K-band (18–22 GHz) Continuum Source Spectra Project TBASEJRF030129, 29 January 2003

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Introduction

The baseline structure towards continuum sources was investigated using the lower section of the K-band (18–22 GHz) receiver. Both IF noise source and cold sky drift scan measurements were made to characterize the IF system and investigate the baseline structure on cold sky. The weather was overcast with temperatures around 30 F.

The spectrometer and DCR were running simultaneously during most of the observing. The receiver to spectrometer connection matrix is shown in Table 1. Each beam/polarization was fed to two different spectrometer samplers corresponding to different banks. The spectrometer was configured in four-bank mode with a bandwidth of 800 MHz and an integration time of 30 sec. The DCR channels 2, 4, 6, and 8 correspond to L1, R1, L2, and R2. Table 2 shows the DCR receiver/phase matrix represented in the FITS files. The IF rack and analog filter rack filters were set to 5360–6640 MHz and 800–1600 MHz, respectively. Beam switching between L1/L2 and R1/R2 was in effect although only the Sig phase has been used unless otherwise noted.

IF Noise Source

IF noise source spectra measured over a period of 20 minutes are summarized in Figures 1–4. Each Figure corresponds to a different optical fiber module (ODM)

Table 1: Receiver to Spectrometer Connection Matrix

Beam	ODM	CM	SF	AC Sampler	AC bank	AC channel
L1	2	1	1	0	A	1
L1	2	3	3	4	C	1
R1	4	5	5	1	A	2
R1	4	7	7	5	C	2
L2	6	10	2	2	B	1
L2	6	12	4	6	D	1
R2	8	14	6	3	B	2
R2	8	16	8	7	D	2

Table 2: DCR Receiver/Phase Matrix

Phase	Rcvr 1	Rcvr 2	Rcvr 3	Rcvr 4
1	L1 (sig/off)	R1 (sig/off)	L2 (sig/off)	R2 (sig/off)
2	L1 (sig/on)	R1 (sig/on)	L2 (sig/on)	R2 (sig/on)
3	L1 (ref/off)	R1 (ref/off)	L2 (ref/off)	R2 (ref/off)
4	L1 (ref/on)	R1 (ref/on)	L2 (ref/on)	R2 (ref/on)

and contains two series of curves for a different spectrometer channel. One series is offset by –0.01 for clarity. (Only three curves are plotted for spectrometer bank B since only 29 of 40 records were written to disk.) The total power level is quite stable over the 20 minute period and does not vary by more than 0.5%. For ODM 2 the series of plots connected to spectrometer sampler 0 show baseline structures with amplitudes of $\sim 0.5\%$ after 10 minutes which do not show up in spectrometer sampler 4. The 60 MHz ripple is present in some spectra.

Cold Sky

Observations towards cold sky over a period of 20 minutes were made with the antenna stationary and are summarized in Figures 5–8. Large-scale fluctuations in total power and with frequency are present in the first beam for both polarizations (L1 and R1). The same structures shows up in both spectrometer samplers for the same beam/polarization, indicating that the problem is probably in the front end. Similar measurements just two days earlier did not show such instabilities (see TBASEJRF030127). Spectra from beams L2 and R2 are much more stable and show total power drifts up to a few percent over 20 minutes that are probably related to fluctuations in the sky. After about 10–15 minutes there does appear to be some baseline structures which varies smoothly with frequency. The 60 MHz ripple shows up in some spectra.

The instabilities in the first beam can be seen in the continuum total power from the DCR. Figure 9 plots the system temperature for each beam/polarization for both the Sig phase (top panel) and the Ref phase (bottom panel). Further investigation is required.

Continuum Source Spectra

Three consecutive 5 minute, on-off pairs were made towards the continuum source 3C123 ($\sim$ 10% of the system temperature) and one on-off pair towards 3C274 ($\sim$ 25% of the system temperature).

Figure 10 plots the system temperature, in units of the CAL, for one of the 5 minute OFF scans. The beam/polarizations consists of L1 (red), L2 (orange), R1 (green), and R2 (green/blue). Each beam/polarization has two curves corresponding to two different spectrometer channels (see Table 1). At least some of the structure in the system temperature appears to come from frequency structure in the CAL (see Figure 11).

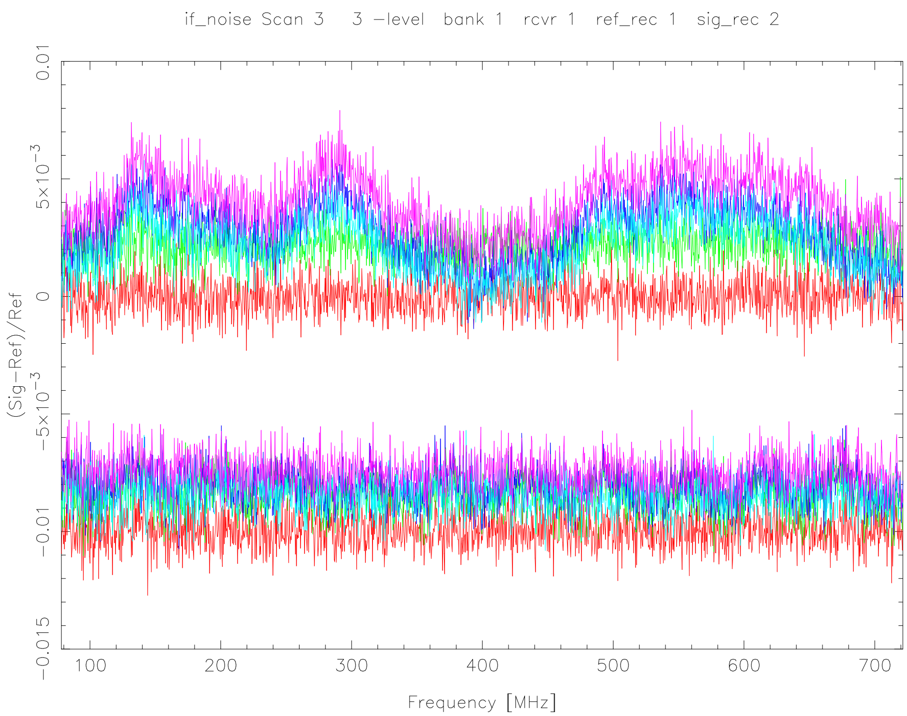


Figure 1: IF noise source spectra for ODM 2. (Record N–Record 1)/ Record 1 is plotted where N = 2 (red), 10 (green), 20 (blue), 30 (green/blue), and 40 (red/blue). The top series of plots is for spectrometer sampler 0, while the bottom series of plots, offset by −0.01, is for spectrometer sampler 4.

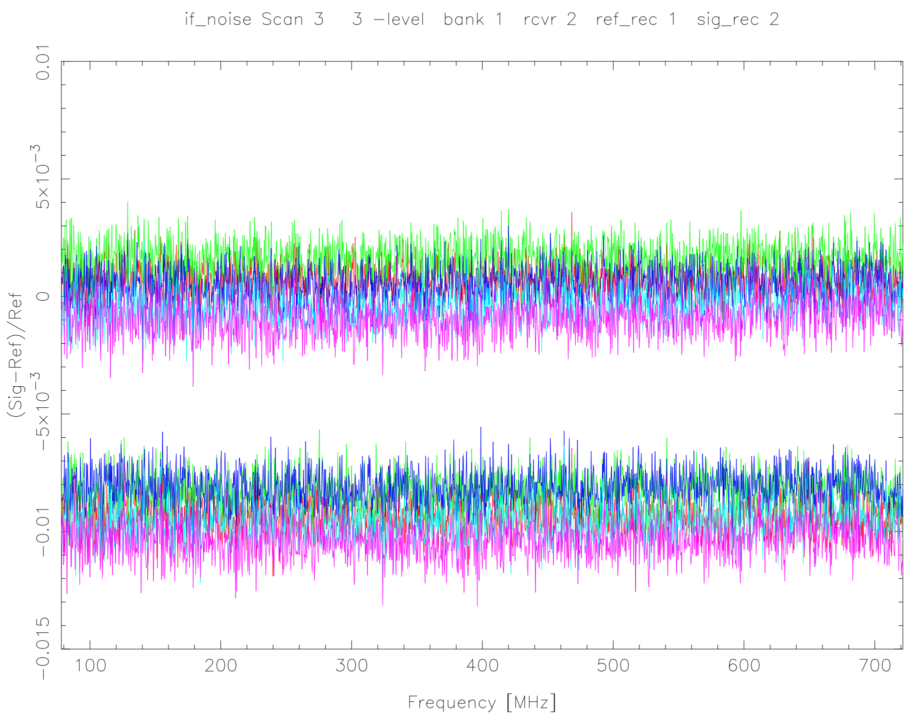


Figure 2: IF noise source spectra for ODM 4. (Record N–Record 1)/ Record 1 is plotted where N = 2 (red), 10 (green), 20 (blue), 30 (green/blue), and 40 (red/blue). The top series of plots is for spectrometer sampler 1, while the bottom series of plots, offset by −0.01, is for spectrometer sampler 5.

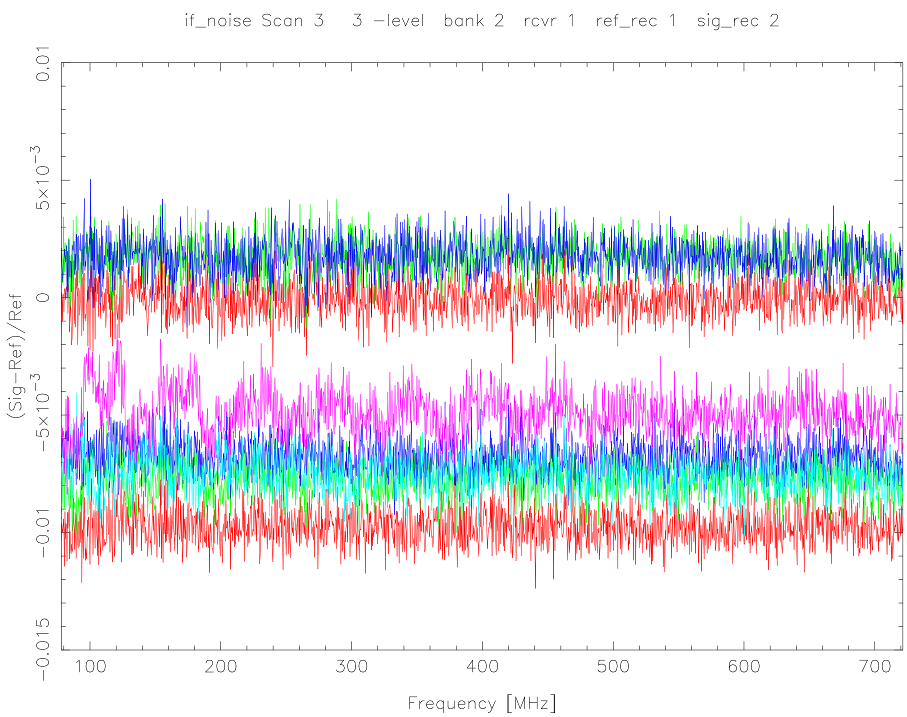


Figure 3: IF noise source spectra for ODM 6. (Record N–Record 1)/ Record 1 is plotted where N = 2 (red), 10 (green), 20 (blue), 30 (green/blue), and 40 (red/blue). The top series of plots is for spectrometer sampler 2, while the bottom series of plots, offset by −0.01, is for spectrometer sampler 6. Note: only 29 records were recorded for Bank B.

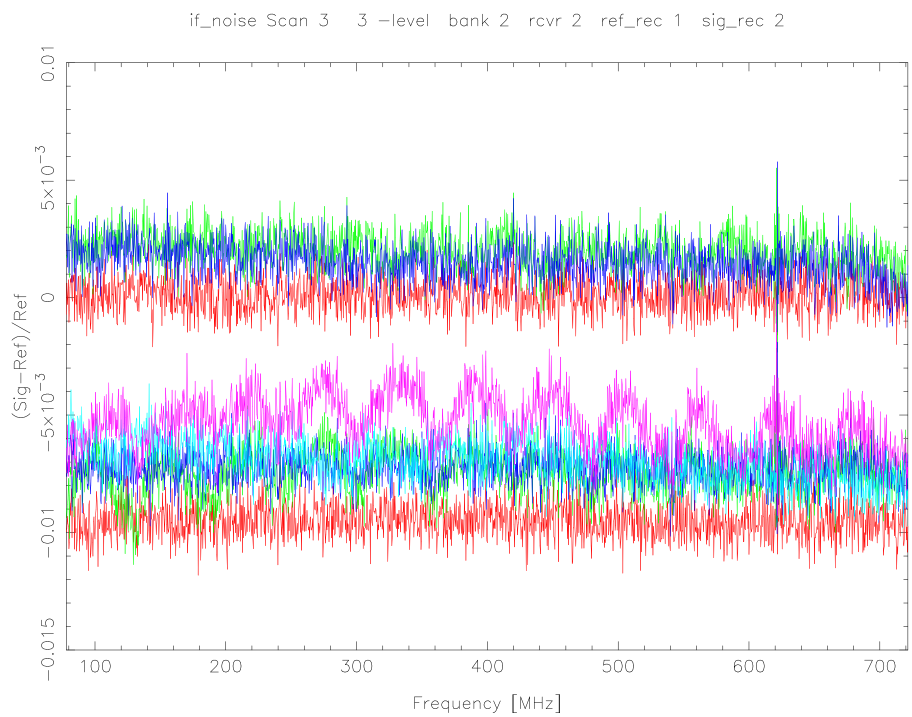


Figure 4: IF noise source spectra for ODM 8. (Record N–Record 1)/ Record 1 is plotted where N = 2 (red), 10 (green), 20 (blue), 30 (green/blue), and 40 (red/blue). The top series of plots is for spectrometer sampler 3, while the bottom series of plots, offset by −0.01, is for spectrometer sampler 7. Note: only 29 records were recorded for Bank B.

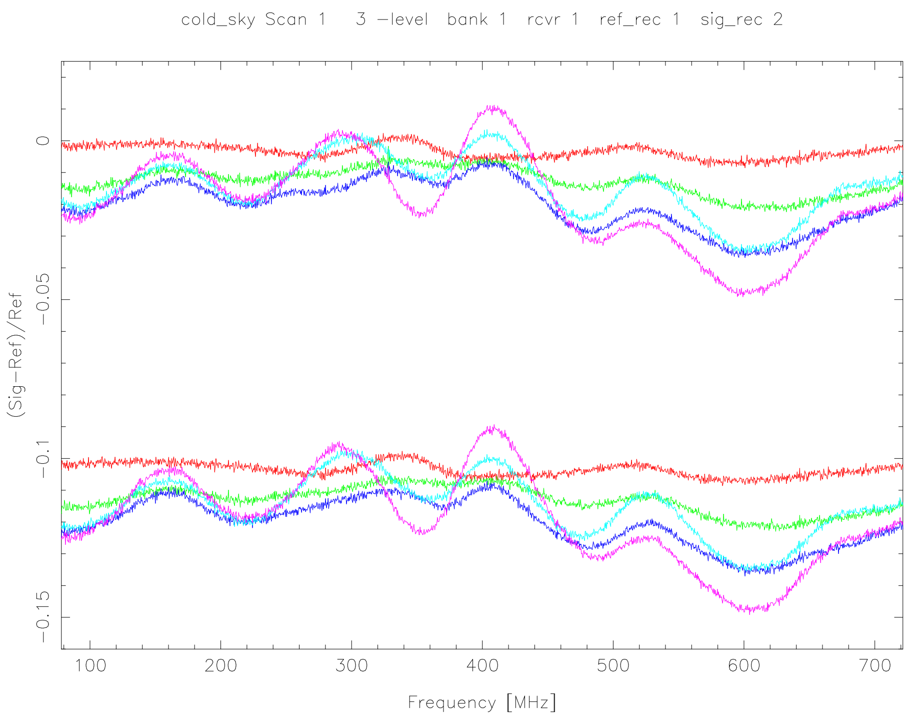


Figure 5: Cold sky spectra for K-band beam L1. (Record N–Record 1)/ Record 1 is plotted where N = 2 (red), 10 (green), 20 (blue), 30 (green/blue), and 40 (red/blue). The top series of plots is for spectrometer sampler 0, while the bottom series of plots, offset by −0.1, is for spectrometer sampler 4.

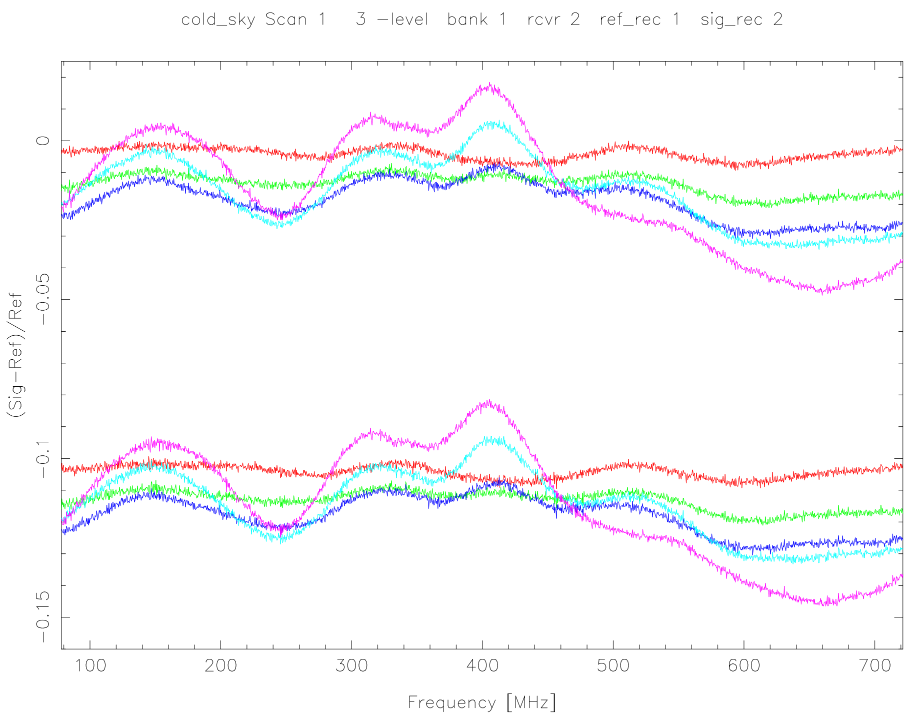


Figure 6: Cold sky spectra for K-band beam R1. (Record N–Record 1)/ Record 1 is plotted where N = 2 (red), 10 (green), 20 (blue), 30 (green/blue), and 40 (red/blue). The top series of plots is for spectrometer sampler 1, while the bottom series of plots, offset by –0.1, is for spectrometer sampler 5.

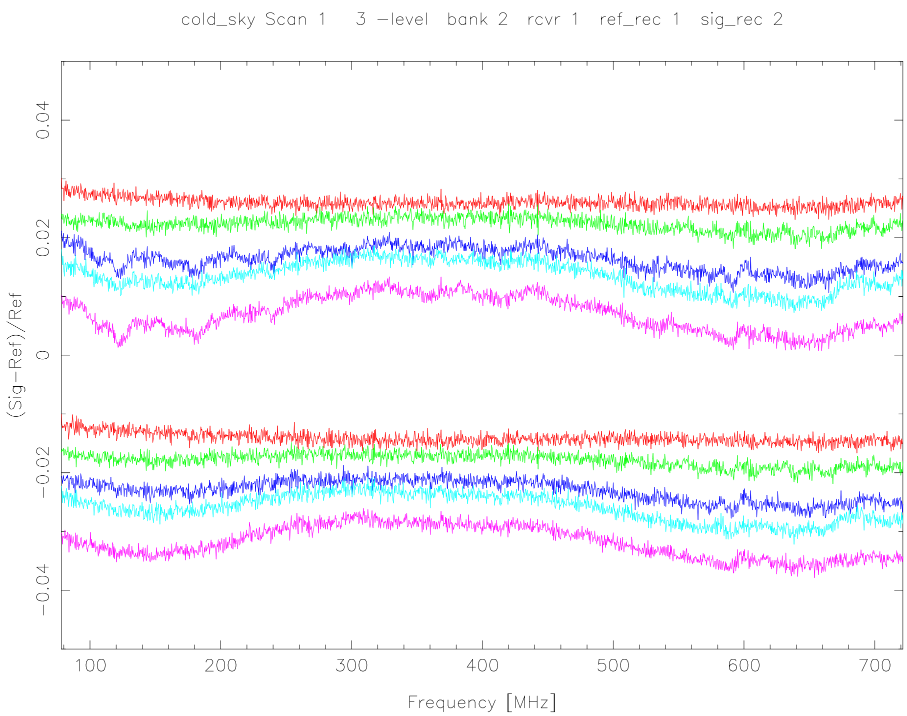


Figure 7: Cold sky spectra for K-band beam L2. (Record N–Record 1)/ Record 1 is plotted where N = 2 (red), 10 (green), 20 (blue), 30 (green/blue), and 40 (red/blue). The bottom series of plots is for spectrometer sampler 2, while the top series of plots, offset by 0.04, is for spectrometer sampler 6.

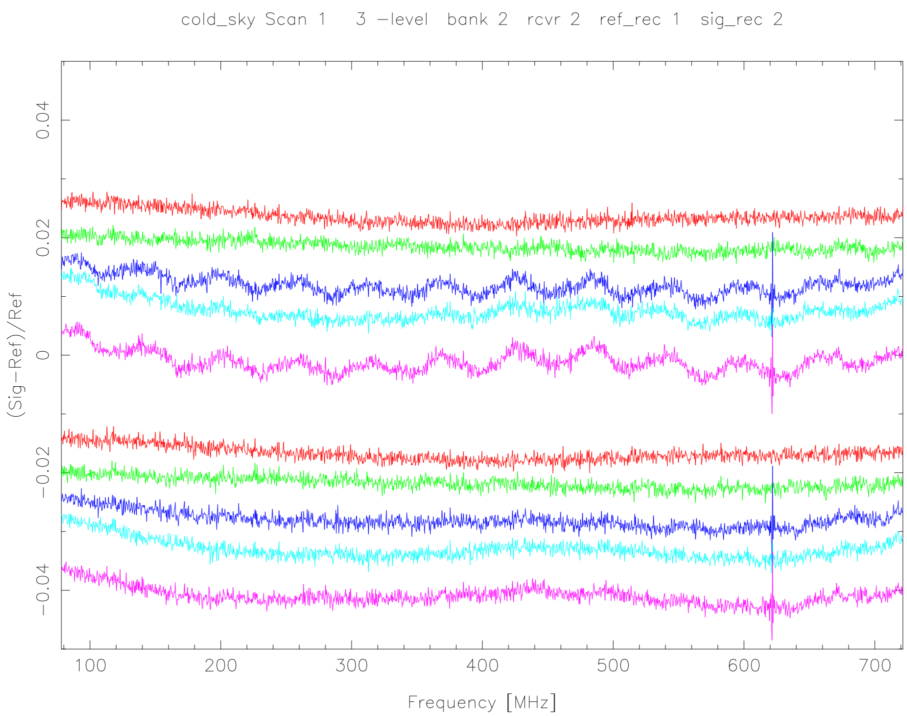


Figure 8: Cold sky spectra for K-band beam R2. (Record N–Record 1)/ Record 1 is plotted where N = 2 (red), 10 (green), 20 (blue), 30 (green/blue), and 40 (red/blue). The bottom series of plots is for spectrometer sampler 3, while the top series of plots, offset by 0.04, is for spectrometer sampler 7.

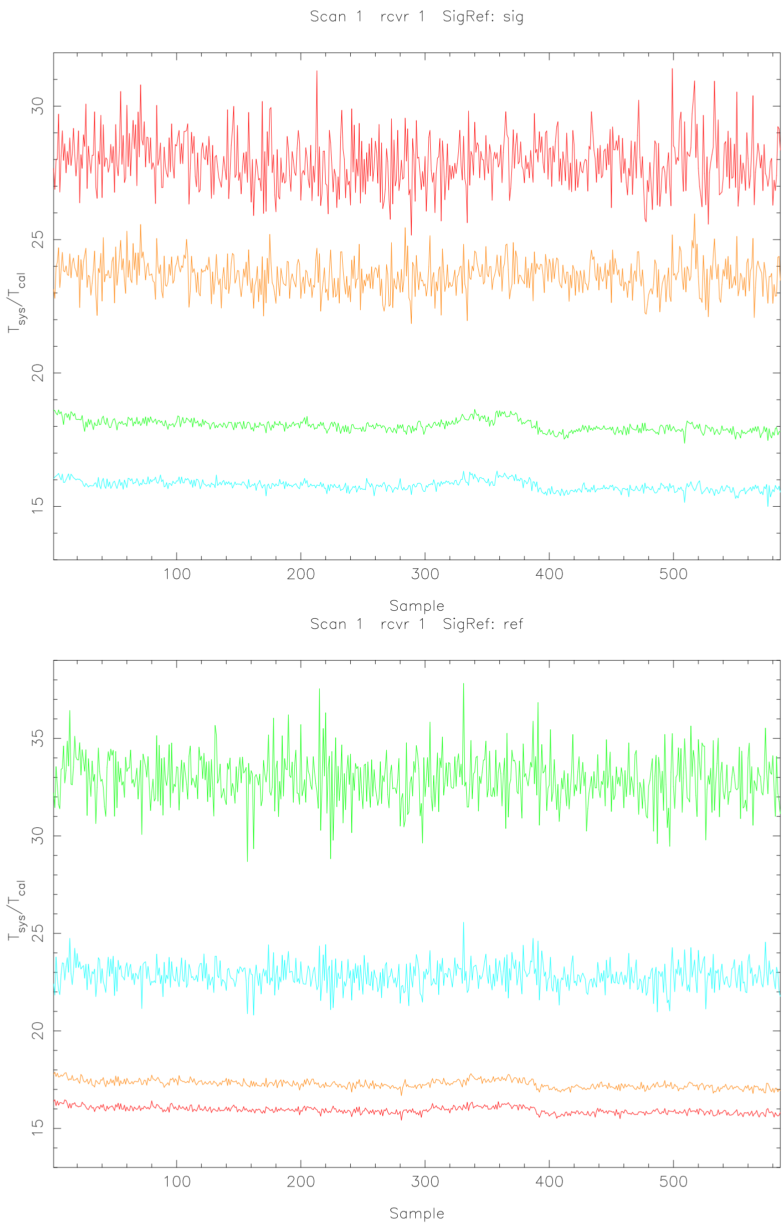


Figure 9: System temperature (in units of the CAL) towards cold sky with the DCR. The plot spans a total time of 20 minutes where each sample is 2 seconds. Plotted are L1 (red), R1 (orange), L2 (green), and R2 (green/blue). The top panel shows the Sig phase while the bottom panel shows the Ref phase.

The antenna temperature for each on-off pair towards 3C123 is shown in Figure 12 for L2 and Figure 13 for R2. (Only the second beam is shown because of the instability problems with the first beam). There are similarities in the spectra between different on-off pair and different spectrometer channels for the same beam/polarization. Small-scale frequency structure exists in all spectra, especially for R2. A closer look at on-off (48,49) for beam R2 is shown in Figure 14. Here every two records (one minute) are plotted. Notice that the phase of the ripple changes with time. The Fourier transform detects a broad feature at $\sim$ 30 MHz (Figure 15). There is also a weaker feature around 60 MHz.

Figure 16 plots the ratio of two spectra from beam R2 (on-off 48,49) which are sent to spectrometer samplers 3 and 7. The 60 MHz ripple is very prominent. The ratio of two different on-off scan pairs for the beam R2 is shown in Figure 17. The ratio of on-off (46,47) to (48,49) is calculated. In this case the $\sim$ 30 MHz ripple is stronger although the 60 MHz feature is detected in the Fourier transform. These features are probably in part coming from the IF system.

Figure 18 plots the antenna temperature for the single 5 minute on-off pair towards 3C274. Although the basic broad baseline shape is similar there are detailed differences in the spectra for the same beam. Note: the two curves in each panel correspond to different IF paths and spectrometer channels. A comparison of the baseline structure with different continuum source intensities is shown in Figure 19. The ratio of the spectrum for 3C123 to 3C274 is plotted for beam R2. Small-scale frequency structures between 30–70 MHz are detected. It is difficult to interpret how much of this structure resides in the IF system compared with effects upstream of the first mixer.

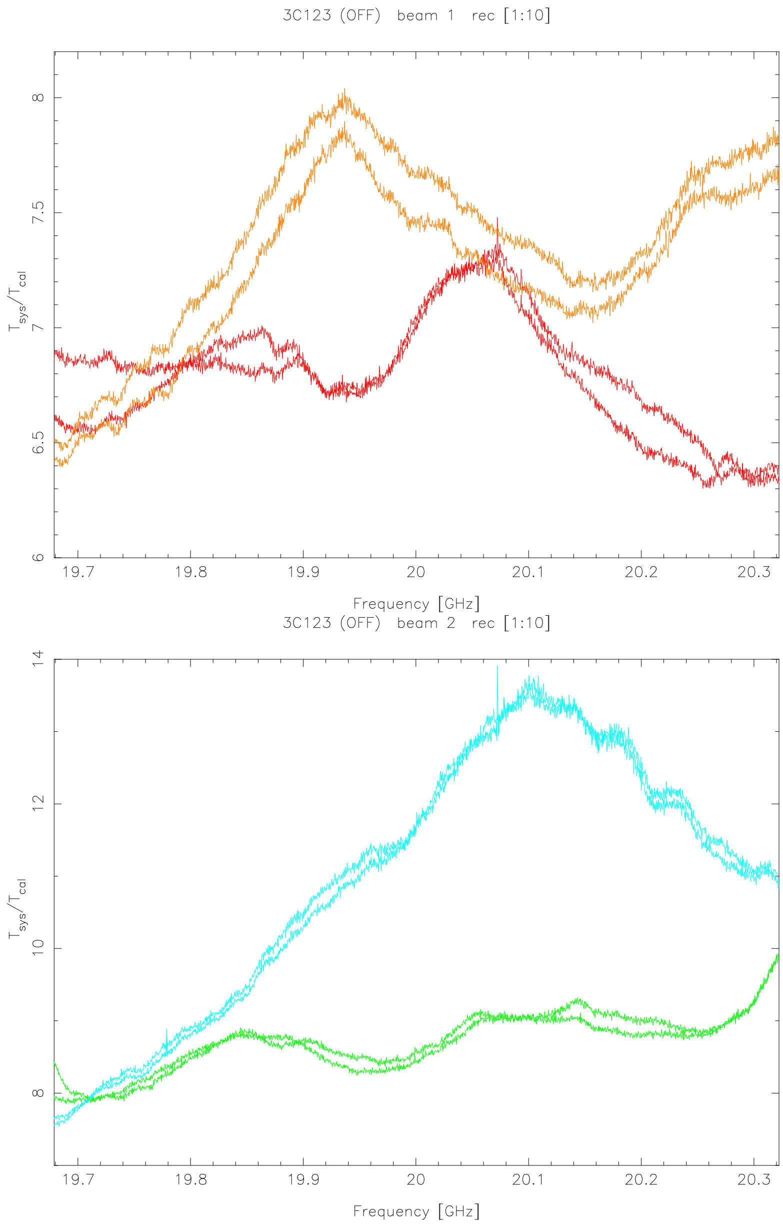


Figure 10: System temperature towards cold sky for scan 45 (the OFF postion for an on-off towards 3C123). Upper panel: The first beam/feed consisting of L1 (red); L2 (orange). Lower panel: The second beam/feed consisting of R1 (green); R2 (green/blue). The two curves for each color correspond to the two different spectrometer channels (see Table 1).

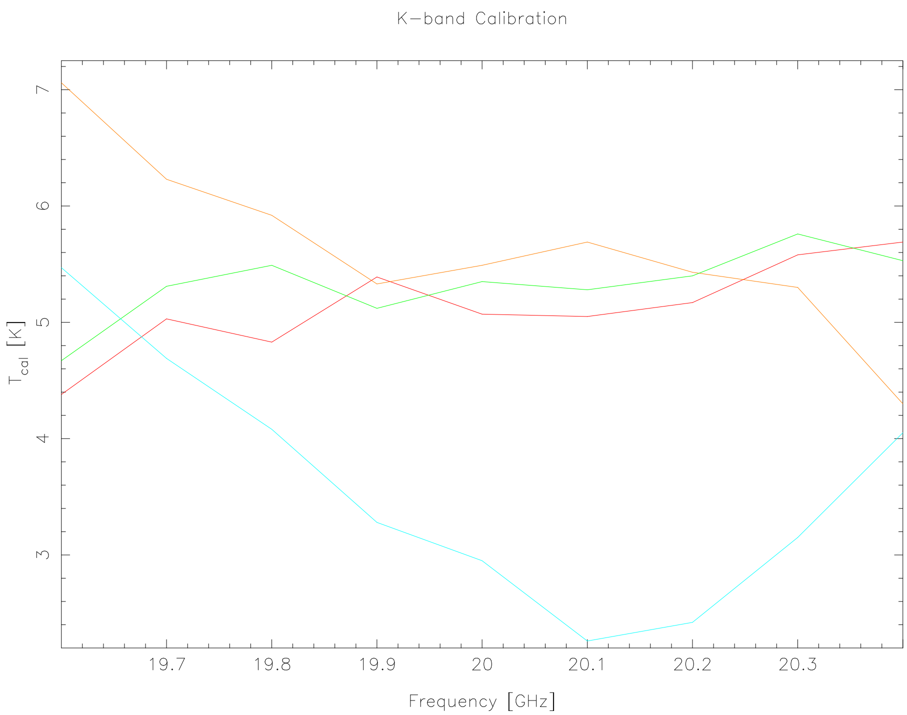
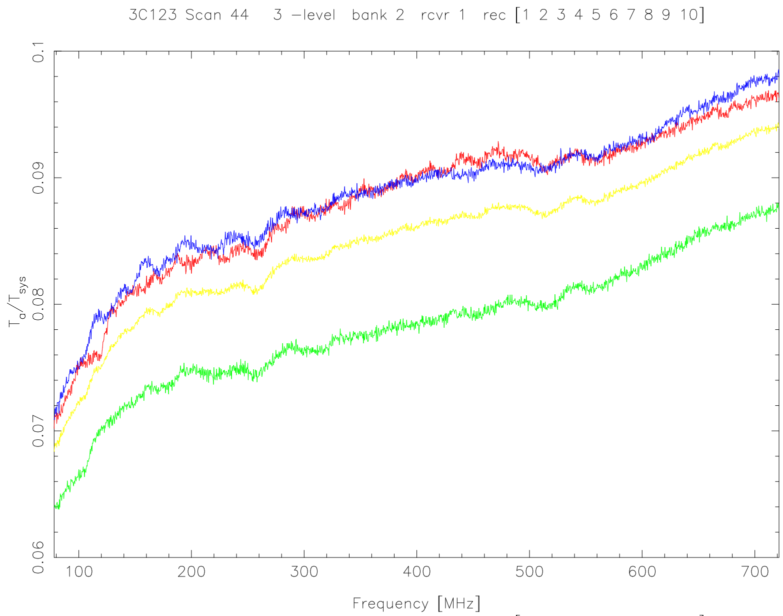


Figure 11: The intensity scale for the calibration noise diode (CAL) versus frequency. The data were taken in the lab using the hot/cold load method on 4 November 2002. Only the lower section of K-band is plotted consisting of L1 (red), R1 (orange), L2 (green), and R2 (green/blue).



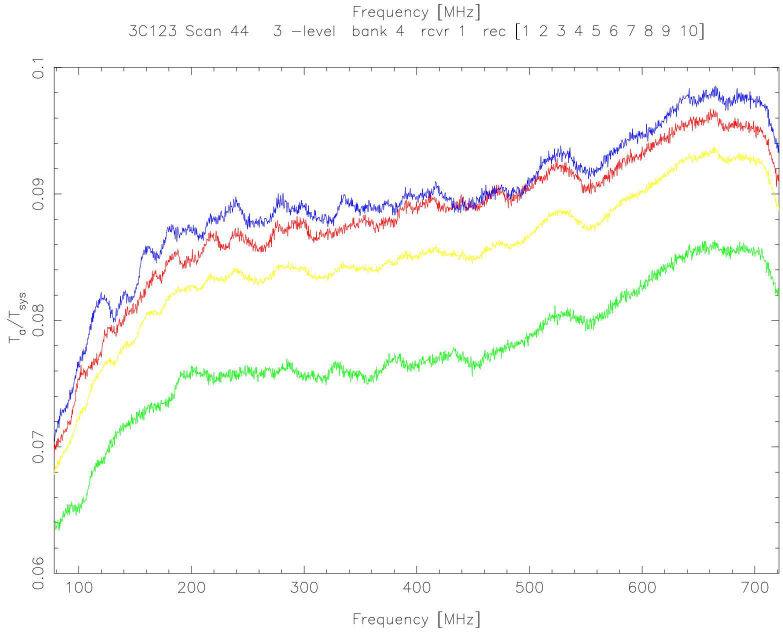


Figure 12: The antenna temperature (in units of the system temperature) towards 3C123 in beam L2. The red, green, and blue curves correspond to three consecutive on-off pairs (scans 44–49) centered at a frequency of 20 GHz, with an integration time of 5 minutes. The yellow curve is an average over the three on-off pairs. Top panel: Spectra for spectrometer sampler 2. Bottom panel: Spectra for spectrometer sampler 6.

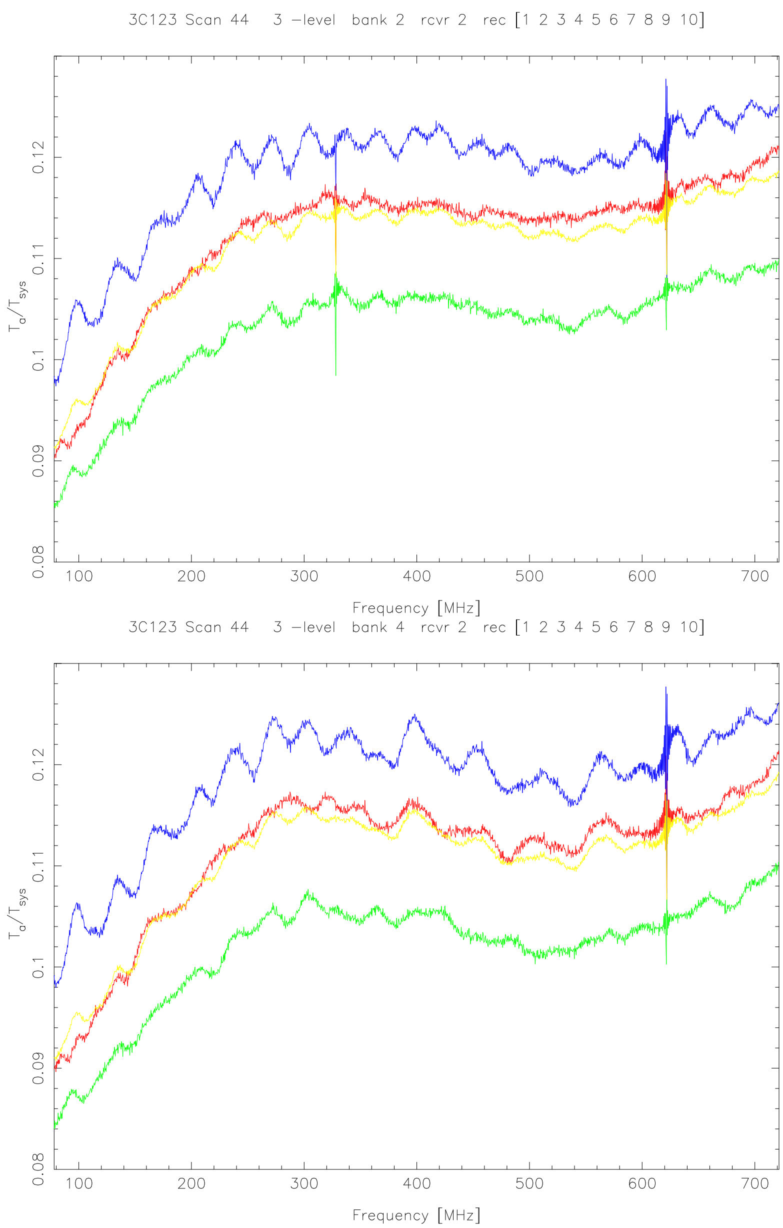


Figure 13: The antenna temperature (in units of the system temperature) towards 3C123 in beam R2. The red, green, and blue curves correspond to three consecutive on-off pairs (scans 44–49) centered at a frequency of 20 GHz, with an integration time of 5 minutes. The yellow curve is an average over the three on-off pairs. Top panel: Spectra for spectrometer sampler 3. Bottom panel: Spectra for spectrometer sampler 7.

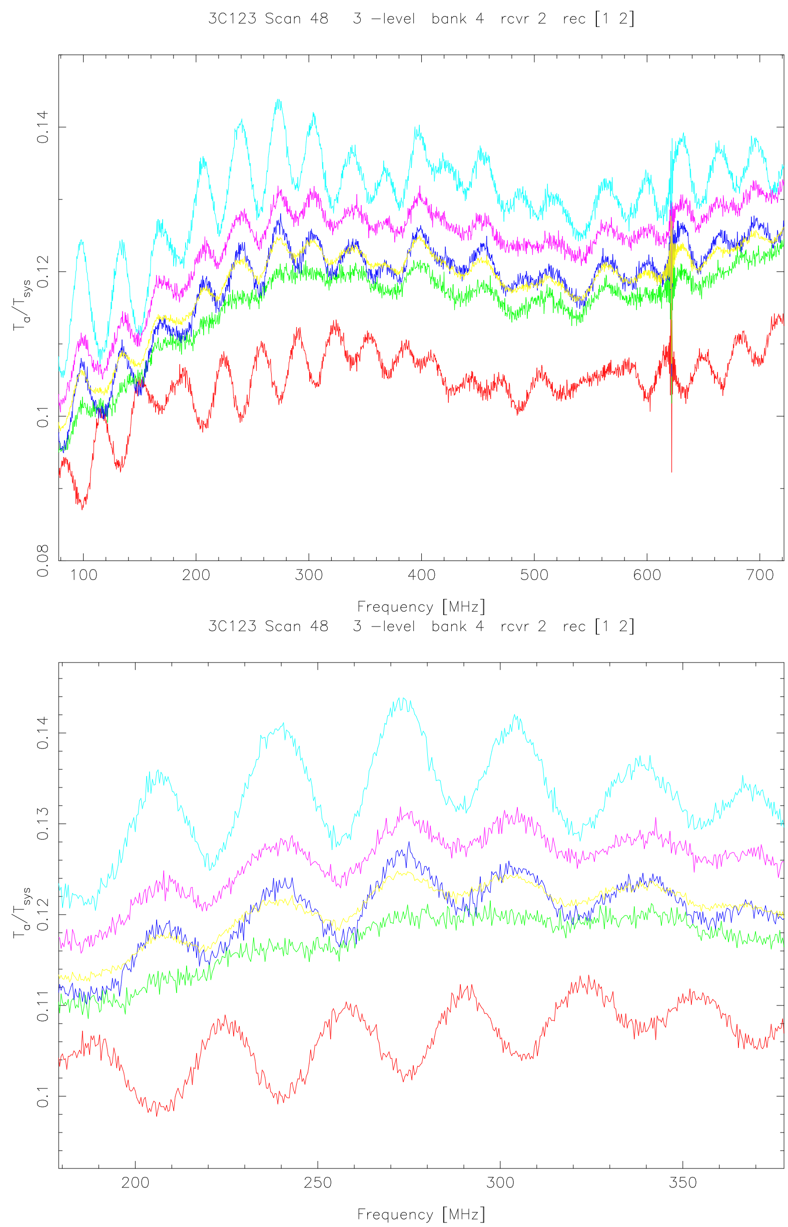


Figure 14: The antenna temperature (in units of the system temperature) towards 3C123 in beam R2 for the on-off pair of scans (48,49). Consecutive one minute records are shown as red, green, blue, green-blue, and red-blue. The yellow curve is an average over all records. The lower panel showns an expanded view.

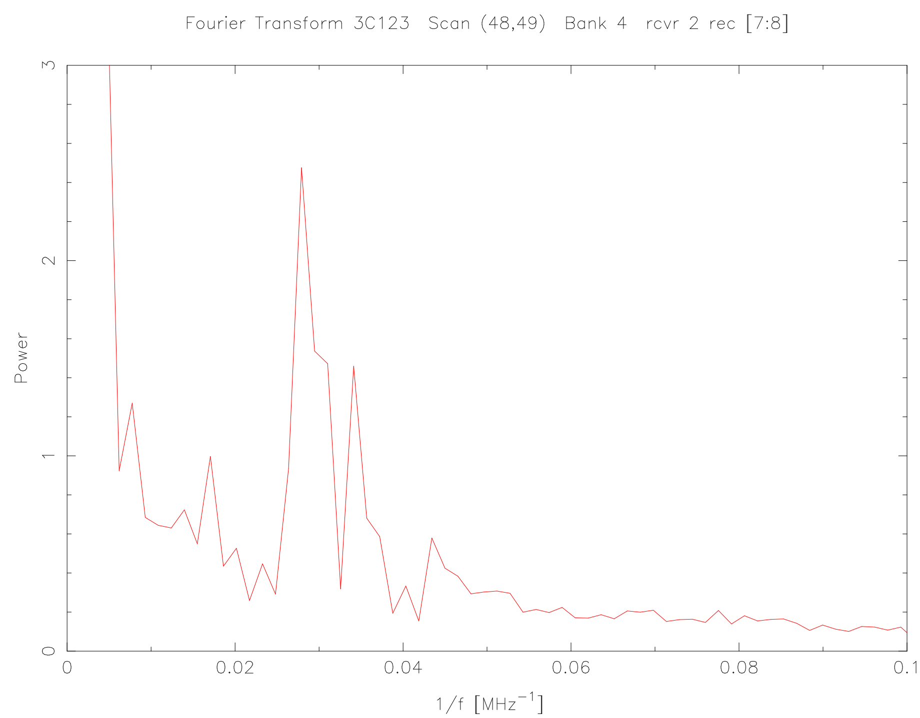


Figure 15: Fourier transform of the spectrum in Figure 14 for records [7,8] (green/blue curve).

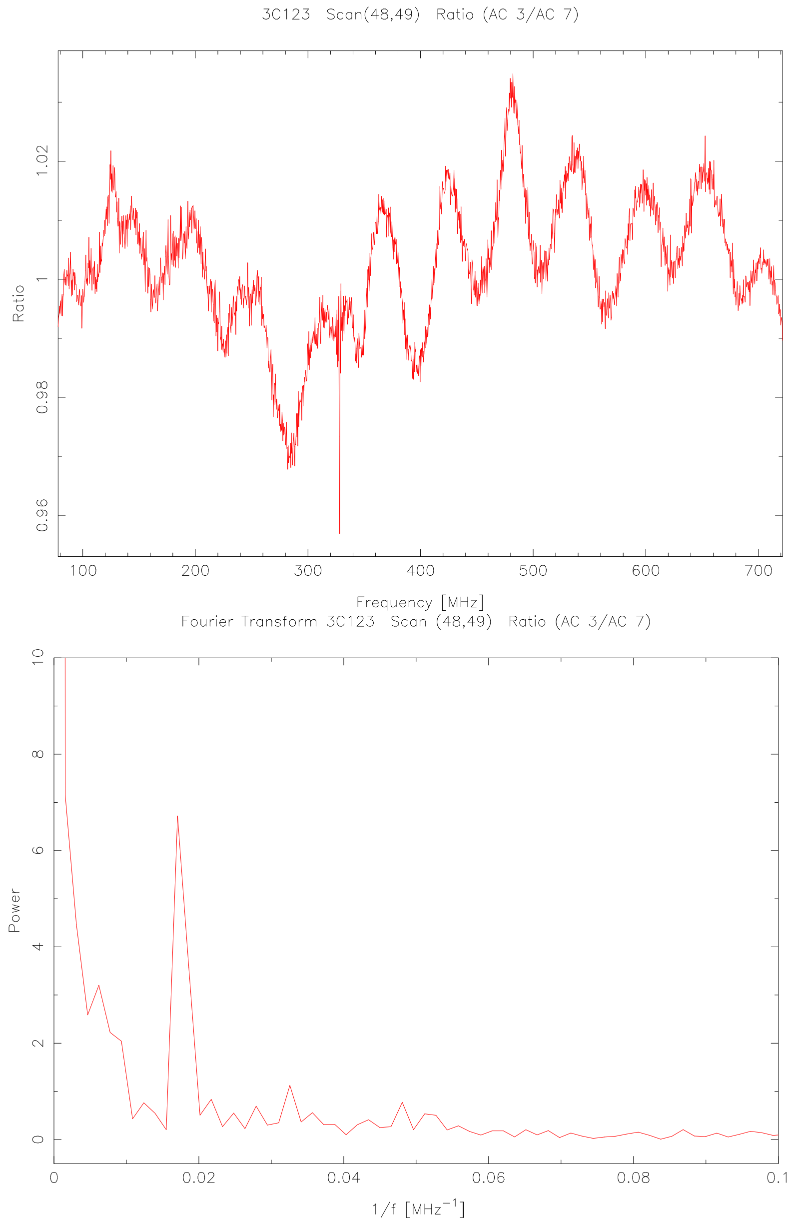


Figure 16: Top panel: Ratio of the on-off pair (48,49) for beam R2 in Figure 13. The spectrometer sampler 3 spectrum is divided by the spectrometer sampler 7 spectrum. Bottom panel: Fourier transform of the spectrum in the top panel.

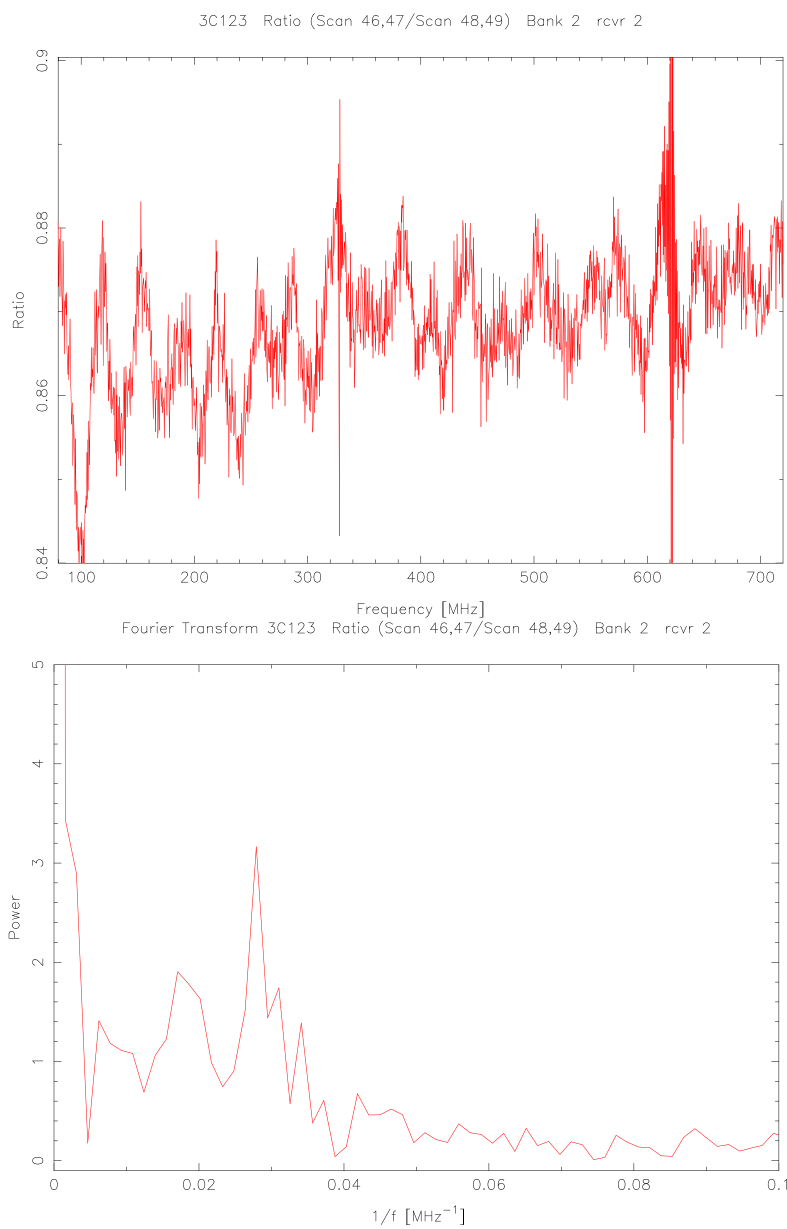


Figure 17: Top panel: Ratio of on-off (46,47) to (48,49) for beam R2 in Figure 13. Bottom panel: Fourier transform of the spectrum in the top panel.

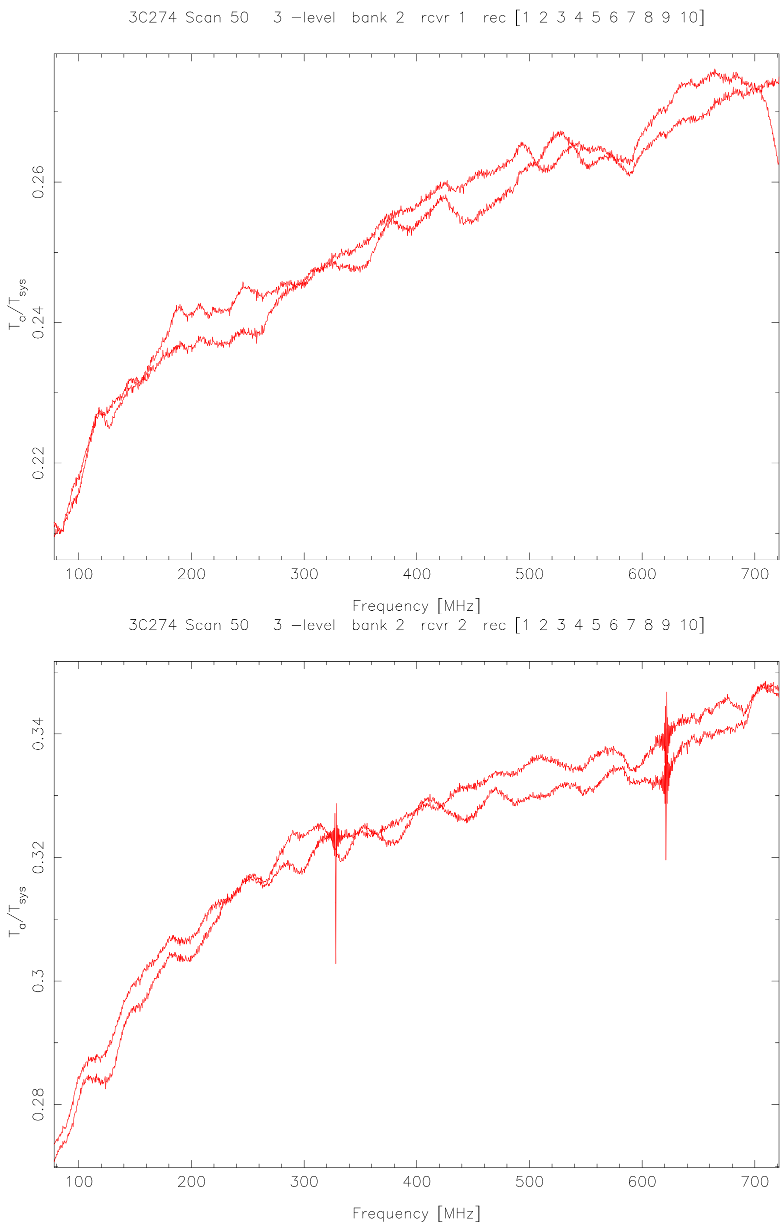


Figure 18: The antenna temperature (in units of the system temperature) towards 3C274 in beam L2 (top panel) and beam R2 (bottom panel) for the 5 minute on-off pair of scans (50,51). The two curves correspond to different spectrometer channels.

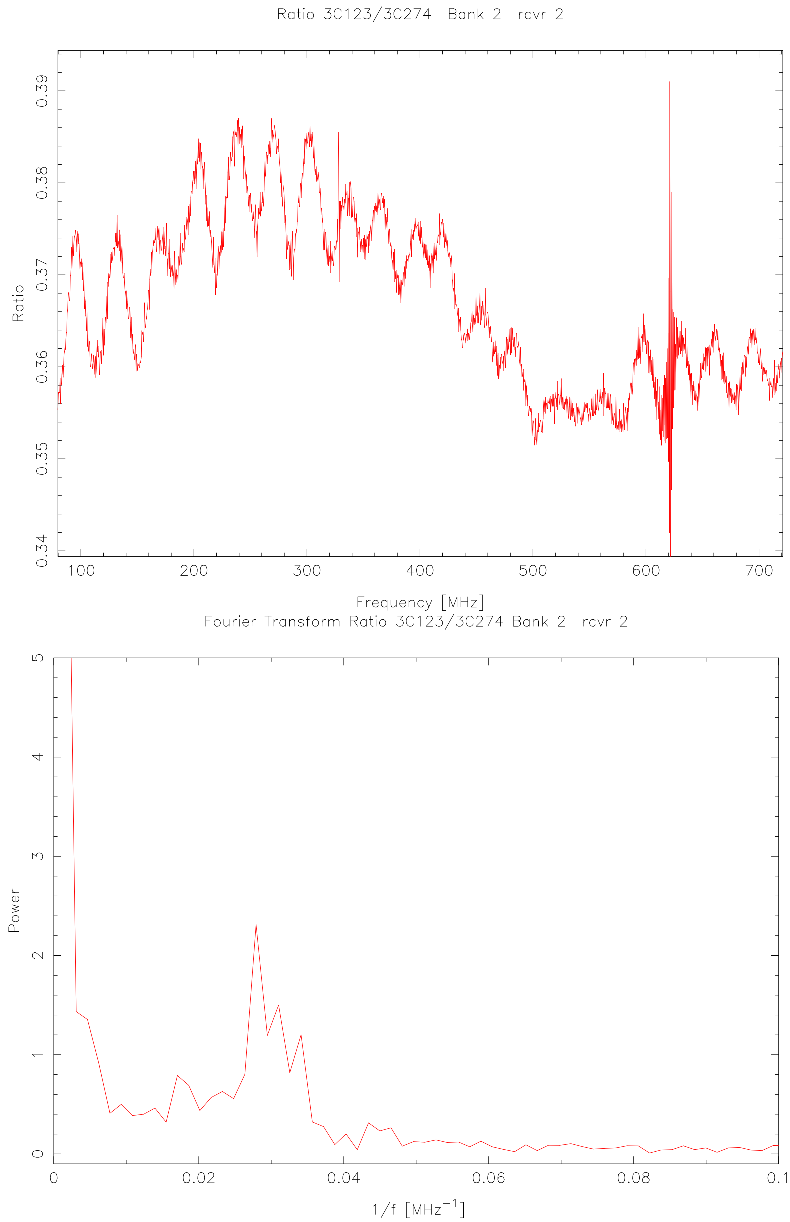


Figure 19: Top panel: Ratio of the on-off spectrum of 3C124 (scans 48,49) to the on-off spectrum of 3C274 (scans 50,51) for R2. Bottom panel: Fourier transform of the spectrum in the top panel.