Evaluate the Options of Implementing Skew Quadrupoles in the High Energy Ring*

Yunhai Cai

Stanford Linear Accelerator Center, Stanford University,
Stanford, CA 94309

Abstract

There are six skew quadrupoles needed in each side of the interaction region to compensate the effects of coupling and vertical dispersion due to the solenoid detector. Two of those skew quadrupoles are at the location of the first pair of the local chromatic sextupoles in the arcs adjacent the interaction region. To avoid introducing high order aberration, the skew quadrupoles could not be placed between the sextupoles pair. In this note, we evaluate two options of implementing the skew quadrupoles at those locations, namely adding trim coil into the sextupoles or vertically displacing the sextupoles.

*Work supported by the Department of Energy under Contract No. DE-AC03-76SF00515.

Evaluate the Options of Implementing Skew Quadrupoles in the High Energy Ring*

Yunhai Cai

March 9, 1999

Abstract

There are six skew quadrupoles needed in each side of the interaction region to compensate the effects of coupling and vertical dispersion due to the solenoid detector. Two of those skew quadrupoles are at the location of the first pair of the local chromatic sextupoles in the arcs adjacent the interaction region. To avoid introducing high order aberration, the skew quadrupoles could not be placed between the sextupoles pair. In this note, we evaluate two options of implementing the skew quadrupoles at those locations, namely adding trim coil into the sextupoles or vertically displacing the sextupoles.

1 Introduction

The version of the lattice used for this study is V1.16, which is about two years old. The tracking code: TRACY[1], which was used then for simulation, could not be used because of a recent upgrade of operating system for IBM workstations. The code could not even be recompiled since the PASCAL compiler is not being supported in at SLAC.

As a result, the first part of the job is to write a parser in LEGO[2] to decode the TRACY input file. And then we use LEGO to simulate the performance of the lattices with many different conditions.

The description of the solenoid compensation scheme and the errors used in the tracking can be found in the paper[3]. All tracking shown in this note are done at the nominal design tunes: $\nu_x = 24.618$, $\nu_y = 23.318$ and $\nu_s = 0.044$. The particles are tracked 1024 turns with 10σ of the relative momentum deviation $\delta = 0.0061$. The damping and quantum excitations due to the synchrotron radiation are turned off in the tracking.

*Work supported by the Department of Energy under Contract No. DE-AC03-76SF00515.

2 Nominal Setting

The ideal case of implementing a skew quadrupole inside the sextupole is to insert a thin skew quadrupole in the middle of sextupole. Given this ideal situation, the dynamic aperture of the lattice with the full set of alignment and multipole errors was evaluated using TRACY two years ago. The result is shown in Fig.1. It is not much different from the case

Figure 1: *Dynamic aperture for the nominal case using TRACY, solid line for the bare lattice and five dotted lines for five random machines with full errors.*

when the solenoid is off. The setting of skew quadrupoles in the lattice is tabulated in Tab.2.

Table 1: Setting of Skew Quadrupoles.

Skew Quadrupole	SQ5L	SQ6L	SQ5R	SQ6R
K1L (10^{-3})	3.96	4.12	-8.63	-1.11

In order to make sure that newly written parser does not contain bugs, we simulated the same lattice and errors using LEGO. The result is plotted in Fig.2

It is clear that the result of the dynamic aperture using two different codes: TRACY and LEGO is about the same statistically. The difference largely is because of the different sequences of assigning the errors.

Figure 2: *Dynamic aperture for the nominal case, using LEGO, solid line for the bare lattice and five dotted lines for five random machines with full errors.*

3 Trim Coil

Adding a trim coil inside the sextupole magnet to make a skew quadrupole component will generate also a strong skew octupole term due to the asymmetry of the sextupole. This effect has been calculated and measured. At a reference radius of 4.5 cm, the ratio of the skew octupole and skew quadrupole field is 45%.

We add this skew octupole term into the four skew quadrupoles as additional multipole errors in the lattice and then track the dynamic aperture. The result is shown in Fig.3.

4 Displaced Sextupoles

The other solution is simply displaced the sextupole vertically. Since there are non-linear fields in the sextupole magnets, the offset of the orbit will generate the additional multipoles, so call feed-down effects. We simulate these effects by displacing the sextupole with its measured multipole errors and turning off the thin skew quadrupole field. The displacements of the sextupoles are listed in Tab.4.

The tracking result is shown in Fig.4 There are not much effects seen in the dynamic aperture. For the real implementation of displacing sextupoles, there are some displacements in the horizontal plane as well because of the restriction of the poles in the magnets. We move the sextupoles horizontally by half amount as in the vertical plane and then compute the dynamic aperture. Again there are not much effects seen in the

Figure 3: *Dynamic aperture for the trim coil option*

Table 1: Vertical Displacement of Sextupole.

Sextupole	SD4A5	SD4A6	SD2A5	SD4A6
Skew Quadrupole	SQ5L	SQ6L	SQ5R	SQ6R
Dy (mm)	-3.02	-3.15	6.59	0.85

dynamic aperture, shown in Fig.5. However, there is about 10% increase of the vertical beta function at the interaction point if not corrected.

5 Conclusion

A parser to decode the TRACY input file has been written in the LEGO. It has been test against the result using TRACY.

We calculate the dynamic aperture using LEGO to evaluate two different ways of implementing the skew quadrupoles in the arcs near the interaction region. Based on the result of the simulations, there are not much differences between the two options. And both solutions work fine. So the decision of selecting a solution should be made based upon the hardware issues not the dynamics of the beam.

Operationally, the trim coil solution is more flexible than the fixed displacement of the sextupole. The flexibility in the solenoid compensation may become important if we need to ramp up the solenoid field during the next commissioning period.

Figure 4: *Dynamic aperture for the vertical displaced sextupoles*

References

- [1] H. Nishimura, "TRACY, A Tool for Accelerator Design and Analysis," Proc. of EPAC, Rome, 1988, p-803.
- [2] Y. Cai, M. Donald, J. Irwin and Y. Yan, "LEGO: A Modular Accelerator Design Code," SLAC-PUB-7642, August 1997.
- [3] Y. Nosochkov, Y. Cai, J. Irwin, M. Sullivan, E. Forest, "Detector Solenoid Compensation in the PEP-II B-Factory," PAC proceedings, 1995.

Figure 5: *Dynamic aperture for displaced sextupoles in both planes*