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RHIC Aperture

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DISCLAIMER

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

$b_{1,coil} = 13.5 \times 10^{-5}$ /cm

$b_{1,iron} = 15.4 \times 10^{-5}$ /cm

$b_1 = 20.5 \times 10^{-5}$ /cm

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

Collared Magnet

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

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

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

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

$b_1 = 16.8 \times 10^{-5}$ (18% 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 $\gamma = 30$, $\Delta(6\ \sigma_H) = 6 \times 3.1 \times .24 = 4.5$ m.m.

Correction: correction of Stopband reduces $\Delta\beta_x/\beta_x$ by 3/4

(b_0-magnet selection.)

Random Dispersion

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

$\rightarrow \Delta X_p$

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

$= 2.2$ mm

Correction: Difficult (?)

Chromatic $\Delta\beta_x/\beta_x$

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

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

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

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

Chromatic χ_p

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

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

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

$\gamma = 30$ $\Delta(2.5\sigma_E) = 2.5(2.8)(.04) = .28$ 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 → ± 33 mm