PBAR NOTE 565
DEBUNCHER 4-8 GHZ PICKUP TESTS II

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Introduction

This document describes the second set of tests that were performed on prototype stochastic cooling pickups located in the 30 sector of the Debuncher. The pickups consisted of a slow wave slot pickup with a center frequency of 6 GHz, an array of sixteen 100 Ω 2-4 GHz planar loop pickups, and an array of eight 100 Ω 2-4 GHz stripline pickups of the TEV I design. The purpose of these tests was to measure the sensitivity of these different types of pickups under the exact same beam conditions.

Description of Pickups

The slow wave pickup and the planar loop pickup designs are described in Pbar Note #564 written in April 1997. The results of the April 1997 tests showed a large amount of microwave modes present in the 6 GHz slow wave pickup. To reduce these microwave modes, a microwave absorber was designed for the slow wave pickup. This absorber consisted of two rectangular sleeves 4.5" long that were located at either end of the slow wave pickup. The sleeves were made out of Emerson & Cuming MF-190 material. The MF190 sheet stock was machined to a thickness of 0.100" and four plates of this material were formed to make a square cross-section with the outside dimensions equal to the size of the beam pipe in the slow wave pickup (1.6" x 1.6"). The absorber reduced the acceptance of the slow wave pickup from 40 π-mm-mrad to 30 π-mm-mrad. Insertion loss tests showed that a single 4.5" long sleeve reduced the transmission of both sum and difference microwave modes in the frequency range of 4-8 GHz in excess of 30 dB.

While the microwave absorbers were being added to the slow wave pickup, the insertion loss from the output of the slow wave pickup to the input of the first pre-amplifier was measured. The measurements included the loss of the cables and the sum and difference mode hybrid. These results are shown in Figure 1. The "insertion loss" for a lossless hybrid would be 3 dB. As shown in Figure 1, there is an additional 3.2 dB for the sum mode and 4.2 dB for the difference mode.

In addition to the slow wave and planar loop pickups, the sensitivity a TEV I stripline pickup array was to be measured as well. The stripline pickup is actually a Debuncher vertical kicker array located in the 30 sector. A stripline kicker that is configured to kick forward moving antiprotons has the same configuration as a pickup wired to detect reverse protons. The travelling wave tube amplifier and microwave hybrid were removed from the input of the kicker array. The input of the kicker array is now considered to be the output of a pickup array for reverse protons. A Petter type hybrid and low noise pre-amp were connected to this newly configured "output". This array is at room temperature and contains eight 100 Ω loops.

Measurements

Reverse protons were injected into the Debuncher and stored. The beam was heated transversely by turning on the Debuncher dampers with the damper pickups disconnected and using the thermal noise of the power amp. The vertical transverse distribution was measured by scrapping the beam with the vertical scrapper D:TJ308. This measurement was repeated 3 times for different beam currents. Each measurement resulted with the same rms beam size at the scraper of 9.4 mm (The vertical beta function at the scraper is 14 m.) The scraper position data was taken with a new application program that stored 500 data points of beam current and scrapper position for each measurement. This program is called X-Y Plot and is currently located at P106. The beam amplitude distribution versus scraper position is shown in Figure 2.

The schottky power spectrum was measured with a spectrum analyzer. To remove the effects of the momentum distribution of the beam, the resolution bandwidth was set to 3 MHz, which is much wider than the 590 kHz spacing of the schottky, bands. A Lab-View program was written to remove the 1000 point traces from the spectrum analyzer and store the data in ASCII format on a disk.
The sum mode impedance of the pickup is:

$$Z_\Sigma = (g-1)\frac{N_f S_{therm.}}{eI_{dc}} \tag{1}$$

The difference mode impedance is:

$$Z_\Delta = (g-1)\frac{N_f S_{therm.}}{2eI_{dc}\left(\frac{\sigma}{d}\right)^2} \tag{2}$$

where N_f is the noise figure of the pre-amp and S_{therm} is the power spectral density of white thermal noise, which is equal to -174 dBm/Hz at room temperature. The quantity "g" is defined to be the ratio of the power per schottky band when there is beam in the machine to when there is no beam in the machine:

$$g = \frac{P_{beam} + P_{noise}}{P_{noise}} \tag{3}$$

The 2-4 GHz arrays had to be measured in two bands because of limitations in the microwave spectrum analyzer. These bands were from 0.5-2.5 GHz and from 2.5-5.0 GHz. To get the results to match up at 2.5 GHz, The fitted noise figure of the pre-amp had to be increased by 1 dB at the lower band as compared to the upper band. The reason for this increase is unknown.

Conclusions

The microwave absorber vastly improved the performance of the 6 GHz slow wave pickup. The 4 dB discrepancy between the measurements and the design can be accounted for by insertion loss in the output cables and the sum and difference mode hybrid. However, the notches in the sum mode measurements in the pass band are much stronger than the design predicts.

The sensitivity of the planar loop array is about equal to the TEV I design at frequencies below 3 GHz. Above 3 GHz, the planar loop array is less sensitive than the TEV I design.

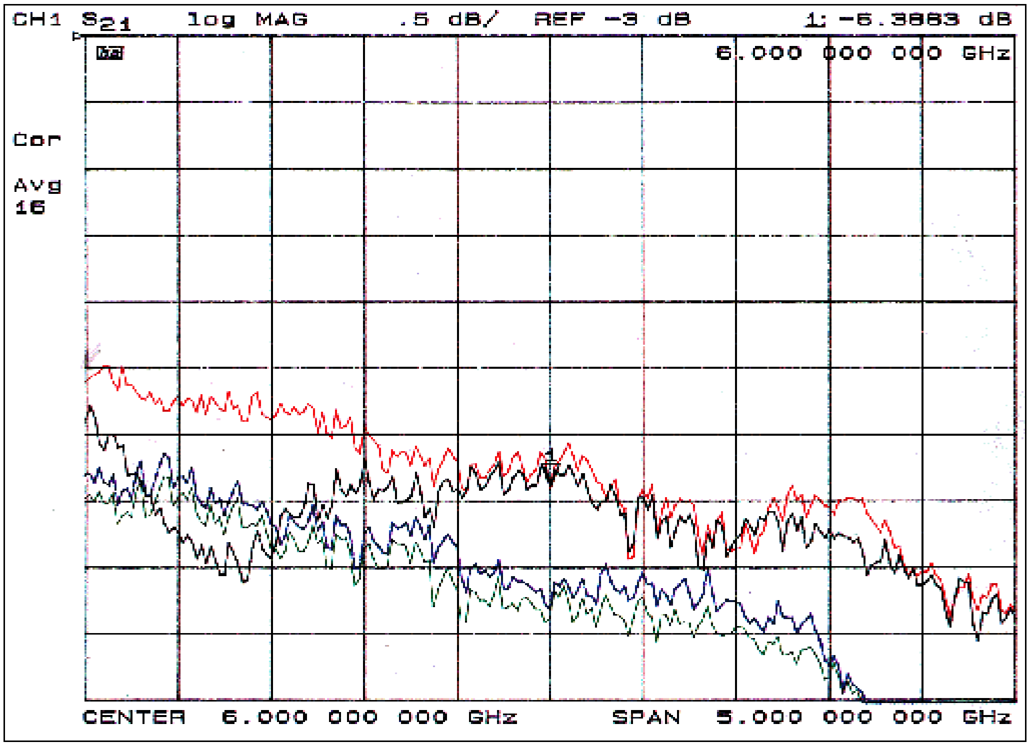

Figure 1. Insertion loss measurements from the slow wave pickup to the input of the first amplifier. The red and black traces are for the sum mode and the blue and green are for the difference mode.

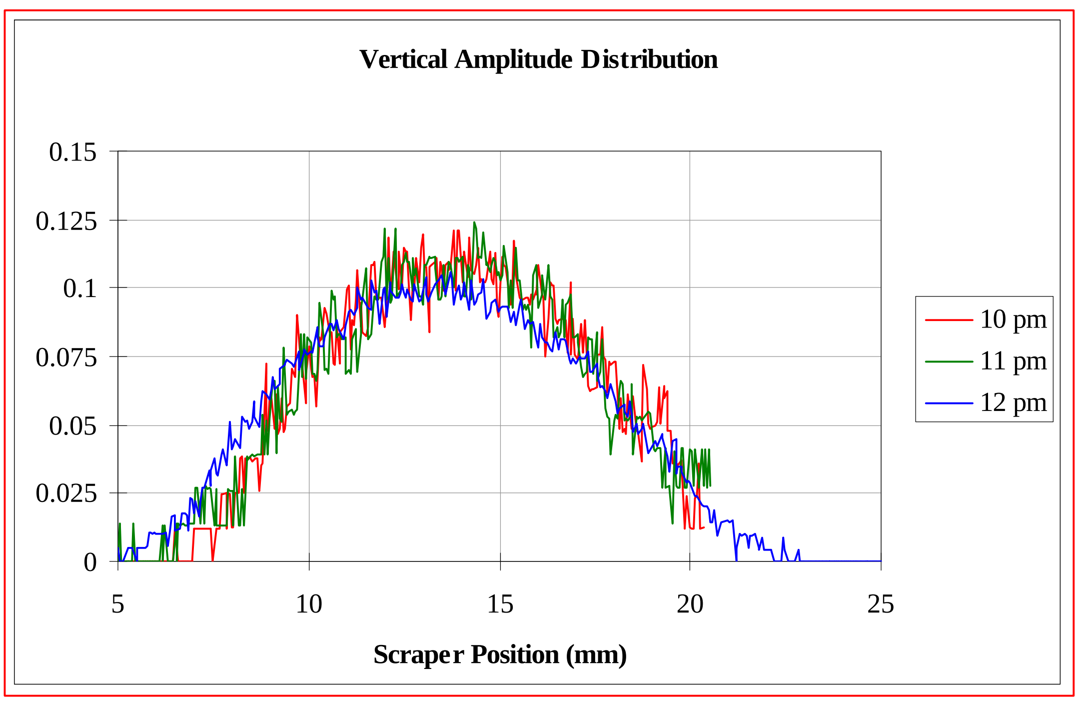

Figure 2. Vertical Beam Amplitude density versus scraper position. All three measurements have and rms value of 9.4 mm.

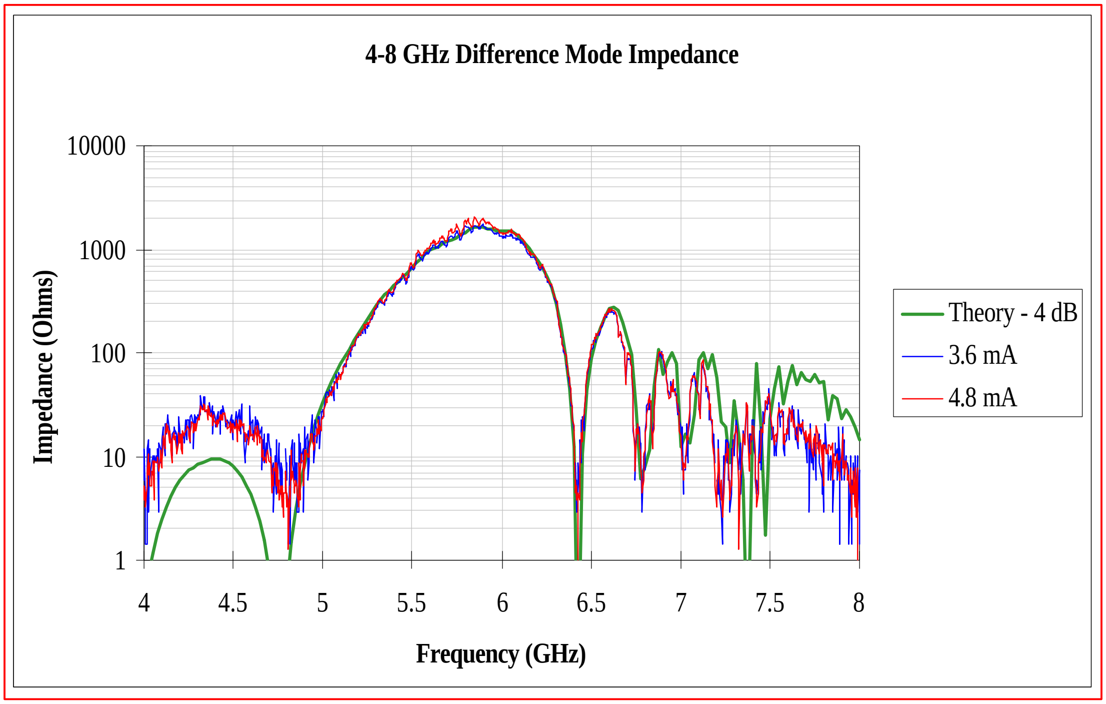

Figure 3. Difference mode response of the 6 GHz slow wave pickup. The blue and red traces are measurements for two separate beam currents.

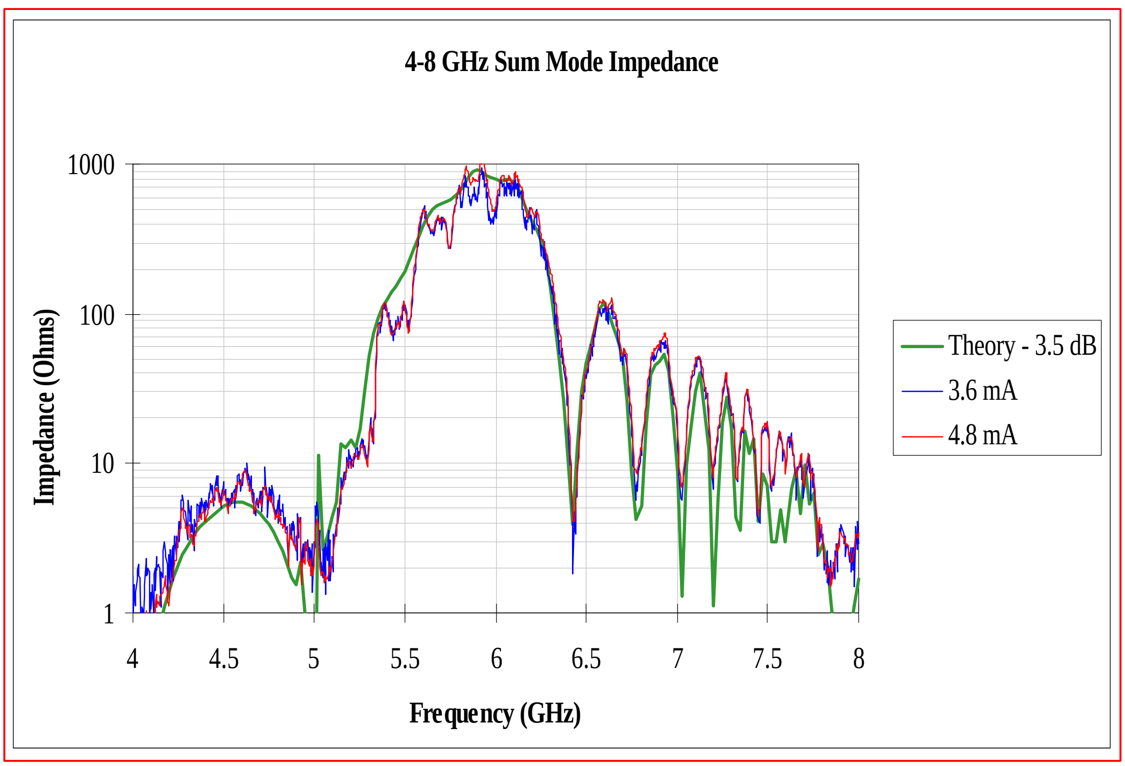

Figure 4. Sum mode response of the 6 GHz slow wave pickup. The blue and red traces are measurements for two separate beam currents.

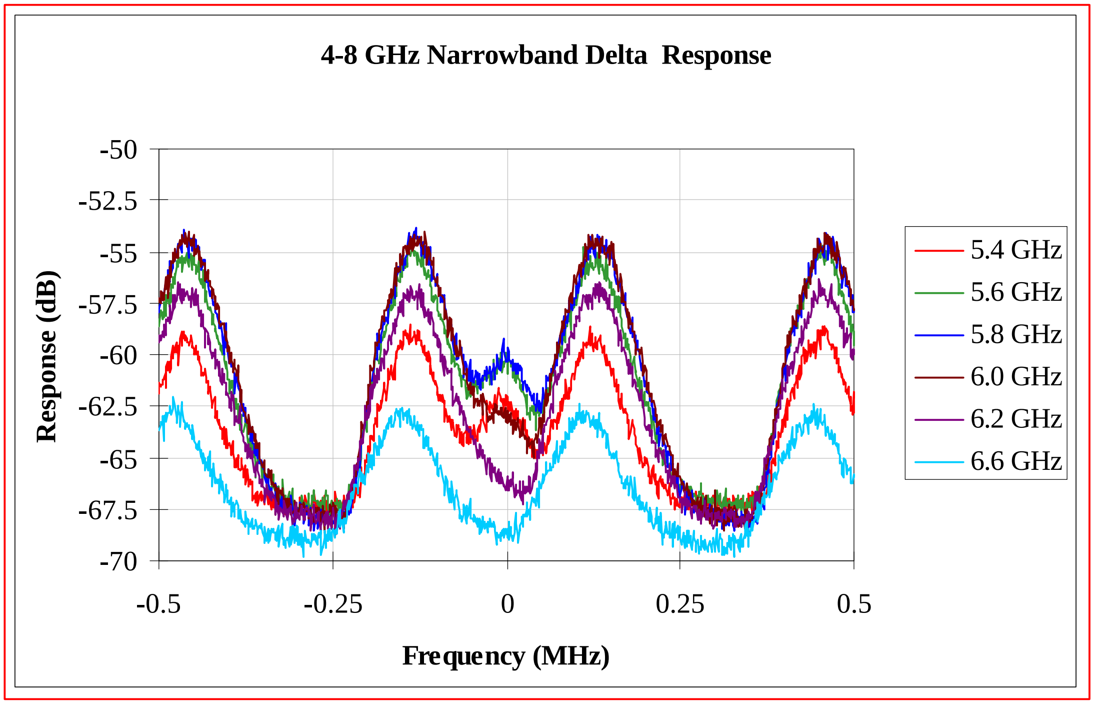

Figure 5. Narrowband signal of the 6 GHz slow wave pickup in the difference mode at several microwave frequencies

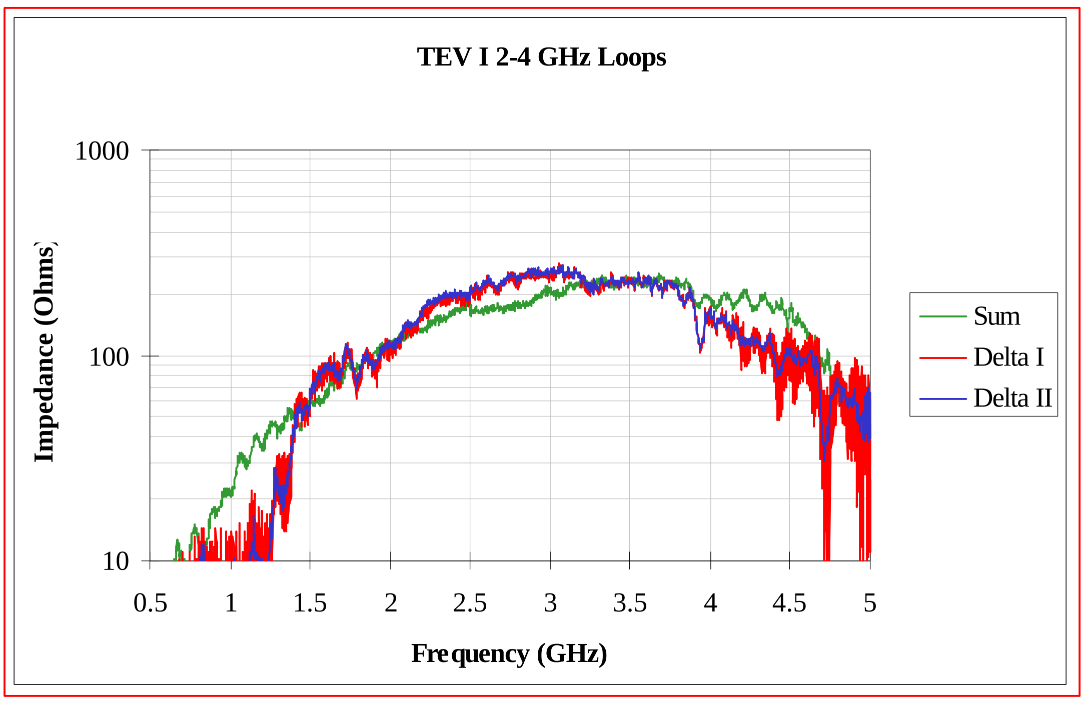

Figure 6. Sum and difference mode impedance for the TEV I stripline array. The array contains eight pair of 100W loops. The red and blue traces are for two separate beam currents.

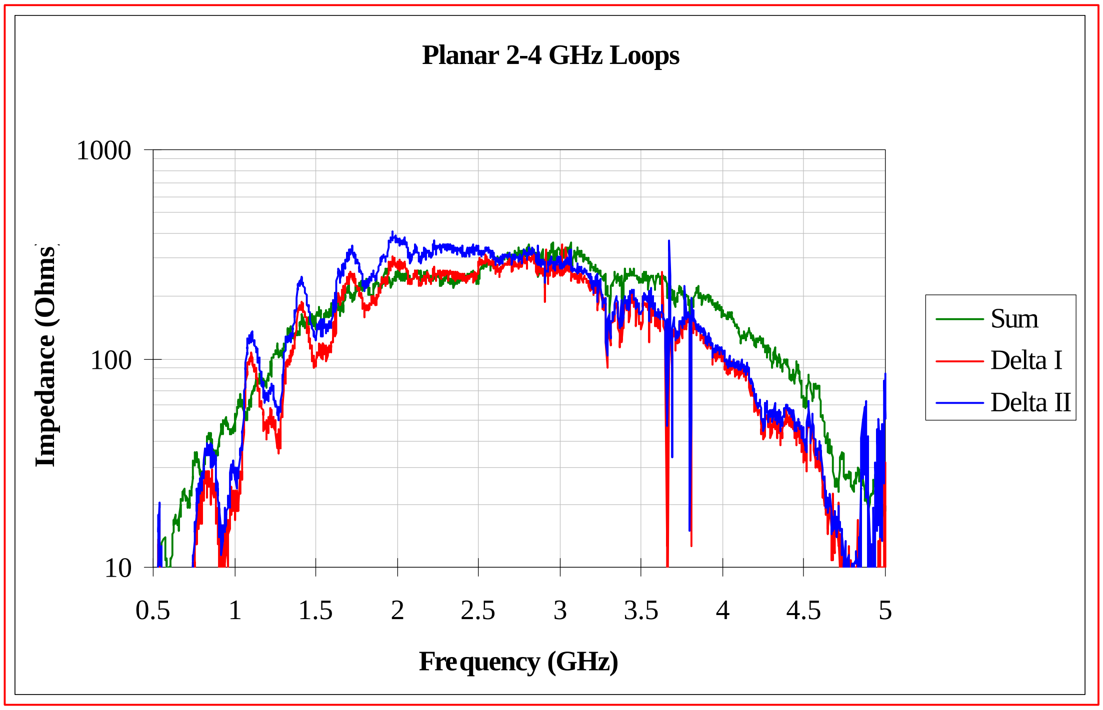

Figure 7. Sum and difference mode impedance for the planar loop array. The array contains sixteen pair of 100W loops. The red and blue traces are for two separate beam currents.

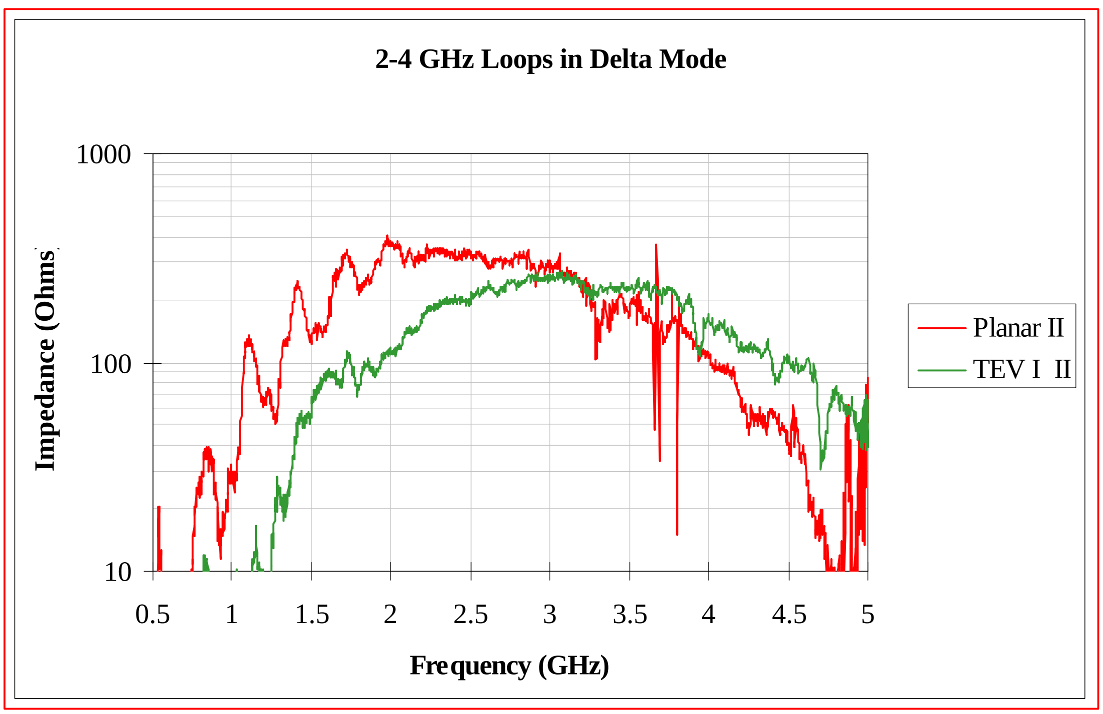

Figure 8. Difference mode impedance of the planar and TEV I arrays. The planar array should have twice the impedance of the TEV I array because it has twice as many loops.

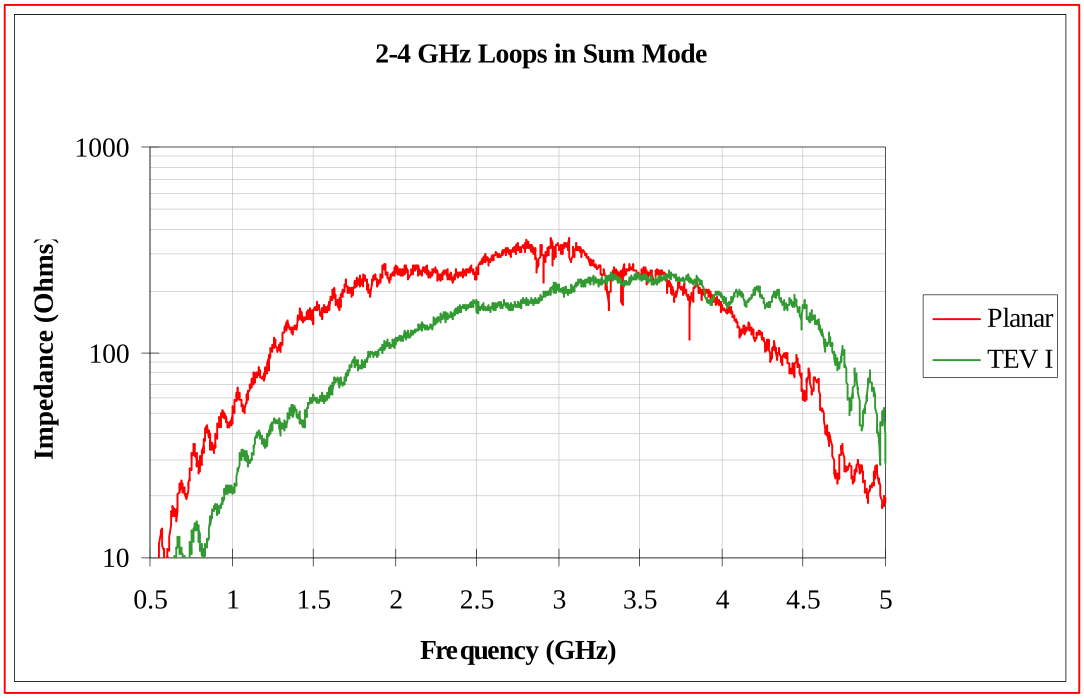

Figure 9. Sum mode impedance of the planar and TEV I arrays. The planar array should have twice the impedance of the TEV I array because it has twice as many loops.

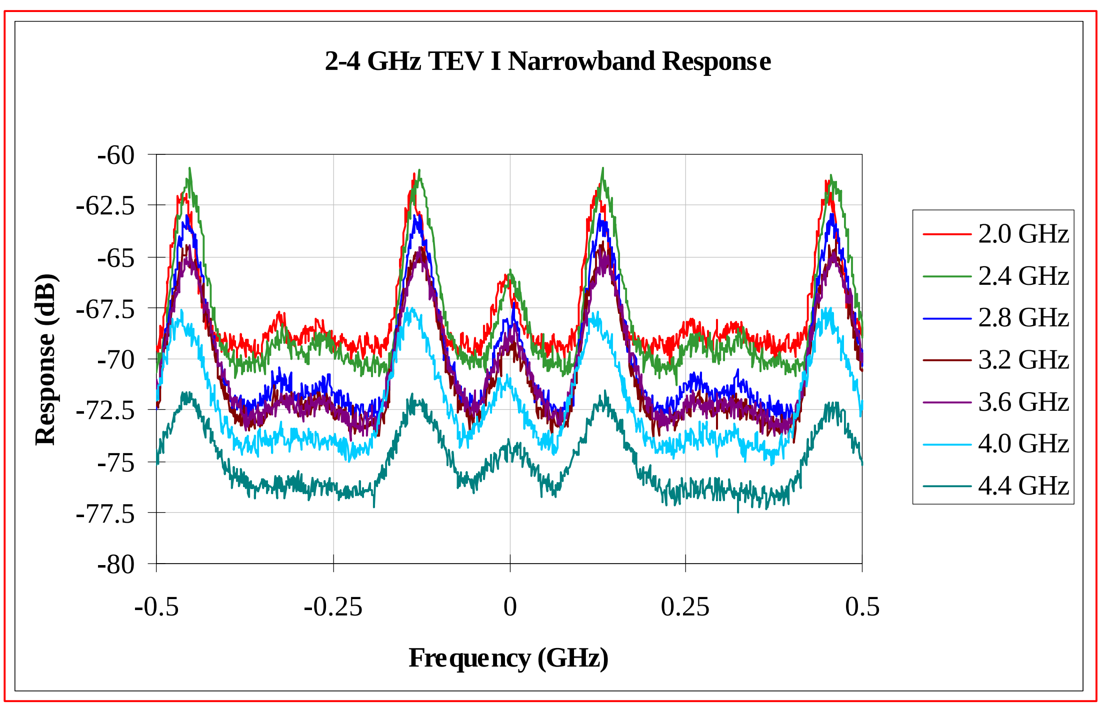

Figure 10. Narrowband signal of the TEV I pickup in the difference mode at several microwave frequencies

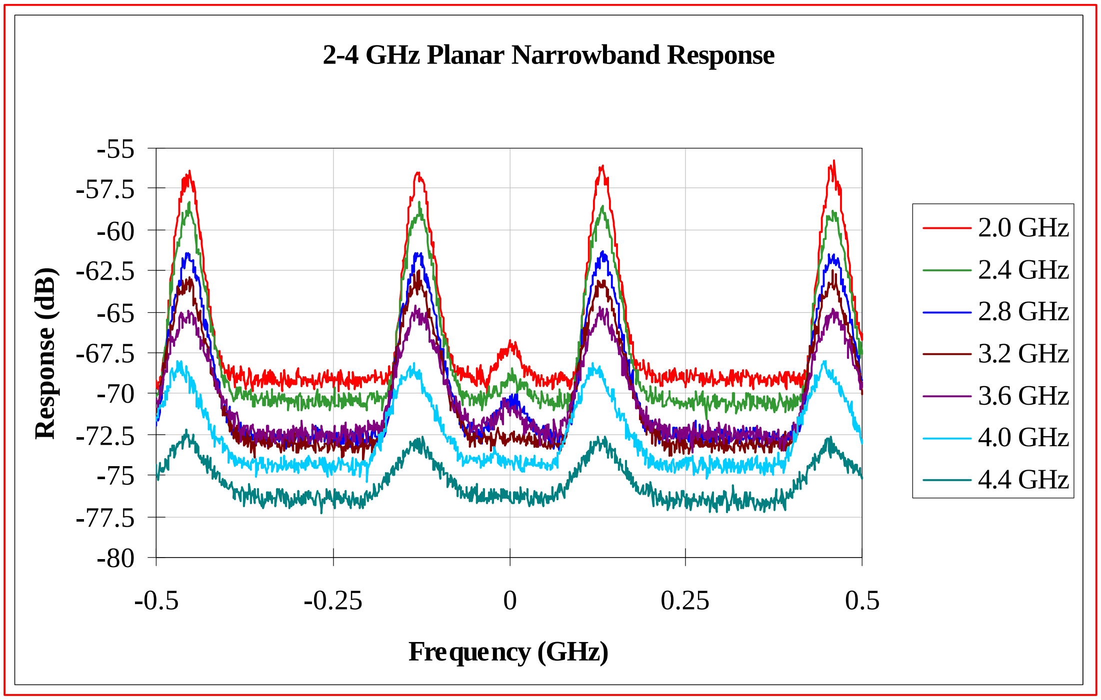

Figure 11. Narrowband signal of the planar pickup in the difference mode at several microwave frequencies