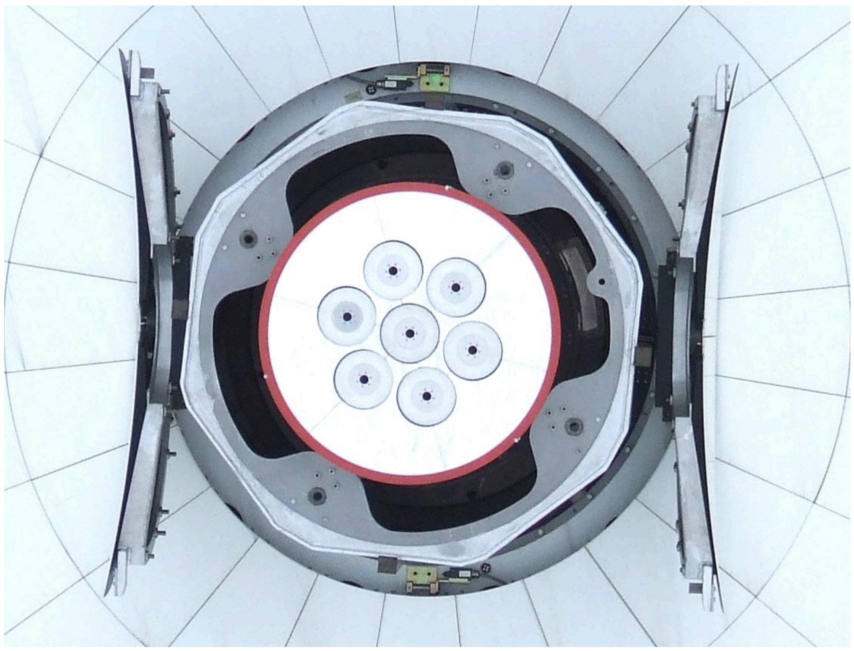
Effelsberg Newsletter

January 2014



Happy New Year 2014 !

Call for Proposals

Deadline:

February 5, 2014, 15:00 UT

Effelsberg Telescope Images, Credit: Norbert Tacken

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.

In the last few years, a number of proposals for Key Science Project (KSP) observations for the 100-meter telescope have been submitted and accepted. As most of these projects are still active and due to the various commitments of the observatory, no KSP proposals could be accepted at the upcoming deadline.

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

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

Observers are especially encouraged to visit the wiki pages!

Observing modes

Possible observing modes include spectral line, continuum, pulsar, and VLBI. Available backends are a FFT spectrometer (with 32768 channels), a digital continuum backend, 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 new 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 4, 2014, 15.00 UT.

by Alex Kraus

Greetings from the Director

If the last year is an example for the coming one, it will be very busy again in Effelsberg. The receiver development program will continue to deliver new instrumentation to the telescope, such as the new K-Band system and the 3-GHz coherently de-dispersing pulsar backend for the UBB system. In addition, the preparation for the arrival of the L-Band PAF system is in full swing, while spring will see the start of the construction of the new building for the workshops. Despite these heavy activities, the observatory staff will be extremely motivated to deliver the usual efficiency, which is indeed needed to work through the thousands of hours of approved observing programs.

Indeed, the over-subscription is so large that in this year, we cannot accept proposals for new Key Science Projects, as we have done in the last February deadlines. However, with new receivers coming in, we will try to make proposal opportunities available for the best scientific projects.

Finally, I like to thank all colleagues around the world who have produced an average of more than 15 publications per month featuring Effelsberg data in 2013! I wish you all luck and success in 2014,

Michael Kramer

TECHNICAL NEWS

The New K-Band Receiver for Effelsberg Telescope

By Gundolf Wieching on behalf of the K-Band Rx project team

Fig. 1 K-Band frontend during lab commissioning. Space limitations require to remove the feed horns for testing. Small picture: CAD model of the K-Band Receiver incl. the feed horns. Credit to C. Kasemann

The superb sensitivity of the 100m-telescope, in particular at higher frequencies, is reflected by the fact that the telescope is highly overbooked especially at the high frequencies. The most requested higher frequencies are within the K-Band, covering the transitions of of water vapour, ammonia, and many more molecules. Thus it was evident that within the update process of the Effelsberg receivers high priority had been given to a new K-Band receiver.

At the end of 2013 the new K-Band receiver saw first light in the lab and will be deployed to the secondary focus at Effelsberg within January 2014. After a comprehensive commissioning the receiver will be available to the community in autumn this year.

In the following some technical details of the new system will be presented to explain the potential of this exceptional machine.

The K-Band receiver is setup as a double feed system, providing two beams at a distance of five times the beam width (HPBW @ 22 GHz: 39.4”). In addition each feed resolves circular left and right hand polarized (LCP, RCP) signals. Combined with the huge instantaneous detection bandwidth of 8 GHz (within the range of 18 – 26.5 GHz), the IF- (Intermediate Frequency) and backend system converts and resolves up to 32 GHz bandwidth.

The frequency resolution is adjustable to the scientific needs. For this purpose a highly complex IF double mixing is implemented providing three different observing modes:

- Mode 1 (“polarisation”):

Both beams and both polarisations (LCP, RCP) each with the full 8 GHz bandwidth and a frequency resolution of 44 kHz (0.5 km/s @ 26.5 GHz)

- Mode 2 (“resolution”):

LCP at one feed and 8 GHz bandwidth with at least 10 kHz (0.12 km/s @ 26.5 GHz) resolution.

- Mode 3 (“zoom”):

Four times 300 MHz bandwidth at both feeds and polarisation with at least 10 kHz (0.12km/s @ 26.5 GHz) resolution.

- Mode 4 (“polarisation / zoom”):

Mode 1 and in addition up to four times 300 MHz LCP at one feed with at least 10 kHz (0.12 km/s @ 26.5 GHz) resolution.

As the first new generation receiver the supporting “infrastructure” such as the control system, data transmission and data reduction is being updated as well. To handle the integrated data rates of contiguous 240 MBit/s special effort is made to provide automated data calibration and reduction pipelines (see Article on page 6). The amount of raw and calibrated data also requires adapted tools to analyse the data. This still leaves some challenges ahead even if the hardware is close to its completion.

The new K-Band receiver is providing unique performance and it will be very exciting to explore its full potential and follow its discoveries to come.

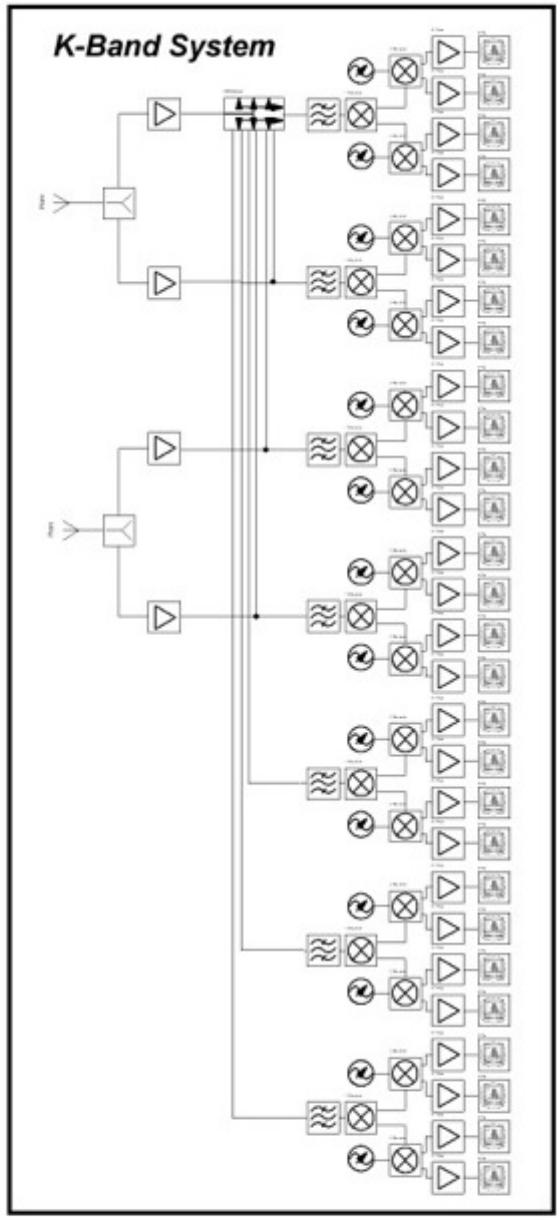
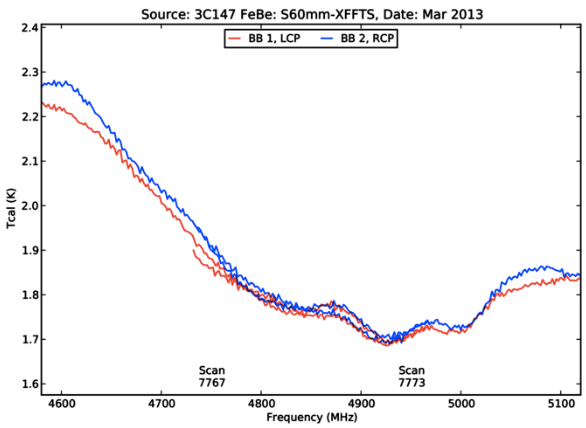


Fig. 2 High level diagram of the K-Band signal processer showing: antenna feeds, OMTs, splitting, double mixing and XFFTS’s (from left to right) Credit to C. Kasemann

About the Calibration of Broadband Receivers

by Benjamin Winkel



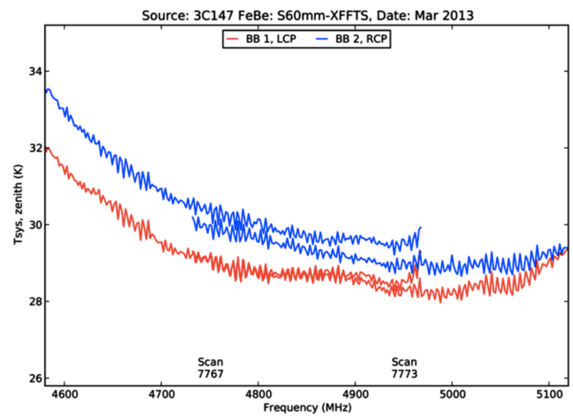


Fig. 1 Even the best receivers exhibit frequency-dependent system temperature and noise-diode spectrum. As an example we show Tsys and Tcal as measured for our 6-cm secondary focus receiver, over a frequency interval of 500 MHz. The ripple in the Tsys spectrum is due to standing waves between the primary dish and the sub-reflector.

If you are a constant reader of this newsletter, then you know about our efforts to make the Effelsberg observatory fit for the coming decades. A central component of our plan is to bring new sensitive broadband receivers to the 100-m telescope. This involves not only major retrofitting of the IF system and receiver control but we also equip the telescope with state-of-the-art backends (see Newsletter 02/2013).

This immense technical endeavor must be accompanied with new developments of data processing and reduction software utilizing new algorithms and methods, as we are going to show in this article.

Working with a broadband receiver (i.e., a system with a large $\Delta\nu/\nu$ ratio) does not only mean that one has to deal with much higher data rates, but also with various other effects which can be neglected when observing smaller bandwidths. This includes differential shifts of the LSR Doppler correction and a much higher vulnerability of the receiving system to radio frequency interferers. However, the probably most important aspect to consider is related to the temperature/flux-density calibration of the data, which means to find the conversion factor between the arbitrary scale (aka counts), the backends provide, to more physical units like Kelvin or Jansky.

In early days of radio astronomy typical bandwidths did not exceed a few MHz. Under such conditions it was well justified to treat quantities like the system temperature Tsys and the spectrum of the noise diode Tcal as constant. Under this assumption many data reduction techniques like position- or frequency switching (in spectroscopy) were invented and became very popular, as the underlying equations are easy to solve.

Unfortunately, when receivers were constantly improved with respect to bandwidth, these data reduction methods were never revised to account for the fact that Tsys and Tcal are indeed frequency-dependent. In a recent paper (Winkel, Kraus & Bach 2012, A&A 540, 140) we described consequences and possible solutions.

In fact, it is possible to enhance both switching techniques to incorporate the frequency dependence. Starting from the most naive approach to simply bin the spectra and calculate the calibration factors for each of the bins separately (using the classic equations) we went a step further and developed a method where one can model the frequency-dependent quantities, e.g. with polynomials or splines, or apply certain filters, e.g. running Gaussian smoothing.

While for position switching (PSW) our proposed approach is pretty robust, frequency switching (FSW) turned out to be a hard problem to solve in a correct way. This is mainly because FSW itself is subject to degeneracy, since each spectrum is divided by a shifted "copy" of itself. Note also, that there is another fundamental shortcoming of the FSW: it can only remove the gain of the IF part of the receiving system, while the RX contribution to the gain is completely unaccounted for. But, even the best frontends will always have a frequency-dependence with respect to their gain.

Therefore, we strongly advise all observers aiming for a precise calibration to use FSW only for narrowband spectroscopic observations (i.e., up to 100 MHz).

About Ghosts: Frequency Switching and the Folding Problem

by Benjamin Winkel

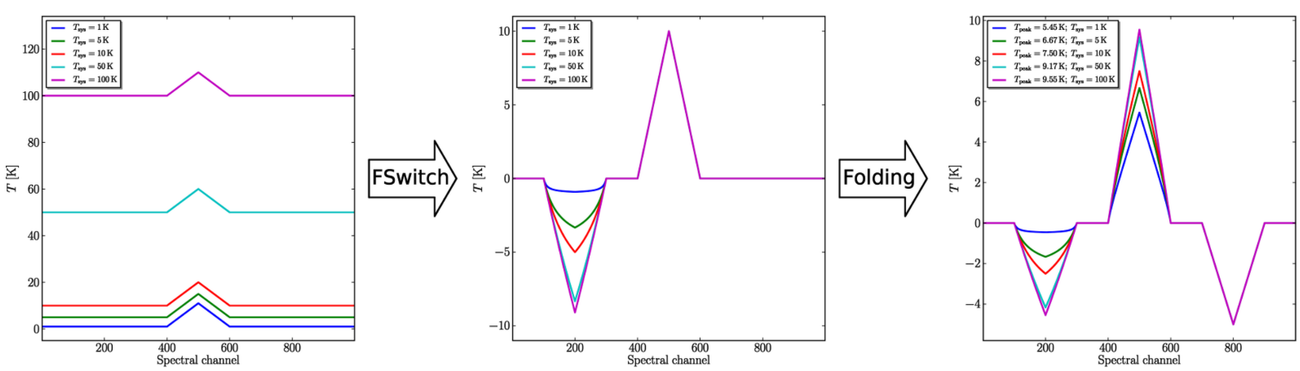


Fig. 1 Left panel: A spectral line of 10 K amplitude (triangular-shaped for visualization purposes) is put on top of a flat continuum/baseline level with five different system temperatures, ranging from 1 K to 100 K. The middle panel shows Tsys(sig-ref)/ref, i.e., the result of the FSW procedure. The spectral line ghosts are visible to the left of the actual emission line. However, as can be easily seen, the amplitude and shape of the ghosts do highly depend on the system temperature! Only if Tsys gets large with respect to Tsou, the ghost is approaching the original amplitude and shape. Consequently, applying the "fold" procedure can result in a wrong calibration of the reconstructed spectral line (right panel). Even if Tsou is only 10% of Tsys, the final amplitude is underestimated by 5%!*

During our work on calibration methods for switching techniques, we also encountered another subtlety in the context of frequency switching (FSW). The aim of FSW is to make best use of given observing time: it measures two spectra independently during one scan on the same target source but with a different local-oscillator shift. For the analysis, the quantity Tsys*(sig-ref)/ref is calculated, where sig and ref are the two independently observed spectra. Since the emission line is also present in the ref(erence) spectrum - at a different spectral position - the FSW produces a so-called "ghost", a spectral-line feature with negative sign.

The analysis software (e.g. “CLASS”) makes use of this ghost by shifting a copy of the FSW spectrum to the appropriate frequency, flip sign and average with the original FSW spectrum (“folding”). This way, both switching phases, sig and ref, contribute to the final result giving optimal sensitivity. Unfortunately, this simple method leads only to correct results if Tsys is far larger than Tsou (see the simple example in fig. 1). This condition is mostly fulfilled when observing at high frequencies, e.g. in the mm- or sub-mm regime, but certainly not at cm-wavelengths.

The better way to approach the optimal sensitivity is to also compute Tsys*(ref-sig)/sig, and to shift this spectrum in frequency followed by averaging with the former. This is similarly easy to calculate and in-fact is what the Effelsberg pipeline does for you.

Science Highlights

Towards the First Data Release of the Effelsberg-Bonn HI Survey

by Jürgen Kerp for the EBHIS team

In 2008 our team at the Argelander-Institut für Astronomie and the Max-Planck-Institut für Radioastronomie started an HI survey of the full northern hemisphere above a Declination of -5 degrees with the Effelsberg 100-m dish. The Effelsberg-Bonn HI Survey (EBHIS, Kerp et al. 2011, AN 332, 637) is the first full-sky HI survey ever performed with a 100-m class telescope. Using state-of-the-art FPGA-based FFT spectrometers a bandwidth of 100 MHz with 16k spectral channels is covered. EBHIS is performed in on-the-fly observing mode, where the sky is subdivided into fields of 5 deg by 5 deg size. These fields are individually calibrated, corrected for bandpass curves, baselines and stray-radiation and - after continuum subtraction - are finally combined by the EBHIS gridder. The complete data reduction software was designed from scratch (see Winkel et al. 2010, ApJS 188, 488) to fit the special requirements of the EBHIS in terms of calibration accuracy and handling the huge amount of data (~10 TByte).

EBHIS will complement the Parkes Galactic All Sky Survey (GASS) and the HI Parkes All Sky Survey (HIPASS) on the northern hemisphere. Eventually providing a full-sky HI map observed with the world's largest fully steerable radio telescopes.

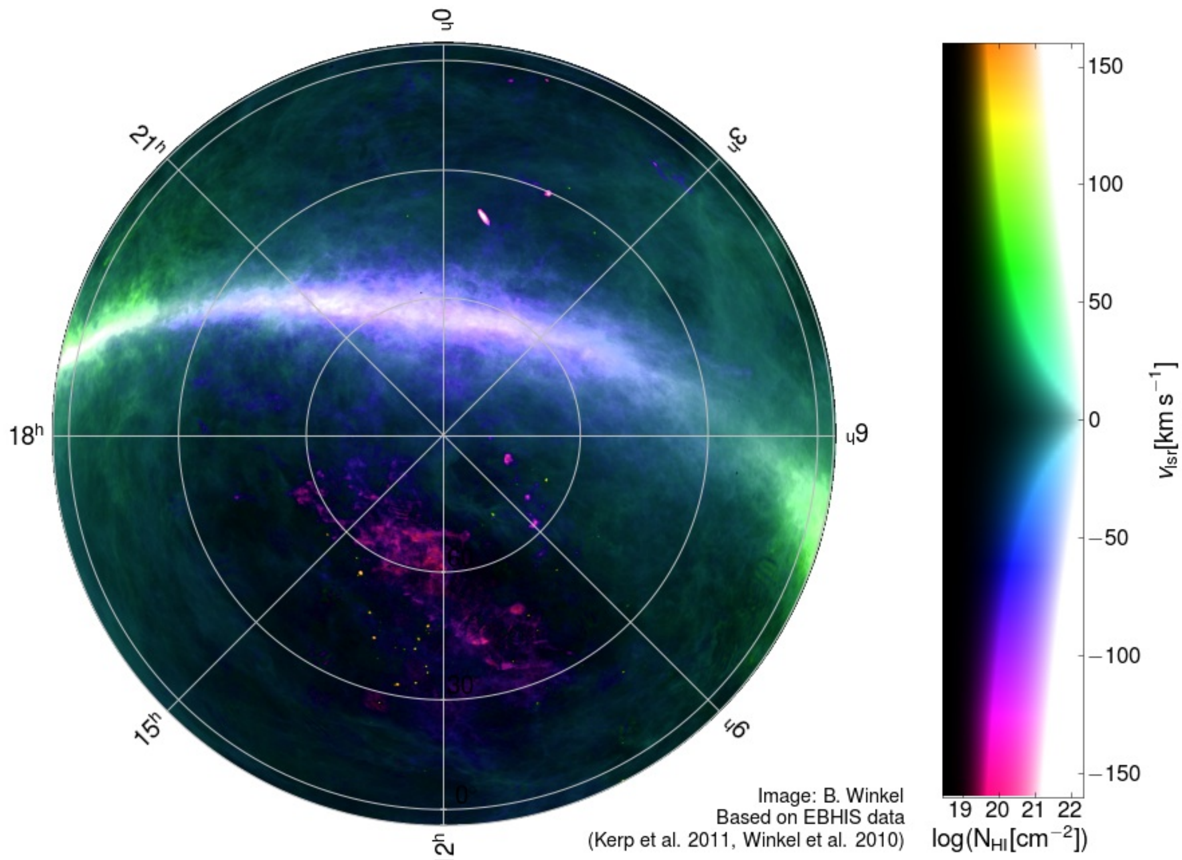


Fig. 1 The Figure shows the full EBHIS sky. Coded in colour is the average Doppler velocity of the HI gas while HI column density is given by brightness. The Milky Way disc is observable across the whole sky, its differential rotation being well visible. Below the galactic plane the HI emission of the Andromeda galaxy and M 33 is visible, showing the large extent of several degrees of these nearest spiral galaxies to the Milky Way galaxy. The reddish diffuse emission north of the Galactic plane is associated with the prominent high-velocity cloud (HVC) complexes C and A.

The high-end FPGA-spectrometers, providing a spectral channel separation of 1.3 km/s, allow for the first time ever in radio astronomy to observe HI in the Local Volume (out to z ~ 0.07) and in the Milky Way at sufficient resolution with a single observing run.

In spring 2013 measurements of the first coverage of the Effelsberg sky have been finished. With a net integration time of 37 sec/Beam EBHIS provides a median brightness temperature sensitivity of 90 mK at full velocity resolution. Systematic artifacts like the stray-radiation contamination have been successfully removed from the data. Data quality has been extensively studied, e.g., by comparing the older Leiden/Argentine/Bonn Survey and GASS with the new EBHIS data. Full data cubes and derived data products (like an all-sky column density map) will soon be released to the scientific community.

In autumn 2013 we started with a second coverage of the northern hemisphere above Dec=30 deg. While driving in right ascension during the first run, we now scan along declination to create a basket-weave-like pattern on the sky. This will help to further improve RFI mitigation and baseline solutions (see Winkel, Flöer & Kraus 2012, A&A 547, 119).

The EBHIS team likes to thank the Deutsche Forschungsgemeinschaft (DFG) for continous funding under the grants KE 757/7-1 to 7-3.

Scientific highlights

Correlation of EBHIS with the Planck satellite:

Quantitative correlation studies between EBHIS and Planck far-infrared radiation (FIR) data have been successfully performed. These studies were focused on lowest HI column density portions of the sky, to disclose the faint emission of the far-infrared background galaxies. The faint glow of the star-forming galaxies formed early in the universe is only visible through the most transparent HI "windows". Here, the correction for stray-radiation is of utmost importance to distinguish between Milky Way foreground emission and the faint signal of these galaxies. First results of these studies have been published just recently by the Planck collaboration and the EBHIS team (Planck paper XXX, astro-ph/1309.0382).

But also the Milky Way HI emission towards high galactic latitudes is of great interest for these EBHIS/Planck correlation studies. Towards one particular region of interest we identified two intermediate velocity clouds (IVCs) which appear similar considering only their HI properties. But they behave extremely different with respect to their FIR properties. Quantitative studies demonstrated that the FIR bright IVC hosts molecular gas while the even denser and warmer IVC is FIR dim. We interpret this observation as ongoing phase transition from a neutral hydrogen IVC to a molecular one. This is of great interest because by warm accretion of matter from intergalactic space the constant star formation rate of the Milky Way galaxy might be maintained (Röhser et al. 2013, submitted).

HVC Complex GCN:

In some of the first EBHIS data sets we identified an interesting HVC population at large negative velocities with unusual physical properties. It turned out, that these objects were part of the HVC complex GCN. In the meantime, by combining EBHIS and GASS data, we obtained a complete high-resolution map of GCN. Complex GCN consists of hundreds of tiny clumps having large spectral line widths of more than ~15 km/s, while no diffuse extended gas phase was detected. We built-up a large sample of clouds and their studied their properties. Statistical analyses revealed that GCN is likely a prime example for on-going warm accretion of gas onto the Milky Way (Winkel et al. 2011, A&A 533, 105).

Study of THINGS galaxies:

About 30 of the 34 of the galaxies in the VLA-THINGS catalogue have been observed by EBHIS. Most of these galaxies are nearby and accordingly they provide a good sample to test the quality of the extra-galactic data of EBHIS. For almost all of the galaxies we find significantly more HI emission than revealed by the VLA. Here two effects act together, firstly EBHIS observes the whole galaxy of interest and not only a fraction of it (the primary beam of the VLA is not large enough in several cases), secondly EBHIS, being a single-dish survey, is not affected by the short-spacings problem.

Comparing EBHIS flux densities with other HI standard data bases shows that so far most galaxies have been underestimated in angular extent. For nearby extended galaxies a single pointing of a radio interferometer as well as of a 25-m single dish telescope is not sufficient to determine the neutral hydrogen amount accurately.

Who is Who in Effelsberg?

Norbert Junkes standing in front of MPIfR's public outreach display board.

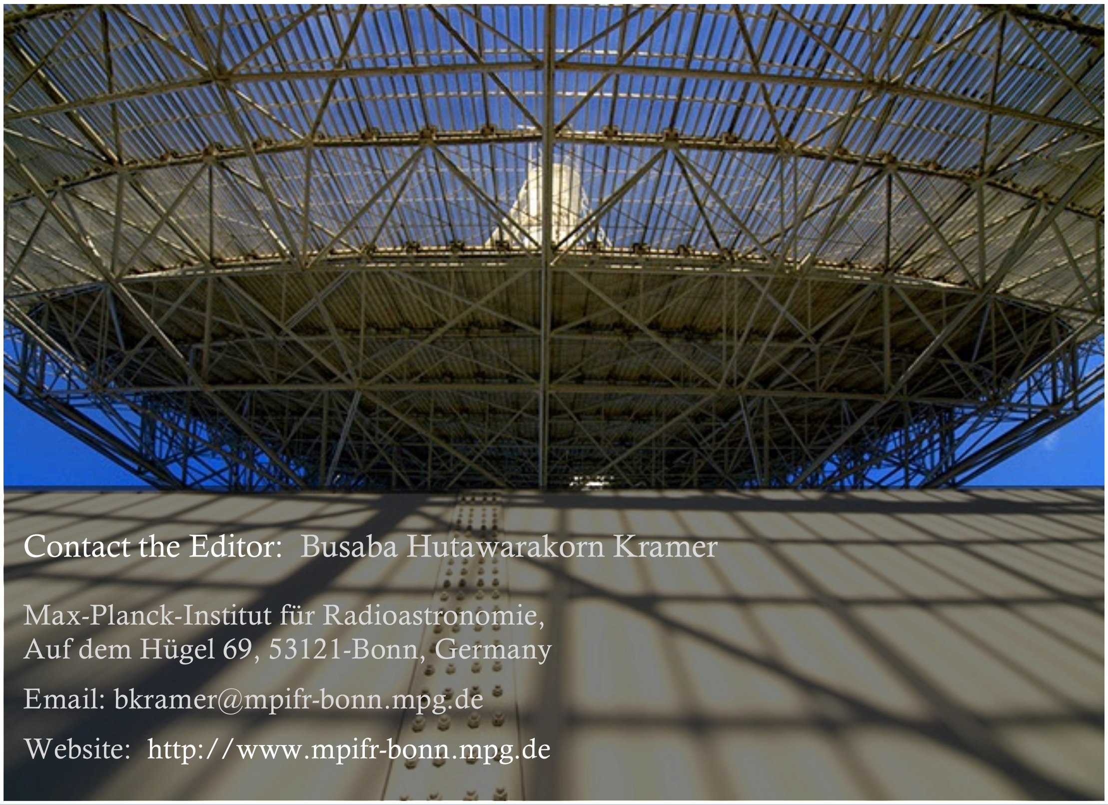
The visitors' pavilion in a winter environment. In the neighbourhood of the pavilion we have three astronomical walks at different scale (Planetary Walk, Milky Way and Galaxy Walk). The access to the viewing spot in direct vicinity of the 100m radio telescope is rebuilt at the moment to become accessible also for people with impairments.

Norbert Junkes

I started work at the Max-Planck-Institut für Radioastronomie quite some time ago. My diploma thesis, finished in 1986, was connected with the radio continuum surveys observed with the Effelsberg 100m radio telescope, in particular polarized emission and magnetic field structure at 11 cm wavelength. The work was extended to an investigation of the interaction of supernova remnants with their environment (PhD thesis, 1989). After finishing my PhD, I left the institute for some time, working as a postdoc, first at ATNF (Sydney, Australia), at Kiel University and the Astrophysikalische Institut in Potsdam. In 1998 I moved back to MPIfR to work in public outreach, specifically talks for groups of people at the visitors' pavilion of Effelsberg radio observatory.

The talks are presented for groups of visitors in the months between April and October from Tuesday to Saturday. In 2013 I finished my 16th season – with a total of 4500 talks since 1998. In the first seven years I gave all talks myself, since 2005 I have support for a couple of days per month.

Besides the talks in the pavilion, our increasing public outreach activities comprises e.g. a number of press releases per year, support of journalists and film teams at both, Bonn and Effelsberg site of the institute, the organization of two series of popular talks at Bad Münstereifel (with the Kurverwaltung Bad Münstereifel) and at the Deutsche Museum Bonn (with Argelander-Institut für Astronomie), and the edition of an annual calendar with pretty images/highlights from the work of the institute.



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