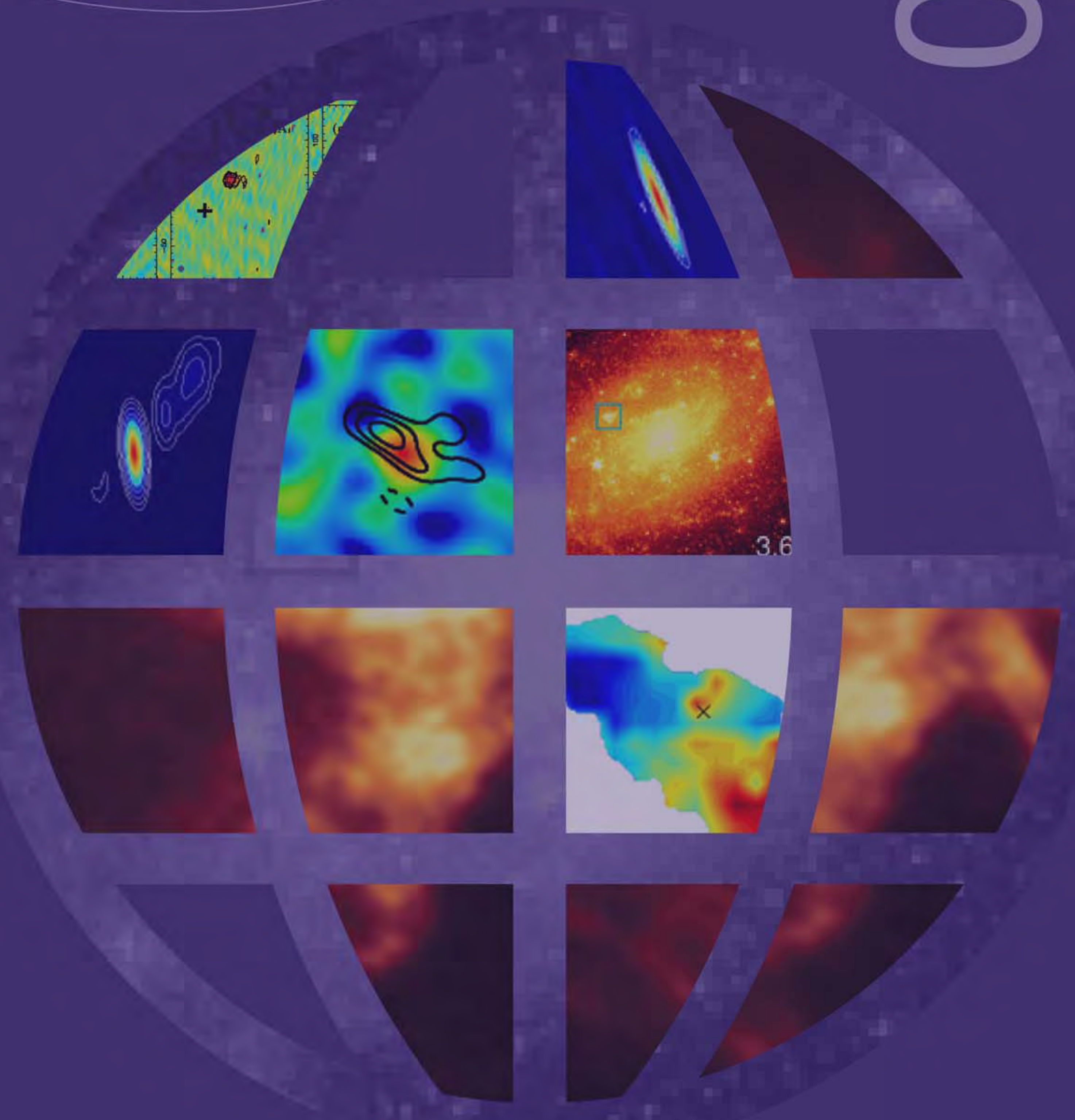
Joint Institute For VLBI in Europe
Biennial report 2009-2010



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

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

Netherlands Institute for Radio Astronomy (ASTRON), the Netherlands,
National Geographical Institute (IGN), Spain,
Italian National Institute of Astrophysics (INAF), Italy,
Max Planck Institute for Radio Astronomy (MPIfR), Germany,
National Astronomical Observatory of China (NAOC), China,
Netherlands Organisation for Scientific Research (NWO), the Netherlands,
Onsala Space Observatory (OSO), Sweden,
Science & Technology Facilities Council (STFC), UK
National Center for Scientific Research (CNRS), France

FOREWORD BY THE CHAIRMAN OF THE BOARD

The Joint Institute for VLBI in Europe (JIVE) plays a key role in transforming the radio telescopes of Europe into a cutting-edge, user-accessible science facility. In 2009-2010 the main instrument for this task remained the EVN data processor. It turns digitized telescope signals into user data. It is JIVE's core business to run this correlator efficiently and effectively, making sure the EVN data quality is at the high level that the astronomers need to turn their proposed observations into scientific results. The JIVE operations and support team have continued to excel at this task and all of us, scientists and facility operators, are benefitting from the continuity that JIVE brings to the EVN as a whole.

Moreover, JIVE is taking a major share in defining new scientific capabilities for our VLBI network. After years of development and quite a few discussions on the required changes to the EVN observing policies, e-VLBI has reached a level of maturity that surprises many of us. Not only has it introduced new scientific capabilities for the EVN, it has also proven to be applicable and advantageous for 'normal' VLBI observations. Together with the EVN partners, JIVE has been very successful transforming this idea into the new EC project NEXPReS, building on the EXPReS structure.

The development effort for e-VLBI at JIVE has now been matched by an equally important programme to define the correlators that follow-up the current Mk4 data-processor. The software correlator that is already operational is presenting the community with unsurpassed flexibility. At its heart is the functionality that was developed for VLBI space applications, in which JIVE is a leading institute. For the future there is the prospect of a correlator based on programmable gate array chips, equally flexible, but with performance characteristics that are attractive even for the Square Kilometre Array (SKA).

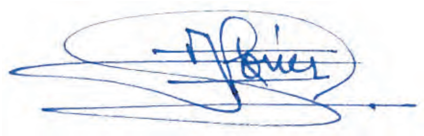
In the e-VLBI deployment, JIVE has also taken the lead in demonstrating the new science capabilities of the real-time array, leading to a considerable number of scientific papers. Similarly we should prepare for the new correlators and their innovative capabilities. Ideally such defining activities should be a common interest of the scientists at the EVN institutes and it should be structured accordingly. Setting up collaborations for training European students in the area of VLBI is a great way to accomplish this.

JIVE has clearly recognized the challenges and opportunities that the global effort to define the SKA offer. It has several development programmes that feed into the SKA preparation and the e-VLBI effort of the EVN is a recognized pathfinder facility. In various capacities, JIVE has actively supported the European SKA effort. At the same time, JIVE has successfully argued that continuity of this truly European radio-astronomical facility is vital for European scientists and engineers for at least the coming decade. In this light it is perfectly understood that JIVE has formulated the ambition to become a European institute, now also formally.

I think that as partner institutes, we are all very happy that JIVE has been a place with a stable profile. Because of the successful applications for external funding, it seems JIVE is able to hold on to vital expertise, as well as astronomical excellence, even when the partner contributions are under pressure. In the JIVE governing board we are aware that this is achieved by a relatively small management team that defines the project portfolio and monitors the funding opportunities. It is impressive that these processes continued even when the director temporarily had to lay down a large fraction of his responsibilities.

It seems the position of JIVE is strong and the staff can be confident that JIVE will continue to have many responsibilities in the European and global VLBI community and probably also for radio astronomy at large. You can see the shape of things to come in this report which covers the JIVE achievements for the years 2009 – 2010.

Prof. Dr. Jesús Gómez-González
Chairman of the board



1 INSTITUTE

1.1 VLBI MOVING AHEAD

In the period 2009 – 2010 the EVN was able to offer e-VLBI as a unique operational facility with capabilities comparable and even superior to traditional disk-based VLBI. With many of the largest and most remote telescopes connected at full bandwidth to the central processor at JIVE, the scientific and logistical benefits of real-time processing had finally become available to a network with competitive sensitivity and resolution. The fact that data can be ready for processing within hours after the observations, which in turn can be scheduled within days after the submission of a proposal, has not gone unnoticed by the user community. The growing popularity of e-VLBI has led the EVN to increase available observing time by more than 30%. While the bulk of EVN observations are still done in the traditional way, through the transport of magnetic media, immediate feedback has also greatly improved the reliability of disk-based VLBI. Data inspection during real-time observations has proven to be of great importance for studies of transient phenomena, but has also added back the excitement of doing live astronomical observations for VLBI users. With the conclusion that e-VLBI had grown into a robust, mature and fully operational mode of the EVN the EXPReS project ended in 2009 (Figure 1.1).

The excitement of e-VLBI has been shared with the astronomical community, funding agencies and the general public on a large number of occasions. 2009, being the international year of astronomy, provided many excellent opportunities to showcase VLBI, with the real-time aspect of e-VLBI adding an exciting interactive component.

Figure 1.1 Participants of the 8th e-VLBI workshop, Science and Technology of Long Baseline Real-Time Interferometry, held in Madrid in June 2009, here in front of the latest addition to the e-EVN, the Yebes antenna.

However, these and other developments have led to an increased pressure on the JIVE operations team, who always try to achieve the best possible science product with the available resources. Accommodating different user requests for different correlator passes, as well as special measures to salvage all telescope data, has become increasingly demanding. At the same time, the need to man frequent e-VLBI runs has necessitated changes to the JIVE operational model itself, while the commissioning of the software correlator has further expanded the range of options for correlation. Moreover, the telescope network itself has undergone a significant growth over the 2009 – 2010 period. As can be read in section 2.2 several new telescopes joined the EVN, among which the Russian KVAZAR antennas and several new antennas in China.

In this report the operational, technical and scientific achievements are highlighted. One has to keep in mind though that the main output of JIVE is the transformational science that these efforts enable (e.g. Figure 2.1). For the first time this biennial report includes an attempt to collect all scientific output based on both EVN and JIVE operations (Appendix 8.10).

1.2 PROPOSING FOR A BRIGHT FUTURE

The success of EXPReS clearly has had an impact on the plans for the future of VLBI. From the perspective of JIVE, the main ingredients for these are the further development of e-VLBI, the construction of a new correlator and the application of VLBI for space missions. During the years 2009 and 2010 important steps were taken in all three areas.

Even at the time of the successful conclusion of the EXPReS programme and the final review in November 2009, a new EC proposal called NEXPReS was being prepared. This proposal did very well and the project was awarded 3.5M€ in 2010, nearly the full amount that was originally requested. Its main objective is to make e-VLBI the operational mode for all VLBI observations in Europe. The work-programme includes a number of activities that aim to introduce transparent high-speed high-capacity storage into the e-VLBI processing chain. Together with (high) bandwidth-on-demand and distributed correlation facilities this will make the e-EVN far more sensitive, flexible and robust.

Although these plans rely to some degree on the large capacity and processing power of the EVN MkIV correlator, it is clear that the availability of a new correlator platform will be essential. The JIVE approach will be to deal with immediate requirements by deploying a software correlator alongside the current hardware correlator, while working towards a far more powerful correlator based on field-programmable gate arrays (FPGAs). The software correlator in use at JIVE is based on an implementation developed specifically for spacecraft detection, notably the tracking of the Huygens probe as it made its descent to the surface of Saturns' moon Titan. In late 2009 a medium size cluster was purchased. Towards the end of 2010 sufficient progress had been made in its commissioning to allow its first use in science observations. During this period JIVE also managed to raise considerable funds for the development of an FPGA-based next-generation correlator. UniBoard, a Joint Research Activity in the European RadioNet FP7 programme, got underway in 2009. This research activity, aimed at creating a generic, high-performance computing platform for radio-astronomical applications, was further strenghtened. by an NWO-funded collaboration between JIVE and ASTRON called ExBoX. The collaboration of JIVE and Shanghai engineers on FPGA-based VLBI correlators is one of the two subjects of an agreement between NWO and Shanghai Observatory.

The other component of the NWO-China agreement deals with VLBI for space science applications, joining the expertise at JIVE and Shanghai Observatory through the exchange of research fellows and PhD students. During the reporting period, a considerable effort was spent by JIVE staff members to ensure that VLBI space science would be considered an integral part of the science programmes of upcoming European Space missions. Moreover, JIVE secured participation in both EU-funded programmes EuroPlaNet and ESPaCE. Indeed, this area promises to be a very important component in future VLBI operations and has the potential to bring exciting new science to the European radio telescopes.

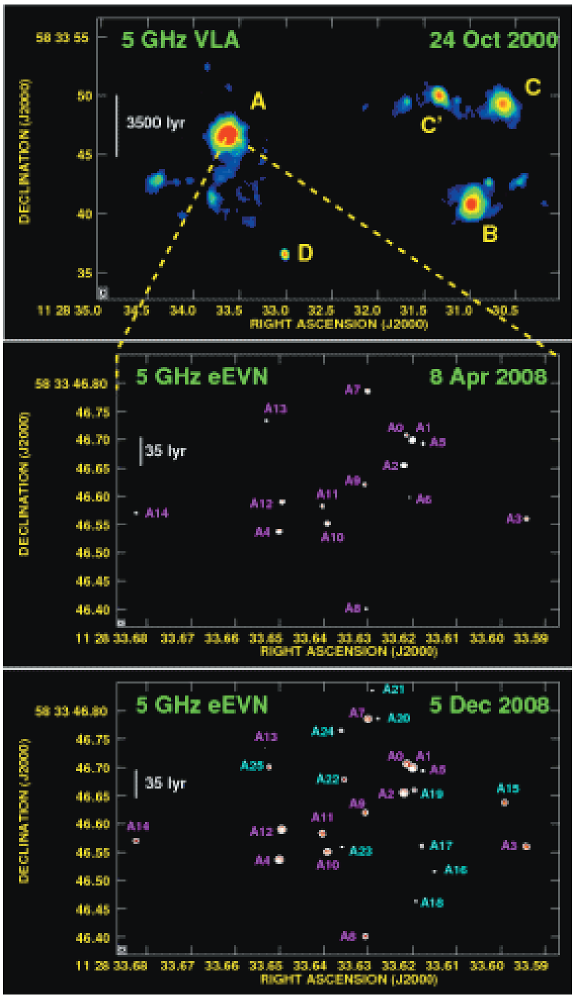


Figure 1.2 The prolific supernova factory in Arp 229 was a scientific highlight and clearly demonstrated the unique and new capabilities of the EVN and JIVE (Perez-Torres et al. 2009)

Together these components form a vital link to the radio astronomy of the future, specifically the common ambition of the global community to define and build the Square Kilometre Array, the SKA. JIVE management has taken the lead in making sure the e-EVN is a recognized SKA pathfinder, contributing to its development in the areas of connectivity and real-time science processing. In addition, care is taken that the research and technical developments taking place at JIVE and in the EVN at large are feeding into the design considerations of the SKA. Finally, JIVE enables the participation of the European radio astronomy community in the SKA project development office by providing the financial and legal structure.

1.3 THE INSTITUTE, THE PEOPLE OF JIVE

The project portfolio of JIVE has never been better filled than during the past two years. At the same time, the astronomical research at JIVE is driven by the personal ambition and creativity of the staff. The diversity of the staff interests is reflected in the wide range of topics covered in this report, from the interplanetary medium to the most distant cosmological sources. JIVE also employs a large number of professional experts with technical skills ranging from networking and digital engineering to software and astronomical processing techniques. Quite often, one single person combines expertise in several fields. During the past two years, staffing at JIVE remained at a constant level, starting the reporting period with 33 staff members and ending with 30. As almost half of the staff is employed on projects, such continuity depends critically on the ability of the management team to identify opportunities and successfully propose for new funds. Importantly, JIVE managed to keep a healthy number of graduate students involved in its activities, while attracting new students of all levels through its very successful summer student programme.

Figure 1.3 JIVE staff in action: Zsolt Paragi showing off his Nature article and Friso Olnon his retirement gifts. Bob Campbell taking the user meeting questions on board, while in the background Arpad Szomoru is staging the future of the EVN. Huib van Langevelde introducing e-VLBI at the IYA09 opening ceremony.

Fortunately, continuity was also one of the main characteristics of the JIVE administrative and project support staff. Obviously, a flexible and knowledgeable administration is crucially important for JIVE, particularly in view of the many different funding schemes that contribute to JIVE and its mission within the EVN. In this area the support from ASTRON plays a vital role, and this interaction was further improved and formalized during the reporting period. Following the example of ASTRON, JIVE introduced a new web site in 2010, giving the institute a much more professional presence on the Internet.

Four board meetings were organised during the reporting period, although one had to be rescheduled due to interrupted flight schedules following the eruption of an Icelandic volcano in April 2010. One of the topics discussed during board meetings, as well as during the monthly Management Team meetings, was the future governance of the JIVE foundation. Re-structuring the (central) operations of the EVN into a so-called European Research Infrastructure Consortium (ERIC) might be an attractive option for JIVE. This could constitute the governance ingredient that, together with the new science capabilities and fantastic people, will provide JIVE with a stable future.

2 SCIENCE OPERATIONS AND SUPPORT

2.1 PRODUCTION PORRELATION

2.1.1 SESSIONS AND THEIR EXPERIMENTS

Session 1/2009 had a total of 20 user experiments correlated at JIVE. There were 10 spectral line experiments, nine of which required multiple correlator passes. Seven experiments used multiple MERLIN outstations in the EVN correlation. The new Yebes 40m telescope participated for the first time at 5cm, as did the Yamaguchi 32m telescope in Japan (data recorded as K5, then translated to Mark5B prior to shipping). With more than eight stations now available at 5cm, recirculation was used for the first time for user experiments to maintain the spectral resolution desired for methanol masers (typically 1024 frequency points over a 2 MHz subband, providing about 88 m/s velocity spacing).

Session 2/2009 had a total of 25 user experiments correlated at JIVE. There were 6 spectral line experiments. Recirculation avoided the need for multiple passes in four of those. Four other (continuum) experiments required multiple passes for separate correlation phase centres. Four experiments used multiple MERLIN out-stations. Yebes 40m participated for the first time at 6cm. The Chinese stations at Kunming and Miyun participated for the first time ever in EVN observations (S/X-band NME for Kunming , an X-band user experiment for both).

Session 3/2009 had a total of 17 user experiments correlated at JIVE. We discovered that recirculation and oversampling can't be used together (see section 2.1.3 Astronomical Features for more details). There were two wide-field mapping experiments that required multiple passes by pairs of subbands to keep the bandwidth smearing to the required level.

In 2009, there were 29 e-EVN user experiments, including six ToOs between April and July. These ToOs included a 3-epoch experiment in which Kashima and three Australian stations participated (Kashima translated their K5-format data to Mark5B prior to transmission, this was successful by the third epoch). On 24-25 March, we had our first truly Gbps real-time correlation in a user experiment, after this time Gbps became the standard mode for continuum e-VLBI observations. An e-VLBI demo for the International Year of Astronomy saw the largest number of stations correlating at once in real-time e-VLBI at 12 (figure 2.1).

Session 1/2010 had a total of 23 user experiments correlated at JIVE. The KVAZAR stations Zelenchukskaya and Badary participated in ftp fringe tests for the first time, and Shanghai participated for the first time at 5cm, providing long baselines for 6.7 GHz methanol maser observations within the EVN.

Session 2/2010 saw the first e-EVN experiments to be scheduled during a disk session. There were a total of 16 disk-based user experiments correlated at JIVE (6 e-EVN experiments scheduled during the session are included in the 2010 e-VLBI summary paragraph below). Zelenchukskaya and Badary participated in many user experiments. In the course of this session, we made the first use of native Mark5B playback during correlation (as opposed to playing a Mark5B recording via the Mark5A+

firmware on a Mark5A unit). Session 2/2010 also saw the first operational use of the SFXC correlator for a user experiment — one requiring pulsar gating.

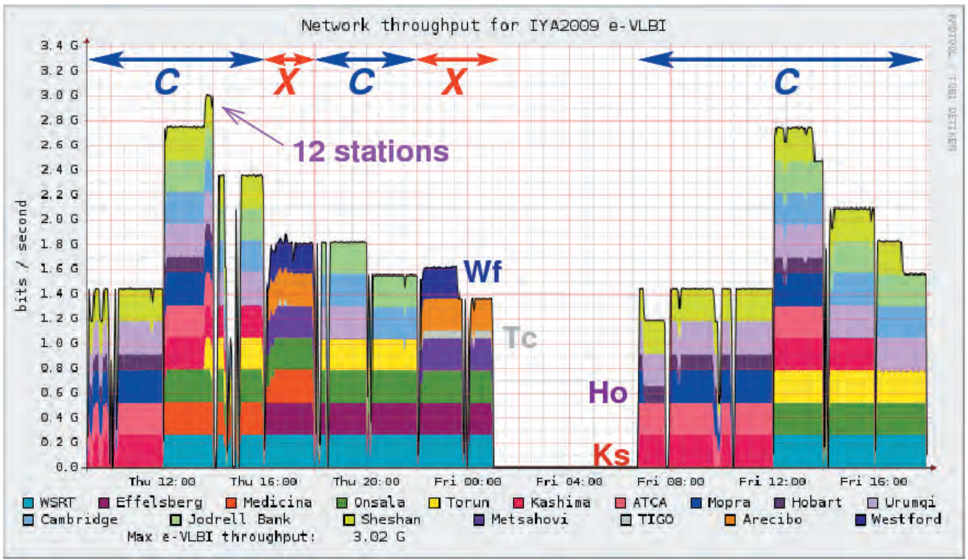


Figure 2.1 Network throughput plot for the International Year of Astronomy e-VLBI demonstrations.

Session 3/2010 continued the practice of placing e-EVN observations in the midst of a disk session, in order to accommodate a ToO. There were a total of 17 disk-based user experiments correlated at JIVE, plus that e-EVN ToO. The KVAZAR station Svetloe participated for the first time in NMEs and user experiments. Hartebeesthoek returned to the array following it successful polar-mount bearing repair. We had fringes for the first time to VERA_Mizusawa, at 5cm, these recordings had to be transferred from the original VERA tapes to a disk-pack in Mark5B format. Two more user pulsar-gating experiments were correlated on SFXC.

In 2010, there were 40 e-EVN user experiments, including 15 ToOs (there were also two disk-based ToOs correlated at JIVE in 2010). Seven e-EVN user experiments took place within regularly scheduled disk sessions. e-VLBI continued to book large gains in 2009-10, both absolutely and as a fraction of total EVN observing. Figure 2.2 shows the evolution of annual EVN network hours since 2004, with the contribution of e-EVN represented by the shaded area. Figure 2.3 focuses on the e-EVN experiments, showing how they divide annual observing hours into different categories: ToOs, triggered observations (see the Astronomical Features section), short (<= 2hr) exploratory observations, experiments proposed for disk recording but conducted in e-VLBI, and the standard e-EVN observations in regularly scheduled sessions. By their nature, all e-EVN observations correlate at JIVE, and occupy a single correlator pass.

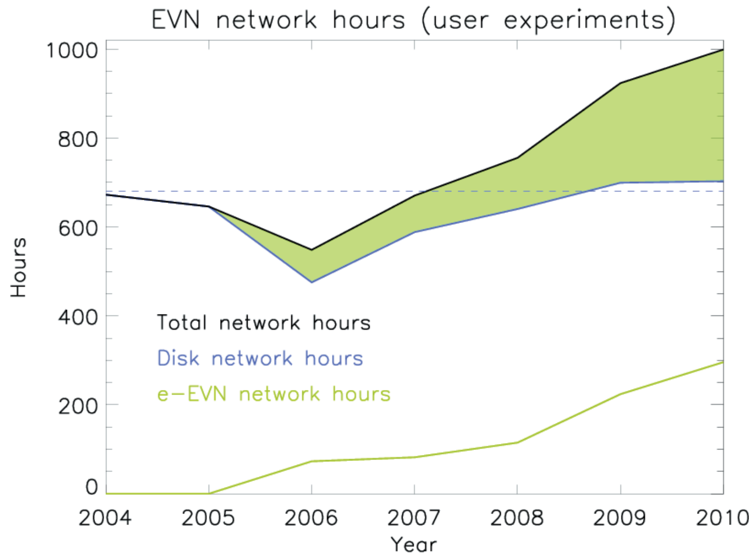


Figure 2.2: Annual EVN network hours, with the contribution by e-EVN observations shown by the shaded area.

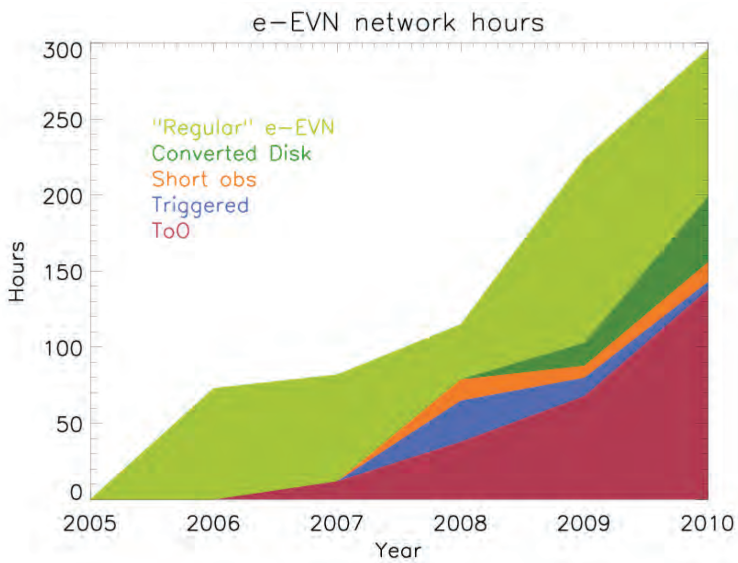


Figure 2.3: Division of annual e-EVN network hours into categories.

Tables 2.1 and 2.2 summarize projects observed, correlated, distributed, and released in 2009 and 2010. They list the number of experiments as well as the network hours and correlator hours for both user and test/NME experiments. Here, correlator hours are the network hours multiplied by any multiple correlation passes required (e.g., because of continuum/line, separate correlation by subband/pol to maximize spectral resolution, etc.).

	User Experiments			Test & Network Monitoring		
	N	Ntwk_hr	Corr_hr	N	Ntwk_hr	Corr_hr
Observed	91	859	1148	35	176	181
Correlated	83	772	983	32	162	172
Distributed	88	824	1065	32	161	166
Released	91	854	1085	34	170	175
e-EVN experiments	29	224	224			
e-EVN ToOs	6	68	68			

Table 2.1: Summary of projects observed, correlated, distributed, and released in 2009.

	User Experiments			Test & Network Monitoring		
	N	Ntwk_hr	Corr_hr	N	Ntwk_hr	Corr_hr
Observed	98	778	1041	16	51	51
Correlated	109	917	1236	19	67	67
Distributed	105	883	1183	20	73	73
Released	98	833	1155	16	61	61
e-EVN experiments	40	296	296			
e-EVN ToOs	15	138	138			

Table 2.2: Summary of projects observed, correlated, distributed, and released in 2010.

Figure 2.4 presents various measures of correlator efficiency. The red line plots the completed correlator hours per during time actively devoted to production correlation. The green line shows completed correlator hours over the total operating time of the correlator - the red and green lines diverge more in periods when production takes up a smaller fraction of the total time available. The blue line shows completed network hours over total operating time - the green and blue lines diverge because some experiments require multiple passes. A twelve-week running average is shown to smooth out spurious peaks caused by periods with no remaining production correlation.

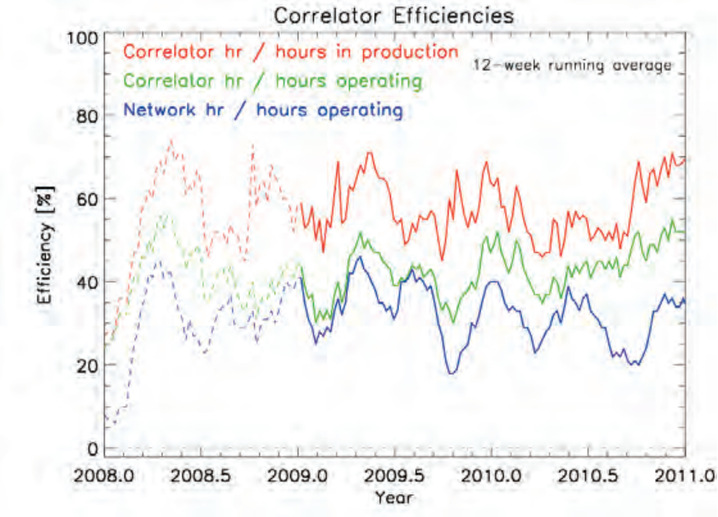


Figure 2.4: Various measures of correlator efficienc.

Figure 2.5 presents the size of the correlator queue at different stages in the processing cycle, showing a snapshot of the status at the end of each week. The red line plots the number of correlator hours that remain to be correlated. The blue line plots the number of correlator hours whose data remain to be distributed to the PI. The green line plots the number of correlator hours associated with recording media that have yet to be released back to the pool (in practice, release occurs prior to the following session, leading to a blocky pattern for the green line).

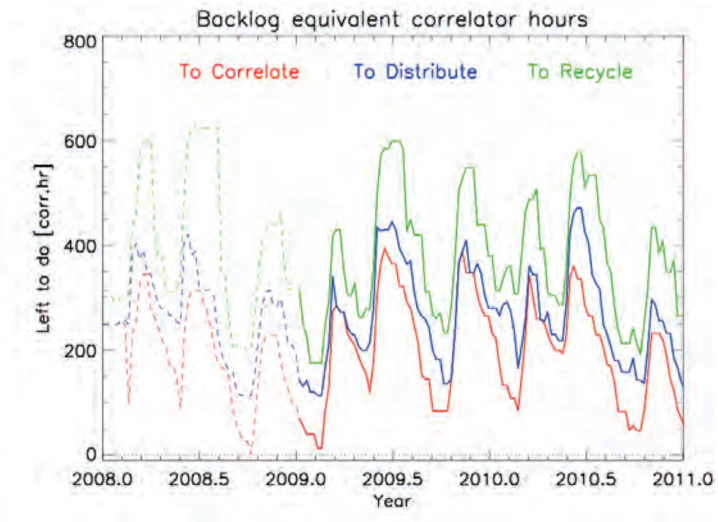


Figure 2.5: Size of various correlator queues, measured in correlator hours.

Figure 2.6 shows the number of user experiments and the number network and correlator hours correlated since 2003, with the hours for user experiments (diamonds) and the combination of user experiments and NME/test observations (squares). The number of network hours correlated at JIVE, especially when considering both user experiments and NME/test observations, shows a steadily increasing trend. The growth in the number of user experiments has accelerated in recent years thanks to the new e-VLBI observations (more than tripling from 2005 to 2010). Both the increasing correlator hours and surging number of experiments place distinct pressures on the Science Operations and Support group, with PI interaction scaling more closely with numbers of experiments rather than their duration.

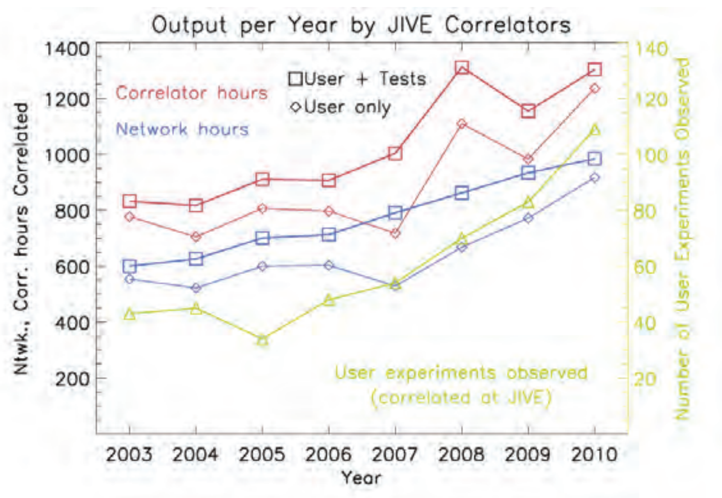


Figure 2.6: Amount of correlator and network hours plus the number of user experiments correlated in each year.

2.1.2 LOGISTICS AND INFRASTRUCTURE

The disk-shipping requirements are derived from the recording capacity needed by a session and the supply on-hand at the stations (from the TOG chairman). The EVN and VLBA stations follow different sets of guidelines. The EVN policy states that stations should buy two sessions' worth of disks, hence the disk flux should balance over the same 2-session interval. Following distribution to the stations for session 3/2010, we had "over distributed" a net cumulative 47.2 TB of disk-pack capacity. On the other hand the VLBA's need for sub-session turn-around, which essentially requires pre-positioning the difference between what NRAO stations will observe in globals to be correlated at JIVE and what EVN stations will observe in globals to be correlated in Socorro. Following the shipments in both directions for session 3/2010, we had "over distributed" a net cumulative 213.12 TB of disk-pack capacity. This has been built up entirely within 2010 (at the end of 2009, it was 6.23 TB) thanks to a series of long globals, that was correlated in Socorro.

Especially in 2010 sessions, experiments have been going to three different correlators. This added some complexity to the pre-session disk-distribution planning. The principal goal is to avoid individual packs containing data for more than one correlator. Should this occur, then some copying of raw data over the web would be required from correlator to correlator. Thus in the disk-distribution plan, the load for each target correlator for each station is computed separately. Packs on-hand at a station are applied to one of these individual-correlator loads prior to calculating what replenishment is required from JIVE. We try to use preferentially the largest-available packs for the farthest stations (to cut down on shipping), but consistent with minimizing unused capacity.

By the end of 2010 the play-back line-up is 14 Mark5As, 2 Mark5Bs, 1 Mark5B+, and 7 Mark5Cs. The MarkIV correlator is still limited to a maximum of 16 stations. Among the standard EVN stations, Westerbork, Yebes, Urumqi, Badary, Zelechukskaya, and Svetloe currently provide Mark5B recordings (as do typically the Japanese stations and Kunming among the non-EVN stations correlated in this biennial period). We can play back via a Mark5B unit (bypassing the station units) or via a Mark5A unit using the capabilities of the 5A+ firmware. Because Mark5B units cannot play back Mark5A recordings, we do need to retain enough 5A units to handle the maximum expected number of Mark5A stations (through 2010: ten EVN stations, plus VLBAs and Robledo) to minimize the conversions between Mark5 "flavours" of the individual units. Playback through the Mark5B units does result in lower statistical noise in the correlated phases, so there is emphasis on moving away from Mark5A as soon as the stations upgrade. Maintaining the proper mix of playback units in light of the phasing of these changes is reminiscent of that required in the initial tape-to-disk transformation. The SFXC could in principle accept a 24-station array, not limited by the number of station units, even for the Mark5A recordings.

We continue to encounter the occasional individual bad disk (or two) in an incoming pack. We maintain a small bench stock of disks of various sizes so that we could replace a bad disk locally if that is the most appropriate course of action (in light of warranty status, urgency of recycling, etc.), and then we would get a new disk from the pack's "owner" to replenish our bench stock. All but the highest data-rate recordings generally play back well with a bad individual disk disconnected. There was an unusually high amount of difficulty with Gbps recordings in session 1/2010, coincident with the introduction of some new 8TB SATA packs, that drove the processing factor (actual correlation time required over the number of correlator hours) up from a typical 2-2.4 to over 4. This did not recur subsequently, so was probably limited to a specific batch of disks.

Figure 2.7 Participants of the 10th EVN symposium, held in Manchester (UK) in September 2010

2.1.3 ASTRONOMICAL FEATURES

The impact of e-VLBI on expanding the kinds of astronomy that can be successfully pursued with the EVN was truly felt in 2009-10. Figures in section 2.1.1 illustrate the rapid growth in e-EVN observating, both absolutely and as a fraction of total EVN time. Target-of-opportunity (ToO) experiments form the greatest advance. There have been 19 ToO proposals submitted in this two-year period (including one global and 2 disk-based ones), considerably more than in the previous decade — illustrating the change in mind-set with which astronomers view the EVN as an instrument that can respond rapidly to outbursting sources. These projects have addressed novae, outbursts in masers, X-ray transients and microquasars, newly discovered supernovae, and also provide the means to coordinate the EVN with observations at other wavelengths — typically high-energy satellite observations looking to study correlations of changes in radio brightness/structure with high-energy brightness variations. In 2010, a full 38% of the observed EVN network hours correlated at JIVE were e-VLBI observations, and 47% of these (18% of the total) were e-EVN ToOs. Triggered observations provide another means to approach transient behaviour of a pre-selected set of sources without the stress of preparing a ToO proposal, enabling e-EVN observations of one of a proposed source when its behaviour prior to an e-EVN session shows that it has entered an interesting state. Once such a triggered proposal has been accepted, the group only needs to submit a short trigger request up to 24hr before the start of an e-EVN session, showing that the triggering criteria are met, to be considered for observation in that session. Such proposals have focused on X-ray binaries, and there have been three "triggers" executed in this period. Short observations have always been possible with the EVN, requiring only a request letter to the PC chair in lieu of a full proposal. For e-

EVN, short observations are considered to be up to two hours, and need to be requested up to three week before the desired e-EVN observing day. There have been 11 short e-EVN observations in 209-10, typically checking for calibrators or confirming compactness of a target prior to a full proposal for a more extensive study.

Recirculation is a means of time-sharing correlator resources for experiments that don't use the maximum sampling rate (32Mb/s , 16MHz Nyquist-sampled subbands), in order to increase the apparent spectral capacity in experiments that would otherwise have had spectral resolution limited by the number of stations or polarizations. The downside of recirculation is that the minimum integration time also scales with R, which may affect narrow-band spectral-line observations wanting a wide field of view. We also learned that the combination of recirculation on oversampled data does not work together. So users wanting 1024 or 2048 frequency points across 0.5 MHz sub-bands, would need to choose oversampling instead of recirculation, with the possible array-size limit of 8 stations. Recirculation was first used operationally for user experiments in session 1/2009, and has been on by default starting from session 2/2009 (we turn it off explicitly for short integration-time or oversampled experiments).

The possibilities for including additional MERLIN out-stations in the EVN correlation continue to expand. We had already incorporated one additional dual-pol and three additional single-pol stations into the Cambridge recording in user experiments (one station/pol per each of the VLBA recorder's four IFs). The extra out-station data can be placed into "unused" subbands - ones in the observing set-up not needed for the 128 Mbps data per out-station transmitted over the MERLIN micro-wave link. We can now use multi-casting techniques developed for e-VLBI to access all stations' data from the single Cm disk-pack directly. The benefit is avoiding having to copy the Cm pack , the cost is use of an additional two Mark5 units during correlation to simulate the e-VLBI transfer into the switch/router. In 2010 e-VLBI testing, more than one dual-pol out-station was able to be placed into the Cambridge data, by putting the 16 MHz signals from two station/pols into a single 500MHz IF by up-converting one of them when mixing into the IF and down-converting again when mixing into the BBCs.

SFXC has provided the capability to provide pulsar-gated correlation at JIVE, three such experiments have been observed in the last two sessions of 2010. A number of independent bins can be placed within a single gate that has a start/stop phase with respect to the pulsar period. Each bin would produce a separate FITS file. Traditional gating in the MarkIII sense corresponds to 1 bin. Figure 2.8 shows an example of a correlation with 100 bins spread over a gate of a tenth of the period for PSR 0329+54 at 1.4 GHz. Figure 2.9 shows the Effelsberg single-dish pulse profile, illustrating that the SFXC pulse profile, built up from the independent bins within the gate, reproduces the pulse profile well. Other types of experiments that would immediately benefit from SFXC would include those with more than 16 stations and spectral-line experiments wanting more than 2048 frequency points per subband/pol.

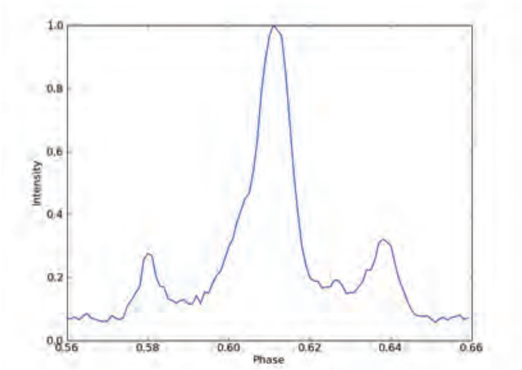


Figure 2.8: Pulse profile for PSR 0329+54 built up from 100 separate bins within a gate of one-tenth of the pulsar's period, from a test observation at 1.4 GHz

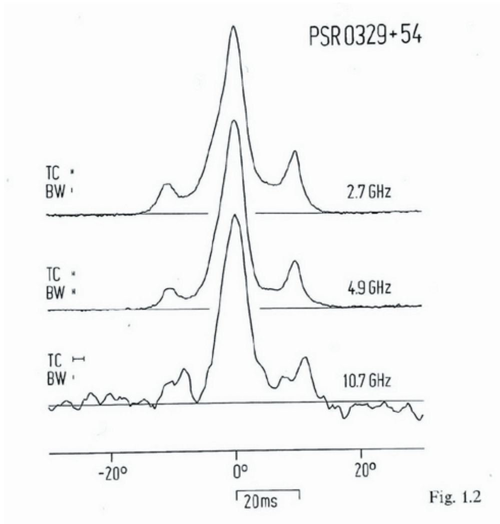


Figure 2.9: Effelsberg single-dish pulse profile from Sieber et al. (1975, A&A, 38, 169).

2.2 EVN SUPPORT

Automatic-ftp fringe tests are included in all network monitoring experiments (NMEs) at the beginning of each new frequency sub-session within EVN sessions, or as a separate fringe-test observation when the NME does not appear first in the schedule or falls outside working hours. Under the control of sched and the field system, a specified portion of a scan is sent directly to the software correlator computer at JIVE. In a three-hour NME, there would typically be ftp transfers from three scans, providing the opportunity to confirm the resolution of any problems identified in the first transfer. Use of ftp transfer and near-real-time correlation permits stations that don't have a full e-VLBI fibre connection to participate. A Skype chat session during the ftp fringe-test observations provides even more immediate feedback between the station friends and the JIVE support scientists. Correlation of the ftp fringe tests takes place on the SFXC correlator, and correlation results go to a web page available to all the stations, showing baseline amplitude and phase across the band as well as autocorrelations. The web-based results from the first and probably the second ftp transfer would be available to the stations before the end of the NME. These ftp fringe tests continue to be very successful in identifying telescope problems and helping to safeguard user experiments by allowing the station friends to take care of any such problems before the actual astronomical observations begin.

The EVN pipeline now runs under ParselTongue (see section 3.6.2). The new pipeline is considerably easier to use, more robust and has much greater scope for future development due to the improved coding environment. The pipeline scripts are available from the ParselTongue wiki and should provide a good basis for other (semi-)automated VLBI reduction efforts. We continue to process all experiments, including NMEs, via the pipeline, with results being posted to the EVN archive. The pipeline provides stations with feedback on their general performance and in particular on their gain corrections, and identifies stations/frequency bands with particular problems. Timely delivery of ANTAB amplitude calibration results from the telescopes seems to be improving, but remains an issue in e-VLBI experiments due to the shorter time-scales involved.

JIVE staff helped Onsala investigate the performance of their new optical-fiber system for getting the RF down from the 25m antenna. Jun Yang determined improved SEFDs for Jodrell Bank Mark2 and Cambridge from a series of NMEs from 2009. Torun appeared to be missing fringes in only some 5cm (methanol maser) experiments in some sessions in 2009, it was discovered to be a LO change between EVN and single-dish observations that isn't under field-system control. Once this was realized, we were able to go back and correlate with the appropriate LO offset (1 MHz) and see fringes in the NME from session 3/2009. The station took measures to avoid the problem subsequently. Session 1/2010 saw the first time Mark5B EVN data went to Socorro for correlation, we passed along the appropriate bit-stream/channel layouts for these stations in the various experiments.

There have been quite a few new stations participating in astronomical observations. The three KVAZAR stations have joined the EVN as members, and strengthen the array's capability to provide long baselines. We conferred with the station friends at IAA to understand how to provide set-up information in the user schedule files to work best with their data acquisition systems (see "PI Support" section). Stations in Japan (Yamaguchi 32m, VERA_Mizusawa) have participated in some methanol-maser astrometric observations. These are not under field-system control, and provide Mark5B-format disk-packs they generate by translating from their natural K5 format and/or VERA recording tapes. Two new stations in China participated for the first time in EVN observations late in 2009: Kunming in the Phoenix mountains in southwest China and Miyun, about 140 km northeast of Beijing (see figure 2.11). Jun Yang helped organize the shipment of Westerbork's Mark4 data acquisition system to Kunming (superfluous at Westerbork since the establishment of their new fully digital TADUmax back-end, cf. section 2.2 of the JIVE biennial report 2007-2008). This Mark4 equipment would enable Kunming to record at a full Gbps, up from their previous 128 Mbps limit.

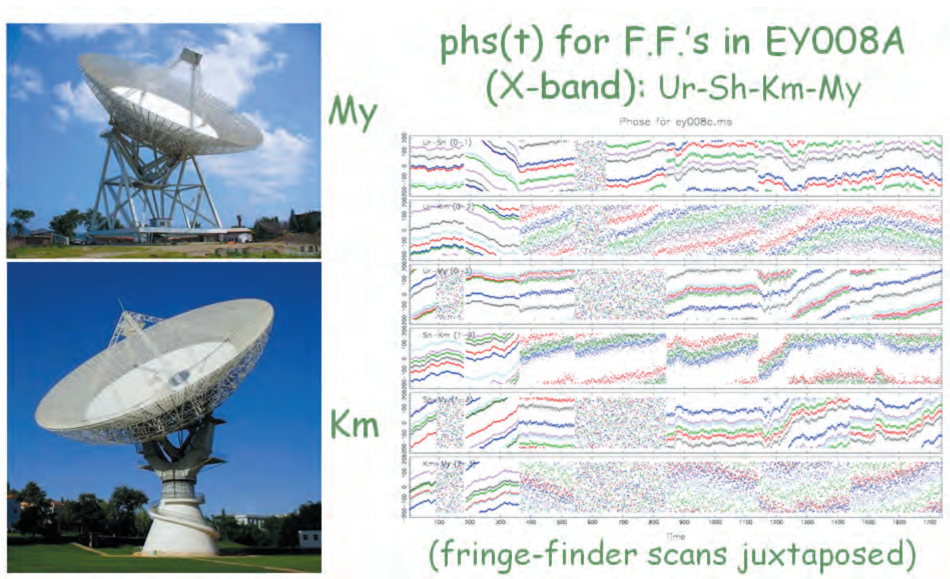


Figure 2.10: The Miyun (My) and Kunming (Km) antennas, along with phase versus time for fringe-finder scans in the experiment EY008A (August 2009) on baselines formed by sub-array Shanghai, Urumqi, Miyun, and Kunming.

2.3 PI SUPPORT

The EVN Archive at JIVE provides web access to the station feedback, standard plots, pipeline results, and FITS files for experiments correlated at JIVE. Public access to the FITS files themselves and derived source-specific pipeline results is governed by the EVN Archive Policy: the complete raw FITS files and pipeline results for sources identified by the PI as "private" have a one-year proprietary period, starting from distribution of the last experiment resulting from a proposal. PIs can access proprietary data via a password they arrange with JIVE. PIs receive a one-month warning prior to the expiration of their proprietary period. The archive machine has 12.8 TB of dedicated disk space, with a buffer of another 1.8 TB that also houses the pipeline work area. The total size of the FITS files in the archive at the end of 2010 was 9.43 TB, figure 2.11 shows the growth of the FITS-file size in the EVN archive size over time.

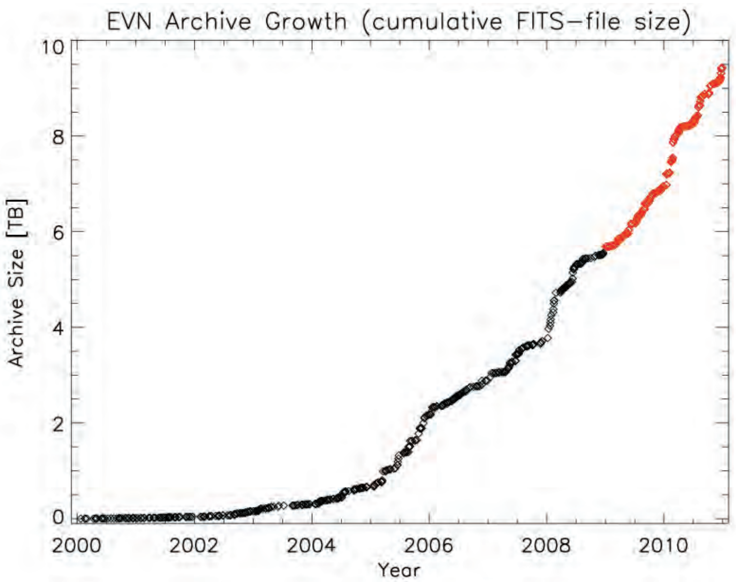


Figure 2.11: Growth in the size of FITS files in the EVN archive. Experiments archived in this biennial period are plotted in red.

We have begun to post two new types of FITS data on the archive: (i) FITS files from the Westerbork-array data obtained during the course of EVN observations, and (ii) the pipeline-calibrated UV-FITS files for individual sources. The Wb FITS files aren't directly available to users as such from the station, we take care of the data transformation from the Wb-archive Measurement Sets, and place the resulting FITS files on the archive along with the FITS files from the EVN correlation. In some cases (e.g., small-field continuum mapping), the Wb FITS data can be several times the size of the EVN FITS data, so this extra processing is currently driven by PI request. The pipeline-calibrated UV-FITS data for individual sources contains the cumulative effects of all steps of calibration within the EVN pipeline. These pipeline-calibrated FITS files associated with "private" sources are protected by the same one-year proprietary period as are the plots/images of these sources and the full set of raw IDI FITS files.

The science operations and support group continues to contact all PIs once the block schedule is made public to ensure they know how to obtain help with their scheduling. There were 14 first-time

EVN PIs in 2009 and another 13 in 2010. We also checked schedules PIs posted to VLBEER prior to stations downloading them, with safeguards in place to minimize the chance that different stations use different versions of an experiment's schedule. In session 3/2010, after the PIs had deposited their schedules we learned that the Lovell telescope would not be able to observe. Behind the scenes, we restored Jodrell Bank Mark2 to schedules that had used the Lovell, including reinserting scans it may have missed in fast cycle-time phase-referencing observations. There continues to be the very occasional instance (only three times this period) of a PI trying to work a non-authorized target into the schedule, we address these to the EVN PC chairman. The pre-observation communication also provides the opportunity to inform eligible PIs about the benefits of the RadioNet trans-national access programme, as well as the extra reporting they would eventually need to provide.

JIVE hosted 8 data-reduction visits in both 2009 and 2010. In addition, there were six post-graduate students who were co-supervised by members of JIVE staff during all or part of this period, and who visited frequently. The visitors' room has five dual-processor PCs running Linux, a MAC-mini, and a windows-based PC. Three of the Linux PCs have been replaced with more powerful machines this period, and these are also dual-boot Linux/windows.

3 TECHNICAL OPERATIONS AND R&D

During the period 2009-2010 the staff members of the Technical Operations and R&D group were involved in a large number of nationally and internationally funded projects. The EC-funded EXPReS project was extended to September 2009, followed by NEXPReS, which kicked off in July 2010. Work on the NWO-funded SCARIe project continued throughout the period, furthering the ambitions of JIVE in the field of distributed software correlation. JIVE also returned to digital engineering, with the start of the RadioNet FP7 UniBoard project, an international collaboration aimed at creating a generic FPGA-based high-performance computing platform along with several demanding radio-astronomical applications. This was accompanied by a number of related NWO-funded projects, such as ExBoX which aims at creating larger computing systems for correlation and beamforming, using the UniBoard as a building block, and the ShAO-NWO collaborative agreement, which stimulates the collaboration between Shanghai Observatory and JIVE through the exchange of scientists and students working in the fields of FPGA-based correlation and space science applications of VLBI.

As a consequence, several of the members of this group had to take on extra responsibilities in the form of the management of internationally distributed work packages. The new projects also posed new engineering challenges, which were met with enthusiasm and creativity.

Staff members also fulfilled many other tasks in international context, liaising with research networks, the EVN partners and VLBI institutes in general, and participating in committees dealing with issues like the standardisation of VLBI formats and the modification of VEX standards.

The maintenance and improvement of the hard- and software infrastructure of JIVE remains one of the key tasks of this group. It is clear that the emphasis of this task will shift more and more towards enabling the large-scale use of the locally developed SFXC software correlator, and the implementation of a next-generation high-bandwidth FPGA-based correlator. While these will eventually completely replace the current EVN MarkIV hardware correlator and its custom-made peripherals, considerations of operational efficiency will determine the exact moment.

The success of the NEXPReS proposal also meant that key personnel could be kept, preserving (in)valuable expertise for JIVE. Throughout this period only one person left the institute, when Friso Olnon, one of JIVE's most experienced software engineers, reached retirement age. In the period between EXPReS and the start of NEXPReS, one software engineer was seconded to NRAO, to work on the ALMA correlator development and gain international working experience.

3.1 DATA PROCESSOR MAINTENANCE

3.1.1 GENERAL

Running a complex piece of machinery like a correlator on a nearly continuous schedule involves the maintenance of a large number of supporting systems. Cooling system, paternoster, fire alarm and extinguishing systems are just a few of the systems that need regular maintenance and occasional repairs. The emergency generator was found to malfunction and taken for service, UPS batteries had to be replaced. A serious failure of the ASTRON main cooling machine in October 2009, right before the first e-VLBI test involving Badary (one of the new EVN stations) forced JIVE and ASTRON staff to take unconventional measures. Emergency rental cooling units were installed in the correlator room and fans throughout the building were commandeered to keep the equipment going (Figure 3.1). Eventually, the test turned out to be a great success. Finally, to accommodate the future expansion of hardware in the JIVE cellar, a new electricity distribution board with its own high-capacity connection to the central mains was designed, to be installed in 2011.

Figure 3.1: first e-VLBI test involving Badary during a cooling machine failure

3.1.2 Station Units

In general, the Station Units (SU) continue to perform well. With two of the Mark5 units permanently converted to Mark5B, it became possible to permanently retire two SUs, which provided some relief with respect to the availability of spare parts. At the end of 2009, an obsolete SU was kindly donated to JIVE by the MPIfR in Bonn. As a result all the remaining SUs at JIVE are now byteslip-free. We expect to be able to retire more SUs as dBBC-Mark5B+/C combinations are installed at the stations.

3.1.3 Mark5 Units

The Mark5s, all upgraded in the previous reporting period, performed reliably. In fact, during the two years only one Mark5 power supply failed. This was repaired in-house. The spare Mark5 which had been on loan to Westerbork for debugging and commissioning of TADUmax was returned to JIVE.

3.1.4 MARK IV CORRELATOR

Still at the heart of EVN operations, the MarkIV correlator performed as it should. The problems that occurred mostly had to do with burned fuses. However, several correlator boards had to be replaced, as well as one power supply. For this the last available spare was used, but fortunately a new spare unit could be had from Westerbork.

3.2 DATA PROCESSOR DEVELOPMENTS AND UPGRADES

3.2.1 MARK5

All Mark5 units were equipped with 10G Ethernet cards. The spare Mark5 was converted to B+ for e-VLBI testing. As part of the NEXPReS project, seven complete Mark5C units were purchased from Conduant, two of which are already rack-mounted and operational. All units were upgraded to identical OS and Sdk versions through the central management server (Debian Etch and Sdk 8.2), and recommendations were made to the stations to follow suit, especially those who regularly participate in e-VLBI observations.

During the EXPReS project, a considerable amount of effort was put into re-writing the Mark5 control code, primarily in order to enable high-bandwidth UDP-based e-VLBI. Several new features were added, such as packet and channel dropping, to make better use of available bandwidth, and simultaneous recording/transmitting at the stations.

In NEXPReS this development continued, with an extensive overhaul of the code base, providing a much more efficient usage of available CPU cores through multithreading. B+ support was implemented and tested (in collaboration with colleagues in Australia and New Zealand). At the end of 2010 the code was nominally stable but not quite sufficiently tested yet.

3.2.2 ARCHIVE

At the end of 2010 the usage of the JIVE data archive reached about 12 TB, more than 75% of the total available capacity of 15 TB. To deal with the expected increase of data output (among others because of the increased use of the software correlator) a new solution to the archive storage will have to be found in 2011.

In 2009 a power failure caused several disks to break. These were restored, and in the course some technical issues were resolved as well, greatly improving backup and restore speeds. Work on specific archive tools dealing with web statistics and search of fits files continued, with improvements both in performance and page layout. Because of the adoption of Drupal (a content management system) for the JIVE webpages, fairly extensive modifications had to be implemented to make the archive pages available within this new system.

In 2010 an archive backup machine was purchased, together with the astronomy support group of ASTRON, and installed at the ASTRON Westerbork location. The machine consists of three SuperMicro SC-846 24 drive chassis, only one of which has a mainboard with CPU, memory etc, running the OpenSolaris operating system. The main node also contains SAS controllers for its internal 24 drives (ZFS filesystem) and for each of the cpu-less chassis.

Initially the storage was divided into a pool for the JIVE archive backup, and a second pool for the astronomy group. The backup machine has recently been expanded by adding a fourth chassis with 24 2TB drives. It is located in one of the Faraday cages at the WSRT and connected via the regular ASTRON network between the WSRT and Dwingeloo. Through this connection a daily updated mirror of the JIVE archive is maintained.

3.2.3 CONTROL AND DATA ACQUISITION SYSTEMS

The three identical Solaris servers handling the correlator control and data acquisition performed reliably. A new database architecture was designed, with the inclusion of replication to guarantee higher availability. The migration of all production databases to this system is now ongoing. The thin clients used for the multiple screen display on the operators desk were replaced by a simple Linux PC with graphics support for four screens.

Figure 3.2: new control displays at operators desk

3.2.4 MARK5A TO B UPGRADE

The upgrade of the Mark5A units currently in use at JIVE to Mark5B has been a long-standing and high-priority issue, as this would allow us to phase out the failure-prone SUs. However, although some of the stations do produce B-data (Yebes, Westerbork, Effelsberg and since recently, the KVASAR stations), the need remains to keep a nearly full implement of operational Mark5A/SU combinations at JIVE.

With the increasing use of the SFXC software correlator, the ongoing roll-out of dBBCs to the EVN stations and the full upgrade of the VLBA nearing its completion, this situation is fortunately bound to improve.

3.2.5 PCINT

The heavily used PCInt cluster, serving as the institute's common data processing platform, has reached an age where reliability issues start to dominate its operation. In order to find a replacement, a careful assessment was made of user demands and the expected size of future data products. By the end of 2010, a platform combining fast disk access, large storage and high performance had been selected and ordered. Likewise, an inventory had been made of user software that will have to be transferred, and various options (re-compilation, binary copies) had been evaluated.

3.3 SOFTWARE CORRELATOR

In the past two years the locally developed SFXC has turned into an operational system, with capabilities and features equalling and even surpassing those of the current EVN hardware correlator. Pulsar gating/binning functionality was implemented, including incoherent de-dispersion across each subband. This was successfully tested using both simulated data and data from a test observation done during EVN session 3 of 2009. The first user experiment was observed in session 2 of 2010, and the data was correlated and distributed after extensive comparisons of the non-gated scans with results from the MarkIV correlator.

The software correlator now also provides sampler statistics (on a per-integration basis), allowing the software correlator to provide better weights in the output data in case some data for an integration interval is missing. Restrictions on the maximum number of spectral channels were removed, and it is believed that the SFXC software correlator can now handle any spectral resolution that can be reasonably asked for by PIs.

Support for the new VDIF standard was added to the software correlator. Some initial testing was done using data produced by the Mark5A – VDIF software converter developed for the UniBoard project.

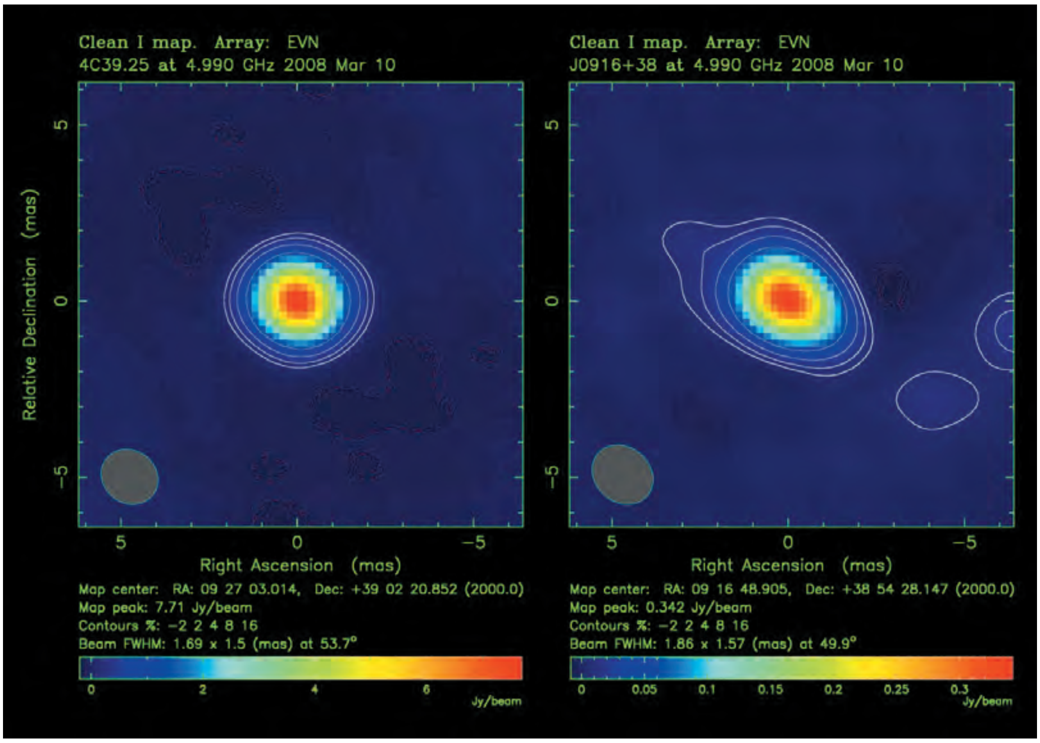


Figure 3.3: first image produced by SFXC of quasars 4C39.25 and J0916+3854.

In early 2010, a modest-sized cluster was acquired to run the software correlator, consisting of 16 compute nodes, each with two quad-core CPUs and a head node with a single quad-core CPU for a total of 132 cores. The machines were mounted in a rack located between the Mark5 playback units, to which they are connected through a dedicated Gbps network. The cluster nodes themselves are interconnected with a 40 Gbps Infiniband network. After installing the hardware, considerable effort was spent on fine tuning and adjusting of the software to achieve the best possible performance. As a result it is now possible to correlate 9 stations @ 512 Mbps with 1024 spectral points faster than real time (10 minutes of data taking just over 9 minutes of wall clock time). Larger arrays and higher bandwidths are easily accommodated by the software correlator at the price of additional correlation time. Based on the performance and operational success of the EVN software correlator, the decision was taken to expand the available hardware by at least a factor of two, which will take place in the first half of 2012.

In the course of NEXPReS, a new interface will be needed for the operators to run different correlators simultaneously, and to enable error handling and remote and (semi) automated operations. A first prototype of this interface has been implemented, currently only incorporating support for the SFXC software correlator. It makes use of the VEX – MySQL database conversion developed for the UniBoard project, and allows the specification of correlation parameters and the selection of specific scans, while providing feedback in the form of weight plots and rudimentary fringe plots.

Figure 3.4: the SFXC cluster, consisting of four Transtec Calleo 642 servers. Each server contains four nodes, each node is equipped with two quadcore Intel Xeon 2.26 GHz E5520, giving a total of 128 cpu cores.

Initially the fuseMark5 file system, developed at Metsahovi Observatory, was used for reading data from disk packs. Unfortunately fuseMark5 interferes with bank switching, so to streamline operations direct reading from Mark5 diskpacks was implemented.

Finally, in a development that will be of great importance for wide-field VLBI, support for correlating multiple phase centres was implemented and is now in the process of being tested. Multiple phase centre correlation is achieved by first correlating with sufficient time and spectral resolution for the entire field. These data are then phase shifted and averaged down for each individual phase centre. As all of this happens inside the correlator, well before the bottleneck that occurs when writing data to disk, these operations can be done extremely efficiently.

3.4 NEXT-GENERATION FPGA-BASED CORRELATOR

With the MarkIV hardware correlator nearing the end of its useful life, and software correlators just about getting close to being able to take over the current correlator functionality and load, the need for a 100-fold more powerful true next-generation EVN correlator remains. Over the past years, JIVE and its partners have sought ways to set this in motion, and have been successful in raising funds to start the development of a fully FPGA-based correlator. Three projects currently support this effort, the EC-funded UniBoard project, the NWO ExBoX project (in collaboration with ASTRON) and the ShAO-NWO collaborative agreement.

3.4.1 THE UNIBOARD

The concept underlying the UniBoard was originally proposed by Sergei Pogrebenko, system scientist at JIVE, in the late 90s. As one of the architects of the MarkIV correlator, he knew like no other the difficulties and technological pitfalls involved in the construction of such a complex instrument, consisting of many separate custom-made electronic components. A single-board, all-station correlator would do away with the need to transfer large, highly synchronized data streams between all these different components, with their associated complicated messaging systems and timing issues. Such a board should have all the CPU power that could be fitted on, in the form of Field Programmable Gate Arrays (FPGA), and as much I/O capacity as possible. However, in those days FPGA technology was not far enough advanced to make this feasible.

When the preparation for the RadioNet FP7 proposal got underway in 2007, the situation had changed completely, with new generations of FPGAs combining massive computing power with ease of programming and fast development. The concept now became the basis for the UniBoard, one of the Joint Research Activities (JRA) in RadioNet FP7.

The aim of this project, which kicked off on January 1 2009, was the creation of a generic high-performance FPGA-based computing platform for radio astronomy, along with the implementation of several demanding applications (correlator, digital receiver, pulsar binning machine). The board has generated a fair amount of interest in the radio-astronomical community, because of its high computing and I/O capacity, its potentially excellent computing/power consumption ratio and its use of generic interfaces. At this time concrete plans exist to use it as the basis for the next-generation EVN correlator, the Apertif correlator and beam former system and at least one all-dipole LOFAR correlator.

3.4.2 PROJECT STRUCTURE AND PARTICIPANTS

Originally the collaboration consisted of 7 participants, and in the course of the project two more partners joined. The first partners and their original roles in the project were:

- JIVE: project lead, VLBI correlator
- ASTRON: hardware and test firmware development
- University of Manchester: pulsar binning machine
- INAF: digital receiver
- University of Bordeaux: digital receiver
- University of Orléans: RFI mitigation in pulsar binning application
- KASI: VLBI correlator

later joined by:

- Shanghai Observatory: VLBI correlator
- University of Oxford: all-dipole LOFAR correlator

At this time the VLBI correlator, digital receiver and pulsar binning machine are all under development, while the RFI mitigation project has expanded to include both pulsar binning and digital receiver applications. In addition to the original applications, work has started or is expected to start soon on an Apertif correlator and beam former (ASTRON), all-dipole LOFAR correlators (ASTRON + University of Amsterdam, University of Oxford). Several other applications are being considered.

3.4.3 THE HARDWARE

At the start of the project, an inventory was made of the hardware requirements posed by the different applications. Considerations of price, availability and pin lay-out led to the selection of the Altera Stratix IV EP4SGX230KF40C2 chip (40 nm, 1288 18x18 multipliers, 14.3 Mb internal block RAM, 24 + 12 transceivers). With 1288 multipliers at 400 MHz each of these chips could yield a maximum of about 0.5 TMAC/s.

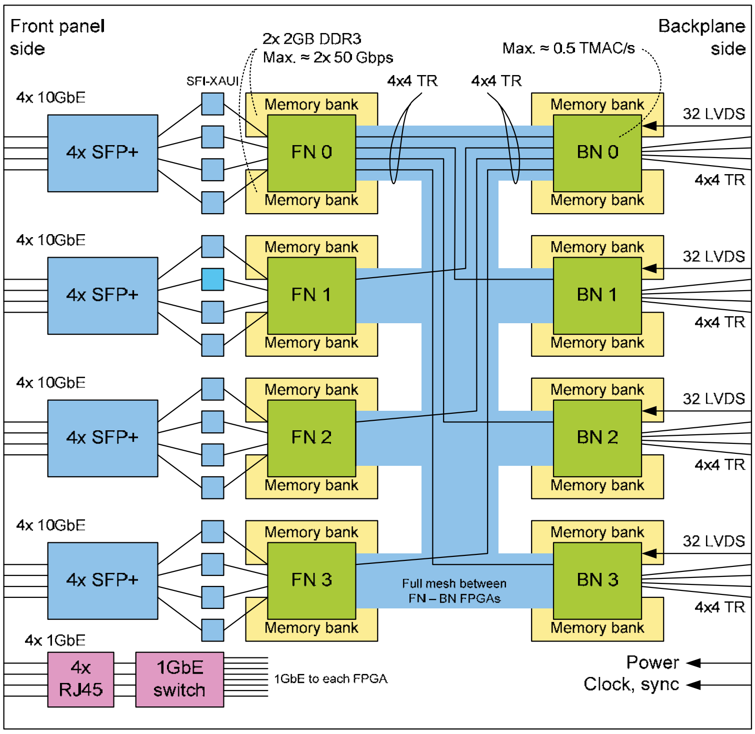


Figure 3.5: high level UniBoard design

A configuration of eight FPGAs per board was found to be optimal in terms of computing power, power consumption, density and complexity of the board (Figure 3.5). Each FPGA is connected to two DDR3 memory banks, mounted on the back side of the board. Four times four 10-GbE links connect to the front nodes (FN) via four SFP+ cages. A high speed mesh connects each FN to all back nodes (BN). The BNs in their turn connect via four times four 8-bits LVDS to a backplane connector. To make the board completely symmetrical, a 10G break-out board (the XGB) has been designed in the form of a mini-backplane, with a total of 16 CX4 connectors (Figure 3.6).

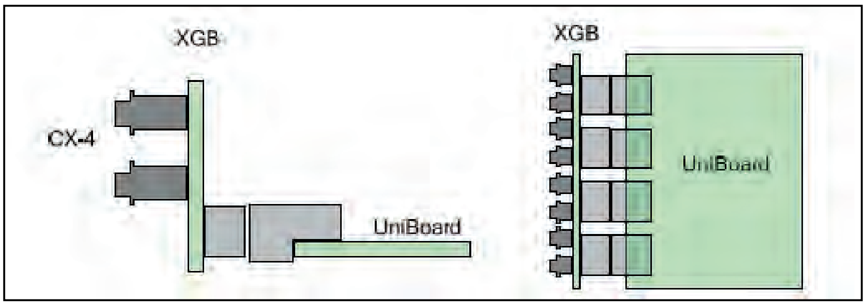


Figure 3.6: UniBoard with XGB mini backplane

For system management, each FPGA also has a 1Gb/s Ethernet connection to an onboard ethernet switch, which offers 4 x 1Gb/s connectivity on RJ-45 connectors. The central power supply of -48V is distributed on the board via DC/DC convertors and regulators, the PCB itself has 14 layers. Control and configuration are done via the embedded NIOS processor.

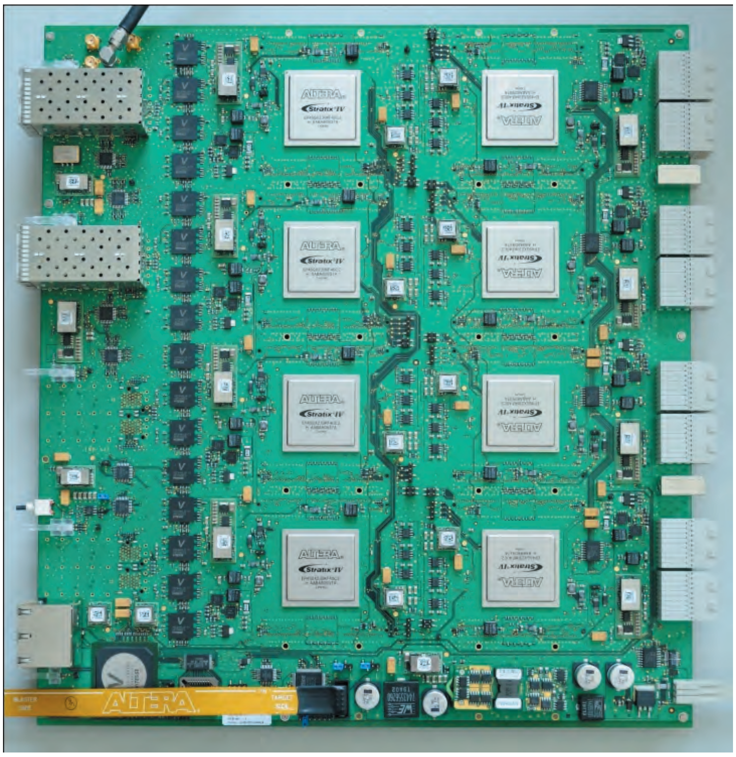


Figure 3.7: prototype UniBoard, delivered May 17, 2010

The actual PCB production and board assembly were outsourced. The prototype was delivered May 17, 2010 (Figure 3.7). No major design flaws have been identified, although power consumption at full load has turned out somewhat higher than the original estimate (~400W versus 280W). After a review of the modified design, a second production run has been initiated and the boards are expected April 2011.

3.4.4 FIRM- AND SOFTWARE

Throughout the board development phase, work on the various applications progressed , design documents were produced and refined, simulations were done and actual VHDL code was written. All documentation is posted on a project wiki, and all code is shared among the partners through a common repository. A large effort by JIVE and ASTRON engineers went into the construction of a general test design, combining tests of all interfaces and interconnections, which will be made available to the partners. The correlator design also progressed well, with most of the individual components (filterbanks, correlator engine, delay) either in place or under development by the end of 2010.

The board control is being written at JIVE, as is the general correlator control system. After careful consideration and the evaluation of a number of test cases the decision was made to do this in Erlang. This high-level programming language, fairly unknown in astronomical software engineering, provides robustness and a very high level of completeness. Importantly, for a project with limited resources, it also enables a very short code development cycle. In spite of the learning curve involved, this decision has worked out very well.

3.4.5 EXBOX

Several configurations for different applications are being considered, illustrated in Figures 3.10 and 3.11. This development is supported by ExBoX, which aims at combining UniBoards into much larger systems through custom-made back- or midplanes, suitable for example for Apertif. This also has a clear relevance for the even larger systems of the future, such as the phase 1 SKA correlator and beam former.

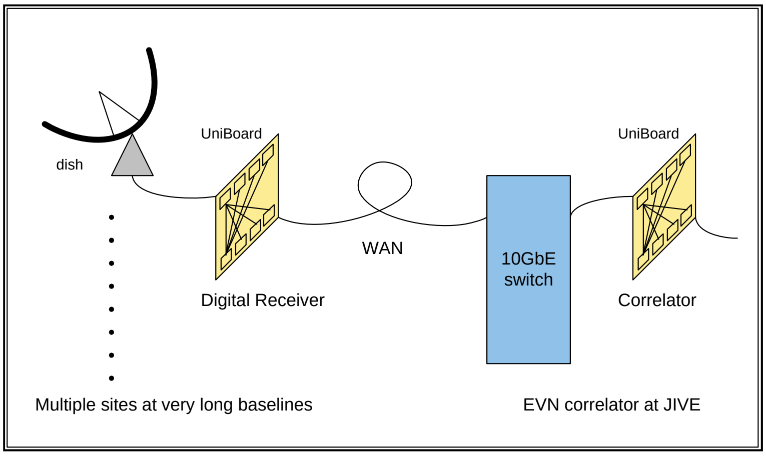


Figure 3.8: UniBoard as digital receiver and VLBI correlator, connected via internet

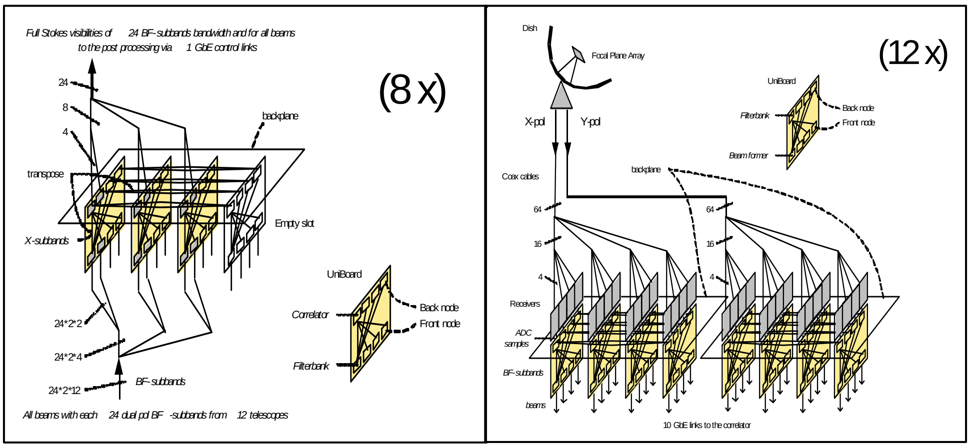


Figure 3.9: UniBoard as Apertif correlator (left) and beam former (right), interconnected via a custom-made backplane, with ADCs connected to the opposite side of the backplane

3.5 E-VLBI

In September 2009 the EXPReS project formally came to an end. By then, e-VLBI had become firmly established as a viable operational mode of the EVN, providing the same sensitivity and even higher reliability than disk-based VLBI. When Hartebeesthoek telescope returned on-line in 2010 after a major repair, at a full 1024 Mbps even, all important long baselines were available for real-time operations.

During 2009 several high-visibility e-VLBI demonstrations for the International Year of Astronomy took place (more on these demos in a next section). One demo featured a 33 hours (near-) continuous real-time tracking of several sources using telescopes from different arrays across the globe, something never done before in real time. The idea was subsequently picked up by a group of radio astronomers and used for a series of highly successful science observations.

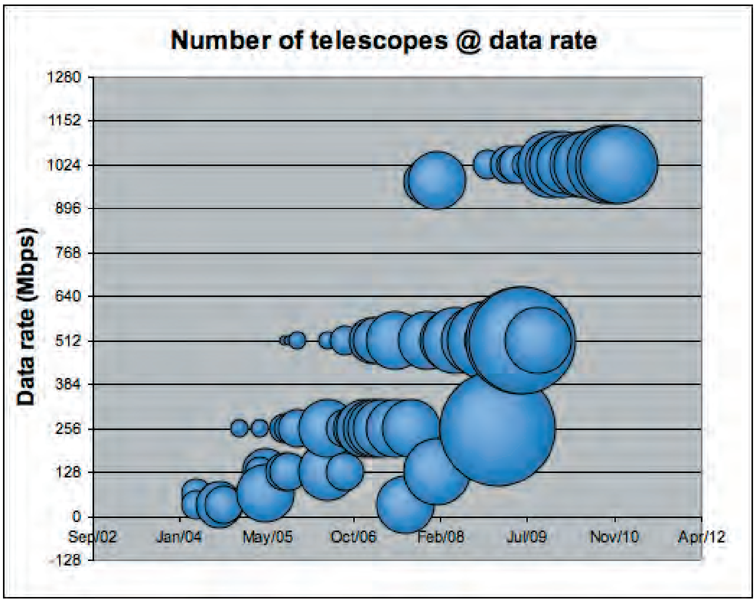


Figure 3.10: e-VLBI Bubble Plot. The size of the bubbles indicate the number of telescopes transferring data at a specific data rate. The smallest bubble is equivalent to one, the largest to twelve telescopes

Using various methods, data rates were optimised until most telescopes could transfer at a full 1024 Mbps. For those that still lack the connectivity, selective channel dropping allows a controlled cutting down of the data rate to maximise the use of available bandwidth.

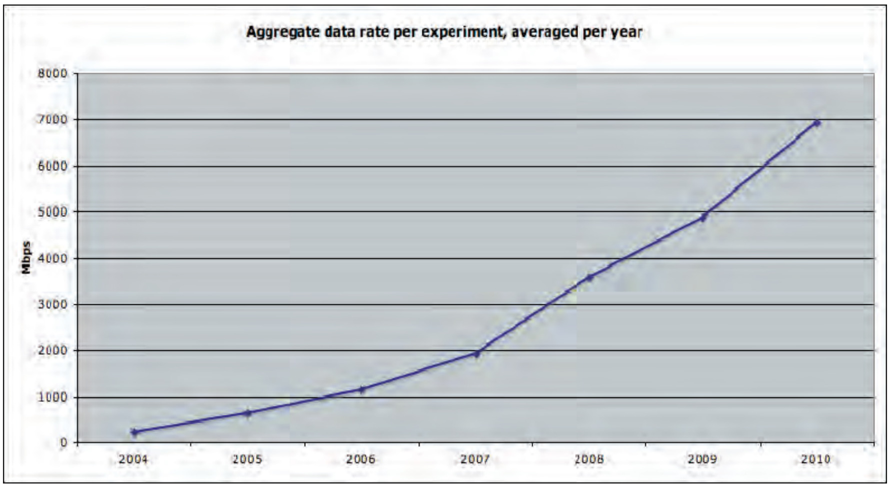


Figure 3.11: aggregate data rate streaming into EVN correlator per experiment, averaged per year

As in the previous reporting period, each year some ten to twelve 24-hour e-VLBI sessions were scheduled throughout the year. In addition, the number of Target of Opportunity and triggered proposals kept on growing, resulting in an unprecedented number of Astronomers' Telegrams, quite apart from the wealth of regular scientific publications. The increased popularity and use of e-VLBI is illustrated in Figure 3.11, showing the aggregate data rate, averaged per year, flowing in real time into the correlator at JIVE.

Technical developments continued, resulting in the precise control of interpacket spacing, which further stabilised data transfers. Optimisation of both correlator and Mark5 control code and additions to and refinements of the control interfaces and feedback mechanisms led to a system that can actually be run for many hours, manned by a single operator. This led to some of the longest uninterrupted correlation jobs on record, as illustrated in Figure 3.12.

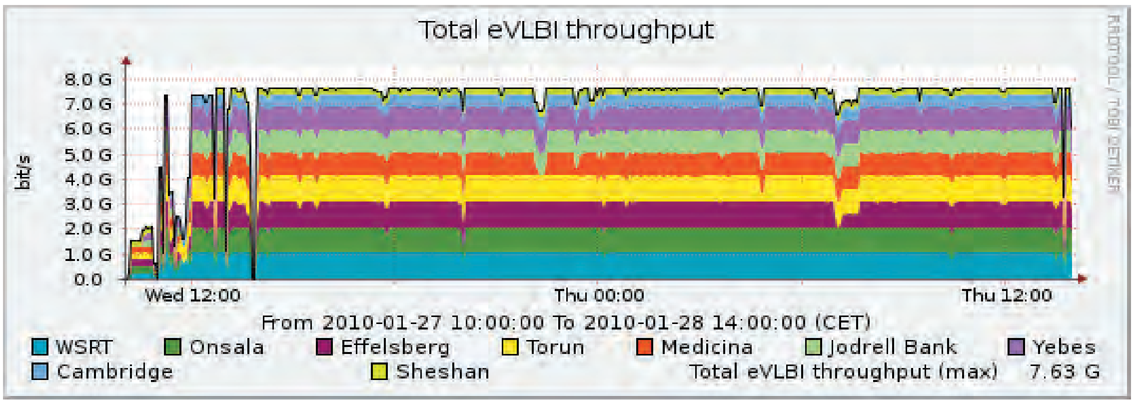


Figure 3.12: data throughput at JIVE during a >24 hour e-VLBI run in January 2010

3.5.1 The next step: NEXPReS

With EXPReS completed and global real-time 1Gbps e-VLBI a reality, a new look was taken at how the future of European VLBI might, or rather, should look. While the development of e-VLBI had been an outstanding technological success and had led to new and exciting science, it also was clear that some serious issues still needed to be resolved.

Connectivity of some telescopes remains an issue, and will remain so for the near future. At the same time, the current EVN rollout of new digital receivers and data acquisition systems will allow more sensitive observations at higher bandwidths, leading to data rates of 4 Gbps and more.

These considerations ultimately led to the successful submission to the EC of a follow-up project, called NEXPReS. The project itself is described in detail elsewhere in this biennial report, but its main aims can be summarised as follows:

- Make all VLBI into e-VLBI: correlate in real-time what can be correlated, with simultaneous recording, record and subsequently transport data from not-connected telescopes for later correlation.
- Investigate the use of bandwidth on demand through dynamical lightpaths at 1, 4 and even 10 Gbps
- Develop distributed correlation, using the assets (in terms of connectivity, storage and computing platforms) of the EVN, rather than the Grid.
- Design and test high-speed simultaneous read-write buffers, to be deployed at both stations and correlator
- Investigate the use of and access to high-capacity Long Term Archive facilities, designed to handle the extremely large data streams that will be generated by instruments such as LOFAR and Apertif.

NEXPReS kicked off in July 2010. In spite of difficulties hiring new staff for this project, work progressed well. The implementation of a new correlator control interface got underway, meant to allow simultaneous control of hard- and software correlators, and enable remote control and ultimately automated operations. The JIVE - developed Mark5 control software was completely overhauled, a MarkIV – VDIF on-the-fly convertor was created, as was a VEX – MySQL database translator. Finally, seven Mar5C units were purchased from Conduant, to be used for high-speed recording and data transfer.

3.5.2 Demonstrations

Live demos played a large role throughout EXPReS, both for outreach purposes and as convenient focal points for the project. The undoubtedly most ambitious of these took place at the opening of the International Year of Astronomy (IYA) in January 2009, at the UNESCO headquarters in Paris.

The original proposal for this demo was to track one source in real-time continuously over a period of 24 hours. The VLBI community responded enthusiastically, and the participants included both EVN and non - EVN telescopes in Europe, China, Australia, Japan and North and South America (unfortunately Hartebeesthoek could not participate due to a mechanical failure). Because of the various limitations imposed by available receivers and geography, a total of three sources were observed at two frequencies, spread over a period of 33 hours. (see figure 2.1)

In spite of a number of last-minute setbacks, which were all overcome through heroic efforts of the station staff members, and in spite of having to deal with 4 different data acquisition systems, and the fact that 4 of the 18 telescopes had never participated in e-VLBI with the EVN before, the demonstration went extremely well.

Extensive use was made at the venue of a large number of outreach tools, specifically created for the IYA demo. These included a special IYA VLBI website, an on-the-fly UV-plane/dirty beam plotter, an hourly updated Pypeline image of the sources, as well as an interactive VLBI demonstrator (Figure 3.13).

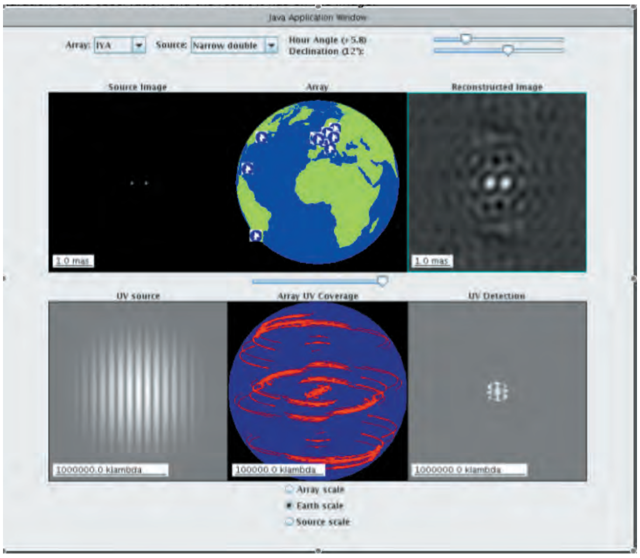


Figure 3.13: Interactive VLBI demonstrator

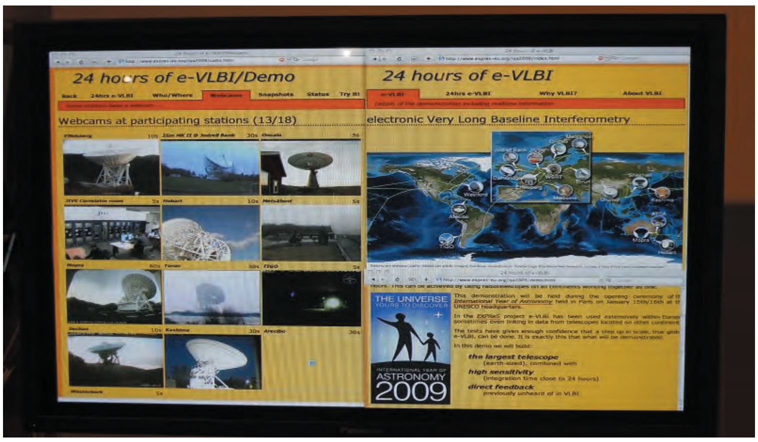


Figure 3.14: IYA VLBI pages, featuring live webcams of participating telescopes

Figure 3.15: JIVE staff in action at opening of the IYA in Paris, January 2009

This demo was followed by a somewhat scaled-down version, involving only EVN and Australian telescopes, during the so-called "Hundred hours of Astronomy". This IYA cornerstone event featured a 24-hour webcast, in which Huib van Langevelde represented the EVN, and displays of real-time results at the NEMO science museum in Amsterdam, at the open day at the Observatoire de Paris and at Arecibo Observatory. In these observations the new Yebes 40m telescope joined the e-EVN for the first time.

A demonstration of software correlation was one of the main attractions at the booth of NWO at the Supercomputing 2010 conference in New Orleans. During that demonstration, which featured the pulsar binning capability of the SFXC correlator, pre-recorded data were streamed from Mark5's at JIVE into the DAS3 cluster at the University of Amsterdam. A pulse profile was displayed on the Exhibition Floor at SC10 showing the profile emerging from the noise floor as more and more data were being correlated.

Figure 3.16: One of the collaborators in the SCARIe project manning the booth at SC10

3.5.3 e-VLBI WORKSHOPS

The 8th international e-VLBI workshop doubled as the concluding conference of the EXPReS project. It was held in June 2009 in Madrid, at the premises of the National Astronomical Observatory (OAN). With 86 registered participants it was one of the best-attended workshops so far. Particularly striking was the large number of excellent scientific contributions, clearly showing that e-VLBI has moved well beyond the stage of an experimental technique. At this workshop the new VDIF data format standard, defined by an international task force, was formally accepted by the VLBI community at large.

In October 2010 the workshop moved to Perth, Australia, where the topics dealing with e-VLBI were supplemented by reports on the exciting radio-astronomical developments in Australia. As always, this workshop was well attended, in this case by more than the usual suspects (Figures 3.17 and 3.18). A half-day meeting with the Australian NREN AARNET followed the 2-day workshop, and dealt with the many networking issues that have to be tackled to make ASKAP and, possibly, the SKA in Western Australia a reality.

Figures 3.17 and 3.18: International VLBI experts discussing the intricacies of certain scripting languages and chewing the fat with local residents

3.6 INFRASTRUCTURE SOFTWARE

3.6.1 ALBiUS

Interoperability

Stephen Bourke has developed software to facilitate the combined use of AIPS and Casa. The work focused on two areas, a combined Python environment, and a calibration transfer mechanism. The combined environment utilises the ParselTongue interface to AIPS, developed at JIVE under the ALBUS project and further enhanced under the ALBiUS project. By modifying the Casa environment (which implements a Python use interface) the simultaneous use of Casa and AIPS is possible, with the latter being accessed via its ParselTongue interface.

AIPS and Casa use different data formats, AIPS uses its own internal format and Casa uses the Measurement Set. The FITS format can be used as a common denominator as both environments have the ability to read and write the format. The size of datasets, however, makes this an inconvenient strategy for all but the most modest of observations. A more acceptable approach is to maintain a copy of the data in each both AIPS and Casa's native formats and convert only the calibration tables which are attached to the data throughout the data processing stages.

The most common use case for such an approach is to use AIPS for the early calibration stages, such as amplitude calibration and fringe fitting, both of which are currently missing in Casa, and then make use of Casa's plotting and imaging capabilities for subsequent processing. To enable this, software was developed to convert AIPS Gain,Delay,Rate and Bandpass (SN & CL, BP) tables into Casa Gain, Bandpass and Delay (G, B, K & KMBD) tables.

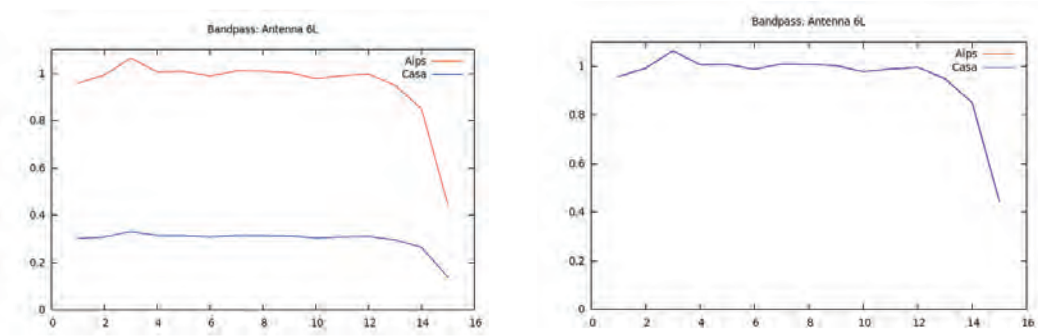


Figure 3.19 AIPS / Casa Calibration transfer. Software has been implemented to transfer calibration data from AIPS datasets to Measurement Sets. ParselTongue and Pyrap are used to directly access and modify calibration data. The first plot shows a bandpass produced in both Aips and Casa. The Casa bandpass was produced with a different normalisation. After transferring the Aips solutions to the MS, plot 2 shows the Aips and Casa tables to be equal.

3.6.2 PARSELTONGUE

During the last two years, ParselTongue saw some major development. An interesting new feature is the integration of AIPSLite. AIPSLite makes it possible to run ParselTongue on computers without a pre-existing AIPS installation. This makes it much easier to do parallel data reduction on a High Performance Computing cluster. AIPSLite was originally developed by Stephen Bourke and integration was done by Mark Kettenis.

Other major improvements are the ability to have random access to visibility data, and the ability to change visibility data. This feature already resulted in the development of some clever alternative calibration strategies, and helped other users in recovering some partly corrupted data. Of course there were the occasional bug fixes as well. The changes warranted a new major ParselTongue release, and ParselTongue 2.0 was made available to the user community in October 2010.

It's difficult to estimate the size of the user community. However it is obvious that it extends well beyond the boundaries of the traditional group of "VLBI back-belt" users. There is a fairly steady stream of new users that need help with installing ParselTongue on their system, and there are the occasional bug reports as well. In many cases these requests/reports come from outside the EVN institutes. User support is also in the hands of Mark Kettenis, with some help from Mike Sipior (ASTRON). The importance of ParselTongue for the community can be judged by the number of papers that cite the original ParselTongue paper. ParselTongue continues to be used for the EVN pipeline as well.

4 SCIENTIFIC RESEARCH

4.1 DISTANT SOURCES AND DEEP VLBI SURVEYS

In collaboration with Sándor Frey (FÖMI SGO, Penc, Hungary) and Péter Veres (Eotvos University, Budapest), Leonid Gurvits and Zsolt Paragi observed the high-redshift (z=4.72) blazar J1430+4204 with the VLBA after its major radio outburst in 2005. There were no major changes in the milli-arcsecond radio structure of the source, no new ejecta were found 569 days after the outburst. The group estimated the Doppler factor, the Lorentz factor, and the apparent transverse velocity of a putative jet component using three different methods. They used total flux density monitoring data from the Ryle telescope to obtain the variability brightness temperature, determined the VLBI brightness temperature by measuring the source size, compared X-ray and radio data assuming they were related via the inverse Compton process. By comparing the VLBI measurements with the variability of T_b they determined the intrinsic brightness temperature of this z=4.7 blazar (this have never been done at so high redshifts) and showed that it is in agreement with the equipartitional brightness temperature, just like as observed in lower redshift blazars (Veres et al. 2010, A&A 521, A6).

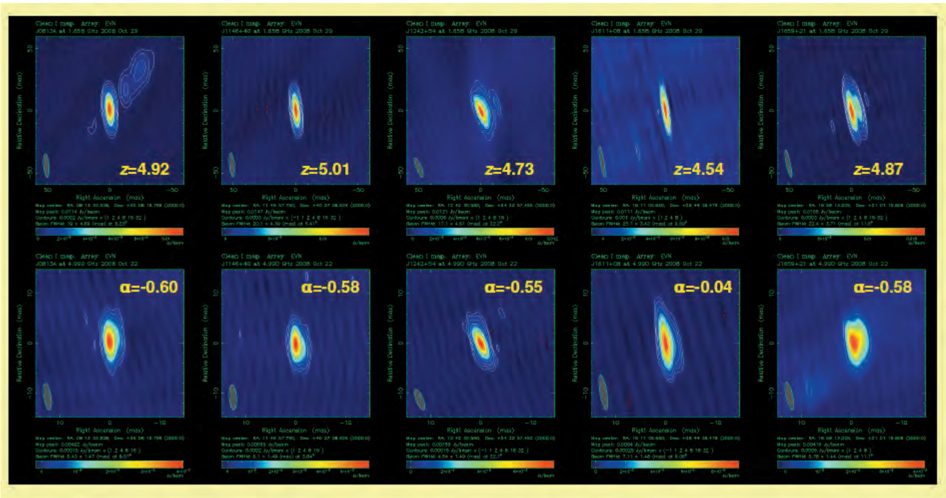
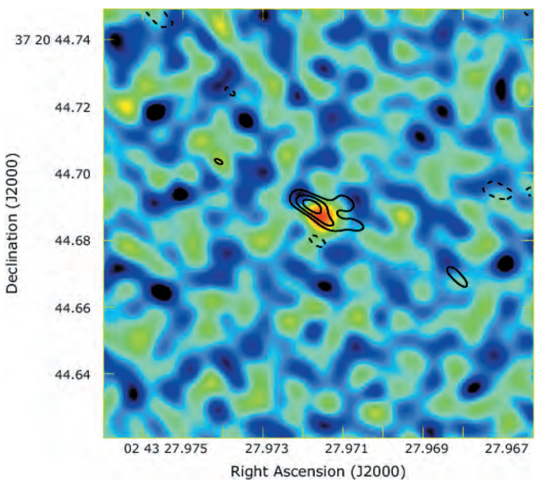


Figure 4.1: The 1.6 (above) and 5 GHz (below) EVN images of 5 very high redhsift quasars. These sources have significantly lower brightness temperatures than quasars at moderate redshifts, and tend to have steep spectra. They are probably young, evolving objects

Until recently there have been only seven quasars at redshifts greater than 4.5 observed with VLBI. This number was almost doubled in a mini-survey of the highest redshift quasars (4.5 < z < 5) with the European VLBI Network. Leonid Gurvits and Zsolt Paragi worked on this survey together with Sándor Frey (PI), Krisztina Gabányi (FOMI SGO, Penc, Hungary) and Dávid Cseh (Universite Paris Diderot, CEA Saclay). All five sources were detected at both 1.6 and 5 GHz, allowing for brightness temperature and spectral index measurements. In contrast to the brightest quasars at moderate redshifts, they had T_b~10^9 K and most of them had steep spectra, suggesting that they were not relativistically beamed sources. This indicates that they are likely to be young, evolving objects, resembling the gigahertz-peaked spectrum (GPS) and compact steep-spectrum (CSS) sources that populate the Universe at lower redshifts. The results were published by Frey et al. (2010), in Astronomy and Astrophysics.

4.2 GAMMA RAY BURSTS AND SUPERNOVAE

Zsolt Paragi, Huib van Langevelde, Arpad Szomoru, Bob Campbell, Yurii Pydoprihora and Stephen Bourke continued the work on the type Ic supernova SN2007gr detected by the e-EVN in 2007, and observed it with the EVN+GBT. The collaboration involved Greg Taylor (Univ. New Mexico, Albuquerque), Chryssa Kouveliotou (NASA MFSC), Jonathan Granot (Univ. Hertfordshire, Hatfield), Enrico Ramirez-Ruiz (Univ. Santa Cruz), Mike Garrett (ASTRON) and others. From the difference of VLBI peak brightness and WSRT/VLA total flux density measurements they concluded that the source must have expanded significantly, and determined a lower limit for the average apparent expansion speed of 0.61c. Monte-Carlo simulations showed that coherence losses could not explain the observed difference. This result was published in Nature (Paragi et al. 2010, Nat., Vol. 463, 516). Late observations with the WSRT in 2010 (after the SN faded) to measure the contribution of diffuse emission in the galaxy and a reanalysis of archival VLA data showed however that the total flux density and thus the expansion speed itself were overestimated and there is no proof for relativistic ejecta. However there was a hint of non-spherical explosion from spectro-polarimetry data (Tanaka et al. 2008). Polarization of ~3% was detected at the absorption feature of the CaII triplet, which can be understood in the context of a model in which bipolar explosion with an oblate photosphere is being viewed from a slightly off axis direction (although spherical photosphere and clumpy CaII distribution may be an alternative explanation). Masaomi Tanaka (Univ. Tokyo, Kashiwa) joined the group and provided 3D radiative transfer simulations which show that the major axis of the SN photosphere had a projected position angle on the sky of about 60 degrees. These new results were presented by Zsolt Paragi at the IAU Symposium 275 in Buenos Aires and the 9th e-VLBI Workshop in Perth.



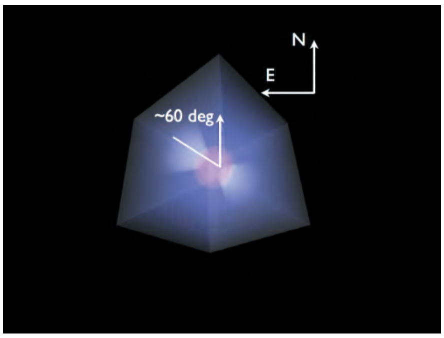


Figure 4.2: Left: EVN e-VLBI (colours) and EVN+GBT (contours) images of SN2007gr.
Right: Geometry of the SN explosion from 3D radiative transfer simulations.

The galaxy NGC2770 hosted two core-collapse supernova explosions, SN2008D and SN2007uy within 10 days from each other and 9 years after the first SN1999eh was found in that same galaxy. In particular SN2008D attracted a lot of attention due to the detection of an X-ray outburst, which has been hypothesized to be caused by either a (mildly) relativistic jet or the SN shock breakout. Zsolt Paragi worked on WSRT and VLBI observations of SN2008D and SN2007uy in collaboration with a large group led by Alexander van der Horst (NASA MSFC). The total flux density monitoring covered about 600 days with observing frequencies ranging from 325 MHz to 8.4 GHz. The VLBI observations (including the EVN and two telescopes from the VLBA) were carried out at two epochs, on 6 February and 18 March 2008. The images of SN2008D appeared unresolved at both epochs, the observed peak brightnesses were 2.0~mJy and 0.9~mJy, respectively, in perfect agreement with the WSRT measurements. From model-fitting of the uv data and Monte-Carlo simulations they determined an upper limit of 0.4 mas and 0.5 mas for the first and for the second epochs. The difference in source position at the two epochs were less than 100 microarcsecond, ie. consistent with no proper motion. Similar result was obtained for SN 2007uy but with larger errors because it was observed for much shorter time. The resulting upper limits for the average apparent isotropic expansion for SN 2008D was 0.59c after 69 days, and the lack of observable proper motion corresponds to an upper limit of 0.38c. For SN 2007uy there is only a reliable upper limit on the angular diameter size, corresponding to an upper limit of the average expansion speed of 0.64c. These observations showed that if there was a relativistic jet in these sources, then it was at most moderately relativistic (van der Horst et al., 2011, ApJ 726 99).

The group observed two other broad-line Type Ic supernovae with the WSRT, PTF10bzf (ATel #2479) and SN 2010br (ATel #2612), which were not detected.

4.3 SCINTILLATION AND PROPAGATION EFFECTS

Giuseppe Cimó continued his work on Intraday Variability of flat spectrum radio sources focusing on the scintillator J1819+3845. This quasar has shown extreme variability with flux density variations in the radio regime up to 600% in less than one hour. In case of intrinsic variability, the brightness temperature calculated via standard causality argument would exceed 10^{21} K and therefore would violate the Inverse Compton limit (10^{12} K). The variability of this source has been proven to be due to scattering in the interstellar medium by a number of different experiments. The extreme variability of J1819+3845 has been observed since its first observation in 1999 and it has continued for more than 8 years. In 2008, Giuseppe Cimó and collaborators conducted EVN observations of J1819+3845 and they observed no signs of any variability (Cimó et al. 2008, 2009).

The source-extrinsic explanation of the extreme variability of J1819+3845 required a close-by scattering screen (few parsecs) and it results in a brightness temperature of about 10^{14} K, still exceeding the inverse Compton limit and implying a very compact structure. A possible explanation for the cessation of the fast variations in the source is that the scattering screen has moved away from our line of sight. On the other hand, the disappearance of the extreme scintillation of J1819+3845 could be due to variations in the source structure at micro-arcsecond scale.

Due to its high brightness temperature and the compact nature, J1819+3845 was expected to expand quenching the scintillation or at least changing its variability characteristics following its internal structural variations. However, the variations have been observed continuously along the years showing also a clear annual modulation due to relative motion of the Earth and the scattering screen. On one hand, the scintillation has prevented to image the milli-arcsecond structure of this puzzling object. On the other hand, it has been a powerful tool to study indirectly the source structure at the micro-arcsecond scale. Macquart & de Bruyn (2007) have compared observations taken at identical epochs each year in order to disentangle the effects of source structural evolution and asymmetry in the scintillation pattern. Analysing the light curves and their power spectra, it was possible to indicate the evolution of the internal structure of J1829+3845. Comparing the scintillation characteristics in 2003, 2004 and 2006, Macquart & de Bruyn (2007) found an expanding double structure at micro-arcsecond scale.

Following the work of Macquart & de Bruyn (2007) and since the discovery of the lack of variability, Giuseppe Cimó has been working with his collaborators on a model of the J1819+3845 in its current quiescent phase. New VLBI observations have also been requested to map the source without the limitation of the interstellar scattering that has affected all the previous attempts to map the innermost jet structures of J1819+3845. Furthermore, a retroactive interpretation of the past data has been investigated to use new scintillation-free data to describe the structure of the innermost jet structures of the source and their evolution in the course of the previous 10 years.

4.4 ACTIVE GALACTIC NUCLEI

Radio-loud narrow line Seyfert 1 (NLS1) are Active Galactic Nuclei that have received considerable attention lately, since they pose a challenge to current unified schemes. Only a small percentage (about 7%) of NLS1 are radio-loud and in these cases the flat radio spectra and VLBI variability suggest that they could host relativistic jets. The detection by the Large Area Telescope (LAT) on board Fermi of gamma-rays from a handful of NLS1 has recently set the definitive confirmation of the presence of a relativistic jet in these sources.

Bob Campbell, Huib van Langevelde, Zsolt Paragi and Arpad Szomoru took part in a series of global e-VLBI observations of PMN J0948+0022 at 22 GHz, the first NLS1 system detected by the space-borne gamma-ray observatory Fermi. The project was carried out in a big collaboration led by Marcello Giroletti (INAF, Bologna). The participating telescopes were Cambridge, Effelsberg, Jodrell Bank (Mk2), Medicina, Metsahovi, Onsala, Shanghai, and Yebes from the EVN, Hobart, Mopra, Parkes, and the ATCA from the LBA, and Kashima in Japan. The observations were a success, with real time fringes detected to all telescopes in at least one epoch. The source was clearly detected on baselines longer than 900 million wavelengths (12,000 km), resulting in a resolution of about 0.2 x 0.5 milliarcsecond. Polarized emission was also detected at a significant level. The results of the multi wavelength campaign (which involved several instruments and satellites from radio to the gamma-rays) were published in a paper by Abdo et al. (2009, ApJ 707, 727). The details of the e-VLBI data analysis were published by Giroletti et al. (2011, A&A 528 L11).

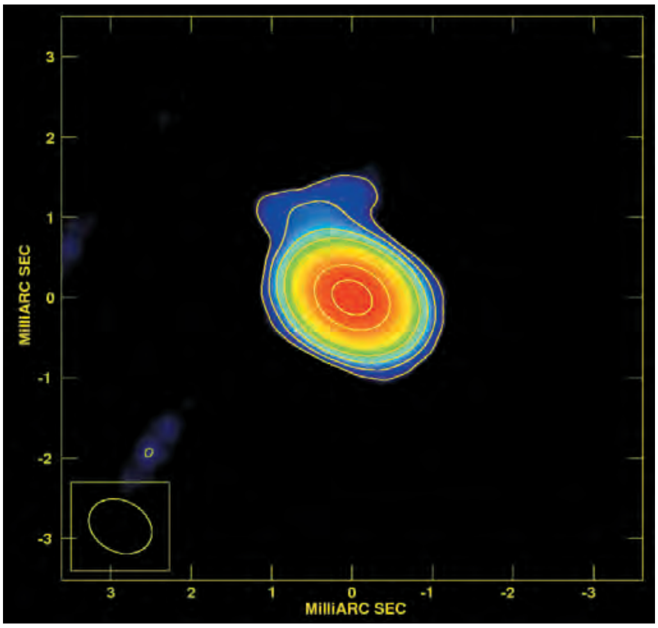


Figure 4.3: 22 GHz image of PMN J0948+0022 obtained with Global e-VLBI on 2009 June 10.
Contours are total intensity levels of +/- (4, 12, 48, 144, 432) mJy/beam, the resolution was 0.2 x 0.5 mas.

Mehreen Mahmud studied the jet kinematics of blazar S5 0716+714 in collaboration with a group led by Elizaveta Rastorgueva (University of Turku, Tuorla Observatory, Finland). They investigated the jet kinematics and the effect of various VLBI imaging methods on the results, based on observations during the active state of 0716+714 in 2004 (Rastorgueva et al. 2011, in press). For the kinematic analysis of the jet up to 12 mas they used six epochs of VLBA data at 5 GHz. The diffuse jet at this scale was found to be mostly stationary with a large scatter of the component positions, that were systematically slower and fainter than those of the inner (< 1mas) jet components. Differences between the inner (0-1 mas) and outer (1-12 mas) regions of the jet in brightness and velocity of the components could be explained by the bending of the jet, which causes the angle between the jet direction and the line of sight to change from ~5 degrees to ~11 degrees. To obtain most accurate kinematics of this source, the group applied two imaging techniques to the raw data: the conventional method based on difference mapping, which uses the CLEAN deconvolution, and the generalized maximum entropy method (GMEM). The group found that while both methods yielded similar results, determination of the jet component positions by the conventional method was less precise and recommend GMEM in combination with the difference mapping technique for restoring the structure of compact AGN and other objects that have a diffuse structure with bright point-like features.

Jun Yang organised the first EVN observations with two new Chinese telescopes in Kunming and in Miyun (40 and 50m dishes, respectively). The group involved Chinese astronomers Tao An (Shanghai Astronomical Observatory), Lang Cur (Urumqi Observatory), Xinying Zhu (National Astronomical Observatories), and Longfei Hao (Yunnan Astronomical Observatory). Other participating telescopes from the EVN were Medicina, Onsala, Shanghai, and Urumqi. Five gigahertz-peaked spectrum (GPS) radio sources were observed: J0132+5620, J1135+4258, J1324+4048, J1756+5748, and J2312+3847. During the project the first EVN fringes to the Miyun 50m radio telescope were successfully detected with the JIVE SFXC software correlator. Compared with kiloparsec-scale radio sources, the five GPS sources show much more simple morphology. Usually, they only have a few compact jet features.

Thus, they are top-priority objects to study jet kinematics of GPS sources and confront the "frustrated AGN" (radio lobes are confined by a dense medium) versus youthfulness scenarios. The position of the components were obtained by model-fitting. Compared with previous VLBA observations (BY020, PI: Jun YANG) in 2005, these jet components have already shown a small increase in separation (e.g. ~0.1 mas for J0132+5620). To extend the time baseline up to more than a decade, the team has recently reanalysized the existing VLBA archive data. A new EVN observations with Kunming and Miyun in 2011 is in preparation.

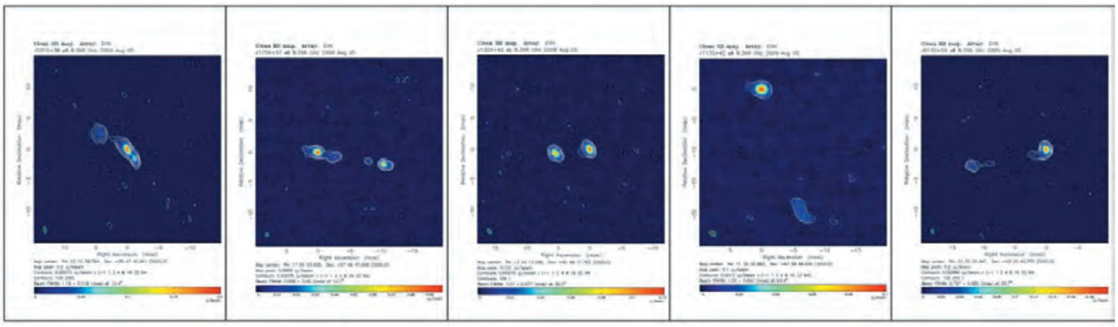


Figure 4.4: Naturally weighted images of five GPS radio sources. Since these sources have high declination and u-v tracks look nearly circular, these images have nice synthesized beam. The image sensitivities are 0.2-0.5 mJy/beam, close to their theoretical values.

Recently Ryan et al. (2008, ApJ 688, 43) found and optical arc which looks like a gravitationally lensed image of a galaxy. However, the foreground lensing object apparently needed for producing such an arc is not seen in the deep optical and infrared images. It was proposed that most of the lensing mass may be in the form of dark matter, or the lensing galaxy is highly obscured. Together with Sándor Frey (PI, FÖMI SGO, Penc, Hungary) and Attila Moór (MTA Konkoly Observatory, Budapest), Bob Campbell and Zsolt Paragi carried out exploratory observations of a nearby radio source from the VLA first survey with the e-EVN. After the quick initial e-VLBI detection, full-track e-EVN observations of J1218+2953 were done at 1.6 GHz and 5 GHz on 24 March 2009 and on 21 April 2009, respectively.

At the lower frequency, the tapered image of this source reveals a rich and complex structure in a nearly symmetrical "inverted S" shape, spanning almost 0.7". Its brightness distribution excludes the possibility that the radio source is a lensed counterpart of the optical arc, therefore both the arc and the radio source J1218+2953 cannot be gravitationally lensed images of the same background object. Instead, the observed radio structure may rather reside within a host galaxy providing the lensing potential to form the optical arc. It appears that J1218+2953 is probably a young, recently triggered and heavily obscured AGN. It grows in a dense interstellar medium which might cause the observed two-sided bent radio jet structure. This makes the "dark lens" interpretation unlikely (Frey et al. 2009, A&A 513, A18).

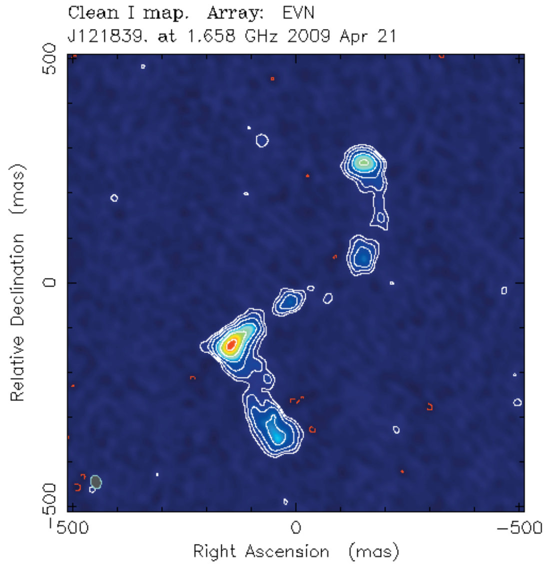


Figure 4.5: Naturally weighted L-band e-EVN image of J1218+2953, a candidate "dark matter" lens. The observations showed that instead the source is a heavily obscured, young AGN.

Zsolt Paragi continued his work on Hanny's Voorwerp, in collaboration with a group led by Mike Garrett (ASTRON). Hanny's Voorwerp is a hot, irregular gas cloud located about 60000 light years from the galaxy IC 2497, which apparently does not contain any heating source. Earlier WSRT and exploratory e-VLBI observations showed evidence for a supermassive black hole at the centre of IC 2497 (Jozsa et al. 2009, A&A 500, L33). New EVN and MERLIN observations at 1.6 GHz and 5 GHz showed two compact radio sources in the central region of the system, with brightness temperatures above 10^5 K, and diffuse emission surrounding the one with flat spectrum, identified as the radio core. The total 1.6 GHz radio emission from the galaxy is dominated by the diffuse emission confined within a sub-kpc central region. IC 2497 therefore appears as a typical luminous infrared galaxy that exhibits a nuclear starburst with a massive star formation rate of 70 $M_{\odot}$/yr. These results are in line with the hypothesis that the ionisation nebula Hanny's Voorwerp at a distance of ~15-25 kpc from the galaxy is ionised by the radiation cone of the AGN (Rampadarath et al. 2010, A&A 517, L8).

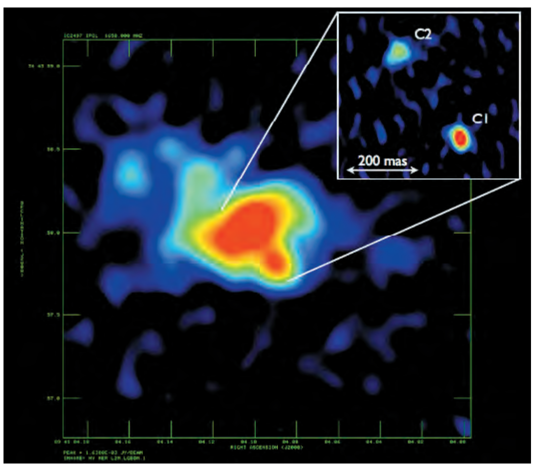


Figure 4.6: This 1.6 GHz MERLIN image shows the double structure and diffuse emission in the sub-kpc central region of IC 2497. The inset EVN image shows two compact sources. The flat spectrum C2 is identified with the radio core, while C1 likely corresponds to shocked ejecta in the jet (the large scale jet discovered earlier by WSRT is along a similar position angle).

Leonid Gurvits and Zsolt Paragi worked in collaboration with a group led by Dávid Cseh (Universite Paris Diderot, CEA Saclay) on EVN observations of two double-double radio quasars, J1036+1326 and J1353+5725. Both or these are dominated by a bright central core and a pair of weaker and nearly symmetric lobes at ~10" angular separation (i.e. core-dominated triples, CDTs). They are optically identified in the Sloan Digital Sky Survey (SDSS) at spectroscopic redshifts z>3. The group investigated the possibility that their CDT morphology can be a sign of restarted radio activity, involving a significant repositioning of the radio jet axis. The sources were observed at 1.6 GHz with the EVN and were found to have compact cores. A range of possible viewing angles and jet Lorentz factors were estimated. It was found that it is not necessary to invoke large misalignment between the VLBI jet and the large-scale radio structure to explain the observed properties of these two sources (Cseh et al. 2010, A&A 523, A34).

With Silke Britzen, Nadia Kudryatseva (both MPIfR), and others, Bob Campbell investigated the kinematics of the pc-scale jet components of the blazar S5 1803+784. Many of the jet components remain at roughly constant radius from the core, but the jet ridge-line itself shows quasi-periodic oscillations in position angle on the order of 10 degrees over the inner 4 mas, with a time-scale on the order of 8-9 years.

4.5 NEUTRAL HYDROGEN IN GALAXIES AND IN THE MILKY WAY'S HALO

Arpad Szomoru worked on the ultra-deep survey of 21cm emission from neutral hydrogen at redshifts z=0.164-0.224 with the Westerbork Synthesis Radio Telescope (project led by Marc Verheijen, Kapteyn Institute, Groningen, Netherlands). In two separate fields, a total of 160 individual galaxies have been detected in neutral hydrogen, with HI masses varying from 1.1×10^{9} to 4.0×10^{10} $M_{\odot}$. The largest galaxies are spatially resolved by the synthesized beam of 23x37 $arcsec^2$ while the velocity resolution of 19 km/s allowed the HI emission lines to be well resolved. The large scale structure in the surveyed volume is traced well in HI, apart from the highest density regions like the cores of galaxy clusters. All significant HI detections have obvious or plausible optical counterparts which are usually blue late-type galaxies that are UV-bright. One of the observed fields contains a massive Butcher-Oemler cluster but none of the associated blue galaxies has been detected in HI. The data suggest that the lower-luminosity galaxies at z=0.2 are more gas-rich than galaxies of similar luminosities at z=0, pending a careful analysis of the completeness near the detection limit. Optical counterparts of the HI detected galaxies are mostly located in the 'blue cloud' of the galaxy population although several galaxies on the 'red sequence' are also detected in HI. These results hold great promise for future deep 21cm surveys of neutral hydrogen with MeerKAT, Apertif, ASKAP, and ultimately the Square Kilometre Array.

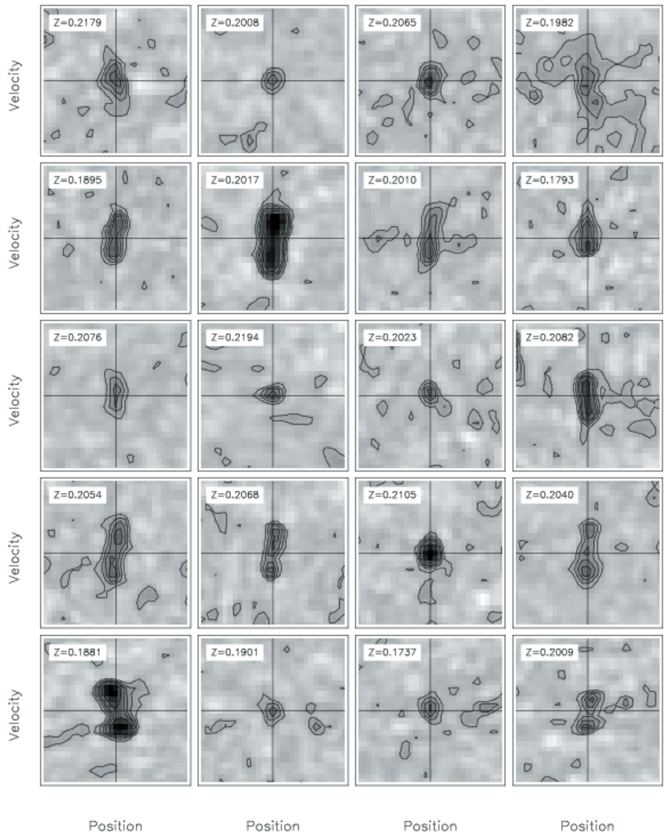


Figure 4.7: Position-velocity diagrams of 20 random HI detections. The vertical axis covers ~1000 km/s in the rest-frame of the galaxies. The horizontal axis covers 1 arcminute on either side of the source. Horizontal lines indicate systemic velocity, the vertical lines correspond to the central position of the HI source. Contour levels are 1.5, 3.0, 4.5, 6.0, 9.0 and 12.0 times the local noise. The FWHM spectral resolution in these maps is 312.5 kHz, or 76 km/s at the centre of the band. Not all sources fulfil the detection criteria at this particular resolution. Note that many galaxies show the typical double-peaked velocity profiles and that several galaxies are spatially resolved.

Yurii Pidopryhora continued his work on the large project to study the extra-planar hydrogen in the inner Milky Way based on the observations of 21 cm HI line with the Green Bank Telescope (GBT), the Very Large Array (VLA) and the Giant Metrewave Radio Telescope (GMRT) performed in 2003-2007. The project is done in collaboration with Felix J. Lockman (NRAO) and, in parts, with K.S. Dwarakanath (RRI), Harvey Liszt (NRAO), Joseph Shields (Ohio University) and Michael Rupen (NRAO).

The effort to make high-resolution maps of a chosen number of bright clouds in the disk-halo interface of the Galaxy continued. VLA observations in D, and in some cases also in C and B configurations, provide high angular resolution view of the clouds and GBT data supply short spacing information, to detect extended, low surface brightness emission which might not have been detected by the VLA observations. Using previously developed successful interferometric-single dish data reduction recipes (involving procedures of both AIPS and MIRIAD packages) the maps for a number of clouds were made, including maps of two clouds (G19.4+6.3 and G27.0+6.3) observed in both D and C VLA configurations. A preliminary analysis of these latter clouds was published (Pidopryhora, Lockman, and Rupen 2011, in press). Previous hypotheses about formation of halo clouds due to superbubble envelope disintegration and of their unstable nature were given a strong experimental support. The findings of this analysis were also reported at several conferences.

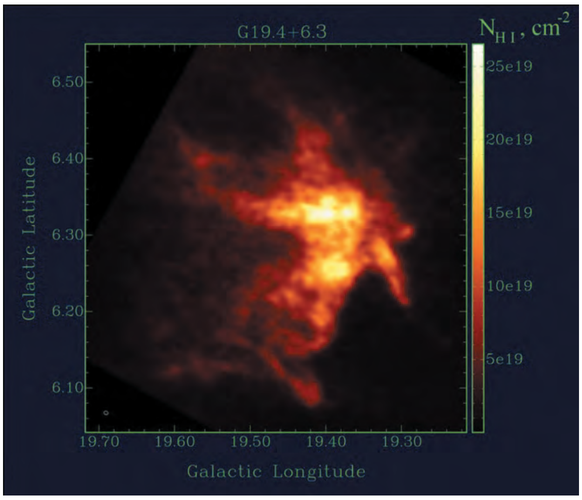


Figure 4.8: Total HI column density map of halo cloud G19.4+6.3, one of the maps produced by combining observations of the VLA in D and C configurations and the GBT. The map shown is integrated over 48 spectral channels of 0.64 km/s width, the rms noise is 8.7×1018 cm-2, the synthesized beam is FWHM 32.5"x25.6". At the estimated distance of 8.0 kpc this is equivalent to the linear resolution of 1.12 pc (the beam is shown in the bottom-left corner). This map was produced using the resulting AIPS VTESS model of the signal.

4.6 MOLECULAR GAS IN GALAXIES

The JCMT Nearby Galaxy Legacy Survey (NGLS) investigates the molecular gas and dust content in an HI flux limited sample of 155 galaxies within a distance of 25 Mpc by mapping the CO(3-2) line emission and the submillimeter continuum emission at 850µm and at 450 µm using the latest instruments at the JCMT, HARP-B and SCUBA-2. Stefanie Mühle and several other collaborators completed the observations of the sample galaxies in the CO(3-2) line with the 4 x 4 pixel receiver HARP-B receiver and the ACSIS spectrometer at the JCMT. The spectral line data are now being reduced and analyzed. So far, fully sampled maps of the CO(3-2) intensity (moment 0) of 9 galaxies - 4 galaxies in the Virgo cluster and 5 galaxies in the field - have been published, as well as 9 maps of the velocity dispersion (moment 2) and other plots of the kinematics. These maps were compared to ancillary data from the literature like CO(1-0) line emission, HI cubes and Spitzer data in order to derive correlations of the warm/dense gas traced by CO(3-2) with other components of the ISM. Some highlights include: Extended CO(3-2) emission with small-scale structure has been found in almost all galaxies published so far. While the gas depletion times appear to be similar in cluster galaxies and field galaxies, the CO(3-2) intensity itself may depend strongly on the environment, i.e. on local excitation conditions, leading to a range of CO(3-2)/CO(1-0) intensity ratios. The gas-to-dust ratio traced in NGC2403 increases with distance to the nucleus and may be a function of metalicity. The cloud-cloud velocity dispersion of the molecular gas in the sample galaxies is significantly smaller than that of the atomic gas in these objects, suggesting that the molecular gas as the dynamically coldest component determines the stability of a galactic disk. In NGC 4631, most of the molecular gas is concentrated within a radius of ~5 kpc, but weaker disk emission has been traced out to 12.4 kpc from the nucleus and up to heights of 1.4 kpc, including evidence for molecular outflows.

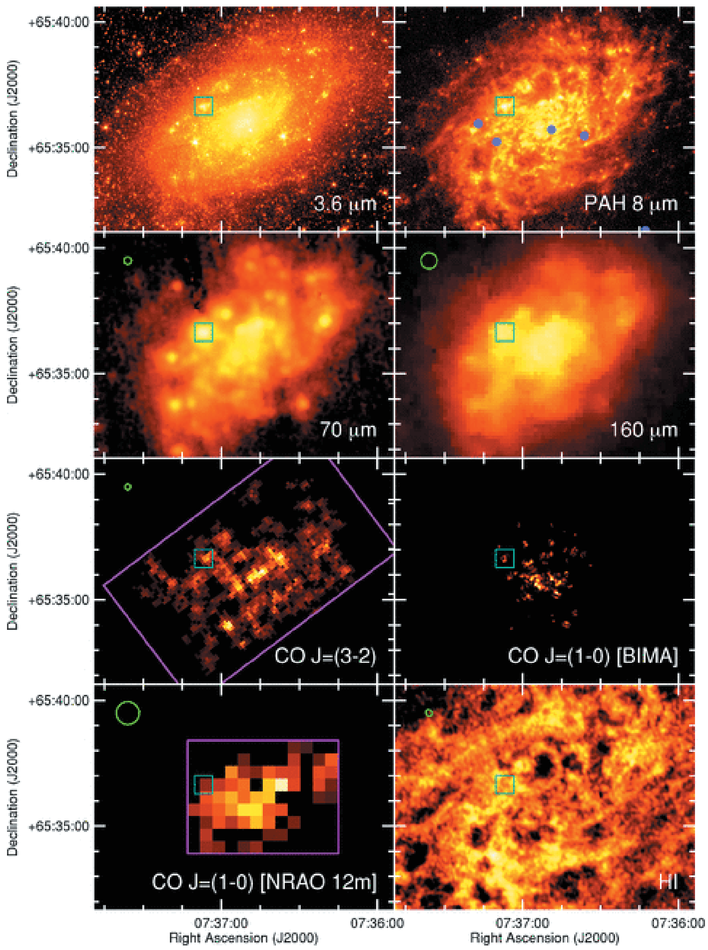


Figure 4.9: Images of NGC 2403 in multiple wave bands. The 3.6 μm image traces starlight. The PAH 8 μm image traces primarily PAH emission. The 70 and 160 μm images trace cold dust emission. The CO(3–2) image shows CO emission associated with molecular gas. The HI image shows atomic gas emission. All images are 12 × 9 arcmin^2 with north up and east to the left. Green circles in the upper left corners of the images show the beam size when the FWHM is greater than 10 arcsec. The blue circles in the PAH 8 μm image show the positions of foreground stars that were masked out in the analysis.

In addition, Stefanie Mühle continued to lead her own investigations on the properties of the molecular gas in starburst galaxies and near AGN. In particular, the kinetic temperature of the dense molecular gas may prove to be crucial for the evolution of a galaxy. Hydrodynamical simulations suggest that the initial mass function (IMF) may be top-heavy if stars form out of dense molecular gas with a kinetic temperature of ~100 K or more. However, the kinetic temperature of the molecular gas is rarely well constrained in external galaxies by the usual molecular tracers. Stefanie Mühle and her collaborators C. Henkel (Max-Planck-Institut für Radioastronomie), S. Aalto (Onsala Space Observatory), M. Rodríguez (Instituto de Astrofísica de Andalucía) and R. Herrero Illana (Instituto de Astrofísica de Andalucía) exploit the diagnostic power of a selected set of formaldehyde (H_2CO) lines in combination with their Large Velocity Gradient (LVG) radiative transfer model to derive fundamental properties of the (dense) molecular gas in external galaxies like the kinetic temperature and gas density, completely independent of other molecular tracers (see e.g. Mühle et al. 2007). With the IRAM 30-m telescope and the new EMIR receivers, they detected the full set of diagnostic formaldehyde lines towards the nearby starburst galaxy Maffei 2. In addition, the group obtained very sensitive spectra of the H2CO lines towards the AGN of NGC 1068, which often serves as a template for nearby AGN, using the same telescope and receivers. Stefanie Mühle and her summer student Tahlia de Maio (University of Colorado) reduced and started to analyze the H_2CO emission of the nearby starburst galaxy NGC 253. The spectra show significant variations in the physical and chemical properties of the molecular gas along the mapped major axis of the galaxy. A first comparison of the derived line intensity ratios with the non-LTE radiative transfer models yield kinetic temperatures that are significantly higher than the temperature of the dense molecular gas in the Galactic disk. The results imply the presence of a warm molecular gas phase even in a galaxy whose starburst is considered to be young.

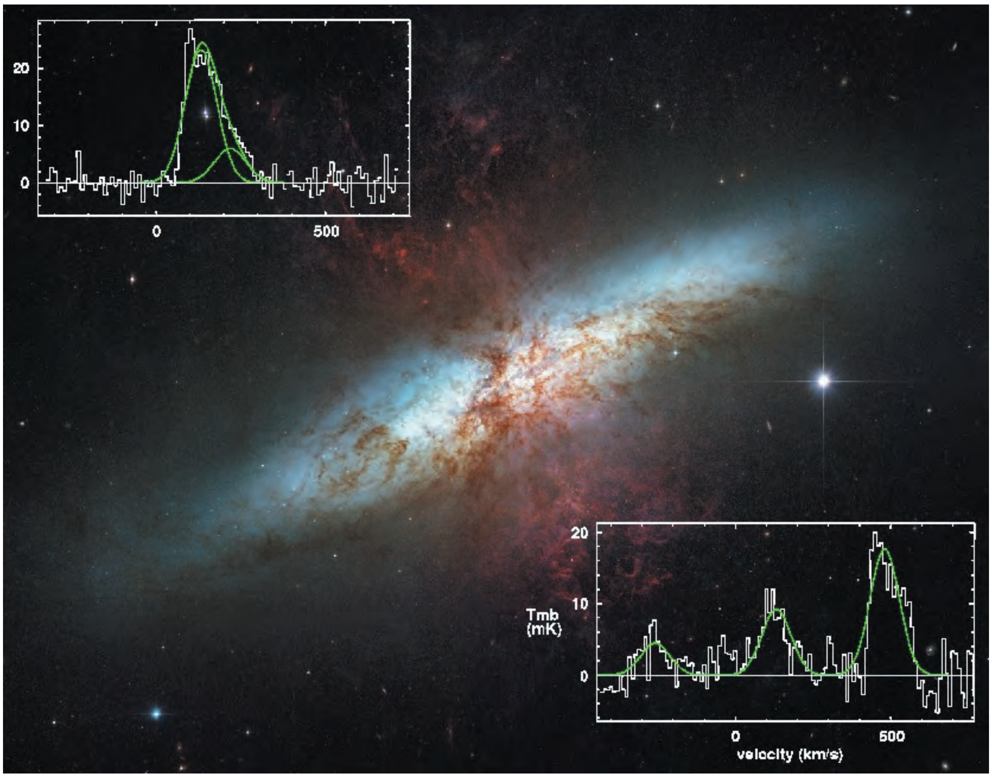


Figure 4.10: Hubble Heritage image of the prototypical starburst galaxy M82 and formaldehyde lines observed towards the south-western lobe of its circumnuclear molecular ring. A non-LTE radiative transfer analysis based on the intensity ratio of these diagnostic lines suggests a kinetic temperature of ~200 K in the traced molecular gas phase (NASA, ESA, and The Hubble Heritage Team (STScI/AURA), Mühle et al. 2007).

Amanda Kepley (University of Virginia) and Stefanie Mühle, with collaborators at the University of Wisconsin-Madison and the Argelander Institut für Astronomie in Bonn, investigated the polarized radio continuum emission of the nearby starburst dwarf galaxy NGC 1569 using data at four wavelengths (3, 6, 13 and 20 cm) observed with the MPIfR 100-m telescope in Effelsberg, the VLA and the WSRT. They found an extended radio continuum halo at 20 cm. The radio continuum feature associated with the western Hα arm is also present at wavelengths shorter than 20 cm. While the spectral indices derived for this galaxy generally steepen towards the halo of the galaxy, there are also filamentary regions of flat spectral indices extending to the edge of the galaxy. In general, the spatial distribution of the spectral indices supports the theory that a convective wind is at work in this galaxy. There is strong polarized emission at 3 cm and at 6 cm and weak polarized emission at 13 cm and at 20 cm. The thermal fraction of the continuum emission is 40-50% in the centre of the galaxy and falls off rapidly with height above the disk. The total magnetic field strength is estimated to be 38 μG in the central regions and 10-15 μG in the halo. The magnetic field is largely random in the centre of the galaxy, the uniform field is ~3-9 μG and is strongest in the halo. The magnetic pressure seems to be of the same order of magnitude but, in general, a factor of a few less than the other components of the interstellar medium in this galaxy. The uniform magnetic field in NGC 1569 is closely associated with the Hα bubbles and filaments. Based on pressure estimates and the morphology of the magnetic field, the outflow of hot gas from NGC 1569 is clearly shaping the magnetic field, but the magnetic field in turn may be aiding the outflow by channelling gas out of the disk of the galaxy.

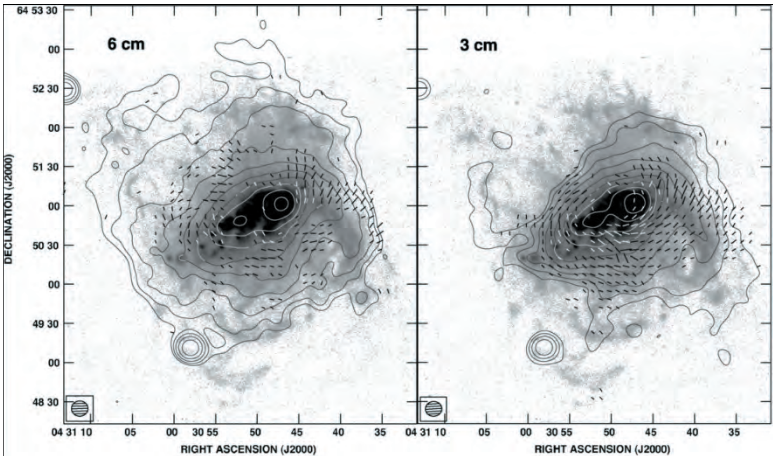


Figure 4.11: E-vectors showing the direction and distribution of polarized intensity at 3 cm and 6 cm. The contours outline the total intensity radio continuum emission at each wavelength, superposed on a greyscale image of the distribution of the Hα emission. The contours start at 3σ and increase by a factor of 2 for each subsequent contour. A polarization vector with a length of 1" has a polarized intensity of 12.8 μJy/beam. The beams are indicated in the lower left corner of each panel.

4.7 GALACTIC PULSARS, VARIABLE AND TRANSIENT RADIO SOURCES

Since 2009, Jun Yang started providing technical support for Ding Chen (National Time Service Centre, Chinese Academy of Sciences, P.R. China) to perform VLBI pulsar astrometry. The first interesting pulsar for the group is the millisecond pulsar PSR J0218+4232. The pulsar is one of brightest pulsars in X-rays and it is one of the candidate pulsars that could be used for deep space navigation of satellites carrying small X-ray detectors. The first VLBI observation of PSR J0218+4232 was done by the group with the EVN on 4 November 2010. The data were correlated on the new SFXC software correlator at JIVE via binning correlation to align pulse signal and to remove off-pulse data. A proposal for follow-up multi-epoch EVN observations was submitted to measure its proper motion and distance. VLBI astrometry will help to reduce the input covariances of the pulsar timing solutions. A possible application could be a network of X-ray pulsars with good astrometric and timing solutions serving as beacons for navigation of deep-space satellites.

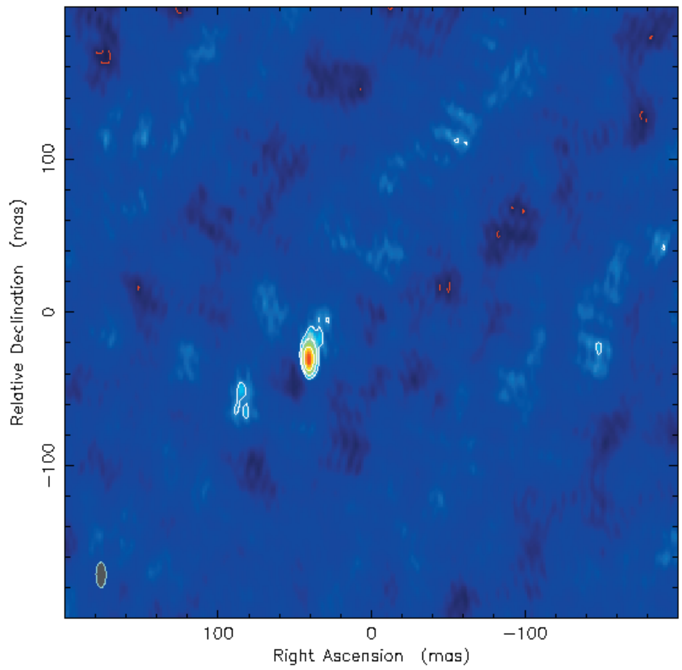


Figure 4.12: The EVN detection of the millisecond pulsar PSR J0218+4232. The contours start from 3-sigma noise level in each image and increase by a factor of 2. The beam is shown in the bottom-left corner. The pulsar has a peak brightness ~0.7 mJy/beam (SNR ~20). The image origin reflects the position inferred from timing observations, including timing-derived proper motion, and the offset shows the residual error (~50 mas).

Zsolt Paragi worked on EVN and CHARA optical interferometry observations of Algol in collaboration with Szilárd Csizmadia (Institute of Planetary Research, Berlin), Tamás Borkovits (Baja Astronomical Observatory, Baja, Hungary) and others. Algol is a triple stellar system that consists of a close semi-detached binary and a more distant third object. The spatial orientation of the close pair is debated in the literature, and the third body perturbation of this pair has received some attention in the last years. The group determined the spatial orientation of the close pair orbital plane using the CHARA Array, a six-element optical/IR interferometer located on Mount Wilson, and additional EVN measurements. The longitude of the line of nodes for the close pair was found to be 48 degrees and the mutual inclination of the orbital planes of the close and the wide pairs was 95 degrees. The earlier value of 100 degrees implied a very fast inclination variation of the system, which was not supported by photometric observations of the eclipsing minima. The group further investigated the dynamical evolution of the system, and found large variations of 170 degrees in the inclination of the close pair with a period of about 20 millennia. This result is in good agreement with the photometrically observed change of amplitude in Algol's primary minimum (Csizmadia et al. 2009, ApJ 705, 436).

Jun Yang, Leonid Gurvits and Zsolt Paragi worked on a sample of Galactic plane variable sources, in collaboration with Yongjun Chen, Zhiqiang Shen, and Weihua Wang from the Shanghai Astronomical Observatory, and Jinjin Li from the Purple Mountain Observatory (P.R. China). Recently, Becker et al. (2010) presented a sample of intriguing variable radio sources in the Galactic plane. These sources show compact morphology in the three epochs of VLA surveys with a flux density in the range of 2 – 50 mJy at 5 GHz and much higher variability (>50% on a time scale of a year) than most extragalactic objects. These variable radio sources have high population density toward the Galactic centre, and have no counterparts at other wavelengths. Thus, the sample is likely dominated by Galactic objects.

However, none of the well-known Galactic sources can be well associated with them. To further unveil their nature, the team proposed a pilot e-VLBI experiment at 5 GHz to directly image a subsample of these sources. The exploratory observations aim to answer whether they are non-thermal radio emitters and whether follow-up observations can be initiated to measure their proper motion and to identify their Galactic origin. The observations were done in the 15 December 2010 e-VLBI session. Through the EVN pipeline calibrations and manual Difmap imaging, the subsample has a detection rate of 8/17 sources above a 5-sigma sensitivity level of ~0.5 mJy/beam. Among them, the source G23.66-0.03 showed clear fringes on the baseline of Ef-Wb.

Jun Yang and Zsolt Paragi observed the new galactic black hole transient XTE J1752-223 with the e-EVN and the VLBA at four epochs in February 2010, in collaboration with Catherine Brocksopp (Mullard Space Science Laboratory, University College London), Stephane Corbel (Universite Paris) and others. A moving jet component was detected. The proper motion analysis showed that it was significantly decelerating by the last epoch (0.34 mas per square day). The overall picture is consistent with a mildly relativistic jet interacting with the interstellar medium or with pre-existing material along the jet. Beside the decelerating ejecta, a new jet component was also detected at the fourth epoch (Yang et al. 2010, vol. 409. p. 64). There were further EVN observations carried out in March 2010 to follow-up on a new radio burst, and additional VLBA observations in April 2010 in order to identify the reactivating core in the system.

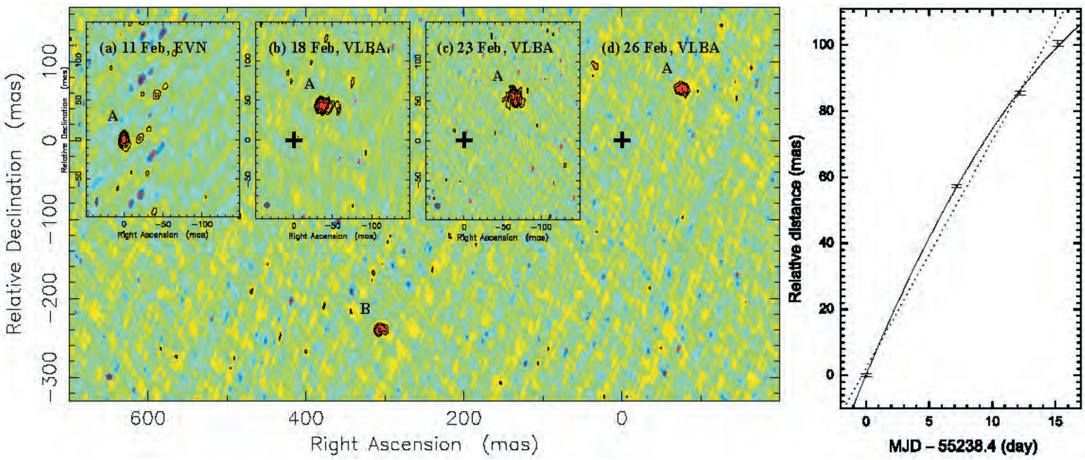


Figure 4.13: The decelerating jet in the Galactic black hole candidate XTE J1752-223. The cross shows the location of the first detection of component A. The contours start from 3-sigma noise level in each image and increase by a factor of 1.4. The right-hand panel plots the fitting results of the proper motion data of component A using the modes with (solid curve) and without deceleration rate (dotted line).

Zsolt Paragi observed the new X-ray transient MAXI J1659-152 at two epochs with the e-EVN (Paragi et al. 2010, ATel #2912) and four epochs with the VLBA between 30 September and 19 October 2010. The project was carried out in a large collaboration of multi-wavelength monitoring, led by Alexander J. van der Horst (NASA MSFC, USA). The transient was initially mistaken for a GRB, but later it was identified as a candidate black hole binary. In fact it appears that the orbital period of the system is only 2.4 hours, the shortest ever discovered (Kuulkers et al. 2010). The very first epoch of e-EVN data showed extended emission in the system but there were no major ejecta found at later epochs, in spite it was very well expected during the full state transition of the accretion disk (evidenced by RXTE and other X-ray data). Zsolt Paragi also collaborated with James Miller Jones (ICRAR, Perth), Anthony Rushton (ESO, Onsala), Valeriu Tudose (ASTRON, Dwingeloo) and others on VLBI observations of microquasars Aql X-1, Cyg X-1 and Cyg X-3.

4.8 MASSIVE STAR FORMING REGIONS

Kalle Torstensson and Huib van Langevelde continued their work on measuring the large-scale thermal methanol distribution in methanol maser bearing high mass star-forming regions. In the nearby star forming region Cep A, which is studied as the archetypical source in the sample, interesting results were obtained which relate to the origin of the maser in collaboration with Floris van der Tak (SRON) and Wouter Vlemmings (Bonn University). Analysis of HARP data taken with the JCMT allows the derivation of the rotation temperature and column density of the thermal methanol gas. The methanol is clearly associated with the central source in this famous HII region and the derived temperature peaks at the location where the maser is found. Excitation models indicate that radiative excitation is limited to the very central region. The direction of the outflow is also roughly consistent with the orientation of the methanol masers on a much smaller scale as observed with the European VLBI Network. The methanol masers that straddle the waist of Cep A are interpreted to outline a large scale ring structure perpendicular to the outflow axis of the central source. Remarkably, the velocity field does not show a rotation signature, but seems to be dominated by a small radial motion. It could be hypothesized that the ring outlines an accretion shock, where in-falling gas hits the accretion disk.

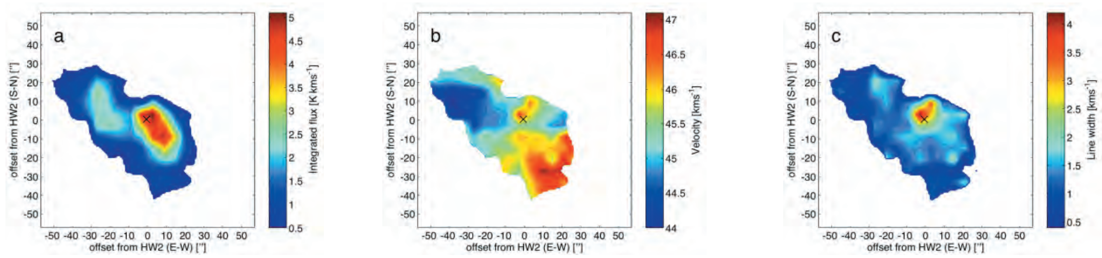


Figure 4.14: line03vel.png, line03widths.png Thermal methanol in Cep A, from left to right the integrated flux, the velocity field and the line width of the methanol (7 1 7 – 6 1 6) E-type transition is shown. This is the strongest unblended line in the JCMT HARP spectra.

In a project led by Wouter Vlemmings the same Cep A methanol masers are observed with MERLIN to obtain measurements of the magnetic field direction. Although the interpretation of maser polarization can be quite complex, the measurements reveal a structured large scale magnetic field, which is perpendicular to the accretion disk in this high mass young stellar object. Combined with measurements of the field strength, this observation reveals that magnetic fields can be the dominant force in regulating the formation of high mass stars. This is an important clue that the formation mechanism of high mass stars may resemble that of less massive stars.

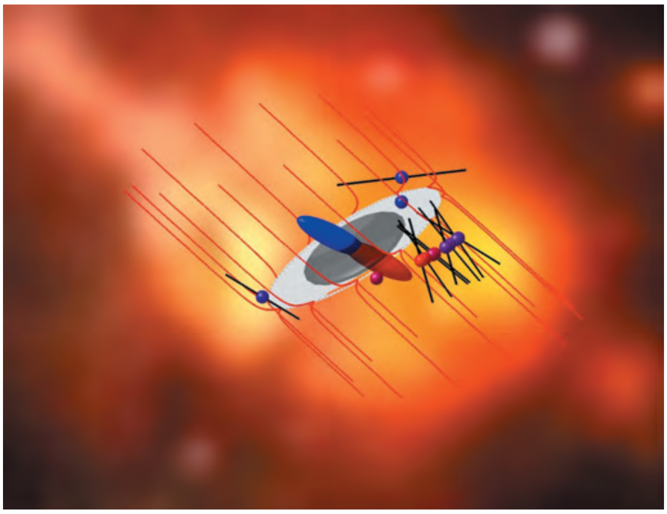


Figure 4.15: The magnetic field configuration around the young massive star Cepheus A HW2 and the location of the methanol regions from which the 3D structure was inferred. The figure shows that the magnetic field is almost perfectly perpendicular to the disk through which matter is transported onto the star

Kalle Torstensson and Huib van Langevelde are extending their studies of the relation between methanol masers and thermal methanol to a small sample. Using JCMT HARP data and the same methods previously applied to Cep A it is possible to determine temperatures and column densities in a number of maser sources. Although some of the well studied sources appear to be very complex, a significant sub-sample of the sources can be characterised by very well confined (young) outflows, which seem to originate from the same location as the maser emission. Like in the relatively nearby source Cep A, this argues for a single location for methanol production in this source.

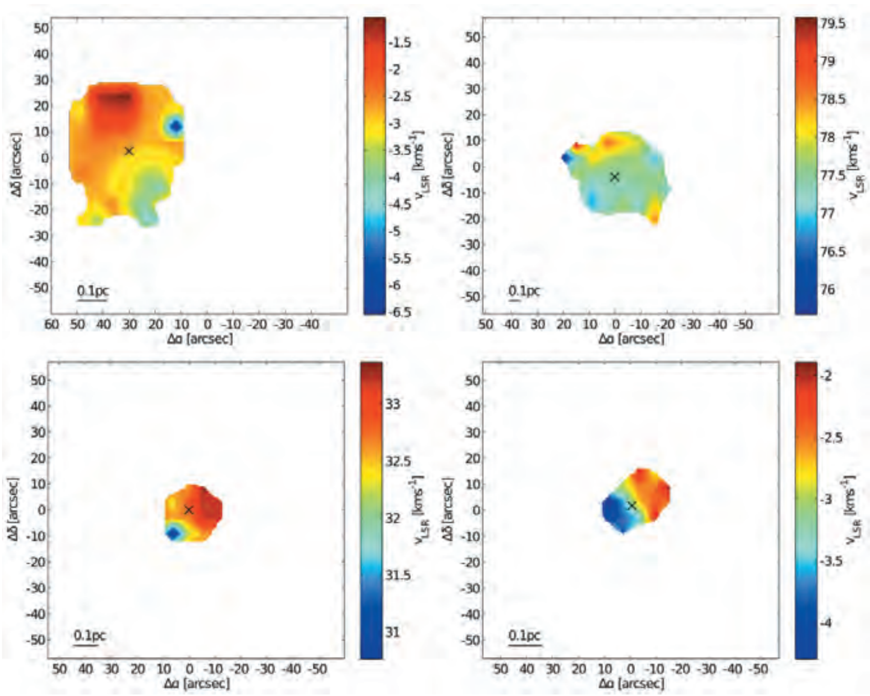


Figure 4.16: Velocity fields of the methanol 7_1 – 6_1 E-type transition in four methanol maser sources. The crosses define the position of the maser, which is argued to be associated with the origin of methanol in these high-mass star-forming regions.

Together with Stephen Bourke, 2010 summer student Dávid Cseh worked on the VLBI mapping of these sources. This will allow one to relate the orientation of the thermal methanol outflow to the

VLBI structure, possibly yielding clues on the physical component that is associated with the maser structures.

The methanol masers feature in several other projects by Huib van Langevelde and Kalle Torstensson. Together with Wouter Vlemmings and Gabriele Surcis (Bonn University) progress has been made in interpreting the methanol and water maser Zeeman effect and observed linear polarization, for example in the source NGC7538-IRS1. Together with Bartkiewcz a sample defines by a blind survey with the Torun telescope has been followed up. For a number of these sources, parallax based distances have been obtained and water masers and infrared speckle observations have been processed in order to understand the geometry of methanol masers in this sample.

4.9 EVOLVED STARS

Nikta Amiri continued her studies of the shaping of evolved stars circumstellar material using masers, together with Huib van Langevelde and Wouter Vlemmings (Bonn). Software was developed to interpret MERLIN observations of OH in so-called water fountain sources. While it was found that in the archetypical source W43A the OH most likely resides in the equatorial region, in one other case the OH may be entrained in the bipolar flow. In all cases the OH polarization measurements point to a large scale magnetic field that could be important in shaping the outflow.

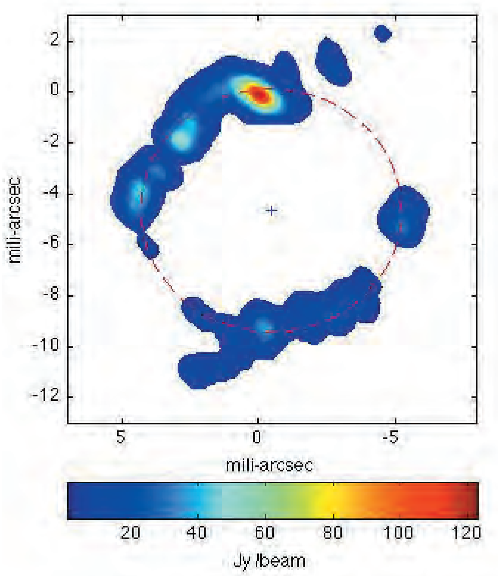


Figure 4.17: The SiO masers around OH44.8 are observed to lie in a 4.75 mas ring, corresponding to 5.6 AU for a distance of 1.13 kpc

The same team also started a research project to use the SiO masers in evolved stars to measure the effect of magnetic shaping. While previous SiO maser imaging has focused on Mira variable, this resulted in a beautiful ring image of the classic OH/IR star OH44.8-2.3. Unlike the predominant tangential linear polarization morphology previously detected for Mira variables, the observations likely show a dipole magnetic field morphology for the SiO maser region of this star. In a collaboration with Athol Kemball (Univ. Illinois) the hard problems of 43 GHz polarization calibration are addressed.

In order to address the questions of the shaping of Planetary Nebulae a continued observing program is aiming to study candidate water fountain sources with the Effelsberg telescope. Two candidates were followed up with the European VLBI Network.

4.10 ULTRACOOL DWARF STARS

Stephen Bourke as part of a team led by Gregg Hallinan (Berkeley University) continued their study of ultracool dwarfs. Of all the ultracool dwarfs detected at shorter wavelengths only 10% have been observed at radio frequencies, with the physical characteristics distinguishing active from inactive dwarfs remaining in question. While geometry, mass, temperature, activity, rotation rate all provide possible explanations, the correlation of radio detections with high *v*sin*i* infrared measurements identifies rotation rate and inclination angle as potential distinguishing factors. Binary systems with a separation less than 10 AU have coplanar equatorial planes within an angle of less than 10 degrees. Binary brown dwarf systems with separations of less than this are known, and with their inclination angles so constrained, can therefore provide a laboratory to examine which of the above two factors is in effect. Emission from a single component of the system would indicate the rotation rate is responsible for the *v*sin*i* correlation indicating that the rotation-activity relationship, well established for main sequence stars, extends into the substellar regime.

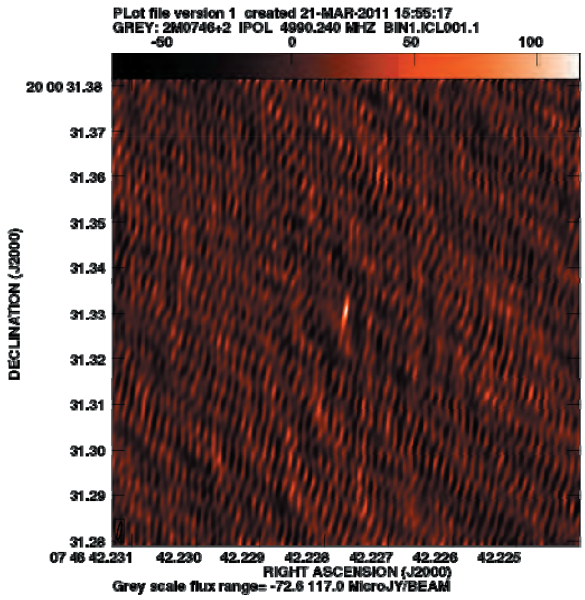


Figure 4.18: Global VLBI image of the ultracool dwarf binary system 2MASS 0746+20. The radio emission is associated with the lower-mass companion

The detection of emission from both components would, on the other hand, imply that very high strength magnetic fields are ubiquitous in the substellar regime, independent of rotation rate. Global VLBI observations of two binary brown dwarf systems were conducted in 2010 resulting in the detection of the radio emitter in the system, 2MASS 0746+20. The source of emission was found to be the lower mass component of the system. ruling out inclination angle as the selection effect and providing valuable constraints on geometry, mass, and rotation rate emission theories. The astrometric accuracy afforded by VLBI allows for the refinement of the orbital parameters of the system, allow the future study of the system in exquisite detail.

4.11 ULTRA-STEEP SPECTRUM RADIO SOURCES

Mehreen Mahmud and Zsolt Paragi studied ultra-steep spectrum (USS) sources in collaboration with Huub Röttgering (Leiden Observatory, Universiteit Leiden), Hans-Rainer Klöckner (University of Oxford) and George Miley (Leiden Observatory, Universiteit Leiden). A small sample of 5 USS sources were observed with the e-EVN at L-band in June 2010 to look for compact emission in these peculiar objects. These exploratory observations resulted in two detections, 0722+291 and 1512+470 with total flux densities of 2 mJy and 42 mJy, respectively (note that only a fraction of the VLA flux density was recovered in both cases). While 0722+291 appeared very compact, 1512+470 showed a resolved structure on milliarcsecond scales. As was expected, it appears that USS sources are not from a homogeneous class of sources, since 3 sources did not possess compact structure, and the two detections were morphologically different on 10-mas scales. Further observations are planned at intermediate resolutions with e-Merlin for a bigger sample.

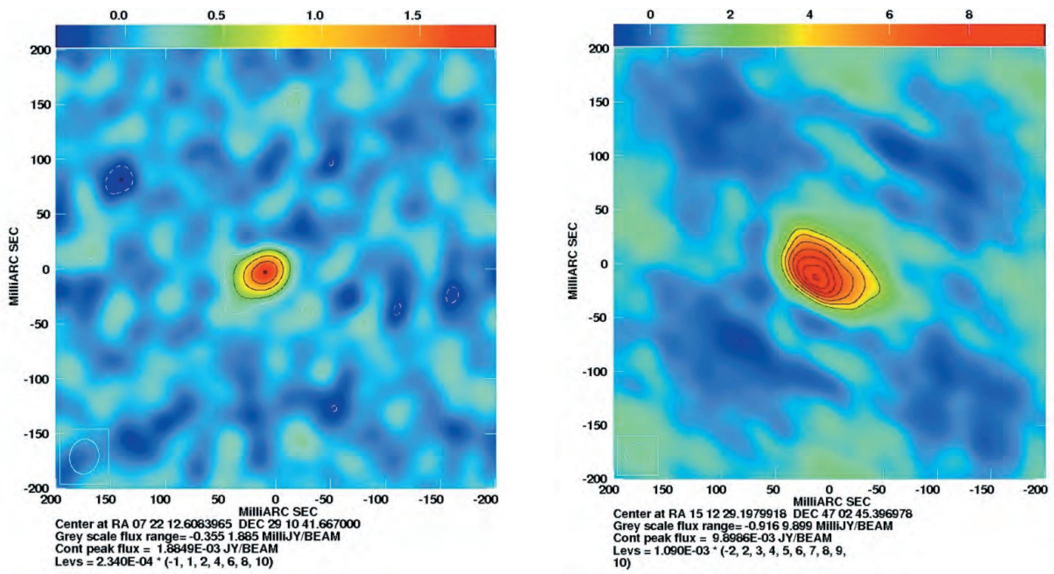


Figure 4.19: L-Band EVN total intensity maps of 0722+291 (left) and 1512+470 (right). The colour bar on top shows the brightness distribution in mJy/beam. For 1512+470, the peak brightness is 9.9 mJy/beam, the 1-sigma rms noise is 0.36 mJy/beam and the restoring beam is 23.88 x 22.31 mas at a position angle of 70.07 degrees. For 0722+291, the peak brightness is 1.88 mJy/beam, the rms noise is 0.085 mJy and the restoring beam is 32.15 x 26.43 mas at a position angle of -9.95 degrees.

4.12 ASTROMETRY, REFERENCE FRAMES

The NASA/Stanford Gravity Probe B (GP-B) experiment comprises a satellite in polar orbit (h=642 km), with four gyroscopes on board. It aims to measure the geodetic precession of the gyro spin axes and frame dragging orthogonal to this, to compare to the predictions from general relativity (6.6 mas/yr and 39 mas/yr, respectively). Directional reference is provided by an on-board telescope with a tracking system to keep a guide object centred in its field of view. This can only track objects brighter than m=6, use of an ICRF source to establish a direct link to an inertial frame was not possible. The RS CVn star IM Peg was selected as the guide star, and a series of VLBI observations was undertaken to be able to separate the motion of the star in inertial space from the estimation of relativistic effects from the gyroscope measurements. With Dan Lebach (CfA), Norbert Bartel (York U.), and others, Bob Campbell worked on ways of combining parameterized model-fitting and phase-referencing mapping techniques to optimize the astrometric results over the span of observations from 1991 to 2005, including ionospheric calibrations prior to the availability of IONEX maps from the IGS.

Bob Campbell was a member of the IAU Division I Working Group on the Second Realization of the International Celestial Reference Frame (ICRF2), whose goal was to oversee the generation, validation, and utility of the ICRF2 and to formulate the resolution to the IAU proposing its adoption as the fundamental astrometric realization of the International Celestial Reference System (Resolution B3 to the IAU XXVII General Assembly [2009]). The ICRF2 was based on S/X-band geodetic VLBI observations, tripling in amount since the previous ICRF (1997), and special attention was paid to the selection of defining sources in terms of positional and structural stability, and consistency among celestial & terrestrial reference frames and the Earth orientation parameters connecting them.

4.13 PLANETARY SCIENCE

In classic VLBI, the sources of radio emission are considered to be at an infinitely large distance. Therefore, the so-called Consensus VLBI delay model assumes the wave front from the source to be flat. This assumption does not hold for sources within the Solar System in typical Earth-based VLBI observations at cm wavelengths. The Space Science Applications group implemented the Sekido-Fukushima algorithm for VLBI delay calculations for a source at a finite distance (Duev et al., in preparation).

In this algorithm, a pseudo source vector is introduced in order to account for the effect of the curved wave front, and the variation of the baseline vector due to the difference of arrival time is taken into account up to the second-order by using the Halley's method. The theoretical precision of the model is better than 1 ps for radio sources at a distance larger than 100 km from the Earth's surface in Earth-based VLBI observations. The algorithm can face computational difficulties at distances greater than ~ 100 AU. However, this problem can be solved on quadruple precision computer platforms. A special test VLBI observation of a spacecraft processed with this software has shown perfectly consistent results. It is shown, that the near-field delay effects on global baselines can be measured at ~ 1 ps level for sources as far as 10 pc from Earth and ~10 ps at the distances of 100 pc for Space VLBI baselines. In addition to the immediate applications in planetary Radio Interferometry and Doppler Experiment with various planetary probes as VLBI targets, future development of the model might enable estimates of distances to Galactic radio sources directly from the VLBI delay data. Such perspective is particularly attractive for future observations of exoplanets orbiting nearby stars using the SKA in its high-resolution configuration.

5 SPACE SCIENCE AT JIVE

Space science applications of radio astronomy methods, and especially the VLBI technique, are becoming a subject of growing demand among the new, large and active user community – planetary scientists and deep space mission specialists. A number of prospective planetary and deep space science missions will include in situ and remote experiments supported by Earth-based networks of radio telescopes. JIVE, with its EVN partners is developing Planetary Radio Interferometry and Doppler Tracking Experiment (PRIDE), a multidisciplinary enhancement of the scientific suite of planetary missions. PRIDE applications range from studies of the dynamics of extraterrestrial atmospheres to gravimetric diagnostics of the planetary interiors to fundamental physics. During the reporting period, the work focused on developments of the PRIDE methodology and data handling algorithms using operational planetary missions as observational targets. The PRIDE observations conducted in 2009-2010 addressed the methodology of spacecraft VLBI tracking and, as a valuable scientific by-product, provided input into the long-term diagnostics of the interplanetary medium at various Sun elongation angles (Molera et al., 2011, in preparation). Below, Venus Express (VEX) and Mars Express (MEX) PRIDE experiments are presented in more details.

5.1 PRIDE-VEX MONITORING CAMPAIGN

The ESA's Venus Express spacecraft has been observed with several EVN stations (Metsähovi, Medicina, Wettzell, Onsala, Matera and Noto) during the 2008-2010 campaign. The goal of the project was to develop and test the full PRIDE data handling pipeline, including scheduling of a near field object VLBI observation, data acquisition and transfer, processing of the spacecraft signals with the specially developed ultra-high resolution software spectrometer/correlator and analysis software based on the near-field delay prediction model.

The ultra-high spectral resolution spectrometer/correlator software was developed at the Metsähovi Observatory, while the analysis software – at JIVE. Several single-dish and multi-station experiments confirmed that high quality data could be acquired and a sub-milliHertz spectral resolution could be achieved. Figure 5.1 illustrates the results of one of the first PRIDE observations of the VEX spacecraft with the Wettzell radio telescope.

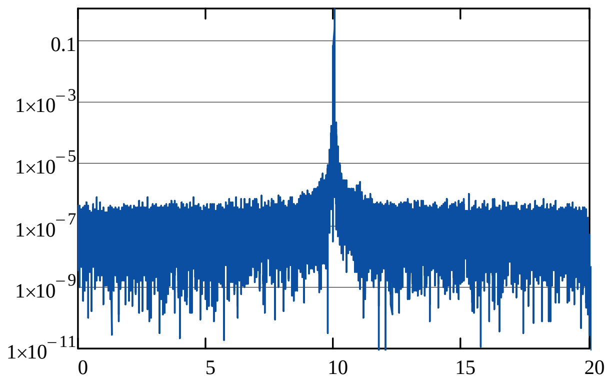


Figure 5.1: Ultra-high resolution spectrum of the VEX signal, obtained from the Wettzell date on 2010.03.31. The horizontal axis indicates the frequency within the tracking band, the vertical axis – the relative spectral power density. The spectral resolution achieved in this experiment is 0.9 mHz, the dynamic range is at the level of 10^7.

The high intrinsic stability of the spacecraft signal and high dynamic range of the signal detection made an investigation possible of the phase scintillations of the signal by the inhomogenities in the interplanetary plasma. This direct phase scintillation technique differs from the classical technique of power scintillations of natural sources and offers consistent results with a higher accuracy providing a possibility of estimating the spectrum of the interplanetary plasma turbulence and its dependence on the solar elongation angle and level of Sun activity. Figure 5.2 presents an example of the phase scintillation spectra detected with different EVN stations at different solar elongations and the dependence of the scintillation index on the solar elongation.

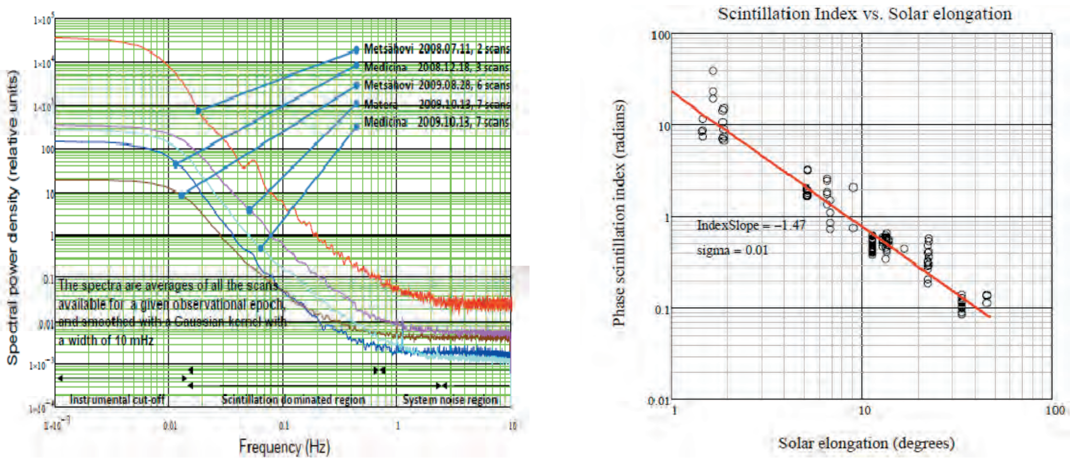


Figure 5.2: Left panel: examples of the phase scintillation spectra, detected by several EVN stations. Right panel: the dependence of the phase scintillation index on the solar elongation angle.

The observations have proven that the phase scintillation spectra have a near-Kolmogorov spectrum. The parameters of the scintillation patterns were measured with an accuracy that made these results very valuable in their own right. In particular, these data help to determine constraints imposed by the interplanetary plasma on the accuracy of astrometric and phase-referencing VLBI measurements and are of crucial importance for future ultra-precise PRIDE observations.

5.2 MEX-PHOBOS FLYBY OBSERVATIONS WITH THE EVN TELESCOPES

The EVN stations Yebes, Wettzell and Metsähovi participated in the observations of the ESA'a Mars Express (MEX) spacecraft during its fly-by of the Martian moon Phobos on 3 March 2010. Using the ultra-high spectral resolution correlator, developed in at the Metsähovi Observatory, the PRIDE team detected the additional Doppler shift of the MEX spacecraft signal caused by the gravitational field of Phobos. The high quality of the Doppler detections (2-5 mHz or 1 mm/s in velocity terms) made improvements possible of the determination of the mass and mass distribution of Phobos. Figure 5.3 illustrates the detection and preliminary analysis results of this experiment.

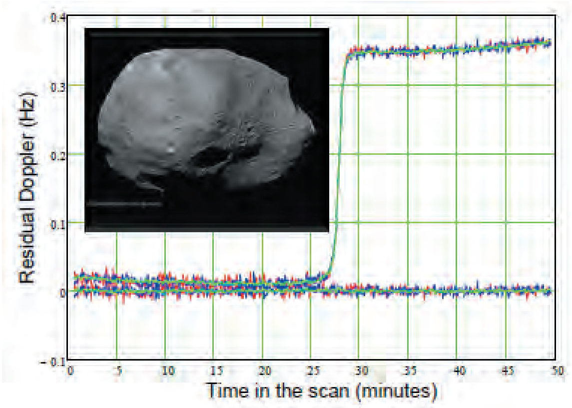


Figure 5.3: The residual Doppler shift of the MEX signal, as detected by the Yebes, Wettzell and Metsähovi stations. The upper traces indicate the case of the Phobos gravity (algorithmically) "switched off" in the spacecraft state vector predictions, the lower traces show the actual measured case in the presence of the Phobos gravity.

5.3 MARS EXPRESS OBSERVATIONS WITH THE RADIO TELESCOPE WARKWORTH, NEW ZEALAND

Observations of the Mars Express spacecraft with the newly built Warkworth 12-m radio telescope (Figure 5.4, left panel) of the Auckland University of Technology (AUT, New Zealand) was one of the pilot projects conducted with this telescope in April 2010. The experiment was organised in the framework of the Memorandum of Agreement on collaboration between JIVE and AUT concluded in 2010. The observational data, acquired by the Warkworth telescope, were electronically transferred from New Zealand to Metsähovi (with support from the EC FP7 NEXPReS project) for processing and then further on to JIVE for analysis. Figure 5.4 (right panel) shows the spectrum of the MEX signal detected at Warkworth with a VLBI data acquisition system. Besides their usefulness for interplanetary plasma diagnostics, the MEX results helped the AUT team to test and tune up their new instrumentation. "Near field" VLBI observations with the Warkworth telescope will continue. Due to the geographical location, Warkworth provides a very valuable addition into the PRIDE telescope network.

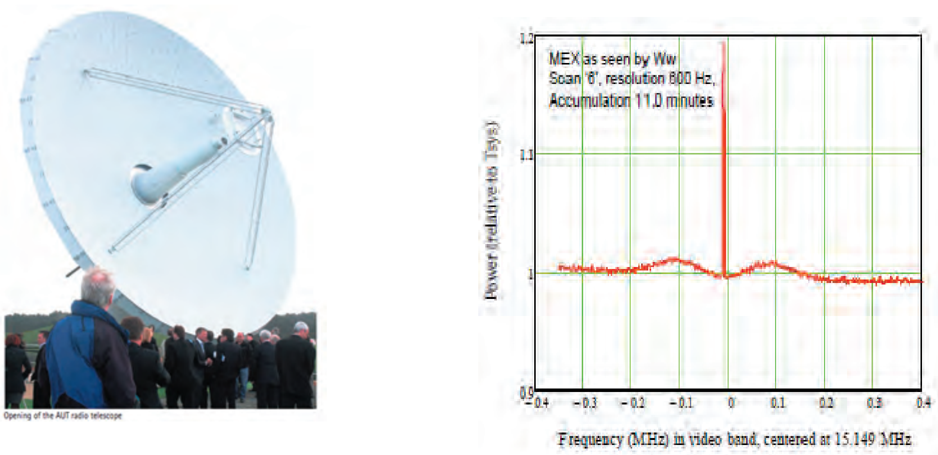


Figure 5.4: The AUT Warkworth radio telescope, New Zealand in February 2010 (left panel), and the MEX signal detected at Warkworth in April 2010.

6 EXTERNALLY FUNDED PROJECTS

6.1 EXPRES

The EXPReS project (Express Production Real-time e-VLBI Service, http://www.expres-eu.org/) was an Integrated Infrastructure Initiative (I3), funded under the European Commission's Sixth Framework Programme (FP6), contract number 026642, from March 2006 through August 2009. Coordinated by JIVE and comprised of 19 astronomy institutes and National Research and Education Network (NREN) providers around the world, EXPReS established and improved network connectivity from some of the world's most sensitive radio telescopes to the correlator at JIVE, and also improved the computing capabilities of the correlator itself.

EXPReS was organized into seven activities (Table 6.1):

Activity #	Activity Type	Activity Name
NA1	Networking	Management of I3
NA2	Networking	EVN-NREN Forum
NA3	Networking	e-VLBI Science Forum
NA4	Networking	e-VLBI Outreach, Dissemination & Communications
SA1	Service	Production e-VLBI Service
SA2	Service	Network Provision for a Global e-VLBI Array
JRA1	Joint Research	Future Arrays of Broadband Radio Telescopes on Internet Computing

EXPReS successfully demonstrated its advances in e-VLBI on a few different occasions in 2009.
In January, a "marathon e-VLBI" session of 33 nearly-continuous hours was coordinated, involving 17 telescopes on five continents, and demonstrated live to attendees of the International Year of Astronomy (IYA 2009) Opening Ceremony in Paris. The EVN participated in IYA 2009's "100 Hours of Astronomy" cornerstone project with:

- e-VLBI observations on 3 and 5 April
- a live webcast as part of the "Around the World in 80 Telescopes, Live 24-hour Research Observatory Webcasts"

Progress made during EXPReS, as well as science enabled by EXPReS, was communicated at the week-long "Science and Technology of Long Baseline Real-time Interferometry: The 8th International e-VLBI Workshop" in Madrid, Spain, in May 2009 (Figure 1.1 in section1).

EXPReS formally ended in August 2009 and had its Final Project Review in November 2009. It was serendipitous that in November 2009, Nature accepted a paper based on e-VLBI observations made possible by EXPReS. The EC graded the project as "extraordinarily successful" and encouraged the team to "explore any opportunity for further development". A press release was issued at the conclusion of the review: EXPReS hailed as "extraordinarily successful" and influential to SKA design

6.2 NEXPRES

6.2.1 OVERVIEW

NEXPReS (Novel EXplorations Pushing Robust e-VLBI Services, http://www.nexpres.eu/) is the follow-on project to EXPReS. Comprised of 15 astronomical institutes and NREN providers, NEXPReS is an e-Infrastructure project of the European Union's Seventh Framework Programme under Grant Agreement RI-261525, and will run from August 2010 through July 2013. NEXPReS is funded at 3.5 million EUR with the aim of further developing e-VLBI services of the EVN, with the goal of incorporating e-VLBI into every astronomical observation conducted by the EVN. JIVE is the coordinator of NEXPReS and plays a lead role in leadership of project.

NEXPReS is organized into three activities via eight work packages (Table 6.2):

Work package #	Activity Type	Work Package Name
WP 1	NA	Management
WP 2	NA	EVN-NREN
WP 3	NA	eVSAG
WP 4	NA	Communications and Outreach
WP 5	SA	Cloud Correlation
WP 6	SA	High Bandwidth on Demand
WP 7	JRA	Computing in a Shared Infrastructure
WP 8	JRA	Provisioning High-Bandwidth, High-Capacity Networked Storage on Demand

6.2.2 SUMMARY

NEXPReS has just completed its first six months, so the progress, while on schedule, is in the early stages. The most relevant activity was the First Board Meeting, held on 20 September 2010 in Manchester, UK.

Figure 6.1 NEXPReS had a sweet kick-off in Manchester

6.3 RADIONET FP7

Following the completion of RadioNet FP6 in December 2008, RadioNet FP7 started in January 2009 with a three-year perspective. JIVE plays major roles in the EVN TNA programme, the JRA projects ALBiUS and UniBoard, but also has a continuing role in implementing the travel for the various Networking activities and Trans-National Access programmes of the other facilities. JIVE staff participates in many of these activities such as the Technical and Scientific working groups and of course the various levels of management, the management team, executive board and the RadioNet board itself. In the second half of 2010 JIVE staff were involved in writing a follow-up proposal called RadioNet3 under coordination by Anton Zensus (MPI, Bonn).

6.3.1 RADIONET EVN TNA

The FP7 RadioNet EVN Trans-National Access (TNA) programme provides funding to EVN telescopes to provide access to eligible projects, and supports travel by investigators from eligible projects to visit JIVE or another EVN institute. An eligible project is one in which the PI and at least 50% of the author list as a whole are associated with institutes in the EU member and associated states, excluding the Netherlands as the host country of JIVE. Table 6.3 summarizes various statistics from the past two years of EVN TNA activity.

	2009	2010
Number of eligible observations	67	87
comprising how many proposals	37	46
comprising how many individual researchers	105	143
Number of different PhD students in supported groups	14	15
Total number of access hours	598.5	747.5
Number of data reduction visits	6	7
number of data reduction visits made to JIVE	3	5

Table 6.3: Annual statistics for various aspects of the EVN TNA programme over 2009-2010.

6.3.2 ALBIUS

ALBiUS (Advanced Long Baseline Interoperable User Software) is a Joint Research Activity within the RadioNet EU FP7 framework. In ALBiUS 9 radio astronomy groups collaborate with a total effort of 18 man-years. The tasks encompass interoperability, calibration and handling large datasets. The overall management is coordinated from JIVE by Huib van Langevelde and Giuseppe Cimó. Additionally JIVE is the leading partner for the interoperability task and the global fringe fitting calibration sub-task.

6.3.3 UNIBOARD

UniBoard is the RadioNet JRA aiming to develop an FPGA platform for intensive digital processing in radio astronomy. Originally 7 partners collaborate to develop a single hardware platform, which could perform various tasks, like correlation, pulsar binning or a digital receiver backend. In the course of the project two more partners joined the activity, which is led by Arpad Szomoru at JIVE.

The project made considerable progress by selecting the processor component and prototyping the hardware. An additional consortium agreement was set up to deal with the purchase of hardware components.

6.4 EXBOX

In 2008, JIVE and ASTRON (PI Huib van Langevelde) proposed a project to the NWO-M programme to develop the "Expandable Box for X-correlation", aiming to prototype a correlator platform for the next generation EVN correlator and the WSRT Apertif backend. The successful proposal was awarded 320k€ in early 2009, and additional budget was made available for 2010, after a resubmission of the proposal. This programme has been used to hire the expertise for the development of FPGA processing and the local hardware. As such it is vital for providing local matching to the UniBoard collaboration, as well as resources to commission the FPGA platform for the JIVE specific application of a VLBI correlator.

6.5 NWO – SHAO

In 2009, NWO started the initiative to set-up special programmes for collaborations between the Netherlands and China or India. Through NWO-EW JIVE was able to further formalize its collaboration with the Shanghai Astronomical Observatory and receive additional funding. The programme was officially started with the signing of an MoU between the Shanghai Astronomical observatory, of the Chinese Academy of Sciences, and NWO, during a visit by NWO-EW Director Dr. Louis Vertegaal to Shanghai in January 2010

Figure 6.2 NWO (Dr. Louis Vertegaal) and ShAO (Prof. Xiaoyu Hong) sign the MoU

The programme strengthens the joint programme for developing FPGA correlator soft- and firmware, as well as the strong collaboration on VLBI Space Science applications. Several exchanges of students and experts are arranged by the MoU and in the course of 2010 the first of these were implemented.

6.6 SCARIE

In 2006, the project SCARIe (Software Correlator Research and Implementation for e-VLBI) was successfully proposed to NWO as a joint project of astronomers at JIVE and computer scientists at the Amsterdam University (UvA). After several personnel mutations in the previous period, this was still a source of funding during 2009 and 2010 to work on software correlation, especially with the objective to deploy software correlation on distributed compute nodes.

6.7 ESTRELA

ESTRELA is short for Early Stage Training Site for European Long-wavelength Astronomy, an EC funded Marie Curie network that provided student positions at observatories in Manchester, Dwingeloo, Onsala, Bologna and Bonn. Until September 2009, Kalle Torstensson was appointed through this scheme at JIVE to work on methanol masers. He then formally took employment with the University of Leiden to finish his thesis. Also under supervision of Huib van Langevelde Nikta Amiri worked on circumstellar masers and the non-sphericity of AGB mass-loss, also based in Leiden. She also moved formally to the University of Leiden, but in September 2010. The ESTRELA programme, which offered 3-year PhD positions, was concluded in 2010.

6.8 ESKAC

During the reporting period, JIVE continued its role as the secretary and banker of the European SKA Consortium (ESKAC). The ESKAC appoints the European delegation to the SKA Science and Engineering Committee (SSEC) and supports the activities of the SKA Programme Development Office (SPDO), in Manchester (UK). As the legal entity representing the European community in the global project, the JIVE director was involved in a number of changes to the global MoU. In its role of banker for the ESKAC, JIVE collects the European funds for SPDO and supports travel and meetings. The ESKAC holds frequent meetings, sometimes by telephone, but often face-to-face.

6.9 FP7 PREPSKA

Throughout the reporting period, JIVE was a partner in the successful EC FP7 proposal for Preparatory Studies for the SKA (PrepSKA). This project aims to define and work out budgetary and governance models for the SKA by 2011. JIVE is a minor party in studies of next generation correlator concepts and PrepSKA simulations. Indeed JIVE expertise was feeding in to these work packages and in addition some JIVE experiences were reviewed in the governance study. Several international board meetings were attended. Within its involvement in the overall SKA effort, JIVE is representing and coordinating activities of the e-EVN as a recognized SKA Pathfinder.

Fig 6.3 JIVE staff at work at the International SKA Forum

6.10 SKADS

JIVE was a partner in the EC FP6 SKADS project, the SKA Design Study and the aligned Marie Curie training network. SKADS ended in 2009 and delivered considerations for the SKA design in 2009. JIVE completed work on SKA simulations for astronomy, as well as spacecraft applications.

6.11 FP7 EUROPLANET AND ESPACE

After the successful EuroPlaNet project in FP6, JIVE was again involved in the FP7 project that started in January 2010. Leonid Gurvits leads this project at JIVE. It provides important contacts with the European planetary science community, especially in view of future space missions. JIVE has a small, but specific role in one of the Joint Research Activities aimed at developing VLBI methods of estimating state-vectors of planetary missions. A much more pronounced role for JIVE is envisioned for the FP7 ESPaCE project, aiming at enhancing the solar system ephemeris system. This programme was successfully proposed in 2010, with an expected start of activities in mid 2011.

6.12 EXOMARS

In 2009 JIVE entered a contract with ESA to carry out an assessment study of the detection of the ExoMars signal using a network of Earth-based radio telescopes. This contract enables JIVE to enhance its space applications group and further develop spacecraft processing capabilities. Several spacecraft observations were carried out in this project.

6.13 KNAW-CAS COLLABORATION

In 2010 a new KNAW-funded radio astronomical collaboration started between JIVE/ASTRON and Chinese institutes. The participating partners in PR China are Shanghai Astronomical Observatory, Beijing Astronomical Observatory, Xinjiang Astronomical Observatory (Urumqi) and Yunnan Astronomical Observatory. Project coordinators are Zhiqiang Shen (ShAO) and Zsolt Paragi (JIVE). The main focus will be on VLBI astrophysical research, exploiting the scientific potentials of the developing Chinese VLBI Network and pushing forward developments within the EVN.

Under the auspices of the KNAW-CAS collaboration, a special grant supports a PhD project by Linjie Chen under co-supervision of L. Gurvits (JIVE), H. Falcke (Radboud University and ASTRON) and Y.Yan (NAOC). The project addresses novel technological aspects of the prospective Moon-based Ultra-Long Wavelength Astronomy (ULWA) interferometric facility. The project is on track for completion in 2011.

Fig. 6.4 Linjie Chen on the roof of the Huygens building of the Radboud University (Nijmegen, the Netherlands) with the prototype ULWA antenna during test measurements

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8 APPENDICES

8.1 JIVE BOARD

Prof. J. Gomez-Gonzalez	National Geographical Institute, Madrid, Spain *Chairman*
Prof. H. Olofsson	Onsala Space Observatory, Onsala Sweden *Vice-Chairman*
Prof. Dr. J.A. Zensus	Max-Planck-Institute for Radioastronomy, Bonn, Germany
Dr. P. Charlot	Laboratoire d'Astrophysique de Bordeaux, France
Dr. L. Feretti	Institute for Radioastronomy, Bologna, Italy
Prof. Dr. M.A. Garrett	ASTRON, Dwingeloo, the Netherlands
Prof S.T. Garrington	MERLIN/VLBI National Facility, Jodrell Bank Observatory, UK
Prof. X.-Y. Hong	Shanghai Astronomical Observatory, China

8.2 JIVE FINANCIAL REPORT FOR 2009/2010*

Balance

(amounts x €1000)

ASSETS	2009	2010
Fixed Assets		
Computer Equipment	69	65
Furniture	24	19
	93	**84**
Current Assets		
Work in Process	41	112
Receivables:		
Debtors	202	110
EU	535	571
Other	10	
	788	**793**
Cash at Bank	3.141	2.832
TOTAL	**4.022**	**3.709**

LIABILITIES	2009	2010
Capital		
General Reserve	2.054	2.057
Other Liabilities		
EXPReS	430	431
ESKAC	94	101
ASTRON	225	108
Creditors	409	249
Leave debts	189	188
Other	11	7
Received in advance:		
ESTRELA	46	
FP7 RadioNet	464	
NEXPReS		409
EuroPlaNet		4
Huygens/Exomars	31	31
NWO -SCARIe	69	65
NWO-JIVE/China		59
	1.968	**1.652**
TOTAL	**4.022**	**3.709**

*provisional, subject to audit

JIVE Financial Report for 2009/2010 (cont.)

Revenues			
Contributions		**2009**	**2010**
INAF	IT	240	240
MPI	DE	90	90
STFC	UK	240	240
IGN	ES	140	140
OSO	SE	140	140
NAOC	CH	40	40
CNRS-INSU	FR	40	40
NWO	NL	450	450
ASTRON	NL	520	520
Projects			
FP7 RadioNet	EU	604	718
NEXPReS	EU		355
EXPReS	EU	327	
SKADS	EU	84	
ESTRELA	EU	135	46
Huygens	EU	10	
Exomars	ESTEC		44
PhD project	KNAW	9	16
CEP	KNAW		8
SCARIe	NWO	55	60
JIVE/China	NWO		31
eBob	NRAO		1
UniBoard MoU	Various	40	15
Other			
Education	NWO	27	36
Leave debts write back		-13	2
Interest		13	10
	TOTAL	**3.191**	**3.242**

Expenditures		
Institute	**2009**	**2010**
Salaries	1.324	1.473
Depreciation	47	44
Other	434	410
ASTRON - Overhead	520	520
	2.325	**2.447**
Projects		
FP7 RadioNet	120	216
FP7 UniBoard	96	102
FP7 ALBiUS	43	44
EXPReS	360	
NEXPReS		225
SKADS	75	
ESTRELA	123	45
Upgrade projects		1
NWO-SCARIe	55	60
Huygens	10	
Exomars		44
KNAW-PhD project	9	16
NWO-JIVE/China		31
KNAW-CEP		8
	891	**792**
TOTAL	**3.216**	**3.239**
Result	**-25**	**3**

8.3 JIVE PERSONNEL

Dr. H.J. van Langevelde*	Director
Mrs. N. Amiri	PhD Student (until 1 Sept 2010)
Ms. T. Bocanegra	MSc Student
Mr. S. Bourke	Postdoctoral Research Assistant
Mr. E.P. Boven	Network/Linux Specialist
Dr. R.M. Campbell*	Head of Science Support and Operations,
Mr. L. Chen	PhD Student
Dr. G. Cimó	Support Scientist (until 1 Jan 2009)
Dr. G. Cimó	Space Apps. Scientist (from 1 Jan 2009)
Drs. B. Eldering	Software Engineer
Dr. L.I. Gurvits*	Head of Space Science and Innovative Applications Group
Dr. J.E. Hargreaves	Digital Engineer (from 1 Jun 2009)
Mr. B. Harms	Operator
Dr. Ing. A. Keimpema	Scientific Programmer
Mrs. Y. Kool-Boeser	Senior Secretary
Dr. Ir. M.M. Kettenis	Scientific Software Engineer
Mr. B. Kramer	Software Technician
Mr. M. Leeuwinga	Hardware Support Engineer
Dr. D.J.P. Lommen	PR/Outreach officer (11 Jun 2009 - 22 Aug 2009)
Mr. J. Luo	Researcher in training (from 14 Dec 2010)
Dr. M. Mahmud	Support Scientist (from 1 Aug 2009)
Mrs. S.K. Mellema	Secretary
Dr. S. Mühle	Support Scientist
Dr. F. Olnon	Online Software Engineer (until 1 Aug 2010)
Dr. Z. Paragi	Senior Support Scientist
Dr. Y. Pidopryhora	Postdoctoral Research Assistant (until 1 Sept 2009)
Dr. Y. Pidopryhora	Support Scientist (from 1 Sept 2009)
Ing. S.P.E.L. Pirruccio	Digital Engineer (from 1 Sept 2010)
Dr. S.V. Pogrebenko	Senior System Scientist
Dr. A. Polatidis	Support Scientist (until 1 Feb 2009)
Drs. A.J. van den Poll	Project Assistant
Mr. H. Rampadarath	PhD Student (until 1 Sep 2009)
Dr. M.S. Sipior	Scientific Software Engineer (until 1 Aug 2009)
Dr. D.M. Small	Scientific Software Engineer
Dr. G.A.S. Sundaram	Doctoral Research Assistant (until 12 Oct 2009)
Dr. A. Szomoru*	Head Technical Operations and R&D
Mr. H. Tenkink	Chief Operator
Mr. K.J.E. Torstensson	PhD Student (until 1 Sept 2009)
Drs. H. Verkouter	Offline Software Engineer
Dr. J. Yang	Support Scientist
Mr. T.C. Yun	Program Manager
Mrs. K.S. Yun	PR/Outreach officer

**MT member*

8.4 VISITORS TO JIVE

2009

D. Ait Allal	Radio Astronomy Station of Nançay, France
P. Andreani	ESO, Germany
A. Baudry	U. Bordeaux, France
S. Britzen	Max Planck Institute for Radioastronomy, Germany
P. Camino	U. Bordeaux, France
P. Charlot	Observatoire de Bordeaux, France
G. Comoretto	INAF Osservatorio di Arcetri, Italy
D. Cseh	Eotvos University, Hungary
C. Dumez-Viou	Observatoire de Paris, France
S. Fischer	University of Cologne, Germany
E. Fomalont	NRAO Charlottesville, USA
W. Frieswijk	U. Groningen, NL
Mai Urata	Kagoshima U., Japan
S. Frey	FOMI/SGO, Hungary
G. Grigorescu	Cambridge, UK
J. Hargreaves	Jodrell Bank, UK
G. Harris	U. Manchester, UK
H. Imai	Kogashima University, Japan
D.H. Je	Astronomy and Space Science Institute, Korea
G. Kenfack	Observatoire de Paris, France
H.-R. Kloeckner	U. Oxford, UK
R. Laing	ESO, Germany
J. Moldon	University of Barcelona, Spain
A. Mujunen	Metsähovi Radio Observatory, Finland
I. Philips	AARnet, Australia
A. Richards	Jodrell Bank, Manchester, UK
A. Roy	MPIfR, Bonn, Germany
C. Shenton	U. Manchester, UK
B.W. Sohn	Astronomy and Space Science Institute, Korea
D. Stoklosa	PSNC, Poland
A. Trejo Cruz	UNAM, Morelia, Mexico
J. Ulvestad	NRAO, USA
W. Vlemmings	Argelander Institut, Germany
R. Weber	University of Orleans
Y. Xiang	ShAO, China
J.H. Yeom	Astronomy and Space Science Institute, Korea
J. Zuther	University of Cologne, Germany

2010

T. An	ShAO, China
N. Amiri	Universiteit Leiden, Netherlands
R. Deane	Oxford University, UK
D. Duev	Sternberg Astronomical Institute, Russia
S. Frey	FOMI/SGO, Hungary
K. Gabanyi	SGO, FOMI, Hungary
G. Hallinan	NUI Galway, Ireland
S. Horiuchi	CSIRO, Australia
E. Ibar	Royal Observatory Edinburgh, UK
B. Li	ShAO, China
J. Moldon	U. Barcelona, Spain
G. Molera	Metsähovi Radio Observatory, Finland
C. Romero Cañizales	IAA Granada, Spain
S. Seager	MIT, U.S.
K. Torstensson	Universiteit Leiden, Netherlands

Summerstudents 2009

David Cseh	24 June - 1 September 2009
Mai Urata	19 June - 1 September 2009

Summerstudents 2010

Rachael Alexandroff	15 June - 23 August 2010
Tahlia De Maio	1 June - 18 August 2010

8.5 PRESENTATIONS

Tatiana Bocanegra

- *"Geodynamical studies of planetary moons with PRIDE"*, YERAC 2010, Madrid, Spain, 6 July 2010

Stephen Bourke

- *"ALBiUS interoperability overview"*, ALBiUS management, Garching, Germany, 16 June 2009
- *"VLBI continuum data calibration"*, European Radio Interferometry School, Oxford, UK, 8 September 2009
- *"ALBiUS interoperability report"*, ALBiUS meeting, Dwingeloo, NL, 12 November 2009
- *"Global VLBI observations of binary brown dwarf systems"*, 10th European VLBI Network Symposium, Manchester, UK, 21 September 2010

Paul Boven

- *"Correlator Use Cases"*, presentation at the UniBoard Kickoff meeting, Dwingeloo, the Netherlands, 26 February 2009
- *"Worldwide Networking for e-VLBI"*, presentation at the Terena TNC 2009, Malaga, Spain, 9 June 2009
- *"e-VLBI Networking Tricks"*, paper and presentation at the 8th e-VLBI Workshop, Madrid, Spain, 22-26 June 2009
- *"e-VLBI Applications and Requirements"*, presentation at the EGEE'09 NRENS and Grids workshop, Barcelona, Spain, 19 September 2009
- *"Results from EXPReS, and the future of e-VLBI"*, presentation at the Terena 2nd E2E provisioning workshop, Amsterdam, the Netherlands, 7 December 2009
- *"High-speed continuous recording and playback for VLBI"*, presentation at the Terena 7th TF-Storage Meeting, Pozan, Poland, 10 September 2010
- *"WP6 - High Bandwidth on Demand"*, presentation at the NEXPReS Board Meeting and Kickoff, Manchester, UK, 20 September 2010
- *"Dynamic Networking for NEXPReS"*, presentation at the 9th e-VLBI Workshop, Perth, Australia, 20 October 2010
- *"NEXPReS: Dyamische Lichtpaden voor e-VLBI"*, presentation at the SURFnet Relatiedagen, Noordwijkerhout, the Netherlands, 9 December 2010

Bob Campbell

- *"e-VLBI and Other Developments from the EVN MkIV Data Processor at JIVE"*, 19th Working Meeting on European VLBI for Geodesy and Astrometry, Bordeaux, France, 24 March 2009
- *"VLBI: Introduction and Astronomic/Geodetic Applications"*, U.S. Naval Academy, Annapolis, Md, US, 21 October 2009
- *"EVN Proposal Tool (NorthStar)"*, 10th EVN Symposium, Jodrell Bank, UK, 22 September 2010
- *"e-EVN and Other Developments at the EVN MkIV Data Processor at JIVE"*, 10th EVN Symposium, Jodrell Bank, UK, 22 September 2010

Giuseppe Cimó

- *"ALBiUS workshop overview"*, ALBiUS management, Garching, Germany, 16 June 2009
- "Planetary Radio Interferometry and Doppler Experiment", Astrofest, Exloo, the Netherlands, 10 June 2009
- *"Active Galactic Nuclei"*, Summer Students Lecture, Dwingeloo, the Netherlands, 28 June 2009
- *"PRIDE and EJSM"*, EuroPlaNet congress, Potsdam, Germany, 16 September 2009
- *"ALBiUS Workshop Introduction"*, ALBiUS meeting, Dwingeloo, the Netherlands, 12 November 2009
- *"ALBiUS report"*, RadioNet Board Meeting, Cagliary, Italy, 4 May 2010
- "Planetary Radio Interferometry and Doppler Experiment", NAC, Cuijk, the Netherlands, 20 May 2010
- *"Active Galactic Nuclei + PRIDE overview"*, Summer Students Lecture, Dwingeloo, NL, 27 June 2010
- *"Multi-epoch VLBI observations of the extreme scintillator J1819+3548"*, poster presented at the IAU Symposium 275: "Jets at all Scales", Buenos Aires, Argentina, 15 September 2010
- *"EVN and Planetary Radio Interferometry and Doppler Experiment"*, EVN Symposium "VLBI and the new generation of radio arrays", Manchester, UK, 22 September 2010
- *"Research Overview: Scintillation and PRIDE"*, Shanghai Radio Observatory, China, 15 October 2010

Peter Friedman

- *"Self-cohering tied arrays"*, SKADS conference, Limelette, Belgium, 4 November 2009

Leonid Gurvits

- *"SKA(DS) telescope simulation and calibration (a wrap-up attempt)"*, SKADS DS2 meeting, Malta, Malta, 8 January 2009
- *"VLBI tracking of deep space probes: objectives and methods"*, working visit to ESAC, Madrid, Spain, 21 January 2009
- *"JIVE SKADS report"*, SKADS board meeting, Madrid, Spain, 23 January 2009
- *"PRIDE-and Europa mission science objectives"*, Europa Science Conference, Moscow, Russia, 11 February 2009
- *"PRIDE-EJSM development status"*, EJSM study meeting, Moscow, Russia, 13 February 2009
- *"SKA configurations, dynamic range and other figures of merit"*, SKA meetings, Cape Town, South Africa, 20 February 2009
- *"Radio astronomy methods and EuroPlaNet science objectives"*, FP7 EuroPlaNet kick-off meeting, Paris, France, 8 march 2009
- *"SKA science in Solar system"*, SKADS DS2 - SKA science meeting, Manchester, UK, 11 March 2009
- *"Space and planetary science in the context of IVS"*, IVS-EVGA meeting, Bordeaux, France, 23 March 2009
- *"Radio properties of active galactic nuclei across the redshift space and galaxy formation"*, "Galaxy evolution and environment" conference, Kuala Lumpur, Malaysia, 2 April 2009
- *"Space and planetary science frontier of the SKA"*, JENAM 2009, Hatfield, UK, 20 April 2009
- *"VLBI measurables of PRIDE and the EJSM mission objectives"*, EPN JRAIWG, London, UK, 24 April 2009
- *"Space horizons of radio astronomy"*, NVR visit to Dwingeloo, Dwingeloo, Netherlands, 8 May 2009
- *"SKA and its space science frontier"*, Working visit to ASIAA, Taipei, Taiwan, 14 May 2009
- *"News from the space science frontier of radio astronomy"*, KNAW-CAS collaboration meeting, Shanghai, China, 18 May 2009
- *"MMO tracking experiments: science objectives"*, BepiColombo & Phobos-Grunt VLBI experiment preparation, Shanghai, China, 20 May 2009
- *"EVN and Space Science: recent developments"*, EVN CBD meeting, Gothenburg, Sweden, 26 May 2009
- *"News from new potential EVN observatories"*, EVN CBD meeting, Gothenburg, Sweden, 26 May 2009
- *"Space science frontier of radio astronomy"*, BepiColombo and OP working meeting, Kiruna, Sweden, 2 June 2009
- *"PRIDE-EJSM: status of the development"*, EJSM DOI coordination meeting, Oslo, Norway, 4 June 2009
- *"Science and technology outlook of PRIDE-EJSM"*, EJSM Technology development workshop, Noordwijk, Netherlands, 11 June 2009
- *"PRIDE-VEX observing campaign"*, PRIDE EVE, Noordwijk, Netherlands, 19 June 2009
- *"Status of the Mars DtE study"*, Exomars meeting, Noordwijk, Netherlands, 19 June 2009
- *"Space science frontier of radio astronomy"*, Lecture for ASTRON-JIVE summer students, Dwingeloo, Netherlands, 23 June 2009
- *"SKA configuration simulations: the status"*, SKADS working meeting at LPI, Moscow, Russia, 28 June 2009
- *"PRIDE-Phobos: the legacy of the ChSrSh software"*, Phobos-Grunt and YH-1 PRIDE preparation meeting, Moscow, Russia, 30 June 2009
- *"Direct-to-Earth data delivery from outer planets"*, Working meeting on DtE with apperture arrays, New York, USA, 14 July 2009
- *"Status of PRIDE-EJSM"*, EJSM ESA/NASA working meeting, Baltimore, USA, 16 July 2009
- *"IAU Div. XI (Spaceborne and High-energy Astrophysics) triennial report"* , IAU GA, Rio de Janeiro, Brazil, 12 August 2009
- *"Water masers in the Kronian system"*, IAU GA Symp. No.263, Rio de Janeiro, Brazil, 13 August 2009
- *"Radio astronomy and in situ planetary science studies"*, OP preparatory meeting, Sao Jose dos Campos, Brazil, 20 August 2009
- *"SKA-DtE potential"*, SKA DtE applications & implementation meeting, Berlin, Germany, 14 September 2009
- *"Progress of MGNS & PRIDE"*, BepiColombo Science working team meetings, Blois, France, 27 October 2009
- *"SKA(DS) & planetary science"*, SKADS conference, Limelette, Belgium, 4 November 2009

- *"VLBI Space Science news"*, EVN CBD meeting, Manchester, UK, 11 November 2009
- *"JIVE Management Report"*, JIVE board meeting, Manchester, UK, 12 November 2009
- *"Status of the PRIDE-EJSM development"*, EJSM-MIR kick-off meeting, Bremen, Germany, 20 November 2009
- *"The radio astronomy frontier of planetary science and exploration"*, Conference "5th anniversary of the Huygens landing", Barcelona, Spain, 14 January 2010
- *"On the accuracy of PRIDE measurements"*, PRIDE Mars and Europa meeting, Brisbane, Australia, 5 February 2010
- *"PRIDE in the IVS context"*, Sixth IVS General Meeting, Hobart, Australia, 10 February 2010
- "Report on the IVS WG5 activities", IVS Directing Board meeting, Hobart, Australia, 12 February 2010
- *"Space and planetary "near field" applications of SKA"*, SKANZ conference, Auckland, New Zealand, 16 February 2010
- *"Phobos PRIDE and DtE preparation: upcoming test campaigns"*, Mars-Phobos (PRIDE) progress meeting, Moscow, Russia, 1 March 2010
- *"Status PRIDE-Phobos"*, International meeting on Mars & Phobos missions, Moscow, Russia, 20 March 2010
- *"SKA developments of JIVE"*, SKA conference 2010, Manchester, UK, 24 March 2010
- *"Single-dish and VLBI experiments with Martian probes"*, Mars-radio science , Moscow, Russia, 4 April 2010
- *"DtE developments for ExoMars"*, PRIDE-ExoMars progress meeting, Koln, Germany, 5 May 2010
- *"PRIDE VLBI tests in preparation for Martian missions"*, Mars-PRIDE meeting, Darmstadt, Germany, 9 May 2010
- *"PRIDE-Phobos test campaign"*, Phobos-PRIDE meeting, Moscow, Russia, 14 May 2010
- *"ExoMars PRIDE options"*, ExoMars meeting, Koln, Germany, 11 May 2010
- *"News from JIVE: from z=0 to z>5"*, Colloquium at ISAS, Sagamihara, Japan, 4 June 2010
- *"VLBI studies in the widest possible range of redshift"*, Colloquium at the Nobeyama Radio Observatory, Nobeyama, Japan, 27 July 2010
- *"Review of science news from EVN and JIVE"*, Colloquium at Mizusawa Observatory, Mizusawa, Japan, 24 August 2010
- *"SKA in the context of space science and planetary exploration"*, JENAM 2010, Lisbon, Portugal, 9 September 2010
- *"PRIDE-EJSM: report on development milestones"*, EJSM evaluation workshop, Cascaix, Portugal, 13 September 2010
- *"Radio astronomy segments of prospective planetary missions"*, European Planetary Science Congress, Rome, Italy, 22 September 2010
- *"IVS WG5 status report"*, IVS Board meeting, Shanghai, China, 23 October 2010
- *"Results of the PRIDE-MMO preparatory VLBI observations"*, BepiColombo collaboration meeting, Tokyo, Japan, 27 October 2010
- *"Space and planetary science VLBI"*, RadioAstron status, EVN CBD, St. Petersburg, Russia, 7 November 2010
- *"Radio astronomy experiments with planetary probes in the Martian system"*, 1st Moscow Solar System symposium, Moscow, Russia, 12 November 2010
- *"Planetary wind dynamics estimates from PRIDE measurements"*, ESA CV M3 proposal writing session, Zurich, Switzerland, 26 November 2010
- *"Lectures on radio interferomertry"*- 10 lectures (20 hours), Lecturing at Ventspils University College (via videolink, Dwingeloo) , April 2010
- *"Space-borne astrophysics"* - 12 lectures (24 hours), Moscow State University - guest professorship (via videolink, Dwingeloo), Spring semester 2010

Jonathan Hargreaves

- *"UniBoard developments at JIVE and SKA"*, PrepSKA WP2 annual meeting, Manchester, UK, 29 October 2009
- *"EVN correlator development with UniBoard"*, UniBoard face-to-face meeting, Bordeaux, France, 12 October 2010

Mark Kettenis

- *"e-VLBI with the SFXC correlator"*, presentation at the 8th International e-VLBI Workshop, Madrid, Spain, 24 June 2009

- *"SCARIe FABRIC: A (distributed) software correlator for VLBI"*, presentation at High Performance Computing in Observational Astronomy, Pune, India, 14 October 2009
- *"ParselTongue Development"*, presentation at the ALBiUS developers meeting, Dwingeloo, The Netherlands, 12 November 2009
- *"NEXPReS"*, presentation at the EGI Technical Forum 2010, Amsterdam, The Netherlands, 14 September 2010
- *"WP7 - Correlation in a shared infrastructure"*, presentation at the NEXPReS board meeting, Manchester, UK, 20 September 2010
- *"Automated distributed correlation on a shared computing infrastructure"*, presentation at the 9th International e-VLBI Workshop, Perth, Australia, 18 October 2010
- *"Smart Infrastructure for VLBI software correlation"*, poster and demonstration at SC10, New Orleans, USA, 16 November 2010

Huib van Langevelde

- *"Introducing the e-VLBI demo"*, International Year of Astronomy, Paris, France, 16 January 2009
- *"EXPReS Continuity"*, EXPReS board, Madrid, Spain, 21 January 2009
- *"EXPReS"*, SKADS board, Madrid, Spain, 22 January 2009
- *"ALBiUS overview"*, ALBiUS kickoff, Dwingeloo, the Netherlands, 3 March 2009
- *"ALBiUS Advanced Long Baseline Interoperable User Software"*, RadioNet kick-off, Amsterdam, the Netherlands, 30 March 2009
- *"ALBiUS management"*, RadioNet kick-off, Amsterdam, the Netherlands, 31 March 2009
- *"Webcast"*, IYA round the world webcast, Dwingeloo, the Netherlands, 3 April 2009
- *"Introducing JIVE, VLBI, e-VLBI"*, SURFnet pres event, Dwingeloo, the Netherlands, 3 April 2009
- *"Een telescoop groter dan Europa"*, NL event NEMO, Amsterdam, the Netherlands, 5 April 2009
- *"JIVE, ASTRON, NWO"*, OR, Dwingeloo, the Netherlands, 9 April 2009
- *"Introducing JIVE, VLBI, e-VLBI"*, TNO visitors, Dwingeloo, the Netherlands, 27 April 2009
- *"Introducing JIVE, VLBI, e-VLBI"*, International ambassadors, Dwingeloo, the Netherlands, 15 May 2009
- *"JIVE report"*, EVN CBD, Gothenburg, Sweden, 26 May 2009
- *"JIVE progress report"*, JIVE board , Gothenburg, Sweden, 27 May 2009
- *"JIVE business"*, JIVE board, Gothenburg, Sweden, 27 May 2009
- *"Exciting rings of methanol"*, Science Fest, Exloo, the Netherlands, 10 June 2009
- *"ALBiUS, workshop introduction"*, ALBiUS management, Garching, Germany, 16 June 2009
- *"EXPReS, NEXPReS"*, DG INFSOC information day, Brussels, Belgium, 18 June 2009
- *"Future EXPReS: NEXPReS"*, eVSAG meeting, Madrid, Spain, 22 June 2009
- *"The future of e-VLBI"*, e-VLBI conference, Madrid, Spain, 24 June 2009
- *"e-VLBI: a telescope larger than Europe"*, dot Astronomy 2009, Leiden, the Netherlands, 1 December 2009
- *"An ERIC 4 JIVE"*, meeting NWO legal advisers, Den Haag, the Netherlands, 1 December 2009
- *"radio interview on SN2007gr and e-VLBI"*, Noorderlicht radio, Hilversum, 2 February 2010
- *"NEXPReS"*, DG-INFSO Evaluation hearing, Brussels, Belgium, 9 February 2009
- *"eVLBI connecting remote telescopes in real-time"*, Kick-off GigaPort3, Den Haag, Netherlands, 18 February 2010
- *"NEXPReS"*, NEXPReS contract negotiation, Brussels, Belgium, 30 March 2010
- *"Introducing JIVE , objectives, organization, ambitions"*, Meeting at the Polish ministry, Warsaw, Poland, 22 April 2010
- *"What users want"*, Geant discussion panel, Vilnius, Lithuania, 1 June 2010
- *"NEXPReS, e-VLBI, Radio-astronomy"*, US-EU meeting on connectivity, Vilnius, Lithuania, 2 June 2010
- *"The future of VLBI has begun"*, A New Golden Age for Radio Astronomy, Assen , The Netherlands, 14 June 2010
- *"VLBI and masers"*, Summer student lecture, Dwingeloo, The Netherlands, 29 June 2010
- *"Management report"*, JIVE board, Schiphol, The Netherlands, 12 July 2010
- *"Coordinators report"*, NEXPReS board, Manchester, 20 September 2010
- *"The magic of non-rotating methanol disks"*, 10th European VLBI Network Symposium, Manchester, UK, 21 September 2010

- *"ALBiUS Advanced Long Baseline interoperable User Software"* , RadioNet mid term review, Ventspils, Latvia, 5 October 2010
- *"JIVE report"*, EVN CBD, Svetloe, Russia, 7 October 2010
- *"The use of the WSRT for VLBI"*, WSRT@40, Westerbork, the Netherlands, 22 October 2010
- *"Een telescoop groter dan Europa"*, ASTRON/JIVE open dag, Westerbork, the Netherlands, 24 October 2010
- *"JIVE ERIC"*, JIVE board, Dwingeloo, the Netherlands, 3 November 2010
- *"JIVE management report"*, JIVE board, Spier, 4 November 2010
- *"Resolving methanol masers with the EVN"*, SA SKA bursary conference, Stellenbosch, 30 November 2010

Martin Leeuwinga

- *"The Impact of Global High-Speed Networks on Radio Astronomy. An Operational Viewpoint"*, paper and presentation at the 4th International Workshop on Distributed Cooperative Laboratories: Instrumenting the Grid, Alghero, Sardinia, Italy, 2 April 2009

Mehreen Mahmud

- *"Connecting Magnetic Towers with Faraday Rotation Gradients in the Jets of AGN"*, contributed talk at the RM 2010 Workshop: Rotation Measure Analysis of Magnetic Fields in and around Radio Galaxies, Riccione, Italy 10-14 May 2010
- *"Searching for Helical Magnetic Fields in AGN"*, contributed talk at the 65th Dutch Astronomy Conference (NAC),Cuijk, the Netherlands 19-21 May 2010
- *"Surprising evolution of Faraday rotation gradients in the jets of AGN"*, oral presentation at YERAC, 40th Young European Radio Astronomers Conference (YERAC), Madrid, Spain, 5-8 July 2010
- *"Probing the Nature of Ultra-Steep Spectrum Radio Sources"*, contributed talk at the 10th EVN Symposium "VLBI and the new generation of radio arrays", Manchester, UK, 20-24 September 2010

Stefanie Mühle

- *e-VLBI demo*, International Year of Astronomy, Paris, France, 15-16 January 2009
- *"JIVE, VLBI en e-VLBI"*, introductory talk during Girls Day 2009, Dwingeloo, NL, 23 April 2009 (Girlsday 2009 at ASTRON & JIVE)
- *"Tracing the Properties of Extragalactic Molecular Gas with ALMA"*, poster presented at the conference "mm and submm Astronomy at High Angular Resolution", Taipei, Taiwan, 8-12 June 2009
- "Molecular gas is cool … or is it?- Formaldehyde as a tracer of the properties of molecular gas in active galaxies", seminar talk at the Joint Astronomy Center, Hilo, HI, USA, 15 June 2009
- *"Characterization of the Molecular Gas in Active Galaxies"*, poster in connection with "FIR2009: The ISM of Galaxies in the Far-Infrared and Sub-Millimetre", Joint Discussion 14 of the XXVII IAU General Assembly, Rio de Janeiro, Brasil, 10-14 August 2009
- *"Een telescoop zo groot als de Aarde"*, introductory talk, guided tour of JIVE and other outreach activities, Dwingeloo, 22 April 2010 (Girls Day 2010 at ASTRON & JIVE)
- *"Molecular gas is cool! Isn't it?"*, seminar talk at the Instituto de Astrofisica de Andalucia, Granada, Spain, 25 May 2010
- *"A telescope as big as the Earth?"*, introductory talk and guided tour of JIVE for the participants of the ASTRON/JIVE Summer School 2010, Dwingeloo, NL, 24 June 2010
- *"How warm is the molecular gas in starburst galaxies and AGN?"*, talk during the conference "Molecules in Galaxies", Oxford, UK, 28 July 2010
- "Molecular gas is cool, isn't it? An Introduction to Methods of Extragalactic Molecular Spectroscopy", summer student lecture, Dwingeloo, NL, 3 August 2010
- *"How warm is the molecular gas in active environments?"*, talk during the 10th EVN Symposium "VLBI and the new generation of radio arrays", Manchester, UK, 21 September 2010

Friso Olnon

- *"Een netwerk van radiotelescopen"*, Sterrendag, Dwingeloo, the Netherlands, 18 October 2009

Zsolt Paragi

- *"The e-EVN: a realtime VLBI instrument"*, European Week of Astronomy and Space Science (JENAM), 20 April 2009, Hatfield, United Kingdom
- *"e-EVN and global VLBI observations of SN 2007gr"*, European Week of Astronomy and Space Science (JENAM), 20 April 2009, Hatfield, United Kingdom
- *"Very Long Baseline Interferometry (VLBI) in the 'golden age' of radio astronomy"*, 1st School on Multiwavelength Astronomy, 2 July, Paris, France
- *"A suspected Dark Lens revealed with the e-EVN"*, Science and Technology of Long Baseline Real-Time Interferometry: The 8th International e-VLBI Workshop, 23 June 2009, Madrid, Spain
- *"Type Ib/c supernovae observations with VLBI"*, A New Golden Age for Radio Astronomy, 10 June 2010, Assen, The Netherlands
- *"Is there a mildly relativistic jet in SN2007gr?"* (poster), IAU Symposium 275: Jets at all Scales, 13-17 September 2010, Buenos Aires, Argentina
- *"Constraints on early expansion in type Ib/c SNe with VLBI"*, e-VLBI and the Path to the Square Kilometre Array, 18 October 2010, Perth, Australia

Yurii Pidopryhora

- *"Extra-Planar HI in the Inner Milky Way: New High-Resolution Data"*, contributed talk presented at the European Week of Astronomy and Space Science (JENAM09), Hatfield, UK, 22 April 2009
- *"The Ophiuchus Superbubble: Disk-Halo Interaction at Work"*, poster presented at the 64th Dutch Astronomy Conference, Kerkrade, the Netherlands, 14 May 2009
- *"The Ophiuchus Superbubble: Disk-Halo Interaction at Work"*, poster presented at the conference "Panoramic Radio Astronomy: Wide-field 1-2 GHz research on galaxy evolution", Groningen, the Netherlands, 3 June 2009
- *"The Latest Tests of the SFXC Software Correlator"*, contributed talk at the 8th International e-VLBI Workshop, Madrid, Spain, 26 June 2009
- *"SN2007gr: a Normal Type Ic Supernova with a Mildly Relativistic Radio Jet"*, poster presented at the 10th European VLBI Network Symposium "VLBI and the new generation of radio arrays", Manchester, UK, 22 September 2010

Des Small

- *"The UniBoard ExBoX Correlator Control System"*, presentation at the UniBoard Face-to-face meeting, Bordeaux, 13 October, 2010

Arpad Szomoru

- *"SA1: third year overview"*, EXPReS board meeting, Madrid, Spain, 21 January 2009
- *"The UniBoard, a multi-purpose scalable computing platform for Radio Astronomy"*, RadioNet FP7 kick-off meeting, Schiphol, the Netherlands, 31 March 2009
- *"EVN/JIVE Technical developments"*, EVN TOG, Torun, Poland, 17 April, 2009
- *"e-EVN update"*, EVN TOG meeting, Gothenburg, Sweden, 26 May 2009
- *"e-EVN progress, 3 years of EXPReS"*, 8th international e-VLBI workshop, Madrid, Spain, 24 June 2009
- *"EXPReS, NEXPReS, UniBoard"*, EVN CBD meeting, Manchster, UK, 13 November 2009
- *"SA1: Production e-VLBI service"*, EXPReS review, Brussels, Belgium, 18 November 2009
- *"EXPReS, NEXPReS, UniBoard"*, EVN TOG meeting, Bonn, Germany, 4 December 2009
- *"The UniBoard, a multi-purpose scalable computing platform for Radio Astronomy"*, SKANZ meeting, Auckland, New Zealand, 16 February 2010
- *"PrepSKA program work"*, SKA 2010 Science and Engineering meeting, Manchester, UK, 23 March 2010
- *"UniBoard progress"*, RadioNet FP7 board meeting, Cagliari, Italy, 4 May 2010
- *"Technical Operations and R&D at JIVE"*, EVN TOG, Helsinki, Finland, 21 June 2010
- *"EXPReS and NEXPReS, the future of European VLBI"*, 4th RadioNet Engineering Forum Workshop, Aveiro, Portugal, 3 September 2010
- *"NEXPReS WP5 – Cloud Correlation"*, NEXPReS board meeting, Manchester, UK, 20 September 2010
- *"EXPReS and NEXPReS, the future of European VLBI"*, 10th European VLBI Network Symposium, Manchester, UK, 22 September 2010

- *"UniBoard progress"*, RadioNet mid-term review, Ventspils, Latvia, 5 October 2010
- *"EXPReS and NEXPReS, the future of European VLBI"*, 9th international e-VLBI workshop, Pert, Australia, 19 October 2010
- *"EXPReS and NEXPReS, the future of European VLBI"*, visit Shanghai Observatory, Shanghai, China, 25 October 2010

Harro Verkouter
- *"The UniBoard: FPGA processing for Astronomy",* presentation at High Performance Computing in Observational Astronomy, Pune, India, 14 October 2009
- *"Communicating with UniBoard",* presentation at the Uniboard Face-to-face meeting, Bordeaux, 12 October, 2010

Jun Yang
- *"A preliminary summary of the latest observations with Kunmin and Miyun"*, workshop "Astrophysics in the times of multibeam radio receivers", Nanjing, China, 22 September 2009
- *"EVN amplitude calibration and performance"*, EVN TOG meeting, Bonn, Germany, 4 December 2009
- *"VLBA Polarimetry Observations of Quasar B0954+556"*, conference "Magnetic fields on scales from kilo-meters to kilo-parses: properties and origin", Cracow, Poland, 18 May 2010
- *"The EVN amplitude calibration, performance and reliability"*, EVN TOG meeting, Helsinki, Finland, 21 June 2010

Kristine Yun
- *"NEXPReS WP4 - Communications: Work Package Overview"*, presentation at NEXPReS board meeting, Manchester, UK, 20 September 2010
- *"Public Outreach for JIVE and NEXPReS"*, presentation at RadioNet outreach workshop, Bologna, Italy, 18 November 2010

Charles Yun
- *"Presentation to the DORII Board"*, DORII planning meeting, Athens, Greece, 10 March 2009
- *"Introducing NEXPReS - e-VLBI (Radio Astronomy), (e-)Infrastructures and Collaboration"*, INGRID, Poznan, Poland, 12 May 2010
- *"NEXPReS, e-VLBI, Radio Astronomy - Major users of networks and network"*, TNC EC Transatlantic Meeting, 29 May 2010
- *"NEXPReS Board Meeting, Management and Financial Presentations"*, NEXPReS, Manchester, UK, 20 September 2010
- *"NEXPReS eInfrastructures for Radio Astronomy"*, eConceration Event, Geneva, Switzerland, 4 November 2010

8.6 MEMBERSHIP OF PROFESSIONAL BOARDS AND COMMITTEES

Bob Campbell

EVN Technical and Operations Group

European VLBI Group for Geodesy and Astrometry (EVGA)

EVN Programme Committee (EVN PC)

EXPReS e-VLBI science advisory group

IAU Div. I working group on 2nd realization of the ICRF

NEXPReS e-VLBI science advisory group

Giuseppe Cimó

EVN Technical and Operations Group

co-manager of the RadioNet Joint Research Activity ALBiUS

Leonid Gurvits

IAU Division XI (Space-borne and high-energy astrophysics) Organizing Committee

ESA- BepiColombo Science Working Group

EuroPlaNet FP7 consortium board

ESPACE FP7 consortium

EVN-RadioAstron mission liaison

VSOP-2 International Science Council

IAU Working Group on Astronomy from the Moon

SKA Simulations Working Group (Chair since 2008)

Mark Kettenis

VDIF Taskforce

VEX2 Committee

Yvonne Kool

LOC 8th International e-VLBI Workshop

Huib van Langevelde

Member consortium board European VLBI Network

Coordinator EXPReS (Expres Production Real-time e-VLBI System), board and management team

Member RadioNet Board and Executive Board

PI, RadioNet research activity ALBiUS (Advanced Long Baseline Interoperable User Software)

Member board ESTRELA (Early Stage Training Site for European Long-wavelength Radio Astronomy)

Member board SKADS (SKA Design Studies)

Member board PrepSKA (Prepatory SKA studies)

Member European SKA Consortium

NOVA Instrumentation Steering Committee

Dutch URSI committee

Member board of directors Leids Kerkhoven Bosscha Fonds

Member board of directors Leids Sterrewacht Fonds

Member board of directors Jan Hendrik Oort Fonds
NWO I-science program committee
SKA klankbordgroep NL
Allegro steering committee
coordinator NEXPReS (Novel Exploration Pushing Robust e-VLBI Systems), board and management team
SOC 8th international e-VLBI workshop
SOC 10th European VLBI Network Symposium

Martin Leeuwinga
EVN Technical and Operations Group

Stefanie Mühle
EVN Technical and Operations Group

Mehreen Mahmud
EVN Technical and Operations Group

Zsolt Paragi
EXPReS e-VLBI Science Advisory Group
EVN Technical and Operations Group

Arpad Szomoru
EVN Technical and Operations Group
EXPReS Board and Management team
EXPReS e-VLBI science advisory group
SOC 8th International e-VLBI workshop
PI of EXPReS Service Activity SA1, member of executive board
PI of RadioNet FP7 Joint Research Activity "UniBoard", member of executive board
PI of NEXPReS Work Package 5 "Cloude Correlation", member of executive board
NEXPReS e-VLBI Science Advisory Group
SOC workshop "The growing demand on connectivity and information processing in radio astronomy from VLBI to SKA"
SOC 10th international e-VLBI workshop

Hans Tenkink
EVN Technical and Operations Group

Charles Yun
RINGRID Advisory Board
DORII Advisory Board

8.7 MEMBERSHIP OF PROFESSIONAL ASSOCIATIONS AND SOCIETIES

Bob Campbell

Sigma Xi

American Astronomical Society

American Geophysical Union

International Astronomical Union

International Union of Radio Science (URSI)

American Association of Physics Teachers

Giuseppe Cimó

Nederlandse Astronomen Club

Leonid Gurvits

American Astronomical Society

Nederlandse Astronomen Club

International Astronomical Union

Committee on Space Research (COSPAR) Associate

International Union of Radio Science (URSI)

European Geosciences Union

Nederlands Nationaal Platform voor Planeetonderzoek

Nederlandse Vereniging voor Ruimtevaart

Aard Keimpema

Nederlandse Natuurkundige Vereniging

Huib van Langevelde

Nederlandse Astronomen Club

International Astronomical Union

International Union of Radio Science (URSI)

Stefanie Mühle

Astronomische Gesellschaft, Germany

Friso Olnon

Nederlandse Astronomen Club

International Astronomical Union

Zsolt Paragi

Eotvos Lorand Physical Society

Hungarian Astronautical Society

Nederlandse Astronomenclub

Yurii Pidopryhora

Eurasian Astronomical Society

American Physical Society

American Astronomical Society

Nederlandse Astronomen Club

Sergei Pogrebenko

International Astronomical Union

Arpad Szomoru

International Union of Radio Science (URSI)

Nederlandse Astronomen Club

Harro Verkouter

Nederlandse Astronomen Club

8.8 MEETINGS ATTENDED

8.8.1 SCIENTIFIC CONFERENCES

Nikta Amiri

- ESTRELA workshop, Bologna, Italy, 18-23 January 2009
- ESTRELA workshop, Gothenburg, Sweden, 26-29 May 2009
- Conference The Origin and Fate of the Sun, Garching, Germany, 1-6 March 2010
- 12th Synthesis Imaging Workshop, Socorro, New Mexico, USA, 7-15 June 2010
- APN5 Asymmetric Planetary Nebulae V, Windermere, UK, 20-23 June 2010

Tatiana Bocanegra

- YERAC 2010, Madrid, Spain, 5-8 July 2010

Paul Boven

- 8th International e-VLBI Workshop, Madrid, Spain, 22-25 June 2009
- 10th European VLBI Network Symposium, Manchester UK, 21 - 24 September 2010
- 9th e-VLBI workshop, Perth Australia, 18 - 20 October 2010

Stephen Bourke

- SKA Continuum Imaging Workshop, Cape Town, South Africa, 14-28 February 2009
- The 10th European VLBI Network Symposium, Manchester, UK, 20-24 September 2010

Bob Campbell

- 19th European VLBI for Geodesy & Astronomy working meeting, Bordeaux, France, 23-26 March 2009
- 10th IVS Analysis Workshop, Bordeaux, France, 27-29 March 2009
- 8th International e-VLBI Workshop, Madrid, Spain, 22-25 June 2009
- Astrofest, Exloo, the Netherlands, 10 June 2009
- International SKA forum, Assen, the Netherlands, 15 June 2010
- 10th European VLBI Network Symposium, Manchester, Uk, 21-24 September 2010
- "WSRT@40: a mini-symposium to celebrate the 40th anniversary of the Westerbork Synthesis Radio Telescope" Westerbork, the Netherlands, 22 October 2010

Linjie Chen

- Loughborough Antennas & Propagation Conference 2010, Leicestershire, UK, 8-9 November 2010

Giuseppe Cimó

- SKA Continuum Imaging Workshop, Cape Town, South Africa, 12-22 February 2009
- CASA school, Garching, Germany, 10-13 May 2009
- Astrofest, Exloo, the Netherlands, 10 June 2009
- Summerschool "En route to Jupiter and Saturn", Leiden, the Netherlands, 29-30 June 2009
- EuroPlaNet, Potsdam, Germany, 4-18 September 2009
- EJSM Science Meeting, Noordwijk, the Netherlands, 17-19 May 2010
- Nederlandse Astronomen Conferentie, Cuijk, the Netherlands, 19-21 May 2010
- IAU Symposium 275: "Jets at all Scales", Buenos Aires, Argentina, 13-17 September 2010
- 10th European VLBI Network Symposium, Manchester, UK, 20-24 September 2010

Bob Eldering

- 8th International e-VLBI workshop, Madrid, Spain, 22-26 June 2009

Jonathan Hargreaves

- 8th International e-VLBI Workshop, Madrid, Spain, 23-26 June 2009

Peter Friedman

- SKADS conference, Limelette, Belgium, 3-6 November 2009

Leonid Gurvits

- European Science Conference and EJSM (ESA-NASA-RSA) study meetings, Moscow, Russia, 9-15 February 2009
- “Galaxy evolution and environment”, Kuala Lumpur, Malaysia, 28 March - 5 April 2009
- “European Week of Astronomy and Space Science”, JENAM09, Hatfield, UK, 19-23 April 2009
- IAU General Assembly, Rio de Janeiro, Brazil, 1-15 August 2009
- IAU GA symp 263, Rio de Janeiro, Brazil, 1-15 August 2009
- SKADS conference, Limelette, Belgium, 3-6 November 2009
- Conference "5th anniversary of the Huygens landing", Barcelona, Spain, 13-15 January 2010
- SKA 2010 Science & Engineering meeting, Manchester, UK, 22-25 March 2010
- JENAM 2010, Lisbon, Portugal, 5-11 September 2010
- EJSM evaluation workshop, Cascaix, Portugal, 12-15 September 2010

Aard Keimpema

- 8th International e-VLBI Workshop, Madrid, Spain, 18-27 June 2009

Mark Kettenis

- 10th European VLBI Network Symposium, Manchester, UK, 20-24 September 2010
- 9th International e-VLBI Workshop, Perth, Australia, 18-20 October 2010
- Supercomputing SCIO Conference, New Orleans, USA, 15-19 November 2010

Huib Jan van Langevelde

- International Year of Astronomy start, Paris, France, 15-16 January 2009
- International SKA Forum, Cape Town, South Africa, 23-27 February 2009
- Netherlands IYA event NEMO, Amsterdam, Netherlands, 4-5 April 2009
- Astrofest, Exloo, the Netherlands, 10 June 2009
- 8th e-VLBI workshop, Madrid, Spain, 21-26 June 2009
- eVSAG meeting, Madrid, Spain, 24 June 2009
- .Astronomy 2009 workshop, Leiden, the Netherlands, 1-3 December 2009
- 6th European Conference on Research Infrastructures, Barcelona, Spain, 23-24 March 2010
- Nederlandse Astronomen Conferentie, Cuijk, the Netherlands, 19-21 May 2010
- A New Golden Age for Radio Astronomy, Assen, The Netherlands, 10-14 June 2010
- APN5 Asymmetric Planetary Nebulae V, Windermere, UK, 20-23 June 2010
- JENAM 2010, Lisbon, Portugal, 7-11 September 2010
- 10th European VLBI Network Symposium, Manchester, UK, 21-24 September 2010
- “WSRT@40: a mini-symposium to celebrate the 40th anniversary of the Westerbork Synthesis Radio Telescope” Westerbork, the Netherlands, 22 October 2010
- SA SKA bursary conference, Stellenbosch, South-Africa, 29 November - 4 December 2010

Mehreen Mahmud

- “Rotation Measure Analysis of Magnetic Fields in and around Radio Galaxies” RM 2010 Workshop, Riccione, Italy, 10-14 May 2010
- Nederlandse Astronomen Conferentie, Cuijk, the Netherlands, 19-21 May 2010
- “Young European Radio Astronomers Conference (YERAC)” Spain, 5-8 July 2010
- 10th EVN Symposium “VLBI and the new generation of radio arrays”, Manchester, UK, 20-24 September 2010

Stefanie Mühle

- International Year of Astronomy start, Paris, France, 15-16 January 2009
- “Millimeter and Sub-Millimeter Astronomy at High Angular Resolution”, Taipei, Taiwan, 8-12 June 2009
- IAU General Assembly, Rio de Janeiro, Brazil, 10-14 August 2009

- Opening of the LOFAR telescope, Exloo, the Netherlands, 12 June 2010
- “Molecules in Galaxies”, Oxford, UK, 26-30 July 2010
- “The 10th European VLBI Network Symposium and EVN Users Meeting: VLBI and the new generation of radio arrays”, Manchester, UK, 20-24 September 2010
- “WSRT@40: a mini-symposium to celebrate the 40th anniversary of the Westerbork Synthesis Radio Telescope” Westerbork, the Netherlands, 22 October 2010
- “Observing with ALMA - Early Science”, Grenoble, France, 29 November - 1 December 2010

Friso Olnon

- Jaarvergadering Nederlandse Astronomen Club, Utrecht, the Netherlands, 20 February 2009
- Nederlandse Astronomen Conferentie, Kerkrade, the Netherlands, 13-15 May 2009
- Astrofest 2009, Exloo, the Netherlands, 10 June 2009
- Katgert Seminarium, Leiden, the Netherlands, 18 September 2009
- Stromfest, Dwingeloo, the Netherlands, 1-2 October 2009
- Sterrendag, Dwingeloo, the Netherlands, 18 October 2009
- Nederlandse Astronomen Conferentie, Cuijk, the Netherlands, 19-21 May 2010

Zsolt Paragi

- “High energy phenomena in massive stars”, Jaén, Spain, 1-6 February 2009
- SKA Continuum Imaging Workshop, Cape Town, South Africa, 17-21 February 2009
- “European Week of Astronomy and Space Science”, JENAM09, Hatfield, UK, 19-23 April 2009
- 8th International e-VLBI workshop, Madrid, Spain, 21-26 June 2009
- “Multi-wavelength” Summer School, invited speaker, Paris, France, 30 June - 3 July 2009
- SKA 2010 Science and Engineering meeting, Manchester, UK, 22-24 March 2010
- "Ultra-Luminous X-ray sources and middle weight black holes science workshop, Madrid, Spain, 24-26 May 2010
- International SKA forum 2010, Assen, the Netherlands, 10-14 June 2010
- IAU symposium 275: Jets at all scales, Buenos Aires, Argentina, 4-17 September 2010
- 9th International e-VLBI workshop, Perth, Australia, 18-20 October 2010

Yurii Pidopryhora

- “European Week of Astronomy and Space Science”, JENAM09, Hatfield, UK, 19-23 April 2009
- Nederlandse Astronomen Conferentie, Kerkrade, the Netherlands, 13-15 May 2009
- “Panoramic Radio Astronomy: Wide-field 1-2 GHz research on galaxy evolution”, Groningen, the Netherlands, 2-5 June 2009
- 8th International e-VLBI workshop, Madrid, Spain, 21-26 June 2009
- 10th European VLBI Network Symposium “VLBI and the new generation of radio arrays”, Manchester, UK, 20-24 September 2010

Sergei Pogrebenko

- EJSM Technology development workshop, Noordwijk, the Netherlands, 11-12 June 2009
- “From quantum to cosmos” Workshop, Bremen, Germany, 21-24 September 2009
- IPPW 2010 workshop, Barcelona, Spain, 14-17 June 2010

Hayden Rampadarath

- 8th International e-VLBI workshop, Madrid, Spain, 21-24 June 2009

Des Small

- 8th International e-VLBI Workshop, Madrid, Spain, 22-25 June 2009

Shanmugha Sundaram

- “Configuration Studies for SKA”, Manchester, UK, 11-13 March 2009
- “Multi-field and Multi-beam Science with the SKA”, Oxford, UK, 16-27 March 2009

Arpad Szomoru

- International Year of Astronomy start, Paris, France, 15-16 January 2009
- 8th International e-VLBI workshop, Madrid, Spain, 22-26 June 2009
- IAU General Assembly, Rio de Janeiro, Brazil, 6-15 August 2009
- SKA 2010 Science and Engineering meeting, Manchester, UK, 22-24 March 2010
- JENAM 2010, Lisbon, Portugal, 5-11 September 2010
- 10th European VLBI Network Symposium, Manchester, UK, 20-24 September 2010
- 9th International e-VLBI workshop, Perth, Australia, 18-20 October 2010

Kalle Torstensson

- ESTRELA Workshop, Bologna, Italy, 18-23 January 2009
- ESTRELA Workshop, Gothenburg, Sweden, 26-29 May 2009

Harro Verkouter

- International Year of Astronomy start, Paris, France, 15-16 January 2009
- Nederlandse Astronomen Conferentie, Kerkrade, NL, 13-15 May 2009
- 8th International e-VLBI workshop, Madrid, Spain, 22-26 June 2009

Jun Yang

- "Astrophysics in the times of multibeam radio receivers", Nanjing, China, 20-24 September 2009
- "Magnetic fields on scales from kilo-meters to kilo-parses: properties and origin", Cracow, Poland, 17-20 May 2010
- 10th European VLBI Network Symposium, Manchester, UK, 20-24 September 2010
- 9th International e-VLBI workshop, Perth, Australia, 18-20 October 2010

T. Charles Yun

- International Year of Astronomy Kickoff, Paris, France, 15-16 January 2009
- Netherlands IYA event NEMO, Amsterdam, Netherlands, 4-5 April 2009
- 8th International e-VLBI Workshop (virtual), Madrid, Spain, 22-25 June 2009
- 10th European VLBI Network Symposium, Manchester, UK, 20-24 September 2010
- 9th International e-VLBI Workshop, Perth, Australia, 18-20 October 2010

Kristine Yun

- International Year of Astronomy Kickoff, Paris, France, 15-16 January 2009
- IAU symposium 260, Paris, France, 19-23 January 2009

8.8.2 *TECHNICAL AND BUSINESS MEETINGS*

Stephen Bourke

- ALBiUS kickoff, Dwingeloo, the Netherlands, 3 March 2009
- ALBiUS meeting, Dwingeloo, NL, 12-13 November 2009
- ALBiUS meeting, Garching, Germany, 13-17 June 2009
- European Radio Interferometry School, Oxford, UK, 6-12 September 2009
- MCCT-SKADS calibration workshop, Nançay, France, 17 September - 13 October 2009
- ALBiUS meeting with ESO, Garching, Germany, 6 May 2010
- EVN user meeting, Jodrell Bank, UK, 22 September 2010

Paul Boven

- UniBoard Kickoff, Dwingeloo, the Netherlands, 26-27 February 2009
- FRFF & V2C Workshops, Wettzell, Germany, 17-22 March 2009
- FP6 ALMA mid-term review, Gothenburg, Sweden, 6-8 May 2009
- Terena TNC2009, Malaga, Spain, 7-11 June 2009
- European Radio Interferometry School, Oxford, UK, 6-11 September 2009
- EGEE'09/NREN Workshop, Barcelona, Spain, 19-23 September 2009

- EVN TOG meeting, Bonn, Germany, 3-5 December 2009
- Terena E2E workshop, Amsterdam, the Netherlands, 6-8 December 2009
- Gigaport3 Kickoff, Utrecht, the Netherlands, 18 February 2010
- Terena TNC2010, Vilnius, Lithuania, 31 May - 3 June 2010
- ISKAF, Assen, the Netherlands, 15 June 2010
- Terena TF Storage, Poznan Poland, 9 - 10 September 2010
- NEXPReS board meeting, Manchester UK, 20 September 2010
- 10th Annual Global LambdaGrid Workshop (GLIF), CERN Geneva Switzerland, 13 - 14 October 2010
- SURFnet Relatiedagen, Noordwijkerhout, the Netherlands, 8 - 9 December 2010

Bob Campbell

- EVN PC meeting, Bologna, Italy, 2-4 March 2009
- ICRF-2 working group meeting, Bordeaux, France, 23-29 March 2009
- EVN TOG meeting, Torun, Poland, 16-18 April 2009
- EVN PC meeting, Madrid, Spain, 21-22 June 2009
- 8th e-VLBI workshop, Madrid, Spain, 22-23 June 2009
- EVN PC meeting, Cambridge, UK, 9-10 November 2009
- EVN CBD meeting, Manchester, UK, 11-13 November 2009
- JIVE Board meeting, Manchester, UK, 12 November 2009
- EVN TOG meeting, Bonn, Germany, 3-5 December 2009
- EVN PC meeting, Hamburg, Germany, 11 March 2010
- EVN TOG meeting, Helsinki, Finland, 21 June 2010
- EVN PC meeting, Dwingeloo, the Netherlands, 29 June 2010
- JIVE/ASTRON open day, Westerbork, the Netherlands, 24 October 2010
- EVN PC meeting, Valencia, Spain, 9 November 2010

Giuseppe Cimó

- ALBiUS kickoff, Dwingeloo, the Netherlands, 3 March 2009
- RadioNet FP7kick-off meeting, Schiphol, NL, 30-31 March 2009
- ALBiUS meeting, Garching, Germany, 16-17 June 2009
- ALBiUS meeting, Dwingeloo, NL, 12-13 November 2009
- Attending PhD talk about "Jets at different scales", Amsterdam, the Netherlands, 10 March 2010
- RadioNet meeting, Cagliari, Italy, 4-5 May 2010
- ESPACE meeting, Paris, France, 31 May - 1 June 2010
- EVN user meeting, Jodrell Bank, UK, 22 September 2010

Leonid Gurvits

- SKADS DS2 meeting, Malta, 4-10 January 2009
- SKADS Board meeting, Madrid, Spain, 22-23 January 2009
- EJSM study meeting, Moscow, Russia, 13-14 February 2009
- SKA meetings, Cape Town, South Africa, 17-28 February 2009
- FP7 EuroPlaNet kick-off meeting, Paris, France, 8-9 March 2009
- SKADS DS2 and SKA SCWG meeting, Manchester, UK, 10-13 March 2009
- IVS -EVGA meeting, Bordeaux, France, 23-24 March 2009
- EPN JRA1WG meeting, London, UK, 24-25 April 2009
- KNAW-CAS collaboration meeting, Shanghai, China, 17-18 May 2009
- BepiColombo & Phobos-Grunt VLBi experiment preparation, Shanghai, China, 19-20 May 2009
- EVN CBD meeting, Gothenburg, Sweden, 26 May 2009
- JIVE Board meeting, Gothenburg, Sweden, 27 May 2009
- BepiColombo and OP working meeting, Kiruna, Sweden, 30 May - 4 June 2009
- EJSM DoI coordination meeting, Oslo, Norway, 4-6 June 2009
- EJSM Technology Development workshop, Noordwijk, the Netherlands, 11-12 June 2009
- PRIDE EVE & ExoMars meetings, Noordwijk, the Netherlands, 19 June 2009
- Phobos-Grunt & YH-1 PRIDE meeting, Moscow, Russia, 30 June - 3 July 2009

- OP meeting, Sao Paulo, Brazil, 19-21 August 2009
- SKADS DtE applications & implementation meeting, Berlin, Germany, 13-16 September 2009
- BepiColombo Science Working Team meeting, Blois, France, 26-29 October 2009
- EVN CBD meeting, Manchester, UK, 10-13 November 2009
- JIVE Board meeting, Manchester, UK, 10-13 November 2009
- EJSM-MIR Kick-off meeting, Bremen, Germany, 19-21 November 2009
- VISC-2 meeting, Sagamihara, Japan, 30 November - 3 December 2009
- MMO Bepi Colombo meeting, Hongkong, China, 4 December 2009
- PRIDE Mars and Europe meeting, Brisbane, Australia, 5-6 February 2010
- Sixth IVS General meeting, Hobart, Australia, 7-11 February 2010
- IVS Directing Board meeting, Hobart, Australia, 12 February 2010
- SKANZ conference, Auckland, New Zealand, 15-18 February 2010
- Mars-Phobos (PRIDE) progress meeting, Moscow, Russia, 26 February – 2 March 2010
- International meeting on Mars & Phobos missions, Moscow, Russia, 16-20 March 2010
- PrepSKA board meeting, Manchester, UK, 26 March 2010
- Mars-radio science, Moscow, Russia, 2-5 April 2010
- PRIDE-ExoMars progress meeting, Köln, Germany, 5 May 2010
- Mars-PRIDE meeting, Darmstadt, Germany, 9-10 May 2010
- Phobos-PRIDE meeting, Moscow, Russia, 11-17 May 2010
- ExoMars meeting, Köln, Germany, 11 May 2010
- European Planetary Science Congress, Rome, Italy, 20-23 September 2010
- EuroPlaNet board meeting, Rome, Italy, 21 September 2010
- IVS board meeting, Shanghai, China, 23 October 2010
- KNAW-CAS collaborative projects meeting, Shanghai, China, 25 October 2010
- BepiColombo collaboration meeting, Tokyo, Japan, 27 October 2010
- EVN CBD meeting, St. Petersburg, Russia, 7 November 2010
- 1st Moscow Solar System symposium, Moscow, Russia, 11-15 November 2010
- ESA CV M3 proposal writing session, Zurich, Switzerland, 26-28 November 2010

Jonathan Hargreaves

- “Expert UHDL”, Bournemouth, UK, 2-8 August 2009
- PrepSKA WP2 meeting, Manchester, UK, 28-31 October 2009
- SKA system CODR, Manchester, UK, 24-25 February 2010
- UniBoard face-to-face meeting, Bordeaux, France, 12 October 2010
- SKA annual work package 2 meeting, Oxford, UK, 27-30 October 2010

Bert Harms

- 5th Technical Operations Workshop, Haystack, USA, 26 April - 3 May 2009
- EVN TOG meeting, Helsinki, Finland, 21-23 June 2010

Aard Keimpema

- SCARIe meeting, Amsterdam, the Netherlands, 28 July 2009
- “European Radio Interferometry School 2009”, Oxford, UK, 6-11 September 2009
- RFI2010 - RFI Mitigation Workshop, Groningen, the Netherlands, 29 - 31 March 2010
- ISKAF, Assen, Netherlands, 15 June 2010
- Visit to University of Amsterdam for SCARIe, Amsterdam, the Netherlands, 6 October 2010

Mark Kettenis

- ALBiUS meeting, Garching, Germany, 16-17 June 2009
- 8th International e-VLBI Workshop, Madrid, Spain, 18-27 June 2009
- SCARIe meeting, Amsterdam, the Netherlands, 28 July 2009
- “High Performance Computing in Observational Astronomy”, Pune, India, 10-18 October 2009
- ALBiUS developers meeting, Dwingeloo, The Netherlands, 12-13 November 2009
- dBBC workshop, Bonn, Germany, 4 December 2009

- EVN TOG meeting, Bonn, Germany, 5 December 2009
- EGI Technical Forum, Amsterdam, the Netherlands, 14-15 September 2010
- NEXPReS board meeting, Manchester, UK, 19 September 2010
- Visit to University of Amsterdam for SCARIe, Amsterdam, the Netherlands, 6 October 2010

Yvonne Kool
- 8th International e-VLBI Workshop, Madrid, Spain, 18-27 June 2009
- EXPReS Board meeting, Madrid, Spain, 20-22 June 2009
- EXPReS review, Brussels, Belgium, 17-18 November 2009
- ISKAF, Assen, Netherlands, 15 June 2010
- NEXPReS Board meeting, Manchester, UK, 20 September 2010

Bauke Kramer
- NorthStar workshop, Dwingeloo, The Netherlands, 30 August - 1 September 2010

Huib Jan van Langevelde
- SKADS Board meeting, Madrid, Spain, 21 January 2009
- EXPReS Board meeting, Madrid, Spain, 22 January 2009
- PrepSKA Board meeting, Cape Town, South Africa, 28 February 2009
- ALBiUS kickoff, Dwingeloo, the Netherlands, 3 March 2009
- NOVA ISC, Dwingeloo, the Netherlands, 5 March 2009
- RadioNet FP7 kickoff meeting, Amsterdam, Netherlands, 30-31 March 2009
- FP6 ALMA mid-term review, Gothenburg, Sweden, 7-8 May 2009
- EVN CBD meeting, Gothenburg, Sweden, 26 May 2009
- JIVE Board meeting, Gothenburg, Sweden, 27 May 2009
- SURFnet press event, Dwingeloo, the Netherlands, 3 April 2009
- ALBiUS meeting, Garching, Germany, 16-17 June 2009
- DG INFSOC information day, Brussels, Belgium, 18 June 2009
- ERIC meeting at EC, Brussels, Belgium, 28 January 2010
- NEXPReS hearing, Brussels, Belgium, 9 February 2010
- Kick-off GigaPort3, Den Haag, Netherlands, 18 February 2010
- AAVP kick-off meeting, Zaandam, The Netherlands, 10 March 2010
- 6th European Conference on Research Infrastructures, Barcelona, Spain, 23-24 March 2010
- NEXPReS contract negotiation, Brussels, Belgium, 30 March 2010
- Meeting at the Polish ministry, Warsaw, Poland, 22 April 2010
- Nederlandse Astronomen Conferentie, Nijmegen, The Netherlands, 19-21 May 2010
- Terena Networking Conference 2010, Vilnius, Lithuania, 31 May - 2 June 2011
- International SKA Forum, Assen, The Netherlands, 15 June 2010
- JIVE board, Schiphol, The Netherlands, 12 July 2010
- eInfrastructure FP7 call meeting, Brussels, Belgium, 5 August 2010
- RadioNet internal review meeting, Bonn, Germany, 9 August 2010
- Meeting on ERICs, Brussels, Belgium, 7 September 2010
- NEXPReS board meeting, Manchester, UK, 20 September 2010
- RadioNet mid term review, Ventspils, Latvia, 5-6 October 2010
- EVN CBD, Svetloe/St. Petersburg, Russia, 7-8 October 2010
- RadioNet meeting, Bonn, Germany, 26 October 2010
- JIVE board, Dwingeloo, the Netherlands, 3 November 2010

Martin Leeuwinga
- Ingrid 2009 "Instrumenting the Grid", Sardinia, Italy, 31 March - 4 April 2009
- EVN TOG meeting, Torun, Poland, 16-19 April 2009
- EVN TOG meeting, Bonn, Germany, 3-5 December 2009
- dBBC workshop, Bonn, Germany, 4 December 2009
- EVN TOG meeting, Helsinki, Finland, 21-23 June 2010

Mahreen Mahmud

- EVN TOG Meeting, Bonn, Germany, 3-5 December 2009

Stefanie Mühle

- Astrochemistry Kick-off meeting, The Hague, NL, 7 October 2009
- EVN TOG Meeting, Bonn, Germany, 3-5 December 2009

Zsolt Paragi

- EXPReS review, Brussels, Belgium, 17-18 November 2009

Yurii Pidopryhora

- EVN TOG Meeting, Metsähovi, Finland, 21-22 June 2010
- EVN User Meeting, Jodrell Bank, UK, 22 September 2010

Salvatore Pirruccio

- UniBoard face-to-face meeting, Bordeaux, France, 12 October 2010

Sergei Pogrebenko

- FRFF & V2C Workshops, Wetzell, Germany, 17-22 March 2009
- EVE & ExoMars meetings, Noordwijk, the Netherlands, 19 June 2009

Aukelien van den Poll

- RadioNet FP7 Kick-off meeting, Schiphol, NL, 30-31 March 2009
- Joint meeting EUPMAN and ECPMA, Amsterdam, the Netherlands, 22 March 2010
- ISKAF 2010, Assen, the Netherlands, 15 June 2010
- RadioNet FP7 Board meeting, Cagliari, Italy, 4-5 May 2010
- RadioNet FP7 Mid Term Review, Ventspils, Latvia, 5 October 2010
- EGL netwerkmiddag, Utrecht, the Netherlands, 7 December 2010

Des Small

- UniBoard face-to-face meeting, Bordeaux, France, 12 October 2010

Shanmugha Sundaram

- CASA School, Garching, Germany, 10-13 May 2009

Arpad Szomoru

- EXPReS Board meeting, Madrid, Spain, 20-22 January 2009
- RadioNet FP7 Kick-off meeting, Schiphol, NL, 30-31 January 2009
- EVN TOG meeting, Torun, Poland, 16-18 April 2009
- EVN CBD meeting, Gothenburg, Sweden, 25-27 May 2009
- EVN CBD meeting, Manchester 10-13 November 2009
- EXPReS Review, Brussels, 17-18 November 2009
- GEANT launch event, Stockholm, Sweden, 1-3 December
- EVN TOG meeting, Effelsberg, Germany, 3-5 December 2009
- NEXPReS hearing, Brussels, Belgium, 9 February 2010
- SKANZ meeting, Auckland, New Zealand, 15-18 February 2010
- AAVP kick-off meeting, Zaandam, the Netherlands, 10 March 2010
- NEXPReS EC meeting, Brussels, Belgium, 30 March 2010
- Cluster meeting, New York, USA, 30 April 2010
- RadioNet FP7 board meeting, Cagliari, Italy, 4-5 May 2010
- EVN TOG meeting, Helsinki, Finland, 21 June 2010
- NEXPReS board meeting, Manchester, UK, 20 September 2010
- 4th RadioNet Engineering Forum Workshop, Aveiro, Portugal, 3 September 2010

- RadioNet FP7 mid term review, Ventspils, Latvia, 5-6 October 2010
- UniBoard face-to-face meeting, Bordeaux, France, 12 October 2010

Hans Tenkink
- EVN TOG meeting, Torun, Poland, 16-19 April 2009
- EVN TOG meeting, Bonn, Germany, 3-5 December 2009

Harro Verkouter
- “High Performance Computing in Observational Astronomy”, Pune, India, 10-18 October 2009
- UniBoard face-to-face meeting, Bordeaux, France, 12 October 2010

Jing Xiang
- RFI mitigation workshop, Groningen, the Netherlands, 29-31 March 2010

Jun Yang
- EVN TOG meeting, Torun, Poland, 16-19 April 2009
- EVN TOG meeting, Bonn, Germany, 3-5 December 2009
- EVN TOG meeting, Helsinki, Finland, 21 June 2010
- KNAW-China exchange program meeting, Shanghai, China, 10 October 2010

T. Charles Yun
- DORII, Athens, Greece, 11-12 March 2009
- EXPReS Board Meeting, Madrid, Spain, 21 June 2009
- 7th e-Concertation, Brussels, Belgium, 12-14 October 2009
- Final EXPReS Review, Brussels, Belgium, 18 November 2009
- SURFnet Gigaport3 kickoff, Utrecht. the Netherlands, 18 February 2010
- NEXPReS hearing, Brussels, Belgium, 9 February 2010
- EC meeting, Brussels, Belgium, 24 February 2010
- BELIEF Workshop, Brussels, Belgium, 24-25 February 2010
- NEXPReS EC meeting, Brussels, Belgium, 30 March 2010
- INGRID, Poznan, Poland, 12 May 2010
- Terena TNC2010, Vilnius, Lithuania, 31 May – 3 June 2010
- DG-INFSO FP7-2011-2 call info day, Brussels, Belgium, 11 June 2010
- ISKAF, Assen, the Netherlands, 15 June 2010
- EGI Technical Forum, Amsterdam, the Netherlands, 14-17 September 2010
- NEXPReS Board Meeting, Manchester, UK, 20 September 2010
- ICT 2010, Brussels, Belgium, 27-28 September 2010
- 8th e-Concertation, Geneva, Switzerland, 4 November 2010

Kristine Yun
- EuroPlaNet science communication workshop, Meudon, France, 17-18 June 2010
- NEXPReS board meeting, Manchester, UK, 20 September 2010
- RadioNet outreach workshop, Bologna, Italy, 17 November 2010

8.8.3 WORKING VISITS AND OBSERVING TRIPS

Nikta Amiri
- Working visit MPIfR, Bonn, Germany, 30 March - 1 April 2009
- Working visit MPIfR, Bonn, Germany, 10-15 November 2009
- Observations with the JCMT, July 2010, Hawaii
- Observations with Green Bank, April 2010, USA
- Observations with Effelsberg, September 2010, Bonn, Germany
- APN 5 meeting, Lake District, United Kingdom, 20-25 June 2010

Stephen Bourke
- ALBiUS working visit, Garching, Germany, 6-7 May 2010

Bob Campbell
- U.S. Naval Academy visit, Annapolis, USA, 21 October 2010

Giuseppe Cimó
- Max-Planck Institute für Radioastronomie, Bonn, Germany, 2-6 October 2010
- Shanghai Radio Observatory, Shanghai, China, 8-24 October 2010

Leonid Gurvits
- Working visit ESAC, Madrid, Spain, 21 January 2009
- Working visit to ASIAA, Taipei, Taiwan, 13-17 May 2009
- SKADS working meeting, Pushchino, Russia, 28-29 June 2009
- Meeting on DtE, Goddard Institute for Space Studies, New York City, USA, 13-14 July 2009
- Meeting on SKA/SKADS DtE applications for ESA/NASA, Laurel MD, USA, 15-17 July 2009
- Sabbatical at ISAS, Sagamihara, Japan, 1 June – 31 August 2010

Mark Kettenis
- ICRAR, Perth, Australia, 21-22 October 2010

Huib Jan van Langevelde
- Leiden, the Netherlands, 19 March 2009
- University of Bonn, Germany, 20 March 2009,
- Leiden, the Netherlands, 21-23 April 2009
- Amsterdam, the Netherlands, 5 June 2009
- Groningen, the Netherlands, 9 November 2009
- The Hague, the Netherlands, 1 December 2009
- Leiden, the Netherlands, 9 February 2010
- Leiden, the Netherlands, 15 March 2010
- Leiden, the Netherlands, 28 April 2010
- Leiden, the Netherlands, 25 August 2010
- Bonn, Germany, 25-27 October 2010

Stefanie Mühle
- Observations with the IRAM 30-m telescope, Pico Veleta, Spain, 18-27 May 2009 (PV 232-08)
- Observations with the JCMT, Hawaii, USA, 14-23 June 2009 (NGLS)
- Observations with the IRAM 30-m telescope, Pico Veleta, Spain, 17-24 May 2010 (PV 238-09)
- Work visit, Instituto de Astrofisica de Andalucia, Granada, Spain, 25 May 2010
- Observations with the IRAM 30-m telescope, Pico Veleta, Spain, 11-19 October 2010 (PV 115-10)
- Work meeting, IRAM headquarters, Granada, Spain, 19 October 2010

Zsolt Paragi
- Data reduction, Bologna, Italy, 20-25 September 2009

Sergei Pogrebenko
- Observations with Effelsberg telescope, Effelsberg, Germany, 31 March - 4 April 2009

Hayden Rampadarath
- Working visit, Manchester, UK, 21-24 July 2009

Arpad Szomoru
- visit to Shanghai Observatory, Shanghai, China, 25-26 October 2010

Harro Verkouter

- International Year of Astronomy Inauguration Event, Paris, France, 14-17 January 2009

Jun Yang

- "The astrophysics in the times of multibeam radio receivers", Nanjing, China, 18-27 September 2009

Charles Yun

- International Year of Astronomy Inauguration Event, Paris, France, 14-17 January 2009

Kristine Yun

- International Year of Astronomy Inauguration Event, Paris, France, 14-21 January 2009
- Weekend van de Sterren, NEMO, Amsterdam, Netherlands, 4-5 April 2009
- ISKAF 2010, Assen, NL, 15 June 2010

8.9 EDUCATIONAL RESPONSIBILITIES

PhD projects supervised:

N. Amiri – by H.J. van Langevelde, Leiden University

L. Chen – by L.I. Gurvits, CAS University

D. Duev – by L.I. Gurvits and S.V. Pogrebenko, Moscow State University

G. Molera Calves – by S.V. Pogrebenko, Aalto University

K. Torstenson – by H.J. van Langevelde, Leiden University

MSc project supervised:

T. Bocanegra – by L.I. Gurvits, TU Delft

Lecturing:

L.I. Gurvits, Ventspils Uiversity College, Latvia,, 16 hours, Radio Interferometry (2009 and 2010, via video-link);

L.I. Gurvits, Moscow State University, Russia, 30 hours, Space-borne astrophysics (2010 year, 50% via video-link)

Secondary affiliations:

H.J. van Langevelde - affiliated with Leiden University

L.I. Gurvits – affiliated with Ventspils University College

8.10 CORRELATOR ACTIVITY

8.10.1 CORRELATOR PROJECTS

All projects having correlator activity in 2009

Expt name	Obs. date	PI	Type	Correl. date	Distrib. date	Release date	Support scientist
GW019A	070608	Wucknitz	USER	(020908)	050109	190109	Campbell
EA038	080608	Amiri	USER	(170908)	050109	190109	Campbell
RT006C	191108	Tudose	USER	(191108)	(011208)	270109	Paragi
N08Q1	161008	Muehle	NME	(241108)	(161208)	130109	Muehle
N08X1	171008	Polatidis	NME	(261108)	(041208)	030409	Polatidis
EB037D	301008	Brunthaler	USER	(021208)	(181208)	130109	Polatidis
EK026	271008	Kunert-Bajraszewska	USER	(031208)	(161208)	130109	Cimó
EZ018B	311008	Zuther	USER	(091208)	(121208)	130109	Cimó
EZ018A	261008	Zuther	USER	(091208)	(121208)	130109	Cimó
EF021A	221008	Frey	USER	(101208)	140109	290109	Yang
EL036B	251008	Xiang	USER	(111208)	090109	260109	Campbell/Yang
TE092	121208	Paragi	TEST	(121208)	130109	130109	Paragi
EK028C	291008	Kovalev	USER	(151208)	(291208)	080409	Polatidis
GP047	211008	Pihlstrom	USER	(161208)	100209	110309	Campbell
VT12E	191208	Phillips	TEST	(191208)	130109	130109	Paragi
VT12F	221208	Paragi	TEST	(221208)	130109	130109	Kettenis
EK028A	191008	Kovalev	USER	(231208)	170309	080409	Polatidis/Yang
VT12G	060109	Paragi	TEST	060109	130109	130109	Paragi
N08K4	031108	Muehle	NME	070109	240209	310309	Muehle
EF021B	291008	Frey	USER	070109	210109	110309	Yang
EB037E	041108	Brunthaler	USER	090109	250209	310309	Yang
GC031B	241008	Conway	USER	140109	120309	310309	Muehle
IYA09C	150109	Paragi	NME	160109	260109	270109	Paragi
IYA09X	150109	Paragi	NME	160109	260109	270109	Paragi
RSF02	220109	Frey	USER	230109	260109	270109	Paragi
GB060B	161008	Bach	USER	230109	190309	020409	Muehle
RP014B	220109	Perez-Torres	USER	230109	260109	270109	Paragi
RM003	220109	Marti	USER	230109	260109	270109	Paragi
RP015A	100209	Paragi	USER	100209	110209	110209	Paragi
GW019B	181008	Wucknitz	USER	100209	180309	020409	Campbell
RF005	100209	Frey	USER	110209	110209	110209	Paragi
F09C1	260209	Polatidis	NME	260209	260209	110309	Muehle
EK028B	221008	Kovalev	USER	230309	240309	080409	Polatidis/Yang
RF006A	240309	Paragi	USER	250309	250309	260309	Paragi
RT006D	250309	Paragi	USER	250309	250309	260309	Paragi
TE093	260309	Paragi	TEST	260309	020409	020409	Paragi
N09C1	260209	Polatidis	NME	310309	240409	290709	Yang/Pidopryhora
APR3C	030409	Paragi	NME	030409	290409	290409	Paragi
APR3X	030409	Paragi	NME	030409	290409	290409	Paragi
APR5C	050409	Paragi	NME	050409	290409	290409	Paragi
EP065	010309	Polatidis	USER	070409	090409	280409	Muehle
EW012B	280209	Wu	USER	080409	140409	280409	Yang
EP064B	280209	Perez-Torres	USER	090409	100409	280409	Campbell
N09L1	060309	Polatidis	NME	100409	240709	290709	Pidopryhora

Expt name	Obs. date	PI	Type	Correl. date	Distrib. date	Release date	Support scientist
N09K1	030309	Muehle	NME	100409	290409	290709	Muehle
N09M1	100309	Yang	NME	140409	230409	290709	Yang
N09Q1	180309	Muehle	NME	150409	280409	290709	Muehle
EW012A	270209	Wu	USER	160409	230409	290709	Yang
EP064A	260209	Perez-Torres	USER	200409	220409	290709	Yang
RSG02	210409	Giroletti	USER	210409	220409	290409	Campbell/Paragi
EP064D	070309	Perez-Torres	USER	210409	290409	290709	Cambpell
RF006B	210409	Frey	USER	220409	290409	290409	Paragi
RB003A	220409	Brunthaler	USER	220409	220409	290409	Campbell/Paragi
N09K2	040309	Muehle	NME	220409	070709	290709	Muehle
RP015B	210409	Paragi	USER	220409	280409	290409	Paragi
EM074	070309	Moldon	USER	280409	080509	290709	Campbell/Pidopryhora
EM064D	110309	Moscadelli	USER	290409	140709	290709	Muehle
EP064C	060309	Perez-Torres	USER	070509	080609	290709	Yang
EA039	070309	Asada	USER	080509	080609	290709	Pidopryhora
EM059D	040309	Moscadelli	USER	130509	080609	290709	Pidopryhora
RB002	120509	Bach	USER	130509	140509	210509	Paragi
TE094	150509	Paragi	TEST	150509	220509	220509	Paragi
EM062B	120309	Moscadelli	USER	180509	190609	290709	Campbell
RB003B	200509	Brunthaler	USER	200509	210509	210509	Paragi
EM064E	110309	Moscadelli	USER	200509	140709	290709	Muehle
RM003B	190509	Moldon	USER	200509	210509	210509	Paragi
RR002	190509	Rampadarath	USER	200509	210509	210509	Paragi
TE095	220509	Paragi	TEST	220509	050609	050609	Paragi
RG001A	230509	Giroletti	USER	230509	250509	050609	Paragi
EM064F	120309	Moscadelli	USER	260509	140709	290709	Muehle
EM069D	130309	Moscadelli	USER	280509	080609	290709	Yang
EM069F	170309	Moscadelli	USER	020609	080609	290709	Yang
EM069E	140309	Moscadelli	USER	040609	080609	290709	Yang
RG001B	100609	Giroletti	USER	100609	110609	150609	Paragi
EM071A	150309	Moscadelli	USER	240609	270709	140809	Campbell
RR003A	020709	Rushton	ABAN	020709	020709	020709	niemand
GC031C	270209	Conway	USER	020709	210709	140809	Muehle
RG001C	040709	Paragi	USER	040709	060709	220709	Paragi
EB039B	160309	Brunthaler	USER	170709	110809	310809	Campbell
N09M2	280509	Muehle	NME	210709	030809	310809	Muehle
N09L2	020609	Muehle	NME	210709	070809	310809	Muehle/Yang
N09C2	110609	Pidopryhora	NME	220709	040809	310809	Pidopryhora
EP063A	070609	Perez-Torres	USER	300709	030809	310809	Campbell
EG040D	130609	Giroletti	USER	310709	050809	310809	Muehle
EP063B	120609	Perez-Torres	USER	310709	190809	040909	Yang
EG040B	080609	Giroletti	USER	030809	100809	310809	Muehle
EG040F	150609	Giroletti	USER	050809	240809	070909	Campbell/Mahmud
EG040E	140609	Giroletti	USER	060809	030909	170909	Mahmud
EG040C	090609	Giroletti	USER	070809	140809	310809	Muehle
EG040A	020609	Giroletti	USER	100809	170909	091009	Mahmud
EP064G	110609	Perez-Torres	USER	130809	190809	040909	Yang
EW013	070609	Wolak	USER	130809	180809	040909	Yang
EP064H	120609	Perez-Torres	USER	130809	070909	210909	Pidopryhora
EM072A	030609	Mezcua	USER	180809	230909	091009	Mahmud
EP064E	030609	Perez-Torres	USER	180809	080909	091009	Yang

Expt name	Obs. date	PI	Type	Correl. date	Distrib. date	Release date	Support scientist
EM072B	040609	Mezcua	USER	190809	130909	091009	Mahmud
EP064F	040609	Perez-Torres	USER	200809	220909	091009	Pidopryhora
ES060A	310509	Szymczak	USER	240809	091009	081209	Pidopryhora
ES060B	010609	Szymczak	USER	240809	091009	081209	Pidopryhora
EB040A	290509	Bartkiewicz	USER	260809	300909	081209	Mahmud
EB040B	300509	Bartkiewicz	USER	260809	091009	081209	Mahmud
TE096	270809	Paragi	TEST	270809	040909	160909	Paragi
EY008A	050809	Yang	USER	280809	140909	140909	Yang
TE097	310809	Paragi	TEST	310809	160909	160909	Paragi
N09SX1	170609	Yang	NME	310809	070909	140909	Yang
EH023A	160609	Hagiwara	USER	310809	080909	081209	Yang
EC030	110909	Cseh	USER	110909	160909	160909	Paragi
RM004	100909	Muxlow	USER	110909	160909	160909	Paragi
EB041B	060609	Biggs	USER	150909	221009	081209	Muehle
EH023B	170609	Hagiwara	USER	170909	051009	081209	Yang
RSF03	300909	Frey	USER	300909	221009	221009	Paragi
RST02	300909	Tudose	USER	300909	221009	221009	Paragi
RP015C	300909	Paragi	USER	300909	221009	221009	Paragi
TE098	151009	Paragi	TEST	151009	161009	081209	Paragi
TE099	211009	Paragi	TEST	211009	221109	081209	Paragi
F09C2	221009	Yang	NME	221009	231009	111209	Yang
F09M1	301009	Pidopryhora	NME	301009	011109	111209	Pidopryhora
F09Q1	111109	Muehle	NME	111109	121109	111209	Muehle
RT009A	191109	Tudose	USER	191109	271109	111209	Paragi
EG043A	191109	Giroletti	USER	201109	271109	111209	Paragi
EL038	191109	Liu	USER	201109	271109	111209	Paragi
EB041A	050609	Biggs	USER	201109	241109		Muehle
TE100	011209	Paragi	TEST	011209	081209	111209	Paragi
EB039C	280509	Brunthaler	USER	081209	231209		Campbell
V2611	261109	Pogrebenko	TEST	081209			Cimó
EG047A	101209	Giroletti	USER	101209	171209		Paragi
EL039A	101209	Liu	USER	111209	171209		Paragi
RP014C	111209	Perez-Torres	USER	111209	171209		Paragi
N09K3	261009	Muehle	NME	141209			Muehle
EC029A	061109	Chi	USER	171209	291209		Campbell/Yang
EC029B	071109	Chi	USER	181209	291209		Campbell/Yang
N09L3	051109	Pidopryhora	NME	221209			Yang
EP067	091109	Parma	USER	241209			Mahmud

All projects having correlator activity in 2010

Expt name	Obs. date	PI	Type	Correl. date	Distrib. date	Release date	Support scientist
EB039C	280509	Brunthaler	USER	(081209)	(231209)	150110	Campbell
V2611	261109	Pogrebenko	TEST	(081209)	150610	301110	Cimó
N09K3	261009	Muehle	NME	(141209)	190110	090210	Muehle
EC029A	061109	Chi	USER	(171209)	(291209)	150110	Campbell/Yang
EC029B	071109	Chi	USER	(181209)	(291209)	150110	Campbell/Yang
N09L3	051109	Pidopryhora	NME	(221209)	220110	250110	Yang
EP067	091109	Parma	USER	(241209)	190110	090210	Mahmud
EM078	091109	Marecki	USER	040110	020210	180210	Pidopryhora
N09C3	231009	Yang	NME	060110	190110	090210	Yang
EB042	231009	Bondi	USER	070110	190210	150310	Pidopryhora
EB044A	251009	Bruni	USER	080110	190210	150310	Mahmud
EB044B	261009	Bruni	USER	120110	250210	060410	Mahmud
GV020A	101109	Vlemmings	USER	190110	150210	150310	Campbell
EA041	271009	Amiri	USER	200110	090310	070410	Muehle
GF015B	081109	Fenech	USER	220110	260310	200410	Muehle
RSD01	270110	Deane	USER	270110	100210	180210	Paragi
EG047B	270110	Giroletti	USER	270110	080210	180210	Paragi
EG043B	270110	Giroletti	USER	280110	080210	180210	Paragi
EL039B	270110	Liu	USER	280110	090210	180210	Paragi
GF015A	241009	Fenech	USER	290110	250210	170310	Campbell
N09M3	311009	Pidopryhora	NME	010210	220310	060410	Mahmud
N09Q2	121109	Muehle	NME	010210	020210	150310	Muehle
ES063A	021109	Surcis	USER	030210	230210	060410	Yang
ES063B	031109	Surcis	USER	050210	230210	060410	Yang
ES062A	301009	Soria-Ruiz	USER	090210	120310	070410	Muehle
RO003	100210	OBrien	USER	100210	120210	180210	Paragi
EG043C	100210	Giroletti	USER	100210	120210	180210	Paragi
EG047C	100210	Giroletti	USER	100210	080310	060410	Paragi
RY001	110210	Yang	USER	110210	110210	150310	Paragi/Yang
ES062B	311009	Soria-Ruiz	USER	120210	160310	060410	Mahmud
RE001	010210	Etoka	USER	260210	020310	060410	Yang
RG002	020310	Giroletti	USER	030310	030310	150310	Paragi
F10C1	180310	Pidopryhora	NME	180310	190310	190310	Pidopryhora
EB039E	041109	Brunthaler	USER	220310	060410	230410	Campbell
EB039D	011109	Brunthaler	USER	290310	070410	230410	Campbell
RSD02A	300310	Deane	USER	300310	310310	060410	Paragi
EG043D	300310	Giroletti	USER	300310	020410	060410	Paragi
EG047D	310310	Giroletti	USER	310310	030410	060410	Paragi
RG003	300310	Giroletti	USER	310310	010410	060410	Paragi
N10C1	180310	Pidopryhora	NME	120410	150410		Pidopryhora
RY002A	220310	Brocksopp	USER	130410	140410	290410	Yang
EO007	190310	Overzier	USER	190410	280410	170510	Muehle
RG004	230410	Giroletti	USER	230410	260410	130510	Paragi
EA043	220410	An	USER	230410	260410	130510	Paragi
EP064J	080310	Perez-Torres	USER	260410	020710	300710	Campbell
M0303	030310	Pogrebenko	TEST	270410	150610	301110	Cimó
EP064K	180310	Perez-Torres	USER	280410	100510	300710	Pidopryhora
EP064L	200310	Perez-Torres	USER	290410	020710	300710	Campbell
EP064I	060310	Perez-Torres	USER	040510	100510	300710	Pidopryhora

Expt name	Obs. date	PI	Type	Correl. date	Distrib. date	Release date	Support scientist
N10L1	040310	Mahmud	NME	060510	080610	020810	Mahmud
EI010	040310	Ibar	USER	070510	070610	300710	Pidopryhora
N10M1	100310	Muehle	NME	110510	310510	020810	Muehle
N10X1	220310	Yang	NME	110510	250610	020810	Yang
N10SX1	230310	Yang	NME	120510	250610	020810	Yang
RSD03	180510	Deane	USER	180510	200510	030710	Paragi
RG005A	180510	Giroletti	USER	190510	200510	030710	Paragi
RG006A	190510	Giroletti	USER	190510	200510	030710	Paragi
EA042A	090310	Alberdi	USER	210510	300610	020810	Mahmud
EA042B	210310	Alberdi	USER	250510	010710	020810	Mahmud
EG046	200310	Gawronski	USER	260510	200710	160810	Mahmud
EM071B	110310	Moscadelli	USER	270510	120710	130810	Yang
ES060C	120310	Szymczak	USER	280510	110610	120810	Pidopryhora
GA025A	090310	An	USER	030610	120710	130810	Yang
GH009B	220310	Hallinan	USER	040610	290710	160810	Mahmud
GH009A	210310	Hallinan	USER	070610	290710	160810	Mahmud
RSD02B	100610	Deane	USER	100610	110610	030710	Paragi
RG006B	090610	Giroletti	USER	100610	010710	030710	Paragi
GA025B	210310	An	USER	110610	120710	130810	Yang
EP070B	110610	Rottgering	USER	110610	180610	030710	Paragi
EP070A	100610	Rottgering	USER	110610	110610	030710	Paragi
RG005B	140610	Giroletti	USER	150610	020710	030710	Paragi
EM079	150610	Marecki	USER	160610	080710	300710	Yang
ES064	080310	Cooprider	USER	180610	060710	300710	Campbell
EB039F	170310	Brunthaler	USER	280610	060810	240810	Campbell
ES060D	130310	Szymczak	USER	290610	130710	120810	Pidopryhora
N10C2	270510	Pidopryhora	NME	300610	170710	160810	Pidopryhora
N10M2	010610	Muehle	NME	010710	020710	160810	Yang
N10L2	040610	Mahmud	NME	010710	190710	160810	Mahmud
EB043A	140310	Bartkiewicz	USER	020710	160810	300810	Muehle
EB043B	150310	Bartkiewicz	USER	050710	130810	300810	Mahmud
EB045A	160310	Bartkiewicz	USER	060710	200710	120810	Campbell
RR004A	080710	Rushton	USER	090710	090710	300710	Paragi
RR004B	100710	Rushton	USER	110710	120710	300710	Paragi
GV020B	070310	Vlemmings	USER	230710	020810	240810	Campbell
EF022B	080610	Frey	USER	020810	180810	030910	Mahmud
ES064B	080610	Cooprider	USER	030810	120810	030910	Campbell
EL040A	060610	Liuzzo	USER	050810	180810	030910	Muehle
EF022A	270510	Frey	USER	090810	240810	100910	Mahmud
EP064P	050610	Perez-Torres	USER	110810	240810	100910	Yang
EE005	080610	Engels	USER	120810	270810	100910	Pidopryhora
EP064O	040610	Perez-Torres	USER	120810	090910	111010	Pidopryhora
EP064M	270510	Perez-Torres	USER	130810	240810	100910	Yang
EP064N	290510	Perez-Torres	USER	160810	080910	111010	Pidopryhora
EP068B	050610	Perez-Torres	USER	240810	191010	201210	Mahmud
TE101	260810	Paragi	TEST	260810	260810	260810	Paragi
EP068A	280510	Perez-Torres	USER	310810	171110	201210	Muehle
EZ020A	030610	Zhang	USER	020910	061010	211110	Campbell
EB045B	010610	Bartkiewicz	USER	030910	080910	111010	Yang
EM081A	230810	Molera	USER	060910	070910		Mahmud
EG050A	080910	Giroletti	USER	090910	090910	090910	Paragi

Expt name	Obs. date	PI	Type	Correl. date	Distrib. date	Release date	Support scientist
GV020C	050610	Vlemmings	USER	220910	181010	301110	Campbell
RSP03	300910	Paragi	USER	300910	071010	081010	Paragi
RP016A	300910	Paragi	USER	300910	011010	081010	Paragi
EG050B	290910	Giroletti	USER	300910	071010	071010	Paragi
ET013A	041010	Tudose	USER	041010	081010	081010	Paragi
RP016B	041010	Paragi	USER	041010	041010	081010	Paragi
EB039G	020610	Brunthaler	USER	201010	011110	211110	Campbell
EL040E	071110	Liuzzo	ABAN	311010	311010	311010	Niemand
EL040D	061110	Liuzzo	ABAN	311010	311010	311010	Niemand
EV018A	280510	Vlemmings	USER	031110	011210	201210	Campbell
RL002	051110	Lobanov	USER	061110	081110	211110	Paragi
EM077D	231110	Mantovani	USER	231110	261110	301110	Paragi
N10K1	291010	Muehle	NME	241110	091210		Muehle
EG051A	231110	Giroletti	USER	241110	261110	301110	Paragi
RP014D	241110	Perez-Torres	USER	241110	261110	301110	Paragi
RL003	231110	Lobanov	USER	241110	261110	301110	Paragi
N10L3	011110	Mahmud	NME	251110	221210		Mahmud
ER025A	291010	Romero	USER	261110	141210		Muehle
ER025B	301010	Romero	USER	291110	141210		Muehle
ED030A	021110	Deane	USER	011210	131210		Mahmud
ED030B	031110	Deane	USER	031210	201210		Pidopryhora
EL040B	031110	Liuzzo	USER	061210	141210		Mahmud
EL040C	041110	Liuzzo	USER	071210	201210		Mahmud
EY012	051110	Yang	USER	091210	281210		Yang
EA044	311010	Amiri	USER	101210			Campbell
N10SX2	081110	Yang	NME	131210	291210		Yang
EB047	301010	Bartkiewicz	USER	131210			Pidopryhora
EY011	041110	Chen	USER	131210			Yang
N10M3	211010	Pidopryhora	NME	141210			Pidopryhora
N10C3	261010	Pidopryhora	NME	141210			Pidopryhora
RSP04	151210	Paragi	USER	151210	181210	201210	Paragi
EY014	151210	Chen	USER	161210	181210	201210	Yang
EM077E	151210	Mantovani	USER	161210	181210	201210	Paragi
EE006	031110	Engels	USER	171210	171210		Pidopryhora
EL040F	071110	Liuzzo	USER	201210			Muehle
EB039H	221010	Brunthaler	USER	221210	281210		Campbell
EZ020B	251010	Zhang	USER	271210			Yang

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9 LIST OF ACRONYMS AND ABBREVIATIONS

2MASS	-	Two Micron All Sky Survey
AARNET	-	Australia's Academic and Research Network
ACSIS	-	Auto-Correlation Spectrometer Imaging System
AGN	-	Active Galactic Nuclei
AIPS	-	Astronomical Image Processing System
ALBiUS	-	Advance Long Baseline Interoperable User Software
ALBUS	-	Advance Long Baseline User Software
ALMA	-	Atacama Large Millimeter Array
ANTAB	-	file containing apriori station calibration information, used in AIPS
ASKAP	-	Australian Square Kilometre Array Pathfinder
ASTRON	-	Netherlands foundation for Research in Astronomy
ATCA	-	Australia Telescope Compact Array
AU	-	Astronomical Unit
AUT	-	Auckland University of Technology
BBC	-	Baseband Channel
BN	-	Back Nodes
BP	-	Bandpass
CAS	-	Chinese Academy of Sciences
CDT	-	Core Dominated Triples
CEA	-	French Atomic Energy Commission
CfA	-	Center for Astrophysics (Cambridge, MA, USA)
CHARA	-	Center for High Angular Resolution Astronomy
CL	-	Calibration table (AIPS)
CNRS	-	Centre National de la Recherche Scientifique
CPU	-	Central Processing Unit
CSS	-	Compact Steep Spectrum
dBBC	-	digital Baseband Channel
DtE	-	Direct to Earth
EC	-	European Commision
e-EVN	–	European VLBI Network operating in e-VLBI regime
EJSM	-	Europa Jupiter System Mission
EMIR	-	Eight Mixer Receiver
ERIC	-	European Research Infrastructure Consortium
ESA	-	European Space Agency
ESKAC	-	European SKA consortium
ESO	-	European Southern Observatory
ESPaCE	-	European Satellite Partnership for Computing Ephemerides
ESTRELA	-	Early-Stage Training for European Long-wavelength Astronomy
EU	-	European Union
EVE	-	European Venus Explorer
EVGA	-	European VLBI Group for Geodesy and Astrometry
e-VLBI	-	electronic VLBI
EVN	-	European VLBI Network
EXPReS	-	Express Production Real-Time e-VLBI Science
FABRIC	-	Future Arrays of Broadband Radio-telescopes on Internet Computing
FITS	-	Flexible Image Transport System
FN	-	Front Nodes
FÖMI	-	Institute of Geodesy, Cartography and Remote Sensing
FP6	-	6th Framework Program
FP7	-	7th Framework Program
FPGA	-	Field-Programmable Gate Array

FWHM	-	Full Width at Half Maximum
GBT	-	Green Bank Telescope
GEANT	-	Pan-European Gigabit Research and Education Network
GLIF	-	Global Lambda Integrated Facility
GMEM	-	Generalized Maximum Entropy Method
GMRT	-	Giant Metre-wave Radio Telescope
GP-B	-	Gravity Probe B
GPS	-	GigaHertz Peaked Spectrum
GPS	-	Global Positioning System
GRB	-	Gamma Ray Burst
HARP	-	Heterodyne Array Receiver Programme
I3	-	Integrated Infrastructure Initiative
IAA	-	International Academy of Astronautics
IAU	-	International Astronomical Union
ICRAR	-	International Centre for Radio Astronomy Research
ICRF	-	International Celestial Reference Frame
ICRF2	-	Second Realization of the International Celestial Reference Frame
IDI	-	FITS - Interferometry Data Interchange Convention
IERS	-	International Earth Rotation and Reference Systems Service
IF	-	Intermediate Frequency
IGN	-	Instituto Geografico Nacional (Spain)
IMF	-	Initial Mass Function
INAF	-	Istituto Nazionale di Astrofisica (Italy)
IONEX	-	Ionosphere Map Exchange
IRAM	-	Institut de Radioastronomie Millimétrique
ISAS	-	Institute for Space and Astronautical Sciences
ISM	-	Interstellar Medium
IVS	-	International VLBI Service
IYA	-	International Year of Astronomy
JAXA	-	Japan Aerospace Exploration Agency
JCMT	-	James Clerk Maxwell Telescope (Hawaii, USA)
JIVE	-	Joint Institute for VLBI in Europe
JRA	-	Joint Research Activity
KASI	-	Korean Astronomy and Space Science Institute
KNAW	-	Royal Netherlands Academy of Arts and Sciences
LAT	-	Large Area Telescope
LBA	-	Australian Long Baseline Array
LO	-	Local Oscillator
LOFAR	-	Low Frequency Array
LVDS	-	Low Voltage Differential Signaling
LVG	-	Large Velocity Gradient
Mbps	-	Megabit per second
MERLIN	-	Multi-Element Radio Linked Interferometer Network
MEX	-	Mars Express
MFSC	-	Marshall Space Flight Center
MIRIAD	-	Multichannel Image Reconstruction, Image Analysis and Display
MMO	-	Mercury Magnetospheric Orbiter
MoU	-	Memorandum of Understanding
MPI	-	Max Planck Institute
MPIfR	-	Max Planck Institute für Radioastronomie (Germany)
MS	-	Measurement Set
MTA	-	Hungarian Academy of Science
NA	-	Networking Activity
NAOC	-	National Astronomical Observatory of China

NASA	-	National Aeronautics and Space Administration
NGLS	-	Nearby Galaxy Legacy Survey
NME	-	Network Monitoring Experiment
NRAO	-	National Radio Astronomy Observatory (USA)
NREN	-	National Research and Education Network
NWO	-	Netherlands Organisation for Scientific Research
NWO-EW	-	Netherlands Organisation for Scientific Research-Physical Sciences
OAN	-	Observatorio Astronomico Nacional (Spain)
OSO	-	Onsala Space Observatory (Sweden)
PC	-	Program Committee
PCB	-	Printed Circuit Board
PCInt	-	Post-Correlator Integrator
PI	-	Principle Investigator
PoS	-	Proceedings of Science
PrepSKA	-	Preparatory Phase for the SKA
PRIDE	-	Planetary Radio Interferometry and Doppler Experiment
PSNC	-	Poznan Supercomputing and Networking Center
R&D	-	Research & Development
RF	-	Radio Frequency
RFI	-	Radio Frequency Interference
RRI	-	Raman Research Institute
RSA	-	Russian Space Agency
RXTE	-	Rossi X-Ray Timing Explorer
SA	-	Specific Service activities
SAS	-	Serial Attached SCSI (controllers)
SATA	-	Serial ATA (AT-Attachment)
SCARIe	-	Software Correlator Architecture Research and Implementation for e-VLBI
SCSI	-	Small Computer System Interface
SCUBA-2	-	Submillimetre Common-User Bolometer Array
SDSS	-	Sloan Digital Sky Survey
SFP	-	Small Form-factor Pluggable
SFXC	-	Software FX correlator
SKA	-	Square Kilometer Array
SKADS	-	SKA Design Study
SN	-	Supernova
SPDO	-	SKA Program Development Office
SRON	-	Netherlands Institute for Space Research
SSEC	-	SKA Science and Engineering Committee
STFC	-	Science and Technology Facilities Council
SU	-	Station Units
SURFnet	-	Dutch Research Organisation
TandEM	-	Titan and Enceladus Mission
TB	-	Terabyte
TERENA	-	Trans-European Research and Education Networking Association
TMAC	-	Tera Multiply Accumulate
TNA	-	Trans National Access
TOG	-	Technical Operations Group
ToO	-	Target of Opportunity Observation
UDP	-	User Datagram Protocol
ULWA	-	Ultra-Long-Wavelength Astronomy
UNAM	-	National Autonomic University of Mexico
UNESCO	-	United Nations Educational, Scientific and Cultural Organization
USS	-	Ultra Steep Spectrum
VDIF	-	VLBI Data Interchange Format

VERA	-	VLBI Exploration of Radio Astronmetry
VEX	-	Venus Express
VHDL	-	Very high speed integrated circuit Hardware Description Language
VISC	-	VSOP International Science Council
VLA	-	Very Large Array
VLBA	-	Very Long Baseline Array
VLBEER	-	EVN schedule server
VLBI	-	Very Long Baseline Interferometry
VSOP	-	VLBI Space Observatory Program
WSRT	-	Westerbork Synthesis Radio Telescope
XGB	-	10GbE Break-out Board
ZFS	-	Zettabyte File System

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