Collimator Impedance

V. Mane

April 1998

Collider Accelerator Department

Brookhaven National Laboratory

U.S. Department of Energy

USDOE Office of Science (SC)

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1   Introduction

The primary betatron collimator is located a few meters downstream of the Q3 in the 8 o' clock IR. This report describes the longitudinal impedance calculations on the final design of the collimator assembly. The impedance is compared with that of the 197 MHz RF Cavity, and a design for further reducing the impedance has been proposed.

2   MAFIA Results

Figure 1 gives a drawing of the collimator assembly, obtained from J. Browdowski. The jaws of the collimator are located inside a rectangular vacuum chamber with sides about 23 cm wide. The length of the jaws and the rectangular chamber is about 46 cm. The long bellows on two sides of the collimator vacuum chamber help position the jaws in the transverse direction with respect to the beam. In the cross section figure, the jaws are shown half way in. The diameter of the beam pipe and the bellows is 19.5 cm. At the end of the bellows, the beam pipe tapers to a diameter of 12.3 cm.

The eigenmodes of this device were determined using MAFIA [1]. Figure 2 shows a cross section of the drawing used in the simulation. In the simulation the size of the rectangular chamber is 22 cm and the length is 45 cm. The diameter of the side pipes is 19 cm and the length is 15 cm. The cutoff frequency of the 19.5 cm side pipe is 1.1 GHz. 20 modes were calculated upto a frequency of 1.1 GHz. Most of these modes have an electric field predominantly in the transverse direction. At the ends of the jaws the electric fields have a longitudinal component, which contributes to the shunt impedance. Figure 2 shows the electric field of the mode at 289 MHz. Figure 4 compares the shunt impedance of this device with a single 197 MHz damped RF cavity. The impedance is comparable to that of the RF cavity, as shown in the figure. The impedance can be eliminated by placing a collar around the jaws and grounding the jaws to the vacuum chamber. In the second simulation (Figure 3), the top figure shows the jaws grounded to the beampipe at both ends, and the bottom figure shows a cross section of the geometry with the collar. As can be seen from the electric field plot, the modes of the rectangular chamber no longer couple with the beam pipe. The shunt impedance of all modes upto 1 GHz is now zero (Figure 4). The collimator drawing in Figure 1, shows the collar but not the grounded ends. The grounded ends are necessary to achieve the above mentioned results.

3   Conclusion

The beam impedance of the collimator assembly was determined using MAFIA. The collimator has resonances starting at 289 Mhz, with shunt impedance of about 30 kohm. These resonances are eliminated by placing a collar around the collimator jaws and grounding the two ends of the jaws to the vacuum chamber.

References

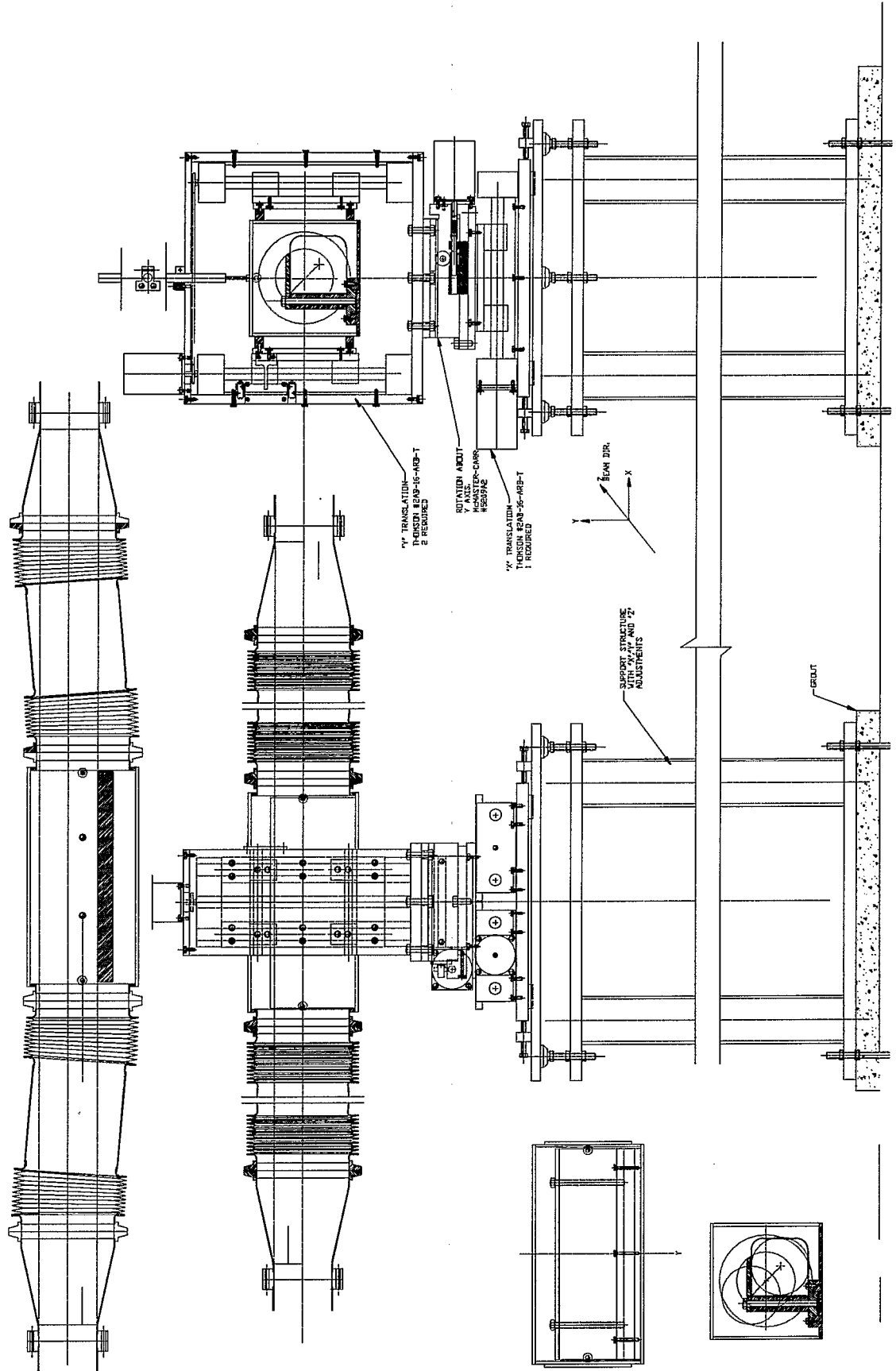[1] T. Weiland, Particle Accelerators 15 (1984), pp. 245-292.

Figure 1: Beam Collimator Geometry

P--:3.23

#ARROW

COORDINATES/M
FULL RANGE / WINDOW
X[-0.12000, 0.12000]
 [-0.12000, 0.12000]
Y[-0.12000, 0.12000]
 [0.0000,   0.0000]
Z[0.0000,   0.75000]
 [0.0000,   0.75000]

SYMBOL = E_1
Y-MESHLINE: 25
CUT AT Y/M: 2.23517E-08
INTERPOLATE.=   1
LOGSCALE....= 2.0000
MAX ARROW =   8.1593

X

+Y
Z

P--:3.23

#ARROW

COORDINATES/M
FULL RANGE / WINDOW
X[-0.12000, 0.12000]
 [-0.12000, 0.12000]
Y[-0.12000, 0.12000]
 [-0.12000, 0.12000]
Z[0.0000,   0.75000]
 [0.15500, 0.15500]

SYMBOL = E_1
Z-MESHLINE: 32
CUT AT Z/M: 0.15500
INTERPOLATE.=   1
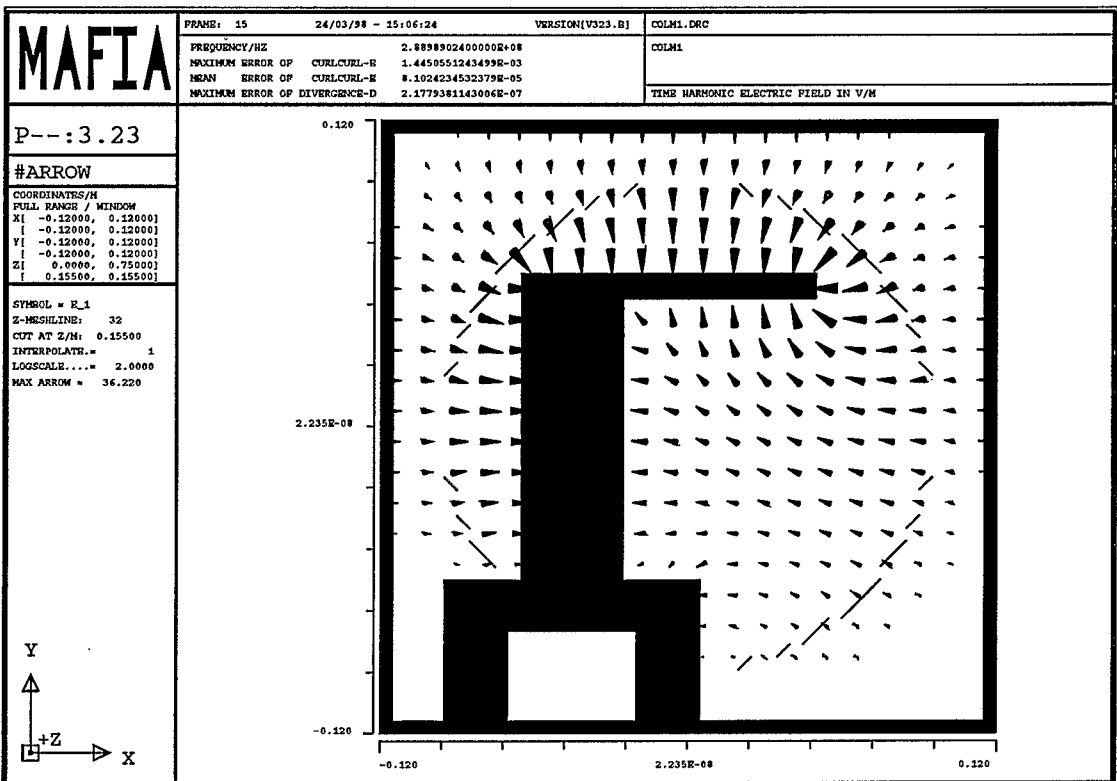LOGSCALE....= 2.0000
MAX ARROW =   36.220

Y

+Z
X

Figure 2: MAFIA simulation of the Beam Collimator shows electric field of the mode at 289 MHz.

Top panel (MAFIA plot)

P--:3.23

#ARROW

COORDINATES/M
FULL RANGE / WINDOW
X[-0.12000, 0.12000]
 [-0.12000, 0.12000]
Y[-0.12000, 0.12000]
 [0.0000,   0.0000]
Z[0.0000,   0.75000]
 [0.0000,   0.75000]

SYMBOL = E_1
Y-MESHLINE: 25
CUT AT Y/M: 2.23517E-08
INTERPOLATE.=   1
LOGSCALE....= 2.0000
MAX ARROW = 23.904

X

+Y

Z

Bottom panel (MAFIA plot)

P--:3.23

#ARROW

COORDINATES/M
FULL RANGE / WINDOW
X[-0.12000, 0.12000]
 [-0.12000, 0.12000]
Y[-0.12000, 0.12000]
 [-0.12000, 0.12000]
Z[0.0000,   0.75000]
 [0.37500, 0.37500]

SYMBOL = E_1
Z-MESHLINE: 76
CUT AT Z/M: 0.37500
INTERPOLATE.=   1
LOGSCALE....= 2.0000
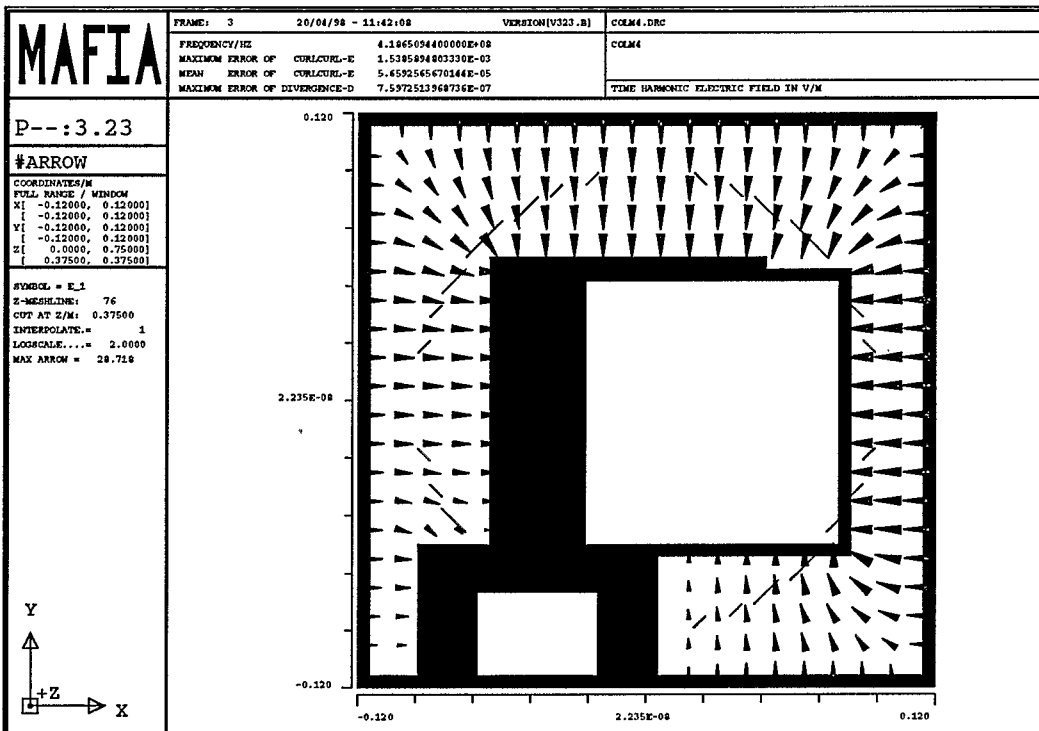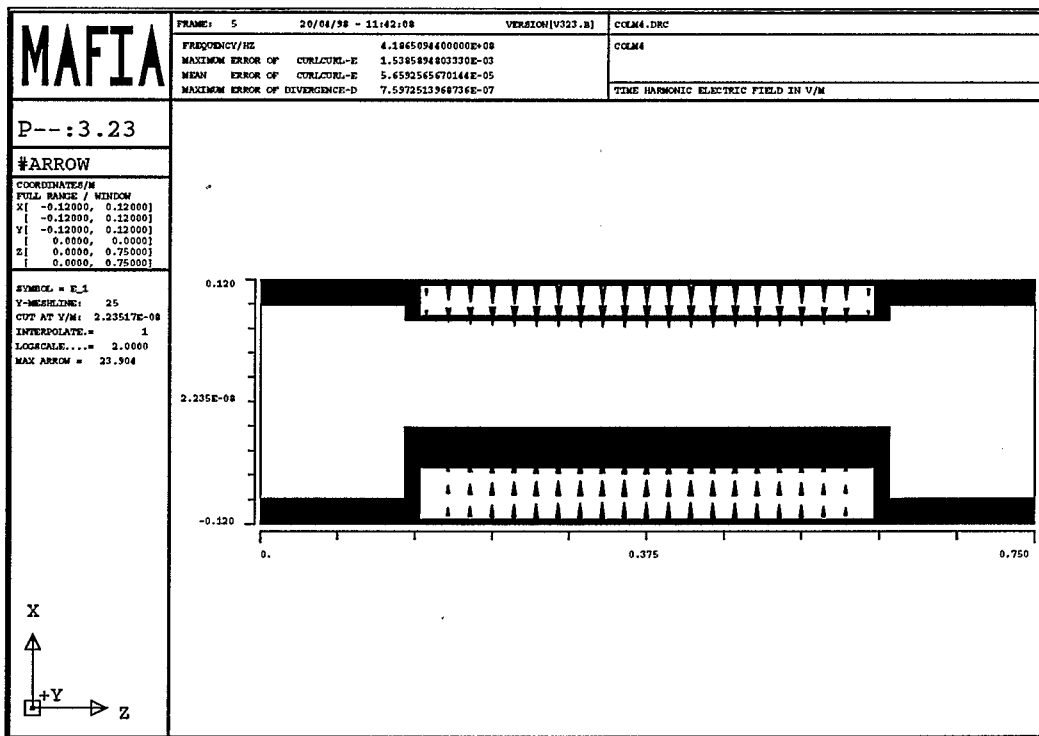MAX ARROW = 28.718

Y

+Z

X

Figure 3: Beam Collimator with collar and grounded ends, the figure shows the electric field of the mode at 418 MHz.
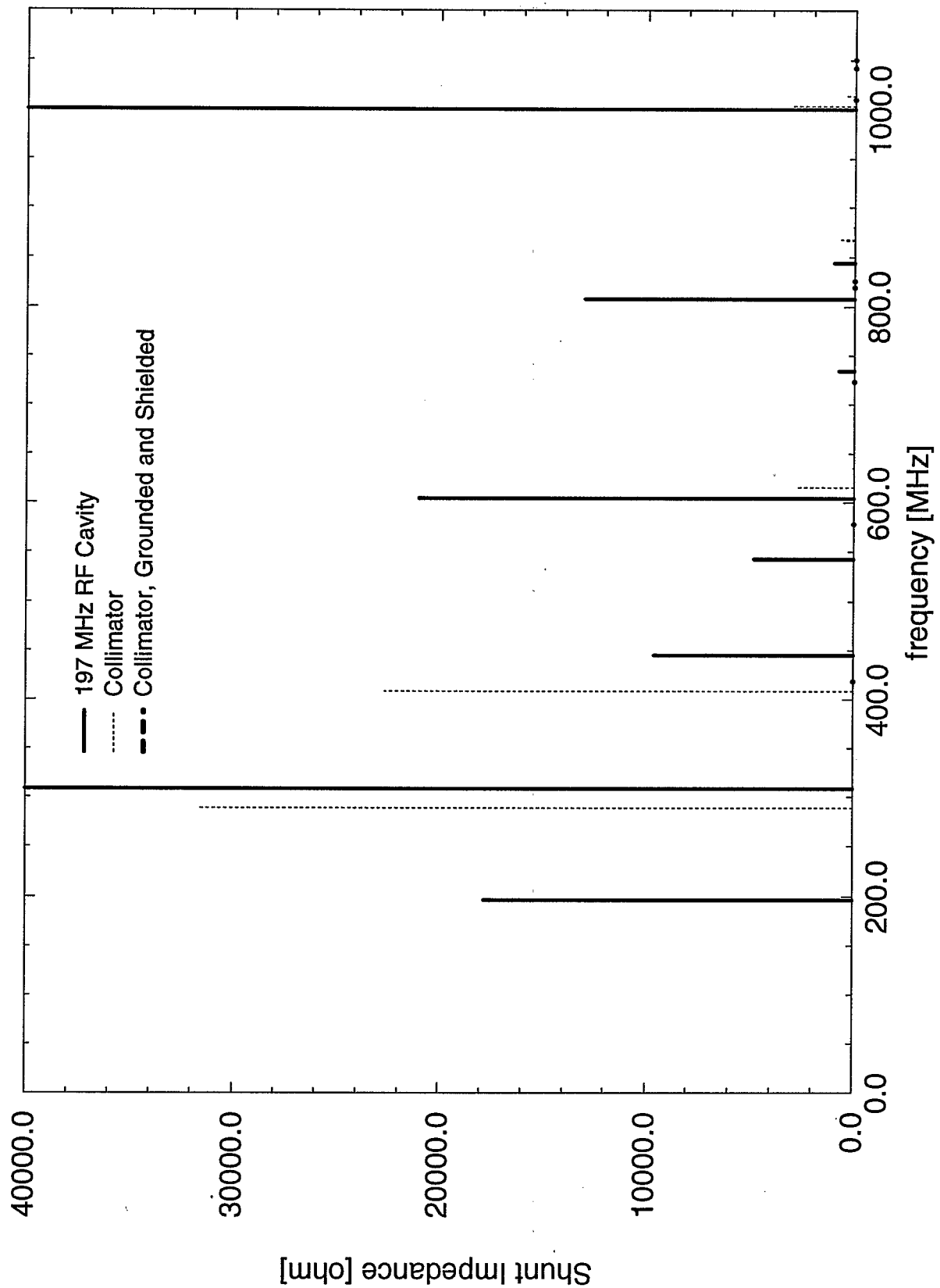
4

Figure 4: Beam Collimator Impedance - after grounding and shielding there are no resonances upto 1 GHz. Modes are compared with 197 MHz RF Cavity