

## Tolerance on ?? Fluctuations in the Dipole

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RHIC PROJECT  
Brookhaven National Laboratory

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## Tolerance on $\Delta\theta$ Fluctuations in the Dipole

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The fluctuation of  $\Delta\theta$  along the dipole increases the effective  $\Delta\theta$  to be used in computing the closed orbit effect. A result for the effective rms  $\Delta\theta$  is

$$\Delta\theta_{ef}^2 = \Delta\theta_{av}^2 + \Delta\theta_f^2 \left( \frac{\Delta(\sqrt{\beta})}{2\sqrt{\beta_c}} \right)^2 \quad (1)$$

$\Delta(\sqrt{\beta})$  is the change in  $\sqrt{\beta}$  over  $L/2$ ;  $L$  is the dipole length.  $\Delta(\sqrt{\beta}) = 1.5 \text{ m}^{1/2}$  in RHIC.  $\beta_c$  is  $\beta$  at the dipole center.

$\Delta\theta_{av}$  is the rms average  $\Delta\theta$  in the dipole.

$\Delta\theta_f$  is the rms amplitude of the  $\Delta\theta$  fluctuation around the average  $\Delta\theta$ .

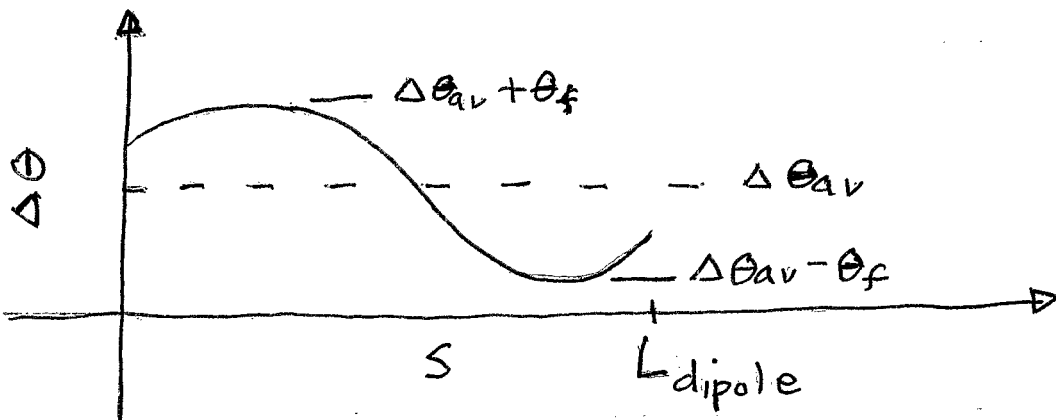
For RHIC dipoles, above gives

$$\Delta\theta_{ef}^2 = \Delta\theta_{av}^2 + (0.15 \Delta\theta_f)^2$$

For  $\Delta\theta_f = 2 \text{ mr}$ , rms, the  $\Delta\theta_{ef}$  is increased from  $\Delta\theta_{ef} = 0.5 \text{ mr}$  rms to  $\Delta\theta_{ef} = 0.58$ , a 17% increase. The increase in the overall  $\Delta\theta_{ef}$ , including the survey error of  $0.5 \text{ mr}$  rms, is 10%.

*$\Delta\theta_f = 2 \text{ mr}$  rms may be a reasonable choice for a tolerance on  $\Delta\theta_f$ .*

The above results assume a model where  $\Delta\theta$  along the dipole is as shown below:



*Note, the tolerance on  $\Delta\theta_{av}$  would still be  $0.5 \text{ mr}$  rms.*

The closed orbit error with this model can be computed from

$$\Delta y \sim \sum_{dipoles} \int ds \Delta\theta g(s)$$

$$g(s) = \sqrt{\beta} \cos(\pi\nu - (\psi - \psi_0))$$

$$\Delta\theta = \Delta\theta_{av} + \Delta\theta_f f(s)$$

Assuming that  $\Delta\theta_{av}$  and  $\Delta\theta_f$  vary randomly from dipole to dipole, and  $f(s)$  has the shape in the above figure, then one derives the above result for the rms effective  $\Delta\theta$ .

A more accurate result than Eq. (1) for  $\Delta\theta_{ef}$ , which includes the effect of the variation in the betatron phase over the dipole, is the following

$$\Delta\theta_{ef}^2 = \Delta\theta_{av}^2 + \Delta\theta_f^2 \left[ \left( \frac{\Delta(\sqrt{\beta})}{2\sqrt{\beta_c}} \right)^2 + \left( \frac{L}{4\beta_c} \right)^2 \right]$$

The added term due to the phase variation can usually be neglected.