3 PF-AR

3-1 Operation Summary

The user operation scheduled in May, June and July was canceled for the restoration work after the Great East Japan Earthquake. Operation of the trial beam started on June 1 and continued to July 7, and regular user operation was resumed in October. As a result of this schedule change, the total operation time in FY2011 fell to about 4000 h as shown in Fig.1, and the scheduled user time decreased to some 30 % lower than the previous year as shown in Table 1.

At the storage ring of the PF-AR, fortunately the beam ducts kept the vacuum during the two-week blackout after the earthquake, but in the summer maintenance of 2011, a vacuum break occurred at an all-metal gate valve. This was probably caused by accumulated damage from the frequent large aftershocks.

Figure 2 shows the results of the magnet level survey in April and July after the earthquake. The displacements from the survey data of 2009 are plotted and the displacement in one year from 2008 to 2009 is also shown for reference. The April survey shows multiple peaks of over 0.5 mm, most of which appeared near the expansion joints of the ring tunnel indicated by the red lines in Fig. 2, and yet these peaks had almost disappeared by the July survey. Many cracks were found at the expansion joints in the ring tunnel; inflow of groundwater from some of these cracks increased temporarily just after the earthquake, then gradually decreased to a normal level in a few months.

The operation statistics for the PF-AR during the last seven years are summarized in Table 1. The mean time between failures (MTBF) was estimated for the regular user time, and the sources of failures are classified in Table 2. The MTBF of FY2011 was similar to that of the previous year. As usual, the most frequent failure was a sudden drop of beam lifetime attributed to trapped dust. In addition, the tendency of frequent troubles with the magnet power supply continued. Beam dumps or interruptions of user operation caused by large aftershocks were recorded five times.

The obsolete magnet power supplies are being updated step by step. The power supplies for the sextupole magnets were manufactured in FY2011 and will be installed during the summer maintenance of 2012.

A new plan to build a direct beam transport (BT) tunnel from the injector linac to the PF-AR has been approved. Two new injection plans are being considered: (1) to inject 4-GeV positron beams provided for the Super KEKB LER, and (2) to inject full-energy 6.5-GeV electron beams using the new direct BT lines. It is essential to achieve simultaneous injection of the PF-AR with the other three storage rings no later than the start of the physics run of the Super KEKB in 2015.

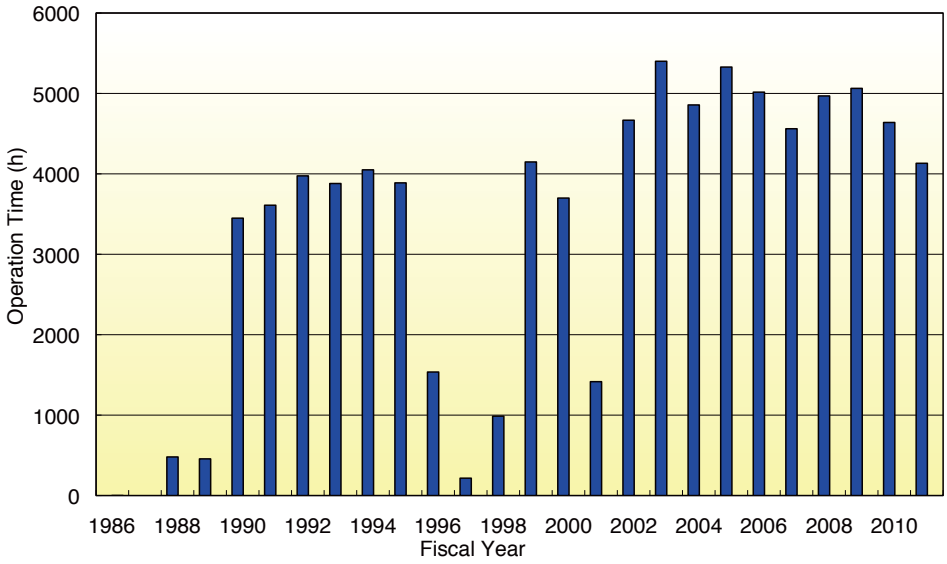

Figure 1
Operation time as a function of fiscal year.

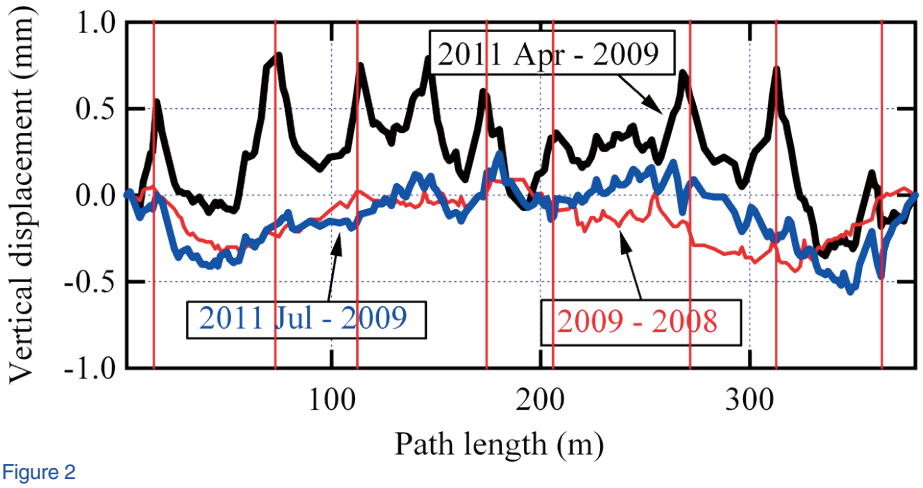

Figure 2
Vertical displacement of PF-AR magnet just after the earthquake.

Table 1
Mean time between failures (MTBF) of PF-AR from FY2005 to FY2011.

Fiscal year	2005	2006	2007	2008	2009	2010	2011
Total operation time (h)	5313	5016	4561	4969	5063	4608	4080
Scheduled user time (h)	4456	4032	3624	4344	4392	4032	2904
No. of failures	79	51	60	40	41	74	49
Total down time (h)	69.3	55.1	45.2	41.7	91.0	73.7	38.7
MTBF (h)	56.4	79.1	60.4	108.6	107.1	54.5	59.3
Mean down time (h)	0.9	1.1	0.8	1.0	2.2	1.0	0.8

Table 2
Classification of failures based on the source of trouble.

Fiscal year	2005	2006	2007	2008	2009	2010	2011
RF	12	10	1	4	8	10	5
Magnet	4	1	1	2	2	10	8
Injection	4	3	8	9	1	6	4
Vacuum	2	6	2	0	2	1	0
Dust trap	37	24	39	15	16	24	20
Insertion devices	0	1	0	0	0	0	0
Control / Monitor	4	0	1	1	1	2	1
Cooling water	5	1	0	3	4	4	1
Safety / Beamline	9	4	5	5	7	17	3
Earthquake	2	0	1	0	0	0	5
Electricity	0	1	2	1	0	0	2
Total	79	51	60	40	41	74	49

3-2 Update of SX Magnet Power System

About 30 years ago, the AR was constructed as an MR injector in the TRISTAN project. The AR had 40 sextupole magnets, which were divided into 4 families, namely SXF1, SXF2, SXD1 and SXD2. The magnet strings were powered by 4 magnet power supplies. The current in the cable flowed clockwise in the tunnel and returned to the source. This arrangement of the cabling naturally formed a one-turn coil loop.

After the TRISTAN project, the AR was converted to a dedicated light source which was named PF-AR. The lattice has 38 sextupole magnets.

In February 2011, a surprising trouble occurred: the current of each power supply jumped simultaneously. For a while, the situation continued and then returned to the normal current. This abnormal situation sometimes occurred. An investigation revealed that the output current was affected by an external noise of 7 MHz. The noise was due to self-oscillation in a high- frequency power amplifier in the beam feedback system. The noise was transmitted through the one-turn loop of SX cabling.

We decided to update the SX power system. Since the dedicated light source operation, the beam optics have been fixed. The currents of SXF1 and that of SXF2 are the same. Also, the currents of SXD1 and SXD2 are the same. Therefore, the SXF1 (SXD1) loop and SXF2 (SXD2) loop can be combined and fed from one power supply. The current circulates in two opposite loops in order to minimize the external field disturbance.

Two power supplies were fabricated in FY2011, and the current stability and the robustness against noise are improved. The new 2 power supplies and the old 4 power supplies are scheduled to be exchanged during the shutdown in the summer of 2012 (Fig. 3).

Figure 3
SXF and SXD power supplies in the factory.