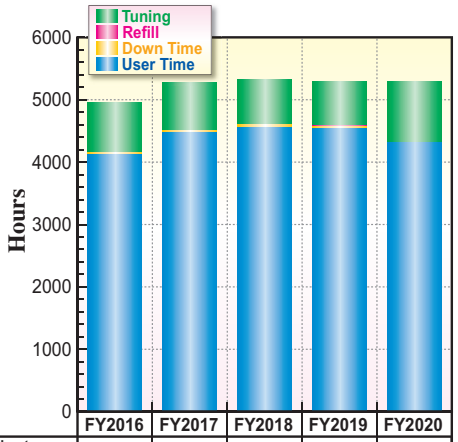
II. Machine Operation

In FY2020, the SPring-8 operation of beam injection from the SACLA linac to the storage ring was started. The total operation time of the entire SPring-8 accelerator complex was 5284.6 h. The operation time of the storage ring was 5274.8 h, 81.7% of which (4309.0 h) was devoted to SR experiments. Most of the user time was taken up by beam accumulation and topping-up by beam injection from the SACLA linac. There was no serious machine trouble in the storage ring that might have led to interruptions of user time for more than two hours. The total downtime caused by failures amounted to 7.4 h, which accounted for 0.17% of the total user time. The considerably shorter downtime than in previous years has led to an excellent storage ring availability of 99.7%. The availability this year was calculated by excluding, from the planned user time, a certain period when normal user operation was not available owing to the COVID-19 state of emergency. For 99.4% of the user time in FY2020, the stored beam current was maintained at 100 mA by the top-up operation wherein the stored beam was filled up on demand at any time. Extreme stability of better than 0.1% in the light source intensity was achieved by the top-up operation. The operation statistics of SPring-8 for the last five fiscal years are shown in Fig. 1.

The large variety of operation modes for the SR experiments is one of the characteristics of SPring-8. The operation modes are classified into two types: the several-bunch and hybrid-filling modes. The several-bunch mode consists of equally spaced bunches or trains of bunches, for example, 203 bunches or 29 trains of 11 bunches. The hybrid-filling mode is composed of a long train of bunches and isolated single bunches. The operation modes of SPring-8 are listed in Table 1 with the share of each operation mode in FY2020. In the operation with beam injection from the SACLA linac, the spurious bunch sweeping system in the SACLA linac and the bunch cleaning system in the storage ring are activated to maintain a sufficient isolated bunch purity. Table 2 shows the beam parameters of the storage ring.



	FY2016	FY2017	FY2018	FY2019	FY2020
Accelerator Operation Time	4951.7	5281.6	5329.8	5285.7	5284.6
Storage Ring Operation Time	4941.1	5270.4	5316.7	5271.2	5274.8
Tuning & Study (Acc. & BL)	803.1	769.6	721.8	701.7	964.6
Refill	3.4	4.6	5.3	5.6	3.6
Down Time	23.1	28.7	43.1	40.5	7.4
Mean Time Between Failures	229.2	194.7	168.9	206.3	718.2
Achieved User Time	4125.5	4478.7	4559.6	4537.9	4309.0
Planned User Time	4152.0	4512.0	4608.0	4584.0	4464.0
Availability (%)	99.4	99.3	98.9	99.0	99.7

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

Table 1. Operation modes in FY2020

	Single bunch current (mA)	Share of operation time (%)
203 bunches		32.6
4 bunch-train × 84		14.0
11 bunch-train × 29		14.6
1/7-filling + 5 single bunches	3	20.8
2/29-filling + 26 single bunches	1.4	5.1
1/14-filling + 12 single bunches	1.6	0
4/58-filling + 53 single bunches	1.0	0
11/29-filling + 1 single bunch	5	12.9

Table 2. Beam parameters of SPring-8 storage ring

Energy [GeV]	8
Number of buckets	2436
Tunes (ν_x / ν_y)	41.14 / 19.34
Current [mA]:	
single bunch	12
multi bunch	100
Bunch length (σ) [psec]	13
Horizontal emittance [nm·rad]	2.4*
Vertical emittance [pm·rad]	4.8*
Coupling [%]	0.2
RF Voltage [MV]	14.4** ~ 16
Momentum acceptance [%]	3.2 (~256 MeV)
Beam size (σ_x / σ_y)* [μm]	
Long ID section	333 / 7
ID section	316 / 5
BM1 section	94 / 12
BM2 section	100 / 12
Beam divergence (σ_x' / σ_y')* [μrad]	
Long ID section	8 / 0.7
ID section	9 / 1.0
BM1 section	58 / 0.5
BM2 section	68 / 0.5
Operational chromaticities (ξ_x / ξ_y)	+2 / +2***
Lifetime [hr]:	
100 mA (multi bunch)	~250
1 mA (single bunch)	~30
Horizontal dispersion [m]:	
Long ID section	0.153
ID section	0.146
BM1 section	0.039
BM2 section	0.059
Fast orbit stability (0.1 – 200 Hz) [μm]:	
horizontal (rms)	~4
vertical (rms)	~1

* Assuming 0.2% coupling
** Power saving mode
*** With bunch-by-bunch feedback