PBAR NOTE 618
SUMMARY OF MEASUREMENTS ON THE ACCUMULATOR STOCHASTIC COOLING SYSTEMS

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Introduction

The following contains an (incomplete) summary of the measurements that were done on the Accumulator Stochastic Cooling Systems during the period of July 28 - August 17, 1999. The measurements can be divided into 3 categories:

1. Transfer Function Measurements
2. Signal to Noise Measurements
3. Stacktail Transfer Function Measurements

Transfer Function Measurements

The transfer function measurements are shown in Figures 1-18 and will be used to design equalizers for most of the cooling systems. Almost all of the bandwidths are half of the design value.

Signal to Noise Measurements

The signal to noise measurements are used to measure the pickup response and impedance. The technique used to measure the pickup impedance is described in Pbar Note No. 564 **Debuncher 4-8 GHz Pickup Tests**. The impedance for a sum mode pickup is:

$$Z_{\Sigma} = \left(\frac{P_{beam} + P_{noise}}{P_{noise}} - 1 \right) \frac{N_f S_{therm}}{eI_{dc}}$$

where $P_{beam} + P_{noise}$ is the power measured by a spectrum analyzer when there is beam over the pickup and P_{noise} is the power when there is no beam in the accelerator. The beam current is given as I_{dc}, the noise figure of the first amplifier is N_f, and S_{therm} is the power spectral noise density at the pickup (-174 dBm/Hz at Room temperature). The impedance for a difference mode pickup is:

$$Z_{\Delta} = \left(\frac{P_{beam} + P_{noise}}{P_{noise}} - 1 \right) \frac{N_f S_{therm}}{2eI_{dc} \left(\frac{\sigma}{d} \right)^2}$$

where σ is the rms beam size and d is the transverse aperture of the pickup. The measurements are shown in Figures 19-35. The notches in Figures 27-35 are due to errant coherent signals being picked up in the switch tree of the StackTail system and are not actually part of the pickup impedance.

StackTail Transfer Function Measurements

StackTail transfer function measurements where made by placing the beam at different revolution frequencies from 628,820 Hz to 628,880 Hz at 5 Hz intervals and measuring the beam transfer function through each of the four legs in the StackTail system individually. Leg 1 is located at 628,822 Hz, Leg 2 is located at 628,837 Hz and Leg 3 is located at 628,854 Hz. Special care was given to make the beam width the same for each measurement and to keep the beam current low enough so as not to saturate the pickups. The measurements were collated in a Microsoft EXCEL spreadsheet. Each leg was given a gain, delay and phase offset. At each revolution frequency, the response due to all the legs was added vectorally and integrated over the bandwidth of the StackTail system.

Figures 36-48 show two cases of Stacktail settings. The first setting is with only Legs 1 and 2 activated. The attenuator of Leg 1 was set 8 dB more than the attenuator of Leg 2. As shown in Figures 36-42, the resulting gain slope is 10 MeV for most of the StackTail range but the gain slope increases dramatically above 628,855 Hz. Since the 2-4 GHz Core Momentum high energy plate is located at 628,862 Hz, this solution will stack. A stacking rate of 12-14 mA hour was achieved with this solution. See Pbar Electronic Log for Evening Shift Monday August 9 & 13, 1999.

The second solution used the compensation leg, Leg 3. The attenuators of both Leg 1 and Leg 2 where set the same and the attenuator of Leg 3 was set to 3 dB. The length of Leg 3 was decreased by 100 pS by changing A:SPTL06 to 271 pS. The results are shown in Figures 43-47. The gain slope for this solution was about 10 MeV. This solution did stack as shown in Figure 48.

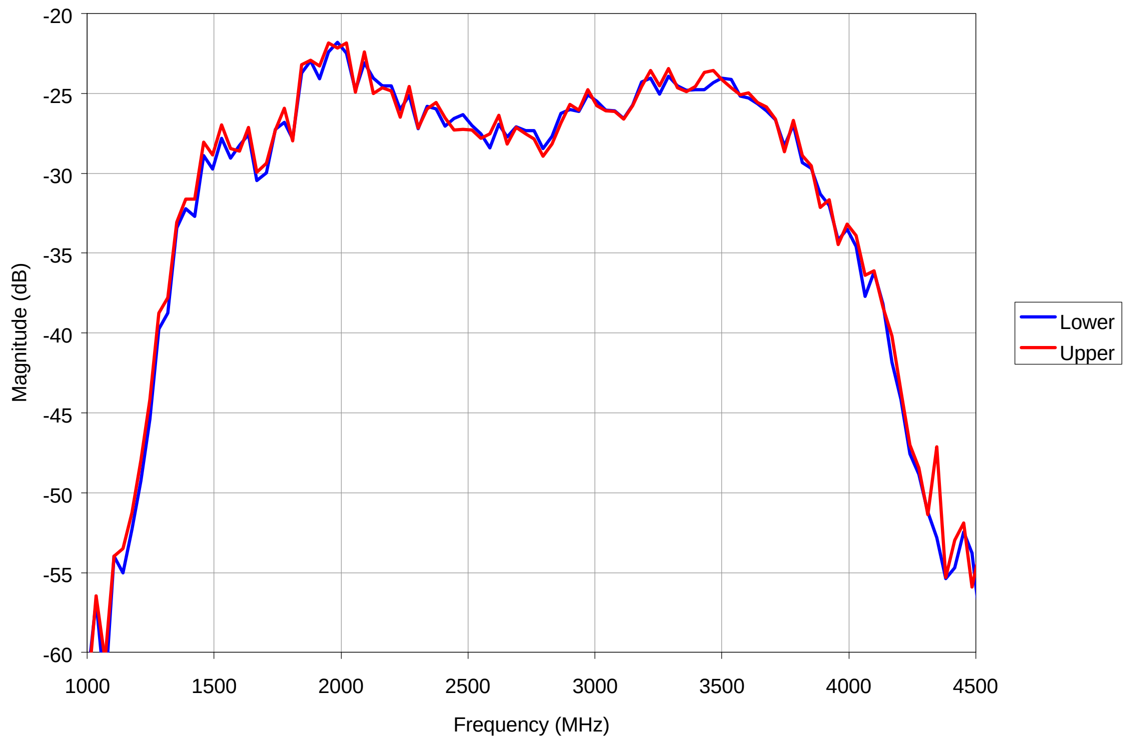


Figure 1. Vertical 2-4 GHz System Gain. Bandwidth = 1.313 GHz

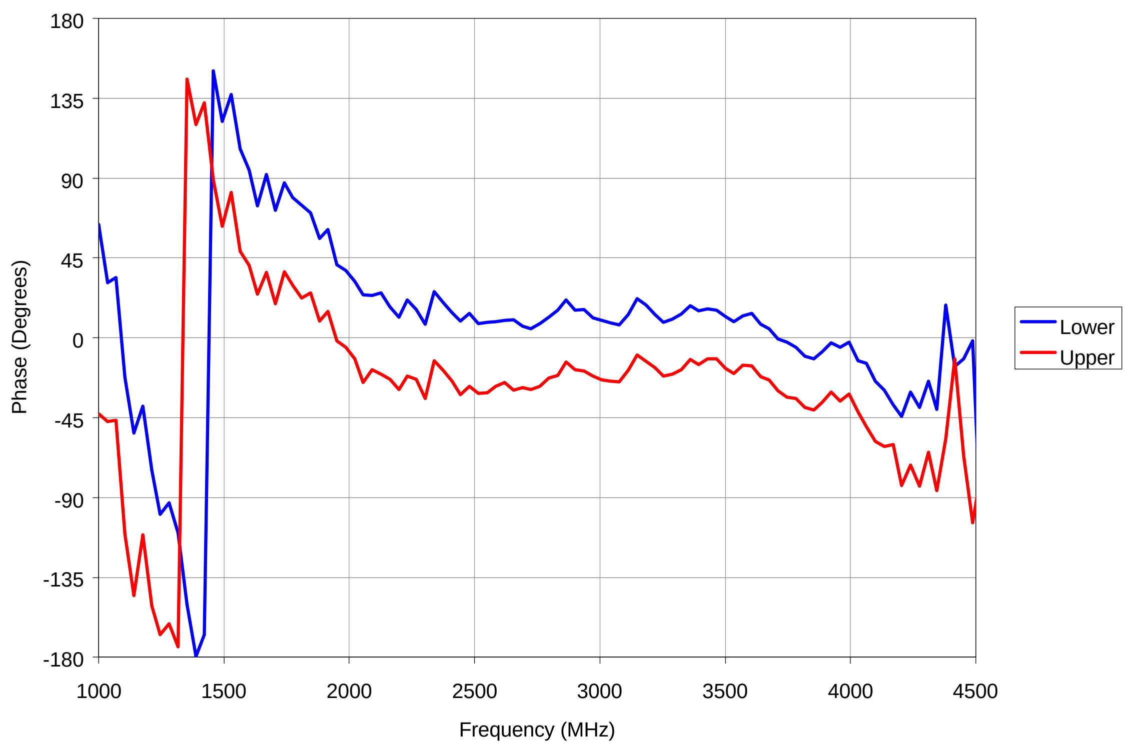


Figure 2. Vertical 2-4 GHz System Phase. Phase offset = 180 degrees.

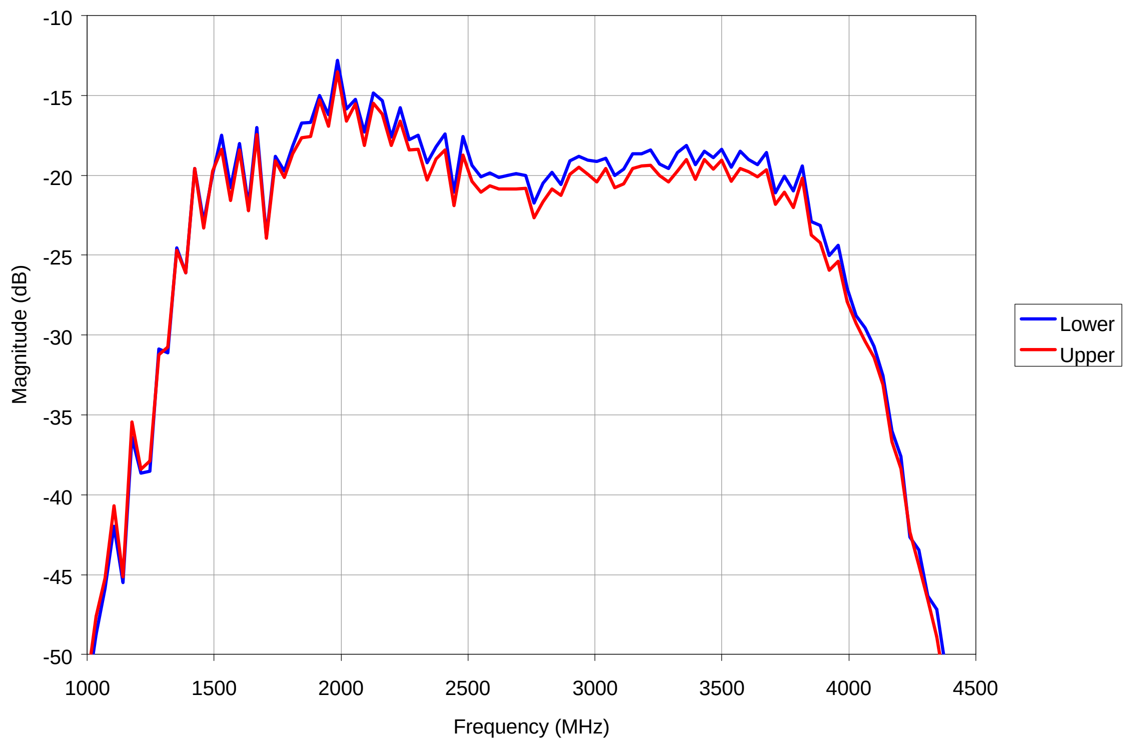


Figure 3. Horizontal 2-4 GHz System Gain. Bandwidth = 1.046 GHz.

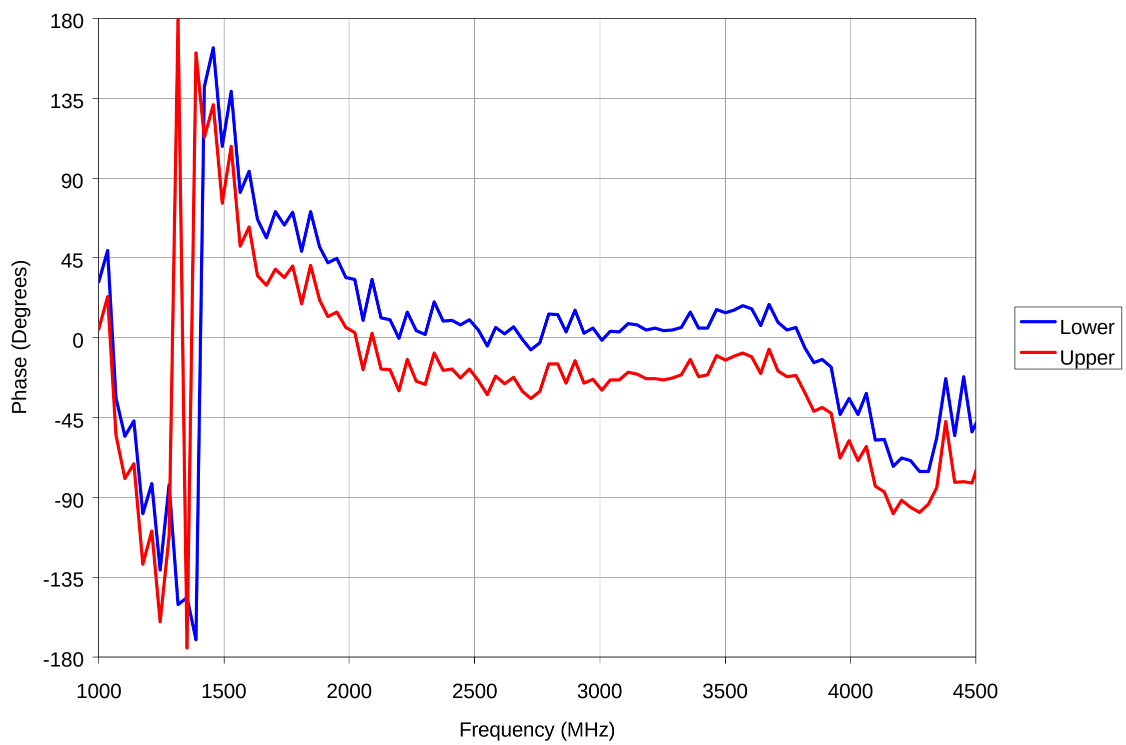


Figure 4. Horizontal 2-4 GHz System Phase. Phase offset = 180 degrees.

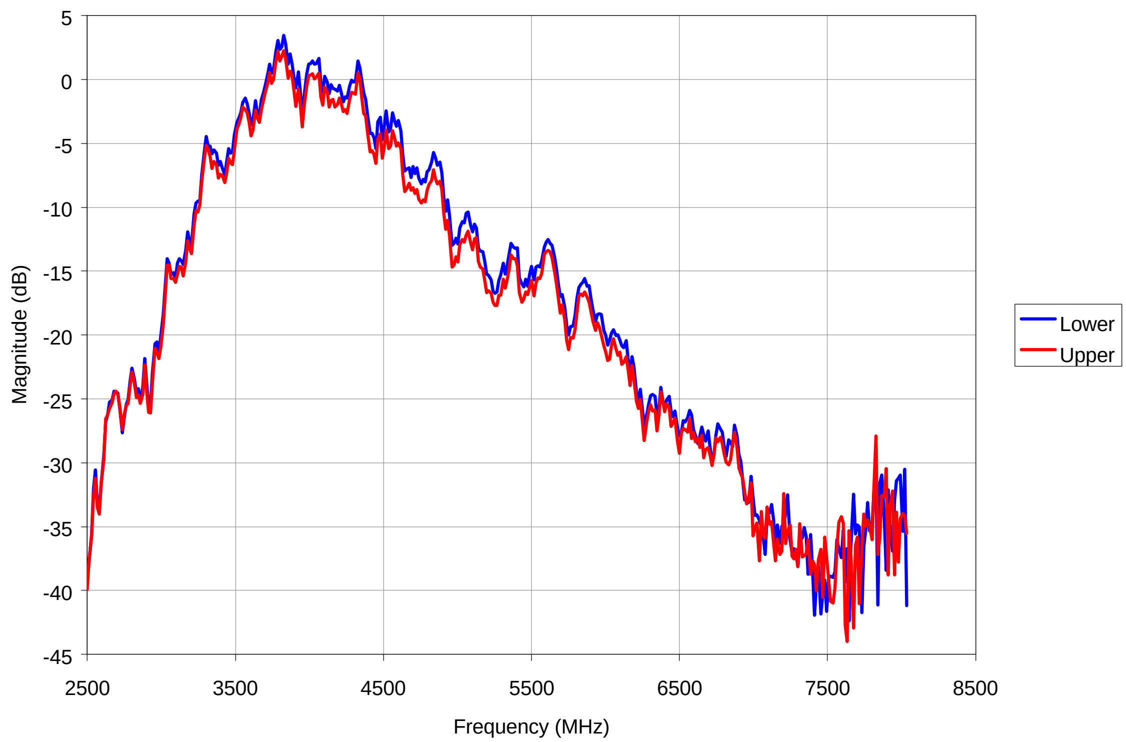


Figure 5. Vertical 4-8 GHz System Gain. Bandwidth = 0.694 GHz.

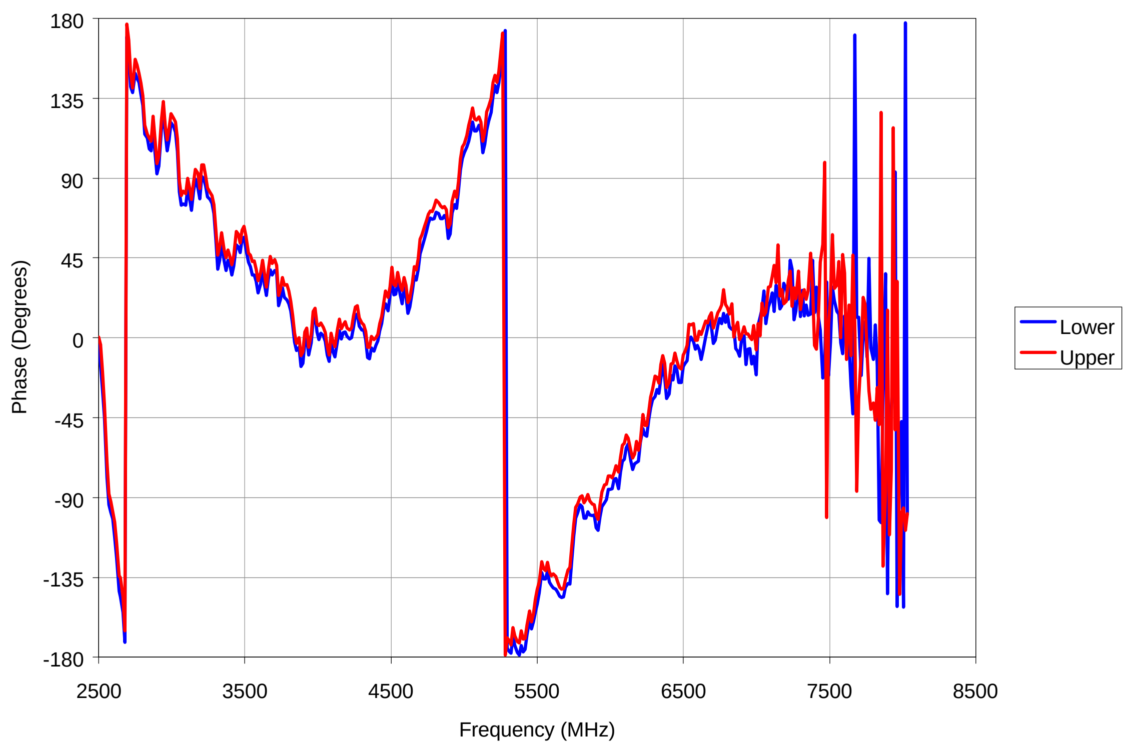


Figure 6. Vertical 4-8 GHz System Phase. Phase offset = 180 degrees.

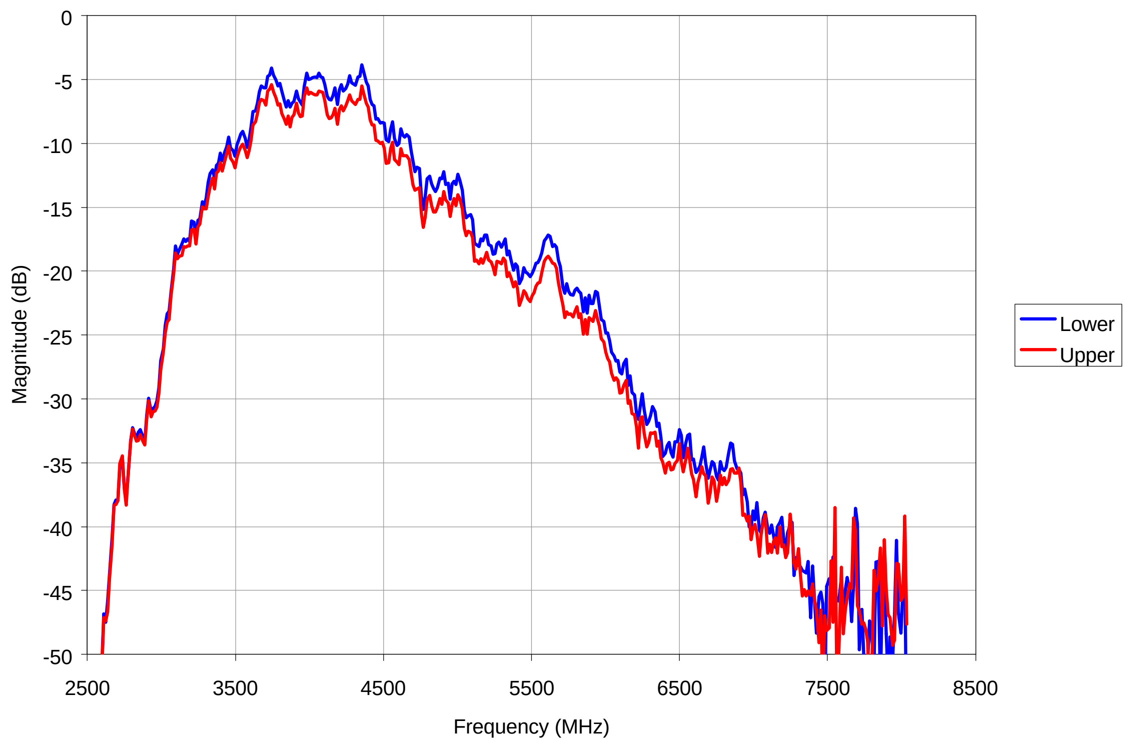
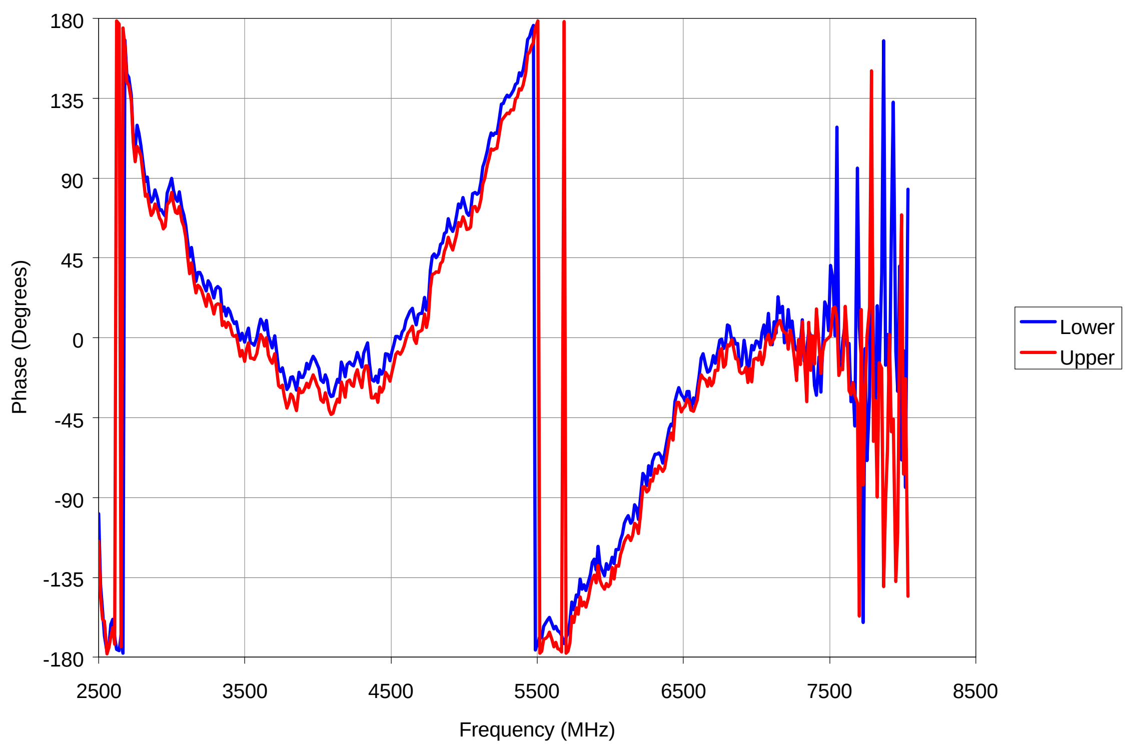


Figure 7. Horizontal 4-8 GHz System Gain. Bandwidth = 0.939 GHz



bFigure 8. Horizontal 4-8 GHz System Phase. Phase offset = 180 degrees.

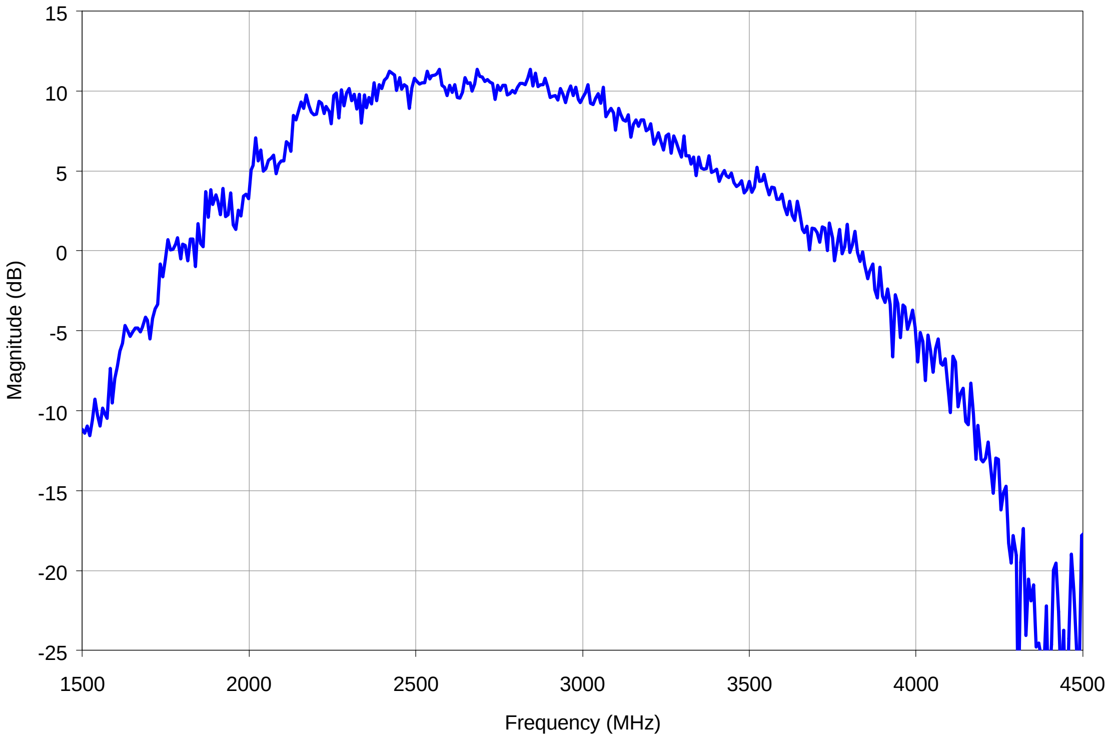


Figure 9. Momentum 2-4 GHz System Gain. Beam over high energy pickup. Bandwidth = 1.313 GHz

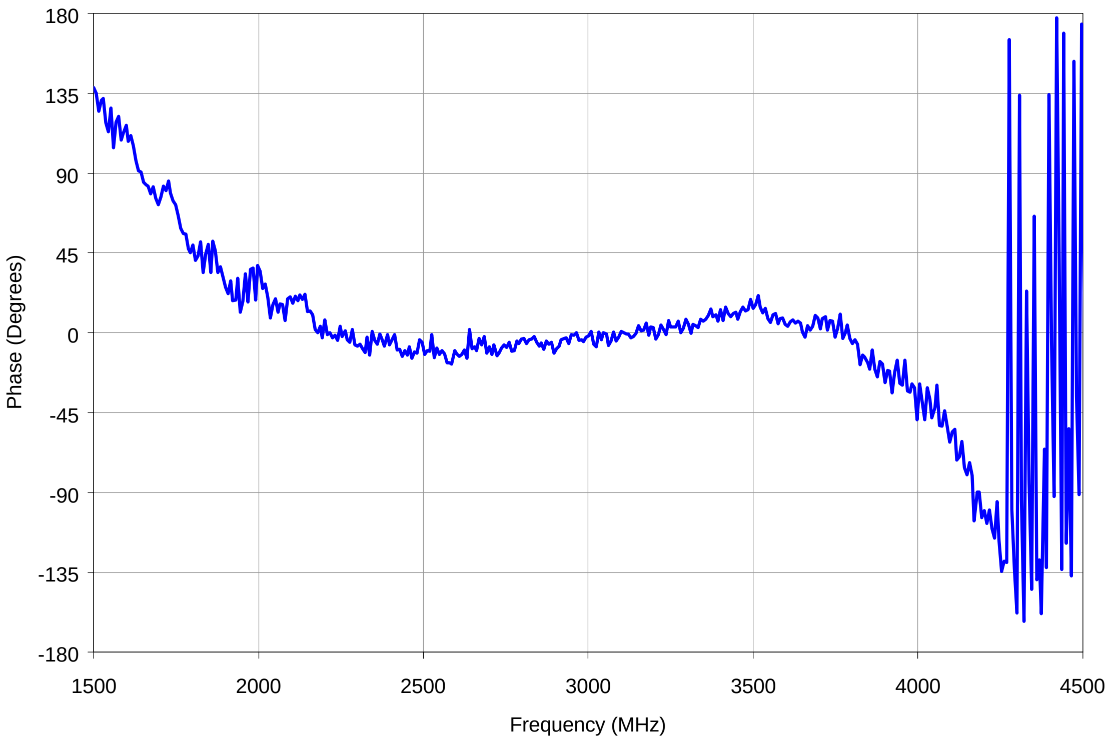


Figure 10. Momentum 2-4 GHz System Phase. Phase offset = -90 degrees. Delay added in = 22 pS.

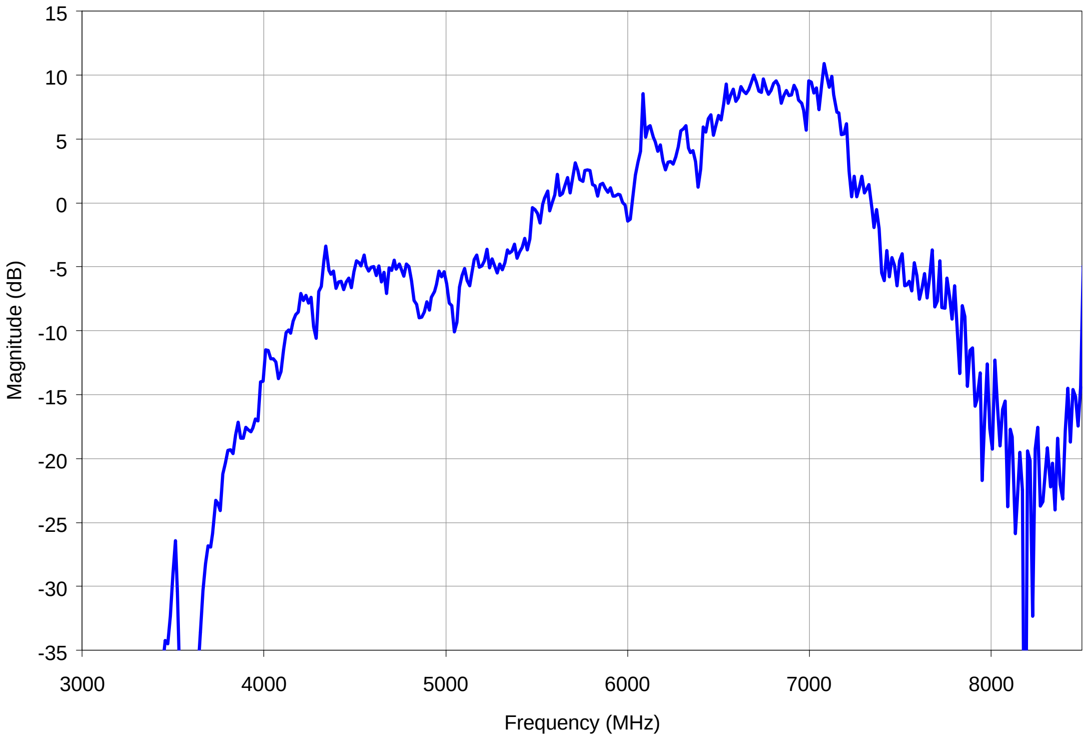


Figure 11. Momentum 4-8 GHz System Gain over the low energy pickup. Bandwidth = 1.105 GHz

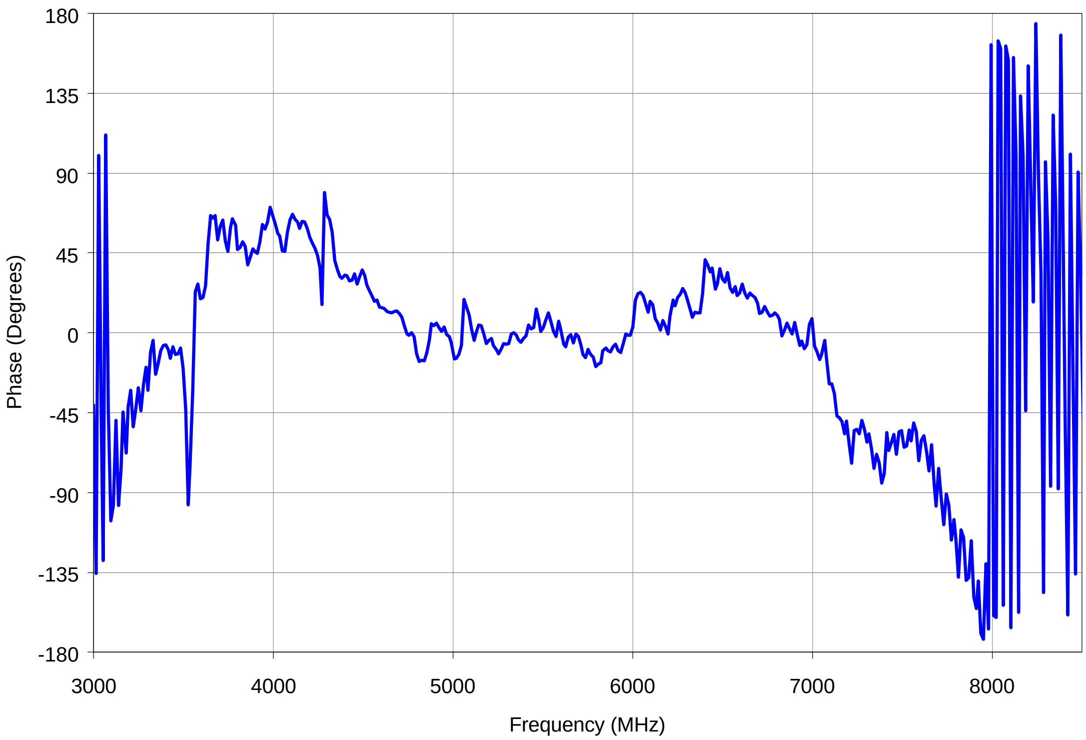


Figure 12. Momentum 4-8 GHz System Phase. Phase offset = 90 degrees.

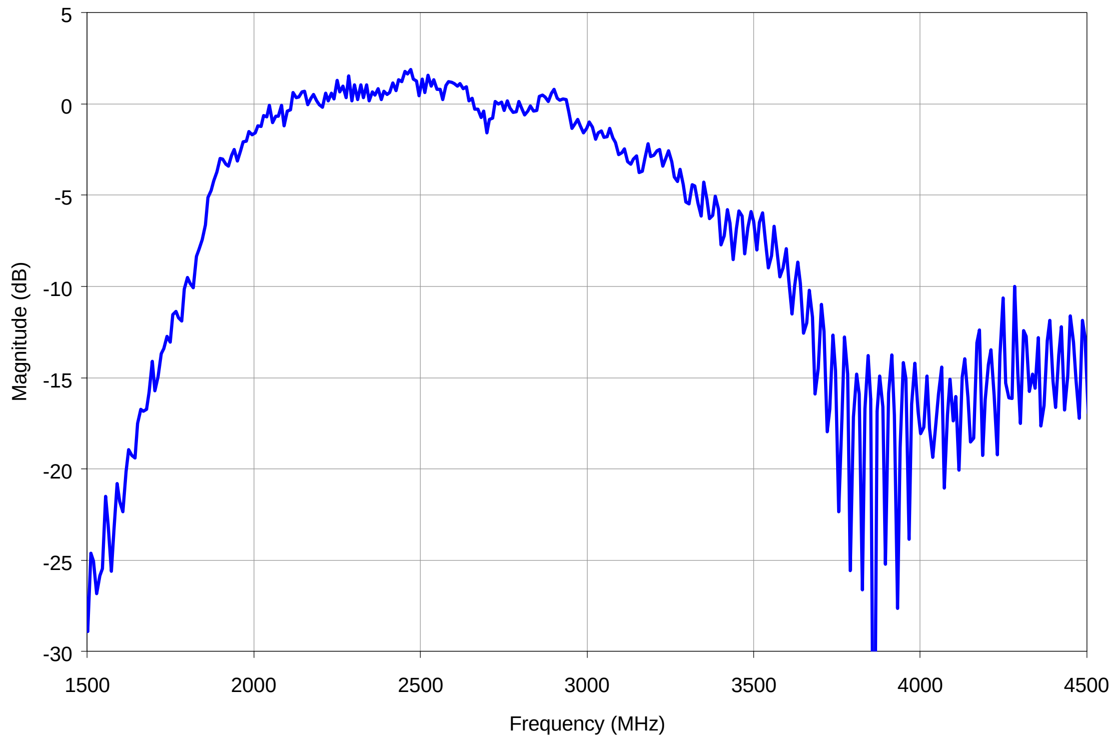


Figure 13. Stacktail Leg 1 Gain with beam over Leg 1. Bandwidth = 1.079 GHz

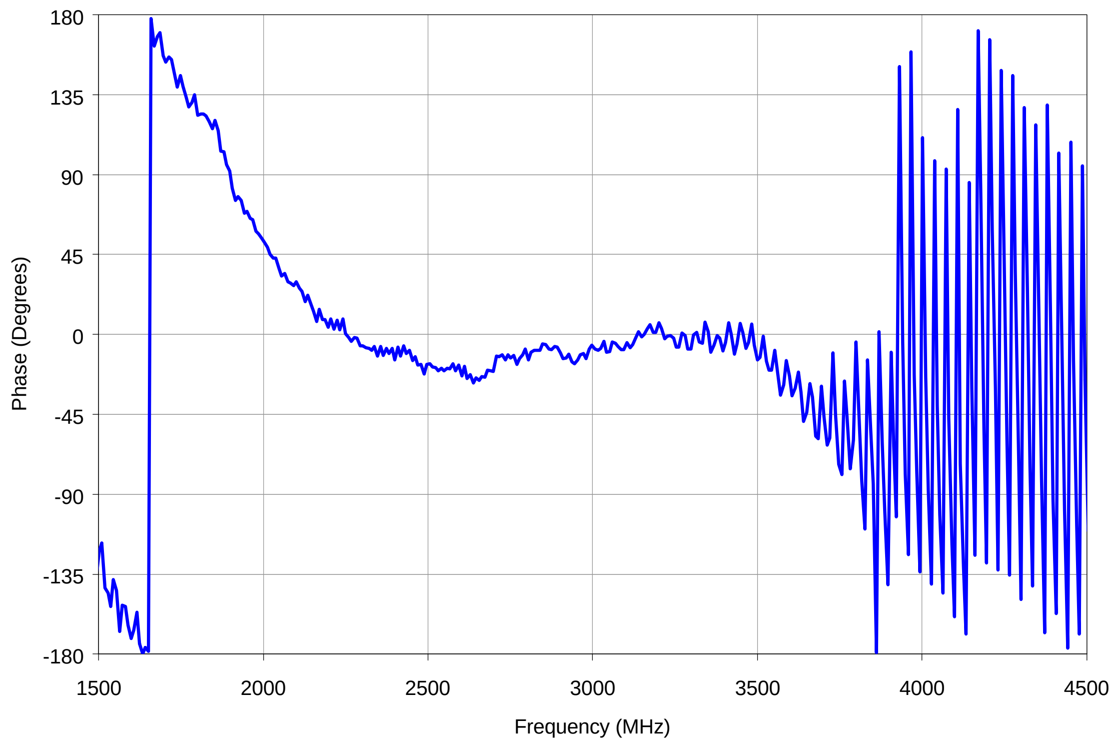


Figure 14. Stacktail Leg 1 Phase Gain with beam over Leg 1. Phase offset = 66.5 degrees with 169 pS of delay added in.

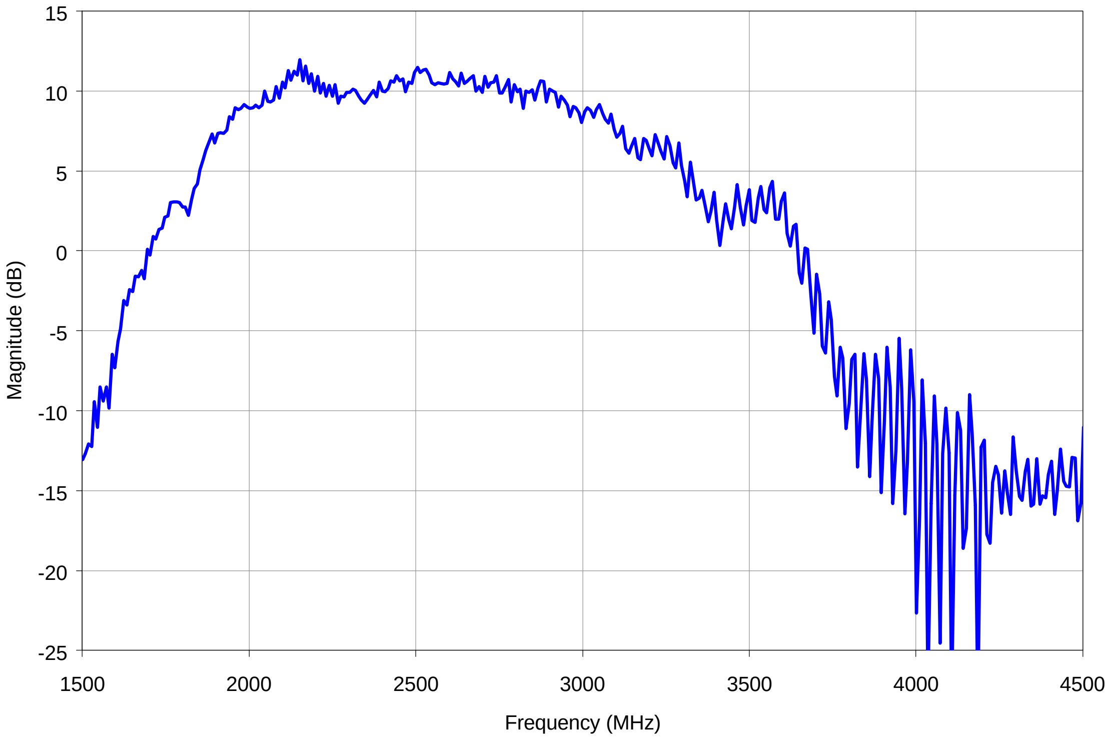


Figure 15. Stacktail Leg 2 Gain with beam over Leg 2. Bandwidth = 1.097 GHz.

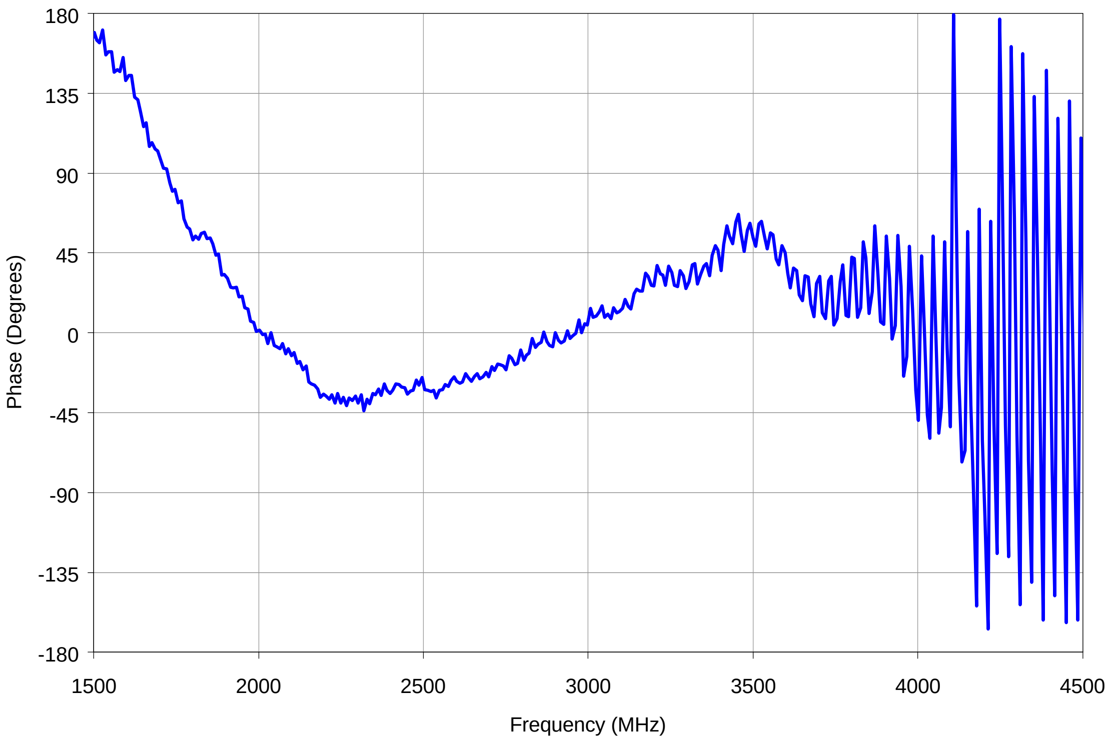


Figure 16 Stacktail Leg 2 Phase with beam over Leg 2. Phase offset = -42 degrees with 125 pS of delay added in.

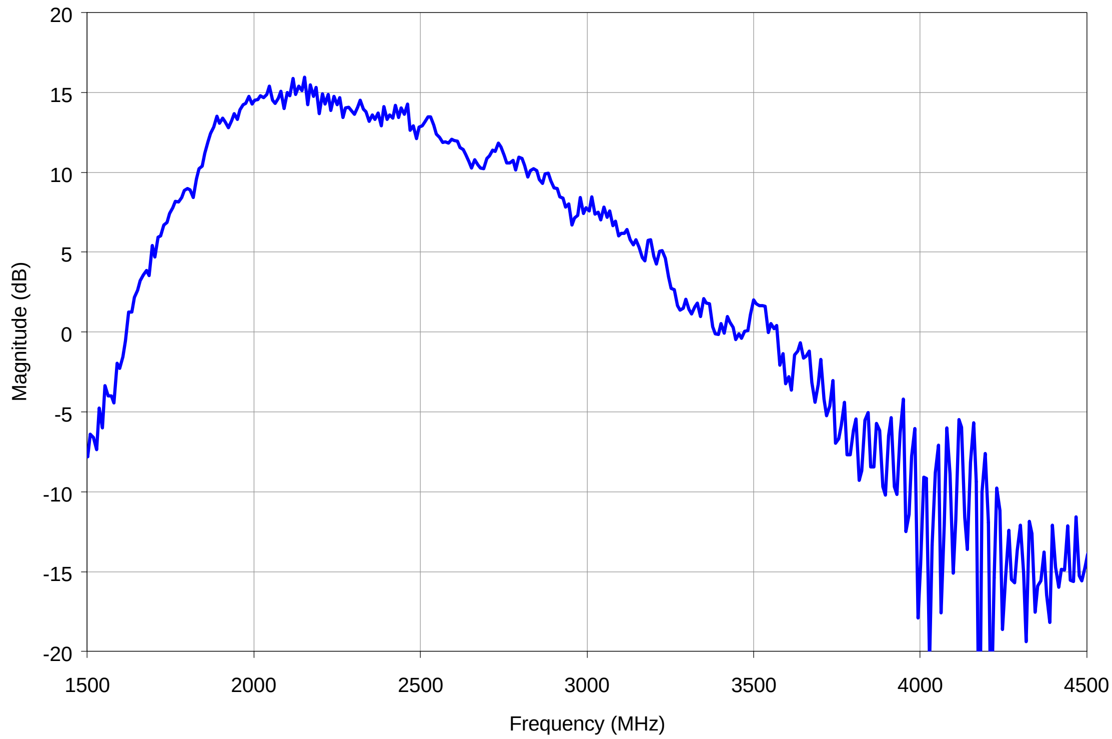


Figure 17 Stacktail System Gain with beam over Leg 2

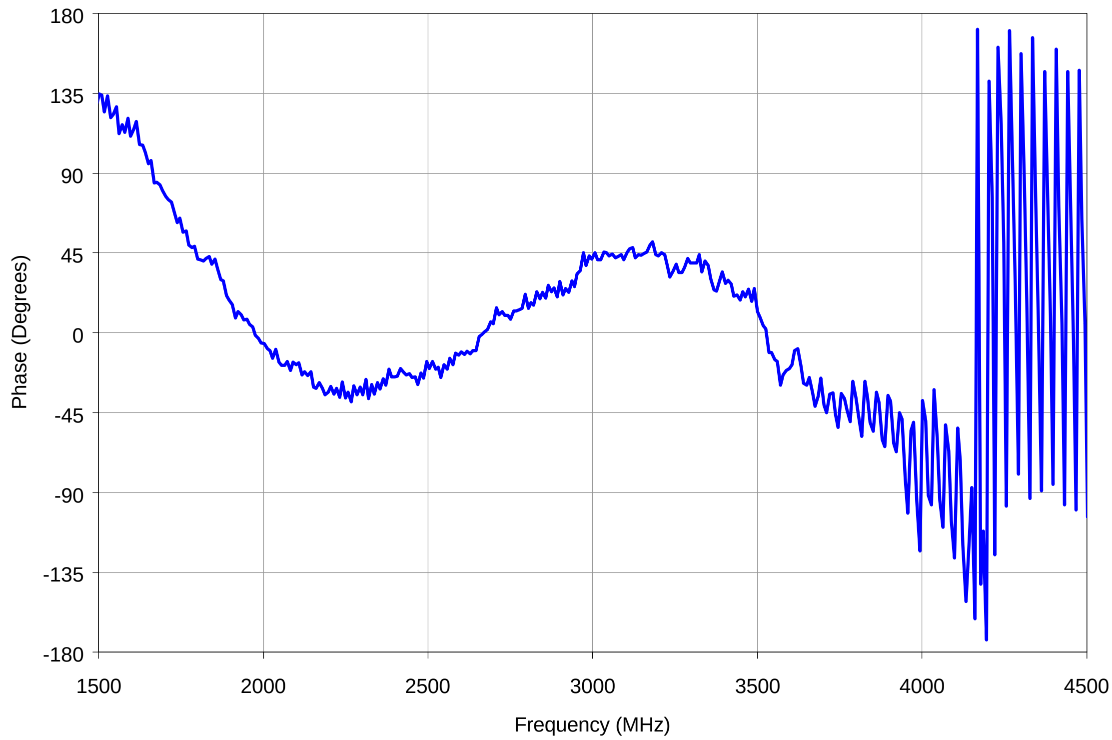


Figure 18. Stacktail System phase with beam over Leg 2.

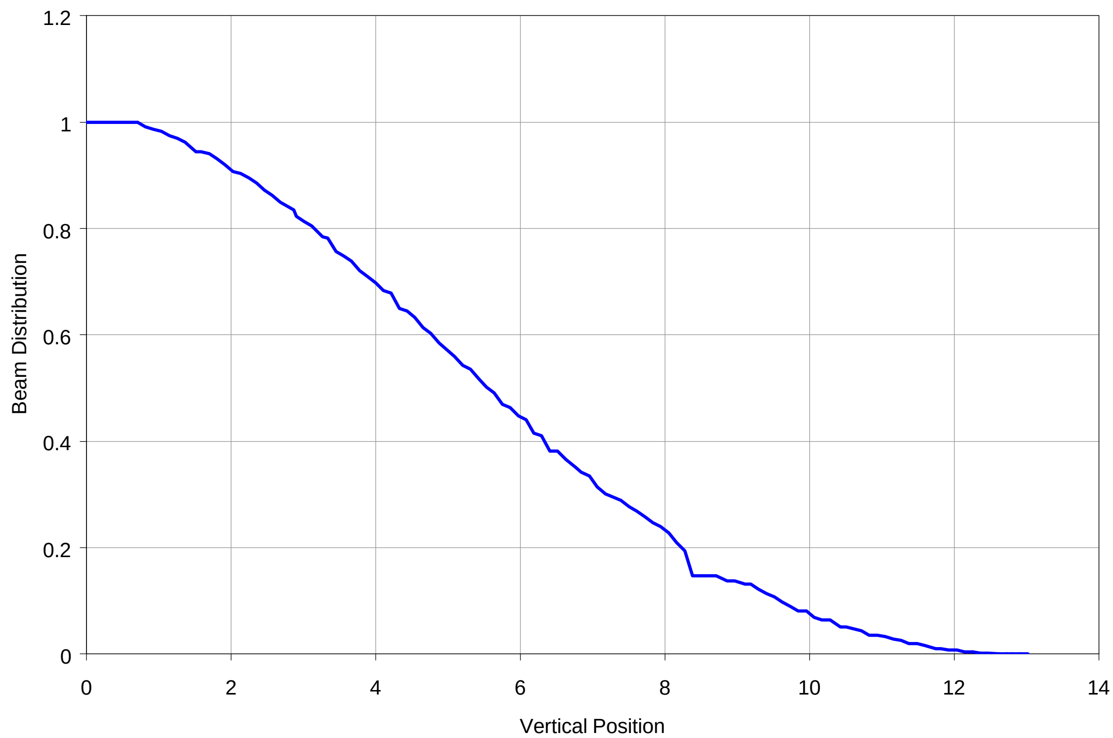


Figure 19. Vertical beam profile derived from scraper scans. Beam sigma is 4.54 mm.

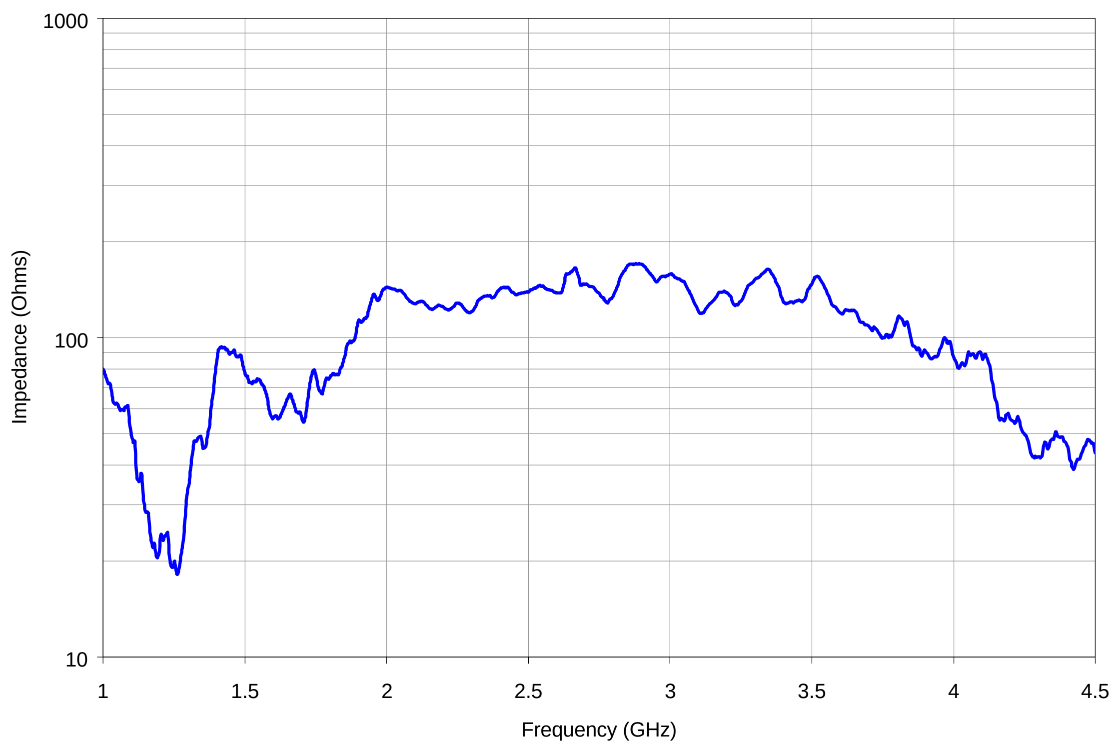


Figure 20. Pickup sensitivity of the 2-4 GHz Vertical system. There are 16 loops in the array. A front end noise temperature of 413K was assumed

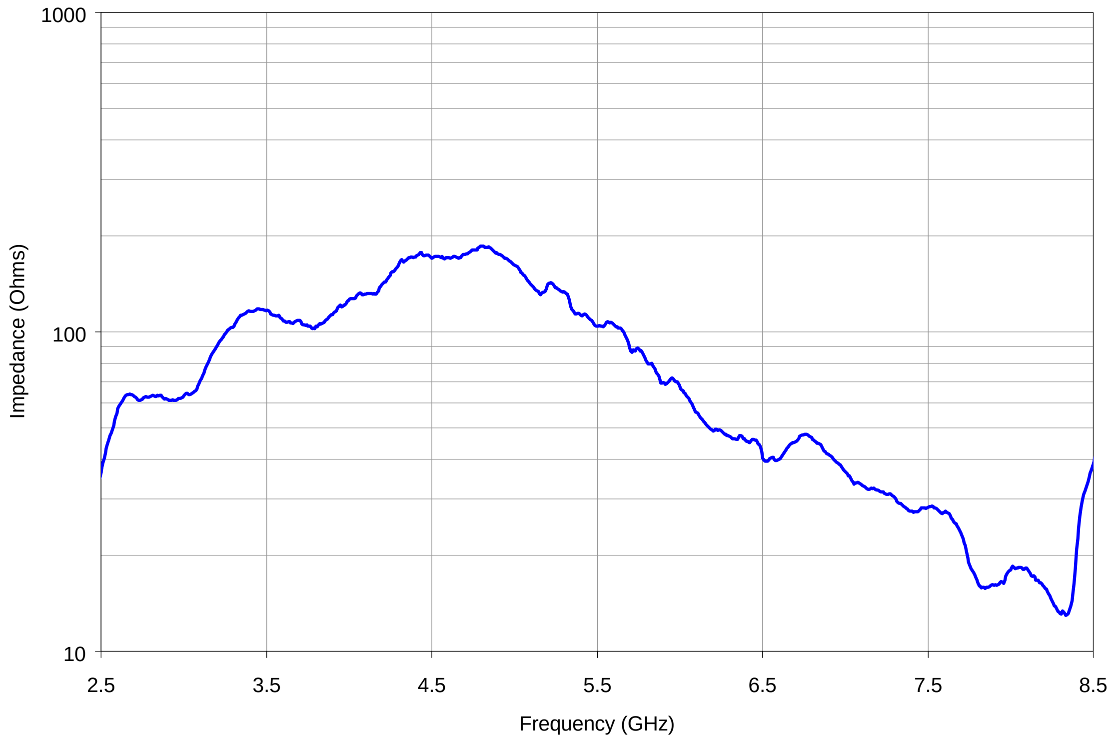


Figure 21. Pickup sensitivity of the 4-8 GHz Vertical system. There are 32 loops in the array. A front-end noise temperature of 413K was assumed.

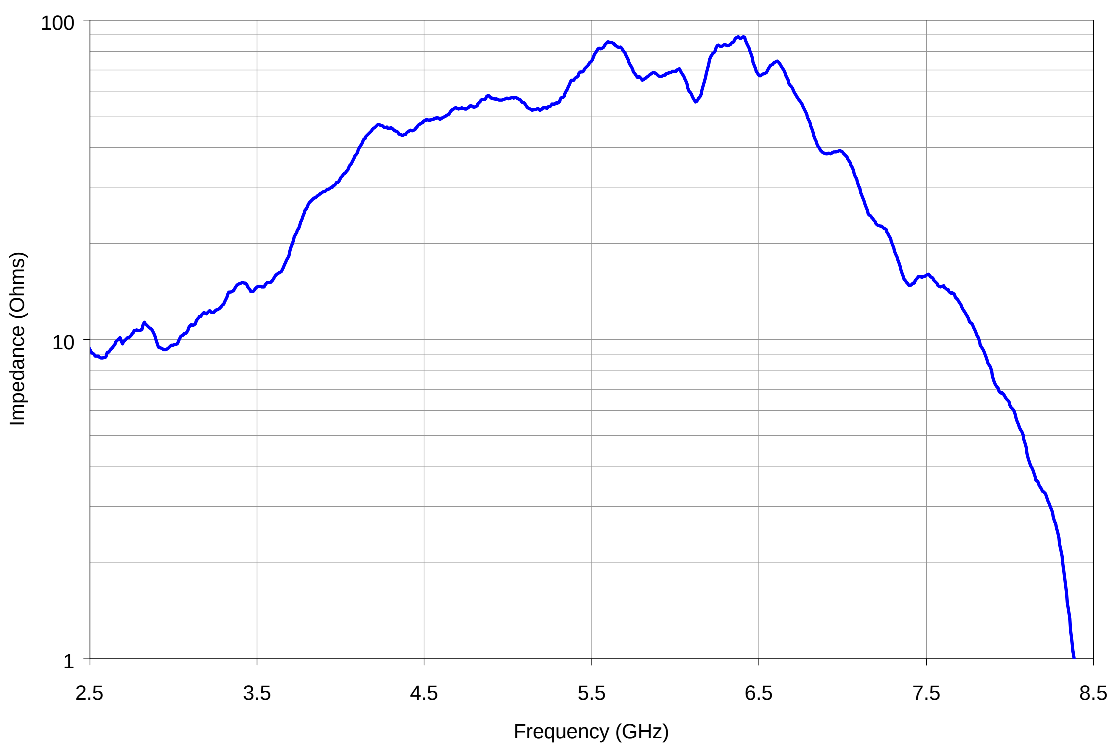


Figure 22. Pickup sensitivity of the 4-8 GHz Momentum system with beam over the low energy pickup. A front-end noise temperature of 413K was assumed.

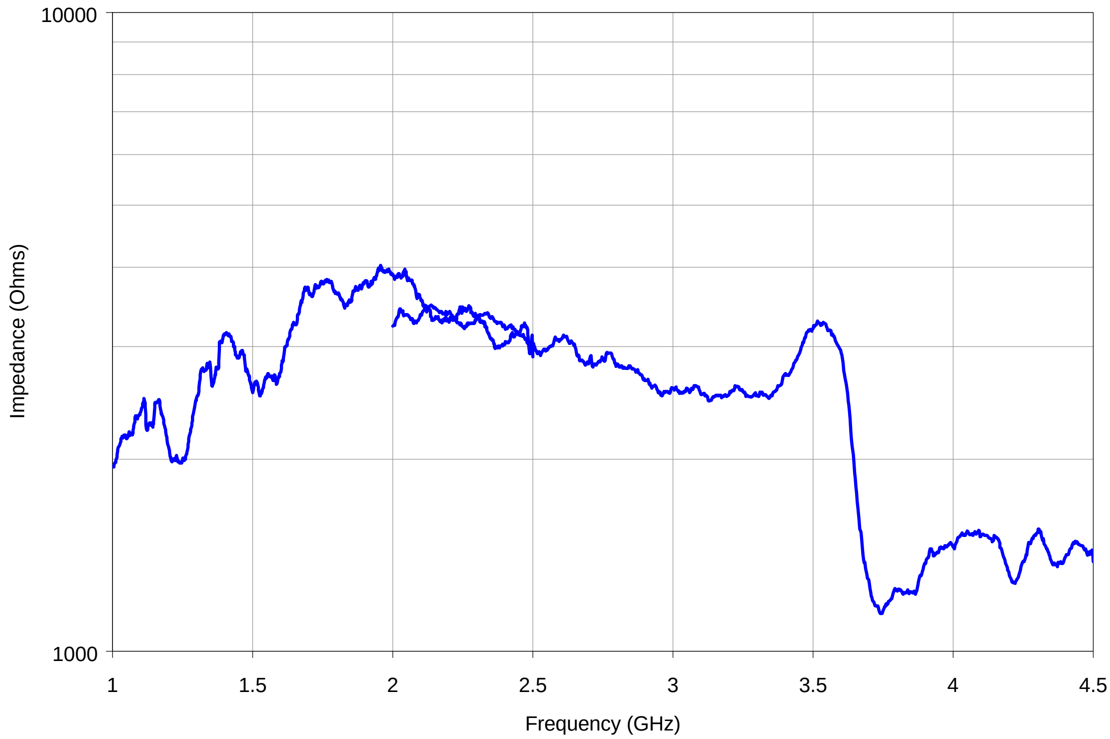


Figure 23. Pickup sensitivity of Leg 1 of the 2-4 GHz StackTail System. There are 256 Loops. A front-end noise temperature of 125 K was assumed.

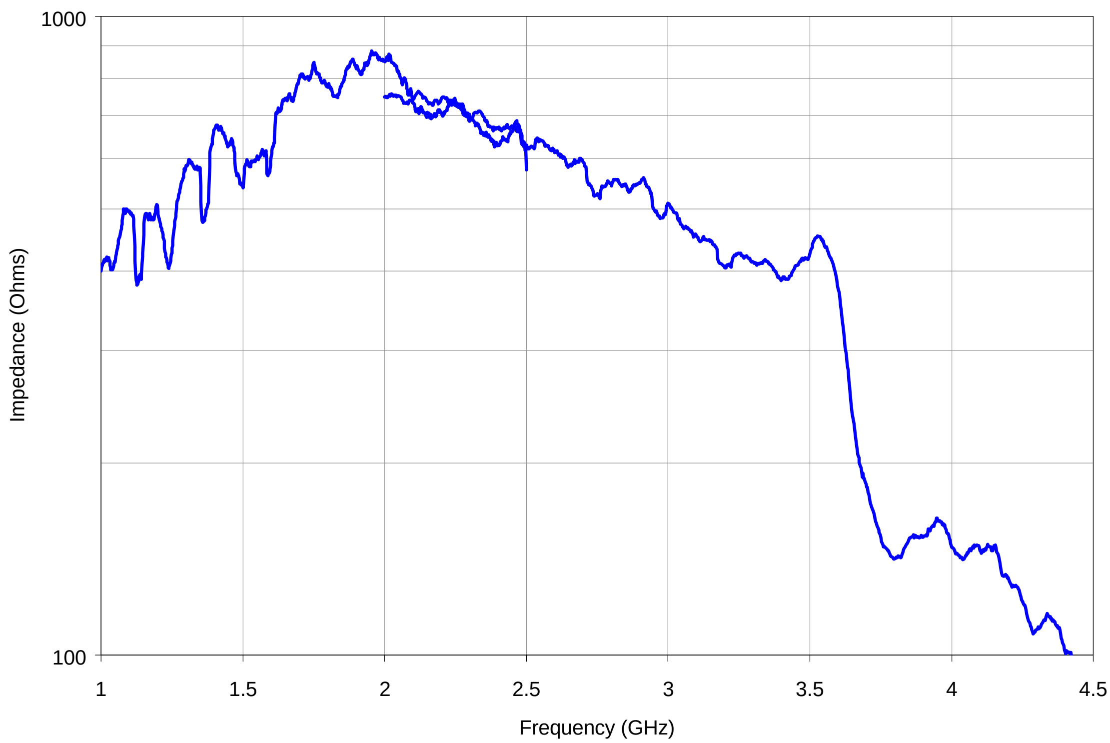


Figure 24. Pickup sensitivity of Leg 2 of the 2-4 GHz StackTail System. There are 48 Loops. A front-end noise temperature of 125 K was assumed.

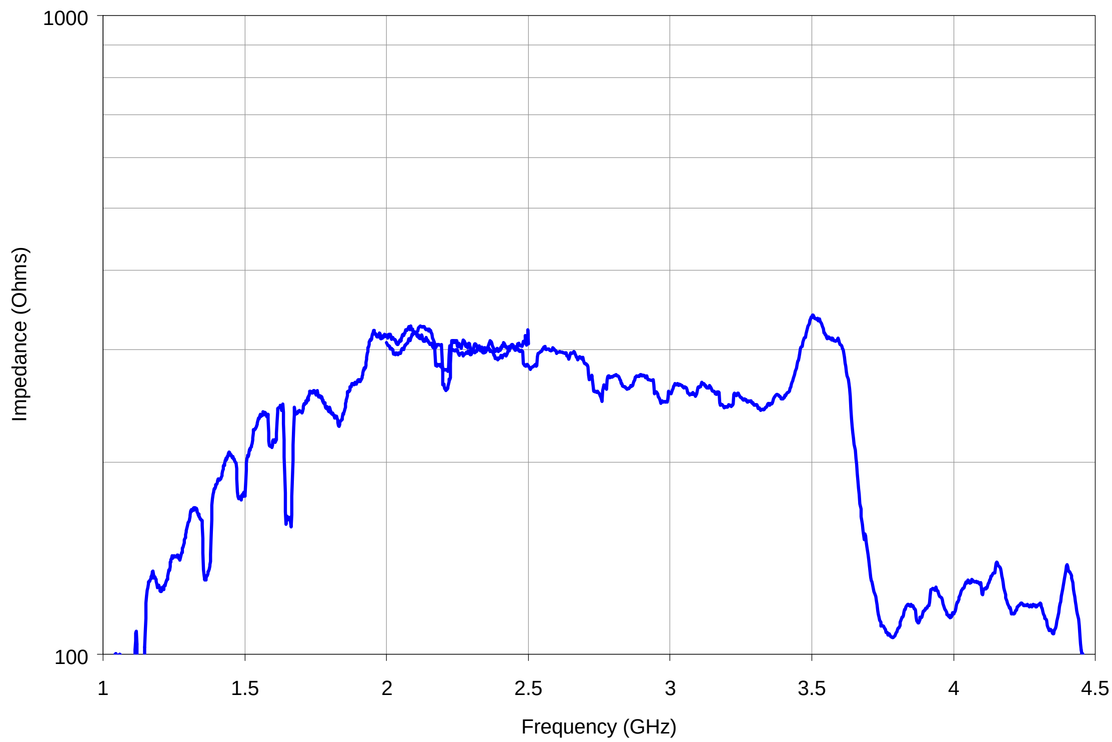


Figure 25. Pickup sensitivity of Leg 3 of the 2-4 GHz StackTail System. There are 16 Loops. A front-end noise temperature of 125 K was assumed.

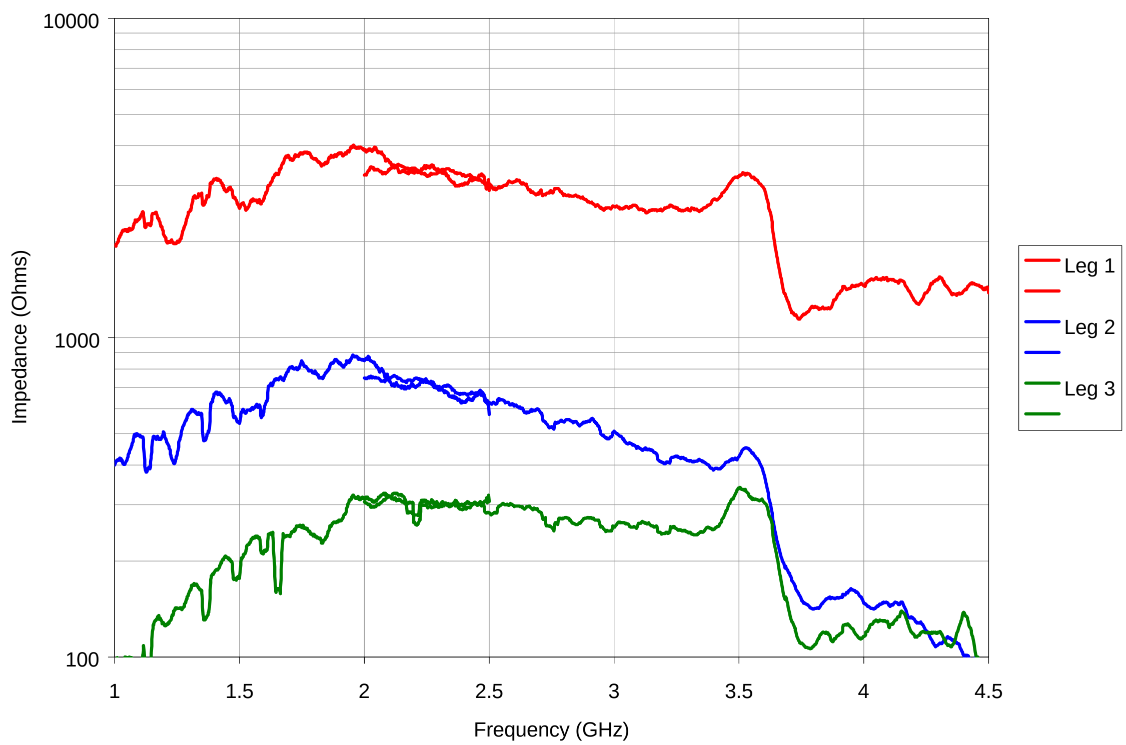


Figure 26. Pickup sensitivity of 2-4 GHz StackTail System. A front-end noise temperature of 125 K was assumed.

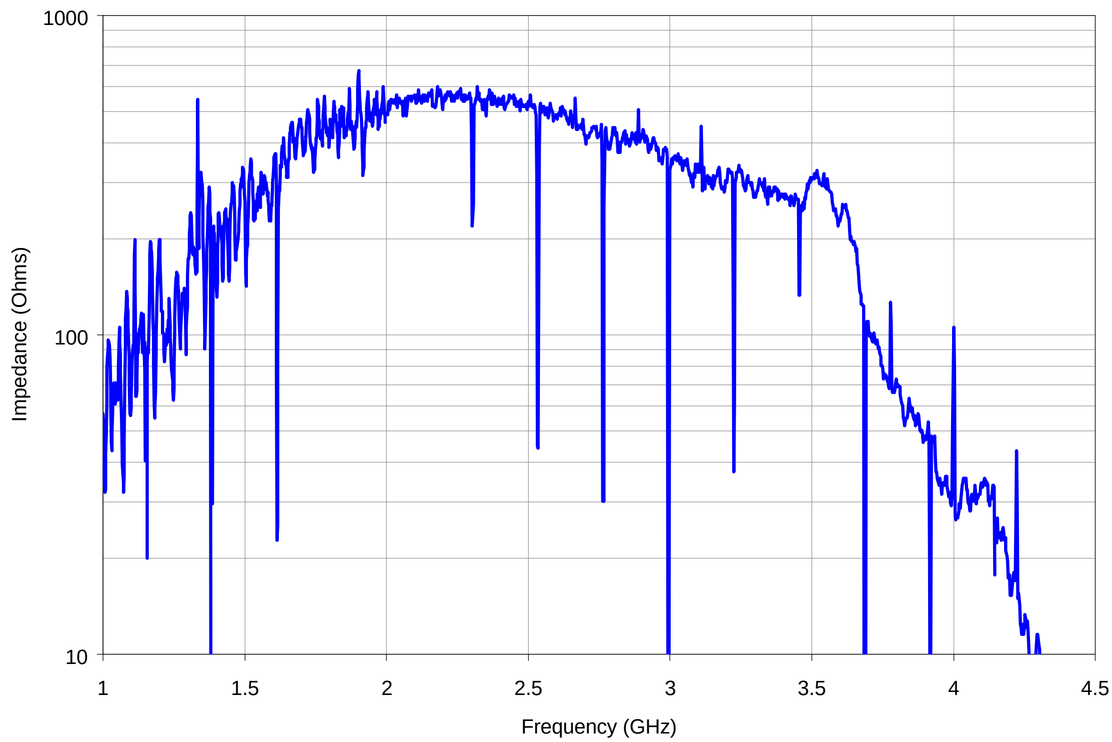


Figure 27. Pickup sensitivity of array 1 of Leg 1 of the 2-4 GHz StackTail System. There are 32 Loops. A front-end noise temperature of 125 K was assumed.

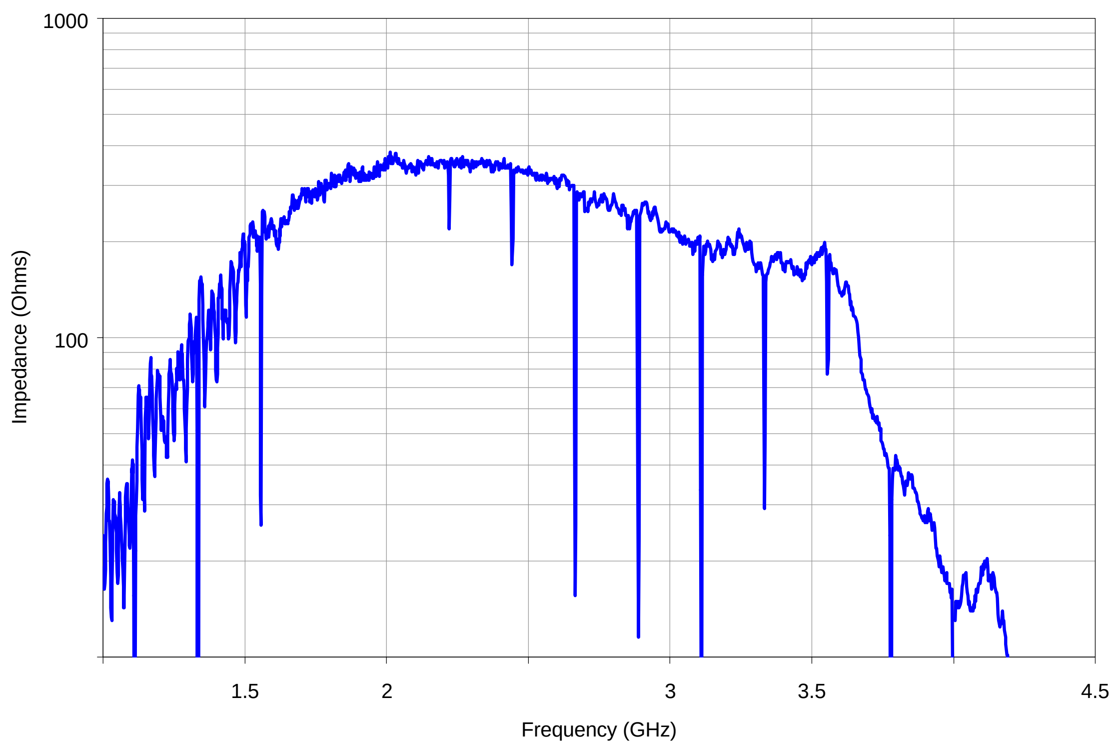


Figure 28. Pickup sensitivity of array 2 of Leg 1 of the 2-4 GHz StackTail System. There are 32 Loops. A front-end noise temperature of 125 K was assumed.

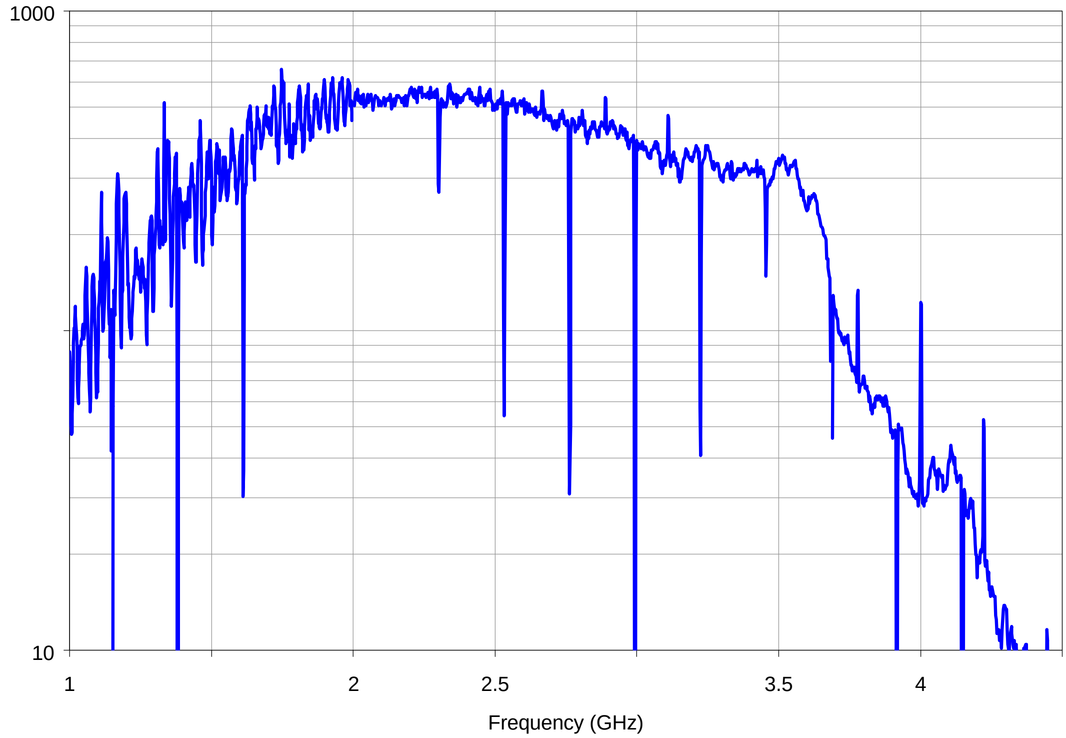


Figure 29. Pickup sensitivity of array 3 of Leg 1 of the 2-4 GHz StackTail System. There are 32 Loops. A front-end noise temperature of 125 K was assumed.

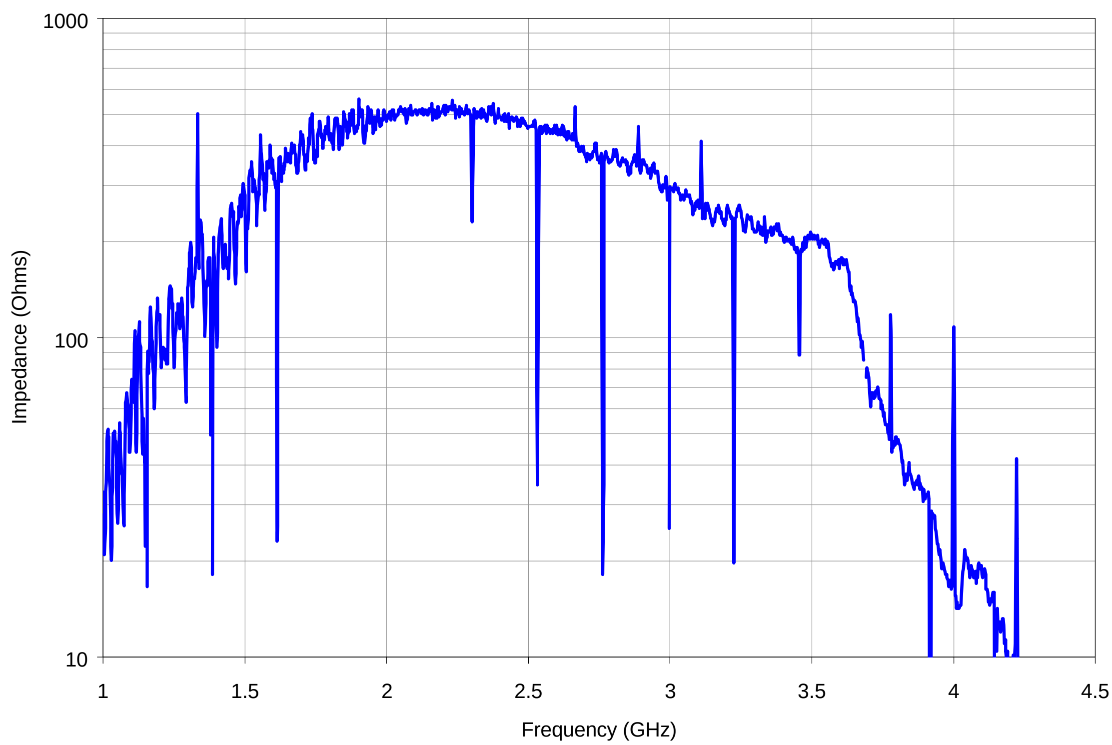


Figure 30. StackTail System. There

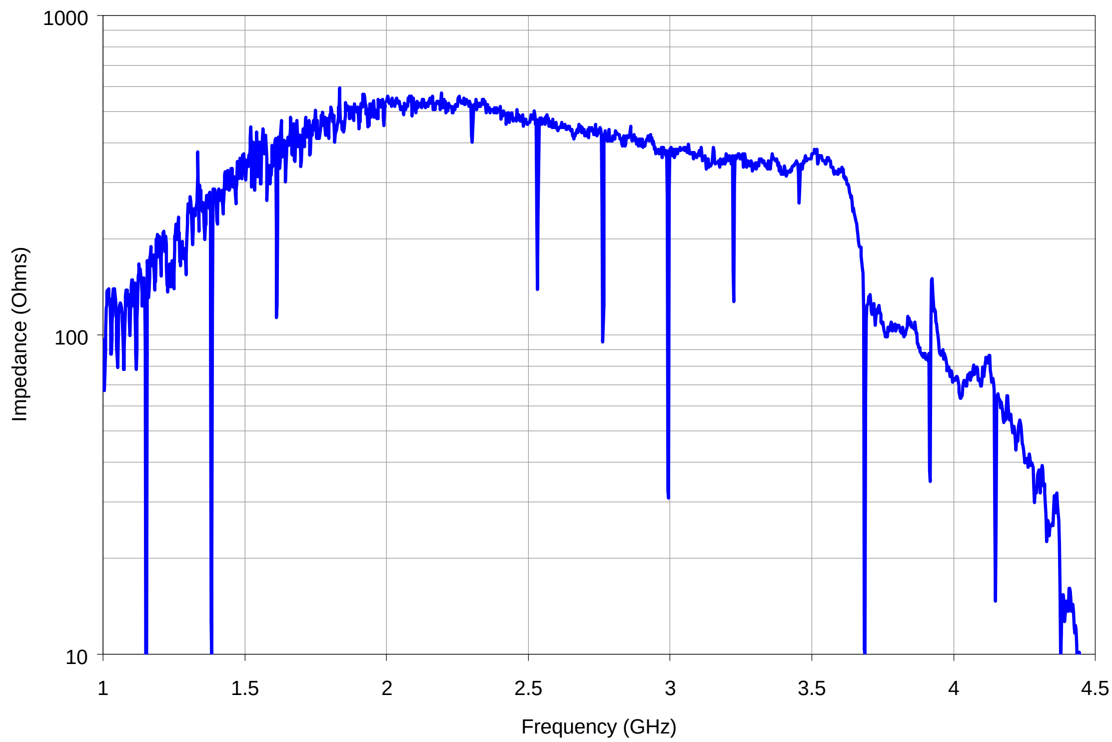
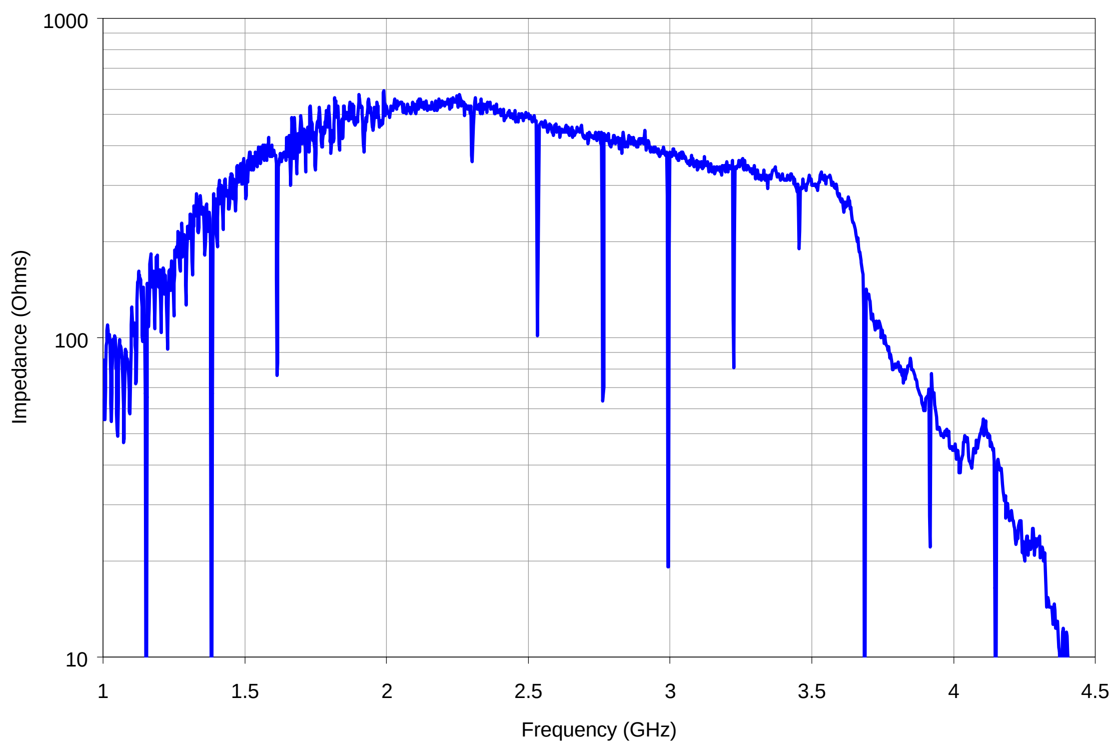


Figure 31. Pickup sensitivity of array 7 of Leg 1 of the 2-4 GHz System. There are 32 Loops. A front-end noise temperature of 125 K was assumed.



Pickup sensitivity of array 8 of Leg 1 of the 2-4 GHz StackTail are 32 Loops. A front-end noise temperature of 125 K was assumed.

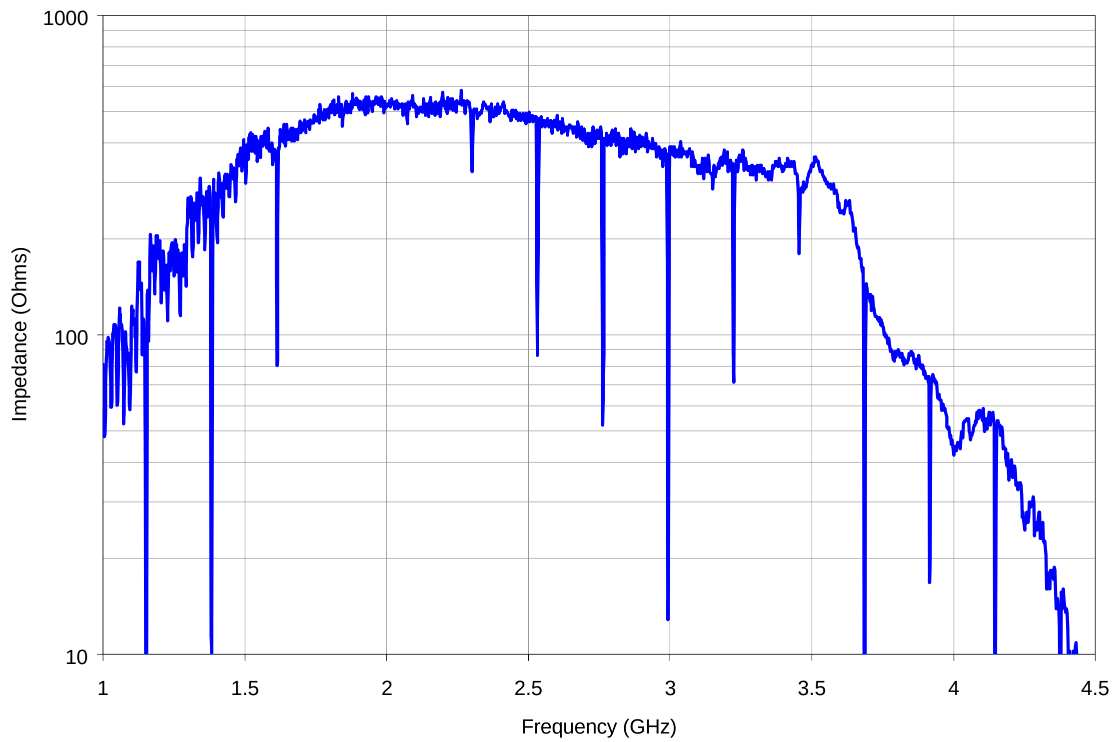


Figure 33. Pickup sensitivity of array 9 of Leg 1 of the 2-4 GHz StackTail System. There are 32 Loops. A front-end noise temperature of 125 K was assumed.

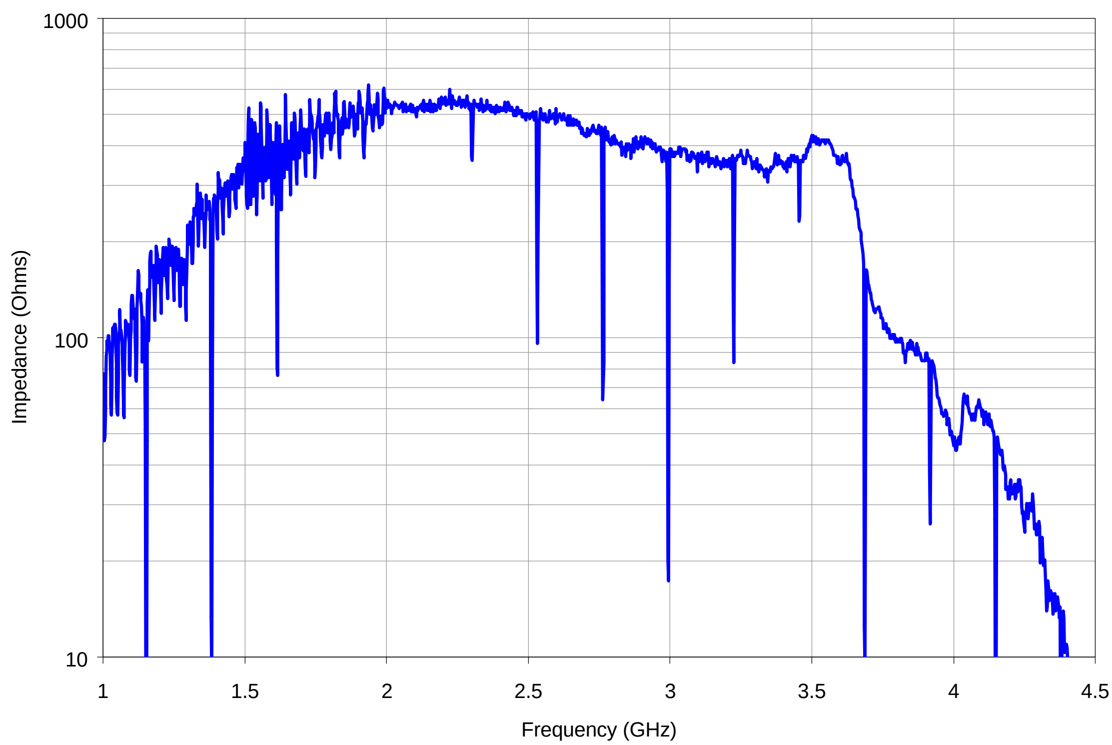


Figure 34. Pickup sensitivity of array 10 of Leg 1 of the 2-4 GHz StackTail System. There are 32 Loops. A front-end noise temperature of 125 K was assumed.

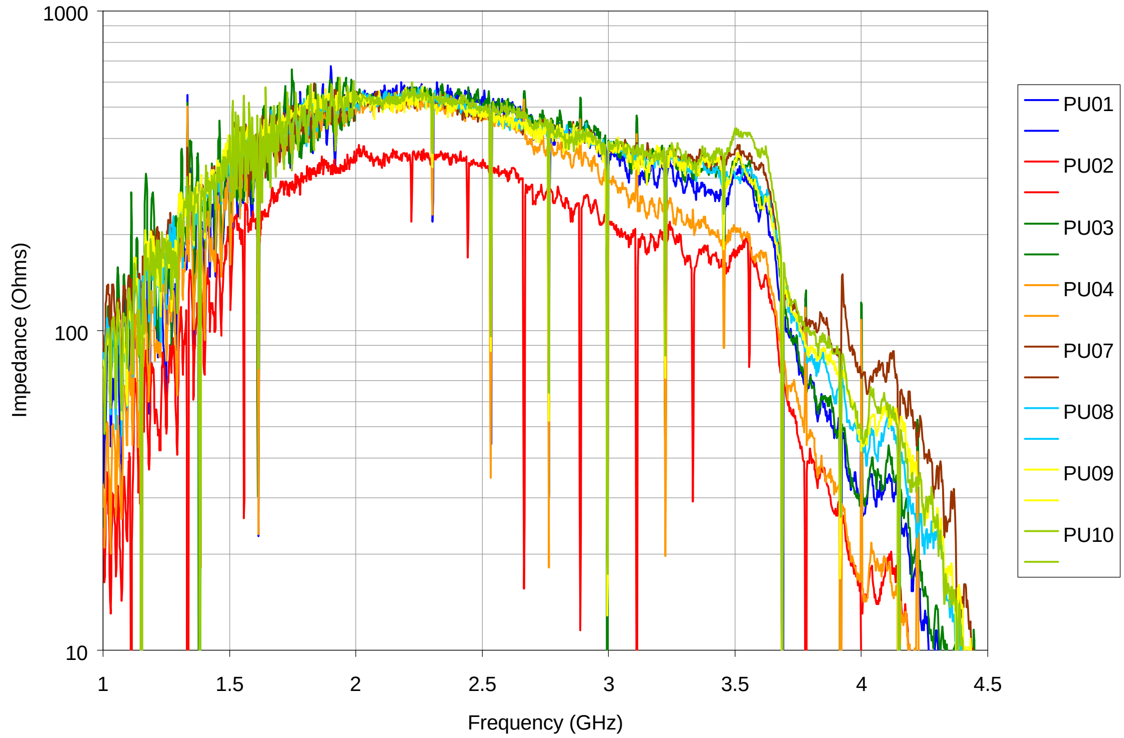


Figure 35. Pickup sensitivity of all arrays of Leg 1 of the 2-4 GHz StackTail System. There are 32 loops per array. A front-end noise temperature of 125 K was assumed.

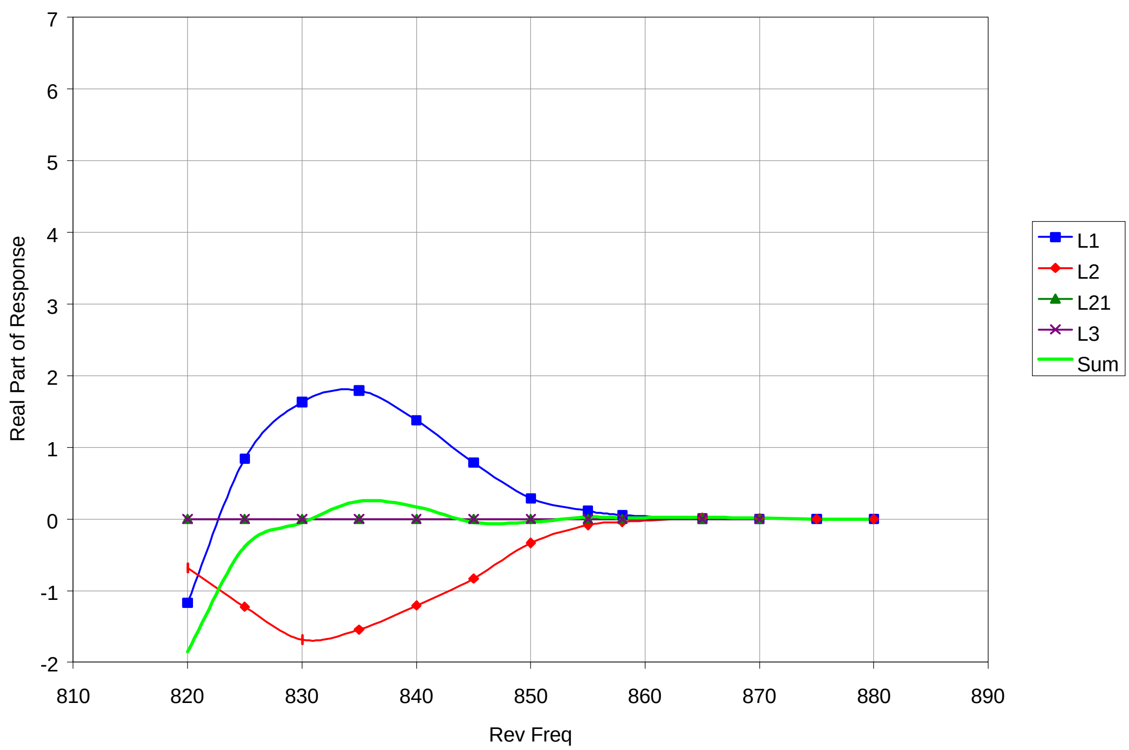


Figure 36. Real part of the Stacktail response vs. revolution frequency of the beam for a 16 MeV gain slope.

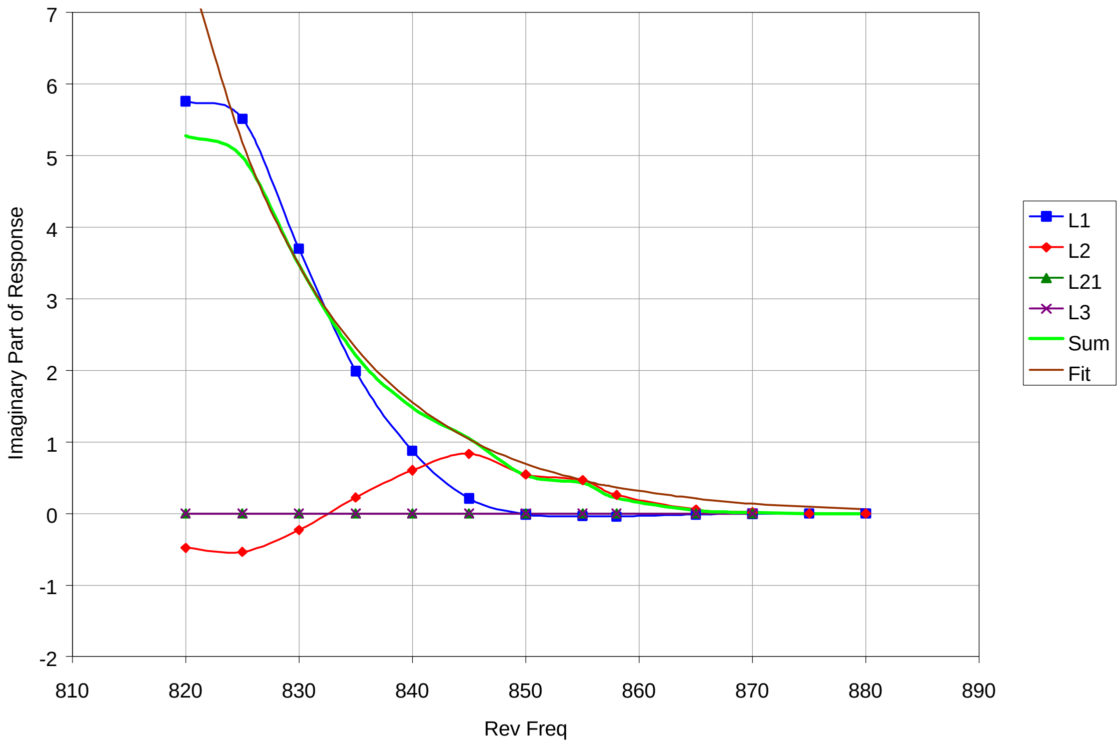


Figure 37. Imaginary part of the Stacktail response vs. revolution frequency of the beam for a 16 MeV gain slope.

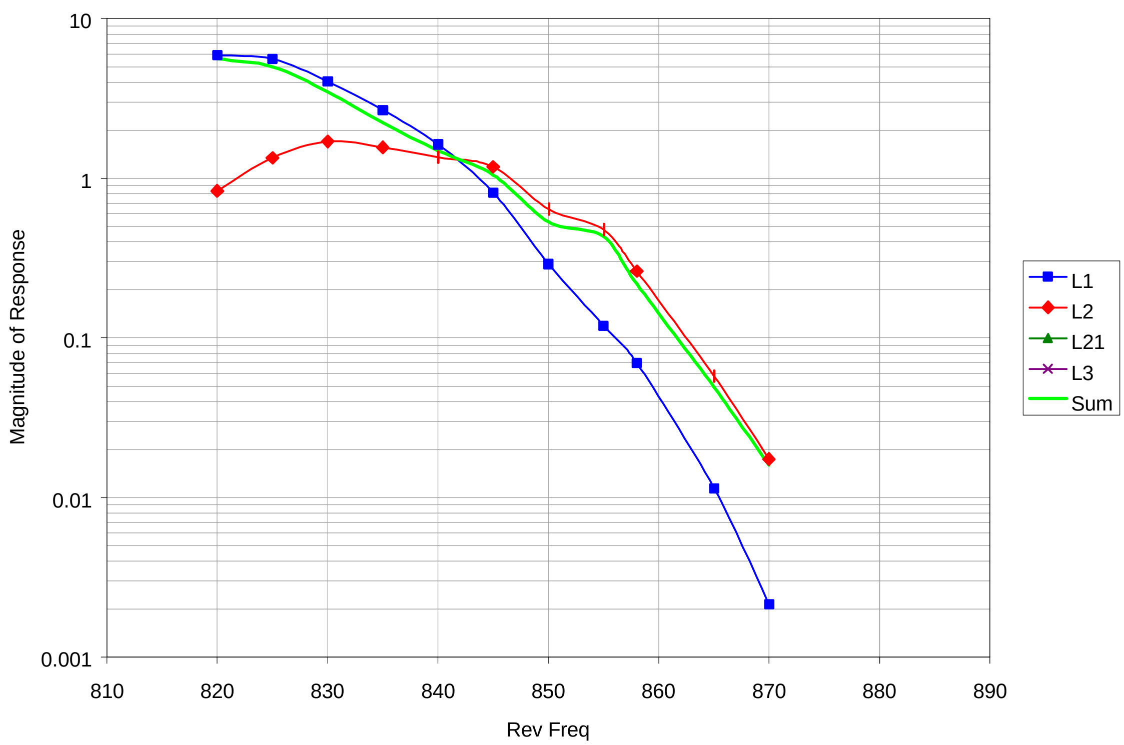


Figure 38. Magnitude of the Stacktail response vs. revolution frequency of the beam for a 16 MeV gain slope.

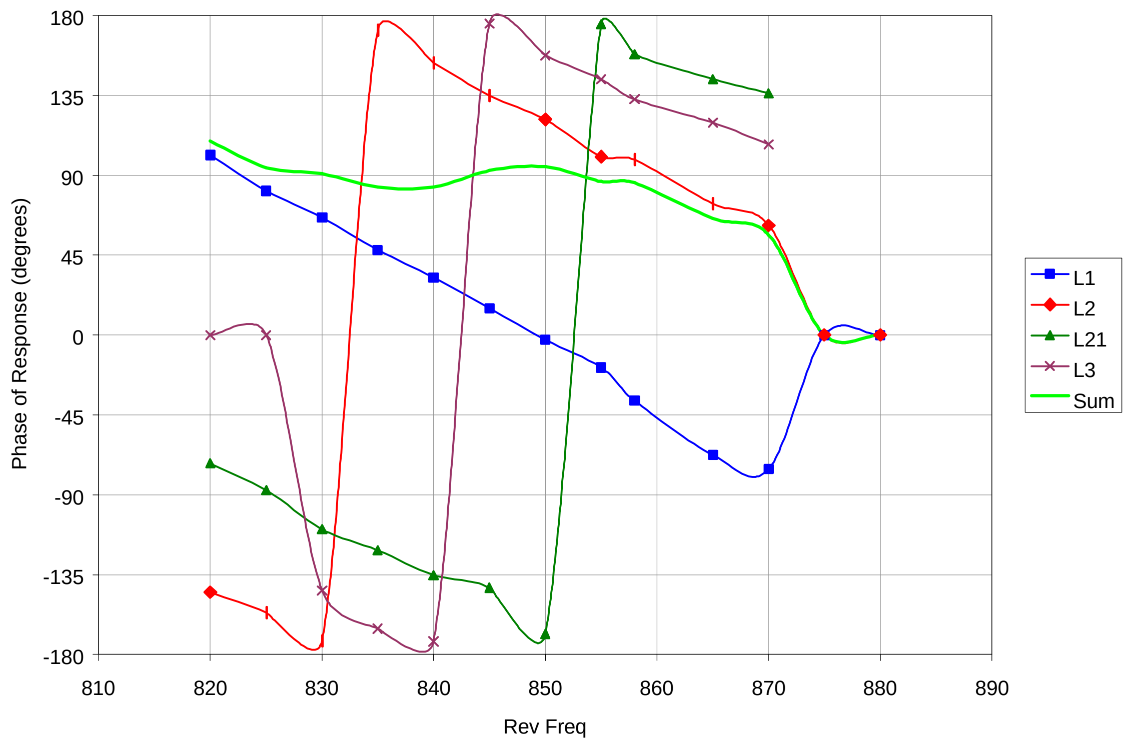


Figure 39. Phase of the Stacktail response vs. revolution frequency of the beam for a 16 MeV gain slope.

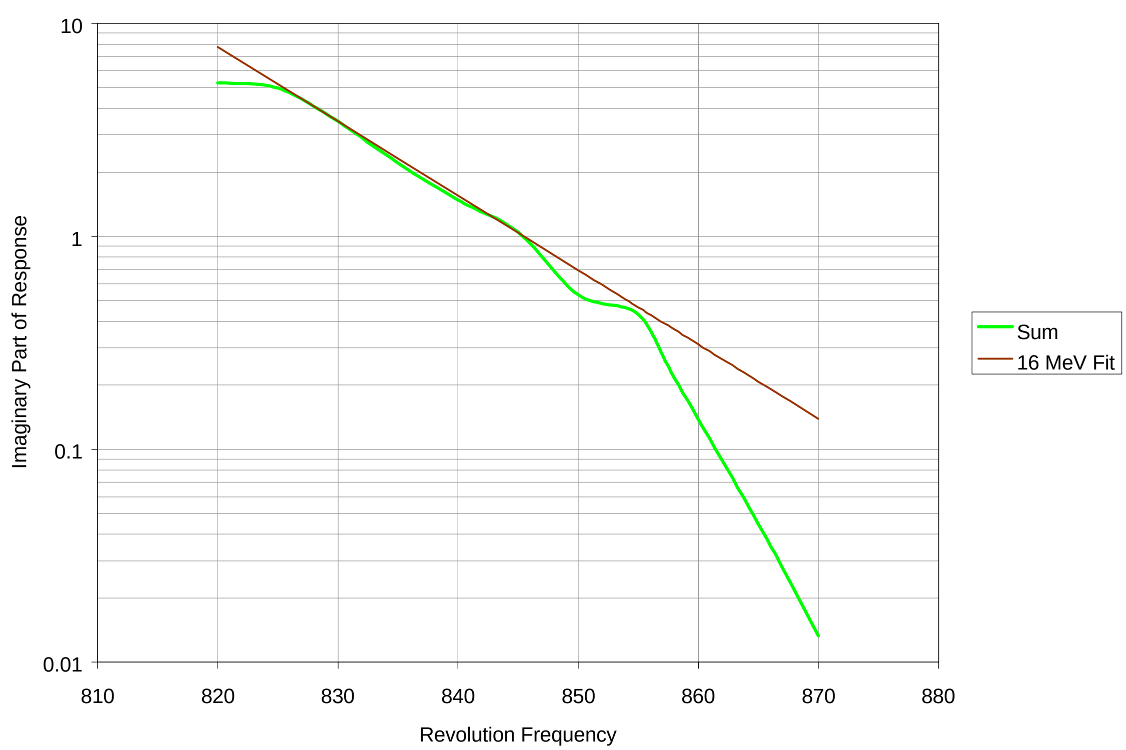


Figure 40. Imaginary part of the Stacktail response vs. revolution frequency of the beam for a 16 MeV gain slope.

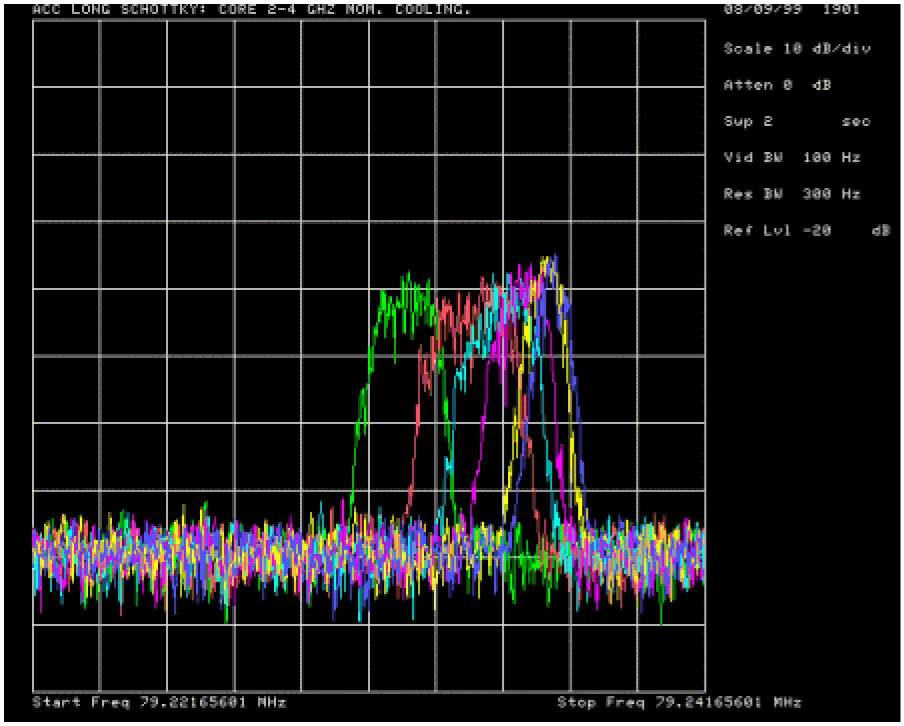


Figure 41. Spectrum analyzer traces at 30 second intervals of the 79 MHz Longitudinal MeV gain slope.

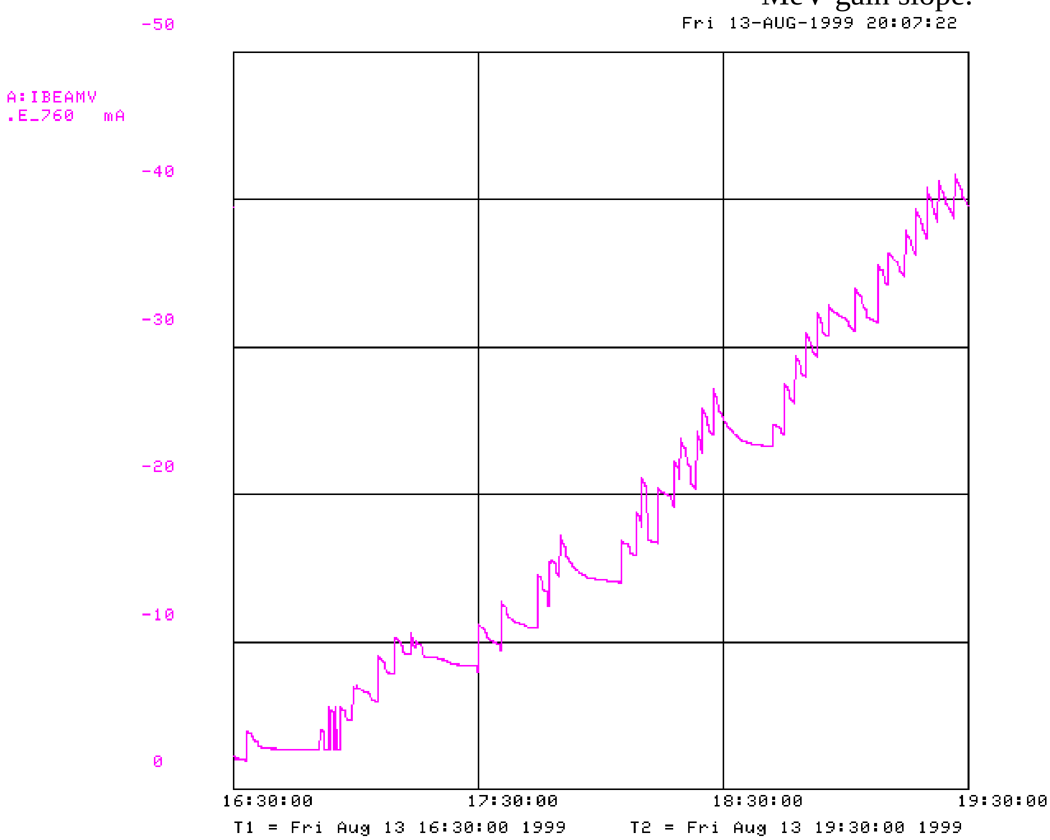


Figure 42. Stack size vs time with proton stacking using the 16 MeV Gain slope in the StackTail. See Pbar Log Entry for Evening Shift, Friday August 13, 1999.

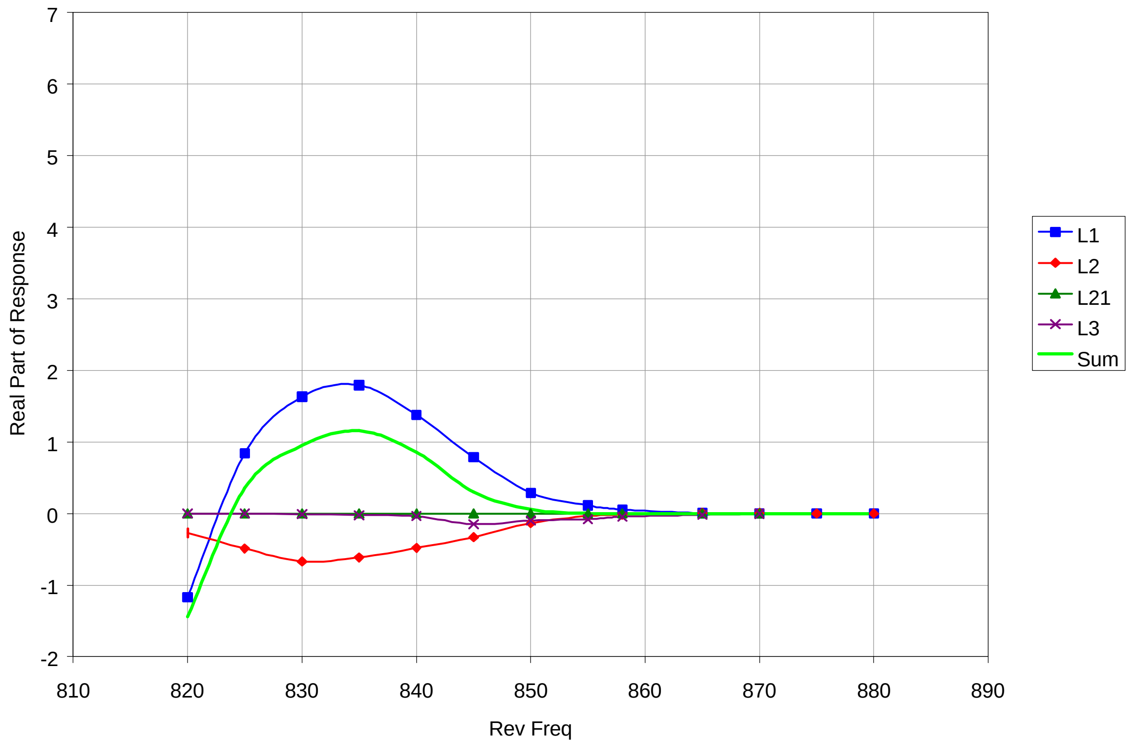


Figure 43. Real part of the Stacktail response vs. revolution frequency of the beam for a 10 MeV gain slope.

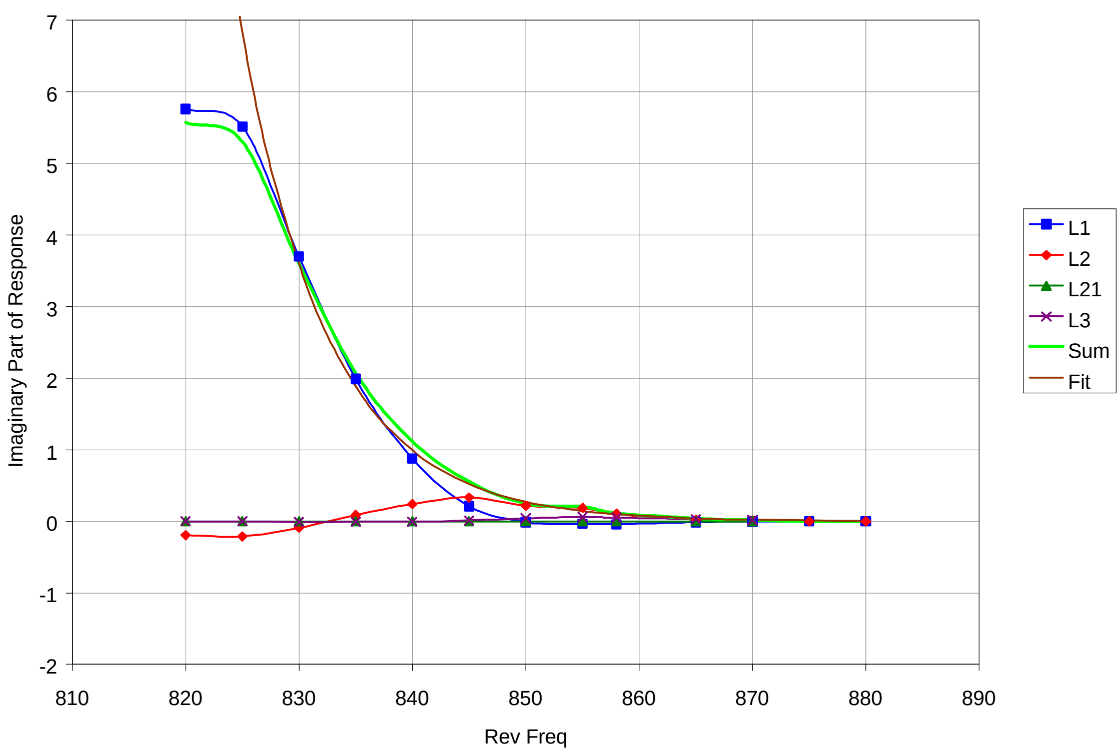


Figure 44. Imaginary part of the Stacktail response vs. revolution frequency of the beam for a 10 MeV gain slope.

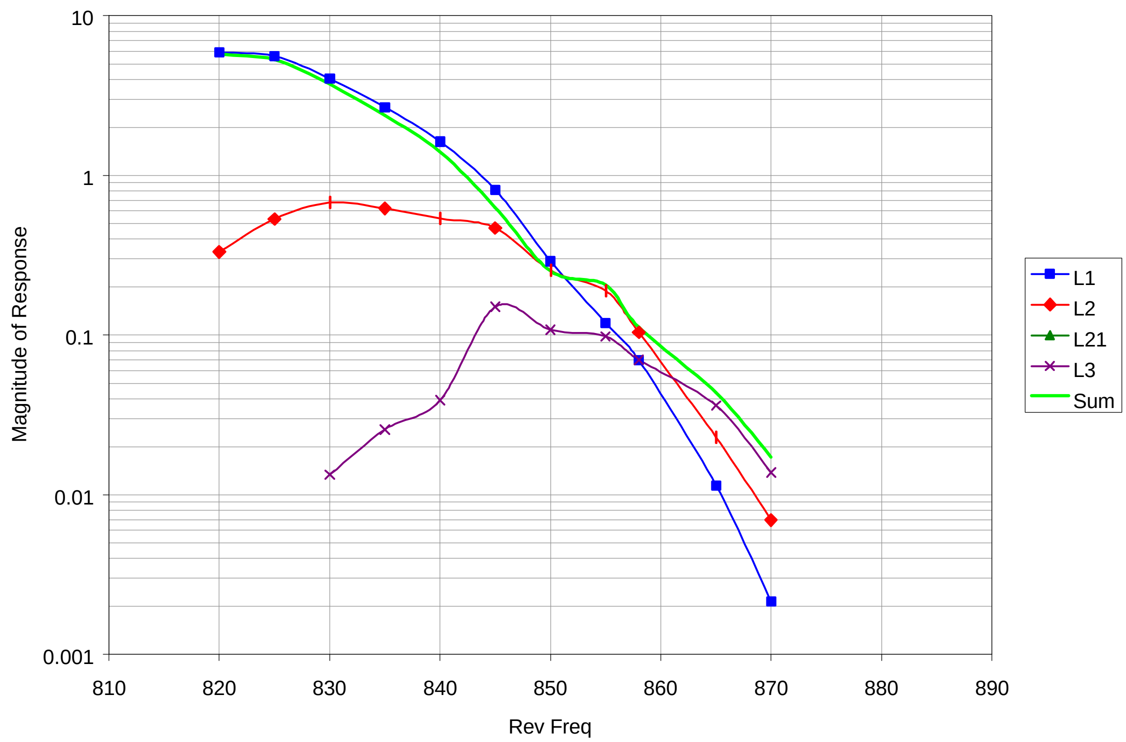


Figure 45. Magnitude of the Stacktail response vs. revolution frequency of the beam for a 10 MeV gain slope.

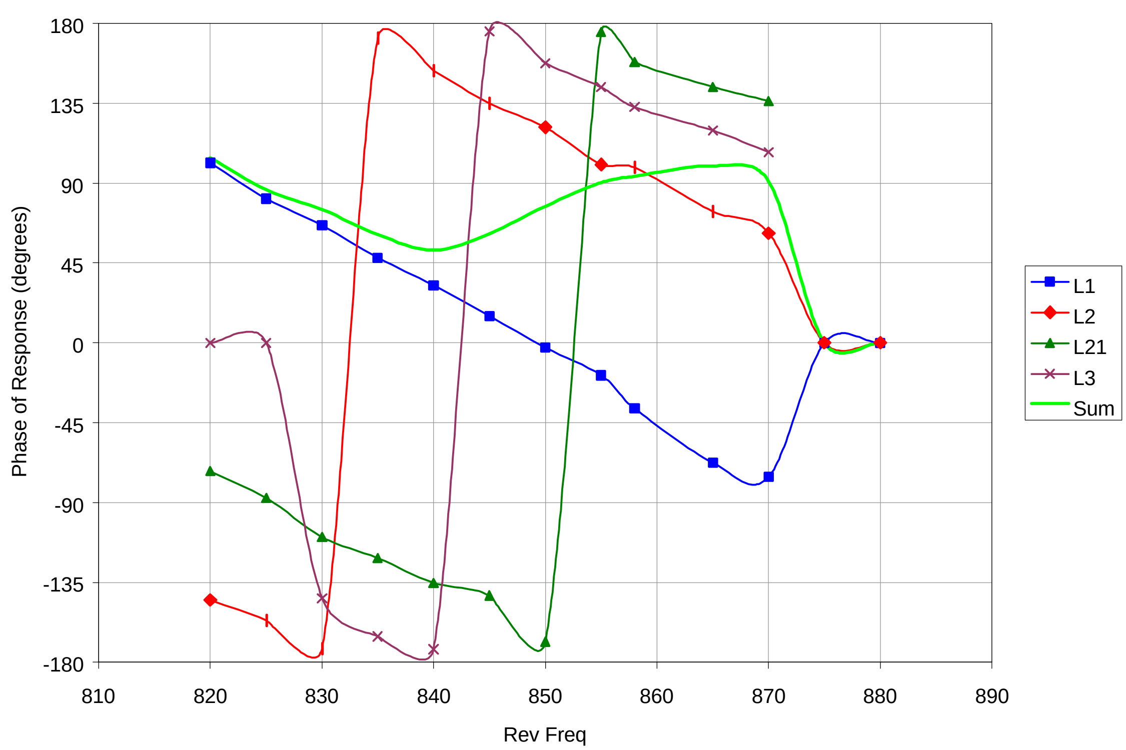


Figure 46. Phase of the Stacktail response vs. revolution frequency of the beam for a 10 MeV gain slope.

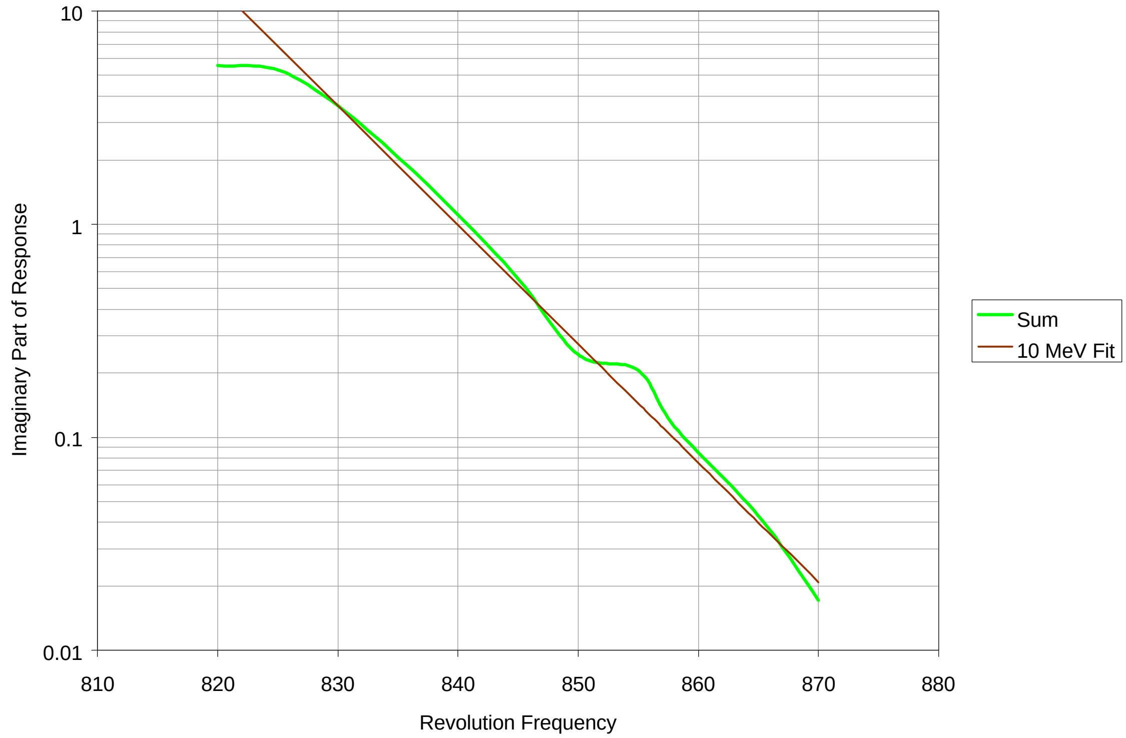


Figure 47. Imaginary part of the Stacktail response vs. revolution frequency of the beam for a 10 MeV gain slope.

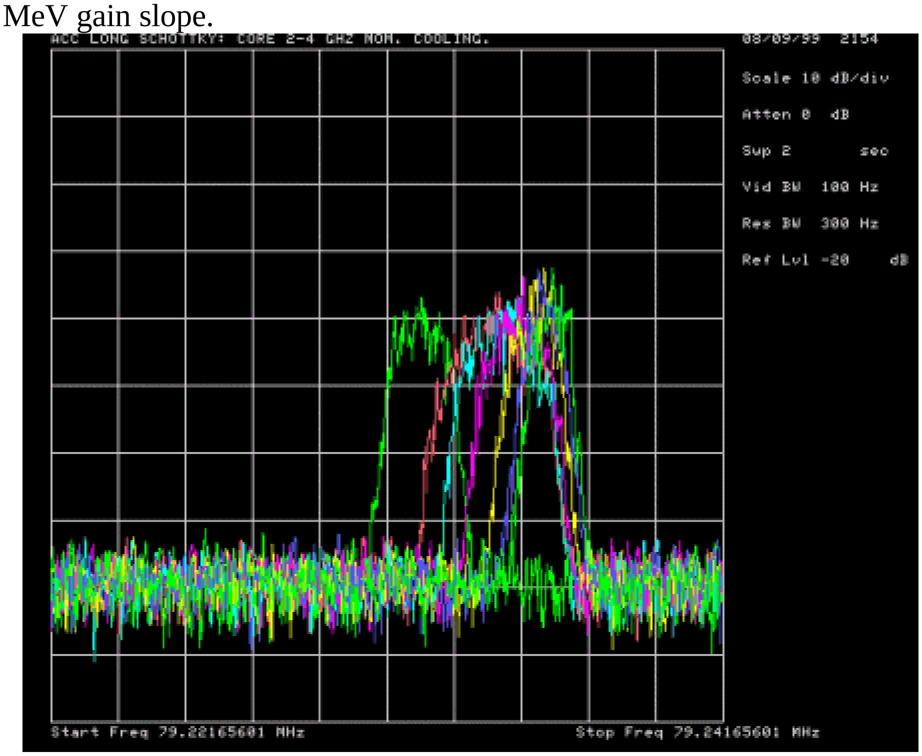


Figure 48. Spectrum analyzer traces at
Schottky Pickup with 5e+09 protons placed in stack using a 10 MeV gain slope.