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LATTICE PERFORMANCE OF THE PEP-II HIGH ENERGY RING*

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Abstract

The High Energy Ring(HER) of PEP-II, an asymmetric B-factory, has been commissioned since June 1997. By the end of the last run, it has successfully stored the beam up to 300mA with a beam-life time of a few hours. Its lattice was resilient and behaved remarkably well. Although we are still in an early stage of the commissioning, we will assess the status of the lattice qualitatively and identify improvements necessary in the near future by simulating the lattice in a way that is closely related to the operation and comparing the results with the measured data.

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ABSTRACT

The High Energy Ring(HER) of PEP-II, an asymmetric B-factory, has been commissioned since June 1997. By the end of the last run, it has successfully stored the beam up to 300mA with a beam-life time of a few hours. Its lattice was resilient and behaved remarkably well. Although we are still in an early stage of the commissioning, we will assess the status of the lattice qualitatively and identify improvements necessary in the near future by simulating the lattice in a way that is closely related to the operation and comparing the results with the measured data.

1 Introduction

The nominal design lattice, featuring a low $\beta_y^\star$ of 1.5cm at the interaction point(IP) was presented in the paper [1]. For the commissioning, we prepared a relaxed lattice with $\beta_y^\star = 6$cm since a permanent dipole and quadrupole inside the solenoid detector at each side of the IP was not available when the commissioning began. The large $\beta_y^\star$ was also chosen to ease the initial commissioning.

In the relaxed lattice, the betatron tunes are maintained to be the same as the nominal design tunes: $Q_x = 24.618$ and $Q_y = 23.638$, by matching two straight

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sections to minimize the changes. Other than the difference of beta function, the synchrotron tune $Q_s = 0.0291$ instead of 0.052 in the nominal design since less RF cavities were available.

2 Tolerances

As a standard procedure developed when the lattices were designed, we apply estimated alignment errors to the ideal relaxed lattice. The RMS values of alignment errors used in the simulation are tabulated in the following table:

Table 1: *alignment errors.*

	placement(mm)	roll(mrad)
dipoles	1.00	0.3
quadrupoles	0.25	0.5
sextupoles	0.25	0.5
BPMs	0.25	0.0
IR quads	0.20	0.1

In addition, we used the measured multipole errors that are the same as the ones in the conceptual design report [2] because the field uniformity of the refurbished PEP magnets did not change much. For magnet setting errors, including power supply setting errors, we assumed 0.1% for dipole and quadrupoles and 0.2% for sextupoles as their RMS values.

All the random errors are assigned with a Gaussian distribution cut at 2σ. In order to obtain a reliable statistic, we simulated 15 different machines generated randomly. A newly developed object-oriented code [3] based on symplectic integrators is used for the simulations.

3 Orbit and dipole correctors

The closed orbit is reduced to 0.5 mm to simulate the condition of the HER during the last run by using a three-bump scheme. The strength of dipole correctors in all 15 seeds is plotted as a histogram in the left column of Figure 1 and the actual setting of the correctors is plotted in the right column.

The result indicates that the alignments of quadrupoles and beam position monitors in the vertical plane are very close to the specification. In the horizontal plane, the larger RMS value implies that the alignments are worse than the specification and the larger average value is consistent with the fact of having a 4mm

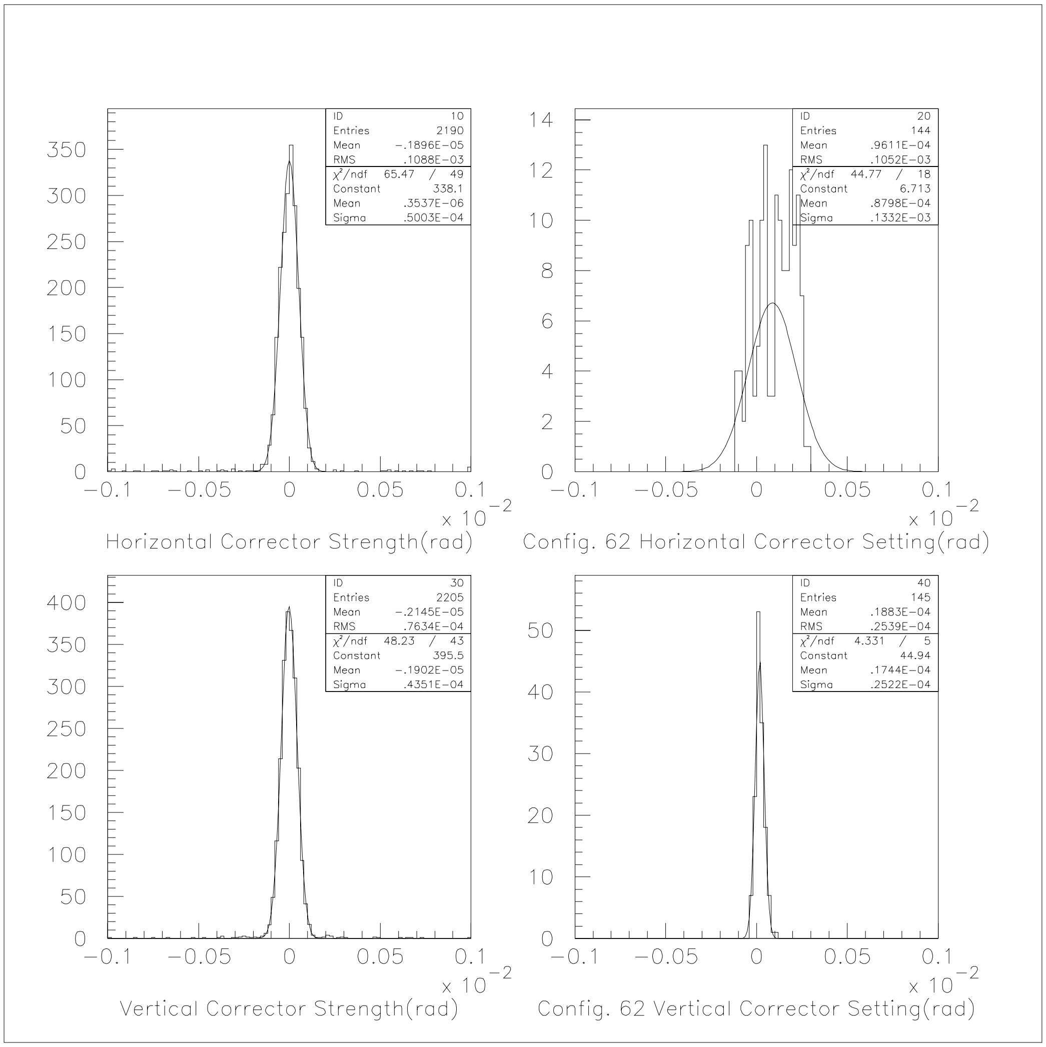

Figure 1: *strength of dipole correctors from simulation and measurement.*

shorter circumference, which causes the orbit to be about 1mm inward in the arcs.

4 Dispersions and emittances

It is crucial to make the vertical beam size small at the IP in order to retain a high luminosity. There are two major sources of errors that contribute to the vertical beam size in a lattice. The first one is the betatron coupling between the horizontal and vertical planes resulting mostly from the rolls of quadrupoles and vertical misalignments of sextupoles. The global coupling is easily corrected with a few skew quadrupoles in dispersion free regions. After the correction, the minimum separation of $Q_x - Q_y$ of the HER is reduced to 0.001, which is considered more than adequate.

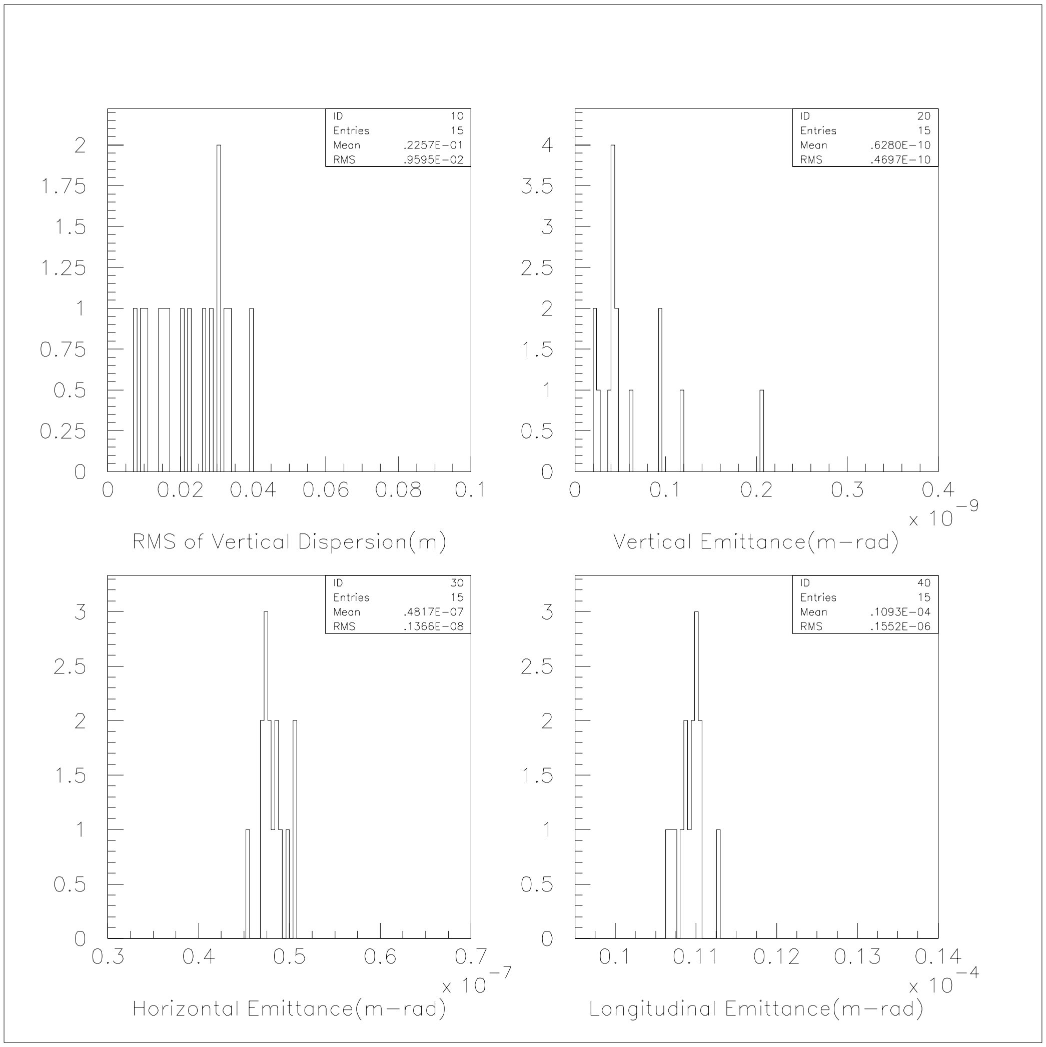

Figure 2: *dispersions and emittances.*

The second effect comes from the combination of the residual vertical dispersion and synchrotron radiation in a circular accelerator. The resulting vertical emittances at an equilibrium are computed for all 15 machines after the orbit and coupling corrections. The computation is based on the beam-envelope formulation [4] including the radiation from all magnetic elements. The result is summarized in Figure 2 and the vertical emittances are small enough to meet the requirement of the aspect ratio, provided the local coupling and dispersion at the IP are minimized at the same level separately.

5 Dynamic aperture and tune scan

Dynamic apertures, defined as the boundary between stable and unstable regions, are evaluated for all the seeds. Particles are tracked 1024 turns with six phase dimensions and synchrotron oscillation of 10σ. The result is plotted in Figure 3. The excellent dynamic apertures assure a beam-life time of more than eight hours which was achieved in the HER.

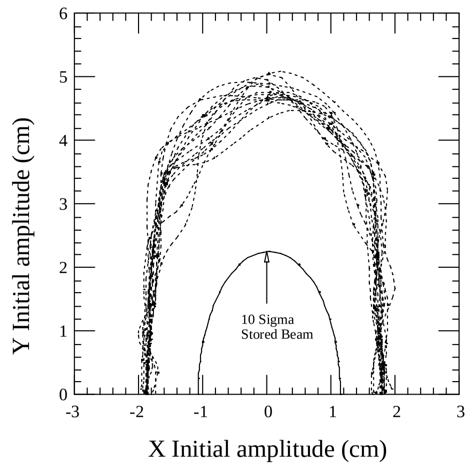

Figure 3: *dynamic aperture with machine errors.*

In addition to tracking many seeds, we also scan the dynamic aperture in the vicinity of selected tunes to make sure that the region of operation is large enough when the beams are collided. One of the scans centered at $Q_x = 24.709$ and $Q_y = 23.634$ is plotted in Figure 4a. A sideband of coupling resonance is clearly seen in the plot.

In the same region of tune, the beam-life time was measured and plotted in Figure 4b. A resonance with different slope is shown in the plot. The different slopes between the simulation and measurement could be explained by the calibration of the tune knobs.

6 Summary

The relaxed lattice is simulated with 15 random seeds. Many measurable quantities related to the optics are calculated so that comparisons to the measured data can be made. Due to space limitation, only a few subjects are selected and written in this note. From these examples, we conclude that the behavior of the HER agrees quantitatively with the simulations. Much work remains to be done before its optics and dynamics are completely understood.

7 Acknowledgements

We would like to thank Uli Wienands for providing the measured tune scan data.

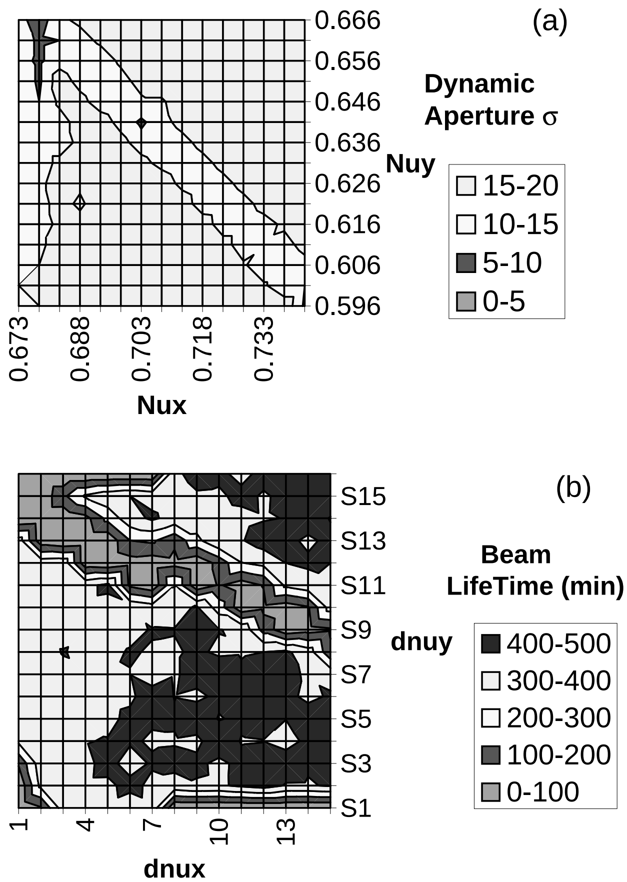

Figure 4: *(a) simulated dynamic aperture and (b) measured beam-life time.*

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