Three new 'at large' members were appointed by the EVN Directors at the end of 2000. The EVN scheduler and representative from the EVN Data Processor at JIVE are also PC members. Proposals requesting the Bonn Correlator or the Arecibo telescope are sent to representatives at these institutes for additional review.

In 2000, three PC meetings were held, approximately one month after the 1 February, 1 June and 1 October deadlines, in Leeds, Onsala and Catania. PC members provide reviews of each proposal in advance of the meeting, which are discussed and a final recommendation to the EVN scheduler is formulated. Summary comments and the detailed comments of each PC member are sent to the PI/contact author.

The EVN PC also reviews VSOP proposals and provides one input to the VSOP Science Review Committee.

During 2000, a total of 61 proposals were received, including 25 Global VLBI proposals and 14 EVN+MERLIN proposals. As usual, the bulk of the proposals requested the prime wavelengths of 18 cm (29 proposals) and 6cm (22 proposals) where EVN sensitivity is greatest and there was strong demand for the unique 5cm capability of the EVN (8 proposals). There was only one VSOP announcement of opportunity during 2000, AO4 for the 1 Oct 2000 deadline, which attracted 28 proposals.

The PIs of EVN and Global proposals are drawn from a large international user community. Almost half of the proposals (26/61) had PIs from non-EVN institutes, although many of these included collaborators from EVN observatories.

The range of EVN proposals received reflects the growing application of the EVN to an increasingly wide range of astrophysical problems, including masers in star-forming regions, individual stars and binary stellar systems, supernova remnants in nearby galaxies, OH and HI absorption in active galaxies, the whole range of active galactic nuclei, and gravitational lenses.

The EVN PC is also a useful channel of communication with the EVN user community. The Call for Proposals, now available as a web page, provides important guidance on preparing proposals. An EVN Users' Meeting was held at the end of the JIVE Symposium in Onsala in June. The agenda covered the whole process of doing VLBI from preparing proposals to anaylsing data. The importance of considering technical feasibility when making proposals was stressed and the support available at this stage from JIVE was highlighted. Users were happy with the 'frequency on demand' approach now adopted by the EVN Scheduler.

The EVN PC Chairman also raises the collective concerns of users at the Consortium Directors' Meeting. Issues during 2000 included the impact of significant telescope downtime, policies on global correlation and tape release and targets of opportunity.

EVN conducted four observing sessions in 2000. The statistics of these sessions is presented in Tables 1 and 2.

Table 1: *Distribution of EVN observing (hours per year) over 6 wavelength bands and various types of experiments.*

Wavelength [cm]	***1.3***	***3.6/13***	***5***	***6***	***18-21***
EVN	-	59	119	117	184
Global	65	46	-	88	158
VSOP	-	-	-	25	12
Test/ad-hoc	-	6	-	54	16
TOTAL	65	111	119	284	370

Table 2: *Number of experiments conducted at various frequencies during 2000.*

Wavelength [cm]	***1.3***	***3.6***	***5***	***6***	***3.6/12***	***18-21***	***Total***
Session 1: 10.02 – 02.03.2000							
EVN	-	1	-	2	-	5	8
Global	3	3	-	1	-	7	14
VSOP	-	-	-	-	-	-	-
Tests/ad-hoc	-	-	-	2	-	-	2
Total Session 1	**3**	**4**	**-**	**5**	**-**	**12**	**24**
Session 2: 23.05 – 09.06.2000							
EVN	-	-	-	5	3	1	9
Global	-	-	-	4	-	2	6
VSOP	-	-	-	-	-	-	-
Tests/ad-hoc	-	-	-	2	1	1	4
Total Session 2	**-**	**-**	**-**	**11**	**4**	**4**	**19**
Session 3: 11.09 – 28.09.2000							
EVN	-	-	7	1	-	2	10
Global	-	-	-	-	-	-	-
VSOP	-	-	-	2	-	-	2
Tests/ad-hoc	-	-	-	3	-	-	3
Total Session 3	**-**	**-**	**7**	**6**	**-**	**2**	**15**
Session 4: 06.11 – 27.11.2000							
EVN	-	-	-	-	-	7	7
Global	2	2	-	1	-	3	8
VSOP	-	-	-	-	-	1	1
Tests/ad-hoc	1	-	-	1	-	3	5
Total Session 4	**3**	**2**	**-**	**2**	**-**	**14**	**21**
TOTAL in 2000							
EVN	*-*	*1*	*7*	*8*	*3*	*15*	*34*
Global	*5*	*5*	*-*	*6*	*-*	*12*	*28*
VSOP	*-*	*-*	*-*	*2*	*-*	*1*	*3*
Tests/ad-hoc	*1*	*-*	*-*	*8*	*1*	*4*	*14*
Total	***6***	***6***	***7***	***24***	***4***	***32***	***79***

3.2. Correlator reports

3.2.1. JIVE correlator operations

2.3.2.1. Throughput and operations
In 1999 the EVN MkIV processor began processing the first user experiments. The target for 2000 was to establish the EVN MkIV data processor at JIVE as the correlator of choice for the bulk of the Network throughput. As far as continuum and absorption experiments with the EVN are concerned, this was established during the year.

Over most of the year the typical mode of operations was that 50 - 60% of the available 80 hrs per week was spent on scientific production. The remaining 40 - 50% was dominated by testing, and in addition clock searching and network support took considerable time (Fig. 21). This division allowed production to keep up with the (initially limited) rate of incoming projects, finishing 1 or sometimes 2 projects per week.

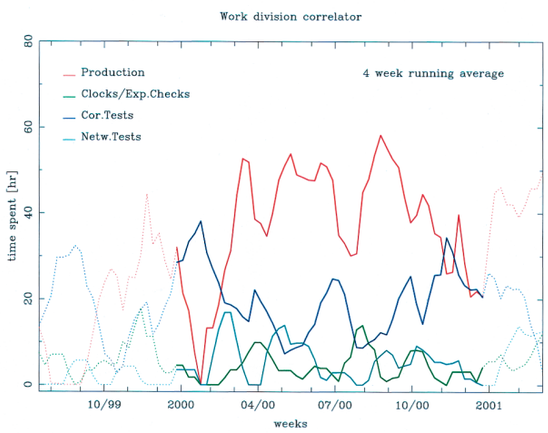

Figure 21. *Operations statistics of the EVN MkIV Data Processor at JIVE in 2000.*

There were 3 periods in 2000 during which the production rate dropped considerably. In February the Data Distributor Unit was brought into operation, which resulted in 3 weeks of down time. There was also some delay in the month of August, not only because of the holidays, but also because of a procedural error which required us to re-correlate 4 projects. The third major period of down-time happened at the end of the year, when testing for the DSP project (below) was started.

In 2000, 49 projects were processed amounting to a total of approximately 400 hours of network time. Of these 49 projects 17 were tests, mostly NME's, fringe tests and recorder tests, but it also included a small number of experiments for specific station and network capabilities. The other 32 projects were user experiments being completed. During the same period, 27 new user projects were received at JIVE for correlation. An equal number (27) of user projects were distributed to the users. It proved a bit more difficult to convince the users to release their project on the same time-scale; for only 11 user projects the tapes were released.

During the early part of the year byte-slips were a major operational concern which required re-correlation of individual scans in many cases.
By the middle of the year these problems had been associated with certain hardware components, which were taken out of the operational system. In the last quarter a problem was encountered in processing 80ips recordings, which also led to some re-correlations.

In the first half of the year the correlated data started piling up and releasing it to the PI's became heavy load on the scientific staff. Several operational enhancements and the arrival of a third support scientist, made this problem manageable. Among the operational enhancements was improved software to measure station clock offsets and to process station logs. The electronic log-book that runs during correlation and collects data on all the scans completed, improved the experiment book-keeping. By the end of the year the correlator operators could do the experiment setup and clock searches autonomously for a large fraction of the projects.

JIVE accepted the responsibility for reporting on the results of the recorder tests. This was carried out for three of the sessions. Dedicated software for these tests was developed.

The introduction in February 2000 of the "dynamic correlator configurations" allowed

more flexible allocation of the correlator capacity and in particular enabled correlation of projects with more than 8 (and up to 16) stations. We also started using "local validity" for practically all projects. This cured a number of problems we had in the earlier data. A special flagging script was developed to deal with fringe rate zero crossings.

Oversampling was tested to work satisfactorily, but still requires a small hardware upgrade to allow it on all playback units. In the last quarter we started to test the DSP software which will increase the correlator capacity 4-fold. This is particularly important for spectral line VLBI.

During the year the content of the data product was reviewed several times. Initially data were produced with incorrect antenna tables and opposite sign definitions from what was expected in AIPS. Later a number of places were identified were AIPS takes the wrong calibration strategy because it does not (yet) recognize EVN/JIVE data. A letter was sent to all JIVE users pointing out the potential problems one can encounter when processing JIVE data in AIPS. In the process of verifying that phase referencing results could be obtained with the correlator, it was realised that quite a few EVN antennas have large position offsets. In a some cases these off-sets could be estimated from calibration experiments.

A number of visitors gave favourable feedback about the data quality.

3.2.2. MPIfR correlator operations

3.2.2.1. MkIIIA correlator

During 2000 the MkIIIA correlator continued to be used for some EVN experiments. In the first week of 2000, the MkIIIA correlator was made Y2K compliant by D.Graham. Later the ability to process experiments observed in 2000 and a correction for 2000 being a leap year were added. Production correlation continued to be done mostly on the MkIIIA correlator until September 2000, although the amount done was ramped down from May. The last operating MkIII correlator in the world was finally shut down on October the 4th after nearly 20 years of MkIII correlator operations at the MPIfR.

3.2.2.2. MPIfR-BKG MkIV correlator

The new MK IV correlator was successfully installed in December 1999. A first astronomical observation which had already been processed on the MK IIIA correlator was correlated for test purposes a week later. Similar comparisons were made for a geodetic experiment to verify the performance of the new correlator. A 2nd comparison was done in late Spring 2000 after the implementation of phase-cal extraction. This test confirmed that the new correlator works correctly for geodetic applications.

Thereafter, production correlation started and was continuously ramped up after the introduction of a new revision of the correlator software which enabled the extraction and application of the phase-calibration signals. Initially the throughput through the MkIV correlator was noticeably lower than that of the MkIIIA correlator - mostly due to a weakness in the design of the pass finding software as well as due to instabilities and bugs in the software as a whole and the station units in particular. In the course of 2000 several new releases of correlator software were installed in order to increase the throughput, the stability of the system and to implement missing features. D.Graham played a leading role in the implementation of new correlator modes, while the majority of the software work was done by Haystack observatory. The introduction of a pass/track-position data-base was the biggest single improvement to increase the correlator throughput beyond that of the MkIIIA correlator. In the 2nd half of 2000 a project to write an interface for the MkIV correlated data into the astronomical software package AIPS was started.

The following list gives an overview of the milestones reached in 2000:

- First fringes with a VLBA mode (64–16 – 1) from a VLBA formatter (test experiment Eb-Mc, Feb 2000) – 16 Feb 2000;
- Playback of a fan-out 1:2 mode – 15 Mar 2000;
- Correlation of dissimilar tape speeds – 5 Apr 2000;

- Extraction of phase-cal signal – 6 Apr 2000;
- Replay of 2-bit sampling mode – 7 Apr 2000;
- Playback of a fan-out 1:4 mode – 7 Apr 2000;
- Playback of mode using "barrel roll" – 12 Apr 2000;
- Increase possible integration times to > 0.5 s – Aug 2000;
- Decrease scan set-up time – Aug 2000;
- Decrease synchronization time to about 1 s for most scans – Aug 2000;
- Increase throughput beyond that of the MkIII correlator with new pass-finding software –Sep 2000;
- Polarization correlation and fringe-fitting – Nov 2000.

3.2.2.3. Operations

The 9 Metrum playback drives were shared between the 2 correlators and could be switched easily from one correlator to the other. Thus we achieved a large degree of flexibility and could maintain a high throughput through the system. The backlog of projects which still existed at the beginning of 2000 disappeared by the end of the year.

In 2000 a total of 40 observations were correlated with the MK IIIA correlator and about 12 with the MK IV. Of these, 14 observations were correlated for the EVN, 12 were observations of MPI scientists and 26 of geodetic origin. All 14 observations correlated in 2000 for the EVN were supervised by MPIfR staff (D. Graham, W.Alef)

Although the EVN Data Processor at JIVE has now become the "default" correlator for EVN observations, the MPIfR/BKG MkIV correlator is still available for limited processing of EVN observations. Suitable projects are those for which the scientific advantage of using the MPIfR Correlator is given in the proposal, or those which include an MPIfR collaborator who wishes to have a closer "hands-on" approach to the data flow.

3.3. Technical and Operations Group

The TOG met twice during the period of this report: at Jodrell Bank Observatory (5 May 2000) and Toruń Center for Astronomy (22 October 2000). Reports from both meetings (and related information) are available on the EVN TOG web site (www.jive.nl/jive/evn/tog/tog.html). Ralph Spencer (JBO) finished his 3 year term of office as TOG chairman at the end of May and was succeeded by Michael Garrett (JIVE). At the same time the EMU (European MkIV Upgrade) team was formally disbanded with all outstanding developments being absorbed by the TOG.

The main emphasis of TOG activities continued to be the reliability and performance of individual telescopes and the Network as a whole. Local activity at the telescopes associated with these efforts are reported elsewhere in this volume (see chapter 4 for example). For the network as a whole, a clear focus of attention for many stations was recording performance. A "Tape Recorder" workshop was held at Jodrell Bank adjacent to the TOG meeting supported in part by the EC-funded Infrastructure Cooperation Network in Radio Astronomy (RadioNET). Recognised experts (from both the US and from within the EVN itself) were on hand to provide direct support to both VLBI Technical and Observing friends. In total 27 people participated in practical and classroom sessions that covered all areas of recorder performance and maintenance. JIVE also began routine analysis of recorder test tapes - tapes written by the stations 6 weeks in advance of the session. In several cases these tests revealed problems that might otherwise have gone un-noticed. The first steps were taken to assign some stations (e.g. the first being Medicina) to be thin-tape only. With all these steps in place a continuation of the general improvement in the performance of nearly all stations in the area of data quality was observed over the course of the year. This was particularly in evidence at Toruń and Westerbork.

Significant improvements were also observed in terms of the general reliability of stations. Whereas previous years have recorded outright failures of major telescopes in entire (frequency) sessions, there were no such incidences in this year. There were of course occasional experiments where telescopes did not produce fringes or were unable to observe, but in general the reliability of network operations was notably improved. In terms of sensitivity, the return of the WSRT in phased-array mode was a welcomed development, providing superb system noise levels of 35 Jy at 18 cm and 70 Jy at 6 cm.

In April of this year the EVN (represented by Spencer – JBO, Wunderlich – MPIfR, Parry – JBO, Tuccari – IRA in collaboration with local Chinese staff and NVI/GSFC) participated in the upgrade of the Chinese antennas (Shanghai and Urumqi) to the MkIV system. After some initial teething problems in Sessions 2 (and part of Session 3) both antennas were again producing fringes by Session 4, 2000. The successful upgrade of both antennas to MkIV provides the EVN with new capabilities in terms of uv-coverage and high angular resolution.

By the end of the year the TOG presented detailed plans to the CBD of proposed areas of development for the coming year. The upgrade of the formatter firmware (Freihold and Graham - MPIfR, Smythe –Haystack Observatory) was already well underway by the end of the year and expected to be installed at the stations in early 2001. The directors approved a programme to develop the Field System in order to facilitate: 2-head recording, use of the new features associated with the formatter firmware upgrade (barrel rolling etc) and improved flagging and calibration data. Tuccari (IRA) began and completed a bulk order for MkIV decoders for the majority of EVN stations. Graham (MPIfR) has continued to investigate a "cheap" design for an IF switch box, in order to make co-observing with pure geodesy telescopes more transparent. Other issues that received attention from the TOG included obsolete parts, improved logistics (freq of posting GPS data, experiment naming conventions, further thin tape procurement). Looking towards the future ("EVN2010") the TOG established a watching brief on the new "off the shelf" tape based recording systems and possible fibre connectivity projects.

4. VLBI operations support at member institutes

4.1. ASTRON, the Netherlands

In 2000 all four network sessions were observed, with one being shortened due to system upgrades at the Westerbork telescope, and using all 14 telescopes. In addition, some ad-hoc VLBI sessions were done to support space-VLBI.

The Upgrade program of the Westerbork Synthesis Radio Telescope (WSRT) is nearing completion. At the end of the year 2000 the new IVC (Intermediate Video Conversion) system has been installed that will provide the telescope with an 8x20 MHz dual polarization system. The system integration of the IF system with the digital DZB correlator and the Telescope Management System has been started and it expected that astronomical commissioning can start in early 2001. In addition to IVC, a new system has been built to add the signals from the 14 telescopes for phased array operation as a 94 m telescope. This new system will come into service during 2001.

The reliability of the WSRT systems has been an important aspect of the operations and system groups at the WSRT. Since many new parts of the systems were being implemented in the same time period, it was important to emphasise the robustness of the system. A steady increase may be seen in reliability of both the specific VLBI components and the other system components. During the year many changes have been made in operational procedures for the benefit of robustness and new ideas have been implemented to visualize failure rates of specific components of the observing process.

In addition, much emphasis has been given to interference mitigation issues at the WSRT. Experiments have been done with digital signal processing (DSP) hardware and software to facilitate interference excision and cancellation as part of handling the data stream for both the local array and VLBI operations.

4.2. Institute of Radio Astronomy, Italy

The Institute of Radio Astronomy participated in EVN/VLBI activities with the 32 m dishes of the Medicina and Noto radio observatories. The Network Server, located at the Institute Headquarters in Bologna, and accessible both via ftp and web, continues to provide support to observatory friends and users for the EVN and Global operations and data archive.

The antenna rail repair took place in Medicina during the summer of 2000. For this reason Medicina could not take part in most of the September VLBI session (6 and 5 cm). It took part into the remaining VLBI sessions, for a total of ~60 observing days. The telescope was also involved in geodetic observations of the EUROPE project (6 experiments) and RTD project (5 experiments), for a total of 264 hours. Medicina switched to thin-tape-only operations in September 2000.

The Noto telescope participated in all EVN observations in 2000, for a total of 80 experiments in 76 days of observations. It observed at all the scheduled frequencies including also, for the first time, observations of the methanol line at 6 GHz. The station also participated in seven VLBI experiments scheduled by the geodetic community in the S/X bands, five for the EUROPE project and two for CORE. The Noto station took part in 13 VSOP Survey observations, eight of them in VLBA mode (correlated in Socorro) and five in S2 mode (correlated in Penticton, Canada, and Mitaka, Japan). In addition, Noto participated in ad-hoc experiments, on CygX-3 at 6 cm during a flare, and one for astrometry of pulsars at S band as part of the “Polar Bear Array", and S2 observations with telescopes in Japan, Russia, Canada and China. In December, four days of observations were dedicated to the INTAS experiment at 18 cm, recorded with the S2 terminal.

The Institute was responsible for the organization of:

- The 14-th Working Meeting on European VLBI for Geodesy and Astrometry, held in Castel San Pietro Terme, Italy, 8 – 9 Sep 2000. The proceedings have been published with

the editors P.Tomasi, F.Mantovani and M.-A. Perez-Torres

- The European TMR Training course on VLBI, held at the Istituto di Radioastronomia (11 – 13 Sep 2000).

4.3. Jodrell Bank Observatory, UK

During 2000, the MERLIN/VLBI National Facility at Jodrell Bank participated in all four EVN sessions, using the 76-m Lovell Telescope at 18/21cm, the 25-m Mk2 telescope at 6, 5 and 1.3 cm and the 32-m Cambridge Telescope at 1.3, 6, and 18/21cm. Three EVN sessions included joint observations with the MERLIN array, which provides baselines from 10 to 217 km, correlated in real-time at Jodrell Bank. The combination of EVN+MERLIN allows the detailed study of radio sources on scales from a few mas to several arcseconds. Scheduling and configuration of the MERLIN observations are handled by MERLIN/VLBI operations staff, based on the PIs VLBI schedule.

A £ 2.3M project to upgrade the Lovell Telescope was started in 2000 with work on the azimuth track and its foundations. During 2001 and 2002, the drive system will be completely replaced, the existing surface will be removed and new surface panels will be installed. The goal is to set the surface with an rms accuracy of 2mm or better, using a combination laser ranging and holographic measurements. This should give the Lovell Telescope full efficiency at 5 GHz, and make it useful at 10 GHz.

Paul Burgess co-ordinates the TOG recorder group and maintains information on spares and obsolete parts for recorders. Les Parry was part of Team China which carried out upgrades to the recorders at Shanghai and Urumqi (see sections 3.4, 5.9, 5.11). Alastair Gunn leads the TOG logistics group and produced ANTAB files for amplitude calibration in the first two sessions in 2000. Anita Richards and Simon Garrington have provided calibrated MERLIN data for a number of MERLIN+EVN experiments. Simon Garrington chairs the EVN PC and Phil Diamond was vice-chair of the CBD and treasurer of the JIVE Board.

4.4. Joint Institute for VLBI in Europe, the Netherlands

The EVN Support Group at JIVE continued to monitor the performance of the EVN, supporting EVN operations in general and EVN users in particular. Many JIVE staff were involved in these activities including Avruch, Campbell, Gabuzda, Garrett, Gurvits, van Langevelde, Phillips, Reynolds and Sjouwerman.

4.4.1. Network Monitoring, Reliability and Performance

Network Monitoring Experiments (NMEs) were scheduled and correlated throughout session 1-4, 2000. For the first time, all NMEs were correlated and analysed at JIVE. The associated reports (both a formal written report and short messages to EVNtech) were distributed in a timely manner (well in advance of the next session). The NMEs proved to be an essential element in monitoring the reliability and performance of the network (see section 3.4 for details).

In addition to the NMEs, regular Fringe Test Tapes (FTT, another short test experiment run several days in advance of the session proper) were scheduled and correlated at JIVE. Feedback to the telescopes was generated within ~ 1 week of the observations being made. Other tests, including Recorder Test Tapes, Team China fringe tests, CM-JB single baseline tests, VIV formatter tests were also correlated at JIVE.

The 6 cm NME of session 1/2000 was specially designed to test the performance of the EVN MkIV Data Processor at JIVE (in particular all polarisation products were generated by the correlator). This 12-hour run was correlated to completion at both the JIVE and Socorro correlators. An initial analysis of the data correlated at JIVE produced an image of DA193 around the 2500:1 level. Further improvements (involving corrections for polarisation cross-talk) uncovered some inconsistencies in the format of JIVE FITS files that included cross polarisation data. The analysis of this data set continues.

Work began on the possibility of "pipelining" the NME experiments. The aim is to design an AIPS based analysis "pipeline" that would run on all calibrator continuum data correlated at JIVE. The pipeline builds on previous work at Jodrell Bank by Muxlow and Diamond.

4.4.2. Network Calibration

The production of ANTAB calibration data was formally passed from J.-F. Desmurs (OAN) to A.Gunn (JBO, sessions 1 and 2) and finally to C.Reynolds (JIVE, session 3 and 4/2000). An investigation into the format of the ANTAB file revealed several errors in the data generated for sessions throughout 1999. Reynolds re-wrote the software responsible for producing the ANTAB format and this resulted in much more reliable files. However, there are still problems with non-standard experiments where the information in the stations logs is either incomplete or entirely misleading.

Investigations of the accuracy of the a priori station amplitude calibration suggest that most of the EVN telescope gains were within about 10-20% of their true values. However, there are often exceptions to this rule, especially at 18 cm where RFI makes antenna calibration almost impossible at some sites.

4.4.3. Data Correlation Support in Socorro

During this year JIVE provided support for the correlation of 14 EVN and Global VLBI projects at the NRAO processor. Feedback was also provided to the stations regarding their performance in these experiments.

4.4.4. Scheduling Software Development

Maintenance and development of Sched continued, especially the part that creates the "VEX" format output used by the EVN antennas. The support for VLBA4 systems was added to the program. Van Langevelde also introduced the necessary concepts for two head recording. Barrel-rolling was fixed and thin tape post-passes were enforced. Other enhancements focused on the user interface; it is now possible to enter "cover sheet" information and the error messages were cleaned up. The catalogs with frequency and station data have a more independent place with respect to the code, in order to allow easier maintenance.

4.4.5. Observing and Telescope support

At the end of January 2000 J.-F.Desmurs left the employ of JIVE after a period of 3 years as JIVE Support Scientist at Yebes. This brought to an end direct JIVE support for observing and telescopes operations.

4.4.6. General Network Support

The EVN web site (www.jive.nl/jive/evn) underwent a substantial overhaul this year, in terms of both content and site navigation. It continues to act as a focus for information about the EVN, from both the user perspective and EVN operations. Several new pages were created this year, including a new EVN image gallery, see

www.jive.nl/jive/evn/gallery/images.html,

featuring various new eye-catching EVN results. The Experiment Feedback Facility continued to be used by the telescopes and correlators for all EVN sessions conducted in 2000. The e-mail exploder EVNtech was relocated to JBO, after various problems with its operation in 1999/2000.

The feasibility of rapid 6/3.6 cm frequency switching was investigated, and the initial results are encouraging. In particular it appears that the phase-offset between individual BBCs is surprisingly stable, irrespective of the frequency band being observed. Other investigations included (i) EVN station positions, (ii) Blind correlation of EVN data.

JIVE staff were involved in the post-correlation analysis of the various test experiments described in other parts of this report.

4.4.7. EVN PI Support

During the year JIVE staff supported PIs in scheduling more than 23 EVN experiments. Assistance was also provided for the preparation of several EVN and Global VLBI proposals. Visitors to JIVE (for the purposes of Data analysis) included: V.Tornatore (Milano),

A.Stirling (U of Lancs), A.MacDonald (JBO), C. de la Force, R.Spencer (JBO), S.Garrington (JBO), S.Frey, Z.Paragi (both FÖMI SGO, Hungary), E.Fomalont (NRAO, USA), W.Scott (University of Calgary, Canada), J.Dennett-Thorpe (U of Groningen), W.Tschager (Leiden), I.Owsianik (MPIfR), A.Roy (MPIfR), P.Augusto (U of Maderia), A.Kozlenkov (Logics Unlimited), M.Ribo, I.Snellen A.Tarchi, E. Ros (MPIfR), Zhang Haiyan (Beijing Normal University), M.Giroletti (U of Bologna), N.Garnich (Moscow State University), E.Middelberg (Univ. Bonn), Jiyune Yi (Onsala Space Obs), M.Aller (U of Michigan), I.Fejes (FÖMI SGO), A.Pushkarev (ASC, Moscow).

4.5. Max-Planck-Institute for Radio Astronomy, Germany

4.5.1. Effelsberg Observatory

As a full member observatory of the EVN, MPIfR makes available the Effelsberg 100 m telescope for all EVN observing sessions. Because of its large collecting area it is a critical element in almost all EVN and EVN/Global VLBI projects, and especially in EVN Space VLBI observations made together with the Japanese HALCA spacecraft.

4.5.1.1. Record Terminals

Two VLBI record terminals are available. The "EVN standard" MkIV terminal, using FS9 control software, is currently used with thick tapes only. A separate VLBA record terminal has been optimized for use together with the VLBA and its correlator, and is run using VLBA control software to maintain close operational compatibility with the VLBA. It is used for most EVN "Global" and all VSOP observations. It records using thin tape only.

In 2000 the VLBA terminal was used for a total of 81 experiments and the MkIV terminal for 30, corresponding to around 25% of the total telescope time. These experiments were done in the 4 EVN sessions, two CMVA sessions (each of a few days duration) and several experiments outside of these sessions (e.g. with the VSOP satellite HALCA).

A technician (H.Boesel) is stationed in Effelsberg and is assigned for maintenance of these terminals. The write head for the VLBA recorder was exchanged in spring 2000. In December 2000 tests were made on the formatter of the MkIV terminal, which was then upgraded with new software produced by D.Graham and A.Freihold (see section 3)

4.5.1.2. Receivers and other VLBI equipment

Low noise receivers are available for the following standard EVN frequencies: 0.61, 0.8 – 1.3,1.4/1.6, 6.0 GHz (prime focus) and 2.3, 5.0 8.4, 22 and 43GHz (secondary focus)

All receivers have dual polarization channels except 2.3 GHz (RHC only). 15 GHz and 86 GHz receivers are also available for VLBA and CMVA observing. Full frequency agility (schedule-driven, computer-controlled change of observing receiver) is available between all secondary focus receivers for observations using the VLBA terminal.

A Hydrogen maser and GPS timing receiver are used to maintain time and frequency standards. A water-vapour radiometer and GPS reference station are under construction to provide remote sensing of the atmosphere (see MPIfR scientific report).

4.5.1.3. Absentee observing

A.Kraus is the "friend of the telescope" in Effelsberg; his responsibilities include the administration of "absentee" observing. When necessary, assistance is provided by D.Graham of the scientific staff in Bonn, especially on matters related to the control software for the MkIV and VLBA record terminals.

4.5.2. EVN administration

R. Schwartz continues as EVN Scheduler. He is responsible for planning EVN observing sessions, including coordinating time at the EVN Observatories and outside organisations such as NRAO-VLBA, the DSN and the Japanese VSOP project. He makes the EVN block observing plan and maintains lists of current EVN projects. He also issues the EVN Call for Proposals 3 times per year, and organises the receipt and distribution of proposals to the EVN

Program Committee. W. Alef assists with electronically submitted proposals. R.Schwartz attends meetings of the EVN CBD.

R.Porcas is a member of the EVN Program Committee. He and R.Schwartz attend meetings of the EVNPC three times per year. R.Porcas also maintains the "PI Instruction Sheet", a guide to EVN observers who have been assigned observing time.

W. Alef organises the distribution of tapes from correlators to observatories prior to observing sessions.

4.6. Metsähovi Radio Observatory, Finland

In 2000, Metsähovi participated in three VLBI sessions; one 86 GHz CMVA session in April and two VLBA + EVN joint sessions at 22 GHz in February and in November. The CMVA session was successful. The 22 GHz sessions were thin tape observations which suffered from poor recording quality, especially that of the upper tracks. Re-contouring of the head with abrasive tape has corrected the problem. In February there were BBC problems and in November the H-maser instabilities troubled one of the sessions. (The reason for the maser instabilities was the failure of the maser room air conditioning system.)

The FS was updated three times within a year, through the latest version 9.4.18.

The antenna control system upgrade is close to the completion. The new VLBI software has been operational since the beginning of year 2000; it is completely independent from the old MicroVAX-based system. The pilot versions of the solar and AOS spectral line Linux software has been completed, the quasar continuum monitoring software is to follow in 2001.

The small VLBI operation support group is heavily involved in other non-VLBI projects and there have been changes in the personnel. Kirsi Karlamaa and Jan Engelberg have left Metsähovi. Prisse Könönen and Pekka Sjöman are the new members in the Metsähovi VLBI group. Prisse Könönen is responsible for the VLBI sessions at Metsähovi and Pekka Sjöman is the new contact person for H-maser and timing issues. The manpower problems caused that Metsähovi's participation in the CMVA session in October 2000 had to be cancelled.

4.7. National Astronomical Observatory, Spain

The 14-m radio telescope of OAN at Yebes (CAY, Guadalajara, Spain) participated in the EVN sessions at S/X frequencies in February and May 2000. Regular geodetic VLBI campaigns for the EUROPE and CORE projects have also been performed. Problems with one of the MKIV formatter boards made the data unusable during the last quarter of the year.

OAN participates in the EU-funded Infrastructure Cooperation Network in Radio Astronomy, RadioNET, with the goal of obtaining sustained reliability in the operations of the network. The contract will provide manpower to coordinate the implementation of several upgrades in the telescope control and VLBI equipment which will enhance the reliability of the operations and quality of the data obtained.

The OAN contributed 14 thin tapes to the EVN pool in 2000 with. Moreover, OAN has ordered an additional 35 new thin tapes, which correspond to the observatory contribution for 2001 and 2002. These tapes have already been delivered.

4.8. Onsala Space Observatory, Sweden

Onsala played a full role in VLBI during 2000 observing in all four of the EVN sessions plus in two week-long sessions of the Coordinated Millimetre VLBI Array (CMVA) in April and October. There was increasing participation in geodetic VLBI with approximately 20 days devoted to CORE (Coordinated Observations of Rotation of the Earth) programmes. In addition the Swedish–ESO SEST 15-m millimetre telescope in Chile was used in both CMVA sessions and in ad-hoc fringe-test 3.6-cm wavelength observations between SEST and the Onsala 20 m antenna In the October CMVA session, strong fringes were found at a wavelength of 3 mm between Pico Veleta in Spain and SEST. Experiments are planned for 2001 to detect fringes at 2 mm (frequency 175 GHz).

John Conway continued to serve on the EVN PC but was replaced as secretary after several years service. Antonis Polatidis and John Conway remained as friends of VLBI. Rune Byström left the staff in mid 2000 and technical duties were shared by Karl-Ake Johansson (hardware) and Biorn Nilsson (software).

4.9. Shanghai Astronomical Observatory, P.R. China

As a full member observatory of the EVN, Shanghai station participated in the VLBI experiments of all four EVN sessions in 2000. Receivers were available at L, C, K, and S/X bands. The station is equipped with VLBA, S2, and MkIV (VLBA4) and S2 terminals. The telescope also took part in VSOP observations, the geodetic VLBI observations which were scheduled by NASA and APSG, and INTAS observations.

4.10 Toruń Centre for Astronomy, Poland

The Department of Radio Astronomy, Toruń Centre for Astronomy, is a division of the Faculty of Physics and Astronomy of the Nicolaus Copernicus University. The Centre operates two parabolic radio telescopes, 15 and 32 m in diameter. The major instrument, the 32 m antenna, is equipped with low noise receivers covering the L– and C–bands and various backends. Of the latter, three basic units are being continuously used: the VLBA4 recording terminal, the broad-band PSPM2 pulsar machine and the 16k channels autocorrelation spectrometer. The total observing time is divided between three major programmes – EVN observations, pulsar timing and search, and spectroscopy of molecules. The telescope is fully used and in 2000 the astronomical observing time covered 90.2% of the total time (the loss is due to 8.6% service and test observations, 1.2% failure). There was about 25% lower demand for VLBI than in 1999.

From 1998 the Toruń Centre for Astronomy is the full member of the EVN Consortium. In 2000 the Torun's 32 m antenna participated in 72 VLBI projects for total of 862 hours of observation. These were mostly EVN programmes; VSOP projects added a few percent. The small 15 m dish is now used for the Low Frequency VLBI Network at 327 MHz and for solar spikes monitoring.

To improve the station's reliability several organisational changes were made to ensure the required high standard is achieved for EVN operations. 24 hour observing is secured by a team of professional operators.

4.11. Urumqi Astronomical Observatory, P.R. China

The Urumqi Astronomical Observatory (UAO) participated in 12 EVN projects and 3 NASA/Geodesy projects using Mk3/Mk4 data recording. In addition, UAO participated in LFVN projects INT001 and VLBR002 in 2000.

4.12. BKG - Wettzell, Germany

Within EVN, the Bundesamt für Kartographie und Geodäsie is an associate member. Since 1983, the Radiotelscope Wettzell contributes mainly to geodetic and astrometric observing programs and occasionally to astronomy experiments. Extended times series exist for the station position and for the velocity. In 2000, the 20-m-Radiotelscope participated in the following IVS coordinated programs:

NEOS-A	52 observations
IRIS-S	12
DUT1 Intensive	228
EUROPE	7
RDV	6
CORE	6
Astronomy	3

Due to the transition of the correlator in Bonn from MkIII to MkIV which limited the correlator throughout in 2000, the amount of observation was slightly less compared to the previous years.

5. VLBI technical activity at member institutes

5.1. ASTRON, The Netherlands

VLBI hardware
During 2000, one worn-out headstack has been replaced by a Spin Physics triple cap unit, while the recorder has also been equipped with double headstacks. Problems have been encountered with reel motor bearings and several replacement units were bought. Most other spare parts are being stocked on the level recommended in the list for all EVN observatories. Westerbork combined with other EVN observatories to place an order for more thin tapes, thus making up for the purchases of 1999, 2000, 2001, and part of 2002.

A very simple dry air system (based on an idea by H. Blaschke) was mounted on the VLBI tape unit in order to keep the humidity below 35% at all times. There is no humidity regulation, but since the room is air-conditioned it is necessary only to warm the air around the headstack with a simple fan and a heating block system.

Field system
A monitoring script ("CtrlFieldSystem") was written to send serious error messages from the Field system log-file to the observatory's standard warning system. This runs on the field system computer and parses the current log file for errors regarded as serious, and these are sent on to the current operator.

Array Activities
During 2000 the array switched to running under the new Telescope Management System (TMS) for all observations. The VLBI operation was the last system to switch over. This meant that several local operating procedures were changed significantly, but for most external users these changes should have little effect.

Since the changeover to TMS operations, there has been one major benefit for phase-referencing observations, as these can now be observed in a 'quasi-mosaic' mode. The observations are now done as a block with several 'pointings', some of which are the main source and some of which are the reference. This procedure is done automatically by reading the VEX file input, and it can cope with arbitrary pointing position changes. This procedure reduces the overhead for starting an observation to that needed for the first observation of the block.

At the end of 2000, the new IF system was installed in Westerbork, which will be commissioned during 2001. In addition, a new tied-array unit (TADU) will be installed for VLBI and pulsar observations. A preliminary TADUmin system with a 16 MHz effective bandwidth has been built and is awaiting installation. The ultimate 20 MHz bandwidth TADUmax system is currently being manufactured. These new systems will allow the retirement of the old DCB tied array system.

5.2. Institute of Radio Astronomy, Italy

5.2.1. Noto technological activities

The technological activity at the Noto Station was centered on the following points.

Data Acquisition
The MkIV formatter is now used as standard in the VLBA4 terminal. This has improved reliability by avoiding manual switching between MkIV and VLBA modes. This involved connecting different cables and change setup in the Field System. The realisation of a new version of TTY distributor to be used in the VLBA4 environment was completed. It has been produced for Cambridge, Effelsberg, Noto, Shanghai, Toruń, Metsähovi, Yebes, Pico Veleta, and three units for Haystack. The assembly of the headstack for the recorder is completed. Two new triple-cap head are available. The first tests will be done after the February 2001 EVN session.

Frequency agility:
Delay in the CSELT production of the L and S/X band feed systems is still affecting the multi-band receiver installation. A production order has been placed before the end of 1999. The receiver three modules operating in the VLBA4 terminal, in the vertex box and in the primary box have been successfully completed and tested. The cryogenic section is not yet completed, awaiting results of the evaluation of the possibility to cool at cryogenic temperatures the S/X feed, as it is done for the L–band one. Part of the new software environment to drive

the complex system has been developed for the VLBA section and a part of the vertex module.

Efficiency optimisation
The active surface for the Noto antenna, developed by the Medicina staff, will be installed in the last quarter of 2001. The necessary parts are being acquired, will be assembled in Medicina and then transferred in Noto. Photogrammetry of the parabola surface carried out in December 2000 confirmed the large deformations measured with phase reference holography two years earlier. This seriously affect performance at 1.3 cm and a reshaping of the surface will have to take this defect into consideration.

Microwave development
A Heybond bonding machine has been acquired and a technician spent a week in MPI to learn the bonding methods. An L–band amplifier developed in Yebes is under construction in collaboration with the Arcetri group. New software for a complete simulation and development computer station was acquired.

Digital electronics development
The development environment has been transferred from Sun to PC computers. Viewlogic, Altera and Orcad are used as schematic entry and simulation. Xilinx and Altera are used for FPGA processing. A patent regarding an instrument using radio waves and a laser beam able to measure phase variations has been deposited.

5.2.2. Medicina technological activities

The main hard- and software upgrades done at the Medicina Station in 2000 can be summarised as follows.

Active surface
The active surface project to realize a movable system for the panels of the primary mirror of the antenna is in the stage of component mass production. The electro-mechanical actuators and the network are completely defined and the control software is under development. The installation at the Noto antenna is foreseen in September-December 2001. Also the panels will be exchanged with a set with better accuracy (0.1 mm r.m.s.). This upgrade will permit very good antenna efficiency up to 43 GHz on an antenna originally designed to work properly up to 5 GHz. Moreover the efficiency will be almost constant with respect to the antenna elevation.

Frequency agility upgrade
The frequency agility project is going on although slower than expected. The delay is caused by the ongoing active surface project and unexpected problem of the grout below the rail of the Medicina antenna. The electronics of the 5 and 7 GHz receivers is ready and the construction of the 5 GHz feed system (horn, polariser, omt) is in progress.

PCAL automatic switch
Automatic switching for the pcal ground unit is enabled by a Field System procedure.

22 GHz pointing model
The pointing model of the 22 GHz receiver now uses two more parameters, P9 and P11 as labeled in the Field System. The results gave an RMS of the error residuals of 10 arcsec both in azimuth and elevation.

5.2.3. Sardinia Radio Telescope (SRT)

The activities connected to the design and construction of the SRT are continuing at the IRA CNR. The engineering design is almost on schedule, and of all the drawings, shop procedures, assembly and erection instructions, and updated cost estimates are expected by 15 March 2001.

A large effort has been devoted to the design of the mechanical structure which has to meet the specification of a sufficient surface accuracy at 22 GHz without necessity of using an active surface. Control of the adverse effect of wind on pointing is being also addressed. Concurrently, several generations of panel actuator prototypes have been designed and built, and the first series of about 250 actuators is under construction. These will be installed at the Noto antenna, which is also being upgraded with new surface panels. This project, whose completion is expected in 2001, is aimed at yielding not only a very substantial upgrade of the Noto antenna (the surface accuracy should become in the range of 200 microns rms) but also an invaluable test of the active surface concept to be applied to the SRT eventually. The foundation design is also under way, and construction is expected to start before Summer 2001.

5.3. Jodrell Bank Observatory, UK

The MK4-VLBA upgrade (VIV) has been completed over a period of about 4 months. A formatter was supplied by external contractors and tested by colleagues at MPIfR. The recorder read/write electronics were supplied by Metsähovi in a partly assembled form. L.Parry has constructed the head drivers from components and played a major role in the construction of the system, which provided fringes in the first EVN session in 2001. There have been two major initiatives directed at improving reliability.

1). A program to automate the switching of IF, LO and calibration signals between single-dish, MERLIN and VLBI observations. This has required the construction of active splitter units, LO and cal switches and computer-controllable filters.

(2) The antenna control and monitoring software for the VLBI Field System at Jodrell has been redesigned and reimplemented, over a period of about 8 months. This has produced a much more robust and better-integrated control system, with additional checks and monitors on antenna and receiver/LO hardware. Additional HPIB-based monitoring and control allows relatively complex receiver setups to be pre-programmed, reducing operator intervention.

A new cryogenically-cooled 5 cm receiver has been built and will be available for EVN observations in 2001. This receiver was successfully used for single-baseline MERLIN observations early in 2001.

5.4. Joint Institute for VLBI in Europe, The Netherlands

5.4.1. Correlator Section

During 2000 the capabilities of correlator were enhanced and expanded. The first step was the introduction of "dynamic correlator configurations" which allowed more flexible allocation of the correlator capacity and, in particular, enabled 16 station correlation. In conjunction some problems, which were identified in the data earlier, were resolved, several by the introduction of lag-by-lag normalization (so called local validity). The change in normalization also halved the number of lags the correlator can produce; an unfortunate result which should have been recognized at the time the chip was designed. Some unavoidable problems were solved by appropriate flagging of data in the off-line software. Correlator modes which use two correlator crates were also de-bugged. The extra correlator capacity is needed for spectral line experiments and continuum experiments which require cross polarisations to be correlated.

The correlator DSP software was replaced with a new real-time kernel allowing more flexible application development. Several hardware problems related to the DSP functionality were discovered and solved by making modifications to the correlator board. Some problems in the correlator board DSP function remained to be solved at the end of 2000.

Phase 1 of the project to integrate pulsar-gating functions into the operational environment of the JIVE correlator was completed in 2000. Test observations of pulsar PSR 0359 were correlated, first without gating to prove that the pulsar had sufficient brightness, and then with gating using low level, manual control functions added to the TSPU software. In phase 2 a high level user interface will be developed.

5.4.2. Station Units

Early in the year the last few repaired Station Unit boards were received from Allied Signal and a series of modifications to solve a clock distribution problem was completed on all units. Remaining problems were occasional byte slips and bad booting of TRMs.

Operationally, the byte-slip problem, which would necessitate re-correlation of affected sub-jobs, was localized sufficiently to avoid its effects with a fair degree of confidence. Efforts to trace the origin of the fault continued but were hampered by its extreme rarity and this remains an unsolved problem.

Thermal cycling was suspected as a cause for some of the hardware problems; a policy of continuous operation during the week was adopted and hardware reliability improved. Nevertheless, throughout the year, a number of Station Unit boards failed and were removed from service. This strategy is sustainable whilst

the full capacity of the data processor is not in use but the problem must be resolved in the near future.

Several Station Unit Control Computer (SUCC) software bugs were traced and corrected. The efficiency of this maintenance was improved when, at last, JIVE mastered the use of its own pSOS tools to build the SU code locally. The SUCC code was placed under CVS version control.

5.4.3. Play Back Units

Confidence and self-sufficiency with the playback drives continued to grow in 2000. All of the tape drives at JIVE were finely adjusted to accurately and safely guide thin tape in the first few months of the year. These adjustments were achieved without the use of complex or expensive instruments, using a procedure (EVNDOC #106) developed by JIVE. A better dry air system was also installed.

Many of the electrical and mechanical parts can now be sourced locally or manufactured in the ASTRON workshop and most hardware faults can be diagnosed and repaired in-house. Only large scale sub-units such as capstan motors need to be returned to the manufacturer for service.

The ability to re-build the DPU software was also attained during 2000. A number of operational problems and inefficiencies having their origin in the DPU software, previously worked around elsewhere, were addressed.

5.4.4. High Level Control Software

The system for controlling and administering the development and maintenance of the control software matured during 2000. Various development streams were merged creating a well-defined and consistent main stream in the CVS code repository. Throughout the year secondary JCCS systems were built to test repairs and to allow testing of various development and performance issues. These included over-sampling, pulsar gating, multi-field correlation, changes in the Station Unit software, and changes on the correlator boards. Approved enhancements were then merged with the current release into a working pre-release which was tested further on the correlator to guarantee a healthy version for production work. Thanks to the discipline accepted by the people contributing code, this scheme worked with an acceptable amount of overhead.

Development activity contributed to the ever-increasing flexibility of the control software. The development program aimed to make it easier (or even possible) to process observations with not-so-simple schedules: stations dropping in and out from scan to scan, some tapes starting a bit later than others, long tape stops between scans, short scans, multiple tapes per station and mixed thin/thick tape experiments. These changes will minimize, and eventually eliminate, the need for risky hand-editing of the VEX file describing the experiment's setup. Changes were also made to generally streamline operations. The pre-scan "peaking" procedure was optimised, the job definition and sub-job selection was tightened, a display of running weight plots during the correlation was added and the reporting of JCCS internal messages was improved.

Ongoing maintenance served to make the software more reliable and more robust. Numerous bugs were identified and cured and risky or obsolete constructions in the code were eliminated. Other work concentrated on problems which manifest themselves as annoying limitations and inefficiencies in the operational procedures. Some of these will be resolved by proper use of the experiment and polynomial databases and efforts continued to achieve this. Two types of relational databases (mSQL and MySQL) were tested and compared and an interface between correlator control software and MySQL was written.

5.4.5. Post correlation software

The JIVE FITS-converter utility was enhanced such that we can now also export JIVE data in IDI-FITS format (the format written by e.g. the VLBA correlator). Existing aips++ code needed to be changed in order to be able to deal with the new version of the MeasurementSet (aips++ internal storage format). More aips++ developments involved writing of a data-visualization tool in glish. Existing glish scripts were extended and updated for MS vs. 2. An important utility was developed that flags data where the delay-rate is ~0 and the baseline delay is an integral number of tape-frame

lengths, causing the MkIV frame headers to be correlated giving rise to anomalously high amplitudes.

Time was also spent in preparing DDD for running parts of the online-software. It necessitated installing support libraries and the online-system itself on this machine. The online-system now compiles on Sun. We still need to verify the system runtime; this will take more time and requires changes in the online system on CCC. A complete suite of offline-tools was installed on DDD; this machine can be used for data inspection and export.

A program to semi-automate correlated data tape labeling and distribution is being worked on.

5.4.6. Infrastructure

JIVE took responsibility for the procurement of thin tapes for the EVN pool and took delivery of 150. One DPU was specially reconfigured for re-reeling and the tapes were spooled to self-packing glass reels. Of these, 24 yielded an unsatisfactory pack and were returned to the manufacturer who agreed to investigate the problem. Following a warning that they would be withdrawn shortly JIVE pre-financed the purchase of 500 self-packing reels, enough to complete the target pool of 1000 tapes. 600 used blue cassettes were purchased for the transport of the new thin tapes. Foam inserts for these cassettes and new aluminum latches were also received from local suppliers. Tapes, glass reels and cassettes were purchased from funds contributed by the EVN institutes.

Measures were taken to ensure the safety of personnel and equipment in the event of a calamity. A system that dials a sequence of preprogrammed telephone numbers in case of an alarm was installed. The automatic fire extinguisher system was connected to the main ASTRON fire detector system and also, via a parallel path, to the JIVE alarm system. A system to protect the Station Units and the DPUs against overheating was added and a UPS system for the CCC and DDD workstations was installed giving a runtime of ~ 15 minutes after a power failure. Software to generate a "controlled power down signal" is still to be incorporated.

5.4.7. Post Correlator Integrator

In 2000 the Post Correlator Integrator (PCInt) design was refined and, for the purposes of replication, completed. The use of separate record an processing boards was abandoned; the final solution uses one VME DSP board per correlator segment, fitted with two plug-in modules for interfacing to the correlator board and a storage device. With this architecture it became possible to plug the PCInt directly into spare slots in the Correlator VME backplane removing the need for a secondary rack.

The PCInt software was merged into a single set of components running under dspOS, a real-time kernel and multi-tasking environment developed in-house. The correlator board also uses dspOS which helps to make use of the PCInt virtually transparent.

5.5. Max-Planck-Institute for Radio Astronomy, Germany

MPIfR staff plays active roles in EVN technical developments. D.Graham, W.Alef, A.Kraus and M. Wunderlich are active members of the EVN TOG and attend their meetings.

D.Graham and A.Freihold from MPIfR, together with Dan Smythe of Haystack Observatory, spent at least 4 man-months in 2000 completing hardware and software revisions of the MK IV formatter. This is a project inherited from EMU/VIV. The revised formatter gives improved reliability and implements new features which improve the data integrity of two-bit, fan-out and oversampling experiments. This should improve performance, particularly for spectral-line observations. The new features have been verified using tapes recorded simultaneously on the two Effelsberg terminals and correlated in Bonn, and also during geodetic observations. Two modified formatters are now in regular service. MPIfR has acquired and prepared upgrade kits and distributed these to EVN stations.

Automatic selection of IF channels on input to MK IV video converters, replacing the present hand-patching scheme, was seen by EVN TOG as a feature which would improve reliability and flexibility and allow easier use of geodetic antennas for astronomy. Under the leadership

of D. Graham, MPIfR staff are currently working on a prototype unit to provide this.

M.Wunderlich played a leading role in upgrading the Urumqi and Shanghai record terminals to the new MK IV standard. He spent 2 to 3 man-months on this project. This included preparation of parts in Bonn - most of the parts for Urumqi were donated by MPIfR - and tools to be shipped to those stations. For the upgrade itself he and others traveled to both stations for a few weeks in the spring. After this trip the complex electronics of the write head from Shanghai, which had been produced elsewhere, was partially re-built at MPIfR. It was successfully installed, with remote support from M. Wunderlich. New VME monitor modules for the record terminals in Yebes and Cambridge were built and tested in MPIfR labs.

5.6. Metsähovi Radio Observatory, Finland

The RCP channel of the 43 GHz receiver is still out of order because of the damaged gate bonding of one of the HEMTs. The LCP channel of the 43 GHz receiver functions as do the 22 GHz and 86 GHz receivers.

Metsähovi has continued to provide Mark IV Read/Write electronics modules and upgrade kits. The kits of EVN VIV upgrade were provided.

The new Mark IV formatter and associated VIV upgrade items were installed in October and used successfully in November sessions. The electronics and mechanical mounts for the second head will be installed after a second fully functional headstack is available.

Jouko Ritakari and Ari Mujunen have written several papers on the impact of the fast Ethernet connections to the VLBI. These documents can be found from the address

http://kurp-www.hut.fi/vlbi/instr/

There have been negotiations with Finnish Geodetic Institute for starting geodetic VLBI observations possibly in 2002. The equipment requirements include a new receiver and a new secondary mirror, full number of BBCs (in addition to currently functional 8) and a renewed phase calibration system which needs to include the cable delay calibrator. New VLBA baseband converters have been ordered from Signatron.

5.7. National Astronomical Observatory, Spain

5.7.1. The 40-m radio telescope

The construction of the new 40-meter radio telescope in Yebes continues. The concrete pedestal has been erected, and the contracts to build the telescope back-structure, bearings, gearboxes, etc, have been signed. The status of the works is shown in Fig. 22; Fig. 23 displays a sketch of the contracted parts. The telescope is expected to be finished in 2003. More information can be found at the URL http://www.oan.es/cay/40m/.

Figure 22. *The pedestal of the new 40-m radio telescope in Yebes, November 2000.*

5.7.2. EU RTD Project

OAN is participating in the EU project "New experimental Techniques" by developing the "Cluster-Cluster" VLBI technique for use with the multi-antenna sites (such as Westerbork) and the EVN correlator at JIVE. This project is led by M.Rioja, who works together with J.-F.Desmurs, F.Colomer and others. Successful correlation of an earlier project (GR019) at MPIfR suggests that these investigations will provide good results. A new proposal to exploit the MkIV modes and correlator has been submitted.

5.7.3. Other VLBI technical activity at OAN

The MkIV formatter has worked well until October 2000, when a failed chip made the data

unusable during the last EVN session of 2000 at S/X bands. It was replaced at the end of the year.

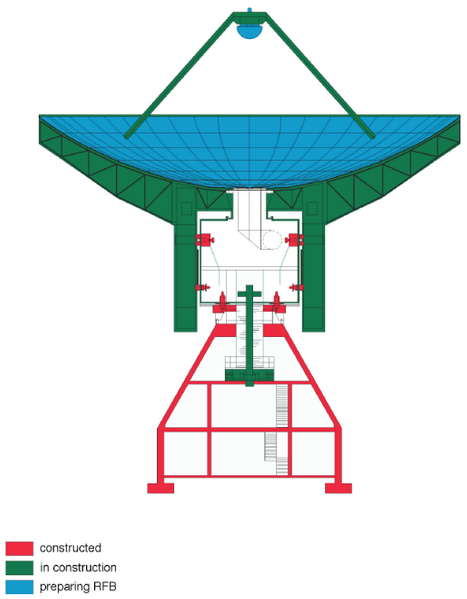

Figure 23. *Schematic view of the new 40-m radio telescope in Yebes.*

De-Vicente and Albo have started the installation of the second headstack and electronics in the VLBA recorder, which will be ready early in 2001.

The software which manages the station equipment and links with the FS has been modified. Meteorological data and data from the maser GPS comparison are now monitored with an independent machine which is queried by the VLBI FS computer through the LAN using sockets. This new design is more modular and allows remote control and monitoring of these parameters independently of the FS computer. The logs from these data are also available through the web and the data from the GPS-maser comparison is transferred to the EVN daily by an automatic procedure.

Problems with the air conditioning and its influence on the instrumental phase of the signal have been investigated, quantified and successfully corrected. A better quality of the data has been achieved. Sporadic problems with the GPS have also been solved by the exchange of the cable and the connectors that link the antenna and the receiver.

5.8. Onsala Space Observatory, Sweden

During 2000 a new septum polariser was built which covers the whole of L-band 1200 – 1750 MHz. This was used for the first time in EVN session 4 of 2000. This new polariser replaces the two polarisers previously used for 21 cm and 18 cm respectively – increasing operational flexibility and making interchange between these two bands much easier. The new polariser also has much lower cross-polarisation with measured cross-polarisation power rejection of between 30 dB and 40 dB. The overall measured cross polarisation D-terms in VLBI experiments should now be less than 5%. Finally the new noise source and cross-coupler to the polariser gives much more stable noise across than band which should improve amplitude cal performance. Finally at L-band two new HEMT receivers were also installed on the 25 m telescope. These new receivers have 5 – 10 K noise temperature.

During the year VLBI operations at OSO switched over to using a Russian built CH1-75 hydrogen maser as the default for VLBI experiments. The short term phase stability as shown by 3 mm wavelength VLBI experiments is as good as that of the EFOS maser, but the long term drift is smaller. The EFOS maser was refurbished during the summer. In 2000 the observations have been conducted with a mixture of thin and thick tape recordings using vacuum switching. Problems with interference in the tape read electronics were identified and corrected.

5.9. Shanghai Astronomical Observatory, P.R. China

Receivers
Five bands of VLBI observations are available at Sheshan Station. The bandwidths of L, S, C, X, and K bands are 1620-1680, 2150-2450, 4700-5100, 8200-9000, and 22100-22600 MHz respectively. The X-band system has been upgraded to a wider band, from 8200 to 9000 MHz.

Dual polarized receivers of L and K bands are available. The Sheshan station participated in the first dual polarized VLBI experiment at L

band on 14 February 2000. The data have been correlated in Socorro and shown RCP and LCP correlated signals as expected.

Plan to build new receivers for C band for dual polarization are being worked out in cooperation with ASTRON and JIVE.

Recording System
The MkIV upgrade of the Sheshan station was carried out with the great help of EVN/JIVE and Team China # 2 in April 2000. Team China # 2 was composed of six experts from Europe and US: R.Spencer, L.Parry (JBO), M.Wunderlich (MPIfR), G.Tucarri (IRA CNR – Noto), Chopo Ma and W.E.Himwich (NASA/GSFC). The upgrade of Sheshan MkIV recording system was completed in the end of August 2000. The VLBA4 terminal has been used successfully for the EVN sessions 3 and 4 of 2000.

VLBA4 (MKIV+VLBA) and S2 recording systems are now available at the Sheshan VLBI station.

Antenna
A plan of electric control system for changing feeds is being worked out.

Shanghai correlator
A two station VLBA FX model correlator was built in Shanghai. First fringe were achieved in January 2000. After some modifications high quality fringes have been detected in August 2000. The correlator is available for MkIII and VLBA thick tapes only. Its upgrade to thin MkIV/VLBA tapes is planned for2001-2002.

5.10. Toruń Centre for Astronomy, Poland

VLBI Terminal
The VLBA compatible terminal, delivered to Toruń in January 1996, has been enriched by adding an MkIV formatter. It works now alternatively in the MkIV or VLBA modes. Tests performed by JIVE staff in October and November 2000 allowed to correct the hardware and enabled the new formatter to work according to the specification. Repair of tape unit electronics, as well as resetting of the tape mechanism and headstack motors, resulted in dramatic improvements of data quality.
Receivers
Here some progress has been made during 2000. At the moment the Torun Observatory 32 m telescope is equipped with:

1). L-band system, covering the range of 1400-1800 MHz, with two orthogonal circular polarization channels with system noise level 25K on both channels. A high quality L-band ultra low noise preamplifiers, made by ASTRON (the Netherlands), are used in the system. The overall telescope sensitivity in this band makes Toruń one of the most sensitive EVN telescopes. This receiver started operation on the telescope in January 1997. In 2000, a new phase cal and calibration units were added.
2). C-band, a cryogenically cooled system, covers 4.4–5.1 GHz range with two polarizations channels (LHC and RHC) both with 30 K system noise. The telescope has the best sensitivity and the best performance at this band.
3). 6.7 GHz dual channel cooled system for methanol line VLBI observations. In 2000 further improvements to the receiver were made. Its system temperature is now ~40 K. This receiver has a broad band OMT (5-7 GHz), HEMT LNA, and allows the use of a single channel as a reference for 5 GHz beam switching radiometer. This receiver was very important for initiating the methanol line VLBI studies. Torun's contribution at 6.7 GHz is vital to the network.
4). UHF band two channel uncooled receiver, covering 750–940 and 960–1100 MHz range, was completed in 1999. The overall sensitivity is low due to limited efficiency of the aperture illumination (~12%). The system uses the L-band horn at the secondary focus. A work to optimise the dish efficiency concentrated in 2000 on the design of an OMT and horn antenna located at the secondary focus. The receiver cuts off the strong RFI at ~950 MHz and the TV transmitters below 780 MHz. The upper frequency limit is fixed by the filter used at both subbands.

Computer controlled IF distribution (500–1000 MHz) has been installed in 1999 and is after several modifications used as the standard unit for all observations. It allows quick remote selection of 4 input channels (2 frequencies with 2 polarizations) out of 16 inputs. Each channel has a gain and a band slope control.

On the small 15 m antenna, uncooled receivers covering 327 and 1350–1530 MHz bands have been installed. It can now be used for single dish observations as well as for low frequency VLBI experiments. The 15 m antenna control system

is integrated with the 32 m control and FS software.

H-maser
The EFOS-15 hydrogen maser clock works since 1994 and its performance is continuously monitored. The station time service has been significantly improved during last year. The measured frequency drift, plus everyday monitoring of a maser clock against GPS UT1, are supplied to the EVN database. A new second GPS receiver and HP counter were bought to improve time service.

Other activities
The autocorrelation spectrometer (16k channels, 50 MHz BW) based on the NRAO chips is operational since 1999. The BBC converters from VLBA terminal serve as SSB mixers and filters. However, this reduces the maximum bandwidth to 4 x 16 MHz and adds instrumental spikes. The spectrometer is intensively used for narrow band spectroscopy (OH, CH3OH).

5.11. Urumqi Astronomical Observatory, P.R. China

With the help from W.E.Himwich (NASA/GSFC) and Xue Zhuhe (ShAO), Liu Xiang and Yang Wenjun have installed a new Y2K-compliant Field System (version 9.4). It was adapted for the specific hardware configuration at Nanshan. In early 2000, with the help from W.E.Himwich, Wang Na, Chen Maozheng and Liu Xiang worked on the communication between the FS computer and the antenna control compute.

In April, TeamChina #2 came and worked on upgrading Nanshan to thin tape and MKIV (see section 5.9). Work was done on recorder, installing formatter, modifying field system and inspecting baseband-convertors. The local staff members, Zhang Hongbo and Yang Wenjun were involved in the work. W.E.Himwich also worked on the communication between the FS computer and the antenna PC. Now the antenna can be controlled by FS and also can do pointing and on-off measurements via FS.

The MkIV upgrade of Nanshan was successful with fringes being found in EVN: MkIV experiments C00C3, C00L4 and NASA: CB802. However, some problems occurred after the experiment in the recorder, investigation of the problem was ongoing at the end of the year.

A new horn-like feed for three bands 30, 49 and 92 cm is under construction in collaboration with Russian experts.

5.12. Bundesamt für Kartographie und Geodäsie, Wettzell, Germany

Some technical improvements have been made in order to increase the reliability and automation. The current implemented field system version is FS-9.4.18. A Software routine has been set up which automatically controls the transfer of log-files and schedule-files to and from the respective databases to make sure that the last versions of those files were applied respectively. As an extension to the regular field system a software routine has been implemented, which allows tracking of satellites. So far an old HP 5316A counter was used for measuring the cable delays and the 'fmout - gps' values. The old system has been replaced by an HP 53132A counter. The required GPIB driver has been written for the integration into the field system.

Several years ago the automatic antenna control unit was replaced by a new system. Due to unexplained effects, occasionally unexpected interference occurs resulting in undefined status for the ACU. This leads to failures of the 20-m antenna. In 2000 some efforts and investigations have been made to overcome the problem. So far it could be minimized but not sufficiently solved. Actions were the employment of an uninterruptible power supply, the replacement of the RS232 connection by a fiber optic and the improvements in grounding. Further investigations are ongoing.

The MkIII decoder has been replaced by an MkIV unit.

The thermal insulation of the antenna concrete support construction (basement up to the moving part) which minimizes the influence of the direct sunshine on the construction has been completely replaced. Over the years water had penetrated the shielding and decreased the insulation capacity.

A K4 VLBI recording system – on loan from the Communications Research Laboratory (CRL, Japan) – had to be removed and returned at the end of 2000. The system had been used for joint observations with Tsukuba and Kashima.

6. Publications - 2000

This list includes:

- publications based on results obtained with the EVN facilities;
- VLBI publications by authors affiliated with EVN institutes;
- other publications by JIVE staff.

6.1 Refereed publications

1. A. Alberdi, J.L. Gomez, J.M. Marcaide, A.P. Marscher, M.A. Perez-Torres, "4C39.25: witnessing the interaction between a moving and a stationary component", A&A 361, p. 529

2. N. Bartel, M.F. Bietenholtz, M.P. Rupen, A.J. Beasley, D.A. Graham, V.I. Altunin, T. Venturi, G. Umana, W.H. Cannon, J.E. Conway, "The Changing Morphology and Increasing Deceleration of Supernova SN1993J in M81", Science 287, p. 112

3. D. Behrend, L. Cucurull, J. Vila, R. Haas, “An Inter-comparison Study to Estimate Zenith Wet Delays Using VLBI, GPS and NWP Models”, Earth, Planets and Space 52, p. 691

4. G.C. Bower, D.C. Backer, “VSOP Brightness Temperature in NRAO 530 Exceeds the Inverse Compton Limit”, ASR 26, p. 731

5. S. Britzen, A. Witzel, T.P. Kirchbaum, R.M. Campbell, S.J. Wagner, S.J. Qian, "Three-year VLBI monitoring of PKS 0420-014", A&A 360, p. 65

6. J. Campbell, A. Nothnagel, “European VLBI for crustal dynamics”, Journal of Geodynamics 30, p. 321

7. X.W. Cao, "Clues to the origin of parsec to kilo-parsec jet misalignments in EGRET sources", A&A 355, p. 44

8. F. Colomer, M.J. Reid, K.M. Menten, V. Bujarrabal, "Spatial and velocity structure of circumstellar water masers", A&A 355, p. 979

9. J.F. Desmurs, V. Bujarrabal, F. Colomer, J. Alcolea, "Observational support for radiative pumping of SiO masers in evolved stars", A&A 360, p. 189

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11. C. Fanti, F. Pozzi, R. Fanti, S.A. Baum, C.P. O’Dea, M. Bremer, D. Dallacasa, H. Falcke, T. de Graauw, A. Marecki, G. Miley, H. Rottgering, R.T. Schilizzi, I. Snellen, R.E. Spencer, C. Stanghellini, “ISO observations of a sample of Compact Steep Spectrum and GHz Peaked Spectrum radio galaxies”, A&A 358, p. 499

12. A.L. Fey, P. Charlot, "VLBA observations of radio reference frame sources. III. Astrometric suitability of an additional 225 sources", ApJS 128, p. 17

13. S. Frey, L.I. Gurvits, D.R. Altschuler, M.M. Davis, P. Perillat, C.J. Salter, M.F. Aller, H.D. Aller, H. Hirabayashi, “Dual-frequency VSOP observations of AO 0235+164”, PASJ 52, p. 975

14. A. Flores, A. Escudero, M.J. Sedo, A. Rius, “A near real time system for trotospheric monitoring using IGS hourly data”, Earth, Planets and Space 52, p. 681

15. E.B. Fomalont, S. Frey, Z. Paragi, L.I. Gurvits, W.K. Scott, A.R. Taylor, P.G. Edwards, H. Hirabayashi, “The VSOP 5 GHz Continuum Survey: The Prelaunch VLBA Observations”, ApJS 131, p. 95

16. E. Fomalont, M. Inoue, H. Hirabayashi, S. Horiuchi, J. Lovell, G. Moellenbrock and the International Survey Team, “Preliminary Results from the VSOP Survey Program”, ASR 26, p. 653

17. S. Frey, L.I. Gurvits, Z. Paragi, W.K. Scott, “Milliarcsecond scale compactness of extragalactic radio sources at cosmological distances”, ASR 26, p. 723

18. K. Fujisawa, M. Inoue, H. Kobayashi, Y. Murata, K. Wajima, S. Kameno, S. Iguchi, S. Horiuchi, S. Sawa-Satoh, N. Kawaguchi, P.G. Edwards, H. Hirabayashi, M. Morimoto, ”Large Angle Bending of the Light-Month Jet in Centaurus A”, PASJ 52, p. 1021

19. D. Gabuzda, P. Kochenov, T. Cawthorne, R. Kollgaaard, "Intraday Polarization Variability Outside the VLBI core of the Active Galactic Nucleus 0716+714", MNRAS 313, p. 627

20. D. Gabuzda, P. Kochenov, R. Kollgaard, T. Cawthorne, "VLBI and VLA Observations of Intraday Polarization Variability in 0917+624 and 0954+658", MNRAS 315, p. 229

21. D. Gabuzda, T. Cawthorne, "VLBI Polarization Images of Eight Compact AGN at 1.3 cm", MNRAS, 319, p. 1056

22. D. Gabuzda, A. Pushkarev, T. Cawthorne, "Analysis of 6 cm VLBI Polarization Observations of a Complete Sample of Northern BL Lacertae Objects", MNRAS 319, p. 1109

23. D. Gabuzda, P. Kochenov, T. Cawthorne, "Seredipitious VLBI Observations of Polarization Intraday Variability in Three BL Lacertae Objects", MNRAS 319, p. 1125

24. M.A. Garrett, A.G. de Bruyn, M. Giroletti, W.A. Baan, R.T. Schilizzi, “WSRT Observations of the Hubble Deep Field region”, A&A 361, L41

25. G. Giovannini, W.D. Cotton, L. Feretti, L. Lara, T. Venturi, "Space VLBI Observations of MKN501", ASR 26, p. 693

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6.3 Other Publications

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2. A. Orfei, F. Mantovani, "Medicina station report", Proceedings of The 14th Working Meeting on European VLBI for Geodesy and Astrometry, Bologna Sept. 8-9 2000

3. "Measurements of gain fluctuations in GaAs and InP cryogenic HEMT amplifiers". J.D. Gallego, I. Lopez-Fernandez. Technical report IT-CAY 2000-1. Centro Astronomico de Yebes (IGN/MFOM), Spain

4. "Definition of measurements of performance of X band cryogenic amplifiers (WP 1000, ESA Contract 14297/00/D/SW)", J.D. Gallego, I. Lopez-Fernandez. Technical report IT-CAY 2000-4. Centro Astronomico de Yebes (IGN/MFOM), Spain

6.4 Ph.D. Theses

1. S. Frey,"VLBI Studies of Extremely Distant Quasars", PhD Dissertation, Loránd Eötvös University, Budapest

2. V. Minier, “Methanol Masers: Tracers of Star Formation", Technical Report No. 395, PhD Thesis at the School of Electrical and Computer Engineering, Chalmers University of Technology, Gothenburg

3. Z. Paragi, “The radio structure of SS433 on milliarcsecond scales”, PhD Dissertation, Loránd Eötvös University, Budapest

B. ANNUAL REPORT OF THE JOINT INSTITUTE FOR VLBI IN EUROPE

Foreword by the Chairperson of the Board

With now over 50% of the data processor time spent on scientific projects JIVE has been able to significantly increase the number of visitors working on EVN data that were correlated at JIVE. Two important milestones were completed in 2000: the data distributor is included in normal data processor operation; and 16-station operation is now feasible. Progress toward higher scientific production of the JIVE correlator together with good local infrastructure and support for visitors resulted in more scientific results. The EVN capabilities have thus been clearly enhanced to allow JIVE to be at the forefront of VLBI science (e.g. HI circumnuclear absorption in NGC 4261). However, future developments of the correlator should also aim at improving processing capabilities for emission line projects as well as for short time integration projects (e.g. flaring events and multiple field imaging).

In September 2000 the ESF Review Panel concluded that the "science case of the EVN and JIVE is rich in substance and impact" and published important recommendations on long-term financing and organizational issues concerning the JIVE Institute. These recommendations have been reviewed by the JIVE Board and are not yet implemented. However, discussions with NWO (The Netherlands) and several national research councils have started by the end of the year on long-term funding questions and there is hope to reach solid conclusions.

JIVE scientists have continued to provide support to European visitors and, at the same time, have produced a broad variety of astrophysical results some of them being conceived as pilot projects for the JIVE data processor. I also want to point out that JIVE successfully manages European funds on behalf of the EVN for a number of EU-funded activities covering technical and research VLBI developments, and allowing better access to the EVN.

JIVE scientific and technical staff and Director are to be warmly congratulated for their permanent and successful effort to make the JIVE correlator a flexible machine accessible to all astronomers.

Alain Baudry, Observatoire de Bordeaux, France

1. Report from the JIVE Board

The 13th meeting of the Board of the Foundation was held in Helsinki, Finland in May and the 14th meeting in Madrid, Spain in December. As usual the Board reviewed the institute budget and staff appointments, as well as progress towards full operation of the data processor, and activity in the various contracts with the European Commission in Brussels that are administered by JIVE on behalf of the EVN. The Helsinki meeting reviewed progress in the review of the EVN and JIVE by the European Science Foundation Panel. In its meeting in Madrid the Board took note of the recommendations of the ESF Review Panel which had been published in September (see section 2, Part B), and considered at length actions being taken and to be taken to implement the recommendations of the Review Panel concerning the long term financing of JIVE operations.

Membership of the Board is listed in Appendix B1. The financial report for the year is given in Appendix B2.

2. JIVE Institute

The scientific highlight of the year from the point of view of the institute was the publication of the first paper reporting on data correlated at the EVN data processor at JIVE (van Langevelde et al. A&A 354, L45). It involved HI absorption in NGC 4261 observed by an international group headed by Huib Jan van Langevelde (JIVE) and Ylva Pihlström (Onsala Space Observatory).

The target for 2000 for the Data Processor Group was to establish the data processor as the correlator of choice for the bulk of the EVN throughput. This was achieved for continuum and absorption experiments with the EVN. Over most of the year, just over 50% of the time was spent on scientific production, with the remainder dominated by testing, clock searches and network support. The processor operations staff were able to maintain a production rate of 1-2 projects per week, with a total of 49 projects processed during the year. Details are given in section 3.2.1 in Part A.

In February, the data processor completed another milestone in its development when the data distributor was brought on-line. At the same time dynamic correlator configurations were introduced allowing 16-station operation for the first time. Many other improvements to the operational capability were also introduced and others were in progress at year's end.

We were happy to welcome another stream of visitors to the Institute during the year, an increasing number of whom came to work on EVN data correlated at JIVE.

The ESF Review Group visited JIVE in February as part of their review of the EVN and JIVE. The Review Group submitted its findings to the ESF in June, and publication of its 67-page report took place in September. The main recommendations concerning JIVE centred on its long term financing and on the policy and legal foundations of the EVN and JIVE. The Review Group stressed that the aim should be to create a "self-organised entity under a European roof", and recommended that the ESF take the initiative together with its Member Organisations and related Institutes to deal with the financial and organisational issues raised. At the end of the year, these questions were under review in NWO, host Research Council for JIVE.

Staff changes

Jean-Francois Desmurs and Maria Massi completed their appointments as Support Scientists at the OAN in Madrid and the MPIfR in Bonn respectively. Paul Kamphuis completed his appointment as a development engineer employed under the EC RTD contract to develop the prototype Post-Correlation Integrator. Heleen de Haas resigned her position as secretary.

Two new Support Scientists took up their appointments at JIVE in Dwingeloo, Cormac Reynolds in the EVN Support Group and Ian M. Avruch in the Data Processor Group.

Publications

The 1999 annual reports for the EVN and JIVE (chief editor: Leonid Gurvits) were issued as usual in a single volume. The four JIVE quarterly reports were posted on the JIVE Webpage. The JIVE Newsletter has been discontinued in view

of the intention to restart the publication of the EVN Newsletter. Fifty-one publications with JIVE staff as principal or co-author are listed in Part A, section 8.

Local infrastructure
Lorant Sjouwerman maintained the standard JIVE visitor UNIX-based environment, the AIPS test version, and the AIPS "midnight job". Denise Gabuzda ran the visitor program. Nico Schonewille maintained the JIVE webpages.

Education and training
JIVE staff were involved in supervising two PhD projects in the Netherlands, two in Hungary, two in China, and one in Russia, as well as one Masters level project in the Netherlands and two in Russia.

3. Support for individual investigators

Astronomers requiring assistance in obtaining EVN data are assigned a Support Scientist from the EVN Support Group. They can receive advice on project planning, and scheduling of observations, as well as the calibration and analysis of the correlated data. The calibration data from the individual telescopes for each of the projects are assembled into project files for the astronomers by the EVN Support Group. The correlation of the observations is done *in absentia* for the astronomer by the Data Processor Group and subsequent scrutiny of the quality of the data is carried out by Support Scientists in that Group. These activities are described in sections 3.3, 4.4 and 5.4 in Part A of these reports.

4. EU supported activities

Access to the EVN
The EVN (via JIVE) had two contracts running concurrently for the first part of 2000 promoting access to the facility. Contract No. ERBFMGECT950012 (EUR 1.875M) from the Training and Mobility of Researchers (TMR) activity in the Fourth Framework Programme came to an end in March, while a new contract HPRI-CT-1999-00045 for EUR 1.5 M funded from the Improving Human Potential (IHP) activity in the Fifth Framework Programme began in February, and will run for three years.

During 2000, one user group made use of the European VLBI Network on the basis of the TMR contract and 13 user groups were supported by the IHP contract. Access to the EVN is open to all professional astronomers around the world; observing proposals are judged on their scientific merit by the EVN Programme Committee. These contracts specifically support EVN users who are not directly affiliated with the institutes that make up the EVN Consortium. The investigators utilised all the facilities of the EVN including absentee correlation of the data at JIVE and assistance by JIVE Support Scientists in scheduling observations, correlation, calibration of the data, and image and post-processing analysis. During 2000, a total of 4 hours of access to the EVN were made available to the one TMR user group, and 244 hours to IHP users. Over the course of the whole TMR contract (1996-2000), a total of 755 hours of observing time was provided to 39 user groups and 62 astronomers.

The programmes of research include varied and wide-ranging investigations of many different classes of astrophysical phenomena, from observations of active galaxies and quasars located on the edge of the universe, to exploding stars in other galaxies, to high resolution studies of masers in star-forming regions in our own galaxy. Visits of TMR and IHP-supported users to the EVN/JIVE facility in 2000 included:
IHP: Z.Paragi, I.Fejes, A.Stirling, P.Augusto, M.Ribo, A.Tarchi, J.Dennett-Thorpe, P.Charlot, I.Snellen, W.Tschager, G.Giovannini, J.Marcaide, J.Guirado, A.Alberdi, L.Moscadelli, R. Cesaroni, S. Beck, N. Gizani.
TMR: V. Tornatore.

Research and Technical Development in the EVN
The third year of the TMR-RTD contract (FMGE-CT98-0101, EUR 1M) saw substantial progress on a number of fronts. The prototype Post-Correlation Integrator developed to enable fast readout of the correlator for wide-field imaging, high spectral resolution, and pulsar gating was completed apart from some interface software. Monitoring of the radio frequency interference (RFI) at a number of EVN observatories continued and the results were used in the design of a prototype RFI-robust receiver. This will be built and tested in the final 10 months of the contract in 2001. Further work on RFI mitigation algorithms continued as did

development of multiple field centre and cluster-cluster techniques. The first tests of pulsar gating on the data processor were successful.

Infrastructure Cooperation Network in Radio Astronomy (RadioNET)
Infrastructure Cooperation Networks are funded by the IHP activity in the Fifth Framework Programme. They are designed to coordinate activities in similar infrastructures in Europe in streamlining and enhancing the collective European performance, as well as to provide forums in which to plan new facilities satisfying the future needs of the scientific community. The radio astronomy community in Europe secured a 4-year grant (contract no. HPRI-CT-1999-40003, EUR 800k) to coordinate the achievement of sustained reliable operation of the EVN, to support EVN Symposia, Schools and workshops on subjects of central importance to the design and performance of the Atacama Large Millimetre Array (ALMA), and to support studies of the design concept and the framework for collaboration on the Square Kilometre Array (SKA). In 2000, progress was made in all of the main themes, with a workshop on good practice in the use and maintenance of the complex data acquisition systems in the EVN, support for the fifth EVN Symposium at Gothenburg in Sweden, support for a workshop on the scientific imperatives for ALMA, and the formation of the European SKA Consortium. The contract runs from March 2000 to February 2004.

5. Other international activities

JIVE was the recipient of a three-year EUR 43k grant from the Netherlands Organisation for Scientific Research (NWO) to stimulate Dutch-Hungarian cooperation and collaboration in radio astronomy and VLBI in particular. The grant is being used primarily to finance visits to Hungary and the Netherlands.

Together with ASTRON, a three-year grant was obtained from the Royal Dutch Academy of Sciences (KNAW) to continue a programme of collaboration in radio astronomy with China. Like the NWO grant, this is being used to finance mutual visits to allow VLBI and other radio astronomical projects to be carried out. Advice is also being given on a Chinese project to develop a 500 m diameter radio telescope in southwest China.

Appendices

Appendix B1

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

Appendix B2

JIVE Financial Report for 2000

Funds received	Kfl	KEuro
JIVE and EVN Activities		
• Multi-national contributions	1334	605
• European Commission (FP4 and FP5*)		
- Access to Large Scale Facilities	1749	794
- Research and Technical Development	608	276
- Infrastructure Cooperation Network	705	320
Thin Tape purchases	562	255
KNAW grant for Dutch-Chinese collaboration	6	3
Accumulated funds	2902	1317
Total	**7866**	**3570**

* JIVE receives and manages these funds on behalf of the EVN as a whole

Expenditures	Kfl	KEuro
JIVE and EVN Activities:		
• Salaries and other personnel expenses	2170	985
• Travel expenses, “Access to EVN”	131	59
• RTD expenditures + allocations to contracts	699	317
• ICN expenditures + allocations to contracts	705	320
• Other expenditures	476	216
Data Processor hardware	25	11
EVN Support: MkIV upgrade	38	17
Thin tape purchases	704	319
Dutch-Chinese collaboration	6	3
Credit balance	2912	1321
Total	**7866**	**3570**

Appendix B3

JIVE Personnel

Prof. R.T. Schilizzi*	Director
Dr. I.M. Avruch	Data Analysis Scientist
Mr. J. Buiter	Tape Recorder Engineer
Dr. R.M. Campbell	Data Analysis Scientist
Ir. J.L. Casse	Senior Development Engineer (retired 15.10.1999)
Dr. J-F. Desmurs	Support Scientist at OAN-Yebes, Alcala de Henares, Spain
Dr. D.C. Gabuzda	Support Scientist
Dr. M.A. Garrett*	Head of EVN Support Group
Dr. L.I. Gurvits	Programme Manager, Senior Scientist
Mrs. H.E.A.M. de Haas	Secretary (until August 2000)
Mr. P. Kamphuis	Development Engineer (until 30 November 2000)
Mr. B. Kramer	Operator
Dr. H.J. van Langevelde*	Head of Data Processor Science Operations
Mr. M. Leeuwinga	Operator
Dr. M. Massi	Support Scientist at MPIfR, Bonn, Germany (until 1 Feb 2000)
Mrs. S.K. Mellema	Secretary
Dr. F. Olnon	Online Software Engineer
Eur. Ing. S.M. Parsley*	Head of Data Processor Technical Operations
Dr. C.J. Phillips	Data Analysis Scientist
Dr. S.V. Pogrebenko	Senior Development Engineer
Mr. C. Reynolds	Support Scientist
Mr. N. Schonewille	Chief Operator
Dr. L.O. Sjouwerman	Support Scientist
Dr. A. Szomoru	Online Software Engineer
Mr. H. Tenkink	Operator
Drs. H. Verkouter	Offline Software Engineer

* member of JIVE Management Team

Appendix B4

Visitors to JIVE

H. Aller	University of Michigan, USA
M. Aller	University of Michigan, USA
P. Augusto	University of Madeira, Portugal
G. Balodis	Ventspils International Radio Astronomy Centre, Latvia
J. Dennett-Thorpe	University of Groningen, NL
I. Fejes	FÖMI, Satellite Geodetic Observatory, Hungary
E. Fomalont	NRAO, Charlottesville, USA
C. de la Force	Jodrell Bank Observatory, UK
S. Frey	FÖMI, Satellite Geodetic Observatory, Hungary
N. Garnich	Moscow State University, Russia
S. Garrington	Jodrell Bank Observatory, UK
M. Giroletti	University of Bologna, Italy
N. Gizani	University of Madeira, Portugal
A. Gun	Jodrell Bank Observatory, UK
P. Hazell	Avonsoll Ltd. Bristol, UK
X. Hong	Shanghai Astronomical Observatory, PR China
A. Kozlenkov	Logics Unlimited Scandinavia AB, Sweden
A. Kus	Torun Centre for Astronomy, Poland
B. Maguire	Jodrell Bank Observatory, UK
A. McDonald	Jodrell Bank Observatory, UK
E. Middelberg	Bonn University, Germany
R. Noble	Jodrell Bank Observatory, UK
I. Owsianik	MPIfR, Bonn, Germany
Z. Paragi	FÖMI, Satellite Geodetic Observatory, Hungary
A. Pushkarev	Astro Space Centre, Moscow, Russia
M. Ribo	University of Barcelona, Spain
E. Ros	MPIfR, Bonn, Germany
A. Roy	MPIfR, Bonn, Germany
W. Scott	University of Calgary, Canada
I. Snellen	Institute of Astronomy, Cambridge, UK
R. Spencer	Jodrell Bank Observatory, UK
A. Stirling	University of Central Lancashire, UK
A. Tarchi	University of Bonn, Germany
W. Tschager	University of Leiden, NL
V. Tornatore	Politecnico Milano, Italy
W. Vlemmings	University of Leiden, NL
C. Walker	NRAO, Socorro, USA
J. Yi	Onsala Space Observatory, Sweden
H. Zhang	Beijing Normal University, China

Appendix B5

Presentations 2000

R.M. Campbell

- “Pulsar Astrometry and the Miracle of VLBI”, US Naval Academy, Annapolis, MD, 1 Jun
- “VLBI Pulsar Astrometry”, IAU S205, Manchester, UK, 18 Aug
- "Pulsar Position, Proper Motion, and Parallax", VLBI Science meeting, Bonn, Germany, 7 Nov

D.C. Gabuzda

- “New results from multi-frequency polarization VLBI observations”, VLBI Science meeting, Bonn, Germany, 7 Nov
- “Evidence for Helical Magnetic Fields in the Jets of BL Lac Objects”, JENAM-2000, Moscow, Russia, June
- “Polarization Measurements in VLBI: Recent Results”, EVN Symposium, Gothenburg, Sweden, June

M.A. Garrett

- “The Routine Detection and Imaging of Faint Radio Sources with VLBI", VSOP Symp, ISAS, Japan, 21 Jan
- "The Nature of Faint MicroJy Radio Sources", Sterrenkundig Instituut, Utrecht, 24 Apr
- "The Nature of Faint MicroJy Radio Sources", Sterrenkundig Instituut, "Anton Pannekoek", Amsterdam, 25 Apr
- "Practical Imaging" Lecture, JBO Imaging School, Jodrell Bank, UK, 25 Apr
- "Wide-field Imaging" Lecture, JBO Imaging School, Jodrell Bank, UK, 26 Apr
- “WSRT Observations of the HDF”, WSRT Users Meeting, Amersfoort, 3 Mar
- “EVN Reliability and Performance”, EVN TOG, Espoo, Finland, 5 May, and EVN CBD, Espoo, Finland, 8 May
- “EVN Access Contracts (IHP and TMR)”, EVN CBD, Espoo, Finland, 8 May
- “JIVE User Support”, EVN CBD, Espoo, Finland, 8 May
- "SKA: the need for transcontinental baselines", SKA Workshop, Jodrell Bank, UK, 4 Aug
- "Faint Radio Sources and Future trends radio astronomy", Ministry of OC&W, Zoetermeer, 6 Sep
- "VLBI Observations of Blank Fields!" The Geo-Astrometry workshop in Castel St. Pietro, Italy, 8 Sep
- "EVN Performance", EVN TOG meeting, Torun, Poland, 20 Oct
- "Deep Field VLBI Imaging", VLBI Science Workshop, Bonn, Germany, 7 Nov
- "EVN Performance", "TOG Report", "Access Report", CBD meeting, Madrid, Spain, 1 Dec
- "ICN and sustained EVN reliability", CBD meeting, Madrid, Spain, 2 Dec

L.I. Gurvits

- “Preliminary results of the VSOP Survey Programme”, lunch talk, JIVE & ASTRON, Dwingeloo, 12 Jan
- “Space VLBI and the need for a large deployable antenna in space”, ESTEC, NL, 15 Jan
- “Why Space VLBI is of special value for studies of high-redshift radio sources”, ISAS, Japan, 20 Jan
- “A next-generation Space VLBI observatory assembled in orbit”, ISAS, Japan 21 Jan
- “Status of the ESA proposal for the European VSOP-2 segment (F2/F3 mission)”, ISAS, Japan, 24 Jan
- “Review of European resources for the VSOP Survey”, ISAS, Japan, 25 Jan
- “VLBI: an example of international collaboration is science”, TV interview, Ventspils, Latvia, 9 Apr
- “EVN: a user oriented facility”, VIRAC, Riga, Latvia, 10 Apr

- Report on the RTD project “Enhancing the European VLBI Network”, EVN CBD, Espoo, Finland, 8 May
- “Parsec-scale radio structures in AGN”, JENAM-2000, Moscow, Russia, 29 May
- “Ultra-compact continuum radio structures in AGN as revealed by the first dedicated Space VLBI mission VSOP”, JENAM-2000, Moscow, Russia, 31 May
- “Radio Universe as seen with milliarcsecond angular resolution”, MPTI, Moscow, Russia, 6 Jun
- “Milliarcsecond radio structures in AGN across the redshift space”, 5th EVN Symposium, Gothenburg, Sweden, 30 Jun
- “Space VLBI observations of the extremely distant quasars 0201+113 and 0537-286”, 5th EVN Symposium, Gothenburg, Sweden, 30 Jun
- “European participation in VSOP-2”, Manchester, UK, 14 Aug
- “Results from the VSOP continuum Survey”, IAU S205, Manchester, UK, 15 Aug
- “Milliarcsecond radio structures in extragalactic radio sources across the redshift space”, IAU S205, Manchester, UK, 15 Aug
- “VSOP/VLBA pre-launch survey at 5 GHz”, IAU S205, Manchester, UK, 16 Aug
- “VLBI news from outer (redshift) space”, VLBI Science Workshop, Bonn, Germany, 7 Nov
- “A European perspective on link and tracking support for VSOP-2 mission”, Pasadena, CA, USA, 12 Dec

H.J. van Langevelde

- "First science from JIVE: Thin HI disk in NGC4261", NRAO, Socorro, USA, 12 Jan
- "Current activities in the EVN", Koetzting, Germany, 22 Feb
- "Status of the JIVE correlator", Leeds, UK, 10 Mar
- "First science from JIVE: Thin HI disk in NGC4261", NAC, Dalfsen, 11 May
- "Status of the EVN MkIV data processor at JIVE", EVN-PC meeting, Gothenburg, Sweden, 28 Jun
- "Current Status of the JIVE processor", EVN-PC, Catania, Italy, 3 Nov

C.J. Phillips

- “Methanol masers: Tracers of discs?” colloquium, Jodrell Bank, UK, 3 May
- “Methanol masers: Tracers of discs?” Volterra, Italy, 31 May - 3 Jun
- “High-mass star formation: An origin in clusters?” Volterra, Italy, 31 May - 3 Jun
- “Methanol masers: Tracers of discs?” 5th EVN Symposium, Onsala, Sweden, 29 Jun

S.V. Pogrebenko

- “MKIV Correlator at JIVE: Current status and further developments”, VSI review meeting, Haystack, USA, 2 Feb
- “Self-calibration and RFI rejection algorithms for Kirchhoff lense”, ASTRON Colloquium, Dwingeloo, Jun
- “Perspectives of optical fiber connected EVN”, 5th EVN symposium, Gothenburg, Sweden, 29 June

C. Reynolds

- “Faraday Rotation in BL Lacertae”, VLBI Science Workshop, Bonn, Germany, 7 Nov

R.T. Schilizzi

- “Infrastructure Network in Radio Astronomy”, European Commission, Brussels, Belgium, 16 May
- “Wide bandwidth data transport in radio astronomy – creating a telescope as large as Europe”, European Group for Policy Coordination for Academic and Industrial Research Networking, Oslo, Norway, 23 June
- EVN Symposium
- “VLBI: one global telescope, a shared instrument for research in astronomy”, OECD Conference on “The Global Research Village III”, Amsterdam, 7 Dec

L.O. Sjouwerman

- "The OH/IR star population in the Galactic center", colloquium, Ruhr Universität, Bochum, Germany, 1 Feb
- "The Galactic center at 86 GHz with SEST", Lunch presentation, AOC, Socorro, USA, 22 Mar
- “New Radio Supernova Remnants in the Core of M31”, Young Supernova Remnants October conference, University of Maryland, USA, 16 Oct

Appendix B6

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
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

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)

Eur. Ing. S.M. Parsley
1998- EVN Technical and Operations 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
2000- IAU Working Group on Future Large Scale Facilities, Chairman

Membership of professional associations and societies

Dr. I.M. Avruch
1993- SIGMA Xi

Dr. R.M. Campbell
1983- SIGMA Xi
1993- American Astronomical Society
1996- American Geophysical Union
2000- International Astronomical Union

Dr. M.A. Garrett
1997- International Astronomical Union

Dr. D.C. Gabuzda
2000- International Astronomical Union

Dr. L.I. Gurvits
1992- American Astronomical Society
1994- Nederlandse Astronomen Club
1997- International Astronomical Union
1998- COSPAR Associate
1999- URSI

Dr. H.J. van Langevelde
1985- Nederlandse Astronomen Club
1997- International Astronomical Union
1999- URSI

Dr. F. Olnon
1972- Nederlandse Astronomen Club

Eur. Ing. S.M. Parsley
1983- Institution of Electrical Engineers
1995- Federation of European Engineering Institutions

Dr. S.V. Pogrebenko
2000- International Astronomical Union

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

Appendix B8

Membership of scientific organizing committees

Dr. L.I. Gurvits

- VSOP Symposium “Astrophysical Phenomena Revealed by Space VLBI”, ISAS, Sagamihara, Japan, 19-21 January

Prof. R.T. Schilizzi

- IAU Symposium No. 205 "Galaxies and Their Constituents at the Highest Angular Resolution", Manchester, UK, 15-18 August (Chair)

Appendix B9

Meetings attended

1. Scientific conferences attended by JIVE staff members

I.M. Avruch
- VLBI Science meeting, Bonn, Germany, 7 Nov

R.M. Campbell
- 5th EVN Symposium, Gothenburg, Sweden, 28Jun – 2 Jul
- 24th IAU General Assembly, Manchester, UK, 9-19 Aug
- 14th Working Meeting on European VLBI for Geodesy and Astronomy, Castel San Pietro Terme, Italy, 7-10 Sep
- VLBI Science meeting, Bonn, Germany, 7 Nov

D.C. Gabuzda
- JENAM-2000, Moscow, Russia, 24 May – 6 Jun
- 5th EVN Symposium, Gothenburg, Sweden, 28 Jun – 2 Jul
- "Particles and Fields in Radio Galaxies", Oxford, UK, 3-5 Aug
- 24th IAU General Assembly, IAU 205, Manchester, UK, 14-18 Aug
- VLBI Science Workshop, Bonn, Germany, 7 Nov

M.A. Garrett
- VSOP Symposium, ISAS, Japan, 19-21 Jan
- WSRT Users meeting, Amersfoort, 3 Mar
- The High-redshift Universe at Low frequencies, Oxford, UK, 21-23 Mar
- Imaging School, Jodrell Bank, UK, 24-26 Apr
- 5th EVN Symposium, Gothenburg, Sweden, 1 Jul
- The SKA workshop, Jodrell Bank, UK, 3-5 Aug
- 24th IAU General Assembly, Manchester, UK, 7-9 Aug
- 14th Working Meeting on European VLBI for Geodesy and Astronomy, Castel San Pietro Terme, Italy, 7-10 Sep
- ESO/ECF/STScI Deep Field meeting, Munich, Germany, 9-12 Oct
- VLBI Science Workshop, Bonn, Germany, 7 Nov

L.I. Gurvits
- VSOP Symposium, ISAS, Japan, 19-21 Jan
- ESA Workshop "Large Deployable Antennas in Space", ESTEC, Noordwijk, NL, 15-16 Feb
- JENAM-2000, Moscow, Russia, 24 May – 6 Jun
- 5th EVN Symposium, Gothenburg, Sweden, 28 Jun – 2 Jul
- 24th IAU General Assembly, Manchester, UK, 7-18 Aug
- H.C.v.d.Hulst Symposium, ESTEC, Noordwijk, NL, 6 Nov
- VLBI Science Workshop, Bonn, Germany, 7 Nov

H.J. van Langevelde
- ALMA Science and technology day, Leiden, 7 Apr
- Oort Symposium, Leiden, 25-27 Apr
- Nederlandse Astronomen Conferentie, 10-11 May
- 5th EVN Symposium, Gothenburg, Sweden, 28-30 Jun

- 24th IAU General Assembly, Manchester, UK, 15-18 Aug
- Dutch ALMA-FC meeting, Dwingeloo, 25 Aug
- VLBI Science Workshop, Bonn, Germany, 7 Nov

F. Olnon
- Nederlandse Astronomen Conferentie, 10-11 May

C.J. Phillips
- "High-mass star formation: An origin in clusters?" Italy, 31 May – 3 Jun
- 5th EVN Symposium, Gothenburg, Sweden, 28 Jun – 1 Jul
- VLBI Science Workshop, Bonn, Germany, 7 Nov

C. Reynolds
- 5th EVN Symposium Gothenburg, Sweden, 28 Jun – 2 Jul
- VLBI Science Workshop, Bonn, Germany, 7 Nov

R.T. Schilizzi
- ALMA Science and technology day, Leiden, 7 Apr
- 5th EVN Symposium, Gothenburg, Sweden, 28 Jun – 2 Jul
- 24th IAU General Assembly, Manchester, UK, 5-19 Aug
- VLBI Science Workshop, Bonn, Germany, 7 Nov

L.O. Sjouwerman
- WSRT Users meeting, Amersfoort, 3 Mar
- Oort Symposium, Leiden, 25-27 Apr
- 24 IAU General Assembly, Manchester, UK, 9-19 Aug
- "Young Supernova Remnants", Maryland, USA, 15-18 Oct

A. Szomoru
- ADASS conference, Haystack, USA, 12-29 Nov

H. Verkouter
- Nederlandse Astronomen Conferentie, 10-11 May

2. International meetings attended by JIVE staff members

J. Buiter
- TOG meeting, Jodrell Bank, UK, 3-6 May
- TOG meeting, Torun, Poland, 19-22 Oct

M.A. Garrett
- FINA meeting, KVI Groningen and JIVE Dwingeloo, 27-29 Apr
- TOG meeting, Jodrell Bank, UK, 3-6 May
- EVN Board meeting, Espoo, Finland, 8 May
- TOG meeting, Torun, Poland, 19-22 Oct
- CBD meeting, Madrid, Spain, 1 Dec
- JIVE Board meeting, Madrid, Spain, 2 Dec
- ICN Annual Meeting, Madrid, Spain, 2 Dec

L.I. Gurvits
- IACG SVLBI panel, ISAS, Japan, 21 Jan
- VISC meeting, ISAS, Japan, 22 Jan
- VSOP-2 coordination meeting, ISAS, Japan, 24-25 Jan
- VSOP Survey workshop, ISAS, Japan, 25-28 Jan
- VIRAC Science Committee meeting, Riga/Ventspils, Latvia, 10-13 Apr
- EVN Board meeting, Espoo, Finland, 8 May
- JIVE Board meeting, Espoo, Finland 9 May
- ICN-OPTIcon meeting, Manchester, UK, 11 Aug

H.J. van Langevelde
- IVS General Meeting, Koetzting, Germany, 20-24 Feb
- EVN-PC meeting, Leeds UK, 9-11 Mar
- EVN-PC meeting, Gothenburg, Sweden, 28 Jun
- EVN PC meeting, Catania, Sicily, 2-5 Nov

S.M. Parsley
- TOG meeting, Jodrell Bank, UK, 3-6 May
- TOG meeting, Torun, Poland, 19-22 Oct
- Meeting on Fiber-linked EVN, Jodrell Bank, UK, 25 Oct
- Meeting with DANTE, Cambridge, UK, 22 Nov

C.J. Phillips
- TOG meeting, Jodrell Bank, UK, 3-6 May

S.V. Pogrebenko
- VSI (VLBI Standard Interface) review meeting, Haystack, USA, 1-2 Feb
- Meeting on Fiber-linked EVN, Jodrell Bank, UK, 25 Oct
- Meeting with DANTE, Cambridge, UK, 22 Nov

R.T. Schilizzi
- Conference on Research Infrastructures, Brussels, Belgium, 15 Feb
- Discussions at INSU, Paris, France, 16 Feb
- VSOP Symposium, ISAS, Japan, 19-21 Jan
- IACG SVLBI panel, ISAS, Japan, 21 Jan
- VISC meeting, ISAS, Japan, 22 Jan
- SPIE meeting, Munich, Germany, 25-31 Mar
- EVN Board meeting, Espoo, Finland, 8 May
- Panel E meeting; Infrastructure Networking, Brussels, Belgium, 16-17 May
- ENPG meeting, Oslo, Norway, 22-23 Jun
- Strasbourg Conference on Research Infrastructure, 18-21 Sep
- Meeting of Steering Committee for an Irish Radio Telescope, Birr Castle, Ireland, 1-3 Oct
- Meeting on Fiber-linked EVN, Jodrell Bank, UK, 25 Oct
- CBD meeting, Madrid, Spain, 1 Dec
- JIVE Board meeting, Madrid, Spain, 2 Dec
- ICN Annual Meeting, Madrid, Spain, 2 Dec
- Meeting of Steering Committee for Irish Radio Telescope, Birr Castle, Ireland, 20 Dec

N. Schonewille
- TOG meeting, Torun, Poland, 19-22 Oct

A. Szomoru
- Roadshow; Design automation & embedded systems, Soestduinen, 25 May

H. Verkouter
- TOG meeting, Jodrell Bank, UK, 3-6 May

3. Working visits by JIVE staff members

R.M. Campbell
- University of Leiden, NL, 8 Feb
- CfA, Cambridge, MA, USA, 5 and 12 May
- USAF Research Lab, Hanscom AFB, MA, USA, 9 May
- Haystack Observatory, Westford, USA, 9 May

D.C. Gabuzda
- Astro Space Center, Moscow, 8-15 Jan
- Workshop, University of Central Lancashire, UK, 3-6 May
- University of Central Lancashire, UK, 6-12 Aug

M.A. Garrett
- Jodrell Bank, UK, 7-11 Feb
- MPIfR, Bonn, Germany, 8 Nov
- Opening of the Bonn MkIV Correlator, 17 Nov

L.I. Gurvits
- MPIfR, Bonn, Germany, 29 Feb - 2 Mar

H.J. van Langevelde
- AOC, Socorro, USA, 11-20 Jan

S.M. Parsley
- Metrum Information Storage, Wells, UK, 8 May

C. Reynolds
- AOC, Socorro, USA, 2-15 Oct
- AOC, Socorro, USA, 5-16 Dec

L.O. Sjouwerman
- Ruhr Univ., Bochum, Germany, 2 Feb
- OSO, Onsala, Sweden, 14 Feb
- AOC, Socorro, USA, 6-21 Mar
- Jodrell Bank, Manchester, UK, 29 Mar – 4 Apr
- Sterrenwacht, Leiden, 30 May
- AOC, Socorro, USA, 3-14 Jul
- IRAM, Granada, Spain, 20-28 Aug
- AOC, Socorro, USA, 2-15 Oct

Appendix B10

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