COMMISSIONING OF THE PLS 2 GEV STORAGE RING

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In Pohang, Korea, construction of a third-generation 2 GeV light source has been in progress since 1988. Installation of the storage ring components started in March 1993 and was completed in August 1994. Initially, only two super-periods out of 12 were baked out in-situ. From September to the end of 1994, the machine commissioning had been carried out. The initial injection energy for the commissioning was chosen to be 1.4 GeV because at this energy the injection kicker magnet can make a design bump, -21 mm. On September 8, the injected beam from the injector linear accelerator was circulated in storage ring more than 500 turns without RF. After accumulating the beam up to 76 mA on October 20, the injection energy was changed to the design value which is 2.0 GeV. At 2.0 GeV, amount of the bumped orbit which the kicker magnet can generate is -15 mm. Additional -6 mm bump is produced by four horizontal corrector magnets located on each side of the injection straight section. On December 24, 1994, the beam was stacked up to 300 mA, exceeding the commissioning goal of 100 mA. From January to March 1995, the ring had been shut down for in-situ bakeout. Since April, the second commissioning has been in progress. The PLS facility will be open to users in July 1995. In this paper, we present the current status of the PLS storage ring commissioning and the future plan for normal operation.

I. INTRODUCTION

The PLS is a third-generation synchrotron radiation facility. The construction project began in April, 1988 and the installation was completed in September, 1994. It was jointly funded by Pohang Iron and Steel Company (POSCO) and Ministry of Science and Technology (MOST) of Korean government. Total construction budget was approximately US $180M.

The PLS is located an area adjacent to the Pohang University of Science and Technology (POSTECH) campus in Pohang, which is about 400 km southeast of Seoul. Total area of the PLS facility is 650,000 m^2, which is large enough to accomodate possible future expansion. The facility itself is situated on stable mud-stone area. On April, 1991, a ground-breaking started and the building construction was completed in September, 1993.

The PLS consists of two major accelerators; a 2.0 GeV full energy injector linear accelerator and a 2.0 GeV storage ring. The linear accelerator is a conventional RF accelerator which provides a 2 A, 2 nsec long electron pulses with a nominal repetition rate of 10 Hz. The operating frequency is 2856 MHz and there are total 42 constant gradient accelerating columns and 10 energy doublers. The bunching of electrons is done by employing a 2856 MHz standing-wave prebuncher followed by a 2856 MHz traveling-wave buncher. The electron bunches leaving the first accelerating column are bunched within 5 degrees in phase. The construction of the linear accelerator was completed in December, 1993 and from January to June 1994, the commissioning had been conducted and the machine is now in normal operation mode so that it can provide an electron beam whenever storage ring demands.

The injection into the storage ring is done by four kicker magnets and one septum magnet, all located in one of the straight sections in the storage ring. Since the injector is located below ground, the output beam from the linear accelerator is transported vertically at an angle and this beam is then deflected vertically by the septum magnet to place it on the same level as the stored beam in the storage ring. The storage ring is 280.56 m in circumference and consists of 12 super-periods. The magnet lattice employs a triple bend achromat structure, with 36 dipole magnets, 144 quadrupoles and 48 sextupoles. The magnetic field of the dipole magnet is 1.058 T at 2.0 GeV, and the critical photon energy from the bending magnet is 2.8 keV.

The installation of the storage ring was started in March 1993 and was completed in August 1994. Actually, most of the storage ring components had been installed by March 1994 and in April, magnet alignment was started. By August, several iterations of survey and alignment had been carried out and as a result quadrupole magnets were aligned within 0.15 mm in rms. The commissioning of the storage ring and the beam transfer line was started in September 1994. In this report, we present the current status of the PLS storage ring commissioning. Status and plan of the beamline construction will also be described.

II. STORAGE RING COMMISSIONING

A. General Status

Prior to the commissioning, only the chambers in two super-periods out of 12 were baked out in-situ due to lack of time. The average vacuum pressure was mid 10^{-9} torr which was sufficient for commissioning purpose. An overall debugging of the control system had been performed during August. This includes a magnet power supply control, vacuum gate valve IN/OUT control, injection and RF control, and machine safety interlock debugging etc. On September 1, 1994, the commissioning of the beam transfer line was started. On the same day, the injected beam appeared at the first screen monitor located between kicker magnets in storage ring. For the initial commissioning, the electron beam energy was set to be 1.4 GeV because below this energy the storage ring kicker magnet can produce a design bump, -21 mm. This corresponds to -15 mm at 2.0 GeV. Therefore at 2.0 GeV, the additional kick is necessary and this can be produced by utilizing four horizontal corrector magnets located on each side of the injection straight.

The injection into the storage ring and the storage ring commissioning began on September 5. On the 8th, the signal from the stripline pickup monitor indicated that the injected beam was circulated in storage ring more than 500 turns without RF turned on, which is in agreement with the estimation. After turning on the RF and with some adjustment of magnet currents and RF frequency, the beam started being stored and as time went by the stored current increased gradually. Immediately after the beam stacking, the vaccum went up by more than two orders of magnitude. For the commissioning, the number of beam bunches was chosen to be 100 to 200 out of maximum 468 bunches. On September 28, the stored beam current reached to 27 mA where the vacuum interlock at the RF straight section prevents from further stacking; the interlock level of the vacuum was set to be at 10^{-6} torr. As the vacuum chamber is being scraped out by the photon beam, the storage ring vacuum has been improved slowly which in turn increased the stored beam current and lifetime.

In order to see the possibility of 2.0 GeV injection with DC bump, at 1.4 GeV the bumped orbit was reduced to -15 mm from -21 mm and on top of this a -4 mm DC bump was applied. The stacking was successful and with minor adjustment of injection conditions, the beam current reached up to 76 mA where again the vacuum interlock at RF was activated . Subsequently on October 24, the beam energy was changed to 2.0 GeV and on October 26, the current went up to 102 mA, exceeding the commissioning goal of 100 mA. Since then, the stored current increased continuously and on December 23, just one day before shut-down, it went up to more than 300 mA. Total beam dose obtained to that date was 8.5 ampere-hours and the beam lifetime was 45 minutes at 100 mA. Normally, the injection rate was 2 mA/sec, with the best perfomance of 3.5 mA/sec. The injection efficiency was approximately 25%.

The storage ring had been shut down from January to March, 1995 in order to bake out all the vacuum chambers in situ and to remove some of the beam profile monitors. After the bake-out, all magnets were resurveyed and aligned and by the end of March, the quadrupoles were aligned within 0.14 mm (rms) in horizontal and 0.09 mm (rms) in vertical directions, respectively.

On April 1, 1995, the second commissioning of the storage ring was started. The base pressure of the vacuum was of the order of 10^{-10} torr. Improvement of the beam lifetime was apparent after the bake-out; immediately after the beam storage, the lifetime at 100 mA was about 2 hours. At 13 ampere-hours of total dose, it became approximately 4 hours at 100 mA and at this current the vacuum pressure was low 10^{-8} torr.

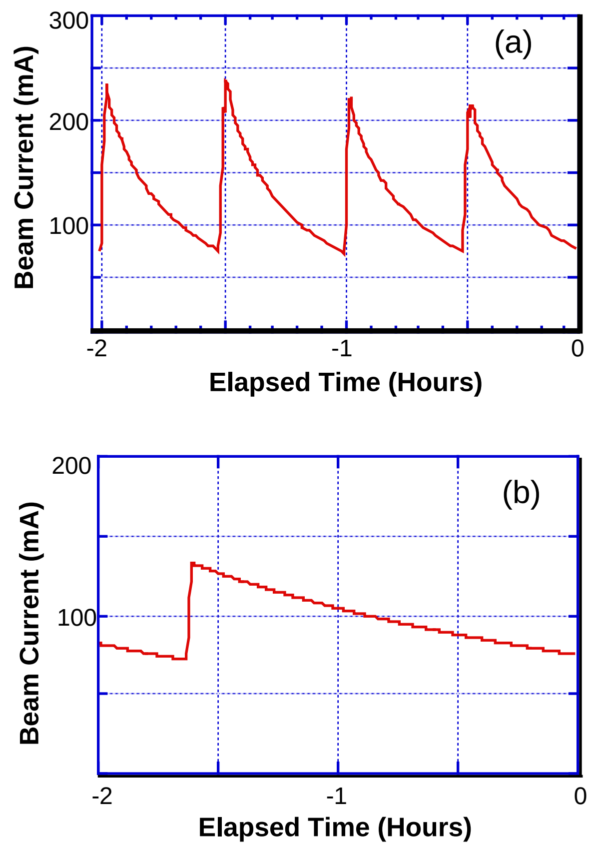

Figure 1: Stored beam current as a function of elapsed time. (a) The data was taken during the first commissioning before bake-out. (b)The data was taken during the second commissioning after bake-out.

In figure 1, the beam current is displayed as a function of time. Fig. 1(a) shows the beam current decay as a function of time when the total dose was approximately 6 ampere-hours and the data was taken before the bake-out. Fig. 1(b) shows a similar plot after the bake-out when the total dose was 10 ampere-hours. Comparing these two figures clearly indicates the increase in beam lifetime after the bake-out. In these two figures, the difference in total dose has some effect on the lifetime difference, but it is clear that the bake-out has more impact on it.

By the end of June 1995 when the second commissioning is scheduled to be completed, we expect the total dose to be 50 ampere-hours and our immediate goal is such that by that time the lifetime is more than five hours at 100 mA.

At present, there are three RF cavities installed in the storage ring, each provides 600 kV . And therefore, with three cavities, total voltage is 1.8 MV, satisfying the design value at 2.0 GeV. In view of our future upgrade to 2.5 GeV, we plan to install one additional cavity sometime at the end of 1995. See [1] for the RF system operation during the PLS commissioning.

B. Commissioning Diagnostics

Diagnostic instruments for the commissioning include the beam profile monitor, beam current monitor, tune monitor, beam position monitor, and stripline pickup etc. Initially we placed five beam profile monitors distributed around the ring. Except the one in the injection straight, the remaining four profile monitors were not impedance matched; the vacuum chamber cross sections were changed abruptly along the beam direction. Since these profile monitors were just to aid in obtaining the first turn on the very first day of commissioning, their large contribution to the impedance was not important. Originally, it was planned to remove the four profile monitors immediately after the first commissioning. However as the commissioning was in progress, it became clear that the profile monitors were very useful to check roughly the beam position from time to time, especially when the injection condition was changed. Because of this, it was decided to retain total three profile monitors permanently and therefore during shut-down period four monitors were removed to be replaced by two impedance-matched new ones. Another useful diagnostics during the commissioning was a number of radiation safety monitors attached on walls in various places of the storage ring. The radiation level of these monitors are closely monitored in the main control room. And therefore, the high radiation level at a certain location indicates the spot where the beam loss occurs.

In PLS, one beamline near the injection area is reserved for the photon beam diagnostics. It will be installed in the next shut-down period which is scheduled to be held sometime in this summer.

III. BEAMLINE STATUS

At present, two bending magnet beamlines have been installed; one for VUV experiments and one for hard X-ray experiments with photons at energies below 10 keV.

For the VUV beamline, two branches are attached to the exit beam port from a bending magnet, which has a horizontal divergence of 42 mrad. Of the two branches, one is a spherical grating monochromator (SGM) beamline for photoemission spectroscopy experiments and the other is a normal incidence monochromator (NIM) beamline for gas-phase experiments. The SGM will accept 10 mrad of white photon beam and provide photons between 13 and 1230 eV. Another 13.5 mrad of white beam can be used for the optics of NIM for 5 - 30 eV photons. At present, only SGM beamline has been constructed and NIM beamline will be installed sometime in 1996.

For the bending magnet X-ray beamline, there will be two experimental stations, each for X-ray scattering and XAFS, respectively. Each experimental station will be located inside a hutch for radiation shielding. X-ray scattering beamline will accept a 3 mrad wide X-ray beam from bending magnet. The X-ray photons will be focussed by a dynamically bent cylindrical Pt-coated sillicon mirror in front of a double crystal monochromator which monochromatizes X-rays between 4-12 keV. The monochromator is being assembled and is planned to be tested with a conventional sealed-tube X-ray source. At present, X-ray deflection beamline has been installed and XAFS beamline will be installed in 1996.

In PLS, there are ten available places for insertion devices to be installed. At present, one undulator (U7) has been designed and will have been constructed by early 1996. Its beamline will be installed in 1996. A decision has just been made to construct a helical undulator. Its design will start in the early 1996 and will be installed in 1997.

IV. SUMMARY

PLS construction was completed and it is now under commissioning. So far, the maximum beam current achieved was more than 300 mA. Total dose is 13 ampere hours and expected to be 50 ampere hours by the end of June. After in-situ bake out of vacuum chambers, the beam lifetime at this dose is more than four hours at 100 mA and this is continuously increasing. At present, two bending magnet beamlines have been constucted and one undulator beamline is scheduled to be installed in 1996. The PLS will be open to users starting from July 1995.

V. REFERENCES

[1] M. Kwon at al, in these proceedings