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Effects of Random b1 Errors in the High Beta Quadrupoles

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1. Introduction

The random b_1 error in the high beta quadrupoles in the insertions can produce large distortions[1] in the beta functions, β_x, β_y. A maximum shift of the beta functions of about 90% may occur for a lattice with 6 $\beta^* = 2$ insertions. The b_1 error in the high beta quads contribute about 85% of this beta function shift. If the b_1 errors in the high beta quads are corrected locally, then a maximum beta function shift of about 20% will remain due to the b_1 errors in the dipoles and arc quadrupoles.

2. $\Delta\beta/\beta$ Results

The largest source of the b_1 error in the high beta quadrupoles is the random error in the effective length. This was assumed to be $\Delta L/L = 2 \times 10^{-3}$ rms.

Table 1 shows the rms contribution to $\Delta\beta_x/\beta_x$ due to various magnets in the lattice. These results are analytical results. Computer simulation have been done, and agree with the analytical results. The results are shown for two lattices; one with 6 $\beta^* = 6$ insertions and one with 6 $\beta^* = 2$ insertions. For computing the 90% probability maximum $\Delta\beta_x/\beta_x$, from the rms $\Delta\beta/\beta$

$$(\Delta\beta_x/\beta_x)_{\rm max} \cong 3 \quad (\Delta\beta_x/\beta_x)_{\rm rms}$$

was used. Table 1 shows the breakdown for $\Delta\beta_x/\beta_x$. The results for $\Delta\beta_y/\beta_y$ are similar, except that certain magnets like Q3 and Q2, and QF and QD interchange roles.

[1] G. Parzen, Linear Random Quadrupole Effects, AD/RHIC-AP-71, (1988).

Table 1 shows that a maximum $\Delta\beta_x/\beta_x$ of 90% may occur for the $\beta^* = 2$ lattice. If the b_1 error in the high beta quadrupoles is corrected locally, then a maximum $\Delta\beta_x/\beta_x$ will remain of about $\Delta\beta_x/\beta_x \simeq 20\%$ due to the b_1 errors in the quadrupoles and dipoles. The maximum $\Delta\beta_x/\beta_x \simeq 20\%$ result came from simulation studies, and is somewhat higher than that suggested by Table 1.

Table 1: Contributions to $(\Delta\beta_x/\beta_x)_{\mathrm{rms}}$ due to the b_1 errors in various magnets for two lattices.

	$(\Delta\beta_x/\beta_x)_{\mathrm{rms}}$	
	$\beta^* = 6$	$\beta^* = 2$
B	0.036	0.035
QF	0.036	0.036
QD	0.007	0.007
Q3I	0.032	0.109
Q2I	0.026	0.079
Q1I	0.023	0.063
Q10	0.024	0.067
Q20	0.080	0.227
Q30	0.014	0.039
Total		
$\frac{\Delta\beta}{\beta}_{\mathrm{rms}}$	0.116	0.29
$\frac{\Delta\beta}{\beta}_{\mathrm{max}}$	0.36	0.90