UVSOR

Current Status of Light Source and Beam Lines

The UVSOR Accelerator Complex in 1999

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1. General

Monthly statistics of the light source operation of the year 1999 are shown in Fig 1. These a couple of years we regularly have 4 shut-off terms for machine maintenance. In 1999, there were the new year shut-off (2-week), the spring term shut-off (4-week), the summer shut-off (4-week) and the fall term shut-off (2-week). Consequently the machine was totally operated for about 240 days (including test operations), and the integrated operation time reached approximately 2700 hours. In the spring shut-off term, pulsars for kicker magnets on the storage ring were replaced by new ones which employed IGBT switchings, and a new controller for charge and discharge of those pulsars was installed. Fall time of the bump orbit for the beam injection was reduced to 1 μs, so that the injection efficiency was improved. To avoid effects of ion-trapping, we have employed a partial filling operation so far. Number of filled buckets was further reduced to 11 from 12 after investigations during the shut-off. In addition to ordinary maintenance of accelerator devices, a klystron of the injector LINAC was replaced by new one in the summer shut-off term.

There was fortunately no serious trouble in the whole year. However the superconducting 4 T wiggler, which had been operated from December, 1998, was completely stopped in the beginning of June because of a fatal malfunction of the refrigerators. We have not decided yet whether the wiggler should be further operated. The wiggler system seemed to be replaced for stable operation, which means an extra budget is required. Continuation of the wiggler operation should be concluded from a view of scientific opportunities, so that a possibility of development of other insertion devices is expected to be considered in the discussion.

Another minor trouble was occurred on the RF

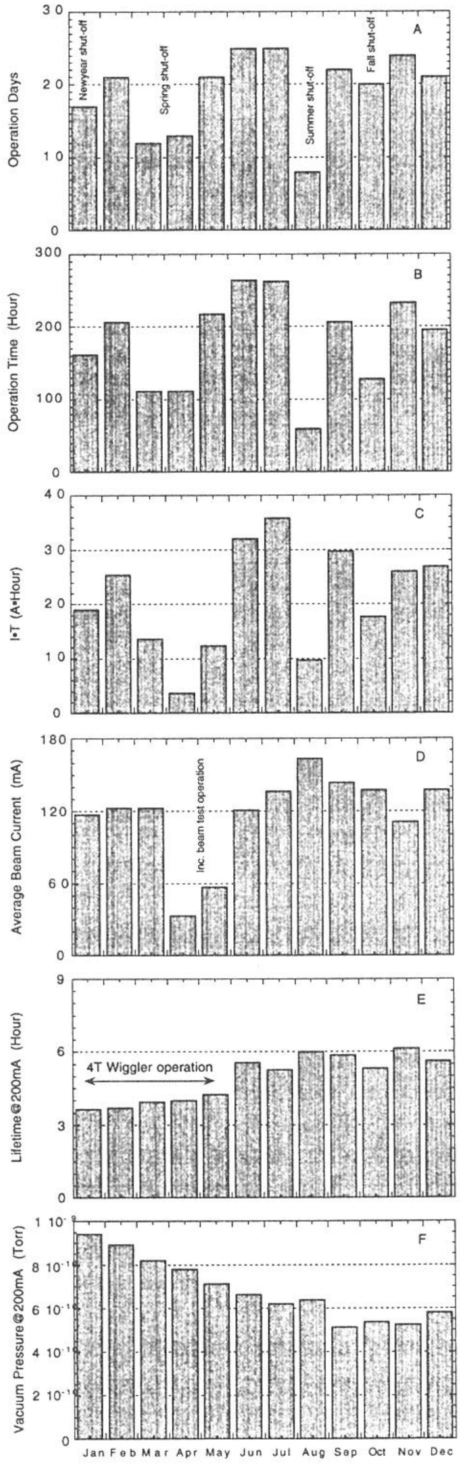


Fig. 1 Monthly statistics of the UVSOR light source in 1999. (A)The total operation days accumulated each month. (B)The total operation time. (C) The integrated beam current. (D) The averaged beam current. (E)The averaged beam lifetime at the multi-bunch beam current of 200 mA. (F)The averaged ring vacuum pressure at the multi-bunch beam current of 200 mA.

system of the storage ring, which was exposed in November. Reflected power from the main cavity has been increased, and then the RF power amplifier was frequently down because of safety. It was finally found that a circulator, which guides the reflected power into a water load, was malfunction. New one will be installed in March, 2000. By setting a tuning angle of the cavity small, the reflected power was reduced to be lower than a threshold power of the interlock system of the power amplifier in the ordinary multi-bunch operation.

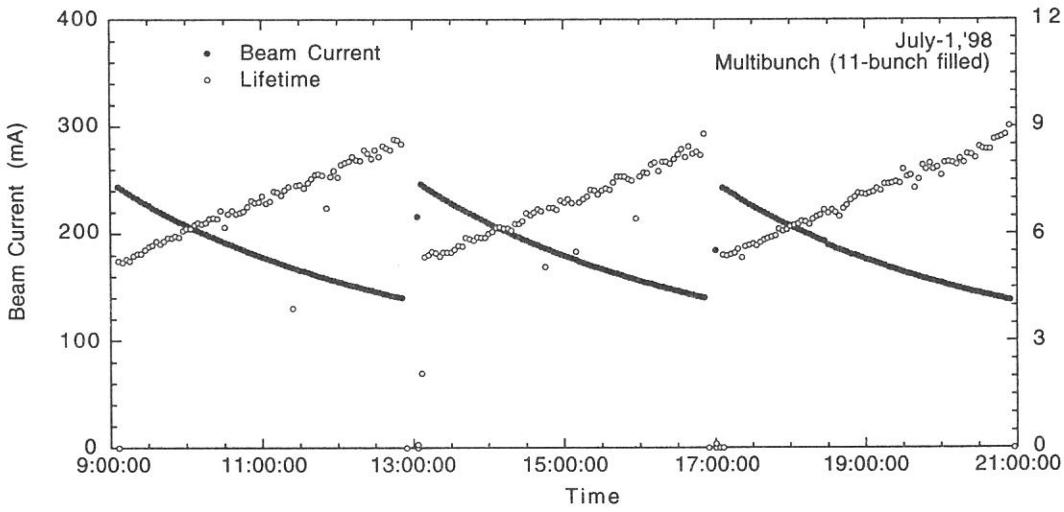


Fig. 2 Variations of the beam current and the lifetime in one-day operation with the multi-bunch mode (July-1, 1999).

Generally speaking, the operation of the UVSOR accelerators in 1999 was pretty stable and successful.

2. Improvement

As mentioned above, the kicker pulsars and the power supplier on the storage ring were replaced by new ones. In the injection scheme of the UVSOR accelerator system, 4-bunch train is extracted from the booster synchrotron. Because the flatness of the fast kicker pulse on the booster is imperfect, the overall horizontal emittance of the bunch train is very large. In order to obtain better injection efficiency, the fall time of the bump orbit of the ring should be fast to avoid beam loss at the septum after the first turn. By adjusting capacitance of the IGBT pulsar, the fall time of ~ 1 μs was achieved (former value was ~ 1.5 μs), so that the beam injection rate was improved to be 2 ~ 3 mA/s from 1 ~ 2 mA/s.

After the spring shut-off term, the beam orbit has been corrected after each beam injection. An on-line software for calculation of linear lattice parameters including effects of insertion devices was completed. This software was linked with an application for steering magnets control to change the beam orbit as one likes. Averaged rms orbit deviations in the horizontal and the vertical directions have been kept within ~ 50 μm and ~ 80 μm, respectively, in the user machine times.

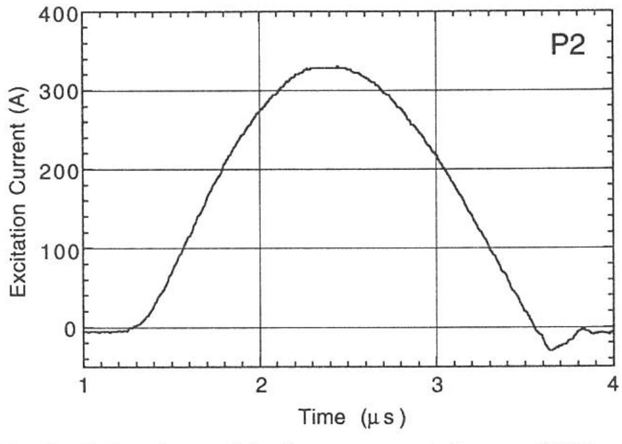


Fig. 3 Pulse shape of discharge current of a new IGBT pulsar for a kicker magnet.

UVSOR

ACCELERATOR COMPLEX

Injection Linac

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

Booster Synchrotron

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

Storage Ring

Lattice Type	Chasman-Green
Energy	750 MeV
Critical Energy	425 eV
Super Cell	4
Bending Radius	2.2 m
Betatron Tune	3.16 (horizontal)
	1.43 (vertical)
Momentum Compaction	0.0264
Emittance	164 nm rad (horizontal)
RF Frequency	90.115 MHz
Harmonics	16
Beam Current	Multi-Bunch 200 mA
	Single-Bunch 70 mA
Life Time	4 h at 200 mA

Additional Equipment

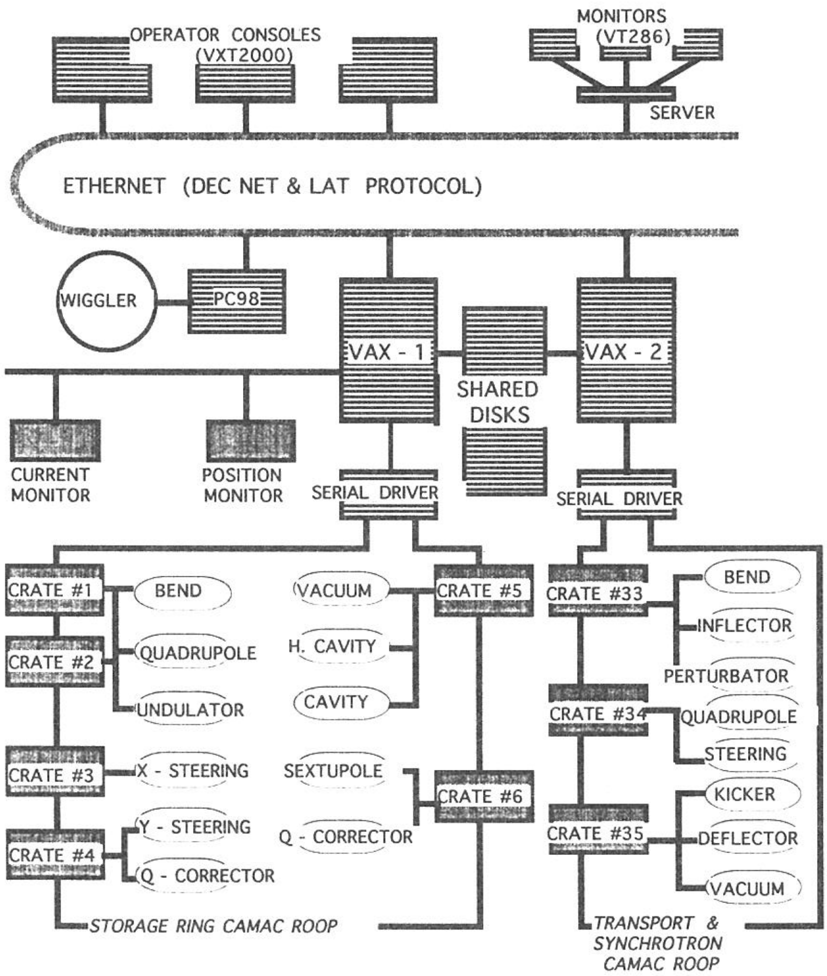
Higher-Harmonic Cavity	3 x 90.115 MHz
Super-conducting Wiggler	4 T (maximum)
Undulator	for SR
Helical Optical Klystron	for Free Electron Laser

Control System

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

Architecture

CPU	VAX4000 x 2
OS	VMS
Connection	DECNET & Local Cluster
Operating Console	X-servers
Interfaces	CAMAC serial loop
	GPIB
	RS232C
Languages	FORTRAN, C, PASCAL



Scheme of Accelerator Control System "UCOSS"

Beam Lines in 1999

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 1999.

<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 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 1999, the computer control system of a 1-m Seya-Namioka monochromator has been renewed. The old control system consisted of motor drivers, encoder, limits, and a computer was replaced completely by the new system. The new system consists of components which can be supplied on commercial base. This improvement may make us easy for maintenance. The gratings were also exchanged by new ones. We installed two G3 and one G1 grating because of usefulness of the G3 grating in VUV region. The upgrade of a second-monochromator system will be done in 2000. We expect that this beam line can be used continuously in VUV region.

○BL2B1

This beam line consists of a grasshopper monochromator, a double-pass CMA, and coincidence analyzer. This beam line has been used mainly for surface science because useful equipment 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 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 1999, a new version of an electron-ion-coincidence instrument has been installed, resulting in better efficiency in collecting data. An analyzing chamber for the experiments in UHV was also improved in order to install many apparatuses for surface science. Moreover, pre-mirror M2 was renewed and the trouble in driving mechanism of a Grasshopper monochromator was fixed, but not completely.

The performance of the monochromator is not good in comparison with similar beam lines in other facilities. This indicates that we must find our own idea such as an EICO method all the time in order to keep the activity of this beam line. We expect users' collaboration and proposal for future.

We would like to express our thanks to Prof. S. Nagaoka for his 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.

In 1999, usual maintenance for vacuum systems has been done to keep activities at BL3A1/3A2. Besides this, the renewal program of the CL-SGM driving system at BL3A2 and also the improvement of the second-monochromators at BL3A1 have started. We have started thinking about a future plan of this beam line for coming century. Everybody having ideas and opinions is welcome.

○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 1999, the mechanism of the pre-mirror VM for SGM-TRAIN monochromator was improved. This could solve the interference of the user experiments with the FEL studies. The powerful laser system consisting of a TiS laser, RegA, and OPA was also installed for user experiments.

○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 recent years, the mechanical and optical components were repaired. The program was also renewed from old digital controller to the computer control system. However, there are several points which should be improved to keep the performance of this beam line.

○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 1999, the new Labview system for FT-FIR was commissioned. Many detectors and beam splitters are always maintained to keep the activity of this beam line. Another IR beam line is now under construction at Spring-8. This means not only many needs for IR beam lines with SR, but also the necessity and the possibility for the improvement of BL6A1. We started to discuss the improvement of this old but still powerful/useful beam line.

○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, KTP, and alumna to cover the soft x-ray region less than 3 keV one hand, and to think deeply about the future of the wiggler and the BL7A with active users on the other hand.

○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 1999. Few points still remain to fix and may be completely established in 2000.

We would like to express our thanks to working group, especially Profs. K. Fukui, K. Nakagawa, T. Kinoshita, and Dr. E. Okamura, 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 1999, 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 1999, the alignment of the CL-SGM monochromator was improved to provide good linear polarization, which was monitored by a multi-layer polarizer

<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 is now going to bio-science use under collaboration with bio-scientists in Okazaki institutes. Many apparatuses for experiments in gaseous phase have been removed in 1999. We would like to express our sincere thanks to all 2A users and active SR persons for their lots of efforts to construct this beam line and to keep activity of BL2A. We never forget the memorial fact that the first scientific data with using UVSOR had been obtained at 2A. We are also expecting many active bio-scientists who want to use UVSOR.

○BL2B2

The construction of a dragon-type new monochromator has commissioned in 1999. The good performance of a high resolving power will contribute experiments in gaseous phase soon.

○BL3B

This beam line consists of 3-m NIM and two-dimensional photoelectron analyzer. This has been used for experiments in gaseous phase. In 1999, the vacuum leakage happened into the monochromator and pre-mirror chamber, but fortunately the interlock system could protect the storage ring from the accident.

○BL4A/4B and BL6B

The re-arrangement of the beam lines at BL4A , 4B, and 6B has started in 1999. The SR-CVD instruments installed at 4B will move to BL4A, and the SR-STM system at BL4B will move to BL6B, since the IR station at BL6B was completely shutdown and the construction of a new soft x-ray beam line at BL4B was proposed.

○BL6A2

The optical elements including gratings and the control system were completely replaced by new ones in 1999. The micro-ESCA system will be installed to this beam line soon.

○BL8B2
The high-performance multi-channel photoelectron spectrometer is under installation. This is powerful for the angle-resolved photoelectron spectroscopy to investigate the relation of molecular orientation on the surface and the electronic states

Therefore, the UVSOR facility will have twenty stations operational; two soft-x-ray stations equipped with a double-crystal monochromator, nine 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 three white-light stations without any monochromator. In 1999, many and interesting results were obtained at 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 1999

Beam Line	Station Master	Sub Master	Supervisor
1B	M. Hasumoto	M. Kamada	M. Kamada
2B1	E. Nakamura	S. Nagaoka	M. Kamada
3A1	M. Kamada	E. Nakamura	M. Kamada
3A2	N. Kondo	T. Gejo	E. Shigemasa
5A	M. Hasumoto	M. Kamada	M. Kamada
5B	M. Hasumoto	E. Nakamura	E. Shigemasa
6A1	E. Nakamura	O. Matsudo	M. Kamada
7A	E. Shigemasa	N. Kondo	T. Kinoshita
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 1999.

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	T. Urisu	VUV Photo Science
6A2	M. Kamada	UVSOR
*6B	K. Yakushi	Molecular Assemblies
8B2	T. Urisu	VUV Photo Science

*The new representatives of BL4B and 6B in 2000 are Profs. E. Shigemasa (UVSOR) and T. Urisu (VUV Photo Science), respectively.

Beam line 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	1-m Seya-Namioka	650 - 30 nm		60	6	Solid (absorption)
BL2A	1-m Seya-Namioka	400 - 30 nm		40	6	photoabsorption
BL2B1	2-m Grasshopper	60 - 1.5 nm		10	1.7	Solif & surface (photoemisson)
BL2B2	18-m Spherical Grating	60 - 6 nm		15	6	Gas (photoionization, photodissociation)
BL3A1	None (Filter, Mirror)		(U)	0.3	0.3	Solid & irradiation (photodissociation)
BL3A2	2.2-mConstant Deviation Grazing Incidence	100 - 10 nm	 (U)	10 0.3	4 0.3	Gas & solid (photoionization & photodissociation)
BL3B	3-m Normal Incidence	400 - 30 nm		20	6	Gas (photoemission)
BL4A1	Multi-Layered-Mirror Monochromator	13 - 23 nm Mo/Si MLMs		16.6	12.8	Irradiation
BL4B	None			8.3	6	Irradiation
BL5A	None SGM-TRAIN	 250 - 5 nm	(OK)	 10	 3	FEL Solid (photoemission)
BL5B	Plane Grating	200 - 2 nm		10	2.2	Calibration, gas (photodissociation) & solid (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 & surface (photoemission)
BL6B	FT-IR	200 - 1.7 mm		70	25	Solid (absorption)
BL7A	Double Crystal	1.5 - 0.8 nm 1.5 - 0.2 nm	 (W)	2 1	0.3 0.15	Solid (absorption)
BL7B	3-m Normal Incidence	1000 - 50 nm		65	10	Solid (absorption)
BL8A	None (Filter)			25	8	Irradiation & user's Instrum.
BL8B1	15-m Constant Deviation Grazing Incidence	40 - 2 nm		10	1.5	Gas & solid (absorption)
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
W: with a wiggler
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.

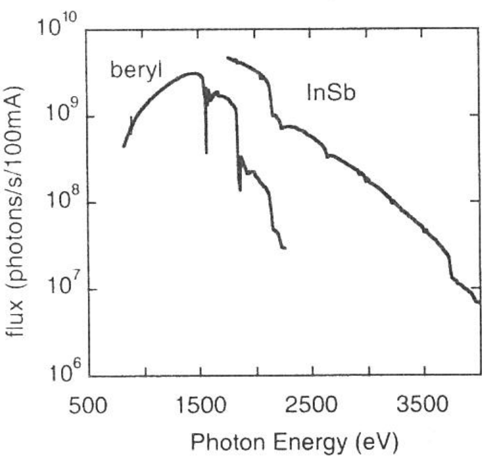


Figure 1. Throughput spectra of the double crystal monochromoator at BL1A.

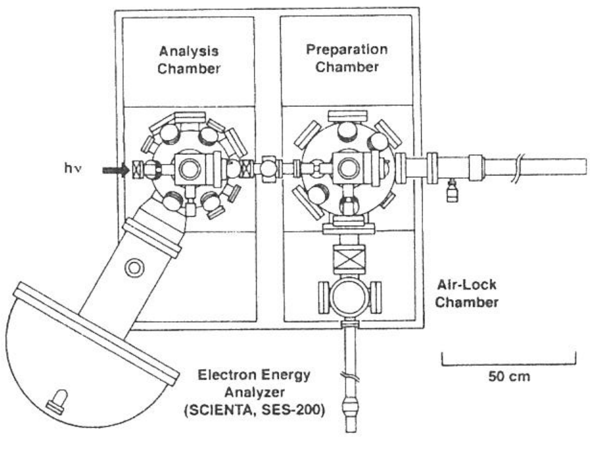


Figure 2. Top view of the UHV apparatus for photoelectron-photoabsorption spectroscopy.

Specification

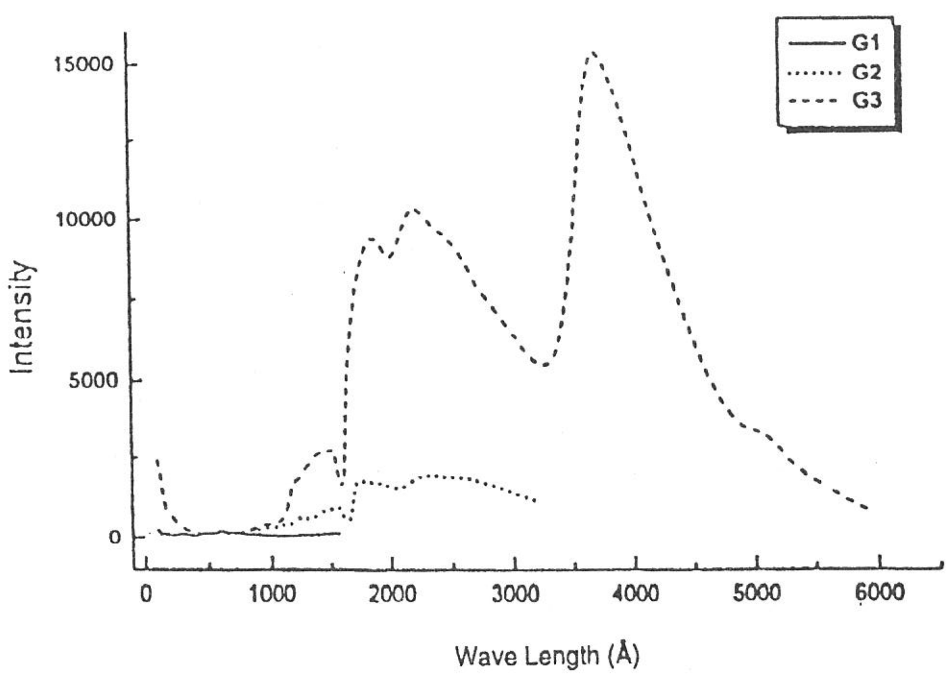
Monochromator	: double crystal monochromator
Monochromator crystals (2d value, energy range)	: β-Al_2O_3 (22.53Å, 585-1609eV), beryl (15.965Å, 826-2271eV), KTP (10.95Å, 1205-3310eV), quartz (8.512Å, 1550-4000eV), InSb (7.481Å, 1764-4000eV), Si (6.271Å, 2104-4000eV)
Resolution	: E/ΔE=1500 for beryl and 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 $\lambda<40$ 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 $105<\lambda<210$ nm range as usual. Thus, the total photo-absorption 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.

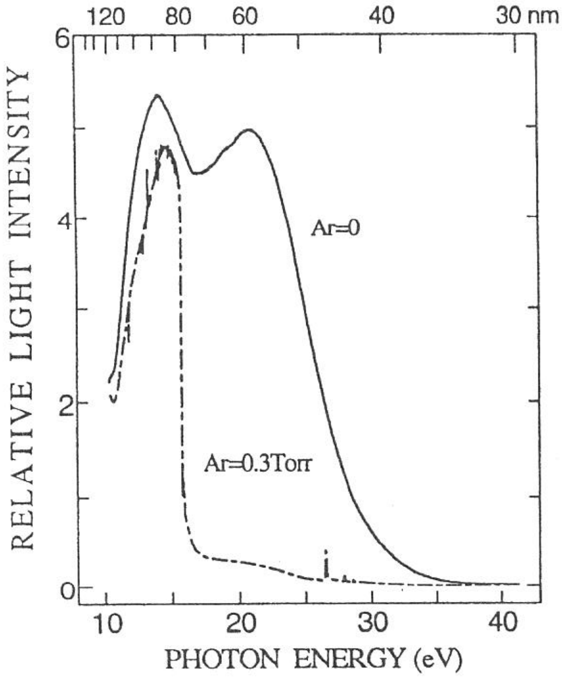


Fig. 1. Transmitted I_0 intensity with and without an Ar gas filter.

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 solid surfaces

BL2B1 is a beamline in order to study solids and solid surfaces by the use of photoabsorption and photoelectron spectroscopy. A 2-meter grazing incidence monochromator ('Grasshopper' type, Mark XV; Baker Manufacturing Co.) is installed. A 2400 l/mm grating has been installed since April 1994, and was replaced by a 1800 l/mm grating at March 1997. The resolving power is better than 600 at C-K edge (about 290 eV). Figure 1 shows the photoelectron yield from the Au mesh (10%-transmission) located near the position of a sample by the use of the 1800/mm grating. The dip around 300 eV is due to carbon contamination of optical elements.

The analyzing chamber is installed at the focusing point of the monochromized light. The pressure is less than 1×10^{-10} Torr. A double-pass CMA, a LEED optics, an ion-gun for sputtering, and a sample holder which can be cooled with liquid nitrogen and heated, etc. are equipped for the 'in-situ' measurements. The photoelectron spectroscopy including CIS (Constant initial state spectroscopy), CFS (Constant final state spectroscopy) can be measured using CMA, which is controlled by a personal computer. Samples can be transferred to the analyzing chamber from the air, through the preparation chamber in which sample treatments (e.g. cleaving, filing, and deposition) can be made.

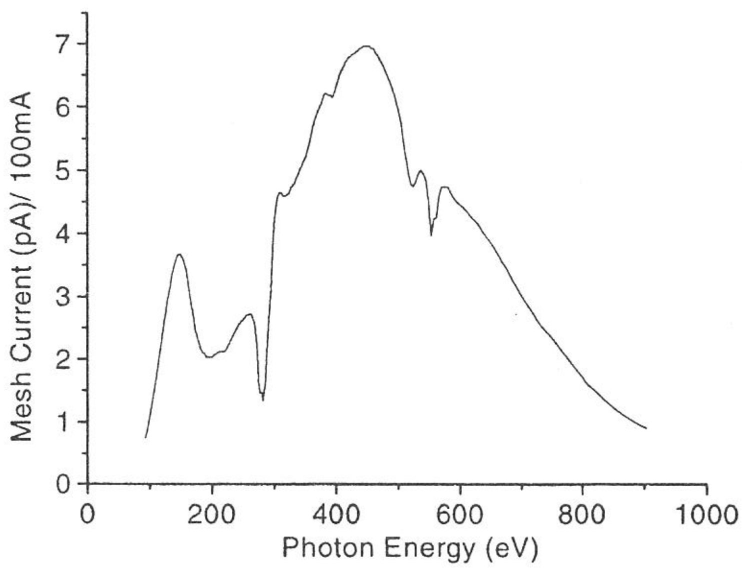


Figure 1. Photoelectron yield measured by the use of the Au mesh

Specification

Monochromator	:2m grasshopper type
Energy range	:95-1000 eV (1800 l/mm)
Resolution of photon	:<0.4eV at 300eV (1800 l/mm)
Resolution of photoelectron	:<0.3eV (hv=150eV)

Experiment : Photoelectron spectroscopy, X-ray absorption spectroscopy,

BL 3A1

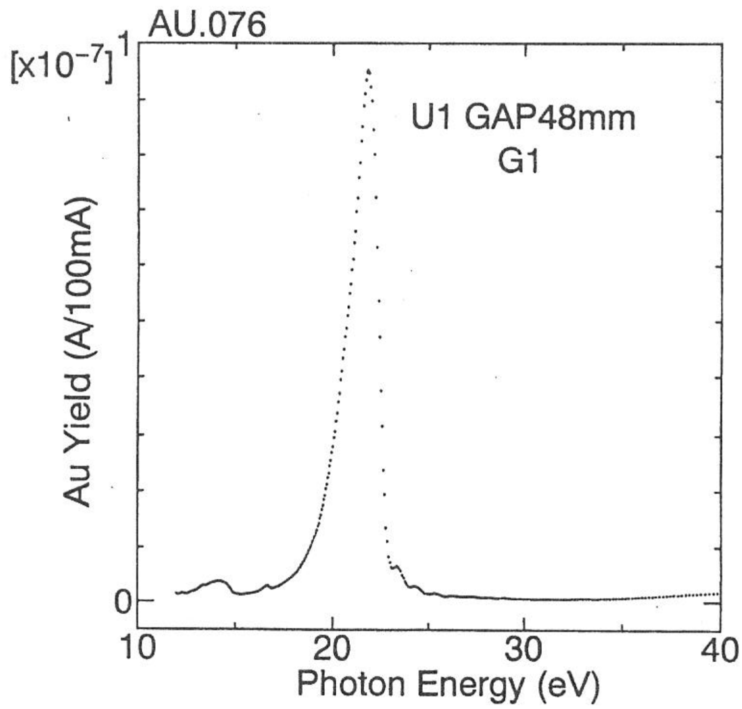
Irradiation Port with Undulator Radiation

The beam line 3A1 has been used for various kinds of experiments with 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-level excitation, and so on have been carried out at the beam line 3A1. The luminescence from High-Tc superconductors, scintilator, and organic materials has been observed. Combination experiments with undulator radiation and lasers has also been successfully conducted for SR-induced desorption and SR-excited light-amplification.

A planar-type undulator installed in a long straight section of the UVSOR storage ring can provide an intense quasi-monochromatic radiation to beam lines 3A1 and 3A2. The photon energy range from 8 to 52 eV is covered by the fundamentals with K-values of 0.62-3.6 and higher harmonics are mixed in the spectral distribution of the undulator radiation in case of high K-values.

The beam line 3A1 has no monochromator between the undulator and a sample chamber. The radiation is introduced by a toroidal focusing mirror into the sample chamber through a pinhole of 1 mm in a diameter and metallic filters (Al, Sn, and In). A gold mesh is always installed in the sample chamber to monitor the incident photon flux. A typical spectral distribution measured with the monochromator at BL3A2 is shown in the figure. The photon flux provided with the gap of 60 mm is about 10^{14-15} phs/s on the samples.

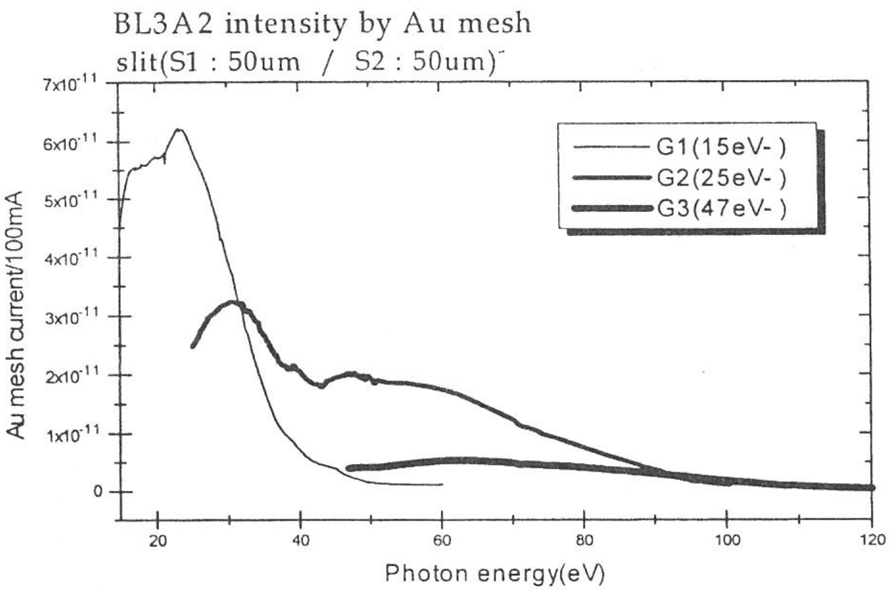
A differential pumping system consisting of three TMP pumps can be available for the users who want to use gaseous materials. Visible and VUV second monochromators for luminescence measurements (Jobin-Yvon HR320 for visible range and home-made NIM monochromator for VUV range) are also provided. A He flow-type cryostat and a TAC system are useful for the time resolved experiments under a single-bunch operation.



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 2.2m focal length and covers wide wavelength region(10-100nm) 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, we detect the coincidence signals of two fragment ions produced from a parent ion, evaluate the kinetic energy release in "Coulomb explosion", and measure the angular distributions for the fragment ions. The sensitivity with respect to high-speed ions (several tens of electron volts) is much improved in comparison with commercial TOFMS.



Specifications

monochromator	:	2.2m Constant-Deviation Grazing-incidence
Spectral range	:	10 - 100nm (15eV - 120eV)
Resolution	:	550 - 800 (0.03eV - 0.18eV)
Mass spectrometer	:	300
Length of the drift tube	:	0.2 - 1m
Rotatable angle	:	0 - 90° with respect to the photon beam

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 nitric oxide which undergo dissociation into N** + O($^1D^e$, $^3P^e$) followed by autoionizing transitions of the superexcited nitrogen atoms,[3)] 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).

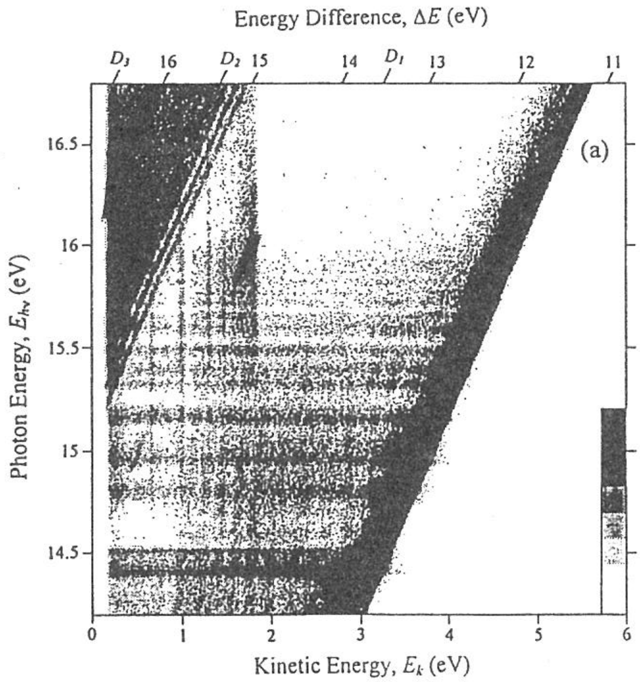


Figure 1. Two-dimensional photoelectron spectrum of OCS taken at the photon energy range from 14.2 to 16.8eV. The electron yield is presented by the plots with eight tones from light to dark on a linear scale.[4)]

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).

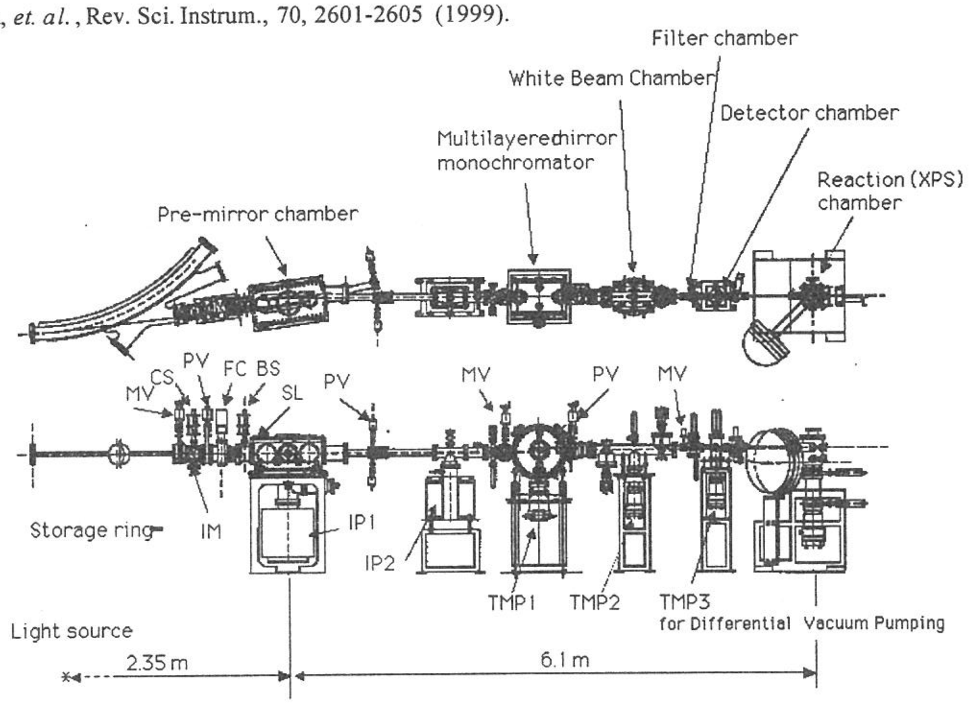


Figure 1. Top and side views of the MLM monochromator beam line (BL4A1) constructed at the UVSOR facility of the IMS.

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

BL 5A

Photoelectron Spectrometer for Solids and Surfaces

The beamline 5A is designed for spin- and angle-resolved photoelectron experiments for solids and surfaces with the circularly polarized synchrotron radiation from a helical undulator and for high-resolution photoelectron experiments 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 linear and circular polarization, (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 0.01mm
Flux: 3×10^{10} phs/sec at 120 eV with slits of 0.1 mm
(for bending manget radiation)

2) Main Instruments

Two-levels UHV chamber (1×10^{-10} Torr)
Hemi-spherical electron-energy analyzer
(OMICRON HR-125)
Spin- and Angle-resolved spectrometer
(low-energy diffused scattering type)
LEED of reverse type (OMICRON)
Ion-gun (ULVAC-Phi)
He-lamp for UPS
Low-temperature cryostat (>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, Kx,y	0.07-4.6 (helical mode)
Deflection parameter, K	0.15-8.5 (planar mode)
Fundamentals	2-45 eV (Circular polarization)

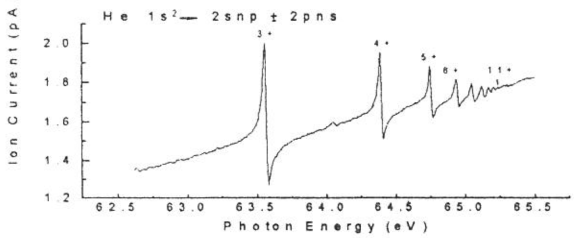


Fig. 1 He ionization spectrum

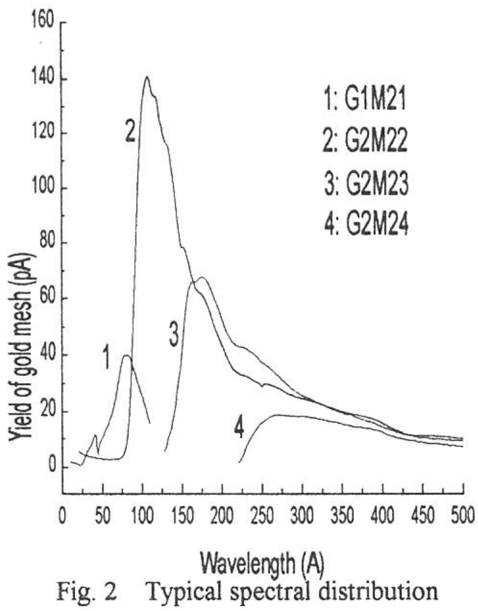


Fig. 2 Typical spectral distribution

Refs: M. Kamada et al., Rev. Sci. Instrum. 66, 1537 (1995), N. Takahashi et al., Jpn. J. Appl. Phys. 35, 6314 (1996).

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).

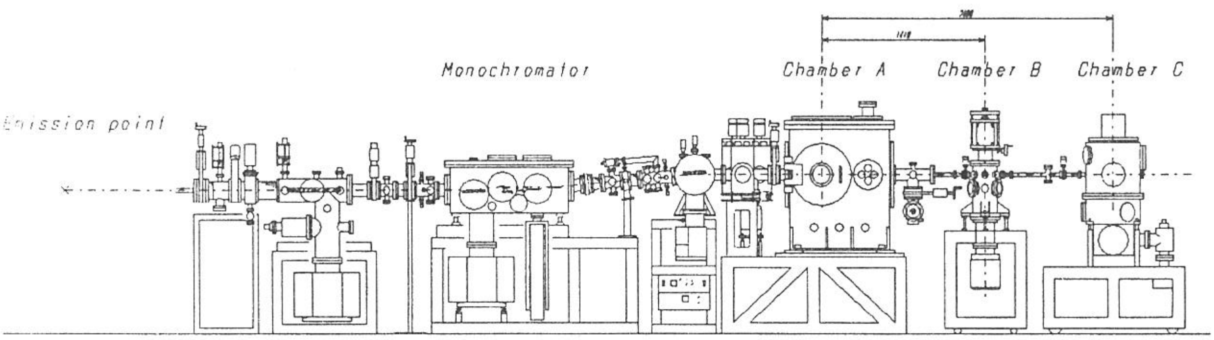


Figure 1. Schematic figure of BL5B spectrometer system.

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.

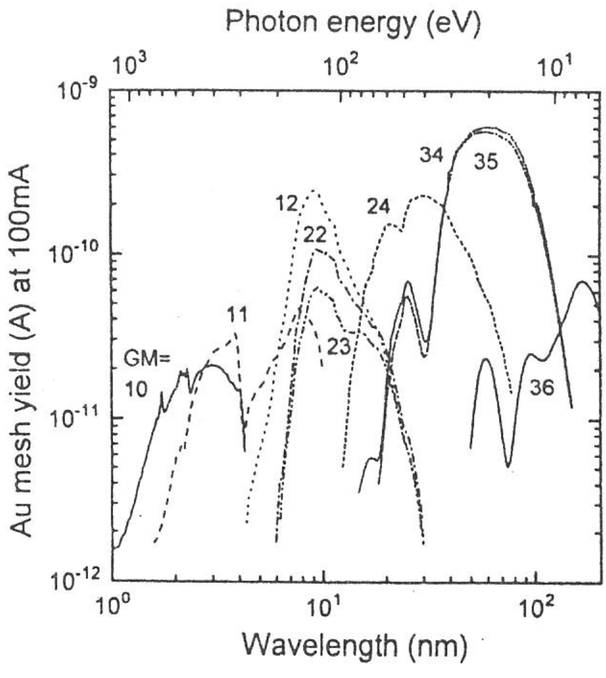


Figure 2. Throughput spectra of BL5B detected by a gold mesh (84% transmission).

BL6A1

Fourier-Transform Middle- and Far- Infrared spectrometers for solids

Synchrotron radiation of UVSOR covers a very wide energy region from soft-X ray to millimeter wave. BL6A1 was constructed in order to cover a long wavelength part in the spectral distribution from near infrared to millimeter wave. The beamline is composed of two kinds of interferometers, a Martin Puplett type and a Michelson type (Fig.1). The spectrum from 0.7 um to 2 mm is measureable by changing three kinds of detectors; MCT, Si-bolometer and InSb hot electron detector (Fig.2). Owing to the high brightness of the SR, the present spectroscopic system is especially favorable to the transmission and reflection measurements on tiny specimens.

In summer 1998, the control system for the Martin-Puplett type interferometer (SPECAC) was replaced owing to its lots of troubles. Most of the components in the control system were newly installed except the chopper controller and the PC. After some correction, the system is now under use regularly.

We have also installed new beamsplitters in the rapid scan type interferometer (Bruker IFS66V): Quartz(II) and myler(23 micron). It expands the measurable region.

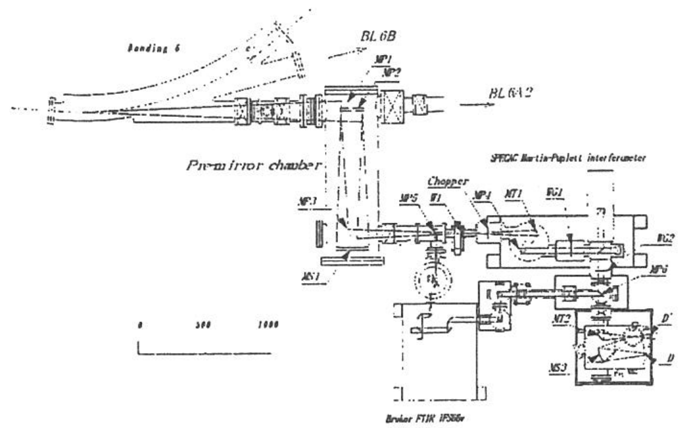


Fig.1 Top view of BL6A1.

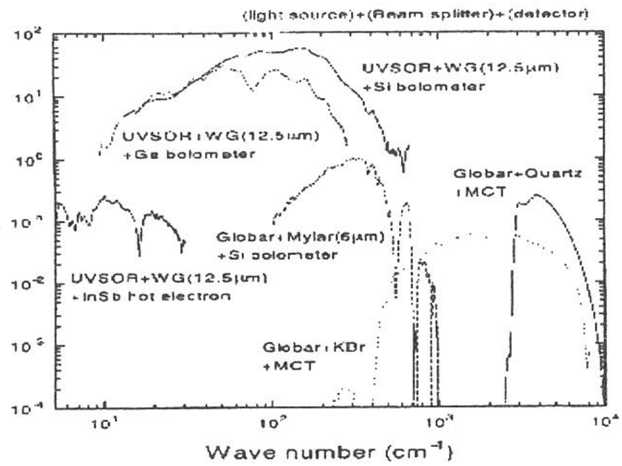


Fig.2 Throughput spectra of BL6A1.

Specification

Interferometers: a Martin-Puplett type and a Michelson type

Detectors: Si bolometer (20-1000 cm-1)

Ge bolometer (with polyethylene window, 30-300 cm-1)

Ge bolometer (with quartz window, 10-200 cm-1)

InSb bolometer (5-50 cm-1)

MCT (400-10,000 cm-1)

Photovoltaic type MCT (400-4000 cm-1, time response: 10 nsec)

Wavelength range: 5~300 cm-1 by the Martin-Puplett type interferometer

40~28,000 cm-1 by Michelson type interferometer

Experiments: Temperature dependence of reflectivity and transmission spectra, absorption under high pressure (up to 20 GPa), reflectivity under magnetic field (up to 8 T) and time-resolved spectroscopy.

BL6A2

Photoelectron Spectrometer for Solids and Surfaces

The beamline 6A2 has been used for photoelectron spectroscopy on solids and surfaces with bending magnet radiation. The beam line consists of a Plane Grating Monochromator (PGM), and an angle-resolved photoelectron spectrometer (ARUPS).

The PGM has several combinations of mirrors and gratings to cover wide energy range of 2-150 eV with less higher order light. Since the monochromator has no entrance slit, resolving power depends on the beam size and the divergence, but not only on the width of the exit slit. The ARUPS is mounted on the two-axes goniometer. The usual instruments for surface analyses are available. Recently, the combined experiments with SR and lasers are being carried out at this beam line. The upgrade of the BL6A2 is also in progress. The renewal of this beam line will be completed in 2000.

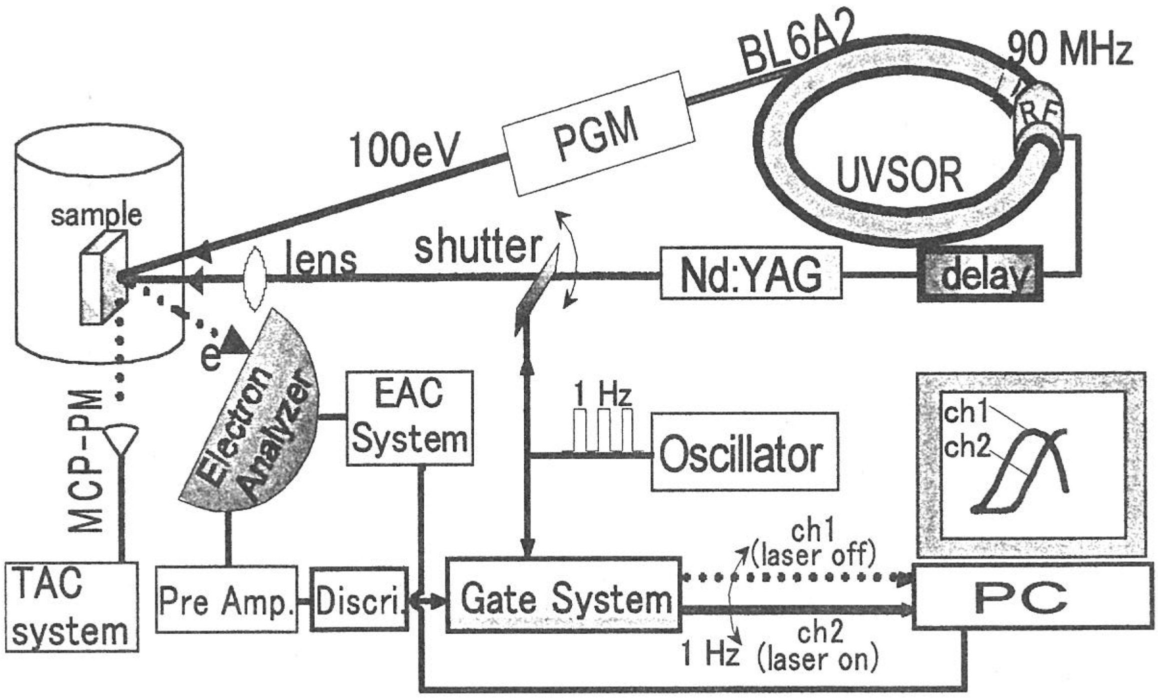
Specifications

1)Monochromator

Type:PGM
(Plane-Grating Monochromator)
Energy Range: 2-150 eV
Resolution: 0.1 eV at 70 eV with slit of 0.01mm
Flux: 1×10^{11} phs/sec at 120 eV with slit of 0.1 mm

2) Main Instruments

Two-levels UHV chamber (1×10^{-10} Torr)
Hemi-spherical electron-energy analyzer
(two-axes)
LEED Optics (OMICRON)
Ar-ion gun (ULVAC-Phi)
Mode-locked Nd:YAG laser



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. Further details can be seen in this activity report (by Shigemasa).

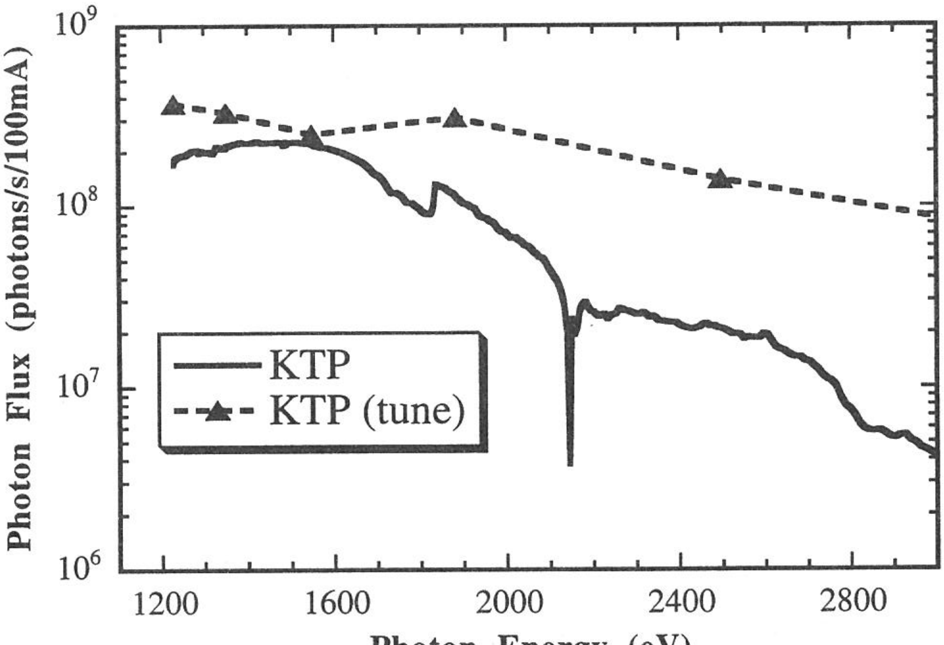


Figure 1. Throughput from KTP monochromator crystals on BL7A.

Specification

Monochromator: Double-Crystal

Energy range: 0.6∼3.0 keV, without wiggler (∼6.0 keV, with wiggler)

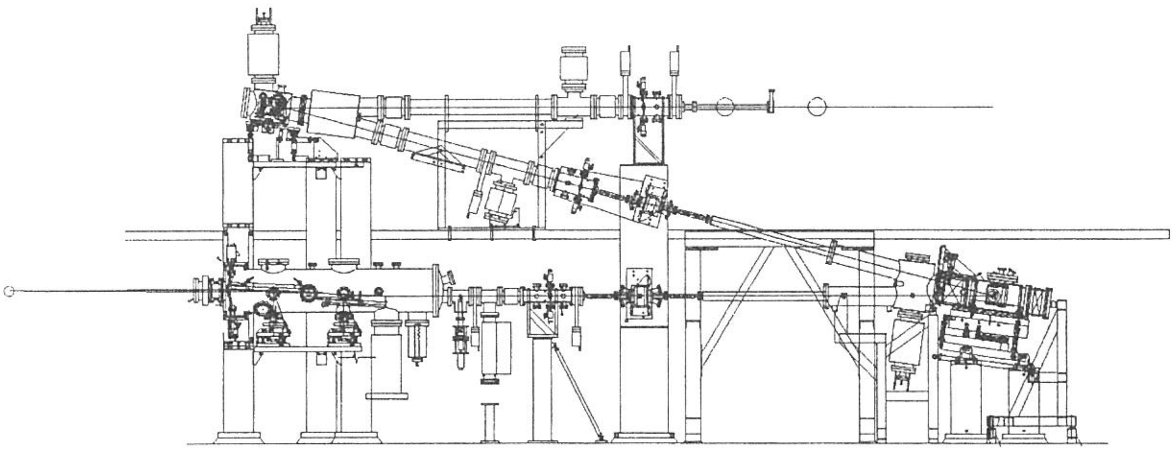
Experiments: X-ray absorption (by total electron- or fluorescence-yield methods)

BL7B

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

The reconstruction of the beamline BL7B has been almost completed. The 1m Seya-Namioka type monochromator was replaced to the 3m normal incidence monochromator (3m NIM; McPherson upgrade model of 2253) for the extended researches of the highest level with the higher resolution and intensity, the wider wave-length region available and so on. It will be also possible to utilize the linear and circular polarization inherent in synchrotron radiation (SR) and to realize some combined experimental systems, for example, with the synchronized laser to SR pulse or with the extended field. The outline of the new beamline is shown in Figure 1. The main parts of the system are a pre-mirror focusing system, a 3-m NIM and a post-mirror focusing system. The light from 50 to 1000 nm wavelength region is covered by changing three gratings *in situ.* Each spherical grating is original laminar type fabricated on SiO_2 and has effective grooved area of 120 x 40 mm^2. The 2 focusing positions are available for the experiments. At the position between 2 positions, LiF or MgF_2 window valve is installed. Therefore, the measurements for the organic materials, liquid and biochemical ones are possible at the 2nd focal position.

This beamline is used for absorption, reflection and fluorescence measurements on various materials with higher performance (high energy resolution, high intensity, well-polarized light, short repetitive pulse light) not only on the VUV region but also in the near UV, VIS and near IR region. The performance of the beamline is presented in this activity report. The beamline has been opened to the users from April, 1999.



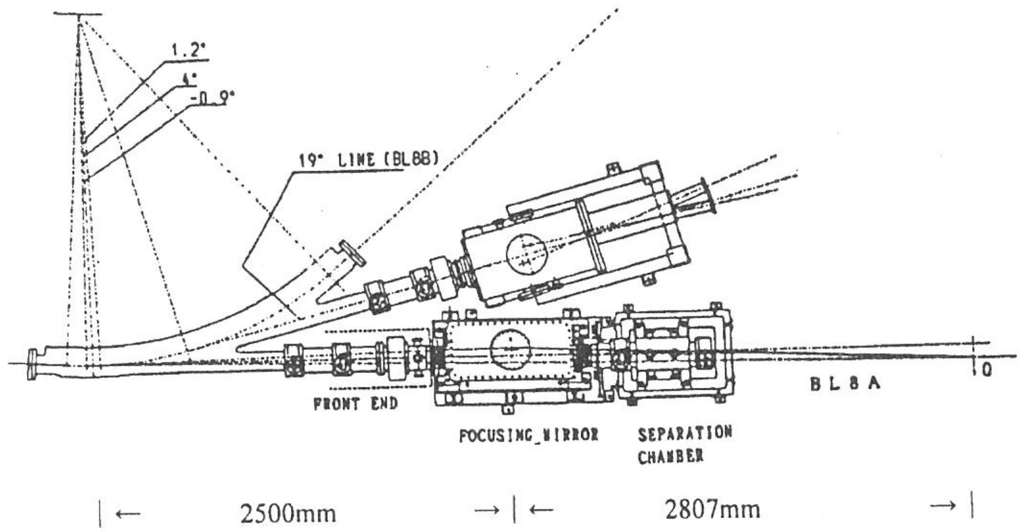
Specification

Monochromator	: 3m Normal Incidence Monochromator
Wavelength range	: 50 nm – 1000 nm
Typical resolution	: $E/\Delta E$ = 4000 – 23000 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

The 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. The entrance and exit slit positions and directions of incident and exit photon beams do not change during its scan. Consequently, it provides us with a resolution ($E/\Delta E$) of 4000 at 400 eV and of 3000 at 245 eV. A current of a Si diode reveals the absolute photon flux normalized by an ring current when two slit widths are 10 μm (Fig. 1).

Being Equipped at the downstream of the monochrometer, an chamber with a time-of-flight ion detector and a photoelectron detector, they 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.

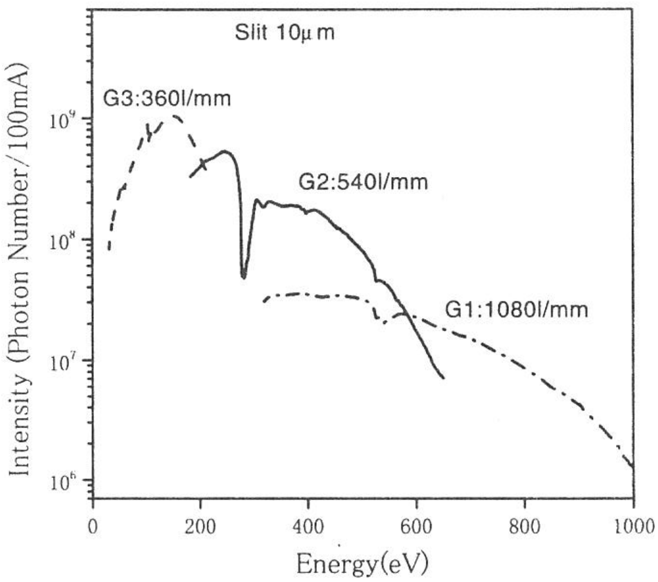


Figure 1. Absolute photon fluxes measured by a Si photodiode

Specification

Monochrometer	: 2.2 m constant-deviation grazing incidence
Wavelength range	: 30 to 800 eV
Resolution	: $E/\Delta E$ = 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 solid such as molecular crystals, organic semiconductor, 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 manipulator for temperature dependence (base pressure 3×10^{-10} Torr), a cleaning chamber (base pressure 2×10^{-10} Torr), and a sample evaporation chamber (base pressure 3×10^{-10} Torr). The cleaning chamber is equipped with back-view LEED/AUGER, Ar^+ gun and an infrared heating units. The PGM consists of pre-mirrors, a plane grating, focusing mirror, and a post-mirror, with an exit slit. It covers the wide range from 2 to 150 eV with exchanging two gratings (G1; 1200 l/mm, G2; 450 l/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 $1 \times 1 mm^2$. The energy resolution at a slit width of 100 μm was found to be 0.004 - 0.3 eV in the wavelength range from 2 to 130 eV. A hemispherical electron energy analyzer of 25 mm mean radius with an angular resolution of 2° can be rotated around vertical and horizontal axes. The sample mounted on a manipulator can be also rotated around two axes.

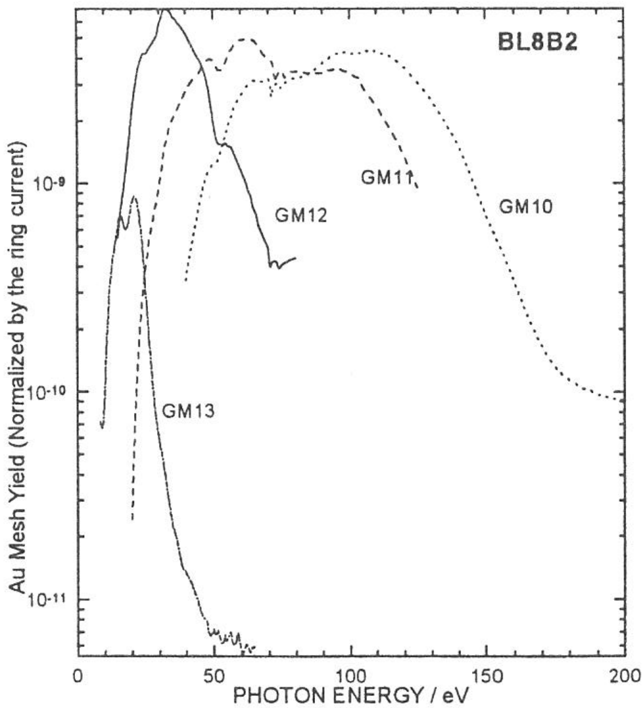
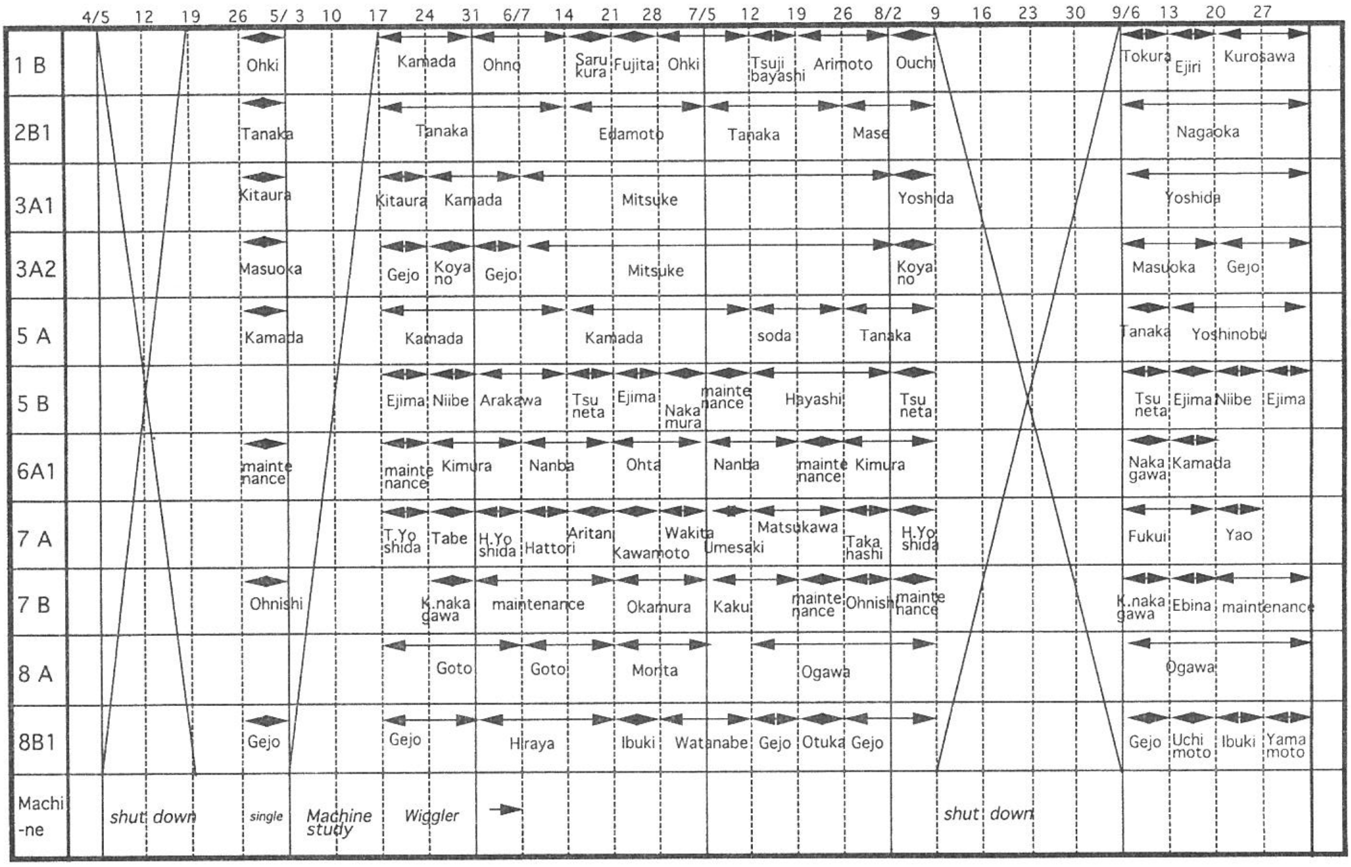


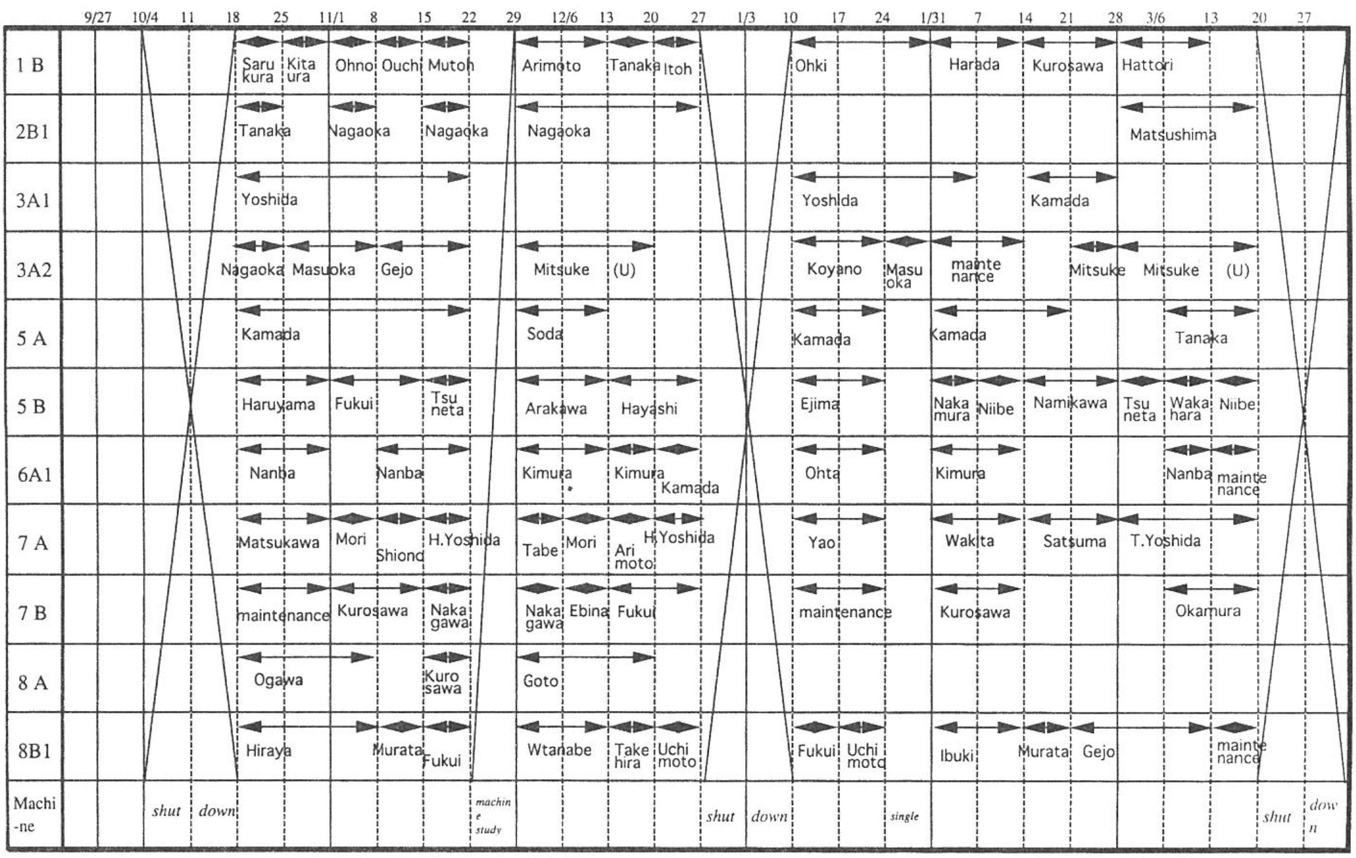
Figure Throughput spectra of plane-grating monochromator at BL8B2 with 100 μm exit slit.

Specification

Monochromator	: plane grating monochromator
Spectral range	: 2 - 130 eV
Resolution	: 0.25 eV at 40 eV, as determined by the Fermi edge of gold.
Experiment	: Ultraviolet Photoelectron Spectroscopy for various organic solids
Polarization	: 85~91 % at 5000 Å

Open beam lines





In-house beam lines