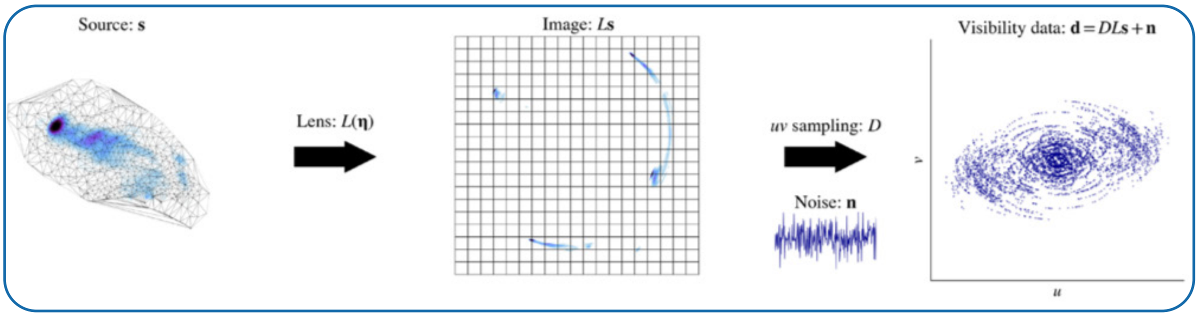
# NEWSLETTER

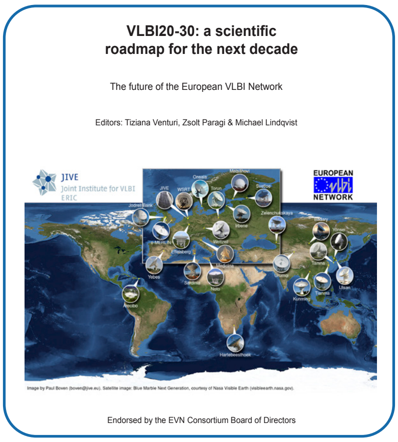
*Edition 58*
*January 2021*

## CALL FOR PROPOSALS

**DEADLINE: 01 FEBRUARY 2021, 16:00:00 UTC**



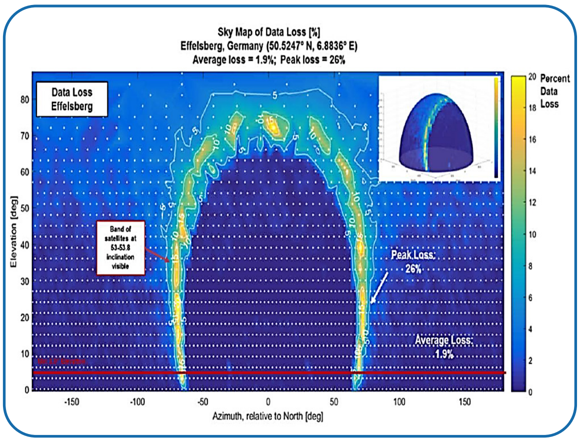

## A NOVEL APPROACH TO VISIBILITY - SPACE MODELLING OF INTERFEROMETRIC GRAVITATIONAL LENS OBSERVATIONS AT HIGH ANGULAR RESOLUTION


VLBI20-30: a scientific roadmap for the next decade

The future of the European VLBI Network

Editors: Tiziana Venturi, Zsolt Paragi & Michael Lindqvist

Endorsed by the EVN Consortium Board of Directors



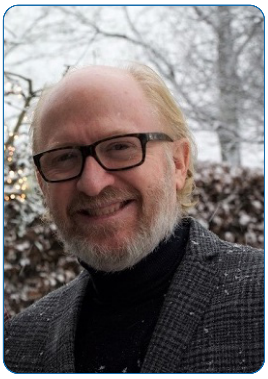

## VLBI20-30: A SCIENTIFIC ROADMAP FOR THE NEXT DECADE AND TECHNICAL CHALLENGES

## CRAF ACTIVITIES TO MITIGATE THE IMPACT OF SATELLITE MEGA-CONSTELLATIONS

# IN THIS ISSUE

# WELCOME

Tiziana Venturi, Chair of the EVN-CBD



Paco Colomer, Director of JIVE

In this issue we first acknowledge the extraordinary work done by Rafael Bachiller as chair of the Board of Directors in the past two years, which have been exciting but also very challenging times. Indeed, 2020 has been very special due to the COVID-19 pandemic. The EVN observatories and JIVE have demonstrated resilience, and thanks to the effort and dedication of the staff at each observatory, most services and projects could continue with minor disruptions. We will miss very much the 305m telescope of the Arecibo Observatory. Possibilities to continue VLBI observations with another AO antenna are under investigation. Travel restrictions have prevented many events to happen in their original form. Being unfortunate, this has opened some opportunities, since online conferences and seminars can now be attended by many more and diverse people. Great examples are the CASA-VLBI workshop and the EVN e-seminars, which are recorded and available at the EVN/JIVE channel in youtube.

Beyond the exciting science, in this issue we have focussed on some very relevant topics. The EVN Science Vision is already serving as the base to a technology roadmap which will maintain and increase the competitiveness of the EVN. The IGN Yebes Observatory reports on broad-band receivers developed along the lines suggested by the science vision document. The "OPTICON-RadioNet Pilot project" (ORP) is approved by the EC. It connects experts from 37 institutions to promote the multi-messenger approach to astronomy, while intensifying and evolving the support to the EVN users and facilitating access to non-VLBI experts.

The protection of the quiet radio sky is more and more urgent. The Committee on Radio Astronomy Frequencies (CRAF) works to mitigate the impact of satellite megaconstellations. Cooperation and mutual understanding are essential for sustainable developments.

We hope we will be able to go back to a regular planning of our activities as early as possible in 2021. In the meantime we are confident the EVN and JIVE facilities will continue to produce great scientific results and support to our users. We wish all our friends, colleagues and families a safe and healthy 2021.

# CALL FOR PROPOSALS

# DEADLINE: 01 FEBRUARY 2021, 16:00:00 UTC

*Details of the call: [https://www.evlbi.org](https://www.evlbi.org)*

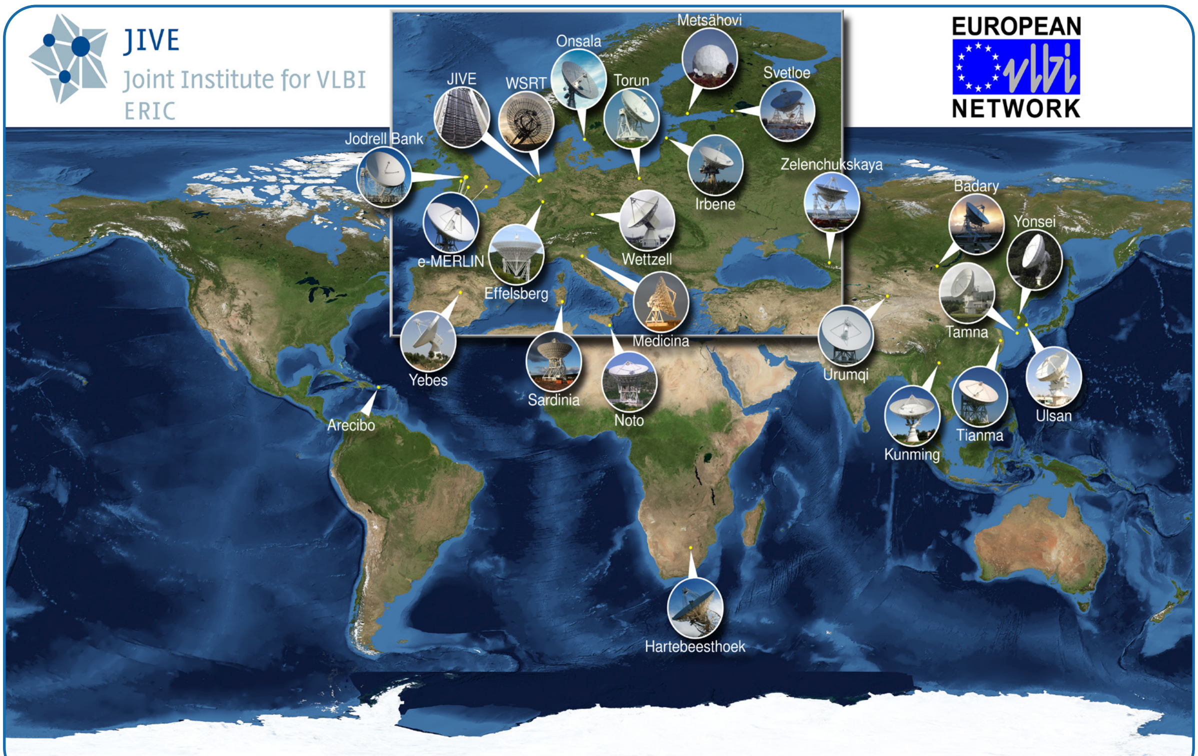


Image by Paul Boven (boven@jive.eu). Satellite image: Blue Marble Next Generation, courtesy of Nasa Visible Earth (visibleearth.nasa.gov).

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).

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 NRAO/ GBO telescopes or with the Long Baseline Array.

EVN observations may be conducted with disk recording (standard) or in real-time correlation (e-VLBI), which guarantees a rapid turnaround . Standard EVN observations are available at wavelengths of 92, 50, 30, 21/18, 13, 6, 5, 3.6, 1.3 and 0.7 cm. e-VLBI observations can be performed at 21/18, 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 separate days are available for e-VLBI observations. More information regarding the EVN capabilities, availabilities of EVN antennas, observing sessions, proposal guidelines, and user support can be found at www.evlbi.org.

**Recording capabilities for the next standard EVN and e-VLBI sessions**

Disk recording at 2 Gbps is available at 6, 3.6, 1.3 and 0.7 cm; telescopes that cannot usefully reach this will use the highest possible bit-rate (mixed mode observation). The present recording status is given here.

New: Disk recording at 4 Gbps is now available at 6, 3.6, 1.3 and 0.7 cm for a subset of antennas for a limited amount of time and on a best-effort basis. Telescopes that cannot usefully reach this data rate will use the highest possible bit-rate (mixed mode observation). Proposals requesting 4 Gbps should clearly justify the need for this data rate.

Given the limited opportunity for such shared-risk 4 Gbps observations, proposals for that bit-rate should therefore include whether they could also be performed at 2 Gbps (mentioning the observing time needed at 2 Gbps) or if the science objectives are impossible to reach at data rates < 4 Gbps. See here for the current 4 Gbps recording status.

e-VLBI at 2 Gbps is available at 6 cm and 1.3 cm; telescopes that cannot usefully reach this will use the highest possible bit-rate (mixed mode observation). Network circumstances might also impose total bit-rate limitations on a particular e-VLBI day. The current status is given in the 'operational modes' section on http://www.evlbi.org/capabilities.

Observations at 18/21 cm in either disk-recording or e-VLBI are limited to a data rate of 1 Gbps due to bandwidth limitations.
The choice of data rate should be clearly justified in the proposal.

**Availability of EVN antennas**

The latest status of the EVN antennas can be found on http://www.evlbi.org/capabilities.

The 305m telescope of the Arecibo Observatory has become unavailable due to decommissioning following the recent structural casualties. Possibilities of including the 12m antenna at Arecibo in EVN observations are being discussed.

The three Quasar antennas of the Russian VLBI Network (Badary, Svetloe and Zelenchukskaya) are also available for e-VLBI.

More information can be found in the EVN Call for Proposals.

# SCIENCE HIGHLIGHTS

# A NOVEL APPROACH TO VISIBILITY-SPACE MODELLING OF INTERFEROMETRIC GRAVITATIONAL LENS OBSERVATIONS AT HIGH ANGULAR RESOLUTION

*Devon Powell, MPIfR, Germany*

Modern VLBI arrays now provide us with milli-arcsecond angular resolution images of strong gravitational lens systems at high signal-to-noise ratios. This is a powerful tool for studying astrophysical phenomena, including the evolution of high-redshift galaxies and the particle nature of dark matter. However, properly modelling these data sets poses a computational challenge due to both the large number of radio visibilities (as high as $10^{10}$) and the high image resolution needed to pixellate the sky.

In Powell et al. (2020), we develop a Bayesian forward-modelling technique for simultaneously reconstructing the source brightness and the lens mass in a self-consistent way from VLBI observations. Our method requires no pre-averaging or other data reduction steps prior to modelling, which sets it apart from previous approaches to this problem.

We achieve this by expressing the sky-plane covariance (which is formally a dense matrix with $>\sim 10^{12}$ elements) as a convolution with the dirty beam of the instrument, which is rapidly computed using an FFT. The dirty beam and dirty image are computed using a non-uniform FFT (NUFFT), which consists of a visibility gridding operation, an FFT, an apodization correction, and a zero-padding operation applied sequentially; this gives an accuracy better than $10^{-8}$ relative to the expensive direct Fourier transform. We perform the gridding operation and FFT on a GPU, which drastically accelerates the computation. Inversion of the source is done using a preconditioned conjugate gradient solver (which requires a convolution with the dirty beam at each iteration), and the lens model parameters are optimized using gradient descent. We apply a custom preconditioner for the conjugate gradient solver, which speeds convergence.

We verify the performance and accuracy of the method on a mock dataset created from the global VLBI observation of the lensed quasar MG J0751+2716 (Spingola et al. 2018). This

*Accepted in: Powell et al. 2020, MNRAS*

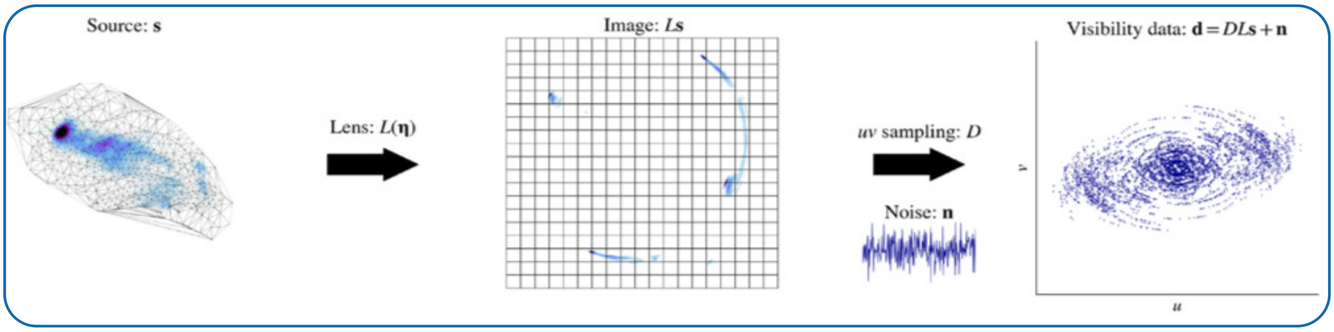



*Fig. 1: A schematic of the forward-modelling process for VLBI data. The source brightness is represented on a Delaunay tessellation, which naturally adapts to the magnification provided by the lens (Vegetti and Koopmans 2009). The lens operator maps the source brightness into the sky plane. The simulated instrument response is then applied using an FFT to arrive at model radio visibilities.*

observation was taken over 18.5 hours using 24 stations from the EVN and VLBA at a data rate of 512 Mbit/s. After correlation, the observation consists of 2-second integrations in 256 spectral channels and 2 polarizations for a total of $7x10^8$ visibilities. We insert our own known sky and lens models and combine the polarizations for testing purposes. Using this mock observation, we verify that this technique recovers the source surface brightness with 1% accuracy, and the lens model parameters within a fraction of a percent.
We also measure the speed of the modelling process; for this mock observation and a source containing $5.4x10^5$ pixels, we are able to fully optimize the source brightness and lens model in 15 hours using one GPU. This includes ~250 gradient descent steps, which each require a source inversion taking ~4 minutes. Note that these performance figures include some algorithmic improvements implemented after the acceptance of the paper.

We are encouraged by the performance of this method, and excited to apply it to observational data. Already, Rizzo et al. (2020) have published a paper in Nature examining the kinematics of a z=4 galaxy in unprecedented detail. We are currently using VLBI observations of strong lenses to constrain the dark matter particle mass. In the future we would also like to include self-calibration as a part of the forward model itself. We note that our method is not limited to gravitational lens modelling, but can also be used as a stand-alone radio imager, which could prove invaluable for future dense arrays like SKA with ~200 antennas. With VLBI as an established observational tool, we hope that others will find this modelling technique to be useful in achieving their own science goals as well.

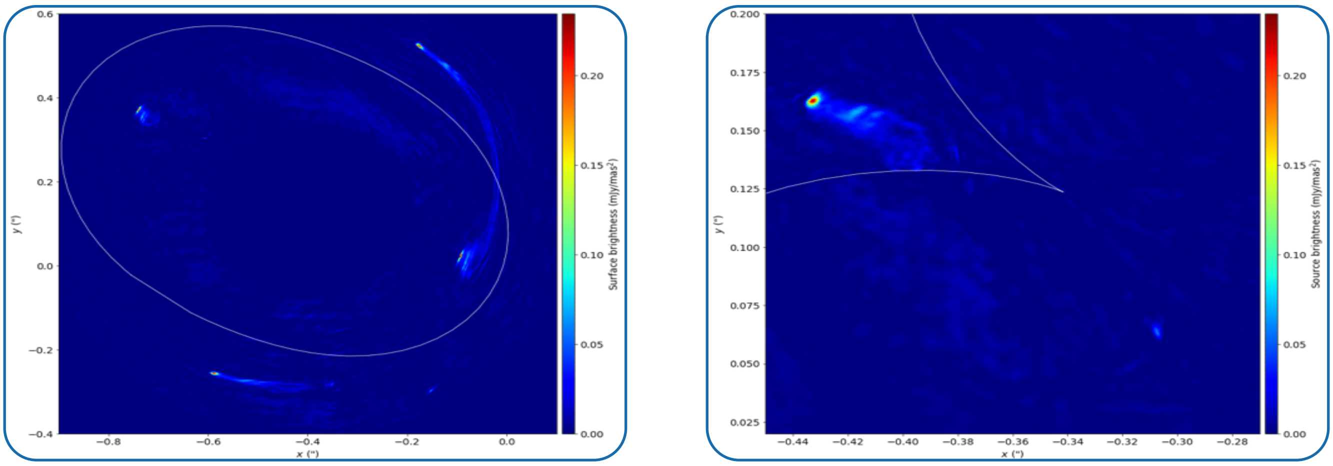


*Fig. 2: Pixelated sky (left) and source (right) models of the lensed quasar MG J0751+2716 obtained using our method. Critical curves of the lens are plotted in white*

# PRECISE RADIO ASTROMETRY AND NEW DEVELOPMENTS FOR THE NEXT-GENERATION OF INSTRUMENTS

*Maria J. Rioja, CASS/ICRAR/OAN, Spain*
*Richard Dodson, ICRAR, Spain*

The field of astrometry, through the measurement of the precise positions of astronomical objects, is a fundamental tool for astrophysics. Radio astrometry with VLBI provides the highest accuracy and precision in astronomy. The next-generation of radio instruments coming online will open up a new era for VLBI studies, resulting from widely applicable ultra-high precision radio astrometry, to perform large unbiased surveys of many objects, at a much wider range of frequencies (hundreds of MHz to hundreds of GHz) than those available today. The next-generation data analysis methods are fundamental in allowing us to reach the potential of the new instruments, by reducing the magnitude of systematic errors.

We have combined traditional and new analysis techniques into a common framework, which paves the way to improve the astrometric accuracy by an order of magnitude. The predictions from this framework allow the easy identification of the dominant astrometric error contributions, arising from: propagation media effects, source pair angular separation (hereafter systematic errors) and instrumental sensitivity (hereafter thermal errors). Fig. 1 shows the thermal error limit for the typical DR of 100:1 achievable with current instruments (shown with grey dotted line). Similar simple estimates based on sensitivity indicate that up to 1microarcsecond astrometry should be routinely achievable with the next-generation instruments, i.e. SKA-VLBI and ngVLA. However it is clear that the analysis with conventional, or even advanced, methods will be dominated by systematic errors (shown with solid lines), preventing one from reaching the potential of the new instruments.

Basic methods (Conv. PR in Fig. 1), relying on alternating observations between the target and a reference source, are suitable for measuring positions accurate to about a mas at ~1GHz, and 20-30 microarcseconds at 22GHz, for 1° pair angular separation (the black line in Fig 1 shows the predicted performance). For high frequencies (>8 GHz)

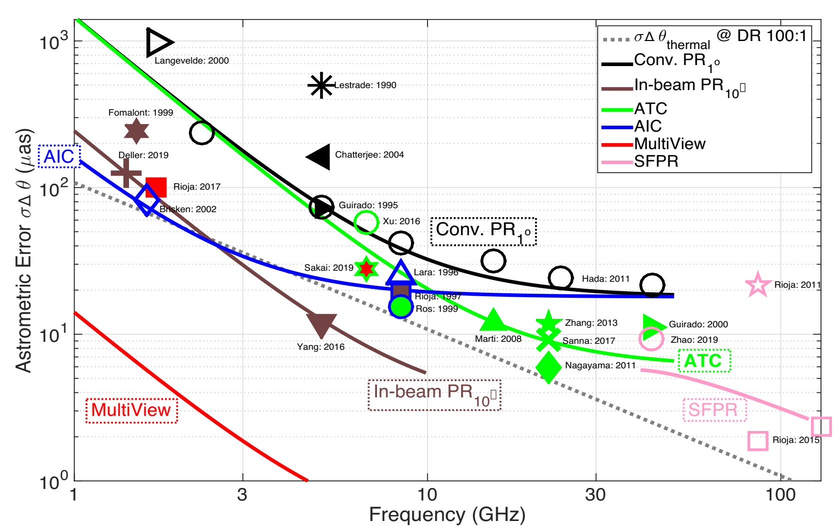



*Fig. 1: Estimates of atmospheric performance over a range of frequencies with different methods (see text)*

advanced tropospheric calibration (ATC, green line), such as GeoBlocks, can achieve position errors of 10 microarcseconds, at 22GHz. For low frequencies (<8GHz), position errors of 0.1mas are reachable using advanced ionospheric calibration (AIC, blue line), but at L-band the main advances came from the regular detection of a very close calibrator source (In-beam PR100 ; brown line), made possible with improved sensitivities.

Next-generation methods of Source/ Frequency Phase Referencing (SFPR, pink line) and MultiView (MV, red line) open up the domain for ultra-precise astrometry up to hundreds of GHz and improve on Inbeam PR100 systematics by an order of magnitude, respectively. SFPR relies on dual frequency observations and uses the solutions at the lower frequency to provide an optimum compensation of tropospheric residuals at the higher frequency. MV uses observations of multiple calibrators around the target to construct a 2D phase surface and deduce precise atmospheric corrections for the target. Overplotted with symbols are a host of "real-life" astrometric precision achieved over the last 3 decades, using the same colour scheme described above. The measurements and predictions show a good agreement.

In order to achieve ultra-precise astrometry

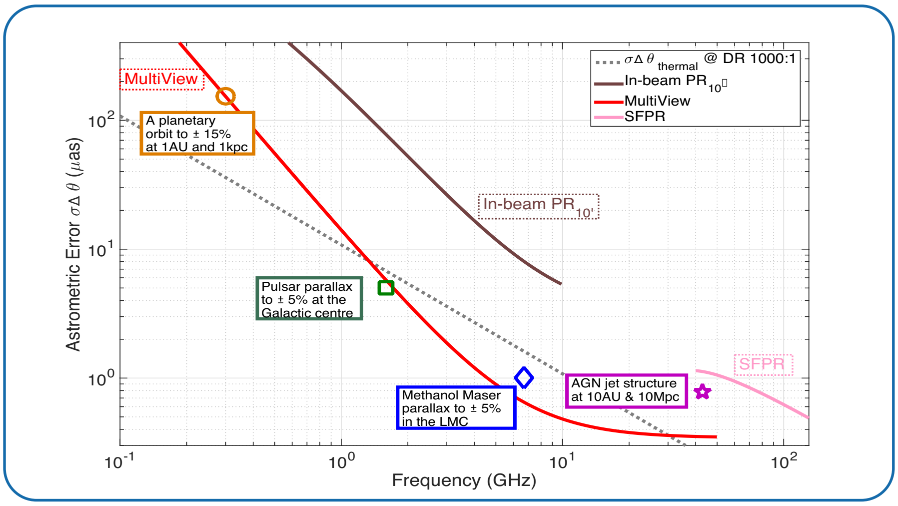



*Fig. 2: Estimates of single epoch astrometric performance for next-generation instruments. For details see Rioja and Dodson 2020, A&ARv, Vol. 28(1), id.6*

with next-generation instruments, these must be equipped with multi-beam systems such as multi-feeds and PAFs, and simultaneous multi-frequency receivers such as the wide single feed systems (e.g. BRAND system and similar developments) and multi-path multi-band systems (e.g. the KVN system and similar developments).

Fig 2 brings together measurements of residuals and shows that SFPR and MV offer matching systematic limits (pink and red solid lines, respectively) to the predictions of the thermal astrometric errors (grey dotted line) of the next generation telescopes. This results in 0.1mas astrometric errors at 300MHz and 1microarcseconds errors at 6.7GHz and up to 130GHz, per epoch. This leads to innovative high-impact science possibilities across the full radio frequency spectrum, examples of which are included in the figure. Finally we note that there is no implicit upper-limit for the application of SFPR and related dual-frequency techniques, which would also be suitable for applications on the ngEHT.

For details see the review paper by Rioja and Dodson (2020), A&ARv, Vol. 28(1), id.6. Maria J. Rioja and Richard Dodson acknowledge support from JUMPING JIVE WP10 "VLBI with the SKA", that has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730884.

*Published in: Rioja & Dodson, 2020, A&ARv, 28(1), id. 6*

# VERY LONG BASELINE INTERFEROMETRY IMAGING OF THE ADVANCING EJECTA IN THE FIRST GAMMA-RAY NOVA V407 CYGNI

*Marcello Giroletti, Istituto nazionale di astrofisica: Bologna, Italy*

It was March 2010 when a transient gamma-ray source was revealed by the Large Area Telescope on board the Fermi gamma-ray satellite. To everybody's surprise, the transient source matched the position of the symbiotic nova V407 Cygni. Initially considered a sort of "stellar exception", V407 Cygni, instead, gave birth to a new class of gamma objects. Symbiotic novae are rare and exceptional objects, couples of stars composed of two very different companions: a small, dense, white dwarf and a pulsating red giant. The red giant emits a wind of material that is accumulated on the surface of the white dwarf and, when it reaches a critical density, gives rise to a very bright explosion.

Soon after the discovery, we observed the source with the EVN in e-VLBI mode. Thanks to its sensitivity and prompt feedback, the EVN revealed a faint, compact 5 GHz feature, which convinced us to follow the evolution of the source for a few more epochs. The following observations, ranging between 31 and 203 days after the optical event, revealed a much richer and rapidly evolving structure.

Not only the observations demonstrated for the first time in a direct way the presence of a shock in this type of events, we could also determine the geometry of the source: the red giant is in the foreground in front of the white dwarf, and from the latter two opposite jets depart, in the plane of the sky, perpendicular to the line of sight. Moreover, the observations also allowed us to reveal traces of previous events in the life of this binary star, one around 2003, one even dating back to the 1930s. A step forward in understanding the evolution of these rare objects.

These results are the outcome of an intense and ambitious observational campaign. The sensitivity of the EVN, in particular in the short baseline range, and its real time capabilitiy, were key elements for the characterisation of the system. The results were published earlier this year in "Very Long Baseline Interferometry imaging of the advancing ejecta in the first gamma-ray nova V407 Cyg" by Giroletti et al., appearing in the 29 June 2020 issue of Astronomy and Astrophysics.

*Published in:* [M. Giroletti et al. 2020, A&A, 638, A130]

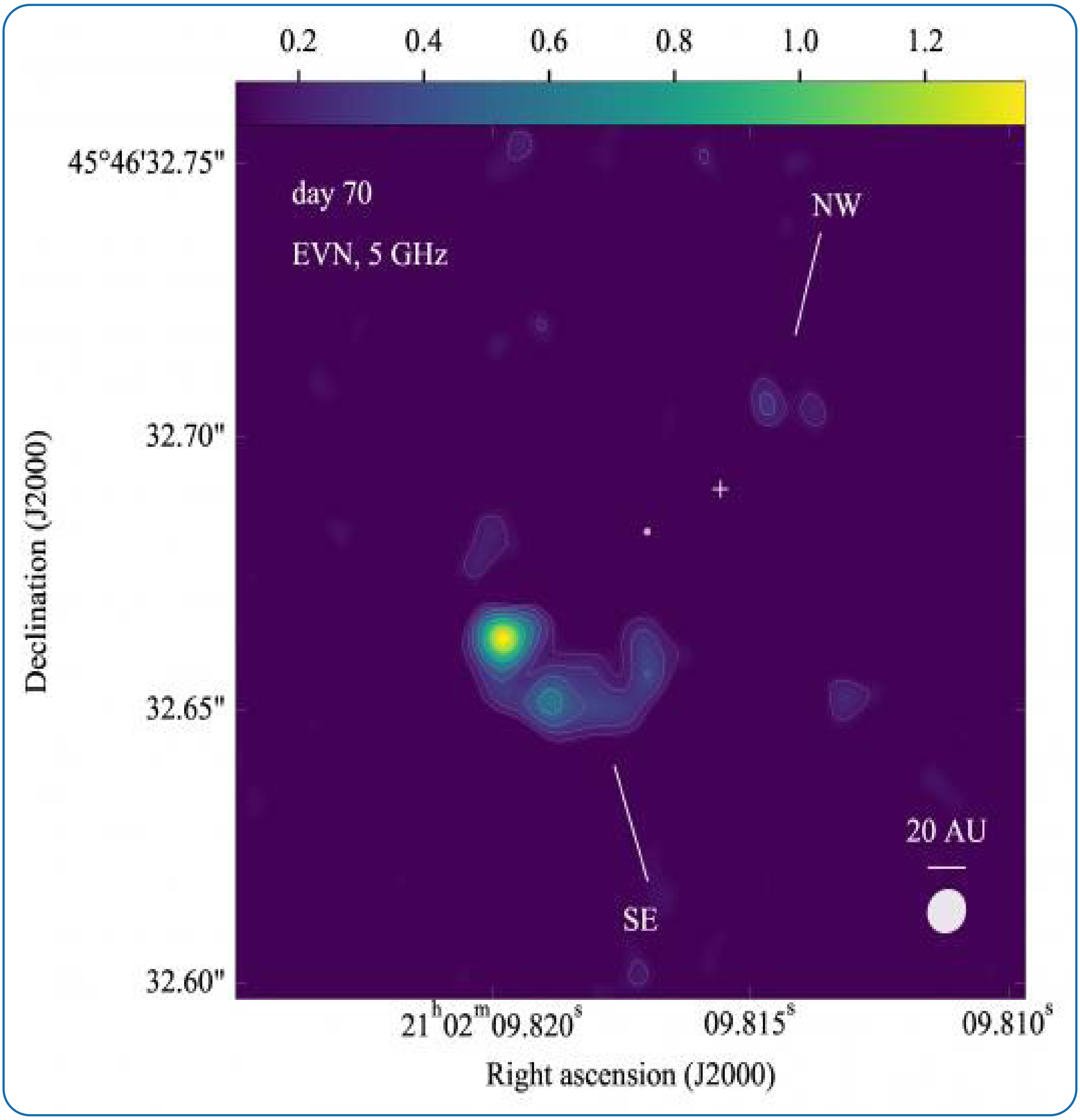



*Fig. 1: A radio image of the emission from V407 Cyg, 70 days after the explosion. The colour scale indicate the intensity of the emission (yellow is brighter), which is developing on two opposite fronts with respect to the location of the central white dwarf.*

NETWORK HIGHLIGHTS

# VLBI20-30: A SCIENTIFIC ROADMAP FOR THE NEXT DECADE AND TECHNICAL CHALLENGES

*Tiziana Venturi, INAF Istituto di Radioastronomia, Italy*

The project JUMPING JIVE has facilitated the process of preparing a scientific roadmap for VLBI, whose main goals are to assess the relevance of milliarcsecond scale science in the current transformational landscape of new radio astronomical facilities, and to highlight the technological and operational developments needed to ensure that the role VLBI plays in astrophysics will continue and further grow in relevance.

The document "VLBI20-30: a scientific roadmap for the next decade - The future of the European VLBI Network" has been completed and is being distributed to the community worldwide.

The previous scientific roadmap for the EVN "EVN2015 - The future of the European VLBI Network" was prepared in 2007. The broadening of the scientific applications of VLBI over the past 10-15 years is impressive. While the study of active galactic nuclei remains one of the most common applications of the milliarcsecond resolution facilities, over the past few years it has become clear that VLBI can play a unique role in several new fields of research. Remarkably, cosmology, transient science and SETI are novel areas in the scientific impact of VLBI.

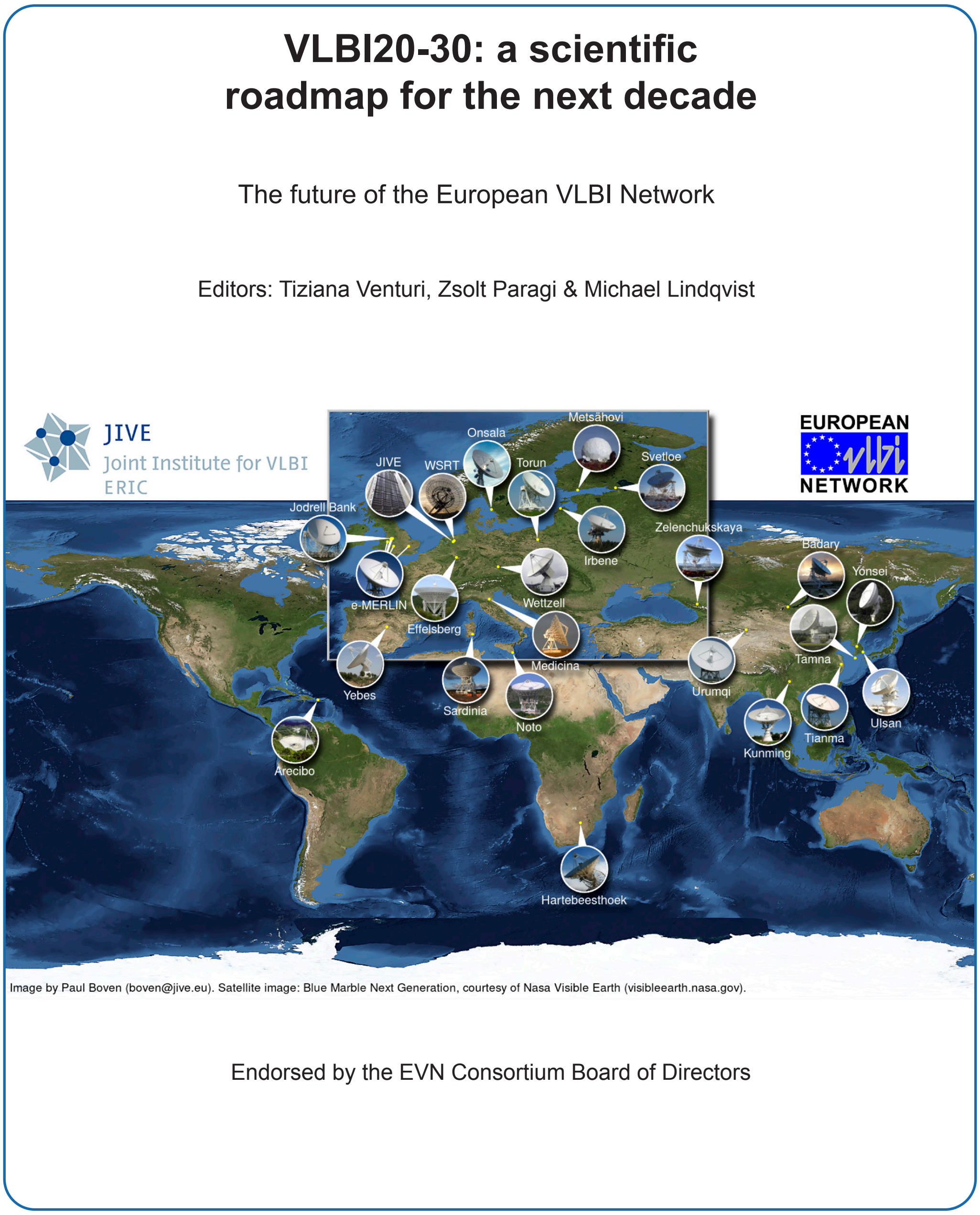
The scientific content of the new roadmap, presented in seven science chapters, led to ten main questions, which VLBI may provide unique answers to:

- What is the nature of dark matter and dark energy?
- When and how did the first black holes form?
- How do relativistic jets form? What is their impact on the host galaxy?
- What is the physics of explosions following gravitational wave events?
- What are the elusive fast radio bursts?
- Are we alone?
- How was the Milky Way born?
- How do stars form? How do they impact the environment at their death?

The document highlights the role VLBI will play in the next decade both in itself, as well as in the landscape of other radio interferometers and ground-based facilities in other domains of the electromagnetic spectrum. Just to name the most relevant, very long baselines are essential for a full scientific exploitation of the SKA potentials, they will be the key for the synergy with ELT, and will be vital to the very high energy studies with CTA.

Such scientific ambitions need to be supported by substantial technological advances. Improved sensitivity and image fidelity are one of the keys to the success. The European VLBI Network is already engaged in the development of suitable front-end and backend systems, such as broad-band receivers and DBBCs. The need for an improved u-v coverage, especially in the north-south direction, emerges clearly from the document, and it is a high priority for the EVN to ensure that African antennas will soon be integrated in the array on regular basis. Broadening the frequency range and moving towards more a flexible use of the array are further crucial requests.

The implementation of such technological requirements is the next step to ensure that our lively scientific VLBI community will be able to pursue the breathtaking goals presented in [“VLBI20-30: a scientific roadmap for the next decade - The future of the European VLBI Network”].


VLBI20-30: a scientific roadmap for the next decade

The future of the European VLBI Network

Editors: Tiziana Venturi, Zsolt Paragi & Michael Lindqvist



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

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# NEW Q AND W BAND RECEIVERS AT THE 40M YEBES RADIOTELESCOPE

*Pablo de Vicente, IGN Yebes Observatory, Spain*

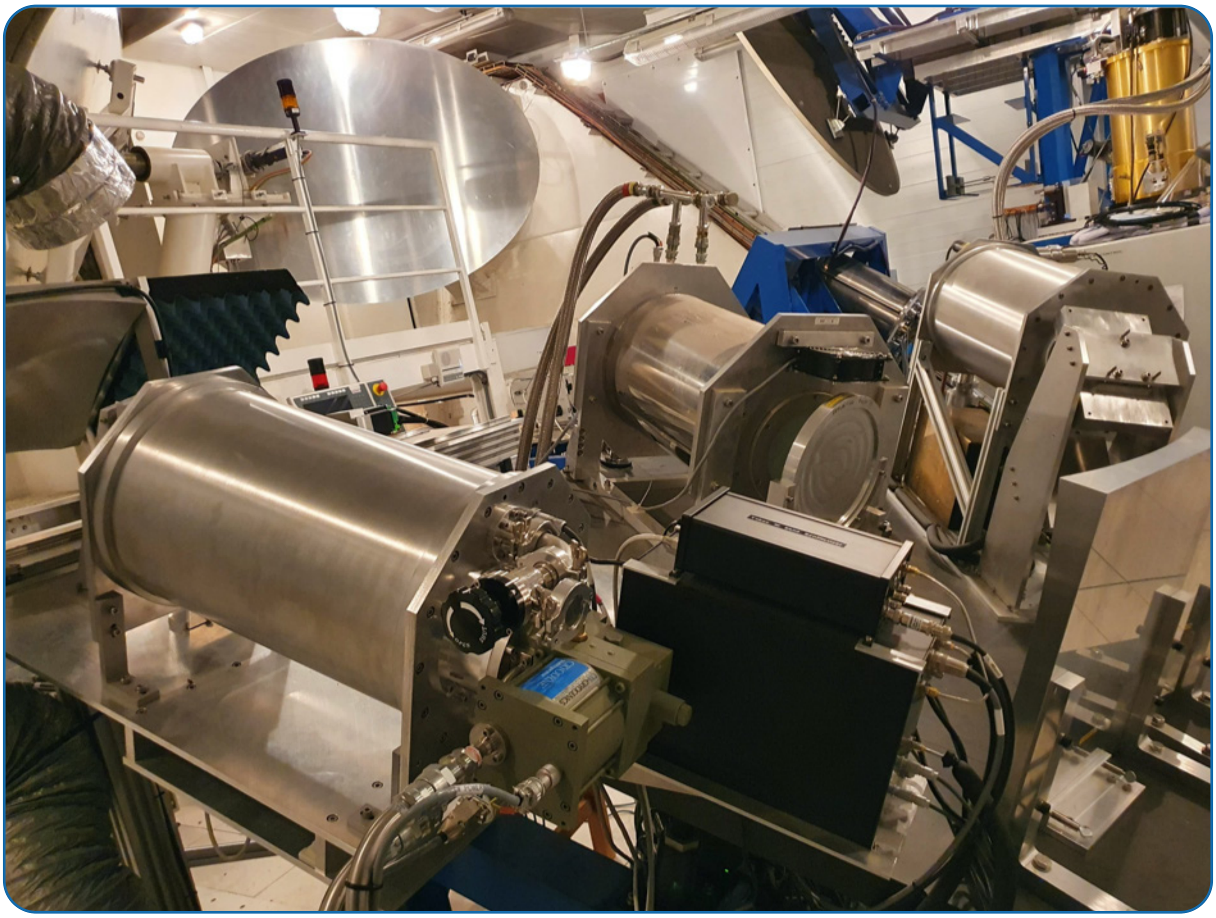


*Fig. 1: Nanocosmos receivers at the 40m cabin. The W band receiver is at the left and the Q band at the right. The receiver in between is the K band one*

Yebes Observatory installed by the beginning of 2020 two new receivers at the 40m radio telescope. These receivers designed and built by the staff of the observatory during the last 3 years were partially funded by the Nanocosmos project, a European Research Council synergy grant in which several institutes have taken part.

The receivers, due to its characteristics, can be considered state of the art, have an instantaneous band of 18.5 GHz between 31.5-50 GHz and 72-90.5 GHz and use Fast Fourier Spectrometers as its primary backend. Their main goal is the study of the spectrum of different astrophysical sources with rich molecular chemistry. A description of the 40m telescope and its Nanocosmos receivers can be found in a recent paper in Astronomy and Astrophysics which will be published in the next weeks. The manuscript can be found in the Forthcoming section of A&A (https://doi.org/10.1051/0004-6361/202038701) and in the ArXiv server (https://arxiv.org/abs/2010.16224). Improvements to the receivers continue after the acceptance of the paper. Updated and useful information for potential observers can be found at the 40m radio telescope web page: http://rt40m.oan.es/.

These receivers which are dual linearly polarized have already been used for VLBI within the GMVA, the EVN and together with the KVN telescopes. The instantaneous bandwidth for VLBI is currently limited to 2.5 GHz around 43.1 GHz and 86.2 GHz. Several dichroic mirrors allow the simultaneous observation of K and Q bands and by the beginning of 2021 of K, Q and W bands.

These three simultaneous receivers match one of the goals of the current EVN Technological roadmap endorsed by the EVN CBD at its last meeting in November 2020. Several EVN stations are pursuing the acquisition or construction of triple band receivers (KASI like) which allow simultaneous observations at these bands. The importance and opportunity of such receivers in VLBI was highlighted in the last Radionet workshop on Future Trends in Radio Astronomy Instrumentation by A. Lobanov.

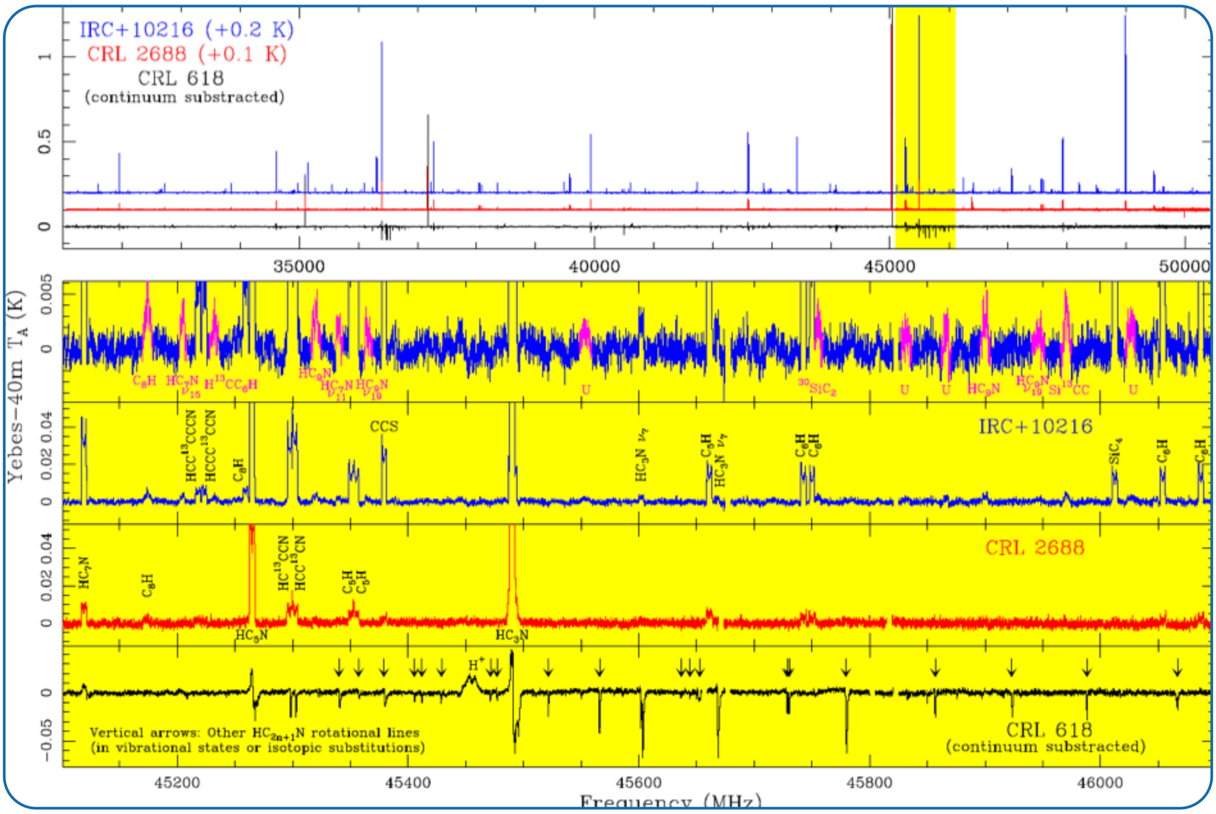
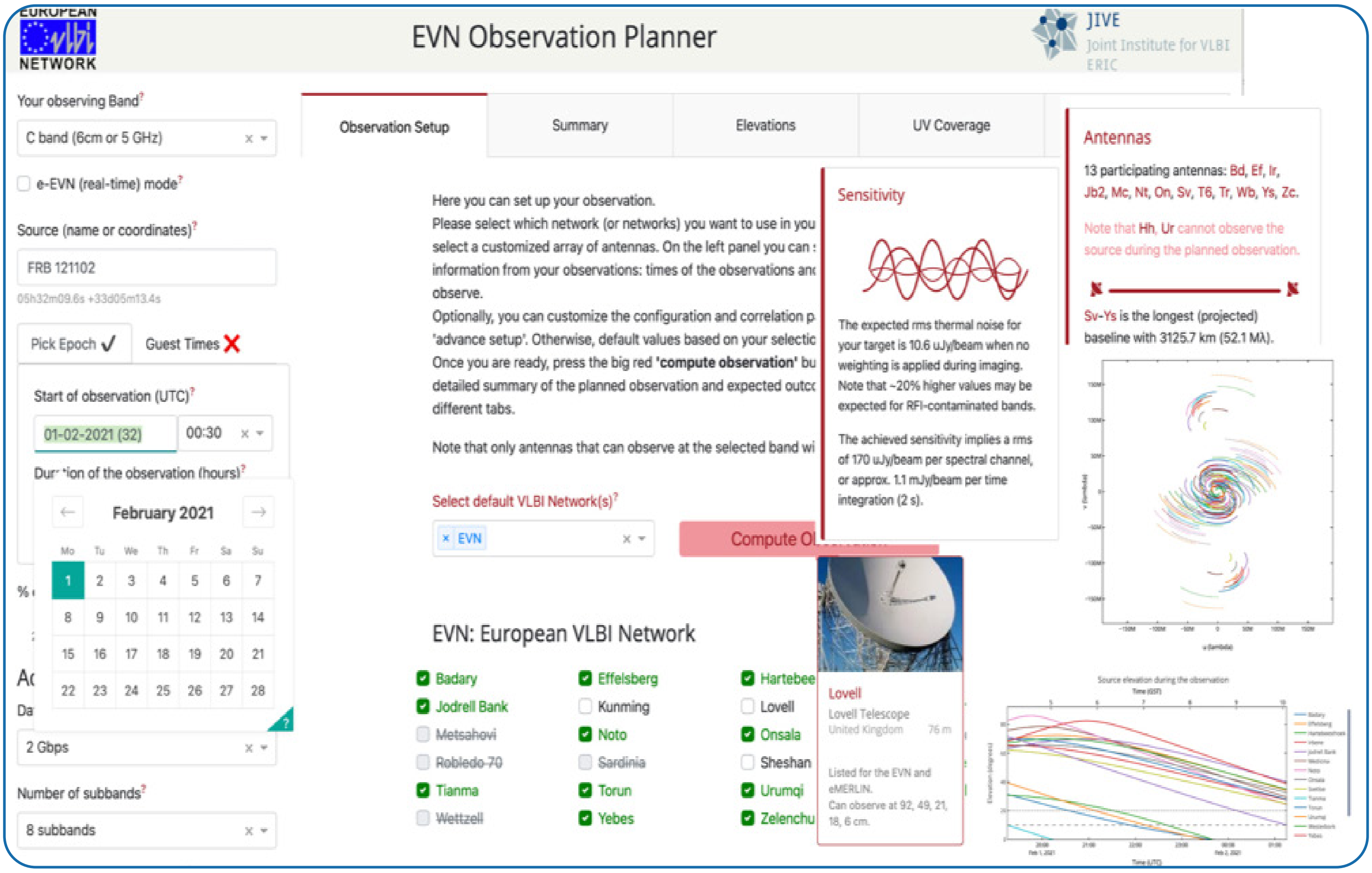



*Fig. 2: 18 GHz spectrum obtained with the Nanocosmos Q band receiver towards IRC+10216, CRL 2688 and CRL 618. Image from Tercero et al. (2021)*

# EVN OBSERVATION PLANNER – A NEW TOOL IN THE VLBI FAMILY

*Benito Marcote, Joint Institute for VLBI ERIC*




The EVN Observation Planner is a new online tool provided by JIVE ([planobs.jive.eu](planobs.jive.eu)) that allows the users to quickly determine when a target source can be observed by the EVN (or with other VLBI antennas), and the expectations of this observations (in terms of reached resolution and sensitivity, or e.g. uv coverage). This tool is thus focused on helping during proposal preparation.

The EVN Observation Planner aims to complement the current [EVN Sensitivity Calculator](EVN Sensitivity Calculator) by adding the benefit of being able to obtain a more reliable rms noise level and synthesized beam estimations, and elevation plots for all participating stations. In this sense, it will save the requirement of using SCHED/pySCHED to know when the target source can potentially be observed by the different antennas and the resolution that they may reach. A detailed output is also shown, quoting a variety of parameters as the expected output file size, GST ranges, the spectral resolution, longest and shortest baseline, or the field of view limitations due to time and frequency smearing. We note that while the EVN Observation Planner can be used for proposal preparations, the final schedules to conduct EVN observations will still require a schedule file created by SCHED/pySCHED.

In addition to the online tool hosted at JIVE, the code is publicly available in [GitHub](GitHub), under license GPLv3.0+. It also offers a non-graphical mode so it can be imported as a Python module. This option allows a fully customized usage and integration within any Python (+3.8) program.

# OTHER NEWS

## THE CASA-VLBI WORKSHOP GOES VIRTUAL

*Ilse van Bemmel & Olga Bayandina,*
*Joint Institute for VLBI ERIC*

With a global pandemic going on, the only option to host the planned CASA-VLBI workshop was in virtual space. This was a challenge for the logistics, especially when almost 200 people had registered, but we had gained some valuable experience with online platforms in the months prior to the meeting and decided to accept the challenge of scaling this up.

The workshop took place as planned from 2-6 November, hosted in the JIVE ZoomRoom and on the Mattermost chat platform. All the lectures were live streamed to YouTube, enabling participants to use live captioning and translation. In combination with the free access, this significantly increased accessibility for the workshop.

Since we had to cover 16 time zones while our tutors were mostly in Europe, the workshop consisted of two equal blocks: one in the morning and one in the afternoon of the workshop time zone. Each block consisted of

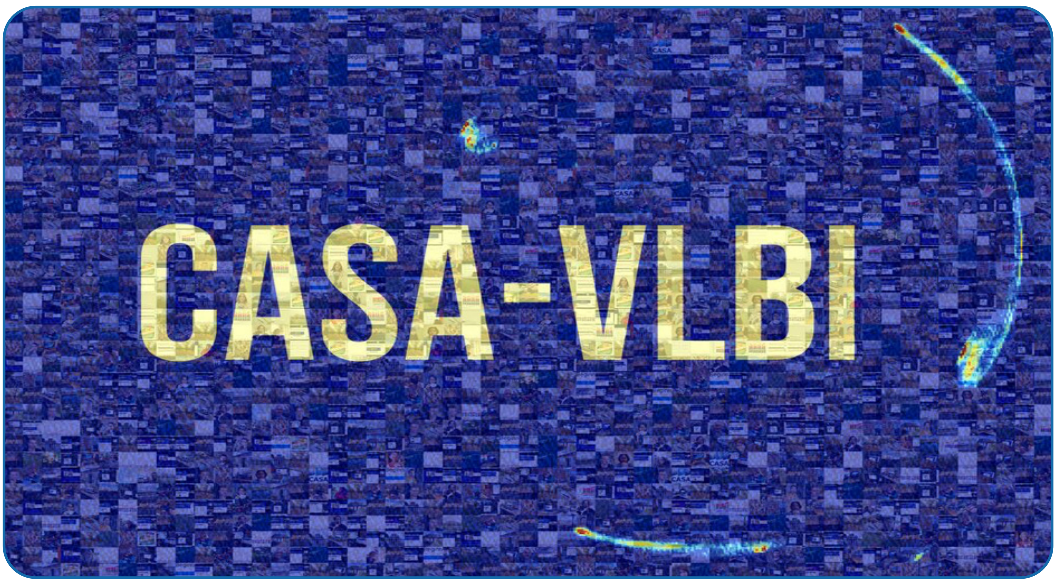



*Fig. 1: . Mosiac made from the submitted images*

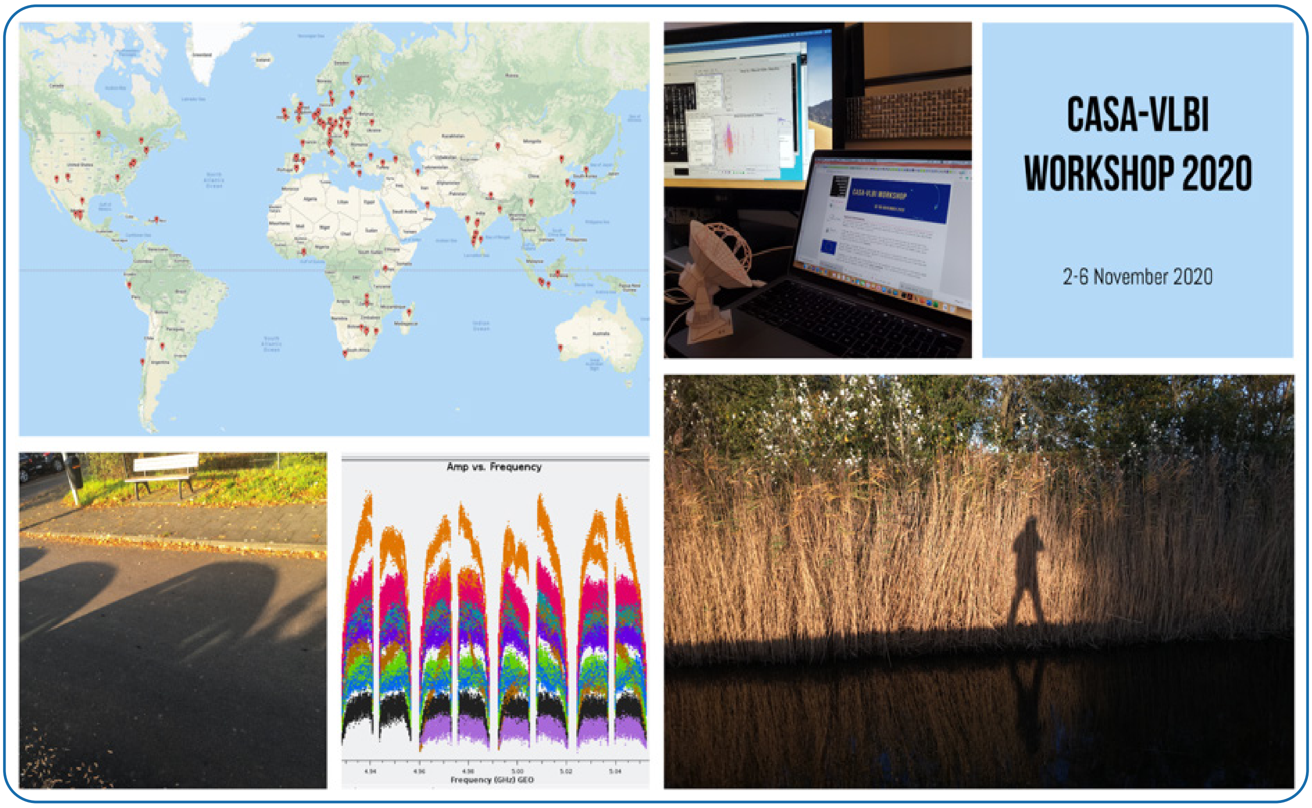



*Fig. 2: Impression of submitted images and map with participant locations*

2-3 lectures and a data processing session. All participants could attend at least one of these blocks in person, and watch the lectures of the other block on YouTube. The dedicated time slots for data processing were somewhat hindered by the non-functioning of the Zoom break-out room feature, causing us to resort to a plenary Zoom session and using Mattermost for the discussion. This didn't hold back the questions though, tutors had their hands full in answering questions and discussing common problems.

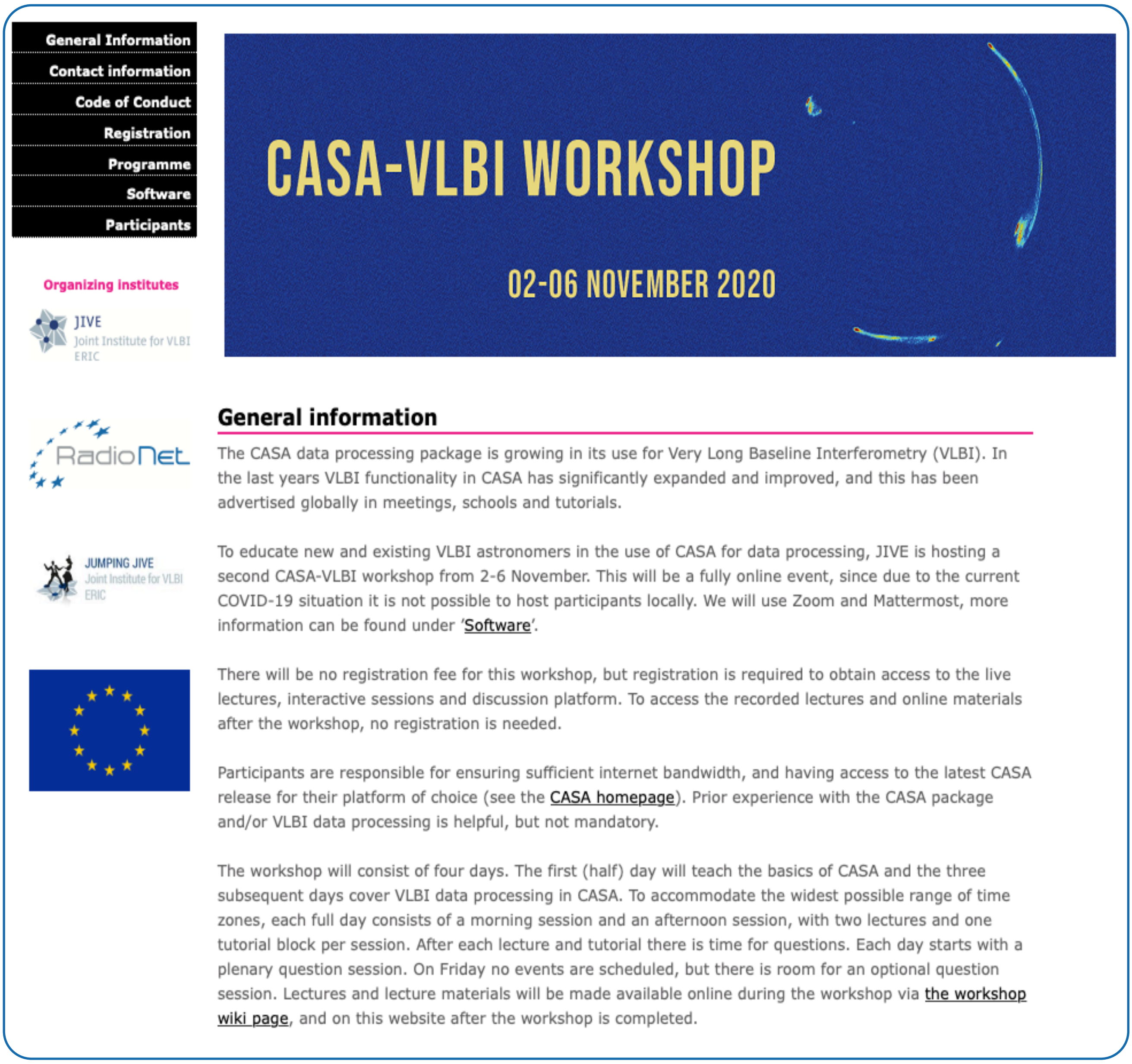
The lectures covered a broad range of topics and levels, but assumed a basic knowledge of interferometric data processing. Monday focused on the basics of CASA, teaching participants how the software is launched and used, which tasks are of importance and how to access the documentation to find answers to any questions they might have. The following days had lectures covering the EVN specifics, calibration and (wide-field) imaging, polarization, mm-VLBI and pipelines. The closing lecture discussed the bright future of VLBI.

Though this was a virtual meeting, a dedicated effort was made to include social events. Participants were encouraged to plan some time away from their screens for a walk, at a time convenient to their time zone. A dedicated timeslot in the programme ensured that a large group of participants could do this during Wednesday afternoon. We used the WorldWalking platform, where participants can share their distance walked, and contribute this to a joint walk effort through the Netherlands. In the end we jointly walked from Maastricht to Rotterdam. In lieu of a conference picture, during the week participants were asked to submit images of their work, environment, or food, to contribute to a conference mosaic (see

Figure 1 & 2). The workshop closed on Thursday with a pub-quiz, and the winner has received a JIVE mug.

The social events were much appreciated and provided the necessary breaks in a very dense programme. Nevertheless, we did not find a good alternative for the networking that usually happens during the breaks, nor did we find a good way to work with participants in one-on-one setting. For tutors it is challenging to help people with only a chat platform at their disposal. In spite of this, participants indicated that they found the workshop extremely useful and educational. Several participants noted that they could not have joined for an in-person workshop due to financial or personal limitations, which adds to the incentive to keep the threshold for these events as low as possible.

For future reference, all the materials remain available on the workshop website. There are links to the YouTube recordings, slides and a document with helpful information that was collected during the workshop. Future workshops are being planned. With the experience gained here, we aim for a hybrid format with in-person and online participants, to combine the best of both options.



# ORP: A NEW EUROPEAN NETWORK COMBINING OPTICAL AND RADIO ASTRONOMY RESEARCH INFRASTRUCTURES


The European astronomy community has been granted 15 M€ to improve how radio and optical telescopes across the continent work together, enabling the fastest-growing type of astronomy - including as many wavelengths as possible in a single study - and in doing so hopefully yield more discoveries.

This network, the OPTICON-RadioNet PILOT (ORP), brings together experts from the ground-based astronomy community to support improved access to a wider range of facilities, while developing appropriate tools. Astronomers from 15 European countries, Australia and South Africa and 37 institutions have joined the ORP consortium, funded by the EU H2020 programme.

Collaborators hope that the joined-up approach to facility access across Europe will improve rapid response capabilities when searching for an astronomical phenomenon, support and training for new users, and specific developments to improve the capabilities of facilities. As our knowledge of the Universe becomes more advanced, astronomers need a range of different techniques to be able to understand different celestial events as they unfold.

Multi-messenger astronomy, as it is called, spanning many wavelengths, and beyond to gravitational waves, cosmic rays, and neutrinos, and highly variable and transient sources, is making dramatic advances.

Reducing barriers between communities will facilitate its development and enable new discoveries. This EC-funded new partnership of the optical-infrared and radio astronomy communities, centred in Europe but spanning the world, is a valuable step towards that future, allowing more and better science by and for everyone.

The ORP will build on the success of the OPTICON Telescopes network for medium size telescopes, and the RadioNet network for radio facilities, in fostering well-connected communities and delivering cutting edge hardware and software.

Each partner will provide access to a telescope, or bring a vital work package to the collaboration, focusing on a specific task such as developing ways to automatically trigger observing modes to capture split-second events from multiple telescopes, or to create a common framework for data access and processing.

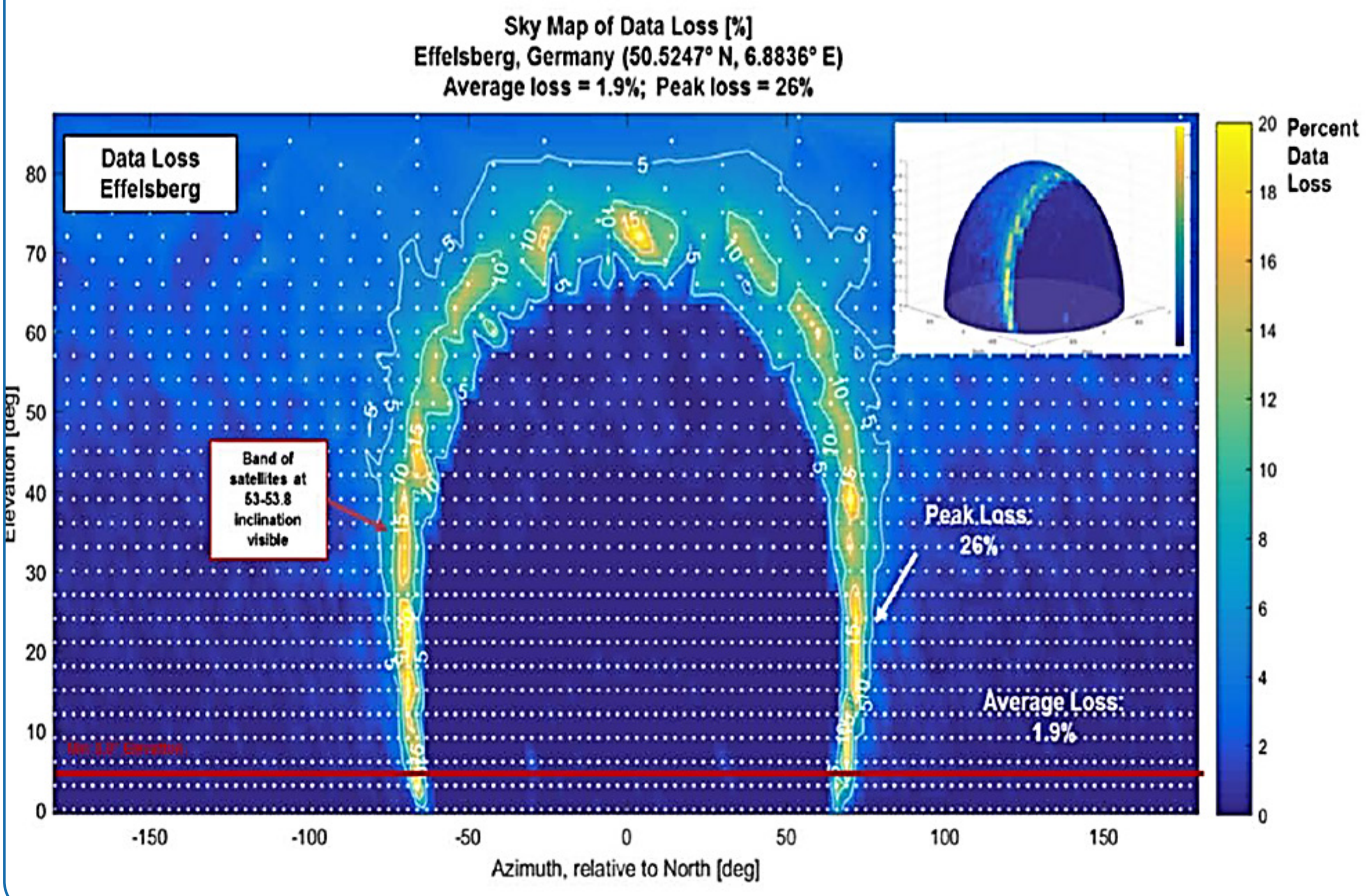
The European VLBI Network (EVN) is an open-skies facility for high spatial resolution radio astronomy, access is granted based only on scientific merit and technical feasibility of the proposals. Users of the EVN are supported by scientists at the Joint Institute for VLBI ERIC (JIVE), with resources contributed by the EVN and complemented by the RadioNet EC projects. The ORP offers the possibility to intensify and evolve such support, facilitating access to non-VLBI experts and therefore promoting the multi-messenger approach to astronomical problems. JIVE will also participate in the study of alternative funding mechanisms, the development of tools for rapid/automatic response of the EVN to the transient Universe, and communications to make visible the ORP goals, partners and results.

The ORP project will start on March 1st, 2021.

# CRAF ACTIVITIES TO MITIGATE THE IMPACT OF SATELLITE MEGA-CONSTELLATIONS

*Waleed Madkour, Joint Institute for VLBI ERIC*

Satellite mega-constellations have become a growing concern for radio astronomers worldwide during the last few years. The concerns in Europe with dense population in a tight geographical area are particularly more worrying. The ranges of Radio Quiet Zones (RQZ) around observatories in Europe are very limited compared to their counterparts in other regions such as the Americas, Australia or South Africa. Although RQZs don't provide protection from air and space-borne transmitters, their presence could help in implementing mitigation measures to reduce the risk of interference. Large enough RQZs could enable satellite operators to design their transmitters to steer their beams away from the radio telescope sites, with minimum impact on their commercial services.




*From [ECC report 271](): Sky Map of data loss at 10.6-10.7 GHz for Effelsberg, Germany. While the average data loss is below the regulatory threshold of 2%, some areas of the sky show peak loss of 26% due to the varying density of satellites distribution at the different altitudes*

The Committee on Radio Astronomy Frequencies (CRAF) on behalf of the radio astronomy observatories in Europe, has been engaged since 2016 and till now in the compatibility studies at the regional regulatory group in Europe, the Electronic Communications Committee (ECC). The satellite systems Starlink and OneWeb downlink transmissions in the frequency range 10.7-12.75 GHz is adjacent to the radio astronomy service (RAS) protected band 10.6-10.7 GHz. The technical studies at ECC project team SE40 of satellite systems have concluded several mitigation measures to protect the RAS band in Europe. The measures detailed in the public ECC report 271 specified filtering requirements for the transmitters, constraints on power amplifier design and deactivation of the adjacent channels in the band 10.7-10.95 GHz when in visibility of a RAS station.

Normally, radio astronomy observations are not limited to the RAS allocated band of 10.6-10.7 GHz. A potential risk arises in this case when radio telescopes might point directly to one of the many transmitting beams expected to be in visibility of the telescopes. CRAF worked with radio astronomy representatives from worldwide under the initiative of "Dark and Quiet Skies for Science and Society" event to study and recommend solutions for the negative impacts expected. The event was organized by the United Nations Office for Outer Space Affairs (UNOOSA) and government of Spain, jointly with the International Astronomical Union (IAU). A draft report has been presented during a workshop in October 2020 describing the risks and recommended solutions. The developed report as a reference for further analysis of the situation, will be presented to the intergovernmental Committee on the Peaceful Uses of Outer Space (COPUOS) for consideration.

In September 2020, CRAF submitted new questions to the International Telecommunications Union – Radiocommunications sector (ITU-R) Working Party 7D of radio astronomy service for the recognition of the VLBI global Observing System (VGOS) services by ITU. VGOS as a new global infrastructure with currently no definition in ITU, makes passive use in four sub-bands of the spectrum in the range of 2-14 GHz to meet the targeted accuracy goals. A recognition of VGOS applications by ITU should allow certain level of coordination with satellite mega-constellations for the overlapping frequency bands.

As satellite operators seek national licenses to start operating in the European countries, one approach to optimize the coexistence with radio astronomy observatories is to get engaged with national regulators during the licensing discussions. CRAF members are currently following the situation in their countries closely in order to secure proper agreements at the national level.

CRAF
Committee on Radio Astronomy Frequencies

# NEWS FROM JUMPING JIVE

*Giuseppe Cimò, Joint Institute for VLBI-ERIC*


This year has been very challenging for everyone everywhere, not just in the exciting world of EC astronomical projects. The Horizon 2020 JUMPING JIVE collaboration has also been affected by the global pandemic; however, the activities continued through the year with the organization of virtual meetings and the remote work of JUMPING JIVE people around the world.

The above picture shows a sample of the effort to Joining up Users for Maximizing the Profile, the Innovation and Necessary Globalization of JIVE. This effort will continue up to the end of July 2021.

We are entering the last months of the project when we will see the culmination of the excellent work carried out in the past three years. With the hope that 2021 will bring fewer health worries and more VLBI successes.

# UPCOMING MEETINGS

- **East Asia VLBI Network (EAVN) workshop:**
  *2–5 March 2021, online;*

- **European Astronomical Society (EAS) General Assembly:**
  *28 June - 2 July 2021, online;*
  https://eas.unige.ch/EAS2021/

  Including a special session "Extreme astrophysics at extremely high resolution"

- **European VLBI Network (EVN) Symposium and Users' meeting:**
  *12–16 July 2021, Cork, Ireland;*
  *https://www.ucc.ie/en/evn2020/*

- **URSI GASS:**
  *28 August–4 September 2021, Rome, Italy;*
  *https://www.ursi2021.org/*
  Including session J04 "Very Long Baseline Interferometry", deadline for contributions is January 31st, 2021

## NEXT NEWSLETTER: MAY 2021

*Contributions can be submitted until*
**10 April 2021**

*Newsletter edited by Aukelien van den Poll at JIVE (communications@jive.eu).*
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