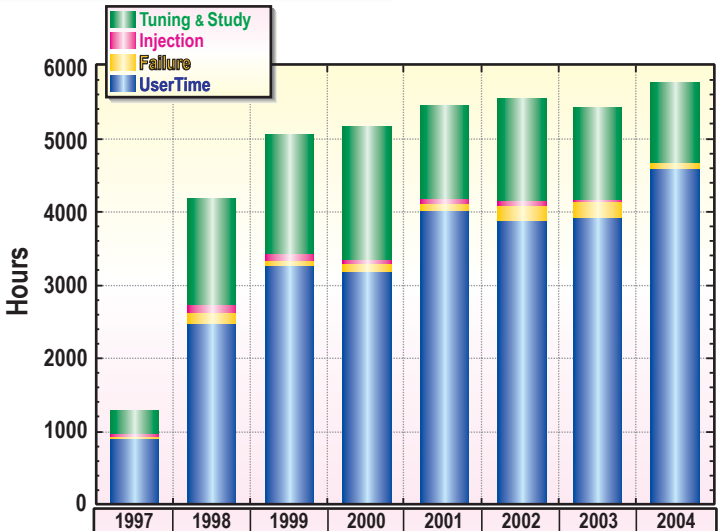
Machine Operation

The operation statistics since the facility was opened to users are shown in Fig. 1. Before summer the shutdown in 2004, the SPring-8 storage ring was operated on four- or five-week period for one operation cycle. After the summer shutdown, the long-term operation cycle was started. The total operation time of the accelerator complex was 5759.2 hours, of which 79.7% (4590.9 hours) was made available to the users. In 2004, there was no injection time because top-up injection was being introduced. The down time due to failure accounted for 1.4% (82.4 hours) of the operation time; in October 2004, a great loss of user time was incurred due to an approaching typhoon, consequently, user time of 28.6 hours was canceled for the suspension of machine operation. The remaining 18.9% (1085.9 hours) was dedicated to (i) machine and beamline study, (ii) machine and beamline tuning, and (iii) the commissioning of new photon beamlines. The high availability (ratio of the net user time to planning user time) of 98.% was achieved.

The operation modes of three different filling patterns were provided for the user time: 36.6% in the multi-bunch mode operation; 43.8% in the several-bunch mode such as the 203-bunch mode (203 equally spaced bunches) and 29 equally spaced 11-bunch trains; and the 19.6% in the hybrid filling mode such as a 1/12-partially filled multi-bunch with 10-isolated bunches. For the hybrid filling mode, 1 or 1.5 mA is stored in each isolated bunch. An isolated bunch purity of better than 10^{-9} is routinely maintained in the top-up operation.

Table I presents a summary of the useful beam parameters of the storage ring. The ring optics were returned to the former HHLV optics from October 2003. In September 2005, the low-emittance optics will be re-introduced to user time with a top-up operation by breaking the achromatic condition.



	1997	1998	1999	2000	2001	2002	2003	2004
Accelerator Operation Time	1286	4189.6	5051.6	5167.5	5456.1	5542.9	5419.5	5759.2
Storage Ring Operation Time	1270.6	4135.4	4863.9	4972.9	5340.6	5484.1	5328.5	5736.7
Tuning & Study (Accel. & BL)	304	1457.6	1624.2	1815	1276.5	1394.9	1245.8	1085.9
Injection	50	110	95.2	70.4	59.3	60.8	39.2	0
Failure	26	110	57.2	88.7	87.1	190.5	208.5	82.4
User Time	906	2512	3275	3193.4	4033.2	3896.7	3926	4590.9
Planning Time	984	2712	3432	3352	4176	4152	4176	4680
Availability (%)	97.2	96.7	98.2	97.4	98	95.3	95	98.1

Fig. 1. Operation statistics since the facility became available to users.

	HHLV Optics	Low Emittance Optics
Tunes (ν_x / ν_y)	40.15 / 18.35	40.15 / 18.35
Current[mA]: single bunch	13	10
multi bunch	100 (120 *1)	100
Bunch length (FWHM) [psec]	32	34
Horizontal emittance [nm·rad]	6.3 *2 / 6.6 *3	3.1 *2
Vertical emittance [pm·rad]	16.9 *3	8.7 *3 / 3.9 *4
Coupling [%]	0.26 *3	0.28 *3 / 0.13 *4
Beam size [μm]: (σ_x / σ_y) *5		
Long ID section	381 / 13.4	283 / 11.4
ID section	397 / 8.5	289 / 7.2
BM section	149 / 21.0	103 / 15.2
Beam Divergence [μrad]: ($\sigma_{x'}$ / $\sigma_{y'}$) *5		
Long ID section	16.1 / 1.2	11.9 / 0.81
ID section	15.9 / 1.9	11.7 / 1.3
BM section	57.4 / 0.78	53.8 / 0.68
Operational Chromaticities: (ξ_x / ξ_y)	+7 / +6 (+2 / +2) *6	+8 / +8
Lifetime [hr]: 100 mA (multi bunch)	~ 150	~ 97
1 mA (single bunch)	~ 24	~ 9
Dispersion distortion [mm]: horizontal (rms)	4	9.3
vertical (rms)	1.1 *7	1.1 *7
Orbit stability (tune harmonics) [μm]:		
horizontal (rms)	–	1.3
vertical (rms)	–	0.35

*1 Maximum stored beam current at machine study.
*2 Measured by a pulse bump and scraper, *3 two dimensional interferometer, and *4 two photon correlation.
*5 Assuming that 0.26% coupling for "HHLV" and 0.2% coupling for "Low Emittance Optics"
*6 With bunch-by-bunch feedback. *7 With correction by 24 skew Q's.

Table I. Beam parameters of SPring-8 storage ring