PRESENT STATUS OF SYNCHROTRON RADIATION FACILITY SAGA-LS

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Abstract

SAGA Light Source (SAGA-LS) is a synchrotron radiation facility located in Tosu, Japan. The SAGA-LS accelerators consist of a 255 MeV injector linac and a 1.4 GeV electron storage ring with a circumference of 75.6 m. The SAGA-LS has been stably operated since the first user run in February 2006. Along with the user operation, machine improvements including upgrade on the control system of the injector linac, construction of a new septum magnet and beam diagnostic systems, installation of insertion devices have been made in the past years.

INTRODUCTION

SAGA Light Source (SAGA-LS) [1, 2] is a synchrotron radiation facility operated by Saga prefecture, a local government in Japan. Since the facility opening in February 2006, the SAGA-LS has been stably providing synchrotron light in a wide spectral range, from VUV to hard x-ray, covering most of the user needs in the field of synchrotron radiation research. There is a total of six operational beamlines in 2009. Figure 1 shows the current layout of the SAGA-LS facility. During the summer shutdown of 2008, experimental hall was expanded towards the east-side.

The SAGA-LS accelerator complex consists of a 255 MeV injector linac and a 1.4 GeV electron storage ring of 75.6 m circumference, the configuration of which is based on eight-fold symmetric double bend with finite dispersion in 2.5 m long straight sections. For fulfilling both the low emittance and small circumference, the non-zero dispersion lattice at the straight sections is employed [3]. The natural emittance is designed to be 25 nm-rad without insertion devices. Main parameters of the injector linac and the storage ring are summarized in Table 1.

The storage ring has been operated for 1739, 1265 and 960 hours in the fiscal years 2006, 2007 and 2008, respectively. Down time during the user operation was below 7% of the total operation time. The reduction of the user time in FY2008 is due to the shutdown for the facility expansion.

Weekly it has been operated from Monday to Friday. Machine studies have been performed on every Monday. In the user operation, beam injection is twice a day for 10 hours user time. The electron beam is not injected at full energy and the injected beam is ramped to 1.4 GeV at the storage ring. Prior to the user time, the stored beam orbit is corrected by a correction system for the closed orbit distortion (COD) using 24 beam position monitors (BPMs) and 40 steering magnets [4], where BPM offset to the quadrupole magnet center has been calibrated using a beam-based alignment method. The accuracy of the COD correction to the reference orbit is within 20 μm. The filling beam current is 250 mA which has been increasing from 100 mA in the past three years.

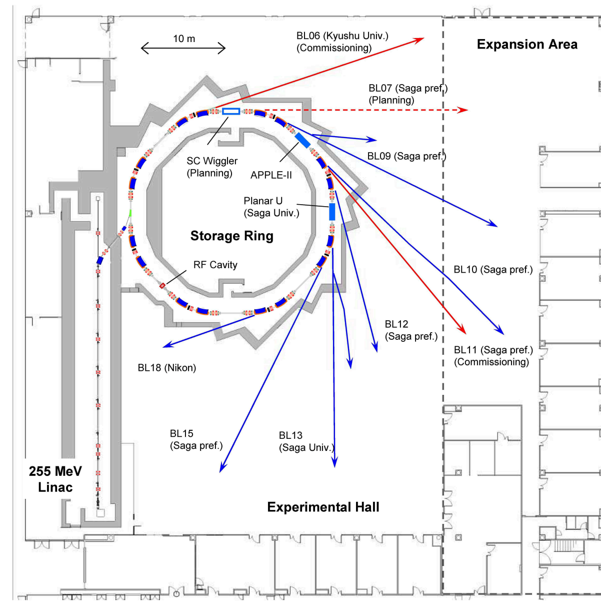

Figure 1: Layout of the SAGA-LS facility as of May 2009. The expansion area is indicated by dotted lines.

Table 1: Main Parameters of the Injector Linac and the Ring.

Injector Linac	
Energy	255 MeV
Repetition rate	1 Hz
RF frequency	2856 MHz
Macro-pulse width	200 ns
Macro-pulse charge	12 nC
Storage Ring	
Maximum energy	1.4 GeV
Circumference	75.6 m
Natural emittance	25.1 nm•rad
RF frequency	499.8688 MHz
Harmonic number	126
RF voltage	550 kV
Betatron tunes (H/V)	5.796/1.825
Energy spread	6.7×10^{-4}
Momentum compaction	0.013
Filling beam current	250 mA

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RECENT MACHINE IMPROVEMENTS AND DEVELOPMENTS

In parallel with the user operation, machine improvements and developments have been made in the past years to enhance the accelerator performance. Recent machine improvements and developments are described in the following sections.

Control System and a Grid Pulser of the Injector Linac

The control system of the injector linac is upgraded from manual control system to a computer based system. Currently, klystron modulator, electron gun and RF system of the injector can be controlled by the new system. This new system allows reliable operation and tuning of the injector linac. In addition, a grid pulser of the electron gun has been replaced with a new one, preparing for various bunch filling, such as single bunch operation, in the storage ring.

Septum Magnet

The in-vacuum type septum magnet used for beam injection has been replaced with a new out-of-vacuum type septum magnet [5] in December 2007. To improve the injection efficiency, the new spectrum magnet having an aperture of sufficient size has been carefully designed to reduce leakage field and ease its alignment and vacuum maintenance. The out-of-vacuum configuration (see Fig. 2) allows precise alignment of the magnet and the vacuum maintenance is greatly facilitated. With the use of the new septum magnet, the injection efficiency has been improved from 40 to 100 mA/min.

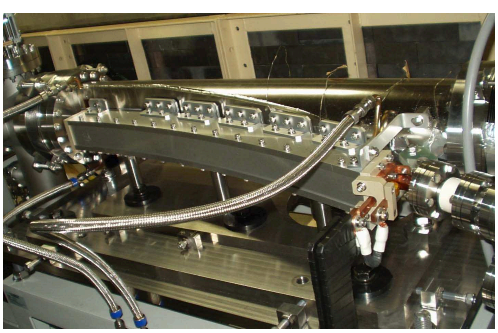

Figure 2: Photograph of the new out-of-vacuum type septum magnet.

Beam Diagnostic Systems

For the beam diagnostic, we have constructed two SR monitor beamlines of BL20 and BL21 in 2007. The BL20 is equipped with a SR interferometer [6] for the beamsize measurement and a streak camera for bunch length measurement. The vertical beamsize has been routinely obtained at every 1 sec for a precise lattice tuning and a control of the betatron coupling [7]. Figure 3 shows the SR interferometer constructed and a PC display of the beamsize monitor located in the control room. Besides the SR interferometer, a simple SR monitor system has been installed in the BL21 where SR is monitored by a CCD camera.

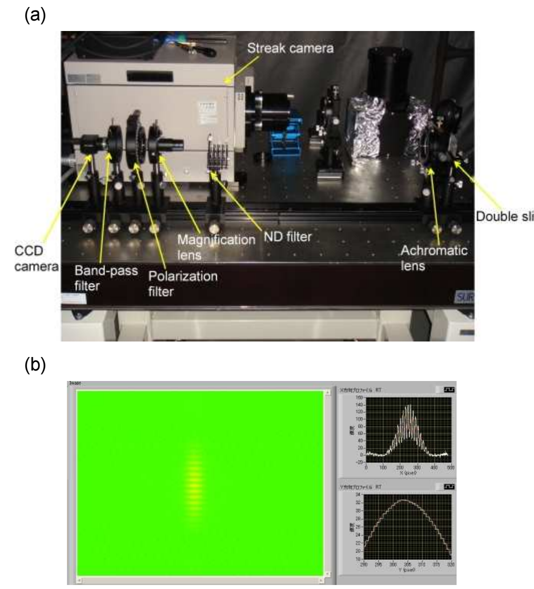

Figure 3: (a) Photograph of the SR interferometer constructed in BL20. (b) PC display of the beamsize monitor based on the SR interferometer. The beamsize information is obtained at every 1 sec.

Skew Quadrupole Magnet

For controlling the betatron coupling, a sextupole magnet was modified to produce skew quadrupole field [8]. To produce the skew field, auxiliary coil circuits used for a beam steering were modified. The betatron coupling was well controlled by the skew magnet.

Insertion Devices

The SAGA-LS storage ring has eight 2.5 m long straight sections, six of which are available for insertion devices. A planar type undulator of Saga University is in operation. In addition, an APPLE-II type undulator [9] has been constructed to produce variably polarizing light in the soft x-ray region. The period length of the APPLE-II undulator is 72 mm and the number of period is 28. The APPLE-II device can generate photons in an energy range from 30 to 1200 eV, and it has been installed during the winter shutdown of 2008 as in Fig. 4.

Following the installation, the APPLE-II undulator light has been delivered to a soft x-ray beamline for commissioning purpose. Along with the beamline commissioning, we have investigated influence of the undulator on the electron beam, resulting from the changes in the pole gap and phase. Based on the measurements, closed orbit distortion due to residual field integrals, and betatron tunes have been compensated by feed-forward controls. In addition to the effects on the orbit and betatron tune, a weak change of

Figure 4: Photograph of the APPLE-II type undulator.

the betatron coupling has been observed depending on the pole gap and phase. To minimize the effects on the betatron coupling, we will adopt a control method using a wire-type skew quadrupole magnet, which is similar to flat wires used in BESSY-II for multipole compensation [10].

In the near future there is a plan to install a superconducting wiggler (wavelength shifter) for generating high flux hard x-ray. This device can produce a peak magnetic field of 4 T on the beam axis, and hard x-rays up to 50 keV will be available for user experiments. Details of the magnet design and cooling method have been discussed. The install of the superconducting wiggler is planed in 2010.

Laser Compton Scattering

We have started construction of an experimental setup for a laser Compton scattering (LCS) experiment to generate MeV photons for a beam energy measurement and user experiments in future. The LCS experiment will be performed at the straight section of LS8 in the storage ring, which is used for the injection. Figure 5 shows a schematic drawing of the LCS experimental setup. Photons from a CO_2 laser of 10.6 μm wavelength are scattered with the 1.4 GeV electron beam in a head-on collision condition. The maximum LCS gamma-ray energy is 3.5 MeV. The electron beam energy is derived from the LCS gamma-ray spectrum. Since the energy acceptance of the storage ring (14 MeV at 1.4 GeV) is well above the maximum LCS gamma-ray energy, the LCS experiment can be carried out along with the user operation. The LCS event rate is estimated by a luminosity calculation in the laser-electron interaction region. The laser optical system is optimized to achieve the largest luminosity, resulting in the total LCS event rate $N_\gamma \simeq 2 \times 10^8\ s^{-1}$ with the beam current of 250 mA and laser power of 10 W.

SUMMARY

The synchrotron radiation facility SAGA-LS has been stably operated since 2006. To enhance the accelerator performance, machine improvements and developments have been made in the past years. Upgrade of the injector control

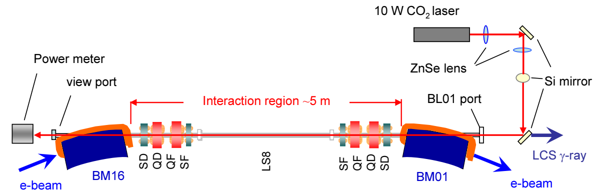

Figure 5: Schematic drawing of the LCS experimental setup.

system, replacement of the septum magnet, construction of beam diagnostic systems, development of the insertion devices were carried out.

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