EDGES MEMO #464

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
HAYSTACK OBSERVATORY
WESTFORD, MASSACHUSETTS 01886

December 10, 2024

Telephone: 617-715-5533

To: EDGES group

From: Alan E.E. Rogers

Subject: Tests of filtering out the effects of Cas A simulations on data from Devon Island

Memos 427, 428 and 463 discuss the possibility that the dominant source of the rapid time variations which limited the measurement of the 21-cm absorption at Devon Island in 2022 are from scintillations of Cassiopeia A . Figure 1 shows an example of the variations from the spectra from each 3-position switch cycle and Table 1 lists the changes in sky temperature at 75 MHz, spectral index and absorption by the ionosphere obtained from a 3-term fit to the spectra.

T 75 MHz K	rms K	spectral index	Ion %	day_hour
2280	17	-2.59	3.14	227_0.00
2262	4	-2.51	-0.96	227_0.01
2286	11	-2.65	7.37	227_0.02
2309	14	-2.79	13.3	227_0.03
2307	25	-2.89	14.9	227_0.04
2293	10	-2.81	12.3	227_0.05

Table 1. Example of 36 second time scale spectra with 3-terms removed 55-102 MHz

The sharp peak at about 62 MHz at 227_0.04 might be from the sun which is at 12 degrees elevation but regardless of the source of the variations in the spectra there is a need to filter out the data with large rms. The shortest time scale possible is that of the 3-position switch cycle and even if real time data samples were available these data would be un-calibrated so that applying a threshold filters beyond those of RFI filters could lead to biases in the results.

In order to apply a rms threshold uniformly on several days some increase in the sizes of the static data arrays in the “longav” c-code were made in order to average over days 221-233. With these changes 32768 spectra from 13 full days can be filtered to find the fraction of spectra within an rms threshold. The results of this filtering are shown in Table 2 where the rms threshold is in column 8 is applied to the fit to the data block with the frequency range and spacing in columns 9 and 10 and the overall fraction of data used in the last column.

case	freq MHz	SNR	sig K	wid MHz	rmsin mK	rms mK	rms thresh	freq range MHz	spacing sec	%used
A	78.1	11	0.66	20.9	225	69	1.6	63-98	36	6
B	77.4	14	0.59	20.9	204	43	0.37	64-98	1800	7
C	77.7	8	0.71	20.9	253	101	1.8(58-98)	62-98	36	3

Table 2. Results of a 21-cm absorption search using 5 loglog terms tau = 7

The threshold is adjusted to obtain a reasonable result for the 21-cm absorption and the filter uses the same 5 term loglog polynomial as used for the grid search of the absorption. Case B is from figure 1 of memo 419. Several tests have been made using a different polynomial for the filter threshold but so far

only one has been found to allow the absorption search to obtain low residuals over a slightly wider bandwidth shown in case C which used the threshold of a 58-98 MHz.

There are a very large number of possible parameters for a “double” level of filtering that have not yet been explored and in addition there are the rfi filters which are applied to the raw un-calibrated data which have to be optimized for an environment in which the spectra are changing rapidly due to scintillation.

Another potential filter is to use a model of the amplitude to exclude the times when the high amplitude Cas A scintillation is expected from a simulation. For example setting a threshold of UT times with rms less than 0.3 K in Figure 2 removes times like 9 UT which has a residual of 0.69 K 58-102 MHz should help improve the results in table 2 but so far I have not been able to predict the scintillation times well enough to improve the results beyond just setting a threshold to filter the data.

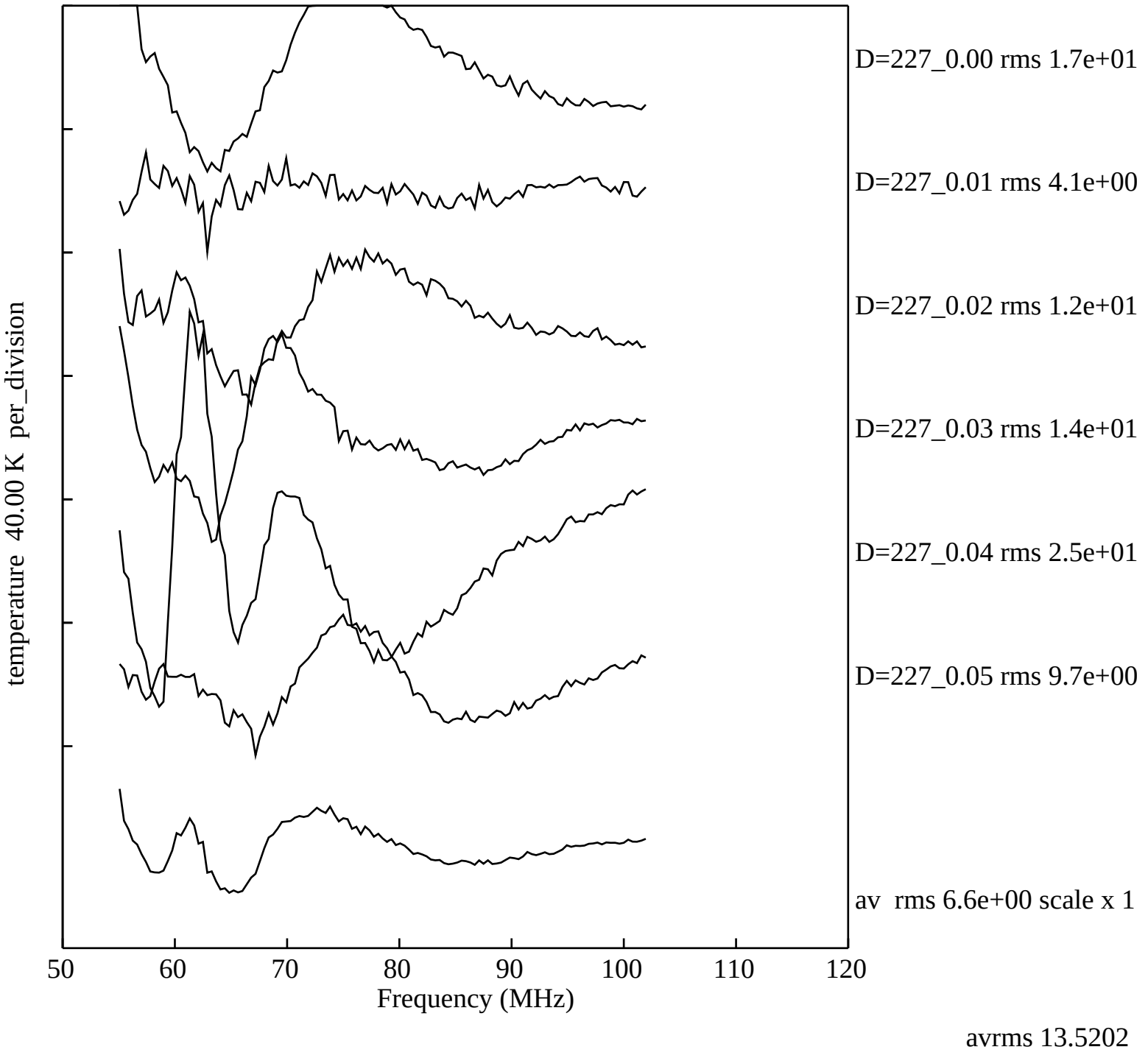

Figure 1. EDGES-3 spectra from Devon Island on time scale of 36 sec with 3-terms removed

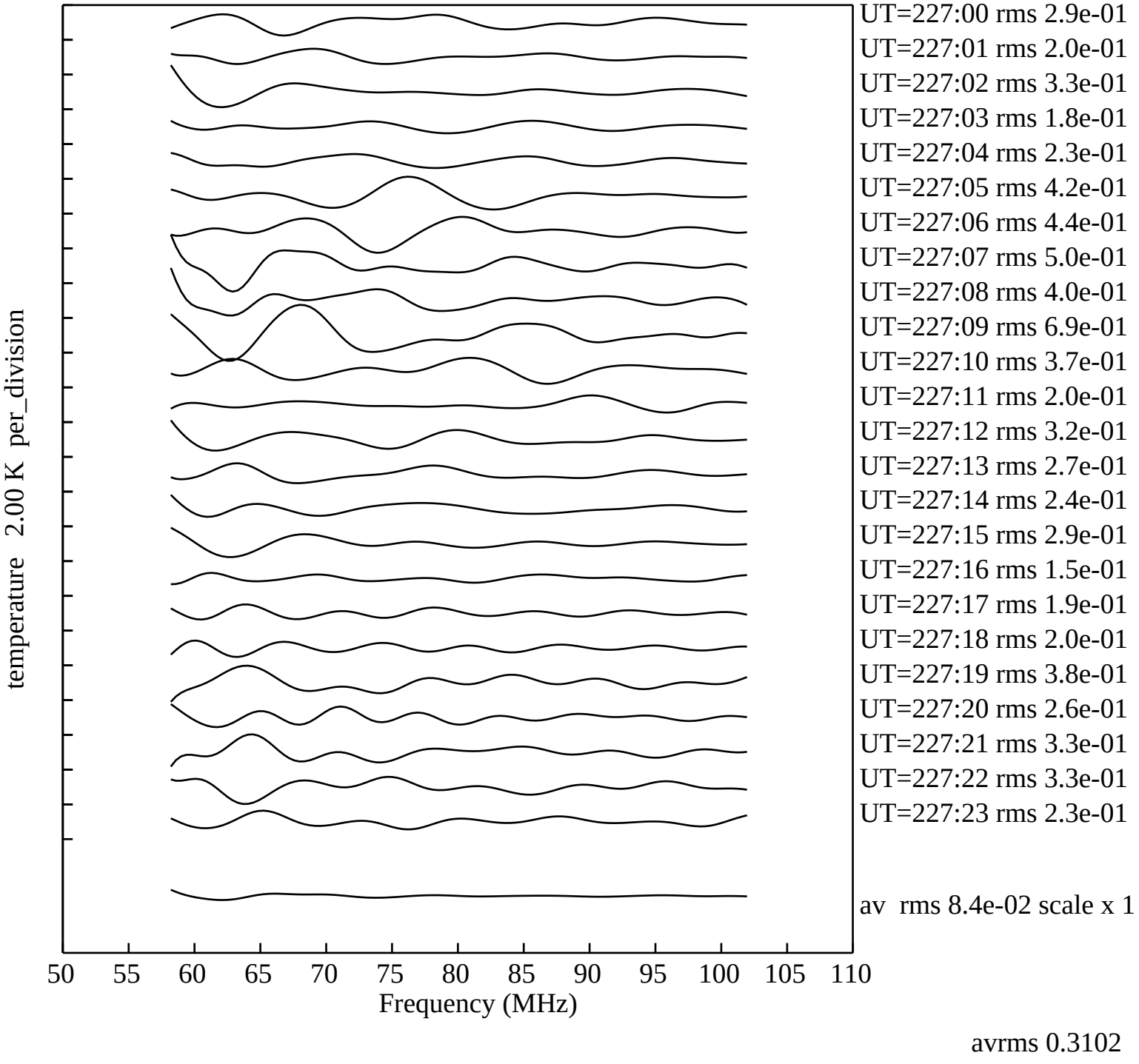

Figure 2. Simulation of scintillation from Devon Island time scale of 1 hour with 5-terms removed