6 Summary of Experimental Stations

About 70 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.

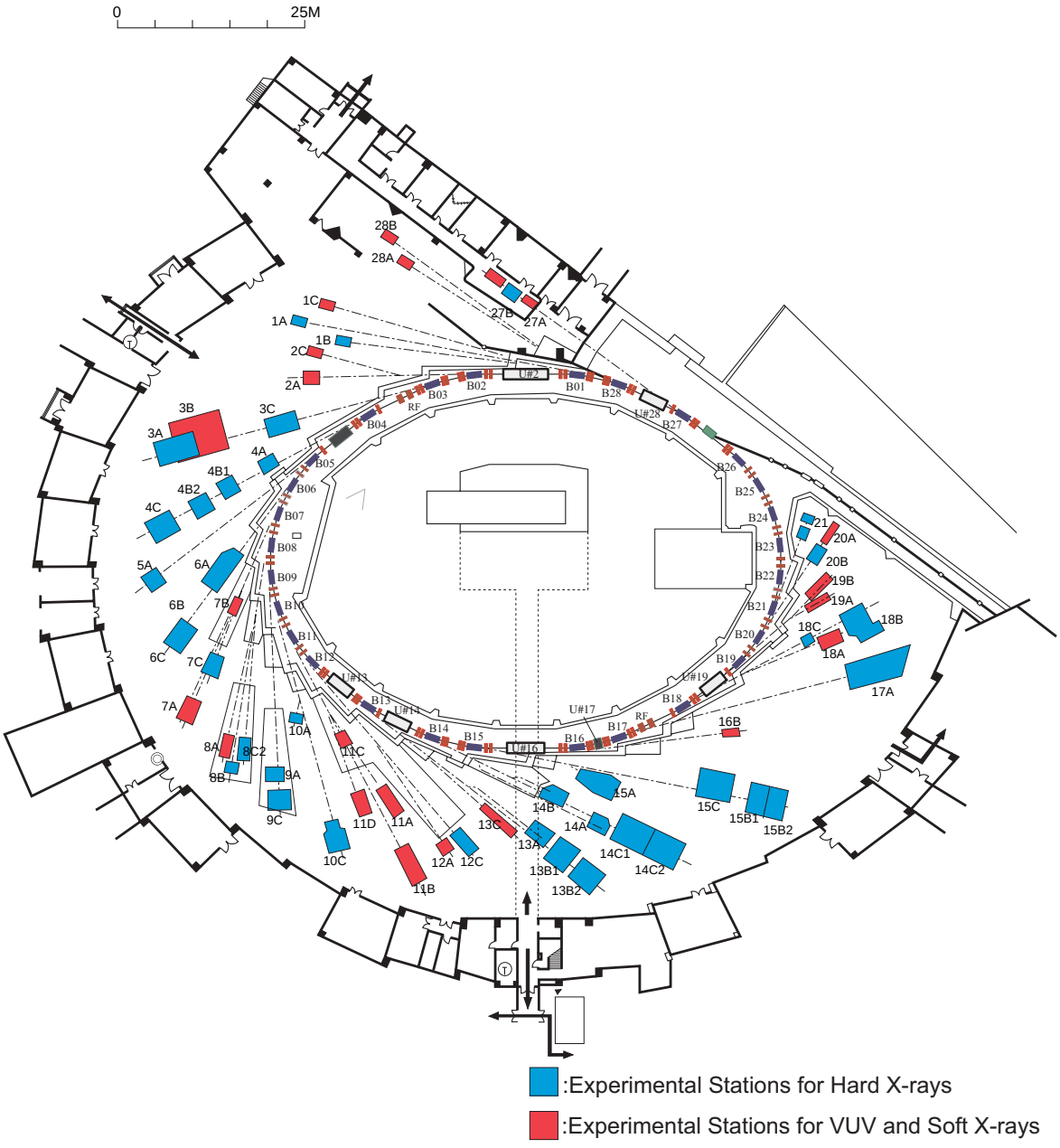

Figure 1
Plan view of the PF experimental hall, showing hard X-ray experimental stations (blue), and VUV and soft X-ray experimental stations (red).

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

Experimental Station			Spokesperson
BL-1			
	A	Crystal structure analysis beamline	H. Sawa
	B	X-ray powder diffraction under extreme condition	H. Sawa
	C	VUV and soft X-ray photoelectron spectroscopy	K. Ono
BL-2		(Undulator)	
	A	Soft X-ray spectroscopy	Y. Kitajima
	C	Soft X-ray spectroscopy	A. Yagishita
BL-3			
	A***	X-ray diffraction and scattering station for materials science	Y. Wakabayashi
	A*	X-ray diffraction and scattering	T. Iwazumi
	B	VUV and soft X-ray spectroscopy	Y. Azuma
	C	Characterization of X-ray optical elements/White X-ray maganetic diffraction	H. Adachi
	C2**	Characterization of X-ray optical elements	X. Zhang
	C3**	X-ray magnetic Bragg scattering by means of white X-rays	H. Adachi
BL-4			
	A	Trace element analysis, X-ray microprobe	A. Iida
	B1	Micro-crystal and Micro-area structure analysis	A. Nakao
	B2	Powder diffraction	A. Nakao
	C	X-ray diffraction and scattering	Y. Wakabayashi
BL-5		(Multipole Wiggler)	
	A	Macromolecular crystallography	Y. Yamada
BL-6			
	A	Macromolecular crystallography	N. Igarashi
	C***	X-ray diffraction and scattering	H. Sawa
BL-7			
	A	[RCS] Soft X-ray spectroscopy	H. Kondo [RCS], K. Amemiya
	B	[RCS] Surface photochemical reaction and angle-resolved photoelectron spectroscopy	H. Kondo [RCS], K. Amemiya
	C	X-ray spectroscopy and diffraction	T. Iwazumi
BL-8			
	A	Soft X-ray spectroscopy	K. Mase
	B	EXAFS	K. Mase
	C	X-ray tomography and X-ray microscopy	K. Hirano
BL-9			
	A	XAFS	Y. Inada
	C	X-ray versatile station	M. Nomura
BL-10			
	A	X-ray diffraction/scattering	A. Nakao
	C	Small-angle X-ray scattering of solution sample	K. Kobayashi
BL-11			
	A	Soft X-ray spectroscopy	Y. Kitajima
	B	Surface EXAFS, soft X-ray spectroscopy	Y. Kitajima
	C	VUV spectroscopy (solid state)	K. Ono
	D	VUV and soft X-ray photoelectron spectroscopy for solid	K. Ito
BL-12			
	A	Characterization of VUV-SX optical elements, soft X-ray spectroscopy	A. Yagishita
	C	XAFS	M. Nomura

Experimental Station			Spokesperson
BL-13		(Multipole Wiggler/Undulator)	
	A	Laser-heating high-pressure and high-temperature X-ray diffraction (DAC)	T. Kikegawa
	B1	Surface-sensitive XAFS, X-ray diffraction	T. Kikegawa
	B2	High-pressure and high-temperature X-ray diffraction	T. Kikegawa
	C	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
	C1	Medical applications and X-ray experimens for general purpose	K. Hyodo
	C2	High-pressure and high-temperature X-ray diffraction (MAX-III)	T. Kikegawa
BL-15			
	A	Small-angle X-ray scattering of muscle and alloys	R. Kato
	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		(Multipole Wiggler/Undulator)	
	A1*	General purpose (X-ray)	Y. Wakabayashi
	A2*	X-ray diffraction and scattering	Y. Wakabayashi
	B	Soft X-ray spectroscopy	J. Adachi
BL-17			
	A	Macromolecular crystallogarphy	N. Igarashi
BL-18			
	A	[ISSP] Angle-resolved photoelectron spectroscopy of surfaces and interfaces	A. Kakizaki [ISSP], A. Yagishita
	B	General purpose (X-ray)	A. Iida
	C	High pressure X-ray powder diffraction (DAC)	T. Kikegawa
BL-19		(Revolver Undulator)	
	A	[ISSP] Spin-resolved photoelectron spectroscopy (Mott detector)	A. Kakizaki [ISSP], A. Yagishita
	B	[ISSP] Soft X-ray emission spectroscopy	S. Shin [ISSP], A. Yagishita
BL-20			
	A	VUV spectroscopy	K. Ito
	B	[ANBF] White and monochromatic beam general-purpose X-ray station	G. Foran [ANBF], H. Kawata
BL-21		[Light Source Division]Beam position monitoring	K. Haga [Light Source]
BL-27		(Beamline for experiments using radioisotopes)	
	A	Radiation biology, soft X-ray photoelectron spectroscopy	K. Kobayashi
	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

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* shutdown at the summer of 2006.
** renovated to new BL-3C at the summer of 2006.
*** set up at the 2006.

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

Experimental Station	Spokesperson
AR-NE1 (Elliptical Multipole Wiggler / Helical Undulator)	
A1 High-resolution Compton and magnetic Compton scattering	H. Kawata
A2 Coronary angiography	K. Hyodo
B Spectroscopy with circularly polarized soft X-rays	T. Koide
AR-NE3 (Undulator)	
A Nuclear resonant scattering	X. Zhang
AR-NE5	
A Medical applications and X-ray experiments for general purpose	K. Hyodo
B Bunch-purity and beam-position monitoring	S. Kishimoto
C High pressure and high temperature X-ray diffraction (MAX-80)	T. Kikegawa
AR-NW2 (Undulator)	
A XAFS/Dispersive XAFS /Time-resolved-X-ray diffraction	Y. Inada
AR-NW10	
A XAFS	M. Nomura
AR-NW12 (Undulator)	
A Macromolecular crystallography	N. Matsugaki
AR-NW14 (Undulator)	
A Time-resolved X-ray diffraction, scattering and absorption	S. Koshihara [ERATO], S. Adachi

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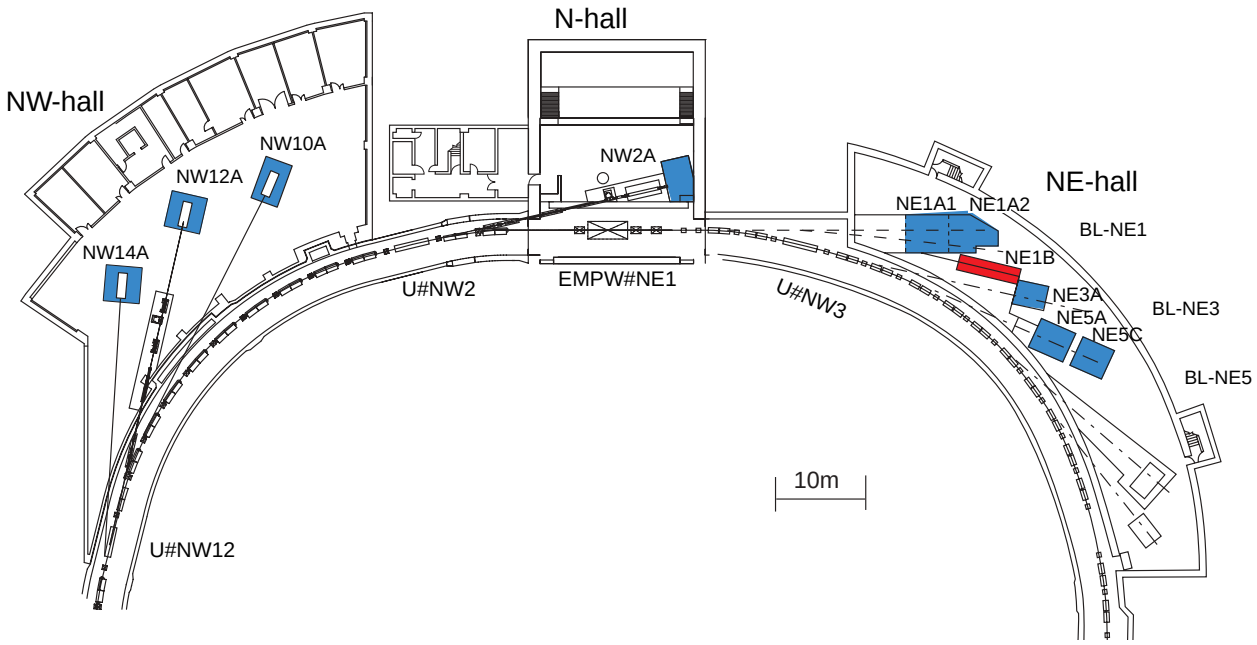

Figure 2
Plan view of beamlines in the PF-AR north-east, north, and north-west experimental halls.

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 ($\Delta E/E$)×10^{-4}	Reference
BL-1A		Flat Double Crystal Si(111)	Bent Cylinder	5 ~ 20	0.7×0.3	4×10^{11}(8.3 keV, 400 mA)	~ 5	
BL-1B	2	Flat Double Crystal Si(111)	Bent Cylinder	6 ~ 21	0.7×0.5	8×10^{10}/4mm^2 (8.3 keV, 300 mA)	~ 5	1
BL-3A***	1	Flat Double Crystal Si(111)	Bent Cylinder	4 ~ 14	0.7×0.2	6×10^{12}	~ 5	
BL-3A*	4	Double Crystal Si(111) Sagittal Focusing	Collimating Focusing Mirrors (Fused Quartz)	6 ~ 20	100×5 2×1		~ 2	2-4
BL-3C	1.75	Double Crystal Si(111)	None	4 ~ 20 or whitle	20×6(mono) 0.1×0.1(white			
BL-3C2**	2	Double Crystal Si(111), Si(311)	None	4 ~ 20 6 ~ 34	5×2	1×10^{10} 2×10^{9}		
BL-3C3**	2	Double Crystal Si(111)	None	5 ~ 30 or white	20×4 0.1×0.1			
BL-4A	6	Double Crystal Sagittal Focusing	Vertical Focusing Mirror	4 ~ 20	50×4 4×1		~ 2	5
BL-4B1	4.5	Double Crystal Si(111)	None	4 ~ 35	50×5		~ 2	6
BL-4B2	4.5	Double Crystal Si(111)	Bent Cylinder	6 ~ 20	13×2		~2	7, 8
BL-4C	2	Flat Double Crystal Si (111)	Bent Cylinder	5 ~ 19	0.7×0.5		~5	9, 10
BL-5A	2	Micro-Channel Double Crystal Si(111)	Bent Plane Si Rh-Coated Bent Cylinder Si Rh-Coated	6.5 ~ 17	1.2×0.4	6.6×10^{11} (12.7keV, 450mA, 0.2×0.2 mm^2)	~2	
BL-6A	1.2	Bent Si(111) (α = 7.5°)	Bent Plane ULE	9.5 ~ 13.5	0.5×0.25 (12.7keV)	1×10^{10} (12.7keV, 450mA, 0.2×0.2 mm^2)	~10	11
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	1×10^{10}/6mm^2 (8 keV, 300 mA) (1×10^{11} when focused)	~ 2	12 - 14

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
BL-8C	5	Channel-Cut Si(220), Si(111), Si(400)	None	5 ~ 40	50×5	6×10^{8}/mm^{2} (10 keV, 300 mA)	~ 2	
BL-9A	3	Double Crystal Si (111)	Collimating and Focusing Bent Conical Mirrors (Rh-Coated) Double Flat Mirror (Rh/Ni-Coated)	2.2 ~ 15	1×0.3	4×10^{11}(9 keV, 300 mA)	2	15, 16
BL-9C	3.5	Double Crystal Si(111)	Bent Cylinder Rh-Coated Si	4 ~ 23 or white	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	17
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	
BL-12C	2	Double Crystal Si(111) Si(311)	Bent Cylinder	6 ~ 23	0.65×0.4	5×10^{10}/1mm^{2} (8 keV, 300mA) w.Si(111)	~ 2	18
BL-13A	1	Double Crystal Si(111), Ge(111)	Cylinder Pt-coat Fused Quartz	30	0.045×0.032	5×10^{10}/1mm^{2}	~ 2	19
BL-13B1 B2	4	Double Crystal Si(111), Si(220) Sagittal Focusing	Bent Plane Fused Quartz	4 ~ 30	4×1		~ 2	20
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	21
BL-14B	2.2 (Vertical)	Double Crystal Si(111),	None	10 ~ 57	5×14		2	
BL-14C1 C2	1.96 (Vertical)	Double Crystal Si(111), Si(220)	None	5 ~ 100 or white	6×70		2	22, 23
BL-15A	2	Bent Crystal Ge(111) (α = 8.0°)	Bent Plane, Fused Quartz Pt-coated	8.0 (fixed)	0.5×0.25	9×10^{10}/mm^{2} (8.0 keV, 350 mA)	~ 10	24
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 ($\Delta E/E$)×10^{-4}	Reference
BL-16A1 A2	1	Double Crystal Si(111) Sagittal Focusing	Bent Plane (Rh on Si) and Bent Plane (Rh on SiC)	4 ~ 25	1.2×0.5	~1×10^{13} (8.3 keV, 300 mA)	~ 1	25
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	26
BL-18B	2	Double Crystal Si(111)	Plane and Bent Cylinder	6 ~ 30			~2	
BL-18C	1	Double Crystal Si(111)	Cylinder Fused Quartz, Pt-coated	6 ~ 25	0.07×0.04		~2	
BL-20B [ANBF]	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	27
BL-27B	4	Double Crystal Si(111)	None	4 ~ 20	100×6		~ 2	28
AR-NE1A1	2	Double Bent Crystal Si(111) Si(400)		40 ~ 70 80 ~ 160	2×0.5	2×10^{13} (60 keV, 35mA)	8	29-31
AR-NE1A2	2.3	Asym. Cut Single Crystal Si(311)		33 ~ 38	95×120 ~140	10^{10}(33 keV)	60	
AR-NE3A	H:0.3 V:0.03	Double Crystal Si(111) High-Resolution Monochromator Nuclear Monochromator of Single Crystal $^{57}Fe_2O_3$(777)		5 ~ 25 8 ~ 26 14.4	15×2	1×10^3 (14.4 keV)	1 5×10^{-3} 1×10^{-7}	32
AR-NE5A	10	Asym.Cut Single Crystal Si(311), Si(511) (α= 4° ~ 6°) Double Crystal Si(311), Si(111), Si(220)		20 ~ 60 20 ~ 100	150×80 100×3	5×10^8 (33.2 keV)	60 2	33, 34
AR-NE5C	3	Double Crystal Si(111)	None	30 ~ 100 or white	60×5		5	35

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-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	36-38
AR-NW10A	1.2	Si(311)	Pt-Coated Bent Cylinder	8 ~ 42	2.2×0.5	1×10^{10}	~1	39
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	
AR-NW14A [ERATO]	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	40

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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-1C	5 × 3	Varied-Line-Space Plane Grating	300 600 1200	20 ~ 60 40 ~ 120 80 ~ 240	1 × 1	1000 ~ 10000 10^{11} ~ 10^{9}	1
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}	2 - 5
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}	6 - 8
BL-3B	10 × 2	Grazing Incidence R = 24 m α+β = 165°	200 600 1800	10 ~ 280	< 2ϕ	200 ~ 3000 10^{12} ~ 10^{9}	9, 10
BL-7A [RCS]	6 × 1	Varied-Line-Space Plane Grating	300 650	50 ~ 1300	2.5 × 0.5	1000 ~ 9000 10^{12} ~ 10^{9}	11
BL-7B [RCS]	6 × 4	1m Seya-Namioka	1200 2400	5 ~ 50	1 × 1	1000	12
BL-8A	0.5 × 1	SX700 Plane Grating	1221	38 ~ 2300	5 × 1	2000 10^{10}	
BL-8B	3 × 0.5	Double Crystal InSb (111), Si (311)	____	1700 ~ 14000	1.9 × 0.5	5000	13
BL-11A	5 × 1	Varied-Line-Space Plane Grating	300 800 1200	70 ~ 1900	2 × 1	500 ~ 5000 10^{12} ~ 10^{9}	14 - 17
BL-11B	4 × 0.6	Double Crystal InSb (111), Ge (111)	____	1760 ~ 3910	5 × 2	2000 10^{10}	4, 18, 19
BL-11C	4.8 × 3	1m Seya-Namioka	1200	4 ~ 35	~1ϕ	1000	20
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}	21
BL-12A	2.2 × 0.34	Grazing Incidence R = 2 m α = 88°	1200	30 ~ 1000	2 × 3	1000 10^{9}	22
BL-13C Undulator	K = 0.3 ~ 4.2 λ_u = 18 cm	Grazing Incidence R = 50 m α+β = 173.2°	350 750	70 ~ 500 150 ~ 1000	5 × 1	1000 ~ 6000 10^{12} ~ 10^{10}	23, 24
BL-16B Undulator	K = 0.5 ~ 5.75 λ_u = 12 cm	Grazing Incidence R = 24 m α+β = 168.6°	400 900 2000	40 ~ 550	< 1ϕ	1000 ~ 10000 10^{12} ~ 10^{1}	25 - 27
BL-18A (ISSP)	2 × 2	Grazing Incidence R = 3 m α+β = 160° R = 6.65 m α+β = 167.5°	300 600 1200 500	15 ~ 150	< 1ϕ	1000~2000 10^{11} ~10^{9}	28

Beamline	Acceptance or H × V (mrad) 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	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}	29, 30
BL-19B Revolver Undulator (ISSP)	K = 1.0 ~ 5.0 λ_u = 10 cm	Varied-Line-Space Plane Grating	800 2400	10 ~ 1200	< 0.5ϕ	400~4000 10^{12} ~10^{11}	30 - 32
BL-20A	28 × 5	3m Normal Incidence	1200 2400	5 ~ 40	2 × 1	300 ~ 30000 10^{12} ~ 10^{8}	33
BL-27A	5 × 0.5	Double Crystal InSb (111)	____	1800 ~ 4000		2000	34
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}	35
AR-NE1B Helical Undulator	K_x = 0.2 ~ 3 K_y = 0.2 ~ 6 λ_u = 16 cm	Grazing Incidence R = 10m $\beta = 89°$	1200 2400	250 ~ 1600	~0.8 × 0.2	1000~5000 10^{11} ~10^{9}	36, 37

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