

Effects of Random Quadrupole Field Errors in RHIC and Their Correction

G. Parzen

February 1986

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.

EFFECTS OF RANDOM QUADRUPOLE FIELD ERRORS IN RHIC
AND
THEIR CORRECTION

George Parzen
February 21, 1986

Effects of Random Quad errors, a_1, b_1

Small aperture in RHIC gives large a_1, b_1 .

Random b_1 causes random $\Delta B_x/\beta_x$, $\Delta B_y/\beta_y$
and ΔX_p

Random a_1 causes coupling and
random Δy_p , vertical dispersion.

These effects can cause loss of aperture
and can worsen the beam-beam
interaction.

They might also worsen non-linear
orbit instabilities.

History

Large effects like $\Delta B_x/\beta_x \approx 50\%$
were predicted. These were reduced
by about a factor of 3 by
2 events

History (continued)

(1) Herrera projection reduced b_1 by factor 2

2) V_x, V_y was moved away from .6 to near .82 (away from $1/2$ integer resonance)

Nevertheless, effects remained substantial — and there was concern over effects on tracking results.

So present correction system was proposed having 36 independent a_1 and b_1 correction coils per ring, 6 per sector — with the b_1 and a_1 correction coils positioned in a complicated way to maximize their effect.

(1)

Results of Studies

$$a_1 = 16.8 \text{ E-5}, \quad b_1 = 8.4 \times 10^{-5} \text{ cm}^{-1} \quad (\text{rms})$$

in dipoles.

Random b_1 effects ($a_1 = 0$)

10 runs, 10 different set of random errors, b_1 .

Linear effects.

$$\left(\frac{\Delta B}{B}\right)_{\max} \approx 15\%$$

$$\Delta(6\sigma_x) = 1.4 \text{ mm in QF at } \gamma = 30$$

$$\Delta X_p(\text{QF})_{\max} = .34 \text{ m, } 207 \text{ of } X_p$$

$$\Delta X = 1.7 \text{ mm at } \Delta P/P = 5 \times 10^{-3} \text{ in QF.}$$

$$\Delta X_p \frac{\Delta P}{P} \pm 6\sigma_x \rightarrow 3 \text{ mm loss, more in insertions at } \gamma = 30$$

$$\Delta X_p(\text{crossing point}) = .10 \text{ m}$$

Important for Beam-Beam Interaction \rightarrow $\begin{cases} 20\% \text{ change in beam size} \\ \frac{\Delta B_x}{B_x} \rightarrow 7\% \text{ change in beam size} \end{cases}$

Results depend on b_1 error and V_x, V_y might get larger.

Above Results Agree with Theory.

(1.a)

Linear effects, b_1

$\frac{1}{2}$ integer stop-band,

$$(\Delta V)_{\max} = .023$$

($\frac{1}{2}$ stop-band width)

(2)

Non-linear effects (random b_1 , $a_1 = 0$)

$\Delta p/p = 0$, 10 runs $\rightarrow A_{SL} = 19 \text{ mm}$
Same result as for $b_1 = 0$

spread in A_{SL} is smaller in 10 runs;
better chance to get larger A_{SL}
when $b_1 = 0$.

momentum study
10 runs - for each $\Delta p/p$

$\Delta p/p$	$A_{SL} \text{ (mm)}$
-0.01	9
-0.005	15
0	19
0.005	19
0.01	11

Results about the same ~~as~~
as for $b_1 = 0$ case

Random Q_1 effects ($b_1 = 0$)

$$Q_1 = 16.3 \times 10^{-5} \text{ (rms) cm}^{-1}$$

Linear effects

Coupling stopband

Within stopband, coupling is 100%

10 runs, 10 different sets of random errors.

$$(\Delta V)_{\max} = .033, \text{ coupling stopband (half-width)}$$

$$\Delta y_p = .48 \text{ mm, at QD.}$$

Vertical dispersion

34% change in beam size
at crossing point.

affects beam-beam
interaction

Random q , (Non-Linear effects) $b_1 = 0$

Tracking study should
be done after correction of linear
coupling.

Without - Correcting Coupling

$\frac{\Delta p}{p} = 0$, 10 runs

$A_{SL} = 19 \text{ mm}$

same result as
for $q_1 = 0$ case?

Momentum study not yet done.
Waiting for coupling correction
procedure.

Possible Conclusions

Presently proposed complicated
a, b, correction system
may not be needed except
for the following corrections

1) a, correctors for coupling
correction in insertion region

2) a, correctors for correction
of vertical dispersion at crossing
point

Correction of $\frac{\Delta B_x}{B_x}$, $\frac{\Delta B_y}{B_y}$, X_p at crossing
point may be done with
insertion quad trims. Required
~~trim~~ strength of trims needs to
be computed.

③ Shuffling of magnets to reduce
a, and b, (Can we commit ourselves
to reducing linear effects by factor 3?)