1 Outline of the Accelerators

The Photon Factory manages two light sources: the 2.5 GeV PF ring and the 6.5 GeV PF-AR. Although the former belongs to the Photon Factory and is operated by the Light Source Division, the latter is operated by the Accelerator Laboratory of KEK because the AR was originally constructed as a booster synchrotron for the TRISTAN collider and parasitically used as an X-ray source. The KEK linear accelerator provides the electron beams for the both rings, with injection energies of 2.5 GeV for the PF ring and 3 GeV for the AR. In the AR, the ring energy is ramped from the injection energy of 3 GeV up to an operation energy of 6.5 GeV. The machine parameters of the two rings are listed in Table 1, and the spectral distributions of SR from the bending magnets and the insertion devices are shown in Fig. 1. The calculated spectral performances are listed in Table 2.

The PF ring was upgraded in FY2005 by extending the ten existing straight sections and creating four new straight sections. Following the upgrade, the ring worked well throughout the FY2006. From FY2006, we began to investigate the possibility of using a top-up injection scheme to maintain constant stored beam current. Top-up injection was tried experimentally several times during the year.

Although the PF ring was predominantly run in multibunch mode at 2.5 GeV, the ring was also run in single-bunch mode at 2.5 GeV and in 3-GeV multibunch mode occasionally. The PF-AR was mainly operated in single-bunch mode at 6.5 GeV. In FY2006, there were no special operations for medical applications at 5 GeV.

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 (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	55 mA (70 mA*)
Number of bunches	280	1
Beam lifetime	40 hr (at 450 mA)	15-20 hr (at 60 mA)

* Two bunch operation at 5 GeV for medical applications.

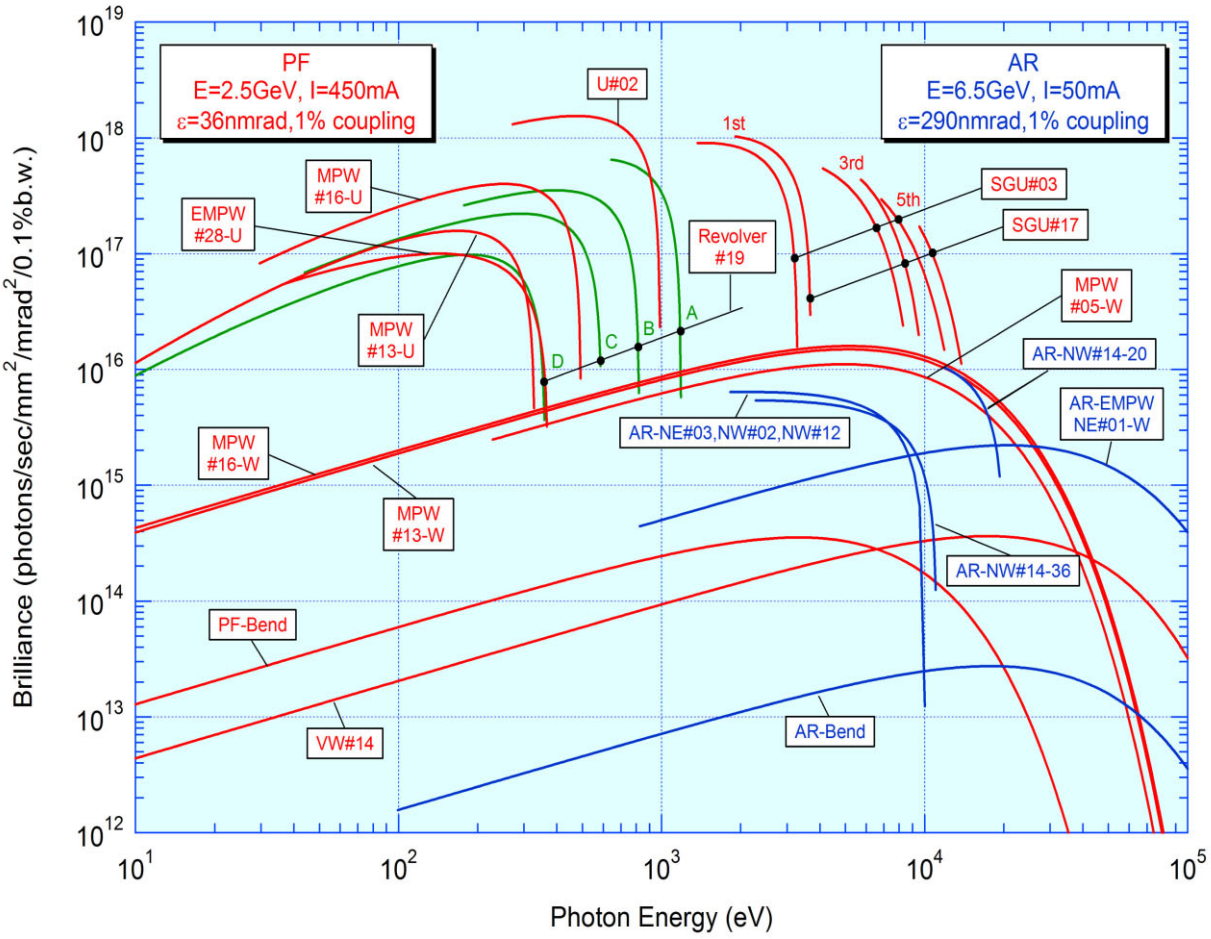

Figure 1
Synchrotron radiation spectra available at the PF Storage Ring (2.5 GeV) and the PF-AR (6.5 GeV). Brilliance of the radiation vs. photon energy are denoted by red curves for the insertion devices, U#02, SGU#03, MPW#05, MPW#13, VW#14, MPW#16, SGU#17, Revolver#19 and EMPW#28, and bending magnets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

Table 2 Insertion devices.

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	2.5/450															
Bend								0.41	0.059	0.178	0.012		4	5.38E+13	3.48E+14	
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	
MPW#16-W		12	26	3.12			H(NdFeB)	0.654	0.042	0.055	0.008	16.8	6.2	2.76E+15	1.58E+16	12.2
MPW#16-U												2		7.13E+16	4.00E+17	0.17
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

Calculated spectral performances of the bend source and all the insertion devices at the PF Storage 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.