

## RHIC Aperture

G. Parzen

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Collider Accelerator Department  
**Brookhaven National Laboratory**

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George Parzen

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## Aperture Considerations

### Previous Considerations

Aperture  $\rightarrow \pm 26$  mm

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

Space for  $6 \sigma_x$  betatron oscillations

$$\text{Aperture} = 2.5 \sigma_E \pm 6 \sigma_x$$

+ closed orbit error

### New Considerations

Calculation of effects of

error multipoles —  $b_1, a$ , especially

Effects are correctable —

Aperture vs. Correction Systems Choice

b, a. Multipoles

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

Present Magnet

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

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

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

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

Collared Magnet

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

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

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

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

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

What is actual  $b_1$ ?

(2)

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

Random  $b_1 \rightarrow$  half-integer stop-band,  $\Delta V$   
 $\rightarrow$  random  $\Delta B_x / B_x$

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

$$\Delta V_{rms} = 1.029, \quad \Delta B_x / B_x = .19 \text{ rms}$$

$$\Delta B_x / B_x = .48 \text{ (95\% probability)}$$

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

Correction: correction of stopband  
 reduces  $\Delta B_x / B_x$  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 ( $b_1 = 20.5 \times 10^{-5}$ )

$$\Delta X_p \Delta P/p = 1.75 \text{ mm for } \Delta P/p = .01 \text{ in } QF. (rms)$$

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

$$= \underline{\underline{2.2 \text{ mm}}}$$

Correction: Difficult (?)

(3)

Chromatic  $\Delta B/B_x$ 

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

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

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

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

Chromatic  $\chi_p$ 

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

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

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

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

(4)

## Aperture Required

	Present Magnet	Collared Magnet	Present Magnet	Collared Magnet
$\gamma$	30	30	$\gamma_{\pm}$	$\gamma_{\pm}$
Random $\Delta B_x/B_x$	4.5	3.7	1.1	.90
Random $X_p$	2.2	1.8	4.4	3.6
Chromatic $\Delta B_x/B_x$	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