# Effects of Random b1 Errors in the High Beta Quadrupoles 

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## RHIC PROJECT

Brookhaven National Laboratory

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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, $\beta_{x}, \beta_{y}$. 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 $\Delta L / L=2 \times 10^{-3} \mathrm{rms}$.

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 $\Delta \beta / \beta$

$$
\left(\Delta \beta_{x} / \beta_{x}\right)_{\max } \cong 3 \quad\left(\Delta \beta_{x} / \beta_{x}\right)_{\mathrm{rms}}
$$

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 $\left(\Delta \beta_{x} / \beta_{x}\right)_{\text {rms }}$ due to the $b_{1}$ errors in various magnets for two lattices.

|  | $\left(\Delta \beta_{x} / \beta_{x}\right)_{\mathrm{rms}}$ |  |
| :--- | :--- | :--- |
|  | $\beta^{*}=6$ | $\beta^{*}=2$ |
| 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 |  |  |
| $\frac{\Delta \beta}{\beta}$ | 0.116 | 0.29 |
| $\frac{\Delta \beta}{\beta}$ | 0.36 | 0.90 |


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