Shielded Bellows in RHIC

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I. Introduction

The impedance of several RHIC devices such as gate valves, bellows, pipe transitions and beam scrapers was calculated and an impedance budget for RHIC was prepared. It was determined that the total broadband impedance |Z/n| is over 1.5 ohm and that the bellows make the largest contribution (about 70 %) to this impedance. Therefore, the impedance of unshielded bellows and the effect of shielding are determined and presented.

II. Unshielded Bellows

The impedance of bellows was calculated numerically using the time domain module T2 in MAFIA. The parameters of the bellows are its total length (L), number of corrugations (N), depth of the corrugation Δ, and beam pipe diameter D [Drawing A]. The RHIC 7 cm bellows have L = 15 cm, N = 30, Δ =1 cm and D = 7 cm.

Figure [1] gives a plot of the wakepotential and impedance of the 7 cm bellows. The impedance is inductive at low frequencies, with an inductance of 4.3 nhenry. There is a resonance at 4.7 GHz with R = 850, Q = 7 and R/Q = 121. In RHIC there are 408 bellows in the cold region, with pipe diameter 7 cm, and 144 bellows in the warm region, with pipe diameter 12 cm. The impedance of several RHIC devices such as gate valves, pipe transitions, beam scrapers, vacuum port, beam position monitors, beam pipe and 7 cm and 12 cm bellows were calculated, and an impedance budget was prepared. Figure [3] gives a plot of the total broadband impedance with unshielded bellows. The impedance is 1.1 ohm at 1 GHz and close to 2 ohm at 3 GHz. The cutoff frequency of the 7 cm beam pipe is 3.3 GHz. In RHIC, the microwave instability sets a limit on |Z/n| at Au^{+79} transition crossing and at Au^{+79} rebucketing. In order for the bunch to be stable near transition, |Z/n| should be less than 1.5 ohm, upto the pipe cutoff frequency [1].

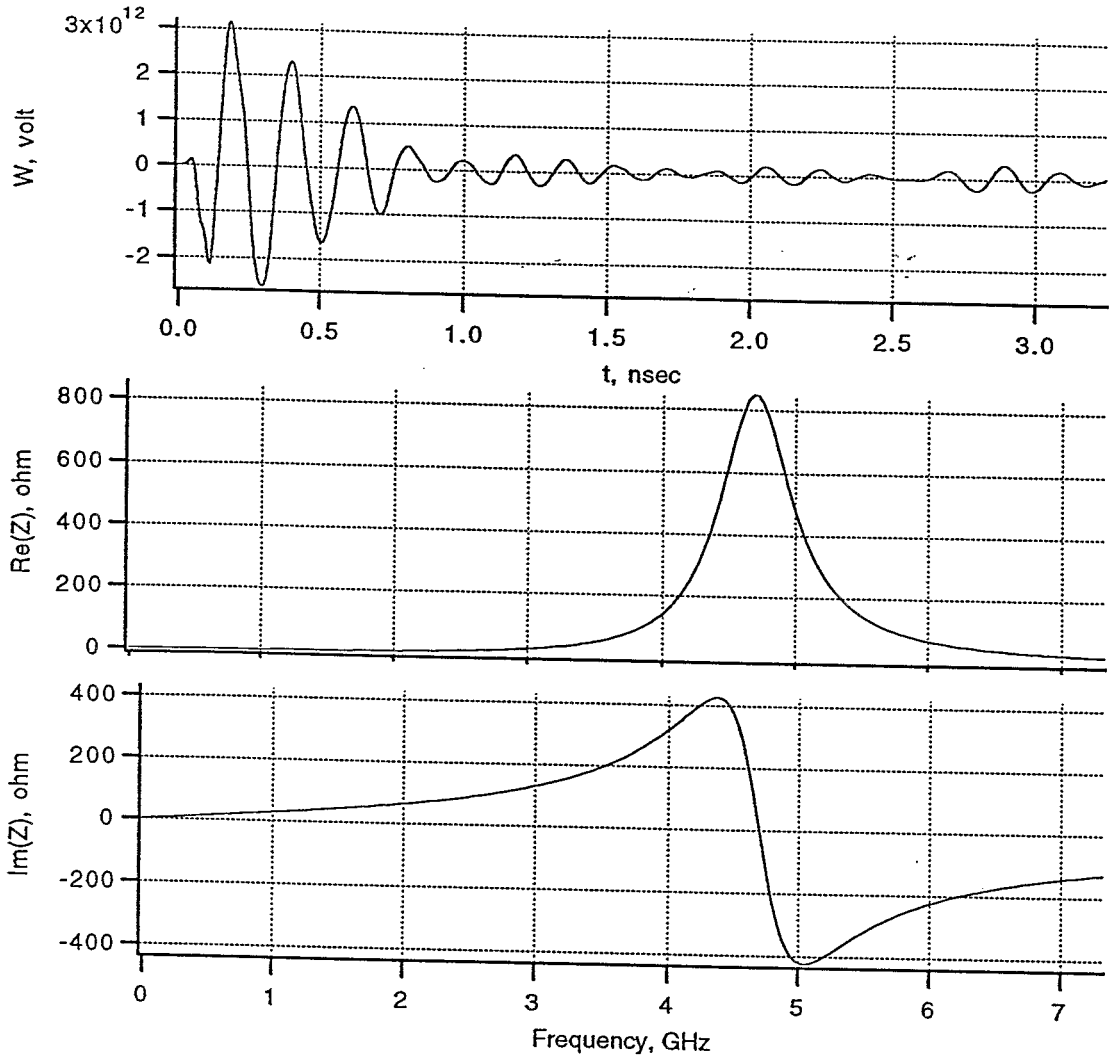


Figure 1. Wakepotential and Impedance of Unshielded Bellows

III. Shielded Bellows

The bellows with shielding are shown in Drawing B [2]. A stainless steel tube with split fingers of gap .01" wide and 2.5" long forms the rf shield. The effect of transition from the beam pipe to the shield [Figure 2] gives the inductance to be .046 nhenry. Figure 4 gives a plot of the total broadband impedance with the shielded bellows. The total contribution to |Z/n| from all the bellows has decreased by 1 ohm at 1 GHz. The broadband impedance is well below the threshold of 1.5 ohm, at all frequencies upto 3 GHz.

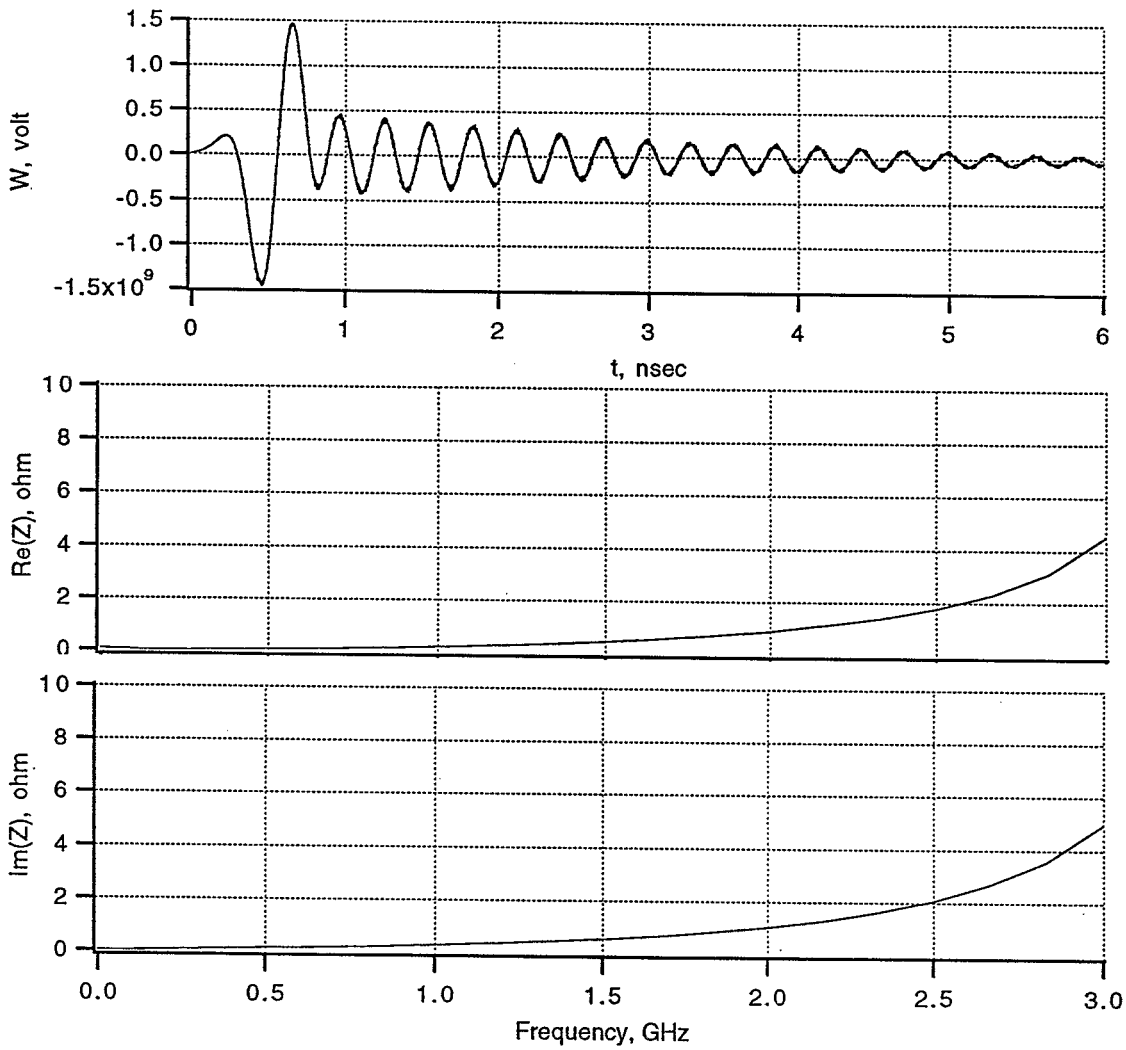


Figure 2. Wakepotential and Impedance of Shielded Bellows

IV. Conclusion

It was determined that the total RHIC broadband impedance |Z/n| is over 1.5 ohm and that the bellows make the largest contribution (about 70 %) to this impedance. In RHIC, the microwave instability sets a limit on |Z/n| to 1.5 ohm. Therefore, it has been decided to shield the bellows, thereby reducing the contribution to |Z/n| by almost 1 ohm.

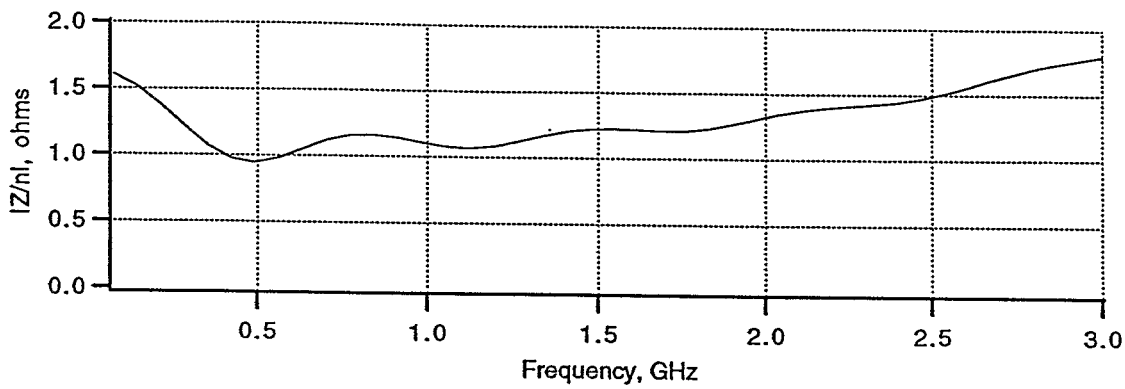


Figure 3. Total RHIC Broadband Impedance with Unshielded Bellows

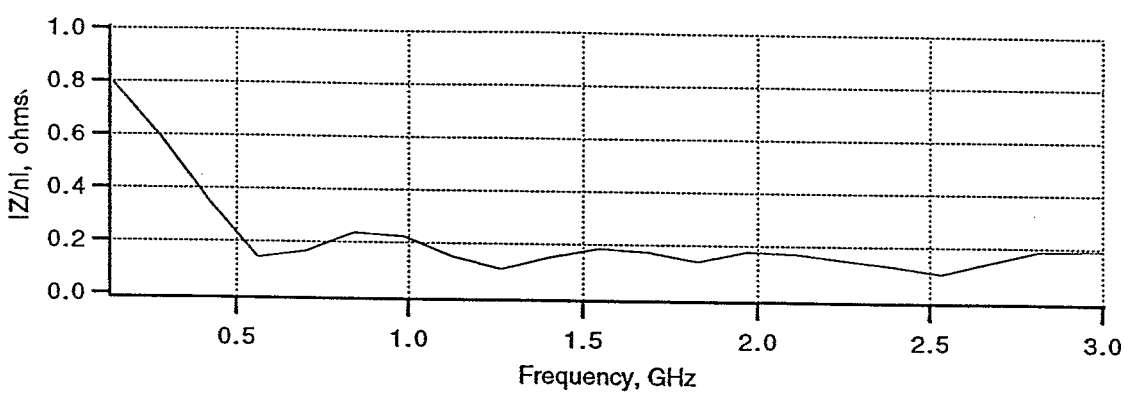


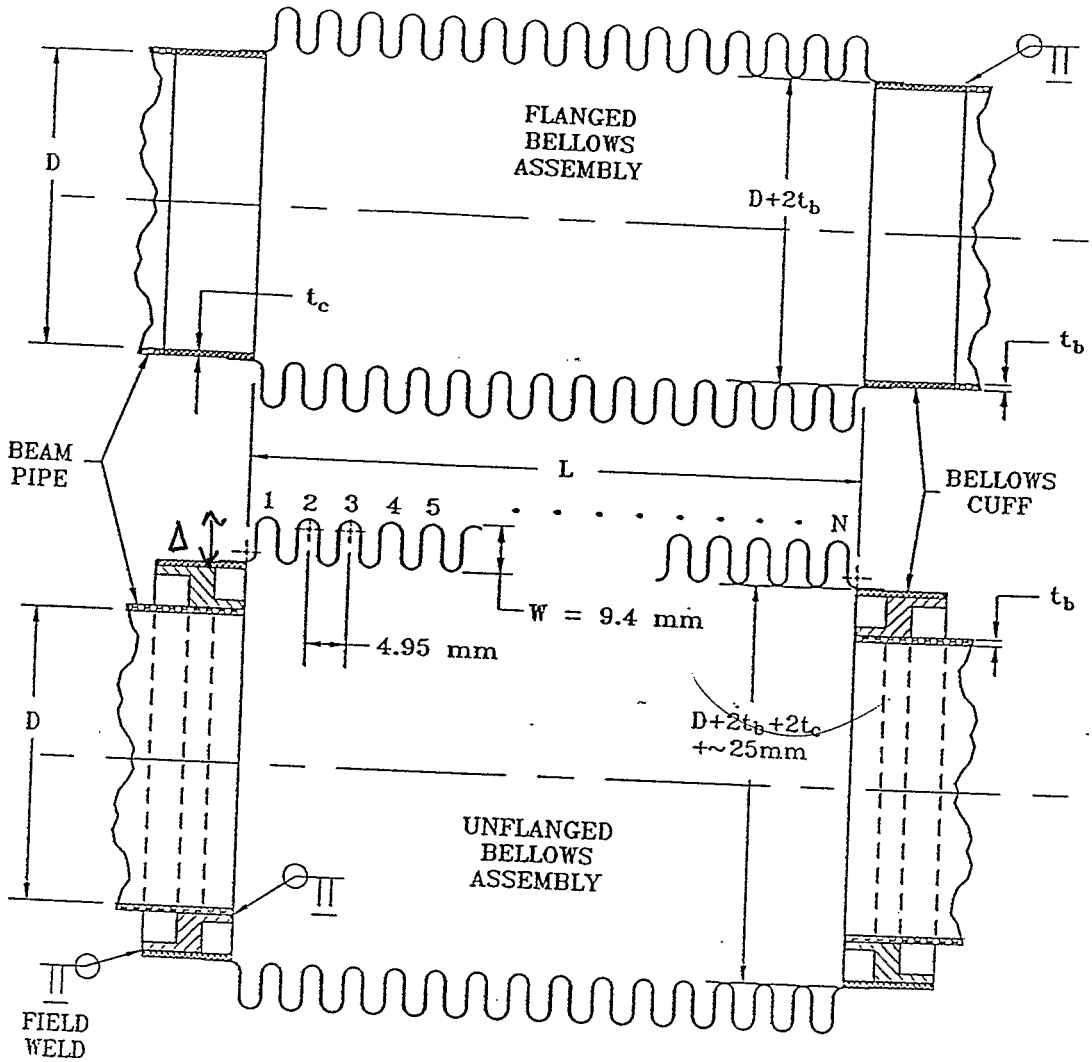
Figure 4. Total RHIC Broadband Impedance with Shielded Bellows

V. References

[1] J. Wei, BNL 45923, March 1991

[2] K. Welch, Private Communication, June 1993.

Drawing A



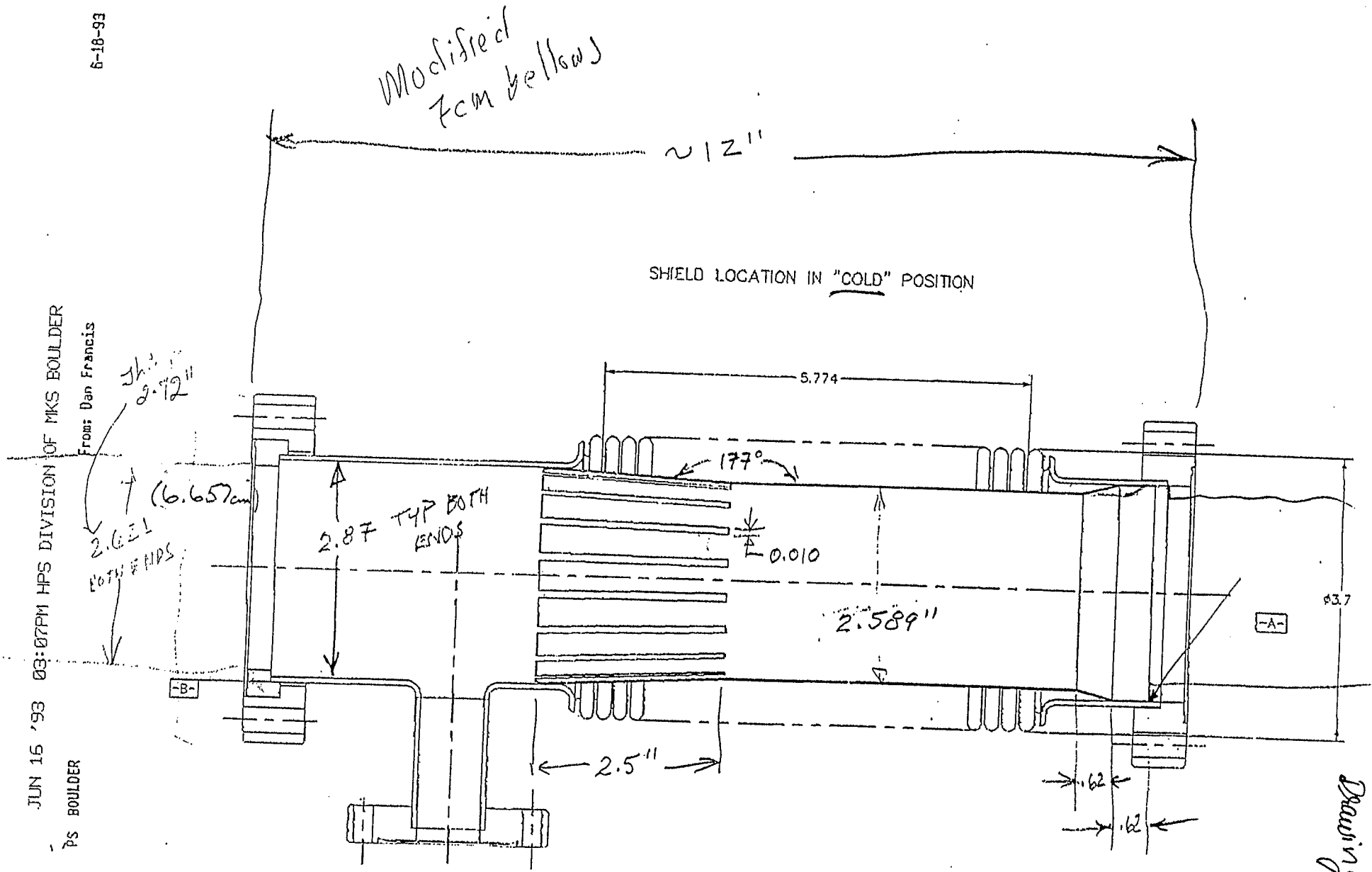
Kimo Welch/Gary McIntyre
12/30/92
"bellows3"
1,0.25; 0.7=1

TABLE OF APPROX. NUMBER OF FORMED BELLOWS IN ONE RHIC RING

BELLOWS LOCATION	QUANT.	D mm	N	t_c mm	t_b mm	L mm
Q3–D0 CRYOSTATS	24	106	22	~2	8.6	75
Q4–Q4 CRYOSTATS	408	69	30	~2	~2	149
~34 m WARM SECTIONS	72	120	30	~2	~2	149
EXPERIMENTAL REGIONS	24	120	30	~2	~2	149
D0–DX TRANSITION	24	?	?	?	?	?

$D+2t_c+2W$ mm	N mm	L mm
91.3	30	149
86.7	41	203
85.8	43	213
81.4	65	322

TABLE OF VARIATION IN BELLOWS LENGTH AND NUMBER OF CONVOLUTIONS AS A FUNCTION OF PARAMETER "W"


Modified Fcm bellows
~12"
SHIELD LOCATION IN "COLD" POSITION
5.774
2.72"
(6.657cm)
2.621 BOTH ENDS
2.87 TYP BOTH ENDS
177°
0.010
2.589"
ø3.7
-A-
-B-
2.5"
.62
.62

Drawing B