

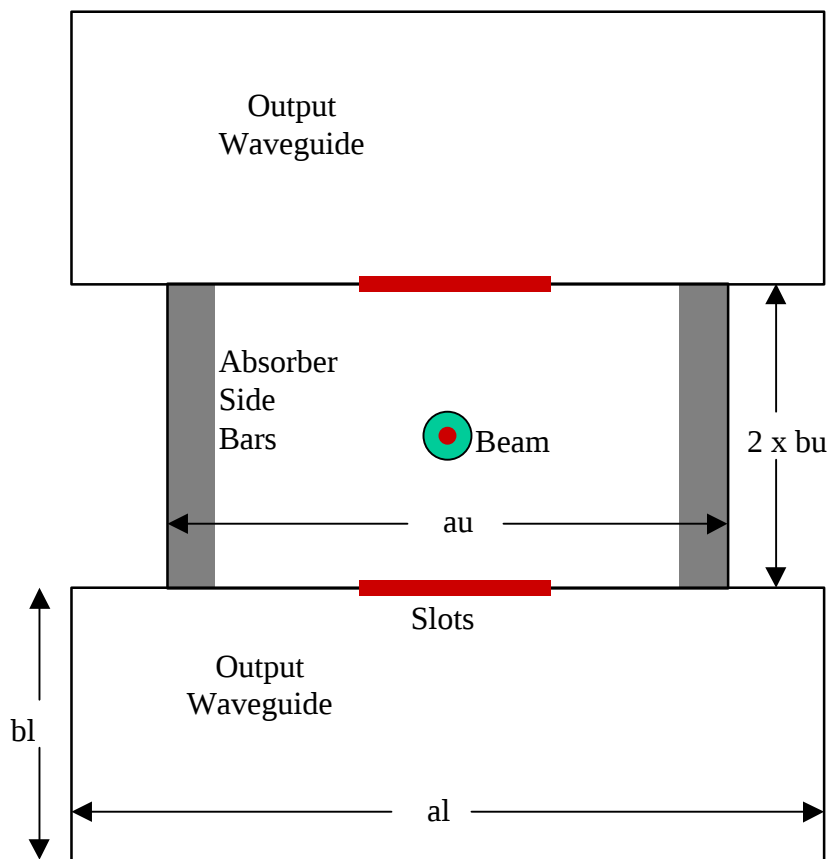
# **Pbar Note 577**

## **OPTIMIZATION OF THE 4.75 GHZ SLOW WAVE PICKUP FOR THE DEBUNCHER UPGRADE**

Dave McGinnis  
October 25, 1997

### Introduction

The lowest frequency band of the present Debuncher Upgrade is 4.75 GHz. Because of the low frequency, this band will have the largest dimensions of any pickup and kicker. The largest aperture for a  $40\pi$ -mm-mrad beam in the Debuncher would be 49 mm in width and 40 mm in height. This note will explore the optimum dimensions for a pickup in this band that can accommodate this aperture. From these dimensions, the minimum size of a cryogenic pickup tank may be determined. This note contains the summary of 76 computer simulations. Each simulation has 121 frequency points and takes about 3050 seconds to complete.



*Figure 1. Cross-sectional geometry of the pickup.*

### Simulation Input.

The cross-sectional geometry of the pickup used in the simulations is shown in Figure 1. The following parameters were varied:

|                         |      |                |
|-------------------------|------|----------------|
| Output waveguide height | (bl) | 11 simulations |
| Output waveguide width  | (al) | 21 simulations |

|                                      |      |                                                  |
|--------------------------------------|------|--------------------------------------------------|
| Beam pipe width                      | (au) | 11 simulations                                   |
| Beam pipe and output waveguide width | (a)  | 11 simulations                                   |
| Absorber thickness                   | (t)  | 11 $\Delta$ simulations, 11 $\Sigma$ simulations |

A typical input file is shown in Table 1.

|                                                                    |                 |                                  |              |             |
|--------------------------------------------------------------------|-----------------|----------------------------------|--------------|-------------|
| Output                                                             | Beam            | Waveguide height in mm (wg_h[2]) |              |             |
| 10.000                                                             | 20.000          |                                  |              |             |
| Output                                                             | Beam            | Waveguide width in mm (wg_w[2])  |              |             |
| 50.001                                                             | 50.001          |                                  |              |             |
| M wg exp. modes                                                    | N wg exp. modes | (mnwgmode, nwgmode)              |              |             |
| 20                                                                 | 100             |                                  |              |             |
| Absorber Properties (lower (0) first line, upper (1) second line ) |                 |                                  |              |             |
| Thickness                                                          | mu mag          | mu tan                           | ep mag       | ep tan      |
| 0.00                                                               | 1.0             | 0.00                             | 1.0          | 0.0         |
| 1.00                                                               | 1.2             | 1.50                             | 10.0         | 0.0         |
| Number of slots                                                    | (nslot)         |                                  |              |             |
| 45                                                                 |                 |                                  |              |             |
| No. of slots                                                       | Width(mm)       | Length(mm)                       | Spacing(mm)  | Conductance |
| 45                                                                 | 2.032           | 19.735                           | 2.032        | 0.000e+00   |
| Number of slot modes                                               | (nslotmode)     |                                  |              |             |
| 2                                                                  |                 |                                  |              |             |
| ! x                                                                | y               | Beam displacement in mm (xb, yb) |              |             |
| 0.000                                                              | 5.000           |                                  |              |             |
| Difference mode                                                    | (array_mode)    |                                  |              |             |
| Pickup                                                             |                 |                                  |              |             |
| Number of freq. points                                             | (nfreq)         |                                  |              |             |
| 121                                                                |                 |                                  |              |             |
| Start frequency                                                    | GHz             |                                  | (start_freq) |             |
| 3.00                                                               |                 |                                  |              |             |
| Stop frequency                                                     | GHz             |                                  | (stop_freq)  |             |
| 6.00                                                               |                 |                                  |              |             |
| Output data table file                                             |                 |                                  |              |             |
| oal62.dat                                                          |                 |                                  |              |             |
| Raw output data file                                               |                 |                                  |              |             |
| xhutupb.prn                                                        |                 |                                  |              |             |

Table1. A typical input file.

### Simulation Output

The impedance of the array is defined as:

$$Z_{\Delta_{pu}} = \frac{P_{\Delta_{total}}}{\left(\frac{i_b}{2}\right)^2 \left(\frac{y}{d/2}\right)^2} \quad (1)$$

where  $P_{\Delta}$  is the sum of the output power of the upper and lower output waveguides,  $i_b$  is the beam current,  $y$  is the displacement of the beam from the midplane of the beam pipe and  $d$  is the height of the beam pipe. The gain of the array is defined as:

$$g = \sqrt{Z_{\Delta_{pu}}^{\pm}} \quad (2)$$

The impedance-bandwidth product of the array is defined as:

$$ZBW = \frac{1}{2\pi} \int_{\omega_l}^{\omega_u} Z_{\Delta_{pu}}(\omega) d\omega \quad (3)$$

where  $\omega_l$  and  $\omega_u$  is the lower and upper frequency of the major lobe of the response. The bandwidth using the impedance is defined as:

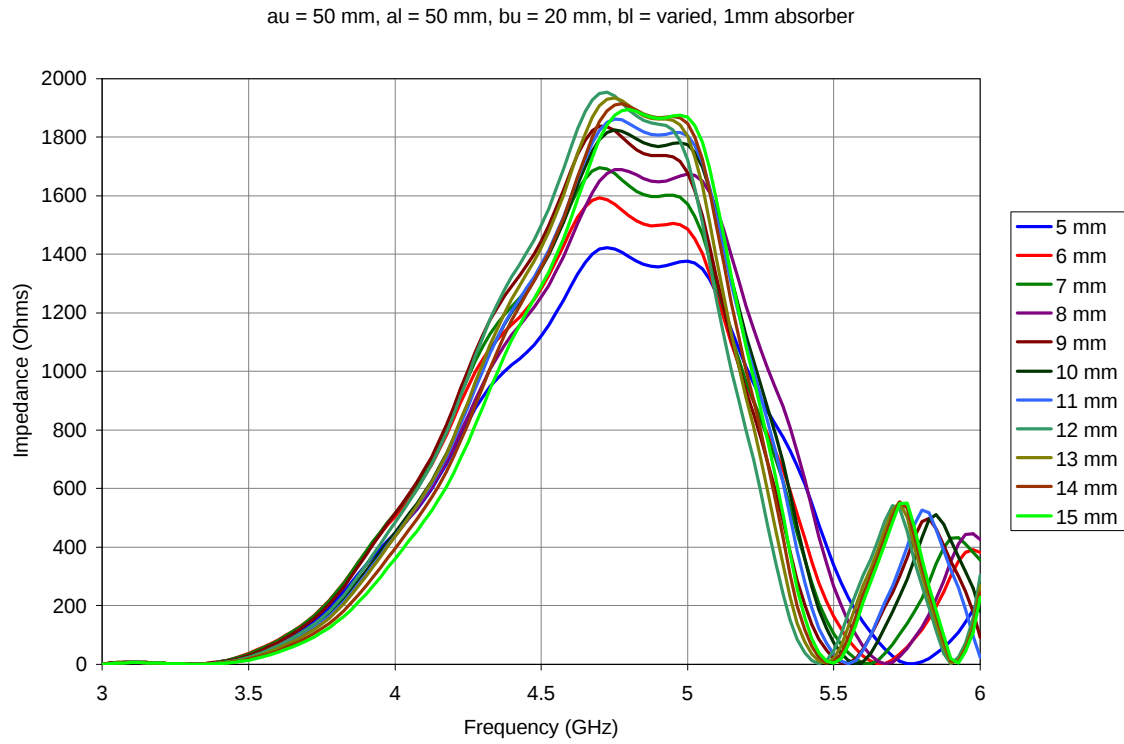
$$BW_Z = \frac{\frac{1}{2\pi} \int_{\omega_l}^{\omega_u} Z_{\Delta_{pu}}(\omega) d\omega}{Z_{\Delta_{pu} \max}} \quad (4)$$

The gain-bandwidth product of the array is defined as:

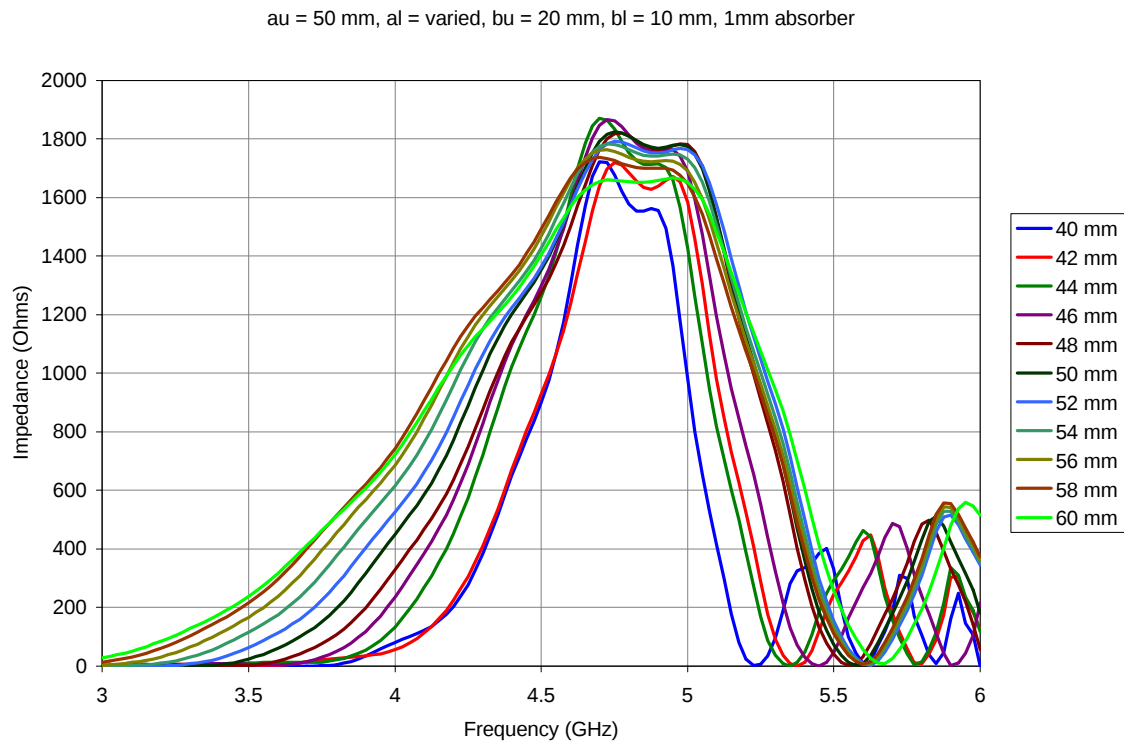
$$gBW = \frac{1}{2\pi} \int_{\omega_l}^{\omega_u} g(\omega) d\omega \quad (5)$$

The bandwidth using the gain is defined as:

$$BW_g = \frac{\frac{1}{2\pi} \int_{\omega_l}^{\omega_u} g(\omega) d\omega}{g_{\max}} \quad (4)$$



*Figure 2. Output waveguide height varied*



*Figure 3. Output waveguide width varied.*

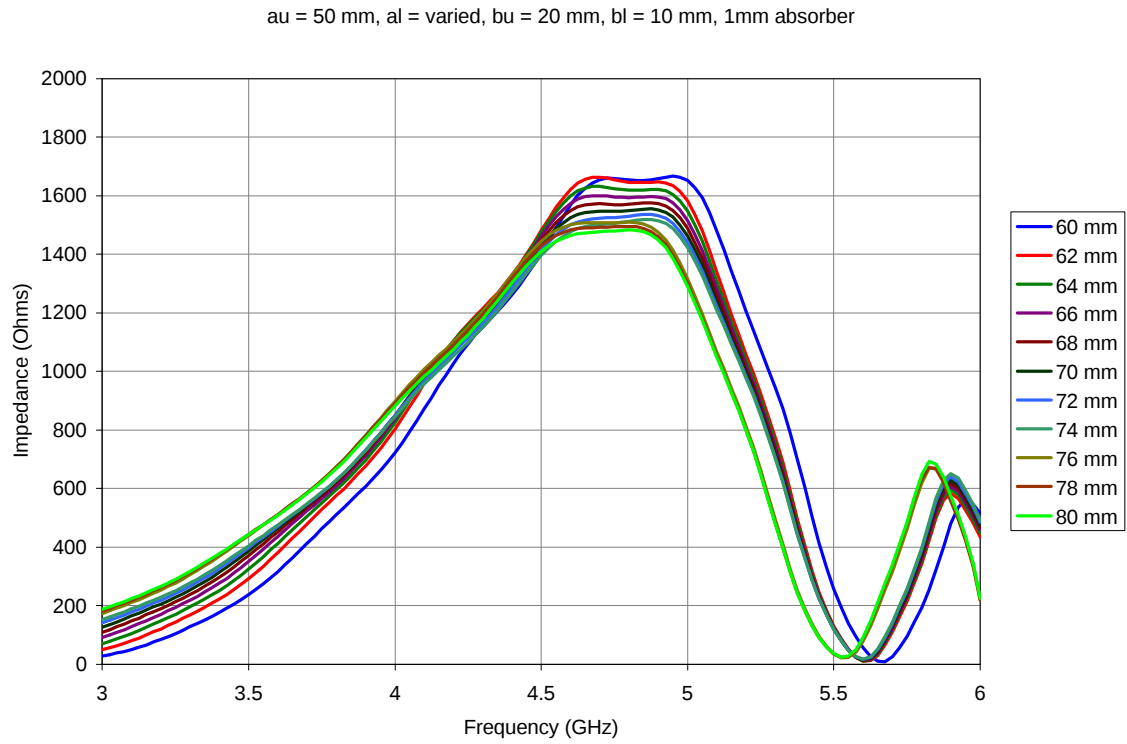


Figure 4. Output waveguide width varied.

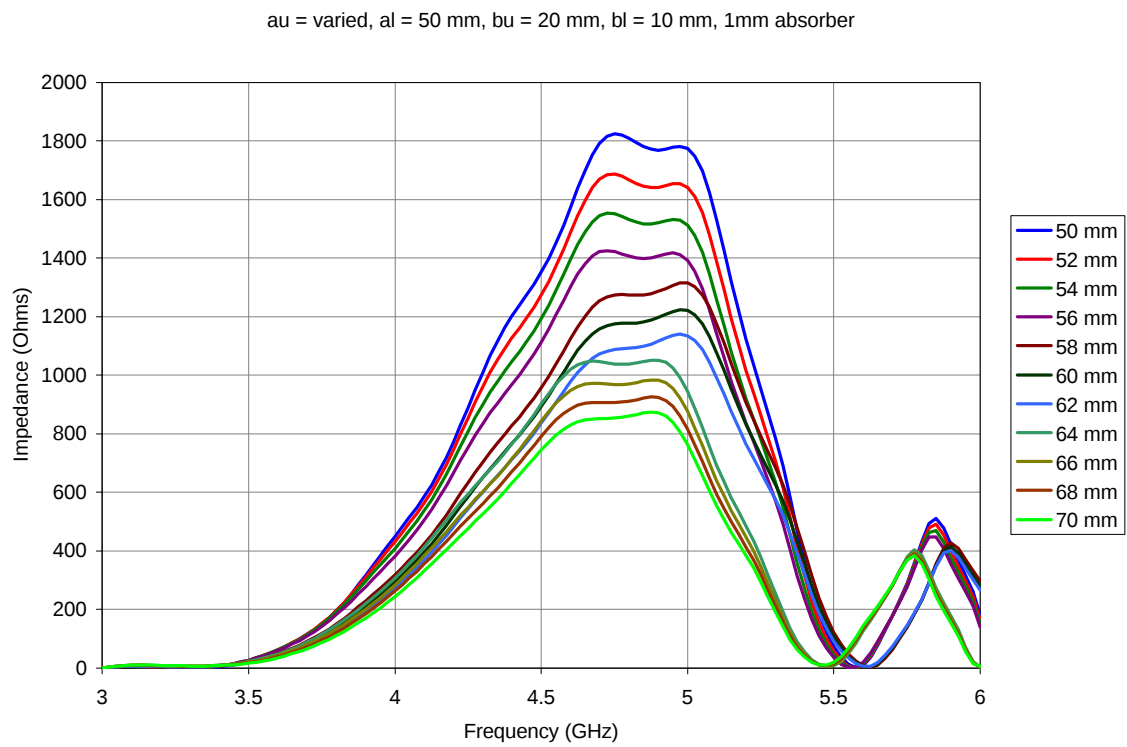


Figure 5. Beam pipe width varied.

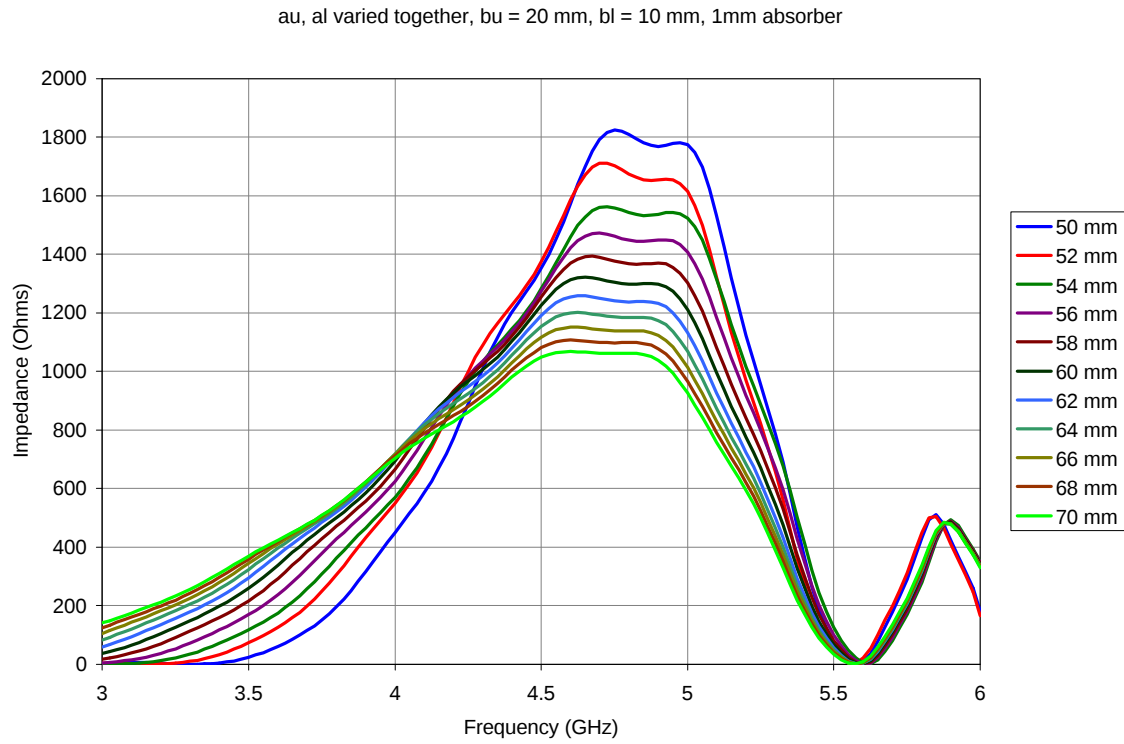


Figure 6. Output waveguide and beam pipe width varied together.

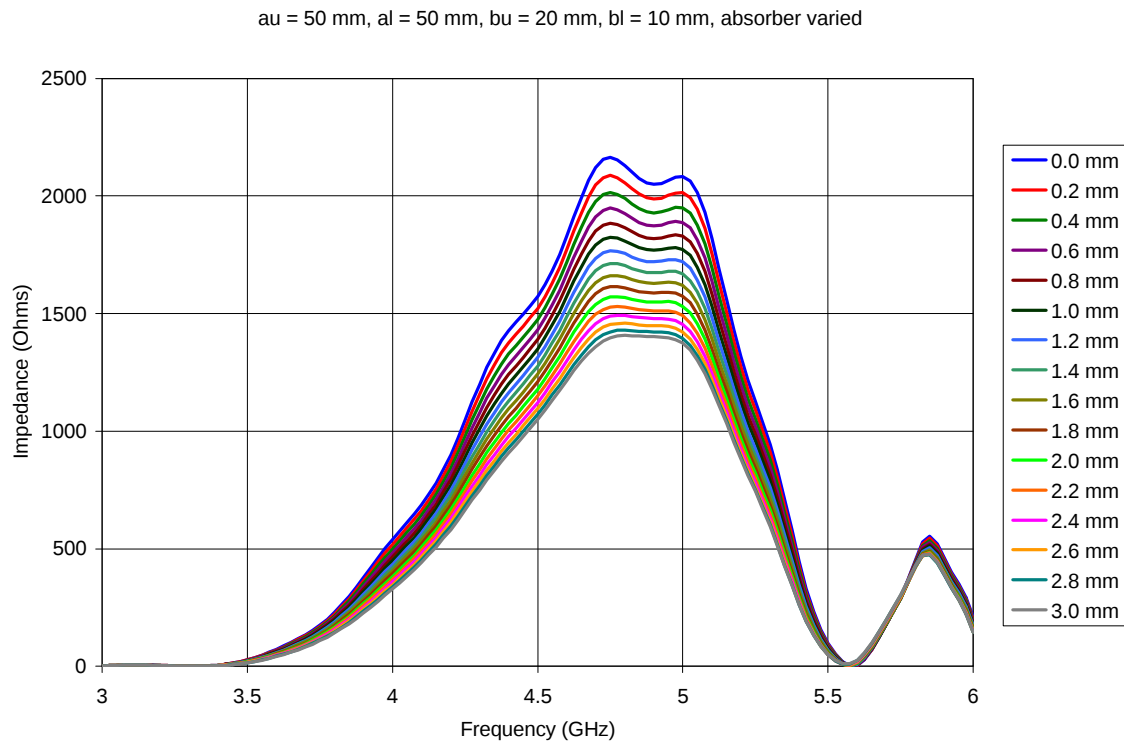


Figure 7. Difference mode impedance with absorber thickness varied.

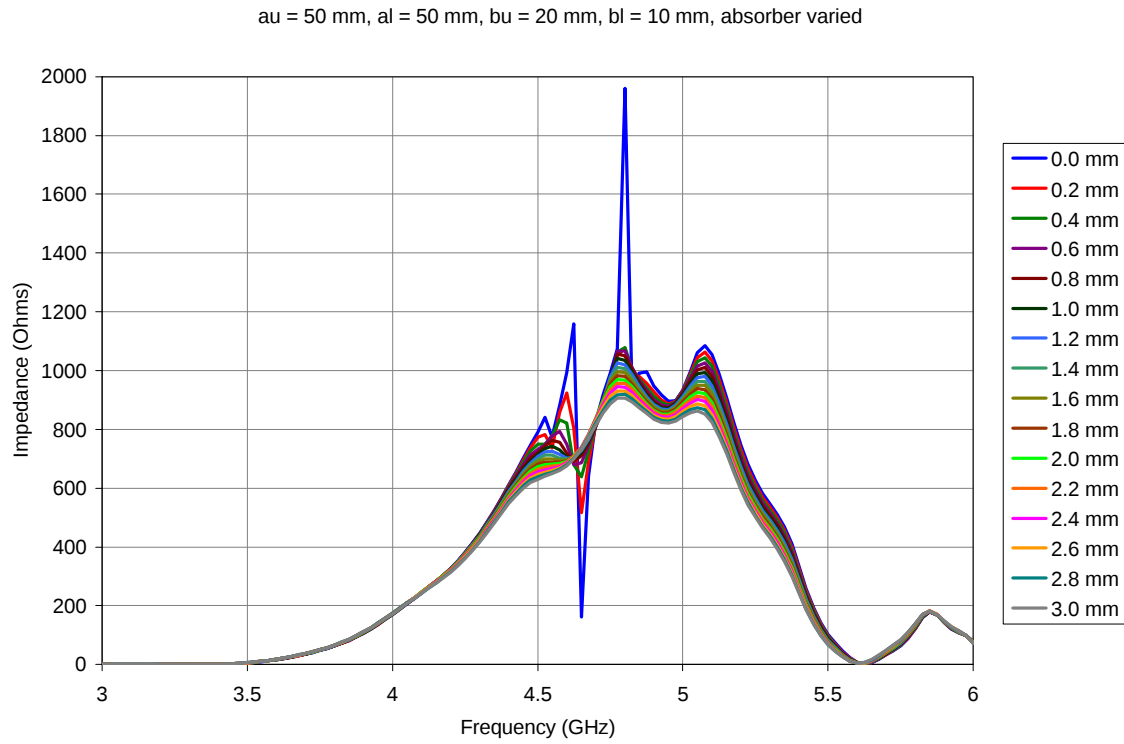


Figure 8. Difference mode impedance with absorber thickness varied.

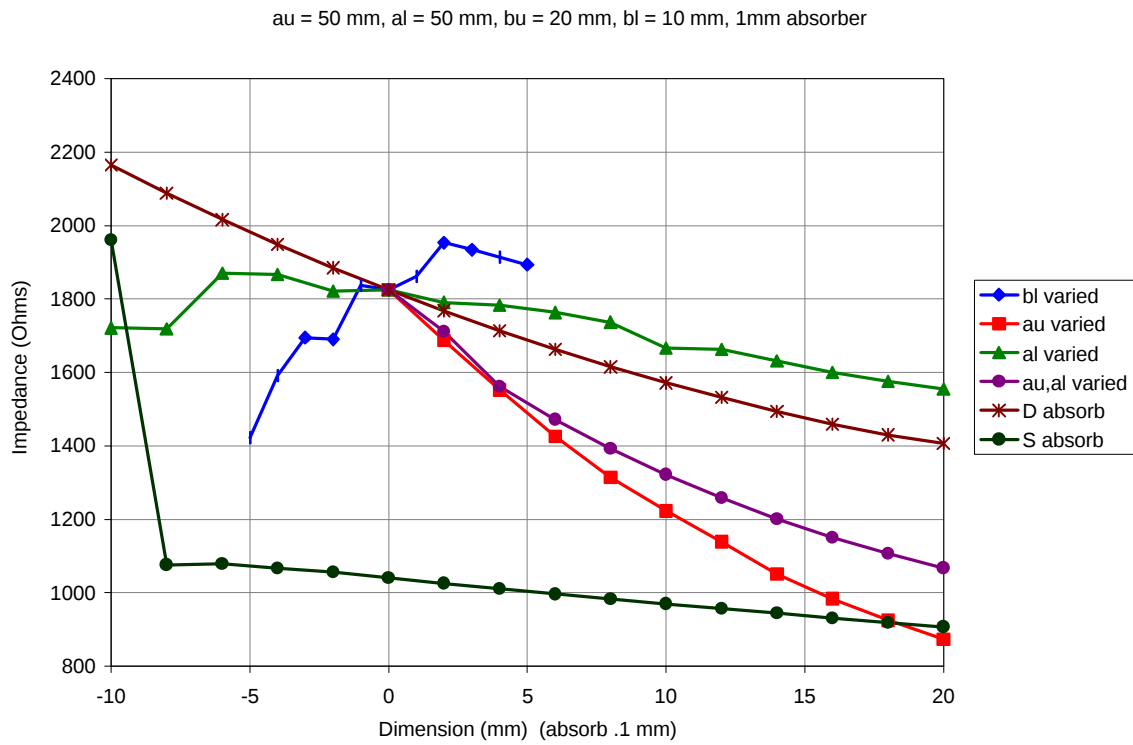
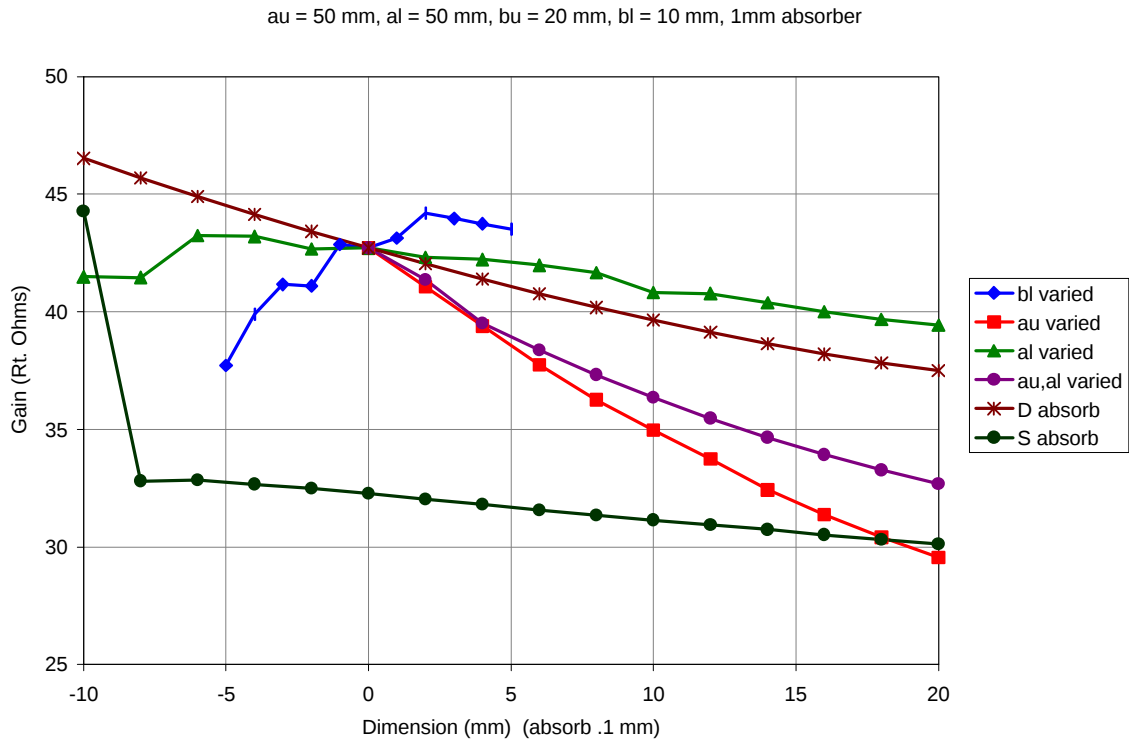
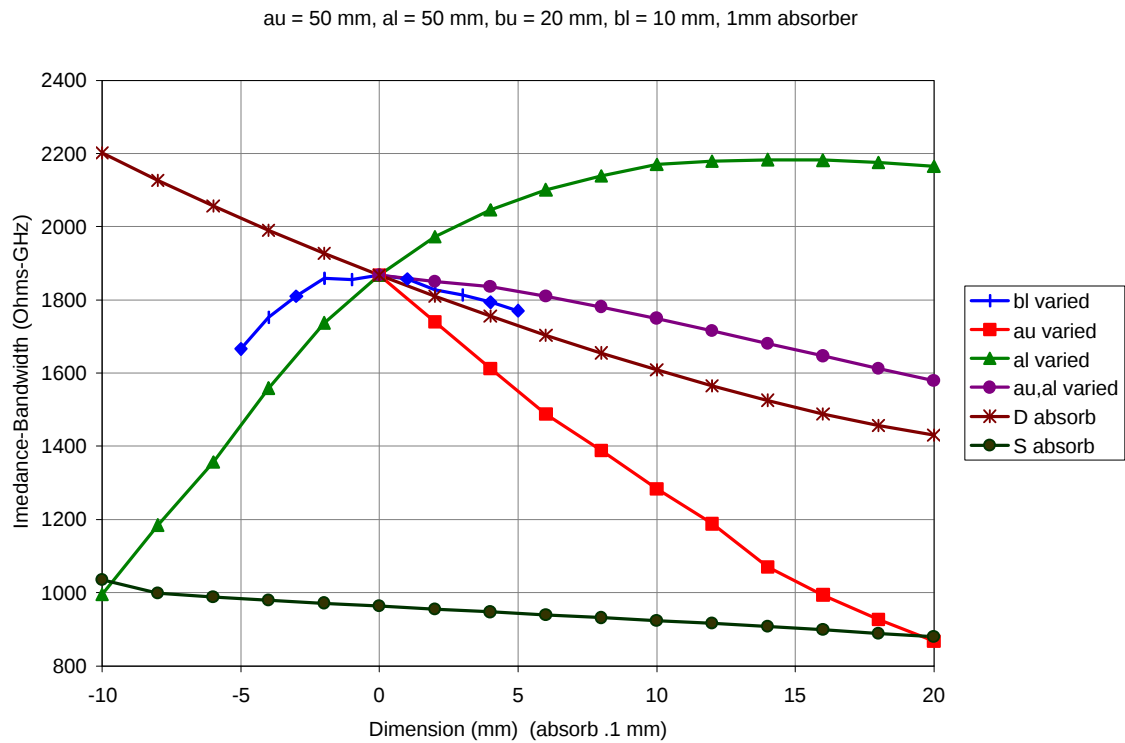


Figure 9. Maximum impedance.



*Figure 10. Maximum Gain*



*Figure 11. Impedance Bandwidth product*

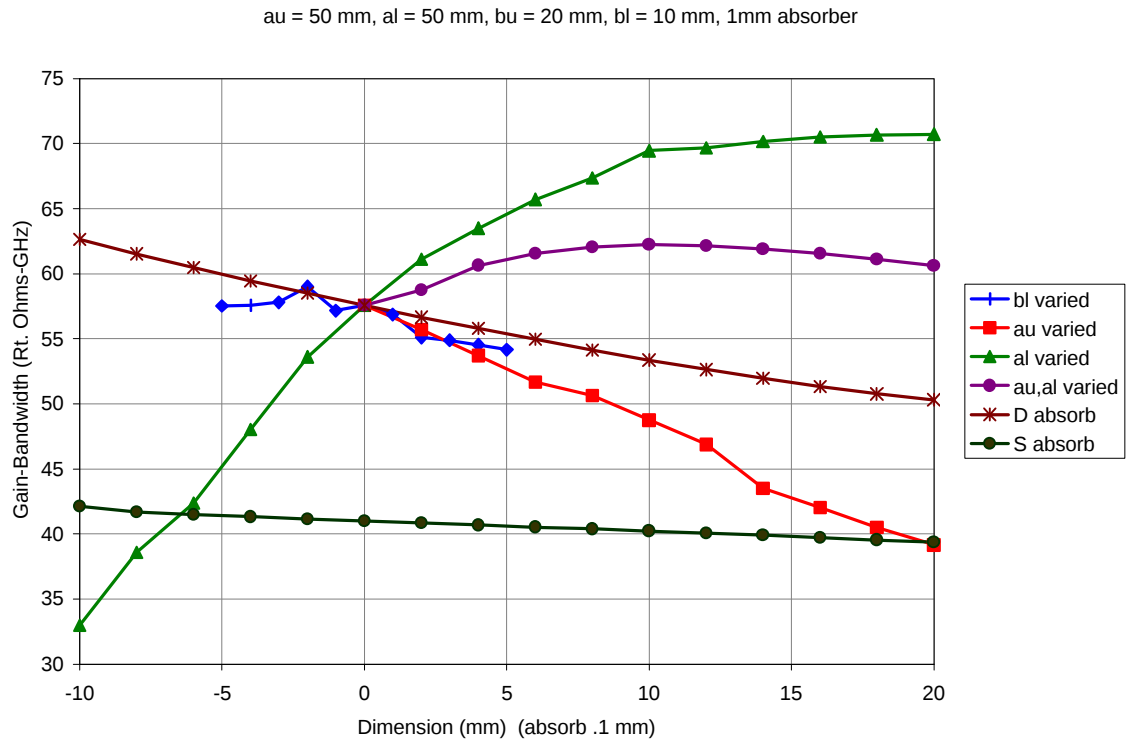


Figure 12. Gain Bandwidth product

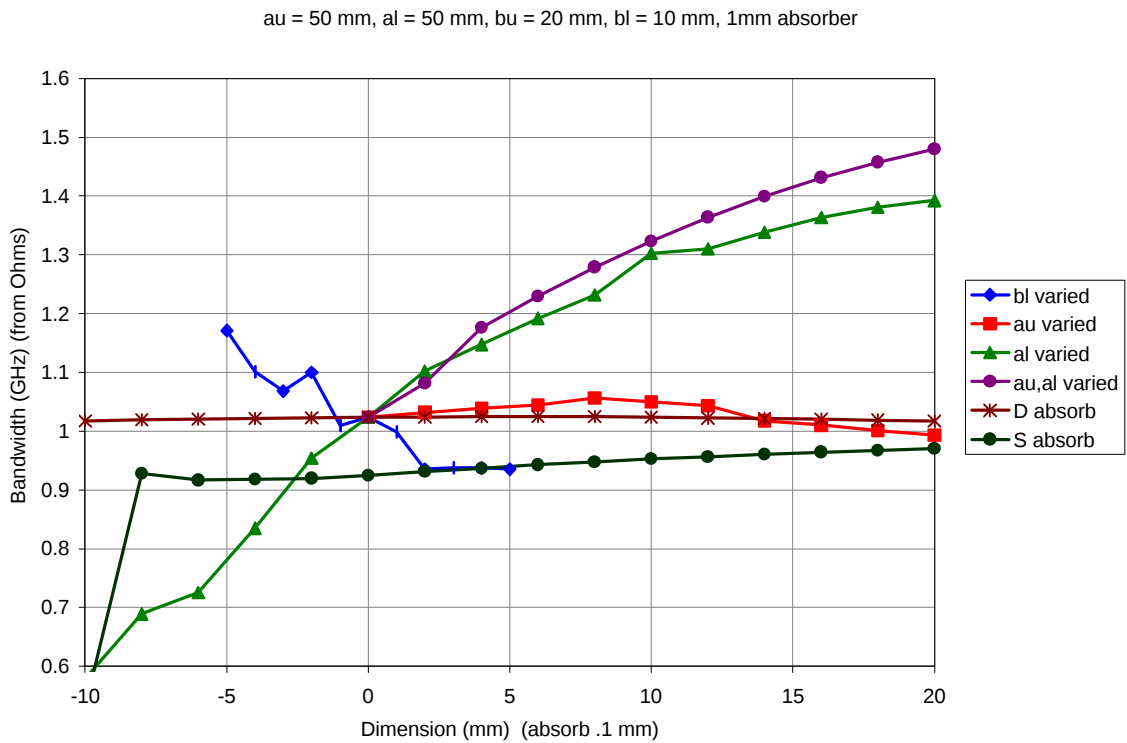


Figure 13. Bandwidth using impedance-bandwidth product.

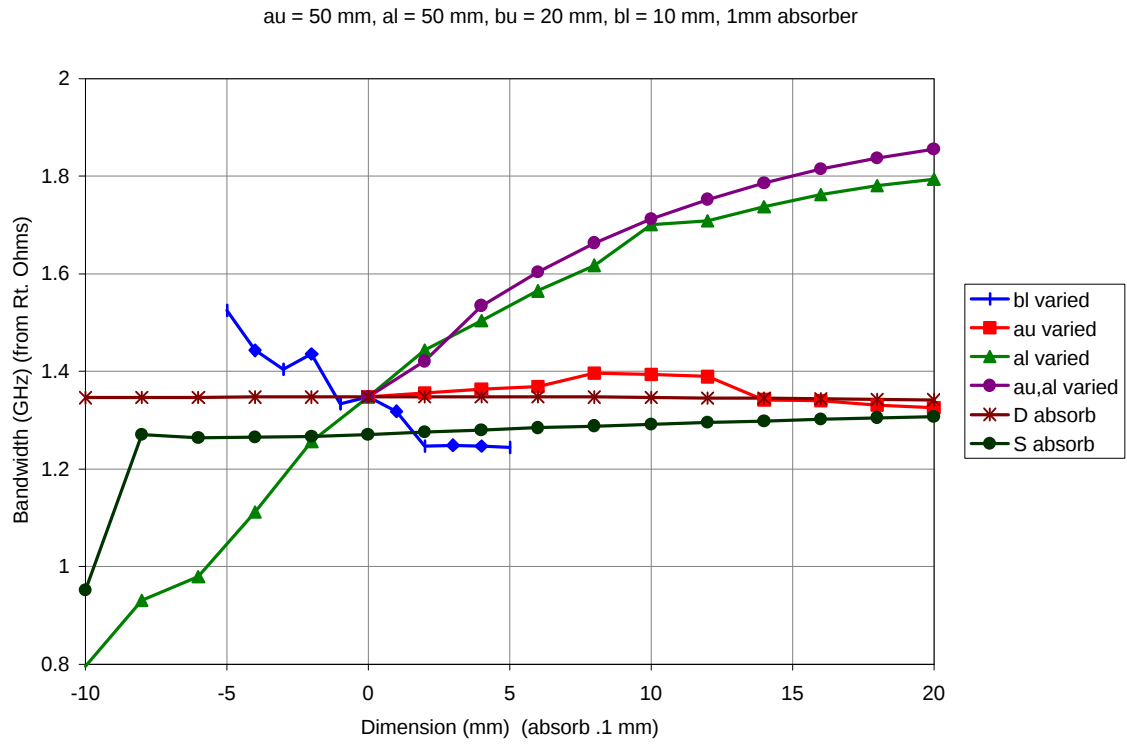


Figure 14. Bandwidth using gain-bandwidth product.