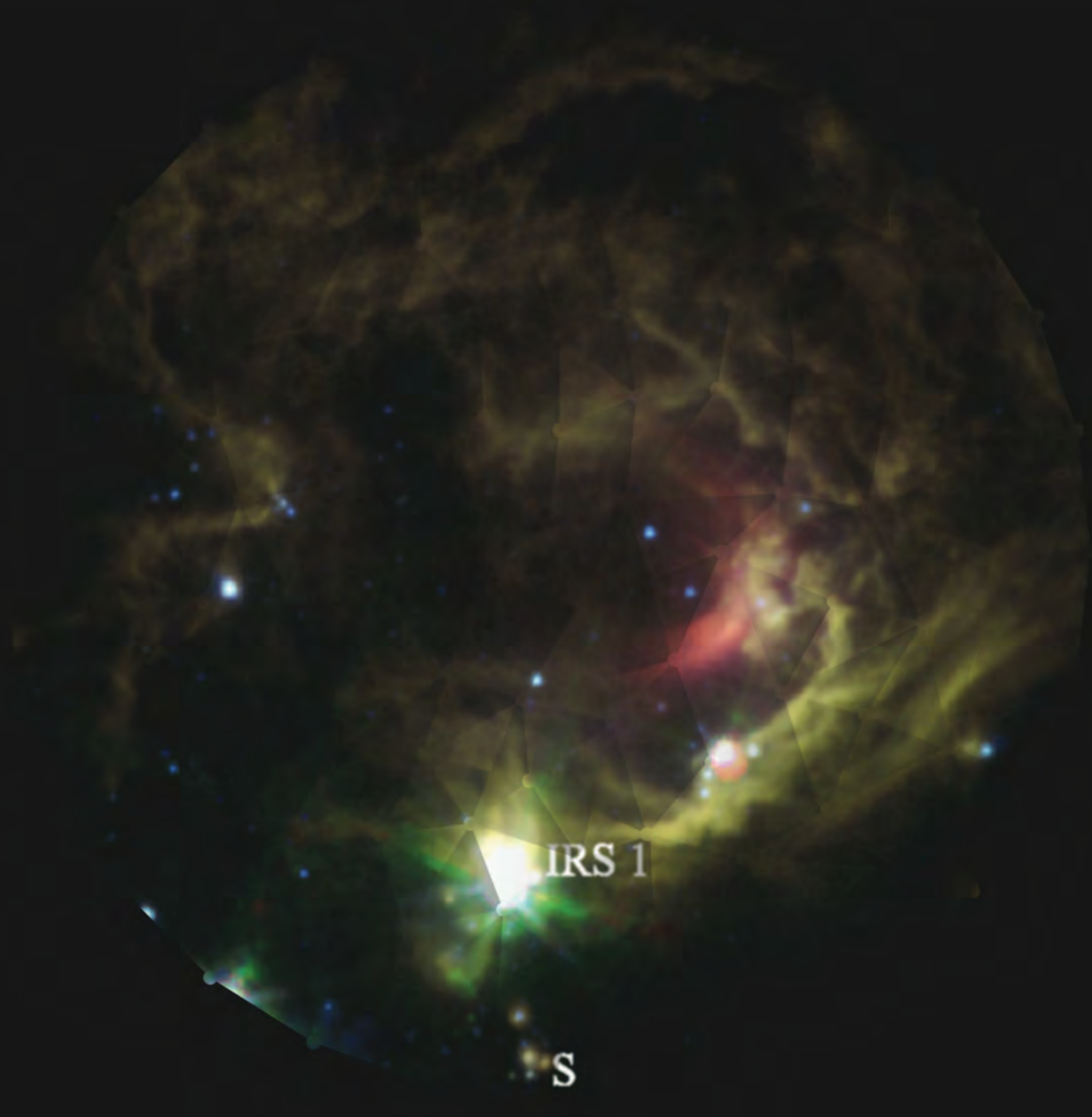

2013-2014

Joint Institute For VLBI in Europe
Biennial report

JIVE
JOINT INSTITUTE FOR VLBI IN EUROPE

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

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Foreword

For JIVE the years 2013-2014 have in every aspect been a period of transition. At the start, funding of the JIVE foundation was established for a two-year period, in anticipation of the transition of the JIVE foundation into a European Research Infrastructure Consortium (ERIC). It is indeed satisfying to see that it has been possible to complete the ERIC application in time; in the last week of 2014 the new legal entity was called into existence by the EC, recognizing the special status of JIVE in the European arena of research infrastructure providers. The establishment of JIVE as an ERIC is a much better fit to the needs of EVN for central operations, user services, innovation and the implementation of community programs. It is beneficial for a more effective use of the funding allocated to the European VLBI, enhancing the stability of JIVE and making it more attractive for new partners.

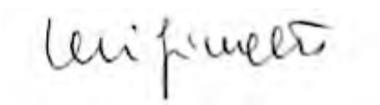
Financially however 2013-2014 was a bit of a challenge for JIVE and its partners, as the economic situation required some cutbacks and major EC projects came to an end. At the same time, European radio astronomers were busy drawing the outlines of the SKA. Many R&D efforts in the community have focused on SKA requirements and for JIVE it became possible to channel some resources into the development of the SKA. But on the whole the institute was forced to reduce its staffing and be more modest in its ambition to push the scientific and technological envelope of VLBI.

We can however be confident that the user community of the EVN and JIVE have experienced little of these issues. During the EVN symposium in Cagliari it was clear that the European VLBI community is as healthy as ever, addressing an incredibly wide range of topics and bringing in new researchers. That same conclusion was also reached by the ASTRONET consultation on radio facilities, which is very positive about the scientific role of the EVN and JIVE in the community.

This is no small accomplishment for the JIVE staff, who celebrated their institute's 20th anniversary in December 2013 in a beautiful new wing of the ASTRON building. All these years JIVE has focused on its main mission to serve the users and the observatories of the EVN, and it is only right that the ERIC will continue to do so under the same name in the future.

Around the world new radio astronomy facilities are under development, many of which will join the VLBI family. With its new European status, JIVE will be ready to take up a prominent role in organising joint operations with these new facilities. On behalf of the board we congratulate the JIVE staff with this new status and we recognize that, with all the paperwork done, this is the last biennial report of the JIVE foundation

Luigina Feretti, chairperson of the board



June 2015

1 INSTITUTE

1.1 Changes & continuity

After about a year of building activities, JIVE moved into the new wing of the Dwingeloo building by the beginning of 2013. With the possibility of having all the personnel in one corridor, a local meeting room and a local coffee corner, the new housing allows for easy communication and an own identity within the ASTRON building. The new corridor is also the location for continued coffee meetings every Thursday that proved to be important for exchanging news and highlighting new achievements.

Figure 1.1: JIVE support scientists enjoying the new JIVE corridor.

The large EC FP7 NEXPReS programme was wrapped up in the first half of 2013, reaching the last milestones in time for the final report and the visit by the review panel on 18 and 19 September. For this event a rather ambitious milestone was promised that would demonstrate 4 Gbps connectivity with a sufficient number of telescope telescopes such that closure phase could be demonstrated. Indeed this was shown to work to the visiting experts during an exciting live demo. The NEXPReS programme could thus be concluded rated “excellent”, leaving JIVE and its partners with a very proud feeling about its various achievements.

However, it proved impossible to identify a suitable funding instrument to cover subsequent innovative work on e-VLBI, connectivity and new correlator platforms. This forced JIVE to set its priorities on a limited number of subjects for which it could fund development from its own resources. This transition was one reason for the serious budgetary shortfall in the 2013 and 2014 accounts, to which the economic situation in Europe also contributed, as some partners were forced to temporarily reduce their contributions.

JIVE management made considerable efforts to identify new ways to channel the institute’s ambition to develop new tools to enhance VLBI science. With the on-going RadioNet research activities and the expertise obtained in NEXPReS it was possible to start making modest contributions to the SKA consortia that are designing the various components for this future telescope. Under ASTRON’s lead, the Dutch radio astronomers secured a considerable programme in 2014 in which JIVE is a beneficiary. The EC synergy grant by Falcke et al., called BlackHoleCam, allowed for a deployment of

JIVE expertise for mm-VLBI. Several more projects were considered and the Horizon2020 ASTERICS proposal, to which JIVE contributed the definition of one work package, was submitted in 2014.

1.2 Core Business

In 2013 processing had already stopped on the Mk4 correlator and at the end of 2013 its hardware was finally decommissioned after 15 years of service. A number of correlator chips were turned into mementos for the 20th birthday of JIVE commemoration. Production continued on the SFXC correlator which was enhanced gradually in order to keep up with production requirements, including e-VLBI at 1 Gbps. Several specialist operational modes were added to the system, including the possibility to derive time series for targeted pulsars anywhere in the field of view of a VLBI observation, a unique capability.

The SFXC correlator was also enhanced with a special mode to accommodate RadioAstron processing. The JIVE team demonstrated that it could be advantageous to use observations of RadioAstron itself to improve the phase stability of the space telescope in space VLBI observations. Other highlights included observations of the Mars Express when it flew by the Mars moon Phobos. The PRIDE experiment that will allow very accurate tracking of space probes was selected as an official experiment in the ESA JUICE mission to Jupiter's moons.

The output of the EVN, including some of the latest results obtained with the SFXC platform, featured at the 12th EVN symposium in Cagliari. It was a very good meeting, demonstrating once again the wide range of capabilities of the EVN and the vibrant user community distributed over Europe and beyond. Cagliari was of course chosen because it allowed the participants to visit the new, big Sardinia Radio Telescope.

Figure 1.2 A big thank you for the organizers of the EVN symposium in Cagliari.

Earlier in 2013, JIVE had organised a meeting at the Leiden Lorentz centre on astrophysical transients. The participants discussed the astrophysical nature of various known and suspected events that could give rise to variable emission. In the context of the NEXPReS project various future observing modes and alerting mechanisms were also addressed. In 2014 a meeting was organized at the same location on Galactic radio astronomy with the SKA and its pathfinders. At this meeting JIVE scientists argued that VLBI capabilities should feature in the SKA design from the earliest stages on.

In 2014 the ERIS (European Radio Interferometry School) was held in Dwingeloo, organised jointly by ASTRON and JIVE and partly funded by RadioNet3. No less than 95 students were introduced to the concepts and practices of all major radio astronomy facilities. Fostering the European radio community is an important aspect of the RadioNet programme. In addition, JIVE hosted the International VLBI Technology Workshop in November 2014. Bringing together Global experts who discussed technology advances relevant for VLBI data acquisition and correlation. This years' workshop featured a special session on clock signal distribution.

Figure 1.3 Bob Campbell capturing the students' attention at the ERIS.

In September 2014 a review took place of the UniBoard based VLBI correlator effort. The external review committee confirmed the idea that such a correlator would be beneficial for providing capacity for large, wide band experiments and future e-VLBI. The team showed first fringes and detailed comparisons of their results with correlations obtained on other platforms.

1.3 Institute

Several more-or-less social events took place. In 2013 there was a garden party and later in the year a farewell party for Charles and Kristine Yun and retirement party for Bauke Kramer.

Figure 1.4 The JIVE 2013 garden party.

Figure 1.5 Saying goodbye to Bauke Kramer

...and Charles and Kristine Yun

In early 2014 JIVE director Huib Jan van Langevelde had the opportunity to become professor at Leiden. This fact and the associated ceremony reflected well on the institute and the field of VLBI in the Netherlands.

Figure 1.6 JIVE's 20th anniversary was celebrated in a Christmas setting.

On 21 December 2013, JIVE formally had existed for 20 years. In view of the on-going preparations for the transition into an ERIC, a modest party was held at the event of the Dwingeloo Christmas party.

Indeed, exactly one year later the formation of the new legal entity was a fact, with the publication of the Brussels decision that the ERIC was established. The preparations for this had focused in 2013 on aligning the intentions of the partners, which was achieved at a meeting of board members and funding agency representatives at the Dutch education, culture and science ministry in The Hague. A first stage proposal was submitted in August 2013. Based on the positive response on that, the final statutes were iterated with the partners, resulting in sufficient commitments such that the final statutes could be submitted in time for a decision in late 2014. After a transition year, it is expected that the JIVE foundation will be discontinued in late 2015.

Figure 1.7 JIVE board in 2013.

In 2014 JIVE board member Mike Gaylard passed away. Mike had been the first South African board member and had been instrumental in making sure the EVN station in Hartebeesthoek was a cornerstone of our VLBI facility. Mike had taken the initiative to identify communication dishes throughout Africa, which could be used for astronomy, enhancing the potential for VLBI science. On a personal, professional and international level he will be remembered as one of the most compassionate scientists one could encounter.

2 SCIENCE OPERATIONS AND SUPPORT

All experiments during this period, both disk-based and e-VLBI, were correlated on the EVN software correlator at JIVE (SFXC). The increased capabilities of SFXC have enabled EVN PIs to pursue new kinds of experiments during this biennial period, which were previously unimaginable. Some highlights are mentioned in the section immediately below; the section "Astronomical Features" (2.1.3) will delve further into these new scientific applications.

2.1 Production correlation

2.1.1 Sessions and their experiments

Session 1/2013 had a total of 26 user experiments correlated at JIVE, including 2 e-EVN experiments conducted during the session. The Kunming telescope participated in a user experiment at X-band (observing SN 2011dh in M51). A target-of-opportunity observation of the Crab nebula following an outburst was the first to use the pulsar gating/binning capability to excise pulsar emission (SFXC also returns the pulse interval outside of the defined gate as a separate output).

Session 2/2013 also had a total of 26 user experiments correlated at JIVE, including 2 e-EVN experiments conducted during the session. Preliminary tests of global-array Gbps observations using the RDBE back-end in its digital down-converter (DDC) personality on VLBA stations were conducted at 18, 6, and 1.3 cm.

Session 3/2013 had a total of 17 user experiments correlated at JIVE, including 1 e-EVN experiment conducted during the session. This session suffered a great deal of weather-related and some station-related losses; one 24-hr experiment (not counted in the total above) was abandoned prior to correlation, and thus was re-queued for observing. In addition, four other experiments requested re-queuing because of related losses following distribution of the FITS files to the PIs; because of the multi-frequency nature of these experiments, this corresponded to 10 observations totalling 64 hours.

In 2013, there were 40 e-EVN user experiments, 5 of which were conducted during the regular disk sessions. There were 7 target-of-opportunity experiments, and 1 triggered observation. The first e-VLBI fringes from the Irbene telescope came during the March e-EVN day. Noto achieved a full Gbps data-rate, removing the need for channel-dropping. Arecibo provides a data-rate of 512 Mbps, regardless of the local time.

Session 1/2014 had a total of 23 user experiments correlated at JIVE, including 2 e-EVN experiments conducted during the session. The first fringes at JIVE from the Sardinia Radio Telescope (18cm) and the new Tianma 65m telescope (18, 6, 5 cm) came in network monitoring experiments (NMEs). The new JPL/DSN digital back-end for Robledo participated in its first user experiment. The first experiment requiring both pulsar gating/binning and multiple phase-centers (not for multiple pulsars) ran; this was also the first to use the new SFXC phased-array mode to assist in the preliminary gate fitting stages.

Session 2/2014 had a total of 28 user experiments correlated at JIVE. Global VLBI observations returned, following the shift of VLBA/GBT telescopes to the NRAO RDBE back-end and the JVLA to the WIDAR correlator. Some of these were at 1 Gbps, which required correlation of different channelizations (NRAO: 8x 32MHz, EVN: 16x 16MHz). Sardinia participated in user experiments at 18cm; Tianma 65m at 5cm (an excited-OH observation at 6035 MHz which Sheshan could not reach), and the KVN at 7 mm.

This session has proved to be the most complicated yet encountered, with nine large experiments (from 3 proposals) requiring new features on unprecedented scales. Four comprised a wide-field spectral-line experiment, producing 5.3 TB of output FITS files; these were the first to use integration times other than 2^n seconds (shifting from 0.25 s to 0.35 s saved about 2.1 TB in output FITS-file size, while maintaining a satisfactory time-smearing field of view). Another four required coherent de-dispersion for the target millisecond pulsar. Finally, one provided to be our most massively multiple phase-center correlation (699 targets, compared with the previous high of about 50). Processing of the latter two groups is still on going at the end of 2014.

Session 3/2014 had a total of 16 user experiments correlated at JIVE. This session saw the first global observations at Gbps including the JVLA, which required some iterations with Socorro to design the optimal set-ups. Another 3 observations (18 hours) were abandoned prior to correlation (not included in the above number).

In 2014, there were 22 e-EVN user experiments, 2 of which were conducted during the regular disk sessions (the KVAZAR stations began observing with the EVN on weekends starting in session 2/2014, which precluded the weekend gaps in which the in-session e-EVN observations had run). There were 5 target-of-opportunity experiments, and no triggered observations. Sheshan achieved a full Gbps data-rate, removing the need to treat them as a 1-bit sampling station.

Figure 2.1 shows the evolution of annual EVN network hours since 2004 (in global observations, EVN hours do not count periods with no participating EVN stations). The green shaded area represents the contribution of e-EVN observations and that of the new category of regularly scheduled out-of-session (OoS) observations by the red shaded area. Note that not all of the disk-based experiments were correlated at JIVE. Figure 2.2 focuses on the e-EVN experiments, showing a division of annual observing hours into different categories: ToOs, triggered observations, short (<= 2hr) exploratory observations not requiring a formal proposal, experiments proposed for disk recording but conducted in e-VLBI (after consultation with the PI), and the standard e-EVN observations in regularly scheduled e-VLBI (or disk) sessions. The fall-off of standard e-EVN hours in 2014 can be attributed to fewer in-session e-EVN observations, which have typically taken place on weekends when the KVAZAR stations were not able to participate -- this situation changed by session 2/2014. By their nature, all e-EVN observations correlate at JIVE, and occupy a single correlator pass.

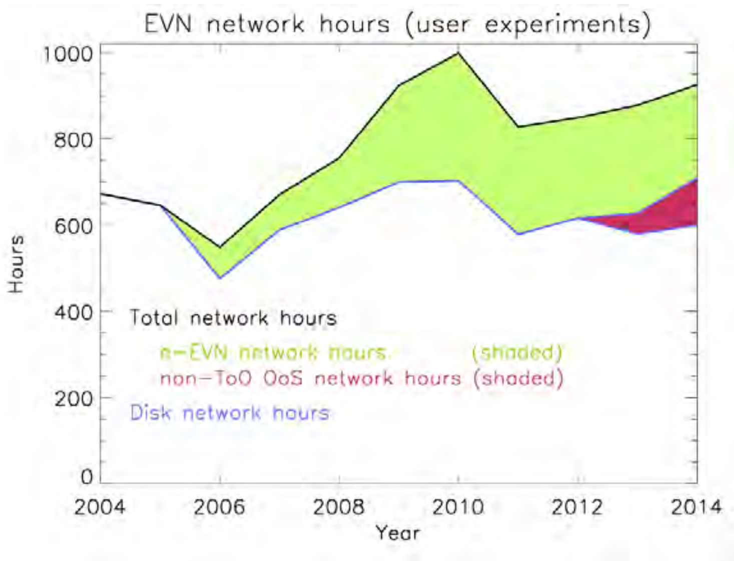


Figure 2.1 Annual EVN network hours, with the contribution of e-EVN observations shown by the green shaded area and of regular out-of-session observations by the red shaded area.

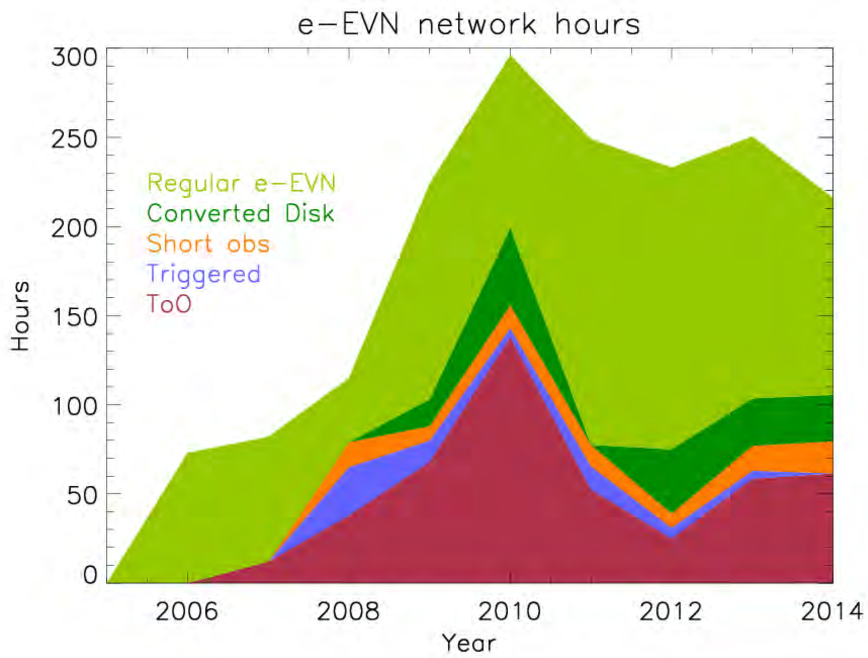


Figure 2.2 Division of annual e-EVN network hours into categories.

Tables 2.1 and 2.2 summarize projects observed, correlated, distributed, and released in 2013 and 2014. 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. This definition carries over to SFXC, even though it may run faster or slower than real time. Because of its enhanced capabilities, multiple correlator passes for SFXC occur only for phase-referenced spectral-line observations (separate "continuum" and "line" passes) and for pulsar observations wanting different gating/binning configurations.

	User Experiments			Test & Network Monitoring		
	N	Ntwk_hr	Corr_h	N	Ntwk_hr	Corr_h
Observed	107	776	891	25	82	84
Correlated	114	817	957	32	99	101
Distributed	120	849	977	27	91	91
Released	129	924	1068	24	89	89
e-EVN experiments	40	250.5	250.5			
e-EVN ToOs	7	58.5	58.5			

Table 2.1: Summary of projects observed, correlated, distributed, and released in 2013.

	User Experiments			Test & Network Monitoring		
	N	Ntwk_hr	Corr_h	N	Ntwk_hr	Corr_h
Observed	90	786	828	24	71	71
Correlated	80	688	740	19	56	56
Distributed	77	666	715	26	68	68
Released	80	676	723	26	74	74
e-EVN experiments	22	216	216			
e-EVN ToOs	5	61.5	61.5			

Table 2.2: Summary of projects observed, correlated, distributed, and released in 2014.

Figure 2.3 presents various measures of correlator efficiency over the past three years (the biennial period is shown as solid lines). The red line plots the completed correlator hours 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 peaks caused by periods with no remaining production correlation.

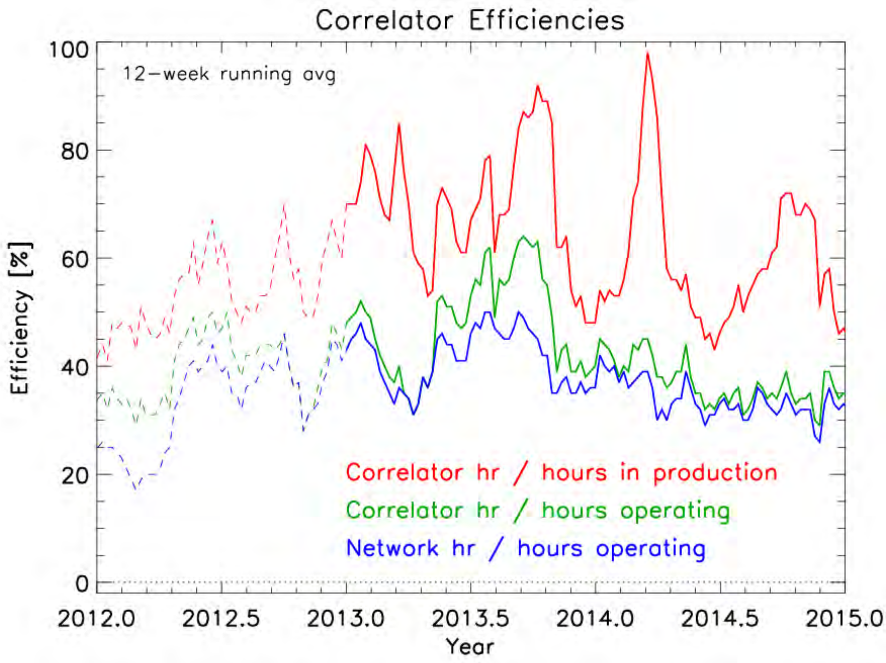


Figure 2.3 Various measures of correlator efficiency.

Figure 2.4 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 blockier pattern for the green line). The flat red line at the end of 2014 represents a period of SFXC development for specific requirements of the unusual session 2/2014 experiments (see section 2.1.3) prior to any session 3/2014 observations being ready to correlate.

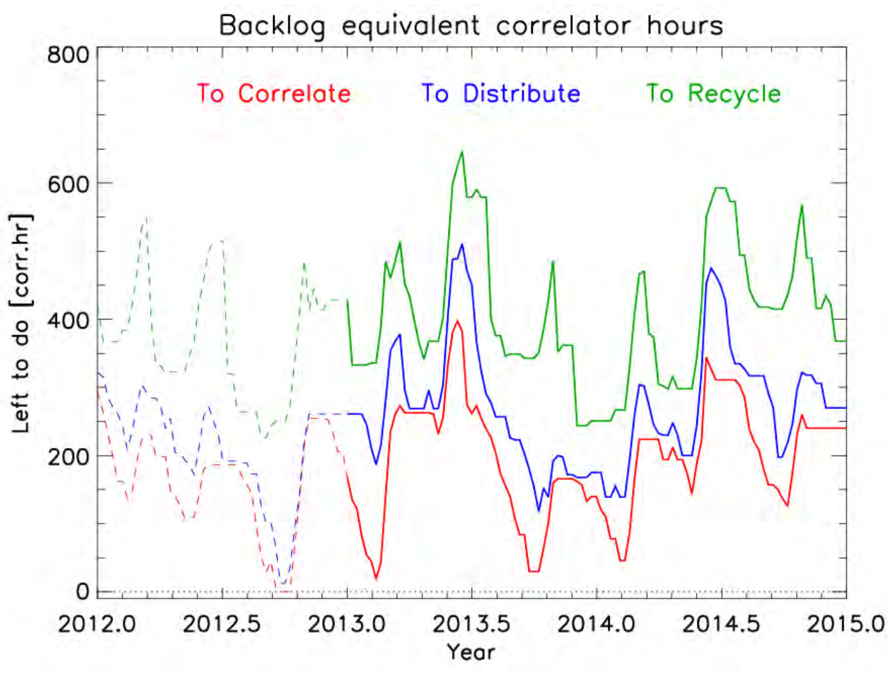


Figure 2.4 Size of various correlator queues, measures in correlator hours.

2.1.2 Logistics and Infrastructure

The foundations of disk-pack shipping requirements have remained the same from the previous biennial period, with the addition of some new considerations that can tend towards less efficient pack usage. Session 2/2014 was the first to require more than 1000 TB of disk-packs to be used across the participating stations. Remaining the same are the guidelines that:

a) EVN stations should buy two sessions' worth of disks, hence the disk-pack flux should balance over a 2-session interval.
b) NRAO stations require pre-positioning the difference between what they will observe in globals to be correlated at JIVE (or Bonn) and what EVN stations will observe in globals to be correlated in Socorro.
c) The sets of packs for observations destined for correlation in different places should be distinct from each other.

New considerations include:

d) The new class of EVN out-of-session (OoS) observations, which can raise a trade-off between rapid shipping of packs and fully using the available space. So far, such OoS observations have comprised relatively low data-rate RadioAstron+EVN/global observations (12hr needs only 1.4 TB). The load for OoS observations between two sessions should be distributed along with the packs for the preceding session.
e) NRAO and KVN stations want only the more modern SATA packs for recording, which establishes an effective minimum-size per each of their stations of 6-8 TB.

There were serious problems encountered in delivering packs to the KVAZAR stations in the initial sessions of 2013. In session 1/2013, the three telescopes (Svetloe, Zelenchukskaya, Badary) missed 2, 7, 5 user experiments (and 2, 3, 2 NMEs) due to lack of packs. Following discussion with the stations, the total distribution was split into multiple shipments, each of no more than 6 packs, spaced a few days apart, and the delivery was shifted from a parcel company to a freight company. By session 3/2013, the difficulties seem to have been overcome.

JIVE began to exploit e-shipping operationally in 2014, initially focusing on the lower data-rate out-of-session observations and as a means to transfer data to another correlator from misdirected disk packs. If there is enough space at the correlator, e-shipping avoids the need to physically send disk-packs before and after correlation, and also permits a more direct experiment-based recycling.

2.1.3 Astronomical Features

e-EVN

The number and duration of e-EVN target-of-opportunity observations was up over the previous biennial period (12 vs. 11; 120 hr vs. 78 hr). The total number of e-EVN hours was slightly down (466.5 hr vs. 482 hr). Over the biennial period, 31.4% of the observed EVN network hours in experiments correlated at JIVE were e-EVN observations, also slightly down from the previous period (34%). The KVAZAR stations' participation in EVN observations on weekends starting from session 2/2014 explains the slight decrease in total e-EVN numbers. In terms of e-EVN network improvements, Noto and Shanghai were able to sustain a full Gbps transmission rate (no channel dropping required any longer), and Arecibo was able to provide 512 Mbps without local-time constraints. A feature in SFXC was developed to allow array-composition changes in the middle of running correlation job. This has removed the need to restart the correlator during e-EVN observations when stations come in / go out of the array.

The principal features that SFXC has enabled astronomers to use in their experiments include essentially unlimited spectral resolution, multiple phase-center correlation, and pulsar gating/binning. These capabilities are described in detail in the previous biennial report, and they continue to see further development. There were six observations using pulsar gating/binning during this biennial period, four of which required the development of coherent de-dispersion of the pulse. In incoherent de-dispersion, each frequency point in the correlation gets its own time offset to undo the frequency-based dispersion the pulsar's signal accumulates traveling through the interstellar medium. For pulsars with large dispersion measures and short pulses/pulse-widths, there may arise conflicting requirements: the number of frequency points would need to be large to maintain a negligible residual dispersion in each frequency point, but would simultaneously need to be small to keep the time-span associated with the samples in the FFT below the desired temporal resolution. Coherent de-dispersion avoids such situations by applying a chirp function directly to the sampled data before correlation. In order to apply coherent de-dispersion, an FFT the size of the dispersion time across a subband in units of the sampling interval is required. For the observations driving development of the coherent de-dispersion, this FFT was 4 million points, which required further development of controls in the operating GUI for managing the number of processes running per SFXC node in order to avoid memory-usage problems.

There were 24 observations using multiple phase-center correlation during this biennial period. This approach performs an "internal" correlation with a very large number of frequency points and a very small integration time (typically >= 8k frequency points and < 10 ms), but then outputs only subsets of this initial wide field using more traditional values for frequency points and integration times.

The most significant new development in this biennial period was the return of global VLBI observations, with the VLBA stations and the Green Bank telescope using NRAO's digital back-end, RDBE, in a "personality" that permits BBC tunability. In such a mode, only eight channels are available, so observations at 1 Gbps required 8 channels of 32 MHz at NRAO stations, while the EVN stations retained their maximum channel bandwidth of 16 MHz. Thus the ability to correlate mixed-bandwidths was developed on SFXC. In this case, the wider channels are split to match the narrower ones. Implicit in this new feature is the ability to correlate lower- and upper-sideband channels with each other. The hiatus in global VLBI observations between the demise of the analog VLBA back-ends and the ability to correlate recordings made with the new RDBEs had led to the creation of a back-log of such observations in the scheduling queue. Following tests of mixed-bandwidth correlation, global VLBI observations returned in session 2/2014, and the back-log is still being worked through going into 2015. With the RDBE back-ends, VLBA stations no longer provide the TSYS section in {exp}cal.vlba files. Instead, JIVE developed programs to extract system temperature from the effects of the 80-Hz noise-diode modulation in their sampler statistics in SFXC output.

A spectral-zooming mode was developed, in which only a portion of an observed channel is correlated. This provides a means for higher spectral resolution without a corresponding increase in the size of the output FITS files (i.e., without spectral zooming, the output would contain frequency points outside the region of interest). In a sense, this mode is a subset of the mixed-BW correlation capability, in that an observed channel is split into a smaller frequency range based on an external specification: in the mixed-BW case, as defined by some other station's observed channel; here based on a user-specified frequency range.

A "phased-array" mode for SFXC was developed, in which calibration information derived in AIPS following an initial correlation is fed back into the correlator to augment the a priori model. This permits "summing" the individual stations or cross-correlations to provide a data-set with time-resolution on the order of the sampling interval on a virtual telescope having an equivalent area to the sum of the areas of the participating stations. This capability has been used for EVN+GBT observations of pulsars in a globular cluster; the phased-array summed data-set can in turn be used with standard pulsar search/timing programs.

The first LO offsets (small enough to permit remaining frequency overlap with other stations) since SFXC took over production correlation occurred. The means to compensate for such incidents was developed for SFXC, and is more flexible than the similar capability was in the MkIV correlator: such an LO offset in more than one station can be handled (because the fringe rotation in SFXC is strictly station-based, as opposed to the MkIV in which the fringe rotation was applied to the "first" station of each baseline taken separately).

2.2 EVN Support

Automatic-ftp fringe tests continued to be 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 did not appear first in the schedule or fell well outside working hours. Under the control of sched and the field system, a specified portion of a scan is sent directly to the SFXC cluster at JIVE. Multiple ftp transfers per experiment provide the opportunity to iterate with the stations in investigating any problems identified. Use of ftp transfer and near-real-time correlation permits stations that don't have a full e-VLBI 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 results go to a web page available to all the stations, showing baseline amplitude and phase across the band as well as autocorrelations and sampler-statistics. Each plot is accessible by moving the cursor over color-coded baseline/subband/polarization cells. These ftp fringe tests continued to be 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 transition from the analog mark4/vlba4 formatters to the DBBC digital back-ends was almost finished. At the beginning of this biennial period, only Effelsberg was using the DBBC in user experiments. During 2013-4, Onsala, Noto, Torun, Yebes, Metsahovi, and Hartebeesthoek successfully tested their DBBCs through parallel-recording in NMEs, and had shifted over to DBBC-only observations by the end of this biennial period. The new stations Tianma 65m and the Sardinia

Radio Telescope used DBBC back-ends from their initial test observations (Tianma65 can also use the CDAS back-end). All EVN/global observations continued to use the DBBC in the "Digital Down-Converter" (DDC) personality, to maintain BBC-tuning capabilities compatible with the previous analog back-ends.

Robledo also shifted to the new DSN digital back-end, the DSN VLBI Processor (DVP), during this biennial period. The DVP outputs VDIF data, in a fixed number of channels (32) regardless of the observing schedule. For 1 Gbps observations, this means that Robledo observes at 2 Gbps (32x 16MHz). SFXC can handle this by assigning 16 extra channels to Robledo, which are read from the disk-pack but which are not correlated. They parallel-recorded DVP along with the existing mark4 back-end in some observations in session 3/2013, and used DVP exclusively for user experiments in 2014. There were a few iterations of liaison between JIVE and Bonn, and later between JIVE and Haystack Observatory, to help with their DiFX correlators' ability to interpret recordings from the DVP back-end in an "astro" or "geo" mode.

Initial tests of global-VLBI observations including VLBA stations using their new digital RDBE back-ends in its DDC personality were conducted in session 2/2013 at 512 Mbps and 1 Gbps. The LO selection for the RDBE systems is somewhat limited, they can use only upper Nyquist zone (512-1024 MHz above/below the LO), and there are "cross-over" frequencies at 128 MHz from the bottom and top ends of their 512 MHz IF range that a individual BBC cannot cross. These extra considerations led to some adjustments in the standard 1 Gbps frequency ranges for globals for some of the standard bands. Global user experiments returned in session 2/2014.

Two, new large telescopes, the Sardinia Radio Telescope and the Tianma 65m telescope, made their first EVN observations in session 1/2014. The plots below show amplitude and phase versus frequency for the baselines between these new stations and Effelsberg, together with the baselines to Effelsberg from their closest EVN neighbor.

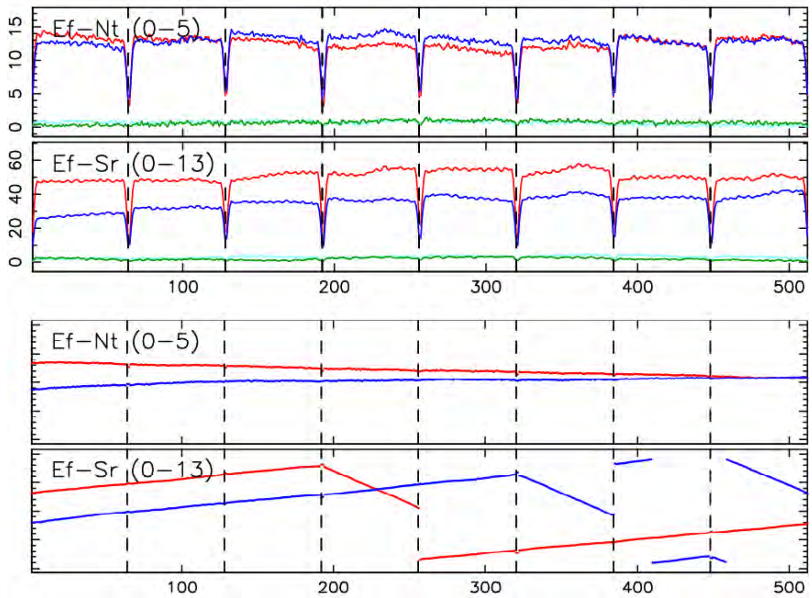


Figure 2.5 Amplitude and phase vs. frequency on the baselines from Effelsberg to Noto and the new Sardinia Radio telescope (Sr), from the session 1/2014 L-band NME, N14L1

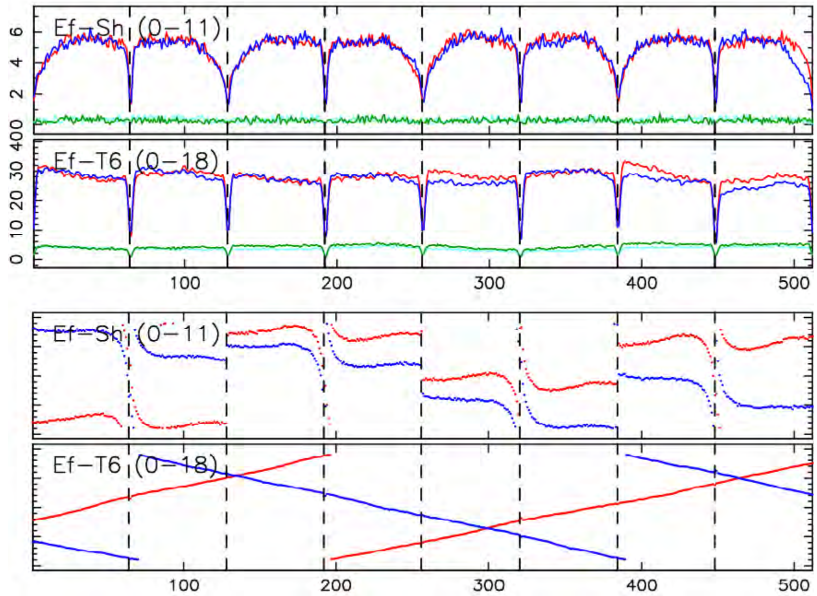


Figure 2.6 Amplitude and phase vs. frequency on the baselines from Effelsberg to Sheshan25 (Sh) and the new Tianma 65m telescope (T6), here using a DBBC backend, from the session 1/2014 L-band NME, N14L1

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 (6 months for target of opportunity observations), starting from the distribution of the last epoch 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 total size of the FITS files in the archive at the end of 2014 was 23.9 TB (a 9.2 TB gain in this biennial period); figure 2.7 shows the growth of the FITS-file size in the EVN archive size over time. A marked surge in the Archive size can be seen at the end of 2014, as the first of the data from the large experiments from session 2/2014 were populating the Archive. In anticipation of faster growth under SFXC, we added another 26 TB of disk space to the server hosting the Archive, bringing the total to a dedicated 48 TB, with another 11 TB that can be shared with the pipeline work area.

The EVN pipeline runs under ParselTongue (a Python interface to classic AIPS), and the pipeline scripts are available from the JIVE wiki, and should provide a good basis for other (semi-) automated VLBI reduction efforts. We continued to process all experiments, including NMEs via the pipeline, with results being posted to the EVN Archive. The pipeline itself was modified to accept ANTAB information for VLBA stations derived from the 80-Hz continuous-cal extractor (cf. Section 2.1.3, Astronomical Features), rather than from the (legacy) vlba.cal files for individual observations.

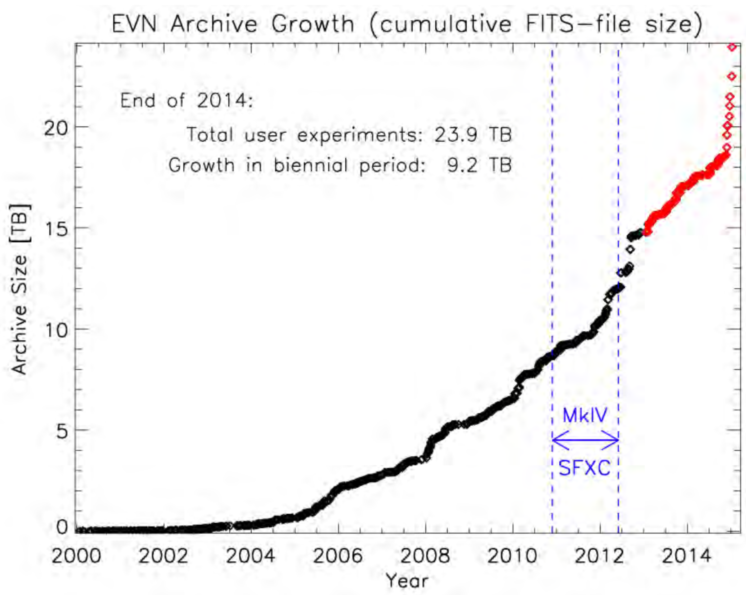


Figure 2.7: Growth in the size of FITS files in the EVN archive. Experiments archived in this biennial period are plotted in red. Vertical blue lines mark the dates of archiving the first data from SFXC correlation and the last data from MkIV correlation (of a disk-based observation).

The science operations and support group continued to contact all PIs once the block schedule was made public to ensure they know how to obtain help with their scheduling, and to check over schedules posted to the VLBEER server prior to stations down-loading them in order to minimize the chance of preventable errors in the observations themselves. There were 7 first-time EVN PIs in 2013 and another 8 in 2014 (there were an additional 4 first-time PIs associated with EVN/global + RadioAstron experiments, but those were scheduled centrally by the RadioAstron Mission Scheduling Team). During this biennial period, in which EVN stations have been making the transition to digital back-ends on their own independent time-scales, this scheduling help has also included providing PIs with template "setini" blocks and station catalogs appropriate to their specific experiment(s) and the version of sched that they were using -- each session presented a unique configuration of back-ends and patching preferences at the various EVN stations, a situation that was continuing to evolve at the end of 2014.

There were three sets of modifications to the EVN-specific portion of the NorthStar Proposal Tool over this biennial period. First, to augment the merger of the EVN+MERLIN and e-EVN observing classes, the possibility of having an e-EVN observation within a global proposal was also added. Thus one or more e-EVN epochs can be requested on an "observation" basis within any proposal. Second, a new row to the array-selection box was added for "EVN stations with individual limitations", to handle the case of a single station having multiple antennas, either of which could be used but with one of them being the "primary" choice at a given frequency – the non-primary one would be listed in this row, while the primary is listed in the regular "EVN" row. Also included in this new row is Hartebeesthoek (declination limits), Cambridge used outside of eMERLIN, and Wettzell. New links into the help pages were added to explain the list of stations appearing in this new row. Finally, to support the new EVN out-of-session policy, the means was added to specify whether any part of the proposal would require "out of session" observing, which if selected would open a further dialog box to provide criteria for a minimally-required array composition (a similar box allowing specification of specific date ranges was already present in the NorthStar tool).

3 TECHNICAL OPERATIONS and R&D

The period 2013 – 2014 saw the wrapping-up of the NEXPReS project, in which many staff members of the Technical Operations and R&D group were involved. This was offset by the kick-off of two new projects in 2014, and the participation in the preparatory phase of an H2020 project named ASTERICS, in which JIVE will lead one of the work packages. Throughout the period JIVE contributed to RadioNet3, leading the UniBoard[2] work package and participating in the Hilado software effort. JIVE also ramped up its contribution to the SKA effort, providing the Synchronisation and Timing (SAT) architect for the Signal and Data Transport (SaDT) Consortium.

An era came to an end with the demise of the MarkIV hardware correlator, after many years of near-continuous operation. The correlator was dismantled, and nearly all correlator boards were shipped to Hawaii, to serve as spare parts for the SMA.

Figure 3.1: Mark IV correlator boards waiting for shipment

A concerted effort got underway to apply the results of the NEXPReS project to actual EVN operations. During several demonstrations 2 and 4 Gbps observations were shown to be ready for operational use, recording and streaming data to the correlator, without the shipping of disk packs, were tested extensively, and semi-automated fringe checks were enabled.

Correlator development continued, with new features being added to the SFXC corrrelator and the JIVE UniBoard Correlator (or JUC) producing its first science-grade results.

After some years of relative inactivity in this field, JIVE embarked once again on the writing of astronomical user software, now in the context of mmVLBI. The first step in this activity will be the implemention of fringe fitting in CASA, something that has often been attempted but never has quite materialized.

Several JIVE staff members were involved in the LOC of the 3rd International VLBI Technology Workshop, hosted by JIVE, which was held in Groningen and Dwingeloo in November 2014. With close to 100 participants it was the best-attended Technology Workshop ever, with many excellent talks demonstrating the impressive technical developments in global VLBI.

3.1 Hardware Insfrastructure

As mentioned, the MarkIV data processor was retired and dismantled. The SFXC software correlator was relocated to the correlator room, to take advantage of the excellent cooling in this room and to minimise ambient noise for the operators. This involved a fairly extensive re-organisation of the local network. In view of the large maintenance costs, the fire extinguisher installation, there to protect the once-irreplacable MarkIV correlator, was dismantled as well. As part of the construction of the new wing of the ASTRON – JIVE headquarters, the general cooling system was re-designed, which necessitated the replacement of the cooling machine in the JIVE correlator room.

Figure 3.2: SFXC cluster in its new environment

3.2 Hardware Developments and Upgrades

3.2.1 Mark5

The Mark5 units at JIVE performed reliably as always. Early 2013 one unit was sent to Toruń, to help with the debugging of their new DBBC, running both an analogue and a digital system in parallel during several EVN sessions.

3.2.2 Archive

Together with ASTRON engineers the archive backup machine, located in one of the Faraday cages at the WSRT, was upgraded to a total of 38 TB of disk space, with the option for additional expansion. The backup machine is used as a daily mirror of the EVN archive located at the JIVE headquarters in Dwingeloo.

3.2.3 Correlator control

The twin Solaris servers used for many years as correlator control machines were replaced by a clustered virtual machine pair. All essential services like DNS and LDAP are hosted by these machines. Most databases used by the control system have been migrated to a replicated dual-master MySQL setup. A replicating LDAP server pair was also built for centralized, secure authentication.

3.3 SFXC Software Correlator

At the end of 2012 additional hardware was bought for the SFXC cluster at JIVE, bringing the number of cores to 384, on a total of 40 nodes. This enabled the correlation, in real-time, of 13 stations at 1 Gbps. Since that time, all operational correlation, both recorded and real-time, has been done on the SFXC.

Development of new features and improvements continued at a rapid pace:

- support for mixed bandwidth correlation was completed and tested
- VDIF support was improved and tested with backends that actually produce VDIF data, such as the VLA WIDAR correlator and the new NASA JPL digital backend
- spectral averaging was improved, keeping the natural labelling of the frequency bins and correctly accounting for the windowing function being used
- spectral masking was implemented in order to increase the S/N of observations that have a sparse signal in the frequency domain, such as spacecraft observations
- switched power extraction was implemented in order to derive system temperatures for stations that have 80 Hz noise injection
- positive delays are now supported, needed in particular for RadioAstron data which can have such delays in certain parts of its orbit. As an additional benefit this prevents the crashing of the correlator during e-VLBI when stations are scheduled while the source is still below the horizon.
- a beam fitting program was developed to obtain the primary antenna beams of the EVN stations, based on a series of deliberate mispointing around a known source. As more EVN stations provide this information, the quality of wide-field EVN observations will improve
- the phased array mode was made operational
- support for coherent de-dispersion was added

Besides all this, the SVN repository holding the SFXC code was made public, basic end-user documentation was written, and VEX support was further improved. The functionality to accommodate triggered observations (pioneered in the NEXPReS project) was finalized and tested. A few insitutes have downloaded and installed the SFXC code base. The Korean VLBI Network started experimenting with the phased array mode, and at Shanghai Astronomical Observatory SFXC is also being tested. Close contact is maintained with the DIFX community, making sure that solutions to specific problems can be used by both correlator implementations.

3.4 FPGA-based Correlators

3.4.1 The JIVE UniBoard Correlator (JUC)

Although the UniBoard project, a Joint Research Activity in RadioNet FP7, ended in 2012, work on the JUC continued. Early 2013 an internal review of the correlator design was held, which did not reveal any major show-stoppers. Many firmware modules were added and/or modified, adding support for dual polarisations and lower side-bands, increasing the size of the delay/phase coefficient registers, adding the second derivative delay coefficient. As larger datasets with more stations were processed, many new and interesting bugs were found and fixed. A new front node control module was written to handle the 32 MHz subbands that are needed for 2 and 4 Gbps EVN observations, but not yet tested.

In September 2014 an external review of the complete UniBoard correlator system, including both firmware and control software, was held. The review panel consisted of Prof. Dr. A. Baudry (chair), Prof. B. Klein, Dr. A. Deller and Dr. P. Harrison. Overall, the report of the panel was very positive, with, among others, the explicit advice to continue funding the further development of the JUC.

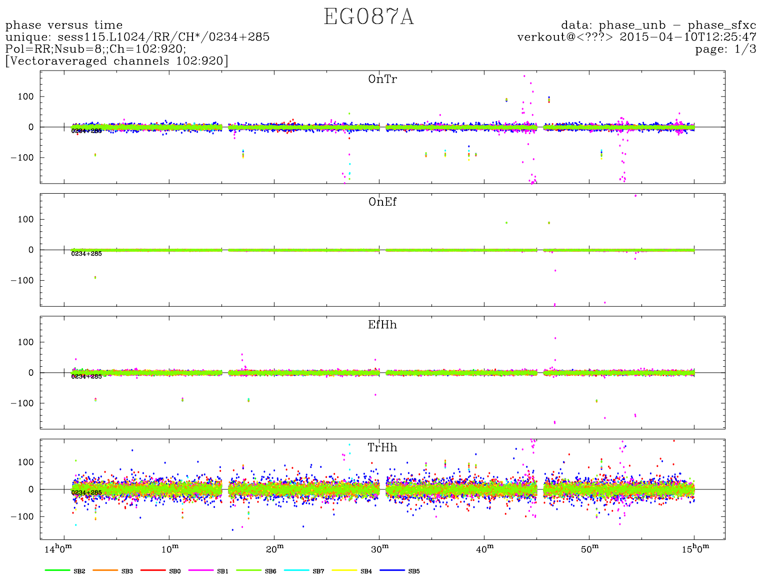


Figure 3.3: Phase difference between SFXC and UniBoard versus time

3.4.2 UniBoard^2

UniBoard^2, a Joint Research Activity in RadioNet3, kicked off in July 2012. As in UniBoard, the intention was to develop a high-performance FPGA-based computing platform, with a number of demanding applications. The UniBoard^2 project timeline however straddled two FPGA technologies, 28 and 20nm, to which later was added 14nm, through the collaboration between the Intel and Altera companies. To make a platform that could be a serious contender for any SKA-related instrumentation, one would have to use the very latest technology.

As a consequence, the decision was made to delay the choice of technology as long as possible. In the summer of 2013 it became clear that the 20nm devices would become available in time for the project, and moreover, that some of the planned 14nm devices would be pin-compatible, allowing easy future upgrades of the board.

After many project-wide discussions, a design was decided upon that would have four Altera Arria10 FPGAs in one singe column. The decision was also made to create a break-out board using a new transceiver-based memory technology called "Hybrid Memory Cube", offering far higher bandwidth and density than DDR memory modules. In the course of 2014 the hardware design took shape, and internal and external design reviews were held in June and December. Technology-independent versions of DDR, transceiver, and flash memory interfaces were developed, allowing these modules to be used for both UniBoard and UniBoard^2, and potentially other boards. A design document was written showing how the EVN correlator firmware could be mapped onto UniBoard^2.

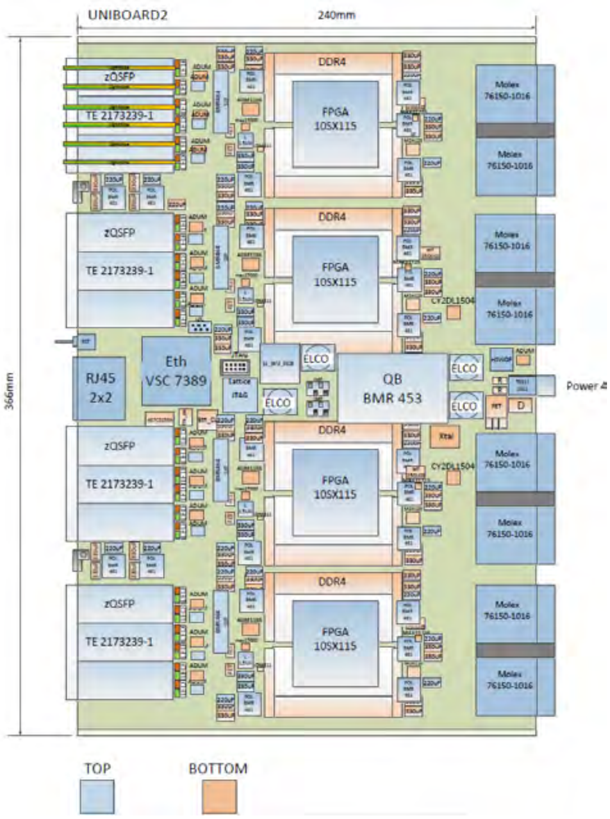


Figure 3.4: High-level design of UniBoard

3.5 Jive5AB

In 2013 the first official version of Jive5AB came out that could be used as a drop-in replacement of MIT Haystack's Mark5A, Dimino and drs programs, fully integrated with the NASA Field System. Among its many features it makes automated fringe checks possible, without interrupting the ongoing science observations (at least, for Mark5 units equipped with Amazon boards). While originally intended for use with Mark5 only, its functionality also came to include FlexBuff recording. The FlexBuff is a VLBI data recording system developed through the NEXPReS project, which allows simultaneous recording/transmitting of data at very high speeds. With its large storage capacity, it is possible to record an entire EVN session at the station, streaming the data to the correlator in near-real time, and thereby removing the need to ship disk packs altogether.

A data transfer program called m5copy was developed, which, rather than copying the data iteself, drives a source and destination instance of Jive5AB. M5copy provides a choice between the (reliable) TCP and UDT transfer protocols, and makes it possible to move nearly any kind of data in any format from any medium to another. Since its release in December 2013, the program has seen a rapid uptake in the VLBI community.

3.6 Other software developments

3.6.1 ParselTongue, Hilado

A new release of ParselTongue came out in January 2014. Support for parallel running of more AIPS tasks was added, faster file creation made possible, bugs fixed. Obit installation was simplified by stripping functionality that is not needed by ParselTongue, and the installation process on MacOS was considerably improved using Homebrew. Some work was done on using ParselTongue with the Swift parallel scripting language, supporting the work done for the Hilado work package in

RadioNet3. This work aims at optimizing data processing pipelines by avoiding unnecessary reprocessing of data when processing parameters are changed.

3.6.2 BlackHoleCam

Work on the BlackHoleCam (BHC) project started with an analysis of the available astronomical software packages, and their suitability for the BHC pipeline. This resulted in the selection of CASA as the packet of choice. An inventory was made of the steps involved in mm-VLBI data processing, and a collaboration was started with the MeqTrees team in South Africa to develop simulations based on earlier work for LOFAR and ongoing work for the Event Horizon Telescope project.

3.7 Towards 4 Gbps VLBI

3.7.1 NEXPReS

The NEXPReS project ended in 2013. The final review took place in Dwingeloo and featured a live 4 Gbps demo, recording and transmitting data to the correlator in real time at up to 4 Gbps from five telescopes: Onsala (Sweden), Metsahovi (Finland), Effelsberg (Germany), Yebes (Spain) and Hartebeesthoek (South Africa). This was to showcase the progress that VLBI had made through NEXPReS.

While in some ways a repeat of the demo of the previous year, most of the hardware, firmware and software was completely new. But in spite of a number of mishaps, like the failure of a production run of Fila10G boards, and the complete lack of any opportunity for testing all this new hard- and software until one week before the review, the demo went very well, with fringes to four out of five stations. And although phase closure could not be shown, the panel was sufficiently impressed and awarded the project the rating of "excellent".

Figure 3.5: Tense moments during the NEXPReS final review demo.

3.7.2 Future developments

With the basis laid by NEXPReS, the next step had to be enabling 2 and 4 Gbps observations operationally. For this, much work was needed on both the DDBC firmware and on the integration of the DBBC in the NASA Field System (FS). Towards the end of 2014 the EVN board of directors agreed to fund the work on the FS. Led by the TOG, a plan was made to reach operational 2 Gbps recording at the end of 2015, with 4 Gbps recording in 2016. Real-time VLBI was to follow suit, although at some point the size of the SFXC cluster might become a bottleneck; by then however the JUC should be capable of taking some of the correlation load.

3.8 International VLBI Technology Workshops

The Korea Astronomy and Space Science Institute, KASI, hosted the 2nd International VLBI Technology Workshop (IVTW) in Seogwipo, Jeju Island, from 10 to 12 October, 2013. Directly following the IVTW 2013, the yearly DiFX workshop was held at the KVN Tamna Observatory from 14 to 18 October. The meeting was well attended, with 42 registered participants from all over the world, and featured many excellent talks on the latest developments in VLBI.

The year after, the IVTW moved to Groningen and Dwingeloo in the Netherlands, where it was hosted by JIVE. With nearly 100 participants this was the largest IVTW ever. Besides covering many topics in VLBI, one whole day was devoted to time and frequency transfer, with invited speakers from several metrology institutes. On the final morning an EVN-NREN meeting took place, sponsored by GEANT.

Figure 3.6: Participants of the Third International VLBI Workshop.

4 SCIENTIFIC RESEARCH

4.1 High-mass star-formation

High-mass stars are prominent in the ecology of the interstellar medium and the evolution of galaxies. Though much needed, there is no general theory of high-mass star formation. The main issue for models is that the intense stellar radiation pressure and the thermal pressure from the surrounding ionized material may reverse the accretion flow and prevent matter from reaching the star. Recent theoretical studies have however demonstrated that radiation pressure can be overcome if accretion occurs through a circumstellar disk. Despite the theoretical evidence, we have not yet conclusively identified a single high-mass protostar in the Galaxy surrounded by an accretion disk.

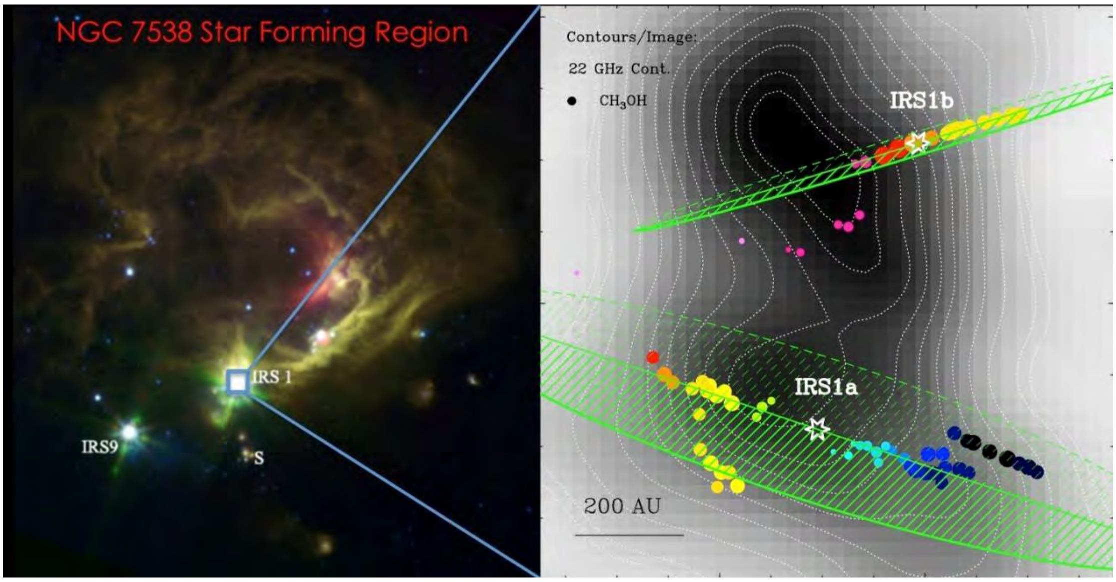


Figure 4.1: The NGC7538 Star Forming Region (2.7 kpc). (Left) Three color IRAC image in the mid-infrared from the Spitzer Space Observatory. (Right) 6.7 GHz methanol maser emission spots (filled circles) observed with the EVN overlaid on the the 22 GHz continuum map imaged with the VLA (black image and white contours). Colors denote line-of-sight velocities, with blue indicating blue-shifted emission and red indicating red-shifted emission. The sizes of the circles scale with the flux density. The ellipses represent the disk planes surrounding the two young stars IRS1a and IRS1b, resolved by the EVN, with the solid lines indicating the near-side and the dashed lines the far-side of the disks.

Ciriaco Goddi and Luca Moscadelli (Osservatorio Astronomico di Arcetri) observed NGC7538-IRS1 (at 2.7 kpc) with the European VLBI Network (EVN) in the 6.7 GHz maser line of methanol, which is a typical signpost of high-mass star formation. Four observing epochs spanning eight years were used to measure positions, proper motions, line-of-sight velocities and accelerations of methanol masers. These measurements provided 3D kinematics and dynamics of circumstellar gas on scales from tens to a thousand AU. They find compelling evidence that NGC7538-IRS1 is forming a multiple system of high-mass young-stars surrounded by disks. Data modelling enabled identifying quasi-Keplerian rotation around a 25 solar mass star and a thick disk containing 16 solar masses around a nearby protostar. These measurements are critical to test theoretical models of accretion for massive stars (Moscadelli & Goddi 2014, A&A, 566, A150).

Gabriele Surcis, Huib van Langevelde and Ciriaco Goddi together with colleagues from Sweden, Spain, Mexico, and South Korea observed the polarized emission of 22 GHz water masers around the massive young stellar objects (YSOs) W75N-VLA2 and W75N-VLA1. The two massive YSOs are

separated by just 1300 astronomical units and are at two different evolutionary stages, i.e., VLA1 is the most evolved and VLA2 the least evolved. The interferometric observations showed at 1 AU scale that while the water masers distribution and the magnetic field around VLA1 have not changed since 2005, the shell structure of the masers around VLA2 is still expanding and increasing its ellipticity. Furthermore, the magnetic field around VLA2 has changed its orientation according to the new direction of the major-axis of the shell-like structure and it is now aligned with the magnetic field in VLA1. This confirms that the water masers around VLA2 are tracing the evolution from a non-collimated to a collimated outflow.
Gabriele Surcis and Huib van Langevelde together with Wouter Vlemmings (Chalmers University of Technology), Busaba Hutawarakorn Kramer (MPIfR), and Anna Bartkiewicz (Nicolaus Copernicus University) continued their work on measuring magnetic fields morphology close to massive YSOs (au scale) by using 6.7 GHz methanol masers. The group measured the magnetic field morphology towards eight new massive YSOs. These sources are part of a large sample of massive YSOs, the so-called flux-limited sample, that is composed of 31 sources. A preliminary statistical analysis of the results obtained from the first 19 sources reveals evidences that the magnetic fields around massive YSOs are preferentially oriented along the molecular outflow (Surcis et al. 2014, A&A, 565, L8).
Furthermore, the group together with Luca Moscadelli (Osservatorio Astronomico di Arcetri) have determined the morphology of the magnetic field at AU scale around the massive YSO IRAS20126+4104 by observing the polarized emission of the 22 GHz water masers and the 6.7 GHz methanol masers. The orientation of the magnetic field derived from the masers agrees with the S-shaped morphology on larger scale by using the dust-polarized emission at 350 mm.

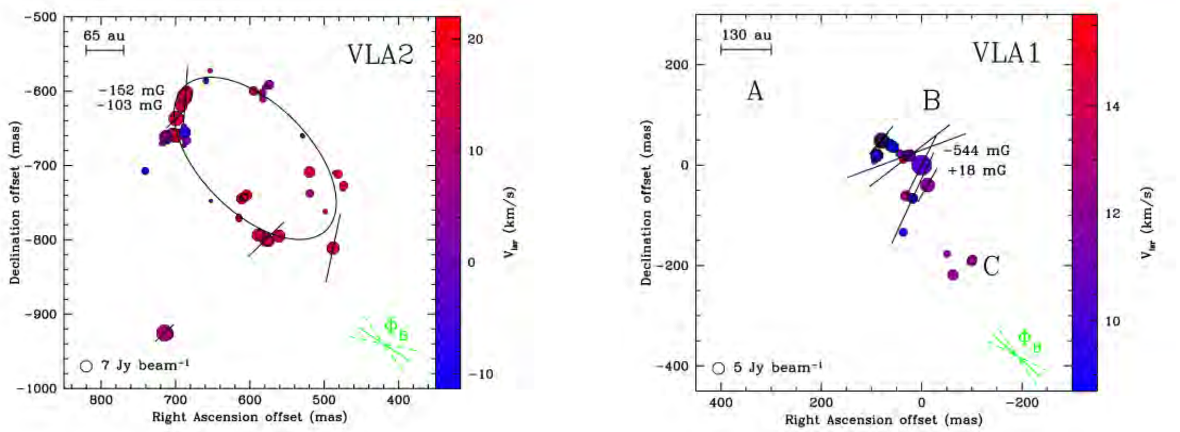
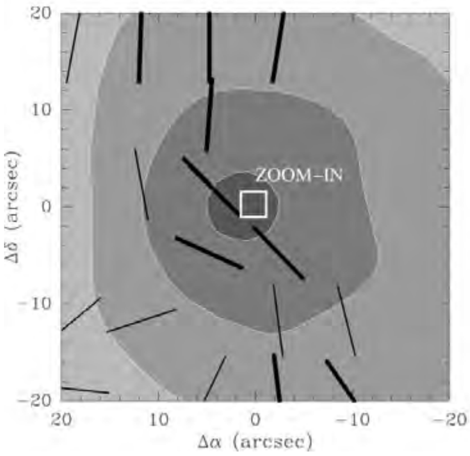


Figure 4.2: A close-up view of the 22 GHz water masers detected in W75N, around YSOs denoted by VLA1 (left panel) and VLA2 (right panel) in Surcis et al. (2014). The octagonal symbols represent the masers identified in these young stellar objects; their size scales logarithmically with their observed peak flux density. The linear polarization vectors, scaled logarithmically according to polarization fraction, are overplotted as well. In the bottom-right corner of both panels the error-weighted orientation of the magnetic field is shown with the uncertainties indicated by the two dashed segments. The ellipse drawn in the right panel is the result of the best fit of the water masers. The estimated values of the magnetic field strength are also shown in both panels next to the corresponding water maser.

Huib van Langevelde worked together with Anna Bartkiewicz and Marian Szymczak (both from Nicolaus Copernicus Univ., Poland) on high-mass star-forming regions associated with both 6.7 GHz methanol and 4.5 mm mid-infrared (MIR) emission, that likely traces outflows from massive young stellar objects (MYSO). The objectives were to determine the milliarcsecond morphology of the maser emission and to examine if it is related to a single or several MIR counterparts in the clusters of MYSOs. They carried out joint 2.1 arcmin EVN and near simultaneous 32m Torun observations.



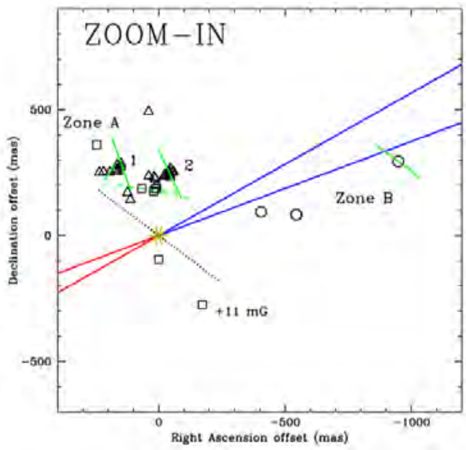


Figure 4.3: Left panel: The black bars represent the magnetic field direction in the young stellar object YSO IRAS20126+4104, determined from the polarized dust emission at 350 mm, with the continuum emission shown in grey scales in the background. The white box indicates the position of the right panel. Right panel: methanol (triangles), OH (squares), and water (octagons) masers in IRAS20126+4104. The gold asterisk represents the B0.5 protostar, while the dotted line represents the Keplerian disk of ~1000 AU. The red and blue lines indicate the red- and blue-shifted lobes of the jet, respectively. The thick green segments represent the magnetic field direction determined from the polarized methanol and water maser emissions. The green dashed segments represent the magnetic field direction determined from the linearly polarized emission of OH masers (Edris et al. 2005, A&A, 434, 213)..

They obtained maps with mas angular resolution that showed diversity of methanol emission morphology: a linear distribution (e.g., G37.753-00.189), a ring-like (G40.425+00.700), and a complex one (e.g., G45.467+00.053). The maser emission is usually associated with the strongest MIR counterpart in the clusters; no maser emission was detected from other MIR sources in the EVN field of view. The maser source luminosity seems to correlate with the total luminosity of the central MYSO. Although the EVN resolves out a significant part of the maser emission, the morphology is still well determined. This indicates that the majority of maser components have compact cores (Bartkiewicz, Szymczak & van Langevelde 2014, A&A 564, 110).

Huib van Langevelde, Gabriele Surcis and Wouter Vlemmings (Chalmers University of Technology) continued their collaboration with the theoretical chemistry group in Nijmegen (Ad van den Avoird, Gerrit Groenenboom, Boy Lankhaar) on the Zeeman splitting of microwave methanol transitions. It was found that earlier laboratory experiments were probably not significant as methanol will display non-linear effects in the magnetic fields that were used in the experiments. It was concluded that more thorough calculations of the hyperfine components involved were needed.

Together with the master student Luis-Henry Quiroga-Nunez (Leiden), Huib van Langevelde started a project to investigate the use of methanol masers for studying Galactic structure. The approach is to set up a statistical simulation of the distribution and dynamics of the masers in the spiral arms of the Milky way. From this simulation a sample of observed masers could be drawn to test the results of large scale astrometry programmes done with the VLBA. Because the observations are limited to northern hemisphere objects in the near spiral arms it is important to test against possible biases. With the simulations one can also test the luminosity distribution of masers, which, among other things, is important for future astrometry projects.

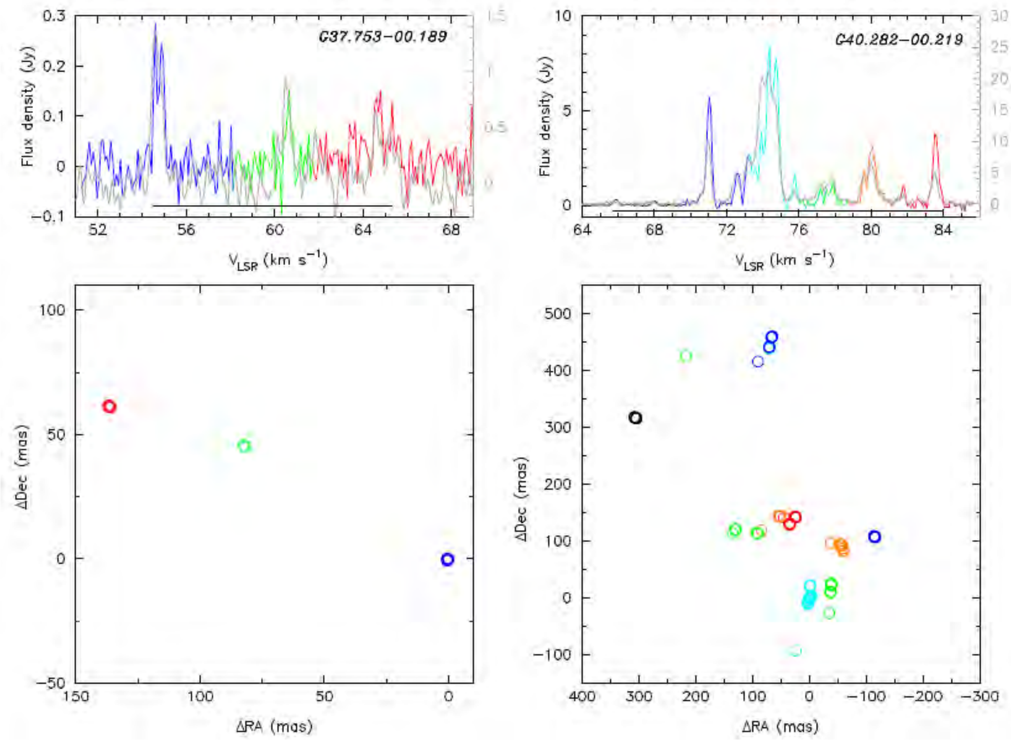


Figure 4.4: Example spectra and maps of 6.7 GHz methanol masers detected using the EVN. The colors of circles relate to the LSR velocities as shown in the spectra. The gray lines show the Torun 32 m dish spectra. If needed, the separate scale of the flux density is presented on the left (EVN) and right (Torun) sides. The thin bars under the spectra show the LSR velocity ranges of spots displayed (Bartkiewicz, Szymczak & van Langevelde 2014).

4.2 Pulsars, supernovae, novae, and variable/transient sources

PSR J0218+4232 is a millisecond pulsar (MSP) with a flux density of 0.9 mJy at 1.4 GHz. It is very bright in the high-energy X-ray and gamma-ray domains. A group of Chinese and European astronomers, including Jun Yang and Bob Campbell, conducted an astrometric program using the EVN at 1.6 GHz to measure its proper motion and parallax. A model-independent distance would help constrain the pulsar's gamma-ray luminosity. They achieved detections of the MSP with signal-to-noise ratios of at least 37 in all five epochs. The EVN-derived proper-motion value has significantly improved upon those arising from long-term pulsar-timing observations. The EVN parallax determination was 0.16 ± 0.09 mas. This was the first trigonometric parallax measurement based solely on EVN observations for any pulsar. This parallax also provided the first model-independent distance estimate for J0218+4232, with a corresponding 3-sigma lower-limit of d = 2.3 kpc. The derived distance suggests that PSR J0218+4332 may be among the most energetic gamma-ray MSPs known to date. The high observed luminosity poses challenges to the conventional outer-gap and slot-gap models (Du et al. 2014, ApJ, 782, L38).

M15 is a massive globular cluster that is known to contain some pulsars and a radio-loud low-mass X-ray binary. Bob Campbell worked with a group led by Franz Kirsten (U. Bonn) and Wouter Vlemmings (Chalmers) conducting multi-epoch astrometric EVN observations to trace the kinematics and variability of compact radio sources in M15. Proper motions of two pulsars, including the double neutron star system M15C, and the LMXB were determined. Two previously unknown compact sources were detected, whose kinematics point to their not being in M15.

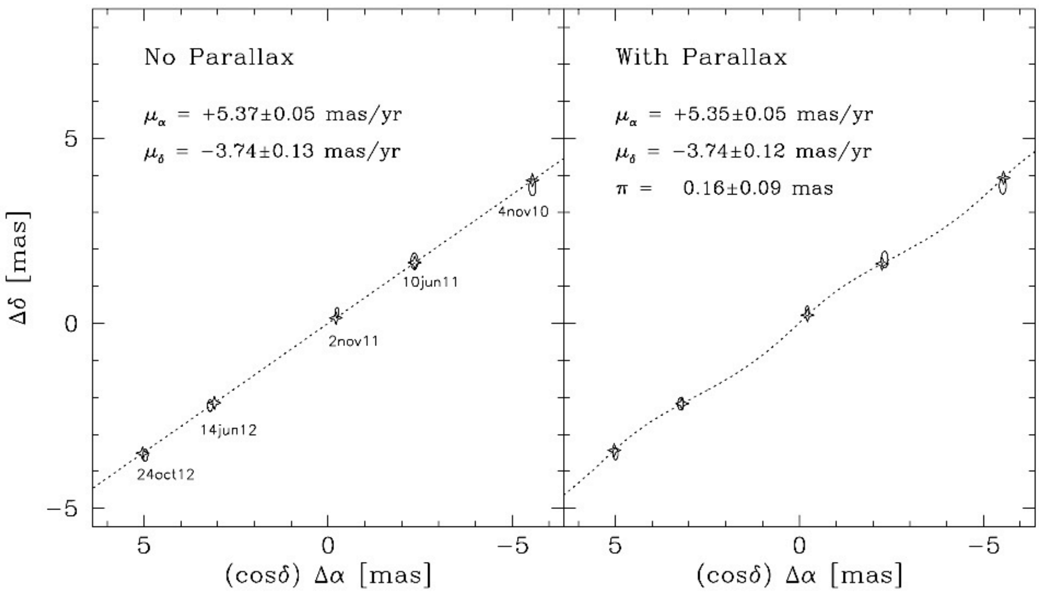


Figure 4.5: Astrometric fit to the motion of the milli-second pulsar J0218+4232 as observed by the EVN. The ellipses show the positional uncertainty at each epoch, the dotted line represents the modelled motion on the sky, and the star symbols mark the modelled position at each epoch. The left-hand panel includes only proper motion in the model, while the right-hand panel also includes parallax.

Brightness variability was seen in M15C (disappearing in epochs 5-6 and re-appearing in epoch 7, accompanied by a slight offset in the pulse phase), which may be a consequence of geodetic precession, as the spin axis of the "visible" neutron star shifts due to coupling with its partner, initially moving the beamed emission out of our line of sight and later returning a different component of the emission cone back into it. The LMXB brightened by a factor of about 2.5 in the third epoch and showed a double-lobe structure with a separation on the order of 140 AU, suggesting that it underwent an outburst during the three months between epochs 2-3 (and recovered before epoch 4). Finally, the lack of central faint emission after stacking all epochs (rms about 3.3 microJy/beam), together with the "fundamental plane" of black hole activity relating radio and X-ray luminosity to mass, places an upper limit to the mass of a putative intermediate-mass black hole in the center of M15 of < 500 M$_\odot$ (Kirsten et al. 2014, A&A, 565, A43).

JIVE scientists were actively engaged in the exploitation of the scientific benefits of e-VLBI for Galactic and extragalactic transients such as black hole and neutron star binary systems, dwarf- and classical novae, supernovae, gamma-ray bursts and tidal disruption events. Regarding e-VLBI transient science, a key event was the Lorentz Center workshop Locating Astrophysical Transients, organized by Zsolt Paragi and Joeri van Leeuwen. This workshop brought together astronomers working in different wavebands, to discuss how transient science could profit more from e-EVN. As for the e-EVN results in the 2013-2014 period, the following two stand out.

Miguel Pérez-Torres (IAA) led a group of European astronomers to carry out deep e-EVN and e-MERLIN observations of the Type Ia SN 2014J in the nearby galaxy M 82. These observations are among the most sensitive radio studies of Type Ia SNe (along with JVLA observations of SN 2011fe). By combining data and a proper modeling of the radio emission, they constrained the mass-loss rate from the progenitor system of SN 2014J to less than 7.0×10^{-10} M$_\odot$ yr^{-1}. Assuming that the medium around the supernova is uniform, then the density of the ISM is less than 1.3 cm^{-3}, which is the most stringent limit for the (uniform) density around a Type Ia SN. These deep upper limits favor a double-degenerate (DD) scenario –involving two white dwarf (WD) stars– for the progenitor system of SN

2014J, as such systems have less circumstellar gas than our upper limits. By contrast, most single-degenerate (SD) scenarios, i.e., the wide family of progenitor systems where a red giant, main sequence, or sub-giant star donates mass to an exploding WD, were ruled out by the observations. Although they discussed possibilities for a SD scenario to pass observational tests, as well as uncertainties in the modelling of the radio emission, the evidence from SNe 2011fe and 2014J points in the direction of a DD scenario for both (Pérez-Torres et al. 2014, ApJ, 792, 38).

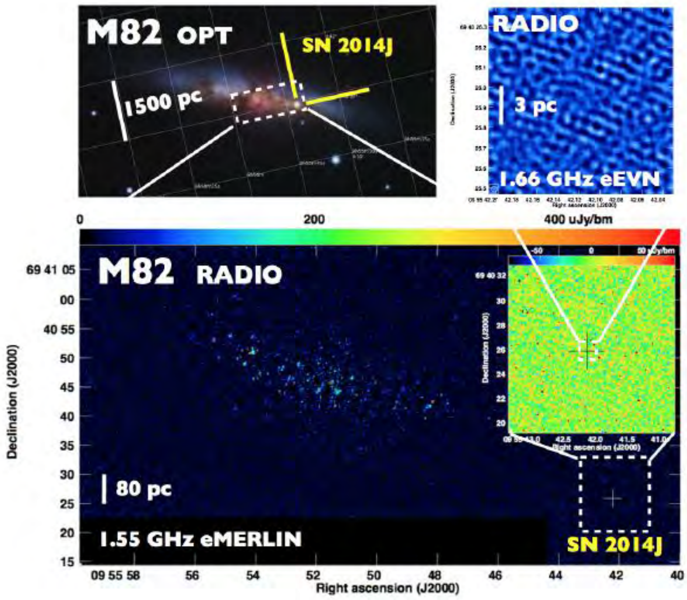


Figure 4.6: e-EVN and e-Merlin images of the region surrounding SN2014J, and an optical image of the M82 host galaxy.

Laura Chomiuk (Michigan State Univ.) led an international team of astronomers from the US, Europe, Africa and Japan including Jun Yang and Zsolt Paragi to study Nova Monoceros in 2012. A classical nova occurs when a dense white dwarf star pulls material onto itself from a companion star, triggering a thermonuclear explosion that blows debris into interstellar space. Astronomers did not expect this scenario to produce high-energy gamma rays. However, in June of 2012, NASA's Fermi spacecraft detected gamma rays coming from a classical nova called V959 Mon, some 6500 light-years from Earth. Radio emission was discovered by the JVLA, which was further studied by the e-EVN at very high resolution. The EVN images revealed compact emission regions of relativistic particles that moved away from each other in a direction that did not line up with the orientation of thermal ejecta observed with the JVLA at various phases of the explosion. This observation, supported by data obtained by e-MERLIN in the UK and the VLBA in the US allowed the group to form a coherent picture of how these emitting regions and the gamma rays were produced. In the first stage of this scenario, the white dwarf and its companion give up orbital energy to boost some of the explosion material, making the ejected material move outward faster in the plane of their orbit. Later, the white dwarf blows off a faster wind of particles moving mostly outward along the poles of the orbital plane. When the faster-moving polar flow hits the slower-moving material, the shock accelerates particles to the speeds needed to produce the gamma rays, and the compact radio emission seen by the EVN. The results were published in the 16 October 2014 issue of Nature.

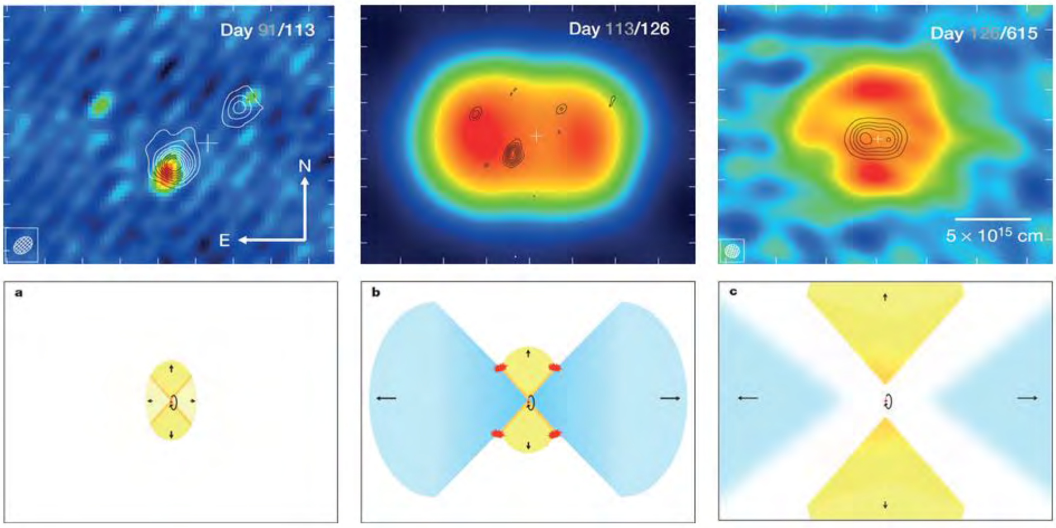


Figure 4.7: The upper panels of the figure show radio images of V959 Mon. The EVN images 91 days and 113 days after the nova explosion are shown in contours and colour scale, respectively. The expanding ejecta as seen by the VLA are shown in the middle and to the right. The lower panels explain the various stages of the explosion: a) the nova envelope expands and interacts with the binary system, yielding dense material in the equatorial plane. b) the white dwarf powers a fast wind that is funnelled towards the low-density poles, causing shocks. c) at late times, the slower-expanding equatorial material will dominate the emission (Chomiuk et al. 2014, Nature, Vol. 514, No. 7522, 339)..

4.3 Active Galactic Nuclei and deep surveys

Observations of nearby LINER galaxy NGC660 have been analyzed by Ilse van Bemmel, in collaboration with Megan Argo and Robert Beswick (both JBO/Manchester Univ.). NGC660 was found to increase in radio flux over a period 2008-2013. Data were taken with the WSRT on regular intervals of 3 months starting in summer 2013. The purpose was to study the evolution of the HI absorption in this source, as well as monitor the total brightness (PI van Bemmel). This analysis is ongoing, the last WSRT observations were taken in December 2014.

In addition EVN and e-MERLIN observations were led by Argo to analyze the source at the smallest possible scales. A core-jet structure is detected in the nucleus, providing evidence for (re-)started nuclear activity. From an in-depth analysis of archival observations at a range of frequencies and resolutions it is confirmed that this is a new radio source, with an age of at most a decade. New EVN observations have been obtained in October 2014, and follow-up with e-MERLIN is ongoing. The team also analyzed Chandra data, which had not enough counts to confirm the AGN nature of the source. WHT service time optical spectroscopy was obtained late November 2014 and is being analyzed.

Iván Agudo led a project designed to make a statistical characterization total-flux and (full-)polarimetric properties of a large (close to complete) flux-limited sample of 211 AGN (most of them blazars) in the northern sky (Agudo et al. 2014, A&A, 566, A59; see Fig. 4.9), with strictly simultaneous observations at 3.5 and 1.3mm from the IRAM 30m Telescope. His collaborators were Clemence Thum (IRAM), Jose L. Gómez (IAA) and Helmut Wiesemeyer (MPIfR).

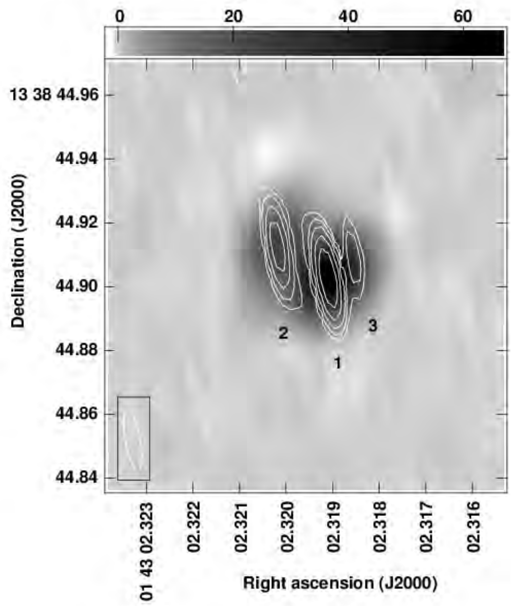


Figure 4.8: EVN image of the central region of NGC660, showing recent nuclear activity.

This survey showed a clear excess of the linear polarization degree at 1.3mm with regard to that at 3.5 mm by a factor of ~1.6, which implies a progressively better ordered magnetic field for blazar jet regions that are located progressively upstream in the jet (Fig. 4.10 left panel). It was also shown that the linear polarization angle at 3.5 and 1.3mm and the jet structural position angle for both quasars and BL Lacs do not show a clear preference to align in either parallel or perpendicular directions (Fig. 4.10 middle panel), which is interpreted as a markedly three dimensional structure of the magnetic field at the emission regions relevant at these wavelengths. The long term variability study in this work points out a large degree of variations in total flux density and linear polarization on time scales of years by median factors of ~1.5 and ~1.7 (with maximum variations by factors up to 6.3 and ~5), respectively. Moreover, 86% of the sources show linear polarization angles evenly distributed with regard to previous measurements, which also explains why there is not a consistent trend of sources showing any particular alignment of their polarization angle with regard to their jet position angle. Circular polarization at 3.5mm was detected for 6% of sources only (Fig. 4.10 right panel).

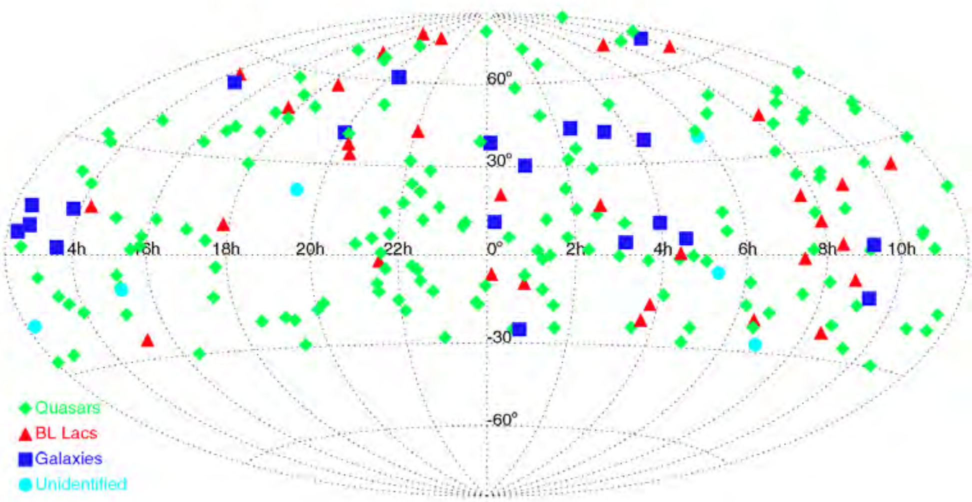


Figure 4.9: Sky distribution of sources in Agudo et al. (2014) sample, in J2000.0 coordinates.

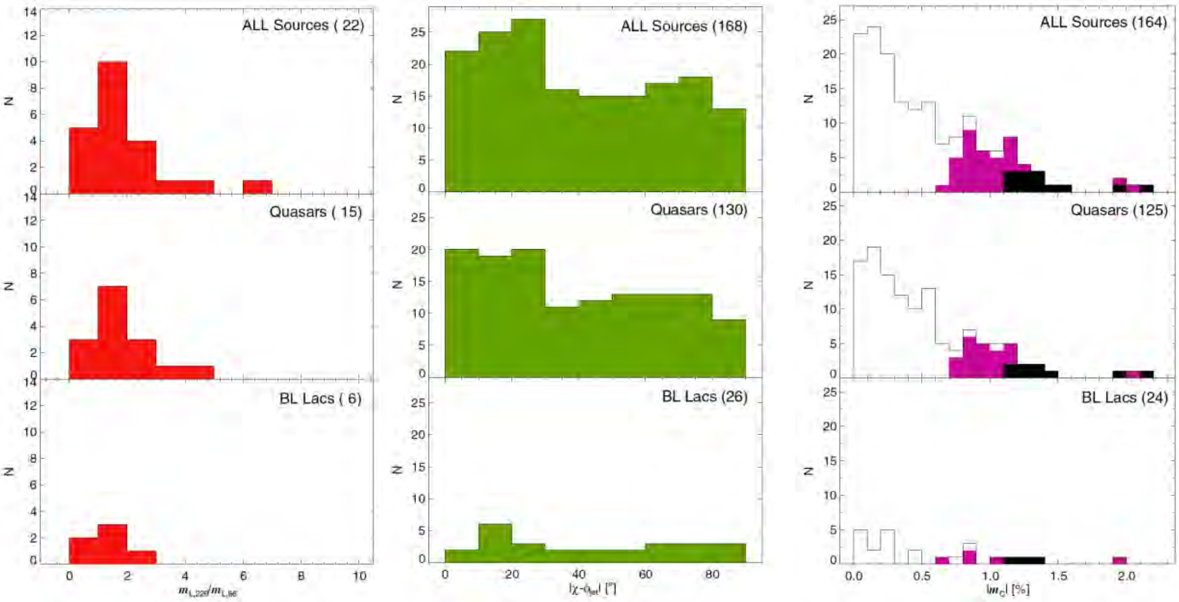


Figure 4.10: Left: Distribution of 1.3mm (229 GHz) to 3.5mm (86 GHz) fractional linear polarization ratio for sources with detected linear polarization at both frequencies (i.e., mL, 229/mL, 86) on the Agudo et al. (2014) sample. Middle: Distribution of misalignment between the 3.5mm polarization angle and the position angle of the jet. From top to bottom, the entire source sample, the quasar, and the BL Lac sub-samples are shown. Right: Distribution of the absolute value of 3.5mm circular polarization for the entire source sample, quasars, and BL Lacs. Black areas correspond to pC detections at >3sigma. Violet shaded areas indicate observing results with >2sigma, whereas unshaded areas symbolize all pC measurements, regardless of their significance. .

In 2014, a European team of scientists involving Iván Agudo reported (according to their claim) the first robust evidence for internal rotation and a helical magnetic field in the jet of an AGN (Molina et al. 2014, A&A 566, A26). This study employed polarimetric multi-epoch VLBI-imaging observations of the bright quasar NRAO150 at 8, 15, 22, 43, and 86 GHz to show how the high frequency emitting regions in the source rotate at high speeds in the plane of the sky with respect to an "a priori" unknown reference point. The observed polarization angle distribution at 22, 43, and 86 GHz during observing epochs with high polarization degree suggests the possible direct detection of the toroidal component of the magnetic field threading the innermost jet plasma regions (Fig. 4.11). The observed source properties are consistent with a scenario in which we see the jet almost face on, the innermost jet plasma rotates around the jet axis, and the jet is threaded by a magnetic field with a significant toroidal component. A simplified model developed to fit helical trajectories to the observed kinematics of the 43 GHz features fully supports this hypothesis (Fig. 4.12).

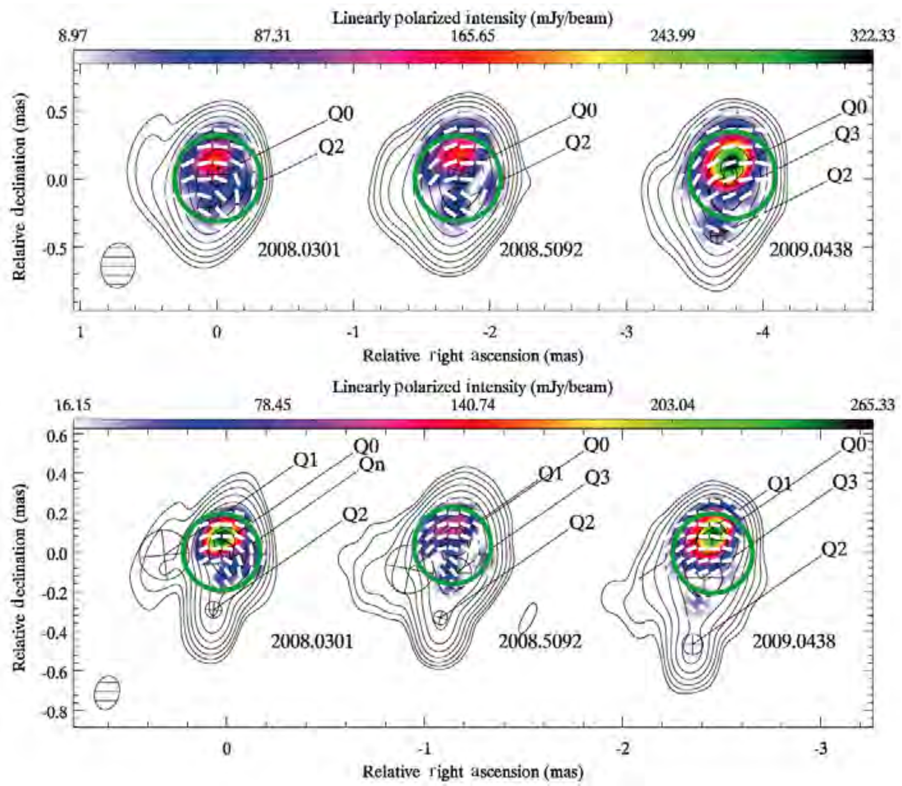


Figure 4.11: VLBA sequence of total intensity images (represented by contours), linearly polarized intensity images (represented by the color scale), and magnetic vector polarization angle distribution (symbolized by short white sticks), of the radio loud quasar NRAO150 (Molina et al. 2014). The top three images were obtained at 22 GHz, whereas the observations on the bottom side correspond to 43 GHz observations. Assuming that the the radio jet in NRAO150 is seen face-on (i.e. pointing directly in our line of sight), the green line would represent the toroidal component. The observed magnetic vectors agree very well with this scenario.

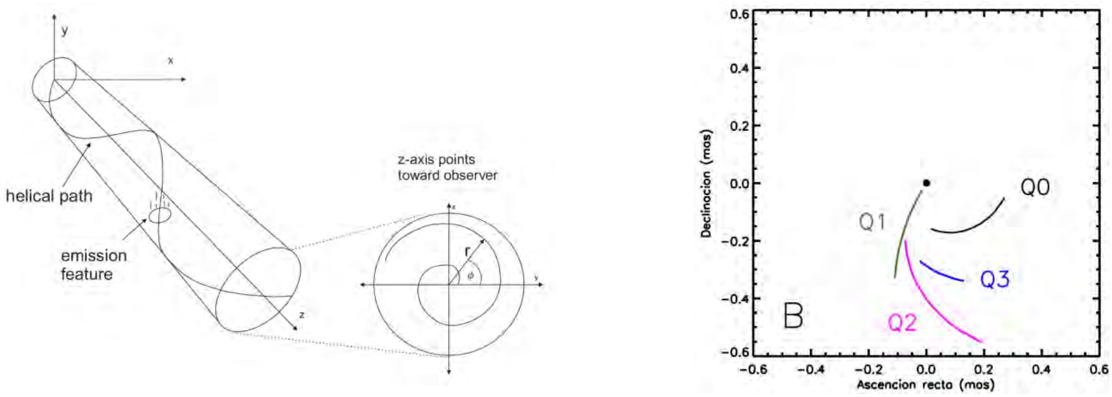


Figure 4.12: Left: conceptual representation of new model proposed by Molina et al. (2014) to explain the bent trajectories of emission features in the 43 GHz images of NRAO150. The plot to the right represents the trajectory of an emission feature when the z-axis points towards the observer within a very small angle from the line of sight (as it has been argued that it is the case in NRAO150). Right: Fit of the kinematic model outlined in the left panel to the trajectories of 43 GHz model-fit jet features as observed in the plane of the sky.

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Iván Agudo have been further involved in a number of multi-spectral-range study of powerful blazars, where VLBI observations have the unique capability to provide information about the actual location of bright emission features propagating downstream the jet. The observed emission features are often identified with the regions of optical and high energy emission by cross correlation studies of multi wavelength light curves and sequences of VLBI images, which provides a robust method to locate such high energy emission regions (see Fig 4.13).

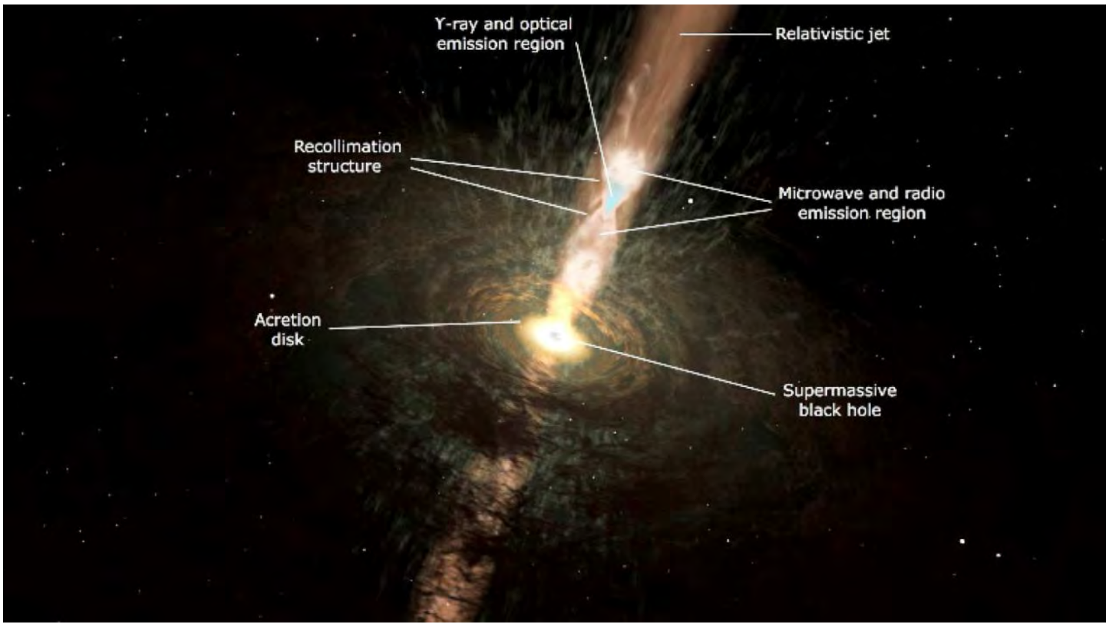


Figure 4.13: Conceptual representation of the multi-wavelength signature of the interaction of a moving shock with a stationary recollimation structure in the innermost regions of a blazar. Reproduced from Agudo (2013, EPJ Web of Conferences, 61, 04002). Image credit W. Steffen (UNAM)..

JIVE summer student Judit Fogasy (now at OSO/Chalmers Univ.) analyzed global spectral-line VLBI data on 4C12.50 under supervision of Raffaella Morganti (ASTRON) and Zsolt Paragi. The goal was to study the spatial distribution of the outflowing natural gas in this young AGN, that is one of the best known ultra-luminous infrared galaxy (ULIRG). The neutral gas has a strong feedback on the ISM, and this feedback plays a key role in galaxy evolution. The group detected a previously known HI absorption feature in the direction of the northern counter-jet, as well as a broad (~1000 km/s in velocity) HI component that was not seen at 10-mas resolutions before; the latter coincided with the termination point of the souther, approaching jet. A significant part of the absorption comes from a compact cloud that is seen—in projection—to be co-spatial with the hot spot observed earlier in radio continuum. There is also a faint and diffuse component that extends at least 50 pc around and in front of the southern lobe. These observations showed that the radio plasma drives the outflow and removes gas from the central regions in 4C12.50, and that jet-driven outflows can play a relevant role in feedback mechanisms in radio-loud AGN (Morganti, Fogasy, Paragi, Oosterloo, Orienti 2013, Science 341, 1082).

Hongmin Cao (ShAO PhD student) observed a patch of sky in the SDSS Stripe 82 region at 1.6 GHz using the EVN, together with JIVE scientists Leonid Gurvits, Jun Yang, Zsolt Paragi, and other collaborators. This was one of the early EVN science projects to fully exploit the multi-phase centre capability of the SFXC software correlator. There are fifteen known mJy/sub-mJy radio sources in the target field defined by the primary beam size of a typical 30-m class EVN radio telescope.

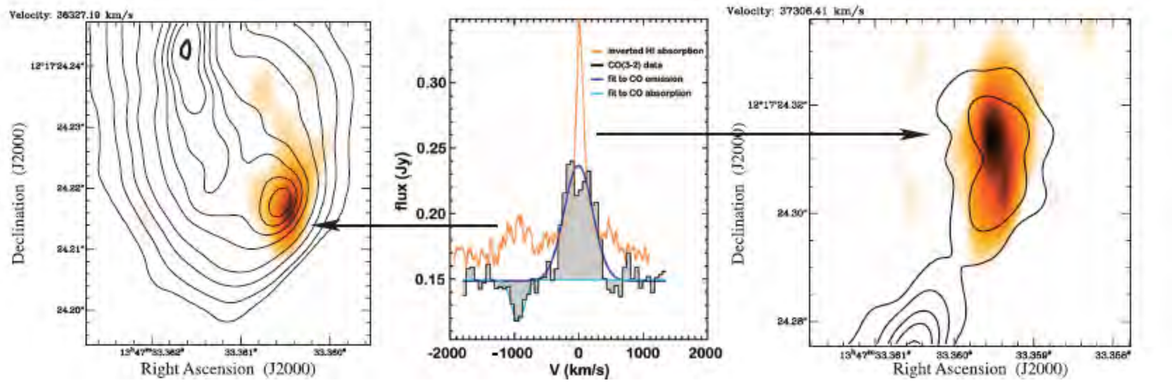


Figure 4.14: Total intensity (contours) and HI absorption (colours) in the approaching southern jet-lobe (left) and on the counter-jet side (right). The inset in the middle shows the HI (orange) and CO (from mm observations by another group, in grey) absorption profiles (Morganti et al. 2013).

The source of particular interest was a recently identified high-redshift radio quasar: J222843.54+011032.2 (J2228+0110) at a redshift of z = 5.95. The aim was to investigate the mas-scale properties of all the VLBI-detectable sources within this primary beam area with a diameter of 20 arcmin. The source J2228+0110 was detected with VLBI with a brightness temperature $T_b > 10^8$ K, as expected for a high-redshift radio-loud AGN. In addition, two other target sources were also detected, one of them with no redshift information. Their brightness temperature values($T_b > 10^7$ K) measured with VLBI suggest a non-thermal synchrotron radiation origin for their radio emission. The detection rate of 20% is broadly consistent with other wide-field VLBI experiments carried out recently. The group also derived the accurate equatorial coordinates of the three detected sources using the phase-referencing technique (Cao et al. 2014, A&A, 563, 111).

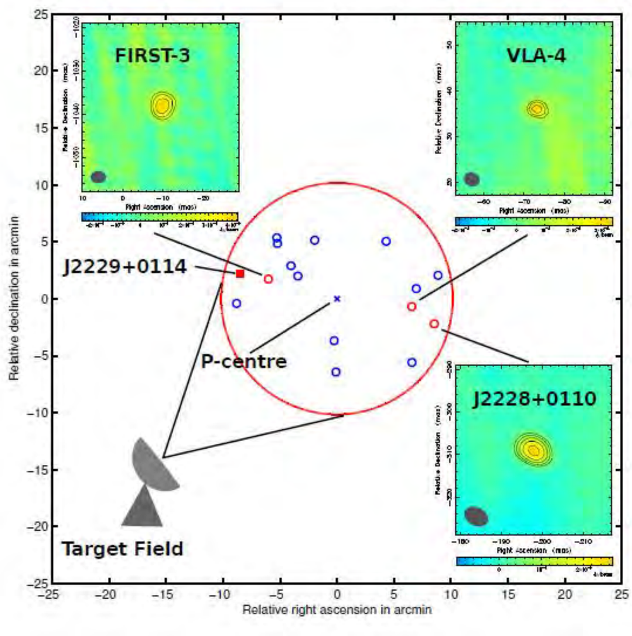
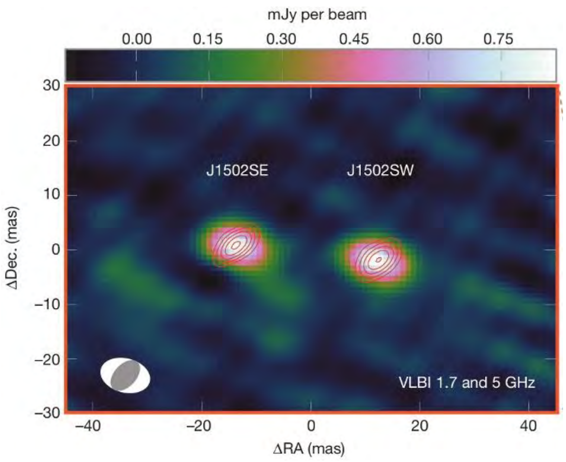


Figure 4.15: EVN detection of the high-redshift quasar J2228+0110 and other two sources with the multi-phase-centre correlation technique. The label "P-centre" marks the pointing centre of the nine smaller telescopes working in the in-beam mode and the primary phase centre. The source J2229+0114 marked with a filled square served as the in-beam phase calibrator. The large circle is the primary beam size (FWHM) of a 32-m antenna at 1.6 GHz

Finding dual, and even multiple supermassive black holes is of great importance because these systems have played an important role in forming galaxies in the early Universe, and they are a potential source of gravitational wave radiation as well. The EVN is particularly well suited for this quest, since its unprecedented angular resolution allows us to resolve the closest pairs of SMBH candidates. In a paper published in the 3 July 2014 issue of Nature, Roger Deane (now at Rhodes UNiv.) and collaborators including Zsolt Paragi reported the detection of a small-separation compact double source with the EVN within the system J1502+1115, that was already known to host a wider separation dual-SMBH. The compact structures and the observed flat spectra pointed to the presence of an inner dual active galactic nucleus (AGN) in a rare type of triple-SMBH system (there are only a handful of suspected candidates are known), with a separation of only 140 parsec for the inner pair. This finding needs to be confirmed by further observations, because another group claimed that the VLBI structure might instead indicate a peculiar Compact Symmetric Object (CSO), a pair of compact radio lobes from a single, young active galactic nucleus. In any case, J1502+1115 remains a high-profile target for sensitive VLBI observations. Deane et al. (2014) also predicted that the orbital motion of very small separation "binary" black holes will be imprinted onto their large-scale jets, twisting them into a helical or corkscrew-like shape. So even though black holes may be so close together that our telescopes cannot resolve them, their twisted jets may help locating these systems with future very sensitive instruments like the Square Kilometre Array (SKA).



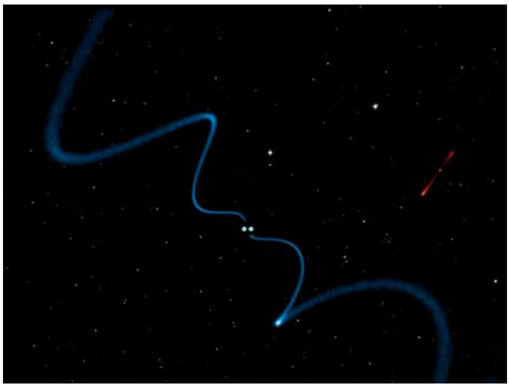


Figure 4.16: Left: EVN 1.7 GHz image (contours) overlaid on the EVN 5 GHz image (colour scale) of the close pair of candidate supermassive black holes. Right: a sketch of spiral jets from a close pair of black holes in a triple SMBH system (Deane et al. 2014)..

5 SPACE SCIENCE

5.1 VLBI and space science

The Space Science and Innovative Applications (SpaSIA) group continued developments of two space-oriented applications, the near-field VLBI for multi-disciplinary scientific applications, as well as support to the operational (RadioAstron) and design studies of prospective Space VLBI missions.

The near-field VLBI technique allows researchers to determine state-vectors of target sources (spacecraft) with high accuracy. The interest of the planetary and space science communities to this technique translates into an enlargement of the user base of VLBI facilities.
Over the reporting period of 2013-14, the SpaSIA group continued developing several key components of the near-field VLBI technique. These include all steps of spacecraft VLBI tracking experiments, from planning to post-processing. In particular, the team has developed and tested a set of software tools, which allow efficient scheduling of near-field VLBI tracking experiments and pipelining of single-dish data in order to estimate radial Doppler-shift of the spacecraft signal. In collaboration with the R&D group of JIVE and Department of Astrodynamics and Space Missions of the Delft University of Technology, the software correlator SFXC has been upgraded with a set of modules specific for near-field VLBI processing. These modules include the correlator delay model tested in VLBI experiments on targets at distances from several astronomical units (e.g. Mars Express) down to Earth satellites (e.g. RadioAstron). The results of these are described in the papers published by the SpaSIA group in 2013-14.

Over the reporting period, most of the JIVE activities in the area of space science applications of VLBI were supported via EC FP7 project ESPaCE (see section 6.3) as well as collaborations between JIVE and Chinese radio astronomy observatories co-sponsored by the NWO and Shanghai Astronomical Observatory (ShAO).

5.2 Planetary Radio Interferometry and Doppler Experiment (PRIDE)

The Planetary Radio Interferometry and Doppler Experiment is based on the near-field VLBI technique developed at JIVE. In 2012, PRIDE was selected and in 2014 adopted as a part of the science suit of the ESA's L1 mission JUICE (Jupiter Icy Satellites Explorer). PRIDE for the JUICE mission is an experiment with zero demand on the science payload mass, and only ad hoc demand on other spacecraft resources (onboard power, commands, telemetry). The experiment is designed as an enhancement of the science output of the mission by means of exploiting the available, mostly the service onboard instrumentation and the infrastructure of Earth-based radio astronomy facilities (Fig. 5.1).

PRIDE addresses the areas of prime JUICE science objectives. In certain applications, its "deliverables" are unique. The latter is most obvious in the astrometric domain where PRIDE can provide precise estimates of the spacecraft celestial position directly in the ICRF frame thus enabling precise determination of the celestial mechanics parameters of the Solar System bodies, in particular, the Jovian satellites.

All scientific applications of PRIDE are based on two measurables: the lateral (transverse) celestial position of spacecraft and its radial velocity (Doppler). The former is the main outcome of VLBI racking of spacecraft, while the latter is an "inevitable" ad hoc product of VLBI tracking (Fig. 5.2).

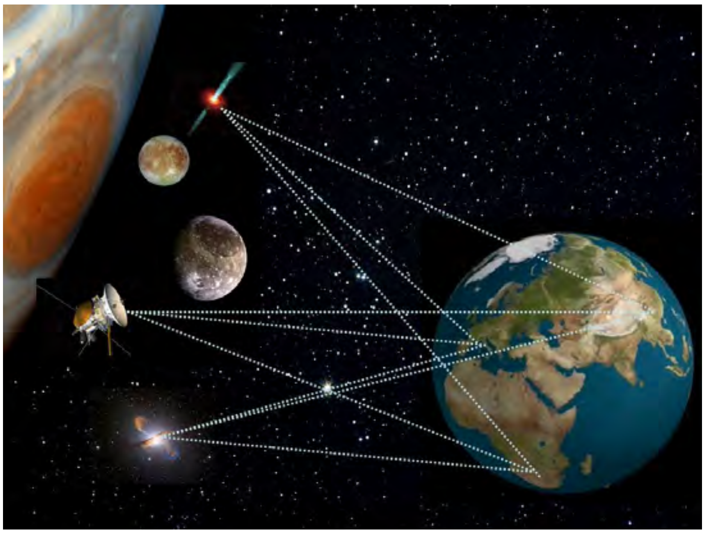


Figure 5.1: Generic configuration of PRIDE-JUICE.

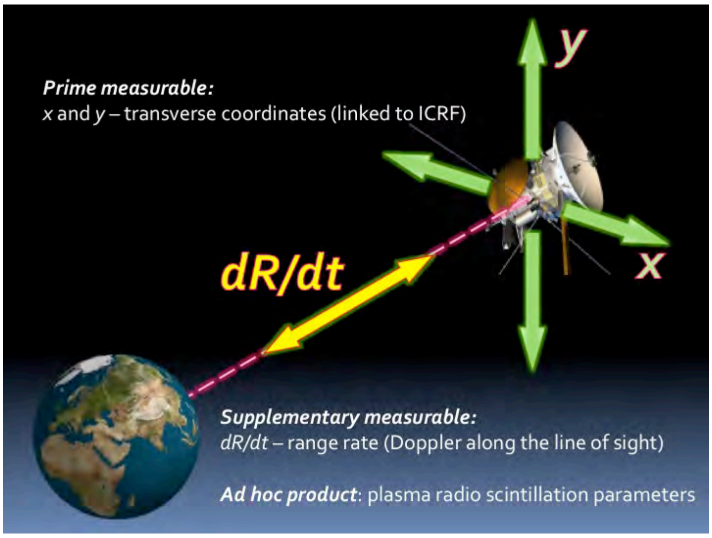


Figure 5.2: PRIDE-JUICE measurable.

Together with oyher JUICE instruments, PRIDE-JUICE addresses the following scientific objectives:
1). Improvement of the ephemerides of the Galilean satellites;
2). Providing accurate input into definition of the Solar System reference frame;
3). Determination of the Ganymede shape (in concurrence with GALA);
4). Measurements of surface slope, near surface dielectric constant and surface density;
5). Characterization of the gravity field parameters of Ganymede, Callisto and Europa;
6). Determination of the vertical structure of the Jovian atmosphere; vertical structure (electron density) of the Jovian ionosphere and characterization of electron density profiles in ionospheres of Ganymede, Callisto and Europa by means of radio occultation.

Scientific applications of PRIDE measurements and some methodological topics of the experiment are described in the recent publications.

Being large and massive bodies, the Galilean moons will strongly influence the JUICE orbit at different phase of the Jovian tour. This is especially the case during Galilean satellites' flybys and the Ganymede's orbital phase. PRIDE will monitor the JUICE spacecraft will detect the gravitational perturbation by the moons, allowing in turn accurate determination of their positions. The moons' positioning accuracy will be highly dependent on the accuracy of the spacecraft state vector. Flybys will provide the position of the related moon at central epoch, while orbital phase around Ganymede will provide continuous tracking of Ganymede. In that last case, Jupiter's ephemeris accuracy will affect Ganymede's observed position too and will need to be solved at the level of accuracy of the PRIDE measurements.

The lateral spacecraft position measurements (ICRF) with the 1-sigma accuracy of about 10-100 µas translates into 30-300 meters at opposition every 60-1000 seconds. This is 103 times better than ground based observations including mutual event observations. During the Ganymede's orbital phase, this will be an improvement of a factor 10,000 compared to Earth-based optical astrometry. Moreover, direct velocity measurements of Ganymede will be available for the first time, owing to Doppler measurements of JUICE during the Ganymede's orbital phase (PRIDE range rate accuracy of ~0.015 mm/s over 60 s integration, X-band tracking in the two-way X/X regime). It is noteworthy that the amount of data to be produced PRIDE-JUICE will enlarge significantly the overall astrometric database on the Jovian system.

JIVE leads the PRIDE-JUICE development in cooperation with the Royal Observatory of Belgium, France Laboratoire d'Astrophysique de Bordeaux, Observatoire de Paris and CNES (France), DLR and TU Berlin (Germany), FÖMI Satellite Geodetic Observatory (Hungary), Delft University of Technology (The Netherlands), Institute for Space Sciences (Romania), and UC Berkeley (USA).

5.3 Space VLBI: radioastron

After completion of the in-orbit checkout period in the beginning of 2012, the Space VLBI mission RadioAstron began implementation of its Early Science Programme, Key Science Programmes and regular PI-led science experiments. The SpaSIA group at JIVE took part in all three stages of the science operations of the RadioAstron mission. The special task addressed by the group dealt with enhancements of the RadioAstron orbit determination by conducting PRIDE-style tracking of the spacecraft. It has been shown that PRIDE tracking can enhance, as necessary for particularly demanding long-baseline experiments, orbit determination enabling sub-nanosecond delay model predictions (Fig. 5.3). After completion of verification tests, the SFXC correlator at JIVE has been declared available for correlating user-led RadioAstron experiments.

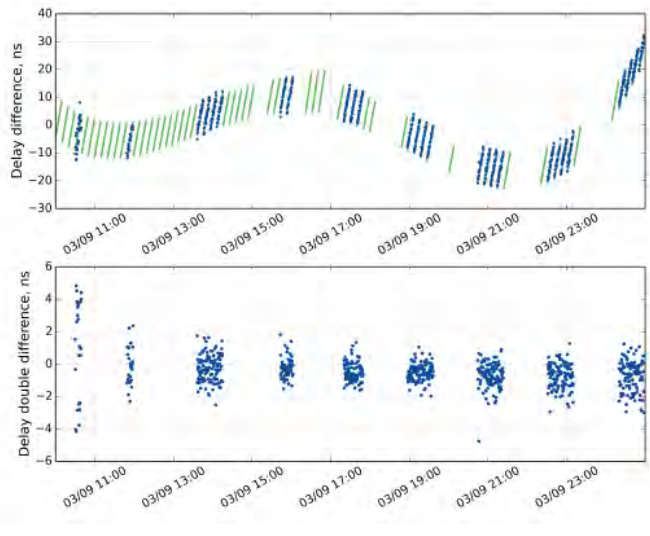


Figure 5.3: Improved versus nominal orbital solution: difference in measured residual delays (blue dots) compared to the difference in modeled delays (green dots) (top), and their double difference (bottom). Baseline Effelsberg – RadioAstron. Experiment GK047A, 2013.03.09-10.

5.4 Toward a space-borne Ultra-Long-Wavelength Interferometer

The Ultra-Long-Wavelength (ULW) regime (300 to 10 m in wavelength or 1 to 30 MHz in frequency) is one of the last major unexplored bands in electromagnetic spectrum of cosmic emission. Opening this unique band will enable transformational scientific results. A joint Sino-European proposal called DSL, Discovering the Sky at the Longest Wavelengths, have been worked on in 2013-14 with participation by JIVE radio astronomers. This joint proposal has been built up on the long productive cooperation between Chinese and European scientists and engineers in radio astronomy, space sciences and technology.

This proposal describes the scientific impact and rationale of a mission in the unique observing window of astronomy, cosmology, Solar- and geo-physics. The technology involved is interferometric in its fundamental nature and JIVE has accumulated relevant expertise. The mission concept aims at a broad variety of topics ranging from cosmology ("dark ages") to astrophysics of ultra-steep spectrum extragalactic radio sources and neutron stars to physical processes in solar-terrestrial plasma. The concept of the DSL mission is based on the advanced technology of micro-satellites (Fig. 5.4). They form a regular constellation on the Moon orbit taking the advantage of partial shielding from terrestrial radio-frequency interferences (RFI). It is expected that in the coming decade the concept will mature and result in the creation of the new space-based radio astronomy facility.

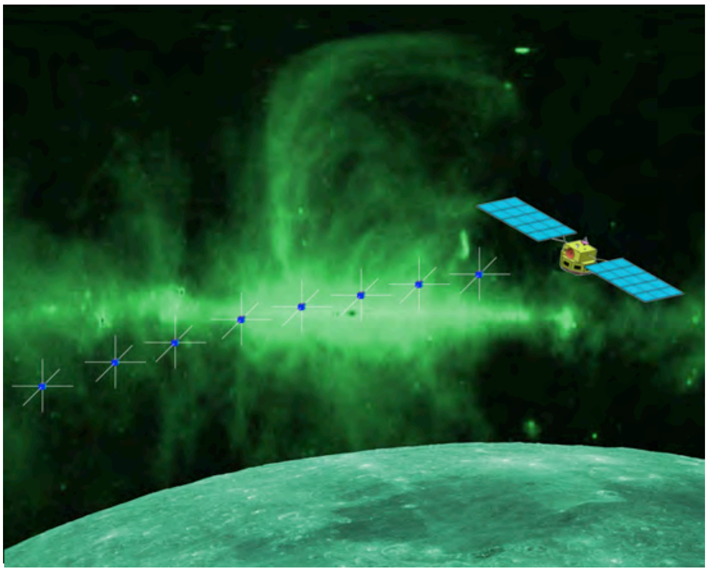


Figure 5.4: An artist's impression of the DSL mission. A formation of 8 micro-satellites equipped with ULW (Ultra-Long Wavelegth) antennas and receivers creates an interferometric array. A larger spacecraft serves, in particular, as an autonomus data processing centre of the DSL mission.

6 EXTERNALLY FUNDED PROJECTS

6.1 RadioNet3

During the entire reporting period the RadioNet3 (grant 283393) programme was active. This collaboration of radio astronomy operators and innovators provides vital resources for JIVE in shaping its user access activities, science and development. JIVE staff participates in the management team, the executive board and as activity leaders. This biennial period corresponded to the second and third year of RadioNet3.

6.1.1 RadioNet3 EVN TNA

The RadioNet3 EVN Trans-National Access (TNA) programme provides funding to EVN telescopes to provide access for 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. Table 6.1 summarizes various statistics from the past two years of EVN TNA activity.

	2013	*2014*
Number of eligible observations	102	72
comprising how many proposals	69	56
Total number of access hours	756	731
Number of data reduction visits	8	11
number of data reduction visits made to JIVE	6	9

Table 6.1: Annual statistics for various aspects of the EVN TNA programme over 2013-14.

6.1.2 QueSERA

This is a Network Activity in RadioNet3 to address "Questions on Structuring Radio Astronomy" and Huib van Langevelde is the overall activity leader. The NA work is divided into 3 parts, where the first part, discussing the governance of European radio astronomy, has the most direct association with the acronym QueSERA. After a number of meetings the QueSERA Study Group, led by Mike Garret from ASTRON, started to formulate the RadioNet view on the recent developments in radio astronomy. In the process it interfaced with similar activities initiated by SKA partners and the ASTRONET. Another initiative focused on advertising the RadioNet (including the EVN) facilities to astronomers who do not traditionally make radio observations. It proved difficult to get sufficient experts involved in this. However, the third activity, focusing on traditional outreach and led from INAF, did produce interesting new material in collaboration between telescope outreach officers.

6.1.3 Hilado

The JRA Hilado is the RadioNet3 collaboration on data processing software. Under this activity JIVE continue to support ParselTongue and develop new data processing approaches in collaboration with international partners (see section 3.6.1).

6.1.4 UniBoard^2

The UniBoard^2 activity is building on previous work in RadioNet FP7 in order to deliver very high capacity digital data processing for a number of radio astronomy applications. While work on various applications progressed at the partner institutes, it was decided to postpone the purchase of the actual hardware to 2015 when new 20nm FPGA devices are supposedly becoming available (see section 3.4.2)

6.2 NEXPReS

The EC project NEXPReS (RI-261525) had started in July 2010 and ended as planned on 30 June 2013 with a review in Dwingeloo in September of that year (see section 3.7.1.). The project centred on making the e-VLBI operations as transparent as possible. The EC and its experts judged the progress as excellent and in March 2014 the final payment was distributed to the partners. Just like the EXPReS project before it, the programme allowed JIVE to innovate a number of the VLBI practices. Unfortunately it was impossible to identify a funding opportunity to continue this development from external sources.

6.3 ESPaCE

This collaboration ran for the entire reporting period and focussed on ephemerids and reference systems for natural satellites. JIVE led a work-package on VLBI applications. Several scientific results from this effort are reported in 5.1.

6.4 Exomars

In 2009 JIVE entered a project to observe the Mars Explorer with radio telescopes in order to test direct-to-earth observations. The work was completed in 2014.

6.5 NWO-ExBoX

The ExBoX project provided JIVE and its partner ASTRON with an important opportunity to develop FPGA-based correlation, matching some of the effort in the UniBoard projects in RadioNet. The successful programme was completed in September 2013.

6.6 NWO-China

Through an MOU between NWO and the Shanghai Astronomical Observatory, JIVE staff worked with Chinese colleagues on correlator technology and space applications. Although a large fraction of the work was carried out in the previous reporting period, this programme did support continued joint efforts in 2013 and 2014. At the end of the reporting period the only activity left active was the research of the graduate student in the project.

6.7 BlackHoleCam

On 1 September 2014 JIVE started work in the ERC synergy project BlackHoleCam led by Heino Falcke at Radboud University Nijmegen, with Huib van Langevelde as one of the associated scientists. The programme aims to enable sub-millimetre VLBI observations and their interpretation in terms of the black hole shadow of the Galactic Centre. In the international collaboration JIVE has a role to introduce e-VLBI methods to the sub-millimetre array for direct feedback, as well as data processing techniques for mm-VLBI, notably fringe fitting in the CASA framework. The programme allows JIVE to build on previous experience in EC projects and strengthen its expertise in data software (see section 3.6.2).

6.8 ESKAC

Although the activity has gone mostly dormant with the advent of a SKA organisation funded by several nations, JIVE continues to act as the banker and secretary of the consortium.

6.9 SKA-NL

In 2014 the Dutch University astronomy groups led by ASTRON received a grant to work on preparations for the SKA. JIVE is a beneficiary of this proposal and receives funding for a few FTEs over the 5-year running to do work in a few areas. Notably this is paying for the role that JIVE plays in the Signal and Data Transport consortium. JIVE is also putting in an effort to promote doing VLBI observations with the SKA-mid.

7 PUBLICATIONS

7.1 Journal Articles

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8 APPENDICES

8.1 JIVE board

- Luigina Feretti - *Institute for Radioastronomy, Bologna, Italy (Chair)*
- Patrick Charlot - *Laboratory of Astrophysics of Bordeaux, Floirac, France (vice-chair)*
- John Conway - *Onsala Space Observatory, Onsala, Sweden*
- Jesús Gómez González - *Instituto Geográfico Nacional, Madrid, Spain*
- Anton Zensus - *MPIfR, Bonn, Germany*
- Michael Garrett - *ASTRON, Dwingelo, The Netherlands*
- Xiao-yu Hong - *National Astronomical Observatories, Chinese Academy of Sciences, Shanghai, PR China*
- Simon Garrington - *Jodrell Bank Centre for Astrophysics, Manchester, UK*
- Mike Gaylard - *National Research Foundation, Pretoria, South* Africa († 14 August 2014)
- Ludwig Combrink (interim) - *National Research Foundation, Pretoria, South Africa*

8.2 JIVE financial report 2013-2014

Balance

(after allocation of results)

	2014	2013
A S S E T S	in €	in €
Tangible fixed Assets		
Tangible fixed Assets	51.294	58.101
Total of Tangible fixed Assets	*51.294*	*58.101*
Current Assets		
Receivables	790.098	1.917.098
Cash at bank	1.220.521	1.505.338
Total of Current Assets	2.010.619	3.422.436
Total Assets	2.061.913	3.480.537
	========	========

	2014	2013
L I A B I L I T I E S	In €	In €
Capital		
General reserve	*800.000*	*894.799*
Designated funds	*511.415*	*730.000*
Total capital	1.311.415	1.624.799
Other Liabilities		
Short term debts	750.498	1.855.738
Total Other Liabilities	750.498	1.855.738
Total Liabilities	2.061.913	3.480.537
	========	========

Statement of PROFIT & LOSS

	2014	2013
	Actual	Actual
R E V E N U E S	in €	in €
Income		
Contributions/subsidies third parties	2.087.216	2.065.670
Interest	382	1.403
Other	195.117	142.565
Total Income	2.282.715	2.209.638
Total Revenues	2.282.715	2.209.638
	========	========

	2014	2013
	Actual	Actual
E X P E N D I T U R E S	in €	in €
Operations		
Expenditures	2.596.099	2.737.506
Total Expenditures	2.596.099	2.737.506
	========	========
R E S U L T	-313.384	-527.868
	======	======

8.3 JIVE personnel

Mr. F. Bloemhof	Scientific Programmer (until 1 May 2013)
Dr. I. Agudo	Support Scientist (from 1 August 2013)
Ms. T.M. Bocanegra	Researcher in training
Mr. E.P. Boven	Network/Linux Specialist
Dr. R.M. Campbell*	Head of Science Operations and Support
Dr. G. Cimo	Space VLBI Scientist
Mr. D. Duev	Support Scientist (from 1 January until 1 August 2013)
Mr. D. Duev	Postdoc Space VLBI (from 1 August 2013)
Drs. B. Eldering	Software Engineer
Dr. C. Goddi	Support Scientist (until 1 November 2014)
Prof. L.I. Gurvits*	Head of Space Science and Innovative Applications Group
Dr. J.E. Hargreaves	Digital Engineer
Mr. B. Harms	Operator
Dr. Ing. A. Keimpema	Scientific Programmer
Dr. Ir. M.M. Kettenis	Software Engineer
Mrs. Y. Kool-Boeser	Senior Secretary
Mr. B. Kramer	Software Technician (until 1 December 2013)
Mr. M. Leeuwinga	Hardware Support Engineer
Mrs. S.K. Mellema	Secretary
Dr. G. Molera Calvés	Postdoc Space VLBI
Dr. Z. Paragi*	Head of User Support
Ing. S.P.E.L. Pirruccio	Digital Engineer (until 1 June 2014)
Dr. S.V. Pogrebenko	Senior System Scientist
Drs. R.A. Schoenmaker	Scientific Programmer (until 18 April 2013)
Dr. D.M. Small	Scientific Software Engineer
Dr. G. Surcis	Support Scientist
Dr. A. Szomoru*	Head Technical Operations and R&D
Mr. H. Tenkink	Chief Operator
Dr. I.M. van Bemmel	Project Scientist (from 1 September 2014)
Drs. A. van den Poll	Project Assistant
Prof. H.J. van Langevelde*	Director
Drs. H. Verkouter	Offline Software Engineer
Dr. J. Yang	Support Scientist
Mr. T.C. Yun	Program Manager (until 1 October 2013)
Mrs. K.S. Yun	PR/Outreach (until 1 October 2013)

*-JIVE MT member

8.4 Visitors to JIVE

2013

Name	Institute	Period	Host
P. Rosenblatt	OMA, Belgium	25-26 February	Gurvits
J.C. Marty	CNES, France	25-26 February	Gurvits
R. Spencer	University of Manchester, UK	10-14 March	Paragi
P. Wolak	PSNC, Poland	3-11 April	Paragi
E. Liuzzo	INAF, Italy	8-18 April	Paragi
W. Wang	Shanghai Astronomical Inst, China	22 April '13- 21 April '14	Gurvits
R. Weber	Station de Radioastr. de Nancay, France	27-28 May	Szomoru
C. Dumez-Viou	Observatoire de Nancay, France	27-28 May	Szomoru
I. Rottmann	MPIfR Bonn, Gemany	27-28 May	Szomoru
G. Knittel	MPIfR Bonn, Gemany	27-28 May	Szomoru
B. Quertier	Lab. d'Astrophysique de Bordeaux, France	27-28 May	Szomoru
S. Gauffre	Lab. d'Astrophysique de Bordeaux, France	27-28 May	Szomoru
G. Comoretto	Ossevatorio Astrofisico di Arcetri, Italy	27-28 May	Szomoru
K. Zharb Adami	University of Oxford, UK	27-28 May	Szomoru
A. Matala	VTT, Finland		Molera
W. Vlemmings	Onsala Space Obs, Sweden	17-19 July	van Langevelde
F. Kirsten	Onsala Space Obs, Sweden	17-19 July	van Langevelde
I. Agudo	CSIC, Spain	25 June - 1 July	Campbell
K. Sokolovski	Astronet Space Center, Russia	21-29 July	Gurvits
D. Xu	Niels Bohr Institute, Denmark	4-17 September	Yang
M. Ceglowski	Torun Radio Astronomical Obs	16-27 September	Paragi
C. Roskowinski	Torun Radio Astronomical Obs	16-27 September	Paragi
L. Chemin	Observatoire de Bordeaux, France	23-27 September	Paragi
J. Cullen	Manchester University	28-31 October	Szomoru
D. Chen	National Space Science Center	13 December	Yang

2014

Name	Institute	Period	Host
A. Matala	VTT, Finland	6-10 January	Molera
C. Garcia Miro	Madrid Deep Space Comm. Complex	26-28 January	Campbell
M. Argo	Manchester University, UK	3-7 February	Paragi
P. Rosenblatt	Royal Observatory Brussels, Belgium	10-14 February	Gurvits
A. Rushton	Oxford University	2-7 March	Paragi
B. Hu	MPIfR, Germany/Purple Mountain Obs, China	4-12 March	Goddi
S. Frey	FOMI, Hungary	3-16 April	Campbell
K. Gabanyi	Konkoly Obs, Budapest, Hungary	3-16 April	Paragi
N. Gizani	Hellenic Open Univ, Greece	21-30 April	Paragi
W. Wang	Shanghai Astr Institute, China	22 April '13 – 21 April '14	Gurvits
R. Azulay	Univ of Valencia, Spain	20-24 July	Campbell
B. Marcote	Univ of Barcelona, Spain	2 Sep. - 2 Nov.	Paragi
L.H. Quiroga Nunez	Univ of Leiden	17-18 September	van Langevelde
E. Borovikova	Science journalist, Russia	18-19 September	Gurvits
S. van Velzen	Radboud Univ Nijmegen, Netherlands	18-19 September	Paragi
R. Coppejans	Radboud Univ Nijmegen, Netherlands	18-19 September	Paragi
A. Alakoz	Astro Space Center, Moscow, Russia	26 Oct. - 6 Nov.	Gurvits

W. Zheng	Shanghai Astronomical Inst/CAS, China	13-15 November	Szomoru
J. Zhang	Shanghai Astronomical Inst/CAS, China	13-22 November	Szomoru
X. Hong	Shanghai Astronomical Observatory	2-4 November	Gurvits
E. Vavilina	Ventspils University	28-29 November	Szomoru
G. Gaigals	Ventspils University	28-29 November	Szomoru

8.5 Presentations

Tatiana Bocanegra Bohamon

- “Studying Venus' atmosphere and ionosphere with Planetary Radio Interferometry and Doppler Experiment (PRIDE)” European Planetary Science Congress 2014, Cascais, Portugal
- “Planetary Radio Interferometry and Doppler Experiment (PRIDE) for studying the thermosphere of Venus” European Planetary Science Congress 2013, London, UK

Paul Boven

- “Timing for VLBI”, White Rabbit Meeting, 20 January 2014, Nikhef, Amsterdam, the Netherlands
- “Using VLBI to demonstrate long-haul fiber-optic frequency transfer”, 3rd IVTWS, 12 November 2014, Groningen, the Netherlands
- “UTC Distribution”, SKA SADT F2F, 5 October 2014, Fremantle, Australia

Bob Campbell

- "VLBI Techniques", 5th European Radio Inteferometry School, 12 September 2013, Dwingeloo, the Netherlands
- "VLBI: Concepts and Astronomical/Geodetic Applications", U.S. Naval Academy, , 18 November 2013, Annapolis, Md, US
- "Software Correlation at JIVE, real-time e-VLBI in the EVN, and Recent Changes to the EVN Proposal Tool", 12th EVN Symposium, 9 October 2014, Cagliari, Italy

Giuseppe Cimo'

- “Near-field VLBI and its applications to Space Science Missions.” European Planetary Science Congress 2014, Cascais, Portugal
- “Planetary Radio Interferometry and Doppler Experiment for current and future Venusian missions” Interplanetary Venus Workshop (IVW) 2013, Catania, Italy
- “Space Science Applications of Near-field VLBI” European Planetary Science Congress 2013, London, UK
- “VLBI in the Solar System” Bonn-Dwingeloo meeting. December 2013, Bonn, Germany
- “Planetary Radio Interferometry and Doppler Experiment for Near-Earth Asteroids ESA mission MarcoPolo-R” MarcoPolo-R workshop, June 2013, ESTEC Noordwijk, The Netherlands

Dmitry Duev

- “RadioAstron as a target and as an instrument: data processing and first results” 68th Dutch Astronomy Conference (NAC) 2013, Lommel, Belgium

Leonid Gurvits

- “Radio Interferometry and Doppler Experiment (PRIDE) for the JUICE mission”, European Planetary Science Congress 2013, London, UK
- “Wide-field observations in the SDSS Stripe 82 with the European VLBI Network”, IAU Symposium 304, 2013, Byurakan, Armenia
- “Exoplanet magnetic field: possible marker of habitability”, EGU General Assembly 2013 Vienna, Austria
- “Recent activities of the FP7 ESPaCE consortium”, JSR, 2013, Paris, France
- “The case for the next generation Space VLBI mission”, Space Very Long Baseline Interferometry Forum, 2013, Beijing, China
- “Atomic Hydrogen at z>5”, 2013, Astrolunch, Dwingeloo
- “PRIDE: a multidisciplinary enhancement of space science missions”, ShAO Colloquium, 2013, Shanghai, China
- “WP4 (VLBI) progress report “, 2nd ESPaCE Annual meeting, 2013 Berlin, Germany
- “EVN status (ad hoc presentation)”, NSSC, 2013, Beijing, China

- “Space science status report”, EVN CBD meeting, 2013, Dwingeloo, the Netherlands
- “Space science news”, EVN CBD meeting, 2013, Jodrell Bank, UK
- “JIVE presentation”, meeting with the NSO delegation, 2013, Dwingeloo, the Netherlands
- “Space science in Horizon-2020: astrophysics and fundamental physics”, EC Space Science and Exploration workshop, 2013, Madrid, Spain
- “Space science in Horizon 2020 Mission concepts: a “grass-root” view”, EC Horizon-2020 workshop,2013, Madrid, Spain
- “News from EVN and JIVE: pushing the limits of science and technology”, ShAO colloquium, 2013, Shanghai, China
- “Space frontier of VLBI”, a lecture to ASTRON and JIVE summer students, 2013, Dwingeloo, the Netherlands
- “The Universe as seen by a radio astronomer”, a presentation to RUG students, Faculty of Medicine, 2013, Westerbork, the Netherlands
- “Very Long Baseline Interferometry: from z=0 to z>6 and back”, University colloquium, 2013, Tel-Aviv, Israel
- “RadioAstro status at JIVE: report to the RISC meeting”, 2013, Moscow, Russia
- “Arecibo Observatory” a long life with very long baselines”, Conference “50 years of the Arecibo Observatory”, 2013, Puerto Rico
- “Space VLBI at Ger’s wavelengths and brightness”, Gerfest, 2013, Groningen, the Netherlands
- “Radio astronomy news from China”, Astrolunch, 2013, Dwingeloo, the Netherlands
- “Early Space VLBI studies and projects”, SVLBI Forum, 2013, Beijing, China
- “e-EVN status in the SKA perspective”, 2013, Jodrell Bank, UK
- Ultra-Long-Wavelength Astronomy concepts”, NAOC colloquium, 2013, Beijing, China
- “Ultra-Long-Wavelength Astronomy in the Moon exploration context”, ESA workshop, 2013, Noordwijk, the Netherlands
- “Space science horizons of radio astronomy”, MMU colloquium, 2013, Moscow, Russia
- “Gaia PRIDE tracking”, GBOT meeting, 2013, Heidelberg, Germany
- “2014 starts with 10^{14} (K)”, Astrolunch, 2014, Dwingeloo, the Netherlands
- “Space Ultra-Long-Wavelength Array”, CAS-ESA workshop, 2014, Chengdu, China
- “SETI in the extragalactic perspective”, IAA workshop, 2014, Paris, France
- “JUICE: a European mission to the Jovian system”, 40th COSPAR Scientific Assembly, 2014, Moscow, Russia
- “Vertical structure of Venus polar thermosphere from in-situ data of the Venus Express Atmospheric Drag Experiment (VExADE)” 40th COSPAR Scientific Assembly 2014, Moscow, Russia
- “Half a century of SETI in the USSR and Russia” 40th COSPAR Scientific Assembly 2014, Moscow, Russia
- “Zooming into the high¬redshift Universe” 40th COSPAR Scientific Assembly 2014, Moscow, Russia
- “Moon exploration: Lunar radio observatory” 40th COSPAR Scientific Assembly 2014, Moscow, Russia
- “Jupiter Icy Moons Explorer (JUICE): Science Objectives, Mission and Instruments” 45th Lunar and Planetary Science Conference, 2014, The Woodlands, TX, USA
- “JUICE: complementarity of the payload in addressing the mission science objectives”, EGU GA, 2014, Vienna, Austria
- “Data mining and distribution of planetary science data on natural satellites”, XXV ADASS meeting, 2014, Calgary, Canada
- “JUICE: The ESA Mission to Study Habitability of the Jovian Icy Moons”, Workshop on the Habitability of Icy Worlds, 2014, Pasadena, CA, USA
- “JUICE: a European mission to Jupiter and its icy moons”, DPS meeting, 2014, Denver, CO, USA
- “JUICE: an ESA-led large mission to the Jupiter system”, AGS assembly, 2014, Sapporo, Japan
- “The Jupiter icy moons explorer (JUICE): complementarity of the payload in addressing the mission science objectives”, Planetary science instruments workshop, 2014, Washington DC, USA

- “VLBI news from the outer redshift frontier or four hundred years of VLBI”, R.W. Porcas Workshop, 2014, Bonn, Germany
- “WP4 (VLBI) progress report”, ESPaCE meeting, 2014, Paris, France
- “Space frontier of VLBI”, a lecture to ASTRON and JIVE summer students, 2014, Dwingeloo, the Netherlands
- “WP4 (VLBI) report to the ESPaCE annual meeting”, 3rd ESPaCE Annual meeting, 2014, Toulouse, France
- “Very Long Baseline Interferometry (VLBI) on Earth and in Space: the RadioAstron mission”, presentation to NVR, 2014, Dwingeloo, the Netherlands
- “Discovering the Sky at Longest wavelengths”, ESA-CAS workshop, 2014, Copenhagen, Denmark
- “Radio segment of the Gaia GBOT: progress report”, GBOT meeting, 2014, Liverpool, UK
- “Space science news” EVN CBD meeting, 2014, Onsala, Sweden
- “Jets in AGN at extremely high redshifts”, IAU Symposium 313, 2014, Purto Ayora, Equador

Jonathan Hargreaves

- “The JIVE UniBoard Correlator (JUC) Firmware”, 3rd IVTWS, 10 November 2014, Groningen, the Netherlands

Aard Keimpema

- ”Phasing up the EVN using the SFXC software correlator”, 3rd IVTWS, 10 November 2014, Groningen, the Netherlands

Mark Kettenis

- “SFXC: The new (e-)VLBI correlator at JIVE”, 2nd IVTW, 10-12 October 2013, Seogwipo, S. Korea
- “VEX2”, 3rd IVTW, 10-13 November 2014, Groningen, the Netherlands

Huib van Langevelde

- “Current JIVE”, “Future and Strategy”, “JIVE funding”, “Process’, Agencies meeting JIV-ERIC, 14 March 2013, The Hague, the Netherlands
- “QueSERA”, RadioNet Board meeting, 18 March 2013, Bologna, Italy
- “Introducing JIVE”, NSO visit, 5 April 2013, Dwingeloo, the Netherlands
- “Radio Astronomy: e-VLBI connecting European and Chinese telescopes in real-time”, DANTE, 12 April 2013, London, UK
- “JIVE report”, EVN CBD/JIVE Board, 16 April 2013, Manchester, UK
- “Management report”, EVN CBD/JIVE Board, 16 April 2013, Manchester, UK
- “The future of the European VLBI Network”, Lorentz workshop, 13 May 2013, Leiden, the Netherlands
- “The Cradle of Life (or Astrobiology) (or the rest of Galactic Astronomy)”, SKA klankbord, 3 June 2013, Dwingeloo, the Netherlands
- “JIV-ERIC”, JIV-ERIC meeting, 12 June 2013, Schiphol, the Netherlands
- “JIVE and the EVN, Very Long Baseline Interferometry in Dwingeloo”, Summer studs lecture, 25 June 2013, Dwingeloo, the Netherlands
- “The Observatory Career, director of the European VLBI facility”, NOVA career dag, , 6 July 2013 Dalfsen, the Netherlands
- “Period 3 Overview: Intro & Science”, NEXPReS review, 19 September 2013, Dwingeloo, the Netherlands
- “JIVE and some more”, Sterrewacht, 20 September 2013, Leiden, the Netherlands
- “Address at the SRT dedication”, SRT dedication, 29 September 2013, Cagliari, Italy
- “JIVE and some more”, visit YERAC, 3 October 2013, Dwingeloo, the Netherlands
- “QueSERA Task1”, QueSERA meeting, 14 October 2013, Brussels, Belgium
- “Cradle of Life related opportunities: VLBI with the SKA1”, SKA CoL get-together, 6 November 2013, Manchester, UK
- “JIVE report”, EVN CBD, 12 November 2013, Dwingeloo, the Netherlands

- "Management report", JIVE Board, 13 November 2013, Dwingeloo, the Netherlands
- "Observing methanol at the EMFL (Nijmegen)", Overleg Chemie, 21 November 2013, Nijmegen, the Netherlands
- "20 years of JIVE", Christmas Party, 19 December 2013, Dwingeloo, the Netherlands
- "Helderheid; brightness and transparency in radio astronomy", Oratie, 28 February 2014, Leiden, the Netherlands
- "Molecular masers in the Milky Way", colloquium, 4 March 2014, Nijmegen, the Netherlands
- "WP2: QueSERA progress report", RadioNet3 Board meeting, 20 March 2014, Garching, Germany
- "From the DRT to VLBI, zooming in on circumstellar masers", Mini-symposium DRT, 4 April 2014, Dwingeloo, the Netherlands
- "Masers as tools for star formation and probes of Galactic structure", Star formation and Galactic structure conference (Blaauw), 8 April 2014, Groningen, the Netherlands
- "JIVE report", EVN Board, 13 May 2014, Onsala, Sweden
- various reports, JIVE Board, 14 May 2014, Gothenborg, Sweden
- "The EVN (and AVN) for Galactic science as a SKA pathfinder", workshop Galactic Science with the SKA and its pathfinders, 22 May 2014, Leiden, the Netherlands
- "WP on joint S&T", ASTERICS meeting, 2 June 2014, Schiphol, the Netherlands
- "VLBI with ALMA", EWASS2014, 4 July 2014, Geneve, Switzerland
- "JIVE and the EVN, VLBI in Dwingeloo", summer student lecture, 8 July 2014, Dwingeloo, the Netherlands
- "JIVE", visit NRF delegates, 15 July 2014, Dwingeloo, the Netherlands
- "Conference summary", EVN symposium, 10 October2014, Cagliari, Italy
- "JIVE report", EVN CBD, 5 November 2014, Bologna, Italy
- various reports, JIVE Board meeting, 6 November 2014, Bologna, Italy
- "Welcome", IVTW2014, 9 November 2014, Groningen/Dwingeloo, the Netherlands

Guifre Molera Calves

- Scintillation of Venus and Mars Express radio signal on interplanetary and ionosphere plasma" EVN symposium 2014, October 2014, Cagliari, Italy
- "Analysis of the interplanetary scintillation tracking Venus Express Spacecraft" European Week of Astronomy and Space Sciences 2013 (EWASS), 2013, Turku, Finland
- "VLBI and Doppler tracking of Venus Express spacecraft" 8th Dutch Astronomy Conference (NAC) 2013, Lommel Belgium
- "Spacecraft observations and IPS with VLBI radio telescopes" Interplanetary plasma scintillation workshop, 2013, Nagoya, Japan
- "Observations and analysis of the phase scintillation of spacecraft signals on the interplanetary plasma" CAWSES-II symposium, 2013, Nagoya, Japan
- "Interplanetary scintillations retrieved from Venus Express communications signal" Interplanetary Venus Workshop (IVW) 2013, Catania, Italy

Zsolt Paragi

- "Locating transients with the e-EVN" Colloquium, 16 April 2013, Radboud University, Nijmegen, The Netherlands
- "Radio-loud LLAGN probed with the EVN" The Modern Radio Universe, 22-26 April 2013, Bonn, Germany
- "How to plan e-EVN experiments Locating Astrophysical Transients", 13-17 May 2013, Lorentz Centre, Leiden, The Netherlands
- "MAXI J1659-152, the shortest orbital period BHXRB with VLBI Locating Astrophysical Transients", 13-17 May 2013, Lorentz Centre, Leiden, The Netherlands
- "An active MBH candidate in NGC 404 Black Hole (g)Astronomy", 2-6 September 2013, Brindisi, Italy
- "VLBI calibration and imaging I-II" (tutorials) European Radio Interferometry School, 9-13 September 2015, Dwingeloo, The Netherlands

- “Radio transient in the Local Universe” 2nd International VLBI Technology Workshop, 10-12 October 2013, Jeju Island, South Korea
- “Compact jets in nearby galaxies - the power of VLBI Black holes, jets and outflows”, 14-18 October, 2013, Kathmandu, Nepal
- “EVN constraints on an active massive BH in NGC404” Bonn-Dwingeloo Neighbourhood Meeting, 2 December 2013, MPIfR Bonn, Germany
- “VLBI science with the SKA” Science Assessment Workshop, 27-28 January 2014, SKA HQ, Jodrell Bank, UK
- “Locating radio transients and massive black holes with VLBI” Colloquium, Univ. Cape Town, 12 February 2014
- “Very Long Baseline Interferometry and the SKA” Advancing Astrophysics with the SKA, 9-13 June 2014, Giardini Naxos, Sicily, Italy
- “An active MBH candidate in NGC 404” NL jets and accretion meeting (NOVA NW3), 22 October 2014, Nijmegen, The Netherlands
- “VLBI in the SKA era” Third International VLBI Technology Workshop, 10-13 November 2014, Groningen/Dwingeloo, The Netherlands

Arpad Szomoru
- “UniBoard and UniBoard^2”, Digital platform study group meeting, 6-8 March 2013, Vancouver, Canada
- “UniBoard^2”, RadioNet3 board meeting, March 2013, Bologna, Italy
- “Technical operations and R&D at JIVE”, EVN TOG, April 2013, Bonn, Germany
- “JIVE and the EVN”, visit by Altera representatives, 3 May 2013, Dwingeloo, the Netherlands
- “UniBoard2”, UniBoard^2 kickoff meeting, 27-28 May 2013, Dwingeloo, the Netherlands
- “e-VLBI and future developments”, Arnold van Ardenne's retirement seminar, 29 May 2013, Dwingeloo, the Netherlands
- “JIVE and the EVN”, visit to Avnet Silica, June 2013, Breda, the Netherlands
- “WP5 Cloud Correlation”, NEXPReS period 3 review, 19 September 2013, Dwingeloo, the Netherlands
- “The hunt for 4Gbps fringes”, NEXPReS period 3 review, 19 September 2013, Dwingeloo, the Netherlands
- “EXPReS, NEXPReS. What next?”, 2nd International VLBI Technology Workshop, 10-12 October 2013, Seogwipo, South Korea
- “EXPReS, NEXPReS. What next?”, Work visit Shanghai Astronomical Observatory, 15 October 2013, Shanghai, China
- “UniBoard and UniBoard^2”, Work visit Shanghai Astronomical Observatory, 15 October 2013, Shanghai, China
- “The development of global real-time e-VLBI”, Radiovetenskap och Kommunikation 2013, 11-12 November 2013, Stockholm, Sweden
- “Technical operations and R&D at JIVE”, EVN TOG, January 2014, Wettzell, Germany
- “RadioNet3 WP8: UniBoard^2”, RadioNet3 board meeting, 20 March 2014, Garching, Germany
- “Use of the GEANT network in radio astronomy”, GEANT IUAC meeting, 29-30 April 2014, Frascati, Italy
- “Towards a disk-shipping-less future?” EVN CBD, 13 May 2014, Onsala, Sweden
- “Data transport in radio astronomy”, ELIXIR BioMedBridges workshop, 16 May 2014, Hinxton, United Kingdom
- “The UniBoard”, visit by Altera representatives, 20 May 2014, Dwingeloo, the Netherlands
- “The correlators at JIVE”, XXXI URSI General Assembly 2014, 18-23 August 2014, Beijing, China
- “UniBoard and UniBoard^2, and beyond?”, High Performance Computing Workshop, October 2014, Valletta, Malta
- “Technical operations and R&D at JIVE”, EVN TOG, October 2014, Cagliari, Italy
- “RadioNet3 WP8: UniBoard^2”, RadioNet3 executive meeting, 23 October 2014, Brussels, Belgium
- “Towards a disk-shipping-less future?” EVN CBD, 5 November 2014, Bologna, Italy

Harro Verkouter

- "jive5ab", EVN TOG, 10 April 2013, Bonn, Germany
- "SDK9", EVN TOG, 10 April 2013, Bonn, Germany
- "a-VLBI with jive5ab", 2nd IVTW, 10-12 October 2013, Seogwipo, S. Korea
- "jive5ab update", EVN TOG, 23 January 2014, Wettzell, Germany
- "jive5ab: take control of your data and recorder", 8th IVS General Meeting, 2-7 March 2014, Shanghai, China
- "jive5ab update", EVN TOG, 6 October 2014, Cagliari, Italy
- "Herding FPGAs or: distributed monitor and control", 3rd IVTW, 10-13 November 2014, Groningen, Netherlands

8.6 Memberships

8.6.1 International boards and commitees

Bob Campbell
EVN Technical and Operations Group (EVN TOG)
European VLBI Group for Geodesy and Astrometry (EVGA)
EVN Programme Committee (EVN PC)
NEXPReS e-VLBI science advisory group (eVSAG)
5th European Radio Interferometry School Scientific Organizing Committee

Leonid Gurvits
ESA BepiColombo Science Working Group
ESA JUICE Science Working Team (PI of PRIDE-JUICE)
ESA Gaia GBOT group
EuroPlaNet FP7 consortium board
ESPaCE FP7 consortium board and executive
RadioAstron International Science Council
IAU Working Group on History of Radio Astronomy

Huib van Langevelde
Coordinator, NEXPReS, board and management team
Member Consortium Board European VLBI Network
Member RadioNet3 Board and Executive Board
Leader of the RadioNet3 WP2 “QueSERA”
Team member Horizon2020 Synergy grant BlackHoleCam
Member ALMA Scientific Advisory Committee (ASAC)
Member ALMA European Science Advisory Committee (ESAC)
Member European SKA Consortium
SKA klankbordgroep Netherlands
Core Member SKA SWG Science Team “Cradle of Life/Astrobiology”
Member SKA SaDT consortium board
Associated board member SKA-NL consortium
Chairman board of directors, Leids Kerkhoven Bosscha Fonds,
Member board of directors Jan Hendrik Oort Fonds
Member board of directors Leids Sterrewacht Fonds
Astronomy board, Lorentz Center
Member Dutch URSI committee
Member of the Royal Society Open Science Astronomy Editorial Board
SOC 12th EVN symposium, Bordeaux
Organizer, Lorentz Center meeting, “Galactic Science with the SKA & Its Pathfinders”
SOC “Revolution in astronomy with ALMA – the 3rd year”, Tokyo

Zsolt Paragi
NEXPReS e-VLBI Science Advisory Group
SKA Transients Science Working Group

Arpad Szomoru
EVN Technical and Operations Group
GEANT International User Advisory Committee
PI of RadioNet3 Work Package 8 “UniBoard^2”, member of executive board

PI of NEXPReS Work Package 5 "Cloud Correlation", member of executive board
NEXPReS e-VLBI Science Advisory Group (eVSAG)
Vice-chair of EVN Technical and Operations Group
SOC 2nd International VLBI Technology Workshop
Chair of SOC of 3rd International VLBI Technology Workshop

8.6.2 Professionnal associations and societies

Bob Campbell
Sigma Xi
American Astronomical Society
American Geophysical Union
International Astronomical Union
International Union of Radio Science
American Association of Physics Teachers

Leonid Gurvits
International Academy of Astronautics (corresponding member)
American Astronomical Society
Nederlandse Astronomen Club
International Astronomical Union
Committee on Space Research (COSPAR) Associate
International Union of Radio Science (URSI)
European Geosciences Union
Nederlandse Vereniging voor Ruimtevaart

Aard Keimpema
Nederlandse Natuurkundige Vereniging

Huib van Langevelde
International Astronomical Union
European Astronomical Union
International Union of Radio Science (URSI)
Nederlandse Astronomen Club

Zsolt Paragi
Eotvos Lorand Physical Society
Hungarian Astronautical Society
Nederlandse Atronomenclub
International Astronomical Union
Hungarian Astronomical Society

Arpad Szomoru
International Astronomical Union
International Union of Radio Science (URSI)
Nederlandse Astronomen Club

8.7 Meetings attended

8.7.1 Scientific conferences

Mark Kettenis
- EVN Symposium, Cagliari, Italy, 7-11 October 2014

Arpad Szomoru
- The Modern Radio Universe 2013, Bonn, Germany, 22-26 April 2013
- Radiovetenskap och Kommunikation 2013, Stockholm, Sweden, 11-12 November 2013
- XXXI URSI GASS, Beijing, China, 16-23 August 2014
- EVN Symposium, Cagliari, Italy, 7-11 October 2014

Bob Campbell
- 5th European Radio Interferometry School, Dwingeloo, the Netherlands, 9-13 September 2013
- 12th EVN Symposium, Cagliari, Italy, 7-10 October 2014
- 3rd International VLBI Technology Workshop, Groningen, the Netherlands, 10-13 November 2014

Huib van Langevelde
- Lorentz workshop "Locating Astrophysical Transients", Lorentz Center, Leiden, the Netherlands, 13- 17 May 2013
- "The Wonderful Century" – A Symposium for George Miley, Leiden, the Netherlands, 10-11 June 2013
- European Week of Astronomy and Space Science, Turku, Finland, 10 - 13 July 2013
- European Radio Interferometry School, Dwingeloo, the Netherlands, 9 - 13 September 2013
- "Star Formation and Galactic Structure": a Centennial Cruise Honoring Adriaan Blaauw as Cartographer of the Heavens, Groningen, the Netherlands, 7 - 8 April 2014
- Galactic Science with the SKA and its pathfinders, Lorentz Center. Leiden, the Netherlands, 19 - 23 May 2014
- European Week of Astronomy and Space Science, Geneva, Switzerland, 1 - 5 July 2014
- The 12th European VLBI Network Symposium and Users Meeting, Cagliari, Italy 6 - 10 October 2014
- Third International VLBI Technology Workshop, Groningen/Dwingeloo, the Netherlands, 9 - 12 November 2014
- "Perspectives of Very Long Baseline Interferometry at extreme precision" (65th birthday Richard Porcas), Bonn, Germany, 26 - 27 November 2014

Zsolt Paragi
- The Modern Radio Universe, Bonn, Germany, 22-26 April 2013
- Locating Astrophysical Transients, Lorentz Centre, Leiden, the Netherlands (SOC), 13-17 May 2013
- Black Hole (g)Astronomy, Brindisi, Italy, 2-6 September 2013
- European Radio Interferometry School, Dwingeloo, the Netherlands (SOC), 9-13 September 2014

8.7.2 Technical and business meetings

Ivan Agudo
- SKA engineering meeting, Manchester, UK, 6-10 October 2013
- Collaboration meeting, Bonn, Germany, 31 October– 3 November 2013
- Conference, Granada, Spain, 16-24 November 2013
- Bonn-Dwingeloo meeting, Bonn, Germany, 2 December 2013
- SKA Cosmic Magnetism Assessment Workshop, Cheshire, UK, 22-23 January 2014
- Transformational Science with the SKA, Stellenbosch, South Africa, 17-21 February 2014,

- Collaboration visit, Boston, USA, 19-27 May 2014
- Advancing astrophysics with the SKA, Giardi Naxos (Sicily), Italy, 9-13 June 2014
- Collaboration visit, Granada, Spain, 27 June – 11 July 2014
- EVN TOG, Cagliari, Italy, 6 October 2014
- EVN Symposium, Cagliari, Italy, 7-11 October 2014
- Spanish SKA day, Granada, Spain, 24 October 2014
- PhD defence Sol Moline, Granada, Spain, 26 October 2014
- 3rd IVTW, Dwingeloo, the Netherlands, 11 November 2014
- Collaboration visit, Granada, Spain, 7-11 December 2014

Tatiana Bocanegra-Bahamon

- Workshop EGU-IVS, Metsahovi-Helsinki, Finland, 1-4 March 2013
- NAC 2013, Lommel, Belgium, 16 May 2013
- European Planetary Science Congress (ESPC 2013), London, UK, 8-13 September 2013
- European Planetary Science Congress (ESPC 2014), Cascais - Lisbon, Portugal, 7-12 Sept 2014
- Collaboration visit, Shanghai, China, 15 -30 September 2014

Paul Boven

- SKA workshop, Utrecht, Netherlands, 7 March 2013
- SKA SADT-SAT-ALL consortium working visit, Manchester, UK, 9-10 March 2013
- SKA SADT-SAT-ALL consortium working visit, Manchester, UK, 16-23 April 2013
- TERENA Networking Conference, Maastricht, the Netherlands, 3-6 June 2013
- SKA engineering meeting, Manchester, UK, 7-9 October 2013
- SADT-DAT F2F meeting, Manchester, UK, 10-13 October 2013
- GEANT BoD workshop, Copenhagen, Denmark, 5-6 November 2013
- White Rabbit Meeting, Nikhef, Amsterdam, the Netherlands, 20 January 2014
- Gluster Community Event, March 4 2014, Amsterdam, The Netherlands
- TNC2014 - Terena Networking Conference, 19-22 May 2014, Dublin, Ireland
- SKA Engineering Conference, 29 September - 2 October 2014, Fremantle, Australia
- Third International VLBI Technology Workshop, Groningen/Dwingeloo, the Netherlands, 10-13 November 2014

Bob Campbell

- EVN PC meeting, Bologna, Italy, 14 March 2013
- EVN TOG meeting and workshop, Bonn, Germany, 10-12 April 2013
- eVSAG meeting, Leiden, the Netherlands, 16 May 2013
- EVN PC meeting, Gothenburg, Sweden, 2 July 2013
- EVN PC meeting, Granada, Spain, 6 November 2013
- EVN CBD meeting, Dwingeloo, the Netherlands, 12 November 2013
- EVN TOG meeting, Wettzell, Germany, 23-24 January 2014
- RadioNet3 TNA face-to-face meeting, Brussels, Belgium, 13 February 2014
- EVN PC Meeting, Valencia, Spain, 14 March 2014
- EVN PC Meeting, Torun, Poland, 1 July 2014
- JIVE Uniboard Correlator Design Review, Dwingeloo, the Netherlands, 3 September 2014
- EVN TOG meeting, Cagliari, Italy, 5-6 October 2014
- RadioNet3 TNA face-to-face meeting, Brussels, Belgium, 21 October 2014
- EVN PC Meeting, Bologna, Italy, 6 November 2014

Giuseppe Cimo

- MarcoPolo-R Science Workshop, Noordwijk, the Netherlands, 2-4 June 2013
- JUICE Interface Workshop, Noordwijk, the Netherlands, 8-11 July 2013
- EuroPlaNet meeting, London, UK, 9-13 September 2013
- Mars/ESPaCE meeting, Munich, Germany, 30 October 2013

- Horizon2020 meeting, Brussels, Belgium, 28 November 2013
- ESPaCE FP7 meeting, Toulouse, France, 16-17 June 2014
- European Planetary Science Congress (ESPC 2014), Cascais - Lisbon, Portugal, 7-12 Sept 2014
- Third International VLBI Technology Workshop, Groningen/Dwingeloo, the Netherlands, 10-13 November 2014

Dmitry Duev
- QU3 – Quantum Universe Symposium, Groningen, the Netherlands, 27-28 March 2013
- NAC 2013, Lommel, Belgium, 16 May 2013
- ST-GUEST meeting, Noordwijk, the Netherlands, 22 May 2013
- 4th Moscow Solar System Symposium, Moscow, Russia, 14-18 October 2013
- Bonn-Dwingeloo meeting, Bonn, Germany, 2 December 2013
- European Week of Astronomy and Space Science, Genève, Switzerland, 30 June – 4 July 2014
- EVN Symposium, Cagliari, Italy, 7-11 October 2014

Bob Eldering
- Third International VLBI Technology Workshop, Groningen/Dwingeloo, the Netherlands, 10-13 November 2014

Ciriacco Goddi
- ALMA conference, Leiden, the Netherlands, 22-24 January 2013
- EVN TOG, April 10th 2013, Bonn, Germany
- Collaboration meeting, Bonn, Germany, 11 April 2013
- The Modern Radio Universe 2013, 22-26 April 2013, Bonn, Germany
- Conference “A Neopolitan of Masers”, Sydney, Australia, 20-22 May 2013
- Science visits, Perth, Australia, 13 May – 4 June 2013
- Protostars & Planets VI conference, Heidelberg, Germany, 15-20 July 2013
- Scientific working visit, Florence, Italy, 23-27 July 2013
- Bonn-Dwingeloo meeting, Bonn, Germany, 2 December 2013
- Workshop Galactic Science with the SKA, Leiden, the Netherlands, 18-19 May 2014
- NAC 2014, Noordwijkerhout, the Netherlands, 20-21 May 2014
- Working visit CFA Cambridge, Boston, USA, 20-25 July 2014
- AAS workshop Dense Cores, Monterey, USA, 27-30 July 2014
- EVN TOG, Cagliari, Italy, 6 October 2014
- EVN Symposium, Cagliari, Italy, 7-11 October 2014

Leonid Gurvits
- Horizon2020 workshop, Madrid, Spain, 18-19 February 2013
- Meetings on JUICE & Ganymede, RadioAstron & Luna resource, Moscow, Russia, 3-16 March 2013
- Agencies meeting JIV-ERIC, Den Haag, the Netherlands, 14-15 March 2013
- EVN CBD/JIVE Board, Manchester, UK, 15-17 April 2013
- GAIA GOBT – ESPaCE meeting, Paris, France, 13-14 May 2013
- Annual ESPaCE meeting, Berlin, Germany, 13 June 2013
- JUICE-ESPaCE meeting, Darmstadt, Germany, 17 June 2013
- RISC and other RadioAstron meetings, Moscow, Russia, 20-26 June 2013
- European Summer School, Puschkino, Russia, 30 June – 7 July 2013
- Working visit St. Petersburg, St. Peterburg, Russia, 8-9 July 2013
- “European Week of Astronomy and Space Science”, Turku, Finland, 10 – 13 July 2013
- Gaia GOBT meeting, Munich, Germany, 18 July2013
- SVLBI workshop, Beijing, China, 14-15 September 2013
- Working visit, Shanghai, China, 16-30 September 2013
- ESPaCE working visit SAT & ASC, Moscow, Russia, 1-8 October 2013

- Symposium “50 years Arecibo Observations”, Arecibo, Puerto Rico, 28-29 October 2013
- Working visit MEX-ExoMars, Puerto Rico, Puerto Rico, 30 October 2013
- ESPaCE/MEX coordination meeting, Berlin, Germany, 18 November 2013
- Azorestelescope in-situ inspection & MEX colloquium, Porta Delgada, Portugal, 22-23 November 2013
- MEX/Gaia VLBI obs. Campaign, Bonn, Germany, 1 December 2013
- Bonn-Dwingeloo meeting, Bonn, Germany, 2 December 2013
- Gaia/ExoMars observing, Pasadena, Arecibo, Puerto Rico, 5-21 December 2013
- EuroPlaNet Horizon2020 meeting, London, UK, 8-9 January 2014
- ESPaCE annual & mid-term meetings, Paris, France, 15-18 January 2014
- CAS-ESA-EC meeting, Chengdu, China, 24-28 February 2014
- Working visit, Shanghai, China, 1-7 March 2014
- EVN Board, Onsala, Sweden, 12-13 May 2014
- JIVE Board, Gothenborg, Sweden, 14 May 2014
- Working visit, Gothenborg, Sweden, 15 May 2014
- Gaia tracking meeting, Liverpool, UK, 22-23 May 2014
- COSPAR Sci Assembly, RadioAstron RISC & WG meetings, Moscow, Russia, 1-12 August 2014
- URSI GASS Beijing, Beijing, China, 17-22 August 2014
- Collaboration activities Shanghai, Shanghai, China, 23-30 August 2014
- IAU symposium 313, Galapagos Islands, Ecuador, 12-22 September 2014
- CAS-ESA meeting, Copenhagen, Denmark, 23 September 2014
- EVN CBD, Bologna, Italy, 4-5 November 2014
- JIVE Board meeting, Bologna, Italy, 6-7 November 2014
- “Perspectives of Very Long Baseline Interferometry at extreme precision (65th birthday Richard Porcas)”, Bonn, Germany, 26 – 27 November 2014

Jonathan Hargreaves
- SKA engineering meeting, Manchester, UK, 6-11 October 2013
- Altera A10 Transceivers and JNEye, Antwerp, Belgium, 20 May 2014
- Third International VLBI Technology Workshop, Groningen/Dwingeloo, the Netherlands, 10-13 November 2014

Aard Keimpema
- EVN TOG, Wettzell, Germany, 23th January 2014
- 8th Annual DiFX Users and Developers Meeting, 3-7 November 2014, Bologna, Italy
- Third International VLBI Technology Workshop, Groningen/Dwingeloo, the Netherlands, 10-13 November 2014
- Bonn-Dwingeloo meeting, Bonn, Germany, 2 December 2013

Harro Verkouter
- EVN TOG, Bonn, Germany, 10 April 2013
- 2nd IVTW, Seogwipo, S. Korea, 10-12 October 2013
- EVN TOG, Wettzell, Germany, 23 January 2014
- 8th IVS General Meeting, Shanghai, China, 2-7 March 2014
- EVN TOG, Cagliari, Italy, 6 October 2014
- Third International VLBI Technology Workshop, Groningen/Dwingeloo, the Netherlands, 10-13 November 2014
- Bonn-Dwingeloo meeting, Bonn, Germany, 2 December 2013

Mark Kettenis
- HILADO Face-to-Face meeting, University of Oxford, UK, 11-12 April 2013
- eVSAG meeting, Leiden, the Netherlands, 16 May 2013
- 2nd International VLBI Technology Workshop, Seogwipo, S. Korea, 10-12 October 2013

- 7th Annual DiFX Users and Developers Meeting, Tamna, S. Korea, 14-18 October 2013
- Bonn-Dwingeloo meeting, Bonn, Germany, 2 December 2013
- EVN TOG, Cagliari, Italy, 6 October 2014
- 8th Annual DiFX Users and Developers Meeting, Bologna, Italy, 3-7 November 2014
- Third International VLBI Technology Workshop, Groningen/Dwingeloo, the Netherlands, 10-13 November 2014

Huib van Langevelde
- ASAC face-to-face meeting, Tokyo, Japan, 12 – 17 February 2013
- Review LOFAR BlueGene successor, Dwingeloo, the Netherlands, 28 February 2013
- Global science/e-Infrastructure consultation, Brussels, Belgium, 4-7 March 2013
- Agencies meeting JIV-ERIC, Den Haag, Netherlands, 14-15 March 2013
- RadioNet Board meeting, Bologna, Italy, 17-19 March 2013
- DANTE Orientplus event, London, UK, 11-14 April 2013
- EVN CBD/JIVE Board, Manchester, UK, 15-17 April 2013
- ESAC, Garching, Munich, Germany, 21-22 April 2013
- JIV-ERIC meeting, Schiphol, the Netherlands, 12 June 2013,
- AERAP, Brussels, Belgium, 17-18 June 2013
- NOVA career dag, Dalfsen, the Netherlands, 6 July 2013,
- NEXPReS review, Dwingeloo, the Netherlands, 18-19 September 2013
- Sardinia Radio Telescope dedication, Cagliari, Italy, 29 September – 1 October 2013
- SKA engineering meeting, Manchester, UK, 7-8 October 2013
- ASAC meeting, Edinburgh, UK, 8-11 October 2013
- QueSERA meeting, Brussels, Belgium, 13-15 October 2013
- Lorentz Astronomy Board meeting, Leiden, the Netherlands, 16 October 2013
- ESAC, Garching, Germany, 20-21 October 2013
- SKA NL klankboard, Schiphol, the Netherlands, 23 October 2013,
- AERAP workshop, Brussels, Belgium, 3-5 November 2013
- SKA Cradle-of-Life, SWG Science Team get-together, Jodrell Bank, UK, 5-7 Nov 2013
- EVN CBD + JIVE board, Dwingeloo, the Netherlands, 12-13 November 2013
- European Radio Astronomy Governance platform, Schiphol, the Netherlands, 14 Nov 2013
- RadioNet3 review, Bonn, Germany, 17-19 November 2013
- Copori, Brussel, Belgium, 4-5 December 2013
- ASAC meeting/working visit, Calama, Santiago, Chile, 26 January – 3 February 2014
- Info days on Horizon2020, Brussels, Belgium, 12-14 February 2014
- ALMA band 2/3 Final review meeting, Garching, Germany, 6-7 March 2014
- RadioNet3 Board meeting, Garching, Germany, 19-21 March 2014
- EVN Board, Onsala, Sweden, 12-13 May 2014
- JIVE Board, Gothenborg, Sweden, 14 May 2014
- ASTERICS definition meeting, Schiphol, the Netherlands, 2 June 2014
- 1st ERIC network meeting, Brussels, Belgium, 12-13 June 2014
- ESAC, Garching, Germany, 19-20 October 2014
- RadioNet Executive and QueSERA study group meeting, Brussels, Belgium, 22-24 October 2014
- EVN CBD, Bologna, Italy, 4-5 November 2014
- JIVE Board meeting, Bologna, Italy, 6-7 November 2014
- Second ERIC Network meeting, Trieste, Italy, 9-11 December 2014

Martin Leeuwinga
- EVN TOG meeting and workshop, Bonn, Germany, 10-12 April 2013
- EVN TOG meeting, Wettzell, Germany, 23-24 January 2014
- EVN TOG, 6 October 2014, Cagliari, Italy

Guifre Molera

- Working visit, Metsahovi, Finland, 27 February – 12 March 2013
- Workshop EGU-IVS, Helsinki, Finland, 1-4 March 2013
- NAC 2013, Lommel, Belgium, 16 May 2013
- International Venus workshop, Catania, Italy, 8-15 June 2013
- "European Week of Astronomy and Space Science", Turku, Finland, 10 – 13 July 2013
- CASES meeting & IPS workshop, Nagoya, Japan, 17-24 November 2013
- EVN TOG, 6 October 2014, Cagliari, Italy
- EVN Symposium, Cagliari, Italy, 7-11 October 2014
- Third International VLBI Technology Workshop, Groningen/Dwingeloo, the Netherlands, 10-13 November 2014

Zsolt Paragi
- Synergy meeting, Bonn, Germany, 11 April 2013
- 2nd International VLBI Technology Workshop, Jeju Island, South Korea (invited), 10-12 October 2013
- Black holes, jets and outflows, Kathmandu, Nepal (invited), 14-18 October 2013
- AERAP 3rd implementation workshop, Brussels, Belgium, 4 November 2013
- The Radio Universe Ger fest, Groningen, the Netherlands, 4-7 November 2013
- Bonn-Dwingeloo Neighbourhood Meeting, MPIfR Bonn, Germany, 2 December 2013
- Science Assessment Workshop, SKA HQ, Jodrell Bank, United Kingdom, 27-28 January 2014
- Transformational Science with the SKA, Stellenbosch, South Africa, 17-21 February 2014
- Binary AGN meeting at ISSI, Bern, Switzerland, 17-20 March 2014
- ULXs – Implications for our View of the Universe, Lorentz Centre, Leiden, The Netherlands, 31 March - 4 April 2014
- Advancing Astrophysics with the SKA, Giardini Naxos, Sicily, Italy, 9-13 June 2014
- 12th EVN Symposium & Users Meeting, Cagliari, Italy, 7-10 October 2014
- NL jets and accretion meeting (NOVA NW3), Nijmegen, the Netherlands, 22 October 2014
- Third International VLBI Technology Workshop, Groningen/Dwingeloo, the Netherlands, 10-13 November 2014
- Duel-AGN meeting at ISSI, Bern, Switzerland, 25-27 November 2014

Sergei Pogrebenko
- GAIA GOBT meeting, Paris, France, 13-14 May 2013
- STE-QUEST meeting, Noordwijk, the Netherlands, 22 May 2013
- JUICE WG1 meeting, Darmstadt, Germany, 16-17 June 2013
- ESPaCE meeting on Phobos fly-by, Munich, Germany, 30 October 2013
- Collaboration visit, Shanghai, China, 21 October – 1 November 2014
- Third International VLBI Technology Workshop, Groningen/Dwingeloo, the Netherlands, 10-13 November 2014

Aukelien van den Poll
- RadioNet management meeting, Bonn, Germany, 14-15 February 2013
- RadioNet Board meeting, Bologna, Italy, 17-19 March 2013
- RadioNet management meeting, Bonn, Germany, 2 July 2013
- RadioNet management meeting, Bonn, Germany, 22 August 2013
- RadioNet Mid-Term Review, Bonn, Germany, 17-19 November 2013
- RadioNet QueSERA outreach meeting, Bonn, Germany, 11 February 2014
- RadioNet TNA f2f meeting, Brussels, Belgium, 12 February 2014
- Workshop "Getting ready for Horizon2020", London, UK, 4-5 March 2014
- RadioNet3 Board meeting, Garching, Germany, 19-21 March 2014
- 1st ERIC network meeting, Brussels, Belgium, 12-13 June 2014
- TNA f2f meeting, Brussels, Belgium, 21 October 2014
- RadioNet Exec meeting, Brussels, Belgium, 23 October 2014

- RadioNet QueSERA outreach meeting, Madrid, Spain, 9 December 2014

Des Small
- HILADO Face-to-Face meeting, University of Oxford, UK, 11-12 April 2013
- Third International VLBI Technology Workshop, Groningen/Dwingeloo, the Netherlands, 10-13 November 2014
- HILADO working visit, Univeristy of Cambridge, UK, 1-4 December 2014

Gabriele Surcis
- Third International VLBI Technology Workshop, Groningen/Dwingeloo, the Netherlands, 10-13 November 2014
- International Symposium on Molecular SpectroscopyChampaign-Urbana (Chicago), USA, 16-20 June 2014
- EVN Symposium, Cagliari, Italy, 7-11 October 2014

Arpad Szomoru
- Digital platform study group meeting, Vancouver, Canada, 6-8 March 2013
- RadioNet3 board meeting, Bologna, Italy, 17-19 March 2013
- EVN TOG, Bonn, Germany, 10-12 April 2013
- Radio Interference in Large Bandwidth Observations, Bonn, Germany, 9-12 April 2013
- eVSAG meeting Leiden, the Netherlands, 16 June 2013
- Visit by Altera representatives, Dwingeloo, the Netherlands, 3 May 2013
- UniBoard^2 kickoff meeting, Dwingeloo, the Netherlands, 27-28 May 2013
- Arnold van Ardenne's retirement seminar, Dwingeloo, the Netherlands, 29 May 2013
- Visit to Avnet Silica, Breda, the Netherlands, June 2013
- NEXPReS period 3 review, Dwingeloo, the Netherlands, 19 September 2013
- 2nd International VLBI Technology Workshop, Seogwipo, South Korea, 10-12 October 2013
- Shanghai Astronomical Observatory, Shanghai, China, 15 October 2013
- GEANT IUAC meeting, Cambridge, United Kingdom, 5 November 2013
- RadioNet Mid-Term Review, Bonn, Germany, 17-19 November 2013
- Bonn-Dwingeloo meeting, Bonn, Germany, 2 December 2013
- EVN TOG, Wettzell, Germany, 23-24 January 2014
- White Rabbit discussion meeting, NIKHEF, Amsterdam, the Netherlands, 20 January 2014
- Information Days on Horizon 2020 Research Infrastructures Work Programme 2014-2015, 13-14 February 2014, Brussels, Belgium
- Transformational Science with the SKA, Stellenbosch, South Africa, 17-21 February 2014
- Copernicus Big Data workshop, Brussels, Belgium, 13-14 March 2014
- RadioNet3 board meeting, Garching, Germany, 20 March 2014
- ASTERICS f2f meeting, Jodrell Bank, United Kingdom, 16 April 2014
- GEANT IUAC meeting, Frascati, Italy, 29-30 April 2014
- ASTERICS fsf meeting, Paris, France, 6 May 2014
- EVN CBD meeting, Onsala, Sweden, 12-13 May 2014
- ELIXIR BioMedBridges workshop, Hinxton, UK, 16 May 2014
- Visit by Altera representatives, Dwingeloo, the Netherlands, 20 May 2014
- ASTERICS meeting, Schiphol, Netherlands, 2 June 2014
- Black Hole Cam meeting, Bonn, Germany, 16 June 2014
- ASTERICS meeting at SurfNet, Utrecht Netherlands, 27 June 2014
- High Performance Computing Workshop, Valletta, Malta, October 2014
- EVN TOG, Cagliari, Italy, 6 October 2014
- RadioNet3 executive meeting, Brussels, Belgium, 23 October 2014
- EVN CBD, Bologna, Italy, 5 November 2014
- 3rd International VLBI Technology Workshop, Groningen, the Netherlands, 10-13 November 2014
- GEANT IUAC meeting, CERN, Geneva, Switzerland, 2-3 December 2014

Hans Tenkink

- EVN TOG meeting and workshop, Bonn, Germany, 10-12 April 2013
- EVN TOG, Cagliari, Italy, 6 October 2014

Jun Yang

- EVN TOG meeting and workshop, Bonn, Germany, 10-12 April 2013
- The Modern Radio Universe 2013, Bonn, Germany, 22-26 April 2013
- Calibration of Multi-Beam Receivers, Bologna, Italy, 28-29 October 2013

Charles Yun

- Infrastructures meeting, Brussels, Belgium, 6 March 2013
- TERENA Networking Conference, Maastricht, the Netherlands, 3-6 June 2013

8.7.3 Working visits and observing trips

Paul Boven

- SKA SADT Face-to-Face meeting, SKAO, Jodrell Bank Observatory, UK, 3-6 June 2014
- MRO Site Visit, Murchinson Radio Observatory, Australia, 3 October 2014
- SKA SADT Face-to-Face meeting, Perth, Australia, 4-7 October 2014

Aard Keimpema

- Working visit, Bonn, Germany, 29-30 October 2013

Mark Kettenis

- HILADO working visit, Univeristy of Cambridge, UK, 1-4 December 2014

Bob Campbell

- U.S. Naval Academy, 18 November 2013
- Haystack Observatory, 2 December 2014

Huib van Langevelde:

- NRAO AOC, Socorro NM, USA, 8 - 12 July 2011
- High Field Magnet Laboratory (part of EMFL), Nijmegen, the Netherlands, 2 - 9 September and 19 - 21 September 2014

Tatiana Bocanegra-Bahamon

- Working visit, Metsahovi-Helsinki, Finland, 5 March 2013

8.8 Educational responsibilities

MSc project supervised
T.M. Bocanegra Bahamon – by L.I. Gurvits, TU Delft (completion in 2015)
L. H. Quiroga Nuñez – by H.J. van Langevelde, University of Leiden (completion in 2015)

Secondary affiliations:
Huib van Langevelde – affiliated with Leiden University
Leonid Gurvits – affiliated with Delft University of Technology and Ventspils University Colleg
Dmitry Duev – affiliated with Sternberg Astronomical Institute
Tatiana Bocanegra Bahamon – affiliated with Shanghai Astronomical Observatory

8.9 Correlator activity

All project action in the 010113 - 311213 period:

FP003	081109	Campbell	TEST	(040411)	(040411)	100113	Campbell
RO004A	060612	Orienti	USER	(310712)	(310712)	070113	Surcis
EG049E	050612	Giroletti	USER	(030812)	(140812)	070113	Surcis
EY018B	310512	Yang	USER	(160812)	(200912)	070113	Yang
EY015C	140612	CHEN	USER	(220812)	(100912)	070113	Yang
EE008D	070612	Etoka	USER	(230812)	(240912)	070113	Surcis
GF018B	130612	Fenech	USER	(300812)	(040912)	070113	Campbell
EP075C	040612	Perez-Torres	USER	(210912)	(250912)	070113	Pidopryhora/Campbell
EP075D	140612	Perez-Torres	USER	(250912)	(270912)	070113	Pidopryhora/Campbell
EO011A	041212	OBrien	USER	(051212)	(071212)	070113	Paragi
EG069A	051212	Gawronski	USER	(051212)	(071212)	070113	Paragi
EG066B	201012	Giroletti	USER	(061212)	110213	080313	Surcis
RM009A	071112	McHardy	USER	(111212)	080213	080313	Yang
RM009B	081112	McHardy	USER	(121212)	080213	080313	Yang
EG066C	211012	Giroletti	USER	(131212)	110213	080313	Surcis
EG066E	271012	Giroletti	USER	(131212)	050313	290313	Surcis
EG066F	281012	Giroletti	USER	(141212)	050313	290313	Surcis
ES070	191012	A.Shulevski	USER	(171212)	300113	080313	Surcis
ED039	241012	Deane	USER	(191212)	020413	160413	Duev
EE009A	211012	Eisenacher	USER	020113	020413	160413	Duev/Campbell
EO009	181012	Oonk	USER	020113	250313	080413	Campbell
EE009D	071112	Eisenacher	USER	030113	020413	160413	Duev/Yang
EE009B	291012	Eisenacher	USER	040113	020413	160413	Duev
EE009C	011112	Eisenacher	USER	040113	020413	160413	Duev
EG062A	291012	Guirado	USER	070113	260213	290313	Campbell
EA051	231012	Argo	USER	080113	110213	080313	Yang
ES069D	051112	Surcis	ABAN	080113	200213	200213	Surcis
ER030	021112	Romero-Canizales	USER	090113	010313	290313	Campbell
N12X3	011112	YANG	NME	100113	130213	080313	Yang
N12L3	181012	YANG	NME	100113	110213	080313	Yang
N12K4	061112	YANG	NME	110113	140213	080313	Yang
N12C3	261012	Surcis	NME	110113	210113	080313	Surcis
N12C4	281012	Surcis	NME	140113	230113	080313	Surcis
N12M2	021112	Surcis	NME	140113	070213	080313	Surcis
EO011B	150113	OBrien	USER	150113	170113	170113	Paragi
RSP07	150113	Perez-Torres	USER	150113	170113	170113	Paragi
EG063C	150113	Giroletti	USER	160113	170113	170113	Paragi
RSF07	160113	Frey	USER	160113	170113	170113	Paragi
RO004B	061112	Orienti	USER	170113	080213	080313	Surcis
ET016A	071112	Tarchi	USER	180113	290313	150413	Goddi
ES069A	041112	Surcis	USER	210113	200213	080313	Surcis

ES069B	041112	Surcis	USER	210113	200213	080313	Surcis
ES069C	041112	Surcis	USER	210113	200213	080313	Surcis
GM070	211012	McKean	USER	250113	070213	080313	Yang
ET016B	081112	Tarchi	USER	280113	290313	150413	Goddi
EY015D	241012	CHEN	USER	290113	070213	080313	Yang
EP075E	311012	Perez-Torres	USER	300113	260313	090413	Campbell
F12C2	261012	Surcis	ABAN	010213	010213	010213	Surcis
EK033A	281012	Kunert-Bajraszewska	USER	010213	250313	080413	Yang
EP076C	251012	Perez-Torres	USER	050213	220313	050413	Campbell
FT006	060213	Schoenmaker	TEST	060213	130213	130213	
EG069B	060213	Gawronski	USER	060213	190213	080313	Yang
EM099A	031112	Moscadelli	USER	140213	130313	290313	Goddi/Campbell
EM099B	031112	Moscadelli	USER	150213	060313	290313	Goddi
EP076D	301012	Perez-Torres	USER	210213	220313	050413	Campbell
ES068A	220213	Spencer	USER	220213	250213	080313	Paragi
ES068B	230213	Spencer	USER	230213	250213	080313	Paragi
FR015B	040313	Surcis	TEST	040313	170413	260413	
ET027	190313	Tudose	USER	190313	260313	260313	Paragi
EG069C	190313	Gawronski	USER	190313	260313	260313	Paragi
EM101B	200313	Miller-Jones	USER	200313	260313	260313	Paragi
RSP08	190313	Perez-Torres	USER	200313	260313	260313	Paragi
EG062B	301012	Guirado	USER	290313	290313	150413	Campbell
TE108	120413	JIVE	TEST	120413	170413	180413	Paragi
RSP08B	160413	Perez-Torres	USER	160413	180413	220413	Paragi
EG070A	160413	Gabanyi	USER	160413	180413	220413	Paragi
EL043A	160413	Lico	USER	170413	180413	220413	Paragi
RSG05	030513	Gitti	USER	030513	070513	260613	Paragi
RSL02	030513	Lobanov	USER	030513	060513	260613	Paragi
EG069D	020513	Gawronski	USER	030513	070513	200913	Paragi
EG063D	020513	Giroletti	USER	030513	070513	260613	Paragi
RP019	030513	Paragi	USER	040513	060513	260613	Paragi
ED039B	130313	Deane	USER	080513	110613	290713	Duev
ET028	100313	Tseng	USER	140513	140613	290713	Yang
N13K1	270213	YANG	NME	150513	030713	290713	Yang
EM100A	110313	Mezcua	USER	160513	020713	290713	Surcis
EM100C	120313	Mezcua	USER	170513	220713	090813	Duev
EM100B	120313	Mezcua	USER	220513	050713	290713	Duev
EM100E	140313	Mezcua	USER	230513	220713	090813	Duev
EM100D	140313	Mezcua	USER	230513	220713	090813	Duev
EP087A	250213	Perez-Torres	USER	270513	240713	090813	Campbell
N13C1	250213	Surcis	NME	280513	180713	090813	Surcis
N13X1	060313	YANG	NME	290513	140613	290713	Duev
F13C2	210213	YANG	NME	300513	240713	090813	Yang
RL005	240313	Lobanov	USER	300513	040613	290713	Campbell
N13L1	110313	Goddi	NME	310513	120713	290713	Goddi
EP087C	130313	Perez-Torres	USER	310513	060813	190813	Campbell

N13M1	280213	Surcis	NME	030613	070613	290713	Surcis
EP087B	070313	Perez-Torres	USER	040613	230713	090813	Campbell
RY005	070613	Yang	USER	070613	100613	260613	Yang
ET026	060313	Tudose	USER	070613	150713	010813	Yang
EL043B	080613	Lico	USER	090613	270613	270613	Paragi
RO004C	270213	Orienti	USER	120613	030713	290713	Surcis
EG066H	240213	Giroletti	USER	120613	040713	290713	Surcis
EG066G	230213	Giroletti	USER	130613	030713	290713	Surcis
EK033B	210213	Kunert-Bajraszewska	USER	170613	160713	010813	Yang
EG070B	180613	Gabanyi	USER	180613	260613	260613	Paragi
RSC01	180613	Ceglowski	USER	180613	260613	260613	Paragi
EC043	190613	Chemin	USER	190613	250613	260613	Paragi
FR016	190613	Yang	TEST	190613	200613	290713	Yang
EM101C	180613	Miller-Jones	USER	190613	250613	260613	Paragi
ET029A	180613	Tudose	USER	190613	250613	260613	Paragi
EK033C	260213	Kunert-Bajraszewska	USER	200613	160713	010813	Yang
EZ024	270213	Zackrisson	USER	240613	050813	190813	Campbell
EB052B	030313	Bartkiewicz	USER	250613	080713	290713	Goddi
EB052C	040313	Bartkiewicz	USER	250613	080713	290713	Goddi
TE108F	090413		ABAN	250613	250613	250613	
EB052A	020313	Bartkiewicz	USER	250613	080713	290713	Goddi
F13L1	080313	Goddi	ABAN	250613	250613	250613	Goddi
ES071A	010313	Sanna	USER	250613	080713	290713	Surcis
EB052D	050313	Bartkiewicz	USER	260613	120713	290713	Goddi
EY019	250213	Yang	USER	010713	300713	190813	Yang
RP020	150713	Paragi	USER	160713	160713	160713	Paragi
EP085	040613	Paragi	USER	170713	250713	061113	Paragi
N13L2	070613	Goddi	NME	170713	260913	061113	Goddi
F13L2	030613	Duev	NME	170713	060813	061113	Duev
N13C2	240513	Duev	NME	170713	060813	061113	Duev
N13M2	290513	Surcis	NME	190713	290713	061113	Surcis
N13K2	100613	Goddi	NME	190713	310713	311013	Surcis
ER034	120613	Rani	USER	250713	250913	061113	Yang
EM106A	230513	Mezcua	USER	290713	200913	061113	Yang
N13X3	090613	Yang	NME	010813	260913	061113	Yang
EM106B	030613	Mezcua	USER	020813	200913	061113	Yang
EB053A	100613	Bartkiewicz	USER	050813	260913	061113	Goddi
EB053B	110613	Bartkiewicz	USER	060813	200913	061113	Goddi
RO004D	110613	Orienti	USER	070813	080813	061113	Surcis
EF024A	280513	Frey	USER	080813	231013	061113	Agudo
EF024B	040613	Frey	USER	120813	231013	061113	Campbell/Agudo
EG066I	260513	Giroletti	USER	130813	300813	061113	Surcis
ES072C	010613	Surcis	USER	160813	290813	061113	Surcis
EG062D	270513	Guirado	USER	160813	081013	061113	Campbell
ES072D	020613	Surcis	USER	160813	290813	061113	Surcis
EG066J	030613	Giroletti	USER	190813	300813	061113	Surcis

ES072A	300513	Surcis	USER	210813	280813	061113	Surcis
ES072B	310513	Surcis	USER	220813	280813	061113	Surcis
EG062C	230513	Guirado	USER	270813	071013	061113	Campbell
EP075F	260513	Perez-Torres	USER	290813	071113	051213	Campbell/Agudo
RP022	310813	Perez-Torres	USER	310813	020913	061113	Yang
EP075H	090613	Perez-Torres	USER	020913	121113	051213	Agudo
GZ013	050613	Zwaan	USER	040913	031013	051213	Yang/Goddi/Surcis
EG072B	040613	Gizani	USER	100913	101013	061113	Campbell
EG072A	280513	Gizani	USER	130913	081013	061113	Campbell
TE109	160913	Bach	TEST	160913	250913	250913	Szomoru
EM101D	170913	Miller-Jones	USER	170913	200913	200913	Paragi
EG069E	170913	Gawronski	USER	170913	200913	200913	Paragi
TE110	180913	Bach	TEST	180913	250913	250913	Szomoru
EY021A	180913	Yang	USER	180913	200913	200913	Paragi
EP075G	060613	Perez-Torres	USER	240913	111113	051213	Agudo
EG073A	290513	Goddi	USER	260913	251013	051213	Goddi
F13C4	280513	Campbell	TEST	300913			Campbell
F13L3	070613	Campbell	TEST	021013			Campbell
F13K1	120613	Campbell	TEST	041013			Campbell
EG079A	081013	Gabanyi	USER	081013	101013	101013	Goddi
F13C1	210213	Kettenis	TEST	081013			Campbell/Kettenis
F13C3	230513	Surcis	ABAN	081013	081013	081013	Surcis
EY021B	091013	Yang	USER	091013	111113	121113	Yang
EH027A	261013	Hada	USER	261013	011113	061113	Paragi
RR007A	081113	Rushton	USER	081113	191113	051213	Paragi/Yang
RA002	131113	Archibald	USER	131113	191113	051213	Paragi
RR007B	121113	Rushton	USER	131113	191113	051213	Yang
N13X4	041113	Surcis	NME	261113	091213		Surcis
TESTBK	010100		TEST	271113	271113	271113	Kramer
N13P1	021113	Surcis	NME	281113	091213		Surcis
N13L3	271013	Agudo	NME	021213			Agudo
EC042	041113	Chemin	USER	021213	041213		Paragi
EG069F	031213	Gawronski	USER	031213	041213	041213	Paragi
EM101E	031213	Miller-Jones	USER	041213	041213	041213	Paragi
EG082A	031213	Gawronski	USER	041213	041213	041213	Paragi
EI012A	221013	Ibar	USER	091213			Goddi
EA054	301013	Argo	USER	201213			Surcis

All project action in the 010114 - 311214 period:

EM081A	230810	Molera	USER	(060910)	(070910)	170414	Mahmud
EM081C	280311	Molera	USER	(150911)	(160911)	170414	
TE105	180912	Mark-Paul	TEST	(180912)	310314	310314	Kettenis/Campbell
F13C4	280513	Campbell	TEST	(300913)	091114	091114	Campbell
F13L3	070613	Campbell	TEST	(021013)	091114	091114	Campbell
F13K1	120613	Campbell	TEST	(041013)	091114	091114	Campbell
N13X4	041113	Surcis	NME	(261113)	(091213)	190314	Surcis
N13P1	021113	Surcis	NME	(281113)	(091213)	190314	Surcis
EC042	041113	Chemin	USER	(021213)	(041213)	190314	Paragi
N13L3	271013	Agudo	NME	(021213)	200114	190314	Agudo
EI012A	221013	Ibar	USER	(091213)	120314	280314	Goddi
EA054	301013	Argo	USER	(201213)	140114	190314	Surcis
EY020A	211013	Yang	USER	080114	130114	190314	Yang
EI012B	301013	Ibar	USER	090114	200314	020414	Agudo
RO004E	171013	Orienti	USER	100114	270214	190314	Surcis
ER035A	171013	Reynolds	USER	140114	190314	020414	Agudo
EC045	140114	Cseh	USER	150114	160114	160114	Paragi
EP087D	231013	Perez-Torres	USER	200114	250314	020414	Campbell
ER030B	241013	Romero-Canizales	USER	200114	200314	020414	Campbell
EP088A	231013	Perez-Torres	USER	220114	280314	020414	Campbell
EH028A	271013	Hu	USER	230114	260214	190314	Goddi
EP087F	051113	Perez-Torres	USER	280114	250314	020414	Campbell
EP087E	291013	Perez-Torres	USER	280114	260314	020414	Campbell
ER030D	041113	Romero-Canizales	USER	290114	200314	020414	Campbell
RP023A	030214	Perez-Torres	USER	040214	040214	200214	Paragi
F13L5	301013	Goddi	ABAN	050214	050214	050214	Goddi
F13X2	011113	Surcis	ABAN	050214	050214	050214	Surcis
F13L4	241013	Agudo	ABAN	050214	050214	050214	Agudo
F13C5	181013	Yang	ABAN	050214	050214	050214	Yang
F13K2	161013	Goddi	ABAN	050214	050214	050214	Goddi
EP088B	291013	Perez-Torres	USER	060214	310314	020414	Campbell
ER030C	311013	Romero-Canizales	USER	070214	200314	020414	Campbell
RSL03	180214	Lobanov	USER	180214	210214	190314	Duev
RP023B	180214	Perez-Torres	USER	190214	200214	190314	Surcis
EH027C	180214	Hada	USER	190214	200214	190314	Goddi
EF025	210214	Frey	USER	220214	040314	190314	Paragi
GA032A	110314	Agudo	USER	110314	070414	080414	Agudo
EG078A	271013	Garrett	ABAN	120314	120314	120314	niemand
RR009	260314	Rushton	USER	260314	270314	270314	Paragi
EG082B	250314	Gawronski	USER	260314	270314	270314	Paragi
EG079B	250314	Gabanyi	USER	260314	270314	270314	Paragi
N13K3	171013	Agudo	ABAN	270314	270314	270314	Agudo
N13C3	211013	Yang	ABAN	270314	270314	270314	Yang
FR017	070314	Eldering	NME	100414	100414	100414	Eldering

GK047A	090313	Kovalev	USER	110414			Duev
N14L1	260214	Duev	NME	140414	070514	300514	Duev
TE111	150414	Paragi	TEST	150414	180714	180714	Paragi
EV020	150414	vanVelzen	USER	160414	160414	160414	Paragi
N14C1	040314	Agudo	NME	170414	010514	220814	Agudo
N14K1	110314	Goddi	NME	180414	070514	300514	Goddi
N14M1	010314	Surcis	NME	180414	010514	300514	Surcis
F14M1	270214	Surcis	NME	220414	300414	300514	Surcis
F14C1	030314	Goddi	NME	230414	180714	180714	Goddi
RSP09	290414	Perez-Torres	USER	290414	010514	010514	Surcis
RC001	280414	Cseh	USER	290414	010514	010514	Agudo
EG082C	290414	Gawronski	USER	290414	010514	010514	Goddi
EH028B	240214	Hu	USER	150514	110814	250814	Goddi
EG062F	050314	Guirado	USER	150514	140714	300714	Campbell
EP088C	230214	Perez-Torres	USER	200514	240714	110814	Campbell
EV019A	240214	Varenius	USER	220514	180714	110814	Agudo
EG080A	260214	Gitti	USER	230514	180714	220814	Agudo
F14K1	100314	Agudo	ABAN	300514	300514	300514	
F14L1	200214	Duev	ABAN	300514	300514	300514	
EM111	200214	Marcote	USER	020614	270614	300714	Surcis
EP088D	030314	Perez-Torres	USER	030614	210714	110814	Campbell
EA053A	040314	Akiyama	USER	040614	260614	300714	Duev
GP053A	040314	Perez-Torres	USER	050614	180714	110814	Campbell
EG062E	050314	Guirado	USER	060614	140714	300714	Campbell
EA053B	050314	Akiyama	USER	060614	260614	300714	Duev
EA053D	060314	Akiyama	USER	100614	260614	170914	Duev
EA053C	050314	Akiyama	USER	100614	260614	300714	Duev
EA053E	080314	Akiyama	USER	120614	260614	300714	Duev
EV019B	060314	Varenius	USER	170614	170714	110814	Agudo
ES072F	020314	Surcis	USER	180614	140714	300714	Surcis
ES072G	030314	Surcis	USER	180614	140714	300714	Surcis
ES072E	010314	Surcis	USER	180614	110714	300714	Surcis
EG080B	090314	Gitti	USER	200614	080814	220814	Goddi
RR010	240614	Romero	USER	240614	270614	180714	Paragi
EG082D	240614	Gawronski	USER	250614	040714	180714	Paragi
TE112	250614	Paragi	TEST	250614	180714	180714	Paragi
ES071B	280214	Sanna	USER	270614	100714	300714	Surcis/Goddi
N14L2	020614	Duev	NME	240714	210814	191114	Duev
N14P1	160614	Agudo	NME	250714	190814	191114	Agudo
N14C2	100614	Goddi	NME	280714	290814	191114	Goddi
N14K2	170614	Agudo	NME	280714	190814	191114	Surcis
EL051B	110614	E.Liuzzo	USER	010814	110914	091114	Surcis
N14Q1	060614	Agudo	NME	040814	190814	191114	Agudo
N14M2	130614	Surcis	NME	050814	200814	191114	Surcis
EP088F	100614	Perez-Torres	USER	070814	281014	201114	Goddi
EP087H	090614	Perez-Torres	USER	080814	191114	081214	Campbell

EL051A	290514	E.Liuzzo	USER	110814	100914	091114	Surcis
EC048	010614	Caccianiga	USER	120814	221014	201114	Goddi
ES072I	130614	Surcis	USER	140814	170914	091114	Surcis
ES072J	140614	Surcis	USER	140814	170914	091114	Surcis
ES072K	150614	Surcis	USER	140814	180914	091114	Surcis
EL048A	020614	Laine	USER	150814	220914	201114	Duev
EP087G	290514	Perez-Torres	USER	190814	191114	081214	Campbell
EP088E	020614	Perez-Torres	USER	210814	281014	201114	Goddi
F14M2	120614	Surcis	ABAN	220814	220814	220814	Surcis
F14P1	120614	Agudo	ABAN	220814	220814	220814	Agudo
F14L2	290514	Duev	ABAN	220814	220814	220814	Duev
F14C2	090614	GODDI	ABAN	220814	220814	220814	Goddi
EL048B	100614	Laine	USER	260814	220914	201114	Duev
EC044	160614	Cui	USER	030914	260914	091114	Goddi
ER035B	180614	Reynolds	USER	050914	090914	091114	Agudo
ES074A	170614	Surcis	USER	090914	230914	091114	Surcis
EH031	030614	Hada	USER	110914	220914	091114	Duev
ES072H	120614	Surcis	USER	240914	260914	091114	Surcis
GP051A	120614	Pihlstrom	USER	290914			Campbell
FR018	300914	Agudo	TEST	300914	091114	091114	Duev
GP051B	130614	Pihlstrom	USER	300914			Campbell
GP051C	140614	Pihlstrom	USER	071014			Campbell
TE113	081014	Paragi	TEST	081014	091114	091114	Paragi
EC052A	081014	Cseh	USER	091014	141014	141014	Paragi
GP051D	150614	Pihlstrom	USER	101014			Campbell
EM110	260214	Moldon	USER	271014	041114	201114	Campbell
GB075A	070614	Boccardi	USER	031114	011214	181214	Agudo
GA032B	070614	Agudo	USER	071114	011214	181214	Agudo
TE114	181114	Paragi	TEST	181114	181214	181214	Paragi
EC052B	181114	Cseh	USER	191114	201114	201114	Paragi
RSC02	181114	Cui	USER	191114	201114	201114	Paragi
RSP10	021214	Perez-Torres	USER	021214	031214	181214	Paragi
RSG06	021214	Gabanyi	USER	021214	031214	181214	Paragi
TE115	021214	Paragi	TEST	021214	181214	181214	Paragi
EW016	031214	Woo	USER	031214	041214	181214	Paragi

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9 LIST OF ACRONYMS & ABBREVIATIONS

AAS	American Astronomical Society
ABAN	Abandoned
AERAP	African-European Radio Astronomy Platform
AGN	Active Galactic Nuclei
AIPS	Astronomical Image Processing System
ALMA	Atacama Large Millimeter Array
AOC	Array Operations Center
ASAC	ALMA Scientific Advisory Committee
BAL	Broad Absorption Lines
BBC	Baseband Channel
BH	Black Hole
BHC	BlackHoleCam
BHXRB	Black Hole X-Ray Binary
CAS	Chinese Acadamy of Science
CAWSES	Climate And Weather of the Sun-Earth System
CBD	Consortium Board of Directors
CDAS	Chinese Data Acquisition System
CERN	European Organization for Nuclear Research
CFA	Center for Astrophysics
CNES	Centre National d'études spatiales
COSPAR	Committee on Space Research
CSIC	Spanish National Research Council
CSO	Compact Symmetric Objects
DBBC	Digital Base Band Converter
DD	Double Degenerate
DDBC	Digital Baseband Converter
DDC	Digital Down Converter
DDR	Double Data Rate
DIFX	Distributed FX correlator
DLR	German Aerospace Center
DNS	Domain Name System
DSN	Deep Space Network
DVP	DSN VLBI Processor
EAVN	East Asia VLBI Network
EC	European Commission
EGU	European Geoscience Union
EMFL	European Magnetic Field Laboratory
ERC	European Research Council
ERIC	European Research Infrastructure Consortium
ERIS	European Radio Interferometry School
ESA	European Space Agency
ESAC	European Science Advisory Committee
ESPC	European Planetary Science Congress
EU	European Union
EVGA	European VLBI Group for Geodesy and Astrometry
EVN	European VLBI Network
EWASS	European Week of Astronomy and Space Science
FITS	Flexible Image Transport System
FPGA	Field Programmable Gate Array
FS	Field System

GAIA	Global Astrometric Interferometer for Astrophysics
GALA	Ganymede Laser Altimeter
GASS	General Assembly and Scientific Symposium
GBT	Green Bank Telescope
GUI	Graphical User Interface
HFF	Hubble Flanking Fields
HQ	Head Quarters
IAU	International Astronomical Union
ICRF	International Celestial Reference Frame
IRAC	Infrared Array Camera
ISM	Interstellar Medium
ISSI	International Space Science Institute
IUAC	International User Advisory Committee
IVS	International VLBI Service
IVTW	International VLBI Technology Workshop
IVW	Interplanetary Venus Workshop
JBO	Jodrell Bank Observatory
JPL	Jet Propulsion Laboratory
JRA	Joint Research Activity
JUC	JIVE UniBoard Correlator
JUICE	Jupiter Icy Satellites Explorer
JVLA	Jansky Very Large Array
JVN	Japanese VLBI Network
KASI	Korea Astronomy and Space Science Institute
KVN	Korean VLBI Network
LDAP	Lightweight Directory Access Protocol
LIRGI	Luminous InfraRed Galaxy Inventory
LLAGN	Low Luminosity Active Galactic Nuclei
LMXB	Low-Mass X-ray Binary
LO	Local Oscillator
LOC	Local Organizing Committee
LPI	Lunar and Planetary Institute
LSR	Local Standard of Rest
MBH	Massive Black Hole
MEM	Maximum Entropy Method
MEX	Mars Express
MHD	MagnetoHydroDynamic
MIR	Mid-Infrared
MIT	Massachusetts Institute of Technology
MOU	Memorandum of Understanding
MRO	Murchison Radio-astronomy Observatory
MSP	Milli Second Pulsar
MT	Management Team
MYSO	Massive Young Stellar Objects
NA	Networking Activity
NAC	Netherlands Astronomy Conference
NASA	National Aeronautics and Space Administration
NREN	National Research and Education Network
NSO	Netherlands Space Office
OMA	Royal Observatory of Belgium
PI	Principle Investigator
PRIDE	Planetary Radio Interferometry and Doppler Experiment
PSNC	Poznan Supercomputing and Network Center

RDBE	Roach Digital Back End
RFI	Radio Frequency Interference
RISARD	Radio Interferometry Survey of Active Red Dwarfs
RISC	Reduced Instruction Set Computer
SADT	Structured Analysis and Design Technique
SAT	Synchronisation and Timing
SD	Single-Degenerate
SETI	Search for Extraterrestrial Intelligence
SFXC	Software Correlator at JIVE
SKA	Square Kilometre Array
SKAO	SKA Organisation
SMA	Submillimeter Array
SMBH	Supermassive Black Hole
SOC	Science Organising Committee
SRT	Sardinia Radio Telescope
SVLBI	Space VLBI
SWG	Science Working Group
TANAMI	Tracking Active Galactic Nuclei with Austral Milliarcsecond Interferometry
TCP	Transmission Control Protocol
TNA	Trans-National Access
TOG	Technical Operations Group
UDT	UDP-based Data Transfer Protocol
ULIRG	Ultra-Luminous Infrared Galaxy
ULW	Ultra-Long-Wavelength
URSI	International Union of Radio Science
VDIF	VLBI Data Interface Format
VERA	VLBI Exploration of Radio Astrometry
VLA	Very Large Array
VLBA	Very Long Baseline Array
VLBEER	EVN's Central Ancillary Data Server
VLBI	Very Long baseline Interferometry
VTT	Technical Research Centre of Finland
WD	White Dwarf
WG	Working Group
WIDAR	Wideband Interferometric Digital ARchitecture
WP	Work Package
WSRT	Westerbork Synthesis Radio Telescope
YERAC	Young European Radio Astronomy Conference
YSO	Young Stellar Object

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