UPGRADE PLAN FOR UVSOR

M. Katoh†, K. Hayashi, Y. Hori*, M. Hosaka, T. Kinoshita, A. Mochihashi,
Y. Takashima, J. Yamazaki, Institute for Molecular Science, Myodaiji, Okazaki, Japan

Abstract

An upgrade plan is proposed for UVSOR, a 750 MeV synchrotron light source. The magnetic lattice will be modified to make the emittance smaller by a factor of 6. New four short straight sections will be created, in adding to the existing four straight sections. All these sections will have small vertical betatron function, which is suitable for installing narrow-gap undulators. The lattice design was completed. Necessary accelerator components are under development, such as a combined-function magnet that is capable of producing both quadrupole field and sextupole field and an in-vacuum undulator that will produce high brilliance soft X-rays.

1 INTRODUCTION

Recently, in some of the 2nd generation synchrotron light sources, they have reconstructed or are planning to reconstruct their accelerators towards high brilliance [1, 2]. In some other light sources, they have tried to reduce the beam emittance by modifying the beam optics without hardware changes [3, 4]. All these efforts are to compete with the 3rd generation light sources and to survive as a modern light source.

UVSOR, a 2nd generation VUV light source of 750 MeV, has been operational since 1983 [5]. 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. For example, in 2000, the UVSOR accelerator complex was operated for about 43 weeks.

The present emittance of UVSOR is 165 nm-rad, which is a typical value of 2nd generation machines. Two undulators and one super-conducting wiggler are in operation. In most of the beam-lines, the SR from bending magnets is provided. It is strongly demanded by the users to install more undulators. It is also demanded to reduce the emittance to make the undulator radiation brighter.

We started a design work and have found a realistic solution [6]. A moderately small change of the magnetic lattice will give a smaller emittance by a factor of 6 and more straight-sections for insertion devices. We have proposed an upgrade plan based on this idea and are waiting for the budget. In this paper, we will describe the upgrade plan and will present some results from the recent developments on accelerator components.

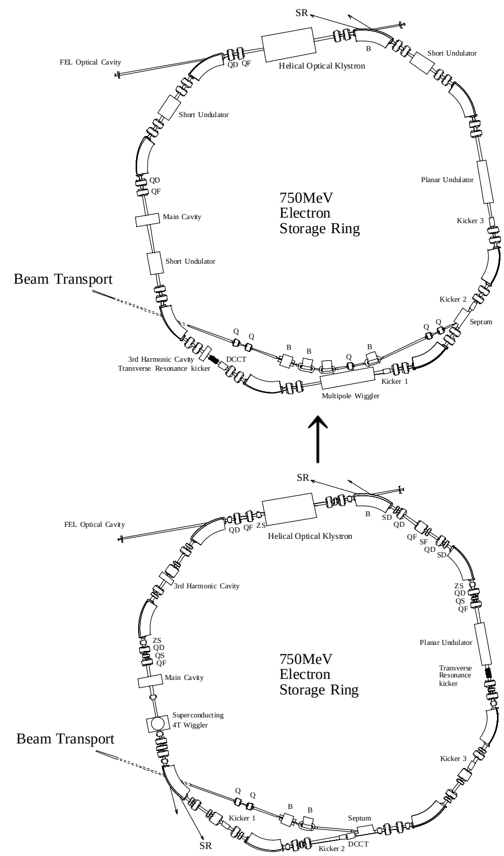

Fig. 1. Upgrade plan for UVSOR
The lower is the present configuration and the upper the upgraded one. The latter is a tentative plan and will be finalized discussing with the users.

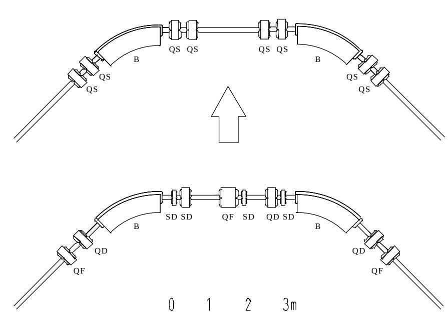

Fig. 2. Lattice Modification
Present (lower) and new (upper) lattice is shown.

†mkatoh@ims.ac.jp *A guest scientist from KEK-PF

Table 1. 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 x 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

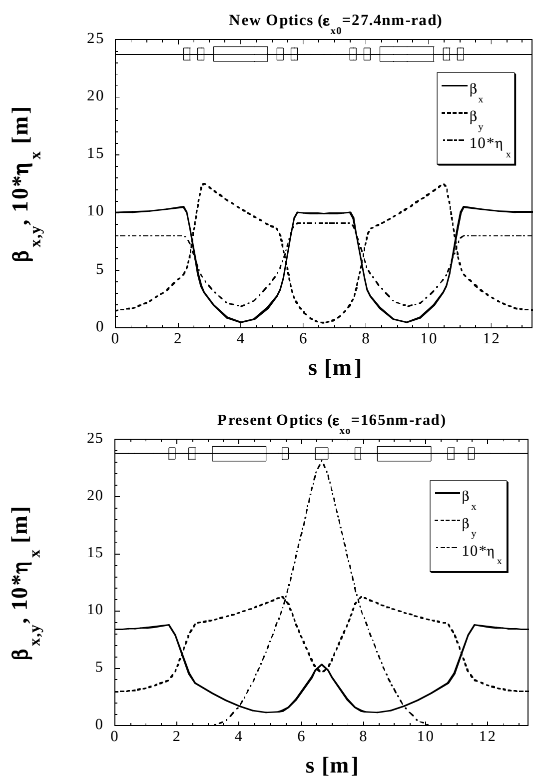

Fig.2. Optical functions of present (lower) and upgraded (upper) lattice (one quadrant of the ring is shown)

2 NEW MAGNETIC LATTICE

The present and new configuration of the UVSOR storage ring is shown in Figure 1. The magnetic lattice will be modified as shown in Figure 2. The original lattice consists of four DBA cells. There is a quadrupole triplet between two bending magnets. It will be replaced with two quadrupole doublets and a new short straight section of 1.5 m long will be created. In addition, the doublets in the present straight sections will be replaced with doublets of same configuration as in the short straight sections. The straight sections of currently 3 m will be elongated to 4 m. Finally, we can have four straight sections of 4 m long and four of 1.5 m long. Totally six undulators can be installed. The layout of the insertion devices and their beam-lines will be finalized after discussing with the users.

The optical functions will be changed as shown in Figure 3. The main parameters are summarized in Table 1. In the new lattice, the dispersion function has non-zero value in all the straight sections. In addition, the horizontal focussing is increased. Both of these contribute to reduce the emittance down to 27 nm-rad, which is smaller by a factor of 6 than the present value. The vertical betatron function at each straight section is small and optimised for installing narrow-gap insertion devices, such as in-vacuum short period undulators.

To make the newly created straight sections as long as possible, all the quadrupoles and sextupoles will be replaced with combined function magnets, which are capable of producing both quadrupole and sextupole fields. The details of the magnets are described in the next section.

Tracking studies have proved that the new lattice have sufficiently large dynamic aperture [6]. Totally four families of sextupoles will be used for compensating the linear chromaticity and optimising the dynamic aperture.

The stronger Touschek effect caused by the smaller emittance will be cured by increasing the accelerating voltage of the main RF cavity [6]. At present, a heat problem of the input coupler is limiting the voltage. The coupler will be replaced in spring 2002. In addition, the existing 3rd harmonic cavity, which is successfully operational [7], is also effective to improve the lifetime.

3 ACCELERATOR COMPONENTS

In the new lattice, the space is very tight. As in some of the modern light sources [8, 9], we are going to integrate the sextupoles in the quadrupole magnets. There are several types of configuration. We have adopted the configuration as shown in Figure 3. The shape of the iron core is same as the present quadrupoles. The auxiliary coils on the pole face (sextupole coils) produce dipole field and sextupole field. Other auxiliary coils on the poles (dipole correction coils) eliminate the dipole field. The main parameters of the magnet are summarized in Table 2. A prototype was constructed as shown in Figure 4. Field measurements are in progress. Some early results have shown that the quadrupole and sextupole field required from the lattice could be well achieved.

The vacuum chambers for the quadrupole doublets are under designing. Because of the space limitation, the chambers will be pumped by NEG's integrated in them. New pickup electrodes for beam position monitor will be installed on these chambers.

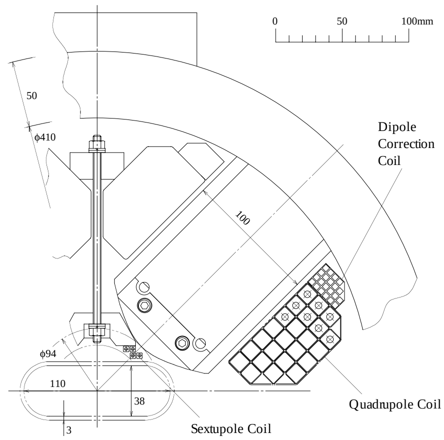

Fig.3 Combined-function (quadrupole/sextupole) magnet (cross-sectional view)

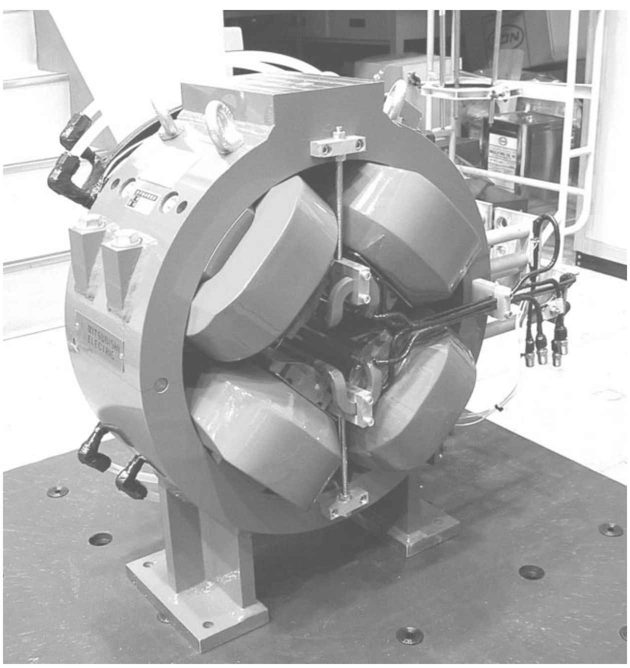

Fig.4 Prototype of the combined function magnet (Constructed by Mitsubishi Electric Co.)

Table 2. Parameters of focusing magnets

Core Length	0.2 m
Bore Diameter	94 mm
Quadrupole Coil	625A x 24 turns
Sextupole Coil	400A x 4 turns
Dipole Correction Coil	40A x 21 turns
Maximum Quadrupole Field	15 T/m
Maximum Sextupole Field	35 T/m^2

4 IN-VACUUM UNDULATORS

In the new lattice, the small vertical betatron function at the straight sections will make it possible to install narrow gap devices. We have started developing an in-vacuum short period undulator in collaboration with the insertion device group at SPring-8. This type of device can produce high brilliance SR in the energy region higher than 100 eV, even with the beam energy of UVSOR.

The construction of the undulator will be finished until the end of 2001. It will be installed at the place of the super-conducting wiggler, which we have recently decided to shutdown. The performance of the undulator and its influence on the electron beam, such as resistive wall effects [10], will be checked.

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)

5 SUMMARY

UVSOR is a relatively small synchrotron light source, which was built early in 1980's. A moderately small change of the magnetic lattice will convert this old machine to a high brilliance light source that can compete with the 3rd generation light sources in the next decade.

ACKMOWLEDGEMENT

The development of the in-vacuum undulator is a joint study of UVSOR and Spring-8/RIKEN (Drs. H. Kitamura, T. Hara and T. Tanaka) supported by the Joint Studies Program (2000-2001) of the Institute for Molecular Science.

REFERENCES

[1] M. Katoh et al., J. Synchrotron Rad. 5 (1998), 336
[2] S. Brennan and R. Hettel, Synchrotron Radiation News, Vol.11, No. 1 (1998), 25
[3] E. B. Blum et al., Proc. 1999 PAC (New York, 1999), 2304
[4] A. Nadji, Proc. EPAC 2000 (Vienna, 2000), 1057
[5] M. Kamada et al., J. Synchrotron Rad. 5 (1988), 1166
[6] M. Katoh et al., Nucl. Inst. Meth. A467-8 (2001), 68
[7] K. Tamura et al., Jpn. J. Appl. Phys. 33, L59
[8] M. Barthes et al., Proc. 9th International Conference on Magnet Technology (Zurich, 1985), p.114
[9] M. Eriksson, Proc. Of 5th European Particle Acc. Conf. (Sitges, 1996), 72
[10] K. Bane and S. Krinsky, Proc. 1993 PAC (1994), 3375