

Review of RHIC Correction System

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REVIEW OF RHIC CORRECTION SYSTEM

G. Parzen

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Closed Orbit Correction

Horizontal orbit dipole corrector, b_0 ,
near each ~~Focussing~~ Focussing Quad

Vertical orbit dipole corrector, a_0 ,
near each Defocussing Quad.

Old Study (done 2-3 yrs ago)

Assumed position errors

$$\Delta \theta = 1 \text{ mr rms}, \text{ dipoles}$$

$$\Delta X_Q = \Delta Y_Q = .25 \text{ mm rms}, \text{ Quads}$$

$$\text{Power Supply error} = 1 \times 10^{-4} \text{ rms}$$

Simulation Study

	Vertical	Horizontal
Max. Initial Orbit error	70 mm	82 mm
Max. Corrected Orbit error (at injection)	1.2 mm	1.4 mm
Max. Dipole Correction (KG-M)	1.7 KG-M	1.2 KG-M
Max. Dipole Correction at 45 KG (KG-M)	2.2 KG-M	1.5 KG-M

Closed orbit Correction (continued)

Dipole Corrector Strength = 3 K.G.m. (yellow book)

Beam Steering at Crossing Points

Purpose: To keep beams from colliding, and to bring beam into collision

CBA Scheme - Use 4 of the closed orbit dipole correctors, 2 on either side of crossing point, to produce local closed orbit bump at crossing points.

Study required to determine dipole strength needed, and beam movement needed.

Sextupole Correctors

To Control $\beta_x(p)$, $\beta_y(p)$, $\gamma_x(p)$, $\gamma_y(p)$

"4-families" of Sextupoles Located near Quads.
in the arcs.

For $\beta^* = 6$ Lattice

$$B_{2LH} = 597 \pm 235 \text{ KG/m} \quad \text{inner arc}$$

$$B_{2LH} = 597 \text{ KG/m} \quad \text{outer arc}$$

at
34KG

$$B_{2LV} = 1208 \pm 483 \text{ KG/m} \quad \begin{matrix} \text{outer} \\ \text{inner arc} \end{matrix}$$

$$B_{2LV} = 1208 \text{ KG/m} \quad \text{inner arc}$$

$$B_2 = \frac{1}{2} B'' \quad , \quad B = B_2 x^2$$

For $\beta^* = 3$

$$B_{2LH} = 692 \pm 138 \text{ KG/m}$$

$$B_{2LV} = 1400 \pm 421 \text{ KG/m}$$

Corrector Strength, $B_{2L} = 4000 \text{ KG/m}$ (yellow book)

Coupling Correction System, Skew Quads

Correctors cant be at Arc Quads

because $\psi_x - \psi_y = 0$ at all quads and this would generate vertical dispersion.

Correctors Need

High $(B_x B_y)^{1/2}$

$\psi_x - \psi_y$ should be different at some places

$\chi_p \approx 0$, Vertical dispersion not generated

Solution

Correctors at either Q_2 or Q_3

2 families needed

1 family near I-O (inner to outer)

Crossing point

1 family near O-I Crossing point

$\psi_x - \psi_y = \pm 1.2$ at ~~the~~ crossing points and alternates in sign.

Strength Needed

$Q_1 L = .36$ at each Crossing ~~Point~~ ^{Point}

$A_1 L = 12.2 \text{ KG}$ at $B_0 = 34 \text{ KG}$

($A_1 = B_0 Q_1$)

(no safety factor)

Crossing Point Correctors

To correct $\beta_x, \beta_y, X_p, Y_p$ at crossing points (to control beam beam interaction)

After shuffling, remaining effects, as percent of beam size at crossing ~~point~~ ^{point}, are

Y_p	8%
X_p	4%
$\Delta\beta_x/\beta_x$	4%
$\Delta\beta_y/\beta_y$	4%

β_x, β_y, X_p can be corrected using insertion quad trims.

Strength needed has to be studied.

Y_p correction needs skew a_1 at $X_p \neq 0$ points in the insertions to produce local Y_p bump.

Some Y_p correction can be done by moving closed orbit vertically.

b_4 Correctors

$b_4' = 6 \times 10^{-4}$ in dipoles at high fields,
produces $\Delta V \approx .01$ (primarily due
to E_x, E_y dependence)

This cannot be corrected entirely with
just two families.

Two families can correct by factor of $1/2$;
this gives remaining $\Delta V = .005$

Strength needed

$$B_4 L = 4.2 \times 10^5 \text{ KG m}^{-3} \quad \text{at } 34 \text{ KG}$$

$$B = B_4 \chi^4$$

See RHIC-28 for more careful and
detailed treatment. This note gives

$$\begin{aligned} B_4 L &= 1.1 \times (B_4 L)_{\text{dipole}} \\ &= 5.2 \times 10^5 \text{ KG m}^{-3} \end{aligned}$$

Note, larger ρ/p suchas may result from $f=214 \text{ MHz}$
rf system, make the above effect worse.

b₃ Correctors

Why b₃ Correctors?

Space Charge ΔV effect

γ -spread due to spacecharge is appreciable

For Gold

$$N_b = 1.1 \times 10^9 / \text{bunch}$$

$$\Delta V \approx 0.8, \quad \gamma = 12$$

$$\Delta V \approx 0.13, \quad \gamma = 30$$

$$\Delta V \approx 0.01, \quad \gamma = 100$$

For Protons

$$\Delta V \approx 0.27, \quad \gamma = 30, \quad N_b = 1 \times 10^{11}$$

Reduction of this effect using octapoles needs study.

Separate Control of $\beta_x(p)$ $\beta_y(p)$ and $\gamma_x(p)$ $\gamma_y(p)$

4-families Sextupoles can be adjusted to optimize either $\beta(p)$ or $\gamma(p)$. Usually they go together. Separate control may be desirable for special insertion arrangements. Study needed.

Strength ^{suggested} ~~needed~~ $B_3 L = 6000 \text{ KG m}^{-2}$ (Yellow Book)
at Present ~~same~~ (Source?)

Random b_k, q_k Correction

~~is~~

How to do this is not known at present.

It may not be feasible, as no single multipole appears to dominate.

Higher Systematic Multipoles $b_k, k \geq 10$

May play a role in the dynamic aperture for large $\Delta p/p$.

A correction system does not appear feasible at present.

Random a_i , b_i Correctors

At present, the only clear need for these correctors is a possible γ_t jump which requires the b_i only.

The Yellow Book has a_i , b_i correctors with ~~the~~ strengths $B, L = 15 \text{ KG}$

Question: If we keep the a_i, b_i correctors, how should they be connected?

They could also be used as a back-up for the shuffling procedure to reduce a_i, b_i effects