Status of the UVSOR Accelerator Complex in 1996

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1. General

Beside scheduled shut-off term at each four-season, some unexpected beam-time losses were caused by malfunctions of many devices. Most of those losses were compensated by additional beam supply in the night. However the troubles have gotten occurred frequently because of the wornout. In these years, many devices, particularly old power supplies for pulse magnets, have been replaced by new one. Basic equipments like a cooling water system and electricity system have become suffering troubles.

Operation time is going to reach the usual level and integrated beam current seems to be a bit higher than that of last year because the beam lifetime is getting longer due to optimization of the storage ring operation and maybe an improvement of the vacuum. As the average ring vacuum in the operation has been gradually improved, the lifetime is obviously increased as shown in Fig. 2. Although, the lifetime was shortened by 20 % in December because of the operation of the superconducting 4T wiggler, the lifetime has improved to 10 hours at 100 mA at the usual multibunch operation. A typical variations of the beam current and the lifetime in a day are shown in Fig. 2. One can see that synchrotron radiation is mostly supplied with the beam current higher than 100 mA.

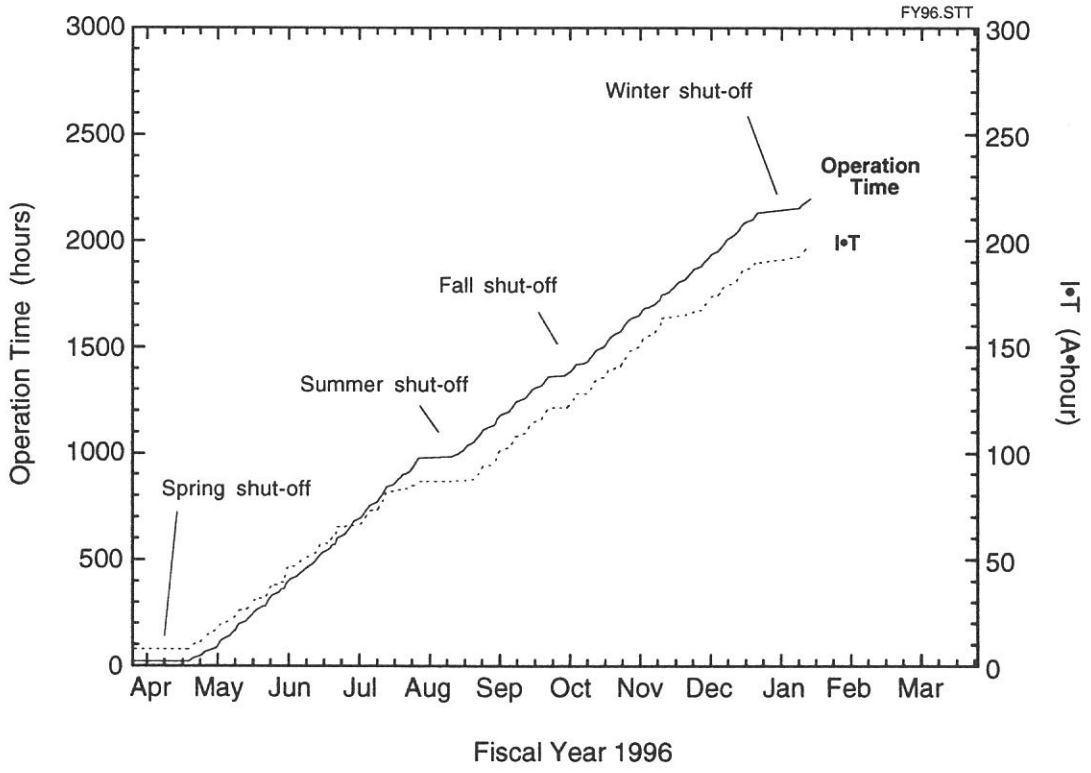


Fig. 1 Progress of operation time of the storage ring, and integrated beam current (IT) in fiscal year 1996.

2. New equipments

A new helical undulator in optical klystron mode was installed in the spring shut-off term. At the moment, the optical klystron-type undulator is used for free electron laser (FEL) experiments. However it was designed to be switched to the helical undulator by replacing the magnets at the dispersive section. Correction of the magnetic field had been already done for the both mode. At the same time a new beam pipe for the undulator straight section was installed. The chamber made of aluminum is a so-called "ante-chamber" type and contains NEG (non-evaporation getter pump) strips to improve the vacuum. The NEG pump is extremely easy to be operated because no power supply is required after an activation.

RF power amplifiers for the acceleration cavities in the storage ring and the synchrotron were also replaced by new ones completely composed of many transistor amplifiers. Each identical unit of transistor amplifier generates power of 600 W maximum. In case of a couple of units are in failure, the whole system can, however, continue to run without any fatal errors. Consequently the maintenance of the system is expected to be easy.

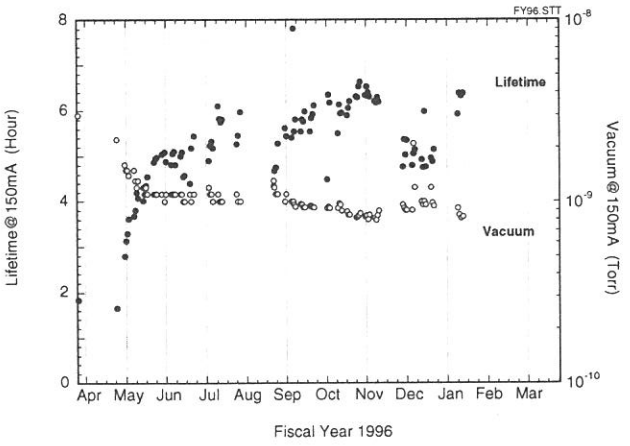


Fig. 2 Progresses of the beam lifetime and the average ring vacuum at 150 mA-beam storage.

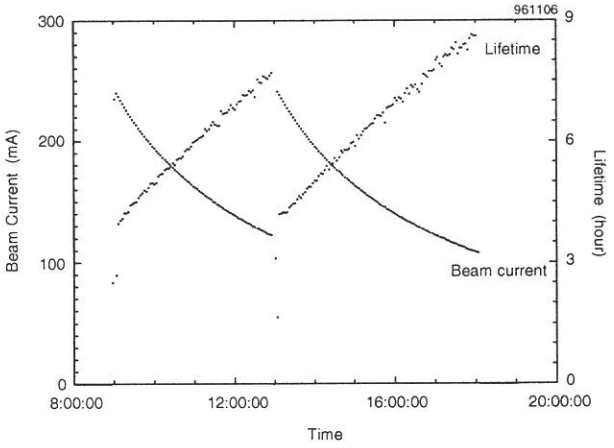


Fig. 3 Typical one-day variations of the beam current and the lifetime at the usual multi-bunch operation.

An old pulse high-voltage power supply for the synchrotron inflector was replaced. Because improper discharge was occurred frequently in the old one, the new one has been specially designed for the electrical insulation.

Fast-switching pulsers for bump-orbit magnets (perturbator) in the storage ring have been getting frequently failed too. As a test module, one pulser was fabricated using a transistor switching circuit (IGBT). A very smooth and fast pulse discharge (1.5 μs in rise time) were obtained, and then the pulser has been put into practice since last December. Although there were some minor troubles, it works very well at the moment. We are going to replace the whole system for the bump-orbit in the next year, if there will be no serious trouble in the test run.

3. Troubles

Beside hardware troubles on the accelerator complex, we have experienced a lot of serious errors on the basic equipments. Particularly the cooling water system has damaged so much. This is also due to exhausted parts. In addition to water leakage and quick degradation of water, an extremely abnormal pressure was discovered in the piping for secondarily circuit going round cooling towers.

It is still under investigation. Moreover on a very cold day in last January, some parts of water circuit in a cooling tower exploded probably due to frozen out. There are two sets of cooling towers, it is able to be managed by one cooling tower. However as it gets warm, heat load may exceed the capacity. It is apparent that these elementary equipments have been also very old and not perfectly maintained. Although most of troubles on the system fill be fixed soon, a management system including crew members should be established for the next ten years.

The superconducting wiggler stopped to run in the beginning of 1997 because of a trouble on the 4 K refrigerator. We found an oddly transformation of the Joule-Thomson valve, however cause of the trouble has not been completely identified yet. We are still trying to find it and hope to fix it in very near future.

The electron gun of the linac is also in an unusual state after exchanged to re-assembled one in December. Assembling of the cathode and the grid was probably wrong. The electron beam was not able to be extracted by the normal bias voltage between the cathode and the grid mesh. Because there was not another electron gun available, we tried to extract the beam by changing the bias voltage and focusing field and finally succeeded to extract ~ 50 % intensity of normal current of the beam. The gun is still used because the electron current is enough for the booster synchrotron. However this type of the gun is also much antiquated, and only two facilities remain to use it. To secure a possibility to procure when the gun fails, it had better to remodel the linac system if possible.

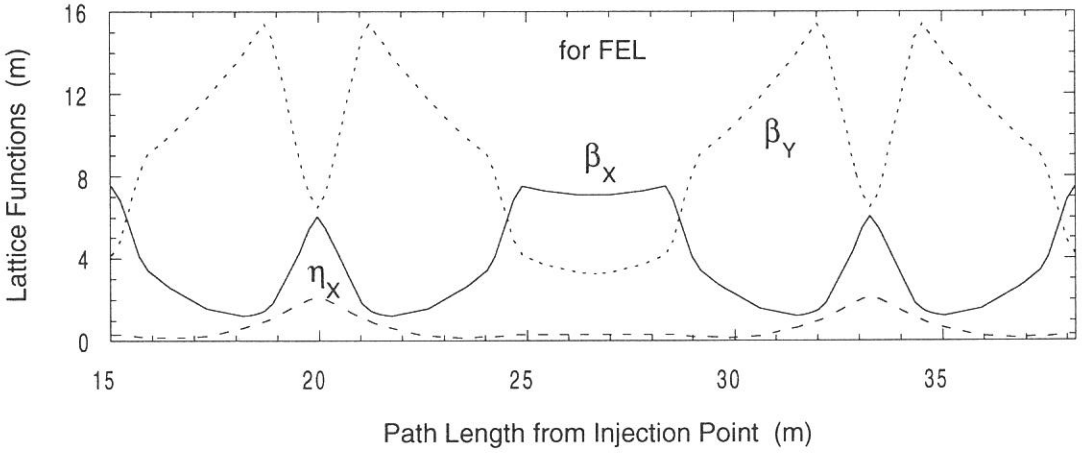


Fig. 4 A new lattice function for the FEL experiment with the helical optical klystron. Betatron tune numbers are 3.2 and 1.2 for horizontal and vertical planes, respectively.

4. Summary

The machine time was consumed almost properly in spite of many troubles. Performance of the storage ring itself has been still improved. For instance, a global orbit correction software for various operation modes has been completed. A new operating point with a different lattice function has been developed to optimize the ring to the helical optical klystron (see Fig. 4), and an FEL oscillation at the shortest wavelength of the world record (239 nm) was obtained. Nevertheless we emphasize an importance of care in the background. In these years many old devices have been replaced. However the number of troubles happened on the facility seems to go beyond our effort. To keep competitive performance and continuous development on the UVSOR, a reliable maintenance program for a long term range should be confirmed.

ACCELERATOR COMPLEX

Injection Linac

Energy	15 MeV
Energy Spread	~ 1.6 MeV
Frequency	S-band 2.856 GHz
Acceleration	2π/3 Traveling Wave
Length	2.5 m
Klystron Power	~ 1.8MW

Booster Synchrotron

Lattice Type	FODO
Energy	600 MeV
Beam Current	32 mA (8-bunch filled)
Circumference	26.6 m
Super Cell	6
Bending Radius	1.8m
Betatron Number	2.25 (horizontal)
	1.25 (vertical)
Momentum Compaction α	0.138
Harmonics	8
RF Frequency	90.115 MHz
Repetition Rate	2.6Hz

Storage Ring

Lattice Type	Chasman-Green
Energy	750 MeV
Critical Energy	425 eV
Circumference	53.2 m
Super Cell	4
Bending Radius	2.2 m
Betatron Tune	3.16 (horizontal)
	2.64 (vertical)
Momentum Compaction α	0.032
Harmonics	16
Emittance	$1.15\ 10^{-7}$ m rad (horizontal)
	1.15×10^{-8} m rad (vertical)
Beam Size	0.39 mm (horizontal)
	0.26 mm (vertical)
Bunch Length	170 ps (at zero current)
Beam Current	Multi-Bunch 200 mA
	Single-Bunch 50 mA
Lifetime	4 h at 200mA
	9 h at 100mA

Additional Equipment

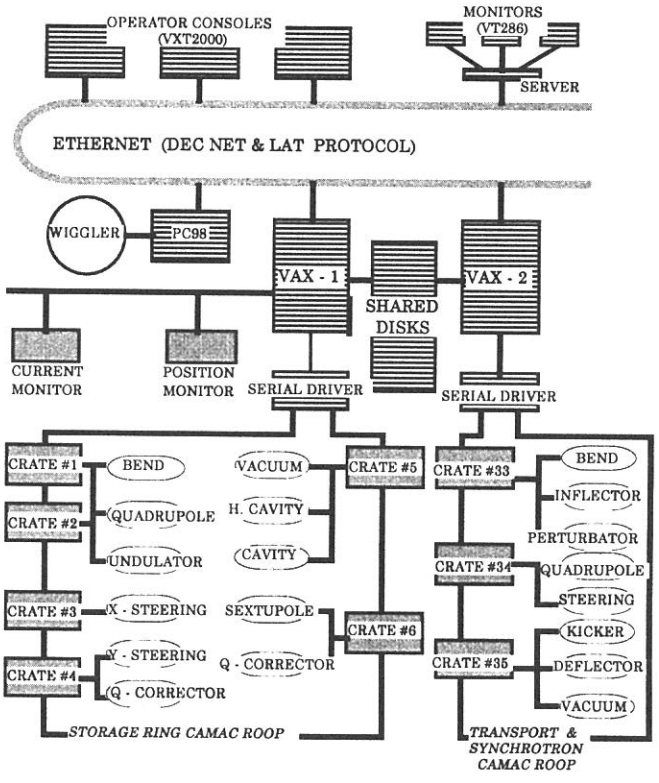
Higher - Harmonic Cavity	3 × 90.115 Mhz
Superconducting Wiggler	4 T (maximum)
Undulator	for SR
Helical Optical Klystron	for FEL

Control System

Preface: Based on Dual-Host system with CAMAC loop and friendly man-machine interface

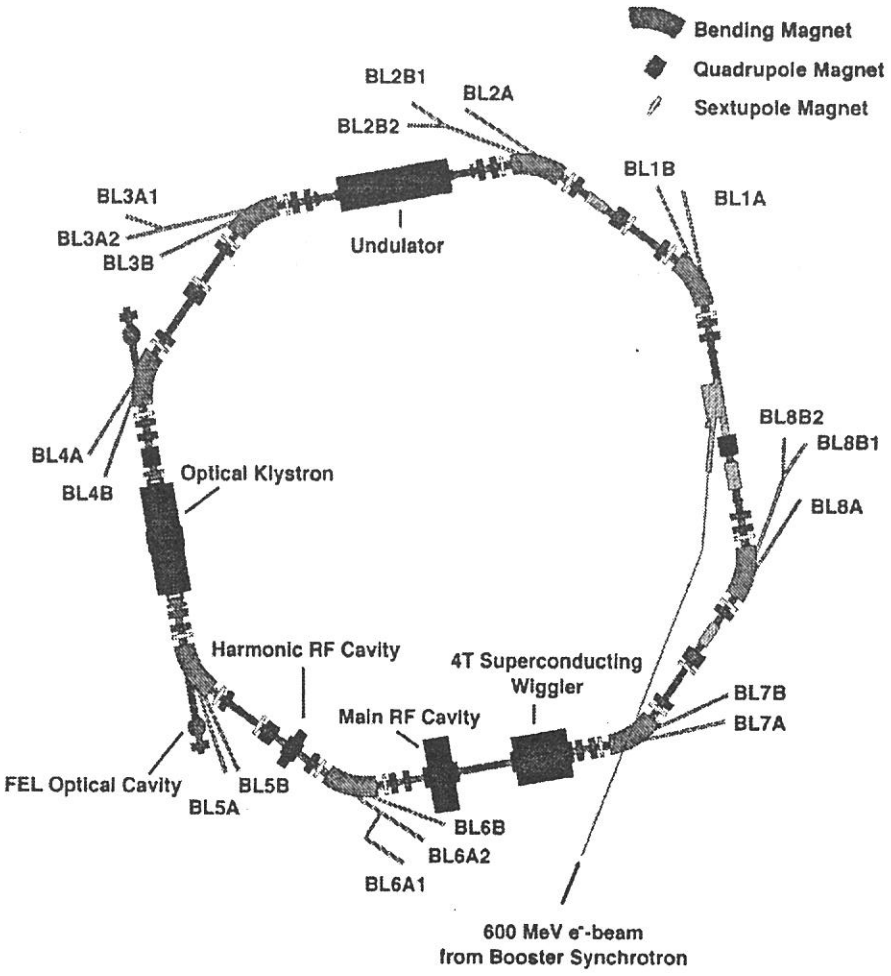
Architecture

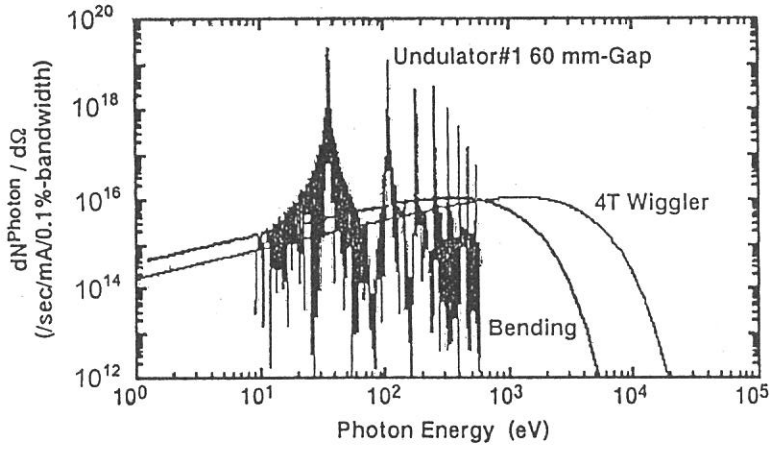
CPU	VAX4000 (× 2)
OS	VMS
Connection	DECNET & Local Cluster
Operator Console	X - Servers (VXT200 × 3)
Status Monitors	VT286s + Macintosh
Interfaces	CAMAC serial loop
	GPIB for Beam Monitors
	RS232C for Host CPU of Wiggler
Languages	FORTRAN, C, Pascal



Scheme of Accelerator Control System "UCOSS"

The UVSOR 750 MeV Storage Ring





On-Axis Photon Intensity with 750 MeV-Electrons