Current Status of Light Source and Beam Lines

Light Source in 2000

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1. Machine Operation

In 2000, the UVSOR accelerator complex was operated for about 43 weeks (including machine tunings) as scheduled. Fortunately, there was no serious trouble during this year. Monthly statistics of the operation time is shown in Figure 1. Three weeks in this year were assigned for single bunch users operation and other two weeks were dedicated for machine studies. We had four shut down period, around the new years day (two weeks), in spring (three weeks), in summer (three weeks) and in autumn (one week).

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 as requested by users. On Thursday, the beam is injected additionally at 17 o'clock and is stopped at 21 o'clock. The filling beam current is 250 mA in multi-bunch mode and 70 mA in single bunch mode. Typical beam current histories in both modes are shown in Figure 2.

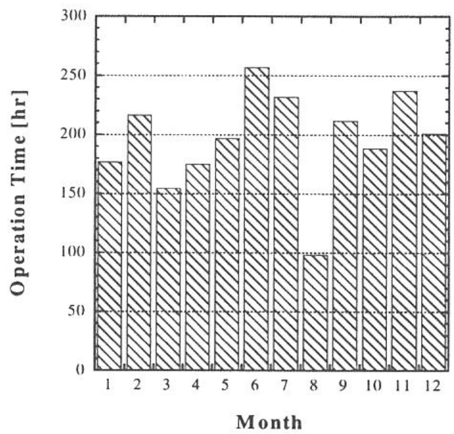


Fig. 1 Monthly statistics of the operation time in 2000.

During the operation periods, there were a few minor troubles, on the magnet power supplies of the booster-synchrotron and on the power source of the harmonic cavity. Both of them are repaired quickly and did not affect the users experiments.

Before the summer shut down, it was observed that the injection efficiency tended to decrease, in spite of the careful tunings. Later, this was found to be due to the troubles on the linac and the extraction kicker, as described later. After the shut down, the injection efficiency was recovered to normal level. In addition, by adjusting the RF voltage of the synchrotron, the electron capture efficiency was increased by a factor of 2. As the result, the injection rate reached 3mA/sec.

In users operations, the closed orbit distortion is corrected after every injection. The deviation from the golden orbit just after the correction is smaller than 100μm (r.m.s.) in horizontal and 50μm (r.m.s.) in vertical. However, it was observed in the beam position measurement that the orbit was drifting slowly by a few hundreds of microns over one injection interval (4 hours). After installing the new beam position monitor system, which will be described in the following section, this phenomenon can be investigated more precisely.

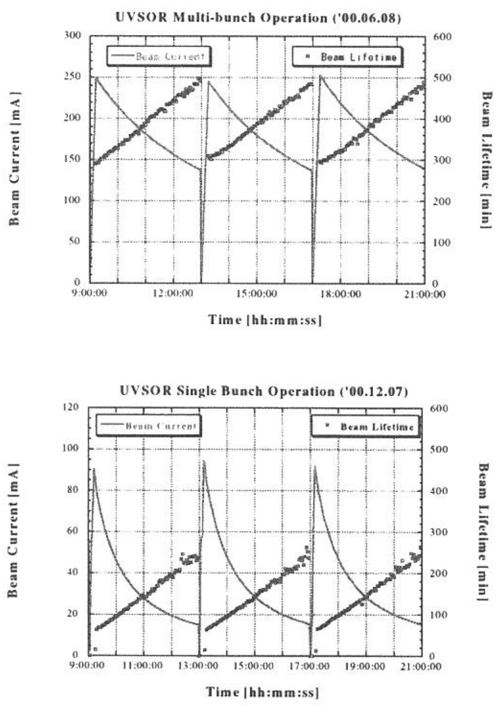


Fig. 2. Typical beam current histories in multi-bunch mode (upper) and single-bunch mode (lower).

During the shut down in spring, about one fourth of the storage ring was vented for the reconstruction works on the SR beam-lines and the optical cavity for FEL. After the baking of the beam pipes, vacuum conditioning with stored beam started and continued for one week. When the users operation started, the beam lifetime reached to about 80% of that before the shut down. After a few weeks of users operation, the lifetime recovered almost completely.

The summer and autumn shut down were assigned for annual maintenance works. A few problems were found on the RF power source of the linac and on the power supply of the extraction kicker of the booster-synchrotron. Although the latter was successfully repaired during the shut down, the former was not solved completely. By temporally adjusting the operating conditions, it does not affect daily operation so seriously. It will be repaired as soon as possible after the necessary parts arrive. During the summer shut down, the circulator of the main RF cavity was replaced, that had been malfunctioned for long time.

It was decided that the super-conducting wiggler at BL7A, which has serious trouble on the refrigerator, would be removed from the ring. An in-vacuum undulator will be installed as described later.

2. Improvements

2-1. New beam position monitor system

The beam position monitor (BPM) system, which has been used for 16 years, is being replaced. Since the old system uses mechanical switches to accumulate the signals from the pick-up electrodes (totally 64), it takes about one minutes to measure an orbit. In addition, since the attenuator control of the BPM signals is not automated, the operator must adjust the attenuation level before the measurement depending on the beam current

The new system comprises 16 signal-processing modules, which are commercial products by Bergoz Co. [1]. These modules give the beam positions in horizontal and vertical as DC voltages. They are AD-converted and accumulated in a PC. A schematic drawing of the system is shown in Figure 3. It is expected to measure an orbit within 1 second, with an accuracy of a few microns. The new system will shorten the time for injection procedure. It will also shorten the time to get orbit correction data for undulators. An orbit feedback system can be constructed based on this system. Construction of the entire system will be completed until March 2001. Performance test will be started in April.

2-2. High Current Operation

The filling beam current in multi-bunch mode has been set at 250 mA for these years. In December, multi-bunch mode operation with 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 beam current history and the temperature rise of the vacuum ducts are shown in Figure 4. The users operation with 300 mA will be realized in near future.

3. Research and Developments

3-1. New Lattice

A new lattice for UVSOR storage ring was designed [2, 3], which has four new short straight sections and much smaller emittance (27nm-rad). The optical functions are shown in Figure 5. All the quadrupoles and sextupoles will be replaced with combined function magnets, which have capabilities of producing both quadrupole and sextupole fields by utilizing

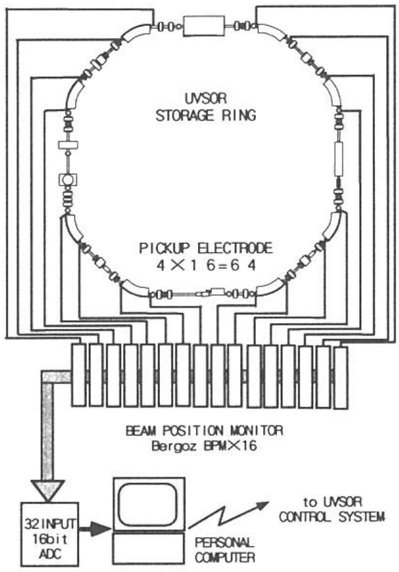


Fig. 3 Schematic drawing of new BPM system.

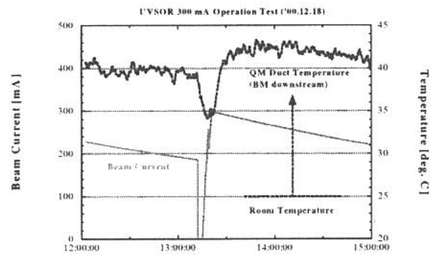


Fig. 4 Beam Current History and temperature rise of the vacuum duct at 300 mA test operation

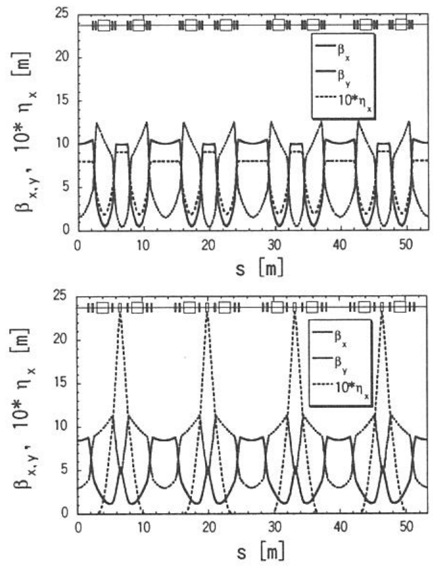


Fig.5 Present (lower) and new (upper) lattice

auxiliary windings. A prototype is under construction and will be completed in March 2001. Field measurements will be started soon after.

3-2. Development of In-vacuum undulator

In the new lattice described in the previous section, each straight section has small vertical betatron function, which enables us to install in-vacuum and small gap devices. A prototype of such a device is now under construction [4]. In this fiscal year, the magnetic arrays are being constructed (Fig. 6). The remaining parts will be constructed in next fiscal year. This undulator will be installed at the straight section between B06 and B07, after removing the super-conducting wiggler. The effects of this device on the circulating beam will be investigated as well as the property of the radiation. Main parameters of the undulator are listed in Table 1.

3-3. Free Electron Laser

Efforts to realize stable oscillation are being continued, such as improving the mechanical stability of the optical cavity and introducing a new feedback system [5]. A two-color experiment using FEL and synchrotron radiation was proposed and is being prepared. Transportation of the FEL beam to a SR beam line (BL7A) was successfully demonstrated and the synchronization between FEL and SR was confirmed [5].

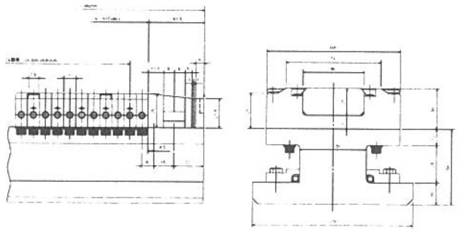


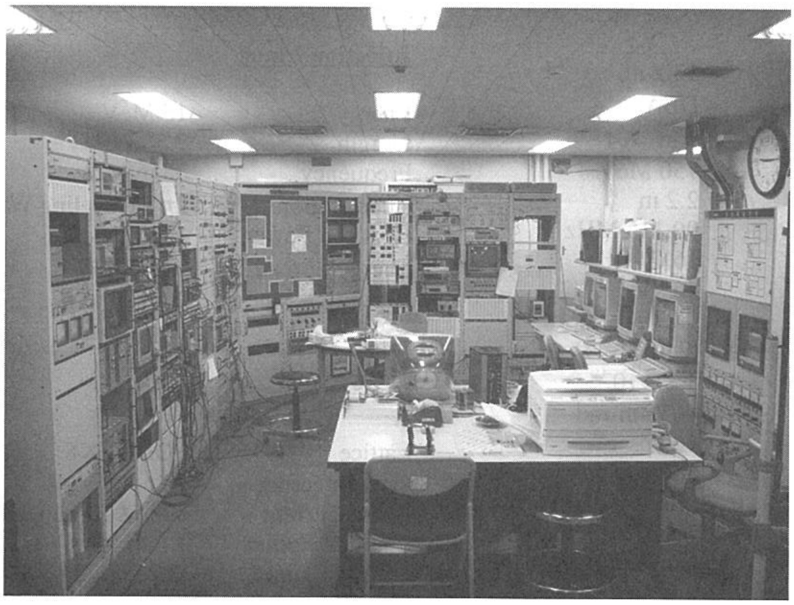
Fig. 6. Magnetic poles of in-vacuum undulator (under construction by Sumitomo Special Metals Co. Ltd.)

Table 1. Parameters of In-vacuum Undulator

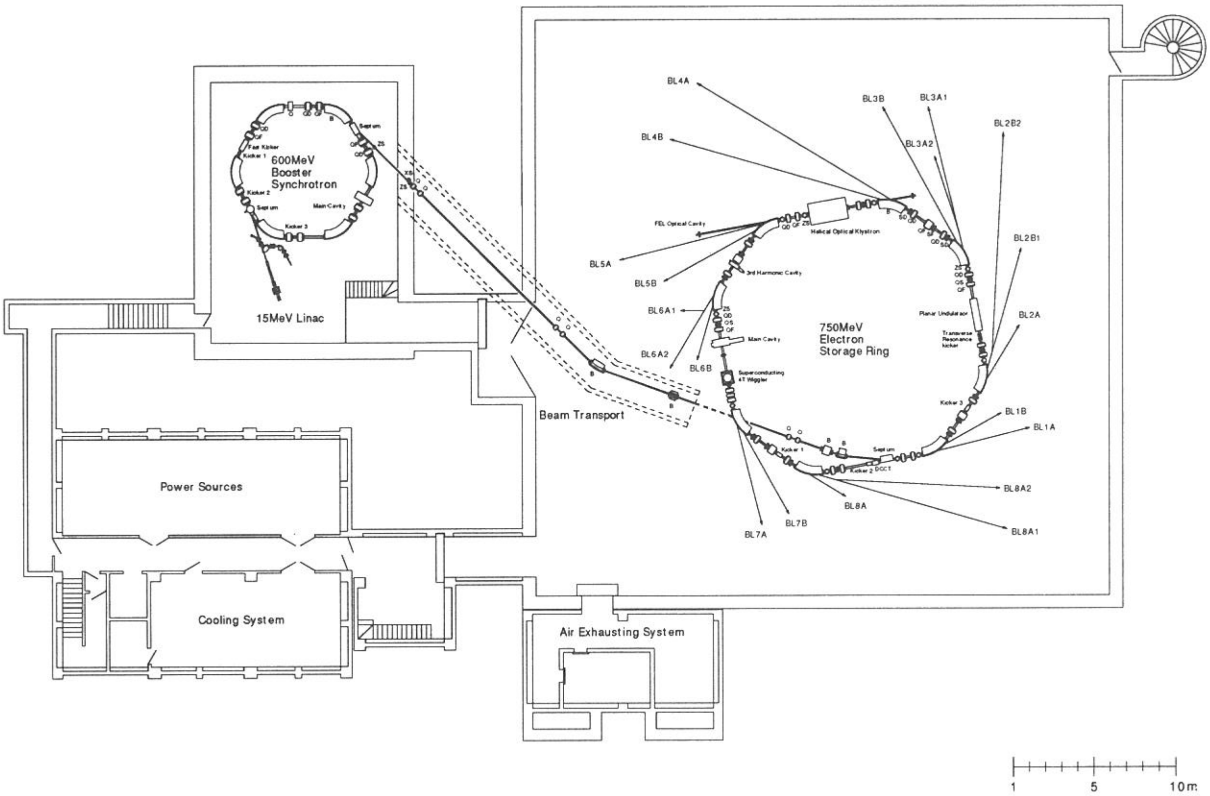
Magnet type	Pure Permanent (Nd-Fe-B)
Remanent Field	1.17 Tesla
Period Length	36 mm
Number of Period	26
Magnetic Length	936 mm
Overall Length	1.4 m
Minimum Gap	10 mm for low-β optics 20 mm for present optics
Max. K-parameter	2.77 for low-β optics 1.15 for present optics
Polarization	linear (horizontal)

References

[1] http://www.bergoz.com/
[2] M. Katoh et al. in this report
[3] M. Katoh et al., Nuclear Instruments and Methods in Physics Section A (accepted)
[4] M. Katoh et al., in this report
[5] S. Koda et al., in this report



Control Room of UVSOR



UVSOR Accelerator Complex

Parameters of UVSOR Storage Ring

Circumference	53.2 m
Lattice	DBA ×4
Straight Sections	3 m ×4
Beam Energy	750 MeV
Bending Radius	2.2 m
RF Frequency	90.115 MHz
Harmonic Number	16
RF Voltage	46 kV
Mom. Comp. Factor	0.026
Betatron Tunes	(3.16, 1.44)
Natural Energy Spread	4.2×10^{-4}
Natural Emittance	165 nm-rad
Natural Bunch Length	160 psec[#1]
Max. Beam Current	300mA (multi-bunch)[#2] 70 mA (single bunch)

#1) About three times longer with harmonic cavity on

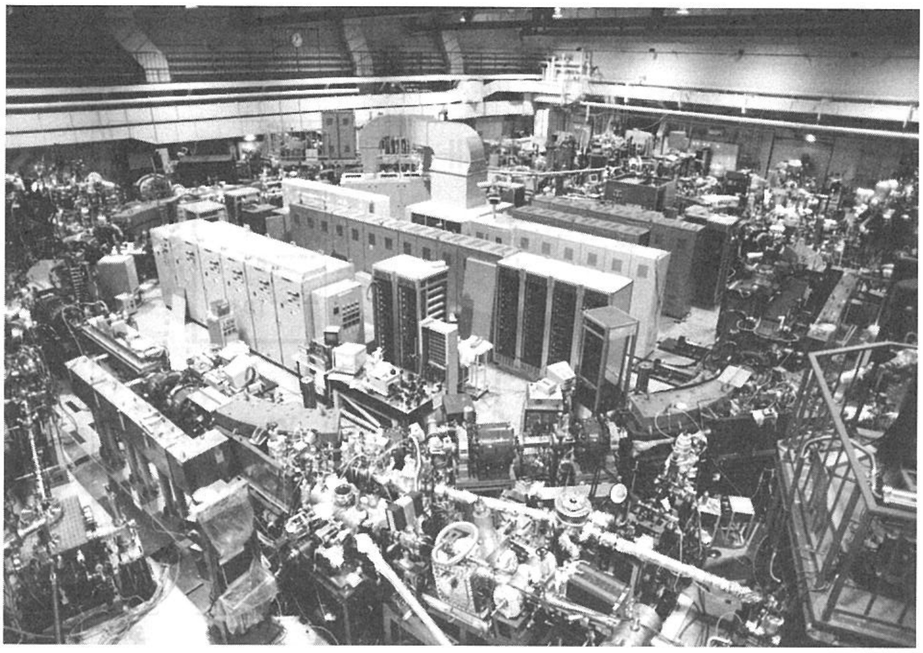
Parameters of UVSOR Injector

Injection Linac

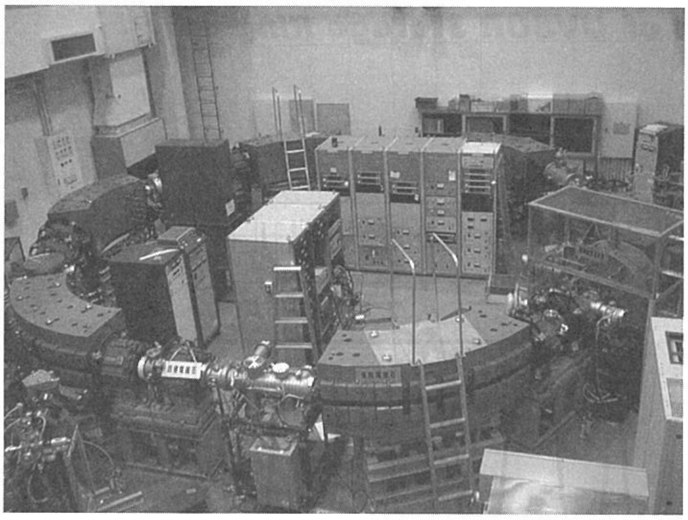
Energy	15 MeV
Length	2.5 m
Frequency	2856 MHz
Acceleration	2π/3Traveling Wave
Klystron Power	1.8 MW
Energy Spread	~1.6MeV
Repetition Rate	2.6 Hz

Booster Synchrotron

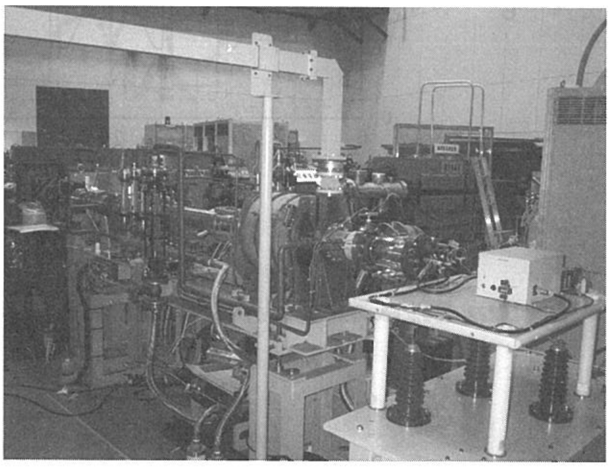
Lattice	FODO ×8
Circumference	26.6 m
Beam Current	32 mA (8-bunch filled)
Bending Radius	1.8 m
Betatron Tune	(2.25, 1.25)
Mom. Comp. Fac.	0.138
Harmonic Number	8
RF Frequency	90.115 MHz
Repetition Rate	2.6 Hz



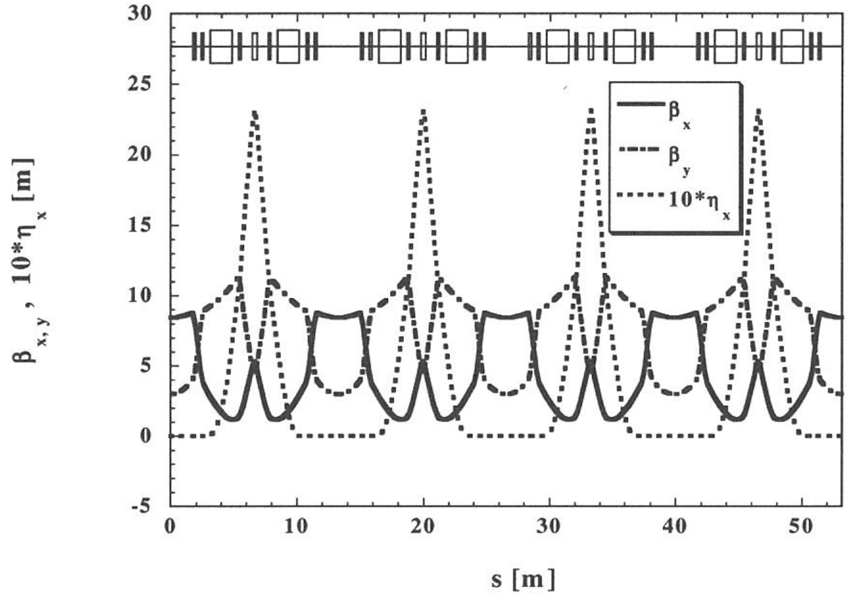
UVSOR Storage Ring



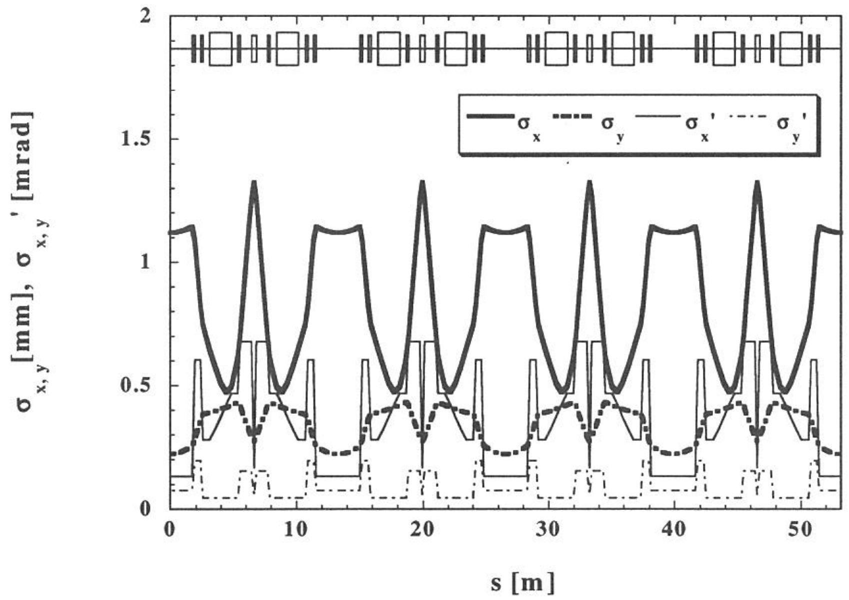
Booster Synchrotron



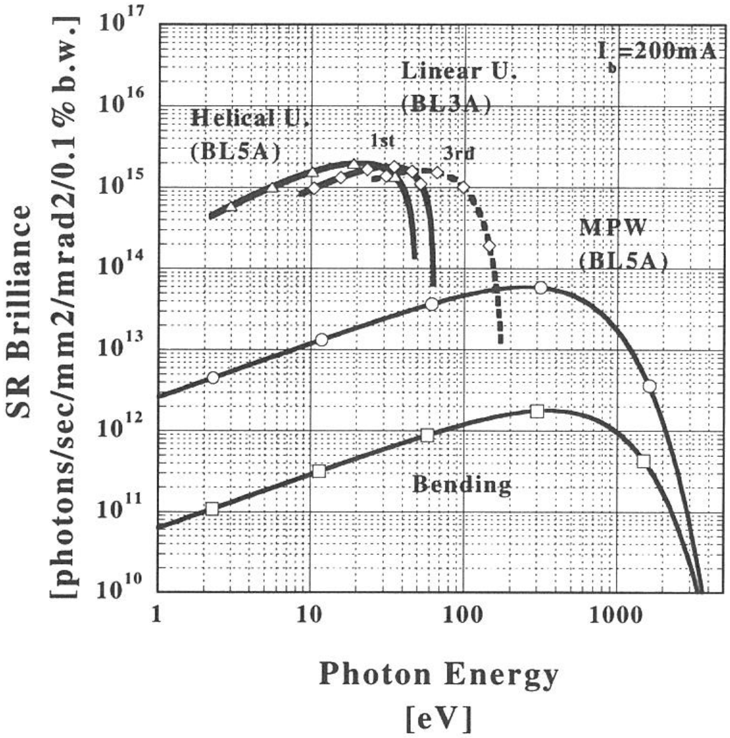
Injection Linac



Optical Functions of UVSOR Storage Ring



Beam Size and Divergence of UVSOR Storage Ring



Synchrotron Radiation Spectra at UVSOR

Light Source Parameters

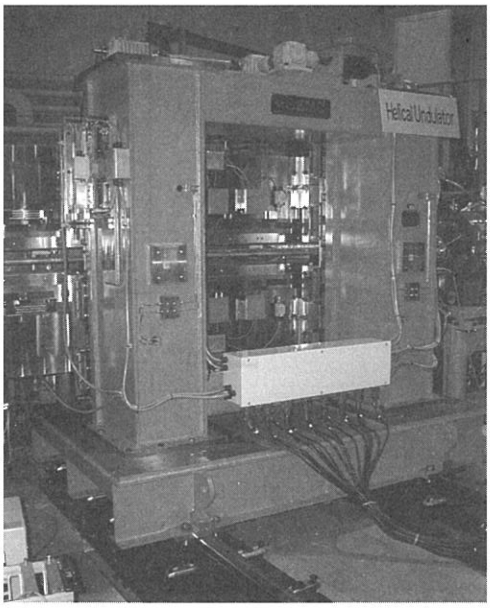
Bending Magnets	
Bending Radius	2.2 m
Critical Photon Energy	425 eV

Linear Undulator (BL3A)	
Number of periods	24
Period Length	84 mm
Total Length	2016 mm
Remanent Field	0.9 T
Magnetic gap	30 – 90 mm
Deflection parameter (K)	0.6 – 3.6

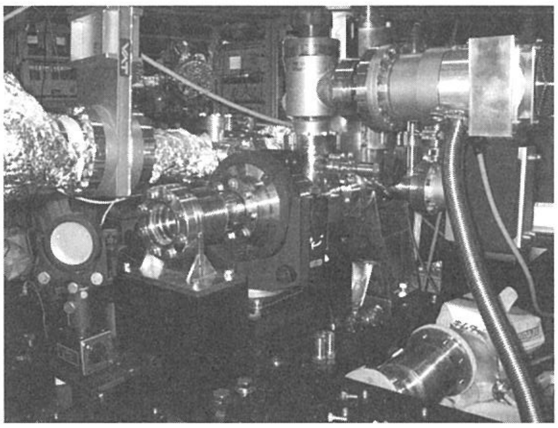
Helical Undulator/Optical Klystron (BL5A)	
Number of periods	18
Period length	110 mm
Length of dispersive part	302.5 mm
Total Length	2351.2 mm
Remanent field	1.3 T
Magnetic gap	30 – 150 mm
Deflection parameter (K)	0.07 – 4.6 (helical mode) 0.15 – 8.5 (linear mode)

Basic Parameters of UVSOR-FEL

Free Electron Laser	
Wave Length	240～570 nm
Spectral Band Width	～10^{-4}
Polarization	Circular
Pulse Rate	11.26 MHz
Typical Average Power	～100 mW (at 520nm)
Storage Ring	
Beam Energy	600 MeV
Natural Emittance	106 nm-rad
Natural Energy Spread	3.4×10^{-4}
Natural Bunch Length	3.4 cm
Number of Bunches	2
Max. Beam Current	50 mA/bunch
RF Frequency	90.1 MHz
Optical Cavity	
Type	Fabry Perot
Cavity Length	13.3 m
Mirror	HfO_2, Ta_2O_5 multi-layer
Optical Klystron	
Polarization	Circular
Length	2.35 m
Period Length	11 cm
Number of Periods	9 + 9



BL5A Helical Undulator (Optical Klystron for FEL)


Optical Cavity for FEL at BL5A

Beam Lines in 2000

Masao KAMADA
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There are 20 beam lines operational in UVSOR facility, 11 beam lines of which are opened beam lines for many users coming from outside of IMS, while the rest 9 beam lines are in-house beam lines dedicated to the research groups in IMS. The followings are the status of the beam lines in 2000.

<Open beam lines>

○BL1B

This beam line is one of the busiest beam line in UVSOR. The beam line has been used for general purposes in VUV region and has welcome many users all the time since the beam line has the following advantages. 1) It has large acceptance angles to provide high flux VUV light. 2) Standard measurements such as absorption, reflection, and luminescence can be conducted at low temperatures down to 10 K. 3) This beam line covers the wavelength ranges from 650 to 30 nm, which overlaps with those of the usual light sources in users' institute or university. 4) Since windows are available in the wavelength more than 110 nm, beginners can start their experiments by themselves without feeling any restriction. 5) The window makes it possible for us to try many materials such as liquid, high-pressure, gaseous phase, high-vapor-pressure, bio-specimens, and so on. 6) Only usual vacuum techniques are required to conduct their experiments. 7) There is no similar beam line in other facilities in Japan.

In 2000, a second-monochromator system has been upgraded but there was a bug in the software of its CCD system, resulting in the delay of the use. The computer control system of a 1-m Seya-Namioka monochromator as well as the moter drivers, which were renewed last year, work well without any serious problems. The instruments including the multi-channnel analyzer and MCP-PM have been improved for time-resolved experiments. Several interesting experiments such as two-photon excitation, photo-reflectance, photo-ionization of liquids, and so on are in progress.

○BL2B1

This beam line consists of a grasshopper monochromator, a double-pass CMA, and a coincidence analyzer. This beam line has been used mainly for surface science because useful equipments for surface science such as LEED, Auger, Ar-ion gun, and gas doser are installed at BL2B1. This beam line covers soft x-ray regions up to 800 eV and therefore it is useful for core-level spectroscopy for C, N, and O elements. Photoelectron spectroscopy and electron-ion-coincidence spectroscopy can be carried out on adsorbed surface and bulk materials. Besides these spectroscopies, NEXAFS/XAFS are also powerful techniques for molecular science.

In 2000, the electron-ion-coincidence instrument had small trouble in electronics during the installation, resulting in the loss of the beam times. The active scientists in the coincidence group worked well to fix it. There were no serious problems on the Grasshopper monochromator and photoelectron spectrometer. However, the resolving power of the monochromator is not good in comparison with similar beam lines in other facilities. This will push us to consider the future of this beam line. We expect users' collaboration and proposal for future.

We would like to express our thanks to Prof. S. Nagaoka and EICO group for their collaboration to maintain the activity of this beam line.

○BL3A1/BL3A2

These beam lines can share intense synchrotron radiation from a planar-type undulator. At BL3A1 the intense undulator radiation has been used without monochromator for SR-CVD, light-amplification, desorption, and luminescence experiments. At BL3A2, a constant-length SGM has been used with the undulator radiation for SR-laser combined experiments in gaseous phase.

On the last user's day in 20th century, the accident happened on the gaseous line, causing the leakage of BF3. Fortunately, the amout of the gas was so small that nobody had any effect from this accident. However, the facility decided to confirm the safety system to avoid future undesirable accidents.

○BL5A

This beam line consists of a high-resolution photoelectron spectrometer and a spin and angle resolved photoelectron spectrometer. Besides SR from a dipole magnet, circularly polarized radiation from a helical undulator can be used at BL5A.

In 2000, the lens system of the spin analyzer was repaired and the vacuum system of the main sample chamber was improved. The first signal after the reinstallation was obtained in January 2001. Both of right and left circulary polarized light from the helical undulator became available in user times. The instruments for time-resolved photoelectron spectroscopy were installed. The combined experiments with SR and the powerful laser system consisting of a TiS laser, RegA, and OPA are in progress too.

○BL5B

This beam line was constructed for calibration of many optical elements and detectors in VUV and soft x-ray regions. Since there are no similar beam lines in other facilities, BL5B has been contributing to the various fields such as astro-science, nano-science, besides synchrotron science and technology.

In 2000, there were small problems on the mechanics of the goniometer, and we decided to improve it in a coming year.

○BL6A1

The BL6A1 has been used as a unique IR and FIR beam line. It consists of FT-IR and FT-FIR interferometers and covers wide wavelength range from sub-milli to near IR. Lots of research studies such as high-pressure with DAC, magnetic circular Dichroism, and time-dependence have been carried out.

In 2000, the optical arrangement of this beam line was upgraded to conduct the experiments more precisely. Also the super-conducting magnet was installed for MCD experiments by Prof. S. Kimura of Kobe University. This arrangement may avoid the loss of the beam time and the inefficient labor works for installation.

○BL7A

This beam line was constructed at the first construction stage of the UVSOR facility in mid of 1980 for soft x-ray spectroscopy. This beam line has been providing soft x-rays in the energy range from 0.6 to 3 keV without the 4T-wiggler and up to 6 keV with the wiggler. However, the mechanical problem happened on the cryogenics for the wiggler in 1998. In 1999, the 4T-wiggler was shutdown completely. We have decided to provide better SR from a dipole magnet with good crystals such as beryl, YB66, InSb, and KTP, to cover the soft x-ray region less than 3 keV.

○BL7B

The 3-m NIM at BL7B was constructed to provide good SR with a high resolving power in a wide wavelength range from near IR to VUV. Although the installation took long times, users have started taking good data at He temperature and showed the good performance of BL7B in 2000. The CCD system was also installed to have fluorescence spectra in 2000. The wall for the radiation protection was constructed in October.

We would like to express our thanks to many members in the 7B-working group, especially Profs. K. Fukui, for their efforts to construct this beam line.

○BL8A

This beam line has no monochromator and any special equipment. This means that users can install their own instruments which are brought from their institute or university. The UVSOR facility will support the users of course. For examples, a differential pump system can be provided for SR-CVD experiments. In 2000, the vacuum condition of the pre-mirror chamber and the differential pump system were improved.

○BL8B1

This beam line can provide soft x-rays with a high resolving power and cover the energy range of K-shell excitation in light elements. The TOF-mass instrument makes it possible to take ionization spectra of various molecules. Yield experiments on solid-state phase are also available. In 2000, the alignment of the CL-SGM monochromator was improved to provide good linear polarization, which was monitored by a multi-layer polarizer with a help from Prof. M. Watanabe of Tohoku University.

<In-house beam lines>

○BL1A

This beam line was constructed for solid-state experiments in soft x-ray region. High performance photoelectron analyzer produces good data in recent years.

○BL2A

This beam line was constructed for experiments in gaseous phase and have produced a lots of scientific results. This beam line was rearranged for bio-science with bio-scientists in Okazaki institutes. We are expecting many active bio-scientists come to use UVSOR soon.

○BL2B2

The construction of a dragon-type new monochromator has commissioned in 1999. The scientific instruments for gaseous experiments have been installed or tested to conduct future experiments in 2000.

○BL3B

This beam line consists of a 3-m NIM and a two-dimensional photoelectron analyzer. This has been used for experiments in gaseous phase, providing interest results. However, the optical elements become worse in recent years, and the gratings will be replaced in coming Spring to achieve higher performance.

○BL4A/4B and BL6B

The re-arrangement of the beam lines at BL4A , 4B, and 6B has started in 2000. The SR-CVD instruments installed at 4B were moved to BL4A, and the SR-STM system at BL4B was installed to BL6B. The old IR station at BL6B was completely removed. A new soft x-ray beam line with a VLS monochromator was constructed at BL4B. The first high-resolution spectra were obtained in January 2001. A party will be arranged in February.

○BL6A2

The post-mirror system was completely changed to get a small spot for the micro-ESCA system. The achievement of the performance was successfully tested. The femto-second laser system was also installed to conduct the combination experiments of SR and lasers.

○BL8B2

The high-performance multi-channel photoelectron spectrometer was installed to measure the precise angle distributions of photoelectrons from well-organized molecules. The performance are under investigation.

Therefore, the UVSOR facility has twenty stations operational; two soft-x-ray stations equipped with a double-crystal monochromator, ten extreme-ultraviolet stations with a glancing incidence or a plane-grating monochromator, four vacuum-ultraviolet stations with a Seya-Namioka-type or a normal incidence-type monochromator, one (far) infrared station equipped with a FT interferometer, a multi-layer monochromator, and two white-light stations without any monochromator. In 2000, many interesting results were obtained at these UVSOR beam lines and they are presented in this activity report.

The UVSOR facility strongly asks all users to conduct their experimental procedures according to the beam line manuals and the guidebook. The persons who want to use the open and the in-house beam lines are recommended to contact with the following station master or supervisor and the representative, respectively. The persons who want to know updated information of the UVSOR facility are recommended to open http://www.uvsor.ims.ac.jp/.

Table I. Station masters and supervisors of open beam lines in 2000

Beam Line	Station Master	Sub Master	Supervisor
1B	M. Hasumoto	M. Kamada	M. Kamada
2B1	S. Nagaoka	E. Nakamura, K. Takahashi	M. Kamada
3A1	M. Kamada	E. Nakamura	M. Kamada
3A2	N. Kondo	T. Gejo	E. Shigemasa
5A	K. Takahashi	M. Hasumoto	M. Kamada
5B	M. Hasumoto	E. Nakamura	E. Shigemasa
6A1	E. Nakamura	O. Matsudo	M. Kamada
7A	E. Shigemasa	N. Kondo, O. Matsudo	E. Shigemasa
7B	K. Fukui	M. Hasumoto	M. Kamada
8A	T. Gejo	E. Nakamura	E. Shigemasa
8B1	T. Gejo	N. Kondo	E. Shigemasa

Table II. Representatives of in-house beam lines in 2000.

Beam Line	Representative	Department/Facility
1A	N. Kosugi	VUV Photo Science
2A	N. Kosugi	VUV Photo Science
2B2	K. Mitsuke	VUV Photo Science
3B	K. Mitsuke	VUV Photo Science
4A	T. Urisu	VUV Photo Science
4B	E. Shigemasa	UVSOR
6A2	M. Kamada	UVSOR
6B	T. Urisu	VUV Photo Science
8B2	T. Urisu	VUV Photo Science

Beamlines of UVSOR

Beam line	Monochromator, Spectrometer	Wavelength Region	Acceptance Angle (mrad) Horiz.	Vert.	Experiment
BL1A	Double Crystal	2.1 - 0.3 nm	4	1	Solid (photoemission)
BL1B	1m Seya-Namioka	650 - 30 nm	60	6	Solid (absorption)
BL2A	1m Seya-Namioka	400 - 30 nm	40	6	Bio-science (irradiation)
BL2B1	2m Grasshopper	60 - 1.5 nm	10	1.7	Solid & Surface (photoemission, absorption)
BL2B2	18m Spherical Grating	60 - 6 nm	15	6	Gas (photoionization, photodissociation)
BL3A1	None (Filter, Mirror)	(U)	0.3	0.3	Solid & Irradiation (photodissociation)
BL3A2	2.2m Constant Deviation Grazing Incidence	100 - 10 nm (U)	10 0.3	4 0.3	Gas & Solid (photoionization & photodissociation)
BL3B	3m Normal Incidence	400 - 30 nm	20	6	Gas (photoemission)
BL4A1	Multi-Layered-Mirror Monochromator	23 - 13 nm Mo/Si MLMs	16.6	12.8	Irradiation
BL4A2	None				SR-CVD
BL4B	3m Varied-line Plane Grating Monochromator	2 - 10 nm	8.3	6	Gas (absorption)
BL5A	None SGM-TRAIN	(OK) 250 - 5 nm	 10	 3	Free Electron Laser Solid (photoemission)
BL5B	Plane Grating	200 - 2nm	10	2.2	Calibration, Gas & Solid (photodissiociation & absorption)
BL6A1	Martin-Puplett FT-IR Michelson FT-IR	3000 - 30 mm 100 - 1 mm	80 80	60 60	Solid (absorption)
BL6A2	Plane Grating	650 - 8 nm	10	6	Solid (photoemission)
BL6B	None		8.3	6	Irradiation
BL7A	Doble-crystal	1.5 - 0.8 nm	2	0.3	Solid (absorption)
BL7B	3m Normal Incidence	1000 - 50 nm	65	10	Solid (absorption)
BL8A	None (Filter)		25	8	Irradiation & User's Instruments
BL8B1	15m Constant Deviation Grazing Incidence	40 - 2 nm	10	1.5	Gas & Solid (absorpton)
BL8B2	Plane Grating	650 - 8 nm	10	6	Solid (photoemission)

SGM-TRAIN : Spherical Grating Monochromator with Translating and Rotating Assembly Including Normal-incidence-mount

U : with an undulator, OK : with an optical klystron

BL1A

Soft X-Ray Beamline for Photoelectron-Photoabsorption Spectroscopy

BL1A is a soft x-ray beamline for photoelectron-photoabsorption spectroscopy. The beamline is equipped with a focusing premirror and a double crystal monochromator [1]. The monochromator serves soft x-rays in the energy range from 585 to 4000 eV by using several kind of crystals such as β-Al_2O_3, beryl, KTP ($KTiOPO_4$), quartz, InSb and Si crystals. The throughput spectra are shown in Fig. 1. Typical energy resolution (E/ΔE) of the monochromator is about 1500 for beryl and IbSb.

For photoelectron-photoabsorption spectroscopy, an ultra-high-vacuum (UHV) apparatus is connected. The top view of the apparatus is shown in Fig. 2. It is equipped with a high-performance electron energy analyzer (SES-200, SCIENTA Co.). The pass energy can be varied between 1 and 500 eV. Using the apparatus, resonant photoelectron spectra for solid samples can be obtained with the total energy resolution of 0.7eV around hν=1000 eV.

Reference

[1] A. Hiraya et al., Rev. Sci. Instrum., **63** (1992) 1264.

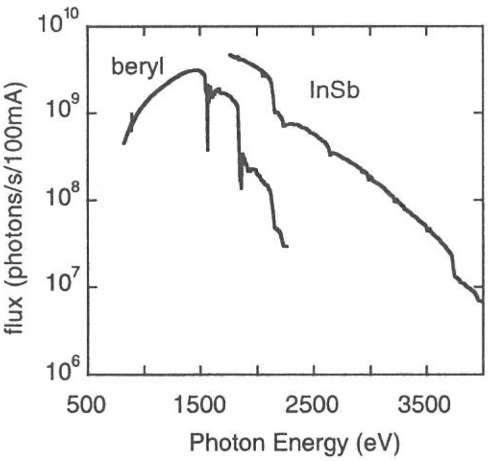


Figure 1. Throughput spectra of the double crystal monochromoator at BL1A.

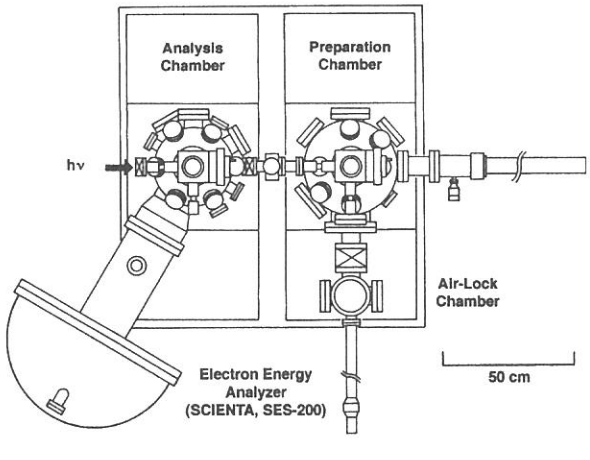


Figure 2. Top view of the UHV apparatus for photoelectron-photoabsorption spectroscopy.

Specification

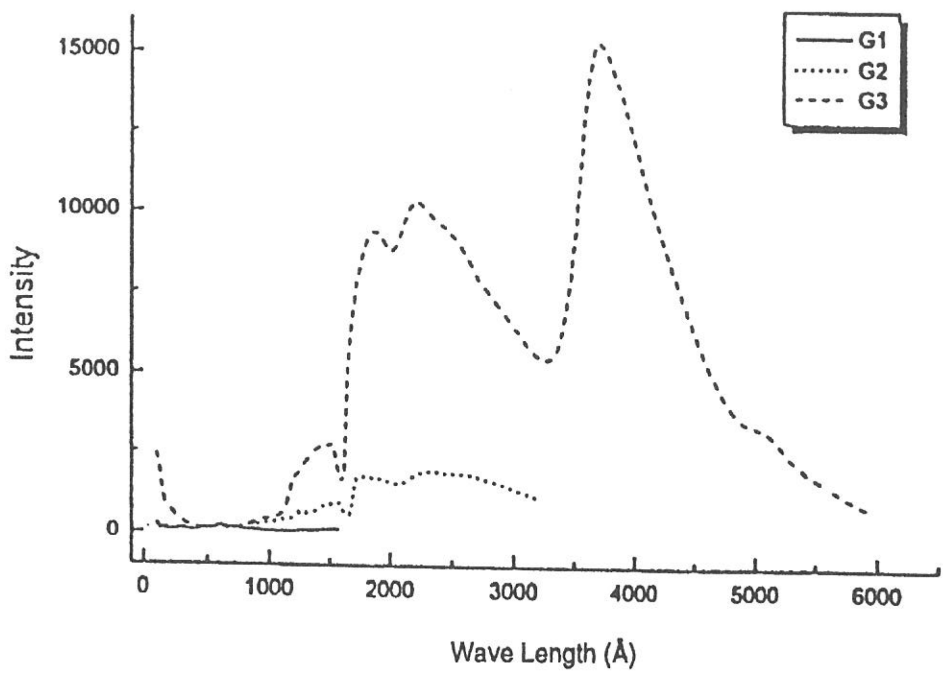
Monochromator	: double crystal monochromator
Monochromator crystals (2d value, energy range)	: β-Al_2O_3 (22.53Å, 585-1609eV), beryl (15.965Å, 826-2271eV), KTP (10.95Å, 1205-3310eV), quartz (8.512Å, 1550-4000eV), InSb (7.481Å, 1764-4000eV), Si (6.271Å, 2104-4000eV)
Resolution	: E/ΔE=1500 for beryl and InSb
Experiment	: photoelectron-photoabsorption spectroscopy for solid

BL1B

Seya-Namioka Monochromator for General Purpose in VUV Region

The beam line 1B has been used for many experiments such as absorption, reflectivity, photo-ionization, and luminescence in condensed phase. The system consists of a pre-mirror, a 1-m Seya-Namioka type monochromator, and a post-mirror. Three gratings with 600, 1200, and 2400 gr/mm can cover the wavelength range from 40 nm to 650 nm, and two post mirror make it possible to change the focus point. A long-focus mirror is usually used with a LiF window to separate a main chamber for spectroscopy in liquids and biospecimens, while a short-focus mirror is suited to solid-state spectroscopy. The output flux from this monochromator is about 10^{10} phs/s around 200 nm with 0.1 mm slits. The spectral distributions obtained with three gratings are shown in the figure, although they are not the best data because of the contamination of the mirrors and gratings due to the recent careless accident.

A second monochromator (Spex 270M) and a LN-cooled CCD detector (Princeton Inc.) are available for luminescence experiments, together with a liquid helium-flow type cryostat. A time-resolved system to observe luminescence and excitation spectra with three time-gates is also possible. The decay measurement is one of the highlights of this station. A couple of weeks are supplied for the decay measurements under single bunch operation. A TAC system is therefore one of the standard instruments at this beam line.



BL2A

Gas Phase Photoabsorption and Fluorescence Spectroscopy

Photoabsorption cross section and fluorescence excitation spectra of gaseous sample are simultaneously measured in a vacuum cell or effusive jet condition. The primary photons in the 30-400 nm region are dispersed by a 1-m Seya monochromator. Higher order light in the 80-120 nm range is suppressed by using a long channel with a cross section 2.5 × 5.0 × 170 mm long filled with argon gas at a pressure ≅0.3 Torr as shown in fig. 1. No filter is used between 30 and 80 nm since the photon flux at λ<40 nm is very weak (see fig. 1). The gas filter and cell are placed in a main chamber which is evacuated by a 5000 *l*/s diffusion pump (Varian, Model VHS10). A LiF window is used for the measurement at the 105<λ<210 nm range as usual. Thus, the total photoabsorption cross section and fluorescence excitation spectra are available in the wide wavelength region 30-210 nm without or with little contamination by the higher order light.

Dispersed fluorescence and polarity of emission from the excited fragment are also measurable in addition to the total photoabsorption and emission cross sections. In the single bunch operation of synchrotron radiation with the period of 178 ns, a radiative life time can be measured.

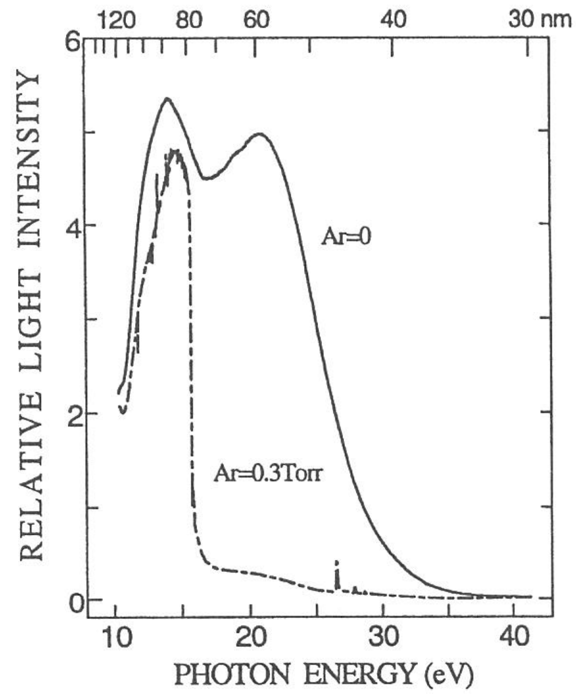


Fig. 1. Transmitted I_0 intensity with and without an Ar gas filter.

Specification

Monochromator :	1-m Seya
Wavelength range :	30-400 nm
Resolution :	$\Delta E/E \cong 10^{-3}$ at 100 nm
Grating :	1200 *l*/mm blazed at 96 nm
Experiments :	•Vacuum cell or effusive jet •Total photoabsorption cross section •Fluorescence cross section •Dispersed fluorescence •Radiative lifetime •Emission polarity

BL2B1

Soft X-ray Beamline for Solids and Surfaces

BL2B1 has been used for soft X-ray absorption and photoelectron spectroscopies of solids and surfaces. A 2-meter grazing incidence monochromator ('Grasshopper' type, Mark XV; Baker Manufacturing Co.) is installed. The monochromator serves soft X-rays in the energy range from 95 to 1000 eV using a 1800 l/mm grating. The resolving power is better than 600 at C K-edge (about 290 eV). Figure 1 shows the total photoelectron yield from a Au mesh of 90%-transmission located between the refocusing mirror and the sample. The dips around 290 and 550 eV originate from the carbon and oxygen contamination of optical elements, respectively.

The analyzing chamber is located at the focusing point of the monochromized light. A double-pass cylindrical mirror analyzer (CMA), a LEED optics of reverse type, a quadrupole mass spectrometer, and an ion-gun for sputtering are installed in the analyzing chamber. A pulsed leak-valve and a variable leak-valve are also installed in order to introduce various kinds of gases. The samples can be cooled with a liquid helium cryostat. The base pressure of the analyzing chamber is better than 1×10^{-10} Torr. The photoelectron spectroscopy including constant initial-state spectroscopy (CIS) and constant final-state spectroscopy (CFS) can be conducted using the double-pass CMA. Besides these standard photoemission measurements, electron-ion-coincidence (EICO) spectroscopy can be carried out on adsorbed surfaces and bulk materials. In 1999, a new version of an EICO instrument has been installed, resulting in better efficiency on collecting data. The users who plan to perform the EICO measurement should make contact with the EICO users group. The sample preparation chamber equipped with a load-lock chamber is connected to the analyzing chamber. Sample treatments such as cleaving, filing, and deposition can be made under the ultra-high vacuum condition.

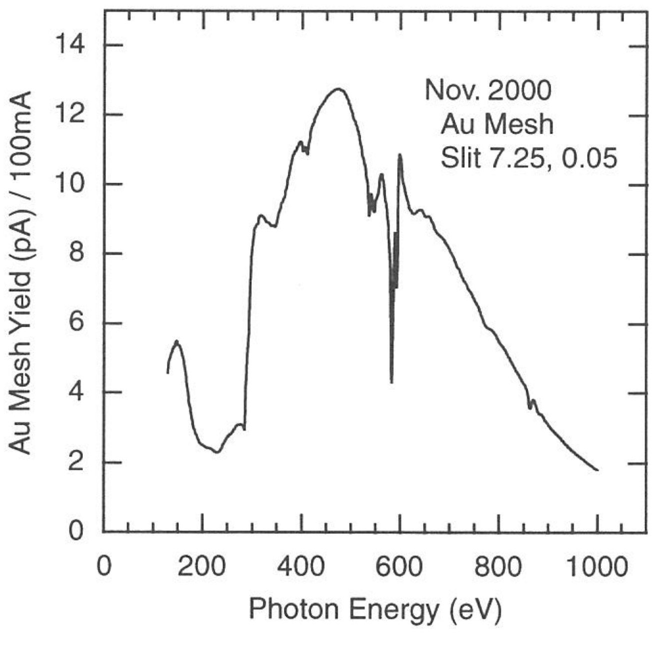


Fig. 1.

Specification

Monochromator	: 2 m grasshopper type
Energy range	: 95-1000 eV (1800 l/mm)
Resolution of photon	: < 0.4 eV at 300 eV
Resolution of photoelectron	: < 0.3 eV for hν = 150 eV
Experiment	: Photoelectron spectroscopy, X-ray absorption spectroscopy, Electron-ion-coincidence spectroscopy

BL2B2

Beamline for Gas Phase Photoionization and Photodissociation Dymanics

This beamline has been developed for the purpose of studying ionization and decay dynamics involving excitation of inner-valence electrons or 2*p* electrons of the third-row atoms. The monochromator is a spherical grating Dragon-type with 18 m focal length. High throuput (1×10^{10} photons s^{-1}) and high resolution ($E/\Delta E$ = 2000 – 8000) are achieved simultaneously (Fig. 1).

The optical system consists of two prefocusing mirrors, an entrance slit, spherical gratings (G1, G2 and G3), two folding mirrors, a movable exit slit and a refocusing mirror. The monochromator is designed to cover the energy range of 20 – 200 eV with the three gratings: G1 (2400 lines mm^{-1}, R = 18 m) at 80 – 200 eV; G2 (1200 lines mm^{-1}, R = 18 m) at 40 – 100 eV, G3 (2400 lines mm^{-1}, R = 9.25 m) at 20 – 50 eV. The including angles are 160° for G1 and G2 and 140° for G3. The detailed parameters of the optical elements [1] and performance [2] are described elsewhere.

References

[1] H. Yoshida and K. Mitsuke, *J. Synchrotron Radiat.* 5, 774 (1998).

[2] M. Ono *et al. Nucl. Instrum. Meth. Phys. Res. A*, in press.

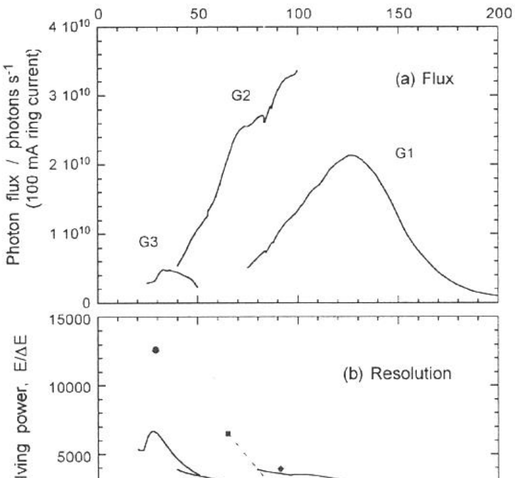


Fig. 1. The photon flux at a 100 mA ring current (a) and resolving power (b) when the entrance and exit slit widths are set to 100 μm. The solid lines in (b) show the expected values[1].

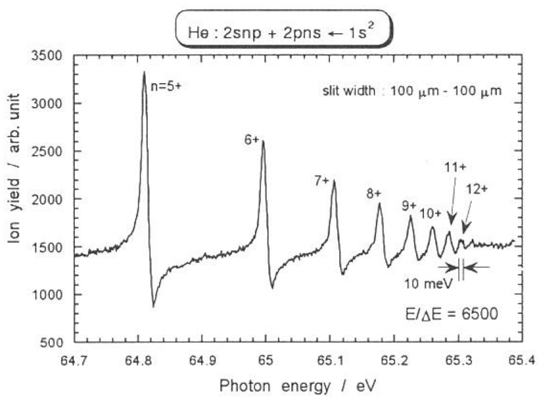


Fig. 2. Ion yield spectrum of He in the doubly excitation region obtained with the slit widths of 100 μm. The resolving power is estimated to be 6500 from the peak width (FWHM) of He(2*s*12*p*+2*p*12*s*).

Specification

Monochromator	:	Dragon-type (18 m spherical grating)
Energy Range	:	20 - 200 eV
Resolution	:	$E/\Delta E$ = 6500 (@65 eV, 100 μm slit width)

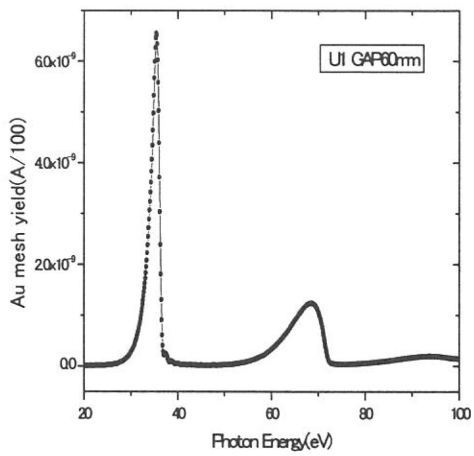
BL3A1

Irradiation Port with Undulator Radiation

The beam line 3A1 has been used for various kinds of experiments need intense undulator radiation. In recent years, photo-desorption photo-chemical reaction, SR-CVD, photo-etching, irradiation damage effects in condensed phase, light amplification induced by core-revel excitation, and so on have been carried out at this beam line. The luminescence yield of which is not high enough at beam lines for bending radiation, has been observed, A time-response measurement of SR-induced desorption. A planar-type undulator installed in a long straight section of the UVSOR storage ring provides an intense quasi-monochromatic radiation to beam lines 3A1or 3A2. The undulator consists of 24 sets of magnets, a period length of which is 80mm,the photon energy range from 8 to 52eV can be covered by the fundamentals with a K-values form 0.62 to3.6, although higher harmonics are mixed into the spectral distribution in case of high K-value. The beam line 3A1 has no monochromator between the undulator and a sample chamber. The radiation is introduced by a toroidal focusing mirror into sample chamber through a pinhole of 1mm in diameter and metallic filter (Al, Sn, and In), A gold mesh is always installed in the sample chamber to monitor the incident photons. Atypical spectrum distribution measured by the monochromator at BL3A2 is shown in the figure, where the undulator gap is 60mm and the photon flux is estimated to be abut 10^{14}-10^{15}phs/s on the samples. A differential pumping system can be provided for the users who want to use gaseous materials. A second monochromator (Jobin-YvonHR-302),another vuv monochromator (home-made one of normal-incident type),and a helium storage-type cryostat are available for luminescence experiments. A TAC system is also one of the standard instruments of this beam line. For liquid or gaseous-phase experiments, MgF_2 windows can be installed to separate the sample chamber from the beam line.

Specifications

Type	planar-type undulator
Source emittance	164nmrad
Period	80mm
Number of periods	24
Magnetic field	Kmax 3.6
Photon Fulux	10^{14}phs/s at 34eV
Energy range	8-52eV



BL3A2

Gas-Phase Dissociative Photoionization Apparatus

This machine has been constructed to study the formation of multiply charged ions and their dissociation processes. The monochromator is constant-deviation grazing incidence type with 2.2-m focal length and covers wide wavelength region (10-100 nm) where many kinds of molecules and multiply charged ions are effectively measured. High intensity photon beam is available by introducing the radiation emitted from the undulator to the monochromator. The apparatus contains an angle-resolved time-of-flight mass spectrometer (TOFM) equipped with automatic data acquisition system for photoion-photoion coincidence measurements. For full understanding of dissociative multiple photoionization, the coincidence signals of two fragment ions produced from a parent ion are detected, the kinetic energy release in "Coulomb explosion" is evaluated, and the angular distributions for the fragment ions are measured. The sensitivity with respect to energetic fragment ions (several tens of electron volts) is much improved in comparison with commercial TOFMs.

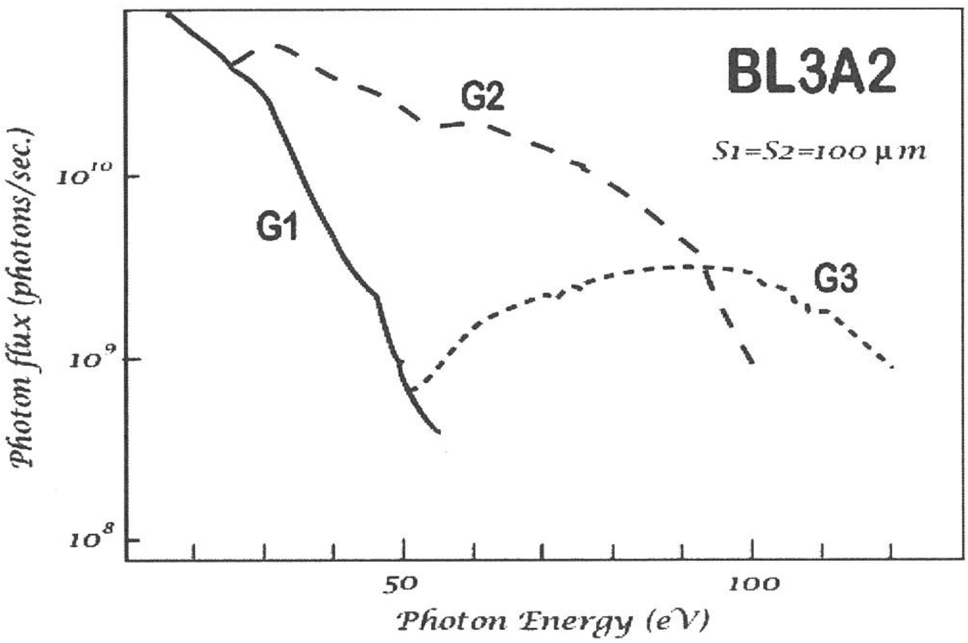


Figure 1. Throughput from the 2.2-m CDM monochromator on BL3A2.
(SR from the bending magnet)

Specification

Monochromator: 2.2-m Constant-Deviation Grazing-incidence

Energy range: 10 to 100 nm (15-120 eV)

Resolution: E/ΔE~550-800 (ΔE~0.03-0.18 eV)

Experiments: TOF photoion spectroscopy for gaseous targets
(variable drift-tube-length: 0.2-1.0 m)

Rotatable angle: 0-90° relative to the electric vector of SR

BL3B

Beam Line for Gas Phase Two-Dimensional Photoelectron Spectroscopy

This beam line is devoted to studies of elementary atomic and molecular processes induced by excitation of valence electrons. A monochromator is a vertically dispersed normal incidence type with 3m focal length and 10° angle between the incident and diffracted photon beams. The maximum wavelength resolution of 0.007nm is narrow enough to separate vibrational levels of excited states for various molecules. A main component in an experimental chamber is a spherical sector electrostatic energy analyzer which has been designed and setup for photoelectron spectroscopy. One can perform two-dimensional photoelectron spectroscopy with good resolution (≤ 30meV) in which the photoelectron yield is measured as a function of both photon energy and electron kinetic energy (binding energy). A two-dimensional spectrum, usually represented as a contour plot (*e.g.* Fig. 1), contains rich information on photoionization dynamics and properties of superexcited states. A great variety of interesting high-lying states involved in autoionization have been studied as follows: (1) a bound valence state of nitric oxide whose autoionization gives rise to a number of irregularly spaced peaks in its photoionization efficiency curve,[1] (2) the $(3\sigma_g)^{-1}(3\sigma_u)^1$ valence state of acetylene which dominates photoionization cross section and leads to strong vibrational excitation,[2] (3) Rydberg states of NO or SO_2 which undergo dissociation into N** + $O(^1D^e, {}^3P^e)$ [3], or S** + $2O(^3P^e)$, [5] respectively, followed by autoionizing transitions of the superexcited N or S atoms, respectively, and (4) multiple-electron-excited Rydberg states of carbonyl sulfide which are primarily produced by conversion from the Rydberg states converging to $OCS^+(B^2\Sigma^+)$ and subsequently dissociate into S** + $CO(X^1\Sigma^+)$ giving rise to autoionizing transitions of the superexcited sulfur atoms.[4]

1) K. Mitsuke *et al.*, *J. Electron Spectrosc. Rel. Phenom.* **79**, 395 (1996).
2) H. Hattori and K. Mitsuke, *ibid.* **80**, 1 (1996); H. Hattori *et al.*, *J. Chem. Phys.* **106**, 4902 (1997).
3) Y. Hikosaka *et al.*, *ibid.* **105**, 6367 (1996).
4) Y. Hikosaka *et al.*, *ibid.* **107**, 2950 (1997); **110**, 335 (1999).
5) K. Mitsuke *et al.*, *J. Electron Spectrosc. Rel. Phenom.* **112**, 137 (2000).

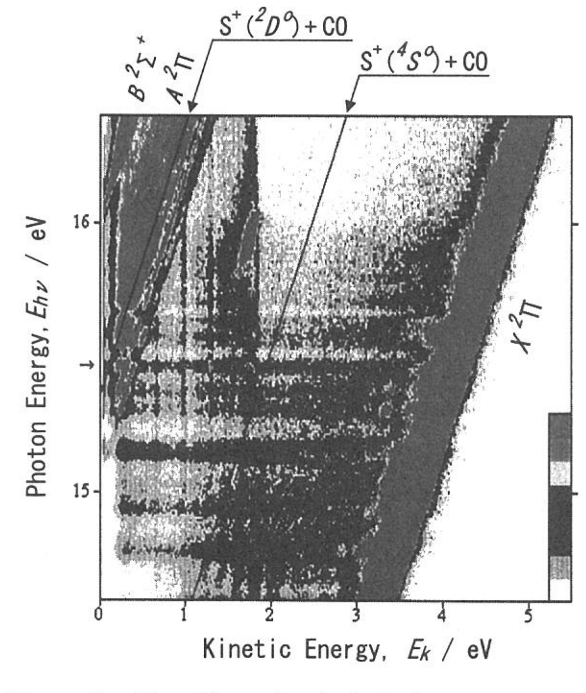


Figure 1. Two-dimensional photoelectron spectrum of OCS taken at the photon energy range from 14.2 to 16.8eV. The electron yield is presented by the plots with eight tones from light to dark on a linear scale.[4]

Specification

Monochromator	: 3 m normal incidence
Wavelength range	: 30 - 200 nm
Resolution	: 0.007 nm at 100 nm

BL4A1

Multilayered-mirror monochromator beam line for the study of synchrotron radiation stimulated process

A multilayered-mirror (MLM) monochromator beam line designed specially for synchrotron radiation (SR) stimulated process experiments has been constructed for the first time. The most important point in constructing a MLM monochromator beam line for the study of SR-stimulated processes is the optimization of the beam line optics to obtain a large photon flux. The second most important point is to remove the background existing in the low energy region caused by the total reflection. Optimization concerning the reduction of the low-energy background due to the total reflection has been made for the combination of the Mo/Si MLMs and the C filter. Mo/Si MLMs have a (normal incident) reflectivity of over 60% can be made for the energy region around 100 eV, which contains the core electron binding energies of Al and Si (important materials in semiconductor processes). The beam line was designed by the criteria ; a beam spot size on the sample surface ≧ 3×3 mm^2, a density of total irradiated photons ≧ 10^{18} photons/cm^2 (for an irradiation time of a few tens of minutes to a few hours) and low-energy background ≦ 1% of the output.[1]

[1] H. Mekaru, *et. al.*, Rev. Sci. Instrum., 70, 2601-2605 (1999).

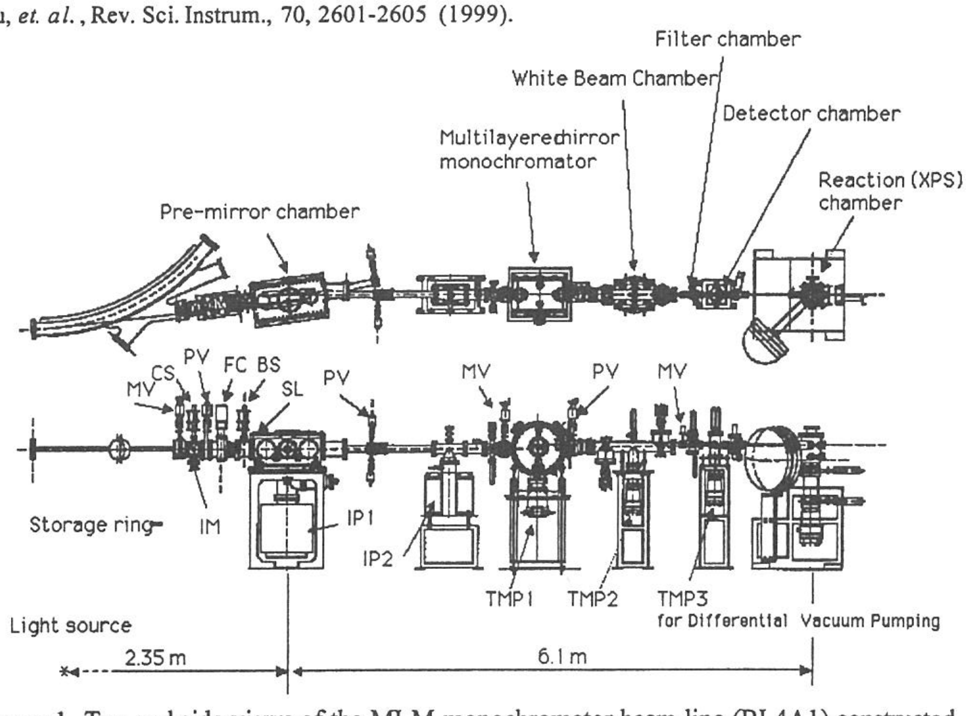


Figure 1. Top and side views of the MLM monochromator beam line (BL4A1) constructed at the UVSOR facility of the IMS.

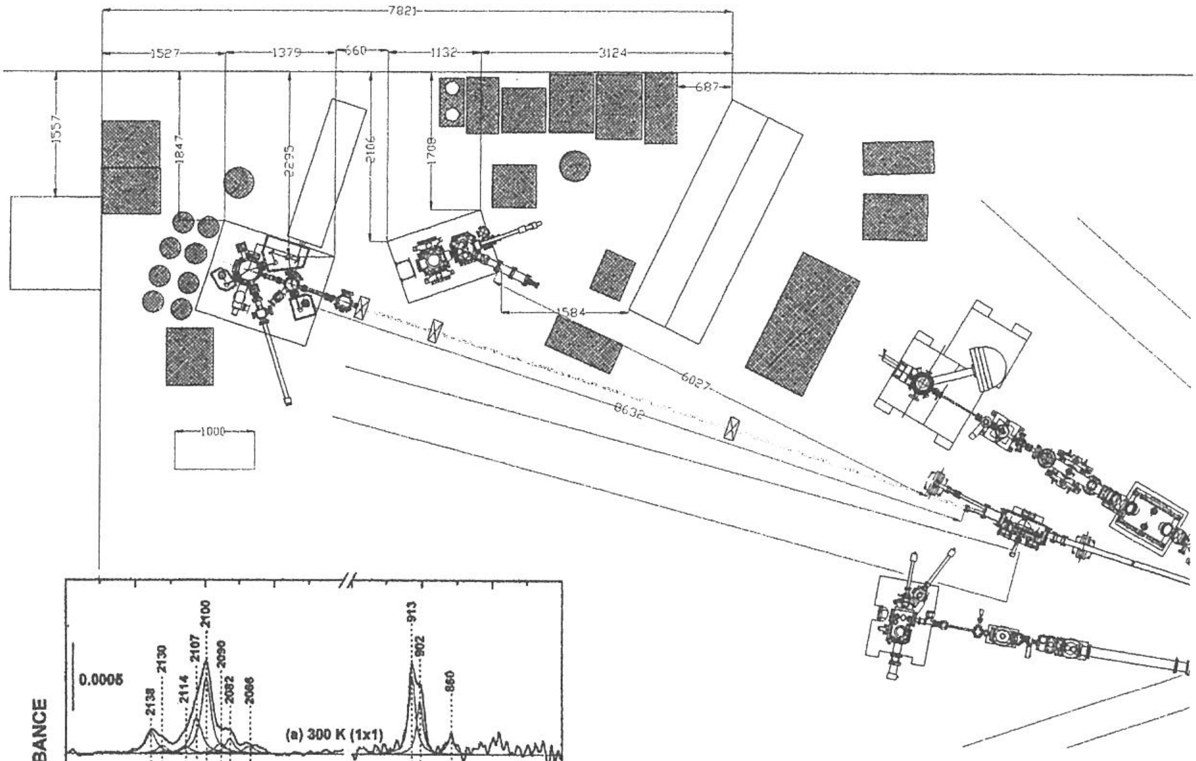
Specifications

Monochromator	:Multilayered-mirror monochromator
Wavelength range	:13.3 - 22.5 nm
Resolution	:5 – 9 eV (FWHM)
Experiments	:Excitation energy dependence of the SR processing

BL4A2

SR-CVD beam line

SR-CVD experimental station, which had been installed at the end of the beam line 4B until 1999, was moved to the end of the new beam line 4A2 at April 2000. The reaction chamber system has been modified as shown in Fig.1. Adjustments of the reaction chamber, in situ observation system of IRRAS and gas supply and extinction systems have already been finished. The pre-mirror chamber is already at high vacuum but the downstream beam line is still under construction. The legally controlled high pressure gases such as SiH4, Si2H6 and GeH4 gas can be used at this beam line and SR stimulated reactions such as SR etching and SR stimulated gas source MBE. The ultra high vacuum STM chamber is also under construction as a blanch experimental station of BL4A2.



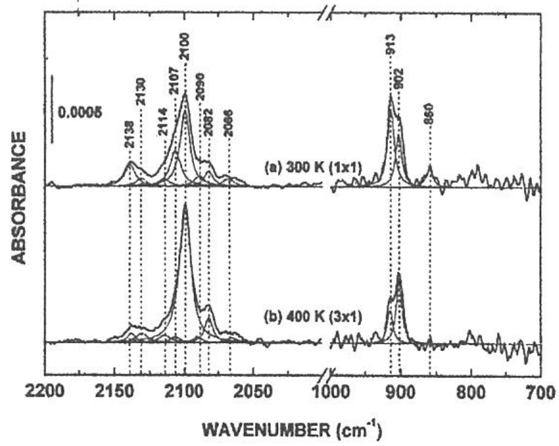


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Fig. 1. p-Polarized BML-IRRAS spectra associated with Hr Si(100) surfaces with (a) 1x1 (b) 3x1. Narrow lines show peak-resolved spectra calculated assuming that the shape of each peak is Lorentzian.

BL4B

Varied-line-spacing Plane Grating Monochromator for Molecular Soft X-ray Spectroscopy

The beamline BL4B equipped with a varied-line-spacing plane grating monochromator was constructed for various spectroscopic investigations in a gas phase and/or on solids in the soft X-ray range. Two holographically ruled laminar profile plane gratings with SiO_2 substrates are designed to cover the photon energy range from 80 eV to 1000 eV. The gratings with the groove densities of 267 and 800 l/mm cover the spectral ranges of 75-300 and 220-1000 eV, respectively, and are interchangeable without breaking the vacuum. Figure 1 shows the absolute photon flux for each grating, with the entrance- and exit-slit openings set at 25 and 10 μm, respectively. Under this condition, the corresponding resolving power is expected to be more than 3000.

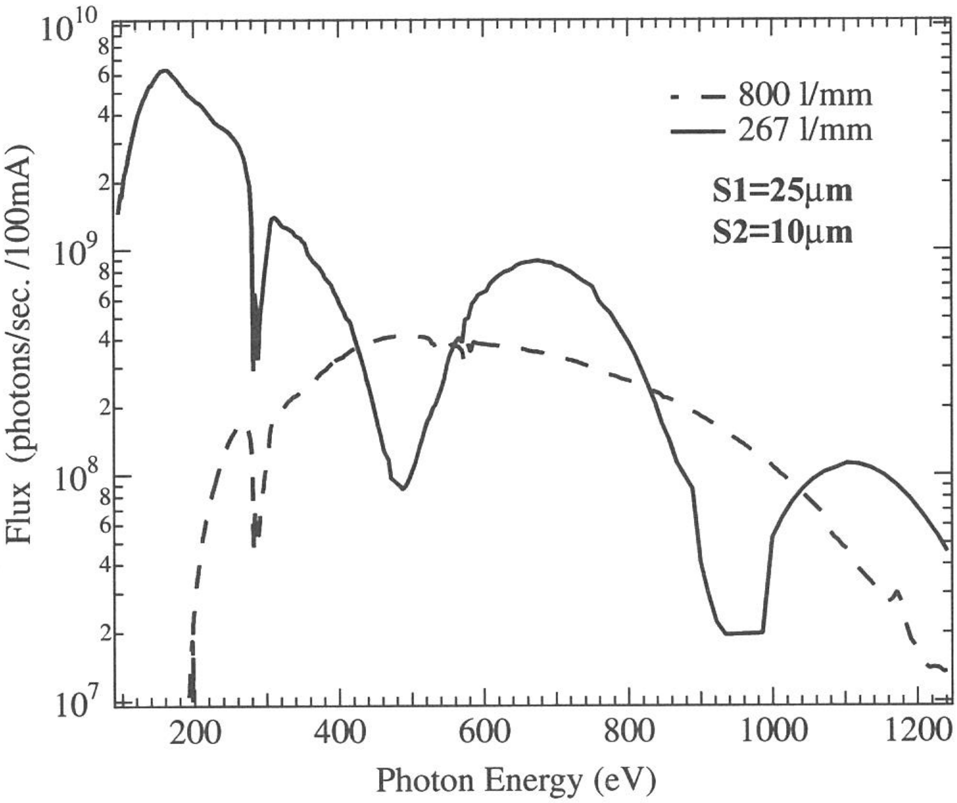


Figure 1. Throughput from the VPGM monochromator on BL4B.

Specification

Monochromator: Varied-line-spacing plane grating monochromator

Energy range: 75 to 1000 eV

Resolution: E/ΔE>5000 (at maximum)

Experiments: Soft X-ray spectroscopy (mainly, angle resolved photoion spectroscopy for gaseous targets and photoelectron spectroscopy for gaseous and solid targets)

BL5A

Photoelectron Spectrometer for Solids and Surfaces

This beamline is designed for spin- and angle-resolved photoemission study for solids and surfaces with the circularly polarized synchrotron radiation from a helical undulator and for high-resolution photoemission spectroscopy with bending magnet radiation. The beamline consists of a Spherical Grating Monochromator with Translational and Rotational Assembly Including a Normal incidence mount (SGM-TRAIN), a spin- and angle-resolved photoelectron spectrometer, and a high-resolution photoelectron spectrometer.

The SGM-TRAIN is an improved version of a constant-length SGM to aim the following points; (1) wide energy range of 5-250 eV, (2) high resolving power, (3) use of linearly and circularly polarized light, (4) reduction of second-order light, and (5) two driving modes by a computer control. The second-order light is well suppressed by using laminar-profile gratings and combinations of mirrors and gratings.

Specifications

1. Monochromator

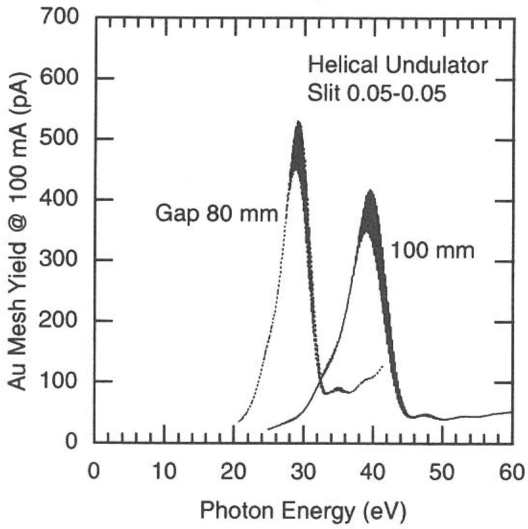
Type : SGM-TRAIN
(two glancing-incidence and one normal-incidence)
Energy range : 5-250 eV
Resolution : 0.5-80 meV (with slits of 0.01 mm)
Flux : 3×10^{10} phs/sec for bending magnet radiation
1×10^{12} phs/sec for undulaor radiation in MPW mode
(at 120 eV with slits of 0.1 mm)

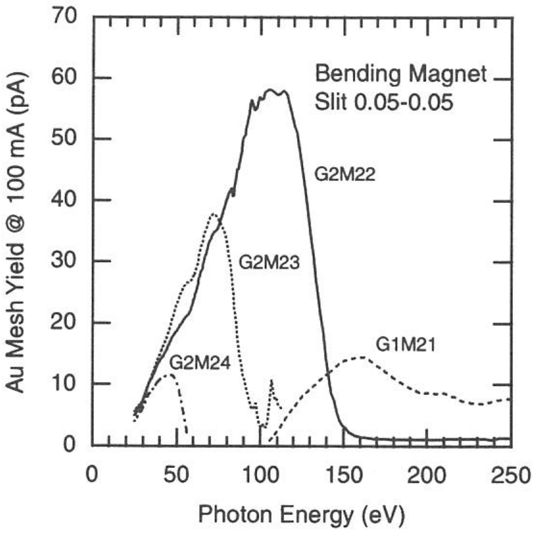
2. Main Instruments

Two-levels UHV chamber (1×10^{-10} Torr)
Hemispherical electron energy analyzer
(OMICRON, EA125-HR)
Spin- and Angle-resolved spectrometer
(low-energy diffused scattering type)
LEED of reverse type (OMICRON)
Ion-gun (ULVAC-Phi)
Low-temperature cryostat (above 30 K)

3. Helical Undulator (Optical Klystron)

Number of periods	18
Period length	110 mm
Length of dispersive part	302.5 mm
Total length	2351.2 mm
Deflection parameter, $K_{x,y}$	0.07-4.6 (helical mode)
Deflection parameter, K	0.15-8.5 (planar mode)
Fundamentals	2-45 eV (Circularly polarized)





BL5B

Calibration Apparatus of Optical Elements

BL5B has been constructed to calibrate optical elements. The beam line consists of a plane grating monochromator (PGM) and three chambers (Fig. 1). The chamber A is used for calibration of optical elements, the camber B for optical measurements of solids and the chamber C for photo-stimulated desorption (PSD) experiments. The chamber C is sometimes changed to a chamber for photoemission microscopy.

The calibration chamber is equipped with a goniometer. The goniometer, which was installed for the characterization of optical components, has six degrees for freedom; X-Y translation of a sample, and interchange of samples and filters. They are driven by vacuum pulse motors. Since the polarization of SR is essential for such measurement, axis of the rotation can be made in either horizontal or vertical direction (s- or p-polarization).

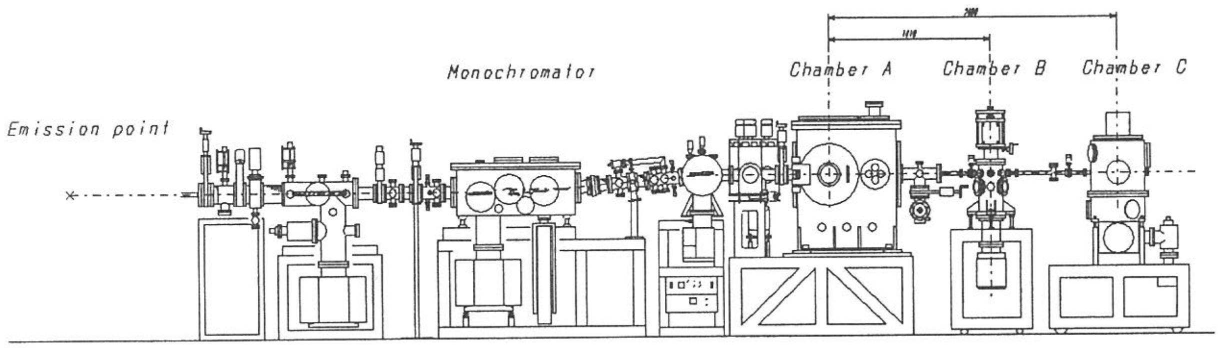


Figure 1. Schematic figure of BL5B spectrometer system.

Specification

Monochromator: Plane grating
Wavelength range: 2 - 200 nm (Fig. 2)
Resolution: $\lambda / \Delta\lambda = 300 \sim 500$
Experiments: Calibration of optical elements, absorption of solids, photo-stimulated desorption from rare gase solids, photoelectron microscopy.

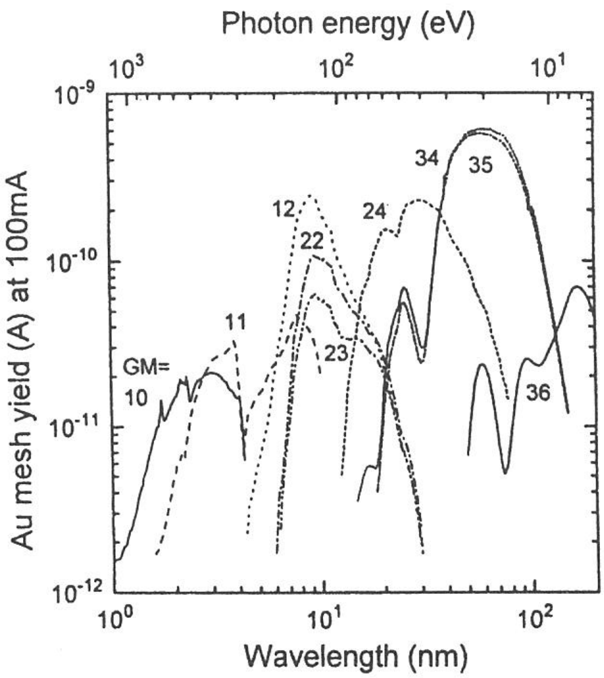
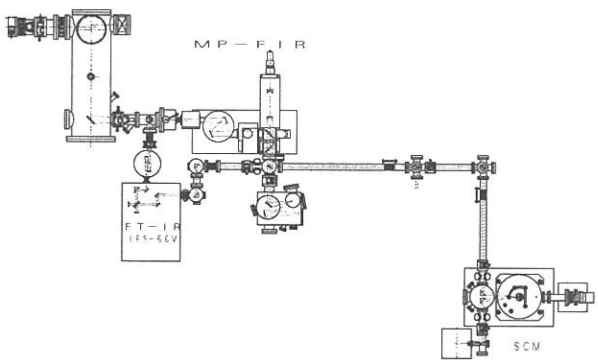


Figure 2. Throughput spectra of BL5B detected by a gold mesh (84% transmission).

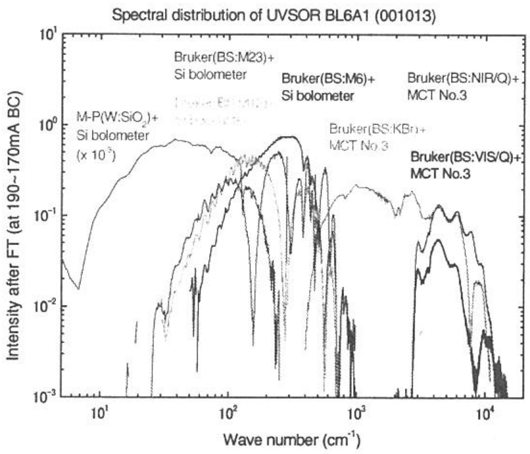
BL6A1

Fourier-Transform Middle and far Infrared spectrometers for solids

UVSOR covers a very wide energy region from a soft-X ray to a millimeter wave. BL6A1 was constructed in order to cover a long wavelength part in the spectral distribution of UVSOR from a near infrared to a milli-meter wave. Beamline are composed of two kinds of interferometers, a Martin Puplett type and a Bruker-IFS66v. The spectrum from 1 μ m to 3 μ m regions is measureable by changing of three kinds of detectors, MCT, Si-bolometer and InSb hot electron detector, according to each available region. Owing to the high brightness of the SR in the long wavelength region, the present spectroscopic system is specially favorable to the transmission and reflection measurements on so tiny specimens..



Top view of BL6A1



Throughput spectra of BL6A1

Spccification

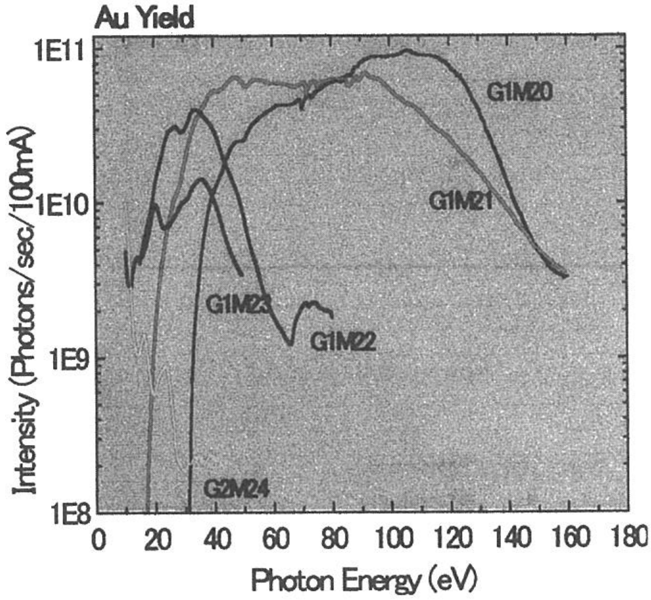
Energy resolution :	500-20000
Energy range :	0.0005-1.5eV
Interferometers :	5-300cm^{-1} by Martin-puplett interferometer
	50-30000cm^{-1} by Michelson type interferometer
Detectors :	Si bolometer(20-1000cm^{-1})
	Ge bolometer(with polyethylene window,30-300cm^{-1})
	Ge bolometer(with quartz window,10-200cm^{-1})
	InSb bolometer(5-50cm^{-1})
	MCT(400-10000cm^{-1}) Photovoltaic type
	MCT(400-10000cm^{-1},time response10nsec)

BL6A2

Photoelectron Spectrometer for Solids and Surfaces

The beamline BL6A2 has been used for photoelectron spectroscopy on solids and surfaces with bending magnet radiation. The beamline consists of a Plane Grating Monochormator (PGM) and a photoelectron micro-spectrometer.

The PGM has several combinations of mirrors and gratings to cover the wide energy range of 2-150 eV with less higher-order light. Since the monochromator has no entrance slit, the resolving power depends on the beam size and the divergence. The beamline was re-arranged to have a small spot for the photoelectron micro-spectrometer. Also the femto-second laser system was installed to conduct the combination experiments with synchrotron radiation and laser.



Specifications

Monochromator;

Type:Plane-Grating Monochromator

Energy range;2-150 eV

Resolution:0.1 eV at 70 eV

Flux:$1x10^{11}$ phs/s at 100 eV

Photoelectron micro-spectrometer;

Type:FISONS, ESCALAB 220i-XL

Spatial Resolution:20 μm for spectroscopy

2 μm for imaging

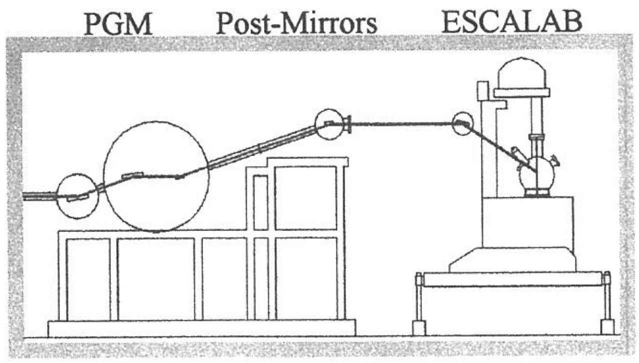
others:XPS, LEED, Ion-gun

Laser;

Type:Spectra Physics, Hurricane

Fundamentals:750-850 nm

SR=>

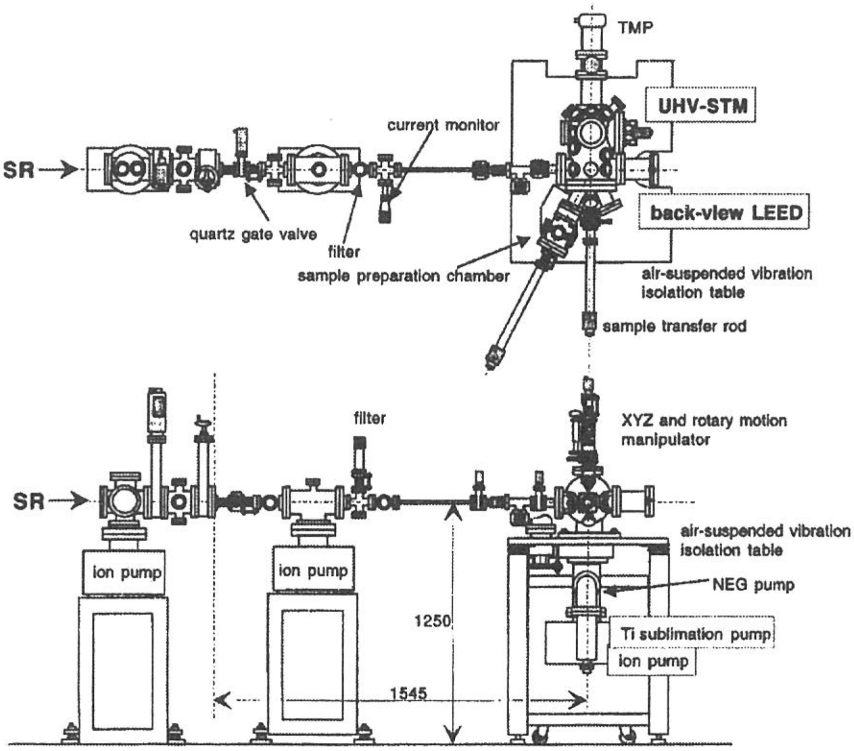


BL6B

UHV-STM beam line

This beam line is constructed for the atom level characterization of the SR illuminated surfaces by the in situ observation of STM. The STM experimental systems, ultra-high-vacuum chamber and STM, have been installed at the upstream of the BL4B SR-CVD chamber until the end of March 2000 and moved here at the last summer shut down.

When it was working at BL4B, the atomic image of clean Si(111) surface was clearly observed even under the SR storage ring operation and STM in situ observation of SR stimulated decomposition of thin SiO_2 film was successfully demonstrated. The BL6B beam line construction has almost finished. The STM experimental systems are now under remodeling. The design of the STM system is changed so that the SR beam can illuminate the sample surface just under the STM chip. By this change, the STM observation can be made just after the SR illumination without the sample transfer. The short undulator which is going to be inserted to the strait part of the storage ring and emit the beam for BL7A, is under construction. The beam line and the UHV STM station are going to be moved to the end of the new BL7A after the completion of the undulator.



BL7A

Soft X-ray Spectrometer for Solids

The beamline BL7A equipped with a double crystal monochromator was constructed for spectroscopic investigation on solids in the soft X-ray range (0.6 to 5 keV). In order to make the EXAFS experiments at the Mg (~1300 eV) and Al (~1550 eV) *K*-edges possible, a pair of $KTiOPO_4$ [KTP] (011) crystals was introduced and its performance test was done in 1999. In the past, it has been necessary to use beryl and quartz crystals to approach these two edges. The combination of an artificial crystal, YB_{66}(400), with the wiggler has been another possibility to access the Al and Mg *K*-edges. However, YB_{66} is unsuitable for the radiation from the bending magnet, due to its low reflectivity, and there is a disadvantageous characteristic caused by a anomalous (600) reflection at the Y *L*-edge for carrying out the EXAFS experiments with the YB_{66} crystals.

Figure 1 shows the photon flux of the KTP monochromator crystals over the photon energy range 1200–3000 eV. It is found that the photon intensity from the KTP crystals without the wiggler is almost the same as that from the YB_{66} crystals combined with the wiggler. The ability to cover the Mg, Al, and Si *K*-edges with a single pair of the KTP crystals seems to be attractive for many users.

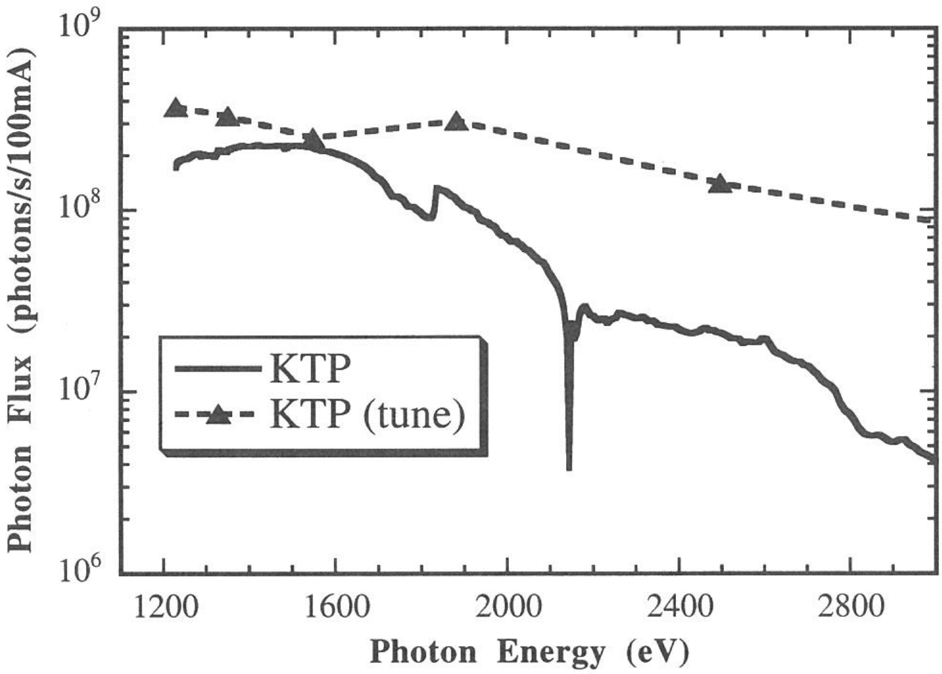


Figure 1. Throughput from KTP monochromator crystals on BL7A.

Specification
Monochromator: Double-Crystal
Energy range: 0.6～4.0 keV
Experiments: X-ray absorption (by total electron- or fluorescence-yield methods)

BL7B

3m Normal Incidence Monochromator for UV, VIS and IR Spectroscopy of Solids

The beamline BL7B is a dedicated beamline for solid-state spectroscopy, and has been reconstructed to provide sufficiently high resolution for solid-state spectroscopy, enough intensity for luminescence measurements, a wide wavelength coverage for Kramers-Kronig analysis, and the minimum deformation to the polarization characteristic of the incident synchrotron radiation for polarization measurements. It is also expected in the future that combined experimental systems are realized at this beamline, for example, with synchronization to the synchrotron radiation pulse or with the external magnetic field. The reconstructed BL7B mainly consists of a 3m normal incidence monochromator which covers the vacuum ultraviolet, ultraviolet, visible and infrared, *i.e.* the wavelength range 40 – 1000 nm, with three gratings and has been opening for users from April 1999.

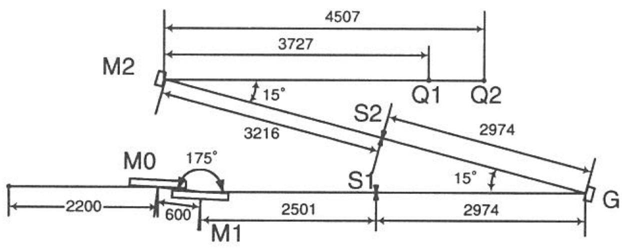


Fig. 1

Figure 1 shows the optical configuration of the beamline which consists of four parts; pre-mirror system (M0, M1), 3 m normal incidence monochromator (modified version of McPherson model 2253)(S1, G, S2), post-mirror system (M2) and experimental area (Q1, Q2). All of the optical elements are on a vertical plane. The beam spot size of the zeroth light at Q1 is about 3 mm (H) × 2 mm (V). Figure 2 shows the output spectra. A silicon photodiode (AXUV-100, IRD Inc.) was used for measurement, and the photon number was calculated from the quantum efficiency table for AXUV-100 photodiodes. The slit widths of both entrance and exit slits are 0.5 mm. The labels a to f represent output spectrum of G1 (a), G2 (b), G2 with a LiF filter (c), G3 with a quartz filter (d), G3 with a pyrex glass filter (e) and G3 with a colored glass cut filter (Toshiba Ltd. O-53) (f). All of these filters are located just before Q1 in Fig. 1. Under normal operation of UVSOR, the average beam current is more than 100 mA, so that the typical output photon number per second is in the range of $10^8 \sim 10^9$ and $10^{11} \sim 10^{12}$ for 0.05-0.05 mm and 1-1 mm slit widths, respectively. In general, the reduction of the higher order light becomes important if a monochromator covers a wide wavelength region. As shown in Fig. 2, the required good spectral purity of the monochromated light is almost fulfilled over the whole spectral range by mean of the lower wavelength cut-off filters and the reflection thresholds of the gratings themselves. It is difficult to estimate the intensity of scattered light, but the transmission spectra at the absorption region of the filters indicate that the intensity of the visible scattered light can be expected to be less than 0.5% of the average output.

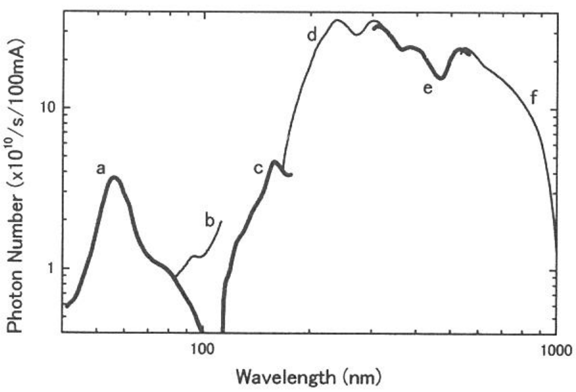


Fig. 2

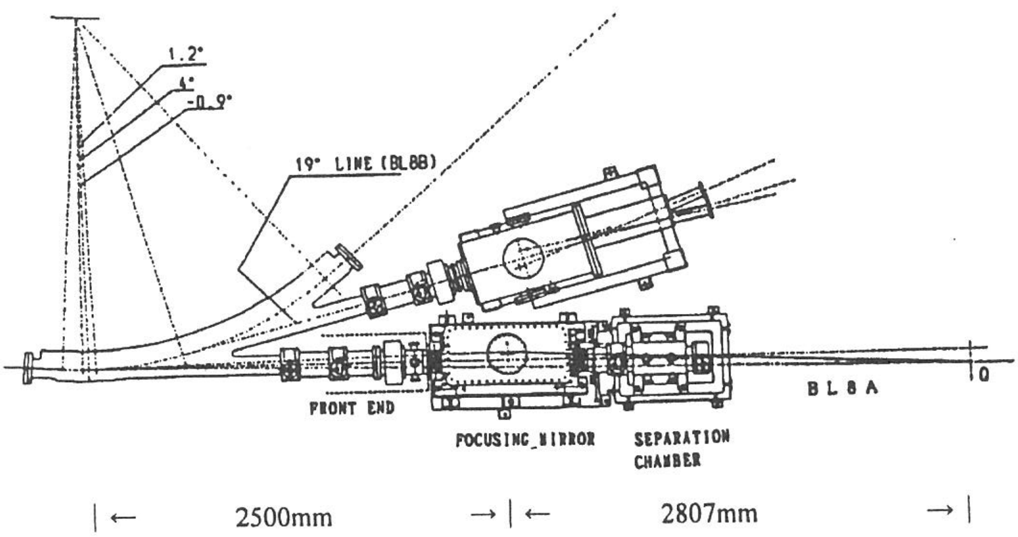
Specification

Monochromator	: 3m Normal Incidence Monochromator
Wavelength range	: 50 nm – 1000 nm
Typical resolution	: E/ΔE = 4000 – 8000 for 0.01 mm slits
Experiments	: absorption, reflection, fluorescence spectroscopy, mainly for solids

BL8A

Free Port

This beamline was constructed as a free port to which user can connect their own instruments. The beamline consists of a front end, a focusing premirror chamber and a separation chamber. Both focused and unfocussed beam can be used. A general purpose reaction chamber and a two (or three) stage differential pumping system are available for the experiments that use gas samples without window. With using three stage differential pumping system, gas pressure at the reaction chamber upto 0.5 torr can be used while keeping ultra high vacuum at the premirror chamber.



UP VEW OF BL8A

Specification

Spectral range : whole range of synchrotron radiation from UVSOR

Acceptance angle

Unfocused beam : 25 mrad (horizontal) × 8 mrad (vertical)
0.6 mrad (horizontal) × 0.6 mrad (vertical)
(with ϕ 3 mm aperture before sample)

Focused beam : 7.7 mrad (horizontal) × 8 mrad (vertical)

Beam spot size at focu : 3 mm (horizontal) × 2 mm (vertical)

Source - mirror distance : 2500 mm

Mirror - focus distance : 2807 mm

BL8B1

Photoabsorption and Photoionization Spectrometer

Last year a new beam line BL8B1 was constructed for observation of high resolution photoabsorption and photoionization experiments in the photon energy range from 30 to 800 eV, which includes the 1s core excitation energy of C, N and O atoms. For high resolution measurement among these energy, a constant-deviation constant-length spherical grating monochromator (CDCL-SGM) with three gratings (G1: R = 15 m; 1080 l/mm, G2: R = 15 m 540 l/mm, G3: R = 7.5 m; 360 l/mm) has been employed, in which entrance and exit slit positions and directions of incident and exit photon beams do not change during its scan. Consequently, it provides us with resolutions (E/ΔE) of 4000 at 400 eV and of 3000 at 245 eV. A drain current of gold foil reveals the absolute photon flux normalized by an ring current when two slit widths are 10μm. (Fig. 1)

Being Equipped at the downstream of the monochrometer, an chamber with a time-of-flight ion detector and a photoelectron detector allows us to measure photoelectron - photoion coincidence (PEPICO) and photoion - photoion coincidence (PIPICO) spectra. Measurements of absorption, electron yield and emission spectra of solid samples are also available.

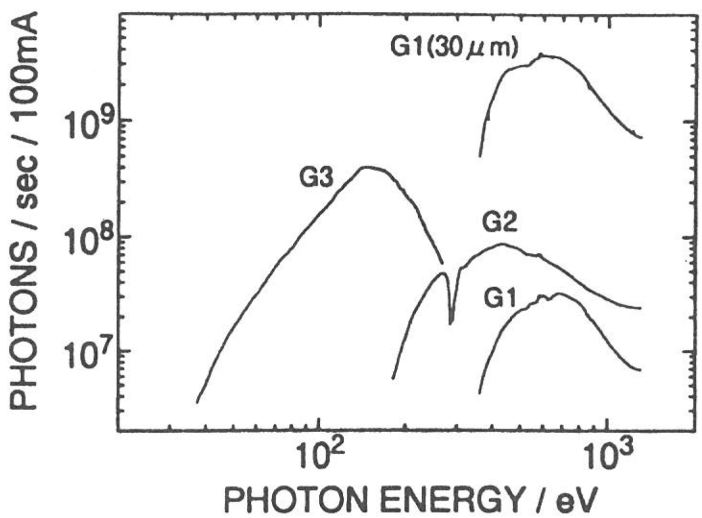


Figure 1. Absolute photon fluxes measured by a drain current of gold foil

Specification

Monochrometer	: 2.2 m constant-deviation grazing incidence
Wavelength range	: 30 to 800 eV
Resolution	: E/ΔE = 4000 at 400 eV and 3000 at 245 eV
Available Experiments	: Measurement of photoabsorption and photoionization spectra for gas and solid sample

BL8B2

Angle-Resolved Ultraviolet Photoelectron Spectrometer for Solids

BL8B2 is a beamline for angle-resolved ultraviolet photoemission spectroscopy (ARUPS) system which is designed for measuring various organic solids such as molecular crystals, organic semiconductors, and conducting polymers. The beamline consists of a plane-grating monochromator (PGM), a sample preparation chamber with a fast entry Load-Lock chamber, a measurement chamber with an accurate for temperature dependence (base pressure 1×10^{-10}Torr), a cleaning chamber (base pressure 1×10^{-10}Torr), and a sample evaporation chamber (base pressure 3×10^{-10}Torr). The cleaning chamber is equipped with a back-view LEED/AUGER, an ion gun for Ar^+ sputtering, and an infrared heating unit. The PGM consists of premirrors, a plane grating, focusing mirror, and a post-mirror, with an exit slit. It covers the wide range from 2 to 150eV with exchanging two gratings (G1: 1200l/mm, G2: 450l/mm) and five cylindrical mirrors. The toroidal mirror focuses the divergent radiation onto the sample in the measurement chamber. The spot size of the zeroth-order visible light at the sample surface is about $1\times1mm^2$. The energy resolution at a slit width of 100μm was found to be 0.004-0.3eV in the wavelength range from 2 to 130eV. A hemi-spherical electron energy analyzer of 75mm mean radius with an angular resolution less than 2° can be rotated around vertical and horizontal axes. The sample mounted on a manipulator can be also rotated around two axes.

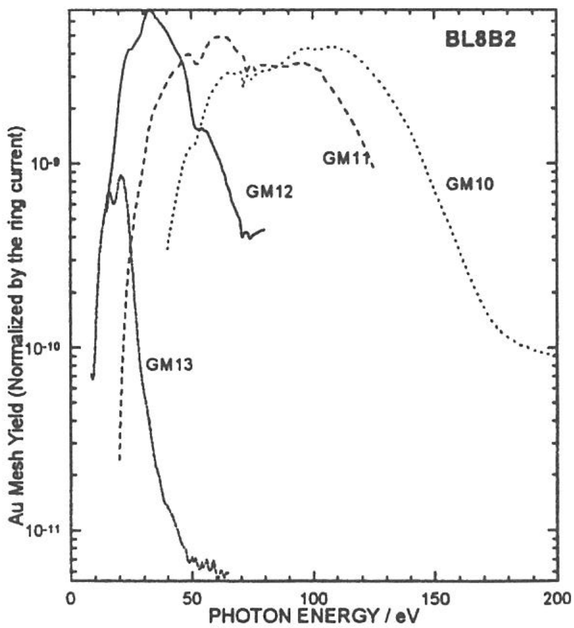
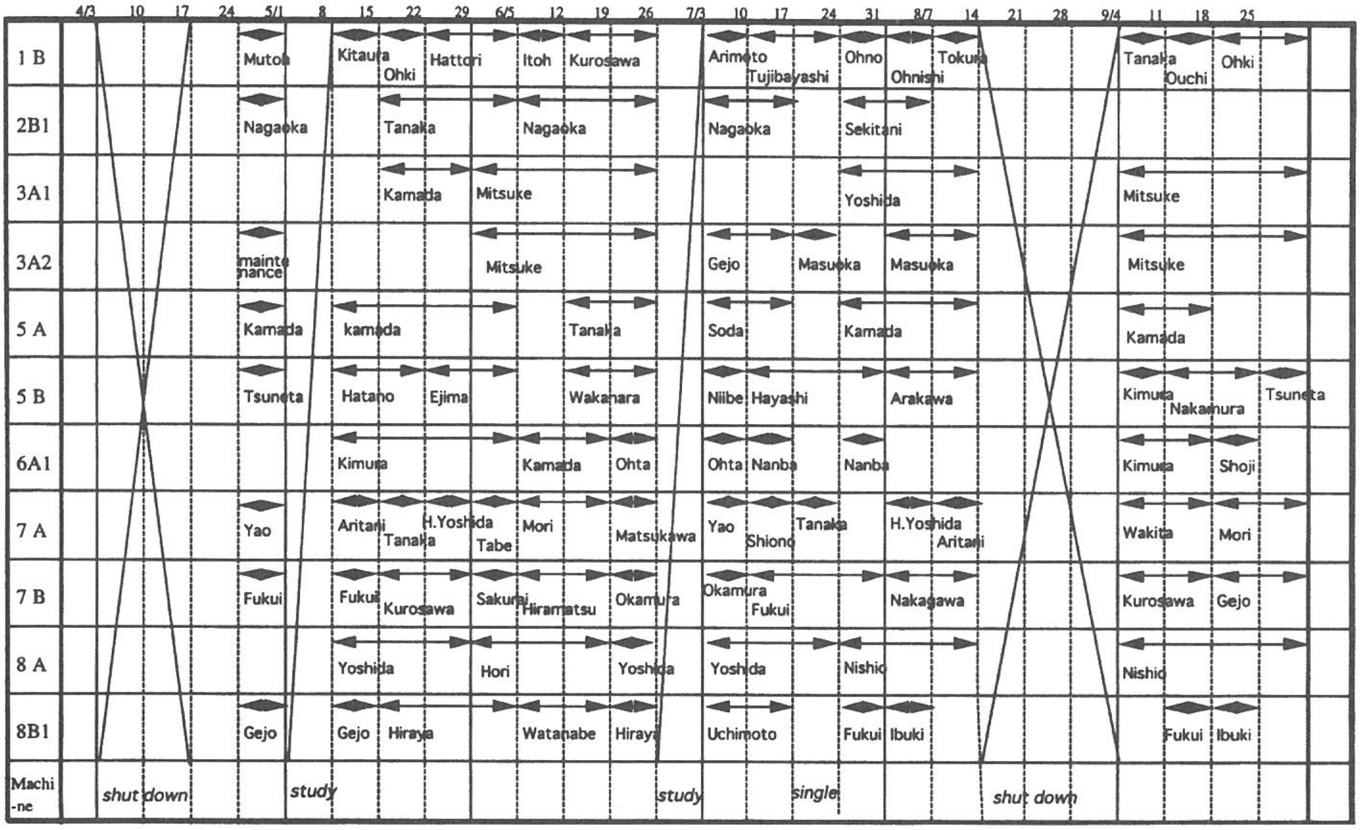


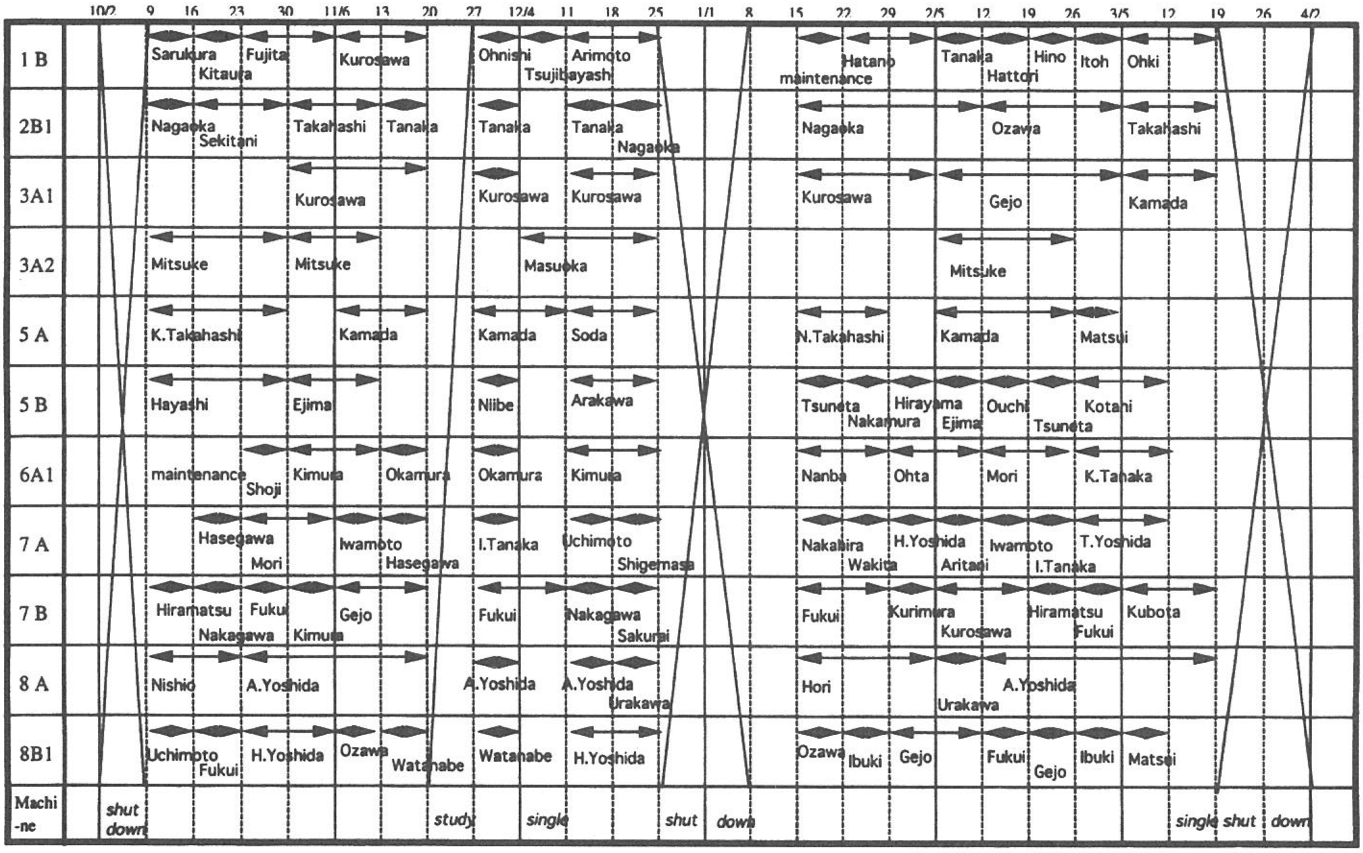
Figure Throughput spectra of plane-grating monochromator at BL8B2 with 100 μm exit slit.

Specification

Monochromator	: plane grating monochromator
Spectral range	: 2-150eV
Resolution	: 100meV at 40eV as determined by the Fermi edge of gold
Experiment	: angle-resolved ultraviolet photoelectron spectroscopy (ARUPS) for various organic solids
Polarization	: 85~91% at 500nm

Open Beam Lines (Apr. 2000 - Mar. 2001)





In-house Beam Lines (Apr. 2000 - Mar. 2001)