PRESENT STATUS OF UVSOR

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UVSOR constructed at the Institute for Molecular Science is an electron storage ring dedicated to synchrotron radiation research in molecular science and its related fields. The construction started in 1981, and the first beam was stored on 10th of Nov. in 1983. The maximum beam current up to this time is 200 mA and the e-folding lifetime of the beam is about 2 hours at the beam current of 100 mA. The injection energy of the ring is 600 MeV, and the injected beam can be accelerated up to 750 MeV. The critical wavelength of the synchrotron radiation from the ordinary bending magnets is 56.9 Å at the electron energy of 600 MeV. A superconducting wiggler of which magnetic field is 4T is installed in 1984. This field strength gives the critical wavelength of 16.2 Å at 600 MeV. An undulator with permanent magnets was also constructed. Single bunch operation was tried successfully. Some experimental works using synchrotron radiation have just started in 1984.

Introduction

The light source is a 600 MeV (max. 750 MeV) storage ring, the injector of which is a 600 MeV synchrotron with a 15 MeV linac. The main parameters of the light source are tabulated in Table 1. The ratio of the circumferences of the storage ring to the synchrotron is 2 and the RF cavities are driven by the same radio frequency, therefore the synchronized transfer of the bunched beam is easy.

Fig.1 shows the plane view of the UVSOR facility. The synchrotron and the storage ring are underground for radiation safety. Electrons of 600 MeV extracted from the synchrotron are transported under the floor of the storage ring room and injected from the inner side of the ring. Optical instruments are installed around the ring. During the injection period experimenters must be out of the storage ring and after the injection, they can reenter the room.

Table 1 Main Parameters of UVSOR

	Designed	Achieved
Linac		
Energy	15 MeV	15 MeV
Frequency	2.856 GHz	
Synchrotron		
Energy	600 MeV	600 MeV
Circumference	26.6 m	
Periodicity	6	
Bending Radius	1.8 m	
Tune (Q_H, Q_V)	(2.25, 1.25)	
Harmonic Number	8	
Radio Frequency	90.1 MHz	
Repetition Rate	1~3 Hz	2.5 Hz
Storage Ring		
Energy	600 MeV (max 750MeV)	750 MeV
Critical Wavelength	56.9 Å	
Current	500 mA	200 mA
Lifetime	1 hr (500 mA)	2 hr (100 mA)
Circumference	53.2 m	
Periodicity	4	
Bending Radius	2.2 m	
Bending Field	0.91 T	
Tune (Q_H, Q_V)	(3.25, 2.75)	
Harmonic Number	16	
Radio Frequency	90.1 MHz	
RF Voltage	75 KV	
Radiation Damping Time		
Horizontal	45.4 mS	
Vertical	40.9 mS	
Longitudinal	19.5 mS	
Emittance		
Horizontal	$8\pi \times 10^{-8}$ m.rad	$16\pi \times 10^{-8}$ m.rad
Vertical	$8\pi \times 10^{-9}$ m.rad	

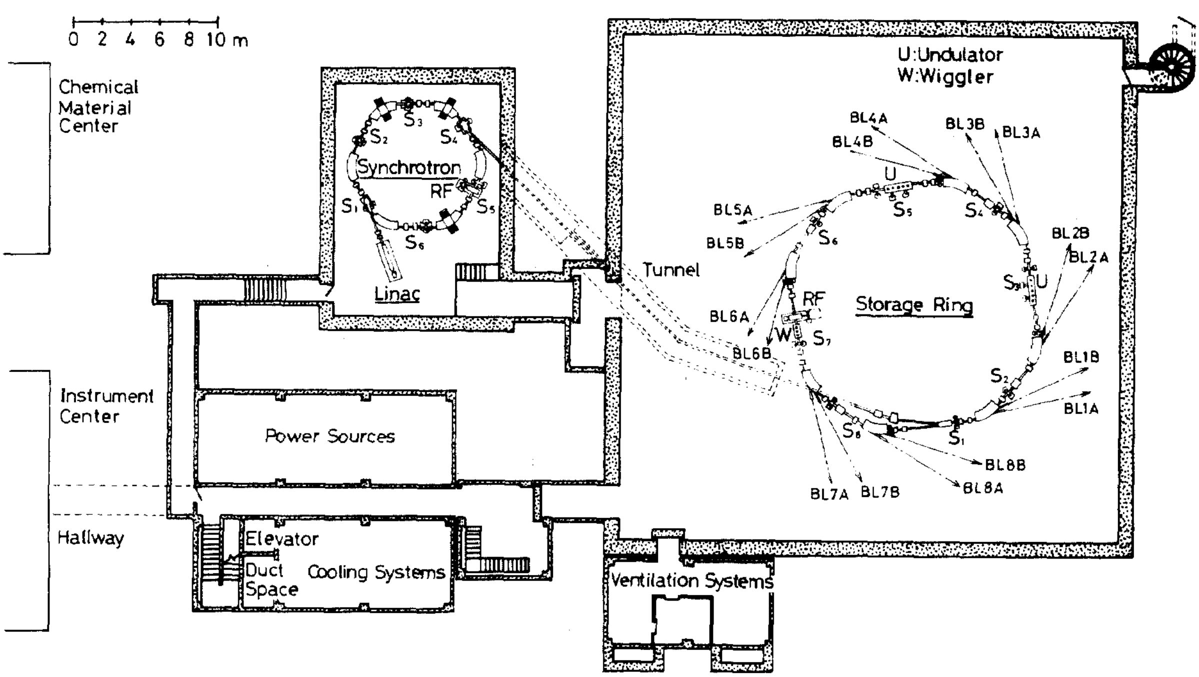

Fig.1 Plane View of UVSOR

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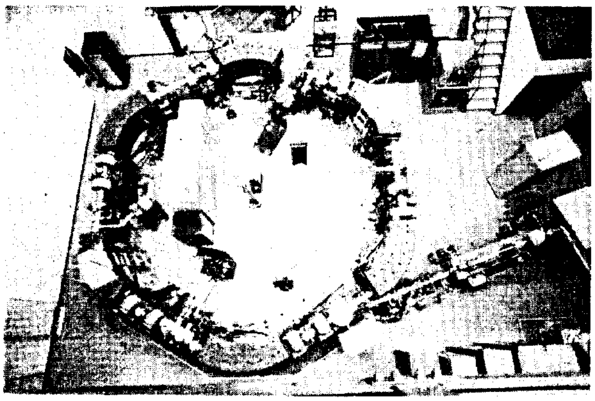

Fig.2 Synchrotron

Synchrotron

The preinjector of the synchrotron is a 15 MeV linac. The frequency of the microwave of it is 2.856 GHz and the peak power of the klystron is 7 MW (10 KW average). Two lengths of electron beam can be chosen, 1.5 μs for the ordinary operation and 5 nS for the single bunch operation. The electron beam from the linac is transported in the beam line where a doublet of quadrupoles, steering magnets and a momentum analyzer are set.

The synchrotron consists of six bending magnets, six doublets of quadrupoles six long straight sections and six short straight sections. An electro-static septum for the injection, a fast kicker magnet,a septum magnet for the extraction, an RF cavity and electrodes for the RF knockout system are installed in the long straight sections. Three pulse magnets which form a bumped orbit for the injection are installed in a long straight section and two short straight sections. Six position monitors and two current transformers are set in the short straight sections. The picture of the synchrotron is shown in Fig.2.

The wave form of the excitation current of the shnchrotron magnets is triangular.The acceleration period is 150 mS and the repetition rate is 2.5 Hz. As the repetition rate is rather high in existing slow cycling machines, and the ratio of the maximum magnetic field to the injection field is high, the tracking between the excitation current of the bending magnet and the quadrupoles is difficult. In order to solve the problem, the coils of the bending magnets and the quadrupoles are connected in series and they are excited by a main power supply. The sub-coils of the quadrupoles are excited by two power supplies to trim the operating point.

Electrons are injected and captured by the RF system. The captured current is 20~30 mA, and the beam loses considerable part in several msec. The final current of the synchrotron is about 5 mA and the fluctuation of the current is somewhat large. The beam loss and the fluctuation seem to be due to the difficulty of the tracking between the bending magnets and the quadrupoles. Though these problems have to be solved, the final current is enough to fill the storage ring in several minutes.

Storage Ring

The storage ring is composed of eight bending magnets, and four long and four short straight sections as shown in Fig.1. In each long straight section, two doublets of quadrupoles and two vertical steering magnets and a skew quadrupole are installed. In each short straight section a triplet of quadrupoles and that of sextupoles are installed. A septum magnet for the injection sits in a vessel which is located in S1 straight section, and three pulse magnets which form an injection bumped orbit are installed in S1, S2 and S8 sections. The vacuum systems of the vessel for the septum and the storage ring are separated by a thin polyimide film (thickness of 50 μm). An RF cavity is located in S7 straight section. The cavity is excited by 20 kW power amplifiers. Sixteen position monitors are attached at both sides of each vacuum doughnut for bending section. A DC current transformer to measure the electron beam current is set in S1, horizontal and vertical scrapers in S5 and electrodes for an RF knockout system in S6. A superconducting wiggler and an undulator are installed in S7 and S3 respectively. The picture of the storage ring is shown in Fig.3.

Trim colis wound on eight bending magnets and eight vertical steering magnets are available to correct the orbit distortions. Maximum horizontal and vertical orbit distortions without the correction are ±5 mm and ±3.6 mm respectively. The correction reduces the orbit distortions to ±2 mm and ±1 mm respectively.

Injection energy of the storage ring is 600 MeV, and the stored beam can be accelerated up to 750 MeV. The test of acceleration was tried successfully.

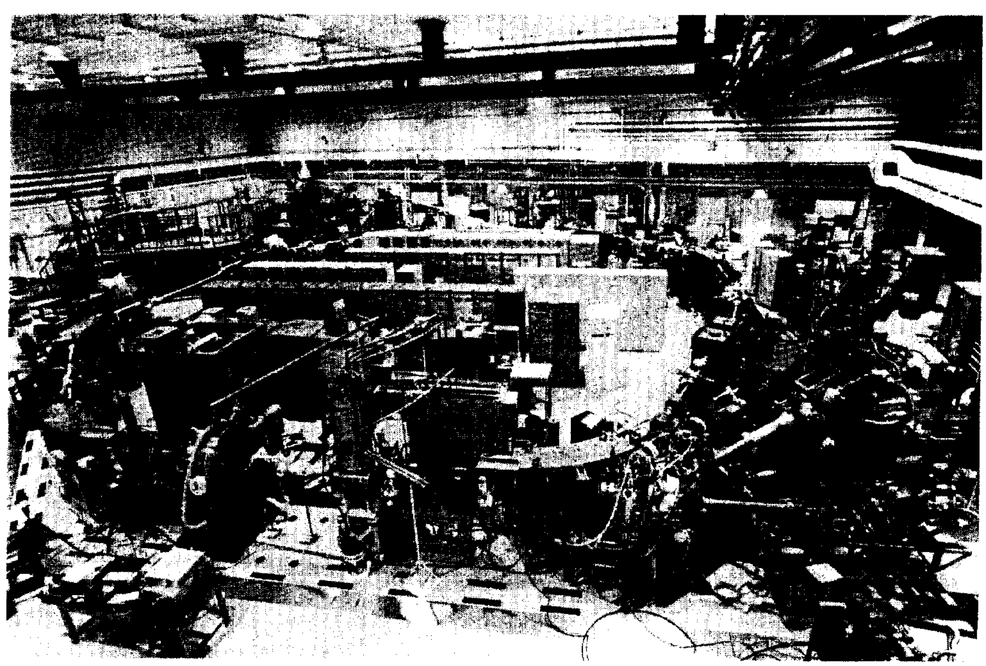

Fig.3 Storage Ring

The tunes of both planes were determined by the RF knockout system. The beta functions for both planes and the energy dispersion function were measured. There are four groups of quadrupoles. Excitation current of one group was perturbed and the tune shift due to the perturbation was measured. The beta function can be determined by the tune shift. The orbit distortion due to the change in the frequency of the RF acceleration system was measured to determine the energy dispersion function. The results of the measurements are shown in Fig.4. Designed beta functions and energy disersion function are shown by solid lines. Circles and crosses in the figure show the measured beta functions, and triangles show the measured energy dispersion function. The measured beta functions and energy dispersion function agree well with the designed ones. The chromaticity was measured and was corrected by means of the sextupole magnets.

The maximum current of 170 mA was achieved in December 1983. We have not tried to increase the current more than 200 mA, since the rated current of a DC current transformer was 200 mA. The beam current will be increased without any difficulty.

Fig.5 shows feature of accumulation and damping of the beam observed in the routine operation. The required beam current was 40 mA, and the injection of the beam into the ring was performed twice on that day. A current of 40 mA was accumulated in a few min. The lifetime in which the stored current of 40 mA decayed till 1/e was about 4 hours.

The maximum magnetic field of the permanent magnet undulator with 35 periods is 0.3 T and the maximum field of the three pole wiggler is 4T. Though the closed orbit was deformed slightly by the undulator, the lifetime was not influenced. Electron beam was able to be injected and stored in the ring when the wiggler was excited with the maximum field level. However it was necessary to excite a correction quadrupole and a vertical steering magnet which were installed near the wiggler. The detailed descriptions of the undulator and the wiggler will appear in this proceedings.

The beam properties of the storage ring were measured in detail. Results of the measurements will also appear in this proceedings.

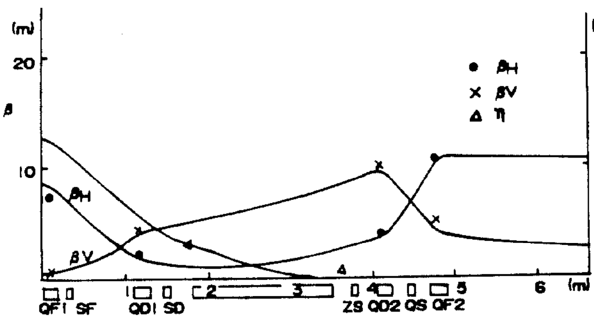

Fig.4 β and η Functions

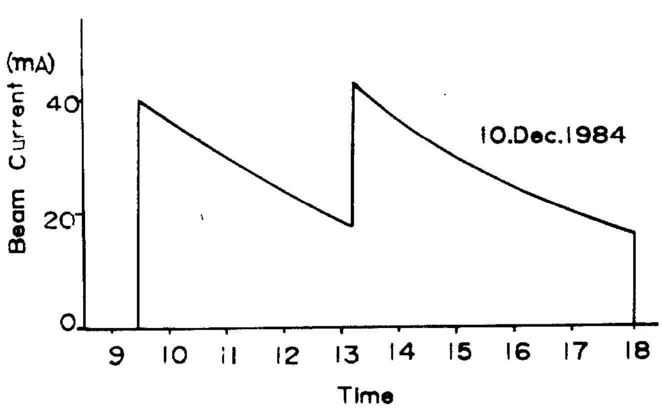

Fig.5 Accumulation and Damping of Beam

Single Bunch Operation

Two methods to store a single bunch in the storage ring were tried.[2] First, nano-second grid pulser method was tested. The grid of the electron gun of the linac is excited by a short pulse which is synchronized to a certain bucket of the synchrotron, and only this bucket can be filled with electrons. Another method is an RF knockout method. All bunches except two bunches in the synchrotron are destroyed by a deflector which excites a betatron side band, and one of two survivors is transfered to the storage ring. As the radio frequency systems of the two rings are synchronized, it is easy to transfer the bunch from the bucket of the synchrotron to the bucket of the storage ring. As the ratio of the harmonic numbers of the two rings is 2, two buckets of the storage ring are synchronized to a bucket of the synchrotron. Therefore the transfer timing must be synchronized to either of the two buckets.

The single bunch formed by the RF knockout method is shown in Fig.6. Upper and lower traces in the figure show the cavity voltage and the signal from a button monitor. Only one bucket in sixteen buckets is occupied. Single bunch purity required by users is better than 99 %, i.e. background current must be less than 1 %. We have no way except oscillograms of the single bunch to measure the low background current precisely at present. The background current measured by the oscillogram is less than few percents. These two methods to form the single bunch can be used together to improve the purity.

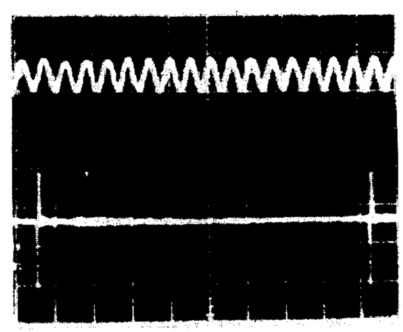

Fig.6 Single Bunch in Storage Ring (20 ns/div)

References

1 T. Kasuga et al., Beam Position Monitoring System in UVSOR Storage Ring, in Proceedings of the 5th Symposium on Accelerator Science and Technology, 1984, pp. 145-147.

2 T. Kasuga et al., Single Bunch Storage in UVSOR Storage Ring, in Proceedings of the 5th Symposium on Accelerator Science and Technology, 1984, pp. 295-296.