JIVE
Joint Institute for VLBI
ERIC

Annual report 2015

JIVE
Joint Institute for VLBI
ERIC

ANNUAL REPORT 2015

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

Currently JIVE has 5 members:

The Netherlands, represented by the Netherlands Organisation for Scientific Research (NWO) and the Netherlands Institute for Radio Astronomy (ASTRON)

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

Spain, represented by the National Geographical Institute (IGN)

Sweden, represented by Swedish Research Council (VR)

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

JIVE is also supported by the following Participating Research Institutes:

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 has been a very significant and remarkable year for JIVE during which the transition into JIV-ERIC has been accomplished. The international partners have discussed and prepared this, of course, for many years, but now having this actually completed is a very important matter.

The establishment of the ERIC is a key ingredient of our joint vision that VLBI offers a great opportunity to make European scientists and engineers work together, providing an excellent astronomical research infrastructure with the telescope elements that are available across the continent. In many ways, it is a stepping-stone for the global collaboration that is required for the SKA, but is also an astronomical facility complementary to the SKA for decades to come.

I think we can look back at a very fitting and entertaining inauguration event, where the achievements of the JIVE team over the years featured very prominently. The inauguration by Robert-Jan Smits from the EC signifies a commitment to make European Research Infrastructures like JIVE a success. I also very much valued the international workshop where global leaders in the field stressed the potential of VLBI for the next decades.

It is not a minor achievement that the JIVE management has been able to push the transition from foundation to ERIC to completion, such that the first (financial) benefits can be enjoyed by the end of the first year. We certainly hope that the ERIC will also be an attractive partner for countries that operate (new) radio telescopes. With growing numbers of contributors, JIVE and the EVN will be a sustainable research infrastructure that will be of great value for engaging the scientific and general community in radio astronomy.

It will be crucial for JIVE to also continue to acquire EC funding in the coming years. It is gratifying to see that JIVE has a role in the ASTERICS programme, where it can contribute its expertise in support of the astronomy facilities on the ESFRI roadmap. But I really view the RadioNet Trans National Access programme to the EVN as the key EC contribution to JIVE's main mission, allowing the institute to support the VLBI technique for astronomers from any European university at any experience level. As 2015 was the last year of the RadioNet3 programme, a lot of effort has gone into defining the programme of the future.

I am convinced that with the JIV-ERIC solidly in place –and this annual report is a witness of that– we have done everything right to provide a bright and solid future for VLBI in Europe.

Patrick Charlot

Charlot

Chairman of the council

Contents

1 Introduction

JIVE mission

The Joint Institute for VLBI ERIC (JIVE) has been established to 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. After the digitized signals are combined at a central dedicated data processor (the correlator), astronomers can use the resulting data to compute an image of the radio sky with extremely high resolution. Besides making images, the technique can be used to measure positions of bright radio sources with the best possible accuracy.

In Europe VLBI is organised through the European VLBI Network (EVN), a consortium that also has members from other continents. JIVE provides the central processing and most of the user services for the EVN. The EVN is open to any astronomer by writing a competitive observing proposal.

JIVE receives the data from the stations, recorded on computer hard disks or streamed directly 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 astronomer through subsequent processing and analysis if requested (see Chapter 4). Calibration data and pipeline results 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, working on new techniques and software to improve the scientific capabilities (Chapter 3). They investigate new methods to record and transport data in order to enhance the sensitivity and flexibility of the research infrastructure. In addition new data processing techniques and platforms are explored. JIVE engineers also work on various user interfaces, like the software 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 (Chapter 2).

Finally, JIVE has a role in the EVN as the central entity in dealing with EC projects (listed on page 35); as an ERIC, JIVE is expected to catalyse innovation and capacity building for European VLBI.

The new map on the wall has room for all future EVN and Global telescopes participating in VLBI

JIVE in 2015

The year 2015 was a year of real transition for JIVE. Starting out as a foundation, by the end of the year all of the legal and financial processes of the JIVE foundation had been transferred to the ERIC. As this was backdated to January 2015, this is the first ERIC annual report, whereas the foundation used to issue biennial reports.

The most visible part of the transition process was the inauguration ceremony on April 21 and the international workshop during the preceding days. Many international radio astronomy experts came to Dwingeloo to participate in these festivities, including a large number of former JIVE employees. During the workshop the past and future scientific significance of VLBI was highlighted. The programme included a number of historic accounts, followed by a wide range of scientific reviews. The workshop concluded with strategic visions of VLBI developments from five continents.

Distinguished speakers at the JIVE inauguration workshop discussing the history, scientific impact and future relevance of VLBI

The inauguration event itself staged representatives from the EVN and JIVE partners, the hosting agency NWO and the Dutch ministry. They were given the opportunity to talk about the significance of JIVE and its transition into a truly European entity during a highly interactive programme. The host of the programme also interviewed a number of researchers from the EVN/JIVE user community, who highlighted their most exciting science results. Finally, director-general Robert-Jan Smits of EC DG Research and Innovation handed the ERIC plaque to JIVE. In the presence of all the council members of the new ERIC, the new logo for JIVE was revealed.

The inauguration ceremony included interviews with EVN users and ended with the presentation of the ERIC plaque

With the ERIC status, JIVE will start to profile itself as a European organisation, although the aim is to deliver almost the same functionality as before for the EVN telescopes and their users. The transition required changes to a number of interfaces with other organisations in the form of new contracts and MoUs. In 2015 the most urgent of these were addressed in order to expedite the transition of assets and liabilities. In the end, this complex process, which involved among other things informing the local chamber of commerce and the tax office, was concluded in time, allowing the administrative year 2015 to be concluded under the flag of the new ERIC legal entity.

JIVE council representatives under the new logo

In addition some good progress was made regarding the partnership of JIVE. At the beginning of the year Spain became the fifth member, joining the Netherlands, the United Kingdom, Sweden and France. Arrangements were made with Italy and South Africa, who had expressed an interest in becoming members. MoAs with Germany and China were extended, with an intention for further collaborations in the future. During the year, Latvia also expressed an interest in joining JIVE. Importantly, the ERIC concluded an MoA with NWO, which formalises the secondment of personnel to JIVE.

Training & Outreach

An important event in 2015 was the European Radio Interferometry School, held at ESO Garching, Germany, to which JIVE staff made important contributions. JIVE staff participated enthusiastically in the very successful Open Day in Dwingeloo on 4 October. Of course JIVE again hosted a number of summer students in a joint programme with ASTRON.

ERIS participants at the ESO Headquarters

JIVE scientists in action during the Open Day

Personnel

In 2015 Sergei Pogrebenko formally retired, but he continues to play a role as an innovator, expanding the horizon of VLBI through his expert knowledge of digital signal processing. We saw the departure of Dmitry Duev and Ivan Agudo from their roles as support scientists, as well as Guifre Molera from his postdoc position.

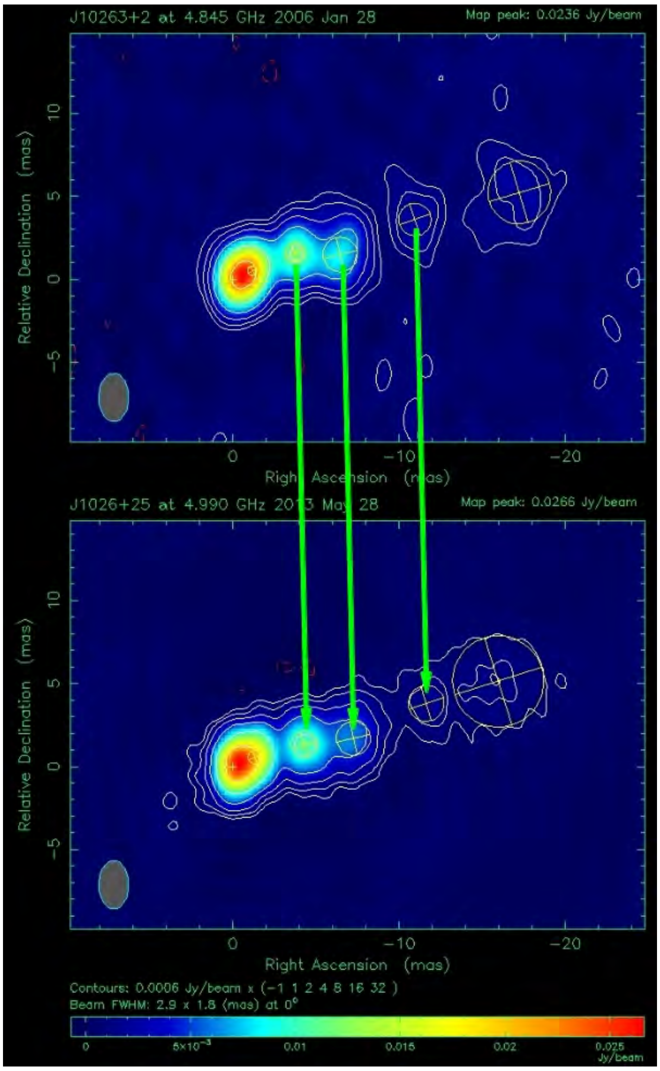
Pictures from the departure parties of Ivan Agudo, Dmitry Duev and Guifre Molera

2 SCIENCE highlights

First detection of proper motion in a jet at a z>5

Despite the relatively large number of known blazars – radio-emitting active galactic nuclei prominent in the radio and other wavebands as well – their detections are still very rare at extremely high redshifts (z>5). One of these is blazar J1026+2542, located at z=5.266. It stands out with its prominent jet with multiple components extending out to tens of milli-arcseconds (mas), as was shown by earlier Very Long Baseline Array (VLBA) observations. New data were obtained on J1026+2542 with the European VLBI Network (EVN) at 5 GHz on 2013 May 28, and at 1.7 GHz on 2013 June 4 by a team comprising of Sándor Frey (FÖMI, Budapest), Zsolt Paragi, Judit Fogasy (Onsala) and Leonid Gurvits.

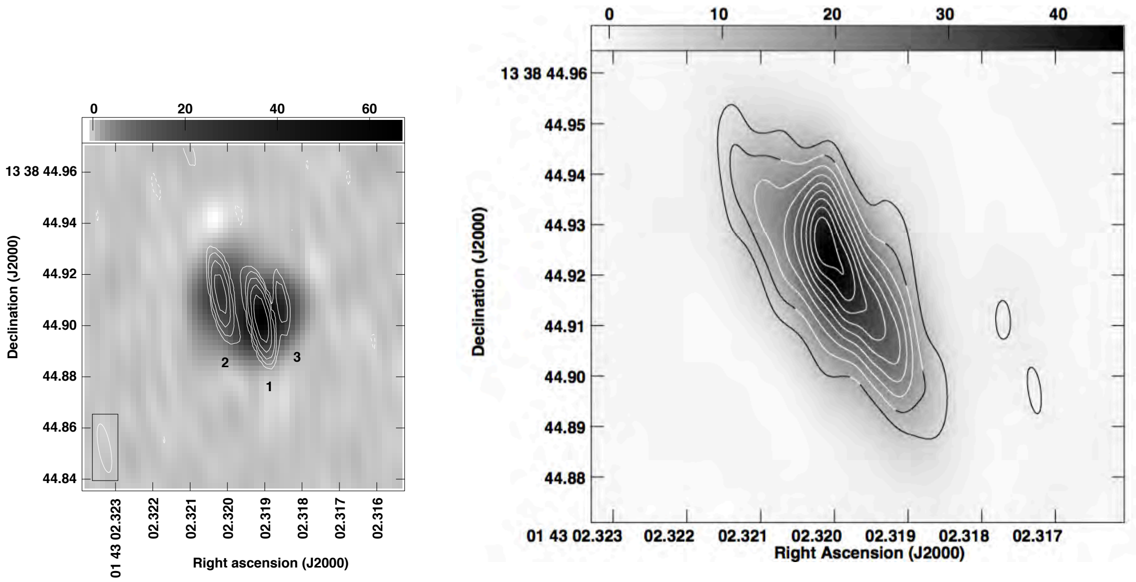
Due to its optically thin steep-spectrum emission, the diffuse end of the jet can be traced out to about 50 milliarcseconds (mas) in the 1.7-GHz EVN image, corresponding to 300 parsec projected linear size. At 5 GHz, the second-epoch imaging gives a time baseline of 7 years with respect to the VLBA observations in 2006. Due to the time dilation caused by the expansion of the Universe this corresponds to a period little more than 1 year in the lifetime of the source.



Comparison of the 5 GHz VLBI structure of J1026+2542 as observed in 2006 with the VLBA and in 2013 with the EVN, with the superluminal components indicated. Frey, Paragi, Fogasy, Gurvits (2015), MNRAS, 446, 2921

Combining the new image at 5 GHz with the archival data from 2006 enables tracking structural changes in the jet. These indicate apparent velocities 11-14 times the speed of light, known as superluminal motion, an 'illusion' often seen in relativistic jets that are aligned close to our line-of-sight. This is the first time that superluminal motion has been detected in an active galactic nucleus so distant. The expansion of the jet agrees well with what is expected in a relativistic cosmological model for a source at that high redshift. The new EVN observations also provide a more stringent constraint on the size of the compact base of the jet, the so-called VLBI core. The lower limit to the core brightness temperature is about 2×10^{12} Kelvin. The parameters derived for the inner radio jet from the EVN data are consistent with an independent estimate of the Lorentz factor (Γ_j=13) and the viewing angle (θ_j=3 deg) from high-energy measurements and the spectral energy distribution.

Serving breakfast to a black hole

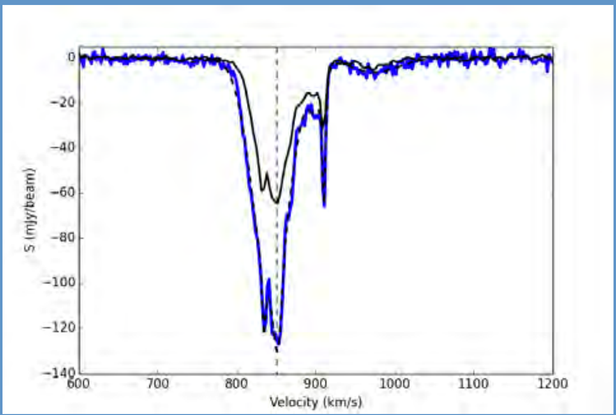


Left: EVN image of the newly-formed jet in NGC660 observed in 2013 (Argo et al. 2015, MNRAS, 452, 1081). Right: the new EVN data taken in 2015 reveal structural changes in the jet

Presumably, all large galaxies have a supermassive black hole in their centre, which grows through accretion of gas. During the accretion, the galaxy can become very bright in radio emission. We know that accretion is fuelled by gas, but how the gas is transported from galactic scales down to the black hole is still unclear. The nearby galaxy NGC660 is the youngest known active galaxy. Since changes are seen on timescales of years rather than thousands of years, it provides an excellent opportunity to study the physics of accretion in active galaxies.

This nearby galaxy increased its 5GHz flux by a factor of 3 from 2008 to 2010, and has been slowly dimming since then. High-resolution observations with EVN in 2013 by Ilse van Bemmel, Megan Argo (Jodrell Bank/Manchester), Sam Connolly (Southampton), Rob Beswick (Jodrell Bank/Manchester) confirmed a previous HSA detection of a new, compact radio source in the centre. Archival studies showed no such source was present priori to 2002. This new radio source is too bright to be a supernova or a tidal disruption event. The only plausible option is that this is a very young active nucleus. The shape of the radio spectrum, as well as the compact core-jet structure seen in EVN data, are both consistent with this theory. This makes NGC660 the youngest known active galaxy.

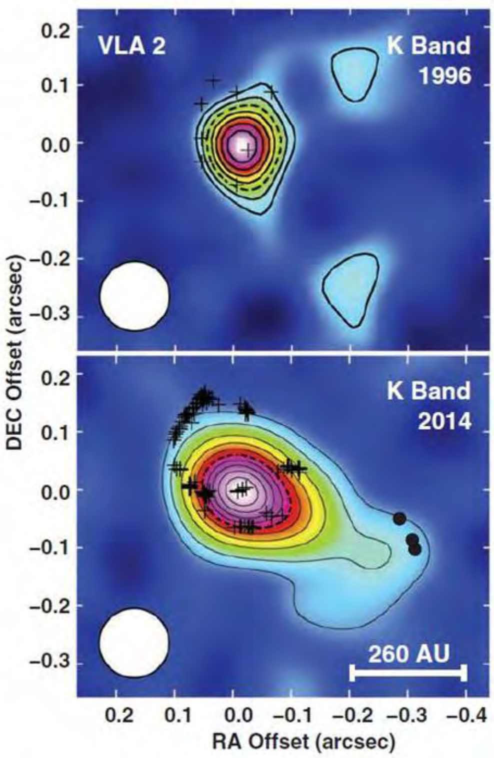
Since 2013, NGC660 has been monitored with the WSRT, EVN and e-MERLIN. Spectroscopy of the HI 21 cm line with EVN and WSRT shows strong absorption against this new radio source. Both spectra show several narrow components, consistent with a line of sight through multiple gas clouds with different kinematics. The annual monitoring with EVN shows the source is evolving fast, and changing shape on a yearly basis. It is also dimming. Analysis of the individual source components is still on-going, with very tentative evidence of jet motion in the source. Many questions remain open. New observations with EVN, e-MERLIN, Chandra, WHT-ISIS are being analysed to shed more light on this intriguing and unique source.

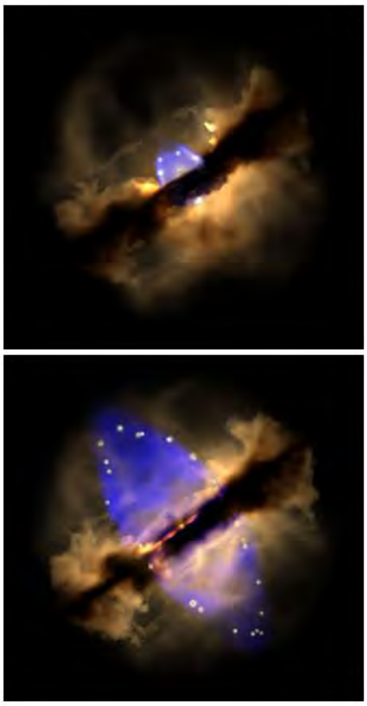


EVN (black) and WSRT (blue) observations of neutral hydrogen against the new radio source. Dashed black curve is a best-fit model, the vertical line shows the systemic velocity

High-mass star formation

The most popular model of high-mass star formation features accretion disks and magnetically driven gas and predicts collimated outflows. New EVN polarimetric observations of 6.7 GHz methanol masers were made towards a sample of massive young stellar objects (YSO), from which the magnetic field around the forming star was determined at scales of a few hundreds of AU. The team, which included Gabriele Surcis, Huib van Langevelde, Wouter Vlemmings (Onsala), Ciriaco Goddi and Jose-Maria Torreles (Barcelona), inferred that magnetic field lines from the central protostar are preferentially aligned with the outflows, as predicted by the theory. EVN polarimetric data obtained using a new observational approach also provided the first detailed picture of the gas dynamics and magnetic field configuration within a radius of 2000 AU of a massive YSO, G023.01-00.41. Overall, the velocity field vectors accommodate the local magnetic field direction well with the gas flow collimating at a distance of about 1000 AU from the disk.





On the left, a comparison of the radio continuum emission of W785N-VLA2 in epochs 1996 (top) and 2014 (bottom) (Image credit: Science Journal). On the right, a 3D hydrodynamic simulation and visualization of the episodic, short lived outflow ejection in 1996 (top) and 2014 (bottom) (Image credit: Wolfgang Steffen, Istituto de Astronomía, UNAM). Carrasco-González et al. 2015, Science, 348, 114

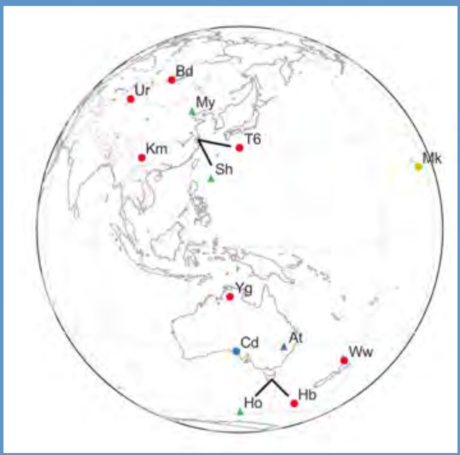
The observed evolution of the collimated radio jet from the high-mass protostar W75N(B)-VLA2 was reported in *Science.* This protostar is located at a distance of 1.3 kpc. A pair of radio images of the young star, made 18 years apart, has revealed a dramatic difference in morphology that provides a unique, "real-time" look at how massive stars develop in the earliest stages of their formation. The first image obtained with the Very Large Array (VLA) in 1996 shows a compact source of a hot, ionized wind ejected from the young star. The recent 2014 image, observed with the Jansky VLA, shows that ejected wind has deformed into a distinctly elongated outflow. This evolution of the morphology of the ejected gas is consistent with that of the associated water maser shell, which changed from a circular morphology to an elliptical one.

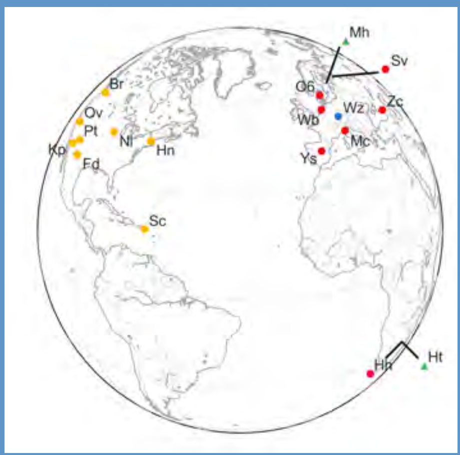
Furthermore, the magnetic field around W75N(B)-VLA2, which was measured by observing the polarized emission of the water maser spots, developed a preferred direction aligned with the large scale magnetic field in the region. This orientation was determined by analysing the polarized emission of methanol masers observed for the first time in 2008 with the EVN.

Near-field VLBI in the interests of planetary science

Over the past decades, the VLBI technique has proven to be a powerful tool for planetary and space science. Precise estimates of lateral coordinates and, as a by-product, radial velocity of a spacecraft, translate into estimates of its state-vector, which in turn enables us to reconstruct its trajectory and derive physically meaningful parameters of the medium through which the radio wave propagates on its way to Earth. JIVE has developed an implementation of this technique as a generic Planetary Radio Interferometry and Doppler Experiment (PRIDE). Its essence lies in accounting for the fact that the radio waves emitted by a spacecraft arrive at the Earth-based telescopes with a non-planar wave-front; this is known as "near-field VLBI".

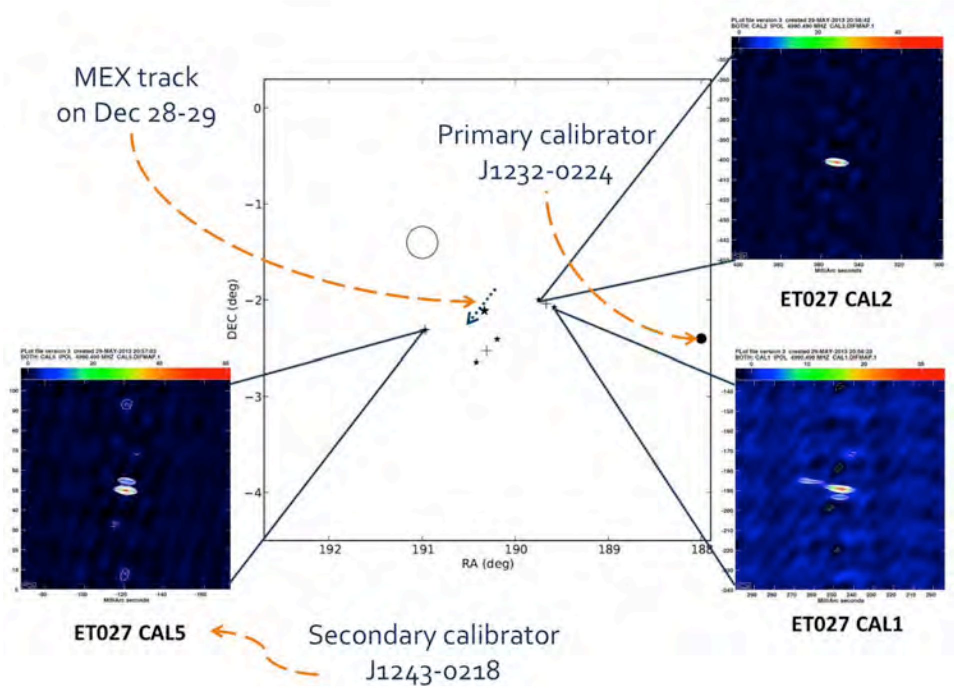
During 2015, the JIVE team including Leonid Gurvits, Dmitry Duev, Guiffre Molera, Sergei Pogrebenko, Giuseppe Cimó and Tatiana Bocanegra in collaboration with partners in Europe, Australia, China, Japan and the US worked on developing the near-field VLBI technique in preparation for experiments with the JUICE (JUpiter ICy moons Explorer) mission – the first large mission in the ESA's Cosmic Vision 2015-2025 programme, planned for launch in June 2022. PRIDE-JUICE, one of the eleven mission experiments, will focus on providing precise ephemerides of the Jovian system and, in combination with other experiments, address the key science quests into the origins and potential habitability of the Solar System planets and their environments.





The global network of radio telescopes involved in the Mars Express Phobos flyby observations

As a part of the PRIDE-JUICE development, JIVE participated in the large global VLBI experiment led by Pascal Rosenblatt, (Royal Observatory of Belgium) – near-field VLBI observations of the ESA's Mars Express spacecraft during its rare close flyby of the Martian moon Phobos. This flyby was the closest ever for the Mars Express mission, passing less than 50 km above the moon's surface. The observations, conducted at 8.4 GHz over three Mars Express evolutions around Mars, lasted for 26 hours and involved 25 radio telescopes around the world. Several background celestial radio quasars were used as phase-reference sources. The experiment resulted in estimates of the lateral position and radial Doppler shift of the Mars Express spacecraft with a precision of about 50 m and 30 μm/s, respectively. These values are consistent with the expectations and create a suitable basis for further refinement of the PRIDE technique for the JUICE mission.



A "sky finding chart" of the Mars Express – Phobos flyby experiment GR035. A black star denotes the field centre; crosses are pointings used in the preparatory EVN experiment ET027 to observe possible secondary calibrators; the circle represents an approximate size of the primary beam of a 30 m antenna. The colour insets show calibrated images of the sources in the field obtained in the ET027 experiment

3 Research and Development

Data recording and transport

Traditionally, VLBI data were recorded on tapes, which then were shipped to the correlator for processing. Since more than a decade, tapes have been replaced by disk packs containing off-the-shelf hard disk drives, and later on, by real-time electronic transport via the Internet.

The jive5ab program was originally developed at JIVE to control the Mark5 recording units that replaced the original tape drives. Versatile and stable, it enabled real-time VLBI as an operational mode within the EVN. Over the years, improvements and increased functionality have steadily been added, in order to accommodate improved versions of the Mark5, the more recently developed Mark6, as well as the FlexBuff system. Developed during the NEXPReS project, the FlexBuff system differs from the Mark6 in that it has a large, non-removable pool of hard disks, using automatic data synchronisation between station and correlator rather than physically shipping disk packs.

Together with the m5copy program, which performs reliable high-speed data transfers using jive5ab instances at start and end points, jive5ab has seen an impressive uptake by the VLBI community both in and outside of the EVN, and is now also in use in geodetic VLBI.

In 2015, the general applicability of jive5ab was further boosted by adding the capability to record on either Mark6 or FlexBuff recorders in either Mark6 or FlexBuff format, essentially making reading and writing to different hardware completely transparent to the user. Work began to support the extremely high data rates that are becoming available in astronomical and geodetic VLBI. As part of the BlackHoleCam project, functionality was added to the m5copy program to detect error/success conditions and thus enable the seamless resumption of interrupted transfers.

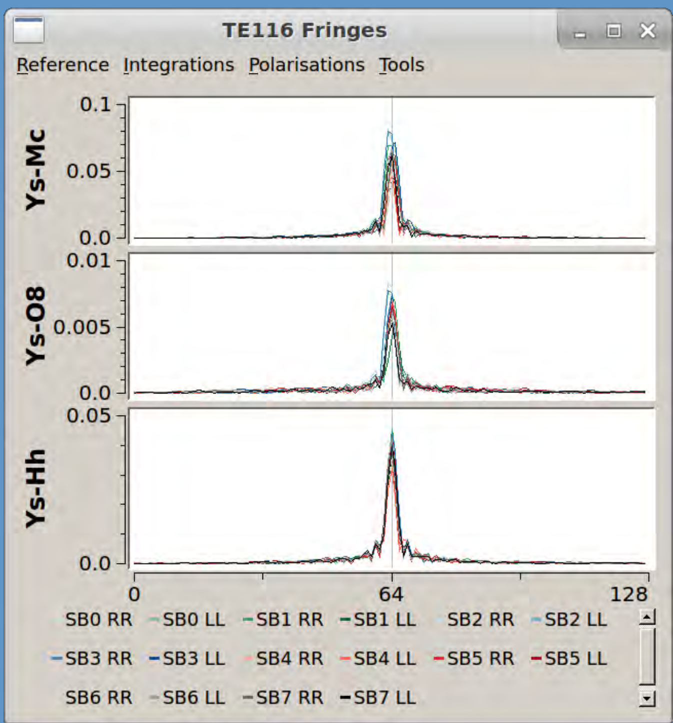
Shipping data electronically from station to correlator was tested extensively throughout the year, using FlexBuffs at Onsala Space Observatory and JIVE. Several observing sessions were recorded in parallel on disk packs, which were then shipped to JIVE in the regular way, and on a FlexBuff, after which the data were e-shipped automatically and compared to the disk-recorded data. In September 2015 Onsala purchased and sent one FlexBuff to JIVE, after which disk pack shipping was discontinued. Several other stations will follow suit, with Effelsberg intending to use a Mark6 unit instead of a FlexBuff for local storage.

The FlexBuffs at JIVE

Software correlation

Correlation, combining the signals from all telescopes to allow an astronomical image to be created, lies at the heart of JIVE data processing. The EVN software correlator at JIVE (SFXC) is the operational correlator of the EVN, used for both recorded and real-time VLBI. SFXC was developed at JIVE, and over the years a very large number of additional features have been implemented, opening up new avenues of VLBI science.

One of the ways to boost the sensitivity of the EVN is increasing the bandwidth of the observations, sampling a larger part of the radio spectrum. This of course will result in higher data rates, and with it, higher demands on the complete chain of equipment, from receivers to correlator.



2 Gbps fringes between Onsala, Yebes, Medicina and Hartebeesthoek

During 2015, a concerted effort got underway within the EVN to upgrade its sensitivity, by first moving from the standard 1 Gigabit per second (Gbps) per telescope to 2 Gbps observing, to be followed by 4 Gbps in 2016. Higher bandwidths imply wider subbands than the standard 16 MHz traditionally used in the EVN. Mixed-bandwidth correlation had to be implemented to support mixed 1 and 2 Gbps observations, as only a sub-set of the EVN currently is capable of 2 Gbps operations. This resulted in the first “official” 2 Gbps user experiment during the October EVN session. 2 Gbps e-VLBI was enabled next, requiring several optimizations in the code to handle the increased data and packet rates. This led to the first successful test in November.

New backends can and will produce very wide bands, which the correlator will have to be able to process in the absence of additional filtering. SFXC can now handle a full 512 MHz in its standard version, but a modified version of the code exists that can go as high as 4 GHz.

The SFXC cluster hardware at JIVE is regularly upgraded, and at the end of 2015 was composed of 44 nodes with a total of 452 cores. In this configuration it is estimated it should be able to process up to 15 stations at 1 Gbps, or 8 stations at 2 Gbps, in real time.

Hardware correlation and digital engineering

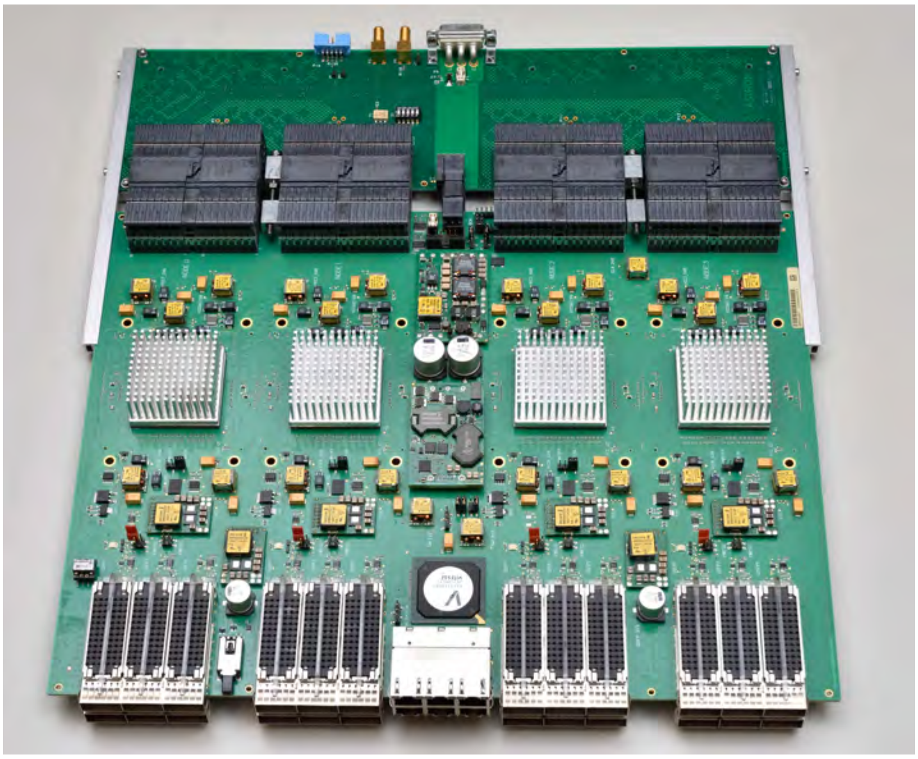
Software correlators, such as SFXC, have the advantage that they are highly flexible and adaptable. Moreover, they run on standard computers, which over the years become ever more powerful and affordable as a result of commercial developments. However, general-purpose computing hardware is not particularly suited for correlation, and as a result, software correlators tend to be not very energy-efficient, and limited in capacity. Particularly in the case of very high data rates and large numbers of stations, a custom-made hardware solution might have considerable advantages.

With that in mind, JIVE embarked on the UniBoard project, a Joint Research Activity in RadioNet FP7. The UniBoard, of which more than a hundred have been produced by now, was designed to be a generic, high-performance computing platform, using Field-Programmable Gate Arrays (FPGA). The JIVE UniBoard Correlator is one of the several applications making use of this hardware, and was entirely developed at JIVE. It combines impressive computing performance with minimal power consumption, and although not as flexible as the SFXC, it could be of great value in the processing of a subset of EVN observations.

During 2015, detailed comparisons were made between the output of JUC and SFXC. After fixing a number of problems, some of which were quite subtle, comparisons of the phase across the band, and phase over time, showed the difference reduced to zero biased noise.

UniBoard[2], a Joint Research Activity in RadioNet3, again led by JIVE, was in many aspects a follow-up of the first UniBoard. The prototype board was delivered in May 2015, and after an intense period of testing and debugging by ASTRON and JIVE engineers, the production run of seven boards took place in November 2015. Equipped with the newest Altera Arria10 20nm FPGAs, which in 2015 were in fact only available as Engineering Samples, these boards are on the cutting edge of technology. Furthermore, they are pin-compatible with the far more powerful 14nm Stratix 10 devices, due to become available in 2017.

Alongside this board, a so-called Hybrid Memory Cube (HMC) extension board was designed and sent out for manufacture at the end of the year. This board will be used to explore the suitability of this completely new type of memory for astronomical data processing systems. In addition a design document was produced, showing ways to map the JIVE correlator onto the UniBoard^2 platform.



UniBoard^2 with test extension board attached

User software

User software development at JIVE picked up speed in 2015, driven by the BlackHoleCam and SKA-NL Roadmap projects. VLBI data reduction is mostly done using AIPS, a suite of programs dating back to the 1970's. Although still used extensively, being legacy software AIPS is extremely hard to modify or expand, practically not supported anymore, and clearly not suited for the new large instruments about to come online.

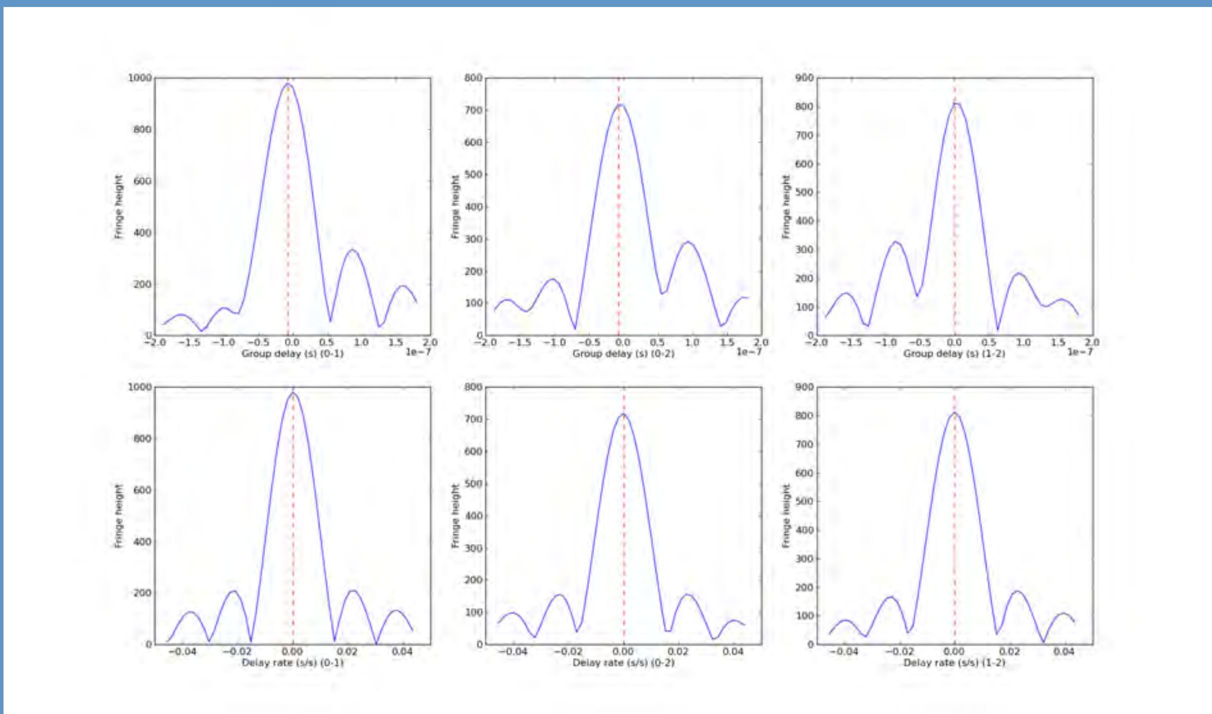
A crucial part of the VLBI data reduction chain involves fringe fitting, which is a technique needed to fine-tune the alignment of the signals from different telescopes. This functionality obviously is available in AIPS, as well as in HOPS, another piece of legacy software.

As a first step towards a VLBI data reduction pipeline for BlackHoleCam, an inventory and assessment were made of current data reduction packages. For reasons of applicability, support and future sustainability the decision was made to use CASA, which is being developed and maintained by NRAO for ALMA and JVLA data reduction.

After this selection, work got underway to write a fringe-fitting routine, in the first instance in Python, a much-used scripting language. An extensive list of additional modifications and functionality needed for end-to-end VLBI data reduction in CASA was compiled. Discussions were held with several software engineers who have previously worked on fringe fitting algorithms, and contact was made with the NRAO to discuss ways of implementing the changes needed to CASA itself and eventually including fringe fitting as a part of the official CASA release. A collaboration was set up with a group at Rhodes University in South Africa to develop the instrument simulations that are needed to validate the calibration software. The fringe fitting code was then successfully verified using the results of simulations performed by both the Rhodes and the JIVE teams.

A workshop was held in Leiden, to discuss the requirements for a mm-VLBI processing pipeline. The workshop was very well attended, and resulted in a document with requirements and recommendations for the design of the pipeline, data format and meta-data. This document was distributed within the BlackHoleCam and Event Horizon Telescope communities.

Good progress was made with the implementation, as demonstrated in the plots below, showing the cross-sections through the peaks of fringes in delay and phase space resulting from a 2D Fourier Transform, as well as the phase along that cross-section. The plots and corresponding code are part of the prototype for the CASA fringe fitter under development. The red dashed lines through the fringe peaks show the results of a global least-squares solver started with initial estimates derived from the peaks.



First results of CASA fringe fitter prototype

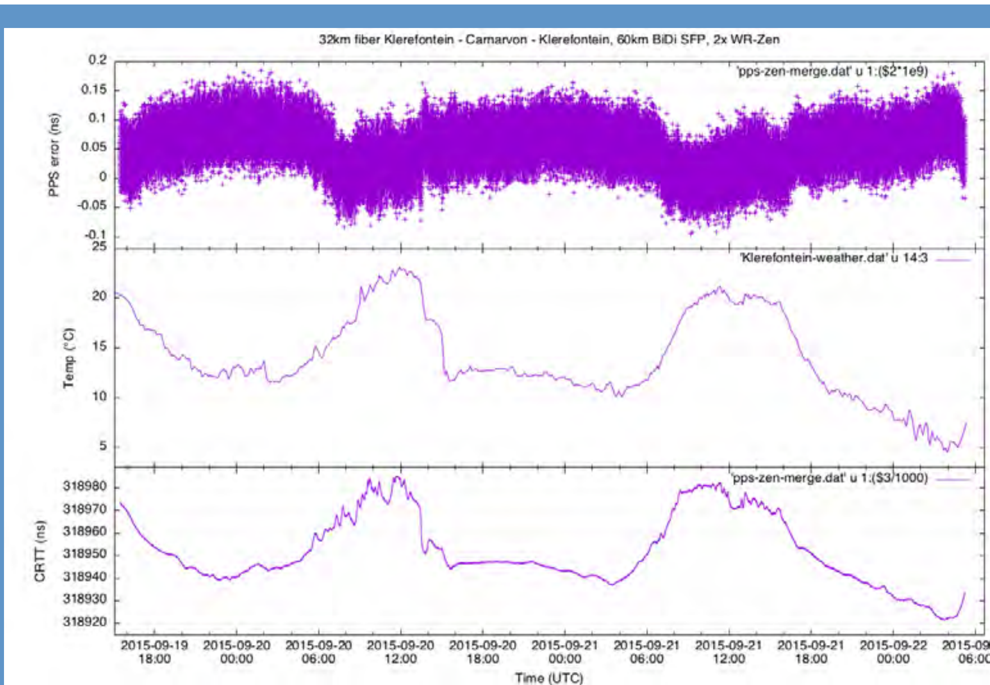
SKA

The development of the Square Kilometre Array (SKA) holds an important place in R&D at JIVE. With its EVN partners, JIVE pioneered real-time e-VLBI, which led to the e-EVN being recognised as an official SKA pathfinder. In line with its expertise in high-speed global data transport, JIVE is strongly involved in the Signal and Data Transport (SaDT) consortium, providing the Synchronisation and Timing (SAT) architect.

Much effort was spent on working out the performance requirements for the time and frequency distribution system of the SKA, and its interfaces to the rest of the telescope. A system design was made for the distribution of UTC timing at nanosecond accuracy, based on the White Rabbit (WR) protocol (http://www.ohwr.org/projects/white-rabbit). WR was originally developed at CERN to provide sub-nanosecond accuracy and picoseconds precision of synchronization for large distributed systems, connecting thousands of nodes at typical distances of 10 km between nodes. As the distances within the SKA are much larger, the performance of WR had to be verified in realistic conditions. What is more, fibres connecting the telescopes of SKA-MID (in South Africa) will most likely be suspended from poles, rather than buried. This implies large fluctuations in temperature, and with it, round-trip time and even of the dispersion within the fibres.

To test the performance of WR in realistic conditions, a field trial was organised on location at the SKA-SA support base in Klerefontein, South Africa. The local overhead fibre infrastructure to the MeerKAT site was used, with loopbacks to create paths of up to 64 km in length. During one week of tests, it was shown that the WR system can actually cope with the very large fluctuations caused by temperature variations, and that overall the system performed according to specifications.

Overhead fibres at Klerefontein, South Africa



Timing error in ns, local temperature and round-trip time in ns

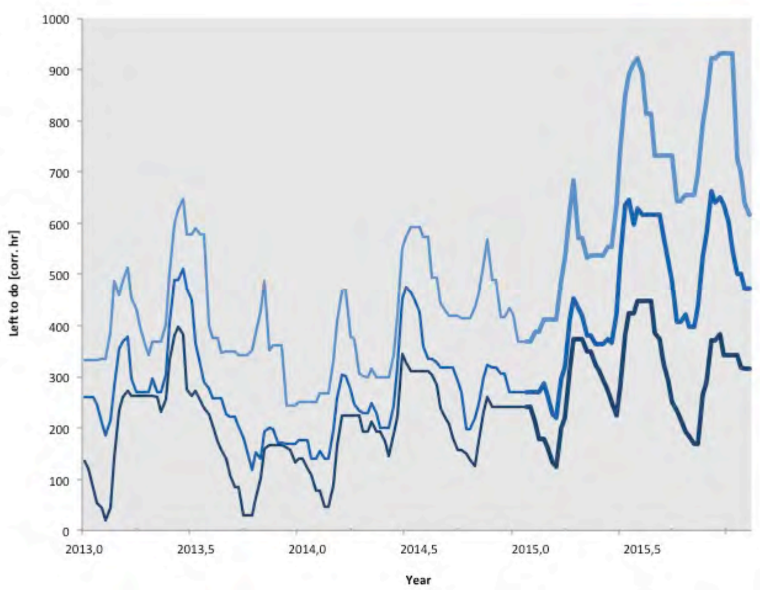
4 Operations

Correlation

The core of JIVE's service is the processing of EVN data; the table below summarizes experiments that were correlated at JIVE. For a detailed table of user experiments that had correlation, distribution, or release activity in 2015, see the overview of Correlator statistics in Section 6.

	User Experiments			Test & Network Monitoring		
	N	Ntwk_hr	Corr_hr	N	Ntwk_hr	Corr_hr
Observed	96	889.5	1125.5	24	88.5	112.5
Correlated	96	864.5	1049.5	28	102.5	126.5
Distributed	87	753	923	23	87.5	111.5
Released	84	727	877	21	60	60
e-EVN experiments	27	191	191			
e-EVN ToOs	2	19	19			

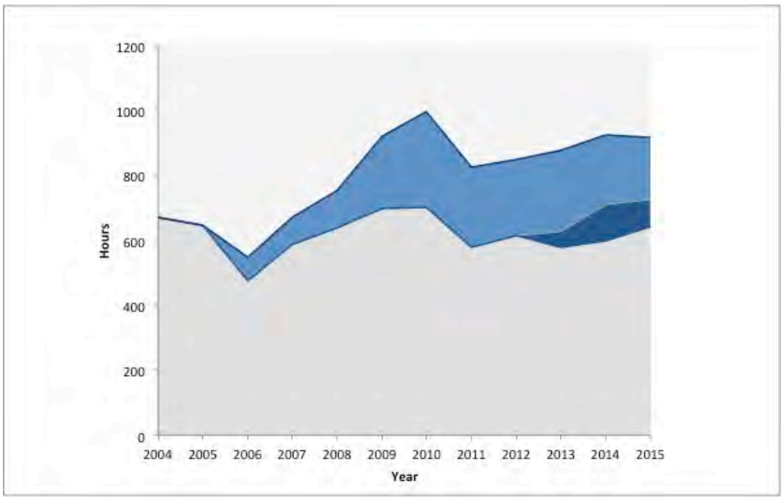
Summary of projects observed, correlated, distributed, or released in 2015. Here, network hours sum the total duration of experiments, and correlator hours are network hours multiplied by any multiple correlation passes.



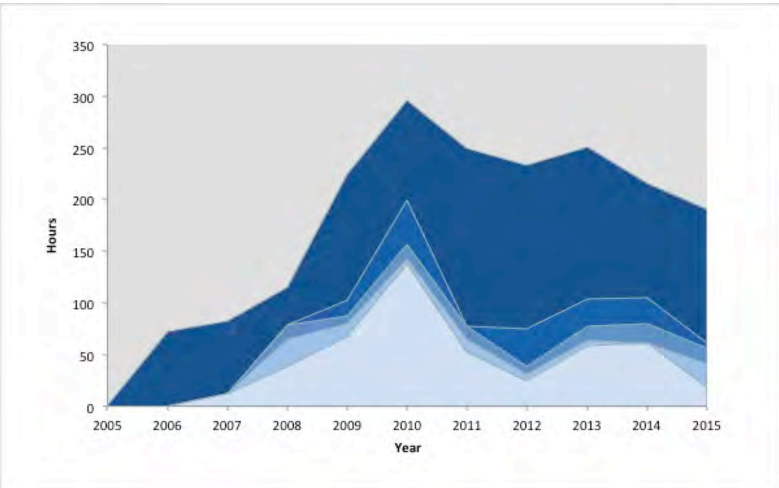
The size of the correlator queue at different stages in the processing cycle. The bottom line shows the number of correlator hours that remain to be correlated. The middle line shows the number of correlator hours in experiments whose data remain to be distributed to the PI. The top line plots the number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

A major consideration for the JIVE operations is to process the data timely, deliver the resulting data to the users and free the recording media for the next observing session. The progress with releasing experiments is carefully monitored by JIVE operations.

The EVN offers a variety of observing modes that provide the users with extra flexibility, but add some complexity to the operations. The top figure shows the evolution of annual EVN network hours. The bottom figure focuses on the e-EVN experiments, showing a division of annual observing hours into different categories. By their nature, all e-EVN observations correlate at JIVE and run in a single correlator pass.



Annual EVN network hours, with the e-EVN network hours in grey, the e-VLBI hours in blue the and the new Out of session hours in dark blue.



Division of annual e-EVN network hours into categories, from bottom to top: Target-of-Opportunity, triggered, short observations, converted from disk, regular,

Session 2/2014 saw some experiments that required new SFXC features, and correlation of two families of these continued into 2015:

GP052, a pulsar scintellometry experiment, used coherent de-dispersion for its target millisecond pulsar. It also needed 3 correlator passes, each using a different gating/binning configuration.

EG078, the first epoch of a survey for faint sources in the Hubble Deep Field, required multiple phase center correlation with 699 targets, extending out to 27' from the pointing center.

The first user experiment to employ the SFXC spectral zooming capability was correlated in April: 0.5 MHz of a 16 MHz observed band in the line correlation in a OH maser experiment that included global stations and the RadioAstron satellite.

Session 2 saw the first EVN user experiment having 32 MHz subbands, a neutral hydrogen absorption experiment of a galaxy with large HI velocity dispersion.

Session 3/2015 saw the first ever EVN user 2 Gbps experiment (a global), and the first time the Irbene telescope participated in user experiments.

The first e-VLBI experiment to record onto FlexBuff at JIVE simultaneously to the real-time correlation was an experiment to localize rotating radio transients in the December 2015 e-EVN day.

Support

EVN Support

The evolution of the back-end situation in the EVN as a whole continued apace. In 2015, JIVE coordinated and analyzed tests involving new DBBC firmware, 2 Gbps observing modes and use of the fila10G output from the DBBC. JIVE continued to support parallel-recording tests for stations shifting to the DBBC and to local FlexBuff recording.

During 2015 JIVE produced the first fringes, at 3 different frequencies, of the refurbished Irbene (Latvia) telescope.

JIVE coordinated and analyzed test observations for Torun using a remote hydrogen maser for clock and frequency control. By the January 2016 e-EVN day, Torun had shifted entirely to remote H-maser control, and tests with optical-lattice clocks continued.

Initial discussions were held with SKA SA about coordinating initial test observations with the Kutunse (Ghana) AVN telescope in 2016.

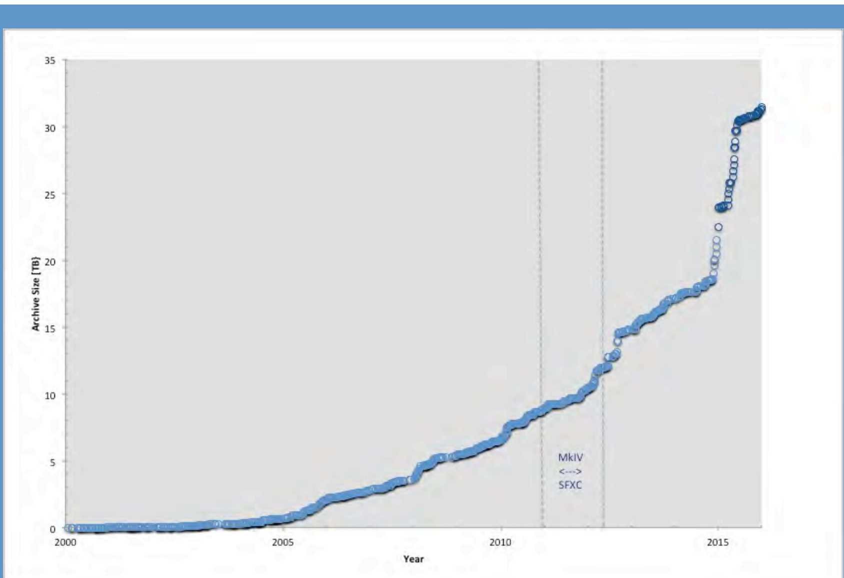
The refurbished Irbene telescope

User Support

JIVE provides support in all stages of a user's EVN observation, from proposal definition to data analysis. There were 14 first-time EVN PIs in 2015 observations, including 5 students. At the 2015 European Radio Interferometry School (ERIS), JIVE staff conducted the VLBI lecture and both VLBI tutorials (see page 8). A list of visits to JIVE can be found at section 6.

JIVE maintains many of the interfaces through which the EVN users interact with the VLBI facility. For example, with back-end configurations at EVN stations still evolving on sub-session time-scales, JIVE continued to provide PIs with experiment-specific scheduling templates. For session 3/2015, a new procedure for depositing schedules was enacted, to avoid instances of stations observing the wrong version of a schedule: PIs send their key-files to JIVE and JIVE runs sched and populates the server. Additional benefits of the new procedure include using a locally modified version of sched at JIVE to enable 2 Gbps recordings with the DBBC/DDC personality and pointing-sector control, as had been requested by some stations.

The archive is another important user service, providing open access to practically all data older than 1 year. The total size of user-experiment FITS files in the EVN Archive at the end of 2015 was 31.45 TB; the figure below shows the growth of the Archive with time.



Growth of user experiments in the EVN archive. Experiments archived in 2015 are plotted in dark blue. Vertical grey lines show the transition period between the MkIV and SFXC correlator

5 JIVE finances

5.1 JIVE financial report 2014-2015

Balance (after allocation of results)

ASSETS	**2015 in €**	**2014* in €**
Tangible fixed Assets		
Tangible fixed Assets	77.831	51.294
Total of Tangible fixed Assets	77.831	51.294
Current Assets		
Receivables	1.055.679	790.098
Cash at bank	1.150.686	1.220.521
Total of Current Assets	2.206.365	2.010.619
Total Assets	**2.284.196**	**2.061.913**
	========	========

LIABILITIES	**In €**	**In €**
Capital		
General reserve	936.117	800.00
Designated funds	511.415	511.415
Total capital	1.447.532	1.311.415
Other Liabilities		
Short term debts	836.664	750.498
Total Other Liabilities	836.664	750.498
Total Liabilities	**2.284.196**	**2.061.913**
	========	========

Statement of PROFIT & LOSS

	2015 BUDGET	2015 ACTUAL	2014 ACTUAL*
R E V E N U E S	**in €**	**in €**	**in €**
Income			
Contributions/subsidies third parties	2.525.103	2.644.675	2.087.216
Interest	10.000	27	382
Other	99.644	168.095	195.117
Total Income	2.634.747	2.812.798	2.282.715
Total Revenues	**2.634.747**	**2.812.798**	**2.282.715**
	========	========	========
E X P E N D I T U R E S	**in €**	**in €**	**in €**
Operations			
Expenditures	2.744.414	2.676.681	2.596.099
Total Expenditures	**2.744.414**	**2.676.681**	**2.596.099**
	========	========	========
R E S U L T	**-109.667**	**136.117**	**-313.384**

**NOTE: 2014 ACTUAL accounts are based on JIVE as a Foundation*

5.2 JIVE Projects

The table lists the projects that JIVE was active in during the reporting period.

Project & Work Packages	Dates	JIVE role
RadioNet3 (EC)	01.01.12 - 31.12.15	RadioNet supports the collaboration of major radio astronomy facilities in Europe.
Management		JIVE processes all travel claims for outside users of the Networking Activities and Trans National Access.
QueSERA		JIVE provides the leader for the outreach and governance work package (Huib van Langevelde).
UniBoard2		JIVE leads the research into a new digital processing platform based on FPGAs (Arpad Szomoru).
EVN TNA		JIVE coordinates the Trans National Access programme for the EVN and the associated user support. (Bob Campbell).
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.
BlackHoleCam (EC)	01.10.14 - 30.09.20	BlackHoleCam is an ERC synergy project to enable sub-mm VLBI in which JIVE is contributing in the areas of real-time data verification and user software.
SKA-NL (NWO)	01.09.04 - 31.12.18	JIVE is an associated partner of the Dutch effort to support the engineering effort for the SKA, contributing in the area of Signal and Data Transport and VLBI with SKA-MID.

6 Tables and metrics

6.1 JIVE Council

Representatives of Members

Dr. Patrick Charlot – Laboratoire d’Astrophysique de Bordeaux, France (Chair)

Prof. Simon Garrington – Jodrell Bank Centre for Astrophysics, Manchester, UK (vice-chair)

Prof. John Conway – Onsala Space Observatory, Onsala, Sweden

Prof. dr. Michael Garrett – ASTRON, Dwingeloo, The Netherlands

Prof. Jesus Gómez González – Instituto Geográfico Nacional, Madrid, Spain

Mrs. Monica Groba Lopez - Instituto Geográfico Nacional, Madrid, Spain

Dr. Denis Mourard – National Centre for Scientific Research, Paris, France

Dr. Catarina Sahlberg – Vetenskapsrådet (VR) / 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

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

Mrs. Vinny Pilay – South African Embassy, Brussels, Belgium

Dr. Grazia Umana – INAF-ORA, Bologna, Italy

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

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

6.2 JIVE personnel

Dr. Ivan Agudo	Support Scientist (until 1 February 2015)
Ms. Tatiana Bocanegra Bahamon	Researcher in training (until 1 August 2015)
Mr. Paul Boven	Network/Linux Specialist
Mr. Wybren Buijs	Linux-/Network Specialist (from 1 November 2015)
Dr. Bob Campbell*	Head of Science Operations
Dr. Giuseppe Cimo	Space VLBI Scientist
Dr. Dominic Dirkx	Researcher (from 1 July 2015)
Dr. Dmitry Duev	Postdoc Space VLBI (until 1 October 2015)
Drs. Bob Eldering	Software Engineer
Prof. Leonid Gurvits*	Head of Space Science & Innovative Applications Group
Dr. Jonathan Hargreaves	Digital Engineer
Mr. Bert Harms	Operator
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. Minnie Mao	Support Scientist (from 13 April 2015)
Dr. Guifre Molera Calvés	Postdoc Space VLBI (until 1 March 2015)
Dr. Zsolt Paragi*	Head of User Support
Dr. Sergei Pogrebenko	Senior System Scientist (until 12 April 2015)
Dr. Des Small	Scientific Software Engineer
Dr. Gabriele Surcis	Support Scientist
Dr. Arpad Szomoru*	Head Technical Operations and R&D
Mr. Hans Tenkink	Chief Operator
Dr. Ilse van Bemmel	Project Scientist
Drs. Aukelien van den Poll	Project Assistant
Prof. Huib Jan van Langevelde*	Director
Drs. Harro Verkouter	Senior Software Engineer

* - JIVE MT member

6.3 Educational responsibilities

MSc project supervision

Luis Henry Quiroga Nuñez – by H.J. van Langevelde, Leiden University (completed in 2015)

PhD project supervision

Tatiana Bocanegra Bahamon – by L.I. Gurvits, TU Delft (completion in 2016)

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

Secondary affiliations:

Tatiana Bocanegra Bahamon – affiliated with Shanghai Astronomical Observatory, Shanghai, and Department of Astrodynamics and Space Missions, Delft University of Technology, the Netherlands

Dmitry Duev – affiliated with Sternberg Astronomical Institute, Lomonosov Moscow State University, Russia

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

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

Guifre Molera Calvés – affiliated with Aalto University, Helsinki, Finland

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

6.4 Visitors to JIVE

Name	Institute	Period	Host
I. Stewart	Sterrewacht Leiden	16 March	Szomoru
P. Rosenblatt	Royal Observatory Brussels, Belgium	7-10 April	Gurvits
M. Argo	Jodrell Bank, UK	12-17 April	Paragi
M. Perez-Torres	IAA-CSIC, Spain	19-21 April	Paragi
F. Kirsten	CIRA - Curtin University of Technology, Australia	19-21 April	van Langevelde
A. Baudry	Laboratoire d’Astrophysique de Bordeaux, France	19-22 April	van Langevelde
R. Deane	Rhodes University/SKA SA, South Africa	19-24 April	Paragi
L.H. Quiroga Nunez	University Leiden, NL	20-21 April	van Langevelde
S. Bourke	California Institute of Technology, USA	21-24 April	van Langevelde
L. Sjouwerman	NRAO Socorro, USA	21 April - 2 May	Paragi
H. Imai	Kagoshima University, Japan	22-24 April	Paragi
J. Yang	Onsala Space Observatory, Sweden	22-25 April	Paragi
X. Hong	Shanghai Astronomical Observatory, China	13-16 May	Gurvits
M. Wang	Yunnan Astronomical Observatory, China	13-16 May	Gurvits
T. Blecher	Rhodes University, South Africa	1-5 June	Van Bemmel
L.H. Quiroga Nunez	University Leiden, NL	3-5 June	van Langevelde
S. Frey	FOMI, Hungary	8-19 June	Paragi
K. Gabanyi	FOMI, Hungary	8-19 June	Paragi
J. Kania	Carnegie Mello University, USA	1 June - 17 August	Cimo
Z. Wen	University of Chinese Academy of Sciences, China	2 June - 29 August	Paragi
V. Singh	University of Wyoming, USA	9 June - 18 August	Mao
S. Horiuchi	CSIRO/NASA, Australia	19-25 June	Gurvits
J. Pelamatti	University of Technology Delft	1 September 2015 - 1 March 2016	Gurvits
B. Cotton	NRAO Socorro, USA	4 November	Kettenis
A. Bartkiewicz	Torun Centre for Astronomy, Poland	9-13 November	Paragi
S. Guo	Shanghai Astronomical Observatory, CAS, China	1-12 December	Hargreaves
J. Gan	Shanghai Astronomical Observatory, CAS, China	1-12 December	Hargreaves
Z. Xu	Shanghai Astronomical Observatory, CAS, China	1-12 December	Hargreaves
M. Kim	KASI Korea Astronomy and Space Science Institute, Korea	9-28 November	Surcis
I. Agudo	Instituto de Astrofisica de Andalusia (CSIC), Spain	26-28 November	Paragi

6.5 Correlator activity

User experiments with correlation, distribution, or release activity in 2015

	Obs. Date/ Session	PI	User Experiments
EA055A	301014	Argo	Tracking the evolution of the new radio source in NGC660
EA055B	171015	Argo	Tracking the evolution of the new radio source in NGC660
EA056A,B	Session 3/2014	Akiyama	Joint EVN+e-MERLIN observations of the extreme blazar candidate HESS J1943+213
EB052E-H	Session 1/2015	Bartkiewicz	Deriving the nature of methanol rings through proper motion measurements
EB056	080615	Biggs	Determining the mass distribution in the lensing galaxy of CLASS B0850+054
EC047A-B	Session 1/2015	Castangia	Exploring the obscured nucleus of the Sy2 IRAS15480-0344
EC052C	100215	Cseh	Do most high-redshift radio-loud quasars have a steep spectrum?
EC052D	240315	Cseh	Do most high-redshift radio-loud quasars have a steep spectrum?
EC052E	230615	Cseh	Do most high-redshift radio-loud quasars have a steep spectrum?
EC053	140115	Coppejans	Searching for the Youngest Black Holes in the Radio Domain
EC054A	150915	Cao	First-epoch VLBI observations of four z > 4 blazars with the EVN
EC054B	061015	Cao	First-epoch VLBI observations of four z > 4 blazars with the EVN
EG078B	050614	Garrett	No place left to hide - AGN among the faint radio source population
EG082E	240315	Gawronski	Project RISARD - part III
EG082F	061015	Gawronski	Project RISARD - part III
EG084A,B	Session 3/2014	Guirado	Radio emission and binarity in PMS stars
EG085	060315	Guidetti	Radio excess sources in the GOODS-N field
EG087A	100215	Gabanyi	Zooming in on the peculiar radio-loud narrow-line Seyfert 1 galaxy J1100+4421
EG087B	240315	Gabanyi	Zooming in on the peculiar radio-loud narrow-line Seyfert 1 galaxy J1100+4421
EH027D	120515	Hada	Harvesting more and more fruits from HST-1

	Obs. Date/ Session	PI	User Experiments
EH028C	120615	Hu	Parallax Measurement to 1.6 GHz OH Masers in the OH/IR Star OH138.0+7.4
EH030A,B	Session 2/2015	Herrero-Illana	Is there a hidden AGN in NGC1614?
EI012C,D	Session 1/2015	Ibar	A detailed view of an AGN buried in a strongly magnified Herschel galaxy
EK035	060615	Koay	Inclination Dependences of Optical-UV Broad Emission Line Profiles in Quasars
EL049	270215	Li	Proper Motions of 1720 MHz OH Masers in Supernova Remnant W44
EL050A	041114	Liuzzo	Hunting the nuclear emission in elusive faint BL Lac objects
EL050C,D	Session 2/2015	Liuzzo	Hunting the nuclear emission in elusive faint BL Lac objects
EL052	160615	Levan	Is GRB 150101B related to an AGN jet?
EM113	171115	Miller-Jones	Verifying the ubiquity of the disc-jet connection with VLBI imaging of SS Cygni
EM115A,B	Session 2/2015	Musaeva	Constraining the mass of the intermediate-mass black hole candidate in NGC4490
EM118A	150915	Mao	Heart of a Spiral DRAGN
EM118B	061015	Mao	Heart of a Spiral DRAGN
EM120	021215	Morganti	Searching for MHz-peaked Sources with LOFAR: A high-redshift GPS candidate?
EO013	180615	Oonk	Peering into the Heart of the Prototypical Cool-Core Cluster
EP088G,H	Session 3/2014	Perez-Torres	EVN imaging of the LIRGI sample
EP091A,B	Session 2/2015	Pasetto	A High angular resolution study of radio sources with large Rotation Measure
EP092A	280215	Perez-Torres	Probing the double-degenerate scenario in Type Ia SNe with the EVN
EP092B	140615	Perez-Torres	Probing the double-degenerate scenario in Type Ia SNe with the EVN
EP093A,B	Session 2/2015	Paragi	Flat/inverted-spectrum doubles: the best dual-AGN candidates?
EP096A	140415	Prieto	Resolving the Radio Emission in the Host Galaxy of the Nearby TDE ASASSN-14li
EP096B,C	Session 2/2015	Prieto	Resolving the Radio Emission in the Host Galaxy of the Nearby TDE ASASSN-14li
EP100	011215	Paragi	e-EVN Localization of millisecond Transient Signals II.

	Obs. Date/ Session	PI	User Experiments
ER030E-G	Session 3/2014	Romero-Canizales	EVN observations of IC 883: a new supernova factory
ER040	170615	Rampadarath	Possible Parsec-scale Jet Motion in the Seyfert Galaxy, M51
ER043A,B	Session 2/2015	Ramirez-Olivencia	Unveiling the nature of the central sources of IRAS15250+3609 and IRAS10565+2448
ES071C	130315	Sanna	3D velocity field of the methanol gas around Cepheus A HW2
ES072L-M	Session 3/2014	Surcis	6.7 GHz CH3OH maser polarization towards massive protostars II
ES075	140315	Szymczak	Understanding periodic maser sources. I. Pilot study
ES076	160315	Szymczak	Short-period methanol maser in G107.29+5.63
ET031A	230615	Tudose	EVN observations of X-ray binary transients
EY020B	090315	Yang	Is there a superluminal jet in Swift J1644+57
EY022	130115	Yang	Locating the accretion zone associated with Seyfert type change in Mrk590
EY022B	130515	Yang	Locating the accretion zone associated with Seyfert type change in Mrk590
GA032C	010615	Agudo	43 GHz Precision Astrometry of the Jet in NRAO 150
GA035A	281014	Alakoz	Imaging of microstructures of OH and H2O masers with ultimate angular resolution
GA036	310515	Asadi	Gravitational millilensing as a probe of dark halo substructure
GB075B	191014	Boccardi	Ultra high resolution imaging of the archetypical radiogalaxy Cygnus A
GB075C	290515	Boccardi	Ultra high resolution imaging of the archetypical radiogalaxy Cygnus A
GJ014	211014	Jackson	Direct detection of a black hole by gravitational lensing
GL039	020615	Lobanov	Filming Rapid Structural and Emission Variability in AE Aquarii
GN002A	020315	Nyland	Tracing the Evolution of Fast Jet-Driven Outflows
GN002B	130615	Nyland	Tracing the Evolution of Fast Jet-Driven Outflows
GP051A-D	Session 2/2014	Pihlstrom	Probing the Proper Motion of M31 with 6.7GHz Methanol Masers
GP052A-D	Session 2/2014	Pen	VLBI scintellometry: precision pulsar mass and distances
GP053E	040315	Perez-Torres	Deep VLBI observations of the star-bursting regions in Arp 299
GP053H	120615	Perez-Torres	Deep VLBI observations of the star-bursting regions in Arp 299
RG007A	181115	Giroletti	Unveiling the progenitor nature and environment of the bright GRB151027

	Obs. Date/ Session	PI	User Experiments
RSF08	181015	Frey	Candidate supermassive black hole binary
RSG07	011215	Giroletti	Accuracy of EG080 astrometry
RSK02	181115	Kunert	Active galactic nucleus in Ultra-Compact Dwarf Galaxy
RSP11	110215	Paragi	A nearby short GRB in an AGN host galaxy
RSP12	130515	Paragi	Short e-EVN observations two RRATs
RSY03	021215	Yang	An ultra-luminous x-ray source in NGC5252
RT012	050715	Tudose	V404 Cyg in outburst

6.6 JIVE Publications 2015

All publications that involve JIVE staff

Refereed papers

- Y. Ao, Y. Matsuda, A. Beelen, C. Henkel, R. Cen, et al (including **M. Y. Mao),** *What powers Lyalpha blobs?*, 2015, Astronomy and Astrophysics, 581, 132
- M. K. Argo, **I. M. van Bemmel**, Sam D. Connolly, Robert J. Beswick, *A new period of activity in the core of NGC 660*, 2015, Monthly Notices of the Royal Astronomical Society, 452, 1081-1088
- J. K. Banfield, O. I. Wong, K. W. Willett, et al. (including **M. Y. Mao**), *Radio Galaxy Zoo: host galaxies and radio morphologies derived from visual inspection*, 2015, Monthly Notices of the Royal Astronomical Society, 453, 2326-2340
- **T. Bocanegra-Bahamón**, Colm Bracken, Marc Costa Sitjà et al. (including **D. Dirkx**), *MUSE - Mission to the Uranian system: Unveiling the evolution and formation of ice giants*, 2015, Advances in Space Research, 55, 2190-2216
- S. Bogdanov, A. M. Archibald, C. Bassa, et al. (including **Z. Paragi**), *Coordinated X-Ray, Ultraviolet, Optical, and Radio Observations of the PSR J1023+0038 System in a Low-mass X-Ray Binary State*, 2015, The Astrophysical Journal, 806, 148
- M. I. Carnerero, C. M. Raiteri, M. Villata, et al. (including **I. Agudo**), *Multiwavelength behaviour of the blazar OJ 248 from radio to gamma-rays,* 2015, Monthly Notices of the Royal Astronomical Society, 450, 2677-2691
- C. Carrasco-González, J. M. Torrelles, J. Cantó, et al. (including **G. Surcis**, **H. J. van Langevelde**, **C. Goddi**), *Observing the onset of outflow collimation in a massive protostar*, 2015, Science, 348, 114-117
- D. Cseh, J. C. A. Miller-Jones, P. G. Jonker, et al. (including **Z. Paragi**), *The evolution of a jet ejection of the ultraluminous X-ray source Holmberg II X-1*, 2015, Monthly Notices of the Royal Astronomical Society, 452, 24-31
- A. T. Deller, J. Moldon, J. C. A. Miller-Jones, et al. (including **Z. Paragi**), *Radio Imaging Observations of PSR J1023+0038 in an LMXB State,* 2015, The Astrophysical Journal, 809, 13
- A. De Rosa, S. Bianchi, T. Bogdanovic, et al. (including **Z. Paragi**), *Multiple AGN in the crowded field of the compact group SDSS J0959+1259*, 2015, Monthly Notices of the Royal Astronomical Society, 453, 214-221
- **D. A. Duev**, M. V. Zakhvatkin, V. A. Stepanyants, et al. (including **G. Molera Calvés**, **S. V. Pogrebenko**, **L. I. Gurvits**, **G. Cimò**, **T. M. Bocanegra-Bahamón**), *RadioAstron as a target and as an instrument: Enhancing the Space VLBI mission's scientific output*, 2015, Astronomy and Astrophysics, 573, 99
- S. Frey, **Z. Paragi**, J. O. Fogasy, **L. I. Gurvits,** *The first estimate of radio jet proper motion at z > 5*, 2015, Monthly Notices of the Royal Astronomical Society, 446, 2921-2928
- K. É. Gabányi, D. Cseh, S. Frey, et al. (including **Z. Paragi**, **L. I. Gurvits)**, *VLBI observation of the newly discovered z = 5.18 quasar SDSS J0131-0321*, 2015, Monthly Notices of the Royal Astronomical Society, 450, L57-L60
- **C. Goddi**, C. Henkel, Q. Zhang, L. Zapata, T. L. Wilson, *Hot ammonia around young O-type stars. II. JVLA imaging of highly excited metastable NH3 masers in W51-North*, 2015, Astronomy and Astrophysics, 573, 109
- **C. Goddi**, Q. Zhang, L. Moscadelli, *Hot ammonia around young O-type stars. I. JVLA imaging of NH3 (6, 6) to (14, 14) in NGC 7538 IRS1*, 2015, Astronomy and Astrophysics, 573, 108
- G. H. Heald, [76 authors collapsed], **I. van Bemmel** and [72 authors collapsed]: *The LOFAR Multifrequency Snapshot Sky Survey (MSSS). I. Survey description and first results*, 2015, Astronomy and Astrophysics, 582, 123

- **A. Keimpema**, **M. M. Kettenis**, **S. V. Pogrebenko**, et al. (including **R. M. Campbell**, **G. Cimò**, **D. A. Duev**, **B. Eldering**, **H. J. van Langevelde**, **Z. Paragi**, **A. Szomoru**), *The SFXC software correlator for very long baseline interferometry: algorithms and implementation*, 2015, Experimental Astronomy, 39, 259-279
- F. Kirsten, W. Vlemmings, **R. M. Campbell**, M. Kramer, S. Chatterjee, *Revisiting the birth locations of pulsars B1929+10, B2020+28, and B2021+51*, 2015, Astronomy and Astrophysics, 577, 111
- P. Kharb, M. Das, **Z. Paragi**, S. Subramanian, L. P. Chitta, *VLBI Imaging of the Double Peaked Emission Line Seyfert KISSR 1494*, 2015, The Astrophysical Journal, 799, 161
- E. Orrù, S. van Velzen, R. F. Pizzo, et al. (including **I. van Bemmel**), *Wide-field LOFAR imaging of the field around the double-double radio galaxy B1834+620. A fresh view on a restarted AGN and doubeltjes*, 2015, Astronomy and Astrophysics, 584, 112
- A. Sanna, **G. Surcis**, L. Moscadelli, et al. (including **C. Goddi**), *Velocity and magnetic fields within 1000 AU of a massive YSO*, 2015, Astronomy and Astrophysics, 583, L3
- **G. Surcis**, W. H. T. Vlemmings, **H. J. van Langevelde**, B. Hutawarakorn Kramer, A. Bartkiewicz, M. G. Blasi, *EVN observations of 6.7 GHz methanol maser polarization in massive star-forming regions. III. The flux-limited sample*, 2015, Astronomy and Astrophysics, 578, 102

Conference papers

- M. Argo, R. Steadman, **Z. Paragi**, et al., *Resolving the nature of compact ultra-steep spectrum sources*, 2015, PoS(EVN 2014)068
- M. Argo, **I. van Bemmel**, S. Connolly, R. Beswick, *Things that go bump in the night: the curious case of NGC660*, 2015, PoS(EVN 2014)006
- **T. Bocanegra-Bahamón**, **G. Cimò**, **D. Duev**, **L.I. Gurvits**, G. Molera Calvés, **S.V. Pogrebenko**, *Planetary Radio Interferometry and Doppler Experiment (PRIDE) for Planetary Atmospheric Studies*, 2015, Geophysical Research Abstracts Vol. 17, EGU2015-2337
- **G. Cimò**, **D. Duev**, G. Molera Calvés, **T. Bocanegra-Bahamón**, **S.V. Pogrebenko**, **L.I. Gurvits**, *Ground-based VLBI observations of orbiters and landers*, 2015, European Planetary Science Congress
- S. Frey, **Z. Paragi**, K. E. Gabanyi, T. An, *Four hot DOGs eaten up with the EVN*, 2015, PoS(EVN 2014)003
- K. E. Gabanyi, G. Dubner, E. Giacani, S. Frey, **Z. Paragi**, *e-MERLIN observations of the puzzling TeV source HESS J1943+213*, 2015, PoS(EVN 2014)078
- C. García-Miró, J.E. Clark, C.S. Jacobs, et al. (including **R.M. Campbell**, **M. Kettenis**,), *VLBI digital terminal at the Deep Space Network: first results from non-JPL correlators*, 2015, PoS(EVN 2014)081
- **C. Goddi**, L. Moscadelli, *3D Gas Dynamics from Methanol Masers observed with the EVN reveals Rotating Disks around O-type Young Stars*, 2015, PoS(EVN 2014)040
- **M. Kettenis**, **A. Keimpema**, *SFXC: The new EVN data processor*, 2015, PoS(EVN 2014)088
- **L. I. Gurvits**, S. Frey, **Z. Paragi**, C. C. Cheung, E. Lopez, A. Siemiginowska, *Jets in AGN at extremely high redshifts*, 2015, IAU Symposium, 313, 327-328
- S. G. Jorstad, A. P. Marscher, D. A. Morozova, et al. (including **I. Agudo**), *The jet of the quasar 4C+21.35 from parsec to kiloparces scales and its role in high energy photon production*, 2015, IAU Symposium, 313, 33-38
- M. Lindqvist, **A. Szomoru**, *The present status and the future of the European VLBI Network*, 2015, IAU General Assembly, 22, 41681
- B. Marcote, J. Moldon, M. Ribó, J.M Paredes, **Z. Paragi**, *The changing morphology of the radio outflow of HESS J0632+057 along its orbit*, 2015, PoS(EVN 2014)095
- G. Molera Calvés, **G. Cimò**, **S.V. Pogrebenko**, **D. Duev**, **T. Bocanegra-Bahamón**, K. Rajpurohit, *Scintillation of Venus and Mars Express radio signal on interplanetary and ionosphere plasma*, 2015, PoS(EVN 2014)050
- M. A. Pérez-Torres, P. Lundqvist, R. J. Beswick, et al. (including **Z. Paragi**), *What is the progenitor of the Type Ia SN 2014J?*, 2015, Highlights of Spanish Astrophysics VIII, , 540-546

- V. Ramakrishnan, J. Leon-Tavares, E. Rastorgueva-Foi, et al. (including **I. Agudo**), *Connection between parsec-scale radio jet and gamma-ray flares in the blazar 1156+295*, 2015, PoS(EVN 2014)015
- A.M.S. Richards, A. Baudry, S. Etoka, et al. (including **H.J. Van Langevelde**), *Sub-mm maser VLBI: how do stellar winds break free from the star's gravity?*, 2015, PoS(EVN 2014)054
- **G. Surcis**, W. H. T. Vlemmings, **H. J. van Langevelde**, B. Hutawarakorn Kramer, A. Bartkiewicz, H. Engelkamp, *Magnetic field measurements at milliarcsecond resolution around massive young stellar objects*, 2015, PoS(EVN 2014)041
- **A. Szomoru**, **H. J. van Langevelde**, *R&D at JIVE: transforming the way VLBI is done*, 2015, IAU General Assembly, 22, 56816
- W. Thuillot, V. Lainey, L.-E. Meunier, et al. (including **D. Dirkx**, **L. Gurvits**), *Data Mining, Ingestion and Distribution of Planetary Data on Natural Satellites*, 2015, Astronomical Data Analysis Software an Systems XXIV (ADASS XXIV), 495, 583-586
- D. Titov, S. Barabash, L. Bruzzone, et al. (including **L.I. Gurvits**), *Jupiter Icy Moons Explorer: mission status after the Definition Phase*, 2015, Geophysical Research Abstracts Vol. 17, EGU2015-13284
- W. Thuillot, V. Lainey, J.-E. Arlot, et al. (including **D. Dirkx**, **L.I. Gurvits**), *The data distribution of the ESPaCE project*, 2015, European Planetary Science Congress
- M. Uunila, J. Kallunki, **G. Molera Calvés,** *Using software spectrometer to ensure VLBI signal chain reliability*, 2015, PoS(EVN 2014)113
- O. Witasse, N. Altobelli, S. Barabash, et al. (including **L.I. Gurvits**, **G. Cimò**), *JUICE: A European Mission to Jupiter and its Icy Moons*, 2015, European Planetary Science Congress
- J. Yang, **Z. Paragi**, T. J. O'Brien, L. Chomiuk, J. D. Linford, *VLBI detection of internal shocks in nova V959 Mon*, 2015, PoS(EVN 2014)053

Revised SKA Science Case: White Papers (refereed)

- I. Agudo, M. Boettcher, H. D. E. Falcke, et al. (including **L. Gurvits**, **Z. Paragi**), *Studies of Relativistic Jets in Active Galactic Nuclei with SKA*, 2015, Advancing Astrophysics with the Square Kilometre Array (AASKA14), 93
- R. Beswick, E. Brinks, M. Perez-Torres, et al. (including **I. van Bemmel**), *SKA studies of nearby galaxies: star-formation, accretion processes and molecular gas across all environments*, 2015, Advancing Astrophysics with the Square Kilometre Array (AASKA14), 70
- S. Corbel, J. C. A. Miller-Jones, R. Fender, et al. (including **Z. Paragi**), *Incoherent transient radio emission from stellar-mass compact objects in the SKA era*, 2015, Advancing Astrophysics with the Square Kilometre Array (AASKA14), 53
- R. Deane, **Z. Paragi**, M. Jarvis, et al., *Multiple supermassive black hole systems: SKA's future leading role*, 2015, Advancing Astrophysics with the Square Kilometre Array (AASKA14), 151
- I. Donnarumma, E. M. Rossi, R. Fender, et al. (including **Z. Paragi**), *SKA as a powerful hunter of jetted Tidal Disruption Events*, 2015, Advancing Astrophysics with the Square Kilometre Array (AASKA14), 54
- S. Etoka, D. Engels, H. Imai, et al. (including **H. van Langevelde**), *OH masers in the Milky Way and Local Group galaxies in the SKA era*, 2015, Advancing Astrophysics with the Square Kilometre Array (AASKA14), 125
- R. Fender, A. Stewart, J. P. Macquart, et al. (including **Z. Paragi**), *The Transient Universe with the Square Kilometre Array*, 2015, Advancing Astrophysics with the Square Kilometre Array (AASKA14), 51
- B. Gaensler, **I. Agudo**, T. Akahori, et al., *Broadband Polarimetry with the Square Kilometre Array: A Unique Astrophysical Probe*, 2015, Advancing Astrophysics with the Square Kilometre Array (AASKA14), 103
- M. Giroletti, M. Orienti, F. D'Ammando, et al. (including **I. Agudo**), *The connection between radio and high energy emission in black hole powered systems in the SKA era*, 2015, Advancing Astrophysics with the Square Kilometre Array (AASKA14), 153
- J. Green, **H. J. Van Langevelde**, A. Brunthaler, et al., *Maser Astrometry with VLBI and the SKA*,

2015, Advancing Astrophysics with the Square Kilometre Array (AASKA14), 119
- M. Hoare, L. Perez, T. L. Bourke, et al. (including **H. J. van-Langevelde**), *SKA and the Cradle of Life*, 2015, Advancing Astrophysics with the Square Kilometre Array (AASKA14), 115
- M. Johnston-Hollitt, F. Govoni, R. Beck, et al. (including **I. Agudo**), *Using SKA Rotation Measures to Reveal the Mysteries of the Magnetised Universe*, 2015, Advancing Astrophysics with the Square Kilometre Array (AASKA14), 92
- L. Koopmans, J. Pritchard, G. Mellema, et al. (including **I. van Bemmel**), *The Cosmic Dawn and Epoch of Reionisation with SKA*, 2015, Advancing Astrophysics with the Square Kilometre Array (AASKA14), 1
- L. Loinard, M. Thompson, M. Hoare, et al. (including **H. J. van Langevelde**), *SKA tomography of Galactic star-forming regions and spiral arms*, 2015, Advancing Astrophysics with the Square Kilometre Array (AASKA14), 166
- **Z. Paragi**, L. Godfrey, C. Reynolds, et al. (including **L. Gurvits**, **A. Szomoru**, **P. Boven**, **H. J. van Langevelde**, **I. Agudo**), *Very Long Baseline Interferometry with the SKA*, 2015, Advancing Astrophysics with the Square Kilometre Array (AASKA14), 143
- T. Robishaw, J. Green, **G. Surcis**, et al., *Measuring Magnetic Fields Near and Far with the SKA via the Zeeman Effect*, 2015, Advancing Astrophysics with the Square Kilometre Array (AASKA14), 110
- A. Siemion, J. Benford, J. Cheng-Jin, et al. (including **L. Gurvits**, **Z. Paragi**), *Searching for Extraterrestrial Intelligence with the Square Kilometre Array*, 2015, Advancing Astrophysics with the Square Kilometre Array (AASKA14), 116
- R. Taylor, **I. Agudo**, T. Akahori, et al., *SKA Deep Polarization and Cosmic Magnetism*, 2015, Advancing Astrophysics with the Square Kilometre Array (AASKA14), 113
- A. Wolter, A. Rushton, M. Mezcua, et al. (including **Z. Paragi**), *Radio investigation of Ultra-Luminous X-ray (ULX) Sources in the SKA Era*, 2015, Advancing Astrophysics with the Square Kilometre Array (AASKA14), 91

Astronomer's Telegrams and other electronic circulars

- V. Tudose, **Z. Paragi**, J. C. A. Miller-Jones, et al., *e-EVN observations of V404 Cyg in outburst*, 2015, The Astronomer's Telegram, 7742, 1
- M. Perez-Torres, M. Argo, I. Marti-Vidal, et al (including **Z. Paragi**), *e-MERLIN radio detection of SN2013df at 5.0 GHz*, 2015, The Astronomer's Telegram, 8452, 1

Other online data and publications (excluding preprints)

- J. A. Acosta-Pulido, **I. Agudo** et al., *The Spanish Square Kilometre Array White Book*, 2015, ArXiv e-prints, 1506.3474
- C. A. Hales, R. P. Norris, B. M. Gaensler, et al. (including **M. Y. Mao**), *VizieR Online Data Catalog: ATLAS 1.4GHz Data Release 2 (Hales+, 2014)*, 2015, VizieR Online Data Catalog, 744, 12555
- E. M. Rossi, I. Donnarumma, R. Fender, et al. (including **Z. Paragi**), *LOFT as a discovery machine for jetted Tidal Disruption Events*, 2015, ArXiv e-prints, 1501.2774
- **G. Surcis**, W. H. T. Vlemmings, **H. J. van Langevelde**, B. Hutawarakorn Kramer, A. Bartkiewicz, M. G. Blasi, *VizieR Online Data Catalog: 6.7GHz methanol maser polarization in SFR (Surcis+, 2015)*, 2015, VizieR Online Data Catalog, 357, 80102

Thesis

- **D. Dirkx**, *Interplanetary Laser Ranging. Analysis for Implementation in Planetary Science Missions,* 2015, Ph.D. Thesis, 44

Popular

- **L.I. Gurvits**, *Searching for life and new physics* (in Russian), 2015

6.7 EVN PUBLICATIONS

Publications based on EVN and JIVE data.

Refereed papers

- M. Kunert-Bajraszewska, M. Ceglowski, K. Katarzynski, C. Roskowinski: *A VLBI survey of compact broad absorption line quasars with balnicity index BI > 0*, 2015, Astronomy and Astrophysics, 579, A109 (**EK033C**)
- Michael Lindqvist, Arpad Szomoru: *The present status and the future of the European VLBI Network*, 2015, IAU General Assembly, 22
- G. Surcis, W. H. T. Vlemmings, H. J. van Langevelde, et al: *EVN observations of 6.7 GHz methanol maser polarization in massive star-forming regions. III*. The flux-limited sample, 2015, Astronomy and Astrophysics, 578 (**ES069A-C, ES071A-E**)
- Lang Cui: *The first VLBI image of 6 GHz OH masers toward PN K3-35*, 2015, IAU General Assembly, 22 (**EC044**)
- K. É. Gabányi, D. Cseh, S. Frey, et al: *VLBI observation of the newly discovered z = 5.18 quasar SDSS J0131-0321*, 2015, Monthly Notices of the Royal Astronomical Society, 450, L57-L60 (**RSG06**)
- M. Ceglowski, M. Kunert-Bajraszewska, C. Roskowinski: *VLBI survey of compact broad absorption line quasars with balnicity index BI = 0*, 2015, Monthly Notices of the Royal Astronomical Society, 450, 1123-1135 (**EK026**)
- D. Cseh, J. C. A. Miller-Jones, P. G. Jonker, et al: *The evolution of a jet ejection of the ultraluminous X-ray source Holmberg II X-1*, 2015, Monthly Notices of the Royal Astronomical Society, 452, 24-31 (**EC045, RC001**)
- F. Mantovani, M. Bondi, K.-H. Mack, W. Alef, E. Ros, J. A. Zensus: VizieR Online Data Catalog: *Sample of weak blazars at mas resolution* (Mantovani+, 2015), 2015, VizieR Online Data Catalog, 357 (**EM077A-F, EM097A-B**)
- F. Kirsten, W. Vlemmings, R. M. Campbell, M. Kramer, S. Chatterjee: *Revisiting the birth locations of pulsars B1929+10, B2020+28, and B2021+51*, 2015, Astronomy and Astrophysics, 577 (**EV018A-D**)
- M. Mezcua, T. P. Roberts, A. P. Lobanov, A. D. Sutton: *The powerful jet of an off-nuclear intermediate-mass black hole in the spiral galaxy NGC 2276*, 2015, Monthly Notices of the Royal Astronomical Society, 448, 1893-1899 (**EM106A-B**)
- S. Frey, Z. Paragi, J. O. Fogasy, L. I. Gurvits: *The first estimate of radio jet proper motion at z > 5*, 2015, Monthly Notices of the Royal Astronomical Society, 446, 2921-2928 (**EF024A-B**)
- F. Mantovani, M. Bondi, K.-H. Mack, W. Alef, E. Ros, J. A. Zensus: *A sample of weak blazars at milli-arcsecond resolution*, 2015, Astronomy and Astrophysics, 577 (**EM077A-F, EM097A-B**)
- A. Keimpema, M. M. Kettenis, S. V. Pogrebenko, et al: *The SFXC software correlator for very long baseline interferometry: algorithms and implementation*, 2015, Experimental Astronomy, 39, 259-279
- A. Szomoru, H. van Langevelde: *R&D at JIVE: transforming the way VLBI is done*, 2015, IAU General Assembly, 22
- M. K. Argo, I. M. van Bemmel, S. D. Connolly, R. J. Beswick: *A new period of activity in the core of NGC 660*, 2015, Monthly Notices of the Royal Astronomical Society, 452, 1081-1088 (**EA054**)
- A. T. Deller, J. Moldon, J. C. A. Miller-Jones, et al: *Radio Imaging Observations of PSR J1023+0038 in an LMXB State*, 2015, The Astrophysical Journal, 809 (**RA002**)
- H. Rampadarath, J. S. Morgan, R. Soria, et al: *A high-resolution wide-field radio survey of M51*, 2015, Monthly Notices of the Royal Astronomical Society, 452, 32-53 (**ER027** (2011, Bonn correlator))
- M. Giroletti, M. Orienti, F. D'Ammando: *The connection between radio and high energy emission in black hole powered systems in the SKA era*, 2015, Advancing Astrophysics with the Square Kilometre Array (AASKA14), 153

- G. Bourda, P. Charlot, A. Collioud: *Aligning VLBI and Gaia Extragalactic Celestial Reference Frames: source selection scenario*, 2015, IAU General Assembly, 22
- G. Surcis, W. H. T. Vlemmings, H. J. van Langevelde, B. Hutawarakorn Kramer, A. Bartkiewicz, M. G. Blasi: *VizieR Online Data Catalog: 6.7GHz methanol maser polarization in SFR (Surcis+, 2015)*, 2015, VizieR Online Data Catalog, 357 (**ES069A-C, ES071A-E**)
- Z. Paragi, L. Godfrey, C. Reynolds, et al: *Very Long Baseline Interferometry with the SKA*, 2015, Advancing Astrophysics with the Square Kilometre Array (AASKA14),
- A. P. Lobanov, J. L. Gómez, G. Bruni, et al: *RadioAstron space VLBI imaging of polarized radio emission in the high-redshift quasar 0642+449 at 1.6 GHz*, 2015, Astronomy and Astrophysics, 583
- C.-I. Björnsson: *Joining Radio with X-Rays: A Revised Model for SN 1993J*, 2015, The Astrophysical Journal, 813
- A. B. Pushkarev, Y. Y. Kovalev: *Milky Way scattering properties and intrinsic sizes of active galactic nuclei cores probed by very long baseline interferometry surveys of compact extragalactic radio sources*, 2015, Monthly Notices of the Royal Astronomical Society, 452, 4274-4282
- R. Deane, Z. Paragi, M. Jarvis, et al: *Multiple supermassive black hole systems: SKA's future leading role*, 2015, Advancing Astrophysics with the Square Kilometre Array (AASKA14), 93
- S. Etoka, D. Engels, H. Imai, et al: *OH masers in the Milky Way and Local Group galaxies in the SKA era*, 2015, Advancing Astrophysics with the Square Kilometre Array (AASKA14), 1255
- I. Agudo, M. Boettcher, H. D. E. Falcke, et al: *Studies of Relativistic Jets in Active Galactic Nuclei with SKA*, 2015, Advancing Astrophysics with the Square Kilometre Array (AASKA14), 93
- J. McKean, N. Jackson, S. Vegetti, et al: *Strong Gravitational Lensing with the SKA*, 2015, Advancing Astrophysics with the Square Kilometre Array (AASKA14), 84
- S. Corbel, J. C. A. Miller-Jones, R. Fender, et al: *Incoherent transient radio emission from stellar-mass compact objects in the SKA era*, 2015, Advancing Astrophysics with the Square Kilometre Array (AASKA14), 53
- G. Cimo, D. Duev, G. Molera Calves, T. Bocanegra Bohamon, S. Pogrebenko, L. Gurvits: *Ground-based VLBI observations of orbiters and landers*, 2015, European Planetary Science Congress 2015, held 27 September - 2 October, 2015 in Nantes, France, Online at http://meetingorganizer.copernicus.org/EPSC2015, id.EPSC2015-212, 10
- G. Giovannini, L. Feretti, I. Prandoni, M. Giroletti: *The new 64m Sardinia Radio Telescope and VLBI facilities in Italy*, 2015, IAU General Assembly, 22
- G. Giovannini, M. Orienti, M. Giroletti, T. Savolainen: *Imaging nearby AGN with Space VLBI (RadioAstron) observations*, 2015, IAU General Assembly, 22
- A. E. Volvach, V. I. Kostenko, M. G. Larionov, et al: *RadioAstron as a target and as an instrument: Enhancing the Space VLBI mission's scientific output*, 2015, Astronomy and Astrophysics, 573
- W. Thuillot: *The data distribution of the ESPaCE project*, 2015, European Planetary Science Congress 2015, held 27 September - 2 October, 2015 in Nantes, France, Online at http://meetingorganizer.copernicus.org/EPSC2015, id.EPSC2015-875, 10
- A. B. Pushkarev, Y. Y. Kovalev: *VizieR Online Data Catalog: Scattering Properties of the Milky Way (Pushkarev+, 2015)*, 2015, VizieR Online Data Catalog, 745
- W. Yi: *An overview of high-redshift radio-loud quasars on the basis of multi-wavelength data*, 2015, IAU General Assembly, 23
- M. Kramer, A. Kraus, G. Wieching: *Novel technology for the the Effelsberg 100-m Radio Telescope and MeerKAT*, 2015, IAU General Assembly, 22
- A. G. de Bruyn, J.-P. Macquart: *The intra-hour variable quasar J1819+3845: 13-year evolution, jet polarization structure, and interstellar scattering screen properties*, 2015, Astronomy and Astrophysics, 574
- J.A. Acosta-Pulido, I. Agudo et al: *"The Spanish Square Kilometre Array White Book"*, 2015, arXiv e-prints, 1506.03474
- T. Bocanegra-Bahamón, C. Bracken, M. Costa Sitjà, et al: *"MUSE - Mission to the Uranian system: Unveiling the evolution and formation of ice giants"*, 2015, Advances in Space Research, 55(9),

2190
- S.L. Breen, G.A. Fuller, J.L. Caswell, et al: *"The 6-GHz methanol multibeam maser catalogue - V. Galactic longitudes 20°-60°"*, 2015, Monthly Notices of the Royal Astronomical Society, 450(4), 4109
- A. Eckart, S. Britzen, M. Valencia-S., et al: *"The Galactic Center Black Hole Laboratory"*, 2015, arXiv e-prints, 1501.02171
- D. Eisenacher Glawion; J. Sitarek, K. Mannheim, P. Colin; for the MAGIC Collaboration; Kadler, Matthias; Schulz, Robert; Ros, Eduardo; Bach, Uwe; Krauß, Felicia; Wilms, Jörn: "*Black Hole Lightning from the Peculiar Gamma-Ray Loud Active Galactic Nucleus IC 310*", 2015, arXiv e-prints, 1508.05031
- B. Duah Asabere, M. Gaylard, C. Horellou, H. Winkler, T. Jarrett: "*Radio astronomy in Africa: the case of Ghana*", 2015, arXiv e-prints, 1503.08850
- K.E. Gabanyi, G. Dubner, E. Giacani, S. Frey, Z. Paragi: "*e-MERLIN observations of the puzzling TeV source HESS J1943+21*", 2015, Proceedings of Science, PoS(EVN 2014)078
- M.J. Gaylard: "*Opportunities for radio observations of southern sources*", 2015, MmSAI, 86, 48
- K. Geréb, F.M. Maccagni, R. Morganti, T.A. Oosterloo: "*The HI absorption "Zoo"*", 2015, Astronomy and Astrophysics, 575, A44 (**GS021A-B**)
- J. Green, H.J. van Langevelde, A. Brunthaler, et al: *"Maser Astrometry with VLBI and the SKA"*, 2015, Advancing the Square Kilometre Array (AASKA14), 119
- N. Kawaguchi, W. Jiang, Z.-Q. Shen: *"VLBI observation of the M 81 core with the CVN in X-band and the Pseudo-Closure Analysis"*, 2015, Publications of the Astronomical Society of Japan, 67(6), 1129
- V. Krishnan, S.P. Ellingsen, M.J. Reid, et al: *"First Parallax Measurements Towards a 6.7 GHz Methanol Maser with the Australian Long Baseline Array - Distance to G 339.884-1.259"*, The Astrophysical Journal, 805(2), 129
- B. Lew, M. Birkinshaw, P. Wilkinson, A. Kus: *"Simulations of cm-wavelength Sunyaev-Zel'dovich galaxy cluster and point source blind sky surveys and predictions for the RT32/OCRA-f and the Hevelius 100-m radio telescope"*, 2015, Journal of Cosmology and Astroparticle Physics, 2, 4
- J.-H. Park, S. Trippe, T.P. Krichbaum, et al: *"No asymmetric outflows from Sagittarius A* during the pericenter passage of the gas cloud G2"*, 2015, Astronomy and Astrophysics, 576, L16
- J. Sitarek, D. Eisenacher Glawion, K. Mannheim, et al: *"Insights into the particle acceleration of a peculiar gamma -ray radio galaxy IC 310"*, 2015, arXiv e-prints, 1502.01126 (**EE009A-D**)
- N. Zacharias: *"IAU Commission 8 Astrometry Transactions Report 2012-2015"*, 2015, arXiv e-prints, 1512.07147

Electronic Articles

- S. Frey, Z. Paragi, K. E. Gabanyi, T. An: *Four hot DOGs eaten up with the EVN*, 2015, ArXiv e-prints, 1504.0 (**EF025**)
- J. Yang, Z. Paragi, T. J. O'Brien, L. Chomiuk, J. D. Linford: *VLBI detection of internal shocks in nova V959 Mon*, 2015, ArXiv e-prints, 1504.0
- J. A. Zensus, E. Ros: *European VLBI Network: Present and Future, 2015*, ArXiv e-prints, 1501.0 (**RO005, RO006, EO011**)
- K. Hada, M. Giroletti, G. Giovannini, et al: *Continuing EVN monitoring of HST-1 in the jet of M87*, 2015, ArXiv e-prints, 1504.0 (**EG063D(A-D), EH027A-B, EG058A-D, EG043A-D**)
- R. Schulz, M. Kadler, E. Ros, et al: *The EVN view of the highly variable TeV active galaxy IC 310*, 2015, ArXiv e-prints, 1502.0 (**EE009A, C, D**)
- O. Wucknitz: *Probing interstellar scattering towards the Galactic centre with pulsar VLBI*, 2015, ArXiv e-prints, 1501.0
- E. Liuzzo, G. Giovannini, M. Giroletti: *Nearby radio loud AGN and the Unified Model*, 2015, ArXiv e-prints, 1504.0
- M. Orienti: *Radio and gamma-ray connection in relativistic jets*, 2015, ArXiv e-prints, 1504.0
- M. Gitti, M. Giroletti, G. Giovannini, L. Feretti, E. Liuzzo: *Twin SMBH candidates in the BCG of RBS 797*, 2015, ArXiv e-prints, 1504.0 (**RSG05**)

- G. Surcis, W. H. T. Vlemmings, H. J. van Langevelde, B. Hutawarakorn Kramer, A. Bartkiewicz, H. Engelkamp: *Magnetic field measurements at milliarcsecond resolution around massive young stellar objects*, 2015, ArXiv e-prints, 1503.0 (**ES069A-C, ES071A-E**)
- M. Massi: *Transient sources at the highest angular resolution*, 2015, ArXiv e-prints, 1502.0
- K. Hada, M. Giroletti, M. Kino, et al: *A strong radio brightening at the jet base of M87 in the period of the elevated TeV gamma-ray state in 2012*, 2015, ArXiv e-prints, 1502.0 (**EG063A, B, EG058B**)
- M. Uunila, J. Kallunki, G. Molera Calvés: *Using software spectrometer to ensure VLBI signal chain reliability*, 2015, ArXiv e-prints, 1504.0
- G. Giovannini, M. Orienti, T. Savolainen, et al: *The Nuclear Structure of 3C84 with Space VLBI (RadioAstron) Observations*, 2015, ArXiv e-prints, 1504.0
- L. Petrov: *Modeling of path delay in the neutral atmosphere: a paradigm shift*, 2015, ArXiv e-prints, 1502.0
- M. Kunert-Bajraszewska, M. Ceglowski, C. Roskowinski, M. Gawronski: *Broad absorption line (BAL) quasars as a class of low luminosity AGNs*, 2015, ArXiv e-prints, 1504.0 (**EK033A-C**)

Conference Papers

- N. Ramírez-Olivencia, E. Varenius, M. A. Pérez-Torres, et al: *EVN imaging of the LIRGI sample*, 2015, Highlights of Spanish Astrophysics VIII, , 378-378
- G. Molera Calves, S. Pogrebenko, G. Cimo, D. Duev, T. Bocanegra: *Scintillation of spacecraft radio signals on the interplanetary plasma*, 2015, EGU General Assembly Conference Abstracts, 17
- T. Bocanegra Bahamon, G. Cimo, D. Duev, L. Gurvits, G. Molera Calves, S. Pogrebenko: *Planetary Radio Interferometry and Doppler Experiment (PRIDE) for Planetary Atmospheric Studies*, 2015, EGU General Assembly Conference Abstracts, 17
- K. Hada, M. Giroletti, M. Kino, et al: *A strong radio brightening at the jet base of M87 during the elevated very-high-energy gamma-ray state in 2012*, 2015, Extragalactic Jets from Every Angle, 313, 340-345 (**EG063A-B, EG058B**)
- J. Moldón, F. Figueras, C. Hernández-Monteagudo, J. Trujillo Bueno, L. Valdivielso: *Structure and nature of gamma-ray binaries by means of VLBI observations*, 2015, Highlights of Spanish Astrophysics VIII, 41-49
- L. I. Gurvits, S. Frey, Z. Paragi, C. C. Cheung, E. Lopez, A. Siemiginowska: *Jets in AGN at extremely high redshifts*, 2015, Extragalactic Jets from Every Angle, 313, 327-328
- A. de Witt: *AGN monitoring: single dish to VLBI*, 2015, 3rd Annual Conference on High Energy Astrophysics in Southern Africa (HEASA2015), 19
- W. Thuillot, V. Lainey, L.-E. Meunier, et al: *Data Mining, Ingestion and Distribution of Planetary Data on Natural Satellites*, 2015, Astronomical Data Analysis Software an Systems XXIV (ADASS XXIV), 495, 583-586
- M. Kunert-Bajraszewska, M. Ceglowski, C. Roskowinski, M. Gawronski, C. C. Cheung, E. Lopez, A. Siemiginowska: *Extragalactic jets of broad absorption line (BAL) quasars*, 2015, Extragalactic Jets from Every Angle, 313, 244-245 (**EK033A-C**)

Astronomer's Telegrams and other electronic circulars

- V. Tudose, Z. Paragi, J. C. A. Miller-Jones, A. Rushton, J. Yang, R. Fender, S. Corbel, M. Garrett, R. Spencer: *e-EVN observations of V404 Cyg in outburst*, 2015, The Astronomer's Telegram, 7742 (**ET031A**)
- M. Perez-Torres, N. Ramirez-Olivencia E. Piconcelli, A. Alberdi, S. Komossa, R. Herrero-Illana: 5.*0 GHz Continuum eEVN Observations of the Recoiling Supermassive Black Hole Candidate SDSSS J113323.97+550415.8*, 2015, The Astronomer's Telegram, 7388 (**RSP10**)

7 LIST OF ACRONYMS & ABBREVIATIONS

AIPS	Astronomical Image Processing System
ALMA	Atacama Large Millimeter Array
AU	Astronomical Unit
AVN	African Very Long Baseline Interferometry Network
CASA	Common Astronomy Software Applications
DBBC	Digital Base Band Converter
DDC	Digital Down Converter
DG	Directorate General
EC	European Commission
ERC	European Research Council
ERIC	European Research Infrastructure Consortium
ERIS	European Radio Interferometry School
ESFRI	European Strategy Forum on Research Infrastructures
eVLBI	electronic Very Long Baseline Interferometry
EVN	European VLBI Network
FITS	Flexible Imaging Transport System
FPGA	Field-Programmable Gate Arrays
Gbps	Gigabit per second
GHz	Gigahertz
HMC	Hybrid Memory Cube
HOPS	H_2O Southern Galactic Plane Survey
JUC	JIVE UniBoard-based Correlator
JUICE	Jupiter Icy moons Explorer
JVLA	Jansky Very Large Array
MHz	Megahertz
MoA	Memorandum of Agreement
MoU	Memorandum of Understanding
NEXPReS	Novel Explorations Pushing Robust eVLBI Services
PI	Principle Investigator
PRIDE	Planetary Radio Interferometry and Doppler Experiment
R&D	Research and Development
SADT	Structured Analysis and Design Technique
SAT	Synchronisation and Timing
SFXC	EVN Software Correlator

SKA	Square Kilometre Array
TB	Terabit
UTC	Coordinated Universal Time
VLA	Very Large Array
VLBA	Very Long Baseline Array
VLBI	Very Long Baseline Interferometry
WHT-ISIS	William Herschel Telescope – Intermediate dispersion Spectograph and Imaging System
WR	White Rabbit
WSRT	Westerbork Radio Telescope
YSO	Young Stellar Objects

Joint Institute for VLBI ERIC
Postbus 2
7990 AA Dwingeloo
The Netherlands

Street Address:
Oude Hoogeveensedijk 4
7991 PD Dwingeloo
The Netherlands

Phone: +31 (0)521 596 500
Fax: +31 (0)521 596 539

Email: secretary@jive.eu
Internet: www.jive.eu

Cover design by beabudai design
www.beabudai-design.nl
ISBN: 978-90-824395-1-9