OPTIMIZATION OF KICKER PULSE BUMP BY USING A SR MONITOR AT THE PHOTON FACTORY

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Abstract

We plan to operate the Photon Factory storage ring by top-up injection mode from 2006. To realize top-up operation mode, remaining coherent oscillation of the stored beam due to error in the injection pulse bump is one of most serious problem. And also a non-linear kick of sextupole magnet in injection pulse bump excites coherent oscillation of the stored beam. To reducing the error in the injection pulse bump, we regulate the kick angles of the four kicker magnets by using the SR monitor which has a high speed gated camera. The coherent oscillation which induced by a non-linear kick of sextupole magnet is observed by same monitor. Without the sextupole magnet in the injection bump, we reduced remaining coherent oscillation less than σ/4 of the beam size by optimizing the kicker magnets.

INTRODUCTION

The operation of the storage ring by top-up or continuous injection is now very important in the SR facility [1][2]. This operation of the storage ring provides us keeping the constant intensity of SR for the users and constant heat load for the optical components of the beamlines. Not only to keep a constant intensity of SR, but also by the top-up injection, we are free from the serious lifetime problem due to small beam size by the small emittance operation, and problem of Touschek effect in low energy ring etc.

In the KEK, a linac upgrade project is now in progress. This project involved in realizing a pulse by pulse multi-energy acceleration of the beam in one linac (8 GeV for HER of B-factory, 3.5 GeV for LER of B-factory, and 2.5 GeV for Photon Factory). By this scheme, we can inject the beam into both B-factory and Photon factory with pulse by pulse switching of the beam. This project will partially finish until autumn 1996, and we can cut in the injection to the Photon Factory (PF) during the operation of B-factory. Then, we plan to operate the PF storage ring by top-up injection mode from the operation in autumn 2006. To realize the operation of the ring by top-up injection mode, a coherent oscillation of the stored beam is one of serious problem. This phenomena is exited in every injection period due to error in the injection pulse bump. Not only the kicker error, but also non-linear kick of sextupole magnet which locates inside of the injection pulse bump will excite a coherent oscillation of the stored beam. In this paper it is described that optimization of injection pulse bump to reducing the oscillation of stored beam for the top-up injection. The observation of nonlinear kick effect for the stored beam under the excitation of injection pulse bump is also described.

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OBSERVATION SYSTEM FOR OSCILLATION OF STORED BEAM

For the observation of motion of the stored beam under the excitation of injection pulse bump, we use a SR monitor. We have a SR monitor which SR source point is located in the injection pulse bump at the Photon Factory [3]. In the Photon Factory, we use 4 kicker magnets to excite an injection pulse bump. The arrangement of kicker magnets is shown in figure 1. Since the source bending magnet B27 is located between kicker magnet No.3 and No.4, we can observe an instantaneous image of stored beam at the timing of the beam just passing through the bump orbit in the B27. The optical layout of the SR monitor is also shown in figure 1 [3]. The visible SR from the synchrotron radiation source magnet B27 follows a 8 m path to the underground optical hatch where the focusing system and the fast gated camera are installed. A doublet lens with focal length of 1000 mm is used as an objective lens. The diameter of the objective lens is 80 mm. A magnifying lens is installed in front of the fast gated camera. This focusing system is designed to have an angular acceptance of +/-3 mrad and a position acceptance of +/-16 mm. These acceptances are wide enough for the observation of the bump orbit and the coherent motion of injected beam.

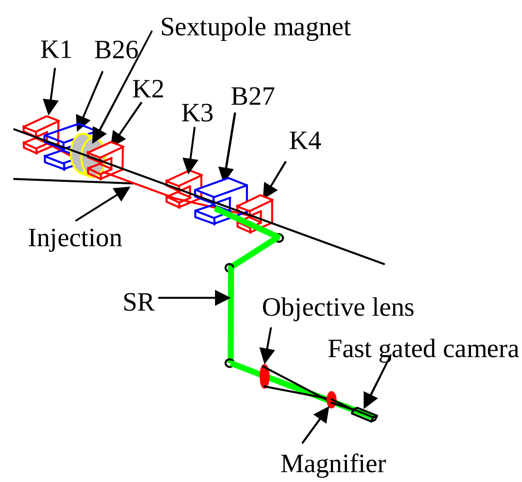

Figure 1: Arrangement of kicker magnets and optical layout of the SR monitor. K1,2,3,4 denote kicker magnet No.1,2,3,4, respectively. B26,27 denotes bending magnet No.26, and 27. The quadrupole magnets are omitted in this figure.

We investigated the turn by turn oscillation of stored beam. A coherent oscillation of stored beam due to the kick error in the injection pulse bump is investigated by optimizing the four kicker magnets by using this monitor.

OPRIMIZATION OF PULSE BUMP WITH SEXTUPOLE MAGNET ON THE PEAK OF BUMP

In the first step, we investigated an optimization of pulse bump at the timing on the peak of pulse bump with an excitation of the sextupole magnet. At first, we set the designed intensities for the four kicker magnets. A result of coherent oscillation of the stored beam in 16 turns after the excitation of the pulse bump is shown in figure 2(b). The first turn of observation is located alone in the left side. This beam position is when the beam comes just at the timing on the peak of pulse bump. Later 15 turns are oscillating around the central orbit in the right side. We also observed vertical oscillation of the stored beam in this figure.

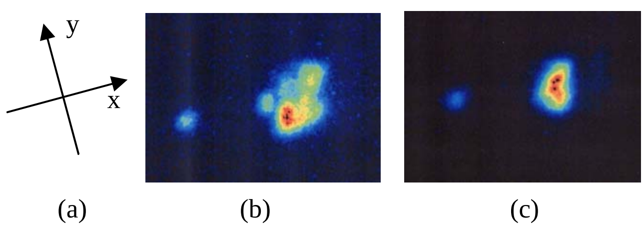

Figure 2: Result of coherent oscillation of the beam before an optimization of pulse bump (b), and after an optimization of pulse bump (c). Coordinate system in these figures is rotated 12° in CCW manner due to alignment of optical system as indicated in (a).

The pulse bump was optimized by choosing the intensities of K3 and K4 for free parameters. A result of the optimization is shown in figure 2(c). The coherent oscillation of the stored beam is reduced less than $\sigma/4$.

OBSERVATION OF COHERENT OSCILLATION DUE TO NONLINEAR KICK OF SEXTUPOLE MAGNET

To optimize the pulse bump at the timing on peak of the bump, we can reduce the coherent oscillation of the stored beam. But according to non-linear kick of the sextupole magnet which locates in the pulse bump will introduce extra oscillation of the stored beam during the pulse rising up and falling down. We observe the oscillation of stored beam by non-linear kick of sextupole magnet with same observation system. We measure the oscillation of the beam at seven points. The interval of the each measuring points is 200 nsec. The relation between measuring points of timing and pulse shape is schematically indicated in figure 4. The results of observations of the stored beam oscillation with and without the sextupole magnet are shown in figure 4.

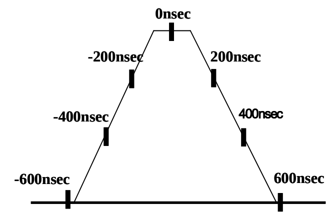

Figure 3: The relation between measuring points of timing and pulse shape of the injection bump.

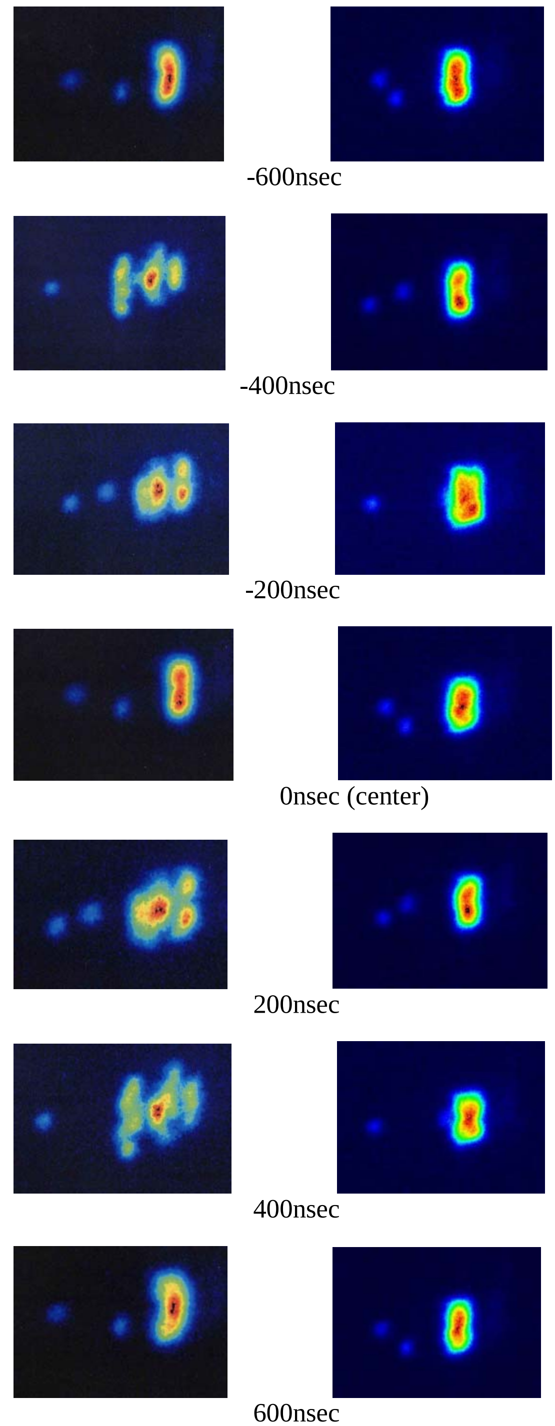

Figure 4: The results of observations of the stored beam oscillation with (left column) and without (right column) the sextupole magnet.

As shown in the left column in figure 4, the oscillation of the beam is only suppressed at the timing on the peak of pulse bump. At the other timing during rise up and fall down, large oscillations are exited by a non-linear kick of sextupole magnet. The oscillation of the stored beam seems similar pattern at the symmetrical timing (at ±400 nsec, and ±200 nsec) against the center of pulse. Although the intensity of pulse bump is only 25% of the peak at the timing ±400 nsec, the large oscillation of the stored beam was observed. Amplitude of the oscillation in the each observation timing is shown in figure 5.

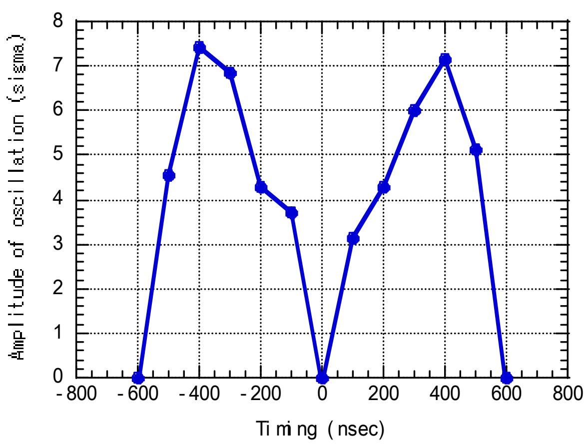

Figure 5: Amplitude of the oscillation in the each observation timing.

From figure 5, even the amplitude of oscillation is suppressed at the centre of the bump pulse, the maximum amplitude in both side reached about 7.5σ of the horizontal beam size. The curvature of amplitude is symmetry against the center of bump pulse. Since the non-linear kick by a sextupole magnet is proportional to square of the deviation, this symmetric pattern in the amplitude indicates the deviation will be symmetric against the pulse center. So, we can conclude the pulse shape is symmetry against the center of pulse. This conclusion is in good agreement with pulse shape by same optical monitor [3].

Results of the observations for the oscillations of stored beam without excitation of the sextupole magnet those are measured at same timings as in the left column are shown in the right column in figure 4. The oscillations at the each timing are almost suppressed when the oscillation at the center of the peak is suppressed with optimization of the pulse bump as mentioned in the upper section. Amplitude of the oscillation measured without an excitation of sextupole magnet is shown in figure 6. From figure 6, maximum amplitude of the oscillation is about 1σ of horizontal beam size. We cannot found more good condition to valance four kicker magnets which suppressed oscillation smaller. We consider this oscillation is due to small difference of pulse shape in the four kicker magnets.

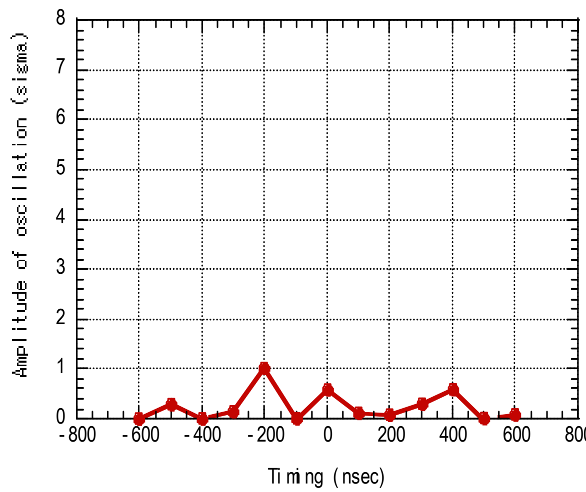

Figure 6: Amplitude of the oscillation in the each observation timing without an excitation of sextupole magnet.

Through in the all observations, we find vertical oscillation of the stored beam, even in the case of horizontal oscillation is suppressed. We consider this vertical oscillation of the stored beam is due to some rotation error in the alignment of the quadrupole magnet.

CONCLUSIONS

We investigate an optimization of kicker pulse bump for top-up injection. An oscillation of the stored beam is suppressed at the center of the pulse bump by regulating the valance of four kicker magnets. The pulse bump was optimized by choosing the intensities of K3 and K4 for free parameters. The coherent oscillation of the stored beam is suppressed less than σ/4. Non-linear kick of sextupole magnet in the injection pulse bump is also investigated. The oscillations of stored beam are measured by every 200 nsec through the pulse. Even the amplitude of oscillation is suppressed at the centre of the bump pulse, the maximum amplitude in both side reached about 7.5σ of the horizontal beam size. Without the excitation of sextupole magnet, the oscillations of stored beam through the pulse are almost suppressed when the oscillation at the center of the peak is suppressed with optimization of the pulse bump.

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