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Review of RHIC Correction System

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AD/RHIC-AP-61

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Closed Orbit Correction

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

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

Old Study (done 2-3 yrs ago)

Assumed position errors

$\Delta\theta = 1$ mr rms, dipoles

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

Power Supply error $= 1 \times 10^{-4}$ 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 KG.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 $\beta_x(p)$, $\beta_y(p)$, $\nu_x(p)$, $\nu_y(p)$

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

For $\beta^* = 6$ Lattice

at 34 KG

B2LH = 597 ± 235 KG/m Inner arc

B2LH = 597 KG/m outer arc

B2LV = 1208 ± 483 KG/m ~~Inner~~ outer arc

B2LV = 1208 KG/m Inner arc

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

For $\beta^* = 3$

B2LH = 692 ± 138 KG/m

B2LV = 1400 ± 421 KG/m

Corrector Strength, B2L = 4000 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 $(\beta_x \beta_y)^{1/2}$

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

$\chi_p \simeq 0$, 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 ~~Pont~~ Point

$A_1 L = 12.2$ KG at $B_0 = 34$ KG

$(A_1 = B_0 \; q_1)$

(no safety factor)

Crossing Point Correctors

To correct β_x, β_y, X_p, Y_p at crossing points (to control beam beam interaction)

After shuffling, remaining effects, as percent of beam size at crossing ~~pt~~ 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 q_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 $\Delta\nu \simeq .01$ (primarily due to $\varepsilon_x, \varepsilon_y$ dependence)

This cannot be corrected entirely with just two families.

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

Strength needed

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

$$B = B_4 x^4$$

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

$$B_4 L = 1.1 \times (B_4 L)_{dipole}$$
$$= 5.2 \times 10^5 \ KG\, m^{-3}$$

Note, larger $\Delta P/P$ such as may result from f=214 mHz rf system, make the above effect worse.

b_3 Correctors

Why b_3 Correctors?

Space Charge $\Delta\nu$ effect

ν - spread due to space charge is appreciable

For Gold $N_b = 1.1 \times 10^9$ /bunch

$\Delta\nu \cong .08$, $\gamma = 12$

$\Delta\nu \cong .013$ $\gamma = 30$

$\Delta\nu \cong .001$ $\gamma = 100$

For Protons

$\Delta\nu \simeq .027$, $\gamma = 30$, $N_b = 1 \times 10^{11}$

Reduction of this effect using octapoles needs study.

Seperate Control of $\beta_x(p)$ $\beta_y(p)$ and $\nu_x(p)$ $\nu_y(p)$

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

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

Random b_K, a_K Correction

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_1, b_1 Correctors

At present, the only clear need for these correctors is a possible γ_t jump which requires the b_1 only.

The Yellow Book has a_1, b_1 correctors with [redacted] strengths $B_1 L = 15$ KG

<u>Question</u>: If we keep the a_1, b_1 correctors, how should they be connected?

They could also be used as a back-up for the shuffling procedure to reduce a_1, b_1 effects