BNL-101682-2014-TECH

RHIC/AP/26;BNL-101682-2013-IR

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)

DISCLAIMER

RHIC-AP-26

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 $\Delta\beta_x/\beta_x$, $\Delta\beta_y/\beta_y$
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 $\Delta\beta_x/\beta_x \simeq 50\%$
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) ν_x, ν_y were 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.

Results of Studies

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

Random b_1 effects ($a_1 = 0$)

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

Linear effects

$\left(\frac{\Delta\beta}{\beta}\right)_{max} \simeq 15\%$ $\quad \Delta(6\sigma_x) = 1.4\,mm$ in QF at $\gamma = 30$

$\Delta X_p(QF)_{max} = .34\,m$, 20% of X_p
$\Delta X = 1.7\,mm$ at $\Delta p/p = 5 \times 10^{-3}$ in QF.

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

Δx_p (crossing point) = .15 m

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

Results depend on b_1 error and ν_x, ν_y & might get larger.

Above Results Agree with Theory.

Linear effects, b_1

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

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

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

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

$\Delta p/p = 0$, 10 runs $\rightarrow$ $A_{SL} = 19$ 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} (mm)
−.01	9
−.005	15
0	19
.005	19
.01	11

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

Random a_1 effects ($b_1 = 0$)

$a_1 = 16.3 \times 10^{-5}$ (rms) cm^{-1}

Linear effects

Coupling stopband

Within stopband, coupling is 100%

10 runs, 10 different sets of random errors.

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

$\Delta Y_p = .48$ mm, at QD.

Vertical dispersion

34% change in beam size at crossing point.

affects beam-beam interaction

Random a_1 (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 $A_{SL} = 19\,mm$

same result as for $a_1 = 0$ 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_1 correctors for coupling correction in insertion region

2) a_1 correctors ~~f~~or correction of vertical dispersion at crossing point

Correction of $\frac{\Delta\beta_x}{\beta_x}$, $\frac{\Delta\beta_y}{\beta_y}$, X_p at crossing point may be done with insertion quad trims. Required ~~[illegible]~~ strength of trims needs to be computed.

3) Shuffling of magnets to reduce a_1 and b_1 (Can we commit ourselves to reducing linear effects by factor 3?)