Cryostat Cavity Noise and the Impact on Spectral Baselines

***Roger D. Norrod*[1]**

[1]National Radio Astronomy Observatory, Green Bank, WV, rnorrod@nrao.edu

Abstract

The GBT Ka-band and Q-band receiver front-ends exhibited a spectral baseline instability of unknown cause. The cause is found to be due to thermal noise radiated from the cryostat interior cavity surfaces. Due to multimoding and multiple reflections in the cryostat cavity, the noise radiation exhibits complex frequency structure sensitive to environmental factors. This radiation can couple into the receiver input signal via waveguide flanges, component bodies, or reflections from vacuum windows. The baseline effects can be mitigated using microwave absorber to smooth the cavity noise ripple, and by shielding the signal path from the noise radiation.

1. Introduction

Spectrometry is one of the primary fields of radio astronomy, and the 100-meter Robert C. Byrd Green Bank Telescope is extremely active in this field. In spectrometry the astronomer attempts tto detect quite weak spectral features (e.g. molecular lines), much smaller in amplitude than unavoidable frequency variations in system noise temperature and gain. Detecting these weak signals requires observing techniques that cancel out the larger systemic variations, and to be effective all these techniques require extraordinary stability of the system gain and noise temperature. For typical GBT observations the rms noise in an observed spectrum is roughly 2 parts in 10^4 for a one-minute integration, and the stability must be several times better than this value over several minutes to avoid masking the target signals.

Many causes can degrade the spectral stability, and much effort has gone into finding and correcting problems in the GBT receiving systems. During commissioning of two GBT receivers, the 40-50 GHz Q-band and the 26-40 GHz Ka-band, a spectral instability was noted that was not seen with other receivers, had unique characteristics, and had an unknown cause. This document reports on the search for the cause of this unique effect, explains how it arises, and how it can be eliminated.