C-band Feedhorn Return Loss Measurements August 2003

R. Norrod

August 25, 2003

Introduction

The GBT C-band (Rcvr4-6 GHz) was removed to make reflection measurements of the feedhorn, as follow-up to earlier tests (see baseline report on project TBASERDN030505), in which baseline observations were made with several obstructions placed on the feed radome. To help quantify the results, we desire reflection measurements with similar obstructions.

The feedhorn, disconnected from the receiver, was mounted on the indoor/outdoor test building focus ring, and pointed at the zenith with the feed aperture elevated above the building roof. Our HP8720 vector network analyzer was used to measure the return loss in both frequency and time domains.

The VNA coaxial test port was connected to a coaxial-rectangular-circular transition, and a waveguide offset short calibration was done at the transition circular waveguide port. Figures 1-3 show the results of the calibration. It can be seen that the cal is not entirely satisfactory, particularly in the lower half of the measured frequency band. I plan to pursue an improved cal standard set for future use, but I believe useful results were obtained despite the calibration concerns.

The feedhorn radome is a Gore membrane, type RA 7943. Figure 4 shows the feedhorn return loss in the frequency domain with the radome dry and clear, and with a dime and with a quarter resting on the radome in the center of the aperture. The coins make measureable differences in the return loss magnitude. Figure 5, a time domain display under the same conditions, clearly identifies the reflection component at the feed aperture. (Note: During these ground tests, there was no air pressure on the feed, and the radome membrane center sagged slightly below the feedhorn rim. On the GBT, the pressurized air causes the radome to dome slightly, so the center will be several centimeters higher.)

The larger peak at marker 1 corresponds to a region of the feedhorn near the transition between ring-loaded slots and straight corrugations. We disassembled the feedhorn and could not identify any mechanical assembly problems in this area. Measured results after cleaning and reassembling the feed were indistinguishable from the prior tests. The peak at marker 1 needs to be revisited when the calibration of the return loss setup is improved. There is some concern that this apparent localized reflection is an artifact of the poor calibration.

As Figure 6 shows, the Gore radome accounts for the reflection peak at the feed aperture. Figure 7 shows the return loss in the frequency domain with the radome removed. Note the "cleaner" return loss ripple, presumably a result of eliminating the localized mismatch at the aperture.

We measured a few other materials to get a comparison with the observed reflection from the Gore material. Figure 8 shows the results. Unfortunately, none of the materials which were on hand are clearly identified, are not durable enough to put on the telescope, and are not significant improvements. Type A is a white 6mil flexible plastic of unknown makeup that has a styrated apperance. Type C is 4mil clear "Builder's Plastic", probably a polyethylene which would quickly degrade in sunlight. Type B is a 10mil white unknown plastic and has higher reflection than the Gore RA 7943.

Summary

These measurements were done during a brief gap in the observing schedule for the C-band front-end so there was not much time to pursue the cal problems or look into alternate radome materials. Despite this, several interesting results were obtained. When the Gore material was selected 10 years ago, it appeared to be the best available. The reflections found are small, and one would think they will be quite stable. Some thought should go into the need to reduce them further. As a matter of course, the results indicate the need to improve the waveguide calibration technique, probably by doing a full two-port cal with additional standards. Then, we should know if there is indeed a localized reflection point in the feedhorn .

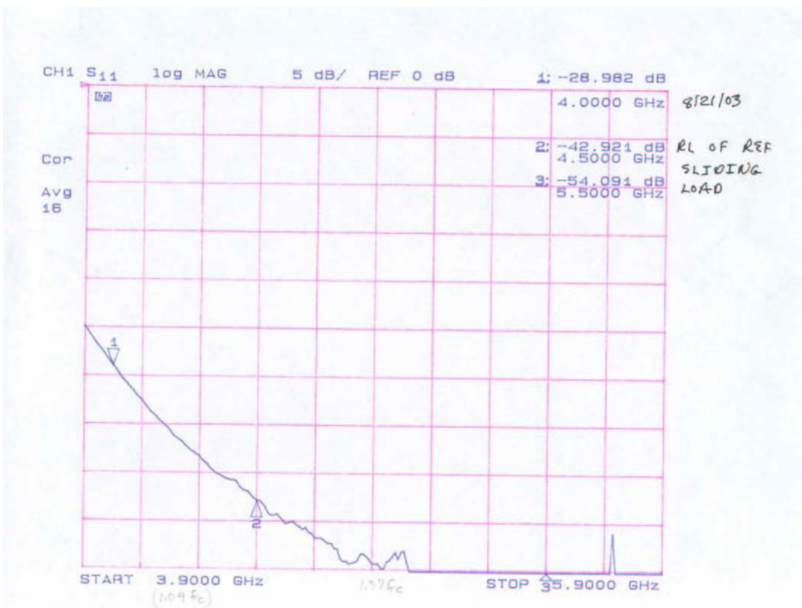

Figure 1: Measured return loss of the cal standard sliding load, after calibration. The plot indicates a somewhat poor calibration in the lower half of the band.

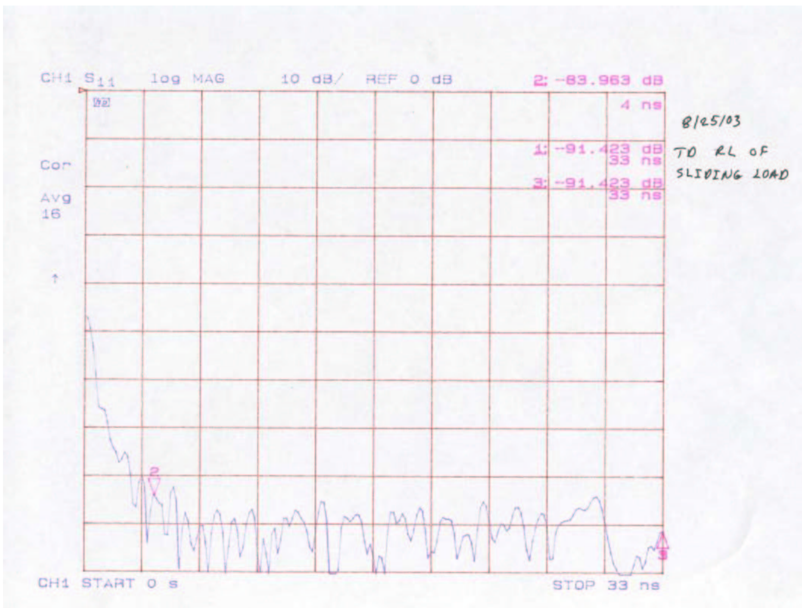

Figure 2: The time domain return loss of the cal standard sliding load after calibration.

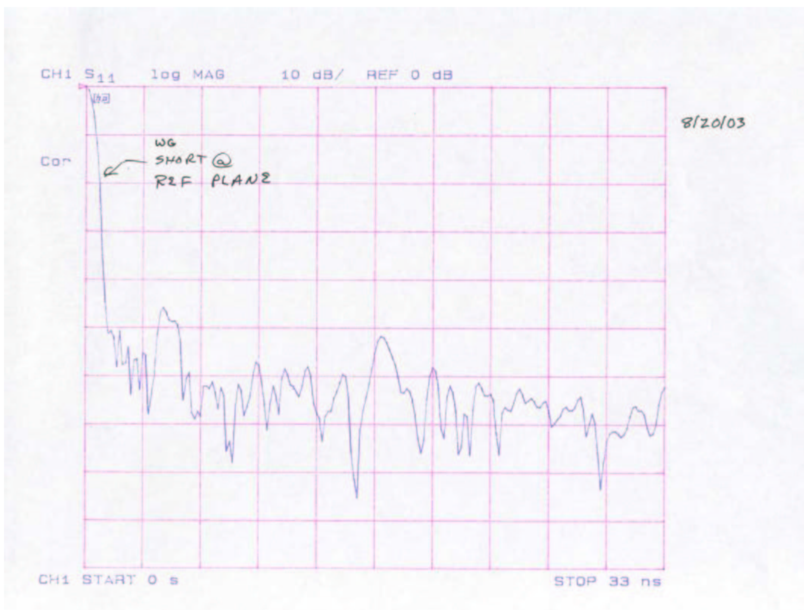

Figure 3: The time domain response with a short at the waveguide reference plane.

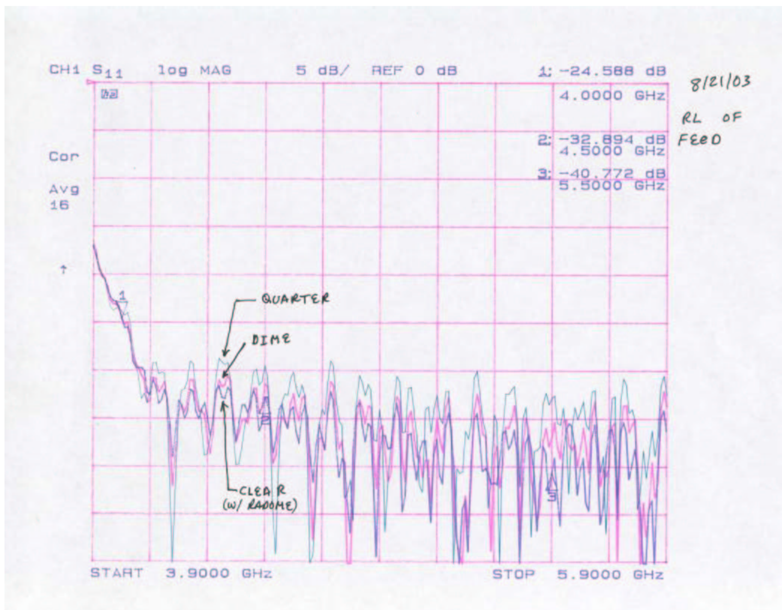

Figure 4: The feedhorn return loss (frequency domain) with the Gore radome, and with a dime or quarter placed in the center of the radome. The feed was pointed at the zenith in clear skies.

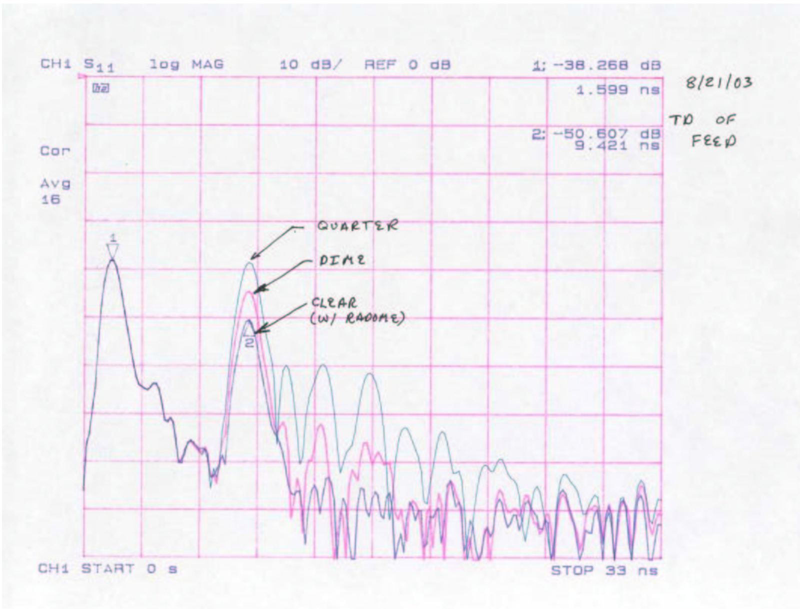

Figure 5: The feedhorn return loss (time domain) with the Gore radome, and with a dime or quarter placed in the center of the radome. The feed was pointed at the zenith in clear skies. The peak at marker 2 is clearly identified with the feedhorn aperture position (9.42nS round-trip delay corresponds to a one-way distance of 141cm in free space). The peak at marker 1 corresponds to the region of the feedhorn where ring-loaded slots transition to straight corrugations.

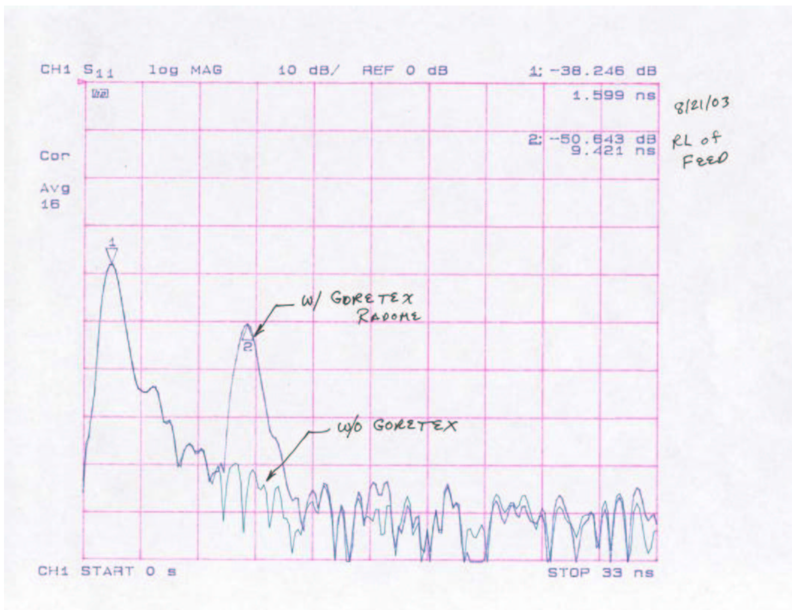

Figure 6: Comparing the feedhorn return loss (time domain) with the Gore radome present and removed. The Gore material used on this feedhorn is type RA7943. It consists of a PTFE woven strength backing with a PTFE waterproofing membrane, having total thickness of about 12 mils.

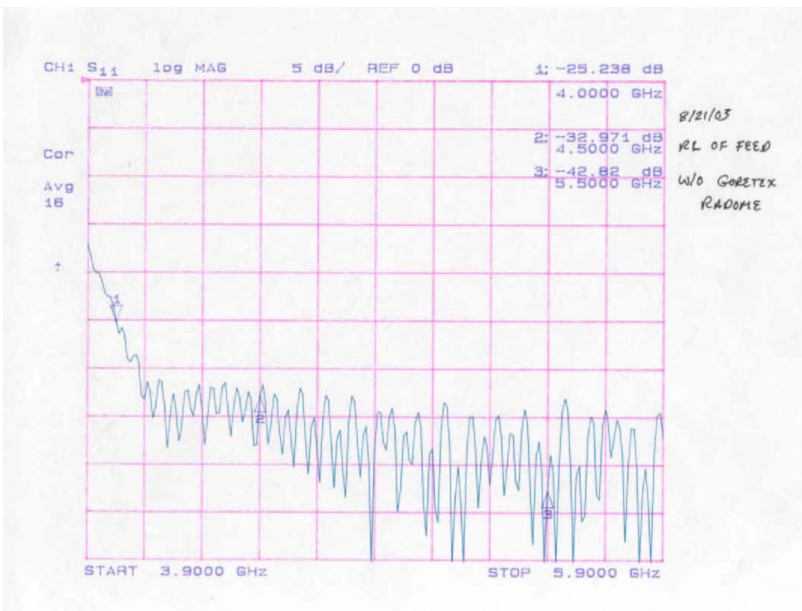

Figure 7: The feedhorn return loss (frequency domain) with the Gore radome removed. Compare with the "Clear" trace in Figure 4.

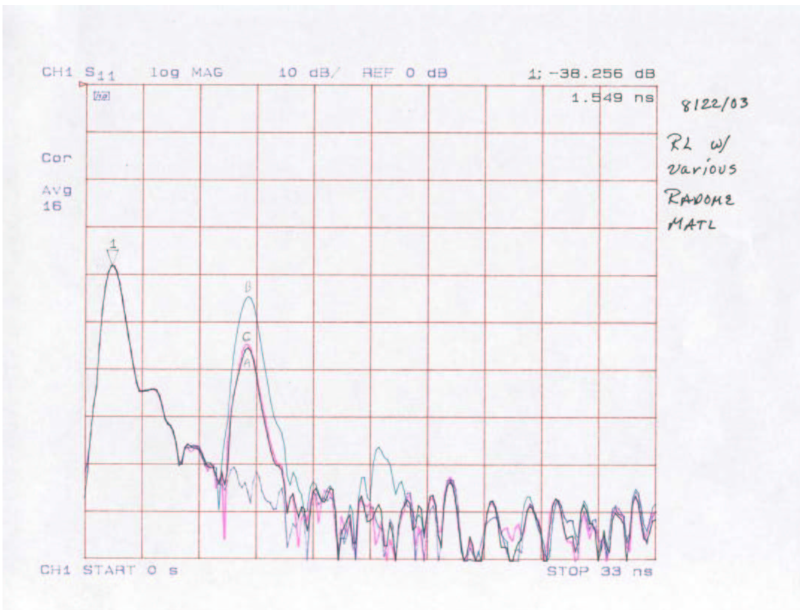

Figure 8: Measured feed return loss (time domain) with various materials as described in the text covering the aperture. A trace with no covering is shown for reference.