1 Outline of the Accelerators

Two electron storage rings, the PF ring and the PF-AR, as dedicated light sources were stably operated at the Photon Factory. The KEK linear accelerator with maximum electron energy of 8 GeV is employed to inject electron beams into the rings. The full-energy injection of 2.5 GeV is carried out at the PF ring, while at the PF-AR it is necessary to increase the injection energy of 3 GeV to the operating energy of 6.5 GeV.

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

In FY2010, the PF ring was predominantly operated in multi-bunch mode with the energy of 2.5 GeV, while it was run in the single-bunch mode for three one-week periods. In both modes, top-up operation was carried out with a beam current of 450.0±0.1 mA and 50.0±0.1 mA, respectively. The PF-AR was operated in single-bunch mode with an initial beam current of 60 mA throughout this year. Fortunately, the operations of both rings were finished at 9:00 on March 11, 2011 just 6 hours before the Great East Japan Earthquake.

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

	PF	PF-AR
Energy	2.5 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	30-35 hr (at 450 mA)	20-25 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* GeV/mA	λ_u cm	*N*	*L* m	$G_y(G_x)$ cm	$B_y(B_x)$ T	Type of magnet	σ_x mm	σ_y mm	$\sigma_{x'}$ mrad	$\sigma_{y'}$ mrad	$K_y(K_x)$	$\varepsilon_1/\varepsilon_c$ keV	*D*	*B*	P_T kW
PF	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	0.4
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-U		18	13	2.5	2.71	1.5	H(NdFeB)	0.74	0.02	0.094	0.019	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#16-1 & 16-2		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+15	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#NE1W		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
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

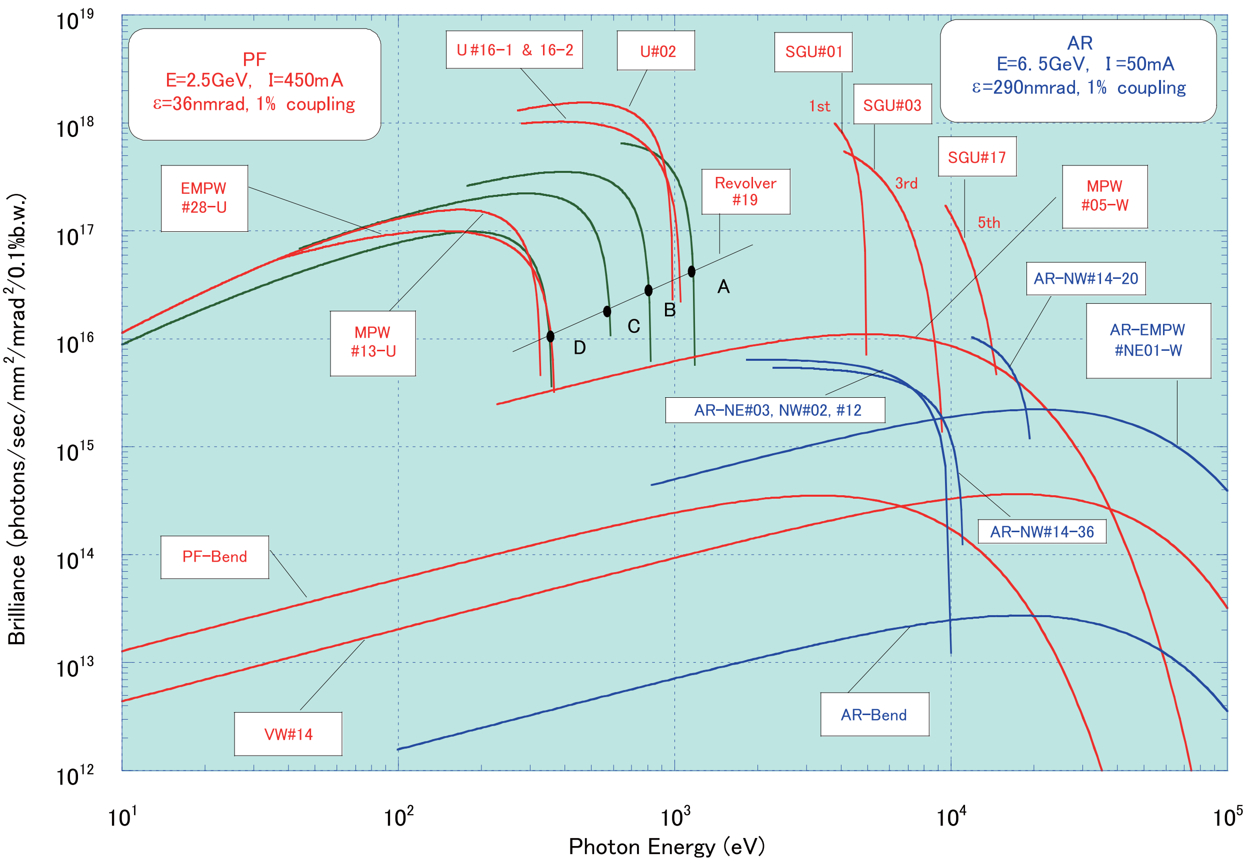

Figure 1
Synchrotron radiation spectra available at the PF Storage Ring (2.5 GeV) and the AF-AR (6.5 GeV). Brilliance of the radiation vs. photon energy are denoted by red curves for the insertion devices, SGU#01, U#02, SGU#03, MPW#05, MPW#13, VW#14, U#16-1 & 16-2, SGU#17, Revolver#19 and EMPW#28, and 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. 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. 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.