Comparison of Alternatives for Calibration of the High-Band Receiver 2015 at 25^{o}C

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Description

This document presents a comparison of results when using different files or conditions for calibration of the EDGES high-band receiver 2015 at 25^{o}C.

Description

The highest-quality spectrum/temperature data available for calibration of the high-band 2015 receiver at 25^{o}C correspond to files:

- ambient_load_2015_070_01
- ambient_load_2015_071_00
- resistance_ambient_load_20150310

- hot_load_2015_074_04
- hot_load_2015_075_00
- resistance_hot_load_20150314

- open_cable_hires_2015_086_07
- open_cable_hires_2015_087_00
- resistance_open_cable_hires_20150327

- shorted_cable_hires_2015_087_15
- shorted_cable_hires_2015_088_00
- resistance_shorted_cable_hires_20150328

There were more data taken for most of the calibrators, but for different reasons they are not adequate for calibration. For instance, spectrum data might not have a corresponding accurate measurement of S11 due to modifications in the calibration load between the two measurements.

The files for the open cable presented above showed some structure at around 60 MHz, probably due to RFI, but in the range of interest for the high-band receiver (90-190 MHz) there is nothing obviously wrong with the data, so these files are still considered for calibration.

Description

The definitive files with the S11 data for receiver calibration are:

- calibration_S11_25degC.txt : for ambient load, hot load, and LNA
- calibration_S11_high_resolution.txt : for open and shorted cable
- semi_rigid_s_parameters.txt : for semi-rigid cable inside hot load

These data were corrected using the DC resistance of the 50-Ω load used for VNA calibration, and also assuming a load delay of 30 ps. The comparisons presented in this document put this last assumption to the test.

Description

The highest-quality spectrum/temperature measurements of the Antenna Simulators to be used for VERIFICATION are:

- simulator1_hires_2015_088_18
- simulator1_hires_2015_089_00
- resistance_simulator1_hires_20150329.txt

- simulator2_2015_075_22
- simulator2_2015_076_00
- simulator2_2015_077_00
- resistance_simulator2_20150316.txt

Two potentially valid S11 measurements of the Simulators are contained in the files:

- calibration_S11_high_resolution.txt
- antenna_simulators_hires_20150330.txt

The comparisons ahead examine both cases.

Description

With the background provided on the previous slides we can define all the cases examined:

Case	50-Ω Load Delay (1)	S11 file for Simulators (2)	Open or Shorted Cable for NWP (3)
1	0 ps	File 1	Open
2	0 ps	File 1	Shorted
3	0 ps	File 2	Open
4	0 ps	File 2	Shorted
5	30 ps	File 1	Open
6	30 ps	File 1	Shorted
7	30 ps	File 2	Open
8	30 ps	File 2	Shorted

NOTE 1:
The same value for the load delay is applied to all the S11 measurements corrected (calibration and verification).

NOTE 2:
File 1: calibration_S11_high_resolution.txt
File 2: antenna_simulators_hires_20150330.txt

NOTE 3:
This corresponds to the measurement used for the computation of the noise wave parameters (NWP).

Results

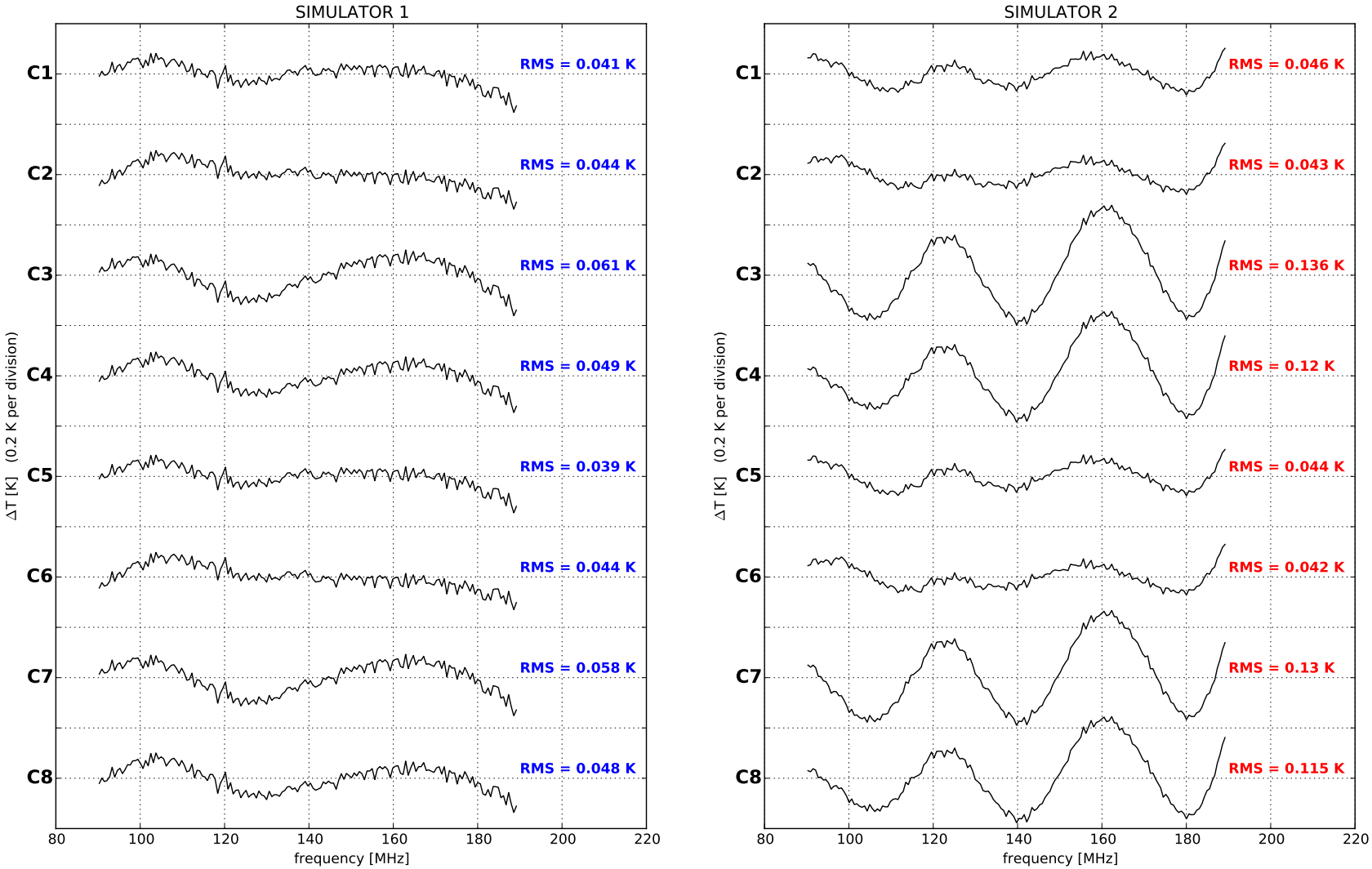

Figure : (1): Calibrated Simulator spectra after subtracting their mean value. The calibrations were done in the range 90-190 MHz. The NWP were modeled with 3rd-degree polynomials. The final spectra are binned at 100 raw points per bin ($\sim$ 0.6 MHz). The Table of page 6 describes the 8 cases shown here. The lowest RMS for both Simulators is obtained in case 5.

Discussion

The following can be said from Figure 1 and the Table of page 6:

1. The worst cases (highest RMS) are cases 4, 5, 7, and 8, especially for Simulator 2. This is an indication that the S11 measurements in File 2 (antenna_simulators_hires_20150330.txt) are not accurate, or representative of the Simulators. Despite this file having been produced by the end of the calibration process (end of March), implying higher expectations, it resulted in larger spectral structure. There is no obvious aspect to target as the origin of this situation. Thus, for now File 1 (calibration_S11_high_resolution.txt) is preferred for the S11 of the Simulators.
2. Assuming a delay of 30 ps for the 50-Ω load used for VNA calibration (in all the S11 measurements involved, calibration and verification) has the effect of reducing the spectral structure. The RMS of cases 5, 6, 7, and 8 are lower than their zero-delay counterparts (cases 1, 2, 3, and 4, respectively), for both Simulators. However, the differences are only between 1 and 3 mK. Still, assuming a delay for the 50-Ω load is preferred. In fact, we could even use the value obtained for the Direct/Reverse method, of 38.8 ps, although the gain would be marginal.
3. For otherwise equal condidions, the difference between using open cable or shorted cable measurements is small, and the spectral structure remains qualitatively similar.
4. Since case 5 is the best for both Simulators, producing RMS of 0.039 and 0.044 K with binning of $\sim$ 0.6 MHz, for calibration of EDGES data it is recommended to use the files listed on page 3, using the open cable instead of the shorted cable, and assuming a delay of 30 ps for the VNA calibration load. The S11 files made available on the FTP server already incorporate this last assumption.