EDGES MEMO #242

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To: EDGES Group

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Subject: Sensitivity of calibration to integration time

The receiver calibration requires a significant integration time for the spectral data taken on the ambient and hot loads. A test of how much integration is required is made by comparing the calibration for one twenty fourth of the total available integration. The first lowband receiver (lowband1) was calibrated in 2015 using approximately 24 hours of integration for the ambient load and another 24 hours of integration for the hot load. Even longer integration were used for the open and shorted cables but it turns out that a factor of 24 less time is required.

Figure 1 shows the simulated difference spectra at GHA=12 hours with 4 polynomial terms removed for calibrations made using 1 hour integrations compared with the calibration using all the available calibration spectral data.

The 1 hour periods at 3, 4 and 5 UT are absent because this time slot was absent in the total integration. An estimate of the calibration error in a 1 hour slot is given by the average rms of 84 mK. From this the 1-sigma error in 24 hours is $84/24^{1/2} \sim 17$ mK.

Figure 2 shows the same analysis for the lowband2 receiver. In this case, the total available integration was about 3 days so the 1-sigma error estimate for 24 hour is

$$39 \times 3^{1/2} / 24^{1/2} \sim 14\, mK$$

The effect of integration time on the open and shorted cable was estimated by applying a 3×1 hour time slot for only the open and shorted cable spectra the final result was about 6 mK for 1 hour integration and 2 mK for 24 hour integration.

The error of about 15 mK for 24 hours using 4 terms removed from 60 to 99 MHz at GHA = 12 hr scales up by a factor of about 4 to 60 mK at GHA= 0 hr. The 1-sigma error also scales up significantly for a larger frequency range and when fewer terms are removed. Figure 3 shows the lowband2 residuals for 1 term removed for 51 to 99 MHz. In this case the estimated 1 sigma for 24 hours integration is about 170 mK.

Figure 4 shows the simulated effect of the difference between lowband2 receiver calibrations made in 2016 and 2017. The main difference is the result of different LNA S11 measurements. At GHA=12 the rms difference is 68 mK increasing to 240 mK at GHA=0.

A test of 3 different calibrations on lowband2 data is shown in Figure 5. The 3 calibrations were made using UT time spans of 0 to 8, 8 to 16 and 16 to 24 hours. In each case each block covers 3 days so that the integration in each calibration is 1 day. The residuals with 4 polynomial terms removed are shown in Figures 5 and 6 to real data and simulated data respectively. This test shows that at least 1 day integration of the ambient and hot load data is needed to avoid a

significant noise contribution to the calibration. Integration times of 6 hours each for the open and shorted cable spectra should be more than sufficient.

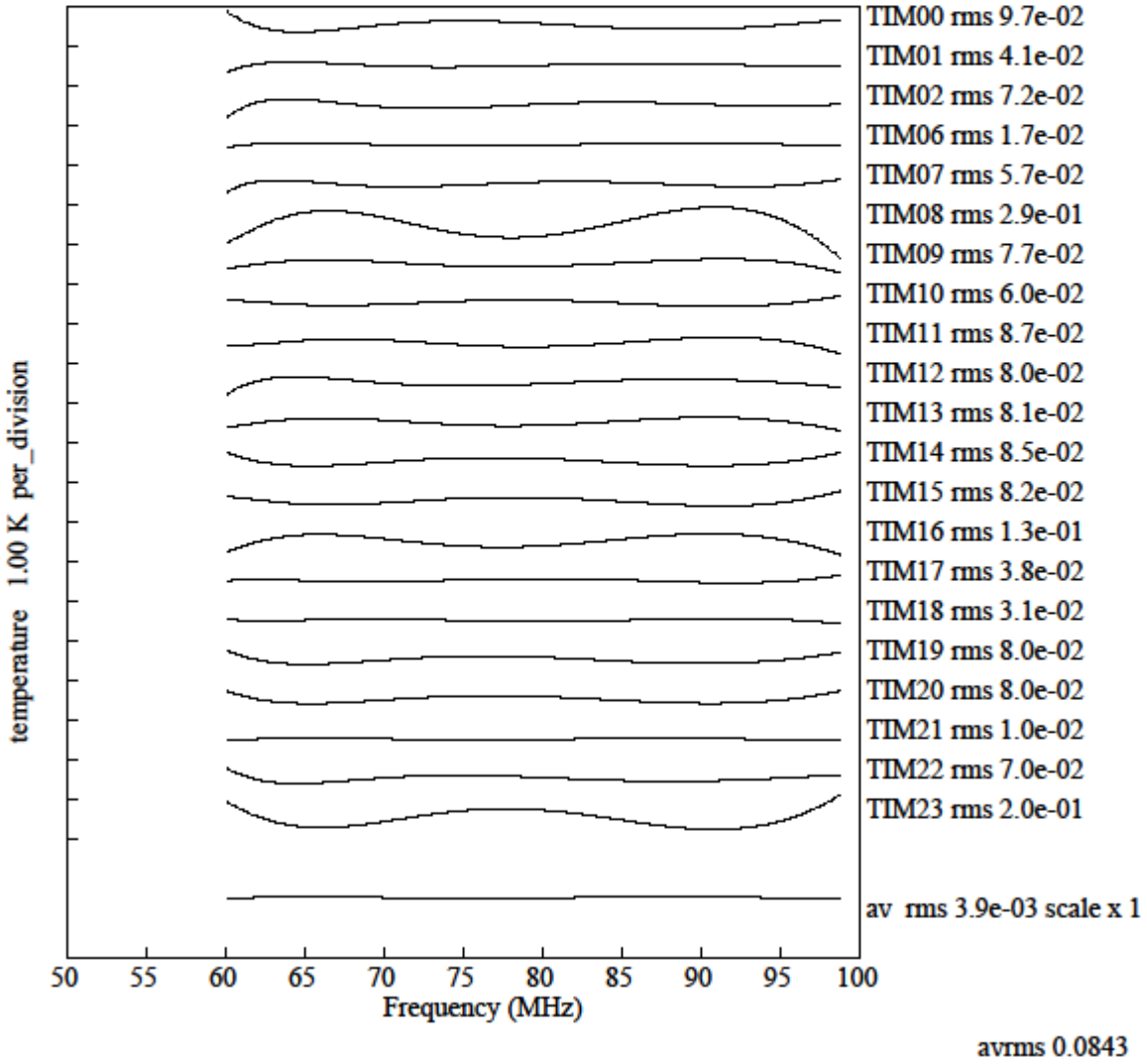

Figure 1. Differences between 1 hour integration and full 24 hour integration for lowband1 receiver simulated for GHA=12 hrs with 4 poly terms removed.

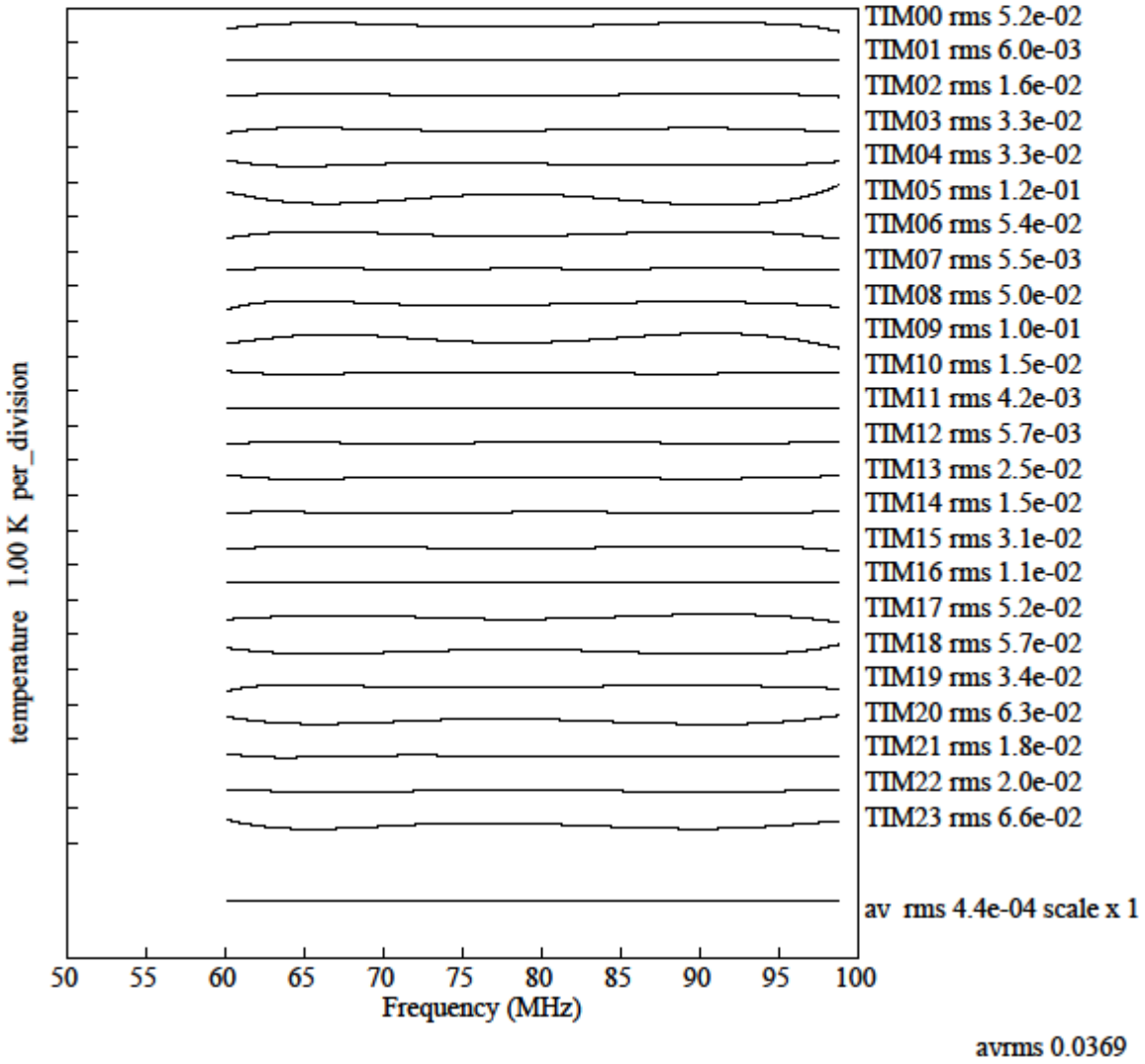

Figure 2. Differences between 3, 1 hour integrations and full 3×24 hour integration for lowband 2 receiver.

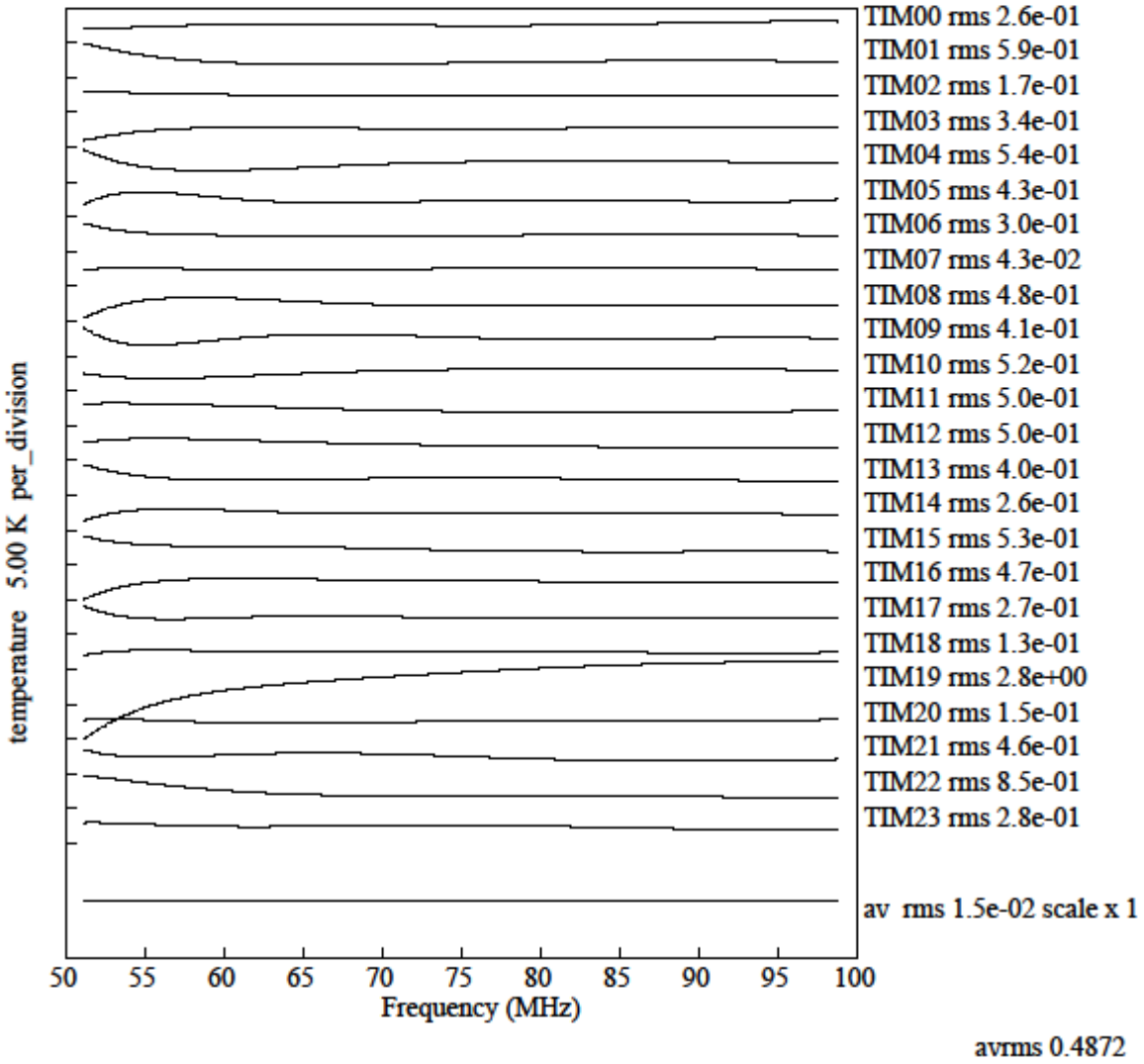

Figure 3. Differences for 1 term removed at GHA=12 hr.

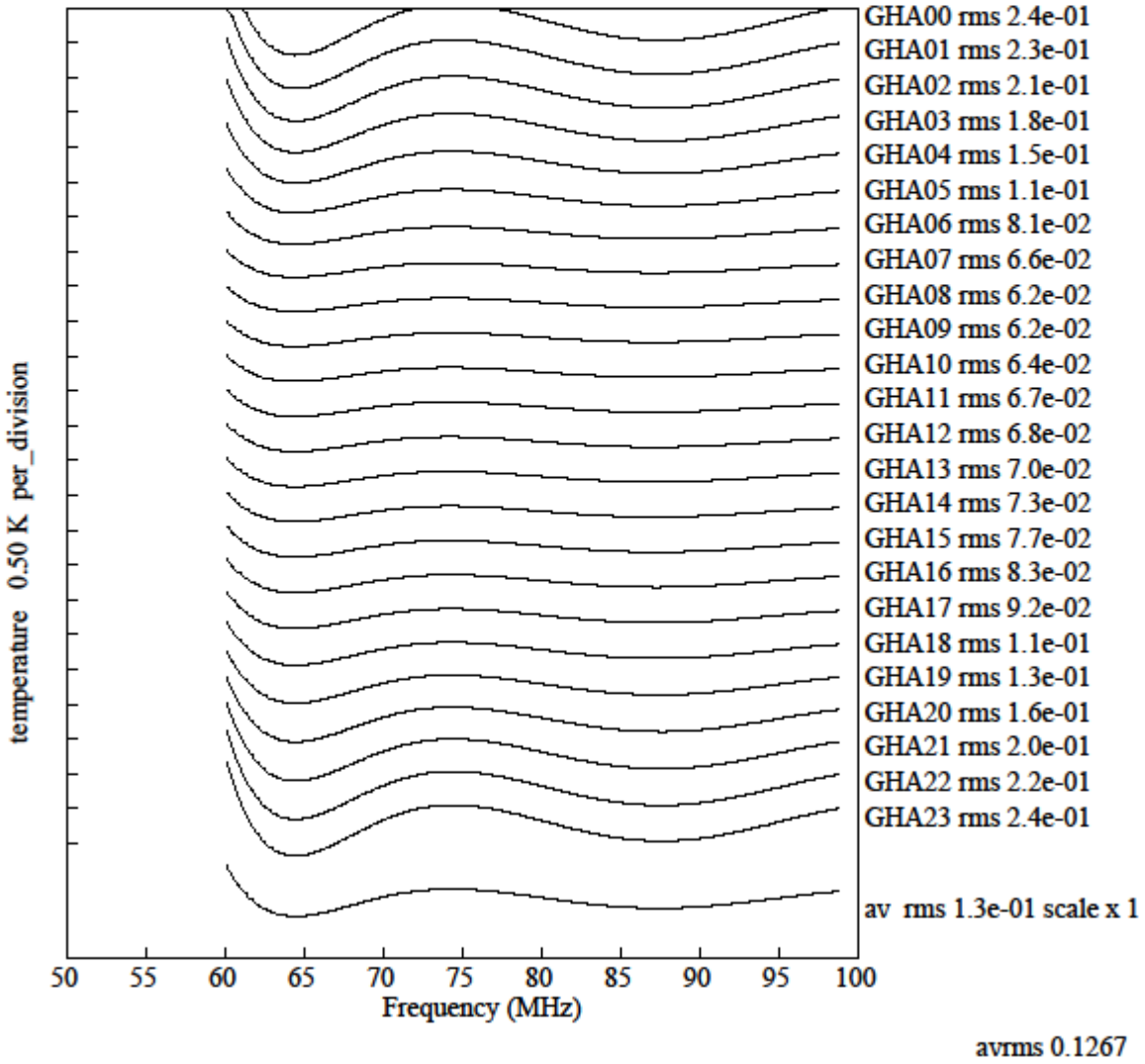

Figure 4. Difference of calibrations with 4 polynomial terms removed in 2016 and 2017 which have different LNA S11.

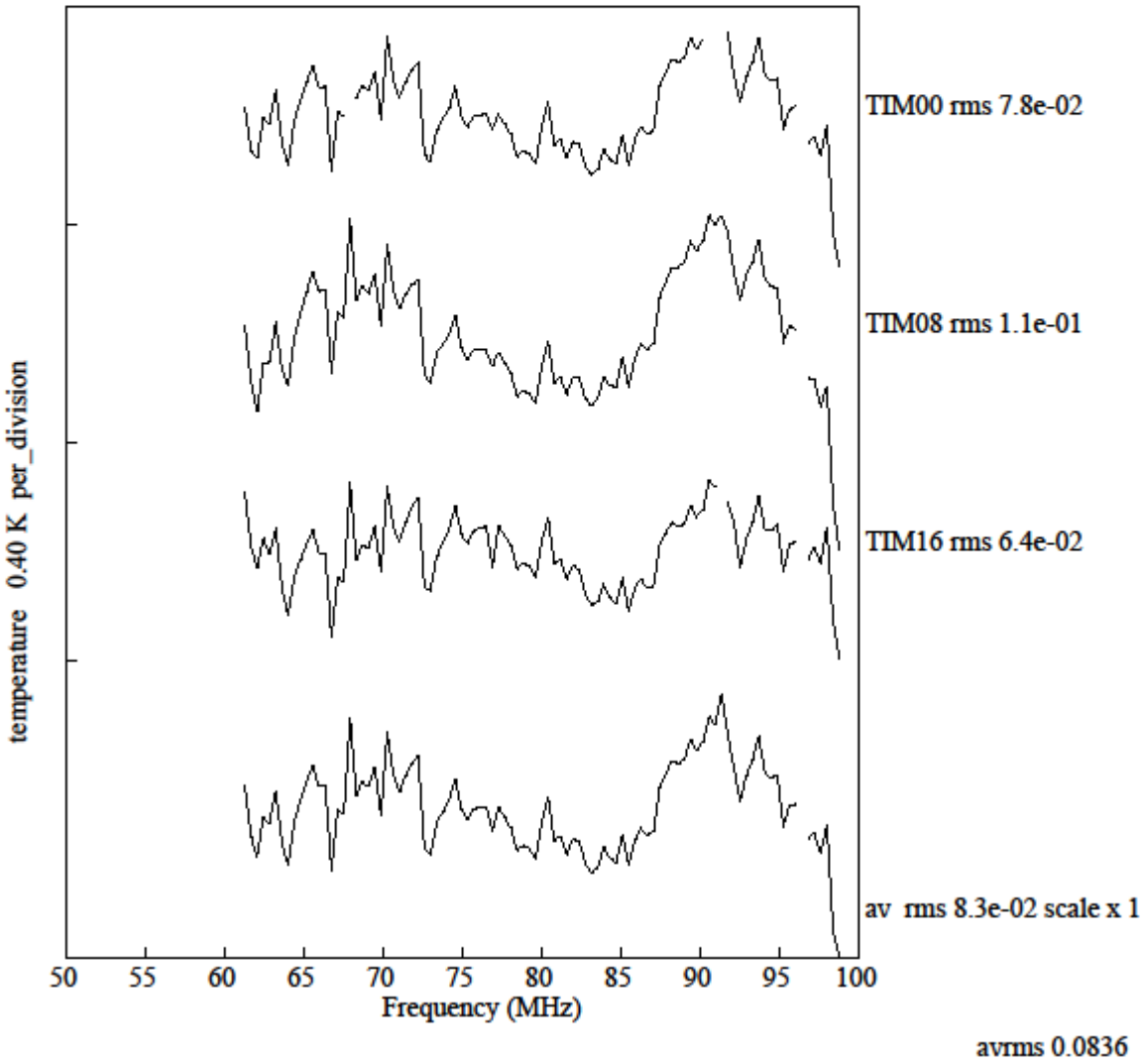

Figure 5. Lowband2 data from 2017_082-088 processed with different 1 day calibrations.

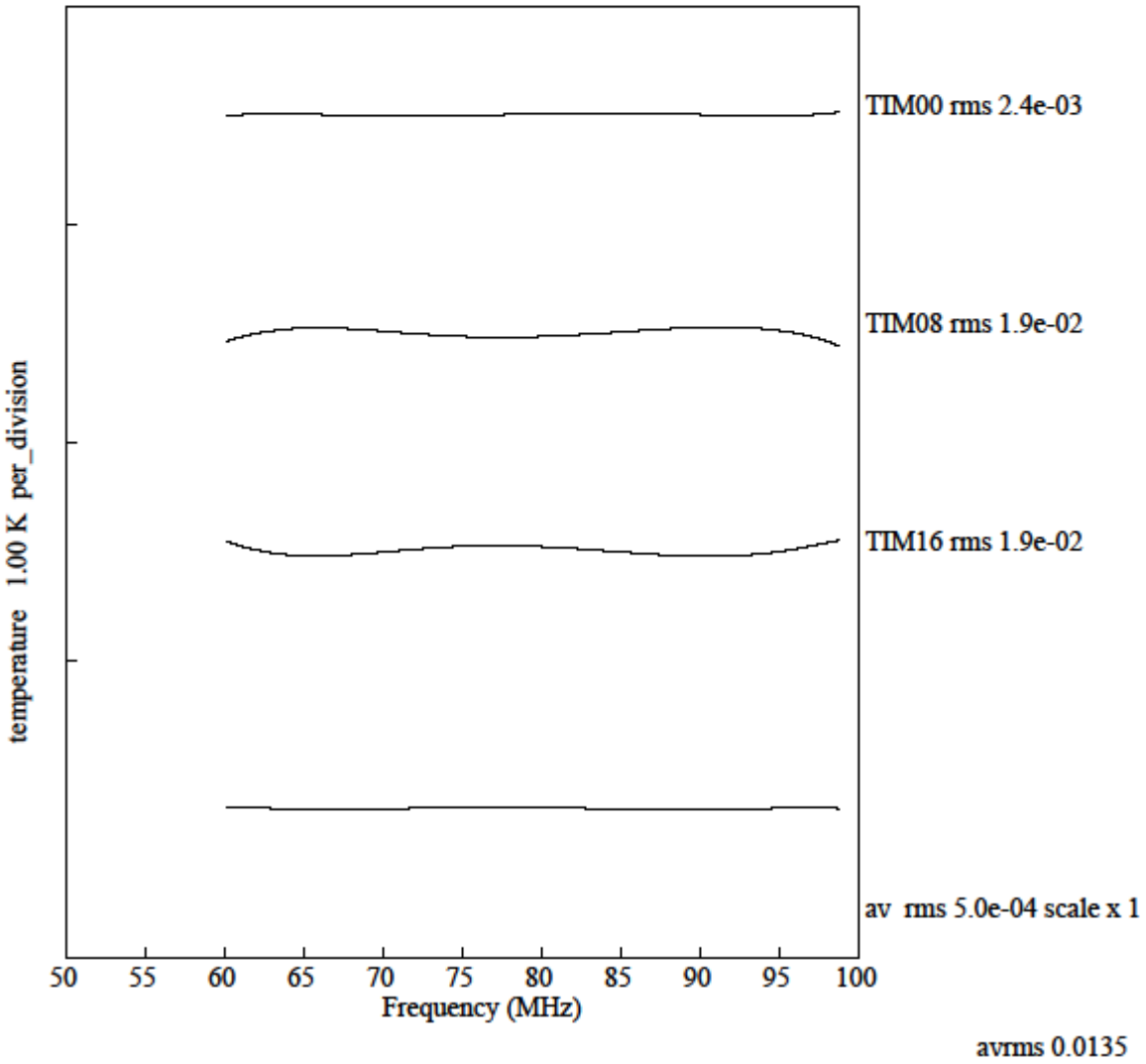

Figure 6. Differences of 3, 1 day calibrations made with 3, 8 hour blocks.