Effelsberg continuum mapping

A brief instruction manual

Effelsberg receivers for continuum observations

1.3-1.7 GHz (18-23 cm): half-power beamwidth (HPBW) 9.3’ at 21cm, polarimeter with 8 small-band (4 MHz wide) frequency channels + one broad-band channel (32 MHz). The frequency channels can be chosen in two ranges: 1290-1430 MHz and 1580-1725 MHz. RFI is strong in parts of these bands. Checking the small-band channels for RFI is recommended. Instrumental polarization is about 2%, but higher in the range 1290-1330 MHz.

1.29-1.43 GHz (21-23 cm), 7 horns, of which the central horn has R+L channels and can be connected to the 8-channel polarimeter (still in test phase).

2.64 GHz (11.4 cm): HPBW 4.5’, 1 horn, polarimeter with 8 small-band (10 MHz wide) frequency channels (covering 2600-2680 MHz) + one broad-band channel (80 MHz). The first small-band channel (2600-2610 MHz) is often affected by RFI, which also affects the broad-band channel. Use of the remaining 7 small-band channels (2610-2680 MHz) is recommended. Instrumental polarization is about 2% in channels 3-6 and lower in the other channels.

4.85 GHz (6.3 cm): HPBW 2.4’, 2 horns, each 1 broad-band (500 MHz) frequency channel; free of RFI over most of the time.

8.35 GHz (3.6 cm): HPBW 1.4’, 1 horn, 1 broad-band (1100 MHz) frequency channel; RFI mostly at low elevations.

10.45 GHz (2.9 cm): HPBW 1.1’, 4 horns, each 1 broad-band (300 MHz) frequency channel

32 GHz (9mm): HPBW 25”, 7 horns (4 with R+L channels), 1 broad-band frequency channel (4 GHz). This system is still in test phase.

All receivers except for the two 1.4 GHz systems are permanently mounted in the secondary focus cabin. The 1.4 GHz systems need to be moved into the primary focus. The receivers in the above list are equipped with feeds to detect circular polarization (R and L). Unpolarized emission gives the same signal in the R and L channels. From the R and L data, the polarimeter backend computes linear polarization data (U and Q). As the result, data in the 4 Stokes channels (R, L, U and Q) are provided from each horn and (in case of the 8-channel polarimeter) from each frequency channel. NOTE: Real signals can be negative in U and Q!

Multi-horn systems allow restoration of the difference signals (software beam switching) and hence overcome part of distortions by clouds. The sensitivities for continuum mapping can be found here.

More details about the calibration parameters of individual receivers are given on: Receiver and calibration parameters for the Effelsberg 100-m Telescope

Given below are a few recommendations how to set up maps in Effelsberg for different receiver systems. The software used for observations at Effelsberg is called "OBSINP". A descrition of the software and how to use it for mapping is given here.

Mapping in Effelsberg

Single-horn systems: Maps ("scans") can be scanned in any coordinate system, i.e. right ascension/declination or Galactic longitude/latitude, and can be turned to align with the major axis of an elongated target. Alternating mapping in two perpendicular directions (e.g. right ascension and declination) is strongly recommended. An individual scanned line or column is called "subscan". For full sampling of structures, the distance between lines should be at least 2.5 times smaller than the half-power beamwidth. The pixel distance in the scanning direction is much smaller in the raw data, but is increased in the first reduction stage to achieve square pixels.

Multi-horn systems: As the horns are fixed in the secondary focus, scanning must be done in **azimuth-elevation system** to allow for restoration of the signals. The maps need to be larger in azimuth by the maximum beam separation on sky, plus one additional beam at each side to improve the baselevel determination

Flux calibration is done by observing maps around at least two primary calibrators per session (3C48, 3C138, 3C286) for which the fluxes at all frequencies are well known. 3C138 and 3C286 are highly polarized and can also be used for calibration of the polarization angle. Maps on calibrators have standard sizes for each receiver (about 4x HPBW). 3C147 and 3C295 can be used as unpolarized calibrators.

A description of the initial data reduction can be found here.

Scanning Velocities for Continuum Maps

(based on input from Rainer Beck)

Smoothing the raw data obtained in the scanning mode with a sinc function requires at least 10 points per telescope beam (Peter Müller, priv. comm.). This limits the scanning velocity to:

v_{max} (arcsec/sec) = v_{max} (arcmin/min) = Θ (arcsec) / (10 t (sec))

(with Θ being the beam size at the observing wavelength).

The continuum backends allow a minimum integration time of t=0.064 sec, yielding:

v_{max} (arcsec/sec) = v_{max} (arcmin/min) ≈ 1.5 Θ (arcsec)

Reasonable maximum scanning velocities at the various frequencies are given in the table below. Please note, that a further reduction might be useful to reduce the turnover time and therefore increase the observing efficiency.

Frequency	FWHM (arcsec)	v_{max} (arcmin/min)
1.4	552	800
2.7	258	380
4.85	147	220
8.35	72	105
10.45	68	100

Frequency	FWHM (arcsec)	v_{max} (arcmin/min)
14.6	50	75
32.0	25	35