3 Accelerator Updates

3-1 Upgrade of Insertion Devices

In the PF ring, two variable polarized undulators (U#13, U#28) were installed in February 2015, and were commissioned in April 2015.

U#13 provides soft X-rays from 50 to 2000 eV for surface chemistry users. Above 270 eV, U#13 can operate in horizontal, vertical, and elliptical polarization modes. The specifications of U#13 are listed in Table 1 and its calculated spectral brilliance is shown in Fig. 1. A photograph of U#13 in the PF ring is shown in Fig. 2.

U#28 is devoted to users of high-resolution angle-resolved photoelectron spectroscopy. The photon energy from 30 to 300 eV is covered by the first harmonics of the undulator radiation. U#28 can operate in both horizontal and vertical polarization modes. The specifications of U#28 are listed in Table 2 and its calculated spectral brilliance is shown in Fig. 3. A photograph of U#28 in the PF ring is shown in Fig. 4.

Table 1: Specifications of undulator U#13.

Period length (mm)	76.0
Number of periods	47
Total length (mm)	3572
Minimum Gap (mm)	23.0
Maximum Ky (Kx) value	5.28 (3.65)
Maximum field By (Bx) (T)	0.74 (0.51)

Table 2 : Specifications of undulator U#28.

Period length (mm)	160
Number of periods	22
Total length (mm)	3520
Minimum Gap (mm)	27
Maximum Ky (Kx) value	4.93(4.93)
Maximum field By (Bx) (T)	0.33(0.33)

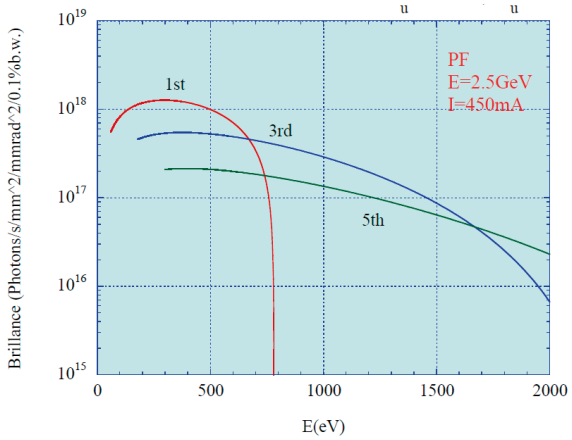

Figure 1: Spectral curves in an elliptical polarization mode of Bx/By=1/2.

Figure 2: U#13 in the PF ring.

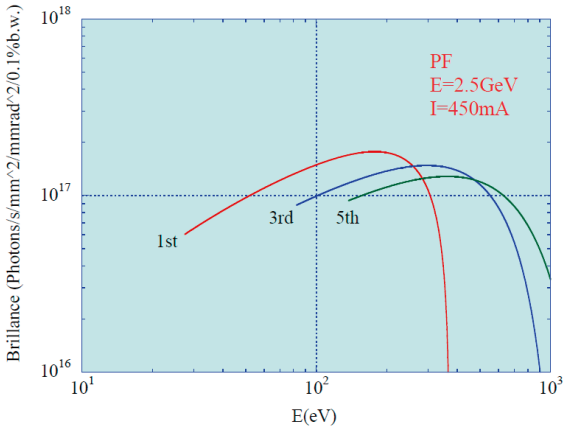

Figure 3: Spectral curves in both a horizontal and a vertical polarization mode.

Figure 4: U#28 in the PF ring.

3-2 Upgrade of Beam Position Monitor Circuit of PF-AR

The existing beam position monitor (BPM) circuits have been in use for more than thirty years since the construction of the PF-AR. Four detection circuits were placed at four different locations in the north, south, east, and west areas. Signals from four pick-up electrodes of the BPM were collected by switching coaxial relays connected to the electrodes. Thus, it took 10–20 s for a one-orbit measurement by the BPM system, making it impractical to apply the BPM system to various beam orbit adjustments. Moreover, in the BPM system, it was impossible to make an orbit correction during the acceleration period from 3 GeV to 6.5 GeV.

In FY2013, the BPM circuit was upgraded and a one-to-one connection between the signal circuit and one of the four electrodes of the BPM was adopted. All the new circuits were installed by August 2014 and operations commenced in October 2014. A component of the new BPM circuit is shown in Fig. 5. Figure 6 shows an example of measurement of the dispersion function; the horizontal axis corresponds to the location of the BPM, and beam position signals, which are proportional to the energy deviation, from all the 83 BPM units are displayed.

The one-orbit measurement time of 100 ms by the new BPM system is a significant improvement over that of the old system, which had a measurement time of 10–20 s. In other words, the new system is more than 100 times faster than the old one, enabling orbit correction to be made during the acceleration period. At present, the new system works efficiently during user operation, so synchrotron users benefit by obtaining a stable light source position.

Figure 5: A part of the new beam position circuits installed into the standard rack.

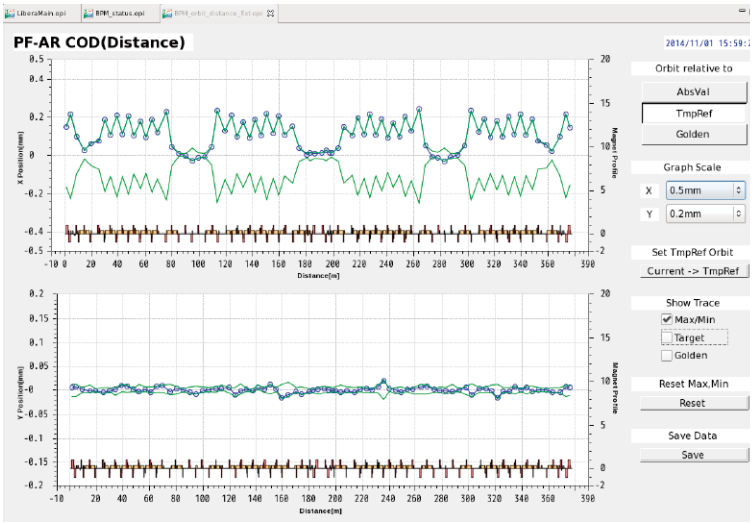

Figure 6: The graphical user interface (GUI) of the new BPM system. The horizontal axis indicates the location of the BPM along the entire ring circumference and the vertical axis indicates the measured beam position. The upper and lower graphs express the horizontal and vertical beam positions, respectively. The blue line with circles denotes the latest beam position, updated every 0.1 s, while the green line denotes the minimum and maximum orbit deviations during the measurement. The GUI can switch an absolute measurement mode into a relative one for a reference orbit. The figure shows an example of orbit measurement; the relative beam position just before and after the RF frequency change represents the dispersion function of the ring.