

UVSOR Synchrotron Facility

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Outline of the UVSOR Synchrotron Facility

Since the first light in 1983, the UVSOR Synchrotron Facility has been successfully operated as one of the major synchrotron light sources in Japan. After the major upgrade of accelerators in 2003, UVSOR Synchrotron was renamed to UVSOR-II Synchrotron and became one of the world's brightest low energy synchrotron light sources. In 2012, it was upgraded again and has been renamed to be UVSOR-III Synchrotron. The brightness of the electron beam was increased further. The storage ring, *ca.* 53 meters in circumference, is regularly operated in the top-up mode, irrespective of multi bunches or single bunch. We have also been planning Post-UVSOR-III as a long-term strategy for sustainable development to UVSOR-IV.¹⁾

The UVSOR accelerator complex consists of a 15 MeV injector LINAC, a 0.75 GeV booster synchrotron, and a 0.75 GeV storage ring. The magnet lattice of the storage ring consists of four extended double-bend cells with distributed dispersion function. The single bunch top-up operation (176 ns, 5.6 MHz) for time-resolved measurements or low current measurements is also conducted for two weeks per year.

Six undulators and eight bending magnets provide synchrotron radiation (SR). The bending magnet, its radius of 2.2 m, produces SR with the critical energy of 425 eV. There are eight bending magnet beamlines (Table 1). Three of the six undulators are in-vacuum soft X-ray (SX) linear-polarized undulators (BL3U, BL4U, and BL6U) and the other three are vacuum/extreme ultraviolet (VUV/XUV or EUV) circular-polarized undulators (BL1U, BL5U, and BL7U). Two beamlines, BL1U and BL6U, are so-called “in-house beamlines,” which are dedicated to strategic projects conducted by internal

IMS groups in tight collaboration with domestic and foreign scientists. Other beamlines are so-called “public beamlines,” which are open to scientists from universities, governmental research institutes, public and private enterprises, and also to overseas scientists. After each development, the in-house beamline will be opened for use as a public beamline.

From the viewpoint of photon energies, we have one SX station equipped with a double-crystal monochromator, seven SX stations with a grazing incidence monochromator, three VUV stations with a normal incidence monochromator, two IR/THz stations equipped with Fourier transform interferometers and one beamline for light source development without any monochromators.

Table 1. List of beamlines at UVSOR-III Synchrotron.

Beamline	Optics	Energy Range	Targets	Techniques
BL1B	Martin-Puplett FT-FIR	0.5-30 meV	Solid	Reflection/Absorption
BL6B	Michelson FT-IR	4 meV-2.5 eV	Solid	Reflection/Absorption
BL7B	3-m normal incidence	1.2-25 eV	Solid	Reflection/Absorption
BL3B	2.5-m off-plane Eagle	1.7-31 eV	Solid	Reflection/Absorption
BL5B	Plane grating	6-600 eV	Solid	Calibration/Absorption
BL4B	Varied-line-spacing plane grating (Monk-Gilleson)	25 eV-1 keV	Gas, Liq, Solid	Photoionization, XAFS, Photodissociation, XMCD
BL2A	Double crystal	585 eV-4 keV	Solid	Reflection/XAFS
BL1U	Tandem undulators/Free electron laser	1.6-13.9 eV	Gas, Solid	Laser Compton Scattering, Orbital Momentum Light
BL7U	10-m normal incidence (modified Wadsworth)	6-40 eV	Solid	Photoemission
BL5U	Varied-line-spacing plane grating (Monk-Gilleson)	20-200 eV	Solid	ARPES, Spin-resolved ARPES
BL6U	Variable-inc.-angle-varied-line-spacing plane grating	40-700 eV	Solid	ARPES, XAFS / XPD
BL4U	Varied-line-spacing plane grating (Monk-Gilleson)	50-700 eV	Gas, Liq, Solid	XAFS, Microscopy (STXM)
BL3U	Varied-line-spacing plane grating (Monk-Gilleson)	60-800 eV	Gas, Liq, Solid	XAFS / Photoemission, Photon-emission

Inter-University and International Collaboration Programs

A variety of molecular science and related subjects have been carried out at UVSOR Synchrotron Facility by IMS and external/overseas researchers. The cumulative total number of visiting researchers (person-days) per year tops > 5000, who come from > 60 different institutes. International collaborations are also pursued actively, and the number of visiting foreign researchers reaches ~70. UVSOR-III Synchrotron invites new/continuing research proposals twice a year. The proposals both for academic and public research (charge-free) and for private enterprises (charged) are acceptable. The fruits of the research activities using UVSOR-III Synchrotron are published as the UVSOR ACTIVITY REPORT annually.

Return of Beam Current Value from 200 mA to 300 mA

Since January 2023, the amount of charge that can be injected into the storage ring has decreased, so from May 2023, the stored beam current value was reduced from 300 mA to 200 mA, and user operations were continued. The cause of the decrease in injection charge was that the electron beam was accelerated under unstable conditions in the booster synchrotron, which is a device that accelerates an electron beam to 750 MeV. In ring-type accelerators, there is a phenomenon that induces instability in the electron beam. It is thought that the operating conditions of the booster synchrotron matched the unstable conditions, causing the spatial spread of the electron beam to increase and resulting in a decrease in the amount of charge injected into the storage ring. To avoid unstable conditions, the excitation waveform of the electromagnets in the booster synchrotron was changed. As a result, it was confirmed that the spatial spread of the electron beam became smaller and the amount of charge that could be incident increased to at least the same level as before 2023. User operation began in June 2025 with a stored beam current value of 300 mA. However, after replacing the vacuum ducts of the booster synchrotron, which had been leaking vacuum, in April 2025, the amount of charge circulating in the booster synchrotron decreased by 50%. The cause is currently unknown. As a result of this impact, operation is being conducted with an increased number of beam injections.

Recent Developments

In line with the ongoing upgrade plan at SPring-8, it was officially decided that the infrared beamline BL43IR will be shut down at the end of FY2025, since the future ring design will no longer allow efficient extraction of infrared radiation. Recognizing the continuing demand for synchrotron-based infrared research, UVSOR has taken the initiative to provide an alternative platform for the BL43IR user community. On September 20, 2023, the “UVSOR/SPring-8 Infrared Beamline Joint Users’ Meeting” was held at IMS. In this meeting, the infrared beamline BL6B at UVSOR was introduced to BL43IR users, and discussions were conducted on the transition of research activities from SPring-8 to UVSOR. As an

outcome, preparations have been launched to transfer experimental capabilities and to ensure that users can continue advanced infrared studies at UVSOR.

As a first step of performance evaluation, measurements of human hair samples were carried out at BL6B by Dr. Ikemoto, the beamline scientist of SPring-8 BL43IR.²⁾ These samples, which have been used as reference specimens at BL43IR, enable assessment of spatial resolution and signal-to-noise characteristics of the microspectroscopy system. The sliced hair samples were prepared with an optimized thickness (~10 μm) and mounted on BaF₂ substrates. Using a JASCO FT/IR-6100, IRT-7000 microscope system, absorption spectra and infrared imaging were obtained under transmission configuration with various optical conditions. The comparison between BL6B and BL43IR clarified both the potential and the current challenges at UVSOR as shown in Figure 1. In particular, mapping of the C–H stretching band (2805–3141 cm^{-1}) revealed the internal cortex structure of hair fibers with sufficient resolution. However, it was also found that when using SR with a linear array detector, the SR spot size is too small to be effectively utilized, resulting in non-uniform images. Based on this observation, a practical measurement strategy has been proposed: To employ the standard internal light source together with a linear array detector for rapid imaging of many samples, and to reserve SR combined with a single-element detector for detailed and high-resolution analysis of selected regions. This dual approach allows both efficient throughput and precise characterization.

These results indicate that UVSOR BL6B can provide a robust platform for continuing infrared microspectroscopy previously performed at BL43IR, while highlighting the need for optimized measurement schemes. Further development of sample environment control devices, including humidity and temperature regulation, is planned to broaden the research scope. UVSOR is committed to supporting the BL43IR user community and to ensuring a smooth and effective transition of their research activities in the coming years.

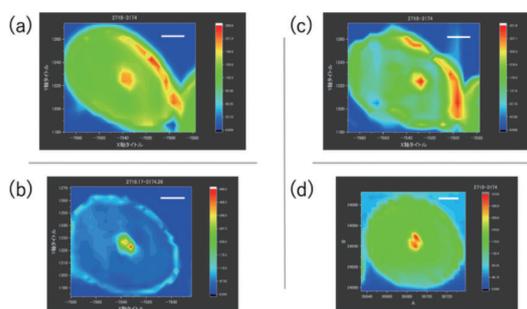


Figure 1. Infrared imaging of sliced human hair samples showing intensity maps of the C–H stretching band: (a) BL6B with standard light and linear array MCT detector; (b) BL6B with SR and single-element MCT detector; (c) BL6B with SR and linear array MCT detector; (d) BL43IR/SPring-8 with SR and single-element MCT detector.

References

- 1) S. Kera *et al.*, *Electron. Struct.* **5**, 034001 (2023).
- 2) *UVSOR Activity Report* **51** (2025), in press.