X-band Continuum Source Baselines
Project TBASERDN031211, December 11, 2003

Rick Fisher, Roger Norrod, Rich Lacasse

December 17, 2003

Introduction

This report describes baseline test observations taken on December 11, 2003. This run was an approximate repeat of the measurements made on October 29 to look for differences in the spectra as the result of modifications to three of the GBT spectrometer samplers to reduce their internal noise. The observational test procedure was to take on-off spectrum pairs of the continuum source NGC 7027, The weather during these tests was partly cloudy, 29 degrees F, 10-15 mph wind.

Setup

For the duration of these tests the receiver LO1 was set to 12 GHz, and the LO2 synthesizers driving all converter modules were set to 12300 MHz to tune the spectrometer center channel to 9000MHz. The modified samples were serial numbers 8, 9, and 4 connected to spectrometer inputs J1, J3, and J5, respectively. The system connections on December 11 were:

LCP	ODM6	CM9	SF1	Bank A, J1, Sampler 1	modified S/N 8
	ODM6	CM10	SF2	Bank B, J3, Sampler 1	modified S/N 9
	ODM6	CM11	SF3	Bank C, J5, Sampler 1	modified S/N 4
	ODM6	CM12	SF4	Bank D, J7, Sampler 1	
RCP	ODM8	CM13	SF5	Bank A, J2, Sampler 2	
	ODM8	CM14	SF6	Bank B, J4, Sampler 2	
	ODM8	CM15	SF7	Bank C, J6, Sampler 2	
	ODM8	CM16	SF8	Bank D, J8, Sampler 2	

Continuum Source Spectra

The radio source NGC 7027 was used to measure the spectral response of the GBT system to continuum input to the receiver. This source has a flux density at 9 GHz of about 6 Jy, which will produce an antenna temperature of a bit over 10 Kelvins or roughly 40 percent of the system temperature. Before the on-off spectra were taken the antenna pointing was checked by adding small offsets to the commanded position to maximize the response to the radio source as measured on one of the IF Rack total power meters. An improved pointing model was in use, and no offset from the nominal pointing position could be detected.

Figure 1 shows the Tsrc/Tsys spectra for NGC 7027 from the two bank A spectrometer channels with one connected to the LCP receiver channel and one to the RCP channel. Three spectra with different sampler level settings are shown for each channel. The red curves were taken with the samplers running at their normal quantization voltage values and the power at the inputs to the spectrometer set to the optimum levels of about -17 dBm. The green curves were measured with the sampler quantization voltages set 2 dB lower (0.8 times) their normal values. The input powers to the spectrometer were set to -19 dBm by increasing the attenuation in the IF Rack. The blue curves were measured with the sampler quantization voltages set 2 dB higher (1.25 times) their normal values, and the input powers to the spectrometer set to -15 dBm. The higher sampler voltage settings appear to produce less variation in the spectra across the band. Figure 1 may be compared with the same figure in the October 29 report. Aside from the fact that both figures show somewhat more spectral ripple at the lowest sampler input level, not much can be inferred from these plots. Note that the sampler input levels in these new measurements were offset by ± 2 dB instead of ± 3 dB from their nominal values and that the IF Rack attenuators instead of the Convertor Rack attenuators were used to change these offsets in the new measurements.

Figure 2 shows the ratios of the Tsrc/Tsys spectra shown in Figure 1. The red curves are the ratios of spectra with normal sampler levels to spectra with 2 dB higher levels, and the green curves are ratios of spectra with 2 dB lower sampler levels to spectra with 2 dB higher levels. As was seen in the corresponding Figure 2 in the October 29 report, almost all of the baseline structure appears to be worse with lower sampler levels. The lower two traces in Figure 2 are from one of the modified samplers on port J1. There does not appear to be a significant improvement in the spectrum roughness.

For comparison, Figures 3 through 8 show the Tsrc/Tsys and ratio spectra for the other three spectrometer banks. The results are essentially the same as for bank A. The baseline structure appears to be worse with lower sampler levels in all cases. In the October 29 measurements the sampler input levels were not changed on banks B through D so a comparison with the new results cannot be made for these samplers.

800 MHz Spectra with 200 MHz Filters

To look for residual noise in the samplers and other components following the anti-aliasing filters we switched to the 200-MHz bandwidth filters while using the 800-MHz spectrometer bandwidth sampler and autocorrelation mode. The

200-MHz bandwidth filters have a passband range of 800-1000 MHz, which is one quarter of the 800-1600 MHz passband of the 800-MHz bandwidth filters. The stop-band attenuation of the 800-1000 MHz is better than 60 dB so the frequency range of 1000-1600 MHz (0-600 MHz at baseband) should show less than 0.0001% of the power level in the 800-1000 MHz (600-800 MHz at baseband) passband.

Figures 9 through 16 show the measured on-source and off-source spectra from spectrometer banks A, B, C, and D. The levels to all samplers in all banks were set close to their normal operating levels. This required about 6 dB less than normal attenuation in the converter modules to compensate for the smaller analog bandwidth in the 800-MHz spectrometer mode. As in the October 29 measurements, the amplified spectra in the 0-600-MHz frequency range show up to 0.5% of the spectral power density measured in the 600-800 MHz range. Figure 17 shows an overplot of the December 11 and October 29 spectra for bank A, channel 1 for the modified sampler connected to port J1. In this case the spectra have been scaled to match the spectrum levels in the passband part of the filters for all four scans. There is some change in the noise spectrum in the stop band, but the general level is about the same before and after the sampler modification. Figure 19 for the modified sampler on J3 shows roughly the same results. Since data from bank C were not available from the October 29 run, we cannot make a comparison on the third modified sampler. Figures 18, 20, 21, and 22 show the spectrum comparisons for the unmodified samplers. The changes from October to December were at least as big on the unmodified samplers as on the modified ones. Either the noise seen in the stop band is from a different source than the one suppressed, or, more likely, this part of the spectrum is an artifact of a small error in the VanVleck quantization correction. A VanVleck correction error could also be the cause of some of the spectrum variations seen in the ± 2 dB sampler level tests, but we cannot draw any firm conclusions.

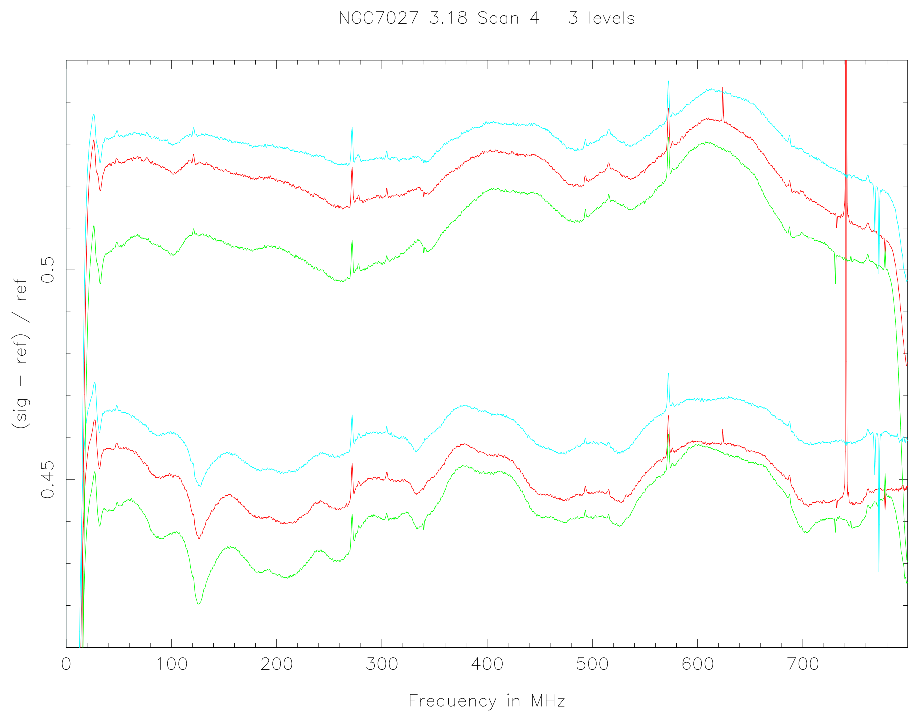

Figure 1: Scans 3-4, 5-6, 7-8: (on - off) / off, i.e. Tsrc/Tsys, spectra for the continuum source NGC 7027 using spectrometer bank A. The lower three traces are for the LCP receiver using samplers connected to spectrometer input J1, and the upper traces are for RCP connected to sampler input J2. The red traces are spectra with the sampler levels set to their normal levels. The green traces are with the sampler levels set 2 dB lower than normal (0.8 times their normal voltages). The blue traces are with the sampler levels set 2 dB higher than normal (1.25 times their normal voltages). The red curves are scaled up by about 13% to correct for gain loss, possibly due to a change in sky noise. The frequency scale of 0 to 800 MHz is for the sampler base band, which corresponds to 1600 to 800 MHz at the spectrometer inputs.

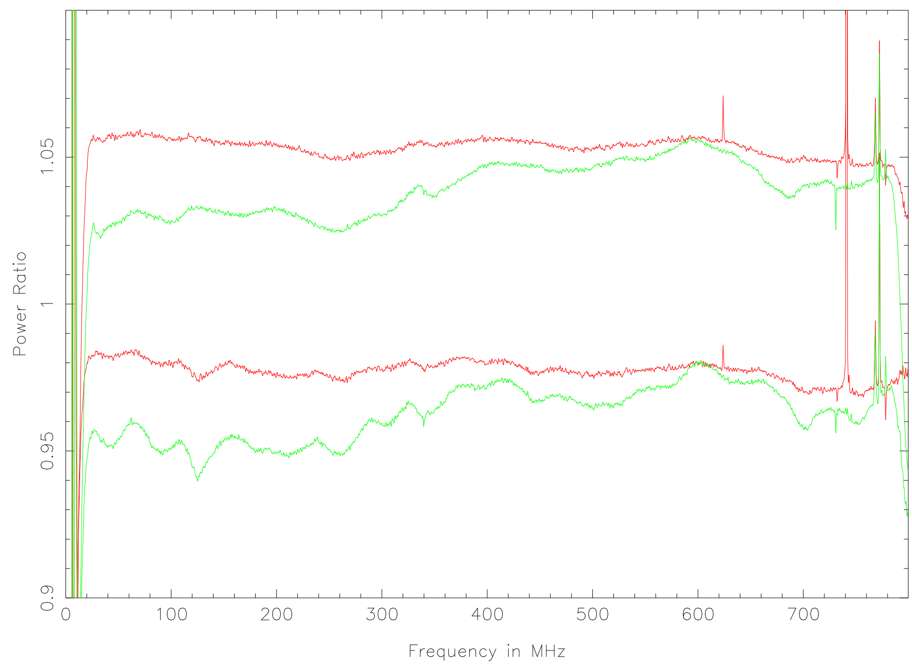

Figure 2: Scans 3-4, 5-6, 7-8: Ratios of (on - off) / off, i.e. Tsrc/Tsys, spectra for the continuum source NGC 7027 using different sampler quantization voltage levels. The lower two traces are for the LCP receiver using samplers connected to spectrometer input J1, and the upper traces are for RCP connected to sampler input J2. The red traces are ratios of spectra with normal sampler levels to spectra with 2 dB higher sampler levels. The green traces are ratios of spectra with 2 dB lower sampler levels to spectra with 2 dB higher sampler levels. The frequency scale of 0 to 800 MHz is for the sampler base band, which corresponds to 1600 to 800 MHz at the spectrometer inputs.

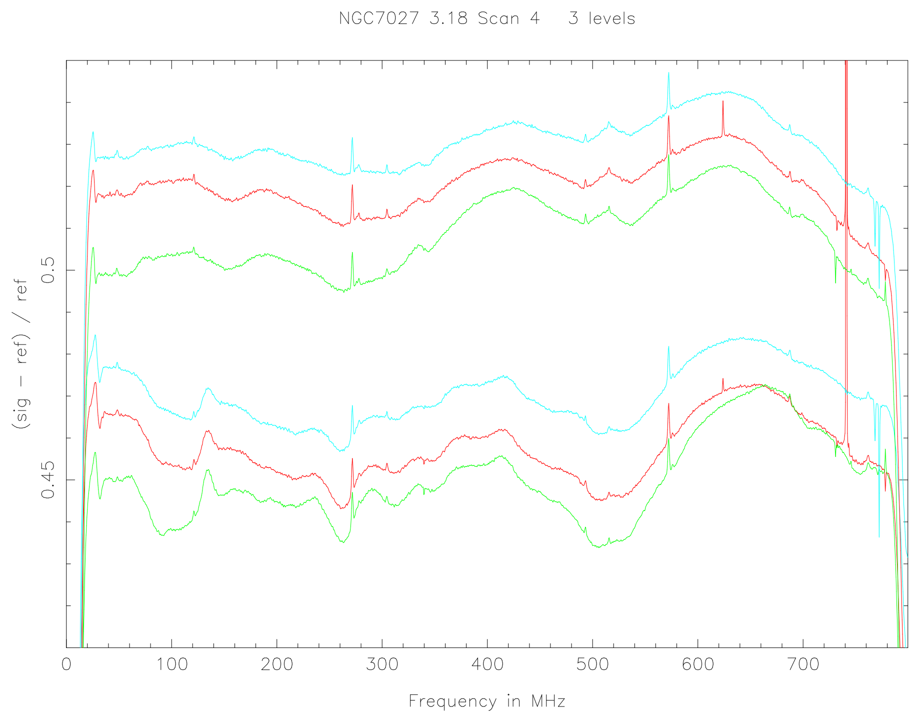

Figure 3: Scans 3-4, 5-6, 7-8: (on - off) / off, i.e. Tsrc/Tsys, spectra for the continuum source NGC 7027 using spectrometer bank B. The lower three traces are for the LCP receiver using samplers connected to spectrometer input J3, and the upper traces are for RCP connected to sampler input J4. The red traces are spectra with the sampler levels set to their normal levels. The green traces are with the sampler levels set 2 dB lower than normal (0.8 times their normal voltages). The blue traces are with the sampler levels set 2 dB higher than normal (1.25 times their normal voltages). The red curves are scaled up by about 13% to correct for gain loss, possibly due to a change in sky noise. The frequency scale of 0 to 800 MHz is for the sampler base band, which corresponds to 1600 to 800 MHz at the spectrometer inputs.

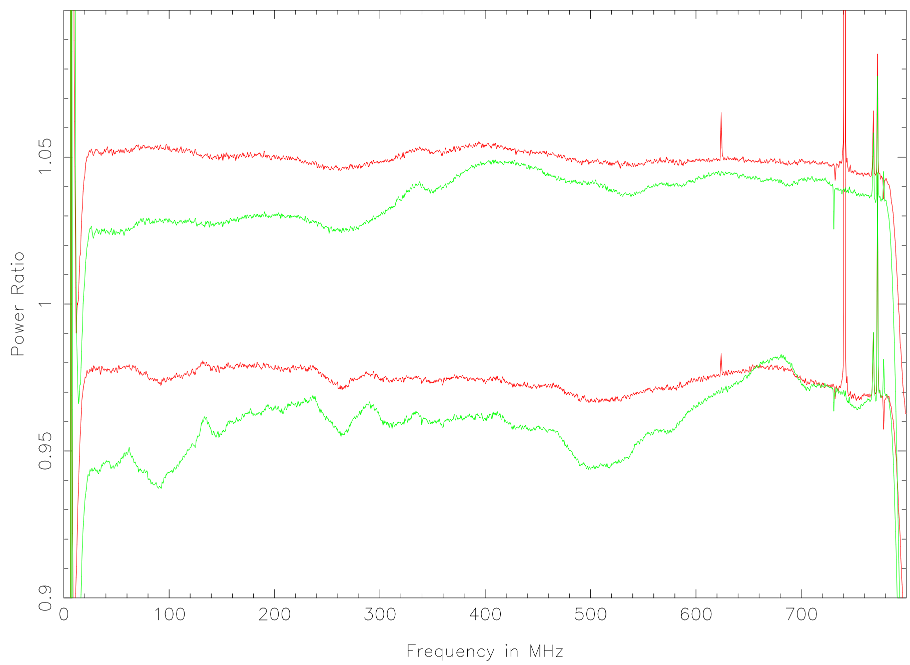

Figure 4: Scans 3-4, 5-6, 7-8: Ratios of (on - off) / off, i.e. Tsrc/Tsys, spectra for the continuum source NGC 7027 using spectrometer bank B. The lower two traces are for the LCP receiver using samplers connected to spectrometer input J3, and the upper traces are for RCP connected to sampler input J4. The red traces are ratios of spectra with normal sampler levels to spectra with 2 dB higher sampler levels. The green traces are ratios of spectra with 2 dB lower sampler levels to spectra with 2 dB higher sampler levels. The frequency scale of 0 to 800 MHz is for the sampler base band, which corresponds to 1600 to 800 MHz at the spectrometer inputs.

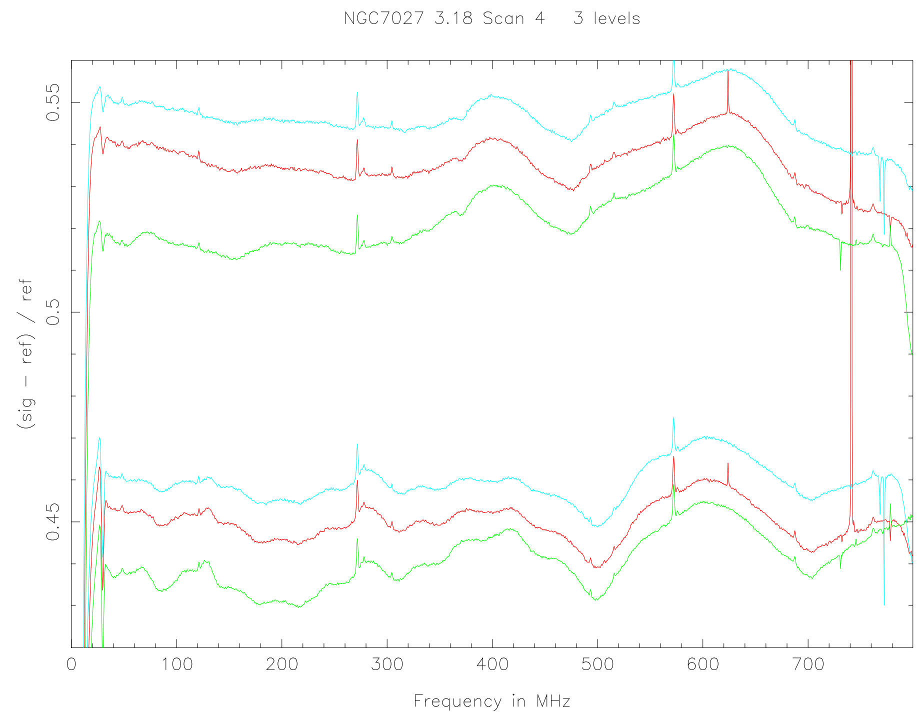

Figure 5: Scans 3-4, 5-6, 7-8: (on - off) / off, i.e. Tsrc/Tsys, spectra for the continuum source NGC 7027 using spectrometer bank C. The lower three traces are for the LCP receiver using samplers connected to spectrometer input J5, and the upper traces are for RCP connected to sampler input J6. The red traces are spectra with the sampler levels set to their normal levels. The green traces are with the sampler levels set 2 dB lower than normal (0.8 times their normal voltages). The blue traces are with the sampler levels set 2 dB higher than normal (1.25 times their normal voltages). The red curves are scaled up by about 13% to correct for gain loss, possibly due to a change in sky noise. The frequency scale of 0 to 800 MHz is for the sampler base band, which corresponds to 1600 to 800 MHz at the spectrometer inputs.

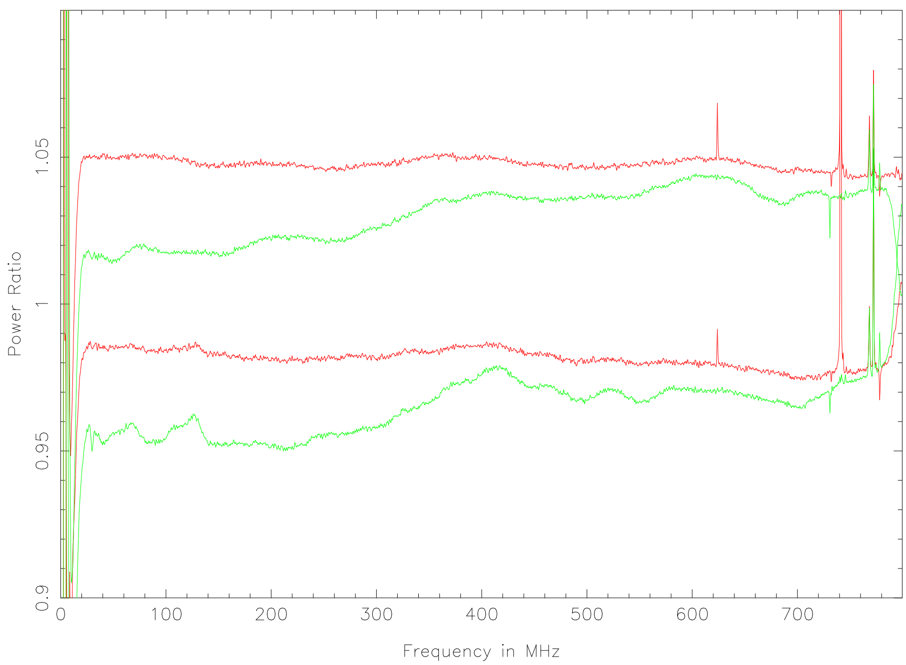

Figure 6: Scans 3-4, 5-6, 7-8: Ratios of (on - off) / off, i.e. Tsrc/Tsys, spectra for the continuum source NGC 7027 using spectrometer bank C. The lower two traces are for the LCP receiver using samplers connected to spectrometer input J5, and the upper traces are for RCP connected to sampler input J6. The red traces are ratios of spectra with normal sampler levels to spectra with 2 dB higher sampler levels. The green traces are ratios of spectra with 2 dB lower sampler levels to spectra with 2 dB higher sampler levels. The frequency scale of 0 to 800 MHz is for the sampler base band, which corresponds to 1600 to 800 MHz at the spectrometer inputs.

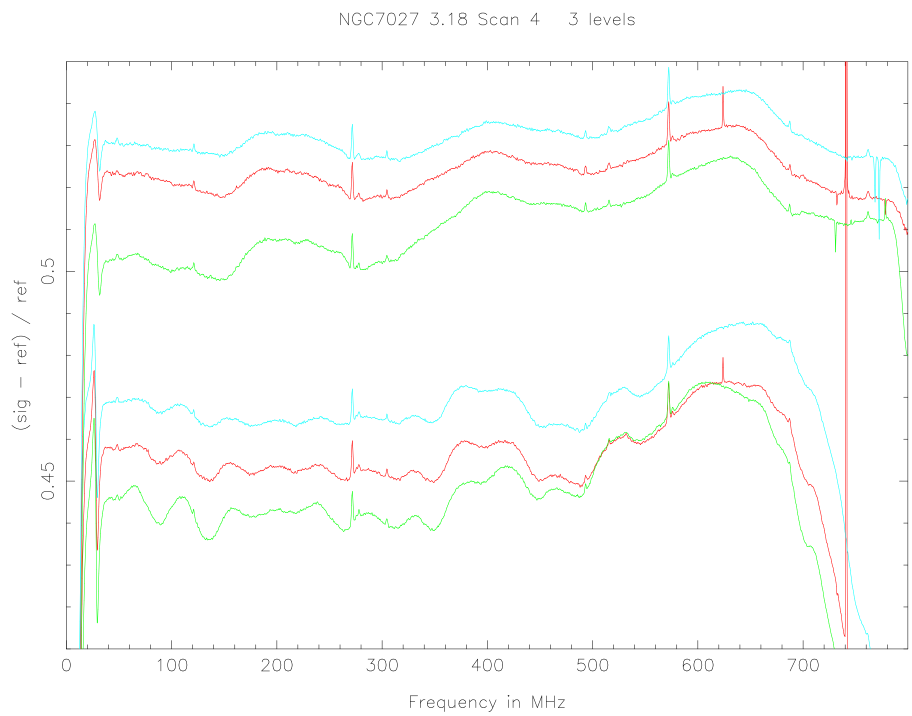

Figure 7: Scans 3-4, 5-6, 7-8: (on - off) / off, i.e. Tsrc/Tsys, spectra for the continuum source NGC 7027 using spectrometer bank D. The lower three traces are for the LCP receiver using samplers connected to spectrometer input J7, and the upper traces are for RCP connected to sampler input J8. The green traces are with the sampler levels set 2 dB lower than normal (0.8 times their normal voltages). The blue traces are with the sampler levels set 2 dB higher than normal (1.25 times their normal voltages). The red curves are scaled up by about 13% to correct for gain loss, possibly due to a change in sky noise. The frequency scale of 0 to 800 MHz is for the sampler base band, which corresponds to 1600 to 800 MHz at the spectrometer inputs.

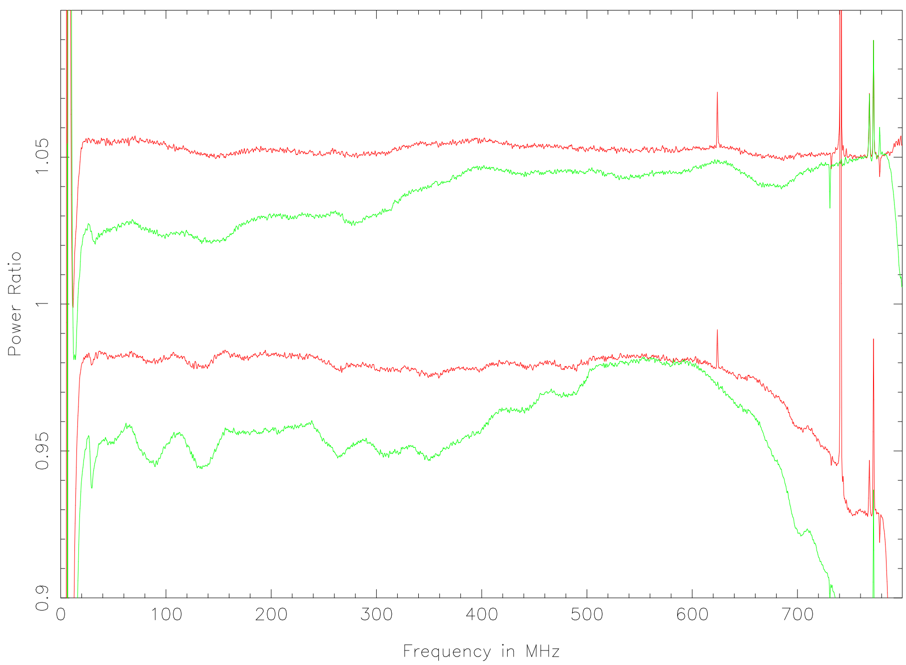

Figure 8: Scans 3-4, 5-6, 7-8: Ratios of (on - off) / off, i.e. Tsrc/Tsys, spectra for the continuum source NGC 7027 using spectrometer bank D. The lower two traces are for the LCP receiver using samplers connected to spectrometer input J7, and the upper traces are for RCP connected to sampler input J8. The red traces are ratios of spectra with normal sampler levels to spectra with 2 dB higher sampler levels. The green traces are ratios of spectra with 2 dB lower sampler levels to spectra with 2 dB higher sampler levels. The frequency scale of 0 to 800 MHz is for the sampler base band, which corresponds to 1600 to 800 MHz at the spectrometer inputs.

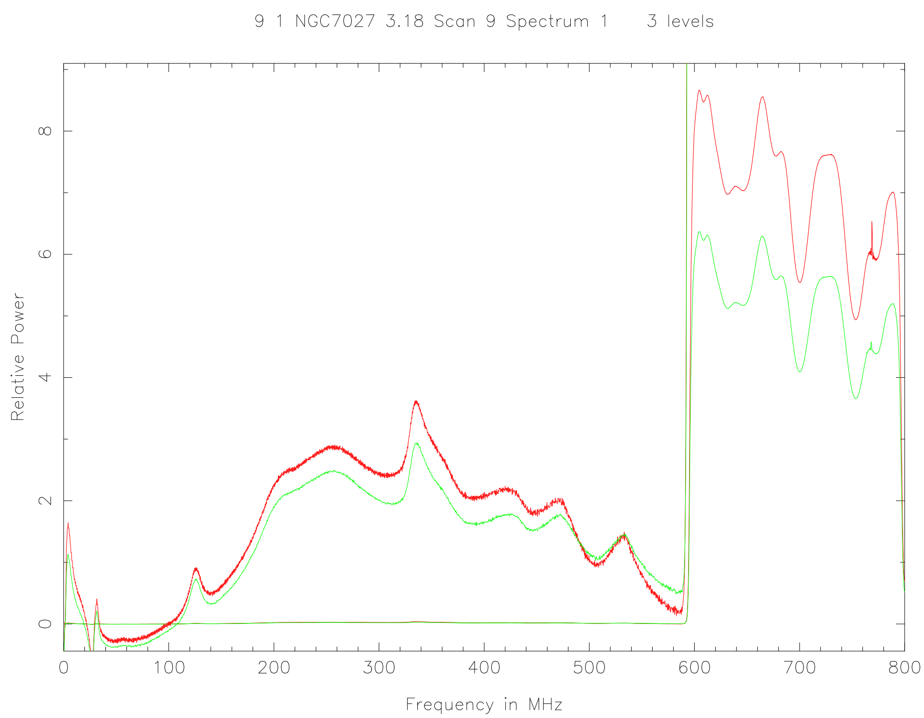

Figure 9: Scans 9-10: On and off total power spectra for the continuum source NGC 7027 using spectrometer bank A input J1 and a 200 MHz anti-alias filter in the analog filter module. The red trace is the on-source spectrum, and the green trace is off source. In the 0-600 MHz stop-band the spectra are replotted with 100 times the vertical scale.

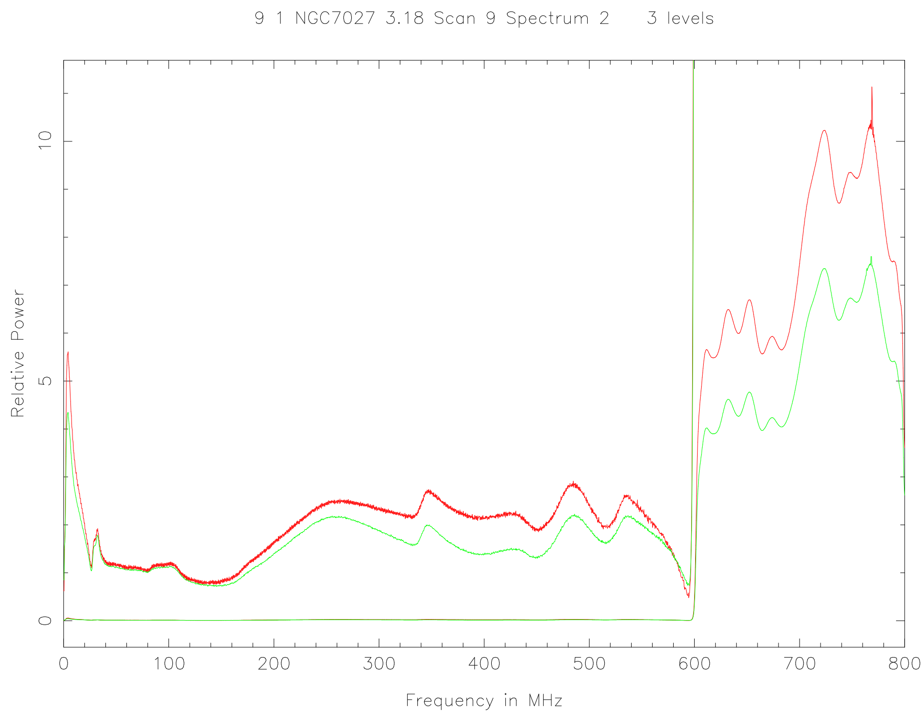

Figure 10: Scans 9-10: On and off total power spectra for the continuum source NGC 7027 using spectrometer bank A input J2 and a 200 MHz anti-alias filter in the analog filter module. The red trace is the on-source spectrum, and the green trace is off source. In the 0-600 MHz stop-band the spectra are replotted with 100 times the vertical scale.

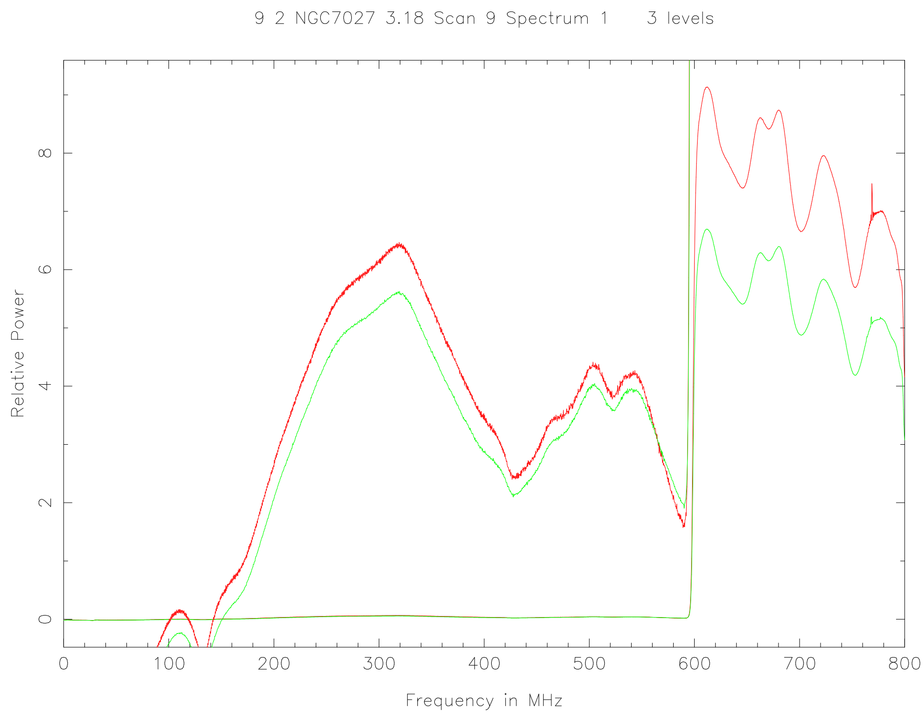

Figure 11: Scans 9-10: On and off total power spectra for the continuum source NGC 7027 using spectrometer bank B input J3 and a 200 MHz anti-alias filter in the analog filter module. The red trace is the on-source spectrum, and the green trace is off source. In the 0-600 MHz stop-band the spectra are replotted with 100 times the vertical scale.

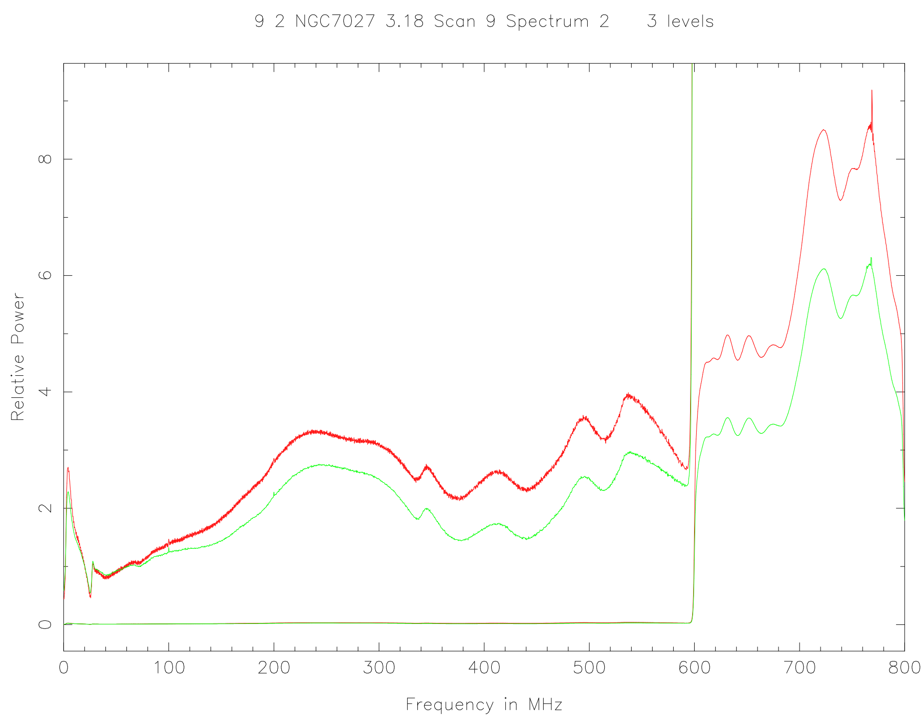

Figure 12: Scans 9-10: On and off total power spectra for the continuum source NGC 7027 using spectrometer bank B input J4 and a 200 MHz anti-alias filter in the analog filter module. The red trace is the on-source spectrum, and the green trace is off source. In the 0-600 MHz stop-band the spectra are replotted with 100 times the vertical scale.

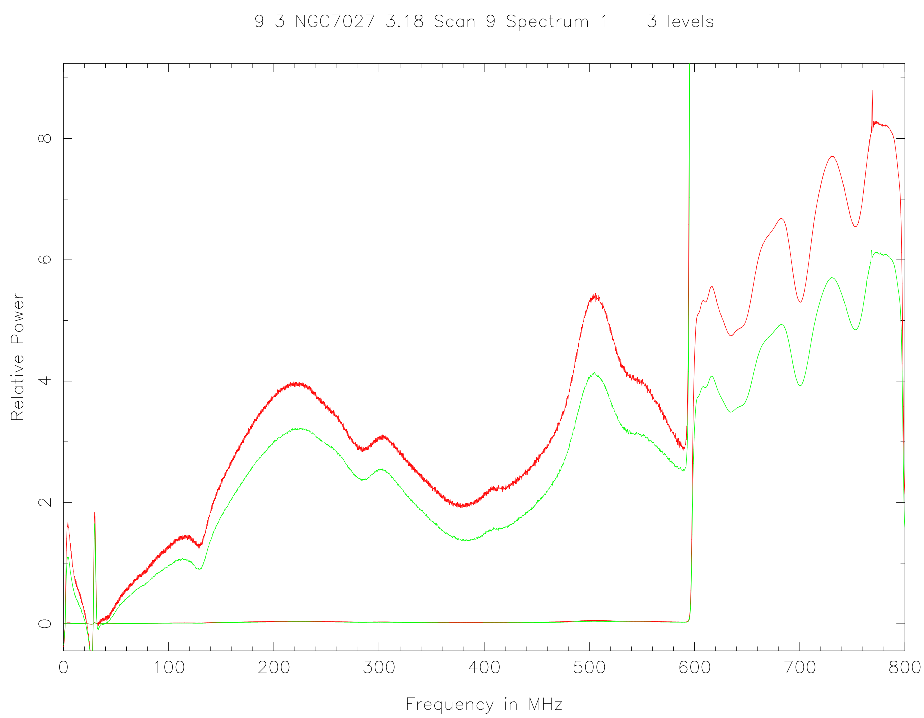

Figure 13: Scans 9-10: On and off total power spectra for the continuum source NGC 7027 using spectrometer bank C input J5 and a 200 MHz anti-alias filter in the analog filter module. The red trace is the on-source spectrum, and the green trace is off source. In the 0-600 MHz stop-band the spectra are replotted with 100 times the vertical scale.

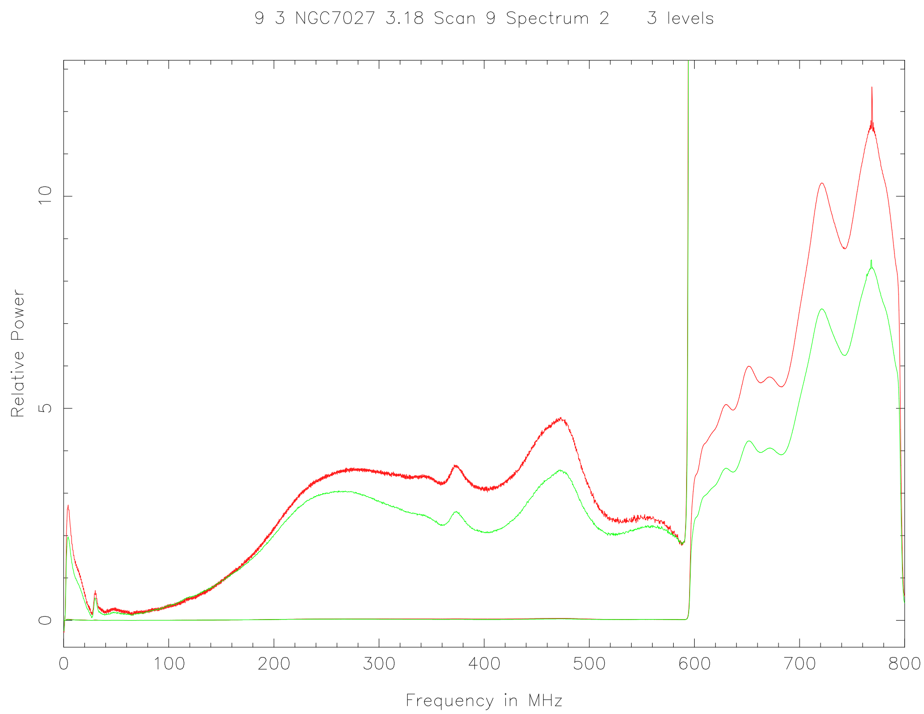

Figure 14: Scans 9-10: On and off total power spectra for the continuum source NGC 7027 using spectrometer bank C input J6 and a 200 MHz anti-alias filter in the analog filter module. The red trace is the on-source spectrum, and the green trace is off source. In the 0-600 MHz stop-band the spectra are replotted with 100 times the vertical scale.

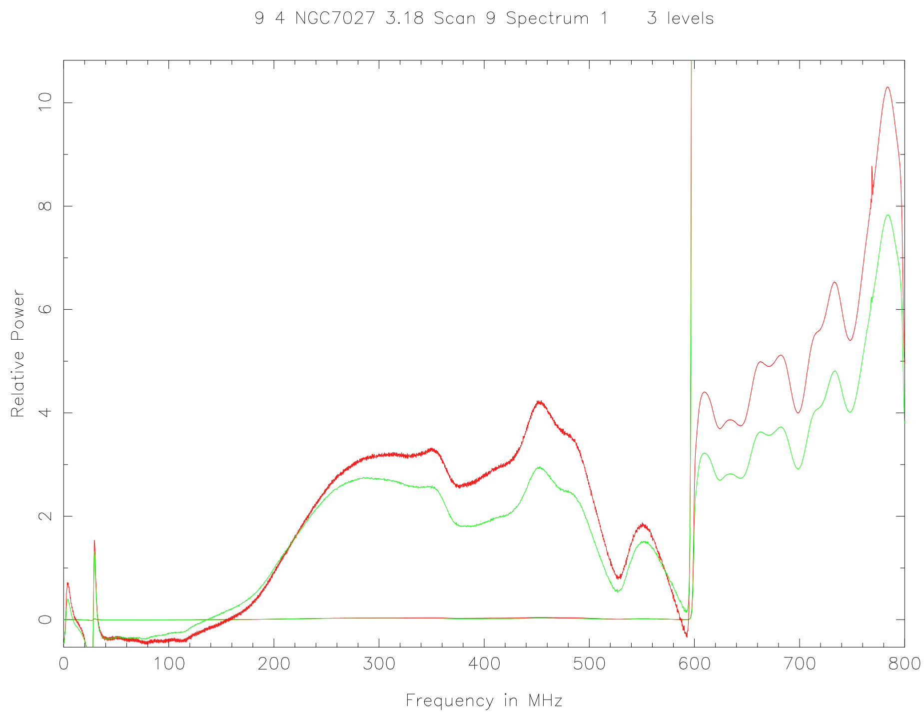

Figure 15: Scans 9-10: On and off total power spectra for the continuum source NGC 7027 using spectrometer bank D input J7 and a 200 MHz anti-alias filter in the analog filter module. The red trace is the on-source spectrum, and the green trace is off source. In the 0-600 MHz stop-band the spectra are replotted with 100 times the vertical scale.

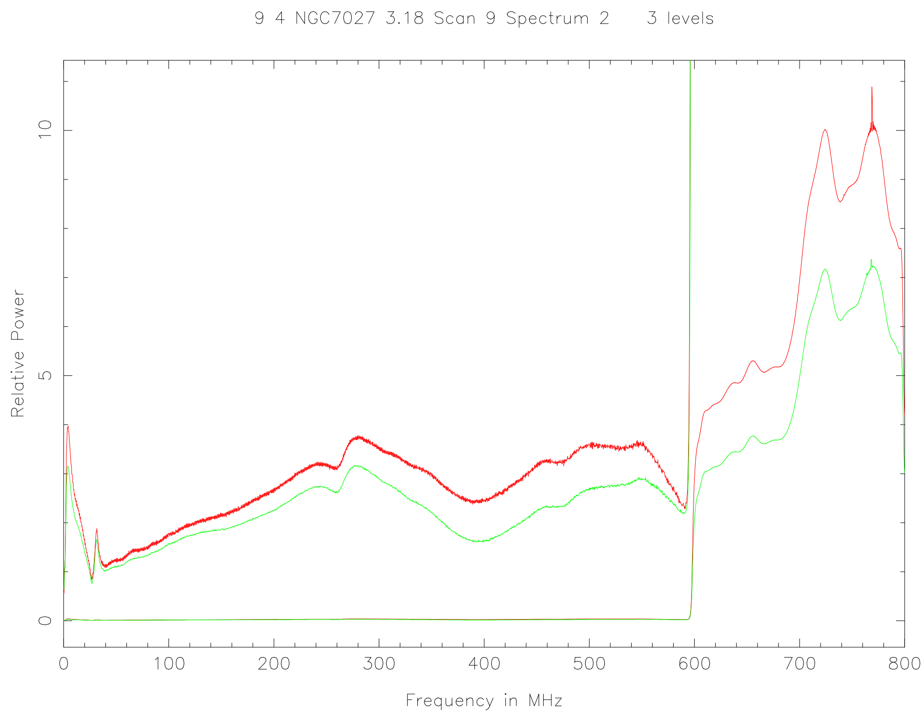

Figure 16: Scans 9-10: On and off total power spectra for the continuum source NGC 7027 using spectrometer bank D input J8 and a 200 MHz anti-alias filter in the analog filter module. The red trace is the on-source spectrum, and the green trace is off source. In the 0-600 MHz stop-band the spectra are replotted with 100 times the vertical scale.

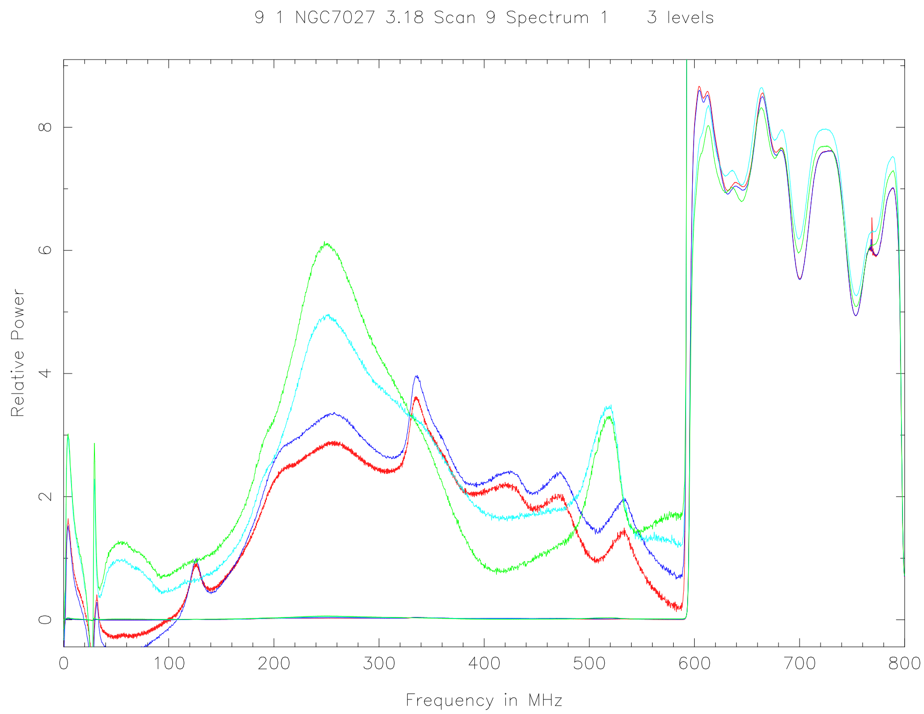

Figure 17: Scans 9-10: Comparison of the October 29 and December 11 data of the on and off total power spectra for the continuum source NGC 7027 using spectrometer bank A, input J1 and a 200 MHz anti-alias filter in the analog filter module. The red trace is the on-source spectrum, and the dark blue trace is off source from December. The blue-green trace is the on-source spectrum, and the green trace is off source from October. The December spectra were taken with a modified sampler. The spectra have been scaled to match the power in the 600-800 MHz filter passband as closely as possible. In the 0-600 MHz stop-band the spectra are replotted with 100 times the vertical scale.

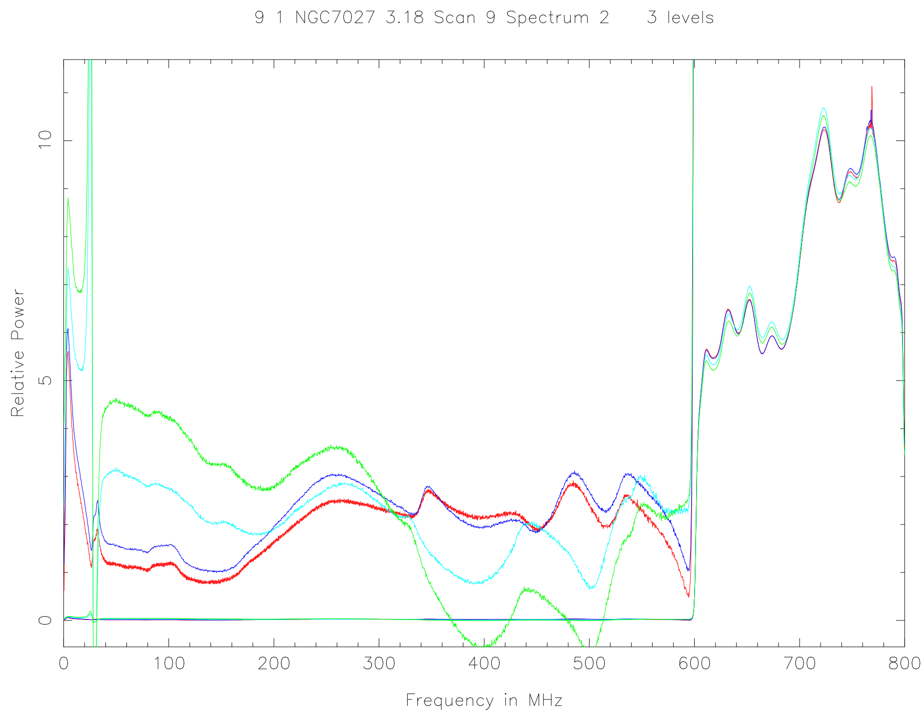

Figure 18: Scans 9-10: Comparison of the October 29 and December 11 data of the on and off total power spectra for the continuum source NGC 7027 using spectrometer bank A, input J2 and a 200 MHz anti-alias filter in the analog filter module. The red trace is the on-source spectrum, and the dark blue trace is off source from December. The blue-green trace is the on-source spectrum, and the green trace is off source from October. The December spectra were taken with an unmodified sampler. The spectra have been scaled to match the power in the 600-800 MHz filter passband as closely as possible. In the 0-600 MHz stop-band the spectra are replotted with 100 times the vertical scale.

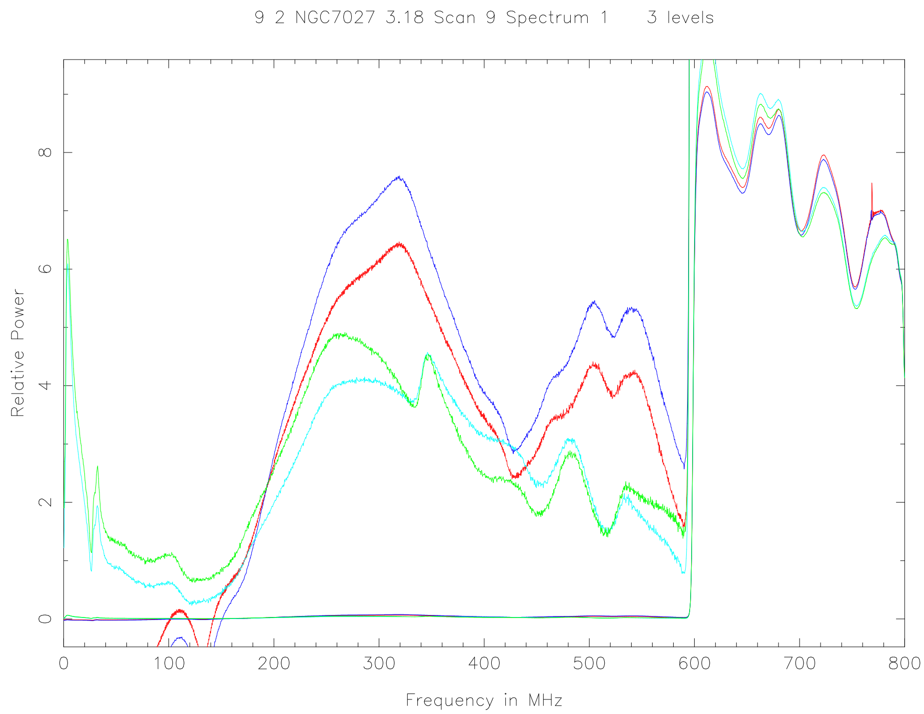

Figure 19: Scans 9-10: Comparison of the October 29 and December 11 data of the on and off total power spectra for the continuum source NGC 7027 using spectrometer bank B, input J3 and a 200 MHz anti-alias filter in the analog filter module. The red trace is the on-source spectrum, and the dark blue trace is off source from December. The blue-green trace is the on-source spectrum, and the green trace is off source from October. The December spectra were taken with a modified sampler. The spectra have been scaled to match the power in the 600-800 MHz filter passband as closely as possible. In the 0-600 MHz stop-band the spectra are replotted with 100 times the vertical scale.

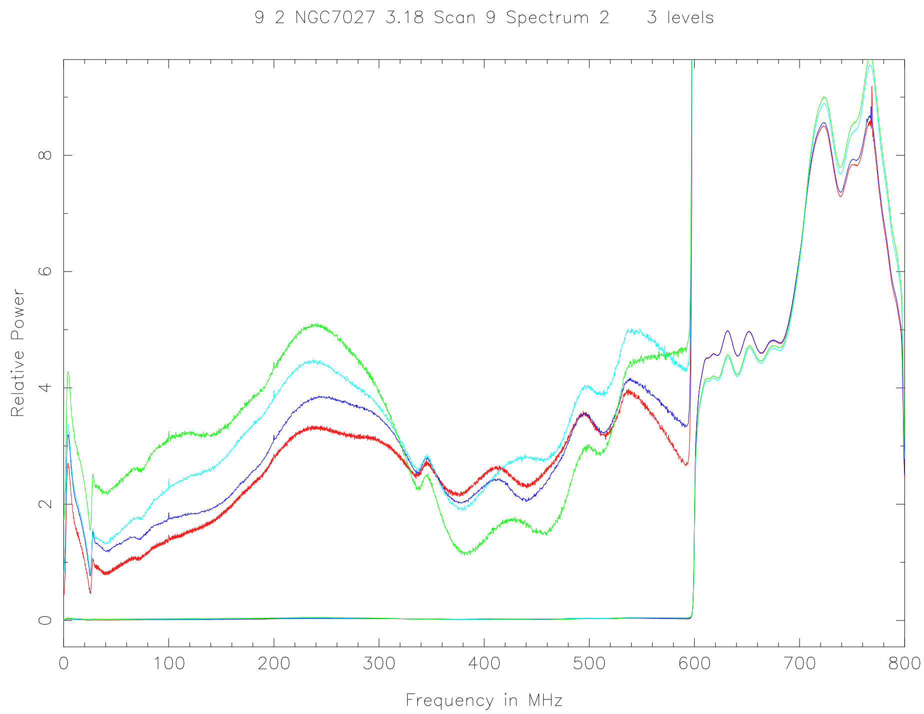

Figure 20: Scans 9-10: Comparison of the October 29 and December 11 data of the on and off total power spectra for the continuum source NGC 7027 using spectrometer bank B, input J4 and a 200 MHz anti-alias filter in the analog filter module. The red trace is the on-source spectrum, and the dark blue trace is off source from December. The blue-green trace is the on-source spectrum, and the green trace is off source from October. The December spectra were taken with an unmodified sampler. The spectra have been scaled to match the power in the 600-800 MHz filter passband as closely as possible. In the 0-600 MHz stop-band the spectra are replotted with 100 times the vertical scale.

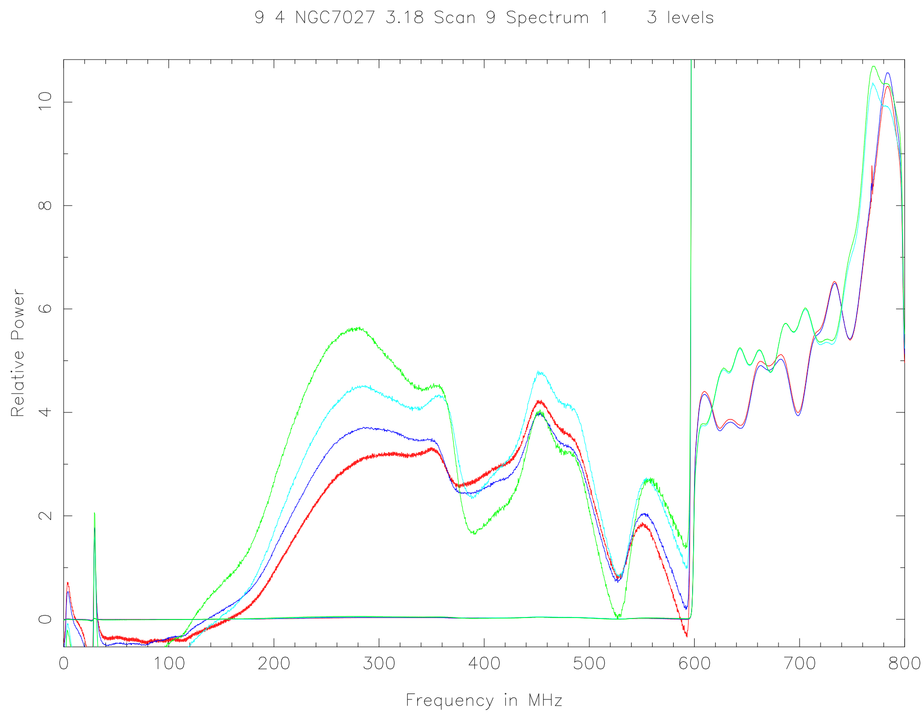

Figure 21: Scans 9-10: Comparison of the October 29 and December 11 data of the on and off total power spectra for the continuum source NGC 7027 using spectrometer bank D, input J7 and a 200 MHz anti-alias filter in the analog filter module. The red trace is the on-source spectrum, and the dark blue trace is off source from December. The blue-green trace is the on-source spectrum, and the green trace is off source from October. The December spectra were taken with an unmodified sampler. The spectra have been scaled to match the power in the 600-800 MHz filter passband as closely as possible. In the 0-600 MHz stop-band the spectra are replotted with 100 times the vertical scale.

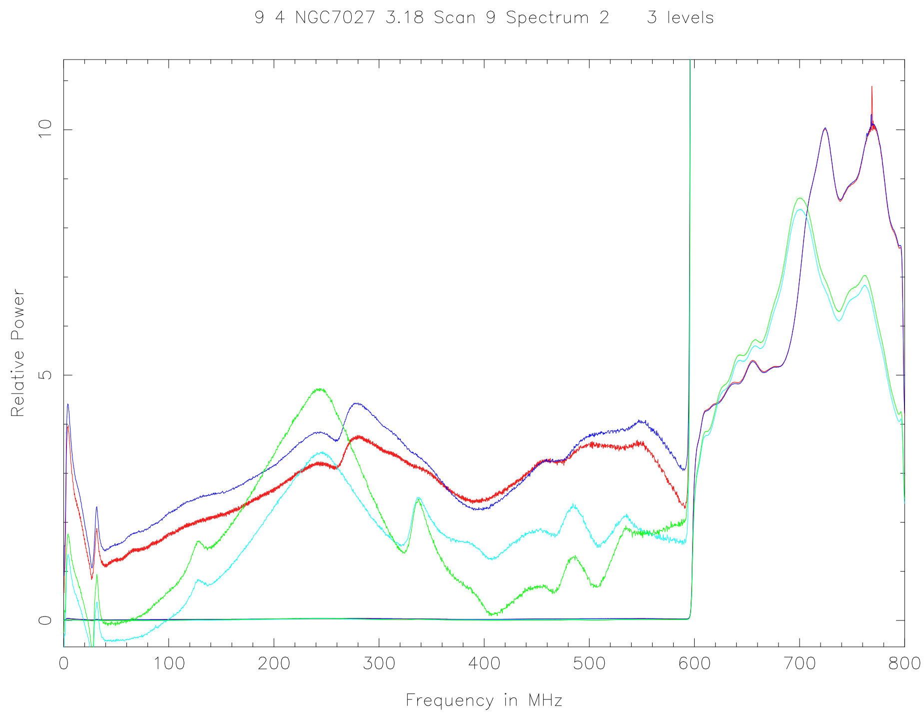

Figure 22: Scans 9-10: Comparison of the October 29 and December 11 data of the on and off total power spectra for the continuum source NGC 7027 using spectrometer bank D, input J8 and a 200 MHz anti-alias filter in the analog filter module. The red trace is the on-source spectrum, and the dark blue trace is off source from December. The blue-green trace is the on-source spectrum, and the green trace is off source from October. The December spectra were taken with an unmodified sampler. The spectra have been scaled to match the power in the 600-800 MHz filter passband as closely as possible. In the 0-600 MHz stop-band the spectra are replotted with 100 times the vertical scale.