2 PF Ring

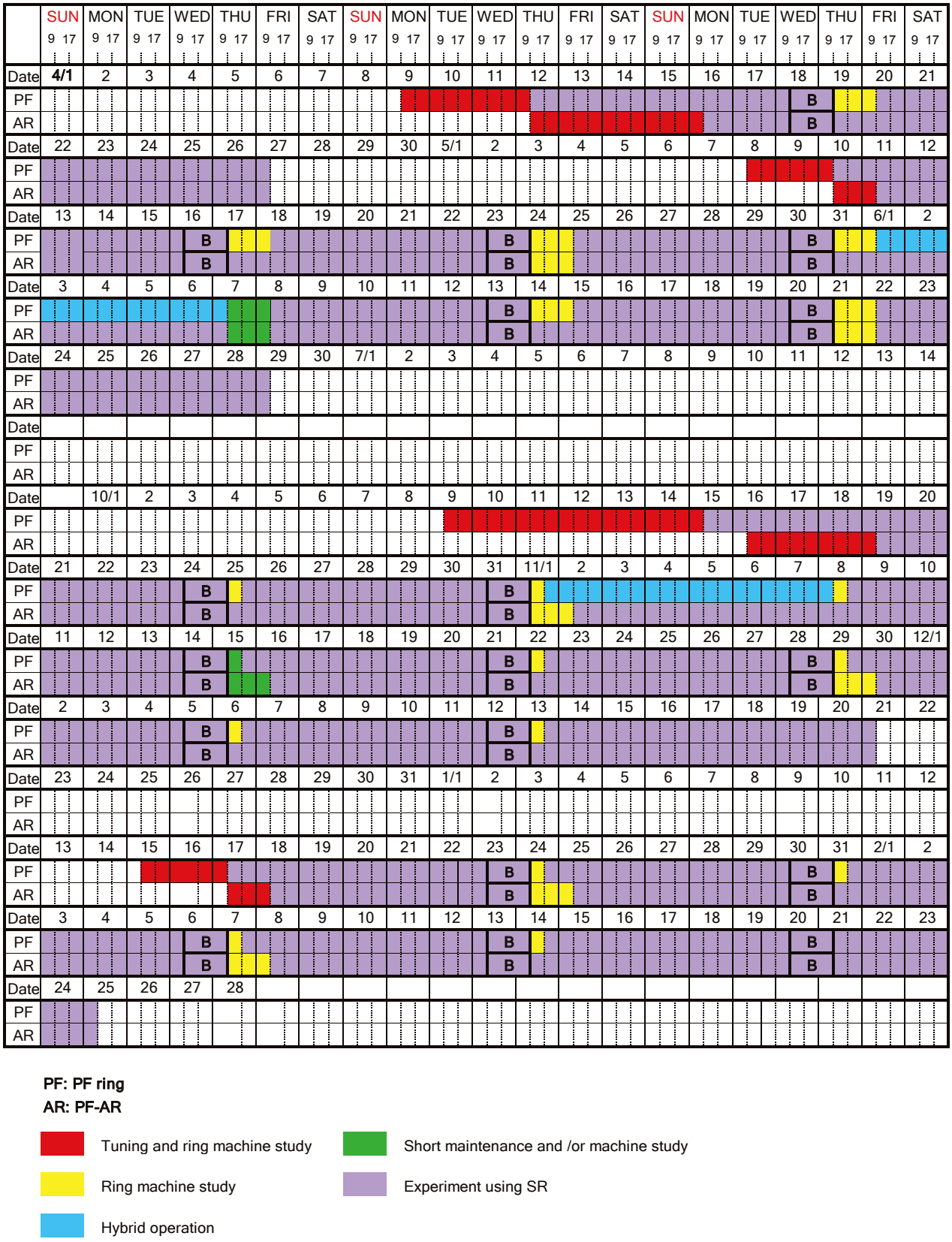
2-1 Operation Summary

In FY2012, PF ring and PF-AR operated stably following several problems caused by the aftereffects of the Tohoku Earthquake. The timetable of operations at the PF ring and PF-AR in FY2012 is shown in Fig. 1.

The operational statistics for the PF ring are summarized in Table 1. The statistics for each fiscal year since the commencement of operation of the accelerator are shown in Fig. 2. In FY2012, the total operation time and actual user time were 4416.0 hrs and 3752.9 hrs, respectively. The actual user operation time was less than 4000 hrs because it was difficult to preserve the total operation time due to an increase in electricity rates, among other factors. The failure time for this year was 39.1 hrs, which is shown as a percentage of the total operation time in Fig. 3. This failure time includes that caused by the aftereffects of the earthquake, such as problems with the rf high-voltage power supplies and the leakage of cooling water from circulators, as shown in Fig. 4. Both of these problems were resolved during the summer shutdown. In the PF ring, a top-up operation mode with an injection scheme that uses a single pulsed sextupole magnet was established. The beam current was usually maintained at 450.0 ± 0.1 mA, which corresponds to a current accuracy of $\pm 1 \times 10^{-4}$ at an injection repetition frequency of 1.0 Hz. User operation of the hybrid mode was also established using a single-bunch current of 50 mA and a multi-bunch current of 350 mA. In addition, the variably polarized undulator demonstrated smooth operation at a switching frequency of 10 Hz.

Table 1: Operation statistics for PF ring in FY2012.

	Total
Ring operation time (hrs)	4416.0
Actual user time (hrs)	3752.9
Machine adjustment time (hrs)	624.0
Failure time (hrs)	39.1



PF: PF ring
AR: PF-AR

Tuning and ring machine study
Short maintenance and /or machine study
Ring machine study
Experiment using SR
Hybrid operation

Figure 1: Timetable of PF ring and PF-AR operation in FY2012.

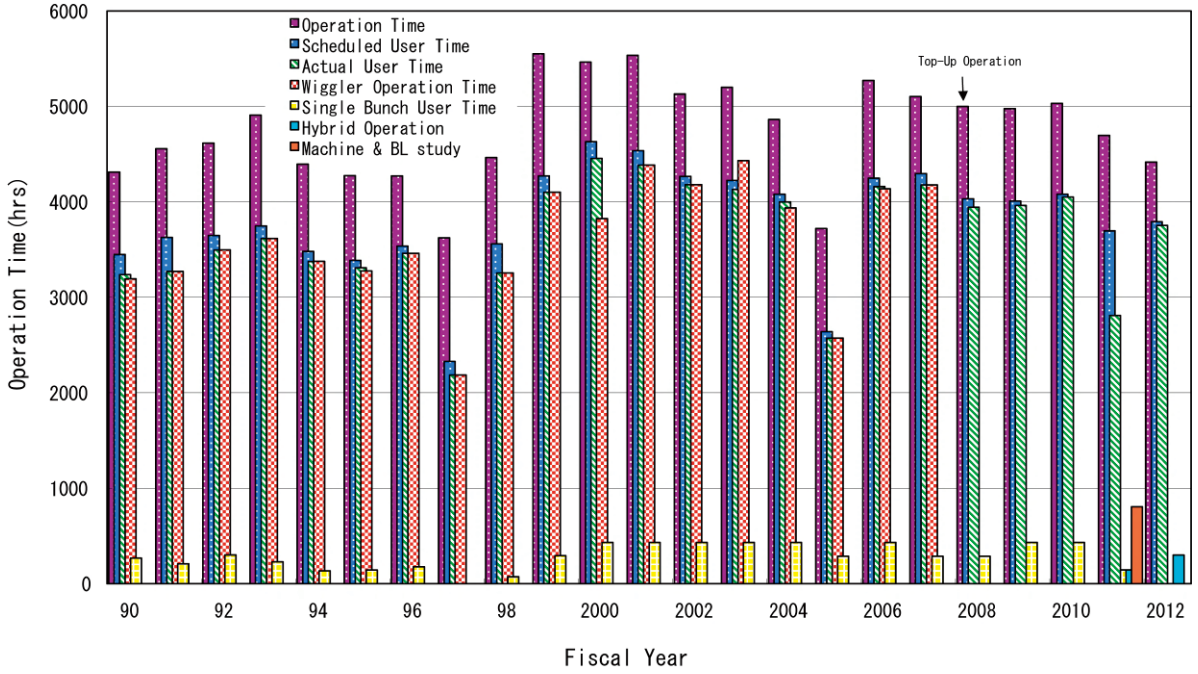


Figure 2: Total operation time, scheduled user time, actual user time, and single-bunch user time for PF ring in each fiscal year since the commencement of accelerator operation.

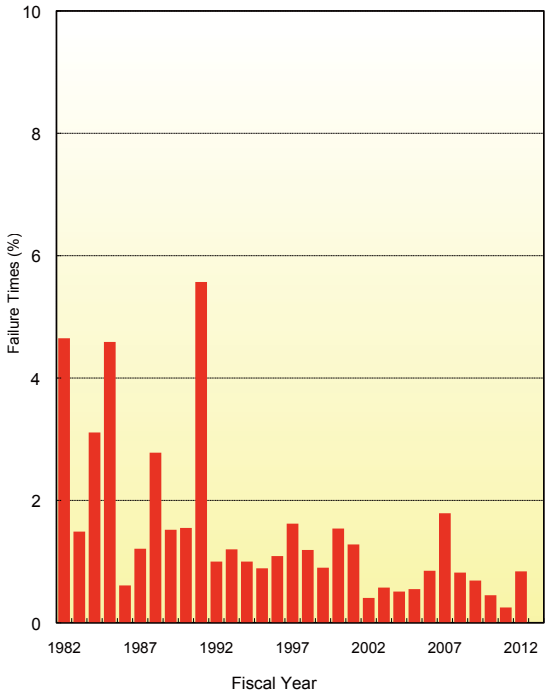


Figure 3: Failure rate for PF ring (percentage of failure time with respect to total operation time).

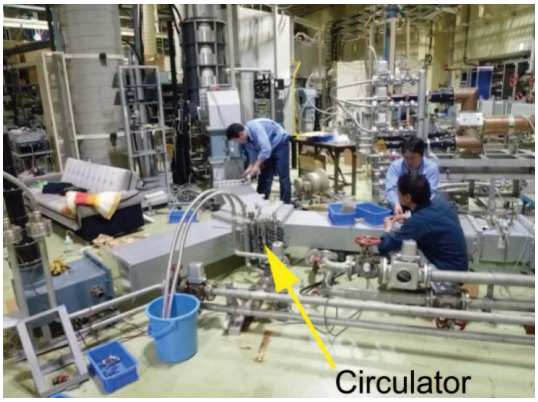


Figure 4: Photograph showing the replacement of the circulator that experienced leakage of cooling water.

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

2-2-1. Construction of a New Short Gap Undulator (SGU#15)

A new short gap undulator (SGU), named SGU#15, is being constructed at the PF ring. This is the fourth SGU and will be installed in the last remaining 1.4 m straight section of the PF ring. SGU#15 is designed as a light source for both small-angle X-ray experiments and XAFS experiments. It has a period length of 17.6 mm and the number of periods is 27. The photon energy region of SGU#15 ranges from 2 keV to 15 keV using the higher harmonics of undulator radiation. One requirement for the magnetic field is that the phase error should be less than 2 degrees in order to use the 9th higher harmonics effectively. To satisfy this requirement, the magnetic field of SGU#15 was carefully adjusted in the autumn of 2012. Figure 5 shows a photograph of SGU#15 during the magnetic measurements, and Fig. 6 summarizes the results of the magnetic field adjustment. The latter figure shows the electron orbits at several typical gaps, which were calculated based on measured magnetic data. The standard deviation of the phase errors was 1.8 degrees at the minimum gap of 4 mm.

We will install SGU#15 in the PF ring in the summer of 2013 after vacuum commissioning, and it will enter operation for user experiments during the autumn operation of the PF ring.

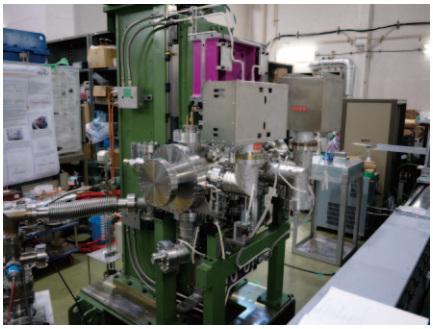


Figure5: SGU#15 during the magnetic measurements.

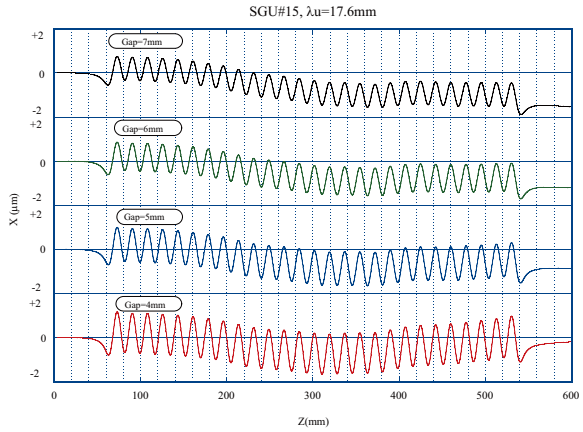


Figure 6: Calculated electron orbits for several typical gaps.

2-2-2. Project to Renew the Undulators for the VUV-SX Beamlines

At the PF ring, we are constructing three new undulators for BL02, BL13 and BL28, which will be called U#02-2, U#13 and U#28, respectively. All these undulators are designed as elliptically polarizing undulators (EPUs) to obtain various polarization states, not only circular (left-handed and right-handed) polarization but also linear (horizontal and vertical) polarization.

The detailed parameters and magnetic configurations of these undulators were determined by the summer of 2012. The mechanical design and construction of the undulators are now progressing steadily. Table 2 summarizes the basic parameters of the new undulators.

For BL02, we plan to move the existing undulator (U#02) to the downstream of the B01-B02 straight section, and install a new undulator (U#02-2) tandem at the upstream of U#02. Figure 7 shows a schematic view of the B01-02 straight section before and after the reconstruction.

We will use U#02 and U#02-2 exclusively to obtain photons over a wide energy region at the single beamline. The photon energy region of U#02 ranges from 400 eV to 2 keV and the target energy region of U#02-2 is from 15 eV to 300 eV with the first harmonic radiation of EPU. The period lengths of U#02 and U#02-2 are 60 mm and 160 mm, respectively.

We renewed the present undulators for BL13 and BL28 to utilize the extended straight section as much as possible. U#13 has a period length of 76 mm and its target photon energy region is from 50 eV to 1.5 keV under various polarization states. U#28 has the same parameters as U#02-2 except the total length.

The magnetic adjustment of U#02-2 is scheduled to be conducted in the winter of 2013 and we will install U#02-2 in the PF ring in March 2014. For U#13 and U#28, we will adjust the magnetic fields continuously in the spring of 2014. The installation of U#13 and U#28 in the PF ring will be carried out at the same time during the summer shutdown of the ring in 2014.

Table 2: Basic parameters of the new undulators in the PF ring.

Name	Period length (mm)	Number of periods	Length (m)	Maximum Bx, By (T)	Target photon energy region (eV)	Type of undulator
U#02-2	160	17	2.72	0.33, 0.33	30-300	EPU
U#13	76	48	3.65	0.68, 0.34	50-1500	EPU
U#28	160	22	3.52	0.33, 0.33	30-300	EPU

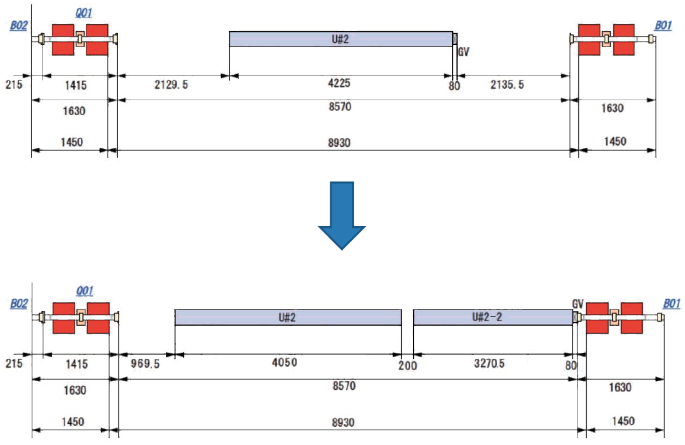


Figure 7: Schematic view of the B01-02 straight section before and after the reconstruction.