Some Observations of RFI using the GBT C-band Receiver and Spectrometer

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Introduction

During the maintenance period on March 13, 2006 we made some test observations using the C-band (3.95-5.85GHz) receiver and the GBT spectrometer (ACS). The purpose of the tests was primarily to assist in determining the dynamic range requirements for a new C-band receiver design. Six ACS high-speed samplers were used (three on each front-end polarization), stagger-tuned using the variable LO2 sources in order to cover the entire front-end range instantaneously. Most of the test time was with the GBT at access, but one azimuth scan was accomplished at an elevation of 20 degrees.

As a general summary, we found that virtually the entire frequency range 3900-4250 almost constantly exhibited time variable RFI that made the spectral baselines (taking 1 minute averages) unstable up to 50% of Tsys. A narrow-band (CW) signal at 5440 MHz was also variable and sometimes caused significant ringing in the ACS.

Setup

The front-end LO1 was fixed at 7900 MHz. The three samplers connected to each polarization were tuned to center frequencies of 5575, 4900, and 4225 MHz by setting LO2 G1, G2, and G3 to 11.625, 12.300, and 12.975 GHz. With the ACS setup in 800MHz mode, this yields about 75MHz of overlap taking into account the filter rolloffs in the Analog Filter Rack.

XL	ODM1	CM1	SF1	Bank A, J1, Sampler 1
	ODM1	CM2	SF2	Bank B, J3, Sampler 1
	ODM1	CM3	SF3	Bank C, J5, Sampler 1
YR	ODM3	CM5	SF5	Bank A, J2, Sampler 2
	ODM3	CM6	SF6	Bank B, J4, Sampler 2
	ODM3	CM7	SF7	Bank C, J6, Sampler 2

Results

Figure 1 shows a series of spectral baselines (60 second averages) for the two linear polarizations taken as the GBT slewed from 400 to 44 degrees azimuth. Figure 2 expands the amplitude and frequency scales. It can be seen that the region below 4380 MHz is almost constantly unstable. We found that to be true even when the GBT was stationary at access. One can see also that often the entire frequency range covered by the samplers tuned to the low range is contaminated when there are large changes in the interference below 4380 MHz. For one pair (the green trace), the entire receiver frequency range exhibits significant ripple and a linear slope but the cause of this is uncertain.

Figure 3 shows a zoom into the region near 5440 MHz, showing in more detail ringing in the ACS response due to the apparently CW RFI.

Figure 4 shows time variation in the raw spectra (10 second averages) from the XL polarization for three scans during the azimuth scan. It can be seen that the signal at 5440 MHz does not exceed about 2 dB above the system noise. The comb of frequencies below 4200 MHz varies up to 6dB above the noise floor. (Note: During our tests, T_{sys} was approximately 30K, and the ACS channel bandwidth was $800MHz/2048 = 390kHz$.) Since we do not know much about the time variability of the interferring signals, it is possible that peak excursions are larger than seen in the 10 second averages. The narrow-band feature at about 4160 MHz is one of four OMT resonances in the band, but these do not show in the baselines because they are stable.

The frequency range 3.7-4.2 GHz is allocated for both fixed and satellite-to-earth communications. It is utilized for point-to-point telecommunications links, and for geostationary satellite video downlinks. The broadband signals in the 4.2-4.4 GHz region are thought to be aircraft related, but we are not sure. The 5440 MHz CW signal origin is unknown at this time.

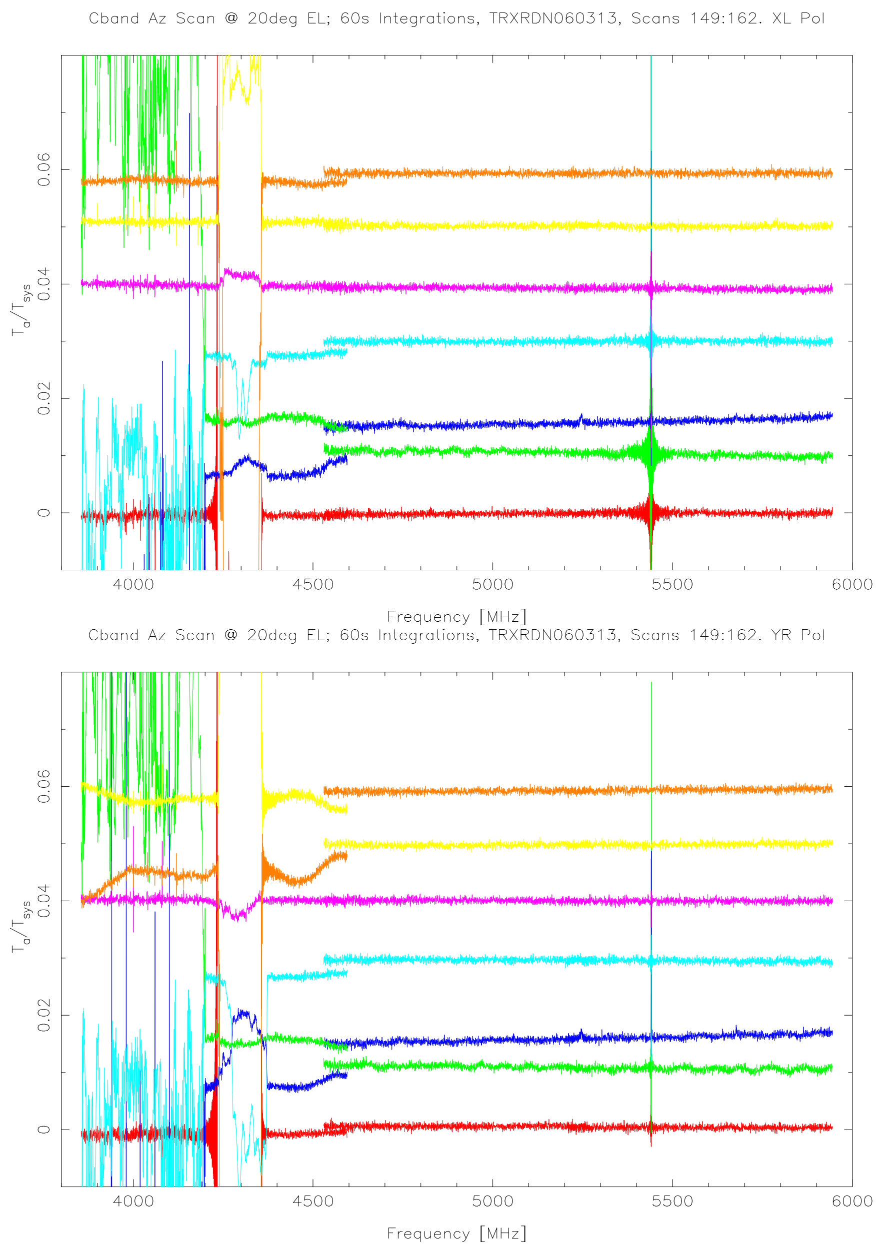

Figure 1: A series of spectral baselines for the two linear polarizations taken as the GBT slewed from 400 to 44 degrees azimuth. Each color trace represents the quantity $(Scan_i - Scan_{i+1})/Scan_{i+1}$ where i = 149, 151, 153, etc.

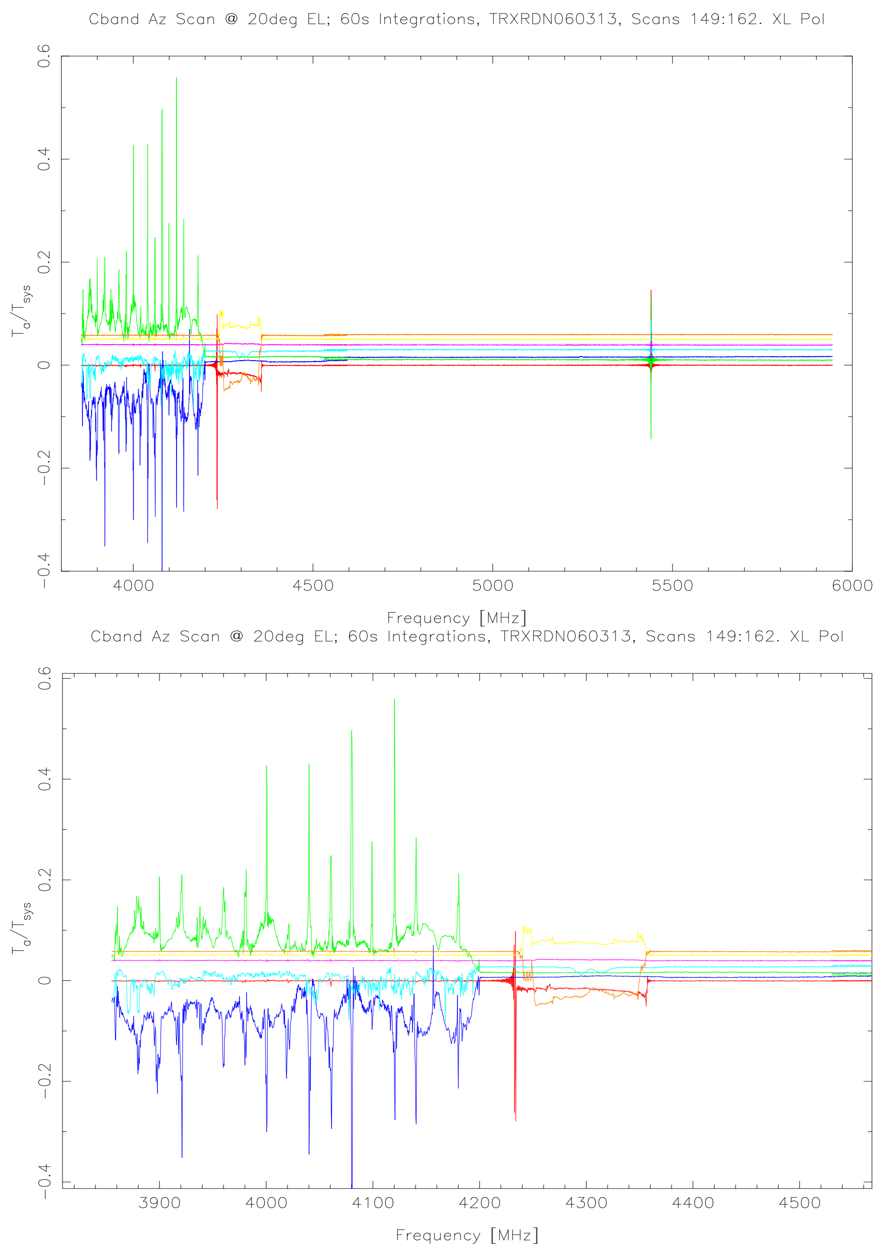

Figure 2: The upper trace is an expansion of the amplitude scale showing the extent of RFI changes during the pairs of 60 second scans. The lower trace is a zoom to the lower portion of the frequency range.

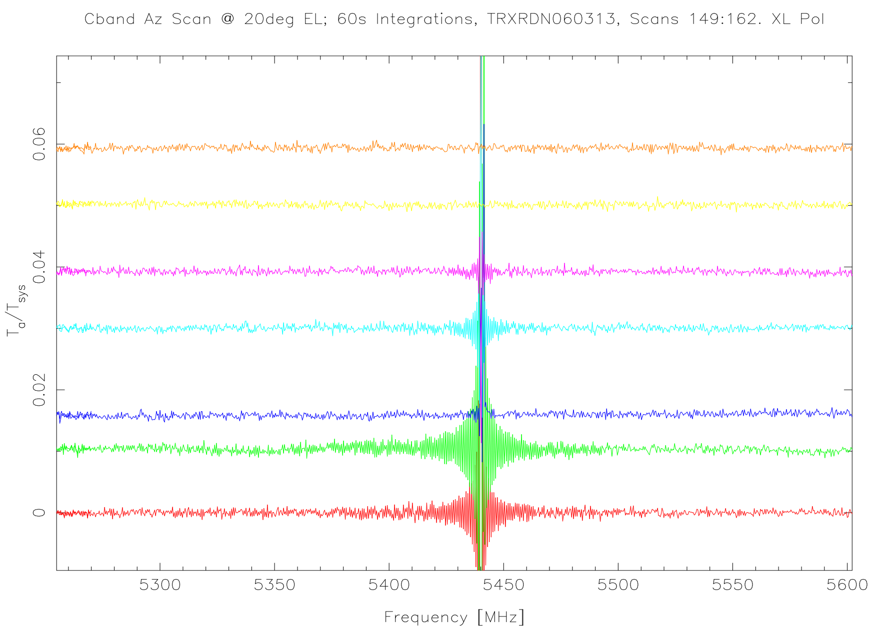

Figure 3: A zoom into the region around 5440 MHz.

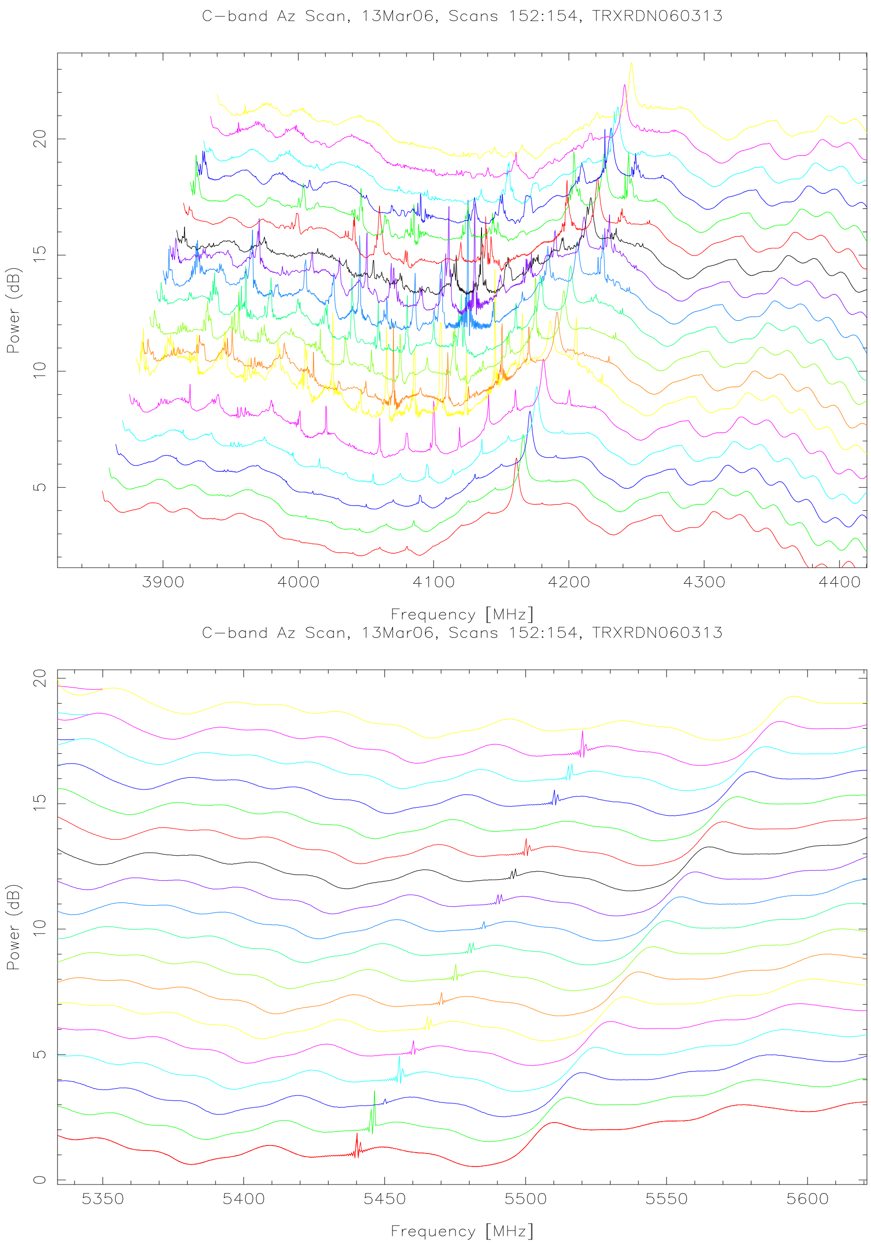

Figure 4: Raw spectra for part of the azimuth scan. Spectra are offset by 1dB in amplitude and 5MHz in frequency for clarity.