EDGES MEMO #245

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To: EDGES Group

From: Alan E.E. Rogers
Subject: Summary of lowband results and tests

The first EDGES lowband receiver was installed at the MRO on a 9.8×9.7 m ground plane in late 2015 and operated from 2015_281 to 2016_204 when the 3-position switch failed. The switch was replaced in the field when the ground plane was extended. The receiver operated from 2016_247 until the 3-position switch controller board failed as the result of a lightening strike on 2017_017. The board was replaced the receiver operated again until 2017_095 when it was removed and sent back for recalibration.

The second lowband receiver was installed on a new extended ground plane 100 m east of the electronics hut and started acquiring data on 2017_082.

Figure 1 and 2 show the results of a signature search using all the currently available data from lowband1 and lowband2 using 4 polynomial terms and covering 61 to 99 MHz. Figures 1 and 2 show the residuals to a 4 term polynomial fit prior to fitting 4 polynomial terms plus a signature, and the residuals to the fit with the best fit signature. The best fit signature is from a grid search for the center frequency and width for a fixed flattening of τ=7 (see memo 220). The lowband1 search in Figure 1 is for nighttime data only while lowband2 in Figure 2 is for both day and night as there is very little nighttime data available so far. In both the data is limited to 6 hours away from transit of the Galactic center.

Many tests have been conducted on both the lowband data in order to determine if the signature is global and not the result of RFI or instrumental systematics.

a) Beam effects

In early 2016 (see memo 186) it was noted that the beam chromaticity effects due to the limited size of the ground plane were very significant and dependent on the soil conductivity and dielectric constant. The fine scale structure in the spectra and those from simulations using the beam derived from FEKO with finite ground plane and soil parameters were found to be correlated. As more lowband data became available it was found that beam corrections using FEKO beam models with soil conductivity around 2e-2 s/m and a dielectric constant of 3.5 made a substantial reduction in the spectral residuals and improved the smoothness of the foreground spectral index variation with LST (see memo 203). Ultimately the lowband ground plane was extended and perforated edges added to reduce the beam chromaticity. Tests now show that while beam correction increases the SNR of the flattened signature (given in memo 222) the signature is still present without beam correction mainly because beam chromaticity effects average out over a range of LST.

b) “Resonances”

An early indication of the presence of a global signature appeared as “dips” at 84 and 7 MHz and expensive search was made to see if these could be the result of poor contact between ground screen panels, reflections from the hut, resonances in the balun shield or other potentially resonant structures. However these “dips” were found to be independent of the LST and do not fit the pattern of expected change with LST. Ultimately it was realized that they are produced by the regions of maximum slope in flattened signature which show up in the residual spectra when more than 4 terms are removed.

c) RFI

Perhaps of greatest concern is that this “signature’ is the result of RFI because constant RFI would appear to be global and invariant see memo 244 for RFI study.

d) Instrumental errors

Based on the deployment of the lowband2 receiver the largest source of error is receiver calibration errors. The 2017 calibrations was used to the lowband2 data shown in Figure 2. The use of the 2016 results in a poor fit to the signature. Other significant sources of instrumental error are the result of insufficient knowledge of ground loss, balun loss and VNA error. See memos 236 237 and 239. Another source of error are changes in the antenna during periods of rain or condensation. However most of the error sources are filtered out using ancillary information or have rms residuals which exceed a threshold.

e) Specials tests

In order to check if a wider signature would fit the data the spectrum range was increased from 61 to 99 MHz to 51 to 99 MHz. Figure 3 shows the signature search on lowband1 using this range. Figures 5 and 6 show search results for lowband2 using the 2017 calibration and lowband2 using the 2016 calibration respectively. These plots show that the same signature is still found to fit the data.

Figure 6 and 7 show that it is possible to use only 3 physical terms in addition to the signature to obtain a good fit especially in the case of lowband1 from 60 to 99 MHz. The 3 physical terms are scale, spectral index and ionospheric absorption. Figure 7 shows the search using the 2017 calibration for the lowband2 data. The result using 2016 calibration does not yield a clear peak with only 3 terms.

A key question is how to show that the signature is not instrumental. Showing that the same signature at the same amplitude is also present in the data close to transit is one way to gain more confidence because many instrumental errors will scale with the foreground strength. This can be accomplished by using “Galaxy calibration” or checking the signature strength change with GHA.

The signature strength vs GHA assuming center frequency 78.5 MHz, width 18.5 MHz and flattened parameter τ=7 using 6 polynomial terms and frequency range 65 to 95 MHz is given in Table 1.

GHA	T at 75 MHz	amp (K)	SNR
0	4532	0.45	5
4	3069	0.46	9
8	1640	0.44	13
12	1658	0.57	21
16	1995	0.59	11
20	3369	0.66	9

Table 1. Signature vs GHA using lowband1 data with extended ground plane.

The search used lowband1 data from 2016_281 to 2017_095. This test and others (see memos 222, 225,226) show that the signature is global and unlikely to be instrumental. It also shows that the signature is unlikely to be from an absorption in the atmosphere as it doesn't increase in proportion to the foreground temperature. However to be sure a search of molecular lines shows that NO (Nitric Oxide) has a series of lines from 60 to 80 MHz. However, they have an estimated opacity orders of magnitude below the 3×10^{-4} needed to produce a significant absorption. No other constituents of the atmosphere were found to have lines which might result in significant absorption.

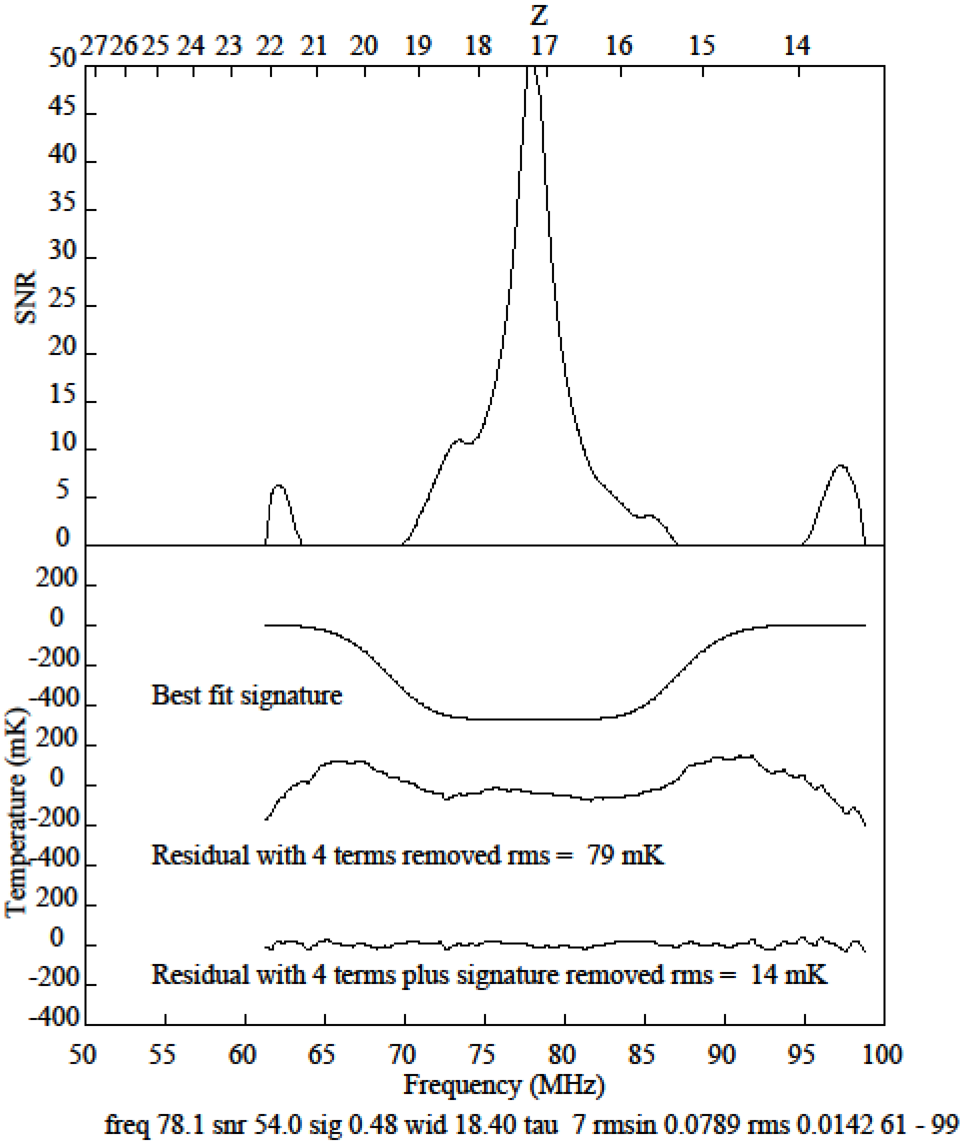


Figure 1. Lowband1 nighttime 2015_281 to 2017_017.

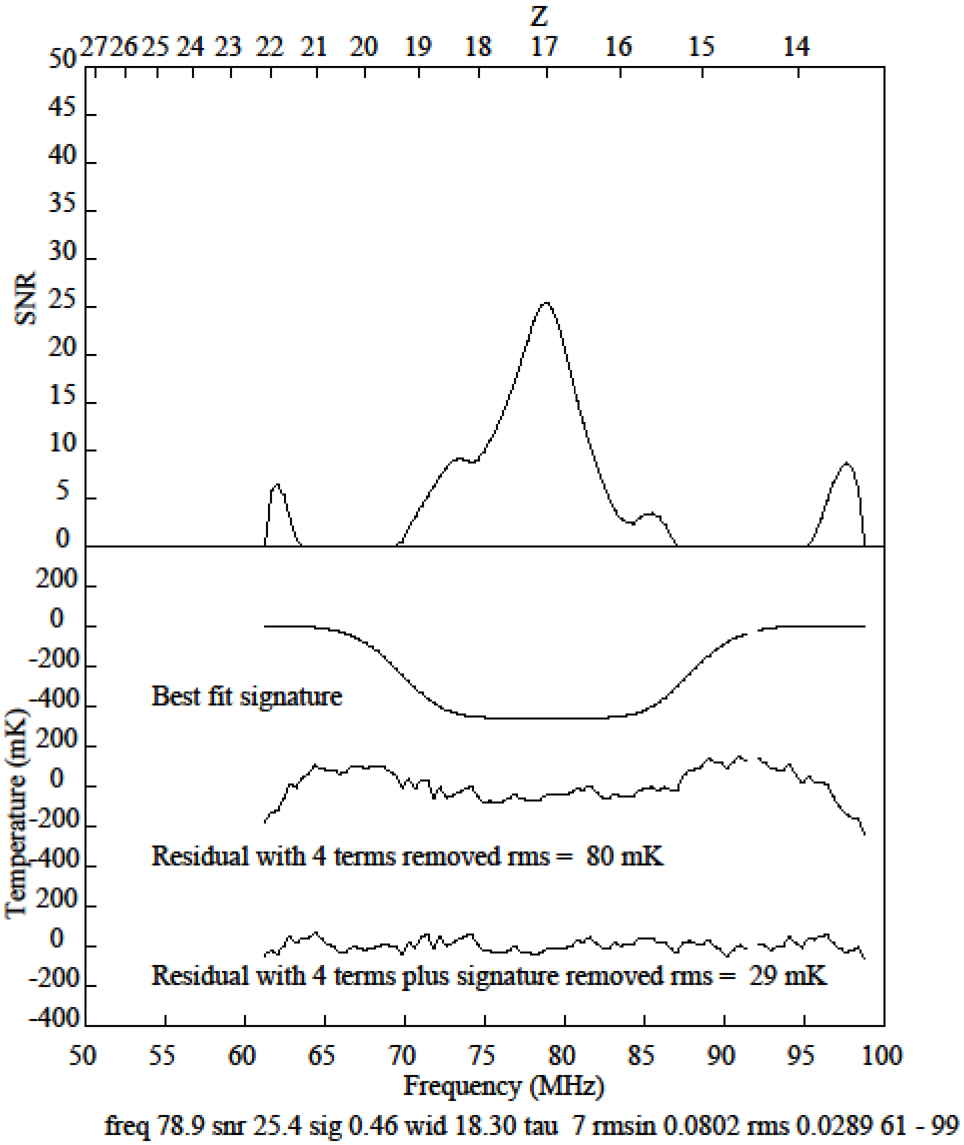


Figure 2. Lowband2 2017_082 to 2017_119 using 2017 calibration.

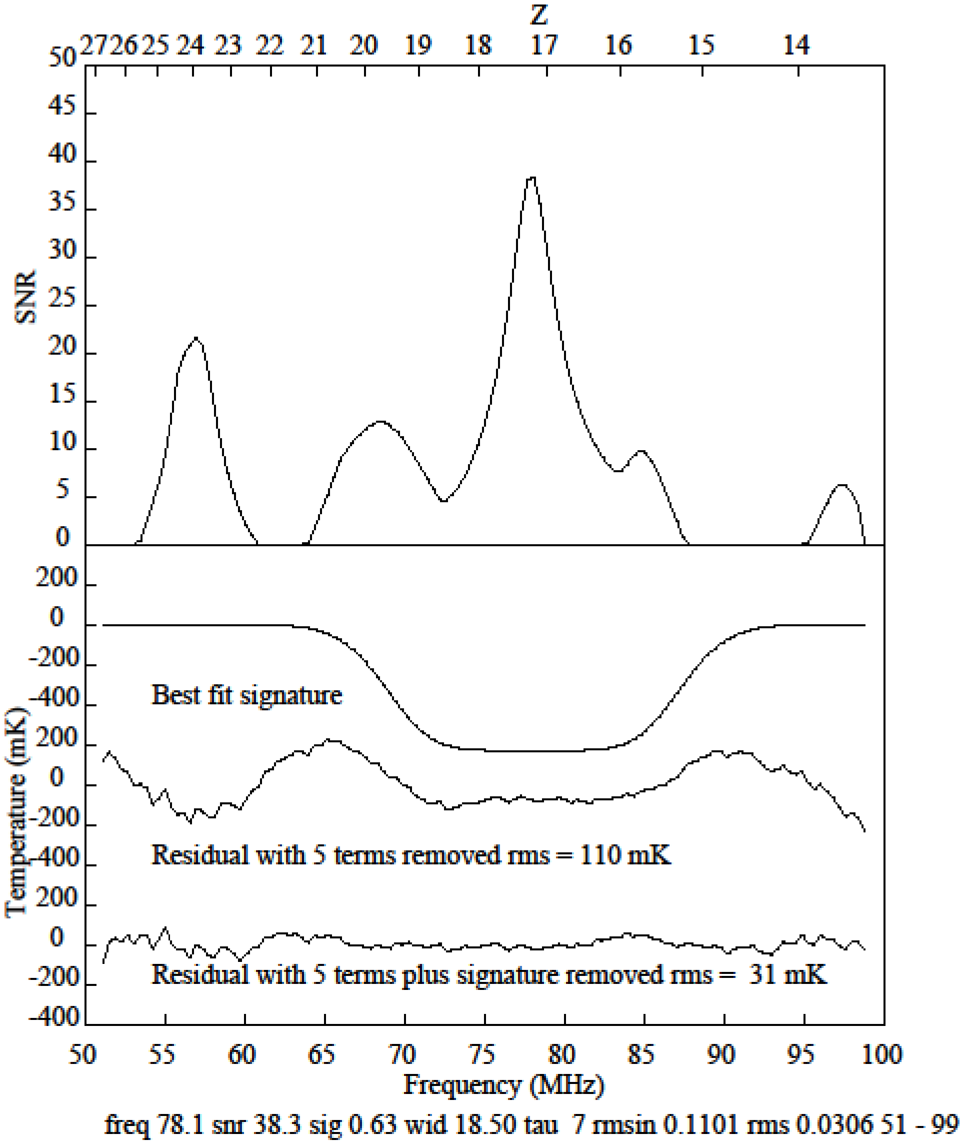
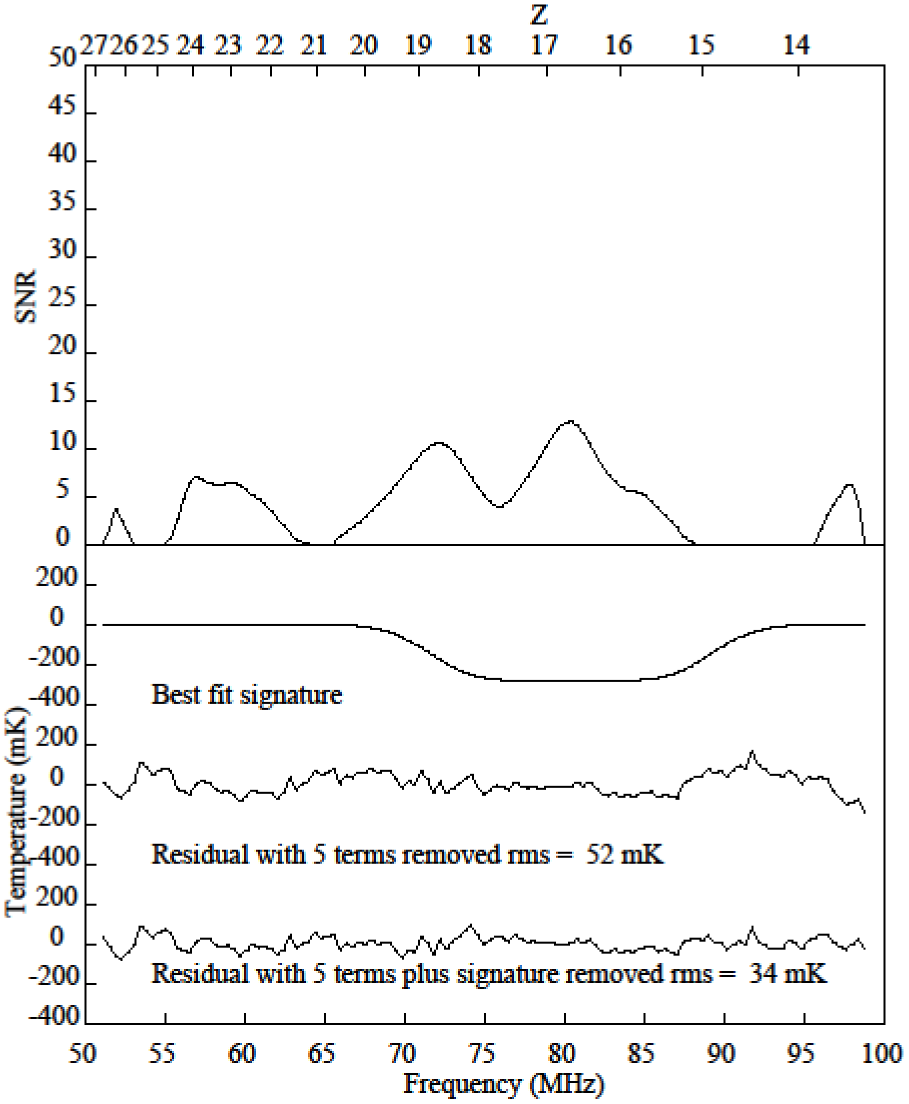


Figure 3. Signature search of lowband1 data over wider range using 5 polynomial terms.



freq 80.5 snr 12.7 sig 0.28 wid 17.80 tau 7 rmsin 0.0522 rms 0.0342 51 - 99

Figure 4. Search using lowband2 data with 2017 calibration.

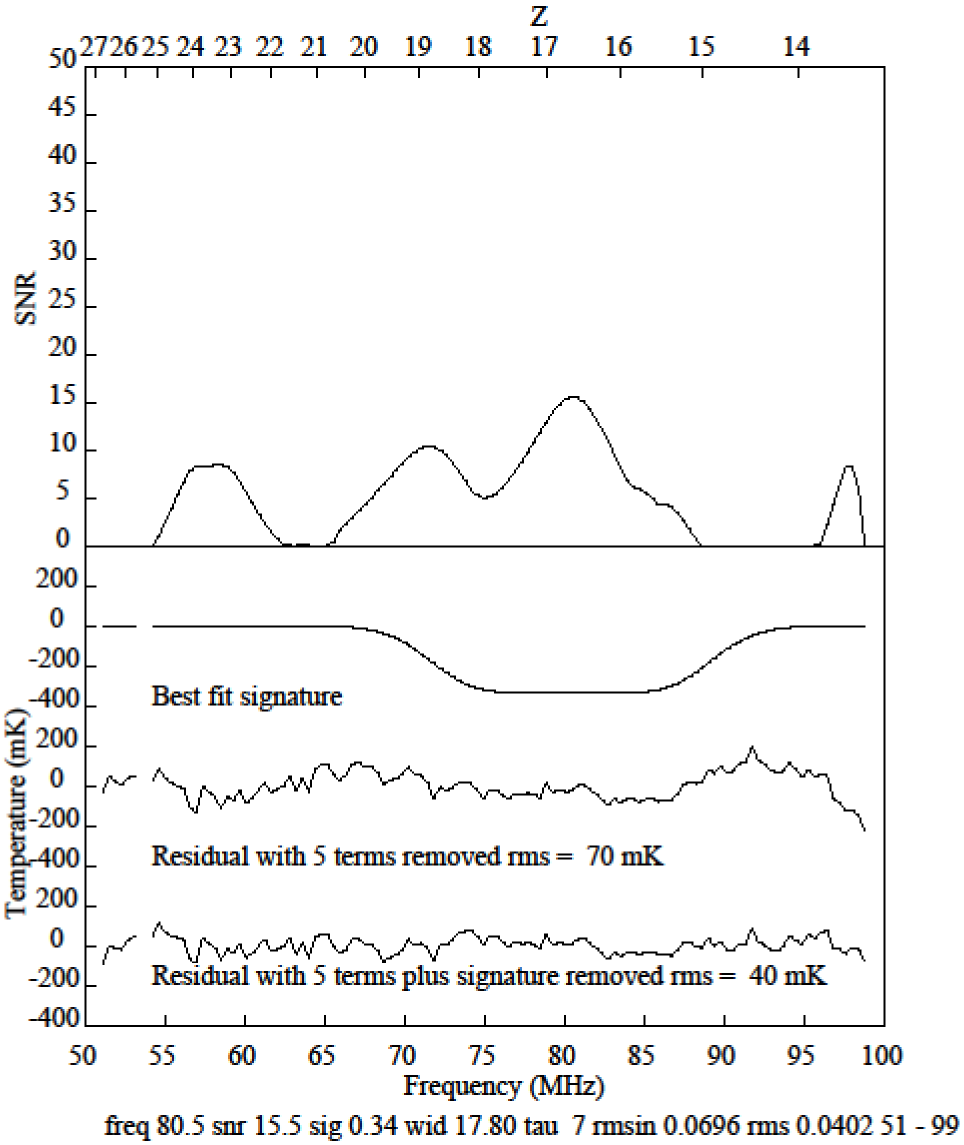


Figure 5. Search using lowband2 data with 2016 calibration.

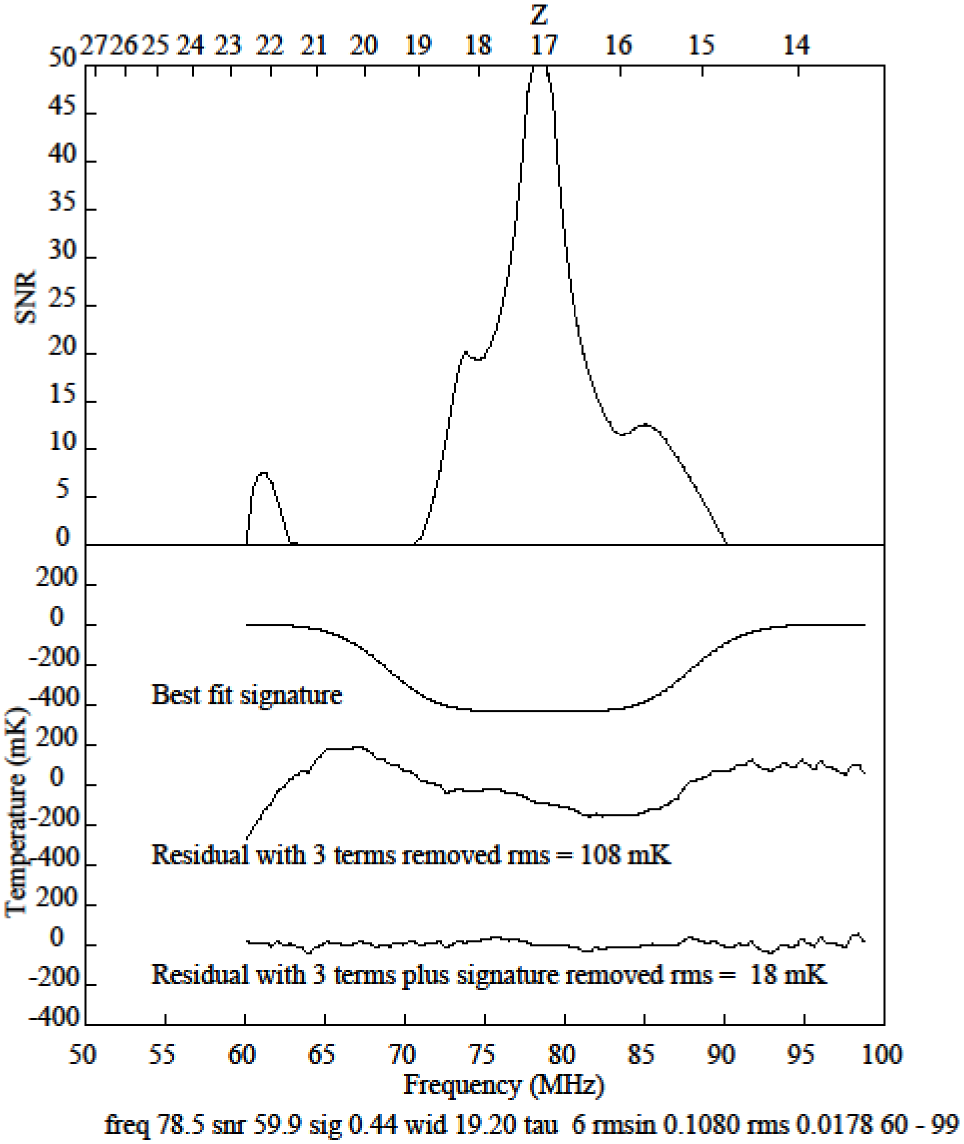


Figure 6. Search using lowband1 data using 3 physical terms giving spectral index of -2.61 and 1.6% ion absorption.

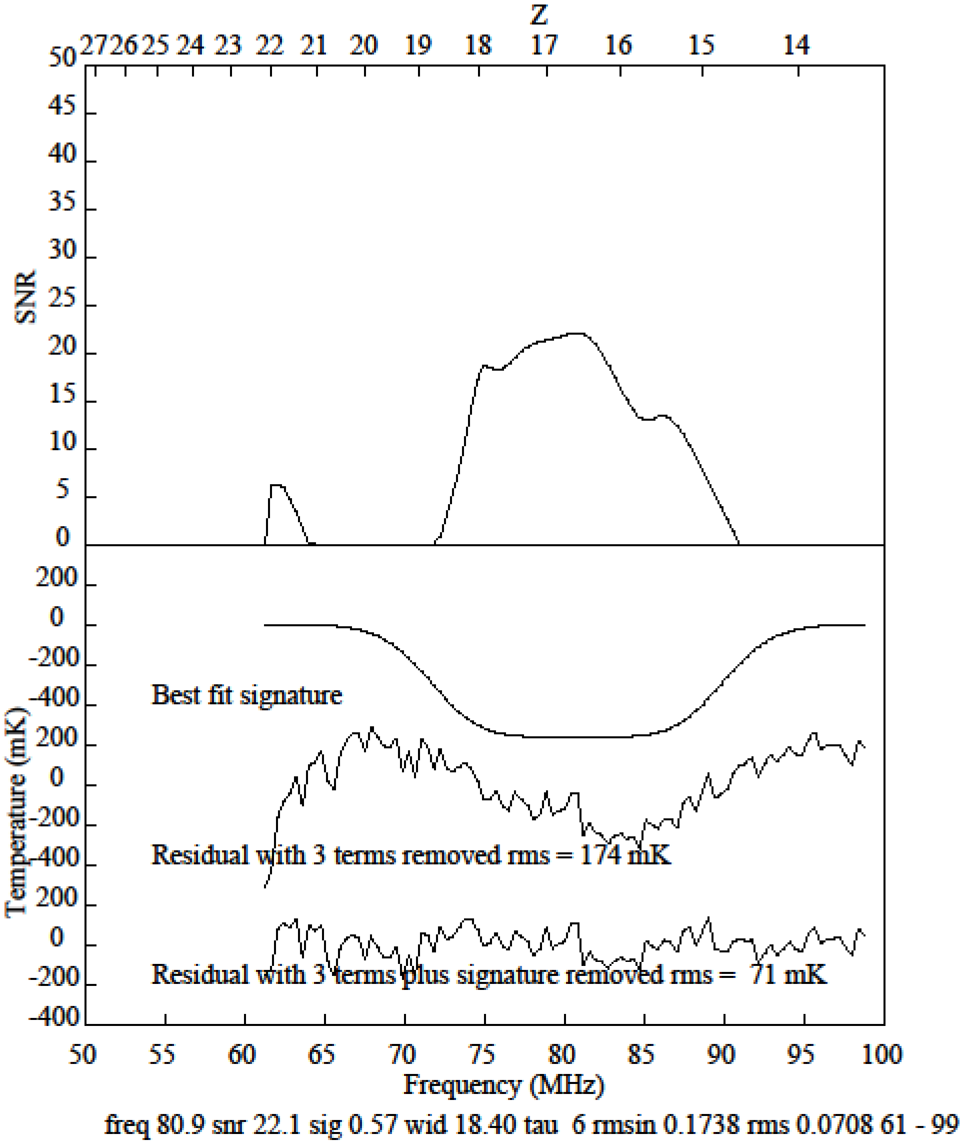


Figure 7. Search using lowband2 data giving spectral index -2.60 and 1.8% ion absorption.