6 Summary of Experimental Stations

About 54 experimental stations are operated at the PF Storage Ring and the PF-AR, as shown in Figs. 1 and 2. Two thirds of the stations are dedicated to research using hard X-rays, with the remaining one third used for studies in the VUV and soft X-ray energy regions. Tables 1 and 2 summarize the areas of the research carried out at experimental stations at the PF storage ring and PF-AR. The specifications in terms of optics and performance of each experimental station differ according to experimental requirements and methodology. Tables 3 and 4 list the details of the optics of the hard X-ray stations and the soft X-ray / VUV stations. The principal performance parameters, including energy range, energy resolution, beam-spot size, and photon flux at the sample position are shown.

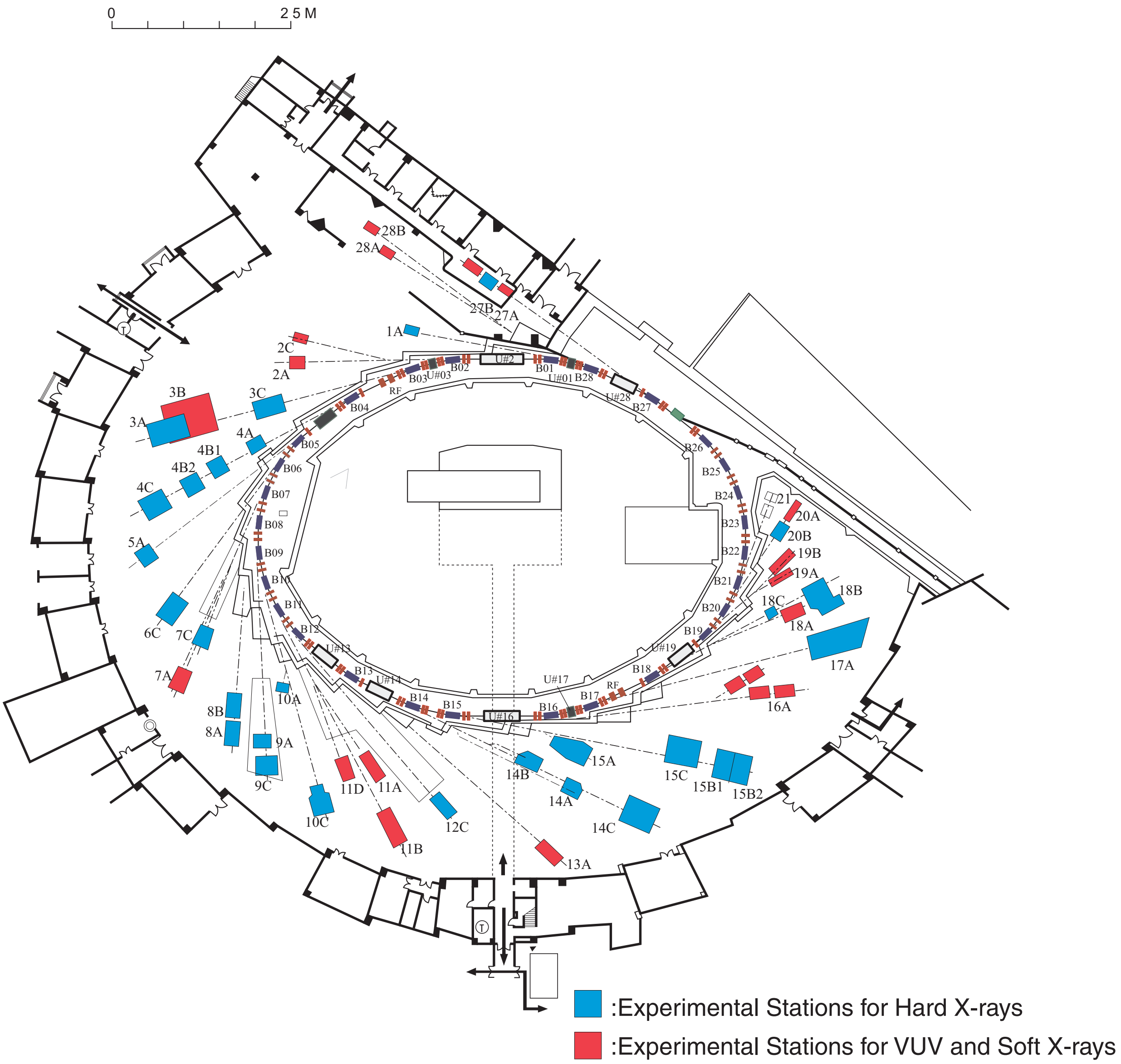

Figure 1
Plan view of the PF experimental hall, showing hard X-ray experimental stations (blue), and VUV and soft X-ray experimental stations (red).

Table 1 Complete list of experimental stations at the PF Storage Ring.

Experimental Station		Person in Charge
BL-1	(Short gap Undulator)	
A	Macromolecular crystallography	N. Matsugaki
BL-2	(Undulator)	
A	Soft X-ray spectroscopy	Y. Kitajima
C	Soft X-ray spectroscopy	J. Adachi
BL-3	(A: Short Gap Undulator)	
A	X-ray diffraction and scattering station for materials science	H. Nakao
B	VUV and soft X-ray spectroscopy(◊)	H. Kato [Hirosaki Univ.], A. Yagishita
C	Characterization of X-ray optical elements/White X-ray maganetic diffraction	K. Hirano
BL-4		
A	Trace element analysis, X-ray microprobe	A. Iida
B1*	Micro-crystal and Micro-area structure analysis	Y. Yamasaki
B2	High resolution Powder diffraction(♠)	T. Ida[Nagoya Inst. Tech.], H. Nakao
C	X-ray diffraction and scattering	Y. Yamasaki
BL-5	(Multipole Wiggler)	
A	Macromolecular crystallography	Y. Yamada
BL-6		
A**	Small-angle X-ray scattering of muscle and alloys	N. Igarashi
C	X-ray diffraction and scattering(♠)	S. Sasaki [Tokyo Inst. Tech.] H. Kawata
BL-7		
A	Soft X-ray spectroscopy(♦)	J. Okabayashi [RCS], K. Amemiya
C	X-ray spectroscopy and diffraction	H. Sugiyama
BL-8		
A	Weissenberg Camera for Powder/Single-crystal measurements under Extreme Conditions	R. Kumai
B	Weissenberg Camera for Powder/Single-crystal measurements under Extreme Conditions	R. Kumai
BL-9		
A	XAFS	H. Abe
C	X-ray versatile station	M. Nomura
BL-10		
A	X-ray diffraction and scattering	Y. Yamasaki
C	Small-angle X-ray scattering of solution sample(♠)	S. Nojima [Tokyo Inst Tech.], N. Igarashi
BL-11		
A	Soft X-ray spectroscopy	Y. Kitajima
B	Surface EXAFS, soft X-ray spectroscopy	Y. Kitajima
D	Characterization of optical elements used in the VSX region	K. Ito
BL-12		
C	XAFS	H. Nitani

Experimental Station		Person in Charge
BL-13	(Undulator)	
A	Soft X-ray photoemission spectroscopy and XAFS	K. Mase
BL-14	(Vertical Wiggler)	
A	Crystal structure analysis and detector development	S. Kishimoto
B	High-precision X-ray optics	K. Hirano
C	Medical applications and General purpose (X-ray)	K. Hyodo
BL-15		
A***	Small-angle X-ray scattering of muscle and alloys	N. Igarashi
B1	White X-ray topography and X-ray experiments for general purpose	H. Sugiyama
B2	Surface and interface X-ray diffraction	H. Sugiyama
C	High-resolution X-ray diffraction	K. Hirano
BL-16	(Variable Polarization Undulator)	
A	Soft X-ray spectroscopies with circular and linear polarization	K. Amemiya
BL-17	(Short Gap Undulator)	
A	Macromolecular crystallogarphy	N. Igarashi
BL-18		
A	Angle-resolved photoelectron spectroscopy of surfaces and interfaces(♦)	K. Yaji [ISSP], A. Yagishita
B	Multipurpose monochromatic hard X-ray station(♦)	M.Mukhopadhyay[India, DST], N. Igarashi
C	High pressure X-ray powder diffraction (DAC)(♠)	S. Nakano[NIMS], T. Kikegawa
BL-19	(Revolver Undulator)	
A	Spin-resolved photoelectron spectroscopy (Mott detector)(♦)	K. Yaji [ISSP], A. Yagishita
B	Soft X-ray emission spectroscopy(♦)	K. Yaji [ISSP], A. Yagishita
BL-20		
A	VUV spectroscopy(◊)	N. Kouchi [Tokyo Inst. Tech], K. Ito
B	White and monochromatic beam general-purpose X-ray station(♦)	J. B. Aitken [ASCo.], H. Kawata
BL-21	[Accelerators Division VII] Beam position monitoring	K. Haga [Accelerators]
BL-27	(Beamline for experiments using radioisotopes)	
A	Radiation biology, soft X-ray photoelectron spectroscopy	N. Usami
B	Radiation biology, XAFS, X-ray diffuse scattering	N. Usami
BL-28	(Elliptical / Helical Undulator)	
A	High-resolution VUV-SX beamline for angle-resolved photoemission	K. Ono
B	High-resolution VUV-SX spectroscopy	K. Ono

♠ User group operated beamline
♦ External beamline
◊ Operated by University
* shutdown at the end of FY2011
** set up at the summer of 2011
*** shutdwon at the summer of 2011

RCS: Research Center for Spectrochemistry, the University of Tokyo
ISSP: Institute for Solid State Physics, the University of Tokyo
ASCo.: Australian Synchorotron Co-operation

Table 2 List of experimental stations at the PF-AR.

Experimental Station		Person in Charge
AR-NE1 (Multipole Wiggler)		
A	Laser-heating high pressure X-ray diffraction and nuclear resonant scattering (DAC)	T. Kikegawa
AR-NE3 (Undulator)		
A	Macromolecular crystallography	Y. Yamada
AR-NE5		
C	High pressure and high temperature X-ray diffraction (MAX-80)	T. Kikegawa
AR-NE7		
A	High pressure and high temperature X-ray diffracition (MAX-III), X-ray Imaging	K. Hyodo
AR-NW2 (Undulator)		
A	XAFS/Dispersive XAFS /Time-resolved-X-ray diffraction	H. Abe
AR-NW10		
A	XAFS	H. Nitani
AR-NW12 (Undulator)		
A	Macromolecular crystallography	L. Chavas
AR-NW14 (Undulator)		
A	Time-resolved X-ray diffraction, scattering and absorption	S. Adachi

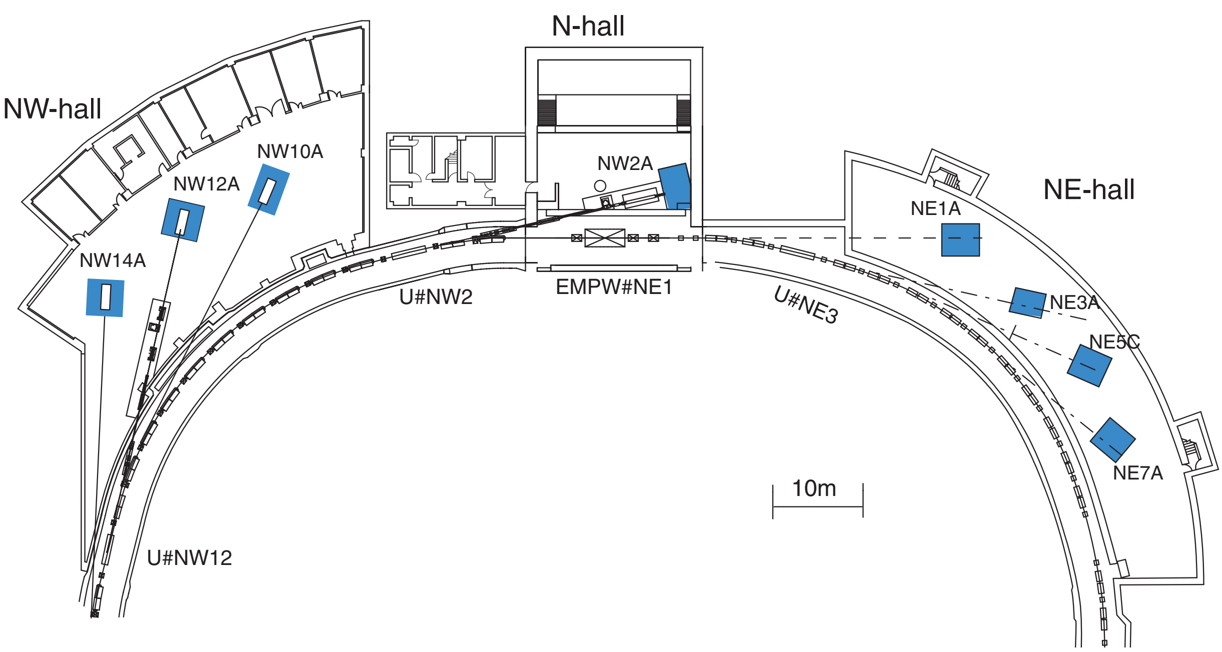

Figure 2
Plan view of beamlines in the PF-AR north-east, north, and north-west experimental halls.

Table 3 Specifications of X-ray beamline optics.

Branch Beamline	Horizontal Acceptance (mrad)	Type of Monochromator	Mirror	Photon Energy (keV)	Beam Size (H×V) (mm)	Photon Flux at Sample Position (/s)	Energy Resolution (∆E/E)×10⁻⁴	Reference
BL-1A	0.2	Channel-cut Si(111) Liquid N_2 Cooling	Bimorph Si Rh-Coated Si Rh-Coated	4.5 11 ~ 13	0.03×0.01	4×10^{11}@11keV	~ 2	
BL-3A	1	Flat Double Crystal Si(111)	Bent Cylinder	4 ~ 14	0.7×0.2	6×10^{12}	~ 5	
BL-3C	1.75	Double Crystal Si(111)	None	4 ~ 20 or whitle	20×6(mono) 0.1×0.1(white)			
BL-4A	6	Double Crystal Sagittal Focusing	Vertical Focusing Mirror	4 ~ 20	50×4 4×1		~ 2	1
BL-4B1	4.5	Double Crystal Si(111)	None	4 ~ 35	50×5		~ 2	2
BL-4B2	4.5	Double Crystal Si(111)	Bent Cylinder	6 ~ 20	13×2		~2	3, 4
BL-4C	2	Flat Double Crystal Si(111)	Bent Cylinder	5 ~ 19	0.7×0.5		~5	5, 6
BL-5A	0.5	Micro-Channel Double Crystal Si(111)	Bent Plane Si Rh-Coated Bent Cylinder Si Rh-Coated	6.5 ~ 17	1.2×0.4	3×10^{11} (0.2×0.2 mm^2)	~2	
BL-6A*	2	Bent Crystal Ge(111) (α = 8.0°)	Bent Plane ULE	8.0 (fixed)	0.5×0.2	$1.0\times10^{12}/mm^2$ (8.0 keV, 430 mA)	~ 10	7
BL-6C	2	Flat Double Crystal Si(111)	Bent Cylinder	5 ~ 12 (~25 non- Focus)	1.2×1.2			
BL-7C	4	Double Crystal Si(111) Sagittal Focusing	Double Mirror Fused Quartz Focusing	4 ~ 20 (4 ~ 13)	5×1	$1\times10^{10}/6mm^2$ (8 keV, 300 mA) (1×10^{11} when focused)	~ 2	8 - 10
BL-8A	2.22	Flat Double Crystal Si(111)	Bent Cylinder	5 ~ 19	0.82×0.52	3.2×10^{11} (12.4keV, 400mA)	~ 5	11
BL-8B	2.21	Flat Double Crystal Si(111)	Bent Cylinder	5 ~ 19	0.75×0.45	2.2×10^{11} (12.4keV, 400mA)	~ 5	11

Branch Beamline	Horizontal Acceptance (mrad)	Type of Monochromator	Mirror	Photon Energy (keV)	Beam Size (H×V) (mm)	Photon Flux at Sample Position (/s)	Energy Resolution (ΔE/E)×10⁻⁴	Reference
BL-9A	3	Double Crystal Si (111)	Collimating and Focusing Bent Conical Mirrors (Rh-Coated) Double Flat Mirror (Ni-Coated)	2.2 ~ 15	0.5×0.3	4×10[11](9 keV, 300 mA)	2	12, 13
BL-9C	3.5	Double Crystal Si(111)	Bent Cylinder Rh-Coated Si	4 ~ 23	1×1	5×10[10](9 keV, 300 mA)	~ 2	
BL-10A	1	Si(111), Si(311) Quartz(100), PG(002) Curved Si(111) (α~ 4°, 8°)	Plane Pt coated Fuzed Quartz	5 ~ 25	10×3		10 ~ 5	14
BL-10C	4	Double Crystal Si(111)	Bent Cylinder	4 ~ 10	1.2×0.2	~10[11]/1.5mm[2] (8 keV, 400 mA)	2	7
BL-12C	2	Double Crystal Si(111)	Bent Cylinder Double Flat Mirror (Nii-Coated)	4 ~ 23	0.65×0.4	5×10[10]/1mm[2] (8 keV, 300mA) w.Si(111)	~ 2	15
BL-14A	1.28 (Vertical)	Double Crystal Si (111) Si (311) Si (553)	Bent Cylinder Rh-coated Fused Quartz	5.1 ~ 19.1 9.9 ~ 35.6 22.7 ~ 84.5	2×1 at focus 5×38		2	16
BL-14B	2.2 (Vertical)	Double Crystal Si(111),	None	10 ~ 57	5×14		2	
BL-14C	1.96 (Vertical)	Double Crystal Si(111), Si(220)	None	5 ~ 100 or white	6×70		2	17, 18
BL-15B1 B2	2	Double Crystal Si (111)	Bent Cylinder	5 ~ 20 or white	0.6×0.4	10[11]/1mm[2] (8.0keV, 350mA)	~ 2	
BL-15C	2	Double Crystal Si (111)	None	4 ~ 30	60×6			

Branch Beamline	Horizontal Acceptance (mrad)	Type of Monochromator	Mirror	Photon Energy (keV)	Beam Size (H×V) (mm)	Photon Flux at Sample Position (/s)	Energy Resolution (ΔE/E)×10^{-4}	Reference
BL-17A	0.1 ~ 0.2	Double Crystal Si(111) Liquid N_2 cooling	Bent Plane Si Rh-Coated Bent Plane Si Rh-Coated	6 ~ 9 11 ~ 13	0.25×0.04	10^{10} (12.4 keV, 450mA, 0.02×0.02mm^2)	~2	19, 20
BL-18B [India, DST]	2	Double Crystal Si(111)	Plane and Bent Cylinder	6 ~ 20			~2	
BL-18C	1	Double Crystal Si(111)	Cylinder Fused Quartz, Pt-coated	6 ~ 25	0.07×0.04		~2	
BL-20B [ASCo.]	2	Channel Cut Si(111) Channel Cut Si(311) Sagittal Focusing Si(111) Double Crystal	None	4.5 ~ 21 10 ~ 36 4.5 ~ 25	25×2 25×1.5 0.6×1		~ 2 ~ 1 ~ 2	21
BL-27B	4	Double Crystal Si(111)	None	4 ~ 20	100×6		~ 2	22
AR-NE1A	0.28	Micro-Channel Double Crystal Si(111), High-resolution Channel Cut Si(4,2,2)&(12,2,2)	Bent Plane W/C Mutilayer Coated Si	6 ~ 50	0.1×0.1	6×10^{11} (14.4keV)	~ 2	
AR-NE3A	H:0.2 V:0.1	Double Crystal Si(111) Liquid N2 Cooling	Pre-Mirror Bent Flat Si Rh-Coated Post-Mirror Bent Cylinder Fused Quartz Rh-Coated	6.5 ~ 17	0.8×0.2	8×10^{11} (0.2×0.2mm^2)	~ 2	23 24
AR-NE5C	3	Double Crystal Si(111)	None	30 ~ 100 or white	60×5		5	25
AR-NE7A	4	Double Crystal Si(111)		25 ~ 50 or white	80×3		5	
AR-NW2A	H:1.0 V:0.2	Double Crystal Si(111) Liquid N_2 Cooling	Bent Cylinder Si Rh-Coated Bent Flat Si Rh-Coated	5 ~ 25	0.6×0.2 ~10×0.06	6×10^{12}	~2	26-28
AR-NW10A	1.2	Si(311)	Pt-Coated Bent Cylinder Double Flat Mirror (Rh-Coated)	8 ~ 42	2.2×0.5	1×10^{10}	~1	29

Branch Beamline	Horizontal Acceptance (mrad)	Type of Monochromator	Mirror	Photon Energy (keV)	Beam Size (H×V) (mm)	Photon Flux at Sample Position (/s)	Energy Resolution ($\Delta E/E$)×10^{-4}	Reference
AR-NW12A	H:0.3 V:0.1	Double Crystal Si(111) Liquid N_2 cooling	Pre-Mirror Bent Flat Si Rh-Coated Post-Mirror Bent Cylinder Si Rh-Coated	6.5 ~ 17	1.3×0.3	2×10^{11} (0.2×0.2 mm^2)	~2	7
AR-NW14A	H:0.3 V:0.1	Double Crystal Si(111) Liquid N_2 Cooling	Bent Cylinder Rh-Coated Bent Flat Rh-Coated	4.9 ~ 25	0.45×0.25	5×10^{12}	~2	30

* set up at the summer of 2011

India DST: Department of Science & Technology
ASCo.: Australian Synchrotron Co-operation

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Table 4 Specifications of VUV and soft X-ray beamline optics.

Beamline	Acceptance H × V (mrad) or Undulator Parameters	Type of Monochromator	Groove Density (ℓ/mm)	Energy Range (eV)	Beam Size H × V (mm)	Resolving Power (E/ΔE) Photon Flux (photons/s)	Reference
BL-2A Undulator	K = 0.5 ~ 2.2 λ_u = 6 cm	Double Crystal InSb (111), Si (111)	____	1740 ~ 5000	< 1ϕ	2000, 8000 10^{11}	1 - 4
BL-2C Undulator	K = 0.55 ~ 2.2 λ_u = 6 cm	Varied-Line-Space Plane Grating	1000 2200	250 ~ 1400	0.9 × 0.1	5000 ~ 10000 10^{11} ~ 10^{10}	5 - 7
BL-3B	10 × 2	Grazing Incidence R = 24 m α+β = 165° 1800	200 600	10 ~ 280	< 2ϕ	200 ~ 3000 10^{12} ~ 10^{9}	8, 9
BL-7A [RCS]	6 × 1	Varied-Line-Space Plane Grating	300 650	50 ~ 1300	2.5 × 0.5	1000 ~ 9000 10^{12} ~ 10^{9}	10
BL-11A	5 × 1	Varied-Line-Space Plane Grating	300 800 1200	70 ~ 1900	2 × 1	500 ~ 5000 10^{12} ~ 10^{9}	11 - 14
BL-11B	4 × 0.6	Double Crystal InSb (111), Si (111)	____	1724 ~ 5000	5 × 2	2000 10^{10}	3, 15, 16, 17
BL-11D	4 × 2	Grazing Incidence Varied Deviation-angle On-Blaze Mount R_1 = 52.5 m R_3 = 22.5 m	2400	60 ~ 245 200 ~ 900	1 × 0.1	2000 10^{11}	18
BL-13A Undulator	K_{max} = 8 λ_u = 18 cm	Variable-included-angle Varied-line-spacing plane grating	300 1000	30 ~ 330 100 ~ 1200	~0.2 × 0.04	4000 ~ 10000 10^{12} ~ 10^{9}	19 20
BL-16A Undulator	K_{max} = 2.37 (Circular Polarization) K_{max} = 3.12 (Horizontal Linear Polarization) K_{max} = 1.98 (Vertical Linear Polarization) K_{max} = 1.73 (45-deg Linear Polarization) λ_u = 5.6 cm	Variable-included-angle varied-line-spacing plane grating	500 1000	250 ~ 1500	~0.2 × 0.1	4000 ~ 8000 10^{12} ~ 10^{11}	21
BL-18A [ISSP]	2 × 2	Grazing Incidence R = 3 m α+β = 160° R = 6.65 m α+β = 167.5°	300 600 1200	15 ~ 150	< 1ϕ	1000~2000 10^{11} ~10^{9}	22

Beamline	Acceptance H × V (mrad) or Undulator Parameters	Type of Monochromator	Groove Density (ℓ/mm)	Energy Range (eV)	Beam Size H × V (mm)	Resolving Power (E/ΔE) Photon Flux (photons/s)	Reference
BL-19A Revolver Undulator [ISSP]	K = 1.0 ~ 9.0 λ_u = 16.4 cm K = 0.5 ~ 1.25 λ_u = 5 cm K = 0.5 ~ 2.5 λ_u = 7.2 cm K = 1.0 ~ 5.0 λ_u = 10 cm	Grazing Incidence R = 2 m $\alpha+\beta$ = 160° R = 4 m $\alpha+\beta$ = 170°	600 1200 600 1200	12 ~ 250	< 0.7ϕ	1000 10^{12}	23, 24
BL-19B Revolver Undulator [ISSP]		Varied-Line-Space Plane Grating	800 2400	10 ~ 1200	< 0.5ϕ	400-4000 10^{12} ~10^{11}	24 - 26
BL-20A	28 × 5	3m Normal Incidence	1200 2400	5 ~ 40	2 × 1	300 ~ 30000 10^{12} ~ 10^{8}	27
BL-27A	5 × 0.5	Double Crystal InSb (111)	____	1800 ~ 4000		2000	28
BL-28A/B Helical Undulator	K_x = 0.23 ~ 3 K_y = 0.23 ~ 6 λ_u = 16 cm	Varied-Line-Space Plane Grating	400	30 ~ 300	0.15 × 0.05	30000 10^{12}	29

RCS: Research Center for Spectrochemistry, the University of Tokyo
ISSP: Institute for Solid State Physics, the University of Tokyo

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