4. Specifications of the Accelerators

Table 1. General parameters of the PF storage ring.

Energy		2.5 GeV	(max 3.0 GeV)
Initial stored current	multi-bunch	450 mA	(max 500 mA at 2.5GeV)
	single bunch	70 mA	(max 100 mA)
Emittance	horizontal	36 nm·rad	
	vertical	~0.4 nm·rad	
Circumference		187 m	(bending radius = 8.66 m)
RF frequency		500.1 MHz	
Harmonic number		312	
Injection		2.5-GeV Linac	(electron/positron)
Beam lifetime		50 h (at 400 mA)	$I \cdot \tau \geq 20$ A·h (at 400 mA)
Average vacuum pressure		$\leq 2 \times 10^{-8}$ Pa (at 300 mA)	
		P/I 6-7 $\times 10^{-8}$ Pa (at 300 mA)	
		~9 $\times 10^{-9}$ Pa (at 0 mA)	
Insertion devices	VW#14	Superconducting vertical wigger 5 T	
	U#02	60 period undulator K = 2.3~0.1	
	MPW#16	26 period multipole wigger/undulator 1.5~0.04 T	
	Revolver#19	Four way revolver-type undulator	
	MPW#13	13 period multipole wigger/undulator	
	EMPW#28	Elliptically polarized multipole wigger/helical undulator	
SR channels		SR experiment 22	
		Beam diagnosis 3	

Table 2. Beam parameters.

Horizontal tune	ν_x	9.60
Vertical tune	ν_y	4.28
Momentum compaction factor	α	0.0061
Natural chromaticity	ξ_x	−12.5
	ξ_y	−12.3
Bunch length	σ_z	1.0 cm
Damping time	transverse	7.8 ms
	longitudinal	3.9 ms
Energy spread		7.3×10^{-4}
Radiation loss		400 keV

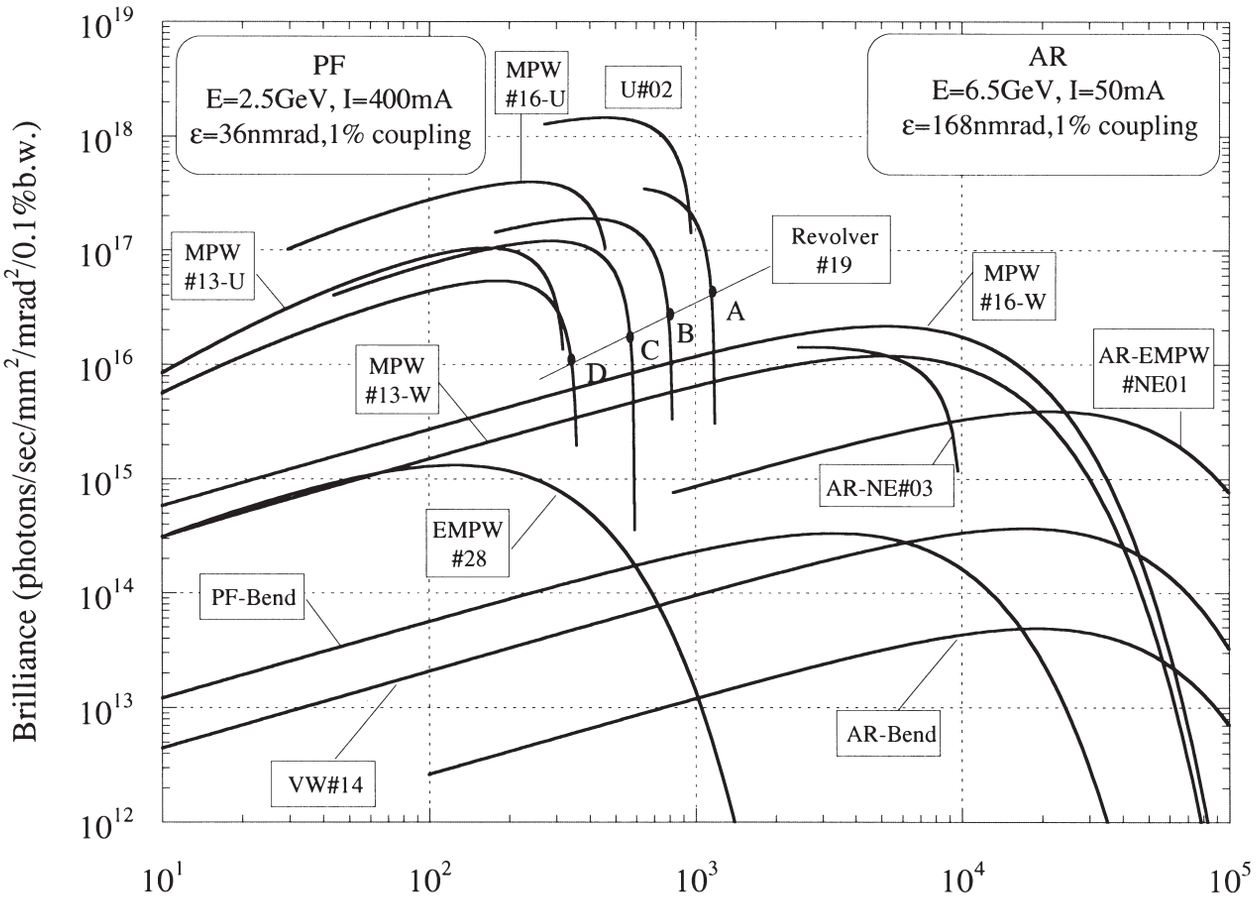

Figure 1.

Synchrotron radiation spectra of the PF Storage Ring (2.5 GeV) and PF-AR (6.5 GeV).

Brilliance of radiation vs. photon energy for the insertion devices (U#02, MPW#13, VW#14, MPW#16, Revolver#19 and EMPW#28) and the bending magnet (Bend) of the PF, and for the insertion device (EMPW#NE1 and UNE3) of the PF-AR. The name of each source of the PF is assigned in Table 3. Several insertion devices have both undulator and wiggler modes, which are denoted by U or W, respectively. The spectral curve of each undulator (or undulator mode of multipole wiggler) is a locus of the peak of the first harmonic within the allowable range of K-parameter. Spectra of Revolver#19 are shown for four kinds of period.

Table 3. Insertion devices

Calculated spectral performances of the bend source and 6 insertion devices at the Photon Factory (2.5 GeV, 300 mA). λ_u: period length, N: number of periods, L: length of undulator or wiggler, G_y (G_x): minimum vertical (horizontal) gap height, B_y (B_x): maximum vertical(horizontal) magnetic field, Mag: Type of Magnet, P: pure configuration, H: hybrid configuration (NdFeB), S.C.: superconducting magnet, σ_x, σ_y: horizontal or vertical beam size, σ'_x, σ'_y: horizontal or vertical beam divergence, K_n (K_v): horizontal (vertical) deflection parameter, $\varepsilon_1/\varepsilon_0$: photon energy of the first harmonic (critical energy in the case of bend source or wiggler), D: photon flux in unit solid angle (photons/s·mrad^2·0.1%b.w.), B: brilliance (photons/s·mm^2·mrad^2·0.1%b.w.), P_T: total radiated power, dP/dΩ: power in unit solid angle. Different operating modes of undulator and wiggler are denoted by -U and -W, respectively.

Name	λ_u cm	N	L m	G_y(G_x) cm	B_y(B_x) T	Mag	σ_x mm	σ_y mm	σ'_x mrad	σ'_x mrad	K_n(K_v)	$\varepsilon_1/\varepsilon_o$ keV	D	B	P_T kW	dP/dΩ kW/mrad
Bend					0.96		0.39	0.059	0.186	0.013		4	4.80E+13	3.31E+14		0.081
U#02	6	60	3.6	2.8	0.4	H	0.42	0.042	0.084	0.008	2.3	0.2	1.49E+17	1.30E+18	0.95	3.93
MPW#13-W	18	13	2.5	2.7	1.5	H	0.86	0.019	0.117	0.018	25	6.2	1.29E+15	1.18E+16	8.64	3.38
MPW#13-U	18	13	2.5	2.7	1.5	H	0.86	0.019	0.117	0.018	2	0.108	1.08E+16	9.25E+16	0.055	0.25
VW#14				5	5	S.C.	0.58	0.036	0.083	0.01		20.8	4.84E+13	3.67E+14		0.42
MPW#16-W	12	26	3.12	1.9	1.5	H	0.42	0.042	0.084	0.008	16.8	6.2	1.03E+15	8.95E+15	10.89	6.46
MPW#16-U	12	26	3.12			H	0.42	0.042	0.084	0.008	2	0.163	4.23E+16	3.63E+17	0.16	0.74
Revolver#19	5	46	2.3	3	0.28	H	0.85	0.056	0.088	0.008	1.3	0.639	1.05E+17	3.47E+17	0.28	1.89
	7.2	32	2.3	3	0.4	H	0.85	0.056	0.088	0.008	2.7	0.176	4.39E+16	1.44E+17	0.56	1.92
	10	23	2.3	3	0.54	H	0.85	0.056	0.088	0.008	5	0.0437	1.28E+16	4.01E+16	1.02	2.02
	16.4	14	2.3	3	0.62	P	0.85	0.056	0.088	0.008	9.5	0.0078	1.71E+15	4.29E+15	1.35	1.41
EMPW#28-W	16	12	1.92	3(11)	1(0.2)	P	0.58	0.036	0.083	0.01	15(3)	4.1(90%)	3.07E+14	2.28E+15	2.84	0.46
EMPW#28-U	16	12	1.92			P	0.58	0.036	0.083	0.01	3(3)	0.182(99%)	1.81E+16	1.33E+17	0.03	0.087

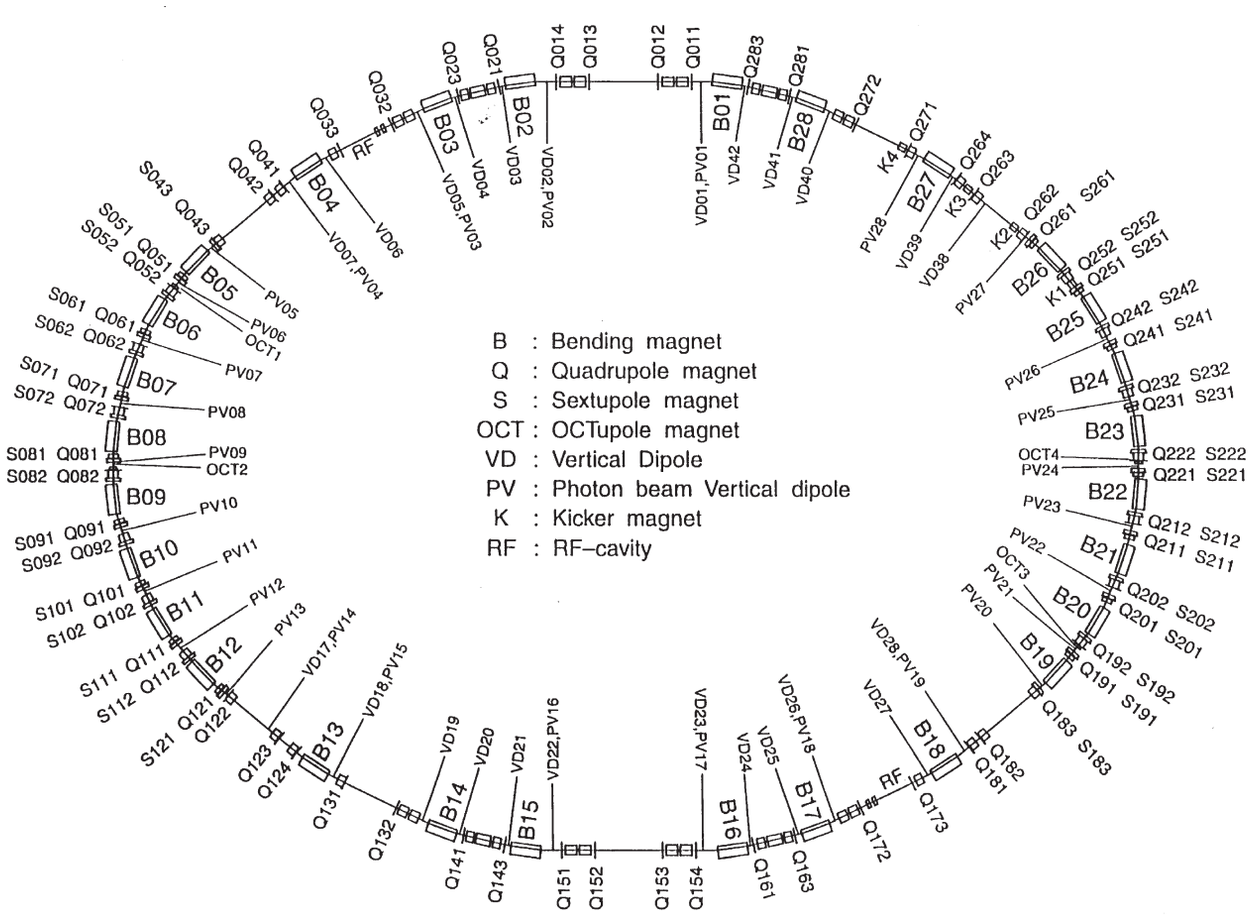

Figure 2.

Ring lattice components.

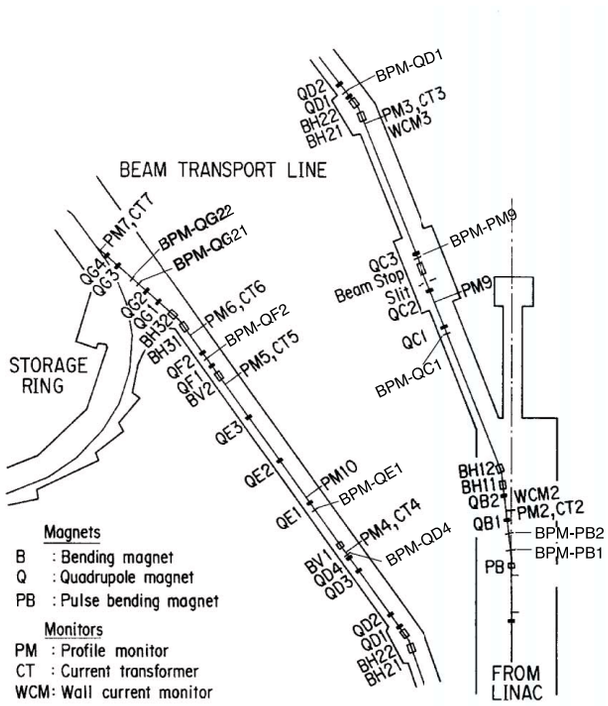

Figure 3.

Beam-transport line.

Table 4. Principal parameters of the accelerator system.

Magnet System

	number of magnets	number of power supplies
Bending	28	1
Quadrupole	74	15
Sextupole	32	3
Octupole	4	3
Vertical steerers	24	24
Fast vertical steerers for global orbit FB	28	28
Backleg windings		
on bendings for horizontal steerers	28	28
on sectupoles for vertical steeres	14	14
on sextupoles for skew quadrupoles	14	14
on sextupoles for field compensation	32	3
Electronic shunts on quadrupoles		
for optics matching and tune compensation	34	48

RF system

Number of RF stations	4	
Number of klystrons	4	(180 kW/klystron)
Number of RF cavities	4	(single cell cavity)
Shunt impedance	27.6 MΩ	(four cavities)
Unloaded Q	39000	
Total power dissipated in cavity wall	105 kW	
Total cavity gap voltage	1.7 MV	
Synchrotron frequency	23 kHz	

Injection system

Septum magnet	Septum 1 (S1)	Septum 2 (S2)
core material	laminated silicon steel (passive type)	
length	1500 mm	1000 mm
maximum current	6000 A	6000 A
deflection angle	7.0°	5.0°
pulse width	120 μs	100 μs

Kicker magnet	K1, K2, K3, K4
core material	ferrite (Traveling wave type)
core length	345 mm
	15000 mm
maximum voltage	4.1 V
pulse width	1.7 μs

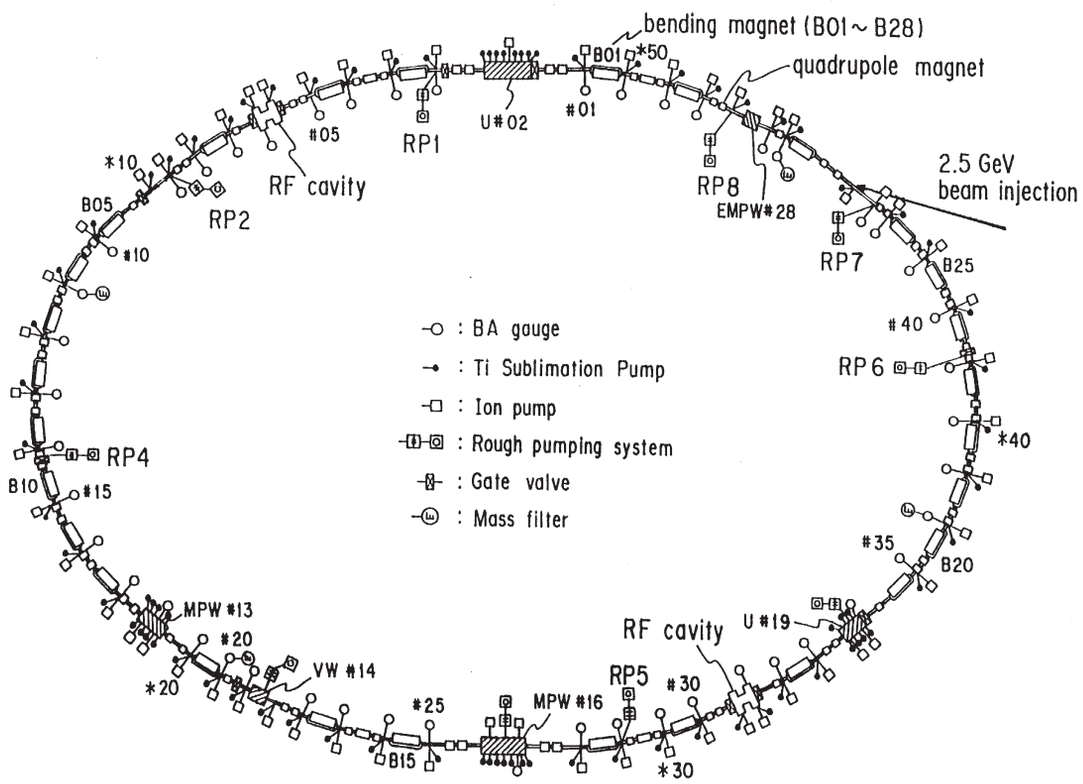

Figure 3.
Vacuum-system componebts.

Vacuum System		
Main Pumping system	pumping speed	number
SIP (sputter ion pump)	128 l/s	54
DIP (distributed ion pump)	150 l/s	26
Ti sublimation	.....	71
NEG (non-evaporable getter)	.....	2
Total effective pumping speed	2×10^4 l/s (for CO)	
Rough pumping system		
TMP (turbo molecular pump)	300 l/s	12
Measurement		number
B-A gauge		48
mass filter		4
cold cathode gauge		24
Sector gate valve		
all metal with RF shield		4
viton seal with RF shield		7

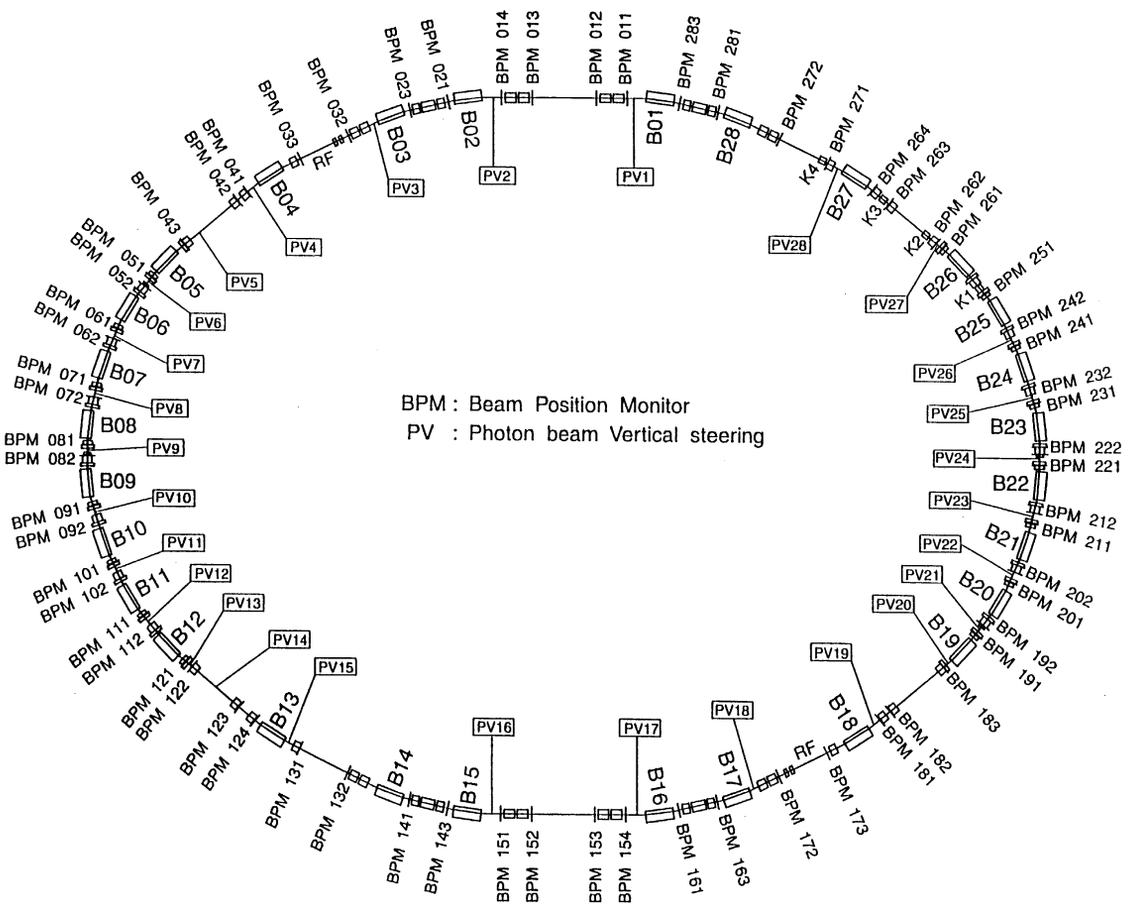

Figure 4.

Beam-position monitors.

Monitor System	
1. Orbiting beam monitors	
PM (Position Monitor)	65
DCCT (Direct Current Current Transformer)	2
RFKO (Radio Frequency Knock-Out system)	1
WCM (Wall Current Monitor)	1
LS (Loss monitor)	30
Visible Light Monitors	
CCD TV camera	1
Streak camera	2
Photon Counting System	1

2. Photon beam position monitors installed in beamlines

Beamline	Source	Upstream	Downstream
BL-3A	B	SPM	
BL-3C	B	SPM	SPM
BL-4C	B	SPM	SPM
BL-6B	B	SIC	
BL-6C	B	SIC	
BL-6C	B	SPM	SPM
BL-7C	B	SIC	SPM
BL-10B	B	SIC	
BL-12C	B	WM	WM
BL-21	B	WM	
BL-27	B	SPM	

Note:

B: Bending Magnet

SPM: Split Photoemission Monitor

SIC: Split Ion Chamber

WM: Wire Monitor

Superconducting vertical wiggler

Maximum field strength on the beam orbit		5 Tesla
Magnet gap		66 mm
Magnet pole size (width × hight)		40 mm × 260 mm
Number of magnetic poles		5 poles (3 poles at nomal operation)
		installedat every 200 mm
Rated exciting current		210 A at 4.8 Tesla
Superconducting wire	NbTi:Cu	1:1
	size	1.70 × 0.85mm^2
Cross section of coils		65 mm × 70 mm
Number of turn		2520
Liquid helium consumption in the permanent current mode		1.1 L/h
Damping rate of the permanent current		1.4 × 10^{-5}/h
Inductance		1.31 H/coil

Control System

Computers

	Server	Workstation	PC	VME
Presentation/Console	–	3	17	–
Control/DB Engine	1	16	5	6
Equipment Control	–	–	3	9
Network Management	–	2	1	–

Network

	number	Port	type	number
ATM Switch (155Mbps)	1		single mode	12
			multi-mode	4
ATM-Ethernet Switching Hub	12	10BASE-T		12

Table 5. Beam parameters at source points.

Beamline	Source	σ_x [mm]	σ'_x [mrad]	σ_y [mm]	σ'_y [mrad]
BL-1	B01(+2.5)	0.203	0.245	0.061	0.0125
BL-2	U#02	0.422	0.084	0.042	0.0084
BL-3 A	B02(-0.0)	0.238	0.263	0.066	0.0125
B/C	B03(+0.0)	0.288	0.228	0.084	0.0066
BL-4	B04(+2.5)	0.319	0.161	0.066	0.0173
BL-6	B06(+2.5)	0.391	0.185	0.059	0.0129
BL-7	B07(+2.5)	0.391	0.185	0.059	0.0129
BL-8	B08(+2.5)	0.391	0.185	0.059	0.0129
BL-9	B09(+2.5)	0.391	0.185	0.059	0.0129
BL-10	B10(+2.5)	0.391	0.185	0.059	0.0129
BL-11	B11(+2.5)	0.391	0.185	0.059	0.0129
BL-12	B12(+2.5)	0.447	0.138	0.054	0.0092
BL-13	MPW#13	0.859	0.115	0.020	0.0186
BL-14	VW#14	0.580	0.083	0.036	0.0098
BL-15	B15(+2.5)	0.203	0.245	0.061	0.0125
BL-16	MPW#16	0.422	0.084	0.042	0.0084
BL-17 A	B16(-0.0)	0.238	0.263	0.066	0.0125
B/C	B17(+0.0)	0.288	0.228	0.084	0.0066
BL-18	B18(+2.5)	0.319	0.161	0.066	0.0173
BL-19	Revolver#19	0.847	0.088	0.057	0.0078
BL-20	B20(+2.5)	0.391	0.185	0.059	0.0129
BL-21	B21(+2.5)	0.391	0.185	0.059	0.0129
BL-27	B27(+1.2)	0.259	0.218	0.090	0.0176
BL-28	EMPW#28	0.580	0.083	0.036	0.0098

Table 6. Summary of beamline front ends in FY2000.

BL	Affiliation	Source	Spectral Range	Status
BL-1	KEK-PF	Bending magnet (B1)	VUV and X-ray	in operation
BL-2	KEK-PF	U#02	Soft X-ray	in operation
BL-3	KEK-PF	Bending magnet (B2&B3)	VUV and X-ray	in operation
BL-4	KEK-PF	Bending magnet (B4)	X-ray	in operation
BL-5	KEK-PF	-		in design
BL-6	KEK-PF	Bending magnet (B6)	X-ray	in operation
BL-7	KEK-PF and RCS	Bending magnet (B7)	VUV and X-ray	in operation
BL-8	Hitachi Ltd.	Bending magnet (B8)	VUV and X-ray	in operation
BL-9	KEK-PF and NEC	Bending magnet (B9)	VUV and X-ray	in operation
BL-10	KEK-PF	Bending magnet (B10)	X-ray	in operation
BL-11	KEK-PF	Bending magnet (B11)	VUV and soft X-ray	in operation
BL-12	KEK-PF	Bending magnet (B12)	VUV and X-ray	in operation
BL-13	KEK-PF	MPW#13	Soft and hard X-ray	in operation
BL-14	KEK-PF	VW#14	Hard X-ray	in operation
BL-15	KEK-PF	Bending magnet (B15)	X-ray	in operation
BL-16	KEK-PF	MPW#16	Soft and hard X-ray	in operation
BL-17	Fujitsu Ltd.	Bending magnet (B16&B17)	VUV and X-ray	in operation
BL-18	ISSP and KEK-PF	Bending magnet (B18)	VUV and X-ray	in operation
BL-19	ISSP and KEK-PF	Revolver#19	VUV	in operation
BL-20	KEK-PF	Bending magnet (B20)	VUV and X-ray	in operation
BL-21	KEK-PF	Bending magnet (B21)	Beam diagnosis	in operation
BL-27	KEK-PF	Bending magnet (B27)	Soft X-ray and X-ray	in operation
BL-28	KEK-PF	EMPW#28	VUV and X-ray	in operation