PBAR NOTE 587
SENSITIVITY OF SLOW WAVE PICKUPS VERSUS APERTURE

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INTRODUCTION

This note will examine the pickup impedance versus the transverse size of the beam pipe waveguide for Horizontal Band 1 (HB1)[1] of the 4-8 GHz Debuncher Upgrade. In each cell (defined as the space between 2 quads) there are two pickup arrays of the same band and the same plane. HB1 is located in sector 601 between quads Q2 and Q1. For the pickup, HB1 is further subdivided into two sub-bands with the lower band centered at 4.15 GHz and the upper band centered at 4.55 GHz. The bandwidth of each sub-band has a bandwidth of about 250 MHz. The upper band is located in the upstream end of the cell and the lower band is in the downstream end of the cell. The beta functions of this cell are shown in Figure 1.

SIMULATION RESULTS

The upper and lower frequency bands of HB1 were simulated using a moment method program[2] for a variety of beam-pipe "heights". For the horizontal arrays, the beam pipe height is the horizontal aperture. A modification was made to the moment method program in which the position of the beam current varied with the beta function along the array in <u>both</u> dimensions. The program "tracked" the particle trajectory for an emittance ellipse 1/6 the value of the maximum emittance (an input variable to the program) of 25 π-mm-mrad. The transverse impedance is defined as[3]:

$$P_{\Delta} = \frac{1}{2}\left(Zn_{\Delta pu}\right) i_b{}^2 \frac{\varepsilon_b}{1\pi - \mathrm{mm} - \mathrm{mrad}} \qquad (1)$$

The input files for the lower and upper bands of HB1 are shown in Table 1. The impedance was calculated for various beam pipe heights. All other variables except for the slot length were kept constant. The slot length was varied so that the maximum of each response was centered in the sub-band. The frequency sweep results are shown in Figures 2 and 3 for the lower and upper sub-bands, respectively. To save computer time, the responses as a function of beam pipe height are not quite centered in frequency because the slot length optimization routine was not run through to completion. The bandwidth of each response did not vary significantly as a function of beam pipe height. The maximum impedance of each response as a function of beam pipe height is shown in Figure 4.

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[1] PBAR Note 579 4-8 GHz Debuncher Upgrade Array Dimensions
[2] PBAR Note 575 Moment Method Formulation for Beam Excitation of Waveguide Slots
[3] PBAR Note 578 New Definition of Stochastic Cooling Kicker and Pickup Impedances

The diamonds in Figure 4 mark the impedance values that were used in the system stochastic cooling calculations.[4] It was assumed in the stochastic cooling calculations that the beam pipe height would be tapered to maintain a constant 40 π-mm-mrad aperture. It has been recently realized that changing the moment method program to handle tapered beam pipes might not be as straightforward as once was thought. If the beam pipe height is not tapered then the aperture of the array is determined by the location in the array were the height beta function is a maximum. The height beta function is a maximum in the location of the lower sub-band of HB1 (the downstream end of the cell).

Lower Band	Upper Band	Description
1.016	1.016	Absorber Thickness (mm)
1.2	1.2	
1.5	1.5	Absorber Mu tan
10	10	Absorber Ep Mag
0	0	Absorber Ep tan
2.032	2.032	Slot Width (mm)
2.032	2.032	Slot Spacing (mm)
20	20	Width Waveguide modes
100	100	Height Waveguide modes
2	2	Slot modes
101	101	Number of frequency points
D	D	Difference or Sum mode
PU	PU	Kicker (KR) or Pickup (PU)
58.166	58.166	Waveguide width (mm)
16.764	16.764	Waveguide height (mm)
48.387	48.387	Beam pipe width (mm)
30	30	Beam pipe center height (mm)
1152.144	1152.144	Array length (mm)
-22.511	-19.463	Slot length (mm)
4.15	4.55	Center Frequency (GHz)
2	2	Frequency Span (GHz)
2.85E-07	2.85E-07	c1 Beta W (m/mm**2)
-2.37E-03	-3.14E-03	c2 Beta W (m/mm)
8.43E+00	1.22E+01	c3 Beta W (m)
3.61E-07	3.61E-07	c1 Beta H (m/mm**2)
3.68E-03	2.70E-03	c2 Beta H (m/mm)
1.22E+01	7.82E+00	c3 Beta H (m)
25	25	emittance (pi-mm-mrad)

Table 1. Input file for lower and upper bands of Horizontal Band 1

If the entire cell is not tapered, than the acceptance of the upper sub-band would have to be made much large than 40 π-mm-mrad in order to have the lower sub-band aperture to meet the 40 π-mm-mrad acceptance requirement. A large acceptance in the upper sub-band would result in reduced array sensitivity. This problem can be alleviated somewhat if the beam pipe height of the upper sub-band was allowed to be different (or

[4] PBAR Note 573 Debuncher Stochastic Cooling Upgrade for Run II and Beyond.

stepped) than the beam pipe height of the lower sub-band. The acceptance of the upper sub-band array as a function of beam pipe height is shown in Figure 5. The blue curve in Figure 5 is for the no-step design and the red curve is for the stepped design. The peak impedance as a function of acceptance for the two different designs is shown in Figure 6. Since the lower sub-band of HB1 is located where the height beta function is largest, there is no difference between the stepped and no-step design of the lower sub-band.

CONCLUSIONS

In order to accommodate a stepped design, the impedance for both sub-bands would be reduced by 25% from the value that was used in the system cooling rate calculations. For the no-step, the impedance of the upper sub-band would be reduced by a factor of over 2 from the value used in the cooling rate calculations. This would clearly be an unacceptable reduction in impedance. However, the mechanical implications of the stepped design are severe.

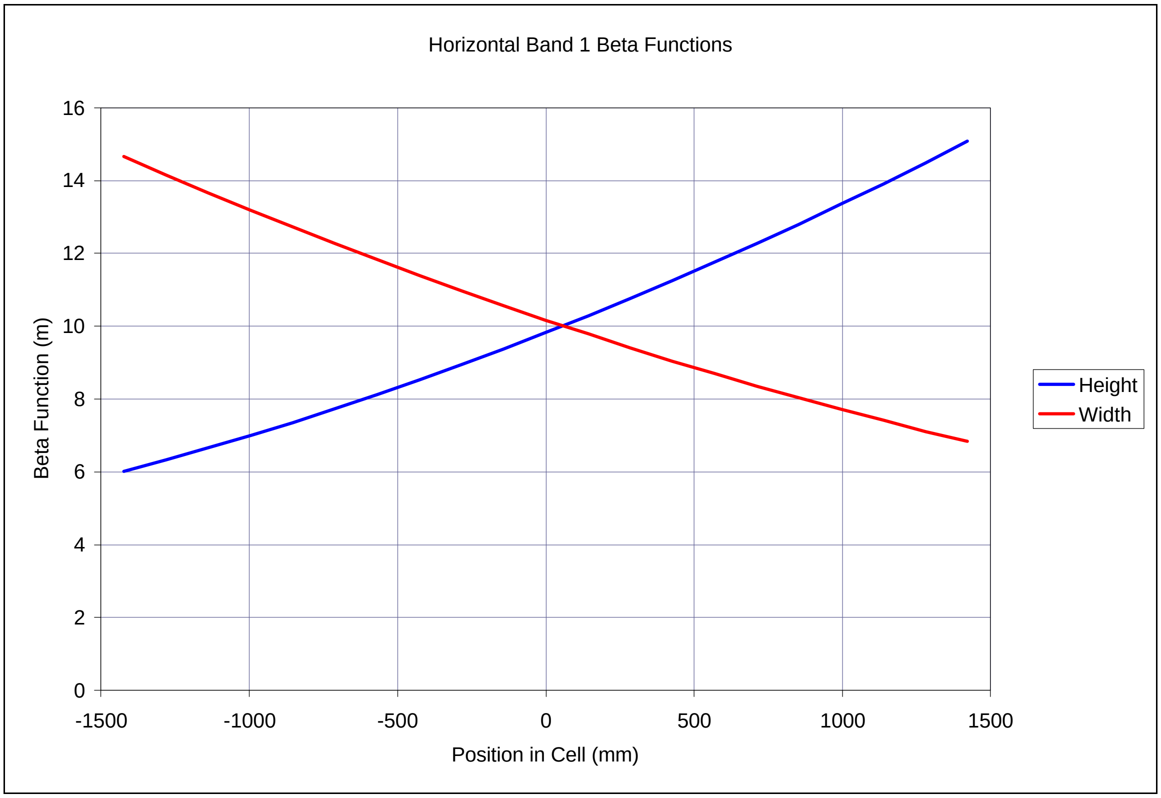

Figure 1. The beta functions for Horizontal Band 1. The Height b is in the horizontal direction and the Width b is in the vertical direction.

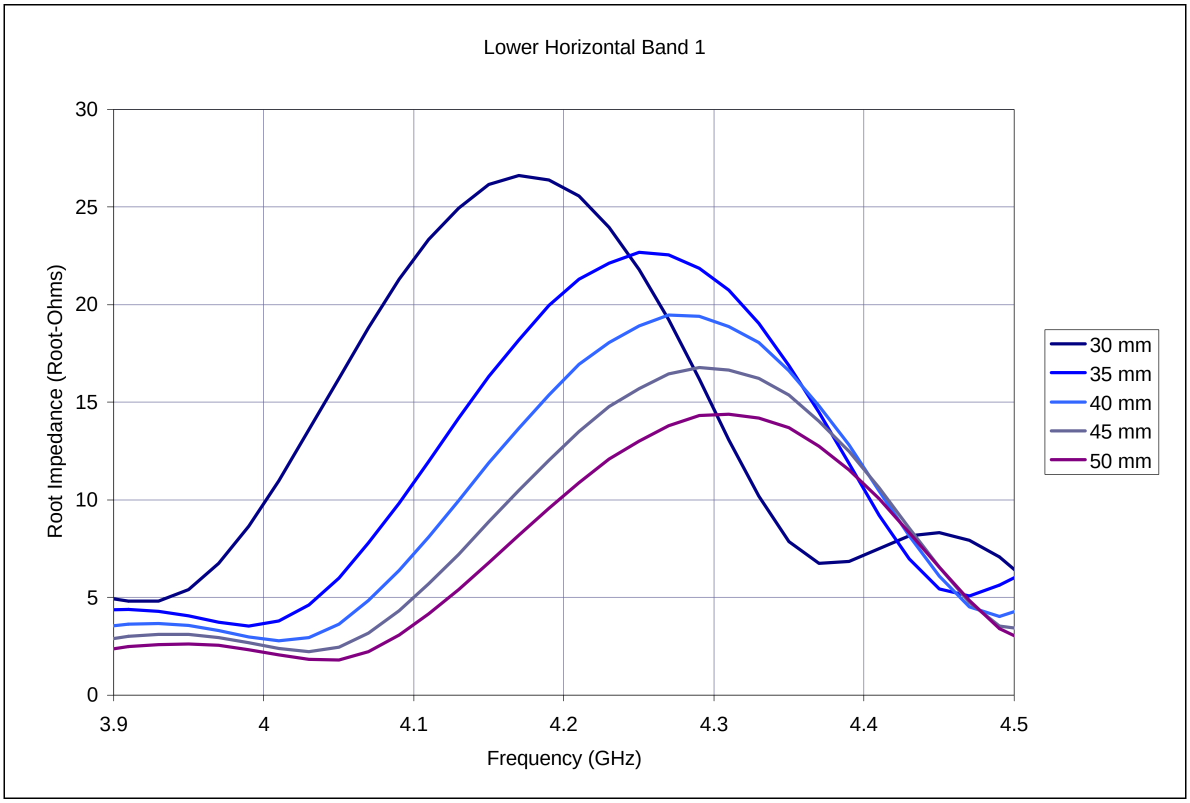

Figure 2. Frequency sweep of the lower band of HB1 as a function of beam pipe height.

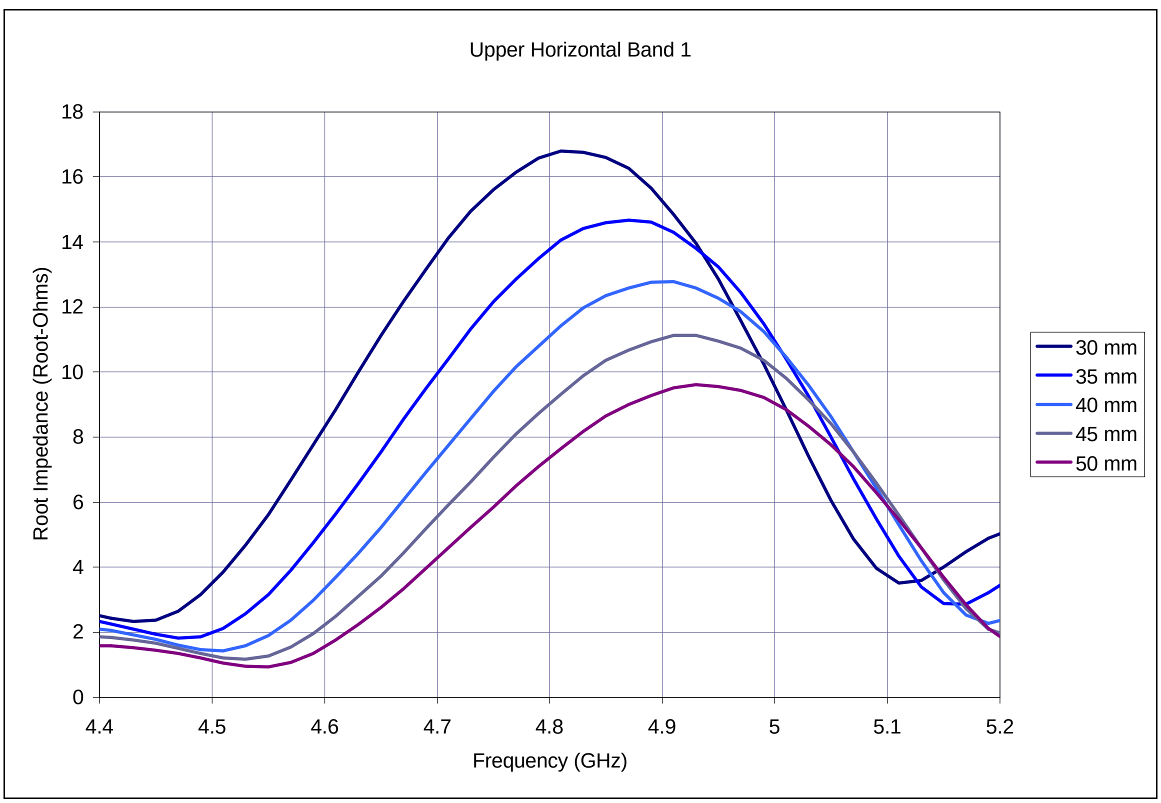

Figure 3. Frequency sweep of the upper band of HB1 as a function of beam pipe height.

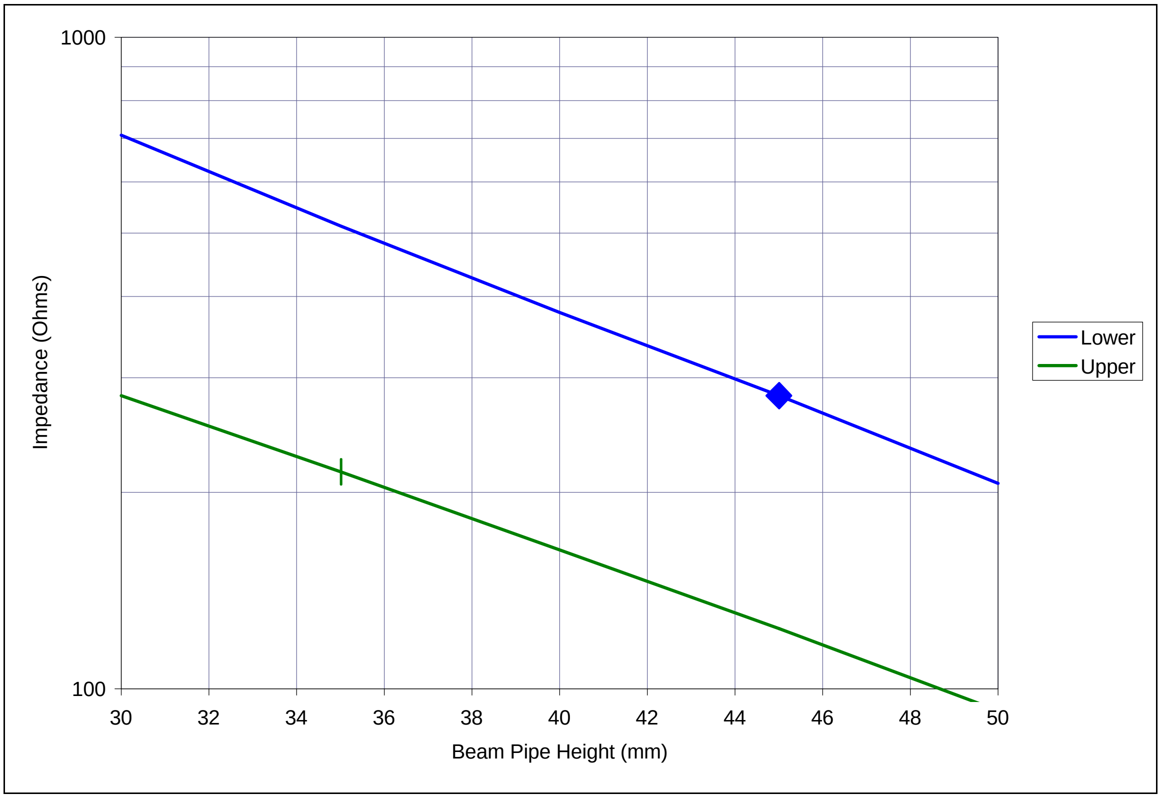

Figure 4. Peak Impedance as a function of beam pipe height. The diamonds mark the location of the beam pipe height used in the system stochastic cooling calculations.

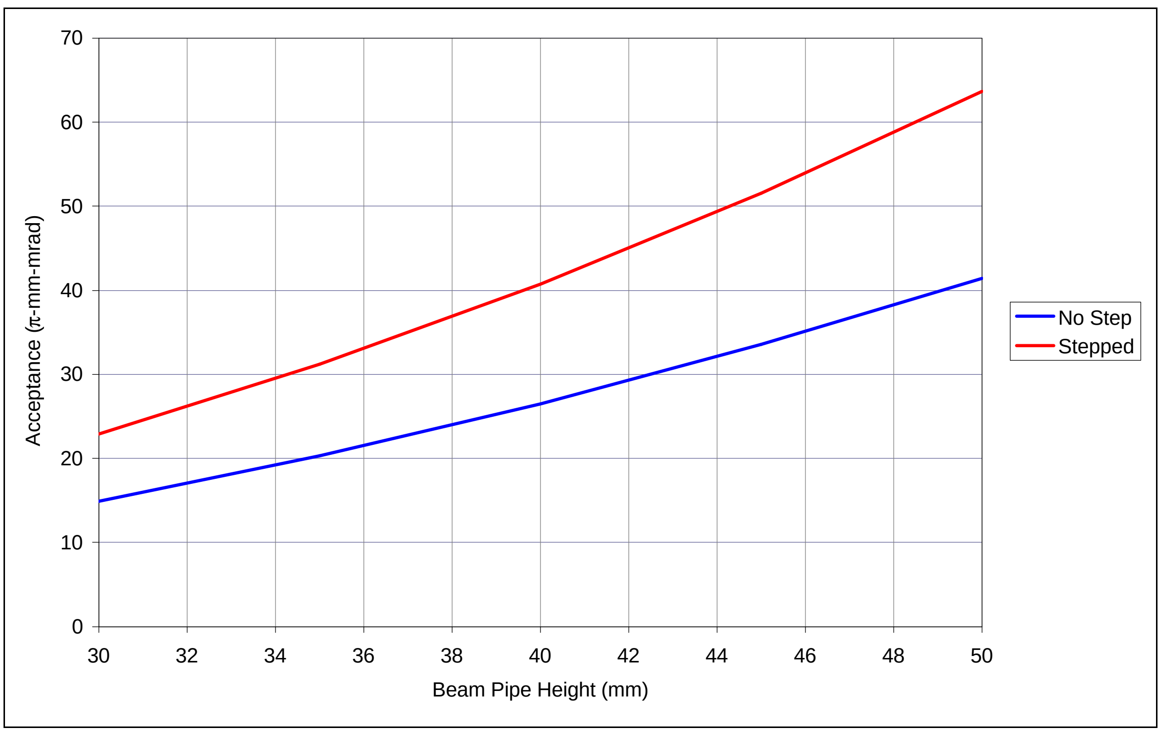

Figure 5. Acceptance for a non-tapered array of the upper sub-band of HB1 as a function of beam pipe height.

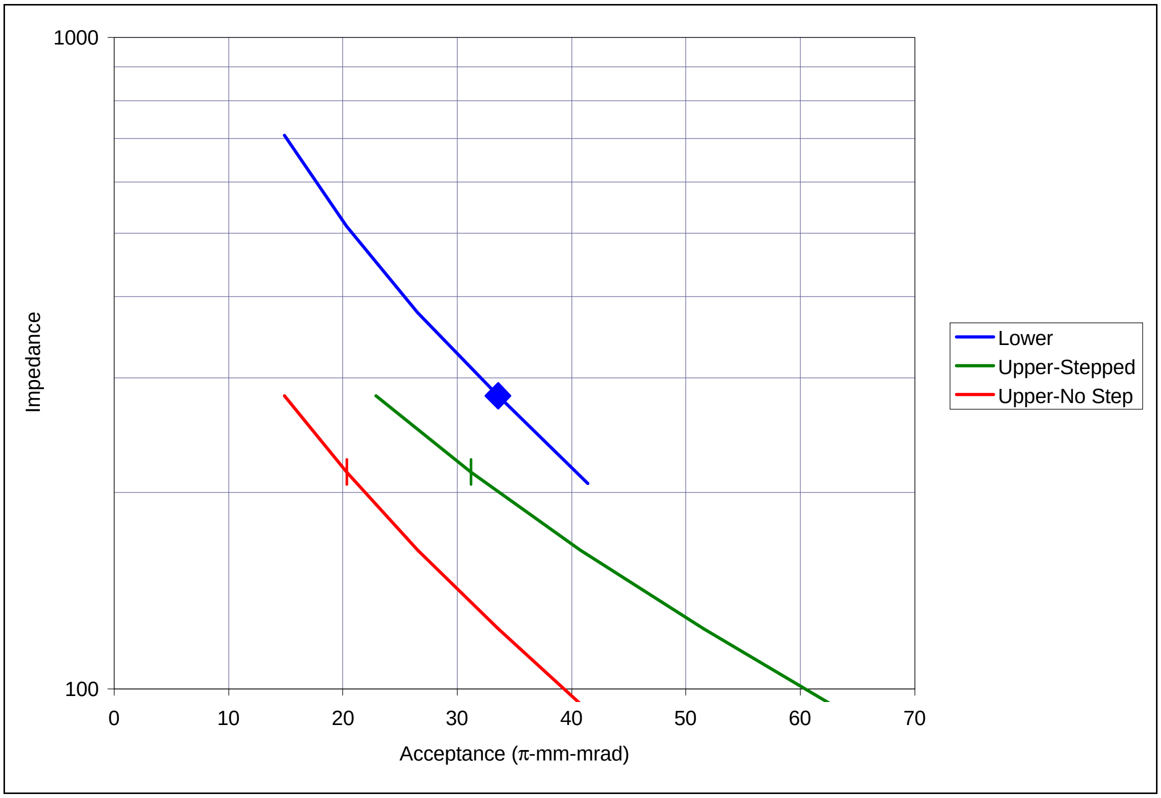

Figure 6. Peak impedance as a function of the acceptance of the beam pipe height.