THE OPERATIONAL STATUS OF PLS *

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Abstract

The Pohang Light Source (PLS) has been operating successfully at 2.0 GeV. But now the energy can be raised up to 2.5 GeV by energy ramping in the storage ring. The operational status of PLS is presented including 2.5 GeV operation. Beam parameters such as emittance, lifetime etc. have been measured at a few energy levels. The measured results are presented and discussed with emphasis on their energy dependence.

1 OVERVIEW

PLS is a 2 GeV third generation light source in Korea. It has been operating successfully, after it started the user service on September 1995. The beam availability has been over 90 % except 1998, when the summer typhoon caused unexpected shutdown of a few days. The operation statistics of the last three years is shown in Table 1.

At the moment there are 8 beamlines are operational and 3 more beamlines will be available this year including the U7 beamline, the first insertion device beamline of PLS [1]. The operational beamlines are listed in Table 2.

The injected current ranged from 160 to 180 mA. The main reason of this current limitation is the longitudinal and transverse coupled bunch instabilities. At the moment, the only device we possess to overcome the instability is the RF cooling temperature system. Unfortunately the RF cooling temperature control is not enough to store more than 180 mA. Therefore we decided to use longitudinal and transverse feedback systems to suppress the coupled bunch instabilities.

This year, we have three plans of major upgrade. The first is the longitudinal and transverse feedback systems. The longitudinal feedback system was manufactured and is now under testing by SLAC. The transverse feedback system was manufactured in our Lab and now under fabrication. The two systems will be installed in April, and after full test will start operation in September. These two feedback systems are expected to increase the stored current more than 300 mA.

The second upgrade plan is the energy ramping up to 2.5 GeV in the storage ring. So far many x-ray users have not been satisfied with the hard x-ray flux of PLS as can be seen in Table 2. The critical photon energy of bending magnet beamlines is 2.8 keV for 2.0 GeV operation and 5.5 keV for 2.5 GeV operation. In general, it is said that photons of energy up to four times of the critical energy can be utilized. But high energy photon flux is not satisfactory. In the 2.5 GeV operation, the bending magnet photon flux of energy above 5 keV increases substantially compared with the 2.0 GeV operation. The photon flux of 10 keV is 3.8 times larger than that of the 2.0 GeV operation. Hence the 2.5 GeV operation is expected to satisfy many X-ray users. Both hardware and software were upgraded to perform the energy ramping up to 2.5 GeV. It takes about 5 minutes from 2.0 GeV to 2.5 GeV. The 2.5 GeV operation for users will start in April.

Table 1: Operation Statistics of PLS

hour

	1996	1997	1998
Scheduled	3,236	3,960	4272
Supplied	3,034	3,618	3,784
Percentage	93.8%	91.4%	88.6%

Table 2: Operational beamlines

Beamline	Energy range
Photoemission	12 - 1230 eV
X-ray scattering	4 - 12 keV
White beam	4 - 12 keV
Lithography	1 - 2 keV
NIM	5 - 30 eV
EXAFS	4 - 14 keV
X-ray diffraction	4 - 12 keV
SAXS	4 - 12 keV

Finally we have a plan to upgrade the BPM electronics. The current BPM electronics system is what we developed and its measurement resolution is within 20 μm. Even though this electronics system is still usable, we decided to upgrade it to the commercial one by Bergoz Co. [2]. This is for more reliable operation of insertion devices. The resolution of Bergoz BPM is expected to be within 10 μm.

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2 ENERGY RAMPING

2.1 Problems

Basically the ramping procedure is simply increasing currents of the magnet power supplies (MPS) step by step. But the real procedure is not easy by two requirements, fast ramping time and keeping the storage ring optics unchanged. Stability was the design key point of the PLS storage ring MPS. Therefore the storage ring MPS is relatively slow changing the currents compared with synchrotron booster MPS. More important is the control time. The computer control system of the PLS storage ring has three layers of hierarchy; operator interface computer (OIC), subsystem control computer (SCC), and machine interface unit (MIU). The SCC acts as a data gateway between the OIC and the MIU. The MIU layer is directly interfaced to individual machine devices for low-level data acquisition and control. Both the SCC and MIU layer is based on VMEbus standard with OS-9 real-time operating system. It takes considerable time, if the ramping procedure passes all the three layers.

The other problem comes from the fact that the relation of the MPS current to the corresponding magnet is not linear. In the normal operating region of 2.0 GeV, it is almost linear, but outside that region the discrepancy grows. Since the discrepancy is different for different magnets, even if all the MPS currents are increased by the same percentage, the real magnetic fields do not change correspondingly and thus the linear optics such as betatron tune is distorted. Even though the amount of distortion in each step is very small, if the ramping procedure keeps going this way, the betatron tune shifts keep growing and finally beam blows up.

2.2 Control System

To reduce the amount of time for the energy ramping significantly, the role of calculating and controlling the MPS current settings in each step was given to the MIU layer, not the OIC layer. The OIC just sends the start signal downwards. Since the various magnets have to change simultaneously in order not to kill the stored beam, the SCC layer generates synchronisation signals in each ramping step. The MIL-1553B field bus, which is already installed for low level data acquisition control, is used for the synchronisation network through which the SCC sends the synchronisation signals to the lower MIU layer. This way, the control time of the ramping was minimized.

Now the amount of ramping time is determined by the magnitude of each ramping step.

2.3 Linear Optics

We tried to keep the betatron tunes in each step. For the purpose, all MPS should not change by the exactly same percentage, but each MPS current should be fine tuned with respect to the basic percentage that is the same for all MPS. The basic percentage was chosen to be 0.3%. By a number of machine studies, we obtained data of appropriate MPS current setting values to keep the betatron tunes in each step. Several machine studies proved that the scheme works. In order to be sure of safe and stable ramping, we chose the conservative value 0.3%. For this choice, the amount of time needed for ramping up to 2.5 GeV is about 5 minutes, which is endurable because the injection from the linac can be finished within a few minutes.

2.4 Current Storage

The amount of stored current depends on the RF cavity power. Since the dependence of radiated power on the beam energy is quartic, 150 mA of 2.5 GeV is equivalent to 366 mA of 2.0 GeV in the sense of RF power. We consider 150 – 200 mA proper region of 2.5 GeV operartion.

2.5 Emittance

The dependence of beam emittance on the beam energy is quadratic. The design emittance of 2.0 operation is 12 nmrad and the diagnostic beamline confirmed that we achieved the goal. Hence the design emittance of 2.5 GeV operation must be 18.9 nmrad. We achieved a value close to it.

2.6 Lifetime

The beam lifetime of PLS storage ring is mainly determined by the Touschek effect just like other third generation light sources. The Touschek lifetime is proportional to the 2.5 th power of the energy [4]. In reality, we raised the beam energy from 2.05 GeV to 2.50 GeV. Therefore we expect the beam lifetime to increase 1.65 times. The measured lifetime of 2.5 GeV operation is close to this expectation.

3 FUTURE UPGRADE PLANS

3.1 Beam Based Alignment

The PLS storage ring has the ground settlement problem. The ground is continuously lowered maximum 2 mm each year. Obviously this is a serious threat for the orbit stability. We survey the storage ring and realign the girders periodically (every two years). Also we survey the BPM positions periodically and use the data to recalibrate the BPM readings. However, we need more reliable methods of BPM calibration especially for the operation of insertion devices. Now we are preparing the beam based alignment that calibrates the BPM reading with respect to the quadupole center. The scheme was already prepared and tested successfully in one superperiod. The remaining work is to extend the necessary hardware to the whole storage ring and construct control system.

3.2 Global Orbit Feedback

In conjunction with the beam based alignment, the global orbit feedback is also planed. The detailed scheme will be prepared soon.

3.3 Third Harmonic Cavity

The beam lifetime of 2.0 GeV operation is endurable at around 170 mA with 20 hours or so. But since the Touschek lifetime decreases with increasing current, the beam lifetime is expected to be very small (less than 10 hours) over 300 mA that will be achieved with the feedback systems soon. To keep the high brightness it is not permissible to increase the vertical size. Therefore the only way to increase the beam lifetime is to increase the bunch length using a third-harmonic RF cavity. A study is going on to apply the third-harmonic cavity to the PLS storage ring.

4 REFERENCES

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