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Call for proposals – Deadline June 5, 2018, UT 15:00

by Alex Kraus

Observing proposals are invited for the Effelsberg 100-meter Radio Telescope of the Max Planck Institute for Radio Astronomy (MPIfR).

The Effelsberg telescope is one of the World's largest fully steerable instruments. This extreme-precision antenna is used exclusively for research in radio astronomy, both as a stand-alone instrument as well as for Very Long Baseline Interferometry (VLBI) experiments.

Access to the telescope is open to all qualified astronomers. Use of the instrument by scientists from outside the MPIfR is strongly encouraged. The institute can provide support and advice on project preparation, observation, and data analysis.
The directors of the institute make observing time available to applicants based on the recommendations of the Program Committee for Effelsberg (PKE), which judges the scientific merit (and technical feasibility) of the observing requests.

Information about the telescope, its receivers and backends and the Program Committee can be found at https://www.mpifr-bonn.mpg.de/effelsberg/astronomers (potential observers are especially encouraged to visit the wiki pages!).

Observing modes

Possible observing modes include spectral line, continuum, and pulsar observations as well as VLBI. Available backends are several FFT spectrometers (with up to 65536 channels per subband/polarization), a digital continuum backend, a number of polarimeters, several pulsar systems (coherent and incoherent dedispersion), and two VLBI terminals (dBBC and RDBE type with MK5 recorders).

Receiving systems cover the frequency range from 0.3 to 96 GHz. The actual availability of the receivers depends on technical circumstances and proposal pressure. For a description of the receivers see the web pages.

Please note, that observing proposals for the new Phased-Array-Feed cannot yet accepted – the system is still being commissioned.

How to submit

Applicants should use the NorthStar proposal tool for preparation and submission of their observing requests. North Star is reachable at https://northstar.mpifr-bonn.mpg.de .

For VLBI proposals special rules apply. For proposals which request Effelsberg as part of the European VLBI Network (EVN) see: http://www.evlbi.org/proposals/ .

Information on proposals for the Global mm-VLBI network can be found at http://www3.mpifr-bonn.mpg.de/div/vlbi/globalmm/index.html .

Other proposals which ask for Effelsberg plus (an)other antenna(s) should be submitted twice, one to the MPIfR and a second to the institute(s) operating the other telescope(s) (eg. to NRAO for the VLBA).

After June, the next deadline will be on Oct 4, 2018, 15:00 UT.

RadioNet Transnational Access Programme

by Alex Kraus

RadioNet (http://www.radionet-org.eu) includes a coherent set of Transnational Access (TA) programs aimed at significantly improving the access of European astronomers to the major radio astronomical infrastructures that exist in, or are owned and run by, European organizations.

Astronomers who are based in the EU and the Associated States but are not affiliated to a German astronomical institute, may also receive additional aid from the Transnational Access (TA) Program of 'RadioNet'. This will entail free access to the telescope, as well as financial support of travel and accommodation expenses for one of the proposal team members to visit the Effelsberg telescope for observations.

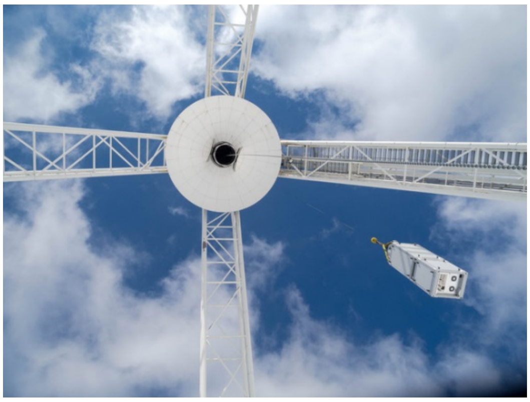
The Transnational Access program is one of the activities of "RadioNet“, an Integrated Infrastructure Initiative (I3) funded under the ECs Framework Program Horizon2020, that has pulled together all of Europe's leading astronomy facilities to produce a focused, coherent and integrated project that will significantly enhance the quality and quantity of science performed by European astronomers.

One - in exceptional cases more - scientists who are going to Effelsberg for observations can be supported, if the User Group Leader (i.e., the PI - a User Group is a team of one or more researchers) and the majority of the users work in (a) country(ies) other than the country where the installation is located. Only user groups that are allowed to disseminate the results they have generated under this program may benefit from the access.

After completion of their observations, TNA supported scientists are required to submit their feedback through the TNA web pages.

A new Q-band Receiver for the 100-m Telescope

by Alex Kraus



Picture taken by Sener Türk, MPIFR

In April, a new Q-band receiver has been installed in the Gregorian focus of the 100-m telescope. This new dual-pixel system covers a frequency range of 33-50 GHz. The multi-purpose receiver allows to observe an instantaneous bandwidth of 5 GHz (split into two sub-bands) together with the continuum and spectroscopy backends, but allows also for a 300 MHz wide high-resolution spectroscopy mode (with 65535 spectral channels) and for VLBI observations.

The receiver is currently being commissioned, but could already be used for scientific programs (on a “shared risk” basis). If you want to use this receiver in the near future, please do not hesitate to contact us!

More information will be provided in the next issue of this newsletter (after the commissioning is finished).

Report on the workshop “The Big Impact of a Big Dish: Science with the Effelsberg 100-m telescope"

by Alex Kraus

The workshop “The Big Impact of a Big Dish: Science with the Effelsberg 100-m telescope" was held on February 20-21, 2018 at the Max-Planck-Institut für Radioastronomie in Bonn.

The intention of this workshop was to bring together various user groups of the 100-m telescope with the support staff of the observatory and the technical developers. The scientific results gained by observations with the 100-m telescope should be presented and discussed, as well as ideas for future research and current technical activities.

61 participants followed the invitation of the Max-Planck-Institut für Radioastronomie and came to Bonn.

Their contributions covered a large range of topics (and also a broad range of frequencies) and included talks on Galactic and Extragalactic Maser observations (detection experiments as well as monitoring of variable maser emission), survey observations of the neutral hydrogen and their impact, Radio Recombination Line studies, and the search for more complex molecules.

The role of the 100-m telescope as cornerstone in various VLBI networks was illustrated by several talks covering observations within the European VLBI Network (EVN), the Global mm-VLBI array (GMVA) and together with the RadioAstron satellite telescope. Additionally, it was emphasized that the telescope is also important for supporting observations in total power and polarization; such measurements support the calibration of the VLBI data and allow to study the long-term evolution of these objects.

Pulsar observations cover nowadays a large part of the observing time of the 100-m telescope. That was reflected in three invited talks which reported about Effelsberg’s participation in pulsar timing arrays like EPTA – the European Pulsar Timing Array – and LEAP – the Large European Array for Pulsars and the various scientific results emerging from these observations. Current research done on the phenomenon of Fast Radio Bursts with the 100-m telescope, and pulsar observations with the LOFAR station at Effelsberg (sometime simultaneously with observations of the 100-m telescope) were presented as well.

The Effelsberg telescope has a long history of doing continuum observations; that was also reflected in the various talks given in the workshop. Among the topics discussed here were historic and recent observations of the Andromeda Galaxy (M31), total intensity and polarization studies of nearby galaxies, studies of Supernova Remnants, measurements of high polarization degrees in galaxy cluster mergers, star-forming galaxies, and multi-frequency observations of Active Galactic Nuclei and X-ray binaries. Recent software developments like the *nod3*-package for the reduction of single-dish maps were discussed as well.

Finally, one session of the workshop was dedicated to current technical activities. That does not only cover current receiver and backend developments, but also recent work on calibration issues for simultaneous broad-band spectroscopic observations and for linear and circular polarimetry. In addition, recent "Out-of-focus" holography observations for the determination of the surface accuracy of the telescope were presented.

Within the workshop it became clear that the 100-m telescope was and is successfully involved in a broad range of research. It was stressed out by the participants of the workshop that the telescope is of high importance for their future work.
The discussions led to a number of ideas about potential future research and desirable technical developments. The presentations, the scientific conversations and also the user's feedback will be of high impact for the planning of future activities by the staff at the Effelsberg observatory.

The website of the workshop can be found at https://events.mpifr-bonn.mpg.de/indico/event/48/; the majority of the contributions are available there.

Picture taken by Aris Noutsos, MPIfR

This event has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730562 [RadioNet].

We are grateful to RadioNet and the RadioNet management for their support of this workshop!

RadioNet

Report on the visit of the Thai Science & Technology Minister and NARIT to MPIfR

by Busaba Hutawarakorn Kramer

In occasion of the annex signing to the existing MoU between NARIT and MPIfR on the joint development of the L-Band and K-Band receivers and the Universal Software Backend System for the new 40-m Thai National Radio Telescope (TNRT), MPIfR had opportunity to welcome the visit of senior Thai government delegates, led by Dr. Suvit Maesincee, Minister of Science and Technology and Dr. Manop Sitidech, Minister Counsellor, Office of Science and Technology, Royal Thai Embassy in Brussels.

The signing ceremony was held at MPIfR in Bonn on April 17, 2018, with three signatories of Prof. Dr. Anton Zensus, Executive Director of MPIfR and Director of Radio Astronomy/VLBI, Prof. Dr. Michael Kramer, Director of Fundamental Physics in Radio Astronomy, and Dr. Saran Poshyachinda, NARIT Executive Director. After the signing ceremony, the Thai delegates toured MPIfR Electronics Division and Mechanical Workshop, guided by Dr. Gundolf Wieching, Head of Electronics Division and Dr. Ewan Barr, Leader of Software Backend Development Group.

In the afternoon, the delegates had opportunity to visit the 100-m Effelsberg radio telescope and tour the facilities, guided by Dr. Alex Kraus, Head of the Observatory and Dr. Heiko Hafok.

Who is Who in Effelsberg?: André Küllenberg

André Küllenberg joined the team of operators at the radio telescope in December 2017.

André was born and raised up in Solingen, a city between Cologne and Düsseldorf which is quite famous for its knives and cutlery. His first contacts with electricity he made at the age of 5, while carefully observing his dad finding short circuits in electrical installations. Later on in his life he took apart all sorts of electrical equipment until his parents finally bought him a Kosmos electronics experiments kit. At the age of 12 he prototyped an 8085 based microprocessor system with lots of wires on a double sized Eurocard to later find out that flash-based microcontrollers are much more fun to deal with.

Side-tracked by computer programming and Linux, he started an apprenticeship as an IT specialist in 2001 and continued his education by studying electrical engineering at the University of Applied Sciences in Düsseldorf until 2008. During the work for his Bachelor thesis, he crossed the thin line between love and hate for LabVIEW several times and developed a long lasting relationship with PIC microcontrollers. From 2008 onwards, André worked with a well-known company for solenoid valves in Düsseldorf as the go-to guy for everything with more than two wires, designed, routed and prototyped circuits, wrote hundreds of reports and learned a lot about in how many ways mass produced products can fail.

Mid 2017 he decided that time was ripe for changes, applied for the vacancy at Effelsberg and hasn't regretted it so far. André now enjoys the virtues of living in a small village, together with three telescopes and a Silicon Graphics workstation, near his new workplace: no more traffic jams, lots of opportunities to go hiking and enjoying nature and decent dark skies that finally makes backyard astrophotography a viable and less frustrating hobby. André is still doing PCB layout – recreationally.

Global Millimetre-VLBI Observations at 86 GHz with the Effelsberg telescope

by Thomas Krichbaum

Introduction

The prime driver for radio-interferometric imaging is the desire for highest possible angular (and spatial) resolution in the images of celestial objects, in particular with regard to the imaging of the 'central engines' in powerful quasars and nearby galaxy nuclei (see Fig. 1 for a GMVA image of the M 87 jet base).

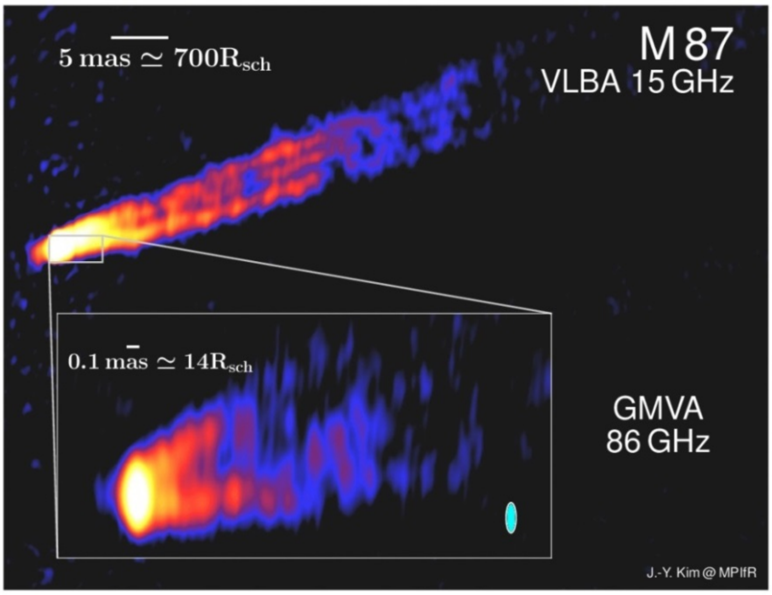


Fig.1: A zoom towards the origin of the M 87 jet. The image on top shows the well collimated VLBI jet at 15 GHz (Kovalev et al. 2007) on scales from ~0.5 - 50 milli-arcseconds (mas). The new 86 GHz GMVA map which is shown below, traces the jet from about 3 mas core separation down to a scale of ~ 50 µas (Kim et al. 2018). At the distance of M 87, this corresponds to only 4.8 light days, which translates into a scale of ~ 7 Schwarzschild radii R_s (for a central black hole mass of 6×10^9 solar masses). Back-extrapolation of the forked jet sheath to its origin therefore suggests that the jet is launched from a very small region of only a few Schwarzschild radii in size. This indicates that the jet is powered by the black hole itself, and not so much by the surrounding accretion flow (which would lead to larger dimensions).

The angular resolution is increased either by extending the separation between the telescopes which leads to space-VLBI (when going beyond the Earth's diameter) or by observations at the shortest possible wavelength, for which phase coherency from widely separated telescopes can be realized. During the past two decades, Very Long Baseline Interferometry (VLBI) has reached the millimetre radio bands, with VLBI at 86 GHz (3 mm wavelength band) being an 'almost' standard observing method, and VLBI at 230 GHz (1.3 mm band) in the process of development. In addition to the high resolution, VLBI imaging in the mm-/sub-mm bands provides other advantages, such as the detailed imaging of regions, which are absorbed at longer wavelength (e.g. via synchrotron self-absorption) and a reduced Faraday depth, which facilitates measuring source intrinsic polarization, from which the magnetic field strength and its topology can be determined. In a multi-wavelength approach, the combination of VLBI observations at different frequencies facilitates spectral and Faraday rotation-measure studies, which are needed for the determination of the fundamental physical parameters in the vicinity of black holes, accretion flows, radio jets and of the interstellar medium.

The GMVA

The Global Millimeter VLBI Array (https://www3.mpifr-bonn.mpg.de/div/vlbi/globalmm/) is a VLBI network which observes primarily in the 3 mm wavelength band and is operated based on a mutual agreement between its participants. Currently the GMVA consist of the following observatories: the Max-Planck-Institut für Radioastronomie with its 100 m radio-telescope in Effelsberg, the IRAM-Institute for mm Radio Astronomy with the 30 m telescope on Pico Veleta (Spain) and the interferometer on Plateau de Bure (France), the Onsala Space Observatory (Sweden) with its 20 m antenna, the Metsähovi Radio Observatory (Finland) with its 14m antenna, and the Long Baseline Observatory (LBO) which operates the VLBA (USA), using those eight 25 m antennas, which are equipped with a 3 mm receiver (excluding the antennas at Hancock and St. Croix).

Affiliate members of the GMVA are the Green Bank Observatory with its 100 m telescope, the Yebes Radio Observatory (Spain) with its 40 m telescope and the Korean VLBI Network (Korea) with its three 21 m telescopes. The network has adopted an open sky policy, which is similar to that of the LBO (formerly NRAO) and issues two proposal calls per year, one in February each year for observations in the next autumn, and one in August for observations in the next spring. Proposals have to be submitted through the NRAO Proposal Submission Tool (PST), and are distributed to the observatories for review or rating by the local program committees. The combined rating is then communicated to the P.I. of each proposal. For logistical reasons the scheduling of the accepted GMVA proposals is done in a single observing block of up to 5 days duration (depending on proposal pressure) in either the spring or autumn session.

Since 2017, also the phased ALMA array supports global 3mm VLBI with the GMVA and by this adds a very sensitive telescope with a large collecting area (currently up to 43 x 12 m dishes phased) in the southern hemisphere. For logistical reasons and because of the limited available VLBI time at ALMA, mm-VLBI observations with ALMA are performed so far only once per year.

3mm VLBI with the Effelsberg telescope

The 100 m radio-telescope (RT) at Effelsberg is located at an elevation of 350 m in a north-south oriented valley of the Eifel mountains, which is not an ideal site for observations in the mm- wavelength regime. The telescope was originally designed for observations down to a wavelength of 3 cm (10 GHz). At the time of its construction, nobody though that the Effelsberg RT might be able to deliver useful scientific data at a wavelength as short as 3.5 mm (86 GHz). The parabolic antenna has a full diameter of 100 m, with a homological designed surface, but residual gravitational deformations cause a gain-elevation curve of concave shape at wavelengths shorter than 6 cm. At 86 GHz the gain loss is about 50 % at very low and very high elevations.

The surface of the Effelsberg dish consists of 2352 panels, which are arranged in 17 rings. The inner 13 rings (up to a radius of 40 m) are aluminium panels with a surface rms of about 0.3 mm, while the outer rings (14-17) consist of perforated aluminium at a lower surface rms, which degrades to about 1 mm for the outermost ring. For observations at 86 GHz the receiver feed is matched to the inner 13 rings, which leads to an aperture efficiency of ~ 7 % and a small beam size of about 10 arcsec.

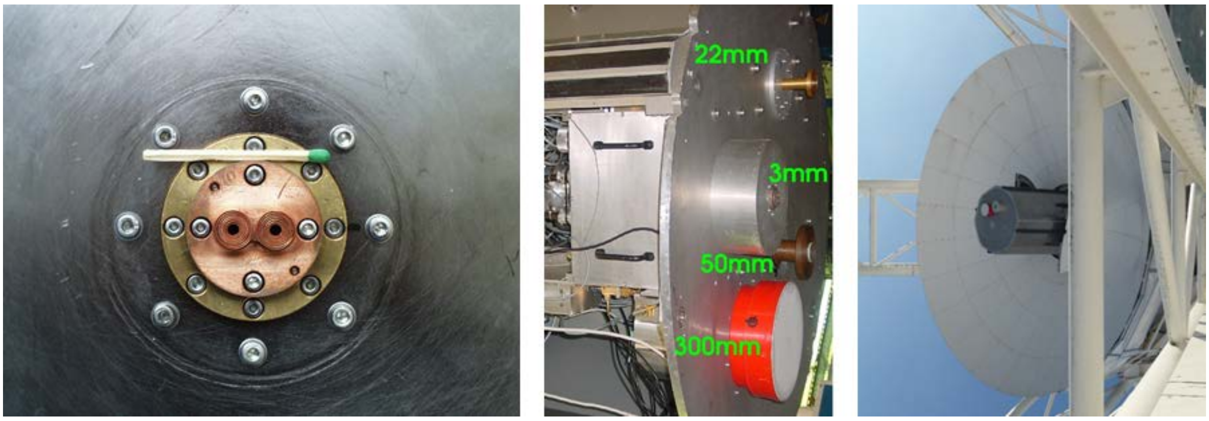


Fig 2: Left: The tiny two horns of the 3 mm receiver and a match visualizing the scale. Center: The feeds of the four receivers, which are installed in the receiver multi-box II. Right: The receiver multi-box II shifted into the prime focus of the telescope, with the 6.5 m adaptive sub-reflector behind.

After a technical upgrade of the 6.5 m solid to a 96-element adaptive secondary sub-reflector in year 2006, a position adjustable hexapod mount was implemented in the prime focus, to move the new mirror and focus cabin. This led to a more flexible receiver access in the primary focus cabin, which now can hold so called multi-frequency receiver boxes, with up to 4 different receivers installed in one exchangeable cylindrical metal tube. By computer-controlled translation and rotation of such a receiver box, the feed of the selected receiver is brought with sub-mm accuracy into the prime focus on a switching time scale of 1-2 minutes. For operation with receivers installed in the secondary focus (most other VLBI receivers), the receiver tube can be pulled back and the central hole in the sub-reflector is closed. The change from prime focus to secondary focus receivers can be done on a time scale of 30-45 min. The 3 mm VLBI receiver uses cooled HEMT amplifiers and has 3 channels, consisting of the main horn (dual circular polarization) and a second horn, which supports one circular polarization and which is offset from the main horn by about 5.5 beams (Fig. 2, left). The offset horn can be used in non-optimal weather conditions (cloudy sky) to subtract the weather from the main horn, using the software beam switch method, with adjustable attenuation of the signal from the weather horn. This improves signal detection and helps with the telescope pointing. For very faint sources, or when weather does not allow pointing at 3 mm, pointing can be done at 22 mm (13 GHz), using another receiver installed in the same multi-frequency receiver box (Fig. 2, center and right).

Prior to a GMVA session the pointing model of the 100 m telescope is adjusted, by fitting its 10 parameters to the data of a well selected sample of about 50-100 point-like sources, which are observed at 13 GHz under stable atmospheric conditions (clear night time conditions) some days before a 3 mm VLBI session begins. These pointing runs are necessary to fine tune the pointing model and to reach an all-sky pointing rms of 3-4 arcseconds.

However, since the telescope beam is small and the pointing is also affected by external temperature gradients on the steel of the telescope support structure (in particular during day time and around sun rise and sun set), the VLBI schedules must allow for regular and long enough time gaps between VLBI scans and prior to larger slews. In such 3-8 minute long gaps pointing scans are performed, either on the VLBI target or on a nearby bright source. These pointing scans consist of typically 4 or 8 sub-scans, each of 15-20 seconds in duration, which move the telescope in azimuth and elevation direction by about 4.5 beams across the source position (cross-scans). From a fit of a Gaussian function to the directional averaged antenna slews, the residual pointing offsets are determined and are corrected in real time. The averaged peak amplitude of the Gaussian fit function also provides a measure of the antenna temperature for a given radio source, which is used to calibrated the VLBI signal in terms of time, elevation and weather dependent losses. In non-VLBI mode, the system- and antenna temperature measurements refer to a switched noise calibration signal (duty cycle of 16 ms), which is used to monitor and correct small residual gain variations in the receiving system using a noise diode. This method provides an accurate and time stable calibration of the signal from the receiver.

It is a tradition, that during the GMVA observing sessions, which typically last 4-6 days with 24 hrs observing around the clock, members of the VLBI group and/or involved project scientists from abroad come to Effelsberg and help with the observations. This provides also a good opportunity for students and young astronomers to become familiar with the observational techniques at a big telescope, and to be trained on the calibration tasks and procedures during an international mm-VLBI campaign.

In a mm-VLBI run responsible interaction with the telescope is needed on time scales of 5-15 minutes. This requires a high level of human attention around the clock. Organization into observing shifts, which last no longer than 4-6 hrs, help to keep the observers mind focused on the task, in particular when the weather is not ideal or the observing schedule is complex.

Data gathering during and after the observations

During the VLBI observations each participating VLBI antenna records its data on hard disks. In the VLBI formatter the down-converted total power signal from the receiver is time tagged using accurate (~100 nano-seconds) time stamps from the GPS system, which is synchronized by the hydrogen maser. The data are formatted into a special VLBI format (eg. Mark 5B or VDIF), and streamed onto the recording hard disks. For GMVA observations the recording on the so called FlexBuff storage RAID-array has become a standard recently. Alternatively – e.g. for special experiments - recording on exchangeable modules, each containing 8 individual hard disks (so-called 8-packs) can be performed as well. With a data acquisition rate of 2 Gbps and an effective VLBI observing duty cycle of typically 50-80 % (the rest is used for pointing and calibration), about 0.5-0.8 Terra-byte of disk space are recorded per hour at each VLBI station. After the VLBI observation, the recorded data are transferred to the correlator, which for the GMVA is the VLBI correlator of the MPIfR in Bonn. Depending on the storage medium, the data transfer is done using fast (10 Gbps) Internet lines (from FlexBuff) or ordinary parcel shipment (for modules).

At the VLBI correlator, the data from all telescopes are combined via cross-correlation. The resulting data product is then delivered to the principal investigator (PI) for each observed experiment, for calibration and final imaging.

Future prospects

The VLBI imaging in the millimeter bands is still a challenge, for the most part due to variable atmospheric conditions, but in some cases also because of not yet fully optimized telescope performance at short mm-wavelengths. The image fidelity depends on the synthesized effective collecting area, a dense uv-coverage and the observing bandwidth. The first two topics are addressed by adding more stations, in particular telescopes, which are designed for operation in the mm-bands (eg. NOEMA, LMT, GLT, ALMA, ...). A larger number of telescopes also better facilitates self-calibration methods, which must be applied in the imaging process, and which converge faster and better when the array is larger. The limited atmospheric phase coherence time at mm-wavelengths (5-20 sec at 86 GHz) prevents long integrations and a higher imaging sensitivity. Therefore, a further increase of the observing bandwidth (and of the data recording rate) appears mandatory. The Event Horizon Telescope (EHT), which operates at 230 GHz with fewer stations than the GMVA, recently observed with 8 GHz bandwidth (64 Gbps data rate) matching both ALMA band 6 sidebands. The planned VLBI recording system upgrade of the VLBA -- a major partner of the GMVA -- to 1 GHz bandwidth (4 Gbps) points in the right direction. For several European GMVA telescopes a bandwidth increase beyond 1 GHz is either already possible or should become feasible during the next few years. A very promising approach to overcome atmospheric coherence time limitations is in the use of multi-frequency receivers, which can observe *simultaneously* at more than one frequency and by this allows to correct the signal phase of the higher frequency by the lower frequency. Our colleagues in East Asia (KVN, Vera) have begun to apply this method successfully paving the way to a better performance of high frequency VLBI.

Finally, one should mention the possibility of mm-VLBI using Earth orbiting telescopes in the more distant future, with either (i) a ground-array combined with some orbiting satellite dish(es) (similar to previous space-VLBI missions operating in the cm-bands; e.g. VSOP & RadioAstron), or (ii) with a (small) array of phase linked satellite antennas, which operate in different Earth orbits and/or on the Moon and are therefore not affected by the terrestrial phase coherence limitations of the atmosphere.

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