THE INJECTION SYSTEM OF SAGA LIGHT SOURCE

Y. Iwasaki, S. Koda, Y. Takabayashi, T. Okajima, K. Yoshida, T. Tomimasu,
SAGA Light Source, Tosu, 841-0005, Japan
H. Ohgaki, Institute of Advanced Energy, Kyoto University, Kyoto, 611-0011, Japan

Abstract

SAGA Light Source is a synchrotron radiation source, which consists of 250MeV injector linac and 1.4GeV storage ring, located in northern Kyusyu, Japan [1]. The beam transfer line from the linac to the ring consists ob a 40-degree bending magnet, a 20-degree bending magnet, two quadrupole doublets and a quadrupole singlet. The bump orbit is generated by four-kickers which are excited by sinusoidal electric currents with a half width of 1μs. We have performed injection tracking studies using TRACY2 [2] to confirm the angle and energy injected beam acceptance. It has been found that the angular acceptance for the injection beam is from -3.5mrad to +2.5mrad and the energy acceptance is 1%.

INTRODUCTION

SAGA Light Source is a middle-scale light source with a 250MeV linac and a 1.4GeV storage ring. DBA lattice was selected in order to make the ring compact [3]. At the nominal tune (5.796,1.825), the emittance is 25nmrad. The storage ring has a eight-fold symmetry, and the circumference is 75.6m. There are eight 2.93m long-straight sections, two of which are used for injection and RF cavity, and the other six sections can be used for insertion devices. A superconducting wiggler will be installed in near future [4].

The 250MeV linac is used as the injector to the storage ring. A 1μs macro-pulsed beam is injected into the ring through a septum magnet with a repetition rate of 1 Hz. The observed macro-pulsed charge at the end of linac was 2nC [5].

Figure 1 shows the geometric layout of the linac, the beam transfer line, and the storage ring. Main parameters of the linac and the storage ring are listed in table 1.

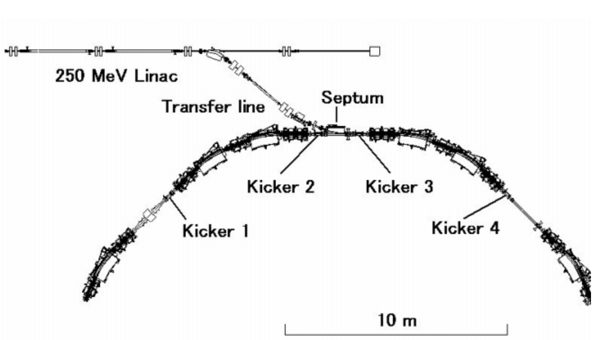

Figure 1: Injection area of SAGA Light Source

Table 1: Main parameters (designed) of the Linac and the Storage Ring

ELECTRON GUN and BUNCHER	
Thermionic triode gun	-120 kV
Grid pulser trigger	22.3125 or 89.25 MHz
Prebuncher RF frequency	714 MHz
Buncher RF frequency	2856 MHz
Macro-pulse	1 μs
Energy	6 MeV
LINAC	
Energy	250 MeV
Repetition rate	1 Hz
Rf frequency	2856 MHz
Micro-pulse length	4 ps
Micro-pulse charge	0.6 nC
Normalized emittance	25×10^{-6}m·rad
Energy spread (FWHM)	1 %
ELECTRON STORAGE RING	
Maximum energy	1.4 GeV
Circumference	75.6 m
Circulating current	100 mA
RF Frequency	499.8 MHz
Peak RF Voltage	500 kV
Betatron Tune (H / V)	5.796 / 1.825
Momentum Compaction	0.0134707
Natural Chromaticty (H/V)	-7.43/-7.32
Energy Spread	6.7×10^{-4}
Natural Emittance	25.1 nm·rad

BEAM TRANSFER LINE

The beam transfer line consists of a 40-degree bending magnet, a 20-degree bending magnet, two quadrupole doublets and a quadrupole singlet. The length from the 40-degree bending magnet to septum magnet entrance is about 6m. The linac room and the storage ring room are separated by radiation shielding wall of 1.6m thick. Figure 2 shows the layout of the beam transfer line and the septum magnet. BPMs represent beam profile monitors made of alumina-ceramic screens. Recently, two additional BPMs are installed. One is behind of the 20-degree bending magnet vacuum chamber for adjusting 40-degree bending angle and the other is just in front of the septum magnet chamber for direct observation of the beam profile at the septum magnet entrance. Two Current Monitors (CMs) are installed at 20-degree bending section. The electron beam spectra can be measured with 40-degree bending magnet combined with the CM. Another CM is for monitoring the beam current going into the septum magnet.

The beam transfer line works to transport the electron beam from the linac to the injection point of the storage ring, also to transform the Twiss parameters of the linac to those required by storage ring. The βx and βy at the end of linac are assumed to be 4.9m and η=0, respectively. Figure 3 shows the Twiss parameters matched to those of the storage ring. Though the storage ring dispersion function at the injection point is not zero, 0.6m, dispersion function at the septum end was fitted to 0.0m to minimize the beam size. The normalized emittance is $25\pi\times10^{-6}$m·rad. The beam sizes (2σ) at the end of septum are horizontal 2.5mm and 2.4mm in horizontal and vertical direction, respectively. It is small enough for the septum minimum aperture, 8ϕ.

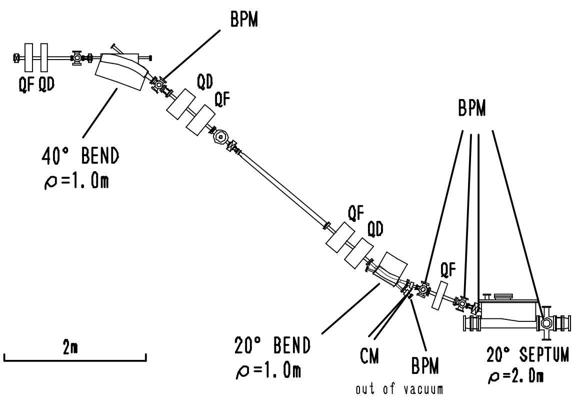

Figure 2: Transfer line layout

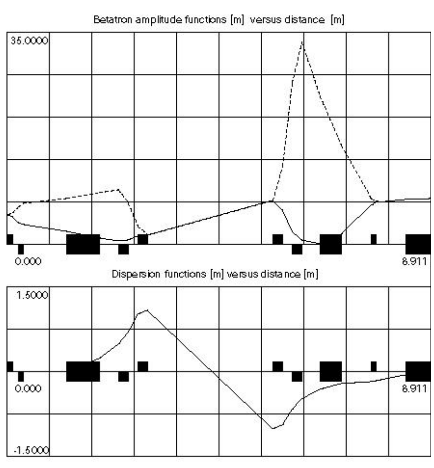

Figure 3: Matched Twiss parameters. The matching calculation was performed using Winagile.

INJECTION SCHEME

The electron beam is injected at 35mm from the equilibrium orbit of the storage ring. The bump orbit is required to be as close as possible to the injected beam. But the maximum shift of the bump orbit is restricted by septum wall and the stored beam size. In addition, the kicker strength shoud be as small as possible. The septum wall is in 25mm from the equilibrium orbit. We decided the kickers layout and the kicker specification to be able to generate 20mm bump at the injection point.

The storage ring lattice structure is complicated because of employing the compact DB(A). One 2.93m long straight section is too short to install all the necessary kickers. The injection bump orbit is therefore formed over three consecutive straight sections. Figure 4 shows the bump orbit generated by four kickers which are excited by sinusoidal electric currents with a half width of 1μs. At the nominal tune, the bump orbit must be turned off in 4turn (1μs) to prevent the injected beam from colliding with the septum magnet vacuum chamber wall.

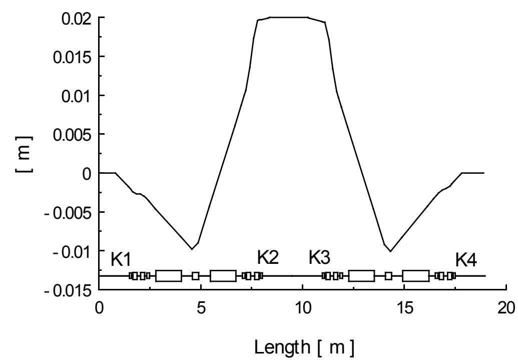

Figure 4: The injection bump with 4 kickers. The closed orbit shift and the slope at the injection point are 20mm and 0.0mrad respectively.

The advantage of using a 4 kicker system is that the the position and the angle of the bump orbit at the septum magnet be adjusted independentry. Three example of the injection bump patterns are listed in Table 2.

Table 2: Closed orbit shift and the slope at the injection point with 4 kickers and 3 kickers. -0.8mrad bump slope at the injection is generated with 3 kickers. The bump slope can be adjusted from 0mrad to -0.8mrad.

Kicker 1 [mrad]	2.84	2.84
Kicker 2 [mrad]	0.78	1.56
Kicker 3 [mrad]	0.84	0
Kicker 4 [mrad]	2.85	2.65
Closed orbit shift at injection point[mm]	20	19.1
Slope of the bump at injection points[mrad]	0	-0.8

INJECTION TRACKING

The tracking of 300 injected electrons distributed over 2σ has been performed using TRACY2. The sextupole is not considered, because the beginning of commissioning phase the sextupole is not turned on. Figure 5 shows the tracking results of horizontal phase space for the nominal injection (Electrons injected paralleled to the equilibrium orbit. The closed orbit shift and the slope at the injection point are 20mm and 0mrad, respectively.) The kickers are decreased linearly toward zero.

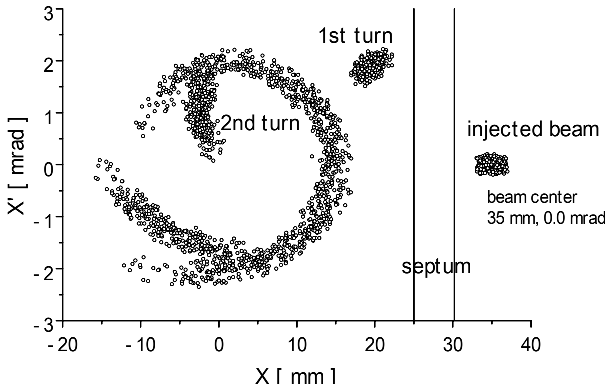

Figure 5: Evolution of the injected beam at the injection point for a 2σ beam.

The angle acceptances of the injected beam with the nominal bump and with the 3 kickers system are shown at figure 6 and figure7. In nominal injection, by increasing the injection angle the beam is blowing up. The allowable maximum injection angle is +2.5mrad. With smaller injection angle, the position of first turn moves to the septum inner wall. The allowable minimum injection angle is 0.8mrad. With 3 kickers system, angle acceptance is from -1.5mrad to -3.5mrad.

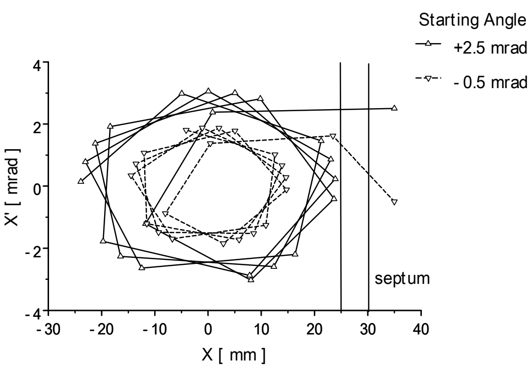

Figure 6: The angle acceptance with the nominal bump

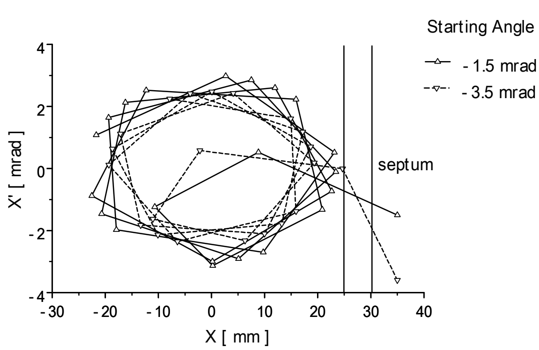

Figure 7: The angle acceptance with the 3 kickers system

Figure 8 shows the vertical angle acceptance is ±2.5mrad..

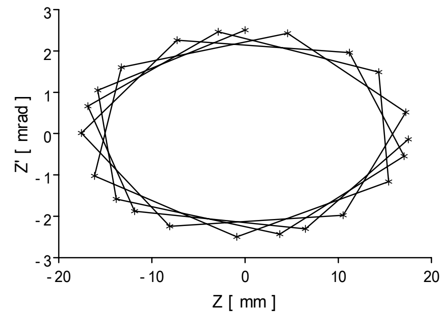

Figure 8: The vertical angle acceptance

The energy acceptance of the injection is shown at figure 9. The acceptance is ±1%. The linac beam energy spectra ΔE/E=1% is sufficient

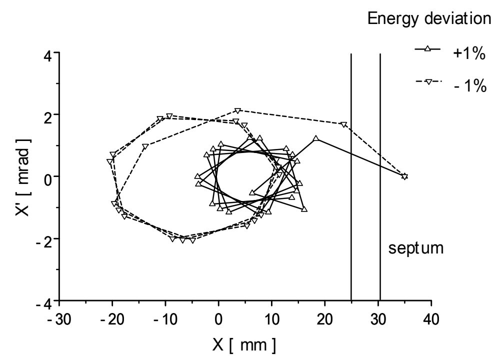

Figure 9: The energy acceptance for the nominal injection.

CONCLUSION

With the four kickers system it should be possible to inject the electron beam into the ring successfully at designed tune. The maximum horizontal angular acceptance for the injection beam is from +2.5mrad to -3.5mrad by optimising the kicker strength. The vertical angular acceptance and energy the acceptance are ±2.5mrad and ±1% respectively.

REFERENCES

[1] T. Tomimasu et al., "SAGA Synchrotron Light Source Design Report", (2001) in Japanese.
[2] TRACY user's manual, unpublished.
[3] Y. Iwasaki at al., "LATTICE DESIGN OF SAGA SYNCHROTRON LIGHT SOURCE", Proc. of the PAC2003,Portland(2003)3270.
[4] S. Koda at al., this proceedings.
[5] T. Tominasu at al., this proceedings.

0-7803-8859-3/05/$20.00