EUROPEAN VLBI NETWORK

JIVE
Joint Institute for VLBI
ERIC

NEWSLETTER

September 2019
Edition 54

Call for Proposals - September 2019

Deadline: 01 October 2019, 23:59:59 UTC

Meetings

SKA-VLBI Key Science Projects and Operations Workshop
14-17 October 2019, Jodrell Bank, United Kingdom

The Eighth International VLBI Technology Workshop
18-20 November 2019, ATNF headquarters, Sydney, Australia

Astronomical Data Analysis Software and Systems (ADASS) Conference Series
6-10 October 2019, Groningen, The Netherlands

Rafael Bachiller,
Chairman, EVN Consortium Board of Directors

It is an honour to have been selected to serve as Chairman of the European VLBI Network (EVN) Consortium Board of Directors (CBD) for the period July 2019-July 2021. It is also an honour and a pleasure to share this responsibility with Tiziana Venturi, new CBD vice-chair, and Pablo de Vicente, new CBD Secretary, during the two years ahead.

I would like to thank the outgoing CBD Chair, John Conway, and the outgoing CBD Secretary, Michael Lindqvist, for their outstanding job guiding the CBD over the last two years. Also thanks to all CBD members for thinking of me to perform this exciting task.
The scientific results of the EVN are compelling and the prospects for the future of the array are outstanding. A new EVN Science Vision document, compiling the formidable science to be produced by the EVN in the future, is being finalised right now.

The technical activities aimed to upgrade the performance of the EVN are also very successful. The e-MERLIN array in the UK and the three KVAZAR stations in Russia joined the e-VLBI network a few months ago, leading to a record of 15 stations operating at a total data rate of 24 Gbps during an e-VLBI session on May 14. The frequency coverage is also improving very fast. We have now 7 mm receivers available at the Yebes, Tianma, and Effelsberg stations. Together with the previously equipped stations (Korean VLBI Network, Metsähovi, Noto, Onsala), nine dishes are now able to observe in Q-band, to which Sardinia, Medicina, and Robledo will be added soon.

The EVN maintains excellent relationships with other VLBI arrays. At the CBD, we are drawing up an initial proposal to constitute a global astro-VLBI coordinating group (the 'Global VLBI Alliance') which will work on setting future standards for calibration, observing bands, other issues affecting interoperability, and mechanisms for easy access to a future 'World Array'.

We at the EVN continue to be very active promoting scientific meetings and schools. The ERIS2019 school will be hosted by Onsala Space Observatory, 7-11 October 2019. The YERAC2020 will be hosted by IRAM in Granada, Spain, by summer 2020, and finally, the 15th EVN Symposium, the great scientific gathering of all EVN friends, will take place in Cork, Ireland on 6-10 July, 2020 under the very appropriate lemma "Providing the sharpest view of the universe".

Paco Colomer,
Director of the Joint Institute for VLBI-ERIC

The EVN newsletter has always been a great opportunity to share VLBI news and updates across the network. It is with pleasure that JIVE has accepted the responsibility of compiling and distributing future editions, led by our Support Scientists.

This is indeed an exciting time for the EVN as we continue to build on the capacity of the network, attract new and diverse users and push scientific and technical boundaries across the globe.

We hope that all members and users of the network will continue to share their news, views and insights over time by emailing them across to communications@jive.eu.

Call for Proposals

Deadline: 01 October 2019, 23:59:59 UTC

The details of the call can be found here: https://www.evlbi.org/call-proposals

Observing proposals are invited for the European VLBI Network (EVN). 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).

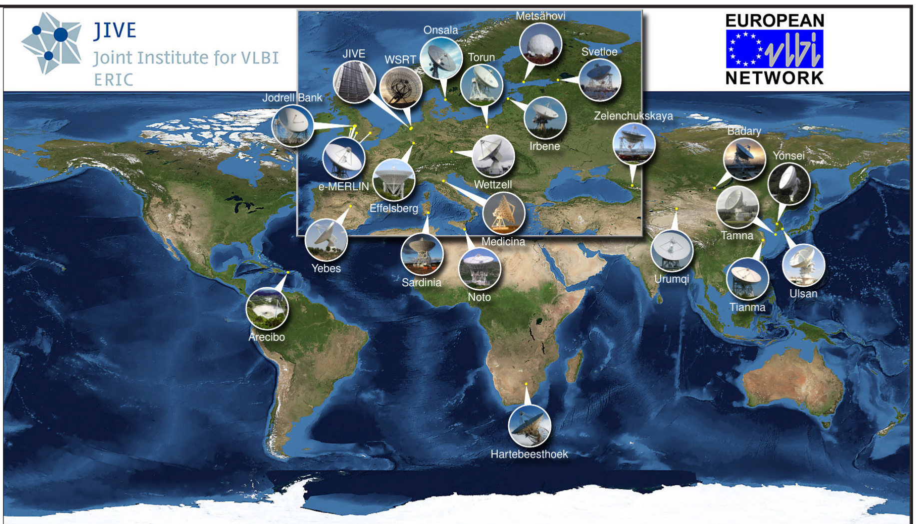


Image by Paul Boven (boven@jive.eu). Satellite image: Blue Marble Next Generation, courtesy of Nasa Visible Earth (visibleearth.nasa.gov).

The EVN is a Very Long Baseline Interferometry (VLBI) network of radio telescopes operated by an international consortium of institutes. It is located primarily in Europe and Asia, with additional antennas in South Africa and Puerto Rico. The EVN provides very high sensitivity images at angular scales of (sub-) milliarcseconds in the radio domain. EVN proposals may also request joint e-MERLIN and EVN observations for an improved uv-coverage at short spacings, significantly increasing the largest detectable angular size to arcsecond scales. Further improvement of the uv-coverage may be achieved in global VLBI observations when the EVN observes jointly with National Radio Astronomy Observatory/ Green Bank Observatory telescopes or with the Long Baseline Array.

EVN observations may be conducted with disk recording (standard) or in real-time (e-VLBI) correlation. Standard EVN observations are available on wavelengths of 92, 50, 30, 18/21, 13, 6, 5, 3.6, 1.3 and 0.7 cm. e-VLBI observations can be performed at 18/21, 6, 5, and 1.3 cm. e-MERLIN can be combined with the EVN in both standard and e-VLBI observations. Global observations are performed only with standard observations. Every year standard EVN observations occur during three sessions of approximately 21 days each and ten days of e-VLBI mode.

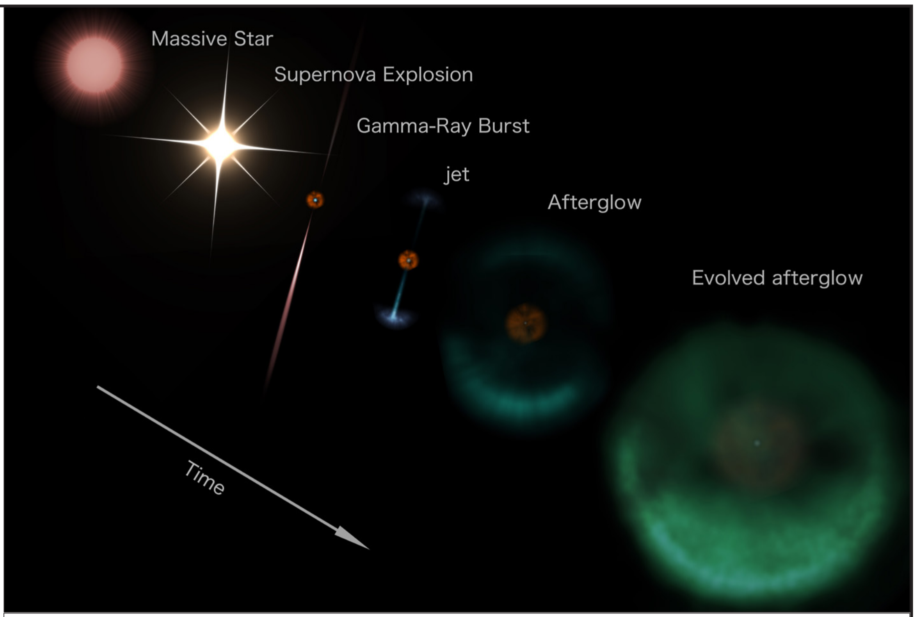
More information regarding the EVN capabilities, observing sessions, proposal guidelines, and user support can be found at www.evlbi.org.

Science Highlights

An ‘orphan’ gamma-ray burst afterglow

Benito Marcote, Kenzie Nimmo, Om Salafia, Zsolt Paragi, Jason Hessels, ASTRON/JIVE, The Netherlands

A radio source that has been decaying for the last 30 years, known as FIRST J1419+3940, is potentially linked to fast radio bursts and/or long gamma-ray bursts. The source is actually located in an environment that resembles FRB 121102. European VLBI Network (EVN) observations of the source have revealed an expansion, which suggests that the source is the orphan afterglow of a long gamma-ray burst.



Artist’s impression of the time evolution of the observed event: from the original massive star, and the explosion during its death that produced a hidden gamma-ray burst, to the afterglow that was finally observed. Credit: Benito Marcote (JIVE).

When the biggest stars in the Universe reach the end of their lives, they collapse due to their own gravity and produce a supernova explosion. In some cases, they also emit a long gamma-ray burst (GRB) lasting seconds or minutes. This GRB is only visible if pointing directly towards the Earth. There is, however, a long-lived afterglow that expands at relativistic velocities and, after isotropization, can be visible at radio frequencies even if the gamma-ray emission was not observed. This is termed an ‘orphan’ GRB afterglow, but so far there were no solid detections of such objects.

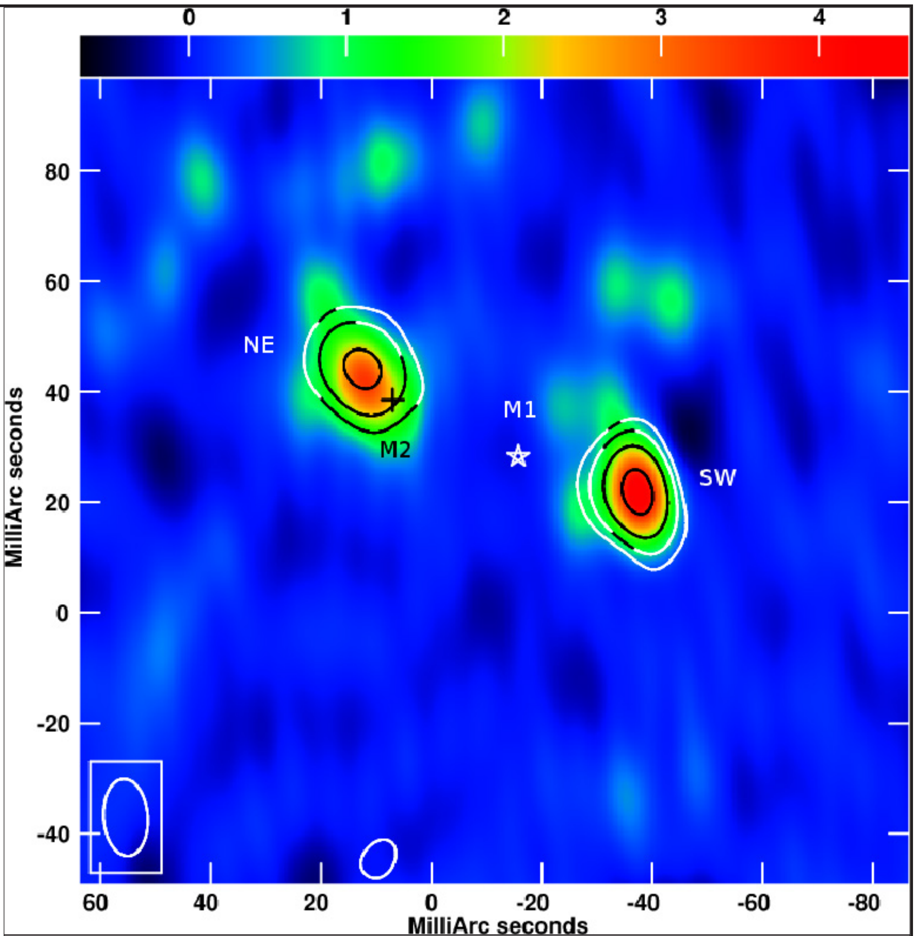
The team conducted observations of FIRST J1419+3940 with the EVN in September 2018 to study the source on milliarcsecond scales and search for Fast Radio Bursts (FRBs) with the Effelsberg single-dish telescope. They detected FIRST J1419+3940 as a compact radio source with a size of 3.9 ± 0.7 mas (1.6 ± 0.3 pc given the angular diameter distance of 83 Mpc). These results confirm that the radio emission is nonthermal and imply an average expansion velocity of (0.10 ± 0.02)c, which is consistent with a GRB jet expansion. Although no FRBs were detected during these observations, FIRST J1419+3940 could still be a potential source of this kind of bursts.

Published in: Marcote et al. (2019, ApJL, 876, L14)

New jet-maser in the nucleus of the Seyfert 2 galaxy IRAS15480-0344 revealed

Paola Castangia, Osservatorio Astronomico di Cagliari, Italy

The study of the physical properties, the structure, and the kinematics of the gas surrounding super-massive black holes (SMBHs) is essential in building detailed models of active galactic nuclei (AGN) and in shedding light on the impact of nuclear activity on galaxy evolution. The radio emission from luminous H_2O masers, the so-called "megamasers", constitutes the only way to directly map the molecular gas at sub-parsec distance from the SMBH. Studies of megamaser sources not only allow us to constrain accretion disk geometry but also to improve our understanding of the jet (or outflows) interaction with the interstellar medium (ISM) of the host galaxies.



Radio continuum emission in the nucleus of IRAS 15480-0344 mapped with the EVN at 1.7 and 5 GHz. The color scale represents emission at L-band, ranging from −0.7 to 4.6 mJy beam^{-1}, while the overlaid contours delineate the C-band emission convolved with the L-band beam (contour levels are −1, 1, 2, 4, 8, 16, 32, 64 × 0.45 mJy beam^{-1}). The positions of the water maser spots detected with the VLBA are also indicated. The star and the cross mark the location of the narrow (M1) and the broad blueshifted line emission (M2), respectively.

With the aim of finding new maser sources, suitable for Very Long Baseline Interferometry (VLBI) follow-ups, we searched for 22 GHz water maser emission in a well defined sample of 36 heavily absorbed AGN ($N_H > 10^{23}$ cm^{-2}), including Compton-thick sources. A new luminous H_2O maser ($L_{H_2O} \sim 200\ L_{Sun}$) was detected in the mid-IR-bright Seyfert 2 galaxy IRAS 15480−0344. We mapped the distribution of the maser emission with the Very Long Baseline Array (VLBA). More recently, we performed deep images of the nuclear radio continuum emission from IRAS 15480−0344 with the European VLBI Network (EVN).

Indeed, employing a sensitive array of EVN antennas, which included the new 64-m Sardinia Radio Telescope (SRT), we resolved the radio continuum emission from the innermost regions of IRAS 15480-0344 into two bright components (labeled SW and NE). The properties of these sources (spectral indices, brightness temperatures, dimensions, and radio power) indicate that their radio emission is synchrotron radiation, most likely produced by two weak knots, which are part of a compact radio jet. Both components show evidence for strong interaction with a dense interstellar medium.

VLBI observations allowed us to locate the masers positions w.r.t. the main nuclear components. The position of the narrow maser line, M1, is along the imaginary line connecting the two radio continuum sources, SW and NE, and is nearly equidistant from them. Hence, it might trace the position of the core (not visible in the radio continuum images) and be associated with the accretion disk or a nuclear outflow. The position of the broad maser feature, M2, instead, coincides with source NE, suggesting that the maser emission might be produced by the interaction of the jet with the interstellar medium, as it was proposed for the maser in NGC 1068 and Mrk 348.

Hence, the fundamental contribution of the EVN maps made it possible to determine the nature of the water maser, adding a new source to the few confirmed jet-masers reported so far. In addition, the combination of VLBI radio continuum and maser observations unveiled the presence of a compact radio jet and strong interactions of the latter with the dense interstellar medium in the nucleus of a relatively radio quiet galaxy. This highlights the potential of maser studies to shed light on the parsec scale environment around AGN and, possibly, on the role of low power jets on galaxy evolution.

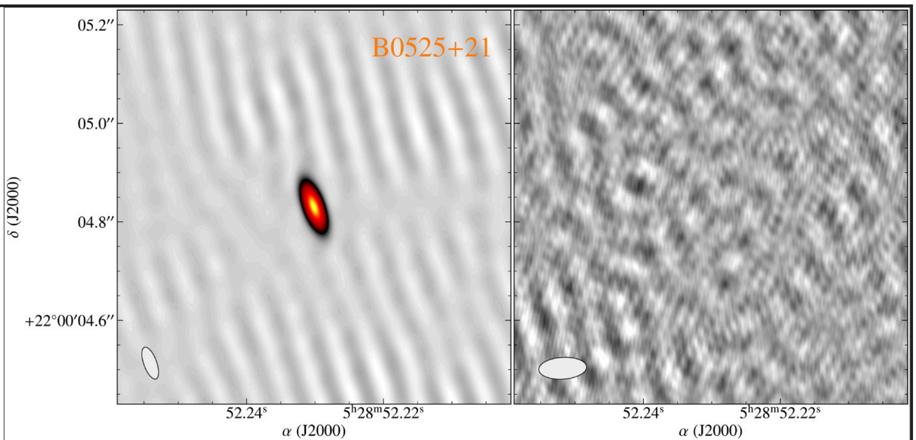
Published in: Castangia et al. 2019, A&A, 629, A25

Origin of the off-pulse emission from pulsars

Benito Marcote, Yogesh Maan (ASTRON/JIVE, The Netherlands

Pulsars typically exhibit radio emission in the form of narrow, periodic pulses originating from confined regions in their magnetospheres. A potential presence of magnetospherically originated emission outside these regions, the so-called off-pulse emission, would challenge existing emission theories.

Detection of significant off-pulse emission has been reported from only two pulsars so far, B0525+21 and B2045−16, at 325 and 610 MHz, with the Giant Metrewave Radio Telescope (GMRT). However, the nature of this newly uncovered off-pulse emission remains unclear.



EVN images of B0525+21 showing the pulsed emission (left) and the off-pulse region (right). The color-scale starts above the 3-σ rms noise level of each image, and gray-scale covers the range -3 to 3-σ.

To probe its origin the team conducted very high resolution radio observations of B0525+21 and B2045−16 with the European VLBI Network (EVN) at 1.39 GHz. Whereas the pulsed emission was detected at an expected level, there was an reported absence of any off-pulse emission above 42 and 96 μJy beam^{-1} (three times the rms noise levels) for B0525+21 and B2045−16, respectively. The stringent upper limits imply the off-pulse emission to be less than 0.4 and 0.3% of the period-averaged pulsed flux density, i.e., much fainter than the previously suggested values of 1–10%.

Since the EVN data are most sensitive to extremely compact angular scales, our results suggest a non-magnetospheric origin for the previously reported off-pulse emission. The presence of extended emission that is resolved out on these milliarcsecond scales still remains plausible. In this case, the emission is constrained to arise from structures with sizes of ~(0.61–19) × 10^3 au for B0525+21 and ~ (0.48–8.3) × 10^3 au for B2045−16. These constraints might indicate that the two pulsars are accompanied by compact bow-shock pulsar wind nebulae.

The previously claimed detections were at slightly lower frequencies (325 and 610 MHz). Consequently, a meagre and perhaps unlikely possibility is that the off-pulse emission somehow abruptly ceases between 610 MHz and 1.4 GHz. Future observations will clarify these possibilities.

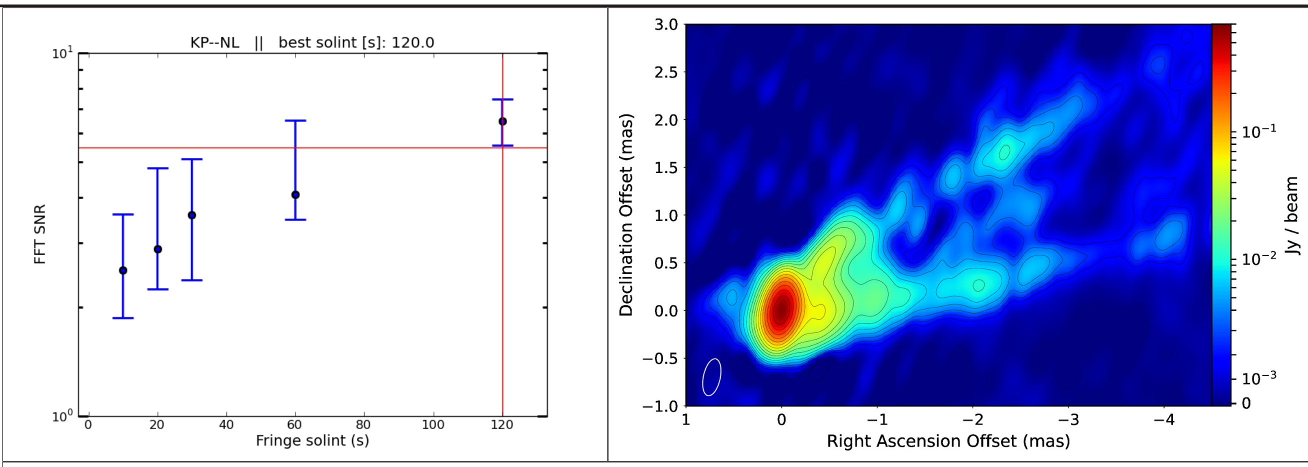
Published in: Marcote et al. 2019, A&A, 627L, 2

Technical Highlights

A CASA-based fully automated Very Long Baseline Interferometry calibration and imaging pipeline

Michael Janssen, Radboud University, The Netherlands

The Common Astronomy Software Applications (CASA) package has become the primary software tool for the reduction of radio interferometric data sets, most prominently for connected element interferometers like Atacama Large Millimeter/Submillimeter Array (ALMA) and the Very Large Arrau (VLA). For Very Long Baseline Interferometry (VLBI) data, CASA was missing a few crucial calibration capabilities and its precursor, the Astronomical Image Processing System (AIPS), has been the standard calibration tool so far. Recently, a joint effort from the Joint Institute for VLBI-ERIC (JIVE) and Radboud University supported by the BlackHoleCam and RadioNet projects in collaboration with National Radio Astronomy Observatory has led to the augmentation of the CASA package with all required VLBI functionalities (e.g., a fringe-fitting task), making it possible to reduce both connected element interferometer and VLBI observations with the same software package. CASA has the advantages of an intuitive IPython user interface resulting in a low learning curve for new generations of radio astronomers, an active



Results from the rPICARD pipeline. The left panel shows how rPICARD optimizes the fringe-fit solution interval for a baseline between the KP and NL antennas for 86 GHz data. The data is segmented with different intervals, which results in the ranges of SNR shown in blue. Increasingly longer intervals are tried until the median SNR is above the threshold of 5.5 for a 120s solution interval, which yields robust fringe detections within narrow delay and rate search windows. The right panel shows an image reconstruction of the 7mm jet of M87 based on VLBA data calibrated and imaged with rPICARD.

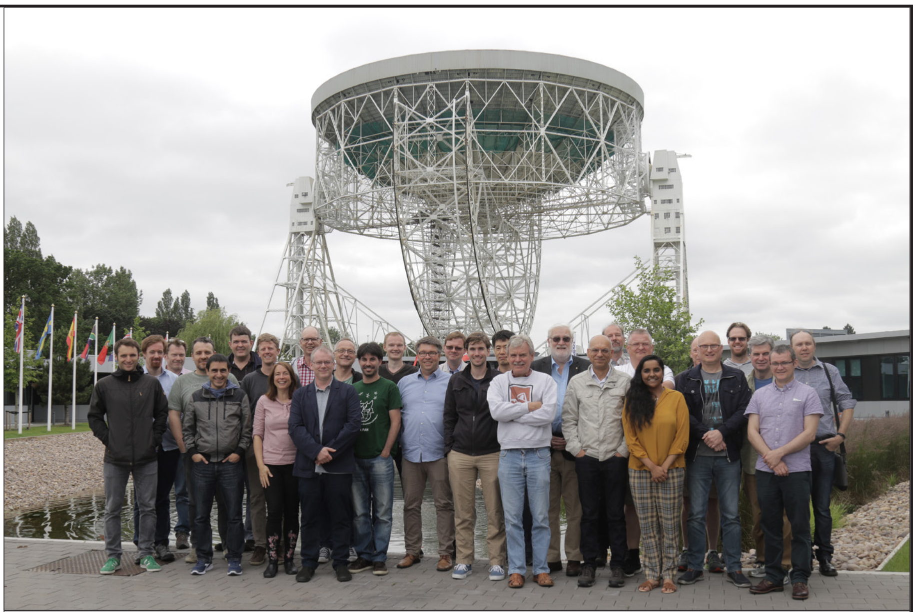
software development and support, a built-in MPI standard satisfying the need for hardware scalability of future observations, and batch processing for science reproducibility is easily facilitated.

Based on the recent VLBI upgrades, a CASA-based VLBI data reduction pipeline called the Radboud PIpeline for the Calibration of high Angular Resolution Data (rPICARD) has been developed. The code is publicly available here and is published by Janssen et al. (2019). The primary purpose of the pipeline is the calibration of VLBI data, but it can also be used to reconstruct images with the CASA multi-scale multi-frequency synthesis tclean task. Using self-tuning parameters, rPICARD is able to deliver high quality calibrated data without human interaction. On the other hand, many parameters can be manually adjusted. Every step of the pipeline can be re-run effortlessly and verbose diagnostics are created so users can quickly review how well the calibration worked. The idea is that users blindly calibrate their data in a first step, check if the science goals can be reached, and re-run specific steps with adjusted parameters as needed for severe data issues. The pipeline is able to reduce data from any standard VLBI array, including the European VLBI Network, Very Long Baseline Array, High-Sensitivity Array, Global mm VLBI Array, and the Event Horizon Telescope. It was used by a team at Radboud University Nijmegen and IRA-INAF Bologna as one of three independent calibration pipelines that lead to the EHT results published earlier this year, revealing the first image of a black hole.

Published in: Janssen et al. 2019, A&A, 626A, 75

EVN Technical Operation Meeting at Jodrell Bank Observatory

Uwe Bach, Max-Planck-Institut für Radioastronomie, Germany



Meeting group picture taken in front of the new SKA Headquarter building and the Lovell antenna.

This year's European VLBI Network (EVN) Technical Operations Group (TOG) meeting took place at Jodrell Bank Observatory (JBO), UK on June 26, 2019. The TOG meetings aim to discuss topics that arose from past Very Long Baseline Interferometry (VLBI) sessions and to plan future developments. In total, 27 participants from 11 countries and 13 different institutes met in the new Square Kilometre Array Headquarters building at JBO. The meeting was supported by RadioNet. Common topics of the meetings are the feedback from the Joint Institute for VLBI-ERIC (JIVE) correlator about the performance of the EVN stations during the last sessions, reports from stations, and VLBI relevant hard- and software developments.

A few achievements from the last years include the implementation of continuous calibration capabilities for VLBI receivers at many of the central European EVN stations, which allows to measure the system temperature not only in gaps between scans, but continuously during the whole scan to, e.g., better trace changing weather conditions. With this, a project started many years ago, will finally reach its completion and should improve the amplitude calibration within the EVN.

Faster internet connections at many sites have allowed to replace Mark5 disk recorders by so called Flexbuffs. Flexbuffs are storage disk raids that are not being shipped physically, but the data is e-transferred to a second raid at the correlator at JIVE. The available space allows to record more and more observations at 2 Gbps recording rates. The faster connections have also increased the number of available antennas for real-time eVLBI. During the eVLBI session in May 2019, 18 stations observed together at 5 GHz at a total bit rate of 27 Gbps demonstrating that eVLBI can now provide a comparable uv-coverage and sensitivity as the disk recording based sessions.

A subject for the next months will be to find and test common modes for data rates of up to 4 Gbps (corresponding to 2 x 512 MHz of bandwidth) within the EVN, but also for global observations with the upgraded Very Long Baseline Array.

Network Highlights

Dwingeloo fringes using the Westerbork H-maser

Paul Boven, JIVE, The Netherlands

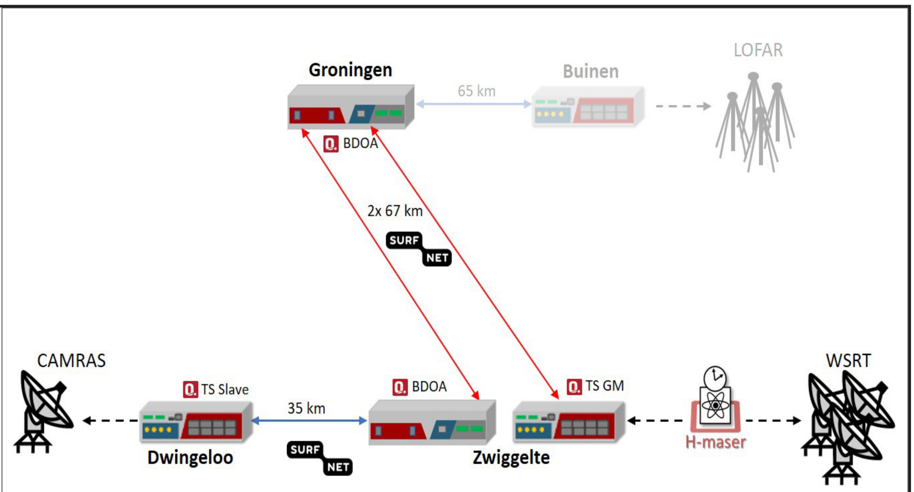
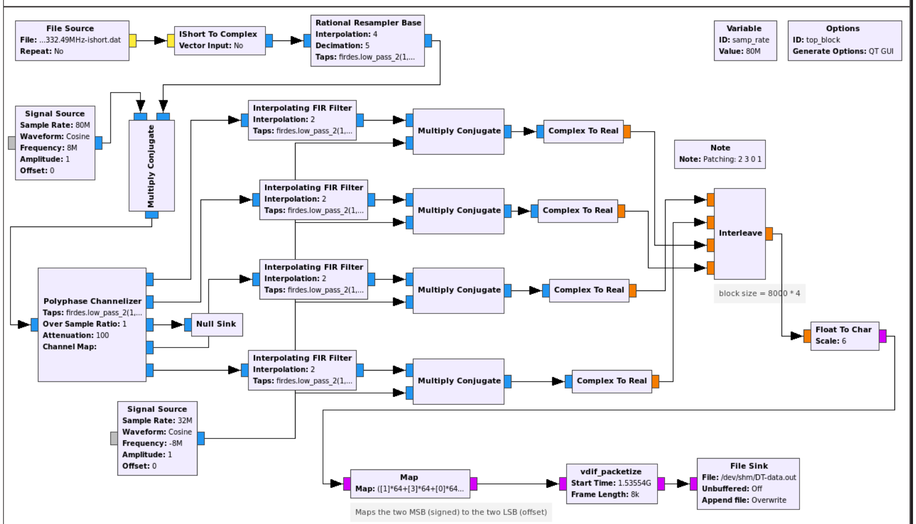


Diagram of the fiber connections between Dwingeloo, Westerbork and Groningen.



VLBI signal processing flowchart.

The ASTERICS H2020 project aimed to address common challenges shared by the various astronomy European Strategy Forum on Research Infrastructures facilities. Within its Cleopatra work package, we studied the distribution of very stable and accurate time and frequency references over fiber, using the open White Rabbit (WR) standard. Our goal was to show that with some modifications, WR offers sufficient frequency stability to obtain good coherence in Very Long Baseline Interferometry (VLBI) observations.

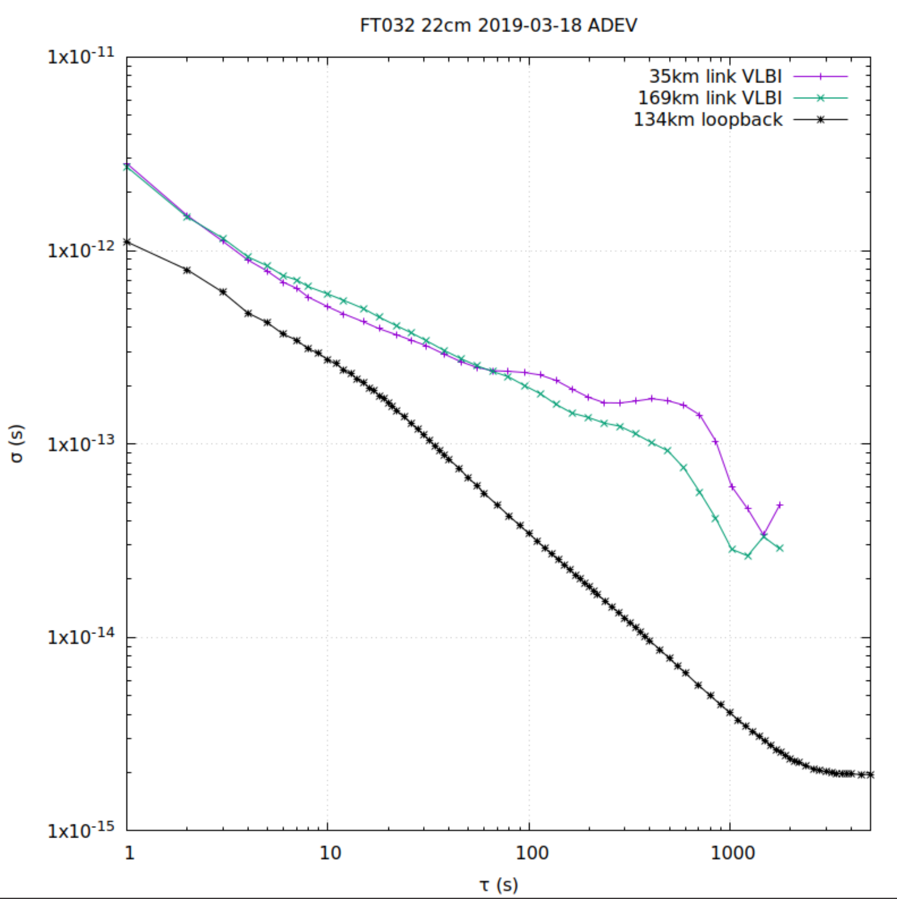
To make this both more relevant, and more challenging, we decided to include the use of WR over an existing production fiber network in our demonstration, where the WR wavelengths would co-exist with other traffic on the same fibers.

The Westerbork (WSRT) and our Dwingeloo offices are connected by 35 km of dark fiber, and both host a networking point of presence for SURFnet, our national research and education networking provider. Their participation in this project allowed us to also build a much longer (169 km) link between both locations, taking a detour via the city of Groningen.

Although WR was not originally

designed with the high frequency stability requirements of VLBI in mind, recent advances (especially a 'low-jitter daughter board') result in much lower phase noise. To further improve the frequency stability, a high quality clean-up oscillator was added at the output of the WR switch in the telescope.

The Dwingeloo radio telescope participated in the first European VLBI tests in 1978 (Schilizzi et al. 1979, A&A 77, 1) but this task soon passed to the then new WSRT. These days, the Dwingeloo telescope is a national monument, and is being run by the volunteers of the CAMRAS foundation. They use it regularly to observe e.g. pulsars and the hydrogen line, making the telescope an ideal candidate for testing our remote clock system. Since the Dwingeloo telescope does not have a VLBI formatter, I decided to make one from a commercial off-the-shelf Software Defined Radio (SDR), using the open source GNU Radio SDR software to re-sample and timestamp the recorded samples. The flowchart shows the actual signal processing blocks used to generate VDIF data, including one custom block that I wrote which supplies the actual VDIF header with timestamps. First fringes (since 40 years) were obtained in August last year using a Rb timebase. This result was presented as a poster at the 2018 EVN symposium.



ADEV measurement on the WSRT-DW baseline, observing 3C84. Purple: using 35km WR link. Green: using 169km link. Black line: directly measured link performance on a long fiber.

Actually connecting the Dwingeloo telescope to the WSRT maser required running about 300 m of fiber between the office buildings in Dwingeloo and the telescope. The CAMRAS volunteers undertook the ground works and fiber installation with enthusiasm, and in February 2019, we finally had the clock signal present in the telescope.

The Dwingeloo telescope participated unofficially in the N19L1 18cm Network Monitoring Experiment, and we obtained fringes to the other stations. As the current receivers in Dwingeloo are better suited for 21 cm, subsequent observations with a smaller number of telescopes (WSRT, Toruń and Jodrell Bank) allowed us to measure the performance of the frequency transfer link. The results show that at L-band, likely up to C-band, the system does indeed provide a suitable reference. No significant difference in performance between the 35 km and 169 km links could be detected.

Our research was subdivided into several deliverables, each reported separately. The links to each of the reports are below, which contain a much more detailed description of the work and results.

* The design of the improved WR hardware (D5.4)
* Design rules for integration in optical networks, and timing calibration (D5.7)
* VLBI demonstration and LOFAR link (D5.14)

Enabling new Very Long Baseline Interferometry equipment at the Arecibo Observatory

Harro Verkouter, JIVE, The Netherlands

The Arecibo Observatory (AO) has been part of the e-European VLBI Network (EVN), participating in real-time Very Long Baseline Interferometry (VLBI) observations since as early as 2004. During a real-time observation somewhere in 2017 it was noted that the equipment being used was still the same as then: a VLBA4 analog rack with the original 1Gbps Mark5A recorder - a PentiumIII based(!) single-core 1.26 GHz CPU equipped with 256 MB of RAM.

As Linux dropped support for the PentiumIII CPU, upgrading the Mark5A's O/S and recording application became impossible. Consequently, AO missed out on bug fixes and new features enabled by Joint Institute for VLBI-ERIC's (JIVE) own recorder software, e.g. to start participating in e-shipping VLBI data.

Besides running the oldest equipment in the EVN, the AO owns four NRAO/MIT Haystack Roach Digital Back End digital receivers (RDBE) and a 16 Gbps 10-core Intel Xeon with 64 GB RAM Mark6 ethernet recorder. The reason this new equipment was not used so far is because the combination RDBE + Mark6 is not officially supported by the FieldSystem (FS).

AO, under its new management of University of Central Florida, Universidad Ana G. Méndez and Yang Enterprises Inc., had funds available to enable an external expert to visit and work on the VLBI equipment. Thanks to the persistence of Kristen Jones (postdoc at the AO at the time) I was invited to spend two weeks on-site at AO in the second half of June 2019.

At the Effelsberg (Ef) radio telescope in Germany, an RDBE + Mark5C combination is used for High Sensitivity Array observations - under FS control. The FS is very versatile in certain dimensions: it is possible to implement new SNAP commands by handling those in the station specific control module. Dave Graham altered the Ef station module code, adding command and query support for RDBEs. This is not enough; the DRUDG program, part of the FS suite, is needed to transform a VLBI schedule in VEX format to SNAP commands and procedures for a station's hardware setup. DRUDG also has no knowledge of the RDBE and its specific commands. Therefore, Dave wrote a simplified DRUDG replacement too - vex2snap.pl - in order to generate the correct procedures for the RDBEs. Together, these pieces of software form the basis of the AO RDBE + Mark6 support.

The three key components in the new system, a new, upgraded, FS computer (9.13.0), the RDBEs and the Mark6 recorder, needed reviewing. All bootup procedures and system configurations were checked and updated to come up in operational state after a reboot. The new FS and the upgrades were readily verified. Then, communication between the local telescope control system (CIMA) and the FS needed to be reinstated. This was more precarious as the RDBE-specific parts of the control code had to be extracted from the Effelsberg specific station control code and transplanted into Arecibo's. The FS interface to CIMA and its configuration had to be well understood in order to get the new FS computer to drive the telescope.

Bob Campbell of JIVE had prepared an observing schedule in the three anticipated observing modes: DDC4 (4x tunable 32 MHz, 512 Mbps), DDC8 (8x tunable 32 MHz, 1 Gbps) and PFB (16x32 MHz untunable, 2 Gbps). Using the rewritten vex2snap program (in Python), these VEX files were converted into FS procedure- (.prc) and SNAP (.snp) files.

An essential part of the upgrade plan was to use jive5ab on the Mark6 as recording software, requiring that Mark6 module mounting/unmounting issues needed to be addressed; normally, this is handled through the Massachusetts Institute of Technology (MIT) Haystack cplane software. Jan Wagner's standalone m6sg_mount script was used as basis and an updated version now allows flexible (un) mounting of one or more modules from the command line.

The RDBEs output their UDP frames (Mark5B if PFB firmware loaded, VDIF if DDC) to a hard-coded port 625. This is a UNIX privileged port and requires root privilege to capture data from. Because running with root privilege is an unacceptable security risk, jive5ab never allows this. A solution was to allow jive5ab to run with SUID privilege and support this mode properly. To this effect jive5ab gained a command line argument: --allow-root. The alternative, running as root, "works", but has the effect that all recorded scans on the disk pack are owned by root, which is unacceptable for production.

With that fix in place, schedules now can be started and recordings reliably made. The PFB data - a stream of Mark5B frames - seems to be working. The VDIF headers of the frames output by the DDC firmware contained the wrong number of channels and bits-per-sample values. Also the TSYS broadcast did not switch from PFB to DDC format if the firmware was changed. After NRAO sent the rdbe_server source code, the latter issue was readily fixed (the problem was a case sensitive string compare). The VDIF header issue was not fixed until after returning home and following this up further with NRAO.

Another advantage of the RDBEs is that the firmwares support measuring continuous calibration information. Unfortunately, the connector on the NRAO RDBEs used at AO, where the 80 Hz continuous calibration signal for the noise diode control can be tapped, is not wired due to a slightly different hardware design. AO staff is working on a solution to generate the linked-to-the-1PPS 80 Hz signal external to the RDBEs. Once this system is in place, it should be possible to get continuous calibration information for the AO as well.

It is safe to say that a lot of work was done before, during and after those two weeks. The project clearly demonstrated the international and cooperational nature of VLBI. Without valuable input from experts around the world, Walter Brisken and Matt Luce (NRAO, USA), Uwe Bach (MPIfR, Germany), Chet Ruszczyk (MIT Haystack, USA), Ed Himwich and Dave Horsley (NVI Inc., USA) and the AO staff - Arun Venkatamaran, Luis Quintero, Kristen Jones and Anish Roshi with their in-depth knowledge of not just the telescope but of VLBI, networks and electronics in general, this visit would not have been half as useful.

Currently, it is possible to reliably record RDBE data to Mark6 disk packs at Arecibo, establishing a solid basis for the future, whether disk modules will be shipped or the data e-transferred. There was not enough time to try to achieve fringes - although with the broken VDIF frames that would have been very difficult to begin with, if not impossible. The commissioning of the new system is ongoing and the upgraded system will be released to the astronomy community after successfully completing commissioning observations.

Integration of e-MERLIN telescopes into the European VLBI Network

Kazi Rygl, INAF-Istituto di Radioastronomia, Italy

Integrated e-MERLIN + European VLBI Network (EVN) observations are now available using up to five e-MERLIN outstations at 512 Mbps; in addition to the selected Jodrell Bank home station. This additional capability provides short-spacing coverage between 11 and 220 km within e-MERLIN, together with intermediate and long baselines between e-MERLIN and EVN antennas in both disk-recording and e-VLBI mode. Principal Investigators (PIs) can request multiple e-MERLIN outstation antennas (all, or a subset of Pickmere, Darnhall, Knockin, Defford, Cambridge) in addition to an EVN home station antenna at Jodrell Bank Observatory (Lovell, Mark II).

For eMERLIN+EVN proposals, it is essential that a clear scientific/technical justification for the inclusion of e-MERLIN outstation telescopes is provided, including why e-MERLIN outstation antennas are required for the delivery of the scientific goal. This is because in addition to EVN Programme Committee (PC) approval, the e-MERLIN outstation contribution has to be approved by the e-MERLIN Time Allocation Group (TAG). For e-MERLIN TAG approved projects, e-MERLIN outstation data will then be available for full correlation with other EVN antennas at the Joint Institute for VLBI-ERIC (JIVE). Note that EVN proposals requesting only the Lovell or Mark II telescopes are still considered as standard EVN proposals and will only require approval by the EVN PC.

For e-MERLIN outstations correlated within the EVN, the maximum bitrate available for each outstation correlation at JIVE (both disk and e-VLBI) is 512 Mbps – equivalent to two polarizations at 64 MHz bandwidth. Thus, the PI may request up to five outstation telescopes in dual polarization mode with a bandwidth of 64 MHz per polarization in addition to the e-MERLIN home station antenna at up to 1 Gbps depending on the observing wavelength (two polarizations at 128 MHz bandwidth).

For further enquiries regarding e-MERLIN + EVN observations please see the e-MERLIN Contact Webpage, or alternatively email: vlbi@jb.man.ac.uk.

University of Tasmania and JIVE sign a Memorandum of Understanding to boost spacecraft tracking activities

Guifré Molera Calvés, University of Tasmania, Australia

Last July, the University of Tasmania (UTas) and the Joint Institute for VLBI-ERIC (JIVE) signed a Memorandum of Understanding (MoU) to formalise the collaboration of UTas in the Planetary Radio Interferometry and Doppler Experiment (PRIDE) project lead by Prof. Leonid Gurvits from JIVE. The purpose of this agreement is to provide a framework to support the role that PRIDE is taking in the Jupiter Icy moons Explorer (JUICE) mission by the European Space Agency (ESA), as well as, investigating opportunities for further potential collaboration in areas of mutual interest.

UTas will provide access to its network of radio telescopes to support ground-based spacecraft VLBI tracking observations of the JUICE mission. The JUICE mission will be launched in 2022 and its arrival on Jupiter is expected by 2029. Prior to this mission, a number of test experiments with current ESA missions will be conducted to improve the observations and to optimise the processing pipeline.

University of Tasmania Hobart-26 m radio telescope (Credit: Jim Lovell).

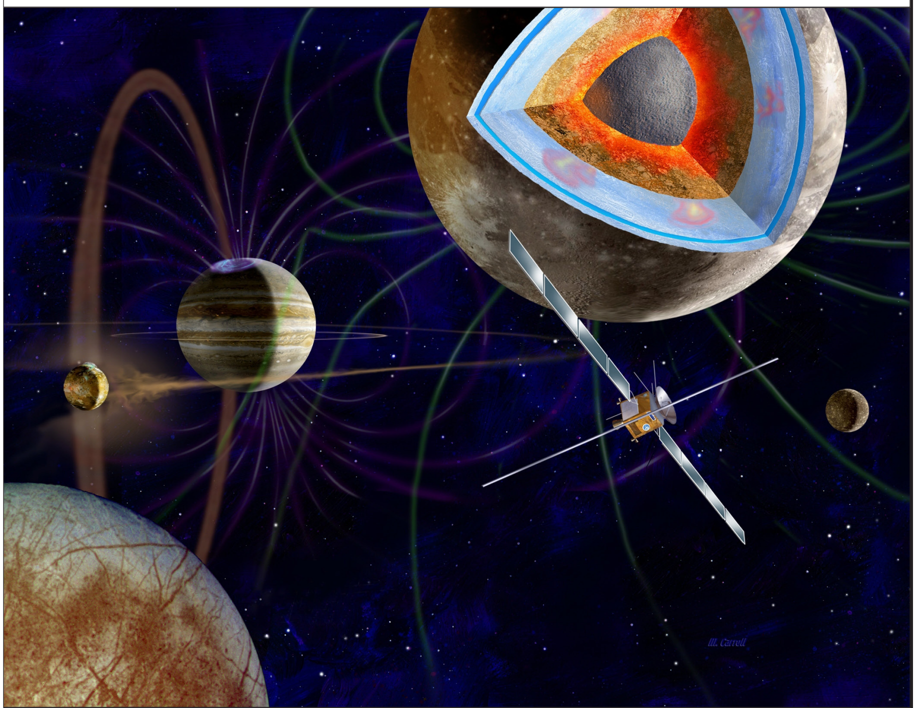


Illustration of the JUICE mission and its environment (Credit:ESA)

Even though the UTas radio telescopes are not members of the EVN, they have already participated in several of the past experiments to demonstrate the Very Long Baseline Interferometry (VLBI) near-field technique in recent years. UTas is currently operating five radio telescopes located around the Australian continent: an ex-NASA 26-m station together with a 12-m dish in Hobart (Tasmania), an old data communications 30-m antenna in Ceduna (South Australia), and two 12-m telescopes in Yarragadee (Western Australia) and Katherine (Northern Territory). All these antennas are operated from the AUscope Operations Centre in Hobart. The radio telescopes take part regularly in the geodetic VLBI session (in coordination with the International VLBI Service) and in the sessions arranged by the Australian Large Baseline Array (LBA), in a broad frequency range of operations.

The three small dishes (12-m) are primarily used for geodetic purposes. They were initially equipped with a standard S- and X-band receiver. However, they are currently being upgraded to the new VGOS-type recommendations. The Hobart-12 telescope has already a broadband receiver (from Callisto) installed with a frequency of operations between 2-14 GHz. Katherine is undergoing the upgrade process right now and it is expected that Yarragadee will be upgraded at the beginning of next year. In addition, a new dedicated tracking station with uplink and downlink capabilities is currently under design for construction in 2020 in Tasmania in collaboration with the Australia Space Agency (ASA).

There is also an active research atmosphere at UTas that is centred around the aforementioned network of radio telescopes. The largest undertaking is an ongoing Australian Research Council Discovery Project that aims to provide accurate distance estimates via trigonometric parallax to a large number of star forming regions only visible from the southern hemisphere. The main goal is to construct a three-dimensional picture of the spiral structure of the Milky Way and determine its fundamental parameters.

The new broadband receivers also allow for novel methods of data calibration and flexible frequency setups to take part in monitoring and VLBI experiments with a number of unique telescope arrays; some of the research topics utilising these arrays include structure studies of active galactic nuclei and the simultaneous monitoring and mapping of different maser transitions. The UTas radio astronomy and geodetic VLBI research group currently hosts about a dozen doctoral and postdoctoral researchers working on these topics.

UTas is currently seeking for 2-3 new doctoral candidates to work in a variety of spacecraft, near-field, space ties related activities and geodetic data series. Check the UTas website for available projects and do not hesitate to contact us at: guifre.moleracalves@utas.edu.au.

JUMPING JIVE Update

Giuseppe Cimò, JIVE, The Netherlands

During the summer, the work for Joining up Users for Maximizing the Profile, the Innovation and Necessary Globalization of JIVE (JUMPING JIVE) continued to produce great results by engaging with prospective new users and expanding the capabilities of the Joint Institute for VLBI-ERIC (JIVE) and the European VLBI Network (EVN).

A very suitable setting for promoting the exciting science with the EVN is the annual meeting of the European Astronomical Society (EAS): the European Week of Astronomy and Space Science (EWASS). The event has grown year after year into a big multi-disciplinary conference. This year, from the 24th to the 28th of June 2019, about 1200 participants enjoyed the 55 parallel sessions and the many plenary talks in the heatwave that scorched Lyon.

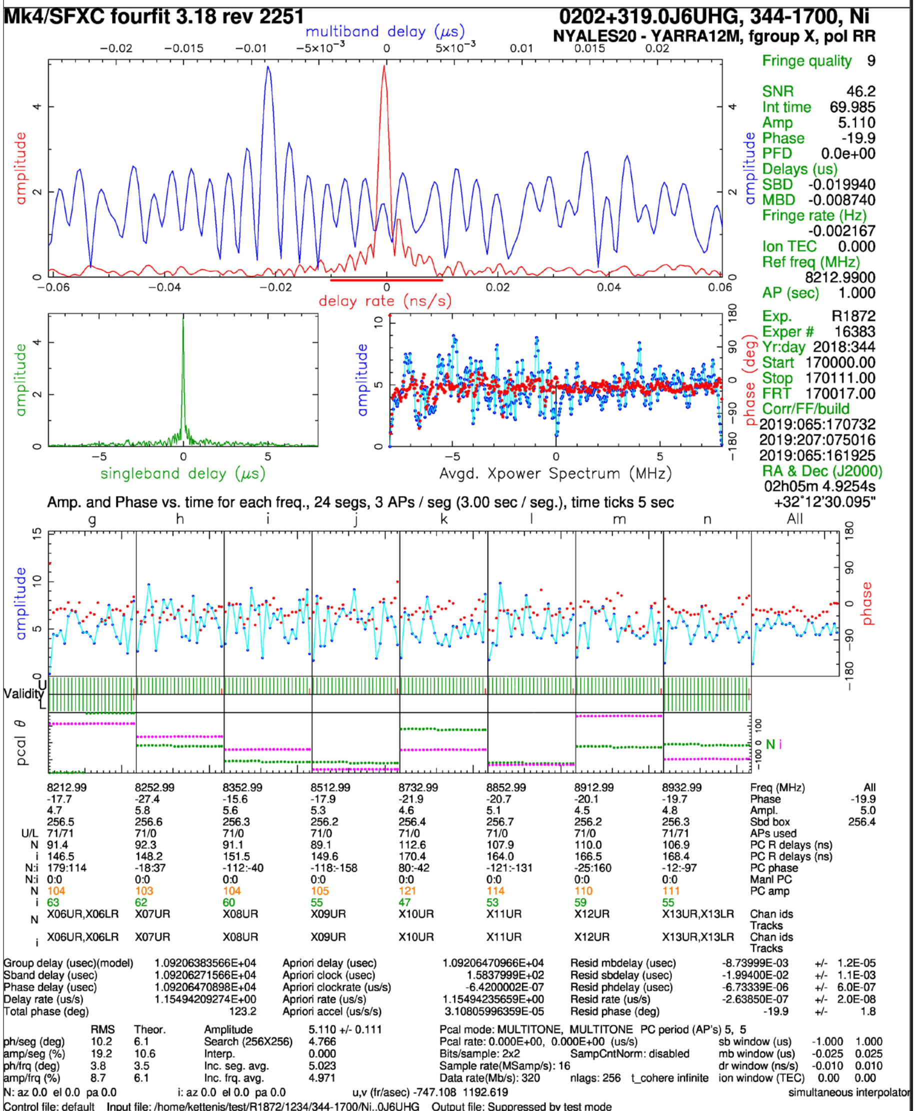
Giuseppe Cimò, JUMPING JIVE project manager, together with Gina Maffey, JIVE's science communication officer, travelled to Lyon to take care of the JIVE booth. The idea behind JIVE's presence at the EWASS was to showcase the scientific applications of Very Long Baseline Interferometry (VLBI) to an audience of astronomers of different fields. Four roll-up banners were designed to highlight a number of scientific results by EVN users in the fields of transient astrophysics, jet physics, space science, and formation, evolution and death of stars. Furthermore, a set of postcards, which were both funny and relevant to VLBI, were very popular among the conference attendees and other exhibitors. The booth was also covered by a tablecloth showing the map of the EVN telescopes. Laminated figurines of all EVN telescopes completed the booth.

The JIVE booth was popular and aroused the curiosity of prospective new users. Besides the compliments on the layout by many people, other exhibitors came to get inspiration and took pictures of our booth. Attracting people at such a dispersive meeting is fundamental. We were busy explaining what EVN and VLBI are, and many astronomers (from optical to high energy, but also a number of planetary scientists) were interested in possible applications of VLBI for their research. The JIVE-EVN brochure helped to highlight the support that JIVE provides.

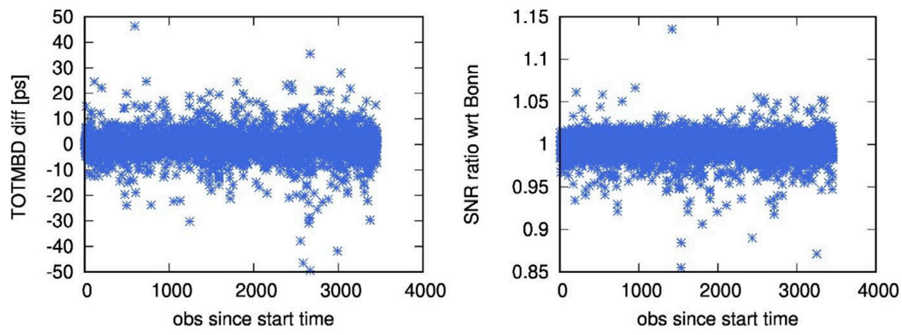
Gina Maffey also gave a talk about how to communicate radio astronomy in a visual world. It was an interactive presentation that showed how it is possible to overcome the difficulties of competing with the beautiful pictures of optical astronomers (before the black hole ‘photo’, of course).

On the technological side, an important advance is the work in Bordeaux and JIVE to improve the geodetic capabilities (work package 6) of JIVE and the EVN. A typical 24-hour International VLBI Service (IVS) session, R1872, that took place in December 2018 with eight stations, was selected for testing

Gina Maffey and Giuseppe Cimò at the JIVE booth (Credit: EAS, taken from EAS Facebook page).



HOPS Fourfit output plot obtained from data of IVS-R1872 session correlated at JIVE.



Comparison of the total multiband delay (TOTMBD) and signal-to-noise ratio (SNR) between the JIVE and Bonn correlators at X band. The plots show the total multiband delay differences (left) and ratios SNR(JIVE)/SNR(Bonn) (right).

the newly-implemented Mark4 data interface and compare the results from the EVN software correlator at JIVE (SFXC) and from the DiFX correlator in Bonn, where the session was originally correlated and post-processed. The session R1872 has been fully processed with SFXC using as much as possible the same parameters as those employed in Bonn. The results of the SFXC correlation were then converted to Mk4 format, post-processed with HOPS and exported into vgosDB format, following the standard geodetic path.

Comparison of those results with the results from the DiFX correlator in Bonn indicates agreement at the 5 ps level, which is the level of consistency expected. Now, any geodetic-style session can be correlated with SFXC, post-processed and exported into standard geodetic format for analysis with the most common geodetic tools. This novel result will appear in the proceedings of the European VLBI for Geodesy and Astrometry (EGVA) meeting held on 18-20 March in Las Palmas (Gran Canaria).

Next Newsletter: January 2020

Contributions can be submitted to communications@jive.eu until **10 December 2019**.

Newsletter edited by Katharina Immer, Support Scientist at JIVE (communications@jive.eu).

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