ANNUAL REPORT 2017

JIVE
Joint Institute for VLBI
ERIC

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The Joint Institute for VLBI ERIC was established by a decision of the European Commission in December 2014, and assumed the activities and responsibilities of the JIVE Foundation, which was established in December 1993. JIVE's mandate is to support the operations and users of the European VLBI Network (EVN), in the widest sense.

In 2017, JIVE had 6 members:

The Netherlands, represented by the Nederlandse Organisatie voor Wetenschappelijk Onderzoek (NWO) and the Netherlands Institute for Radio Astronomy (ASTRON)

France, represented by the Centre National de la Recherche Scientifique (CNRS)

Latvia, represented by Ventspils Augstskola (VeA)

Spain, represented by the Ministerio de Fomento (MF)

Sweden, represented by the Vetenskapsrådet (VR)

The United Kingdom, represented by the Science & Technology Facilities Council (STFC)

JIVE was also supported by the following Participating Research Institutes in 2017:

National Astronomical Observatories of China (NAOC), China

Max Planck Institute for Radio Astronomy (MPIfR), Germany

Italian National Institute of Astrophysics (INAF), Italy

National Research Foundation (NRF), South Africa

Foreword

It is a pleasure to provide this foreword because 2017 marks the start of a new chapter in the continuing success story of JIVE in several ways.

A primary goal of JIVE is to enable and support excellent science with the European VLBI Network (EVN). The successful localisation - at the milliarcsecond level - of the source of radio emission in a (repeating) Fast Radio Burst (FRB) using the EVN telescopes and specially modified software correlation of these data at JIVE is a scientific and technical tour de force for both the EVN and JIVE. The astrophysical implications of this result continue to be explored but equally significant is the way in which this success demonstrates the application of the VLBI technique to the new field of transient astronomy. The growing appetite to capitalise on this opportunity can be seen across the European and international astronomical community. The immediate involvement of JIVE and VLBI in the study of the radio counterpart to the neutron star merger event captured via gravitational waves shows that VLBI will bring crucial information to this brand new field of multi-messenger astronomy. We await new insights, whether from this particular object, or future events where VLBI will surely play an important role.

The depth and quality of support that JIVE provides to the astronomical community to do this and other new science have been strengthened by the trans-national access programme of RadioNet, funded by the EC and commencing at the beginning of 2017 for another four-year period. In addition, the JUMPING JIVE project, initiated and led by JIVE, not only consolidates this fundamental operational and support role but also extends the reach of JIVE and VLBI on a global scale. The initiatives to foster and support VLBI in developing African nations represent a truly unique opportunity to train enthusiastic scientists in these countries, using in some cases high-performance existing satellite communications equipment, in a field of globally cooperative endeavour. JUMPING JIVE is also developing VLBI capabilities at the Square Kilometre Array, ensuring long baselines in SKA1-MID. Through this and the AENEAS project, in which JIVE also plays a role, the role of VLBI in general and JIVE in particular are being strengthened.

Last but not least, 2017 marks the transition to a new director, Dr Francisco (Paco) Colomer takes charge at the beginning of 2018, following Prof. Dr. Huib van Langevelde's decision to step down after ten very successful years. Huib brought his considerable, scientific and organisational skills to JIVE - and used them to foster an extremely professional organisation - which can be rightly proud of every aspect of its business - from supporting users and carrying of the key central functions of the EVN to its relationship with the EC. Huib nurtured a scientific culture where individual scientists could flourish so that JIVE has an internationally recognised and respected scientific profile, and he had a clear technical vision for JIVE, developing key projects in hardware, software, e-VLBI etc. so that JIVE is very much a technical leader and innovator in VLBI. Finally, it was Huib's work with colleagues across Europe and in the EC that culminated in the establishment of JIVE as an ERIC - a long lasting testament to his tenure at JIVE.

It only remains for me, on behalf of the JIVE Council, to wish Paco every success, as he will doubtless continue to build on the strengths of JIVE in this new and exciting era.

Simon Garrington

Chairman of the JIVE Council

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1 Introduction

1.1 JIVE Mission

The Joint Institute for VLBI ERIC (JIVE) was established to support, progress and promote the use of Very Long Baseline Interferometry (VLBI). VLBI is a technique in which radio telescopes hundreds to thousands of kilometres apart observe the same radio source in the sky. The observations from the telescopes are presented as digital signals, which are then combined at a central, dedicated data processor (the correlator). Astronomers can use the resulting data to produce an extremely high resolution image of the radio sky. Alongside making images, the technique can be used to measure positions of bright radio sources with very high accuracy.

In Europe VLBI is organised through the European VLBI Network (EVN), a consortium that also includes members from other continents. JIVE hosts the correlator that provides the central data processing for the EVN and also supports most interactions with the astronomers who use the facility. The EVN is open to any astronomer who can write a competitive observation proposal.

JIVE receives the data from the telescope stations as computer hard disk recordings, or by direct streaming over fibre links (e-VLBI). The JIVE support team verifies the data quality, interacts with the staff at the telescopes if necessary, and provides support to the end user through subsequent processing and analysis if requested (see *6 Operations*).

Calibration data and images from a standard data pipeline are included in the final user product.

In order to keep the EVN and JIVE at the forefront of scientific research, JIVE harbours a team of scientists and engineers, who continually work on the development of new techniques and software to further the scientific capabilities of VLBI (see *3 Research and Development*). The team's primary focus is to investigate new methods to record and transport data, in order to enhance the sensitivity and flexibility of the research infrastructure. Novel data processing techniques and platforms are also explored, and JIVE engineers work on various user interfaces, such as the software that astronomers use to process their data. In addition, there is considerable expertise at JIVE in deploying VLBI for space applications.

Of course, the JIVE staff members also do scientific research themselves in a number of exciting areas, from active galactic nuclei at cosmological distances to star formation in the Galaxy (see *2 Science Highlights*).

Finally, JIVE has a role in the EVN as the central entity in dealing with EC projects (see *7.2 JIVE projects*); as an ERIC, JIVE has a responsibility to catalyse innovation and capacity building for European VLBI.

JIVE staff demonstrating that VLBI is 50 years young!

1.2 JIVE in 2017

In contrast with 2016, when there were considerable constraints on user support and outreach activities, 2017 promised to be a year of new projects and initiatives. As the year began, two important EC projects kicked off that will provide the framework and financial support for JIVE to address some of its major scientific and strategic priorities.

The first project is RadioNet, coordinated by JIVE partner: the Max Planck Institute for Radio Astronomy (MPIfR) in Bonn, Germany - with the first project meeting occurring in January in Berlin, Germany. As with previous RadioNet programmes, JIVE was able to implement adequate user support due to trans-national access funding for the EVN provided by this EC integrating activity. Alongside the training, engineering and science networks that RadioNet helps to maintain, many of the RadioNet activities are also of great relevance to JIVE, for example, the EVN will benefit from a work package on next generation receivers and JIVE contributes directly to a project to provide new data processing tools, notably for fringe fitting VLBI data in the RINGS work package.

The other major project is JUMPING JIVE, for which JIVE is the coordinator. It is an opportunity for the new ERIC to profile itself with its potential partners, the user base and the international radio astronomy community. In practice, it means that JIVE can enhance its effort in outreach, in particular to advocate its relevance for European and global science. It also offers a possibility to address some key operational interfaces that will be important in the foreseen globalisation of VLBI. A highlight this year was the support for the radio astronomy effort in Ghana, where the new station of Nkuntunse delivered its first results.

A number of future astronomy facilities in Europe have been identified as scientific priorities, among which the SKA is the radio astronomy flagship. In this context JIVE continued to contribute to the EC funded ASTERICS effort, pioneering data processing techniques and showcasing, for example, the use of Jupyter (an open source web application) for data handling in the software package CASA. This work also provides interesting links to the science effort on astrophysical transients and the work that JIVE is doing on the distribution of timing signals. Considering this area of expertise, the focus has been on contributing to the SKA consortium responsible for designing the SKA signal and data transport mechanisms. Through SKA-NL JIVE has both aided the development of SKA technology, and promoted the scientific use of VLBI with the SKA. In 2017 the EC-funded AENEAS project, that concerns the future data processing needs of the SKA user community, also started, in which JIVE has a small role.

Transient phenomena were part of the science highlights in the radio astronomy community this year, which began with considerable press attention for the successful localisation of a Fast Radio Burst (FRB) with VLBI precision. The research was presented in a Nature paper with additional VLBI and optical results published simultaneously. Following detections of a special, repeating FRB with Arecibo and later the VLA, tailor-made processing at the JIVE correlator allowed the team to locate the source with VLBI precision in a far away dwarf galaxy; investigations continue to reveal the nature of this phenomenon.

Later during the summer, JIVE also facilitated attempts to observe the radio emission from the first gravitational wave detection of a neutron star – neutron star merger; however, a first detection was not made, yet.

Participants of the first JUMPING JIVE meeting in Leiden.

The team of JIVE and ASTRON scientists involved in the localisation of a special repeating FRB.

1.3 Personnel

With the advent of JUMPING JIVE and the RadioNet project, several new faces joined JIVE. The only person leaving JIVE was Jonathan Hargreaves, who transferred to ASTRON. However, 2017 was the 10th year of Huib van Langevelde in the role of director. As he made the personal decision to step down, preparations started to select a new director. Towards the end of the year it was announced that Francisco "Paco" Colomer, who came earlier in the year from the Spanish National Geographic Institute (IGN) to manage JUMPING JIVE, will be the new director in 2018.

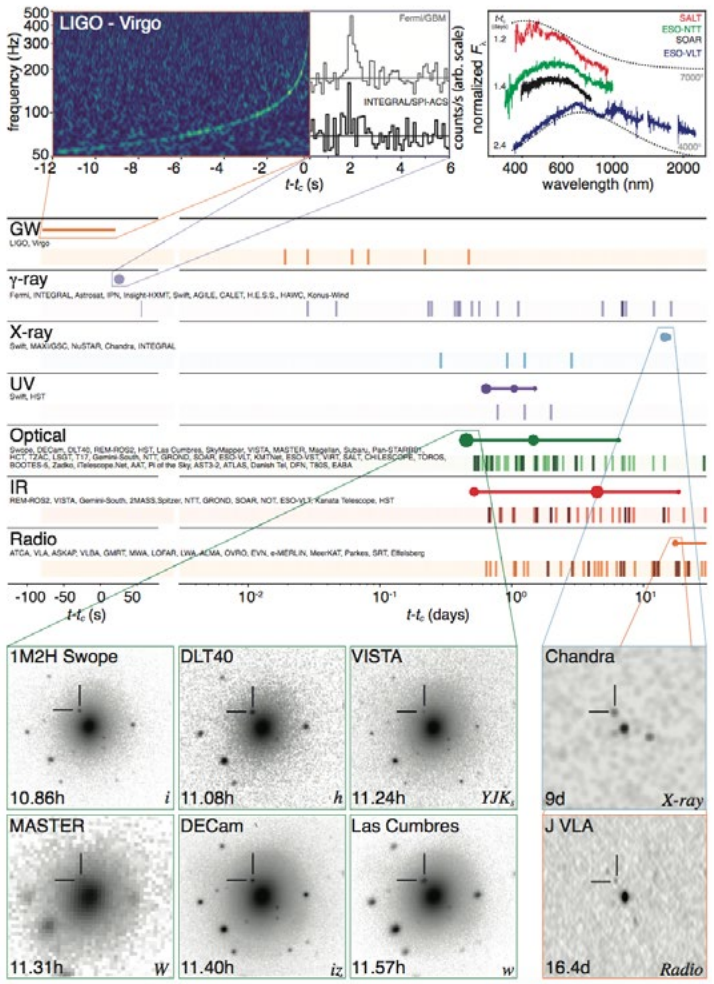
Outgoing JIVE director Huib van Langevelde receives the appreciation of his colleagues in the EVN Consortium Board of Directors.

2 Science Highlights

2.1 Gravitational waves from a merging neutron star binary

On August 17th at 8.41 AM Eastern Daylight Time two identical Laser Interferometer Gravitational-Wave Observatory (LIGO) detectors, located in Hanford, Washington, and Livingston, Louisiana made an initial detection of the gravitational wave signal GW170817. Virgo, situated near Pisa, Italy, also recovered a signal that allowed scientists to precisely triangulate the position of the source in a relatively small patch of the southern sky. At nearly the same time that this detection was made, the Gamma-ray Burst Monitor on NASA's Fermi Space Telescope had detected a burst of gamma rays. The LIGO-Virgo analysis software put the two signals together and saw it was highly unlikely to be a chance coincidence, and another automated LIGO analysis indicated that there was a coincident gravitational wave signal in the other LIGO detector.

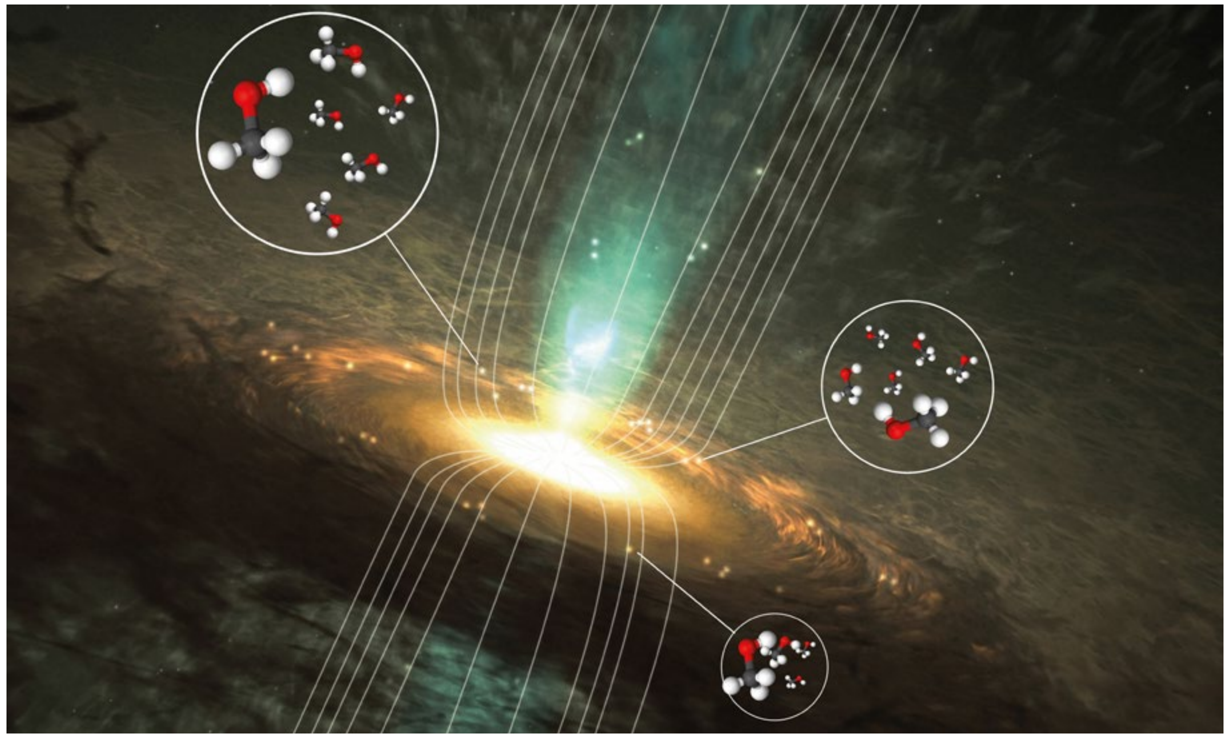
Rapid gravitational-wave detection by the LIGO-Virgo team, coupled with Fermi's gamma-ray detection, enabled the launch of follow-up observations by telescopes all around the world. In this follow up, an optical transient was identified in the galaxy known as NGC4993 - which is located over 130 million light years away from Earth. Galaxy NGC4993 is in the same region of the southern sky that the gravitational wave detection of a faint, transient radio emission was reported by the Jansky Very Large Array (VLA) on September 2nd, 16 days after the initial detection of the gravitational wave signal.



The timeline of the discovery of the gravitational wave event GW170817, the related short gamma-ray burst, and X-ray, optical/near-IR and radio counterparts (Abbott et al. 2017, ApJL, 848, L12).

A collaboration of scientists (the "Euro VLBI group" – an ASTERICS initiative) was formed in 2016 for very high resolution radio interferometry monitoring of gravitational wave events. This group (PI Zsolt Paragi; JIVE members Jay Blanchard, Huib van Langevelde, Benito Marcote, Mark Kettenis and Arpad Szomoru) has extensively monitored the radio emission from the GW170817 signal electromagnetic counterpart with the e-EVN and e-MERLIN. Their initial results were reported in a paper that describes the multi-messenger follow-up efforts, carried out by some 3,600 astronomers all over the world. They have further joined efforts with an Italian collaboration to carry out very sensitive global VLBI observations to observe the GW170817 counterpart near its expected peak of radio emission around February-March 2018.

2.2 Magnetic secrets of methanol around massive stars



The illustration shows the surroundings of a forming massive star, and the bright regions where radio signals from methanol can be found. The bright spots represent methanol masers and the curved lines represent the magnetic field. (Lankhaar et al. 2018, Nature Astronomy, 2, 145).

Credit: Wolfgang Steffen/Chalmers/Boy Lankhaar (molecules: Wikimedia Commons/Ben Mills).

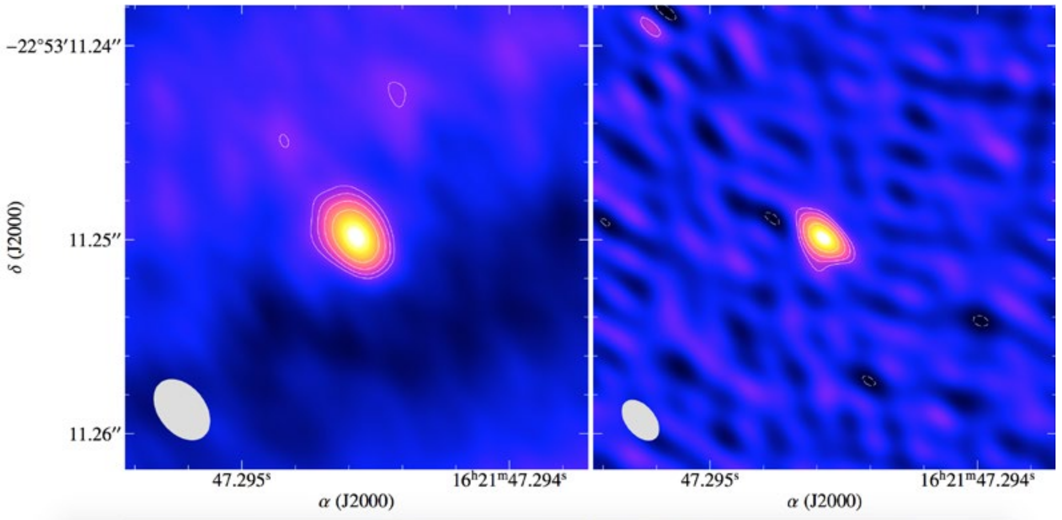
Molecules in the dark, dense clouds of young stellar systems can indicate a lot about the physical conditions of the environments where stars and planets are born. By studying the signature of molecules detected in radio waves it is possible to derive the temperature, pressure and kinematics of gases present. It is however very difficult to measure an important player in star formation, especially in regions where the most massive stars are born: the strength and orientation of magnetic fields. A team of scientists, including Huib van Langevelde from JIVE, has made a fundamental contribution to this important puzzle in astrochemistry: how to measure magnetic fields in space using methanol (CH_3OH), the simplest form of alcohol.

In the dense gas surrounding many newborn stars, methanol molecules shine brightly as natural microwave lasers, or masers. The signals that can be measured from methanol masers are both strong and emitted at very specific frequencies, and their spectrum can change in the presence of magnetic fields through the so-called Zeeman effect. Yet, earlier attempts to calibrate the magnetic properties of methanol in laboratory conditions were met with problems. Therefore, to help to understand how magnetic fields exactly affect these masing sources, a new and detailed theoretical model was derived from the principles of quantum mechanics.

This new insight to methanol masers allows a much deeper interpretation of data collected by radio astronomers, and opens up new possibilities for understanding magnetic fields in the universe. The EVN has been used to make detailed observations of the Zeeman effect, and these new results can inform how these observations should be interpreted in terms of the strength of the magnetic field at the location of the bright masers.

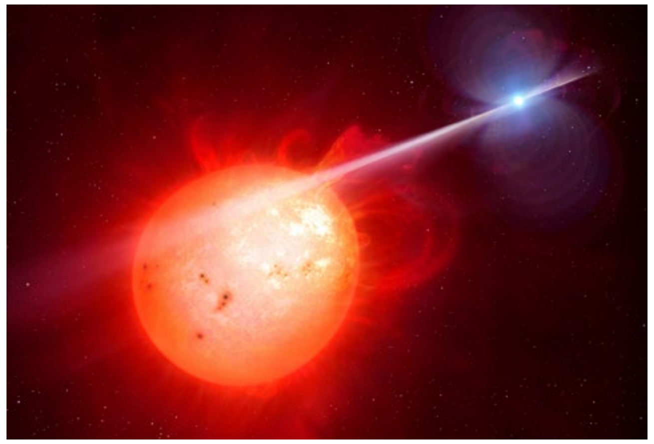
2.3 The first radio pulsing white dwarf binary

Ar Scorpii is a binary stellar system that lies 380 light years away. What makes it special is the composition of the binary: a red and a white dwarf star orbit one another with a period of 3.6 hours. In addition to that, there are strong, regular pulses observed in most of the electromagnetic spectrum (from X-rays to radio) every 1.97 minutes.



Images of AR Sco obtained with the LBA on 20 October 2016 at 8.4 GHz. Left: Image obtained with a natural weighting and no self-calibration. Right: Image obtained with a Briggs robust weighting of zero after self-calibration in phase. (Marcote et al. 2017, Astronomy and Astrophysics, 610, L7).

Similar to neutron star pulsars, the white dwarf component of Ar Scorpii produces collimated beams of light and particles. This beam intercepts the surface of the red dwarf as the white dwarf rotates, and accelerates electrons to speeds close to the speed of light in the atmosphere of the cool companion. The phenomenon, discovered by Tom Marsh and collaborators in 2016, has never been seen in binary stars before.



Artist's impression on the Ar Sco binary system.

Credit: M. Garlick/University of Warwick/ESO.

The origin of the emission was, however, unclear and two competing scenarios were proposed: that the emission is coming from the surface of the red dwarf that is intercepted by the beam launched by the white dwarf, or that it comes from this collimated beam itself. The only direct way to challenge each of these scenarios is to image the system in the radio with very high angular resolution. A team led by Benito Marcote (JIVE) carried out Australian Long Baseline Array (LBA) observations of Ar Scorpii on 20 Oct 2016 at 8.5 GHz, to study the compactness of the radio emission. They have shown that the emission is compact down to spatial scales of ≲0.02 AU, or 4 $R_\odot$. They have also shown that the short timescale variation of the radio emission shows orbital modulation, just like the optical and UV emission. From these results, one can conclude that the radio emission in Ar Scorpii is not produced in an outflow, or in the beam launched away from the system (jet), rather, that it is a consequence of the white dwarf pulsar beam interaction with the atmosphere of the cool companion star.

3 Research and Development

3.1 Data recording and transport

During 2017 the trend from previous years of adding data recorders to the storage pool at JIVE accelerated, with five new FlexBuffs (the EVN-developed Commercial Off-The-Shelf (COTS) based high-capacity data recorders). As 10 TB disks started to become affordable, the capacity of the individual units increased to 250 TB. Some of the early contributing stations also began to consider upgrading their units by replacing the original 4 TB disks with 10 TB disks, using the freed-up disks to populate Mark5 disk packs.

The WSRT is the only EVN station with a dark fibre connecting the telescope to the correlator. Due to this, it is possible to eliminate the need for a local unit and record directly on a JIVE FlexBuff. A digital backend and a FlexBuff were ordered and the complete setup was close to being operational by the end of the year.

All the control code developed in-house, including the jive5ab recording and data transfer program, continued to function smoothly, requiring relatively few bug fixes and upgrades.

3.2 JIVE hardware upgrade

A massive upgrade of the SFXC cluster (the EVN correlator developed at JIVE), as well as a complete overhaul of the local network, was set in motion in early 2017. Following a careful evaluation of various options, a design was completed after the summer, and hardware was procured. The choice was made to purchase three SuperMicro MicroBlades, containing 14 servers each, with 20 2.2GHz cores, 128 GB RAM, 120 GB SSD storage and 2 x 10 G Ethernet on each server. 840 cores were added to the existing 512 cores; while 128 of the oldest existing cores were decommissioned, to prevent them slowing

New correlator and network hardware during installation at JIVE.

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down the correlation. In total, the SFXC cluster now has 1224 cores.

The network was designed around four Mellanox SN2100 16-port 100G/40G switches, connected in pairs. For all machines where it is possible, they are interconnected at two times 10 Gbps, those that cannot interconnect are connected to the old switches, which remain in use. This upgrade means that JIVE is very well prepared for a future with many more stations and higher bandwidths.

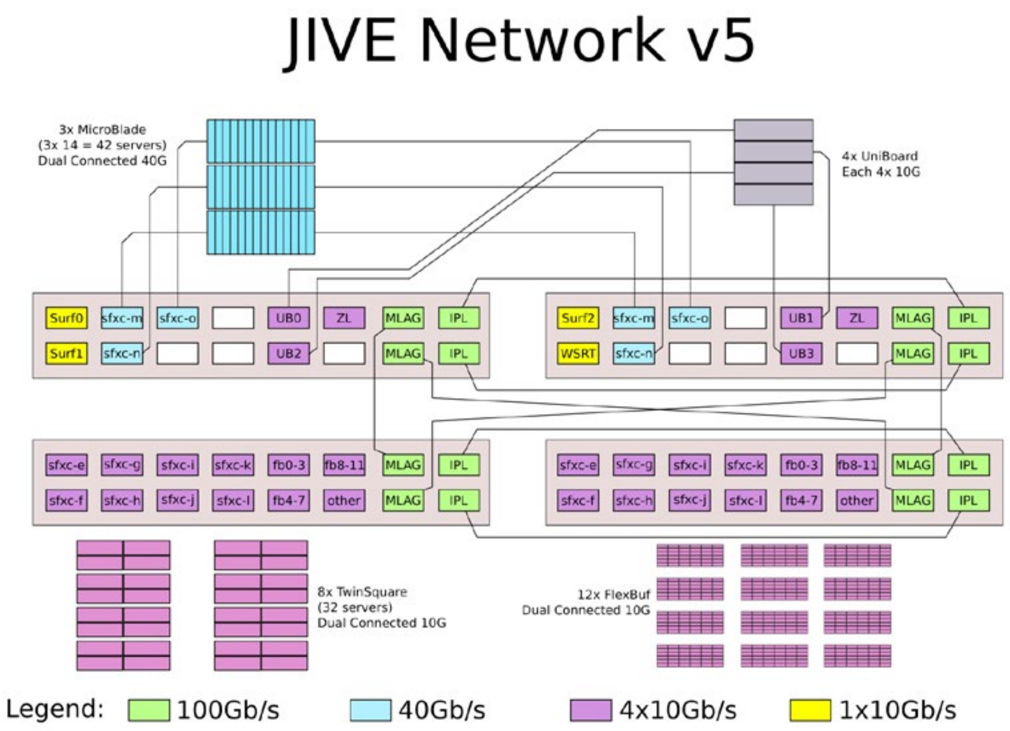


Diagram of the re-designed internal JIVE network.

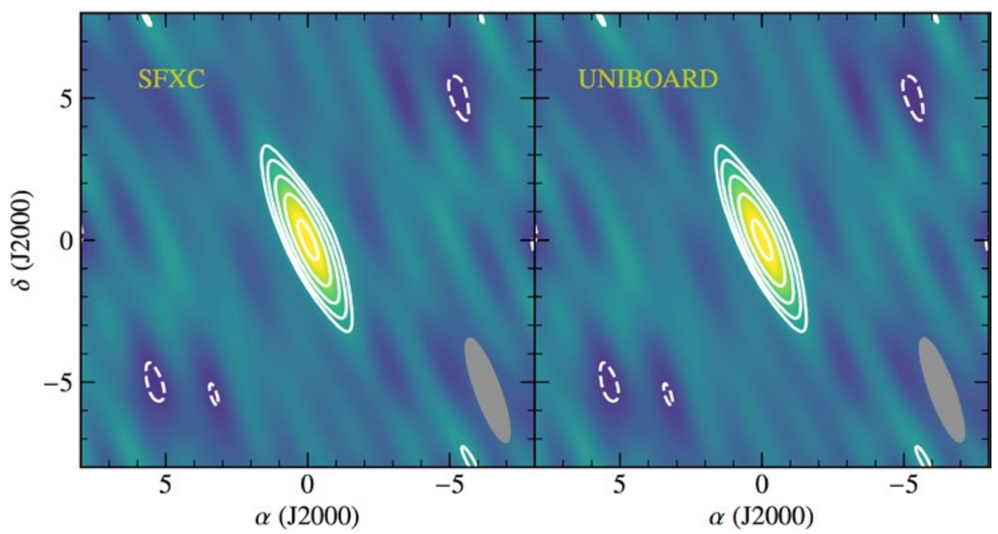
3.3 Software correlation

Development of the features of SFXC continued throughout the year. A Polyphase Filter Bank (PFB) mode was implemented. The advantage of a PFB compared to the default windowed Fast Fourier Transform (FFT) is a much lower spectral leakage and a higher spectral resolution. This in turn gives a major improvement in data quality for spectral line observations. In the context of the JUMPING JIVE project, support for processing geodetic VLBI schedules that use sub-netting was built in. These new features and various bug fixes were published in a new release, SFXC 3.5.

3.4 Hardware correlation and digital engineering

The JIVE UniBoard Correlator (JUC) was tested extensively and results were compared in great detail with the SFXC software correlator. Further improvements were made to the control code and methods were implemented to fine-tune the playback speed, in order to prevent outbursts and packet loss inside the local network. In principle, the JUC is now an operational correlator, capable of correlating 16 stations at a full 4 Gbps, once all four UniBoards are connected through the new network.

As reported last year, it was unclear whether the hardware at the stations could produce data in a mode that would be optimal for real-time correlation with the JUC. Fortunately, after discussions with the hardware designer, it was found that this mode could be accommodated, albeit using quite small data packets. This however meant that the control code, which by necessity had to deal with a sub-optimal data format, had to be re-written to handle properly formatted data packets. At the end of the year this work resulted in a first successful real-time transfer of data from the telescopes to the correlator. As generated test data were used no fringes could be obtained, however the JUC kept up with the real-time processing without any problems.



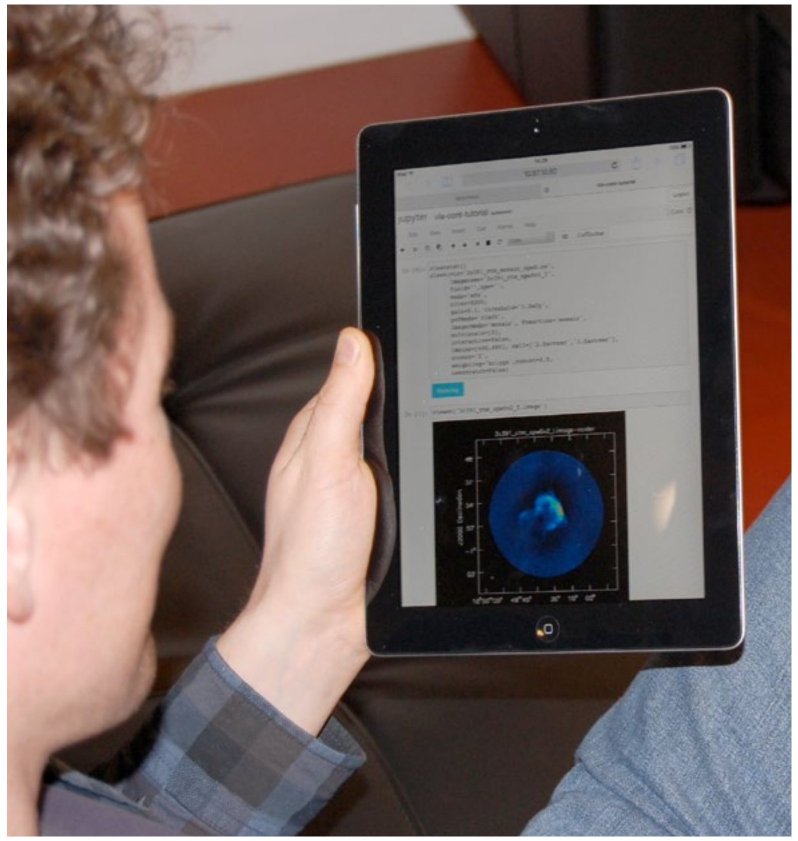
First light with JIVE UniBoard Correlator: single 2.5-min scan of J1955+5131 from a recent EVN observation at 6 cm with seven stations: Effelsberg, Medicina, Noto, Onsala, Tianma, Zelenchukskaya, and Badary, correlated with both SFXC and JUC.

3.5 User software

Work on the CASA VLBI fringe fitter continued, now supported by the RadioNet RINGS work package. A full C++ implementation was created and will be included in the official CASA release 5.3. Two workshops were organised in the fall of 2017, bringing together local and international experts to exercise the new code using data sets from various instruments, like LOFAR, VLBA, EVN, ATCA and ALMA (see *5.1 Events*). For the RINGS project, work also got underway on wide-band and dispersive fringe fitting.

The JIVE effort to enable remote data processing, bringing the computer to the data instead of the other way around, attracted much attention in the field. A Jupyter kernel was created specifically for CASA, which, for ease of deployment, is distributed as both a Singularity and Docker container.

Much work went into the re-factoring of SCHED, the time-honoured scheduling software used by many



Bringing the compute to the data: a Jupyter notebook of the CASA 3C391 VLA continuum tutorial running inside a web browser on a tablet.

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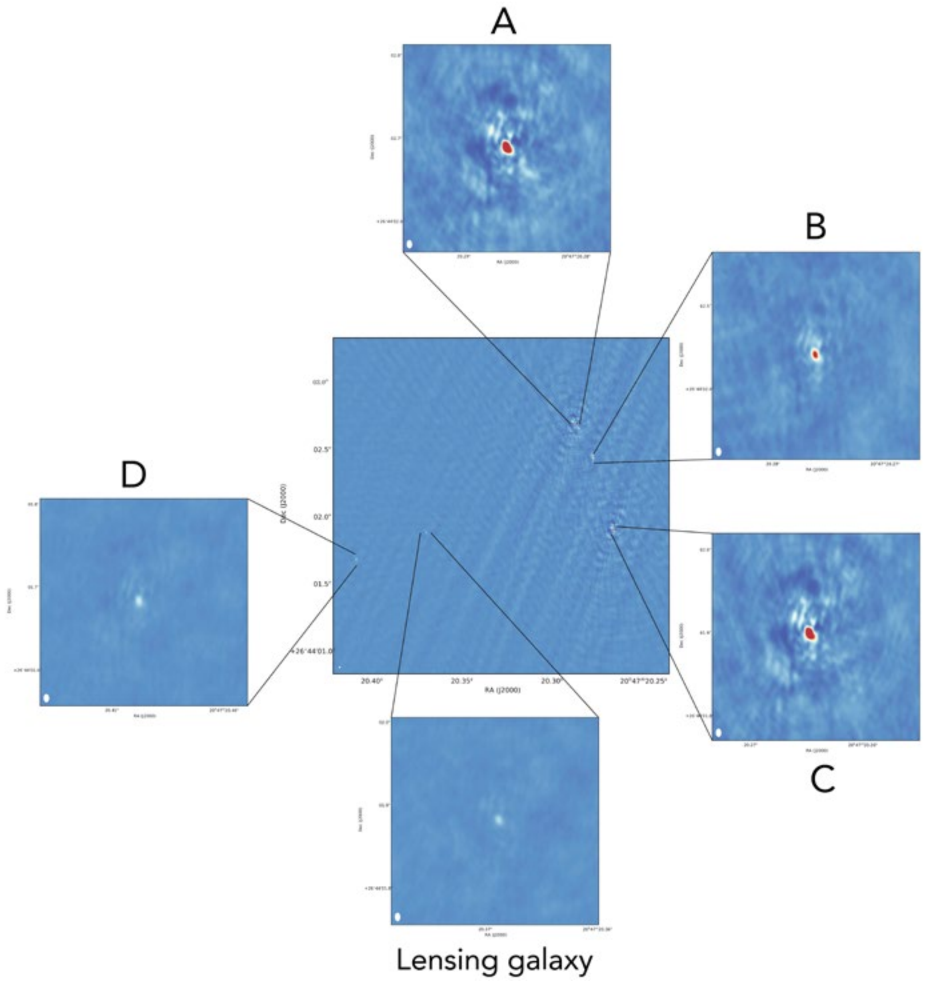
VLBI networks around the world. This code was developed in the eighties and written in Fortran, and is not easy to modify or even to maintain. Enabling Python additions and modifications to the code should help to keep SCHED in sync with the rapid development of new VLBI equipment and observing modes, without the need to re-write the entire code base.



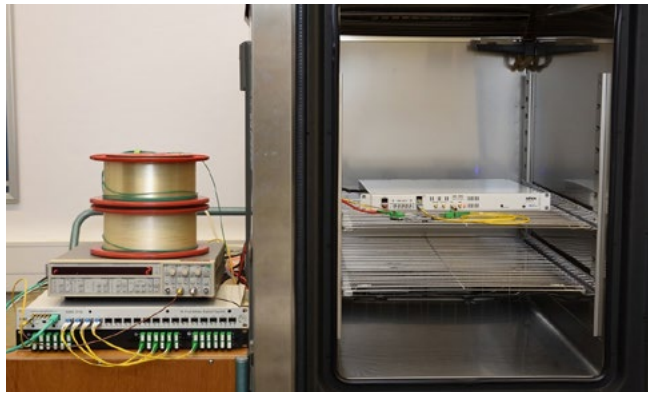
First science image from the CASA VLBI tools: the image is of a gravitational lens with emission from four images of the lensed source (A through D) and from the lensing galaxy. The data were obtained with the VLBA at L-band, in a 12 hour run. The data was amplitude calibrated, phase calibrated with the new fringe fitter, imaged and cleaned fully in CASA.

Credit: Cristiana Spingola, Kapteyn Institute, University of Groningen.

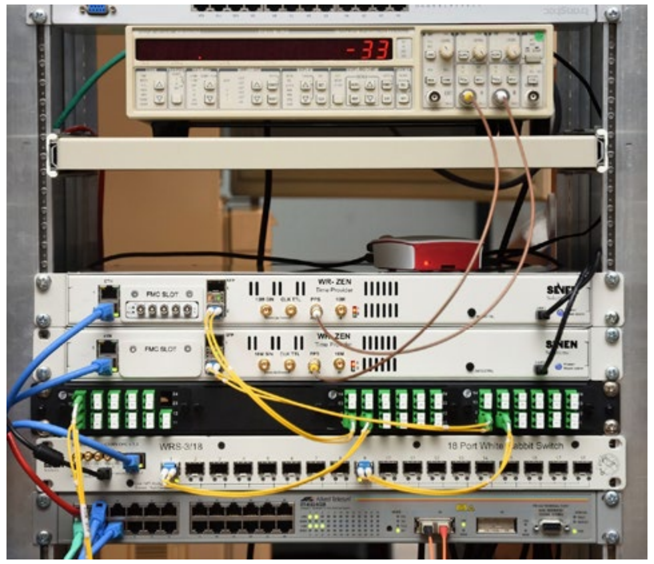
3.6 Contributing to the SKA design

As was the case last year, an important contribution of JIVE to the SKA effort consisted of providing the Synchronisation And Timing (SAT) architect in the Signal and Data Transport (SaDT) consortium. A large effort was made by Paul Boven (and the entire consortium) to finalise the designs and ready SaDT for the Critical Design Review, which will take place in 2018.

Verifying the UTC Distribution design for the SKA required extensive testing, both in the field on long fibre runs, and in the climate chamber and EMI facilities at ASTRON. The result of this effort is a complete description of the systematic and random error contributions on the link performance down to the pico-second level. The model shows that the completed design meets the SKA timing



The White Rabbit distribution switch (in white, on the left) and, underneath it, an enclosure holding wavelength filters. Above the distribution switch are a time interval counter to measure the link performance and two spools of 10km fibre. Inside the climate chamber (on the right) is the White Rabbit end-point, about to experience its first taste of what winter and summer will be like, in rapid succession.



White Rabbit setup at JIVE, used for link performance testing on the fibre connections between Dwingeloo and the Westerbork Radio Synthesis Telescope (adding up to a total distance of 140km).

accuracy requirements, even on the longest links and in the harsh climatic environments of the future SKA sites.

Cristina Garcia-Miro began working as the SKA-VLBI scientist at the SKA headquarters in Jodrell Bank in 2017. This position was established by JIVE and the SKAO under the framework of the EC funded JUMPING JIVE project (under work package 10 – 'VLBI with the SKA'). The main responsibilities of the SKA-VLBI scientist are: to assist with the SKA design process to ensure that all VLBI requirements are fulfilled; to work towards establishing an operational model for SKA-VLBI; and, to support the SKA-VLBI focus group. Cristina Garcia-Miro contributed the VLBI performance aspects during the preparation of an SKA performance document.

In addition, she also initiated the formation of a Resolution Team for SKA1-MID (the first phase mid frequency instrument located in South Africa) to revise the Level 1 VLBI requirements; participated in the revision of the Assumptions for the Level 2 requirements of the Central Signal Processor (the central processing "brain" of the SKA where digitised astronomical signals detected by SKA receivers are converted); and began a full revision of the VLBI Interface Control Document (ICD), which explores the compatibility of SKA data with VLBI experiments.

4 Space and Planetary science

4.1 PRIDE developments

Planetary Radio Interferometry and Doppler Experiment (PRIDE) is a VLBI-based technique developed at JIVE that aims to enhance the multi-disciplinary science output of planetary and space science missions. The essential components of this technique are near-field VLBI, which considers the challenges of conducting VLBI observations on objects within the solar system, and high-resolution spectrometry of artificial radio signals (emitted by spacecraft). Over the past decade, the validity of the technique has been demonstrated on several planetary missions, such as Huygens Probe, Smart-1, Venus Express and Mars Express, coordinated by the European Space Agency (ESA). PRIDE has also been selected as one of the eleven experiments of the ESA's Jupiter Icy Satellites Explorer (JUICE) mission scheduled for lift-off in 2022.

Since 2016, the JIVE group and its partners from other organisations furthered the PRIDE development by applying this technique in several scientific domains. Tatiana Bocanegra-Bahamón and co-authors (Bocanegra-Bahamón et al. 2018, A&A 609, A59) presented a complete formulation of PRIDE observed and computed values, together with the overall noise budget in observations of the Phobos fly-by by the ESA's Mars Express spacecraft in 2013 (Global VLBI experiment GR035). Figure 1 illustrates the Doppler residual measurements obtained in the GR035 experiment and NASA DSN stations at the down-link frequency of 8.4 GHz. The experiment and developed methodology of data processing confirm the conformity of the experimental precision with the specifications of the PRIDE implementation for the JUICE mission.

In another application of PRIDE for diagnostics of the planetary atmospheres, Tatiana Bocanegra-Bahamón and co-authors demonstrated the experimental potential of PRIDE in radio occultations using several observations of the ESA's Venus Express using the EVN, AuScope (Australia) and Kashima (Japan) radio telescopes (Bocanegra-Bahamón et al. 2018, in preparation). As illustrated in Figure 2, the sensitivity and resolving power of PRIDE measurements enabled the researchers to reach an unprecedented depth of "penetration" in the very dense atmosphere of Venus, helping to reconstruct the model of the atmosphere of Earth's cosmic neighbour.

An ad hoc demonstration of PRIDE potential for future solar system studies has been presented by Guifre Molera Calvés and co-authors (Molera Calvés et al. 2017, Space Weather 15, 1523). In this work, PRIDE observations of the ESA's Mars Express on 6th April 2015 resulted in an unexpected detection of an Interplanetary Coronal Mass Ejection (ICME) event (Figure 3). The PRIDE measurements conducted with the 26-m radio telescope of the Hartebeesthoek Radio Observatory (South Africa) and 32-m Badary radio telescope of the Institute of Applied Astronomy (Russia) showed that the phase scintillation indices increased by a factor of four during the passage of the ICME. These large-scale magnetic structures of ICME are one of the most important space weather phenomena as they cause large geomagnetic storms on Earth, which can have an impact on communications systems, satellites and power grids. Consequently, studies of these phenomena carry a significant practical importance for daily routines of modern life on our planet.

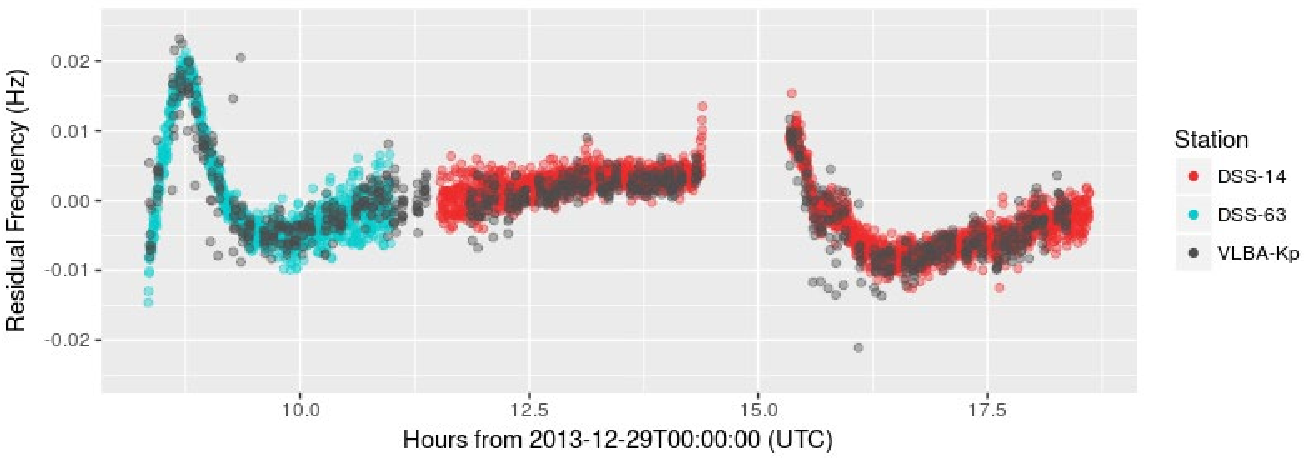


Figure 1. Comparison of the Doppler residuals obtained with VLBA-Kp (in black), NASA DSS-63 (in blue), and NASA DSS-14 (in red). The median value of the difference between the fit of VLBA-Kp and the fit of DSS-63 and DSS-14, respectively, remains below 1 mHz, for an integration time of 10 s.

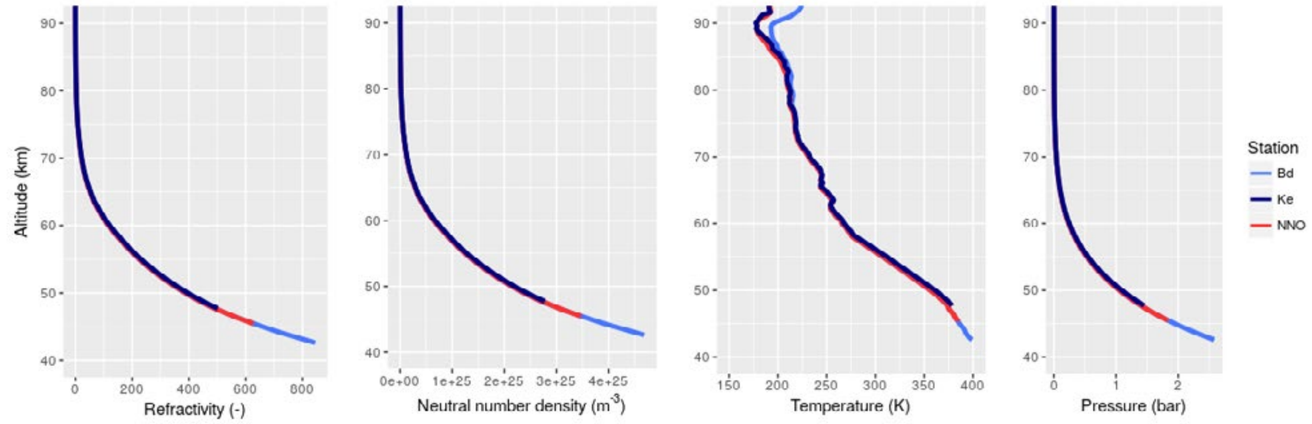


Figure 2. Refractivity, neutral number density, temperature and pressure profiles of the Venus Express occultation of 2012.04.29. The profiles corresponding to the 32-m Bd and 12-m Ke were derived from the open loop Doppler data obtained with the PRIDE setup, and the profiles of the 35-m ESA's Estrack station in New Norcia (NNO - Western Australia) were derived using the frequency residuals obtained from ESA's PSA, corresponding to close loop Doppler tracking data.

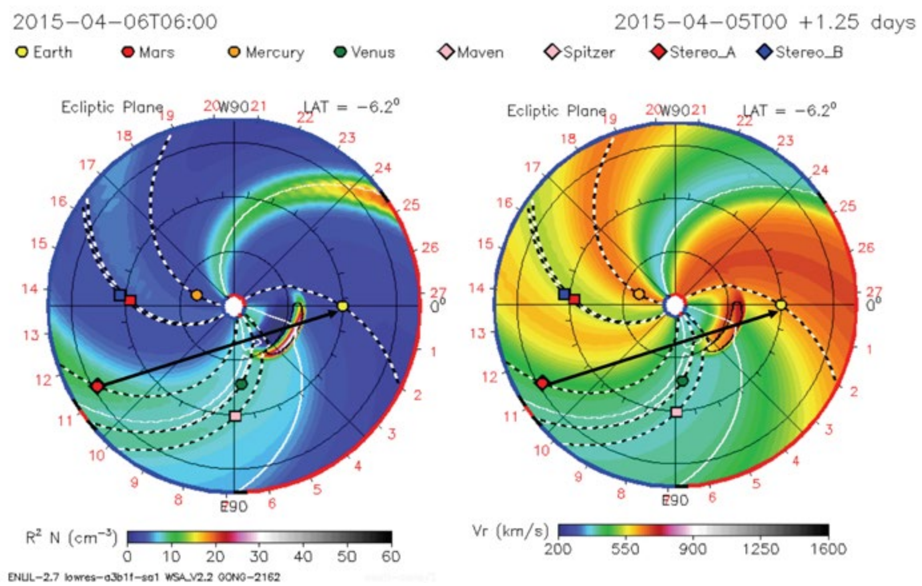


Figure 3. Geometrical configuration and plasma properties of the heliosphere when the ICME was at about 0.5 AU. Left: Electron density content times R2 [N(cm−3)]. Right: Solar wind radial speed on the elliptic plane in km/s. The simulation is for the time of the PRIDE observations (6 April 2015 at 06:00 UTC). A black arrow is added to show the line of sight from Mars (red circle) to the Earth (yellow circle).

(Simulations are available through the Integrated Space Weather Analysis System: https://ccmc.gsfc.nasa.gov/iswa/).

JIVE

5 Outreach and Training

5.1 Events

As part of the JUMPING JIVE project JIVE has been able to invest in outreach events and resources throughout 2017. This included participation in local events, such as the ASTRON-JIVE-NOVA open day as part of the national Weekend of Science in October and hosting visits from schools, journalists and invited guests to the correlator.

ERIS 2017 kicks off in Dwingeloo.

The summer student programme ran once again in 2017, providing a number of young scientists with the opportunity to work with JIVE staff for an extended period, as well as the chance to experience the Dutch culture for the summer period.

Despite short notice, JIVE and ASTRON accepted the responsibility to host the biennial European Radio Interferometry School (ERIS) in October 2017. Building on previous experiences, this was again a great event, with many young scientists from all over the world being introduced to the trade of radio interferometry. JIVE staff gave a lecture on VLBI techniques, conducted VLBI tutorials (one for the full school, plus a follow up parallel-tutorial session for those that selected it), and mentored the group writing VLBI-related proposals for their 'practical exercise'.

Two dedicated workshops invited users to trial a toolkit for VLBI data processing in the software package CASA (see 3.5 User software). The aim is to ensure that VLBI is more accessible to the broader radio astronomy community, particularly as younger students are familiar with CASA. The workshops uncovered important issues with the software, as well as providing an opportunity for users to create a functionality 'wishlist' for future iterations. During the course of the second workshop the first image of a VLBI science target was successfully fully processed with the new CASA tools.

Participants at the first CASA VLBI workshop in Dwingeloo in October.

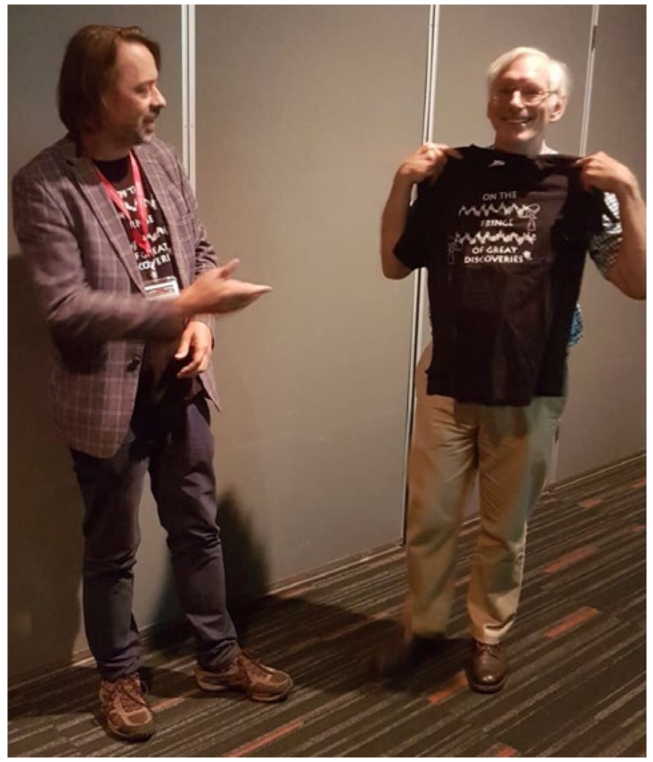
Further afield, and as part of the JUMPING JIVE project, support scientist Jay Blanchard participated in a two-week training programme coordinated by Development in Africa with Radio Astronomy (DARA). The students involved in this programme will likely go on to become the first operators and users of the African VLBI Network (AVN). The Nkuntunse telescope, where the training took place, also celebrated the first successful detection of fringes during a VLBI test experiment in the Spring (see *6.2 EVN support*).

JIVE staff participated in a number of international meetings of which the SKA engineering forum in Rotterdam was notable, as was the European Week of Astronomy and Space Science (EWASS) in Prague, where there was a special session on the synergy between VLBI astrometry and Gaia. At the International Union of Radio Science (URSI) General Assembly in Montreal, Canada, there was a special attention for the fact that in 2017 it was 50 years ago that the technique of VLBI produced first results.

5.2 Resources

JIVE contributed to the production of a number of resources for outreach throughout the course of the year. News articles on the website were maintained and the JIVE twitter account reactivated in March.

2017 also marked 50 years since the first successful VLBI experiment, a milestone that JIVE commemorated in a number of publications, but also, notably, with a t-shirt that was widely distributed.



At the URSI General Assembly VLBI pioneer Jim Moran is presented with the T-shirt highlighting 50 years since the first VLBI results.

Together with ASTRON and NOVA, JIVE produced a set of kwartet cards for families in Dutch, which is a readily played game in the Netherlands where players collect sets of four cards. Sets covered topics such as 'telescopes'; 'teamwork' and 'computers'. The cards were distributed at local events and schools throughout the year and, due to high demand, plans are in place to produce an English version.

Dutch kwartet cards for the whole family.

Ongoing projects included the design of materials to attract new users to the EVN – with intentions for these to be used initially at EWASS 2018 (as part of JUMPING JIVE), as well as monitoring of the JIVE and EVN websites with ongoing discussion for redesign in 2018.

JIVE

6 Operations

6.1 Correlation

The core of JIVE's service is the processing of data from the European VLBI Network (EVN); table 1 summarizes experiments that were correlated, distributed, or released in 2017. For a detailed list of the user experiments, see *8.5 Correlator activity*.

	User Experiments			Test and Network Monitoring		
	N	Ntwk_hr	Corr_hr	N	Ntwk_hr	Corr_hr
Correlated	97	706	759	26	88	88
Distributed	95	691	751	25	86	86
Released	84	614.5	674.5	23	81	81
e-EVN experiments	36	227	227			
e-EVN ToOs	9	81.5	81.5			

Table 1. Summary of projects correlated, distributed, or released in 2017. Here, 'network hours' sum the total duration of experiments, and 'correlator hours' are network hours multiplied by any multiple correlation passes required.

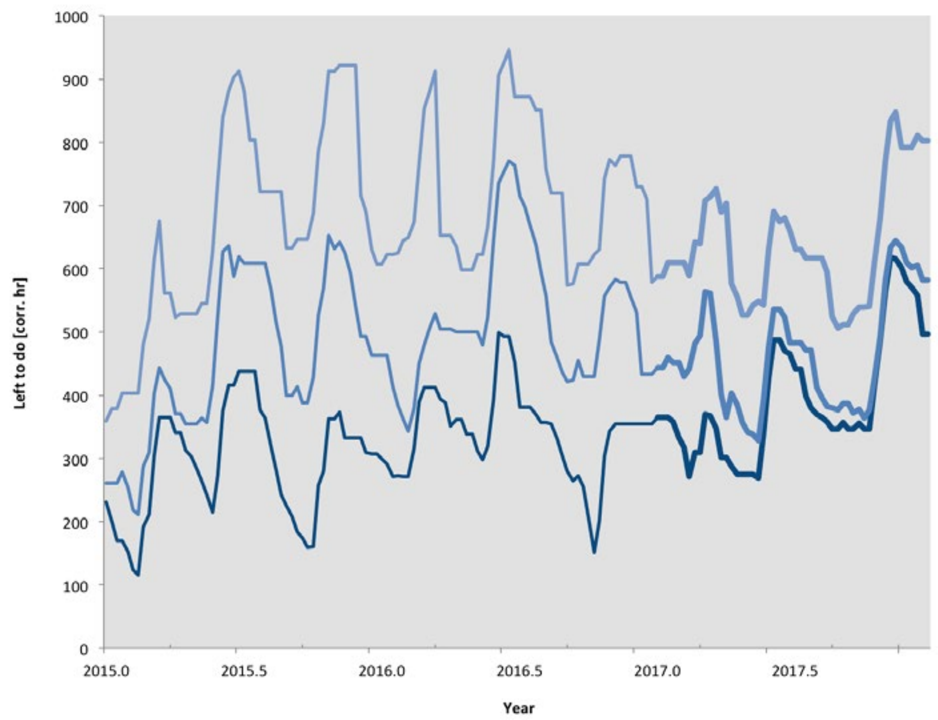


Figure 1. The size of the correlator queue at different stages in the processing cycle. The bottom line shows the number of correlator hours that remain to be correlated. The middle line shows the number of correlator hours in experiments whose data remain to be distributed to the PI. The top line plots the number of correlator hours associated with recording media that have yet to be released back to the pool.

The EVN offers a variety of observing modes that provide users with extra flexibility, but adds some complexity to the operations. Figure 2 shows the evolution of the annual EVN network hours. Figure 3 focuses on e-EVN experiments, showing the break-down into individual proposal categories.

2017 continued to see new ground broken in various (mostly e-EVN) experiments:

- First e-EVN observation to use pulsar gating/binning (EM128A, January);

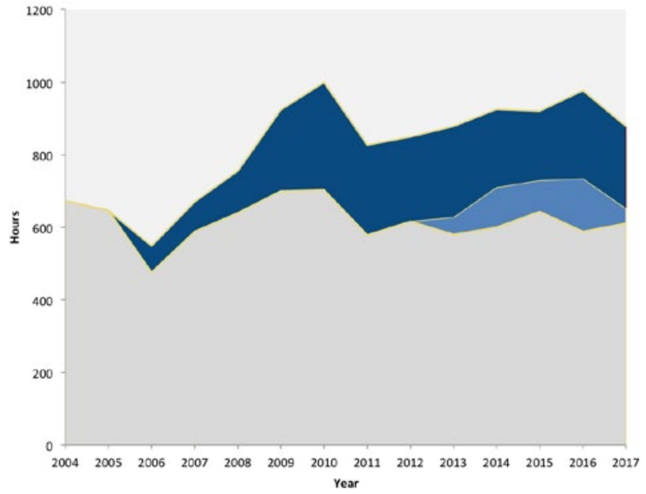


Figure 2. Annual EVN network hours, with 'traditional' disk-based observations in grey, e-EVN hours in dark blue, and scheduled disk-based out-of-session hours in light blue.

- First 2Gbps e-EVN observation including Arecibo, who is limited to 16MHz subbands (mark4). Centring 16MHz USB BBCs in the 2Gbps stations' 32MHz subbands avoided the copying implicit in standard mixed-BW correlation (two 16MHz subbands packed into a 32MHz subband), which might not have been able to keep up with real-time correlation with the 12-station array. (RP027, March);
- First use of simultaneous real-time correlation and recording onto FlexBuffs at JIVE for a 2 Gbps observation (RM013, September);
- There were 9 e-EVN ToO observations (arising from 7 proposals), covering targets ranging from E-M counterparts to gravitational wave events, X-ray binaries, the (only yet known) repeating fast radio burst, to other transients (including giant bursts from stellar masers). In addition, there were 4 e-EVN triggered observations (arising from 3 proposals), covering targets ranging from SWIFT-detected Gamma-ray Bursts, X-ray binaries, to gravitational-wave event counterparts. Three of the triggered observations belonged to the relatively new class of 'generic triggers';
- User e-EVN experiments at 6cm now routinely run at 2 Gbps for most stations (Ef, Mc, Nt, On, Ys, Hh, Ir); with four others currently at 1 Gbps (Jb, Wb, Tr, T6) and perhaps Ar at 512 Mbps, a total of 18.5 Gbps streaming into JIVE for real-time correlation is similarly routine. During the November e-EVN day clock-search/test period, real-time correlation of a new record of 20 Gbps was sustained (On sent two back-ends'-worth of 2 Gbps).
- 2017 saw a record for the number of ToO proposals (14; previously 12) and the number of hours requested in ToO proposals (269, previously 192.5); the previous records date from 2010 and 2011 respectively. These numbers combine both e-EVN and disk-based ToO proposals.
- GS039 was the first joint EVN/global + LBA observation at 18cm.
- It has occurred that a station observes using linear rather than circular polarizations. We have made scripts to wrap around the casa PolConvert program (I. Marti-Vidal) in order to reconstruct circular polarizations for such stations, both in continuum and spectral-line observations, within the FITS files prior to distribution to the PI.

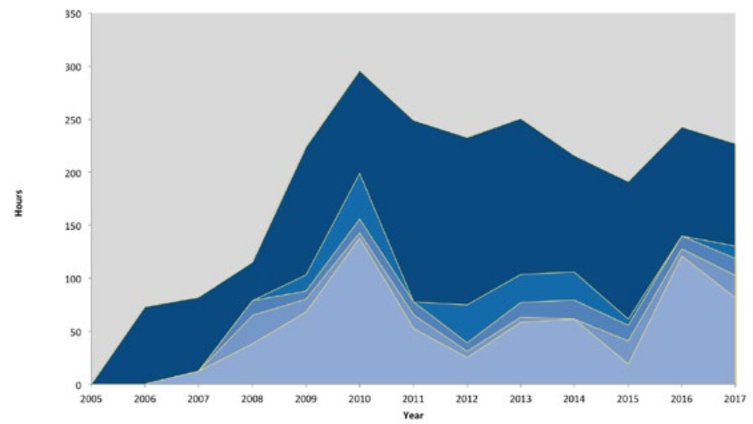


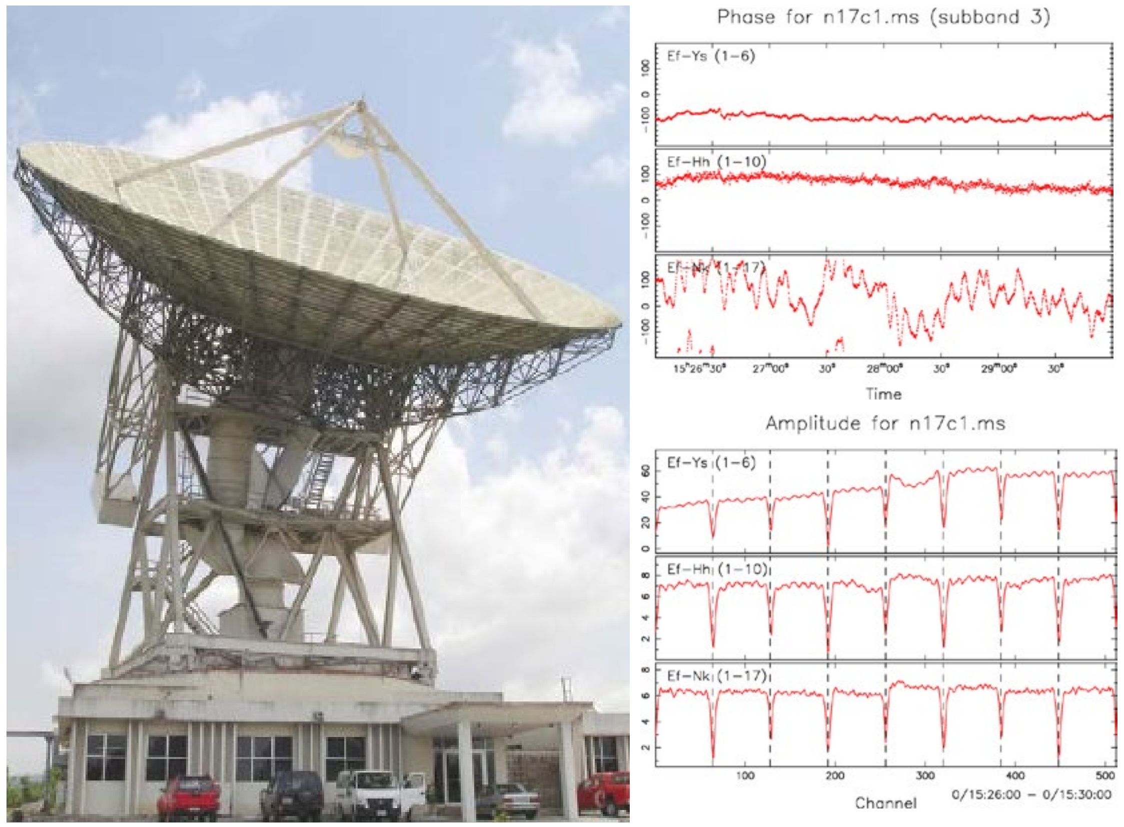
Figure 3. Division of e-EVN network hours into proposal categories, from the bottom to the top: target-of-opportunity, triggered, short observations, converted from disk, and regular.

6.2 EVN support

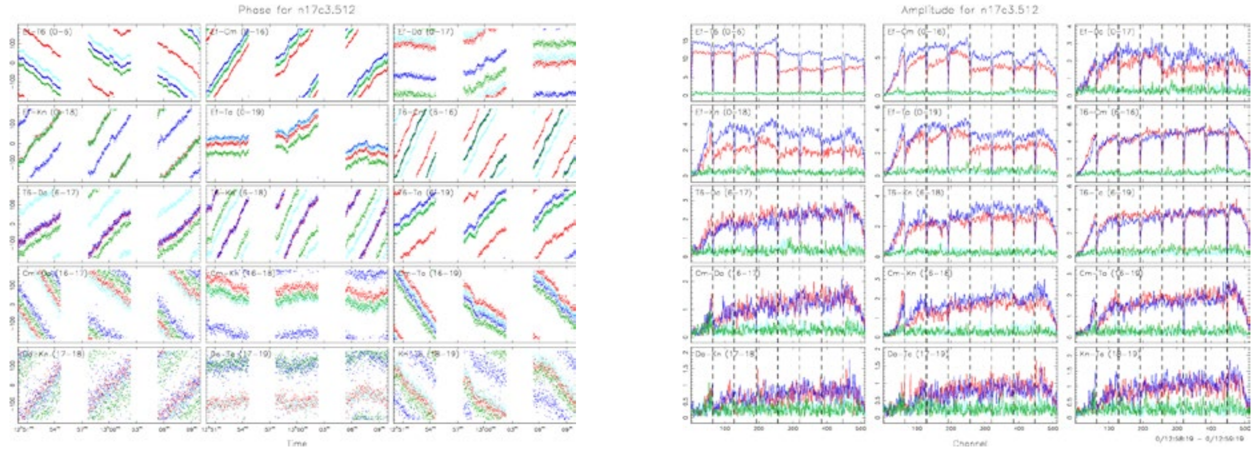
The Nkuntunse telescope in Ghana (just to the north of Accra) participated in the 6cm Network Monitoring Experiment (NME) in session 1/2017 (N17C1). This is the first of the future AVN telescopes to join an EVN observation. Fringes were detected, with phase stability limited by the current rubidium frequency standard. Jay Blanchard, JIVE support scientist, taught at a two-week Development in Africa with Radio Astronomy (DARA) training programme in Ghana in April (see *5.1 Events*).

The first compelling fringes from e-MERLIN out-stations came in the 6cm NME in session 2/2017 (N17C2). This comprised 4 out-stations, each observing at a bit-rate of 512 Mbps. The sampler statistics were not good (essentially 1-bit sampling with a ~20% asymmetry around 0), and some of the out-stations had occasional jumps in phase(time). By the 6cm NME of session 3/2017 (N17C3), the behaviours had noticeably improved. e-MERLIN out-stations also participated in five 18cm user experiments in session 3/2017 (not yet correlated). The short baselines provided by being able to include e-MERLIN out-stations as individual telescopes in an EVN correlation has been a long standing desire expressed by users, in order to improve sensitivity to more diffuse emission and help wide-field mapping.

The Kunming telescope in Yunnan (southwest China) participated in NMEs and some user experiments at 5cm and 6cm in session 2/2017, and in the entire 3.6/13cm block of session 3/2017. No significant problems have arisen. The Urumqi telescope recorded in parallel using their existing (mark4) and new (DBBC) back-ends in the initial 18cm and 5cm blocks of session 2/2017, using specially prepared schedules. Upon reliable success with the DBBC, they shifted to entirely-DBBC operation for the following 6cm block of that session.



A view of the Nkuntunse telescope, with phase(t) and amplitude(frequency) for one subband/polarization over a four-minute period from N17C1. The behaviour of phase on the baseline to Nk compared to the other baselines is consistent with the respective frequency standards (Rb at Nk, H-maser at the others). The passband shape for Nk is fine (Nk uses a DBBC back-end).



Phase(t) and amplitude(frequency) for 4 e-MERLIN out-stations from N17C3, shown also with Effelsberg and Tianma65. The phase(t) plot shows parallel-hand polarizations in two (of 8) subbands for three scans; the amp(freq) plot shows a 1-minute slice from the middle scan. e-MERLIN out-stations observe with a "native" 64MHz channel per polarization; the others use eight 8MHz channels, and the wider e-MERLIN channel is sub-divided to match in the multi-BW correlation.

e-Shipping, in which JIVE pulls data from the telescopes to FlexBuffs at JIVE, continued to grow in importance in 2017. By the end of the year, six stations had shifted over to this mode of operation (Hh, Mc, Nt joining Ef, On, Ys). e-shipping avoids the need to ship disk-packs, and provides the opportunity for finer control over freeing up space for future observing. Receiving data from the Australian LBA also proceeds via e-shipping. Some other stations resorted to 'unbudgeted' e-shipping to help overcome some pack-related issues, including some VLBA packs containing data destined for correlation both at JIVE and at Bonn. For now, there was enough slack in the FlexBuffs at JIVE to accommodate such instances.

6.3 User support

JIVE provides support at all stages of a user's EVN observation, from proposal definition to data analysis. There were 14 first-time PIs in 2017 observations, including four students. Six of these first-time PIs had an e-EVN observation (two of them students). JIVE continued to provide PIs with experiment-specific scheduling templates to track the evolving configurations of equipment at EVN stations.

The upgrade of three work-stations in the JIVE visitor room was completed; this comprised larger screens and significantly increased disk capacity, a portion of which was in the form of Solid State Drives (SSDs). The target application is the better support of larger data sets arising from the enhanced wide-field capabilities of SFXC. A list of visitors to JIVE can be found in *8.4 Visitors to JIVE*.

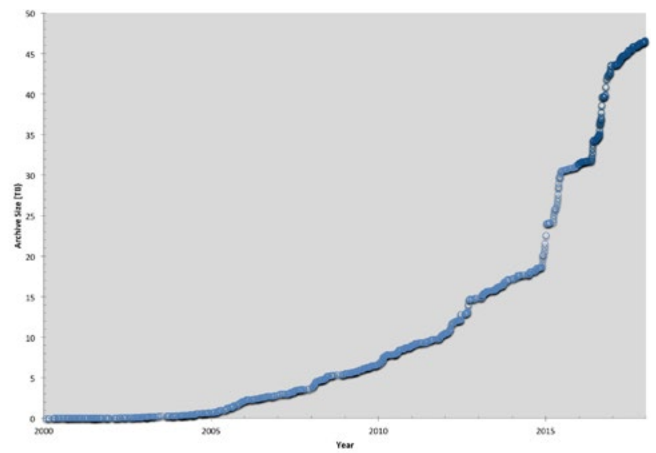


Figure 1. Growth of user experiments in the EVN Archive. Experiments archived in 2017 are plotted in dark blue.

JIVE

ASTRON and JIVE hosted the biennial European Radio Interferometry School (ERIS) in October (see *5.1 Events*). JIVE also made a major revision to the EVN Data Reduction Guide on the EVN Users' Guide web page, with revisions still being conducted on the spectral-line portion. In addition, links were added to the ERIS VLBI tutorials in the analysis section of the Users' Guide page.

The EVN Archive is another vital user service, which is openly accessible following the expiry of the proprietary period (one year, but six months for ToO projects). The total size of user-experiment FITS files in the Archive at the end of 2017 was 46.63 TB, an increase of 7% during the year. Figure 1 shows the growth of the Archive with time. We have adjusted the EVN Archive at JIVE and supporting utilities in order to host FITS files resulting from EVN observations correlated at Bonn. The fitsfinder utility, which databases information from the archived FITS files to permit searching the Archive across a variety of query parameters, was modified to also work on FITS files from Bonn. Thus, the first experiment correlated at Bonn is now fully incorporated into the EVN Archive. We have also adjusted the main 'tabs' of the EVN Archive (e.g., FITS files, standard plots, pipeline results) to include a separate tab for proposal abstracts, which will be populated for observations resulting from proposals submitted on or after the October 2017 deadline. Abstracts from proposals submitted via the NorthStar tool are extracted automatically from the NorthStar database; those from ToO or short-observation proposals are extracted manually from the proposal and passed via the standard archiving script.

7 Finances

7.1 JIVE financial report 2017

Balance [after allocation of results]

	2017	2016
ASSETS	**in €**	**in €**
Tangible fixed Assets		
Tangible fixed Assets	231,734	69,831
Total of Tangible fixed Assets	231,734	69,831
Current Assets		
Work in process	0	0
Receivables	844,974	822,411
Cash at bank	2,169,131	2,498,396
Total of Current Assets	3,014,105	3,320,807
Total Assets	**3,245,839**	**3,390,638**
	========	========
LIABILITIES	**In €**	**In €**
Capital		
General reserve	1,335,197	807,767
Designated funds	299,678	409,783
Total capital	1,634,875	1,217,550
Other Liabilities		
Short term debts	1,610,964	2,173,088
Total Other Liabilities	1,610,964	2,173,088
Total Liabilities	**3,245,839**	**3,390,638**
	========	========

Statement of profit and loss

	2017 BUDGET	2017 ACTUAL	2017 DIFFERENCE	2016 ACTUAL
REVENUES	in €	in €	in €	in €
Income				
Contributions/subsidies third parties	2,353,596	2,662,987	309,391	1,809,747
Interest	0	0	0	0
Other	208,429	178,506	-29,923	235,762
Total Income	2,562,025	2,841,493	279,468	2,045,510
Total Revenues	**2,562,025**	**2,841,493**	**279,468**	**2,045,510**
	========	========	========	========
EXPENDITURES	in €	in €	in €	in €
Operations				
Grants/Expenditures	2,509,040	2,424,168	-84,872	2,275,492
Total Operations	2,509,040	2,424,168	-84,872	2,275,492
Total Expenditures	**2,509,040**	**2,424,168**	**-84,872**	**2,275,492**
	========	========	========	========
RESULT	**52,985**	**417,325**	**364,340**	**-229,982**

7.2 JIVE projects

Project & Work Packages	Dates	JIVE role
SKA-NL (NWO)	01.09.14 - 31.12.18	JIVE is an associated partner of the Dutch effort to support the engineering contribution for the SKA, contributing in the area of Signal and Data Transport and VLBI with SKA-MID.
BlackHoleCam (EC)	01.10.14 - 30.09.20	BlackHoleCam is an ERC synergy project to enable sub-mm VLBI in which JIVE is contributing to the areas of real-time data verification and user software.
ASTERICS (EC)	01.05.15 - 01.09.19	ASTERICS is a collaboration to provide common tools and interfaces for ESFRI-listed astronomy projects.
Cleopatra		JIVE is a major contributor to research on time-distribution and data-transport methods and provides the work package leader (Arpad Szomoru).
Obelics		JIVE is a partner in some of the user data processing development projects.
JUMPING JIVE	01.12.16 - 31.01.21	JIVE is the coordinator for the JUMPING JIVE project.
AENEAS	01.01.17 - 31.12.19	AENEAS (Advanced European Network of E-infrastructures for Astronomy with the SKA) is an EC funded study to develop a concept and design for a federated data science centre for the SKA. JIVE contributes expertise on various work programmes that concern data processing and user support issues.
RadioNet4	01.01.17 - 31.12.20	RadioNet supports the collaboration of major radio astronomy facilities in Europe. JIVE is involved in the RINGS workpackage and receives trans-national access funds.

JIVE

8 Tables and metrics

8.1 JIVE council

Representatives of Members

Dr. Patrick Charlot – Laboratoire d'Astrophysique de Bordeaux, Pessac, France (Chair until May 2017)

Prof. Simon Garrington – Jodrell Bank Centre for Astrophysics, Manchester, UK (Vice-chair until May 2017, Chair from May 2017)

Prof. John Conway – Onsala Space Observatory, Onsala, Sweden (Vice-chair from May 2017)

Dr. Valdis Avotins – Ventspils International Radio Astronomy Center, Ventspils, Latvia

Prof. Carole Jackson – ASTRON, Dwingeloo, the Netherlands

Ms. Inga Jekabsone – Ministry of Education and Science of the Republic of Latvia, Riga, Latvia

Prof. Jesus Gómez González – Instituto Geográfico Nacional, Madrid, Spain (until May 2017)

Mrs. Monica Groba Lopéz – Instituto Geográfico Nacional, Madrid, Spain

Dr. José Antonio López Fernández – Instituto Geográfico Nacional, Madrid, Spain (from May 2017)

Dr. Guy Perrin – National Centre for Scientific Research, Paris, France

Dr. Catarina Sahlberg – Vetenskapsrådet / Swedish Research Council, Stockholm, Sweden

Dr. Ronald Stark – NWO, Den Haag, the Netherlands

Dr. Colin Vincent – Science and Technology Facilities Council, Swindon, UK

Representatives of Associated Research Institutes

Prof. Ludwig Combrinck – National Research Foundation, Pretoria, South Africa

Daan du Toit – South African Department of Science and Technology, Pretoria, South Africa

Prof. Xiaoyu Hong – NAOC, Shanghai Astronomical Observatory, Shanghai, China

Dr. Tiziana Venturi – INAF-IRA, Bologna, Italy

Dr. René Vermeulen – representing the EVN Board of Directors, ASTRON, the Netherlands

Prof. dr. Anton Zensus – MPIfR, Bonn, Germany

8.2 JIVE personnel

Dr. Jay Blanchard	Support Scientist
Mr. Paul Boven	Network/Linux Specialist
Mr. Wybren Buijs	Linux-/Network Specialist
Dr. Ross Burns	Support Scientist
Dr. Bob Campbell*	Head of Science Operations
Dr. Giuseppe Cimò	Space VLBI Scientist
Dr. Francisco Colomer Sanmartín	Policy Officer and Project Manager (from 1 April 2017 until 31 December 2017)
Drs. Bob Eldering	Software Engineer
Prof. Leonid Gurvits*	Head of Space Science & Innovative Applications Group
Dr. Jonathan Hargreaves	Digital Engineer (until 31 December 2017)
Mr. Bert Harms	Chief Operator
Dr. Katharina Immer	Support Scientist (from 1 September 2017)
Dr. Ing. Aard Keimpema	Scientific Software Engineer
Dr. Ir. Mark Kettenis	Software Project Scientist
Mrs. Yvonne Kool-Boeser	Senior Secretary
Mr. Martin Leeuwinga	Hardware Support Engineer
Dr. Gina Maffey	Science Communication Officer (from 1 March 2017)
Dr. Benito Marcote Martin	Support Scientist
Dr. Zsolt Paragi*	Head of User Support
Mr. Luis Henry Quiroga-Nuñez	PhD student
Dr. Des Small	Scientific Software Engineer
Dr. Arpad Szomoru*	Head of Technical Operations and R&D
Dr. Ilse van Bemmel	Project Scientist
Drs. Aukelien van den Poll	Project Assistant
Prof. Huib Jan van Langevelde*	Director (until 31 December 2017)
Drs. Harro Verkouter	Senior Software Engineer

* - JIVE MT member

JIVE

8.3 Educational responsibilities

MSc project supervision

Giovanni Granato - by L. Gurvits and D. Dirkx, TU Delft (completion in 2018)

PhD project supervision

Tatiana Bocanegra-Bahamón – by L.I. Gurvits and L.L.A. Vermeersen, TU Delft (completion in 2018)

Luis Henry Quiroga-Nuñez – by H.J. van Langevelde, Leiden University (completion in 2019)

EC Erasmus Traineeship

Dora Klindžić (Zagreb University, Croatia) - by L.I. Gurvits (October 2017 - April 2018)

Lecturing

Space-borne astrophysics (graduate course), Department of Astronomy, Moscow Lomonsosov State University - by L.I. Gurvits (spring semester 2017)

Radio astronomy, University of Leiden - by H.J. van Langevelde (spring semester 2017)

Secondary affiliations:

Giuseppe Cimò – affiliated with ASTRON, the Netherlands

Francisco Colomer-Sanmartin - affiliated with Instituto Geográfico Nacional, Madrid, Spain

Leonid Gurvits – affiliated with the Department of Astrodynamics and Space Missions, Delft University of Technology, the Netherlands

Huib Jan van Langevelde – affiliated with Sterrewacht Leiden, Leiden University, the Netherlands

Luis Henry Quiroga-Nuñez – affiliated with Sterrewacht Leiden, Leiden University, the Netherlands

8.4 Visitors to JIVE

Name	Institute	Period	Host
M. Mao	Jodrell Bank Observatory, UK	31/01/17 – 11/02/17	Paragi
M. Janssen	Radboud University, the Netherlands	27/02/17 – 01/03/17	Van Bemmel
P. Edwards	ATNF CSIRO, Australia	02/03/17	Blanchard
V. Pallichadath	Delft University of Technology, the Netherlands	04/04/17 – 05/04/17	Gurvits
K. Selvan	Delft University of Technology, the Netherlands	04/04/17 – 05/04/17	Gurvits
K. Immer	ESO Garching, Germany	01/05/17 – 12/05/17	Paragi
G. Orosz	Kagoshima University, Japan	01/05/17 – 15/07/17	Burns
M. Olech	Torun Centre for Astronomy, Poland	05/05/17 – 13/05/17	Paragi
T. Bocanegra-Bahamón	Delft University of Technology, the Netherlands	08/05/17 – 12/05/17	Gurvits
L.H. Quiroga-Nuñez	Leiden University, the Netherlands	09/05/17 – 11/05/17	Van Langevelde
I. Marti-Vidal	Onsala Space Observatory, Sweden	10/05/17 – 12/05/17	Van Bemmel
P. Saikia	Radboud University, the Netherlands	15/05/17 – 19/05/17	Paragi
A. Parmar	Savitribai Phule Pune University, India	06/06/17 – 25/08/17	Blanchard
A.N. Ng'endo	University of Nairobi, Kenya	12/06/17 – 11/09/17	Burns
M. Argo	University of Central Lancashire, UK	03/07/17 – 22/07/17	Van Bemmel
D. Duev	Caltech, USA	07/07/17 – 13/07/17	Gurvits
J. Bochenek	Inter-University Institute for Data Intensive Astronomy, South Africa	07/07/17 – 15/07/17	Szomoru
L. Chen	NAOC, China	21/07/17 – 25/07/17	Gurvits
M. Mao	Jodrell Bank Observatory, UK	27/07/17 – 01/08/17	Paragi
J. Radcliffe	Kapteyn Astronomical Institute, the Netherlands	01/08/17	Paragi
L. Petrov	NVI Inc, USA	09/09/17 – 23/09/17	Gurvits
V. Marthi	Canadian Institute for Theoretical Astrophysics, Canada	24/09/17 – 30/09/17	Keimpema
V. Beskin	Lebedev Physical Institute, Russia	14/10/17 – 17/10/17	Gurvits
J. Romney	Long Baseline Observatory, USA	15/10/17 – 17/10/17	Campbell
M. Mao	Jodrell Bank Observatory, UK	16/10/17 – 21/10/17	Paragi
P. Habing	Christelijk Lyceum, the Netherlands	16/10/17 – 20/10/17	Van Langevelde
I. M. Mutie	Technical University of Kenya, Kenya	21/10/17 – 28/10/17	Blanchard
J. Radcliffe	Kapteyn Astronomical Institute, the Netherlands	22/11/17 – 23/11/17	Van Bemmel
C. Spingola	Kapteyn Astronomical Institute, the Netherlands	22/11/17 – 23/11/17	Van Bemmel
C. Goddi	Radboud University, the Netherlands	22/11/17 – 23/11/17	Van Bemmel
H. Stacey	Kapteyn Astronomical Institute, the Netherlands	22/11/17 – 23/11/17	Van Bemmel
P. Mohan	Shanghai Astronomical Observatory, China	30/11/17 – 12/12/17	Paragi
X. Chen	Shanghai Astronomical Observatory, China	30/11/17 – 12/12/17	Paragi
P. Hall	Curtin University, Australia	05/12/17 – 07/12/17	Gurvits
R. Schilizzi	University of Manchester, UK	05/12/17 – 07/12/17	Gurvits

8.5 Correlator activity

User experiments with correlation, distribution, or release activity in 2017.

Project code	Observation Date/ Session	Principal Investigator	User Experiments
EA058A	Session 3/2016	Argo	Tracking the evolution of the new radio source NGC660
EB060A	Session 1/2017	Bach	A second active nucleus in Cygnus A?
EB060C	Session 2/2017	Bach	A second active nucleus in Cygnus A?
EB061	100517	Burns	OH, EGOs
EC057B	Session 1/2017	Cutini	Morphological changes after a bright optical/gamma-ray flare in S51803+78
ED040A,B	Session 3/2016	Deane	Binary supermassive black holes and radio-jet feedback in post-merger galaxies
ED042	210617	Davelaar	Core position angle measurements of M81*
EG088	Session 2/2016	Giroletti	Magnetic field structure in the jet of a gamma-ray narrow line Seyfert 1
EG091B	140217	Ghirlanda	Modeling the emission of the brightest Swift GRBs from the radio to the X-ray
EG092C	Session 3/2016	Guirado	Radio emission in ultra-cool dwarfs: the nearby planetary system VHS1256-1257
EG093B	Session 2/2017	Gawronski	Search for massive substellar companions around main sequence A-type stars
EG096A	140217	Gawronski	AR Ursae Majoris - a second identified persistent radio polar
EG096B	200617	Gawronski	AR Ursae Majoris - a second identified persistent radio polar
EG096C	200917	Gawronski	AR Ursae Majoris - a second identified persistent radio polar
EG096D	151117	Gawronski	AR Ursae Majoris - a second identified persistent radio polar
EG098A,B	Session 2/2016	Gabanyi	G8+1 in the sky
EG102A	141217	Gabanyi	Towards solving the puzzle of high-z radio sources: extending the VLBI sample
EH033	090517	Hada	e-EVN observation of M87: Joining the large MWL campaign in the spring 2017
EJ018A	170117	Jarvela	Radio morphologies of narrow-line Seyfert 1 galaxies
EJ019A-D	Session 2/2017	Janson	Closing the orbits on four young, low-mass benchmark binaries
EL056	Session 1/2017	Landoni	SDSS 0040-0915: a z 5 BL Lacertae, a blue FSRQ, or a weak emission line QSO?
EL058A	150217	Lobanov/J.Yang	Periodic activity in pulsating white dwarf binary AR Scorpii
EL058B	120417	Lobanov/J.Yang	Periodic activity in pulsating white dwarf binary AR Scorpii
EL058C	200617	Lobanov/J.Yang	Periodic activity in pulsating white dwarf binary AR Scorpii
EL058D	190917	Lobanov/J.Yang	Periodic activity in pulsating white dwarf binary AR Scorpii
EM117F,H	Session 2/2016	Moscadelli	A 3-D view of high-mass star formation: gas kinematics and magnetic fields
EM121B	Session 3/2016	Marcote	The possible connection of a compact radio source and an unidentified TeV source
EM122A,B	Session 3/2016	Mezcua	A Candidate Intermediate-Mass Black Hole in NGC 3310
EM123A,B	Session 3/2016	Mezcua	Searching for intermediate-mass black holes in metal-poor galaxies

Project code	Observation Date/ Session	Principal Investigator	User Experiments
EM124	Session 3/2016	McKean	Resolving the AGN/starburst connection in a high-z quasar on parsecscales
EM125A	111016	Marcote	Unveiling the radio counterpart of the possible gamma-ray binary HESS J1832-093
EM125B	151116	Marcote	Unveiling the radio counterpart of the possible gamma-ray binary HESS J1832-093
EM126A-C	Session 3/2016	Miller-Jones	The proper motion of a globular cluster black hole candidate
EM127A,B	Session 1/2017	Maan	Probing the off-pulse emission from pulsars B0525+21 and B2045-16
EM128A	Session 1/2017	Moldon	Mapping the orbit of PSR J2032+4127 with EVN astrometry
EO014	061216	Olech	Position and structure of 6.7 GHz methanol emission in a new periodic maser
EP099A-C	Session 3/2016	Pasetto	A high angular resolution study of radio sources with large Rotation Measure
EP101A-H	Session 1/2017	Pihlstrom	Candidate VLBI Q-band Calibrators
EP102	Session 2/2017	Paragi	Triggering AGN activity and star formation in the Compact Group J0959+1259
EP103A,B	Session 1/2017	Hessels/Paragi	Proper Motion and Variability of FRB121102
EP103D	Session 2/2017	Hessels/Paragi	Proper Motion and Variability of FRB121102
EP104A,B	Session 2/2017	Perger	Is there a blazar hiding in the core of the radio galaxy 3C 411?
EP105A	111017	Paragi	Following-up electromagnetic counterparts to candidate gravitational wave events
EP105B	151117	Paragi	Following-up electromagnetic counterparts to candidate gravitational wave events
ER045A	Session 3/2016	Romero-Canizales	Characterising the core-jet components in the nearby TDE ASASSN-14li
ER045B	Session 2/2017	Romero-Canizales	Characterising the core-jet components in the nearby TDE ASASSN-14li
ES079C	Session 3/2016	Szymczak	Periodic methanol maser in G107.298+5.639
ES081B	110417	Saikia	Spin dependence of jet power in super-massive black holes
ES081C	101017	Saikia	Spin dependence of jet power in super-massive black holes
ES088A	141217	Schulz	The parsec-scale view of the last Westerbork HI absorption survey
ET033A	120417	Tudose	EVN observations of X-ray binary transients
EW019	Session 2/2017	Wu	EVN and MERLIN observations of OH megamaser galaxy IRAS10173+0828
EY025	Session 3/2016	J.Yang	Deep EVN observations of a pc-scale binary black hole candidate: B0402+379
GA032D	Session 1/2017	Agudo	43 GHz Precision Astrometry of the Jet in NRAO 150
GK050	Session 1/2017	Koyama	Probing the inner jet collimation profile of Mrk 501 with global VLBI at 43 GHz
GP054	Session 2/2016	Perez-Torres	Probing the jet-sidedness of the TDE Swift J1644+57
GR040	Session 2/2017	Romero-Canizales	The nature of the radio emission in PGC043234, the ASASSN-14li's host
GS037A,B	Session 2/2016	Spingola	Measuring dark matter substructure in the gravitational lens JVAS B1555+375
GS038A,B	Session 3/2016	Spingola	Confirming the detection of a dark matter substructure with Global VLBI
GS039	Session 2/2017	Savolainen	Proper motion of the newly discovered helical filaments in the M87 pcscale jet
GV022A	Session 1/2017	Varenius	Continued monitoring of compact SNe/SNRs/AGNs in the starburst galaxy Arp 220
GV022B	Session 2/2017	Varenius	Continued monitoring of compact SNe/SNRs/AGNs in the starburst galaxy Arp 220

Project code	Observation Date/ Session	Principal Investigator	User Experiments
RB004	021017	Burns	Double maser super-burst
RE004A	100417	Egron	Imaging the jets of the microquasar Cyg X-3 during the exceptional giant flare
RE004B	130417	Egron	Imaging the jets of the microquasar Cyg X-3 during the exceptional giant flare
RE005	Session 2/2017	Etoka	EVN+eMERLIN ToO to trace the evolution of the ongoing long-lasting flare in omicron Ceti
RG007D	161116	Ghirlanda	Unveiling the progenitor nature and environment of the bright GRB151027
RM010A	210517	Miller-Jones	Astrometric observations of the high Galactic latitude black hole X-ray binary Swift J1357.2-0933
RM013	110917	Marcote	Localizing the bursts of FRB 121102 during an active period
RP024D	240516	Paragi	Pinpointing the position of the unique repeating fast radio burst FRB 121102
RP024E	250516	Paragi	Pinpointing the position of the unique repeating fast radio burst FRB 121102
RP026A	190916	Hessles	Pinpointing the position of the unique repeating fast radio burst FRB 121102
RP026B	200916	Hessels	Pinpointing the position of the unique repeating fast radio burst FRB 121102
RP026C	210916	Hessels	Pinpointing the position of the unique repeating fast radio burst FRB 121102
RP027	240317	Paragi	e-EVN follow-up of AGL J1914+1043
RP028	190917	Perez-Torres	ToO EVN observations of the nuclear transient in IRAS 23436+5257
RP029A	260817	Paragi	An electromagnetic counterpart to the gravitational-wave event G298048
RP029B	200917	Paragi	An electromagnetic counterpart to the gravitational-wave event G298048
RSD04	151217	Ding	Identify in-beam calibrators for VLBI astrometry on PSR J1939+2134
RSG08	110417	Gabanyi	Candidate gamma-ray blazar J1331+2932
RSM01	141117	Marecki	J084408+462744, the core of a newly discovered giant radio galaxy
RSO02	170117	Orru	Are giant radio galaxies the result of recurrent activity?
RSY05	170117	J.Yang	Exploring the massive black hole in a dwarf galaxy
RSY06	141117	X.Yang	X-shaped dual AGN candidate J0725+5835

8.6 JIVE publications

Journal articles

B. P. Abbott, R. Abbott, T. D. Abbott, et al. (including **Z. Paragi**, **M. Kettenis**, **B. Marcote**, **A. Szomoru**, **H. J. van Langevelde**): *Multi-messenger Observations of a Binary Neutron Star Merger*, 2017, The Astrophysical Journal Letters, 848, L12

C. G. Bassa, S. P. Tendulkar, E. A. K. Adams, et al. (including **B. Marcote**, **Z. Paragi**, **H. J. van Langevelde)**: *FRB 121102 Is Coincident with a Star-forming Region in Its Host Galaxy*, 2017, The Astrophysical Journal Letters, 843, L8

R. A. Burns, T. Handa, H. Imai, et al. (including **H. J. van Langevelde)**: *Trigonometric distance and proper motions of H2O maser bowshocks in AFGL 5142*, 2017, Monthly Notices of the Royal Astronomical Society, 467, 2367-2376

H.-M. Cao, S. Frey, K. É. Gabányi, et al. (including **Z. Paragi**): *VLBI observations of four radio quasars at z > 4: blazars or not?*, 2017, Monthly Notices of the Royal Astronomical Society, 467, 950-960

S. Chatterjee, C. J. Law, R. S. Wharton, et al. (including **A. Keimpema**, **B. Marcote**, **Z. Paragi**, **H. J. van Langevelde**): *A direct localization of a fast radio burst and its host*, 2017, Nature, 541, 58-61

Rocco Coppejans, Sjoert van Velzen, Huib T. Intema, et al. (including **Z. Paragi**): *Radio spectra of bright compact sources at z > 4.5*, 2017, Monthly Notices of the Royal Astronomical Society, 467, 2039-2060

A. De Rosa, S. Bianchi, T. Bogdanovic, et al. (including **Z. Paragi**): *Unveiling multiple AGN activity in galaxy mergers*, 2017, Astronomische Nachrichten, 338, 262-268

D. Dirkx, **L. I. Gurvits**, V. Lainey, et al. (including **G. Cimò**, **T. M. Bocanegra-Bahamón**): *On the contribution of PRIDE-JUICE to Jovian system ephemerides*, 2017, Planetary and Space Science, 147, 14-27

C. Goddi, H. Falcke, M. Kramer, et al. (including **I. van Bemmel**, **H. J. van Langevelde**): *BlackHoleCam: Fundamental physics of the galactic center*, 2017, International Journal of Modern Physics D, 26, 1730001-239

C. Goddi, G. Surcis, L. Moscadelli, et al. (including **H. J. van Langevelde**): *Measuring magnetic fields from water masers in the synchrotron protostellar jet in W3(H2O)*, 2017, Astronomy & Astrophysics, 597, A43

Tomoya Hirota, Masahiro N. Machida, Yuko Matsushita, et al. including **Ross A. Burns**): *Disk-driven rotating bipolar outflow in Orion Source I*, 2017, Nature Astronomy, 1

P. Kharb, S. Subramanian, S. Vaddi, et al. (including **Z. Paragi**): *Double-peaked Emission Lines Due to a Radio Outflow in KISSR 1219*, 2017, The Astrophysical Journal, 846, 12

P. Krehlik, L. Buczek, J. Kolodziej, et al. (including **R. M. Campbell**): *Fibre-optic delivery of time and frequency to VLBI station*, 2017, Astronomy & Astrophysics, 603, A48

Yi Liu, D. R. Jiang, Minfeng Gu, **L. I. Gurvits**: *Multifrequency VLBA polarimetry of the high-redshift GPS quasar OQ172*, 2017, Monthly Notices of the Royal Astronomical Society, 468, 2699-2712

B. Marcote, T. R. Marsh, E. R. Stanway, **Z. Paragi**, **J. M. Blanchard**: *Towards the origin of the radio emission in AR Scorpii, the first radio-pulsing white dwarf binary*, 2017, Astronomy & Astrophysics, 601, L7

B. Marcote, **Z. Paragi**, J. W. T. Hessels, et al. (including **A. Keimpema**, **H. J. van Langevelde**, **R. M. Campbell**): *The Repeating Fast Radio Burst FRB 121102 as Seen on Milliarcsecond Angular Scales*, 2017, The Astrophysical Journal Letters, 834, L8

G. Molera Calvés, E. Kallio, **G. Cimò**, et al. (including **T. M. Bocanegra Bahamón**): *Analysis of an Interplanetary Coronal Mass Ejection by a spacecraft radio signal: A case study*, 2017, Space Weather, Vol. 15, Issue 11, pp. 1523-1534

Makoto Nakano, Takashi Soejima, James O. Chibueze, et al. (including **Ross A. Burns**): *Interaction between the H II region and AFGL 333-Ridge: Implications for the star formation scenario*, 2017, Publications of the Astronomical Society of Japan, 69, 16

Iniyan Natarajan, **Zsolt Paragi**, Jonathan Zwart, et al.: *Resolving the blazar CGRaBS J0809+5341 in the presence of telescope systematics*, 2017, Monthly Notices of the Royal Astronomical Society, 464, 4306-4317

C. S. Ogbodo, **R. A. Burns**, T. Handa, et al.: *Bow shocks in a newly discovered maser source in IRAS 20231+3440*, 2017, Monthly Notices of the Royal Astronomical Society, 469, 4788-4795

G. Orosz, H. Imai, R. Dodson, et al. (including **R. A. Burns**): *Astrometry of OH/IR Stars Using 1612 MHz Hydroxyl Masers. I. Annual Parallaxes of WX Psc and OH138.0+7.2*, 2017, The Astronomical Journal, 153, 119

Songyoun Park, Jun Yang, J. B. Raymond Oonk, **Zsolt Paragi**: *Discovery of five low-luminosity active galactic nuclei at the centre of the Perseus cluster*, 2017, Monthly Notices of the Royal Astronomical Society, 465, 3943-3948

P. Pinilla, **L. H. Quiroga-Nuñez**, M. Benisty, et al.: *Millimeter Spectral Indices and Dust Trapping By Planets in Brown Dwarf Disks*, 2017, The Astrophysical Journal, 846, 70

L. H. Quiroga-Nuñez, **H. J. van Langevelde**, M. J. Reid, J. A. Green: *Simulated Galactic methanol maser distribution to*

constrain Milky Way parameters, 2017, Astronomy & Astrophysics, 604, A72

M. Ribó, P. Munar-Adrover, J. M. Paredes, et al. (including **B. Marcote**): *The First Simultaneous X-Ray/Radio Detection of the First Be/BH System MWC 656*, 2017, The Astrophysical Journal Letters, 835, L33

A. P. Rushton, J. C. A. Miller-Jones, P. A. Curran, et al. (including, **Z. Paragi**): *Resolved, expanding jets in the Galactic black hole candidate XTE J1908+094*, 2017, Monthly Notices of the Royal Astronomical Society, 468, 2788-2802

A. Sanna, L. Moscadelli, G. Surcis, et al. (including **H. J. van Langevelde**): *Planar infall of CH3OH gas around Cepheus A HW2*, 2017, Astronomy & Astrophysics, 603, A94

P. Scholz, S. Bogdanov, J. W. T. Hessels, et al. (including **Z. Paragi**): *Simultaneous X-Ray, Gamma-Ray, and Radio Observations of the Repeating Fast Radio Burst FRB 121102*, 2017, The Astrophysical Journal, 846, 80

T. W. Shimwell, H. J. A. Röttgering, P. N. Best, et al. (including **I. M. van Bemmel**): *The LOFAR Two-metre Sky Survey. I. Survey description and preliminary data release*, 2017, Astronomy & Astrophysics, 598, A104

S. P. Tendulkar, C. G. Bassa, J. M. Cordes, et al. (including **Z. Paragi**, **H. J. van Langevelde**): *The Host Galaxy and Redshift of the Repeating Fast Radio Burst FRB 121102*, 2017, The Astrophysical Journal Letters, 834, L7

F. L. Vieyro, G. E. Romero, V. Bosch-Ramon, et al. (including **B. Marcote**): *A model for the repeating FRB 121102 in the AGN scenario*, 2017, Astronomy & Astrophysics, 602, A64

P. Wurz, D. Lasi, N. Thomas, et al. (including **L. I. Gurvits**): *An Impacting Descent Probe for Europa and the Other Galilean Moons of Jupiter*, 2017, Earth Moon and Planets, 120, 113-146

Xiaolong Yang, Jun Yang, **Zsolt Paragi**, et al.: *NGC 5252: a pair of radio-emitting active galactic nuclei?*, 2017, Monthly Notices of the Royal Astronomical Society, 464, L70-L74

Yingkang Zhang, Tao An, Sándor Frey, et al. (including **Zsolt Paragi**, **Leonid I. Gurvits**): *J0906+6930: a radio-loud quasar in the early Universe*, 2017, Monthly Notices of the Royal Astronomical Society, 468, 69-76

Conference Papers

G. Cimò, **D. Dirkx**, D. A. Duev, et al. (including **T. M. Bocanegra Bahamón**, **L. I. Gurvits**): *PRIDE: Ground-based VLBI observations for the JUICE mission*, 2017, European Planetary Science Congress 2017, held 17-22 September, 2017 in Riga Latvia, id. EPSC2017-492

F. Colomer, J.F. Desmurs, V. Bujarrabal, et al. Studies of circumstellar shells in AGB stars by multifrequency (sub) mm-VLBI observations of maser emission, 2017, Highlights on Spanish Astrophysics IX, Proceedings of the XII Scientific Meeting of the Spanish Astronomical Society held on July 18-22, 2016, in Bilbao, Spain p. 361-366

F. Colomer. Masers, what can VLBI do for you?, 2017, IAU Symposium 336 "Astrophysical masers: Unlocking the Mysteries of the Universe", Cagliari

K. É. Gabányi, S. Frey, **Z. Paragi**, et al.: *Searching for a pair of accreting supermassive black holes in J1425+3231*, 2017, New Frontiers in Black Hole Astrophysics, Proceedings of the International Astronomical Union, IAU Symposium, Volume 324, pp. 223-226

L. I. Gurvits: *The first half-century of Space VLBI*, 2017, 32nd URSI GASS, Montreal, 19-26 August 2017

L. I. Gurvits: *Science case for Ultra-Long-Wavelength Astronomy from the Moon's surface and vicinity*, 2017, European Planetary Science Congress 2017, held 17-22 September, 2017 in Riga Latvia, id. EPSC2017-212

B. Lankhaar, A. van der Avoird, W. H. T. Vlemmings, et al. (including **Huib Jan van Langevelde**): *Quantum-Chemical Calculations Revealing the Effects of Magnetic Fields on Methanol*, 2017, 72nd International Symposium on Molecular Spectroscopy, June 19-23, 2017 at The University of Illinois at Urbana-Champaign, Abstract id.#TF08

B. Marcote, M. Giroletti, M. Garrett, et al. (including **Z. Paragi**): *The origin of the Fast Radio Bursts, still an open question*, 2017, Highlights on Spanish Astrophysics IX, Proceedings of the XII Scientific Meeting of the Spanish Astronomical Society held on July 18-22, 2016, in Bilbao, Spain, ISBN 978-84-617-8931-3. S. Arribas, A. Alonso-Herrero, F. Figueras, C. Hernández-Monteagudo, A. Sánchez-Lavega, S. Pérez-Hoyos (eds.), p. 511

B. Marcote, M. Ribó, J. M. Paredes, et al.: *Measuring the expansion velocity of the outflows of LS I +61 303 through low-frequency radio observations*, 2017, 6th International Symposium on High Energy Gamma-Ray Astronomy, Volume 1792, Issue 1, id.040018

Z. Paragi, J. Yang, S. Komossa, et al. (including **L. I. Gurvits**, **R. M. Campbell**): *Swift J1644+5734: the EVN view*, 2017, New Frontiers in Black Hole Astrophysics, Proceedings of the International Astronomical Union, IAU Symposium, Volume 324, pp. 223-226

Astronomer's Telegrams and other electronic circulars

J. Moldón, R. Beswick, **Z. Paragi**, et al. (including **M. Kettenis**, **B. Marcote**, **A. Szomoru**, **H. J. van Langevelde**): LIGO/Virgo G298048 - e-MERLIN upper limits on 5 GHz compect emission from SSS17a, LVC GCN 21804

J. Moldón, R. Beswick, **Z. Paragi**, et al. (including **M. Kettenis**, **B. Marcote**, **A. Szomoru**, **H. J. van Langevelde**): *LIGO/Virgo G298048 - Record of all e-MERLIN results to date on SSS17a*, LVC GCN 21940

Z. Paragi, T. An, P. Bacon, et al. (including **M. Kettenis**, **B. Marcote**, **A. Szomoru**, **H. J. van Langevelde**): LIGO/Virgo G275404 - European VLBI Network (EVN) follow-up of the near-IR transient in the AGL J1914+1043 field, LVC GCN 20981

Z. Paragi, I. Agudo, T. An, et al. (including **M. Kettenis**, **B. Marcote**, **A. Szomoru**, **H. J. van Langevelde**): LIGO/Virgo G298048 - European VLBI Network (EVN) upper limit on 5 GHz compect emission from SSS17a, LVC GCN 21763

Z. Paragi, J. Yang, **B. Marcote**, et al. (including **M. Kettenis**, J. Moldón, **A. Szomoru**, **H. J. van Langevelde**): *LIGO/Virgo G298048 - Further European VLBI Network (EVN) observations of SSS17a*, LVC GCN 21939

Other online data and publications (excluding preprints)

A. De Angelis, V. Tatischeff, I. A. Grenier, et al. (including **B. Marcote**): *Science with e-ASTROGAM (A space mission for MeV-GeV gamma-ray astrophysics)*, 2017, ArXiv e-prints, 1711.0

D. A. Litvinov, V. N. Rudenko, A. V. Alakoz, et al. (including, **G. Cimò**, **L. I. Gurvits**, **S. V. Pogrebenko**): *Probing the gravitational redshift with an Earth-orbiting satellite*, 2017, Physics Letters A (online)

T. W. Shimwell, H. J. A. Rottgering, P. N. Best, et al. (including **I. M. van Bemmel**): *VizieR Online Data Catalog: LOFAR Two-metre Sky Survey (Shimwell+, 2017)*, 2017, VizieR Online Data Catalog, 359

R. J. van Weeren, W. L. Williams, C. Tasse, et al. (including **I. M. van Bemmel**): *VizieR Online Data Catalog: LOFAR Bootes and 3C295 field sources (van Weeren+, 2014)*, 2017, VizieR Online Data Catalog, 179

W. L. Williams, R. J. van Weeren, H. J. A. Rottgering, et al. (including **I. M. van Bemmel**): *VizieR Online Data Catalog: Bootes field LOFAR 150-MHz observations (Williams+, 2016)*, 2017, VizieR Online Data Catalog, 746

8.7 EVN publications

Journal articles

Guirado, J.C., R. Azulay, B. Gauza, et al. 2018. Radio emission in ultracool dwarfs: The nearby substellar triple system VHS 1256-1257. Astronomy and Astrophysics, 610, A23. **(EG092A-C)**

Lyne, A. and I. Morison 2017. The Lovell Telescope and its role in pulsar astronomy. Nature Astronomy, 835-840.

Prandoni, I., M. Murgia, A. Tarchi. 2017. The Sardinia Radio Telescope. From a technological project to a radio observatory. Astronomy and Astrophysics, 608, A40.

Petrov, L.and Y.Y. Kovalev. 2017. Observational consequences of optical band milliarcsec-scale structure in active galactic nuclei discovered by Gaia. MNRAS 471, 3775-3787. **(GC030; GC034A-F)**

Abbott, B.P., R. Abbott, T.D. Abbott et al. 2017. Multi-messenger Observations of a Binary Neutron Star Merger. APJL 848, L12. **(RP029A-B)**

Bogdan, A., R.P. Kraft, D.A. Evans, et al. 2017. Probing the Hot X-Ray Gas in the Narrow-line Region of Mrk 3. APJ 848, 61.

Herrero-Illana, R., A. Alberdi, M.Á. Pérez-Torres, et al. 2017. No AGN evidence in NGC 1614 from deep radio VLBI observations. MNRAS 470, L112-L116. **(EH030A-B)**

Nyland, K., T.A. Davis, D.D. Nguyen, et al. 2017. A Multi-wavelength Study of the Turbulent Central Engine of the Low-mass AGN Hosted by NGC 404. APJ 845, 50.

Bruni, G., J.L. Gómez, C. Casadio, et al. 2017. Probing the innermost regions of AGN jets and their magnetic fields with RadioAstron. II. Observations of 3C 273 at minimum activity. Astronomy and Astrophysics, 604, A111. **(GA030C)**

Quiroga-Nuñez, L.H., H.J. van Langevelde, M.J. Reid, and J.A. Green 2017. Simulated Galactic methanol maser distribution to constrain Milky Way parameters. Astronomy and Astrophysics, 604, A72.

Rushton, A.P., J.C.A. Miller-Jones, P.A. Curran, et al. 2017. Resolved, expanding jets in the Galactic black hole candidate XTE J1908+094. MNRAS 468, 2788-2802. **(RR007A-B; RR009)**

Sanna, A., L. Moscadelli, G. Surcis, et al. 2017. Planar infall of CH_3OH gas around Cepheus A HW2. Astronomy and Astrophysics, 603, A94. **(ES071A; ES071B; ES071C)**

Krehlik, P., Ł. Buczek, J. Kołodzeij, et al. 2017. Fibre-optic delivery of time and frequency to VLBI station. Astronomy and Astrophysics, 603, A48.

Ahnen, M.L., S. Ansoldi, L.A. Antonelli, et al. 2017. First multi-wavelength campaign on the gamma-ray-loud active galaxy IC 310. Astronomy and Astrophysics, 603, A25. **(EE009A-B; EE009C-D)**

Etoka, S., E. Gérard, A.M.S. Richards, et al. 2017. Recurring OH Flares towards o Ceti - I. Location and structure of the 1990s' and 2010s' events. MNRAS 468, 1703-1716. **(RE001)**

Kundu, E., P. Lundqvist, M.A. Pérez-Torres, et al. 2017. Constraining Magnetic Field Amplification in SN Shocks Using Radio Observations of SNe 2011fe and 2014J. APJ 842, 17. **(EP092A-B)**

Azulay, R., J.C. Guirado, J.M. Marcaide, et al. 2017. Young, active radio stars in the AB Doradus moving group. Astronomy and Astrophysics, 602, A57. **(EG062A-F; EG084A-B)**

Petrov, L. and Y.Y.Kovalev 2017. On significance of VLBI/Gaia position offsets. MNRAS 467, L71-L75. **(GC030; GC034A; BCD; EF)**

Cao, H.-M., S. Frey, K. É .Gabányi, et al. 2017. VLBI observations of four radio quasars at z > 4: blazars or not?. MNRAS 467, 950-960. **(EGC054A-B; EC054C-D)**

Main, R., M. van Kerkwijk, U.-L. Pen, et al. 2017. Descattering of Giant Pulses in PSR B1957+20. APJL 840, L15. **(GP052A-D)**

Moscadelli, L., A. Sanna, C. Goddi, et al. 2017. Extended CH_3OH maser flare excited by a bursting massive YSO. Astronomy and Astrophysics, 600, L8. **(RS002; EL032)**

Park, S., J. Yang, J.B.R. Oonk, and Z. Paragi 2017. Discovery of five low-luminosity active galactic nuclei at the centre of the Perseus cluster. MNRAS 465, 3943-3948. **(EO009)**

Natarajan, I., Z. Paragi, J. Zwart, et al. 2017. Resolving the blazar CGRaBS J0809+5341 in the presence of telescope systematics. MNRAS 464, 4306-4317. **(RSC02)**

Nappo, F., A. Pescalli, G. Oganesyan, et al. 2017. The 999th Swift gamma-ray burst: Some like it thermal. A multiwavelength study of GRB 151027A. Astronomy and Astrophysics, 598, A23. **(RG007A; RG007B)**

Chatterjee, S., C.J. Law, R.S. Wharton, et al. 2017. A direct localization of a fast radio burst and its host. Nature, 541, 58-61. **(RP024A-E; RP026A-C)**

Yang, X., J. Yang, Z. Paragi, et al. 2017. NGC 5252: a pair of radio-emitting active galactic nuclei? MNRAS 464, L70-L74. **(RSY03)**

Caccianiga, A., D. Dallacasa, S. Antón, et al. 2017. SDSSJ143244.91+301435.3 at VLBI: a compact radio galaxy in a narrow-line Seyfert 1. MNRAS 464, 1474-1480. **(EC048)**

Marcote, B., Z. Paragi, J.W.T. Hessels, et al. 2017. The Repeating Fast Radio Burst FRB 121102 as Seen on Milliarcsecond Angular Scales. APJL 834, L8. **(RP024A-E; RP026A-C)**

Electronic articles

Acero, F., J.T. Acquaviva, R. Adam, et al. French SKA White Book - The French Community towards the Square Kilometre Array. arXiv:1712.06950.

Sun, X.N., R.Z. Yang, F.M. Rieger, et al. 2017. The energy distribution of relativistic electrons in the kilo-parsec scale jet of M87 with Chandra. arXiv:1712.06390.

Quiroga-Nuñez, L.H., H.J. van Langevelde, L.O.Sjouwerman, et al. 2017. Maser, infrared and optical emission for late-type stars in the Galactic plane. arXiv:1710.05441.

Deane, R.P. 2017. Extragalactic VLBI surveys in the MeerKAT era. arXiv:1709.03512.

Marti-Vidal, I. 2017. APSYNSIM: An Interactive Tool To Learn Interferometry. arXiv:1706.00936.

Titov, O. 2017. Testing of General Relativity with Geodetic VLBI. arXiv:1702.06647.

Varenius, E., J.E. Conway, F. Batejat, et al. 2017. The population of SNe/SNRs in the starburst galaxy Arp 220. A self-consistent analysis of 20 years of VLBI monitoring. arXiv:1702.04772. **(GL015; GL021; GL026; GD017A; GD017B; GD021A; GC028; GC031A; GC031B; GC031C)**

Catalogs

Bruni, G., J.L. Gómez, C. Casadio, et al 2017. VizieR Online Data Catalog: 22GHz image of 3C 273. VizieR Online Data Catalog 360. **(GA030C)**

Tseng, C.-Y., K. Asada, M. Nakamura, et al. 2017. VizieR Online Data Catalog: Radio obs. of NGC 6251 jet. VizieR Online Data Catalog 183. **(ET028)**

Conference Papers

Cui, L., J.Yang, H.Ma et al. 2017. What can VLBI astrometry tell us about AR Sco? Planetary Nebulae: Multi-Wavelength Probes of Stellar and Galactic Evolution 323, 376-377.

Marcote, B., M. Giroletti, M. Garrett, et al. 2017. The origin of the Fast Radio Bursts, still an open question. Highlights on Spanish Astrophysics IX 511-511. **(RP024A-E; RP026A-C)**

Kundu, E., P. Lundqvist, and M.A. Pérez-Torres. 2017. Constraints on environs around SN 2011fe and SN 2014J from radio modeling and observations. Supernova 1987A:30 years later - Cosmic Rays and Nuclei from Supernovae and their Aftermaths 331, 69-74. **(EP092A-B)**

Laine, S.J., E. Momjian, T.Krichbaum, et al. 2017. EVN VLBI Imaging of the Jet in the Nucleus of the Barred Spiral Galaxy NGC 7479. American Astronomical Society Meeting Abstracts #229 229, 144.06. **(EL048A-B)**

Hessels, J., PALFA Survey Team, VLA+AO FRB121102 Simultaneous Campaign Team, and EVN FRB121102 Campaign Team 2017. The Enigmatic Fast Radio Burst FRB121102. American Astronomical Society Meeting Abstracts #229 229, 109.02. **(RP024A-E; RP026A-C)**

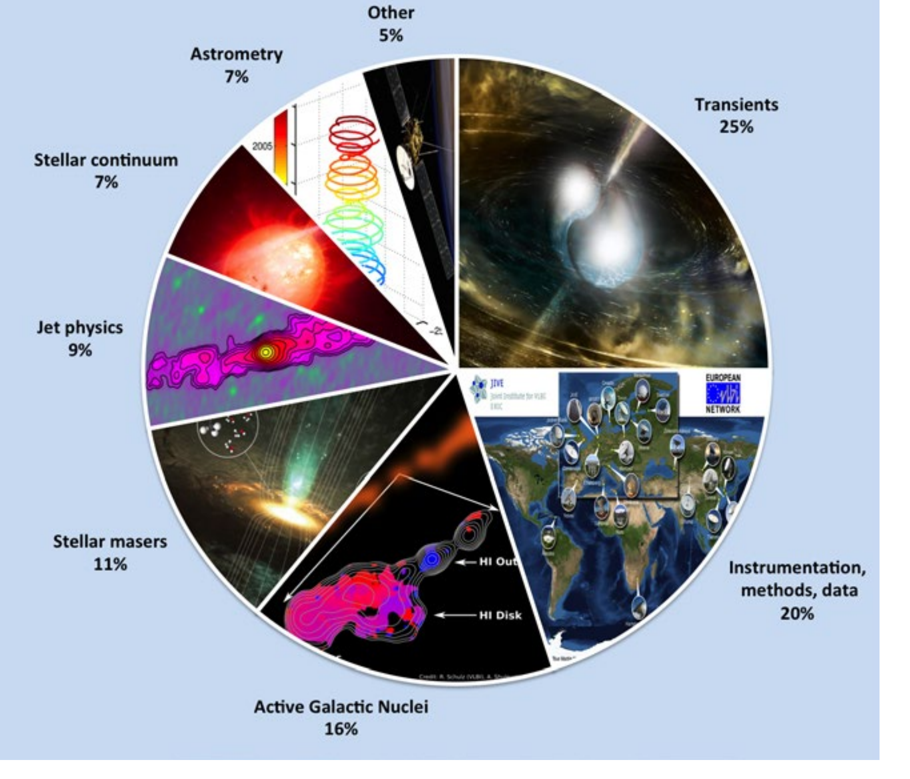
Paragi, Z., J. Yang, S. Komossa, et al. 2017. Swift J1644+5734: the EVN view. New Frontiers in Black Hole Astrophysics 324, 119-122. **(RP017; EY018A; EY018B; EY019; EY020A)**

Astronomer's Telegrams and other electronic circulars

Paragi, Z., An, T., Bacon, P. et al. 2017. LIGO/ Virgo G275404 - European VLBI Network (EVN) follow-up of the near-IR transient in the AGL J1914+1043 field. LVC GCN 20981 **(RP027)**

Paragi, Z., Agudo, I., An, T. et al. 2017. LIGO/Virgo G298048 - European VLBI Network (EVN) upper limit on 5 GHz compect emission from SSS17a. LVC GCN 21763 **(RP029A)**

Paragi, Z., Yang, J., Marcote, B. et al. 2017. LIGO/ Virgo G298048 - Further European VLBI Network (EVN) observations of SSS17a. LVC GCN 21939 **(RP029B)**



EVN papers during 2017 according to the science area they are published in.

9 Acronyms and abbreviations

AENEAS	Association for European NanoElectronics ActivitieS
AGN	Active Galactic Nuclei
ALMA	Atacama Large Millimeter/submillimetre Array
ASTERICS	Astronomy ESFRI & Research Infrastructure Cluster
ASTRON	Netherlands Institute for Radio Astronomy
ATCA	Australian Telescope Compact Array
ATNF	Australia Telescope National Facility
AVN	African VLBI Network
BBCs	Base Band Convertors
Bd	Badary station, Russia
BW	Band Width
CASA	Common Astronomy Software Applications
CM	Centimetre
CNRS	Centre National de la Recherche Scientifique
	National Center for Scientific Research
COTS	Commercial off-the-shelf
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DARA	Development in Africa with Radio Astronomy
DBBC	Digital Base Band Converter
DSN	Deep Space Network
EC	European Commission
e-EVN	electronic European VLBI Network
Ef	Effelsberg station, Germany
e-MERLIN	electronic Multi-Element Radio Linked Interferometer Network
ERIC	European Research Infrastructure Consortium
ERIS	European Radio Interferometry School
ESA	European Space Agency
ESO	European Southern Observatory
e-VLBI	electronic Very Long Baseline Interferometry
EVN	European VLBI Network
EWASS	European Week of Astronomy and Space Science
FFT	Fast Fourier Transform
FITS	Flexible Imaging Transport System
FRB	Fast Radio Burst
G	Gigabit
Gbps	Gigabit per second
GHz	Gigahertz
GPS	Global Positioning System
HESS	High Energy Stereoscopic System
Hh	Hartebeesthoek station, South Africa
ICME	Interplanetary Coronal Mass Ejection
IGN	Instituto Geográfico Nacional
	National Geographic Institute
INAF	Instituto Nazionale di Astrofisica
	Italian National Institute of Astrophysics
Ir	Irbene station, Latvia
IRA	Istituo di Radio Astronomia
	Institute of Radio Astronomy
Jb	Jodrell bank station, United Kingdom
JIVE	Joint Institute for VLBI ERIC
JUC	JIVE UniBoard Correlator
JUMPING JIVE	Joining up Users for the Maximising the Profile, the Innovation and the Necessary Globalisation of JIVE
Ke	Kathrine station, Australia
LBA	Long Baseline Array
LIGO	Laser Interferometer Gravitational-Wave Observatory
LOFAR	Low Frequency Array
Mbps	Megabit per second
Mc	Medicina station, Italy
MHz	Megahertz
MNRAS	Monthly Notices of the Astronomical Society
MPIfR	Max Planck Institute for Radio Astronomy
MT	Management Team
NAOC	National Astronomical Observatories of China
NASA	National Aeronautics and Space Administration
Nk	Nkuntunse station, Ghana
NL	The Netherlands
NME	Network Monitoring Experiment
NNO	New Norcia station, Australia
NOVA	The Netherlands Research School for Astronomy
NRAO	National Radio Astronomy Observatory
NRF	National Research Foundation
Nt	Noto station, Italy
NWO	Nederlandse Organisatie voor Wetenschappelijk Onderzoek
	Netherlands Organisation for Scientific Research
On	Onsala station, Sweden
PI	Principle Investigator
PFB	Polyphase Filter Bank
PRIDE	Planetary Radio Interferometry and Doppler Experiment
Rb	Rubidium
R&D	Research and Development
RINGS	Radio Interferometry Next Generation Software
SaDT	Signal and Data Transport
SAT	Synchronisation And Timing
SCHED	Scheduling software
SFXC	EVN Software Correlator
SKA	Square Kilometre Array
SKA-NL	Square Kilometre Array Netherlands
STFC	Science and Technologies Facilities Research Council
T6	Tianma station, China
TB	Terabyte
TDE	Tidal Disruption Event

ToO	Targets of Opportunity
Tr	Torun station, Poland
UK	United Kingdom
URSI	International Union of Radio Science
USA	The United States of America
USB	Universal Serial Bus
UTC	Coordinated Universal Time
UV	Ultraviolet
VeA	Ventspils Augstskola
	Ventspils University College
VLA	Very Large Array
VLBA	Very Long Baseline Array
VLBI	Very Long Baseline Interferometry
VR	Vetenskapsrådet
	Swedish Research Council
Wb	Westerbork station, the Netherlands
WSRT	Westerbork Radio Telescope
YS	Observatorio Astronómico Nacional-Yebes station, Spain
YSO	Young Stellar Objects

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