Effelsberg Newsletter

January 2016

Planet Effelsberg - Credit: Patrick Müller, Volkssternwarte Bonn

Happy New Year 2016 !

Greetings from the Director

A Happy New Year 2016!

As it is tradition, in the first issue of the newsletter in a new year, I take the opportunity to wish all staff, colleagues and other readers of this newsletter a happy, successful and, importantly, a healthy new year 2016.

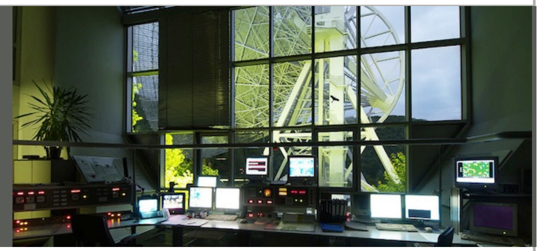
As usual, we take the opportunity to look ahead of what's going to happen in this year. Of course, with the year being a leap year, we'll have one extra day of observing! But that's not the only exciting event to happen: After years of expectation, the ATNF Phased Array Feed (PAF) will finally arrive at the telescope. Following its commissioning at the Parkes telescope in the next few months, it will be the first time that such a large PAF will be installed on a very large dish like the 100-m telescope. We are keen to see what we can achieve with this technology. RFI is always a worry and an unwelcomed 'guest', but only experience will tell. This PAF is a first step towards a cooled system and the science, currently driven by the search for Fast Radio Bursts (FRBs), is hot as ever before. With new FRBs results coming in, the timing couldn't be better.

Besides looking ahead, it is also a pleasure to look back when an important project is completed or a major milestone is reached. That has clearly happened with the EBHIS project last year, and it is reported on here by a contribution of Benjamin Winkel and Jürgen Kerp. It is a wonderful data set, that even caught the eye of the local boulevard press as front page news! Fortunately, none of you has to rely on the corresponding article to learn more about it, simply consult the article here or the published paper in A&A. In any case, congratulations to Benjamin and Jürgen! It is not only a great achievement but also another example of close and successful collaboration with the University.

Happy New Year, Michael Kramer

Call for Proposals

Deadline: February 3, 2016, 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.

Information about the telescope, its receivers and backends, the Program Committee and selection process can be found at the observatory's web pages:

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 February, the next deadline will be on June 9, 2016, 15:00 UT.

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

Recent Technical Developments in the EVN: Towards 4 Gbps VLBI

By Uwe Bach

Since 2013/2014 many EVN VLBI stations installed new digital VLBI backends, mostly the DBBC, at their observatories. All of those stations, including Effelsberg, are now capable of doing 2 Gbps VLBI observations with 2x256 MHz (dual pol) or 1x512 MHz bandwidth (single pol), spread over sixteen 32 MHz base band channels (BBCs). Early tests were made in poly-phase filter bank (PFB) mode where the BBCs are at fixed frequencies and fixed side bands which requires the same local oscillator frequencies at all stations, as no mixing of the signal is happening in the VLBI backend. As most EVN stations have their own individual receivers this is not always possible and restricted the usage of the new capabilities. Also the Field System, the VLBI control program used at most stations, did not support the PFB mode directly which was an additional difficulty for 2 Gbps observations.

In 2015 a new digital down conversion (DDC) firmware for the DBBC was released, which supports 32 MHz base-band channels (BBCs) at individual frequencies and side bands. Up to 8 BBCs with upper and lower side band can be set within the IF frequency band (Fig. 1). Shortly after this release Ed Himwich (FS development, NVI Inc.) incorporated the new DDC features in the Field System. After several successful tests in early 2015, this mode became available in the EVN and was advertised in the May 2015 call for proposals. Three user observations requesting the new mode have been performed in the following sessions. The list of stations with 2 Gbps capability can be found under the following link:

https://deki.mpifr-bonn.mpg.de/Working_Groups/EVN_TOG/2Gbps

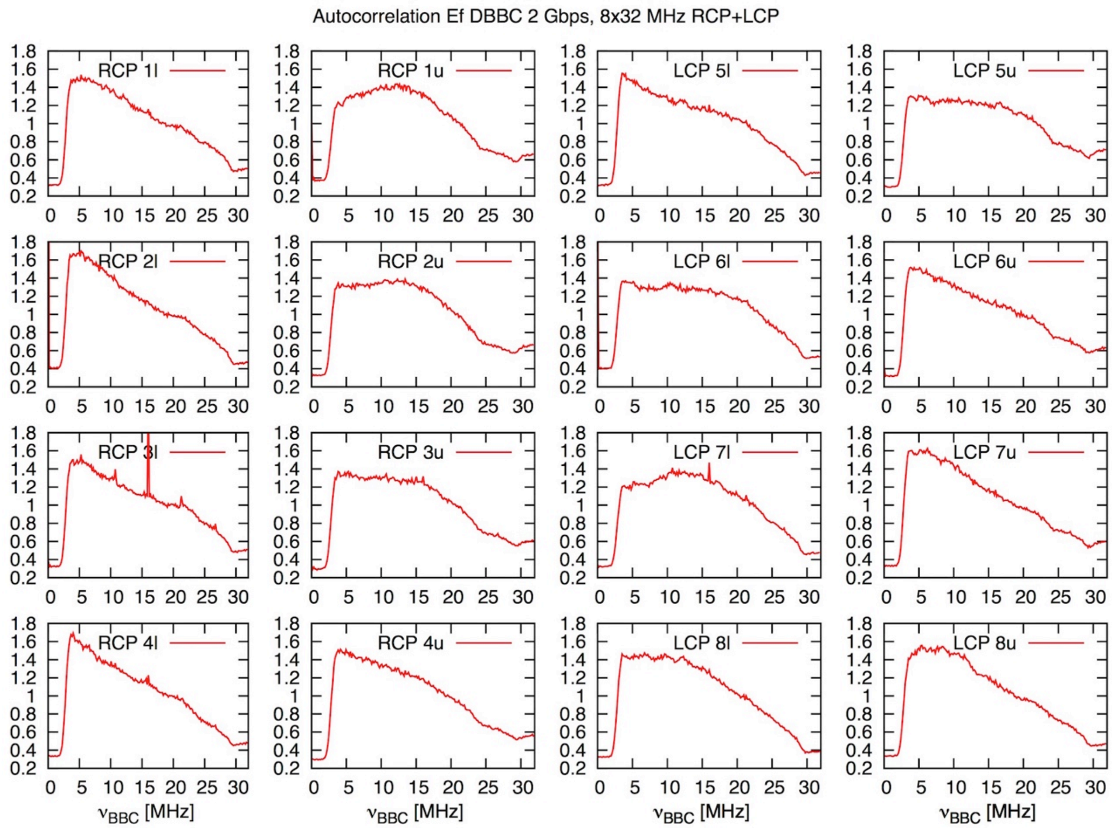


Fig. 1 Example of a 16 channel autocorrelation of the 32 MHz DDC channels from the Effelsberg DBBC. Channels are alternating between RCP and LCP and upper and lower sideband.

A later release of the Field System added support for the Fila10G. The Fila10G is a module that provides two 10 Gb/s outputs from the two VSI (VLBI Standard Interface) inputs of the DBBC. It interfaces the DBBC to the VLBI recorders (Mark5C, Mark6, Flexbuff) or directly to the correlator via the Internet (eVLBI) and the data is recorded in the VLBI Data Interface Format, short VDIF. The recording on a Mark6 or Flexbuff and later e-transfer of the data to the correlator allows VLBI without the need for shipping recording media, which is an aim for many VLBI stations. The 2 Gbps eVLBI capability is currently under test, so that this mode of operation might become available soon, too.

The development of the Field System continues now with the support of the PFB mode of the DBBC. Once realized, even 4 Gbps VLBI observations are within reach and will lead to a doubling of the current EVN sensitivity compared to the current typical recording rate of 1 Gbps.

Science Highlights

Effelsberg-Bonn HI Survey: Milky Way Data Released

By Benjamin Winkel & Jürgen Kerp

Six years of observations and software development culminate in the release of the Milky Way data of the first full coverage of the northern hemisphere. The data of the Effelsberg-Bonn HI Survey (EBHIS, PI: J. Kerp) is now available to the scientific community via the Strasbourg astronomical data center (CDS). Observations for a second sky coverage are already underway.

The January issue of Astronomy & Astrophysics in 2016 presents not only a beautiful map of the northern-sky HI gas in the Milky Way but also reports in detail on the data reduction techniques and data quality of EBHIS (Winkel et al. 2016; A&A 585, A41). EBHIS is the first full-sky survey ever conducted with a 100-m-class single dish telescope in the northern hemisphere. EBHIS aims to substitute the famous Leiden-Dwingeloo Survey (LDS, Hartmann & Burton 1997), which was carried out more than 20 years ago with the 25-m Dwingeloo telescope. In 2005 the LDS was combined with the Instituto Argentino de Radioastronomía Survey (IAR Survey, Arnal et al. 2000, Bajaja et al. 2005) that mapped the HI distribution across the southern sky. The joined data set is known as the Leiden/Argentine/Bonn Survey (LAB, Kalberla et al. 2005). Today it is the standard reference for Milky Way HI astrophysics.

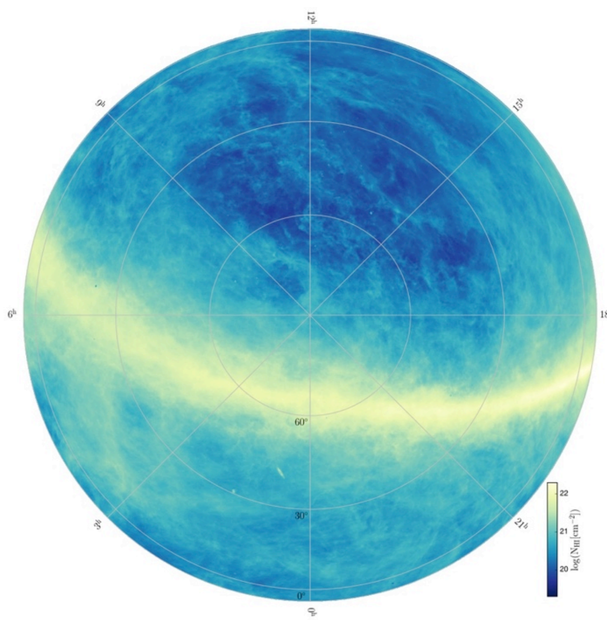


Fig. 1: All-sky HI column-density (N_{HI}) map as observed with EBHIS. A logarithmic intensity scale is used to cover the three orders of magnitude of N_{HI}.

Thanks to a sophisticated stray-radiation correction, the LAB survey offered for the first time reliable HI column density information across the whole sky. Stray radiation refers to an inevitable contamination of each individual HI spectrum caused by the side lobes of a radio telescope. At most observing frequencies, only the near-side lobe pattern is usually of interest. However, HI is distributed all over the sky and Milky Way emission is so bright, that even the far-side lobe contribution becomes significant. In fact, in the important "HI windows to the universe", featuring the lowest column densities, the contribution from far-side lobes can easily exceed the true sky brightness. As such, high-quality stray-radiation correction is a must, if accurate HI column density values are desired.

In contrast to the LAB survey, EBHIS is not only much more sensitive - by an order of magnitude - it also features full-angular sampling. For observing time constraints, LAB was only beam-by-beam sampled, with serious consequences. In fact, we identified (high-significance) objects in EBHIS that are not present in LAB at all.

Together with the Parkes-telescope HI survey of the southern hemisphere, the Galactic All-Sky Survey (GASS, McClure-Griffiths et al. 2009, Kalberla et al. 2010, Kalberla & Haud 2015), we now have the ingredients to build-up a new full-sky image of the HI in the Local Volume, superseding the LAB survey. Especially in view of the upcoming interferometric surveys (e.g., ASKAP/Wallaby and WSRT/WNSHS) the single dish observations comprise an invaluable resource of information, because the interferometers are blind to large angular scales. EBHIS and GASS will certainly set the benchmark for many years if not decades.

In earlier newsletters we reported regularly about science goals and first results of EBHIS. Here, we like to give a brief summary of the data release paper, concentrating on the data quality and data products of the first release.

EBHIS Data Products

Being a spectroscopic survey, the main data product is of course the HI data cube. At full angular and velocity resolution, the single data cube (e.g., in zenith-equal area projection) has a size of 40 GBytes. We decided to split the sky into sub-regions to ease downloading and handling of the EBHIS data. We provide 22x22 sq. deg. sub fields (with 1 deg overlap on each side) in three different map projections (CAR, SIN, and SFL).

For all-sky studies, the HEALPix grid (see Górski et al. 2005) has become a quasi-standard. For example, it is extensively used for Planck satellite all-sky data. To support multi-wavelength studies we therefore provide FITS binary tables containing EBHIS spectra for the grid with an nside value of 1024.

Often, just the velocity-integrated intensity, i.e., the HI column density, for a certain sky position is of interest. Therefore, we also published two HI column density maps (in zenith-equal-area, ZEA, projection, and on the HEALPix grid) for convenience; see Fig. 1.

All these data sets are available for download at CDS. In case you're interested in only a handful of sight lines, you can use our HI survey server, where you will also find LAB and GASS data. If you need maps with a different sky projection or a larger special-purpose data cube, be encouraged to contact us directly. We have software to grid onto any of the sky projections defined in the FITS WCS standard (e.g. Greisen & Calabretta 2002, Calabretta & Greisen 2002).

Data Quality

EBHIS raw data has a volume of several TBytes. Therefore, major effort was necessary to process the data. For this purpose, new software was developed that can automatically calibrate the spectra, detect and flag radio frequency interference, and fit residual baselines. Of course, EBHIS is also corrected for stray-radiation contamination. As an example for the impact of stray radiation on a typical HI observation, Fig. 2 displays a channel map.

Automatic processing of a huge amount of spectra (about 100 million) always has the potential risk that, at least for some fraction of the data, things go wrong. Therefore, an entire section in the data release paper is dedicated to the study of the data quality of EBHIS. Here, we only want to highlight two major aspects and refer the reader to Winkel et al. 2016 for further details.

As EBHIS was designed to serve as a drop-in replacement for the northern-hemisphere part of the LAB survey, it is very important to analyze the cross-calibration properties. In Fig. 2 we show the HI column density (N_{HI}), brightness temperature (T_B), and Moment-1 (intensity-weighted velocity) values of EBHIS vs. LAB. They match almost perfectly. The brightness temperature panel displays a large scatter about the best-fit relation. It is very likely that this is caused by the LAB data,

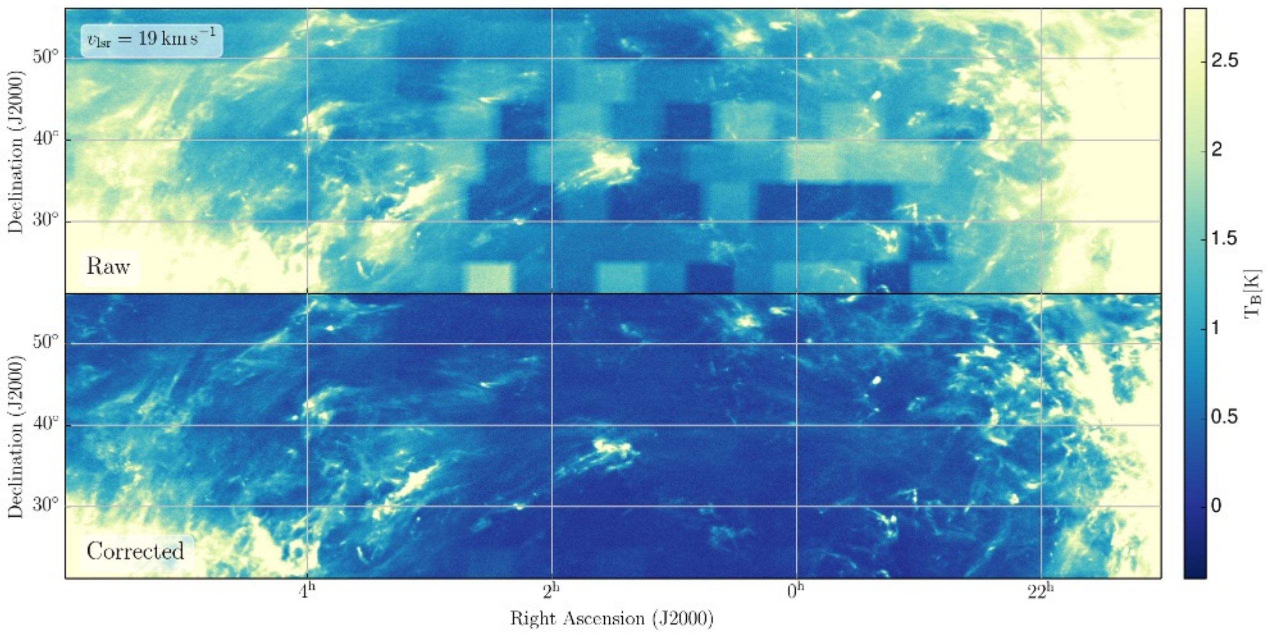


Fig. 2: Example for the impact of stray-radiation (SR) on a typical HI observation. The upper panel shows an EBHIS channel map at LSR velocity of -19 km s^{-1} without SR correction applied. A lot of patches are clearly visible, originating mainly from the far-side-lobe contribution. The patches have a size of 5x5 sq. deg., following the EBHIS observing strategy. The bottom panel contains the final EBHIS data, with SR correction applied.

because we don't observe a similar feature when we compare EBHIS and GASS data. However, we could not identify the origin for this behavior. Note, that we used the spectra for the original LAB pointing positions and resampled EBHIS spectra for these sight lines, because the LAB was not fully sampled in the angular domain.

The HI column densities inferred from LAB and other HI surveys have a tremendous legacy value (e.g., to correct high-energy X-ray data for foreground absorption). Surprisingly, so far no serious attempt was made to evaluate the overall uncertainties of the data, except for smaller areas of interest, usually in the low-column density regime (e.g., Martin et al. 2015). This can be understood in part, because it is very difficult to study the impact of errors in the stray-radiation correction or baseline subtraction for the broad and very intense Milky Way disk line profiles. For EBHIS column densities and brightness temperatures the total ensemble uncertainties have been evaluated (i.e., statistical and systematic). For the brightness temperature the uncertainty is ranging between 2% and 2.5% (for $T_B >> RMS$). Most likely this can be attributed to intensity/flux-density calibration errors. The column density ensemble uncertainty can entirely be explained by error propagation of this calibration inaccuracy and the summation of noisy data for the Moment-0 calculation. Only for the lowest HI column density values, a slight excess in the measured error distribution is found, caused by residual baseline and stray-radiation correction uncertainties.

The authors like to express their special thanks here to Dr. Peter Kalberla, who dedicated many many months of his life to EBHIS stray-radiation correction even after his official retirement. We like also to acknowledge the funding by the Deutsche Forschungsgemeinschaft under the grants KE757/7-1 to 7-3.

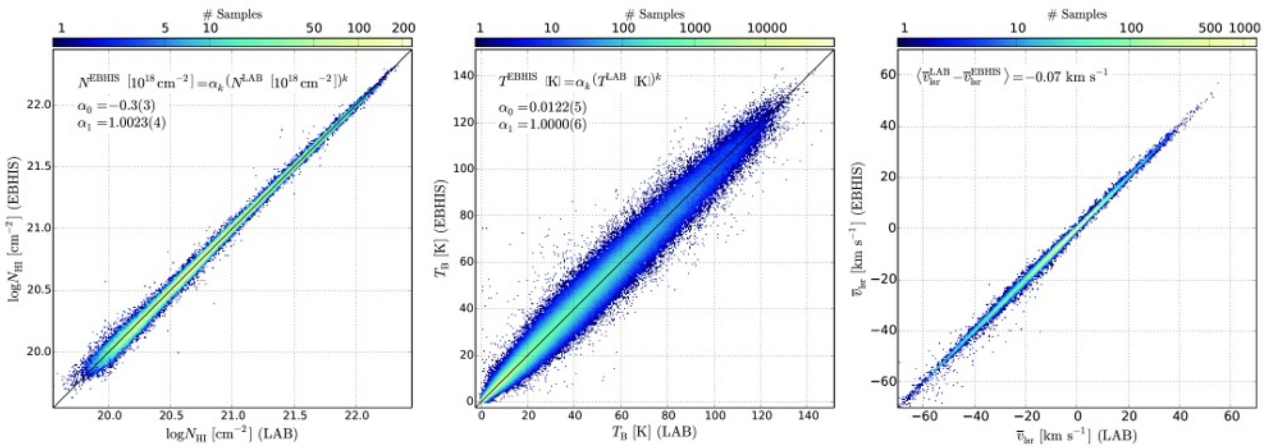


Fig. 3: Comparison of EBHIS and LAB HI column densities, brightness temperatures, and mean profile velocities. The two surveys seem to match almost perfectly in intensity and velocity calibration, and no significant bias (intensity offset) is visible.

Links:

Article: http://www.aanda.org/articles/aa/abs/2016/01/aa27007-15/aa27007-15.html

CDS data: http://cdsarc.u-strasbg.fr/viz-bin/qcat?J/A+A/585/A41

HI survey server: https://www.astro.uni-bonn.de/hisurvey/

References

Arnal, E. M., Bajaja, E., Larrarte, J. J., Morras, R., & Pöppel, W. G. L. 2000, A&AS, 142, 35
Bajaja, E., Arnal, E. M., Larrarte, J. J., et al. 2005, A&A, 440, 767
Calabretta, M. R., & Greisen, E. W. 2002, A&A, 395, 1077
Górski, K. M., Hivon, E., Banday, A. J., et al. 2005, ApJ, 622, 759
Greisen, E. W., & Calabretta, M. R. 2002, A&A, 395, 1061
Hartmann, D., & Burton, W. B. 1997, Atlas of Galactic Neutral Hydrogen (Cambridge University Press, UK), 243
Kalberla, P. M. W., & Haud, U. 2015, A&A, 578, A78
Kalberla, P. M. W., Burton, W. B., Hartmann, D., et al. 2005, A&A, 440, 775
Kalberla, P. M. W., McClure-Griffiths, N. M., Pisano, D. J., et al. 2010, A&A, 521, A17
Martin, P. G., Blagrave, K. P. M., Lockman, F. J., et al. 2015, ApJ, 809, 153
McClure-Griffiths, N. M., Pisano, D. J., Calabretta, M. R., et al. 2009, ApJS, 181, 398
Winkel, B., Kerp, J., Flöer, L., et al. 2016, A&A, 585, A41

Public Outreach

By Norbert Junkes

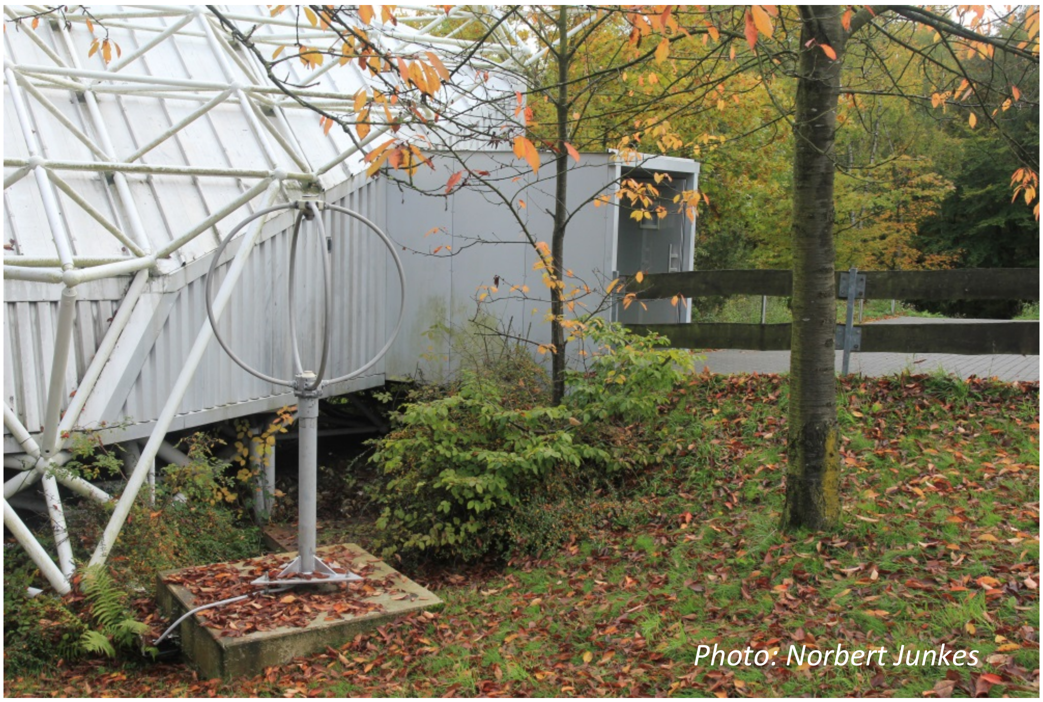


Photo: Norbert Junkes

Low-frequency antenna at the Visitors' Pavilion

Some observers and visitors at the Effelsberg Radio Telescope may have noticed a newly built antenna near the visitors' pavilion which is obviously designed for VERY low frequencies.

At only 162 kHz, far beyond the ionospheric boundary it is used for an investigation of the Earth's ionosphere. The Leibniz Institute for Atmospherical Physics (IAP) in Kühlungsborn at the Baltic Sea coast performs indirect phase-height measurements via analysis of long-frequency radio waves. They use the signal from a transmitter in Allouis (France), in a distance of about 1000 kilometers from the institute in Kühlungsborn.

In order to remove the phase ambiguity in the results, observations of the same transmitter at different distances are required. The low-frequency antenna at Effelsberg approximately half-way between Allouis and Kühlungsborn is suited for that purpose.

Link:

https://www.iap-kborn.de/1/research/department-radar-soundings-and-sounding-rockets/instruments/indirect-phase-height-measurements/

Planet Effelsberg

In October 2015 a Bonn group of amateur astronomers ("Volkssternwarte Bonn") visited the Effelsberg Radio Telescope. One of the participants, Patrick Müller, used the opportunity to create a very special image of the 100-m telescope (see Cover Photo).

"Planet Effelsberg" contains the telescope itself, the old subreflector (lower right) and a container building. It's a really small world.

Link: http://www.volkssternwarte-bonn.de/wordpress/ (only in German)

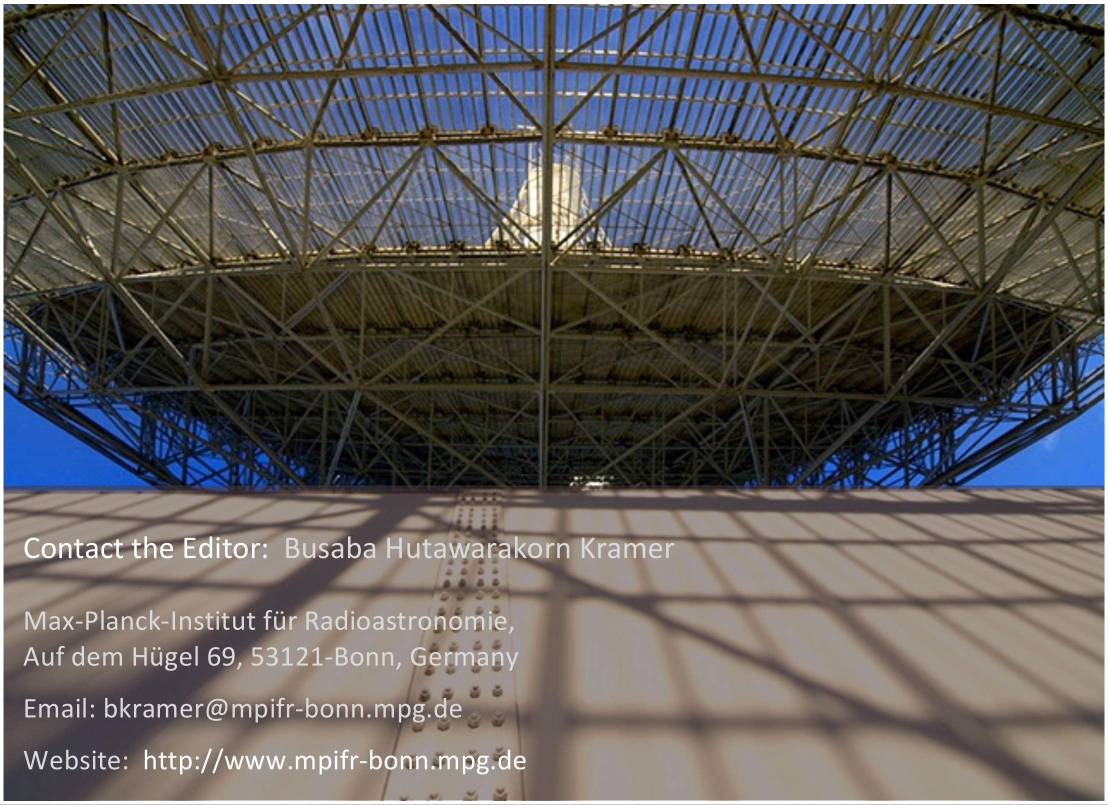
The Red Couch. Photo: Norbert Junkes.

The Red Couch

At one certain day in October 2015 the 100-m radio telescope looked a bit strange. There was nothing wrong with the big white dish, but taking a close look one could spot a tiny red blotch at the edge of the dish. What was it? Within maintenance time that day a red couch was lifted onto the telescope and a series of photos was taken.

The whole thing is part of an art project of Horst Wackerbarth and his pictures and videos of different sites/showcases within North Rhine-Westphalia will be presented in an exhibition for the NRW anniversary (70 years) in September 2016.

Link:
http://nrw-heimat.de/aktuelles/11-milliarden-lichtjahre-und-3,5-millimeter



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