HiSOR

ACTIVITY REPORT

2021

Hiroshima Synchrotron Radiation Center, HiSOR
Hiroshima University

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Preface

The Hiroshima Synchrotron Radiation Center was inaugurated in 1996 as part of the academic policy of the Ministry of Education, Culture, Sports, Science, and Technology (MEXT), Japan. A compact 700 MeV electron-storage ring known as HiSOR (our center is also often referred to as HiSOR) produces synchrotron radiation in the ultraviolet and soft X-ray range. The mission of HiSOR is to promote advanced research in the field of condensed matter physics, including interdisciplinary fields, using synchrotron radiation and develop human resources in the international research environment established inside the national university. HiSOR has been authorized as a "Joint Usage/Research Center" by MEXT since FY2010. After an evaluation of the research activities in the 3rd mid-term goal period, authorization was successfully extended to the 4th mid-term goal period (FY2022–FY2027).

In FY2021, Dr. Shinichiro Ideta arrived from UVSOR at the Institute for Molecular Science as an Associate Professor. He will advance high-resolution angle-resolved photoemission spectroscopy systems and promote the research field of correlated electron systems, such as high-Tc superconductors. Dr. Mohamed Ibrahim arrived from the National Institute of Oceanography and Fisheries in Egypt as an Assistant Professor. He will advance the structure-function studies of organic molecules and polymers in marine organisms in solution using vacuum ultraviolet circular dichroism.

The number of accepted proposals in FY2021 was 118, including 17 overseas proposals. The number of proposals increased compared with that in FY2020 (78 proposals). However, owing to the COVID-19 pandemic, some collaborators could not travel to run experiments. The HiSOR staff performed six experiments instead of international collaborators and three experiments instead of domestic collaborators.

Despite these difficulties, we published 40 refereed papers in 2021. Among them, 31 papers (78% of the refereed papers) were published under international collaborations. The number of the top 10% most cited papers was amount to 12% for the 2016–2021 period, indicating the quality of our published papers.

The 26th Hiroshima International Symposium on Synchrotron Radiation (74 participants, including ten overseas participants) was held on-site, combined with online sessions, on Mar. 10–11, 2022. We also held the 26th HiSOR workshop on the chiral spectroscopy of biomolecules (73 participants) and six online HiSOR seminars (201 participants in total). To introduce our facility to junior and senior high school students during the pandemic, we developed content using virtual reality (VR) devices. We sent VR devices to junior and senior high schools in the Shimane, Tottori, Fukushima, and Saitama Prefectures. In total, 158 students participated in the online program.

To further enhance international collaboration, we recently established cooperation agreements with the Faculty of Physics and Astronomy at the Julius-Maximilians-Universität Würzburg in

Germany, the Institut des Sciences Moléculaires d'Orsay at Université Paris-Saclay in France, and the Department of Physics at the Southern University of Science and Technology in China. We also extended cooperation agreements with the National Laboratory for Superconductivity, the Institute of Physics at the Chinese Academy of Sciences in China, and the Solid State Physics Division of the Ioffe Physical-Technical Institute at the Russian Academy of Sciences in Russia.

In closing, I would like to thank all the staff for their great effort in operating HiSOR and maintaining and advancing the experimental stations. I also want to thank our students and collaborators for their excellent scientific achievements and for making full use of our facilities. Finally, I deeply appreciate the continued support of Hiroshima University and MEXT.

July 2022

Kenya Shimada

Director of the Hiroshima Synchrotron Radiation Center

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Current Status of HiSOR

Status of the HiSOR storage ring

1. Introduction

The HiSOR is a synchrotron radiation (SR) source of Hiroshima Synchrotron Radiation Center, Hiroshima University, established in 1996. It is a compact racetrack-type storage ring having 21.95 m circumference and 700MeV electron energy. It has two 180-degree normal-conducting bending magnets which generate a strong magnetic field of 2.7 T. Due to this compact configuration, the natural emittance of the electron beam is 400 nm-rad, which is rather large compared with other synchrotron light sources. It has two straight sections, where two insertion devices, a linear undulator and an APPLE-II undulator, are operational. The most outstanding advantage of the facility lies in good combination with state-of-the-art beamlines (BL's) for high-resolution photoelectron spectroscopy in the photon energy ranges between VUV and soft X-ray. Moreover, the high field bending magnets produce synchrotron radiation in wide spectral range including tender X-rays, which can be powerful probes in various research fields.

The principal parameters of HiSOR are shown in Table 1. Major parameters of these undulators are listed in Table 2. The photon energy spectra of the SR from HiSOR are shown in Figure 1.

Table 1: Main parameters of the HiSOR Storage ring.

Circumference	21.95 m
Type	Racetrack
Bending radius	0.87 m
Beam energy at Injection	150 MeV
at Storage	700 MeV
Magnetic field at Injection	0.6 T
at Storage	2.7 T
Injector	150 MeV Racetrack Microtron
Betatron tune (ν_x, ν_y)	(1.72, 1.84)
RF frequency	191.244 MHz
Harmonic number	14
RF voltage	200 kV
Stored current (nominal)	300 mA
Natural emittance	400π nmrad
Beam life time	~10 hours@200 mA
Critical wavelength	1.42 nm
Photon intensity (5 keV)	1.2×10^{11} /sec/mr^2/0.1%b.w./300mA

Table 2: Main parameters of the undulators.

Linear undulator (BL-1)	
Total length	2354.2 mm
Periodic length λu	57 mm
Periodic number	41
Pole gap	30-200 mm
Maximum magnetic field	0.41 T
Magnetic material	Nd-Fe-B (NEOMAX-44H)
Quasi-Periodic APPLE-II undulator (BL-9A,B)	
Total length	1845 mm
Periodic length λu	78 mm
Periodic number	23
Pole gap	23-200 mm
Maximum magnetic field	0.86 T (horizontal linear mode)
	0.59 T (vertical linear mode)
	0.50 T (helical mode)
Magnetic material	Nd-Fe-B (NEOMAX-46H)

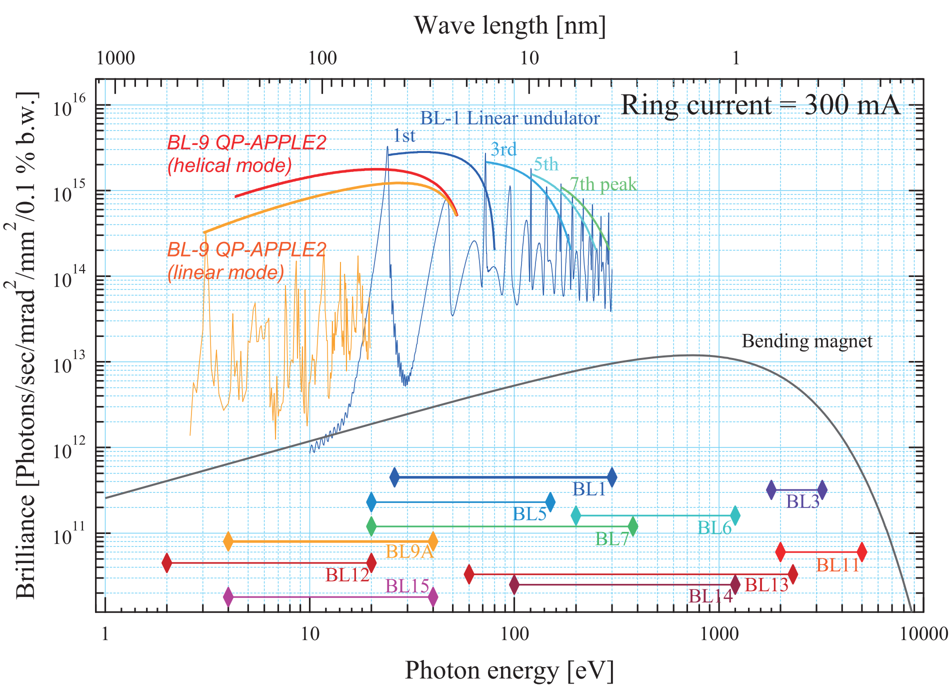

Figure 1: Photon energy spectra of the SR from HiSOR.

2. Operation status in FY 2021

The ring is operated for users from Tuesday to Friday. Figure 2 shows an example of typical users operation for one day. Beam injection for HiSOR is executed twice a day, at around 9:00 and 14:30. The beam injection is normally completed within 30 minutes. The filling beam current is about 300mA. Machine is operated for machine conditionings and studies on Monday.

Figure 3 shows monthly operation time of HiSOR storage ring in FY 2021. HiSOR regularly has a long-term shutdown period for maintenance works in every summer. One of the reasons is the planned electricity outage which is regularly set at the end of August. Although, in 2020, the outage was irregularly set in the middle of November and the shutdown was shifted to November, it was as usual in 2021 and so was the shutdown. Fortunately, in 2021, there was no cancellation of the machine time for COVID-19 pandemic. The total user time of FY2021 achieved 1470 hours.

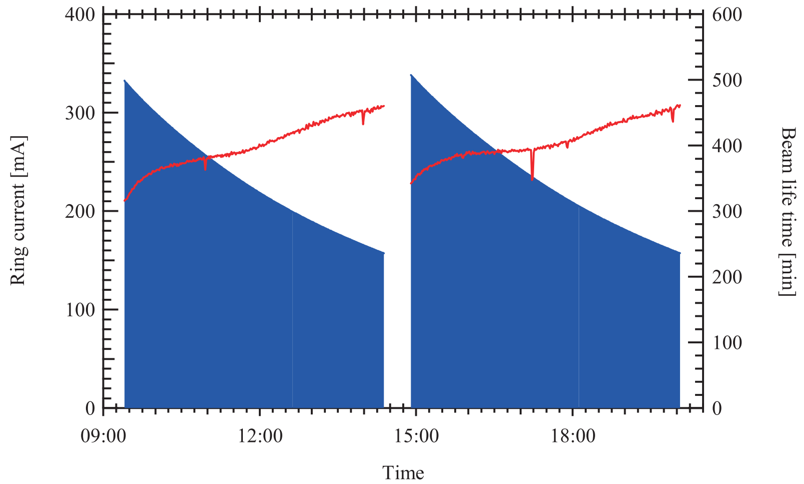

Figure 2: Typical daily operation status.

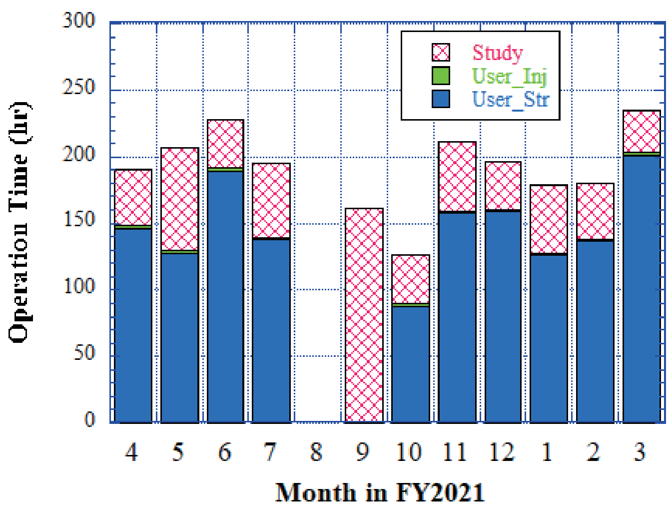

Figure 3: Monthly operation time in FY 2021.

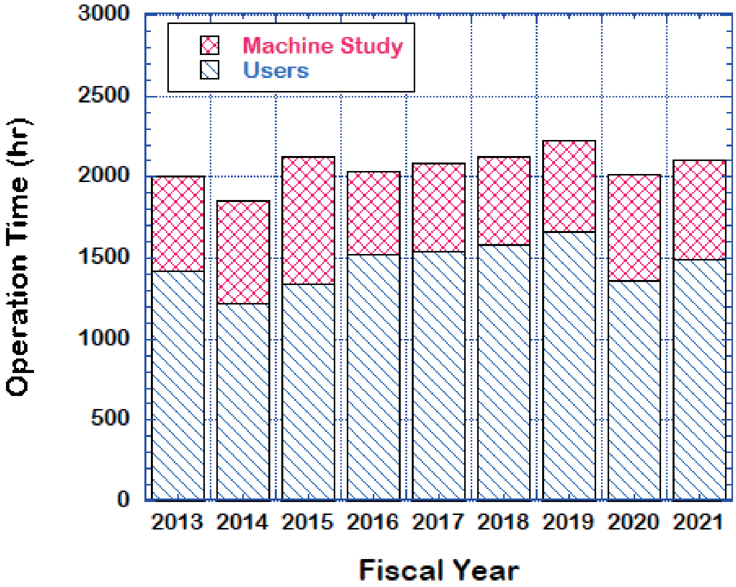

Figure 4: Operation time in FY 2013-2021.

Beamlines

A total of 13 beamlines has been constructed so far; three normal-incidence monochromators, seven grazing-incidence monochromators, two double crystal monochromators and apparatus for white beam irradiation (Fig. 1). Table 1 lists the beamlines at present together with the main subject, energy range and monochromators.

Table 1: List of Beamlines

Beamline	Source	Monochromator	Subject	Energy range (eV)	Status
BL-1	LU	GIM	Polarization dependent high-resolution ARPES	22-300	In use
BL-3	BM	DCM	Surface XAFS	1800-3200	In use
BL-4	BM		White beam irradiation		Closed
BL-5	BM	GIM	ARPES and PEEM	40-220	In use
BL-6	BM	GIM	Gas-phase photochemistry	200-1200	In use
BL-7	BM	GIM	ARPES	20-380	In use
BL-8	BM		Beam diagnosis		In use
BL-9A	HU/LU	NIM		5-35	In use
BL-9B	HU/LU	GIM	High-resolution spin-resolved ARPES	16-300	In use
BL-11	BM	DCM	XAFS	2000-5000	In use
BL-12	BM	NIM	VUV-CD of biomaterials	2-10	In use
BL-13	BM	GIM	Surface photochemistry	60-1200	In use
BL-14	BM	GIM	Soft-XMCD of nano-materials	400-1200	In use
BL-15	BM	NIM	VUV-CD of biomaterials	4-40	Closed
BL-16	BM		Beam profile monitor		In use

At present, nine beamlines BL1, BL3, BL6, B7, BL9A, BL9B, BL11, BL12, BL13 and BL14 are opened for users. Furthermore, three offline systems, resonant inverse photoemission spectrometer (RIPES), low-temperature scanning tunneling microscope (LT-STM) system, high-resolution angle-resolved photoemission spectrometer using ultraviolet laser (Laser ARPES) are in operation (Fig. 2).

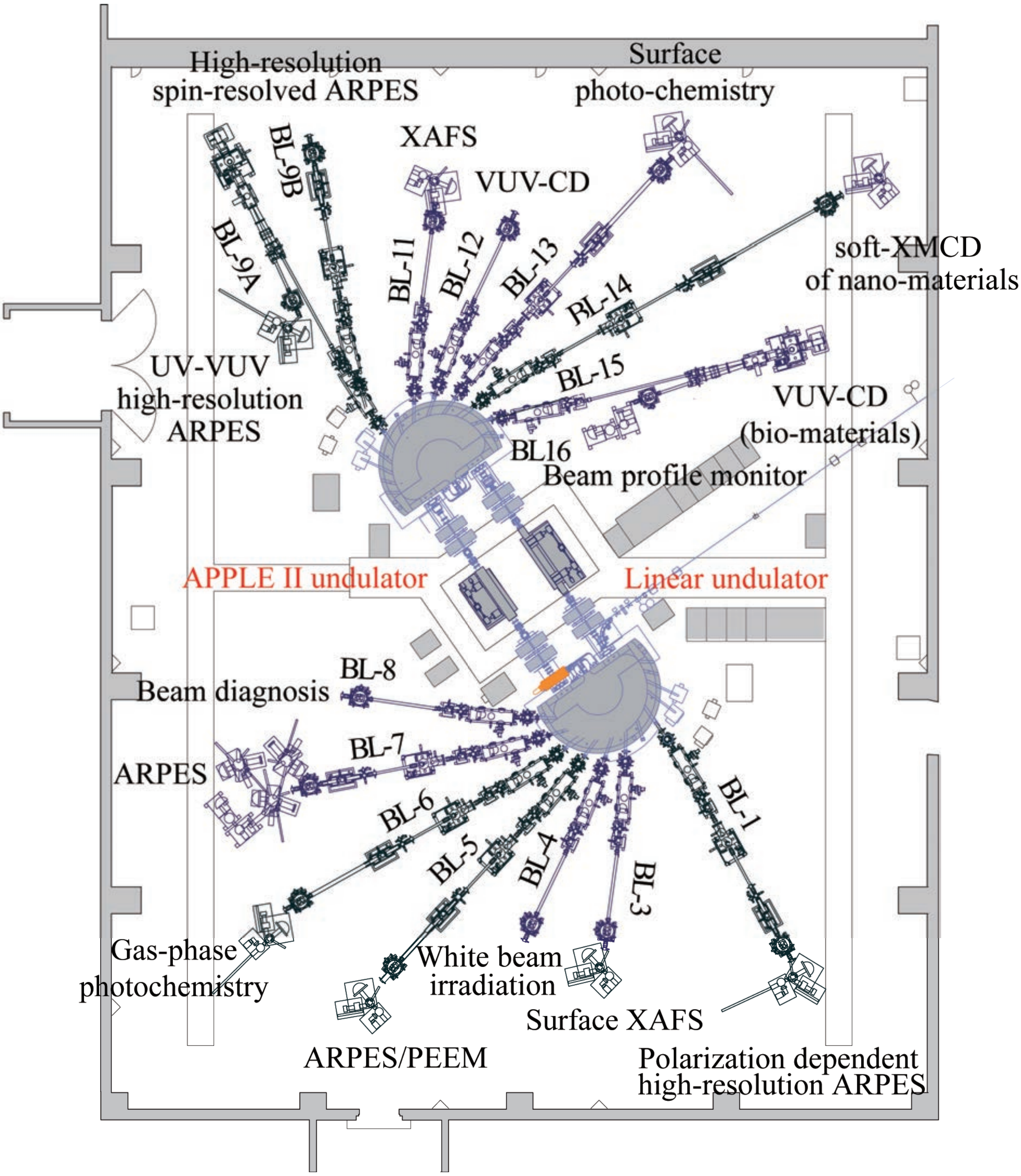

Fig. 1: Schematic view of the experimental hall.

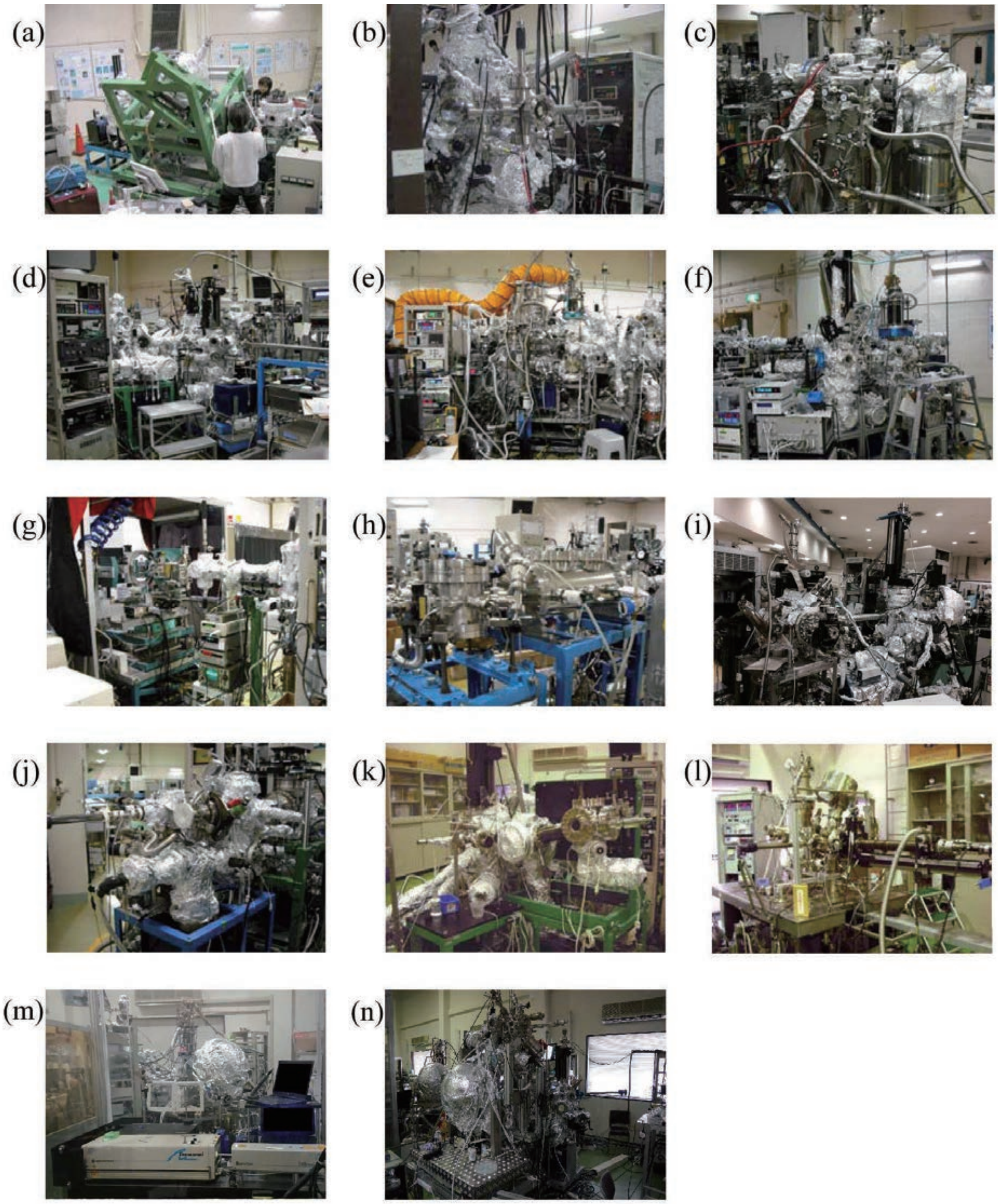

Fig. 2: Experimental stations on the beamline and offline: (a) BL-1, (b) BL-3, (c) BL-6, (d) BL-7, (e) BL-9A, (f) BL-9B, (g) BL-11, (h) BL-12, (i) BL-13, (j) BL-14, (k) RIPES (offline), (l) LT-STM (offline), (m) Laser ARPES (offline), (n) Laser spin-ARPES (offline).