1 Outline of the Accelerators

Two electron storage rings, namely, the PF ring and the PF-AR that are used as the dedicated light sources were stably operated at the Photon Factory. The KEK linear accelerator with a maximum electron energy of 8 GeV was employed to inject an electron beam into the rings. Full energy injection of 2.5 GeV was carried out at the PF ring, while the injection energy of 3 GeV had to be increased to the operation energy of 6.5 GeV at the PF-AR.

The machine parameters of the rings and the calculated spectral performances are listed in Tables 1 and 2, respectively. The spectral distributions of synchrotron radiation (SR) from the bending magnets and the insertion devices are shown in Fig. 1.

In FY2008, the PF ring was predominantly operated in the multibunch mode with an energy of 2.5 GeV, while it was run in the single-bunch mode for two one-week periods and the multibunch mode with the energy of 3.0 GeV for one-week periods. With the adoption of simultaneous injection of three rings, namely, KEKB high-energy electron ring (HER) (8.0 GeV), low-energy positron ring (LER) (3.5 GeV), and PF ring (2.5 GeV), the top-up operation in the multi-bunch mode at the PF ring was carried out for approximately two months from January to March 2009. The PF-AR was operated in the single-bunch mode throughout FY2008.

Table 1 Principal beam parameters of the PF ring and PF-AR.

	PF ring	PF-AR
Energy	2.5 GeV (3 GeV)	6.5 GeV
Natural emittance	34.6 nm rad	293 nm rad
Circumference	187 m	377 m
RF frequency	500.1 MHz	508.6 MHz
Bending radius	8.66 m	23.2 m
Energy loss per turn	0.4 MeV	6.66 MeV
Damping time		
Vertical	7.8 ms	2.5 ms
Longitudinal	3.9 ms	1.2 ms
Natural bunch length	10 mm	18.6 mm
Momentum compaction factor	0.00644	0.0129
Natural chromaticity		
Horizontal	–12.9	–14.3
Vertical	–17.3	–13.1
Stored current	450 mA	60 mA
Number of bunches	280	1
Beam lifetime	40 hr (at 450 mA)	15-20 hr (at 60 mA)

Table 2
Calculated spectral performances of the bend source and all the insertion devices at the PF ring (2.5 GeV, 450 mA) and the PF-AR (6.5 GeV, 50 mA). λ_u: period length, N: number of the 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, Type of magnet, H: hybrid configuration, S.C.: super conducting magnet, σ_x,σ_y: horizontal or vertical beam size, σ_x',σ_y': horizontal or vertical beam divergence, $K_y(K_x)$: vertical (horizontal) deflection parameter, D: photon flux density (photons/sec/mrad^2/0.1%b.w.), B: brilliance (photons/sec/mm^2/mrad^2/0.1%b.w.), P_T: total radiated power. Different operating modes of undulator and wiggler are denoted by -U and -W, respectively.

Name	*E/I*	λu	*N*	*L*	*Gy(Gx)*	*By(Bx)*	Type of magnet	σ_x	σ_y	$\sigma_{x'}$	$\sigma_{y'}$	*Ky(Kx)*	$\varepsilon_1/\varepsilon_c$	*D*	*B*	P
	GeV/mA	cm		m	cm	T		mm	mm	mrad	mrad		keV			kW
PF ring	2.5/450															
Bend								0.41	0.059	0.178	0.012		4	5.38E+13	3.48E+14	
SGU#01		1.2	39	0.5	0.4	0.7	P(NdFeB)	0.6	0.012	0.088	0.029	0.78		4.56E+16	9.90E+17	
U#02		6	60	3.6	2.8	0.4	H(NdFeB)	0.65	0.042	0.054	0.008	2.3		2.73E+17	1.55E+18	1.07
SGU#03		1.8	26	0.5	0.4	1	P(NdFeB)	0.6	0.012	0.088	0.029	1.68		2.50E+16	5.44E+17	0.82
MPW#05-W		12	21	2.5	2.64	1.4	H(NdFeB)	0.71	0.045	0.078	0.009	16	5.9	2.22E+15	1.10E+16	8.83
MPW#13-W		18	13	2.5	2.71	1.5	H(NdFeB)	0.74	0.02	0.094	0.019	25	6.2	1.45E+15	1.47E+16	9.73
MPW#13-U												2		1.70E+16	1.57E+17	0.06
VW#14					5	5	S.C.	0.53	0.045	0.128	0.008		20.8	5.42E+13	3.59E+14	
U#16-I		5.6	44	2.5	2.1	0.6(0.38)	P(NdFeB)	0.654	0.042	0.055	0.008	3(2)		1.03E+18	1.82E+17	0.88
SGU#17		1.6	29	0.5	0.4	0.92	P(NdFeB)	0.6	0.012	0.088	0.029	1.37		7.88E+17	1.71E+17	0.69
Revolver#19		5	46	3.6	2.8	0.28	H(NdFeB)	0.7	0.045	0.078	0.009	1.3		1.31E+17	6.48E+17	0.31
		7.2	32			0.4	H(NdFeB)					2.7		7.17E+16	3.52E+17	0.63
		10	23			0.54	H(NdFeB)					5		4.53E+16	2.22E+17	1.15
		16.4	14			0.62	P(NdFeB)					9.5		2.02E+16	9.81E+16	1.52
EMPW#28-U		16	12	1.92	3(11)		P(NdFeB)	0.53	0.045	0.127	0.008	3(3)		1.55E+16	1.00E+16	0.26
PF-AR	6.5/50															
Bend								1	0.2	0.593	0.036		26	3.25E+13	2.59E+13	
EMPW#NE1-W		16	21	3.36	3(11)	1(0.2)	P(NdFeB)	1.07	1.07	0.268	0.032	15(3)	28(90%)	1.53E+15	2.12E+15	4.6
EMPW#NE1-U												3(3)		3.41E+15	4.70E+15	0.35
U#NE3		4	90	3.6	1	0.8	P(NdFeB)	1.57	0.17	0.312	0.029	3		1.08E+16	6.39E+15	3.09
U#NW2		4	90	3.6	1	0.8	P(NdFeB)	1.57	0.17	0.312	0.029	3		1.08E+16	6.39E+15	3.09
U#NW12		4	95	3.8	1	0.8	P(NdFeB)	1.57	0.17	0.312	0.029	3		1.08E+16	6.39E+15	3.26
U#NW14-36		3.6	79	2.8	1	0.8	P(NdFeB)	1.35	0.14	0.338	0.036	2.8		6.41E+15	5.41E+15	2.6
U#NW14-20		2	75	1.5	0.8	0.63	P(NdFeB)	0.75	0.07	0.383	0.038	1.17		6.41E+15	5.41E+15	0.78

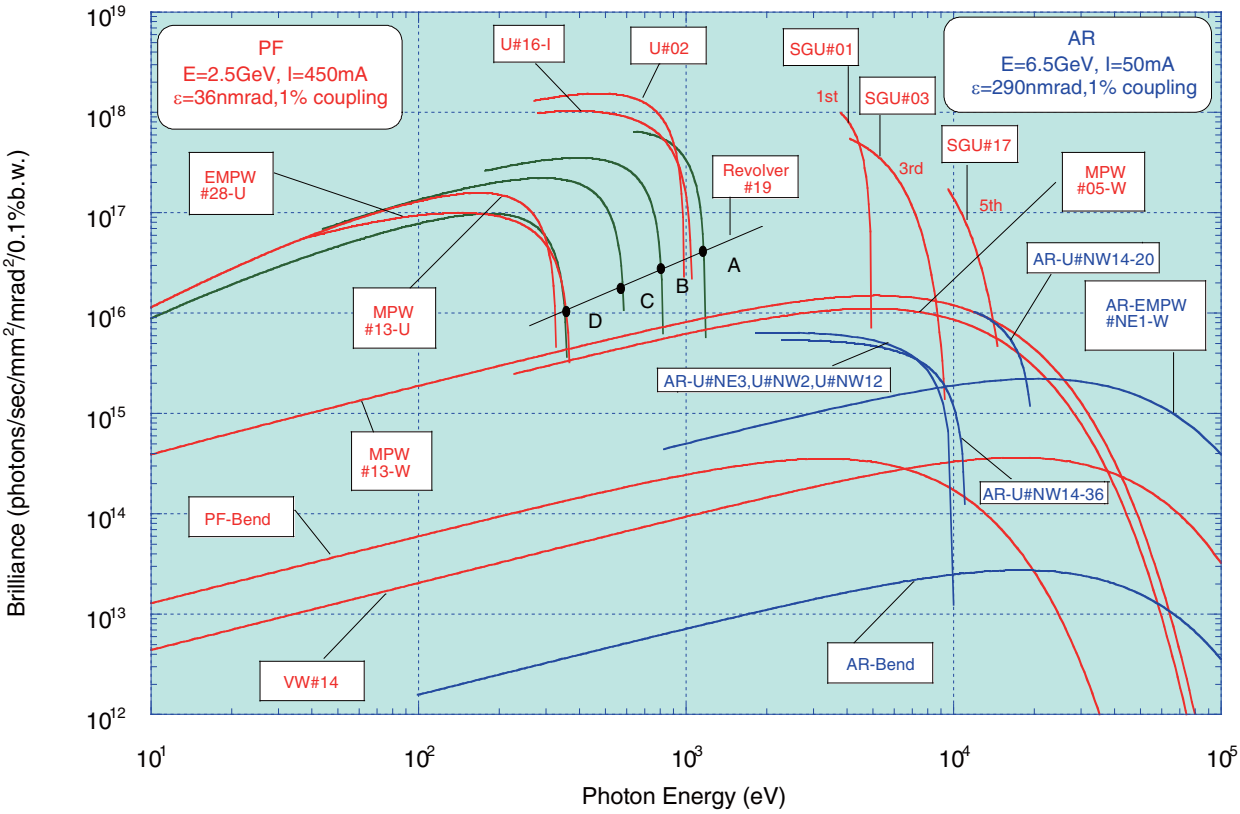

Figure 1
Synchrotron radiation spectra available at the PF ring (2.5 GeV) and the PF-AR (6.5 GeV). Brilliance of the radiation vs. photon energy are denoted by red curves for the insertion devices, SGU#01, U#02, SGU#03, MPW#05, MPW#13, VW#14, U#16-1, SGU#17, Revolver#19 and EMPW#28, and bending magnets(PF-Bend) at the PF Storage Ring. Blue curves denote those for the insertion devices, EMPW#NE01, U#NE03, U#NW02, U#NW12, U#NW14-36 and U#NW14-20, and the bending magnets (AR-Bend) at the PF-AR. The name of each source is assigned in Table 2. Several insertion devices have both undulator and wiggler modes,which are denoted by U and W, respectively (the undulator mode of MPW#05 and AR-EMPW#NE01 is not shown). The spectral curve of each undulator (or undulator mode of multipole wiggler) is a locus of the peak of the first harmonic within the allowance range of K parameter. For SGU#01, SGU#03 and SGU#17, spectra are shown for the first, third and fifth harmonic regions. Spectra of Revolver#19 are shown for four kinds of period.