2 PF Ring

2-1 Operation Summary

A timetable of the PF ring and PF-AR operations in FY2013 is shown in Fig. 1. The operational statistics for the PF ring are summarized in Table 1. The statistics of the accelerator's operation for each fiscal year are shown in Fig. 2. In FY2013, the total operation time and actual user time were 4176.0 h and 3451.4 h, respectively. The actual user operation time was less than 4000 h because it was difficult to obtain the sufficient total operation time, owing to an increase in electrical charges, among other factors. The failure time for this year was 52.6 h, which is shown in Fig. 3 as a percentage of the total operation time.

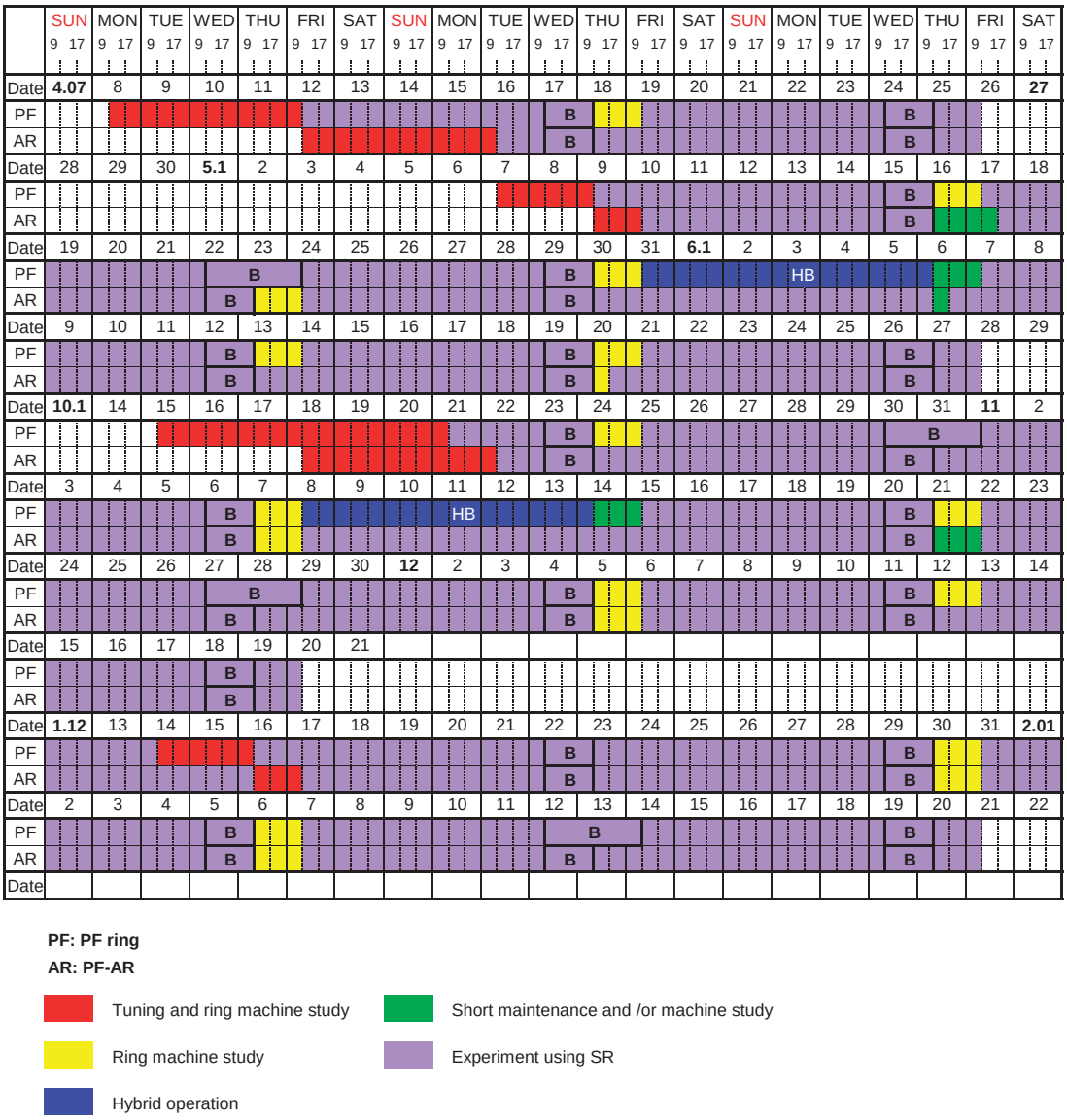

Figure 1: Timetable for the PF ring and PF-AR operation in FY2013.

Table 1: Operation statistics for PF ring in FY2013.

	Total
Ring operation time (h)	4176.0
Actual user time (h)	3451.4
Machine adjustment time (h)	672.0
Failure time (h)	52.6

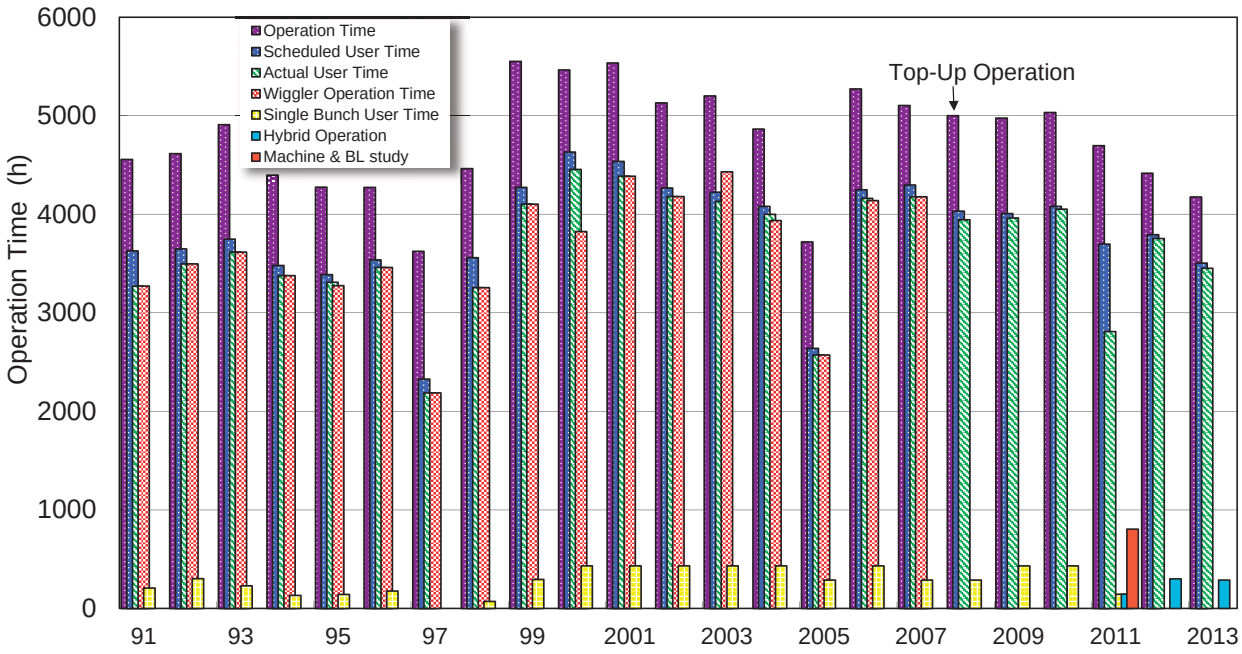

Figure 2: Total operation time, scheduled user time, actual user time, and single-bunch user time for the PF ring in each fiscal year since 1991.

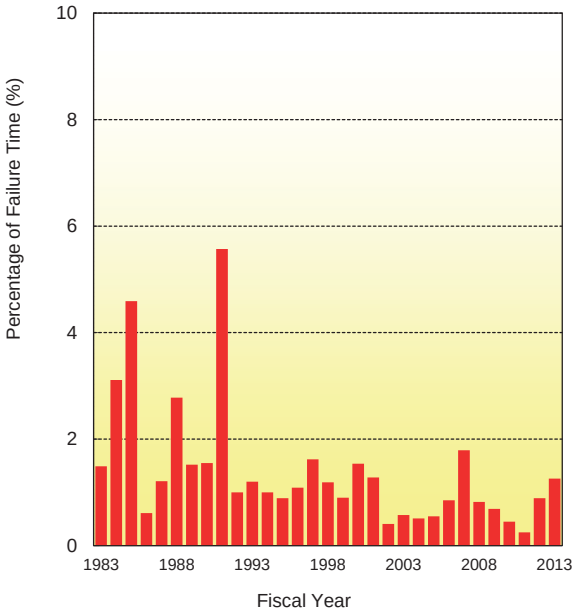

Figure 3: Percentage of failure time with respect to total operation time in the PF ring.

2-2 Project to Renew the Insertion Devices at the PF Ring

2-2-1. Installation of a new short gap undulator (SGU#15)

A new short gap undulator (SGU), SGU#15, was installed at the straight section of B14-15 during the summer shutdown of the PF ring. In the PF storage ring, there are four 1.4m-long straight sections for SGU in an in-vacuum configuration for the X-ray light source with energy of around 10 keV. We have constructed three SGUs with a period length of less than 20 mm step by step over the last eight years. SGU#15 is the fourth SGU with a period length of 17.6 mm as a light source for both small-angle X-ray scattering experiments and XAFS experiments. Table 2 compares the basic parameters of the SGUs.

We installed SGU#15 in the PF ring in August 2013 after commissioning of the vacuum system. Figure 4 shows a photograph of the baking of SGU#15 and Figure 5 shows a photograph of the installation of SGU#15. User operation of SGU#15 started steadily following the autumn operation of the PF ring. During the commissioning study, we confirmed the operation with the minimum gap of 4 mm and tuned the correction magnets at both ends of the SGU for the independent tuning operation of SGU#15.

Table 2: Basic parameters of SGUs in the PF ring.

Name	Period length (mm)	Number of periods	Maximum By (T)	Minimum gap (mm)	Target photon energy region (KeV)	Year of construction
SGU#17	16	29	0.92	4	6-13	2005
SGU#03	18	26	1.0	4	4-14	2006
SGU#01	12	39	0.7	4	4-13	2009
SGU#15	17.6	29	0.96	4	2-15	2013

Figure 4: SGU#15 during vacuum commissioning.

Figure 5: SGU#15 during installation.

2-2-2. Construction of the new undulator (U#02-2) for BL02

At the PF ring, a project to renew the insertion devices for BL02, BL13 and BL28 is under way. These three insertion devices are all elliptically polarizing undulators (EPUs) to obtain various polarization states. As the first step, we constructed U#02-2 for BL02 this year.

U#02-2 has a period length of 160 mm to obtain photons in the VUV energy region from 30 eV to 300 eV with the first harmonic radiation. The periodicity number of U#02-2 is 17 and the maximum K value is 5. U#02-2 has the same magnetic arrangement of the SPring-8 circular undulator as the EPU. U#02-2 has six variable rows of magnetic arrays to control the various polarization states of radiation. The two center arrays produce a vertical magnetic field and the four side arrays produce a horizontal field. The polarization states are selected by controlling the longitudinal positions of these rows individually. The available polarization modes of U#02-2 are linear polarization in the horizontal and vertical directions, circular polarization (Bx/By = 1) and elliptical polarization (Bx/By = 1/2).

The magnetic adjustment of U#02-2 was finished as scheduled. First, we adjusted the vertical magnetic field produced by the center arrays in December 2013. After magnetic measurements of the vertical magnetic field, we assembled and adjusted the four side magnet arrays for the horizontal magnetic field in February 2014. Figure 6 shows a photograph of U#02-2 during the magnetic adjustment.

We installed U#02-2 at the straight section of B01-B02 of the PF ring in March 2014. We moved the existing undulator (U#02-1) to the downstream of the straight section, and installed U#02-2 in tandem at the upstream of U#02-1. Figure 7 shows a photograph of U#02-1 and U#02-2 during installation in the PF ring. The right-side undulator is the new U#02-2. We use U#02-1 and U#02-2 exclusively to obtain photons over a wide energy region at the single beamline. U#02-2 became operational for user experiments after commissioning in the PF ring. User operation of U#02-2 started in linear polarization mode along the horizontal and vertical directions in May 2014. The other operation modes will soon become available in turn.

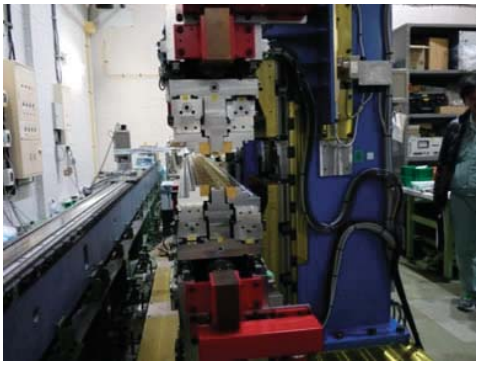

Figure 6: U#02-2 during the magnetic adjustment.

Figure 7: U#02-1 and U#02-2 during installation.