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Systematic Multipoles in the Quadrupoles

and

Their Effect on Dynamic Aperture and A ν-spread

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Introduction — Systematic b_5

The systematic b_5 in the quadrupoles can also produce an appreciable ν spread in the beam.

The two systematic multipoles, b_5 and b_4 appear to be responsible for most of the ν spread. It may then be desireable to control these two multipoles to be below a certain tolerance level. A tolerance (or guideline) for b_5 is given below.

The effect of b_5 on the dynamic aperture is not large, and this effect appears to be less important than the ν-spread

ν spread effect, b_5

Tolerances (guide lines)

at $\gamma = 30$, $\varepsilon_t = 1.92$, $\Delta p/p = \pm .005$, b_5' to give $\Delta\nu_{spread} = 3 \times 10^{-3}$ with $\beta^* = 6$

$$b_5' = 2.2 \qquad \text{for } G/B = 21.4$$

b_5' is given relative to B_0.
To get b_5' ~~relative~~ relative to the Gradient, multiply by 2.

Note, random $b_5' = 1.7$ ... rms

at $\gamma = 100$, $\varepsilon_t = 1.16$, $\Delta p/p = \pm .002$, $\beta^* = 2$

$$b_5' = 2.6$$

For $\gamma = 100$, about 50% of $\Delta\nu$ due to Q1Q2Q3.

$$\Delta\nu \text{ due to Q1Q2Q3} \simeq 1/\beta^{*3} \qquad \text{for } b_5$$

Thus, systematic b_5 in Q1Q2Q3 may limit the lowest possible value of β^*.

$\Delta\nu$ spread, b_q

Tolerances (guidelines)

$\gamma = 30$, $\beta^* = 6$, b_q' to give $\Delta\nu$ spread $= 3 \times 10^{-3}$

$b_q' = 10.4$ for $G/B = 21.4$

$\gamma = 100$, $\beta^* = 2$, b_q' to give $\Delta\nu$ spread $= 3 \times 10^{-3}$

$b_q' = 6.0$

Note, random $b_q' = .3$

For $\gamma = 100$, about 70% of $\Delta\nu$ is due to Q1Q2Q3

$\Delta\nu$ due to Q1Q2Q3 $\simeq 1/\beta^{*5}$ for b_q

Systematic b_q may become important for low values of β^*.

Dynamic Aperture Effect

For $\beta^* = 6$, $\Delta p/p = 0$

$A_{SL} = 14.5$ mm, $b_5 = b_9 = 0$

$A_{SL} = 14.5$ mm $b_5' = -3$, $b_9' = 1$

$\beta^* = 2$, $\Delta p/p = 0$

$A_{SL} = 7.5$ mm $b_5 = b_9 = 0$

$A_{SL} = 6.5$ mm $b_5' = 5$, $b_9' = 1$

$A_{SL} = 6.5$ mm $b_5' = 12$, $b_9' = 1$