

Summary of Data Analysis: Low-Band 1, Extended Ground Plane

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Here we show results for the analysis of data from the Low-Band 1, Extended Ground Plane instrument. An equivalent report for the Low-Band 1, Original Ground Plane instrument, can be found here:

http://loco.lab.asu.edu/loco-memos/edges_reports/report105.pdf

Nominal choices and calibration settings:

1. Dates: 2016-258 to 2017-95
2. Sun cut: none
3. Moon cut: none
4. Receiver calibration S11 file: `s11_calibration_low_band_LNA25degC_2015-09-16-12-30-29_simulator2_long.txt`
5. Receiver parameter polynomial terms: Nfit=6, Wfit=5
6. Antenna S11 file: `S11_blade_low_band_2016_243.txt`
7. Antenna S11 modeling: 9 polynomial terms after removal of delay
8. Balun loss correction: yes
9. Ground loss correction: yes, 0.5%
10. Beam correction: yes, using beam file *newniv* rotated to $AZ = -7^\circ$, and Haslam sky map scaled to 76 MHz using $\beta = -2.5$.

The results are summarized in the following figures.

The first nine figures (after Figure 1 described below) provide a overview of the data.

- Figure 2: daily residuals to 7-term polynomial over 50-100 MHz, for all days considered. The GHA range is 0-24 hr.
- Figure 3: residuals for 4-hr GHA averages, to 7-term polynomial over 50-100 MHz.
- Figure 4: residuals for 6-hr GHA averages, to 6-term polynomial over 65-95 MHz. Averaging over 6 hours produces estimates that are more stable as a function of GHA.
- Figure 5: residuals for 6-hr GHA averages, to 6-term polynomial plus 21-cm signature, over 65-95 MHz. The signature center frequency was fixed at 78.5 MHz.
- Figure 6: amplitude of 21-cm signature as a function of GHA for 6-hour averages, in parallel to the total sky temperature. The signature center was fixed at 78.5 MHz.
- Figure 7: residuals and model for average over GHA 0-24 hr, to 1) 7-term polynomial over 50-100 MHz; 2) 7-term polynomial over 53-97 MHz; 3) 7-term polynomial plus 21-cm signature over 53-97 MHz.
- Figure 8: residuals and model for average over GHA 0-24 hr, to 1) 7-term polynomial over 50-100 MHz; 2) 7-term polynomial over 60-100 MHz; 3) 7-term polynomial plus 21-cm signature over 60-100 MHz.
- Figure 9: residuals and model for average over GHA 0-24 hr, to 1) 6-term polynomial over 50-100 MHz; 2) 6-term polynomial over 60-98 MHz; 3) 6-term polynomial plus 21-cm signature over 60-98 MHz.
- Figure 10: residuals and model for average over GHA 6-18 hr, to 1) 6-term polynomial over 50-100 MHz; 2) 6-term polynomial over 60-98 MHz; 3) 6-term polynomial plus 21-cm signature over 60-98 MHz.

The next five figures show the results for the nominal data average, and compare them with those obtained for different data cuts and calibrations. All the cases correspond to data averages over GHA 6-18 hr and 60-98 MHz, modeled with a 6-term polynomial plus a 21-cm signature. In these cases, the frequency and duration of the 21-cm signature, as well as its amplitude, are found by maximizing the ratio $\text{SNR} = |a_{21}/\sigma_{21}|$.

- Figure 11: residuals and 21-cm signature for three different averages of consecutive subsets of data.
- Figure 12: residuals and 21-cm signature for four different averages: 1) daytime only ($\text{EL}_{\text{sun}} \geq 0^\circ$), 2) nighttime only ($\text{EL}_{\text{sun}} < 0^\circ$), 3) Moon up only ($\text{EL}_{\text{moon}} \geq 0^\circ$), 4) Moon down only ($\text{EL}_{\text{moon}} < 0^\circ$).
- Figure 13: residuals and 21-cm signature for two alternative receiver calibrations: 1) cal2015, Nfit=7, Wfit=7, and 2) cal2017, Nfit=7, Wfit=7.
- Figure 14: residuals and 21-cm signature for three alternative antenna S11: 1) 2017-93 (2015 switch parameters), 2) 2016-243 (2017 switch parameters), 3) 2017-93 (2017 switch parameters).
- Figure 15: residuals and 21-cm signature for two alternative corrections: 1) applying no ground loss correction, and 2) applying no beam correction.

Finally, Table 1 compares the estimates for the different data cuts and calibration alternatives, and Figure 1 shows the values.

Table 1: Signature amplitude estimates for all the cases considered. In all cases, the GHA range is 6-18 hr. The frequency range is 60-98 MHz and, in addition to the signature, the fit model includes six polynomial terms.

Case	Description	Amplitude estimate [mK]
0	Nominal	447 ± 16
1	1st data subset	428 ± 27
2	2st data subset	446 ± 23
3	3st data subset	515 ± 26
4	Daytime only	493 ± 34
5	Nighttime only	452 ± 17
6	Moon up only	482 ± 18
7	Moon down only	448 ± 23
8	recv cal2015, Nfit=7, Wfit=7	571 ± 21
9	recv cal2017, Nfit=7, Wfit=7	503 ± 17
10	ant S11 2017-93, switch2015	455 ± 16
11	ant S11 2016-243, switch2017	465 ± 16
12	ant S11 2017-93, switch2017	475 ± 17
13	No ground loss correction	451 ± 16
14	No beam correction	452 ± 17

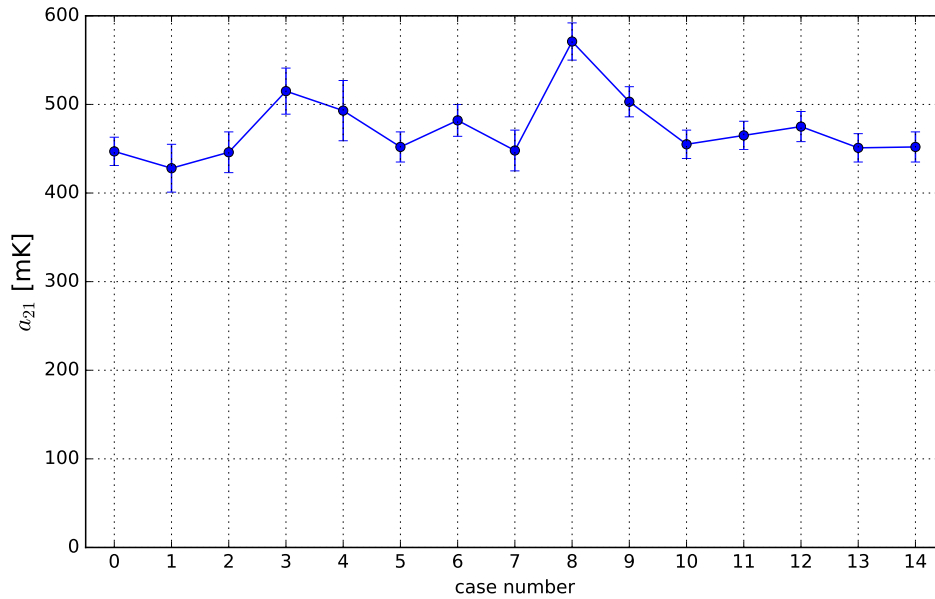


Figure 1: Signature amplitude for the conditions and cases of Table 1.

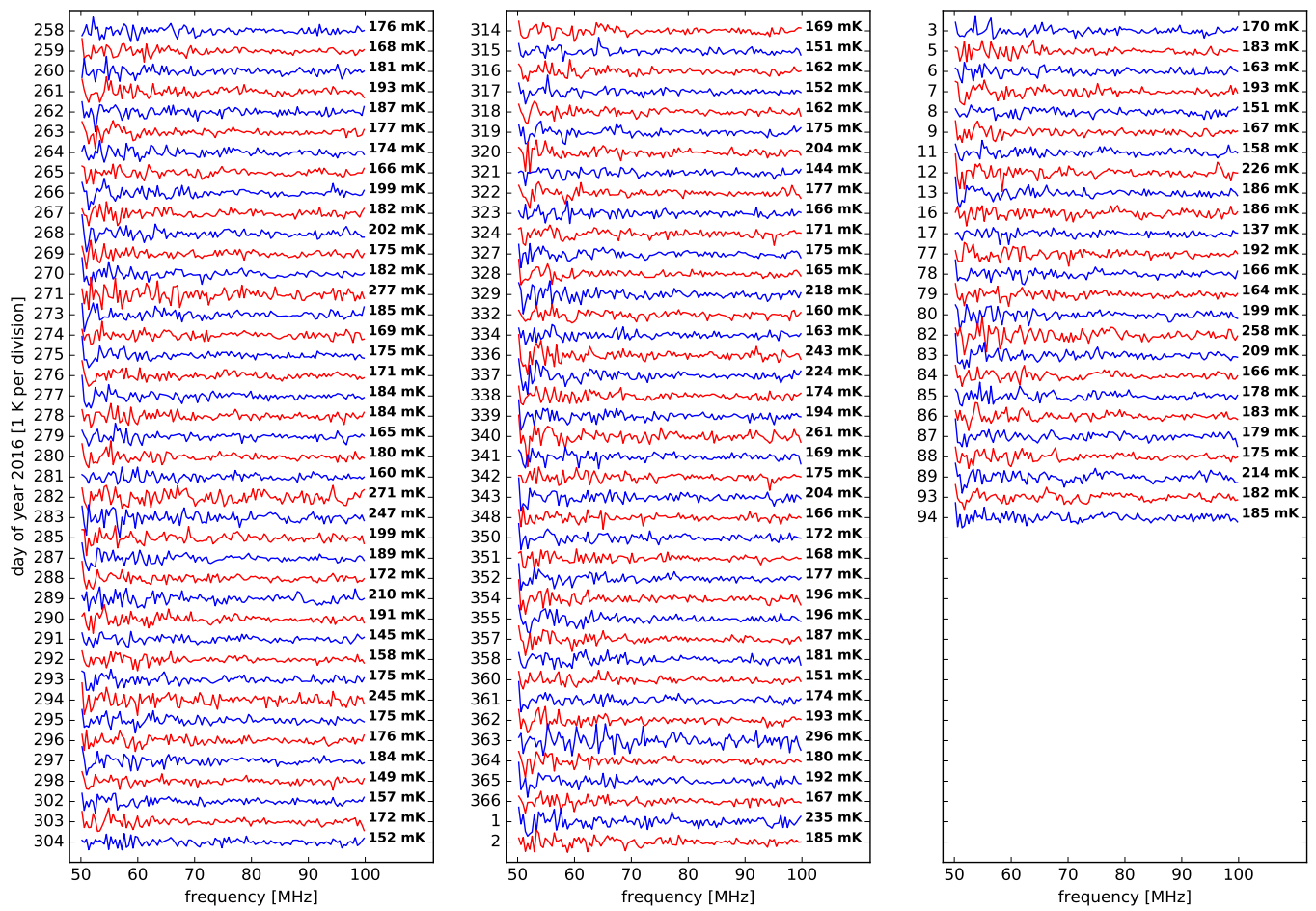


Figure 2: Daily residuals to 7-term polynomial over 50-100 MHz, for all days considered. The GHA range is 0-24 hr.

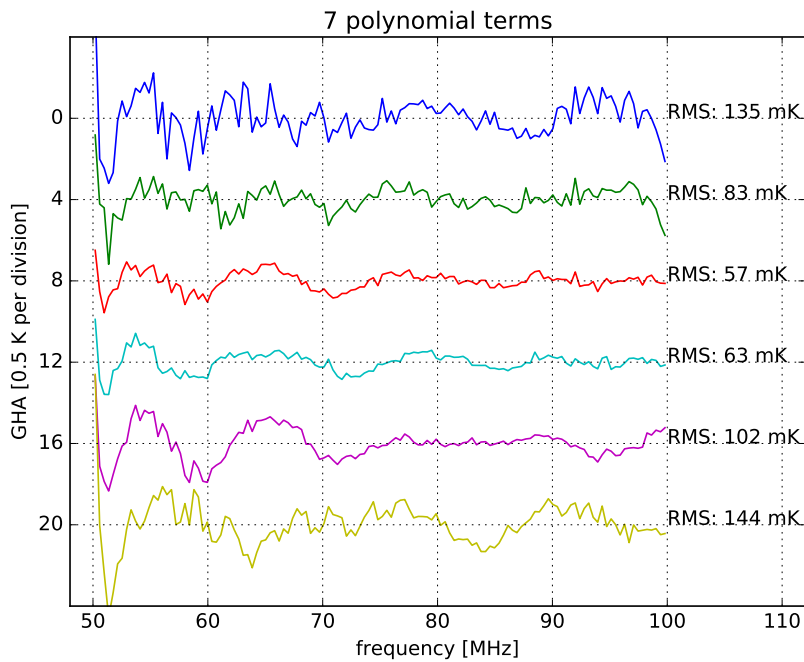


Figure 3: Residuals for 4-hr GHA averages, to 7-term polynomial over 50-100 MHz.

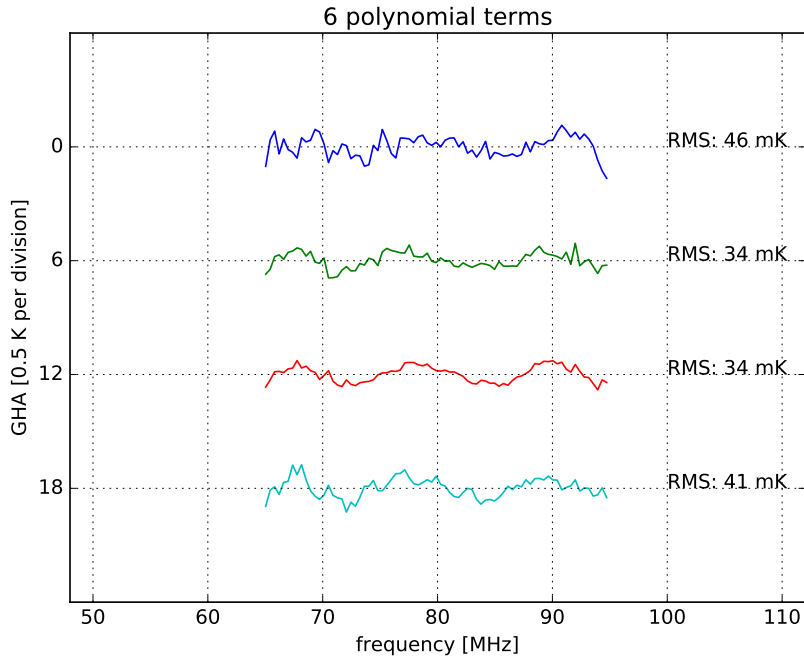


Figure 4: Residuals for 6-hr GHA averages, to 6-term polynomial over 65-95 MHz.

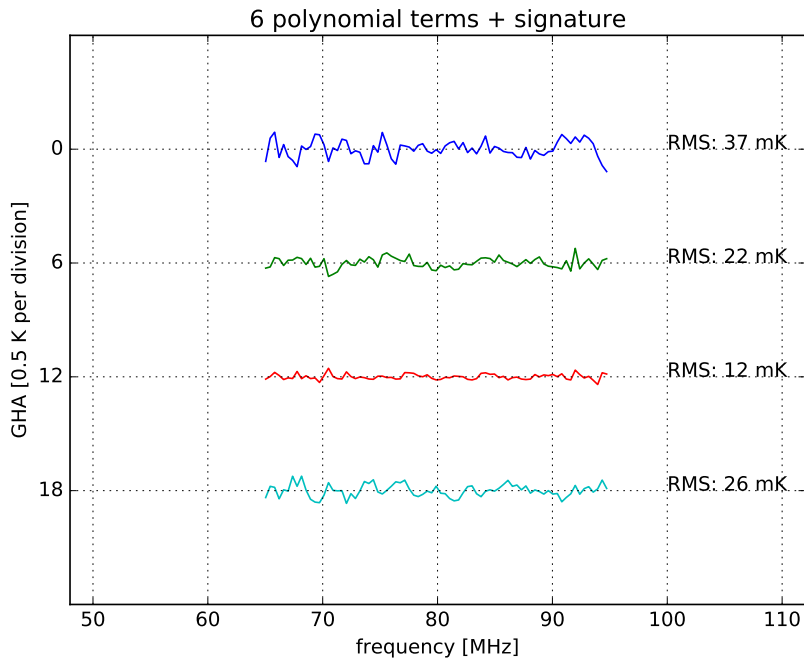


Figure 5: Residuals for 6-hr GHA averages, to 6-term polynomial plus 21-cm signature, over 65-95 MHz. The signature center frequency was fixed at 78.5 MHz.

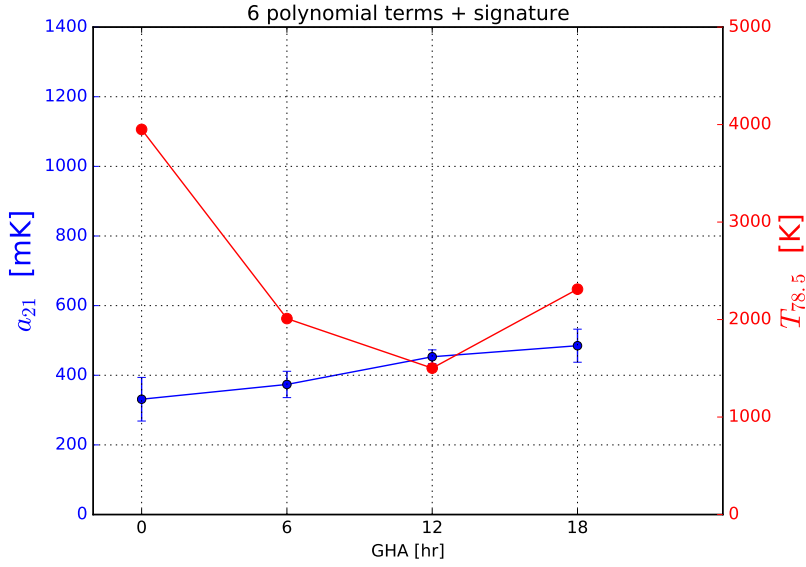


Figure 6: Amplitude of 21-cm signature as a function of GHA for 6-hour averages, in parallel to the total sky temperature at 78.5 MHz. The signature center frequency was fixed at 78.5 MHz.

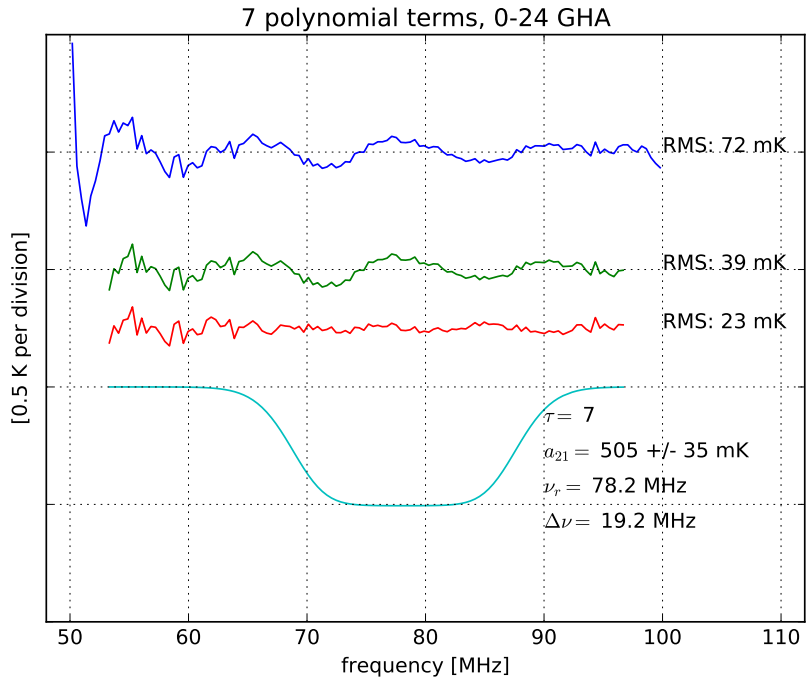


Figure 7: Residuals for average over 0-24 GHA, to 1) 7-term polynomial over 50-100 MHz (blue); 2) 7-term polynomial over 53-97 MHz (green); 3) 7-term polynomial plus 21-cm signature over 53-97 MHz (red). Also shown (cyan) is the best fit 21-cm signature over 53-97 MHz.

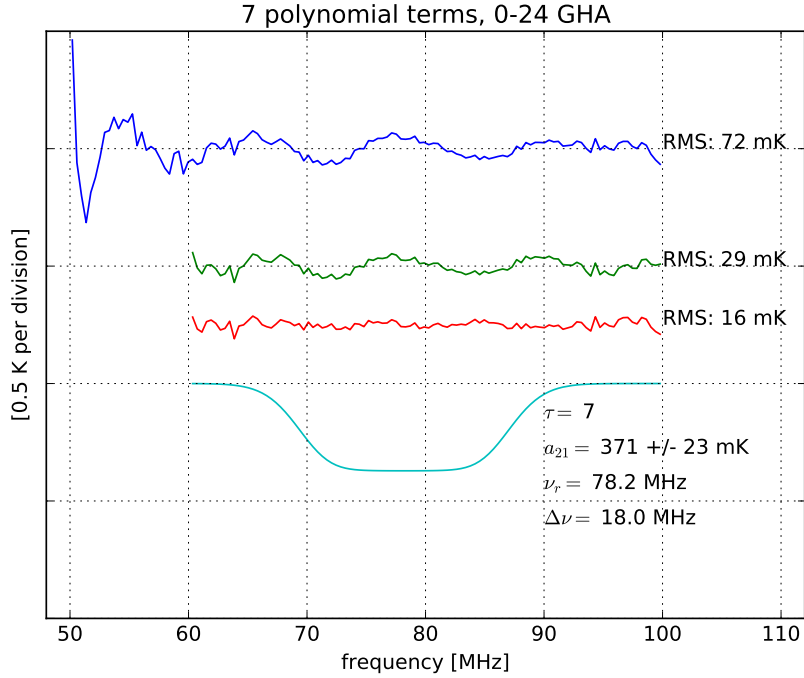


Figure 8: Residuals for average over 0-24 GHA, to 1) 7-term polynomial over 50-100 MHz (blue); 2) 7-term polynomial over 60-100 MHz (green); 3) 7-term polynomial plus 21-cm signature over 60-100 MHz (red). Also shown (cyan) is the best fit 21-cm signature over 60-100 MHz.

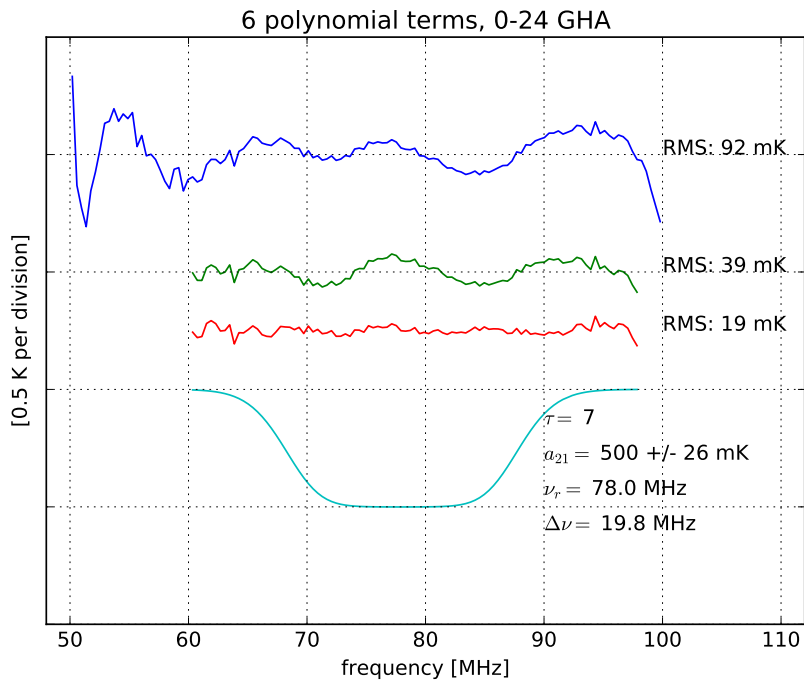


Figure 9: Residuals for average over 0-24 GHA, to 1) 6-term polynomial over 50-100 MHz (blue); 2) 6-term polynomial over 60-98 MHz (green); 3) 6-term polynomial plus 21-cm signature over 60-98 MHz (red). Also shown (cyan) is the best fit 21-cm signature over 60-98 MHz.

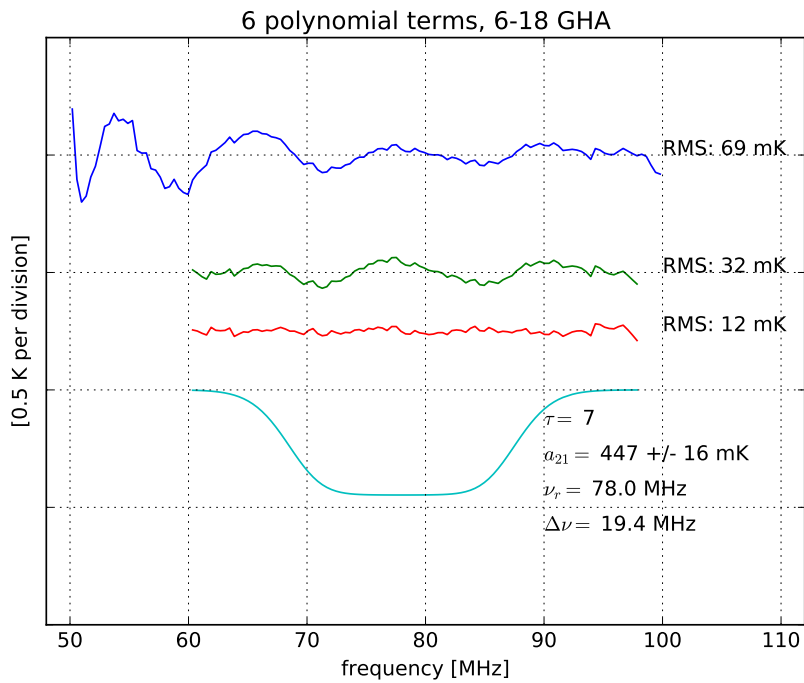


Figure 10: Residuals for average over 6-18 GHA, to 1) 6-term polynomial over 50-100 MHz (blue); 2) 6-term polynomial over 60-98 MHz (green); 3) 6-term polynomial plus 21-cm signature over 60-98 MHz (red). Also shown (cyan) is the best fit 21-cm signature over 60-98 MHz. The signature estimate shown here over 6-18 GHA, is close to the estimate over 0-24 GHA, shown in the previous figure.

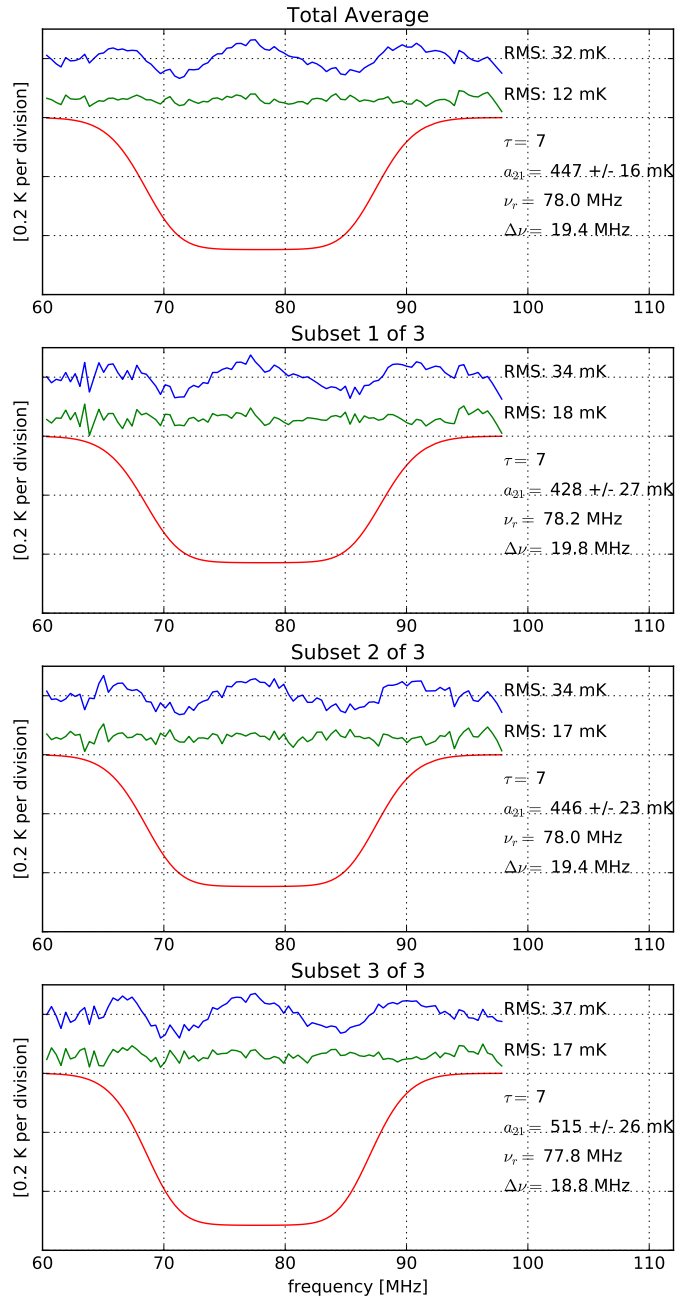


Figure 11: Residuals and 21-cm signature for three different averages of consecutive subsets of data. Each subset contains one third of the total data. Top panel is the nominal case.

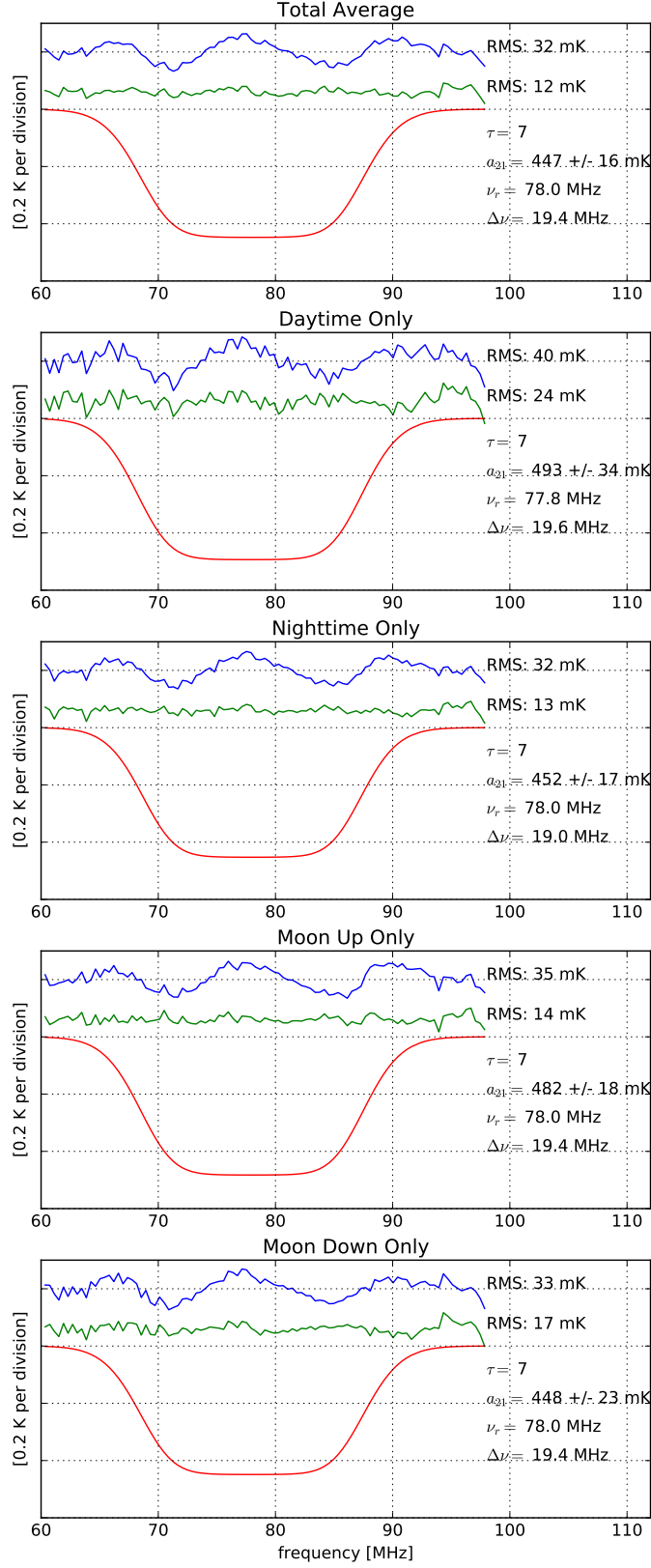


Figure 12: Residuals and 21-cm signature for four different averages: 1) daytime only ($EL_{\text{sun}} \geq 0^\circ$), 2) nighttime only ($EL_{\text{sun}} < 0^\circ$), 3) Moon up only ($EL_{\text{moon}} \geq 0^\circ$), 4) Moon down only ($EL_{\text{moon}} < 0^\circ$). Top panel is the nominal case.

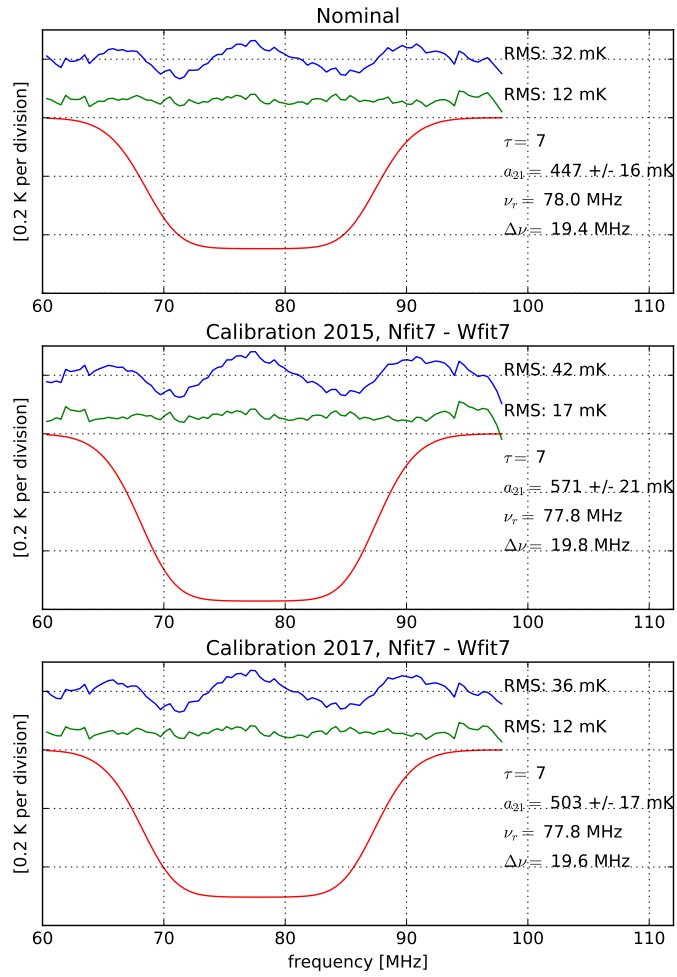


Figure 13: Residuals and 21-cm signature for two alternative receiver calibrations: 1) cal2015, Nfit=7, Wfit=7, and 2) cal2017, Nfit=7, Wfit=7. Top panel is the nominal case.

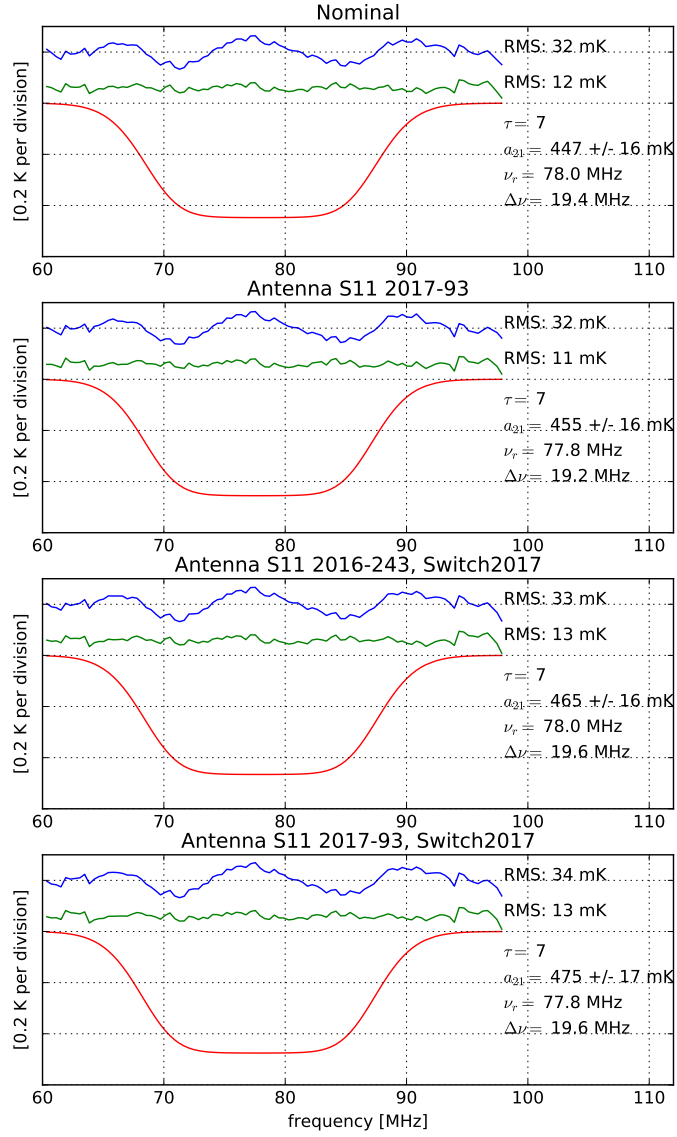


Figure 14: Residuals and 21-cm signature for three alternative antenna S11: 1) 2017-93 (2015 switch parameters), 2) 2016-243 (2017 switch parameters), 3) 2017-93 (2017 switch parameters). Top panel is the nominal case.

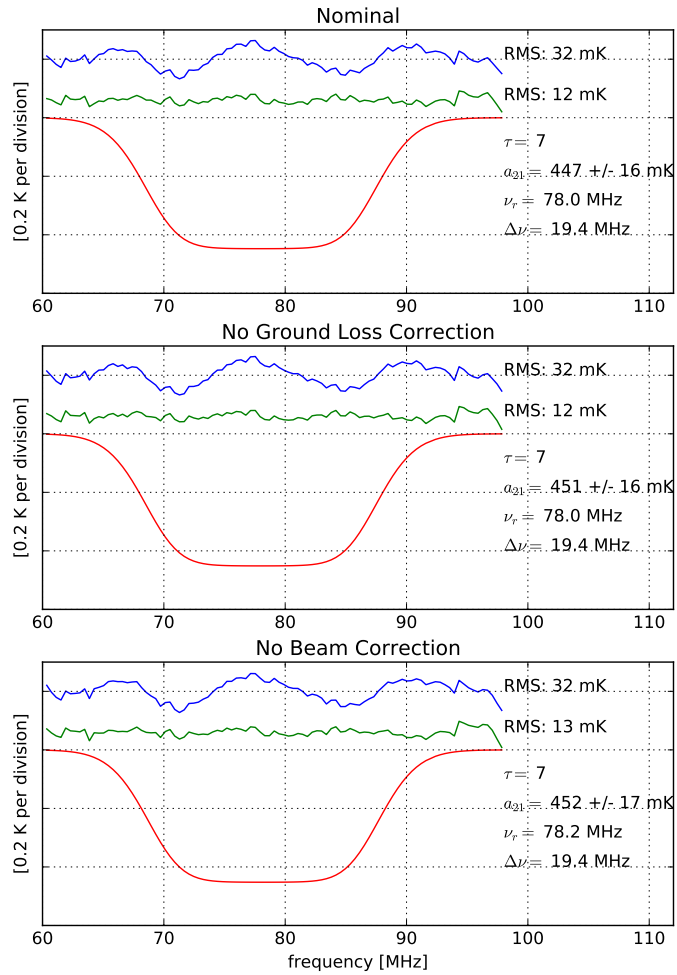


Figure 15: Residuals and 21-cm signature for two alternative corrections: 1) applying no ground loss correction, and 2) applying no beam correction. Top panel is the nominal case.