UVSOR UPGRADE PROJECT

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Abstract

An upgrade project of UVSOR has started in FY2002. The original DBA lattice will be modified to have smaller emittance and more straight sections available for insertion devices. All the quadrupole and sextupole magnets will be replaced as well as their beam ducts. An in-vacuum undulator will be installed. A part of the injection linac will be replaced. Re-construction and re-commissioning will be completed until summer 2003.

1 INTRODUCTION

UVSOR, a second-generation synchrotron light source of 750 MeV, has been operational since 1983 [1]. This relatively small storage ring, whose circumference is 53 m, is providing VUV and soft X-rays to 20 experimental stations. We have proposed an upgrade plan for UVSOR, in which the emittance will be reduced by a factor of 6 and the number of straight sections will be doubled [2]. Fortunately it was soon approved. In this fiscal year (FY2002), the UVSOR upgrade project has started. Fabrication of the accelerator components will be completed until the end of FY 2002. Reconstruction of the accelerators will be started in March 2003 and will continue for about three month.

2 MAGNETIC LATTICE

The magnetic lattice will be modified as shown in Figure 1. The original lattice consists of four DBA cells. The quadrupole triplet between two bending magnets will be replaced with two doublets and a 1.5m free space between them. In addition, the doublets in the present straight sections will be replaced with more compact ones. As the result, we will have four straight sections of 4 m long and four of 1.5 m long.

The optical functions will be changed as shown in Figure 2. 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.

Table 1. Main Parameters of UVSOR

	Present	Upgraded
Circumference	53.2 m	
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	300 mA	> 300 mA
Beam Lifetime (200mA)	~6 hr	> 6hr

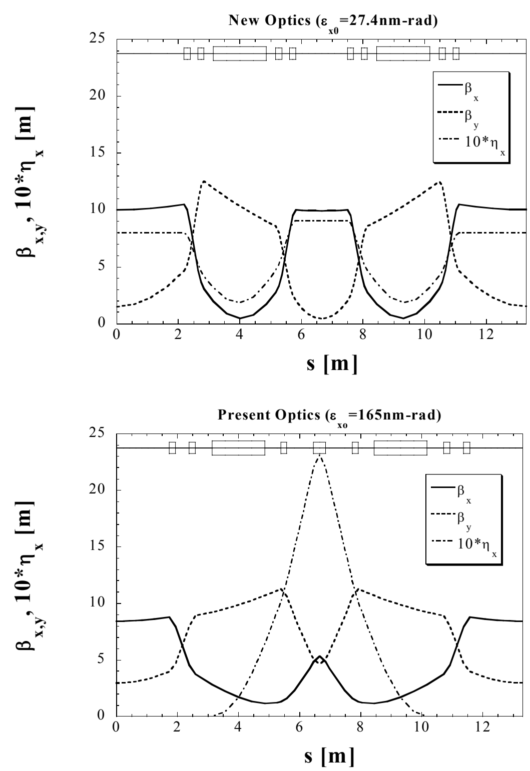

Fig.1. Optical functions of present (lower) and upgraded (upper) lattice. One quadrant of the ring is shown.

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3 ACCELERATOR COMPONENTS

3-1. Multi-pole magnets

To create four additional straight sections as shown in Figure 2, we are going to integrate the sextupoles in the quadrupoles as in a same manner described in ref. [3]. The multi-pole magnets have auxiliary coils on the pole face (sextupole coils) and on the poles (dipole correction coils) as shown in Figure 3. The main parameters are summarized in Table 2. Field measurements on a prototype showed that the quadrupole and sextupole field required from the lattice could be well achieved [4].

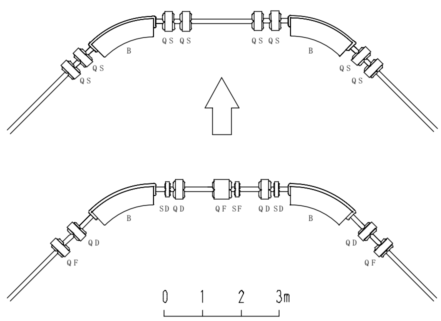

Fig.2 Present (lower) and new (upper) lattice
One quadrant of the ring is shown.

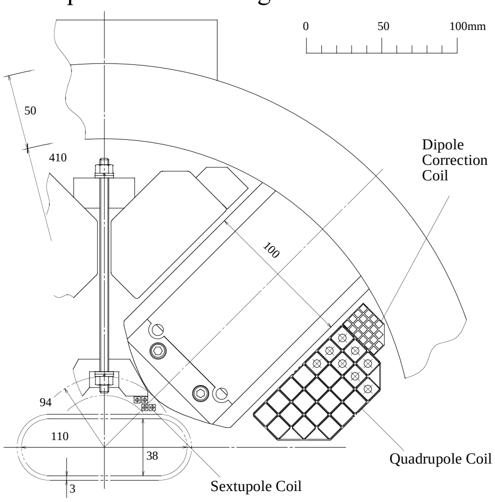

Fig.3. Cross-sectional view of the multi-pole magnet
One quadrant is shown.

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
Good Field Region (quadrupole)	+ - 40 mm

3-2. Vacuum system

The beam ducts at straight sections will be made of same material (SUS) and will have same cross-section (110mm x 38mm racetrack) as the present ones. New ducts will have cooling-water channel on the outer sidewalls, preparing for the future increase of the beam current. They have one pumping port, on which an SIP and a TSP will be installed, at each doublet of the multi-pole magnets.

Three of eight bending ducts will be replaced to be fit the upgraded beam lines. Since a numerical estimation suggested that reinforcements on pumping at bending sections would effectively reduce the average pressure, the new ducts will have a TSP on an additional pumping port, in adding to DIP. Other five bending ducts will be replaced one by one in future.

3-3. RF system

The RF system of 90 MHz, including the third harmonic cavity [5], will not replaced during this project. Since a higher gap voltage is required to keep the lifetime long against the Touschek effect [1], we have replaced the RF input coupler during the spring shutdown 2002, which had limited the input RF power for many years. New coupler has basically same configuration as the old one, but there are some improvements, such as a thicker coupling loop and TiN coating on the ceramic window to prevent multipactor effect. The new coupler is successfully in operation for the same RF power as in the past operation, which is about 7 kW. The maximum output power of the present RF power source is 20 kW. The performance for higher RF power will be tested just before the coming summer shutdown.

3-4. Beam Monitors

We have 16 beam position monitor (BPM) heads in the ring, all of which are installed on the both ends of the bending ducts. During the project, new 8 BPM heads will be installed at both ends of four long straight sections, preparing for more precise orbit control, especially at undulators. The signal processing system, which was already upgraded last year [6], will be expanded during the project.

We will have 16 vertical steering magnets and 8 horizontal steerers utilizing the auxiliary windings on the bending magnets. We are going to construct a slow (<1Hz) orbit feedback system using these correctors and the BPM system described above.

We are going to install a photon beam position monitor, at the front-end of a beam line, to observe the orbit movement more precisely.

3-5. Injectors

The injector of UVSOR consists of a 15 MeV S-band linac and a 600 MeV booster synchrotron. During the project, we have replaced and upgraded some parts of linac, including electron gun. The upgraded linac will have capability of single bunch injection to the booster synchrotron and the storage ring.

3-6. Undulators

New lattice has short but low-β straight sections, as described previously, which are suitable to install in-vacuum and short period undulators. We constructed an in-vacuum undulator shown in Figure 4, collaborating with RIKEN/SPring-8 [4]. This undulator was already installed this spring. The performance test is in progress. Second in-vacuum undulator will be constructed during the project. The parameters will be almost same except for the period length of 3.8 cm and the number of periods of about 50, which is twice larger.

4 SUMMARY

UVSOR will be converted to a high brilliance light source that can compete with the 3rd generation light sources in the next decade.

Configuration of UVSOR storage ring just after the reconstruction is shown in Figure 5. We will have totally three undulators. Two of which (U3A, U7A) are in-vacuum type described above and the remainder is a helical undulator (U5A) parasitically used for free electron laser [7]. Several beam lines will also upgraded during this project.

After this reconstruction, we are going to continue upgrading the machine. Two short undulators of about 1m long will be installed in near future at the straight sections between B3 and B4, and between B5 and B6. The present main RF cavity will be removed and new cavity, which is capable of producing higher gap voltage, will be installed at the free space in the straight section for injection. The long straight section between B6 and B7 will be available for new optical klystron for free electron laser. The present helical optical klystron/undulator at B4-B5 section will be converted to a pure undulator, which can be done by some rearrangement on the magnetic arrays [7].

5 ACKNOWLEDGEMENT

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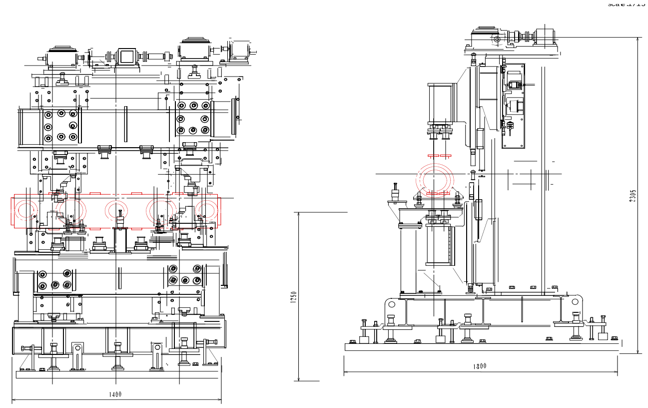

Fig. 4. 1st in-vacuum undulator in UVSOR (U7A). The overall length is 1.4 m (flange to flange), the period length, 36mm, the number of periods, 26 and the minimum gap, 8mm[4].

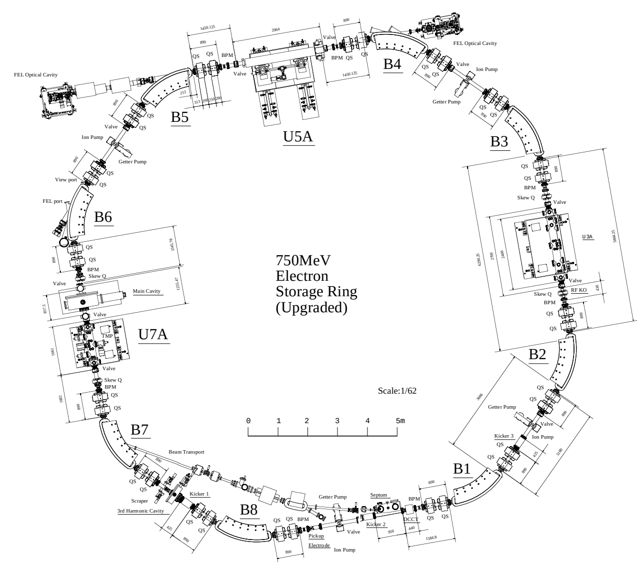

Fig. 5. Configuration of UVSOR storage ring just after the reconstruction

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