DOUBLE-MINI-BETAY OPTICS FOR THE SSRF STORAGE RING

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Abstract

Two long straight sections in the SSRF storage ring will be installed with dual-canted in-vacuum insertion devices in the SSRF Phase-II beamline project. The lattice upgrade with super-bend is also proposed. This paper summarizes the design results of double mini β_y optics, based on the upgraded lattice with super-bend.

INTRODUCTION

In the near future, SSRF will implement the Phase II beamline project. In this project, the dual-canted in-vacuum insertion devices will be installed in two long straight sections. The vertical beta function should be reduced in all the source points, as double-waist, in order that high brightness and good beam lifetime could be obtained with mini gap IDs. This kind of optics was implemented in many light sources, such as SPEAR3 [1], BESSY-II [2], SOLEIL [3], and so on. Spring-8 [4, 5] has a unique setting, in which triple-waist optics is applied due to the very long straight section. Because of the not very long beamline in SSRF, it doesn't need to do alpha-matching in the horizontal plan for focusing the photon beam, as DIAMOND did [6, 7].

In the SSRF Phase II beamline project, it is proposed to replace eight dipoles in four symmetric DBA cells with high field and short dipoles (super-bend), and then form four new straight sections [8]. By this way, the brightness of the hard X-ray radiated from super-bend will be enhanced, and more IDs can be installed in SSRF. However, the natural energy spread increases, and thus the effective emittance increases. In order to counteract this increased effective emittance, the horizontal tune increase by one unit to get a less natural emittance. Due to the lower symmetry and stronger nonlinearity, it needs to do much more careful design and optimization of the double-mini-β_y optics in the SSRF storage ring.

LINEAR OPTICS DESIGN

The length of the long straight section is about 12 m. Four identical short dipoles are used to generate angle separation of the IDs. A new triplet of quadrupoles is installed in the center of the long straight section, and is used to reduce β_y. The drift between these magnets will be installed with the necessary BPMs and correctors. Space for each ID is about 3.5m.

In order to get sufficient dynamic aperture, the

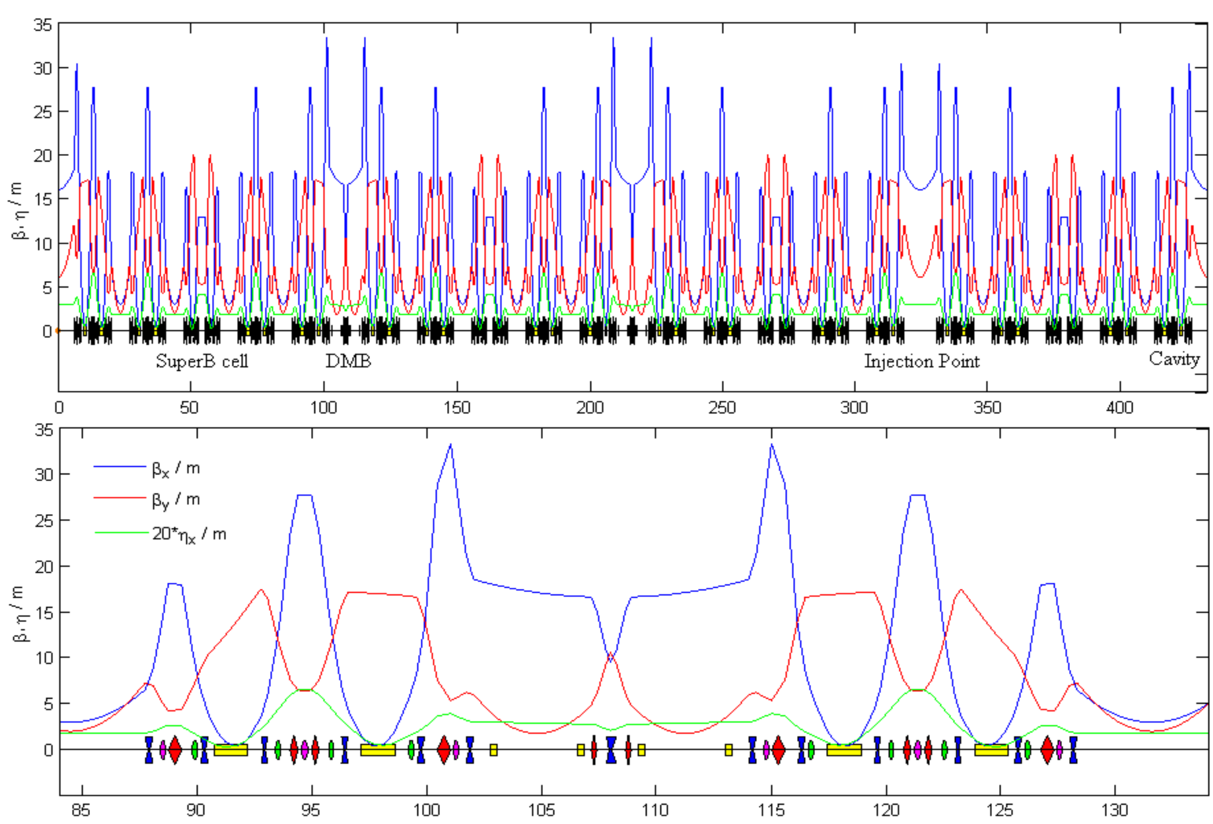

Figure 1: Linear optics along the SSRF storage ring and its double-mini-β_y optics (DMB: Double-Mini-Betay).

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horizontal beta function in the new optics with super-bend increase to 16 m. In order to fit the IDs, the vertical beta function at the source points are reduced to 2 m, and the vertical tune increase form 11.29 to 12.17. Figure 1 plots the linear optics in the whole ring and the details of double-mini-β_y.

Table 1 summarizes the beam parameters. Circumference has a little change rather than 432 m, due to the path length change in the super-bend. The natural emittance is reduced from the nominal one of 3.9 nm.rad to 3.49 nm.rad. However, because of the higher energy spread generated by super-bend, the effective emittance at the source points is almost the same as the nominal operation mode.

Table 1: Beam Parameters of the double-mini-β_y Optics of the SSRF Storage Ring

Beam parameter	Value
Energy / GeV	3.50
Circumference / m	431.97848
Working point (H, V)	23.232, 12.170
Natural emittance / nm.rad	3.49
Natural energy spread	0.0011
Momentum compaction factor	0.00036
Natural chromaticity (H, V)	-72.65, -23.34
Corrected chromaticity (H, V)	1.0, 1.0
Damping time (H, V, E) / ms	6.09, 6.04, 3.01
Energy loss per turn / MeV	1.67
Synchrotron tune	0.0067 (V_{RF}=4.2 MV)
Bunch length / ps	13

NONLINEAR OPTIMIZATION

The nonlinearity of this optics is stronger than the nominal one, and the symmetry is broke by the double-mini-β_y optics. We have increase the horizontal beta function and re-classified all the sextupoles into 14 families rather than 8 families. A good nonlinear optimization solution was obtained. Figure 2 plots the dynamic aperture, including on-momentum and off-momentum particles. These results are simulated with AT mode, which includes radiation damping, cavity compensation, physical aperture, and the measured magnet multipole errors. The horizontal dynamic aperture of on-momentum particle is about 15 mm, and it could fulfill an efficient beam injection. The energy acceptance exceeds ±3%, and it can provide a long beam lifetime.

Figure 3 plots the on-momentum particle dynamic aperture at the injection point and its frequency map with tune diffusion rate. This result is also simulated with a realistic mode, only without radiation damping. It shows that more nonlinear resonances are generated by the low symmetry, and it is very difficult to get any better solution with resonance-free dynamic aperture. Its effects on the beam injection or stability should be carefully studied, but no injected beam loss is observed in the simulation, as shown in Figure 2.

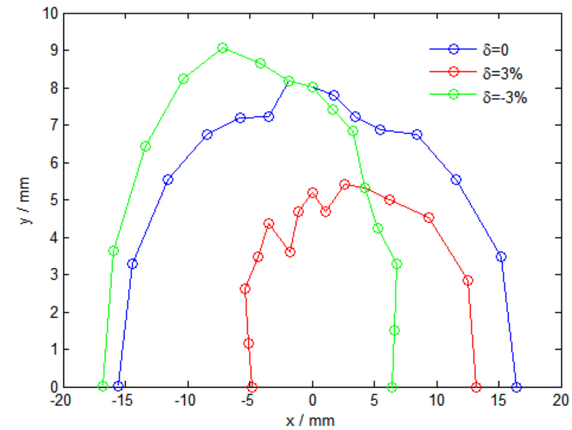

Figure 2: Dynamic aperture at the injection point of the new optics in the SSRF storage ring.

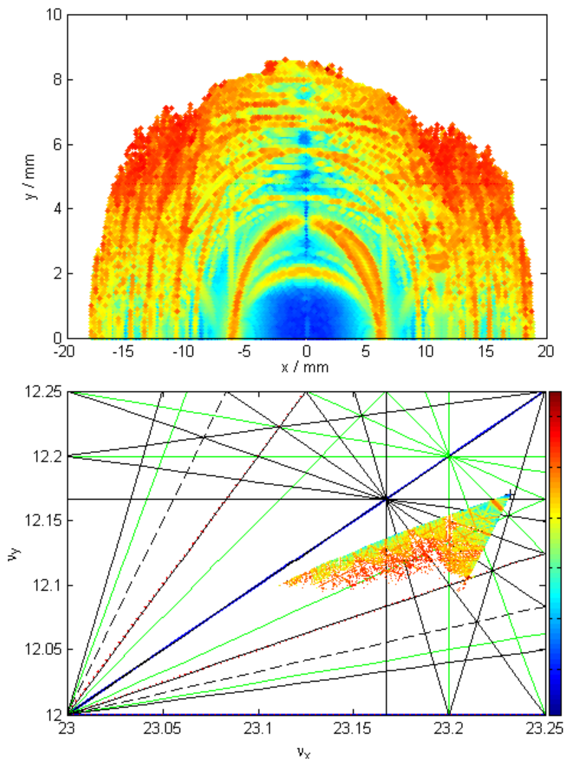

Figure 3: Dynamic aperture and frequency maps of on-momentum particle in the SSRF storage ring.

CONCLUSIONS

The double-mini-β_y optics is designed and optimized based on the upgraded lattice of SSRF with super-bend. Triplet of quadrupoles is installed in the center of the long straight section, and reduces the vertical beta function to 2 m. All the sextupoles are re-classified into 14 families, so new power supplies are necessary. The horizontal dynamic aperture reaches about 15 mm, which will fulfill an efficient beam injection. The energy acceptance exceeds ±3%, and the long beam lifetime is foresaw.

REFERENCE

[1] J. Corbett et al., in Proceedings of EPACE2006, Edinburgh, Scotland, 2006, p. 3472
[2] J. Bahrdt et al., in Proceedings of IPAC2010, Kyoto, Japan, 2010, p. 3108
[3] A. Loulergue et al., in Proceedings of IPAC2010, Kyoto, Japan, 2010, p. 2496
[4] K. Soutome et al., in Proceedings of IPAC2010, Kyoto, Japan, 2010, p. 4497
[5] K. Soutome et al., in Proceedings of IPAC2012, New Orleans, Louisiana, USA, 2012, p. 1188
[6] B. Singh et al., in Proceedings of PAC2009, Vancouver, BC, Canada, 2009, p. 3772
[7] B. Singh et al., in Proceedings of IPAC2011, San Sebastian, Spain, 2011, p. 2103
[8] Z. Zhao, these proceedings

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