Ku-band Cold Sky Focus Offsets
Project TBASEJRF030113, January 13, 2003

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January 27, 2003

Introduction

This is part of a standard set of baseline test observations on the Ku-band receiver to measure baseline changes caused by moving the subreflector in the Y direction.

Setup

The Ku-band circularly polarized receiver has two feeds, channels L1, R1 and L2, R2. These were connected to fibers 2, 3, 6, and 8, respectively. The IF rack filters were set to either 2360 to 3640. The analog filter rack outputs were set to 800 to 1600 MHz passband. The spectrometer was set up for 800 bandwidth, 3-level, 4 samplers, 4 banks, 4096 channels per IF configuration (1W1-0X-800). The signal path connections are shown in Table 1. An integration time of 30 seconds was used for all measurements. All spectra were Hanning convolved.

The Measurements

Table 2 lists the telescope beam positions for the series of observations. Each line in this table corresponds to an on-off scan pair, where the 'off' position was 5 min and 30 sec east of the 'on' position. The "FocusEighth", "FocusQuarter","Focus3Eighths", and "FocusHalf", are focus offset measurements at one-eighth, one-quarter, three-eighths, and half wavelength subreflector offsets in the +Y direction in the 'on' scan.

Table 1: IF Rack to Spectrometer Connection Matrix

Rcvr	OR	CM	SG	Sampler
L1	2	1	1	0
R1	3	10	2	2
L2	6	11	3	4
R2	8	4	4	6

Table 2: Telescope positions at the beginning of each scan or scan pair.

Source	Scans	UTC	Azimuth	Elevation	Frequency
FocusEighth	6-7	23:15:55	177.7	81.59	14000
FocusQuarter	8-9	23:27:21	194.4	81.35	14000
FocusEighth	10-11	23:38:42	209.1	80.52	14000
FocusQuarter	12-13	23:49:57	221.0	79.25	14000
FocusEighth	14-15	00:01:05	230.2	77.68	14000
FocusQuarter	16-17	00:12:07	237.4	75.94	14000
FocusEighth	18-19	00:23:04	243.1	74.08	14000
FocusQuarter	20-21	00:33:57	247.7	72.14	14000
FocusEighth	22-23	01:07:28	258.0	65.89	14000
FocusQuarter	24-25	01:18:18	260.5	63.78	14000
FocusEighth	26-27	01:29:08	262.8	61.68	14000
Focus3Eighths	28-29	01:41:08	265.1	59.35	14000
FocusHalf	30-31	01:52:00	267.0	57.22	14000

A quick summary of the data is that there was a lot of instability in the spectra of all four receiver channels throughout the 2-1/2 hour session. Unfortunately, a scan on the IF noise source was not taken at be beginning of the run so we can only speculate on whether the instability was in the receiver, the IF electronics, the spectrometer, or something peculiar in the way the system was configured. The is some question that the configuration given is Table 1 may be at least partially illegal. This needs further investigation.

To verify that the spectrometer was measuring front-end noise on four different channels the total power noise spectra for the cal-on and cal-off integration phases are shown in Figures 1 through 4. Aside from the expected power difference with the cal on, the most notable feature of these spectra is the strong, nearly sinusoidal ripple with a period of about 30 MHz in receiver channels L1 and R2.

Figure 5 shows the (calOn - calOff) / calOff spectra for the four receiver channels. Each spectrum shows a very regular sinusoidal ripple with a period of about 24 MHz. This period is distinctly different from the 30 MHz period seen in the total power spectra in Figures 1 and 4. Figure 6 shows the FFTs of the spectra in Figure 5. The feature at 6.3 meters corresponds to the period of 24 MHz. It has very nearly the same amplitude in all four receiver channels.

Figures 7 through 10 show cold sky (on - off) / off spectra for two different scan pairs for each of the four receiver channels. All four channels show considerable variation in baseline ripple between the two scan pairs. Scan pairs 16-17 and 26-27 were chosen for comparison, but similar variations can be seen in the entire set of scans. The on-off pairs were intended to look for baseline change due to subreflector offsets, but any such effects are probably buried in the apparent changes in the receiver or IF electronics.

Figure 11 shows the FFT's of the (on - off) / off spectra for scan pair 16-17 shown in Figures 7-10. There are some ripple periods, but not all, common to the four channels. The strong period at 30 MHz (5 meters) is common to channels L1 and R2, but the strong feature in R2 at about 60-MHz period (2.5 meters) is very weak in L1. The weak features between 15 and 16 meters seen

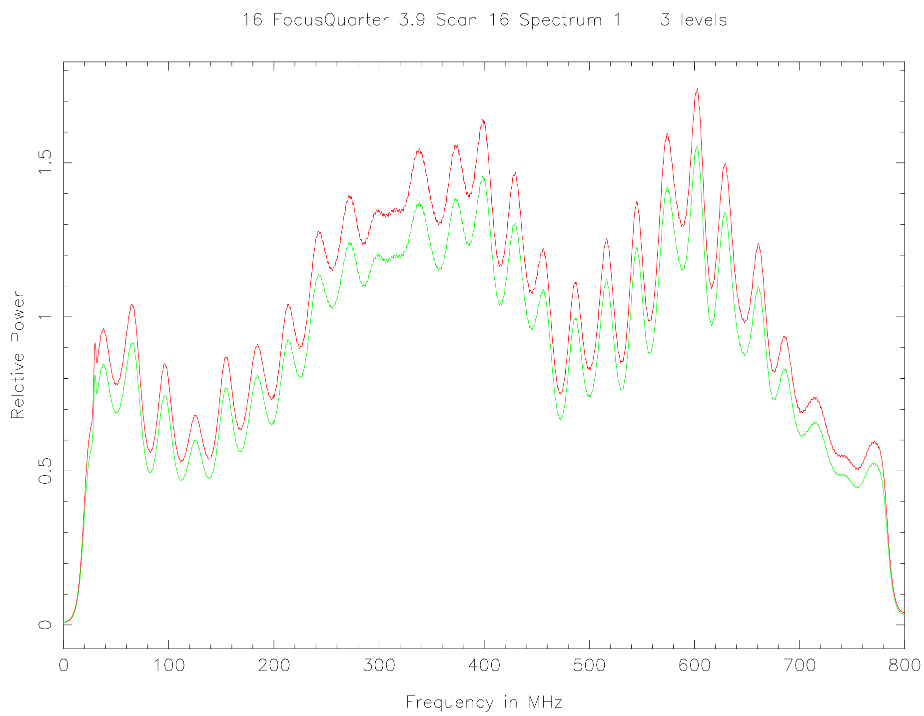

Figure 1: Scan 16, total power spectrum of receiver L1 with the calibration noise source on (red) and off (green).

in all channels is very likely due to subreflector reflections.

Figure 12 shows the progression of baseline distortions over the five-minute period of Scan 16 for channel L2. This confirms that most of the baseline ripple seen in an on-off scan pair is very likely due to electronics drifts rather than changes in subreflector position. Figure 13 shows the progression of baselines in the same scan for channel R1. This channel is relatively stable, but there was significant drift and ripple in the last two records as can be seen in Figure 14, which is the FFT of the (record10 - record1) / record1 spectrum. The features at about 2.5 and 7.8 meters correspond to ripple periods of about 60 and 20 MHz.

Figure 15 shows the FFT of the last four scan pairs where the subreflector offset was varied from 1/8 to 1/2 wavelength. It is hard to say what changes in these periodograms are due to subreflector offsets and what are due to electronics drifts. It might be worth another look at these data after understanding the stability and configuration issues, but for the moment further analysis is probably not warranted.

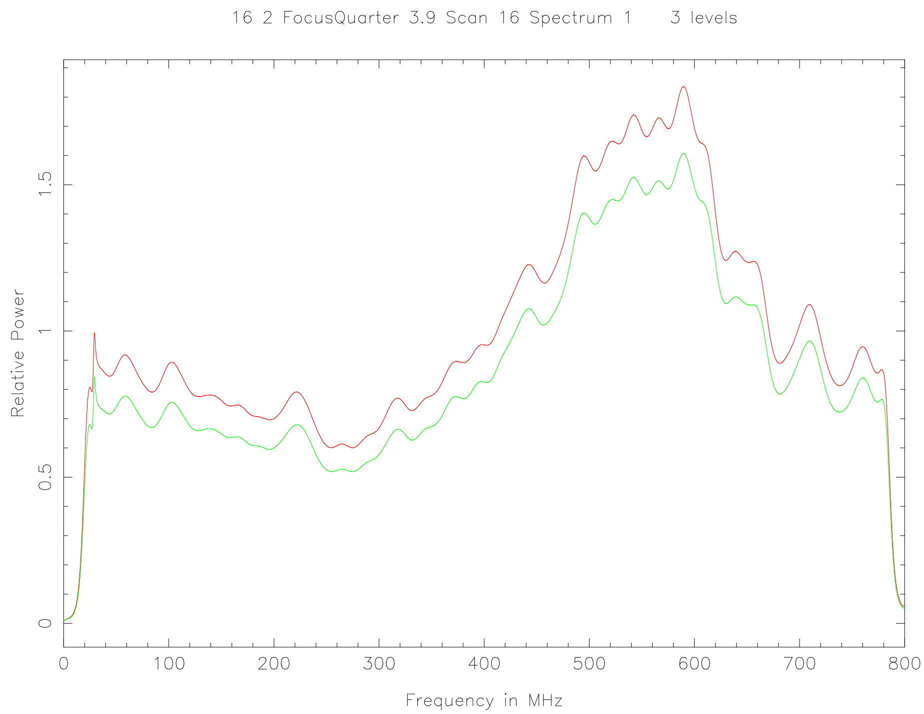

Figure 2: Scan 16, total power spectrum of receiver R1 with the calibration noise source on (red) and off (green).

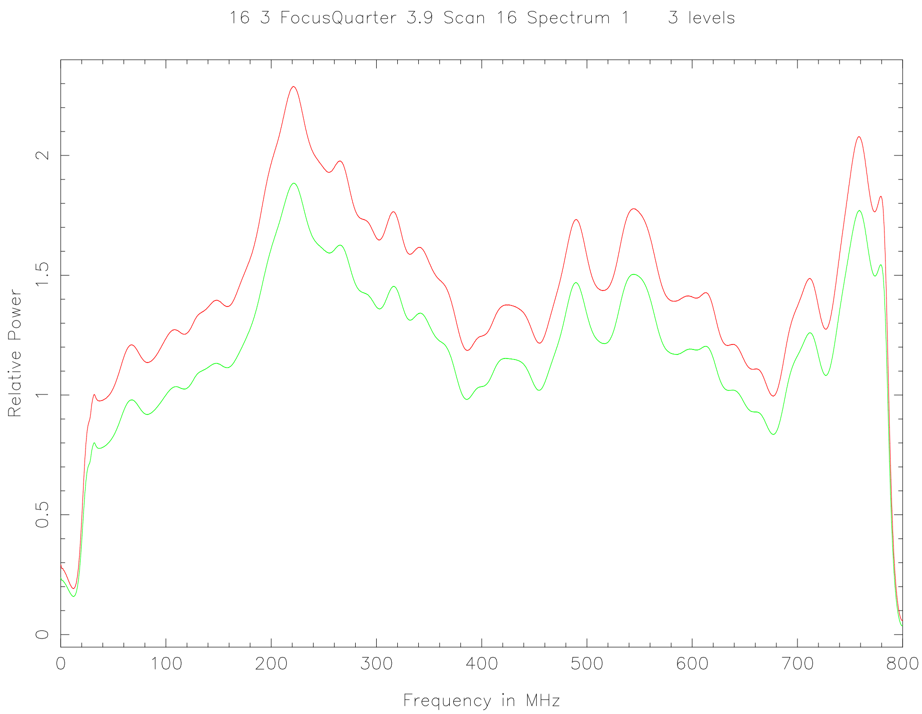

Figure 3: Scan 16, total power spectrum of receiver L2 with the calibration noise source on (red) and off (green).

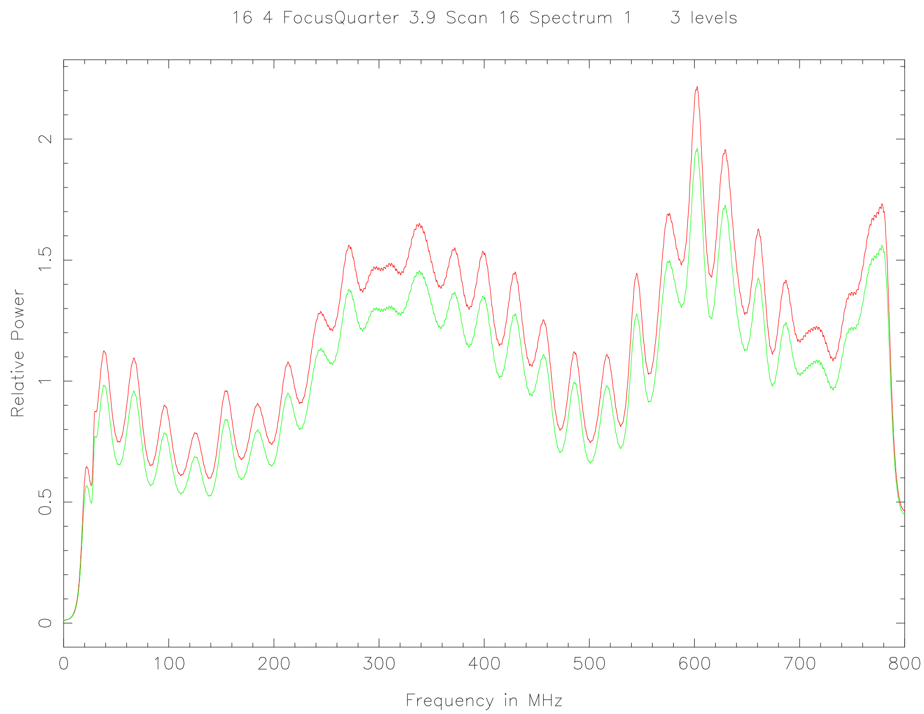

Figure 4: Scan 16, total power spectrum of receiver R2 with the calibration noise source on (red) and off (green).

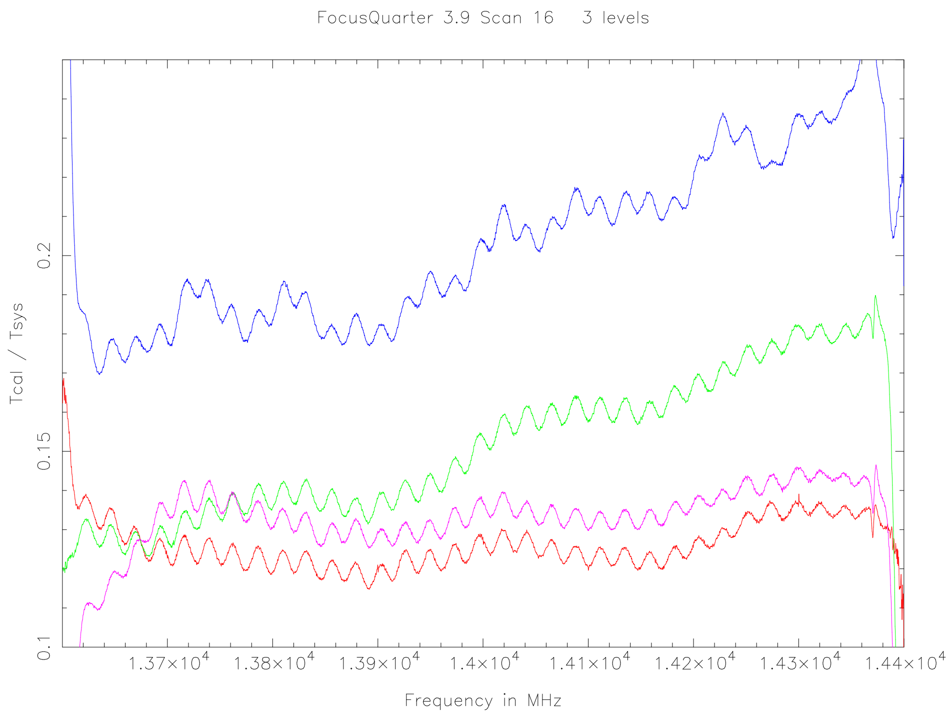

Figure 5: Scan 16, ratio of Tcal / Tsys, i.e., (calOn - calOff) / calOff, for receiver channels L1 (red), R1 (green), L2 (blue), and R2 (violet). For comparison with periodograms in earlier reports the horizontal scale is given in one-way distance to a reflection that would cause the measured periodicity due to multipath interference. The baseline ripple period can be obtained by dividing 150 MHz by the one-way distance in meters.

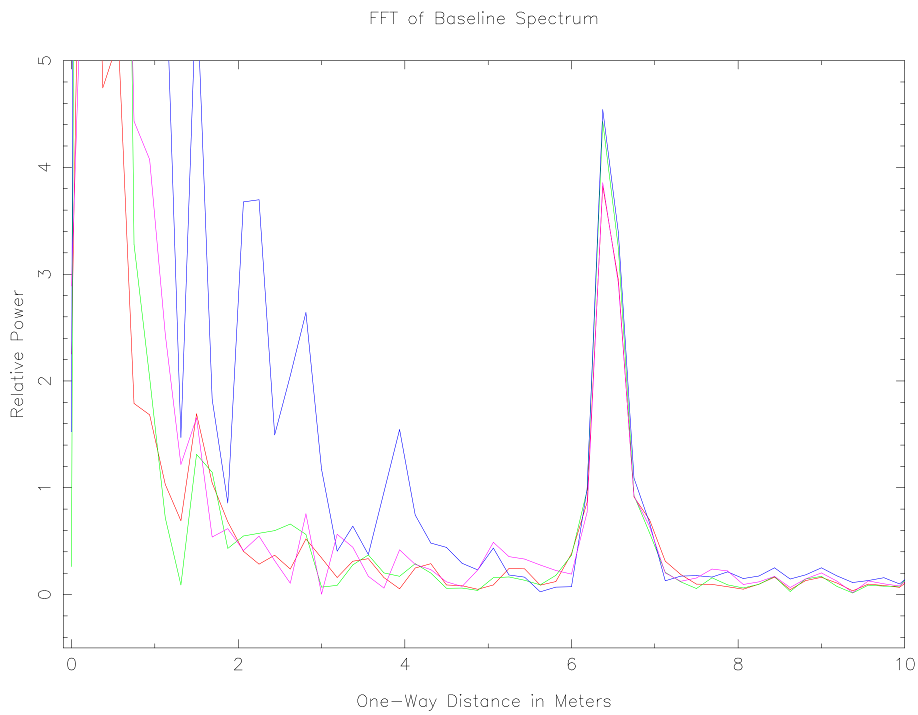

Figure 6: Scan 16, FFT of the Tcal / Tsys spectra shown in Figure 5 for receiver channels L1 (red), R1 (green), L2 (blue), and R2 (violet). For comparison with periodograms in earlier reports the horizontal scale is given in one-way distance to a reflection that would cause the measured periodicity due to multipath interference. The baseline ripple period can be obtained by dividing 150 MHz by the one-way distance in meters.

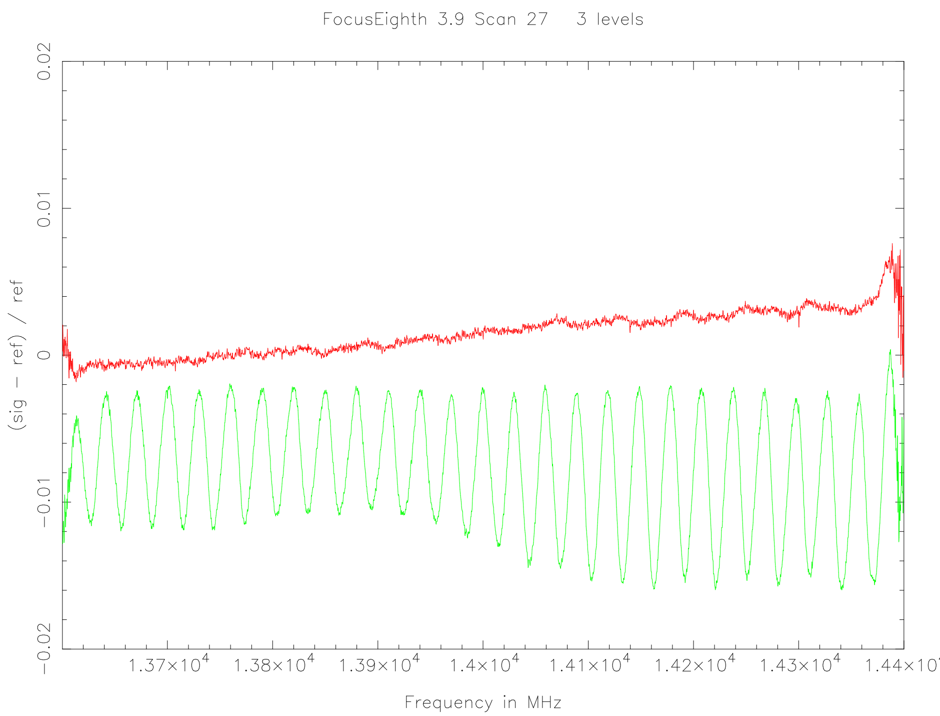

Figure 7: Scans 16, 17, 26, and 27; cold sky (on - off) / off for receiver channel L1 for scan pairs 16 and 17 (green) and 26 and 27 (red). The subreflector was displaced by 1/4-wavelength from its nominal focus position in scan 16 and by 1/8-wavelength in scan 26. In scans 17 and 27 the subreflector was at its nominal focus position.

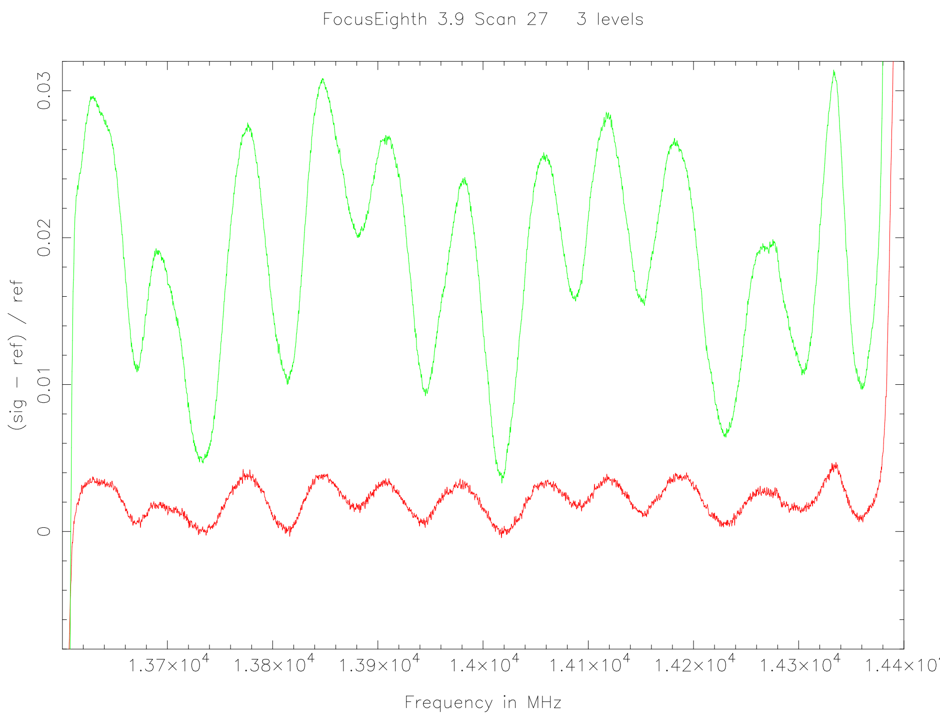

Figure 8: Scans 16, 17, 26, and 27; cold sky (on - off) / off for receiver channel R1 for scan pairs 16 and 17 (green) and 26 and 27 (red). The subreflector was displaced by 1/4-wavelength from its nominal focus position in scan 16 and by 1/8-wavelength in scan 26. In scans 17 and 27 the subreflector was at its nominal focus position.

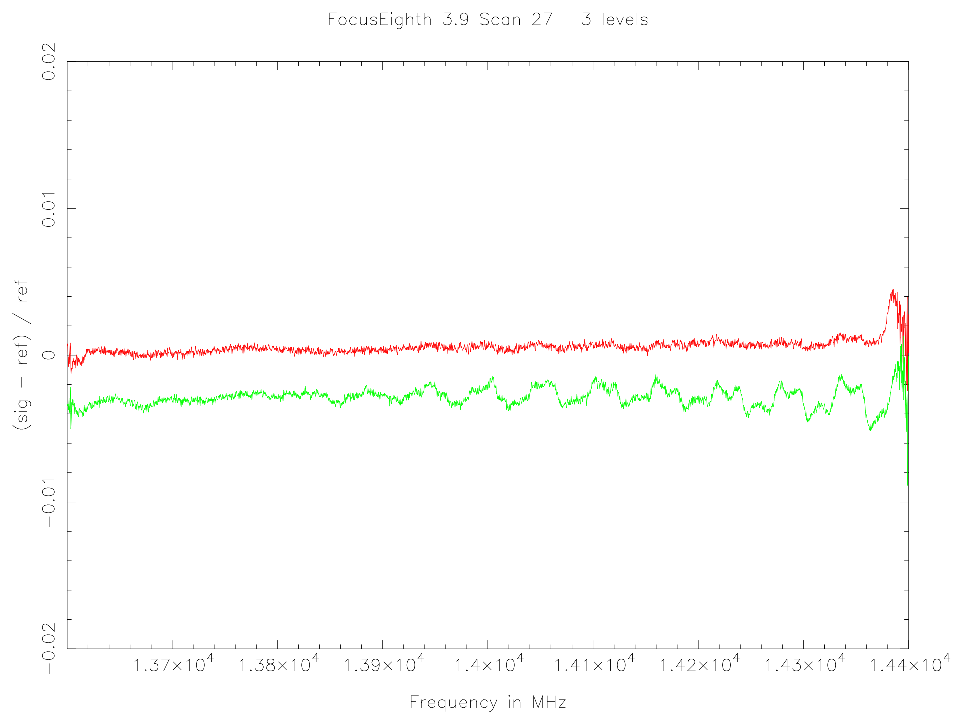

Figure 9: Scans 16, 17, 26, and 27; cold sky (on - off) / off for receiver channel L2 for scan pairs 16 and 17 (green) and 26 and 27 (red). The subreflector was displaced by 1/4-wavelength from its nominal focus position in scan 16 and by 1/8-wavelength in scan 26. In scans 17 and 27 the subreflector was at its nominal focus position.

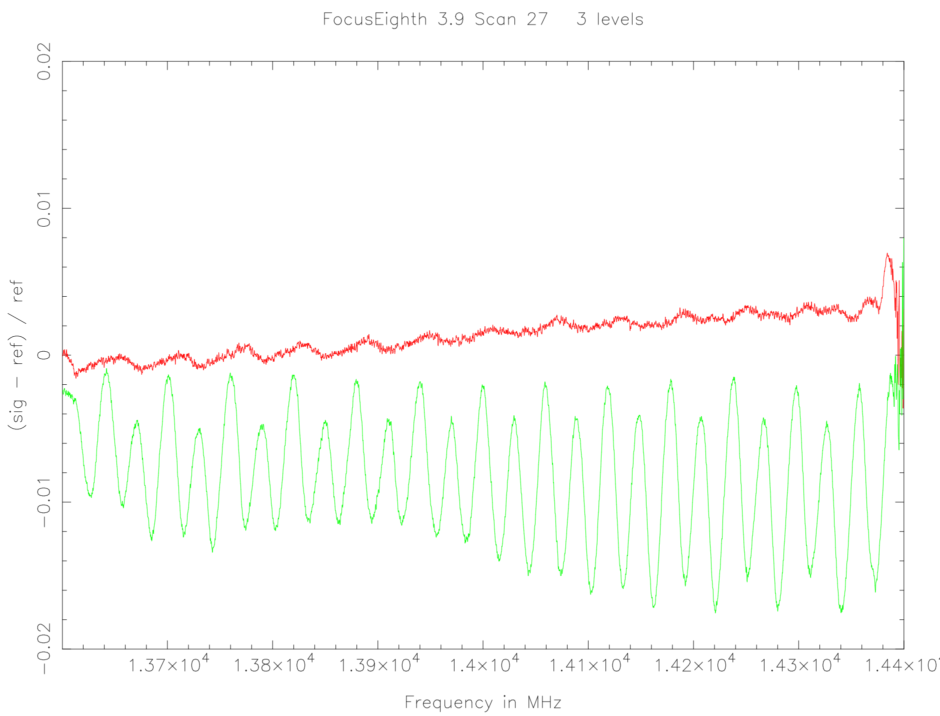

Figure 10: Scans 16, 17, 26, and 27; cold sky (on - off) / off for receiver channel R2 for scan pairs 16 and 17 (green) and 26 and 27 (red). The subreflector was displaced by 1/4-wavelength from its nominal focus position in scan 16 and by 1/8-wavelength in scan 26. In scans 17 and 27 the subreflector was at its nominal focus position.

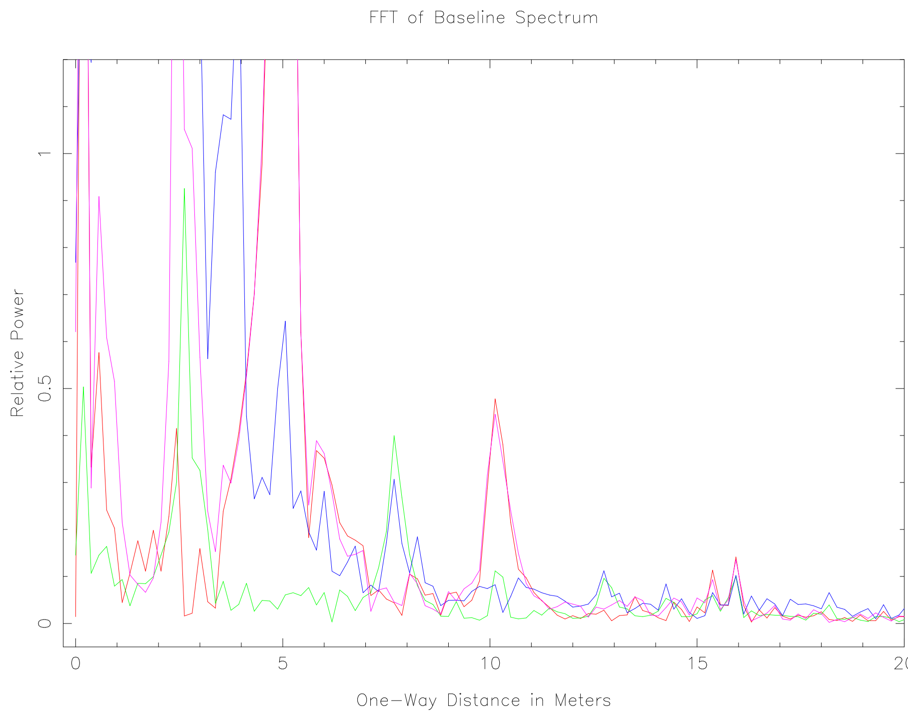

Figure 11: Scans 16 and 17, FFTs of cold sky (on - off) / off spectra for receiver channel L1 (red), R1 (green), L2 (blue), and R2 (violet). The subreflector was displaced by 1/4-wavelength from its nominal focus position in scan 16. For comparison with periodograms in earlier reports the horizontal scale is given in one-way distance to a reflection that would cause the measured periodicity due to multipath interference. The baseline ripple period can be obtained by dividing 150 MHz by the one-way distance in meters.

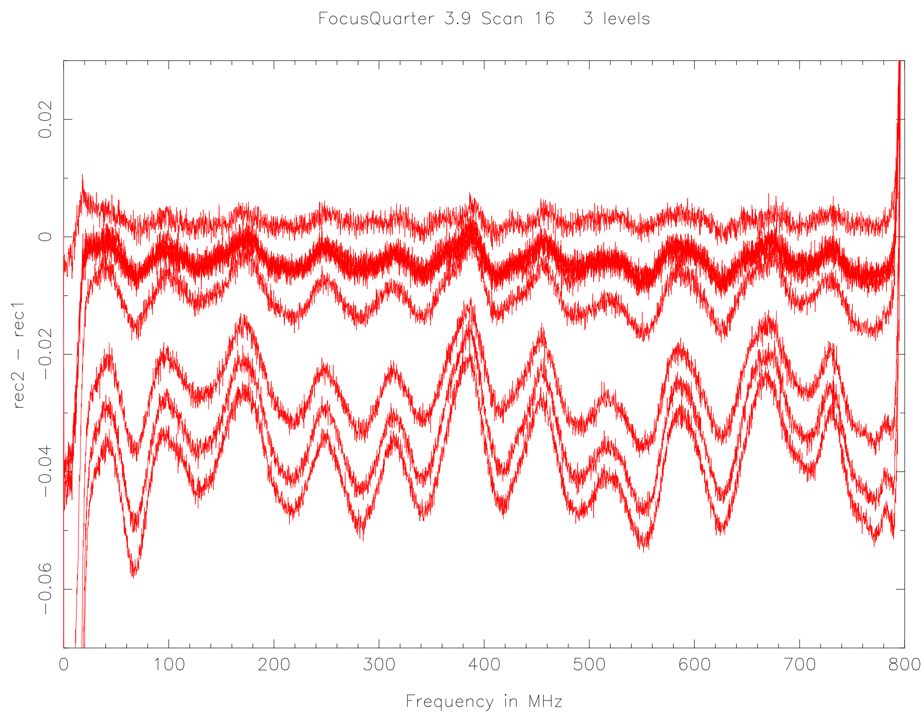

Figure 12: Scan 16, cold sky (recordN - record1) / record1 spectrum for receiver channel L2, where recordN is records 2 through 10. The top spectrum is (record2 - record1) / record1, and the bottom plot is (record10 - record1) / record1 with a monotonic progression between the two.

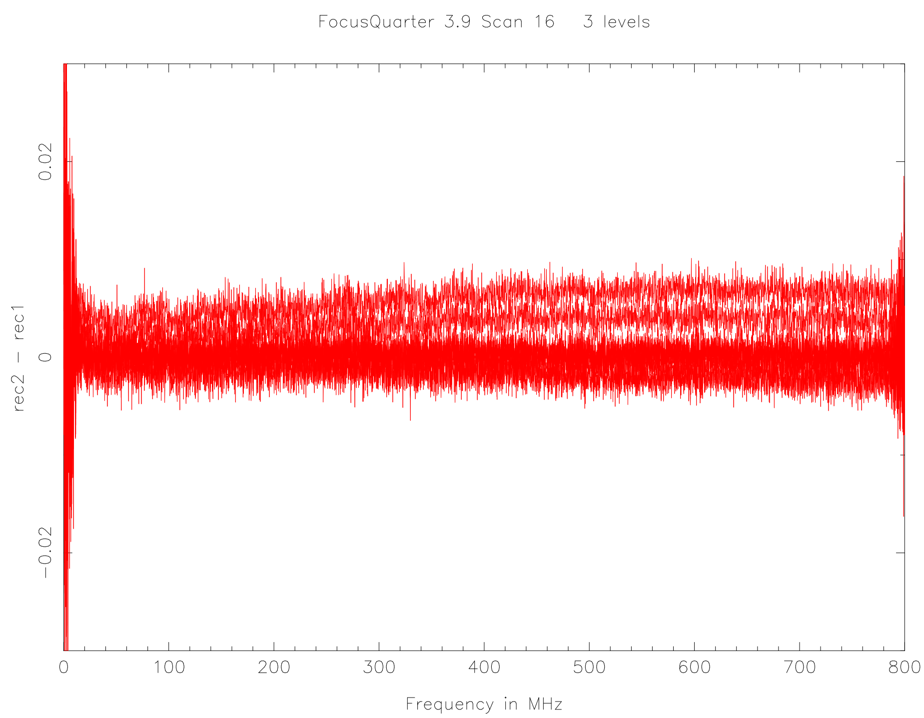

Figure 13: Scan 16, cold sky (recordN - record1) / record1 spectrum for receiver channel R1, where recordN is records 2 through 10. Records 2 through 8 fall near zero amplitude. The top two plots with a bit of ripple are from records 9 and 10.

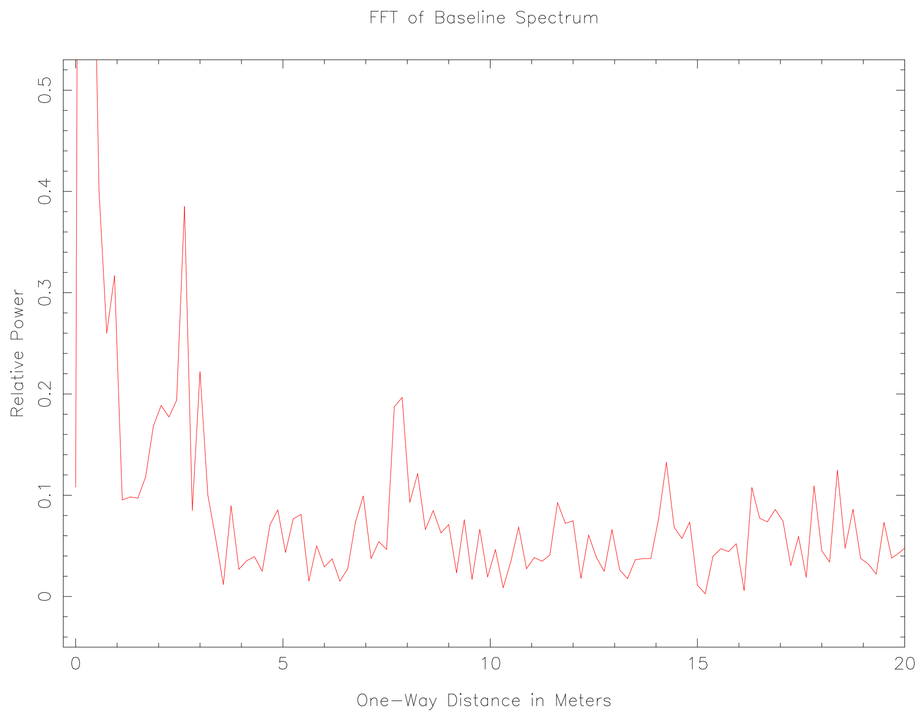

Figure 14: Scan 16, FFT of cold sky (record10 - record1) / record1 spectrum for receiver channel R1. For comparison with periodograms in earlier reports the horizontal scale is given in one-way distance to a reflection that would cause the measured periodicity due to multipath interference. The baseline ripple period can be obtained by dividing 150 MHz by the one-way distance in meters.

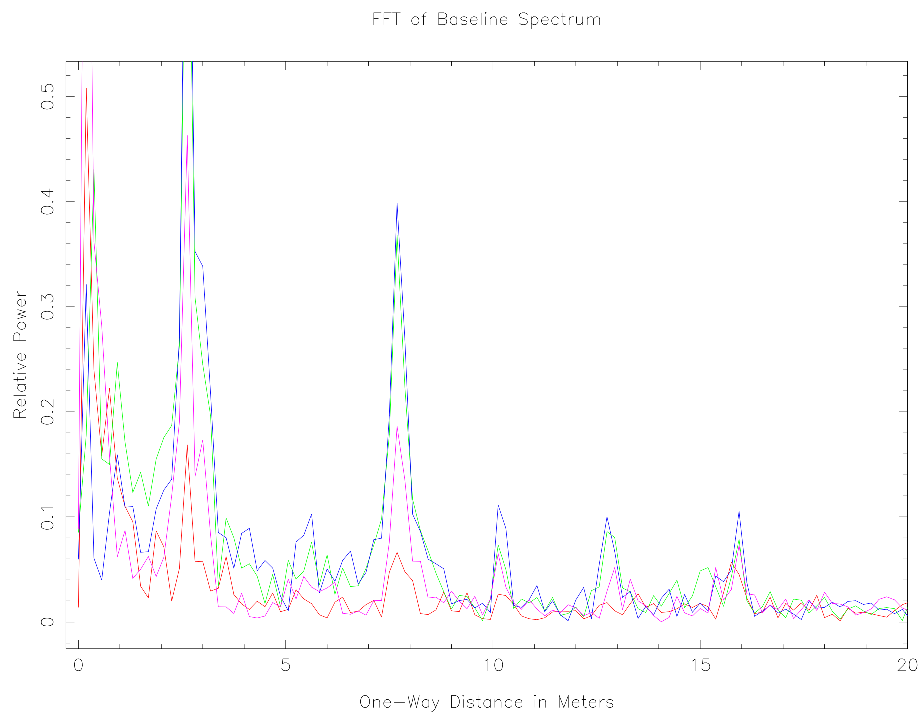

Figure 15: Scans 24-31, FFTs of cold sky (on - off) / off spectra for receiver channel R1 for scan pairs 24 and 25 (green), 26 and 27 (red), 28 and 29 (blue), and 30 and 31 (violet). The subreflector was displaced by 1/8-wavelength from its nominal Y focus position in scan 26 (red), by 1/4-wavelength in scan 24 (green), by 3/8-wavelength in scan 28 (blue), and by 1/2-wavelength in scan 30 (violet). In scans 25, 27, 29, and 31 the subreflector was at its nominal focus position. For comparison with periodograms in earlier reports the horizontal scale is given in one-way distance to a reflection that would cause the measured periodicity due to multipath interference. The baseline ripple period can be obtained by dividing 150 MHz by the one-way distance in meters.