# The Saga Synchrotron Light Source I

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**Abstract**

The Saga 1.4-GeV third-generation synchrotron light source (SLS) with a distributed dispersion system is being constructed and is operated before the fall of 2004 in Tosu City, Saga Prefecture. The Saga 1.4-GeV SLS consists of an eight-fold symmetry storage ring with eight 2.95-m long straight sections and a 250-MeV electron injector. The circumference is 75.4 m and the emittance is 15 nm·rad at 1.4 GeV. Six insertion devices including a 7.5-T wiggler can be installed. The 250-MeV linac beam is used for electron injection and a 40-MeV linac beam is used for two-color infrared free electron laser (FEL) generation.

## I Introduction

We are constructing the 1.4-GeV third-generation synchrotron light source (SLS) with the double-bend achromat lattice and a distributed dispersion system for scientific researches and industrial applications in Tosu City, Saga Prefecture in the northern part of Kyushu-island to operate it before the fall of 2004.

Tosu City is 25 km north-east of Saga City and 25 km south of Fukuoka City. The Saga SLS project is operated by the Saga Prefectural Government. The site is 1.5 km west of Yayoigaoka station of the JR Kagoshima line.

The Saga SLS consists of a 1.4-GeV, low-emittance storage ring with eight 2.95-m long straight sections and a 250-MeV linac injector. The circumference is 75.4 m and the emittance is 15 nm·rad at 1.4 GeV.

The 250-MeV linac beam is used for electron injection and a 40-MeV linac beam is used for two-color infrared free electron laser (FEL) generation. The construction of the building starts in the fall of 2001 and the installation of the Saga SLS starts in the fall of 2002. We can supply high brilliant photon beams covering wavelength range from 0.036 nm (34 keV) to 60 $\mu$ m (0.021 eV) by using the Saga 1.4-GeV storage ring with six insertion devices including a 7.5-T wiggler and the two-color infrared FEL facility.

## 2 The Saga 1.4-GeV Storage Ring

The layout of the Saga 1.4-GeV third-generation storage ring, the 250-MeV linac injector and a two-color infrared free electron laser (FEL) facility [1] are shown in Fig. 1. The storage ring has eight double-bend achromatic cells and eight-fold symmetry with eight 2.95-m long straight sections. It has been designed by relaxing the constraint of zero-dispersion in the long straight section as MAX-II [2]. For various dispersion functions, the rms electron beam dimensions are calculated from the electron beam emittance, the horizontal and vertical beta functions, and the relative momentum spread, assuming 1 % coupling ratio in the vertical direction. Table 1 shows main parameters of the Saga storage ring beam at $\eta = 0.62$, the dipole, quadrupole, and sextupole magnets.

Eight 2.95-m long straight sections are used for six insertion devices (IDs), a septum magnet, a current monitor and an RF cavity. Their available lengths for IDs are 2.6 m x 5 and 2.2 m x 1. The beam ports of the first bending magnet of the cell are at the deflection angles of 0° and 5° and the beam port of the second bending magnet is at 4°. In total, twenty beam ports are constructed and more than twenty beam lines can be installed. All vacuum chambers are made of aluminum alloy. Their vertical aperture except the long straight sections is 36 mm and their horizontal aperture is 100 mm because the damping time is of the order of 1 second due to the 250-MeV injection. An HOM damped cavity with SiC beam-duct [3] is used for stable storage of high-current beam and the expected RF voltage is 500 kV.

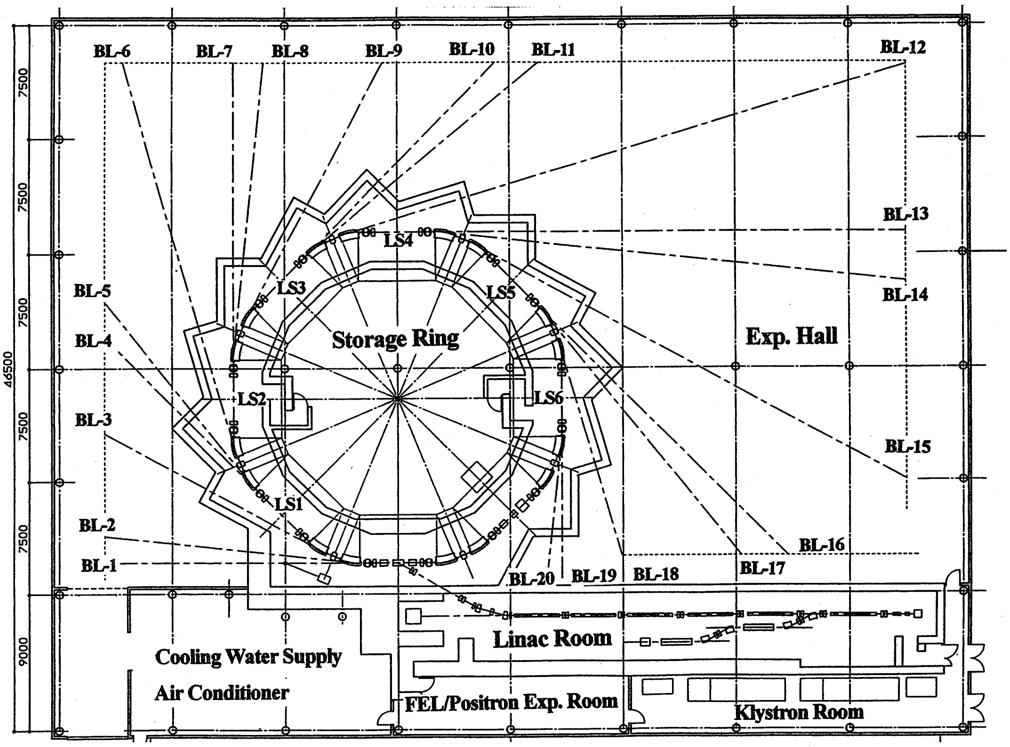


Fig.1 Layout of the 1.4-GeV Saga storage ring and the 250-MeV linac injector.

The Saga SLS provides space for the installation of six insertion devices. At the present time, we are planning to install a 7.5-T superconducting wiggler, two permanent magnet undulators, and four beam lines after the storage ring commissioning. The wiggler is to shift the synchrotron radiation spectrum to the hard X-ray region (critical energy $E_c$ = 9.8 keV) and a permanent magnet undulator ($\lambda_u$ = 5 cm, K=1.2, N=49) provide high intensity photons of 4.8 x $10^{15}$ [photons/s ・(0.1mrad)$^2$ ・(1%bw)$^{-1}$]. The wiggler is three-pole planar type as the 7.6-T wiggler of Electrotechnical Laboratory Tsukuba Electron Ring for Accelerating and Storage(ETL-TERAS) [4] and the 7-T wiggler of the Louisiana State University, Center of for Advanced Microstructure and Devices (LSU-CAMD) [5]. Orbital distortion induced at the 7.5-T wiggler operation can be corrected by reducing the exciting current applied to QF1-QD1 doublets installed on each side of the wiggler to 95~85 %, at most, of the exciting current applied to the other QF1-QD1 doublets. The insertion effect of the 7.5-T wiggler for the beam parameters is also shown in Table 1.

Fig. 2 shows the emittance of the existing or planned storage rings at 1.4 GeV as a function of its circumference. The

Table 1 Main parameters of the Saga storage ring and insertion effect of a 7.5 T wiggler.

| | | |
|---|---|---|
| Electron beam energy | 0.2~1.4 GeV | |
| Beam current & life | 300 mA & 5 hs at 1.4 GeV | |
| Circumference | 75.4 m | |
| Lattice | DBA x 8 (eight fold symmetry) | |
| Straight sections | 2.95 m x 8 | |
| Emittance (nm-rad) | 15 | 35 ( with a 7.5-T wiggler) |
| Tunes $\nu_x$, $\nu_y$ | 6.796, 1.825 | 6.796, 1.825 |
| Momentum compaction | 0.008074 | |
| Energy spread | 0.000672 | 0.00079 |
| Radiation loss (keV) | 106 | 123 |
| RF frequency (MHz) | 501.053 | |
| RF power & field | 90 kW & 500 kV | |
| Harmonic number | 126 | |
| Bunch length $\sigma$ (mm) | 8.8 | 10.35 |
| Beam sizes at straight section (coupling = 0.01) at $\eta$ = 0.62 | | |
| $\sigma_x$($\mu$m) | 580 | 680 |
| $\sigma_y$($\mu$m) | 34 | 52 |
| Injection energy (MeV) | 250 | |
| Dipoles & number | 11.25° edge focusing & 16 | |
| Radius & field | 3.2 m & 1.459 T | |
| Number of quadrupoles | 40 (16QF1, 16QD1, 8QF2) | |
| Length (m) | 0.2, 0.2, 0.3 | |
| Max. gradient | 27 T/m | |
| Number of s | 32 (16SF, 16SD) | |
| Length (m) | 0.10, 0.14 | |
| Max. gradient | 350 T/m$^2$ | |

solid line shows the present lowest emittance of the available small-scale storage ring. It well demonstrates that the Saga storage ringis of a compact and lowest-emittance type.

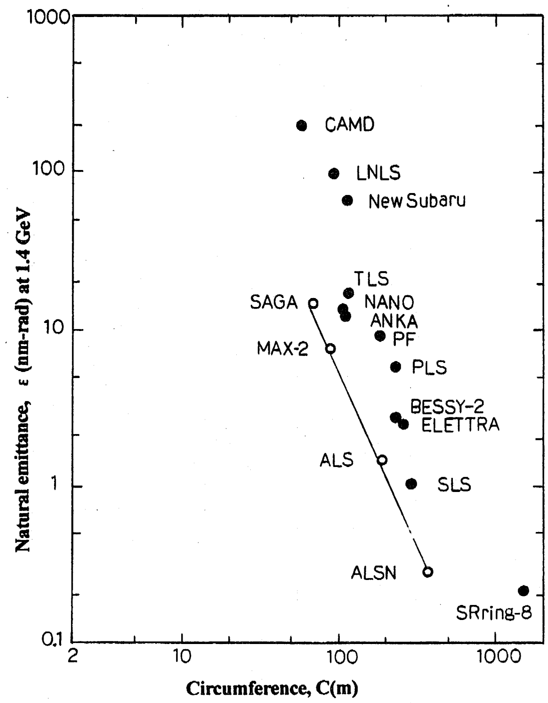


Fig.2 Emittance and circumference of existing and planned storage rings at 1.4 GeV.

## 3 The magnetic lattice and the 250-MeV Linac Injector

Fig.3 shows the magnetic lattice of the Saga ring with the distributed dispersion system. The 250-MeV linac injector is operated in two modes; 1-$\mu$s and 12-$\mu$s macro-pulse operations. The electron beam consists of a train of several ps, 0.6-nC microbunches repeating at 22.3125 or 89.25 MHz as the Free Electron Laser Research Institute (FELI) linac [6]. The 1-$\mu$s macropulse operation mode at the 250 MeV is for electron injection and an electron charge of 1.2 nC (0.6 nC x 20 pulses) is injected to the storage ring per second. The beam energy is ramped from 250 MeV to the operation energy after beam storage. Before installation of the 7.5 T wiggler in the fall of 2005, we expect that the stored beam current and its lifetime will be 300 mA at 1.3 GeV and 5 hours, respectively.

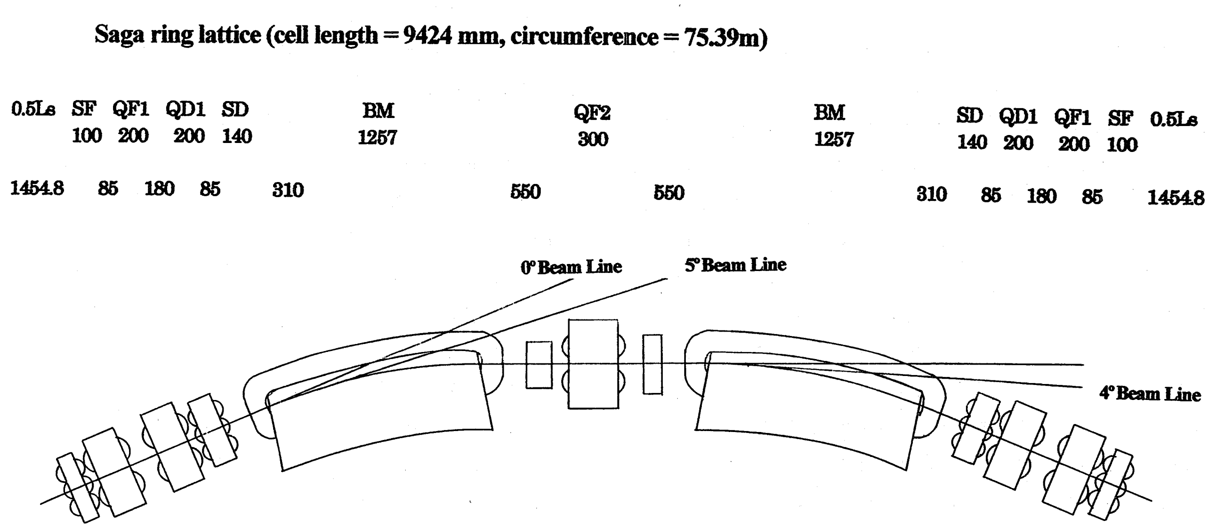


Fig.3 The magnetic lattice of the Saga ring.

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