LIFETIME MEASUREMENT WITH PSEUDO MOVEABLE SEPTUM IN NSLS X-RAY RING*

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Abstract

The National Synchrotron Light Source II (NSLS-II) is a state of the art 3 GeV third generation light source currently under construction at Brookhaven National Laboratory and will start to commission in 2014. The beam injection works with two septa and four fast kicker magnets in an injection section. To improve the injection stability and reproducibility, we plan to implement a slow local bump on top of the fast bump so that the fast kicker strength is reduced. This bump works as a pseudo movable septum. We can also use this 'movable' septum to measure the storage ring beam partial lifetime resulting from the septum edge and possibly increasing the lifetime by moving the stored beam orbit away from the edge. We demonstrate the feasibility of this idea, by implementing DC bump in NSLS X-ray ring. We report the results of beam lifetime measurements as a function of the amplitude of this bumped orbit relative to the septum and the idea of a slow bump that could reduce the fast bump magnet strengths.

INTRODUCTION

The NSLS-II [1] is a 3 GeV third generation synchrotron light source under construction at Brookhaven National Lab. Due to its short lifetime, NSLS-II storage ring requires the top-off injection (once a minute) to keep the storage ring current constant to +/-1%. During the top-off injection, the stored beam orbit is highly desired as transparent.

The design emittance of the ring results in extremely small beam size and even a small disturbance, from the SR pulsed magnets (four kickers and pulse septum) at the injection straight line, would excite the stored beam betatron oscillation and perturb some user experiments. As a consequence, the fast kickers have to be extremely well characterized to make the bump magnets' mechanical placement to high accuracy and very tight requirements to maintain pulse-to-pulse stability and magnet-to-magnet reproducibility. Also, the pulse septum field has to be well shielded to control the leakage field at μT-m range.

We propose to implement a DC/slow ramping local bump [2] on top of the fast bump to reduce the fast kicker strength by a factor of 2/3, so that the fast kick power supply operates in a more stable region. Besides the improvements on kicker's stability and reproducibility, it also relaxes the tolerances on the kicker's tilt error and timing error. Furthermore, these magnets could provide a DC/slow ramping bump, which can be used to optimize the store beam lifetime by optimizing the beam relative position to the septum knife.

To demonstrate the feasibility of this idea, we implemented a DC local bump at the injection region of NSLS X-ray ring and measured the beam lifetime change by changing the stored beam relative position to septum knife.

LOCAL DC BUMP

To make a local bump at the injection region, we choose 3 horizontal correctors around the injection point. The possible combinations are (X8BH16, X1H2, X1H8) and (X8BH16, X1H5, X1H8). Here X1H2 is located just

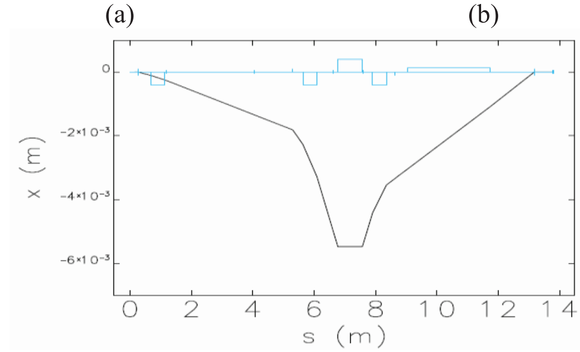
Table 1: Kick strength for the 2 sets of correctors (a) X8BH16, X1H2 and X1H8 (b) X8BH16, X1H5 and X1H8, to make a local bump around the injection point as in Fig. 1.

corrector	kick angle
X8BH16	-0.26
X1H2	-0.99
X1H8	-0.76

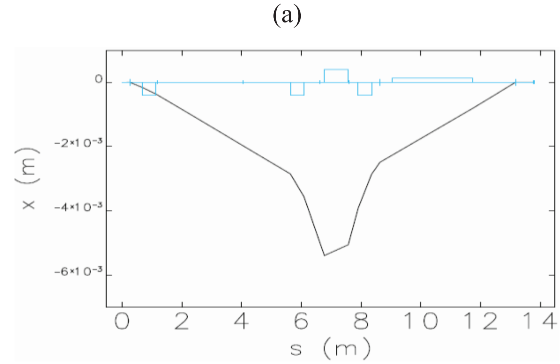
(a)

corrector	kick angle
X8BH16	-0.38
X1H5	-0.79
X1H8	-0.57

(b)



(a)



(b)

Figure 1: Simulated beam center with local bump around the injection point, corresponding to the kick angles in Table 1.

* This manuscript has been authored by Brookhaven Science Associates, LLC under Contract No. DE-AC02-98CH10886 with the U.S. Department of Energy.
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before the injection point and X1H5 is located just after the injection point. To select a more efficient corrector set for the experiment, we generate the same bump amplitude at the septum position. Table 1 lists the needed kicker strength and Fig. 1 shows the corresponding beam center for different configuration.

By comparing case (a) and (b) in Table 1, we can see that set (b) is more efficient to make the bump and we use this set for the measurement. Fig. 2 shows the injection region layout. The correctors for DC bump are indicated by arrows. The boxes in the Fig. 2 show the locations of fast kickers and the bump amplitude are measured with BPM, XPU2 to measure the turn by turn beam position.

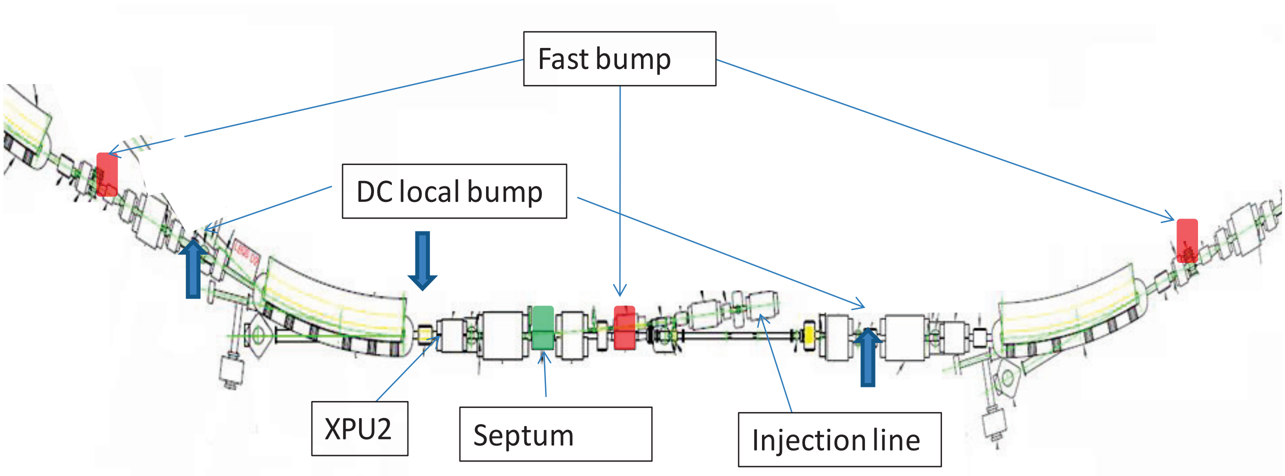

Figure 2: Injection layout of NSLS X-ring. The correctors for DC bump are indicated by the blue arrows. The fast injection kickers are marked with pink boxes.

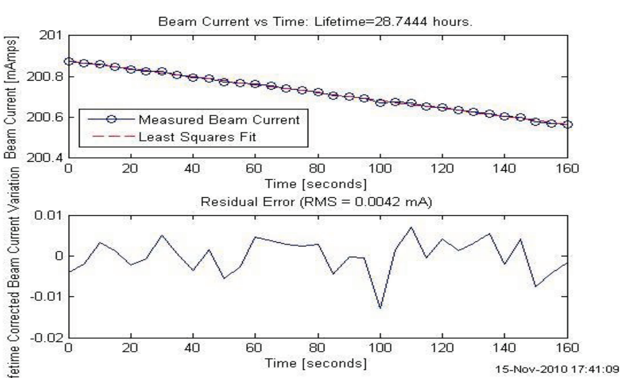

Figure. 3: Beam current variation and the residual error.

We use a DCCT to monitor the beam current change during 160 seconds and fit the beam lifetime with least square fitting method. Figure 3 shows the beam current and the fitting curve for 5.8 mm bump. The second graph shows the beam current variation relative to the fitted curve. It should be pointed out that the measured beam position is not equal to the beam position change at the septum location, but is good to reflect the beam position change.

LIFETIME OPTIMIZATION

The beam lifetime optimization was done by changing the beam position at septum with the local DC bump. The vacuum pipe aperture is +30.15 mm/-50.8 mm at the injection region.

The nominal operation set point is -2.8mm for full energy operation. The lifetime change relative to bump amplitude at BPM XPU2 is shown in figure 4 at 160 mA. The beam position changes from 0 to -12mm, limited by the correctors' strength and vacuum chamber temperature raise. As we want to push the beam relative position in both sides as far as possible, the closed orbit is changed by tuning all horizontal correctors in X ring. The blue line and the red line correspond to different closed orbit, as shown in figure 5. For the red line, the DC bump does not scan larger range because of the vacuum chamber temperature raise from synchrotron radiation heat. In the horizontal plane, the red closed orbit at septum region is -11.1 mm, comparing with the blue closed orbit at -0.1 mm. The closed orbits in vertical plane are similar. The horizontal big offset changes the momentum aperture and affects the beam lifetime, which explains the lifetime gap in figure 4. The curve shows that the optimal position is -8 mm from the beam lifetime viewpoint, which means the nominal operation set can be optimized at this energy. -8 mm is close to the vacuum middle position at the injection region.

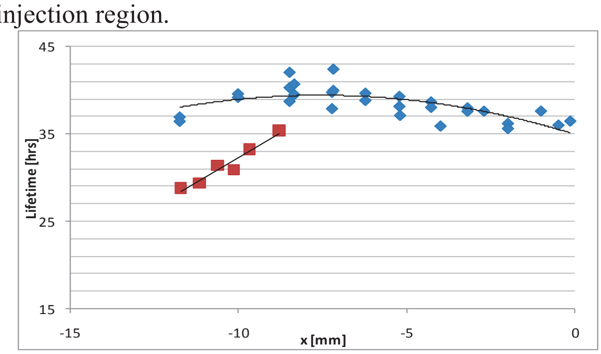

Figure. 4: Lifetime dependecy on the local bump position at beam energies 2.8 GeV.

Meanwhile, at lower beam energies, 1.5 GeV and 745 MeV, the lifetimes were also studied and it shows that the beam lifetime decreases as the beam approaches to the septum. That is because the closed orbit relative to the ideal position is different, depending on beam energies. It comes from the non-zero dispersion at the injection region as can be seen in figure 6. For different energy operation, we should optimize the beam position at the septum.

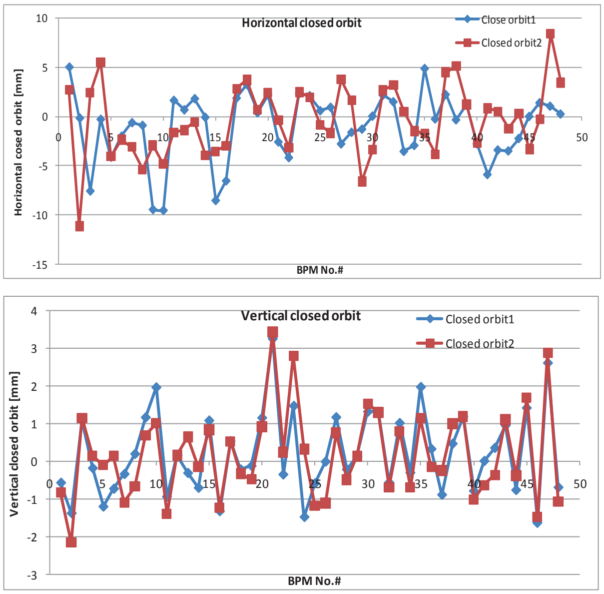

Figure 5: X-ray ring horizontal and vertical closed orbit

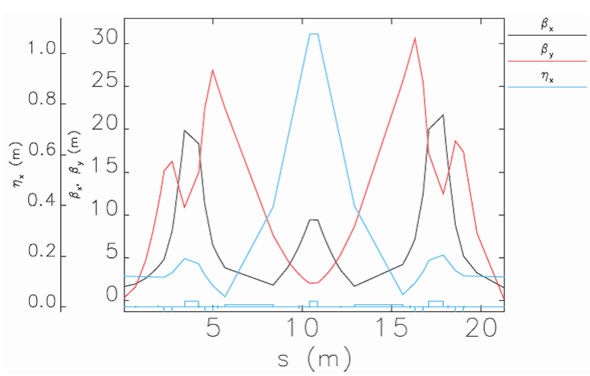

Figure 6: Horizontal and vertical beta functions and dispersion in NSLS X-ray ring.

SUMMARY

By moving the beam position to ~ -8 mm with a local DC bump, the beam lifetime in X-ray ring could be improved by ~15%, compared with the normal operation where the beam position is about -2.8 mm. However, at the new optimal set point, the beam loss induced vacuum chamber temperature rise in other region is out of tolerance, because the local bump is not ideally closed. The residual orbit change could be a contribution to the lifetime change. Furthermore, the beam current drops from 300 mA to half value, which also affects the beam lifetime. In the future, we will do more dedicated beam studies by avoiding the beam loss at other region due to non-closed bump.

REFERENCES

[1] F.J. Willeke, Status of the NSLS-II Project, TUOBS3, These Proceedings

[2] G.M. Wang, et.al, Implementation of a DC bump at the storage ring injection straight section, THP135, These Proceedings