MI-0178

Beta Function Distortions from Systematic and Random Gradient Errors in Combined Function and Quadrupole Magnets for Lattice RRV7

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This note updates information presented in MI-0160 to reflect the newly considered lattice, RRV7. The primary change relative to the lattice RRV6 is that the phase advance/cell has been adjusted slightly to reduce sensitivity to systematic skew quadrupole and octupole components. Tables 1 and 2 are affected and presented here. It should be noted that these tables now present gradient errors in Fermilab "units" rather than as a percentage gradient error, and that roll sensitivity is now referenced to 0.5 mr.

Table 1: Recycler tune shifts, rms β-function distortions, and minimum tune split arising from a systematic gradient and skew quadrupole error of $1x10^{-4}$ of nominal in the combined function and quadrupole magnets. Recycler lattice RRV7.

	$\Delta\nu_x$	$\Delta\nu_x$	$\Delta\beta_x/\beta_{x(rms)}$	$\Delta\beta_y/\beta_{y(rms)}$	$\Delta\nu_{min}$
Gradient Magnet (4.1m)					
integrated gradient $\Delta_{B'L/BL}$=.0001/inch	.028	-.028	$28x10^{-4}$	$35x10^{-4}$	
skew quadrupole $\Delta B'_sL/BL$=.0001/inch					$16x10^{-4}$
Gradient Magnet (2.7m)					
integrated gradient $\Delta_{B'L}/BL$=.0001/inch	.0096	-.0096	$21x10^{-4}$	$33x10^{-4}$	
skew quadrupole $\Delta B'_sL/BL$=.0001/inch					$2x10^{-4}$
Quadrupole magnets					
integrated strength $\Delta_{B'L}/B'L$=.0001	.0004	-.0004	$2.7x10^{-4}$	$3.9x10^{-4}$	

Table 2: Recycler rms β-function distortions, and minimum tune split arising from a random gradient errors of $1x10^{-4}$ of nominal, a random transverse displacement of 0.25 mm (in the long combined function magnets), and a 0.1 mr roll in the combined function and quadrupole magnets. Recycler lattice RRV7.

	$\Delta\beta_x/\beta_{x(rms)}$	$\Delta\beta_y/\beta_{y(rms)}$	$\Delta\nu_{min}$
Gradient Magnet (4.1m)			
integrated gradient $\sigma_{B'L/BL}$=.0001/inch	$158x10^{-4}$	$174x10^{-4}$	
transverse displacement σ_d=.00025 m	$25x10^{-4}$	$44x10^{-4}$	
skew quadrupole $\Delta B'_sL/BL$=.0001/inch			$96x10^{-4}$
roll σ_ϕ=.0005			$31x10^{-4}$
Gradient Magnet (2.7m)			
integrated gradient $\sigma_{B'L/BL}$=.0001/inch	$70x10^{-4}$	$71x10^{-4}$	
skew quadrupole $\Delta B'_sL/BL$=.0001/inch			$39x10^{-4}$
roll σ_ϕ=.0005			$24x10^{-4}$
Quadrupole magnets			
integrated strength $\sigma_{B'L}/B'L$=.0001	$4.9X10^{-4}$	$5.0X10^{-4}$	
roll σ_ϕ=.0005			$14X10^{-4}$

Conclusions

Tables 1 and 2 show the rms β-function distortion around the ring and the minimum tune split expected for the designated errors. With the exception of the tune split arising from a systematic skew quadrupole component, the sensitivities are very similar to RRV6. The splitting of the horizontal and vertical phase advance has reduced the coupling sensitivity in RRV7 by nearly a factor of 50 relative to RRV6.