JIVE

Joint Institute for VLBI ERIC

Annual Report 2024

annual report '24

THE JOINT INSTITUTE FOR VLBI ERIC (JIV-ERIC) WAS ESTABLISHED BY A DECISION OF THE EUROPEAN COMMISSION IN DECEMBER 2014. IT 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 BROADEST SENSE.

ERIC established by the European Commision Implementing Decision 2014/923/EU.

JIVE MEMBERS

The French Republic: National Centre for Scientific Research (CNRS)

The Kingdom of the Netherlands: Dutch Research Council (NWO) and the Netherlands Institute for Radio Astronomy (ASTRON)

The Kingdom of Sweden: Swedish Research Council (VR)

The Republic of Latvia: Ministry of Education and Science of the Republic of Latvia

The Kingdom of Spain: Spanish National Geographic Institute (IGN)

The United Kingdom of Great Britain and Northern Ireland: Science and Technology Facilities Council (STFC)

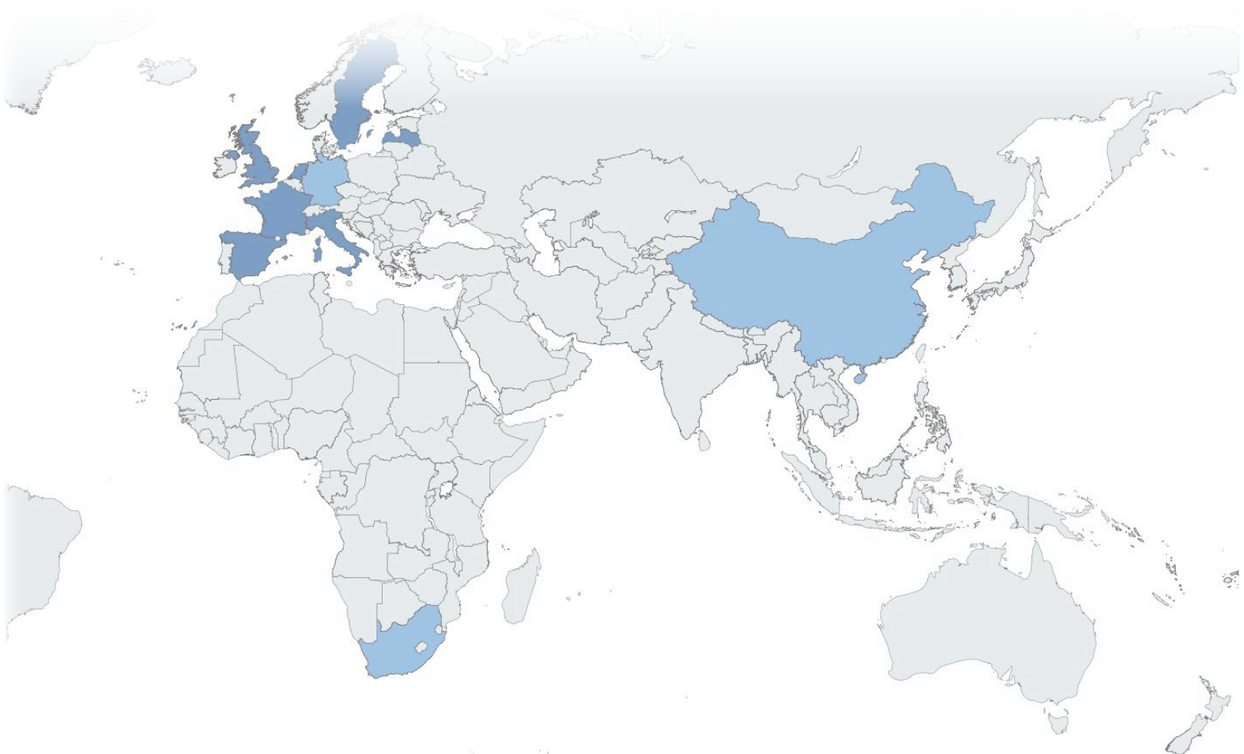
The Italian Republic: National Institute for Astrophysics (INAF)

JIVE PARTICIPATING RESEACH INSTITUTES

China: National Astronomical Observatories of the Chinese Academy of Sciences (NAOC)

South Africa: National Research Foundation (NRF)

Germany: Max Planck Institute for Radio Astronomy (MPIfR)



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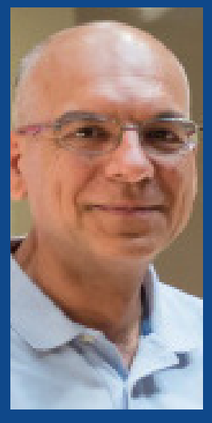


PABLO DE VICENTE

Chair, JIV-ERIC Council

2024

The year 2024 marked a significant turning point for JIVE, with the institute focused on securing the budget for the 2025–2029 operational period. A proposal for a 50% increase in partner contributions was unanimously approved during Council meetings in May and December, laying a solid financial foundation for JIVE's operations and long-term continuity.

Alongside this, 2024 saw strong project engagement. JIVE was active in three EU-funded initiatives: ORP; Radioblocks, which continues to grow under JIVE's coordination; and ACME, launched in September. These projects highlight JIVE's leadership in collaborative, cutting-edge radio astronomy research.

Within the broader European research infrastructure landscape, JIVE remained active and visible. Together with the EVN, it continues to be recognised as a key infrastructure by the ESFRI working group. The institute also leads Work Package 13 in the ERIC Forum, contributing to efforts that address shared challenges across diverse infrastructure models.

JIVE strengthened its educational mission. It played a key role in the ERIS School in Granada, providing organisational support and expert lectures. The EVN online seminar series, originally a COVID-19 response, has become a highly valued and widely accessed resource hosted by JIVE.

A special moment came in September, when JIVE celebrated its 30th anniversary during the EVN Symposium in Bonn, honouring three decades of scientific excellence in a warm and collegial atmosphere.

I extend my sincere gratitude to JIVE's director and staff for their exceptional dedication and professionalism. Their support to the EVN enables it to deliver world-class scientific results. Their commitment—and the continued backing of the JIVE Council—has made my role as Council Chair both fulfilling and enjoyable.

Our Mission

The Joint Institute for VLBI ERIC was established to support, progress, and promote the use of Very Long Baseline Interferometry (VLBI). VLBI is a technique in which radio telescopes, located hundreds to thousands of kilometers apart, simultaneously observe the same radio source in the sky. These telescope observations are recorded as digital signals, which are then combined at a central, dedicated data processor known as the correlator. Astronomers use the resulting data to produce extremely high-resolution images of the radio sky and measure the positions of bright radio sources with very high accuracy.

In Europe, VLBI is organised through the European VLBI Network (EVN), a consortium that includes members from other continents. JIVE hosts the correlator that provides central data processing for the EVN and supports most interactions with astronomers who use the facility. The EVN is an open-sky facility that accepts observation proposals from anyone.

JIVE receives data from the telescope stations via computer hard disk recordings, offline downloads, or direct streaming over fiber links (e-VLBI). The JIVE support team verifies data quality, interacts with staff at the telescopes, and provides support to end users through subsequent processing and analysis as requested. The final user product includes calibration data and images from a standard data pipeline.

To keep the EVN and JIVE at the forefront of scientific research, JIVE harbours a team of scientists and engineers who continually develop new techniques and software to enhance the scientific capabilities of VLBI. The team's primary focus is to develop observing modes by investigating new methods to record and transport data, thus increasing the research infrastructure's sensitivity and flexibility. Novel data processing techniques and platforms are also explored. JIVE engineers work on various user interfaces, such as the software astronomers use to schedule their observations and process their data. Additionally, JIVE has considerable expertise in deploying VLBI for space applications.

JIVE staff members also conduct scientific research in several exciting areas, ranging from active galactic nuclei at cosmological distances to star evolution in the Galaxy. This research is essential for maintaining expertise and providing excellent service to EVN stations and users.

JIVE has developed a reputation for fostering coordination, innovation, and capacity building for European and global VLBI. As a central entity in the EVN and through its status as an ERIC, JIVE shares these qualities with multiple institutes and European Commission (EC) projects.

JIVE in Numbers

24
JIVE staff

3
Participating research institutes

153
Experiments completed in 2024

7
Member countries

1,331.5
Network hours completed in 2024

56
JIVE staff publications

1,539
Correlated hours within 2024

3
EC projects

205.2
Total size of user-experiment data in the Archive [TB]

600k+
Reached via comms

Director's Overview

AGNIESZKA SŁOWIKOWSKA
Director,
JIV-ERIC

The year 2024 marked a pivotal chapter in JIVE's journey. As I stepped into the role of Director in 2023, one of my first responsibilities was to secure the institute's financial stability for 2025–2029. Together with the JIVE Council and a group of JIVE staff, we developed a funding strategy based on a detailed financial analysis. This led to a proposal recommending a 50% increase in partner contributions, which was unanimously approved during the December 2024 Council meeting. Thanks to this collective commitment, JIVE can move forward with strategic clarity and long-term sustainability.

Throughout the year, JIVE remained actively involved in three EU-funded projects: the Opticon RadioNet Pilot (ORP), Radioblocks, and ACME. ORP continues to support transnational access until early 2025. Radioblocks, under JIVE's leadership, expanded successfully, with a vibrant all-hands meeting in Madrid bringing together over 100 participants. ACME launched in September, bridging astronomy and astroparticle physics. JIVE leads the development of expertise centres and contributes broadly to the project.

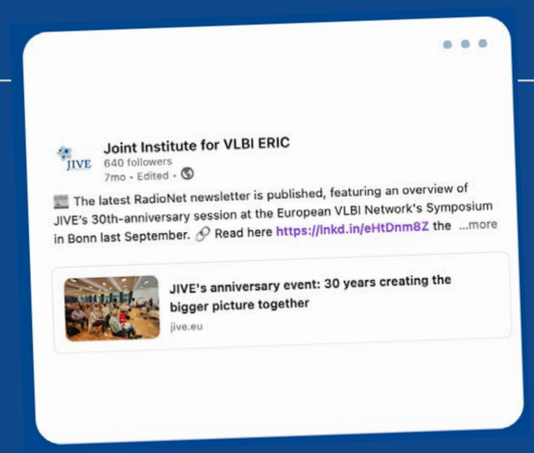
In January 2024, JIVE renewed its collaboration with the National Astronomical Research Institute of Thailand (NARIT), marking a new chapter in our partnership with the anticipated integration of the 40-meter Thai National Radio Telescope (TNRT) into the EVN. The MoU renewal ceremony in Chiang Mai reaffirmed our shared commitment to advancing radio astronomy and future VLBI collaboration. We look forward to building on this strong foundation in the years ahead.

We also strengthened our communication, outreach, and training efforts. JIVE provided organisational support and specialised lectures at the European Radio Interferometry School (ERIS 2024) in Granada. The EVN online seminar series, initially launched during the pandemic, has become a widely accessed and enduring resource, with archived talks reaching a global audience via YouTube.

A special highlight of 2024 was JIVE's 30th anniversary, celebrated at the EVN Symposium in Bonn. The event brought together past and present directors, users, and collaborators in a warm and festive atmosphere — a fitting tribute to three decades of scientific excellence and community spirit.

JIVE maintained strong visibility for the institute and the EVN within the European research infrastructure landscape. Within the ESFRI framework, JIVE and the EVN continued to be recognised as essential components of Europe's radio astronomy ecosystem. JIVE also led Work Package 13 in the ERIC Forum, which identifies shared challenges across different research infrastructure models and contributes to policy development.

I deeply appreciate the JIVE team's commitment and expertise, which are the foundation of the institute's ability to support the EVN at the highest scientific level. I'm also grateful to the JIVE Council for its ongoing trust and strong partnership, which help us move forward with vision and confidence.



2024 in Pictures


JIVE DIRECTOR OPENING THE RADIOBLOCKS MEETING IN MADRID

Science Highlights

JIVE staff is actively involved in scientific research across a broad range of topics, reflecting their diverse areas of interest. These include planetary science, stellar astrometry, gas in and around galaxies, black holes of all sizes—from stellar-mass to supermassive, such as those in active galactic nuclei—and various types of transient sources.

COLD GAS OUTFLOW DRIVEN BY A NEW-BORN RADIO JET

MURTHY ET AL. 2024, ASTRONOMY & ASTROPHYSICS, VOLUME 688, A84

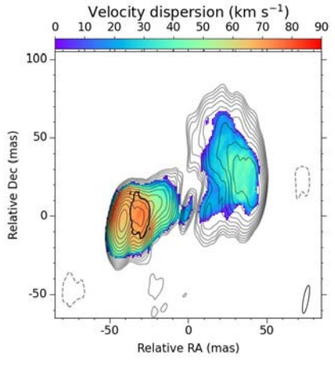
The role of radio jets emitted by supermassive black holes (SMBHs) at the centres of galaxies in halting the growth of their host galaxies remains poorly understood. Models of galaxy evolution have typically considered these jets to exert influence only at the circumgalactic level, where they inhibit the accretion of gas onto the host galaxy, effectively cutting off the fuel required for star formation. However, recent findings suggest that radio jets also have a direct impact on the gas within their host galaxies. As these jets are launched and propagate through the interstellar medium (ISM), they interact with gas clouds, driving them out and inducing significant turbulence within the ISM.

To investigate this impact in greater detail, it is necessary to “zoom-in” to the sites of jet-ISM interaction and study the properties of the gas. Fortunately, such high spatial resolution studies are feasible through observations of the 21 cm transition of neutral atomic hydrogen (HI) using Very Long Baseline Interferometry (VLBI) networks.

In the present study, a very young (around 5,000 years old) radio source, 4C 31.04, that is expanding into a gas-rich environment at the very centre of its host galaxy, was observed. Utilising the Global VLBI array, the researchers successfully mapped the distribution and kinematics of cold gas at a spatial resolution of 2 parsecs. The observations revealed that the cold gas enveloped the expanding radio jets and, as a consequence of the interaction, exhibited high levels of turbulence. Additionally, it was found that the southern radio jet was driving an outflow of cold gas located just 35 parsecs in projection from the SMBH.

This study adds to the growing body of evidence indicating that radio jets play a significant role in shaping the evolution of their host galaxies from within, beginning at a very early stage in their development. It also presents a compelling question regarding the mechanisms by which cold gas can persist in such extreme environments.

JIVE scientist Suma Murthy is the lead author and JIVE scientist Zsolt Paragi is a co-author on this paper.



The contours represent the young radio jets, while the colour scale illustrates the distribution of atomic gas surrounding the radio source. Bluer regions correspond to relatively quiescent gas, whereas greener and redder areas indicate highly turbulent gas. The gas enveloping the radio jets exhibits significant turbulence, with the highest levels observed at the eastern lobe. The black contour delineates the region from which a gas outflow has been detected. This region lies just 35 parsecs in projection from the supermassive black hole.

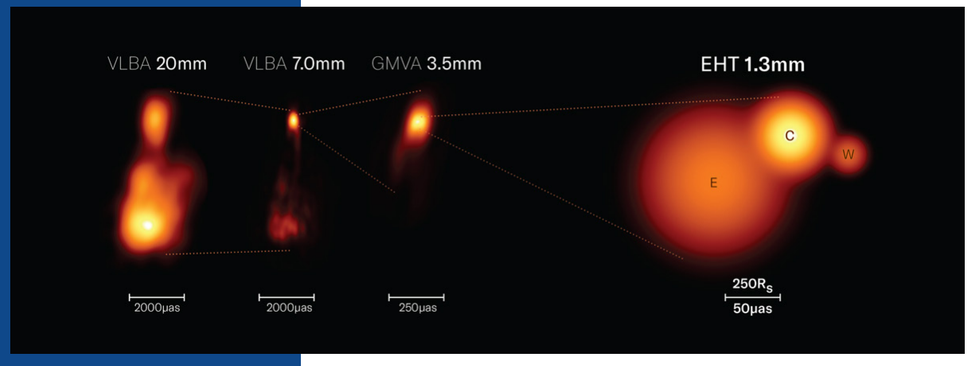
ORDERED MAGNETIC FIELDS AROUND THE 3C 84 CENTRAL BLACK HOLE

PARASCHOS ET EL. 2024, ASTRONOMY & ASTROPHYSICS, VOLUME 682, L3

In this study, the formation of relativistic jets in the 3C 84 (NGC 1275) was investigated using high-resolution polarimetric observations with the Event Horizon Telescope (EHT) at 228 GHz. Understanding jet formation remains a major challenge in astrophysics, with two leading models: jets launched by magnetised accretion disks (Blandford & Payne 1982) and those powered directly by black hole spin (Blandford & Znajek 1977). By analysing the polarisation properties of the compact region near the jet base, the study aimed to distinguish between these scenarios. The observations revealed a highly ordered and strong magnetic field, suggesting that the jet structure in 3C 84 may be dominated by toroidal magnetic fields, which could favour a disk-driven jet scenario.

The analysis incorporated multi-frequency VLBI data from the EHT (228 GHz), GMVA (86 GHz), and VLBA (43 & 15 GHz), allowing a comparison of the jet structure at different frequencies. The results indicated a significant increase in fractional polarization at 228 GHz, suggesting that the region transitions to an optically thin regime at this frequency. The study found that the compact jet structure can be well described by three Gaussian components and that the detected polarisation is consistent with theoretical expectations for a magnetically dominated jet-launching mechanism. These findings provide crucial observational constraints on jet formation models and contribute to a better understanding of the role of magnetic fields in shaping relativistic jets in AGN.

JIVE scientists Mark Kettenis, Huib Jan van Langevelde, Junghwan Oh, and Des Small are co-authors.



Total intensity jet morphology of 3C 84 at different wavelengths. From left to right, we display the 15, 43, 86 (images), and 228 GHz (model) measurements. The horizontal line below each image represents the angular scale. The effective beam sizes, corresponding to these observations are, from left to right, 0.40 × 0.60 mas, 0.34 × 0.16 mas, 0.11 × 0.04 mas, and 107 × 14 μas. R_S denotes the Schwarzschild radius.

EVOLUTION OF THE OUTFLOW FROM THE RS OPHIUCHI NOVA

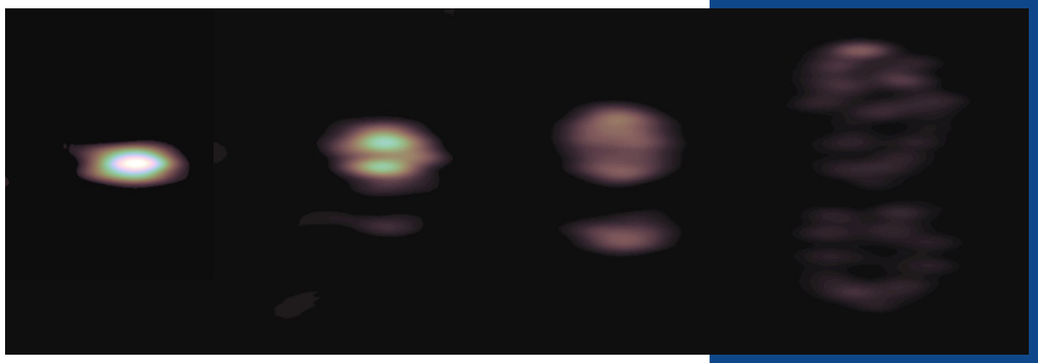
LICO ET AL. 2024, ASTRONOMY & ASTROPHYSICS, VOLUME 692, A107

RS Ophiuchi (RS Oph) is a well-known recurrent and symbiotic nova. The system erupted and went into outburst in August 2021, marking a significant event as it was the first nova detected at very high energies. Through high-resolution radio observations using the EVN and e-MERLIN, a team researchers led by Ricco Lico (INAF-IRA), with participation from JIVE astronomer Benito Marcote, monitored the expansion of the bipolar ejecta over a period of 14 to 65 days post-explosion. The study reveals a complex structure consisting of a compact core and two elongated lobes expanding in opposite directions, with an average projected speed of approximately 7,000 km/s.

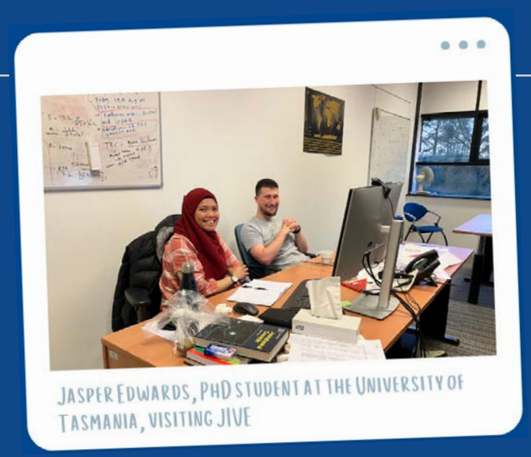
The analysis indicates a notable radial dependence of density within the ejecta. There is a density enhancement along the orbital plane that plays a crucial role in understanding the mass distribution during the outburst. Additionally, these observations allowed to estimate the total mass ejected during the eruption, with most of it contributing to the surrounding circumstellar environment rather than being accreted by the white dwarf.

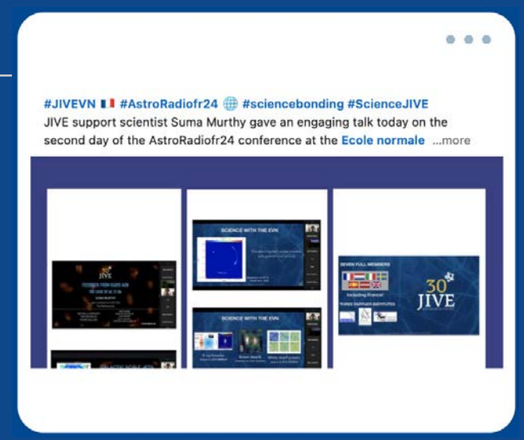
These findings enhance our understanding of nova phenomena and contribute to broader astrophysical knowledge regarding stellar evolution and mass loss processes in binary systems. The detailed characterisation of RS Oph's ejecta morphology and physical conditions surrounding them underscores the importance of multiwavelength observational campaigns in unraveling the complexities of such transient astronomical events.

JIVE scientist Benito Marcote is a co-author on this paper.

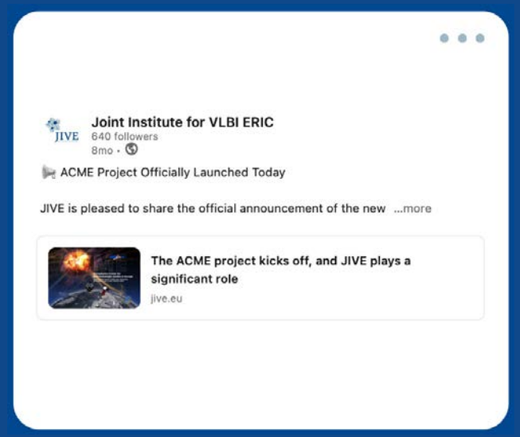


High-resolution images of RS Oph's outflow as observed with the EVN + e-MERLIN from 14 (left) to 65 days (right) post-burst at 18 cm.





2024 in Pictures



OPERATIONS

OVERVIEW

The core of JIVE's service is the correlation of astronomers' observations conducted with the EVN and global VLBI arrays. In 2024, JIVE established a new record for correlator hours produced from user experiments at 1539 hr, over 12% more than the previous highs of 1370 hr (in 2019) and 1363.5 hr (in 2023). This was the sixth year in a row with over 1100 correlator hours produced. This sustained effort of the correlator operators and support scientists saw the remaining load to correlate and to distribute decrease sharply from highs that had built up over 2021-23, which were the three largest years ever in terms of EVN total and disk-based observing hours (and, taken as a whole, 27% more than any other distinct consecutive three-year period). JIVE has also coordinated various tests for telescopes that could be new additions to the EVN, ranging from South Africa to India to Japan.

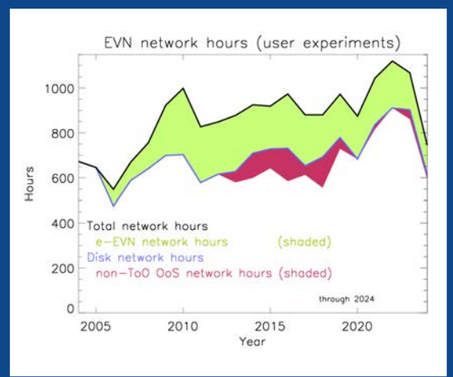
CORRELATION

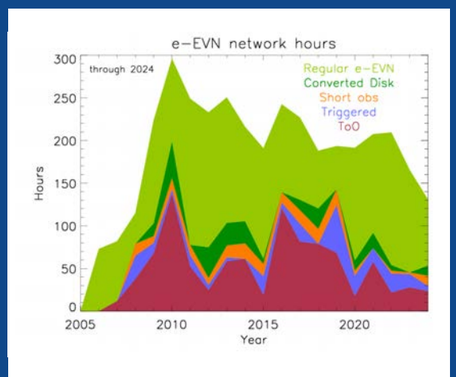
The table below summarises experiments whose correlation finished in 2024, and for user observations, those that were distributed in 2024, together with the number of network and correlator hours they comprised. For a detailed list of the user experiments, see "Correlator Activity".

	User Experiments			Test & Network Monitoring		
	N	Ntwk_hr	Corr_hr	N	Ntwk_hr	Corr_hr
Correlated	153	1331.5	1917	14	40.5	40.5
Distributed	142	1311.5	1804.5			
e-EVN experiments	21	131	131			
e-EVN ToO/Triggers	4	29.5	29.5			

Summary of experiments for which correlation or distribution to PIs finished in 2024. Here, "network hours" sum the total duration of experiments, while "correlator hours" are the network hours multiplied by any multiple correlation passes required. The actual time to correlate can be several times larger than this for the more complex correlations.

The left-hand panel of the figure below traces the evolution of the annual EVN network hours. The total for 2024 was down markedly; equipment casualties at multiple telescopes in the third EVN session led to most PIs in the session deciding to defer their observations (of the original 33 user observations scheduled, only nine went ahead, with network hours falling from 259.5 to 95). The right-hand panel focuses on e-EVN experiments, showing their division among the proposal categories. Total e-EVN network hours in the latter half of the year were also similarly affected by the unavailability of those telescopes.

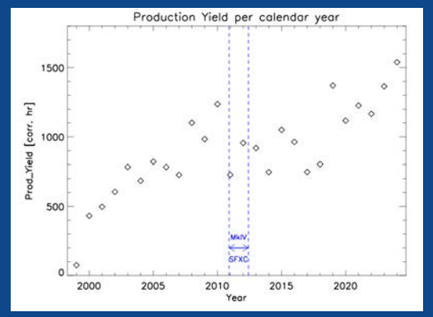


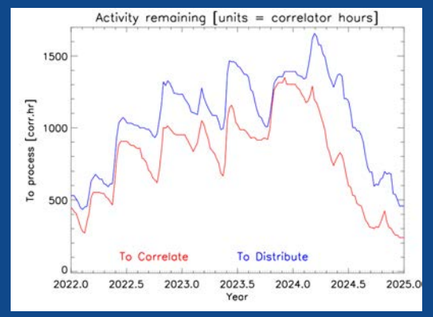


Left: Annual EVN network hours, with separate colour-coded areas for different categories of user observations, from top to bottom: real-time e-EVN (light green), regularly scheduled disk-based out-of-session (dark red), and "traditional" disk-based (white). Right: e-EVN network hours, with separate colour-coded areas for different proposal categories, from bottom to top: target-of-opportunity, triggered, short observations, converted from disk, and regular.

The number of user-experiment correlator hours produced within 2024 was 1539, the most ever in any calendar year. The left-hand figure below shows the evolution of this statistic over time. Note that this quantity, accumulating correlator hours within 2024 independent of the completion of all correlator passes for any given observation, differs from the quantity in the table above, which accumulates the correlation for all passes of observations that finished in 2024 regardless of when the correlation of each pass took place. These statistics can diverge when different correlation passes for an experiment happen in different years (e.g., the first highlight below).

Also within 2024, the amount of correlation and distribution that had built up over the previous couple years has been largely worked away, as illustrated in the right-hand figure below. This of course contributed to the record number of correlator hours produced.





Left: Evolution of the number of correlator hours in user experiments produced per calendar year. The transition period from the MkIV to SFXC correlators is annotated (beginning with the first user experiment correlated on SFXC and ending with the last one correlated on the MkIV).
Right: The size of the correlator queue at different stages in the processing cycle. The red line shows the number of correlator hours that remain to be correlated. The blue line shows the number of correlator hours in experiments whose data remain to be distributed to the observing teams.

2024 HIGHLIGHTS

- A bug in the multiple-phase-center correlation was discovered and fixed within SFXC early in the year. This reduced the SNR of phase centers other than the first within a pointing by the square root of the number of sub-integrations within an integration, typically a factor of 2 to 2.8. Other than this equivalent loss of sensitivity, there were no biases in the amplitudes or phases. There were 17 already-correlated observations for which we still had data on FlexBuff, and thus were able to re-correlate.

- A means to handle cases where Usuda observed one subband each at 18cm and 6cm in some EVN+RadioAstron observations (scheduled as two distinct one-subband stations each appearing in different but simultaneous sub-netted scans, but provided data as a single two-subband station) was successfully devised.

- There were four EVN target of opportunity observations (three via e-EVN) and one e-EVN trigger observation. These projects covered scientific topics ranging from FRB localisation and persistent sources (two different projects), a newly discovered XRB, the Lorentz factor of a TDE jet, and whether jets in blazars could be associated with neutrinos detected by IceCube.

- There were two FRB triggers from the on-going projects based primarily on shadowing CHIME (EK056A-B) on the same FRB target. Correlation is triggered if a burst is detected by the tracking facilities. The underlying EVN-lite programmes comprised 27 observations and 267 network hours, resulting in the two triggered correlations comprising 11.5 correlator hours.

- The first user observation having multiple data streams was successfully correlated. Such observations require correlation from a VEX2 file and place more stringent constraints on the naming conventions of the separate files comprising the multiple data streams. The complication that different versions of the vex-file are required for observing (still needs VEX1.5) and correlation remains.

EVN SUPPORT

Local Oscillator (LO) offsets at Urumqi for 6cm (-183.1 Hz) and 5 cm (167.8458 Hz) that had begun in session 3/2023 were accommodated via values entered into the standard runjob GUI used for production correlation. These LO offsets were no longer required by session 3/2024.

The JAXA telescopes Usuda (64m) and Misasa (54m) in Japan joined the 3.6cm NME in session 3/2023, observing at 2Gbps within the 4Gbps NME. Once colleagues in JAXA had translated the data from K5 to Mark5B format, fringes were successfully found in April for all channels. This was the first fringe ever from Misasa in an EVN observation and the first fringe from Usuda at 3.6 cm.

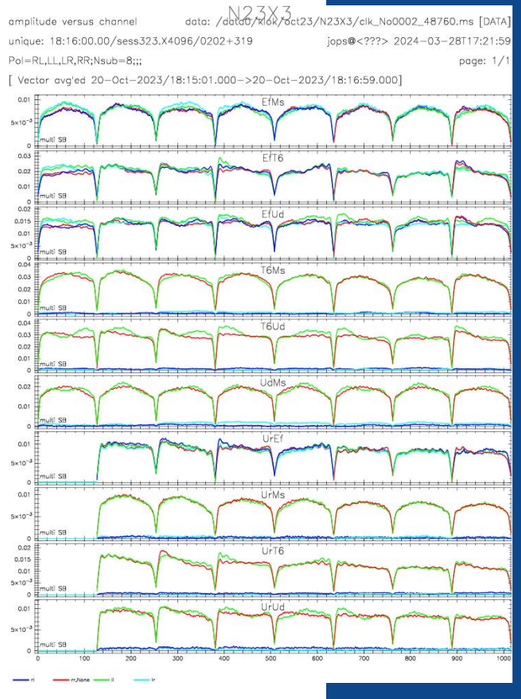
In session 3/2024, a number of diverse stations participated in various test observations; at the end of the year the resulting data were in process of being transformed into a format that SFXC can use.

- Three of the four VERA stations joined the 1.3cm NME and a user experiment (Ishigaki could not observe because of a passing typhoon). This is the first time for EVN observations at 1.3cm, and the first time ever for Iriki and Ogasawara (Mizusawa and Ishigaki had joined some 5cm observations in the 2009-11, before 5cm was available on VLBA stations, as a means of providing long east-west baselines at that band). Data were provided in headerless Mark5B format.

- GMRT had a separate test observation at 21cm.

- MeerKAT joined some scans of the 18cm NME, following up their first observation with tied-array fringes from the session 3/2023 18cm NME.

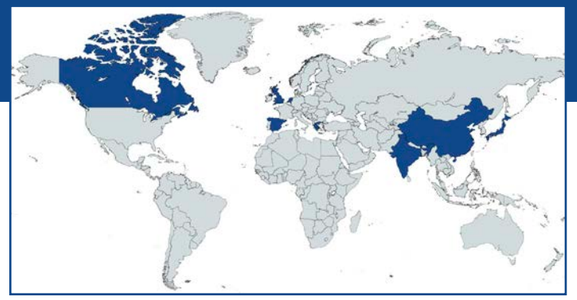
Initial discussions have taken place among JIVE, Paris Observatory, CNES, Eutelsat, and current/past TOG chairs about possibilities for rehabilitating a currently unused 18m antenna at the Eutelsat Rambouillet site (near Versailles) for participation in EVN observations.



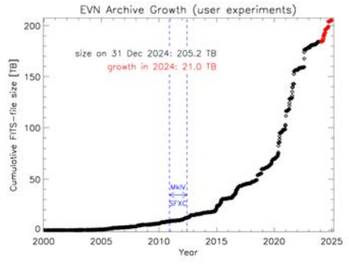
Amplitude versus frequency for selected baselines to Usuda and Misasa telescopes in their first 3.6cm observation in an EVN context.

EVN User Support

JIVE provides support in all stages of a user's EVN observation, from proposal definition to data analysis, including providing experiment-specific set-up templates when needed to track the evolving configurations of equipment at EVN stations, and making corresponding updates to the pySCHED catalogues. There were eleven first-time PIs in 2024 observations: eight of these were students and two of those students were female. Countries represented include Canada, China (4), Greece, India, Japan, the Netherlands, Spain, and the UK. The first-time users from the Netherlands and Spain were from non-EVN institutes. The observations from their "first-time PI" projects accounted for 136 network hours in 2024 (18% of the total for the year). Two of these projects will continue into 2025.



The EVN Archive remains the entry point for users to retrieve their correlated EVN data and provides open access to others following the one-year proprietary period (six months for ToO projects). The total size of user-experiment FITS files in the Archive reached almost 205.2 TB by the end of 2024, increasing by 11% during the year.



Growth of user experiments in the EVN Archive. Experiments archived in 2024 are plotted in red. Vertical dashed lines show the transition period between the MkIV and SFXC correlators

In April 2024, JIVE organised an EVN online training day, where practical information was presented about how to propose for the EVN, how to use the tools provided on the JIVE and EVN websites, and how to schedule an EVN observing run. In preparation for the 16th EVN Symposium and Users' Meeting in Bonn, we prepared an online questionnaire for EVN users about their experience with the network in general, and with our user support in particular. The results were evaluated and summarised during the EVN Users' Meeting session, which took place as part of the Symposium. On the first day of the Symposium, we also held a special session celebrating more than 30 years of JIVE supporting the network and its users.

Among the visitors to JIVE, in addition to the regular data reduction trips, we hosted two students for a month in the spring — Deokhyeong Lee and Seung-Yeon Lee from South Korea — who received training in data reduction. They compared results obtained through AIPS and CASA processing.

JIVE support scientists continued working together with the R&D team to tackle various issues and improve our services. With the ACME project, which started in September 2024, our goal is to streamline all processes to improve the experience for non-expert users.

Training and Seminars

EUROPEAN RADIO INTERFEROMETRY SCHOOL

The tenth edition of the European Radio Interferometry School, ERIS 2024, took place in Granada from 30 September to 4 October 2024. It was jointly co-organised by the Instituto de Astrofísica de Andalucía (IAA-CSIC) and JIVE. The school aimed to provide a comprehensive overview of radio interferometry, covering fundamentals, data processing, analysis techniques, and practical hands-on sessions.

The target audience consisted mostly of PhD students, but also included master's students and postdocs with limited or no prior experience in radio interferometry. Tutors were selected by the Scientific Organising Committee (SOC) to form a diverse group of radio interferometry experts, representing a range of experience levels, career stages, scientific interests, genders, prior involvement with ERIS schools, and international recognition.

The program was very dense, featuring lectures, tutorials, and additional talks related to career development, optical interferometry (within the ORP framework), and equity. At the end of the school, students presented the scientific and technical cases for a project they developed during the week.

JIVE contributed three tutors who delivered the introductory lectures and led the hands-on sessions on VLBI. They also mentored two student groups developing science cases on Fast Radio Bursts (FRBs) and Tidal Disruption Events (TDEs), one of which won the student competition at the end of the school. Some of the students expressed interest in visiting JIVE for further training.

The tutors of ERIS 2024. JIVE contributed three: Benito Marcote, Gábor Orosz, and Zsolt Paragi. Photo: ERIS

VLBI tutorial conducted by Gábor Orosz. Photo: ERIS

ERIS group picture. Photo: ERIS

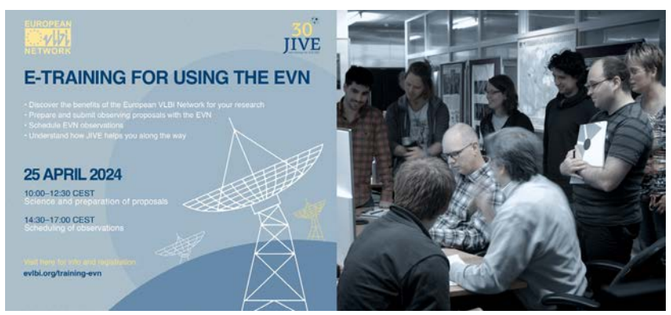
NEW E-WORKSHOP ON USING THE EUROPEAN VLBI NETWORK

On 25 April 2024, JIVE organised the second online training event for using the European VLBI Network (EVN), aiming to support first-time users of the network. This one-day training guided participants through the various steps involved in planning, proposal preparation, and scheduling EVN observations. Participants also received a general introduction to the EVN, its current capabilities fo teh array, and the science that can be carried out with the network.

A total of 105 participants registered for the training, spread across 33 countries. These numbers more than doubled compared to the first training organised two years ago, demonstrating the community's growing interest in the EVN. Forty-five participants joined online, although the recording was made available to all registered participants. Due to its success, JIVE aims to organise these events on a (bi-)annual basis.

The survey conducted after the workshop revealed that 100% of the participants who completed it (five in total: three PhD students, one staff member, and one respondent from an unspecified country and with an unspecified career stage) would recommend the training and gave it the highest rating.

Most have noted a data reduction tutorial should be part of the training program. In response to this demand, JIVE initiated the organisation of a JIVE VLBI School for 2025.



THE RETURN OF THE EVN SEMINARS

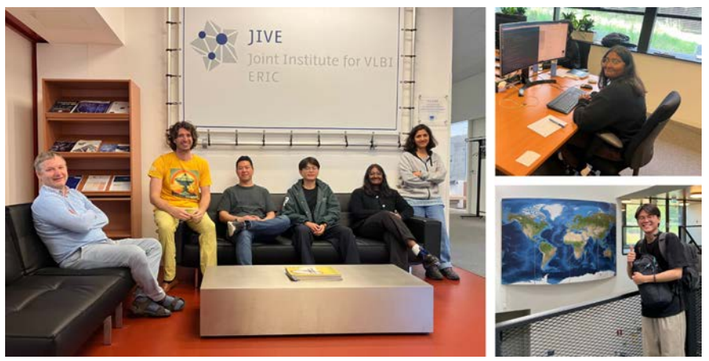
After a one-year pause, the EVN resumed the EVN Seminars with a new series of talks showcasing the relevance of VLBI in diverse scientific fields. In 2024, the EVN hosted six engaging talks that presented cutting-edge VLBI results and developments to the broader astronomical community.

These seminars covered a diverse range of topics, including prospects for bringing wide-field imaging to standard VLBI observations (Jack Radcliffe), the critical efforts of the CRAF project to maintain a radio-interference-free sky for observations (Benjamin Winkel), how VLBI can be conducted at megahertz frequencies with LOFAR-VLBI (by Leah Morabito), capturing the brightest fluxes of maser emission (Ross Burns), a fascinating historical overview of JIVE, the EVN, and SKA through the decades (Richard Schilizzi), and how the radio domain is not isolated but has multiple synergies, especially with very-high-energy observations, illuminating blazar physics (Cristina Nanci).

Almost 500 participants joined the talks in real time, demonstrating strong interest in VLBI techniques and results across the astronomical community. Even more remarkably, the sessions have already accumulated almost 2,000 views on the public YouTube channel, highlighting the enduring value of these presentations for researchers and enthusiasts alike long after the seminars.

SUMMER STUDENTS 2024

Coral Pillay from South Africa analysed multi-epoch astrometry data on a number of radio stars, some observed with the Very Long Baseline Array (VLBA) and others with the European VLBI Network (EVN). This work was also connected to the efforts made within the Radioblocks project, coordinated by JIVE, to develop Bayesian inference methods for estimating astrometric parameters. She worked with Huib van Langevelde and Paul Boven. Jeongwoo Joo from South Korea was supervised by Junghwan Oh. He worked on Bayesian imaging of EVN data.



From left to right: the Head of User Support, Zsolt Paragi, support scientists Gábor Orosz and Junghwan Oh, summer students Jeongwoo Joo and Coral Pillay, and support scientist Suma Murthy. Photo: JIVE

Technical Operations and R&D

ANNUAL REPORT '24

OVERVIEW

The year 2024 was marked by overall system stability and steady progress across multiple technical fronts. No major disruptions occurred, and any hardware failures were handled without data loss or interruptions to production workflows such as correlation, analysis, or archiving.

The EVN Storage pool at JIVE grew by 3 PB. Hard disk drive (HDD) reliability improved, with fewer failures than usual. Several migration projects reached completion, a new one was initiated, and the internal monitoring system continued to evolve.

Development work progressed toward a GPU-enabled and more portable version of the SFXC software correlator. This involved reworking some of the algorithms to support different floating point precisions and operate on different hardware platforms. A prototype GPU-based multiple-phase centre implementation was created to investigate its feasibility and efficiency limits. The 8-bit per sample VDIF support was tested in collaboration with Onsala staff.

In user software developments, an Earth Orientation Parameter (EOP) correction task was formally integrated into CASA. The fringefit task gained a "Fast Radio Burst option". Work also continued on CASA's successor, RADPS, contributing to the development of its calibration framework, middleware, and data format.

TECHNICAL OPERATIONS

The continued investment of effort and equipment into professionalising the JIVE hardware setup is its foundation: without the combination of maintaining RAID systems for storage, installing and operating redundant hardware (compute and networking) for critical services, building centralised, coordinated management, running a centralised monitoring and alert system for a wide range of events, and configuring an extensive backup infrastructure (including backup success monitoring), this would not be possible.

HARDWARE

Towards the end of 2024, just before Christmas, three FlexBuff-type storage servers were delivered to JIVE. A 0.5 PB system from HartRAO (SA) and a 1.3 PB system from e-Merlin (UK) arrived for immediate expansion of the correlator EVN Storage pool, and a 1.5 PB system for the PI-led Synoptic Wide-field EVN-e-MERLIN commensal Public Survey (SWEEPS) project. The latter's purpose is to keep the project's allocated EVN observations' raw voltage data available for future wide-field reprocessing.

In 2024, not as many Hard-Disk Drives (HDDs) failed as in previous years, possibly because most of the older 8 TB HDDs have now been replaced. The number of drives that were replaced under warranty — a five-year period on most HDD types — remains extremely low, indicating an ageing pool and impacting the Technical Operations group's budget. The addition of another 183 HDDs to the pool (the total number of HDDs in the three new FlexBuffs) will likely eventually add to this, as HDD replacements scale with the number of HDDs in operation.

The new cooling system installed in JIVE's host institute in 2023, does not always operate reliably, causing six pre-emptive shutdowns of equipment, mostly the FlexBuffs in JIVE's correlator room, to avoid overheating. The systems went down on two more occasions: once due to a mains power failure and once because of a (false) fire alarm.

Re-spooling the old LTO-[345] and DAT tapes onto the LTO-8-based system was completed on 13 August 2025, after having purchased and installed an “old stock” DDS1 tape drive from eBay. The DDS1 drive's use is also offered to ASTRON staff in order to enable the restoration of some special old WSRT data.

1

Replaced HDDs	Warranty		
Year	no	yes	Total
2024	12	1	13
2023	30	2	32
2022	29	2	31

HDD replacement under warranty over time.

2

Paternoster's broken mains power supply filter.

3

EVN correlator power usage at JIVE under varying (production) workloads.

4

2024	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
MWh	16.38	16.19	17.22	18.14	17.64	17.25	17.86	16.70	15.67	15.79	15.70	16.07	200.61

Monthly and total power consumption (MWh) of the EVN Correlator system as billed to JIVE.

The Paternoster's net filter almost literally went up in smoke, and the maintenance company quoted an outrageous price for the repair. After internal discussion on feasibility and safety, the component was replaced by local staff with a refurbished item purchased through eBay for approximately 1/10 of the quoted price. After judging contract cost over merit for the Paternoster's maintenance contract, it was decided to cancel it, meaning that, from now on, all Paternoster maintenance and repairs will have to be done in-house.

Ongoing building modernisations at JIVE's host institute offered the opportunity to reinstate physical access control to the JIVE's basement and correlator room. As of October 2024, only (sub)sets of JIVE and ASTRON staff have access to those rooms, improving cyber security by limiting the exposure of JIVE equipment with unprotected (USB, network, serial, and keyboard) ports that may provide network access to the 100 Gbps link, ASTRON's internal network and servers, or even direct access to the information, configuration, and tools stored and installed on the servers.

The mini-PC driving JIVE's map-on-the-wall Light-Emitting Diodes (LEDs) failed during 2024. A fresh Raspberry Pi was purchased. Porting the (bespoke) software driving the hardware LED controllers was time-consuming due to significant changes in the new operating system and LED driver API.

An extensive analysis of power usage during different correlation loads was carried out. The figure in Box 3 shows the results. The important takeaways are the ~20 kW baseline power consumption even when no correlation is happening: the graph's Y-axis does not go to zero but is auto-scaled from the power consumption data peak-to-peak, and that running the correlator flat-out adds approximately 4-5 kW to the power consumption. Many more detailed findings are included in a report, which can be shared on request.

This power usage “baseline” is clearly reflected in the monthly power consumption measurements that ASTRON uses to bill JIVE for consumed power in 2024 (see the table in Box 4). Power consumption remains remarkably stable throughout the year. If anything, the small EVN Sessions 2024/II and 2024/III can be inferred from the slight reduction in power consumption during Sep–Nov.

Together with the Science/Support group, requirements for a replacement Evaluation and Export Engine (EEE) server were gathered. The current machine is almost a decade old, is difficult to reboot due to deteriorating hardware, and has been out of warranty since 2022. This is despite the machine being vital for the post-correlation workflow by the Science/Support group to generate the data sets that go into the EVN Archive.

In order to accommodate the increased demands driven by an increase in EVN science capabilities offered to the users and alleviate bottlenecks identified using the current (old) hardware setup, it was decided to invest in an extraordinary machine in terms of very fast and voluminous NVMe[1] Solid-State Drive (SSD) storage (11x 13 TB, with room for expansion!) combined with 64 AMD-EPYC CPU cores and 512 GByte of memory. After the machine's arrival, it was first used to test different storage configuration options to assess the best-performing one for the intended workload. The process of migrating and adapting the necessary workflow components to the new operating system and environment had started by the end of the year. Once that is complete, the workflows need to be validated before the machine can be handed over for production.

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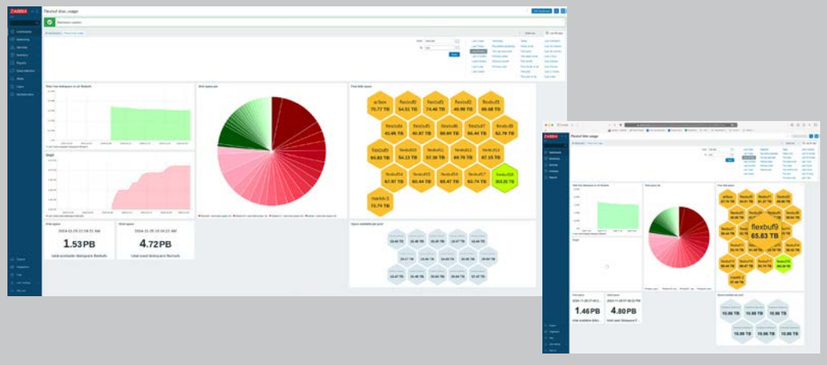


Left: Overview at a glance of the total EVN FlexBuff storage pool. Right: Clicking on a FlexBuff provides immediate access to detailed information.

SOFTWARE

The EVN Archive migration project, moving the EVN Archive and its workflow components onto a new server and operating system, was finalised after extensive validation and verification. Follow-up modernisations that were paused waiting for this, such as DOI integration into the archiving workflow and new website design, were restarted.

JIVE staff supported the ORP-PILOT Multi-Facility Call for Proposals (MF-CfP) at several levels, but mostly through building a separate, modified to match the MF-CfP requirements, Northstar instance, and making it available to the community. After the MF-CfP single process time allocation and analysis of the meta data thereof (see ORP-PILOT Deliverable D3.9—not published publicly, available on request), was finished the full virtual machine system was taken offline[2] and archived for future recall, if necessary.

New dashboards for the (internal) monitoring system were developed. As the figure in Box 5 illustrates, they allow users to assess the EVN FlexBuff Storage pool at JIVE status at a glance, while more detailed information is a single click away.

RESEARCH AND DEVELOPMENT

Technical Operations and R&D staff participated in several EC-funded projects and contributed to multiple deliverables or milestones.

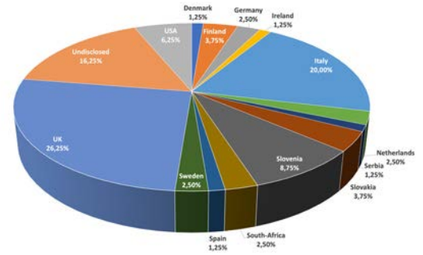
JIVE received a sample of re-converted N22L3 MeerKAT data from SARAO staff, using their new correlator/beamformer data to VLBI compatible VDIF conversion tool, which runs on a GPU and appears fast enough to make production conversion feasible; a speed-up of the proof-of-concept code by approximately a factor of 1000 was needed — see older Annual Reports. A timestamp encoding bug was found and fixed, after which the 10-second snapshots of two scans correlated successfully. Together with JIVE staff, SARAO set up and tested an e-shipping system, compatible with existing EVN stations and based on jive5ab. Since then, several data sets have been downloaded using the production system, and re-correlation/analysis of two NME experiments including MeerKAT could begin.

ORP-PILOT

JIVE staff ran the proposal tool for the ORP-PILOT Multi-Facility Call for Proposals and analysed the meta data and characteristics of the fourteen submitted proposals in one of the deliverables (D3.9 – Report on a new access model for multi-facility science). One finding was that the MF-CfP drew authors from countries not previously represented in, for example, the EVN Program Committee (see the chart below). This indicates that, while such authors likely would not request radio observing time, an explicit multi-wavelength access modality could expose "radio" to a wider audience.

Going beyond the project's original goals of adding the EVN as a facility in the Blackhole TOM (BHTOM) instance, JIVE staff began evaluating another potentially interesting system: Las Cumbres Observatory's Observatory Control System (OCS)[3].

This is a dynamic, priority- and constraint-based queue-scheduling system where observing requests can be submitted (e.g., via a TOM Toolkit instance such as BHTOM). The scheduler then evaluates, at regular intervals, which observing request(s) to handle next based on the current status of connected telescopes and instruments. A short internal report is expected by the end of the project, in February 2025.



Author country distribution for all Multi-Facility Call for Proposals submissions.

RADIOBLOCKS

Following the demonstration of the SFXC delay model and in-house developed correlation working on GPUs (see Annual Report 2023), JIVE staff is now working on integrating this VLBI-grade delay model block with the highly efficient Tensor-Core Correlator[4] developed by one of the project’s partners. The delay block was modified to work correctly using 32-bit single-precision as well as 64-bit double-precision floating-point arithmetic. The computations were reorganised and optimised to minimise SNR loss when using the single-precision version. On hardware platforms that do not natively support double-precision (GPUs so far, some CPUs) single-precision computation can lead to a x1.5 performance gain.

Investigations towards a Multiple Phase Center block were started, with initial tests indicating that, up to a small number of phase centers, this might be integrated with the high-efficiency correlator block without negatively impacting performance. The number of simultaneous phase centers that can be processed is limited by the amount of local GPU memory available for integrating the different phase center data.

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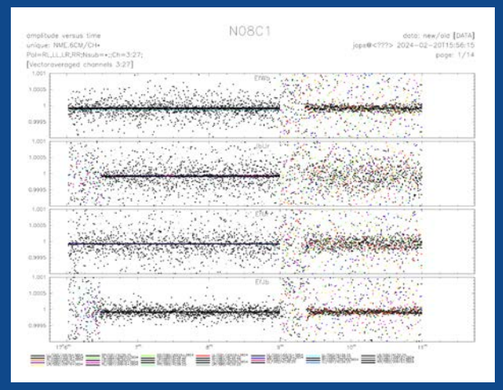
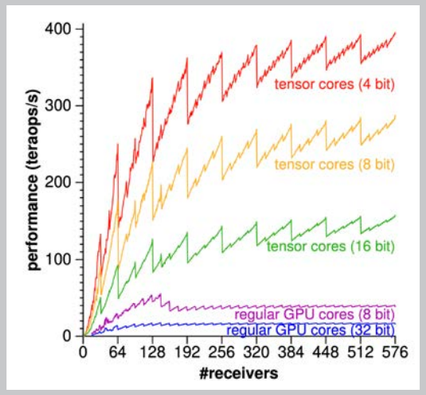


Left: Amplitude ratio versus time. Right: Phase difference versus time. Both compare 16-bit versus 32-bit floating point used internally by the algorithm.

JIVE staff also ported the sfxc software to the Grace Hopper ARM64 architecture, including support for that platform's 16-bit floating-point capabilities. This allowed it to be run on the Radioblocks cluster's NVIDIA GH200 with 72 power-efficient ARM64 CPUs, targeting two main goals: the ability to perform speed and/or power consumption comparisons between the current Intel© X86_64 architecture CPUs and the GH200 GPUs, and to assess (loss of) precision when using 16-bit floating point internally instead of the standard 32 bits.

Results show this leads to a sensitivity loss on the order of 1% (see the figures in Box 6). If deemed acceptable, using 16-bit floating point offers several advantages: memory requirements are halved, and the GH200 GPUs have extremely efficient 16-bit floating point operations (see the figure in Box 7, which corresponds to Fig. 3 from Romein's Tensor-Core Correlator paper).

7



Tensor-Core Correlator performance as a function of data type and number of inputs (Fig. 3 in Romein et al.).

SOFTWARE CORRELATION

The sfxc code base was migrated from svn to git, and (re-)hosted on JIV ERIC's own git server[5] with the intent of moving to a more modern version control system and making it easier to share the code with external users and inviting contributions or issue tracking.

The sfxc 8-bit per sample VDIF support modification also includes support for 4 bits per sample, which some stations may prefer to use. Tests performed running Onsala's DBBC3 in 8-bit mode concurrently with a DBBC2 in 2-bit mode did not lead to convincing results so far.

During analysis of the data, some DBBC3 firmware issues came to light. For the experiment, 32 MHz bands were selected, which give the best DBBC2 bandpass, but the equivalent DBBC3 mode provides a non-optimal bandpass, meaning that any gains going from 2- to 8-bit per sample on a baseline to another 2-bit station would be nullified by the drop in bandpass response. Narrow RFI lines seemed to be handled better in the 8-bit auto-correlation data, but since both the hardware and firmware are different, it is not easy to attribute this fully to the increase from 2-bit to 8-bit per sample.

Another issue found was a different implementation of the quantisation levels compared to what is stated in the VDIF standard. When sampling at more than two bits per sample, there is a choice between symmetric or asymmetric encoding of the sampled values, and interpreting data as one standard while it was generated using the other leads to a DC offset in the signal. This issue was communicated to the DBBC3 firmware developers and fixed.

The sampler statistics of the 8-bit data were analysed and found to represent an RMS dynamic range of approximately twenty, allowing for six-σ outliers. JIVE staff went on to test the theoretical increase in sensitivity of approximately 7% going from a baseline of 2-bit x 2-bit to 2-bit x 8-bit. In order to do this, the 8-bit data was "manually" converted to 2-bit data and recorrelated. The signal-to-noise ratio difference between those two correlations on baselines to the 8- vs 2-bit data indeed changed only by a few percent (as expected). Having said that, the difference would be small at best, and it seems individual equipment features may dominate at this point.

USER SOFTWARE

CASA

The Earth Orientation Parameter (EOP) correction task in CASA was officially introduced in the CASA6.6.5 release from autumn 2024[6].

In parallel, the post-correlator tools were updated to support carrying EOP information from the correlator control VEX file into the intermediary MeasurementSet, used internally for data quality assessment, and from there into the FITS-IDI output. Work is underway to change the internal workflow to include EOPs in the EVN Archive data products as a standard service.

The C++ PolConvert implementation working on CASA MeasurementSet v2 (see below) now produces near-identical results to the official Python version operating on FITS-IDI data for one data set, even for linear-to-linear baselines, arguably the most difficult case. Tests on more use cases (polarised and unpolarised sources) can now be done — and need to be — to verify and validate the implementation.

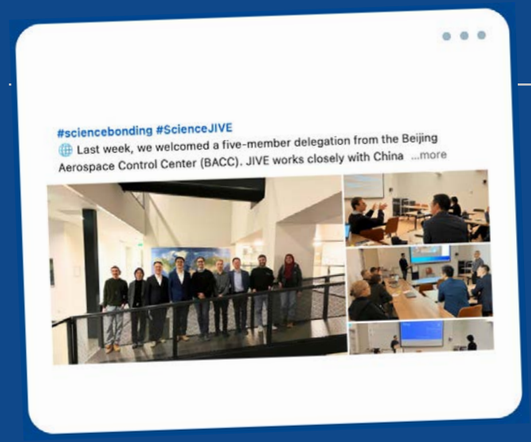
A modification to the fringefit task, supporting single-integration fringe-fit, was submitted for inclusion in CASA. This modification is essential for Fast Radio Burst localisation, where the signal is only present in a single integration.

Within the Radioblocks project, JIVE staff continued to work on the Radio Astronomical Data Processing System (RADPS), the new CASA Python Dask-based framework, with the final goal of delivering a fringe-fit algorithm in this system. However, after having developed a working prototype, it was found that the framework's calibration infrastructure, as well as saving corrected data — the framework's “middleware” — is not fully operational yet. JIVE staff worked, and continues to work, with the core RADPS development team to define and implement this necessary layer.

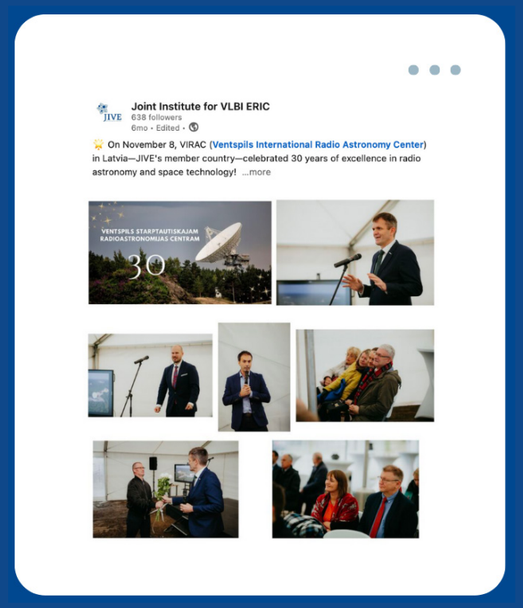
The labelling of MeasurementSet with "v2" (version 2) in a previous paragraph is motivated by the fact that, for the RADPS framework, a new, cloud-native, MeasurmentSet data format is in the process of being defined - MeasurementSet v4[7] JIVE staff participated both in the design discussions as well in the MSv4 review panel — but not after duly discussing conflict-of-interest/impartiality issues. There are only so many radio astronomy data format and usage experts worldwide that selecting a completely independent review panel would be near-impossible.

FOOTNOTES

1. Non-Volatile Memory express, an access and transport protocol for solid-state storage devices.
2. The ancient Northstar software is a huge cyber security risk.
3. https://observatorycontrolsystem.github.io
4. *The Tensor-Core Correlator*, Romein J., https://doi.org/10.1051/0004-6361/202141896
5. https://code.jive.eu/JIVE/sfxc
6. https://casaguides.nrao.edu/index.php/VLBA_AIPS_and_CASA_Walkthrough#Earth_Orientation_Parameter_Correction
7. A version 3 format of the MeasurementSet was discussed between stakeholders but was never implemented on account of it being merely a revision of the v2 structure without changing the underlying storage mechanisms, making it undesirable for use with the Dask infrastructure.



2024 in Pictures



Space and Planetary Science

The core objective of space and planetary science activities at JIVE is to expand and connect the VLBI community with new users and collaborations. Space applications demonstrate the synergies between VLBI and communities beyond the typical radio astronomy user base, and it is further testimony to the innovative space applications of VLBI.

SPACECRAFT OBSERVATIONS TO FOSTER COLLABORATION

2024 marked significant progress in space applications, from making VLBI observations of planetary spacecraft more accessible to the planning of future space VLBI missions. While ESA's JUICE mission is on its long journey to the Jupiter system to explore the largest giant gas planet in our solar system and its three large ocean-bearing icy moons, JIVE continued its leadership in developing tools for observing the spacecraft with VLBI networks. The JIVE-led experiment PRIDE (Planetary Radio Interferometry and Doppler Experiment) provides the most accurate measurements of the celestial position of spacecraft's radio transmitter with a precision measured in tens of meters. The primary science objective of PRIDE for the JUICE mission is to support the improvement of the Jovian system ephemerides. Throughout its journey in the Solar System, JUICE will perform a series of gravity-assist manoeuvres. These include multiple flybys of the Earth, the Earth-Moon system, and one flyby of Venus. The latter, scheduled for August 2025, is especially important as it is a unique opportunity to assess PRIDE end-to-end operations, and to evaluate the improvement that PRIDE observables can make to planetary ephemerides. In 2024, a team of Hungarian radio astronomers from the Hungarian Research Centre for Astronomy and Earth Sciences, part of the PRIDE collaboration, performed several preparatory VLBI observations using the European VLBI Network in preparation for the Venus flyby.

Collaboration with the University of Tasmania on space weather observations, a valuable tool to monitor solar activity, continued in 2024. Two PhD candidates collaborated with JIVE on VLBI observations of ESA's JUICE and Mars Express missions to study the solar wind environment at different solar elongations.

Spacecraft tracking and navigation are a practical application of VLBI observations. At JIVE, a student internship from Delft University of Technology was dedicated to refactoring the original PRIDE software into a more modern language. This has made the code more modular and easier to implement in other “near-field” VLBI applications. Space agencies also rely on “near-field” VLBI for determining the orbit of satellites. At the same time, they value the scientific information carried by spacecraft.

In December 2024, JIVE welcomed a delegation from the Beijing Aerospace Control Center (BACC) in China, one of JIVE’s key international partners. The one-day event featured a productive exchange of expertise, engaging discussions on topics of common interest, and exploration of potential synergies to strengthen collaboration. The BACC representatives shared their extensive experience applying VLBI to Deep Space Exploration and their scientific work studying the solar wind using radio signal from satellites. They also offered valuable insights into China’s lunar exploration programme and highlighted the critical role of the Chinese Deep Space Network (CDSN) in supporting these missions.

JIVE’s key role in space science applications was reaffirmed in 2024 through its involvement in the creation of a planetary science community in the Netherlands. This newly formed expertise network received €690,000 from the Dutch Space Office to fund shared postdoc positions to investigate how space missions could be used to observe possible traces of life in the solar system. JIVE contributes to the study of internal processes of icy moons. The kick-off meeting of the Dutch expertise network on planetary research took place in Amsterdam on 2 December 2024.

VLBI IN SPACE

Current ground-based VLBI capabilities are inherently limited both by the atmosphere and the size of the Earth since the maximum baseline length achievable is constrained by the size of our planet. Placing radio telescopes in orbit opens a new window onto the universe at previously inaccessible frequencies and resolutions.

In 2024, JIVE participated in several preparatory studies for future space VLBI missions at higher frequency. There are various approaches to implementing very long baseline interferometry in space: some rely on an array of spacecraft in orbit, others on a single space antenna that can observe with an Earth-based network. A space-based high-frequency interferometer would have a fundamental impact on the study of very compact objects, such as black holes. However, it would require a deep understanding of the technological difficulties involved in accurate orbit determination and in processing the data from a VLBI instrument. JIVE is already playing an important role in the ongoing discussion around developing VLBI-capable instrumentation in space.

The delegation from the Beijing Aerospace Control Center visits the EVN correlator at JIVE. Photo: JIVE

Graphical summary of the proposed expertise network on planetary science, highlighting the three focus areas of the projects on which various partners will collaborate. Image: Delft University of Technology

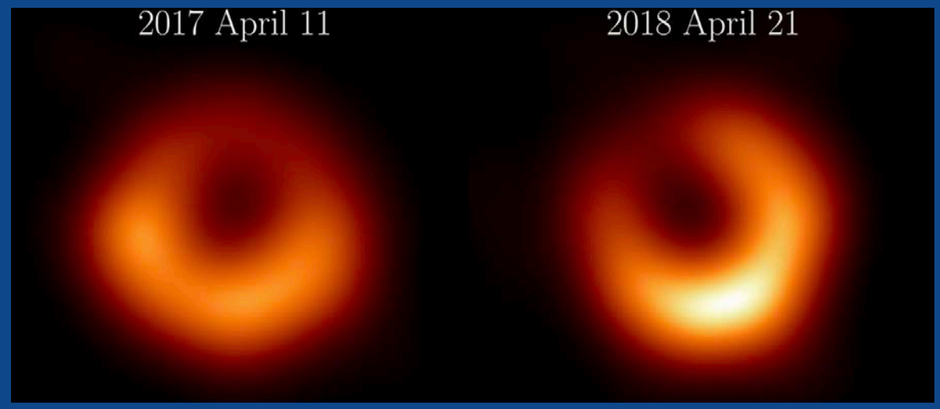
Event Horizon Telescope

The Event Horizon Telescope (EHT) continued to advance our understanding of supermassive black holes with several milestone publications in 2024. From JIVE, the team included Mark Kettenis, Junghwan Oh, Des Small, and Huib Jan van Langevelde, who also serves as EHT Project Director.

The iconic M87 image, originally produced with data from 2017, was confirmed with independent data. As expected, the 2018 image revealed a ring of the same diameter, but the brightest part of the emission had shifted, highlighting the need for improved time cadence in future observations of M87.

In 2024, the collaboration also published the first polarisation images of SgrA*, demonstrating that magnetic fields are at work in shaping the immediate surroundings of the black hole and connecting to the jet launch.

On the management side, much of the focus was on developing the mid-term science plan, setting the direction for the EHT’s work in the coming years.



In 2024, the Event Horizon Telescope Collaboration released new images of M87* from observations taken in April 2018, one year after the first observations in April 2017. The new observations in 2018, which feature the first participation of the Greenland Telescope, revealed a familiar, bright ring of emission of the same size as EHT found in 2017. This bright ring surrounds a dark central shadow, and the brightest part of the ring in 2018 has shifted by about 30º relative from 2017 to now lie in the 5 o’clock position. Image: EHT Collaboration.

Committee on Radio Astronomy Frequencies

ACTIVITIES IN 2024

Following the outcomes of the World Radiocommunication Conference 2023 (WRC-23), preparations for WRC-27 began in 2024, with various ITU-R study groups initiating their work. For the new WRC study cycle (2024-2027), the Committee on Radio Astronomy Frequencies (CRAF) identified over 12 conference agenda items of interest to the radio astronomy service in Europe. Among these, the protection of radio astronomy from satellite services is a top priority. Other key agenda items include spectrum needs for space weather monitoring, lunar communications, and terrestrial services such as mobile networks.

To more effectively address the radio astronomy agenda items, a dedicated internal team led by Spectrum Manager Waleed Madkour was formed, focusing on topics under ITU-R Study Group 7 – Working Party 7D (WP7D), which covers the radio astronomy service. In 2024, the team developed CRAF positions and prepared input contributions for two WP7D meetings held in April and September.

At the regional level, CRAF members actively participated in numerous CEPT/ECC meetings, addressing a wide range of topics. The work within CEPT/ECC is divided into two main areas: technical studies and regulatory framework development, with the regulatory aspects primarily managed by the Spectrum Manager.

The CRAF Spectrum Engineering team (SEnn) has been engaged in compatibility studies for short-range device applications, including car radars, wireless power transfer devices, and security scanners. The team conducted several studies to estimate the exclusion zones required around radio astronomy observatories to mitigate interference.

The CRAF Satellite Team continued its work on studies related to the authorisation of satellite systems in the European region. Notable efforts included updates to the ECC Report on large satellite constellations (Starlink and OneWeb) and satellite systems providing Internet of Things (IoT) services. In 2024, the team finalised a new ECC Report on the aggregate effects of multiple satellite systems on radio astronomy.

CRAF members also contributed to LOFAR measurements of the Starlink satellite constellation, revealing that newer satellites exhibit even stronger electromagnetic leakage than previously observed in 2023. CRAF is actively collaborating with SpaceX to address these issues and has agreed to initiate a coordinated measurement campaign at select CRAF observatories, including Onsala, Yebes, and potentially Effelsberg.

THE PROTECTION OF RADIO ASTRONOMY FROM SATELLITE SERVICES IS A TOP PRIORITY FOR CRAF.

FUTURE WORK AND CHALLENGES

Mega-constellations and WRC-27

Large satellite constellations remain the most significant challenge for radio astronomy in the near to medium term. Maximising favourable outcomes for radio astronomy at WRC-27, particularly through the two relevant agenda items, will require extensive technical, regulatory, and political efforts throughout the current study cycle.

Direct-to-cell satellite services

The integration of satellites as base stations in mobile communication networks (referred to as International Mobile Telecommunications – IMT in ITU terminology) is under investigation at both regional and ITU WRC levels. Traditional mitigation methods to protect radio astronomy from terrestrial mobile networks may become ineffective in scenarios where satellite base stations are visible to radio telescopes from very far distances.

Upper 6 GHz band for mobile and WiFi networks

Following WRC-23 outcomes, the harmonised use of the upper 6 GHz band in Europe for mobile and/or WiFi networks is under evaluation through sharing and compatibility studies. These studies, expected to conclude by 2026/2027, will also assess compatibility with the radio astronomy 6.6 GHz methanol spectral line. However, the lack of a primary allocation for this spectral line will be challenging in enforcing protection measures.

Short-range devices

The demand for spectrum by the short-range device applications, such as radio determination devices, car radars, security scanners, and wireless power transfer (WPT) systems, is rapidly increasing across Europe. Ensuring adequate protection for the radio astronomy service will require corresponding increasing efforts by the team to address potential interference risks.

CRAF Spring Meeting in Bologna, June 2024. CRAF members meet twice a year to track and discuss work progress; one of these is an in-person meeting, typically held in the spring. Photo: CRAF

Yertay Yeskaliyev, PhD student at GFZ Helmholtz Centre for Geosciences, visiting JIVE

2024 in Pictures

JIVE comms officer speaking at the Netherlands Astronomers' Conference (NAC)

Communications and Outreach

In 2024, JIVE significantly strengthened its ties with both the scientific community and the wider public through consistent communication efforts and thoughtfully designed outreach initiatives.

A primary goal of the communications work in 2024 was to highlight JIVE's multidimensional operations. Particular emphasis was placed on informing JIVE's diverse audiences about the scientific and technological work carried out by its staff. Special attention was also given to promoting the activities and achievements of the European VLBI Network (EVN) and the EU projects to which JIVE contributed.

Curated content on all related topics, delivered through JIVE's various communication channels, was at the center of these efforts. As a result, high-quality information was provided, engagement with JIVE's activities was enhanced, and its network expanded. JIVE's website and its social media platforms (LinkedIn, Facebook, and X/Twitter) were the main vehicles for dissemination. A mix of in-depth topics and snapshots of daily life provided a clear view of JIVE's role, contributions, and day-to-day work. The EVN/JIVE Newsletter, published online three times per year and edited by JIVE, remained the primary communication tool for sharing EVN achievements. News from other projects in which JIVE plays a role—and which are of interest to the EVN community—continued to enrich its pages.

Throughout 2024, valuable input from members of the EVN community was gathered with a view to updating the EVN newsletter—enriching its content and refreshing its design. The goal is to create a publication that reflects a broader range of EVN developments, with a clear, engaging, and easily shareable layout. It aims to foster community building while also extending its reach beyond the EVN to engage the wider astronomical community. The updated newsletter will be designed to be versatile and open to new sections, allowing it to evolve alongside the network it represents.

The inextricable bond between JIVE and the EVN was highlighted during JIVE's 30-year anniversary session at the 16th EVN Symposium and Users Meeting, held in Bonn from 2-6 September 2024. A video prepared by JIVE's communications officer featured interviews with EVN users sharing their experiences at JIVE. Alongside the talks from key individuals who have shaped the institute into what it is today, the video contributed to the reflection on JIVE's past and future that the anniversary session inspired—further strengthening its connection with the community.

Scan the QR code to watch a short video with EVN users' testimonials at JIVE, shown during JIVE's anniversary session at the EVN Symposium in Bonn.

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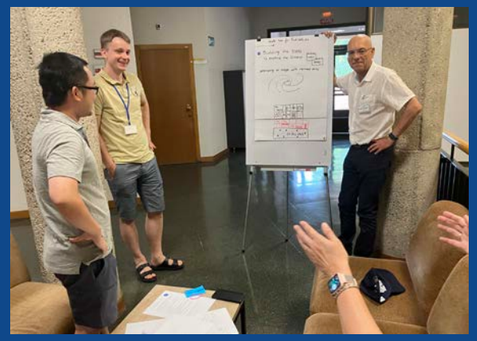
Slides from the presentation by JIVE's communications officer at the 79th Netherlands Astronomers' Conference. Photo: JIVE



One of the groups participating in the communication activity during the Radioblocks all-hands meeting in Madrid. Photo: JIVE

JIVE staff participation in workshops and conferences throughout the year was well prepared in terms of informational materials and consistently covered on our social media channels. A key event was the European Astronomical Society (EAS) meeting in Padova, Italy, from 1–5 July 2024, where JIVE organised a booth with rich content and engaged in numerous conversations with the many visitors who stopped by. JIVE's relationship with the EAS—and, through it, the broader European astronomical community—took a significant step forward in November, when JIVE officially joined the European Astronomical Society as an Organisational Sponsor. JIVE's emphasis on its ties with the EAS will be reflected in upgraded communication materials and strong representation at the 2025 EAS event in Cork, Ireland.

At a special communications session during the 79th Netherlands Astronomers' Conference (NAC), held from 13–15 May 2024 in Egmond aan Zee, our communications officer presented the role of JIVE and the EVN to communication and outreach professionals from Dutch astronomy and space institutes, as well as to other participants.

She also attended online the Communicating Astronomy with the Public (CAP) conference, held in Toulouse from 24-28 June, and the international Public Awareness and Engagement with Research Infrastructures (PAERI) conference in Morges, Switzerland, from November 27–29, 2024.

Both events provided valuable insights into activities, initiatives, and ideas in science communication and outreach.

On an ongoing basis, our communications officer actively participates in the ERIC Forum's group of communicators, where valuable expertise is also exchanged. As in the previous year, she successfully fulfilled her role in the EU-funded Opticon RadioNet Pilot project: she reported on the activities of its members across the project's online platforms and, together with the other two outreach team members, organised online events that helped highlight its scientific work and results.

Her work on the Horizon Europe project Radioblocks, which JIVE coordinates, was systematic. She gathered information from the project's various working groups, contributed to drafting the reports submitted to the European Commission, and was preparing the project's website update. At the all-hands meeting in Madrid (4-6 June 2024), she designed and led a social activity that encouraged project members to act as communicators of the project themselves—raising awareness of how different aspects of the project should be shared with different audiences. The activity was both successful and enjoyable.

For the newly initiated EU-funded project ACME (Astrophysics Centre for Multimessenger Studies in Europe), in which JIVE astronomers play a significant role, the JIVE communications officer supports the dissemination of project news—maintaining close contact with the team members responsible for ACME's communication and outreach.

JIVE's communications officer was actively involved in the Sharing a Baseline project, a collaboration among schools, scientists, and radio astronomy infrastructures across five countries. Presenting the project at CAP, IAU-GA 2024, and PAERI, a role successfully undertaken by the project's initiator, Onsala Space Observatory's communicator Robert Cumming, significantly contributed to raising the visibility of JIVE and the EVN among wider audiences.

JIVE'S "COMMUNICATION INFRASTRUCTURE" HAS BEEN SHAPED THROUGH NUMEROUS CHANNELS AND DIVERSE OCCASIONS.

The emphasis that JIVE places on its ties with society and on promoting scientific knowledge—especially among young people—was also demonstrated during the Open Day on October 6, 2024. Hundreds of visitors of all ages gathered in a festive atmosphere at the shared headquarters of JIVE, ASTRON, and NOVA in Dwingeloo, as part of the annual Netherlands-wide Science Weekend. Through a variety of engaging and entertaining activities, the public became acquainted with the science and collaboration behind JIVE and the EVN: radio telescopes spread across the globe, experts working across disciplines, and data combined to produce the sharpest images of the sky.

These, in short, are the ways and occasions through which JIVE's "communication infrastructure" has been built: maintaining close internal connections with JIVE staff to share updates as they happen; strengthening network with partners within the EVN and across projects in which JIVE is actively involved; engaging with the broader scientific and science communication communities; producing high-quality communication materials and content; and fostering two-way communication with our audiences.

To close out 2024—a double anniversary year for JIVE, marking 30 years as JIVE and 10 years as an ERIC—and to look ahead to 2025, a season card was created to encapsulate what JIVE is and what it achieves together with the EVN: creating a telescope the size of the Earth, enabling us to zoom deep into the greatest mysteries of the universe.

European Commission Projects

Group photo of the attendees at the Consortium Meeting held at the Palais du Pharo in Marseille, February 2024. Photo: ORP

HORIZON 2020
OPTICON RADIONET PILOT

Launched in 2021 and funded by the EU H2020 programme, the Opticon RadioNet Pilot (ORP) aims to enable astrophysical discoveries with a comprehensive set of Research Infrastructures across the domains of optical and radio astronomy. From November 5 to 7, ORP hosted its Consortium Meeting at the Palais du Pharo in Marseille, France. With the project officially concluding on February 28, 2025, the meeting aimed to review the ongoing and upcoming activities of the ORP leading up to its conclusion, as well as reflect on the project's overall achievements. JIVE, a key partner of the ORP, also contributed to the meeting.

Group photo of the attendees at the 2024 ERIC Forum Annual Meeting in Brussels. Photo: ERIC Forum

HORIZON EUROPE
ERIC FORUM 2

The ERIC Forum project aims to strengthen the coordination within the European Research Infrastructure Consortium (ERIC) community and enhance collaboration between partners. The strategic approach of the ERIC Forum contributes to addressing critical challenges, developing best practices and framing the necessary knowledge to support ERICs in various aspects. Moreover, this will contribute to building the brand identity of ERICs as an important body and stakeholder in consultation of related policy action. Participating in the ERIC Forum has allowed JIVE to explore a network of infrastructures that share common challenges, such as long-term sustainability, reporting, VAT exemption practices, and training of governance representatives. JIVE had a prominent role in the project, with Paco Colomer (JIVE director at the time) serving as Chair of the Forum. From 27 to 28 February, the ERIC Forum held its Annual Meeting in Brussels. JIVE Director Agnieszka Słowikowska contributed with a talk on how JIVE enables science with the sharpest view of the Universe.

HORIZON EUROPE
RADIOBLOCKS

Radioblocks unites leading European radio astronomy institutes, industry, and academia to strengthen Europe's role in global radio astronomy. Officially launched on March 1, 2023, and set to run for four years under the coordination of JIVE, the project includes 33 partners working across five targeted work packages.

Radioblocks aims to develop new technological components that will enhance the entire data chain, from signal reception to data processing. These building blocks have been recognised as essential by radio astronomy research infrastructures for achieving higher sensitivity, wider frequency coverage, larger fields of view, and more advanced data processing.

Progress across these themes will open up new opportunities for breakthroughs in radio astronomy and provide a significant boost to Europe's scientific competitiveness.

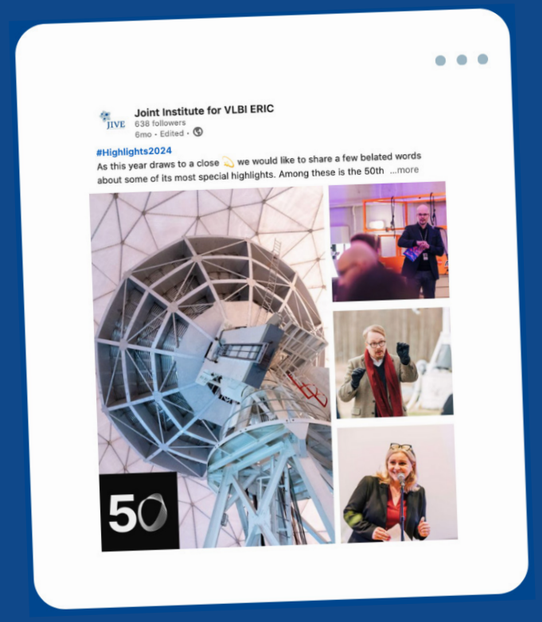
From Tuesday, June 4, to Thursday, June 6, 2024, the first all-hands meeting of Radioblocks was held in Madrid, Spain. This meeting was crucial for sharing and discussing the advancements made through the Radioblocks collaboration. The program included a series of engaging talks on the exciting achievements from the project's first year, along with several splinter meetings.

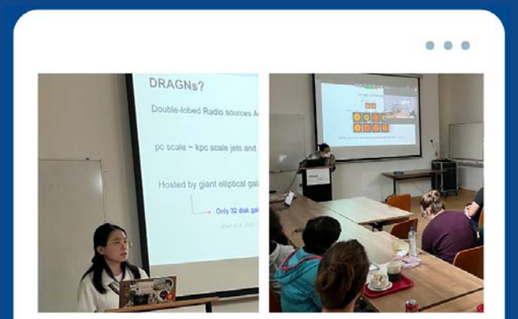
A few weeks after the meeting, the European Union's review of Periodic Report #1 strongly acknowledged the progress and potential of the project contributors: "The consortium has fully achieved its objectives and milestones for this period", it read. "It is extremely strong scientifically and technically."

Collaboration with industry is a core goal of Radioblocks. Therefore, in the late months of 2024, JIVE began establishing an Industry Advisory Board (IAB) to enhance industry engagement in the project and to help ensure the long-term impact of its innovations.

At the same time, JIVE began updating the project's website. The revised structure is being designed to reflect the dynamic nature of the project and to support its evolving research and technological goals. Both the organisation of the content and the language used are shaped with broader audiences in mind.

JIVE Director, Agnieszka Słowikowska, opening the Radioblocks all-hands meeting in Madrid, June 2024. Photo: JIVE





2024 in Pictures

JIVE Finances

BALANCE

(AFTER ALLOCATION OF RESULTS)

ASSETS	31-12-2024	31-12-2023
TANGIBLE FIXED ASSETS		
Tangible fixed assets	€ 87,190	€ 92,559
Total of tangible fixed assets	*€ 87,190*	*€ 92,559*
CURRENT ASSETS		
Work in process	€ 0	€ 0
Receivables	€ 545,764	€ 314,346
Cash at bank	€ 2,827,592	€ 2,800,464
Total of current assets	*€ 3,373,356*	*€ 3,114,810*
TOTAL ASSETS	**€ 3,460,546**	**€ 3,207,369**

LIABILITIES	31-12-2024	31-12-2023
CAPITAL		
General Reserves	€ 1,457,185	€ 1,511,454
Designated funds	€ 300,000	€ 300,000
Total capital	*€ 1,757,185*	*€ 1,811,454*
OTHER LIABILITIES		
Short term debts	€ 1,703,361	€ 1,395,915
Total of current liabilities	€ 1,703,361	*€ 1,395,915*
TOTAL ASSETS	**€ 3,460,546**	**€ 3,207,369**

STATEMENT OF PROFIT AND LOSS

		2024		2023
	BUDGET	ACTUAL	DIFFERENCE	ACTUAL
REVENUES				
INCOME				
Contributions/subsidies third parties	€ 2,471,143	€ 2,517,056	€ 45,913	€ 2,494,311
Interest	€ 30,000	€ 105,552	€ 75,552	€ 117,648
Other	€ 231,215	€ 227,462	- € 3,753	€ 271,733
Total income	*€ 2,732,358*	*€ 2,850,070*	*€ 117,712*	*€ 2,883,692*
TOTAL REVENUES	***€ 2,732,358***	***€ 2,850,070***	***€ 117,712***	***€ 2,883,692***

		2024		2023
	BUDGET	ACTUAL	DIFFERENCE	ACTUAL
EXPENDITURES				
OPERATIONS				
Grants/Expenditures	€ 3,045,528	€ 2,904,339	- € 141,189	€ 2,909,642
Total operations	*€ 3,045,528*	*€ 2,904,339*	*- € 141,189*	*€ 2,909,642*
TOTAL EXPENDITURES	***€ 3,045,528***	***€ 2,904,339***	***- € 141,189***	***€ 2,909,642***
RESULT	***- € 313,170***	***- € 54,269***	***€ 258,901***	***- € 25,950***

Tables and Metrics 2024

Council Members

JIVE MEMBER REPRESENTATIVES

Dr. Patrick Charlot	*Laboratoire d'Astrophysique de Bordeaux,* Pessac, France
Dr. Chiara Ferrari	*Observatoire de la Côte d'Azur*, France
Dr. Tiziana Venturi	*Istituto di Radioastronomia (IRA-INAF)*, Italy
Michele Crisafi	*Ministero dell'Istruzione, dell'Università e della Ricerca,* Roma, Italy
Dr. Mārcis Donerblics	*Ventspils University of Applied Sciences,* Ventspils, Latvia
Prof. Dr. Andrejs Krauklis	*Ministry of Education and Science,* Latvia
Prof. Dr. Jessica Dempsey	*ASTRON,* Dwingeloo, the Netherlands (Vice Chair)
Mrs. Saskia Matheussen	*NWO,* Den Haag, the Netherlands
Dr. José Antonio López Fernández	*Instituto Geográfico Nacional, MITMA*, Madrid, Spain
Dr. Pablo de Vicente	*Instituto Geográfico Nacional, MITMA,* Madrid, Spain (Chair)
Tomas Andersson	*Swedish Research Council,* Stockholm, Sweden
Prof. John Conway	*Onsala Space Observatory,* Onsala, Sweden
Prof. Simon Garrington	*Jodrell Bank Centre for Astrophysics,* Manchester, UK
Dr. Jenny Hiscock	*Science and Technology Facilities Council,* Swindon, UK

ASSOCIATE RESEARCH INSTITUTES REPRESENTATIVES

Prof. Zhinqiang Shen	*Shanghai Astronomical Observatory, NAOC,* Shanghai, China
Dr. Fernando Camilo	*National Research Foundation, South African Radio Astronomy Observatory,* Cape Town, South Africa
Prof. Anton Zensus	*Max-Planck-Institut für Radioastronomie,* Bonn, Germany

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JIVE Staff

Mr. Paul Boven	*Network Systems Engineer*
Mr. Wybren Buijs	*Linux/Netwerk Specialist*
Dr. Bob Campbell *	*Head of Science Operations*
Dr. Giuseppe Cimò *	*Head of Space Science and Innovative Applications Group*
Drs. Bob Eldering	*Software Engineer*
Mr. Bert Harms	*Chief Operator*
Dr. Ioanna Kazakou	*Communications Officer (from 1 september 2023)*
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. Waleed Madkour	*CRAF Frequency Manager*
Dr. Benito Marcote Martin	*Support Scientist*
Dr. Mas Md Said	*Postdoctoral Near-field VLBI Support Scientist*
Dr. Suma Murthy	*Support Scientist*
Dr. Junghwan Oh	*Support Scientist*
Dr. Gábor Orosz	*Support Scientist*
Dr. Zsolt Paragi *	*Head of User Support*
Dr. Agnieszka Słowikowska *	*Director*
Dr. Des Small	*Scientific Software Engineer*
Dr. Ilse van Bemmel	*Project Scientist*
Drs. Aukelien van den Poll	*Finance and Project Officer*
Prof. Huib Jan van Langevelde	*Chief Scientist*
Drs. Marjolein Verkouter *	*Head Technical Operations and R&D*

* MT member

Visitors to JIVE

Name	Institute	Period	Host
W. Baan	Xinjiang Astronomical Observatory, Urumqi, China	19 dec 2023 - 26 jan 2024	Paragi
R. Burns	RIKEN Cluster for Pioneering Research, Japan	2-3 January	Orosz
S. Bayram	Erciyes University Turkey/ Erasmus University, the Netherlands	16 January - 31 March	Murthy
D. Lee	Kyungpook National University, Republic of Korea	26 February - 22 March	Paragi
S.Y. Lee	Kyungpook National University, Republic of Korea	26 February - 22 March	Paragi
Z. Pronk	Nationaal Ruimtevaart Museum, the Netherlands	28 February	Gurvits
M. Janssen	Radboud Universiteit Nijmegen, the Netherlands	14 March	van Bemmel
S. Garriatana	INAF-IRA, Italy	2-10 May	Marcote
W. Baan	Xinjiang Astronomical Observatory, Urumqi, China	3 May - 15 June	Paragi
J. Yang	Onsala Space Observatory, Sweden	6 May	Campbell
A. Sargent	George Washington University, USA	17-19 June	Paragi
G. Baldini	INAF-IRA, Italy	4-21 June	Marcote
C. Pillay	University of Witwatersrand, South Africa	13 June - 4 Sept	van Langevelde
J. Yoo	KyungHee University, Republic of Korea	15 June - 6 Sept	Oh
A. Sanchez Rodriguez	Delft University, NL	1 Sept - 1 March 2025	Cimo
D. Dirkx	TU Delft, the Netherlands	8 October	Cimo
L. Gisolfi	TU Delft, the Netherlands	8 October	Cimo
J. Edwards	University of Tasmania, Australia	11-13 November	Cimo
N. Grollimund	Paris Cité University/CEA Paris-Saclay, France	2-6 December	Paragi
Y. Liu	Beijing Aerospace Control Center, China	3 December	Cimo
L. Chen	Beijing Aerospace Control Center, China	3 December	Cimo
W. Lu	Beijing Aerospace Control Center, China	3 December	Cimo
J. Kong	Beijing Aerospace Control Center, China	3 December	Cimo
T. Le	Beijing Aerospace Control Center, China	3 December	Cimo
Y. Yeskaliyev	GFZ Potsdam/Research Centre for Geosciences, Germany	4-13 December	Orosz
P. Veres	Ruhr University Bochum, Germany	9-12 December	Orosz

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Correlator Activity

Project Code	Month or Session	PI	Title
EA071B	Feb.24	An	Jet proper motion in two radio quiet quasars
EA071C	Sep.24	An	Jet proper motion in two radio quiet quasars
EA071D	Dec.24	An	Jet proper motion in two radio quiet quasars
EA072	s.3/23	Aberfelds	Structure and variability studies of three methanol maser sources
EA075	Mar.24	Alvarez-Ortega	Potential gravitational lens system at milliarcsecond scales
EA077A	Oct.24	Atri	Parallax of an unclassified, circularly polarized source
EA077B	Dec.24	Atri	Parallax of an unclassified, circularly polarized source
EB081C	s.1/21	Boven	Astrometry Ross 867
EB089A	s.3/21	Boven	Astrometric observations of WX UMa
EB089B	s.1/22	Boven	Astrometric observations of WX UMa
EB089C	s.2/22	Boven	Astrometric observations of WX UMa
EB091A	s.1/22	Boven	Extending the astrometry on Ross 867
EB091B	s.2/22	Boven	Extending the astrometry on Ross 867
EB091C	s.3/22	Boven	Extending the astrometry on Ross 867
EB100C-D	s.3/23	Bhandari	Long-term monitoring of FRB20121102A and its associated persistent radio source
EB100E-F	s.1/24	Bhandari	Long-term monitoring of FRB20121102A and its associated persistent radio source
EB103A-D	s.1/24	Njeri	Growing black holes or supernova factories in extremely opaque LIRGs
EB103E	s.2/24	Njeri	Growing black holes or supernova factories in extremely opaque LIRGs
EB106	s.1/24	Bruni	Changing-look AGN 1ES 1927+654: probing the onset of a newborn jet
EB107	s.1/24	Bietenholz	SN 2014C: Unprecedented Possible Bi-Polar Morphology and Increased Deceleration
EB111	Jun.24	Bakowska	Simultaneous optical and radio observations of AM Her
EC090A-C	s.1/24	Chang	Revealing the parsec-scale radio emission in 5 nearby radio-quiet Seyferts
EC090D-E	s.2/24	Chang	Revealing the parsec-scale radio emission in 5 nearby radio-quiet Seyferts
EC092	s.2/23	Charlot	Geodesy, astrometry and high-resolution imaging with the EVN at K-band
EC096A-B	s.2/24	Cheng	AGN or Starburst? Confirming the Nature of Off-nuclear Radio Emission in NGC2146
EC098A	s.3/24	Cala	Magnetized “water fountain” and circumstellar structure of a nascent PN
EF030A-C	s.3/23	Fellenberg	Confirming the jet precession of M81*
EF030D	s.2/24	Fellenberg	Confirming the jet precession of M81*
EG120	s.3/22	Giroletti	High angular resolution of a long-lived GRB outflow

Project Code	Month or Session	PI	Title
EG124A-B	s.3/23	Gabanyi	A sub-kpc separation dual radio-AGN?
EG125	s.2/23	Gabanyi	A gamma-ray emitting NLS1 or a gamma-ray emitting radio galaxy?
EG126A-B	s.3/23	Guirado	Exoplanetary studies in two binary cool objects
EG126C	s.1/24	Guirado	Exoplanetary studies in two binary cool objects
EG128A-B	s.2/23	Giroletti	Setting up for the outburst of nova T CrB
EG129A	s.2/24	Gabanyi	Looking for a kpc-scale separation dual AGN at z=4.11
EG131A-E	s.2/24	Ghosh	Tracing the Radio Outflows in RQ AGN from Pc- to Kpc-scales
EG131F	s.3/24	Ghosh	Tracing the Radio Outflows in RQ AGN from Pc- to Kpc-scales
EH041A-B	s.3/23	Hagiwara	Double nuclei in the Mid-stage Merger VV 114
EH043	s.3/23	Hagiwara	OH Maser emission in NGC1068
EK050C	Feb.22	Kirsten	Correlation of an ad-hoc VLBI array monitoring CHIME repeating FRBs II
EK050D	Mar.22	Kirsten	Correlation of an ad-hoc VLBI array monitoring CHIME repeating FRBs II
EK050F	May.22	Kirsten	Correlation of an ad-hoc VLBI array monitoring CHIME repeating FRBs II
EK050G	Jul.22	Kirsten	Correlation of an ad-hoc VLBI array monitoring CHIME repeating FRBs II
EK051A-B;D	Aug.22	Kirsten	Correlation of an ad-hoc VLBI array monitoring CHIME repeating FRBs III
EK052A	s.2/23	Kobak	g-factor of 6.7 GHz methanol maser via polarization observation
EK056A-B	Feb.24	Kirsten	Localising repeating FRBs with EVN-lite II
EL062B	Apr.24	Liu	Radio emission from the radio-weak quasars at the reionization era
EL065D	s.3/23	Lunz	Enhancing the VLBI/Gaia alignment with new observations of radio stars
EL065E	s.1/24	Lunz	Enhancing the VLBI/Gaia alignment with new observations of radio stars
EL071A-B	s.1/24	Lazda	Early evolution of a likely magnetar wind nebula
EL073A	s.2/24	Leung	High-resolution imaging of late-time radio rebrightening in SN2022xxf
EL075	s.2/24	Li	Subpc-scale jet from extremely low accretion rate SMBH in M60
EM156D	s.2/23	Miller-Jones	Outflow speed of a long-lived thermal tidal disruption event
EM164A-B	s.2/22	McKean	AGN evolution and feedback by combining the ILT and e-MERLIN/EVN
EM164C-D	s.3/22	McKean	AGN evolution and feedback by combining the ILT and e-MERLIN/EVN
EM164E-F	s.2/23	McKean	AGN evolution and feedback by combining the ILT and e-MERLIN/EVN
EM164G-H	s.1/24	McKean	AGN evolution and feedback by combining the ILT and e-MERLIN/EVN
EM165B	Jan.24	Marcote	Origin of the gamma-ray binary HESS J1832-093
EM165C	Mar.24	Marcote	Origin of the gamma-ray binary HESS J1832-093
EM165D	May.24	Marcote	Origin of the gamma-ray binary HESS J1832-093
EM165E	Sep.24	Marcote	Origin of the gamma-ray binary HESS J1832-093
EM165F	Nov.24	Marcote	Origin of the gamma-ray binary HESS J1832-093
EM167	s.3/23	Mai	Off-arm mini starburst in G34 region?
EM170B	s.3/23	Miller-Jones	Jet Lorentz factor in a tidal disruption event
EM171A	Aug.23	Motta	Disc-jet connection in Sco X-1 with the EVN and IXPE
EM172A-C	s.3/23	Motta	Resolving the Mini Mouse with the EVN
EM173A	s.3/23	Marcote	CEN 1a and 1b: The third case of a colliding-wind binary emitting gamma rays?
EM173B	s.1/24	Marcote	CEN 1a and 1b: The third case of a colliding-wind binary emitting gamma rays?
EM174A-B	s.3/23	Murthy	AGN feedback only 430 Myr after Big Bang
EM178	s.2/24	Marti	Microblazar candidate IRAS 18293-0941
EN011F	Feb.24	Nanci	Are blazar jets associated with IceCube neutrinos?
EN015	s.1/24	Nakagawa	Circumstellar mass transfer and acceleration scenario in NSV17351

Project Code	Month or Session	PI	Title
EO020	s.3/23	Olech	Relative motion of edge-on disk in periodic 6.7GHz methanol maser G59.633-0.192
EP124C	s.3/22	Perez-Torres	Arp 299: detection of nuclear transients & testing TDE jet physics
EP129	s.1/24	Perger	Potential VLBI calibrator sources for the JUICE Venus flyby
ER054	s.1/24	Rygl	Flaring water masers in MYSO S255 NIRS3 - sign of another accretion event?
ES109	s.1/24	Shu	Possibly evolved radio jet ejections associated with AGN outburst
ES110A-B	s.1/24	Stanghellini	The path of a precessing jet in a compact jetted radio galaxy
EV024A	s.1/22	Vaddi	Orbital period evolution of candidate supermassive BH binary 3C66B
EV024C	s.2/22	Vaddi	Orbital period evolution of candidate supermassive BH binary 3C66B
EV024G	s.1/23	Vaddi	Orbital period evolution of candidate supermassive BH binary 3C66B
EV024H	s.2/23	Vaddi	Orbital period evolution of candidate supermassive BH binary 3C66B
EV024J	Dec.23	Vaddi	Orbital period evolution of candidate supermassive BH binary 3C66B
EV026A-C	s.1/24	Vohl	Over-luminous compact radio sources (OCRs) in dwarf galaxies
EV026D-G	s.2/24	Vohl	Over-luminous compact radio sources (OCRs) in dwarf galaxies
EV028	Mar.24	Veres	TDE candidate coincident with a neutrino source
EW039A-C	s.3/24	HC.Wang	The surprising excess of radio emission in extremely stable QSOs
EW040A	Dec.24	HC.Wang	Dual-quasar candidates with projected separations < 0.1 kpc
EX010A-B	s.2/24	WC.Xu	Two Varstrometry Selected Dual-Quasar Candidates
EY038A-C	s.3/23	XL.Yang	Newborn ejecta associated with the changing-look AGN 1ES1927+654
EY043A	s.1/24	J.Yan	NGC1068: probing its thermal outflow disc and nonthermal shocks
EY044A	s.3/24	J.Yang	Search for an unprecedented radio jet from a nearby thermal TDE
GC039	s.3/23	Climent	Aurorae and radiation belt: deep exploration of an ultracool dwarf magnetosphere
GG087B	s.3/23	Giarratana	Structure and the dynamics of the outstanding GRB 221009A
GK049E-F	Jan.19	Kirsten	Probing pulsar emission with picoarcsecond precision
GL046	s.1/24	Lonsdale	Spectropolarimetric study of the jet and its termination region in 3C205
GM082	s.2/23	Moscadelli	MHD disk winds across the YSO mass spectrum
GP061A-B	s.2/24	Paraschos	The jet base in the prominent radio galaxy 3C84
GW023A-C	s.1/24	Wen	Magnified view of an ionized scattering medium in a z=1.145 late-type galaxy
RA007	s.2/24	An	High-precision localization of EP240425a - a newly discovered X-ray binary
RB009	s.3/23	Bruni	Changing-look AGN 1ES 1927+654: probing the onset of a newborn jet
RB010	Nov.23	Burns	6.7 GHz methanol maser imaging during likely high-mass protostellar accretion burst
RG014	s.1/24	Giroletti	High-resolution imaging of late-time radio rebrightening in SN 2022xxf
RK002	Feb.24	Kirsten	Precisely locating FRB 20240114A
RM020	Oct.24	Miller-Jones	Lorentz factor of the jet from a tidal disruption event
RN002	Apr.24	Nimmo	Compact radio nebula associated with FRB 20221022A
RSB04	Oct.24	Bloot	Pulse ephemeris and candidate phase-reference sources for LOFAR ultra-long period transient
RSG18	s.2/24	Gawronski	Candidate phase-reference sources for XTE J1810-197
RSG19	Jun.24	Garrett	Compactness of VLASS J233532.86-000424.9 and candidate phase-reference sources
RSM06A	Dec.24	Marti	Scatter-broadening of calibrator for microblazar candidate IRAS 18293-1035
RSY11	Jan.24	Yang	Optimizing the phase-referencing astrometric tactics for TDE AT2018cqh

ANNUAL REPORT '24

JIVE Publications

- Pallichadath, V., Dirkx, D., Fayolle, M. S., et al. (including **Gurvits, L. I., Boven, P., Cimò, G., Said, N. M. M.**), *Planetary radio interferometry and Doppler experiment as an operational component of the Jupiter Icy Moons Explorer mission*, 2025, CEAS, 17, 3, 339-359, arXiv:2408.14965
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Acronyms and Abbreviations

ACME	Astrophysics Centre for Multimessenger Studies in Europe
AGN	Active Galactic Nucleus
AIPS	Astronomical Image Processing System
ASTRON	Netherlands Institute for Radio Astronomy
BACC	Beijing Aerospace Control Center
BH	Black Hole
BHTOM	Black Hole Target Observation Manager
CHIME	Canadian Hydrogen Intensity Mapping Experiment
CASA	Common Astronomy Software Applications
CEPT	European Conference of Postal and Telecommunications Administrations
CNES	Centre national d'études spatiales
CPU	Central Processing Unit
CRAF	Committee on Radio Astronomy Frequencies
DAT	Digital Audio Tape
DBBC	Digital Base Band Converter
DOI	Digital Object Identifier
EC	European Commission
ECC	Electronic Communications Committee
EEE	Evaluation and Export Engine
e-EVN	electronic (realtime) European VLBI Network
EHT	Event Horizon Telescope
EOP	Earth Orientation Parameter
ERIC	European Research Infrastructure Consortium
ESA	European Space Agency
e-VLBI	electronic Very Long Baseline Interferometry (implies real-time correlation: e-EVN)
EVN	European VLBI Network
FITS	Flexible Image Transport System
FRB	Fast Radio Burst
Gbps	Gigabit per second
GHz	Gigahertz
GMRT	Giant Metrewave Radio Telescope
GPU	Graphics Processing Unit
GRB	Gamma Ray Burst
ITU	International Telecommunication Union
H2020	Horizon 2020 EC Funding Programme
HDD	Hard Disk Drive
IAB	Industry Advisory Board
INAF	Istituto Nazionale di Astrofisica, Italian National Institute of Astrophysics
INAF-IRA	Istituto di Radio Astronomia, Institute of Radio Astronomy (Italy)
ISM	Interstellar Medium
JAXA	Japan Aerospace Exploration Agency
JUICE	JUpiter ICy moons Explorer
LO	Local Oscillator
LOFAR	Low Frequency Array
LTO	Linear Tape-Open
M87	Messier 87
Mbps	Megabit per second
MHz	Megahertz
MITMA	Ministerio de Transportes y Movilidad Sostenible (Spain)
MPIfR	Max-Planck-Institut für Radioastronomie
NAOC	National Astronomical Observatories of the Chinese Academy of Sciences
NARIT	National Astronomical Research Institute of Thailand
NRF	National Research Foundation (South Africa)
NME	Network Monitoring Experiment
NWO	Nederlandse Organisatie voor Wetenschappelijk Onderzoek, Netherlands Organisation for Scientific Research
OCS	Las Cumbres Observatory's Observatory Control System
OPTICON	Optical Infrared Coordination Network for Astronomy
ORP	OPTICON RadioNet Pilot

PB	PetaByte
PRIDE	Planetary Radio Interferometry and Doppler Experiment
R&D	Research and Development
RADPS	Radio Astronomical Data Processing System
RAID	Research Activity Identifier
SCHED	VLBI Scheduling software
SFXC	Software Correlator at JIVE
SKA	Square Kilometre Array
SMBH	Supermassive Black Holes
SOC	Scientific Organising Committee
SWEEPS	Synoptic Wide-field EVN-e-MERLIN commensal Public Survey
TB	Terabyte
TDE	Tidal Disruption Event
TNRT	Thai National Radio Telescope
TOM	Target Observation Manager
ToO	Target of Opportunity
VDIF	VLBI Data Interchange Format
VERA	VLBI Exploration of Radio Astrometry
VEX	VLBI Experiment Description
VIRAC	Ventspils International Radio Astronomy Centre
VLBA	Very Long Baseline Array, United States of America
VLBI	Very Long Baseline Interferometry
VR	Vetenskapsrådet, Swedish Research Council
WPT	Wireless Power Transfer
WSRT	Westerbork Synthesis Radio Telescope
WRC-23	World Radiocommunication Conference 2023
WRC-27	World Radiocommunication Conference 2027
XRB	X-ray Binary

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