PRESENT STATUS OF UVSOR ACCELERATORS

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Abstract

UVSOR has been successfully operated for 18 years, as a synchrotron light source opened for nation-wide users. The aged accelerator components have been replaced one by one, year by year, to keep the performance of the machine as high as possible.

To compete with the 3rd generation synchrotron light sources, we are proposing an upgrade plan, in which the number of straight sections for insertion devices will be doubled and the emittance will be reduced by a factor of 6. The lattice design was completed and the hardware developments are in progress.

This year, we have started a users experiment by using the free electron laser on UVSOR. We have found that the storage ring FEL is a very powerful tool for pump-probe experiments because of its high average power and natural synchronization with synchrotron radiation.

1 MACHINE OPERATION

UVSOR, a 750 MeV synchrotron light source, has been successfully operational since 1983. Although this is a relatively small light source, whose circumference is about 53m, it has totally 20 synchrotron radiation (SR) beam lines. About half of them are dedicated for in-house users and the remainders are opened for nation-wide users.

The UVSOR accelerator complex consists of a 15 MeV linac, a 600 MeV booster-synchrotron and a 750 MeV storage ring. Three insertion devices are installed in the ring. To keep the performance of the machine as high as possible, the aged components have been replaced one bye one, year by year. In 2000, the UVSOR accelerator complex was operated for about 43 weeks (including machine tunings) without serious troubles.

Typical operation pattern in a week is as follows. Monday and Saturday morning (from 9 to 13 o'clock) are assigned for machine tunings and machine studies. From Tuesday to Friday, the machine is operated for users. The beam is injected twice a day, at 9 and 13 o'clock. The beam is stopped at 18 o'clock. It can be extended until 21 o'clock if requested by users. On Thursday, the beam is injected additionally at 17 o'clock and is stopped at 21 o'clock. A typical beam current history in multi-bunch mode is shown in Figure 1. The machine is operated normally in multi-bunch mode and, only for a few weeks in a year, in single bunch mode.

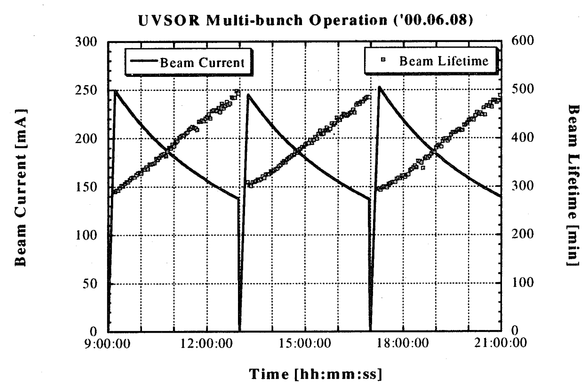

Fig.1 Typical beam current history in multi-bunch mode

2 RECENT DEVELOPMENTS

2.1 New Beam Position Monitor System

The beam position monitor (BPM) system was replaced this spring. Since mechanical switches are used in the old system to accumulate the signals from the pick-up electrodes, it took about one minutes to measure an orbit. In addition, the attenuator control of the BPM signals was not automated.

The new system comprises 16 signal-processing modules, which are commercial products of Bergoz Co. [1]. These modules give the beam position in horizontal and vertical as DC voltages. They are AD-converted and accumulated in a PC. The new system can measure one orbit in a second with resolution of a few microns. The detail of the new system is described elsewhere in these proceedings [2].

2.2 High Current Operation

The filling beam current in multi-bunch mode has been 250 mA in these years. As requested by some users, last winter, multi-bunch operation at 300 mA was tested. The beam stability, the temperature rises of the vacuum chambers and the radiation level of the experimental floor were observed and no problem was found. The users operation with 300 mA will be started soon. Higher current would be challenged after improving beam lifetime, which would be realized by some improvements on the RF cavity and the vacuum system.

2.3 In-vacuum Undulator

We have started developing an in-vacuum short period undulator in collaboration with the insertion device group

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of SPring-8. This type of device can produce high brilliance SR in the energy region higher than 100 eV, which cannot be produced by the existing undulators at UVSOR. In the upgrade project described later, this type of devices will play important roles.

The construction of the undulator will be finished until the end of this year. It will be installed at the place of the super-conducting wiggler, which was recently decided to be shutdown. The performance and its influence on the electron beam, such as resistive wall effects [3], will be checked. After finishing the performance test, an SR beam-line will be constructed and will be opened for users. Main parameters of the undulator are listed in Table 1. The expected undulator spectrum is shown in Figure 2.

Table 1. Parameters of In-vacuum Undulator

Magnet type	Pure Permanent (Nd-Fe-B)
Remanent Field	1.17 Tesla
Period Length	36 mm
Number of Period	26
Magnetic Length	936 mm
Overall Length	1.4 m
Minimum Gap	10 mm for low-β optics 20 mm for present optics
Max. K-parameter	2.77 for low-β optics 1.15 for present optics
Polarization	linear (horizontal)

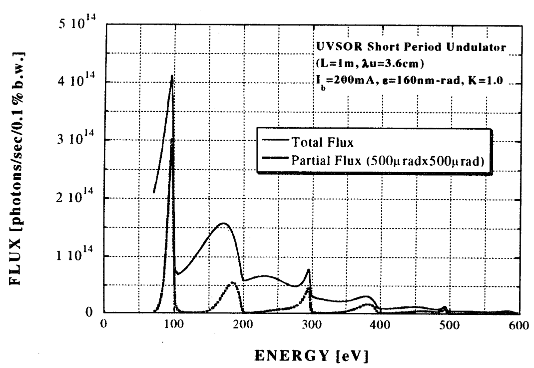

Fig. 2 The expected SR spectra from the in-vacuum undulator

2.4 Recent Progress in Free Electron Laser

The UVSOR free electron laser (FEL) has successfully oscillated in wide spectral range from 590 nm to 240 nm. Last winter, a users experiment was started, which utilized the natural synchronization between FEL and SR. The detail of this experiment was described elsewhere [4]. Towards the experiment, many efforts have been made to realize stable oscillation and high average power. Recently, we have achieved an average power of 1.2 W, which is the world highest record of a storage ring FEL, as shown in Figure 3. The beam lifetime was successfully increased by optimising the XY-coupling, without reducing the average power significantly. Transportation of the FEL beam to a SR beam-line, as shown in Figure 4, was successfully demonstrated and the synchronization between FEL pulses and SR pulses was confirmed.

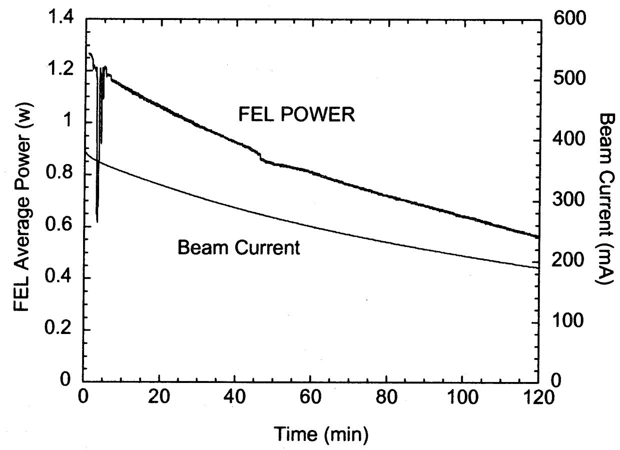

Fig. 3 Average output power of UVSOR-FEL

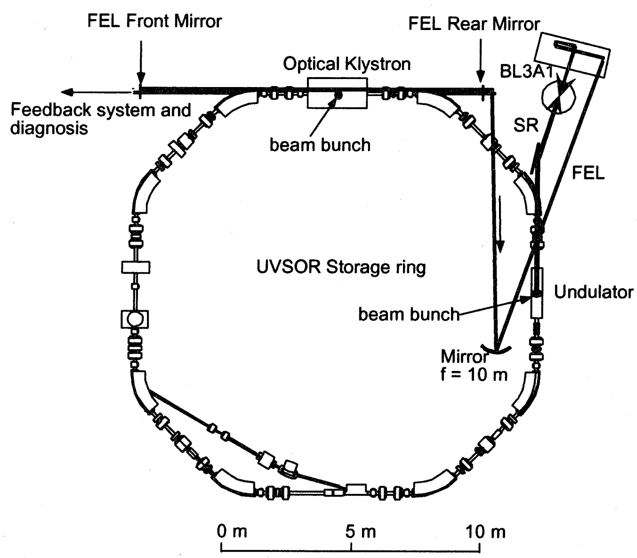

Fig. 4 FEL Transport Line
The FEL is transported to an undulator beam-line (BL3A1) by using a set of mirrors. The path length is adjusted so as to realize the synchronization between SR and FEL.

3 UPGRADE PLAN

We are proposing an upgrade plan of UVSOR, to compete with the 3rd generation light sources in the next decade. We have designed a new lattice [5], which has four new short straight sections and much smaller emittance (27nm-rad). The magnetic lattice and the optical functions are shown in Figure 5 and 6. Tracking simulations proved that the new lattice has sufficiently large dynamic aperture for injection and storage. The vertical betatron function at each straight section is small and optimised for installing narrow-gap insertion devices, such as a short-period undulator described in the previous section.

All the quadrupoles and sextupoles will be replaced with combined function magnets, which have capabilities of producing both quadrupole and sextupole fields. Construction of a prototype was completed and field measurements are in progress. The design of the vacuum system is in progress. The details of these works are described elsewhere in these proceedings [6].

To keep the beam lifetime long against the stronger Touschek effect on the low emittance optics, we are going to increase the RF accelerating voltage. We have to remove the heat problem of the input-coupler of the cavity, which is currently limiting the input power. We are going to replace the coupler in next spring.

Table 2. Main Parameters of UVSOR

	Present	Upgraded
Circumference	53.2 m	
Lattice Type	DBA	extended DB(A)
Number of Cells	4	4
Straight Sections	3m x 4	4m x 4, 1.5m x 4
Beam Energy	750 MeV	
Emittance	165 nm-rad	27.4 nm-rad
Energy Spread	4.2×10^{-4}	
Betatron Tunes	(3.16, 1.44)	(3.75, 3.20)
Nat. Chromaticity	(-3.4, -2.5)	(-8.1, -7.3)
XY Coupling	~10%	
Mom. Comp. Factor	0.026	0.028
RF Frequency	90.115 MHz	
Harmonic Number	16	
RF Voltage	46 kV	>80 kV
RF Bucket Height	0.74 %	>1.1 %
Max. Beam Current	250 mA	> 250 mA
Beam Lifetime (200mA)	~6 hr	> 6hr

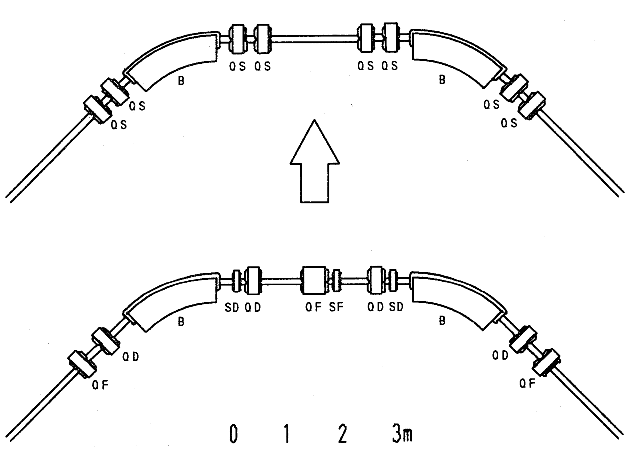

Fig. 5. Lattice modification
The lower is the present configuration and the upper is the upgraded one. One quadrant of the ring is shown.

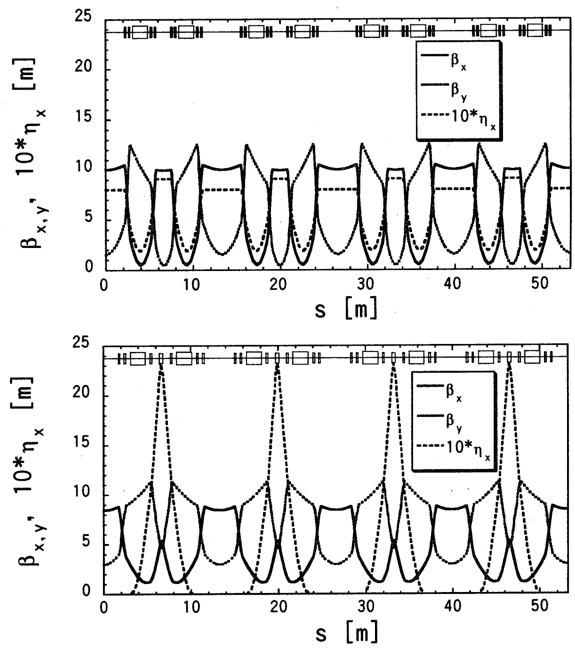

Fig.6. Optical functions of present (lower) and upgraded (upper) lattice

4 SUMMARY

UVSOR is a relatively small synchrotron light source, which was built early in 1980's. Although this is a typical 2[nd] generation light source, a moderate change of the magnetic lattice will convert this old machine to a high brilliance light source that can compete with the 3[rd] generation light sources in next decade. A new lattice was designed. The hardware developments are in progress. We are waiting for the budget.

We have started users experiments using the storage ring FEL on UVSOR. We have found that its high average power and its perfect pulse-to-pulse synchronization with SR make the FEL a very unique and powerful tool for pump-probe experiments.

We are confident that, as upgrading the machine and promoting the application of the storage ring FEL, UVSOR will survive in next decade among many synchrotron light sources as a unique facility dedicated for molecular science.

5 REFERENCES

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