# THE OPERATION OF INJECTION SYSTEM IN THE SSRF

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*Abstract*

The injector and the storage ring of the Shanghai Synchrotron Radiation Facility (SSRF) have been built and operate more than one year [1]. The injection system of the storage ring is composed of four kickers and two septa. The operation shows that fine injecting efficiency and smaller disturbance are carried out. The eddy current septum magnets with a sheet of magnetic screen around the stored electron beam to reduce the leakage field and four identical kicker magnets with titanium coating ceramic vacuum chamber provide the symmetric bump in 10 meter long straight sections. The design and performance of the injection system are described in this paper.

## INTRODUCTION

The SSRF accelerator consists of 150MeV LINAC, Booster synchrotron and 3.5 GeV storage ring. The beam is injected into the booster with the energy of 150MeV and boosted up to 3.5GeV within 250ms. Than the beam is extracted from booster and injected into the storage ring (SR) [2]. The SR injection system have four identical kickers with coated ceramic vacuum chamber and two eddy current septa. The magnets are installed at a 12m long straight section of the SSRF storage ring (Fig. 1). For the top-off injection the septa are stressed on minimizing the leakage field, while kickers are emphasized on achieving the best possible tracking in time and amplitude of the magnetic field waveforms so that the residual closed orbit disturbance is minimized.
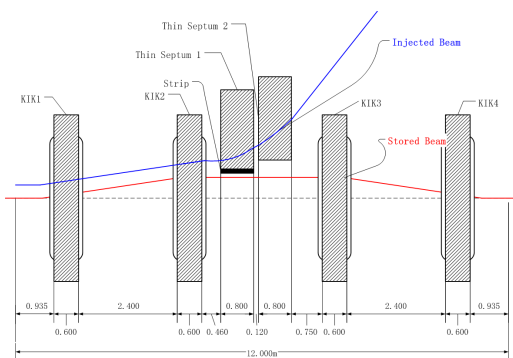


Figure 1: Layout of SSRF SR injection.

## SEPTUM

The type of septum is chosen to be eddy current shielded magnet. The magnet core is C shaped, 0.1mm laminations, operation in vacuum chamber. The in-vacuum design of the magnets made it easier to achieve good magnetic performance. The assembled lamination core is designed to follow the beam trace so that maximizing the beam aperture and increasing the thickness of septum sheet. A special profile OFC tube was machined beside the magnets to smooth the impedance saw by stored beam. Moreover, a magnetic screen is placed around the stored beam tube to further attenuate the septum leakage field (Fig. 2).

The septum magnets are excited with a 60 micro-second pulse of half sine wave. At the maximum bumped beam position which is 14.5mm away from the stored beam center, the leakage field was measured to be below 0.6 G·m. The performance of the septum is list on Table 1.
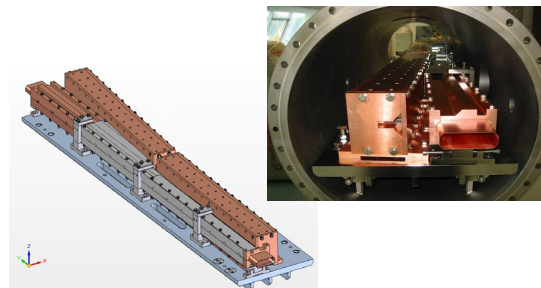


Figure 2: SSRF SR injection septum.

Table 1: SR Septum Parameters

| Beam Energy (GeV) | 3.5 |
|---|---|
| Deflection (mrad) | 52 |
| Core Length (mm) | 800 |
| Aperture H*V(mm) | 32 * 12 |
| septum thickness (mm) | 2.5-10 |
| leakage field (μT·m) | <60 |
| Pulse width (μs) | 60 |
| Waveform | half sine |
| Peak Current (A) | 8500 |
| Stability (rms) | 0.03% |

## KICKER

Four identical kickers with ceramic vacuum chamber are installed at a long straight section of the SSRF storage ring for symmetric bump up of the stored beam. The kicker magnet is conventional window-frame ferrite core type and the ceramic chambers are used to allow external time varying field to penetrate the vacuum chamber and to carry the beam image current.

The kickers are excited independent and each pulsers are designed with fine tuning circuit to balance the waveform. Beside the identical exciting waveform it is important that the titanium coat inside the chamber should be uniform with same thickness for symmetric bump up of the stored beam. The uniform and thickness depend on the

metallization technique. The ceramic chambers currently in used have DC resistances of 1.96 ohm ±3%.

The kicker is excited by 3.8 micro-seconds width half-sine pulse of 3.6kA peak current. By comparing pairs of pulsers, we conclude that the pulser waveforms can be matched to within $\pm1*10^{-3}$ during the complete pulse. Measurement results show that field homogeneity is better than ±1.0% in the region ±15mm*±5mm relative to the chamber center. Amplitude stability is better than 0.3%(p-p), and jitter is less than 2ns. The pulse width mismatch between four kickers is adjusted to be less than ±3ns.

## OPERATION

For SSRF storage ring, top-off injection will be a prospective operation mode. Top-off injection implicates that highly reliable and low disturb to stored beam are needed. Very careful set-up of the injection system is required. The distortion of the stored beam will directly affect the data acquisition of the experiments and any particle losses during injection may hit the optic components of the beam line through open beam-shutters [3].

The store beam orbit stability during injection is depends on the performance of injection elements, such as leakage field of septa, jitter and field difference of kicker's waveforms, etc. The commissioning result show that the residual orbit disturbance of stored beam are about 50 micron (Fig. 3).
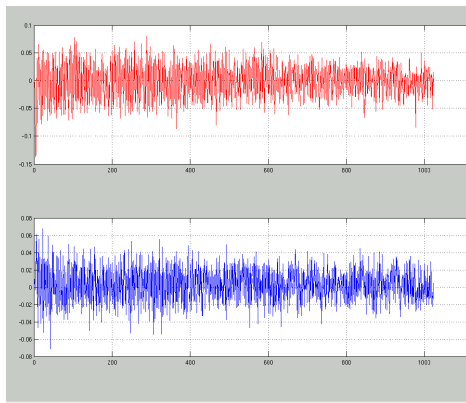


Figure 3: Orbit disturb at injection.

By measurement separately we found that the disturbance from the septa leakage field is lass than 10 micron (Figure 4.) which means the leakage field of septa is about 0.6 G.m calculated. And its decay character shows the leakage field came from the eddy current.
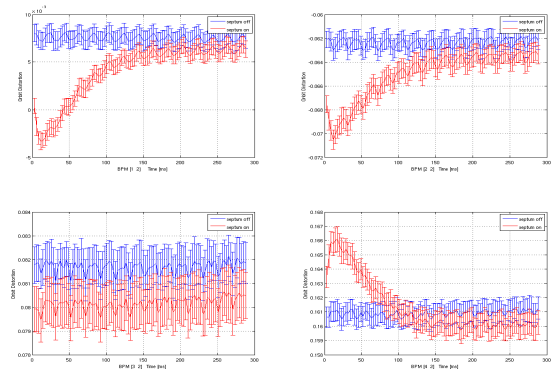


Figure 4: Disturbance of the stored beam by septum (without injection beam and kicker off)

Considering the injection components the main disturbance is come from injection kickers since the septum offer small action. Jitter, difference of waveforms and alignments of the kicker magnets are the main factors. For correcting alignment in real time we are developing remote adjustable platforms for kicker magnets. The commissioning for top-off injection will be done this year.

## CONCLUSION

The injection system of SSRF storage ring is running perfectly. The yearly operation proved that the injection system is reliable. These magnets, power supplies and controllers operated perfectly and high injection efficiency of 97% from booster to storage ring is achieved. Further effort to reduce the disturbance from pulsed magnets will be done for top-off operation.

## REFERENCES

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