INJECTION SCHEME INTO THE HIGH FIELD ILSF STORAGE RING*

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Abstract

The ILSF is a third generation synchrotron light source which is currently in design stage. The extracted 3 GeV electron beam from the booster synchrotron is transferred via the BTS transfer line and injected into the ILSF storage ring. The injection system will greatly affect the quality of electron beam. This article will describe the injection procedure into the ILSF storage ring and will present the electron tracking results of the injected beam.

INTRODUCTION

The ILSF injector to the ring consists of four main systems.

- Pre-injectors (electron gun and linear accelerator)
- Linac to booster (LTB) transfer line
- Booster synchrotron
- Booster to storage ring (BTS) transfer line

An electron beam produced with an electron gun, is accelerated by a travelling wave linear accelerator (Linac) to the energy of 150 MeV. Then the electrons enter into the booster synchrotron via LTB transfer line. The full energy booster accelerates the electron beam to the energy of 3 GeV using a radio frequency (RF) cavity with the frequency of 500 MHz. After reaching the target energy, the BTS line transfer the fully energy accelerated electron beam to the storage ring. For more information about the ILSF accelerators, the reader is recommended to see Ref [1-6].

For the stable operation, minimization of disruption of the low field ILSF storage ring and to reach top-up operation mode, the injection procedure into the ring must be very effective in such that no electrons should be lost. That would protect problems due to radiation and would provide very stable x-ray beam for the users without any interruptions during their experiments. Main body of the designed injection system is composed of one septum magnet placed at the end of the booster to storage ring transport line and four injection kicker magnets which are distributed symmetrically in one 7.88 m long straight section of the ring. Length of the each kicker is 850 mm and can provide maximum kick angle of 6.7 mrad. Schematic drawing of the injection system is shown in Figure 1.

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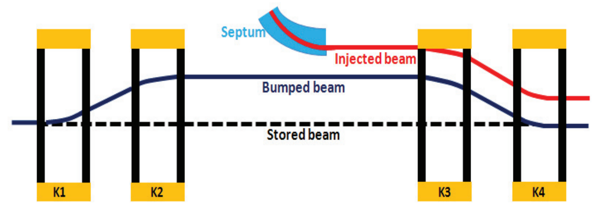

Figure 1: Schematic drawing of the injection equipment into the ILSF ring.

The space between kicker 1 named as K1 and kicker 2 (K2) and also kicker 3 (K3) and kicker 4 (K4) is 500 mm while the distance of 2.2 m between kicker 2 (K2) and kicker 3 (K3) is reserved to place the septum magnet. The kicker magnets produce a smooth orbit bump near the septum magnet to capture the injected electron beam. The half sinusoidal waveform of the kicker's pulse is 8 µs, see figure 2.

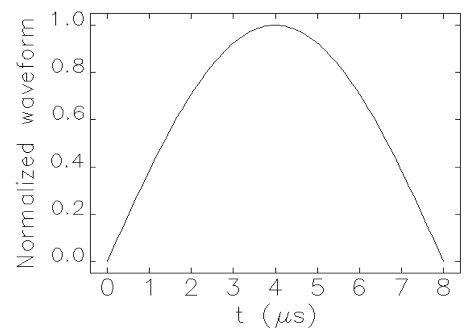

Figure 2: Normalized half waveform of the kicker magnets.

This is roughly 8 times of the beam revolution time (0.992 μs) in the ILSF ring and thus the injected beam will not sense the kick angle of kickers after 4 turns if we inject the beam at 4.0 µs. Moreover, it should be noted that several monitors have been distributed before and after the each injection kickers and after the septum magnet to observe phase space coordinate of the electron beam. The monitors have not shown in Figure 1.

ORBIT BUMP

To increase injection efficiency, the stored beam should be bumped as high as possible and be close to the injected beam. However, space between the septum and the beams is required to be large enough to prevent scraping of electrons. The kickers are set to produce a maximum orbit bump height of 10 mm in a single turn. The space between the stored, bumped and injected beams is depicted schematically in figure 3 and horizontal trajectory of beam centroid during 20 turns passing through the injection kickers is depicted in figure 4.

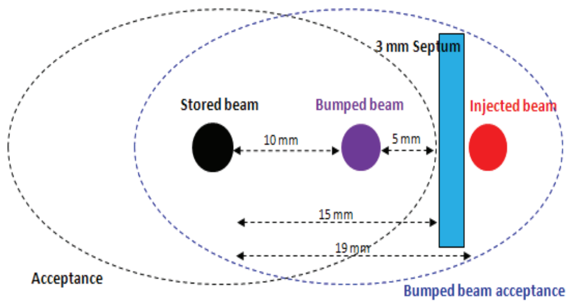

Figure 3: The reserved space for the stored, bumped and injected beams.

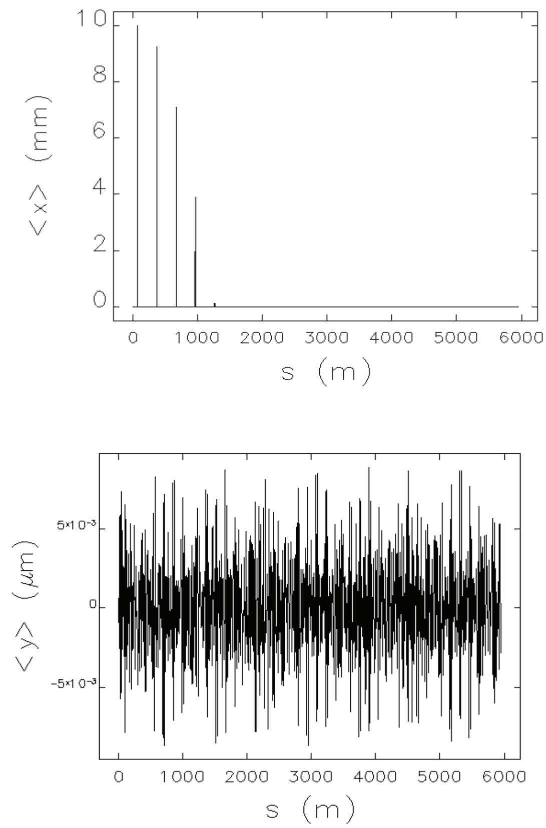

Figure 4: (top) Horizontal, (bottom) vertical trajectory of the electron beam centroid during 20 turns passing through the kicker magnets. No errors have been assumed in operation of the kickers.

As seen, the horizontal orbit is bumped to 10 mm while no effects in vertical orbit are given. It shows different height of horizontal orbit bump due to different strength of kickers at each turn and indicates to no effect in the rest of the ring. After 4 turns passing through the ring, the kickers would be switched off and thus electrons will move in the main ideal orbit. As an advantage of this injection system, local orbit bump only depends on the strength of kickers. This is because no storage ring magnets are appeared in between the injection kickers and strength of kickers directly affects the height of orbit bump. Since the injection system is located in the long straight section, perfect orbit bump would exist if the kickers operate without any error, see figure 5. However, to observe a real motion of the electron beam and study its orbit, errors must be included in our simulation. We predict that the errors disturb the perfect bump and small residual oscillations will be appeared in which after the damping time, it will damp by the synchrotron radiation.

PHASE SPACE TRACKING

In order to study performance of the designed injection system and find how efficient injection procedure is, the ELEGANT [7] code as a 6D particle tracking software has been used and 1000 electron with a Gaussian distribution per bunch is tracked through the ring. The phase space coordinate of the bumped beam observed with the monitor located after the K4 are depicted in Figure 5 which indicates that the bumped orbit has been perfectly compensated by the 4th kicker.

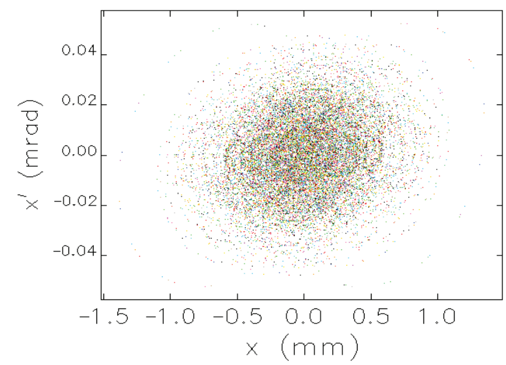

Figure 5: Phase space coordinate of the stored beam monitored after K4. Color indicates to the number of turns.

Phase space tracking result of the matched injected beam is depicted in Figure 6. This gives phase space of electrons after 25 turns passing through the ring. The tracking result determines the required minimum acceptance of the storage ring.

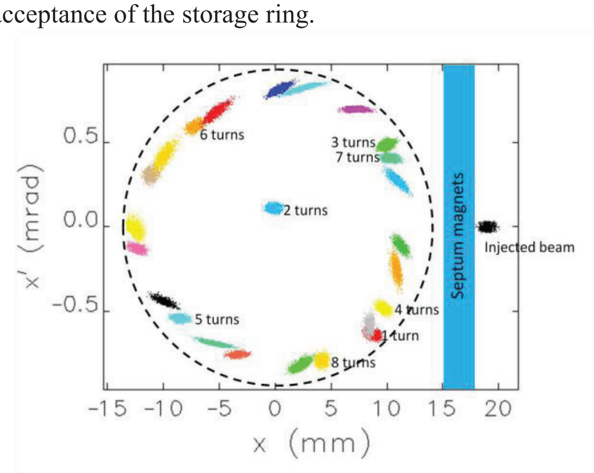

Figure 6: Phase space coordinate of the matched injected beam during 25 turns passing through the ring. Color in phase space graph indicates to the number of turns.

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The injected beam with a horizontal displacement of 19 mm specified with black color is oscillating around the main reference orbit and will be damped by synchrotron radiation. Damping process has not been added to our simulation. The acceptance angle is below than ±1 mrad. No loss of electrons is found which indicates to very efficient injected procedure.

CONCLUSIONS

The injection systems for the storage ring of the ILSF have been designed and their optimized specifications have been reported. Four kickers have been used to provide a local orbit bump to capture the injected beam. Results of electron tracking reveal to an efficient injection of electron beam in the ring. In our feature study, we will re-optimize the injection scheme and add randomly some expected errors to find efficiency of injection system.

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