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Effects of Changes to Arc Dipole Length

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Introduction

The arc dipole magnetic length in the design is $9.45m$. The first arc magnets were made with BNL parts and have the proper length, however, the dipoles made with Grumman parts has a shorter magnetic length [1]. The current projected magnet length of the Grumman dipoles is $9.422m$ [2]. In this note we discuss the consequences of this change.

Ring Geometry

The stands for many of the magnets have been placed in the tunnel based on a ring geometry with the design arc dipole length. Since changing the stands is too expensive and time consuming, alternative corrections are sought:

(I) Using the horizontal orbit correctors in the arcs
(II) Increasing the current in the arc dipoles.

In the arcs there is one horizontal corrector for every two dipoles. The design bending angle of an arc dipole is $38.924mrad$. Hence, each horizontal arc corrector must have systematic correction of $0.231mrad$ (i.e. current of $33.4Amps$) added. This will require additional power supplies since they are in steps of $25Amps$.

The second approach is to change the current in the arc dipoles. The problem here is that the insertion dipoles D5I, D5O, D6 and D9 are on the same power supply (note, DX and D0 have shunt supplies and need not be condsidered here). Since these magnets haven't been built yet, there lengths can be proportionately adjusted to use the new current. Furthermore, the path length through these magnets is different leading to change in the overall circumference.

In Fig. 1 is a schematic of a dipole showing the bending angle, θ, the reference orbit through the magnet and outside the magnet. If the dipole is shortened, the new reference orbit outside the magnet must overlap the original reference orbit so that the rest of the ring geometry remains unchanged. Thus, the point A, denoted as the apex (or intersection point of a dipole), shown in Fig. 1 which is the intersection of the reference orbits external to the dipole is to remain fixed.

For the shortened dipole the reference orbit outside of the dipole is extended by length, l_e. From this we can find the radius of curvature of the original dipole, ρ, and the shortened dipole, ρ_s, as:

$$\rho = \frac{l}{\tan\theta/2} \qquad \rho_s = \frac{l-l_e}{\tan\theta/2}$$

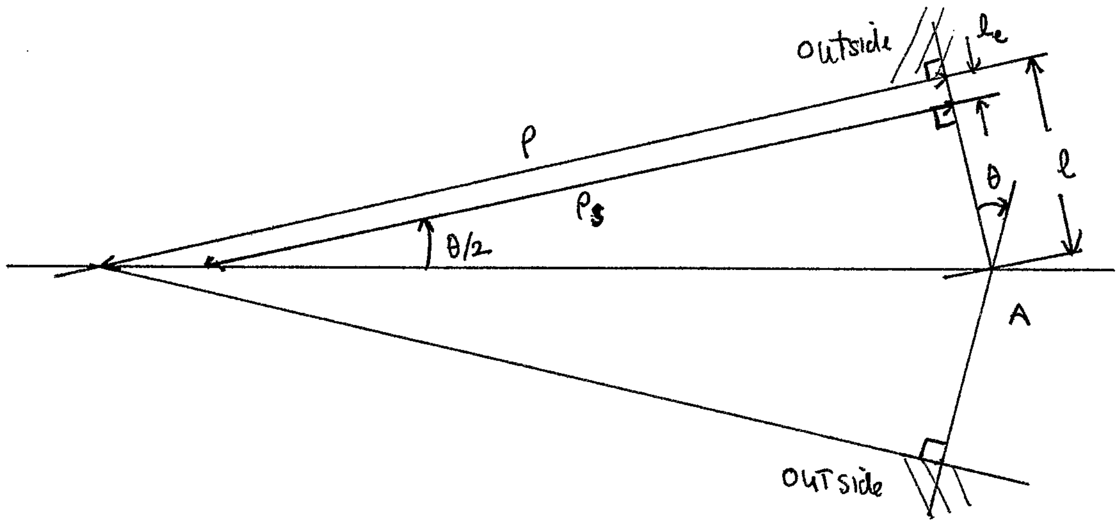

Figure 1 Schematic of a dipole in the ring. The original and shortened dipole is shown.

where l is the length from the apex to the end of the magnet edge of the original dipole. From these equations we can find the arc lengths of the original dipole, a, the shortened dipole, a_e, and the arc length difference, Δ

$$a = \rho\theta \qquad a_s = 2l_e + \rho_s\theta$$

$$\Delta a = a_s - a = l_e\left[2 - \frac{\theta}{\tan\theta/2}\right]$$

For the dipoles on the same power supply we obtain:

Table 1:

Dipole	Design Length [m]	Revised Length [m]	Bending Angle [mrad]	Number per Ring	Δa per Dipole [m]	Δa subtotal [m]
D (arc)	9.45	9.422	38.9240268	144	$3.535*10^{-6}$	$5.09*10^{-4}$
D5I	6.9228451	6.9023329	28.5148155	6	$1.390*10^{-6}$	$8.34*10^{-6}$
D5O	8.7070588	8.6812601	35.8638930	6	$2.765*10^{-6}$	$1.66*10^{-5}$
D6, D9	2.9523461	2.9435984	12.1605501	24	$1.078*10^{-7}$	$2.59*10^{-6}$
Total						$5.37*10^{-4}$

Thus, the RHIC circumference is increased by 0.54*mm*.

References

[1] P. Wanderer, private communication
[2] A. Jain, R. Gupta and S. Peggs, private communication