Pump Out Port Impedance

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I. Introduction

There are broadly two kinds of vacuum pump out ports in RHIC. The port with aperture smaller than the beampipe aperture (Small Aperture Ports) make a small inductive contribution upto the pipe cutoff frequency and therefore do not require shielding. The port with aperture comparable to the beampipe aperture (Large Aperture Ports) have resonances, which couple with the beam. Therefore these require shielding, and an appropriate shield design is presented.

II. Small Aperture Ports

The vacuum ports at the interconnect between the arc dipole and the CQS package have a port ID of 2.2 cm and a beampipe ID of 6.91 cm [1]. There is one such port at every other interconnect, with a total of approximately 233 ports. The inductance of each port, as determined numerically using MAFIA [2] is 1.4×10^{-11} henry.

The vacuum ports at the warm to cold transition have a port ID of 2.5 cm and beampipe ID of 12.28 cm. There are a total of 16 such ports. The inductance of each port as determined from MAFIA is 5.5×10^{-12} henry.

The total contribution to broadband impedance $|Z/n|$ from the above mentioned ports is less than 0.002 ohm. This is very small compared to the broadband impedance threshold of 1.5 ohm, due to microwave instability [3].

III. Large Aperture Ports

The vacuum port in the warm pipe have a port ID of 12 cm and beampipe ID of 12.28 cm, with a total of 36 such ports [4]. The unshielded port has several resonances below the cutoff frequency of the beampipe. The eigenmodes of the geometry were determined using MAFIA [2]. Figures 1 and 2 (top) show that the transverse electric modes of the port couple with the beam.

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The mode in Figure 2 is at frequency 1.52 GHz and has a shunt impedance R = 7100 ohm, Q = 3400 and R/Q = 2. Several other modes of the port (not shown in the figures) couple with the beam. This is unacceptable, and therefore requires shielding.

A standard fine mesh shield reduces the pumping capacity of the port by 17%. Therefore, a simpler shield which would not reduce the pumping capacity as much, is investigated. The properties of the required shielding are given below:

- Shield must consist of wires, both parallel and perpendicular to the beam direction.

- Center to center spacing between the wires must be less than or equal to 3 cm.

- The size of the wire is determined by mechanical reasons, and dissipated power.

With the above mentioned specifications, a shield with 3 cross wires in each direction, as shown in Figure 3, removes all of the impedance contribution from these ports. If the diameter of each cross wire is taken to be 1 mm, the pumping capacity reduces only by 5%. Figures 1 and 2 (bottom) show that the eigenmodes of the shielded port are decoupled from the beampipe. Figure 4 gives a 3-dimensional plot of the port with the cross wire shield.

IV. Conclusion

The small aperture pump out ports at the interconnects between the arc dipole and the CQS package, and at the warm to cold pipe transition make a total broadband contribution $|Z/n|$ of less than .002 ohm and therefore do not require shielding.

The large aperture pump out ports have a pipe ID of about 12 cm, which is comparable to the beampipe ID of 12.28 cm. The resonances of these ports will couple with the beam, and hence they require shielding.

V. References

[1] G. McIntyre, Private Communication.

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

[3] Collective Instabilities in RHIC, Eds. S. Peggs, W.W. Mackay

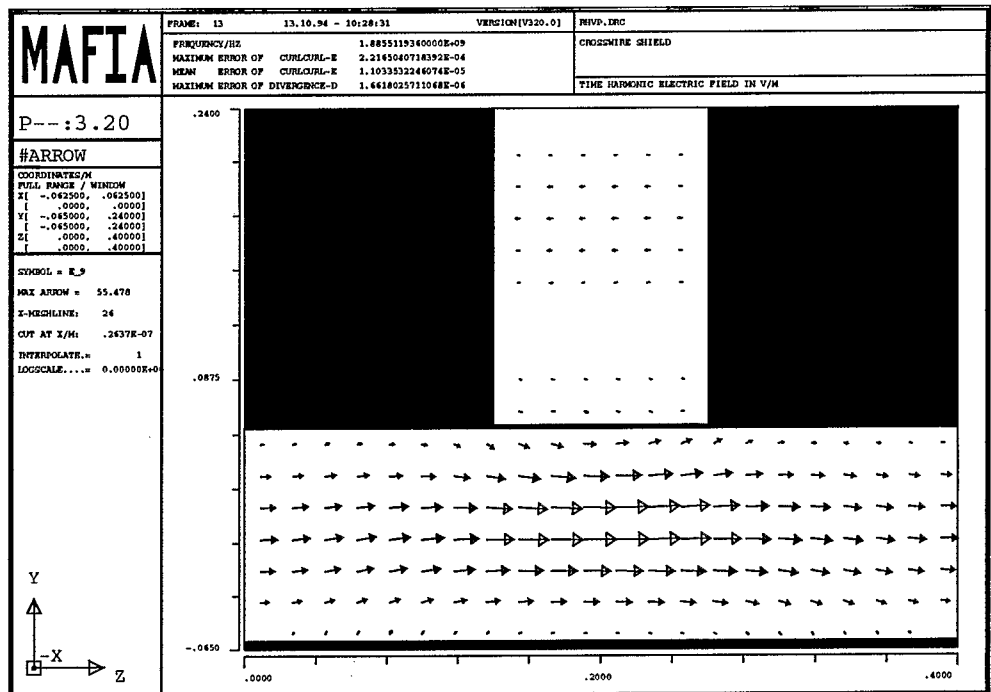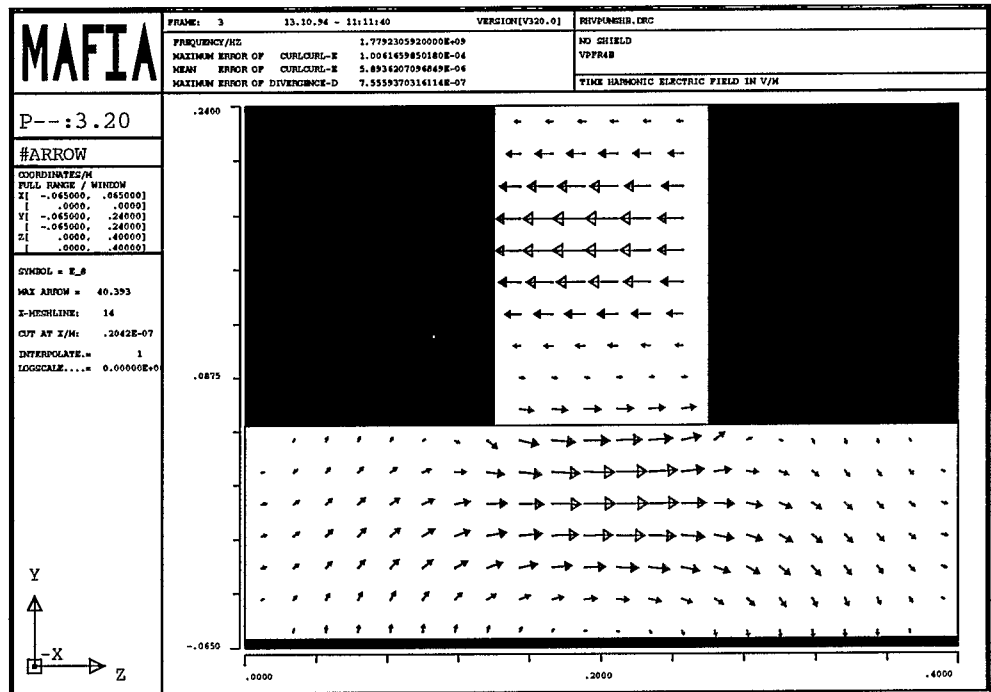[4] D. Weiss, Private Communication.

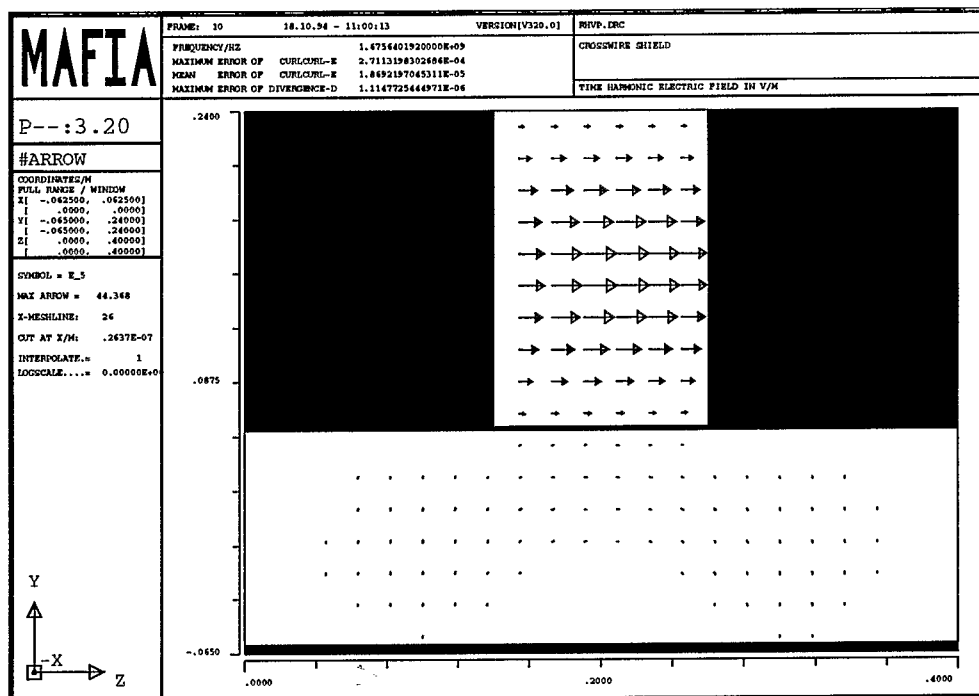Figure 1: Electric Field of Unshielded Port (top) and Crosswire Shield Port (bottom)
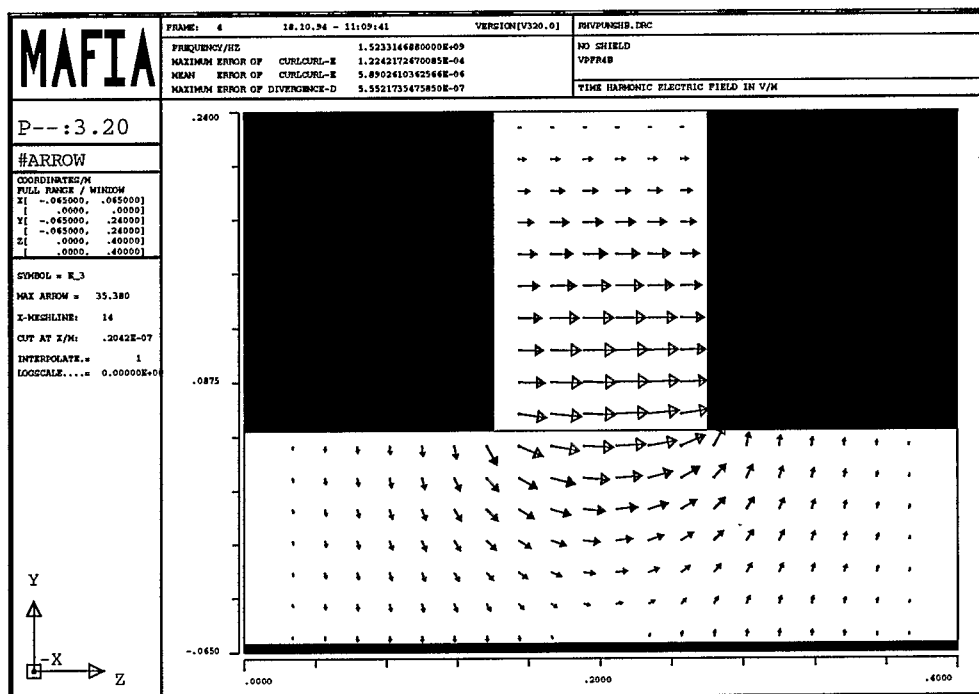
Figure 2: Electric Field of Unshielded Port (top) and Crosswire Shield Port (bottom)

MAFIA

VPFR7

CUT PLOT OF THE MATERIAL DISTRIBUTION IN THE MESH

M--:3.20

#2DPLOT

COORDINATES/M
FULL RANGE / WINDOW
X[-0.062500, 0.062500]
 [-0.062500, 0.062500]
Y[-0.065000, 0.24000]
 [0.060000, 0.060000]
Z[0.0000, 0.40000]
 [0.12000, 0.28000]
MATERIALS: 0,3,

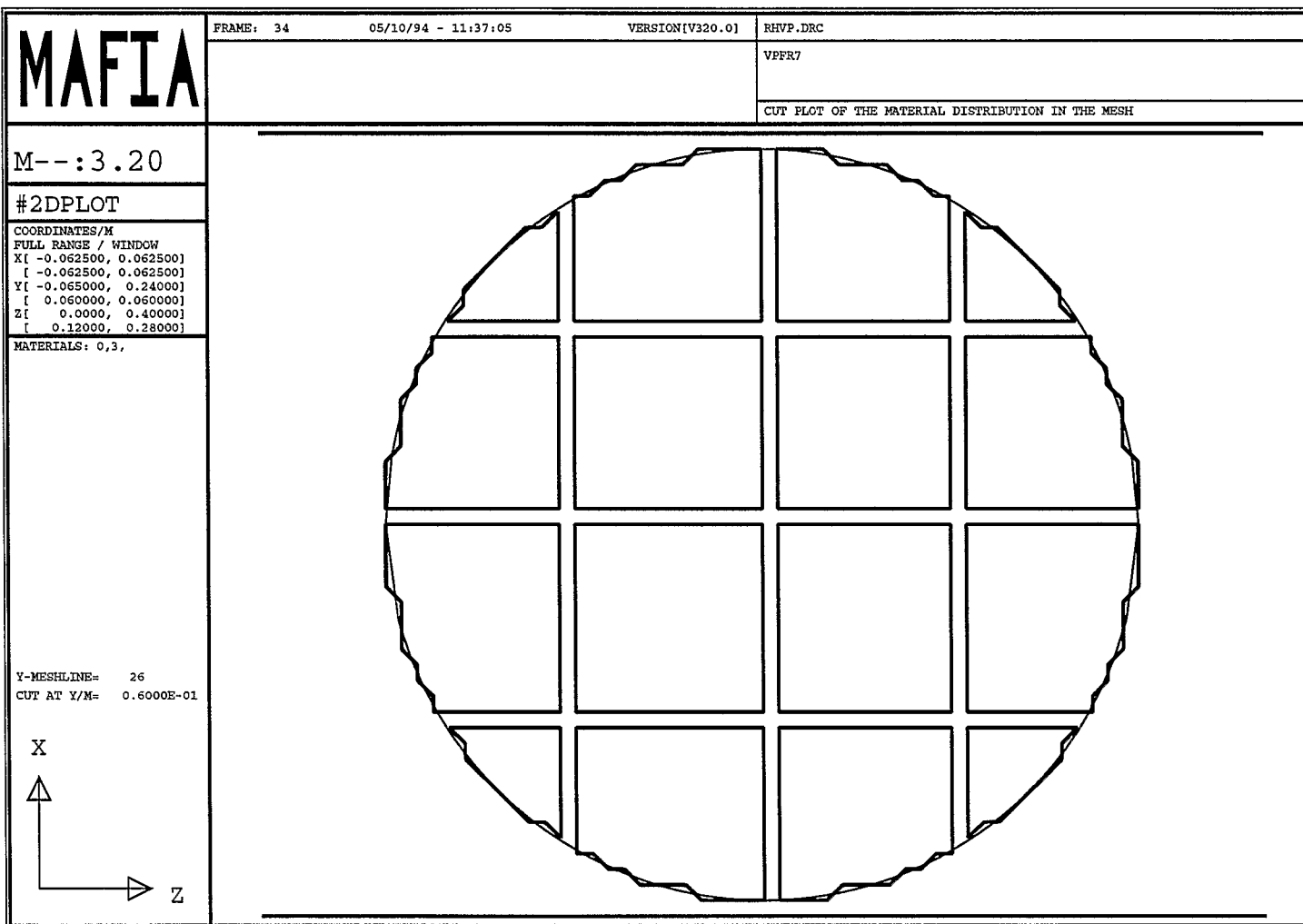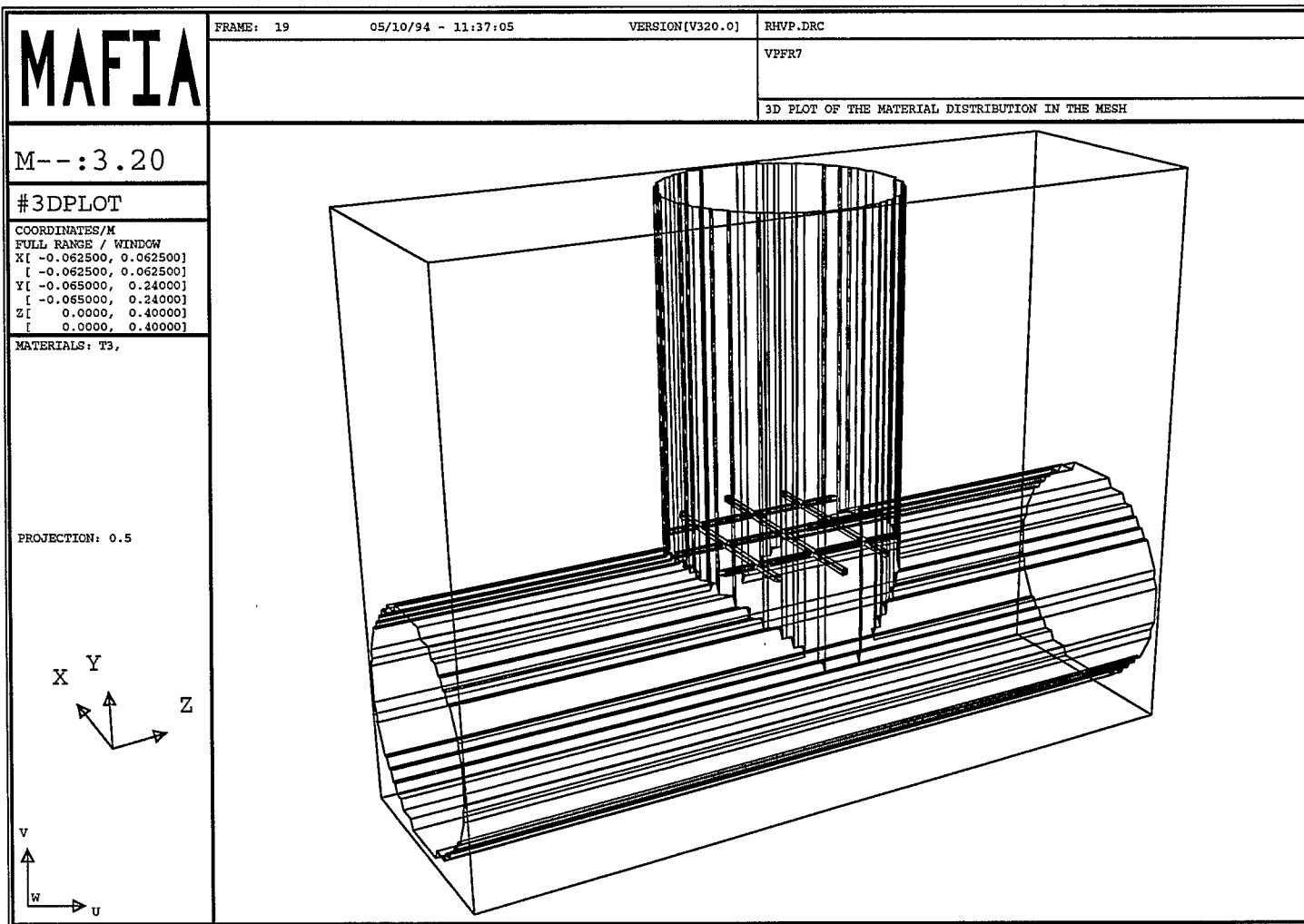Y-MESHLINE= 26
CUT AT Y/M= 0.6000E-01

X

Z

Figure 3: Cross Wire Shield

Figure 4: Pump Out Port with Cross Wire Shield

MAFIA

M--:3.20

#3DPLOT

COORDINATES/M
FULL RANGE / WINDOW
X[-0.062500, 0.062500]
 [-0.062500, 0.062500]
Y[-0.065000, 0.24000]
 [-0.065000, 0.24000]
Z[0.0000, 0.40000]
 [0.0000, 0.40000]
MATERIALS: T3,

PROJECTION: 0.5

X Y
   Z

V

W   U