OPERATIONAL STATUS OF THE POHANG LIGHT SOURCE*

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Abstract

Since 1995, the Pohang Light Source has been serving as the unique synchrotron radiation facility in Korea. In 2001, beam time scheduled for users was 4,056 hours. The actual beam time supplied to users was 3,806 hours recording a beam availability of 93.8%. Number of beamline experiments was 292, carried out by 1,087 users. On the technical side, the most important issue in PLS operation is the beam stabilization in 2001. Significant effort has been focused on the study of temperature effects of the accelerator components to identify the sources of the orbit error. There have been remarkable progresses in the beam stabilization activities. These progresses and other issues of the PLS operation will be discussed further.

1 INTRODUCTION

Pohang Light Source (PLS) [1] is a 2.0~2.5GeV, third generation light source dedicated to users since 1995. Until 1998, PLS had been run at 2.0GeV. After the demonstration of higher-energy beam operation in the storage ring in 1998, and further tuning of the machine for the 2.5GeV operation in 1999, the nominal operation energy is 2.5GeV from 2000. Though the design performances of the machine have been achieved, PLS still need significant improvements for the competitive performances. In table 1, operational parameters of the PLS are summarized. Here the number of emittance is still controversial because of the measurement errors. To check the consistency and accuracy, a special diagnostic station equipped with a pinhole imaging system has been installed and under commissioning now.

Table 1: Basic operation parameters

Beam energy	2.5GeV (injection at 2.0GeV)
Injection Current	180mA
Lifetime @ 100mA	~30hr
Number of bunches	400 (harmonic number : 468)
Beam emittance	11.1 nm-rad (to be confirmed)
Coupling	0.7%
Orbit stability (12hr)	< 10 μm-rms (measured at a BPM)
Injection period	12 hours

In 2001, the most important project was the stabilization of the closed orbit. There have been mysterious orbit drifts in PLS storage ring until recently, which has been suspected of the temperature effect on various accelerator components.[2] We investigated various kinds of environmental factors affecting the beam orbit drifts. One of the dominant effects is the output variation of bending magnet power supply (MPS) with ambient temperature variations in the MPS building.

There are 17 beam lines in operation including two new insertion device beamlines (EPU6 and U10) under commissioning. Total 292 experiments had been performed out of 408 proposals submitted in 2001. See table 2. and Ref[3] for more details.

2 MACHINE OPERATION IN 2001

The dedicated machine operator group composed of 6 technicians was organized in 2001. Two operators are on duty for a 8-hour shift, three shifts a day. The linear accelerator had been operated 5,280 hours, with 2.045GeV, 10Hz, 1ns pulsed beam. The operation time of the klystron and modulator system was 6,800 hours with the system availability of 94%. The number of modulator faults that caused injection delays has decreased from 29 in 2000 to 16 in 2001 [3]. For the full energy injection study, 2.5GeV operation of the Linac is practiced periodically. The storage ring was operated for 4,955 hours in 2001 with the basic operational beam parameters listed in Table 1. The beam time scheduled for users was 169days, 4,056 hours. Since 10 days of the user beam time was allocated for the EPU6 commissioning study and one day for special beamline alignment, the beam time supplied to users decreased from 180 days to 169 days. The actual time supplied to users was 3,806 hours with the beam availability of 93.8%. Beam time and user service history of PLS are summarized in the Table 2.

Table 2: Beam-time and user service history

year	'98	'99	'00	'01
Beam-time provided(hr)	3784	3831	3834	3806
Beam availability(%)	88.6	90.7	90.9	93.8
Experiments carried out	130	156	237	292
Number of users	646	659	883	1087

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3 ORBIT STABILIZATION ACTIVITY

One of the most important requirements of the 3rd generation light sources is the orbit stability of the stored electron beam. Since it is directly related to the quality of photon beams, modern light sources are required to have 1µm level orbit stability. In PLS, there have been continuous efforts to improve the performance of BPM(Beam Position Monitor) which is the most important tool for estimating the orbit stability.[4] Also improved was the air temperature control within ±0.1°C in the storage ring tunnel. With the improved BPMs we have performed various measurements to identify the sources of the orbit drifts during normal operation of the storage ring. Issues related to the beam stability are 10Hz beam oscillation observed at the U7 undulator beamline, orbit drift during normal operation, orbit shift between beam injections, and the strong dependence of the BPM reading on beam current. These topics will be discussed in the following subsections.

3.1 10Hz Beam Oscillation at U7 Beamline

After the commissioning of U7 undulator beamline, there have been fluctuations of beam intensity caused by 10Hz vertical oscillation of the photon beam. Intensive investigations on the vibrations of optical components followed by the significant improvements on the cooling system as well as mechanical supports, 10Hz vibration still remained. Measurements of the closed orbit showed same behavior with peak-to-peak 20 µm beam oscillation. This was identified to be due to the bending magnet power supply (MPS). By modifying the control circuit of the MPS, fluctuation of the MPS output has been reduced from 150ppm to less than 50ppm. As a consequence, beam oscillation has been disappeared and the slow drift of the closed orbit has been significantly reduced. Fig. 1 shows the photon beam oscillation before and after the improvement of the bending magnet power supply. Further discussions should be referred to Ref[5].

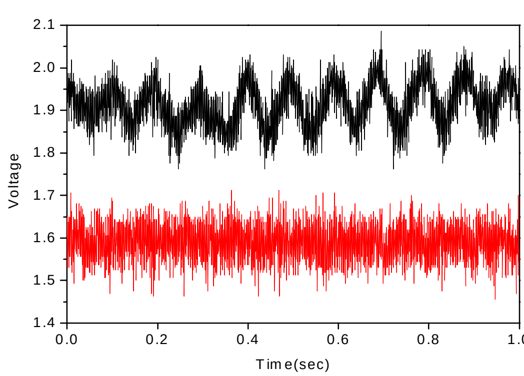

Figure 1: Photon beam intensity fluctuations observed at U7 beamline. Top trace shows 10Hz oscillation, lower trace after the modification of MPS circuit.

3.2 Slow Drift of Closed- Orbit

For a long while of the PLS operation, slow orbit drift had been a problem. To identify the source of the orbit drift, investigations are extensively performed on the thermal effect to the BPM reading accuracy, distortions of the mechanical lattice elements, drift of magnet power supply, and building and ground. Detailed descriptions will be presented in two papers in this Conference.[6][7]

Most significant effect to the slow orbit drift during normal operations was caused by the variation of the bending magnet power supply output by the change of air temperature in the MPS room. After controlling the air temperature of the MPS room, slow drift of the closed orbit reduced to <10 µm-rms during the 12-hour beam storage period.

3.3 Orbit Shifts between Beam Injection

During machine startup after the long shutdown, displacement of magnets, girders, and vacuum chambers was as large as 100µm by heating of the cooled components. For shutdown time shorter than 5 hours, it depends on the shutdown time because of the heat capacities of heavy and large components. This variation is reduced to <5µm after the machine reached steady-state operation. Significant transients also occur during the beam injection in the normal operation period. By the de-ramping/ramping processes, bending and quadrupole magnets moved as large as 20µm and 10µm respectively. After beam injection, the bending magnet promptly restored to its original position whereas the quadrupole takes few hours. Vacuum chamber and the girder moved <10µm vertically during the beam injection, but the effect to the closed orbit was negligible. Fig.2 shows the strong correlation between a quadrupole magnet movements and the BPM reading. The orbit shifts before and after the beam injection is as large as 50µm. Part of this orbit shift is attributed to the transverse electric modes excited in the beam channel in the storage ring, which will be discussed more in the following subsection.

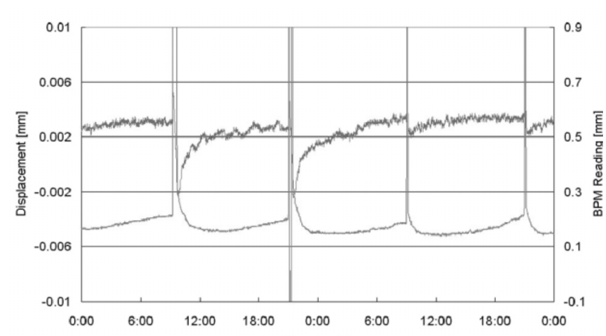

Figure 2: Displacements of the top plane of a quadrupole magnet (Q5D) and the BPM5-1 reading during machine study. Four beam injections in 8 hours.

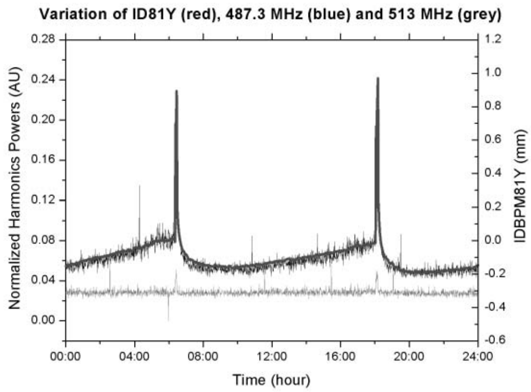

Figure 3: Plot of the IDBPM reading and the amplitude of 487MHz pickup signal (top trace). For comparison, amplitude of 513MHz does not change at all (lower trace).

3.4 Current Dependence of BPM reading

After the operation of U7, IDBPM(insertion device BPM) for U7 has shown large drift of the vertical beam position. With intensive machine studies, we suspected of some TE (transverse electrical) mode as the cause of abnormal vertical beam position drift. Indeed, spectrum of the beam signal showed a sharp peak at 483MHz [6], which is near the 500MHz beam signal for BPM electronics. This signal shows strong correlation with the current dependence of the BPM signal as can see in Fig. 3. To avoid this, will try to use second harmonic (1GHz) signal for the BPM processors.

3.5 Other Issues

Because of the soil characteristics of the PLS site, floor of the accelerator tunnel is still moving without slowdown. Fig. 4 shows it moved as much as 2mm peak-to-peak in 2001. To increase the stored beam current with all scheduled insertion devices installed, we started to add rf power from 2001. As the first step, one of four 60kW klystrons has been replaced by a new 75kW one. By replacing four of them, total gain in rf power will be 60kW. With this power, beam storage of >200mA will be possible. For further need of rf power, we will install the 5th rf cavity, making full capacity of rf power 375kW.

EPICS based upgrade of control system started from 2001. Both PC-Windows and Vx-Works based IOC's are under development. PC-Windows based IOC programs are developed for the BPM and correction magnets control system [8].

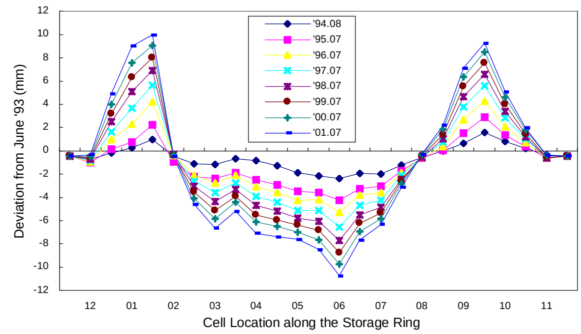

Figure 4: Movement of the storage ring floor since 1993.

4 SUMMARY

PLS has served 3,806 hours to users for the beamline experiments out of 4,056 scheduled hours. The beam availability was 93.8%. Extensive studies have been done to identify the source of the orbit error for the stabilization of the closed orbit. As the result, we have found reasonable clues. To summarize, strong dependence of vertical beam position readings at certain BPMs attributes to the TE mode of the beam signal excited in the vacuum chamber. Closed orbit shifts between beam injection to injection is caused by the transient thermal change of the quadrupole magnet current during the energy de-ramping and ramping between 2.0GeV and 2.5GeV. Slow drift and 10Hz oscillation are mainly due to the MPS electronics. Most of these problems has been cured now, and further improvements are planned for the sub-micron beam stability.

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