# GBT Spectral Baseline Investigation

Rick Fisher, Roger Norrod, Dana Balser (G. Watts, M. Stennes)

## Points to Note:

Wider bandwidths than were used on 140 Foot

Cleaner antenna so other effects show up

Larger antenna: 1. Reflections have longer paths
2. Higher Ta on continuum sources

Our tests intentionally provoked baseline distortions

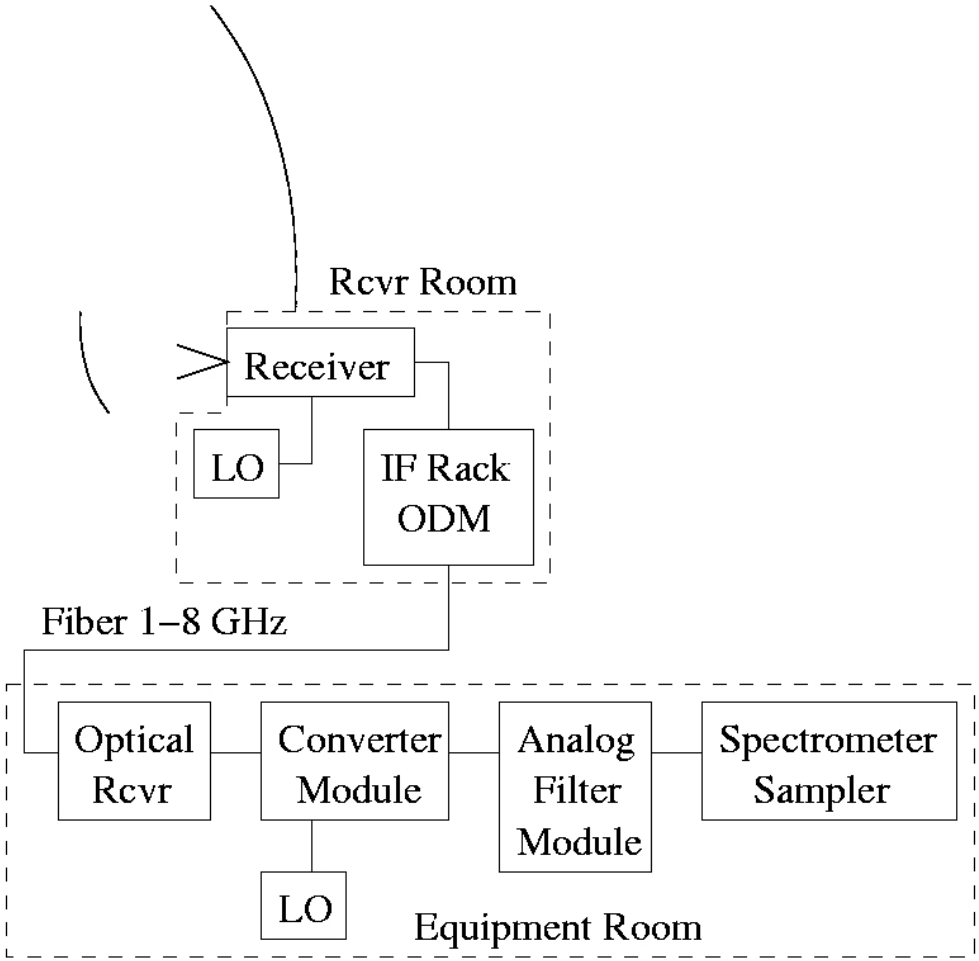
# Talk Outline

- Baseline Distortion Points
  - Antenna
  - Receivers
  - IF system
  - Spectrometers
  - RFI
- Observing Strategies
- Continuing Work

# Total Power Observations

$$\frac{\text{“ON” - “OFF”}}{\text{“OFF”}} = \frac{G_{src}(f) * T_{src}(f)}{G_{sys}(f) * T_{sys}(f)}$$

# System Block Diagram



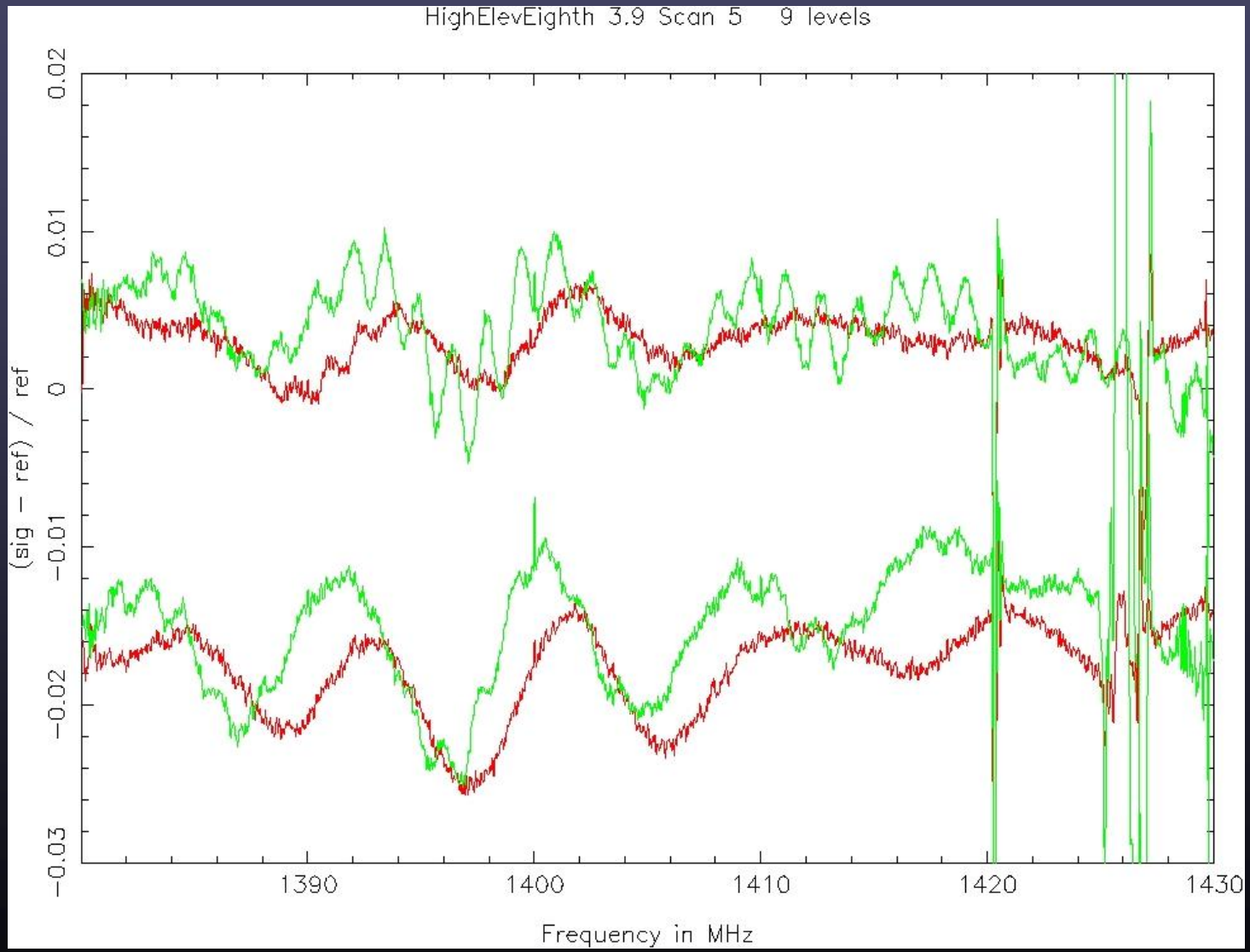
# Antenna Noise Spectrum

Background

Atmosphere

Spillover

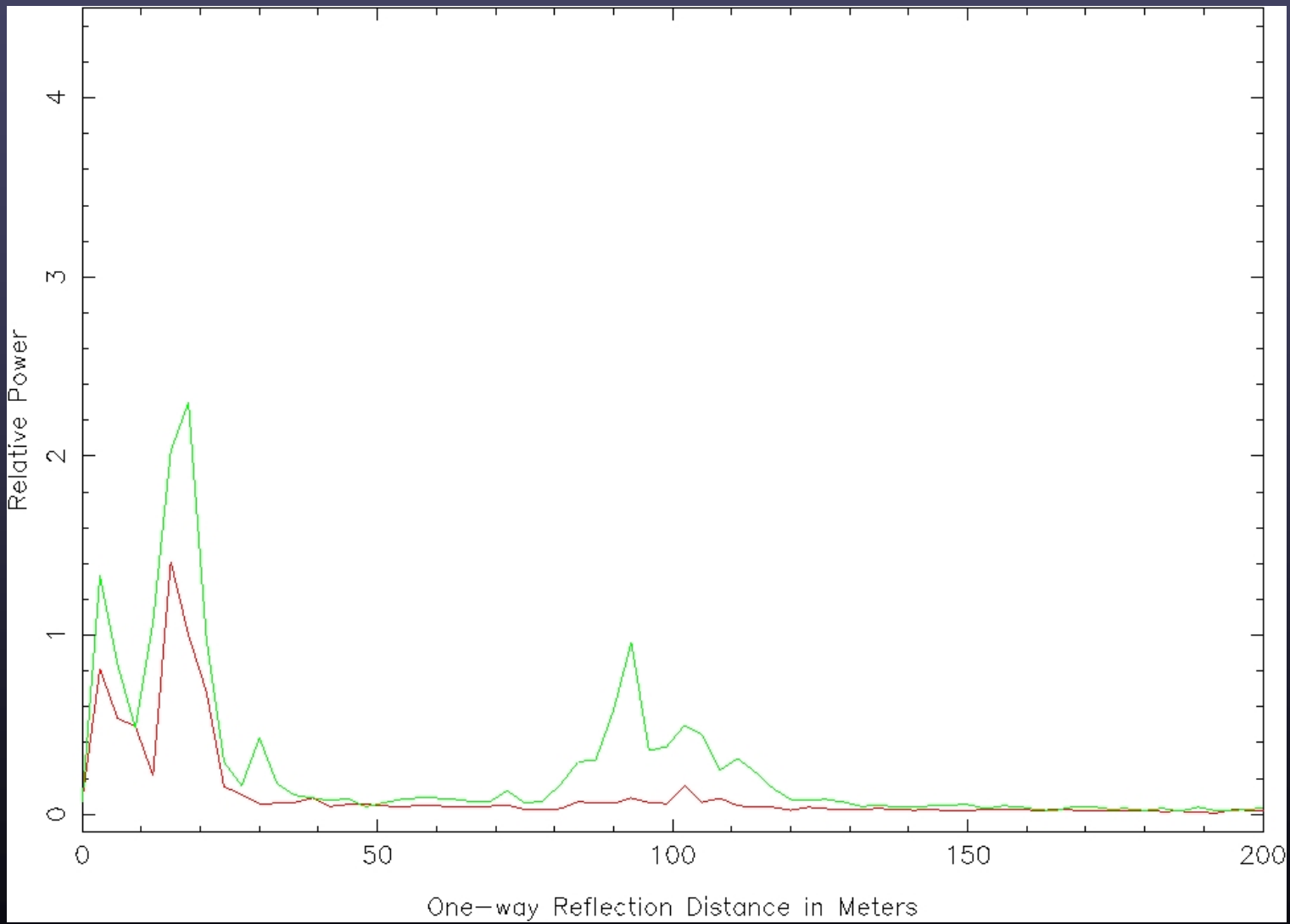
## (ON - OFF) / OFF Spectra (1.4 GHz)
## Sub-reflector has been displaced for ON scan
## Red: horizontal pol'n; Green : vertical pol'n



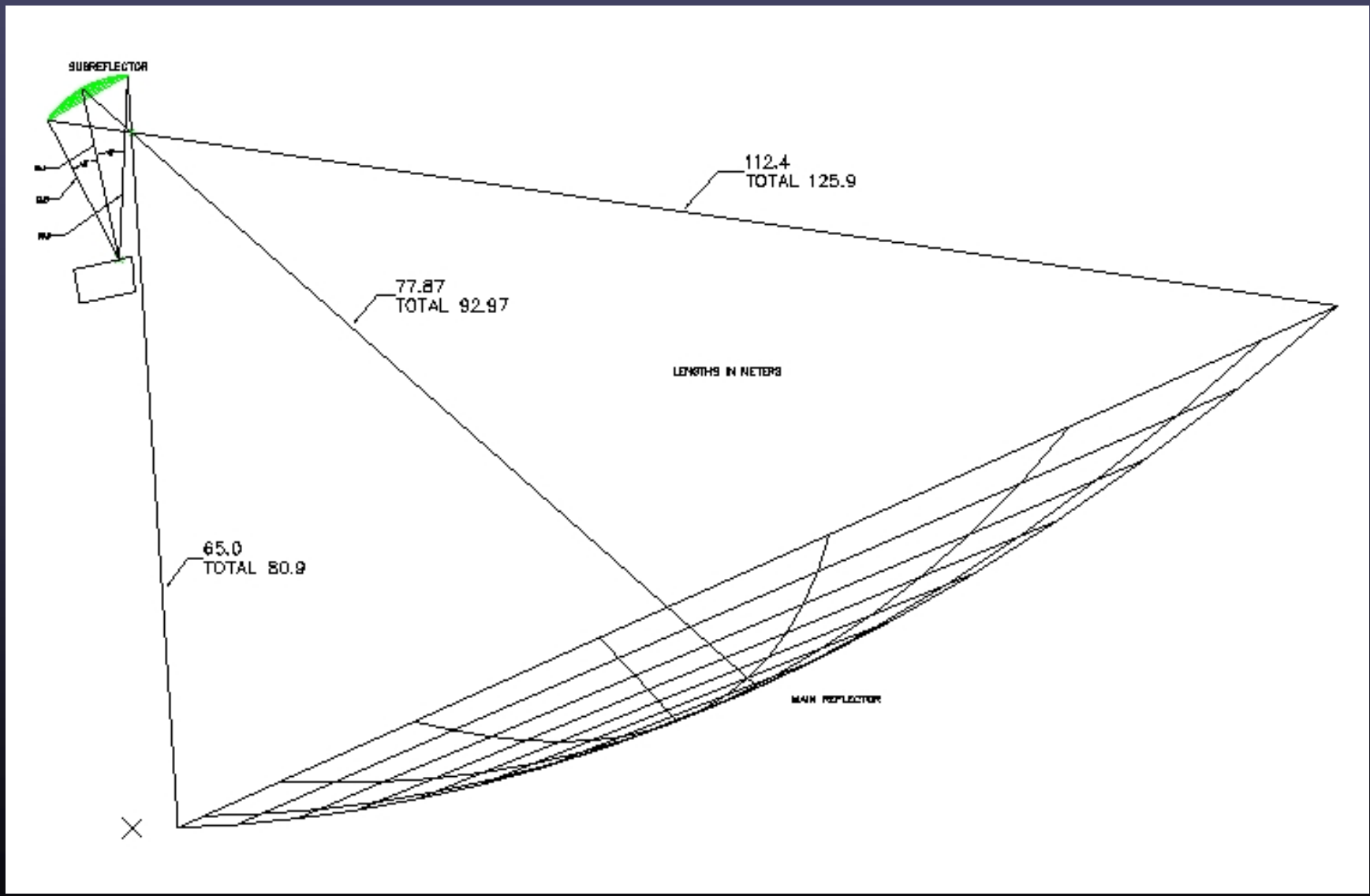

$\lambda/8$

$\lambda/4$

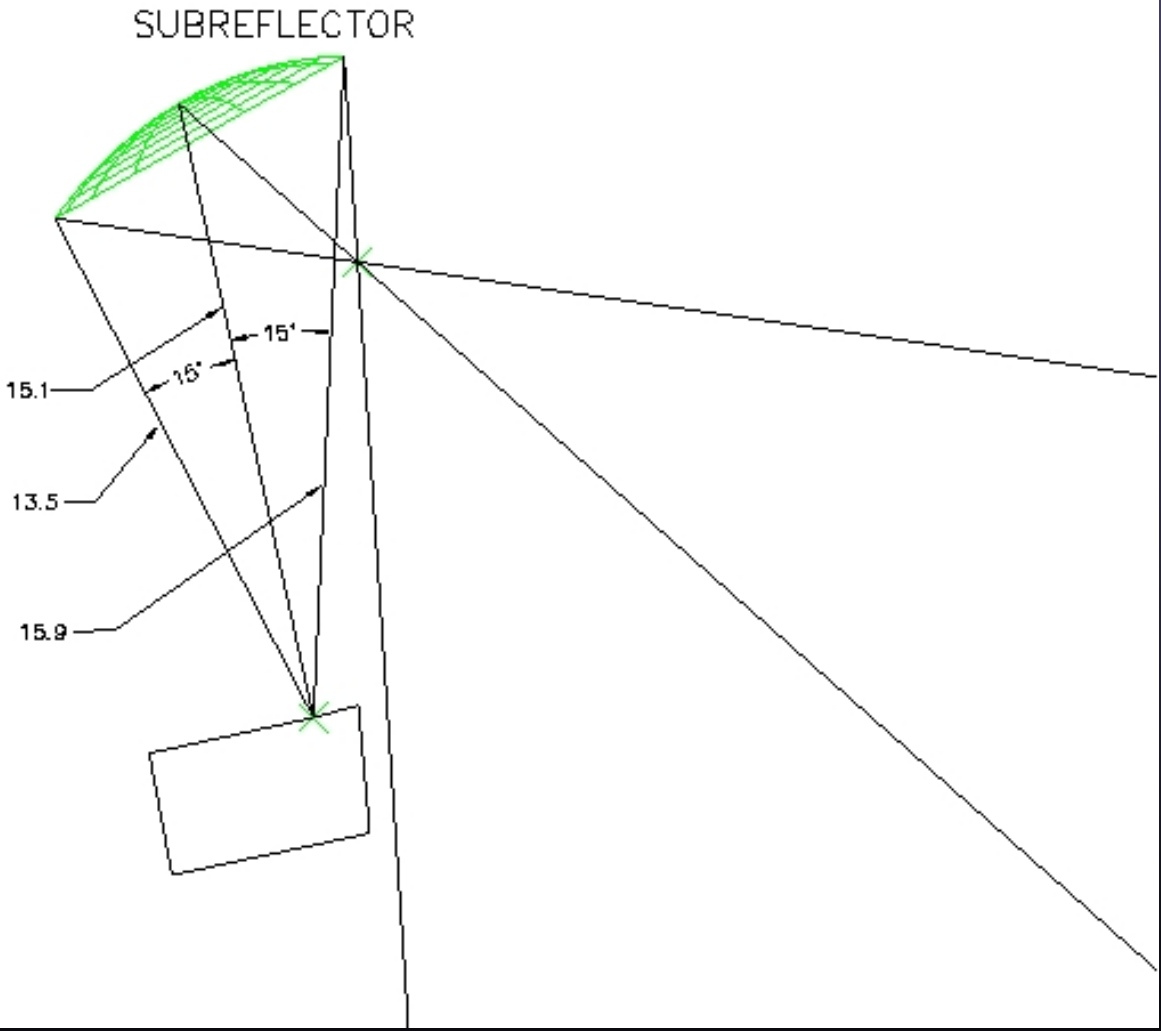
# Periodogram of 1/8-wavelength Sub-reflector Displacement Spectra (1.4 GHz)
# Red: horizontal pol'n,  Green: vertical pol'n



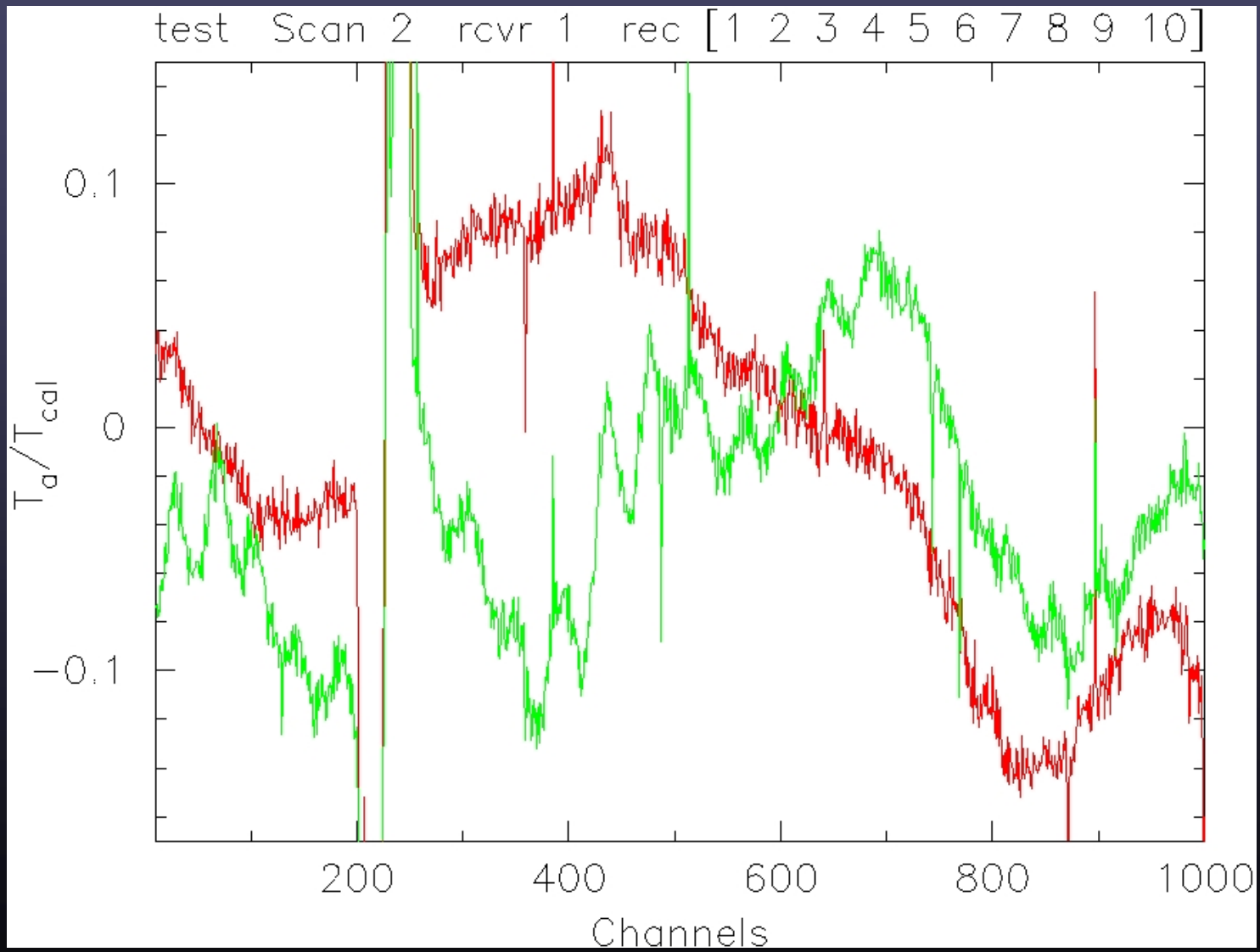
# GBT Geometry



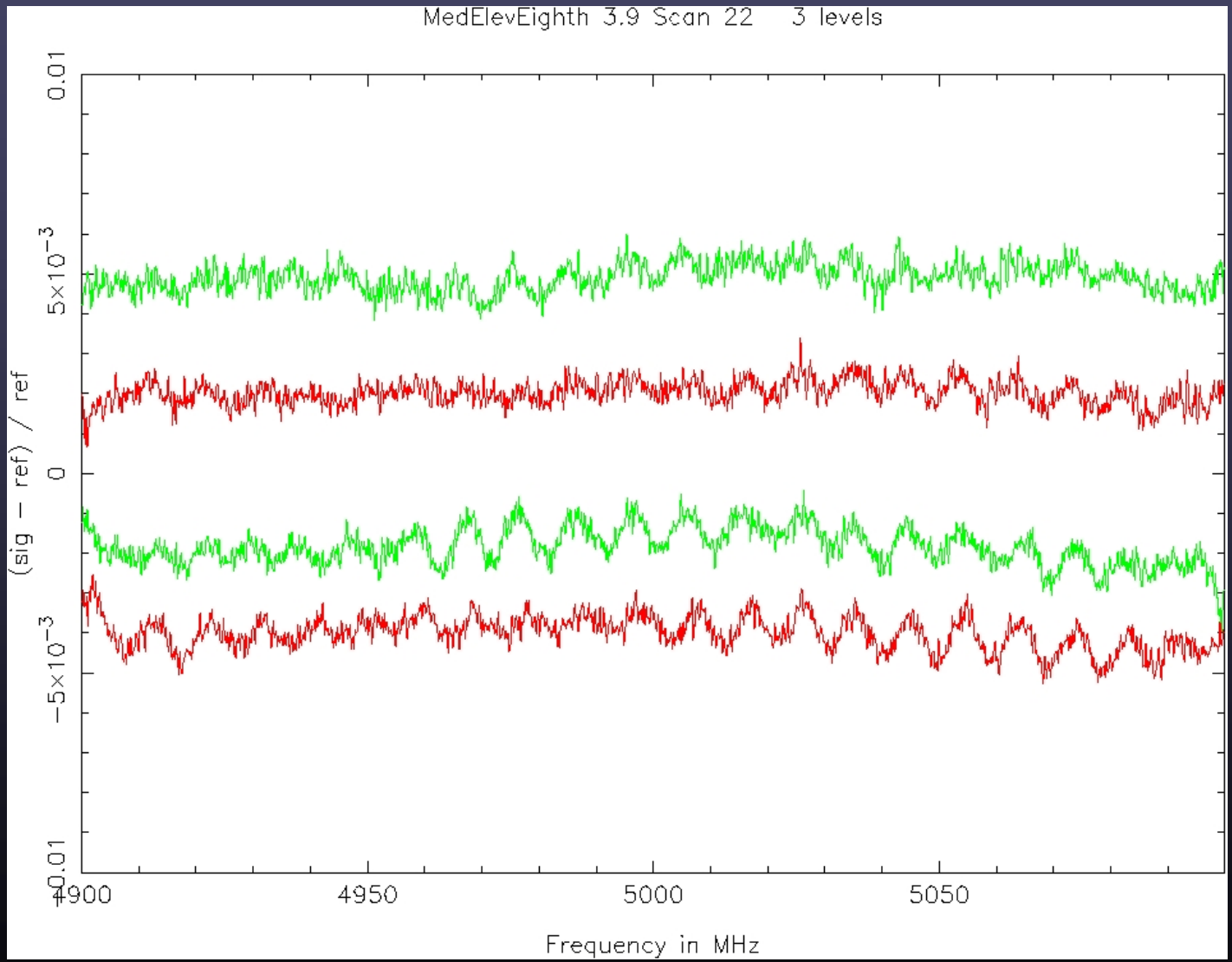
# GBT Sub-reflector Geometry



# 21-cm Frequency Switched Spectrum (Ta/Tsys) (BW = 40 MHz; Delta-f = 1 MHz)



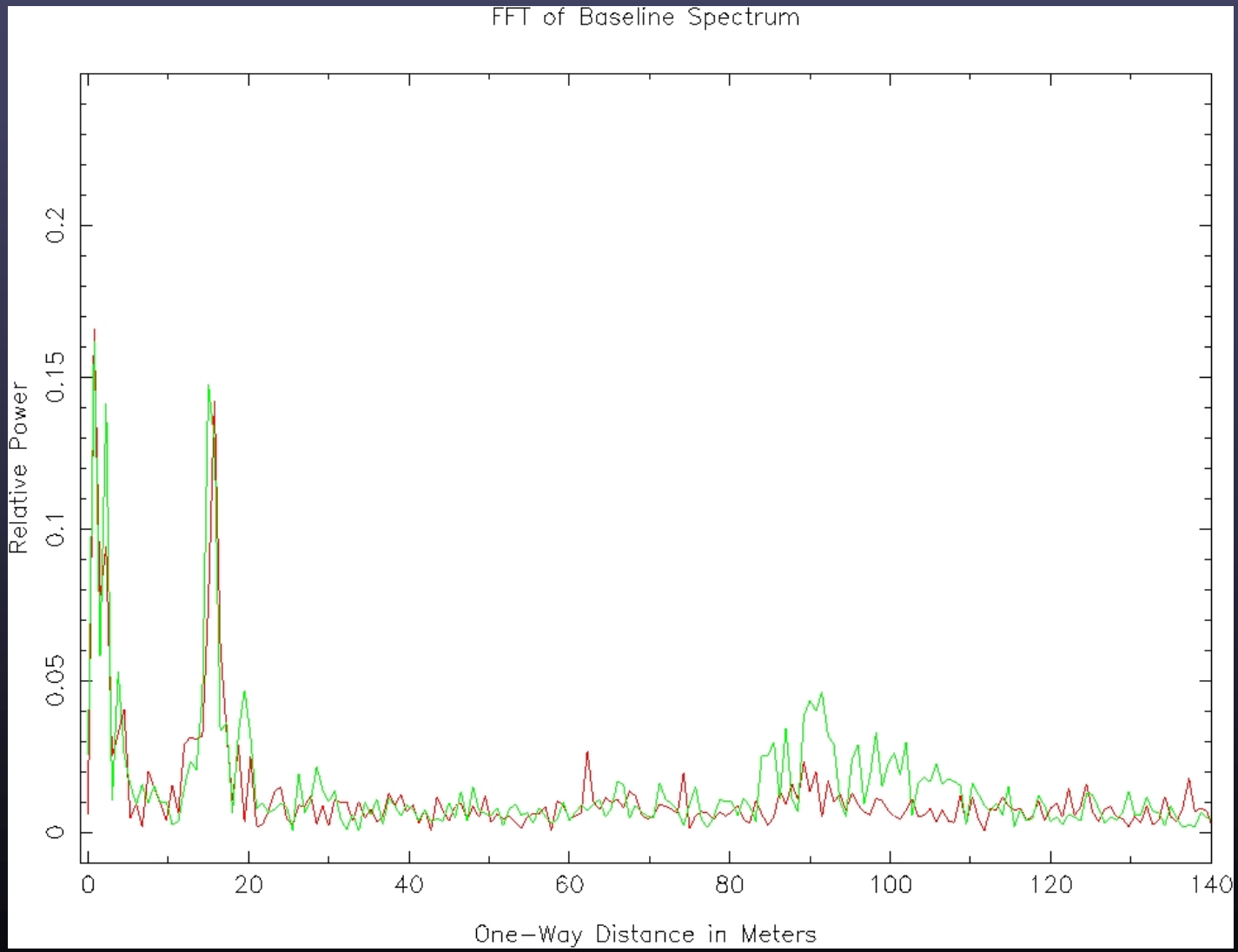
## (ON – OFF)/OFF Spectra (5 Ghz)
## Sub-reflector has been Displaced for ON scan
## Red: horizontal pol'n, Green: vertical pol'n



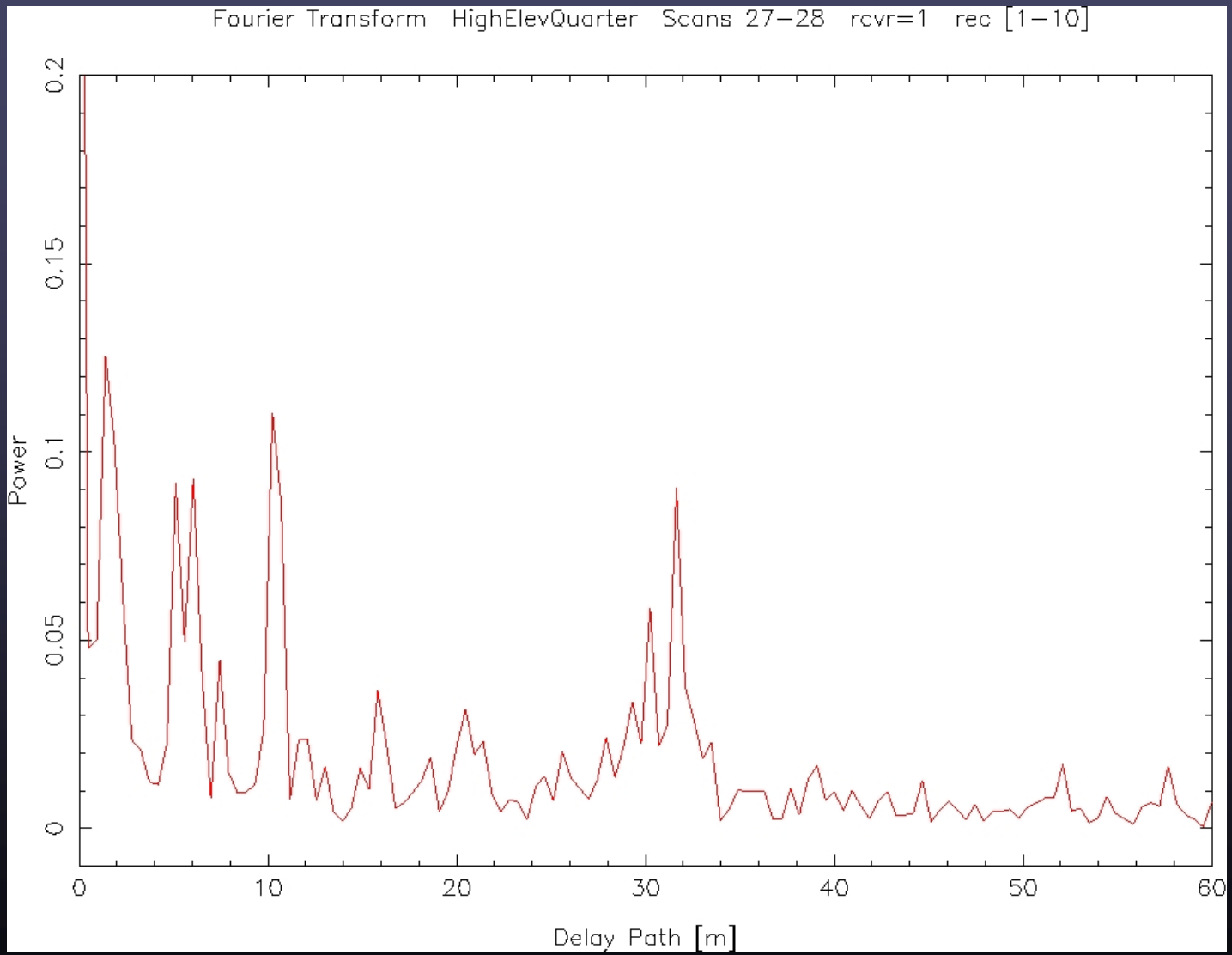

$\lambda/8$

$\lambda/4$

# Periodogram of 1/8-wavelength Sub-reflector Displacement Spectra (5 GHz)
# Red: horizontal pol'n,  Green: vertical pol'n

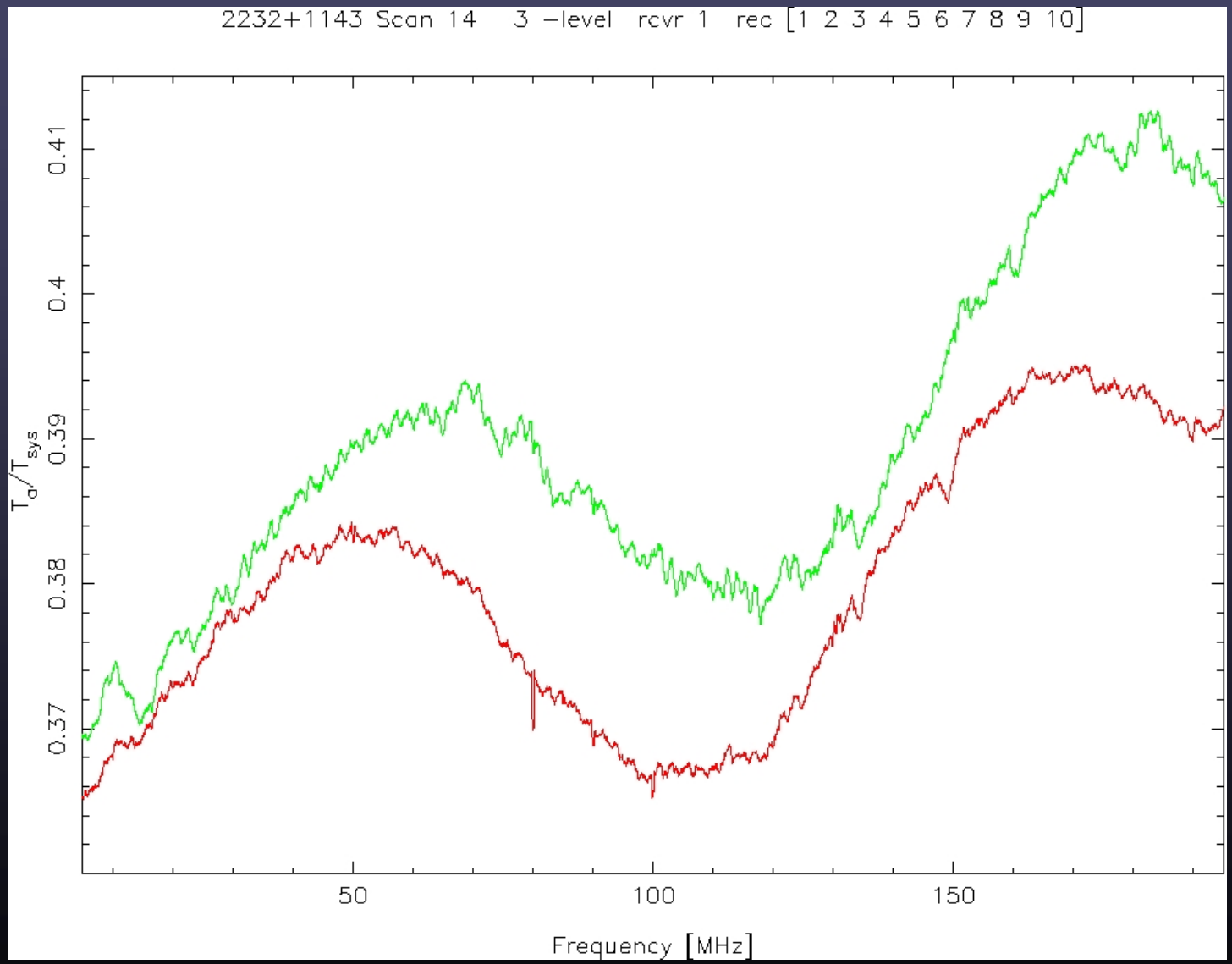


# Periodogram of 1/8-wavelength sub-reflector displacement spectra (9 GHz, BW = 800 MHz)

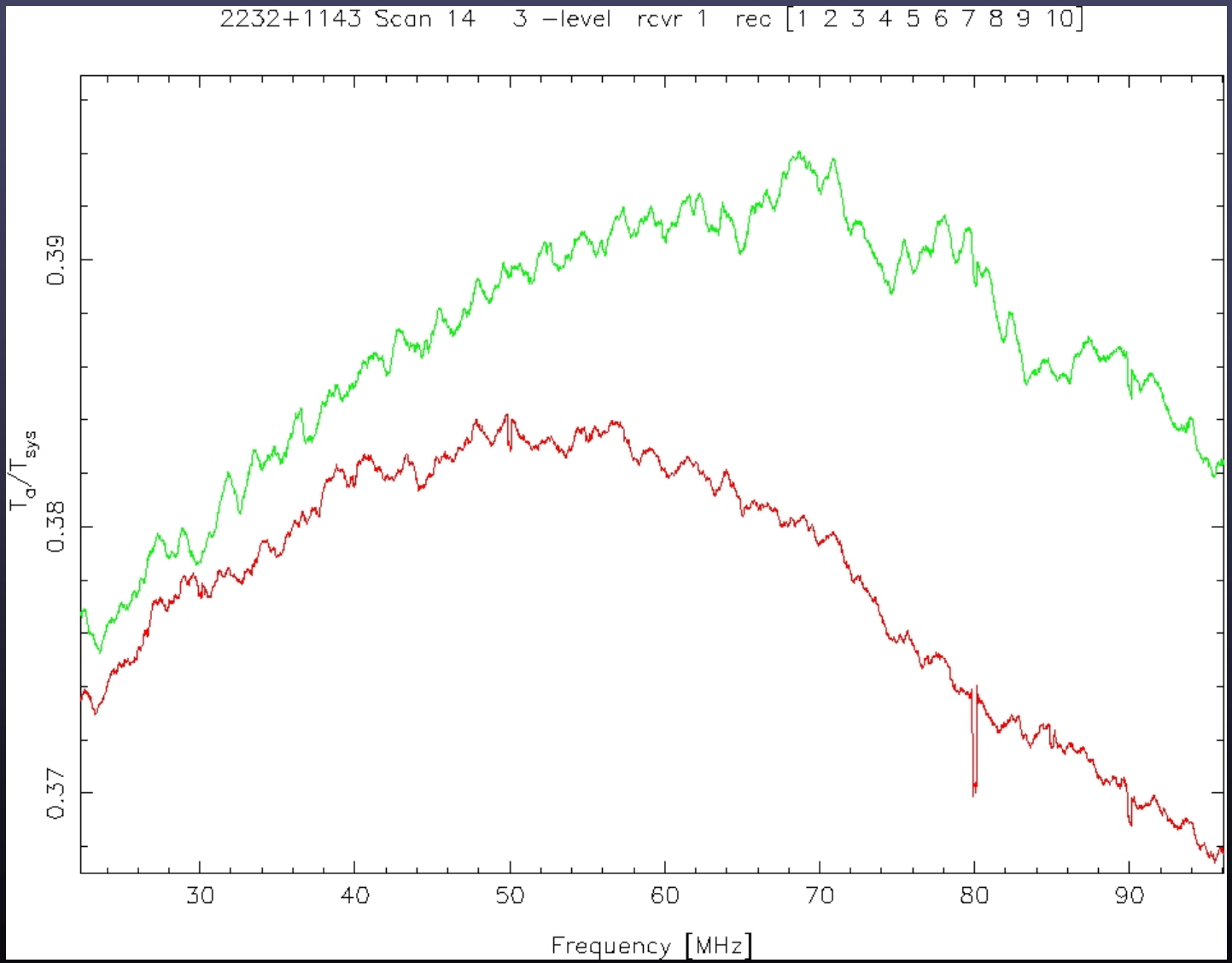


# Continuum Source Spectra

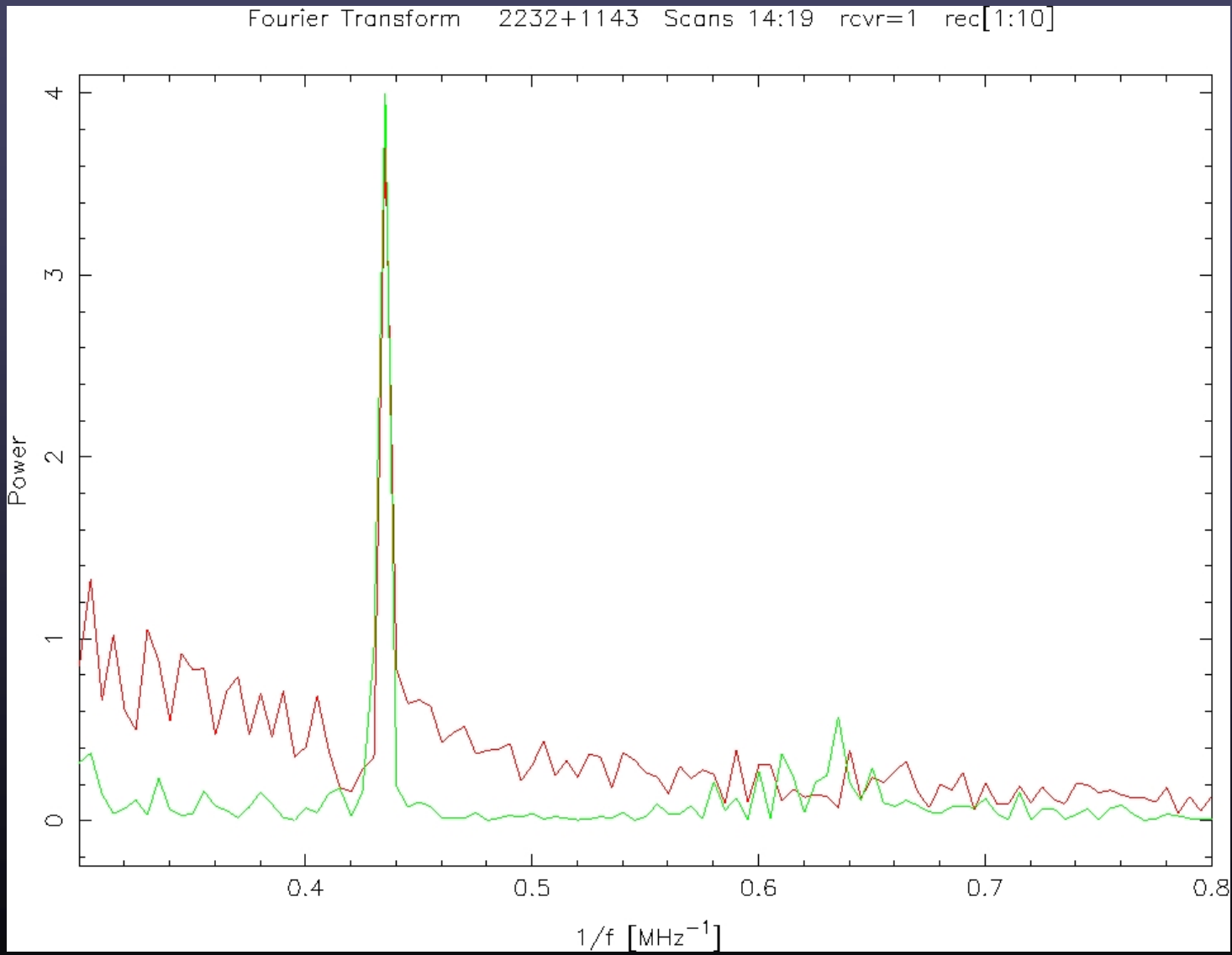
# (ON – OFF)/OFF Continuum Source Spectra (1.99 GHz; Flux = 5.7 Jy)
# Red: channel X, Green: channel Y



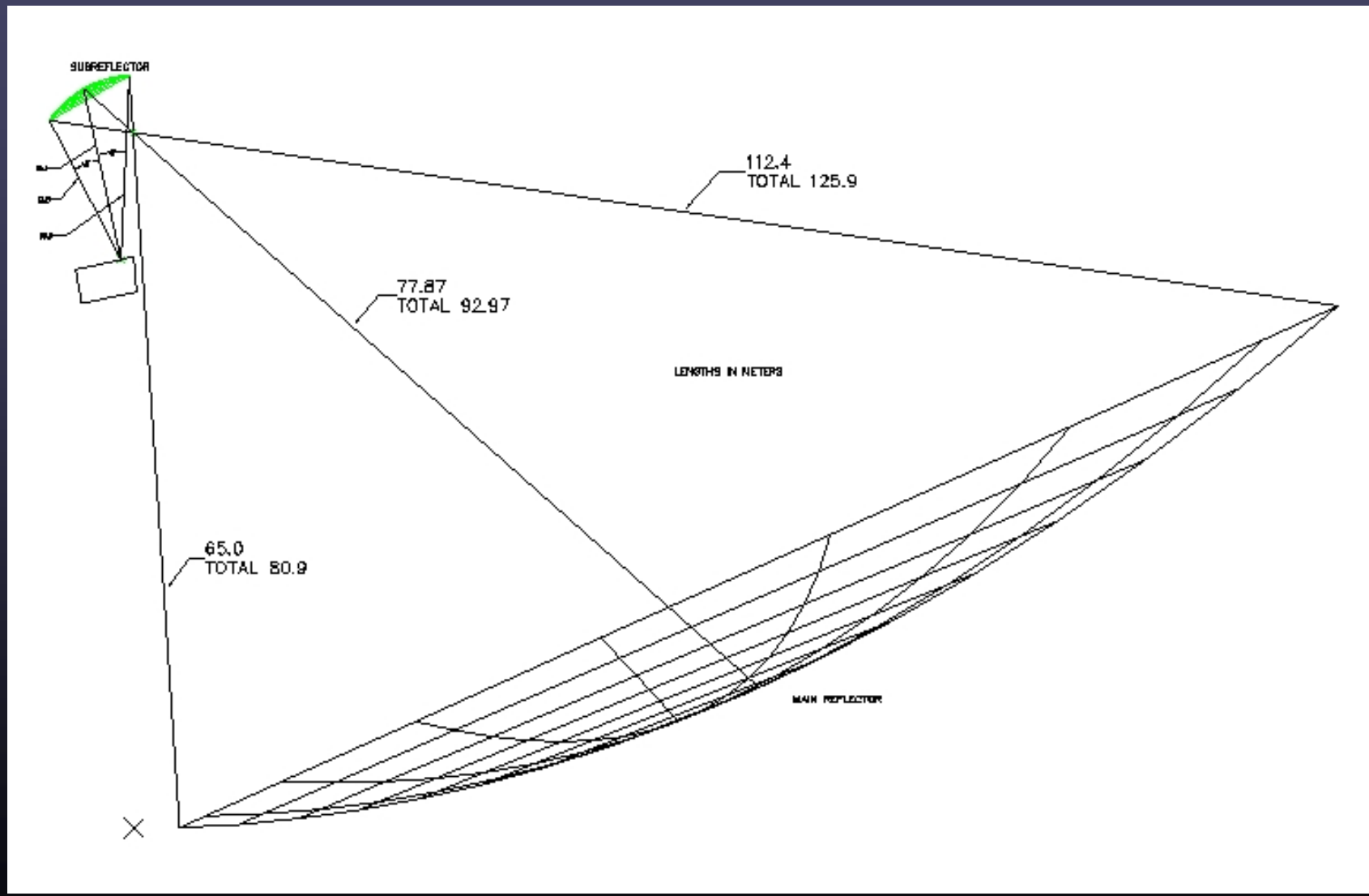
# (ON – OFF)/OFF Continuum Source Spectra (1.99 GHz, Flux=5.7 Jy)
# Red: channel X,  Green: channel Y



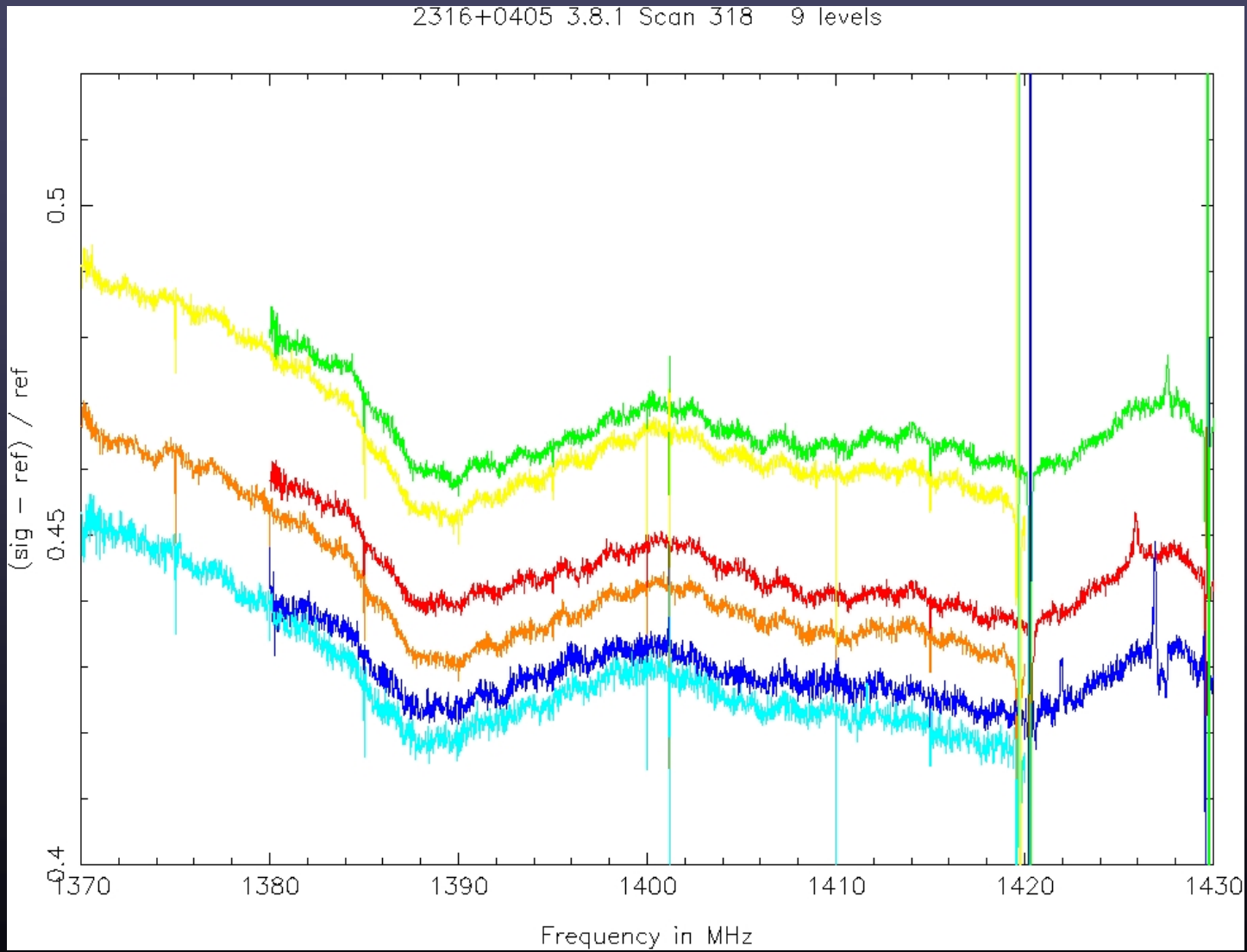
# Periodograms of Continuum Source Spectra (1.99 GHz, BW = 200 MHz)
# Red: channel X, Green: channel Y



# GBT Geometry



# (ON – OFF)/OFF Source Continuum Spectra (1.4 GHz)

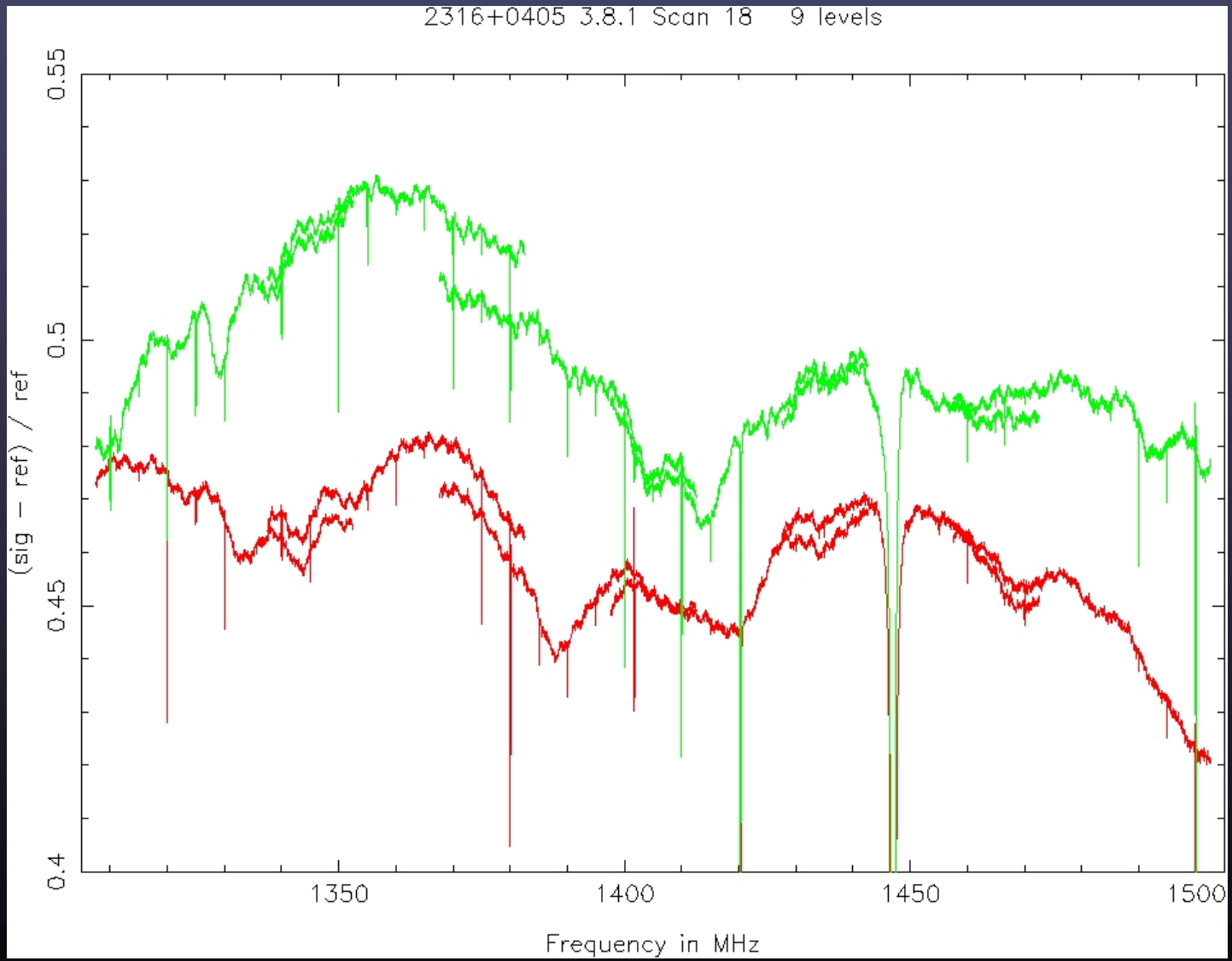



5.08 Jy

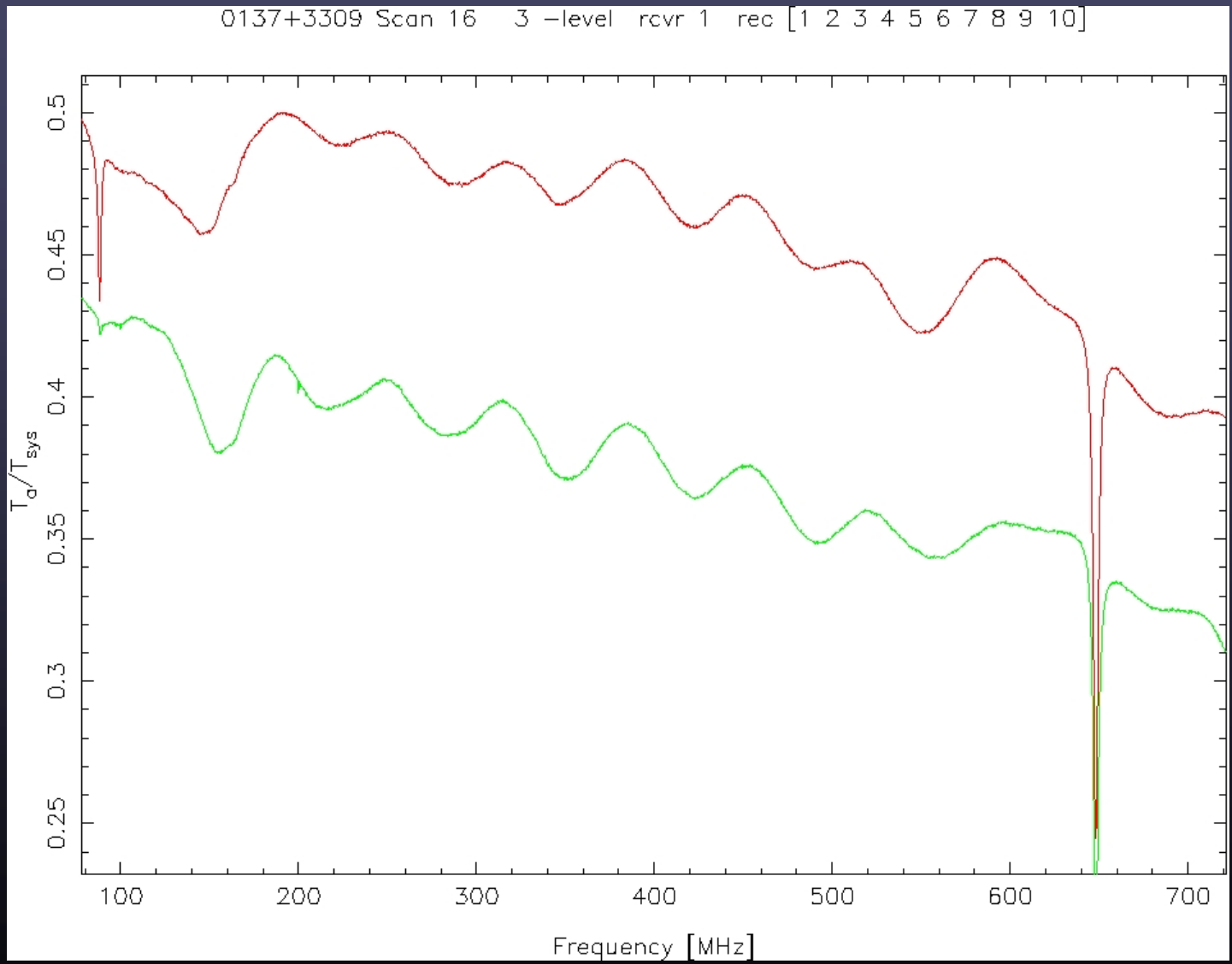
4.68 Jy

2 x 2.21 Jy

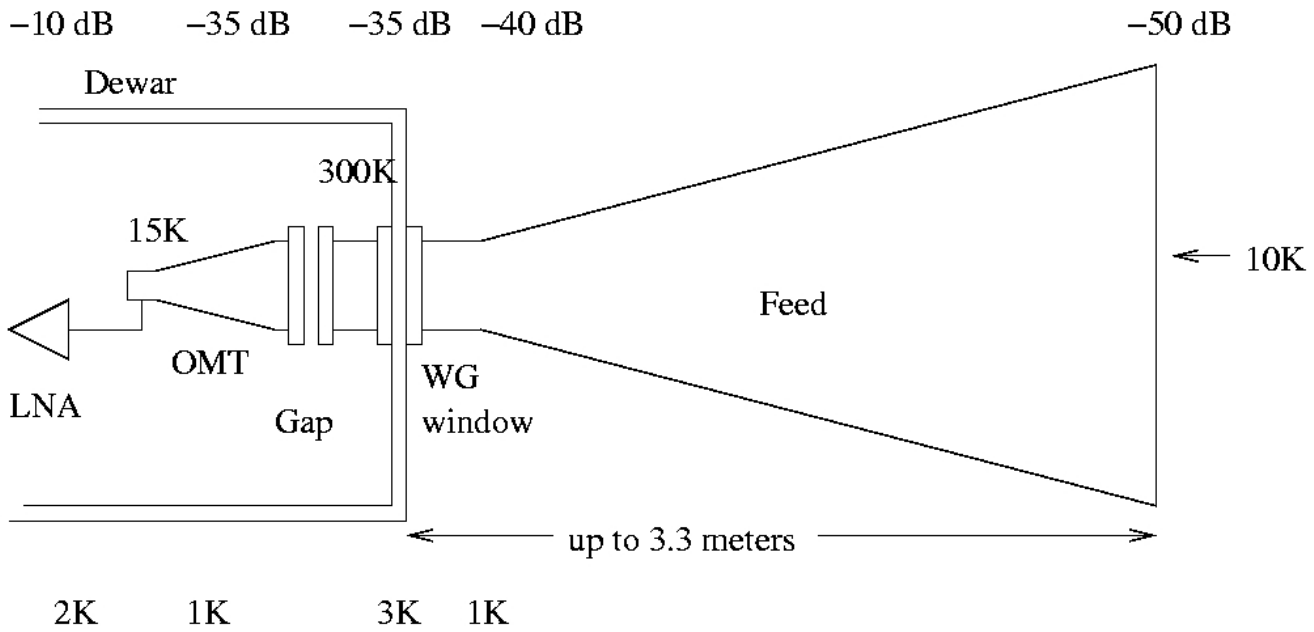
# Composite Continuum Source Spectrum (1.4 GHz, Flux = 4.68 Jy)
# Red: channel X,  Green: channel Y



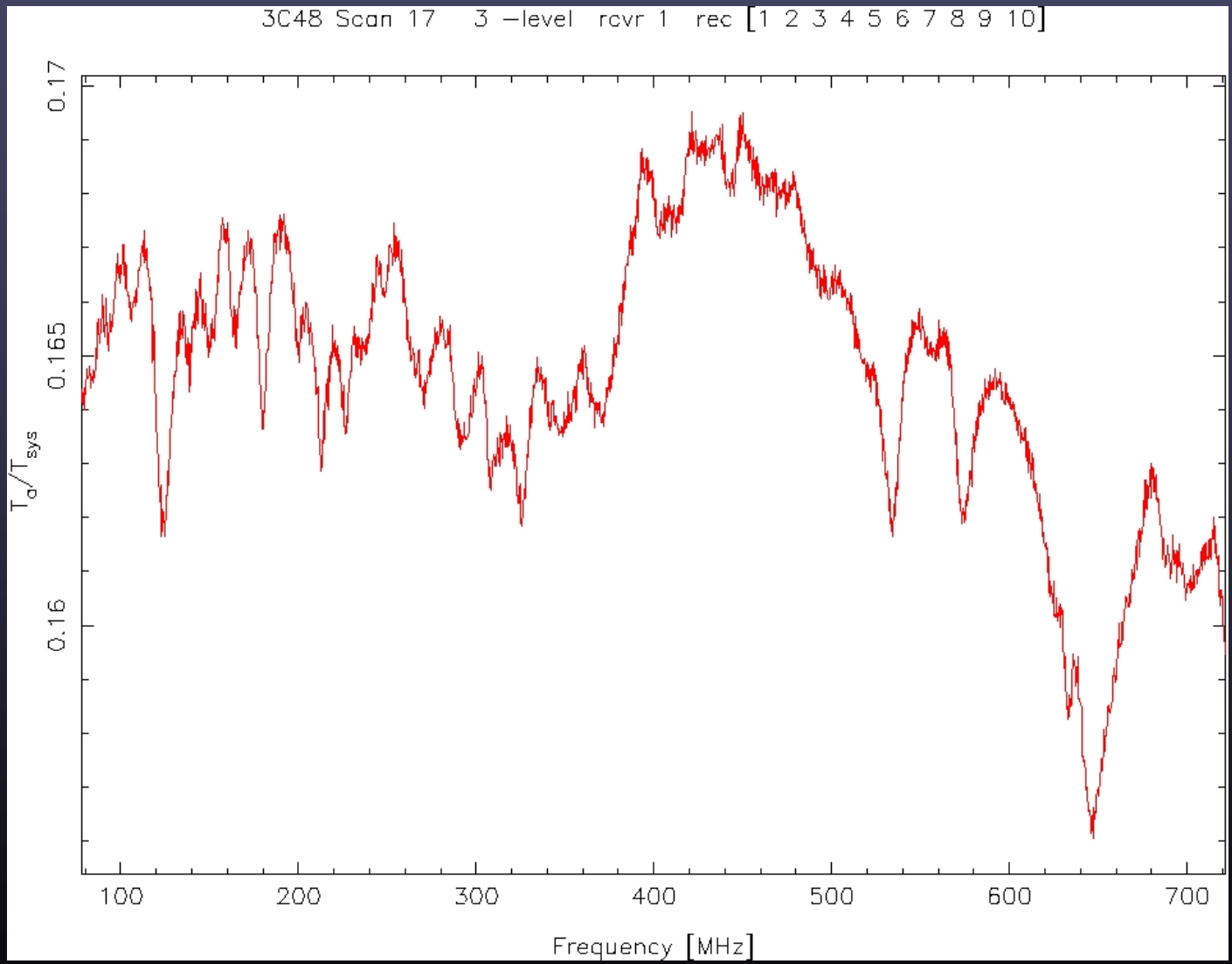
# Continuum Source Spectrum (5 GHz, Flux = ~5 Jy)
# Red: channel X, Green: channel Y



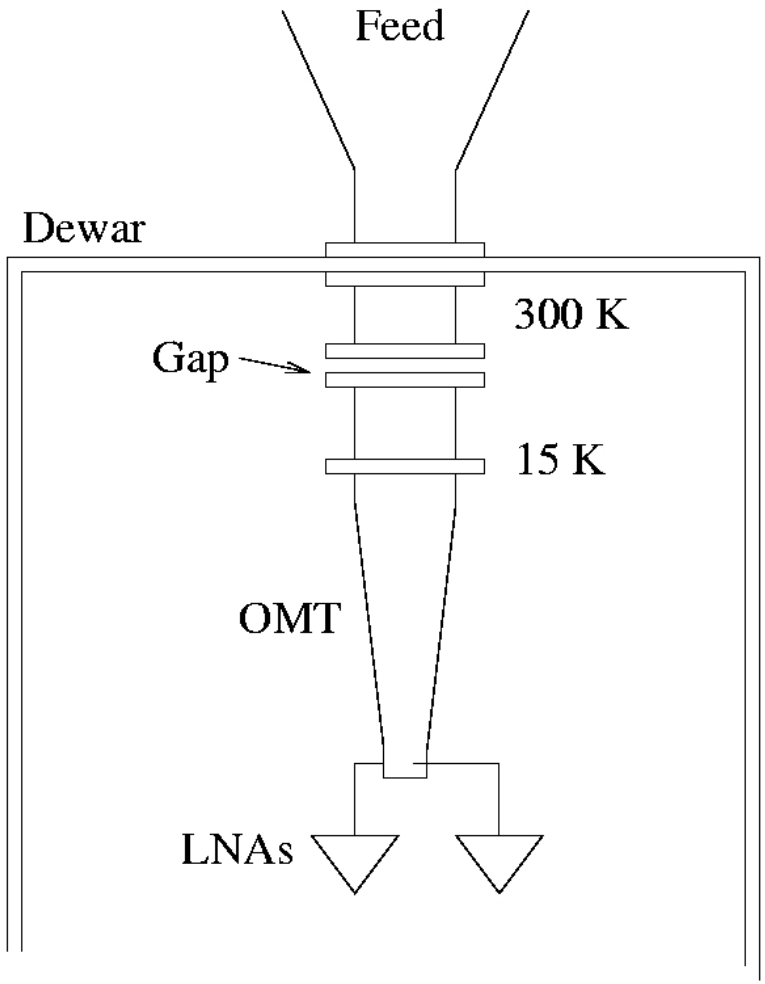
# Noise Reflections within Feed/LNA System



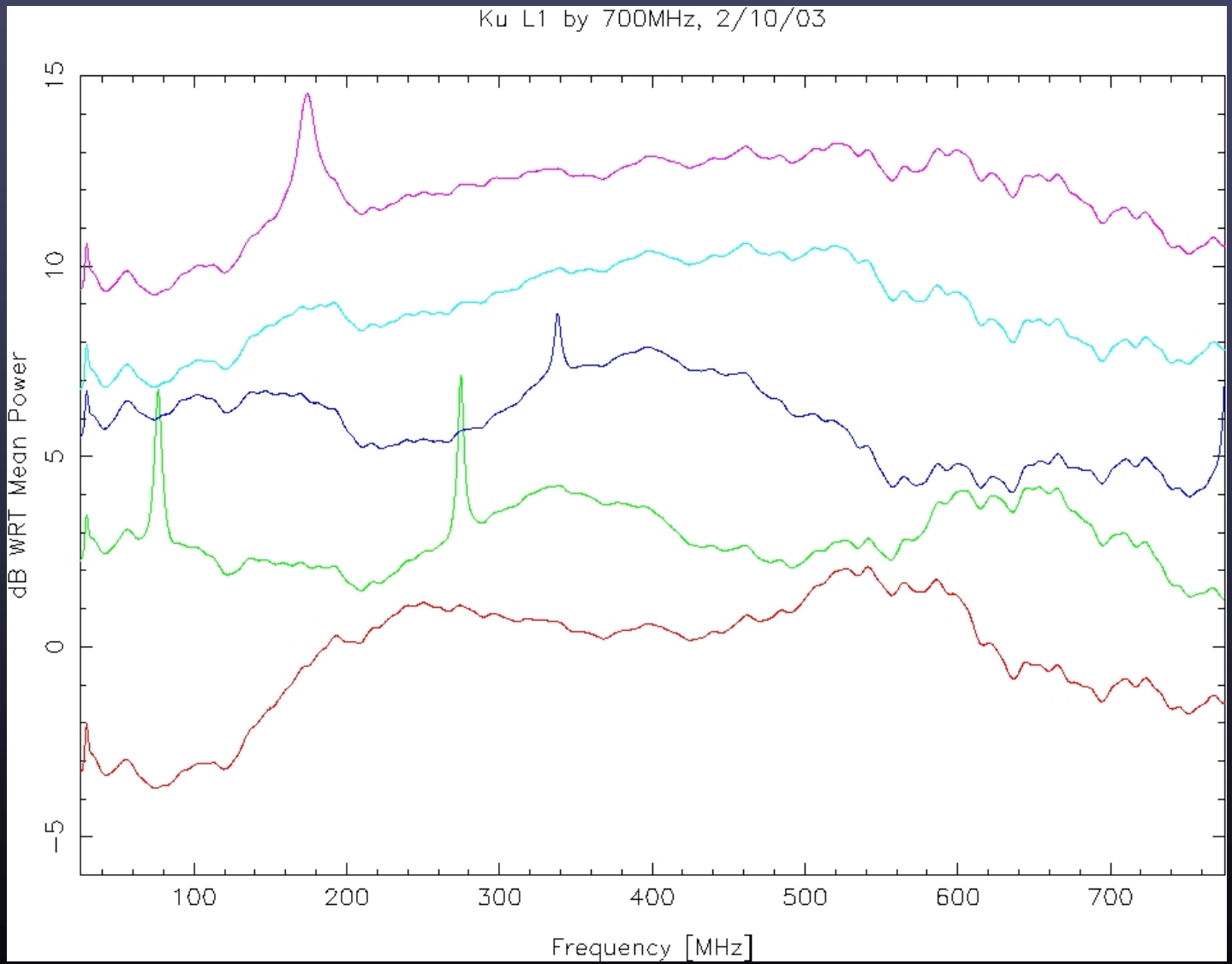
# Continuum Source Spectrum (8.8 GHz, Flux=3.4 Jy)



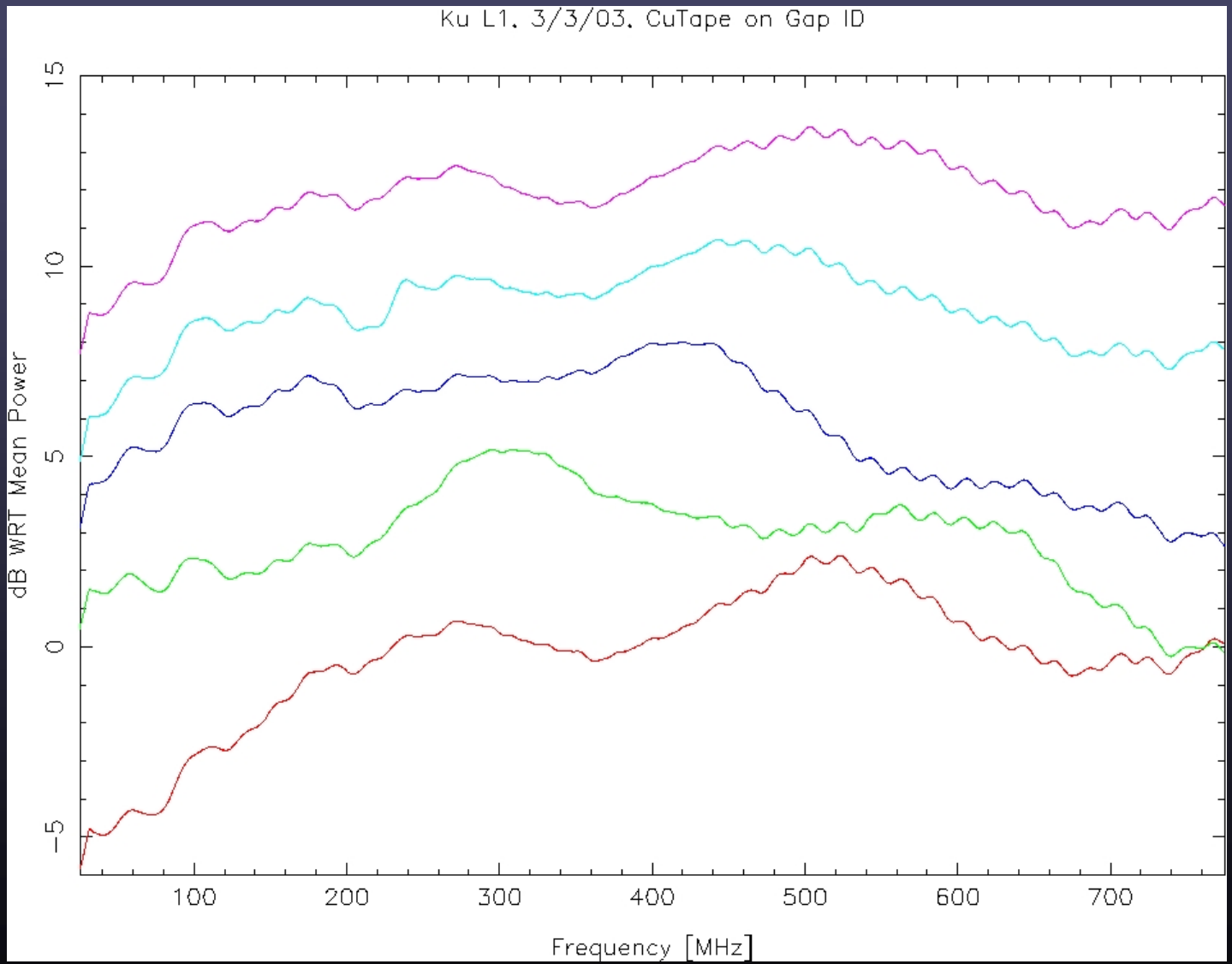
# Waveguide Thermal Gap



# Ku-band Receiver Total Noise Power
# 15.2 GHz (top left) to 11.7 GHz (bottom right)



# Ku-band Receiver Total Noise Power (copper tape over gap)
# 15.2 GHz (top left) to 11.7 GHz (bottom right)



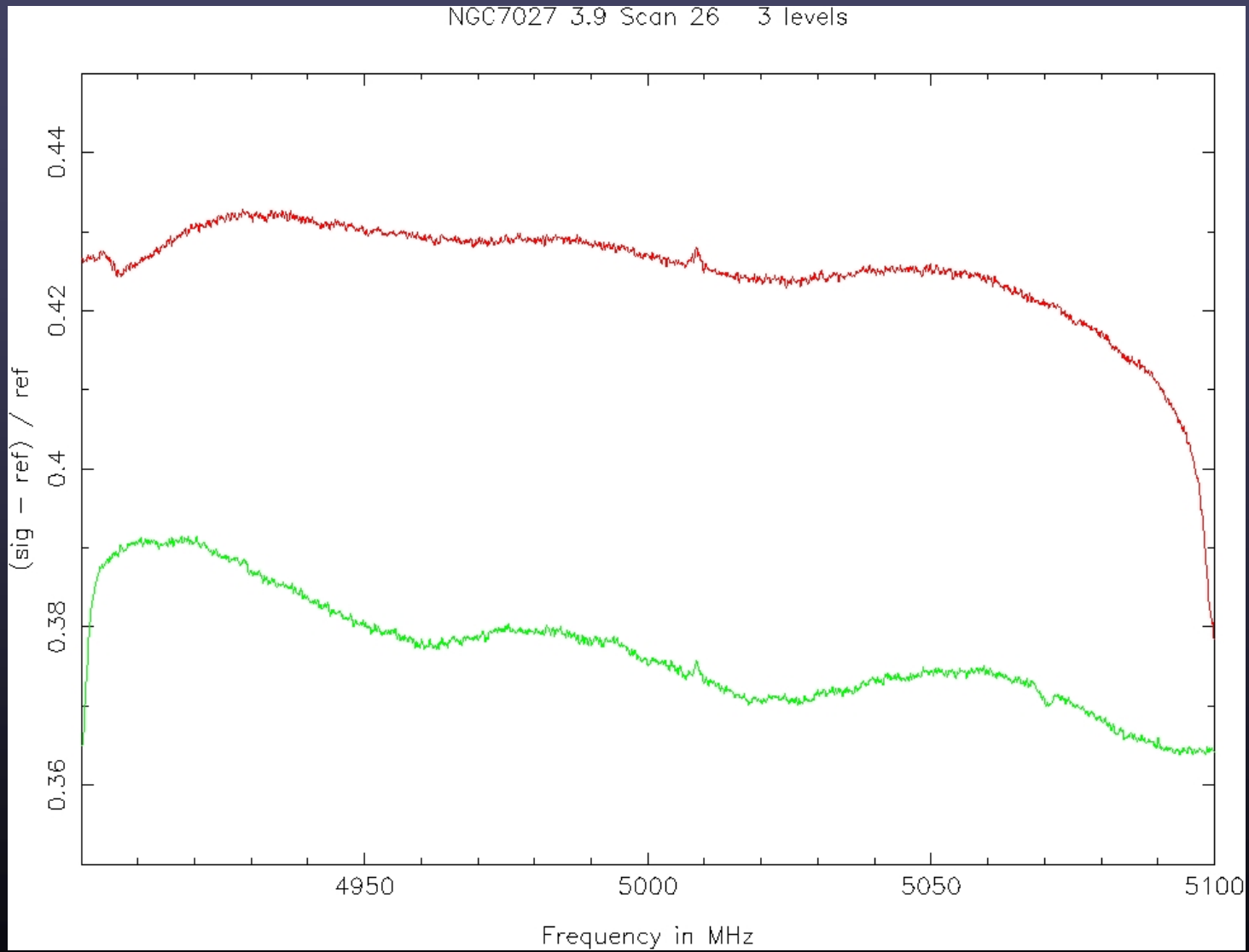
# Continuum Source Baseline Strategies

Reduce small-scale structure in receiver noise

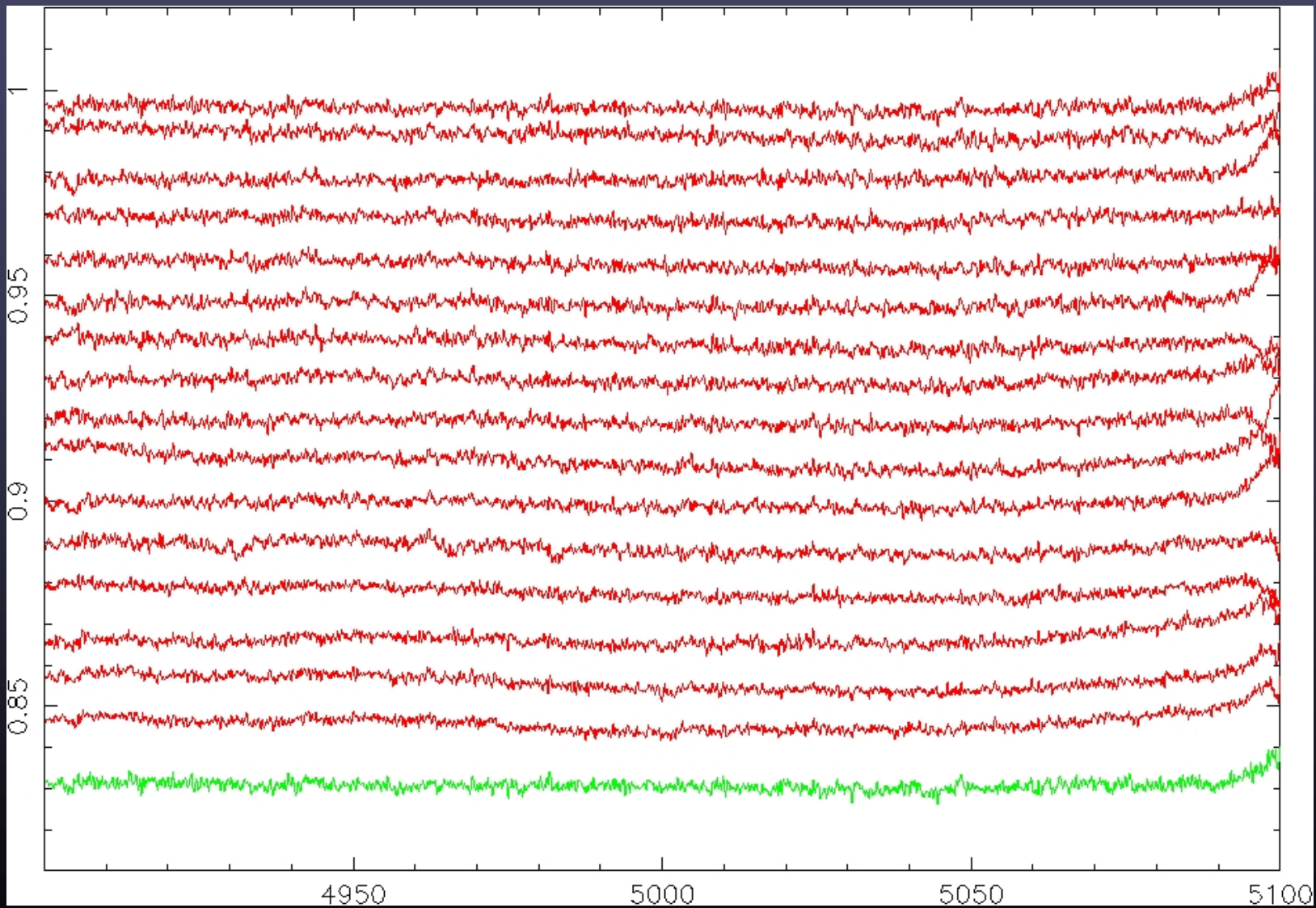
Verify LNA/OMT/Feed noise structure (improve designs)

Calibrate with strong continuum sources

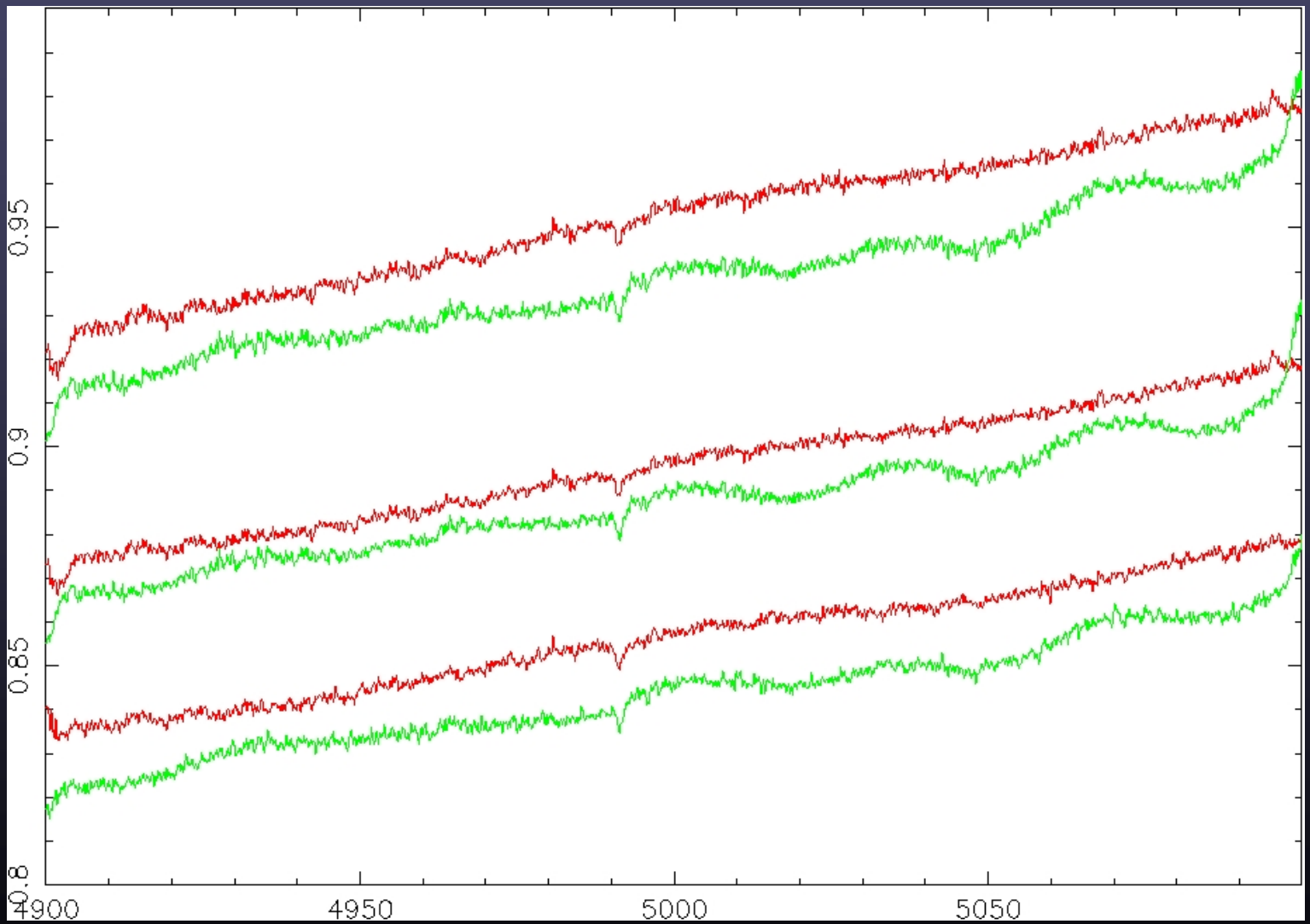
# NGC7027 Continuum Spectra (5 GHz, Flux = 5.4 Jy)
# 5-minute ON, 5-minute OFF
# Red: channel X, Green: channel Y



# Ratios of NGC7027 Continuum Spectra (5GHz, Flux = 5.4 Jy)
# 11 Minute Intervals for 3 Hours
# Note: spectra offset for illustration



## Ratios of 3C48 to NGC7027 Continuum Spectra (5 GHz)
## Red: channel X, Green: channel Y
## Note: spectra offset for illustration

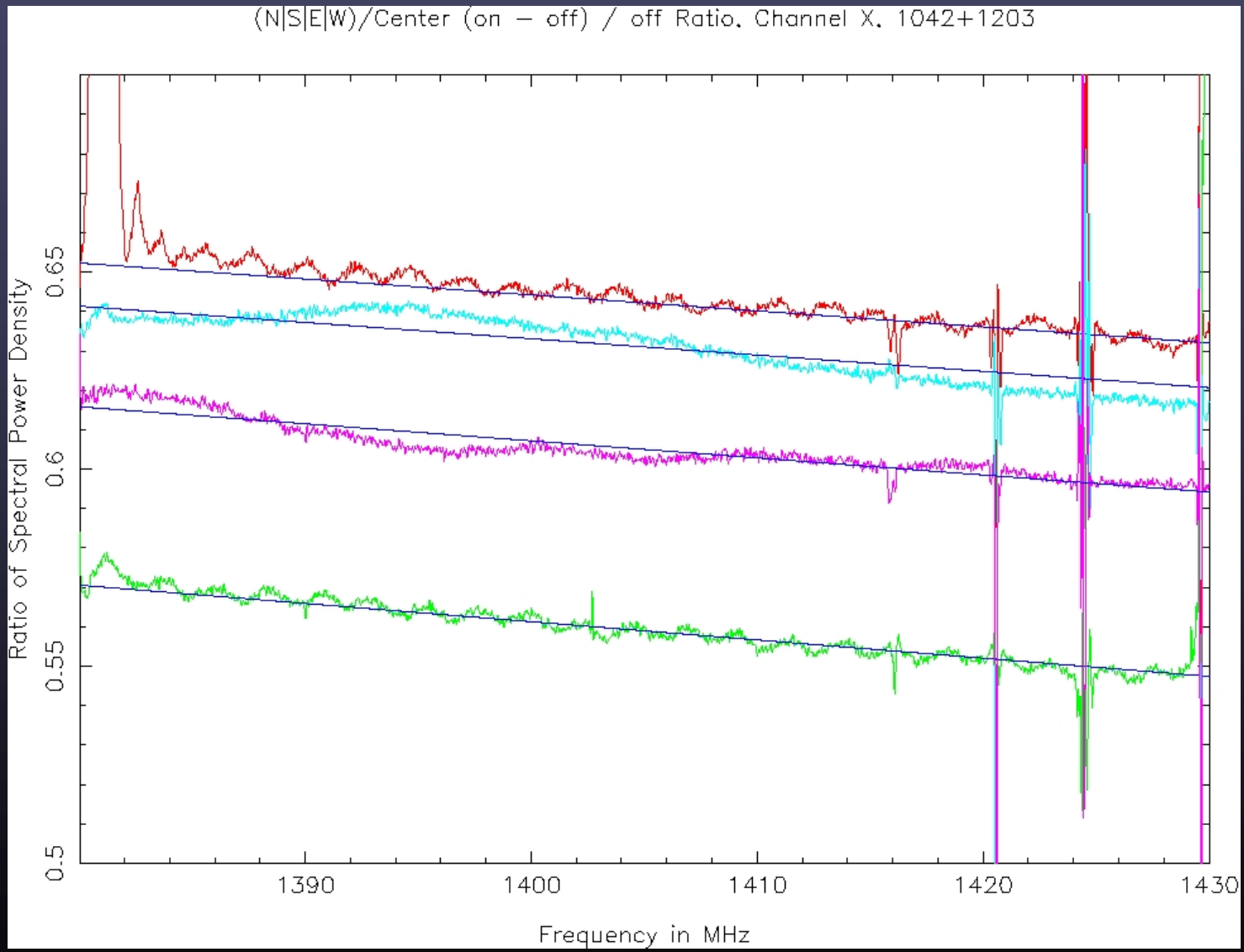



(on-off)/off

(on-off)

(on-off)

# Ratio of Continuum Spectra of 1042+1203 between Beam Center and Roughly Half Power Points (1.4 GHz)




North

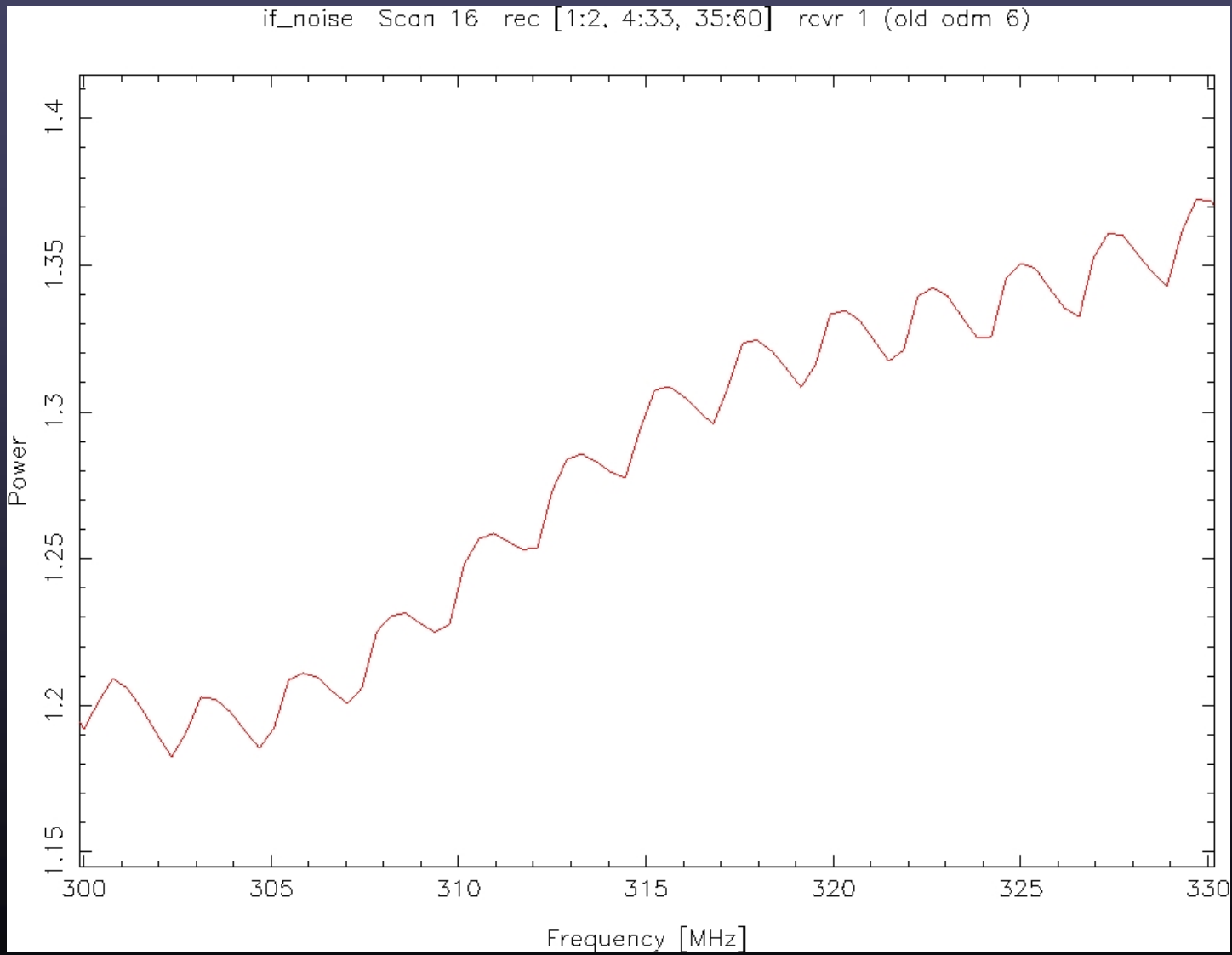
East

West

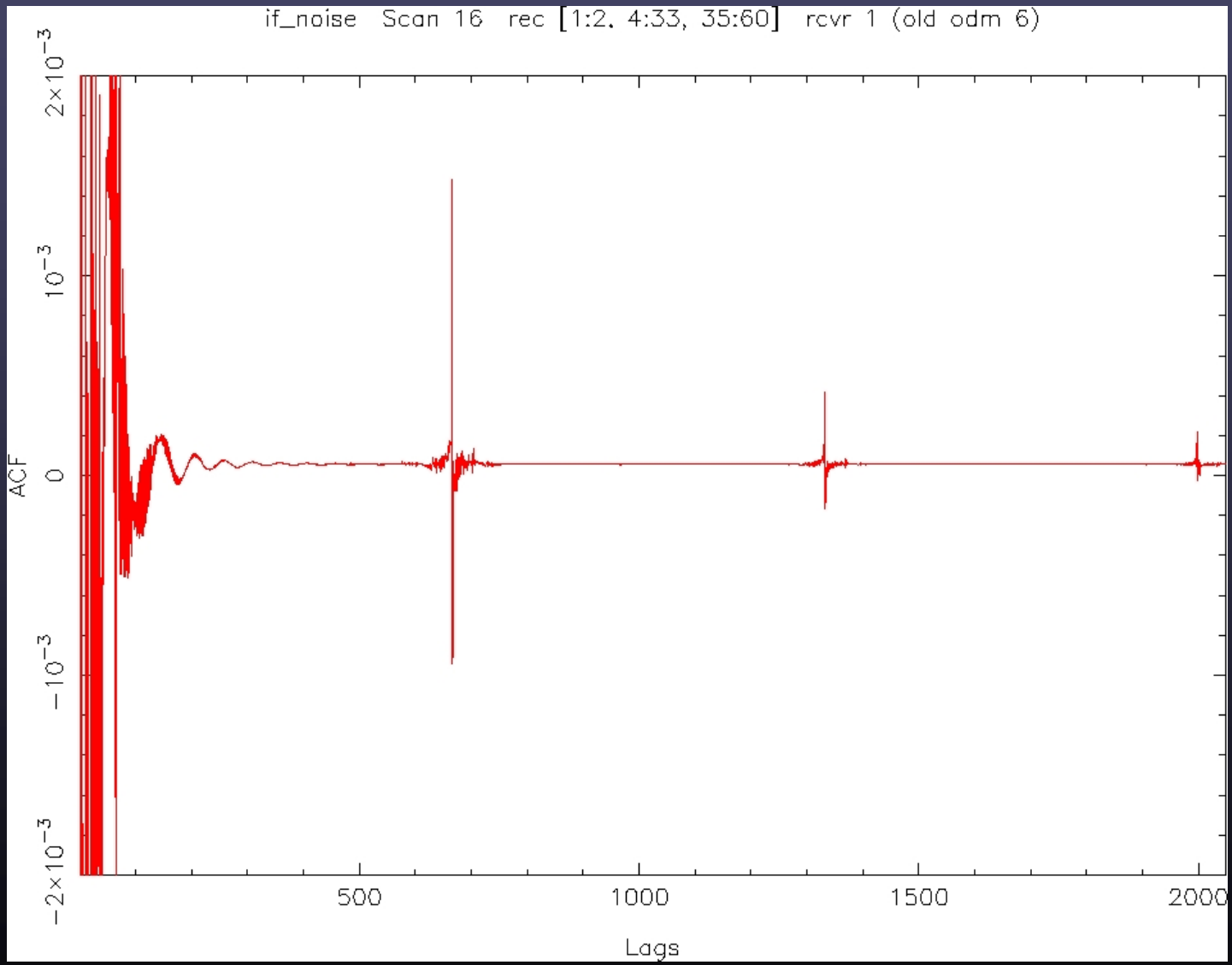
South

# IF System

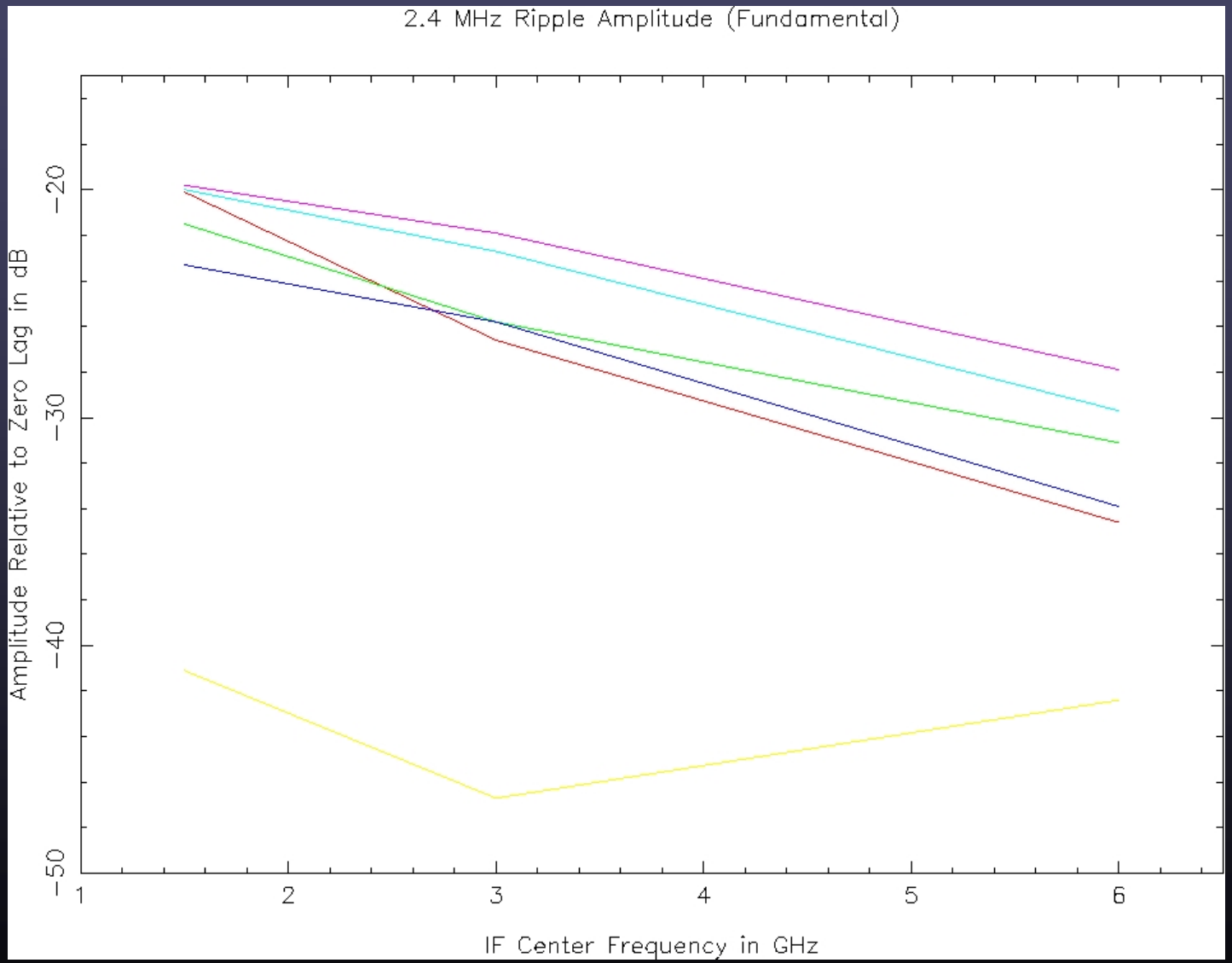
# Total Power IF Spectrum Sample (3 GHz)
# 2.4 MHz Ripple Period in Optical Modulators



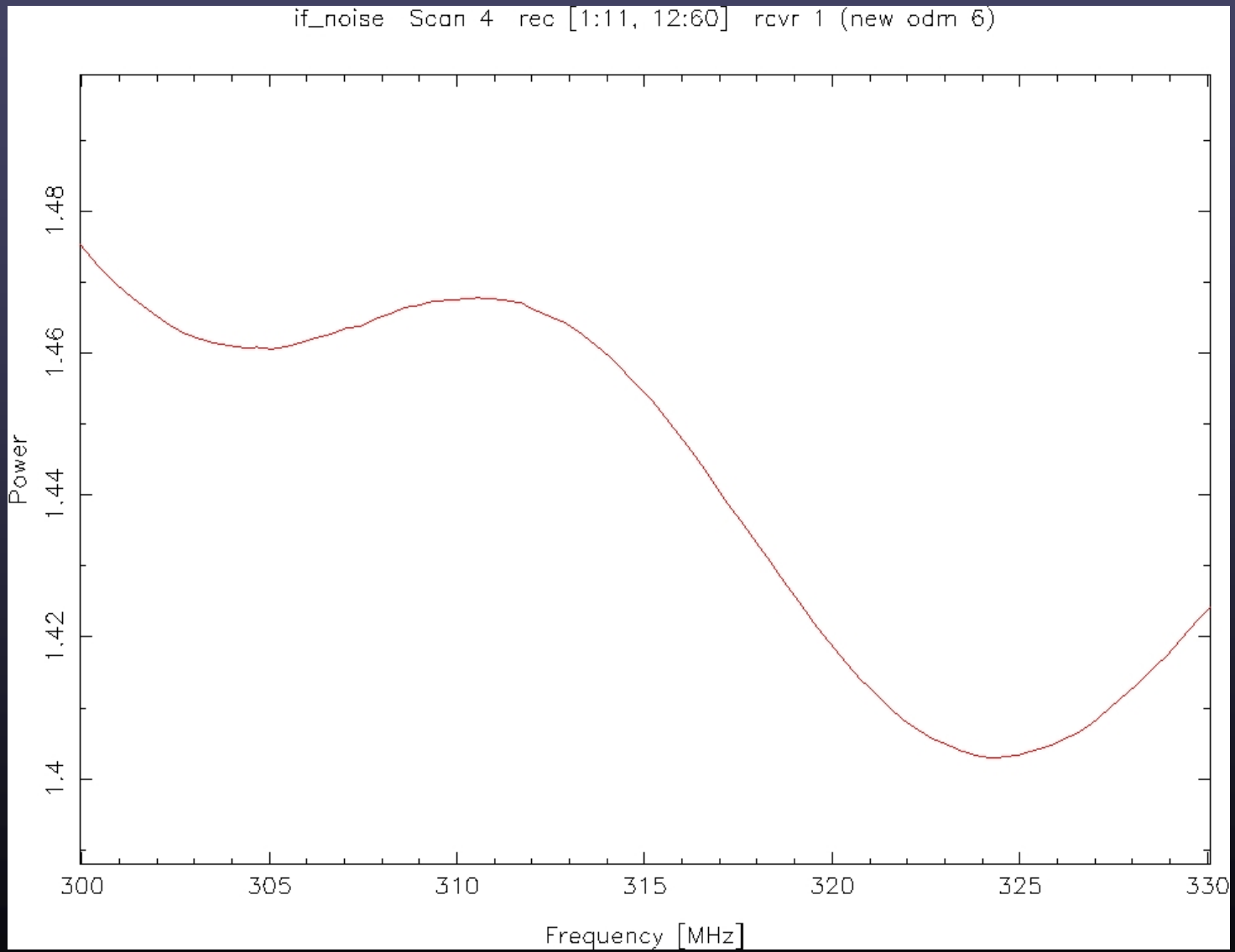
# IF Spectrum Autocorrelation Function



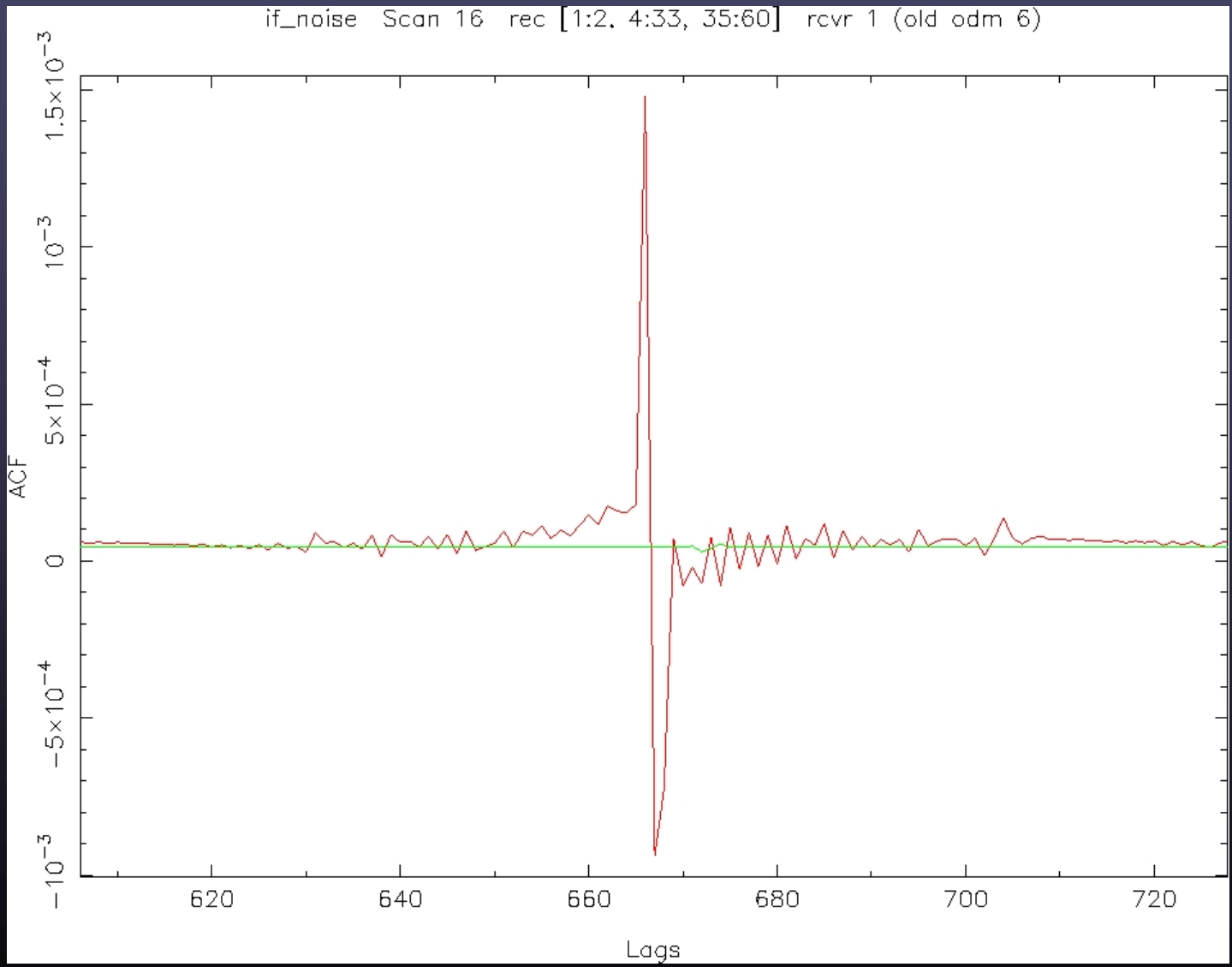
# Frequency Dependence of Optical Modulator Gain Ripple Amplitude



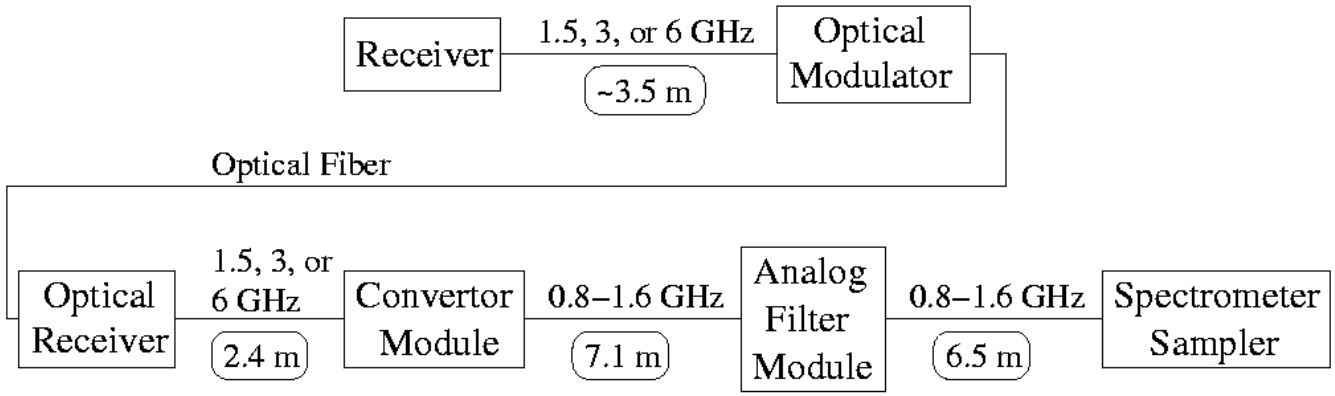
# Total Power IF Spectrum Sample of Modified Modulator (3 GHz)



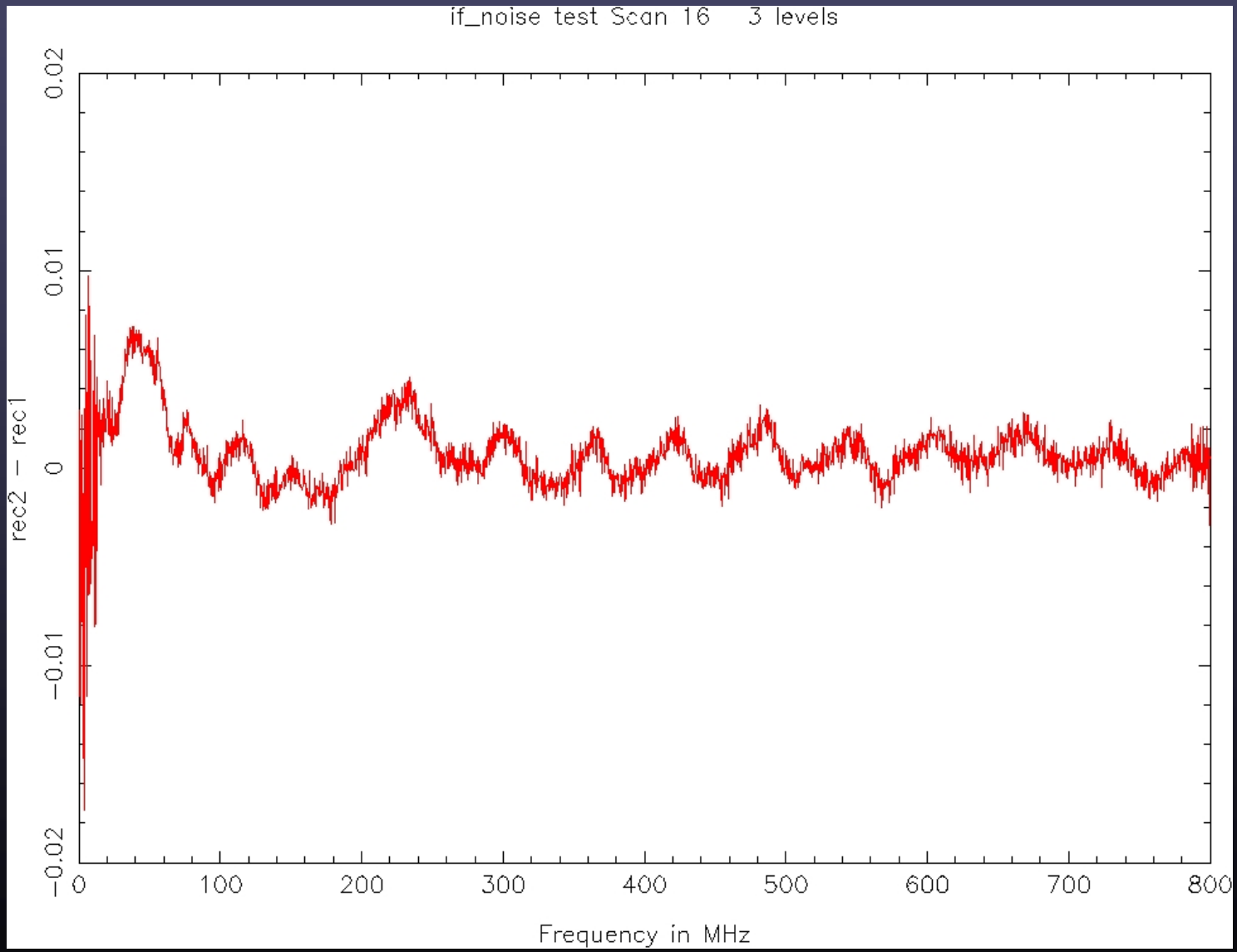
# IF Spectrum Autocorrelation Function
# Red: original modulator, Green: modified modulator



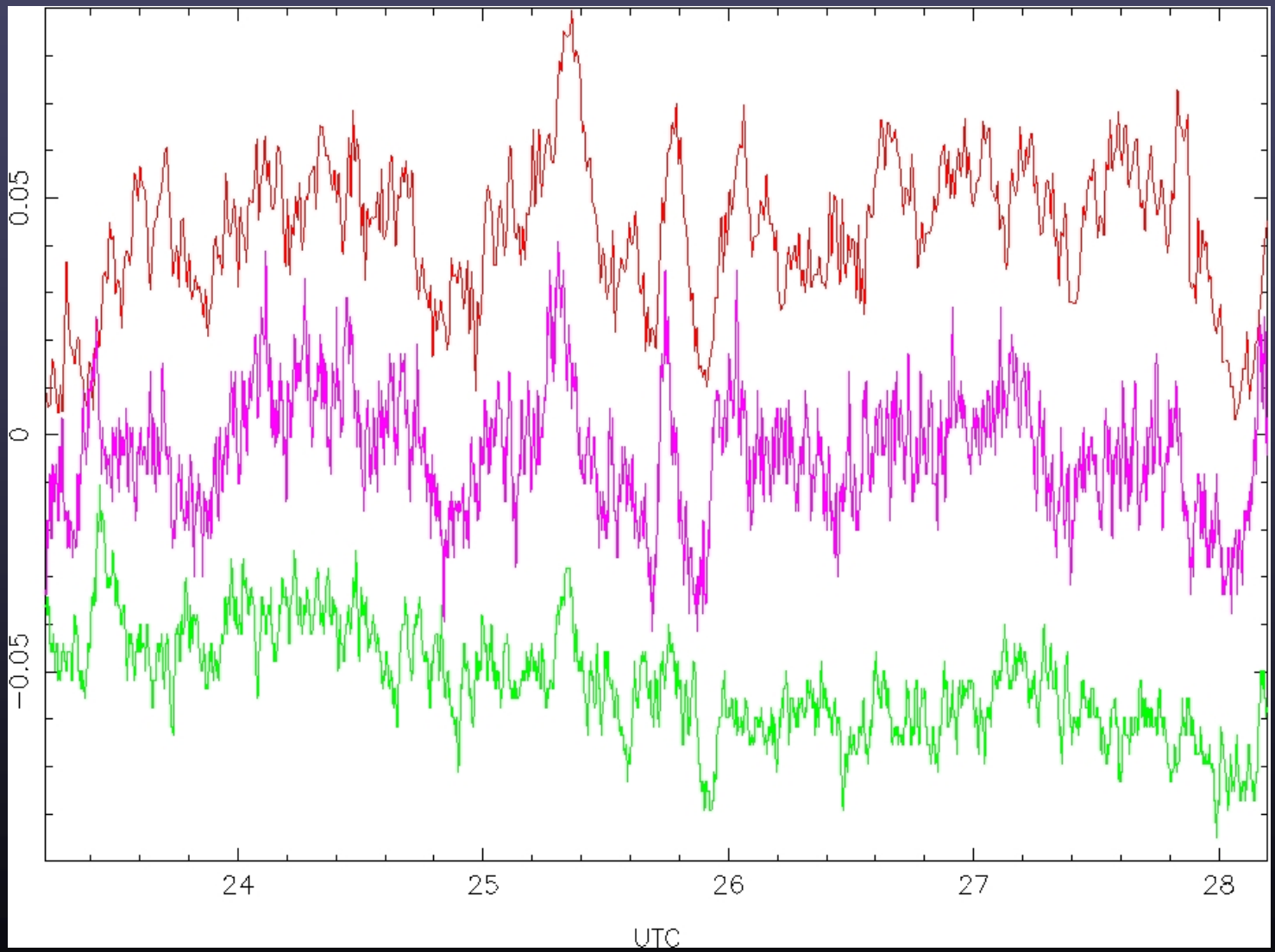
# IF System Cable Connections



# IF Spectrum Difference of 30-second Records 5 Minutes Apart



# Correlation of IF Ripple Amplitude with Temperature

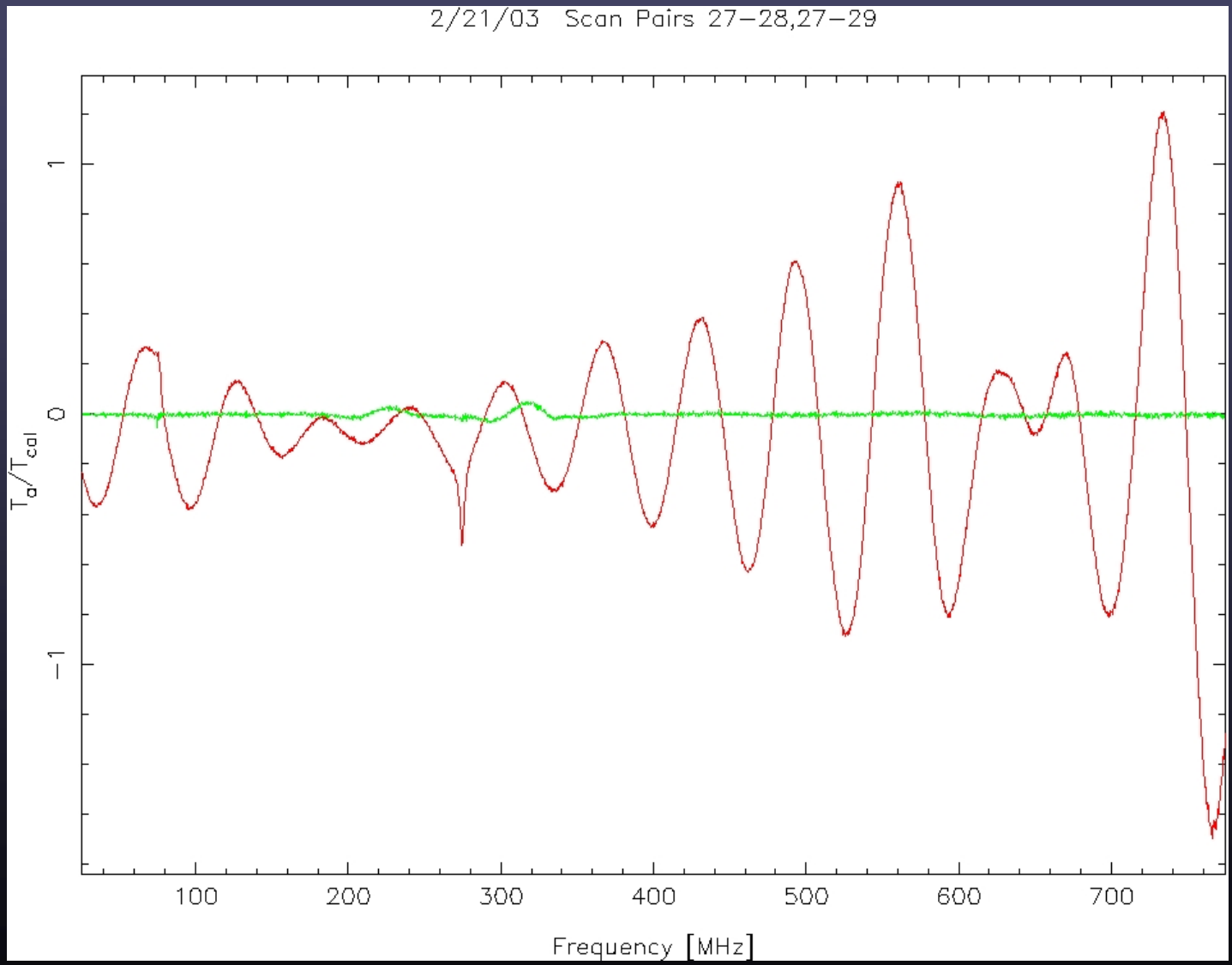



62-MHz Ripple Amplitude

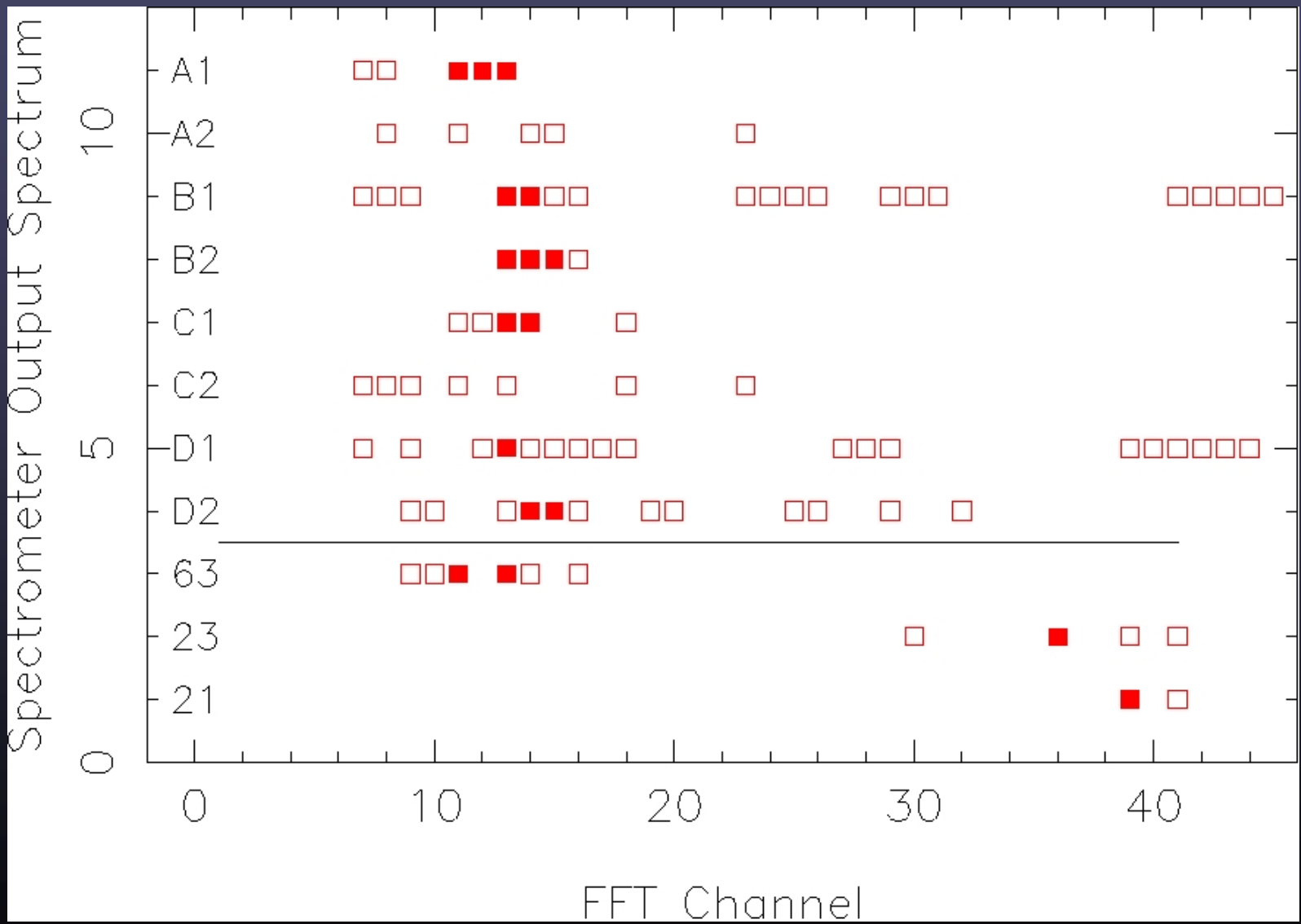
Rack Air Temp.

Room Temp.

# IF Spectrum Difference due to 19mm Change in 6-GHz Cable Length between Optical Receiver and Converter Module (63 MHz Ripple)



# Detected IF Ripple Periods for 8 IF Channels
# Period = 800 MHz / FFT Channel



# General Strategy

Stabilize 63 MHz ripple (phase-stable cables)

Re-measure (and fix) other IF spectrum ripple periods

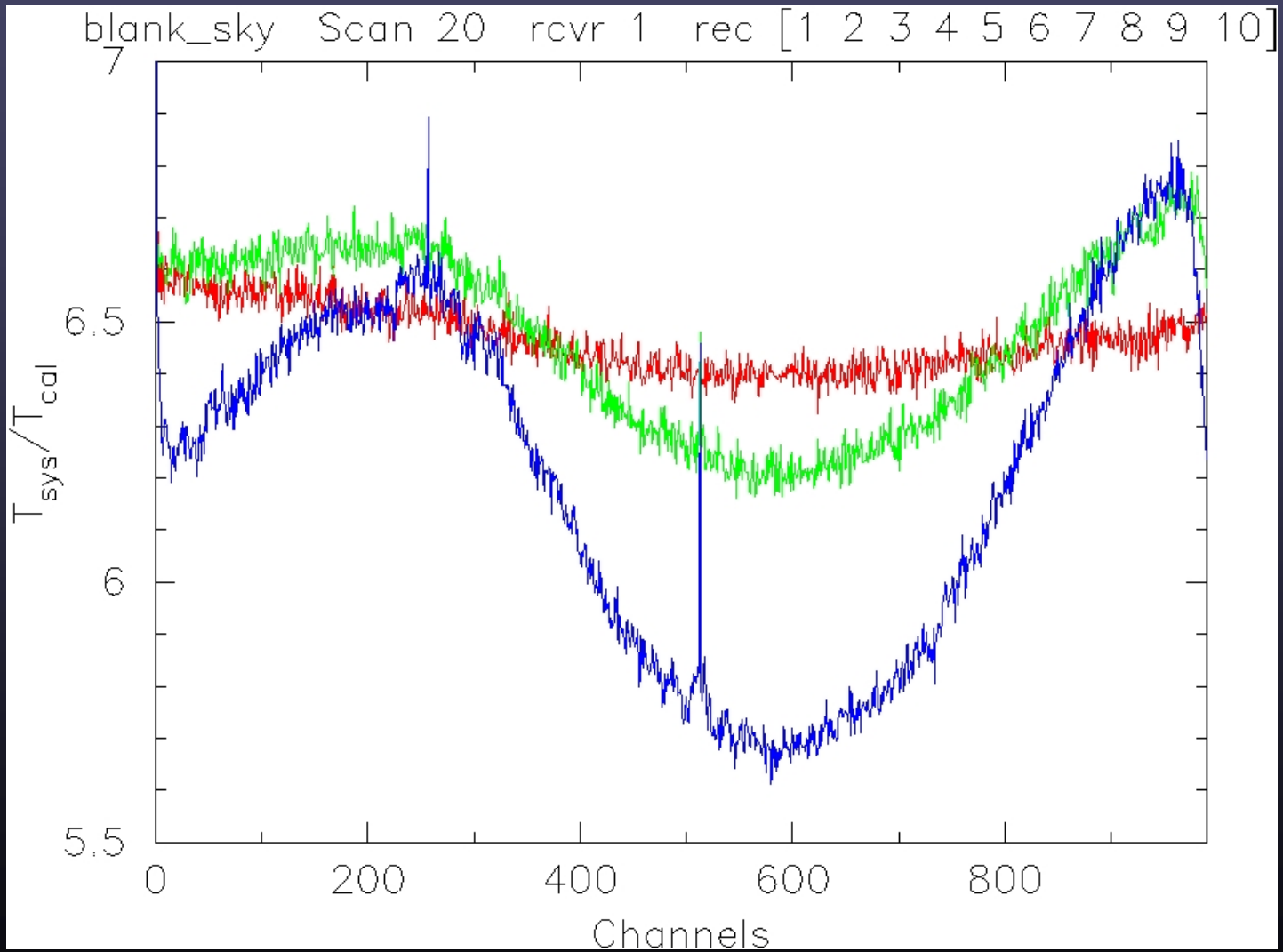
Return to receiver stability measurements

# Other Sources of Baseline Problems

Spectral Processor quantization (?)

RFI

## (Tsys / Tcal) for Different Spectral Processor Input Levels (BW = 40 MHz)
## Red: -5 dBm,  Green: -12 dBm,  Blue: -15 dBm

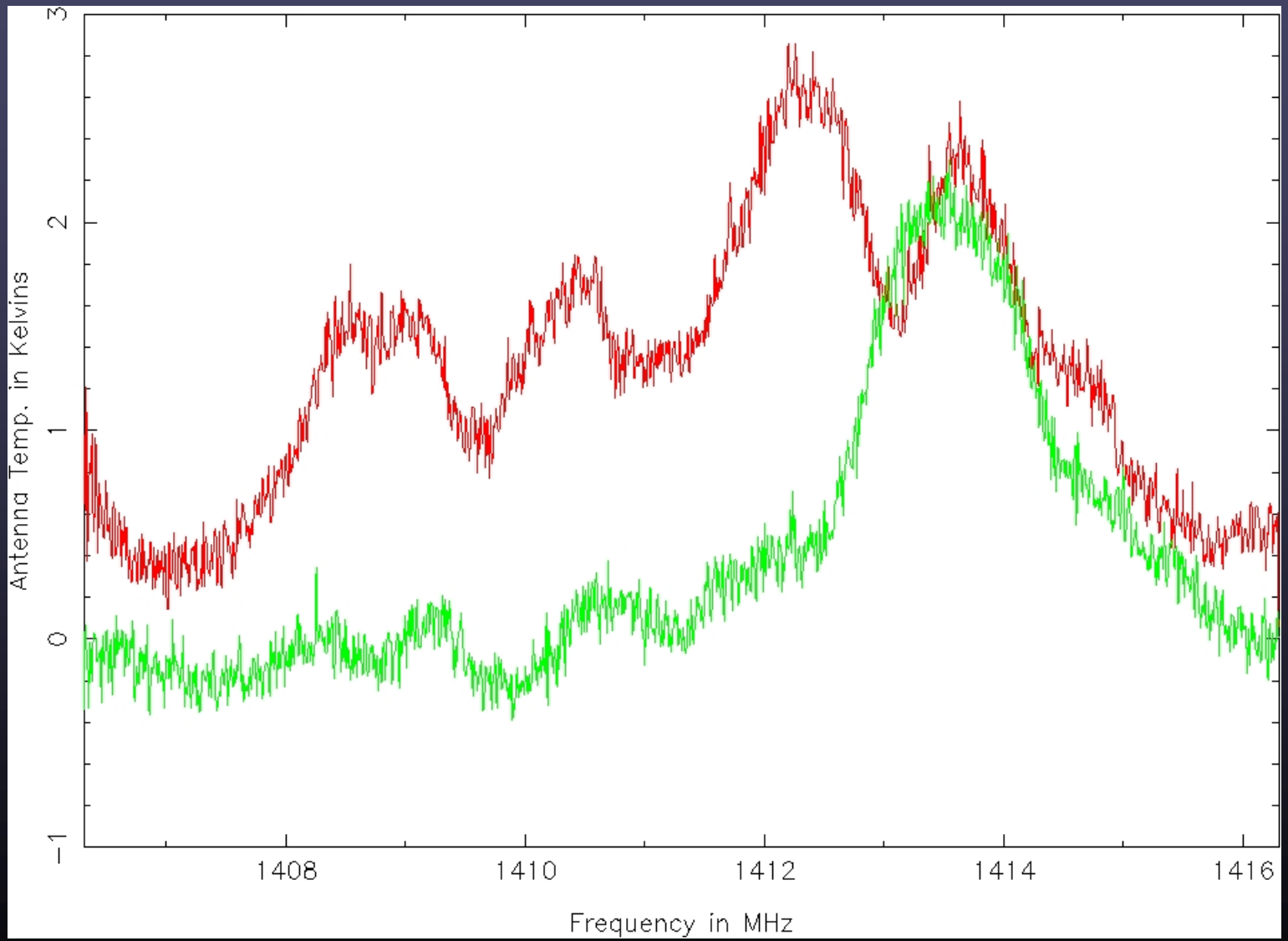


# Other Sources of Baseline Problems

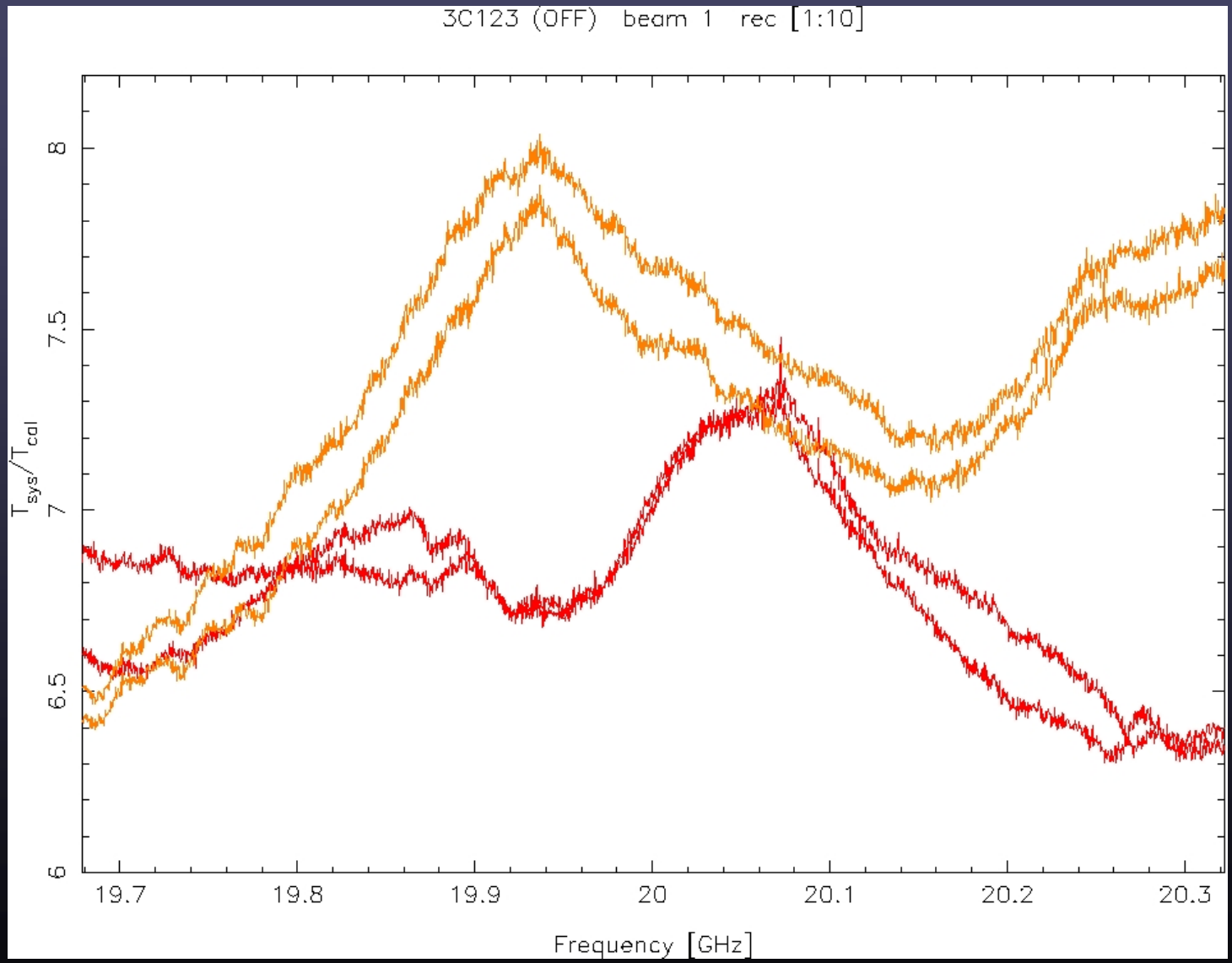
Spectral Processor quantization (?)

RFI

# 1.4 GHz, 10 MHz BW, Spectral Distortion Probably due to Wideband RFI or Receiver Overload due to RFI; ~ 40 seconds duration



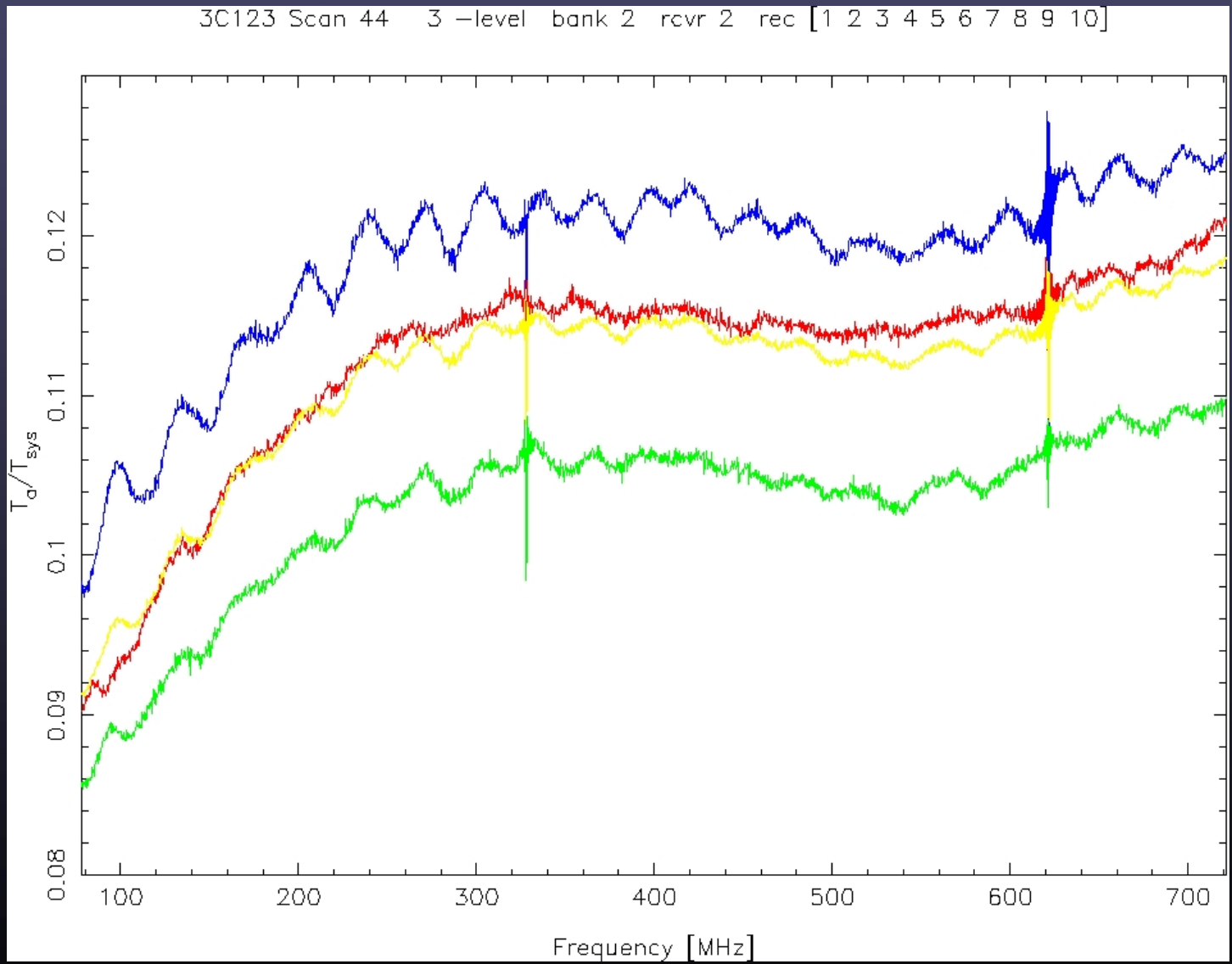
## 20 GHz System Temperature
## Note: Two Curves use Different IF and Spectrometer Channels



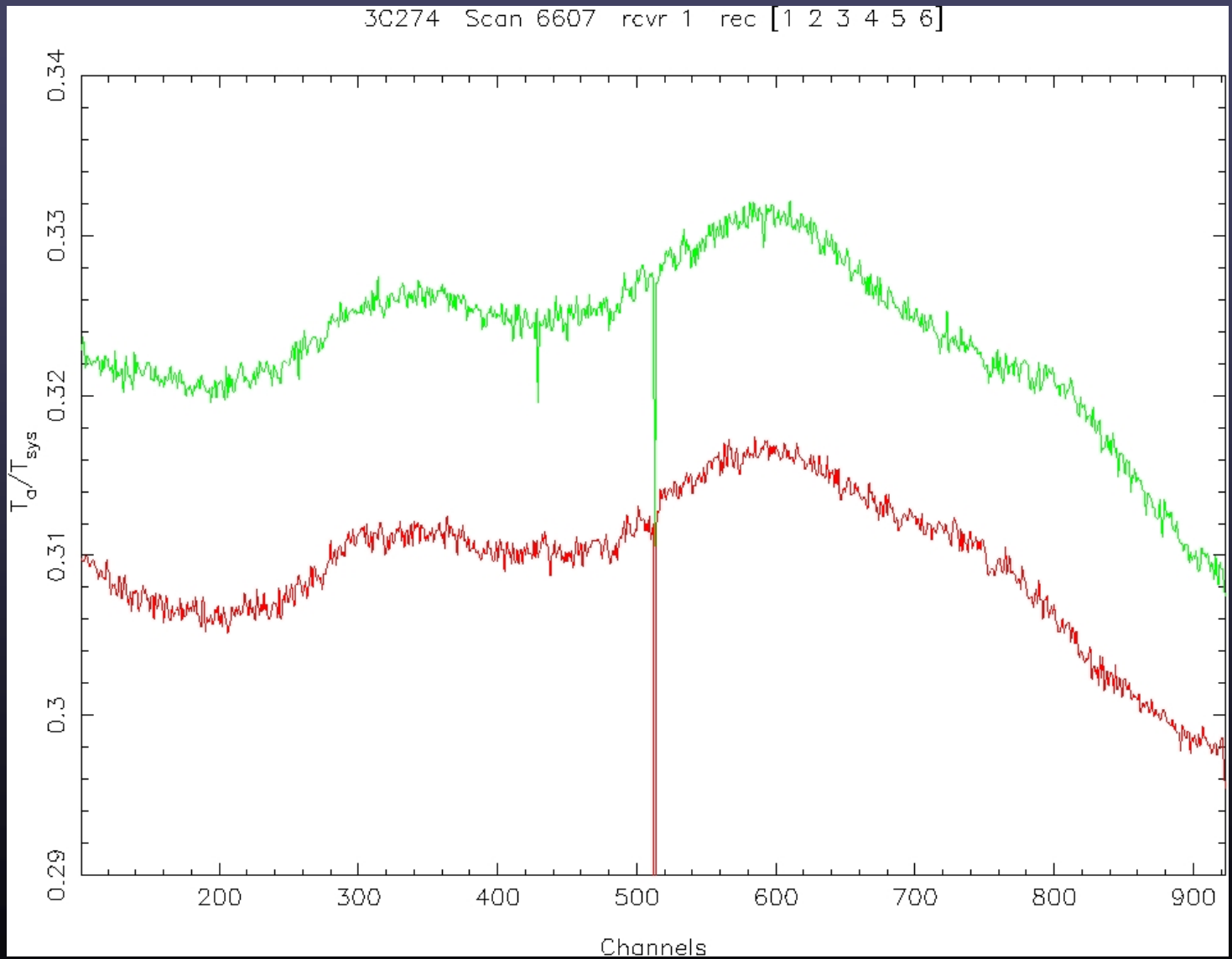

Receiver L2

Receiver L1

# 20 GHz Continuum Spectrum of 3C123, Receiver R2
# Successive 5-minute ON-OFF Pairs



# 140 Foot Continuum Source Spectra (8.4 GHz, BW = 40 MHz)
# 6-minute ON, 6-minute OFF; Taken with the Spectral Processor



# 140 Foot Continuum Source Spectra (1.38 GHz, BW = 40 MHz)
# 6-minute ON, 6-minute OFF; Taken with the Spectral Processor