

Long-baseline tutorial exercise: fringe-fitting of LBCS data

LBCS¹ is a survey using the Lofar long baselines in HBA, in order to characterise long-baseline calibrator sources. It is necessary because not all sources which are strong at HBA frequencies have the necessary compact (sub-arcsecond scale) structure to be seen with the long-baseline array.

More than 20000 sources have so far been observed, with 3 MHz bandwidth and an integration time of 3 minutes in each case. An automated pipeline is used for the data processing; however, in this exercise five individual sources are examined by hand.

The sources are shown in Table 1. They were all observed simultaneously on 9 November 2015, using different beams. Each of the five UV FITS files is available in

1hd001:/data/scratch/DATASCHOOL2016_T5_LB.

Observation ID	Position
L410196	00:01:21.34 44:40:27.0
L410198	00:00:53.12 40:54:01.5
L410200	00:31:31.11 44:18:26.0
L410206	00:01:01.52 41:49:29.2
L410210	00:01:19.70 41:53:10.1

The data are pre-processed by the long-baseline pipeline. This pre-processing involves combining core-stations into a single tied-station, adjusting the phases on a bright calibrator to make sure phase coherence is achieved in the combination. The pre-processing also involves a rotation of linear to circular polarization, so that Faraday rotation appears as a phase offset between “L” and “R” polarization. In the LBCS pipeline itself, fringe-fitting is performed on each source to solve for the delays and phases in each polarization. The scatter on the resulting solutions is then used to evaluate whether significant signal is present, and thus whether the source is suitable as a calibrator. In addition, we can use the technique of fringe-rate mapping to produce a very crude image, from single baselines, of the surrounding region to the source. We use AIPS because it has a full-service fringe-fitter, in the form of the FRING program.

Suggested investigations are as follows:

1. Load the data into AIPS using FITLD.
2. Using PRTAN look at the stations present in the data. You should see a limited number of remote stations (RS), the international stations (601 to 609) and the tied station ST001. (ST002 is a tied station formed with a restricted range of core stations). The German stations 601, 605, and 609 are on the short baselines to ST001.
3. Produce phase and delay solutions using FRING. Read the help file for FRING carefully before doing this. For reference, the LBCS pipeline uses the following (detailed explanations can be found in the help file):

¹Long-Baseline Calibrator Survey, formerly “LOBOS”: Jackson et al., astro-ph/1608.02133

- ST001 as the reference antenna
 - Phase solutions using ST001 and the international stations 601–609 only
 - A short solution interval (0.1 minute), low minimum S:N for the solutions (2)
 - A delay window of 600 ns and rate window of 5 mHz.
 - Antenna weighting (parameter WEIGHTIT) of 3, representing no differential weighting of the antennas
4. Inspect the phase, delay and rate solutions using SNPLT. Look particularly at the scatter in the solutions. Which do you think are suitable candidates for calibration? Compare with the “official” catalogue on www.jb.man.ac.uk/~njj/lbcs_stats.sum.
 5. Try fiddling with some of the above parameters, to see if you can see what difference this makes (e.g. using ST002 instead, changing the delay/rate windows, weighting, solution intervals...)
 6. Can you see any similarity in the phase and delay solutions between close-by strong sources? What does this tell you about spatial scales in the ionosphere?
 7. L410198 and L410210 are close to each other. How would you look for one object in the data of the other? (Hint: use SPFLG to look at the short baseline amplitudes and phases of L410210). For reference, the fringe-rate/delay map of L410198 is shown below).

