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To: EDGES Group

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Subject: Results of measurements of an artificial antenna noise source.

Tests were run on the artificial antenna simulator described in memo #199 using the second low band receiver. For these tests spectra were taken with

a) The noise source connected directly to the receiver.
b) The noise source connected to the receiver through a 3 dB attenuator.
c) The noise source connected to the receiver through a 6 dB attenuator.
d) The noise source connected to the receiver through the 3 dB attenuator and then the cable box.

These spectra are calibrated and a loss correction made to noise (NS) source or the noise source plus 3 dB. While the noise source spectrum is unknown the same spectrum should be obtained via different paths. For example, the spectrum of the noise source obtained directly should equal that obtained from the calibrated spectrum of the noise source plus 3 dB corrected for the 3 dB loss using the algorithms of memo 132.

Table 1 shows the antenna temperature at 75 MHz and rms residuals for fits to the spectra.

For the temperature of the noise source without any attenuation there are 3 paths. The level of agreement of only 2% is probably due to extreme sensitivity to antenna S11. A change of only 0.002 dB brings the temperature for the direct case in line with the others. For the temperature of the noise source plus 3 dB the agreement between the temperature for 3 dB and 3 dB plus cable box is within 7×10^{-4}. While the correction of the spectrum with 6 dB corrected by 3 dB is shown the 6 dB was formed by a single attenuator so a 3 dB correction can only be made using the s-parameters of the 3 dB attenuator as a guess.

For further analysis, we concentrate on the difference spectra for the last two cases in Table 1.

Figure 1 shows the spectra for the noise source with 3 dB attenuation along with that for the noise source with 6 dB attenuation. The rms difference of 0.69 K with 3-terms removed is not unreasonable given that the temperature at 75 MHz is 10,000 K and the antenna S11 is about – 7 dB.

Figure 2 shows the difference for the comparison of the case with the added cable box and has a much larger residual of 4.4 K with 3-terms removed. This residual is very sensitive to the value of S11 used in the correction for the loss of the cable box. The addition of 0.0006j to S11 reduces the rms residual from 4.4 K to 1.3 K. This change in S11 is higher than the approximately 0.0002 difference between the reflection coefficient measured for the NS+ 3 dB + box and that calculated from the reflection coefficient of the NS and the s-parameters for the 3 dB and those for the box.

							Difference		Ref
	Spectra	Loss correction	Temperature at 75 MHz	Correction	rms 3-terms	rms 5-terms	rms 3-terms	rms 5-terms	
a	Direct	None	570588	To NS	3842	2132			
b	3 dB	3 dB	581889	To NS	768	133	3300	2100	a
c	6 dB	6 dB	584456	To NS	1096	174	360	150	b
d	3 dB + box	3 dB + box	592629	To NS	1822	901	1800	900	b
e	3 dB	None	10611	NS+3 dB	8.9	0.268			
f	6 dB	3 dB	9884	NS+3 dB	8.4	0.294	0.69	0.38	e
g	3 dB + box	Box	10618	NS+3 dB	7.8	0.997	4.4	1.0	e

Table 1. Results of tests. Temperatures are in Kelvin. The rms residuals are given to a polynomial of the form $f^{-2.5+i}$ for j=0 to n-terms -1. The "Ref" column indicates the spectrum against which the difference was taken.

A number of alternative explanations for the need to correct S11 of the cable box have been explored as follows:

a) Change in LNA S11
The rms of residual spectra in Figure 2 can be reduced from 4.4 K to 1.4 K by subtracting 0.001*j* from the LNA S11 but this increases the rms residual for the calibration residuals and the rms of simulator 2 from 15 to 32 mK making this unlikely unless the LNA S11 has changed since the calibration data was taken.
b) Change in cable box S11
The rms of the residual spectra in Figure 2 can be reduced from 4.4 K to 1.3 K by subtraction 0.0006*j* from the antenna S11.
c) Errors in cable box S11 and antenna S11
The rms can be reduced to about 1.3 K by adding 0.003*j* to the box S11 and subtraction 0.003*j* from the antenna S11. There appears to be no way to separate the effects of cable box S11 and antenna S11 as they have the same signature with opposite signs.

In summary more tests will be needed to uncover the true cause of the systematic in the residuals. However, the noise source based artificial antenna provides a good check on the level of systematics in the receiver. Simulations show that the difference check of Figure 2, while at the level of about 4 K would be reduced to a level of about 0.3 K for Galaxy down, antenna S11 equal to that of the blade and cable box s-parameters equal to that of the balun on the assumption of an error of 0.0006*j* in antenna S11 and only 0.15 K if the error is in the cable S11. The effects on "Galaxy calibrated" data is even smaller. For example, if 0.0006j is subtracted from the antenna S11 of the low band antenna in the residuals shown in Figure 12 of memo 217 the GHA00 spectrum rms is reduced from 330 Mk TO 300 Mk and the GHA10 spectrum rms is reduced from 190 Mk TO 170 Mk while the spectrum of the "Galaxy calibrated" difference remains unchanged at 130 mK rms.

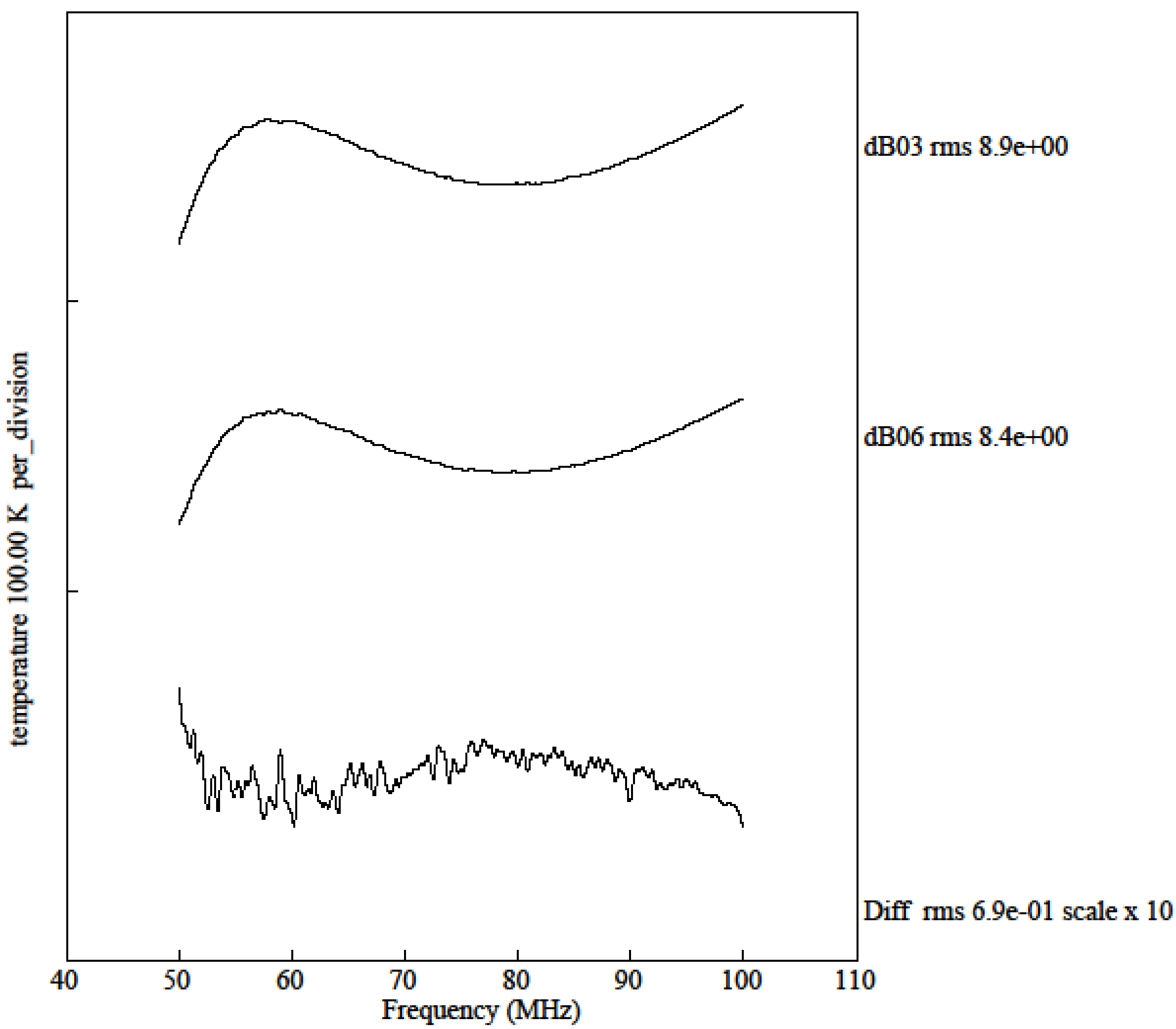

Figure 1. Top is spectrum of noise source plus 3 dB with 3-terms removed. Middle is spectrum of noise source plus 6 dB corrected with 3 dB.

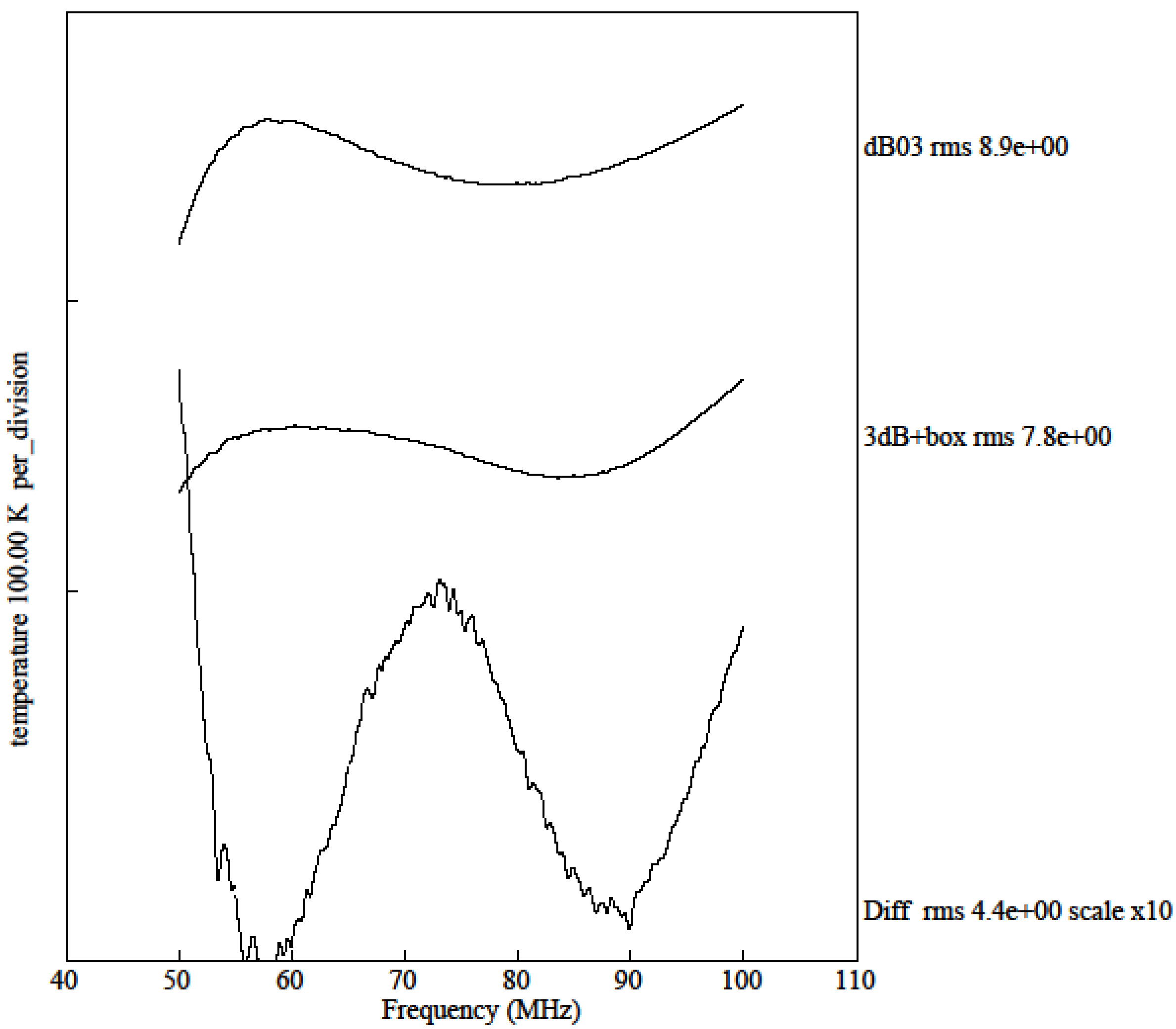

Figure 2. Top is same as in Figure 1. Middle is spectrum of noise source plus 3 dB plus cable box corrected for loss of cable box.