LBWG memo 26

What is the ST001 FOV really?

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Motivation

It is in principle possible to calculate fields of view of antennas, or combinations of antennas, theoretically. This becomes more difficult for phased-up combinations of stations such as ST001, which is usually made up as the phased-up CS stations, and ST002, which is made by default in LBCS observations as the phased-up sum of the stations on the superterp island.

However, it is useful to verify this observationally. In principle, this can be done by imaging observations, but this is not straightforward since each image contains data from multiple baselines. A straightforward test would ideally require

- A well-understood and simple field
- Examination of one baseline at a time.

An ideal field is provided by the pair of compact sources 3C343 and 3C343.1, which are 0.484 degrees apart and at a high declination. These were observed in LBCS (observations L388295 and L388299) in two separate pointings, but in each pointing the other source is close enough to be visible. We cannot make images from LBCS data, but each baseline can be used to make a fringe-rate/delay (FRD) map (Jackson et al. 2016) in which both sources are visible. Because we have exactly the same pair of sources with the same baselines, but pointed at the two different sources, we can solve for the intrinsic source brightness, together with the amplitude reduction caused by the offsets. This amplitude reduction will contain a number of factors, but if we study baselines to CS001 on its own, together with baselines to ST001 or ST002, we can deduce the reduction that is due to the larger size of the superstations.

FRD mapping

Fringe-rate/delay maps have been produced on nine baselines, between the remote stations DE601 (Effelsberg), DE605 (Jülich) and DE609 (Norderstedt) and the core stations CS001, ST001 (combined core stations) and ST002 (CS002-007 superterp island stations).

Fig. 1 shows the results for the three baselines to Effelsberg, and for the two observations pointed at 3C343 and 3C343.1 respectively. In each case it is apparent that the source at the centre of the field appears brighter than the source away from the centre. The two sources obviously have intrinsically approximately the same brightness on this baseline, and the differences are due to a mixture of aperture FWHM and smearing effects; the latter will, however, be the same for all three baselines.

We can infer the effects of aperture size by measuring the flux ratios between 3C343 and 3C343.1 in these maps, in the observation pointed at 3C343 and in the observation pointed at 3C343.1. Measurements have been done by hand using AIPS TVSTAT. For each reference station (CS001, ST001, ST002) the square root of the ratio of these two ratios is the reduction in amplitude at 0.48° distance caused by all instrumental effects (beam FWHM and smearing) together, the ratios of the source brightness having divided out. We can calculate these for each of the stations CS001, ST001 and ST002 (Table 1).

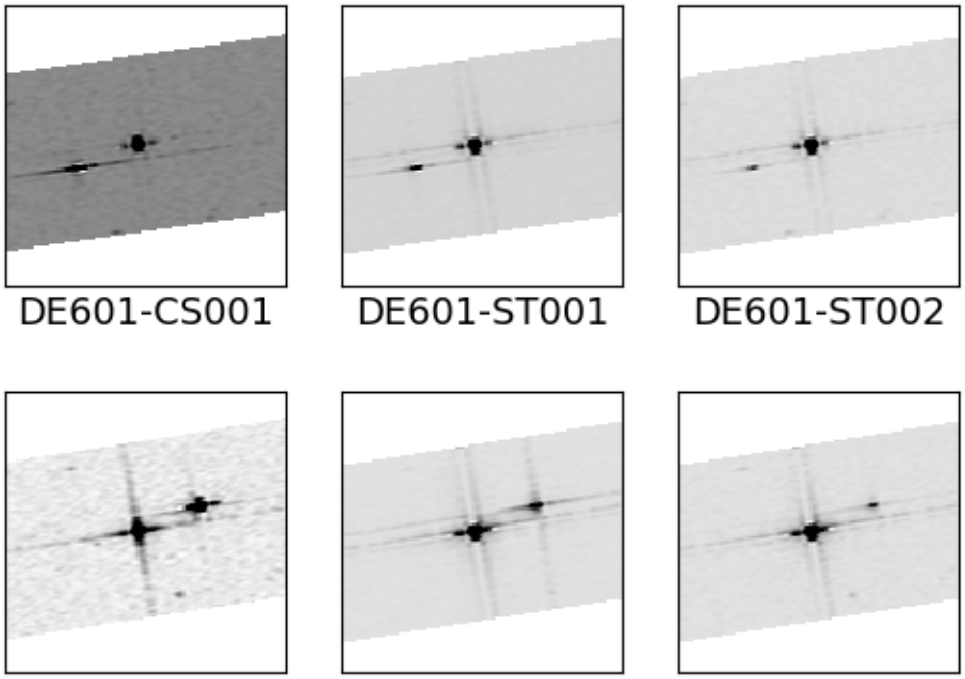

Figure 1: FRD maps of 3C343 and 3C343.1 for three different baselines to DE601. Upper row: observation pointed at 3C343.1; Lower row: observation pointed at 3C343.

Each of these ratios individually involves beam FWHM and smearing effects together. However, the smearing effects are the same for all reference stations, so by division we can obtain the relative beam effects, or the absolute effect of ST001 and ST002 if we assume that that of CS001 is small.

ST001

The result for ST001 is understandable. The ratio of between 0.20-0.32, compared to 0.72-0.81, implies that the effect of the ST001 beam is an amplitude reduction of 0.34 ± 0.07 at approximately 0.5 degrees.

ST002

The result for ST002 is not understandable, because it implies a larger amplitude reduction than ST001 despite ST002 covering a much smaller error. There are two possibilities: (i) an error in the pipeline, (ii) a poorer phasing performance in the construction of ST002 in NDPPP resulting in an effective amplitude reduction.

Ant 1	Ant 2	Ratio (3C343.1)	Ratio (3C343)	Reduction
CS001	DE601	0.73	1.35	0.74
	DE605	0.64	1.22	0.72
	DE609	1.13	1.39	0.81
ST001	DE601	0.142	3.51	0.20
	DE605	0.264	2.55	0.32
	DE609	0.217	4.04	0.23
ST002	DE601	0.065	11.9	0.074
	DE605	0.084	9.3	0.095
	DE609	0.084	15.4	0.073

Table 1: Ratio of apparent brightnesses of 3C343 and 3C343.1 in observations pointed at 3C343.1 (column 3) and 3C343 (column 4). The reduction factor (column 5) is the square root of the ratio of the numbers in columns 3 and 4.