NEWSLETTER

Edition 61
January 2022

EUROPEAN VLBI NETWORK

JIVE
Joint Institute for VLBI
ERIC

CALL FOR PROPOSALS

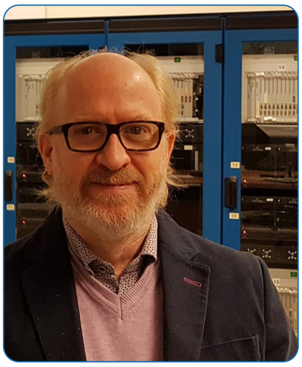
DEADLINE: 1 FEBRUARY 2022, 16:00:00 UTC

ONLINE VERSION OF NEWSLETTER

IN THIS ISSUE

WELCOME

Tiziana Venturi,
EVN Consortium Board of Directors Chair



Francisco "Paco" Colomer,
JIVE Director

Welcome to the new issue of the EVN/JIVE Newsletter.

A lot has happened since the last edition, and this issue reports on exciting new scientific results, as well as updates on international projects and collaborations.

We wish to draw your attention to the results of the coronal radio-sound measurements of the ESA's Mars Express, which were obtained with the EVN thanks to uncommon applications of the VLBI technique. We further wish to highlight the report on the review paper on star formation and nuclear activity in LIRGs, a science area where the contribution of the EVN has been invaluable.

In the framework of the Global VLBI Alliance and the long-standing collaboration with the EVN, we congratulate our colleagues in the East Asian VLBI Network for the important step forward with their recently updated Memorandum of Understanding. The JUMPING JIVE project has very successfully ended, and the European radio community is now engaged in ensuring success to the EC-H2020 OPTICON-RadioNet Pilot.

Finally, the successful series of EVN online seminars is continuing, with an exciting calendar of speakers and topics throughout 2022.

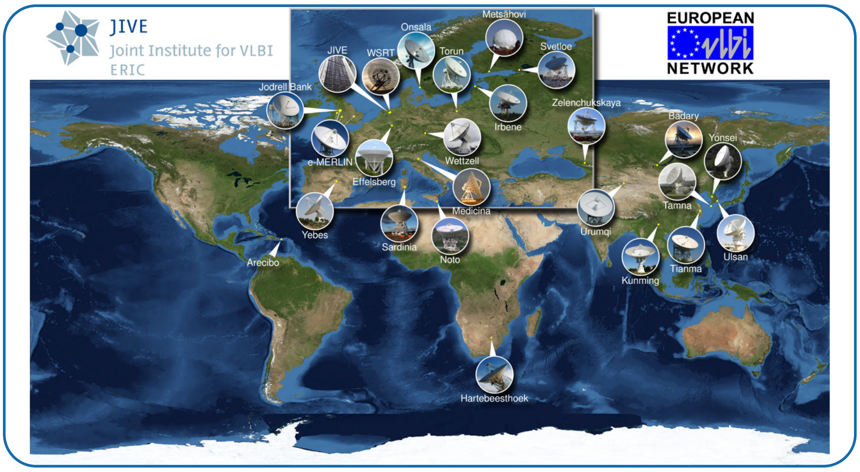
All this and much more are included in this issue.
We thank our community for the continuous dedication which ensures advances, observations and excellent science delivery.

Tiziana Venturi, EVN Consortium Board of Directors Chair
Francisco "Paco" Colomer, JIVE Director

CALL FOR PROPOSALS

DEADLINE: 1 FEBRUARY 2022, 16:00:00 UTC

Details of the call: https://www.evlbi.org



Observing proposals are invited for the European VLBI Network (EVN). **Deadline: 1 February 2022, 16:00:00 UTC.**

The EVN facility is open to all astronomers. Astronomers with limited or no VLBI experience are particularly encouraged to apply for observing time. Student proposals are judged favorably. Support with proposal preparation, scheduling, correlation, data reduction and analysis can be requested from the Joint Institute for VLBI ERIC (JIVE).

Check details of the call for proposals here.

EVN Support+ programme

JIVE/EVN initiates a pilot programme to provide extended support to teams new to the EVN, with little or no direct VLBI experience. This includes the scheduling of the VLBI run and the VLBI-specific parts of the data reduction (including a-priori amplitude calibration and fringe-fitting). Imaging, and the interpretation of the data is the responsibility of the team. We aim to support some standard VLBI projects, evaluated by the EVN Program Committee with the highest grades. See the call for proposals. For further questions please contact the Chair of the EVN PC, Zsolt Paragi (evnpc@jive.eu).

SCIENCE HIGHLIGHTS

SMILE: SEARCHING FOR MILLI-LENSES

Carolina Casadio, Institute of Astrophysics, FORTH, Greece

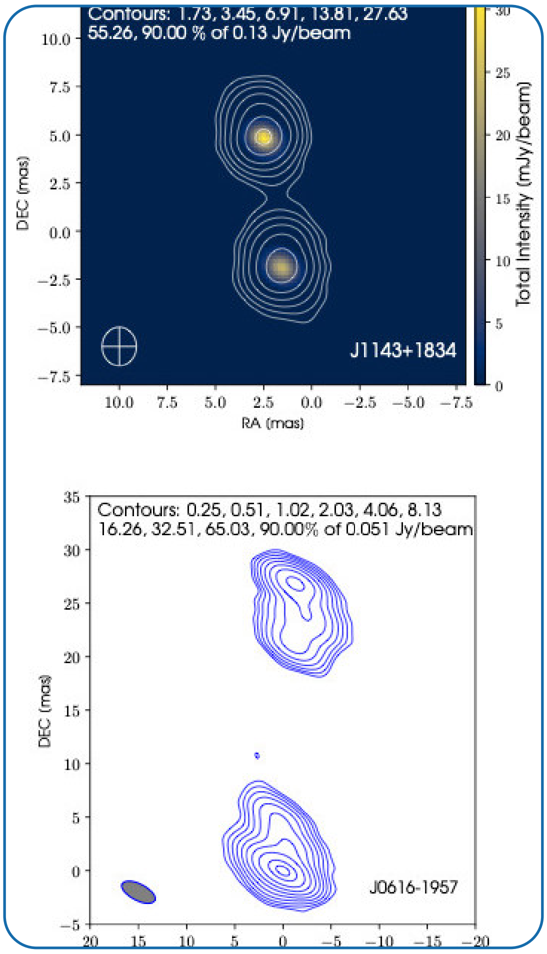


Figure 1: New 5 GHz (contours) and 22 GHz (colours in J1143+1834) EVN images of two milli-lens candidates.

One of the most compelling mysteries in both cosmology and particle physics is the nature of Dark Matter. Its elusive detection coupled with unsolved discrepancies between some standard cosmo-logical (Lambda-CDM) model predictions and observations have paved the way to alternative DM models.

A critical prediction of the CDM paradigm is the number of DM halos at sub-galactic scales, i.e. masses below ~10^{10} solar masses. Constraining this number would help discarding many currently viable Dark Matter models. We investigate this problem using strong gravitational lensing of active galaxies on the key but poorly-explored milli-arcsecond scales, i.e. milli-lenses. Gravitational lensed images with angular separation on milliarcsecond scales probe gravitational lens systems where the lens is a compact object with mass in the range 10^6 – 10^9 solar masses.

Published in: [Casadio et al. 2021. MNRASI]

Compact objects in this mass range could be i) sub-galactic Dark Matter halos (in the surroundings of galactic Dark Matter halos or in the field), ii) primordial black holes, also considered an alternative candidate to Dark Matter particles, (iii) supermassive Black Holes hosted by galaxies.

The most direct way to explore these small angular scales is through the high-resolution of radio Very Long Baseline Interferometry (VLBI). We performed a pilot search for milli-lenses with angular separation < 150 mas, using the publicly available multi-frequency VLBI data in the Astrogeo VLBI FITS image database, containing data of 13,828 sources. For our search, we visually inspected all images creating a web-page based on the idea of citizen-science projects. 5 PhD scientists and 9 undergraduate Physics students from the University of Crete (Greece) were involved in the search, and asked to mark as "Lens" sources showing multiple compact components in at least one of the available observing bands, and as "No Lens" the rest of the sources. Each source in the database was inspected by one user and the corresponding choice was recorded. After many visual selection steps, we finally use the surface brightness preservation criterion to obtain the list of 40 best milli-lens candidates. Since gravitational lensing preserves the surface brightness of the background source, we expect the lensed images to have all the same intrinsic brightness.

The 40 best milli-lens candidates have been followed up with the European VLBI Network (EVN) observations at 5 and 22 GHz (Project ID: EC071; PI: C. Casadio), and the analysis of data is currently on-going. New EVN images of two (J1143+1834, and J0616-1957) of the best milli-lens candidates are shown in Figure 1. The two sources confirm their double structure, but while the two components in J1143+1834 are slightly resolved, in J0616-1957 we clearly distinguish two jet-like features that may indicate a different nature for this object. Further analysis will allow us to reject or confirm the milli-lens candidates. Any sources rejected as milli-lens candidates can still be investigated as candidates for a binary supermassive black hole or a compact symmetric object.

STAR FORMATION AND NUCLEAR ACTIVITY IN LUMINOUS INFRARED GALAXIES: AN INFRARED THROUGH RADIO REVIEW

Miguel Pérez Torres, Instituto de Astrofísica de Andalucía (IAA-CSIC), Spain

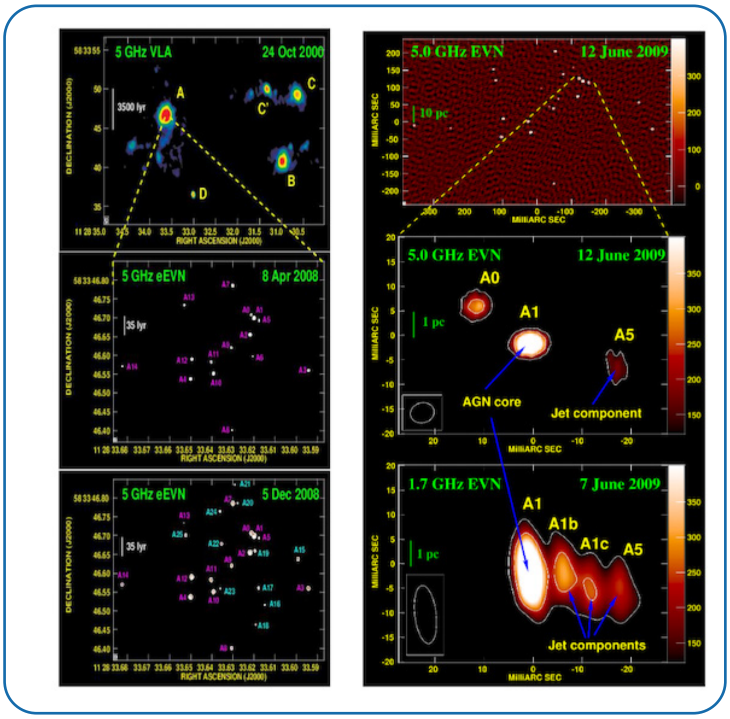


Figure 1:Left: 5 GHz VLA archival observations of Arp 299 (top) and 5.0 GHz EVN images of the central 200 pc of Arp 299-A (bottom). Right: EVN image at 5 GHz of the central 200 pc region of Arp 299-A (top), and blow-ups of the inner 8 parsecs as imaged with the EVN at 5.0 GHz (middle) and 1.7 GHz (bottom).

Nearby galaxies offer unique laboratories allowing multi-wavelength spatially resolved studies of the interstellar medium, star formation and nuclear activity across a broad range of physical conditions. In particular, detailed studies of individual local luminous infrared galaxies (LIRGs) are crucial for gaining a better understanding of these processes and for developing and testing models that are used to explain statistical studies of large populations of such galaxies at high redshift for which it is currently impossible to reach a sufficient physical resolution.

In a recent review (Pérez-Torres et al. 2021), we provide an overview of the impact of spatially resolved infrared, sub-millimetre and radio observations in the study of the interstellar medium, star formation and active galactic nuclei as well as their interplay in local LIRGs. We also present an overview of the modelling of their spectral energy distributions using state-of-the-art radiative transfer codes. Those codes are also a powerful 'workhorse' tools for the study of LIRGs (and their more luminous counterparts) at higher redshifts, and whose morphology cannot be spatially resolved. We also discuss how

Published in: Perez-Torreset al. 2021, A&A

spatially-resolved time domain observations have recently opened a new window to study the nuclear activity in LIRGs.

Finally, we describe in detail the observational characteristics of Arp 299, one of the best studied local LIRGs, to exemplify the power of combining high-resolution observations at infrared to radio wavelengths, together with radiative transfer modelling used to explain the spectral energy distributions of its different components.

Radio interferometric observations at the highest angular resolution, i.e., VLBI, play a very relevant role in the review. This role is summarised in Figures 1 and 2, all of them of the iconic LIRG Arp 299. Figure 1 (left panel) shows 5 GHz VLA archival observations of Arp 299 (top), displaying the five brightest knots of Arp 299, while the bottom panels show 5.0 GHz EVN images of the central 200 pc of Arp 299-A on 8 April 2008 and 5 December 2008. The EVN clearly reveals a large population of compact, non-thermal emitting sources (white contours), mostly identified with young radio SNe and SN remnants (Pérez-Torres et al. 2009; Bondi et al. 2012). On the right panel of Figure 1, we show an EVN image at 5 GHz of the central 200 pc region of Arp 299-A (top panel), and blow-ups of the inner 8 parsecs, as imaged with the EVN at 5.0 GHz (middle panel) and 1.7 GHz (bottom panel). The morphology, spectral index and luminosity of the A1–A5 region are very suggestive of a core-jet structure. Finally, in Figure 2 we show the first observations of a resolved radio jet in a TDE ever, obtained using VLBI observations. The initially compact, unresolved 8.4 GHz radio source in the nuclear region of Arp 299-B (left panels: pre-discovery image (top) and discovery image (bottom), develops into an expanding jet structure as a fraction of the accretion power is channeled into a relativistic outflow (right panel).

In the review, we summarise previous achievements obtained using high-spatial resolution observations and provide an outlook into what we can expect to achieve with future facilities.

We hope this article is of use to the whole community, but especially for undergraduate and graduate students interested in the diversity of phenomena that take place in LIRGs, and how VLBI can help, sometimes in truly unique ways, to solve puzzling mysteries.

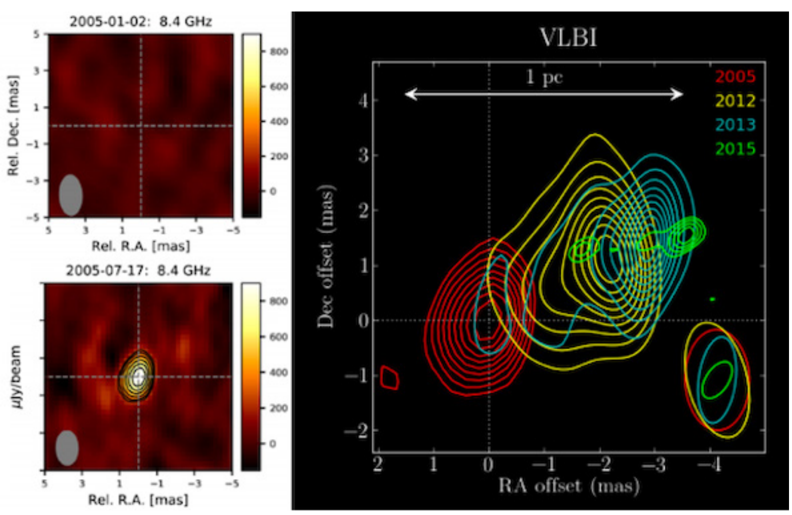


Figure 2: unresolved 8.4 GHz radio source in the nuclear region of Arp 299-B (left panels: pre-discovery image (top) and discovery image (bottom), develops into an expanding jet structure as a fraction of the accretion power is channeled into a relativistic outflow (right panel).

CORONAL RADIO-SOUNDING MEASUREMENTS OF ESA'S MARS EXPRESS USING THE EUROPEAN VLBI NETWORK

Maoli Ma, Shanghai Astronomical Observatory and Shanghai Astronomical Observatory, Chinese Academy of Sciences, China, et al.

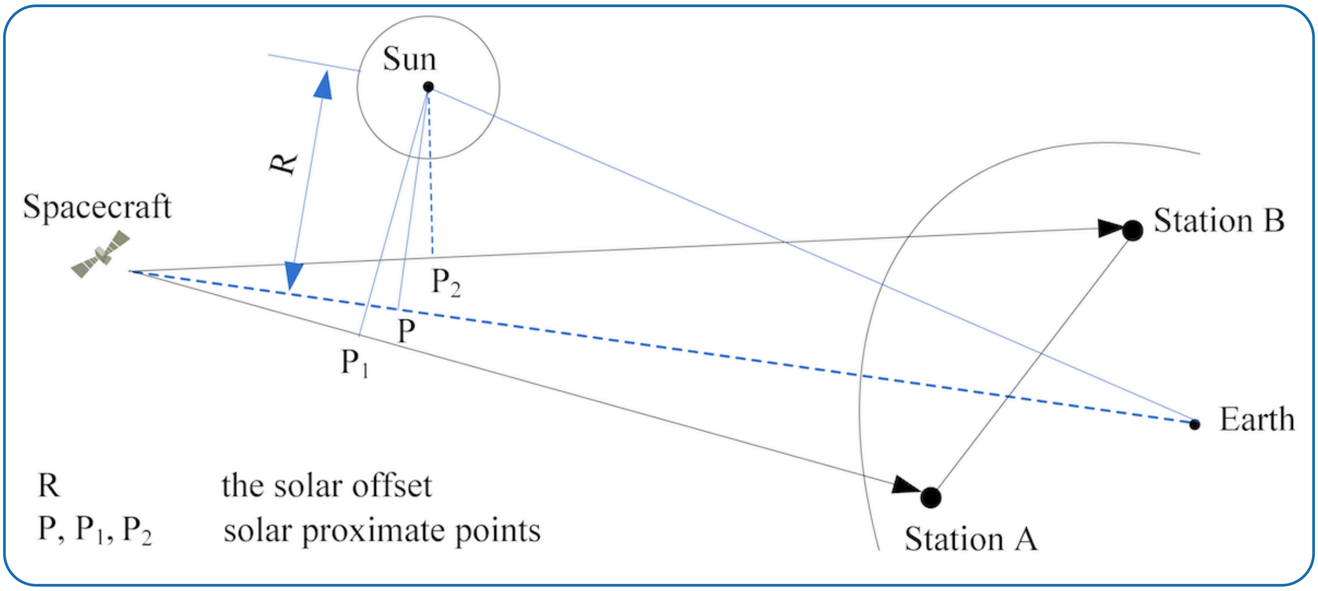


Figure 1: Schematic representation of the observation of the spacecraft by two spaced stations during a radio sounding experiment. P1P2 is the actual projected baselines of the radio ray paths from the spacecraft to two ground stations A and B.

Very Long Baseline Interferometry (VLBI) observations of spacecraft inside the solar system have been applied to a broad range of research interests in recent years. One application is to remote sense the solar wind by the observation of a spacecraft during its solar conjunction. The VLBI baselines distributed along different Earth longitudes and latitudes form a network of projected baselines near the sun (Figure 1), provide a unique advantage to analyse the cross correlation of fluctuations among different stations, especially in the inner of the solar wind, with 10 Rs (solar radii).

The goal of our coronal radio-sounding technique is to characterise the electron density turbulence on the received signals. We have introduced two measurement methods to extract the frequency and phase fluctuations. The first method follows the pipeline processing developed by the Planetary Radio Interferometry and Doppler Experiments (PRIDE) group at the Joint Institute for VLBI ERIC (JIVE). The second called the local correlation method can be used to analysis the cross correlation of the fluctuations on multi-stations observations. Both methods have been applied to the solar conjunction observations of the European Space Agency's Mars Express (MEX) using ground-based VLBI telescopes of the European VLBI Network (EVN) in 2015 and 2017.

First of all, we characterised the electron

Published in: Ma et al. 2021, AJ, 162, 4

density turbulence from single antenna observations. The power spectral density of the frequency fluctuations at different solar offsets shows that the spectra have a near power-law shape with the mean of the measured spectral index 0.58, close to the theoretical value expected from a Kolmogorov-type turbulence spectrum. The RMS intensity of the frequency fluctuations at 11.2 Rs on 25 July 2015 is stronger than the fluctuations at 4.9 Rs and 9.9 Rs on 29 July and 3 August 2017. This is consistent with the images of the Solar and Heliospheric Observatory (SOHO/LASCO), which shows a number of bright coronal rays emanating radially from the coronal hole and crossing the LOSs (line of sights) between Earth and S/C on 25 June 2015. However, on 29 July and 3 August 2017, the LOSs were closer to the northern coronal regions with heliolatitudes of the coronal region at 70o and 40o respectively, where the rays were much fainter. The match of the fluctuations with the LASCO images further verify the correctness of our measurement methods.

Secondly, we characterized the electron density turbulence from multi-station observations. With the local correlation methods, we have obtained the electron column density fluctuations along the different LOSs from the multi-station observations on 29 July and 3 August 2017 when the solar offsets were 4.9 Rs and 9.9 Rs, respectively. The power spectral density analysis on the electron column density fluctuations shows that the fluctuations at different stations are correlated when v < 0.01 Hz (Figure 2).

Furthermore, based on the hypothesis of frozen-in plasma turbulence, we have obtained the time lag and eventually the convective velocity of the solar wind irregularities from the cross-correlation analysis on the fluctuations from multiple stations. The velocities obtained with our method are significantly larger than the measurements made by the Space Weather Prediction Center (SWPC). The faster solar wind velocities correspond to the higher heliolatitude of the coronal region, while the velocities provided by SWPC relate to the region upwind of Earth, typically orbiting the L1 Lagrange point.

Encouraged by the performance of this method for characterising the electron density turbulence from VLBI baselines as well as from single stations, we are now using radio telescopes of the University of Tasmania and the EVN to observe, in the same primary beam, the ESA's MEX and the Chinese Mars orbiter Tianwen to study the correlation of the scintillation along baselines and to estimate the solar wind velocity profile at different solar offsets.

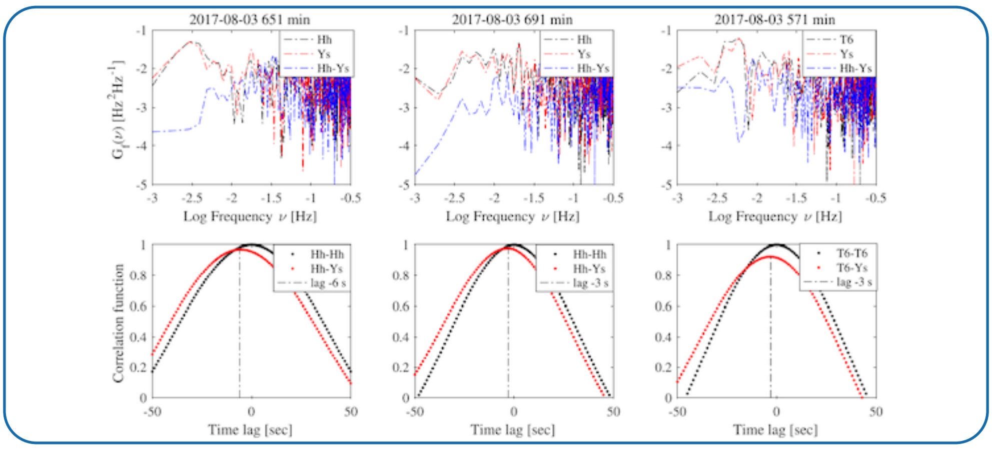


Figure 2: The correlation function of fluctuation frequency for three individual scans at the baselines Hh-Ys, T6-Ys on 3 August when solar offset was 9.9 Rs.

VLBI OBSERVATIONS REVEAL THE NUCLEAR JET PROPERTIES OF FANAROFF-RILEY TYPE 0 RADIO GALAXIES

Xiaopeng Cheng, Shanghai Astronomical Observatory, Chinese Academy of Sciences, China and Korea Astronomy and Space Science Institute, Republic of Korea, et al.

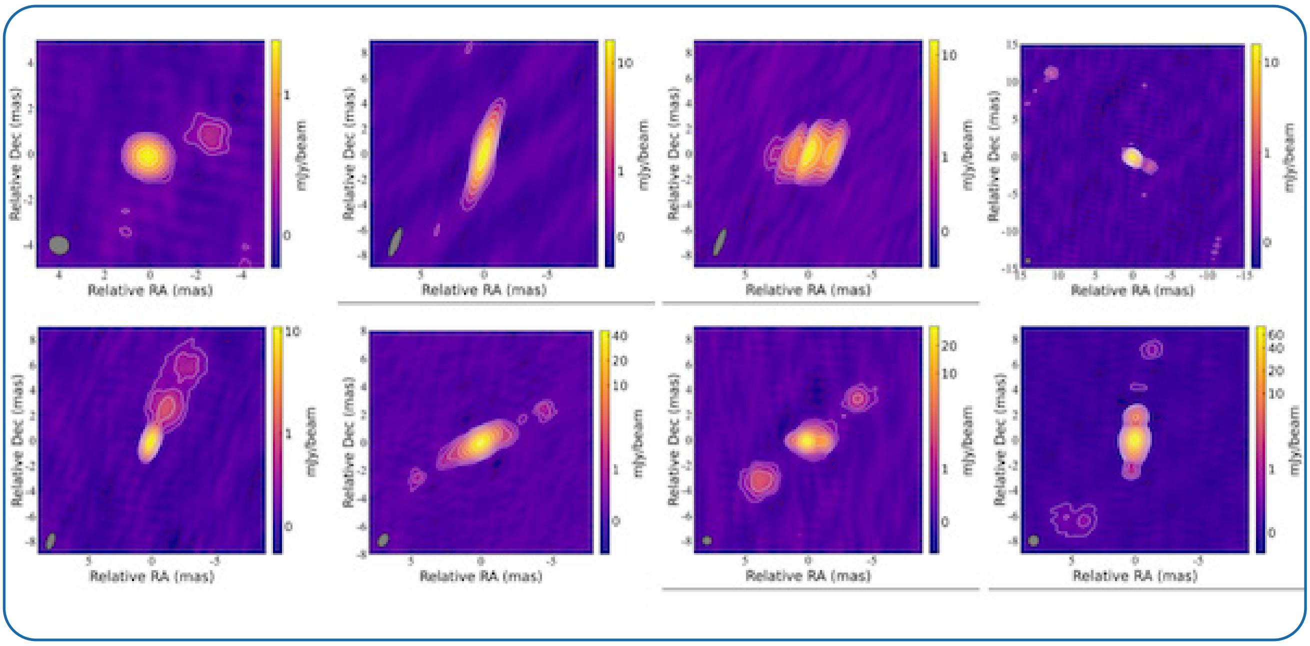


Figure 1: 8-GHz EVN images of eight FR0 galaxies.

Radio galaxies are divided into two groups according to their morphology, namely Fanaroff-Riley type I (FRI) and type II (FRII). FRIIs generally have higher jet power than FRIs. The evolutionary models of FRII and FRI galaxies have been extensively studies [1,2]: each radio source starts as a compact symmetric object (CSO), grows gradually through a medium-sized symmetric object (MSO) phase, and then a fraction of MSOs successfully evolve into large symmetric objects (LSOs), including FRII and FRI galaxies. The practical radio galaxy evolution of individual FRII or FRI is very complex and depends on several factors such as the initial jet power, the duration of the nuclear activity, the recurrence of the radio activity, and the loss of jet kinetic energy due to the jet-ISM interactions.

A class of radio sources, which have a compact morphology in arcsec-scale resolution images and lack extended jets (larger than 5 kpc) [3], was recently discovered and cannot be directly classified as FRIs or FRIIs, and is therefore treated as a separate class named FR0 radio galaxies. The number density of FR0s in the local Universe ($z < 0.05$) far exceeds that of FRIs and FRIIs, making this class important for a complete understanding of the radiative properties of radio galaxies and the radio feedback to the host galaxy. In terms of galactic nuclei and host properties, FR0s are not significantly different from FRIs, indicating that both classes have the same type of central engines and that the jet provides the main contribution to the overall radio power. Based on these commonality between FR0s and FRIs, it is thought that

Published in: Cheng et al. 2021, MNRAS

FR0s may be early-stage FRIs, but it is still not clear whether FR0s can eventually evolve into FRIs. Although FR0s lack extended jets of tens of kpc, sub-arcsec resolution imaging observations show the presence of kpc-scale jets in at least a fraction of FR0s. In addition, some FR0s (and candidates) have been detected in the gamma-ray band and have been suggested as possible sources of cosmic neutrinos and high-energy cosmic rays, indicating the presence of relativistic jets in FR0s. One of the direct ways to detect the relativistic jet in FR0s and to explore the connection of FR0s with other FR galaxies is to study the pc-scale radio emission with very long baseline interferometric (VLBI) observations.

A team of astronomers (X. Cheng & T. An) selected 14 FR0s with highest radio flux densities to study their radio properties on pc scales based on Very Long Baseline Array (VLBA) observations [4]. Pc-scale jets were detected in 80% of the sample sources (at higher resolutions, this percentage may reach 100%). The jets show a diverse characteristic: lower bright temperatures than typical radio-loud quasars, slow structure and flux density variations, compact structures with two-sided jets or one-sided jet, steep spectra, and moderate jet velocities, implying that these FR0s may be mixed with CSOs and MSOs [4]. The team continued to observe eight of 14 FR0s using the European VLBI Network (EVN) and VLBA at 5 and 8 GHz (Figure 1), determining the jet kinematics and radio spectral properties, and found that the jets are mildly relativistic with velocities between -0.08c and 0.51c, and that the jets have low bulk Lorentz factors and large viewing angles. Detection of mildly relativistic jets in FR0s provides important information for discerning the nature of FR0s.

The above VLBI research is focused on brightest FR0s. In a follow-up work made by Baldi, Giovannini & Capetti [5] selected a sample of 15 FR0s with lower radio luminosities and carried out observations with the EVN and eMERLIN. Parsec-scale jets were detected in 11 sources (73%), suggesting that although FR0s lack extended emission, pc-scale jets are prevalent. The low brightness of the pc-scale FR0 jets requires high-sensitivity VLBI imaging observations.

The jet luminosity detected by VLBI is more representative of the jet power because the pc-scale radio emission region is closer to the jet launching zone. By investigating the correlation between radio jet power, optical spectroscopic luminosity, and black hole mass, a disc-jet link in FR0s similar to FRIs is explored to establish a homogeneous class with a common accretion-jet coupling mode, revealing a continuous population distribution from the low-luminosity radio-loud AGN to the powerful FRIs.

The similarities and differences between FR0s and FRIs can be explained in the framework of radio galaxy evolution. FR0s reside in moderately host environments, powered by low-spinning BHs and low accretion rates. This scenario predicts that FR0s are characterised by low jet velocities, consistent with the observations. Most FR0s have a jet structure in which the outer mildly relativistic spine is more easily disrupted by the gas in the host galaxies, leading to their inability to develop extended jets like FRIs.

Future high-resolution and high-sensitivity radio facilities, such as the SKA and ngVLA, offer promising opportunities to discover large numbers of FR0s, and follow-up VLBI observations enable to place tighter constraints on the jet velocities, thus improve the understanding of this rich population of compact radio galaxies.

NETWORK HIGHLIGHTS

THE INSTITUTE OF RADIOASTRONOMY IN ITALY TELLS THE STORY OF ITS ORIGINS

Tiziana Venturi, INAF, Istituto di Radioastronomia, Italy

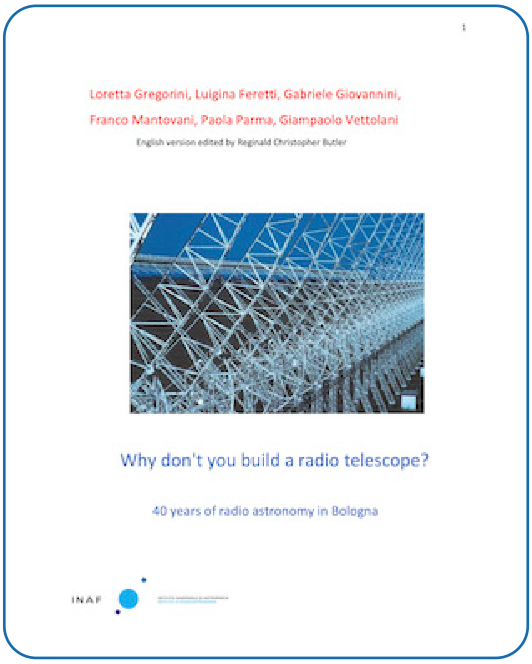


Figure 1: Book cover. Credit: INAF, Istituto di Radioastronomia.

The Institute of Radioastronomy recently published a book on its origins, from the very early discussions among a group of young physicists, to the construction of the radio telescopes all the way to the science, technology and computing developments up to year 2000.

The first conversations on radio astronomy in Italy date back to the end of 1950's, a time when the field was new and full of promises for scientists. A group of young physicists at the University of Bologna started to think of building a radio telescope almost as a joke, as the title of the book suggests, Why don't you build a radio telescope? 40 years of radio astronomy in Bologna.

The enthusiasm for this new branch of astronomy shortly led to the birth and growth of international collaborations with colleagues who were already engaged in the construction of radio telescopes throughout Europe, Australia and in India.

The Northern Cross, the transit interferometer located in Medicina operating at 408 MHz, started its operations in the record time of 4 years, and already by the end of 1964 the first catalogue of radio sources at 408 MHz was produced and presented to the community. During its active life, the Northern Cross has provided 3 catalogues of radio sources, and has paved the way to the well-recognised Italian expertise in the area of radio galaxies, galaxy clusters and pulsars. Collaborations and strong friendships among colleagues from all over the world have been built around the Northern Cross.

As the proverb says, appetite comes with eating, and during the 1970's interest in joining the very long baseline interferometry (VLBI) observations started to take hold, and back in 1978 the first plan to have three antennas on the Italian territory operating up to 20-30 GHz was presented at the National Council of Research. We all know that it took much longer to finalise the full project, and in the meantime a lot has happened. The original idea was to have three identical antennas located in Bologna, in Sicily and in Sardinia, but during the process the antenna in Sardinia doubled its diameter to become among the largest dishes in the world operating up to 100 GHz. The interest in VLBI had two sides, astronomical and geodetic, partly because of the geodetic origin itself of some of the VLBI technology, and partly because of the peculiar Italian territory, which is found on a very seismic are, in a point where the African and the Eurasian plates meet.

The 32m-dish in Medicina was the first to join the observations of the newly born European VLBI Network (EVN), in 1985 and Noto followed in 1989. Some of you may remember the episode of the PBS series "The Astronomers" devoted to the study of black holes at milliarsecond scale resolution, where the campaign on 3C84 was followed at each observatory: those were the first network observations with the inclusion of Noto.

Together with the technological developments of VLBI grew the science, and the Institute became a reference for the study of compact steep spectrum radio sources, low power radio galaxies and masers together with many friends and collaborators worldwide.

All this, and much more, is narrated in the book, together with a selection of original documents and pictures, which powerfully bring the reader back to those times. The story of the birth of radio astronomy is the personal story of its founders, too, and of the connection between the enthusiasm of the young scientists and the social environment of the early '60s.

The story ends in the year 2000, the idea being that the younger generations will continue to write this wonderful journey of scientific advances, international cooperation and long-lasting friendships.

The book is available online through this link.

CONCLUDING A NEW MEMORANDUM OF UNDERSTANDING FOR THE EAST ASIAN VLBI NETWORK

Kiyoaki Wajima, Korea Astronomy and Space Science Institute, East Asian VLBI Network Collaboration, Republic of Korea

Figure 1: Concept map of the EAVN including the three correlator sites in China, Japan, and Korea. FAST 500 m telescope, which is to be used for EAVN observations at lower frequencies (< 1.6 GHz), and the Thai National Radio Telescope (TNRT), which is under construction, are also included in the map. Photograph of each radio telescope and correlator site are overlaid on 'the Blue Marble' image. Credit of the ground image: NASA's Earth Observatory.

The East Asian VLBI Network (EAVN) consists of 21 radio telescopes and three correlator sites located in East Asia and is operated mainly at 6.7, 22, and 43 GHz (see Figure 1). The EAVN started its open-use programme from the second half of 2018. Prior to launching the open-use programme, the current Memorandum of Understanding (MoU) has been concluded on 6 September 2018 between four institutes - Korea Astronomy and Space Science Institute (KASI), National Astronomical Observatory of Japan (NAOJ), Shanghai Astronomical Observatory (SHAO, China), and Xinjiang Astronomical Observatory (XAO, China) in order to promote collaboration on scientific research and technical development for the EAVN, as well as to operate the EAVN.

At the beginning of EAVN open-use programme in 2018, the programem was operated with 10 radio telescopes (KVN 21m x 3, VERA 20 m x 4, Tianma 65m, Nanshan 26m, and Nobeyama 45m). After that, 6 telescopes joined the program, the Takahagi 32m in the first half of 2020, the Hitachi 32m, the Yamaguchi 32m, and the Sheshan 25m in the first half of 2021, the Kunming 40m in the second half of 2021, and the Sejong 22m in the first half of 2022. This results in the EAVN growing into one of the biggest VLBI arrays in the world with 16 radio telescopes participating in the open-use program. In the second half of 2021, the EAVN provided a total observing time of 550 hours including target of opportunity observations and test observations for performance evaluation. In addition, some EAVN observations were conducted with non-EAVN telescopes in Italy, Russia, and Australia.

Radio telescope facilities and the radio astronomy community is spreading not only in East Asia but also in Southeast Asia, with the construction of the 40m radio telescope (Thai National Radio Telescope; TNRT) in Thailand, plans to convert a 32m telecommunication antenna into radio telescope in Indonesia, and a new 7m radio telescope operated by the Universiti Pendidikan Sultan Idris (UPSI) – Universiti Malaya (UM) Radio Astronomical Observatory in Malaysia. Especially, the commissioning of the TNRT 40m telescope will begin early in 2022 and the TNRT will participate in the EAVN open-use program in 2024 at the earliest. This will become a powerful upgrade of the EAVN thanks to its unique location.

These developments motivate us to update the current EAVN MoU by inviting three new institutes: Yunnan Observatories (YNAO, China), National Geographic Information Institute (NGII, Republic of Korea), and the National Astronomical Research Institute of Thailand (NARIT), all of which operate upcoming radio telescopes for the EAVN open-use program. A new MoU was concluded on 1 October 2021. This MoU will accelerate further practical collaboration in the wide fields of VLBI sciences in Asian region and become a key milestone in realizing the Global VLBI Alliance.

HARDWARE UPDATES AT JIVE

Marjolein Verkouter, Paul Boven, Martin Leeuwinga, JIVE, the Netherlands

Figure 1: The fire-proof safe at JIVE. Credit: Marjolein Verkouter.

JIVE's core business is supporting the European VLBI Network (EVN). One of those core businesses is the archiving of the correlated data sets that are created from observations carried out by the participating stations. Production correlation started at the end of 1999 and we have been backing up all those observations and other important data to magnetic tapes (DATs and LTOn), to safeguard the EVN science output from computer mishaps.

Due to lack of resources these tapes have no duplicates (for your peace of mind: the archive itself has an on-line but off-site copy as well as a tape backup.) so they themselves become a point-of-failure should a restore from destruction, such as the building burning down, become necessary. In order to make sure these irreplaceable tapes are safeguarded against heat and water JIVE ordered a fire-proof safe of the highest quality (EN 1047-1 S120 DIS for those who would like to know) to be installed. This qualification guarantees protection of heat-sensitive media for up to two hours from an 1,100°C fire, water, and a drop of 5m. Figure 1 shows JIVE's own Martin Leeuwinga with the safe for a sense of scale of the vault. Rest assured that your valuable historical EVN data is now as safely protected as is practically possible.

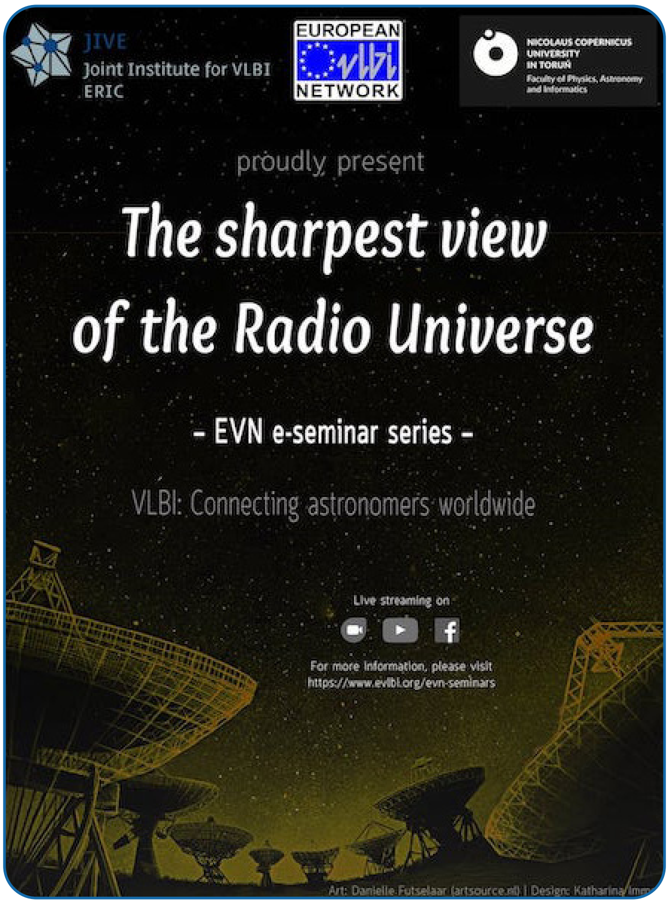
Another important core business of JIVE is buffering the raw observation data from the stations and correlating it. The EVN Consortium Board of Directors have agreed that the array should work towards an increase of the nominal observed bandwidth.

A direct consequence of that is an increase in the number of bits having to be stored at JIVE. Even though individual bits currently only weigh 37 picogram, multiplying that by the increased EVN session's number of bits it meant a noticeable increase in weight to be carried by the raised computer floor in the JIVE correlator room where our FlexBuff storage systems are located. To safeguard the raised floor from collapsing under the increased amount of storage systems and allow for future expansion of the correlator equipment, the correlator room was stripped completely and a new, reinforced and rated for up to 20 kN m-2, raised floor was installed. Given that all JIVE's core services are run from equipment in that room this meant that for several days production correlation was impossible; all equipment was shut down, disconnected, removed from the room and, after the new floor was installed (which only took half a day!), put back and reconnected. The occasion was also used to change the orientation of the racks to allow more cabinets to be placed in the room than previously and at the same time improve the cooling flow. All equipment except a single redundant power supply survived the operation unscathed. All in all JIVE suffered five days of correlator and e-shipping downtime but essential services such as Mattermost, databases and some webservices remained running, except for two short moments of interrupted service.

The operation was exceptionally well planned, prepared and executed by Paul Boven and Martin Leeuwinga; congratulations on a job well done! Figure 2 show the reinforced raised floor under construction (note the size of the supporting beams) and the racks being put in their new position.

Figure 2: Left - The reinforced raised floor in progress of being installed. Right - A rack with several FlexBuff storage systems and software correlator microblade server chassis being put in its new position after the floor upgrade. The cabinet with the cyan fibers (2nd from the left) was offline for only two brief periods; it was relocated and reconnected with the highest priority because it contains the core switches connected to the 100 Gbps external link and servers running services such as Mattermost, ntp, ldap, databases and some webservices. Credit: Paul Boven.

SECOND EDITION OF EVN ONLINE SEMINAR SERIES



The European VLBI Network (EVN) is pleased to announce the second edition of the series of online seminars "The sharpest view of the radio Universe: VLBI – Connecting Astronomers Worldwide". Five seminars will cover different science topics illustrating how Very Long Baseline Interferometry can improve our understanding of many astronomical phenomena and how this technique is useful for the whole astronomical community. The new seminars started on 29 November 2021 and will be organised around every six weeks, leading up to the organisation of the 2022 EVN Symposium on 11-15 July 2022.

Following a successful first edition in 2020-2021, the seminars comprise 35-40 minute talks, followed by a Q&A and discussion session. The seminars can be followed live via Zoom as well as through the JIVE/EVN YouTube Channel.

The first seminar took place on Monday 29 November 2021. Giuseppe Cimò (Joint Institute for VLBI ERIC) gave a talk titled "Observing Interplanetary spacecraft with radio telescopes: connecting astronomers and space scientists".

The second seminar of the series will be on Friday 28 January 2022 - 16:00 CET (15:00 UTC) by Cornelia C. Lang (University of Iowa) with the talk "High resolution observations of magnetic fields in the Central Molecular Zone of the Galactic Center".

More information about the seminars can be found at the EVN Seminars webpage.

RADIO ASTRONOMY AND SPACE SCIENCE IN AZORES: ENHANCING THE ATLANTIC VLBI INFRASTRUCTURE CLUSTER

Domingos Barbosa, Bruno Coelho, Miguel Bergano, Instituto de Telecomunicações, Portugal.

Figure 1: SATCOM Earth Station in São Miguel (Azores) - Intelsat Standard A 32-metre parabolic antenna, Altice Portugal. We can see the typical large waveguide system below the dish.

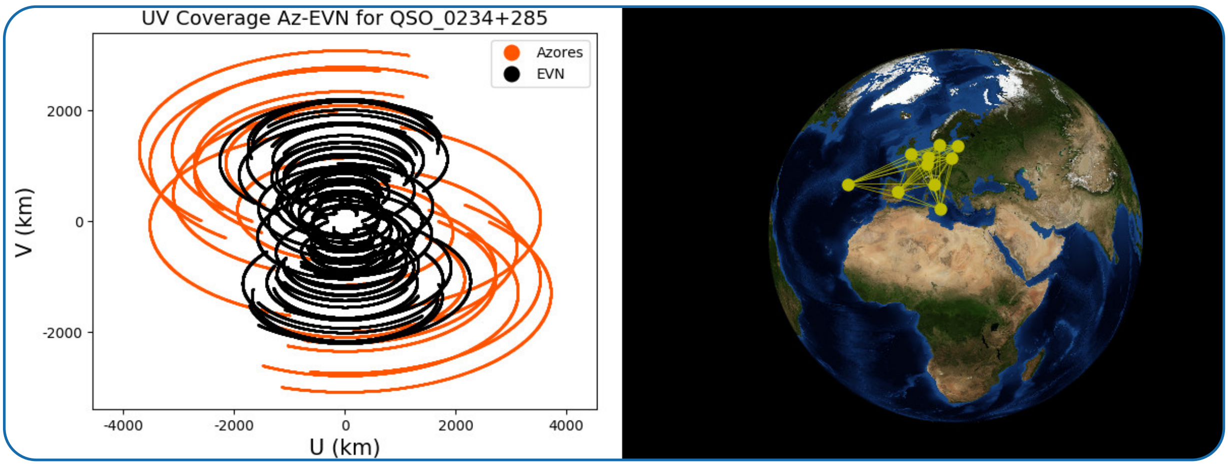
Radio astronomy and Space Infrastructures in the Azores region (Portugal) do present a great scientific and industrial interest because they benefit from a unique geographical location in the middle of the North Atlantic allowing a vast improvement in the sky coverage. This fact obviously has a very high added value for: i) the establishment of space tracking and communications networks for the emergent global small satellite fleets ii) it is invaluable to connect the radio astronomy infrastructure networks in Africa, Europe and America continents using Very Large Baseline Interferometry (VLBI) techniques, iii) it allows excellent potential for monitoring space debris and Near Earth Objects (NEOs). There is in S. Miguel island a 32-metre SATCOM antenna for upgrade that could be integrated in advanced VLBI networks and be capable of additional Deep Space Network ground support. The upgrade of this SATCOM antenna would enable a Deep Space Network mode and would constitute a key space facility for data production, promoting local digital infrastructure investments and the testing of cutting-edge information technologies. Its

Atlantic location also enables improvements in angular resolution, provides many baselines in East–West and North–South directions connecting the emergent VLBI stations in America to Europe and Africa VLBI arrays therefore contributing for greater array imaging capabilities especially for sources or well-studied fields close to or below the celestial equator, down to -52º in latitude where joint research programs or follow up of Key Science Programs or legacy programs from ESO, including ALMA and VISTA, SKA and other facilities targeting transient phenomena in the Universe like Auger, HESS and CTA.

Radio astronomy and space sciences are domain areas that can benefit from the unique location of Azores, and projects considering the installation of new stations in St. Maria or Flores islands or the update and retrofit of a large space communications (SATCOM) dish in S. Miguel, have been proposed. One of the projects that has already began is the deployment and operation of a 13.2 metre radio telescope with VLBI capabilities of the Rede Atlântica de Estacões Geo-Espaciais (RAEGE, or Atlantic Network of Geo-Spatial Stations). This telescope is deployed at St. Maria island (Azores Western group), a project led by the National Geographical Institute of Spain (IGN-Spain) and the Government of the Autonomous Region of Azores (Haas and Colomer, 2015).

It is well known the angular resolution of an interferometer is determined by the longest antenna will have baselines of about 1900 km to the nearest VLBI stations (Robledo and Yebes, in Spain), ~ 6,000 km to Mexico and spanning up to 11,000 km towards the VLBI stations in South Africa or Eastern Asia (China and Republic of Korea). As an example, for observations carried at 5 GHz (6 cm wavelength), the addition of the Azores station to the EVN (Europe; see Figure 2) would improve typical angular resolution from 2.1 miliarcseconds (mas) to ~1.6 mas and if we add it to the longest continental baseline EVN (with Asia), the angular resolution would improve from 1.54 mas to ~1.28 mas.

Figure 2 demonstrates the improvements in the UV coverage with the contribution of the Earth Station's 32-metre antenna in São Miguel (Azores). The figure also illustrates a representation of the corresponding baselines and some EVN stations. The simulated UV-plane coverages correspond to an Earth rotation period (24 h), considering all the stations that observe the source QSO 0234 + 285 with elevation >15º at 5 GHz (C-band). Barbosa et al. 2021, Advances in Space Research (doi:10.1016/j.asr.2021.05.023).



Left: UV-plane coverage of European VLBI Network stations + Azores (in red). Azores provides a unique and fantastic coverage and enhances the dynamic range of observations. Right: Baselines of European VLBI Network stations + Azores used in the simulation. In this case Azores would provide the largest baseline, contributing to improve the resolution of the European Network. Source used: QSO 0234 + 285.

THE JUMPING JIVE PROJECT SUCCESSFULLY CLOSES ITS ACTIVITIES

Giuseppe Cimò, JIVE, The Netherlands

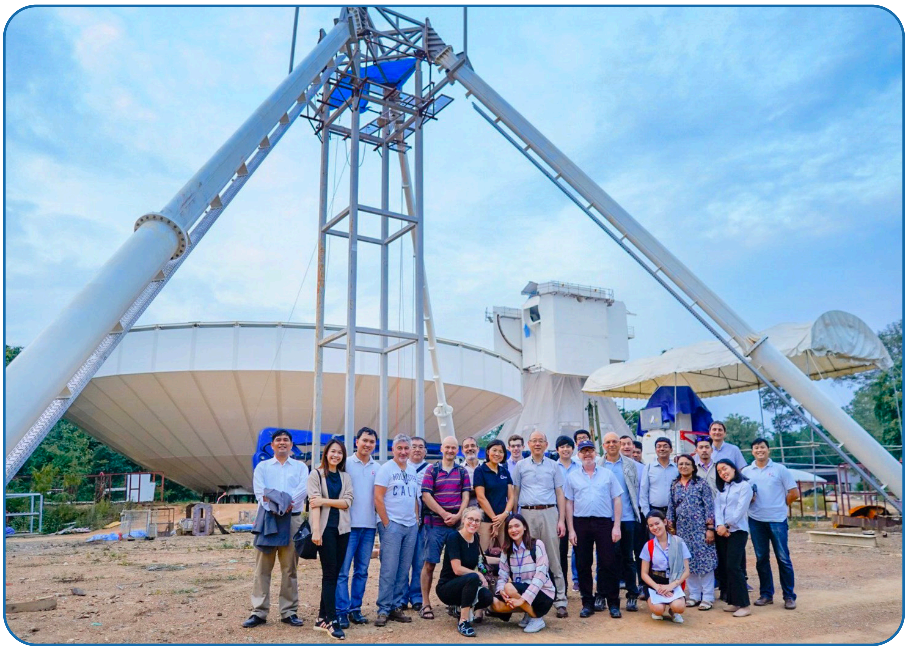


Figure 1: Attendees of the ITAC-TNRT meeting in Thailand in November 2019. Credit: TNRT

The H2020 JUMPING JIVE project, which successfully passed its final review by the European Commission, has been instrumental during the past 4 years in the development and reinforcement of JIVE and the European VLBI Network (EVN) activities in key aspects for their sustainability that will impact the VLBI community in the next decades.

The Joining up Users for Maximizing the Profile, the Innovation and Necessary Globalization of JIVE (JUMPING JIVE) project aimed to strengthen JIVE, enhance the European VLBI Network (EVN), advocate its services and enlarge its partnerships, and prepare JIVE and the EVN for future scientific and technological challenges in preparation for global VLBI in the era of multi-messenger astrophysics. The 4-year project funded by the European Commission comprised the participation of 12 institutes from 8 European countries.

Towards a Sustainable JIVE

JUMPING JIVE worked towards strengthening the sustainability of JIVE with actions to establish new partnerships including, most notably, efforts to support new countries to become JIV-ERIC members, which resulted in the formal adoption of Latvia (2017) and Italy (2021) as JIV-ERIC members; the assistance to VLBI groups and facilities in several countries around the world to start collaborations that eventually could initiate the process to become JIV-ERIC members - e.g. the signature of Memorandum of Agreement between JIVE and NARIT (Thailand); or actions to support national radio astronomical communities, e.g. efforts linking the Portuguese interests (and membership) in SKA and those of the EVN expansion in Azores and Africa.

"The effort that resulted in the success of JUMPING JIVE started already at the

time of the formation of the collaboration that became an H2020 project. All partner institutions demonstrated the importance of working in synergy to reach common goals," says JUMPING JIVE Project Manager Giuseppe Cimò. *"The activities of the project, such as supporting the development of radio astronomical communities in Africa or the work in the definition of the SKA-VLBI science cases, have highlighted to potential new partners the role of JIVE and the EVN as centers of technological and scientific excellence."*

The project provided a forum to explore potential synergies between JIVE and the International LOFAR Telescope (ILT), which finally resulted in the support of JUMPING JIVE to ILT in their first steps in 2021 to become a European Research Infrastructure Consortium (ERIC). Both entities are open to the possibility of collaborating in the future, e.g. in the overall astronomy research infrastructure landscape.

Over the course of the project, JIVE has been established as an open and welcoming community with a strong emphasis on its ability to provide high-quality support for anyone interested in doing science with the EVN. In this sense, JUMPING JIVE fostered an active presence at international astronomy meetings, reaching thousands of astronomers by bringing the scientific potential of VLBI to a broad community.

New Science Capabilities

A key achievement of the JUMPING JIVE project was the improvement of VLBI user capabilities. On one hand, this was done through the integration of new telescopes that enhanced the EVN roster. On the other hand, the project worked on new technical implementations for the EVN such as incorporating geodetic capabilities, which ensure relevance for new audiences and therefore will eventually increase the number of EVN users.

JUMPING JIVE also focused on modernising tools used by the VLBI community, including setting up a centralised monitoring system for the EVN at JIVE and building pySCHED, a modernised version in Python of the legacy programme SCHED that is used for the scheduling of VLBI networks around the world. Both new tools have seen a good uptake within the VLBI community in general and the EVN users specifically.

Towards JIVE Future

One of the most important achievements of the project was the development of the VLBI20-30: a scientific roadmap for the next decade – The future of the European VLBI Network White Paper, describing the science case for VLBI and providing suggestions towards upgrade paths for the EVN. The White paper - involving 80 astronomers and engineers from different countries around the world in its preparation - has become a scientific roadmap for the VLBI community as well as becoming one of the reference scientific white papers of the present decade.

Another key focus of JUMPING JIVE was building capacity for VLBI in Africa. For this, the project enhanced the awareness of the opportunities in physics and astronomy to broaden the knowledge of astronomy and related projects within African institutes and local communities, including the training of over 250 early-career researchers in seven African countries in collaboration with the UK and South African Development of Radio Astronomy in Africa (DARA) programme, and support for short-term placements in EU institutions for several African students.

The participating early-career researchers benefited in a variety of ways with the majority transferring the training, skills and knowledge obtained to local colleagues and institutes in Africa, including success stories such Dr. Asabere (Ghana) who after attending JUMPING JIVE training lead the development, commissioning and operations of the converted 32-m in Ghana that, with the assistance of JUMPING JIVE, became the first African radio telescope, outside of South Africa, to link with and gain fringes with the EVN.

Finally, JUMPING JIVE pursued the globalization of VLBI in the era of the Square Kilometre Array (SKA). The project was instrumental in developing a possible operational model for SKA-VLBI and based on that, initial steps have been taken to form a Global VLBI Alliance as well as a SKA VLBI Consortium. JUMPING JIVE also supported the VLBI science working group for the elaboration of the portfolio of SKA-VLBI science cases.

JUMPING JIVE Legacy

JUMPING JIVE has been instrumental in the development of JIVE and the strengthening of the EVN, ensuring its future relevance and sustainability and reasserting the role of JIVE as a key global player in the field of VLBI, with the EVN at the core of its activities. Many actions of the project are considered core activities of JIVE and the EVN nowadays, ensuring its continuation beyond the lifetime of the project.

"The support in the EC Horizon2020 program to research infrastructures provided the opportunity to explore areas that are essential contributions to the sustainability of JIVE", says Francisco Colomer, JIVE Direct and JUMPING JIVE Coordinator. *"The activities in the JUMPING JIVE project have provided the main scientific and technological ingredients for a bright future, and have had a huge impact in the visibility of VLBI among astronomers, other facilities, and society in general"*.

Figure 2: VLBI training in Africa –
JUMPING JIVE Lecture, Sarrvesh Sridhar (ASTRON) teaching Interferometric data.

The JUMPING JIVE project received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730884.

VERY LONG BASELINE INTERFEROMETRY AT THE XXXIV GENERAL ASSEMBLY AND SCIENTIFIC SYMPOSIUM OF THE INTERNATIONAL UNION OF RADIO SCIENCE (URSI)

Francisco Colomer, JIVE, The Netherlands

Figure 1: Participants at the VLBI session at URSI GASS. Credit: Francisco Colomer.

A Session on "Very Long Baseline Interferometry" was held on 2 September 2021, co-organised by JIVE as part of the XXXIV General Assembly and Scientific Symposium of the International Union of Radio Science (URSI GASS 2021) in Rome, Italy.

The session scope was to highlight the relevance of VLBI in the fields of astrophysics, Earth and planetary sciences by bringing together experts in each field of application, providing a view of the state-of-the-art and the desired developments, to assess the central relevance of VLBI in the continuously evolving landscape of these disciplines. VLBI is a mature technique, whose applications are unique now that the need for milliarcsecond angular resolution and for extremely accurate localisation are the ultimate frontiers for some of the hottest scientific areas. For this reason, VLBI is in the heart of some of the most advanced present and future instruments and developments (EHT, ngVLA, SKA, VGOS).

A total of 15 oral presentations reviewed the VLBI contribution to the latest developments on imaging supermassive black holes and blazar jets, faint extragalactic radio sources, neutrino production in blazars, astrophysical masers, astrometry, geodesy and construction of reference frames, next generation instrumentation and calibration techniques, and space and planetary science.

The GASS of URSI are held at intervals of three years to review current research trends, present new discoveries and make plans for the future research and special projects in all areas of radio science. The URSI GASS 2020 edition was postponed due to the COVID-19 outbreak. URSI GASS 2021 was held as a hybrid event, on-site at Sapienza Faculty of Engineering, with provision for online participation and presentations. The full program is available here.

The URSI GASS J04 session on VLBI was convened by Francisco Colomer (JIVE, the Netherlands), Taehyun Jung (KASI, Republic of Korea), Chris Jacobs (Jet Propulsion Laboratory, Caltech, USA) and Tiziana Venturi (IRA-INAF, Italy).

NEWS FROM ORP

Hélène Dworak, Jean-Gabriel Cuby, CNRS/LAM, France

Credit: Beabudai Design.

The OPTICON RadioNet Pilot (ORP), launched in March 2021, is one of the European Commission's new transnational access 'pilots' under Horizon Europe. This four-year project is the result of the merger of RadioNet and OPTICON, two well-established and successful programmes of the ground-based astronomy community that have received EC funding for over 20 years. It brings together 37 institutions, including funding agencies, observatories, institutions developing enhanced services and key technologies, and universities, in an effort to support and develop seamless access to radio and optical facilities.

The ORP mission is to facilitate astrophysical discoveries through a comprehensive set of research facilities by supporting a harmonised access procedure, unified data interfaces and improved services. It also aims to develop a new strategic framework for advancing European astronomy in the era of mega-installations such as ELT, SKA, CTA and the rapidly evolving field of multi-messenger and time domain astronomy, such as the identification of gravitational waves and neutrino events.

Providing Transnational and Virtual Access to observatories and nodes around the world is the main action of ORP. With over twenty telescopes and networks of telescopes, access to observing time is provided through competitive processes based on scientific-merit. ORP also provides a transnational and virtual access program dedicated to the on-sky testing of new instrumentation concepts and technologies needed for future astronomical instruments, for single telescopes and arrays of telescopes, including the VLTI.

For the fourteen optical and infrared telescopes and networks, it is a single Time Allocation Committee (TAC) that decides on the allocation. Since the project began, three committees have taken place (2021A, 2021B and 2022A) and have granted 504.6 nights to 55 PIs applications. A ratio between CEE and non-CEE countries is done to contribute to diversity.

For radio observation, ORP portfolio consists of arrays (EVN, e-MERLIN, NOEMA, and LOFAR), single dish telescopes (Effelsberg, IRAM PV, APEX, SRT) and European ARC nodes, each with its own Programme Committee (PC), as well as virtual access to archives of LOFAR and WSRT. Since March 2021, 4,785 hours of observation have been provided for 46 projects.

In parallel, ORP is leading the adoption of a set of common principles and tools to enable all scientists and researchers to have simplified and improved access to ORP facilities. At the first meeting on access to time domain, multi-facility and multi-frequency research facilities, preliminary discussion took place on the current status and expansion plans of Black Hole Tom (BHT) and the inclusion of the radio interferometry network in the BHT project. A report compiling the agreed standards and data model for the Pilot facilities should be published by the end of 2021.

Training courses and schools are also being organised for users in the radio and optical fields. Students will learn how to use the new harmonised access and analysis procedures, as well as how to increase their knowledge and expertise on astronomical infrastructures such as EVN, e-MERLIN, LOFAR, IRAM NOEMA, IRAM PV and ALMA. The 10th IRAM School on Millimetre Astronomy was held as a virtual edition on 15-19, 22 and 23 November 2021. The NEON Archival School Using ESO and ALMA Data also had a virtual edition on 19 - 26 June 2021.

In line with the former joint research activities of OPTICON, ORP continues to improve key infrastructure services through targeted technical developments. In this way, researchers will benefit from increased attention to their needs.

In 2021, the focus has been on the design and fabrication of new dispersion elements based on Volume Phase Holographic Gratings (VPHG) to improve the performance of optical spectrographs especially in small and medium-sized facilities in the European context. A call for proposals was launched in October 2021 and a feasibility study is underway on the proposals received. Projects are expected to start in early 2022.

Additionally, the First ORP Time-Domain Astronomy meeting 2021 took place on the occasion of the 12th GAIA Science Alerts Workshop, on 8-12 November 2021 in FORTH in Greece. The event brought together 80 scientists for a hybrid meeting on time-domain astronomy in optical and radio in the context of Gaia Science Alerts (see picture). This was the 12th meeting in the series, but the first where ORP is directly associated.

Finally, ORP coordinates efforts to preserve access to the sky for astronomical observations. In response to the external threats posed by mega-constellations of satellites, this policy-oriented forum brings together key stakeholders from different communities to share information on the impact and conduct advocacy. A working group was created and met several times to decide on an action plan and strategy. A joint policy could help provide support and coordination for activities within or beyond ORP.

Through the different components, ORP will examine and understand the basis for providing access for all current and potential facilities and infrastructures (including large-scale ESFRI facilities). As the ultimate goal of the project is to establish a pilot for transnational access provision, ORP will investigate the different mechanisms available to enable transnational access, while improving and maintaining open access.

The Pilot will involve all agencies, the whole community and the wider astronomical community. We will also try to link ORP with other pilots to exchange best practices and lessons learned, as well as to create common ground to ensure sustainability for all parties by integrating their needs and vision in the provision of transnational access.

For more information, please visit the ORP website.

UPCOMING MEETINGS

- **RFI 2022**: Reading, UK, 14 - 18 Feburary 2022*;*
- **VLBI in the SKA era**: online, 14 - 18 February 2022;
- **International VLBI service for Geodesy and Astrometry (IVS) 2022 General Meeting**: Helsinki, Finland, 27 March - 1 April 2022;
- **3rd URSI Atlantic Radio Science Meeting**: Gran Canaria, Spain & online, 30 May - 4 June 2022;
- **EAS 2022**: Valencia, Spain, 27 June - 2 July 2022;
- 2022 EVN Symposium: Cork, Ireland, 11-15 July 2022;
- **European Radio Interferometry School (ERIS 2022):** Dwingeloo, the Netherlands, 19 - 23 September 2022 (preliminary dates).

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