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 for historical reasons since it was constructed as a booster synchrotron for the TRISTAN collider for particle physics and only parasitically used as an X-ray source. The two rings are provided with electrons by the KEK linear accelerator. The injection energy of 2.5 GeV of the PF ring is its operation energy, whereas it is necessary to ramp the energy of the PF-AR from its injection energy of 3 GeV to its operation energy of 6.5 GeV. The machine parameters of the two rings are tabulated in Table 1, and the spectral distributions of SR from the bending magnets and the insertion devices are shown in Fig. 1. Calculated spectral performances are listed in Table 2, and the annual operation schedule for FY2004 is shown in Fig. 2. Although the PF ring was predominantly run in multibunch mode at 2.5 GeV, it was run in single bunch mode at 2.5 GeV for 18 days and in 3 GeV multibunch mode for 12 days. On the other hand, the PF-AR was mostly operated in single bunch mode at 6.5 GeV. There was no special operation for medical applications at 5 GeV in FY2004.

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	36 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	0.0061	0.0129
Natural chromaticity		
Horizontal	–12.5	–14.3
Vertical	–12.3	–13.1
Stored current	450 mA	60 mA (70 mA*)
Number of bunches	280	1
Beam lifetime	60-80 hr (at 450 mA)	12 hr (at 60 mA)

* Two bunch operation at 5 GeV for medical applications

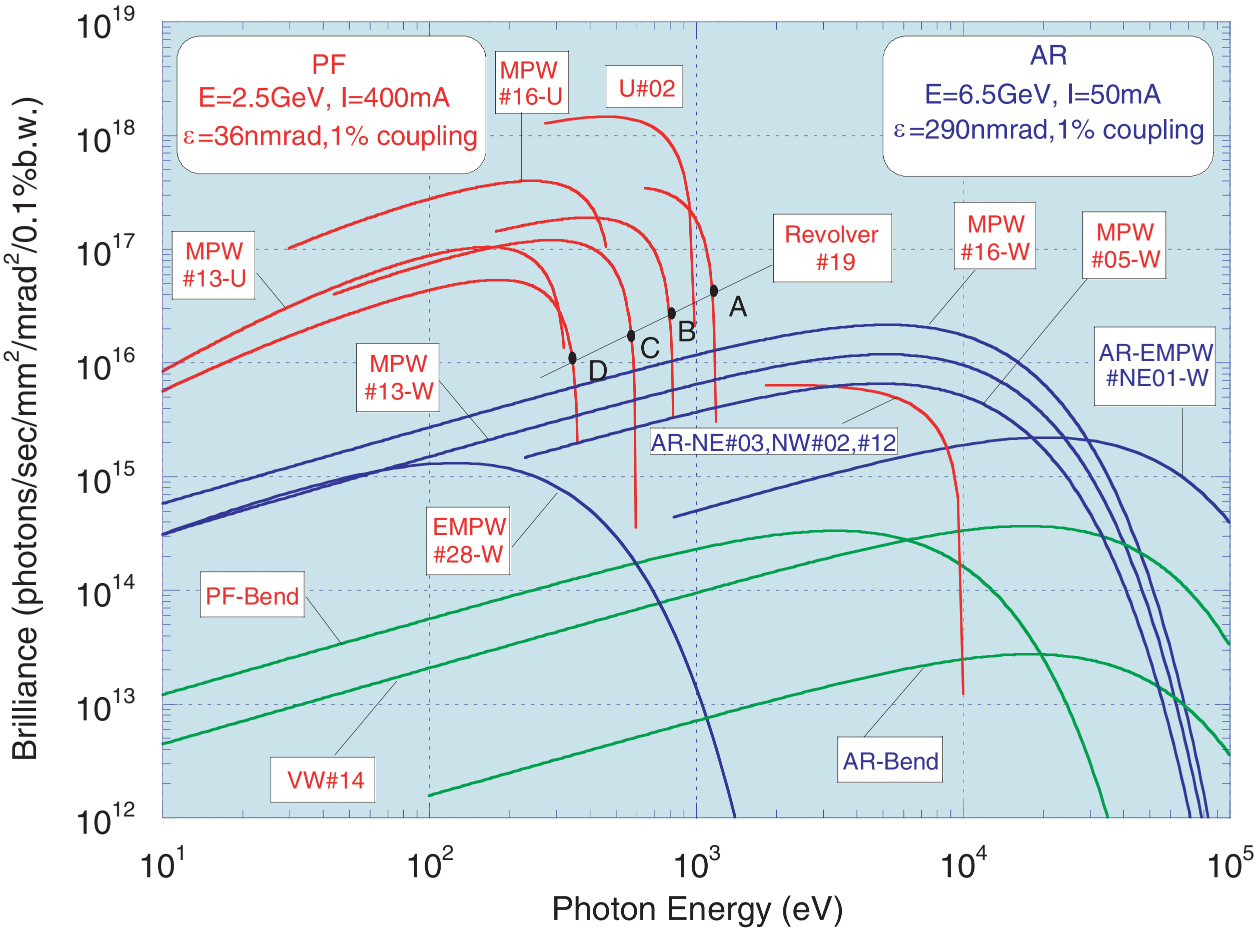

Figure 1
Synchrotron radiation spectra available at the PF Storage Ring (2.5 GeV) and the PF-AR (6.5 GeV). Brilliance of radiation vs. photon energy for the insertion devices (U#02, MPW#05, MPW#13, VW#14, MPW#16, Revolver#19 and EMPW#28) and the bending magnet (PF-Bend) of the PF Storage Ring, and for the insertion devices (EMPW#NE1, U#NE03, U#NW02 and U#NW12) and the bending magnet (AR-Bend) of 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 EMPW#28, MPW#05 and AR-EMPW#NE01 are 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. Spectra of Revolver#19 are shown for four kinds of period. Please note that not the first harmonic but the third or fifth harmonic is used for X-ray experiments at AR-NE3, AR-NW2 and AR-NW12 beamlines.

Table 2 Insertion devices.

Name	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	σ'_x mrad	σ'_y mrad	$K_y(K_x)$	$\varepsilon_1/\varepsilon_c$ keV	D	B	P_T kW	$dP/d\Omega$ kW/mrad^2
PF Storage Ring																
Bend					0.96		0.39	0.059	0.186	0.013		4	4.80×10^{13}	3.31×10^{14}		0.081
U#02	6	60	3.6	2.8	0.4	H(NdFeB)	0.42	0.042	0.084	0.008	2.3	0.27	1.48×10^{17}	1.28×10^{18}	0.95	3.93
U#05-W	12	21	2.5	2.64	1.4	H(NdFeB)	0.85	0.056	0.088	0.008	16	5.9	2.00×10^{15}	6.61×10^{15}	7.85	4.91
MPW#13-W	18	13	2.5	2.71	1.5	H(NdFeB)	0.86	0.019	0.117	0.018	25	6.2	1.29×10^{15}	1.18×10^{16}	8.64	3.38
MPW#13-U											2	0.108	1.08×10^{16}	9.25×10^{16}	0.055	0.25
VW#14				5	5	S.C.	0.58	0.036	0.083	0.01		20.8	4.84×10^{13}	3.67×10^{14}		0.42
MPW#16-W	12	26	3.12	1.9	1.5	H(NdFeB)	0.42	0.042	0.084	0.008	16.8	6.2	1.03×10^{15}	8.95×10^{15}	10.89	6.46
MPW#16-U											2	0.163	4.23×10^{16}	3.63×10^{17}	0.16	0.74
Revolver#19	5	46	2.3	3	0.28	H(NdFeB)	0.85	0.056	0.088	0.008	1.3	0.639	1.05×10^{17}	3.47×10^{17}	0.28	1.89
	7.2	32			0.4	H(NdFeB)					2.7	0.176	4.39×10^{16}	1.44×10^{17}	0.56	1.92
	10	23			0.54	H(NdFeB)					5	0.0437	1.28×10^{16}	4.01×10^{16}	1.02	2.02
	16.4	14			0.62	P(NdFeB)					9.5	0.0078	1.71×10^{15}	4.29×10^{15}	1.35	1.41
EMPW#28-W	16	12	1.92	3(11)	1(0.2)	P(NdFeB)	0.58	0.036	0.083	0.01	15(3)	4.1(90%)	3.07×10^{14}	2.28×10^{15}	2.84	0.46
EMPW#28-U											3(3)	0.182(99%)	1.81×10^{16}	1.33×10^{17}	0.03	0.087
PF-AR																
Bend					0.94		1	0.2	0.593	0.036		26	3.25×10^{13}	2.59×10^{13}		0.34
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%)	1.53×10^{15}	2.12×10^{15}	4.6	17.7
EMPW#NE1-U											3(3)	0.25(97%)	3.41×10^{15}	4.70×10^{15}	0.35	0.77
U#NE3	4	90	3.6	1	0.8	P(NdFeB)	1.57	0.17	0.312	0.029	3	1.8	1.01×10^{16}	6.09×10^{16}	3.09	25.7
U#NW2	4	90	3.6	1	0.8	P(NdFeB)	1.57	0.17	0.312	0.029	3	1.8	1.01×10^{16}	6.09×10^{16}	3.09	25.7
U#NW12	4	95	3.8	1	0.8	P(NdFeB)	1.57	0.17	0.312	0.029	3	1.8	1.07×10^{16}	6.38×10^{16}	3.26	27.2

Calculated spectral performances of the bend source and all the insertion devices at the PF Storage Ring (2.5 GeV, 400 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, $\varepsilon_1/\varepsilon_0$: photon energy of the first harmonic (critical energy in the case of bend source or wiggler), 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, $dP/d\Omega$: power in unit solid angle. Different operating modes of undulator and wiggler are denoted by -U and -W, respectively.

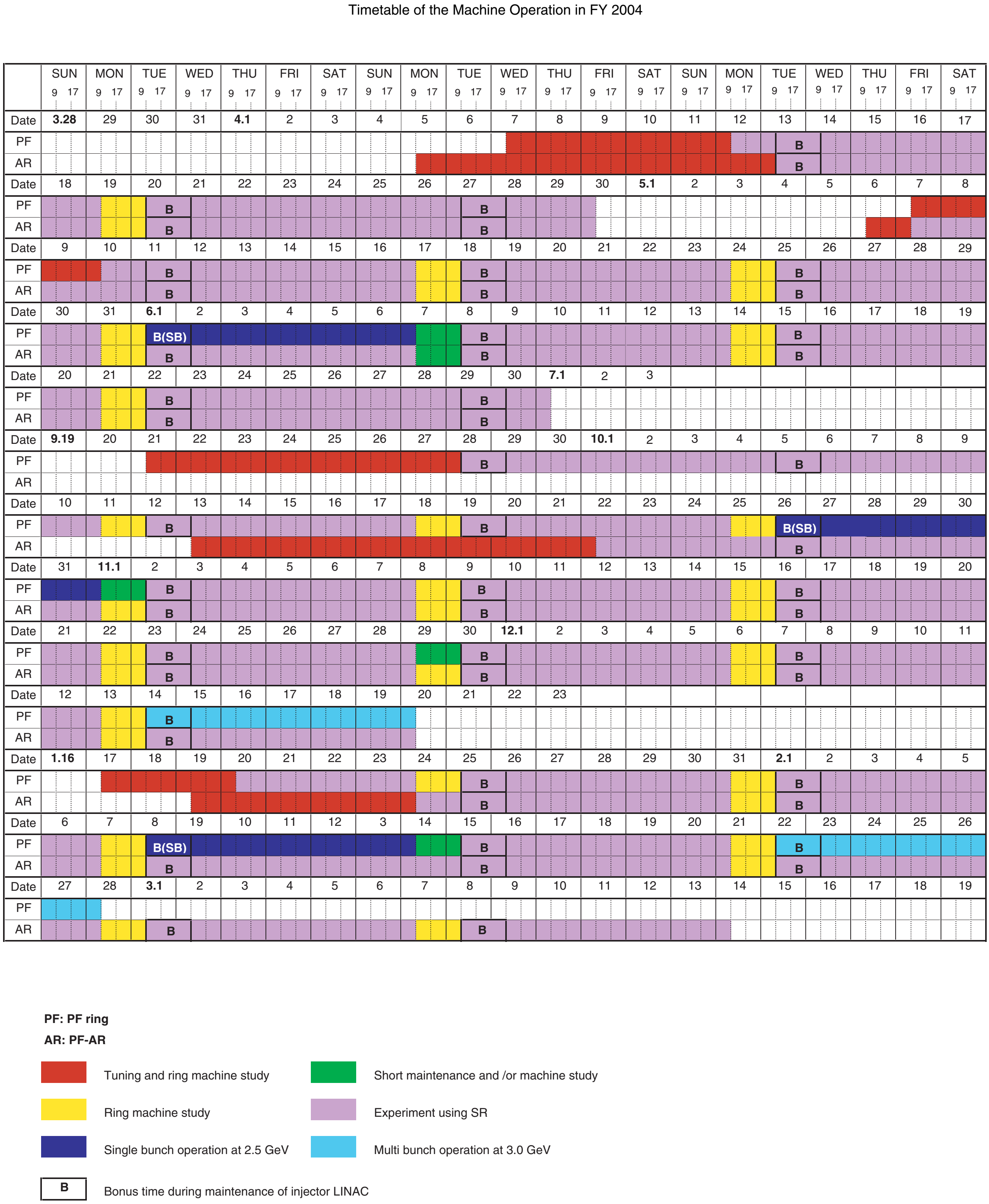

Figure 2
Timetable of machine operation in FY2004.