Characterising the performance of GWB-II: Understanding (i) the performance of two LO-lock schemes and (ii) the range of optimal values of OF attenuation

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1 Overview

Initial tests, see reports

"Characterising the performance of new GWB system"
(`http://ncralib1.ncra.tifr.res.in:8080/jspui/handle/2301/605`)
Lal, Dharam V.

and

"Analysis of Lband data from the new GMRT Wideband Backend, or the GWB, in order to test long term amplitude and phase stability"
(`http://ncralib1.ncra.tifr.res.in:8080/jspui/handle/2301/593`)
Sherkar, Sachin S. and Lal, Dharam V.

showed that the GWB (GMRT wideband backend) appears to match the GSB (GMRT software backend, currently in use) for some baselines or antennas, but not for all, and that there appears to be inconsistencies in the relative values of cross-correlation count (ccf) for different baselines involving the same antenna. In addition, the presence of two Local Oscillator (LO) lock schemes in the GAB (GMRT analog baseband), synthesiser and signal-generator modes, available at the L-band added more inconsistencies. This feedback was given the GMRT backend team, who have fixed many of these issues and brought out a few more changes in the analog baseband.

This report is organized as follows. Sections 2 and 3 explain respectively the motivations and the qualitative features of two LO-lock schemes. Section 4 explains methodology of these tests in order to observe nature of ccfs and its dependence on OF attenuation. The data presented here and results from several series of GMRT tests performed using GWB-II and GAB are listed at
`http://www.gmrt.ncra.tifr.res.in/~sachin/`.
A summary of results of the analysis are presented in subsequent sections, namely, Section 4.1 and 4.2 show results obtained at the four sub-bands, 1060 MHz, 1170 MHz, 1280 MHz and 1390 MHz of the L-band using synthesiser and signal-generator modes of the LO-lock schemes, respectively. We summarise our findings in Section 5, and make some final concluding remarks with regard to testing of GWB-II interferometry modes with different OF attenuation values using different LO-lock schemes.

2 Motivations

Motivated from this, we performed another set of tests, where optical-fiber (OF) attenuations were put in at various levels and data recorded for several calibrator sources using GSB and GWB-II for a faithful comparison between the two backends. Since, two LO-lock schemes, synthesiser and signal-generator modes are available at the L-band, we record data from both LO-lock schemes in the GAB. Here, we have two key aims to achieve, *i.e.*,

– to test if results from the signal-generator and the synthesiser LO-lock schemes provide consist results at all sub-bands of the L-band and

– to test variation of ccf with different OF-attenuation values of the interferometry mode of GWB-II, thereby provide optimal values of OF attenuation.

Similar to our previous effort, hereagain we use ccf[1], for a baseline at a given frequency as a measure of performance of the GWB-II.

[1] The ccf from a point/calibrator source with flux density, $S\nu$ is defined as

$$\text{ccf} = \frac{G \times S_\nu}{T_{\text{sys}}},$$

where G and T_{sys} are Gain (in K Jy^{-1}) and system temperature (in K) of a GMRT antenna, respectively.

3 'Signal-generator' and 'Synthesiser' modes of LO-lock schemes

The LO subsystem is responsible for establishing time and phase synchronization in the array. It essentially generates the sinusoidal signals necessary for phase-locking the received signals from RF and for tuning these as required, *e.g.*, for fringe tracking and for other interferometer-specific features, if any. This LO subsytem also provides coherent references to other devices so as to achieve synchronization and accurate timing. It does this by providing an interface to an external time scale, say GPS and by measuring the difference between external time and array time. At the L-band of the GMRT, generation of reference signal is performed using phase-coherent LO and is performed via two mechanisms, namely, generating a reference LO signal ('signal-generator'), and creation of a synthesised LO signal ('synthesiser') in the GAB. (GMRT analog staff occassionally refer the signal generator as master/reference LO which plays role in putting RF signal coherent for all antennas.) Former is an off-the-shelf product used to lock the reference frequency, whereas in the latter, FSW generates LO from synthesiser and is used to lock the reference frequency. In GAB system there 100, 200, 400 MHz baseband filters, and also a direct path (without the filter), which can be fed to the new backend system. More details are available in the report

> "Backend system upgrade: LO generation scheme"
> (`http://www.gmrt.ncra.tifr.res.in/gmrt_hpage/Upgrade/Backend-LO.pdf`)
> Ajith B. Kumar and Navnath D. Shinde .

4 Data

GMRT data using new GMRT wideband backend (GWB), now called GWB-II are acquired using the new GMRT analog baseband (GAB) chain at several frequencies in order to understand the performance of GWB-II and its comparison with the existing GSB. The observing log for the test data presented in this report is shown in Table 1.

Table 1: GMRT test data presented in this report.

Frequency	Obs. Date	Target	Expected ccf
1390 MHz	2014-09-10	3C 286	0.055
1280 MHz	2014-09-10	3C 286	0.055
1170 MHz	2014-09-10	3C 286	0.055
1060 MHz	2014-09-10	3C 286	0.055
1390 MHz	2014-09-17	3C 48	0.061
1280 MHz	2014-09-17	3C 48	0.061
1170 MHz	2014-09-17	3C 48	0.061
1060 MHz	2014-09-17	3C 48	0.061

Since, these are an upgrade related tests of GMRT to understand varying ccf scales from GWB-II on various baselines with respect to the GSB, (i) both, broadband system and related antennas are a must and (ii) data from GWB-II and GSB needs to be recorded simultaneously. All observations were typically made in the following manner:

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- OF attn 4 dB - 4 dB, perform power-eq and record data
- OF attn 7 dB - 7 dB, (DO NOT power-eq) and record data
- OF attn 9 dB - 9 dB, (DO NOT power-eq) and record data
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- OF attn 1 dB - 1 dB, (DO NOT power-eq) and record data
- OF attn 4 dB - 4 dB, (DO NOT power-eq) and record data
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4.1 Tests using ‘synthesiser’ LO-lock scheme

Following the recipe mentioned above, several tests were performed at the various sub-bands of the L-band to understand (i) the clear trend for falling ccf with increasing OF attenuation still persists, and (ii) if the data still show low ccf in the GWB-II as compared to the GSB at several sub-bands of the L-band, which were reported in our earlier report

“Characterising the performance of new GWB-II system”

(`http://ncralib1.ncra.tifr.res.in:8080/jspui/handle/2301/605`)

for the ‘synthesiser’ based LO-lock scheme mode.

Briefly, from Figure 1, following conclusions can be drawn.

i The GWB-II data from all the sub-bands of the L-band behave as good as or better than the GSB data.

ii There is a marginal trend for falling correlation with increasing OF-attenuation. This fall is maximum for the 9 dB OF-attenuation and is seen at all the sub-bands of the L-band.

iii Marginal differences in ccfs for baselines at each sub-band are insignificant, less than 3-6 $\times\sigma$.

In Section 5, we would compare these results with results from ‘signal-generator’ LO-lock scheme and make further concluding remarks.

4.2 Tests using ‘signal-generator’ LO-lock scheme

Hereagain, in this section, we present results from several tests at the various sub-bands of the L-band to understand (i) the clear trend for falling ccf with increasing OF attenuation still persists, and (ii) if the data still show low ccf in the GWB-II as compared to the GSB at several sub-bands of the L-band, which were reported in our earlier report

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(`http://ncralib1.ncra.tifr.res.in:8080/jspui/handle/2301/605`)

for the ‘signal-generator’ based LO-lock scheme.

Briefly, from Figure 2, following conclusions can be drawn.

i The GWB-II data from all the sub-bands of the L-band behave as good as or better than the GSB data.

ii There is a marginal trend for falling correlation with increasing OF-attenuation. This fall is maximum for the 9 dB OF-attenuation and is seen at all the sub-bands of the L-band.

iii Marginal differences in ccfs for baselines at each sub-band are insignificant, less than 2-5 $\times\sigma$.

Below, in Section 5 we would compare these results with results from ‘synthesiser’ LO-lock scheme that are now available at the L-band. Finally, we would make further concluding remarks and make recommendations for the optimal OF-attenuations that can be used at the L-band and its four sub-bands.

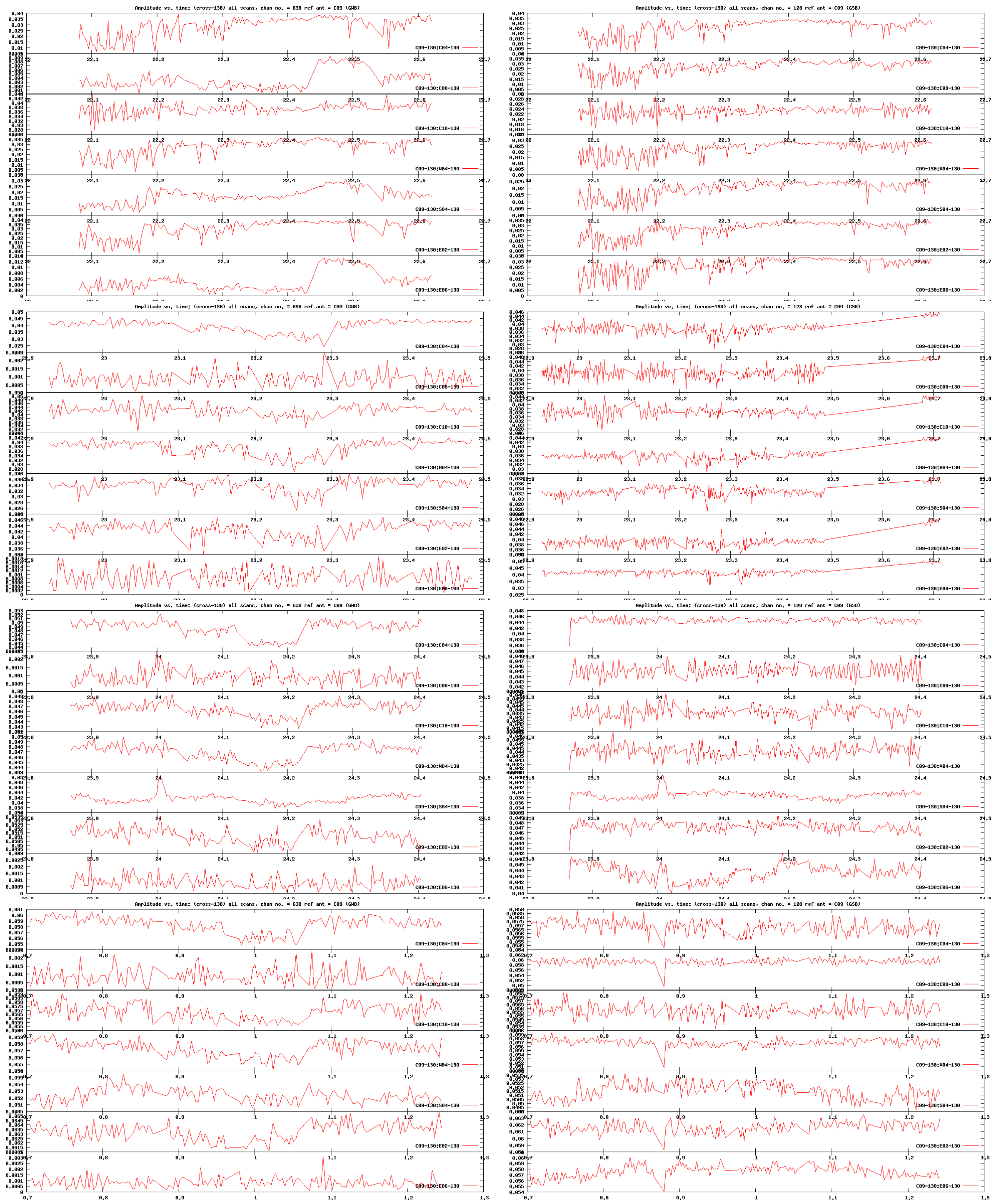

Figure 1: Plot showing ccfs (amplitudes) as a function of time for a channel at the centre of the frequency band for the ‘synthesiser’ LO-lock scheme. Four panels are ordered as, 1390 MHz (Top-first), 1280 MHz (Upper-second), 1170 MHz (Lower-third) and 1060 MHz (Bottom-fourth). Note (i) in both, left (GWB-II) and right (GSB) panels, channels (channel-638 in the left panel and channel-128 in the right panel) are chosen such that they correspond to the same frequency, and (ii) no-power equalisation was performed (see Section 2). Scan-0, scan-1, ..., and scan-4 correspond to OF attenuations of 4 dB–4 dB, 7 dB–7 dB, 9 dB–9 dB, 1 dB–1 dB, and 4 dB–4 dB, respectively.

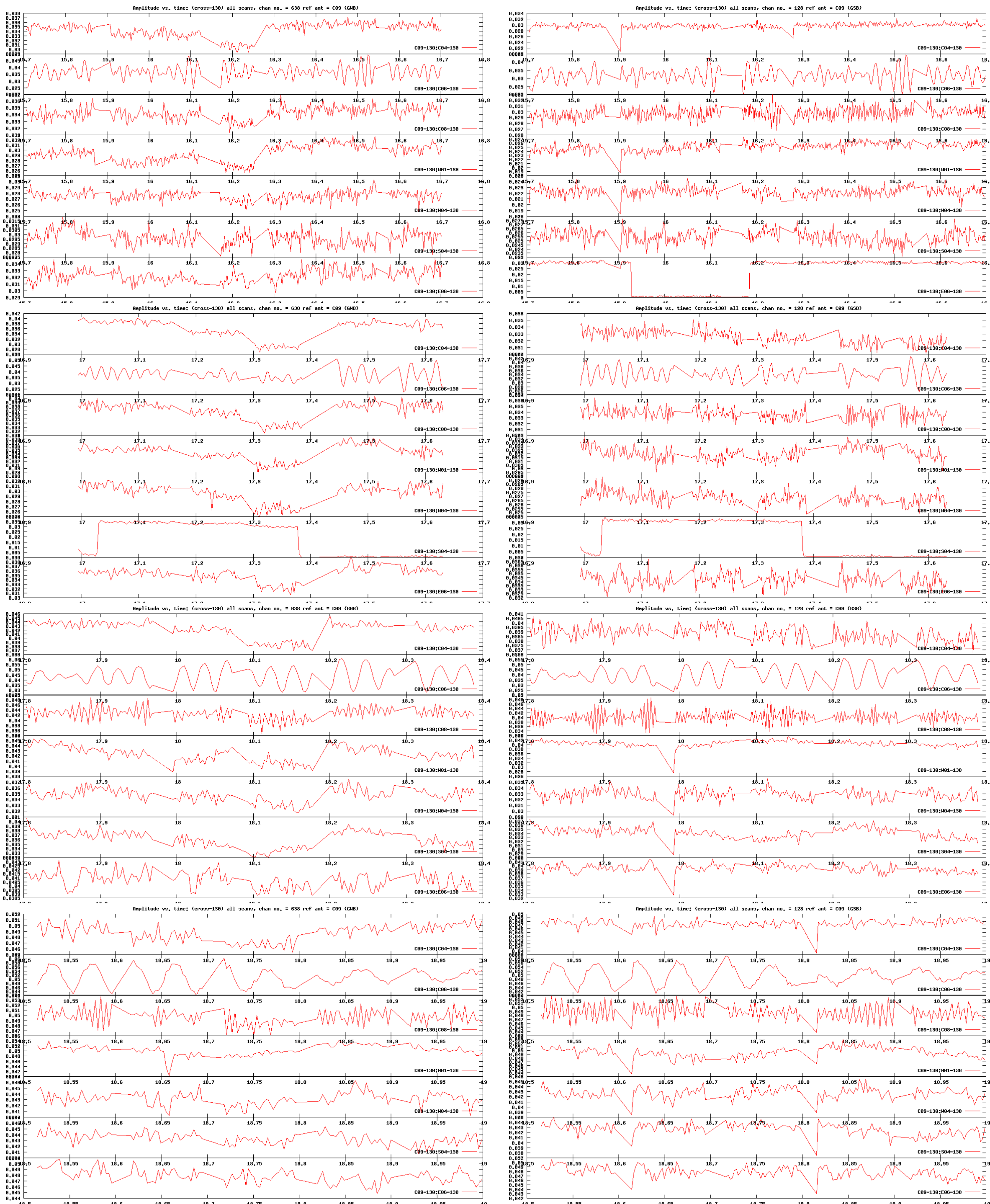

Figure 2: Plot showing ccfs (amplitudes) as a function of time for a channel at the centre of the frequency band for the ‘signal-generator’ LO-lock scheme. Four panels are ordered as, 1390 MHz (Top-first), 1280 MHz (Upper-second), 1170 MHz (Lower-third) and 1060 MHz (Bottom-fourth). Note (i) in both, left (GWB-II) and right (GSB) panels, channels (channel-638 in the left panel and channel-128 in the right panel) are chosen such that they correspond to the same frequency, and (ii) no-power equalisation was performed (see Section 2). Scan-0, scan-1, ..., and scan-4 correspond to OF attenuations of 4 dB–4 dB, 7 dB–7 dB, 9 dB–9 dB, 1 dB–1 dB, and 4 dB–4 dB, respectively.

5 Summary

We have presented results from a series of tests performed at several sub-bands of the L-band frequency of the GMRT. Figures 3 and 4 show ccf as a function of OF-attenuation using data shown in Figure 1 and 2, respectively. C09 is the reference antenna. (Two antennas C08 and E06 failed, hence there are five plots in synthesiser LO-lock scheme.) In the plots shown in each of these Figures, we show mean (+/- rms) for each run of the OF-attenuation. Our conclusions from these new observations can be summarized as follows.

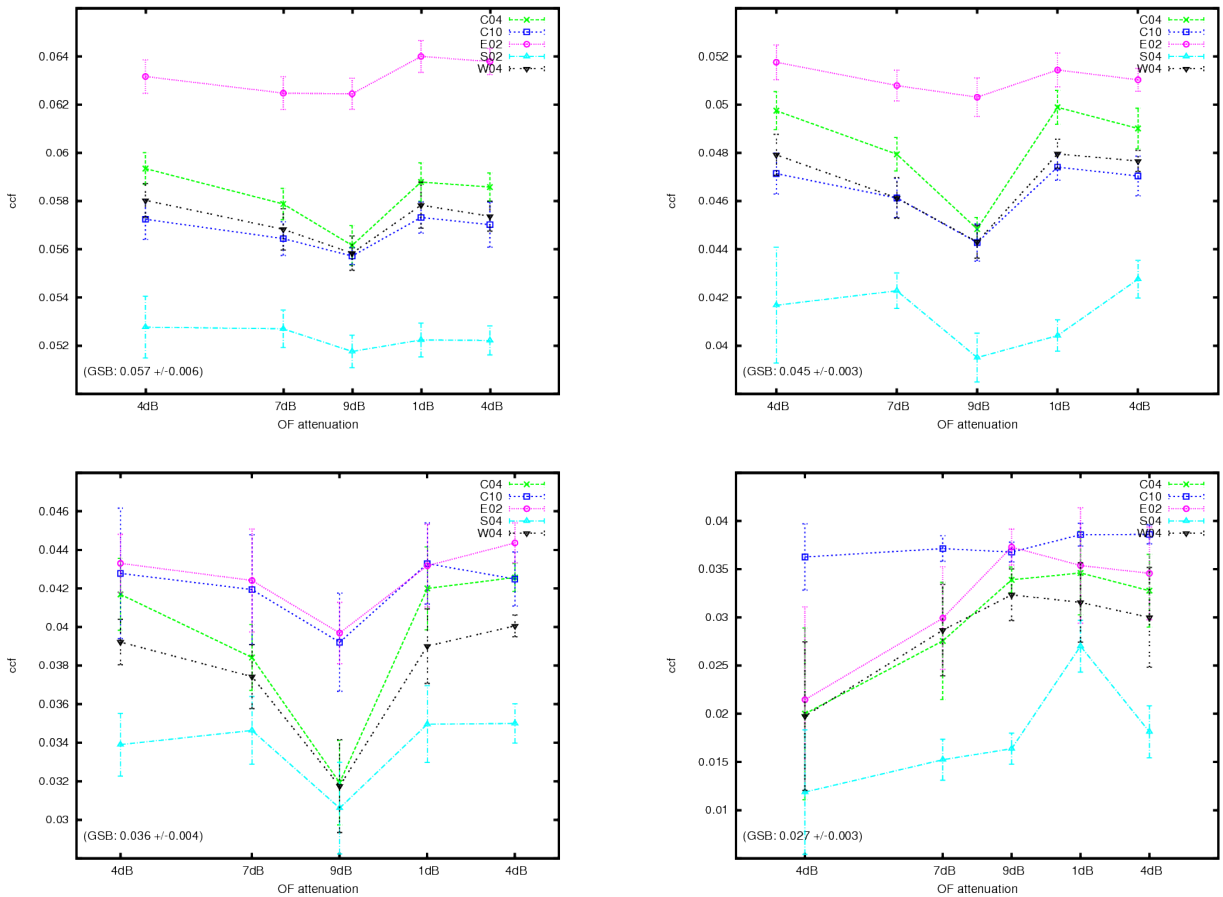

Figure 3: Plot showing ccfs (amplitudes) for 3C 48 as a function OF-attenuations using data shown in Figure 1 for the 'synthesiser' LO-lock scheme. C09 is the reference antenna. (Two antennas C08 and E06 failed, hence there are five plots in synthesiser LO-lock scheme.) Four panels in each plot are obtained for four sub-bands of the L-band, Top-left: 1060 MHz, Top-right: 1170 MHz, Bottom-left: 1280 MHz, and Bottom-right: 1390 MHz. Each plot shows, mean (+/- rms) for each run of OF-attenuation, and the corresponding value for the GSB data is given in the lower-left corner.

i The GWB-II data from all the sub-bands of the L-band from both LO-lock schemes, 'synthesiser' and 'signal-generator' behave as expected and there is no appreciable/noticeable change between these two LO-lock schemes for any of the four sub-bands of the L-band.

ii The GWB-II data from these two LO-lock schemes is as good as or better than the GSB data.

iii Marginal differences in ccfs for baselines at each sub-band are insignificant, less than 3–6 $\times\sigma$ and 2–5 $\times\sigma$ for synthesiser and signal-generator modes of LO-lock schemes, respectively.

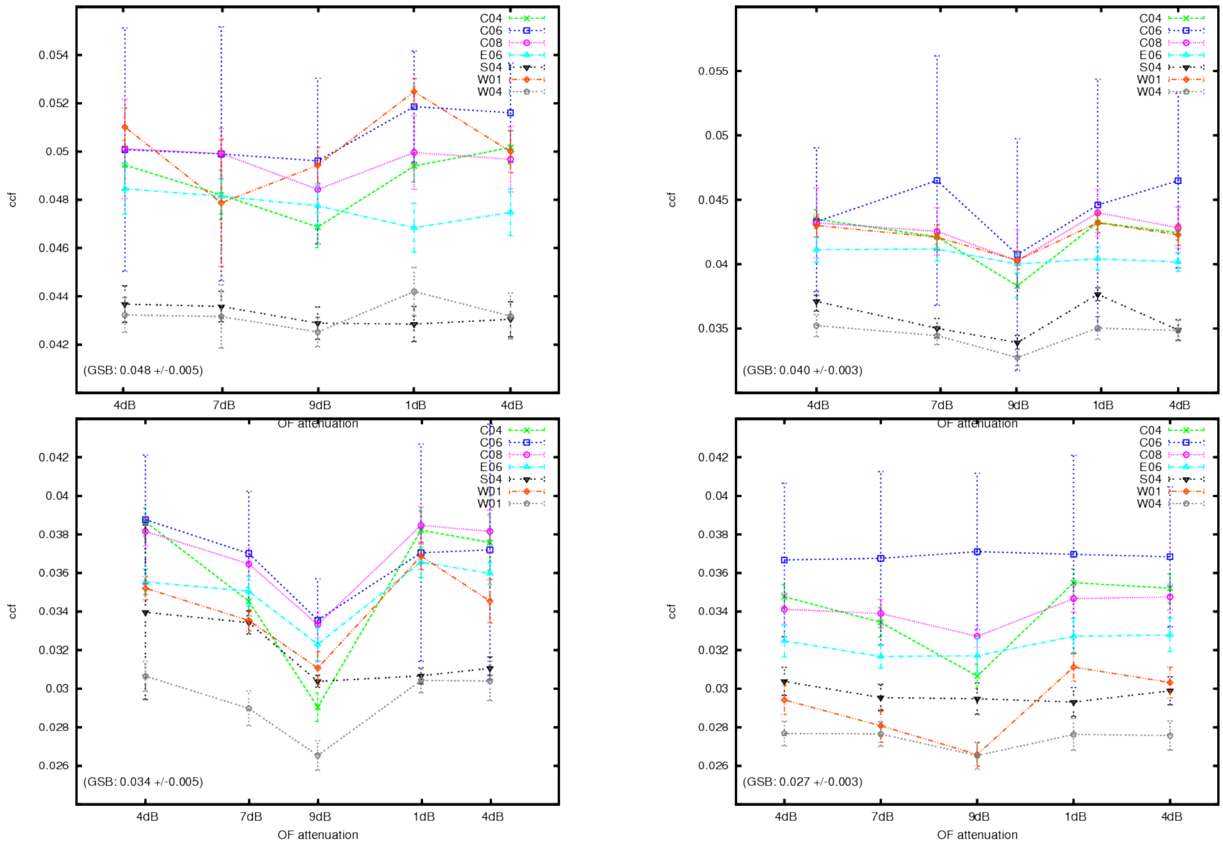

Figure 4: Plot showing ccfs (amplitudes) for 3C 286 as a function OF-attenuations using data shown in Figure 2 for the 'signal-generator' LO-lock scheme. C09 is the reference antenna. Four panels in each plot are obtained for four sub-bands of the L-band, Top-left: 1060 MHz, Top-right: 1170 MHz, Bottom-left: 1280 MHz, and Bottom-right: 1390 MHz. Each plot shows, mean (+/- rms) for each run of OF-attenuation, and the corresponding value for the GSB data is given in the lower-left corner.

iv There is a marginal trend for falling correlation with increasing vlaues of OF-attenuation. This fall is maximum for the 9 dB–9 dB OF-attenuation and is seen at all the sub-bands of the L-band for both LO-lock schemes.

v The comfortable or the acceptable range of OF-attenuation is from 1 dB–1 dB to 7 dB–7 dB.

Acknowledgments

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