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In this note, the effects of this wiggler on the beam are estimated by means of the computer program MAGIC (Ref. 2) and various matching schemes are investigated.

Parameters of the Wiggler.

The optical equivalent and synchrotron radiation integrals of the SSRL wiggler were calculated by a computer program written for this purpose, and are discussed in a previous report (Ref. 3). It was shown that the only significant quantities are the vertical focusing (k_y), the energy loss integral (ΔI_2), and the excitation integral (ΔI_3). On the basis of computed design fields (Ref. 1) these functions were found to be

$$k_y = 0.05001(B_0/18\ \mathrm{kG})^2(E/1.5\ \mathrm{GeV})^{-2}\ \ (\mathrm{m}^{-1})$$

$$\Delta I_2 = 0.05042(B_0/18\ \mathrm{kG})^2(E/1.5\ \mathrm{GeV})^{-2}\ \ (\mathrm{m}^{-1})$$

$$\Delta I_3 = 0.01424(B_0/18\ \mathrm{kG})^3(E/1.5\ \mathrm{GeV})^{-3}\ \ (\mathrm{m}^{-2})$$

where B_0 is the peak field and E is the beam energy.

Simulating the Wiggler in MAGIC.

Since MAGIC models only rectangular uniform-field magnets, the problem is to simulate the effects of the actual wiggler with a squared-off field model. Luckily, as may be seen from the results given above, we only need to fit two of the three functions (since k_y and ΔI_2 scale in the same way). Consequently only two adjustable parameters are needed in our model. By making a series of runs with the wiggler program (Ref. 3) it was

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found that the effective pole length (ℓ_w) and the effective peak field (B_o) can be adjusted so that the squared-off representation fits the above functions accurately. The effective parameters as compared to the actual peak field and integrated pole length are

$B_o = 18.0$ kG	$B_w = 14.1386$ kG
$\ell_o = 0.094488$ m	$\ell_w = 0.104429$ m

where $\ell_o = \frac{1}{B_o}\int_{pole} B\, ds$

The wiggle period and number of poles were fixed at the actual values. While the above numbers are based on the design fields, they are not expected to be much different for the measured fields.

MAGIC Results.

Since there is no longer any symmetry in the ring, it was necessary to use a special version of MAGIC with expanded dimensions to accomodate the complete SPEAR ring.

Five cases were run and compared to the unperturbed reference case:

(1) No special matching for the wiggler.

(2) β_y matched by varying the pair of QF's nearest the wiggler (designated as QFW).

(3) β_y matched by varying the nearest pair of QD's (designated as QDW).

(4) β_y and η_x matched by varying the nearest pairs of QD's and QF's (designated as QDW and QFW).

(5) β_x^* and β_y^* matched by independent trimming of all the Q3's and Q2's south of the IP's (designated as Q3SE, Q2SE, Q3SW, and Q2SW).

Table I shows the unperturbed values for the configuration used in the calculations. Table II summarizes results before tune corrections. Additional runs were made to correct the tunes, but the parameters other than the $\Delta\nu$'s changed only marginally.

Conclusions.

Regarding the five cases summarized in Table II:

(1) No matching. The differences in β_y^* of ±3.5 % at the two IP's may be tolerable.

(2) β_y matched by QFW. This case is a disaster because of the large differences in β_x^* and η_x^* at the two IP's (1.671 m and 1.280 m for β_x^* and +0.203 m, −0.360 m for η_x^*). This is especially worrisome because η_x^* is believed to be implicated in the "flip-flop" effect (Ref. 4). Moreover, the change of 24 % required for QFW is far out of range of the trim windings.

(3) β_y matched by QDW. Better than Case 2, but the η_x^* mismatch (−0.022 m, +0.040 m at the IP's) is probably still too large.

(4) β_y and η_x matched by QDW and QFW. Quite good optically. The match could be made exact by varying one more set of quadrupoles, but this seems unnecessary. The changes required in QDW and QFW (2.5 % and 1.2 % respectively) are probably within the range of the trims, at least at low energies.

(5) β_x^* and β_y^* matched by trimming Q3's and Q2's in south arc. Exact match at the IP's. The effect of the +12 % β_y mismatch (which occurs only in the south arc) would have to be considered. Quadrupole trim requirements are minimal.

In summary, it appears worthwhile to try running the ring with the wiggler with no special matching (Case 1, above). If the β_y^* difference appears unacceptable, either Case (4) or (5) could be tried.

Some other possibly adverse effects are:

(a) Unequal betatron phase advances in the south and north arcs. This could in principle be corrected by making all the quadrupole families independent in the two arcs.

(b) Local energy loss at the wiggler, which might relate to the "flip-flop" effect (Ref.4). This could be partially compensated by dephasing cavities in the north arc.

Acknowledgements:

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References:

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Table I. Configuration Specifications. (E = 1.5 GeV). Note: the tunes used here are considerably closer to the integer than tunes which now are commonly used in SPEAR -- i.e., $\nu_x = 5.27$, $\nu_y = 5.18$. Thus the present example is somewhat of a "worst case" as regards mismatch effects.

Tune:	ν_x	5.144
	ν_y	5.09872
Machine Functions:		
	$\beta_x{}^*$	1.20 m
	$\beta_y{}^*$	0.10 m
	$\eta_x{}^*$	0.0 m
Emittance	ϵ_o	0.1229 mm-mrad
Luminosity:	$\mathscr{L}_0$	3.6×10^{29} cm^{-2} sec^{-1}
Damping time:		
$\tau_{xo} = \tau_{yo} = \tau_{Eo}/2$		0.067 sec

Table II. Effects of Wiggler with Various Matching Schemes.

		Case 1	Case 2	Case 3	Case 4	Case 5
Matching		None	β_y	β_y	β_y, η_x	β_x^*, β_y^*
Tunes:	$\Delta\nu_x$	0.0	0.0679	-0.0051	-0.0010	-0.0002
	$\Delta\nu_y$	0.0119	-0.0108	0.0378	0.0361	0.0171
IP Functions:						
β_x^*	(WP)	1.20	1.671	1.194	1.217	1.20
	(EP)	1.20	1.180	1.203	1.193	1.20
β_y^*	(WP)	0.101	0.100	0.100	0.100	0.100
	(EP)	0.094	0.100	0.100	0.100	0.100
η_x^*	(WP)	0.0	0.203	-0.022	0.0	0.0
	(EP)	0.0	-0.360	0.040	0.0	0.0
Mismatch in Arcs:						
$\Delta\beta_x/\beta_x$		0.0	±0.36	±0.01	±0.02	±0.004
$\Delta\beta_y/\beta_y$		+0.11	0.0	0.0	0.0	±0.12
$\Delta\eta_x/\eta_x$		0.0	±0.53	±0.06	0.0	0.0
Energy Loss:	U/U_0	1.103	1.103	1.103	1.103	1.103
Emittance	$\varepsilon/\varepsilon_0$	1.31	2.24	1.36	1.34	1.31
Luminosity:	$\mathscr{L}/\mathscr{L}_0$	1.31	1.61	1.37	1.32	1.31
Damping:	τ_x/τ_{xo}	0.907	0.907	0.907	0.907	0.907
Matching Quadrupoles:						
	ΔQDW/QD	---	---	+0.0257	+0.0251	---
	ΔQFW/QF	---	+0.2436	---	+0.0116	---
	ΔQ3SE/Q3	---	---	---	---	-0.0027
	ΔQ2SE/Q2	---	---	---	---	-0.0008
	ΔQ3SW/Q3	---	---	---	---	+0.0043
	ΔQ2SW/Q3	---	---	---	---	+0.0010

R. H. Helm
July, 1978

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