EDGES MEMO #167

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To: EDGES Group

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Subject: Preliminary results for the period 18 April to 5 May 2015.

Following the flooding of the EDGES high band system in February 2015. Judd Bowman returned to the MRO to install another receiver to replace the receiver which was damaged when moisture penetrated the receiver box. The preliminary results from the January deployment were given in memo #160. An important feature of the data from 18 April through 5 May 2015 is that it was taken during “EDGES EoR Time” during which the galactic center is overhead at night and the period when the galactic plane is mostly below the horizon is also at night.

For example, on day 116 the Galaxy is “up” from 18:30 to 22:40 local time and the Galaxy is “down” are obtained when the Sun is more than 10 degrees below the horizon.

The average Galaxy up and Galaxy down calibrated antenna temperatures for these periods is 740 and 360 K at 150 MHz for these periods making it almost ideal for the method described in 48 and updated in memo 145.

1] Tests of RFI removal

The basic method is to excise blocks of time when very strong signal are present based on the total antenna power and peak power in any one frequency channel in a single 3-position switch cycle. The best threshold for the acceptance of a block of data from a 3-position switch cycle are 3 percent and 40 dB above the sky noise. The exclusion of frequency channels with weak RFI is based on the comparison of each frequency channel with the rms noise in a sliding window of the residual spectrum after the removal of the best fit 37 term Fourier series. The assignment of zero weight is given to any frequency which exceeds the rms by a fixed threshold. The process is repeated until no more channels exceed the threshold as rms, which is based on channels with non zero weight, declines. A threshold of 2.5 times the rms was found to give the best results. It is also found that an integration of several hours is best and the integration of each day’s Galaxy up and down data was close to optimum. Following the assignment of weights to each spectral channel fit was found desirable to assign zero weight to frequencies adjacent to spectral channels with very strong signals. The best scheme was to extend the range of adjacent channels from 4 initially to 8 and 165 for signals of 25 to 250 times the rms.

2] Spectral smoothing

To maximize the sensitivity for the detection of narrow band RFI all processing is done without smoothing to reduce the resolution. However in the final stages of plotting the data it is easier to examine the data by reducing the resolution from 6 kHz (32768 channels) to 390 kHz by averaging 64 channels. This is done by convolution with a Gaussian of 390 kHz full width at half power.

3] Stages of averaging

The raw data files for each day were RFI filtered and averaged for each Galaxy up and down period for each day with acqplot7. The output files from acqplot7 were processed by edges2K. This software calibrates the data and corrects for the frequency dependence of the antenna beam. The output files from EDGES2K are processed by longaver3 which corrects the Galaxy down data using the S_{diff} function from equation 2 of memo 145. The S_{diff} spectra for each day are plotted and weighted average computed for all days.

4] Data plots

Figure 1 shows plots of S_{diff} for each day with removal of one term Figure 2 shows plots with the removal of 5 polynomial terms given in Table 1.

	Function	Purpose
0	$(\log f)\, f^{-s}$	Derivative of spectral index
1	f^{-s-2}	Ionosphere absorption
2	f^{-2}	Ionosphere emission
3	$(\log f)^2\, f^{-s}$	"gamma" of spectral index
4	$(\log f)^3\, f^{-s}$	Derivative of gamma
5	$(\log f)^4\, f^{-s}$	Second derivative of gamma
6	f^{-s}	

Table 1. Functions used for fitting spectra. S is the spectral index of the region outside the Galactic plane.

Figure 3 shows plots with 6 polynomial terms removed. Plots in Figures 2 and 3 show the average on a fine scale. The purpose is to show that the "noise" is reduced by the square root of the number days. With only 5 terms removed there are remaining systematics which are probably due to the inability to take out the frequency dependence of the antenna beam. With 6 terms removed there is little evidence of remaining systematics. Further the presence of an EoR signature of 100 mK and 10 MHz at 150 MHz is clearly evident in Figure 4 when the signature is added to the data. When the EoR signature is added to the terms in the solution is given an EoR SNR of 30.

With 16 days of data a 30 mK EoR signature of less than 10 MHz can be excluded at the 4σ level. More data will be needed for a wider signature unless the systematics with only 5 terms removed can be reduced or shown to come from the hydrogen line.

Comments on plotted data.

A] RFI removal

The signals from the Orbcom satellites (137-138 MHz) is all either excised by not including the blocks of strong signal data in the integration or excluded by the assignment of zero weight to these frequencies. Most other signals are not evident in the RFI filtered and smoothed data of the plots, however careful examination of the unsmoothed data show occasional zero weight assigned to the following frequencies:

131.55 MHz ACARS

125.2 MHz Perth air control

As a result the “dip” at 130 MHz and the “bump” at 125 MHz are the result of reduced integration at these frequencies.

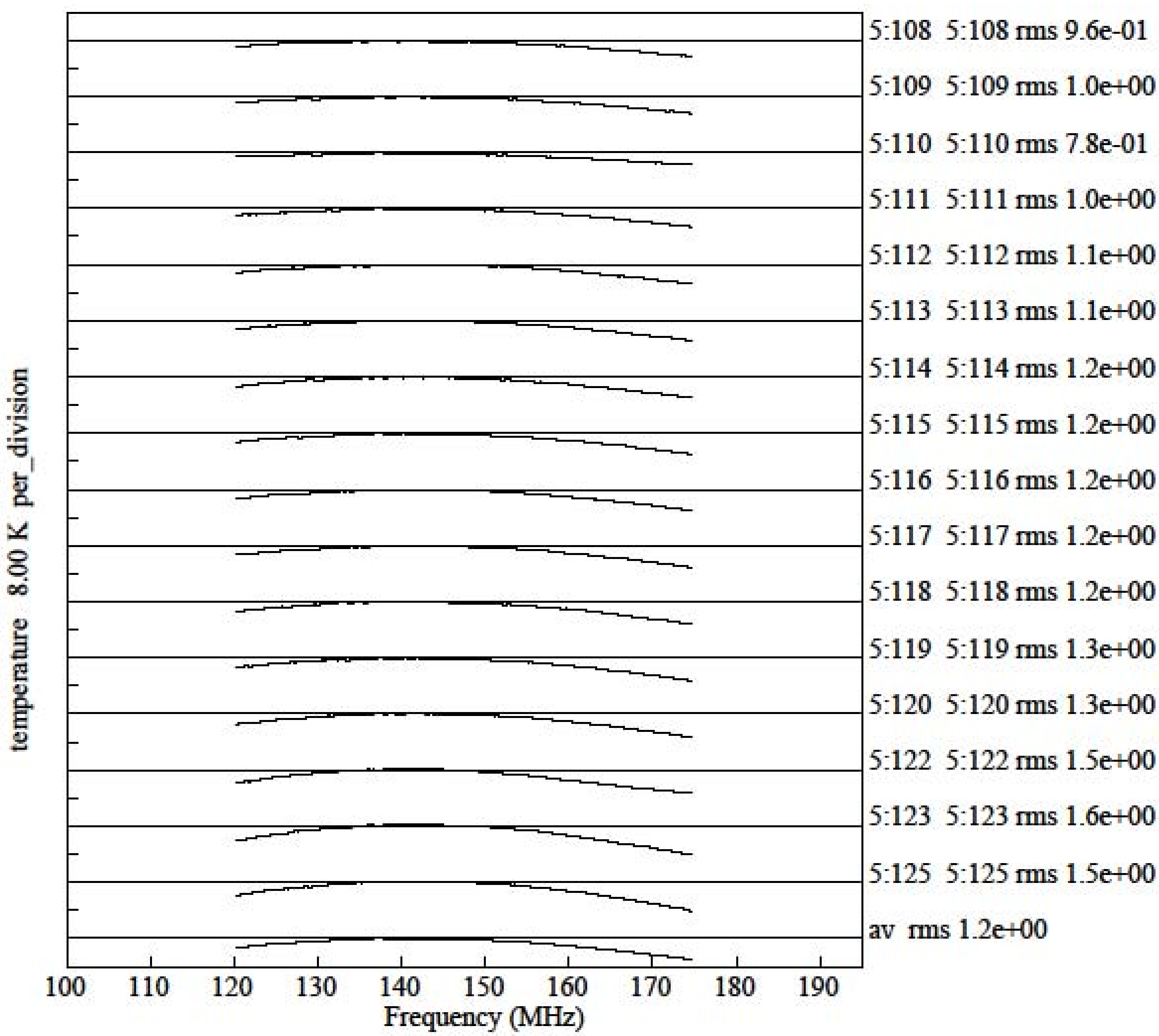

Figure 1. Galaxy spectral difference, S_{diff}, with first term in Table 1 removed.

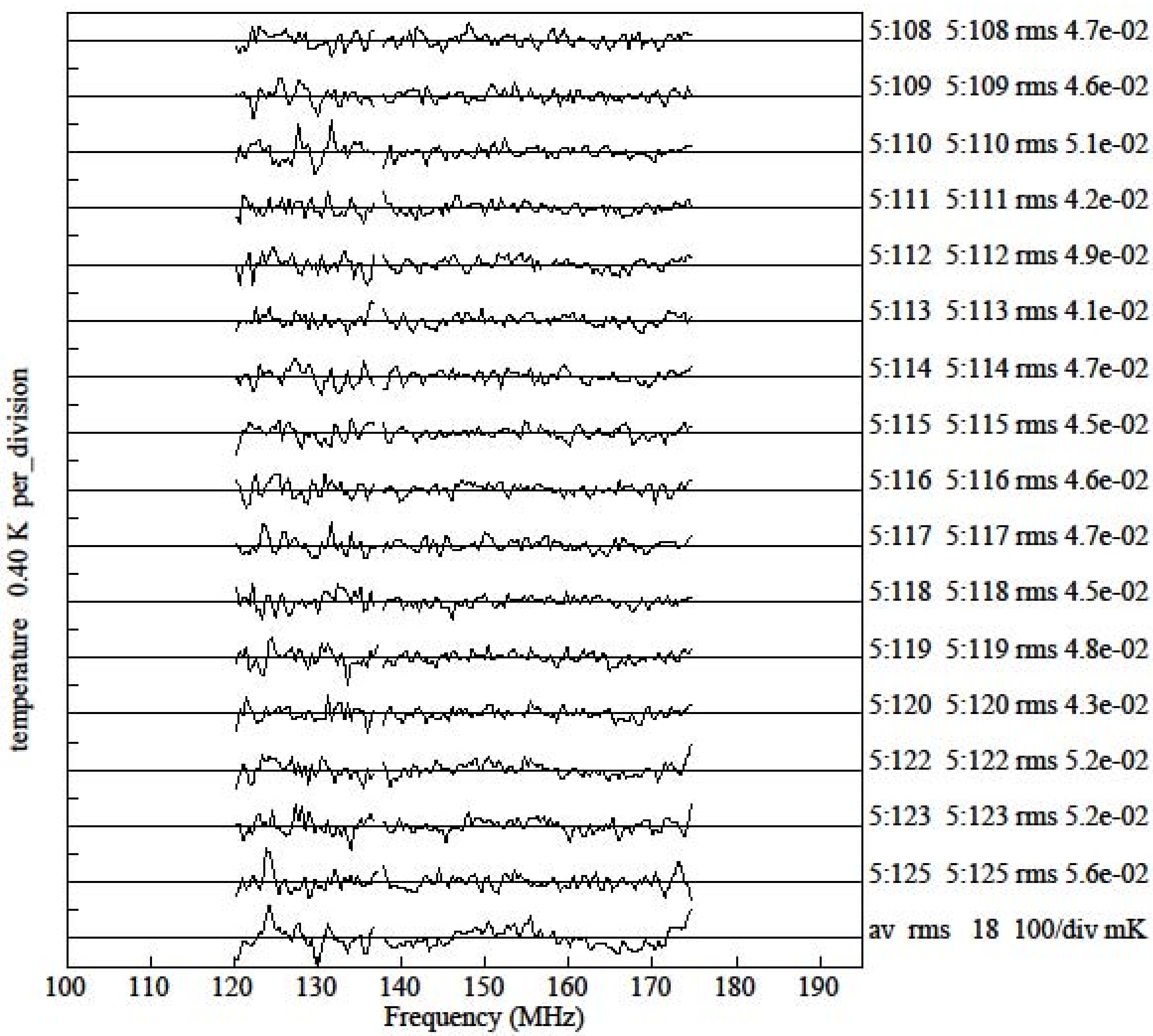

Figure 2. S_{diff} with 5 terms removed.

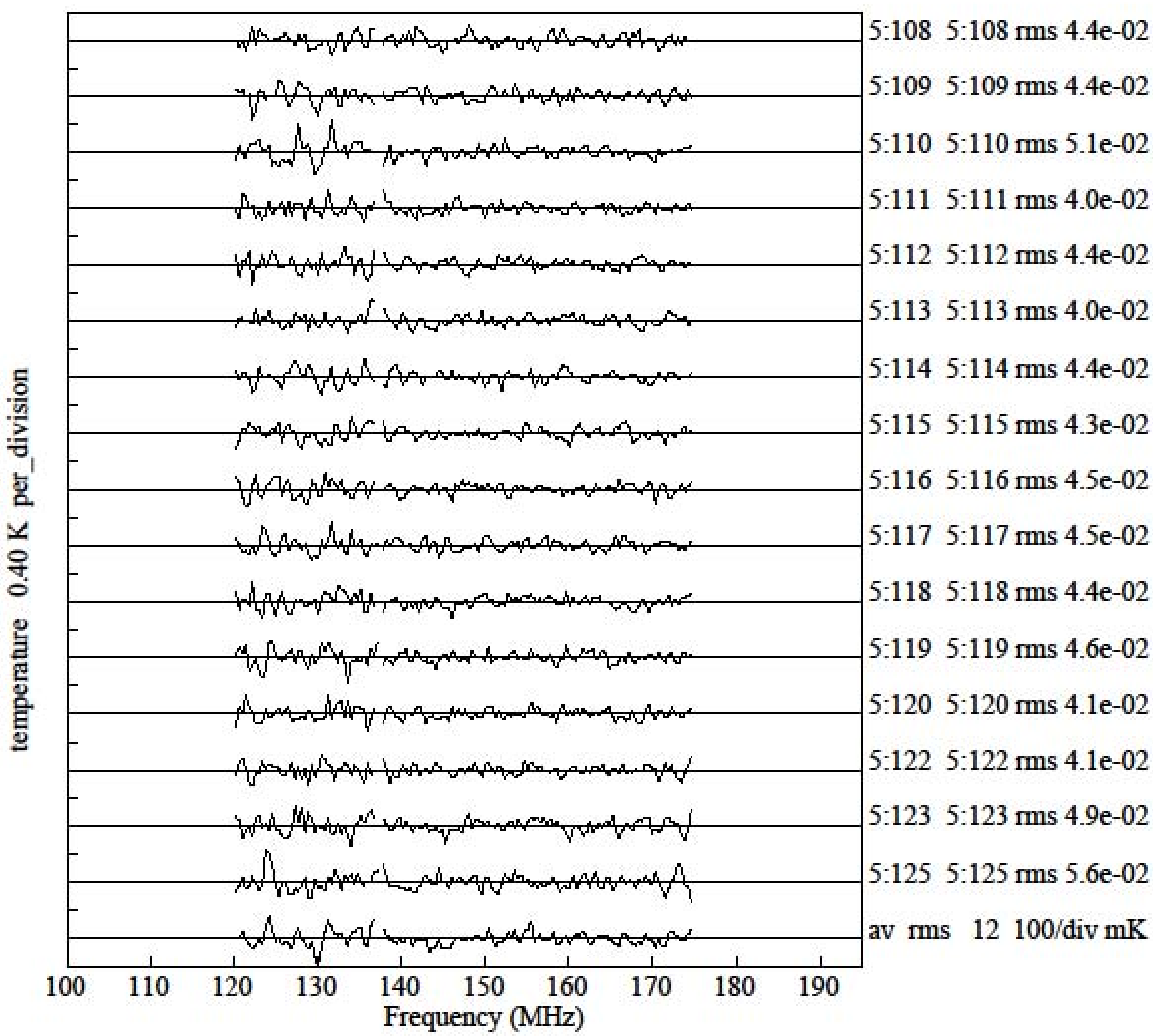

Figure 3. S_{diff} with 6 terms removed.

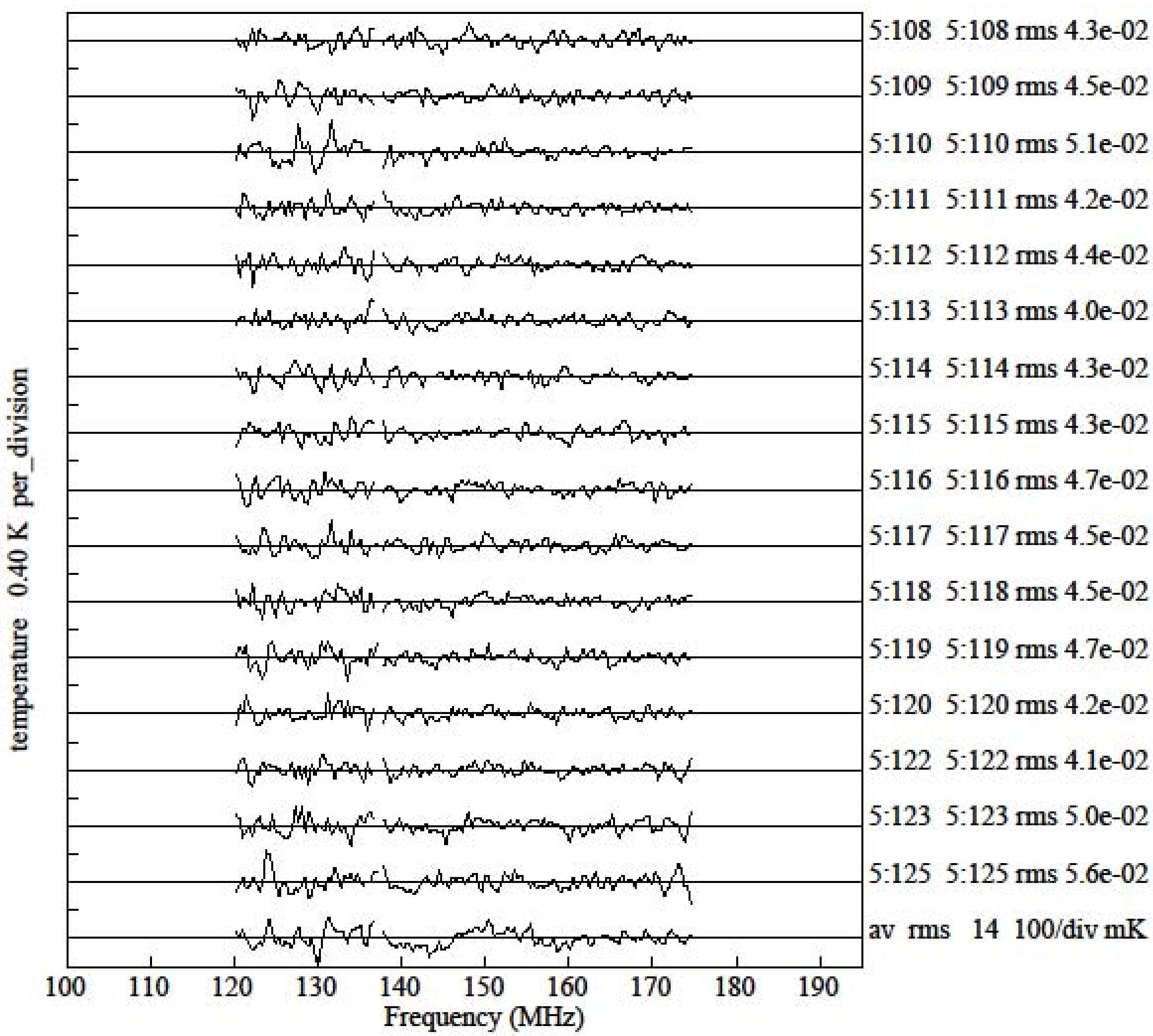

Figure 4. S_{diff} with 6 terms removed and 100 mK 10 MHz wide EoR signature added at 150 MHz for test.

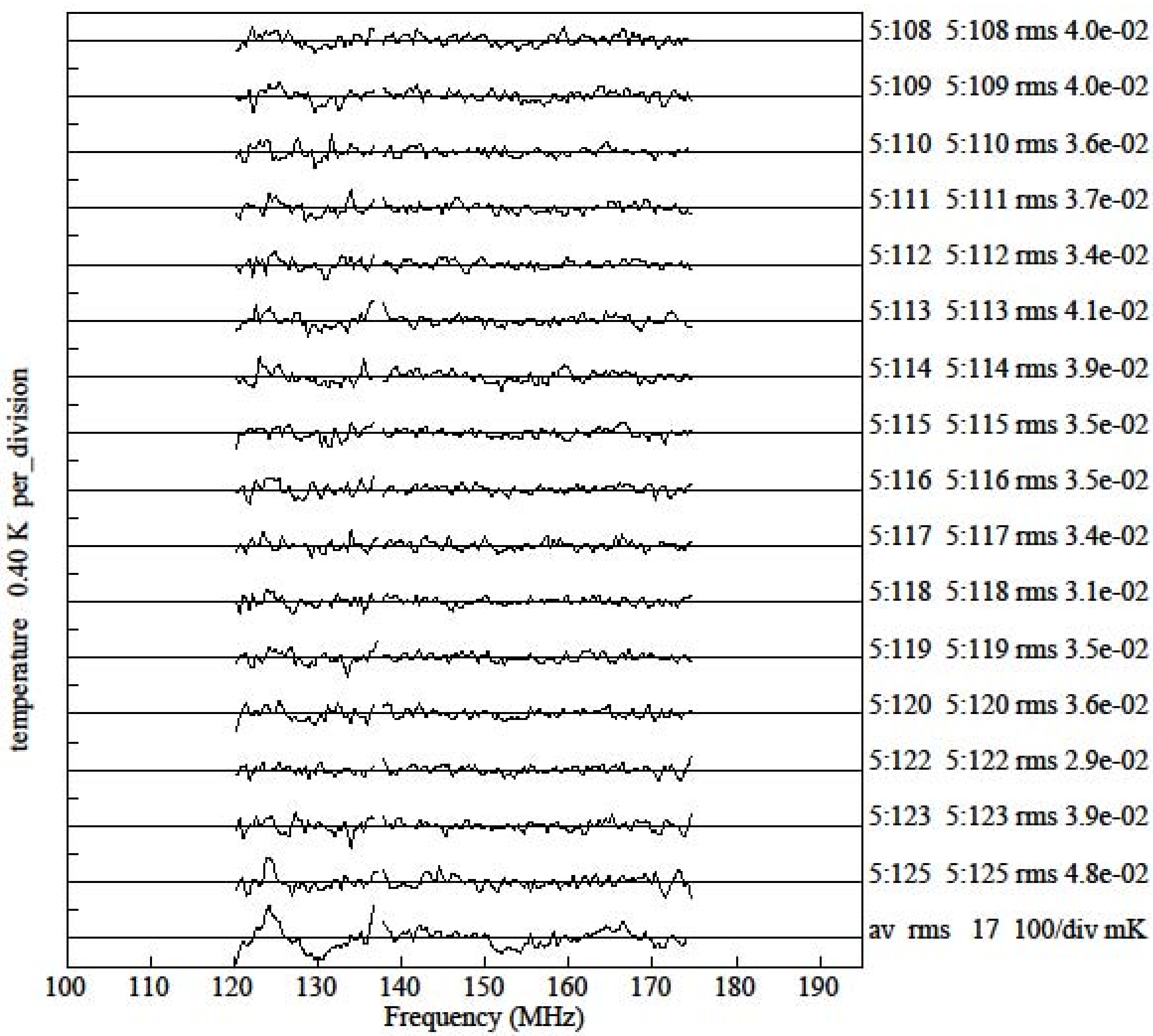

Figure 5. Galaxy down spectra with 6 terms removed.