Dual band multi-pointing: observing and analysis
June 2015

GMRT has the facility to allow simultaneous observations in the 235 and 610 MHz bands due to the use of concentric feeds at the focus of the GMRT antennas. Although the primary beams at the two bands are different, it allows simutaneous mapping of the angular region equal to the primary beam at 610 MHz at two radio frequencies, thus allowing an instantaneous spectral index determination in addition to variability of the sources in that field. This is extended to allow mapping of the 235 MHz beam (118') by the 610 MHz beam (44') which can achieve reasonably good sensitivity due to the differences in beamsizes and system temperatures. A facility to generate the required pointings has been enabled. A test field centred on the CDFS field has been observed using this procedure and the data has been analysed to reveal encouraging results: 1.8 mJy/beam at 235 MHz in central pointing and 0.4 mJy/beam at 610 MHz in the mosaiced image for a total of 22m integration. This note gives a short summary for interested users and encourages them to use this multi-pointing facility for their science problems. Queries can be addressed to ngk@ncra.tifr.res.in with 'Dual band multi-pointing' in the subject line.

1 Generate the pointings

This script generates the coordinates of the pointing centres of the six adjoining fields given the coordinates of the pointing centre of the central field and the desired offset as shown in Figure 1. For our experiment we used an offset of 50'. The output can then form the source file with the list of sources required by the GMRT control system. A command file which cycles through these sources can then be generated. This tool will be made available at http://www.gmrt.ncra.tifr.res.in/ astrosupp.

2 Preliminary results from observations of a test field

We have observed the CDFS field which has been well studied at radio frequencies thus affording several comparison fields. Seven pointings towards this field were observed for a total observing time of four hours with each pointing being observed for 4.5m and cycled through five times. We observed the amplitude calibrator at the beginning and the end of the 4h run. No separate phase calibrator was observed, a strategy already proven by some GMRT users to be effective at 150 MHz. We find it works for 610 MHz and 235 MHz due to the presence of several strong sources in the field.

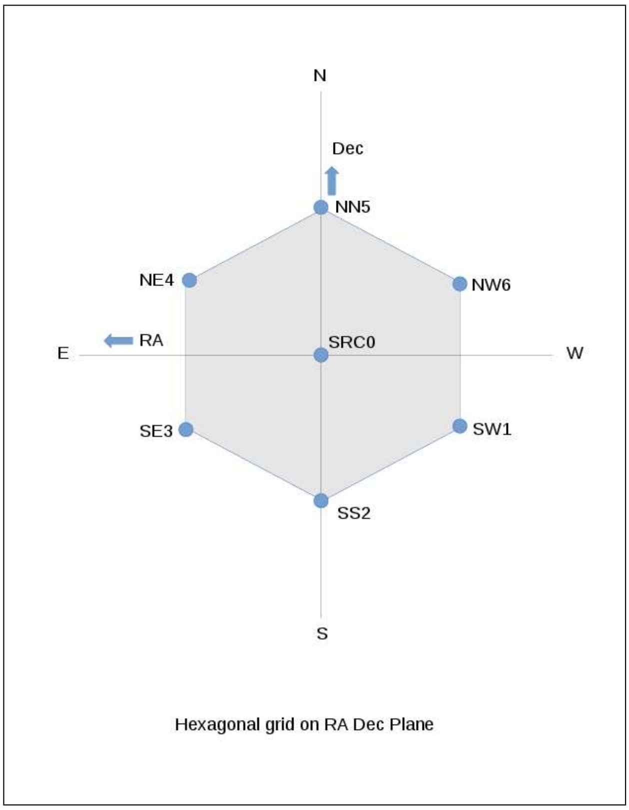

Figure 1: The location of the six pointing centres surrounding the central pointing.

2.1 Data Analysis

The presence of RFI in the data required extensive flagging. We used several tasks - amongst them FLGIT, UVFLG, TVFLG and so on to identify and remove bad data. All the seven fields at 610 MHz were separately self-calibrated and imaged. The images of the seven pointings at 610 MHz were finally mosaiced using FLATN. SAD was used on the central 235 MHz pointing and the mosaiced image at 610 MHz to generate a listing of sources which were then matched to within 10" in both the coordinates.

The preliminary data reduction of the fields at 235 and 610 MHz has given the following encouraging results:

- The typical rms noise on the 235 MHz field observed for about 22m was 1.8 mJy/beam with a beamsize of 17.5" $\times$ 10.5". 5σ is 9 mJy. The expected noise was 0.6 mJy.
- The typical rms noise on the 610 MHz field was 0.4 mJy/beam with a beamsize of $7.5'' \times 6''$ for the 25m data. 5σ is 2 mJy. The expected noise was 0.16 mJy. When convolved to the resolution of the 235 MHz image, the rms noise increased to 0.8 mJy/beam.
- In a box of size $95' \times 75'$ centred on the central pointing position, SAD

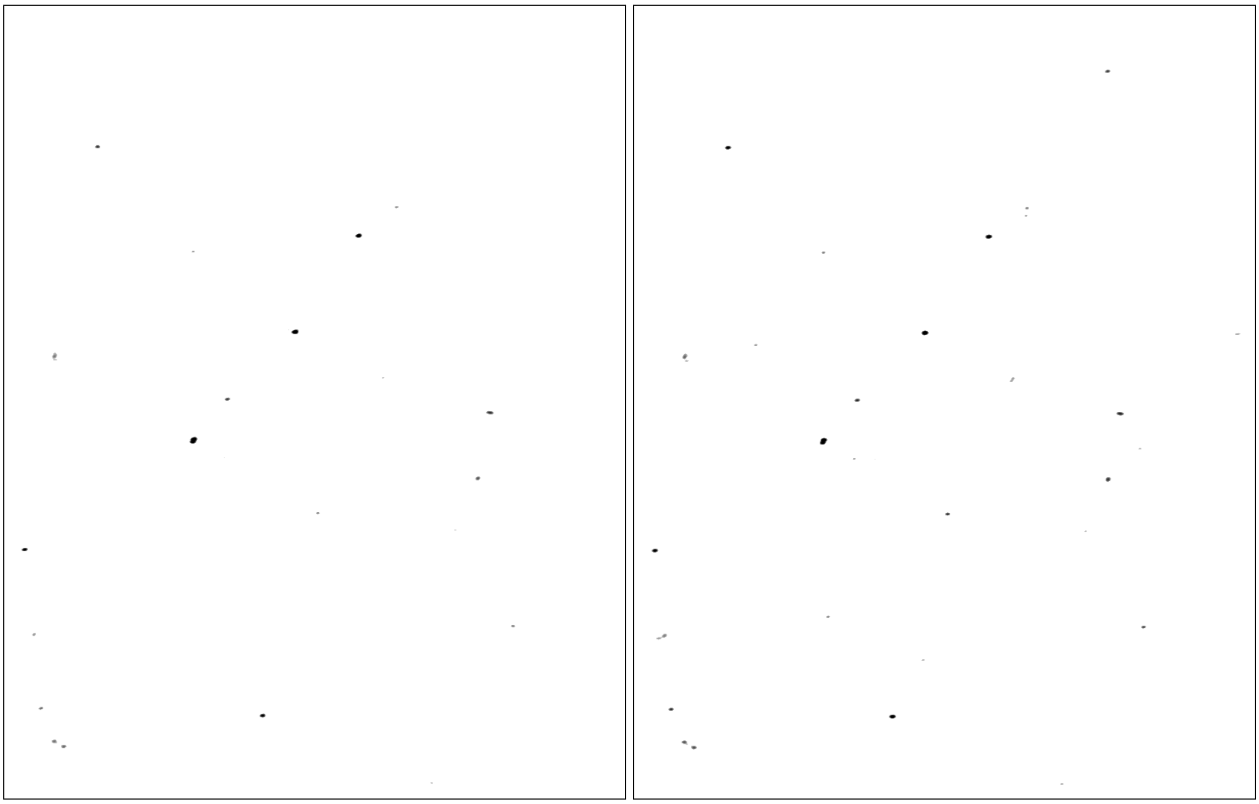

Figure 2: 235 MHz (top) and 610 MHz (bottom) images. The sources are seen as black dots. Both the maps have the same angular resolution and all sources above 8σ are shown.

located 52 sources at 235 MHz above 14 mJy (8σ) and 69 sources at 610 MHz above 6 mJy. The spectral index was estimated for the ~ 40 common sources and is shown in Figure 2. Most of the sources have a spectral index steeper than -0.5 as expected. This will be useful in quantifying the realistic flux scale errors when the different 235 MHz fields are ready for further analysis.

3 Summary

The aforementioned results using the dual band multi-pointing observations are encouraging. For a 22m observing run, we have obtained a rms noise of 1.8 mJy/beam at 235 MHz and 0.4 mJy/beam at 610 MHz. If all the pointings are averaged at 235 MHz, this should result in a reduction of the rms noise at least by a factor of 2 ie to about 0.9 mJy/beam for the central field. These multiple pointings can be used to examine fast variability of the sources, if any, within the flux errors, since the large 235 MHz beam samples the same region several times. Sources having peculiar spectra (e.g. extremely steep spectra of extragalactic origin or pulsars) between 235 and 610 MHz can be instantly examined and further observations undertaken. For comparison, a 15m observing

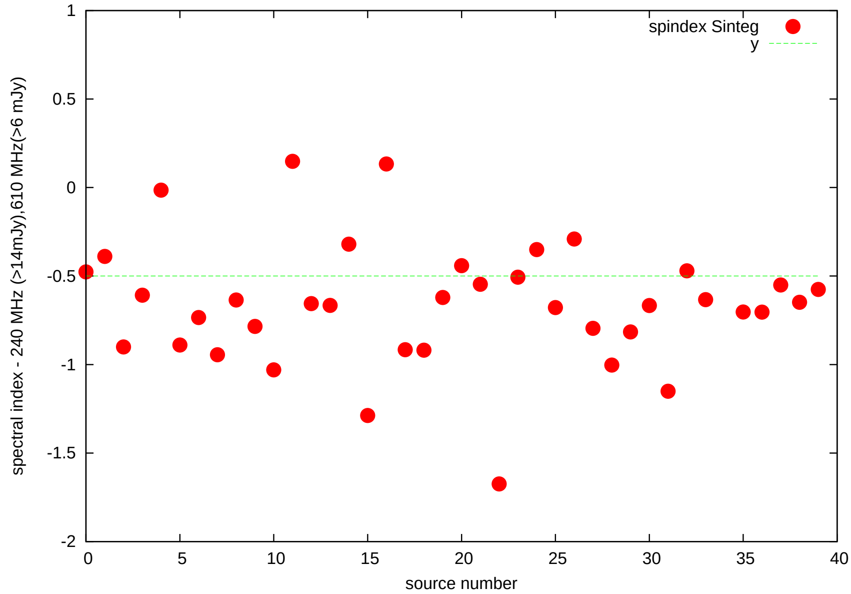

Figure 3: Spectral index estimated between 235 MHz and 610 MHz in the central $95' \times 75'$ region formed by mosaicing the 610 MHz pointings and the central pointing at 235 MHz. About 40 common sources were found in the two bands, where both the coordinates matched within 10".

run at 150 MHz results in a rms noise of about 6 mJy (16 MHz, dual polarisation channel; TGSS) whereas at 235 MHz results in a rms noise of about 2.2 mJy (12 MHz, single polarisation channel; extrapolated from these results)

This note is released to encourage users to think of using this multi-pointing mode of dual band observing for their science. The procedure-developing + data gathering + data reduction was done by Santaji Katore, Subhashis Roy and N. G. Kantharia. If you have any queries or doubts, please write to ngk@ncra.tifr.res.in and mention 'Dual band multi-pointing' in the subject line. More tests on the same data are underway and we hope to share the results soon. We thank Huib Intema for showing that the observing strategy which requires no separate phase calibrator is effective at the low GMRT frequencies and which has been successfully used for this test.