NEWSLETTER

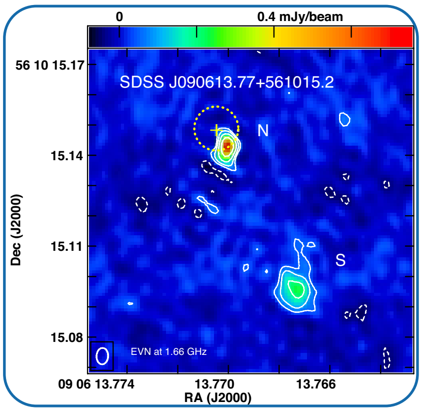
Edition 57
September 2020

CALL FOR PROPOSALS

DEADLINE: 01 OCTOBER 2020, 23:59:59 UTC

FINDING A "GIANT" JET LAUNCHED BY AN INTERMEDIATE-MASS BLACK HOLE IN A DWARF GALAXY

European VLBI Network (EVN) observations discover a rarely-seen powerful jet associated with the central intermediate-mass black hole of the dwarf galaxy SDSS J090613.77+561015.2.



UPGRADES OF METSÄHOVI AND TORUŃ OBSERVATORIES

The steering system of the 14-metre Metsähovi radio telescope was fully updated in March–April 2020 and the protective radome replaced in June 2020.

The major renovation of the Toruń radio telescope included the removal of numerous corrosion centres from the antenna structure and the repainting of the entire instrument.

EUROPEAN VLBI NETWORK E-SEMINAR SERIES – CONNECTING ASTRONOMERS WORLDWIDE

The European VLBI Network (EVN) has just initiated a series of online seminars "The Sharpest View of the Radio Universe". Seven talks will be spread out between early July 2020 and the 15th EVN Symposium in July 2021.

IN THIS ISSUE

WELCOME

Rafael Bachiller, Chairman of the European VLBI Network Consortium Board of Directors

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

We are happy to bring you a new issue of the EVN Newsletter full of exciting new scientific results and reporting important technical improvements in the network. The times are indeed difficult, the pandemic has imposed restrictions to normal life in every country, and particularly to observatories. However, the EVN and JIVE staff have demonstrated their skills and commitment to make possible the continuation of operations and projects to very high level, and the EVN user community has continued to be extremely active.

One very important recent milestone is the publication of the EVN Science Vision ("VLBI20-30: a scientific roadmap for the next decade – The future of the European VLBI Network"), a detailed compilation of the VLBI impact on contemporary and future astrophysics, which will serve as the base to a technology roadmap in order to maintain and increase the competitiveness of the EVN. Some consequences are already incorporated in the Call for Proposals for the next observing session, deadline on 01 October, with the possibility to request observations at 4 Gbps.

After the decision to postpone the EVN symposium to 2021, we have started a series of e-seminars (seven seminars, every seven weeks, on seven different science topics) which keep the user community informed and engaged. These online seminars are recorded and available for further dissemination of the unique VLBI capabilities.

At the time of writing this message, there are many unknowns about the future evolution of COVID. More than anything, we wish that all our friends, colleagues and families are and remain in good health. We also wish that the excellent work of the EVN and other research infrastructures can continue with minor disruption, and that soon we can again travel and meet our colleagues face to face. Till then, many events will happen online, like the CASA workshop (on November 2-6), with the possibility to demonstrate ourselves that a new and different way of collaboration is also possible. Lessons that we are to learn.

CALL FOR PROPOSALS

DEADLINE: 01 OCTOBER 2020, 23:59:59 UTC

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

The European VLBI Network. 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 very long baseline interferometry (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 enhanced Multi Element Remotely Linked Interferometer Network (e-MERLIN) and EVN observations

for an improved uv-overage 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](#).

On a shared-risk basis, 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. Telescopes that cannot usefully reach this 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 Arecibo Observatory is temporarily unavailable due to the break of one of the auxiliary support cables. Operations are stopped until repairs can be made.

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

The Tianma 65m telescope (T6) is located about 6 km away from the 25 m Seshan Itelescope (Sh). Both of these telescopes can observe at 18, 13, 6, 5 and 3.6 cm. T6 can also observe at 21, 1.3 and 0.7 cm. T6 is the default telescope; Sh will be used if T6 is not available for some reason. If you select both, you should also discuss the motivation for the very short baseline in the proposal.

Korean VLBI Network ([KVN](#)) telescopes may be requested for EVN observations at 1.3 cm and 7 mm wavelengths.

More information can be found in the [EVN Call for Proposals](#).

SCIENCE HIGHLIGHTS

FINDING A "GIANT" JET LAUNCHED BY AN INTERMEDIATE-MASS BLACK HOLE IN A DWARF GALAXY

Jun Yang, Onsala Space Observatory, Chalmers University of Technology, Sweden

Intermediate-mass black holes (IMBHs) have masses from one hundred to one million solar masses (M_{sun}). With European VLBI Network (EVN) observations, a rarely-seen powerful jet associated with the central IMBH of the dwarf galaxy SDSS J090613.77+561015.2 (hereafter J0906+5610) has been discovered.

It is very hard to find light IMBHs in the local Universe because of the rapid growth of galaxies and black holes (BHs). Finding these nearby "leftover" objects plays an important "ground truth" role in exploring the formation and growth of seed BHs and jet activity in the very early Universe.

To date, radio jets or steady radio-emitting polar outflows, compact on sub-pc scales, have been revealed in only one dwarf galaxy, NGC 4395, at a distance of 4.4 Mpc. The dwarf elliptical galaxy J0906+5610 hosts an IMBH with a mass of about 400 000 M_{sun} at 193 Mpc. To strengthen the identification of its accreting IMBH and search for jet activity, a group of astronomers, led by Dr. Jun Yang, has performed EVN observations of J0956+5610. The observations reveal two 1 mJy extended features. In Fig. 1, the yellow cross and circle mark the central position and the error circle of the optical counterpart. The northern feature in the top region is located in the yellow circle and most likely represents the inner jet base or emerging jet component powered by the accreting IMBH. The southern bottom feature is the more elongated and might be a dying jet component ejected in the early time. The radio structure can only be explained as a consequence of the IMBH jet activity because there is no evidence for the significant stellar activity in the host galaxy.

Compared to the first IMBH jet in NGC 4395, the second IMBH jet in J0906+5610 has a ~160 times larger structure and a ~100 000 times higher radio luminosity. This finding indicates that more IMBH jets will be detectable with the existing and future radio facilities, in particular in nearby dwarf galaxies.

Published in: [Yang et al. 2020, MNRAS, 495, L71]

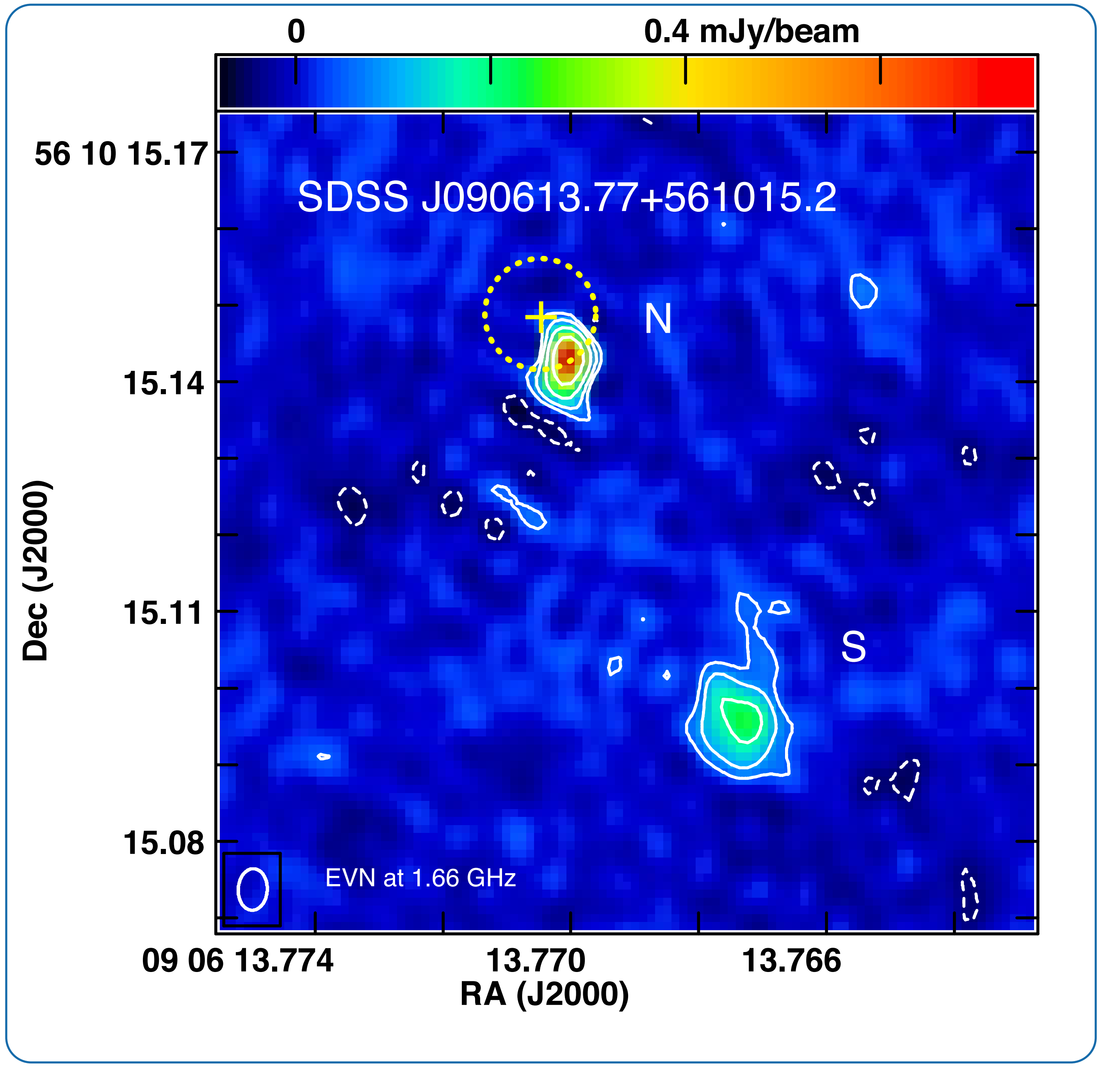


Fig. 1: A two-component brightness distribution found by the European VLBI Network (EVN) at 1.66 GHz in the dwarf galaxy SDSS J0906+5610, hosting an accreting intermediate-mass black hole. The yellow cross and circle mark the optical (Gaia DR2) centroid and the error circle. The contours increase by a factor of two.

THE "HOME ADDRESS" OF THE H_2O GIGAMASER IN TXS 2226-184

Gabriele Surcis, INAF Istituto di Radioastronomia, Italy

TXS 2226-184 is an elliptical/S0 galaxy located at a distance of about 110 Mpc that is spectroscopically classified as a low-ionization nuclear emission-line region (LINER), evidence for the presence of an Active Galactic Nucleus (AGN) and/or enhanced nuclear starburst activity. The weak radio emission from the core (see Fig. 1, left panel and zoom-in inset; Taylor et al. 2004, ApJ, 612, 780) is produced by a jet that extends over 100 pc. This galaxy gained importance in the extragalactic maser community because it is the site of one of the most luminous extragalactic H_2O masers ever observed (about 6000 solar luminosities; Koekemoer et al. 1995, Nature, 378, 697). Because of its unprecedented extreme luminosity, this maser source was labeled as "gigamaser". Since its discovery in 1995, no interferometric observations aimed to determine its absolute position have been conducted till 2017, when we started a series of very long baseline interferometry (VLBI) observations with the Very Long Baseline Array (VLBA, epoch 2017.45) and the European VLBI Network (EVN, epochs 2017.83 and 2018.44). In the last EVN epoch, we also carried out polarimetric observations to try, for the very first time, to detect the polarized emission of an extragalactic H_2O maser.

We succeeded in measuring the absolute position of the H_2O maser both with the VLBA and with the EVN; the measured positions agree within the uncertainties, confirming the potential contribution of the EVN also in this kind of studies. The EVN, in fact, is rarely used for determining the absolute position of extragalactic masers due to the limited frequency coverage of the K-band receivers installed at some of the European antennas which, in some cases, cannot cover the extragalactic H_2O maser line (note that the frequency of the line in extragalactic objects is offset from the rest frequency because of the Doppler effect, sometimes by up to one or more gigahertz). Unfortunately, no polarized emission was detected (PI<15%). However, this provides a relevant lower limit for similar future measurements.

We found that the H_2O maser emission originates close to the most luminous north clump of emission detected by Taylor et al. (2004, ApJ, 612, 780); in particular, the blue- and red-shifted maser features follow the arc-like morphology of the radio continuum emission of the brightest knot in the clump (see Fig. 1). However, what the maser features trace is still uncertain because the position of the nucleus of the galaxy is unknown yet. We can identify three possible scenarios considering the continuum emission as produced by a jet-outflow. Case I: the black hole of the AGN is located in the gap between the two largest continuum emissions. In this case, the maser features trace a shock due to the SE-NW orientation of the jet (jet-like maser). Case II: the black hole is located in the most luminous north clump. Two options are viable: the black hole is at the center of the continuum emission (case IIa) or the black hole is where the H_2O maser features arise (case IIb). In case IIa, the H_2O maser features trace a jet oriented SW-NE (jet-type maser) while in case IIb, they trace an edge-on accretion disk oriented SW-NE (disk-type maser). It is possible to wonder if the profile of the H_2O maser features can help to disentangle the nature of the maser.

Published in: Surcis, Tarchi, & Castangia 2020, A&A, 637A, 57S

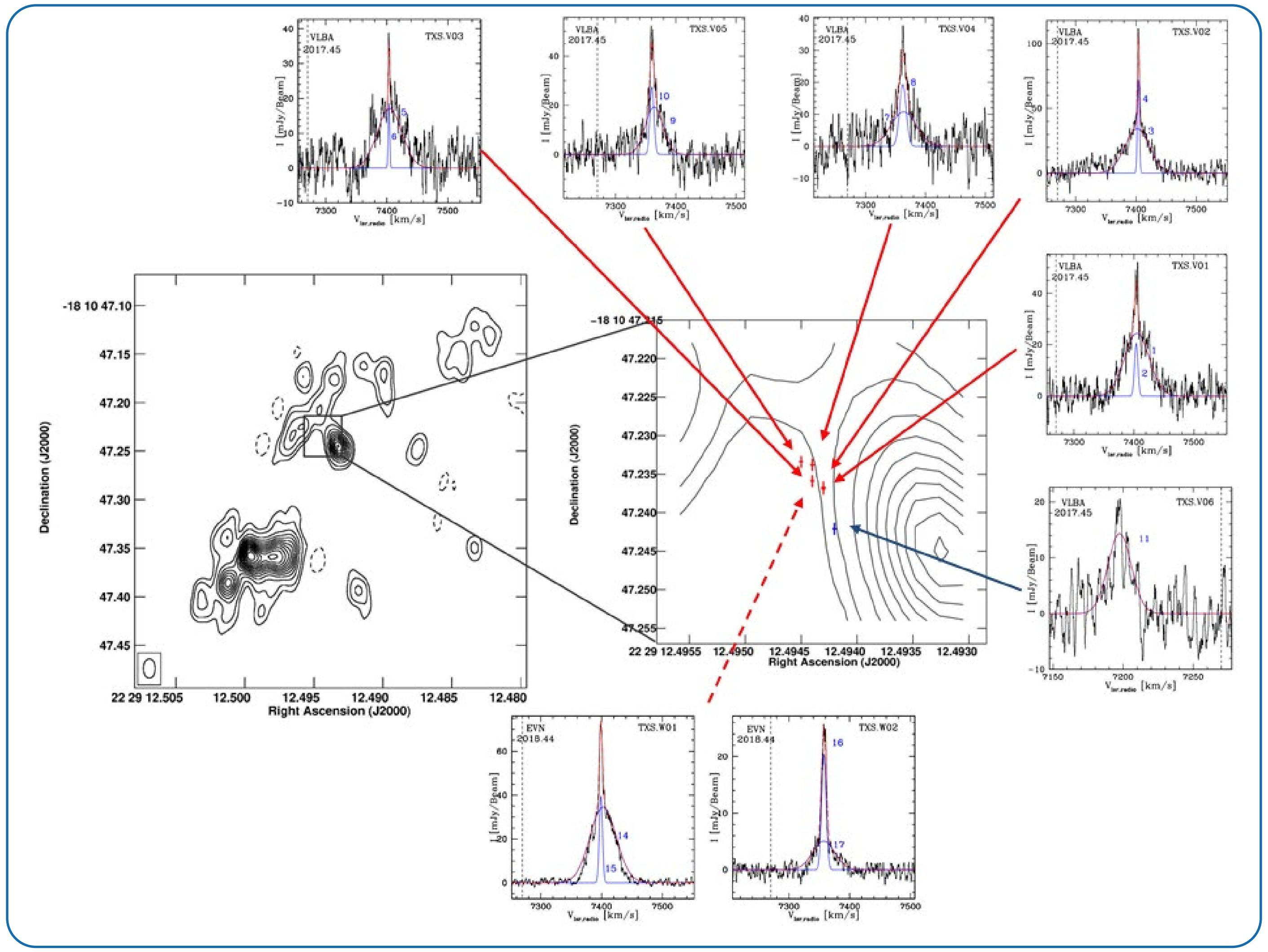


Fig. 1: Location of the red- and blue-shifted H_2O masers with respect to the systemic velocity of the galaxy detected with the Very Long Baseline Array (VLBA) in epoch 2017.45 (crosses). The six spectra (small panels) from top to the right are the H_2O masers detected with the VLBA in epoch 2017.45 (solid-line arrows), the two spectra at the bottom are the H_2O masers detected with the European VLBI Network (EVN) in epoch 2018.44 (dashed-line arrow). The continuum (left panel and zoom-in inset) is the 1.4 GHz emission of the nuclear region of TXS 2226-184 as observed with the VLBA in 2002 (Taylor et al. 2004, ApJ, 612, 780).

Actually, this adds more uncertainty. Indeed, the single-dish profile of the H_2O maser (e.g., Surcis, Tarchi, & Castangia 2020, A&A, 637A, 57S) shows only one group of maser features around the systemic velocity of the galaxy and it does not show the other two satellite groups, which are typically present in disk-type masers. On the other hand, the single-dish profile shows a notable stability over a time span of years, which is rarely found in jet/ outflow associated masers.

Further ongoing multi-frequency EVN observations of the radio continuum in the nucleus will allow us to determine the nature of the different radio knots and will help to disentangle between the aforementioned scenarios, providing a definite answer on the puzzling nature of the "gigamaser" in TXS2226-184.

VERY LONG BASELINE INTERFEROMETRY REVEALS THE ORIGIN OF HIGH-ENERGY NEUTRINOS

Alexander Plavin, Astro Space Center of Lebedev Physical Institute, Russia

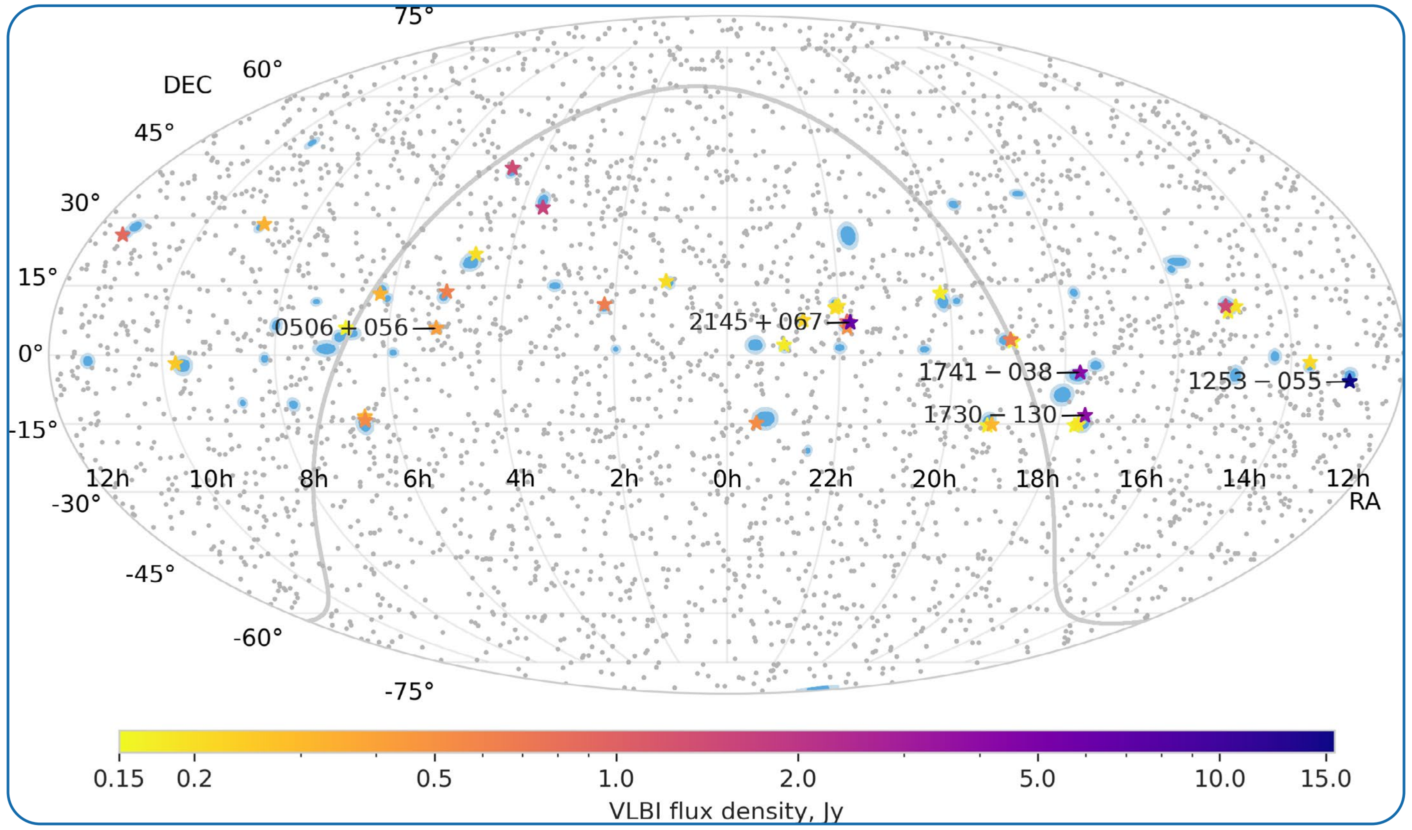


Fig. 1: Stars indicate Active Galactic Nuclei (AGNs) from the complete very long baseline interferometry (VLBI) sample that fall within the IceCube error regions (blue ellipses), and the flux density at 8 GHz is represented by the color. Four most probable associations are labeled, together with the first neutrino-AGN association, TXS 0506+056. Grey dots show all AGNs from the complete sample stronger than 150 mJy.

Neutrinos are mysterious particles that barely interact with other objects. They are observed with massive telescopes filled with ice or water, such as the IceCube Neutrino Observatory on the South Pole or Baikal-GVD at the Baikal lake; neutrinos with energies on the order of PeVs are routinely detected. Their origins and nature have mostly been unknown until recently, despite various dedicated searches.

We utilized 8 GHz very long baseline interferometry (VLBI) observations of a complete sample of 3388 Active Galactic Nuclei (AGNs) to determine whether they are the sources of high-energy neutrinos. It turned out that VLBI positions of bright quasars coincide with IceCube detection events more often than expected by chance: the p-value is 0.2%, corresponding to a significance of more than 3σ. Our findings reveal that a large fraction of neutrinos with energies of 200 TeV and higher are produced in the very central regions of quasars. These production regions are no larger than several parsecs - a size comparable to features typically seen in VLBI images. The four most probable AGN-neutrino associations not reported before are objects 3C 279, NRAO 530, PKS 1741-038, and OR 103. Moreover, we found a temporal coincidence between neutrino events and radio flares in AGNs on the timescale of months. This analysis was done using data from the long-term multi-frequency monitoring of VLBI-selected quasars at the Russian RATAN-600 telescope. The most pronounced example of a major radio flare correlated with a neutrino detection happened in 2019 at the source PKS 1502+106.

Our observational results strongly argue that a significant fraction of high-energy neutrino sources consists of AGNs with bright Doppler-boosted jets pointing towards us. Observed neutrinos are most likely produced in interactions of relativistic protons with photons from the accretion disk or other parts of active nuclei. For these interactions to happen, protons have to be accelerated to at least several PeVs in the central parsecs of AGNs along their compact jets. The mechanism of such acceleration is yet to be studied and explored in detail. We have started new dedicated programs with VLBI and RATAN-600 to cross-correlate with and follow new neutrino events. They will enable us and other astrophysicists to pinpoint the specific neutrino production sites within AGNs, evaluate the quantity of protons in the jets, and find out how and where these heavy particles are accelerated.

Published in: Plavin et al. 2020, ApJ, 894, 101

THE MOST DETAILED IMAGING OF THE BLAZAR'S 0716+714 JET FROM SPACE-VERY-LONG-BASELINE-INTERFEROMETRY OBSERVATIONS

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Blazars are a class of active galactic nuclei (AGN) that show extreme variability on various timescales. It is commonly accepted that they are powered by accretion onto super massive black holes, which is accompanied by the formation of two-sided relativistic jets. Due to a preferential orientation close to the line of sight (~5 degrees), they exhibit apparent superluminal speeds of a few tens of the speed of light, which yields significant enhancement of their emission. These mechanisms make AGNs some of the most powerful objects in the Universe.

0716+714, known as one of the most active blazars on the sky, was the first AGN imaged with the RadioAstron space very long baseline interferometry (VLBI) mission that featured a 10m antenna on board of the Spektr-R satellite. Few years later, in 2015, new high-resolution polarimetric observations of the blazar have been conducted with RadioAstron and eleven radio telescopes of the European VLBI Network (EVN). As a result, the most detailed to-date radio image of the 0716+714 jet has been constructed, at an unprecedented resolution of 24 μas, shown in Fig. 1.

In this image, we revealed that the radio core or visible base of the jet remains unresolved. Meanwhile, we captured a significantly bent structure of the central 100 μas, such that the jet initially extends toward the southeast and then bends toward the more-larger-scale structure. We suggest that due to the small viewing angle of the 0716+714 jet of about 5 degrees and intrinsic opening angle of the outflow of about 2 degrees, we observe the jet directly from inside. Therefore, the inner jet may appear bent as individual emerging features are ejected at different position angles that are amplified by projection effects. Additionally to this, we detect a compact linearly polarized component located about 58 μas downstream from the core. Presence of such compact structures in the 0716+714 jet can explain the strong intrinsic variability of the blazar in total and polarized intensities on the timescales of about two days to a week. However, the nature of the much faster, intra-day variability of 0716+714 still remains an open question.

Published in: Kravchenko et al. 2020, ApJ, 893, 68

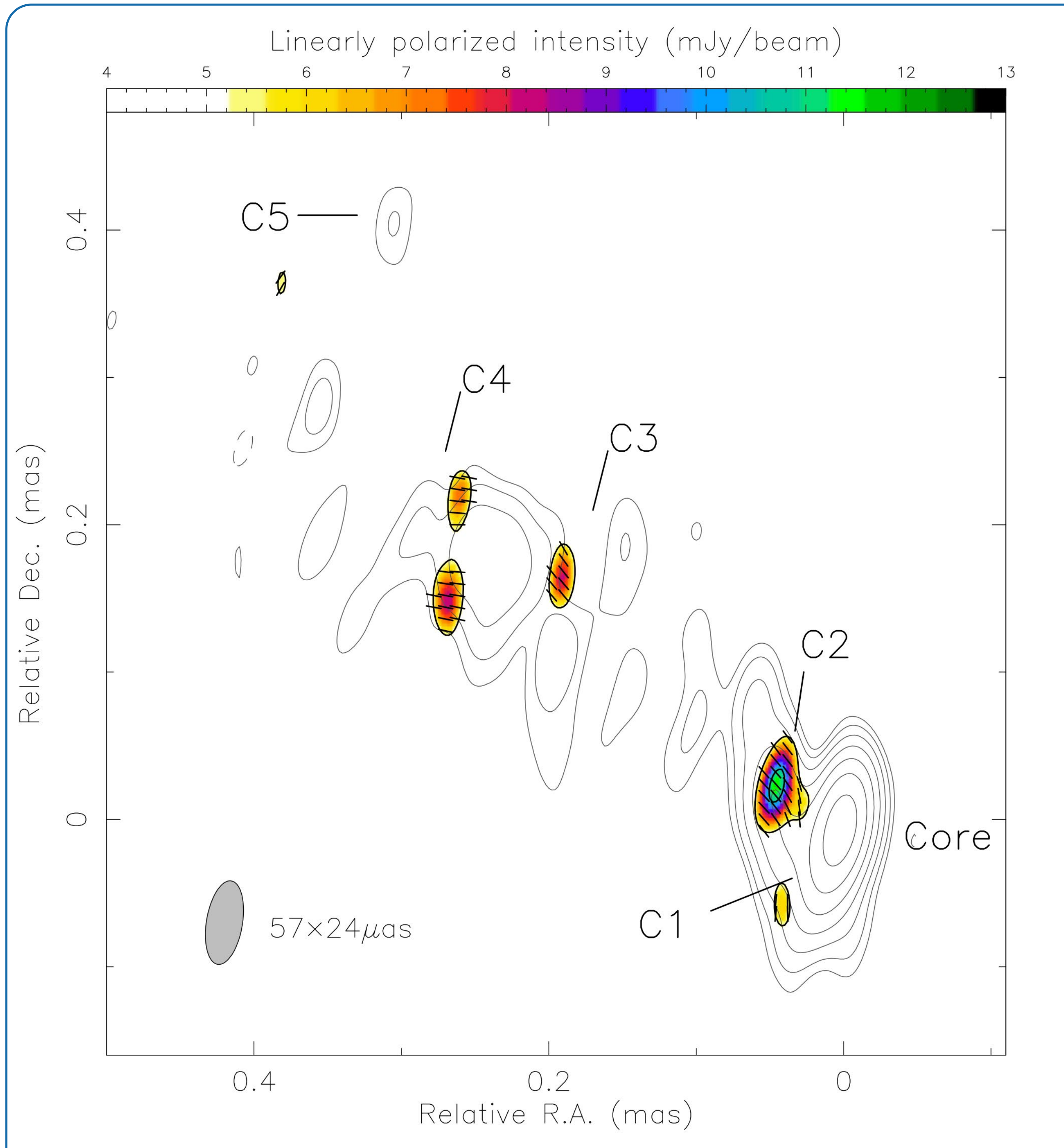

Fig. 1: The most detailed RadioAstron image of the 0716+714 jet from observations taken on 3–4 January 2015 at 22 GHz (Kravchenko et al. 2020). Black contours depict the total intensity and the linearly polarized intensity is given in color. The modelled radio core and emission jet features are indicated in the image. The shaded ellipse displays the synthesized beam.

THE E-MERLIN GALAXY EVOLUTION SURVEY OF GOODS-NORTH – E-MERGE DR1 RELEASE

Thomas Muxlow & Alasdair Thomson, Jodrell Bank Centre for Astrophysics, University of Manchester, UK

The e-MERGE consortium is producing a μJy-sensitivity high resolution (≥~270 mas) survey at low frequencies with the unique capabilities to resolve, image, and characterise the star-formation (SFG) and Active Galactic Nucleus (AGN) components associated with galaxy formation across cosmic time utilising the steep-spectrum synchrotron emission emitted in galaxies within the GOODS-N field. GOODS-N has excellent deep multi-band datasets with the Hubble Space Telescope (HST) imaging at comparable angular resolution to the enhanced Multi Element Remotely Linked Interferometer Network (e-MERLIN). e-MERGE imaging separates SFG emission from AGN-powered core-jet structures to investigate any interaction and feedback. e-MERGE is a combination of the Very Large Array (VLA) and an e-MERLIN Legacy programme with images at both 1.5 and 5.5 GHz. The 1.5 GHz element contains >400 hrs of e-MERLIN observations (including the Lovell telescope) & 40 hrs of the VLA with a wide-field covering the central 30 arcminutes (around 36M highest resolution beam areas) of GOODS-N with sub-μJy sensitivity at the field centre which will contain ~5000 detectable radio sources. The spatial-frequency coverage of the VLA + e-MERLIN combination datasets (Fig. 1) are near complete allowing very high fidelity imaging on angular scales from ~30–~0.15 arcsec for radio structures found in the sources detected within GOODS-N.

The first e-MERGE data release (DR1) contains just 25% of the e-MERLIN data with combination images across a range of 1.5 GHz resolutions from the VLA alone to full enhanced Multi Element Remotely Linked Interferometer Network e-MERLIN with a best combination sensitivity ~1.25 μJy/beam at the centre of a 15 arcminute field containing 848 catalogued VLA sources. The majority are SFGs. Only two classical double radio-structured AGN (one Wide-Angled Tail (WAT) & one Fanaroff & Riley Class I (FRI)) are seen, with the remaining radio AGN showing core-jet structures (both one- & two-sided) with extensions on (sub-) galactic scales. The characteristics of the radio sources with optical counterparts are shown in Fig. 2.

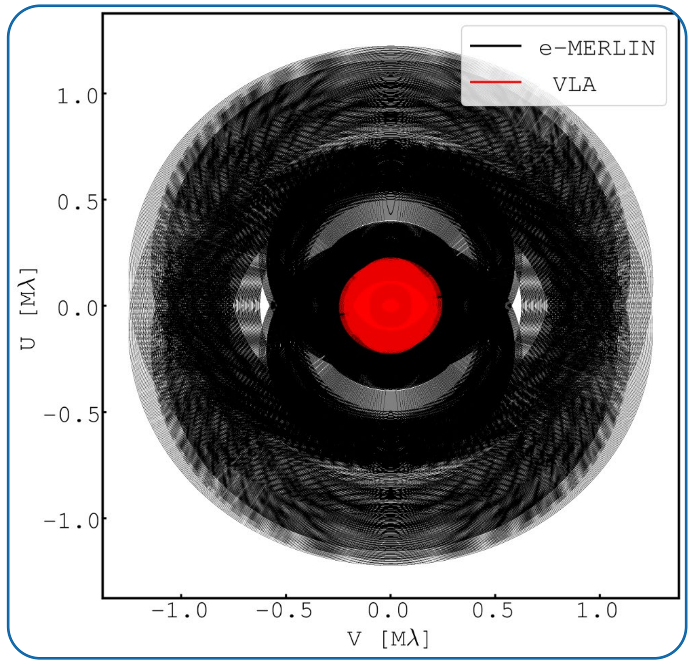

Fig. 1: Enhanced Multi Element Remotely Linked Interferometer Network (e-MERLIN) + Very Large Array (VLA) 1.5 GHz combined spatial frequency coverage.

All but the two classical AGN double radio sources thus have linear sizes <20 kpc. The WAT (Fig. 3, at full e-MERLIN resolution) is respectively ~3x more luminous and ~4x more compact than typical local WAT systems at redshifts between 0.1 and 0.5. Spectral index imaging between 1.5 and 5.5 GHz derives a synchrotron spectral age of 50–70 Myr, indicating that this may be a young object. The WAT (total flux density at 1.5 GHz of 5.5 mJy, with a peak of 217 μJy/beam, beam= 309 x 213 mas) has a central compact component overlying the nucleus of

Published in: Muxlow et al. 2020, MNRAS, 495, 1188

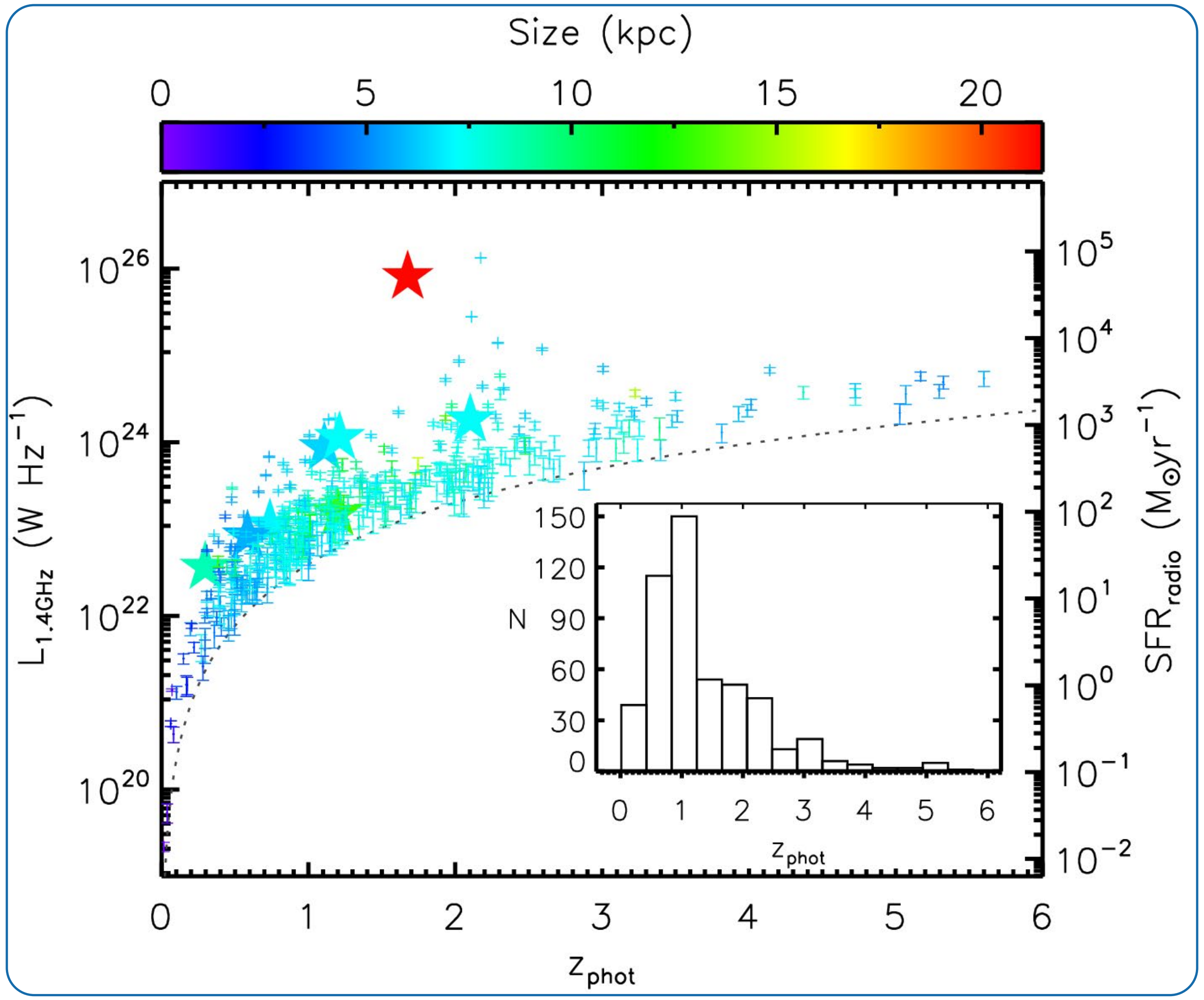

Fig. 2: The luminosity–redshift plane for e-MERGE DR1, including the 587 radio-detected sources with optical counterparts within 1.5″ from the 3D Hubble Space Telescope catalogue (Skelton et al. 2014). We measure rest-frame L1:5 GHz from our observed-frame 1.5 GHz flux densities using this redshift information, along with the measured radio spectral index. To illustrate our sensitivity to star formation rate (SFR) as a function of redshift, we use the 1.5 GHz-to-SFR conversion factor of Murphy et al. (2011), which highlights our ability to detect high-SFR systems at large-redshift (i.e. SFR ~100–1000 M_{Sun} yr^{-1} at z ~2.5). Points are colour-coded by the fitted radio sizes, with sources which lack a significant size measurement coloured in charcoal. The Fanaroff & Riley Class I (FRI) with a linear size of ~370 kpc is the only radio source excluded from this figure. Large symbols refer to sources discussed in the description paper (Muxlow et al. 2020). The large red symbol refers to the Wide-Angled Tail (WAT) discussed below. Inset: The photometric redshift distribution of e-MERGE Data Release 1 peaks at <z> = 1.08 ± 0.04, with a tail (accounting for ~15% of the sample) lying between z = 2.0–5.6.

a high redshift massive I= 23 mag elliptical galaxy, which is coincident with a mas core component (marked in red) detected by Radcliffe et al. (2018) as observed with the European VLBI Network (EVN; EG078). This figure demonstrates the quality of imaging provided by e-MERGE on the weak radio source population in GOODS-N.

Imaging using the EVN in combination with e-MERGE, which extends the spatial frequency coverage to baselines >10 000 km is underway (Radcliffe et al. 2020, submitted), allowing detailed studies of AGN induced feedback in many of the GOODS-N submillimeter galaxies (SMGs); and by mapping the core-jet structures of those AGN systems present, will probe the evolving nature of the AGN population in faint radio sources at high redshift.

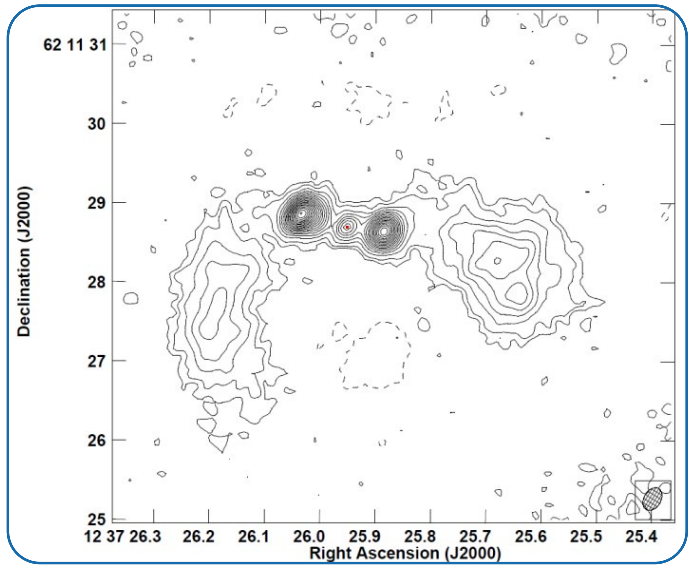

Fig. 3: e-MERLIN 1.5 GHz image of the Wide-Angled Tail Source. Contours: -1, 1, 2, 4, 6, 8, 10…..40 x 2.5 σ (1σ= 2.38 μJy/beam; primary beam corrected for 4.5 arcmin from beam centre).

The Lovell telescope essentially doubles the sensitivity of e-MERLIN. The e-MERGE sensitivity would not have been possible without the contribution of the Lovell telescope to the central 15 arcminute field – ultimately leading to the sub-μJy sensitivity which will be available with the full e-MERGE dataset release (DR2) scheduled for 2021.

Photo credit: Ant Holloway, JBCA

MULTI-FREQUENCY OBSERVATIONS OF PERIODIC MASER SOURCE G107.298+5.639

Mateusz Olech, Nicolaus Copernicus University, Poland

One of the most important tracers of high-mass star formation is the methanol maser emission at 6.7 GHz. High angular resolution and sensitivity of the European VLBI Network (EVN) allows us to study this phenomenon in unprecedented detail. Among all known sources of this type, a small group of 23 masers was discovered showing peculiar behavior – repeating flares with periods ranging from ~20 to ~600 days. In 2016, we reported the discovery of the first known object G107.298+5.639, showing anti-correlated bursts of the methanol 6.7 GHz and water 22 GHz masers (Szymczak et al. MNRAS, 459, L56–L60, 2016).

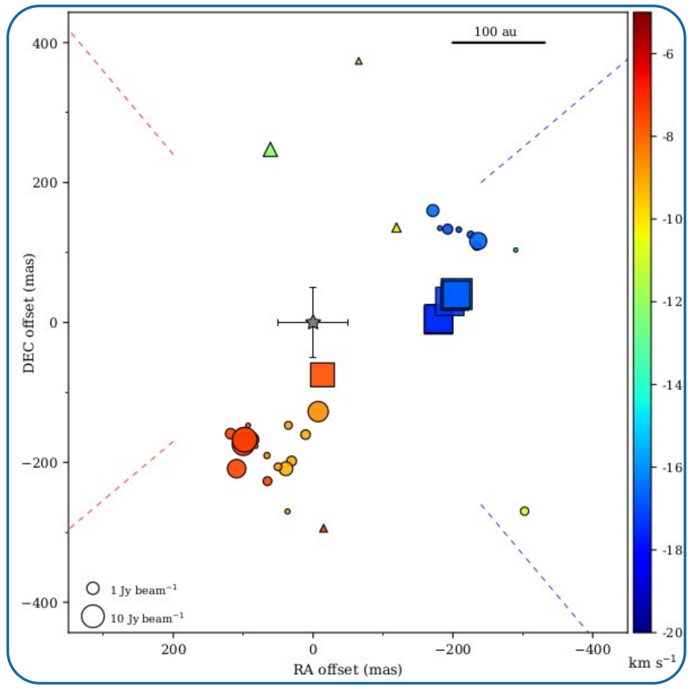

Fig. 1: Composite map of methanol (circles), water (squares) and hydroxyl (triangles) maser emission in the source G107.298+5.639. The grey star represents the known 1.3 mm continuum position and the dotted lines show directions of large scale molecular outflows.

This discovery posed the question which process could trigger this kind of behavior. Current understanding is that those transitions are powered by different mechanisms. Methanol masers are pumped by infrared (IR) radiation and water vapor masers by shocked gas. Furthermore, further observations have shown that OH masers at 1.6 GHz are periodic synchronously with the methanol masers.
To understand this source, we devised a very long baseline interferometry (VLBI) observation plan, covering all of those transitions.

The results show that all species are located no more than ~400 au from the continuum source and water and methanol features of similar velocity are close to each other. That suggests that they could occupy the same physical region (Fig. 1). This could give the explanation to anti-correlated behavior. An excess of IR radiation could in theory lower the pumping efficiency of water masers causing them to decrease in brightness while at the same time powering methanol and hydroxyl masers.

Thanks to long-lasting single dish monitoring we could detect and calculate delays in flares between features in the 6.7 GHz and 1.6 GHz lines. Combining those values and assuming a radially expanding IR wave of radiation, we could recover the 3D structure of the source (Fig 2.). Most features of the methanol masers show a circular structure with a radius of 242 au and an average thickness of 30.1 au suggesting that they are located in an accretion disc.

Published in: Olech et al 2020, A&A 634, A41

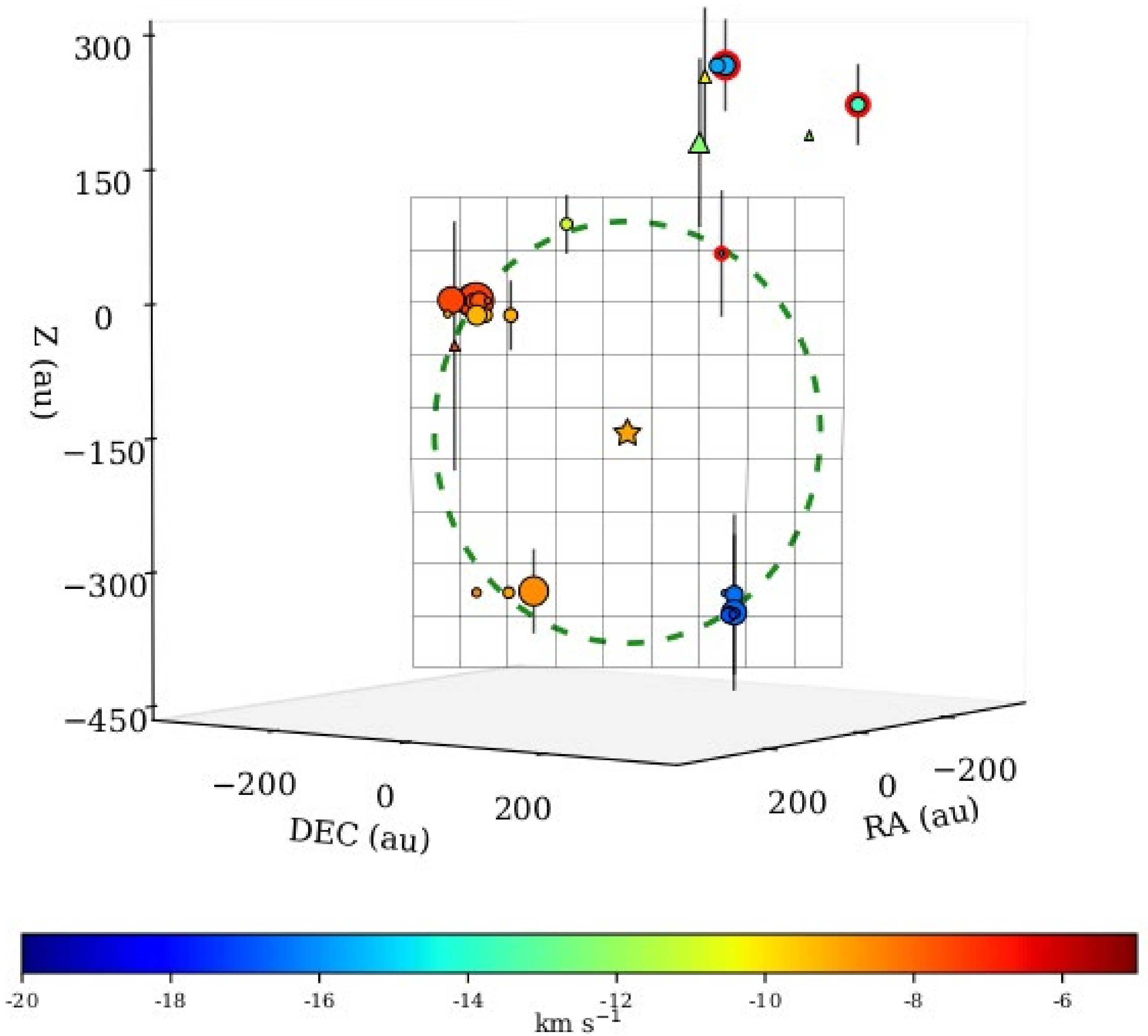

Fig 2: 3D structure of the methanol and hydroxyl masers. The yellow star represents the central source. The green dashed line shows the best fit to the circular structure of the methanol maser cloudlets.

STATUS UPDATE FROM THE MEDICINA AND NOTO STATIONS

Tiziana Venturi, INAF Istituto di Radioastronomia, Italy

At the end of November 2019, during a planned maintenance of the actuators of the Noto Active Surface System, anomalies and strange "rifts" of the paint in some beams of reticular structure where the counterweight supports are tightened, were reported. After a closer investigation, we discovered deep "cracks", affecting a large part of the section of two steel girders. The girders are located in between panels girth 5 and 6 at the location of the two counterweights of the telescope. Taking the counterweights as reference point, the two broken beams were the ones on the side where the telescope descends in elevation. A week later, during a dedicated inspection, exactly the same damage emerged in the twin telescope of Medicina. For safety reasons, our institute decided an immediate stop of all movements of both telescopes.

Fig. 1: Crack after the coating removal.

The type of damage was reasonably traceable to a "fatigue" issue as a consequence of the load cycles of the backup structure during movements along the elevation. In recent years (from 2010 to 2020), we had other failures with the same origin, the load cycles caused the break of the shaft and the bearing of an azimuth driving wheel three times. In the light of these facts and in order to better understand the general status of the mechanical structure of the two telescopes, our institute assigned a fatigue analysis to an engineering company (BCV).

The company performed a complete study based on the Finite Element Model (FEM) of our antennas, taking into account only the effects of gravity (no wind or other factors).

The fatigue of critical nodes and beams of the structure was computed considering a duty cycle deduced from an average involvement (European VLBI Network (EVN), International VLBI Service for Geodesy and Astrometry (IVS) and single-dish experiments) of the two telescope throughout their activity, i.e. starting from 1983 for Medicina and 1988 for Noto.

The final report was delivered in January 2020. It clearly shows that the stress and the strain concentration on the broken steel girders was well beyond the limits of the low cycle fatigue. It also highlights the areas of the structure that are most sensitive to the phenomenon of the fatigue. This information will be particularly useful for future inspections which will be focused on these parts and for further analysis which will be carried out through a more detailed modelling of the critical nodes. The maintenance, consisting of the replacement of the steel girders, was delayed several months due to the lockdown imposed by the Italian government to counter the COVID-19 pandemic. Noto started operation again in July, Medicina in August 2020.

Other extraordinary repairs, worth to be mentioned, were recently carried out. In particular:

- Installation of a new L-S-X-band receiver in Noto
- Refurbishment of Noto's Active Surface. Electronic components and cabling of some actuators were replaced with new spare parts.
- Replacement of rail carts of linear actuators of Noto's secondary mirror.
- Replacement of the shafts and the bearings of the two not driving wheels in Medicina.

Development for higher frequencies and increased bit rates

Projects aimed at increasing the observing frequency and raising the data rates of both Medicina and Noto are funded and ongoing. It is worth to mention:

- A new Active Surface System is to be installed in Medicina. The upgrade will involve:
  - * new aluminum panels with enhanced surface accuracy;
  - * electromechanical actuators to move panels in order to compensate for gravitational deformation;
  - * completely new sub reflector with low RMS surface (one will be provided for Noto as well).
- Simultaneous 3-bands receiver (18-26, 34-50, 80-116 GHz) to be installed both in Noto and Medicina. The receiver outputs large bandwidth IFs (K-Band: 8 GHz, Q-Band: 16 GHz and W-Band 16+16 GHz) that will be down-converted to tuneable 2-GHz bands.
- A new DBBC version 3 is to be installed at Medicina and Noto.

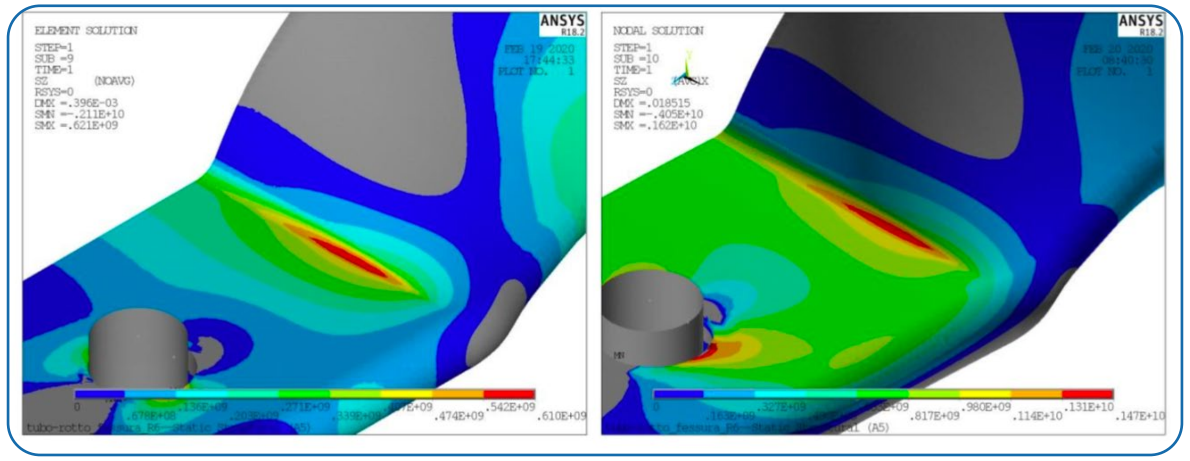

Fig. 2: Stress lines on the broken beam resulting from the Finite Element Analysis.

UPGRADES FOR METSÄHOVI RADIO OBSERVATORY

Juha Kallunki & Joni Tammi, Aalto University, Metsähovi Radio Observatory, Finland

Fig. 1: The 14-metre radio telescope saw daylight for the first time in decades on 24 June 2020; but only for a few hours (photo credit: Aalto University / Kalle Kataila).

Summer 2020 has seen major upgrades for the Aalto University Metsähovi Radio Observatory (MRO), Finland.

First, the main instrument, the 14-metre radome-enclosed radio telescope, had its steering system fully updated in March–April 2020: the old DC-servo motors were replaced with a modern AC-servo system, and the high-speed gears and position sensors were renewed. The main motivation for the upgrade was to reduce maintenance needs, but additional minor improvements include slightly faster movement (maximum turning speed increased from 1.2 to 1.5 m/s) and lower maintenance and usage costs. The upgrade was made by a local company, Roll Research International Ltd, originating from R&D work in the Aalto University's Department of Machine Design. Similar motor upgrade is currently ongoing for one of MRO's smaller solar radio telescopes (1.8 m).

In addition to the telescope upgrades, the protective radome of the 14-m radio telescope was replaced in June 2020. The new 20-metre radome, manufactured by LT3-Harris (former ESSCO), is identical to the old one. The installation work was managed by Polish Radome Service (PRS). After initial delays due to the COVID-19 pandemic, the actual work proceeded quickly, aided by exceptionally good weather and long Finnish summer days with roughly 20 hours of sunlight each day allowing for long and uninterrupted work. The whole construction, including dismantling the old radome, took only 14 days, which, according to PRS, was "the fastest assembly ever." The actual change of the radome took place on 24 June 2020, starting at sunrise, before 4 AM, when the wind and humidity were minimal.

Finally, the observatory itself has been completely renovated during 2019–2020. The work includes demolishing the original 1970s observatory building (still existing in the aerial photograph, to the right of the radio telescope, but now removed), renovating the office wing built in the 1990s, and building a completely new wing with seminar facilities and student offices, social and kitchen spaces, with fully upgraded infrastructure including geothermal heating, etc. This work has been progressing slowly because of Metsähovi's zero-tolerance for radio frequency interference, but finally, in August 2020, the new premises became finally available for staff. The last phase of the renovation, an external laboratory building is still under construction, and should be finished in December 2020.

In total, Aalto University has been investing more than three million euros for Metsähovi's upgrades in the last two years, which is very exceptional in Finland, where other universities have been closing their observatories and reducing funding for astronomy. Despite the bad start of the 2020s globally, all things considered, for MRO the new decade is looking good.

A SUCCESSFUL JBO AND E-MERLIN RESTART IN TIME TO 'RE-JOIN' EVN OBSERVATIONS

Robert Beswick, Jodrell Bank Centre for Astrophysics & Jodrell Bank Observatory, UK

Fig. 1: Rainbow over MK2 (photo credit: Ant Holloway (JBCA/UMAN)).

Following the longest shutdown of operations in its history, Jodrell Bank Observatory (JBO) and enhanced Multi Element Remotely Linked Interferometer Network (e-MERLIN) operations were successfully restarted in May/June 2020. This was just in time for the first science operations of e-MERLIN telescopes to be part of the European VLBI Network (EVN). Due to the hard work of the engineering and operations team up to six e-MERLIN telescopes were available for the later part of the 2020 EVN session II, helping to mitigate for other unavailable stations.

Like many activities in Europe and around the world, e-MERLIN observations and onsite operations at Jodrell Bank Observatory were paused on 17 March 2020 in order to help to curb the COVID-19 pandemic. This necessary action was put in place ahead of the UK's nationwide lockdown and was in-step The University of Manchester's closure of campus activities to all but essential services and COVID-19 related research and activities. During this period Jodrell Bank Observatory and e-MERLIN team, like so many other people, have been working incredibly hard from home to keep services available and prepare to restart full observatory operations, whilst maintaining all safe working protocols. This complex task was completed well ahead of our expected recommissioning schedule which allowed a substantial proportion, and in some case up to six, of the e-MERLIN telescopes to participate in EVN and electronic very long baseline interferometry (e-VLBI) experiments through May and June. Involvement in the EVN session II was a key driver and deadline for this effort. Many thanks go to all staff at JBO, Joint Institute for VLBI-ERIC (JIVE) and across all of the EVN stations involved and whose commitment helps make the EVN be such a productive instrument.

Since July 2020, e-MERLIN Legacy, PI-proposal observing programmes are now fully underway, albeit in a largely remote operational mode. We expect e-MERLIN involvement to be available in future EVN and e-VLBI experiments. The current active e-MERLIN Cycle-10 observing period has been extended so that no projects are negatively affected by the disruption. However, we recognise that some time-critical programmes, and student or early career scientist programmes may be more impacted by these delays. Where this is the case we invite PIs (or contact authors) to contact the e-MERLIN scheduling team (schedulers@jb.man.ac.uk) to discuss requirements so that we can provide as much assistance as possible. Additionally, e-MERLIN is now open and accepting Target of Opportunity requests from active programmes, and Director's requests for Observing time for exceptional events.

The next open PATT e-MERLIN call for proposal (Cycle-11) will be announced in September with a deadline later in autumn 2020.

The e-MERLIN science and operations team are available to offer remote support to users, including delivery of data that has been observed and supporting data reduction tasks. If you require any assistance please do not hesitate to email: emerlin-support@jb.man.ac.uk.

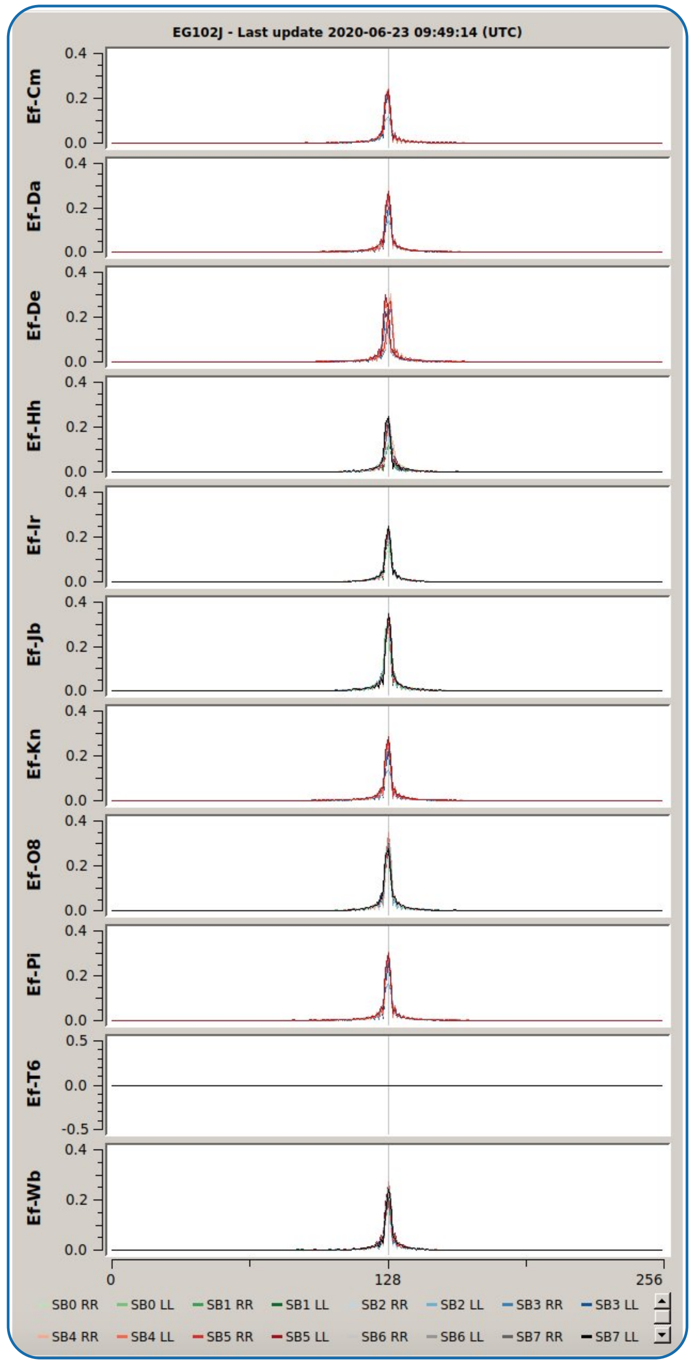

Fig. 2: European VLBI Network (EVN) fringes from 23 June 2020, involving six enhanced Multi Element Remotely Linked Interferometer Network (e-MERLIN) telescopes (MK2, Kn, Pi, Da, De, Cm).

RENEWAL OF THE 32-METER RADIO TELESCOPE IN TORUŃ

Krzysztof Katarzyński & Agnieszka Słowikowska,
Nicolaus Copernicus University in Toruń, Poland

The 32-meter radio telescope located at the Institute of Astronomy of the Nicolaus Copernicus University in Toruń is the largest instrument of this type in Poland. This antenna is an important part of the European VLBI network. After almost 25 years of uninterrupted observation work, the radio telescope has undergone a major renovation. Numerous corrosion centres have been removed from the antenna structure, and the entire instrument was repainted with particular attention paid to the appropriate protection of reflective surfaces of the antenna. The defects in the concrete foundations of the radio telescope will be also supplemented and renewed.

Additionally, during renovation works, the signal cables between the antenna and the control room were replaced. The new cables will ensure the transfer of intermediate frequencies in the 0 to 2 GHz range, with much lower attenuation above 1 GHz compared to the previously used connections. Parallel to this work, thorough maintenance of the receiving systems was carried out, where some cryogenic preamplifiers and filters were replaced. The break in the operation of the radio telescope was also used to modernize the computer and internet infrastructure. The instrument will be restored to scientific work by 16 October 2020 at the latest.

Fig. 1: Toruń 32-m radio telescope (photo credit: Przemyslaw Szatkowski (left), Pawel Wolak (right)).

OTHER NEWS

EUROPEAN VLBI NETWORK E-SEMINAR SERIES – CONNECTING ASTRONOMERS WORLDWIDE

Denise Gabuzda, University Collage Cork, Ireland
Benito Marcote, Joint Institute for VLBI-ERIC

The European VLBI Network (EVN) has just initiated a series of online seminars "The Sharpest View of the Radio Universe". Seven talks will be spread out between early July 2020 and the date of the 15th EVN Symposium, which has been rescheduled to 12–16 July 2021. These talks aim to illustrate how very long baseline interferometry (VLBI) can improve our understanding of many astronomical phenomena, from

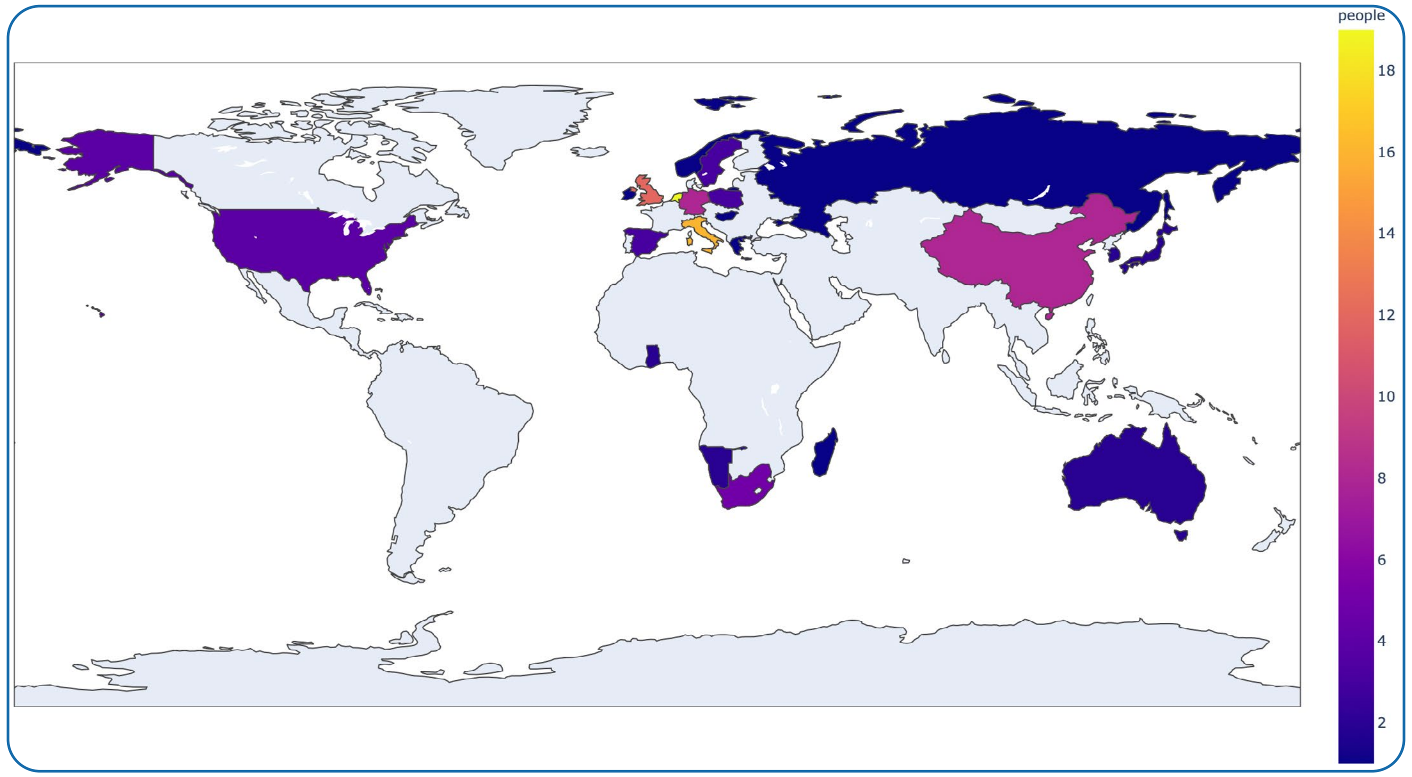

Fig. 1: Number of participants from various countries who joined the first European VLBI Network e-seminar via Zoom.

stars to galaxies. The talks target a broad astronomical audience, and include ample time for questions and discussion. The speakers will come from VLBI groups around the world.

Full information about the webinars, which are run using Zoom and simultaneous streaming to YouTube, can be found at https://www.evlbi.org/evn-seminars.

The first seminar took place on Wednesday, 8 July 2020, with Dr. Cristiana Spingola (University of Bologna) talking about "Using Strong Gravitational Lensing to Zoom in on High-Redshift Galaxies". The talk was attended by about 100 participants, and a similar number of viewers have watched the recorded seminar on YouTube since then.

The map in Fig. 1 shows the locations of the Zoom participants by country. Despite the fact that the time was not convenient for some time zones, the seminar reached a global audience.

The next seminar will be given by Dr. Yuri Kovalev on 4 September 2020 at 14:00 CEST, on the topic "VLBI as a Key to the Origin of Neutrinos".

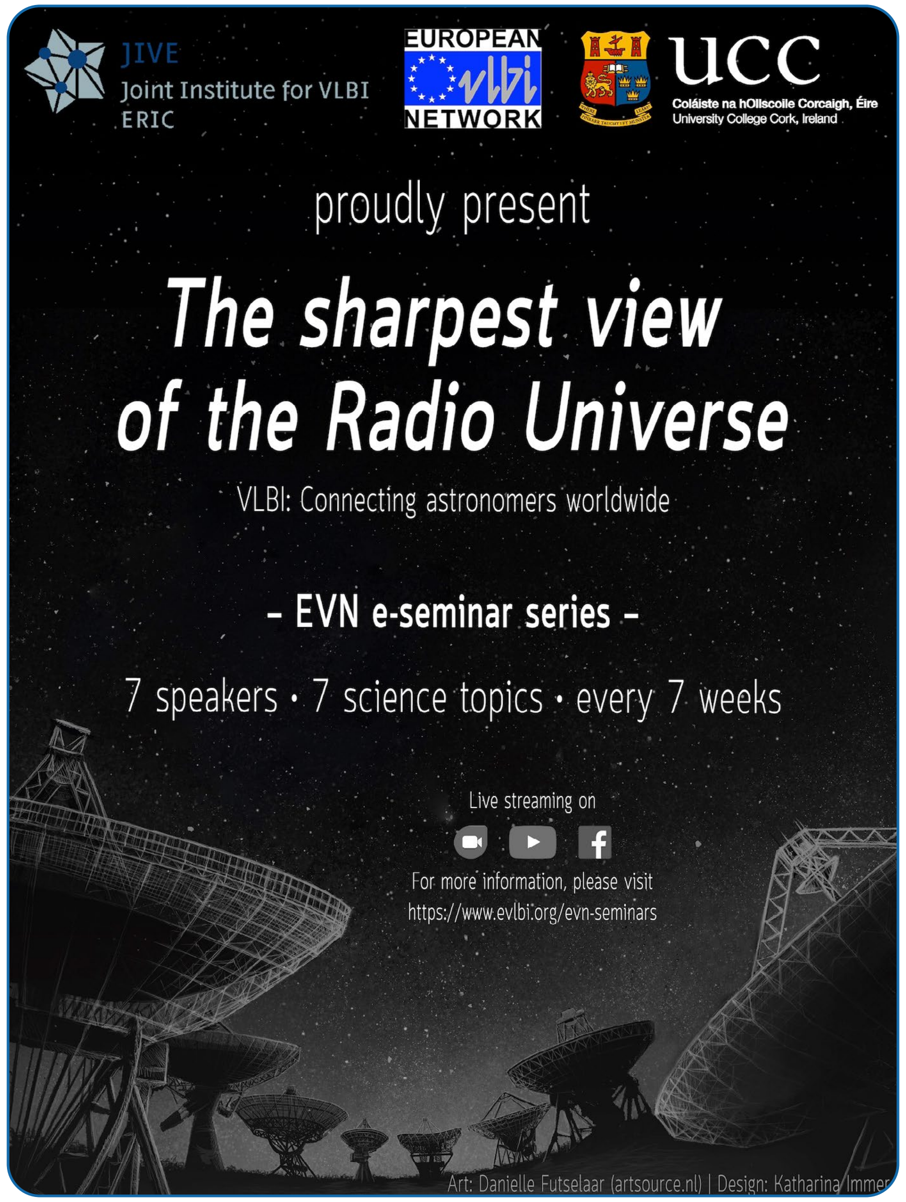

Fig. 2: Poster for the European VLBI Network e-seminar series.

EAS SPECIAL SESSION 16: REGISTERING THE UNIVERSE AT THE HIGHEST ANGULAR RESOLUTION

Ilse van Bemmel, Joint Institute for VLBI-ERIC

One of the main goals of the Joining up Users for Maximizing the Profile, the Innovation and Necessary Globalization of JIVE (JUMPING JIVE) project (see "News from JUMPING JIVE" on page 30in this newsletter) is to advocate the use of very long baseline interferometry (VLBI) to the astronomical community. In that context, a special session was organized at the European Astronomical Society (EAS) annual meeting, which took place from 29 June through 3 July 2020 on a virtual platform.

The aim of this special session was to demonstrate the potential of VLBI observations in a range of astronomical fields. The session took place on Monday, 29 June, and covered stellar evolution, active galaxies, multi-wavelength, transients and multi-messenger astronomy.

The multi-wavelength approach was a common theme in many of the presentations. Sera Markoff illustrated the necessity and complexity of studying M87 at a range of radio frequencies and high energies, in order to pin down the physics close to the black hole. This was further explored in the session on active galaxies, where Monica Orienti showed how VLBI observations complement high energy data, enabling localization, spatial resolution and, therefore, a better understanding of the connection between radio and high energy emitting processes.

On a smaller scale, this link is also explored in studies of Young Stellar Objects, where the combination of VLBI and X-ray observations traces the non-thermal emission close to the young star, and yields important information about the accretion processes. These are not smooth but can vary strongly with time, as shown in very interesting talks by Agnés Kóspal and Jan Forbrich.

Laura Spitler gave an update on the latest findings in Fast Radio Bursts (FRBs), where the localization capabilities of VLBI played an essential role. Only the VLBI spatial resolution allows for identifying the location of the burst inside the host galaxy, and thus opens the way for studying the environment of the burst and its physics.

At low frequencies, the Low-Frequency Array (LOFAR) is complementing the cm-VLBI. Leah Morabito presented the ongoing work and pipeline development of the LOFAR long-baseline team and the enormous scientific potential of this instrument. The entire Northern hemisphere has been surveyed at full resolution and is being processed by the team.

At the high energy end of the "radio" spectrum, the Extremely Large Telescope (ELT) will provide unprecedented spatial and spectral resolution in the near-infrared. Michele Cirasuolo demonstrated the power and discovery potential of this instrument, which is under construction and will come online in the next decade. Christina Garcia Miro highlighted the science opportunities of VLBI with the Square Kilometre Array (SKA), a timeline which overlaps with the ELT operations. Almost every field in astronomy will make enormous leaps when these two instruments can be combined.

The special session very clearly demonstrated how the unique capabilities of VLBI can play a key role in many fields and many different ways. The role of VLBI in global astronomy is still growing, and with the advent of new instruments will only continue to do so.

In addition to the invited speakers named above, seven contributed speakers presented their work, and there were five poster pitches. Around 60–70 people attended the session, with peaks of over 80 attendees for highly popular talks. Most presentations of the session are available through the JUMPING JIVE wiki.

The Scientific Organizing Committee (SOC) wishes to thank the team at Kuoni and the EAS for making this meeting possible in very adverse conditions. It was a unique and very positive experience, and hopefully will open new ways of sharing scientific results.

This special session and the invited speakers have received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 7308844 (JUMPING JIVE).

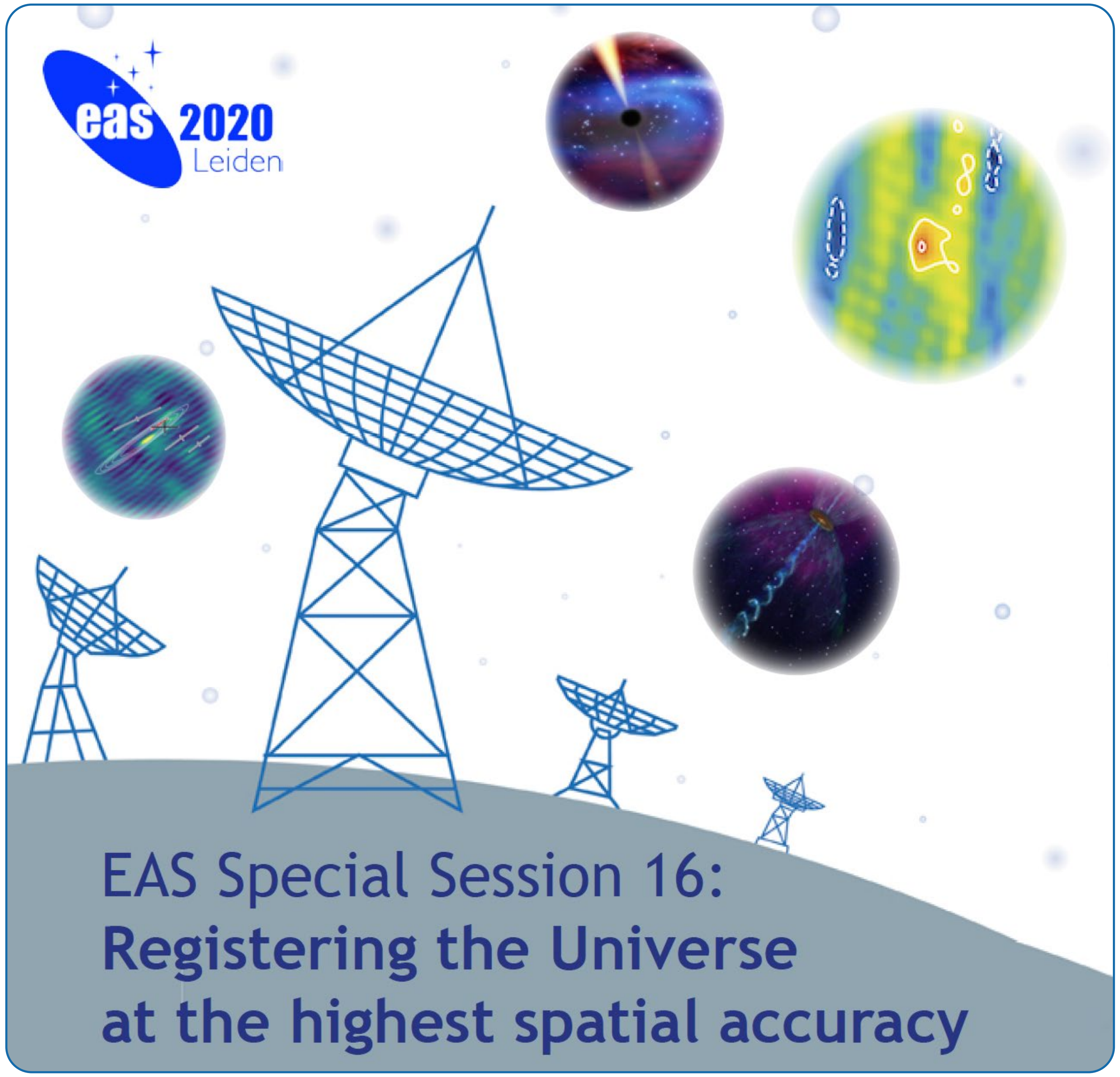

Fig. 1: Announcement poster for the European Astronomical Society (EAS) Special Session 16.

NEWS FROM JUMPING JIVE

Giuseppe Cimò, Joint Institute for VLBI-ERIC

The work of the European Union's Horizon 2020 project JUMPING JIVE (Joining up Users for Maximizing the Profile, the Innovation and Necessary Globalization of JIVE) has continued during these months of pandemic. Although lockdown regulations have limited some of the project activities, JUMPING JIVE is in good health and everyone involved in the project has worked hard to maintain the high impact that JUMPING JIVE is making in the astronomical community and beyond.

With less than a year remaining in the project, it is worth to look at the outstanding efforts of JUMPING JIVE in advancing the sustainability of the Joint Institute for VLBI-ERIC (JIVE), developing new capabilities for the European VLBI Network (EVN) and working towards the future of very long baseline interferometry (VLBI).
An important part of the project is to strengthen existing collaborations, to build new partnerships and to attract new users. JUMPING JIVE has supported trips and promoted activities to raise awareness of JIVE and the EVN among the public, the astronomers and the policymakers. A recent example is the organization of a special session at the EAS 2020 (see "EAS Special Session 16: Registering the Universe at the highest angular resolution" in this newsletter).

Another goal of JUMPING JIVE is to enhance the capabilities of the EVN so that old and new users can benefit from a modern and competitive array. Several improvements at existing stations have been shared with the EVN community and with prospective new partners. New tools for operation and user feedback have been developed within JUMPING JIVE and are currently used during the EVN sessions. A more modern way of scheduling EVN observations is now available to the users: pySched makes the process of scheduling VLBI observations much easier for old and new users. The feedback on the refactored SCHED and the new possibility of supporting a larger variety of hardware indicate that pySched is the way to retain decades worth of gained experience whilst providing a way to support the fast-changing world of hardware in the field of digital radio astronomy. Moreover, the EVN userbase can be expanded thanks to the work on the correlation of geodetic data.

Fig. 1: Logo.

JUMPING JIVE is also focussed on the scientific, technical and societal challenges that VLBI will face in the next decade. The document "VLBI20-30: a scientific roadmap for the next decade – The future of the European VLBI Network" has been presented to the community (http://arxiv.org/abs/2007.02347). The preparation of this document required scientific discussion within the whole astrophysical community. The list of contributors includes 75 experts, many of them experts in areas outside radio astronomy. This has considerably increased the awareness of the potentials of VLBI, and most of all of the role VLBI can play in the forthcoming decade, with several new facilities in many other bands becoming operational. This activity is closely linked to the effort of bringing awareness of the potentials of VLBI science to Africa, a necessary step to ensure that the African VLBI Network project is completed and in view of the VLBI capabilities of the Square Kilometre Array (SKA). In collaboration with the Development in Africa with Radio Astronom (DARA) project, JUMPING JIVE supported the training of hundreds of students from Africa.

Fig. 2: Ann Njeri Ng'edno (VLBI PhD student) with school girls during an outreach programme in Kenya.

Enhancing the awareness of the opportunities in physics and astronomy aims to broaden the awareness of astronomy within African institutes and local communities, as well as engage with African University students regarding the opportunities provided via advanced Science, Engineering and Technology education and training. Africa is also one of the hosting continents of the SKA. JUMPING JIVE has demonstrated leadership in developing VLBI capabilities and science cases for the SKA, at the same time forming the future VLBI landscape in Europe, Africa and worldwide. A SKA-VLBI workshop was successfully organized at the SKA Organisation (SKAO) headquarters, where the science cases of SKA-VLBI have been presented. Furthermore, VLBI is now part of the SKA system design and the documents written within the JUMPING JIVE project are now formally recognised in the baseline design SKA technical documents, showing full dedication from SKAO towards implementing SKA-VLBI.

Fig. 3: In-person and remote meeting of the chapter coordinators of the European VLBI Network vision document (Jodrell Bank, 16 October 2019).

With less than a year before the end of JUMPING JIVE, with the CoVid-19 pandemic still upon us, we can look back and acknowledge the great impact the JUMPING JIVE project has already had in VLBI and other astronomical communities. We are, therefore, optimistic that the last months of the project will be very productive, not only in delivering all the work as promised as an H2020 project but also in having a strong impact on the current and future developments of VLBI in Europe and worldwide.

UPCOMING MEETINGS

- **RadioNet Workshop on Future Trends in Radio Astronomy Instrumentation:**
  21–22 September 2020, Max-Planck-Institute for Radio Astronomy, Bonn, Germany;
  https://events.mpifr-bonn.mpg.de/indico/event/154/

- **CASA-VLBI workshop 2020:**
  2 - 6 November 2020, JIVE, Dwingeloo, Netherlands;
  https://www.jive.eu/casa-vlbi2020/

  With the current COVID-19 developments and associated travel limitations, the organisers decided that the CASA workshop will become a **fully online event**. The dates of the workshop will not change, the format and platform are still to be decided. The aim is to have live lectures, interactive tutoring sessions, and a Slack-like discussion forum for questions and chats. Lectures will be recorded and remain available online after the workshop. Since more participants can be accomodated in an online format, **registration has been re-opened**. If you have not yet registered, please do so on the CASA workshop website. Next year an in-person workshop at JIVE is planned, information on that will be shared through the EVN newsletter and usual e-mail exploders.

- **Astronomical Data Analysis Software and Systems (ADASS) conference:**
  8–12 November 2020, Granada, Spain;
  https://adass2020.es/

- **15th EVN Symposium and Users Meeting:**
  12–16 July 2021, Cork, Ireland;
  https://www.ucc.ie/en/evn2020/

NEXT NEWSLETTER: JANUARY 2021

Contributions can be submitted until
10 December 2020.

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