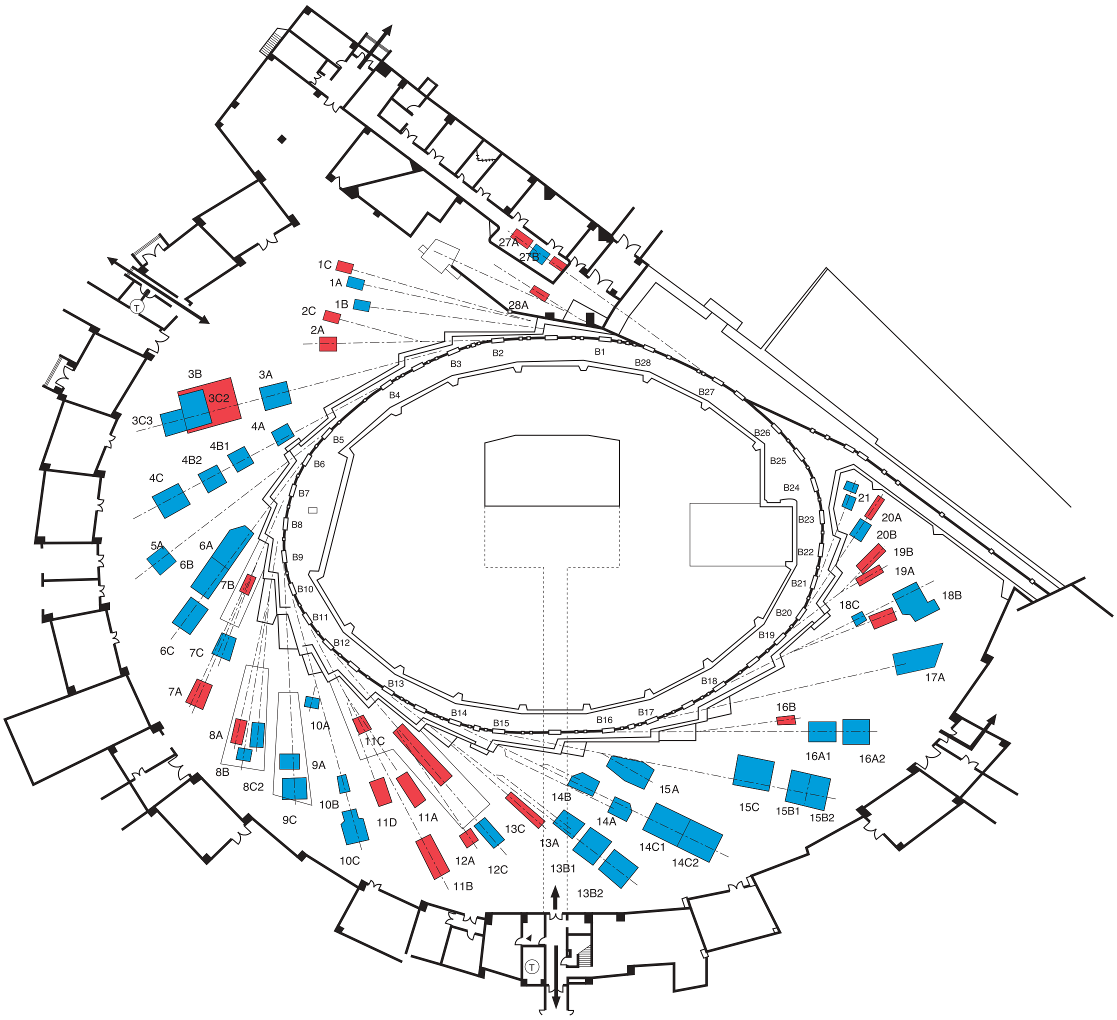
6 Summary of Experimental Stations

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.



: Experimental Stations for Hard X-rays

: Experimental Stations for VUV and Soft X-rays

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 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
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 Micro-area structure analysis	K. Ohsumi
B2	Powder diffraction	H. Sawa
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	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 (Oct. 2005~)
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. Ito
BL-12		
A	Characterization of VUV-SX optical elements, soft X-ray spectroscopy	A. Yagishita
B*	VUV high-resolution sepctroscopy	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 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)	H. Sawa
A2	X-ray diffraction and scattering	H. Sawa
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], 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	High-resolution VUV-SX beamline for angle-resolved photoemission	K. Ono

SBSP Structural Biology Sakabe Project, Foundation for Advancement of International Science
RCS Research Center for Spectrochemistry, the University of Tokyo
ISSP Institute for Solid State Physics, the University of Tokyo
ANBF Australian National Beamline Facility

* shutdown at the summer of 2005.
** shutdown at the end of FY2005.
*** shutdown at the end of 2005.

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. Adachi

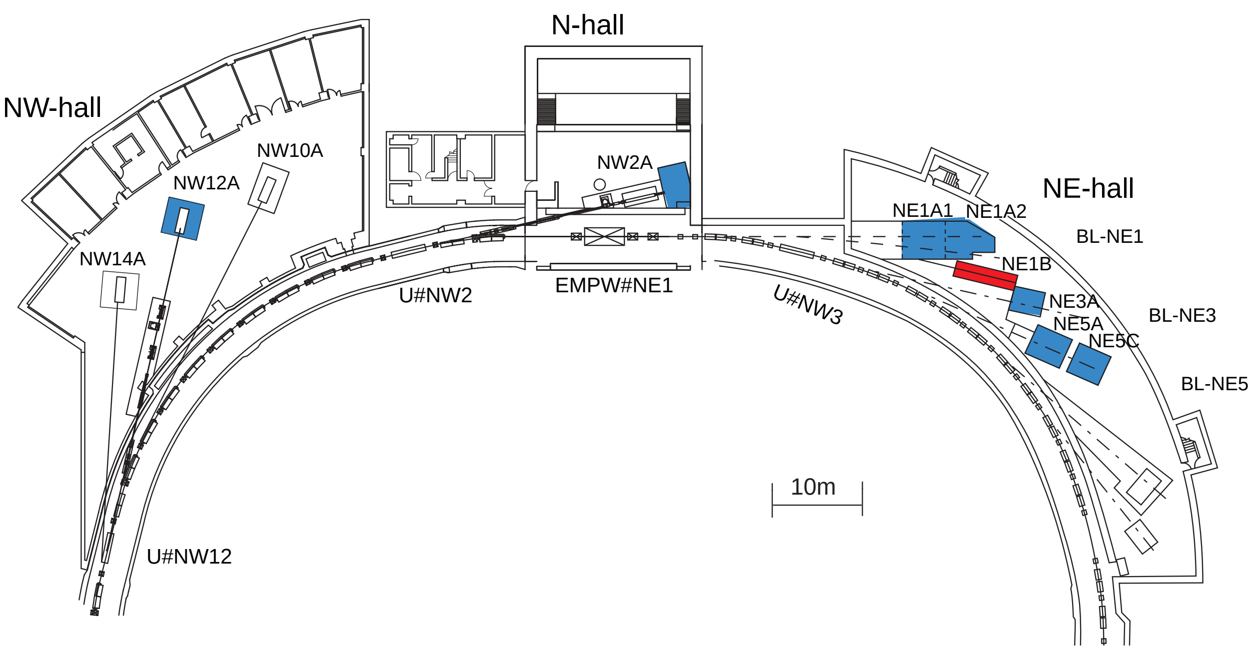


Figure 2
Plan view of beamlines in the PF-AR north-east, north, and north-west experimental halls.

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 ($\Delta E/E$)×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	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 $(\Delta E/E)\times10^{-4}$	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	$\sim1\times10^{13}$ (8.3 keV, 300 mA)	~ 1	27
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	
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	28
BL-27B	4	Double Crystal Si(111)	None	4 ~ 20	100×6		~ 2	29
AR-NE1A1	2	Double Bent Crystal Si(111) Si(400)		40 ~ 70 80 ~ 160	2×0.5	2×10^{13} (60 keV, 35mA)	8	30-32
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}	33
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	34, 35
AR-NE5C	3	Double Crystal Si(111)	None	30 ~ 100 or white	60×5		5	36

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	37, 38
AR-NW10A	1.2	Si(311)	Pt-Coated Bent Cylinder	8 ~ 42	2.2×0.5	1×10^{10}	~1	
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		1.4×0.18 1.3×0.3	2×10^{11} (0.2×0.2 mm^2)	~2	
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	

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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 [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-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 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 α+β = 160° R = 4 m α+β = 170°	600 1200 600 1200	12 ~ 250	< 0.7ϕ	1000 10^{12}	29, 30
BL-19B Revolver Undulator (ISSP)		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 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 β = 89°	1200 2400	250 ~ 1800	~0.8 × 0.2	1000~5000 10^{11} ~10^{9}	36, 37

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