

Gradient Errors and Correction System Summary

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b_1 Errors

Effects:

- Tune shift horizontal & vertical
- Half integer stopbands $\sim \Sigma \beta b_1 \ell e^{i2\psi}$
- $\Delta\beta/\beta$ for on-momentum particles $\sim \Sigma \beta b_1 \ell e^{i2\psi}$
- Horizontal dispersion $\sim \Sigma \sqrt{\beta_H} X_p b_1 \ell e^{i\psi}$
- Uncorrectable closed orbit error for off-momentum particles
- Reduced acceptance
- Reduced luminosity if β^* , X_p^* increased
- Increased beam-beam effect (??)

Source of errors:

b_1 in dipoles

Δb_1 i.e. mostly length errors in quadrupoles (insertions dominant)

Feed down for sextupoles if closed orbit off

No installation errors!

Correction:

- Sorting of arc dipoles + QF/QD reduces $\Delta\beta/\beta$ & stopband
(No b_1 random correctors in arc required.)
- Closed orbit error control (eliminates sextupole feed down)
- Trim power supply at each insertion Q eliminates insertion errors
Correct β^* & X_p^* at X-ing point
- Correction of horizontal dispersion by using b_1 at QF in arc (2 families/arc)
(same lead arrangement as for transition jump however power supply conflict?
CDR wiring has to be changed.)

— Correct *residual* $\Delta\beta/\beta$ & stopband

Parzen \longrightarrow Insertion Quads

Ruggiero \longrightarrow Need b_1 at QF (different lead configuration from transition jump)

Need b_1 at QD (Incompatible with a_1)

Compromise \longrightarrow Bypass on QF & QD in arcs

(This solution is in effect a stop band correction system in the arc. It is separate from the gamma transition system and leaves space for the a_1 correctors.)

a_1 — Errors

Effects:

- Stop bands
 - Difference resonance (coupling) $\nu_x = \nu_y$
 - Sum resonance 57, 58th harmonic
- Coupling ($\nu_x, \nu_y \rightarrow \nu_1, \nu_2$ / $\beta_x, \beta_y \rightarrow \beta_1, \beta_2$)
 - Driven by average (systematic) a_1
- Betatron function distortion
 - resulting in loss of acceptance
 - Driven by sum resonances
- Tune splitting ($\nu_1 - \nu_2 > 10 \times 10^{-3}$)
 - equivalent to lacking control over betatron tunes
- Vertical Dispersion
 - 1) at X-ing points: loss in luminosity
 - 2) at injection & beam dump

Sources:

- a_1 in dipoles
 - dominant contribution to systematic a_1
- Rotation of quads: INSTALLATION ERROR
 - $\beta^* = 6$ m Arc Quads \approx Insert Quads contribution
 - $\beta^* = 2$ m Insertion quads dominate
- Vertical closed orbit errors in sextupoles (feed down)

Correction System

- Sorting of dipoles but improvement limited due to quadrupole installation error
- Vertical closed orbit error control (eliminate feed down)
- Coupling correction
 - 1) Skew correctors at Q2/Q3 and Q5
 - 2) Error correction at the source with a_1 at QD in arc
 - Compensate systematic a_1 in each arc (this is dominant source of coupling)

- Betatron distortion correction
 - Sum resonance stopband correction with a_1 at Q2/Q3 and Q5 individually adjusted
- Vertical dispersion correction
 - S.Y. Lee: a_1 at Q9
 - together with a_1 at Q2/Q3 and Q5
 - (This solution would provide space for b_1 stopband correctors at QD)
 - Parzen: a_1 at QD in arcs
 - (Wiring configuration simulates Q9 and allows simultaneous coupling correction)