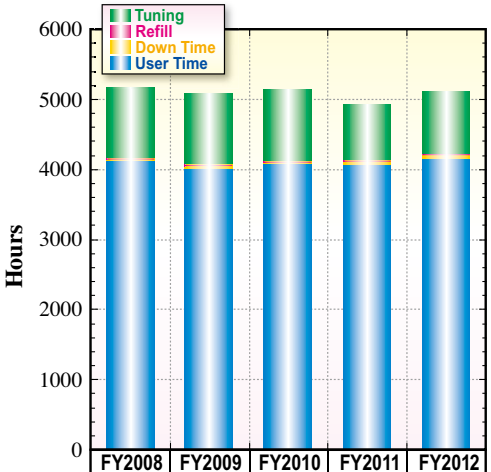
II. Machine Operation

The operation statistics for the last five fiscal years are shown in Fig. 1. In FY2012, the total operation time of the accelerator complex was 5078.8 h. The operation time of the storage ring was 5063.1 h, 82.1% of which (4155.6 h) was made available for SR experiments. The downtime resulting from failure accounted for 0.94% (39.2 h) of the total user time. In FY2012, no great loss of user time exceeding several hours occurred. Since FY2004, top-up injection was introduced. Concerning user service operation, a high availability (ratio of net user time to planned user time), e.g., 98.9%, was achieved in FY2012. The total tuning and study time of 884 h was used for machine tuning, for the study of the linac, booster synchrotron and storage ring, and also for the beamline tuning and study.

Operations in two different filling modes were provided for the following user time: 60.6% in the several-bunch mode, such as the mode of 29 equally spaced trains of 11 bunches, and 39.4% in the hybrid filling mode, such as the mode of 1/14-partially filled multi-bunch with 12-isolated bunches. In FY2012, there was no operation in the multi-bunch mode. The several-bunch mode was the dominant filling mode. The 203-bunch mode and the mode of 29 equally spaced trains of 11 bunches reached 29.8% and 30.9% of the total user time, respectively. The new hybrid filling mode of 11/29-partially filled multi-bunch with a 5.0 mA isolated bunch. For the hybrid filling mode, 1.0 mA, 1.6 mA, 3.0 mA, or 5.0 mA is stored in each isolated bunch. An isolated bunch impurity better than 10^{-10} is routinely maintained in the top-up operation. Table I shows a summary of the useful beam parameters of the storage ring. Table II shows a summary of the beam filling patterns.



	FY2008	FY2009	FY2010	FY2011	FY2012
Accelerator Operation Time	5150.1	5068.8	5125.6	4918.6	5078.8
Storage Ring Operation Time	5133.3	5035.4	5096.3	4904.2	5063.1
Tuning & Study (Acc. & BL)	1008.2	1019.1	1026.6	803	884
Refill	10.1	6.3	5.0	4.4	5.2
Down Time	31.0	34.8	27.5	57	39.2
Mean Time Between Failures	153.8	122.9	178.4	117.7	107.7
Achieved User Time	4110.9	4014.9	4071.6	4058.5	4155.6
Planning User Time	4152.0	4056.0	4104.0	4120.0	4200.0
Availability (%)	99.0	99.0	99.2	98.5	98.9

Fig. 1. Operation statistics for the last five fiscal years.

Table I. Beam parameters of SPring-8 storage ring

Energy [GeV]	8
Number of buckets	2436
Tunes (ν_x / ν_y)	40.14 / 19.35
Current [mA]:	
single-bunch	12
multi-bunch	100
Bunch length (σ) [psec]	13
Horizontal emittance [nm·rad]	3.5 *
Vertical emittance [pm·rad]	6.9 *
Coupling [%]	0.2
RF Voltage [MV]	16
Momentum acceptance [%]	±3 (±240 MeV)
Beam size (σ_x / σ_y)* [μm]	
Long ID section	297 / 10
ID section	303 / 6
BM1 section	108 / 13
BM2 section	115 / 14
Beam divergence (σ_x' / σ_y')* [μrad]	
Long ID section	13 / 0.7
ID section	12 / 1.1
BM1 section	57 / 0.6
BM2 section	74 / 0.6
Operational chromaticities (ξ_x / ξ_y)	+1 / +1**
Lifetime [h] :	
100 mA (multi-bunch)	~200
1 mA (single-bunch)	~20
Horizontal dispersion [m]:	
Long ID section	0.103
ID section	0.107
BM1 section	0.032
BM2 section	0.070
Fast orbit stability (0.1 – 200 Hz) [μm]:	
horizontal (rms)	~4
vertical (rms)	~1

* Assuming 0.2% coupling
** With bunch-by-bunch feedback

Table II. Filling patterns

	bunch current (mA)	life time (h)
203 bunches	0.5	25 ~ 30
11 bunch-train × 29	0.3	35 ~ 50
11/29 - filling + 1 single bunch	5.0 (single)	40 ~ 50
1/7 - filling + 5 single bunches	3.0 (single)	18 ~ 25
1/14 - filling + 12 single bunches	1.6 (single)	18 ~ 25
4/58 - filling + 53 single bunches	1.0 (single)	18 ~ 25