Progress toward testing the millimeter wavelength absolute gain measurement scheme

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June 15, 2004

1 Introduction

The plan is to develop an absolute antenna gain measurement scheme that can be used at any of the wavelengths of the ALMA System at any time. The goal is for an absolute accuracy of 1%. A recent experiment at 28.5 GHz using the BIMA Array (Gibson et al, 2004, in press) resulted in an antenna gain determination and a flux for Jupiter with an absolute accuracy of 1.5%. We plan to repeat that experiment at 90 GHz, striving for an accuracy of 1%, just a little better. Two related experiments are planned. The first is essentially a repeat of the earlier work with some improvements based on our experience. The second will use a scheme related to amplitude self calibration. If this is successful, it could be carried out at shorter (sub-millimeter) wavelengths where waveguide switch components are not readily available.

2 The Waveguide Switch Method

Similar to the recently completed experiment at 28.5 G-Hz, we use two BIMA antennas operating as an interferometer pair with a standard horn attached to one of them which can be substituted for the host antenna in the cross-correlation. The substitute switching will be enabled by standard waveguide components. The absolute blackbody loads will consist of an ambient load and a Liquid Nitrogen load each of which can be placed over the aperture of the standard gain horn. Figure 1 shows the basic block diagram, including a black-body load. The standard gain horn is fastened to the edge of one BIMA antennas. There are two feeds in the focal plane which will permit rapid switching for the total flux measurement of Jupiter. The same switch will enable connecting either one of the feed horns or the standard horn to the receiver for alternate cross-correlations with the signal received by an adjacent BIMA antenna. The ratio of these two measurements gives the ratio of the antenna gain to that of the standard horn whose gain is known. From the knowledge of the antenna gain found in this way, the flux of Jupiter is subsequently measured in the rapid comparison switching. No extinction correction is needed for the first experiment, but it is needed for the second part. The plan is to use the standard gain horn for tipping measurements to determine the atmospheric extinction. The standard gain horns pattern is known and can be reliably convolved with an atmospheric model to obtain the extinction from the tipping experiments. Figure 2 shows the layout of the components on the receiver plate.

3 The Amplitude Self-Cal Scheme

No switching is needed here. We just form ratios of pairs of cross correlations. The standard gain horn uses the antenna to which it is affixed as a mount. Its gain is known and its system temperature scale is determined from the two loads. We use three other antennas so that rations of pairs of cross-correlations can be formed. The ratios of pairs of cross-correlations allow the system temperature and antenna gain to be transferred to the other antennas. Then the flux can be found from any of the cross-correlations. This scheme must be tried and its result compared to that of the above scheme. Its advantage, if it works, is that it requires only the interferometer multipliers, and knowledge of the system temperature and the antenna gain of the standard horn. A tipping curve is needed to evaluate the extinction. It will be done as discussed above. No microwave switches are required, so it can be done at submillimeter wavelengths. All of the components used for the first experiment can be used, and , in addition, there must four of the BIMA array antennas used.

4 Status

Observations of Jupiter along with MWC349 and W3OH have already been obtained recently with array. Once the flux of Jupiter is known, it can be transferred to those other sources. All components are in hand and the receiver construction is nearly complete. The two loads are nearly complete as well. We expect to begin the observations by the beginning of July and should need only about a week to complete them.

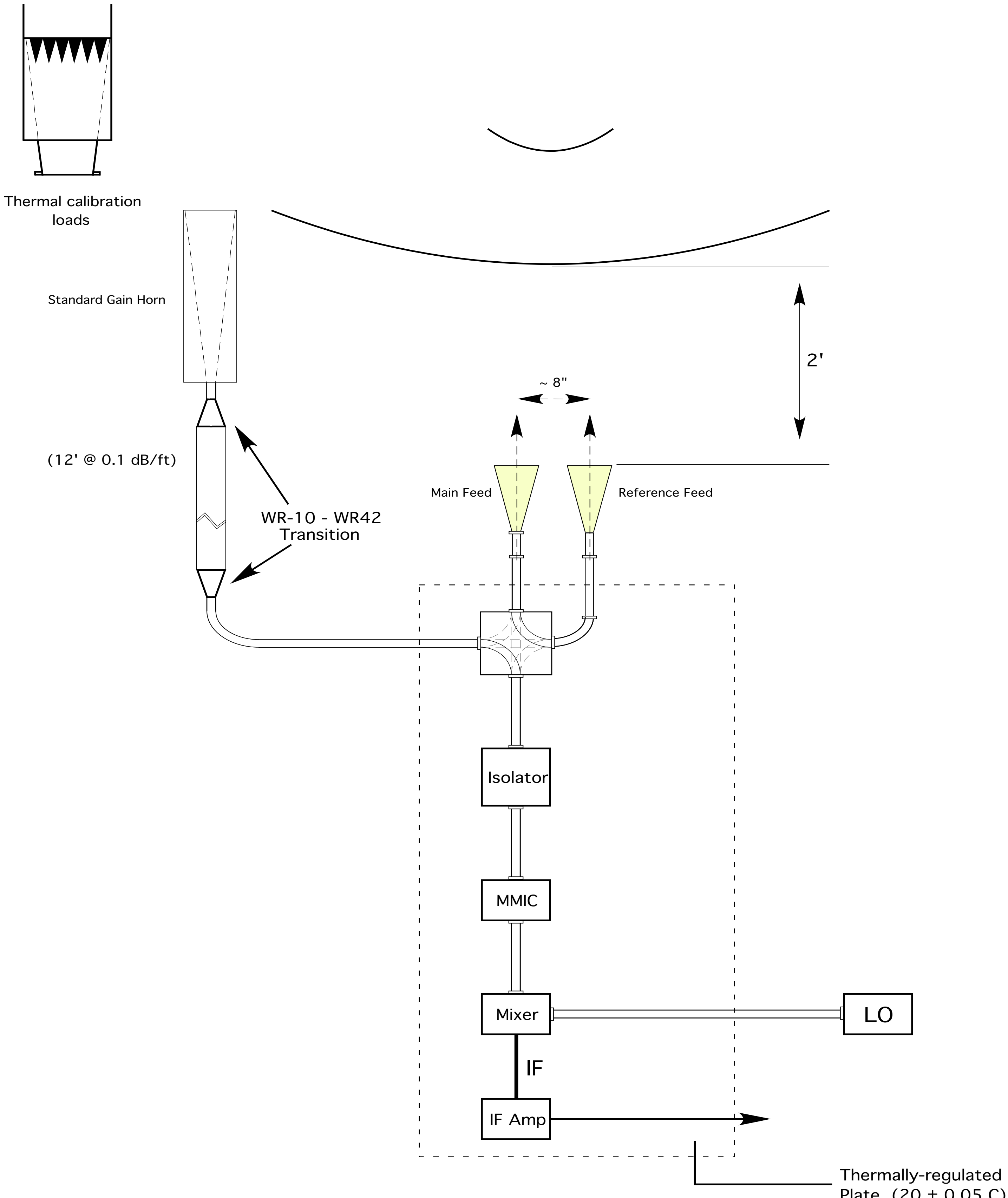

Figure 1: Overall diagram for the calibration receiver. The standard gain horn is shown. Also shown is one of the calibration loads.

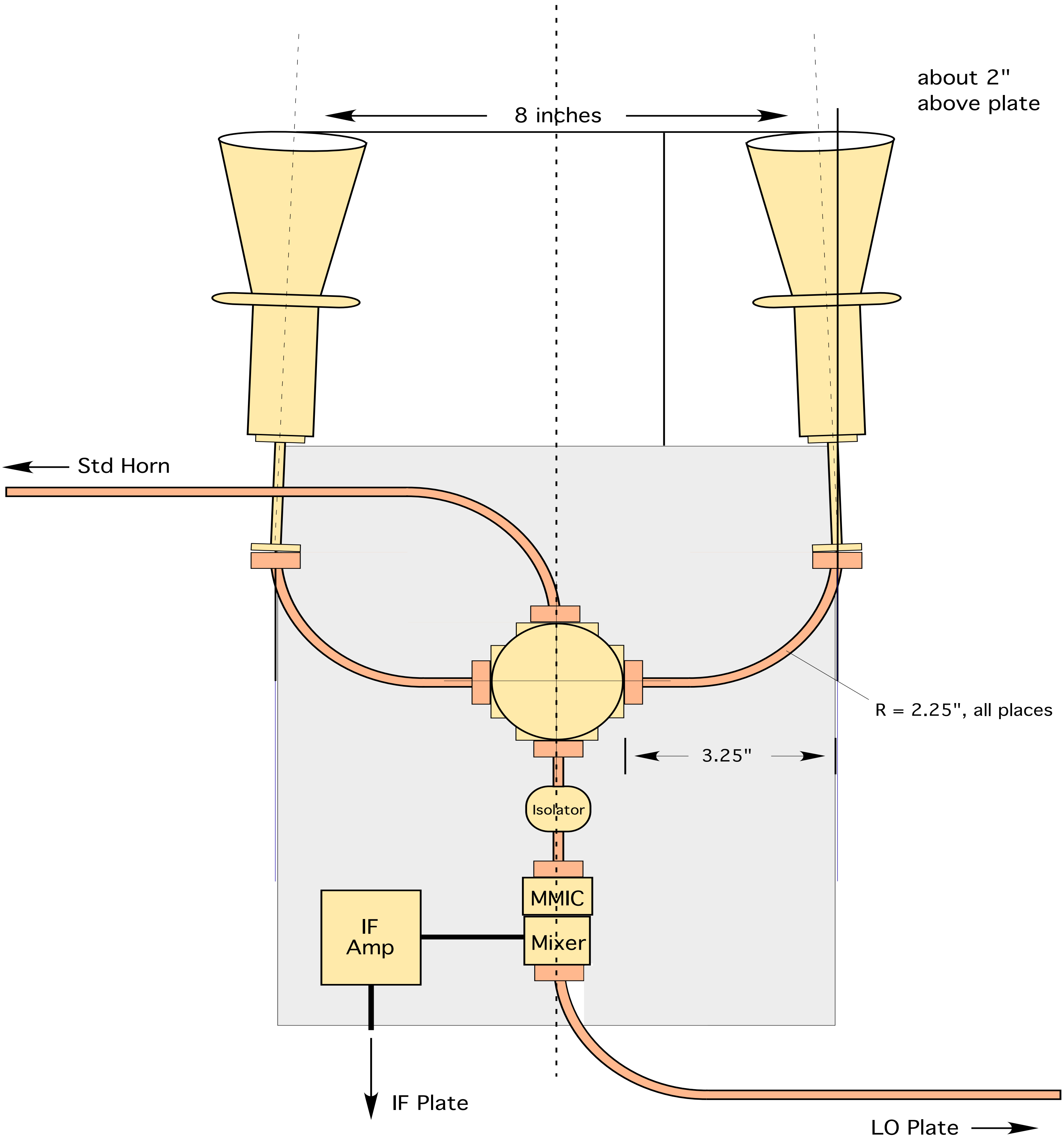

Figure 2: Detailed layout of the receiver plate.