7 Summary of Experimental Stations

There are over 70 experimental stations attached to the PF storage ring and the PF-AR, as shown in Figs. 1 and 2. Two thirds are dedicated for research using hard X-rays, while the remaining one third are used in the VUV and soft X-ray regions. Tables 1 and 2 summarize the research areas carried out in these experimental stations for the PF storage ring and PF-AR, respectively. Each experimental station has a different specification in optics and performance depending on the methodology performed. Tables 3 and 4 list the optics of hard X-ray and soft X-ray or VUV stations, respectively, together with the principal performances, such as energy range, spot size, photon flux and energy resolution.

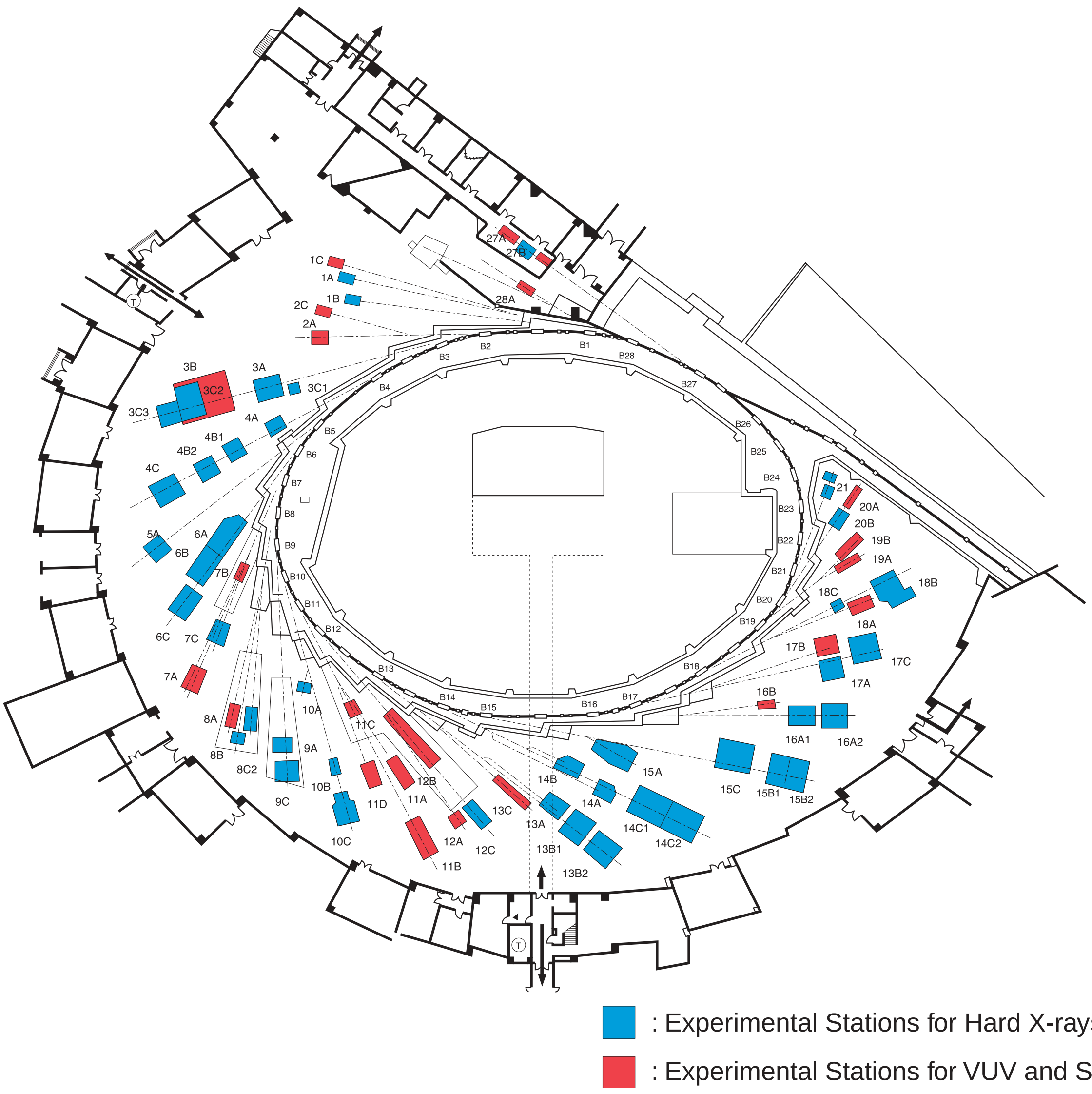

Figure 1
Plan view of the PF experimental hall.

Table 1 List of experimental stations at the PF Storage Ring.

Experimental Station			Spokesperson
BL-1			
	A	Crystal structure analysis beamline of collaboratory	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	T. Iwazumi (Dec. 2004~)
	B	VUV and soft X-ray spectroscopy	Y. Azuma
	C1	X-ray diffraction	H. Kawata
	C2	Characterization of X-ray optical elements	M. Ando
	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 -area structure analysis	K. Ohsumi
	B2	Powder diffraction	H. Sawa (Dec. 2004~)
	C	X-ray diffraction and scattering	Y. Wakabayashi
BL-5		(Multipole Wiggler)	
	A	Macromolecular crystallography	N. Matsugaki
BL-6			
	A	Macromolecular crystallography	N. Igarashi
	B	[SBSP] Macromolecular crystallography	N. Sakabe [SBSP], M. Hiraki
	C	[SBSP] Macromolecular crystallography by Weissenberg camera	N. Sakabe [SBSP], M. Kawasaki
BL-7			
	A	[RCS] Soft X-ray spectroscopy	K. Amemiya [RCS], K. Ito
	B	[RCS] Surface photochemical reaction and angle-resolved photoelectron spectroscopy	K. Amemiya [RCS], K. Ito
	C	X-ray spectroscopy and diffraction	T. Iwazumi
BL-8			
	A	[Hitachi] Soft X-ray spectroscopy	K. Ogata [Hitachi], K. Mase
	B	[Hitachi] EXAFS	K. Ogata [Hitachi], K. Mase
	C	[Hitachi] X-ray tomography and X-ray microscopy	K. Ogata [Hitachi], K. Mase
BL-9			
	A	XAFS	M. Nomura
	C	X-ray versatile station	M. Nomura
BL-10			
	A	X-ray diffraction/scattering	K. Ohsumi (Dec. 2004~)
	B	XAFS	N. Usami
	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. Ono
BL-12			
	A	Characterization of VUV-SX optical elements, soft X-ray spectroscopy	A. Yagishita
	B	VUV high-resolution spectroscopy	K. Ito
	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 general purpose (X-ray)	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	[Fujitsu] XAFS	N. Awaji [Fujitsu], A. Iida
B	[Fujitsu] Photochemical vapor deposition	N. Awaji [Fujitsu], A. Iida
C	[Fujitsu] Grazing incident X-ray diffraction, X-ray fluorescence analysis	N. Awaji [Fujitsu], A. Iida
BL-18		
A	[ISSP] Angle-resolved photoelectron spectroscopy of surfaces and interfaces	T. Kinoshita [ISSP], A. Yagishita
B*	Macromolecular crystallography	N. Igarashi
C	High pressure X-ray powder diffraction (DAC)	T. Kikegawa
BL-19	(Revolver Undulator)	
A	[ISSP] Spin-resolved photoelectron spectroscopy (Mott detector)	T. Kinoshita [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], K. Ohsumi
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	VUV and soft X-ray spectroscopy with circularly polarized undulator radiation	T. Koide (~ Jun. 2004)
	High-resolution VUV-SX beamline for angle-resolved photoemission	K. Ono (Jul. 2004~)
B	Spectroscopy and scattering with circulary polarized X-rays	T. Iwazumi (~ Jun. 2004)

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* shutdown at the end of FY2004.

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	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	S. Adachi
AR-NW12	(Undulator)	
A	Macromolecular crystallography	N. Matsugaki

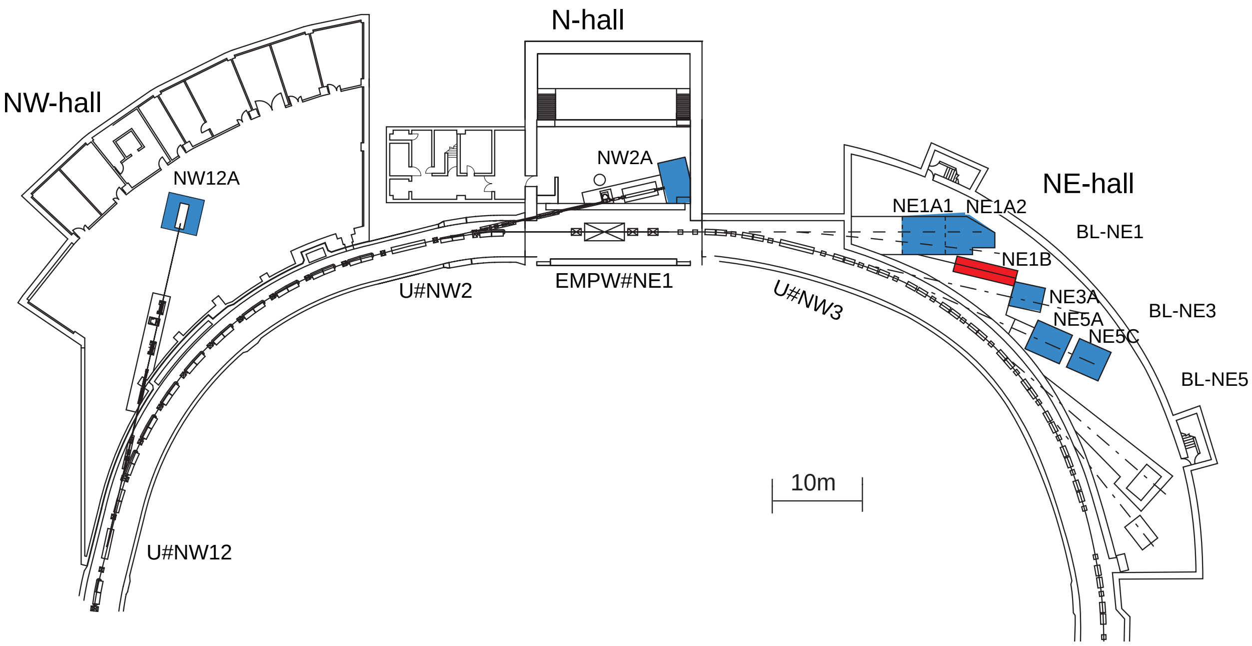

Figure 2
Plan view of the beamlines in the PF-AR north-east, north, and north-west experimental halls.

Table 3 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 (ΔE/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	4	Double Crystal Si(111) Sagittal Focusing	Collimating Focusing Mirrors (Fused Quartz)	6 ~ 20	100×5 2×1		~ 2	2 - 4
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-6B [SBSP]	1	Bent Si(111)	Bent Plane Si Pt-coated		1.7×0.2			12
BL-6C [SBSP]	2	Bent Si (111)	Bent Plane Si Pt-coated					13
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	14 - 16
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	

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 (Rh/Ni Coated)	2.2 ~ 15	1×0.3	4×10^{11}(9 keV, 300 mA)	2	17, 18
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	19
BL-10B	2	Channel-Cut Si(311)	None	6 ~ 30	5×1	1×10^{9}/7mm^2	1	
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	20
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	21
BL-13B1 B2	4	Double Crystal Si(111), Si(220) Sagittal Focusing	Bent Plane Fused Quartz	4 ~ 30	4×1		~ 2	22
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	23
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	24, 25
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	26
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 $(\Delta E/E)\times10^{-4}$	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	$\sim 1\times10^{13}$ (8.3 keV, 300 mA)	~ 1	27
BL-17A* [Fujitsu]	4	Double Crystal Si(111)	None	5 ~ 13	100×10		~ 2	28
BL-17C* [Fujitsu]	1	Double Crystal Si(111)	None	5 ~ 13	20×5		~ 2	29
BL-18B*	2	Double Crystal Si(111) Si(220) Ge(111) Ge(220)	Bent Cylinder Fused Quartz, Pt-coated	6 ~ 30	0.6×0.4	1.5×10^{9} (12.4 keV, 300 mA, $0.2\times0.2mm^2$)	~ 2	30
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) Double Crystal Sagittal focusing Si(111)	None	4 ~ 25	26×3		~ 2	31
BL-27B	4	Double Crystal Si(111)	None	4 ~ 20	100×6		~ 2	32
BL-28B (~ Jun. 2004)	H: 4 V:0.2	Double Crystal Si(111) Si(220) InSb(111)	Pre-mirror Bent Cylinder Si Pt- & Ni-coated Post-mirror Bent Plane Fused Quartz Pt- & Ni-coated	2 ~ 10	2.0×0.2	3×10^{10} (9 keV, 300mA Si(220) Pc ~ 0.5)	~ 2 (Si(111))	33
AR-NE1A1	2	Double Bent Crystal Si(111) Si(400)		40 ~ 70 80 ~ 160	2×0.5	2×10^{13} (60 keV, 35mA)	8	34 - 36
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}	37

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
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	38, 39
AR-NE5C	3	Double Crystal Si(111)	None	30 ~ 100 or white	60×5		5	40
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	41, 42
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	7 ~ 17	1.4×0.18 1.3×0.3	2×10^{11} (0.2×0.2 mm^2)	~2	

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Table 4 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 λu = 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 λu = 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 [Hitachi]	0.5 × 1	SX700 Plane Grating	1221	38 ~ 2300	5 × 1	2000 10^{10}	
BL-8B [Hitachi]	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-12B	5 × 3.6	6.65 m Off-Plane Eagle	1200 4800	5 ~ 30	____	2.5 × 10^{5} 10^{4}	23 - 25
BL-13C Undulator	K = 0.3 ~ 4.2 λu = 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}	26, 27
BL-16B Undulator	K = 0.5 ~ 5.75 λu = 12 cm	Grazing Incidence R = 24 m α+β = 168.6°	400 900 2000	40 ~ 550	< 1ϕ	1000 ~ 10000 10^{12} ~ 10^{1}	28 - 30
BL-17B* (Fujitsu)	8 × 1	Toroidal Mirror	____	____	10 × 1	____	____

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-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}	31
BL-19A Revolver Undulator (ISSP)	K = 1.0 ~ 9.0 λu = 16.4 cm K = 0.5 ~ 1.25 λu = 5 cm K = 0.5 ~ 2.5 λu = 7.2 cm K = 1.0 ~ 5.0 λu = 10 cm	Grazing Incidence R = 2 m α+β = 160° R = 4 m α+β = 170°	600 1200 600 1200	12 ~ 250	< 0.7ϕ	1000 10^{12}	32, 33
BL-19B Revolver Undulator (ISSP)		Varied-Line-Space Plane Grating	800 2400	10 ~ 1200	< 0.5ϕ	400~4000 10^{12} ~10^{11}	33 - 35
BL-20A	28 × 5	3m Normal Incidence	1200 2400	5 ~ 40	2 × 1	300 ~ 30000 10^{12} ~ 10^{8}	36
BL-27A	5 × 0.5	Double Crystal InSb (111)	____	1800 ~ 4000		2000	37
BL-28A Helical Undulator (~Jun. 2004)	K_x = 0.23 ~ 3 K_y = 0.23 ~ 6 λu = 16 cm	Grazing Incidence R = 2 m α+β = 160° R = 4 m α+β = 170°	600 1200 600 1200	30 ~ 250	< 0.5ϕ	1000 10^{10}	38
BL-28A Helical Undulator (Jul. 2004~)	K_x = 0.23 ~ 3 K_y = 0.23 ~ 6 λu = 16 cm	Varied-Line-Space Plane Grating	400	30 ~ 300	0.15 × 0.05	30000 10^{12}	
AR-NE1B Helical Undulator	K_x = 0.2 ~ 3 K_y = 0.2 ~ 6 λu = 16 cm	Grazing Incidence R = 10m β = 89°	1200 2400	250 ~ 1800	~0.8 × 0.2	1000~5000 10^{11} ~10^{9}	39, 40

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