PRESENT STATUS OF PF-RING AND PF-AR IN KEK

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Abstract

The present statuses of the Photon Factory storage ring (PF-ring) and the Photon Factory advanced ring (PF-AR) in KEK are reported. The operation times of the PF-ring and the PF-AR were more than 5100 and 4500 hours in FY2007, respectively. During this spring shutdown, one circular/linear polarized undulator with a fast switching orbit bump system was installed at a long straight section of 8.9 m in the PF-ring. The undularor has been stably operated and the orbit switching up to a frequency of 10 Hz using the bump system has been examined. The pulsed bending magnet as the first bend in the PF-BT (beam transport) line was installed in January 2008 and a top-up operation for the single-bunch mode was demonstrated for six days.

INTRODUCTION

In KEK, two synchrotron light sources have been operated since early 1980s. One is the Photon Factory storage ring (PF-ring) and the other is the Photon Factory advanced ring (PF-AR). The PF-ring is usually operated at 2.5 GeV and sometimes ramped up to 3.0 GeV to provide photons with the energy from VUV to hard X-ray region. The PF-AR is mostly operated in a single-bunch mode of 6.5 GeV to provide pulsed hard X-rays [1]. Main parameters of the PF-ring and the PF-AR are listed in Table 1. During this spring shutdown, one circular/linear polarized undulator with a fast orbit switching system was installed in a long straight section of 8.9 m [2]. It allows us to produce a fast switching circular/linear polarized photon beam for the useres. The preperation for a top-up operation is in progress in the PF-ring. The pulsed bending magnet to realize the fast switching between KEKB and PF-ring injections was installed in the 3rd switch yard of the linac tunnel during the winter shutdown. In the PF-AR, The movable masks for protecting the rf cavities from the strong synchrotron radiation were installed during last summer shutdown. In this conference, we present operational statuses of the PF-ring and the PF-AR, including other machine developments.

PF-RING

Operation

In the last fiscal year, since the beam lifetime was over 50 hours at an initial current of 450 mA in the multi-bunch mode, once-a-day injection was maintained during the user operation. In the single-bunch operation, a top-up operation with a continuous injection was carried out for six days in February 2008. The beam current was preserved to be 51.0 mA with an accuracy of 0.1 mA.

Table 1: Main Parameters of the PF-ring and the PF-AR.

Parameters	PF-ring	PF-AR
Beam energy	2.5/3.0 GeV	6.5 GeV
Circumference	187 m	377 m
Natural emittance	35/50 nm·rad	293 nm·rad
RF Frequency	500.1 MHz	508.6 MHz
Injection Energy	2.5 GeV	3.0 GeV
Typical num. of bunches	280/280/1	1
Initial Stored Current	450/200/50 mA	60 mA
Beam lifetime (at init.cur.)	50/75/1.3 hours	20 hours
Num. of insertion devices	9	6

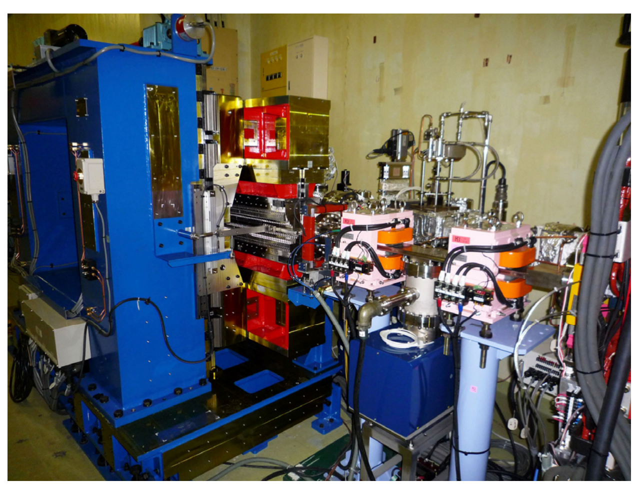

Figure 1: Photograph of the circular/linear polarized undulator with a fast switching orbit bump system.

Insertion Devices

Nine insertion devices are quite stable, including new circular/linear polarized undulator (U#16-1), which was installed during this spring shutdown. The principal parameters are listed in Table 2.

Table 2: Parameters of the insertion devices at the PF-ring are listed. The U, MPW, SCW, CLPU and EMPW denote a planar undulator, a multi-pole wiggler, a super-conducting wiggler, a circular/linear polarized undulator and an elliptical multi-pole wiggler, respectively. The revolver has magnetic configurations of four different periods. The λu, N, L, and G indicate a period length, a number of period, a total length of insertion devices and a minimum gap.

Name	λu (mm)	N	L (m)	Gy/Gx (mm)
U#02	60	60	3.60	28.0
U#03	18	26	0.50	4.0
MPW#05	120	21	2.52	26.4
U(MPW)#13	180	13	2.34	27.1
VW(SCW)#14			1.20	50.0
U(CLPU)#16-1	56	44	2.56	21.0
U#17	16	29	0.50	4.0
U#19 (Revolver)	50,72, 100,164	46,32, 23,14	2.30	30.0
U(EMPW)#28	160	12	1.92	30.0/110.0

Top-Up Operation

We progress the preparation for a top-up operation with a continuous injection in multi-bunch mode from next autumn 2009. The pulsed bending magnet, which is the most upper bending magnet along the PF-BT, was installed during the winter shutdown in the 3rd switch yard of the linac tunnel to realize the pulse-by-pulse switching between KEKB and PF injections. The specifications of the system are listed in Table 3. In the injection scheme, we have to achieve common optics, electron gun and beam diagnostic system in the linac. Thus, we started the beam study from February 2008. The pulsed sextupole magnet (PSM) was developed to further suppress the coherent dipole oscillation during the injection time for the top-up operation. The magnet was installed in this April, and the successful injection and storage using the PSM were demonstrated in May 2008 [3].

Table 3: Specifications of the pulsed bending magnet system.

Peak current	32 kA
Pulse width	200 μs
Stability	< 0.1 %
Max. repetition	25 Hz
Turn number	1
Core length	990 mm
Gap height	30 mm
Max. magnetic field	1.22 T
Magnetic field uniformity	$< 5\times10^{-3}$
Bending angle	7 deg

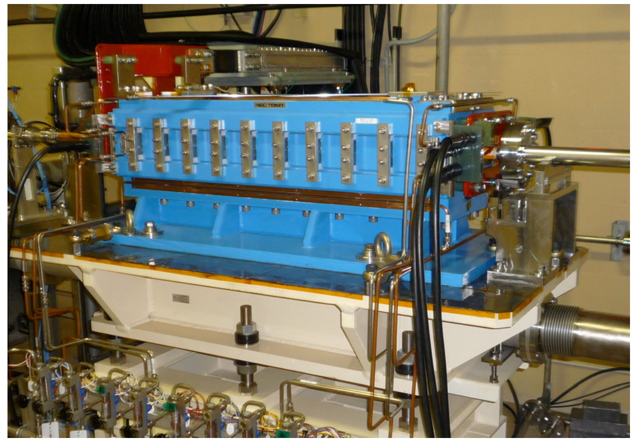

Figure 2: Photograph of the pulsed bending magnet as the most upper bend along the PF-BT installed in the 3rd switch yard of the linac tunnel.

Longitudinal Bunch-by-Bunch Feedback System

A bunch-by-bunch feedback system has been developed to suppress longitudinal coupled-bunch instabilities [4]. A longitudinal kicker based on a DAFNE-type overdamped cavity has been designed and installed in the ring, and a general purpose signal processor, essentially called iGp, has been developed by the collaboration of the KEK, SLAC, and INFN-LNF. The entire feedback loop has been closed by the end of June 2007, and the feedback system has successfully suppressed the longitudinal dipole-mode instabilities up to 430 mA. The photograph of the system is shown in Fig. 3.

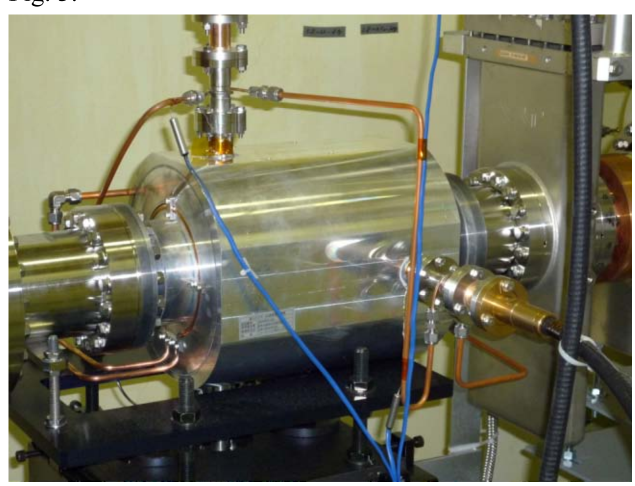

Figure 3: Photograph of the longitudinal kicker based on the DAFNE-type overdamped cavity for the longitudinal feedback system.

PF-AR

Operation

Though there existed some troubles in the renewal of the bending power supply, the operation of the PF-AR was quite smooth in FY2007.

Insertion Devices

Six insertion devices have been stably operated at the PF-AR. The principal parameters are listed in Table 4. The U#NW14-36 and U#NW14-20 are tandem undulators located in the same straight section NW14, but one quadrupole exists between them. The U#NW14-20 with a shorter period enables us to produce a higher brilliant hard X-ray than other undulators.

Table 4: Same as Table 2, but the parameters of the PF-AR are listed. The U and EMPW denote an undulator and an elliptical multi-pole wiggler, respectively.

Name	λu (mm)	N	L (m)	Gy/Gx (mm)
EMPW#NE1	16	21	3.36	30.0/110.0
U#NE03	40	90	3.60	10.0
U#NW02	40	90	3.60	10.0
U#NW12	40	95	3.80	10.0
U#NW14-36	36	79	2.84	10.0
U#NW14-20	20	75	1.50	8.0

Movable Mask

In order to protect the rf cavities from the strong bending synchrotron radiation, the fixed masks were installed in front of the cavities. However, we could not employ the fixed mask for the closest cavities to the preceding bending magnet since we had to insert the mask to a position of 19 mm from the central orbit and this limited the acceptance of the injected beam. Thus, we have developed the movable mask which was produced from a material of GLIDCOP ®. After the beam injection, the mask is inserted till the position of 19 mm. The mask has also the SiC absorber to avoid the strong wake field generated by the beam. The photograph of the movable mask is shown in Fig. 4. The two masks were installed into the ring during last summer shutdown and they have been smoothly operated.

Vacuum System

Though the PF-AR is usually operated at a high bunch current of 60 mA, the beam lifetime is still limited by residual-gas scattering rather than Touschek intra-beam scattering because the beam emittance and the bunch length are relatively large and the stored energy is very high. There is still room for extension of the beam lifetime by improvement of the vacuum pressure. As principal vacuum pumps, about 200 TSPs (titanium sublimation pump) and 56 DIPs (distributed ion pump) are adopted in the ring. In these three years, the number of SIP (sputter ion pump) has been increased to 3 times from 30 to 90. The PF-AR has a problem of the sudden drop of the beam lifetime frequently disturbing the user experiment. The DIP suspected as an origin of the problem, is now entirely turned off for the user operation. The reduction of the total pumping speed is well covered by the additional SIPs, and we can keep stable operation with a long lifetime. The lifetime has reached about 20 hours for the maximum current of 60 mA.

Pulsed Quadrupole Magnet

New injection scheme using a pulsed quadrupole magnet (PQM) has been demonstrated [5]. The successful injection was achieved over a stored current of 68 mA. However, the strong dependence on the total rf voltage was observed in the maximum current which could be stored using the PQM. In order to clarify this, we have investigated the relation between the beam instabilities and the injection due to the PQM [6].

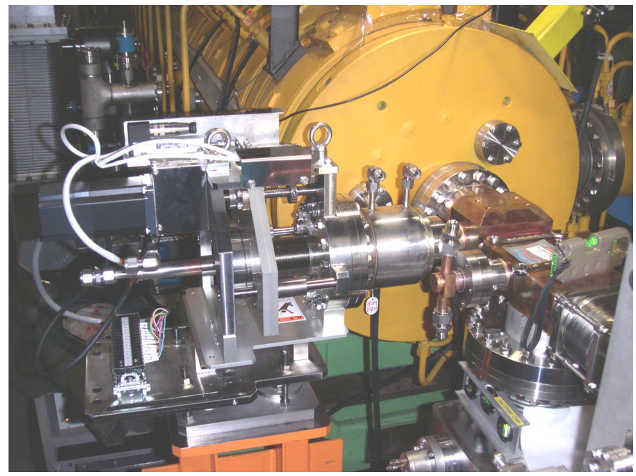

Figure 4: Photograph of the movable mask for protecting the most upper rf cavity from the strong bending synchrotron radiation.

SUMMARY

Both of the PF-ring and the PF-AR have been stably operated with trouble rates of 1.9 % and 5.0 %, respectively in FY2007. The machine maintenances and developments are continued to supply the stable synchrotron radiation for users. A top-up operation for the single bunch mode has already been carried out. The continuous injection for the multi-bunch mode will be conducted from autumn 2009 at the PF-ring.

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