RHIC Aperture

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Aperture Considerations

Previous Considerations

Aperture → ± 26 mm

Primarily, Intra beam Scattering at $\gamma = 30$

Space for 6 σ_x betatron oscillations

Aperture = $2.5\,\sigma_E + 6\,\sigma_x$

+ closed orbit error

New Considerations

Calculation of effects of error multipoles — b_1, a_1 especially

Effects are Correctable —

Aperture vs. Correction Systems Choice

b_1, a_1 Multipoles

$$b_1 = \left\{ b_{1,\,coil}^2 + b_{1,\,iron}^2 \right\}^{\frac{1}{2}}$$

Present Magnet

$$b_{1,\,coil} = 13.5 \times 10^{-5} \text{ /cm}$$
$$b_{1,\,iron} = 15.4 \times 10^{-5} \text{ /cm}$$
$$b_1 = 20.5 \times 10^{-5} \text{ /cm}$$

$$b_{1,\,CBA} = 7 \times 10^{-5} \text{ /cm}$$

Collared Magnet

$$R_{FE} = 5.08 \rightarrow 7.08 \text{ cms}$$

$$b_{1,\,iron} = 2\,\Delta x \frac{R^2}{R_{FE}^4} \frac{1}{1 + R/\rho}, \quad \rho = R_{FE}^2 / R$$

$$= 5.1 \times 10^{-5}$$

$$b_{1,\,coil} \simeq 16 \times 10^{-5}$$

$$b_1 = 16.8 \times 10^{-5} \quad (18\% \text{ reduction})$$

What is actual b_1?

Random $\Delta\beta_x/\beta_x$ (additional aperture required)

Random b_1 $\rightarrow$ half-integer Stop-band, $\Delta\nu$

$\rightarrow$ random $\Delta\beta_x/\beta_x$

Present Magnet ($b_1 = 20.5 \times 10^{-5}$)

$\Delta\nu_{rms} = .029$, $\Delta\beta_x/\beta_x = .19$ rms

$\Delta\beta_x/\beta_x = .48$ (95% probability)

at $\gamma = 30$, $\Delta(6\ \sigma_H) = 6 \times 3.1 \times .24 = \underline{4.5\ m.m.}$

Correction: correction of Stopband reduces $\Delta\beta_x/\beta_x$ by 3/4 (b_0-magnet selection.)

Random Dispersion

Random b_1 $\rightarrow$ $\Delta B_y = B_0\, b_1\, X_p\, \Delta p/p$

$\rightarrow$ ΔX_p

Present Magnet ($b_1 = 20.5 \times 10^{-5}$)

$\Delta X_p\, \Delta p/p = 1.75$ mm for $\Delta p/p = .01$ in QF. (rms)

at $\gamma = 30$, $\Delta p/p = .005$, $\Delta(2.5\ \sigma_E) = 2.5 \times 1.75 \times .5$

$= \underline{2.2\ mm}$

Correction: Difficult (?)

Chromatic $\Delta\beta_x/\beta_x$

$$\beta_x = \beta_x(\Delta p/p)$$

$$\frac{\Delta\beta_x}{\beta_x} = .5 \quad \text{at} \quad \Delta p/p = .01$$

$$= .125 \quad \text{at} \quad \Delta p/p = .005$$

$$\gamma = 30, \quad \Delta(6\sigma_H) = 6(3.1)\times .125 = \underline{\underline{2.3\ mm}}$$

Chromatic χ_p

$$\chi_p = \chi_p(\Delta p/p)$$

$$\Delta\chi_p/\chi_p = .08 \quad \text{at} \quad \Delta p/p = .01$$

$$= .04 \quad \Delta p/p = .005$$

$$\gamma = 30 \quad \Delta(2.5\sigma_E) = 2.5(2.8)(.04) = \underline{\underline{.28\ mm}}$$

Aperture Required

	Present Magnet	Collared Magnet	Present Magnet	Collared Magnet
γ	30	30	γ_t	γ_t
Random $\Delta\beta_x/\beta_x$	4.5	3.7	1.1	.90
Random x_p	2.2	1.8	4.4	3.6
Chromatic $\Delta\beta_x/\beta_x$	2.3	2.3	1.1	1.1
Chromatic x_p	.3	.3	1.3	1.3
Total	7.6	6.7	6.9	6.1

Good Field
Aperture Required $\rightarrow \pm 33$ mm