European VLBI Network Newsletter Number 2 May 2002

EVN Homepage | Publications | Meetings | User Support | Proposals | JIVE Homepage | Newsletter Archive

Contents

1. Report from the Chairman of the Consortium Board of Directors (CBD) of the EVN

China has been a full member of the EVN for many years now and for all that time our Chinese colleagues have travelled to the biannual meetings of the EVN CBD in Western Europe. In Spring 2002 we accepted the invitation of Prof. Zhao of the Shanghai Astronomical Observatory to hold our meeting in China, so on April 26/27 we met in the smart surroundings of the observatory in the centre of Shanghai. The hospitality of our Chinese hosts was superb as they looked after the CBD and several spouses. The traditional CBD dinner was an exotic seafood feast, which will be hard to match at the next meeting. We visited the Seshan VLBI station outside Shanghai, went on a night cruise of the Huangpu river and also toured the silk centre of Suzhou and the city of Zhouzhuang (the 'Chinese Venice').

Figure 1: Some members of the CBD and spouses enjoying a 'Venetian' experience (picture courtesy Greg Taylor).

There was also a full programme of business to discuss. A brief summary of the principal points arising from the meeting is:

1. The overall performance and reliability of the EVN is steadily increasing as

the effects of the last few years of upgrades take effect. Mike Garrett (chairman of the Technical and Operations Group (TOG)) showed an impressive plot of the reliability indicator ramping up with time.
2. Amplitude calibration needs greater attention and a RadioNET-funded workshop attended by VLBI technical friends from the network's telescope will focus on this at the TOG meeting in Bologna in September.
3. Test observations at 18cm with 512Mbps, following 6cm tests reported last year, have demonstrated that noise-limited observations can be routinely obtained with the EVN enabling the full exploitation of the high-sensitivity large dishes. The EVN is 5 times more sensitive that the VLBA at its prime observing frequencies.
4. There are impressive developments in Europe (JIVE & Metsahovi: PC-EVN) and the USA (Haystack: MkV) in the area of new disc-based recording systems. Haystack are conducting tests of their system, tests with the European system are planned for the coming summer. The future of disc-based recording will be a major agenda item of the Global VLBI Working Group, which will meet at the URSI General Assembly in August.
5. Phil Diamond reported on the continuing discussions for making VLBI more accessible to the broader astronomical community. A large variety of improvements are underway within the EVN, all aimed at improving the 'ease of use'. Various outreach initiatives have also been proposed. The next issue of the Newsletter will contain a more detailed report on this area.
6. The next EVN Symposium will take place at MPIfR, Bonn from 25-28 June 2002. Please see the webpage at: http://www.mpifr-bonn.mpg.de/div/vlbi/evn2002/index.html

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2. EVN Call for Proposals - Deadline 1 June 2002

Observing proposals are invited for the EVN, a VLBI network of radio telescopes in Europe and Asia operated by an international Consortium of institutes. The EVN is open to all astronomers, and encourages use of the Network by astronomers not specialised in the VLBI technique. The Joint Institute for VLBI in Europe, JIVE (http://www.jive.nl/) can provide support and advice on project preparation, scheduling, correlation and analysis. See http://www.evlbi.org/support/evn_support.html.

PIs can apply for time by completing a coversheet (http://www.evlbi.org/proposals/prop.html) and attaching a scientific justification (maximum 2 pages). The detailed call for proposals (http://www.jb.man.ac.uk/vlbi/EVN/evncall-long-jun2002.html) has further information on Global VLBI, EVN+MERLIN and guidelines for proposal submission. The EVN User Guide is available at http://www.evlbi.org/user_guide/user_guide.html, the EVN Status table (http://www.oso.chalmers.se/~vlbi/EVN/EVNstatus) gives current antenna

capabilities and the on-line VLBI catalogue (http://www.ira.bo.cnr.it/~tventuri/cata.html) details sources observed by the EVN and Global VLBI.

EVN Observing Sessions in 2002/3

2002 Session 3	Nov 07 - Nov 28	18/21cm (with Jb-1 & Cm), 6cm+MERLIN, 1.3cm + MERLIN
2003 Session 1	Feb 06 - Feb 27	18/21cm + MERLIN, 5cm, 6cm? +...
2003 Session 2	May 22 - Jun 12	6cm, 18/21cm+MERLIN
2003 Session 3	Nov 06 - Nov 27	Frequencies to be determined

Proposals received by 1 June 2002 will be considered for scheduling in Session 3, 2002 or later. Finalisation of the planned observing wavelengths will depend on proposal pressure. Most proposals request 12-48hrs observing time. The EVN PC also encourages larger projects (>48 hrs) but these may be subject to additional scrutiny, and the EVN PC may, in some cases, attach conditions on the release of the data.

Special features for Sessions in 2002/3;

- 1.3cm EVN+MERLIN session in Nov 2002 should include the resurfaced Noto telescope and a new receiver at Torun
- 512 Mb/s capability at 6cm and 18cm. Tests show close to expected noise at both wavelengths
- Phase referencing performance now greatly improved with new telescope positions. See http://www.evlbi.org/user_guide/stapos.html
- EVN Data Analysis Pipeline is now in operation. See http://www.evlbi.org/pipeline/user_expts.html

3. Automatic Pipelining (Calibration) of EVN User Data

The NME pipeline, which has been used since early in 2000 for calibrating Network Monitoring Experiments (NME), has been extended to automatically process EVN user data. The use of the pipeline on user data not only permits us to trace the performance of the array over the entire session but also relieves the PI from the painful task of performing the initial calibration.

The pipeline generates many different data products - including a series of data plots similar to those previously produced for the NME. For EVN users, the pipeline also produces various calibration tables - these include a priori amplitude calibration and other post-correlation corrections that may be required (e.g. updated telescope positions). In addition, amplitude gain/phase/delay/rate corrections are derived from scheduled calibrators. PIs have the option (of course) to derive their own calibration tables. The pipeline

script itself and all external data associated with it (ANTAB files, UVFLG files, etc.) are also provided in their final form. In this way the pipeline can be easily re-started in order to produce target images or (once the PCInt project is complete) on-the-fly, off-target processing outside the original field of interest. Target images are only produced at the users request.

So far only a couple of user experiments have been pipelined but we now aim to keep pace with all EVN and Global VLBI experiments released by the EVN MkIV correlator at JIVE. It takes about 6 hours to pipeline a typical 12 hour run (most of the time is taken up in the generation of the plots). More time is required to make detailed comments on the data quality - these will comment on gross errors only. Hiroshi Imai, a new member of the EVN support group at JIVE, pipelined the first project. Hiroshi will be the main person responsible for pipelining user data. Cormac Reynolds continues to play the major role in the development of the pipeline. JIVE invites all VLBI friends to frequently look at the pipeline output in order to check the performance of their telescope. The associated web page is at http://www.evlbi.org/pipeline/user_expts.html. Any feedback on this service should be provided to Mike Garrett.

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4. Report on the e-VLBI Meeting at Haystack Observatory

Approximately 70 attendees, representing 15 institutions worldwide, participated in a two-day workshop held at MIT Haystack Observatory on 8-9 April 2002. The purpose of this workshop was to explore the current state of high-speed astronomy data transmission, concentrating on the transmission of pre-correlation VLBI data, dubbed 'e-VLBI'. Among the topics discussed were international networking facilities, user requirements for high-speed networking, networking protocols for real-time data transmission, public versus dedicated networks and international standards for e-VLBI data transfer. Presentations from the workshop are available on-line at http://web.haystack.mit.edu/e-vlbi/abstract.html.

Representatives from several major research networks outlined their current status and future plans. Within the U.S., the Internet2 research network provides backbone connections spanning the country at 10 Gbps, primarily between major research institutions and universities, but 'last-mile' connections to most antennas remains a major hurdle. In Europe, the Geant network is in the process of establishing a similar network; again, 'last-km' problems pose a major cost obstacle for direct connections. In Japan, several dedicated high-speed networks, as well as the research network Scinet, have already been used for e-VLBI at data rates up to 2 Gbps. For the short term most global e-VLBI usage will have to share bandwidth with other users on research networks.

Though there exists a well-advertised excess capacity of installed national and international fiber, most of this fiber remains unlit and will likely continue to be

unlit until commercial demand is sufficient. The time scale for such demand is unclear. Research uses of this excess capacity remains problematical at best, though there has been some success in some instances of fiber and communications companies allowing access to research users at low cost. That being said, most government-supported research networks are developing rapidly and are looking for users to fill their available bandwidth. It was made quite clear that these networks are not likely to expand significantly unless there is sufficient usage and demand to justify such expansion.

Based on current usage statistics, most shared high-speed research networks operate, on average, at only a small fraction of their available capacity. Usage tends to be 'bursty', with average length high-speed bursts ranging from seconds to minutes. e-VLBI has the potential to fill a significant fraction of this unused capacity, but it must do so in a non-obtrusive manner that does not significantly affect other users. This suggests that special protocols might be developed which keep e-VLBI as a lower-priority 'background' usage; but it also suggests that large buffers may be required at the correlators in order to accommodate large time 'jitter' (seconds, minutes, hours?) in data return.

Several networks have already been established and demonstrated in Japan capable of data rates as high as 2 Gbps. Primarily, these have been over dedicated non-IP links, but work is now in progress to use shared IP networks as well. The MERLIN array in the UK is in the process of developing and installing a multi-Gbps dedicated network. Haystack Observatory is preparing a Gbps e-VLBI demonstration experiment between Haystack and NASA/GSFC in Maryland using IP over shared networks.

The general consensus at the meeting among networking experts was that 1 Gbps over a WAN is now 'possible, but difficult', requiring special skills. However, it is the goal of the networking community to make 1 Gbps connections 'easy' in the near future.

The advent of relatively inexpensive wavelength-division multiplexing (WDM) on optical fibers is having a huge impact on the telecommunications industry and promises to considerably expand available bandwidths at a reasonable cost. 'Private' e-VLBI wavelengths on existing lit fibers are a future possibility. The development of COTS-based VLBI/e-VLBI data systems makes transfer of e-VLBI data to/from high-speed networks relatively straightforward using standard network interfaces. The connection of telescopes to high-speed nodes, dubbed the 'last-mile' problem, remains a high barrier for many sites. For almost all cases, the cost of fiber installation is the dominant cost and is not likely to fall significantly. A cost of several tens of thousands of US$ per km is expected to be typical, though in some special cases it may be as low as a few thousand US$ per km. Lighting the fiber with the bandwidths needed by e-VLBI is becoming quite affordable, the cost usually being small compared to fiber-installation costs.

Much interest was expressed by both network providers and VLBI users to pursue both national and international e-VLBI efforts. Charles Yun of Internet2 generously offered the support of Internet2 to assist in the organization and

propagation of e-VLBI initiatives; a web site for e-VLBI has been set up at http://www.internet2.edu/vlbi as part of this effort, which is now under construction. Follow-on e-VLBI workshops are planned for Dwingeloo in 2003 and Japan in 2004, perhaps with a rotation back to the U.S. in 2005. A provisional working group consisting of Jon Romney, Richard Schilizzi and Alan Whitney was established to draft a white paper to set e-VLBI goals, determine current observatory connectivities, provide the beginnings of a master global e-VLBI development plan, and establish the tasks of a permanent e-VLBI working group. Among the tasks of the permanent working group will be: coordinate standardization of e-VLBI data formats, identify continuing goals (both scientific and technical), coordinate international e-VLBI efforts and proposals, maintain current state of connectivity of global VLBI observatories, maintain e-VLBI as a visible user of global high-speed networks and promote continued interactions with networking specialists.

The time for e-VLBI to enter into the use of national and international high-speed networks appears ripe. These networks not only need credible users, but e-VLBI has a real need to use them. It is incumbent upon the global VLBI community to develop a well-structured and rational program to pursue e-VLBI goals. This workshop is the first step in that direction, and mechanisms have been put into place with the goal of maintaining this initial momentum and seeing e-VLBI through to a successful international realization.

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5. Science Highlight: MERLIN and Global VLBI Observations of theta^1 Orionis A

The Orion Nebula Cluster (ONC) offers a unique opportunity to study the formation of both low and high-mass stars. The Trapezium Cluster lies within the central 0.1 pc of the nebula and is the densest stellar clustering known in the Galaxy. High resolution radio observations of the complex have played an important role in studies of star-formation and YSOs. High resolution VLA observations have identified compact thermal sources, now known to be associated with the spectacular 'proplyds' revealed by the HST, as photo-evaporating proto-stellar disks, as well as a number of non-thermal active stars. The brightest of these (theta^1 Ori A) has been detected with the EVN by Felli et al. (1991, A&A, 248, 453) but its nature has been unclear. MERLIN observations of the whole Trapezium cluster at 6cm reveal details of the proplyds (Graham et al., 2002, ApJ, 570, 222; Henney et al., 2002, ApJ, 566, 315) as well as detecting a number of variable, active stars. The richness of the population of active stars in Orion has also been demonstrated in a recent Chandra image (Schulz et al., 2001, ApJ, 549, 441).

The MERLIN position for theta^1 Ori A, measured with respect to an ICRF calibrator, is 220 mas north of the Hipparcos position for this star. The Hipparcos positions themselves are only accurate to 30 mas or so in this crowded field, and the MERLIN position may have an error of 15 mas (because of the low declination). However, it is now clear that the radio emission is not

associated with the primary star, as had hitherto been assumed. Recent IR speckle imaging by Weigelt et al. (1999, A&A, 347, L15) shows a companion exactly 220 mas north of the primary star. The idea that the radio emission might be associated with a companion was also suggested by Petr et al. (1998, ApJ, 500, 825) based on lower resolution VLA and AO images. The star also has a closer companion, with a 65d orbital period (~1 AU orbit), and previous investigations have suggested that the radio emission might be related to this close binary system.

Global VLBI observations were made in June 2001 with VLBA and 7 EVN telescopes at 6cm. The data were correlated using the EVN Correlator at JIVE with a separate pass for a wider field image to cover the proplyds around theta^1 Ori C. The image presented is a preliminary image, based on a rapid analysis of the data, and using phase referencing only. But it clearly confirms the MERLIN position, and shows that the radio emission associated with this star is compact on scales of a few mas (~1AU). The implied brightness temperature is 100 MK. The IR colours of theta^1 Ori A2 place it on the evolutionary track of a 4-5M_{solar} pre-main-sequence star of approximately 1 Myr age. PMS stars with non-thermal emission have been identified with weak-lined or diskless T-Tauri stars without significant wind ionization. The radio emission from theta^1 Ori A2 implies strong magnetic fields, but their generation by the dynamo mechanism in this object is an enigma since early-type PMS stars generally do not have convective envelopes. Work is continuing to decipher the nature of this anomalous star.

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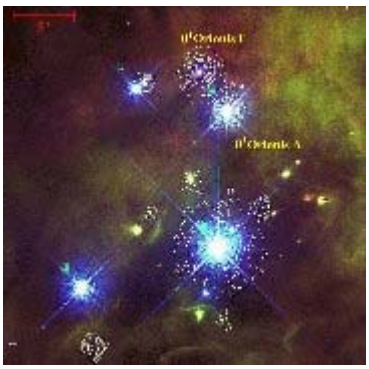

Figure 2: (a) HST optical image of the Trapezium Cluster with Chandra X-ray contours overlaid, showing the position of theta^1 Ori A.

(click on image for larger version)

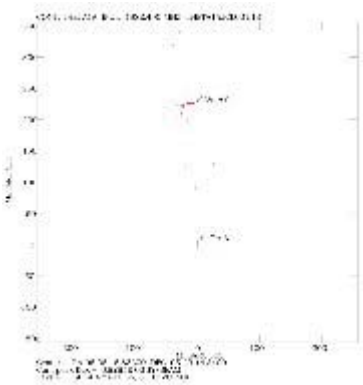

Figure 2: (b) Global VLBI 6cm image of the field around theta^1 Ori A showing the position of the main component and the detection of the radio star theta^1 Ori A2 offset by about 220 mas from the optical position. (click on image for larger version)

The European VLBI Network (EVN) website (http://www.evlbi.org/) is hosted by the Joint Institute for VLBI in Europe (http://www.jive.nl/).