Survey of X-band (8-10 GHz) receiver with the new InP LNAs
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Setup

The goal was to investigate the baseline structure of the X-band receiver with the new (interim) InP low noise amplifiers (LNAs). The old amplifiers were GaAs LNAs (XL13 for LCP and XL10 for RCP). The new amplifers are InP 3-13 GHz LNAs (number 27 for LCP and number 26 for RCP).

The signal path consisted of channel 1 (RCP) and channel 2 (LCP) connected to optical driver modules (ODMs) 5 and 8, converter modules 9 and 13, and sampler filters 1 and 5, respectively. ODM 5 was used instead of 6 because we were unable to get enough power to properly balance the spectrometer. The IF rack filters were 2360-3540 MHz and the analog filter rack filters 800-1600 MHz. The spectrometer was configured with two samplers (0 and 1), a bandwidth of 800 MHz, 2048 channels ($\Delta\nu$ = 391 kHz), and an integration time of 30 sec (1W2-001-800).

IF Noise Source

The IF noise source was used to test the stabiltiy of the IF system. Figure 1 plots (Record N - Record 1)/Record 1 for N = 2, 10, 20, 30, and 39. The gain drifts very smoothly with time by about 1.5% of the system temperature after 20 minutes. But after 10 minutes there is some smoothly varying frequency structure. The antenna was staitionary during the observations.

Cold Sky

The same experiment was performed on cold sky with the antenna staitionary (see Figure 2). After 20 minutes the large-scale frequency structure is flatter than for the IF nosie source; although there is some small-scale frequency structure present. The gain fluctuates more over shorter time-scales (5-7 minutes), although this may be due to variations in the sky at X-band or possibly the temperature fluctuations observed in the equiptment room.

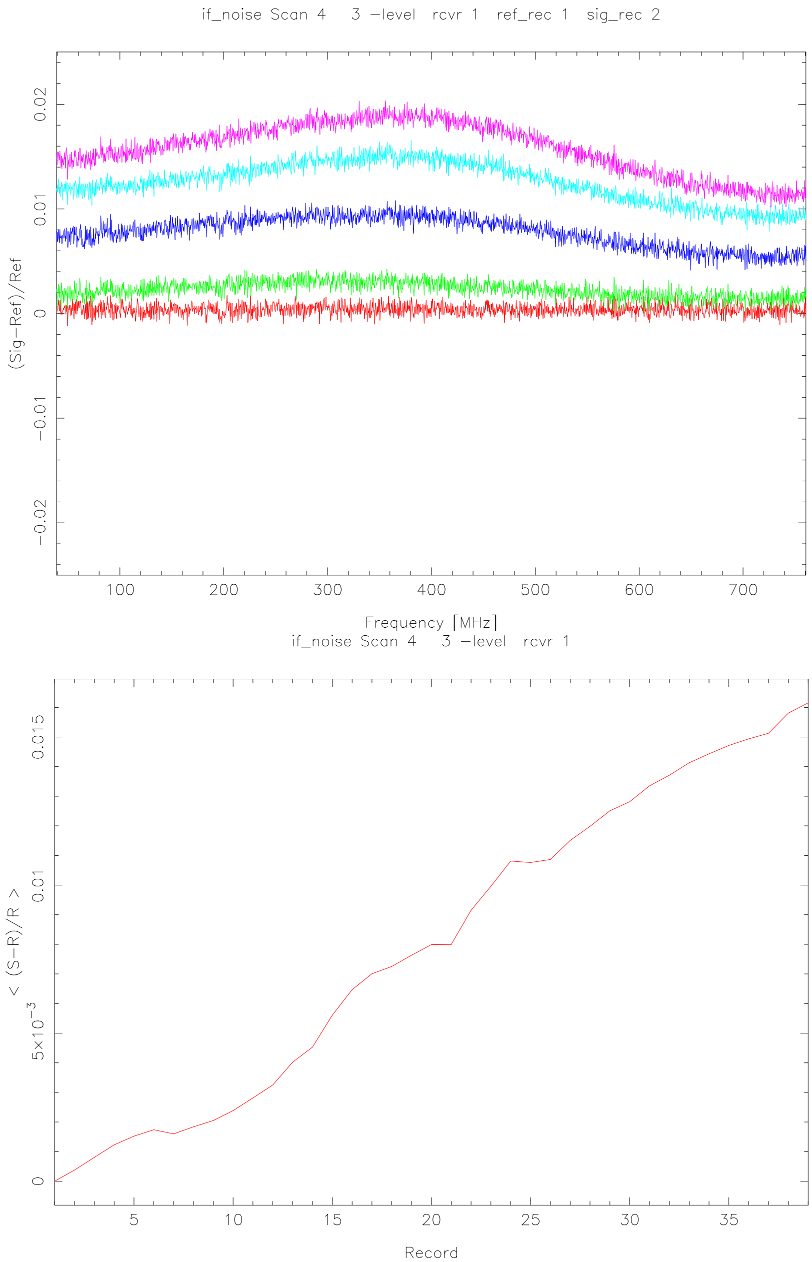


Figure 1: Project TBASEDSB030103, scan 4. Upper panel: IF noise source spectra plotting (Record N - Record 1)/Record 1 where N = 2 (red), 10 (green), 20 (blue), 30 (green/blue), and 39 (red/blue). Each record corresponds to 30 sec. Lower panel: Averaged spectrum over the inner 80% of the spectrum versus record. The antenna was stationary during the observations. The IF center frequency was 3000 MHz.

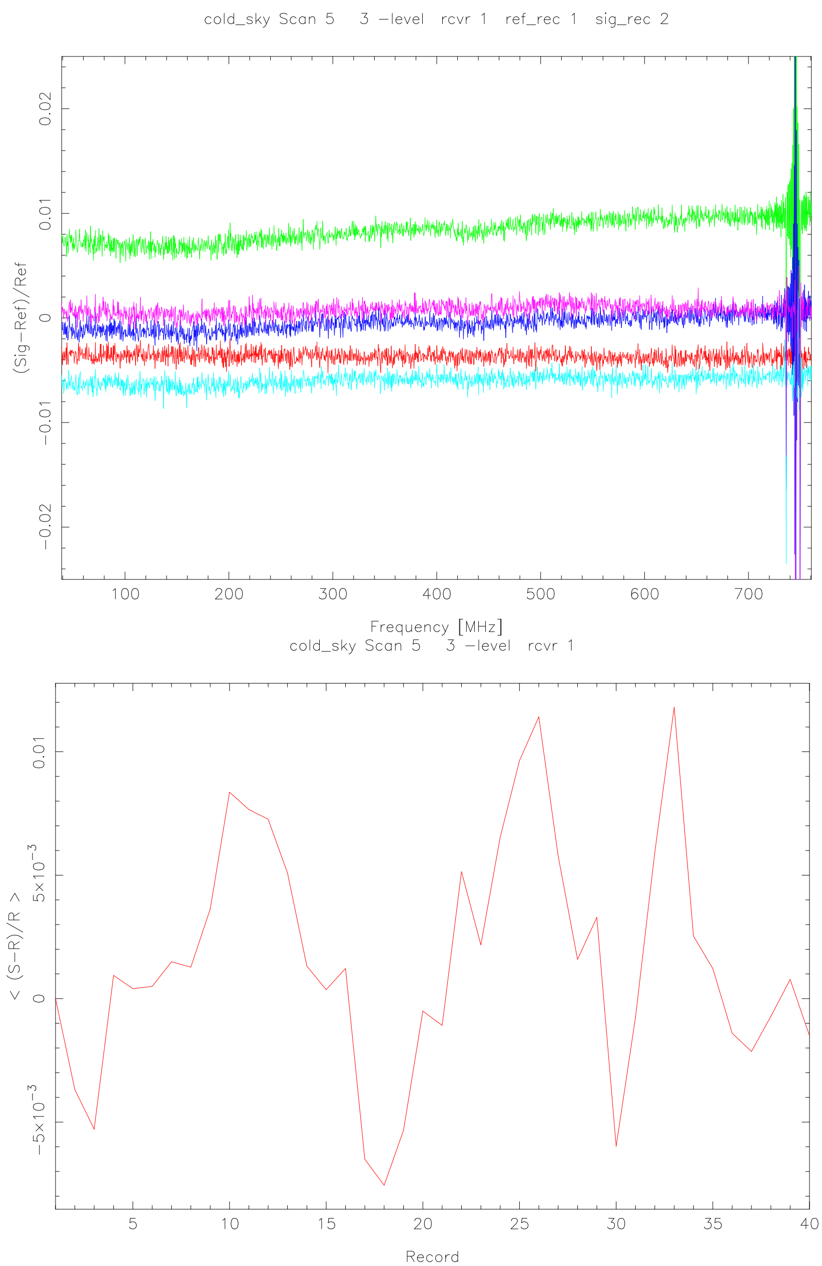


Figure 2: Project TBASEDSB030103, scan 5. Upper panel: Cold sky spectra plotting (Record N - Record 1)/Record 1 where N = 2 (red), 10 (green), 20 (blue), 30 (green/blue), and 39 (red/blue). Each record corresponds to 30 sec. Lower panel: Averaged spectrum over the inner 80% of the spectrum versus record. The antenna was stationary during the observations. The center sky frequency was 9000 MHz.

Sub-reflector Offsets

The sub-reflector was offset $+\lambda/4$ and $+\lambda/8$ to probe reflections in the optics which produce frequency baseline structure. Figure 3 plots the on-off spectrrum towards cold sky where the "on" scan was taken with the Y (axial) focus offset $+\lambda/4$ and the "off" scan was taken with the nominal focus. Figure 4 shows the Fourier transform plotted versus 1/f and the delay path. The delay path in meters equals $300 * 1/f[\mathrm{MHz}^{-1}]$. Signals are detected at 9.1, 29, 54, and 196 MHz corresponding to a delay path of 33, 10, 5.5, and 1.5 meters, respectively.

The same data is plotted for a Y focus offset of $+\lambda/8$ in Figures 5 and 6. The results are similar but the signals in the the Fourier transform plot are all relatively much weaker in the $+\lambda/8$ data then for the $+\lambda/4$ case, indicating that they correspond to a single reflection. It is not clear what is causing the smaller delay paths. Figure 7 plots the Fourier transform for the on-off spectrum consisting of the two cold sky scans 26 and 28 which both had the nominal Y focus. These scans were not part of an on-off pair and the system temperatures are different by 0.7%. Nonetheless, the Fourier transform shows similar features.

Continuum Source Spectra (3C48)

On-off spectra were taken towards 3C48 to probe the baseline structure towards a continuum source. 3C48 has a flux density of 3.4 Jy at 8 GHz. The system temperature in units of the CAL is shown in Figure 8. For both the on and off spectra there is large-scale structure with a period of 280 MHz with a peak-to-peak amplitude of 5% of the system temperature and small-scale structure with a period of 23 MHz with a peak-to-peak amplitude of 1% of the system temperature. The $T_{\mathrm{source}}/T_{\mathrm{sys}}$ data are shown in Figure 9. There appears to be irregular spectral baseline structure on several different scales. The Fourier transform, shown in Figure 10, does not show any strong signals below 50 MHz and may be dominated by the large baseline features between 500-700 MHz. These features appear to be similar to the OMT reasonances observed with other receivers. Such OMT reasonances are not expected in the receivers with frequencies higher than C-band and the features in Figure 9 do not show up in the total power spectra.

Figure 11 shows on-off spectra of 3C48 across the X-band receiver. Because of strong RFI the spectrum centered at 9600 MHz is not plotted. The blue line corresponds to a slope of $\nu^{-0.9}$, the expected flux density spectrum of 3C48. The intensity scale is the antenna temperature in units of the CAL. Notice the 10% difference in $T_{\mathrm{a}}/T_{\mathrm{cal}}$ between the spectra centered at 8800 MHz and 9200 MHz over channels with the same sky frequency. It is not clear what is causing these differences.

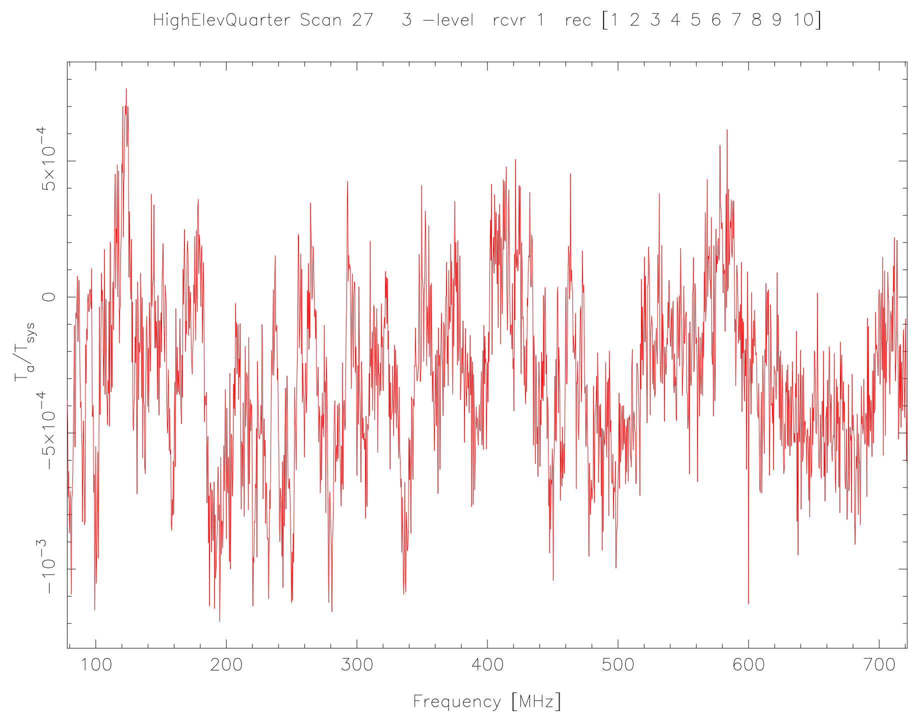


Figure 3: Project TBASEDSB030103, scans 27-28. On-off spectra towards cold sky. Each scan had an integration time of 5 minutes. The "on" scan was taken with the Y (axial) focus offset $+\lambda/4$ (0.328 inches) where the "off" scan was taken with the nominal focus. 200 channels were dropped from each end of the spectrum.

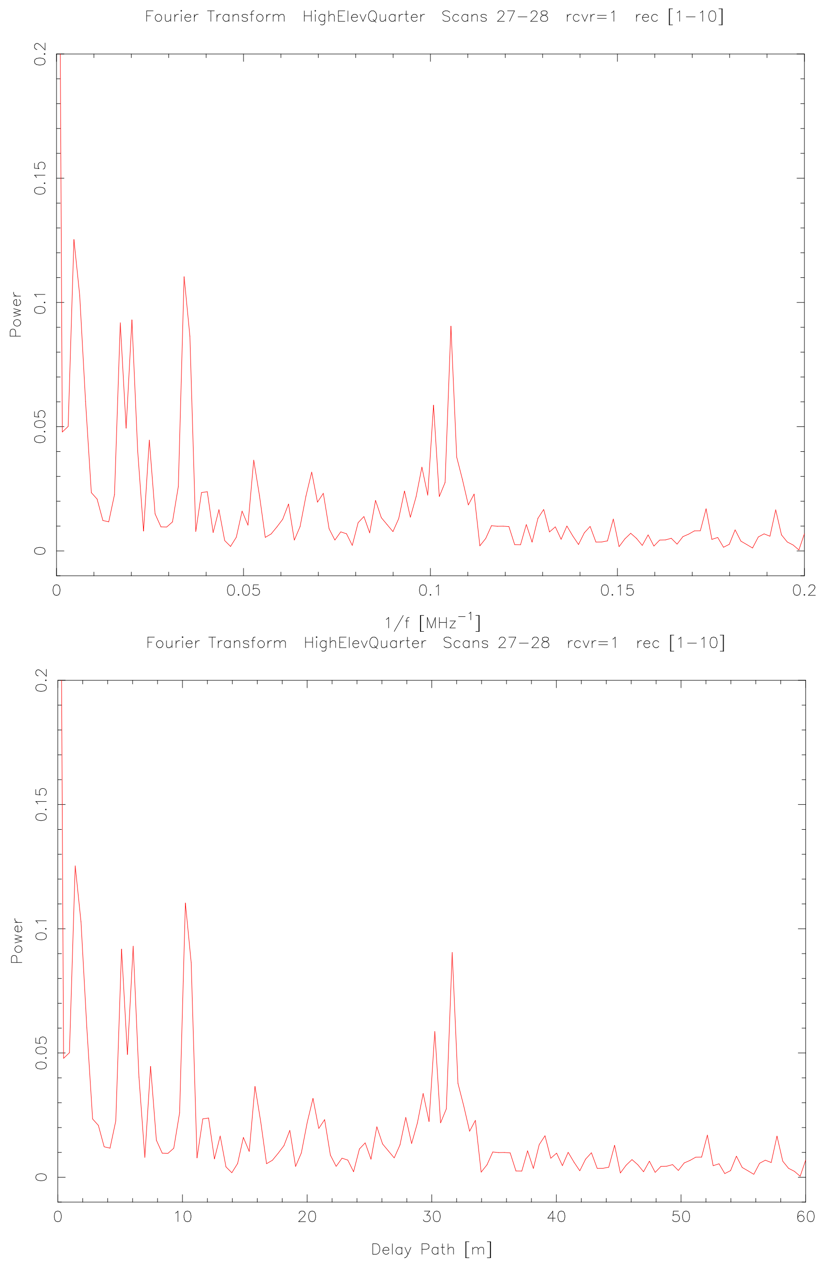


Figure 4: Project TBASEDSB030103, scans 27-28. The Fourier transform of the spectrum in Figure 3. Upper panel plots the power versus 1/f while the lower panel plots the power versus the delay path in meters. The total power is 0.492

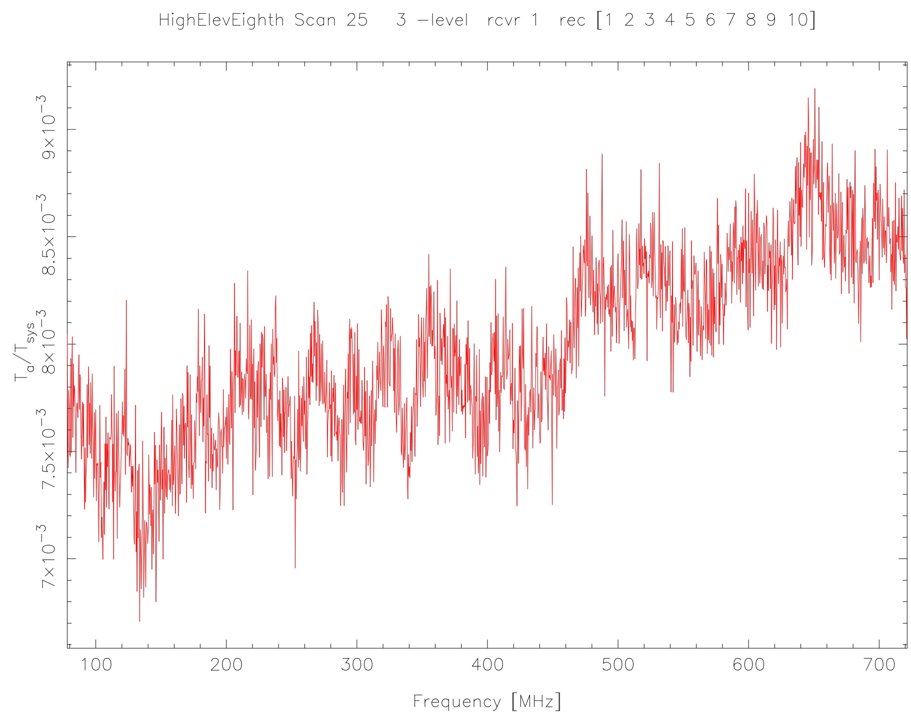


Figure 5: Project TBASEDSB030103, scans 25-26. On-off spectra towards cold sky. Each scan had an integration time of 5 minutes. The "on" scan was taken with the Y (axial) focus offset $+\lambda/8$ (0.164 inches) where the "off" scan was taken with the nominal focus. 200 channels were dropped from each end of the spectrum.

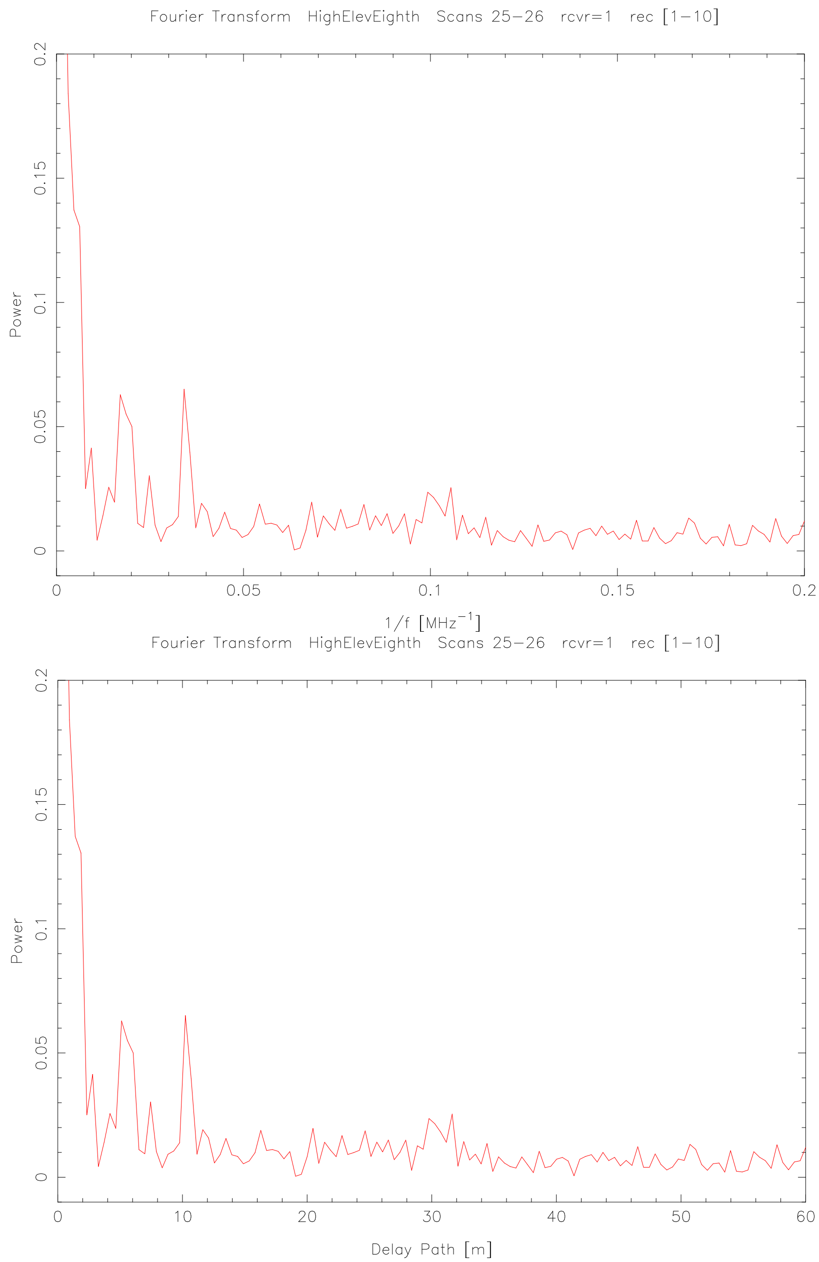
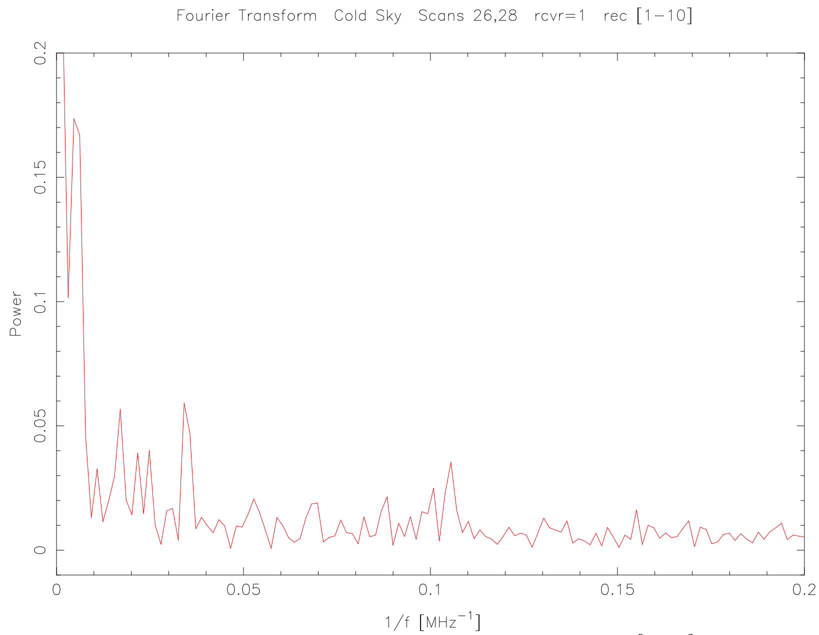


Figure 6: Project TBASEDSB030103, scans 25-26. The Fourier transform of the spectrum in Figure 5. Upper panel plots the power versus 1/f while the lower panel plots the power versus the delay path in meters. The total power is 13.1



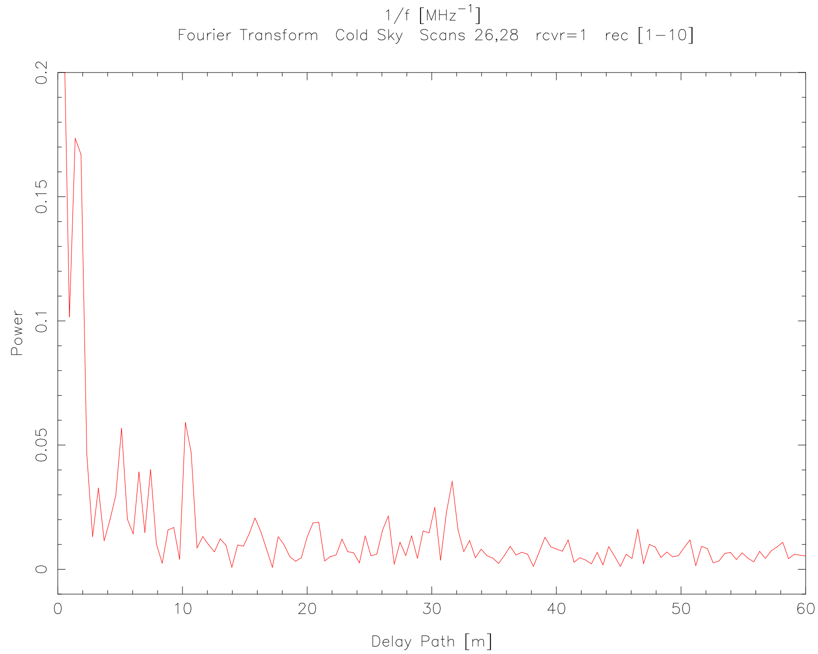


Figure 7: Project TBASEDSB030103, scans 26,28. The Fourier transform of the on-off spectrum consisting of the two nominal focus scans 26 and 28. They were not part of a normal on-off pair and the sysytem temperature changed by 0.7% between the two scans. Upper panel plots the power versus 1/f while the lower panel plots the power versus the delay path in meters. The total power is 12.2

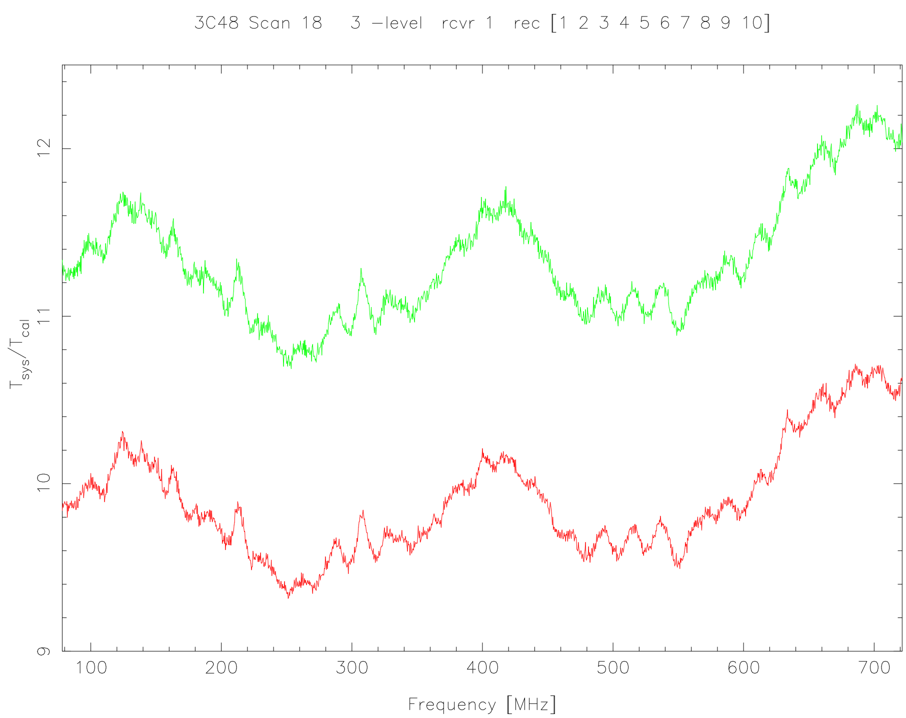


Figure 8: Project TBASEDSB030103, scans 17-18. The system temperature on cold sky (scan 18, red) and on 3C48 (scan 17, green). The spectrum is centered at a sky frequency of 8800 MHz. The integration time was 5 minutes for each scan. 200 channels have been dropped from the edges of the spectrum. The large scale structure has a wavelength of 280 MHz, while the smaller scale ripple has a wavelength of 23 MHz.

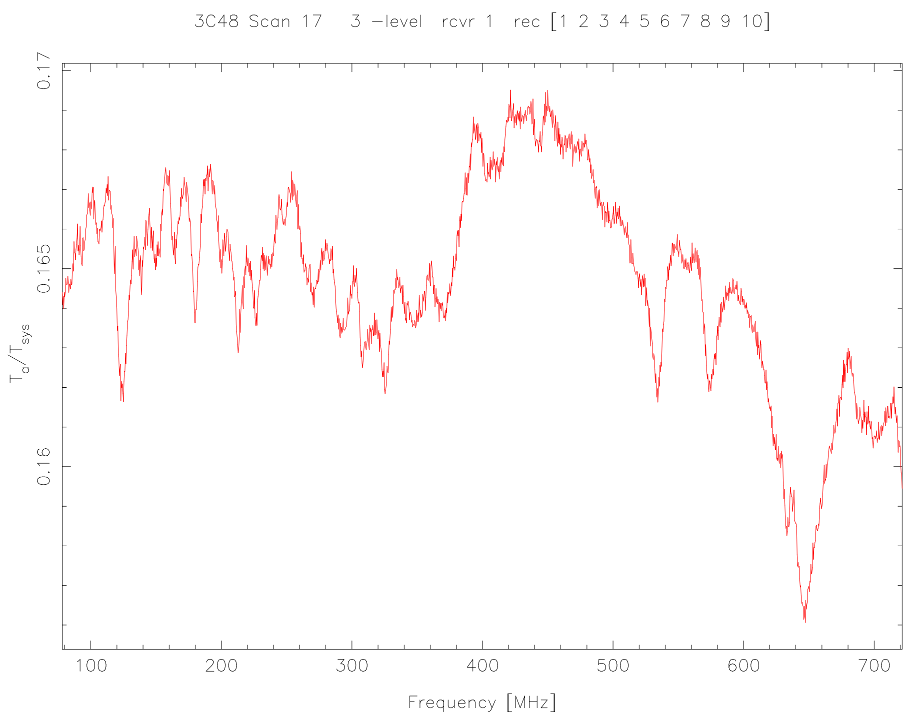


Figure 9: Project TBASEDSB030103, scans 17-18. The on-off spectrum of 3C48. The spectrum is centered at a sky frequency of 8800 MHz. The integration time was 5 minutes for each scan. 200 channels have been dropped from the edges of the spectrum.

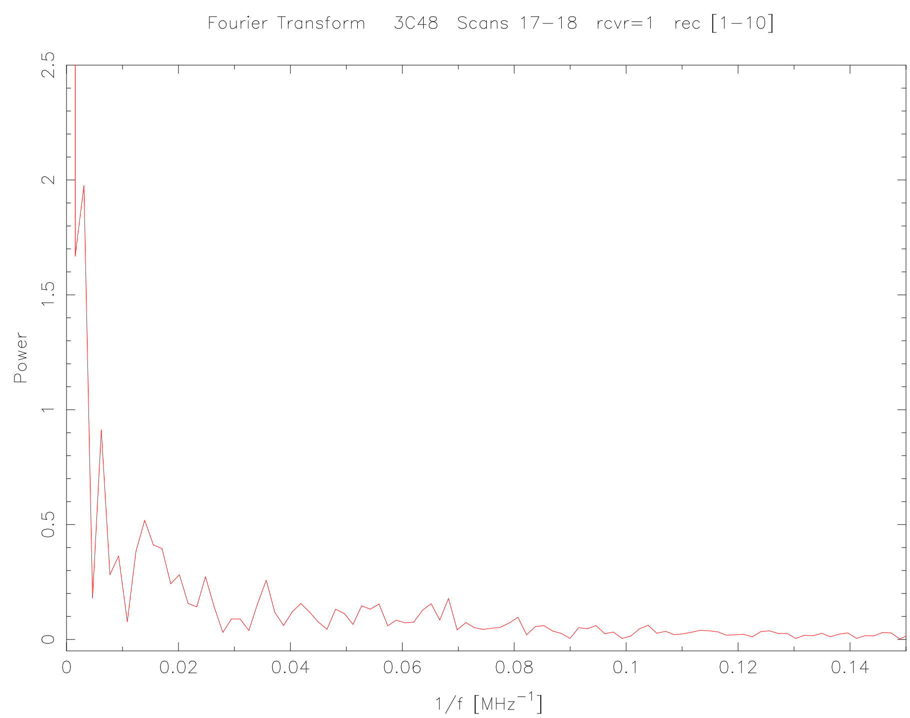


Figure 10: Project TBASEDSB030103, scans 17-18. The Fourier transform of the spectrum in Figure 9. There is no strong signal for the smaller (< 50 MHz) scale structure observed in Figure 9.

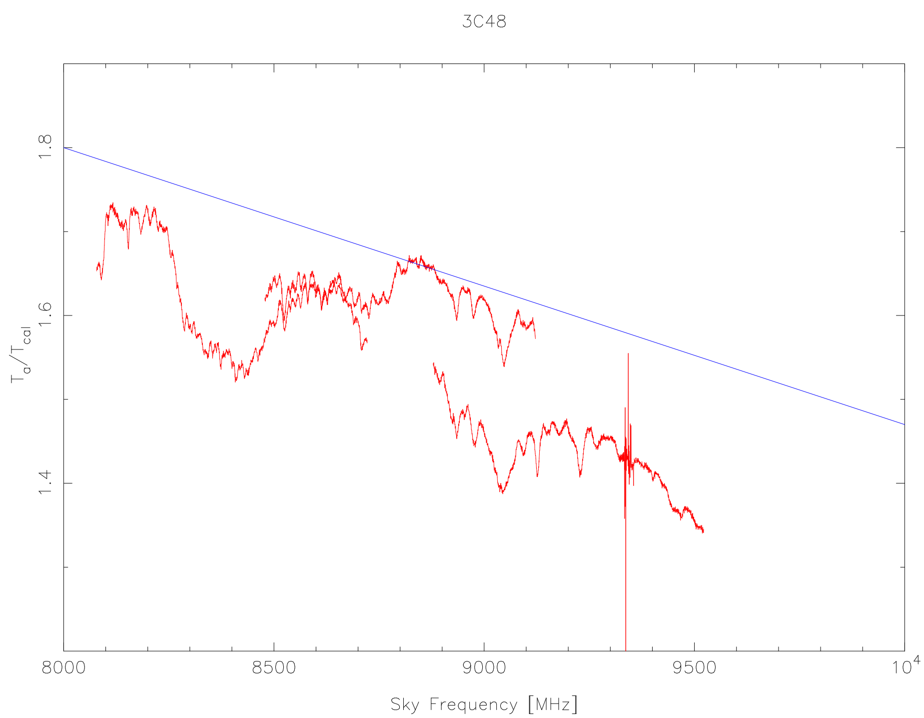


Figure 11: Project TBASEDSB030103, scans 15-20. On-Off spectra towards 3C48 centered at 8400, 8800, and 9200 MHz with a total integration time of 5 minutes for each position. (The spectrum centered at 9600 MHz has a significant interference and is not shown.) A median value of Tsys for the off spectrum was used to caluculate $T_{\rm a}/T_{\rm cal}$. The blue line corresponds to a slope of $\nu^{-0.9}$, the expected spectral index for 3C48.