STATUS OF POHANG LIGHT SOURCE

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Abstract

The Pohang Light Source (PLS) is a national users' facility for basic and applied science research using synchrotron radiation. It consists of a 2-GeV linac as a full-energy injector and a low-emittance, third-generation storage ring. It has been serving users since September of 1995. The beamlines have been increased from two to eight units as the increased number of users. The first undulator, U7 was installed in July 1997. In order to reduce the HOMs from RF cavities, we installed a new precision cooling system for RF cavities. We are also a preparing longitudinal feedback system to reduce the beam instabilities. We will introduce recent activities to improve PLS performances and key statistics in the machine operations.

1 INTRODUCTION

The PLS, a third generation light source, consists of the 2-GeV linac and the storage ring [1]. The project started in 1988, and the construction was completed in 1994. The PLS linac is working as the full energy injector to the storage ring. It consists of 11 klystrons and modulators, 10 pulse compressors, and 42 accelerating sections. The PLS storage ring has a triple bend achromat structure (TBA) with 12 superperiods and 280.56 m circumference. Each superperiod has a mirror symmetric configuration. Each half superperiod contains six quadrupoles -- three in the dispersion section and three in the non-dispersion section.

Since the completion of the construction in August 1994, the PLS storage ring underwent the one-year long commissioning. The total dose attained during this commissioning was about 114 ampere-hours (A-H) [2]. On September 1, 1995, the PLS have opened for users.

2 FY1997/1998 OPERATIONAL STATUS

There are two different operation modes for the storage ring: user service mode and accelerator study mode. In 1997, the PLS has operated for 252 days in total. There were two long-term maintenance periods in 1997. During these periods, we made regular maintenance work for the accelerator and installation work for new beamlines. Also, we made several system upgrades including a new RF cooling system and additional accelerating sections in the linac.

In 1998, we have made the operation schedule with 18 runs. Each run lasts for two weeks. It starts with one-day (first Monday) long accelerator study and follows by the 10-day long user service mode. We have two days (second Friday and Saturday) for short maintenance work. For longer maintenance, there is one-week break after 3 runs. There are also two 4-weeks long maintenance periods in January and August to install beamlines and other elements. By the end of May 1998, we have finished 7 user service runs.

2.1 Accelerator Operation

In 1997, there were 15 user service runs. Table 1 shows the annual operation time and user service time from September 1995 when the PLS started its user service.

Table 1. Operational statistics for 1997 run.

	1995*	1996	1997	1998#
Operation time (hours)				
Linac+	1,870	4,810	5,481	5,500(1,951)**
SR	1,820	4,680	4,839	5,000(1,762)
User service time (hours)				
Planned	1,275	3,236	3,960	4,272(1,701)
Serviced	1,142	3,034	3,618	4,000(1,558)
Availability (%)	89.6	93.8	91.4	93.6(91.5)

* From September to December
\# Estimated
\+ Counted only for scheduled operations
** Number in parentheses: Data as of May 31, 1998.

In the 1997 operation, the total accumulated beam dose was 500 A-H and the average beam lifetime was about 18 hours at 100 mA. After the 1997 summer maintenance period, we made a low-emittance lattice. The horizontal emittance measured by a streak camera for the visible synchrotron radiation is 11.3 nm-rad, and the lifetime was decreased significantly due to the smaller size of the beam. However, there were strong demands from the users to increase the beam lifetime despite of degrading the beam size. So, we added small vertical coupling by introducing the skew quadrupole. The average stored current (max. value) was improved from 120 mA to 180 mA by improving the precision temperature control system for RF cavities. With new cooling system, we could avoid harmful higher order modes from the RF cavities better than before.

Major failures of beam delivery are listed in Table 2. There were 231 failures in the linac and 214 failures in the storage ring. For the linac, one-half of total failures came from 11 modulator systems. Control system, vacuum system and the timing system were also major sources of the linac failures. For the storage ring, RF system, MPS system, and control system were major sources of SR failures. To improve this situation, several upgrade plans are being carried out in 1998.

Table 2: Accelerator failures in 1997.

Storage Ring		Linac	
RF system	65	Modulator	127
MPS system	48	Control system	35
Control system	28	MPS system	30
LCW system	19	Timing system	25
Vacuum system	18	Vacuum system	8
Interlock system	13	Power failure	8
Timing system	12	Microwave system	3
Power failure	6		
Injection system	5	E-gun	1
Total	**214**	Total	**231**

2.2 Linac

In 1997, the operation time of the linac was about 7,598 hours based on the auxiliary systems run-time, and that of the klystron-modulator system was 7,128 hours. This run-time corresponds to about 93% of system availability, similar to the 94% of availability in 1996.

Maintenance work for the klystron–modulator system is a major role in the linac operation. We replaced two klystrons in 1997. At the time of replacement, the heater running time for each klystron was 26,772 hours and 27,290 hours, respectively. We also replaced three thyratrons that had been operated for an average of 31,754 hours. For the high power RF load, we replaced 4 units with new SiC loads developed by ATF team of KEK, Japan. We will replace old high power loads with new SiC loads in the near future.

In addition to 11 accelerating modules installed during the accelerator construction, we added one more module at the end of the linac. This module includes two accelerating sections manufactured by Mitsubishi Co., Japan and one Toshiba E3712 klystron and a SLED cavity. The installation was completed in January 1998, and the PLS linac can now produce 2.5-GeV beams.

2.3 Storage Ring

For SR RF system, we added one more RF station in summer 1996 to provide enough RF power to store up to 400 mA with 1.6 MV of the accelerating voltage at 2 GeV and 200 mA at 2.5 GeV. New control electronics were also added for enhanced performance of the phase feedback and the automatic gain control. A transient data acquisition system was installed for better analysis of the unknown beam losses. Efforts to identify the higher order modes causing the collective instabilities were made, and a strategy to reduce their effects was established.

The cooling water control system for the RF cavities was massively upgraded during the summer maintenance period of 1997 to shift the harmful HOMs and to regulate the operation temperatures of cavities at stable condition. Upgraded temperature control system should be a closed loop system and should have larger control ranges (~30 degrees) and better stabilities within 0.2 degrees at each set value. To achieve this requirement, the cooling line was designed to have two loops: the primary and the secondary loops. The primary loop has two circuits; cold water from the heat exchanger and hot water from the electric heaters. The temperature of cold circuit is maintained at about 27^0C and that of hot circuit is variable between 30 and 65^0C, depending on the operation temperature of the cavities after tuning. The secondary loop is connected with main utility system through the heat exchanger, and the low conductivity water (LCW) of about 25^0C should be circulated into heat exchanger to dissipate the RF power.

The temperature control of the input water into the cavity is performed in two stages. The first rough control is obtained by three-way electric motor-driven control valve with a full range of linear characteristics, provided by the proportional-integral-differential temperature controller. Regulating two-way valves installed down-stream at each cold circuit and hot circuit with computer controllers carry out the fine temperature control. A linear-coefficient type, quartz crystal with oscillator circuit is used as a temperature sensor.

After installing the new system, the maximum stored current with a stable condition was increased to 200 mA and the designed emittance of 12 nm-rad has been achieved. With optimization and tuning, it is anticipated to achieve higher currents and quiescent operations soon.

2.4 Survey and Alignment

After the completion of the storage ring installation in 1994, we surveyed the storage ring two times a year and determined the change of positional errors from 1994 to 1997. As shown in Fig. 1, the comparison of each ENET survey shows changes of the reference elevation which was established in June 1993, the settlement of the storage ring tunnel keeps going on unevenly about 3.0 mm (peak to valley) per year. The lateral deformations are within the range of ±1.0 mm. When the storage ring installation was completed in August 1994, the magnets were aligned to the ideal beam path with the positional accuracy (rms) of 0.15 mm in both transverse and vertical directions. Then it was found the storage ring had a deformation at the end of 1994. We realigned the storage ring to the ideal beam path in February 1995.

Results of the case studies for the estimation of relative positional errors by a smoothing analysis from 1995 to 1997 are summarized as follows; a low filter method for the smoothing analysis was successfully employed, and the storage ring magnets are placed within 2σ (±0.3 mm) range from the smoothed curve. While the relative positional errors are well within the tolerance of 0.15 mm, the absolute positional tolerance that is the range of maximum deviations of magnets from the ideal beam path is extended to ±3 mm, which is derived from the experience of storage ring operation. Therefore, it is expected that the PLS storage ring is to be realigned in every two years [6].

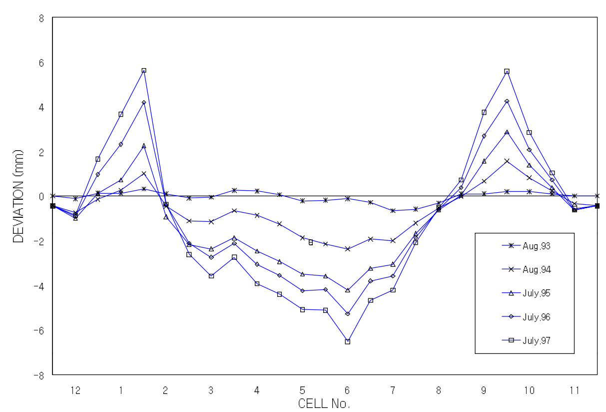

Figure 1: PLS storage ring settlement surveys.

3 BEAMLINES AND IDS

At present, one insertion device (U7) is installed in the storage ring. It was installed during 1997 summer maintenance period. We have tested the U7 operation with 1 mA beam because there was no beam abort system installed at the time of test. The U7 will start its operation from August 1998. The U7 undulator has 59 periods with 7 cm of period length. Its overall length is 4.3 m and the peak magnetic field is 1.01 T. We are also planning to install an elliptically polarized undulator (EPU6) with 6-cm period. It has 25 periods and its overall length is 1.57 m. The EPU6 will be available in 1999 [9].

When PLS started user service in September 1995, the number of beamlines was 2. This number is increased to 8 under the normal operations. And two more beamlines will be available by the end of 1998. Table 3 summarizes the beamlines under normal operations and under construction.

In 1997, there were 173 proposals applied to carry out the experiment using above beamlines and 135 experiments were approved. Since September 1995, a total of 226 experiments have been conducted at PLS. At present, the number of users' association member is increased to 433.

Table 3: Summary of beamlines

Beamline	Area of Research	Status
Whitebeam	X-ray Microprobe	1996
Photoemission	Surface Science	1995
NIM	Atomic/Molecular Science	1995
EXAFS	Chemical Engineering	1996
X-ray Scattering	X-ray Diffraction	1995
Lithography	Semiconductor	1996
Crystallography*	Marchromolecule Crystallography	1997
SAXS*	Small Angle X-ray Scattering	1997
U7 undulator		1998
Slitless		1998

* These beamlines were completed in November 1997, and there was no user in 1997.

4 FUTURE PLAN

In the near future, we will try to store up to 400 mA. Major obstacle to achieve this designed current is strong instabilities (especially longitudinal instability) caused by higher order modes of RF cavities. To suppress this instability, we already improved the precision temperature control system for the RF cooling system. In this way, we have increased the beam current up to about 200 mA. However, we need a longitudinal feedback system (LFS) to increase the stored beam current up to 400 mA. We have ordered fast signal processing electronics of the LFS to SLAC while we are manufacturing the kicker system. This kicker is similar to the one developed by DAΦNE, Italy. We will start the LFS commissioning from August 1998. This LFS will help to operate the U7 undulator from August 1998 [2].

There is also a great demand on the higher X-ray beam from users' community. To achieve this demand, we will operate the storage ring at 2.5-GeV energy. We have operated the storage ring at this energy by ramping. However, we need more study to reduce the ramping time and to improve the lattice at 2.5-GeV. This effort will continue throughout the year of 1998.

In addition to these efforts, we are planing to upgrade the control system of the linac and the storage ring by introducing recent technologies such as JAVA, EPICS, and better hardware.

5 ACKNOWLEDGMENTS

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REFERENCES

[1] Design Report of Pohang Light Source (revised ed.), Pohang Accelerator Laboratory, 1992.

[2] M. Kwon, et al., "Issues for the Next Phase Operation in PLS," in these proceedings.