

## DX-D0 Interconnect Shielding

V. Mane

July 1997

Collider Accelerator Department  
**Brookhaven National Laboratory**

**U.S. Department of Energy**

USDOE Office of Science (SC)

Notice: This technical note has been authored by employees of Brookhaven Science Associates, LLC under Contract No. DE-AC02-76CH00016 with the U.S. Department of Energy. The publisher by accepting the technical note for publication acknowledges that the United States Government retains a non-exclusive, paid-up, irrevocable, world-wide license to publish or reproduce the published form of this technical note, or allow others to do so, for United States Government purposes.

## **DISCLAIMER**

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or any third party's use or the results of such use of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof or its contractors or subcontractors. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

# DX-D0 Interconnect Shielding

Vibha Mane

## 1 Introduction

The two rings of the RHIC collider merge into a common Interaction Region (IR) between the DX and D0 magnets. Figure 1 prepared by D. Weiss shows the interconnect region. It is designed to reduce the amount of material seen by the calorimeter ZCAL placed between the two beampipes, to detect neutrons close to 0 degree. The two beampipes with 4.8 in ID and .060 in thickness change to perforated pipes about .018 in thick enclosed by a larger 16.5 in ID pipe, at plane MM. The perforated pipes are required to shield the beam from the modes of the 16.5 in cavity. They are made of stainless steel Type 304L, with .25 in holes and .375 in distance between the center of the holes. Starting at plane DD, there is a transition from a racetrack enclosing the two perforated circular pipes to a circular pipe of 11.5 in ID at plane BB. The modes of the 11.5 in pipe were determined using MAFIA [1]. Due to smooth transitions at both ends, the modes from this cavity have a small shunt impedance and hence pose no problem. This interconnect design is agreeable to both the Detector Group and the RAP group, and is mechanically feasible.

## 2 Power Dissipation

This report gives the power dissipated by the beam image current into the thin .018 in shieldings. It is given by [2]

$$P = 2I_{ave}^2 \sum_{n=1}^{\infty} R_c \left( \frac{n}{n_c} \right)^p \exp(-n^2 \alpha^2) \quad (1)$$

where n gives the nM harmonic of the revolution frequency,  $p = 1/2$ ,  $n < n_c$  and  $p = 2/3$ ,  $n > n_c$

$$n_c \simeq \left( \frac{\sigma}{l} \right)^2 (\rho \delta_1)^2 \quad (2)$$

gives the critical frequency above which the anomalous skin depth expression must be used, l is the mean free path,  $\sigma = 1/\rho$  is the conductivity of the pipe. The skin depth is

$$\delta = \frac{\delta_1}{\sqrt{n}} \quad (3)$$

where

$$\delta_1 = \sqrt{\frac{2\rho R}{MZ_0}} \quad (4)$$

$Z_0 = 377$  ohm is the impedance of free space and R is the average machine radius. The critical resistance is

$$R_c = \frac{R}{b} \rho^2 \left( \frac{\sigma}{l} \right) \quad (5)$$

where b is the beampipe radius. The average beam current is

$$I_{ave} = \frac{ZN_b e \beta c M}{2\pi R} \quad (6)$$

where Z is the charge state,  $N_b$  is the number of particles per bunch and M is the number of bunches.

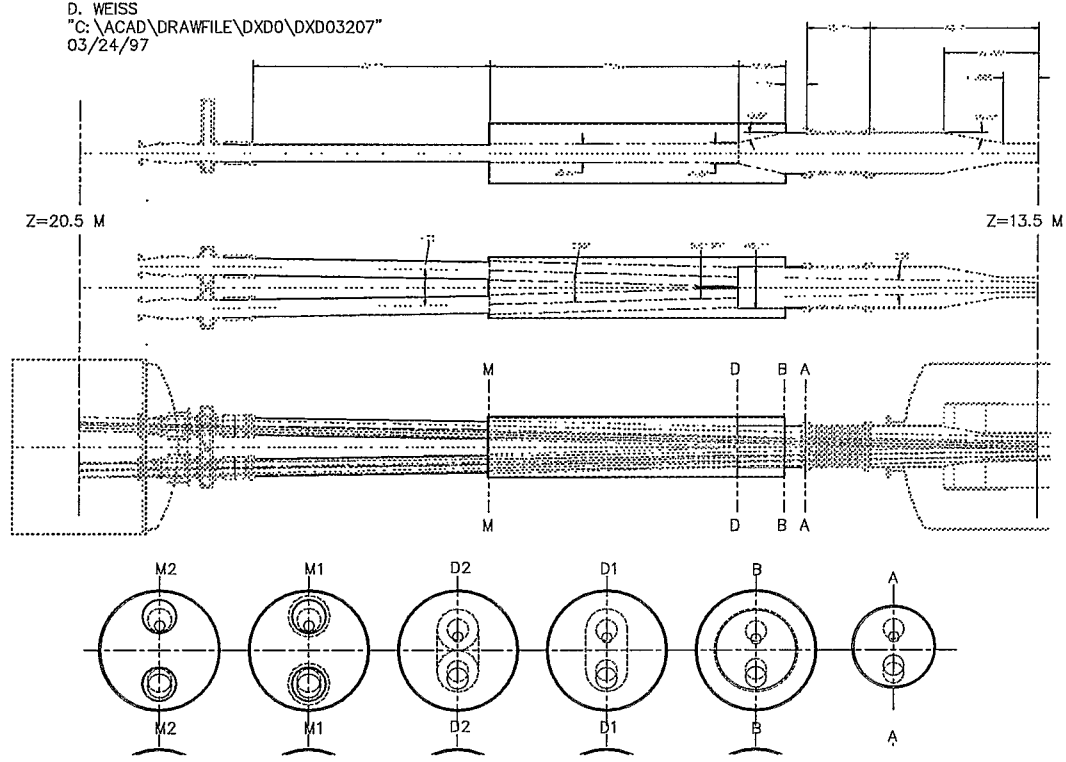


Figure 1: DX-D0 Interconnect

The parameter  $\alpha$  is given by

$$\alpha = \frac{M\sigma_L}{R} \quad (7)$$

where  $\sigma_L$  is the rms bunch length.

The conductivity of stainless steel Type 304L is  $\sigma = 1.25 \times 10^6 \text{ ohm}^{-1}\text{m}^{-1}$  at room temperature [3]. Due to the perforations in the pipe the cross section area is reduced by 40% and the effective conductivity is decreased by the same amount. Using  $\sigma = 0.75 \times 10^6 \text{ ohm}^{-1}\text{m}^{-1}$ ,  $\sigma_L = 7.2 \text{ cm}$  for protons at storage,  $M = 120$  bunches in the upgrade,  $N_b = 10^{11}$ ,  $b = 2.4 \text{ in}$ ,  $\sigma/l = 1.37 \times 10^{15} \text{ ohm}^{-1}\text{m}^{-2}$  gives  $n_c = 12 \times 10^{10}$  and the total power dissipated in the perforated pipe is 0.3 Watt/m. As the total length of the perforated pipe is 71 in, and the interconnect sees 120 bunches from both rings, the total dissipated power is about 1 Watt.

### 3 Conclusion

The 16.5 in cavity at the DX-D0 interconnect is shielded from the beam with a .018 in thick perforated pipe. It shields frequencies above 1.5 MHz. The total dissipated power of 1 Watt is acceptable.

### References

- [1] T. Weiland, Particle Accelerators 15 (1984), pp. 245-292.
- [2] A. G. Ruggiero, S. Peggs, RHIC/AP/46, Nov 1994.
- [3] D. Hseuh, Private Communication.