Effelsberg Newsletter

January 2015

Credit: Norbert Tacken

Happy New Year 2015 !

Greetings from the Director

A Happy New Year 2015!

Another year has passed. Maybe it is because we are all getting older, or - hopefully - it is because so many exciting and interesting things happened, that one finds him- or herself wondering where the time has gone. Looking back at the results from the last year, lots of things come to mind. It was difficult to choose among the many interesting topics for this newsletter, but we hope that you find the reports exciting and stimulating. The beginning of the year is also the time to look ahead to what this and next years will bring. Here, clearly, the obtained funding and the decision by the MPG to support MeerKAT with instrumentation is among those we are looking forward to eagerly. The technology is derived from that used recently at the 100-m telescope; together the 100-m and MeerKAT will complement each other perfectly. It is still a little while until this is all in operation, but we won't be bored, since the 100-m results will keep us busy, excited and entertained.

Happy New Year, Michael Kramer

Call for Proposals

Deadline: February 5, 2015, 15:00 UT

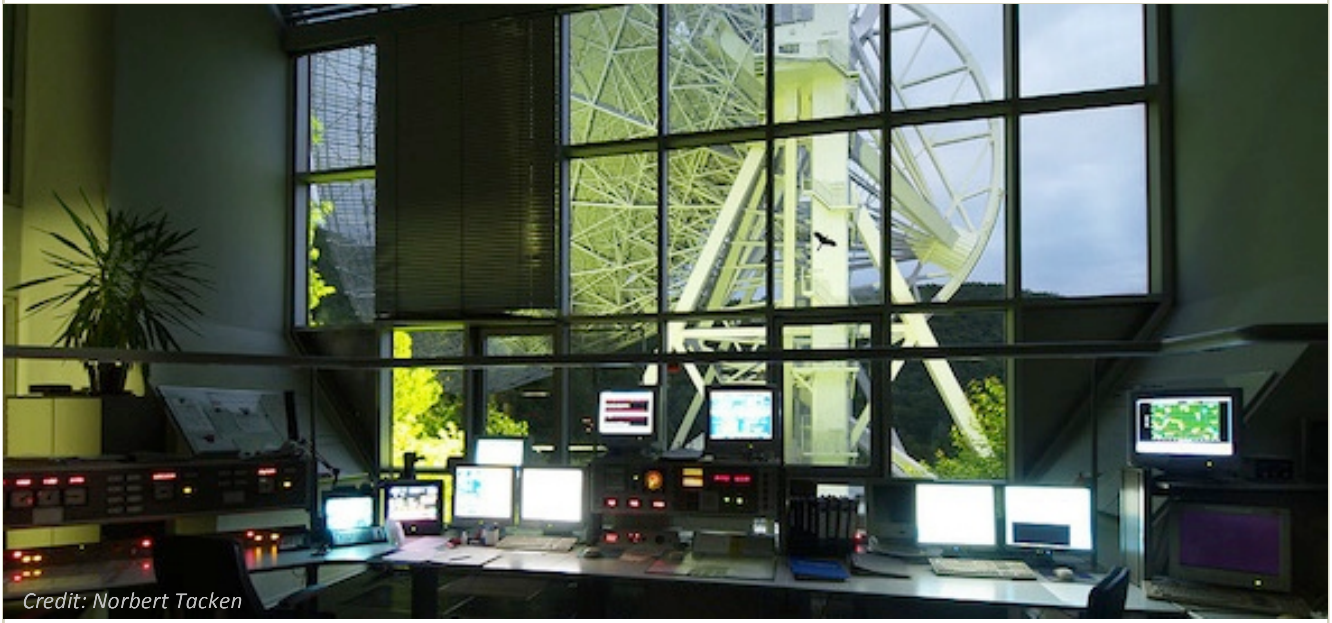
Observing proposals are invited for the Effelsberg 100-meter Radio Telescope of the Max Planck Institute for Radio Astronomy (MPIfR).

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.

Credit: Norbert Tacken



Credit: Norbert Tacken

Information about the telescope, its receivers and backends and the Program Committee can be found at

http://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.

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) (e.g. to NRAO for the VLBA).

After October, the next deadline will be on June 3, 2015, 15:00 UT.

by Alex Kraus

RadioNet Transnational Access Programme

RadioNet (see http://www.radionet-eu.org) includes a coherent set of Transnational Access 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. Observing time at Effelsberg is available to astronomers from EU Member States (except Germany) and Associated States that meet certain criteria of eligibility. For more information:

http://www.radionet-eu.org/transnational-access

Time on these facilities is awarded following standard selection procedures for each TNA site, mainly based on scientific merits and feasibility. New users, young researchers and users from countries with no similar research infrastructure, are specially encouraged to apply. User groups who are awarded observing time under this contract, following the selection procedures and meeting the criteria of eligibility, will gain free access to the awarded facility, including infrastructure and logistical support, scientific and technical support usually provided to internal users and travel and subsistence grants for one of the members of the research team.

by Alex Kraus

Key Science Projects for the 100-m Telescope

The MPIfR invites scientist to submit Key Science Proposals (KSPs) for the 100-m telescope at Effelsberg. This kind of proposals should obey the following rules:

1. The proposed project should address high-quality and high-impact science that requires significant observing efforts.
2. The observations should utilize the core strength of the 100-m telescope.
3. KSPs should be large projects that cannot be realized (or only with difficulties) with standard observing proposals, i.e. projects requiring between 150 and 500 hours of observing time per year. (The exact amount of time available for KSPs may be limited depending on proposal pressure and requested observing frequency).
4. The project should also have a strong potential for outreach.

Key Science Projects can only be submitted to the February proposal deadline for the 100-m telescope.

They should be submitted using the North Star Tool as normal proposals accompanied by a more extensive justification (up to 10 pages) explaining the

- Scientific background
- Observing procedure
- Data analysis plan and data release policy
- Publication strategy

The proposals will be judged by the Effelsberg PC (PKE) and by the directors of the MPIfR who might consult external referees. The MPIfR expects progress reports periodically and a quick publication of the data (preferably online).

In case absentee-observations are desired, clear instructions for the execution of the project (observing strategy, acceptable weather conditions, etc.) have to be given.

by Alex Kraus

TECHNICAL NEWS

Opening the African Sky:
MPIfR Builds New Receivers for the MeerKAT Telescope in South Africa

By Gundolf Wieching

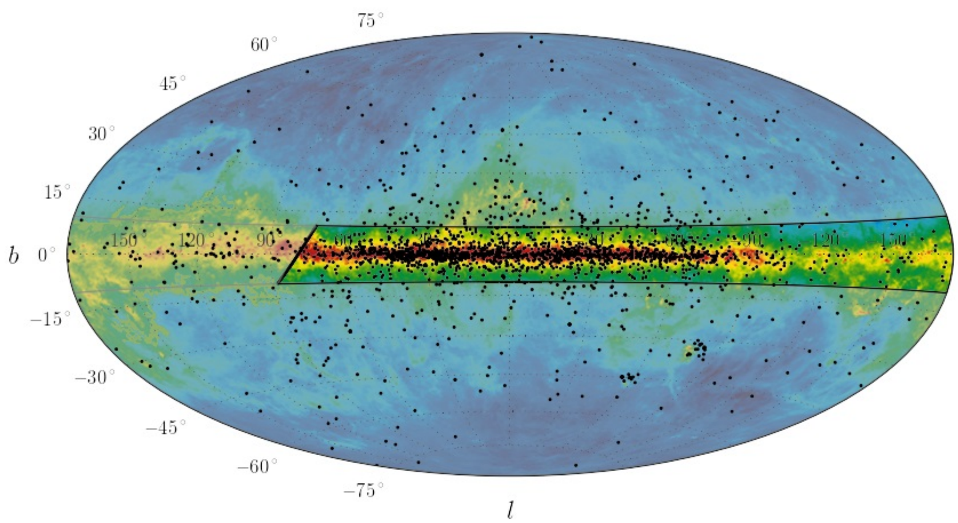


Fig. 1: All-sky radio image at 408 MHz with overlaid pulsar positions. Most pulsars (black dots) are found in the Galactic plane (the horizontal axis). The new receivers in combination with the MeerKAT radio observatory will search the area shown by the black box for unusual pulsar systems that can be used as laboratories for fundamental physics. Credit: MPIfR, Haslam et al. 1982 (Radio Image); MPIfR, Cherry Ng (pulsar positions).

A new radio astronomical receiver project of the Max Planck Institute for Radio Astronomy (MPIfR) has received full funding by the Max Planck Society. Within this project, the MeerKAT observatory, currently under construction in South Africa, will be equipped with broad-band receivers for the 1.6 to 3.5 GHz range. MeerKAT, will be the most sensitive observatory of the southern hemisphere in the centimetre wavelength regime. Thanks to its unique location at the Karoo semi-desert in South Africa, MeerKAT is hardly influenced by interference. The 11 Million Euro receiver project will not only grant the Max Planck scientists access to a world-class facility and its unique unrestricted view on our galaxy but also extend the frequency range for all MeerKAT scientists and thus empower MeerKATs scientific potential even further.

Radio astronomy provides an independent view of the cosmos. It allows the study of objects and processes that are otherwise not accessible, and enables the study of a wide range of questions in fundamental physics and astrophysics. The discovery space is mostly limited by the sensitivity of the radio telescopes, but other factors like sky access, time and frequency resolution, throughput (or "survey speed") and complementarity to existing facilities, are hugely important factors. Currently, major efforts are underway to make progress on all these factors. An upfront development is provided by the MeerKAT observatory in South Africa. When completed it will already be a world-class facility in stand-alone mode.

Fig. 2: MeerKAT antenna and the night sky.. Credit: SKA South Africa (Picture taken in March 2014).

MeerKAT will even be more sensitive than the largest fully-steerable radio telescopes in the Northern hemisphere, the 100-m radio telescope at Effelsberg and the Green Bank Telescope in West Virginia. In addition, it will provide a spatial resolution comparable to an 8 km diameter telescope. The science potential of MeerKAT is therefore enormous.

“The MeerKAT receiver project at our institute provides a receiving system that is finely tuned to the science interests of Max Planck scientists”, says Gundolf Wieching, head of the Electronics division at MPIfR where the new receiver will be built. “This will allow us to exploit this formidable new instrument and to bring Max Planck scientists to an optimal position to harness other future facilities.”

The funded receiver for a frequency range from 1.6 to 3.5 GHz will enable science that falls into the core interests of the MPIfR. “Our research interests include fundamental physics with tests of theories of gravity and gravitational wave detection by means of pulsar observations”, states Michael Kramer, Director at MPIfR and Head of its Fundamental Physics research department. “The project is actually expected to do transformational science on pulsars and other areas of astronomy.” Other areas include the exploration of the dynamic radio sky, for example with the detection of fast cosmological radio bursts, and also highly sensitive molecular spectroscopy of the interstellar medium or high-resolution imaging of radio sources using Very Long Baseline Interferometry. Each of these science topics alone makes the exploitation of MeerKAT extremely desirable, but together they provide the most compelling background for an excellent positioning of Max Planck scientists in this highly active research field.

In addition to providing the frontend, the complete project also includes the design and the construction of a state-of-the-art digital backend system which will turn MeerKAT into a discovery machine for pulsars and other time-domain phenomena. The receiver system will be designed and constructed by the MPIfR in collaboration with colleagues from the Universities of Manchester and Oxford, “The investment is an endorsement of the excellence of the MeerKAT and the South African team which designed and is building it”, concludes Bernie Fanaroff, Director of the SKA South Africa project. “We welcome the strong and growing collaboration between South African and German scientists in astronomy.”

The MPIfR MeerKAT Receiver will provide a receiving system, i.e. a frontend plus a backend system for time-domain processing. The detection frequency covers a range from 1.6 to 3.5 GHz, it is a dual polarization system with an analogue to digital converter stability below one pico second (10-12 s, this is equivalent to a light travel distance less than 0.3 mm)

The continuous data rate of 5.5 TeraBit/sec (1 TeraBit = 10^{12} Bit) is equivalent to the content of 147 DVDs per second or 0.5 million DVDs per hour. With such a huge amount of data they have to be reduced online, requiring a calculation power of several PetaOps (10^{15} operations per second). These highly demanding requirements will lead to new technological developments also useful for future instrumentations beyond the scope of radio astronomy.

MeerKAT is a fully funded radio observatory under construction in the Northern Cape of South Africa. It will be the largest and most sensitive radio telescope in the Southern hemisphere until its integration into the Square Kilometer Array (SKA) in the middle of the next decade. MeerKAT will consist of 64 13.5-m dishes, each with an offset-Gregorian configuration, designed by the German VERTEX company. Such configuration provides an unblocked aperture for increased sensitivity but also facilitating optical, imaging quality and good rejection of unwanted radio frequency interference from satellites and terrestrial transmitters. When completed, MeerKAT will be nearly 5-times more sensitive than the 64-m Parkes radio telescope, the largest radio telescope in the Southern Hemisphere now.

All Those Little Helpers: Part III
Online Plotter

by Benjamin Winkel

This is the next part of our series of articles about software tools at the Effelsberg 100-m telescope, which we provide to make your observations easier, more effective (and also more fun!).

During a measurement, it is always useful for the astronomer to have a quick look at the data. In some cases this is even vital for the observations, e.g., think of the cross- and focus-scans during a session to ensure the pointing model and focus position be correctly adjusted. But it also allows our operators to easily check whether the receiving system is properly working. Such functionality is provided by many (radio) observatories. At Effelsberg we used an "Online Plotter" for many years, but recently have put effort into improving its capabilities.

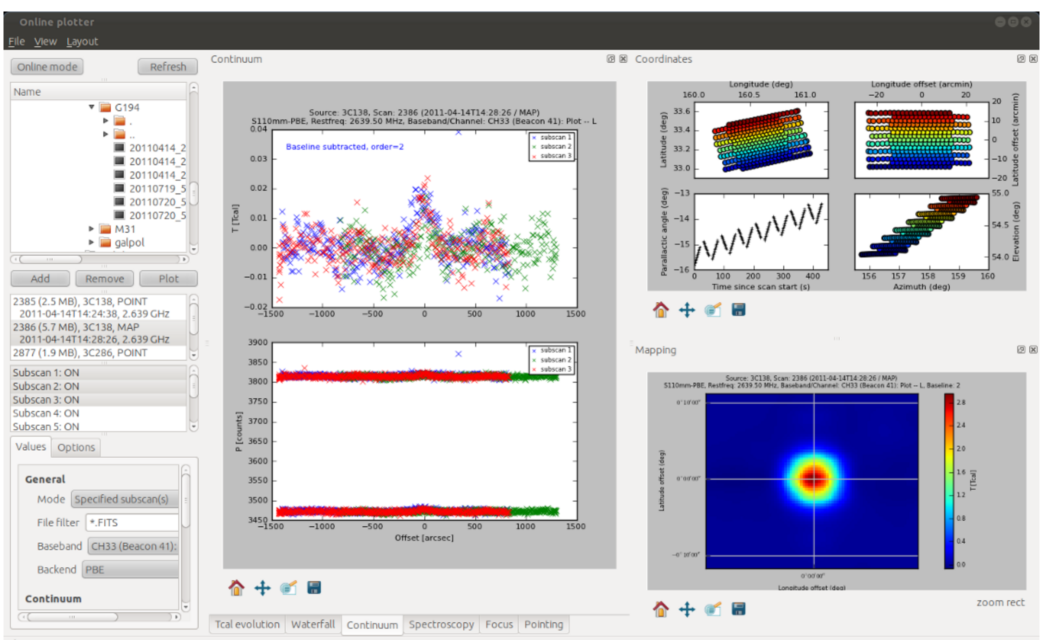


Fig. 1: Screenshot of the new Online Plotter. The user can arrange the various plotting widgets to fit her/his needs. For plotting, the python-matplotlib library is used which out-of-the-box provides panning/zooming, as well as saving to disk in many common file formats (e.g., pdf and png).

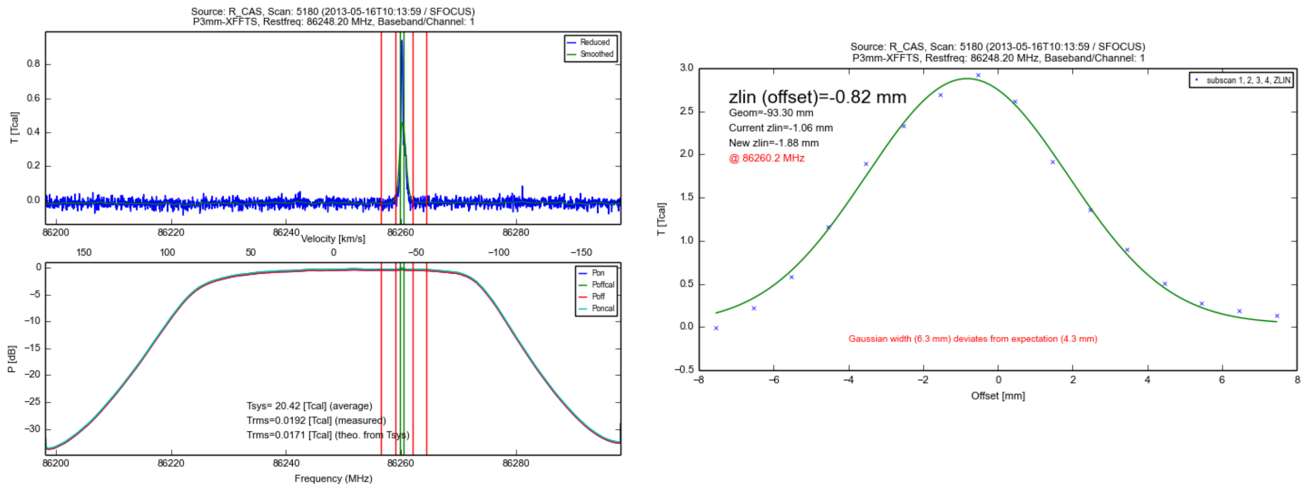


Fig. 2: Example for a spectroscopy Focus measurement at 3-mm. The SiO line (left panel) is interactively chosen (vertical green lines). A baseline is subtracted, as calculated in the region marked by the vertical red lines, which removes weather effects. The right panel shows the resulting Focus curve.

The new Online Plotter (Fig. 1) has a lot of features, too many to cover them here in full detail. Apart from visualizing the more common Pointing, Focus, and Spectroscopy scans, it can also deal with new observing modes like Spectroscopy-Pointing, -Focus, and -Skydips. This has been proven very useful for the commissioning of our new wide-band receivers where calibration must be dealt with in a frequency-dependent manner, or for situations where the spectrum is polluted by RFI. In Fig. 2 an example for a Spectroscopy-Focus measurement is shown. The user can interactively define a spectral interval of interest for which the continuum or line signal is extracted. Using spectroscopic line emission for Pointing/Focus can sometimes work much better at higher frequencies (especially under bad weather conditions).

The software also provides several diagnostic tools: (1) A waterfall plot for spectroscopy scans. Very useful to test the general quality of your data, e.g., to look for RFI (Fig. 3). (2) Evolution of the G x Tcal signal. This

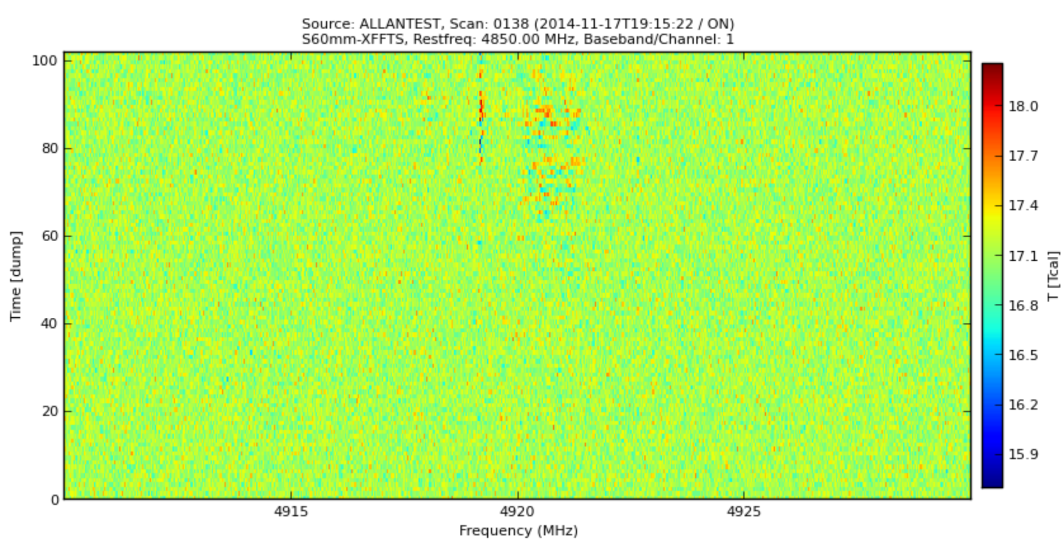


Fig. 3: Waterfall plot of a Spectroscopy scan at 6-cm. In the second half two distinct RFI signals set in. Such information can be useful for flagging of bad data during post-processing.

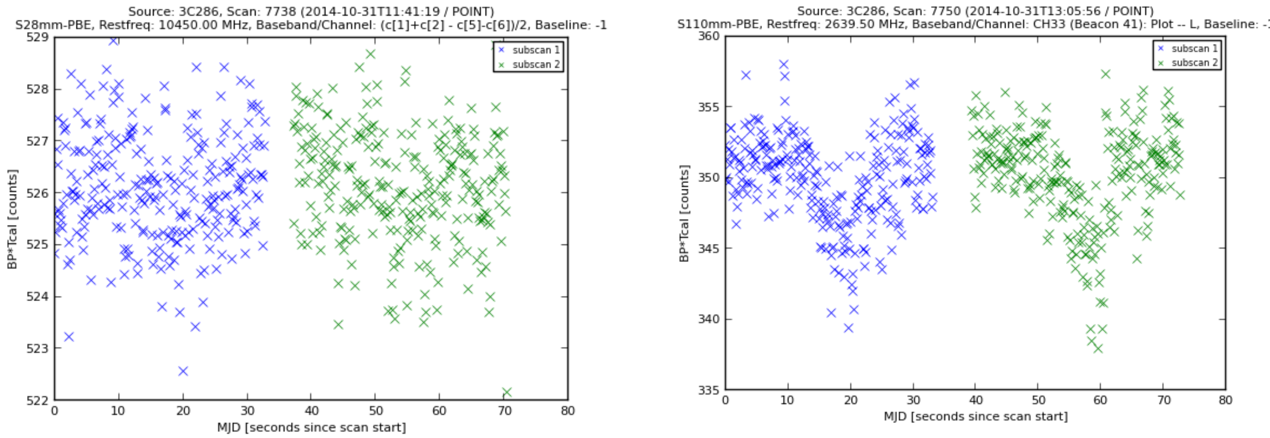


Fig. 4: Analyzing the temporal behavior of the G x Tcal signal can reveal non-linearities in the receiving system. The graphs show G x Tcal for a Pointing (cross-scan) observation where the blue/red curve is for the azimuthal/elevation direction. In the middle of each subscan the telescope "hits" the source. In the left panel this does not change the gain, while in the right panel a drop-off is visible which is caused by the receiver going into compression (non-linear regime).

is computed by taking the simple difference of the raw data with Tcal switched ON minus signals with Tcal OFF. Since Tcal is expected to be very stable, this allows to track the total amplification/gain, G, of the system as a function of time. It is easy to see in this plot, if the receiver is outside the linear regime (Fig. 4). (3) The coordinate plot shows the observed positions in the chosen (astronomical) system, as well as in the horizontal one.

Last but not least, it is possible to produce maps, both from continuum as well as from spectroscopy observations (Fig. 5). Because we make use of the python-matplotlib module for plotting, it is possible to save any of the plots to file in various formats. And, of course, despite its name, you can use the program as an Offline Plotter, too.

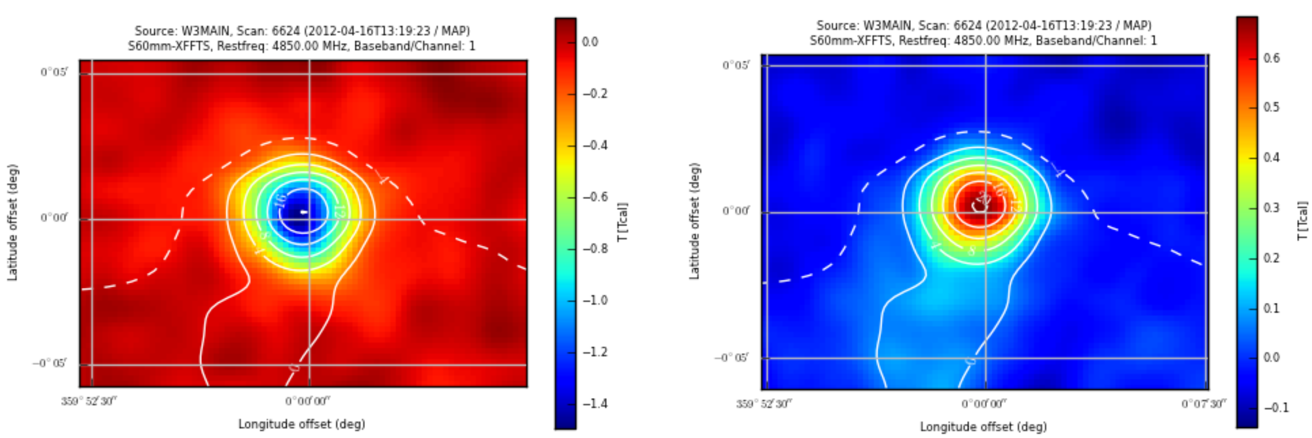


Fig. 5: The Online Plotter allows to preview mapping observations, both for continuum and spectroscopy. As an example, we display data from a 6-cm spectroscopy map of the W3 (IRS5) region. Left panel shows formaldehyde absorption, right panel contains the H110a RRL. Contour lines mark the continuum emission.

Science Highlights

RadioAstron Delivers First Space VLBI Polarisation Image at 22 GHz

by G. Bruni (MPIfR), J.L. Gómez (IAA, Granada) & A.P. Lobanov (MPIfR)

The ongoing space VLBI mission "RadioAstron" has achieved a new milestone, delivering the first ever space VLBI polarisation images at 22 GHz (wavelength of 1.3 cm). The observations were made on November 11, 2013 as part of the RadioAstron Key Science Program (KSP) on AGN Polarisation, targeting the well-known compact radio source BL Lacertae (BL Lac). For these observations, the orbiting 10-meter Space Radio Telescope (SRT) of the RadioAstron mission was supported by the Global VLBI array, including the 100-meter antenna of Effelsberg.

The were correlated at the DiFX correlator facility of the MPIfR, which was upgraded to be capable of processing space VLBI observations in the polarisation mode. The SRT was shown to have an excellent polarisation performance, with the instrumental polarisation (D-terms) measured to be less than 10%,

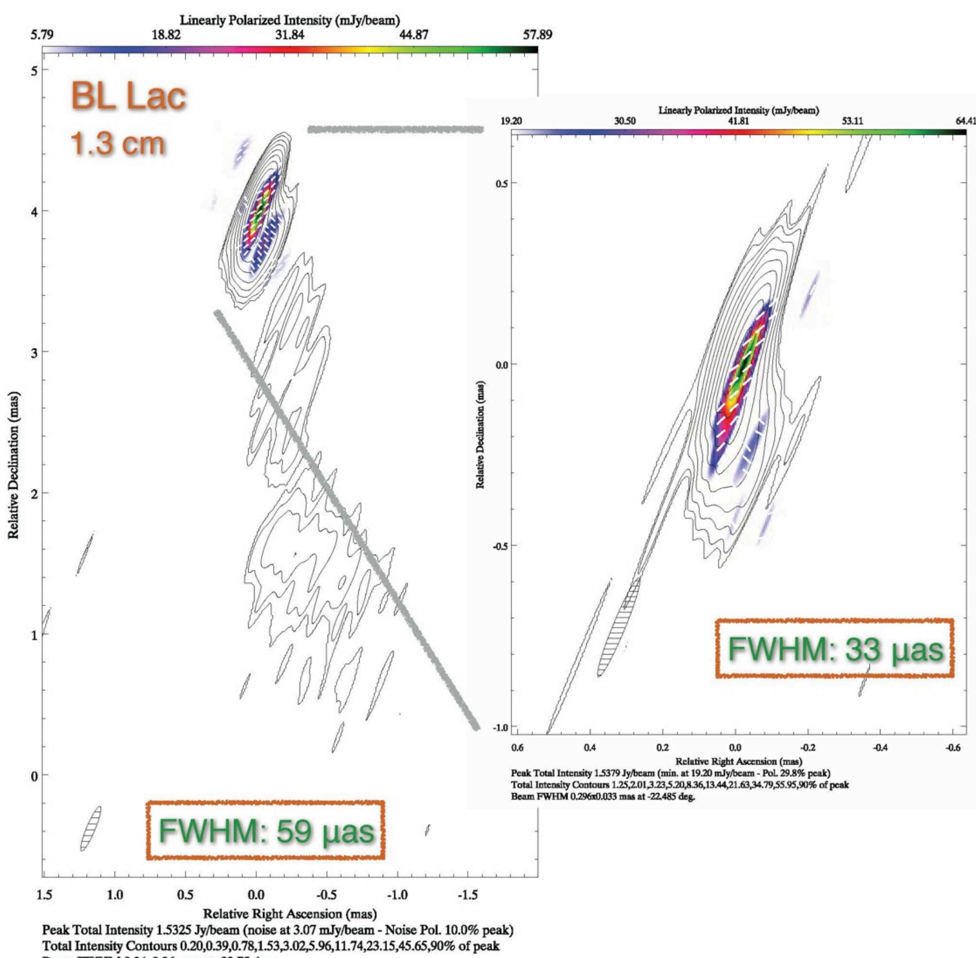


Fig. 1: RadioAstron image of total and polarised emission in the jet of BL Lacertae observed at 22 GHz (1.3 cm). The left panel shows an image made with the uniform weighting of the visibility data, and the right panel displays an image made with super-uniform weighting which emphasises the data on baselines to the SRT and hence provides the best resolution (33 microarcseconds) achievable in the observation.

which has brought a strong encouragement for the entire AGN Polarisation program of RadioAstron. Correlated visibilities on the baselines to the SRT have been detected up to a projected baseline distance of 6 Earth diameters, which corresponds to an angular resolution of 33 microarcseconds, the highest achieved to date in an astronomical imaging experiment.

The image of BL Lac shown in Figure 1, reveals a rich morphology and complex polarisation structure in the jet within the innermost 0.2 milliarcseconds (projected linear distance of 0.25 parsecs), suggesting a strongly twisted magnetic field possibly related to magneto-hydrodynamic instability developing the jet plasma. The KSP team is currently performing a detailed analysis of the image and modelling of the polarisation properties of the jet in BL Lac.

This and further observations made within the RadioAstron AGN Polarisation Key Science Program are expected to provide better clues for understanding the physics of the innermost regions of AGN jets.

The Effelsberg LOFAR Sky Survey

by Jana Köhler

The Low Frequency Array (LOFAR) is a new telescope array operating at frequencies in the range 10 to about 250 MHz. It consists of stations mostly in the Netherlands but some spread over other European countries. The earliest such international station is the one in Effelsberg, next to the 100m telescope (Fig. 1).

Most imaging work is based on interferometry between these stations, with baselines ranging from a few 100 metres up to more than 1000 km and resolutions ranging from degrees to sub-arcseconds. These baselines, however, cannot detect the large-scale structures on the sky, the most obvious and famous of which is our Milky Way itself. Low-frequency observations of these structures are particularly important in order to measure and understand the weak magnetic fields of the outer disk and the halo of our Galaxy.

Fig. 1: Effelsberg LOFAR station seen from the 100m radio telescope. Photo Credit: Norbert Junkes.

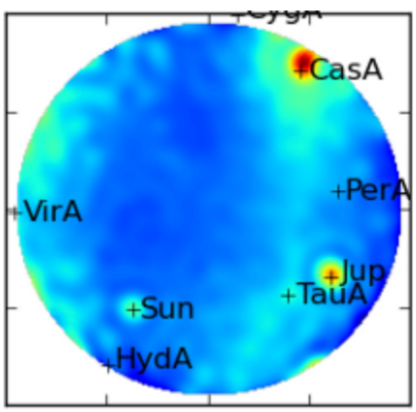


Fig. 2: Snapshot image of 1.3 sec integration time at 32 MHz done with a single LOFAR core station. Even so the bandwidth is just 200 kHz, strong structures and sources can be seen. Most noticeable is Cas A in the north (top) and Jupiter in the south-west, as well as the Sun in the south-east. Jupiter and the Sun can be detected at this low frequency only during active bursts as in this observation.

Our project uses interferometry with the single Effelsberg LOFAR station, using the much shorter baselines between the antennas within the station. These baselines, ranging from a few metres up to the diameter of the station of about 65m, provide resolutions of ca. 10 deg at 30 MHz to 1.3 deg at 240 MHz but are still sensitive to the largest structures as well.

There are a number of 'classical' sky surveys already, even at low frequencies, e.g. the Bonn 408 MHz survey conducted with the 100m telescope. Interferometric all-sky surveys with LOFAR do now allow entirely new types of studies. Our survey for the first time allows to map out the entire sky over a large frequency range within 30 to 240 MHz simultaneously, with virtually unlimited frequency resolution (currently using a few kHz). Besides investigations of the spectral behaviour, this allows us for the first time to study the large-scale polarisation at low frequencies by resolving the rapid turns caused by Faraday rotation that would otherwise wash out the signal.

Our survey consists of single snapshot observations of the entire visible sky with 1.3 sec integration time that are combined afterwards. With a number of such snapshots taken every 15 minutes over 24 hours, the entire northern sky can be mapped out. In addition, these 24-hour observations were repeated at different times of the year, so that each part of the sky is observed at day and at night time and at different apparent positions. This is the first time that a sky survey is produced by combining many half-sky images instead of scanning or mosaicing with small individual fields of view.

Our observing mode uses the Transient Buffer Boards (TBB) that provide short snapshots of raw voltage measurements from all dipole antennas. These are channelised and correlated with own software, which provides the required spectral resolution. The simple correlator that is part of the station itself cannot be used, because its bandwidth and spectral resolution is fixed to about 200 kHz, which is not sufficient for our purpose. In the gaps between snapshots, pulsars are observed in a more standard pointed mode. These observations serve as additional calibrators for polarisation.

A major challenge is strong interference (RFI) at many frequencies that is partly radiation from distant sources scattered by the 100m telescope. Often this RFI is so strong that it cannot be ignored in the calibration process. Therefore an own self-calibration code is used to calibrate the single snapshots before the combination. This code is able to deal with the RFI, and even turns the curse into a blessing by using the RFI as a calibration source.

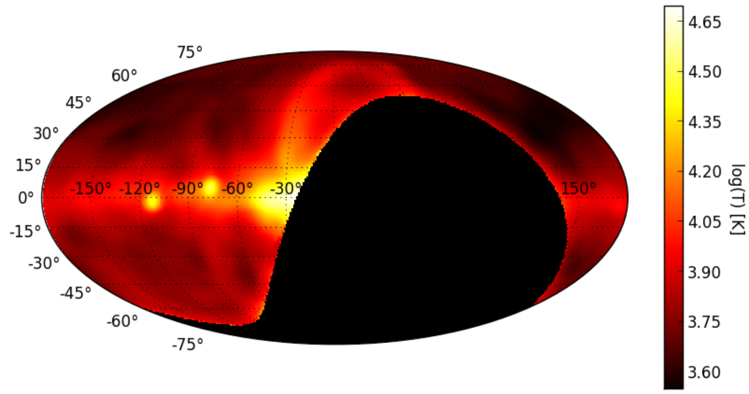


Fig. 3: All-sky map of the entire northern sky as seen with the LOFAR station in Effelsberg at 45 MHz, which leads to a beam resolution of 6.5 deg. For this image around 400 single observations between January and September 2013 have been combined to reach an integration time of 8.5 minutes.

Figures 2 and 3 show a single snapshot and a combined image of the entire northern sky. Even with the limited resolution of several degrees, many details can already been distinguished.

Most obvious is of course the Milky Way and mainly the strong emission from the inner disk, which becomes strongest towards the Galactic centre. In addition, several loops, most prominently the famous North Polar Spur, are easy to see, as well as other weaker filaments. Besides large-scale emission, a number of discrete bright radio sources, like Cas A, Cyg A, Vir A, Tau A and Her A are becoming visible. In some single snapshots the Sun can be detected, as well as Jupiter bursts at the lowest frequencies. Both sources are removed from the maps before combining them. The observations for this project have been performed between January and September 2013 and the analysis is ongoing. The entire process and the results will be presented in detail in the PhD thesis of the author.

Public Outreach

New Film Presentation at the Visitors' Pavilion

By Norbert Junkes

The visitor's centre at Effelsberg Radio Observatory provides a program of talks for registered (and also spontaneous) groups of visitors which take place from April to October every year on five days per week (Tuesday to Saturday).

For several years, a monitor directly at the exterior of the pavilion gave the opportunity to start a film about the scientific work with the 100m radio telescope where scientists from different areas of research (continuum, pulsar observations, spectroscopy and VLBI) describe their research and provide some background information. This was complemented by the explanation of technical properties of the radio telescope.

The presentation of the film at the backside of the pavilion (the screen was actually mounted beneath the building itself) was not optimal. Moreover, the setup only allowed the presentation of one particular movie. Several foreign language visitors asked for the possibility to watch the film not only in German, but also in English language.

Thus, a new system has been installed in November 2014 which allows the presentation of more than one film and also an easy implementation of new contents now. Fig. 1 shows the courtyard of the visitor's pavilion with the new display at the opposite side of the building. It is an HTML based system with a 47 inch full HD screen which can be steered via touchscreen. The present setup includes two films (one of them in both, German and English language) and a table with technical data of the 100m telescope in both languages.

The film about the scientific work at the telescope is accessible in German and English language, a second film about a walk to the very top of the telescope is available only in German at the moment. That film presents a guided tour through different stations with Alex Kraus, the site manager of the Effelsberg Radio Observatory. The stations include the pavilion, the control room, azimuth engines and circular rail, elevation platform 20 m above ground and a walk from the tower lab to the primary focus cabin. A highlight of the film is the tilting of the telescope dish by 90 degrees with Alex (and the camera) in the focus cabin. The final station is the secondary focus cabin with a walk on the dish itself (taking care where to set ones feet!) An English version of that film is planned for 2015.

Fig. 1: Courtyard of the Visitor's Pavilion at Effelsberg Radio Observatory with the 100m Radio Telescope in the background. The pavilion is at the left side of the image, and a part of the Planetary Walk (Stations "Sun", "Mercury" and "Venus") at the right side. The new film display, framed by two poster displays, is shown between Sun and Mercury. Photo Credit: Norbert Junkes

Fig. 2: Station "Sun" of the Planetary Walk, poster display, new film display and another poster display with a large-scale image of the 100m radio telescope (from left to right). Photo Credit: Norbert Junkes

Fig. 3: Film display at the Visitor's Centre of the Effelsberg Radio Observatory. A touch panel menu offers two different films ("Science at Effelsberg", also in English language, and "Telescope Tour"), moreover a table with a number of properties of the 100m radio telescope. Photo Credit: Norbert Junkes

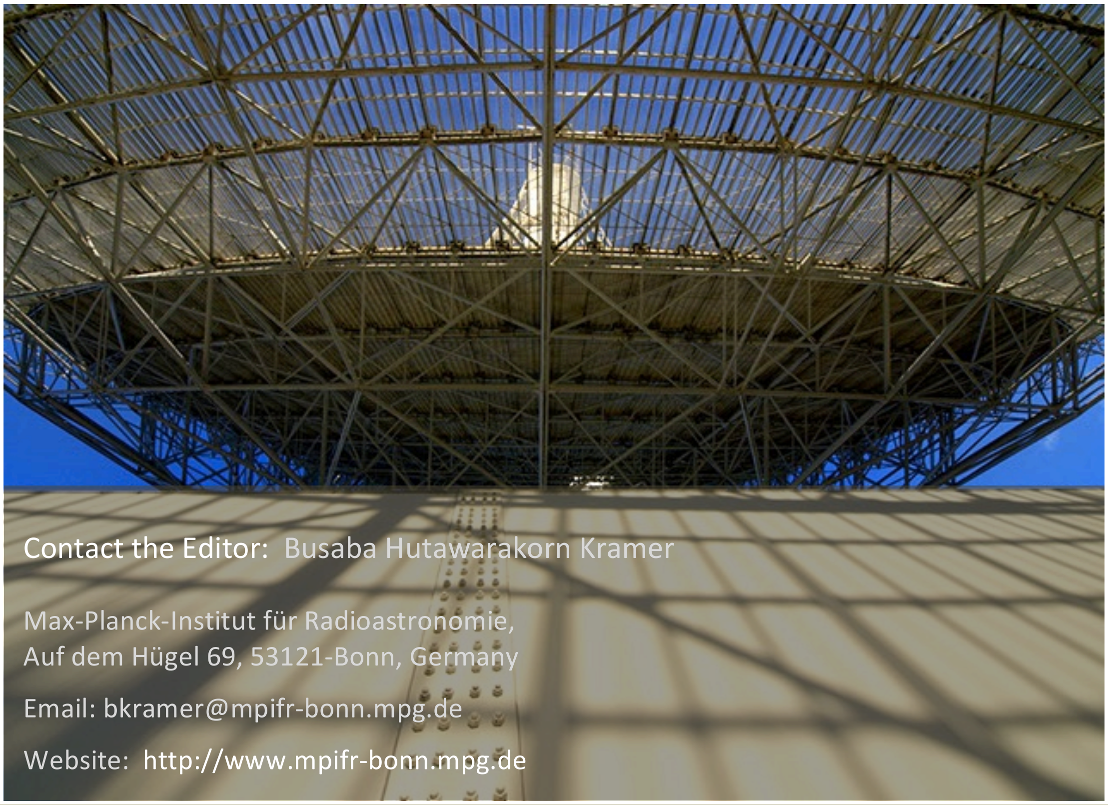
The film display is complemented by two poster displays with additional information (see Fig. 2). Fig. 3 shows the menu of the display with touch panels to start/change the presented films (flag symbols).

Pre-registration for the talks is possible via +49 (0) 2257 301-101 (Mrs Franzen or Mrs Wilfert). Talks are usually held in German language. English talks are possible on request.

The films can be started at any time during the day. At the moment the system is active from 8am to 8pm every day.

Link: Effelsberg Radio Observatory – Visitor's Program

http://www.mpifr-bonn.mpg.de/effelsberg/visitors



Contact the Editor: Busaba Hutawarakorn Kramer

Max-Planck-Institut für Radioastronomie,
Auf dem Hügel 69, 53121-Bonn, Germany

Email: bkramer@mpifr-bonn.mpg.de

Website: http://www.mpifr-bonn.mpg.de